The LEDA Correlators

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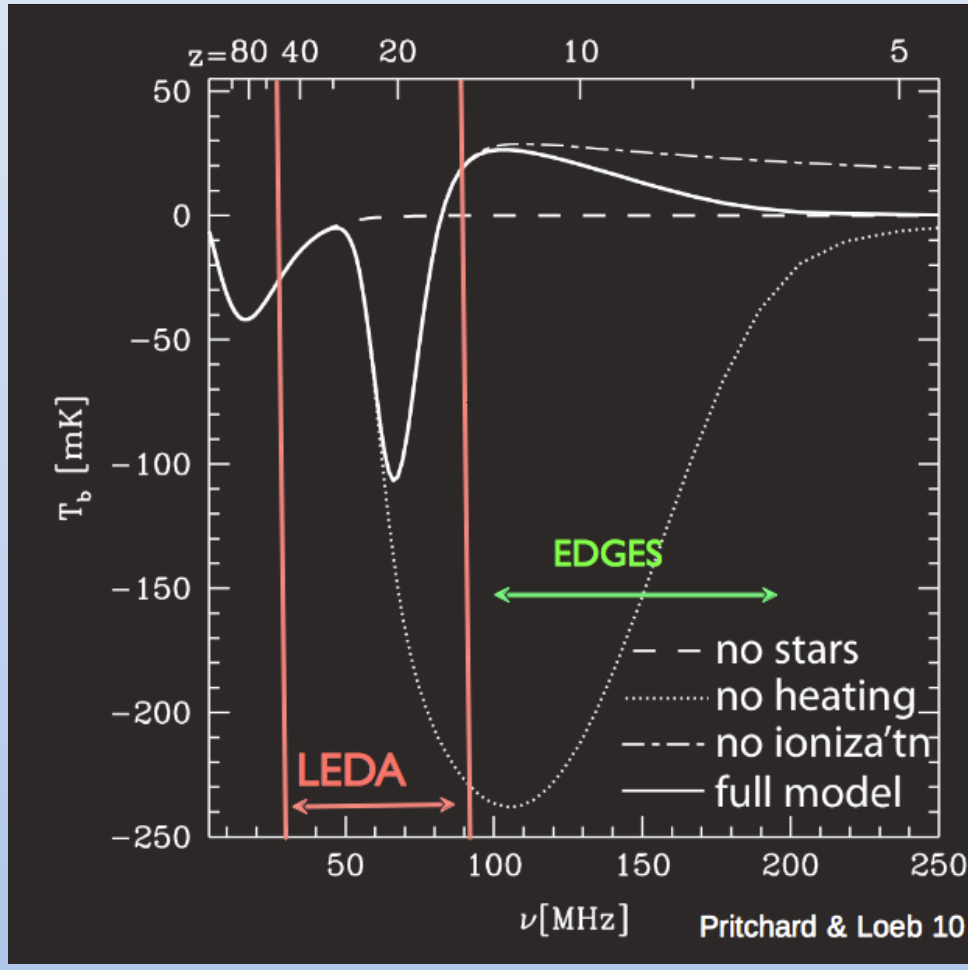
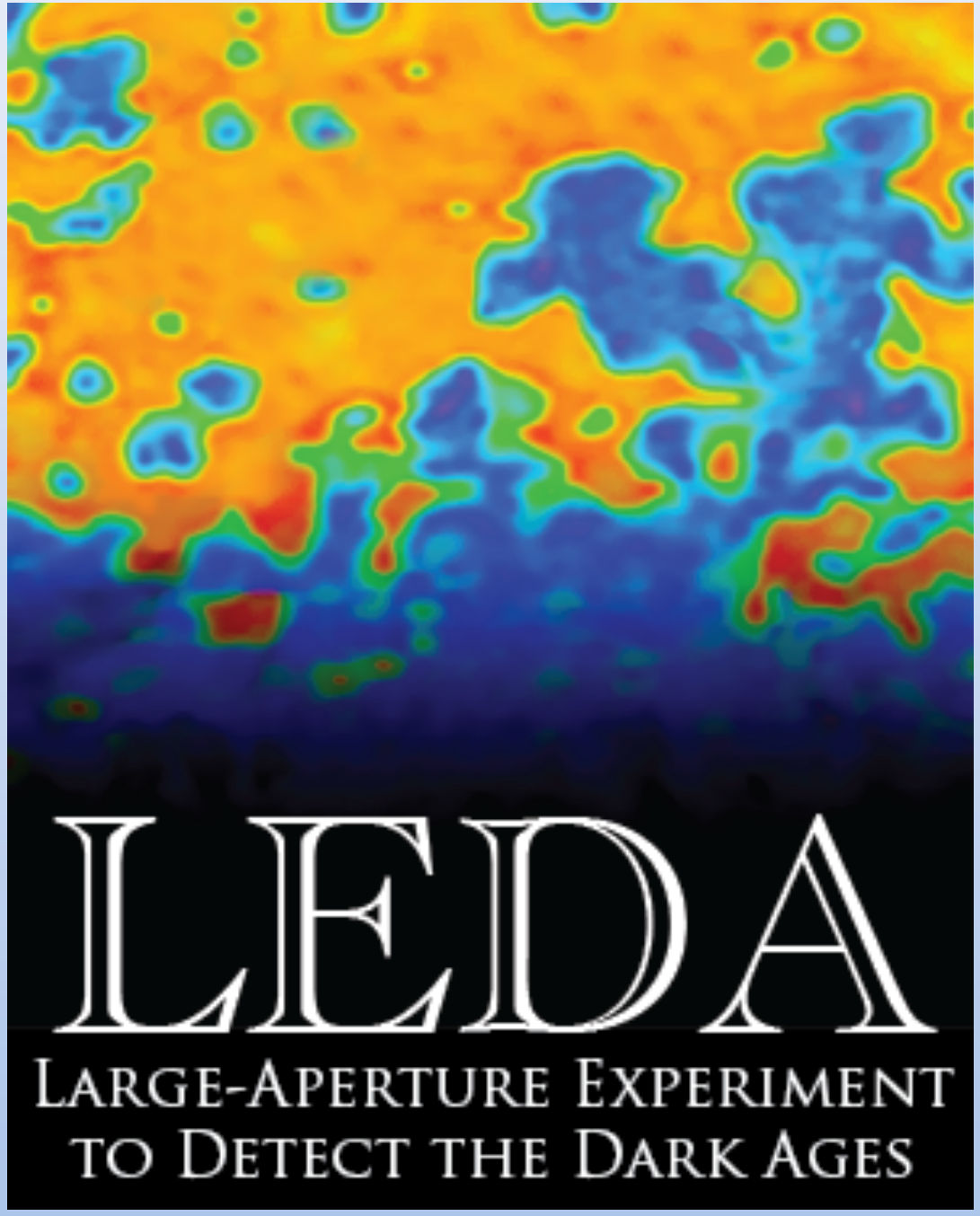
LEDA Summary

- Discovery of the HI absorption feature to infer the initial conditions of reionization (see following talk!)
- Implementing a full correlation backend for LWA installations (N=512, 100MHz BW)
- Demonstrate a large-N correlator
  - A scalable design (O~1000's inputs)





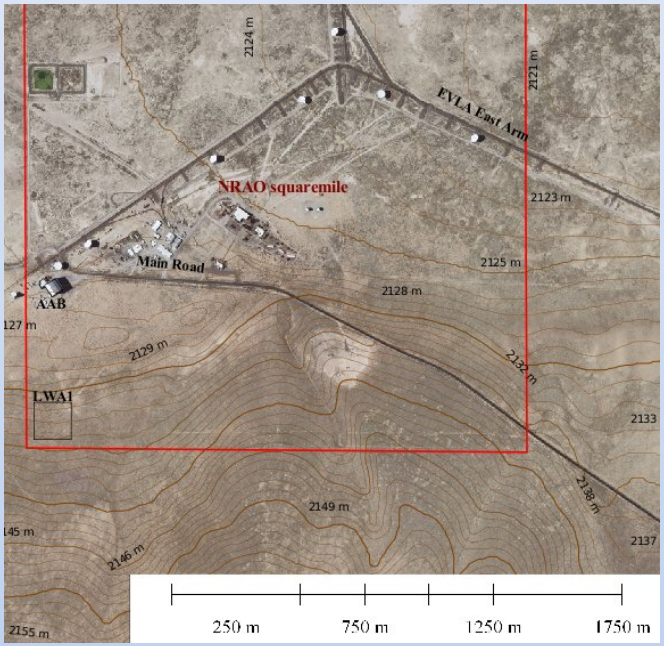
Correlator Deployment Schedule:

