# CHIME

The **C**anadian **H**ydrogen **I**ntensity **M**apping **E**xperiment

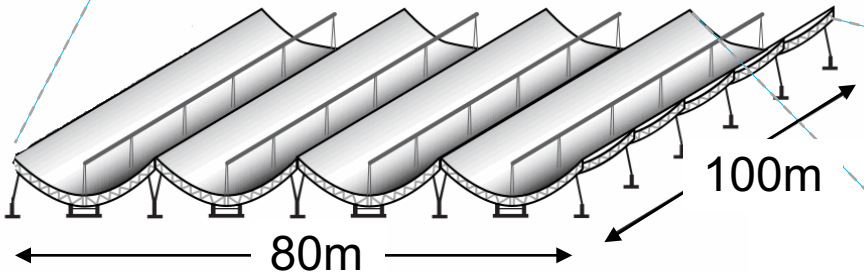
## FRB project: Science goals and progress updates

**Cherry Ng (UBC)**

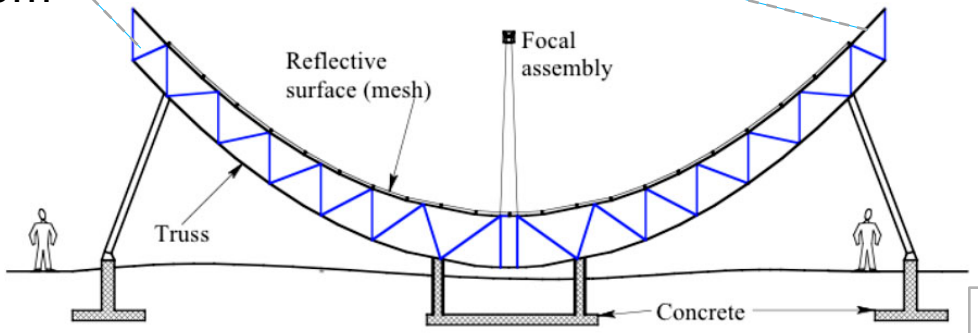
June 2017 @Workshop on FRB, McGill

*photo credit: Keith Vanderlinde*

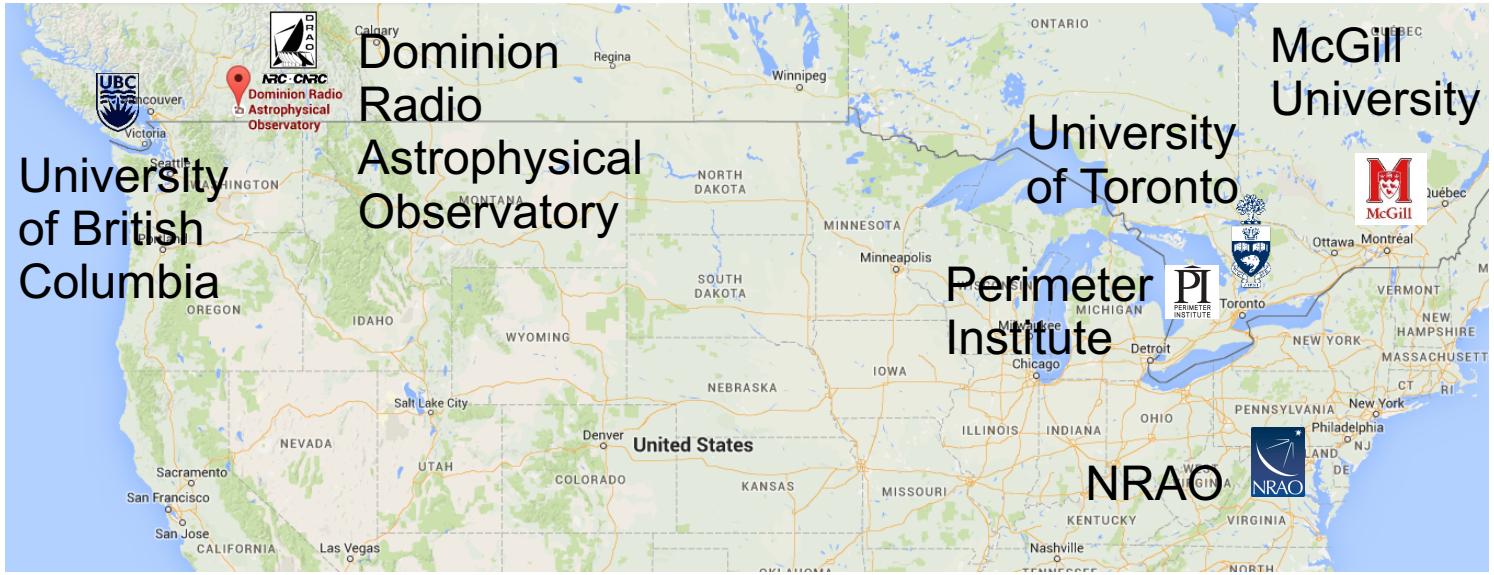
# Location


4 Cylindrical reflectors
No moving parts



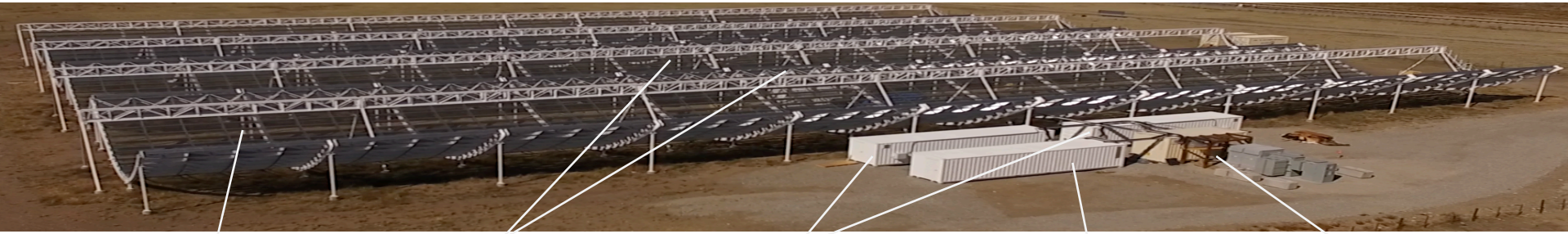
# The CHIME/FRB team

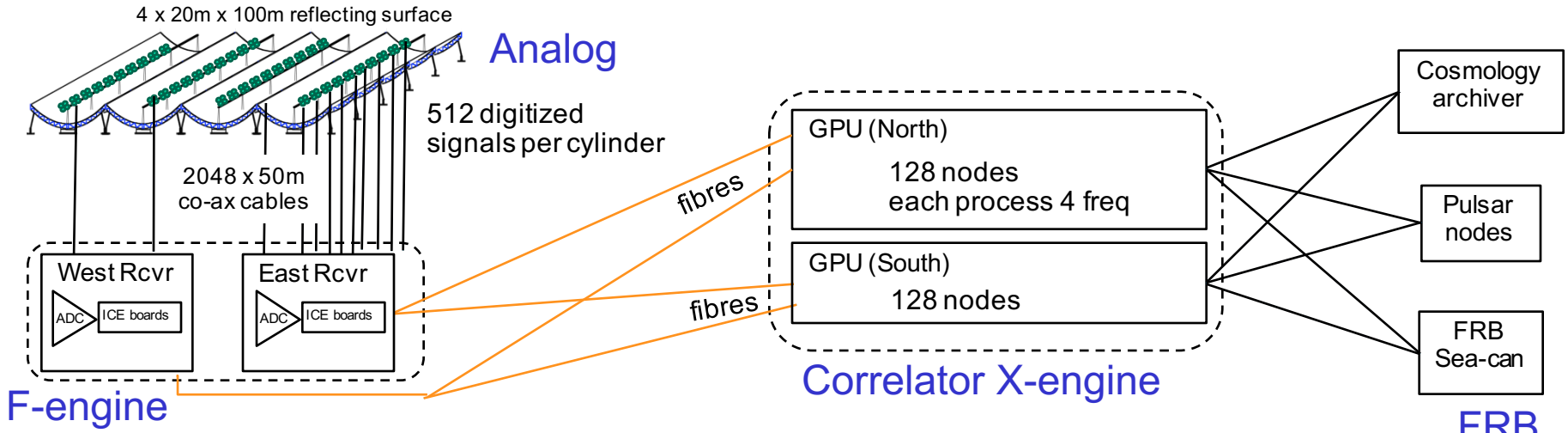



# Virtual visit

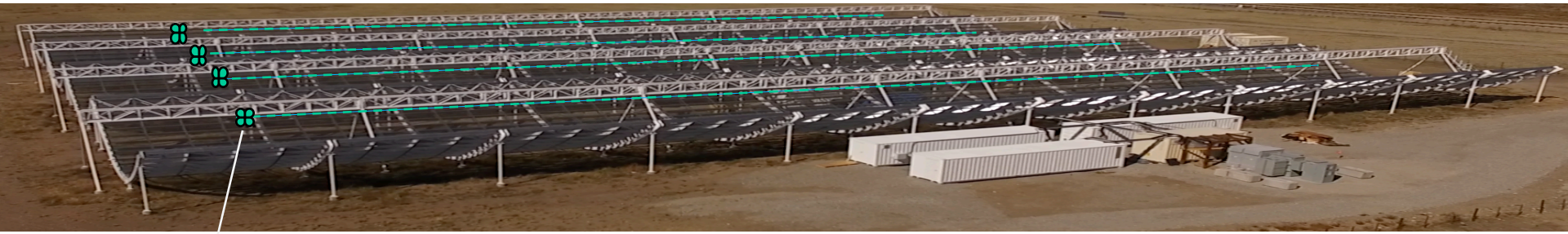
Drone video taken in September 2016 (Richard Shaw)

