

OVRO-LWA-352



**Mt. Cuba
Foundation**

Wilf Family



***Adapt the LWA antenna to all-sky imaging
at ~few arcminute resolution***

352 antennas spaced over ~2.6 km

Full cross-correlation = All-sky FOV

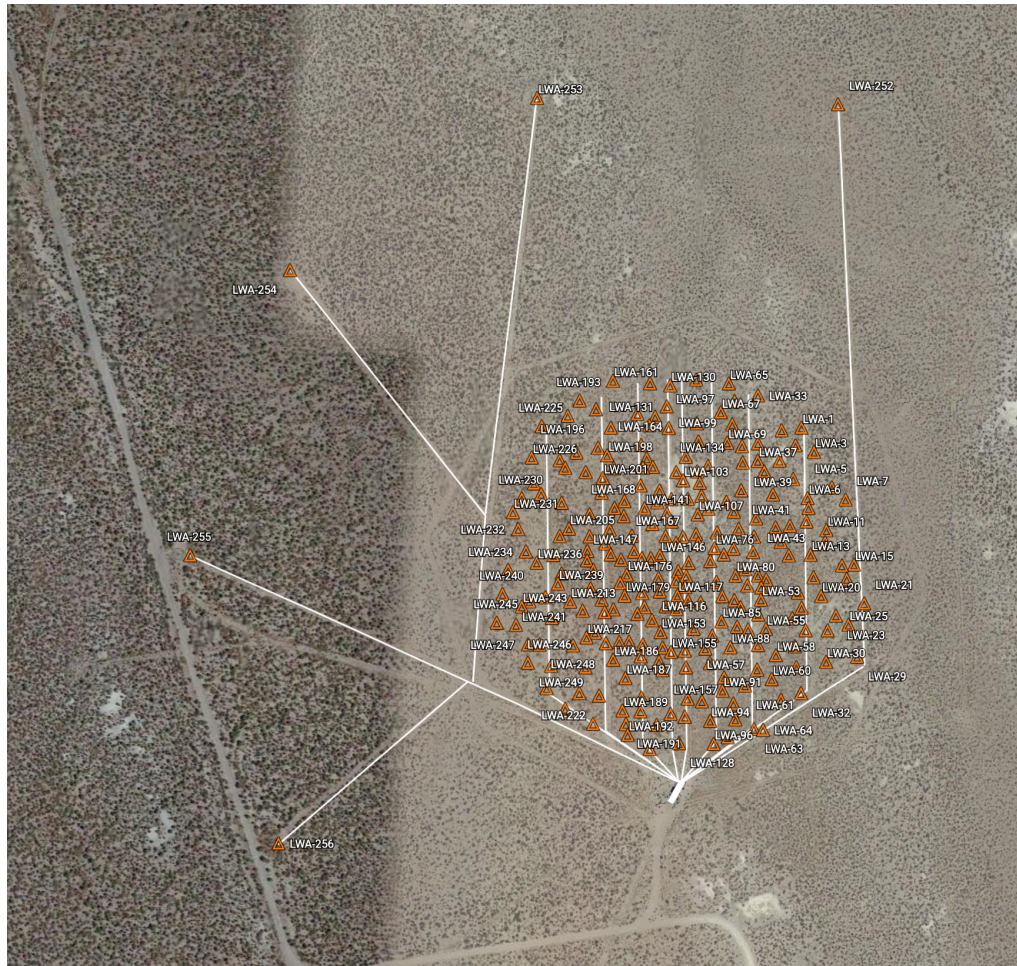
15-85 MHz (2900 channels)

5 arcminute spatial resolution

Construction in 3 stages...



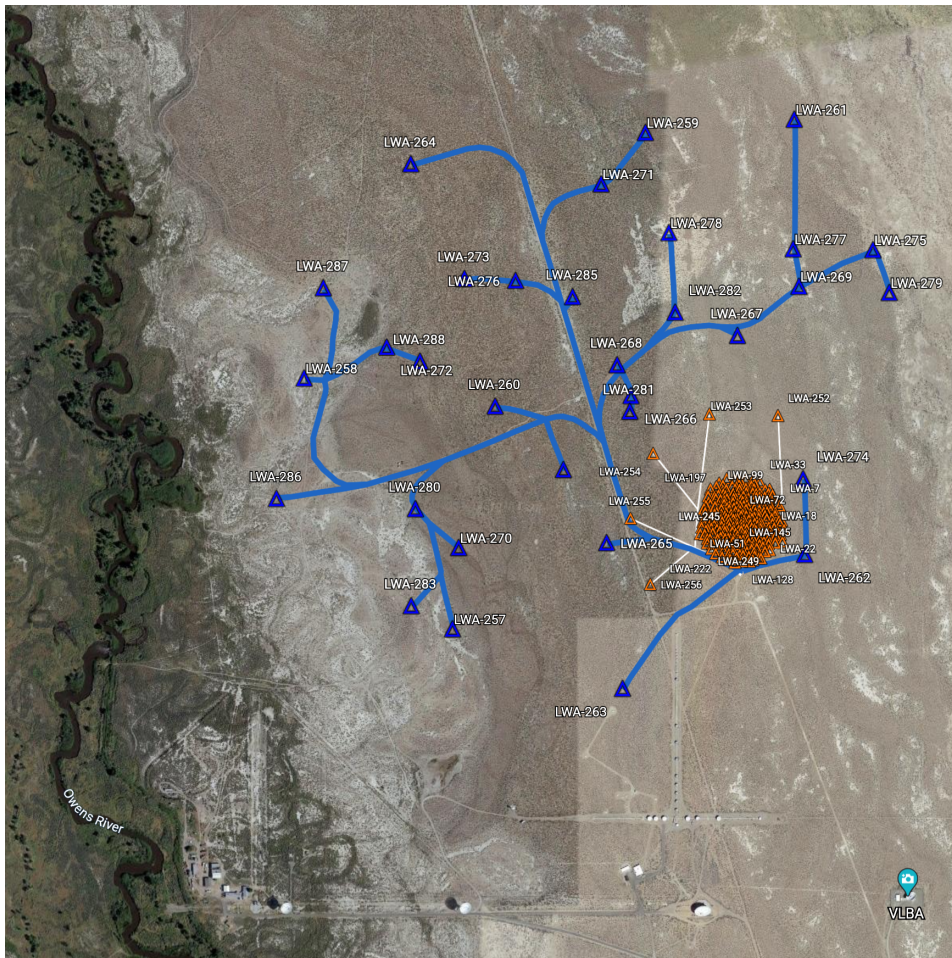
Stage 1



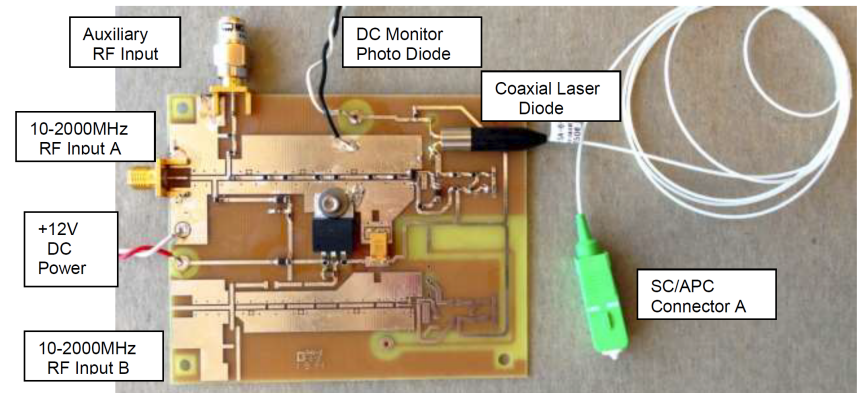
- 251 antenna in the core, 5 LEDA outriggers
- LEDA digital backend (58 MHz)
- Small cluster for data processing
- Longest baseline: ~200 m

