OVRO-LWA

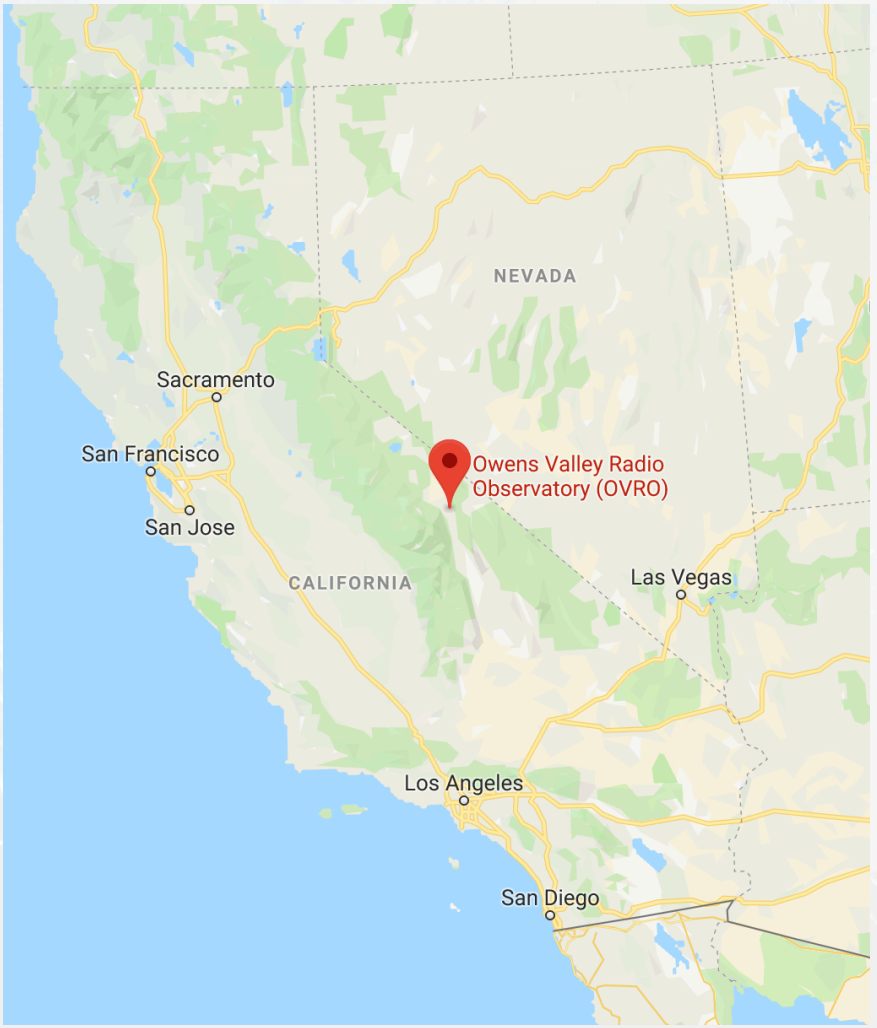
Science Results & Stage III Upgrade

Marin Anderson
(on behalf of the OVRO-LWA collaboration)

LWA Users Meeting
08/02/2019

RICE ASU JPL Jet Propulsion Laboratory California Institute of Technology Caltech NJIT New Jersey Institute of Technology LWA Long Wavelength Array NSF

Owens Valley Radio Observatory
Long Wavelength Array



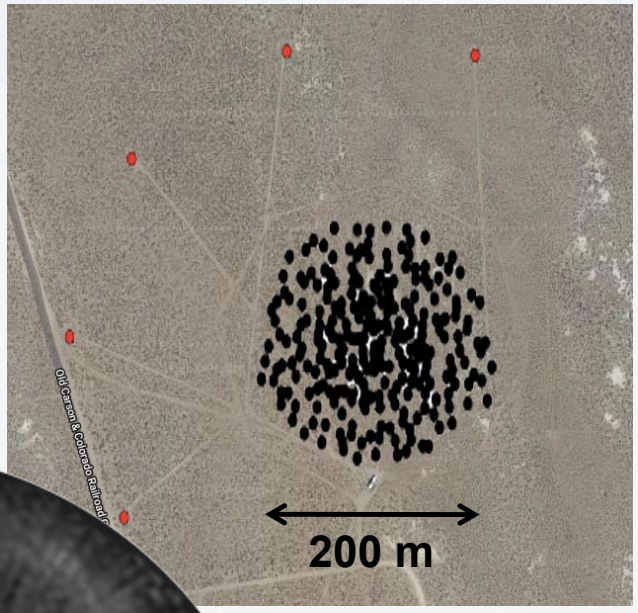
Stage I OVRO-LWA (2013-2014)

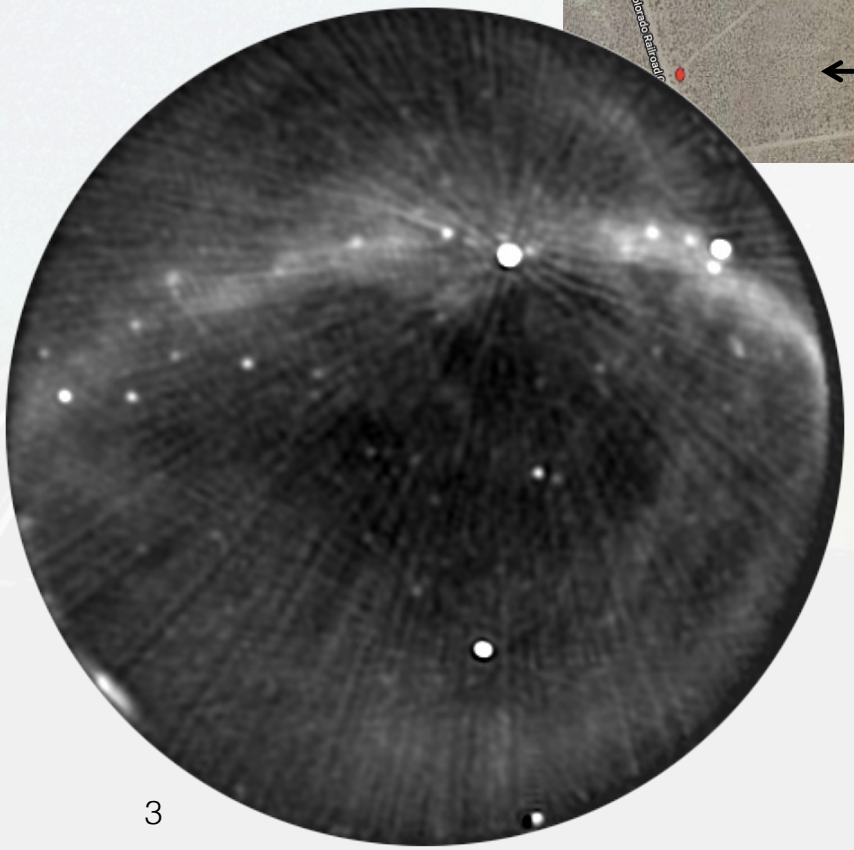
Stage II OVRO-LWA (2015-2016)

Stage III 352-OVRO-LWA (2019-)

OVRO-LWA Stage I (2013-2014)

