From UCLA to The Long Wavelength Array

Greg Taylor (UNM)

Nedfest, 8/25/2017

THE ASTROPHYSICAL JOURNAL, **339**:619–628, 1989 April 15

EFFECTS OF A HOT INTERGALACTIC MEDIUM

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Received 1988 May 5; accepted 1988 September 14

ABSTRACT

A hot intergalactic medium (IGM) may make a significant contribution to the average density of the universe with few other observable effects. One effect it would have would be to produce an isotropic X-ray background through thermal bremsstrahlung. We have modeled such a background, including both relativistic electron-ion and electron-electron emission, and we can fit the observed X-ray measurements with a current temperature of 10.2 keV and Ω_{IGM} of 0.27, assuming that the IGM was instantaneously heated at a redshift of 5 and cools by relativistic adiabatic expansion and Compton cooling. Such a hot IGM would also distort the cosmic microwave background spectrum by inverse Compton scattering off relativistic electrons. We have modeled this distortion using the relativistic treatment, and we find when including the recent data of Matsumoto *et al*, an undistorted radiation temperature of 2.86 K and an Ω_{IGM} of 0.41. We present similar models for heating redshifts from 2 to 7.

Subject headings: cosmic background radiation — cosmology — galaxies: intergalactic medium — radiation mechanisms

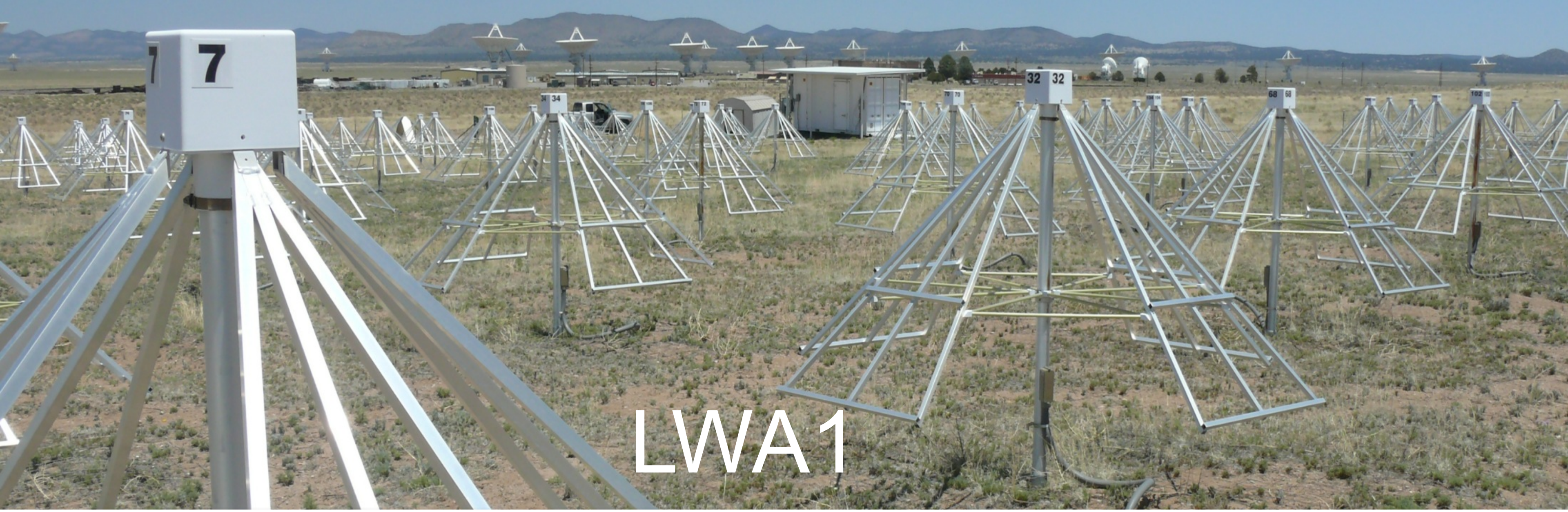
Ned's Research Guide

- If your program is taking a long time to run, its probably wrong.
- Don't use more words on the answer than were used in the question.
- Understanding Ned's answers may be as challenging as understanding the original question.
- In research, the answer is not in the back of the book.

Ned’s Fashion Guide

- ✧ Only wear a jacket and tie if over $1M is at stake, or
- ✧ at a thesis defense for a customary fee of $0.25.
- ✧ Tennis shoes are always acceptable

LWA1



LWA1

10-88 MHz usable Galactic noise-dominated (>4:1) 24-87 MHz

4 independent beams x 2 pol. X 2 tunings each ~16 MHz bandwidth

All sky (all dipoles) modes: TBN (70 kHz-bandwidth; continuous)

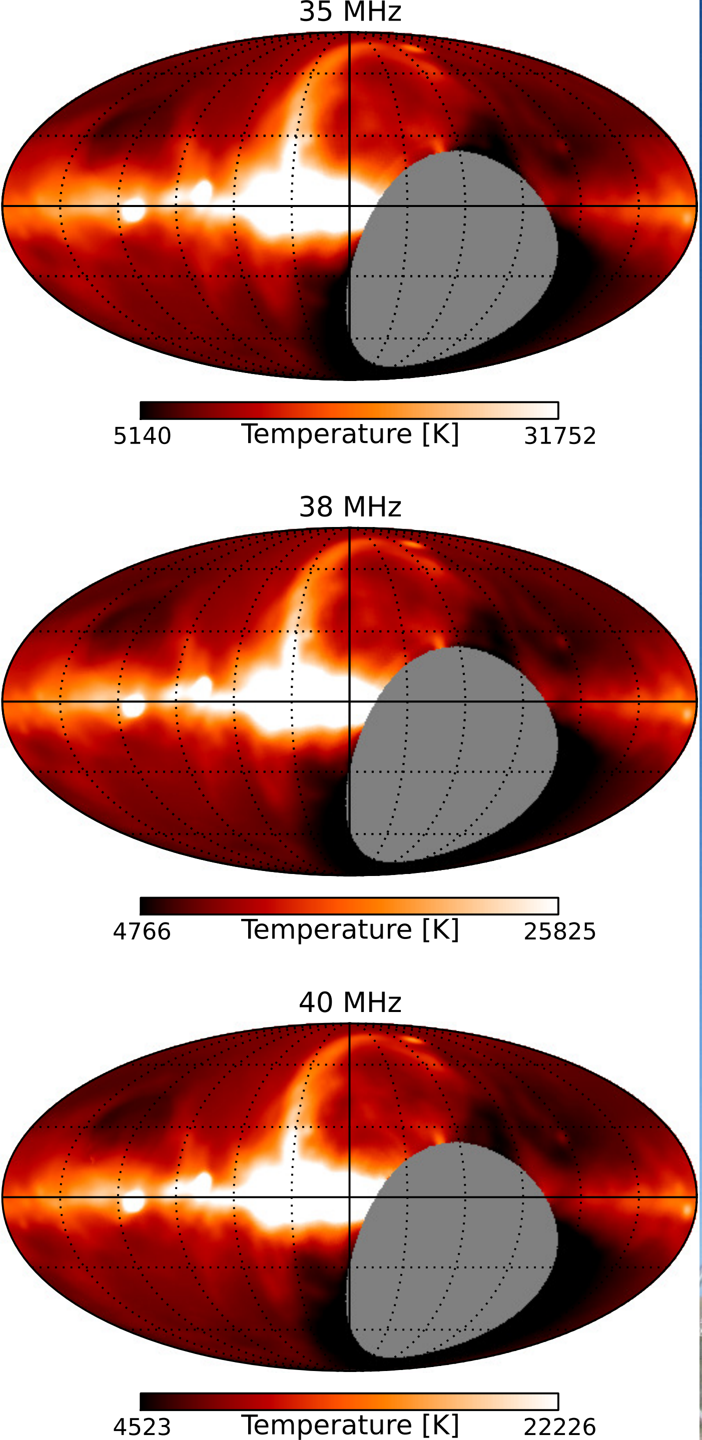
TBW (78 MHz-bandwidth, 61 ms burst)

40+ publications, now observing jointly with VLA

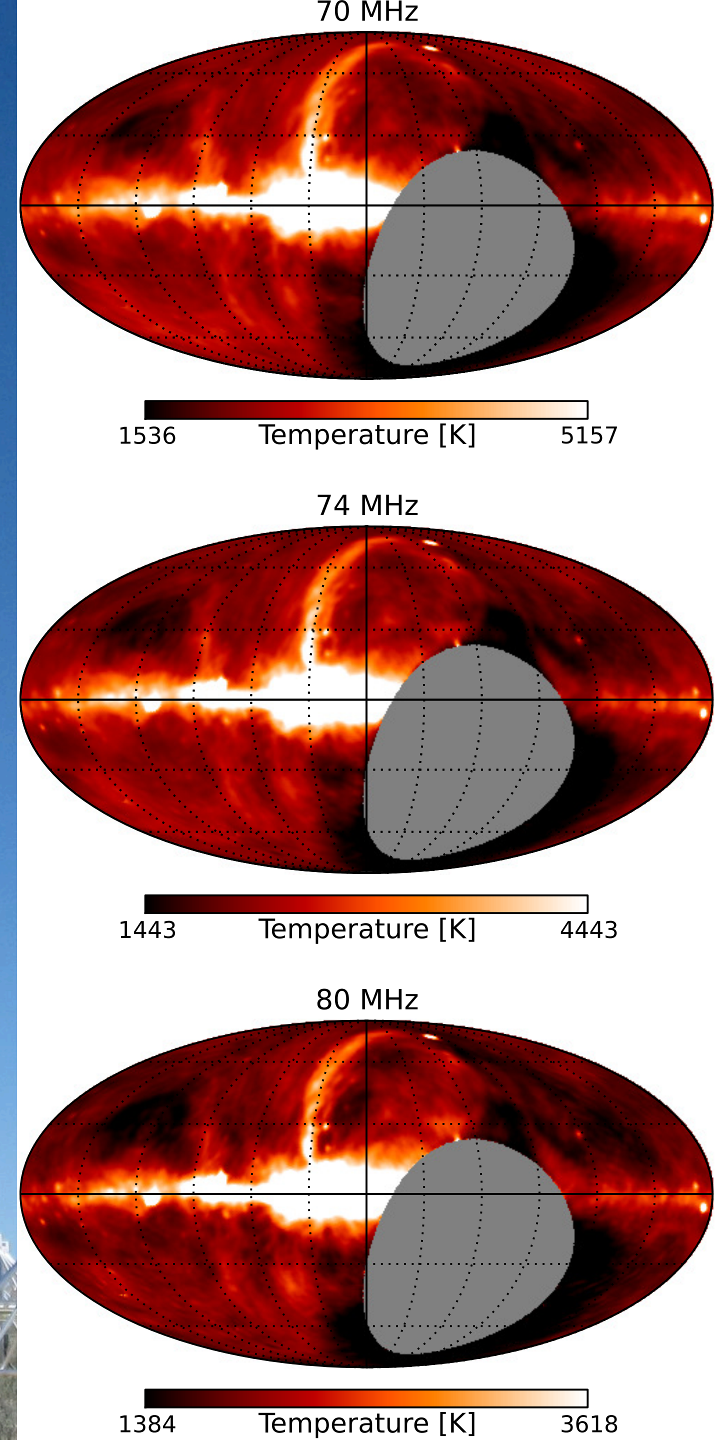
Five “outrigger” antennas at up to 500 m baselines

