Mysterious fast radio bursts and the new radio telescope in Taiwan: BURSTT

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Pic: FRB 2024 in Thailand
Nov 2024

Multi-Messenger conf
11 Nov. 2024

國立中興大學
NATIONAL
CHUNG HSING UNIVERSITY

National
Chung Hsing
University
(NCHU)

Outline

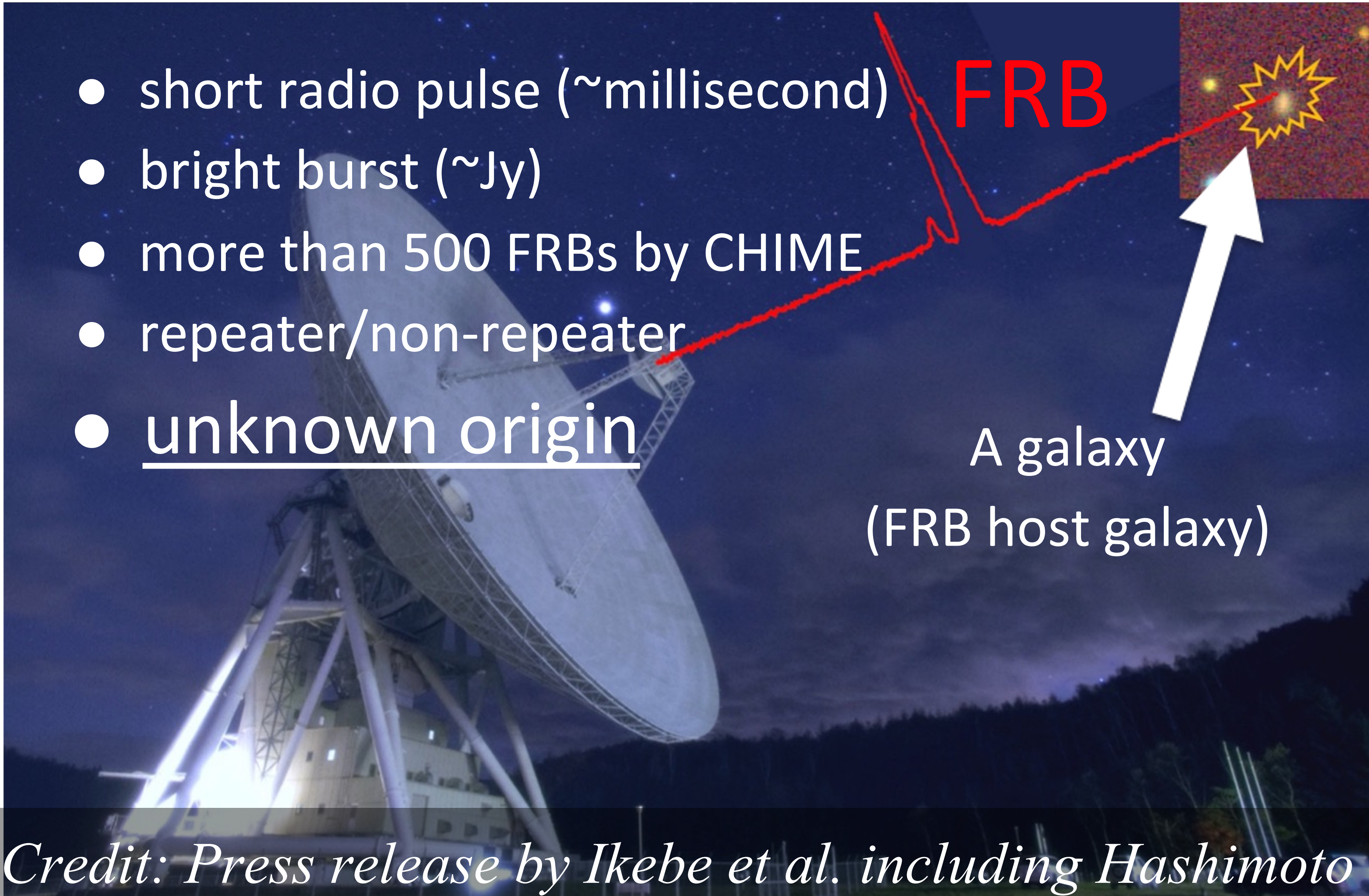
1. Fast radio bursts (FRBs)
2. The BURSTT project in Taiwan

   expected science cases and the current status
3. Origin of FRBs (updates from FRB2024)
4. FRBs as cosmological probes

If time is allowed

1. Fast radio burst (FRB)

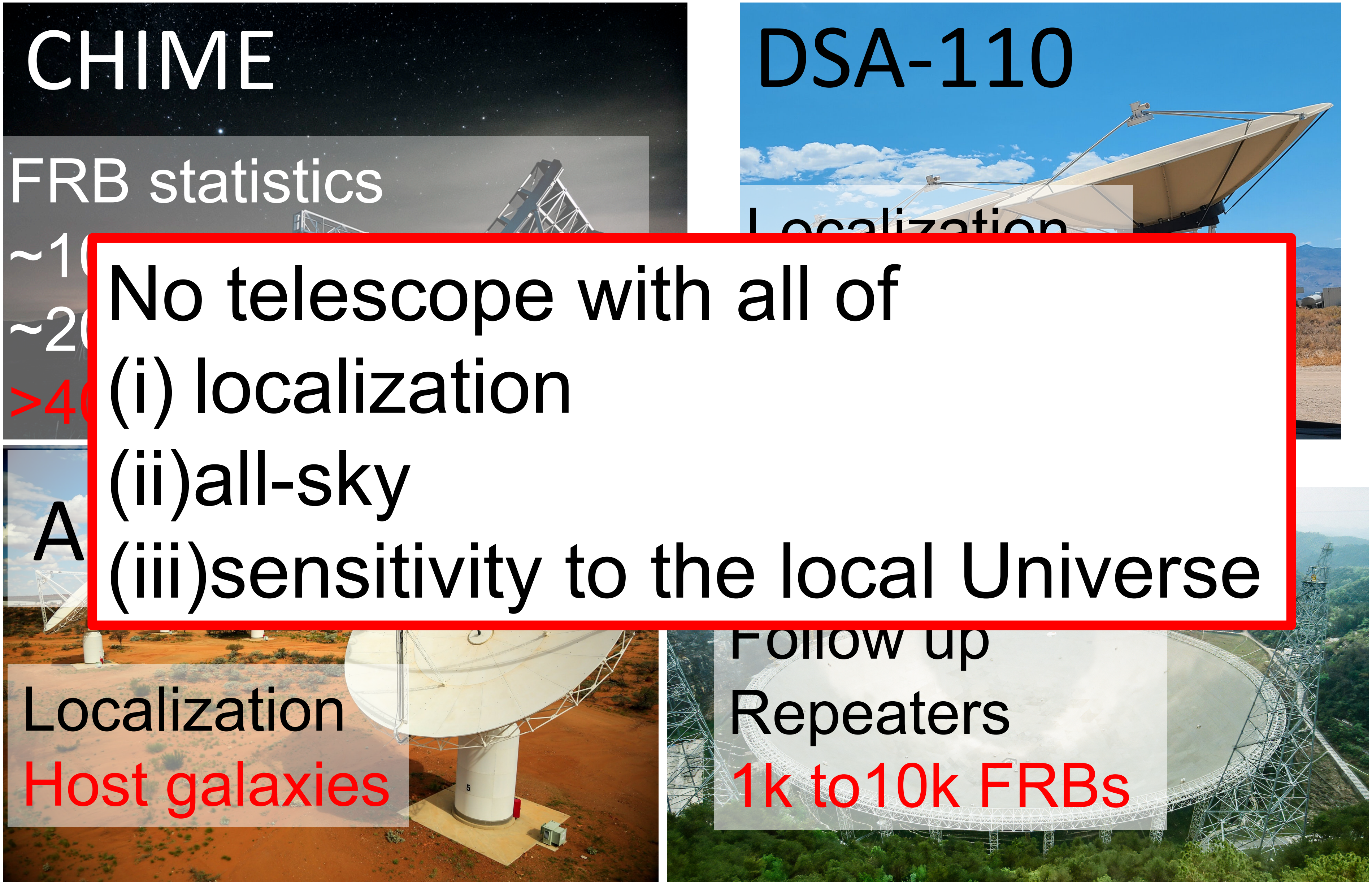
- short radio pulse (~millisecond)
- bright burst (~Jy)
- more than 500 FRBs by CHIME
- repeater/non-repeater
- <u>unknown origin</u>



Credit: Press release by Ikebe et al. including Hashimoto

Currently leading telescopes

Leading telescopes



No telescope with all of
(i) localization
(ii)all-sky
(iii)sensitivity to the local Universe

