

Physics and Applications of High Brightness Beams

An ICFA and UNESCO endorsed workshop

March 28-April 1, 2016 in Havana, Cuba



Abstract Booklet

Conference at a glance

Time	Monday	Tuesday	Wednesday	Thursday	Friday
	<i>Electron Sources</i> Chair Ferrario / Guzman	<i>Beam Manipulation</i> Chair: Puppín, Chiadroni	<i>Advanced Accelerators.</i> Chairs: Meier, Luiten	<i>Compton</i> Chair: Serafini	<i>Caribbean</i> Chair: Musumeci, Cruz
Morning A 8:30 – 10.15	Rosenzweig	Lemery	England	Variola	Rosenzweig
	Castro Smirnov	Lifschitz	Andonian	Petrillo	Biscari
	Floettman	Ha	Marchetti	Zomer	Puppín
	Cahill	Maxson	Corliss	Pogorelsky	
		Tomizawa	Martinez de la Ossa	Gadjev	
Coffee Break (30 m)					
Morning B 10.45 – 12.30	Kozak	Cianchi	Nanni	Murokh	Winick
	Hidding	Craievich	Carbajo	Gonzalez-Lazo	Final discussion
	Luiten	Lindstrom	Chiadroni	Curatolo	Closing remarks
		Bacci	Deng	Hernandez	
			Mosnier	Cruz-Inclan	
Lunch (1h 30 m)					
Afternoon A 2 – 3.30 pm	<i>FEL Chairs: Zholents/ La Guardia</i>	<i>All optical/Medical</i> Chair: Musumeci	<i>5th generation</i> Chair: Giannessi, Rosenzweig	Excursion	Excursion
	Giannessi	Cesar			
	Duris	Zhou	Rossi		
	Hemsing	Conde	Candler		
	Emma	Corsini	Meier		
		Pellegriti			
Coffee Break (30 m)					
Afternoon B 4 – 5.30 pm	Marinelli	Medical roundtable Castro Smirnov	Zholents		
	Prat	See detailed program for participants	Gover		
	Iverson	Poster session 6.00-8.00 pm	Pellegrini		
	Villa				

Schedule

Monday March 28th

Electron Source session I. Chair: M. Ferrario

8.30 – 9.00 am F.A. Castro Smirnov, J. B. Rosenzweig. Opening remarks.

9.00 – 9.25 am K. Floettman (DESY). Generation of Ultra-Short Bunches.

9.25 – 9.50 am D. Filippetto (LBNL). High repetition rate photoinjectors.

9.50 – 10.15 am A. Cahill (UCLA). An Ultra-High Field Cryogenic RF Photoinjector.

10.15 – 10.45 am Coffee break

Electron Source session II. Chair: F. Guzman Martinez

10.45 – 11.10 am M. Kozak (Erlangen). Electron sources for dielectric laser accelerators

11.10 – 11.35 am B. Hidding (U. Strathclyde). High-brightness beams from the Trojan-Horse mechanism

11.35 – 12.00 pm J. Luiten (U. Eindhoven). Laser cooled electron source

12.30 – 2 pm Lunch

FEL session I: Chair: A. Zholents

2.00 – 2.25 pm L. Giannessi (Elettra-Sincrotrone Trieste and ENEA) Advanced FEL seeding schemes.

2.25 – 2.50 pm J. Duris (UCLA) High efficiency energy extraction from high brightness beams

2.50 – 3.15 pm E. Hemsing(SLAC National Accelerator Laboratory). Echo-seeding results.

3.15 – 3.30 pm C. Emma (UCLA). High efficiency, Terawatt X-ray free electron lasers via fresh bunch self-seeding

3.30 – 4.00 pm Coffee Break

FEL session II. Chair: Dr. Rodolfo Alfonso La Guardia

4.00 – 4.25 pm A. Marinelli (SLAC National Accelerator Laboratory). Custom made x-rays: temporal shaping of x-ray laser pulses at the Linac Coherence Light Source.

4.25 – 4.50 pm E. Prat (Paul Scherrer Institute). Enhanced FEL performance from tilted electron beams.

4.50 – 5.15 pm R. Iverson (SLAC National Accelerator Laboratory). Demonstration of energy-chirp control in relativistic electron bunches at LCLS using a corrugated structure.

5.15 – 5.30 pm C. Villa (INFN-LNF) Generation, measure and FEL radiation of ultrashort electron beam at SPARC_LAB

7.00 – 9.00 pm Welcome cocktail

Tuesday March 29th

Beam manipulation and diagnostics: Chair E. Puppin

8.30 – 8.55 am F. Lemery (Hamburg University, CFEL) Beam manipulation and acceleration using dielectric lined waveguides

8.55 – 9.20 am A. Lifschitz (LOA CNRS/ENSTA/Polytechnique). Improving stability and acceleration length on laser-plasma accelerators.

9.20 – 9.45 am G. Ha (POSTECH). Demonstration of longitudinal bunch shaping with double dog-leg emittance exchange beamline.

9.45 – 10.00 am J. Maxson (UCLA). Measurement of high brightness photoelectron beams at low charge and small spatial and temporal scales.

10.10 – 10.15 am H. Tomizawa (RIKEN, SPring-8) Stabilization of a HHG-seeded FEL by time-synchronization control with EO-sampling

10.15 – 10.45 am Coffee break

Beam manipulation and diagnostics session II. Chair: E. Chiadroni

10.45 – 11.10 am A. Cianchi (INFN-LNF) Diagnostics for high brightness beams

11.10 – 11.35 am P. Craievich (Paul Scherrer Institute). Temporal profile measurements using self-induced fields

11.35 – 12.00 pm C. A. Lindstrom (Oslo University) Emittance preserving staging optics for LWFA and PWFA.

12.00 – 12.25 pm A. Bacci (INFN-MI) Ultrashort electron beams generation.

12.25 – 12.40 pm V. Litvinenko (Stony Brook) Project towards CO₂-laser driven wakefield accelerator with external injection.

12.40 – 2 pm Lunch

All optical session I. Chair: P. Musumeci

2.00 – 2.15 pm D. Cesar (UCLA). RF photoinjector-based ultrafast electron microscopy

2.15 – 2.30 pm F. Zhou (SLAC National Accelerator Laboratory). LCLS injector operational experience and improvements

2.30 – 2.45 pm M. Conde (Argonne National Laboratory). Recent experimental results at the Argonne Wakefield Accelerator Facility (AWA).

2.45 – 3.00 pm R. Corsini (CERN). The CALIFES-based Accelerator Test Stand proposal at CERN, status and perspectives.

3.00 – 3.15 pm M. G. Pellegriti (INFN-CT) Eurogammas Gamma Characterization System for ELI-NP: The Nuclear Resonance Scattering Technique

3.15 – 3.30 pm Coffee Break

Medical session II. Chair: F. A. Castro Smirnov

3.30 – 3.55 pm K. Sheng (UCLA Medical). X-ray and electron radiotherapy.

3.55 – 4.20 pm P. Maxim (Stanford Medical) High energy electron beam radiotherapy

4.25 – 6.00 pm Medical roundtable

4.25 – 4.40 pm C. Ceballos-Sanchez (CEADEN) BNCT: a binary radiotherapy at cellular level

4.40 – 4.50 pm E. Musacchio (CEADEN) An accelerator-based BNCT facility based on the ${}^7\text{Li}(p,n){}^7\text{Be}$

4.50 – 5.00 pm MSc. Adlin López (Head, Nuclear Medicine Department, Hosp. Hnos. Ameijeiras). Approaches on the role of medical physicists in implementing the hybrid technologies in Nuclear Medicine.

5.00 – 5.15 pm Dr. Leonel Torres (Vice-director, Centro de Investigaciones Clínicas). Development of tools for internal dosimetry and establishing Quality Management Systems in Nuclear Medicine.

5.15 – 5.25 pm MSc. Carlos Calderón (Department of Nuclear Medicine, National Oncology Institute, INOR). Radiobiology concepts for treatment planning of combined Metabolic Radiotherapy.

5.25 – 5.35 pm MSc. Rogelio Díaz, (Department of Radiotherapy, INOR). Photon beams applied to stereotactic radiation treatments

5.35 - 5.45 pm Dr. Fernando García Yip (expert in Medical Physics, Department of Radiotherapy, INOR). Updates in dosimetry of small beams.

5.45 – 5.55 pm Dr. Rodolfo Alfonso (Department of Nucl. Eng., InSTEC) Image Guidance Systems for Radiotherapy Beams.

5.55 – 6.05 pm MSc. Jorge L. Morales (Head, Brachytherapy Section, Department of Radiotherapy, INOR). Introduction of Intraoperative Radiotherapy with electron beams: the Cuban Experience.

6.05 – 6.20 pm Dr. Luis Ducat Pages Isotope center (CENTIS): Facilities for the production of radiopharmaceuticals.

Other important participants:

Lic. Roberto Fraxedas, Experto OIEA en Física Médica

Dr. Joaquín González, Jefe de Física Médica, Departamento de Medicina Nuclear, InSTEC

MSc. Ileana Fleitas, físico médico funcionaria de la OPS, Habana

MSc. Consuelo Varela, Jefe de Departamento de Física Médica, Centro de Control Estatal de Medicamentos y Equipos Médicos.

MSc. Roberto Caballero, Jefe de Física Médica, Departamento de Radioterapia, Hosp. Hnos. Ameijeiras.

MSc. José L. Alonso, Experto de Física Médica, Dpto. de Radioterapia, INOR

Lic. Maika Guerrero, Coordinadora de Física Médica, CIMEQ

Lic. Yoslán Brito, Físico Médico, CIMEQ.

6.30 – 8.15 pm Poster session

8.30 pm Parisien show

Wednesday March 30th

Advanced accelerator session I: Chair A. Meier

8.30 – 8.55 am R. J. England (SLAC National Accelerator Laboratory) Dielectric Laser Acceleration

8.55 – 9.20 am G. Andonian (UCLA). GV/m acceleration in dielectric structures.

9.20 – 9.45 am B. Marchetti (DESY-Hamburg). High brightness beam research at SINBAD.

9.45 – 10.10 am R. Corliss (MIT). Searching for a dark photon with DarkLight.

10.10 – 10.25 am A. Martinez de la Ossa (DESY/ University Hamburg). Self-similar staging and wakefield-induced ionization injection.

10.15 – 10.45 am Coffee break

Advanced accelerators session II. Chair: J. Luiten

10.45 – 11.10 am E. Nanni (SLAC National Accelerator Laboratory) THz Gun development.

11.10 – 11.35 am S. Carbajo (SLAC National Accelerator Laboratory) Free-space longitudinal electron acceleration.

11.35 – 12.00 pm E. Chiadroni (INFN-LNF). Beam manipulation for resonant PWFA.

12.00 – 12.15 pm A. Deng (UCLA). Progress of Trojan-Horse Injection PWFA experiment at FACET.

12.15 – 12.30 pm A. Mosnier(CEA). Advanced electron acceleration experiments planned in the Long Focal Area of the CILEX-Apollon Facility.

12.30 – 2 pm Lunch

5th generation session I. Chair: L. Giannessi

2.00 – 2.25 pm A. R. Rossi (INFN-MI) All-optical FELs: a challenging, next generation radiation source.

2.25 – 2.50 pm A. Meier (CFEL/University Hamburg) Commissioning of the LUX Beamline for Laser-plasma driven undulator radiation.

3.30 – 4.00 pm Coffee Break

5th generation session II. Chair: J. B. Rosenzweig

4.00 – 4.25 pm A. Zholents (ANL) Dielectric accelerator based 5th generation light source.

4.25 – 4.50 pm A. Gover (Tel Aviv University) Fundamental processes of emission from an electron bunch: spontaneous, super-radiant and stimulated super-radiant emission.

4.50 – 5.15 pm C. Pellegrini (UCLA)

Thursday March 31st

Compton sources session I: Chair L. Serafini

8.30 – 8.55 am A. Variola (INFN-LNF). Compton sources for gamma and X-ray applications.

8.55 – 9.20 am V. Petrillo (INFN-MI). Advanced topics in the physics of Compton back-scattering.

9.20 – 9.45 am F. Zomer (CNRS/University Paris-Sud). ThomX and advanced optical systems for Compton Sources.

9.45 – 10.00 am I. Pogorelsky(BNL) Drafting a roadmap to gamma colliders driven by mid-IR lasers.

10.10 – 10.15 am I. Gadjev (UCLA). IFEL driven Inverse Compton Scattering source.

10.15 – 10.45 am Coffee break

Compton sources session II. Chair: L. Serafini

10.45 – 11.10 am A. Murokh (Radiabeam Technologies). Towards industrial X-ray source based on Inverse Compton Scattering.

11.35 – 11.50 am C. Curatolo (INFN). Phase space analysis of secondary beams generated in hadron-photon collisions.

11.50 – 12.05 pm D. Hernandez (InSTEC/CEADEN) Channeling of charged particle beams in carbon nanotubes.

12.05 – 12.20 pm C. M. Cruz Inclan (CEADEN) Methodology trends on gamma and electron radiation damage simulation studies in solids under high frequency irradiation environments.

Excursion

Friday April 1st

Caribbean Light Source session I: Chair P. Musumeci

8.30 – 8.55 am J. Rosenzweig (UCLA)

8.55 – 9.20 am C. Biscari (ALBA synchrotron). The African Light Source Roadmap

9.20 – 9.45 am E. Puppini (CNISM-PoliMi). The STAR project: a TBS X-ray source in a southern Italian region

10.15 – 10.45 am Coffee break

Caribbean Light Source session II: Chair Dr. Carlos Cruz

10.45 – 11.25 am H. Winick (SLAC National Accelerator Laboratory)

11.25 – 12.00 pm Final discussion and closing remarks. M. Ferrario

Excursion

List of abstracts

Monday March 28th List of abstracts

Name: Klaus Floettmann
University: DESY
E-mail: Klaus.Floettmann@DESY.De
Type: invited talk
Abstract: Generation of Ultra-Short Bunches

Electron sources providing bunch length down to the fs regime and below are of increasing interest for applications as time resolved electron diffraction or ultra-fast magnetics, but also as injectors for advanced accelerator experiments. Analytic and numerical studies demonstrate that sub-fs bunch length can be generated at low charge with simple ballistic bunching schemes if nonlinearities in the longitudinal phase space are corrected. The correction can be achieved by adding a higher harmonic rf system or by operating the rf gun in an unusual phase range in the so-called stretcher mode. The presentation will give an overview of ballistic bunching concepts and correction methods. Limits and options for ultra-short bunch generation at low energies will be discussed.

Name: Daniele Filippetto
University: LBNL
E-mail: dfilippetto@lbl.gov
Type: Invited talk

Abstract: The next generation of scientific tools is assigned with the challenging task of resolving the details of atomic and molecular motions during transformational changes, bridging the gap between structure and function of complex organic structures, and studying phase transitions in condensed matter. Characteristic times associated with atomic scales fall in the femtosecond region, asking simultaneously for ultrafast and ultraslow probes. In terms of electron instrumentation, this maps directly into beam brightness and flux.

The effort of our team at LBNL over the last few years has been focused on the development of a new type of electron source blending ultra-fast, ultra-bright pulses and MHz operations, with a leap in terms of average flux respect to present sources.