LWA1 discoveries: meteors, pulsars, Sun, Jupiter & Ionosphere

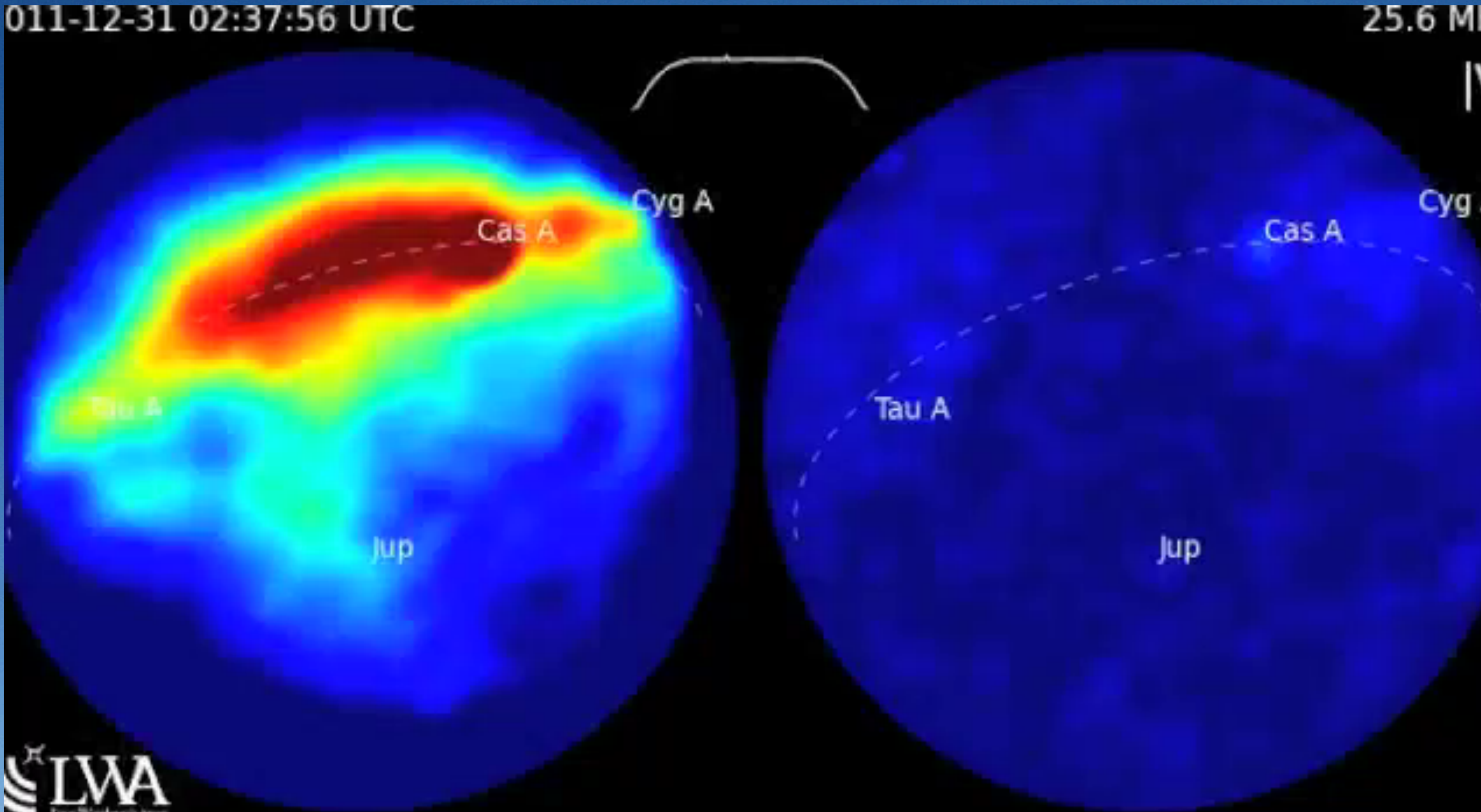
Open skies – LWA1 is funded by NSF and AFRL