2. Bustling Universe Radio Survey Telescope in Taiwan (BURSTT, PI: Ue-Li Pen)

台灣宇宙電波爆廣角監測實驗

Intro: possible FRB origins

White dwarf

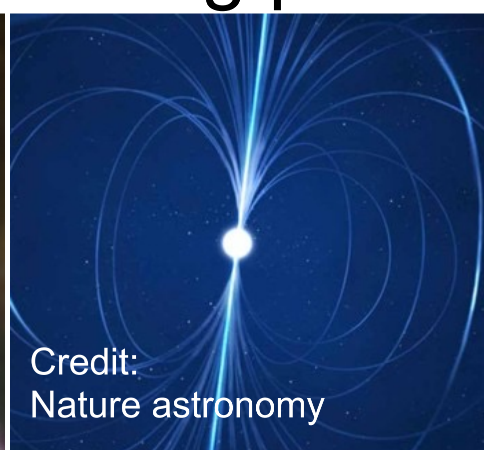
Neutron-star binary

Old stellar-mass black hole (BH)

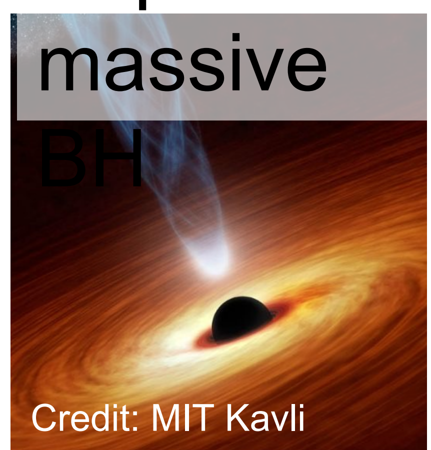
?

Magnetar

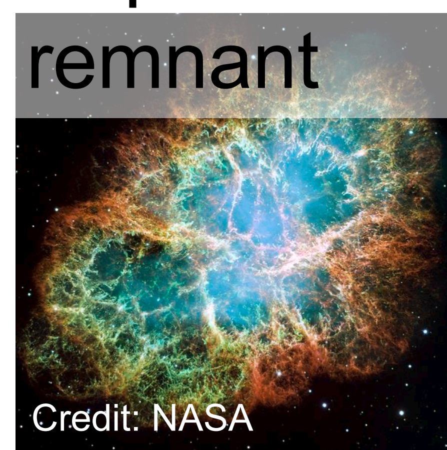
Young pulsar



Super massive BH



Supernova remnant



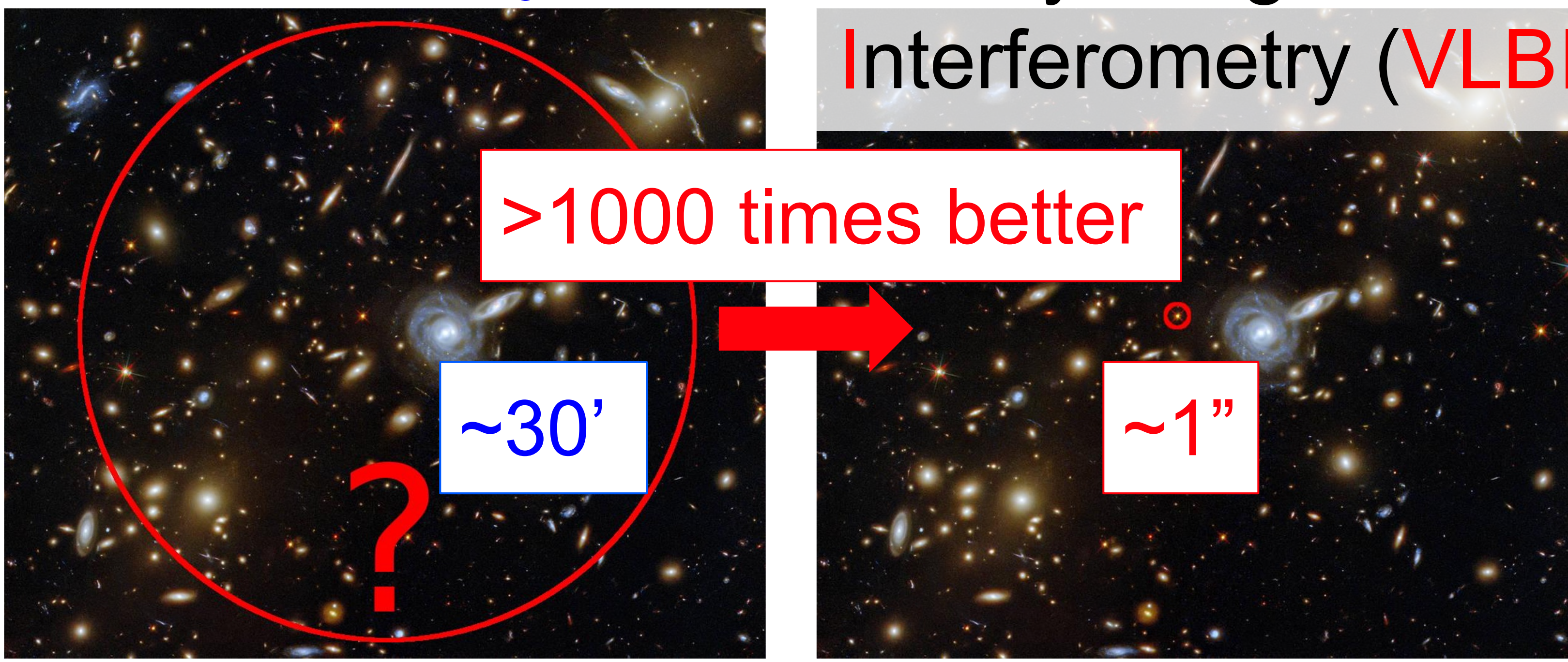
Bottlenecks and our solutions

Previous observations

Poor localization capability

Need

Accurate localization ⇒ Very Long Baseline Interferometry (VLBI)



