GReX & future ChASMs

Local Universe FRBs with all-sky monitors

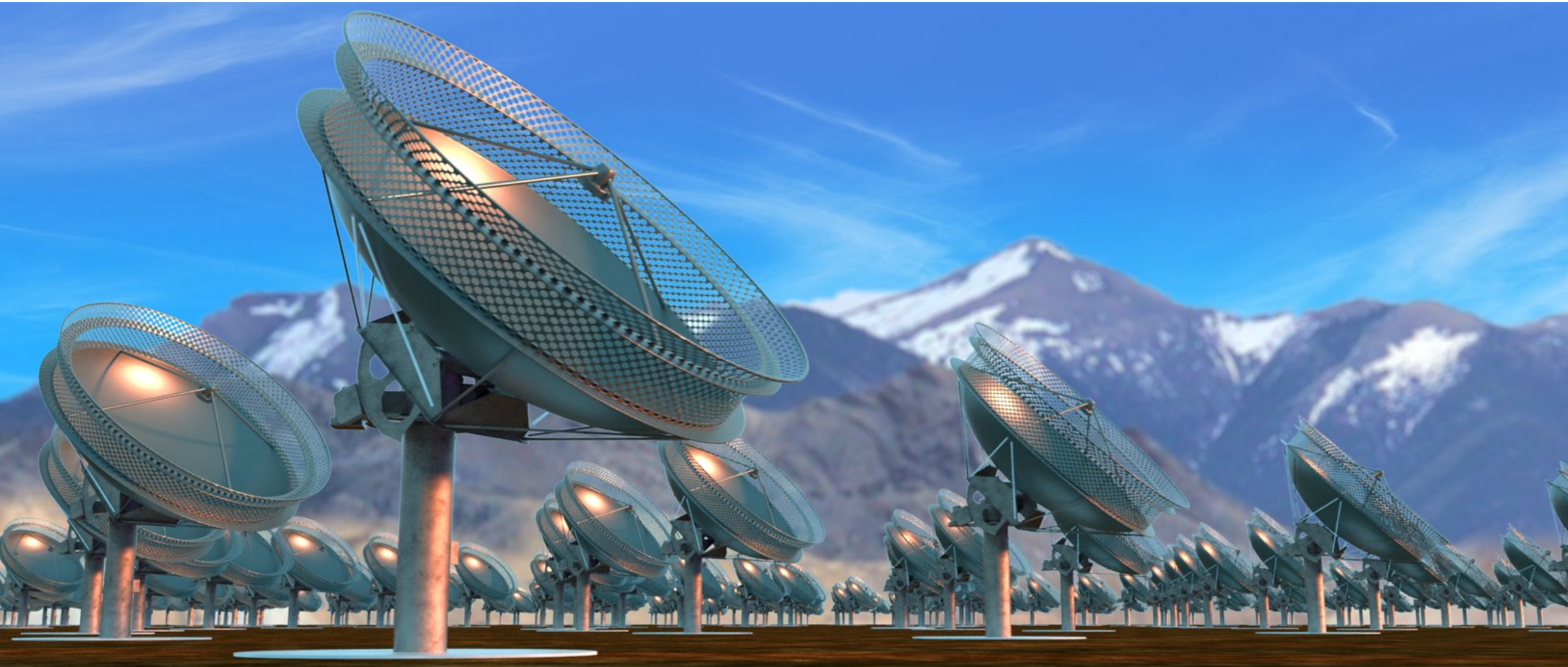
Liam Connor Oct 2022

Caltech

DSA-2000

700—2000 MHz SEFD ~ 2.5 Jy

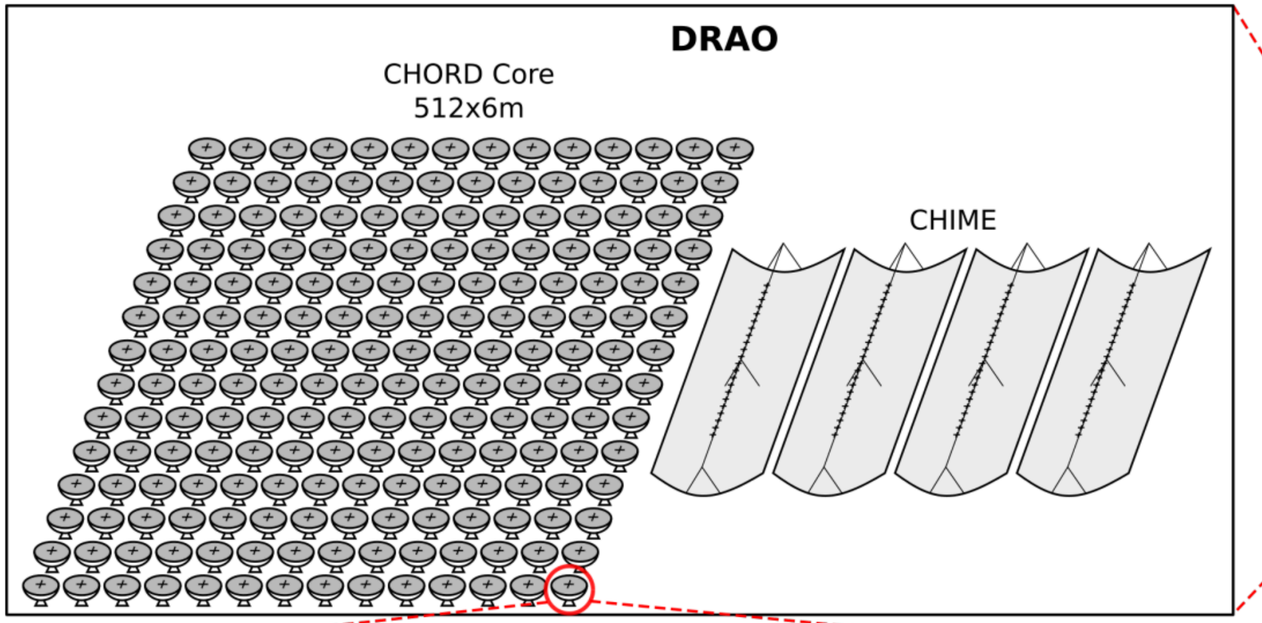
~100k beam search ~10 deg^2

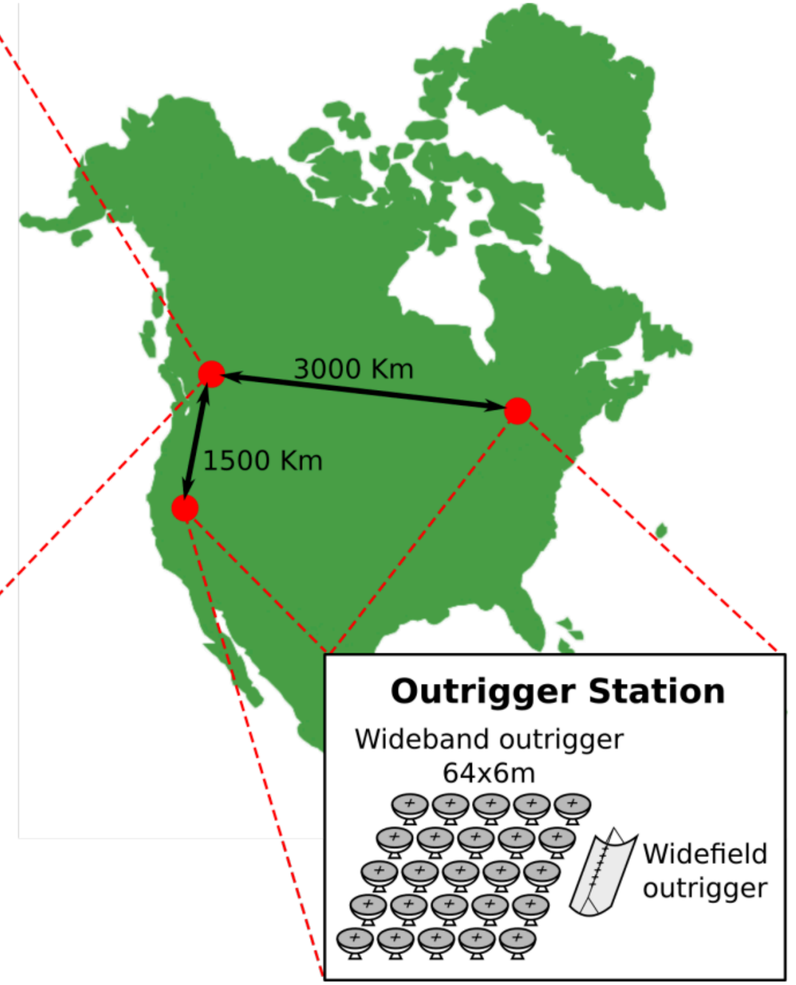


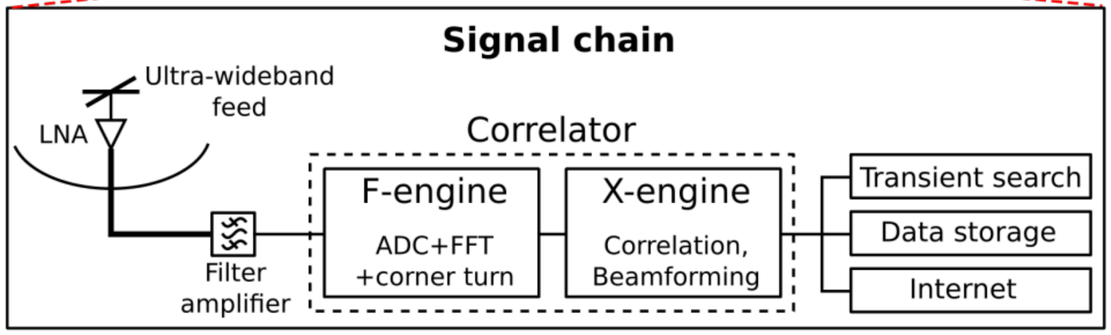
CHORD