35 MHz
5140
Temperature [K]
31752
38 MHz
4766
Temperature [K]
25825
40 MHz
4523
Temperature [K]
22226

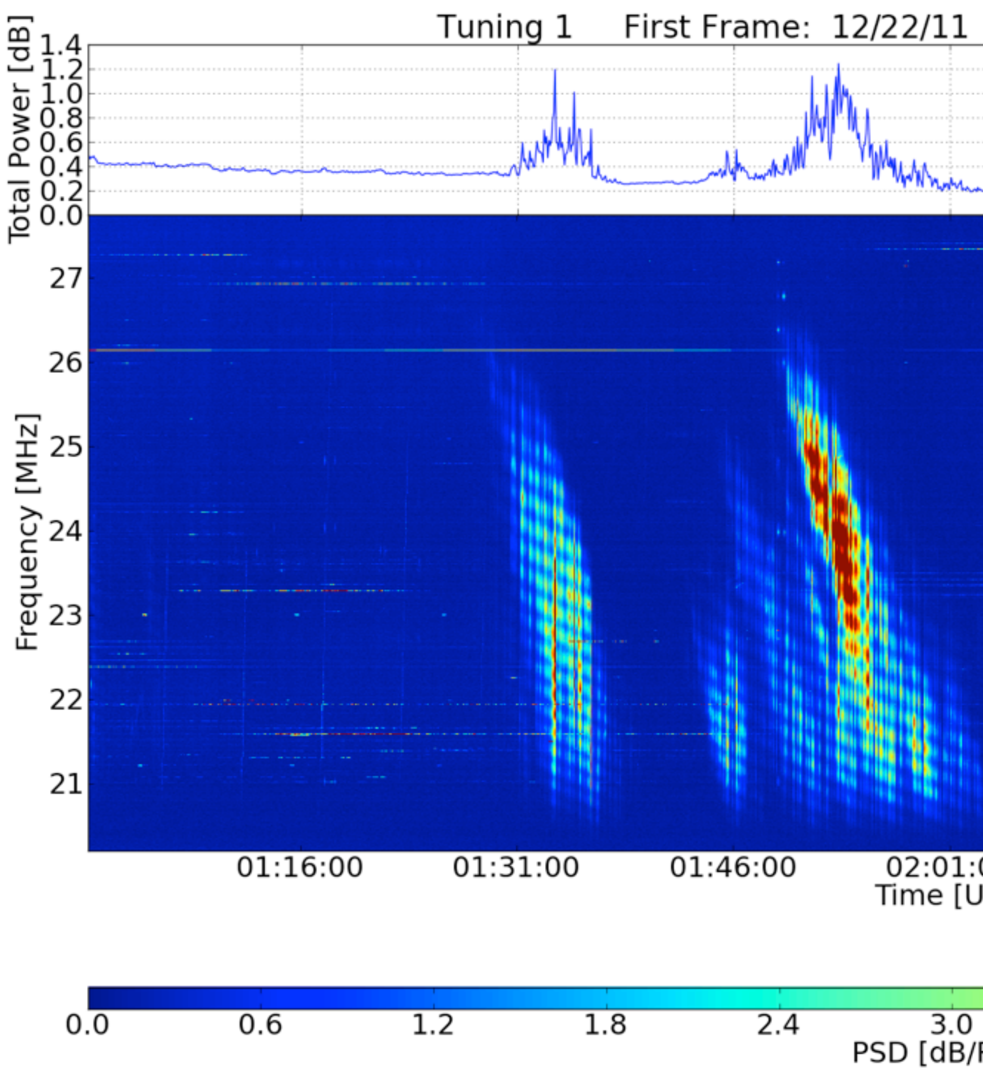

The Sky
35-80 MHz
Dowell et al.
2017
+ New Low
Frequency Sky
Model generator

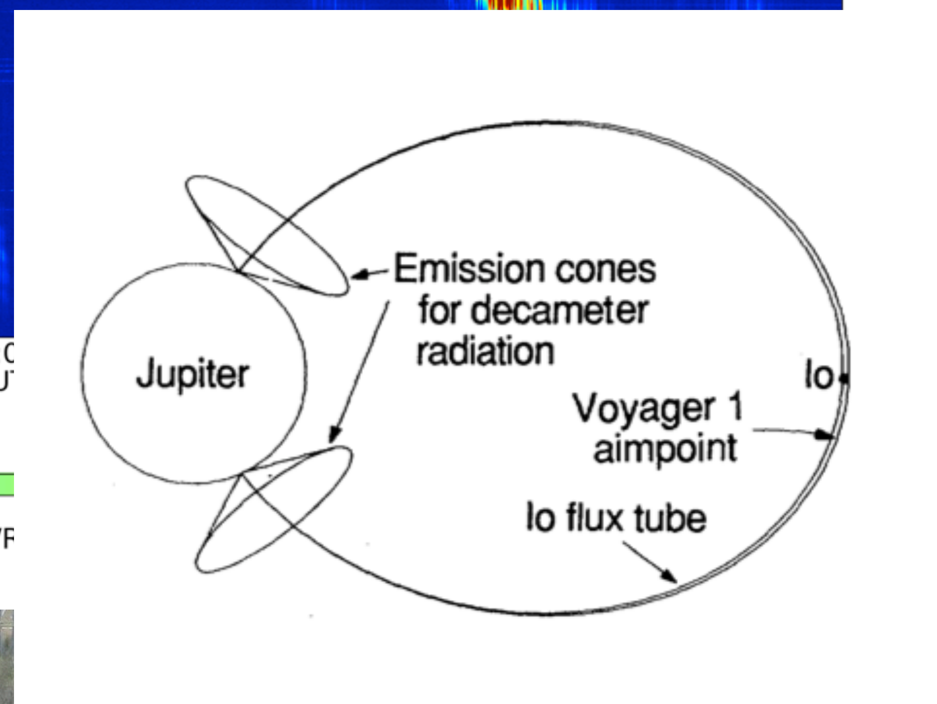

70 MHz
1536
Temperature [K]
5157
74 MHz
1443
Temperature [K]
4443
80 MHz
1384
Temperature [K]
3618

Jupiter


011-12-31 02:37:56 UTC
25.6 MH
Cyg A
Cas A
Tau A
Jup
Cas A
Tau A
Jup
LWA

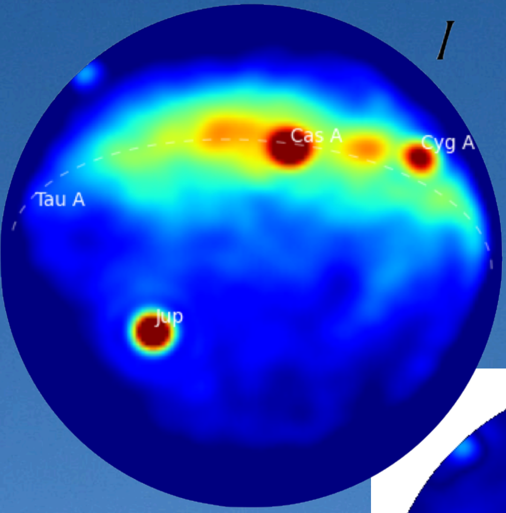
Decametric Jovian Emission

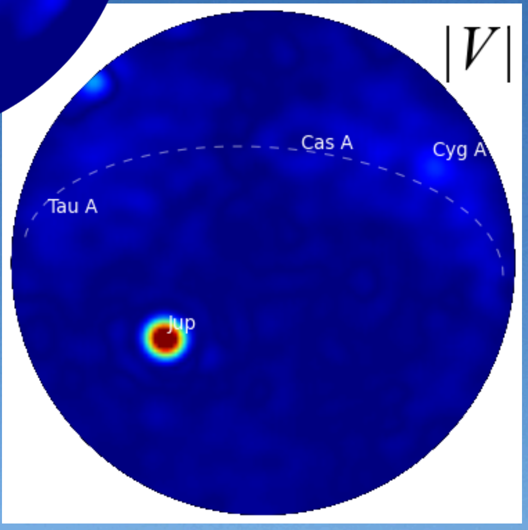




Emission from Jovian Planets

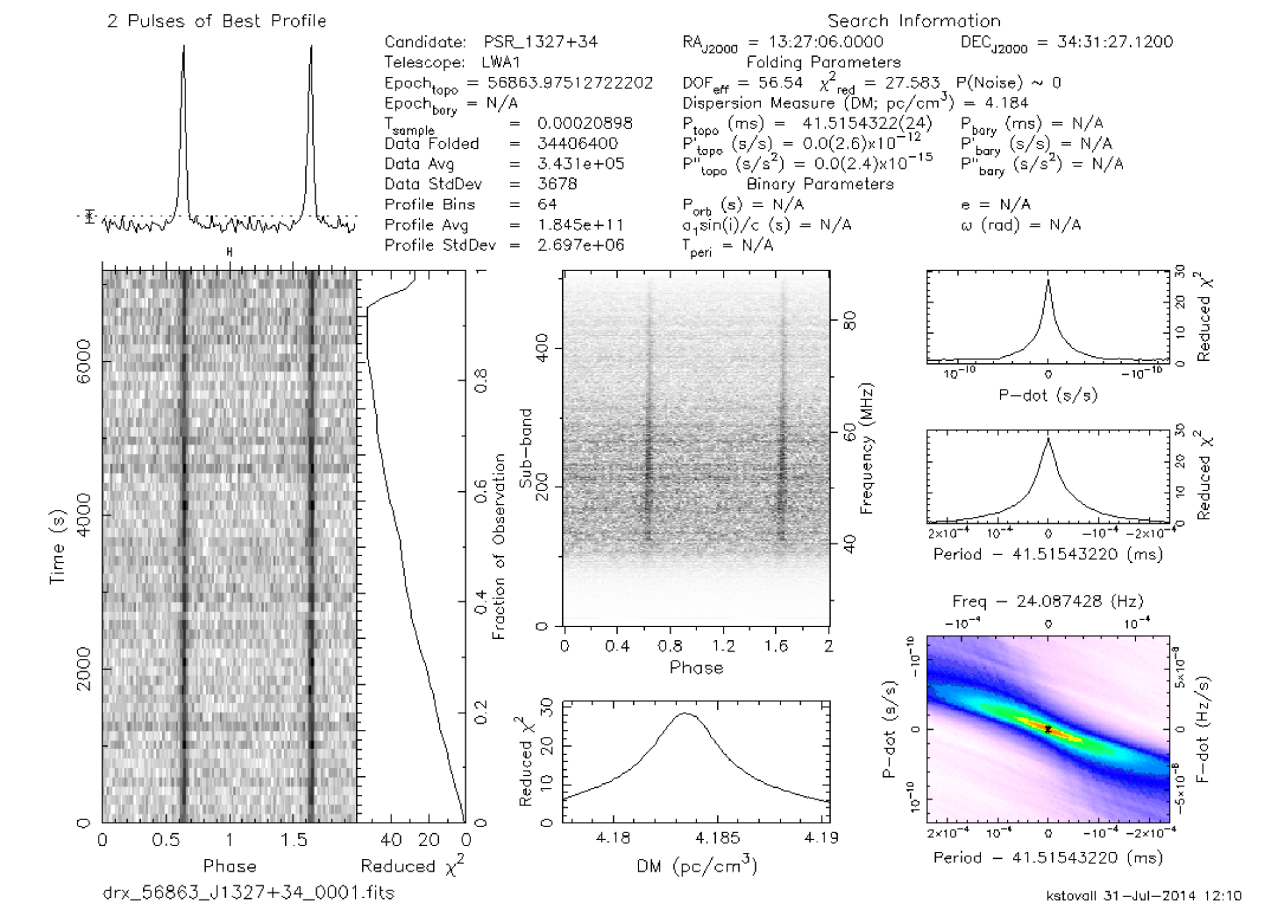
- Low frequency:
  $eB / 2\pi m_e = 28$ MHz at 10 G
- Bright! ~100 mJy flux density predicted at 10 pc
- High circular polarization: LWA is very good at this!
- Predictably time-variable:
  - pulsar-like emission
  - secondary eclipses
  - periastron passages of high-eccentricity HJs