We don't know where they come from

We can identify progenitors/host galaxies

Bottlenecks and our solutions

Previous observations

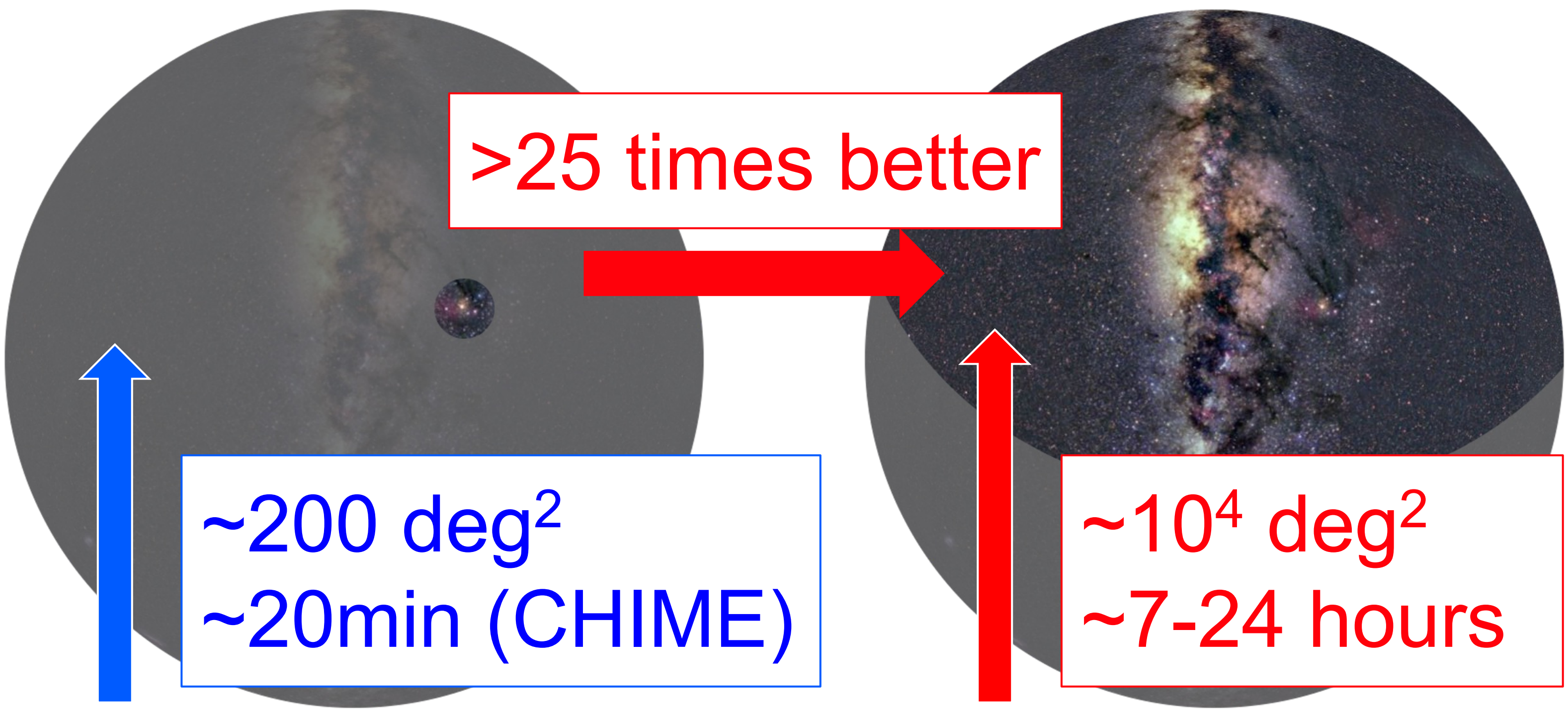
Narrow FoV

Short obs. Time

Need

Extremely wide FoV

Long obs. time

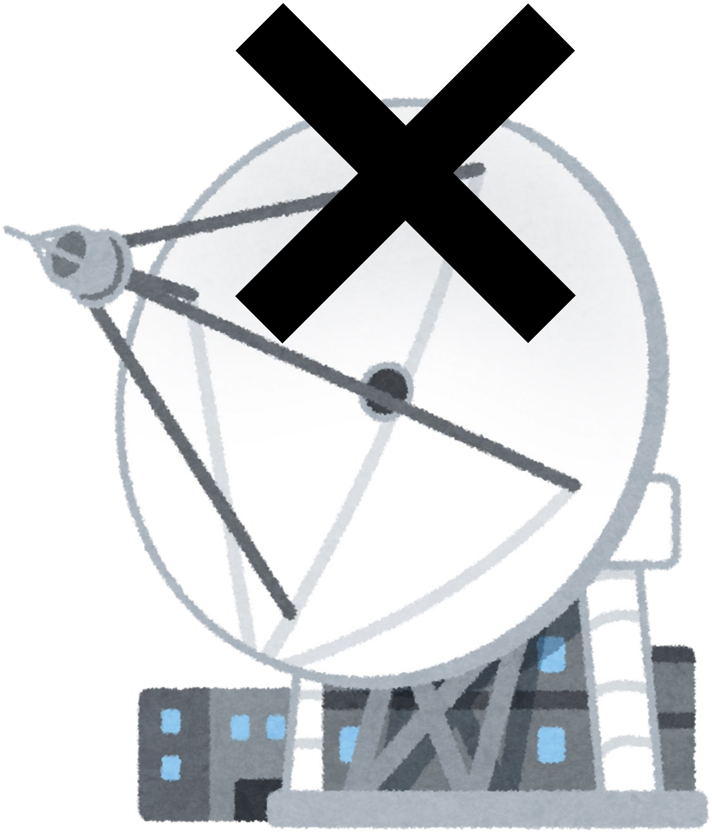


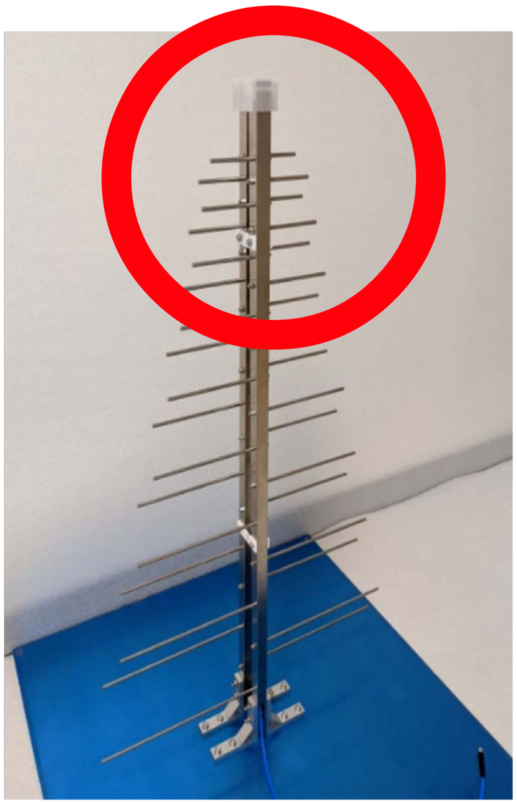
No detection if an FRB happens here

can detect

Bottlenecks and solutions

Previous observations	Need
Narrow FoV	Extremely wide FoV
Short obs. Time	Long obs. time

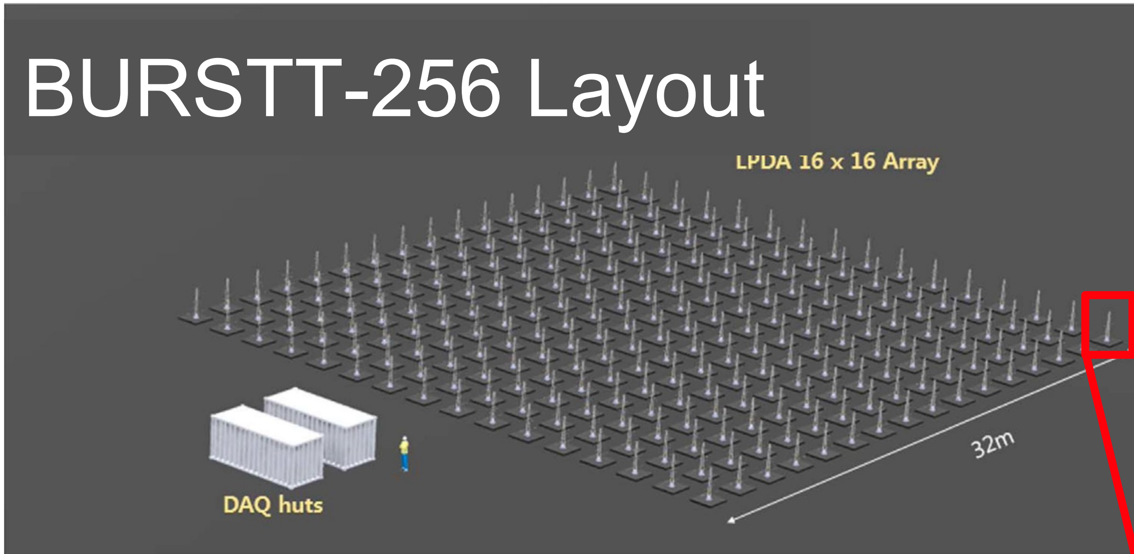




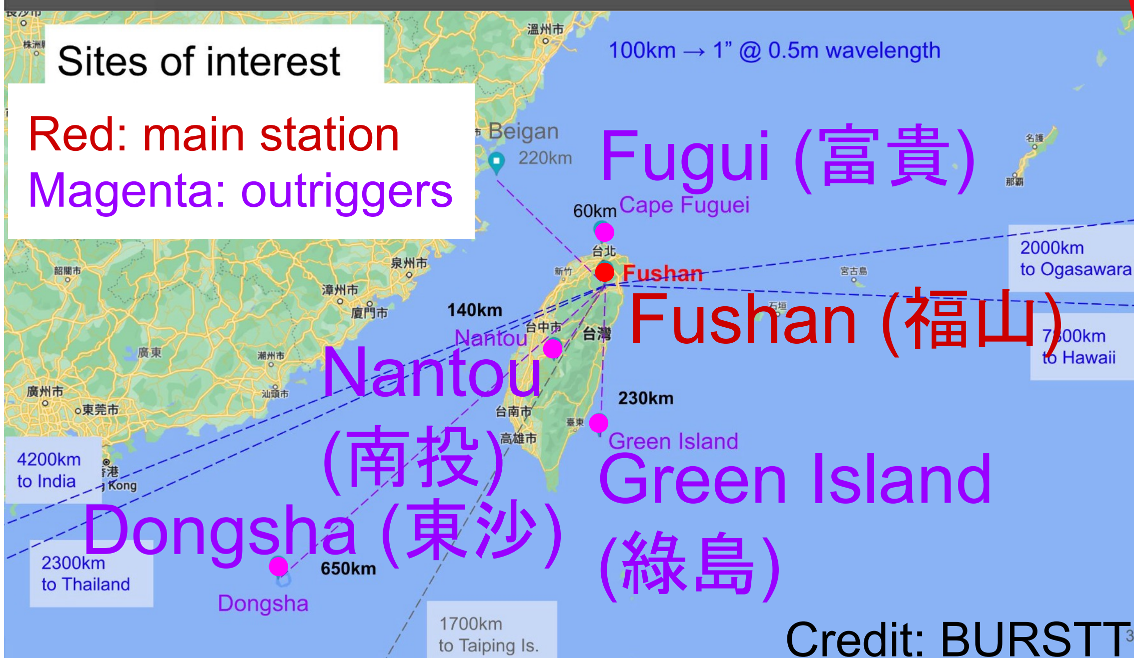
Bustling Universe Radio Survey Telescope in Taiwan (BURSTT, PI: Ue-Li Pen)

