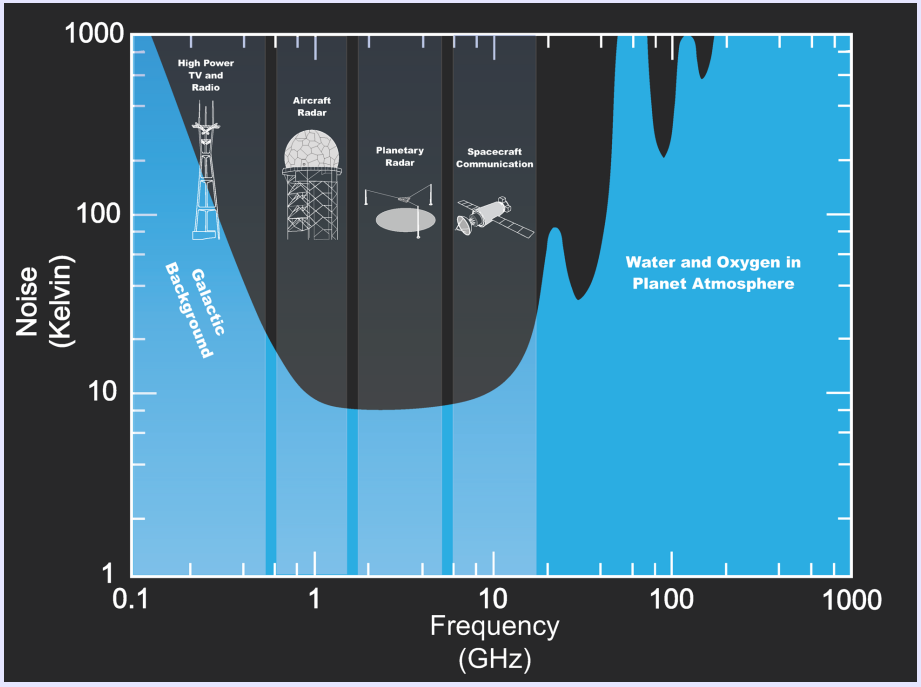
COSMIC: Commensal SETI on the VLA

Paul Demorest (NRAO), on behalf of the COSMIC team
New Mexico Symposium, 2023/02/17

SETI background

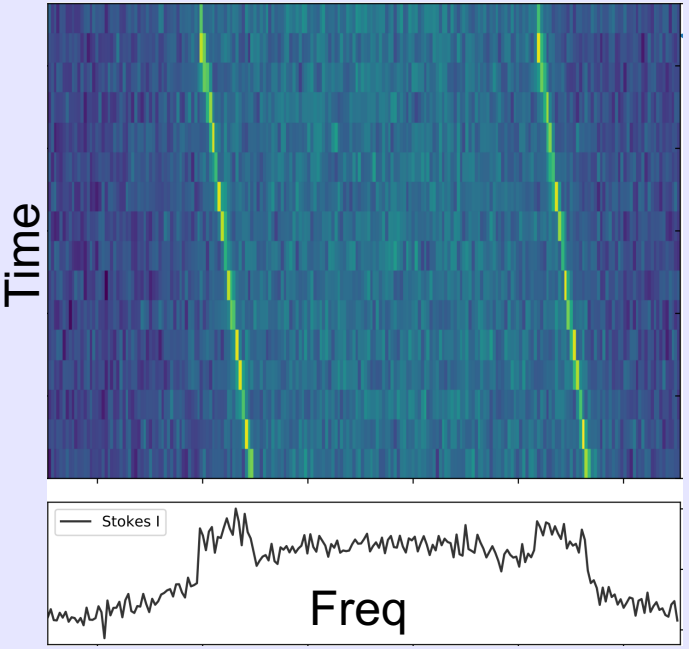
- SETI = the Search for Extraterrestrial Intelligence
  - Goal is to take a scientific/observational approach to answer the question of whether intelligent life exists elsewhere in the universe.
- A radio search is potentially good for this because:
  - First long-distance communication method invented by humans.
  - Travel relatively easily through interstellar gas, planetary atmospheres, etc.
  - We have big radio telescopes!



(BSRC)

SETI – how to do it?

- Want to detect a non-terrestrial radio signal that can not be generated by known natural (non-intelligent) astrophysical processes.
  - Narrowband – ~1 to 10 Hz bandwidth
  - Frequency may drift vs time due to motion
- Frequency is unknown. Need very high spectral resolution over wide band → custom backend system
- More questions:
  - Where do we look?
  - When do we look?



