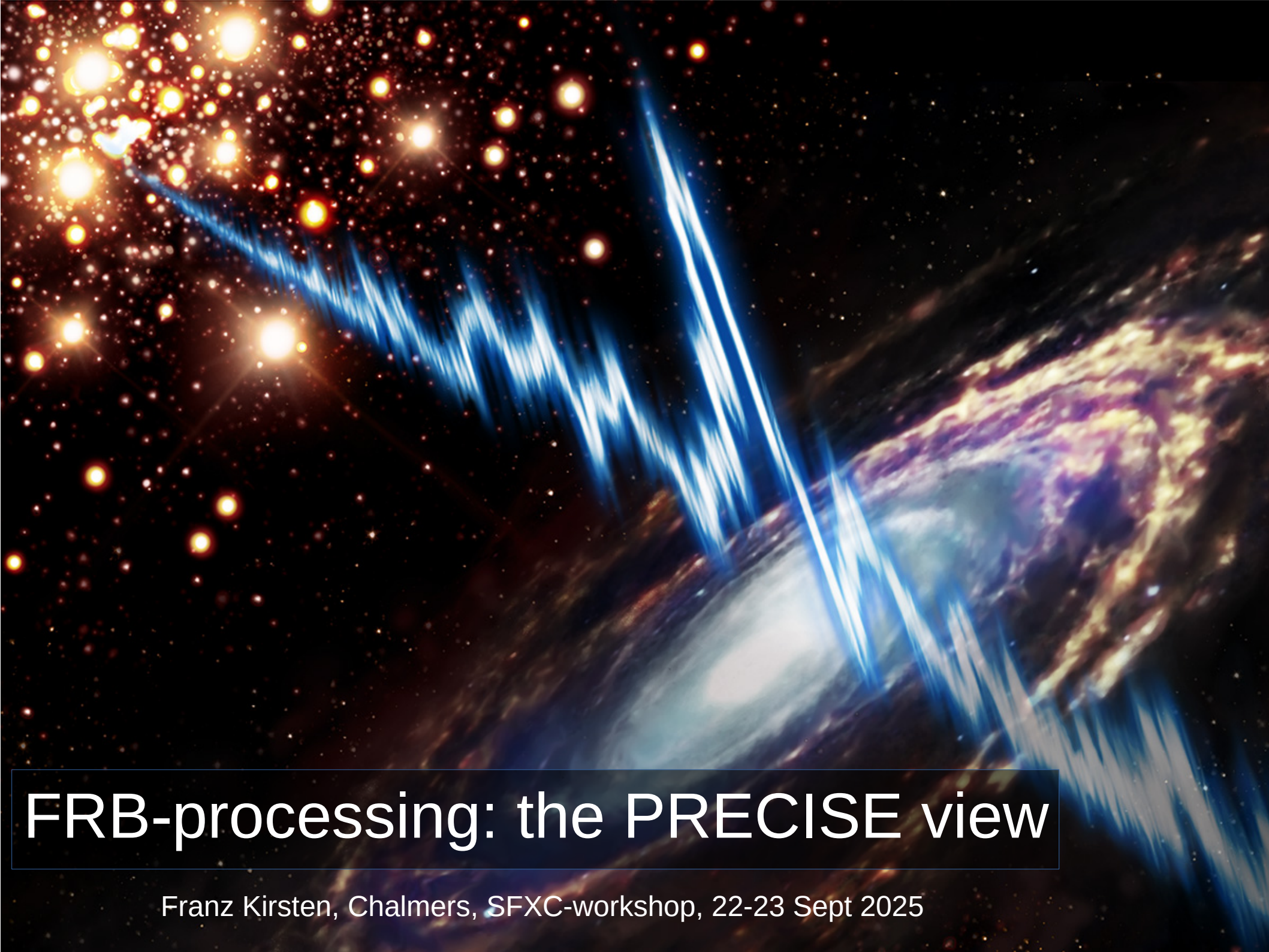




FRB-processing: the PRECISE view

Franz Kirsten, Chalmers, SFXC-workshop, 22-23 Sept 2025