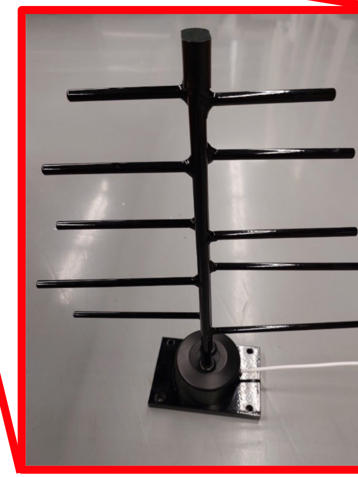
BURSTT

Wide FoV



VLBI





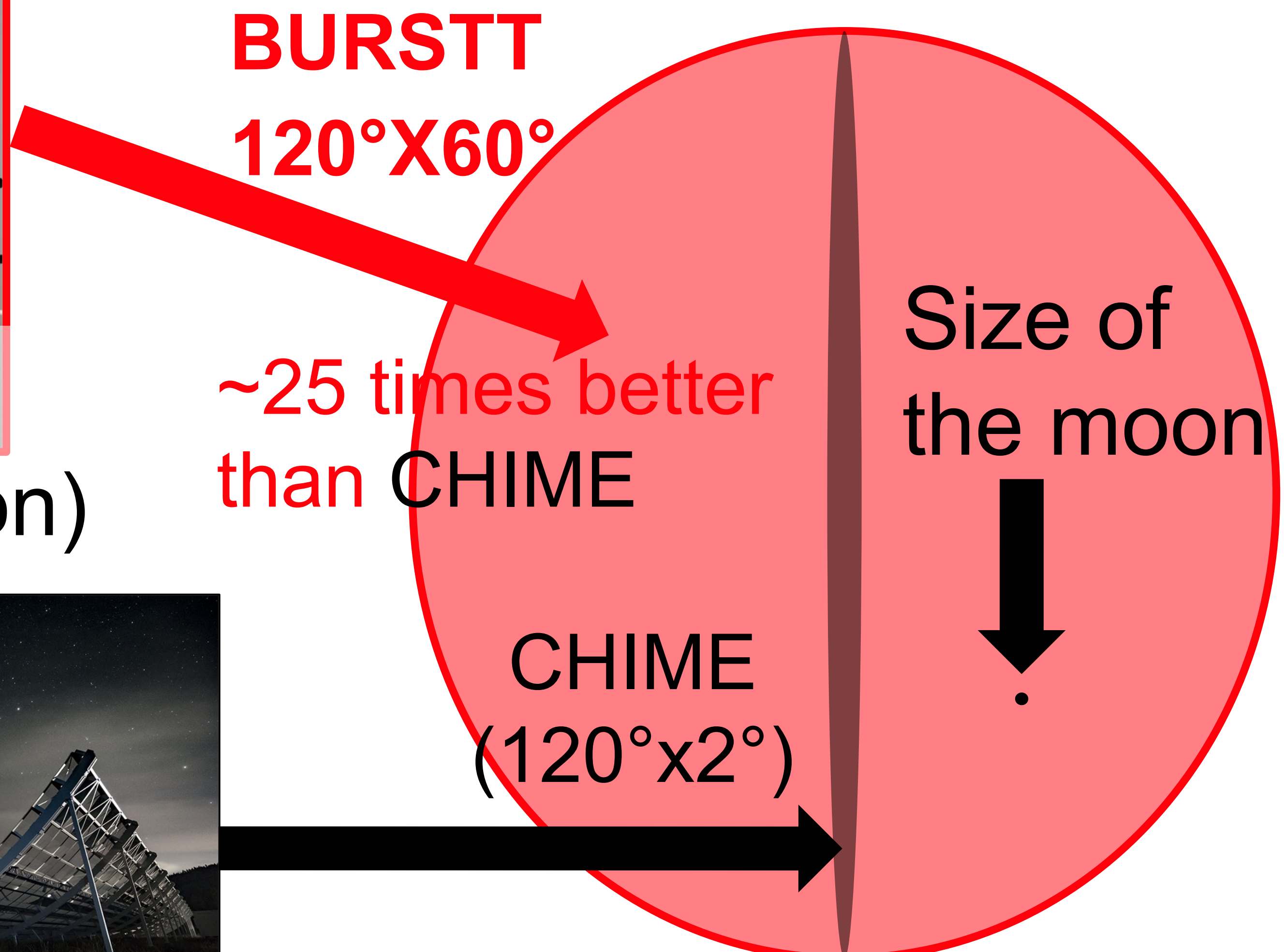
Log-Periodic Dipole Array (LPDA) antenna for the main station

Antenna design

BURSTT

(main station)