PASI image of a Jovian burst at 25.61 MHz

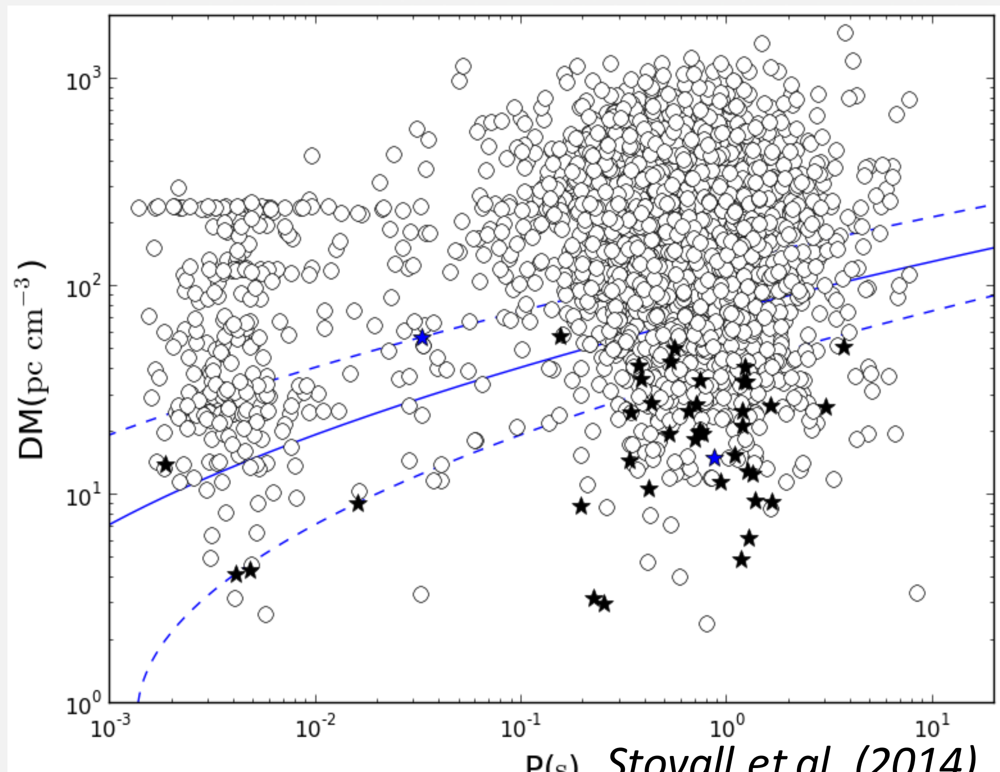
LWA1 Pulsar Detections



LWA1 Pulsar Detections

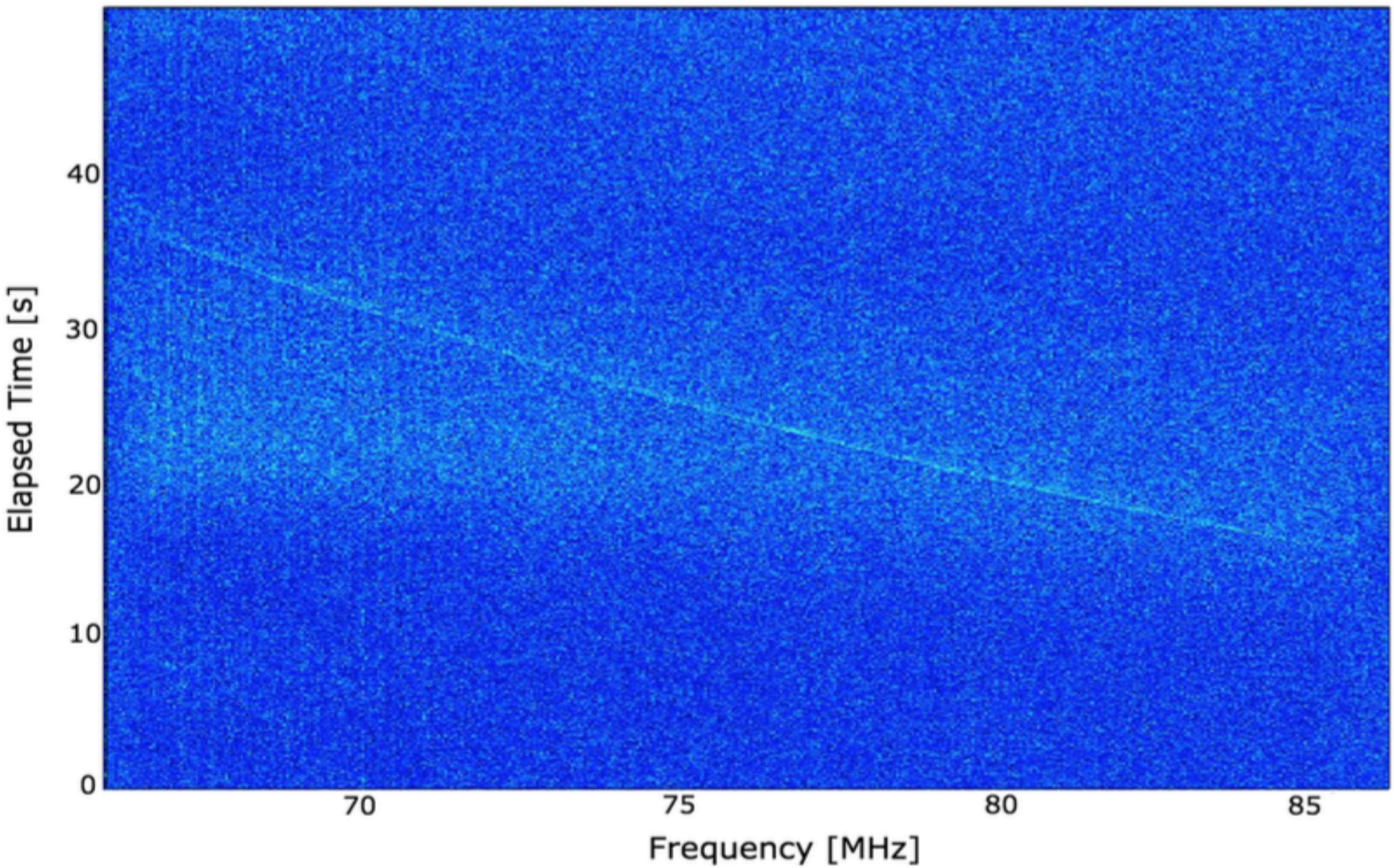
J0030+0451
B0031-07
J0034-0534
B0138+59
J0203+70
B0320+39
B0329+54
B0355+54
B0450+55
B0525+21
B0531+21*
B0628-28
B0655+64
B0809+74
B0818-13
B0823+26
B0834+06
B0919+06
B0943+10
B0950+08
B1112+50
B1133+16
B1237+25
J1327+34
B1508+55
B1540-06
B1541+09
B1604-00
B1612+07
B1642-03
B1706-16
B1749-28
B1822-09
B1839+56
B1842+14
B1919+21
B1929+10
B2020+28
B2110+27
J2145-0750
B2217+47
J2324-05

- 99 Pulsars detected (58 through pulsations, 2 through single pulses)
- 7 MSPs detected
- Periods from 1.9ms to 3.7s



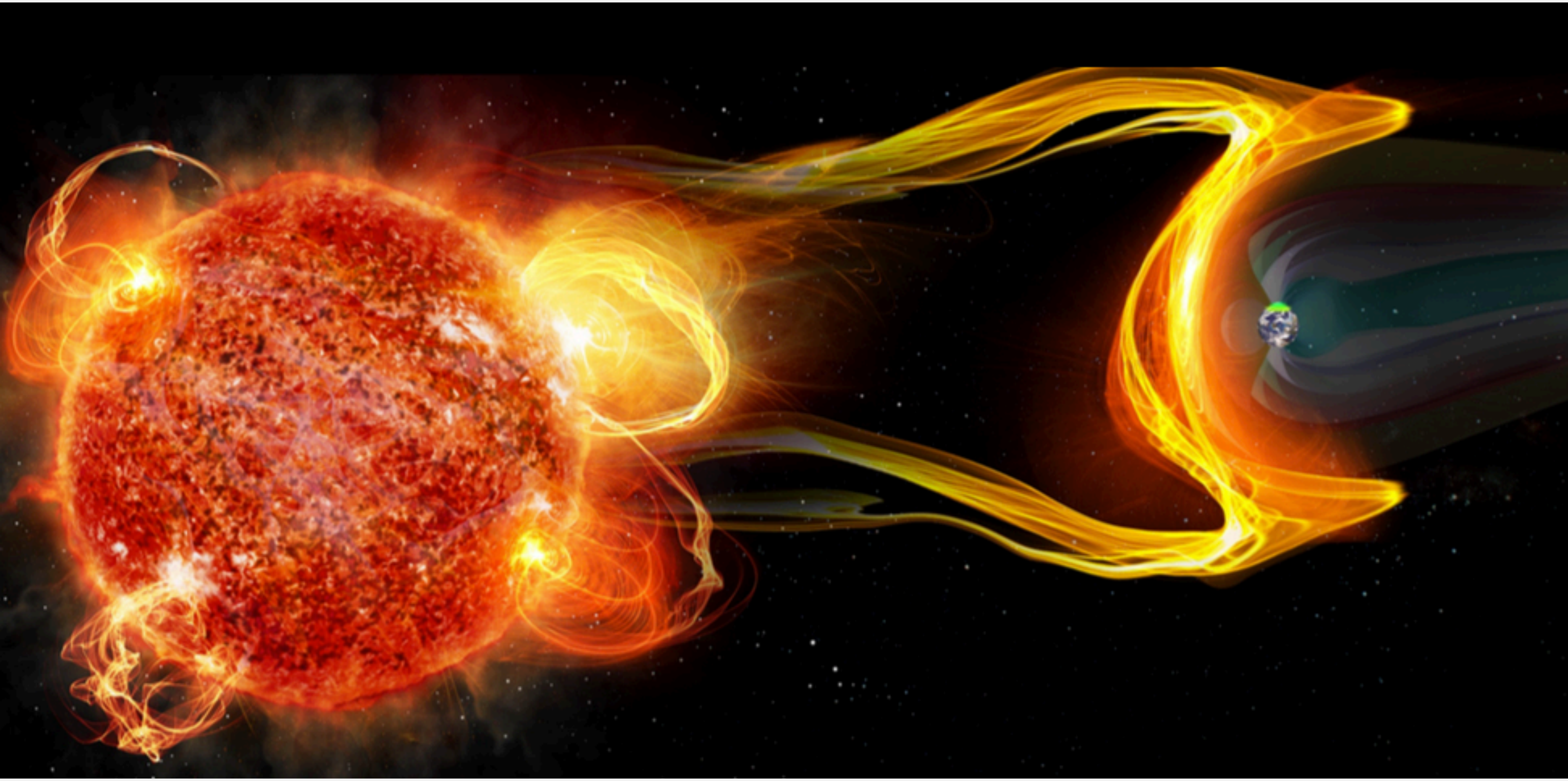
Stovall et al. (2014)

Dispersion of a Pulse

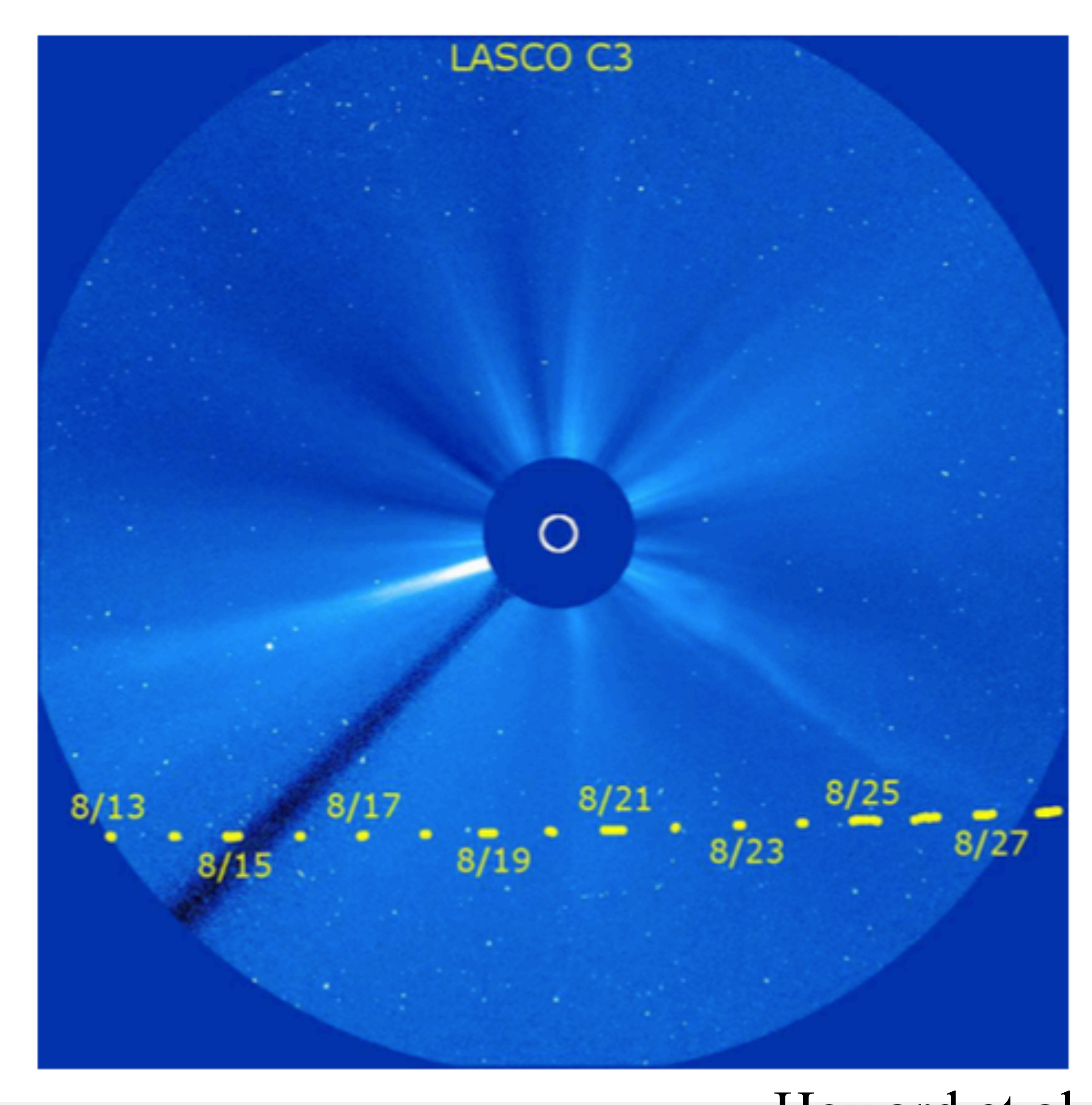


Eftekhari et al. (2016)