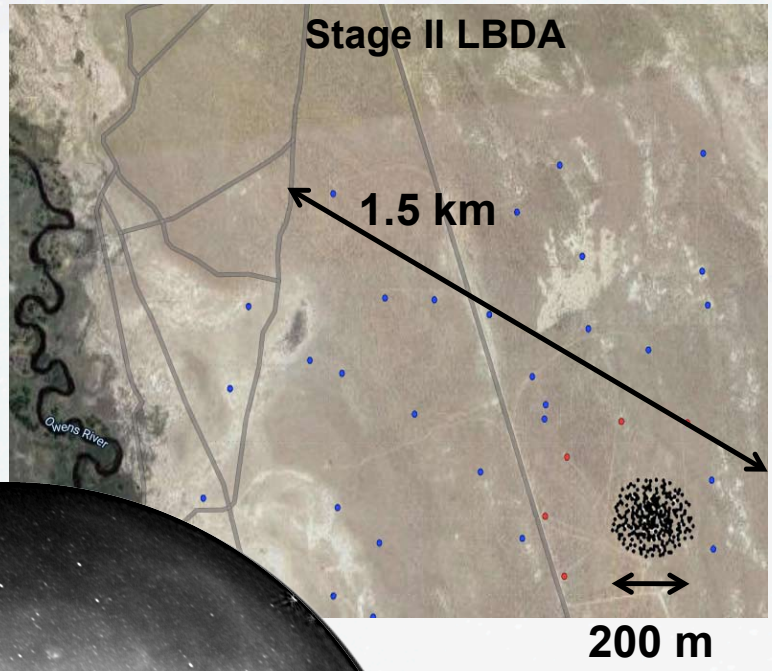
- 251 LWA crossed-dipole antennas, in 200 m diameter core
- 5 LEDA antennas — total power measurements (**Price+2018**)
- 28-84 MHz band, 24 kHz resolution
- full cross-correlation with 512-input LEDA correlator (**Kocz+2015**)
- 1 deg resolution

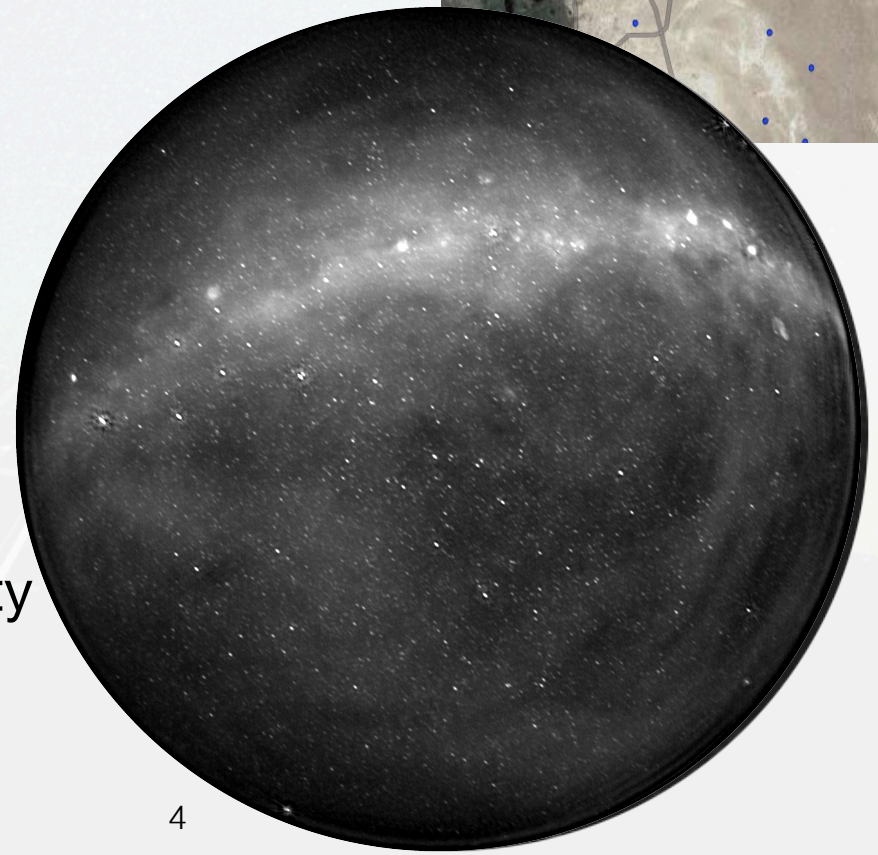


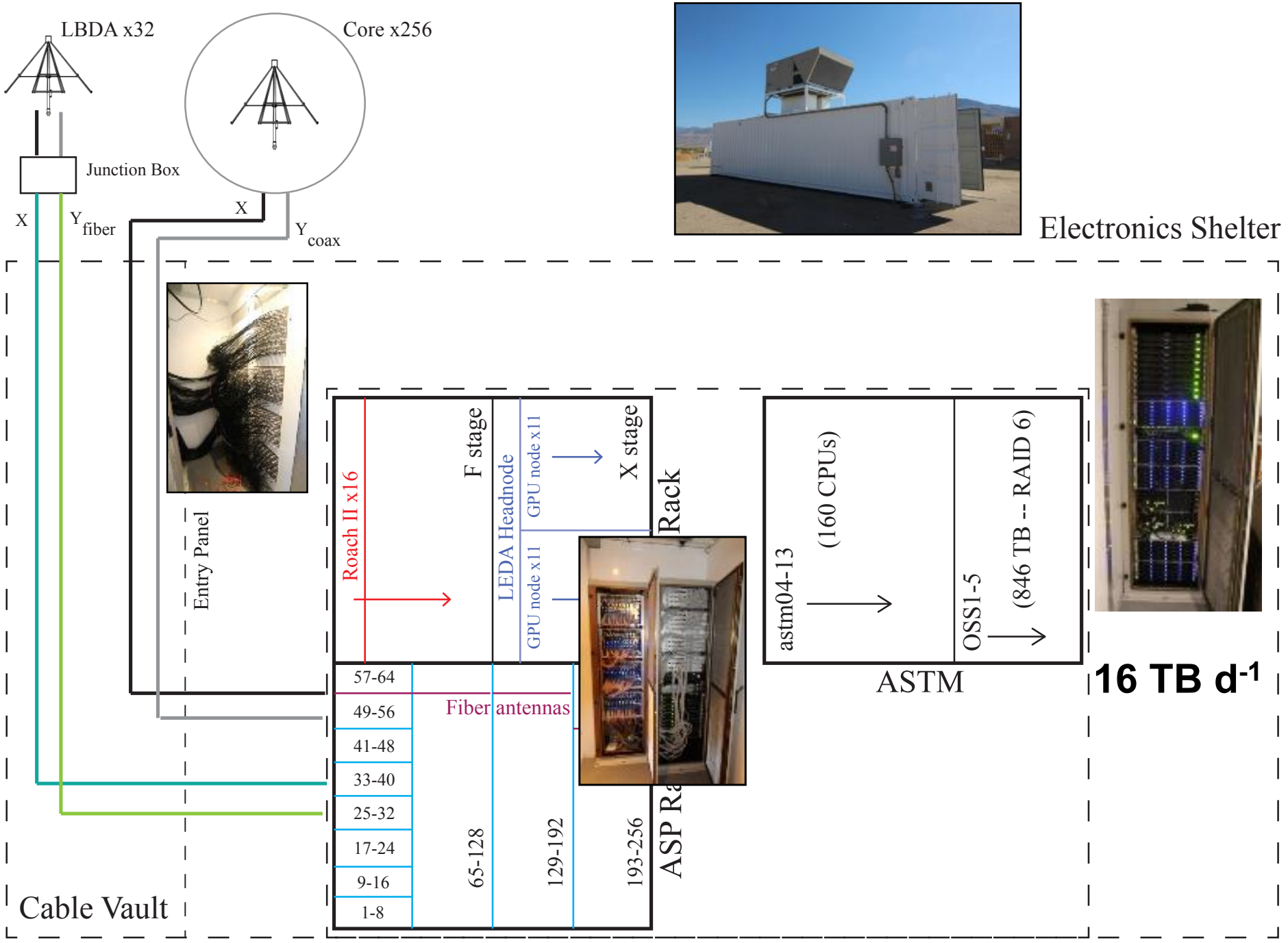


OVRO-LWA Stage II (2015-present)

- 32 additional antennas out to 1.5 km (Long Baseline Demonstrator Array)
- RF signal transport over optical fiber
- 7 arcmin resolution at top of band
- >10,000 point sources in single 13 s snapshot
- ~800 mJy snapshot sensitivity





