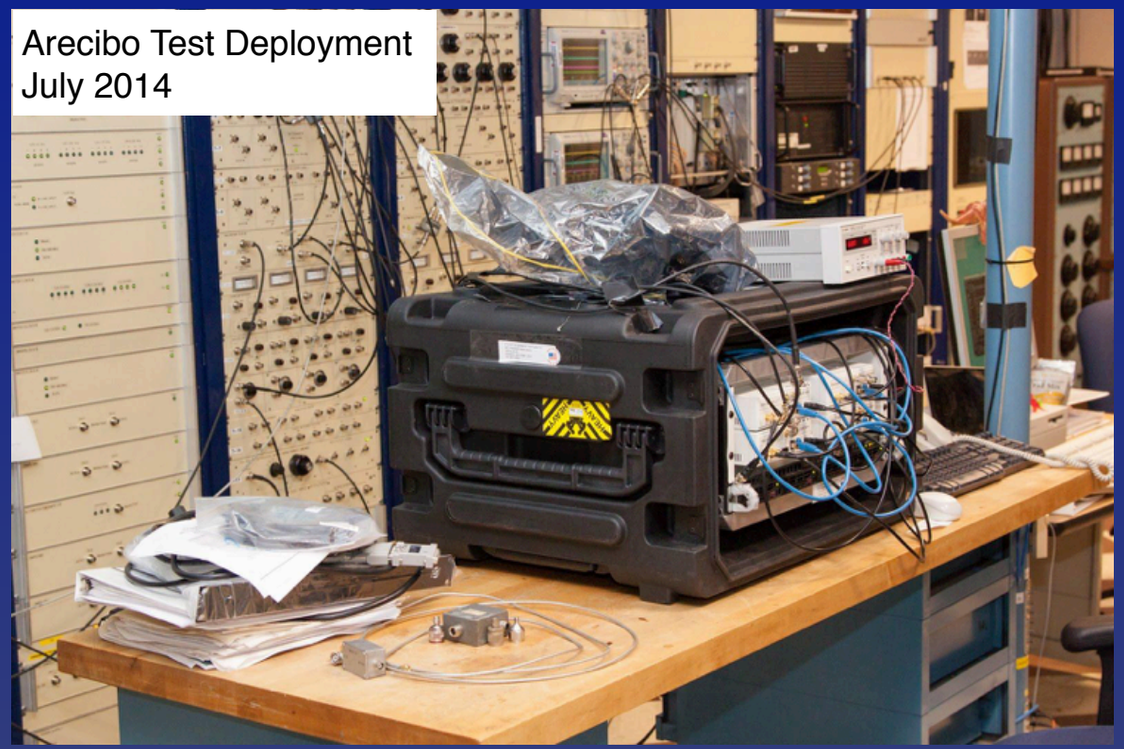
IS Radar Technical Development, Shared With The Community

Arecibo Test Deployment
July 2014



Nestor Aponte <naponte@naic.edu> Feb 23 (4 d

to Juha, Phil, Phil, Michael

Juha, Phil,

A very fruitful collaboration between you at MIT and Phil, Mike, Arun here.

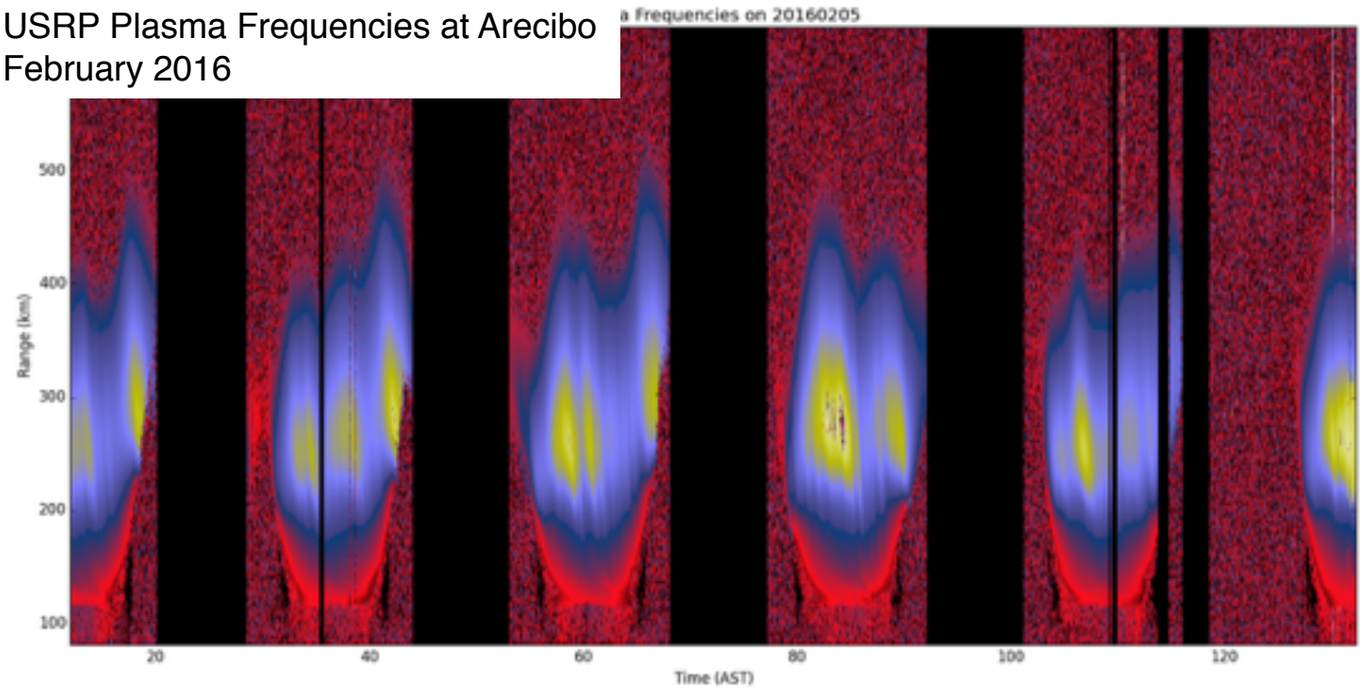
The february world day, was the first with continuous daytime usrp operation. Attached image of plasma line frequencies (up-shifted) for the whole world day.