I will describe the results of the commissioning of the APEX injector to date, with beam parameters optimized for FEL operations. I will also discuss the use of the electron source as direct tool for ultrafast science, with present and future plans.

Name: Alexander Cahill
University: UCLA

E-mail: acahill@physics.ucla.edu

Type: Invited Talk

Abstract: A Ultra-High Field Cryogenic RF Photoinjector:

Experiments at SLAC have shown improvements in performance of normal conducting copper reduced to cryogenic temperatures. The peak surface gradients observed reached 500 MV/m at 11.4 GHz (X-Band) about two times fields seen at room temperatures. We propose to use this technique to design a new photoinjector. The photoinjector presented here will be S-Band to be easily used to replace the current photoinjector at LCLS X-ray free-electron laser. We believe that with a twofold increase in surface field from cryogenic operation, and another factor of two increase in launch field from a change in geometry we can attain greater than an order of magnitude increase in peak beam brightness over the current LCLS photoinjector. This increase in brightness would lead to a factor of two decrease in FEL gain length and an increase in X-ray radiative efficiency. I will present here designs of the photoinjector, tests on cryogenic copper, as well as beam dynamic simulations.

Name: Feng Zhou

University: SLAC

E-mail: zhoufeng@slac.stanford.edu

Type: plan to have an oral presentation

Abstract: LCLS injector operational experience and improvements

F. Zhou et al

Since the start of LCLS operation for FEL users in 2009, a number of improvements have been placed for the LCLS injector such as dramatic QE enhancement and emittance reduction. This talk will present the details of the improvements and the idea for further emittance reduction.

Name: Martin Kozák

University: Friedrich-Alexander-Universität Erlangen-Nürnberg

E-mail: martin.kozak@fau.de

Type: invited talk given instead of prof. Hommelhoff, in case he will be present, he will give the talk himself

Abstract: In this contribution we discuss the latest progress of dielectric laser accelerators (DLAs) designed to accelerate sub-relativistic electrons. DLA devices utilize optical near-fields of dielectric nanostructures excited by femtosecond laser pulses. This technique offers high acceleration gradients (GeV/m range), thus enabling the scaling down of the size of future accelerator facilities based on DLAs by about 1-2 orders of magnitude in comparison with RF accelerators. However, building a DLA-based beamline requires the development of various components to achieve precise control of the particle beam properties along its orbit. Here we present an overview of experimental tests of new structures designed to operate as laser-driven acceleration, deflection and focusing elements. Moreover, optical near-fields are demonstrated as a powerful tool for electron bunch duration and transverse density distribution measurements.

Name: Bernhard Hidding

University: University of Strathclyde

E-mail: bernhard.hidding@strath.ac.uk

Type: invited talk

Abstract: High-brightness beams from the Trojan Horse mechanism

The Trojan Horse underdense photocathode plasma wakefield acceleration strategy may generate electron beams with brightness orders of magnitude larger than state-of-the-art. This brightness in combination with the inherent tunability may have transformative impact on a wide range of applications, including advanced plasma-based light sources which appear on the fringes of the scientific horizon. This talk gives an overview on the fundamentals and limits of the idea, and sketches a multi-year journey towards proof-of-concept experiments, which most recently has been rewarded with breakthrough results at FACET. These results support start-to-end design and plans to put the scheme to use for lab-scale realization of high performance free electron lasers, for example.

Name: Jom Luiten

University: Eindhoven University of Technology

E-mail: o.j.luiten@tue.nl

Type: invited talk

Abstract: Laser-cooled electron source

We are developing a pulsed, ultracold electron source based on near-threshold photoionization of a laser-cooled and trapped atomic gas. This new and exotic technique allows us to enter entirely new regimes of beam brightness.

The electrons are produced in pulsed mode using femtosecond photoionization resulting in picosecond bunches containing $\sim 10^3$ electrons with a high degree of coherence. The intricate dependence of the source properties on acceleration field strength, ionization laser wavelength, and laser polarization have been studied in detail both theoretically and experimentally. By a proper choice of these parameters it is possible to achieve a much lower source temperature (~ 10 K) and thus a much higher degree of coherence than was previously thought possible. An important goal is to produce bunches with much more charge, preferably in excess of 10^6 electrons, while retaining a high degree of coherence. This would enable single-shot electron diffraction of macromolecules and thus dynamical studies of biomolecules at atomic length and timescales.

We are investigating various methods for realizing even lower source temperatures. The ultimate goal is a quantum degenerate electron beam. The properties of such ultimate beams is the subject of a theoretical study.

Name: David Cesar

University: UCLA

E-mail: dcesar@ucla.edu

Type: Contributed talk

Abstract: Ultrafast electron microscopy at the high brightness Pegasus photoinjector

In this presentation we will discuss our efforts at the Pegasus photoinjector laboratory to adapt high brightness beams for use in ultrafast electron microscopy. We have recently taken the first picosecond-long, single-shot TEM images by using a novel permanent magnet quadrupole based 25x objective lens.

The compact PMQ design, using record field gradients of nearly 600 T/m, paves the way toward multiple magnification stages and the observation of unique ultrafast phenomena. Such high resolution electron microscopy places unique constraints on the beam brightness, which we have met by operating Pegasus in an ultra-low charge, ultra-low emittance regime.

Name: Roberto Corsini

University: CERN

E-mail: Roberto.Corsini@cern.ch

Type: poster

Abstract: The CALIFES-based Accelerator Test Stand proposal at CERN, status and perspectives.

A recent proposal has been made by the CLIC Collaboration to adapt the CALIFES linac, presently part of the CLIC Test Facility CTF3, to serve as a user facility from 2017, when CTF3 will have completed its experimental program. A small electron linac of this type can address several goals, including advanced high-gradient energy-frontier accelerator R&D and beam-line and instrumentation component tests aimed at consolidating and upgrading the CERN accelerator complex. It also will support strategic partnerships with other science fields in Europe that need electron-beam test capability, namely X-ray FELs, medical, space and industrial communities. We present here such a proposal, address beam parameters and specifications and discuss possible experiments, applications and perspectives.

Name: Luca Giannessi

University: Elettra-Sincrotrone Trieste and ENEA

E-mail: luca.giannessi@elettra.eu

Type: Invited

Abstract: The injection of a seed to initiate the high gain amplification in a free electron laser is a concept initially introduced to shorten the amplifier length and improve the spectral brightness. This concept was first demonstrated at BNL, a few experiments done later have shown the possibility to extend the method to reach VUV wavelengths and FERMI was built as a facility exploiting this technique to provide to user experiments, coherent light down to the soft X-ray range of the spectrum. Since the beginning of the operation at FERMI, a number of other possibilities which go beyond the simple improvement of the spectral quality of the emitted pulses have been exploited. The seed has indeed offered the capability of controlling synchronization, polarization, pulse duration and phase, to generate multiple pulses for the implementation of multiple color schemes. The layout of FERMI is also flexible enough to permit the implementation of frequency mixing schemes as the echo enabled harmonic generation, or to drive multicolor emission by seeding microbunching instability.

Name: Joseph Duris

University: UCLA

E-mail: jduris@physics.ucla.edu

Type: Invited talk

Abstract: Title: High efficiency energy extraction from high brightness beams

Abstract: Efficient coupling of relativistic electron beams with high power radiation lies at the heart of advanced accelerator and light source research and development. Recent inverse free electron laser experiments using strongly tapered undulators have demonstrated high-gradient acceleration of >50% of injected electrons, producing beams of high-quality. By accommodating the evolving radiation field in the design of the undulator tapering, a large fraction of energy may be transferred between the electrons and laser, enabling compact, high-current GeV accelerators and various wavelength light-sources of unprecedented peak and average powers.

Name: Erik Hemsing
University: SLAC
E-mail: ehemsing@slac.stanford.edu
Type: invited talk
Abstract: Echo seeding results

Echo enabled harmonic generation (EEHG) is a promising laser-based electron beam manipulation technique aimed at producing fully transform-limited soft x-ray pulses in upcoming free electron lasers. I will present the recent results of the Echo program at the SLAC NLCTA facility, where the 75th harmonic has just been observed. New features of echo seeding will also be discussed that enable harmonic selectivity and tunable multicolor pulses.

Name: C. Emma
University: UCLA
E-mail: claudio.emma@physics.ucla.edu
Abstract: Title: High efficiency, terawatt X-ray free electron lasers via fresh bunch self-seeding

High efficiency, terawatt peak power X-ray Free Electron Lasers (XFELs) are a promising tool for enabling 3D atomic resolution single molecule imaging and nonlinear science using X-ray beams. Increasing the efficiency of XFELs while maintaining good longitudinal coherence can be achieved via self-seeding and tapering the undulator magnetic field. The efficiency of tapered self seeded XFELs is limited by two factors: the ratio of seed power to beam energy spread and the ratio of seed power to electron beam shot noise. We present a method to overcome these limitations by producing a strong X-ray seed and amplifying it with a small energy spread electron bunch. This can be achieved by selectively suppressing lasing for part of the electron beam in the SASE section and using the rest of the bunch to generate the seed radiation. In this manner one can reach saturation with the seeding electrons and the strong seed pulse can be overlapped with the "fresh" electrons downstream of the self-seeding monochromator. Simulations of this scenario demonstrating an increased efficiency are presented for two systems, an optimal superconducting undulator design and the Linac Coherent Light Source. In the case of the LCLS we examine how the betatron oscillations leading to selective suppression can be induced by using the transverse wakefield of a parallel plate corrugated structure, a dechirper. We also discuss extending the selective suppression scheme to chirped electron bunches.

Name: Agostino Marinelli
University: SLAC National Accelerator Laboratory
E-mail: marinelli@slac.stanford.edu
Type: Invited talk
Abstract: Custom made x-rays: temporal shaping of x-ray laser pulses at the Linac Coherent Light Source.

The x-ray free-electron laser is the brightest source of x-rays, with a peak brightness ten orders of magnitude higher than conventional synchrotron radiation sources. Much like conventional lasers, xFELs are extremely flexible machines and the properties of the x-rays can be controlled by accurately manipulating the lasing medium, i.e. the electron beam.

In my talk I will discuss our ongoing efforts to shape the temporal properties of the x-rays at the Linac Coherent Light Source (LCLS). I will discuss the recently developed two-color FEL modes and their applications in user experiments. I will then present the recent demonstration of single-spike hard x-ray pulses, with an estimated duration in the sub-fs region. Finally I will discuss our results on laser-shaping of x-ray pulses and our plans for attosecond operation in the soft-x-ray regime.

Name: Eduard Prat
University: Paul Scherrer Institute
E-mail: eduard.prat@psi.ch
Type: Invited talk
Abstract: Title: Enhanced FEL performance from tilted electron beams

Abstract:
A transverse tilt of the electron beam is normally not wanted in free-electron-laser (FEL) facilities, since in a typical undulator beamline with quadrupole magnets only the central part of the beam with negligible small betatron oscillations will produce significant FEL radiation. In this contribution we present special configurations for which a transverse tilt can actually be used to improve the FEL performance. In particular, we show with numerical simulations how tilted electron beams can be employed to generate ultra-large bandwidth FEL radiation, two-color FEL pulses, and high-power and short duration FEL radiation. The latter feature is especially important for compact FEL sources operating at low beam energies, since these low energies reduce the available saturation power level. We present different mechanisms to generate the transverse tilt, namely a transverse deflector structure and introducing dispersion to an energy-chirped beam.

Name: Richard Iverson
University: SLAC National Laboratory
E-mail: rhi@slac.stanford.edu
Type: poster
Abstract: Title:
Demonstration of Energy-Chirp Control in Relativistic Electron Bunches at LCLS Using a Corrugated Structure

Abstract:

An experimental study is presented of a corrugated structure that uses wakefields to remove linear energy correlation in a high energy (4.4 - 13.3 GeV) electron beam (a dechirper). Time-resolved measurements of both longitudinal and transverse wakefields of the device are presented and compared with simulations. We demonstrate flexible control of the LCLS FEL bandwidth and present novel uses of the device in addition to energy chirp control.

Name: Fabio Villa

University: Laboratori Nazionali di Frascati - INFN

E-mail: fabio.villa@lnf.infn.it

Type: Poster

Abstract: Poster title: Generation, measure and FEL radiation of ultrashort electron beams at SPARC_LAB

Abstract: The technique for producing and measuring few tens femtoseconds electron beams and the consequent generation of a few tens femtoseconds FEL radiation pulse at SPARC_LAB is presented. The undulator has been used in the double role of radiation source and diagnostics for the characterization of the electron beam. The connection between the electron length and radiation bandwidth measurements is analyzed.

Tuesday March 29th List of abstracts

Name: Francois Lemery

University: Universität Hamburg / Center for Free Electron Laser Science (CFEL)

E-mail: francois.lemery@gmail.com

Type: talk

Abstract: Beam Manipulation and Acceleration using Dielectric Lined Waveguides

High-impedance mediums such as dielectric lined waveguides (DLW) have gained interest for their applications in advanced accelerator concepts for the acceleration and manipulation of electron beams. We discuss recent work on beam manipulation in the low-energy regime where DLWs can provide the necessary energy chirp from a self-wake for e.g. ballistic bunching and longitudinal beam shaping. We also discuss developments for beam-driven acceleration and alternative longitudinal shaping techniques to generate ideal transformer ratio bunches.

Name: Agustin Lifschitz

University: LOA (CNRS/ENSTA/Polytechnique)

E-mail: agustin.lifschitz@ensta-paristech.fr

Type: Invited Talk

Abstract: Improving stability and accelerating length on laser-plasma accelerators

Laser-plasma wakefield accelerators can produce high quality electron beams, up to giga-electronvolts energy, from a centimeter scale device. Two very recent theoretical & experimental studies dealing with how to improve the

features of the electron beam and the associated X-ray emission produced in these accelerators are presented here. The first work is a study about the reduction of the shot-to-shot fluctuations by using high Z gas targets as accelerating media. It will be shown in particular the effect of ionization injection over the stability of the betatron emission, which is a key requirement for most applications foreseen for this light source. The second study deals with how to tailor the plasma density profile to retard the dephasing of trapped electrons with respect to the accelerating wave, and thus to boost the energy gain.

Name: Gwanghui Ha
University: POSTECH
E-mail: homehe@postech.ac.kr
Type: invited talk

Abstract: Title: Demonstration of longitudinal bunch shaping with double dog-leg emittance exchange beam line

Abstract: Manipulation of the longitudinal bunch shape (LBS) has many potential accelerator applications. For example, collinear wakefield acceleration schemes require special longitudinal shapes (e.g. triangle) to achieve a high transformer ratio. A variety of desired longitudinal bunch shape can be generated with a transverse profile mask and an emittance exchange beamline. This idea was first suggested in 2011 and it has recently been demonstrated at the Argonne Wakefield Accelerator (AWA). The goals of the experiment were to first demonstrate this method and then characterize the aberrations of an "ideal" shape due to higher order and collective effects. Three different transverse masks, located at the entrance of the EEX beamline, were used to select a transverse profile of the electron beam to demonstrate LBS. The transverse (longitudinal) phase space of the incoming beam was manipulated to explore the aberrations using four quadrupoles (linac phase) in front of the E EX beamline. I will present three special profiles generated by the EEX beamline, and measured aberrations due to the second order and collective effects.