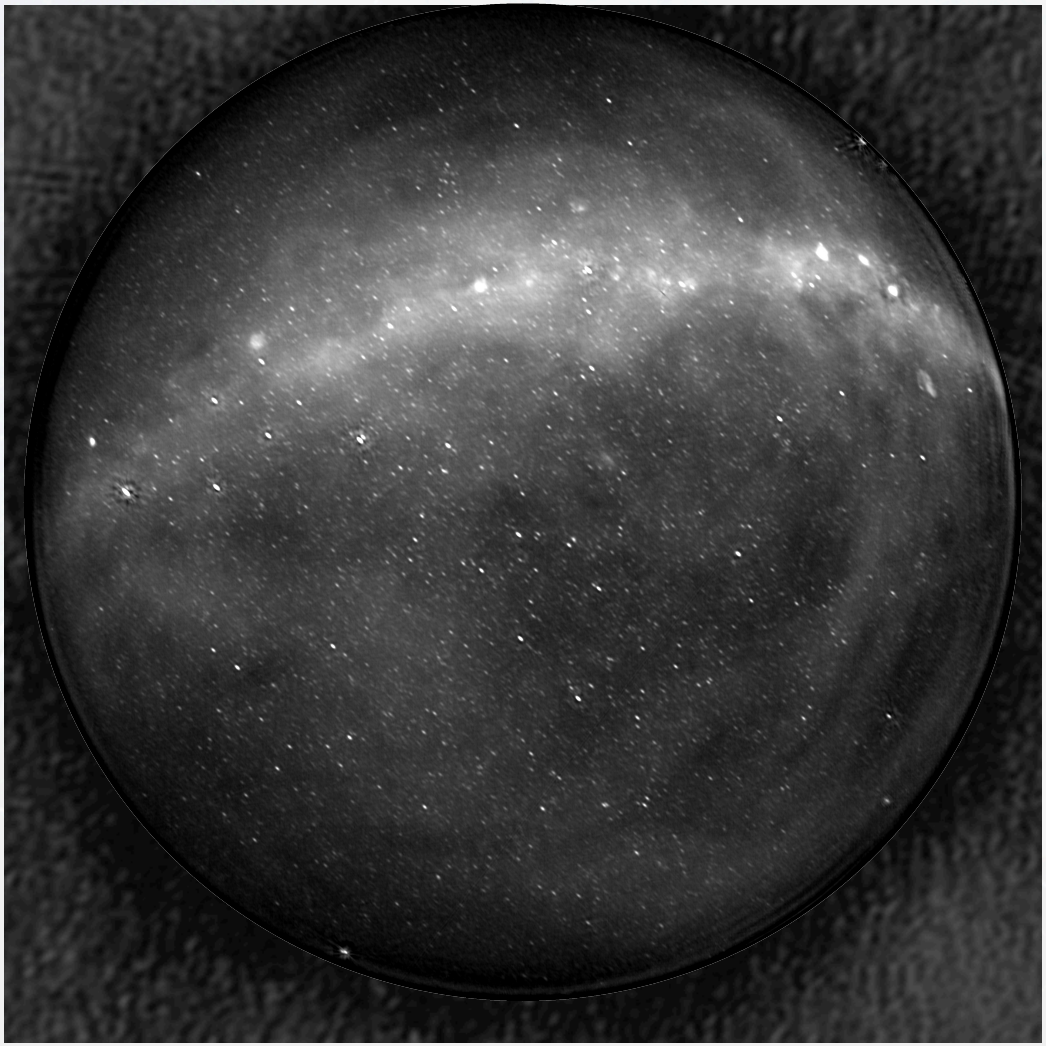

LBDA x32
Core x256
Junction Box
X
Y fiber
X
Y coax
Electronics Shelter
Entry Panel
Roach II x16
F stage
LEDA Headnode
GPU node x11
GPU node x11
X stage
Rack
57-64
49-56
41-48
33-40
25-32
17-24
9-16
1-8
Fiber antennas
65-128
129-192
193-256
ASP Ra
astm04-13
(160 CPUs)
OSS1-5
(846 TB -- RAID 6)
ASTM
16 TB d-1
Cable Vault

OVRO-LWA Stage II Operations

1. **Science datasets**
   - 28 hour run (February 2017)
   - 120 hour run (March 2018)

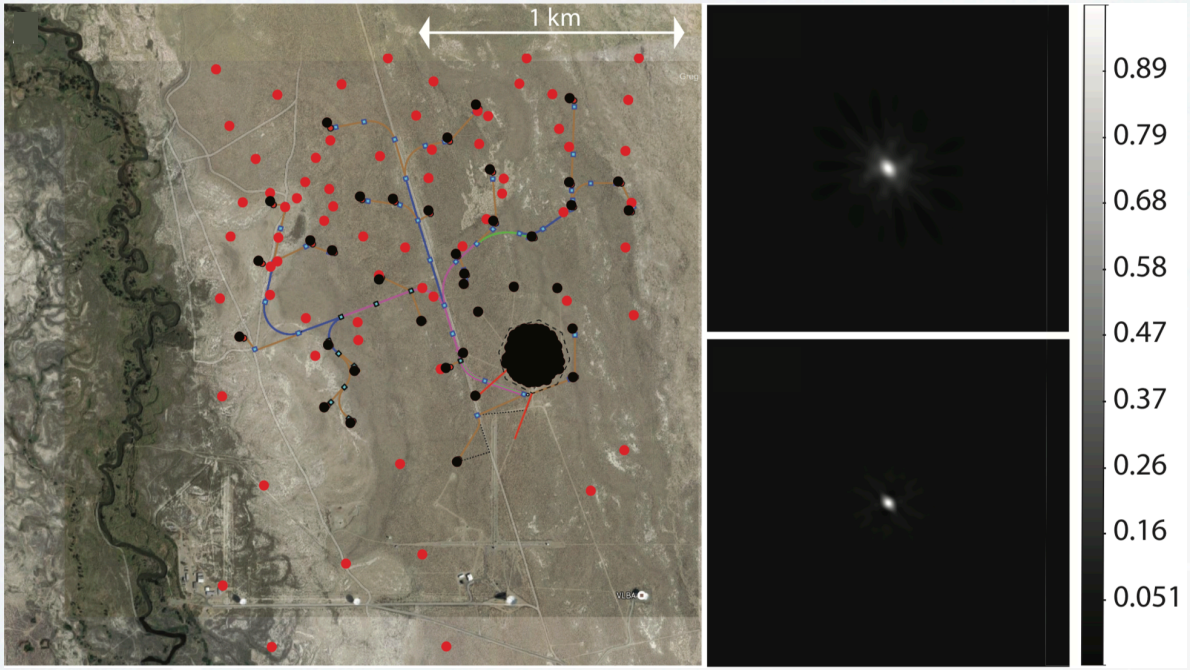
2. **Triggered observations**
   - 24 hour buffer of visibilities

3. **Non-standard observing**
   - Cosmic ray observations



OVRO-LWA Stage III (2019-)