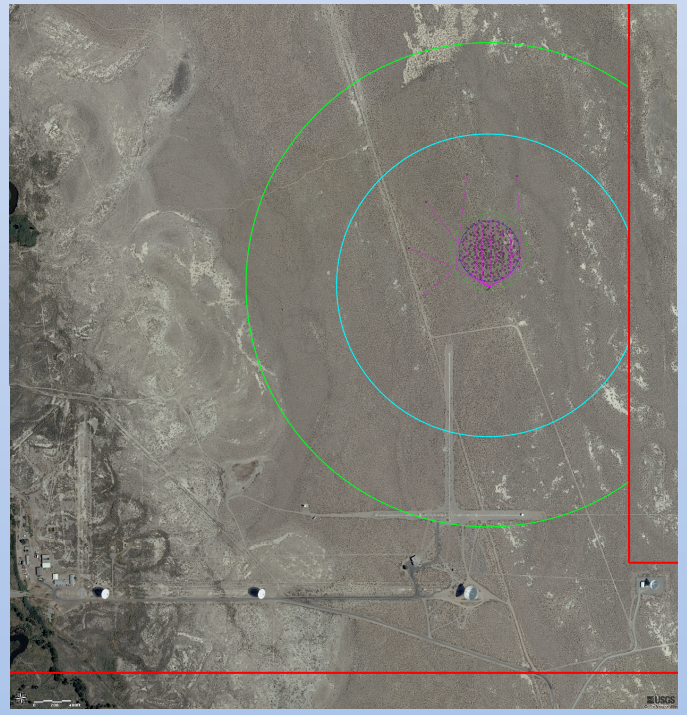
- LEDA-32 August 2012
- LEDA-64 February 2013
- LEDA-512 August 2013

LEDA Correlators

LWA1:

- 27 LWA antennas
- 5 outriggers

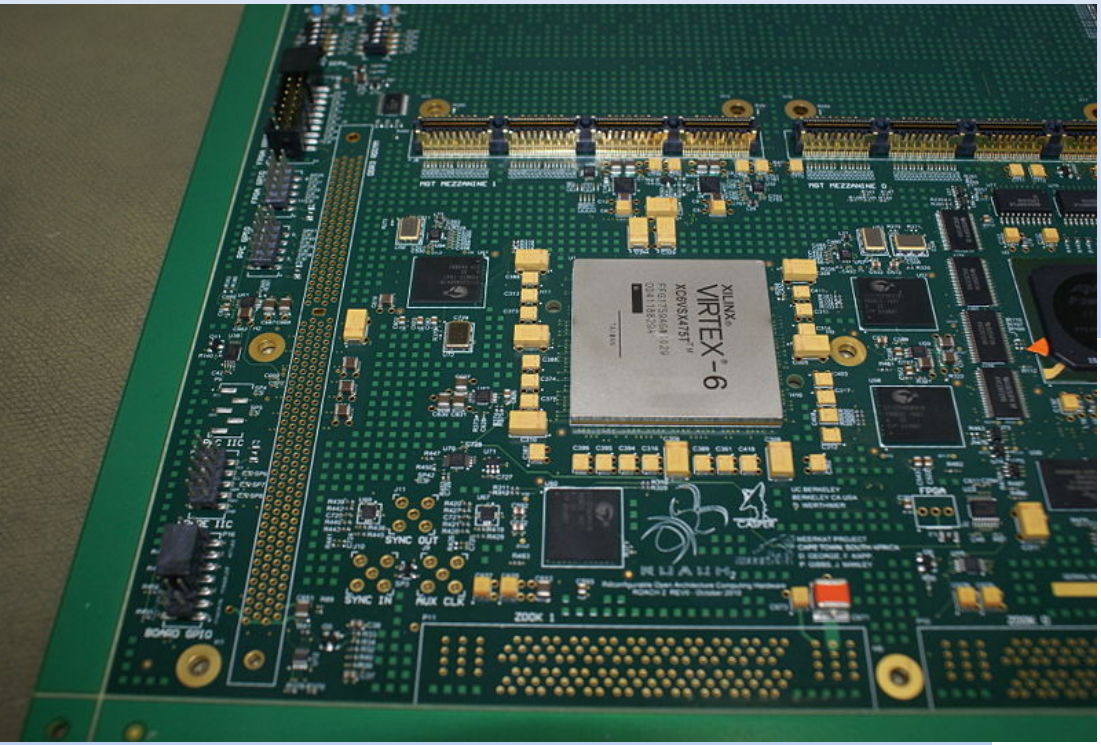




LWA-OVRO

- 251 LWA antennas
- 5 outriggers

Correlator – Hybrid Design



LEDA-64: LWA1

FPGA:

2 x ROACH2
4 x 16-input ADCs
(64 inputs total)

Performs:

PFB (4096 channels)
Channel Selection (2400 channels)
10GbE packetisation

→

CPU:

2 x 8-core
2 x 10GbE inputs
Receiving 14.7 Gb/s

Performs:

Data capture
Data unpacking

→

GPU:

Dual GeForce GTX690
Read ~7.35 Gb/s per core

Performs:

Cross-multiplication
Time pre-averaging of output
Total power calculation

LEDA-64: LWA-OVRO

FPGA:

2 x ROACH2
4 x 16-input ADCs
(64 inputs total)

Performs:

PFB (4096 channels)
Channel Selection (2400 channels)
10GbE packetisation

→

CPU:

2 x 8-core
1 x 40GbE inputs
Receiving 14.7 Gb/s

Performs:

Data capture
Data unpacking

→

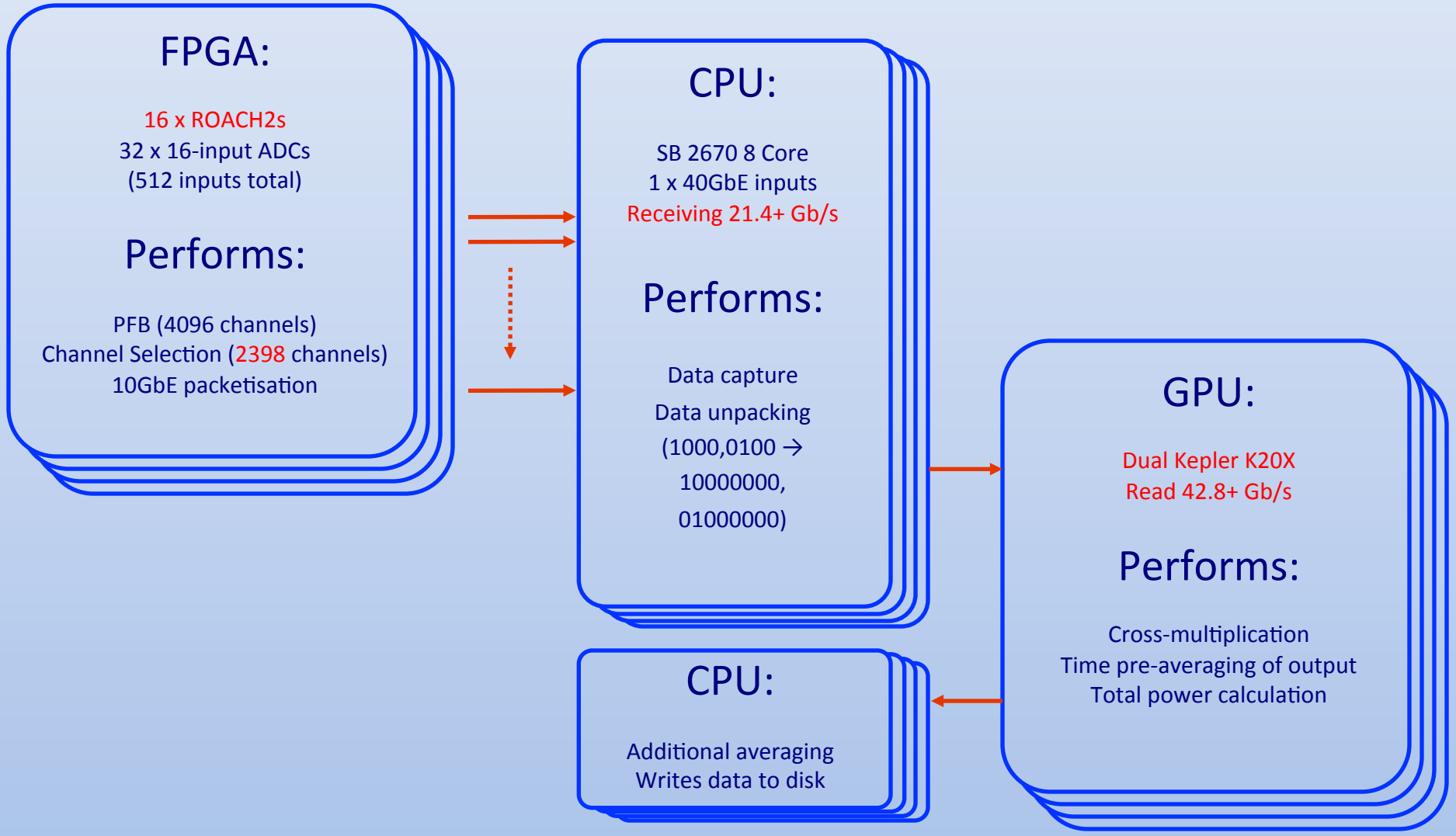
GPU:

Kepler K10
Read ~14.7 Gb/s per core

Performs:

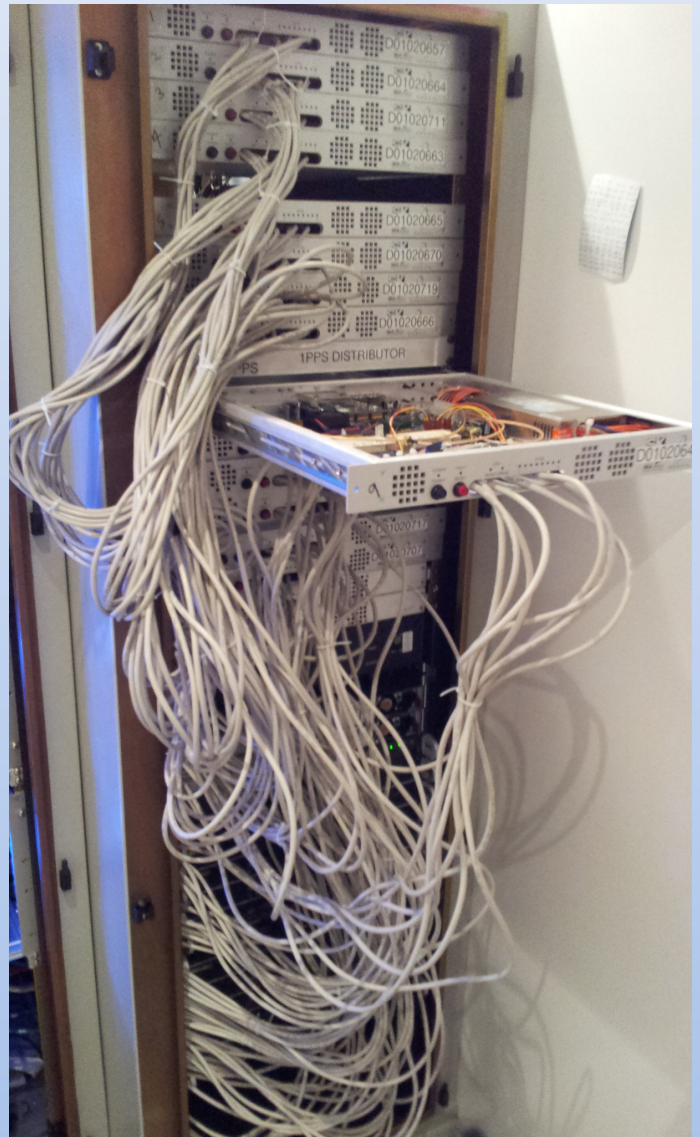
Cross-multiplication
Time pre-averaging of output
Total power calculation

LEDA-512


FPGA:
16 x ROACH2s
32 x 16-input ADCs
(512 inputs total)
Performs:
PFB (4096 channels)
Channel Selection (2398 channels)
10GbE packetisation
CPU:
SB 2670 8 Core
1 x 40GbE inputs
Receiving 21.4+ Gb/s
Performs:
Data capture
Data unpacking
(1000,0100 →
10000000,
01000000)
GPU:
Dual Kepler K20X
Read 42.8+ Gb/s
Performs:
Cross-multiplication
Time pre-averaging of output
Total power calculation
CPU:
Additional averaging
Writes data to disk