Name: Jared Maxson
University: UCLA
E-mail: jmaxson@ucla.edu
Type: poster/contributed talk

Abstract: Measurement of high brightness photoelectron beams at low charge and small spatial and temporal scales

Ultrafast electron microscopy and diffraction (UEM/D) performed with radiofrequency photoelectron sources requires high peak brightness beams at much smaller charges and emittances than have traditionally been used in high brightness linacs. For example, the UCLA Pegasus photoinjector regularly delivers 10's of nm transverse emittances at bunch charges below 100 fC for UEM/D. This charge and emittance regime allows access to ultrasmall spatial and temporal beam sizes. In this work I will describe novel diagnostics at UCLA Pegasus for the measurement of spot sizes with few micron resolution, as well as a novel single shot slice phase space technique applicable to emittances of 10's of nm. Using a velocity buncher, I will present results of ongoing work to measure ultrashort bunch lengths with a transverse deflection cavity, inspired by a recent novel technique [1] proposed for longitudinal emittance reduction, wherein simulations show that the beam may achieve <10 fs temporal extent for several millimeters of beamline.

Name: HIROMITSU TOMIZAWA

University: RIKEN, SPring-8 Center,

E-mail: hiro@spring8.or.jp

Type: Stabilization of a HHG-seeded FEL by time-synchronization control with EO-sampling

Abstract: A fully coherent FEL seeded with a higher-order harmonic pulse from high-order harmonic generation (HHG) is successfully operated for a sufficiently prolonged time in pilot user experiments by using a timing drift feedback. For HHG-seeded FELs, the seeding laser pulses have to be synchronized with electron bunches. Despite seeded FELs being non-chaotic light sources in principle, external laser-seeded FELs are often unstable in practice because of a timing jitter and a drift between the seeding laser pulses and the accelerated electron bunches. Accordingly, we constructed a relative arrival-timing monitor based on non-invasive electro-optic sampling (EOS). The EOS monitor made uninterrupted shot-to-shot monitoring possible even during the seeded FEL operation. The EOS system was then used for arrival-timing feedback with an adjustability of 100 fs for continual operation of the HHG-seeded FEL. Using the EOS-based beam drift controlling system, the HHG-seeded FEL was operated over half a day with an effective hit rate of 20%~30%. The output pulse energy was 20 mJ at the 61.2 nm wavelength. Towards seeded FELs in the water window region, we investigated our upgrade plan to seed high-power FELs with HH photon energy of 30~100 eV and lase at shorter wavelengths of up to 2 nm through high-gain harmonic generation (HG) at the energy-upgraded SPring-8 Compact SASE Source (SCSS) accelerator. We studied a benefit as well as the feasibility of the next HHG-seeded FEL machine with single-stage HG with tunability of a lasing wavelength.

Name: Alessandro Cianchi

University: University of Rome "Tor Vergata" and INFN

E-mail: alessandro.cianchi@roma2.infn.it

Type: invited talk

Abstract: Diagnostics for High Brightness Beams

The brightness is the figure of merit of electron beams used to drive novel radiation sources, like Free-Electron Lasers, Compton backscattering, THz radiation and also pioneering compact accelerators.

The generation and optimization of such high brightness beams require advanced diagnostic tools. 6D electron beam diagnostics will be reviewed with emphasis on emittance measurement.

Name: Paolo Craievich

University: Paul Scherrer Institut

E-mail: paolo.craievich@psi.ch

Type: Invited talk

Abstract: Temporal profile measurements using self-induced fields.

A complete characterization of the time-resolved longitudinal beam phase space is important to optimize the final performances of an accelerator, and in particular this is crucial for Free Electron Laser (FEL) facilities. A novel method to characterize the profile of a relativistic electron bunch is

proposed, which is based on passively streaking the beam using its self-interaction with the transverse wakefield excited by the bunch itself passing off-axis through a dielectric-lined or a corrugated waveguide. Results of a proof-of-principle experiment at the SwissFEL Injector Test Facility are discussed.

Name: Carl Andreas Lindstrom
University: University of Oslo
E-mail: c.a.lindstrom@fys.uio.no
Type: Invited talk

Abstract: Emittance preserving staging optics for LWFA and PWFA
Reaching TeV-scale energies for next-generation electron-positron colliders using laser-driven (LWFA) or beam-driven (PWFA) plasma wakefield accelerators requires acceleration in multiple stages. Between these stages, the depleted drive beam must be extracted and a new drive beam injected, and the highly diverging main beam must be captured and refocused while preserving its emittance. Chromaticity correction emerges as a main challenge of the staging optics. Achromatic focusing, a method of correcting chromatic errors without sextupoles and dipoles, is demonstrated as a viable and compact solution. Examples of LWFA staging optics lattice designs are shown.

Name: Alberto Bacci
University: INFN Milano
E-mail: alberto.bacci@mi.infn.it
Type: invited talk

Abstract: TITLE: Ultrashort electron beams generation
Abstract

The generation of ultrashort electron bunches is presently one of the primary issue in the field of high brightness electron beams, with more challenging applications, as ultra-fast science or new acceleration techniques. Considering the external injection into laser wake field accelerators or the plasma wake field accelerators, ultralow charge bunches (pC orders) with lengths around, or shorter than 10 fs are a necessary requirement. Further for the PWFA, where the acceleration field scales as the driver charge over its squared length (Q_b/ℓ^2), the shortness is still a main issues. Many laboratories world-wide are investigating the ultrashort bunch generation by simulating different schemes, and some laboratories start to obtain very interesting experimental results. In this work we present the state of the art of the ultrashort electron bunch generation, focusing on the rf compression technique coupled to a pre-corrective rf short cavity working in deceleration phase. This configuration takes advantage from space-charge effects, more than from the rf curvature correction, stacking the electrons distribution more uniformly and improving the final compression performance.

Name: Cameron Geddes
University: LBNL
E-mail: cgrgeddes@lbl.gov
Type: invited talk

Abstract: All-optical Thomson/Compton photon sources from laser-plasma accelerators

C.G.R. Geddes, S. Steinke, H.-E. Tsai, J. van Tilborg, J.-L. Vay, A.J. Gonsalves, K. Nakamura, Kelly Swanson, A. Bonatto, C. Benedetti, C.B. Schroeder, E. Esarey, W.P. Leemans
BELLA Center, Lawrence Berkeley National Laboratory

Compact, high-quality photon sources at MeV energies are being developed based on Laser-Plasma Accelerators (LPAs). Simulations are presented on production of controllable narrow bandwidth sources using the beam and plasma capabilities of LPAs. An independent scattering laser, combined with appropriate pulse shaping and laser guiding is important to realize high photon yield. Plasma optics are described to tailor beam divergence in cm-scale distances, reducing photon source bandwidth. The LPA can further be used to de-accelerate the electron beam after photon production to reduce undesired radiation. Combination of laser driven and beam driven deceleration is presented to reduce residual beam energy, as is important for a laboratory or field operable source. Design of experiments and laser capabilities to combine these elements will be presented, towards a compact photon source system. Both applications of the MeV photon beams and use of the radiation produced to infer beam properties and evolution to support development of LPAs will be discussed.

Name: Manoel Conde
University: Argonne National Laboratory
E-mail: conde@anl.gov

Type: poster

Abstract: Recent Experimental Results at the Argonne Wakefield Accelerator Facility (AWA)

The AWA facility uses high charge electron bunches to generate and study wakefields in various types of RF structures. Single bunches of up to 100 nC, and bunch trains of up to 32 bunches with an energy of 70 MeV are used to excite wakefields. A second, independent electron beam is used to probe these wakefields. Experiments have been conducted at 11.7, 26 and 91 GHz, and some of these recent results will be presented. Some of the main goals of the facility are the generation of short RF pulses with GW power levels, corresponding to accelerating gradients of hundreds of MV/m and energy gains on the order of 100 MeV per structure, and also the demonstration of staging capability.

Work supported by the U.S. Department of Energy under contract No. DE-AC02-06CH11357.

Name: Ke Sheng
University: University of California, Los Angeles
E-mail: KSheng@mednet.ucla.edu

Type: Invited talk

Abstract: Opportunities and Challenges in Modern Radiation Therapy

Ionizing radiation is effective to induce damage in both cancerous and normal cells. By exploiting the difference in radiosensitivities, a therapeutic window may exist to eradicate the tumor cells while maintaining tolerable normal tissue toxicities. Modern radiation therapy has further improved the geometric specificity of tumor targeting by intensity modulation, inverse optimization and improved 3D image guidance. With these improvements, 40% of the curative cancer patients receive radiation therapy. To further increase

the number of curative patients and to improve the patient overall survival, radiation therapy techniques must be advanced in planning algorithms, better images, and beam physics. Currently, high energy X-rays are clinically used to treat cancer but the X-rays do not stop in the body, resulting in high entrance and exit normal tissue doses that can be only partially mitigated by inverse planning. Heavy charged particles have more desired physical properties to release most energy in the Bragg's peak and leave no exit dose. Particles heavier than proton are biologically more potent than X-rays for the same physical dose. These new modalities therefore have the potential to overcome tumor radioresistance. Improved tumor control also relies on the image sensitivity to tumor volume. Phase contrast CT is more sensitive to difference in soft tissues than conventional CT and thus superior in tumor detection. However, these new treatment and imaging modalities are associated with significant challenges in engineering complexities and economical costs. New methods and new beam modalities may be developed to overcome these challenges.

Name: C. M. Cruz-Inclan

Methodology trends on gamma and electron radiation damage simulations studies in solids under high fluency irradiation environments.

¹⁾ Carlos M. Cruz Inclán ¹⁾, Eduardo González Lazo ¹⁾, Arturo Rodríguez Rodríguez ²⁾, F. Guzmán Martínez ²⁾, Yamiel Abreu Alfonso ¹⁾, Ibrahim Hernández Piñera ¹⁾ and Antonio Leyva Fabelo ^{1,3)}.

¹⁾ Centre of Technological Applications and Nuclear Development, CEADEN, Havana, Cuba.

²⁾ High Institute of Technologies and Applied Sciences, InSTEC, Havana, Cuba.

³⁾ Joint Institute of Nuclear Researches, Dubna, Russia.

ABSTRACT: The present work deals with the numerical simulation of gamma and electron radiation damage processes under high brightness and radiation particle fluency. In this case two new radiation induced atom displacement processes are regarded, which concern with both, the Monte Carlo methods based numerical simulation of the occurrence of atom displacement process as a result of gamma and electron interactions and transport in a solid matrix and the primary knockout atom, PKA, defect formation probability dependence on the PKA excitation energies and their crystal direction movements by Molecular Dynamic, DM, methodologies. For simplicity sake, electron and gamma radiation damage processes were considered in the **BaTiO₃** ferroelectric material with crystalline tetragonal structure. The two new radiation damage processes to be considered in the framework of high brightness and particle fluency irradiation condition are: 1) The defect formation due to a single PKA (Ba, Ti and O) excitation in the **BaTiO₃** crystal matrix with former crystal defects (vacancies, interstitials and Frenkel pairs) with increasing excitation energies and for different crystal movement directions and 2) The Multiple PKA (Ba, Ti and O) excitations for the same or different atomic species in an ideal **BaTiO₃** crystal matrix inducing defect formation by the coincidence during a given material relaxation time τ of two or more radiation particles inducing damage in the neighborhood of an occupied crystal position.

It was assumed that, as a result of these two new radiation damage processes under high brightness and particle fluency, the atom displacement threshold energy values E_d at the different atomic species and crystal directions will change consequently, leading to significant changes of the atom displacement per atom (*dpa*) in-depth profiles. In electron and gamma irradiated solid **BaTiO₃** matrix, which is normally regarded as a measurement of radiation damage effects.

In the present work a review of numeral simulation attempts of these two new radiation damage processes are presented, starting from the former MCSAD algorithm and code [1,2] for Monte Carlo simulation of atom displacements induced by electron and gamma and, in addition, Molecular Dynamics calculations [3] of PKA defect formation dependence on the PKA excitation energies and movement directions radiation (see contributions [4] and [5], respectively, submitted to his meeting).

References:

[1]. Carlos M. Cruz, Ibrahim Piñera, Antonio Leyva and Yamiel Abreu. **"Studies on the Gamma Radiation Responses of High Tc Superconductors"**. In Superconductors, Chapter 7, pags. 135 - 160. Edited by Adir Moysés Luiz, published by Sciyo, Croatia, 2010.

[2]. Carlos M. Cruz, Ibrahim Piñera, Camilo Correa, Yamiel Abreu, and Antonio Leyva. **"MCSAD: Monte Carlo Simulations of Atom Displacements induced by Fast Electrons in Solids"**. 2011 IEEE Nuclear Science Symposium Conference Record, RTSD.S-282, p.4622- 4626.

[3]. E. Gonzalez, Y. Abreu, C.M. Cruz, I. Piñera, A. Leyva. **"Molecular-dynamics simulation of threshold displacement energies in BaTiO₃"**. NIM B 358 (2015) 142 - 145.

[4] Arturo Rodríguez Rodríguez, Carlos M. Cruz Inclán, Eduardo González Lazo, F. Guzmán Martínez, Yamiel Abreu Alfonso, Ibrahim Hernández Piñera and Antonio Leyva Fabelo. **"Upgrading attempts of the Monte Carlo simulation of Atom Displacements, MCSAD, in solids induced by electron and gamma irradiation algorithm under high fluency irradiation environments"**. Submitted to this meeting.

[5] Eduardo González Lazo, Carlos M. Cruz Inclán, Arturo Rodríguez Rodríguez, F. Guzman Martinez, Yamiel Abreu Alfonso , Ibrahim Hernández Piñera and A. Leyva Fabelo. **"Effects of vacancies on atom displacement threshold energies calculation through Molecular Dynamic Methods in BaTiO₃ with tetragonal crystalline structure"**. Submitted to this meeting.

Name: P. Maxim

University: Stanford Medical

Email: pmaxim@stanford.edu

Type: Invited talk

Abstract: High energy electron beam radiotherapy

In the U.S., cancer is one of the leading causes of death. Worldwide, the global burden of cancer is increasing dramatically, and the number of patients who could benefit from radiotherapy far exceeds its availability.

Radiation therapy is a key curative treatment for many cancers. Despite

several technological advances in radiotherapy, there is much room for improved outcomes. One of the most dramatic advances is stereotactic ablative radiotherapy (SABR)/stereotactic body radiation therapy (SBRT), a highly focused and accurate radiation delivery method that is administered in a few large doses rather than the conventional long series of small doses. SABR has been used for early stage lung cancer in patients with high surgical risk or contraindications and excellent primary tumor control rates of over 90%, rivaling historical surgical results, have been demonstrated in clinical studies.

Since SABR utilizes high radiation doses in very few fractions, every treatment has to be delivered very accurately in order to avoid compromising adequate tumor coverage. One of the biggest challenges in lung SABR is organ and/or tumor motion caused by respiration, which can be significant in size. This aggravates the accuracy and precision of the treatment, as targeting a moving target is difficult. To address this, several motion management strategies have been proposed that deal in various ways with tumor and/or organ motion. However, these strategies are complex, prone to errors, time consuming and require adequate training of the care team, thus it is not fully utilized at many cancer centers, even in a developed country such as the U.S.

