Andrew Siemion

SpaceTech - 7 November 2023

BREAKTHROUGH
LISTEN

UNIVERSITY OF OXFORD

Detectable Signatures of Intelligence: Technosignatures

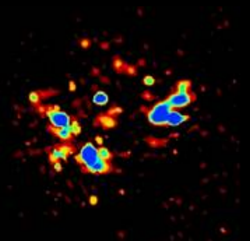
Direct Technosignatures: Coherence

Pulsars, Gamma Ray Bursts, Fast Radio Bursts

Thermal emission

Frequency Compression

Artificial Sources

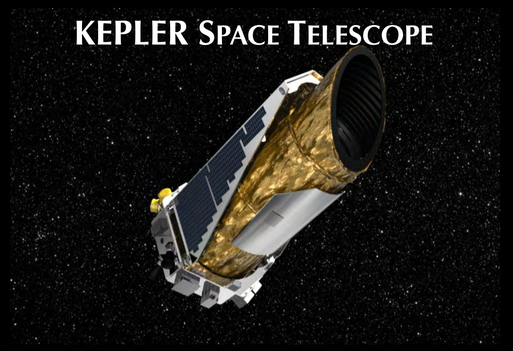


Astrophysical Masers

Temporal Compression

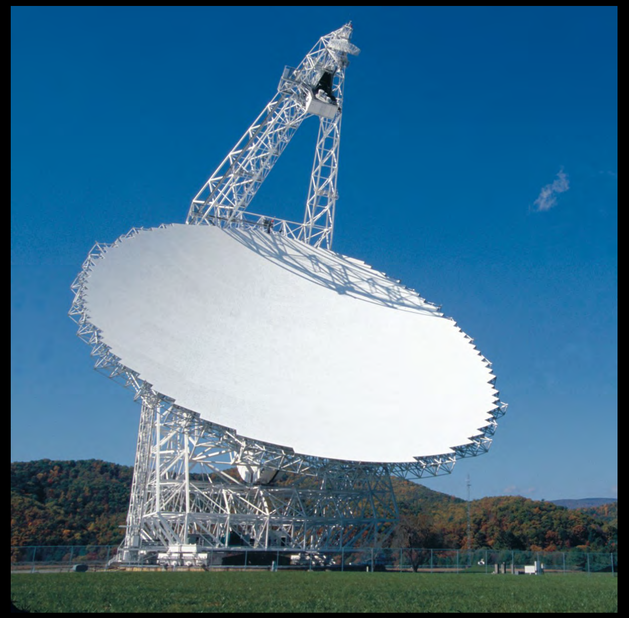
* Polarization
* Spatial Coherence
* g(2) Coherence
* Orbital angular momentum
* Mass-energy coherence

SETI Facilities in 2023



Direct Technosignatures: Coherence

FAST 500m

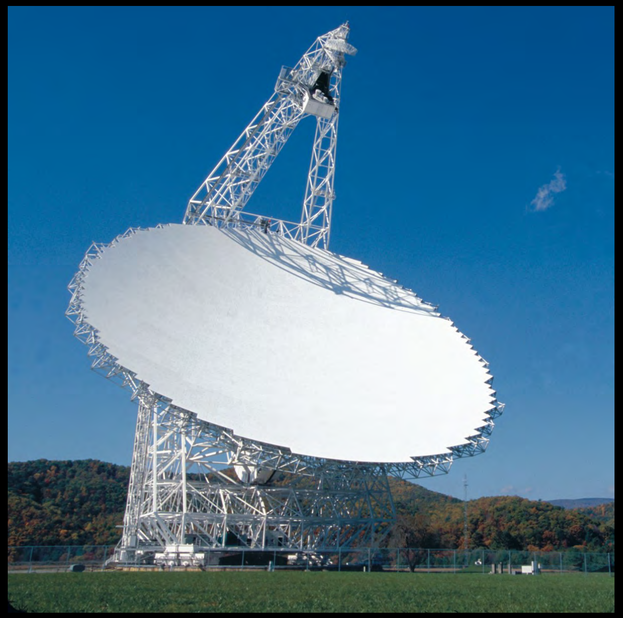


Green Bank Telescope
Planetary Radar (10^{13} W)