LEDA-512

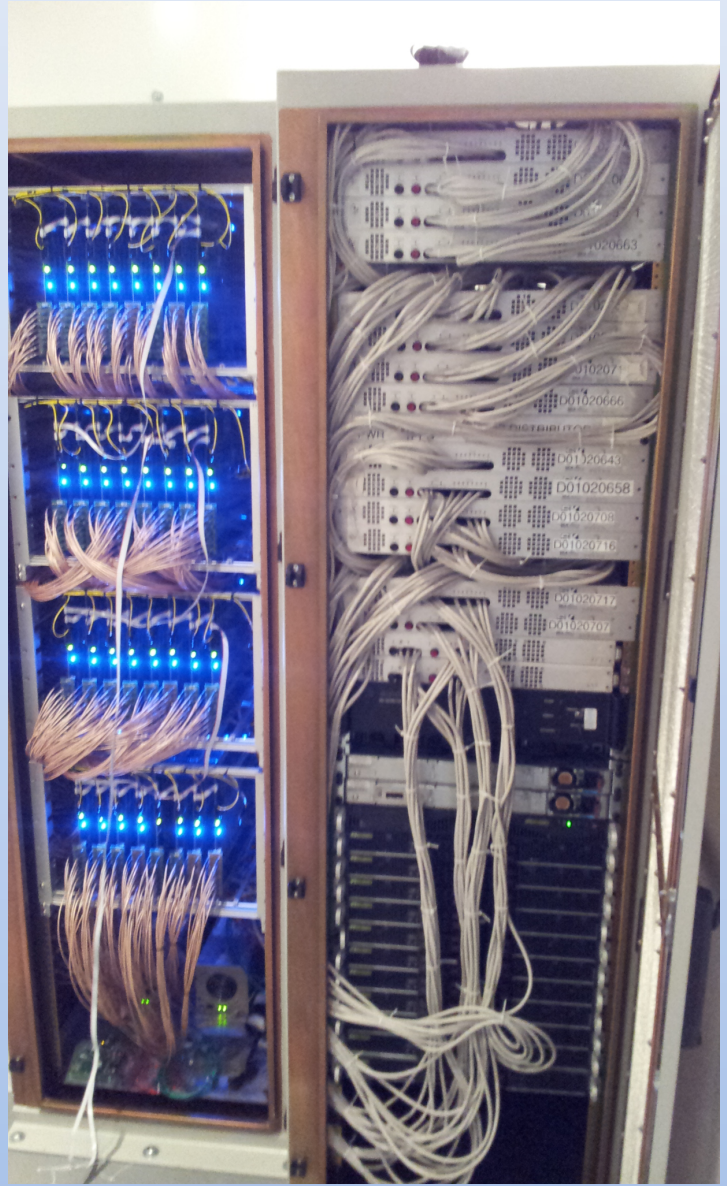
LEDA-512

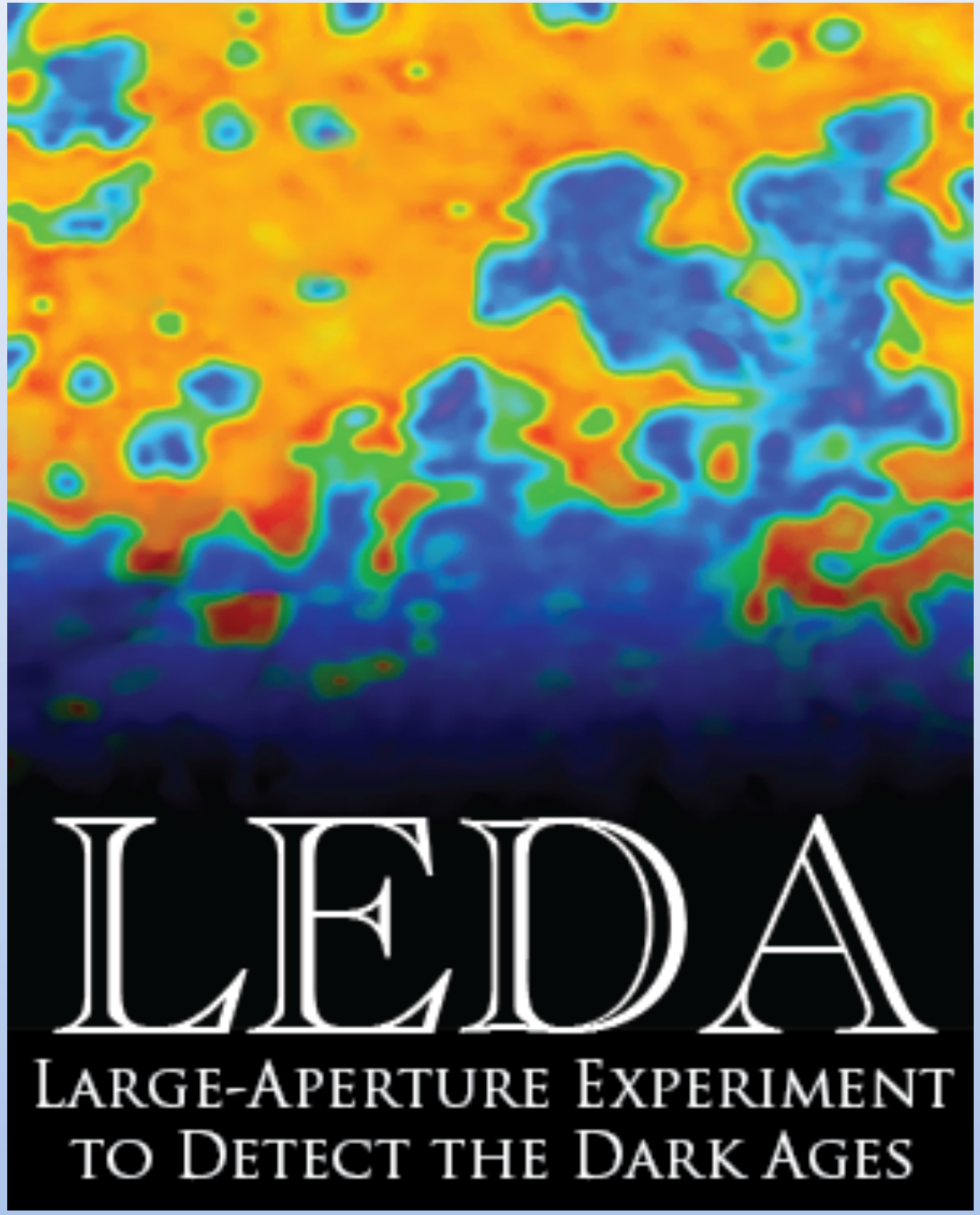


Resources

Power consumption @ Peak:

- FPGA/Switch:
  - 9.5A
  - 1648W
- GPU servers:
  - 35A (Estimated)
  - 7370W
- Total estimated:
  - 44.5A
  - 9018W





Correlator Deployment Schedule:

- LEDA-32 August 2012 ✓
  - 36 hrs
- LEDA-64 ~~February~~ June 2013 ✓
  - 7 days & 3 days
- LEDA-512 August 2013✓
  - 5 days

What can we deliver?

OVRO:

- Output of 512 antennas
- Correlator dump times of 2 seconds
- Total power (single dual pol, or multiple cycling antennas)
- Low duty cycle:
  - Raw ADC output
  - Unaveraged FFT output
  - Correlator output at 41us

LWA1:

- Output of 64 antennas
- Correlator dump times of 1 second
- Total power (single dual pol, or multiple cycling antennas)

Control & Visualization

Control | Monitor

LEDA
LARGE-APERTURE EXPERIMENT TO DETECT THE DARK AGES

Control

Start | Stop | Kill

Record total power (interval= 100)

ROACHes | Buffers

Pipeline status

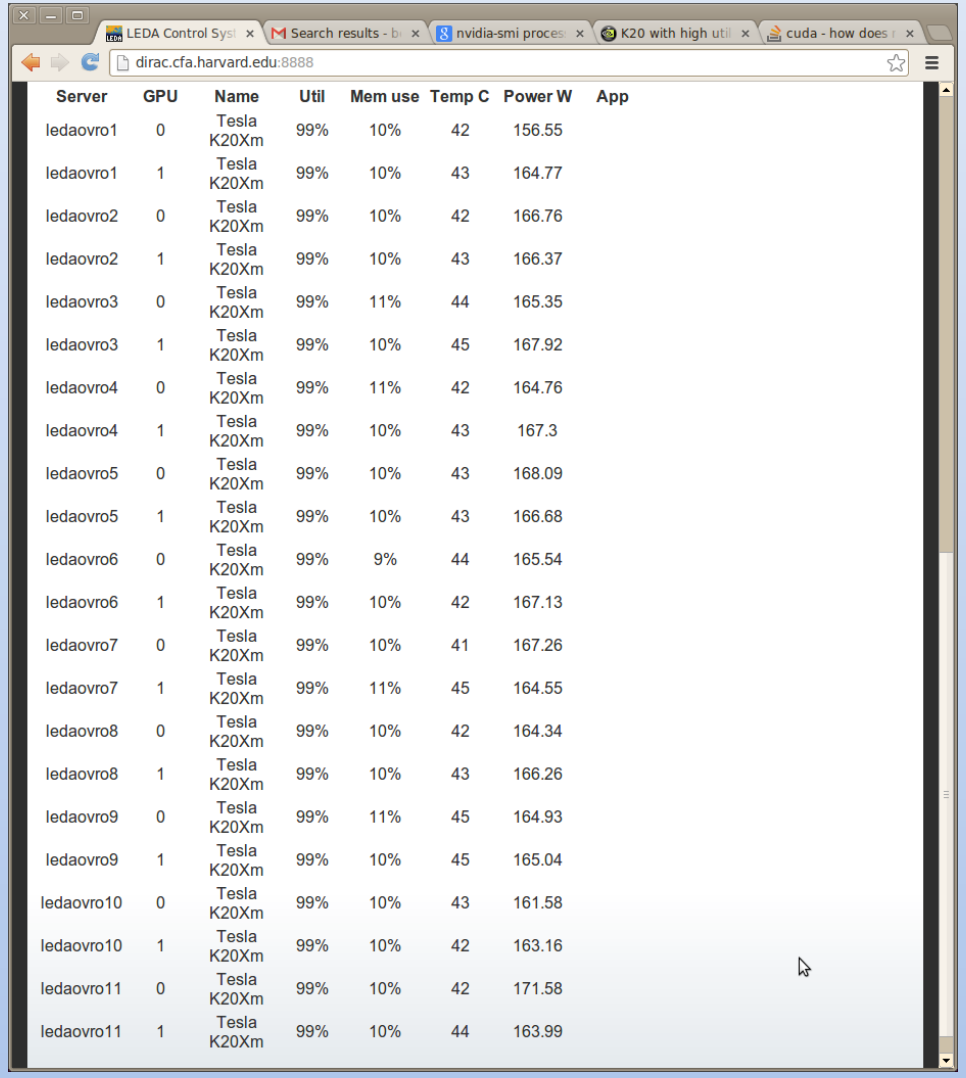
Head node	Alive	Control
ledaovro	✓	✓

Roach	Flow
1	✓
2	✓
3	✓
4	✓
5	✓
6	✓
7	✓
8	✓
9	✓
10	✓
11	✓
12	✓
13	✓
14	✓
15	✓
16	✓

Server	Stream	Buffers	Capture	Unpack	X-engine	Disk	Disk use	Recv Gb/s	Drop MB/s	Lost pkts
ledaovro1	1	✓	✓	✓	✓	✓	4%	10.716	0	0
ledaovro1	2	✓	✓	✓	✓	✓	3%	10.715	0	0
ledaovro2	1	✓	✓	✓	✓	✓	3%	10.716	0	0
ledaovro2	2	✓	✓	✓	✓	✓	3%	10.716	0	0
ledaovro3	1	✓	✓	✓	✓	✓	2%	10.716	0	0
ledaovro3	2	✓	✓	✓	✓	✓	2%	10.716	0	0
ledaovro4	1	✓	✓	✓	✓	✓	2%	10.715	0	0
ledaovro4	2	✓	✓	✓	✓	✓	2%	10.715	0	0
ledaovro5	1	✓	✓	✓	✓	✓	2%	10.716	0	0
ledaovro5	2	✓	✓	✓	✓	✓	2%	10.716	0	0
ledaovro6	1	✓	✓	✓	✓	✓	2%	10.716	0	0
ledaovro6	2	✓	✓	✓	✓	✓	2%	10.716	0	0
ledaovro7	1	✓	✓	✓	✓	✓	2%	10.716	0	0
ledaovro7	2	✓	✓	✓	✓	✓	2%	10.715	0	0
ledaovro8	1	✓	✓	✓	✓	✓	2%	10.716	0	0
ledaovro8	2	✓	✓	✓	✓	✓	2%	10.716	0	0
ledaovro9	1	✓	✗	✓	✓	✓	2%	?	?	?
ledaovro9	2	✓	✗	✓	✓	✓	2%	?	?	?
ledaovro10	1	✓	✓	✓	✓	✓	2%	10.716	0	0
ledaovro10	2	✓	✓	✓	✓	✓	2%	10.716	0	0
ledaovro11	1	✓	✓	✓	✓	✓	2%	10.716	0	0
ledaovro11	2	✓	✓	✓	✓	✓	2%	10.716	0	0