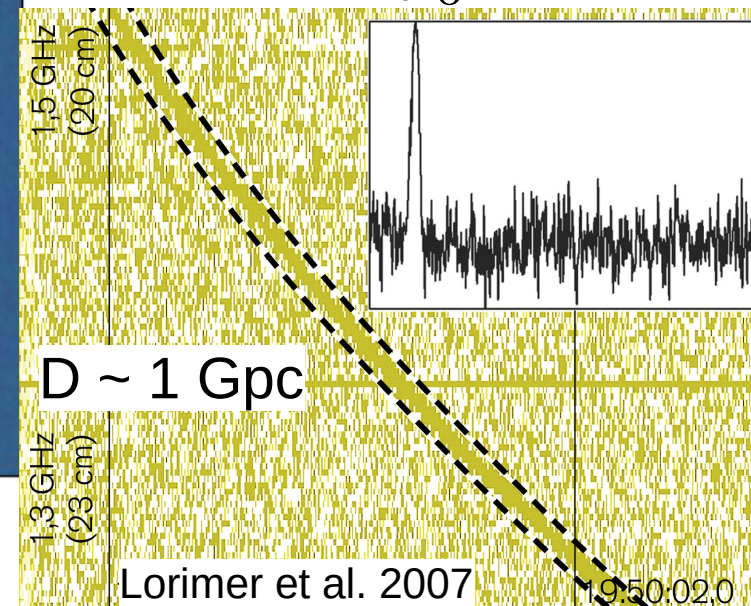
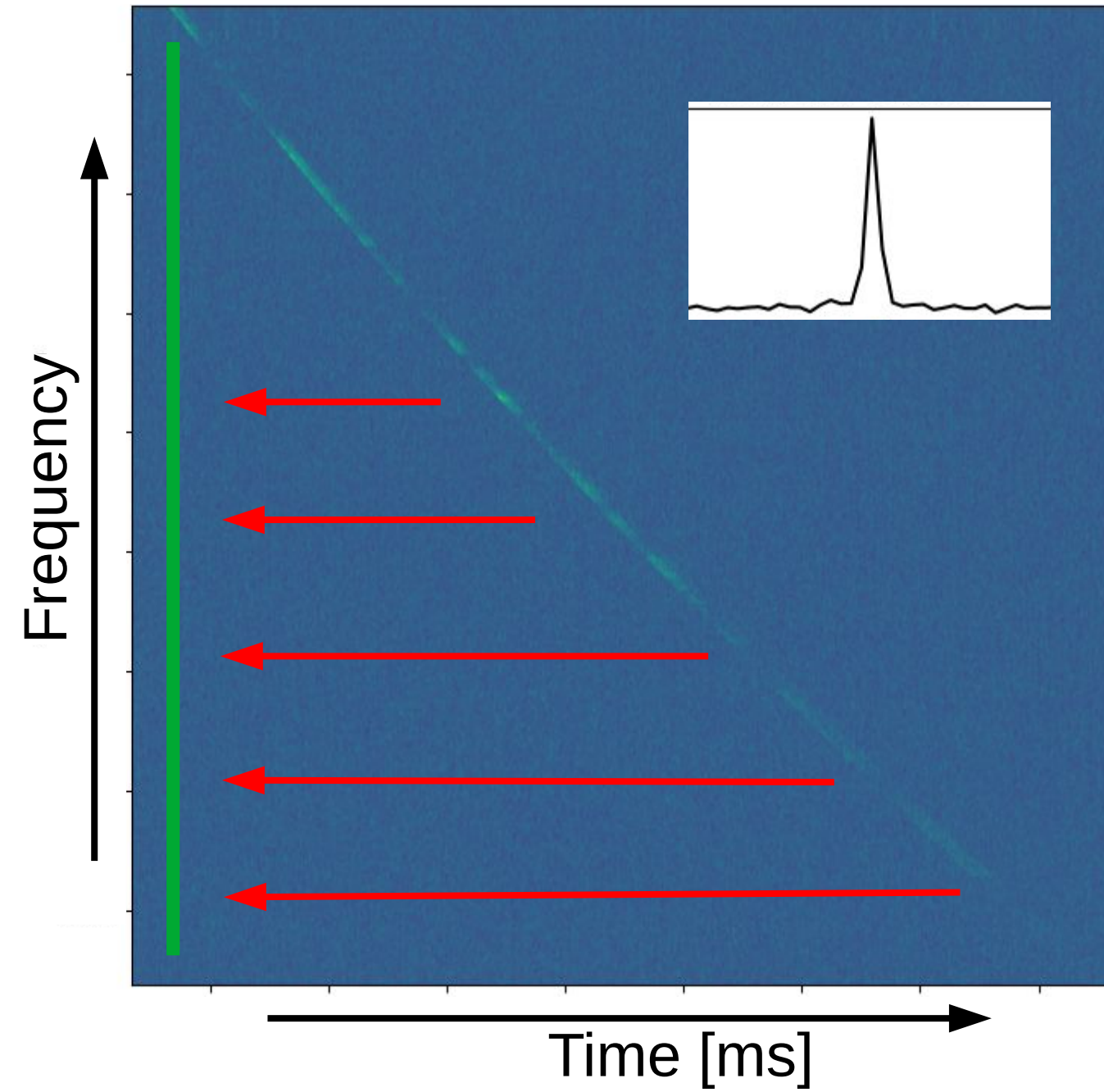
Fast Radio Bursts – FRBs