~ 20000 lightyears

Direct Technosignatures: Coherence

FAST 500m

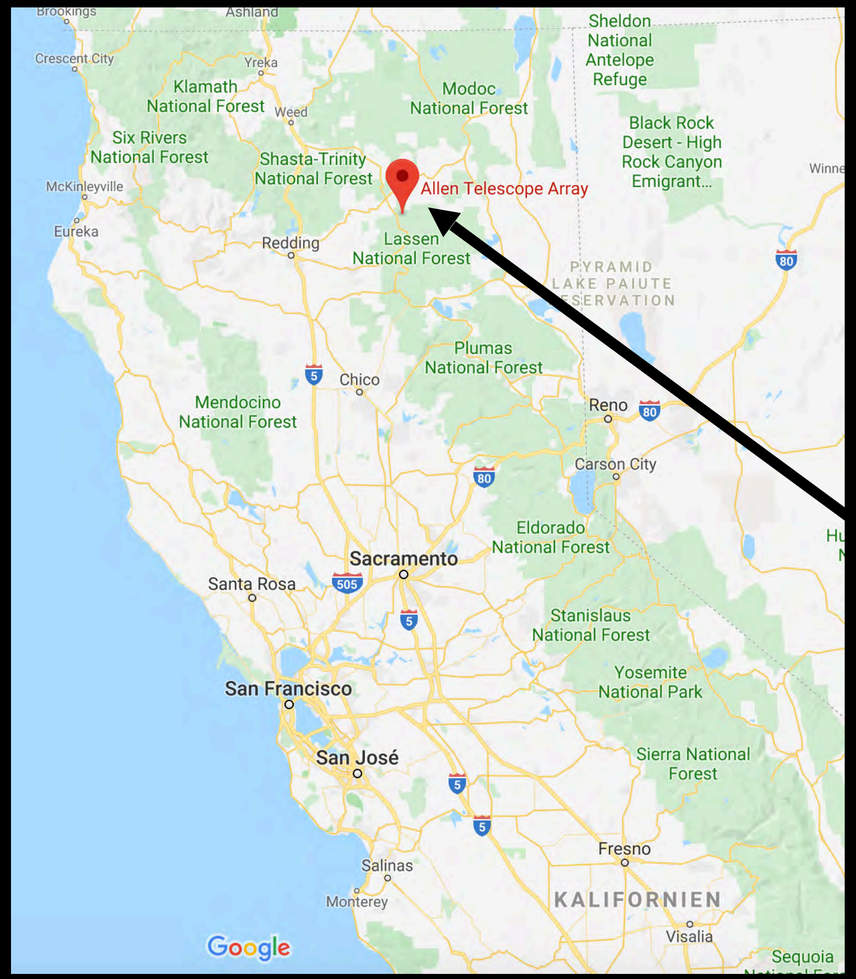


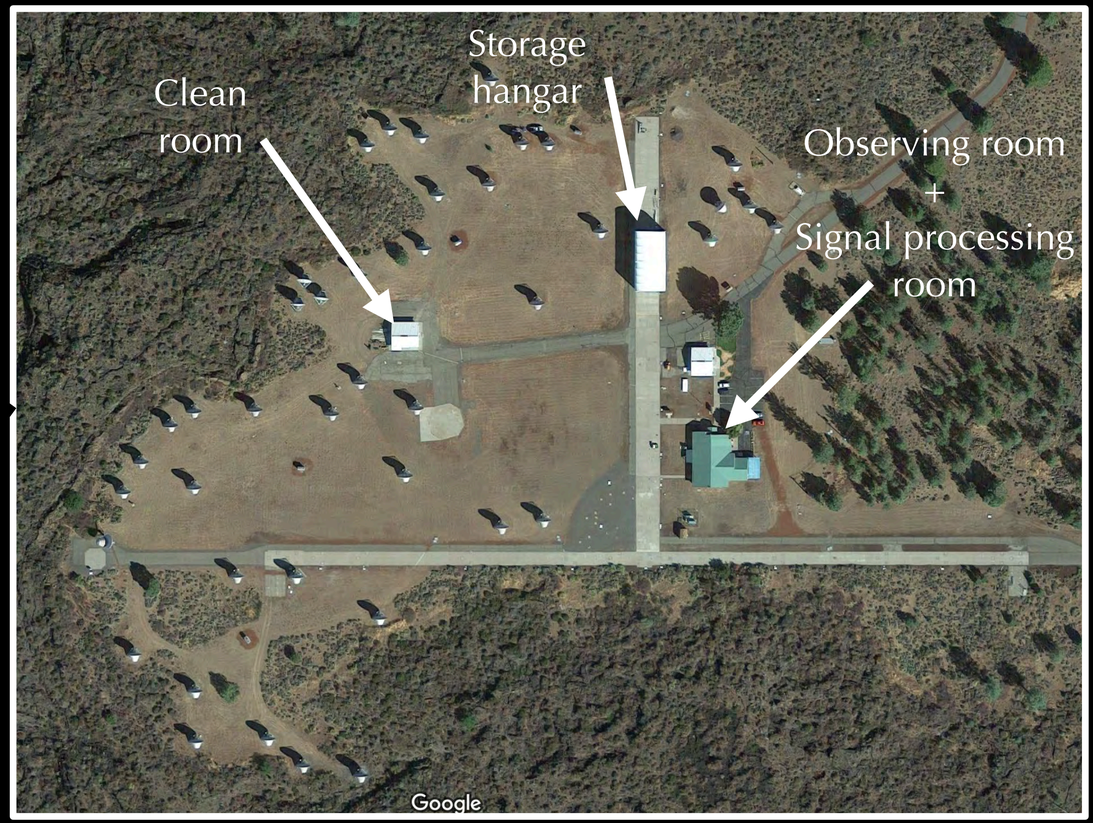
Green Bank Telescope
Planetary Radar (10^{13} W)

~ 20000 lightyears

→ Earth-level technosignatures detectable from hundreds of billions of extrasolar planets.

