THE LONG WAVELENGTH ARRAY

Jayce Dowell (UNM)

on behalf of the LWA Collaboration

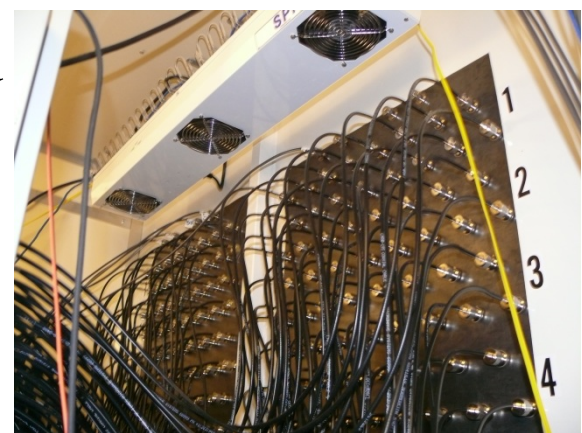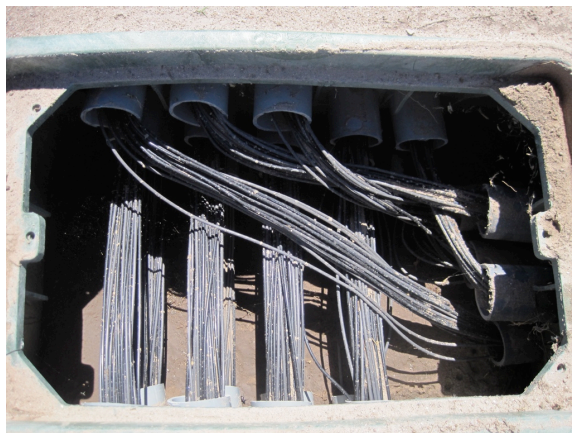December 2, 2015

LWA STATIONS

LWA by the Numbers

- 4 years operating the first LWA station
- 10 to 88 MHz frequency range
- 4 independent beams with 2 x 16 MHz tunings
- Triggered observing mode – on sky in < 2 minutes
- 81 active projects on LWA1
  - 117 active users for 42 institutions
  - 23 refereed publications on LWA1 results
- 1 new station being commissioned in Owens Valley
  - See Gregg Hallinan's talk
- 1 new station under construction at Sevilleta, NM

LWA1

LWA1 shielded electronics shelter
(100 dB shielding w/ RF tight racks)

~50 km of cables buried

LWA-SV

- 3-88 MHz frequency range
- All 256 antennas + outrigger deployed
- Advanced Digital Processor being commissioned

LWA Radio Observatory Staff - UNM

Faculty and Staff

Greg Taylor	Trish Henning
Jayce Dowell	John Dickel
Lanie Dickel	HAL

Students

Karishma Bansal	Veronica Dike
Joe Malins	Jessica Lopez

Postdocs

Frank Schinzel	Kevin Stovall

HAL

```
HAL has successfully created the following schedule for UTC 2014/09/04:

Schedule:
 * 2014/09/04 00:04:00 /home/op1/MCS/exec/acquireTBWAndProcess.py
 * 2014/09/04 01:30:00 /home/op1/LO001/runLO001_split.py 14280
 * 2014/09/04 05:39:00 /home/op1/MCS/sch/INIdp.sh
 * 2014/09/04 05:54:00 /home/op1/MCS/exec/setASP_LS003.sh
 * 2014/09/04 05:59:03 LS003001, session 1806 starts on beam 2
 * 2014/09/04 05:59:03 LS003001, session 1807 starts on beam 1
 * 2014/09/04 05:59:03 LS003001, session 1808 starts on beam 4
 * 2014/09/04 05:59:03 LS003001, session 1809 starts on beam 3
 * 2014/09/04 06:59:13 LS003001, session 1806 stops on beam 2
 * 2014/09/04 06:59:13 LS003001, session 1807 stops on beam 1
 * 2014/09/04 06:59:13 LS003001, session 1808 stops on beam 4
 * 2014/09/04 06:59:13 LS003001, session 1809 stops on beam 3
 * 2014/09/04 07:01:00 /home/op1/MCS/sch/INIdp.sh
 * 2014/09/04 07:02:00 /home/op1/MCS/exec/setLEDA64_split.sh
 * 2014/09/04 07:20:00 /home/op1/MCS/sch/startTBN_split38.sh
 * 2014/09/04 07:24:00 /home/op1/MCS/exec/acquireTBWAndProcess.py
 * 2014/09/04 08:31:00 /home/op1/MCS/sch/INIdp.sh
 * 2014/09/04 08:51:55 LS006, session 112 starts on beam 2
 * 2014/09/04 08:51:55 LS006, session 113 starts on beam 4
 * 2014/09/04 09:52:05 LS006, session 112 stops on beam 2
 * 2014/09/04 09:52:05 LS006, session 113 stops on beam 4
 * 2014/09/04 09:54:00 /home/op1/MCS/sch/INIdp.sh
 * 2014/09/04 10:59:55 LH011, session 121 starts on TBN/TBW
 * 2014/09/04 12:00:05 LH011, session 121 stops on TBN/TBW
 * 2014/09/04 12:04:00 /home/op1/MCS/sch/startTBN_split38.sh
 * 2014/09/04 12:08:00 /home/op1/MCS/exec/acquireTBWAndProcess.py
 * 2014/09/04 12:52:00 /home/op1/MCS/sch/startTBN_split38.sh
 * 2014/09/04 16:11:00 /home/op1/MCS/exec/acquireTBWAndProcess.py
 * 2014/09/04 20:26:00 /home/op1/MCS/exec/acquireTBWAndProcess.py
 * 2014/09/04 20:52:00 /home/op1/MCS/sch/INIdp.sh
 * 2014/09/04 21:12:30 LS006, session 114 starts on beam 2
 * 2014/09/04 21:12:30 LS006, session 115 starts on beam 4
 * 2014/09/04 22:12:40 LS006, session 114 stops on beam 2
 * 2014/09/04 22:12:40 LS006, session 115 stops on beam 4
 * 2014/09/04 22:14:00 /home/op1/MCS/sch/INIdp.sh
 * 2014/09/04 22:34:00 /home/op1/MCS/sch/startTBN_split38.sh
```