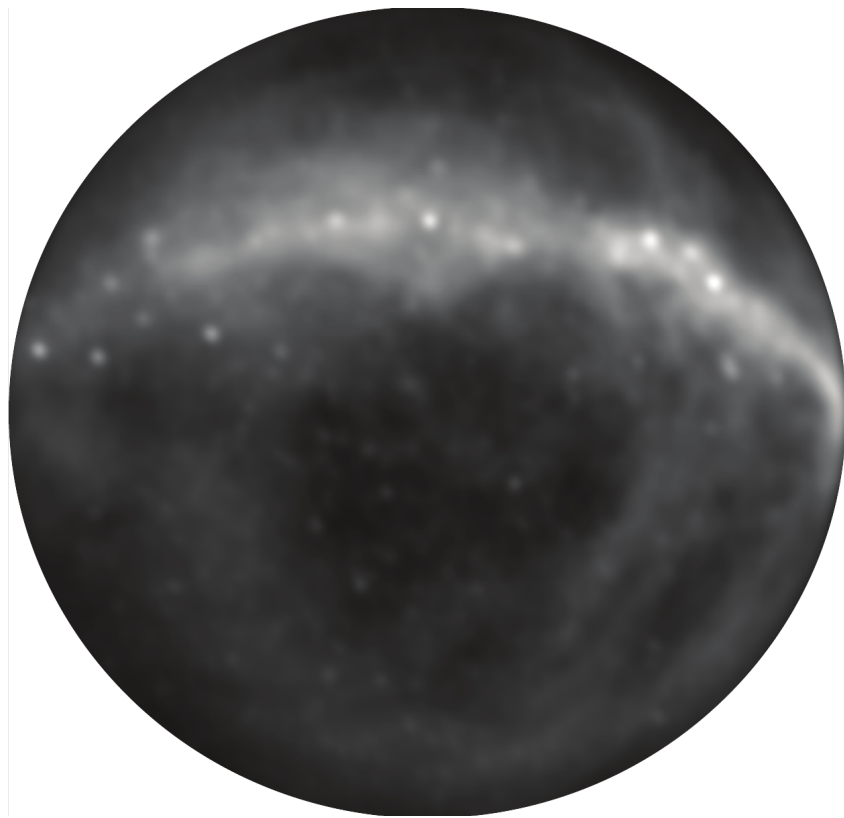


Stage 2

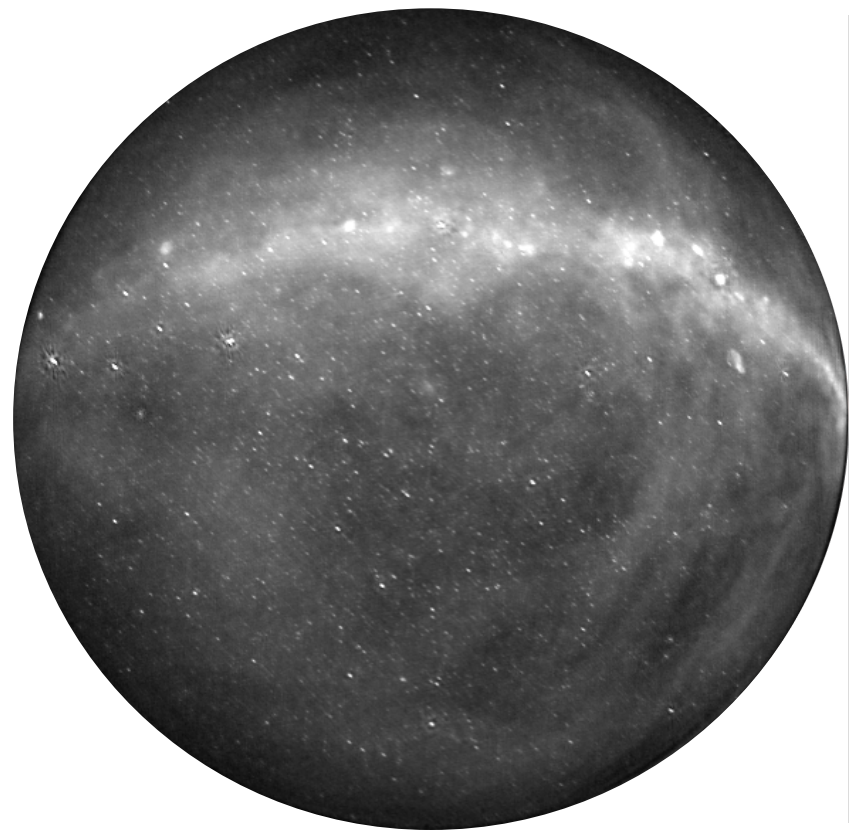


- Addition of 32 fiber-fed antennas
- Large network of conduit holding 43 km of optical fiber
- Custom fiber-link board (Sandy Weinreb)
- Larger cluster (13 compute nodes; 750 TB storage)
- Longest baseline ~ 1.5 km



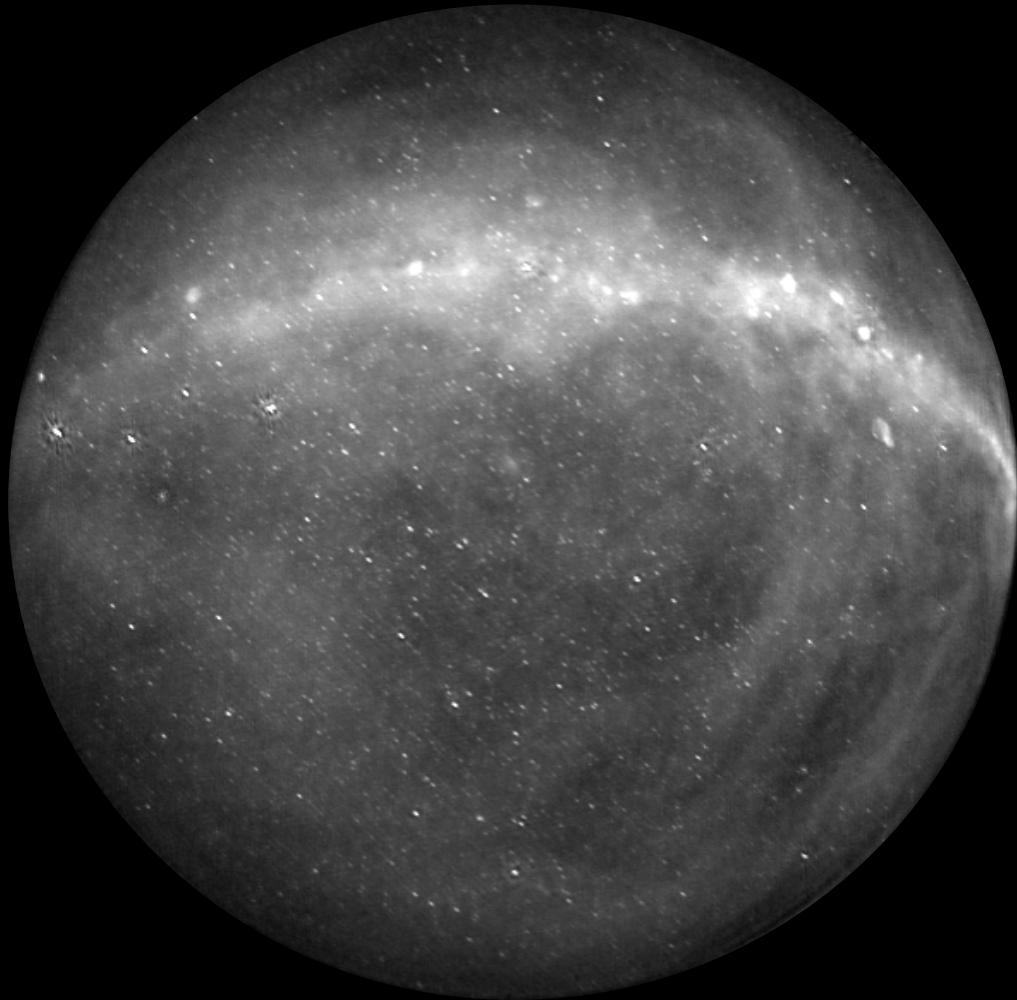


Stage 1



Stage 2

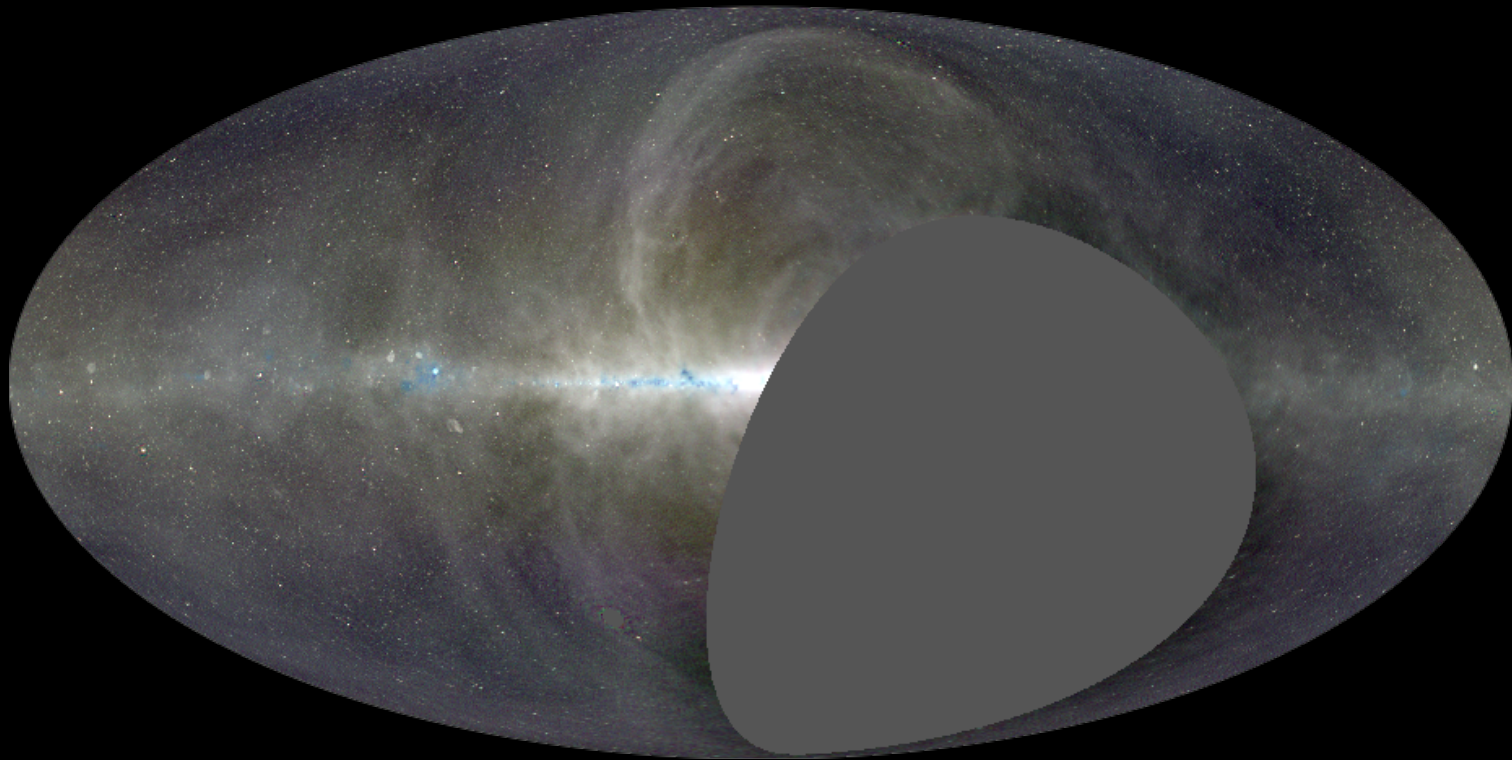
Data Product 1: All-sky images



- Extrasolar space weather
- LIGO/Virgo searches
- Transients
- Solar
- Galilean moons