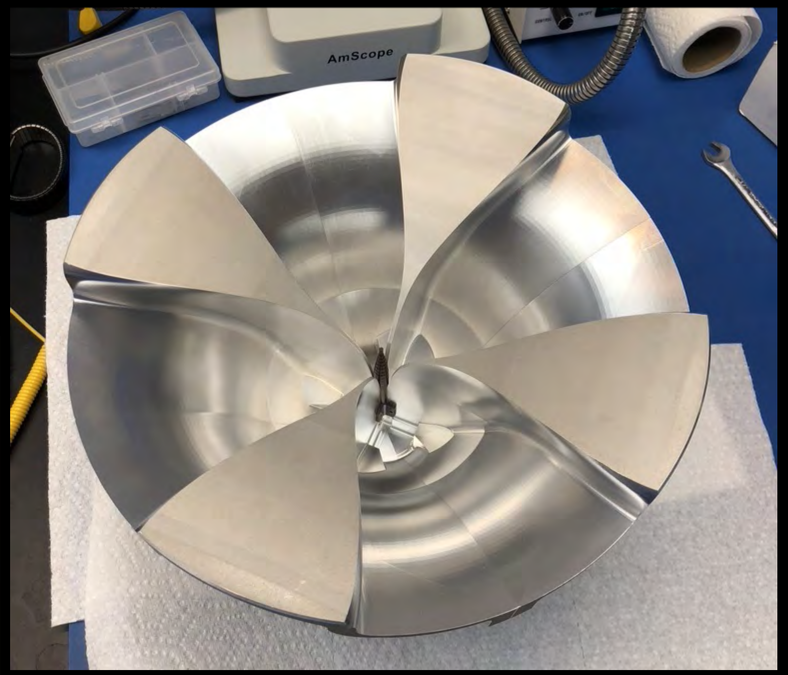
Technosignature Technology: The Allen Telescope Array





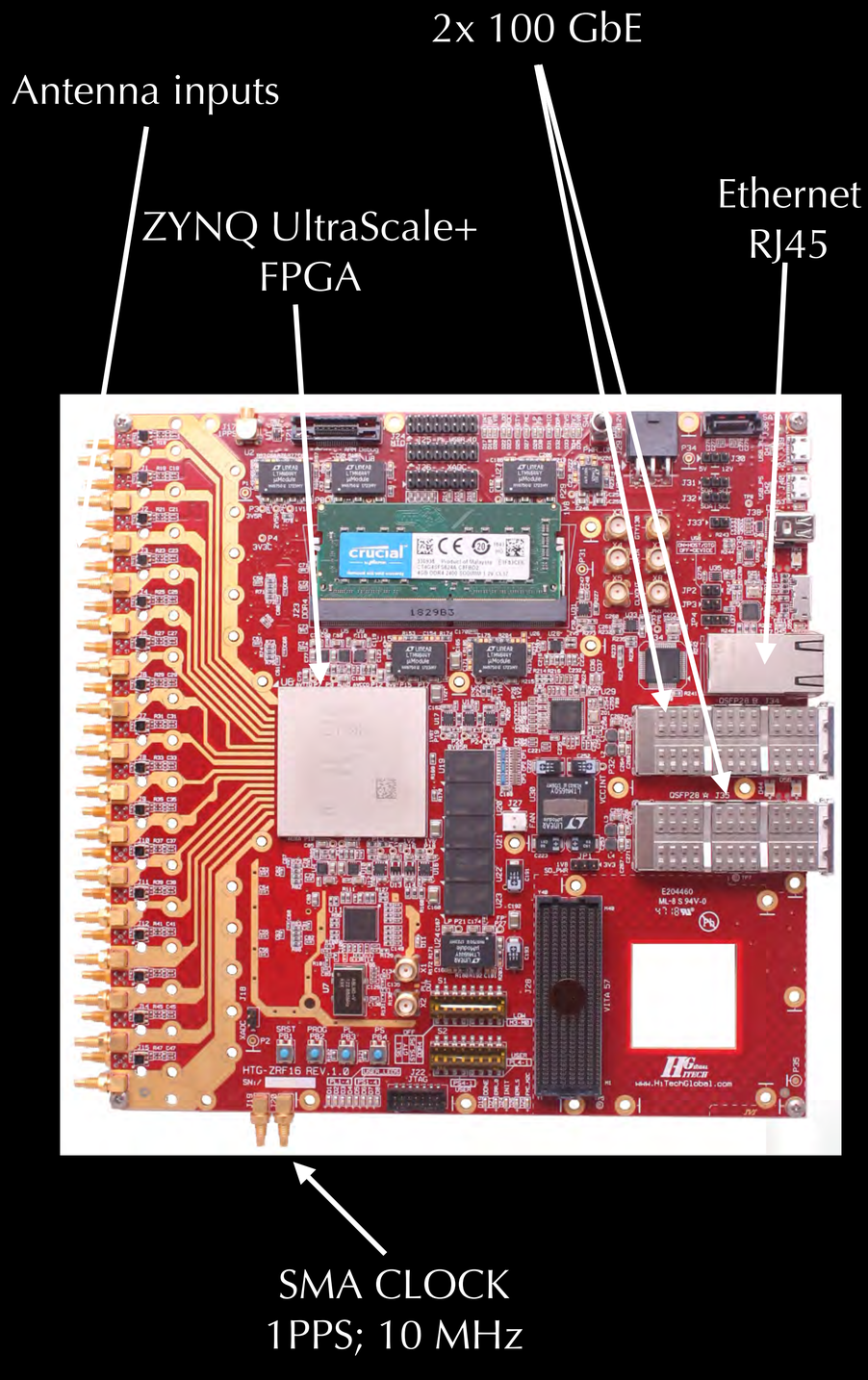
The Allen Telescope Array: QRFH

In collaboration w/ Jonas Flygare (Caltech), Bob Watkins (Oxford)