Fully autonomous operation of LWA1

- Generation of static schedule
- Dynamic scheduling of filler observations
- Accepts automatic triggering of observations
- Reacts on environmental issues:
  - Electronics overheating
  - Lightning protection mode
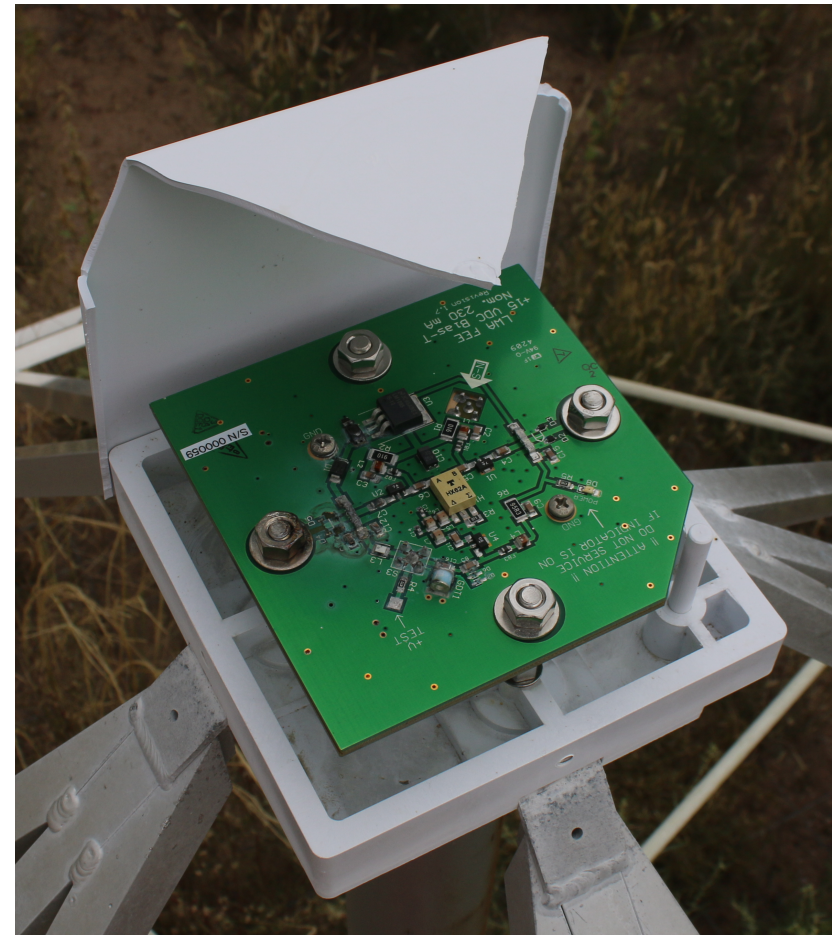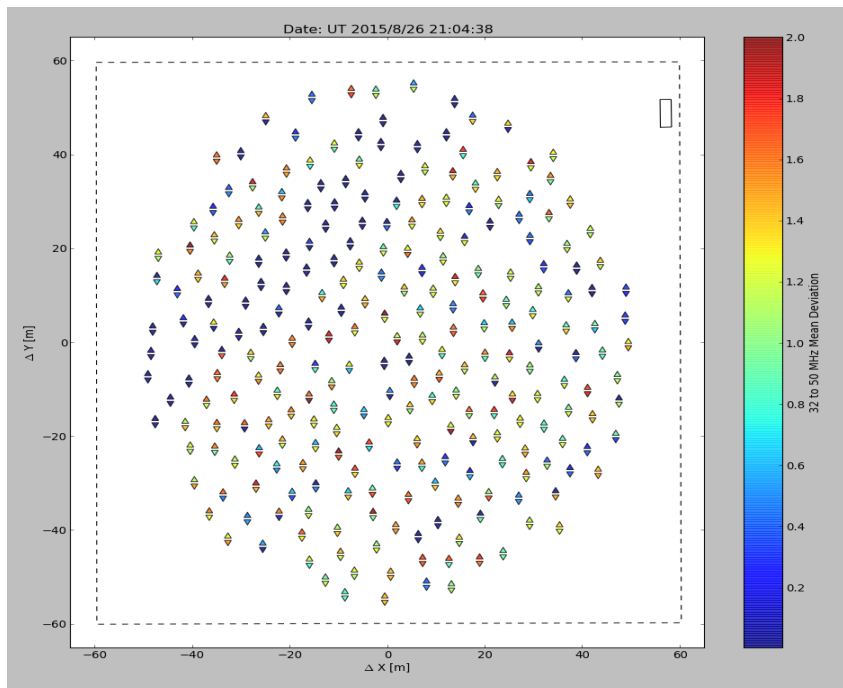- Automatic station health checks

```
HAL is taking control of LWA1 in order to protect ASP and DP by shutting both
systems down.  Observations will be canceled until the lightning has cleared the
area.

The following 'at' commands have been canceled:
 * 5920
 * 5921
```
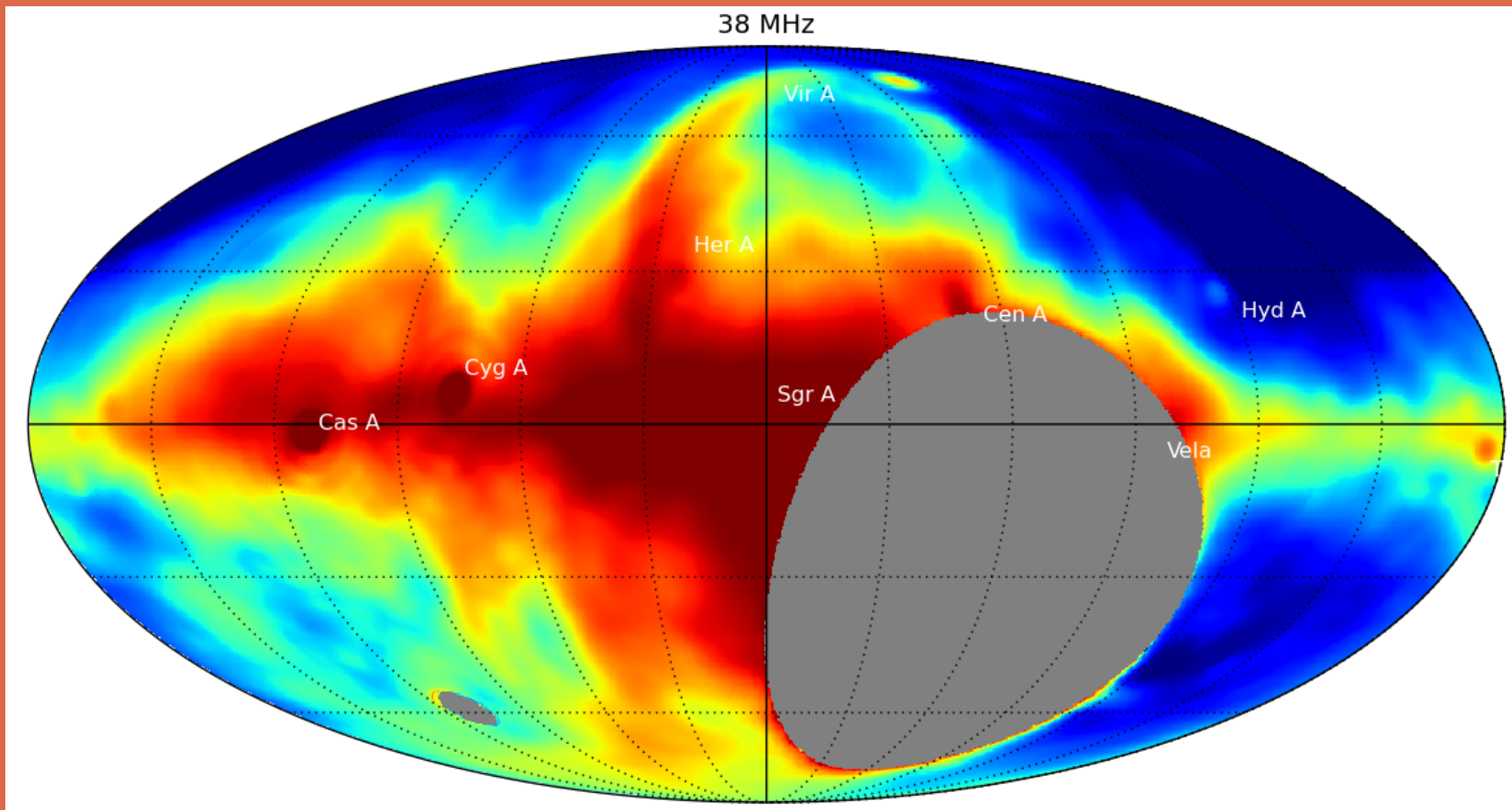
LWA1 Lightning Damage