Coronal Mass Ejection

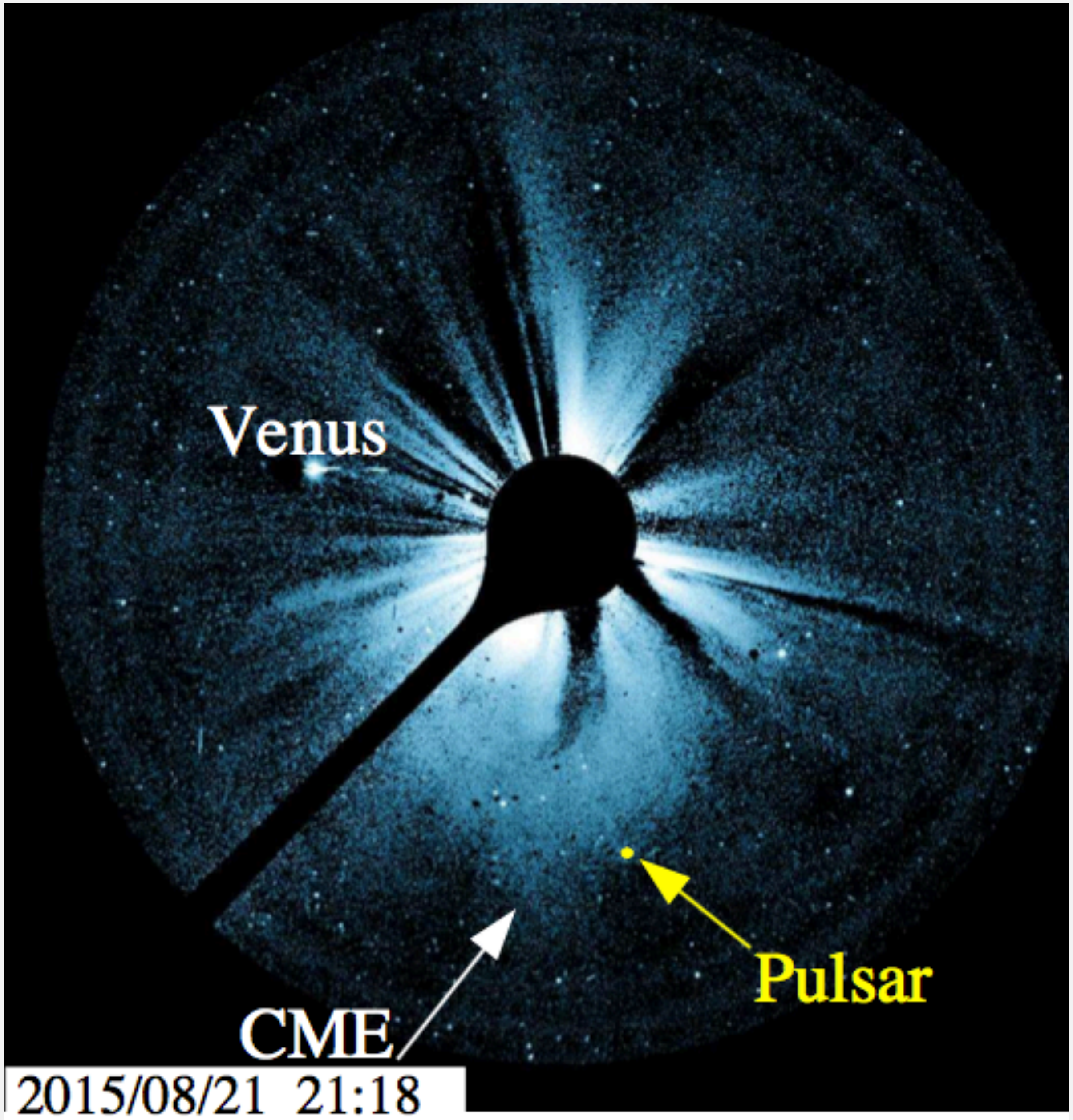


Catching a Coronal Mass Ejection

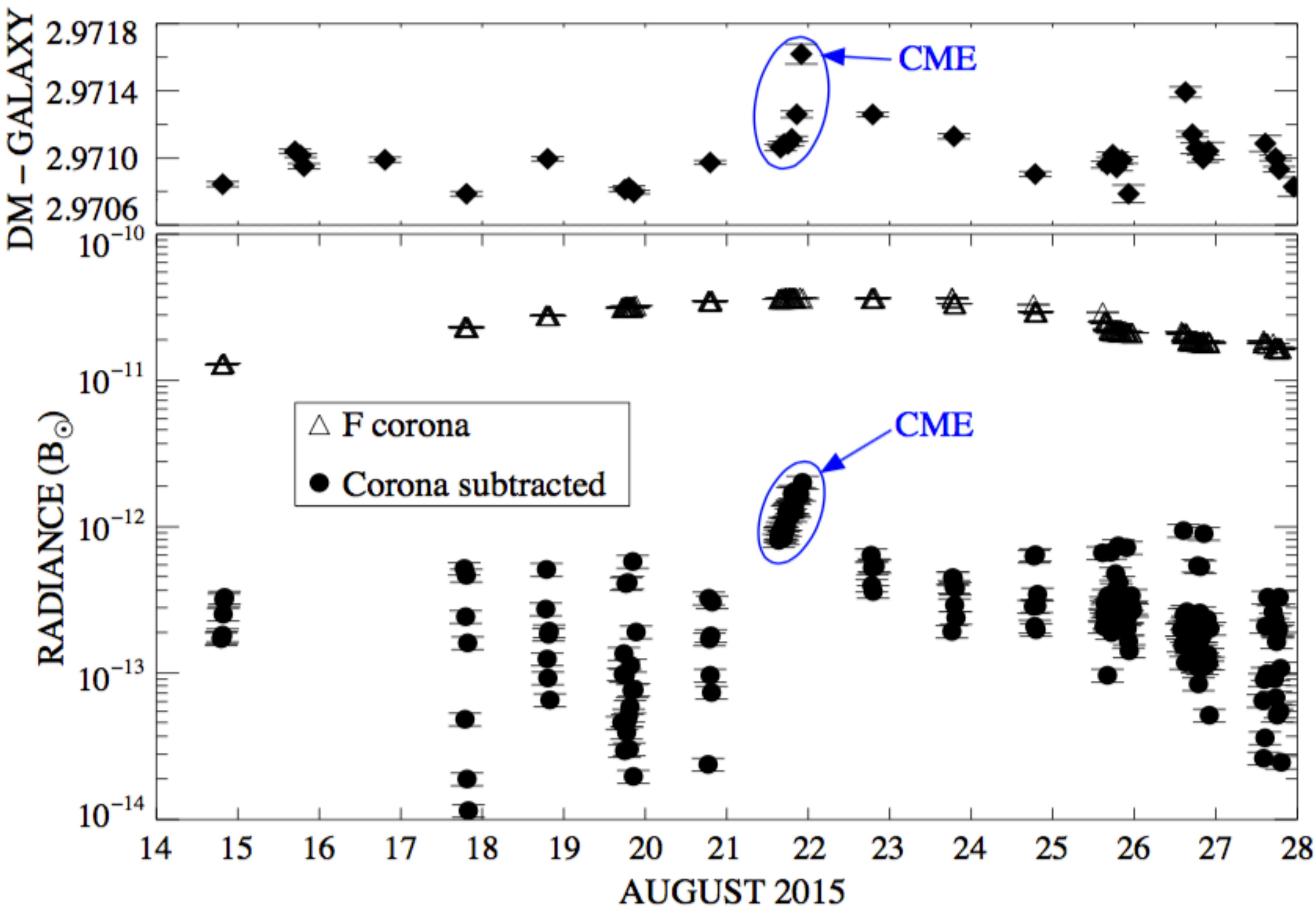


Howard et al 2016

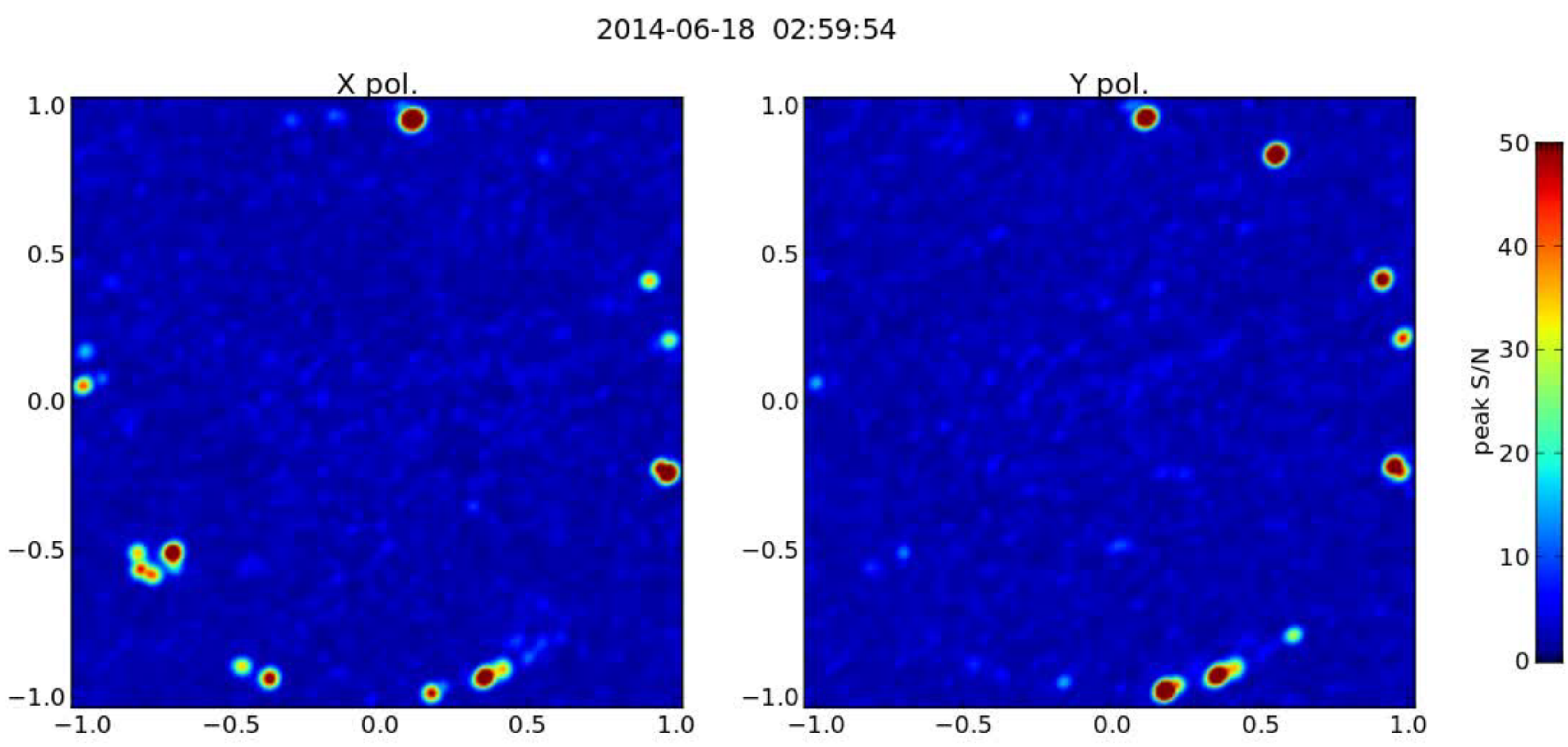