The Allen Telescope Array: RFSoC digitizer boards

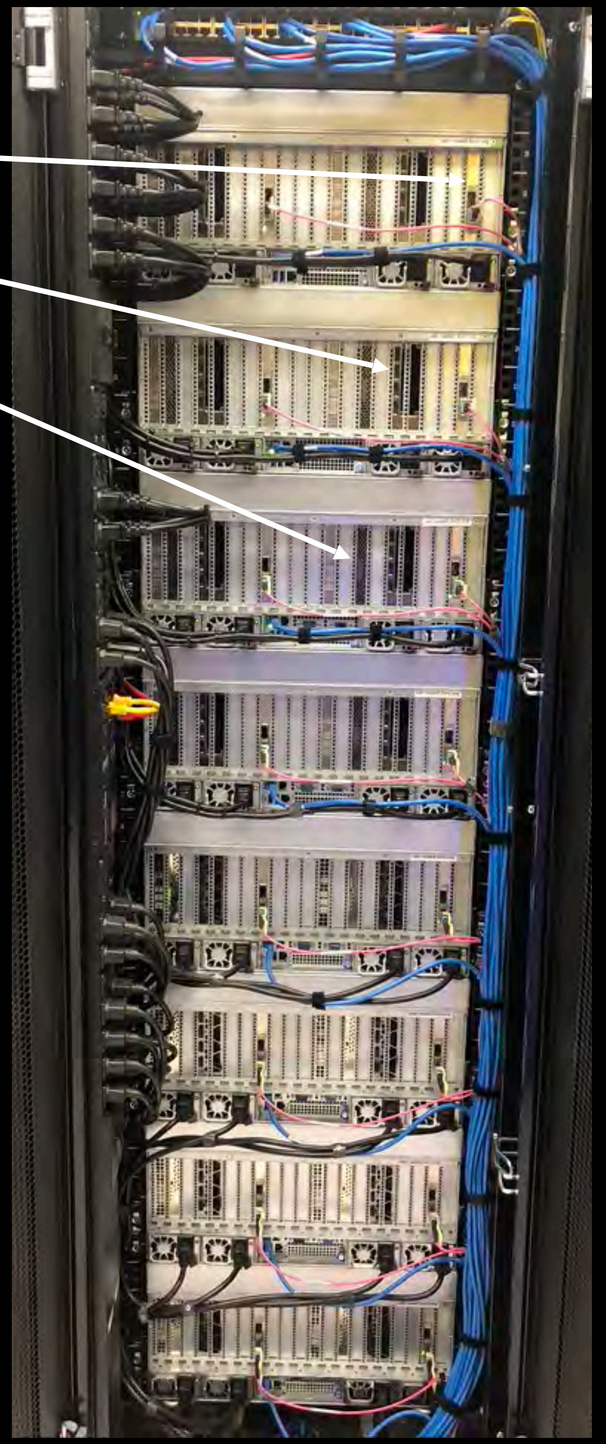
- 5x Xilinx UltraScale+ RFSoC ZCU216
- 5x16 inputs = 80 => 20 ant x 2 pol x 2 IF
- Role:
  - **Digitization:** 16 input, 14-bit ADC at 2048 Msamples/s
    => 1.024 GHz of bandwidth
  - **Polyphase filterbank:** 1st stage channelization
    4-tap 2048-channel PFB
  - **Delay engine + fringe rotation:**
    Sample and subsample delay compensation
    Fringe rate @ 25 Hz
  - **Data packetizing + streaming**



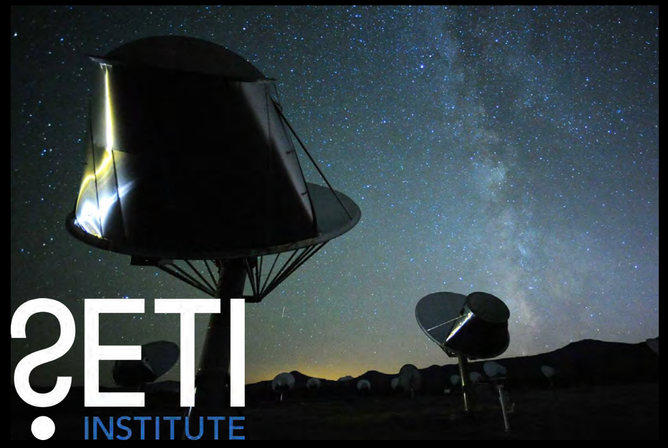
The Allen Telescope Array: Digital Backend

- Prototype system consisting of 8 SuperMicro 4124GS-TNR 4U GPU Server DP AMD EPYC
- 4x server equipped with Nvidia RTX A6000
- 4x server equipped with Nvidia RTX 3090
- Each has 2x 100Gbe ethernet and 2x 4TB NVME buffer storage (PCIe 4.0)

- Power requirement for entire rack approx. 10kW under full load
- 1.2PB of Storage available