# Site Updates



# Site Updates (Analog)



1024
feeds

- 1024 feeds & LNA designed at UBC (Meiling Deng et al)
- Each records 2 polarizations

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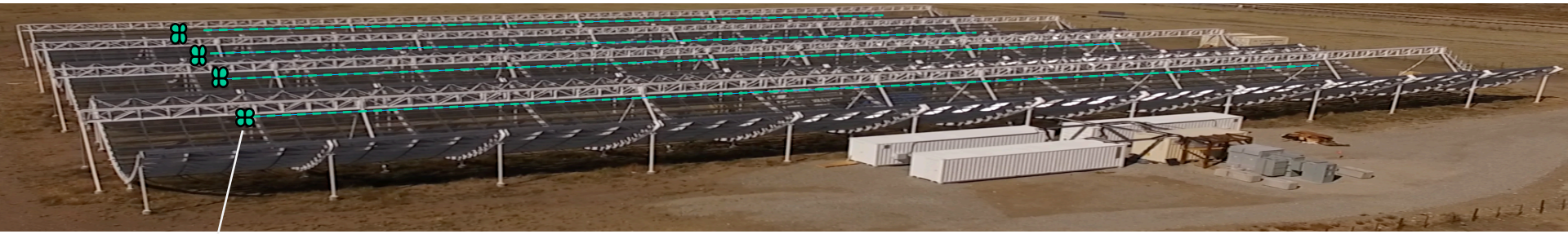

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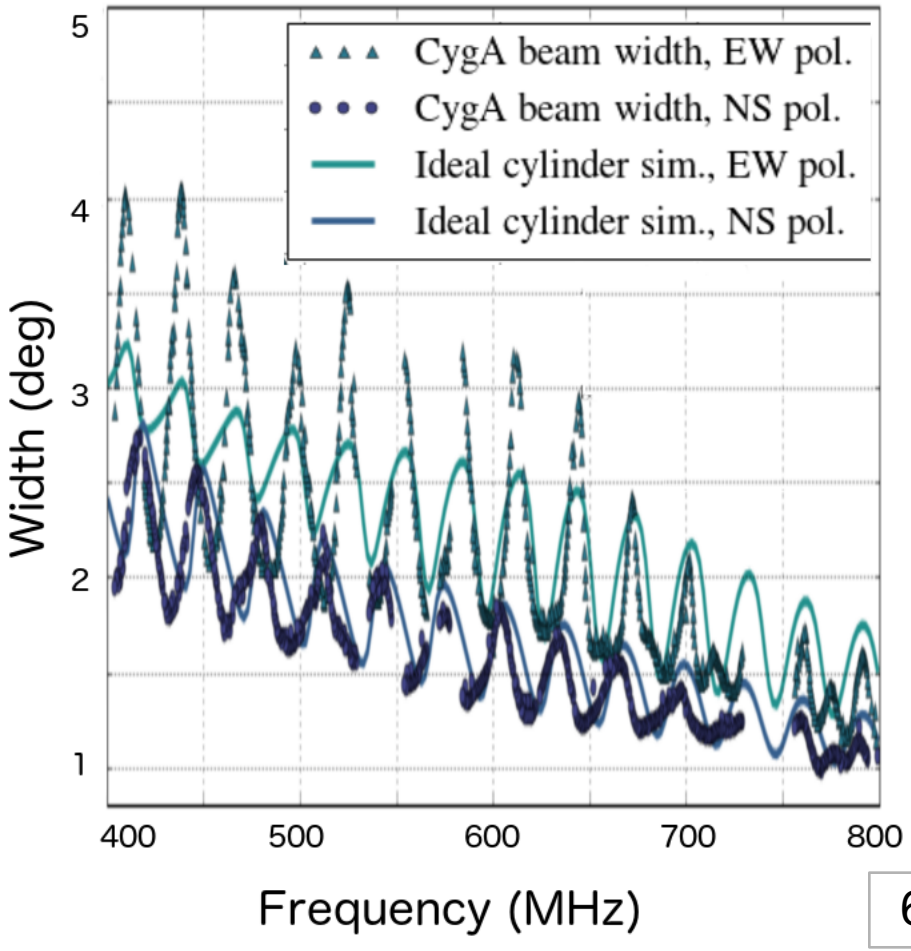
- Beam shape study: holography with the Pathfinder (Phil Berger et al., 2016, 1607.01473)



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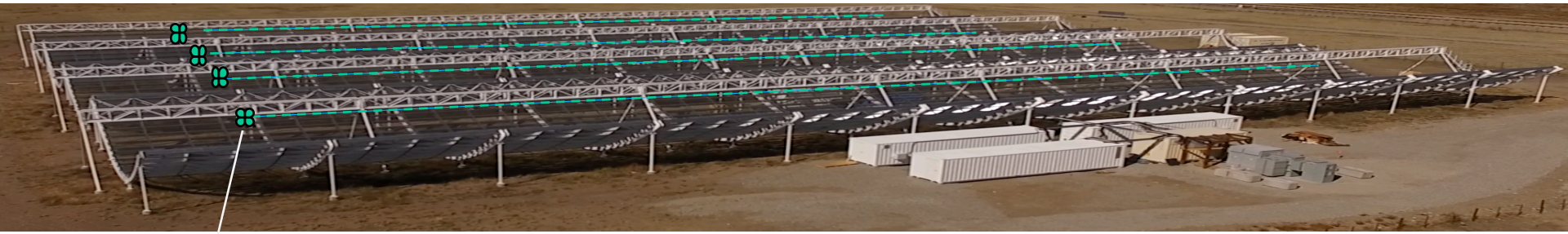

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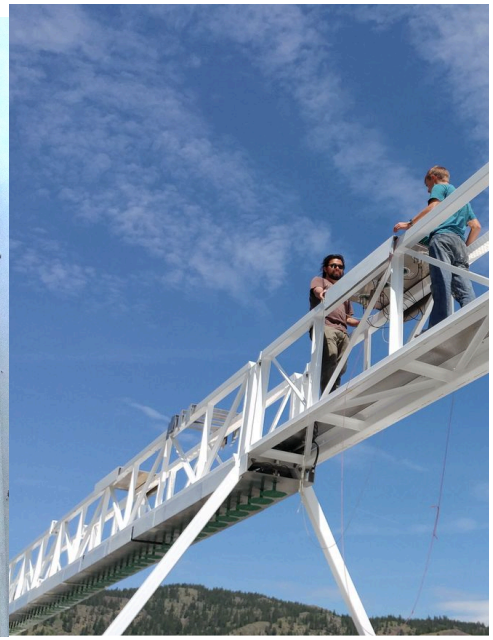
- Beam shape study: holography with the Pathfinder (Phil Berger et al., 2016, 1607.01473)

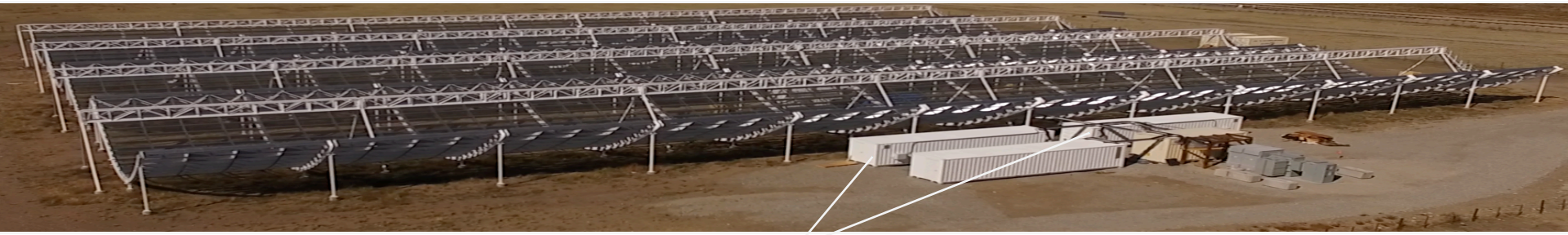
- ➔ Focal line work complete!
- Focal line to digitizer connectivity in progress