Catching a Coronal Mass Ejection



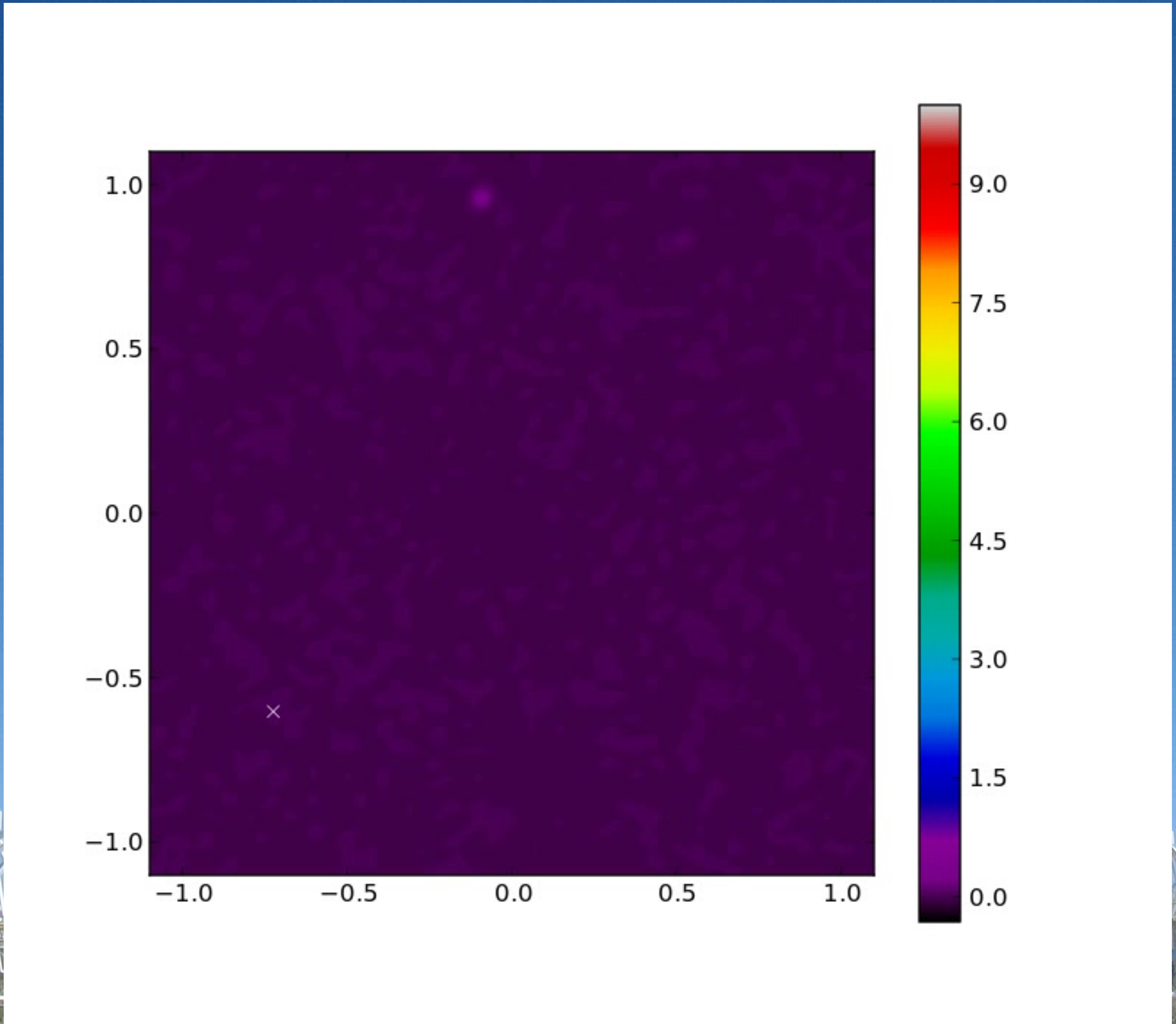
Catching a Coronal Mass Ejection



Meteors – by reflection

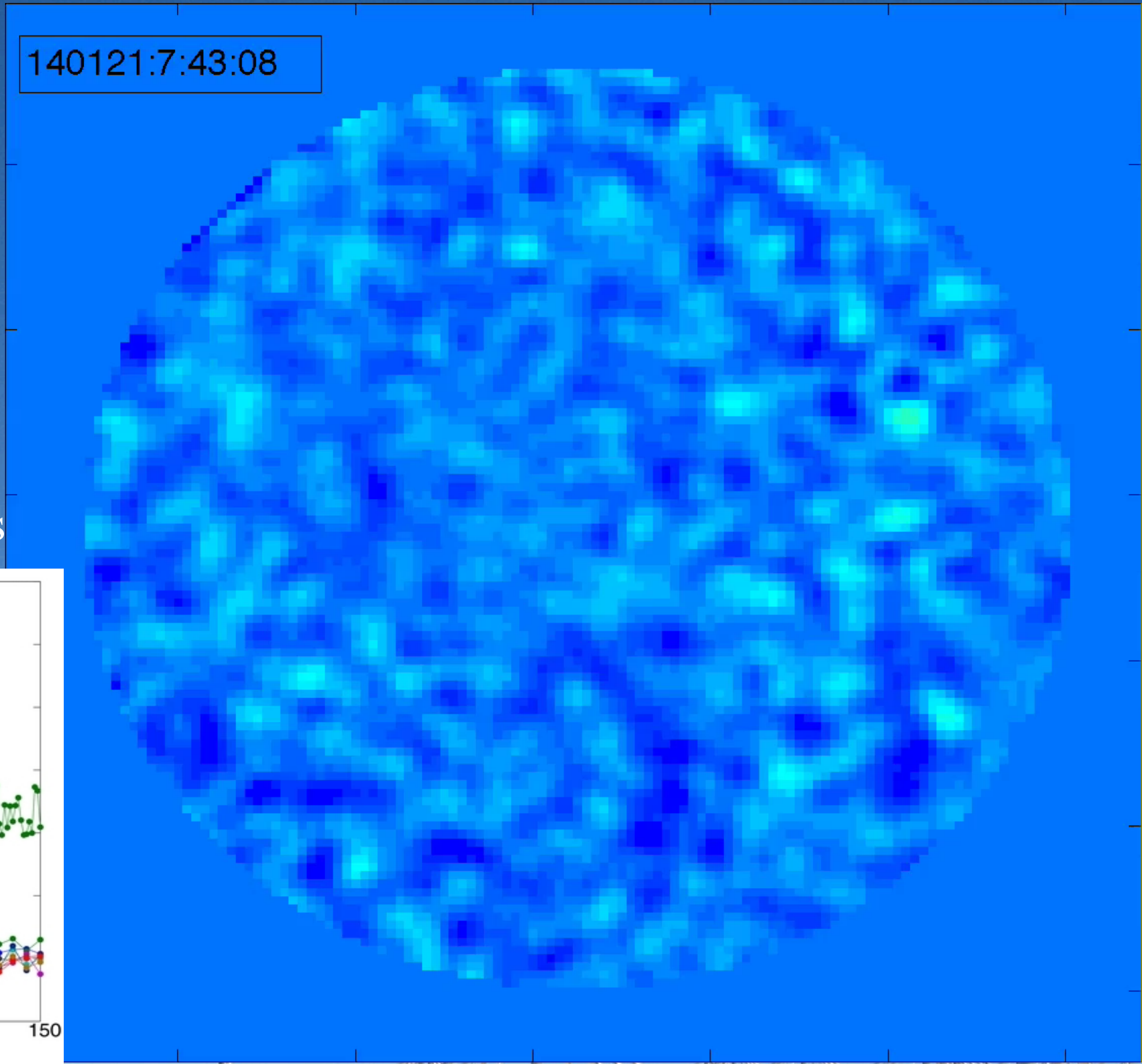


International Space Station