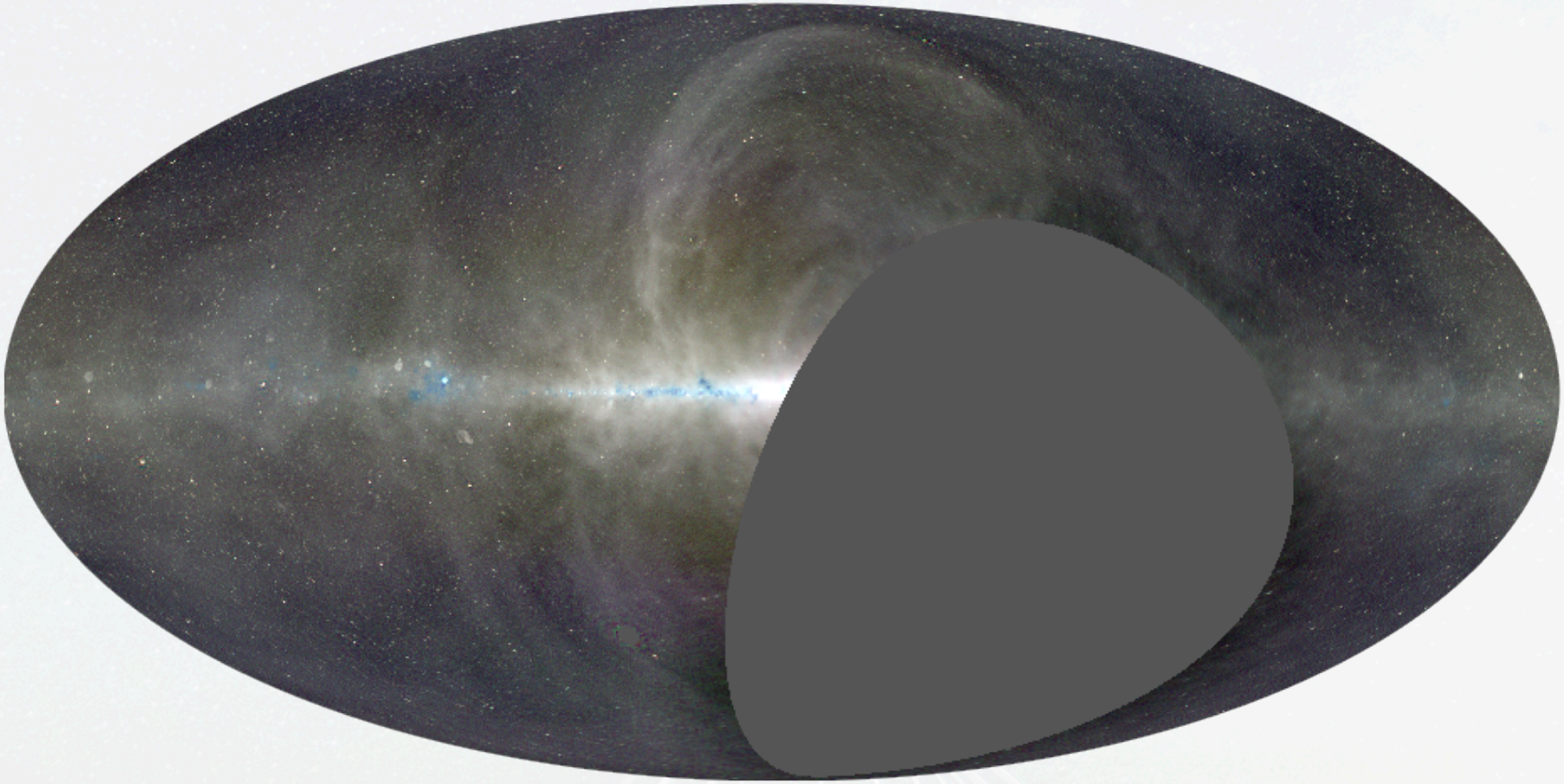
- Additional 64 antennas **out to 2.6 km**, for a **total of 352**
- Complete redesign of the analog receiver boards
- Digital backend redesign, next-gen correlator (maintaining the FPGA/GPU architecture of the existing 512-input LEDA), with **704 inputs and 70 MHz BW**
- Upgraded calibration and imaging cluster, **3 PB usable storage and 4 TB RAM**



Simultaneous!

standard correlation mode
beamforming mode (12 beams)
cosmic ray detection

Cosmic dawn and m-mode analysis



Eastwood+2018, 2019

- High fidelity, high resolution all-sky maps at <100 MHz, using 28 hour observation with <100 kHz BW
- First power spectrum upper limit in the frequency range of the EDGES feature (**Bowman+2018)**

Cosmic dawn and m-mode analysis

OVRO-LWA-352

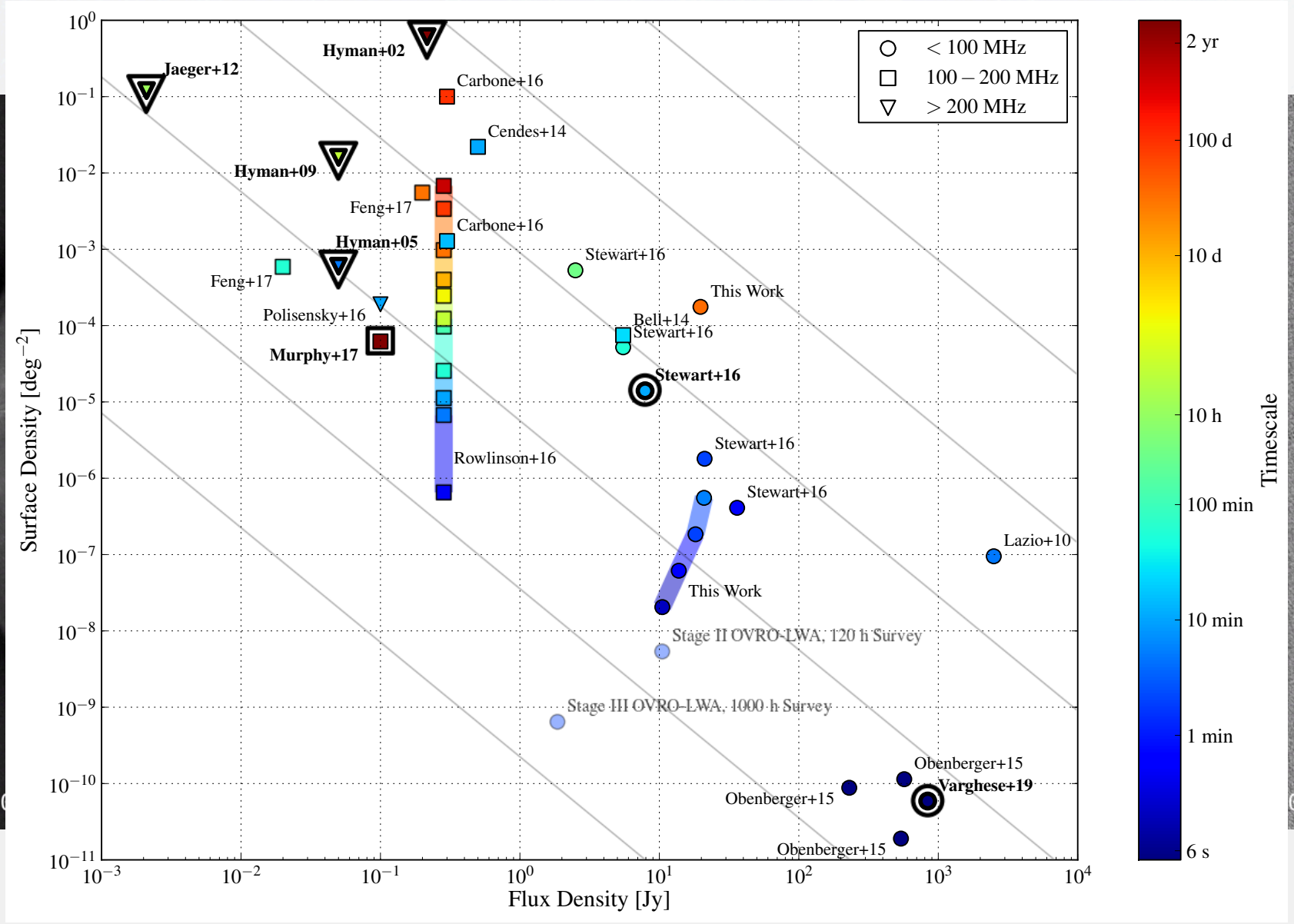
Led by **Judd Bowman, Gregg Hallinan, Danny Jacobs, +**

- Stokes I / V m-mode analysis maps across full 70 MHz BW, with 1000 hour dataset
- Observing band overlaps with EDGES signal

Eastwood+2018, 2019

- High fidelity, high resolution all-sky maps at <100 MHz
- First power spectrum upper limit in the frequency range of the EDGES feature (**Bowman+2018**)