A fundamentally different approach to managing tumor motion is to deliver the treatment so rapidly that tumor motion is effectively frozen during radiation delivery.

At Stanford, we are actively developing a novel ultra-fast radiation therapy technology, referred to as pluridirectional high-energy agile scanning electron radiotherapy (PHASER) that is capable of delivering high doses of highly focused radiation to the tumor in subsecond timescales. In comparison, state-of-the-art X-ray treatments currently require 5-60 minutes to deliver an entire fractions. Significant tumor motion occurs at this time scales, thus complex motion management strategies need to be employed.

The PHASER utilizes very-high energy electrons for the treatment of cancer. Through novel and innovative technologies that are currently developed at SLAC National Laboratory, the electron beam can be directed very rapidly and continuously to the patients through any angles with a better degree of dose conformity than the best X-ray therapy. The ability of delivering the radiation highly focused to the tumor with great accuracy and precision will ultimately translate in better outcomes. Rapid treatment will also lead to greater clinical efficiency and patient throughput: the treatment room occupancy time could be greatly reduced and therefore more patients could be treated. We anticipate that these advantages of the PHASER can be achieved at costs comparable to conventional X-Ray therapy systems, and at much lower cost than proton therapy systems. These factors will make PHASER a viable replacement technology that will improve clinical outcomes, cost effectiveness, and accessibility for lung cancer patients in the U.S. and globally.

Our research team combines the clinical, medical physics, and radiobiology expertise of the Department of Radiation Oncology at Stanford University, where we have implemented a pioneering clinical and research program in 4-D image-guided high dose rate SABR, with the world-class accelerator design expertise of SLAC, where the enabling technologies underlying the PHASER concept are already being developed.

Name: Ceballos

Name: Dr. César Ceballos Sánchez, CEADEN.
"BNCT, a binary radiotherapy at cellular level"

Abstract:

The Boron Neutron Capture Therapy (BNCT) is a radiation therapy based on the destructive effects of helium and lithium ions emerging from the nuclear reaction $^{10}\text{B}(n,\alpha)^7\text{Li}$, which takes place when a ^{10}B nucleus absorbs a thermal neutron. Because of the very short ion ranges (9 and 6 μm , respectively), the destructive effect is confined inside the living cell where the ^{10}B has been previously transported in. BNCT is therefore a cellular radiation therapy suited to treat tumors infiltrated into the surrounding healthy tissues. The therapeutic success depends on several factors. Namely, the capacity of concentrating a relatively high quantity of ^{10}B inside tumor cells and contemporaneously a small quantity of ^{10}B inside healthy cells; a high enough thermal neutron fluency rate and the minimization of healthy tissue damage due to unwanted fast neutrons and gamma rays.

Name: Elizabeth Musacchio González. CEADEN.

ABSTRACT TITLE: An accelerator-based BNCT facility based on the $^7\text{Li}(p,n)^7\text{Be}$

Abstract

BNCT (Boron Neutron Capture Therapy) is a therapeutic modality used to irradiate tumors cells previously loaded with the stable isotope ^{10}B , with thermal or epithermal neutrons. This technique is capable of delivering a high dose to the tumor cells while the healthy surrounding tissue received a much lower dose depending on the ^{10}B biodistribution. In this study, the therapeutic gain, as a parameter to evaluate the treatment quality, was calculated. The common neutron-producing reaction $^7\text{Li}(p,n)^7\text{Be}$ for accelerator-based BNCT, having a reaction threshold of 1880.4 keV, was considered as the primary source of neutrons. Energies near the reaction threshold for deep-seated brain tumors were employed. These calculations were performed with the Monte Carlo N-Particle (MCNP) code. A simple but effective beam shaping assembly was calculated producing a higher therapeutic gain compared to previously proposed facilities with the same nuclear reaction.

Name: Jorge Luis Morales

University: National Institute of Oncology and Radiobiology (INOR)

E-mail:

Type: round table

Abstract TITLE: Introduction of Intra Operative Radiotherapy (IORT) with electron beams: the Cuban Experience

ABSTRACT: In November 2013, an dedicated unit for Radiotherapy Intraoperatoria (IORT) was installed in the National Institute of Oncology and Radiobiology (INOR). This unit is a NOVAC 11 manufactured by the company

Sordina IORT Technologies S.p.A. (SIT) from Italy. A summary of the general characteristics and implementation of this technology in Cuban is presented.

Name: Adlin López

University: Hosp. Hnos. Ameijeiras.

Email:

Type: round table

Abstract TITLE: Approaches on the rol of medical physicists in implementing the hybrid technologies in Nuclear Medicine.

ABSTRACT: NM hybrid technologies combined the best of anatomical and functional advanced imaging devices in order to warranty the accurate of diagnostic and treatment process. The medical physicists play an important role in the multidisciplinary team, witch not be limited to doing QA/QC. A summary of current available technologies and the Cuban experience is presented.

Name: Carlos Calderón

University: Department of Nuclear Medicine, National Oncology Institute (INOR.

Email:

Type: round table

Abstract TITLE: Radiobiology concepts for treatment planning of combined Metabolic Radiotherapy

ABSTRACT:The combination of local external beams and systemic targeted radiotherapy modalities could be a reliable alternative for patients with multiple lesions or those where treatment planning maybe difficult because organ(s)-at-risk (OARs) constraints. Radiobiological models should have the capacity for predicting the biological irradiation response considering the differences in the temporal pattern of dose delivering in both modalities. Summarized results on radiobiological modeling by using dose-response formulations that may be used for biological evaluation of prescriptions and biological treatment planning methods of combined therapeutic schemes in clinical situation will be presented.

Name: Luis Ducat Pages

University: Isotope Center (CENTIS)

E-mail: ducat@centis.edu.cu

Type: round table

Abstract: TITLE: Isotope center: Facilities for the production of radiopharmaceuticals

ABSTRACT: The Isotope Center (CENTIS) is the biggest nuclear facility in Cuba. Its mission: to produce and supply all radiopharmaceuticals and labelled compounds for the needs of Public Health. CENTIS covers 95% of the national demand and export to several countries.

Name: Rogelio Diaz Moreno

University: National Institute of Oncology and Radiobiology (INOR)

E-mail:

Type: round table

Abstract: TITLE: Radiosurgery and experiences at INOR

ABSTRACT:

MSc. Rogelio M. Díaz Moreno, Eng. Albin García Andino, Eng. Adrian Acosta Andres, Dr. Yelena Cuervo Muñoz, Dr. Ivonne Chon Ribas, Dr. Iosmil Morales Perez, Eng. José Félix Pico

Radiosurgery treatments apply intense narrow radiation beams in order to deliver a therapeutic ionization dose on pathological tissues in the body, mostly on the nervous system, in one or few fractions. Several complex mechanisms are applied to collimate and shape these beams so they can interact with the treatment targets and spare the near healthy tissue. Instituto Nacional de Oncología y Radiobiología is a leading institution at implementing moderna radiant treatments in Cuba. Between 2009 and 2015, radio surgical treatments were performed, using a linear accelerator (linac) and a tertiary micro multi leaf, and both rigid stereotactic frame and relocatable thermoplastic masks. A new linac based radiosurgery system is being commissioned for clinical use. It uses image-guided capabilities and stereotactic cones, as well as the rigid frame. Simultaneously, research is performed to develop auxiliary devices and quality assurance methodologies.

Name: Dr. Rodolfo Alfonso, Department of Nucl. Eng., InSTEC; Dr. Fernando García Yip.

University: INOR

E-mail:

Type: Round table

Abstract TITLE: Updates in dosimetry of small beams.

ABSTRACT:

The diversity in collimation types used currently in radiotherapy can generate narrow photon beams quite different in shape and size from the conventional reference field. The paper summarizes the local plans to address both absolute and relative dosimetry issues of small fields following the joint international (AAPM/IAEA) recommendations/code of practice (expected this year).

Name: Jorge Luis Morales

University: INOR

E-mail:

Type: Round table

Abstract TITLE: Introduction of Intraoperative Radiotherapy with electron beams: the Cuban Experience

ABSTRACT:

In November 2013, an dedicated unit for Radiotherapy Intraoperatoria (IORT) was installed in the National Institute of Oncology and Radiobiology (INOR). This unit is a NOVAC 11 manufactured by the company Sordina IORT Technologies S.p.A. (SIT) from Italy. A summary of the general characteristics and implementation of this technology in Cuban is presented.

Name: Maria Grazia Pellegriti

University: INFN - Sezione di Catania - Italy

E-mail: mariagrazia.pellegriti@ct.infn.it

Type: invited talk

Abstract: TITLE: EuroGammaS Gamma Characterisation System for ELI-NP: The Nuclear Resonance Scattering Technique

ABSTRACT: ELI-NP Gamma Beam System (GBS) that will be implemented in Magurele, Romania, will deliver an intense gamma beam, obtained by collimating the radiation emerging from an inverse Compton interaction, with unprecedented performances in terms of brilliance, photon flux and energy bandwidth in an energy range from 0.2 to 20 MeV [1,2]. A gamma beam characterisation system providing a measurement of the energy spectrum, intensity, space and time profile is crucial for the commissioning. A precise energy calibration of the gamma beam and an evaluation of its stability during operation are also mandatory specifications of the ELI-NP-GBS. The gamma-beam characterisation system, designed by the EuroGammaS consortium, consists of four elements: a Compton spectrometer (CSPEC), to measure and monitor the photon energy spectrum, in particular the energy bandwidth; a sampling calorimeter (GCAL), for a fast combined measurement of the beam average energy and its intensity, to be used also as monitor during machine commissioning and development; a nuclear resonant scattering spectrometer (NRSS), for absolute beam energy calibration and inter-calibration of the other detector elements; and finally a beam profile imager (GPI) to be used for alignment and diagnostics purposes. During this presentation, a general overview of the ELI-NP gamma characterisation system will be given and the NRSS system will be discussed.

- [1] O. Adriani et al. arXiv:1407.3669 [physics.acc-ph] (2014)
[2] D. Filipescu et al. Eur. Phys. J. A 51 (2015) 185

Wednesday March 30th List of abstracts

Name: R. J. England

Recent Results in Dielectric Laser Acceleration of Electrons

Acceleration of particles in laser-driven dielectric structures fabricated using semiconductor manufacturing techniques is a new and promising approach to developing future generations of ultra-compact particle accelerators, with accelerating gradients up to an order of magnitude beyond those of conventional accelerators, and the potential for high-brightness beams of attosecond-scale bunch duration. The new Accelerator on a Chip International Program (ACHIP) in this area has been initiated under support of the Gordon and Betty Moore Foundation. We review the current state of research, including sub-relativistic energy experiments at Stanford and FAU Erlangen Universities and recently achieved gradients up to 1 GV/m with relativistic electrons in joint experiments by UCLA and SLAC. We will also describe future plans and experimental goals.

Name: Gerard Andonian

University: UCLA

E-mail: gerard@physics.ucla.edu

Type: invited talk

Abstract: Title: GV/m acceleration in dielectric structures

Beam-driven, dielectric wakefield acceleration has long held the promise to deliver high gradients for applications in high-energy physics and next generation light sources in a compact, cost-effective package. Over the past decade, there has been much progress in fabrication technology and high-brightness electron beam development, allowing unprecedented access to sub-mm wavelengths. This has led to a surge of experimental advances in this field of study.

This talk will report on a series of experiments conducted at the SLAC FACET facility, that focus on the demonstration of sustained, \sim GV/m gradients in sub-mm dielectric structures, with complimentary measurements on beam spectra and field mode characterization. The study includes discussion of different structure geometries and materials with comparison to theory and simulations. In addition, this presentation will highlight some of the recent work in dielectric structures used, not only for high-field acceleration, but also in the context of beam phase space manipulation and generation of narrowband THz radiation. Finally, the talk will briefly introduce upcoming experimental plans focussed on strategic tailoring of dielectric structure features for enhancement of localized wakefield effects.

Name: Barbara Marchetti (on behalf of the SINBAD team)

University: DESY - Hamburg

E-mail: barbara.marchetti@desy.de

Type: invited talk

Abstract: High Brightness Beam Research at SINBAD

Science is presently advancing into the ultra-fast regime of sub-femto-second pulses, the atto-second regime. The SINBAD project (Short Innovative Bunches and Accelerators at DESY) aims at the production of ultra-short electron bunches, which can complement atto-second science with lasers. The electron bunches in SINBAD offer the potential of ground-breaking applications but can also be crucial tools for the development of ultra-high gradient accelerators. SINBAD converts the DORIS collider and synchrotron facility into a dedicated accelerator R&D facility. In this talk we present the status of SINBAD. We describe the properties of the electron bunches as simulated, discuss possibilities for further acceleration in various high gradient acceleration setups and comment on the suitability of some schemes for the production of photon light.

Name: Ross Corliss

University: MIT

Abstract: Searching for a Dark Photon with DarkLight

Despite compelling astrophysical evidence for the existence of dark matter in the universe, we have yet to positively identify it in any terrestrial experiment. If such matter is indeed particle in nature, it may have a new interaction as well, carried by a dark counterpart to the photon. The DarkLight experiment proposes to search for such a beyond-the-standard-model dark photon through complete reconstruction of the final states of electron-proton collisions. In order to accomplish this, the experiment requires a moderate-density target and a very high intensity, low energy electron beam. I will describe DarkLight's approach and focus on the implications this has for the design of the experiment, which centers on the use of an internal gas target in Jefferson Lab's Low Energy Recirculating Facility. I

will also discuss upcoming beam tests, where we will place our target and solenoidal magnet in the beam for the first time.

Name: Alberto Martinez de la Ossa

University: DESY/University Hamburg

E-mail: alberto.martinez.de.la.ossa@desy.de

Type: talk

Abstract: Self-similar staging and wakefield-induced ionisation injection

We discuss on the possibility of using electron beams from plasma wakefield accelerators as drivers in a second plasma stage of increased density in respect to the first one. Provided that these beams are short and of high-current they fulfil the essential requirements to drive plasma waves in blowout regime in a higher density plasma. A new witness beam can be then generated in the second plasma stage by means of wakefield-induced ionisation injection [1]. Owing to the increased density, the witness bunches generated in the second plasma stage will have a dramatically reduced size and normalised emittance, while featuring high-current to keep a low energy spread by means of beam loading. This means an increase of about two order of magnitudes in brightness of the second beam in respect to the first. Besides, due to the high transformer ratio in the blowout regime, the energy of the newly generated electron bunch can be double or thrice the energy of the electron bunch generated in the first stage.

- [1] A. Martinez de la Ossa et al., Phys. Rev. Lett. 111, 245003 (2013).
A. Martinez de la Ossa et al., Phys. Plasmas 22, 093107 (2015).

Name: Vladimir Litvinenko

University: Stony Brook University

E-mail: vladimir.litvinenko@stonybrook.edu

Type: Talk

Abstract: Project towards CO₂-laser-driven wake-field accelerator with external injection.