**Anderson et al. 2018, 2019,
Callister et al. 2019, Chabbra et al. 2020**

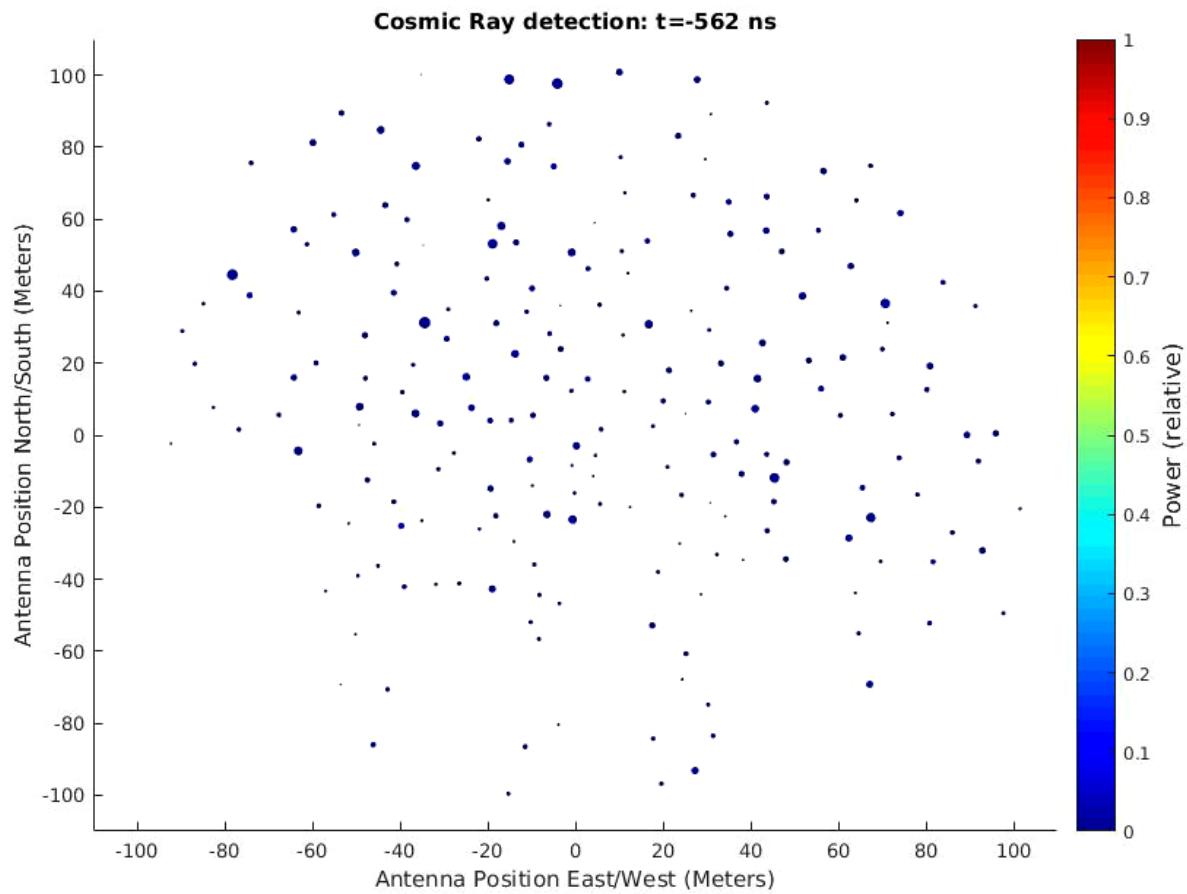
Data Product 2: m-mode images



**Tikhonov regularized m-mode analysis (Eastwood et al. 2018, 2019)
(Technique based on Shaw et al. 2014, 2015)**

Cosmic dawn, survey catalogs, Galactic structure, polarization

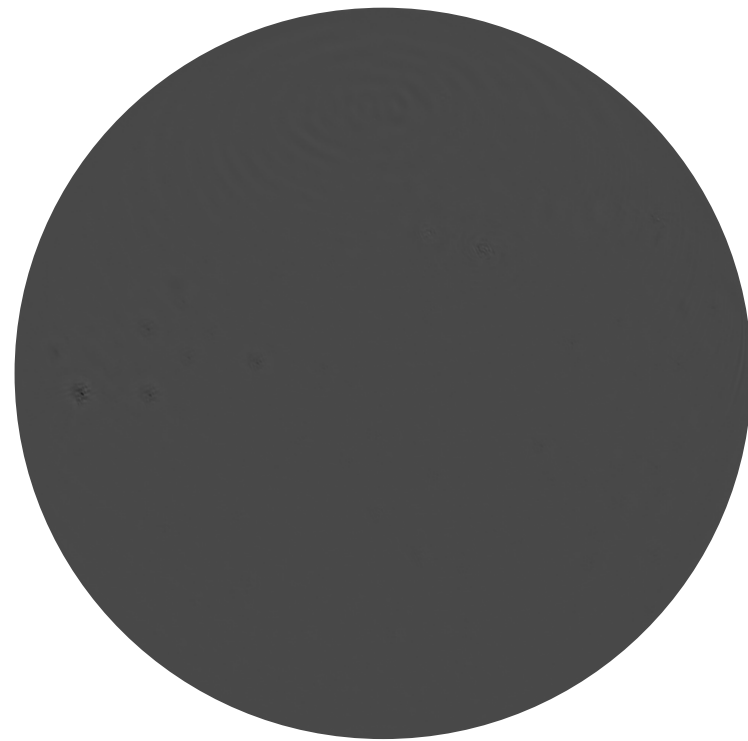
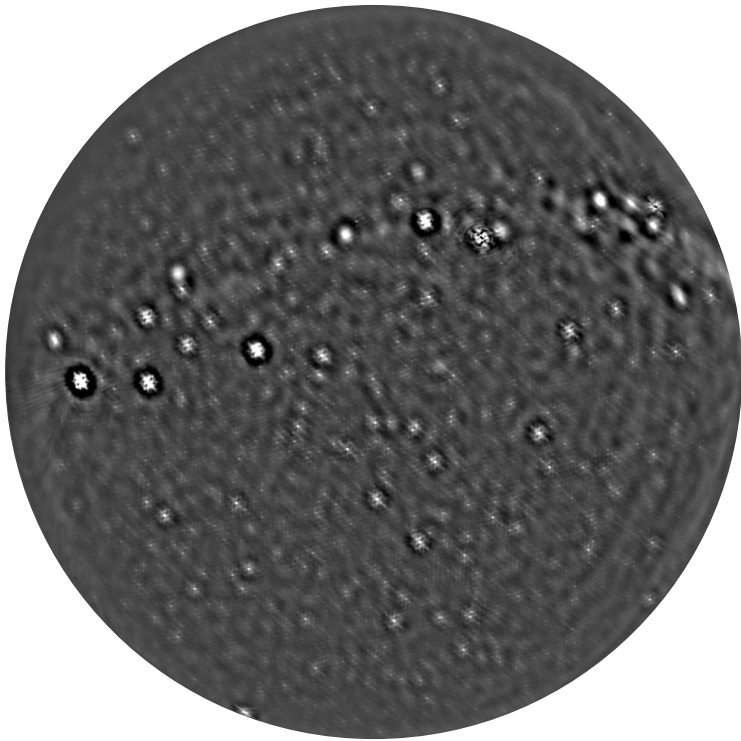
Data Product 3: Astroparticle air showers



Monroe et al. 2019

1000-survey in exoplanet band

- LEDA correlator switched off in early 2020
- 1000-hour data set (Nov 2019 - Feb 2020) in exoplanet band (32-47 MHz)
- 137-hour data set for transients and Cosmic Dawn



2-hours Stokes V 35-45 MHz
Rms \sim 35 mJy at zenith

NSF MRI (Oct 2019 – Oct 2021)

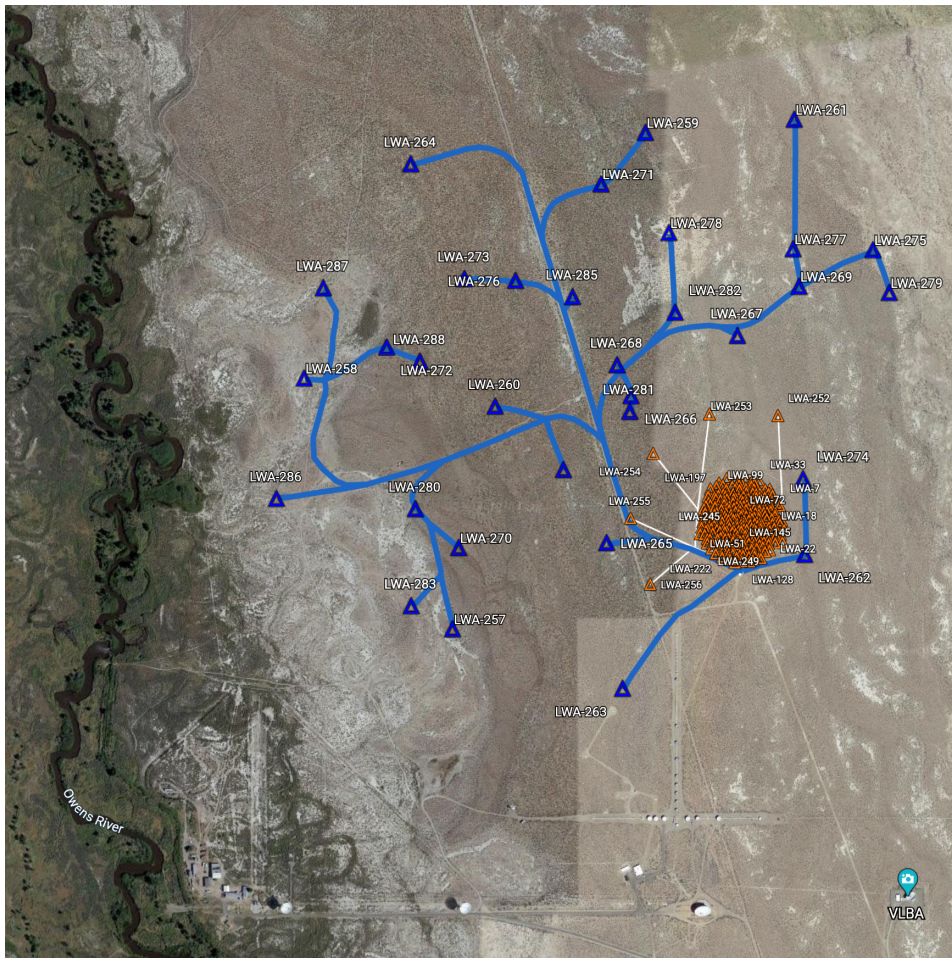
Total funding including matching funds: \$2.2 million

PI: Gregg Hallinan Co-PI: Judd Bowman, Dale Gary, Andrea Isella, Andres Romero-Wolf

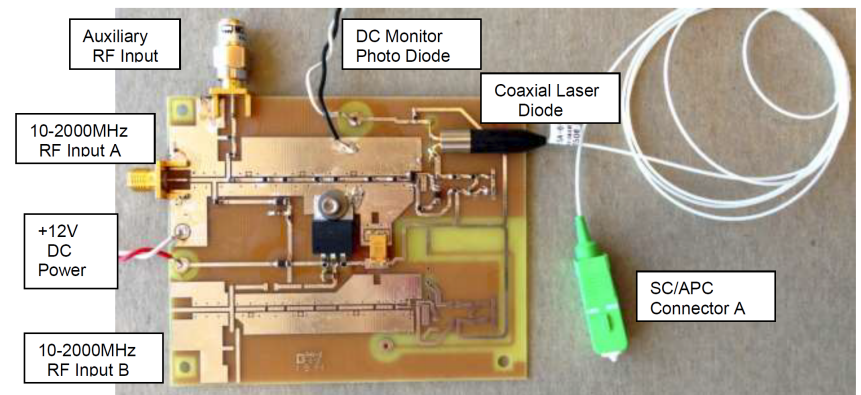
2-year construction effort culminating in a science-ready instrument

- Addition of 64 antennas to 2.4 km baselines
- New receiver boards
- New 704-input digital backend, 12x beam-former, real-time cosmic-ray detection, voltage buffer
- Large compute cluster, 5PB storage and significant pipeline development
- 40m dish LWA-band feed for dipole holography