2048 x 50m co-ax cables all installed (Oct 2016)



All feeds installed one week ago! (June 2017)

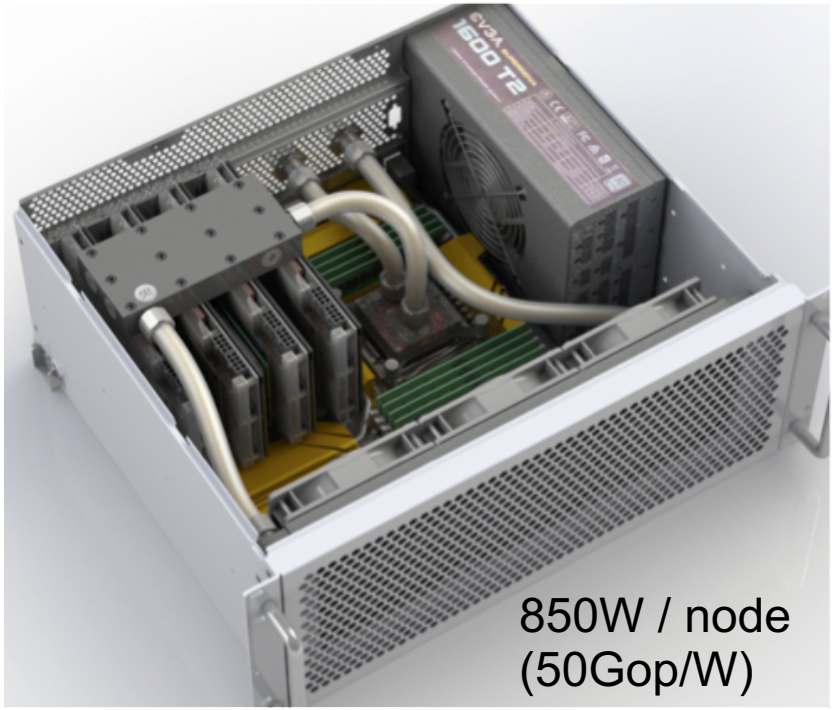
# Site Updates (Correlator)



Correlator
X-engine

Nolan Denman et al 2015, 1503.06202
Andre Recnik et al 2015, 1503.06189
Peter Klages et al 2015, 1503.06203

- 256 nodes @ 4 GPUs
- AMD FirePro™ S9300 x2
- Liquid cooled, leak-tight chassis



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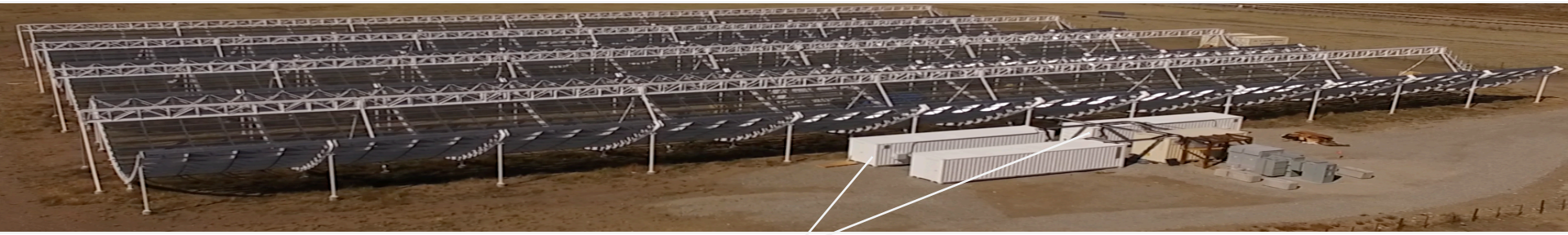

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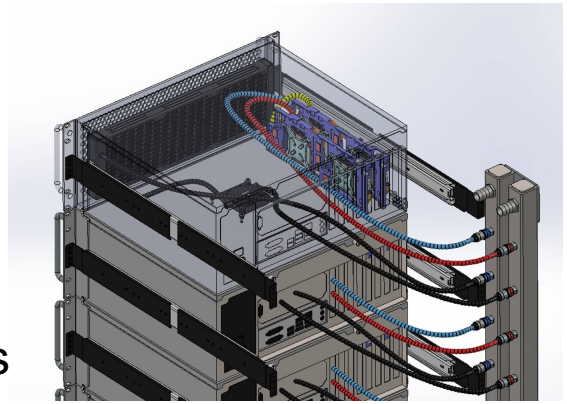
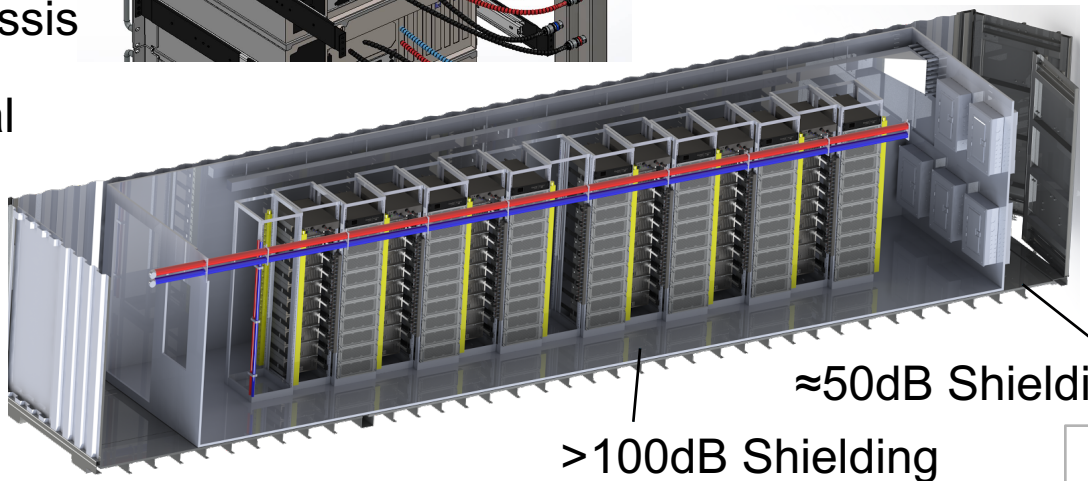


9kW / rack,
120 kW / can

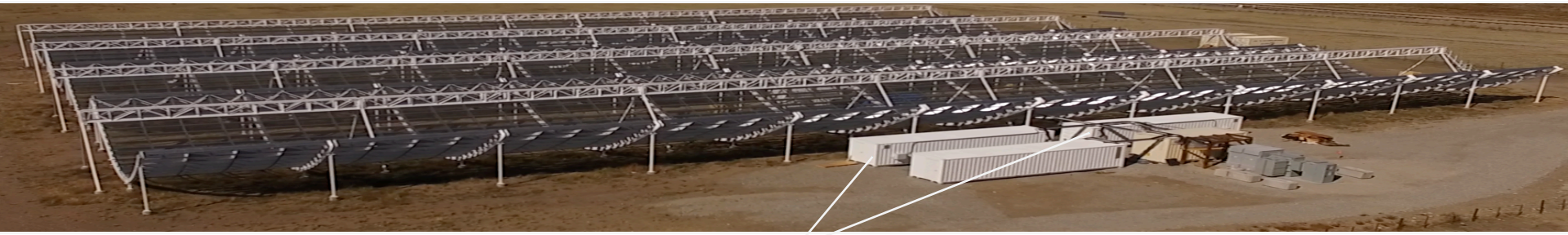
- Isolated RF/cooling/electrical
- 13 racks in each Sea-can