300—1500 MHz SEFD ~ 9 Jy

~6—150 deg^2

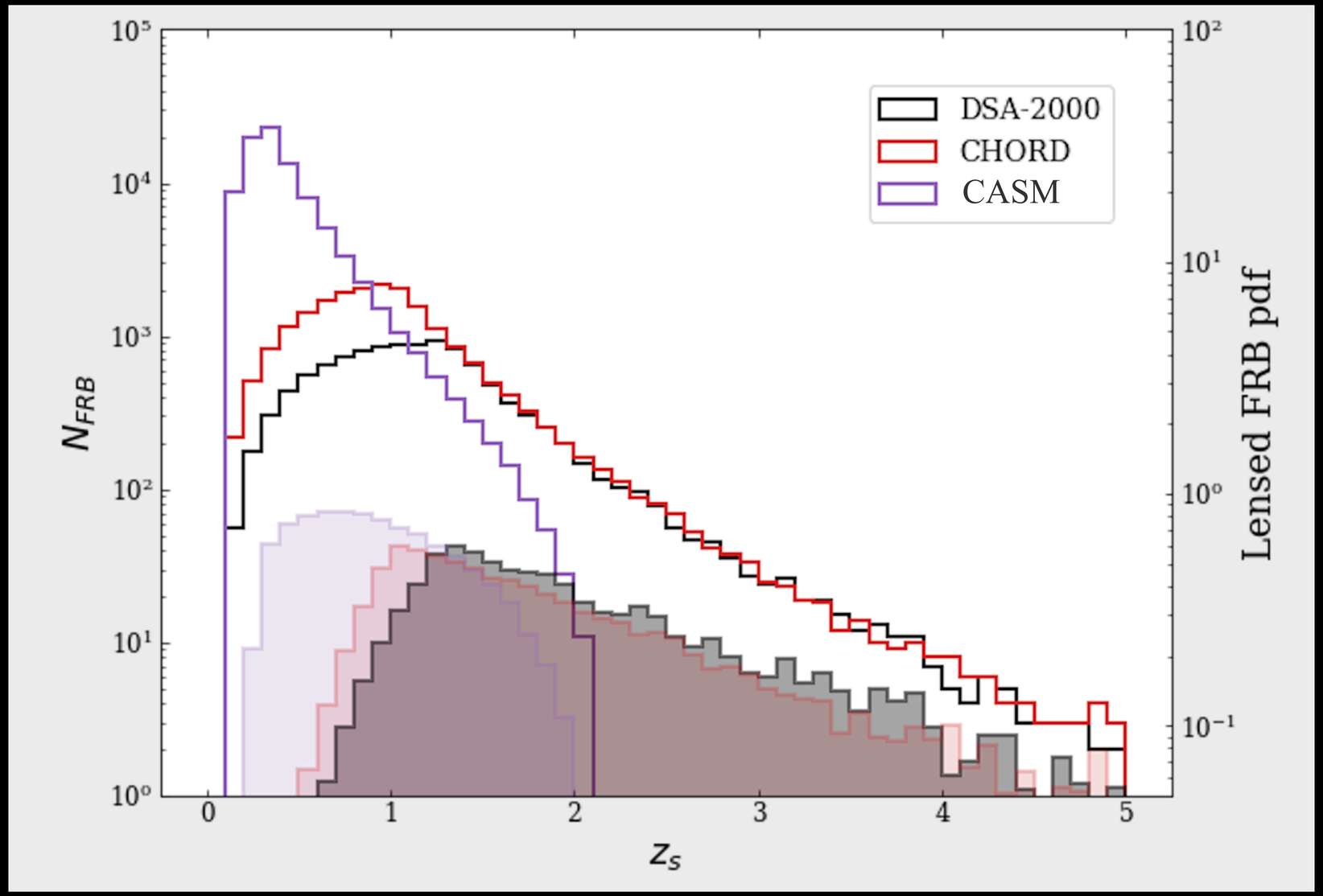






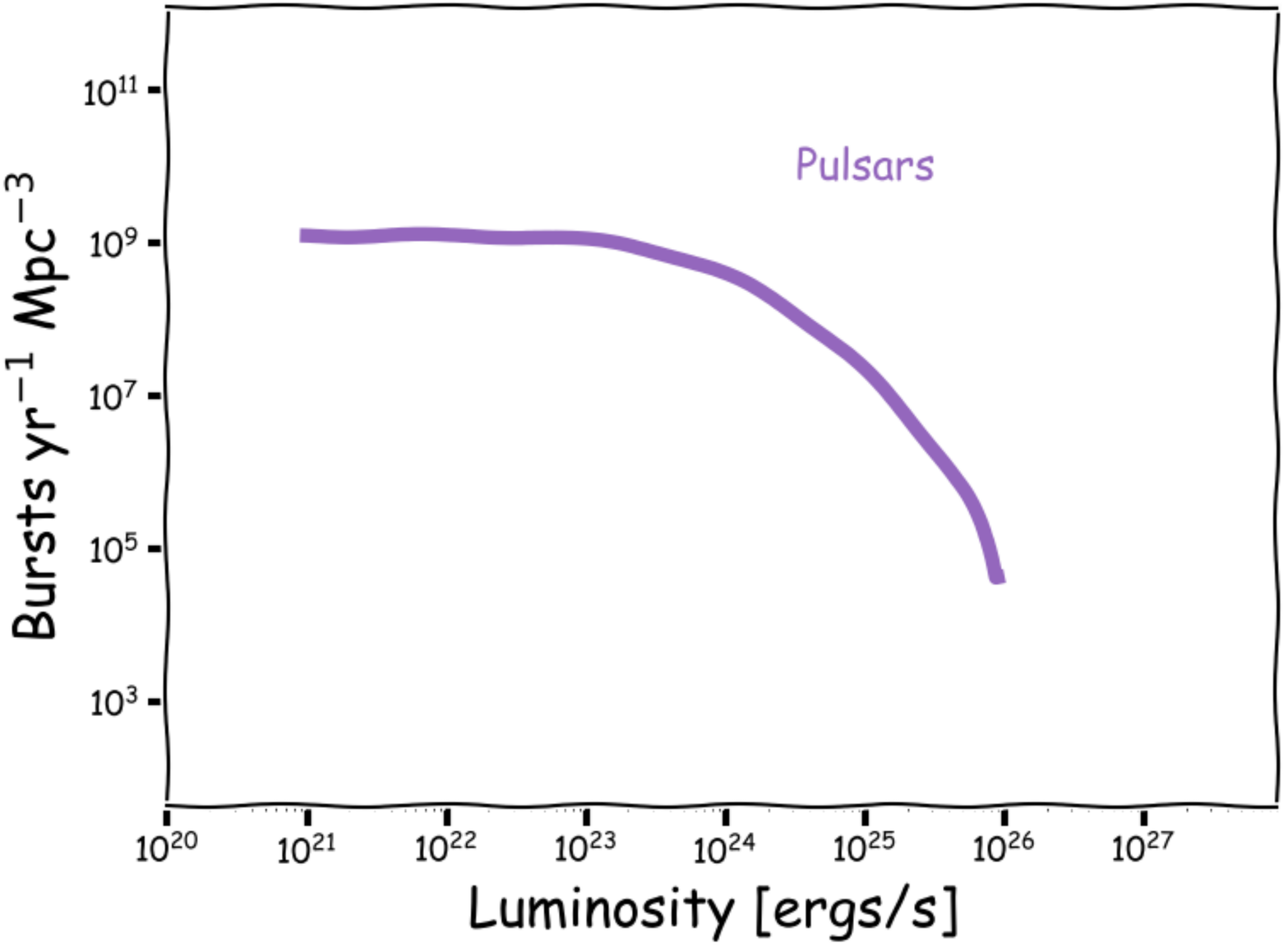
ASKAP/CRACO

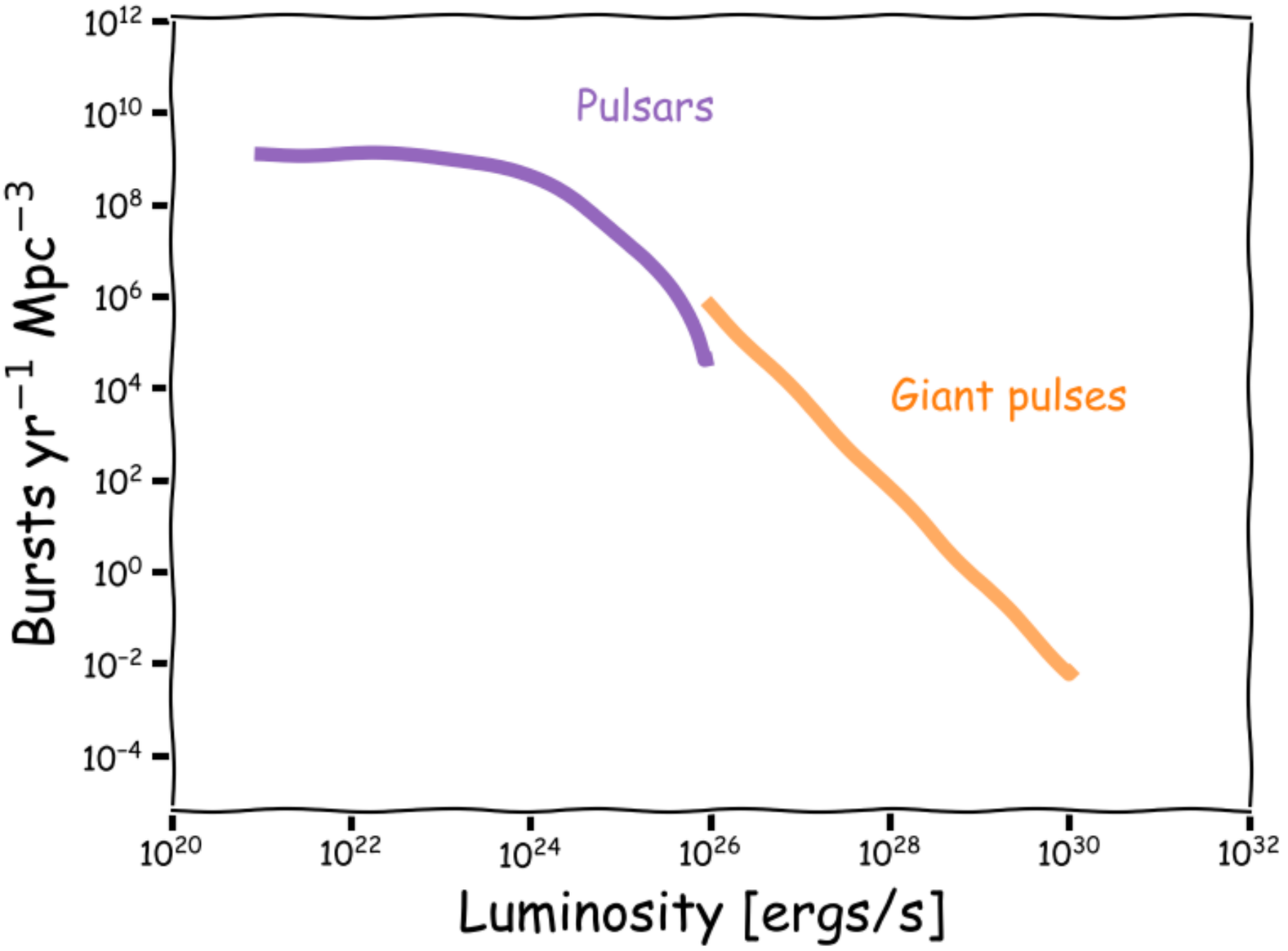
Trade off between FoV and sensitivity

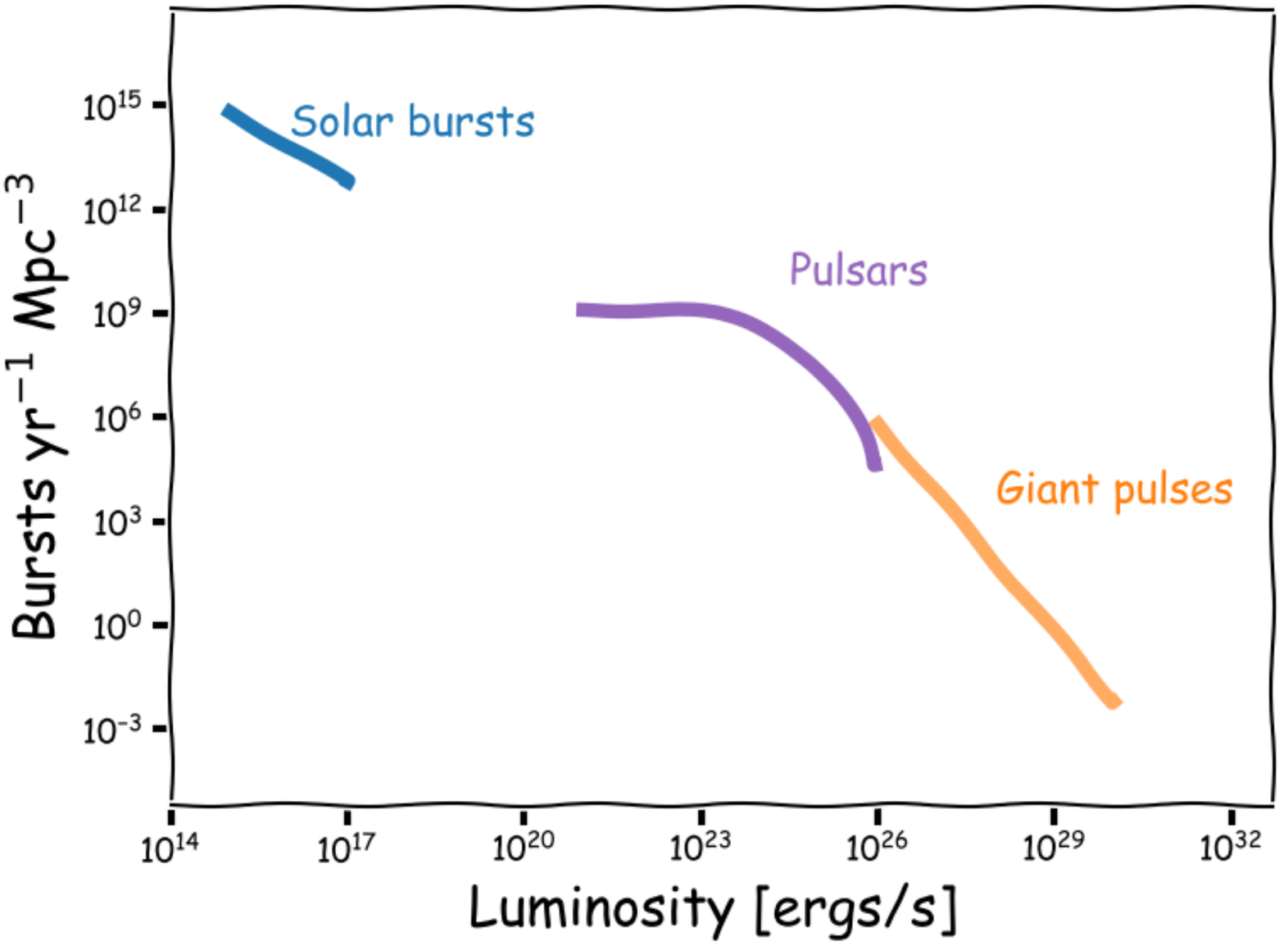


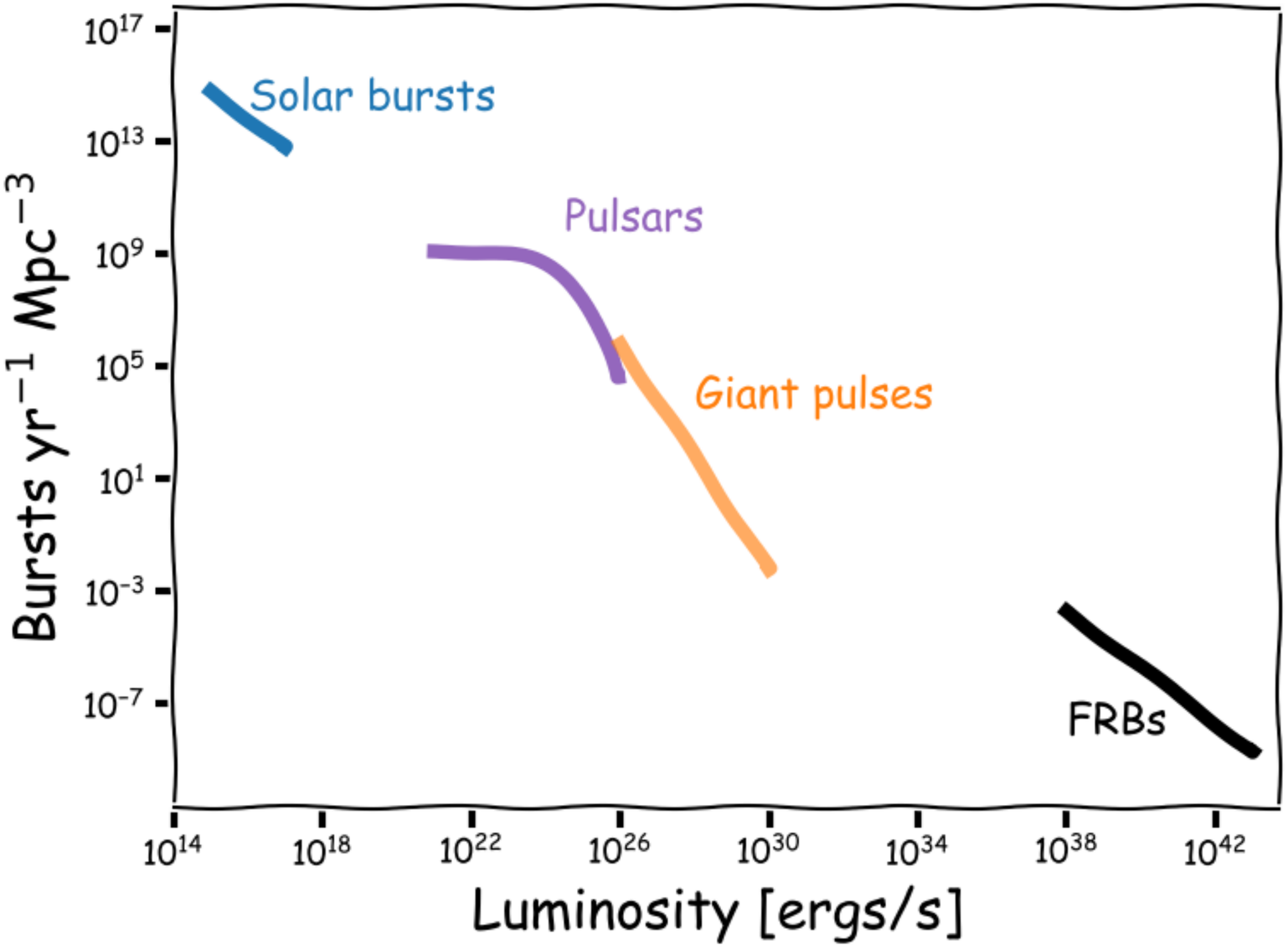
Connor & Ravi (2022)