The project will explore a large (e.g. psec or 0.5 mm) length of "bubble" in CO₂-laser driven plasma wake-field accelerator. Injecting of an external high quality electron bunch with duration ~ 10 fsec synchronized with the "bubble" would allow us to accelerate high quality electron beams with energy stability and spread reaching towards 1E-4. We rely on CO₂-laser power upgrades that are in progress at BNL. We present our considerations for visible diagnostics, plasma source with ramp-up and ramp-down density profiles and the electron bunch compressor to 10 fsec with emittance preservation. We present current status of the project. This project is supported by DoE HEP office grant #215125.

Name: Emilio Nanni

University: SLAC National Accelerator Laboratory, Stanford University

E-mail: nanni@slac.stanford.edu

Type: Invited Talk

Abstract: Title: THz Gun Development

Compact high-gradient accelerators operating at high repetition rates are of interest for a wide variety of applications such as ultrafast electron diffraction, free electron lasers and medical accelerators. We are exploring the use of intense optically-generated THz pulses to power accelerators efficiently and with high-gradients. In a first demonstration, a single-cycle THz pulse was used to accelerate an electron bunch in a dielectrically-loaded waveguide. An energy gain of 7 keV observed with a 10 micro-Joule pulse energy. The performance of these THz accelerators will scale rapidly with increased THz pulse energy and control of the THz spectrum.

In a parallel effort with the development of high-power narrow-band THz sources we are investigating an electron gun operating at 0.3 THz. This 3.5 cell standing-wave electron gun is less than 2 mm long and is capable of producing 1 MeV electrons. The electron gun will be powered by an optically-driven THz source capable of 1 MW, 10 ns pulses at 120 Hz under development at the SLAC National Accelerator Laboratory. The THz source is an optical parametric amplifier (OPA) powered with a 1064 nm, 250 mJ, 10 ns optical pump pulses. The THz signal for the OPA is generated by a solid-state amplifier multiplier chain with full amplitude and phase control. In addition to using a novel power source for accelerators, this electron gun is a new particle source with unique features and capabilities such as high gradients and short electron bunches of $\lt;10$ fs.

Name: Sergio Carbajo

University: SLAC National Accelerator Laboratory

E-mail: scarbajo@slac.stanford.edu

Type: Invited talk

Abstract: Title: "Free-space longitudinal electron acceleration";

Abstract: Few-cycle highly-intense cylindrical vector beams, such as radially polarized lasers, are capable of manipulating and controlling electron beams in free-space without the assistance of any medium. One good example of this capability is in-vacuum compact acceleration for direct longitudinal electron acceleration and bunching. First, we will review the means to efficiently producing relativistic few-cycle radially-polarized pulses. Second, we will delve into the first proof-of-concept of free-space longitudinal acceleration of electrons that yielding highly-directional multi-GeV/m accelerating gradients at non-relativistic electron energies. We will conclude with future directions of the technique towards producing usable quality accelerated electron bunches, as well as other manipulation schemes using intense cylindrical vector beams.

Name: Enrica Chiadroni

University: INFN-LNF

E-mail: enrica.chiadroni@lnf.infn.it

Type: invited talk

Abstract: Title: Beam manipulation for resonant PWFA

Abstract:

Plasma-based acceleration has already proved the ability to reach ultra-high accelerating gradients. However the step towards the realization of a plasma-

based accelerator still requires some effort to guarantee high brightness beams, stability and reliability. A significant improvement in the efficiency of PWFA has been demonstrated so far accelerating a witness bunch in the wake of a higher charge driver bunch. Both the transformer ratio and the energy transfer from the driver to the witness beam can be increased by resonantly exciting the plasma with a properly pre-shaped drive electron beam. Theoretical and experimental studies of beam manipulation for resonant PWFA will be reviewed here.

Name: Aihua Deng

University: UCLA

E-mail: aihuadeng1985@gmail.com

Type: Talk

Abstract: Progress of Trojan horse Injection PWFA Experiment on FACET
The "Trojan Horse" Plasma wakefield acceleration (PWFA) is a promising acceleration scheme for high brightness electron beams with normalized emittance of 10^{-8} (m rad) level. Latest experiment results along with the experiment diagnostics systems on FACET are introduced. Temporal and spatial synchronization of electron beam and laser pulse are critical for the experiment success. Electro-optical sampling (EOS) and plasma filament diagnostic were commissioned for the synchronization of FACET e-beam and the laser pulse that is used for the Trojan Horse injection. The EOS can give us sub-ps synchronization and a shot-by-shot jitter information. And the dark current which comes from the self-injection in PWFA was suppressed by optimize the plasma parameters which is good for the witness bunch measurement by Trojan Horse injection.

Name: Mosnier Alban

University: CEA

E-mail: alban.mosnier@cea.fr

Type: contributed talk

Abstract: - Advanced electron acceleration experiments planned in the Long Focal Area of the CILEX-Apollon facility -

The CILEX-Apollon facility combines multiple high intensity laser beams, up to 10^{22} W/cm² and with high contrast which will enable a series of laser wakefield experiments of electron acceleration. Two laser beams, of power 1 PW and 10 PW maximum will be focused towards two plasma targets. The optical layout allows independent single-stage experiments or two-stage experiments thanks to an achromatic and matching transport line between both target stations. During the first phase, and after validation of the laser beam performance, single-stage experiments in non-linear regime will first explore the high energy domain and then focus on the optimization of a stable and monoenergetic beam at low energy, around 200 MeV. In a second phase, the optimal electron beam will be transported and matched to the second target station, where a longer plasma structure operating in the linear regime will further accelerate the beam at high energy. A series of optical diagnostics for plasma preparation and beam diagnostics to measure the energy and beam distribution in longitudinal and transverse planes will be developed to fully characterize the beam properties and stability.

Name: Andrea Renato Rossi
University: INFN - Milan
E-mail: andrea.rossi@mi.infn.it
Type: Invited talk
Abstract: All optical FELs: a challenging, next generation radiation sources

The All Optical - Free Electron Laser (AO-FEL), realized by coupling a high brightness electron bunch produced by laser wakefield acceleration and an electromagnetic undulator, is nowadays a major goal of research teams worldwide. Demonstrating its feasibility would boost the spread of FELs based applications, due to its compactness and relative inexpensiveness. At date, all key ingredients are available for its implementation and numerical simulations show exciting performances. However, a number of practical operational challenges must be faced before a working AO-FEL could be commissioned and operated. In this contribution, we review the state of the art and emphasize the still open issues, together with possible solutions.

Name: Jeroen van Tilborg
University: Lawrence Berkeley National Laboratory
E-mail: JvanTilborg@lbl.gov
Type: Invited talk
Abstract: From table-top laser plasma accelerator to free electron laser

Laser Plasma Accelerators (LPAs) rely on the non-linear interaction of ultra-intense laser pulses (intensity $> 10^{18}$ W/cm²) and underdense gas targets. Following ionization, the laser generates a strong co-propagating plasma wave in which background electrons can be self-injected in accelerating field gradients in excess of 100 GV/m. Over recent years, several groups have reported on the production of well-directed GeV-class electron beams from cm-scale targets. At the BELLA Center, recent experiments have addressed key LPA advances in several ways: 1) pushing the electron energy to higher levels (> 4.2 GeV) and accomplishing this at 1 Hz instead of single-shot [PRL, Leemans 2014], 2) realizing a single-element tunable strong-focal-length lens for electrons beams, critical to LPA applications [PRL, van Tilborg 2015], and 3) the coupling of two LPA stages by observing energy gain of the first stage electron beam inside the second stage plasma wave [Nature, Steinke 2016]. I will highlight the contribution these results have made towards our recently funded effort to realize an LPA-driven free electron laser (intense coherent femtosecond X-rays in the 10-100 eV range).

Name: Andreas Maier
University: CFEL Center for Free-Electron Laser Science & University of Hamburg
E-mail: andreas.maier@desy.de
Type: contributed talk / poster
Abstract: Commissioning of the LUX Beamline for Laser-Plasma Driven Undulator Radiation

Within the LAOLA Collaboration, the University of Hamburg and DESY work closely together, combining university research with the expertise of a large accelerator facility, to enhance the performance of plasma accelerators for applications. Here, we discuss and present first results from the commissioning of the so-called LUX beamline for plasma-driven undulator radiation.

We address the challenges of setting up the beamline in the environment of an accelerator facility, and describe laser operations using an accelerator control system, laser transport and diagnostics, as well as the target area and plasma target. As an outlook, we will discuss the experimental strategies in Hamburg towards a first proof-of-principle FEL experiment using plasma-driven electron beams available today.

Name: Alexander Zholents

University: ANL

E-mail: azholents@aps.anl.gov

Type: Invited talk

Abstract: DIELECTRIC ACCELERATOR BASED 5-th GENERATION LIGHT SOURCE

A concept is presented for a multi beamline soft x-ray FEL facility where several free-electron laser (FEL) undulator lines are driven by equal number of high repetition rate single-stage dielectric wakefield accelerators (DWA). A preliminary design of the DWA that achieves a highly efficient transfer of the drive bunch energy to the wakefields and to the witness bunch is considered. The single bunch breakup instability is a major limiting factor for accelerator efficiency, and the BNS damping is applied to obtain the stable multi-meter long propagation of a drive bunch. Various means to mitigate the adverse collective effects are considered and a practical design of the DWA embedded into a quadrupole wiggler to control a beam breakup instability, and extending over 20 meters is presented. It is shown that the maximum achievable strength of the quadrupole gradient defines a threshold charge in the drive beam and a maximum attainable acceleration gradient for the witness beam. Numerical simulations using a 6D particle tracking computer code are performed and tolerances to various errors are defined. Obtaining the witness bunch with a minimum energy spread is discussed. Finally, results are presented for the expected FEL performance using an appropriately tapered undulator.

Name: Avraham Gover

University: Tel Aviv University

E-mail: gover@eng.tau.ac.il

Type: invited

Abstract: FUNDAMENTAL PROCESSES OF EMISSION FROM AN ELECTRON BUNCH:

SPONTANEOUS, SUPER-RADIANT AND STIMULATED-SUPER-RADIANT In the context of radiation emission from an electron beam, Dicke's superradiance (SR) [1] is the enhanced "coherent" spontaneous radiation emission from a pre-bunched beam, and Stimulated-Superradiance (ST-SR) is the further enhanced emission of the bunched beam in the presence of a phase-matched radiation wave [2]. These processes were analyzed for Undulator radiation in the framework of radiation field mode-excitation theory. In the nonlinear saturation regime the synchronism of the bunched beam and an injected radiation wave may be sustained by wiggler tapering - TESSA [3]. Same processes are instrumental

also in enhancing the radiative emission in the tapered wiggler section of seeded FELs [4].

Here we outline the fundamental physical concepts of Spontaneous Superradiance (SR), Stimulated Superradiance (ST-SR), Taper-Enhanced Superradiance (TES) and Taper-Enhanced Stimulated Superradiance Amplification (TESSA), and compare their Fourier and Phasor formulations in a model of radiation mode expansion. Conservation of energy without radiation reaction terms is demonstrated in the self-interaction case of SR, TES. Detailed further analysis can provide better design concepts and improved tapering strategy for enhancing the power of seeded short wavelength FELs. We further discuss the extensions of the model required for full description of these radiation processes, including diffraction [5] and spectral widening effects[6].

Reference

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2. A. Gover, Superradiant and stimulated-superradiant emission in prebunched electron-beam radiators. I. Formulation, Phys. Rev. ST-AB 8, 030701 (2005).
3. J. Duris, A. Murokh, and P. Musumeci, Tapering enhanced stimulated superradiant amplification, New J.Phys. 17 063036, 2015.
4. Y. Jiao et al, Modeling and multidimensional optimization of a tapered free electron laser, PRST-AB 15, (050704) (2012).
5. E. A. Schneidmiller, M. V. Yurkov, Optimization of a high efficiency free electron laser amplifier, PRSTAB 18, 03070 (2015).
6. C. Emma, K. Fang, J. Wu, and C. Pellegrini, High Efficiency, Multi-Terawatt X-ray free electron lasers, FEL 2015 Conference, August 23-28, Daejeon, Korea, 2015.

Name: C. Pellegrini

Thursday March 31st List of abstracts

Name: Alessandro Variola

University: LNF INFN

E-mail: alessandro.variola@lnf.infn.it

Type: invited talk

Abstract: Compton sources for gamma and X rays applications.

Recently a strong interest is given to new radiation sources based on Compton effect. Thanks to the very high photon energy boost these sources can provide hard photons with relatively low energy electrons accelerators, opening the way to a new class of compact facilities. The drawback is given by the relatively low cross section, resulting in a limited flux in respect to the synchrotron or FEL facilities. To overcome this limitation different high technology R&D are carried out taking into account the improvement of both the accelerator and the optical systems (lasers, recirculators, optical cavities).

A short introduction of the Compton effect appeal for compact light sources will be given. After this, a review of the main on-going projects with the description of the associated technologies will be illustrated. The case of the ELI-NP-GBS project will be provided with a particular attention on the need in high brilliance beams.

Name: Vittoria Petrillo
University: Università degli Studi di Milano-INFN
E-mail: Petrillo@mi.infn.it
Type: Petrillo@mi.infn.it
Abstract: Advanced topics in the physics of Compton back-scattering
V. Petrillo

Compton back-scattering has been demonstrated to provide compact, highly tunable, versatile and not expensive sources of X-gamma rays. In this presentation, new possibilities for improving the performances of the Compton sources are analyzed. A method for increasing the spectral density is based on the chirp of the laser. In this way, the oscillations and the broadening of the spectrum occurring in non linear regime can be eliminated, obtaining highly monochromatic signals. Also the tilt of the laser pulse can improve the radiation quality. The occurrence of collective effects, taking place when the laser is characterized by high energy and long pulses, permits to increase both the spectral density and the total number of photons. The control of polarization, the encoding of orbital momentum on the radiation and the possibility of producing two color radiation are also discussed.

Name: F. Zomer
University: CNRS / Université Paris-Sud
E-mail: zomer@lal.in2p3.fr
Type: talk
Abstract: ThomX and advanced optical systems for Compton Sources
The ThomX project will be described. Applications of this machine will be reviewed. Emphasis will also be put on the laser/optical systems required for these machines.