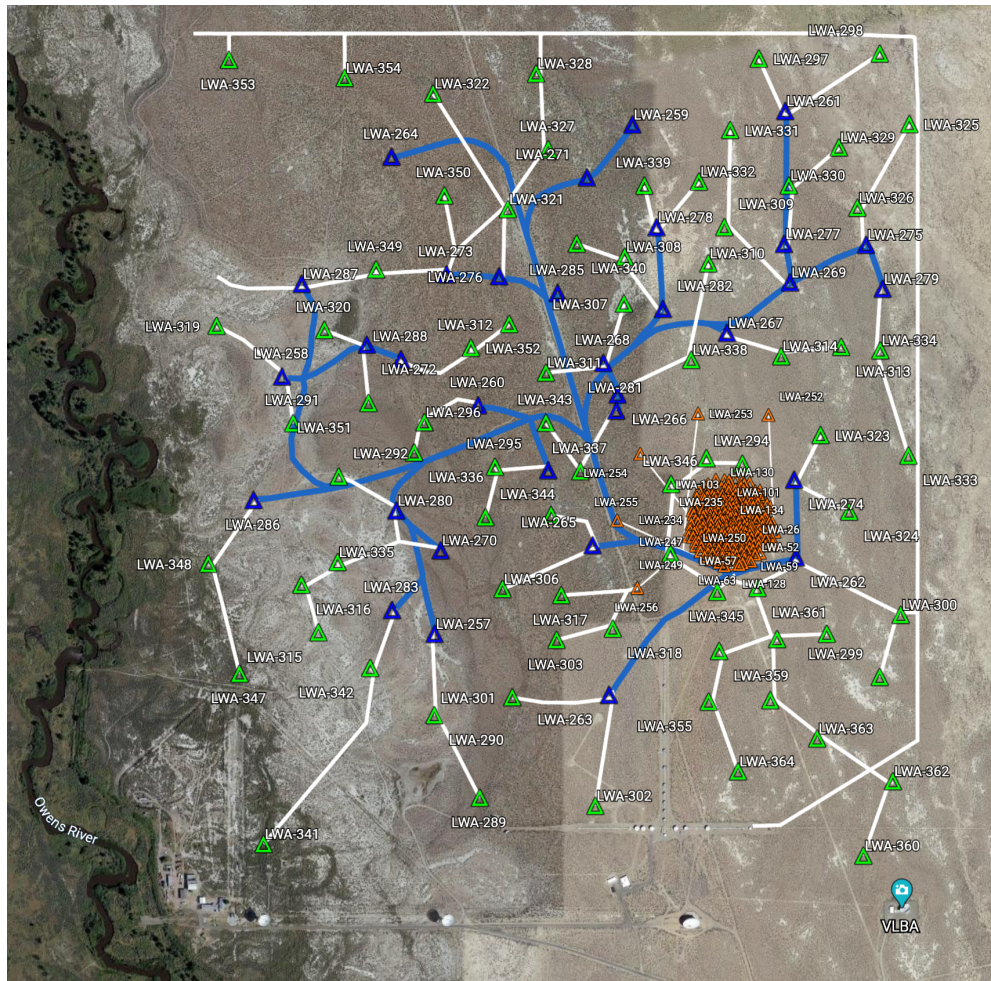
Stage 2



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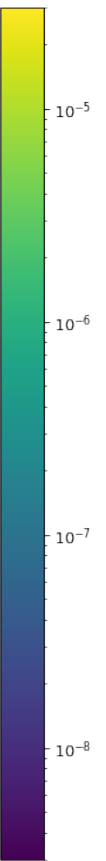
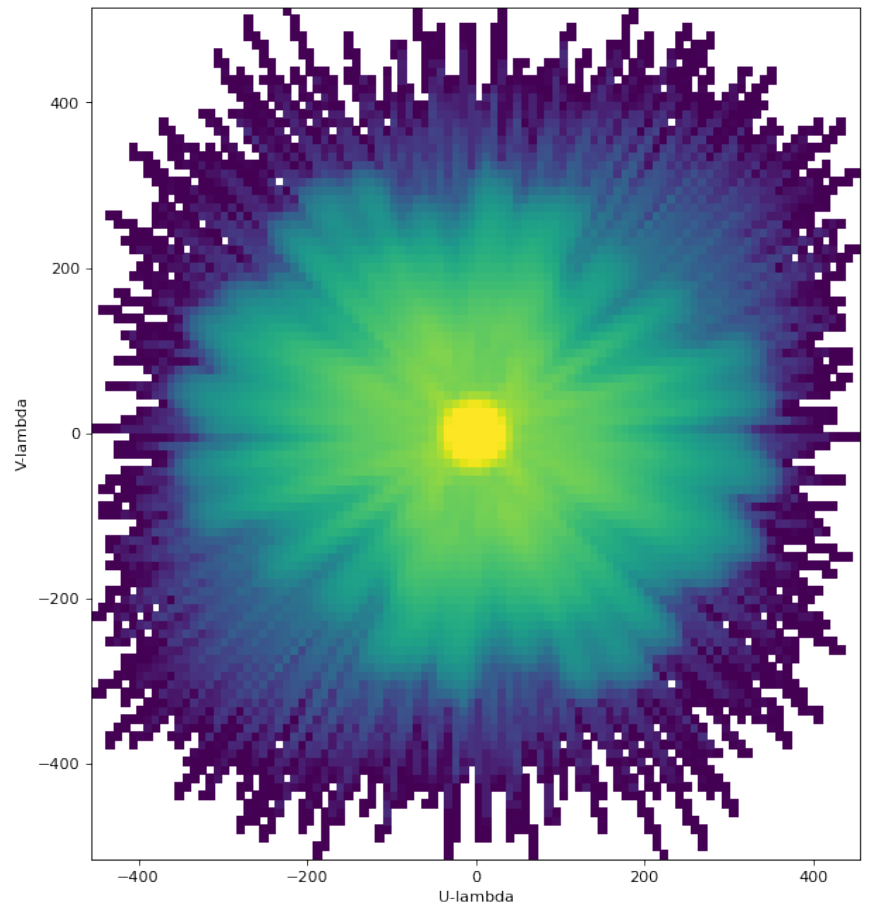
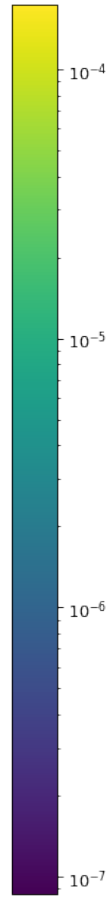
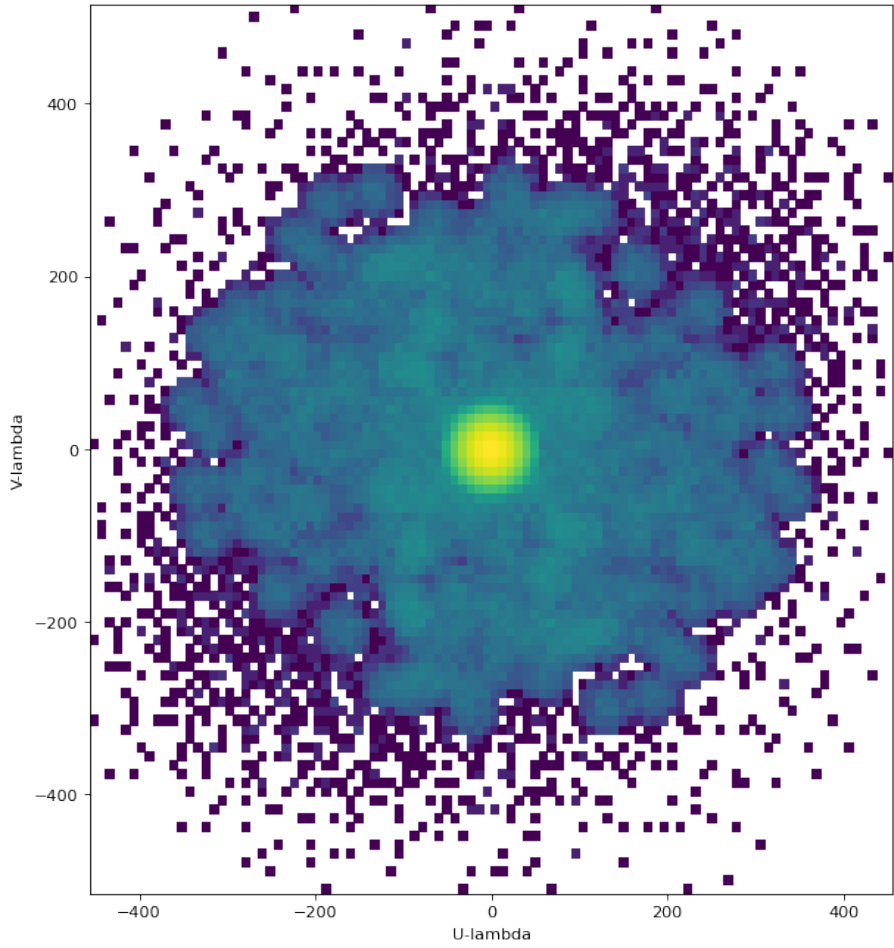


Stage 3



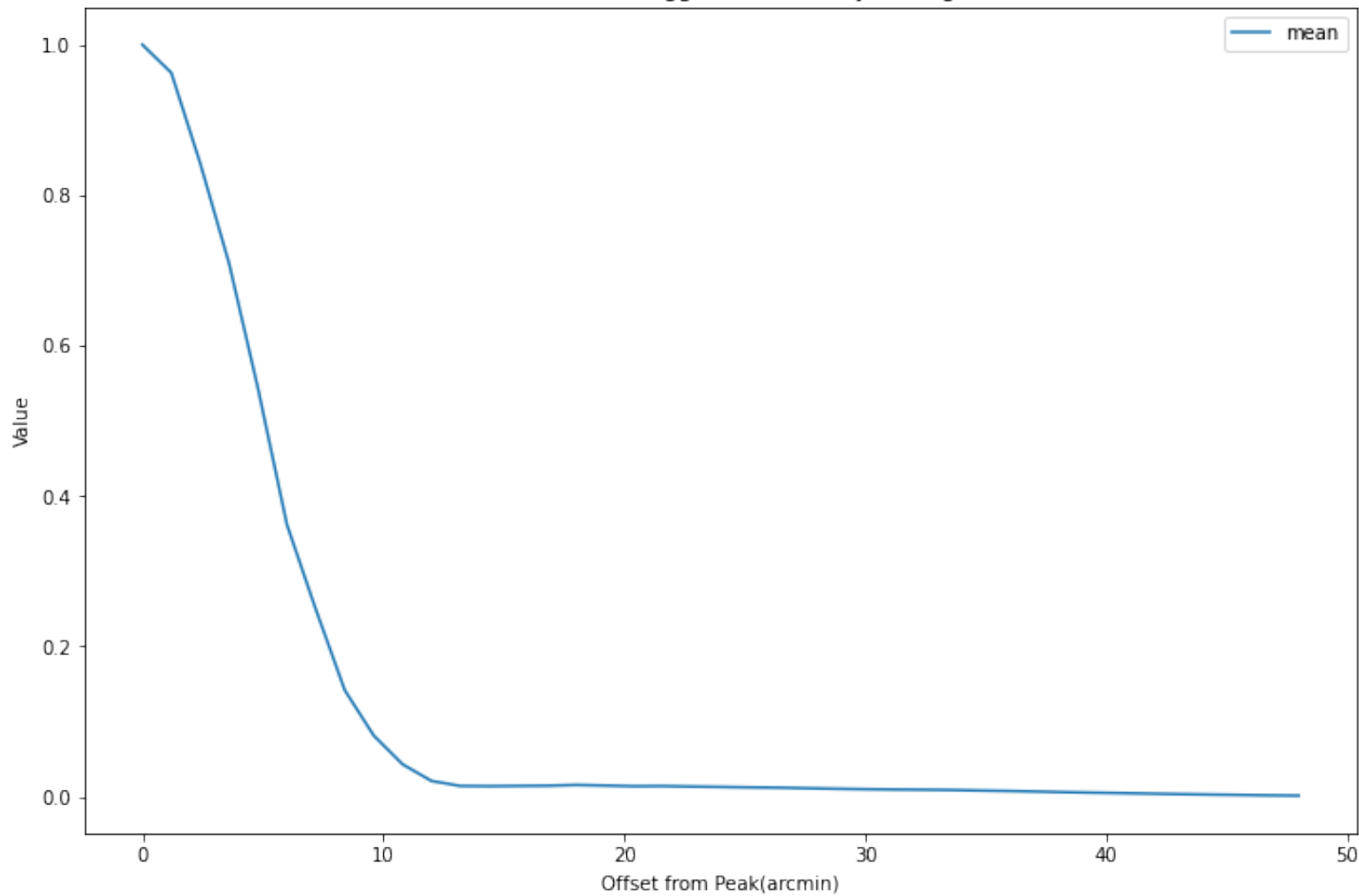
- 243 core antennas
- 109 outrigger antennas
- Longest baseline ~ 2.4 km
- A lot more trenching!