Voyager signal
drift rate ~0.36 Hz/s

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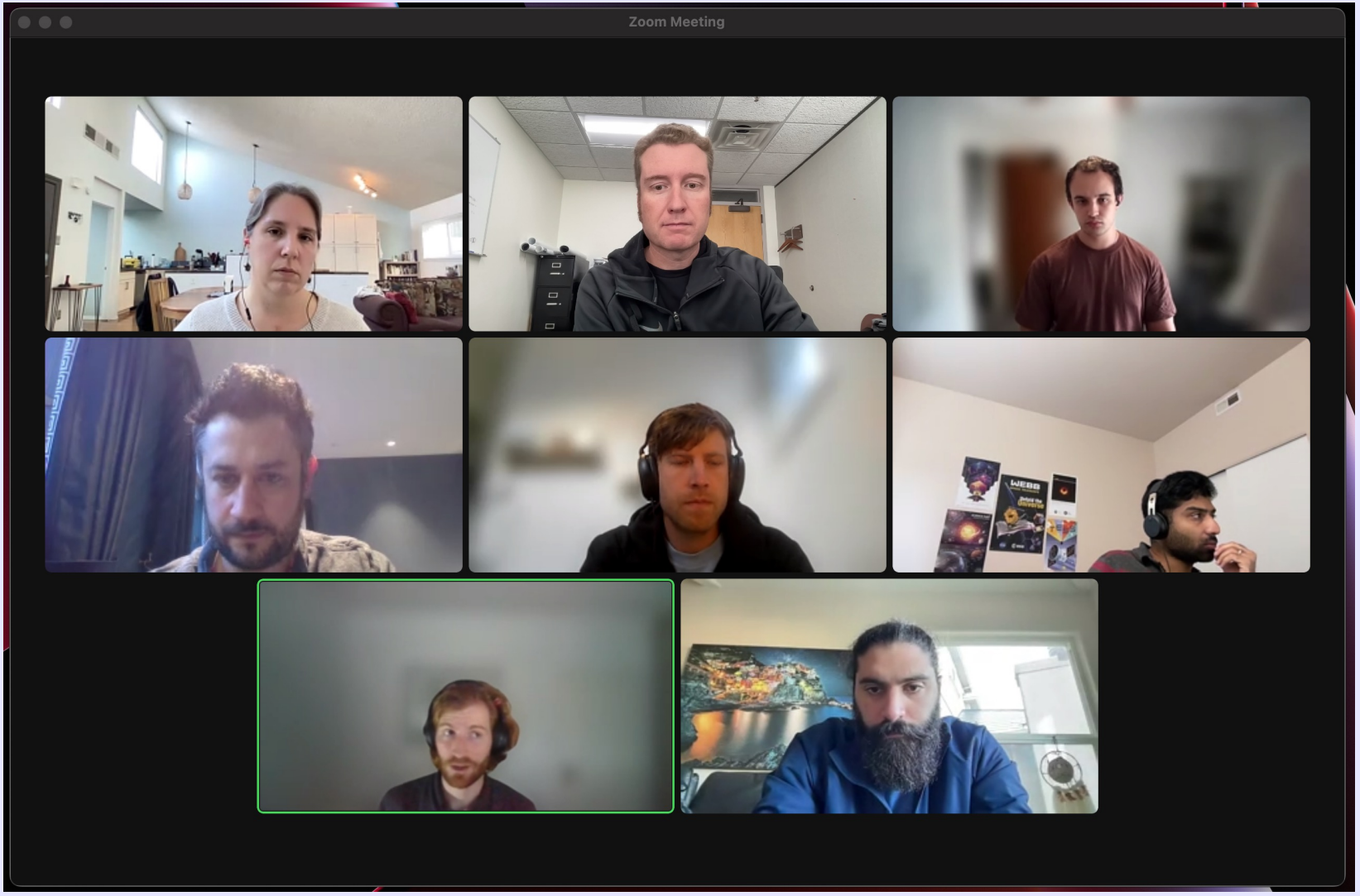
- More questions:
  - Where do we look? Everywhere!
  - When do we look? All the time!
- Of course not practical to devote entire VLA to SETI…

COSMIC SETI project

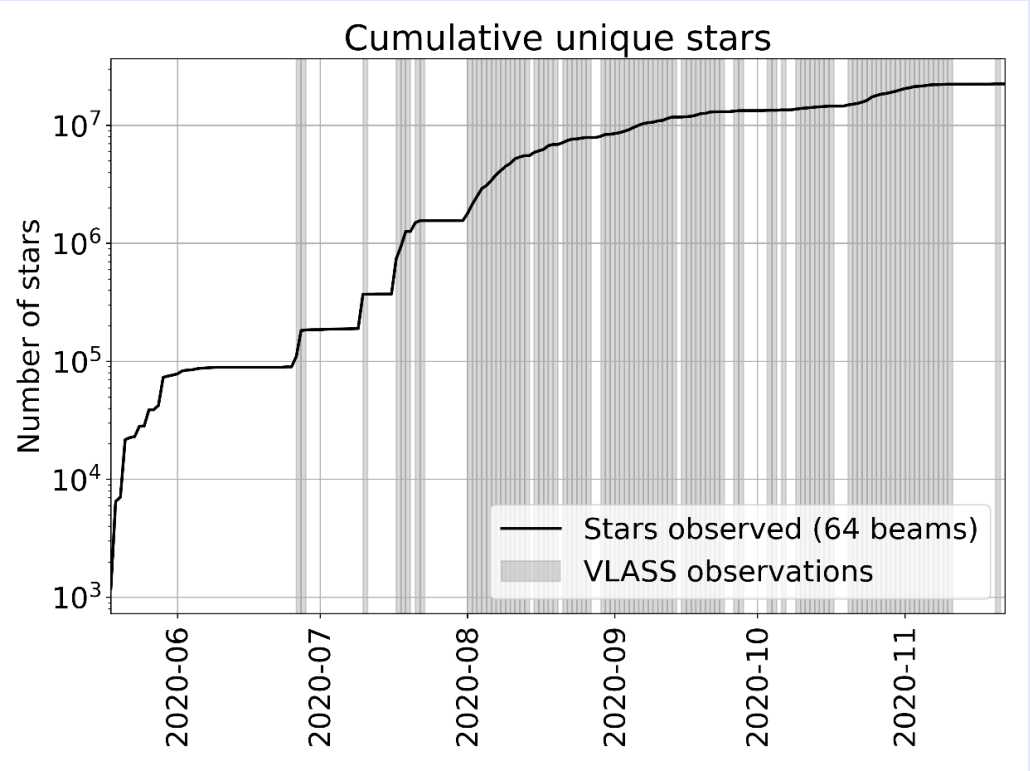
- COSMIC = "Commensal Open-Source Multimode Interferometer Cluster"
- Project led by SETI Institute to build a commensal SETI backend for the VLA
  - https://science.nrao.edu/observing/proposal-types/commensal-observing-with-nrao-telescopes
- COSMIC Contributors:
  - SETI Institute: Daniel Czech, Ross Donnachie, Wael Farah, Jack Hickish, Kevin Lacker, Ty Larrabee, Dave MacMahon, Talon Myburgh, Cherry Ng, Mark Ruzindana, Andrew Siemion, Chenoa Tremblay, Savin Varghese
  - NRAO: Isaiah Acevedo, Tom Baker, Claire Chandler, Jon Cooper, Paul Demorest, Michael Erwin, Ephraim Ford, Doug Gerrard, Cindy George, Chris Langley, David Paul, Doug Whiton