Field of view on the sky



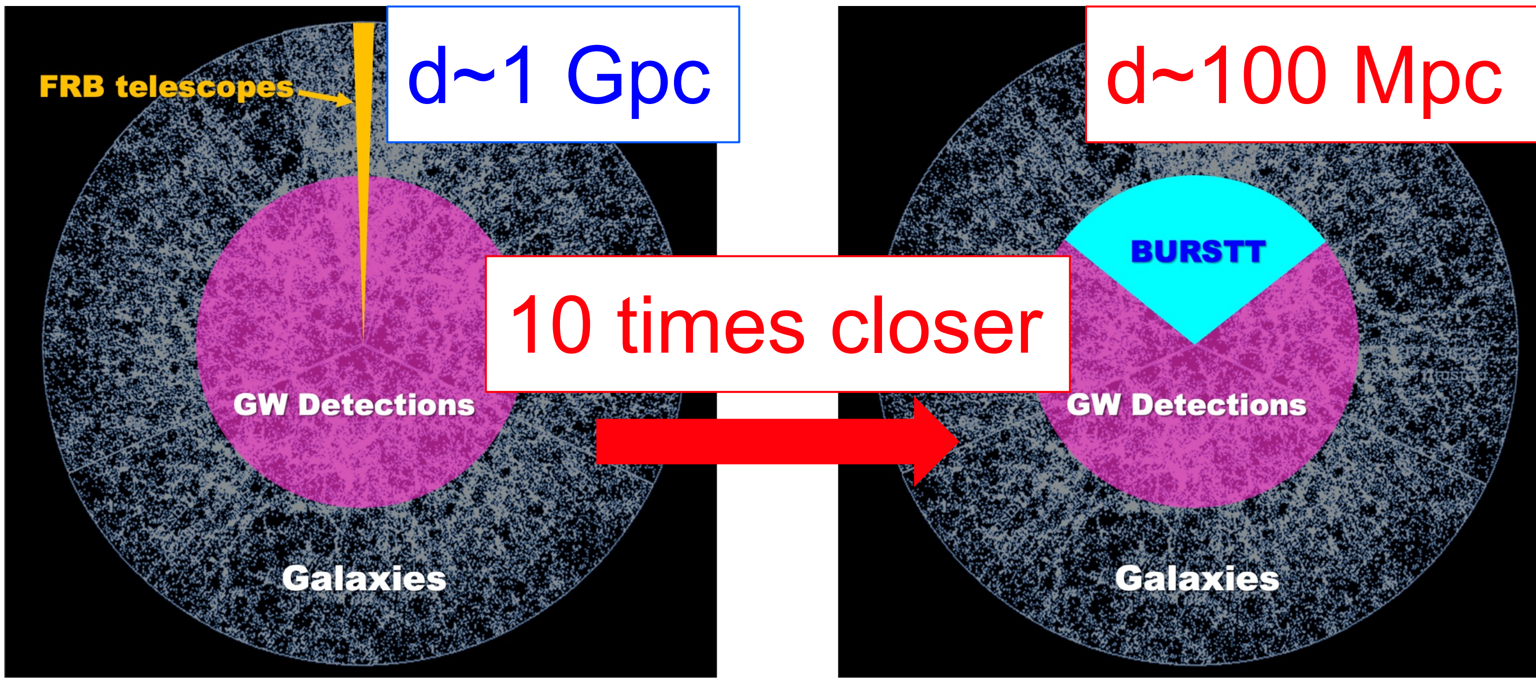
Bottlenecks and our solutions

Previous observations

Mismatch with multi-messengers

BURSTT

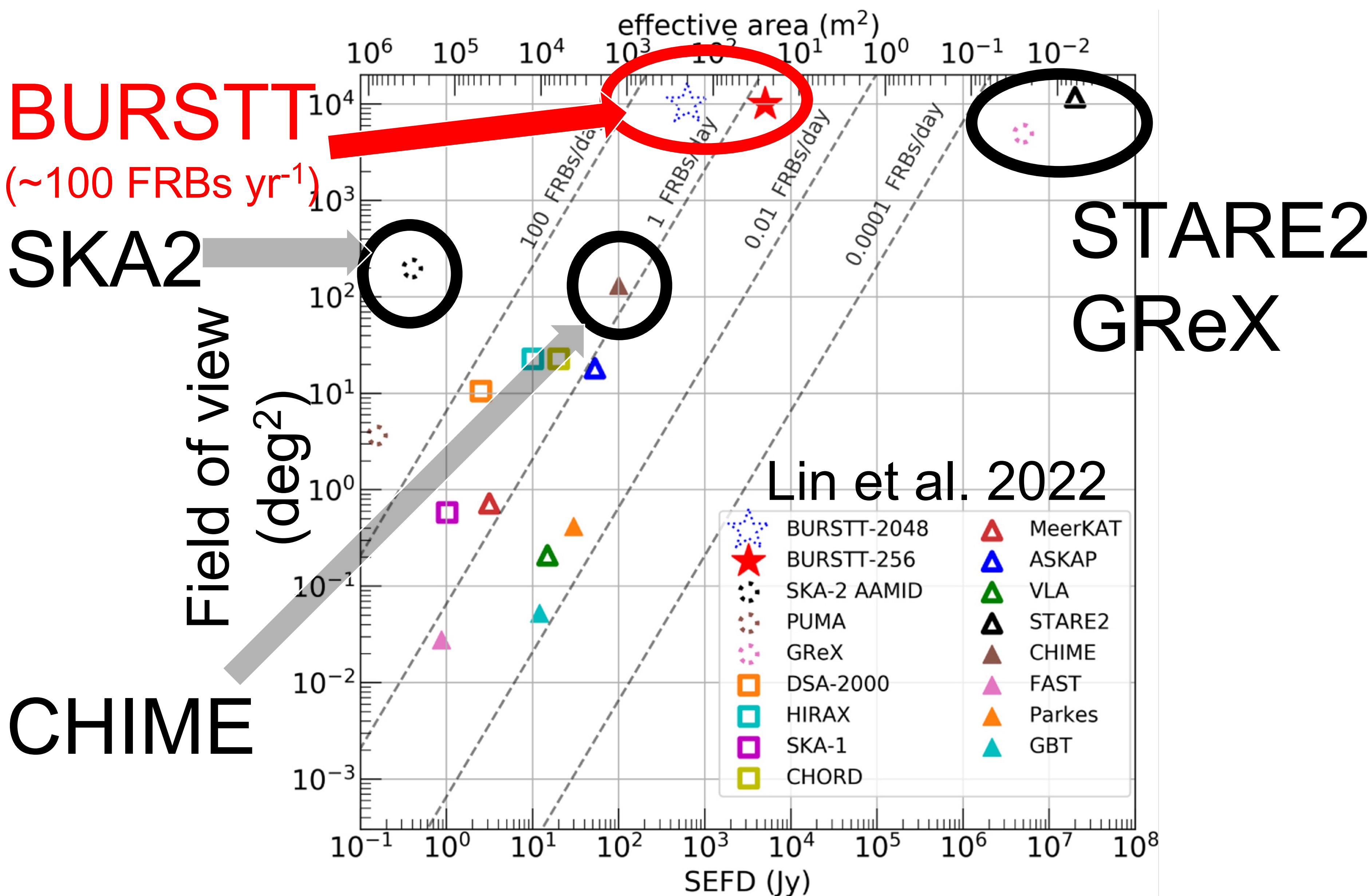
Synergy with multi-messengers



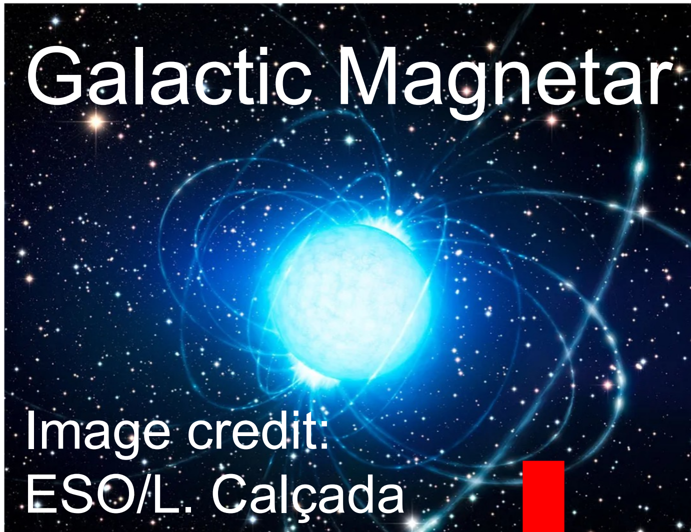
A very small overlap in the survey volume

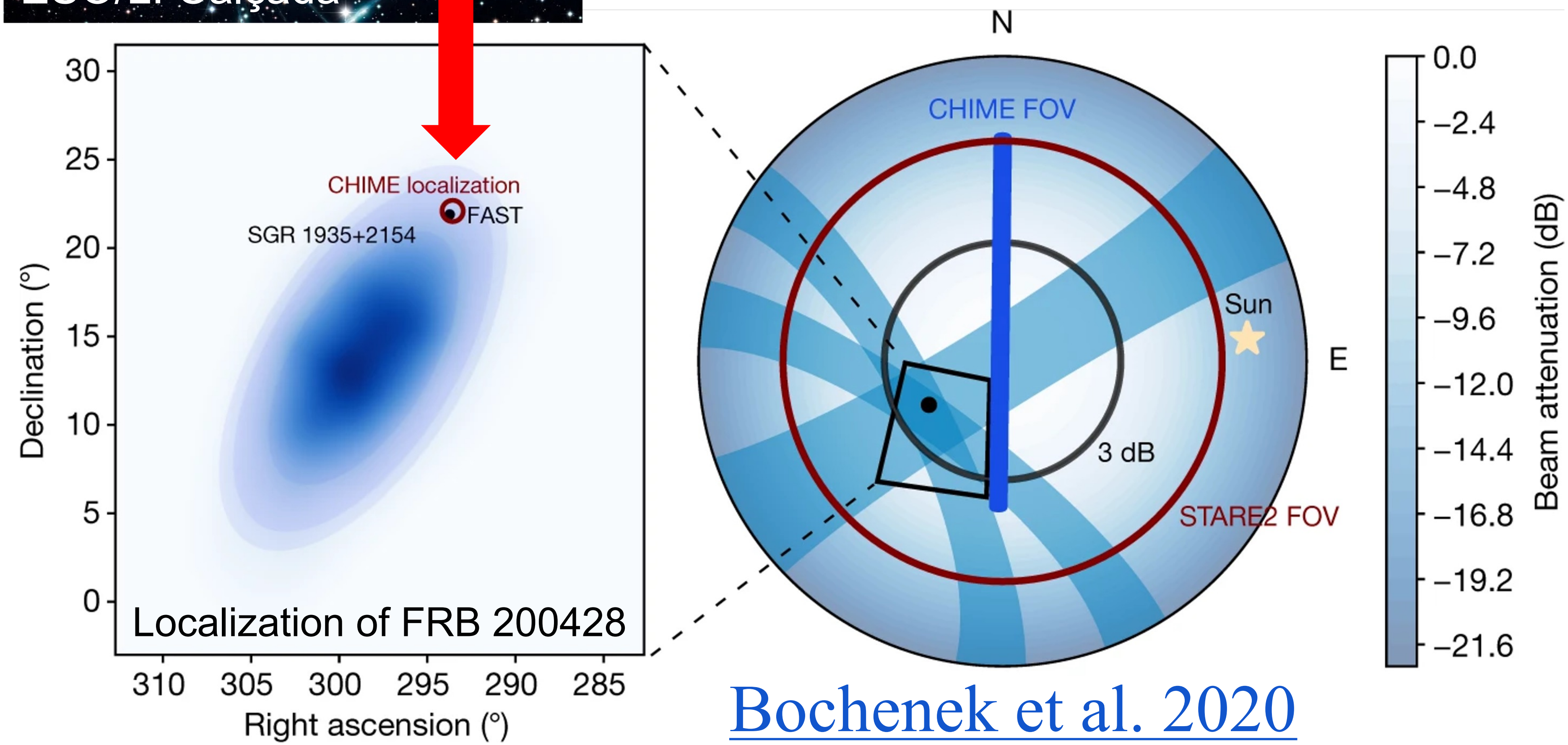
Maximize the chance of multi-messenger detection