"Lucky" Stand #83 was struck
at 4:59pm on August 21

SCIENCE HIGHLIGHTS

LWA1 & LWA-SV Science

Astrophysics

- **Cosmology**
  Observing cosmic dawn through redshift 30 absorption of the 21 cm line. High redshift radio galaxies, containing the earliest black holes

- **Acceleration, Propagation & Turbulence in the ISM**
  Origin, spectrum & distribution of Galactic cosmic rays, Supernova remnants & Galactic evolution, Pulsars and their environments

- **Solar Science & Space Weather**
  Radio heliography of solar bursts & coronal mass ejections, Solar magnetic fields

- **Exploration of the Transient Universe**
  New coherent sources, GRB prompt emission, poorly explored parameters space …
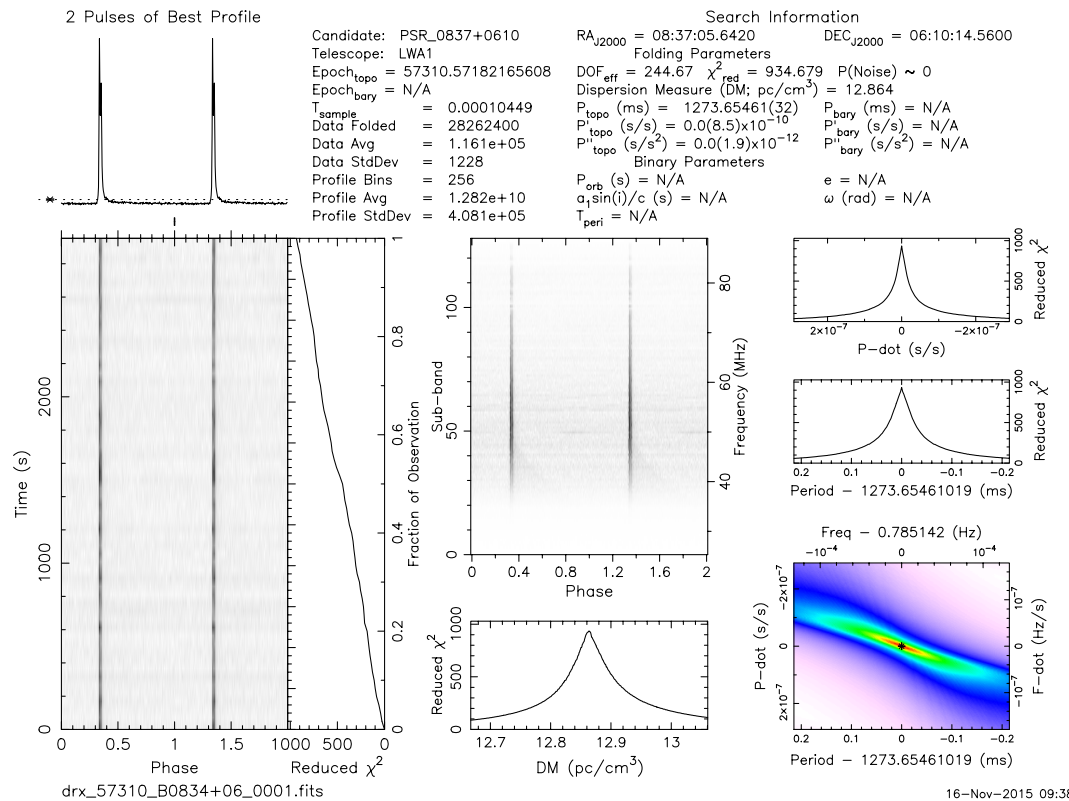
Iono- & Atmospheric Physics