>Gentlemen, a happy user of the usrp data would like to >acknowledge all your many efforts.

Thank you so much for bringing your system twice and then allowing Arecibo to use your software.

Regards,
nestor

First Full Production Run
USRP Plasma Frequencies at Arecibo
February 2016



Voltage Level Data Pattern

Voltages are the Fundamental Data
Handling Voltages Properly is Hard
Good Metadata is Critical for Use and Archival
Minimize Complexity Prior to A/D Converter
Universal Radio Signal Processing

METADATA
Pointing, Pattern
Calibration, etc...

METADATA
Gain, Switch Settings
Frequency Translations,
Filtering settings, etc...

METADATA
Converter Type
Performance,
Dynamic Range
Physical Scaling, etc...

Analog
Transfer
Function

A/D
Converter

Conversion
Coherence

Namespace
(implicit or
explicit)

Data Format
Transport
Layout

METADATA
Time Alignment
Trigger Alignment
Intervals, Stability, etc...

Digital
Transfer
Function(s)

Voltage
Data
Sequence(s)

Voltage
Representation

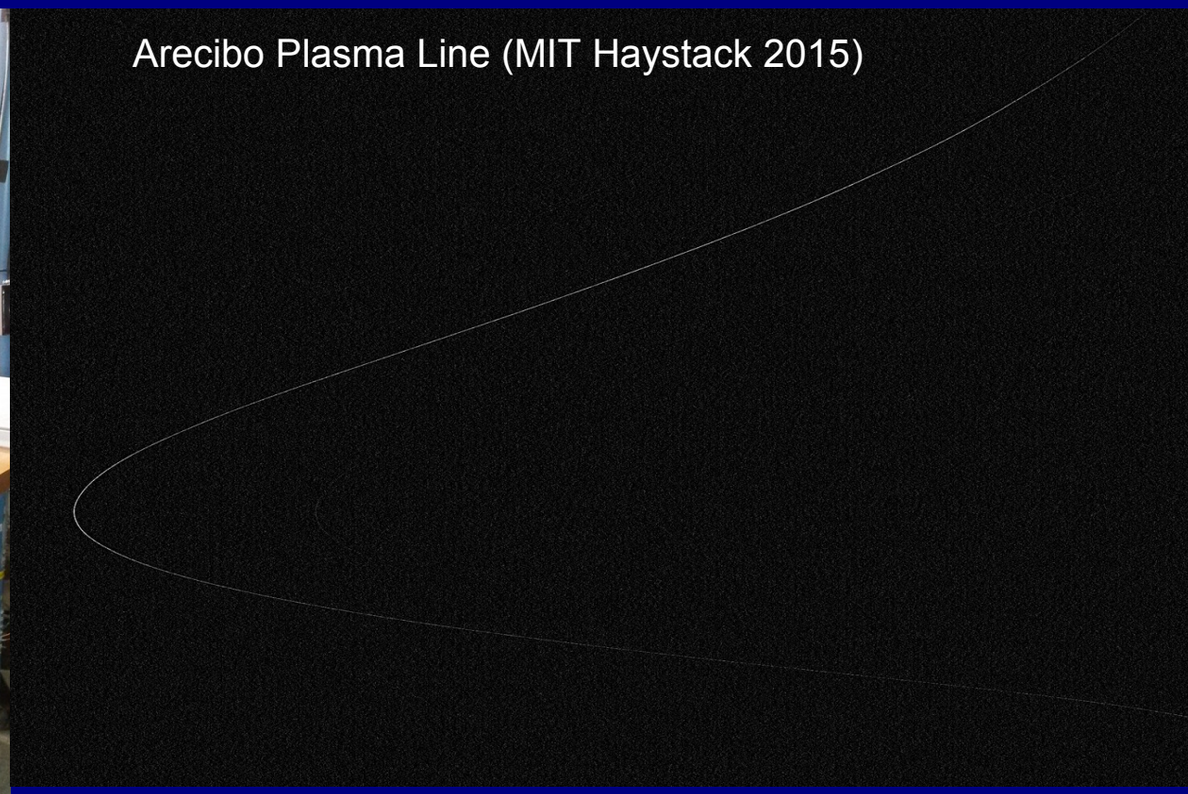
Transport
and/or
Persistence

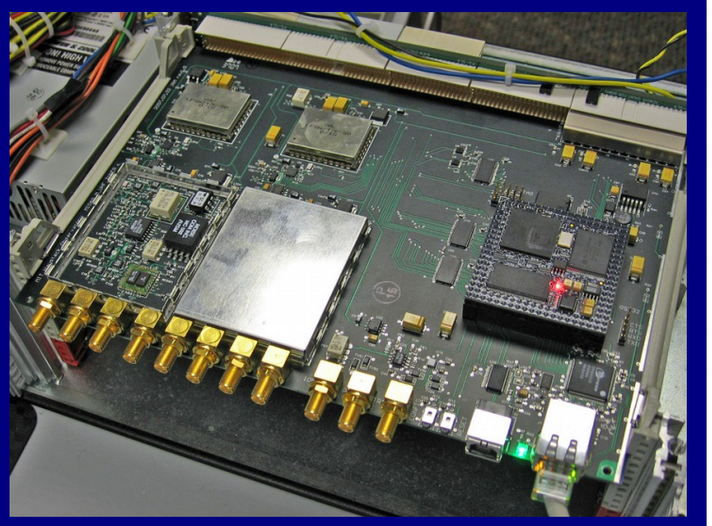
METADATA
Frequency Translations,
Filter Stages,
Filter Taps, Scaling,
etc...