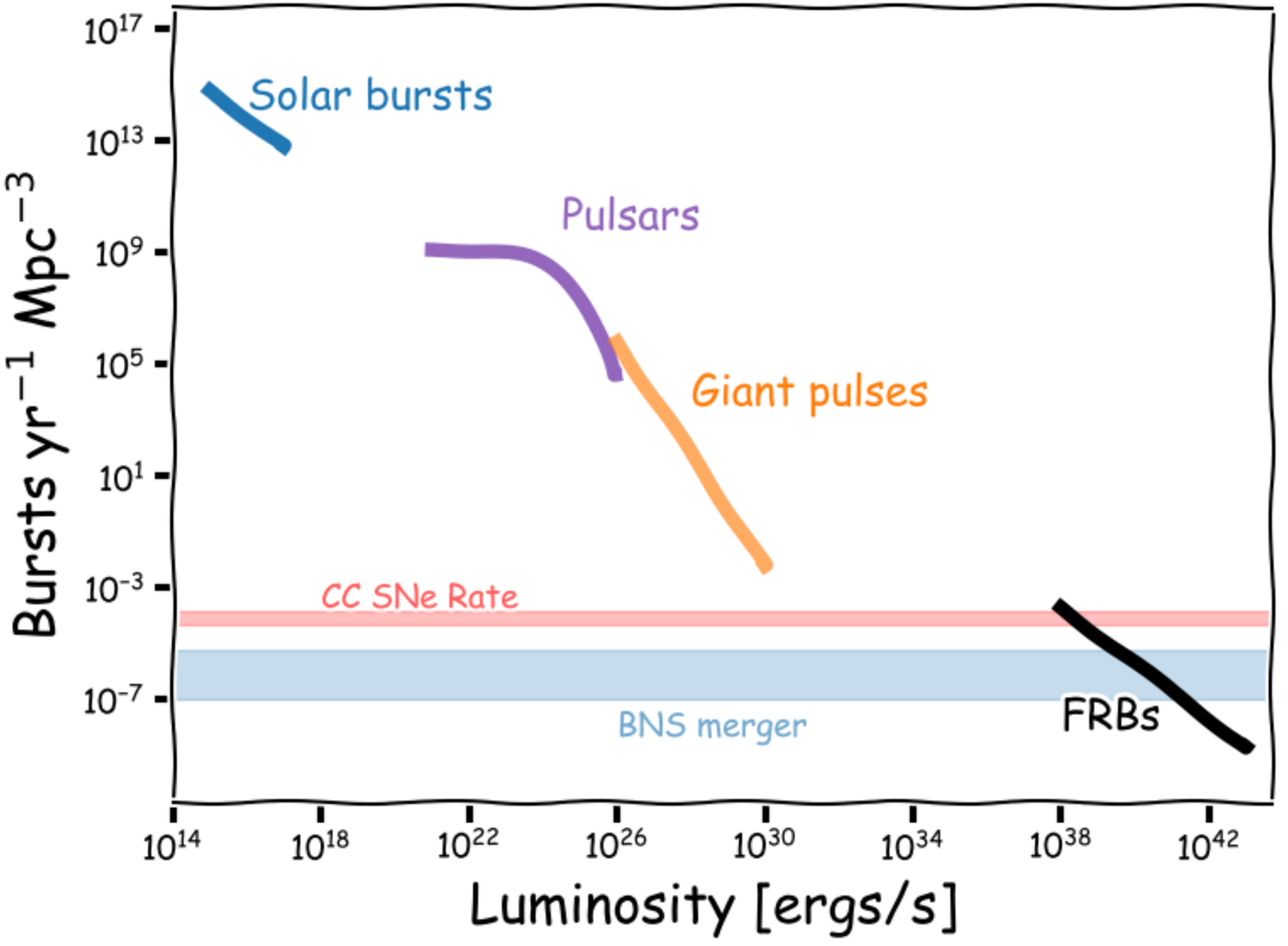
Luminosity function of the ~ms Universe

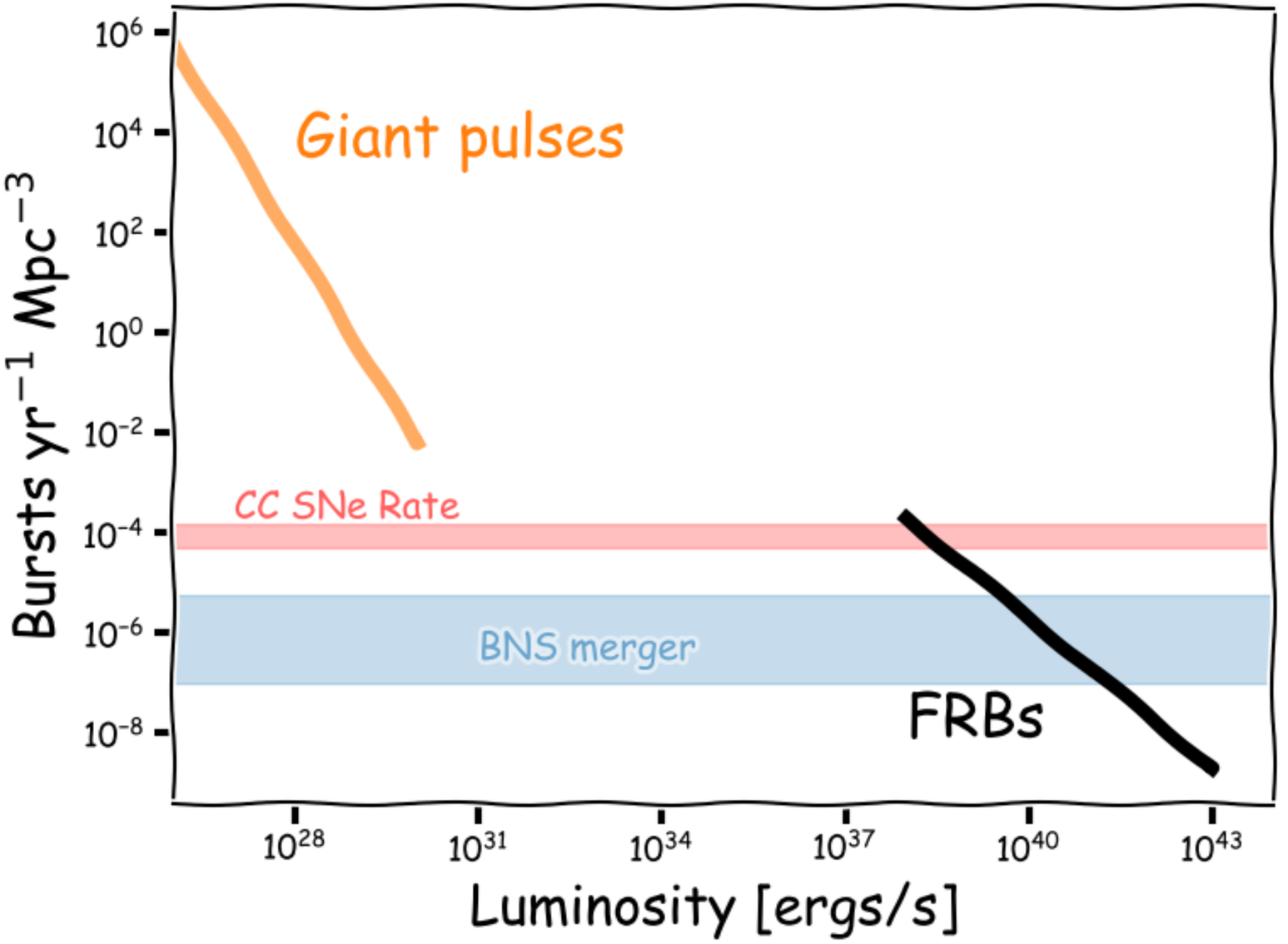


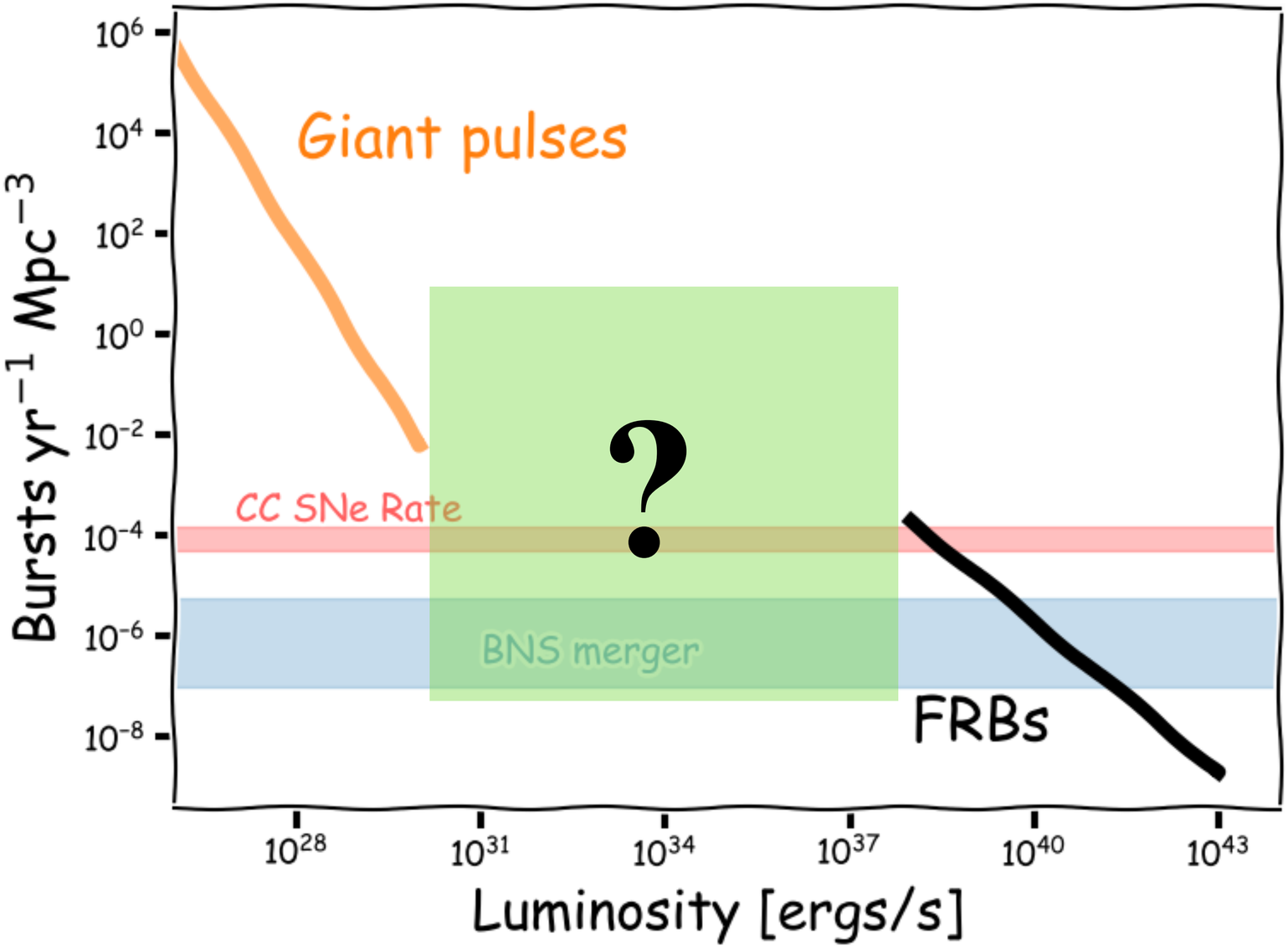

Pulsars
Giant pulses
10^{12}
10^{10}
10^{8}
10^{6}
10^{4}
10^{2}
10^{0}
10^{-2}
10^{-4}
Bursts yr^{-1} Mpc^{-3}
10^{20}
10^{22}
10^{24}
10^{26}
10^{28}
10^{30}
10^{32}
Luminosity [ergs/s]