≈50dB Shielding

>100dB Shielding

# Site Updates (Correlator)

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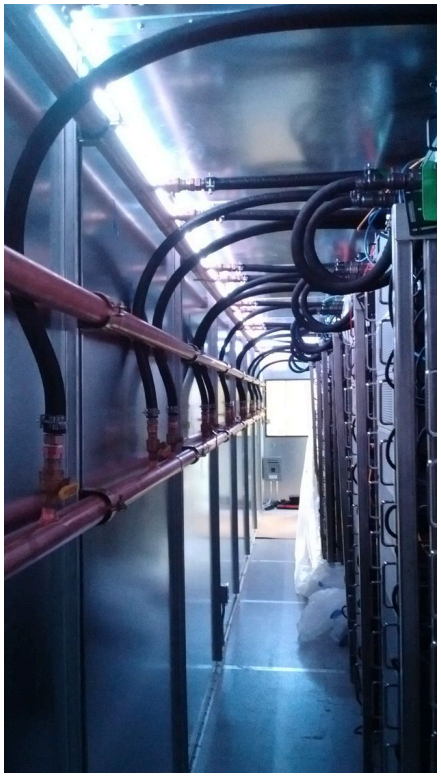
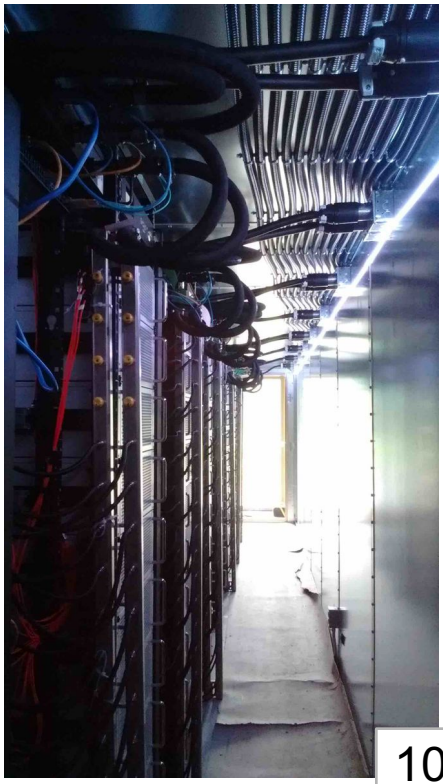
- 256 nodes @ 4 GPUs
- AMD FirePro™ S9300 x2
- Liquid cooled, leak-tight chassis

- Isolated RF/cooling/electrical
- 13 racks in each Sea-can

- 90% GPUs installed as of now
- Plumbing completed (Jojo Boyle)
- Scheduled turn on next week!





# Science goal of CHIME

Three simultaneous configurations:

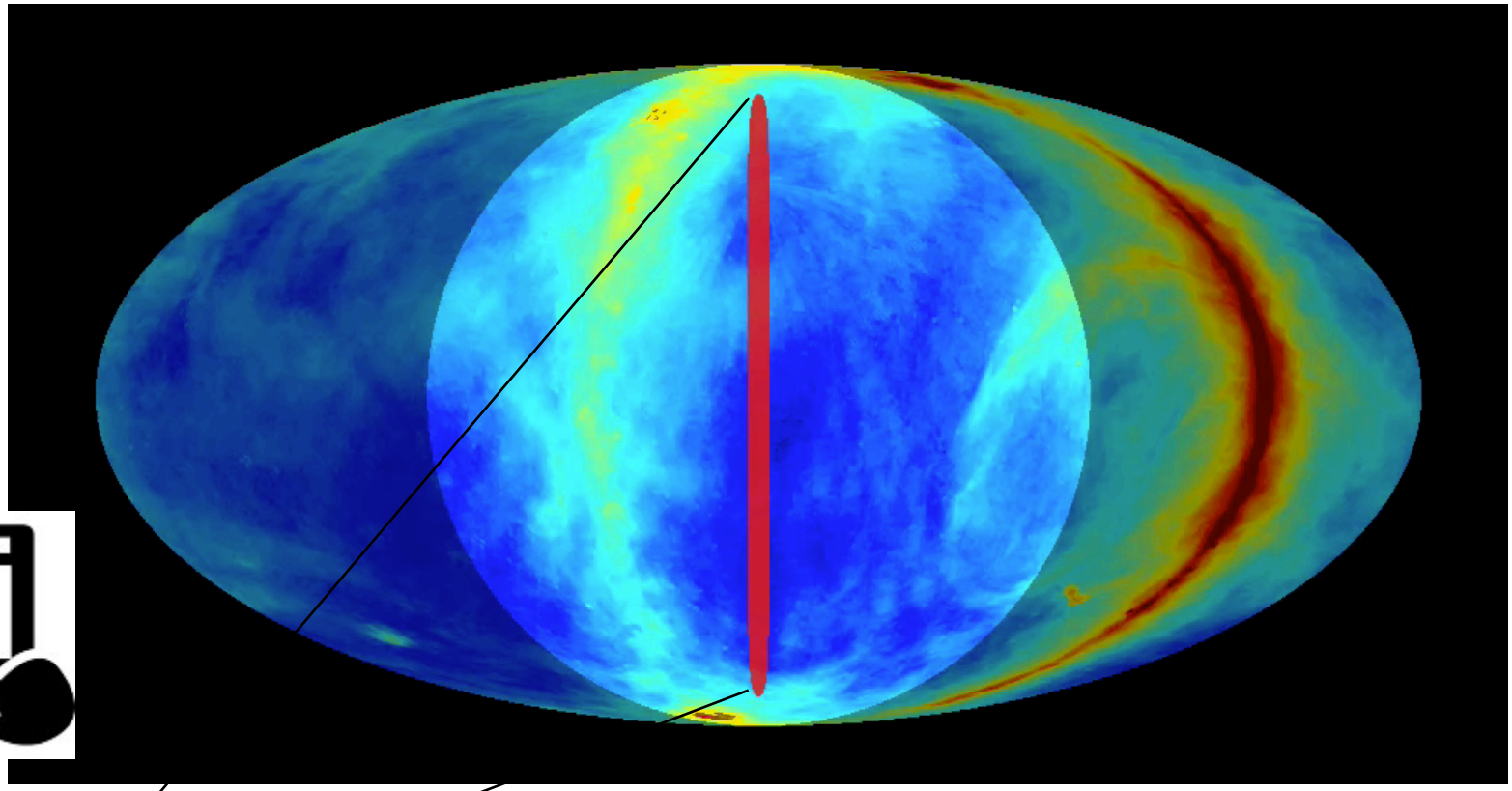
1. Cosmology ($N^2$ correlation) – CFI funded $12M
    - Neutral Hydrogen over $0.8<z<2.5$ to study the baryon acoustic oscillations

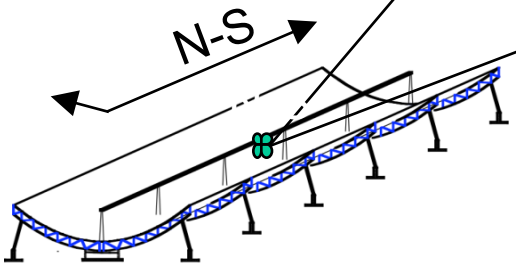
2. Pulsar timing (10 Tied-array beams) – RTI funded $128k
    - Cycle through all N-hemisphere pulsars in ~10 days
    - Daily observation of PTA sources