Highest frequency UV density



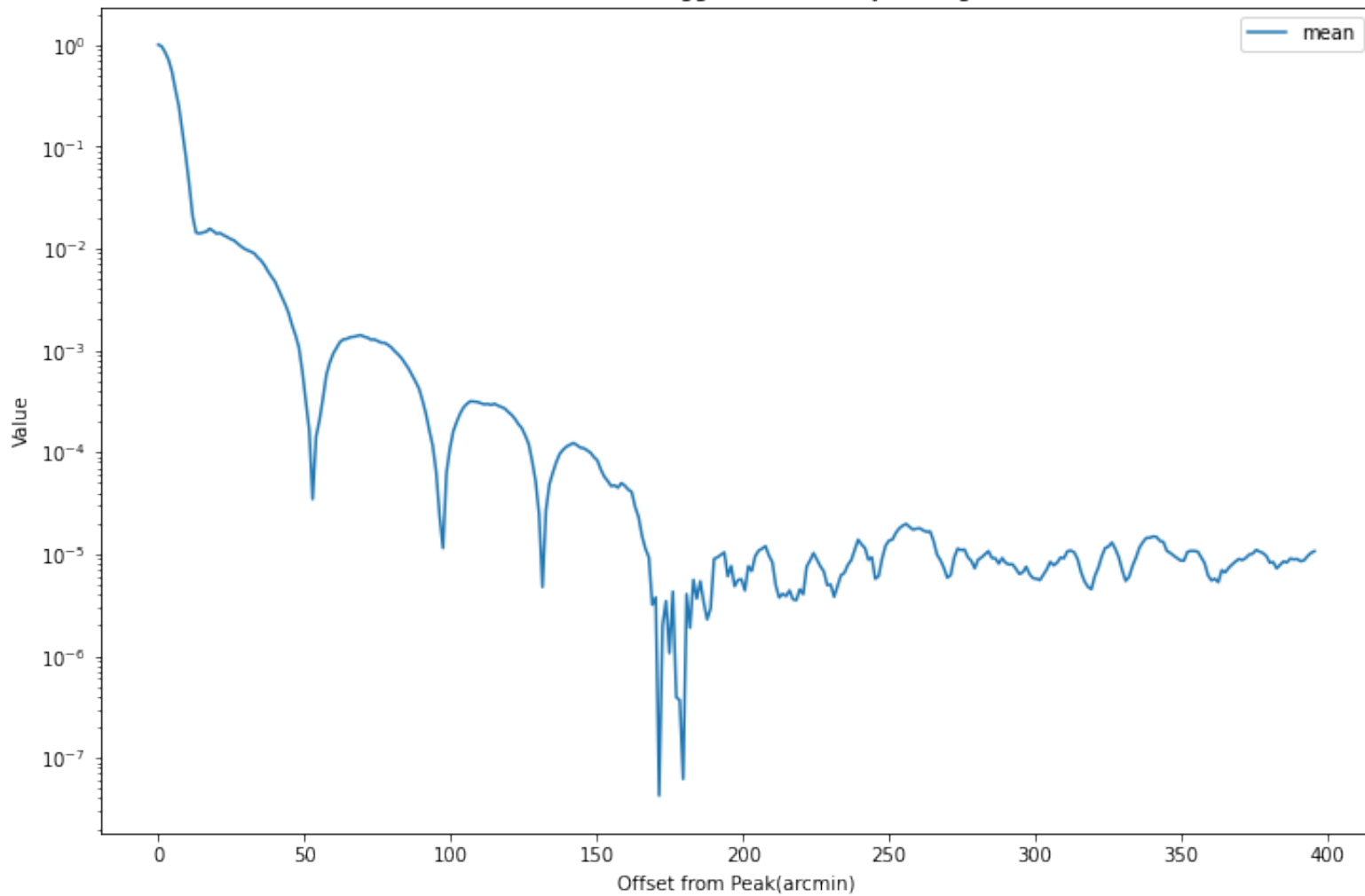
Credit: Yuping Huang

20200413 fullband Briggs 0 Azimuthally averaged PSF



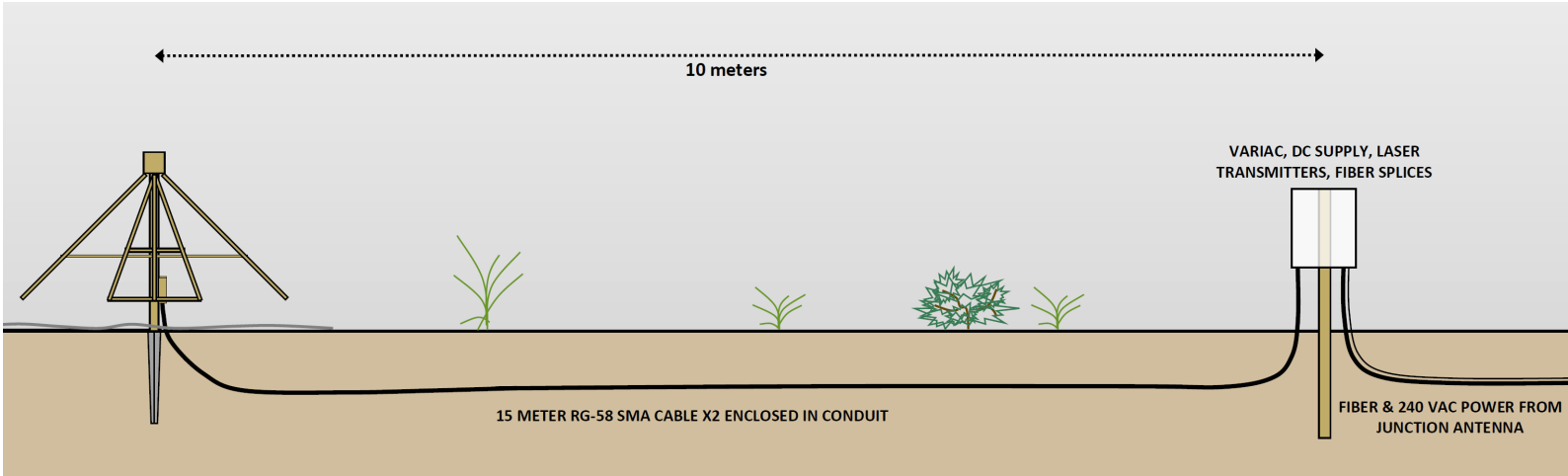
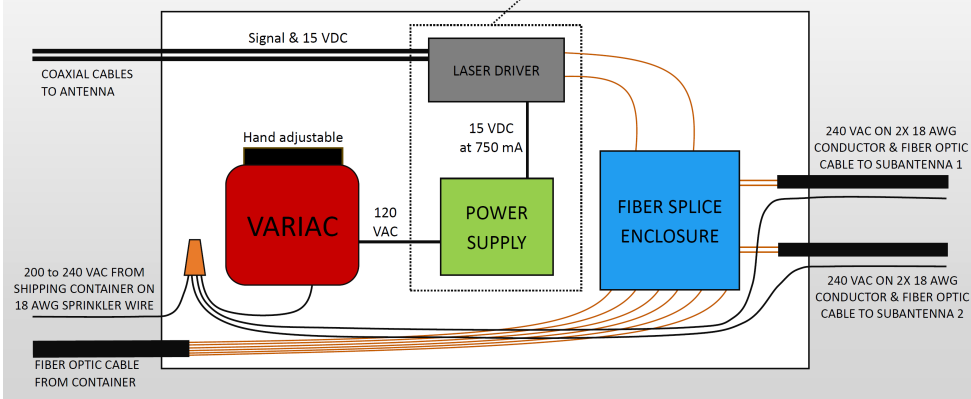
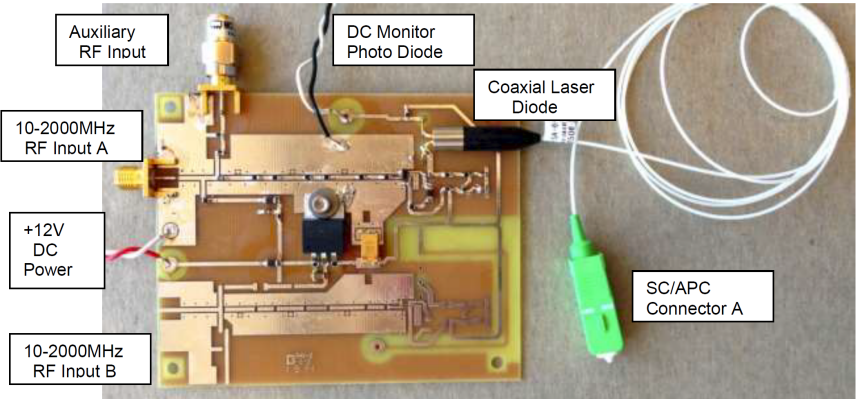
Credit: Yuping Huang