Solar bursts
Pulsars
Giant pulses
10^{15}
10^{12}
10^{9}
10^{6}
10^{3}
10^{0}
10^{-3}
Bursts yr^{-1} Mpc^{-3}
10^{14}
10^{17}
10^{20}
10^{23}
10^{26}
10^{29}
10^{32}
Luminosity [ergs/s]


Solar bursts
Pulsars
Giant pulses
FRBs
10^{17}
10^{13}
10^{9}
10^{5}
10^{1}
10^{-3}
10^{-7}
Bursts yr^{-1} Mpc^{-3}
10^{14}
10^{18}
10^{22}
10^{26}
10^{30}
10^{34}
10^{38}
10^{42}
Luminosity [ergs/s]


Solar bursts
Pulsars
Giant pulses
CC SNe Rate
BNS merger
FRBs
Bursts yr^{-1} Mpc^{-3}
10^{17}
10^{13}
10^{9}
10^{5}
10^{1}
10^{-3}
10^{-7}
10^{14}
10^{18}
10^{22}
10^{26}
10^{30}
10^{34}
10^{38}
10^{42}
Luminosity [ergs/s]


Giant pulses
CC SNe Rate
BNS merger
FRBs
Bursts yr^{-1} Mpc^{-3}
10^{6}
10^{4}
10^{2}
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{28}
10^{31}
10^{34}
10^{37}
10^{40}
10^{43}
Luminosity [ergs/s]


Giant pulses
CC SNe Rate
?
BNS merger
FRBs
Bursts yr^{-1} Mpc^{-3}
10^{6}
10^{4}
10^{2}
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{28}
10^{31}
10^{34}
10^{37}
10^{40}
10^{43}
Luminosity [ergs/s]

Article | Published: 04 November 2020

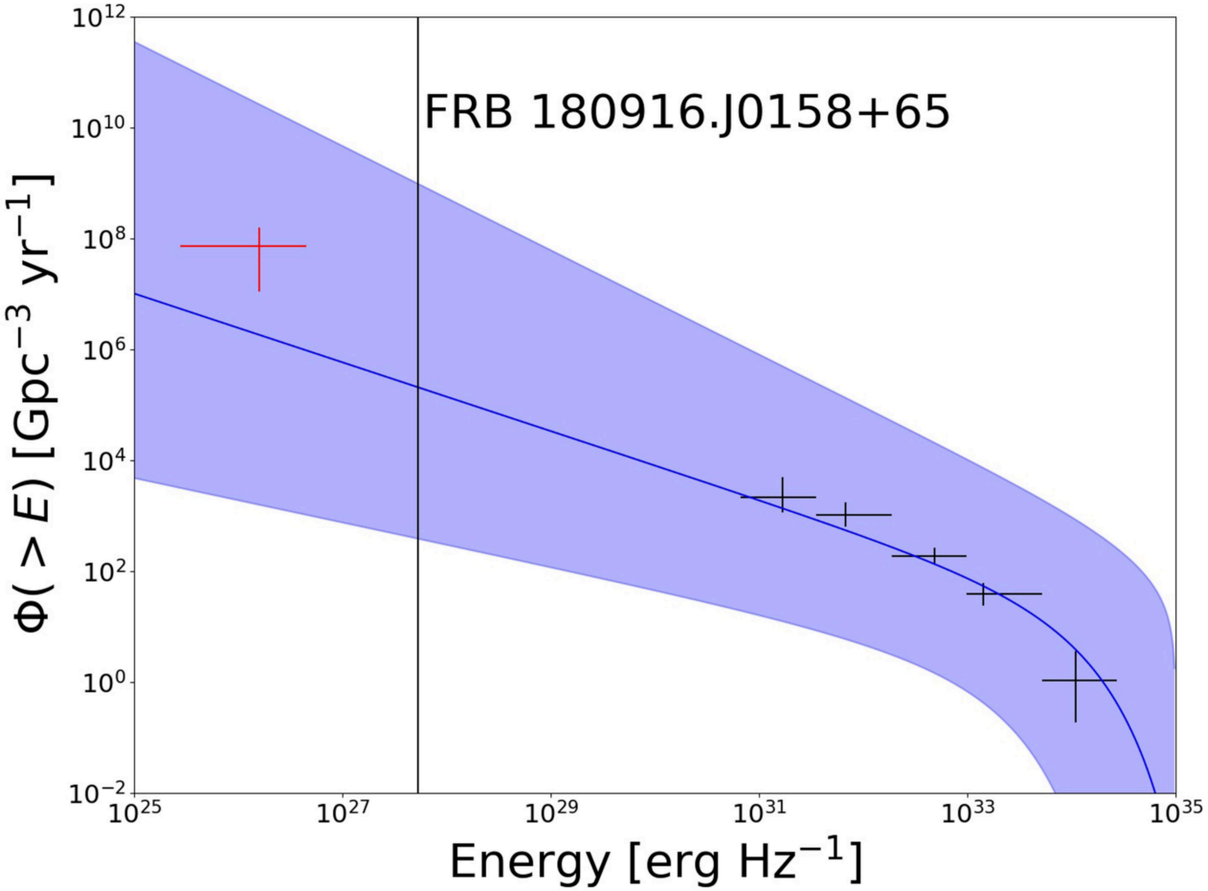
A fast radio burst associated with a Galactic magnetar

C. D. Bochenek ✉, V. Ravi, K. V. Belov, G. Hallinan, J. Kocz, S. R. Kulkarni & D. L. McKenna

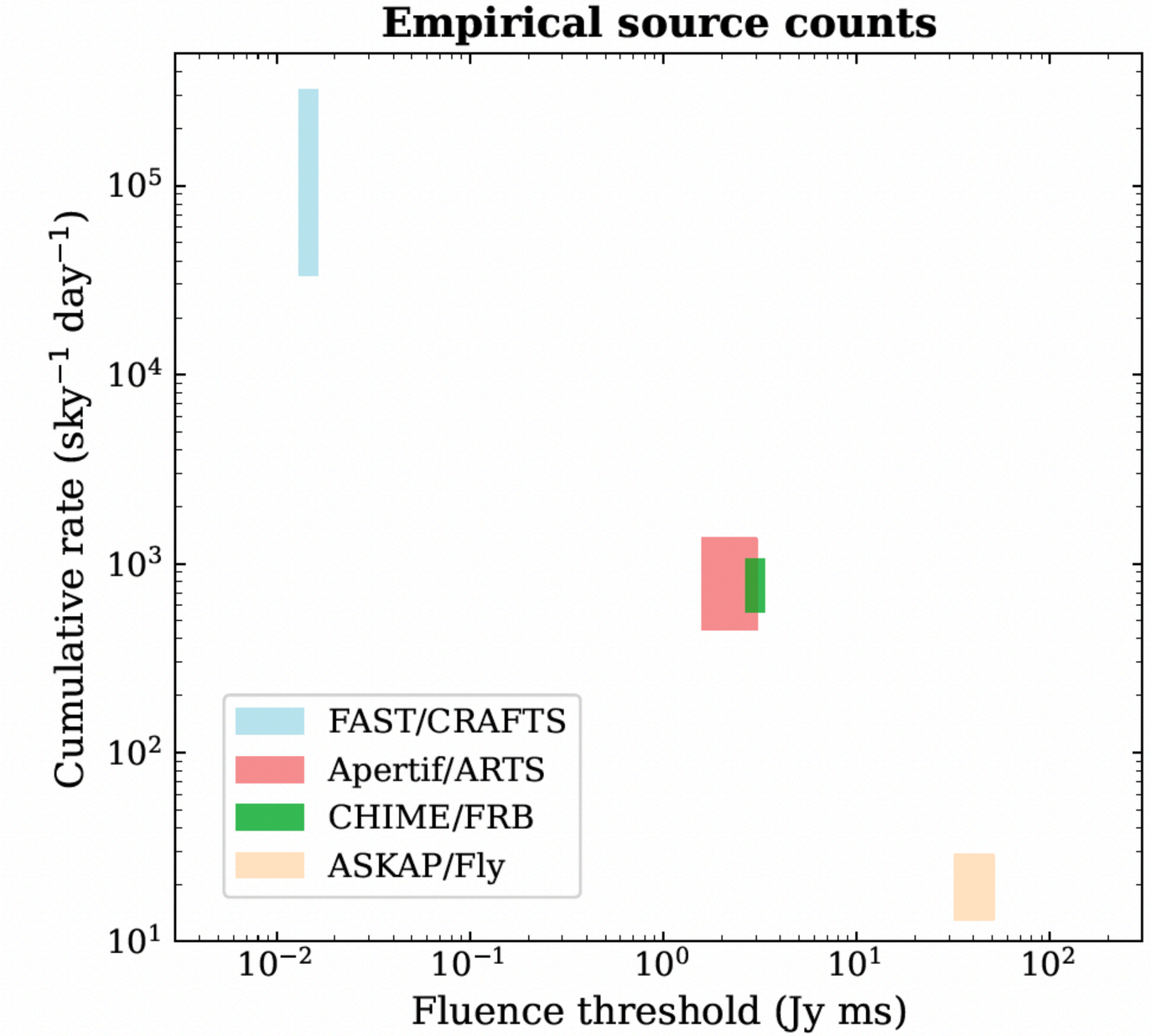
Nature **587**, 59–62 (2020) | Cite this article

Abstract

Since their discovery in 2007[1], much effort has been devoted to uncovering the sources of the extragalactic, millisecond-duration fast radio bursts (FRBs)[2]. A class of neutron stars known as magnetars is a leading candidate source of FRBs[3,4]. Magnetars have surface magnetic fields in excess of 10^{14} gauss, the decay of which powers a range of high-energy phenomena[5]. Here we report observations of a millisecond-duration radio burst from the Galactic magnetar SGR 1935+2154, with a fluence of 1.5 ± 0.3 megajansky milliseconds. This



Plenty of action in the mJy ms radio sky!



Gohar and Flynn (2021)