Strategic Collaboration - nvidia



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NVIDIA

Holoscan – NVIDIA's Streaming Sensor Platform

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- Implementation of radio astronomy / SETI pipelines with mainstream industry-supported software infrastructure
- Access to high performance GPU and NIC features w/o huge NRE investment
- Bridge to integration of RF/sensor processing techniques from other domains (classification, localization, streaming ML, etc)
- Enable GPU-accelerated edge-processing, i.e. ADC → GPU
- Potential public demonstration platform for nvidia

Strategic Collaboration

NVIDIA

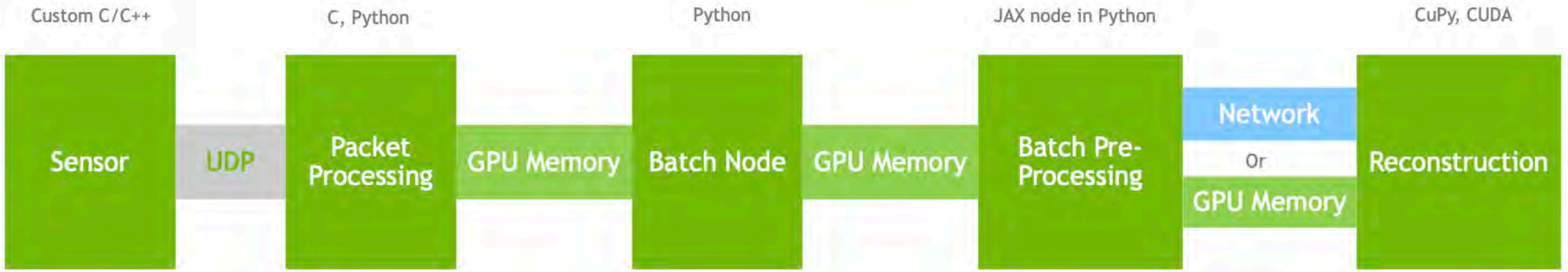
GPU-Accelerated Sensor Processing

Adam Thompson | Senior Technical Product Manager | adamt@nvidia.com

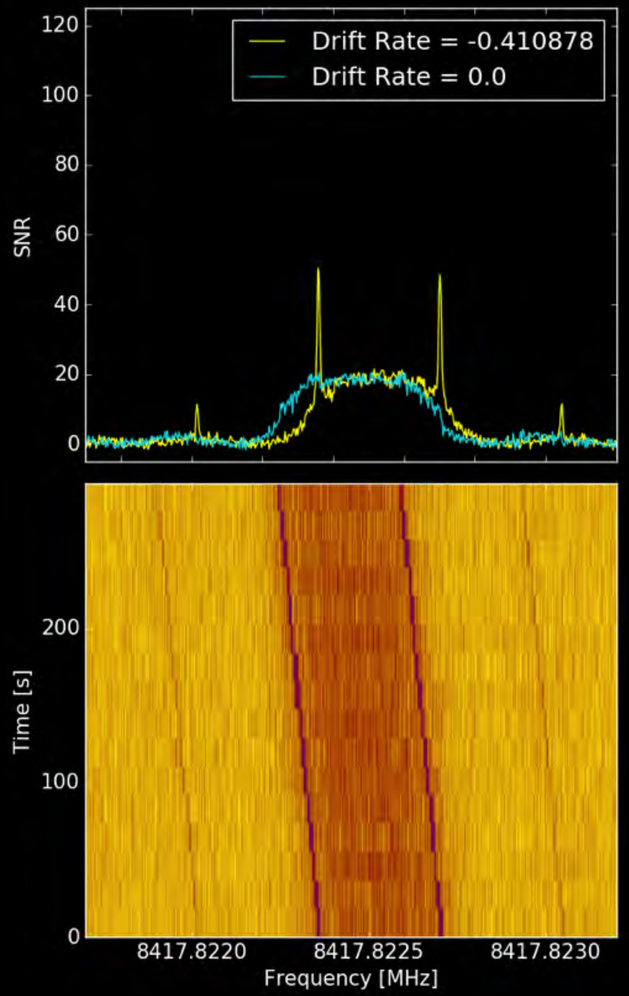
Holoscan – NVIDIA's Streaming Sensor Platform