Blind transients survey

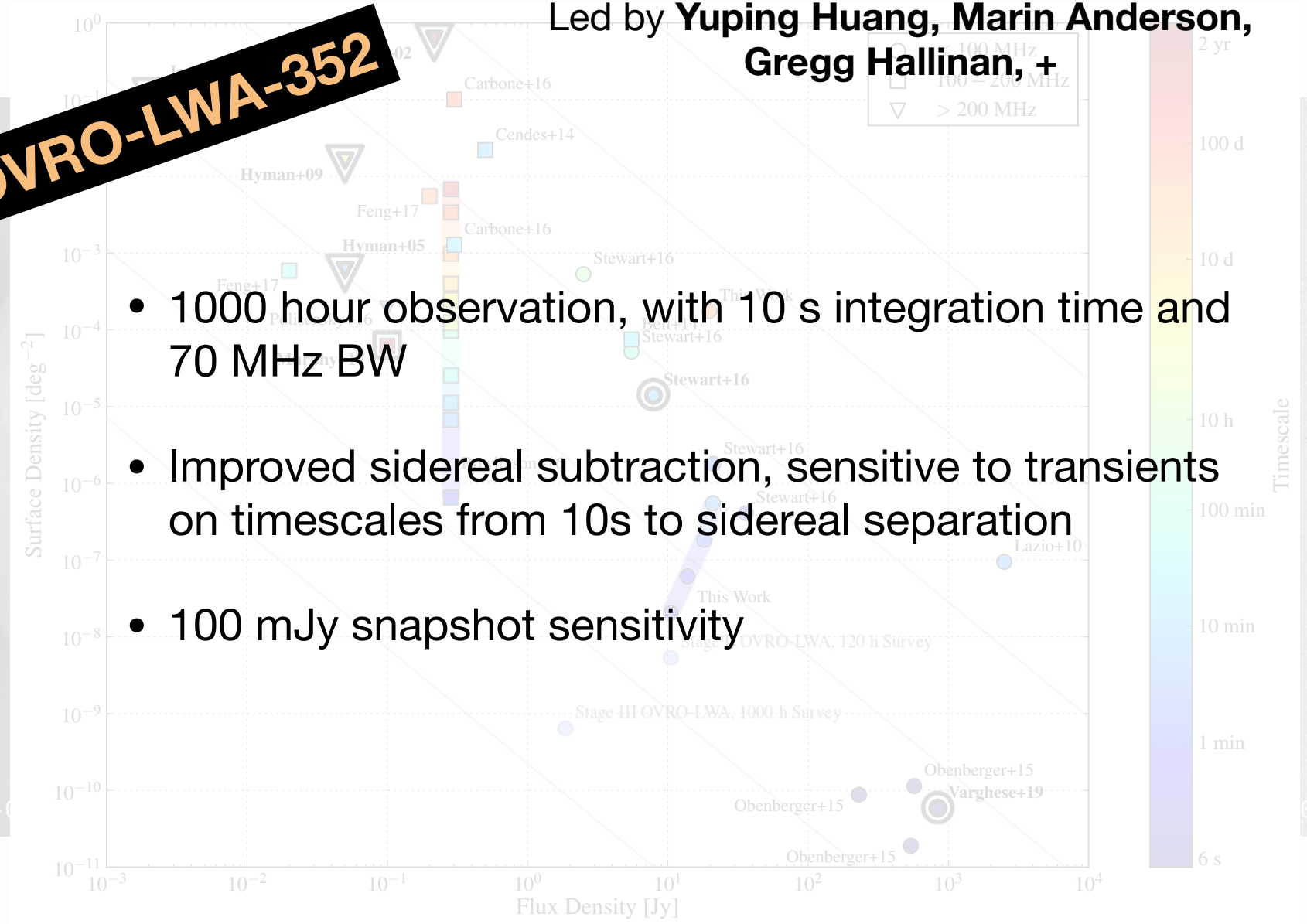


Anderson+2019

Blind transients survey

OVRO-LWA-352

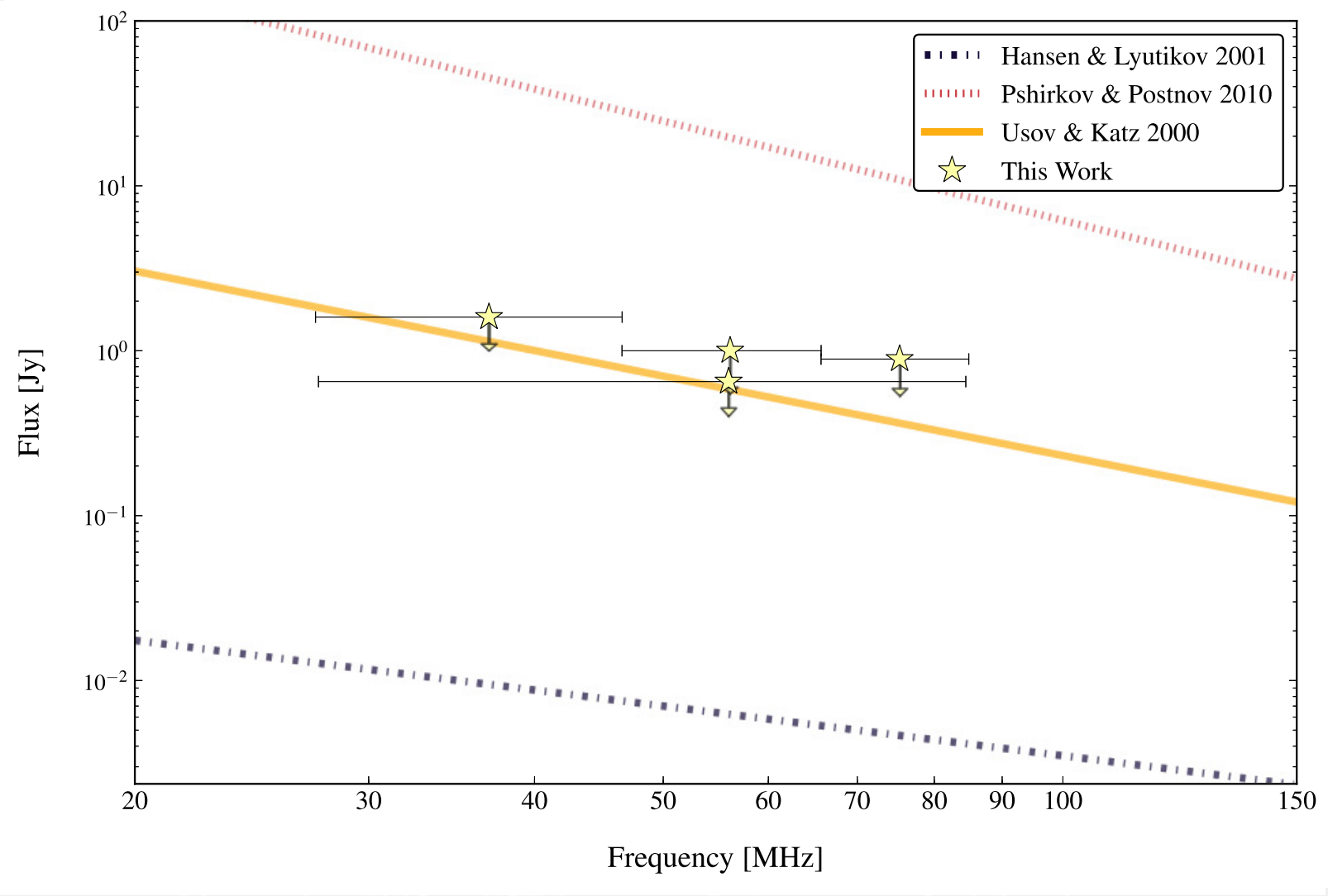
Led by **Yuping Huang, Marin Anderson, Gregg Hallinan, +**



- 1000 hour observation, with 10 s integration time and 70 MHz BW
- Improved sidereal subtraction, sensitive to transients on timescales from 10s to sidereal separation
- 100 mJy snapshot sensitivity