BURSTT explores unique param. space



1. Direct identification of an FRB progenitor

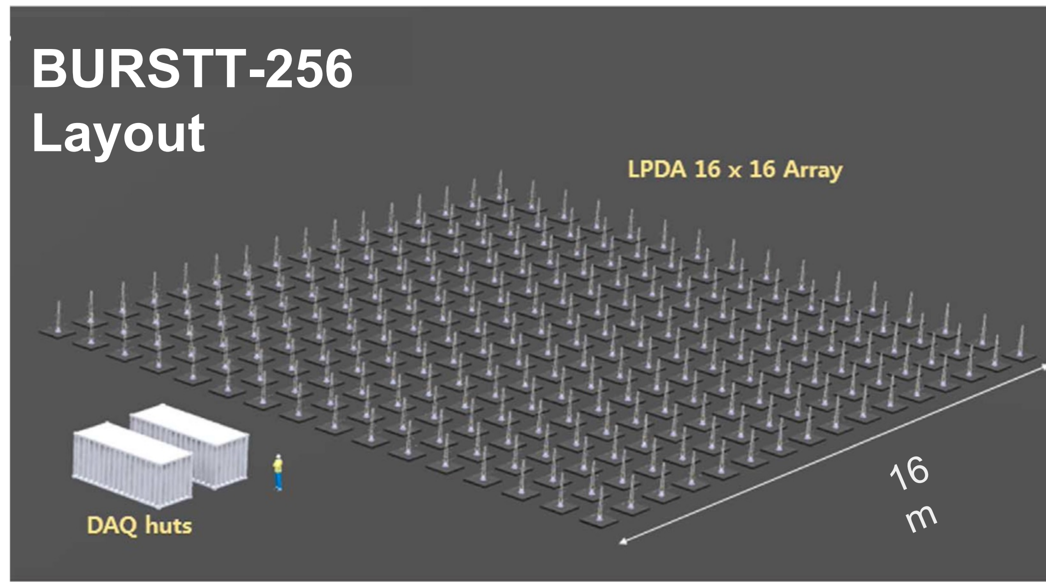




Bochenek et al. 2020

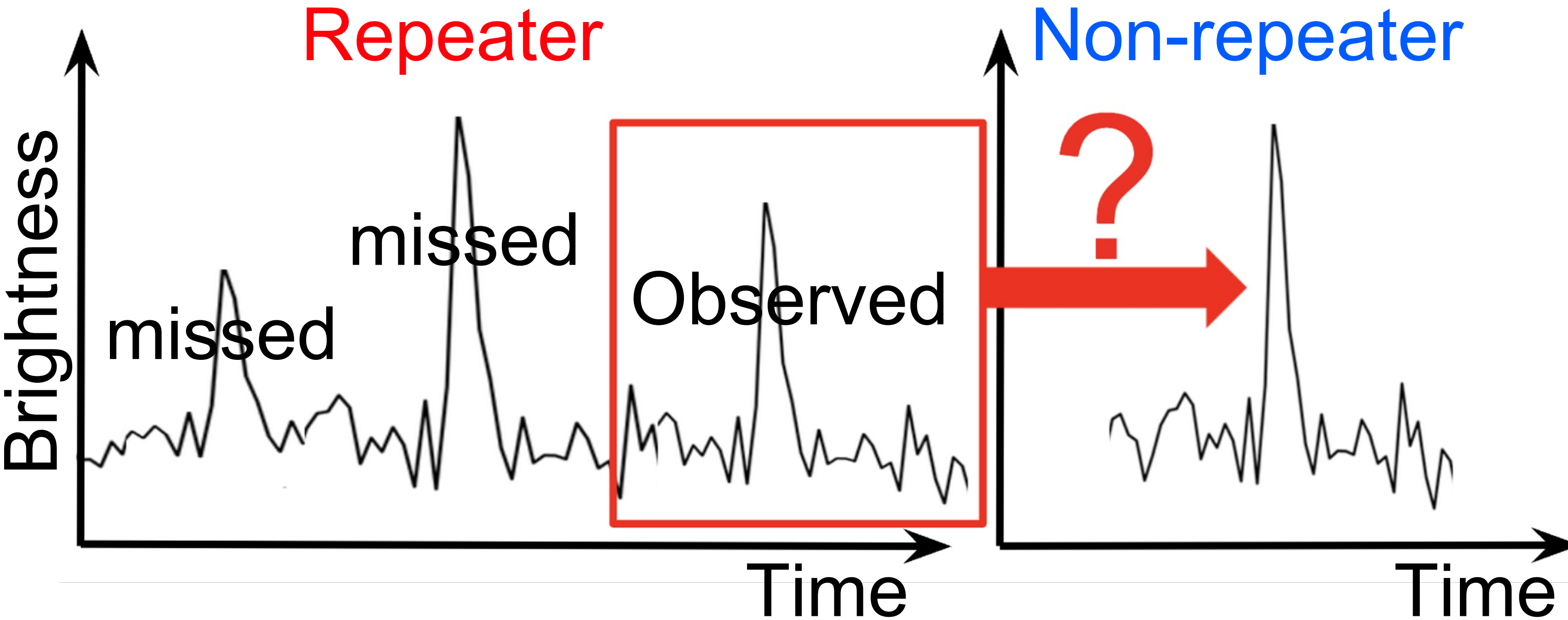
1. Direct identification of FRB progenitors

BURSTT



→ increase progenitor ids.

2. Complete census of nearby FRBs

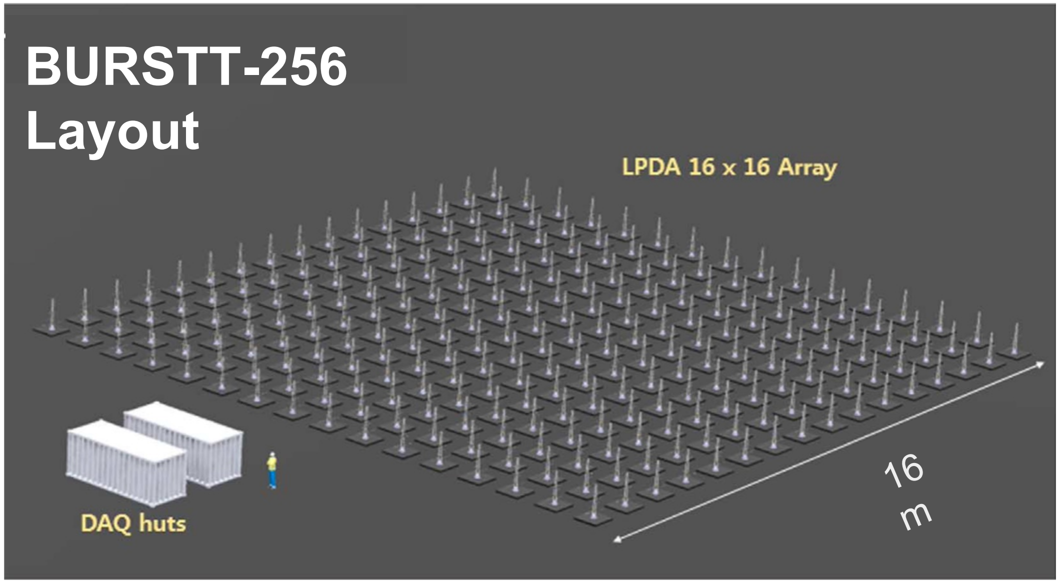


- The true number fraction of repeaters/non-repeaters (f_{rep}) ➡ ?
- True repeating rates

need long monitoring observations with high cadences

2. Complete census of nearby FRBs

BURSTT will answer

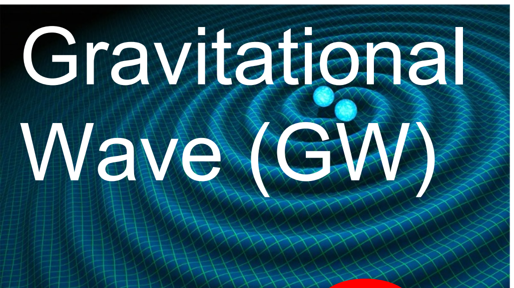


- The true number fraction of repeaters/non-repeaters (f_{rep}) ➡ ?
- True repeating rates