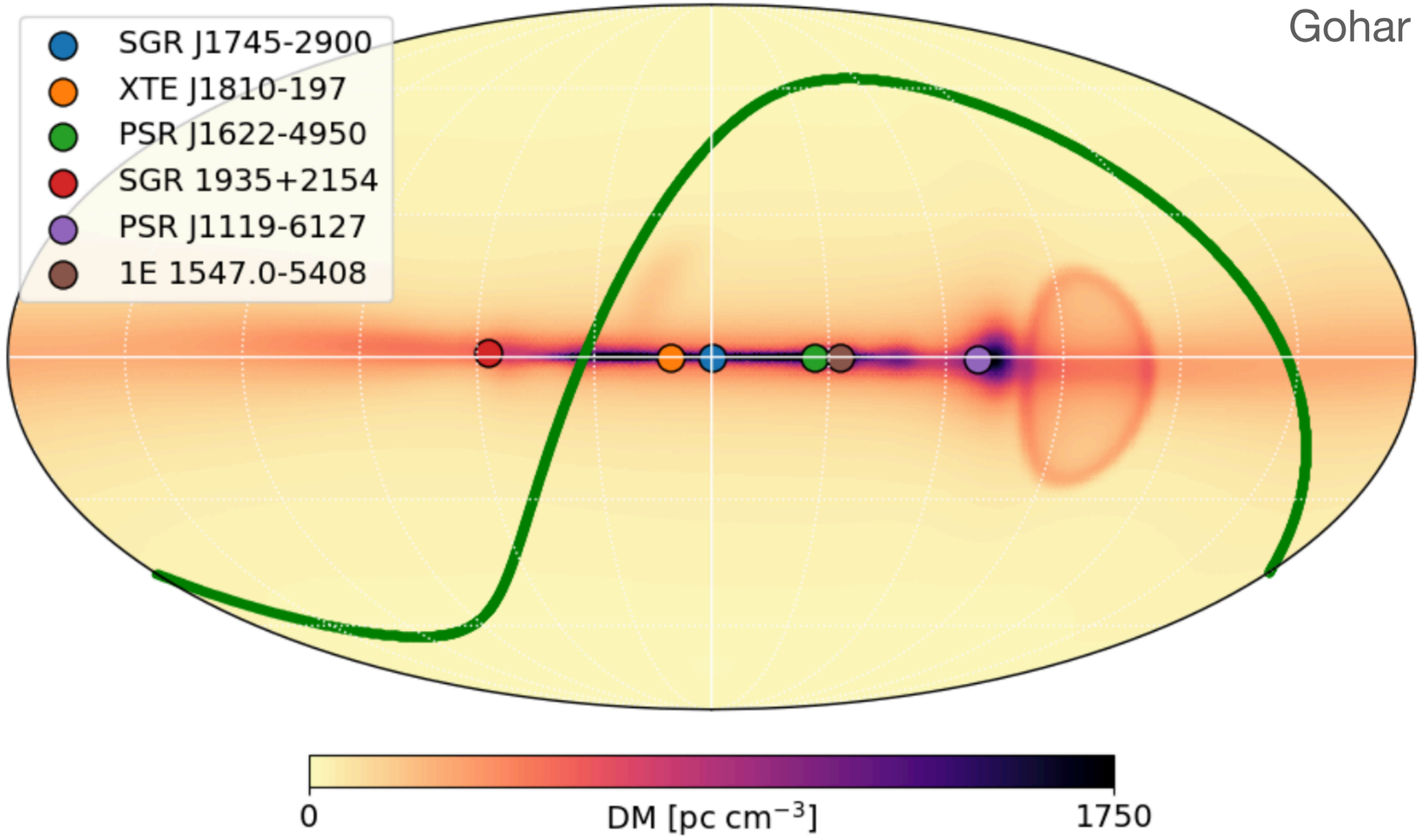
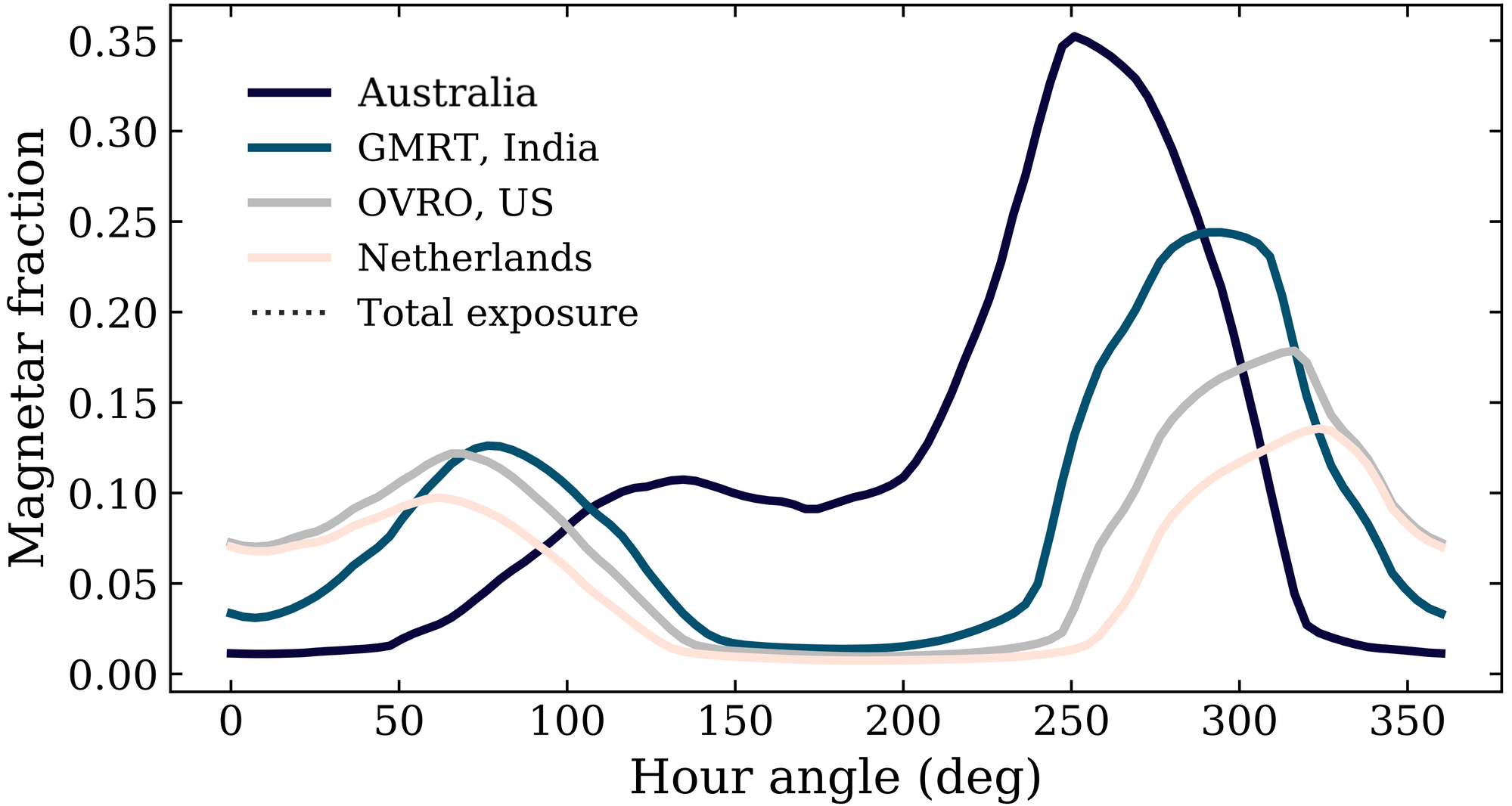
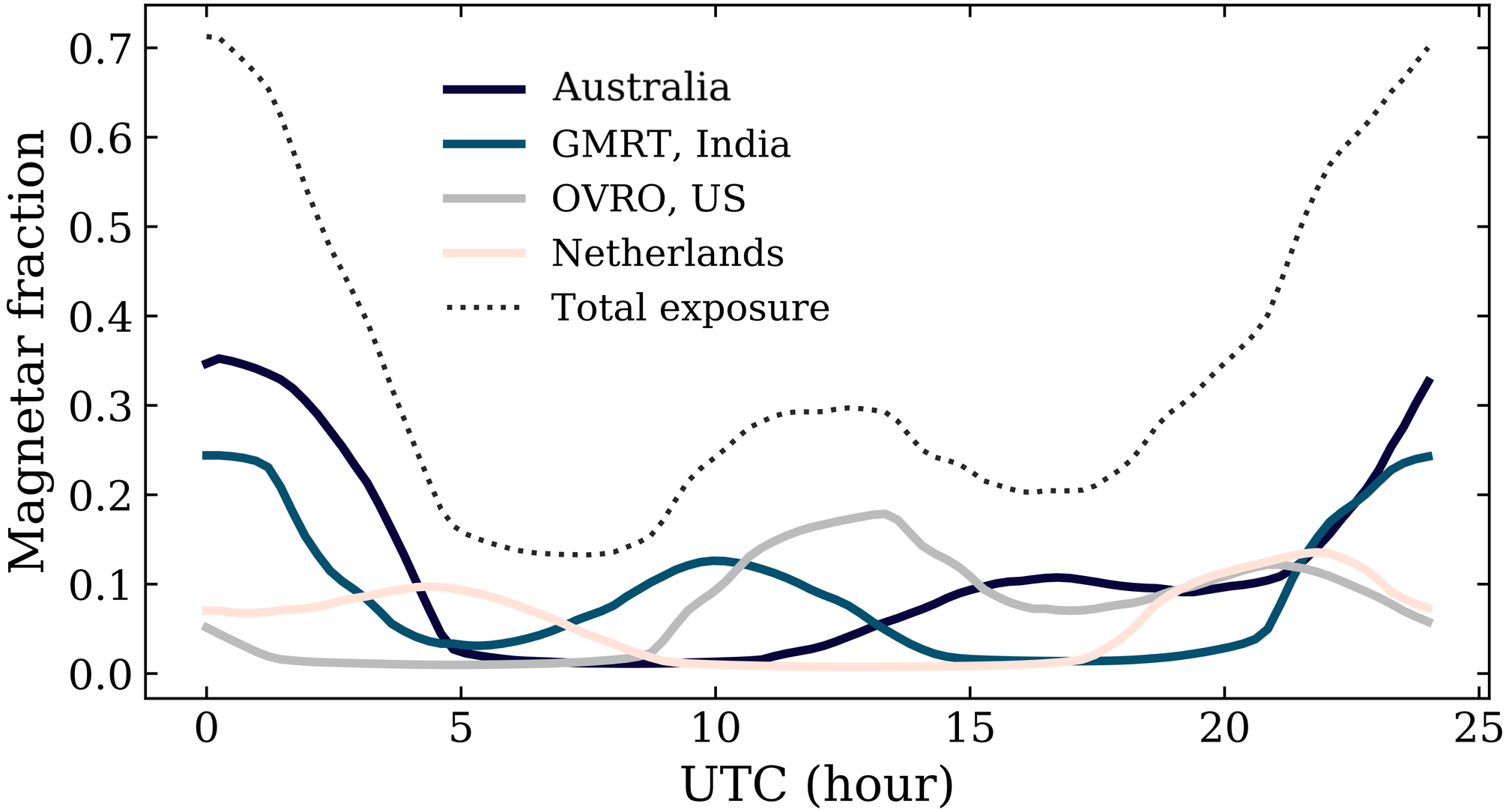


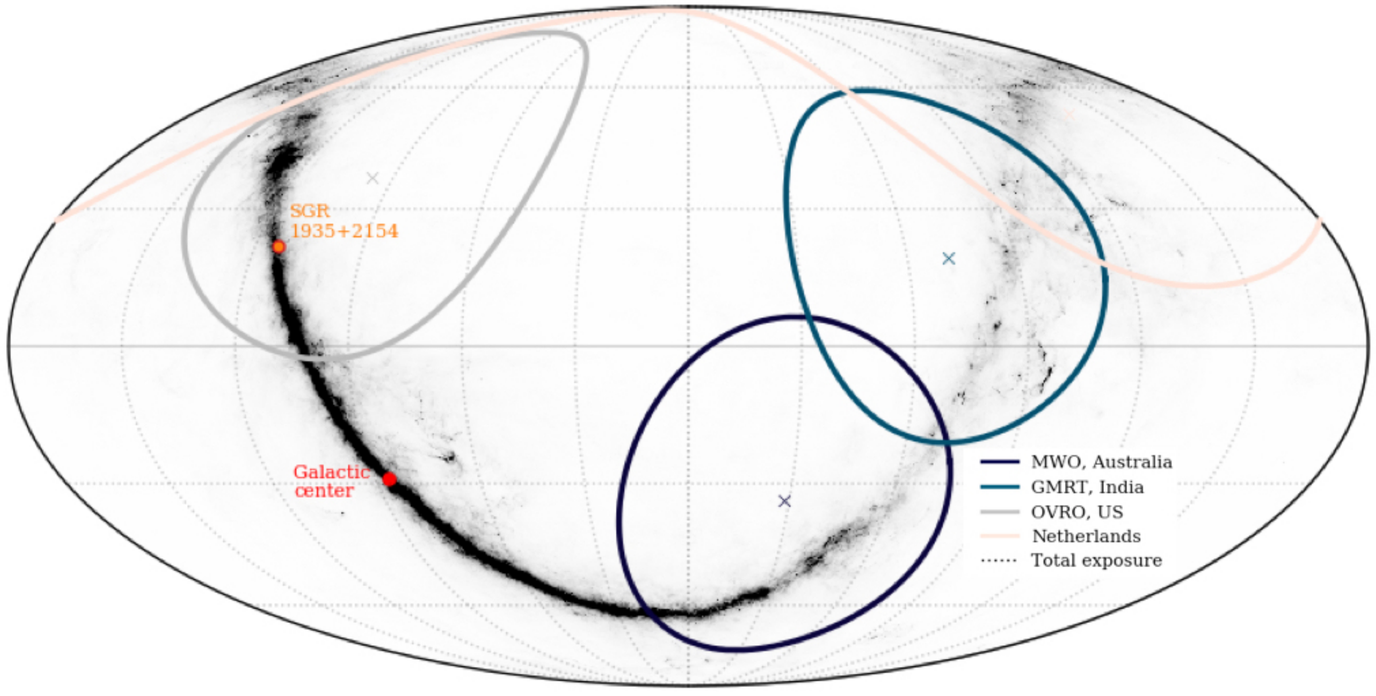
Figure 12. Positions of 6 magnetars for which radio detections have been made, shown in Galactic coordinates. The DM of the YMW16 model is shown in the background, and the green line marks the divide between the northern and southern hemispheres.