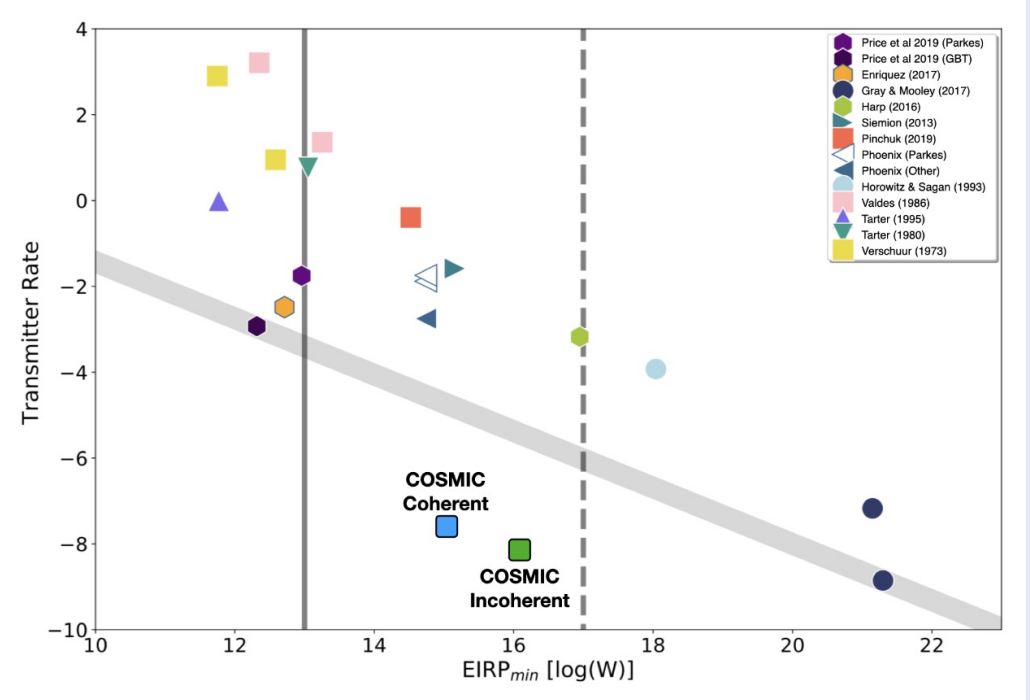
COSMIC contributors



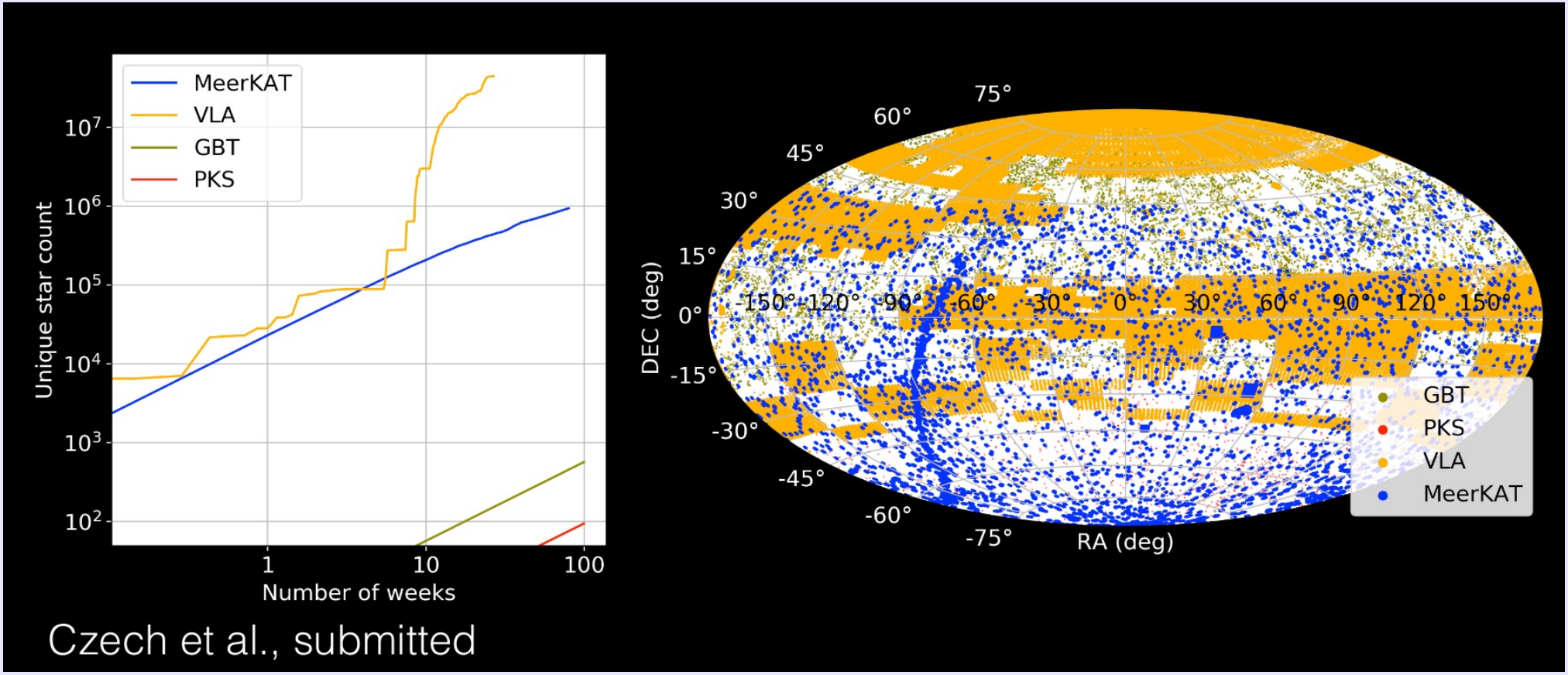
COSMIC science goals

- Operate in parallel with all VLA observations.
- Form up to 64 beams within FoV to target nearby stars.
- Process each beam to look for very narrow-band (~Hz) signals, drifting up to ~tens of Hz/sec.
- Goal of being operational during VLASS epoch 3 (ie, ~now!)