METADATA
Sequence(s)

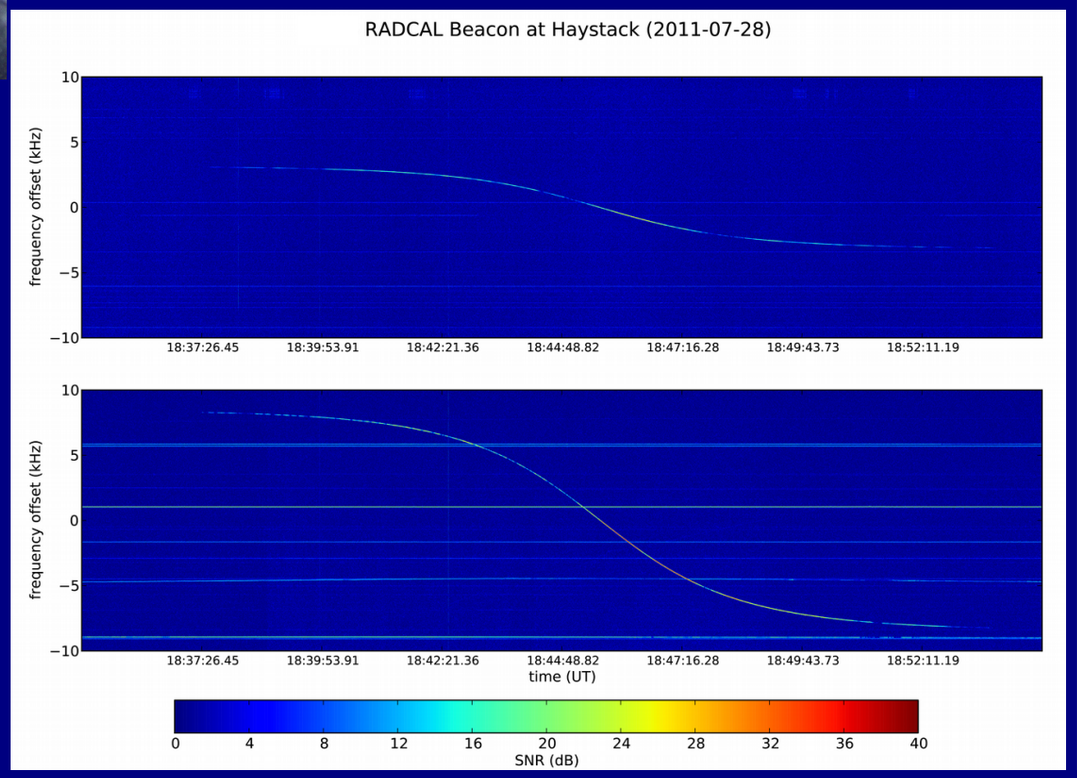
Data Format
Persistence
Layout

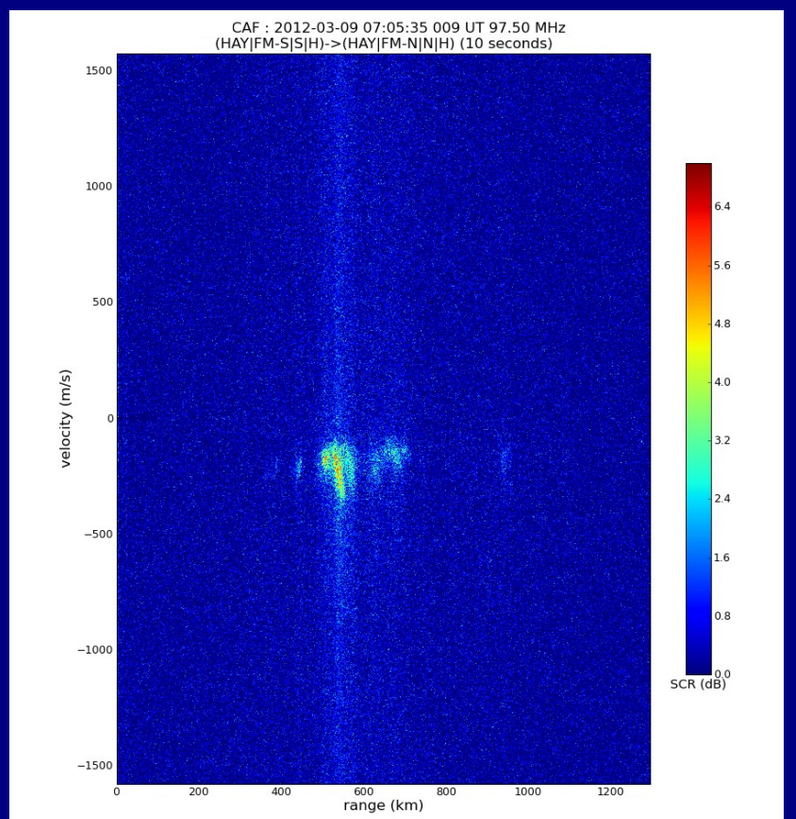
Software Radios in Transport Racks





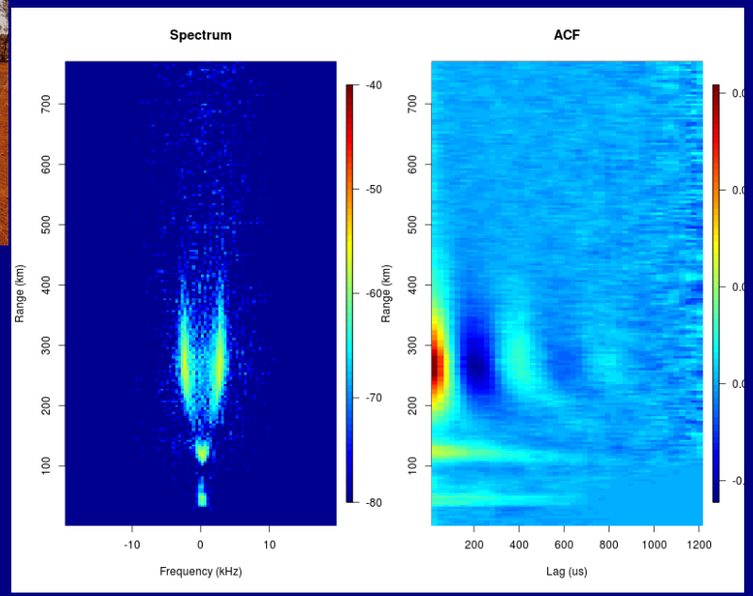
MIDAS-M Radar Downconverter
(MIT Haystack 2006)