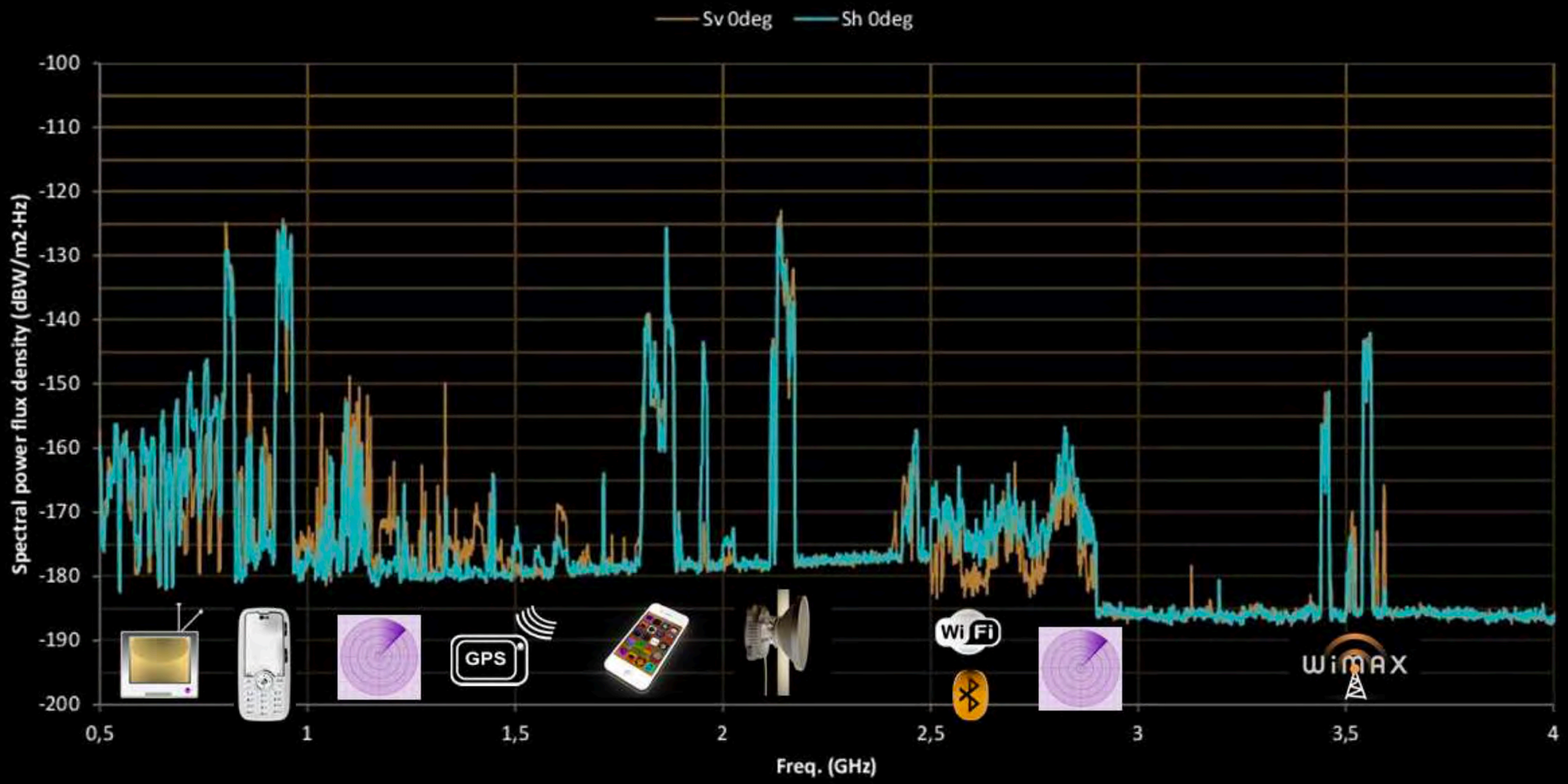
A Reference Streaming Application

The Benefits of Pipelining



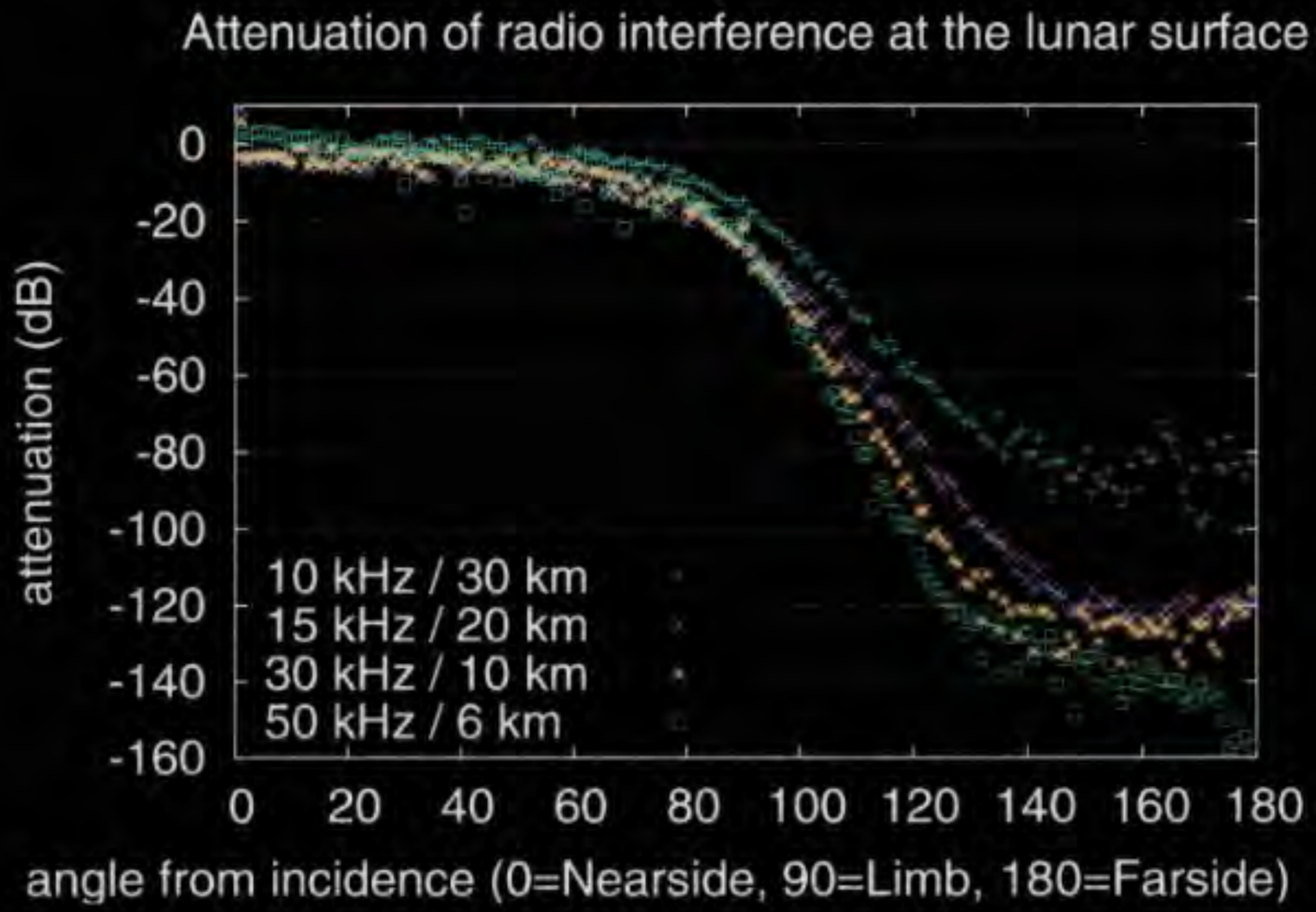
The Singular Challenge of Radio Frequency Interference