with 25 times larger (longer) FoV (obs. time) than CHIME

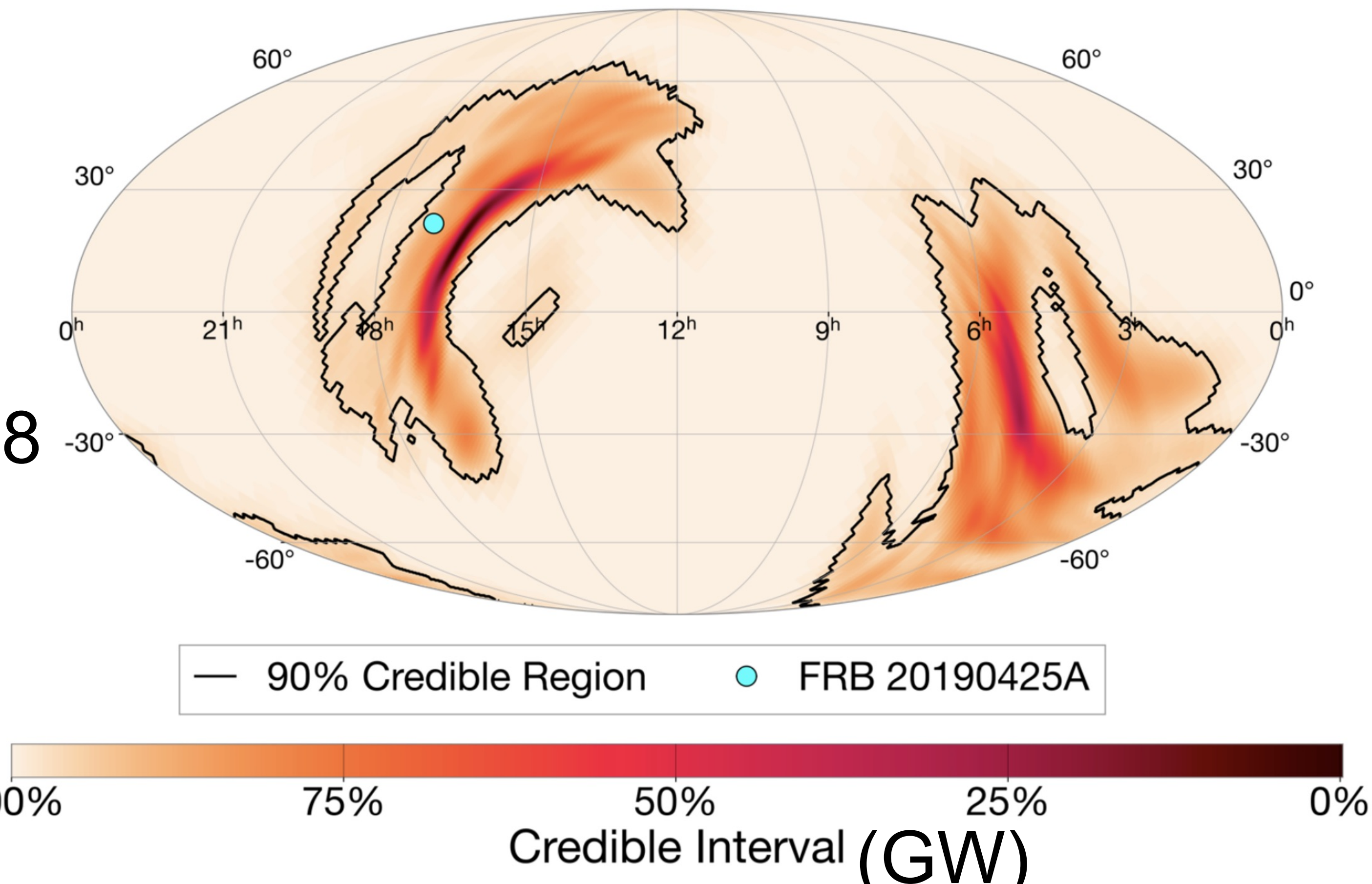
3. FRB counterparts

3.1 Multi-messenger



+?

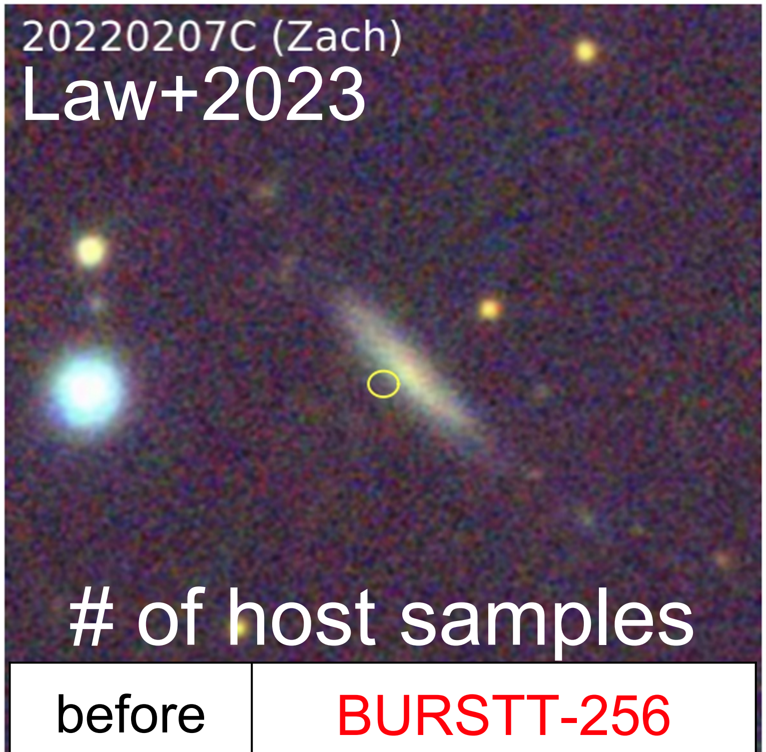
cf.
Yamasaki+2018



Moroianu et al. 2023, *Nature Astronomy*

3.2 Multi-wavelengths

Host identification

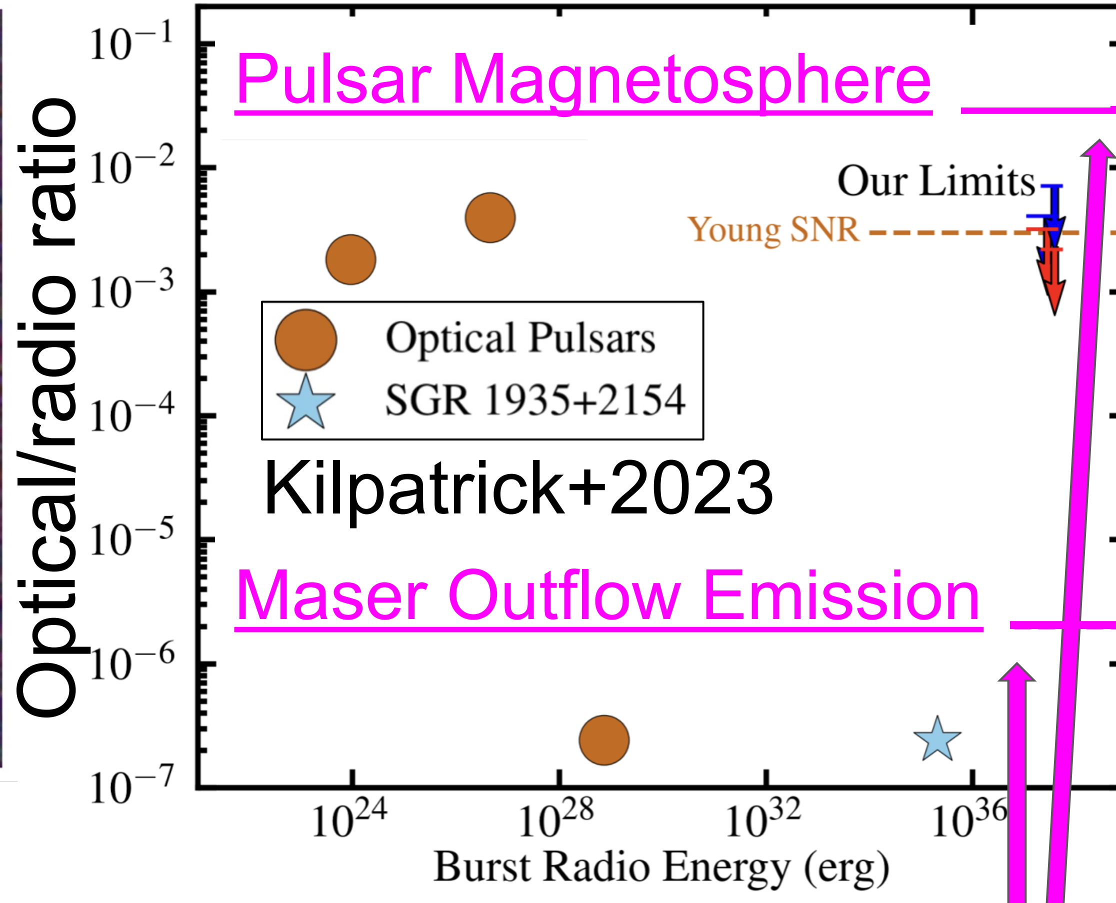


# of host samples

before	BURSTT-256
~40	~100 yr^{-1} (max)

Physical environments and progenitor types

Burst counterparts



Radiation mechanisms and progenitors (eg. LOT)