(Barsdell)

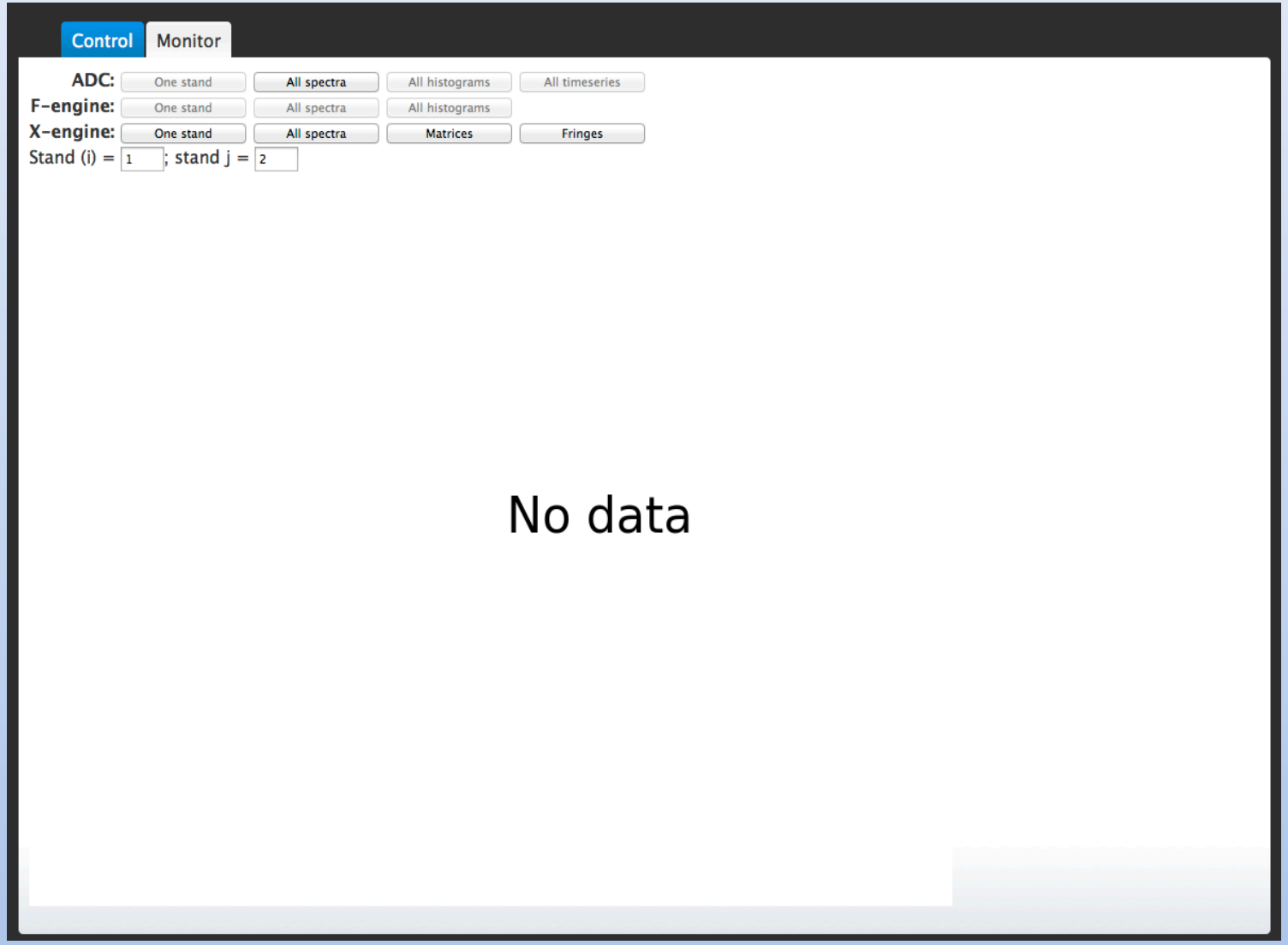
Control & Visualization



Server	GPU	Name	Util	Mem use	Temp C	Power W	App
ledaovro1	0	Tesla K20Xm	99%	10%	42	156.55	
ledaovro1	1	Tesla K20Xm	99%	10%	43	164.77	
ledaovro2	0	Tesla K20Xm	99%	10%	42	166.76	
ledaovro2	1	Tesla K20Xm	99%	10%	43	166.37	
ledaovro3	0	Tesla K20Xm	99%	11%	44	165.35	
ledaovro3	1	Tesla K20Xm	99%	10%	45	167.92	
ledaovro4	0	Tesla K20Xm	99%	11%	42	164.76	
ledaovro4	1	Tesla K20Xm	99%	10%	43	167.3	
ledaovro5	0	Tesla K20Xm	99%	10%	43	168.09	
ledaovro5	1	Tesla K20Xm	99%	10%	43	166.68	
ledaovro6	0	Tesla K20Xm	99%	9%	44	165.54	
ledaovro6	1	Tesla K20Xm	99%	10%	42	167.13	
ledaovro7	0	Tesla K20Xm	99%	10%	41	167.26	
ledaovro7	1	Tesla K20Xm	99%	11%	45	164.55	
ledaovro8	0	Tesla K20Xm	99%	10%	42	164.34	
ledaovro8	1	Tesla K20Xm	99%	10%	43	166.26	
ledaovro9	0	Tesla K20Xm	99%	11%	45	164.93	
ledaovro9	1	Tesla K20Xm	99%	10%	45	165.04	
ledaovro10	0	Tesla K20Xm	99%	10%	43	161.58	
ledaovro10	1	Tesla K20Xm	99%	10%	42	163.16	
ledaovro11	0	Tesla K20Xm	99%	10%	42	171.58	
ledaovro11	1	Tesla K20Xm	99%	10%	44	163.99	

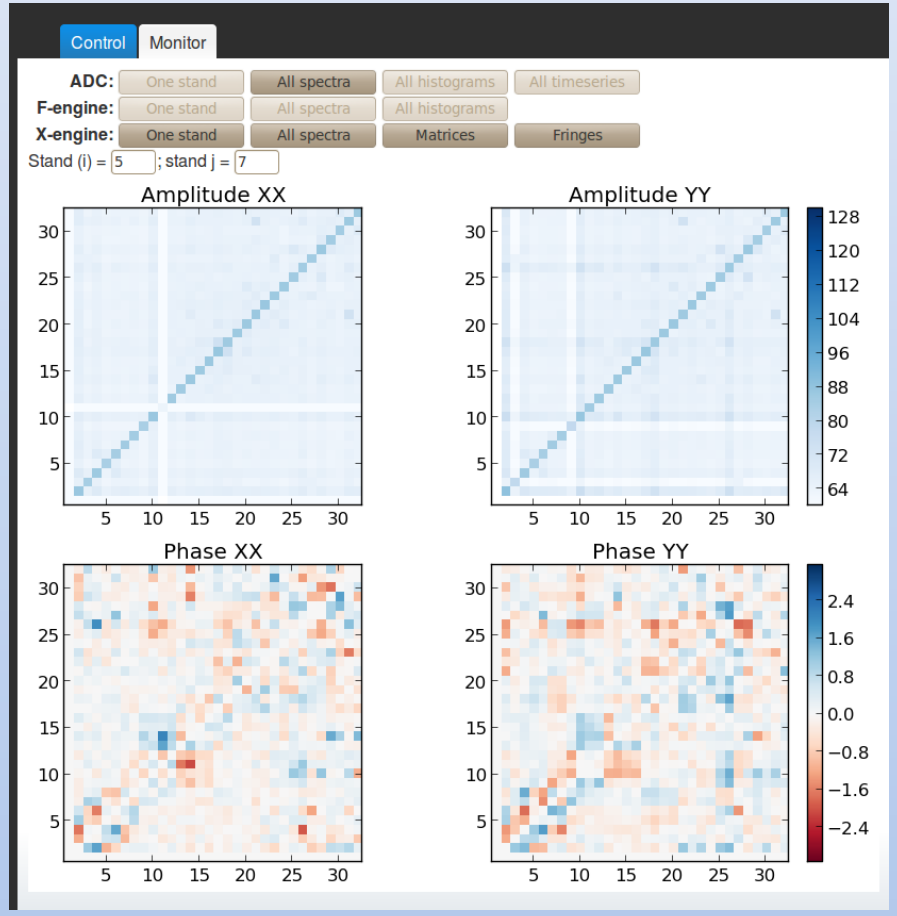
(Barsdell)