- Unprecedented continuous spatial & temporal imaging of the ionosphere

- Test and improve global ionospheric models

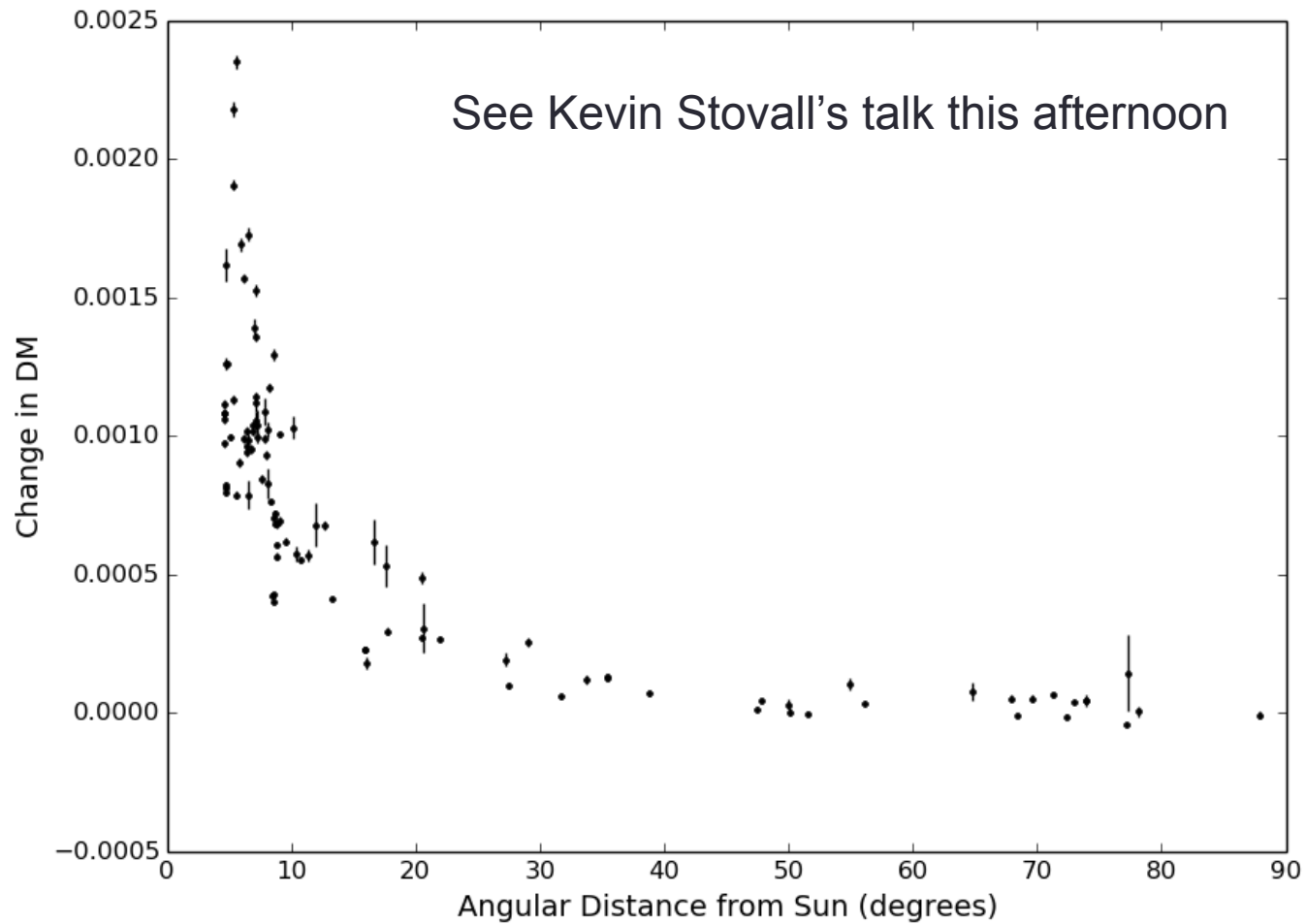- High-time-resolution Imaging of Lightning

Your ideas?
All of LWA1 time is open skies. Your observing proposals are welcome!

LWA1 Pulsar Detections

- 61 pulsars detected
  - 58 pulsations
  - 3 single pulses
  - Many in the LWA Pulsar Archive
- MSPs
  - J0030+0451
  - J0034-0534
  - J2145-0750
- GPs and RRATs
  - J0054+66
  - J0207+7005
  - B0531+21
 - J2325-0530
- Mode Switching
  - B0823+26
  - B0943+10

2 Pulses of Best Profile

Search Information

Candidate: PSR_0837+0610
Telescope: LWA1
$Epoch_{topo}$ = 57310.57182165608
$Epoch_{bary}$ = N/A

RA_{J2000} = 08:37:05.6420 DEC_{J2000} = 06:10:14.5600

Folding Parameters
DOF_{eff} = 244.67 χ^2_{red} = 934.679 P(Noise) ~ 0
Dispersion Measure (DM; pc/cm^3) = 12.864

T_{sample} = 0.00010449	P_{topo} (ms) = 1273.65461(32)	P_{bary} (ms) = N/A
Data Folded = 28262400	P'_{topo} (s/s) = 0.0(8.5)x10^{-10}	P'_{bary} (s/s) = N/A
Data Avg = 1.161e+05	P''_{topo} (s/s^2) = 0.0(1.9)x10^{-12}	P''_{bary} (s/s^2) = N/A
Data StdDev = 1228	Binary Parameters	
Profile Bins = 256	P_{orb} (s) = N/A	e = N/A
Profile Avg = 1.282e+10	$a_1 sin(i)/c$ (s) = N/A	ω (rad) = N/A
Profile StdDev = 4.081e+05	T_{peri} = N/A	

P-dot (s/s) 2×10^{-7} 0 -2×10^{-7} Reduced χ^2

Period $-$ 1273.65461019 (ms) 0.2 0.1 0 -0.1 -0.2 Reduced χ^2

Freq $-$ 0.785142 (Hz) -10^{-4} 0 10^{-4}

Time (s) Fraction of Observation

Phase Reduced χ^2

Sub-band Frequency (MHz)

Phase

Reduced χ^2 DM (pc/cm^3)

P-dot (s/s) F-dot (Hz/s) Period $-$ 1273.65461019 (ms)

drx_57310_B0834+06_0001.fits

16-Nov-2015 09:38

Solar DM Enhancement

See Kevin Stovall's talk this afternoon

Preliminary Polarization Profiles (sight-lines far from the Sun)

PSR B0950+08

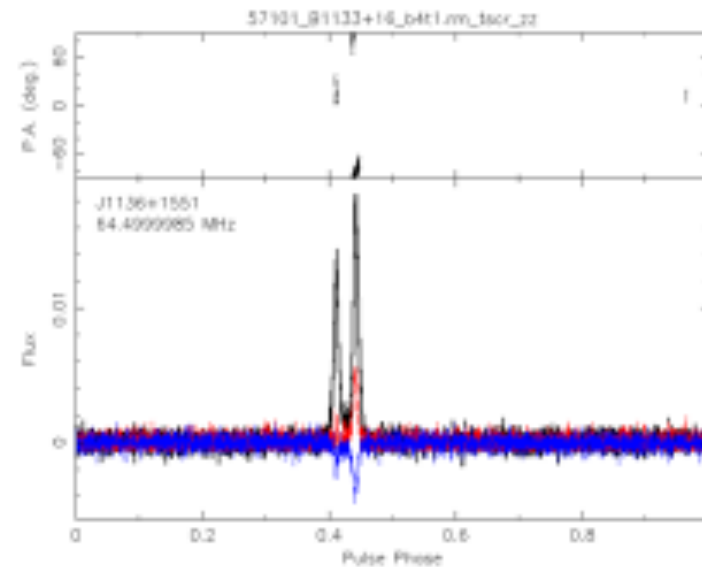$RM_{Meas} = 2.36(4)$

$RM_{Ion} = 1.2(1)$

$Rm_{cor} = 1.2(2)$
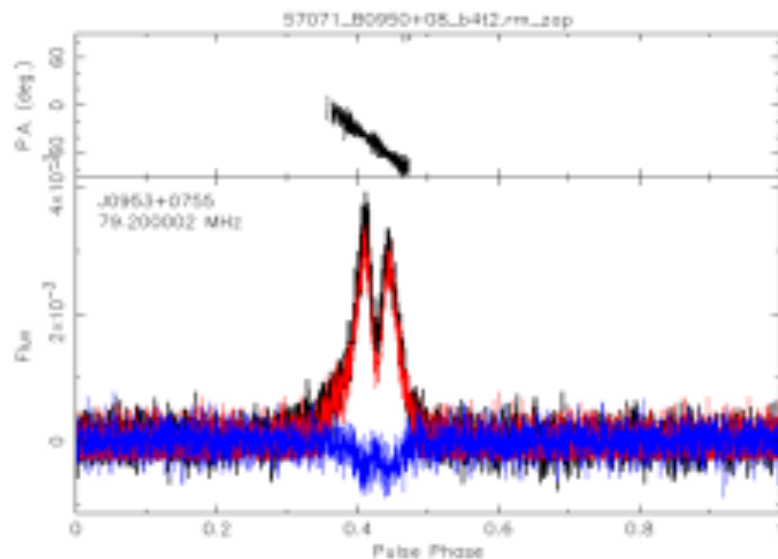
PSR B1133+16

$RM_{Meas} = 4.61(1)$

$RM_{Ion} = 0.84(4)$

$Rm_{cor} = 3.77(5)$

Rotating Radio Transients (RRATs)