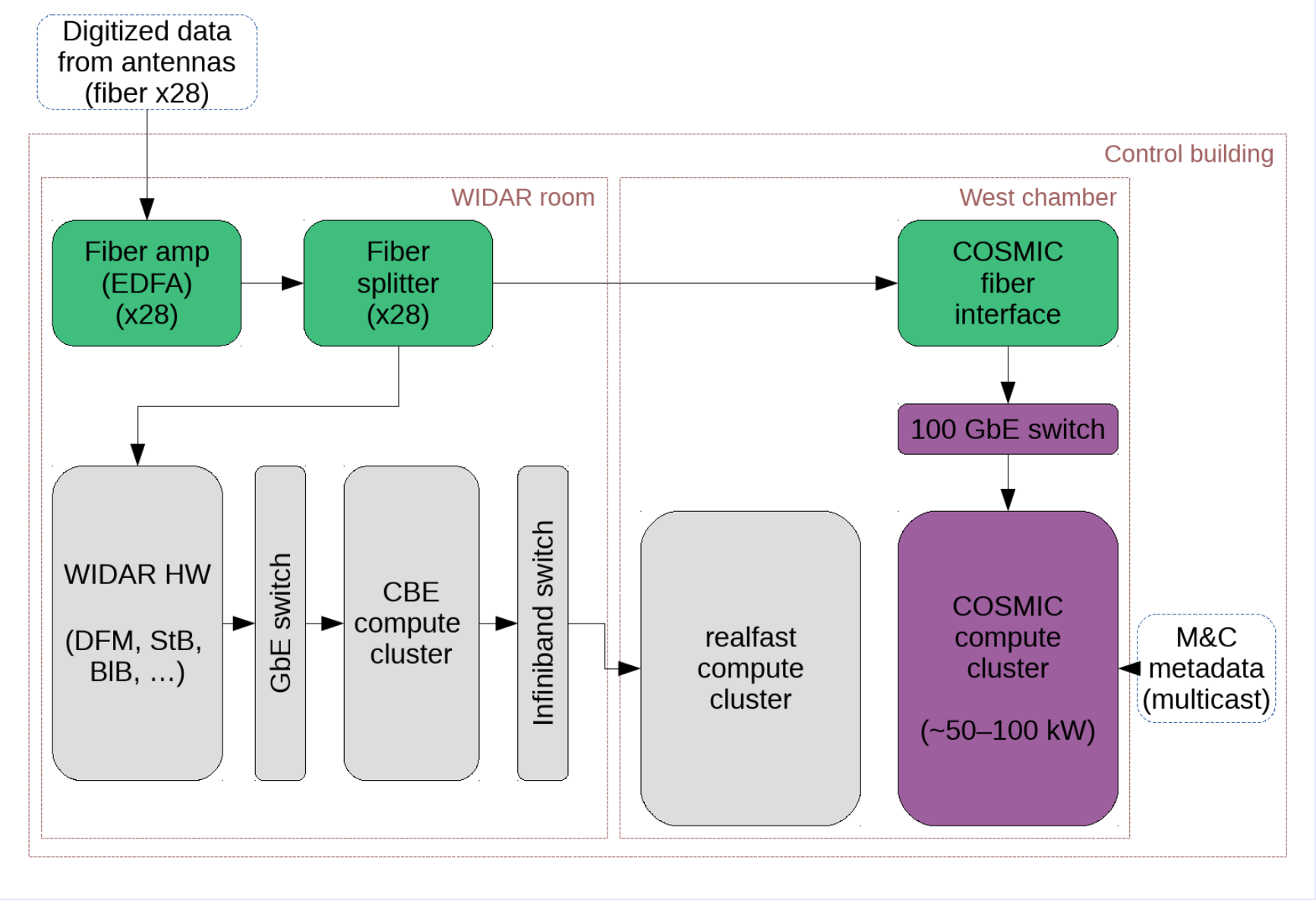




SETI survey sky coverage

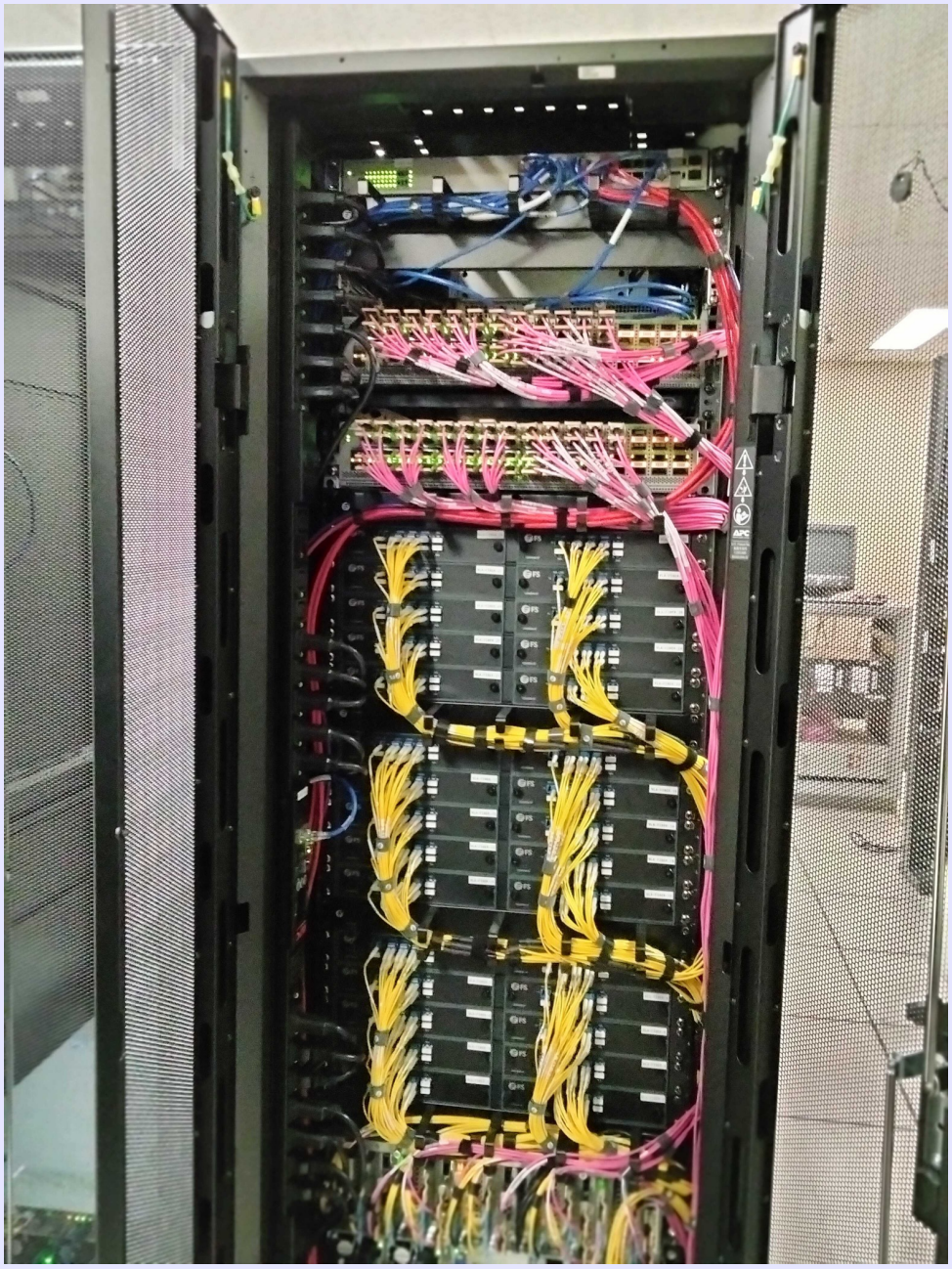


COSMIC in the VLA context



Fiber / DTS / F-engine – splits 1-GHz band into 1-MHz channels, Ethernet packetize
Network / compute / GPU – correlator, beamformer, narrowband spectral processing

COSMIC pictures!