Name: Igor Pogorelsky
University: BNL
E-mail: igor@bnl.gov
Type: contributed talk
Abstract: Drafting a roadmap to gamma colliders driven by mid-IR lasers Igor V. Pogorelsky¹, Wei Lu², Mikhail N. Polyanskiy¹, Wayne Kimura³
¹Accelerator Tests Facility, Brookhaven National Laboratory, Upton, NY USA 11973
² Tsinghua Univ, Beijing, China
³ STI Optronics, Redmond, WA USA
Abstract.
We outline a self-consistent roadmap to a TeV-class gamma-gamma collider based on multi-staged laser wakefield electron accelerators driven by a CO₂ laser. This includes: Analytical approach to optimize plasma- and laser- parameters to achieve required collider luminosity at realistically feasible laser parameters. PIC simulations that show agreement with analytical predictions for single accelerator stage. We lay down plans for developing ultra-fast CO₂ lasers to drive such a stage. This includes using isotopically enriched amplifiers, CPA technique, and nonlinear femtosecond compression. The requirements for a collider's high repetition rate calls for implementing new solutions for high voltage switches to support such a laser regime and are further explored in this paper. Computer modeling of a CO₂ laser amplifier

predicts considerable enhancement in wall-plug efficiency by circulating multiple laser pulses during a single amplifier shot. This is important for achieving a competitive operational cost of a future collider. A low plasma density regime, which is advantageous for long-wavelength CO₂ lasers, may not be well suited for e⁺e⁻ colliders due to a relatively high charge per bunch that causes strong beamstrahlung, which can adversely affect the e⁺e⁻ collider performance. This explains why we restrict our consideration to gamma colliders where beamstrahlung is not an issue. Justification for selecting a CO₂ laser as a Compton source for the gamma collider completes our analysis. A number of critical issues pertinent to ultra-fast mid-IR laser technology, which are addressed here, will lay the milestones for a roadmap towards building compact colliders based on plasma wakefield acceleration driven by next-generation mid-IR lasers. Progress along this route will benefit also other applications such as plasma-based compact synchrotron- and THz- radiation sources, laser-driven ion accelerators, etc.

Name: Ivan Gadjev
University: UCLA
E-mail: igadjev@ucla.edu
Type: poster

Abstract: The need for high-brightness X-ray light sources stretches from areas in basic science research to medical and industrial uses. The goal of this experiment is to produce ICS X-rays by reflecting the CO₂ laser pulse used to accelerate electrons in an IFEL accelerator. Previous IFEL experiments at ATF have demonstrated accelerating gradients of 100 MV/m with 60% capture rate. At 52 MeV input energy, the electron beam is expected to have energy of 93 MeV on exiting the IFEL undulator and going into the ICS interaction point. The CO₂ pulse is reflected back onto the electron bunch by a copper mirror downstream of the undulator. We expect to generate 2.5x10⁷ photons at 18 keV per scattering event. The coupling of the IFEL beam into an ICS event is a unique way to recycle the power of the CO₂ laser. Furthermore, the current collaboration between UCLA and BNL-ATF in both IFEL and ICS experiments presents a great opportunity to attempt the unification of the two. A successful implementation will demonstrate the applicability of IFEL and justify the potential of ICS as an X-ray source for scientific research and medical imaging.

Name: Alex Murokh
University: RadiaBeam Technologies, LLC.
E-mail: murokh@radiabeam.com
Type: Invited talk

Abstract: Towards industrial X-ray source based on Inverse Compton Scattering

Recent advances in laser and electron beam technologies make it possible to generate synchrotron quality light in compact laboratory scale devices based on Inverse Compton Scattering (ICS). A successful development and deployment of ICS technology would enable numerous new applications in industry, medicine, basic research, and homeland security. We compare ICS properties to other promising source techniques in soft and hard X-ray spectral regions, and discuss a road map towards commercially viable ICS sources. In addition, recent experimental results to increase ICS output flux are presented.

Name: LUIGI PALUMBO
University: LA SAPIENZA - University of Rome
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Type: INVITED

Abstract: ELI: New frontiers of particle acceleration and radiation sources
ELI is a laser facility that aims to host some of the most intense lasers worldwide, develop new interdisciplinary research opportunities with light from these lasers and secondary radiation derived from them. It's a European Research Infrastructure distributed on three sites in Hungary, Czech Republic and Romania with an investment volume exceeding 850 M euro which will be in operation in 2018. The ultra-intense laser systems will allow the realization of new physics with potentially important applications in the near future. ELI will serve as a research center for development and application of laser-based particle acceleration in both the intense and ultra-intense regimes, and laser plasma based proton sources for medical applications.

Name: C. Curatolo, L. Serafini, F. Broggi
University: INFN Milano and Università degli Studi di Milano
E-mail: camilla.curatolo@mi.infn.it
Type: talk

Abstract: Phase space analysis of secondary beams generated in hadron-photon collisions.

Present availability of high brilliance photon beams in combination with intense TeV hadron beams makes it possible to conceive the generation of low emittance TeV-class energy pion/muon beams via photo-production in a highly relativistic Lorentz boosted frame. The kinematics of all the events given by the hadron-photon beams interaction have been studied: pion photo-production and further decay into muon and neutrino, lepton pair photo-production (electron/positron and muon pairs) and Compton scattering.

We analyze the secondary beams brightness achievable by the coupling of advanced high efficiency high repetition rate FEL pulses and Large Hadron Collider or Future Circular Collider hadron beams. The phase space distributions of the pion and muon beams are obtained by means of an event-generator code and the characteristics, such as emittance and energy spread, are benchmarked against analytical expressions.

Name: Hernandez

Friday April 1st List of abstracts

Name: J. B. Rosenzweig

Name: Caterina Biscari
University: ALBA Synchrotron
E-mail: cbiscari@cells.es
Type: invited talk

Abstract: The African Light Source Roadmap

The impact of a light source in developing countries is worldly accepted as an extremely powerful tool for the transformation into advanced societies. In Africa a group of scientists from several countries is now leading the proposal for a future African Light Source (AfLS), with the aim that African countries take control of their destinies and become major players in the international community, promoting peace and collaborations among African nations and the wider global community. A workshop in Grenoble, which took place in November 2015, was the official starting point for the future African project, with the outcome of the so-called "Grenoble Resolutions". A roadmap has also been depicted, with the aim of producing a Conceptual Design Report a few years from now.

Name: Ezio Puppini

University: CNISM - Politecnico di Milano

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Type: Invited

Abstract: The STAR project: a TBS X-ray source in a southern Italian region

The STAR Project is in progress at the University of Calabria (UniCal) in the frame of the PON Materia initiative. Based on a collaboration among UniCal, CNISM, INFN and ST, it comprises the construction of a Thomson back-scattering X-ray source for applied research. The installation of main machine components (RF laser-driven photo-injector, collision laser system, beam lines, control system and diagnostics) has just started, with perspectives to begin the machine commissioning late in 2016. We will present the advancement status as well as future plans for machine upgrade that are being prepared in the context of the European 2020 calls for proposal for research infrastructure upgrades.

Name: G. Kamel

Name: H. Winick

University: SLAC National Accelerator Laboratory

E-mail: winick@slac.stanford.edu

Type: Invited

Abstract TITLE: Synchrotron Light Sources in Developing Countries.

Abstract:

The more than 50 light sources now in operation around the world include facilities in Brazil, Korea, and Taiwan which started their programs in 1980's when they were developing countries. They came on line in the 1990's and have since trained hundreds of graduate students locally, without sending them abroad and losing many of them. They have also attracted dozens of mid-career diaspora scientists to return. Their growing users communities have demanded more advanced facilities, leading to the funding of higher performance new light sources that are now coming into operation. Light sources in the developing world now include the following:

SESAME in the Middle East which is scheduled to start research in 2016. See:

www.sesame.org

<http://wpj.sagepub.com/content/32/4/92.full.pdf+html>

The African Light Source, in planning stage. See:

www.safricanlightsource.org

<http://www.lightsources.org/press-release/2015/11/20/grenoble-resolutions-mark-historical-step-towards-african-light-source>

The Mexican Light Source, in planning stage. See:

<http://www.aps.org/units/fip/newsletters/201509/mexico.cfm>

Upgrading attempts of the Monte Carlo Simulation of Atom Displacements, MCSAD, in solids induced by electron and gamma irradiation algorithm under high fluency irradiation environments.

A. Rodríguez ²⁾, C. M. Cruz Inclán ¹⁾, E. González ¹⁾, F. Guzmán ²⁾, Y. Abreu ¹⁾, I. Hernández ¹⁾ and A. Leyva ^{1,3)}. D. Arrebato ²⁾, D. Delfin ²⁾, S. Alfonso ²⁾, J. Fragoso ²⁾, F.A. Castro-Smirnov ²⁾, H. Negrín ²⁾.

¹⁾ Centre of Technological Applications and Nuclear Development, CEADEN, Havana, Cuba.

²⁾ High Institute of Technologies and Applied Sciences, InSTEC, Havana, Cuba.

³⁾ Joint Institute of Nuclear Researches, Dubna, Russia.

ABSTRACT

The Monte Carlo Simulation of Atom Displacement, MCSAD, algorithm and code have been development and applied in solid materials for the assessment of electron and gamma radiation damage [1, 2]. In this code, single primary knockout atom, PKA, processes were taken into the account on regard to atom displacement occurrences, which give a well-suited description of radiation damage effects on relative low particle fluency irradiation environments. In addition, target matrix main properties on regard with electron and gamma quanta transport are assumed to remain constant, which suppose a weak radiation damage effects on the target properties, and consequently, material related atom displacement threshold energies E_d and density do not change at different calculation history trails.

However, under high brightness and fluency irradiation environments, the foregoing MCSAD algorithm and code assumptions are not adequate for describing progressive and intensive radiation damage effects on a given target matrix.

In the present work, two new radiation damage processes are considered in the framework of MCSAD algorithm and code (upgraded MCSAD) in order to take into the account progressive and intensive radiation damage effects in

solids: 1) The defect formation due to a single PKA (Ba, Ti and O) excitation in the **BaTiO₃** crystal matrix with former crystal defects (vacancies, interstitials and Frenkel pairs) with increasing excitation energies and for different crystal movement directions and 2) The Multiple PKA (Ba, Ti and O) excitations inducing defect formation for the same or different atomic species in an ideal **BaTiO₃** crystal matrix; by the coincidence during a given material relaxation time τ of two or more radiation particles inducing damage in the neighborhood of an occupied crystal position. A general overview of this new approach is presented in this meeting in [3].

Consequently, in upgraded MCSAD algorithm and code Ed values and material density change locally in a progressive way in dependence of the accumulated atom displacement per atom as the number of calculation history trails are executed.

Partial calculation results by applying the upgraded MCSAD code for the simulation of gamma quanta irradiation on a BaTiO₃ target are reported and compared with those ones at same target matrix through the application of the former MCSAD version.

References:

[1]. Carlos M. Cruz, Ibrahim Piñera, Antonio Leyva and Yamiel Abreu. **"Studies on the Gamma Radiation Responses of High Tc Superconductors"**. In Superconductors, Chapter 7, pags. 135 - 160. Edited by Adir Moysés Luiz, published by Sciyo, Croatia, 2010.

[2]. Carlos M. Cruz, Ibrahim Piñera, Camilo Correa, Yamiel Abreu, and Antonio Leyva. **"MCSAD: Monte Carlo Simulations of Atom Displacements induced by Fast Electrons in Solids"**. 2011 IEEE Nuclear Science Symposium Conference Record, RTSD.S-282, p.4622- 4626.

[3]. Carlos M. Cruz Inclán, Eduardo González Lazo, Arturo Rodríguez Rodríguez, F. Guzmán Martínez, Yamiel Abreu Alfonso, Ibrahim Hernández Piñera and A. Leyva Fabelo. **"Methodology trends on gamma and electron radiation damage simulations studies in solids under high fluency irradiation environments"**. Submitted to this meeting.

Effects of vacancies on atom displacement threshold energies calculations through Molecular Dynamic Methods in BaTiO₃ with tetragonal crystalline structure.

Eduardo González Lazo ¹⁾, Carlos M. Cruz Inclán ¹⁾, Arturo Rodríguez Rodríguez ²⁾, F. Guzmán Martínez ²⁾, Yamiel Abreu Alfonso ¹⁾, Ibrahim Hernández Piñera ¹⁾. and Antonio Leyva Fabelo ^{1,3)}.

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ABSTRACT

Under progressive and intensive radiation damage conditions atom displacement threshold energy, E_d , calculations through Molecular Dynamic Methods must take into the account, in addition to the framework of single recoil atom excitation in an ideal crystalline lattice, multiple excitations and real crystal structures with point defects, like vacancies and interstitials, in order to reach a better approach to situations emerging from severe and intensive radiation damage impacts on irradiated materials. On the other hand, gamma and electron high fluency irradiations through inelastic scattering, like ionization processes, might cause weakness of interatomic bonds, modifying on this way the whole lattice dynamical processes, like interatomic self - diffusion and PKA defect formation probability functions.

At the present work, atom displacement threshold energies evaluations are performed by application of Molecular Dynamics, MD, calculation tools under the assumption that the **BaTiO₃** tetragonal crystalline structure possesses vacancies.

Taking into the account future works on this subject by the application of the Density Functional Theory, DFT, several overdimensioned unit cells (supercells, SC) owing vacancies on Ba, Ti and O atomic positions were proposed containing several primitive unit cells, under the requirements of electrical charge balance, tetragonal crystal symmetry, and avoiding that in each vacancy first neighborhood a second vacancy is excluded.

As a result, 1x1x2 and 3x3x1 supercells were chosen. In the case of the 1x1x2 SC (1, 0, 1) the following vacancy composition was according taken: 1 O - vacancy at the ($\frac{1}{2}$, $\frac{1}{2}$, u_0) and 1 Ba - vacancy at (0, 0, $\frac{1}{2}$) positions, yielding a BaTi₂O₇ SC whole composition. For 3x3x1 SC two different vacancy distribution model are possible: SC(1,0,1) SC and Sc(0,1,2) SC, where SC(n_v (Ba), n_v (Ti)), n_v (O)) means a SC containing a n_v (A_k) number of vacancies at the A_k atomic positions, A_k = Ba, Ti and O.

The present MD E_d calculations concern with the BaTiO₃ 1x1x2 SC vacancy distribution model, following a previous report [1], Ba, Ti and O - PKA defect formation probability functions dependence on the initial excitation energies were calculated at principal crystal directions, and compared with previous one calculated at an ideal BaTiO₃ ideal tetrahedral crystal structure.

References:

[1] E. Gonzalez, Y. Abreu, C.M. Cruz, I. Piñera, A. Leyva. Molecular-dynamics simulation of threshold displacement energies in BaTiO₃. NIM B 358 (2015) 142 - 145.

Name: D. Hernandez

"Channeling of charged particle beams in carbon nanotubes"

D. Hernández*, A. Rodríguez, D. Arrebato, J. Fragoso, S. Alfonso, H. Negrín
F.A. Castro-Smirnov and F. Guzmán

Higher Institute for Technology and Applied Sciences (InSTEC)

Abstract:

High brightness beam manipulation is a important topic in several applications of accelerators in medicine and other industrial and scientific areas. The key question is dealing with the emittance control through the whole accelerator system including the tools for focusing and bending. In recent years, particular efforts are payed to improve the quality of the beams by means of nanostructures in order to obtain low emittance in micro and nanobeams. This contribution is devoted to the simulation of channeling of charged particles in nanotubes. The simulation is based on a dynamical continuum approach for the interaction potential along the nanotube axis taking into account the nanotube symmetry and the particle energy. Monte Carlo methods are used for the beam generation, the particle multi-scattering (on the electron cloud) contribution, and for the stopping power during the channeling process. Finally, it is discussed the effects on emittance in channeling by chiral carbon nanotubes.

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Name: J. Fragoso

" Simulation of the influence of nanobeam emittance in nanodosimetry".