Voyager I (GBT, 2016)

The Lunar Farside



Takahashi 2003

Reduced cost-to-launch

Commercial low-cost space-borne signals intelligence

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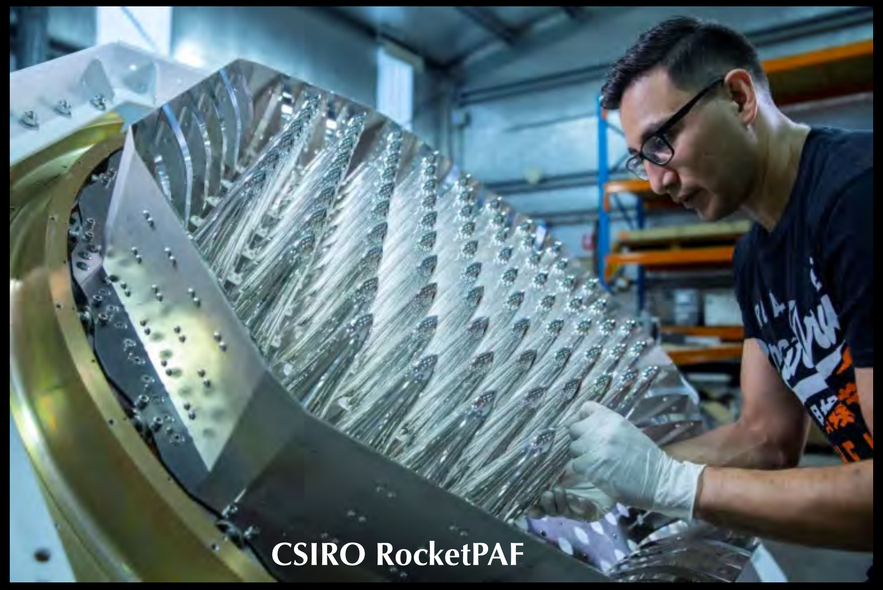
Aperture-array radio astronomy receivers