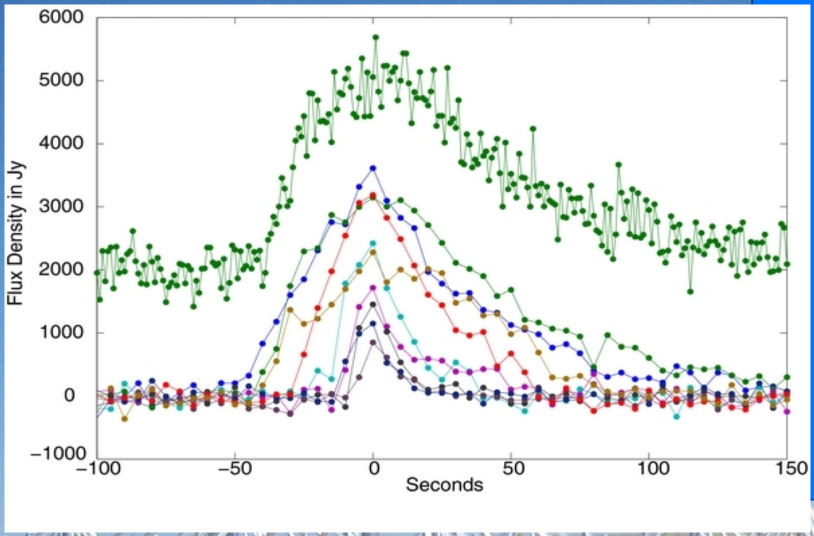


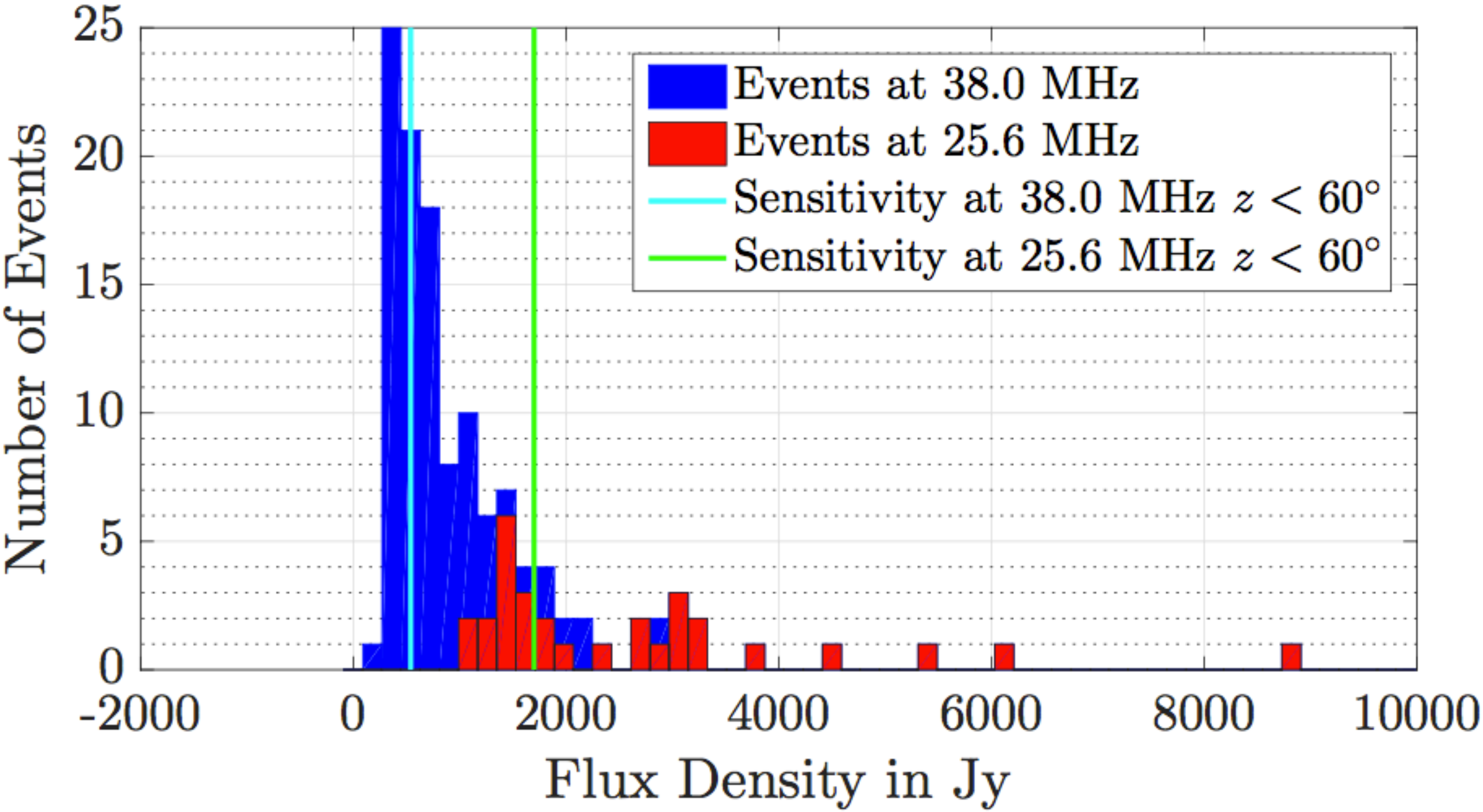
Great Balls of Fire!

Obenberger et al. 2014, 2016



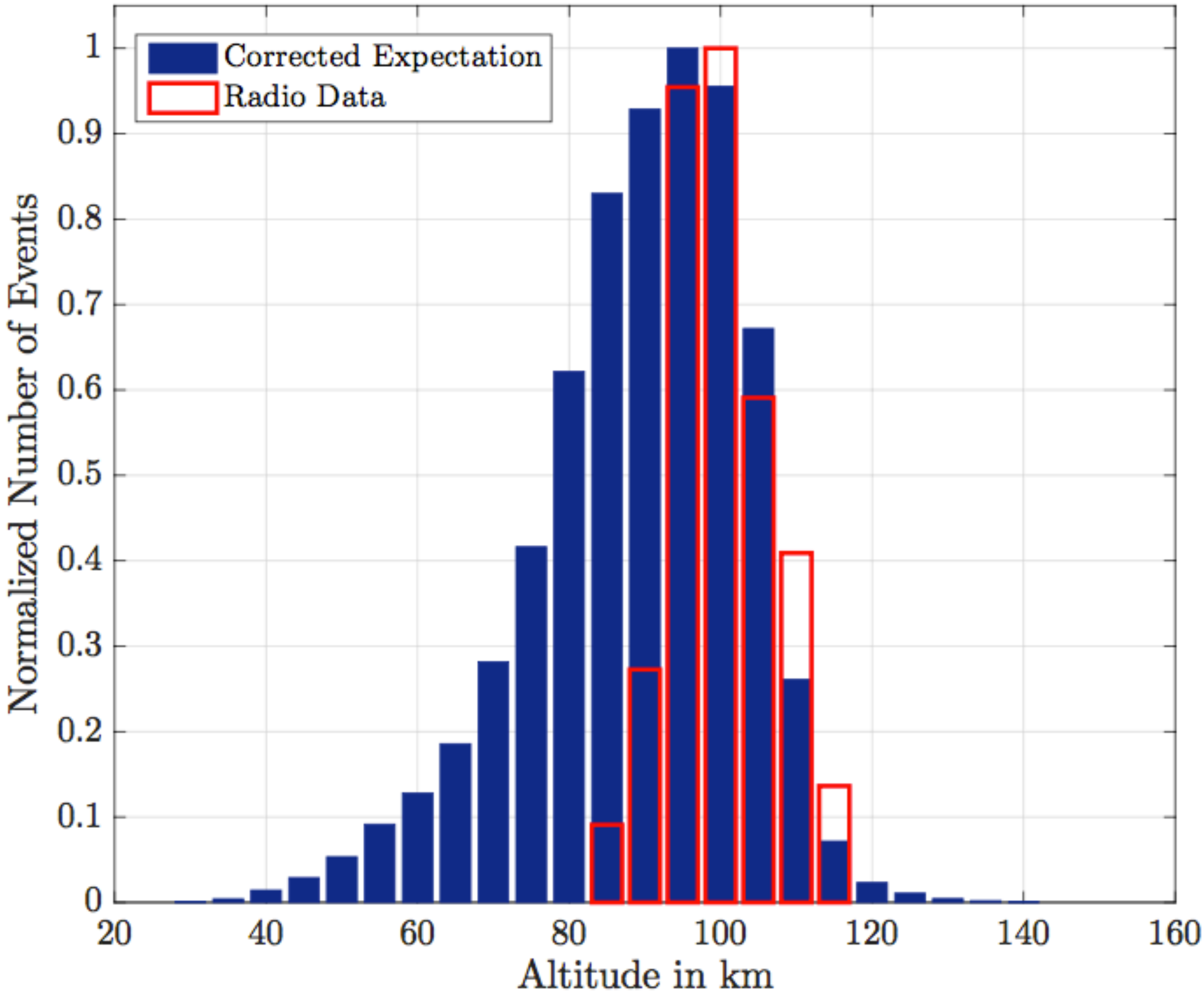
Light curves of the brightest transients