20200413 fullband Briggs 0 Azimuthally averaged PSF



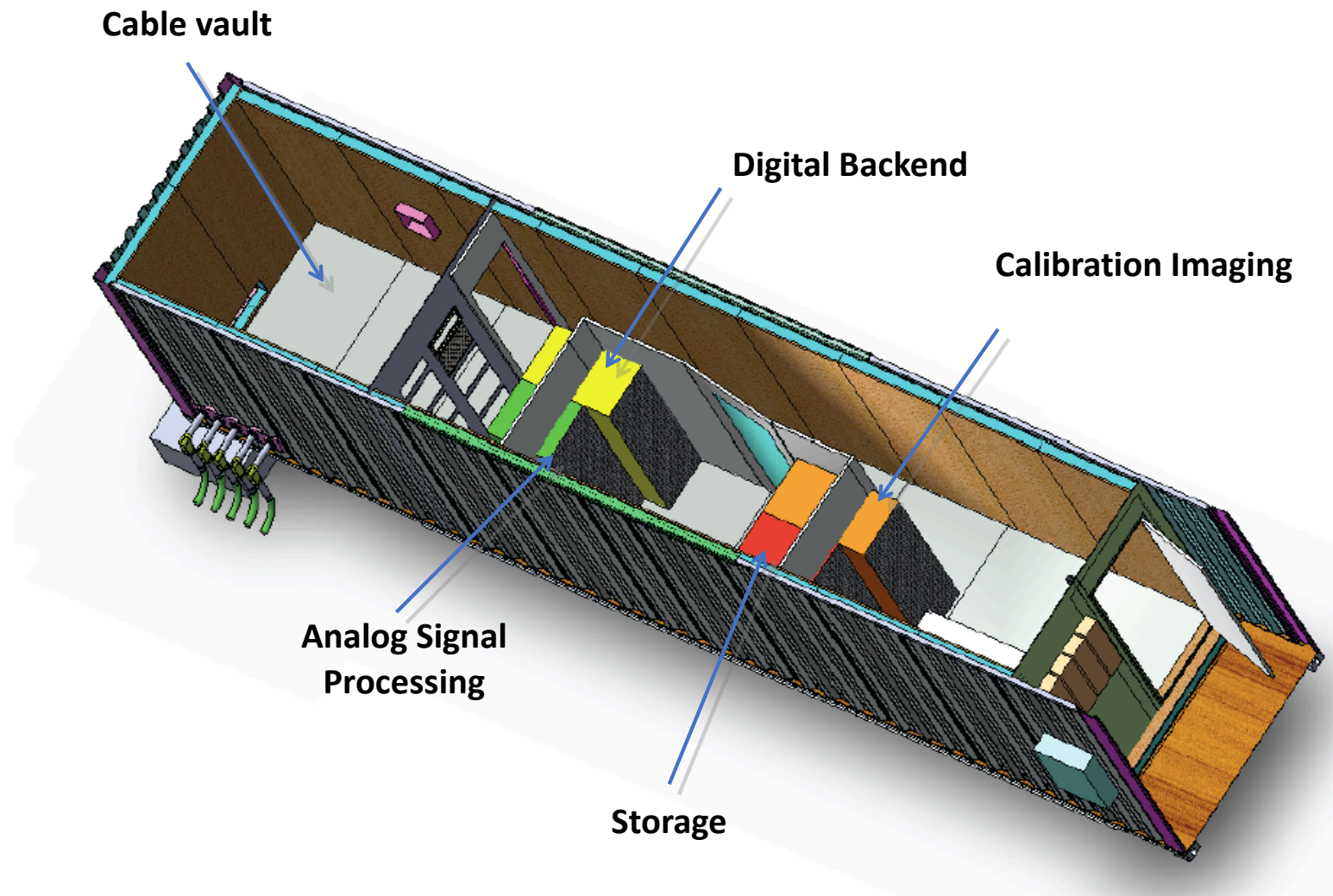
Credit: Yuping Huang

Junction box

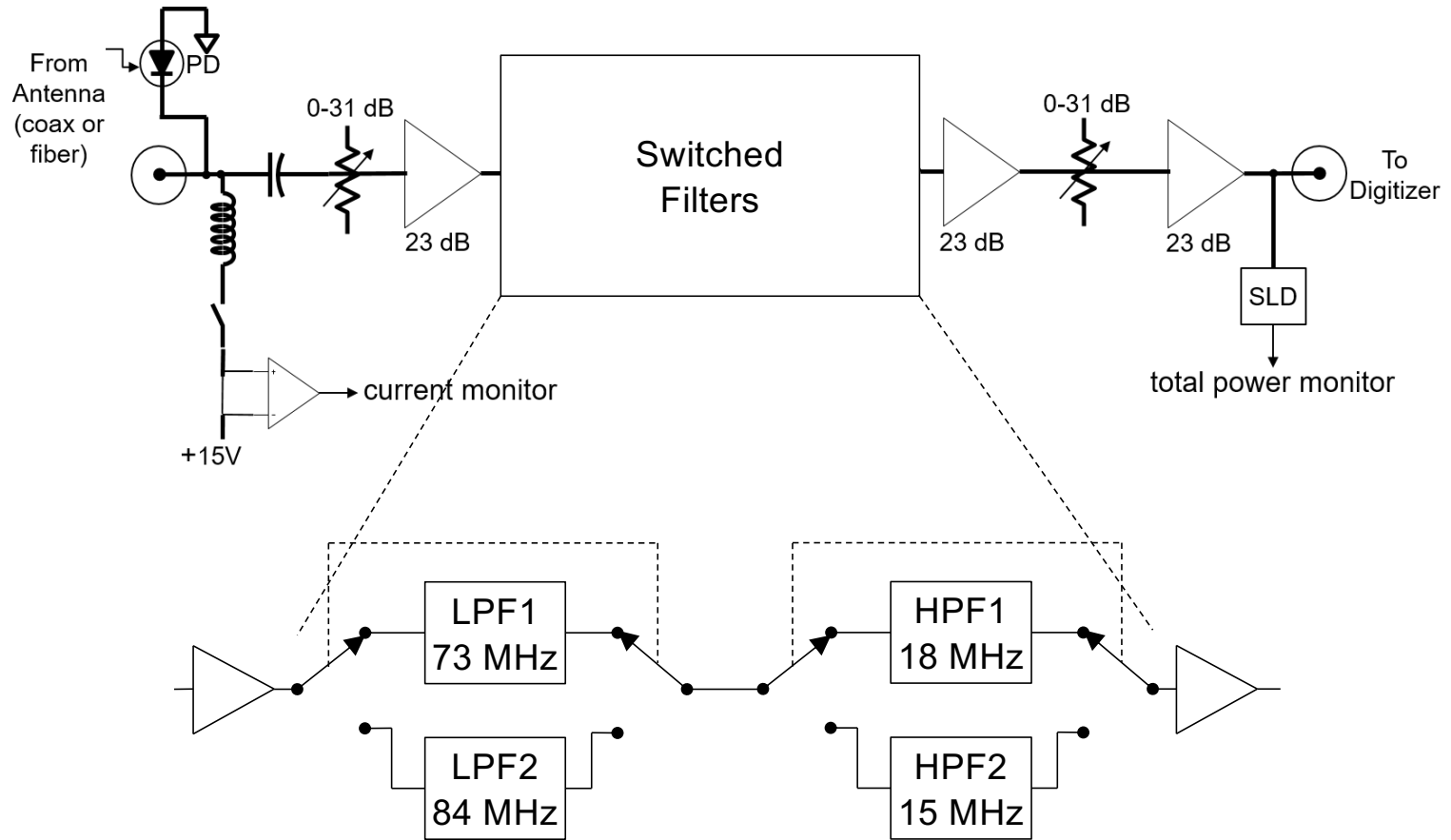


Credit: Morgan Catha

Electronics Shelter



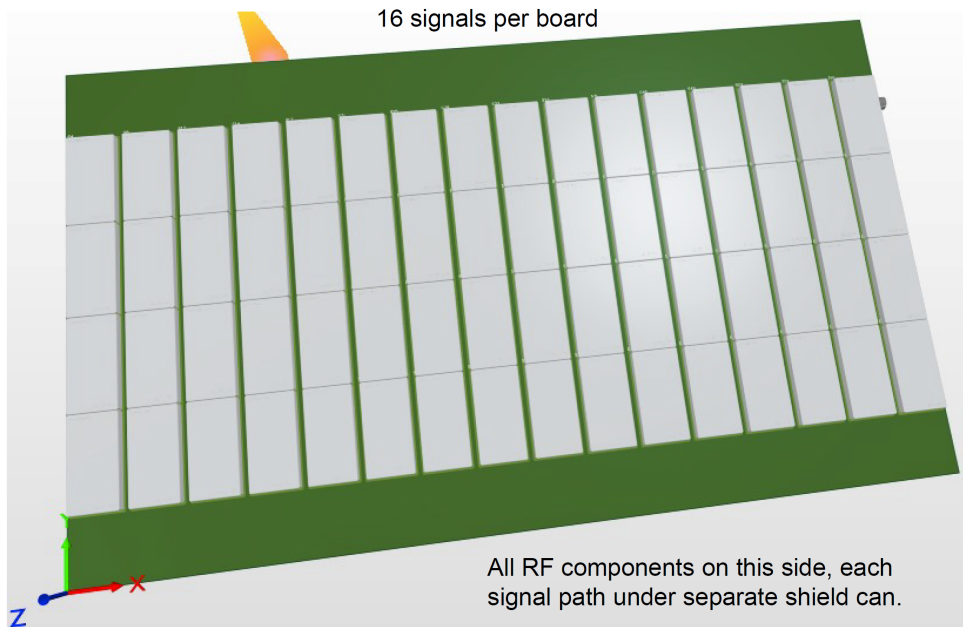
Analog Receiver Channel Block Diagram (16/board)