J. Fragoso*, S. Alfonso, D. Arrebato, D. Delfin, A. Rodríguez, H. Negrín, F.A. Castro-Smirnov and F. Guzmán

Higher Institute for Technology and Applied Sciences, Havana, Cuba

Abstract:

As is well known, the track structure of charge particles induce damage to genes and cells due to their ionizing . As result of this a specific number of ionizations (the so-called ionization cluster-size) is formed per primary particles. One of the aims of nanodosimetry is to determine ionization cluster-size distributions in nanometric volumes of liquid water which is strongly depending on the radiation quality. In this contribution the influence of emittance (as measure of beam quality) of a nanobeam on the formation of cluster-size in a DNA volume are computed. For this propose, a Monte Carlo simulation code using Geant4 toolkit was developed. This work provide a basic idea about the future radiation protection dosimetry in sophisticated radiation treatment, in particular, in the field of heavy ion therapy.

Poster session abstracts

Name: Georgios Kourkafas

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Type: Poster

Abstract: Transverse beam matching under the influence of space charge

The matching of a particle beam to specific transverse parameters, dictated by various operational, functional and diagnostic reasons, is an essential procedure in most types of accelerators. While well-established methods can easily match beams of negligible self fields, their accuracy is significantly reduced in the presence of strong space-charge forces. In a pursuit of time-efficient matching solutions for space-charge influenced beams, two approaches are demonstrated: a faster and more approximative one for symmetric beam transport along periodic and dense lattices, and a more analytic one for broader beam and lattice conditions. Beam dynamics simulations and experimental measurements are used to validate the performance of the suggested methods for the matching requirements of the Photo Injector Test Facility at DESY, Location Zeuthen (PITZ).

Name: Emma Curry

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Type: poster

Abstract: A THz deflector scheme for longitudinal beam diagnostics with femtosecond scale resolution

The length scale of the THz frequency regime presents an opportunity for a longitudinal beam diagnostic that achieves optimal resolution while projecting the longitudinal profile of an electron bunch into a single transverse streak. However, the limited power and efficiency of today's THz sources can make practical implementation in beam interactions a formidable challenge. We discuss a "zero-slippage" interaction to extend the duration of efficient coupling to a near-single cycle THz pulse. In this scheme, a waveguide is used to reduce the group velocity of the THz pulse to match the propagation of the electron beam and to support a mode profile which, when coupled to the transverse momentum of the electrons oscillating in an undulator field, induces a transverse deflection along the beam that can be viewed on a standard fluorescent screen after a drift period. With the beam parameters available at the UCLA PEGASUS laboratory for a proof-of-concept experiment, we predict a temporal resolution better than 10 fs after deflection within a curved parallel plate waveguide.

Name: Siara Fabbri

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Type: Poster

Abstract: Streaking UED Beams with an RF Deflecting Cavity

At the Particle Beam Physics Laboratory (PBPL) at UCLA, we will be implementing a radio-frequency (RF) deflecting cavity to provide images with resolution as fine as 100 fs of a diffracted electron beam as well as perform beam diagnostics. A direct and sophisticated technique, the RF cavity will manipulate the beam's distribution in phase space so as to create a linear correlation between the longitudinal axis of the beam and a transverse coordinate. This process of "streaking" the electron beam has unique advantages for measurement of certain atomic scale, ultrafast processes in specific materials and allows the probe electron beam to remain comparatively long (10's of ps), and contain a large number of electrons ($\sim 10^8$).

Name: Franz-Josef Decker

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Type: Poster

Abstract: Issues to get Two Bunches with up to 1 us Separation at LCLS
To get two electron bunches with a separation of up to 1 us at LCLS is important for LCLS-II developments. Two lasing bunches up to 35 ns have been demonstrated. Many issues have to be solved to get that separation increased by a factor of 30. The typical design and setup for one single bunch has to be questioned for many devices. RF pulse widths have to be widened, BPMs diagnostic can see only one bunch, feedbacks have to be doubled up, the main Linac RF needs to run un-SLEDED, and special considerations have to be done for the Gun and L1X RF.

Name: Renato Pakter

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Type: poster

Abstract: Adiabatic-nonadiabatic transition in the transport of warm intense inhomogeneous beams

We investigate the role of the temperature in the onset of singularities and the consequent breakdown in a macroscopic fluid model for the transport of intense inhomogeneous charged particle beams. We find that there exists a critical temperature below which the fluid model always develops a singularity and breaks down as the system evolves. As the critical temperature is approached, however, the time for the occurrence of the singularity diverges. Therefore, the critical temperature separates two distinct dynamical phases: a nonadiabatic transport at lower temperatures and a completely adiabatic evolution at higher temperatures. These findings are verified with the aid of self-consistent simulations and are shown to be directly related to how fast emittance grows in the system. The results are expected to be of relevance within the context of ultrahigh brightness rf photoinjector and FELs.

Name: Yunfeng Xi
University: UCLA
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Type: Poster
Abstract: "Trojan horse" experiment (E210) update in FACET

Electro-Optic Sampling (EOS) system has been recovered and tested successfully after installation of new injection chamber. Two systems are installed: one exists in new injection chamber for general timing synchronization, the other resides in Cube 4 particularly for E210. Signal is more consistent and prominent than last run. Electron bunch and laser beam are synchronized at 100 fs same as before.

Name: Nathan Majernik
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Type: Poster
Abstract: Resonant betatron excitation

By combining elements of a plasma wiggler with a magnetic undulator limitations on each can be addressed via resonant excitation. In particular, the upper bound on the field imposed by both conventional and superconducting magnets and the difficulties associated with beam injection and integrity in a plasma wiggler. Resonant betatron excitation provides a tunable photon source with implications for both high K FELs and high flux polarized positron production.

Name: Marco Marongiu
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Type: Poster
Abstract: "Design issues for the optical transition radiation screens for the ELI-NP Compton Gamma source"

Abstract

A high brightness electron LINAC is being built in the Compton Gamma Source at the ELI Nuclear Physics facility in Romania. To achieve the design luminosity, a train of 32, 16ns spaced, bunches with a nominal charge of 250pC will collide with the laser beam in the interaction point. Electron beam spot size is measured with optical transition radiation profile monitors. In order to measure the beam properties along the train, the screens must sustain the thermal stress due to the energy deposited by the bunches; moreover the optical radiation detecting system must have the necessary accuracy and resolution. This paper deals with the analytical studies as well as numerical simulations to investigate the thermal behaviour of the screens impinged by the nominal bunch; the design and the performance of the optical detection line is discussed as well.

Name: Massimo Placidi

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Type: Poster

Abstract: An inverse Compton scattering source of high-energy gamma rays and UV radiation.

We explore the feasibility of producing quasi-monochromatic Gamma-ray sources in the multi-MeV range via an Inverse Compton Scattering (ICS) system where a relativistic electron beam interacts with its own undulator radiation in a compact layout. The proposed system generates simultaneously UV, in the 15-20 eV range, and High Energy Gamma rays, in the 10-30 MeV range, and can be used for Cultural Heritage, Nuclear Physics and UV science applications.

Name: Ryan Roussel

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Type: Poster

Abstract: Space Radiation Simulation Using Blowout Plasma Wakes at the SAMURAI Lab

We discuss the creation of broadband electron energy spectra using Plasma Wakefield Acceleration at the SAMURAI Lab as part of the UCLA Particle Beam Physics Laboratory group. As the development of space increases, it will become important to efficiently replicate radiation conditions that exist in low earth orbit and planetary space. Missions such as satellite deployment and exploration of other planets, i. e. the Juno probe launched to explore Jupiter, require electronics that are able to withstand the electron radiation spectrum present in these locations. This requires Earth-based testing for development of robust electronics with respect to electron radiation exposure. Conventional accelerators are poorly suited for this purpose because they are designed for monoenergetic electron beams. Current simulation schemes involve the interpolation of discrete exposure tests. Unfortunately, this idea poorly captures the radiation damage physics seen in the real world. Conversely, the wakefields produced in the blowout regime of plasma wakefield accelerators can be used to create the full spectrum of space radiation including high energy "killer" electrons by injecting a long longitudinal bunch to excite the plasma blowout. While monoenergetic plasma wake accelerator schemes use short driver and witness bunches (much less than a plasma wavelength) to reduce the final energy spread of the witness bunch, a long bunch (3-4 plasma wavelengths) will feel both accelerating and decelerating fields longitudinally, resulting in the exponential energy spectrum distribution seen in regions outside the Earth and Jupiter. This can be achieved at the new SAMURAI lab at UCLA resulting in broadband energy spectra with maximum energies up to 100 MeV that correctly reflect the radiative conditions of space in low Earth orbit and around Jupiter.

Name: Vittoria Petrillo
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Abstract: Optical beam with vortices: a first order paraxial analysis
V. Petrillo, G. Dattoli, I. Drebot and F. Nguyen
Helically phased light beams or optical vortices, in the visible and infrared wavelength domains, have orbital angular momentum directly transferable to atoms, molecules, and nanostructures, allowing applications as optical data transmission, crystal micromanipulation, microscopy, detection of spinning terrestrial and astronomical objects. We provide an analysis of the relevant properties of orbital momentum beams (OAM) and discuss the associated transformations under paraxial propagation. We analyze different forms of OAM, their Poynting vector and angular momentum. We extend the analysis at first order in the paraxial approximation, calculating the transverse component of the Poynting vector and the longitudinal component of the angular momentum, which give the rotation of the energy flux around the vortices.

Name: Anusorn Lueangaramwong
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Type: poster

Abstract: Simulation of plasmon-enhanced photocathodes with applications to the production of structured electron beams

High-brightness electron sources are a key ingredient to the development of compact accelerator-based light sources. The electron sources are commonly based on (linear) a photoemission process where a laser pulse with proper wavelength impinges the surface of a metal and semiconductor cathodes. Very recently the use of plasmonic-cathode "cathode with nano-patterned surface" have demonstrated great enhancement in quantum efficiencies [1]. Alternatively, these types of cathodes could support the formation of structured beams composed of transversely separated beamlets. In this paper we develop and present numerical simulations aim at exploring the possible generation of patterned electron beam. We carry early-stage simulation of the field/photoemission process within the WARP [2] framework. This elaborate model is used to investigate the properties of beams emitted from various cathode geometries. These initial beam distributions are then pass to other beam dynamics programs for tracking through a radiofrequency photoinjector and downstream beamline. The possible phase-space exchange of the produced distributions to form a temporal comb as discussed in Ref. [3] is also explored.

References:

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- [2] J. L. Vay, D. P. Grote, R. H. Cohen, and A. Friedman, "Novel Methods in the Particle-In-Cell Accelerator Code Framework Warp" Comput. Sci. Disc. 5 014019 (2012).
- [3] WS Graves, FX Kärtner, DE Moncton, P Piot, Phys. Rev. Lett. 108, 263904 (2012).

Name: Simona Bettoni
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Type: Poster
Abstract: Title: Precise slice energy spread measurement method based on bunching measurements

Abstract: The beam slice energy spread is a key quantity to characterize the bunch especially in FEL facilities. This quantity is expected to be between 1 and 3 keV at the end of a photo-injector. A method based on the analysis of a streaked beam in a dispersive section does not typically reach the necessary resolution. A different approach, based on the coherent harmonic generation using two undulators, demonstrated the capability of reaching a resolution in the range of keV. Following this idea we propose to use the laser of the laser heater to generate a time-energy modulation in the beam and to measure the bunching downstream of a compressor as a function of the compression factor to determine the slice energy spread. In this proceeding we discuss simulations done for SwissFEL, which indicated a resolution below-of the order of 0.5 keV.

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Type: Poster
Abstract: Title:
Bunch train generation based on wakefield excitation

Abstract:
Generation of train of electron bunches of picoseconds down to tens of femtosecond length is attractive for several applications, as free electron lasers (FELs), x-ray generation, plasma wakefield accelerators (PWFA), and other advanced schemes such as the particle acceleration by stimulated emission of radiation. Different methods have been studied to produce such a bunch pattern. The most used ones consists in illuminating a photocathode with multiple laser pulses, or using a mask in a dispersive region where the beam has a time-momentum correlation. We propose a non-invasive approach based on the interaction of the beam with a sinusoidal longitudinal wakefield source. We present in this paper the design of the device applied to SwissFEL.

Name: Eduard Prat
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Type: Poster
Abstract: Title: Laser acceleration experiment at SwissFEL

Authors: Eduard Prat, Simona Bettoni, Micha Dehler, Franziska Frei, Rasmus Ischebeck, and Sven Reiche

Abstract:

The ACHIP collaboration, funded by the Gordon and Betty Moore foundation for a 5 year period, pursues basic R&D for a super compact accelerator on a chip, where the accelerating structure is a dielectric microstructure excited by a laser. PSI will contribute to this by providing the international collaboration with access to the high-brightness electron beams in SwissFEL, where we are planning to do a proof-of-principle demonstration of the acceleration of a relativistic beam. In this contribution we present the conceptual layout of the experiment, which will focus the beam down to sub-micrometer beam sizes. Start-to-end simulation results of the tracked electron beam, and expected energy gain of the electrons traveling through the microstructure will be shown.

Name: Feng Zhou

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Type: plan to have oral presentation

Abstract: LCLS-II CW injector design

F. Zhou, D. Dowell, R. Li, J. Schmerge, T. Raubenheimer (SLAC)

C. Mitchell, F. Sannibale (LBL)

LCLS-II CW injector beamline consists of a 186 MHz normal conducting (NC) RF gun for beam generation and acceleration to 750 keV, two solenoids for the beam focusing, two BPMs, 1.3 GHz NC buncher for bunch compression down to 3-4 ps rms, 1.3 GHz superconducting standard 8-cavity cryomodule to boost beam energy to 100 MeV. The beamline is optimized to accommodate all essential components and maximize beam quality. The beamline layouts and beam dynamics are presented and compared. The 3D RF field perturbation due to cavity couplers where the beam energy is very low (~ 1 MeV) causes significant emittance growth especially for a large-size beam. A theory of rotated fields predicted and simulations verified using a weak skew quadrupole located even a significant distance from the perturbation can completely eliminate the emittance growth. The results are presented and analysed. RF tolerances are studied to meet the arrival time requirement.

Name: Phuc Hoang

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Type:

Abstract: Beam driven dielectric wakefield is an acceleration technique that offers high accelerating gradient greatly surpassing that of traditional RF technology. In a recent experiment with dielectric loaded tubes, we measured a decelerating gradient of 1.35GV/m of the drive charge. Subsequently, in following drive-witness experiment, we measured an 80% average energy transfer between the two. Such high gradients and efficiency also come with challenges. First, transverse deflecting modes are present when the beam orbit is not coincident with the symmetry axis of the structure. Second, the high field, high radiation environment can metalize the dielectric and dissipate the wakefield. Such phenomena were measured in a series of

experiments and will be presented. Nonetheless, these challenges can be addressed by introducing more sophisticated geometries such as slab-symmetric structures and structures with corrugated surfaces at the vacuum/dielectric boundary. Both numerical simulations and measurements in this vein will be discussed. Finally, in the spirit of going all dielectric, we will discuss use of photonic crystals as an alternative for metals to confine wakefield.