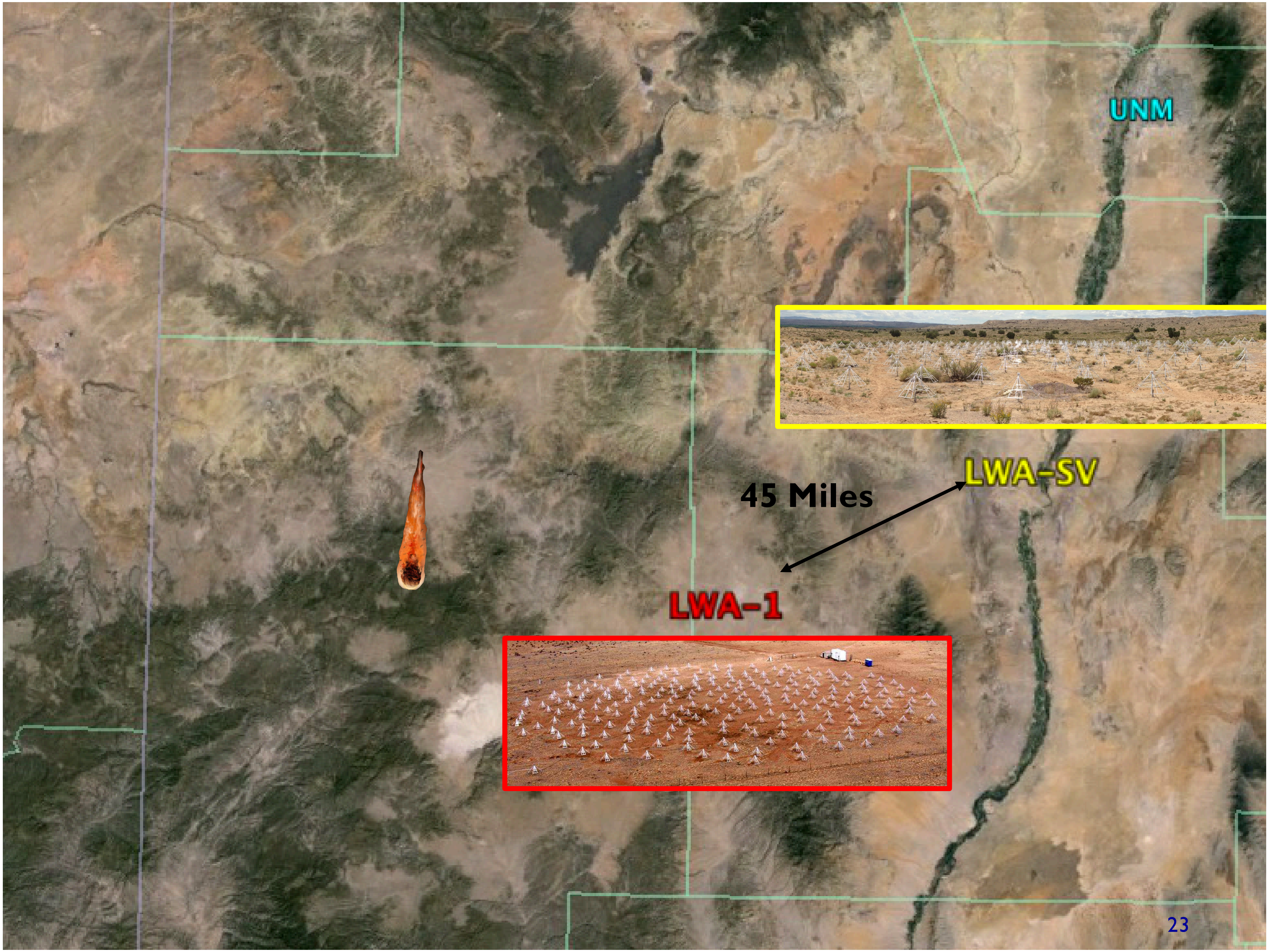


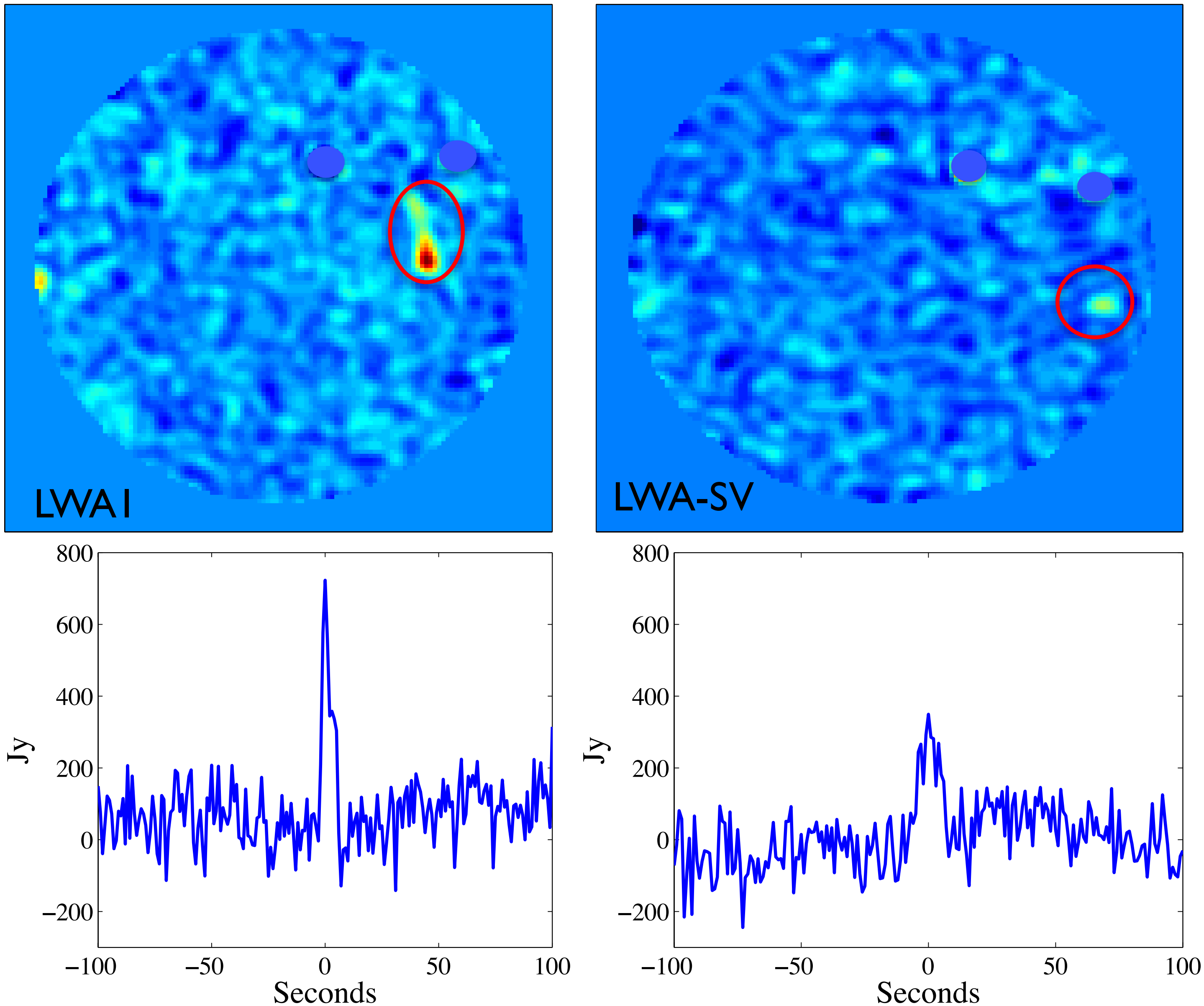


Number of Events
Flux Density in Jy
Events at 38.0 MHz
Events at 25.6 MHz
Sensitivity at 38.0 MHz $z < 60°$
Sensitivity at 25.6 MHz $z < 60°$
0
5
10
15
20
25
-2000
0
2000
4000
6000
8000
10000

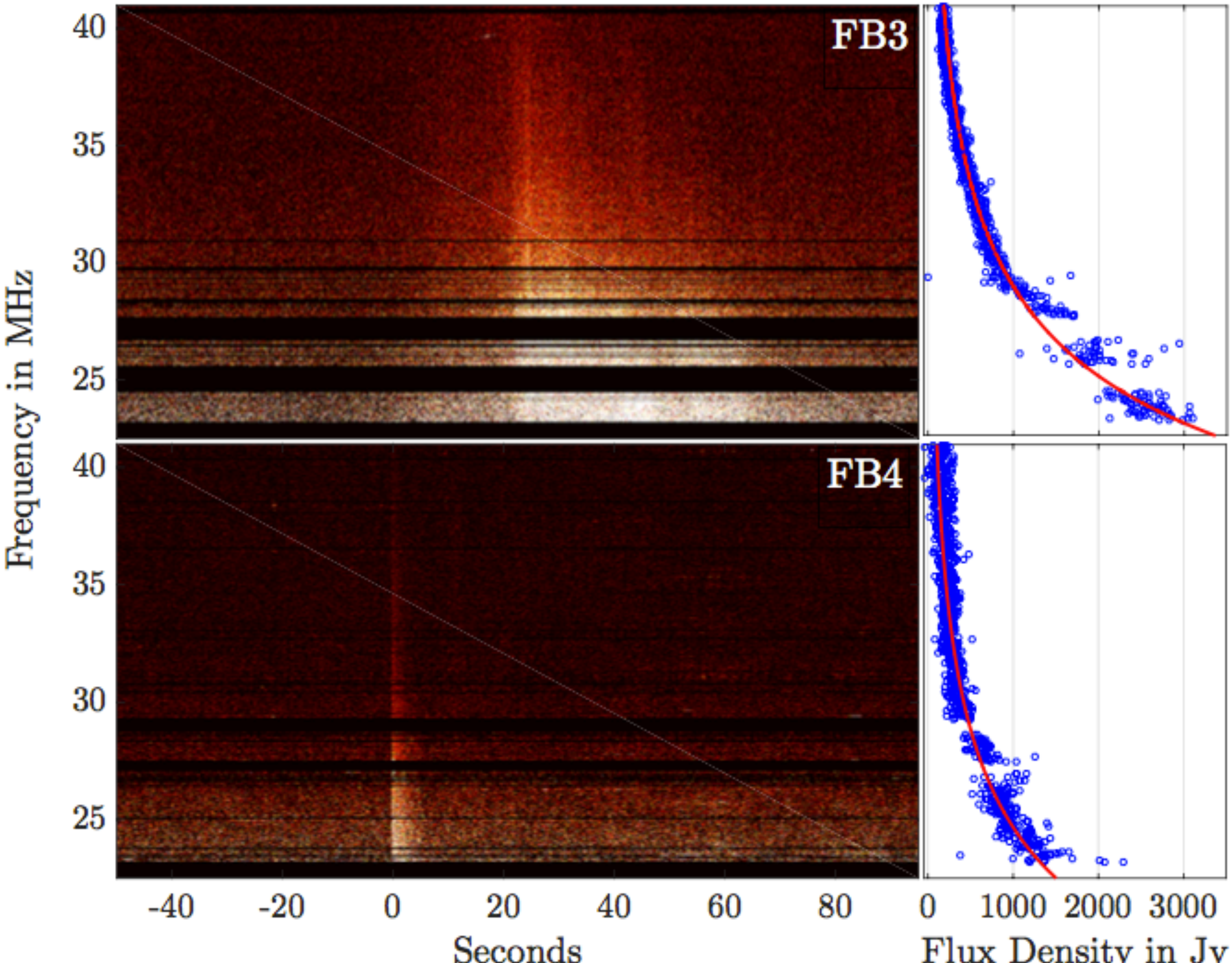
Obenberger et al 2016


Corrected Expectation
Radio Data
Normalized Number of Events
Altitude in km
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
20
40
60
80
100
120
140
160


UNM
LWA-SV
45 Miles
LWA-1



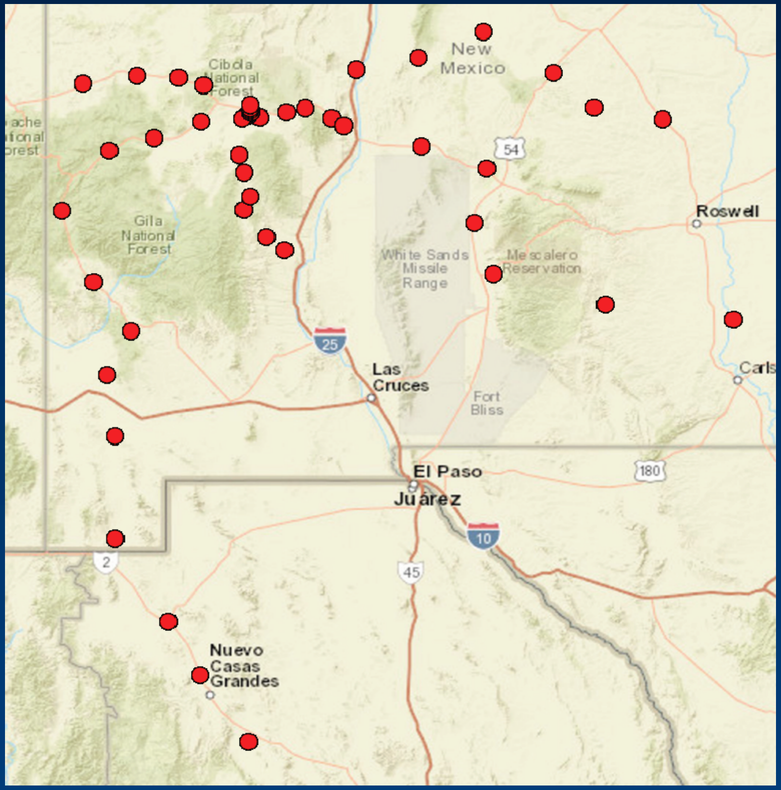
LWA1
LWA-SV
800
600
400
200
0
−200
Jy
−100
−50
0
50
100
Seconds


FB3
FB4
Frequency in MHz
40
35
30
25
-40
-20
0
20
40
60
80
Seconds
0
1000
2000
3000
Flux Density in Jy

Fireballs – Persistent Trains

Fireballs – Persistent Trains

A Next Generation Very Large Array (ngVLA)



Improvements over current VLA

- ~10x Sensitivity at 30 GHz
- ~10x Resolution at all bands
- 1.2 – 116GHz (vs. 1 – 50GHz)
- 5 MHz – 800 MHz option

✧ 5-150 MHz Aperture Array
✧ >4 beams
✧ AGN, transients, exoplanets, stellar flares, pulsars, follow-up at high resolution and sensitivity (~0.1 mJy in 1 hour)

✧ 150-800 MHz Prime Focus Feeds
✧ Commensal
✧ AGN, exoplanets, stellar flares, pulsars

Juno at Jupiter