Advanced Radio Apertures


The AAVS1 station. Photo Credit: ICRAR



[McKay-Bukowski, et al., 2014]

The Astronomy Community has invested heavily in Low Frequency Radio Array Technology Development

Imaging Radio Interferometers Enabled by Software Radio (Radars with Transmitters!)

MIT Haystack Cloud Scale Software Radio

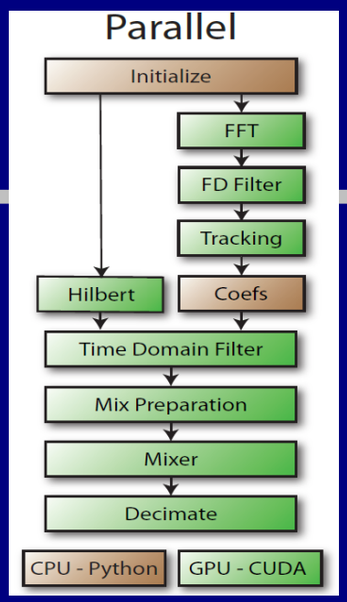
Digital Receiver(s)
or Subarray

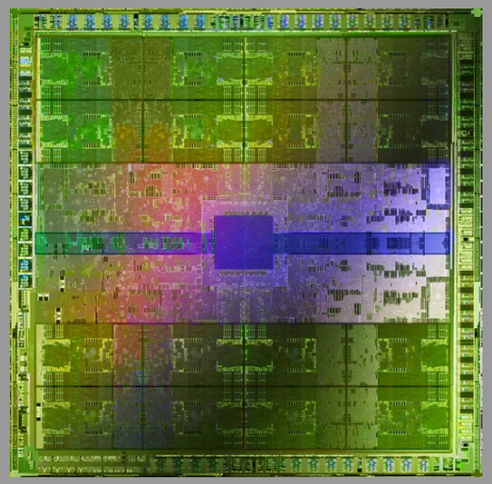
Deep Solid State
Ring Buffer

Tbps Switch Backplane

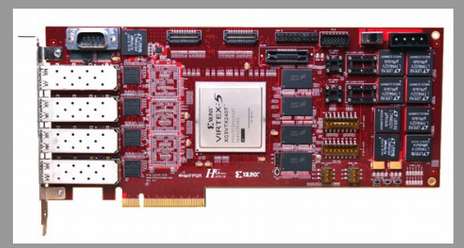
End User via
Web Interface

Real Time or
Batch Signal Chains





GPU



Processing
/ Accelerator

CPU + Disk

Deep Solid State
Memory Buffer

Cloud Computing System
Distributed Cloud File System

RAPID

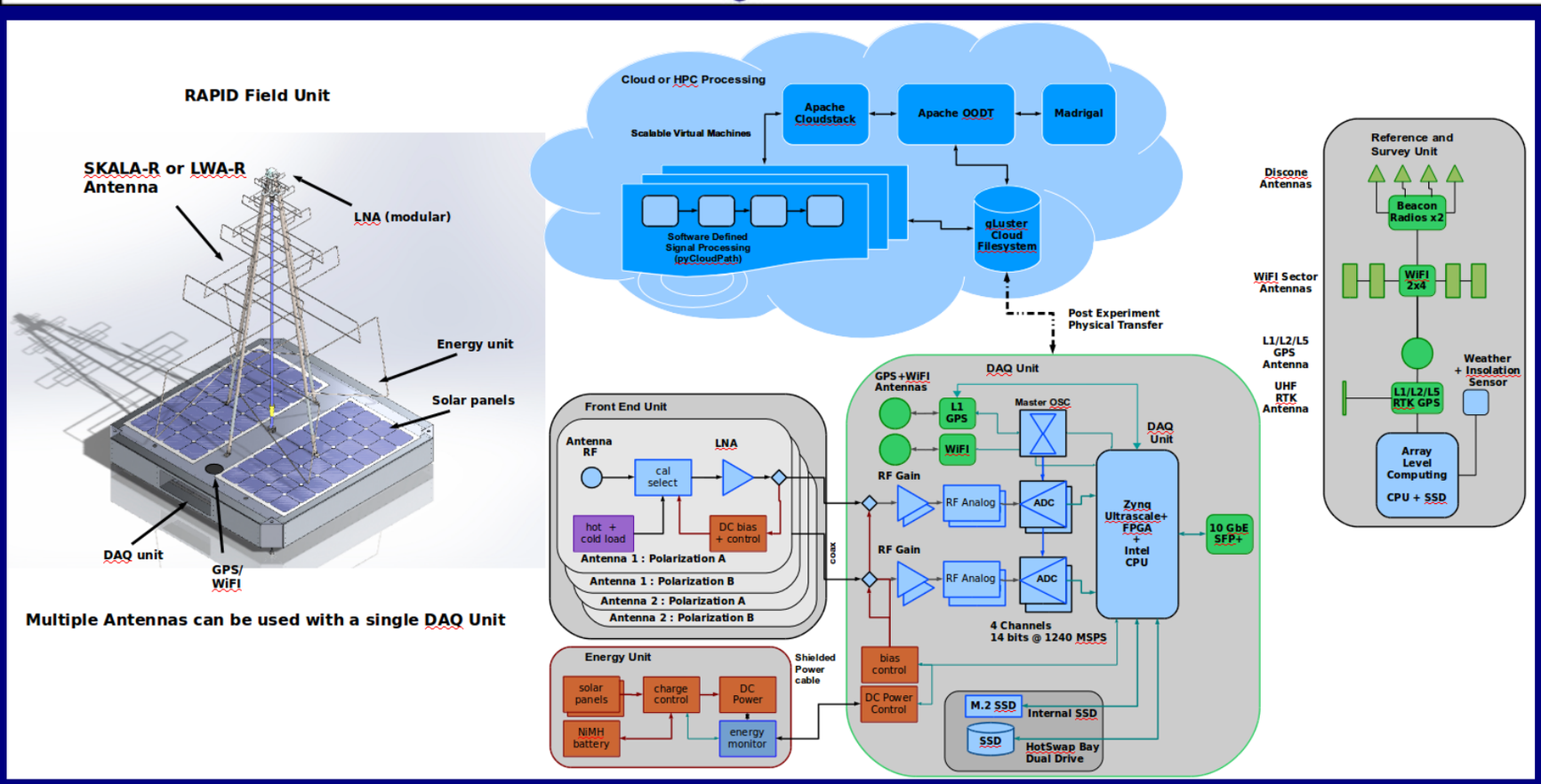
Radio Array of Portable Interferometric Detectors