Pulses traverse ISM, i.e. encounter free electrons. Causes group delay because of frequency dependent refractive index of the cold plasma

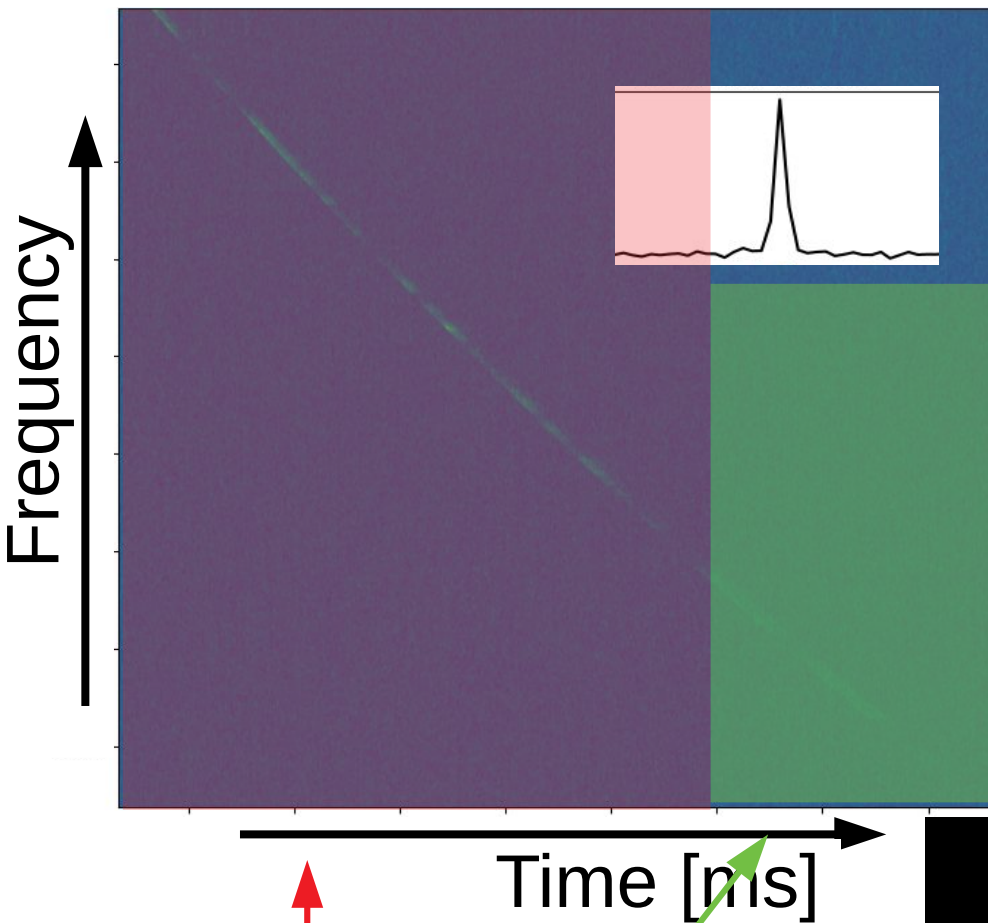
$$\mu = \sqrt{1 - A \frac{n_e}{f^2}}$$

Dispersion measure

$$DM = \int_0^D n_e dl$$