J0203+7005

J2324-0530
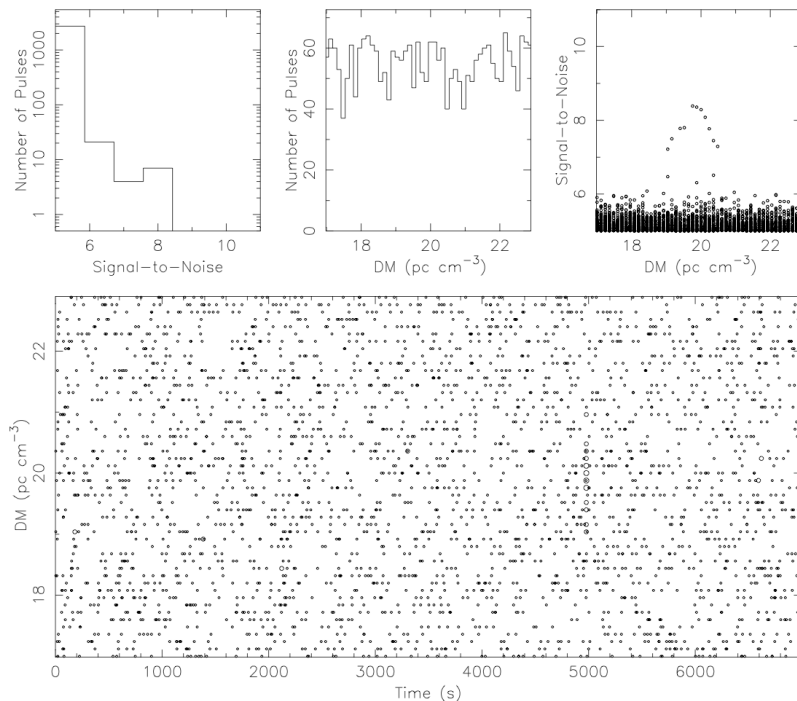
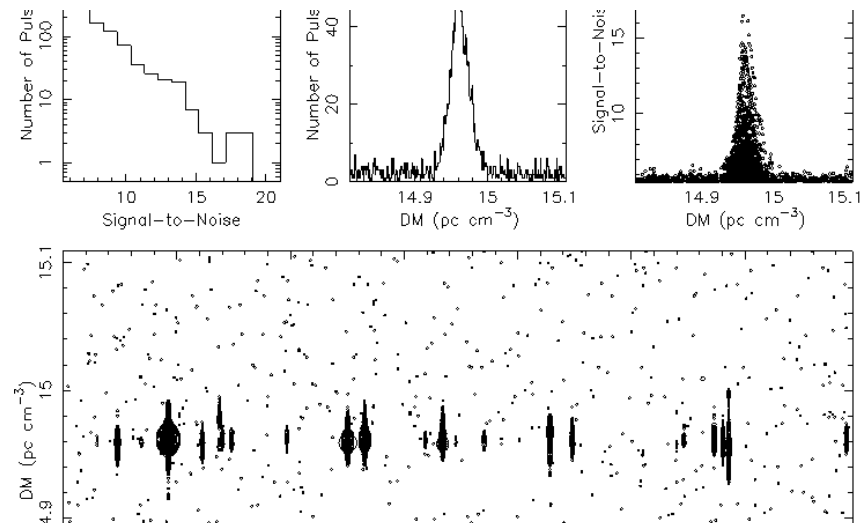