Connor et al. (2021)

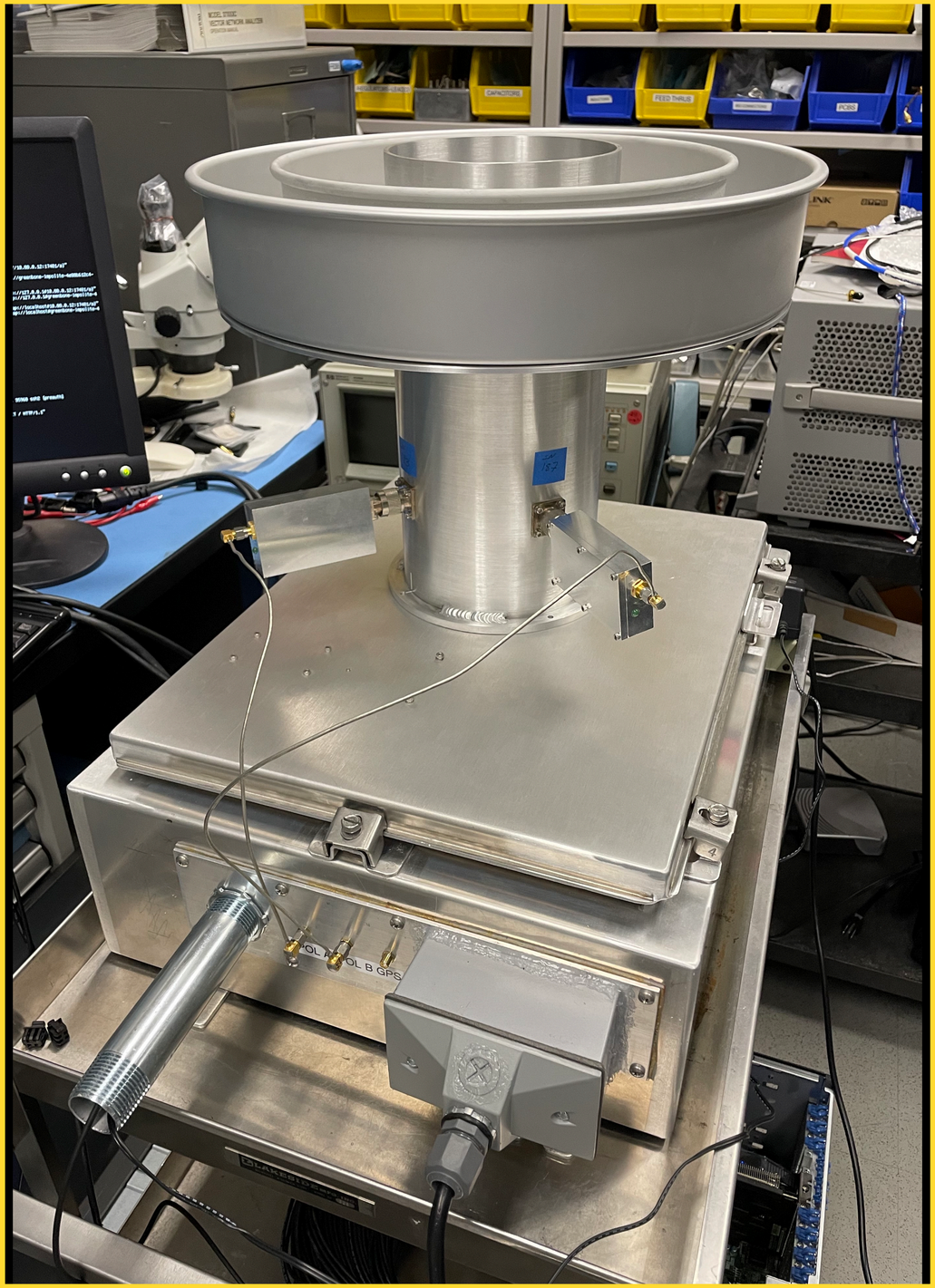


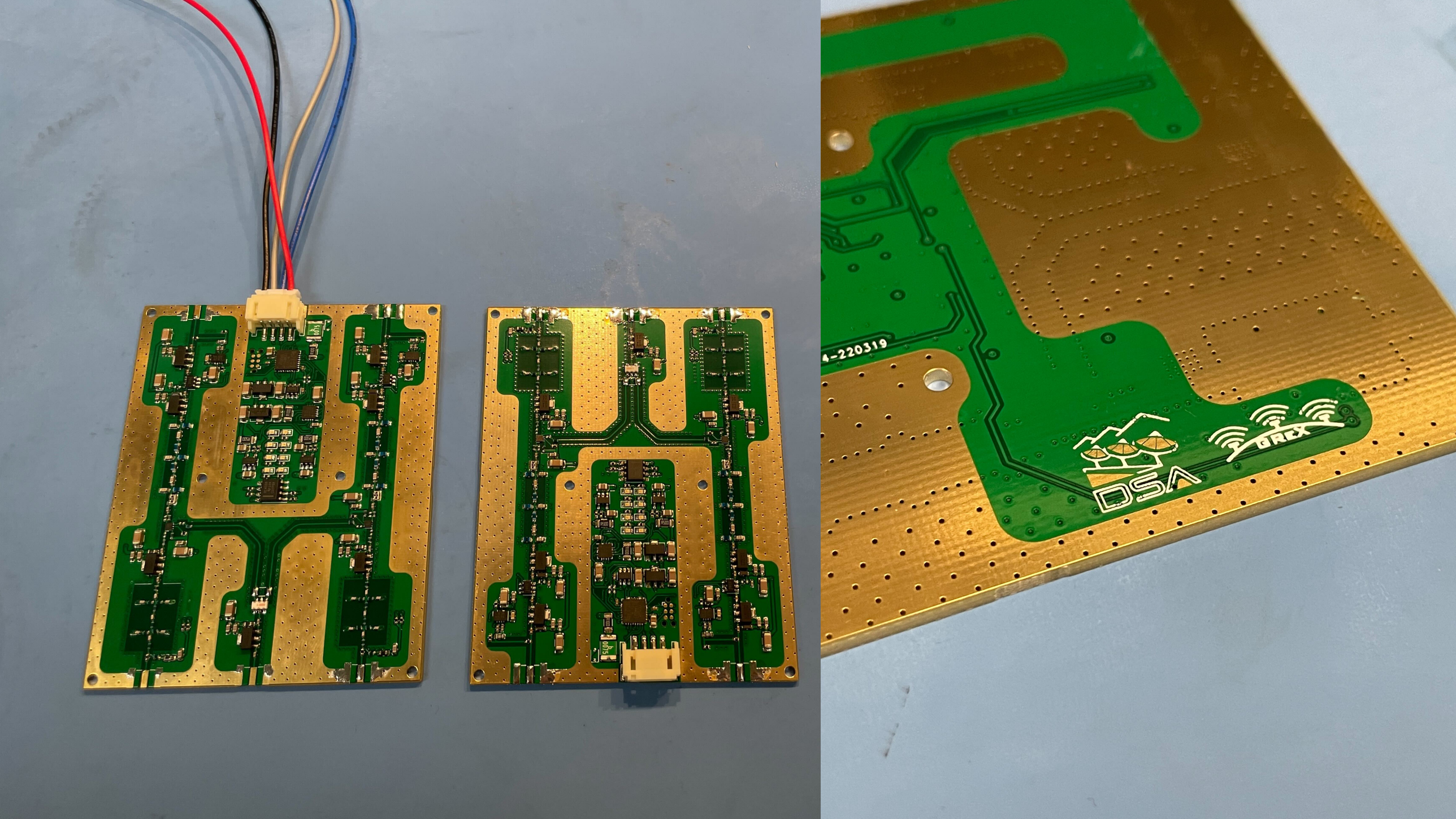
Connor et al. (2021)

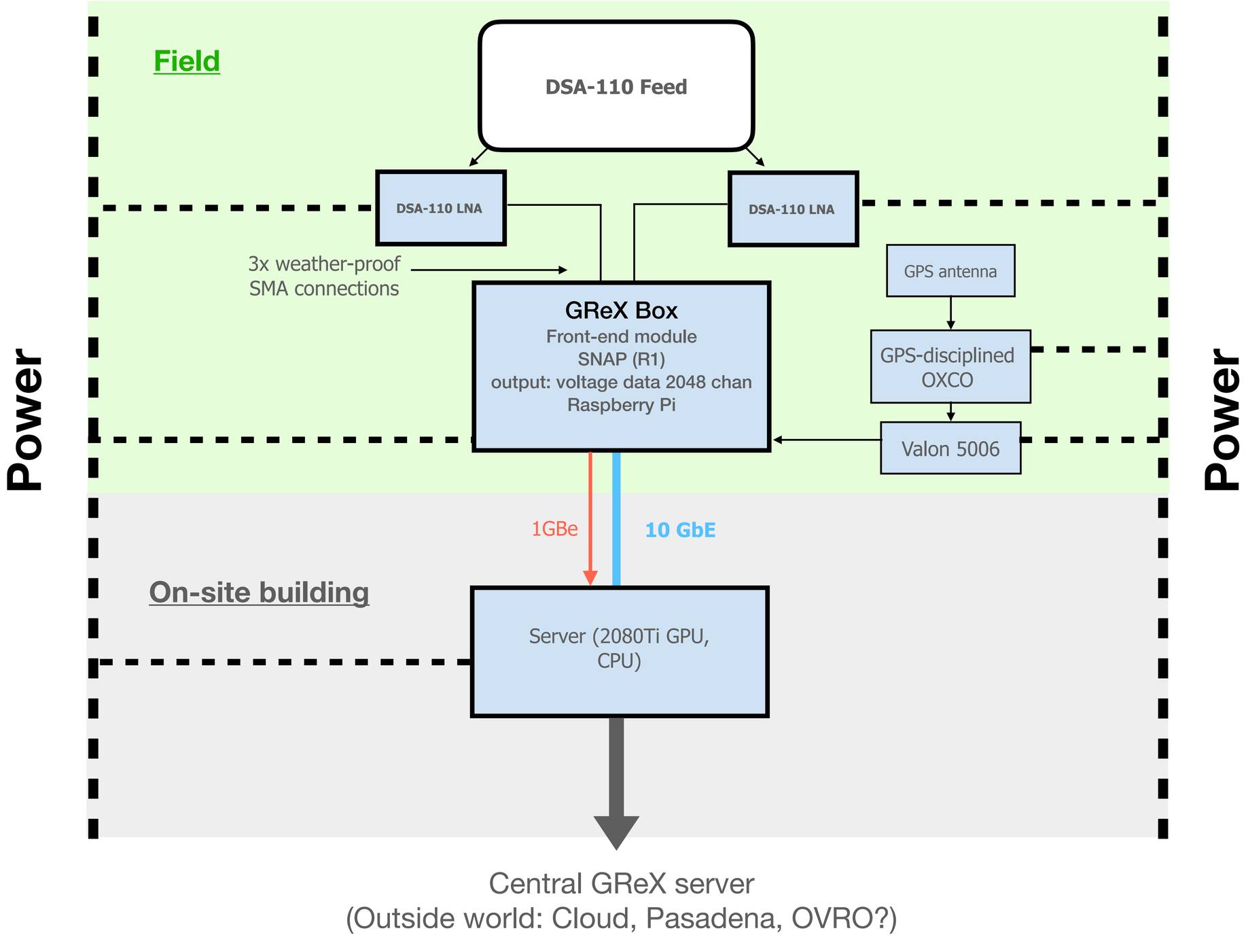


GReX Phase-I

- DSA-110 band: 1.25-1.5 GHz
- Very low noise electronics
- Sensitive to ~100 kJy burst @ 1ms
- ~20 microsecond blind search
- One cluster in US, two clusters in the Southern Hemisphere
- Simplifies things, could start to deploy right away!



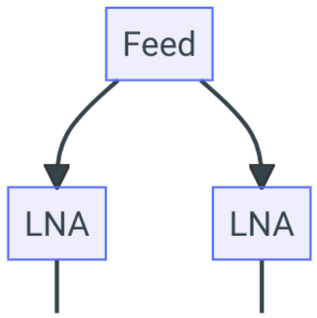

4-220319
DSA

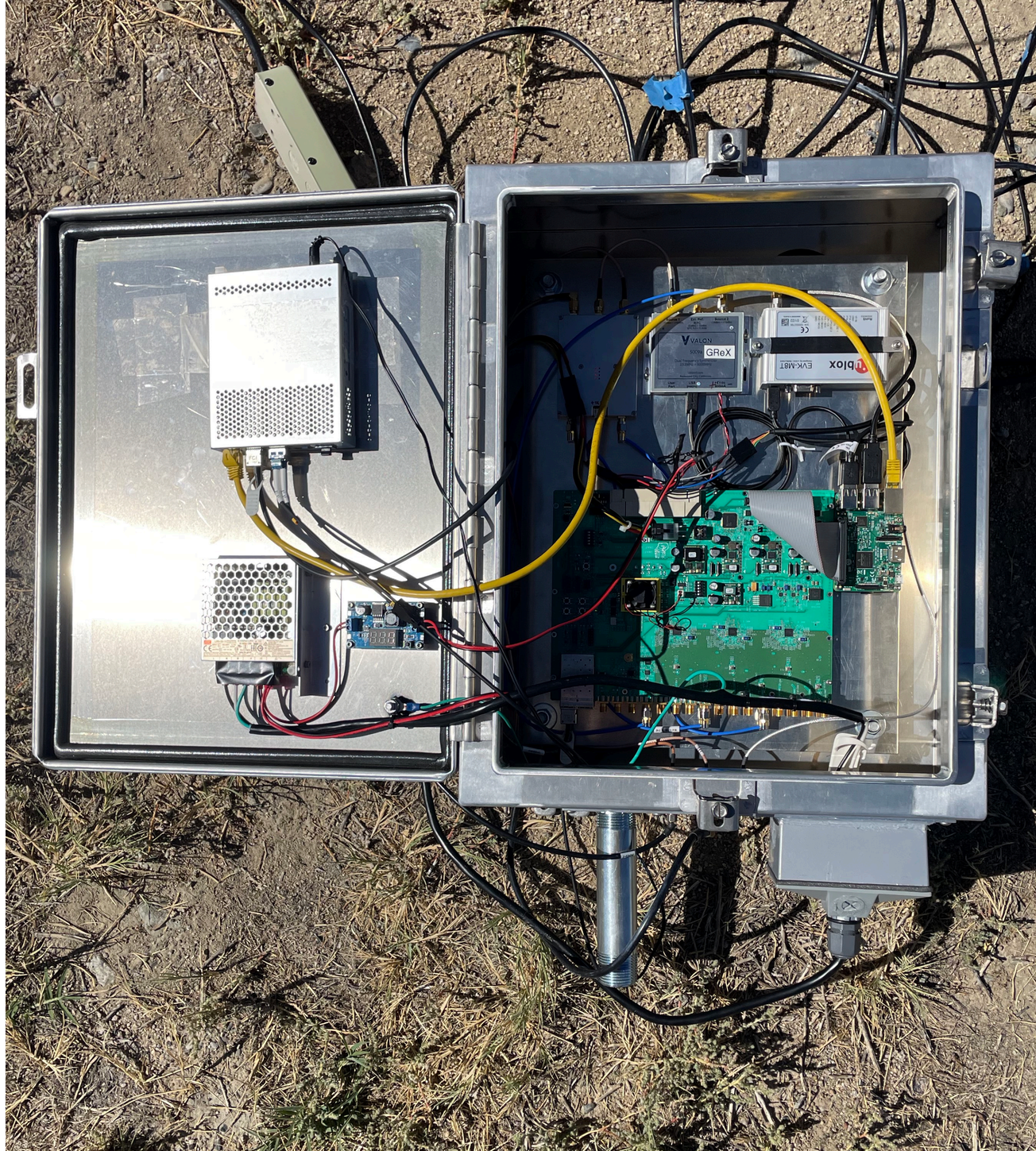

Field
DSA-110 Feed
DSA-110 LNA
DSA-110 LNA
3x weather-proof
SMA connections
GPS antenna
GReX Box
Front-end module
SNAP (R1)
output: voltage data 2048 chan
Raspberry Pi
GPS-disciplined
OXCO
Valon 5006
Power
Power
1GBe
10 GbE
On-site building
Server (2080Ti GPU,
CPU)
Central GReX server
(Outside world: Cloud, Pasadena, OVRO?)