MIT HAYSTACK OBSERVATORY

UNIVERSITY OF CAMBRIDGE

JPL

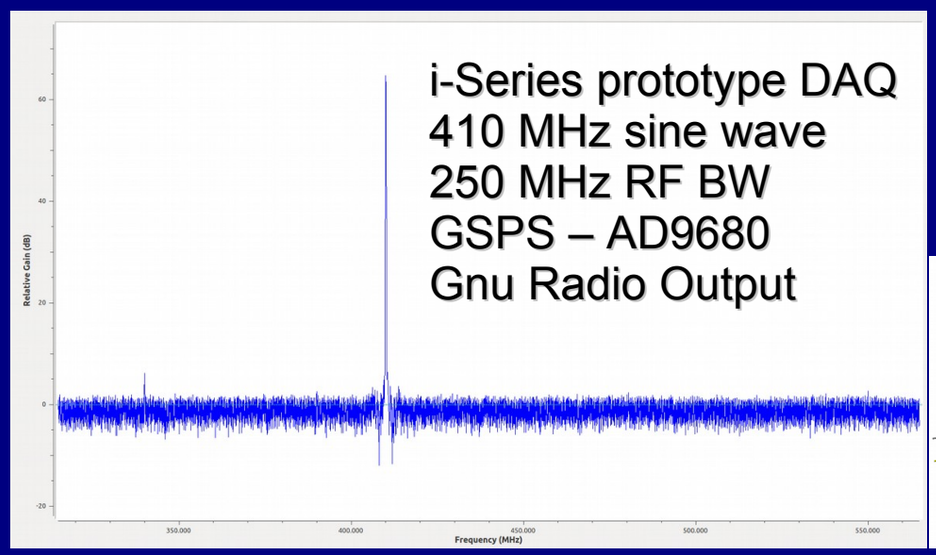
NSF

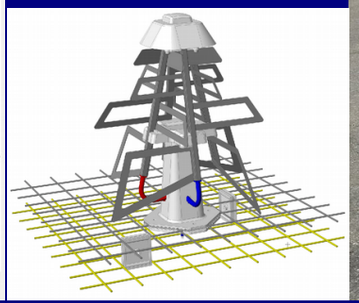


Go Where the Science is Best!
Deploy Easily and Anywhere
Reconfigure as Necessary
Capture the Radio Environment