3 detected so far, search is ongoing
McCrackan el al., in prep

Crab Giant Pulses

Flux densities 10-120 kJy
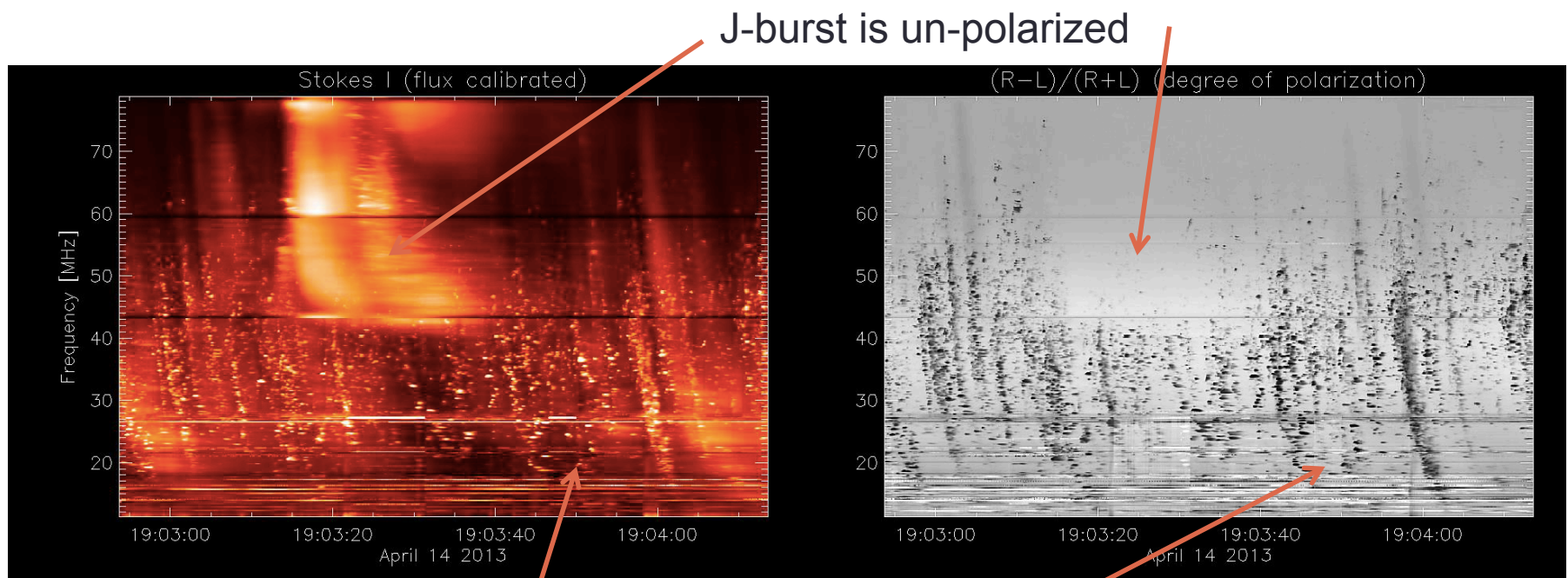Number of pulses/hour went up by factor 3 over 6 month period
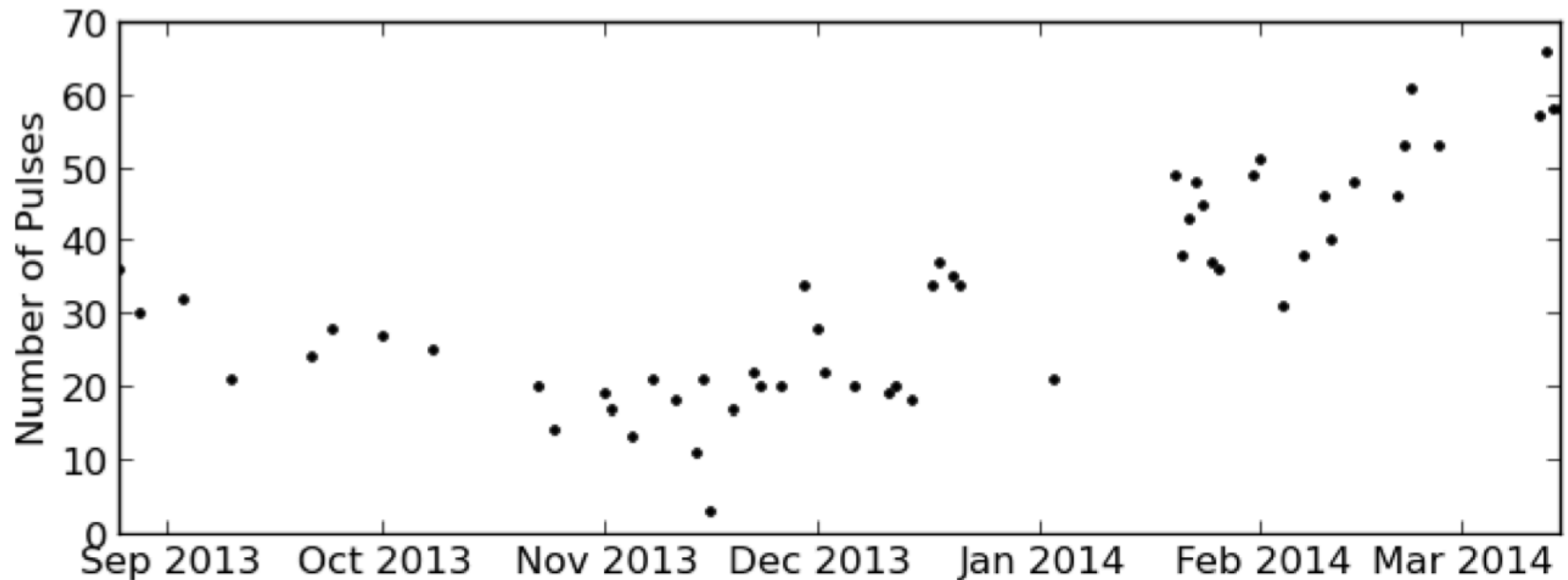
Jovian Decametric Emission

Io A/C bursts from 2013 March 06
Clarke et al. 2014

Io A – right handed

Io C – left handed
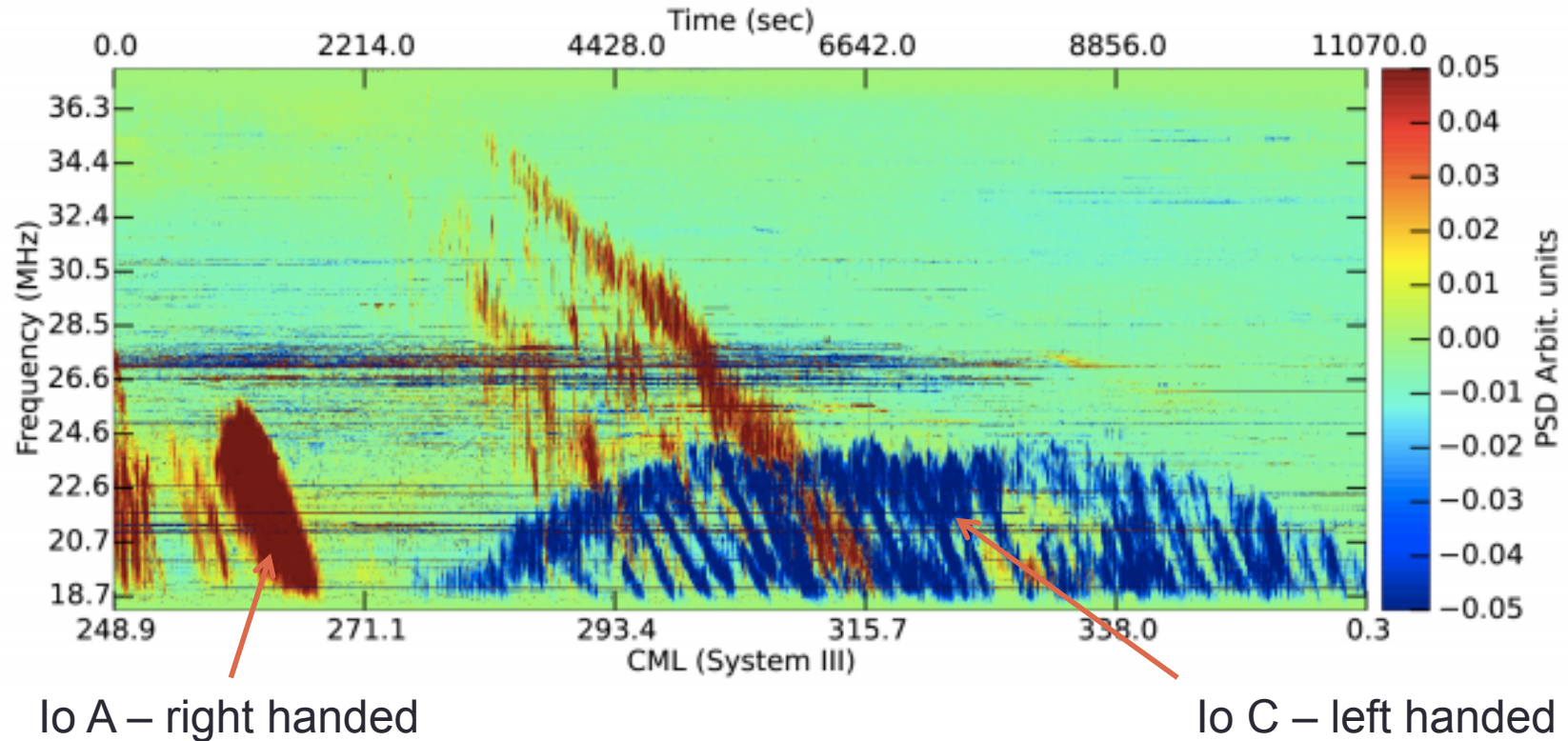
See Chuck Higgins' talk this afternoon