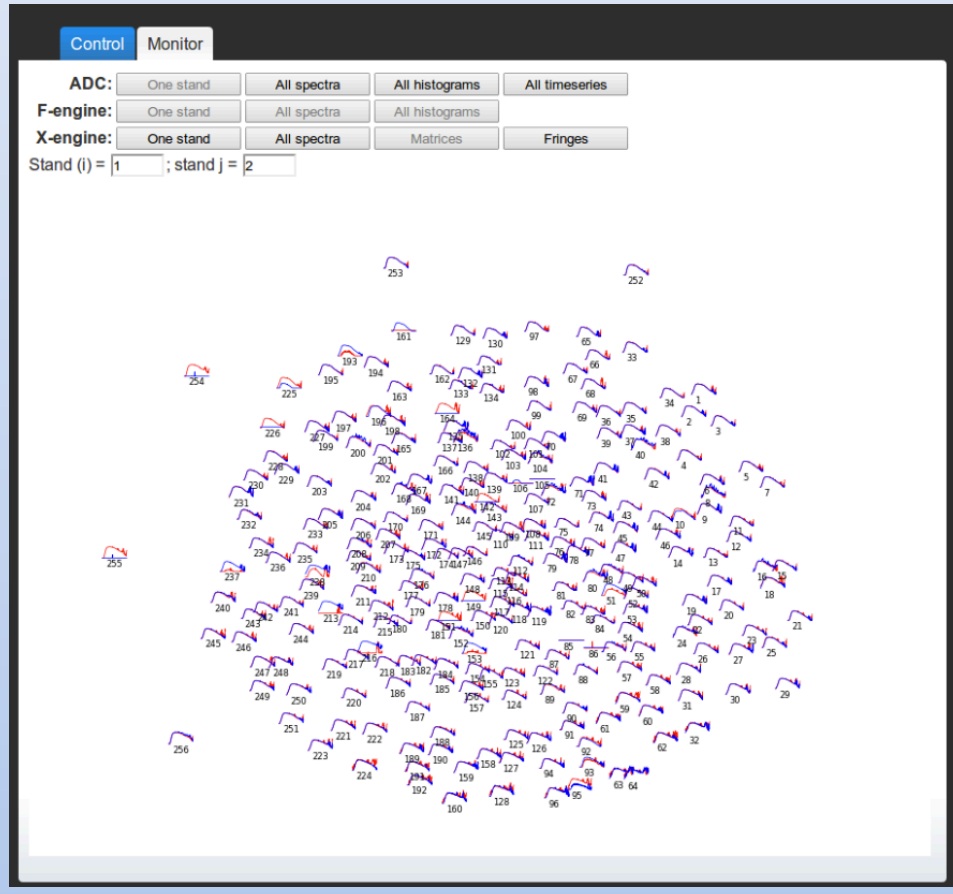
Control & Visualization



(Barsdell)