Anderson+2019

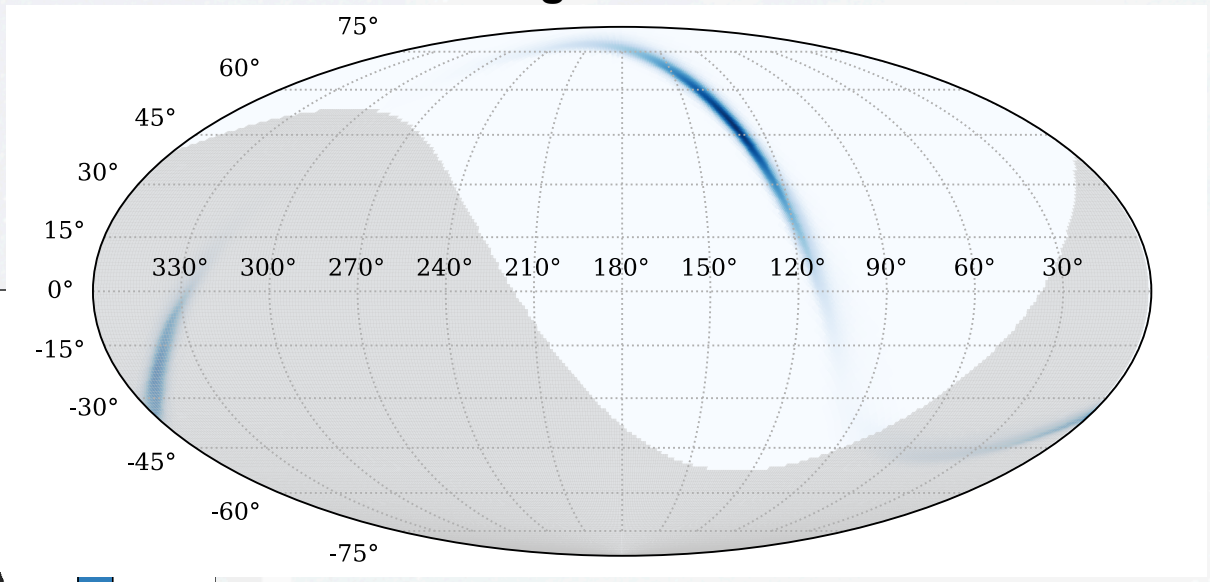
Prompt emission from compact object mergers



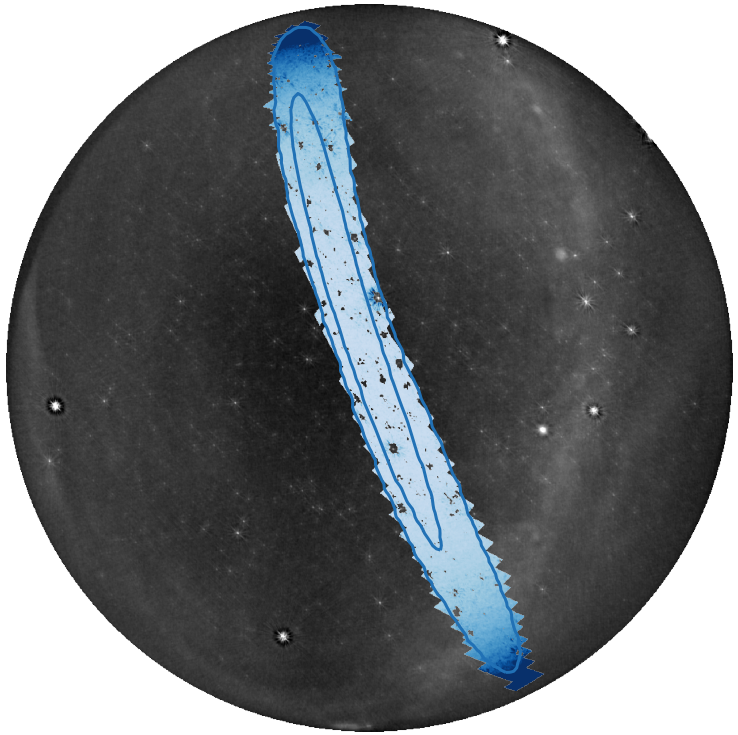
- Ma ciated wit
- Mo cursor em
- Demonstration of follow-up capabilities with OVRO-LWA using observation of sGRB 170112A (**Anderson+2018**)

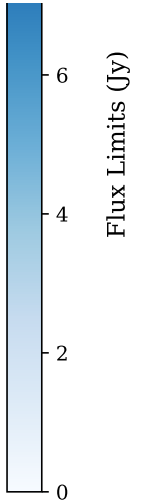
Prompt emission from compact object mergers

Localization region for GW 170104



Callister+2019





- Demonstration of LIGO follow-up with BBH GW 170104
- 24-hour buffer observations on-going, in preparation for O3 events

Prompt emission from compact object mergers

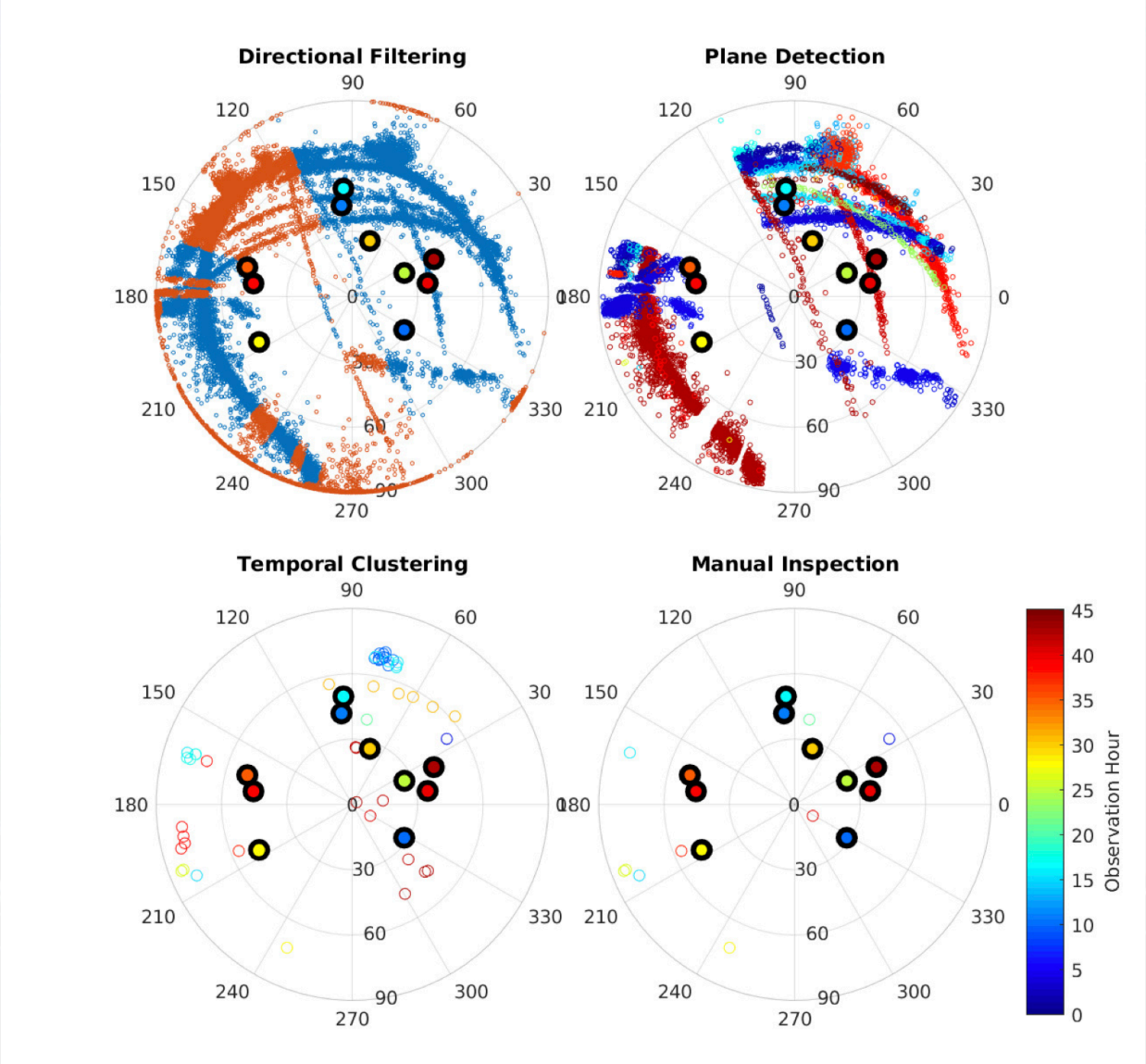
OVRO-LWA-352

Led by **Tom Callister, Marin Anderson, Gregg Hallinan, +**

- Will continue to buffer visibility data in preparation for LIGO/Virgo events
- Beam available for higher time-resolution observations
- Plan in place for minutes-long buffer of raw voltage data from all antennas in response to automated GW trigger