The Dynamic Sun
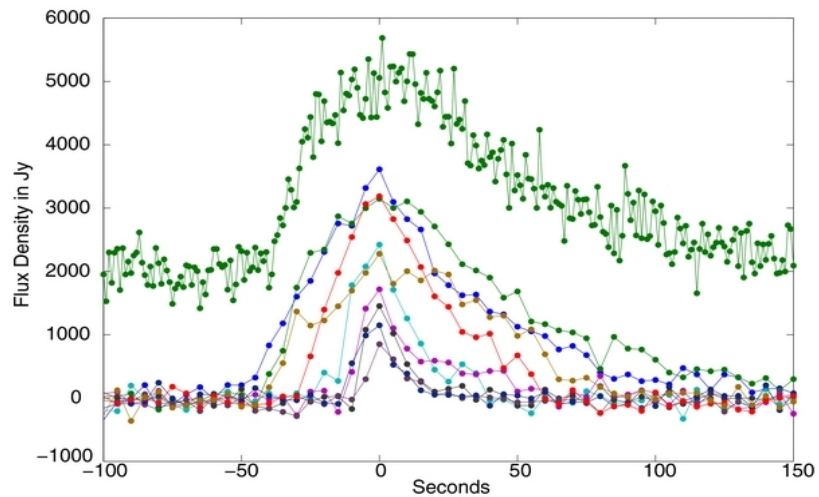

J-burst is un-polarized

Type IIIb bursts are strongly left-hand polarized

Tun, Cutchin, & White, 2015, submitted

Fireball Emission

http://
lda10g.alliance.unm.edu/
PASI_Fireballs/

Ken Obenbergers's talk
Friday morning

Light curves of the brightest transients
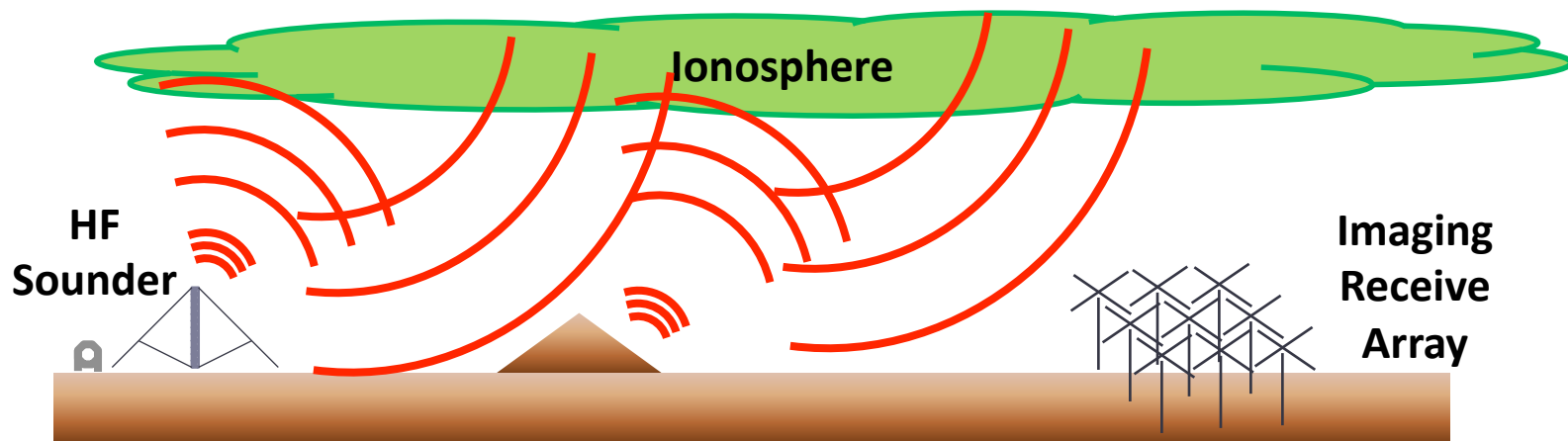

140121:7:43:08
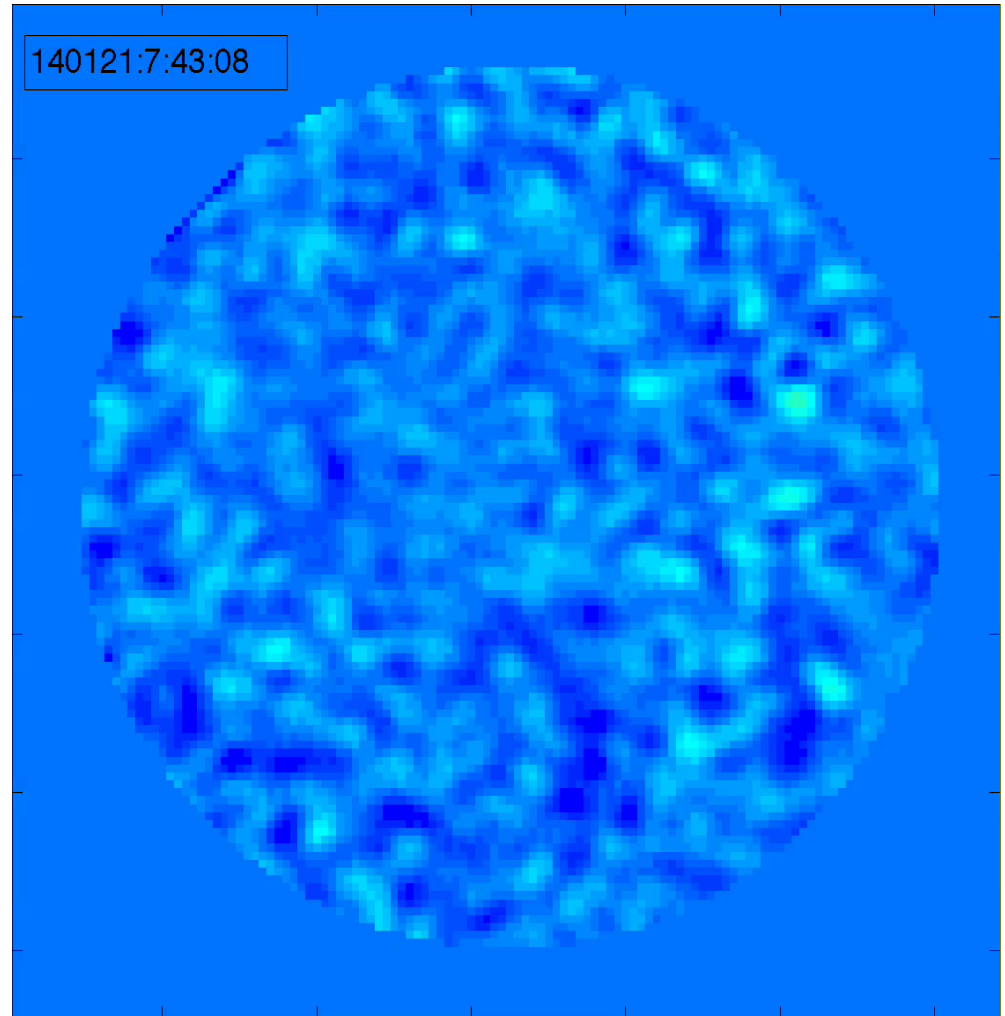
Ionospheric & Terrain Mapping