50 Antenna Elements

A Partnership with
University of Cambridge
Square Kilometer Array Efforts



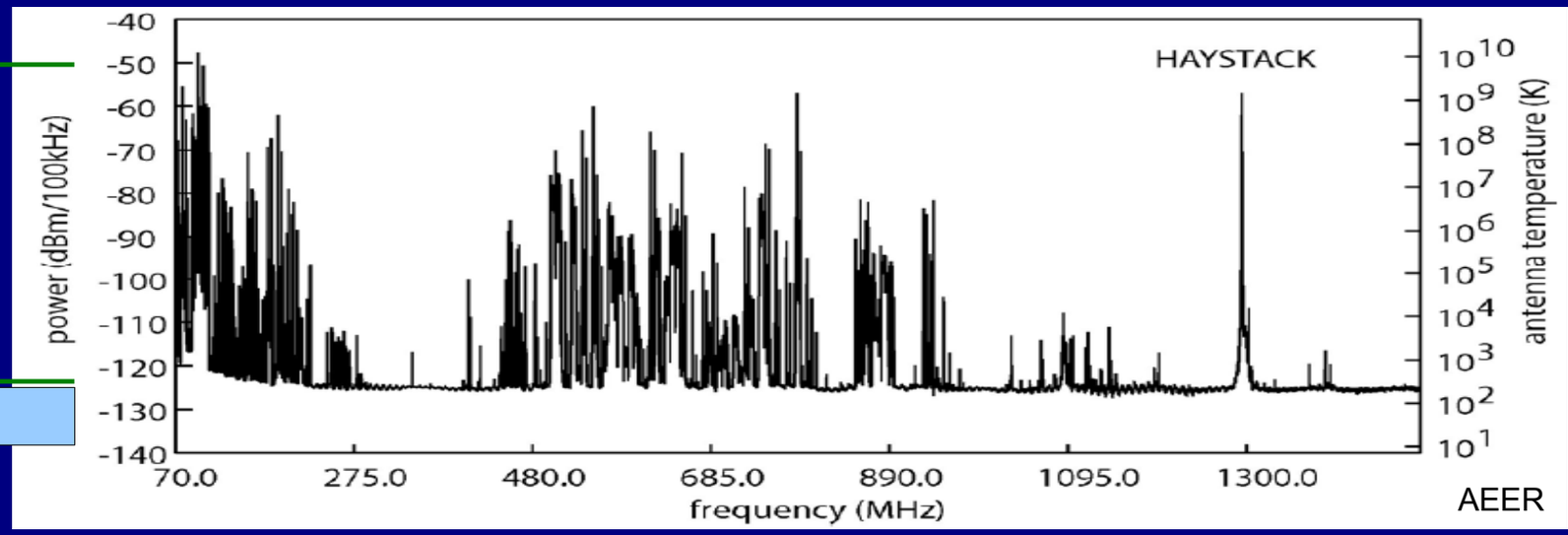


RAPID Electromagnetic Coverage

Strongest Signals

~ 70 – 85 dB

Geospace Scatters + Astronomy Sources



Typical Strong Signal Environment

10 MHz — 48 MHz — **RAPID Baseline Coverage** — 615 MHz — **RAPID Extended Coverage** — 2000 MHz

HF | **VHF** | **UHF** | **L-band**

49-50 MHz

54-108 MHz

174 - 240 MHz

420-450 MHz

500 MHz

470-862 MHz

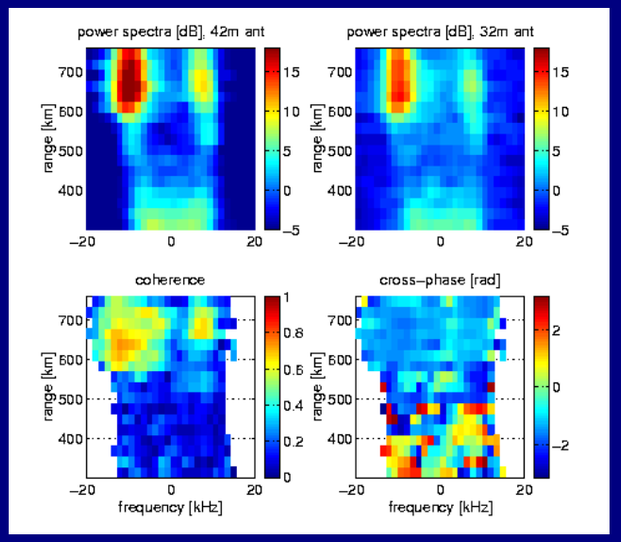
1280-1300 MHz

1176-1575 MHz

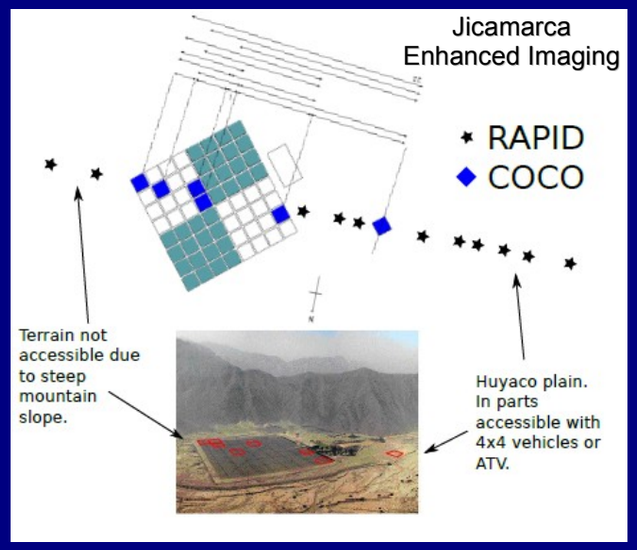
Geospace radar transmissions
- 50 to 1295 MHz, Narrow bandwidth (< 6 MHz)
- 2-3 MW (6 – 20 % duty cycle)
- Aeff ~ 1000 to 2000 m^2 @ UHF

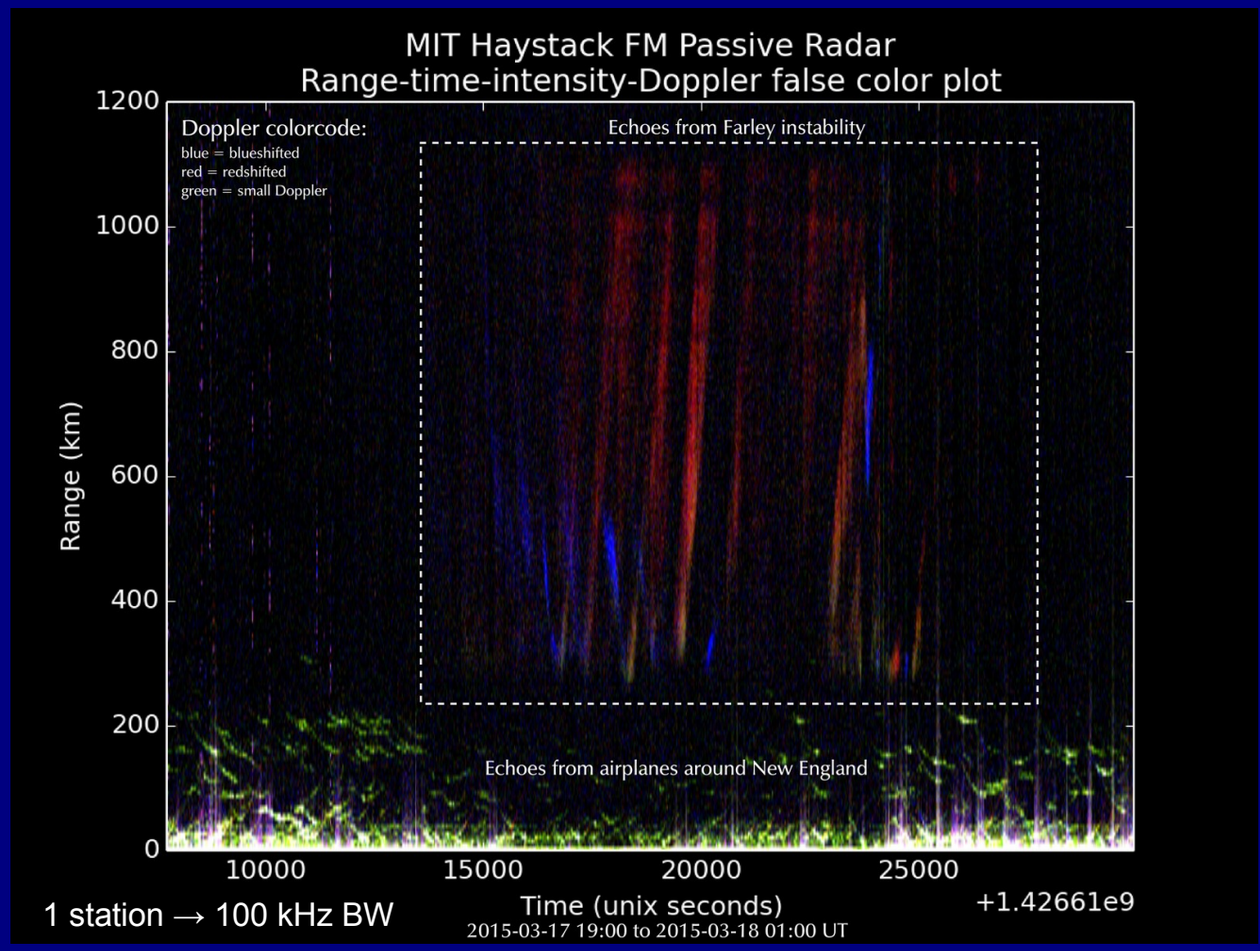
Signals of opportunity (i.e. Passive Radar)
- HF to L-band, Moderate bandwidth (< 20 MHz)
- 100 kW to 1 MW ERP + GPS