Control & Visualization





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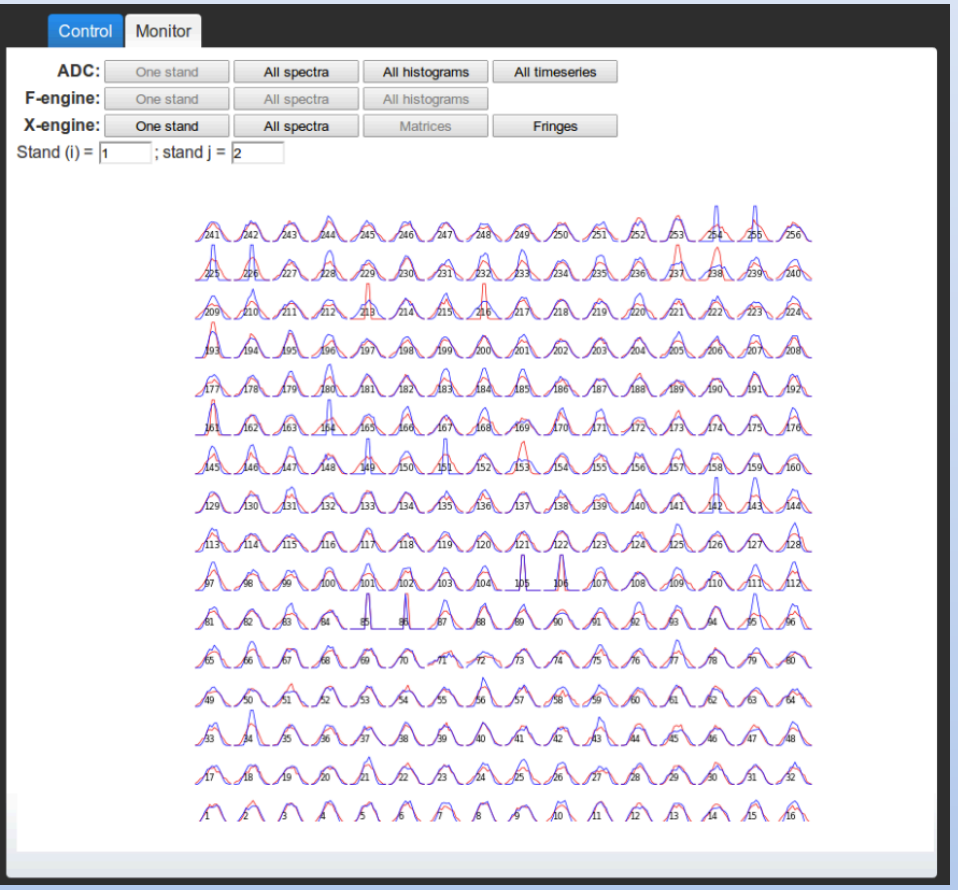
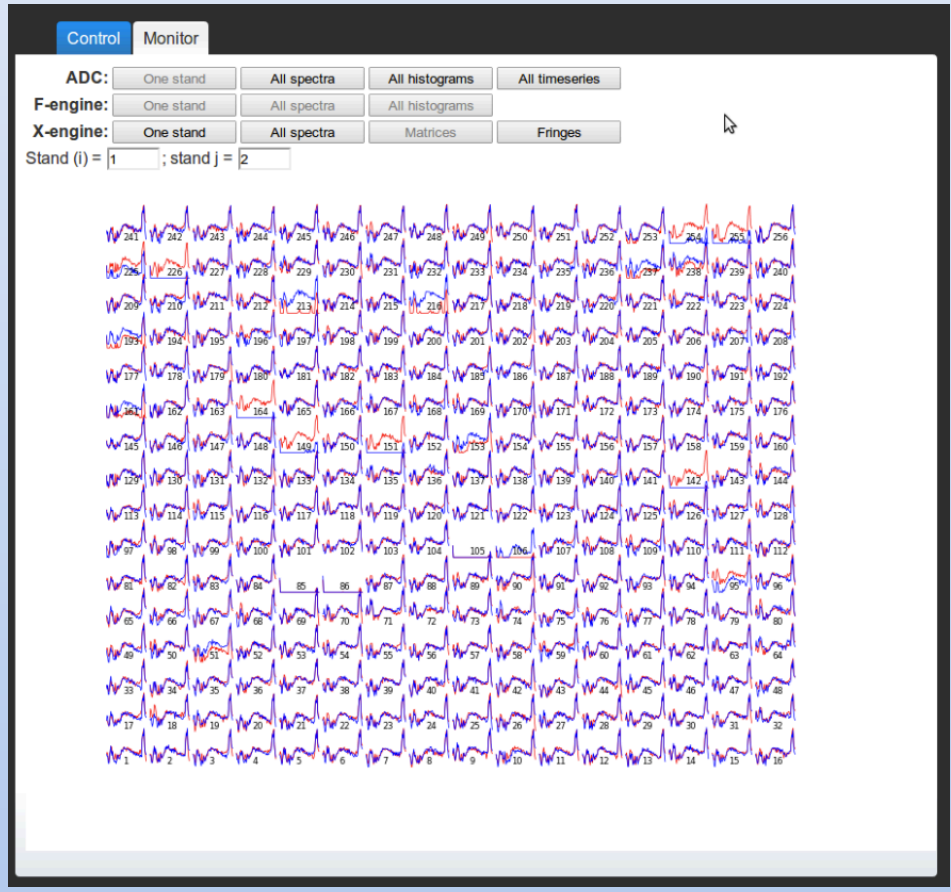
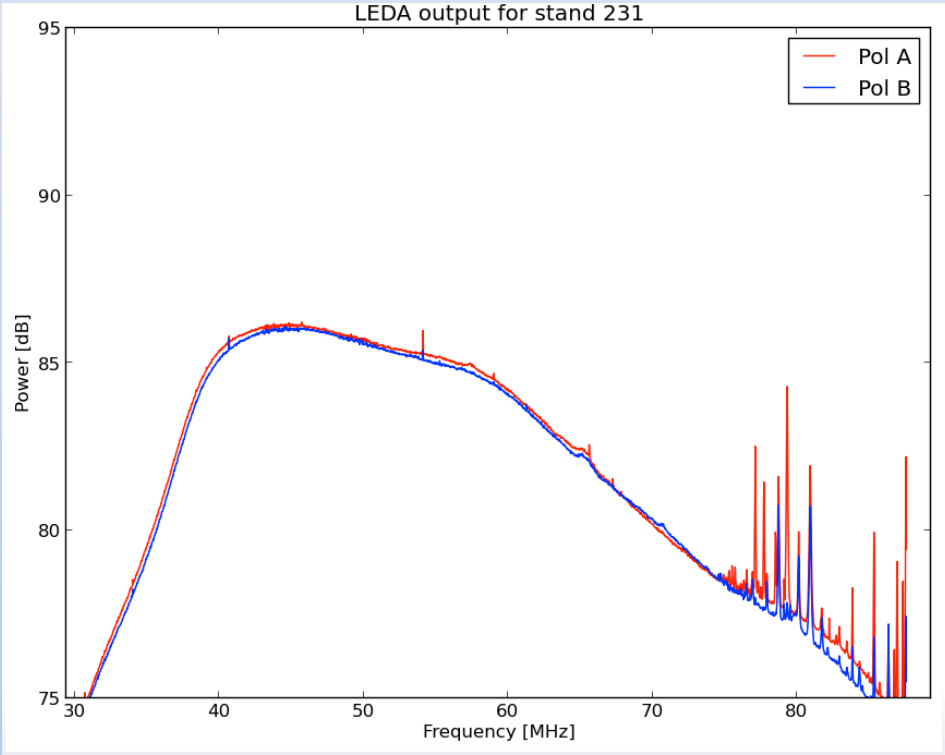
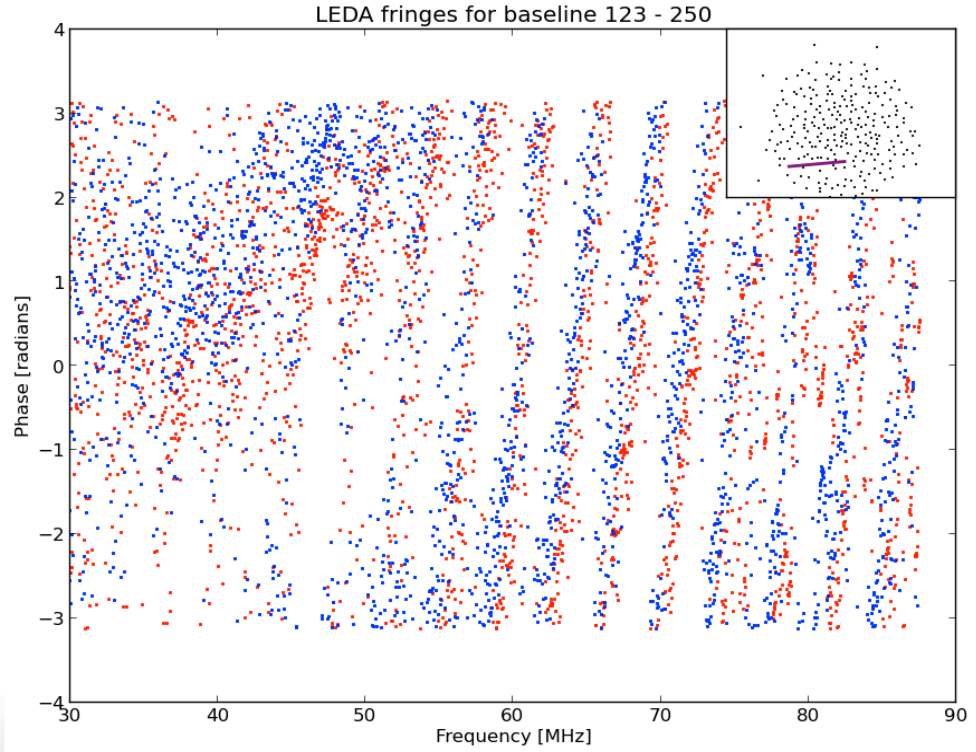




(Barsdell)