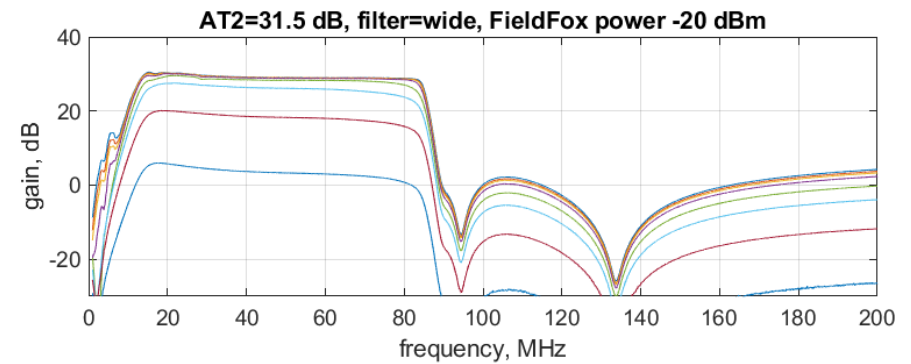
Ideal -3dB frequencies shown

Credit: Larry D'Addario

Analog Receiver

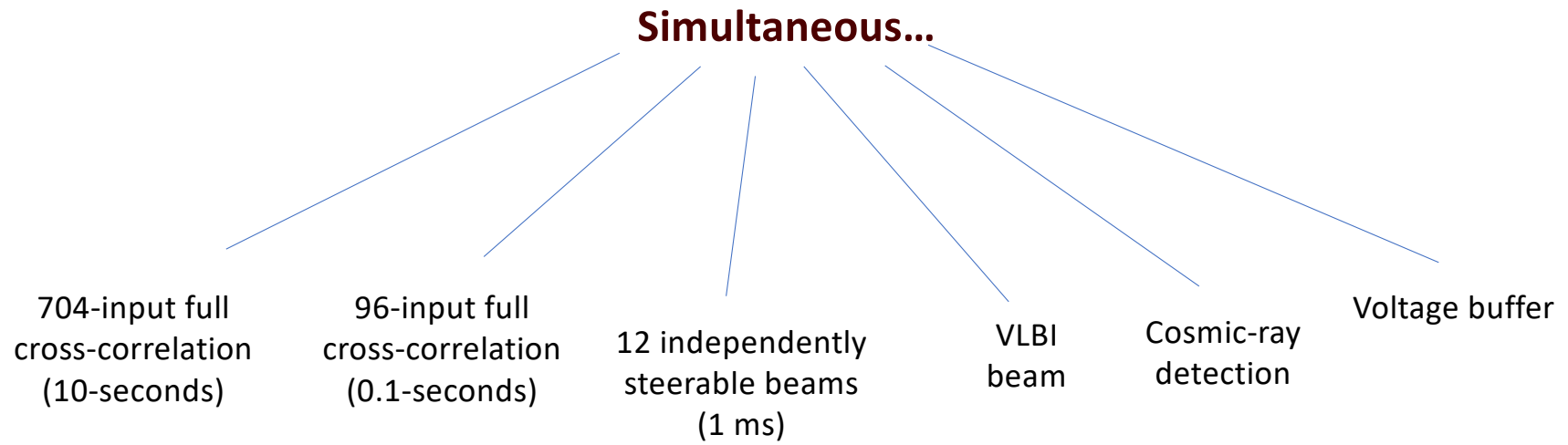


- adjacent channels have about 120 dB isolation



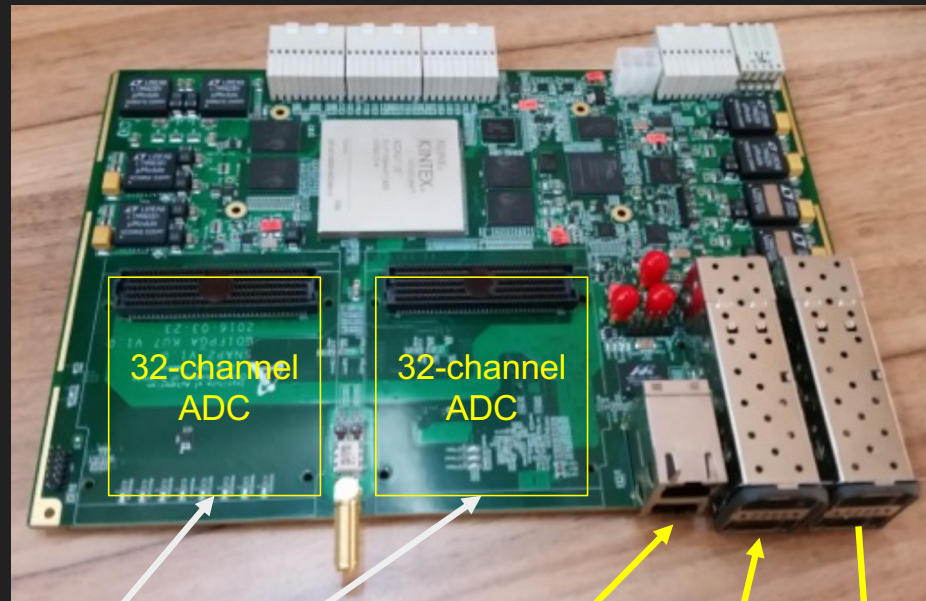
Credit: Larry D'Addario

All-singing, All-dancing Digital Back-end



Digitization / Channelization

Custom ADC boards
Enabling 64x 10-bit ADCs
(ADS5296A)



64 analog RF inputs
(coax)