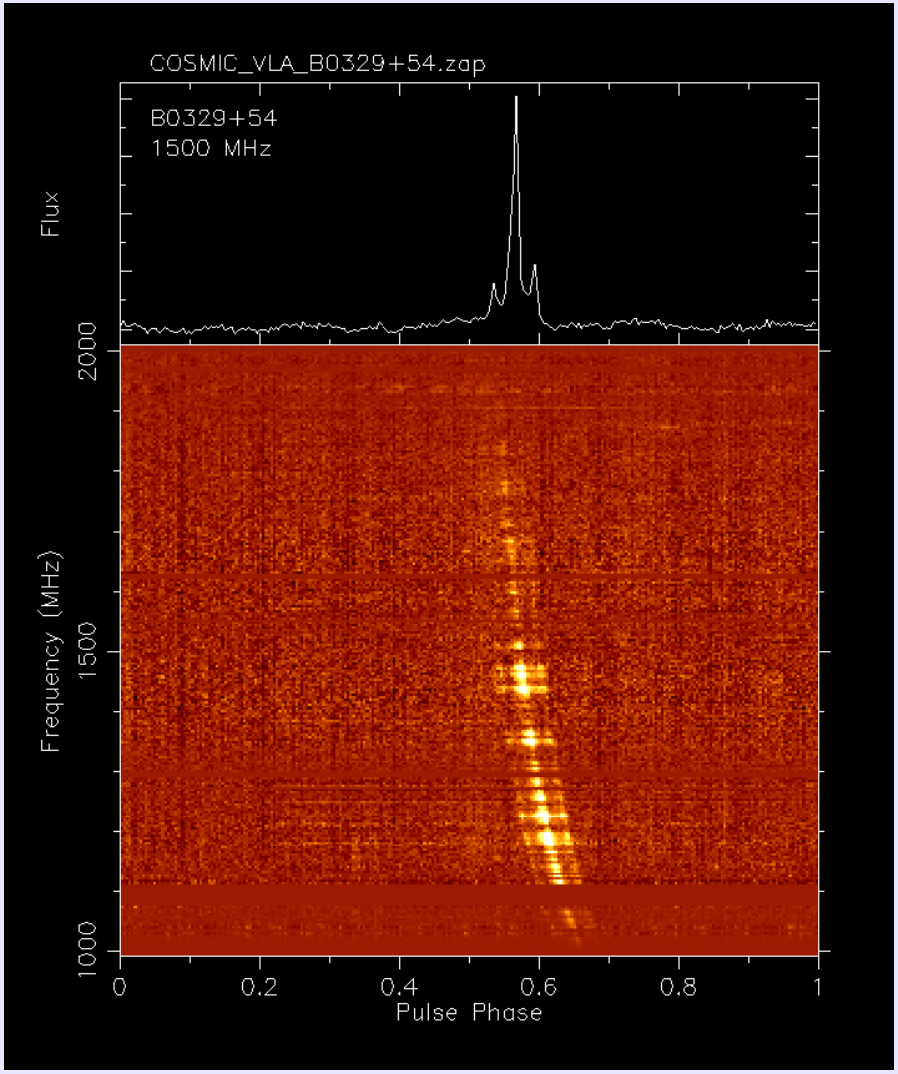
28 antennas * 13 signal fibers (yellow), ethernet (pink) ~ 400 total fiber connections

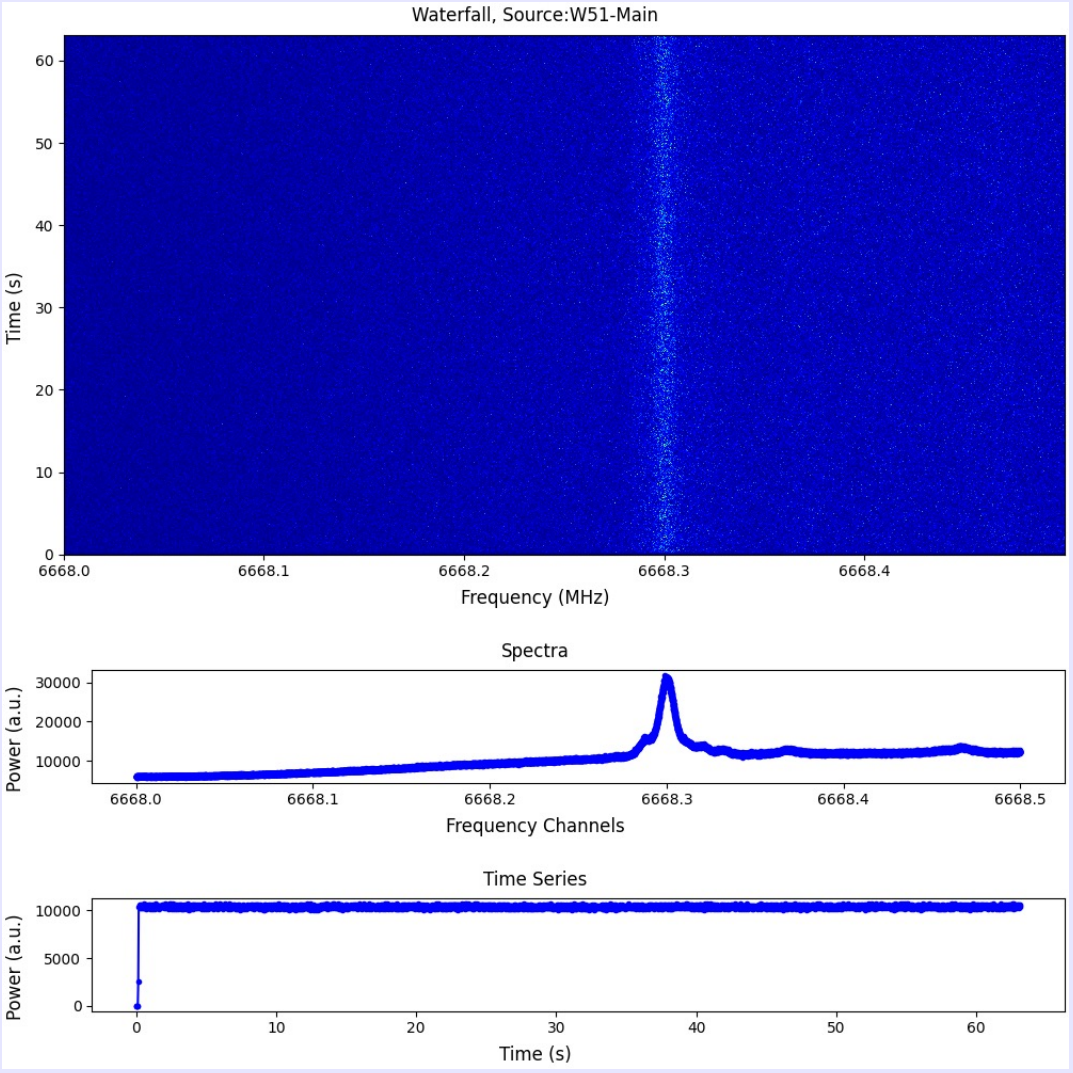
COSMIC pictures!

6 out of 10 racks currently half-filled: 17 total GPU nodes, 2 storage nodes, many fiber connections.