BURSTT main station

Completed: 256/256 antennas

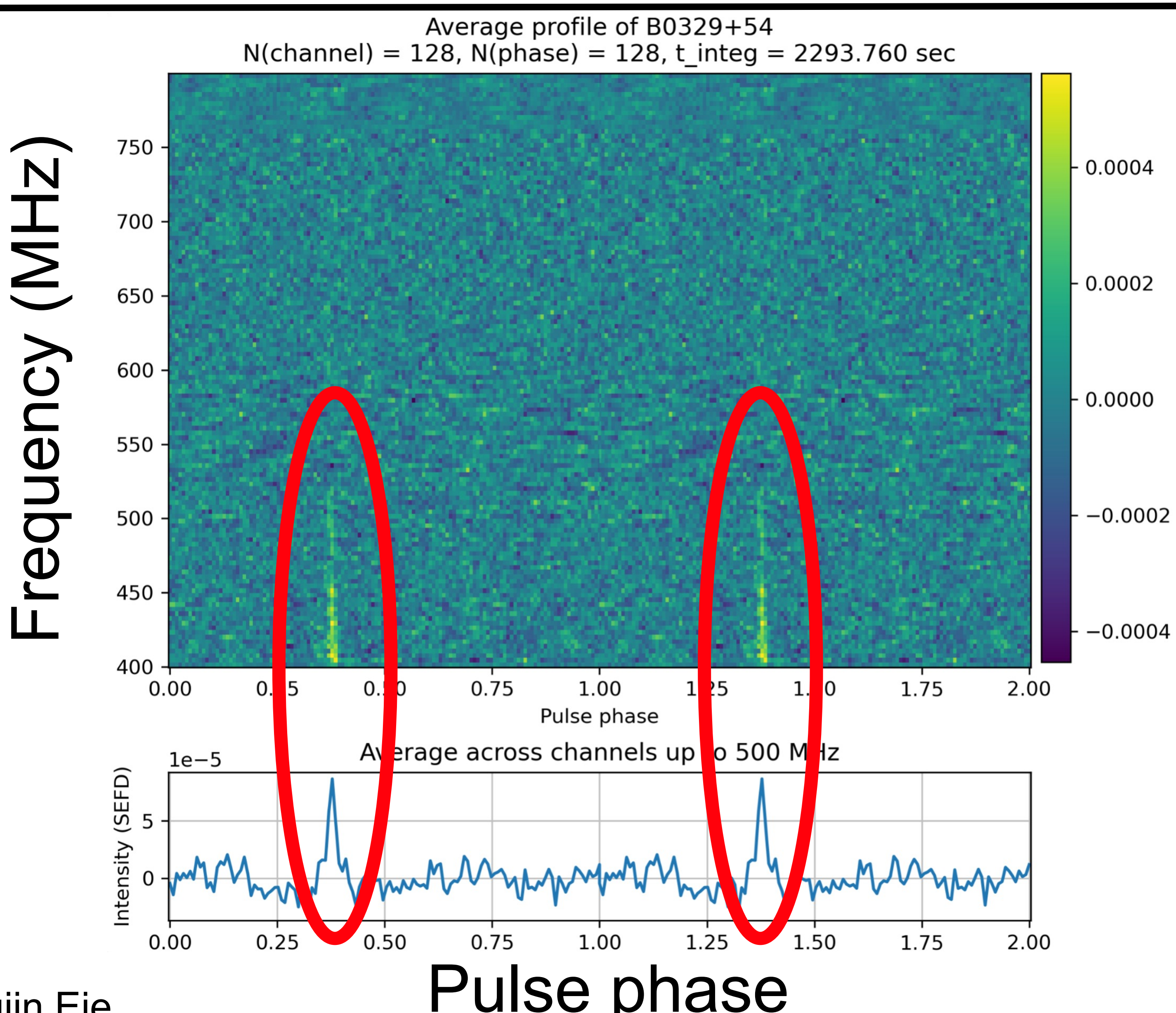
@Fushan Botanical Garden in northern Taiwan

Credit: Sujin Eie

Domestic outrigger stations

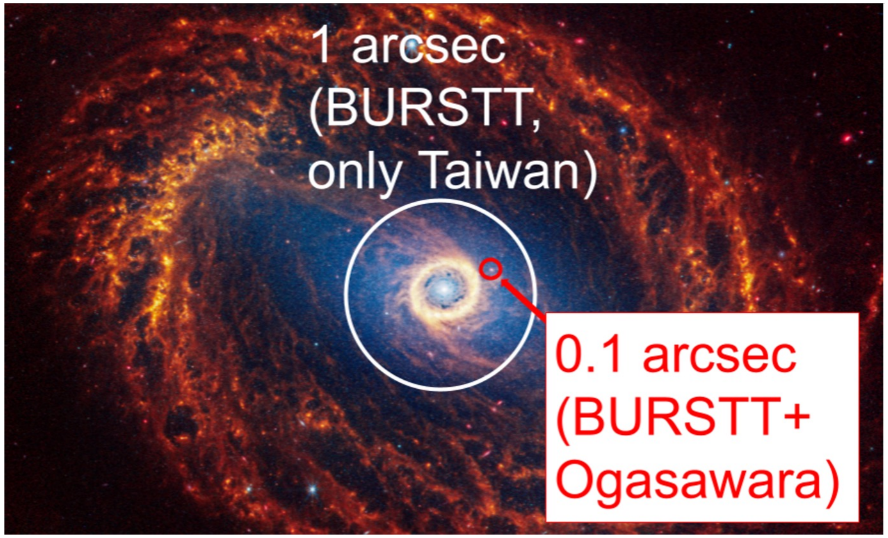
Credit: Sujin Eie

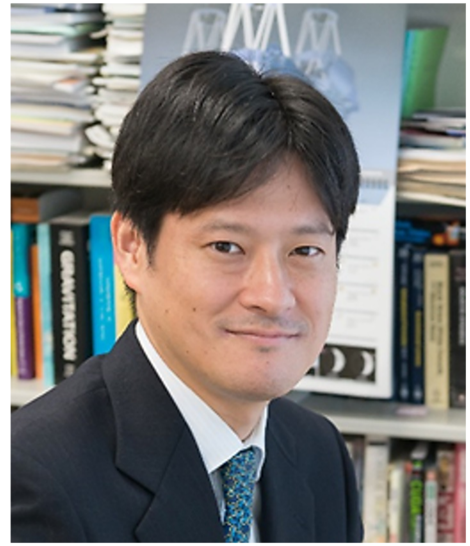
Success: detection of a bright pulsar



Credit: Sujin Eie

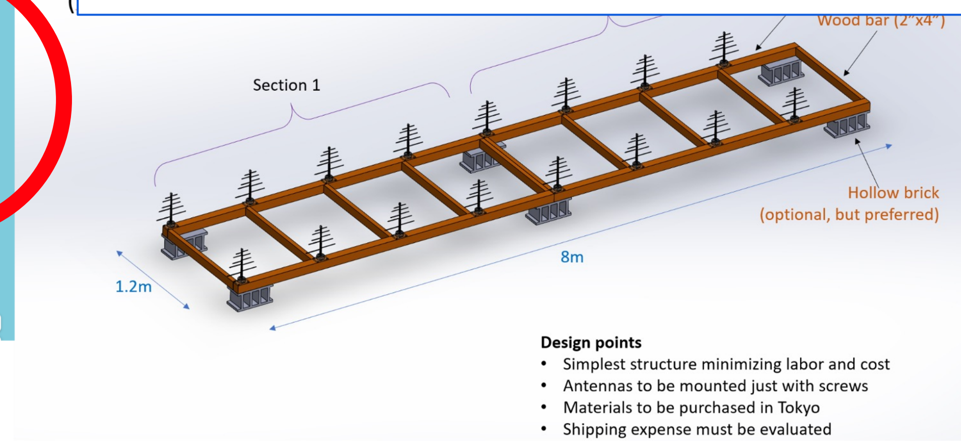
International collaboration (Japan)





Prof. Honma Mr. Masaoka

Prototype → Dec. 2024



Where are we now?

So far

- **BURSTT-256 (close) + 1 outrigger**
  - 256 antennas at the main station + 64, 16 antennas at two outrigger stations
  - Real-time 2D beamforming with 64 antennas
  - Testing VLBI with GPS timing

Single/folded pulsar signals detected

2024 (goal)

- **BURSTT-256 + 2(+) outriggers**
  - Beamforming with 256 antennas
  - Hopefully, first BURSTT FRB
  - ~100 localized FRBs/yr >> 40 (now)

After 2025

- **BURSTT-2048* + 8(+) outriggers**
  - ~10 FRBs per day (10,000 FRBs for 3 years)

*2048 is our plan (partially granted)

BURSTT-256 is covered by Vanguard

Credit: Sujin Eie

Conclusion

- FRB is exciting!
  progenitors, galaxies, and cosmology

- BURSTT: the first FRB telescope with an extremely wide field of view and the localization capability in the world

- BURSTT starts this year with ~100 localized FRBs per year