3. FRB (FFT beamforming) – CFI funded $5.6M
    - To be incoherently dedispersed for a range of DMs to search for FRBs

# Why is CHIME/FRB good?

1. Large FOV (~250 sq deg)






Primary beam of a single feed - analogue beamforming

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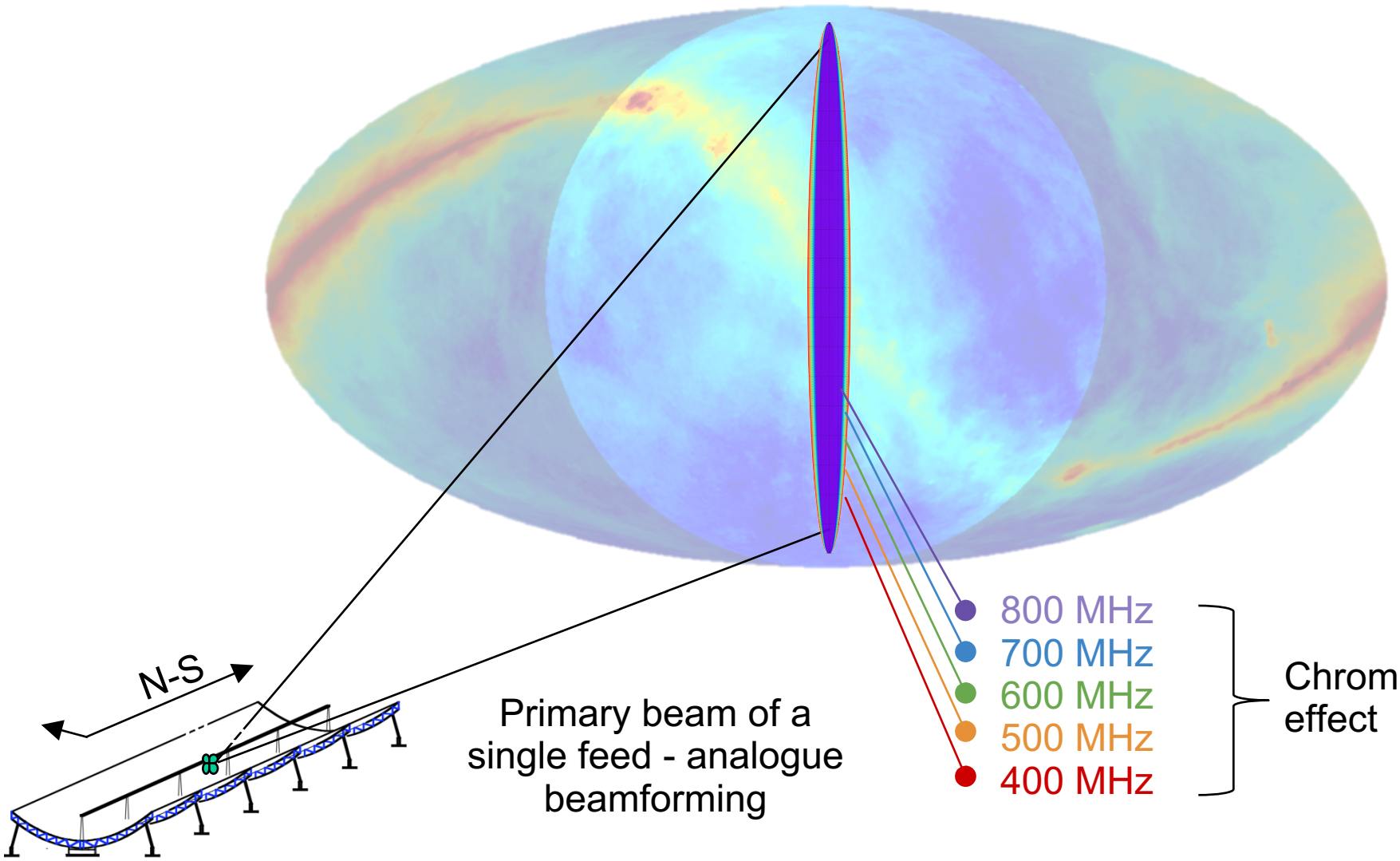
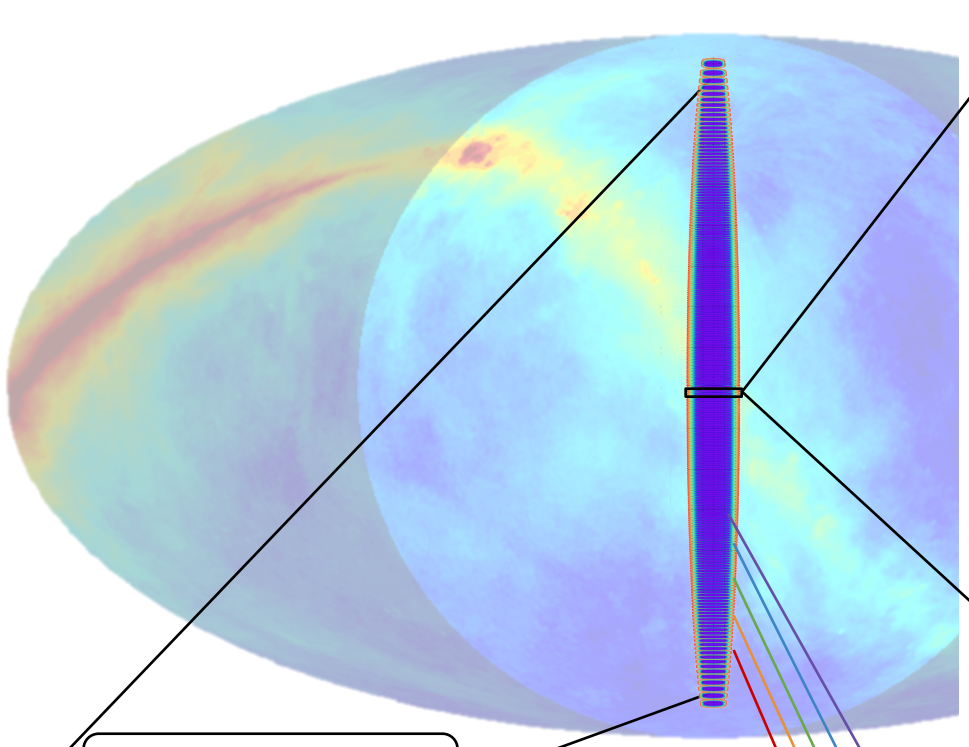
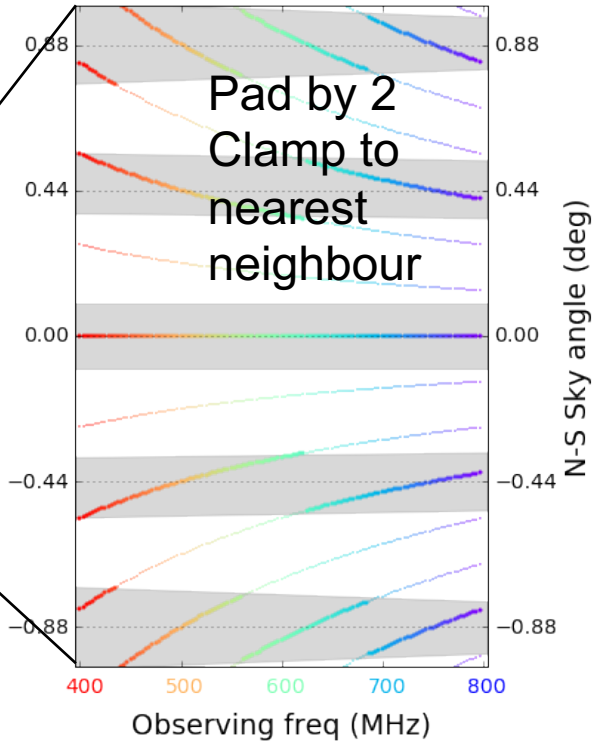


# Why is CHIME/FRB good?

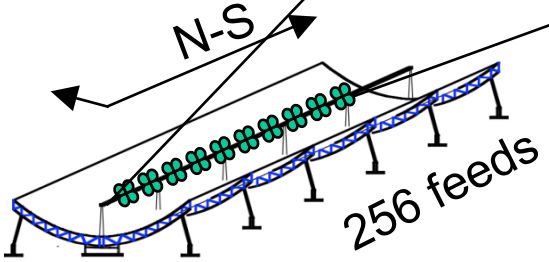
1. Large FOV (~250 sq deg)
   - FFT beamforming (Cherry Ng et al 2017, 1702.04728)






Hybrid:
1D Dish + 1D Interferometry

FFT Correlator




800 MHz
700 MHz
600 MHz
500 MHz
400 MHz

Chromatic effect

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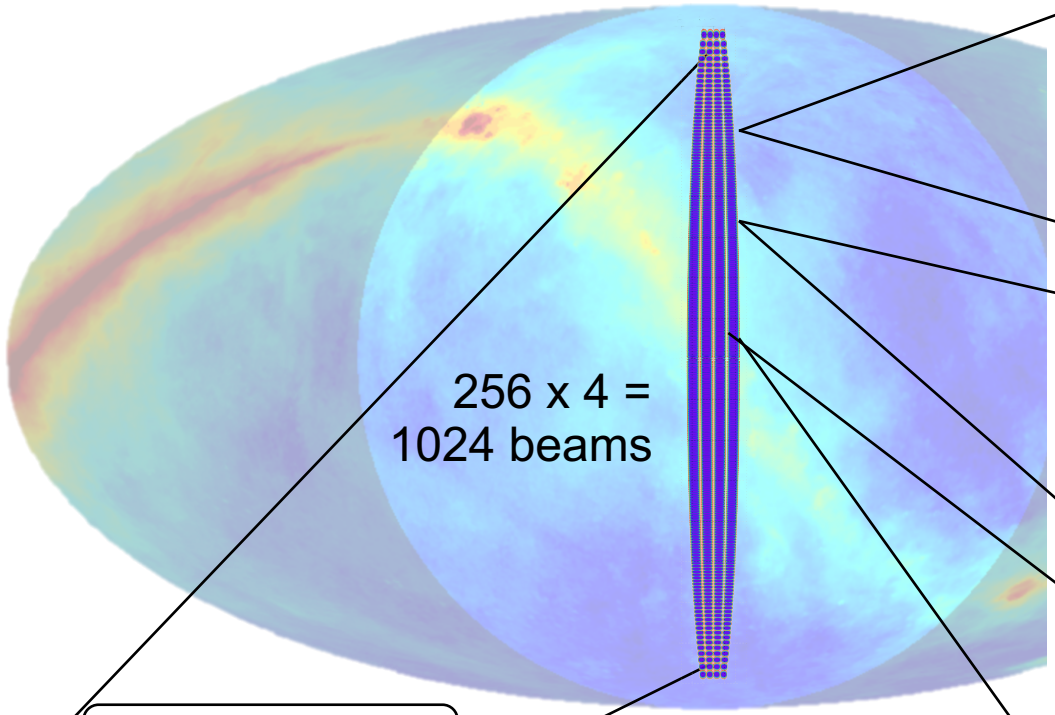
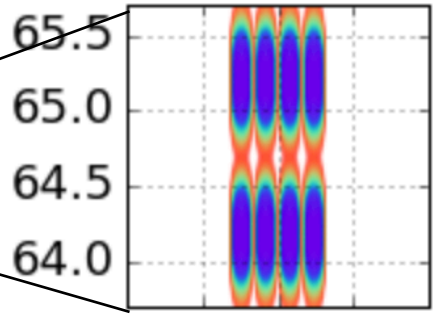
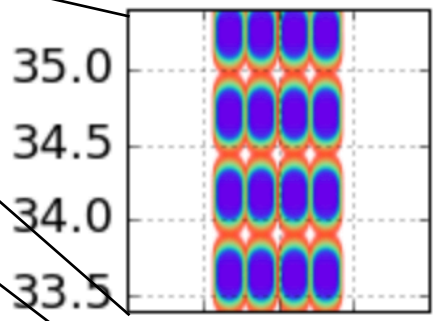
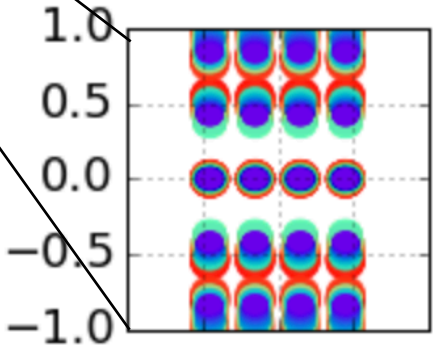