Name: Pardis Niknejadi

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Type: Poster

Abstract: Title: Analytical study and discussion for inclusion of advance field and boundary condition in theory of free electron lasers (FELs)

Abstract: By the covariant statement of the distance in space-time separating transmitter and receivers, the emission and absorption of the retarded and advanced waves are all simultaneous. In other words, for signals carried on electromagnetic waves (advanced or retarded) the invariant interval $(cdt)^2 - dr^2$ between the emission of a wave and its absorption at the non-reflecting boundary is always identically zero. Utilizing this principle, we have previously explained the advantages of including the coherent radiation reaction force as a part of the solution to the boundary value problem for FELs that radiate into "free space" (Self Amplified Spontaneous Emission FELs) and discussed how the advanced field of the absorber can interact with the radiating particles at the time of emission. Here we present the modification of Ming Xie's theory of optical guiding and derive a solution that includes this effect. We also discuss the application of this analysis to different configurations of FEL devices.

Name: Anna Giribono

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Type: poster

Abstract: Electron beam dynamics for the new SPARC_LAB high brightness RF gun

The Frascati INFN-SPARC_LAB test facility consists of a high brightness photo injector, SPARC, and the 250TW FLAME laser system. At SPARC the electron beam is generated in a 1.6 cell S-band RF gun equipped with a copper photocathode and an emittance compensation solenoid. An upgrade is foreseen at SPARC by installing a new S-band RF gun as the one developed at LNF in the framework of the ELI-NP collaboration, that should allow a better control of the electro-magnetic asymmetries due to dipole and quadrupole modes. Hence, the electron beam dynamics has been investigated and is here illustrated.

Name: Giovanna Campogiani

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Type: Poster

Abstract: Electron beam trajectory and optics control in the ELI-NP Gamma Beam System LINAC

Magnetic field errors as misalignments of magnetic and diagnostic components induce a spurious emittance growth that degrades the beam quality. The aim of this study is to correct the impact of such spurious on the ELI-NP Gamma Beam System, in particular for the low energy line, for an effective commissioning of the machine. To perform this study we use the simulation code elegant. We study different alignment and orbit stabilization methods such as one-to-one steering, Fast-Orbit-Feedback through Single Value Decomposition factorization and Dispersion Free Steering.

Name: Stephen Webb
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Type: poster

Abstract: Title: Kinetic Relaxation of Wakes in Plasma Accelerators

Abstract: Future plasma accelerator driven facilities such as colliders or free-electron lasers will require operational repetition rates in the kHz-MHz range. The long-time relaxation of the plasma wakes are currently poorly understood -- numerical artifacts limit the reliability of simulations and conventional analytic approaches are invalid for long times. We present a perturbation formalism, built on Hamiltonian perturbation theory and symplectic maps, which is capable of capturing the full phase space kinetics in self-consistent plasmas. This formalism is used to compute a dressed Hamiltonian for the dynamics of the wake in a plasma wakefield accelerator in the blowout regime. We arrive at a scaling law for the decay of the wake, yielding a fundamental limit to the repetition rate of a plasma accelerator.

Name: Shaukat Khan
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Type: talk preferred

Abstract: The brightness of short-wavelength photon beams can be increased by coherent emission in which the radiation intensity scales with the number of contributing electrons squared. This requires a micro-bunched longitudinal electron distribution, which is the case in free-electron lasers (FELs), where the bunched distribution either emerges from noise or is seeded by external laser pulses. The brightness of light sources based on electron storage rings has recently profited from novel magnetic multi-bend schemes, higher beam currents and top-up injection, but also here coherent emission can be induced by seeding techniques similar to those applied to FELs. One particular goal is coherent emission from a short "slice" within an electron bunch in order to produce radiation pulses which are much shorter (typically by a factor 1000) than the bunches and still are brighter than the incoherent radiation from the whole bunch. If a larger portion of the bunch could be seeded that way, the gain in brightness would be enormous. At the 1.5-GeV electron storage ring DELTA, operated by the TU Dortmund University in Germany as a light source as well as for accelerator studies, coherent

harmonic generation (CHG, a seeding scheme analogous to HGHG in FELs) is routinely performed and the laser-interaction process is studied in detail. The next step will be to modify the storage ring and employ echo-enabled harmonic generation (EEGH), a seeding scheme in which a two-fold laser-electron interaction allows to reach shorter wavelengths.

Name: A. Rodriguez

Name: C. Cruz Inclan

Name: E. Gonzalez-Lazo

Name: Ahmad Fahim Habib

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Type: Poster

Abstract: Energy Spread Reduction in the Highest Brightness Beam Plasma-Accelerator Scheme.

Abstract:

High-brightness beams from advanced scheme beam-driven plasma accelerator (PWFA), such as underdense photocathode mechanism (aka "Trojan Horse"; TH), could support the 5th generation light sources substantially. However, the witness bunch from TH-PWFA has an intrinsic large correlated energy spread (energy chirp) as a byproduct of huge (GV/m level) accelerating electric field gradient. In this work, we present a technique of compensating the energy chirp in a single TH-PWFA plasma stage. We show that the dechirping process due to the new methods can reduce the energy spread down to 0.1%. We investigate this dechirping technique by 3D particle-in-cell simulation.

Name: Georg Wittig

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Type: talk or poster

Abstract: Improvements on the optical plasma torch electron bunch generation technique in plasma wakefield accelerators

Laser (LWFA), and particle beam driven (PWFA) plasma wakefield acceleration has been proven to be a promising candidate as a driver for next generation light sources, introducing the capability to accelerate ultra-short, high quality bunches to GeV energies within meters. We report on a novel and flexible electron bunch injection method in PWFA that is more flexible and faster when compared to hydrodynamically controlled gas density transition injection. This technique applies a transversally propagating laser pulse to ionize a plasma column (aka plasma torch) in front of an electron beam driven wakefield, in order to inject electrons into the wakefield in a controlled manner during passage of the optical plasma torch [1]. The shape, charge, and trapping position of the injected electron bunch can be controlled by changing the plasma density, laser pulse form and focusing. Besides its use for injection, the optical plasma torch can be applied to kick electron bunches on fs time scales, by tilting the angle of the optical plasma torch.

It is also suited for probing a wakefield and timing purposes. The concept and its limits for use as diagnostics, for beam manipulation and injection recently gained additional import in the context of breakthrough results obtained at FACET aiming at generation of high brightness electron beams.

[1] G. Wittig et. al., PRSTAB 18, 081304 (2015)

Name: Thomas Heinemann
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Type: invited talk
Abstract: Passive plasma lenses for all-optical hybrid plasma acceleration

Recent theoretical and experimental studies emphasize the suitability of passive plasma lenses on focusing a laser wakefield generated electron beam. Those plasma lenses are a crucial component in an all-optical hybrid plasma accelerator, where a beam provided by a laser-plasma accelerator subsequently drives a plasma wave itself.

Then, a small fraction of the initial laser intensity is utilized for underdense photocathode injection (â€œTrojan Horseâ€œ), generating high brightness electron beams.

Exploiting plasma lenses for the laser- to beam driven transition might thus pave the way for future compact light sources.

Name: Paul Scherkl
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Type: invited talk
Abstract: Tunable multicolor radiation from inverse Compton scattering with Trojan Horse accelerated electron beams.

The underdense plasma photocathode accelerator (Trojan Horse) is expected to generate next-level electron beams providing extreme brightness and kA currents. The inherent dynamics of this scheme will furthermore enable control of most beam parameters, leading to a versatile technology for a broad range of next-generation applications. Especially novel high-energy radiation sources providing ultra-short narrow bandwidth pulses are in demand and currently under investigation.

Inverse Compton scattering off (multiple) electron beams generated in the Trojan Horse accelerator is discussed. Their combined tunability might support innovative experimental fields and cover several applications inaccessible by other radiation sources.

Name: Patrizio Antici
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Type: Talk

Abstract: Challenges and Bottlenecks of Laser-generated Beamlines

Laser-generated particles are more and more considered to become a competitor to particle beams generated by traditional accelerator facilities such as Linac or synchrotrons. In particular, the high accelerating gradient that can be reached with laser-acceleration mechanisms, almost 1000 times stronger than for conventional accelerators, makes them an attractive alternative. A stronger accelerating gradient would reduce potentially the size and hence the costs of big accelerator facilities (e.g the LHC accelerator ring at CERN-Geneva, where the electron storage ring is around 27 km long). Unfortunately, the quality of the laser-generated beam parameters is currently not sufficient for replacing traditional facilities based on radiofrequency technology.

In this talk we present the key issues and bottlenecks that we have identified in order to make laser-generated beams competitive to traditional accelerators. Results have been obtained using different particle-tracking codes commonly in use in the conventional accelerator community and coupling laser-generated beams to conventional accelerator devices in order to generate a traditional beam line. The particle tracking codes allow studying the relevant parameters needed for an efficient capture, transport and control of those beams. This would then generate reliable and controllable particles sources based on higher power laser systems, such as foreseen by many infrastructures, e.g. the Extreme Light Infrastructure (ELI).

Name: Vladimir Litvinenko

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Type: Talk

Abstract: Progress with Coherent electron Cooling at RHIC

An Coherent-electron Cooling (CeC) based on the FEL and micro-bunching instability had been proposed few years ago. Being a very flexible version of stochastic cooling, the CeC approach promises significant increase in the bandwidth and, therefore, significant shortening of cooling time in high-energy hadron colliders. In principle, it also can be considered as a possible final-stage cooling technique for muon colliders. In this paper we present our plans of simulating and testing the key aspects of this proposed techniques using the coherent-electron-cooling proof-of-principle experiment at BNL. We present current status of the project and results of its commissioning.

RADIATION-INDUCED SYNTHESIS AND CHARACTERIZATION OF POLY(VINYLPYRROLIDONE) NANOGEL.

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ABSTRACT:

Due to the importance of bioactive peptides, proteins and drug for pharmaceutical purpose, there is a growing interest for suitable delivery systems, able to increase their bioavailability and to target them to the desired location. Some of the most studied delivery systems involve encapsulation or entrapment of drugs into biocompatible polymeric devices. This important factor has stimulated research on radiation-induced reactions of polymers in aqueous solution for synthesizing new materials or modifying the properties of polymers.

The use of radiation has involved, as might be expected, the field of nanotechnologies in the production of new materials and structures that have both fundamental interest and potential applications in areas such as biomedical sciences, electronics, optics, and material sciences.

Polymeric micro and nanogels are probably the most prominent examples of water-borne products obtained by radiation technology. They have a broad field of actual and potential applications ranging from filler materials in coating industry to modern biomaterials. Nanogels are promising novel pharmaceutical carriers for small biologically active agents and biomacromolecules. The advantages of these systems include simplicity formulation with the drugs, high loading capacity, and stability of the resulting formulation in dispersion. These systems allow immobilization of biologically active compounds of diverse structure including charge drugs, low molecular mass hydrophobes, and biopolymers. Furthermore, nanogels can be chemically modified to incorporate various ligands for targeted drug delivery. The in vivo and vitro studies suggest that nanogels can be used for efficient delivery of biopharmaceuticals in cell as well for increasing drug delivery across cellular barriers.

A multitude of techniques have been described for the synthesis of polymeric micro and nanogels, however, the use of ionizing radiation (γ , e-), to obtain nano- and polymer microgels are characterized by the possibility of obtaining products with a high degree of purity. The main factors that contribute to the success of these technologies are: water as a human-and environment-friendly solvent, lack of any potentially harmful chemicals (monomers, initiators, crosslinking agents, etc.), simple production schemes, parallel synthesis and sterilization of the products in the sealed, final packages, valuable medical properties of the products, broad range of applications, and the possibility of manufacturing "smart" gels reacting to temperature, pH, light, etc.

The synthesis of Polyvinylpyrrolidone (PVP) nanogels by ionizing radiation techniques (gamma irradiation), for their evaluation as potential system of drug delivery was the aim of this research.

Solutions were prepared with water purified by distillation and in order to remove any dust particles and/or polymer aggregates, solutions were filtered subsequently through filters of 0.45 and 0,22 μm pore size. Gamma irradiation were carried out with a panorama 60 Co source at dose ranging from 5-25KGy.

Particularly, the polivynilpirrolidone nanogels can be obtained by gamma radiation, based not on polymerization, but on intramolecular crosslinking of polymers chains, in aqueous solutions.

The nanogel characterization was performance by electron microscopy (TEM, SEM), DRX, spectroscopy (UV-visible and IR), light scattering, viscosimetry, delivery of an active agents and cytotoxicity trials

The results showed that in dependence on the polymer concentration and the dose rate two different crosslinking reactions can be obtained. Irradiation experiments at room temperature in diluted solution with further increasing

of the radiation dose lead to the formation of PVP nanogels due to an intramolecular crosslinking reaction. By using both light scattering and TEM the PVP nanogels were measured, these showed a size distribution of 50.10 nm. They have lots of advantages over conventional systems since they enhance the delivery, extend the bioactivity of the drug by protecting them from environmental effects in biological media, show minimal side effects, demonstrate high performance characteristics, and are more economical since minimum amount of expensive drugs are used.

Name: A. Bacci (INFN-MI)

Two-photon and electron-positron pairs produced by gamma-gamma scattering.
A. Bacci, I. Drebot, D. Micieli, E. Milotti, A. Papa, V. Petrillo, A .R. Rossi, L. Serafini, E. Tassi, M. Rossetti Conti

The recent development of Compton sources allows the production of high-brilliance photon beams in the MeV energy that can be used as primary gamma beams for a gamma-gamma collider with the aim of studying two fundamental processes: the elastic photon-photon scattering and the Breit-Wheeler reaction, so far never observed directly experimentally. Start-to-end simulations of an ideal machine devoted to the gamma-gamma collisions are presented. The Compton back scattering between high brightness electron bunches, produced and accelerated by two counter-propagating linacs, and two high energy laser pulses permits to generate a couple of counter-propagating gamma beams, which at the interaction point have a center of mass energy ranging between 0.7-1.5 MeV, around the photon-photon scattering and Breit-Wheeler cross-sections maximum. The efficiency of these reactions is analyzed, together with technological problems like the geometry of the interaction or the most suitable electron linac, in order to fix the parameters of this peculiar collider.

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Type: poster

Abstract: High-Gain FEL in the Space-Charge Dominated Raman Limit
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While FEL technology has reached the EUV and X-ray regime at existing machines such as LCLS and SACLA, the scale of these projects is often impractical for research and industrial applications. Sub-millimeter period undulators can reduce the size of a high-gain EUV FEL, but will impose stringent conditions on the electron beam. In particular, a high-gain EUV FEL based on undulators with a sub-millimeter period [1] will require electron beam currents upwards of 1 kA at energies below 100 MeV. Coupled with the small gap of such undulators and their low undulator strengths, $K < 0.1$, these beam parameters bring longitudinal space-charge effects to the foreground of the FEL process. When the wavelength of plasma oscillations in the electron beam becomes comparable to the gain-length, the 1D theoretical FEL model transitions from the Compton to the Raman limit [2]. In this work, we investigate the behavior of the FEL's gain-length and efficiency in these two limits. The starting point for the analysis was the one-dimensional FEL theory including space-charge forces. The derived results were compared to numerical results of Genesis 1.3 simulations. This theoretical model predicts

that in the Raman limit, the gain-length scales as the beam current to the $1/4^{\text{th}}$ power while the efficiency grows as the square root of the beam current.

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