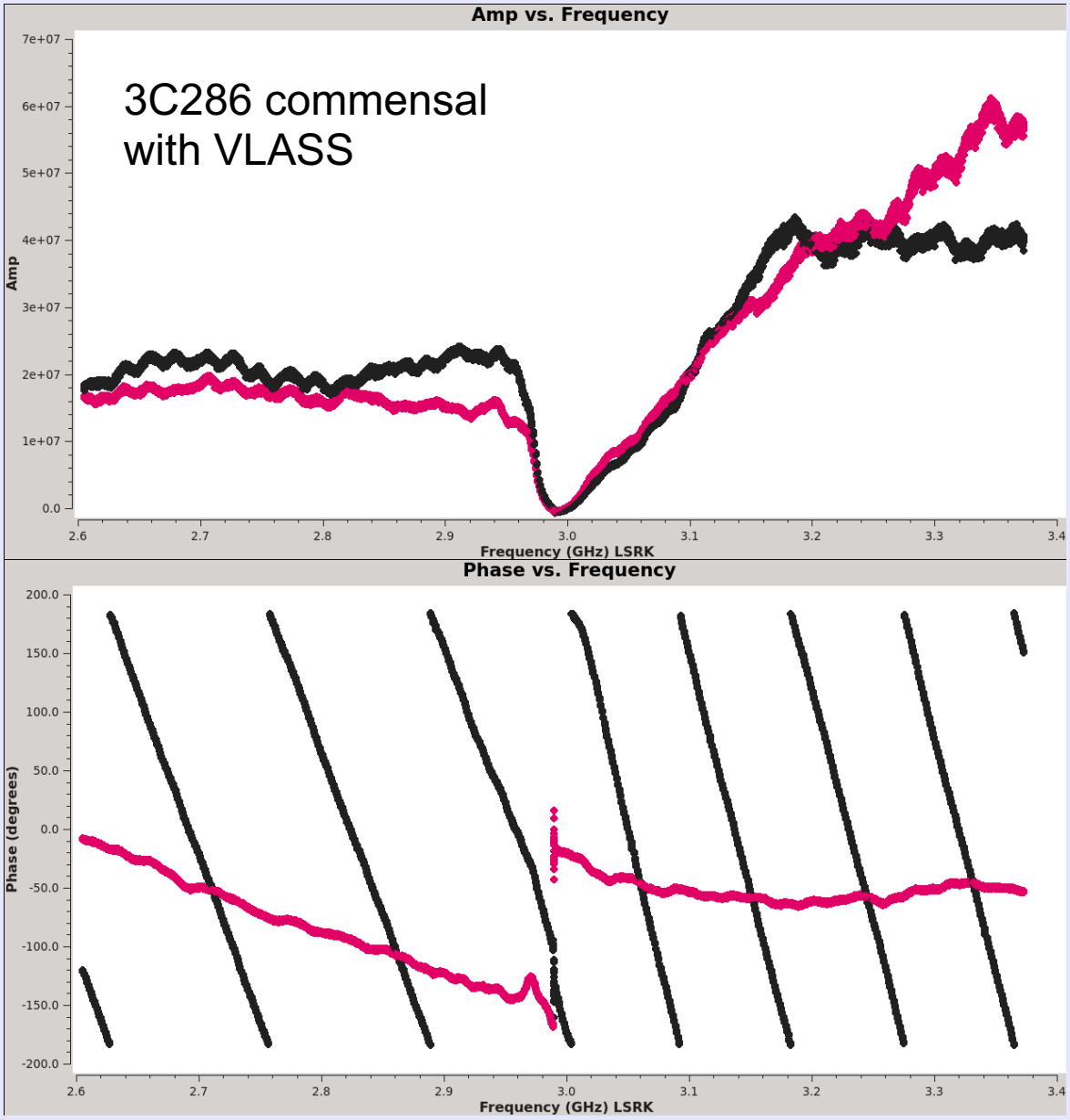
Lots of room for future expansion, likely requires upgraded electrical and cooling infrastructure.