1GbE
control

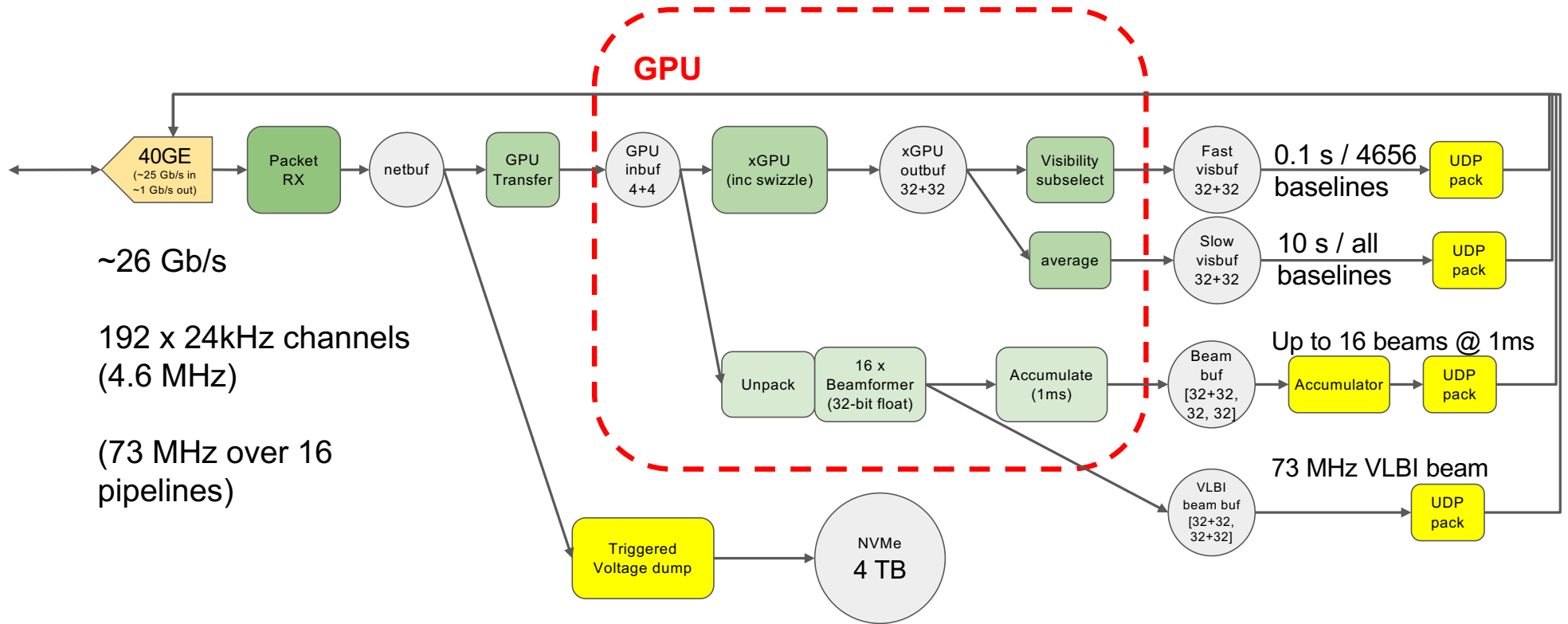
Cosmic Ray
Triggers / data

40 Gb Ethernet output
(4+4 bit; channelized @
24kHz)

Credit: Jack Hickish

Silicon Mechanics Rackform R353.v7

GPU: 2 x PNY NVIDIA GeForce RTX 2080 Ti Blower Edition

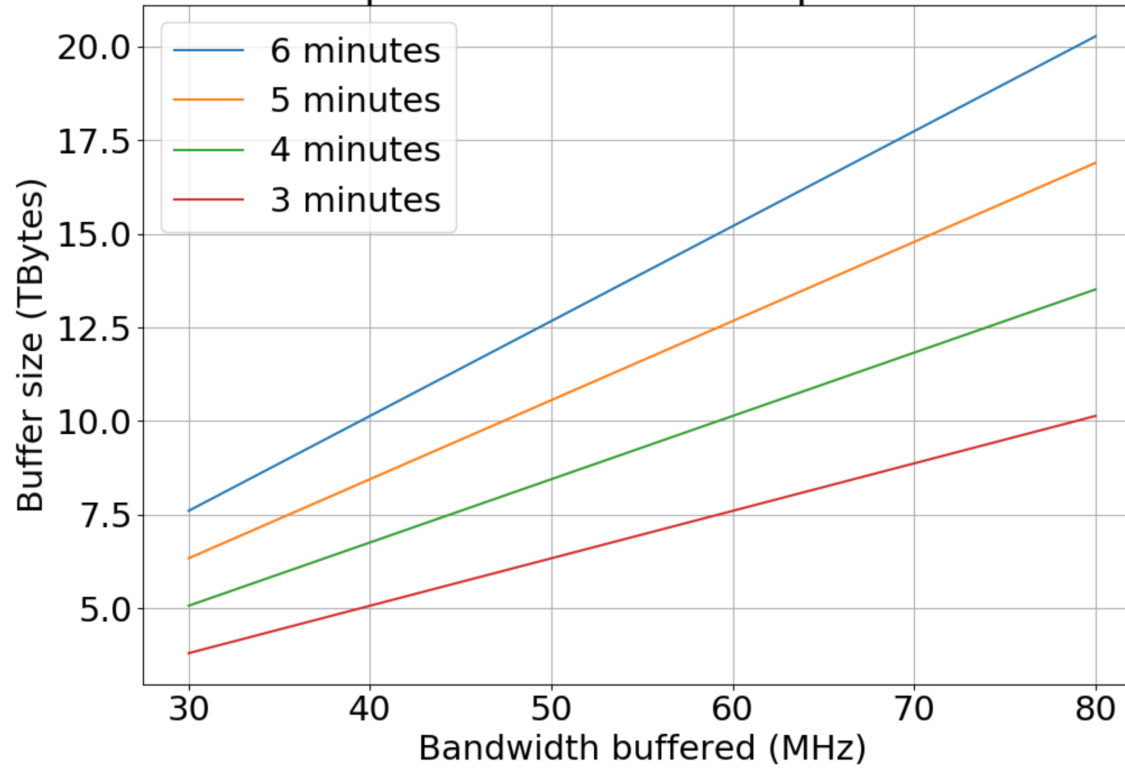


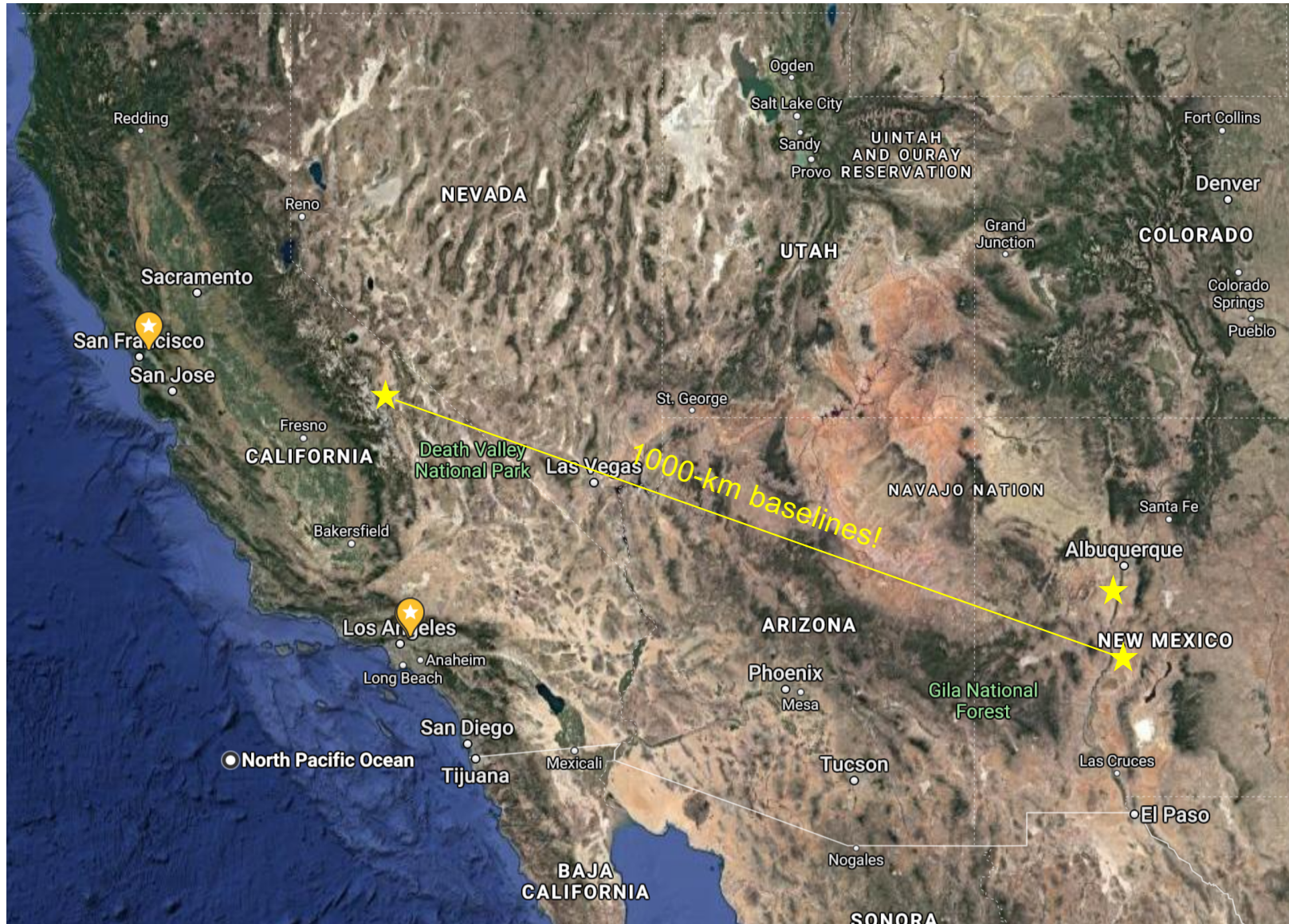
>20 minute post-trig buffer (6 TB RAM)

~2 minute pre-trig buffer (60 TB NVMe SSD)

Credit: Jack Hickish

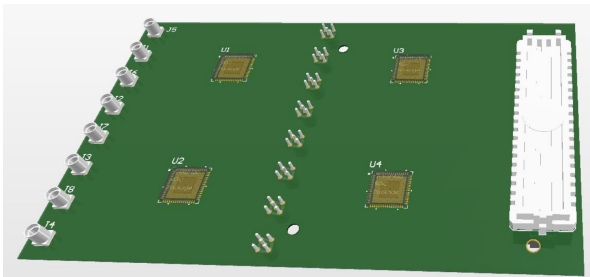
Buffer Requirements for 704 inputs at 4+4 bits





Status

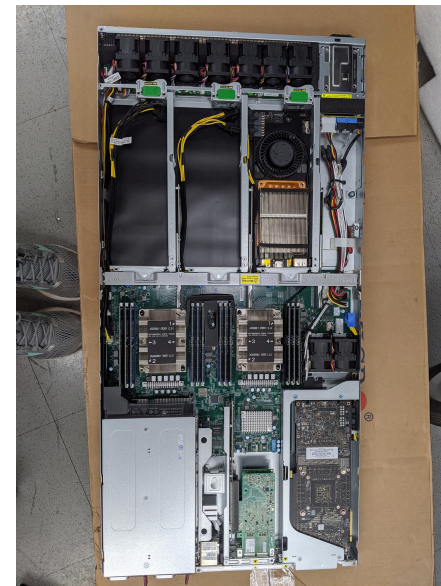
**Prototype ADC
boards ordered**



**13 SNAP2 boards at
Caltech**

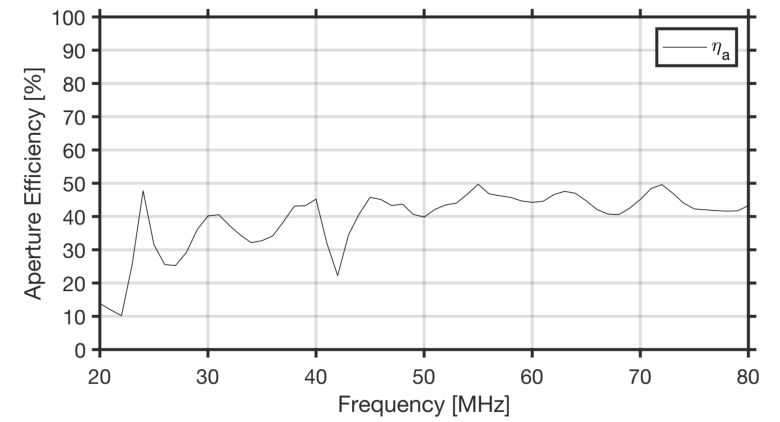
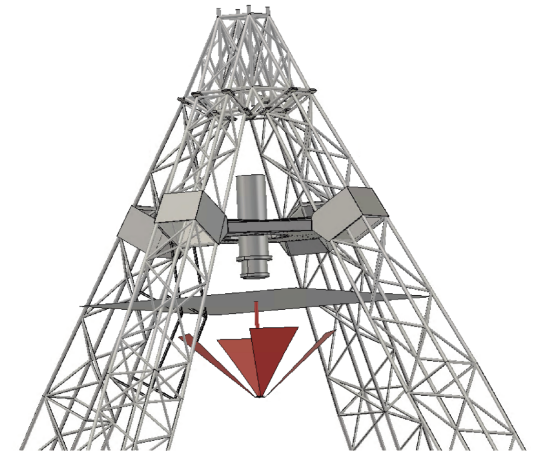


**GPU Servers
First test server at
Caltech**

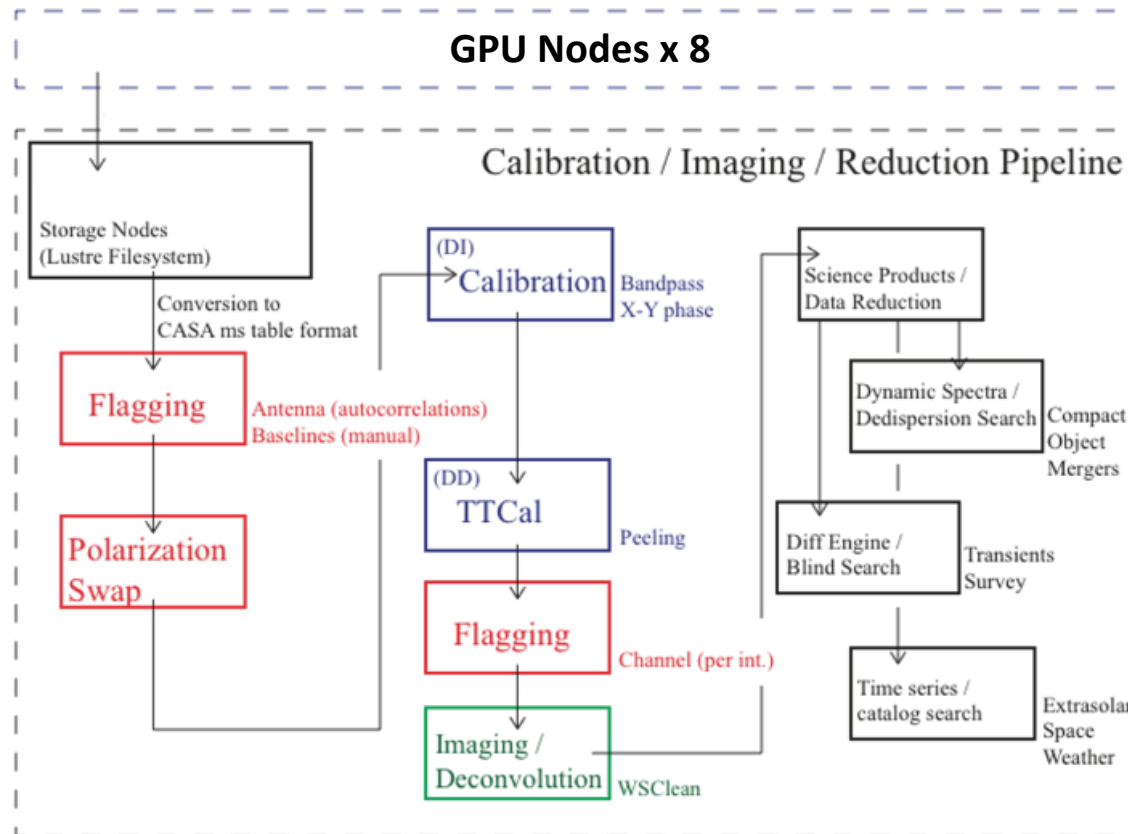


Credit: Kathryn Plant

40m LWA-band Antenna



Calibration and Imaging (Cal-Im)



Credit: Marin Anderson

Pipeline is an evolution of existing system
Workflow migrated to Celery on RabbitMQ (led by Yuping Huang)
~1000 cores, ~10 TB RAM, 5 PB storage (enables continuous operation)

Summary

- 2-year upgrade underway
 - Addition of 64 antennas to 2.4 km baselines
 - New receiver boards
 - New 704-input digital backend, 12x beam-former, real-time cosmic-ray detection, voltage buffer
 - Large compute cluster, 5PB storage and significant pipeline development
 - 40m dish LWA-band feed for dipole holography
-
- PDR complete!
 - First light with the core and existing outriggers: late 2020
 - First light with full array: 2021