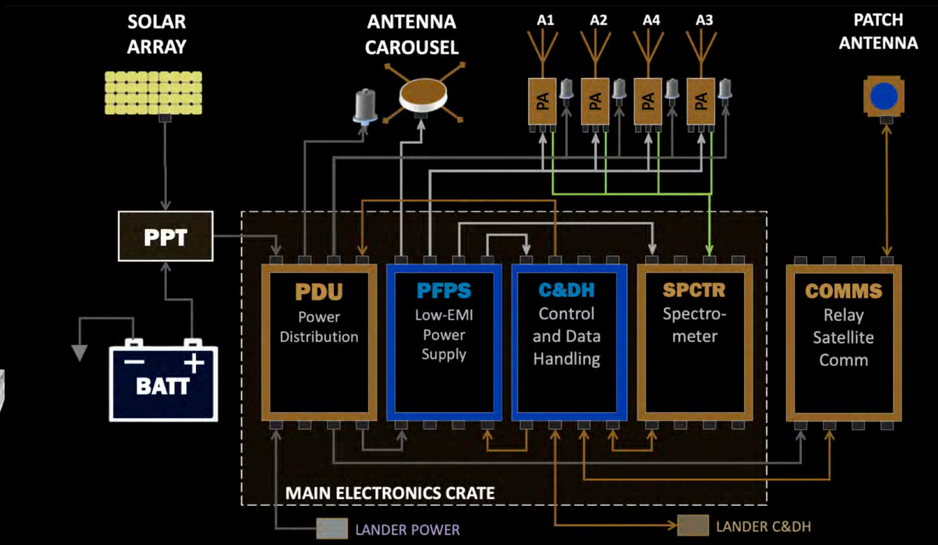


Growth in
commercial lunar exploration

NASA

Commercial Lunar Payload Services

LuSEE Night Schematic



Lunar radio cosmology mission development

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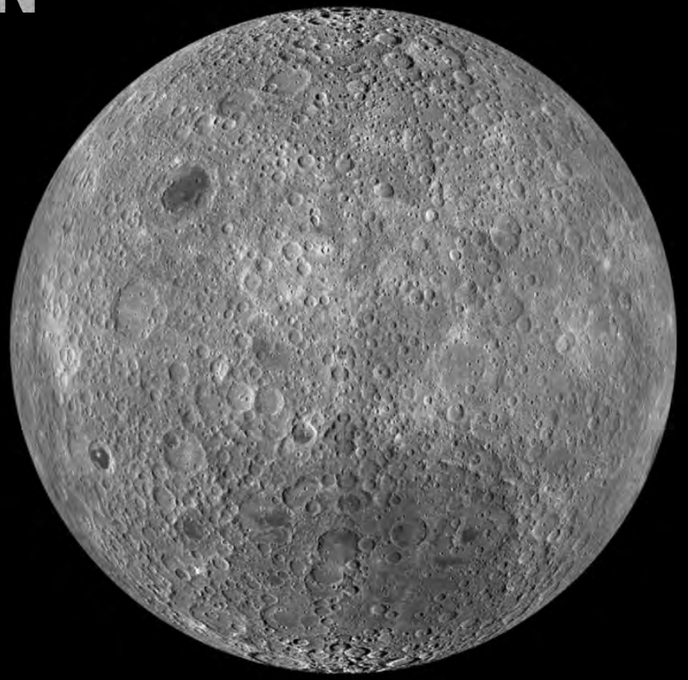
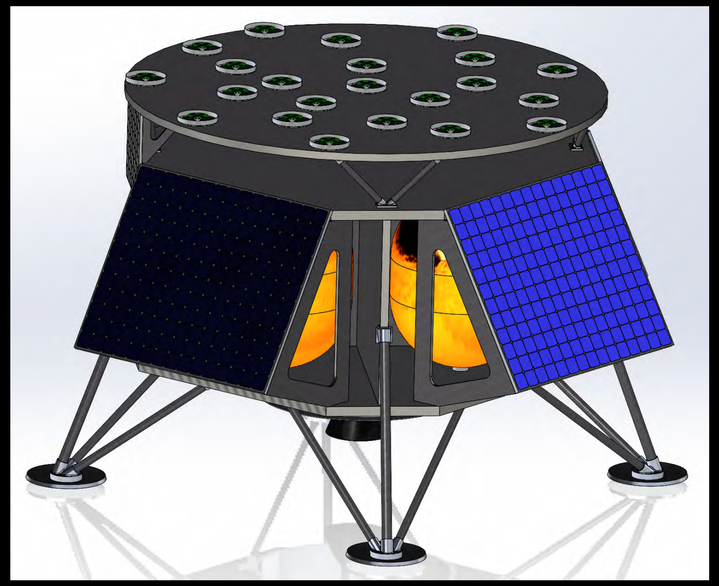
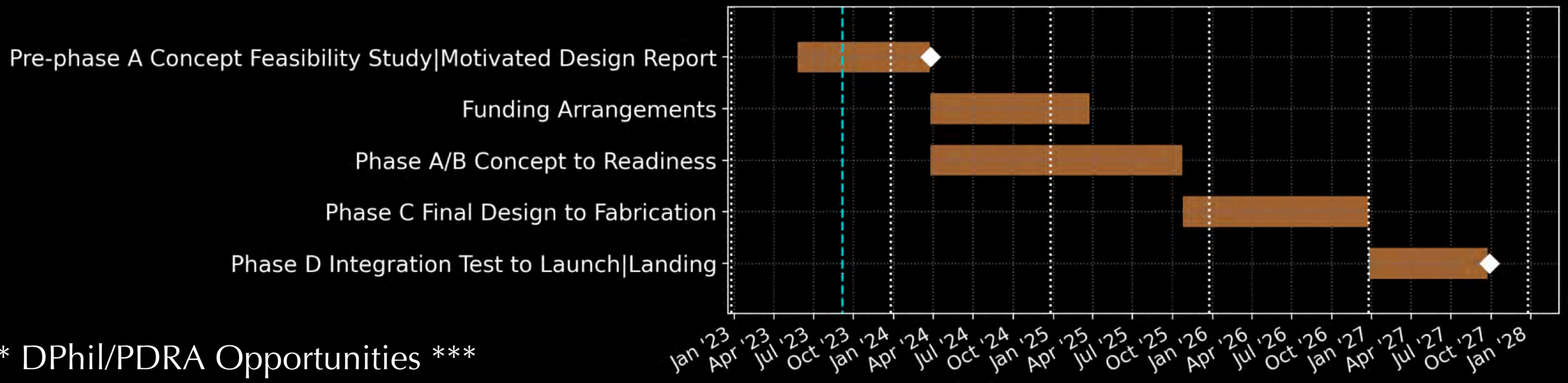
Lunar Farside Technosignature and Transients Telescope (LFT3)







*** DPhil/PDRA Opportunities ***

Breakthrough Listen UK Kickoff Meeting

Where: SKAO Headquarters, Jodrell Bank, UK

When: 13 - 15 November 2023

What: Breakthrough Listen will be headquartered at the University of Oxford's sub-Department of Astrophysics from 1 July 2023. Join us to learn more about the modern technosignature search and opportunities for collaboration.

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The University of Manchester

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