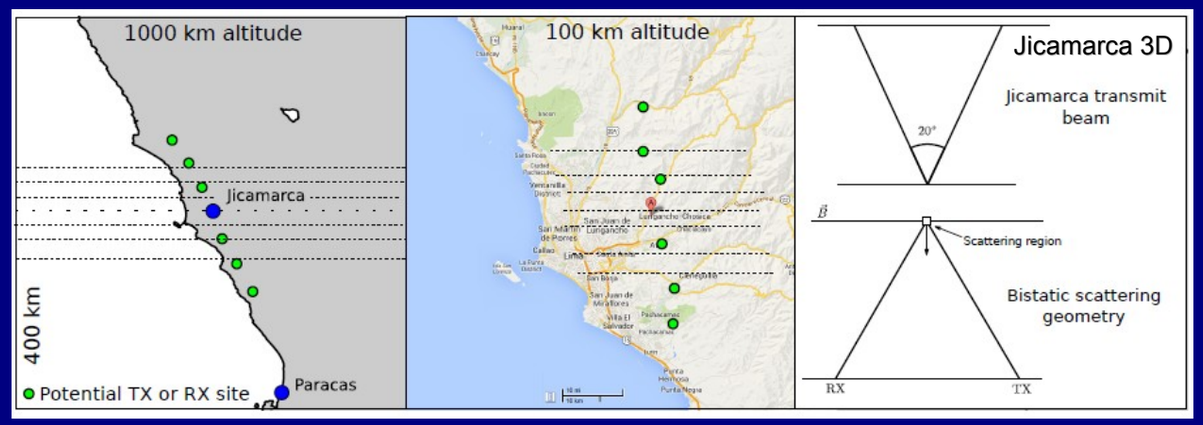
RAPID for Geospace Radar



[Svalbard NEILs, Grydeland, et. al, 2004]







Coherent scatter using existing Facilities and Broadband Passive Radar (FM / HDTV for HF → UHF)

E-region irregularities, naturally enhanced ion acoustic lines, RF heater generated irregularities

Configurable interferometric imaging array for any RX application (10 MHz to 2 GHz)

SKALA-R, LWA-R, or MFAA antennas as needed (e.g. HF for meteor radar, GPS, etc.)

Deployable facility asset for use by the Geospace community

Low Cost Radars for Space Weather

Separate Transmit and Receive Arrays (i.e. locally bi-static / multi-static)

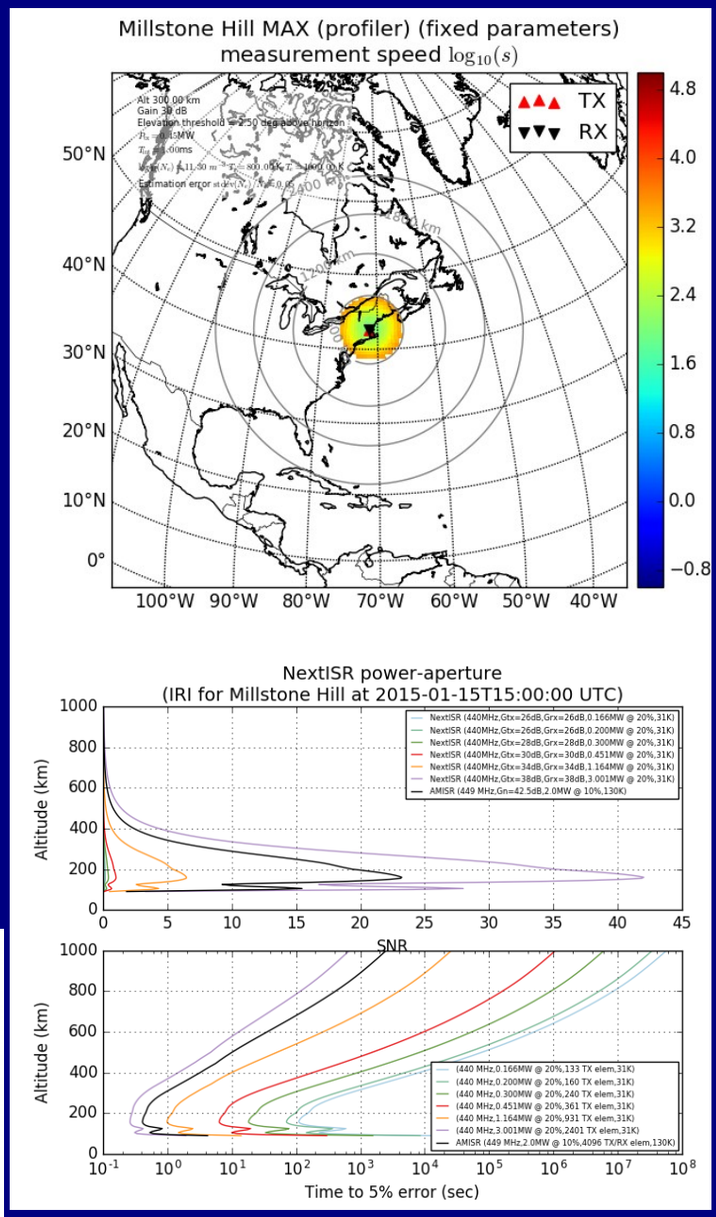
Narrow Band TX at High Power Per Element (no T/R switch!)