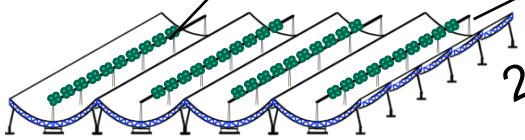




Hybrid:
1D Dish + 2D
Interferometry

FFT Correlator

N-S



256 feeds
x 4 = 1024

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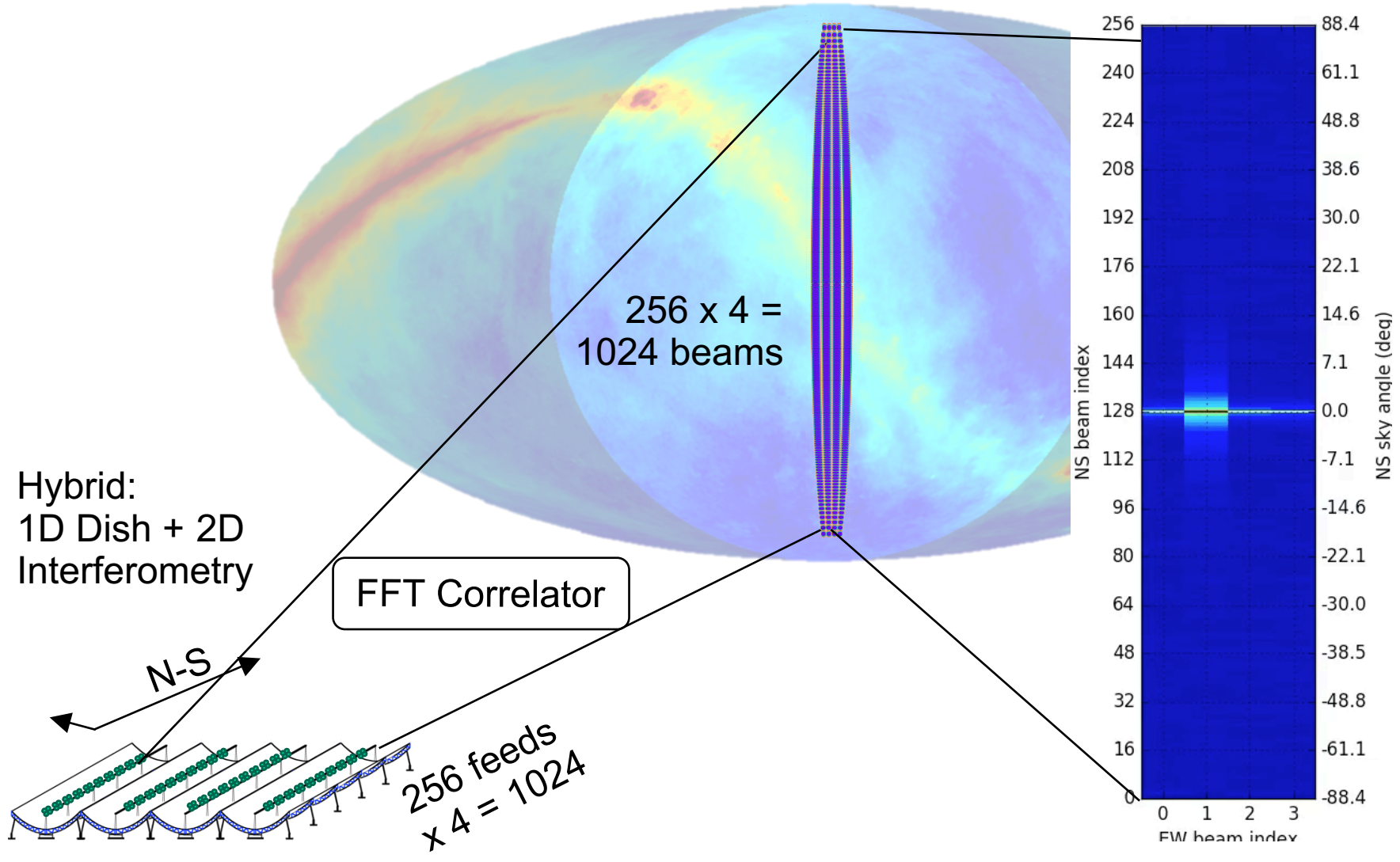
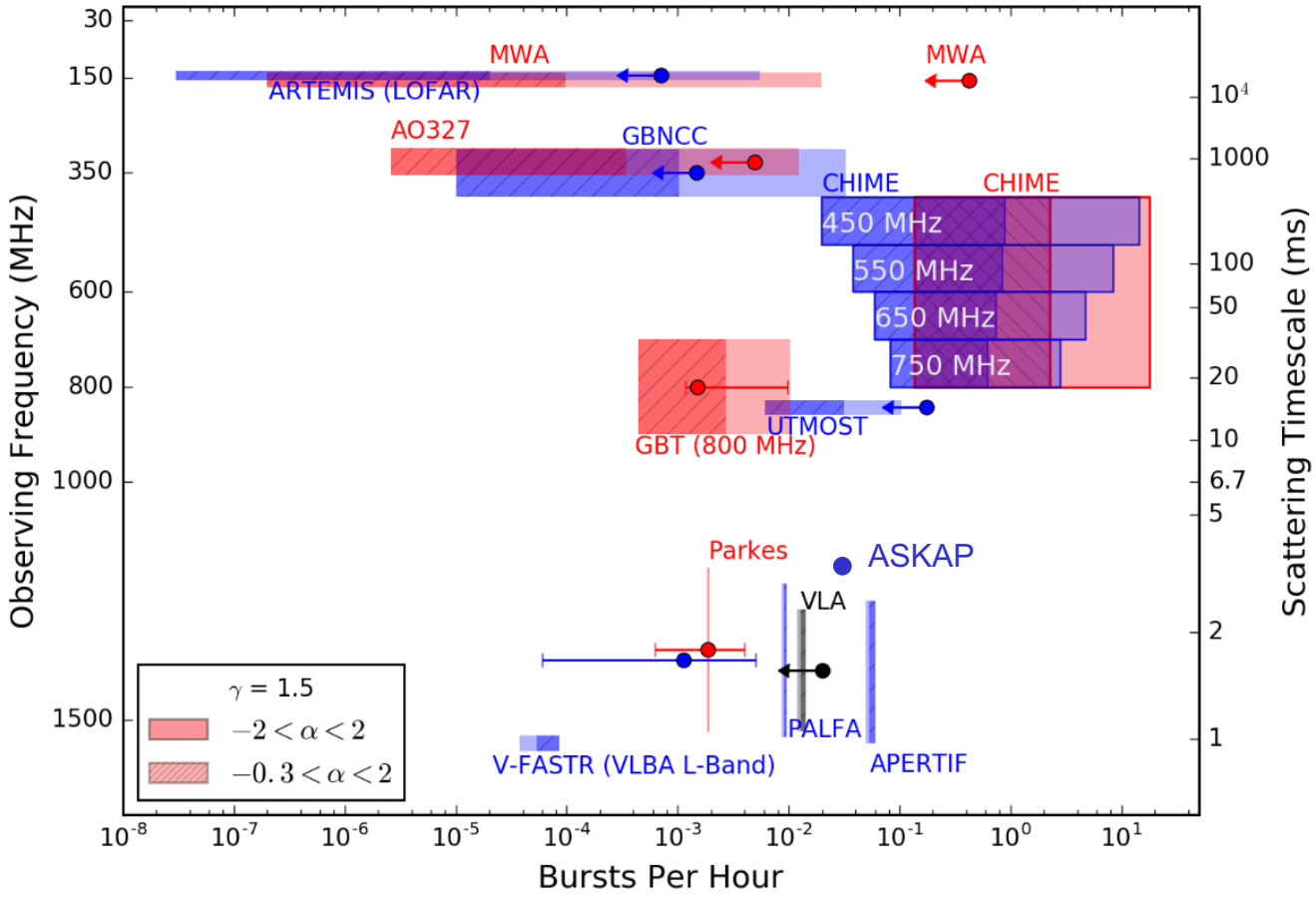