Hardware Overview

The GReX hardware system has several "top level" components, which constitute the entire system. These include the feed antenna and low noise amplifiers (LNA), the frontend module, the digital backend, and of course the server. The following diagrams lay out general overview of the interconnections. Showing them all at once would be a bit much, so they're broken down here into discrete kinds of signals.

RF Signal Path




VALON
GReX
ublox
EVK-M8T

GReX in the Southern Hemisphere

We require:

- Three stations or “terminals”
- Radio infrastructure
- Rack space 1x4U server
- Willing hosts!

We provide:

- Assembly kits with feed, GReX front-end box, server
- Personnel to install and commission

GReX in the Southern Hemisphere

We require:

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We provide:

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- Personnel to install and commission

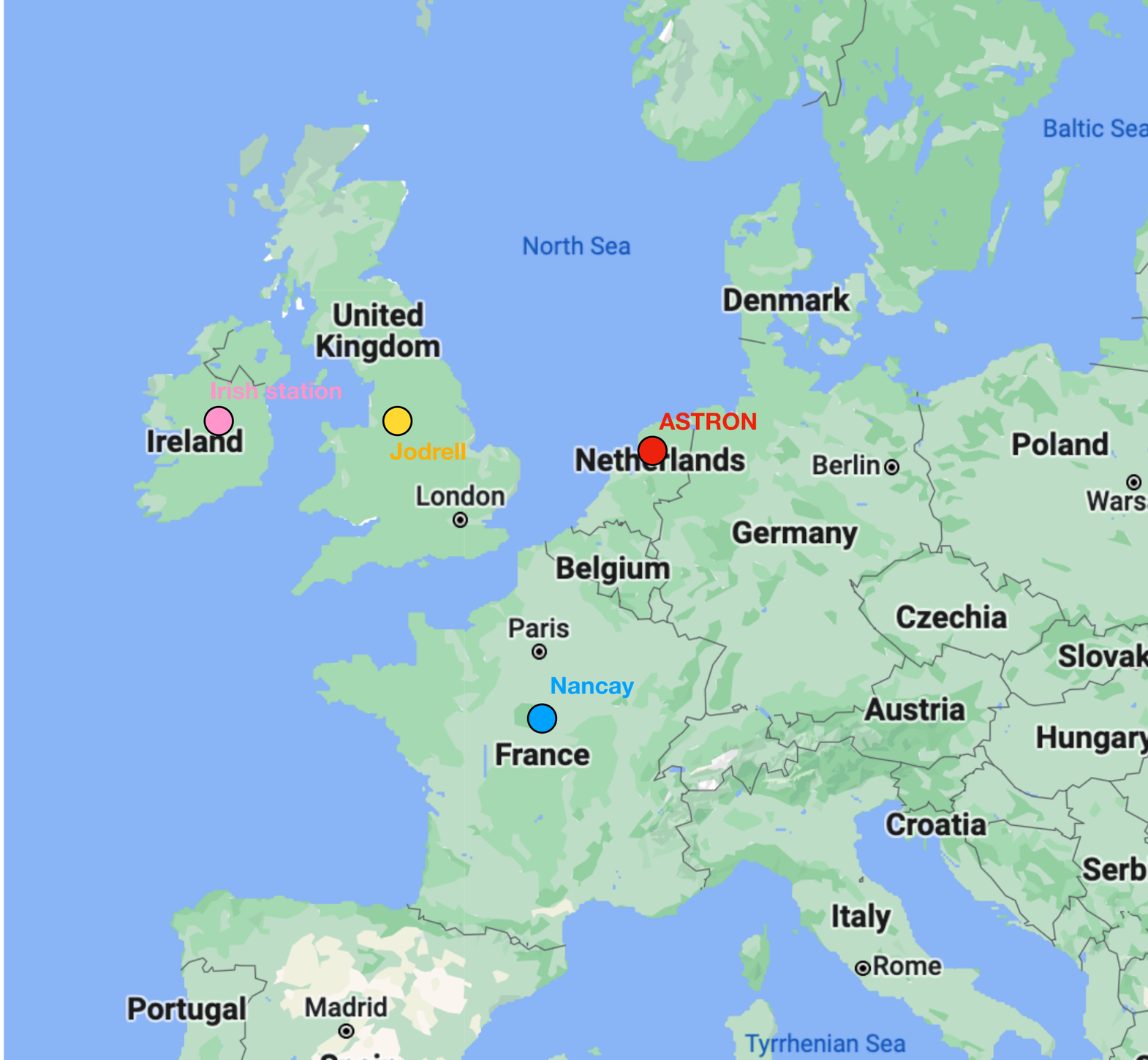
GReX in Western Europe

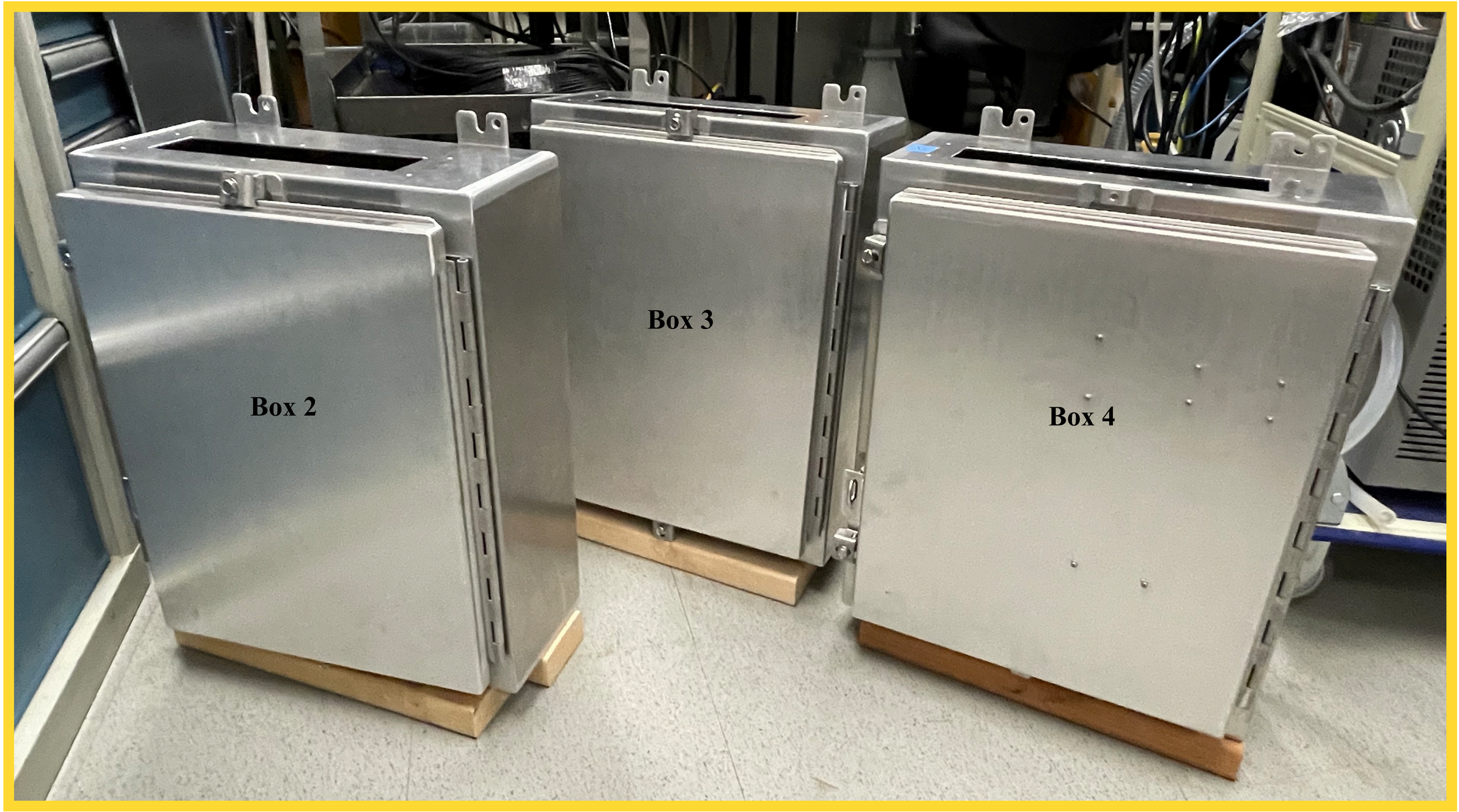
We require:

- Three stations or “terminals”
- Radio infrastructure
- Rack space 1x4U server
- Willing hosts!

We provide:

- Assembly kits with feed, GReX front-end box, server
- Personnel to install and commission