Flexible Transmitter Duty Cycle and Bandwidth (to 100% with STAR)

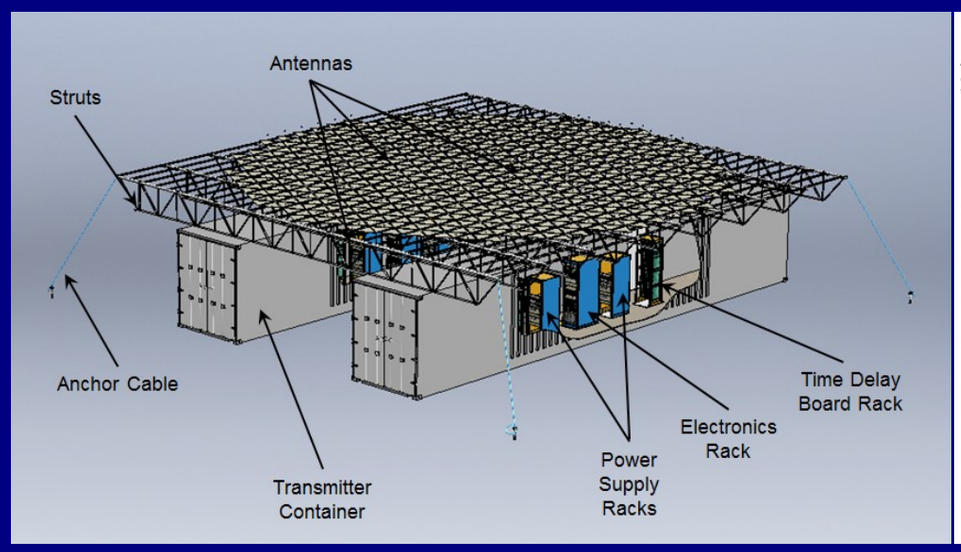
Large Aperture, Distributed, Digital, Broadband Receive Arrays

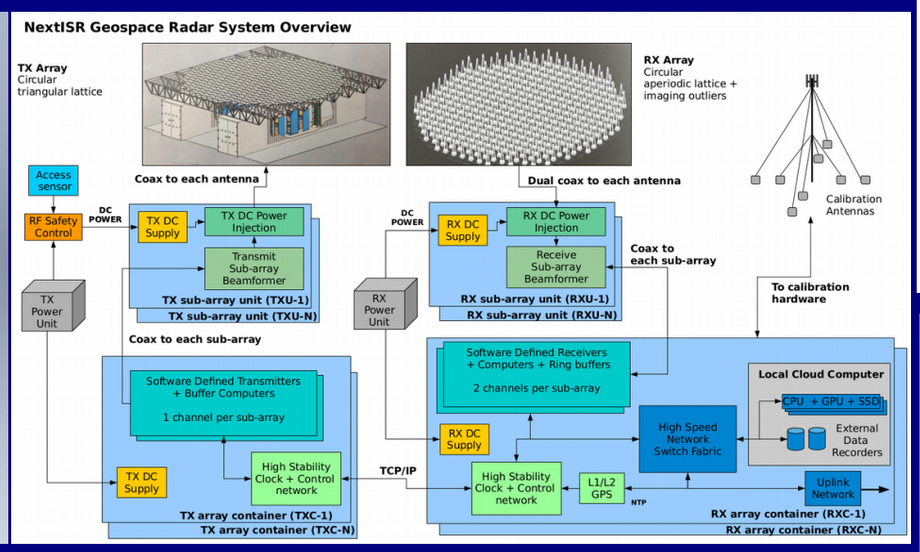
Centrally Dense Aperiodic RX Array Layout with GaN LNA + low Tsys

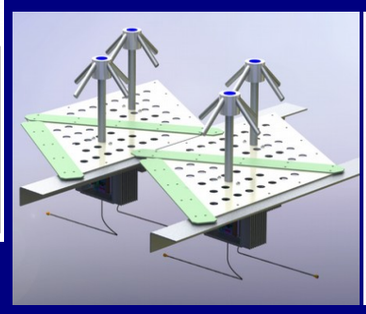
Digital RX / TX (per element) + Cloud Based Software Signal Processing

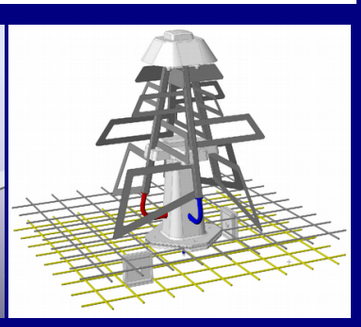


Get Rid of Everything Possible → Lower Per Element Costs









In partnership with:

DIVERSIFIED TECHNOLOGIES, INC.®

The NextISR System

How Low is Possible?
Less Infrastructure + Production volume are critical to per element cost….