# Why is CHIME/FRB good?

1. Large FOV (~250 sq deg)
   - FFT beamforming (Cherry Ng et al 2017, 1702.04728)
   - Event rate: a few dozen / day (Pragya Chawla et al, submitted)
   - Repeatability, FRB distribution & population



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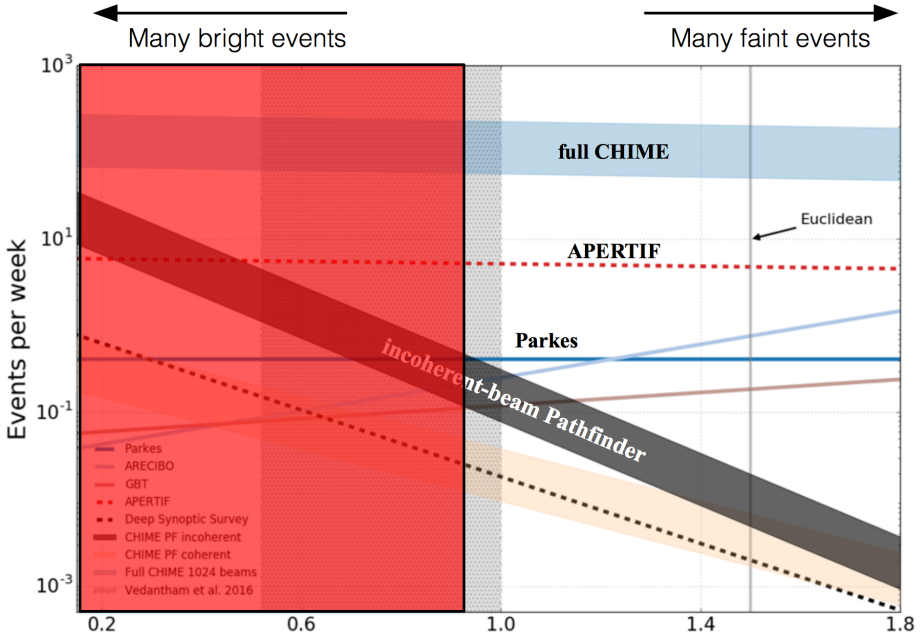
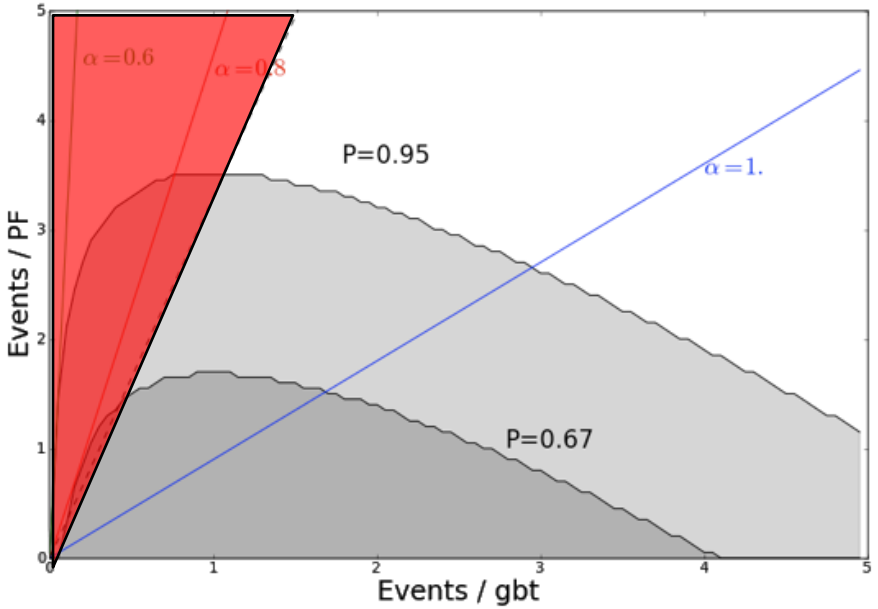
   - Event rate: a few dozen / day (Pragya Chawla et al, submitted)
   - Repeatability, FRB distribution & population
   - $\log N$-$\log S$ from Pathfinder (Liam Connor et al, 2017, 1702.08040)