- **In addition to transmitter direct echoes, terrain features illuminated by sounder also potential control points for ionospheric reconstruction**

  - **Appear as "2ⁿᵈ-hop" echoes**

  - **Echo strength depends on surface tilt and roughness**

    - **Readily computed from digital elevation models**
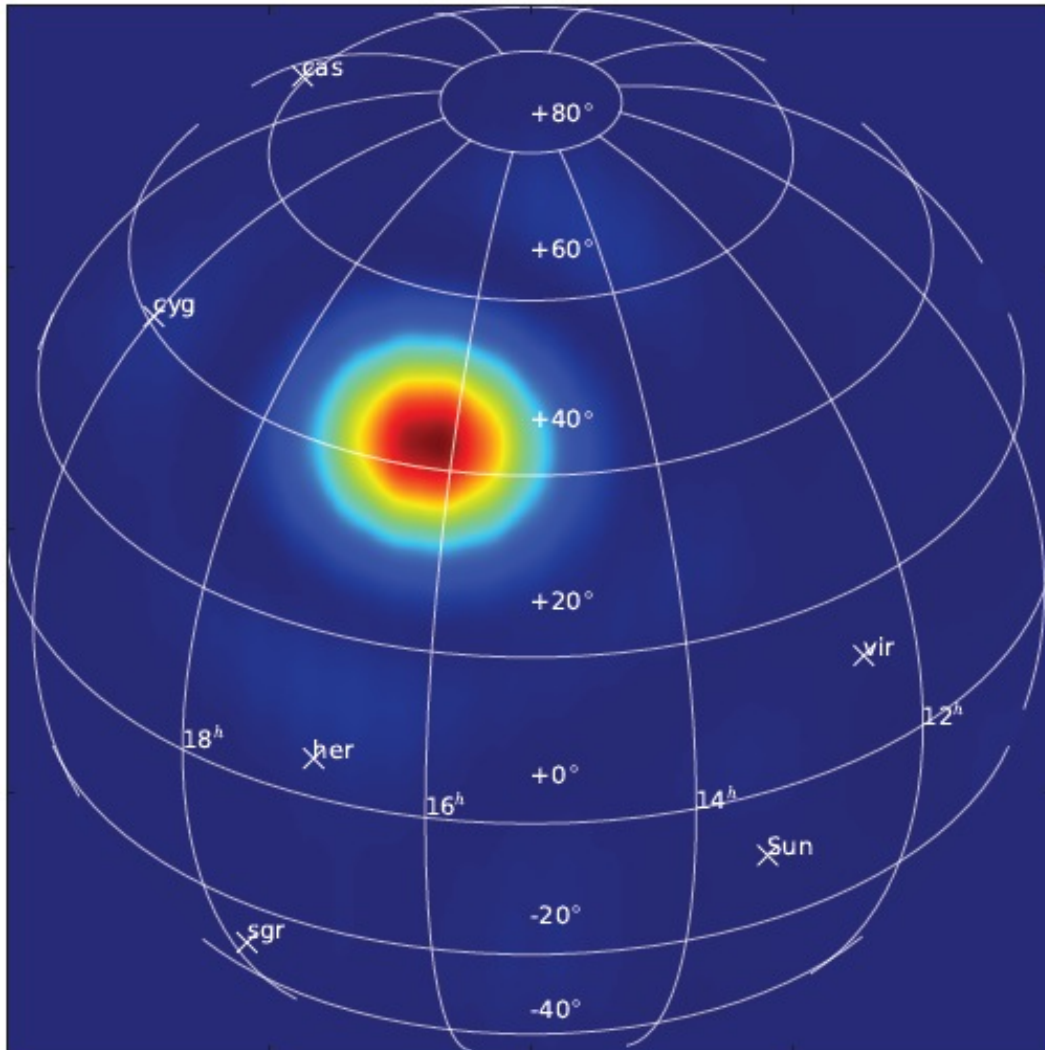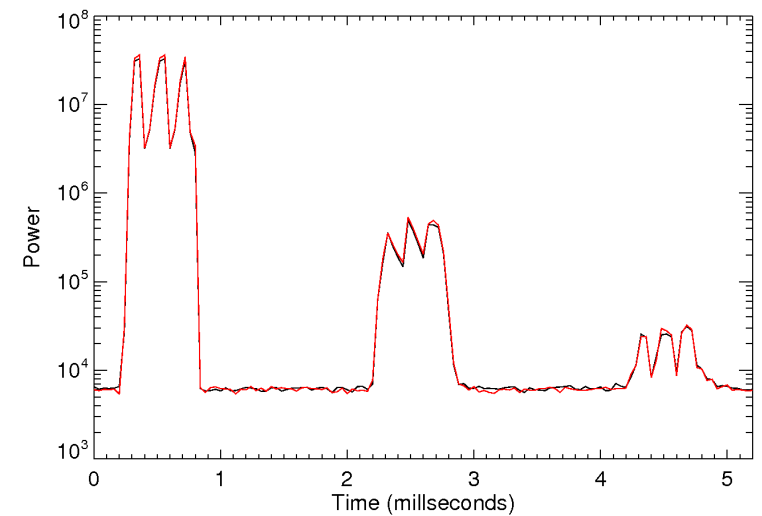
Ionospheric Mapping

Image of the
Kirtland digisonde
reflecting
off the ionosphere

THE FUTURE

The LWA

- Goal of 53 LWA stations

- Baselines up to 400 km for resolution 2" at 80 MHz with mJy sensitivity

- Cost is ~$1M/ station

State of New Mexico, USA

The Expanded LWA

- Leverage the new 4-band system on the VLA to build a commensal system
- VLA 4-band + 2 LWA stations doubles the resolution and triples the sensitivity of the VLA

The Expanded LWA

- Early tests show that this is feasible
  - 3C196 with LWA1 and six VLA antennas
- See Frank Schinzel's talk Friday afternoon

3C196 at 0.076 GHz 2015 Sep 17

Map center: RA: 08 13 36.060, Dec: +48 13 02.601 (2000.0)
Map peak: 101 Jy/beam
Contours %: −0.3 0.3 0.6 1.2 2.4 4.8 9.6 19.2 38.4
Contours %: 76.8
Beam FWHM: 64.1 x 22.2 (arcsec) at −50.5°