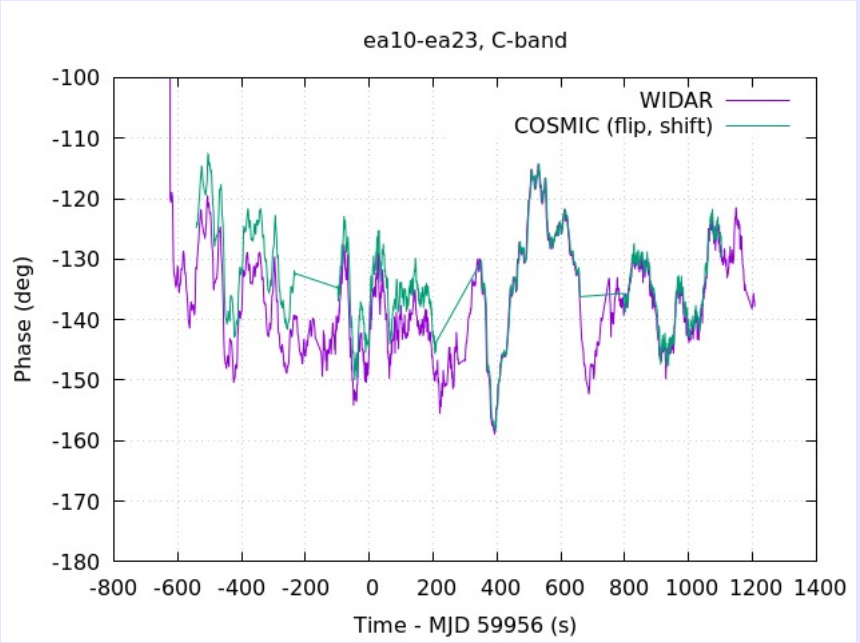
COSMIC data! Single-antenna tests



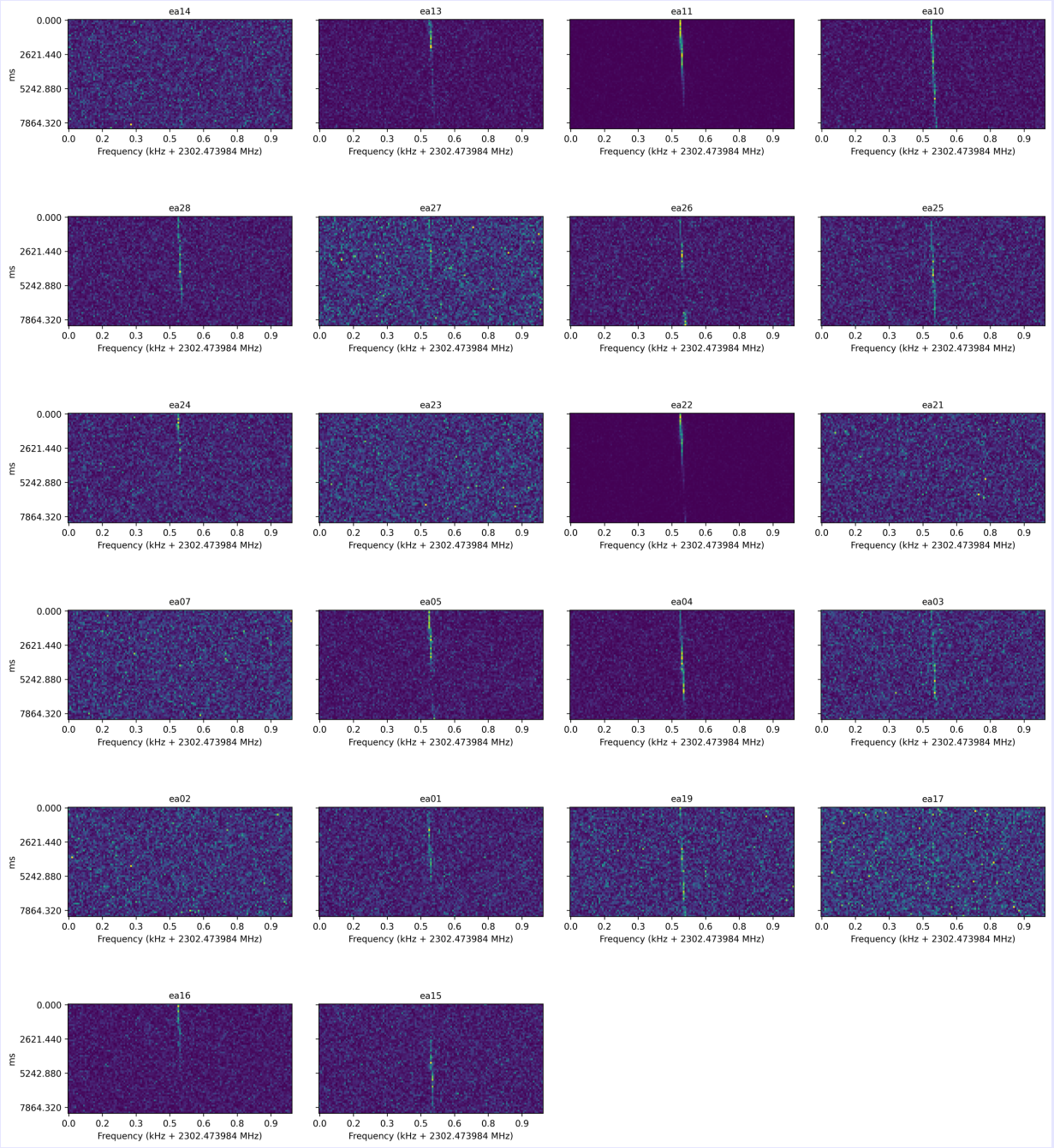


COSMIC data! Cross-correlations (fringes)





COSMIC data! narrowband “hits” (RFI)



COSMIC summary and future

- COSMIC will commensally search ~all VLA science observations for drifting narrowband signals potentially indicative of advanced technology.
- Currently transitioning from commissioning/testing to early science operation – processing 1 GHz BW during VLASS is imminent!
  - Ongoing work: improve calibration reliability, verify beamforming software.
  - Expect to observe ~10^7 unique stellar targets during VLASS
- Ethernet/software-based system is very flexible – please contact NRAO or COSMIC team about other possible uses.
- https://science.nrao.edu/facilities/vla/observing/cosmic-seti

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SETI background / history

- Historical connection to NRAO – Frank Drake ran first modern radio SETI search at Green Bank in 1960s
  - 85-ft telescope, 2 nearby stars, ~1420 MHz frequency
- No detections, but led to development of “Drake Equation” for estimating number of radio-emitting ETs:

Many terms in this equation are very uncertain, but it is a great tool for science education.

In general SETI provides excellent opportunity for outreach/education!

(Drake Eqn plaque at GB)

Commensal observing

- Split telescope signal and process it for multiple scientific uses in parallel
  - “Primary” project controls pointing, receivers, etc
  - Commensal projects get lots of time on sky for “free”
- Currently, two commensal systems operating at the VLA:

VLA Low Band Ionospheric and Transient Experiment (VLITE)