$$N(>S) = S^{\alpha}$$

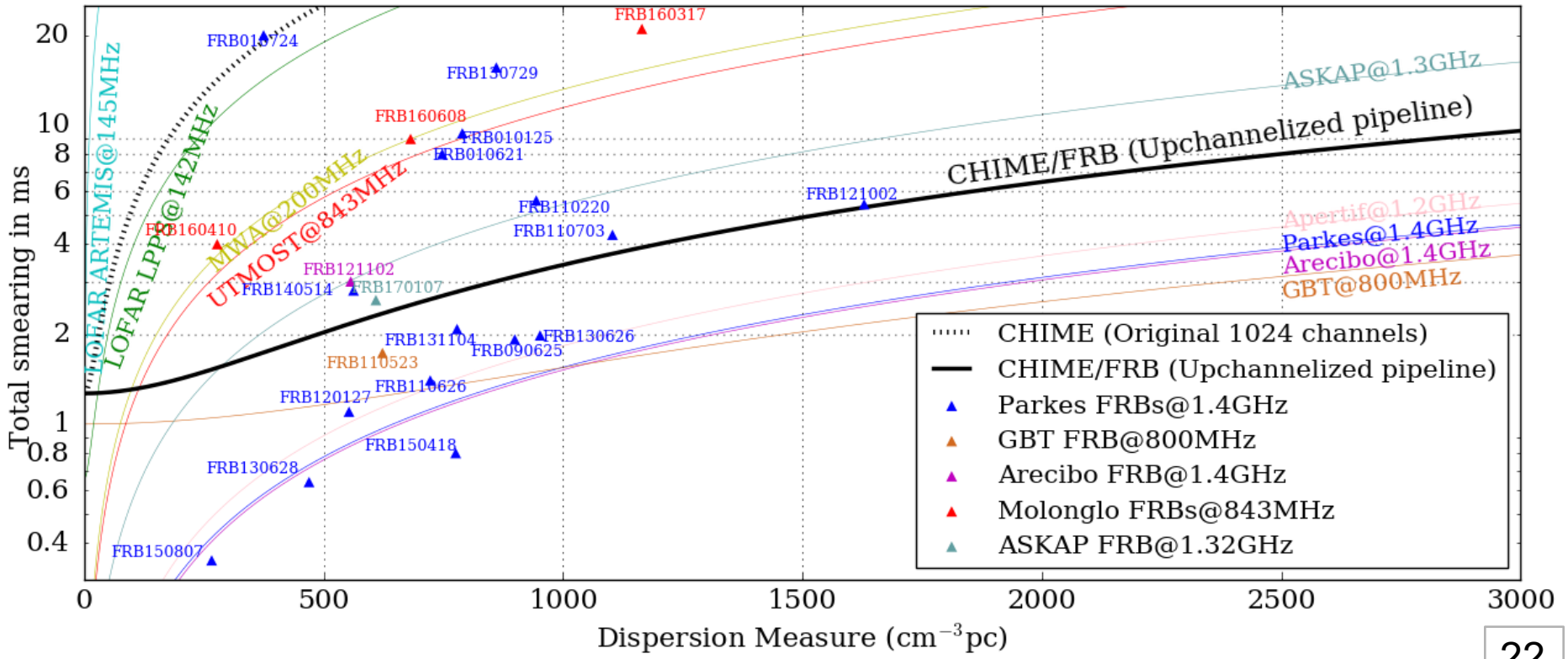
Mark Halpern




Rule out $\alpha$ < 0.9 with 95% confidence

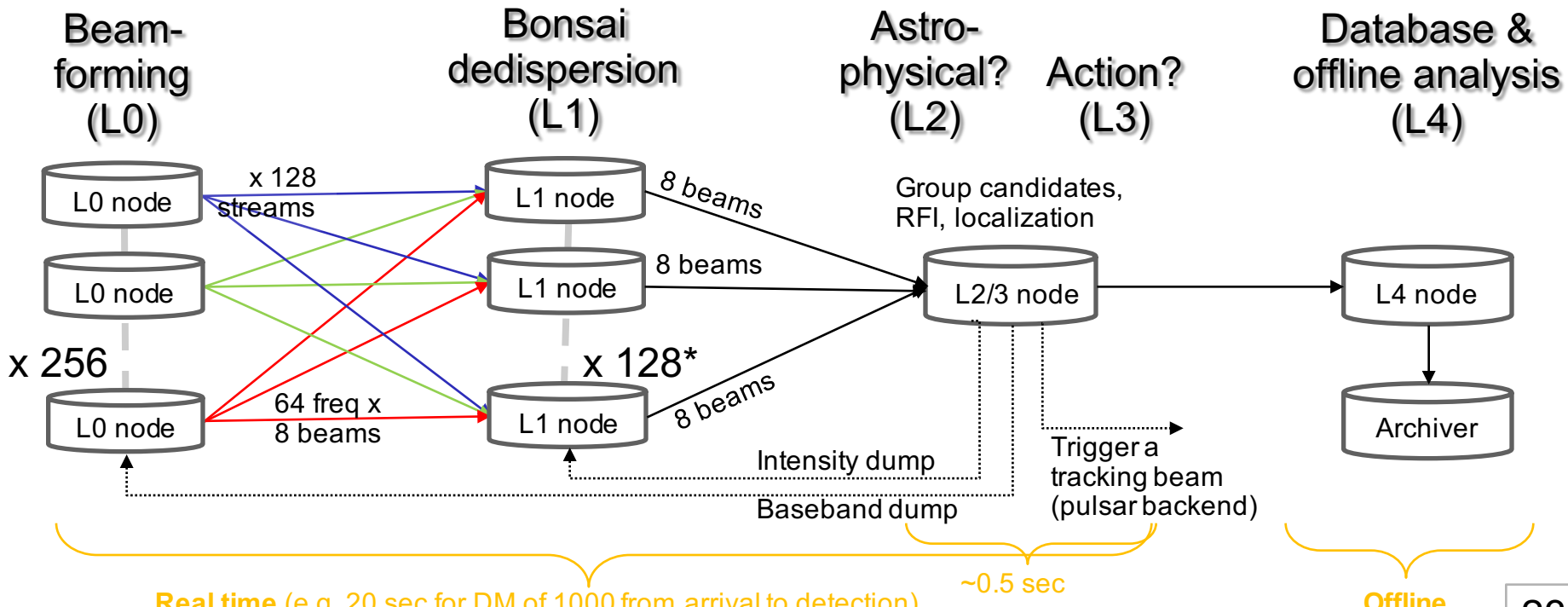
# Why is CHIME/FRB good?

1. Large FOV (~250 sq deg)
2. High resolution & Wide bandwidth
   - Input: 256 rcvr × 4 cyl × 2 pols = 2048-input voltages, 1024 nchan, 2.56 μs
   - Output:1024 power beams, pol summed, 8-bit int, 16k nchan, 0.983 ms
   - Upchannelize to minimize intra-channel smearing (Cherry Ng et al 2017, 1702.04728)



# Why is CHIME/FRB good?

1. Large FOV (~250 sq deg)
2. High resolution & Wide bandwidth
3. Highly optimized search (c.f. Talk by Kendrick Smith)
   - All beams, spectral index, width, DM<10,000
   - Low latency, basically real-time
   - Work by Boyce, Boyle, Brar, Burhanpurkar, Fonseca, Giri, Josephy, Kaspi, Lang, Patel, Pleunis, Ravandi, Scholz, Smith, Tendulkar




* Still deciding between 128 or 64 nodes

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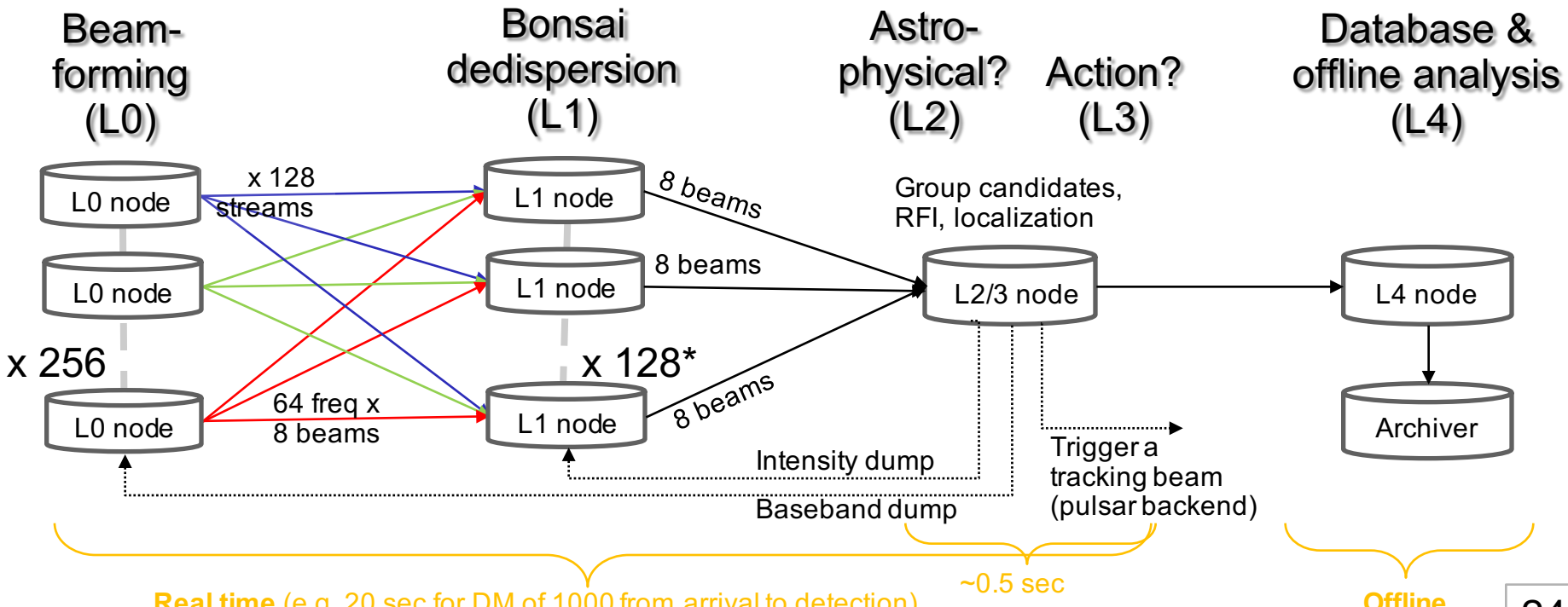
1. Large FOV (~250 sq deg)
2. High resolution & Wide bandwidth
3. Highly optimized search (c.f. Talk by Kendrick Smith)
4. Localization
   - ~20' nominal, better if multi-beam detection
   - few arcmin real-time trigger baseband dump (Kiyo Masui, Davor Cubranic)
   - Arcsec possible if opt/X-ray counterparts, VLBI (Ue-Li Pen et al)

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2. High resolution & Wide bandwidth
3. Highly optimized search (c.f. Talk by Kendrick Smith)
4. Localization
5. Association
    - Real-time trigger to other telescopes, Atel, multi-wavelength
6. Ancillary science
    - RRAT, Magnetar, dwarf stars, LMXB…

# Summary

1. Large FOV (~250 sq deg)
2. High resolution & Wide bandwidth
3. Highly optimized search
4. Localization
5. Association
6. Ancillary science

➔ A great FRB instrument !

Expect “first light”

end of summer 2017 !

| | |
|---|---|
| Bandwidth | 400-800 MHz |
| Number Feeds/cylinder | 256 dual pol feeds per cylinder |
| System temperature | <30 K |
| FOV | 90° (N-S) ; 1.3–2.5° (E-W) = 250 sq deg |
| Beam size | 0.26° at 800 MHz; 0.52° at 400 MHz |
| FRB frequency channels | 16k output frequency channels, $\Delta\nu$ = 24 kHz |
| FRB time resolution | 0.983 ms |