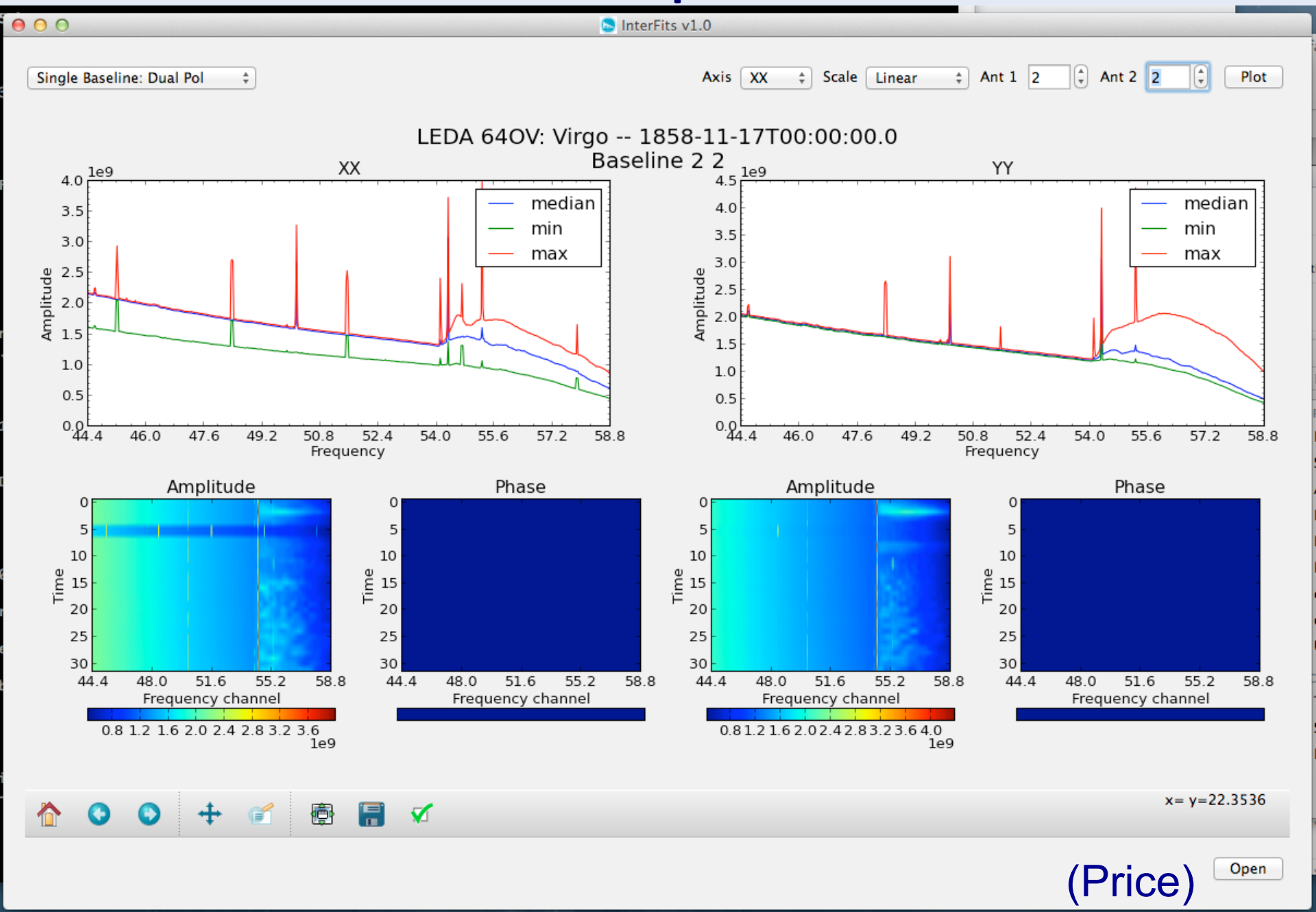
Control and Visualisation





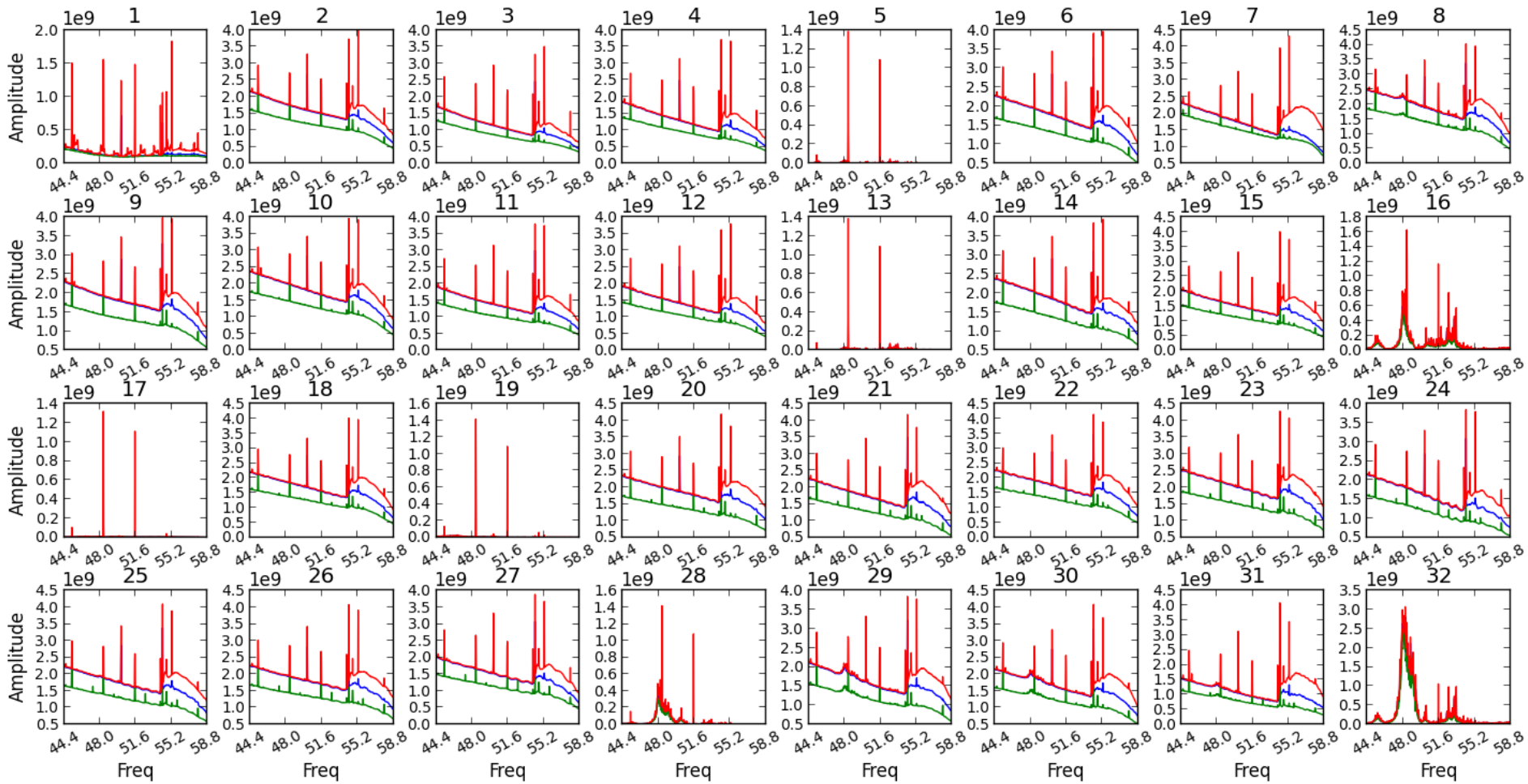
(Barsdell)

Data Inspection



(Price)

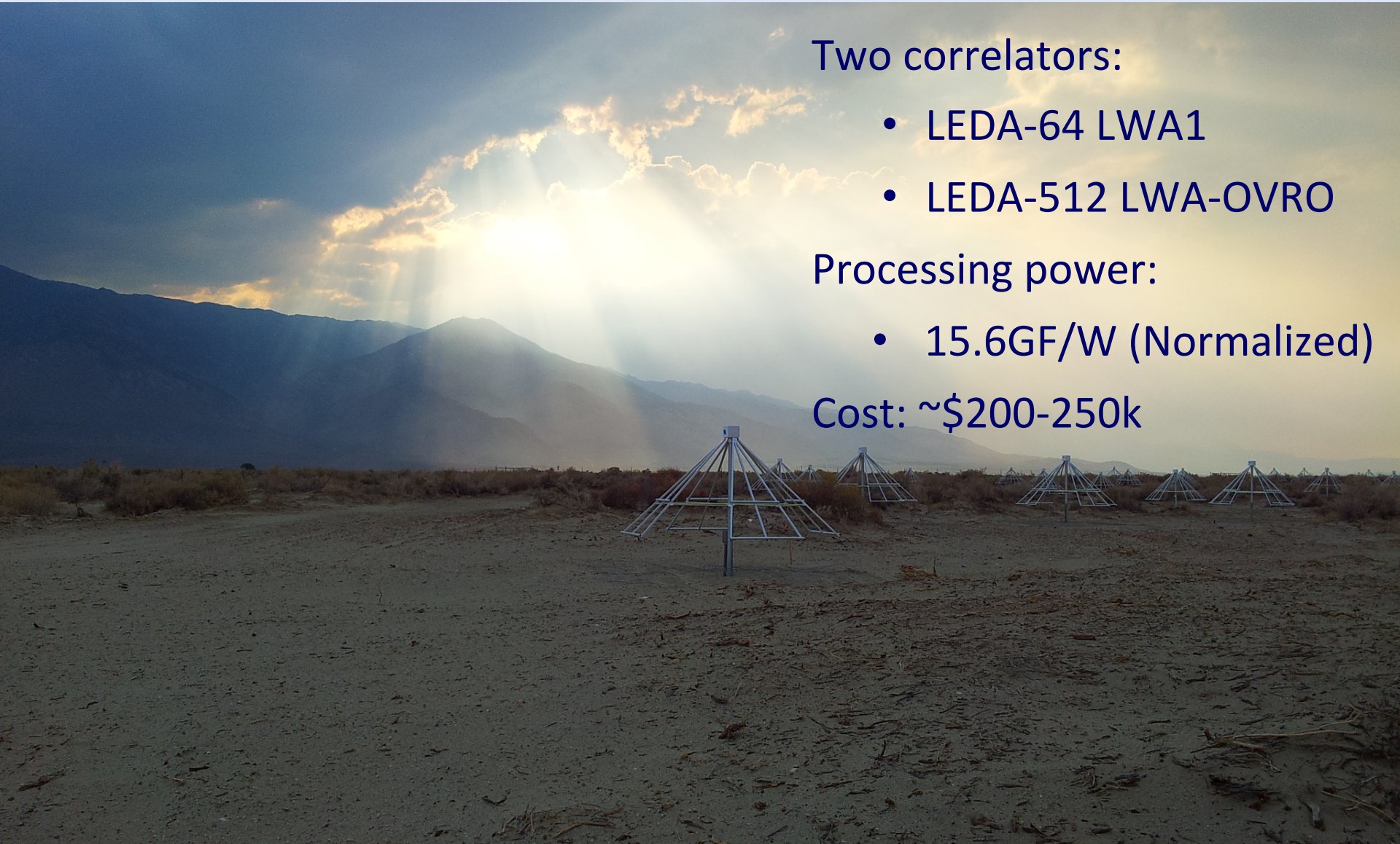
Data Inspection



(Price)

LEDA-512

LEDA-512



Two correlators:

- LEDA-64 LWA1
- LEDA-512 LWA-OVRO

Processing power:

- 15.6GF/W (Normalized)

Cost: ~$200-250k

– END –