Mass composition of high energy cosmic rays

- First demonstration of RF-only detection of cosmic rays.
- 10 events detected in 40 hour observation (out of 6 million triggers)
- Sensitive to airshowers from cosmic rays with E ~ 3×10^{16} - 10^{18} eV (critical transition from Galactic to extragalactic CRs)



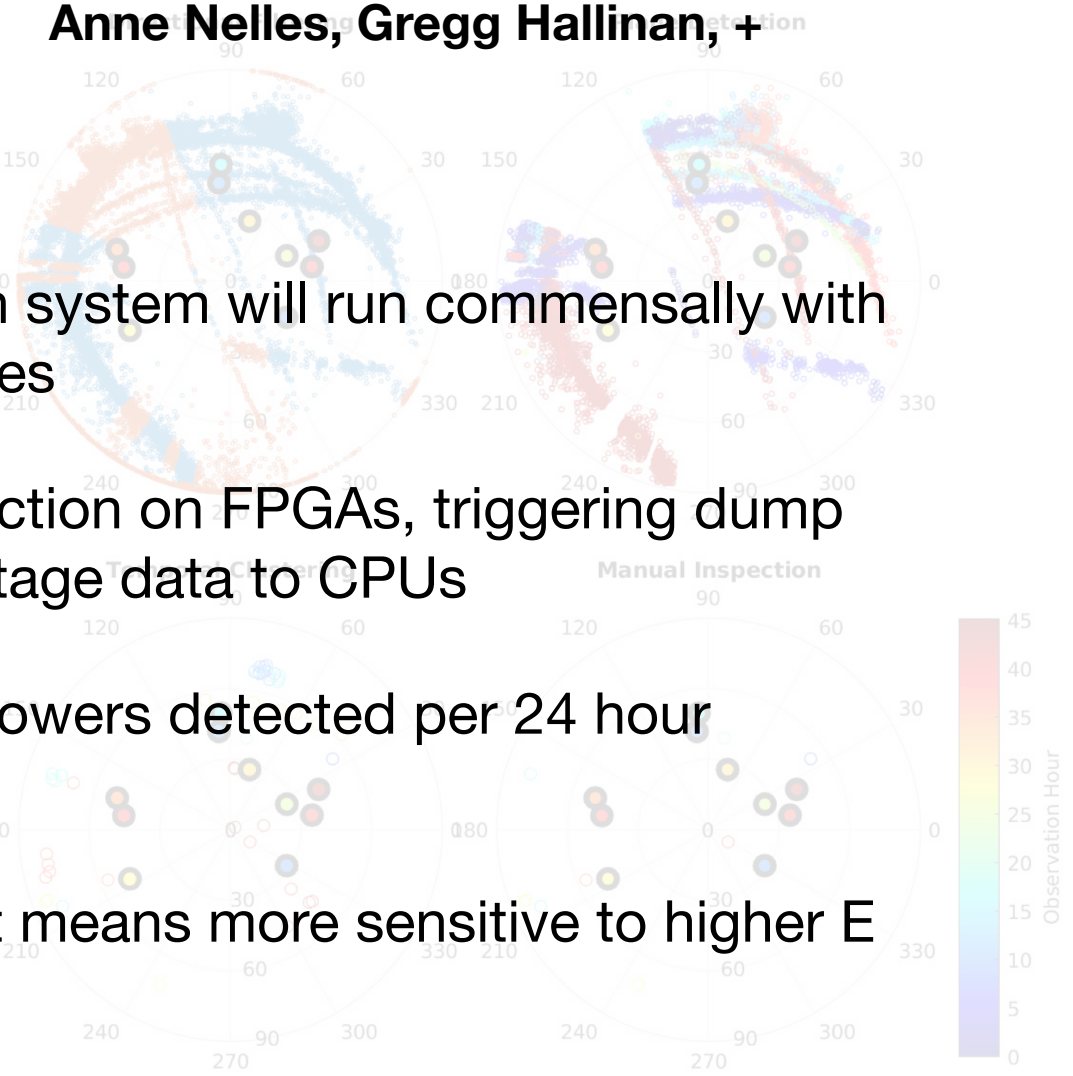
Monroe+2019

Mass composition of high energy cosmic rays

OVRO-LWA-352

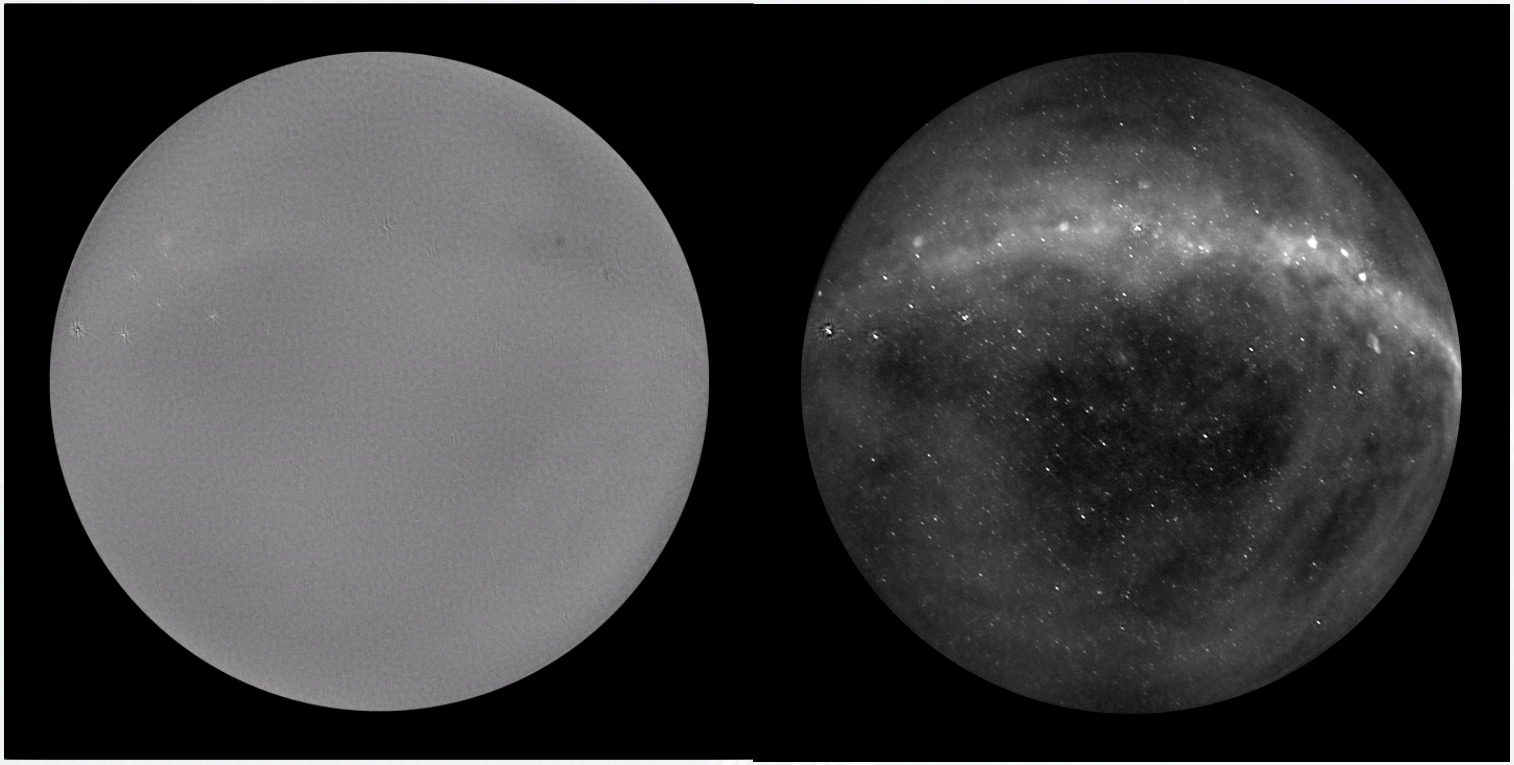
Led by **Kathryn Plant, Andrés Romero-Wolf, Anne Nelles, Gregg Hallinan, +**