Box 2
Box 3
Box 4

Coherent All-Sky Monitor (ChASM) for FRBs

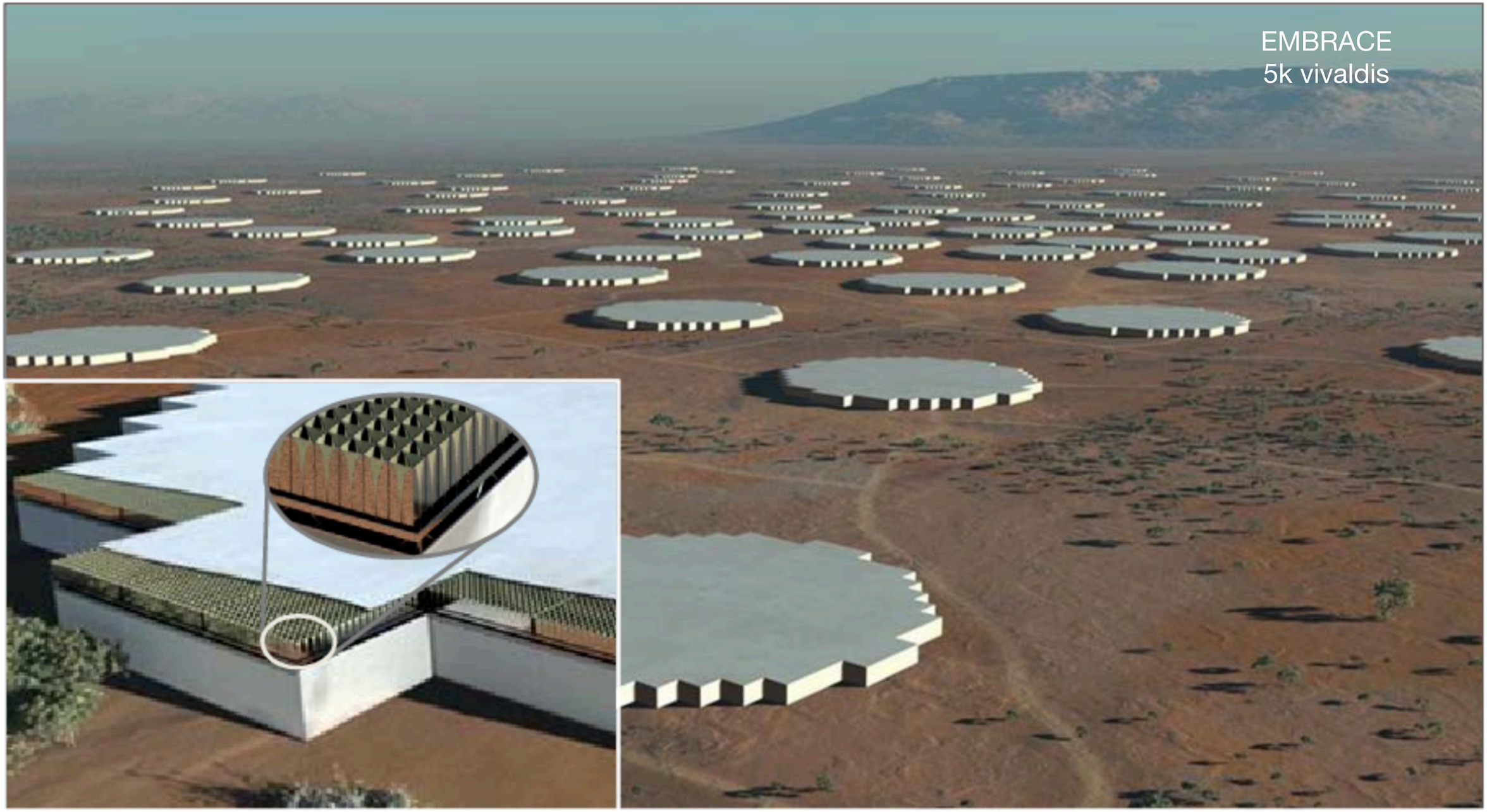
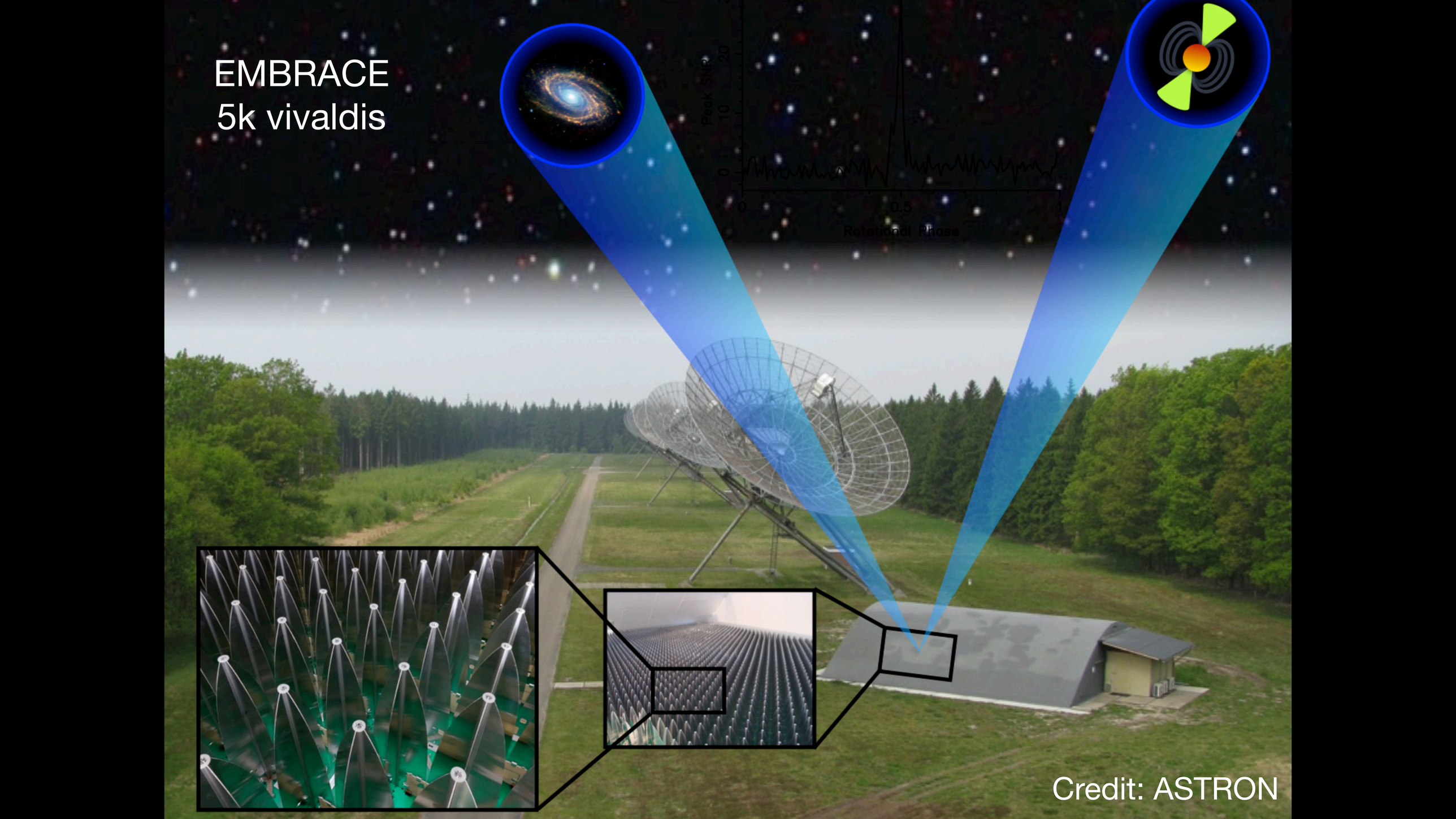
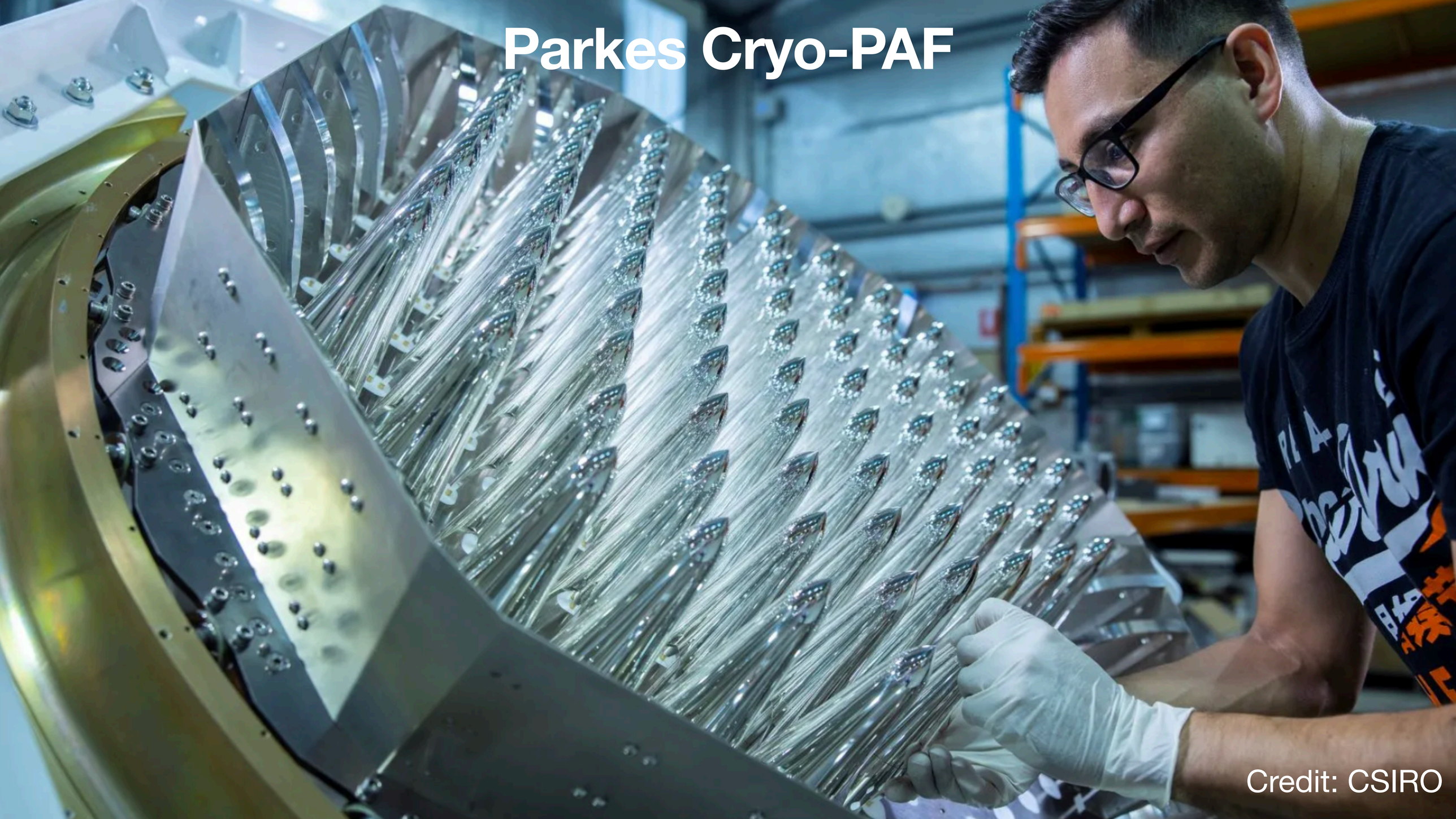


Figure 1: Artists view of the SKA dense AA core, with inset showing the Tile structure within the array and a close up of the regular element pattern.


EMBRACE
5k vivaldis
Peak SNR
0
10
20
0
0.5
Rotational Phase
Credit: ASTRON

Parkes Cryo-PAF



Credit: CSIRO

Quantity	Value	
Project	BURSTT-256	BURSTT-2048
SEFD	~5000 Jy	~600 Jy
Effective area	40-200 m^2	320-1600 m^2
Number of antennas (main station)	256	2048

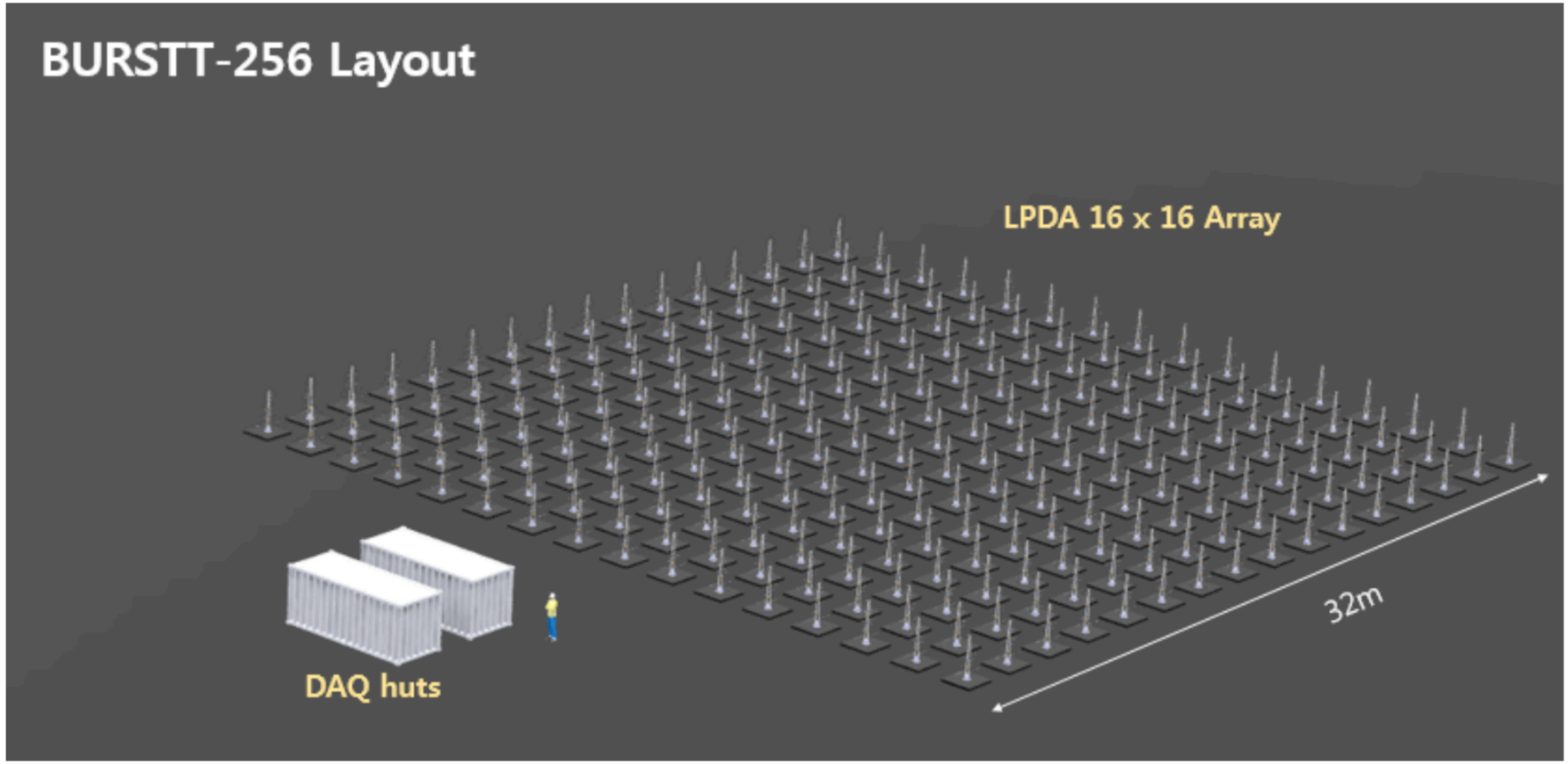


Figure 6. BURSTT 256-antenna array station layout.

Lin et al. (2022)

GReX as a platform

From ASM to ChASM

- GReX is simple, low cost, and can be on sky quickly
- It will act as a Pathfinder in terms of logistics, building up a global network
- Sites can be developed to host ChASMs: one primary site with multiple two outriggers

Why GReX? Why now?