- Cosmic ray detection system will run commensally with other observing modes
- Real-time event detection on FPGAs, triggering dump of corresponding voltage data to CPUs
- ~10 cosmic ray airshowers detected per 24 hour observation
- Larger array footprint means more sensitive to higher E CRs



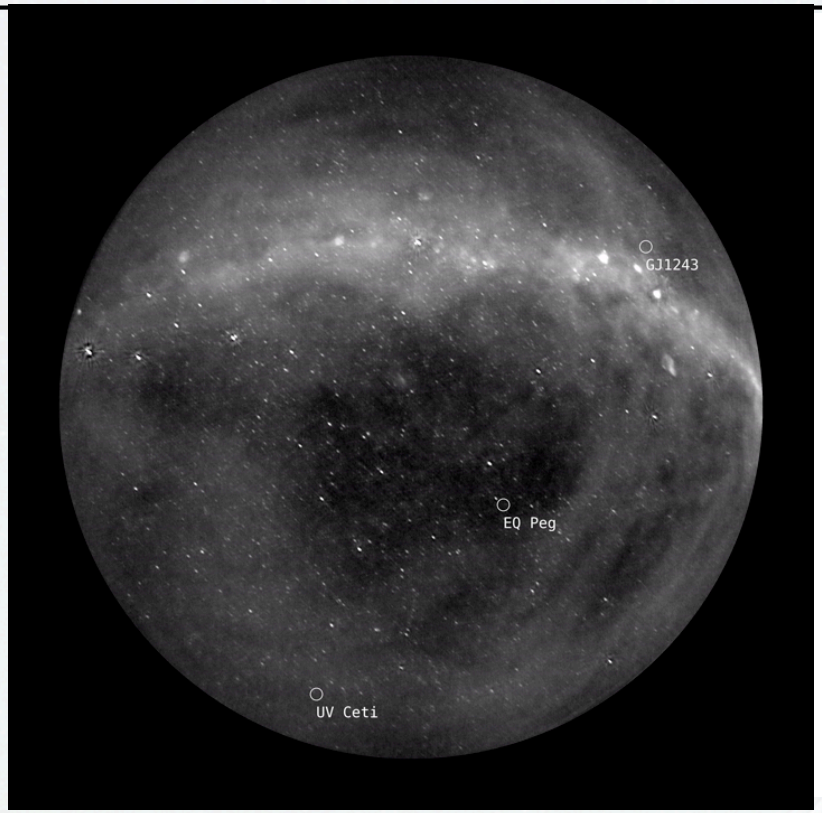
Monroe+2019

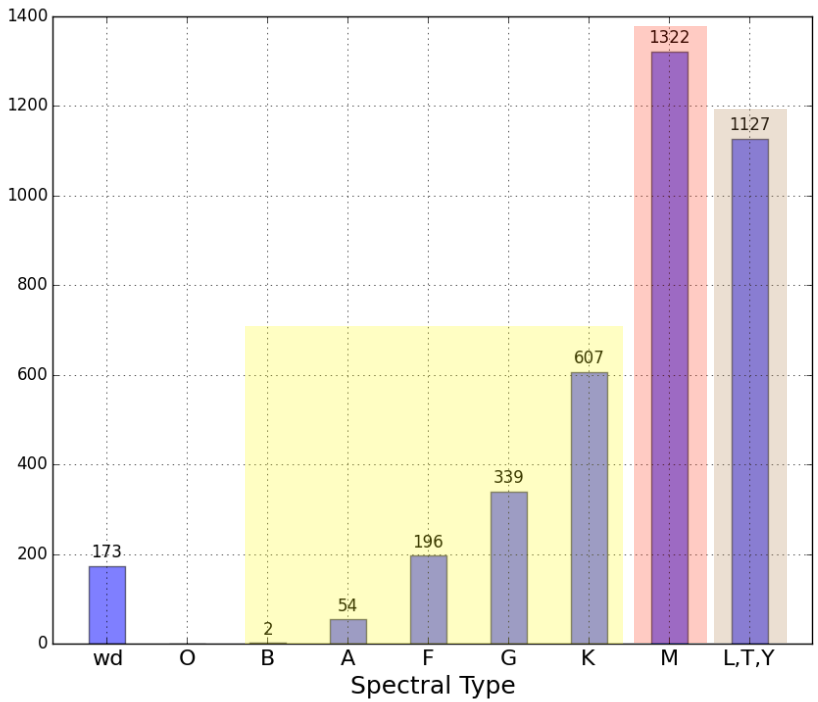
Extrasolar space weather monitoring



- Simultaneous monitoring of nearly 4000 systems out to 25 pc
- Current 24-hour buffer allows for responding to triggers of interest (e.g. *Swift* stellar flares)
- Initial 31 hour dataset with 13 s time resolution and ~60 MHz BW; equivalent to ~5 years targeted observations (**Anderson+in prep**)

Extrasolar space weather monitoring





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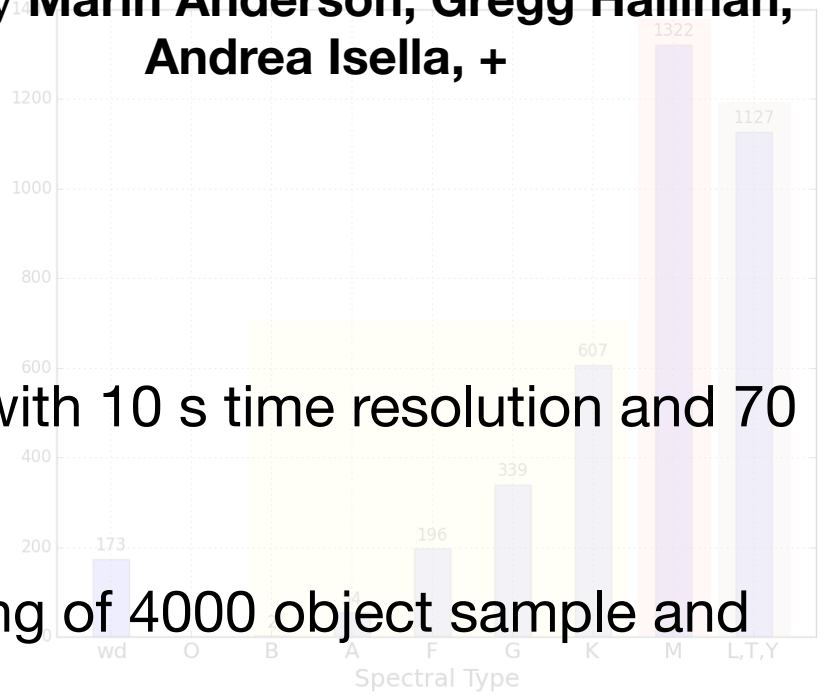
Extrasolar space weather monitoring

OVRO-LWA-352

Led by **Marin Anderson, Gregg Hallinan, Andrea Isella, +**



- 1000 hour observation with 10 s time resolution and 70 MHz BW
- Stokes I and V monitoring of 4000 object sample and other targets of interest
- Simultaneous monitoring of nearly 4000 systems out to 25 pc
- 100 mJy snapshot sensitivity in Stokes I
- Current 24-hour buffer allows for responding to triggers of interest (e.g. *Swift* stellar flares)
- 10 mJy sensitivity in 24-hour m-mode Stokes V maps
- Initial 31 hour dataset with 13 s time resolution and ~60 MHz BW; equivalent to ~5 years targeted observations (**Anderson+in prep**)

Summary of OVRO-LWA-352 capabilities

Full cross-correlation, all-sky imaging (10 s, 24 kHz resolution)

- m-mode analysis, cosmic dawn (1000 hours, Stokes I / V)
- transient surveys
- extrasolar spaceweather
- GW / compact object merger follow-up
- solar dynamic imaging spectroscopy

Beamforming observations (12 simultaneous; 1 ms, 24 kHz resolution)

- solar monitoring (dedicated beam)
- passive sounding of Jovian icy moons (dedicated beam)
- high-time resolution science, RFI characterization, antenna beam holography

Raw voltage stream (5 ns)

- cosmic ray air shower detection
- GW / compact object merger follow-up

Supplementary Slides

Extrasolar space weather monitoring