Fast Radio Bursts – FRBs

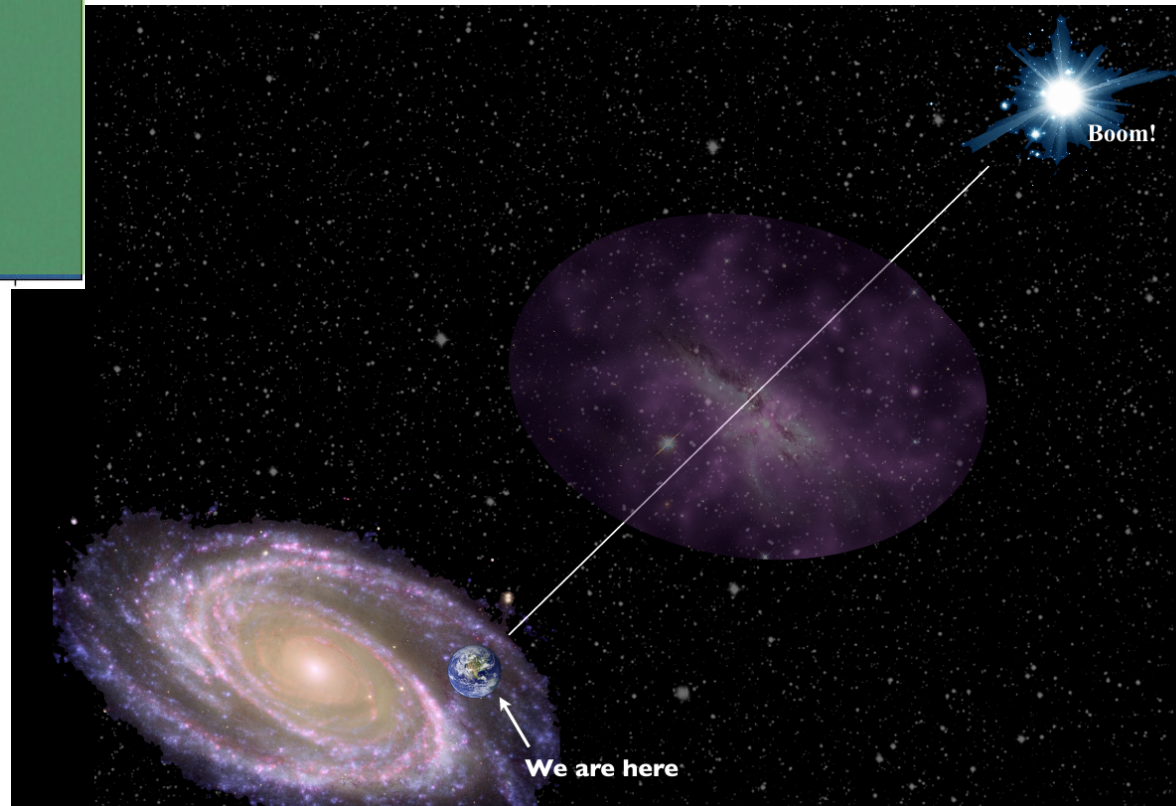


Contribution from
intergalactic space!

Contribution from
our Galaxy

Dispersion measure
 $\sim 100 < DM < \sim 3000$
 $\rightarrow 0.03 < z < 2.2$

Cosmologic origin



CHIME/FRB – FRB hunting



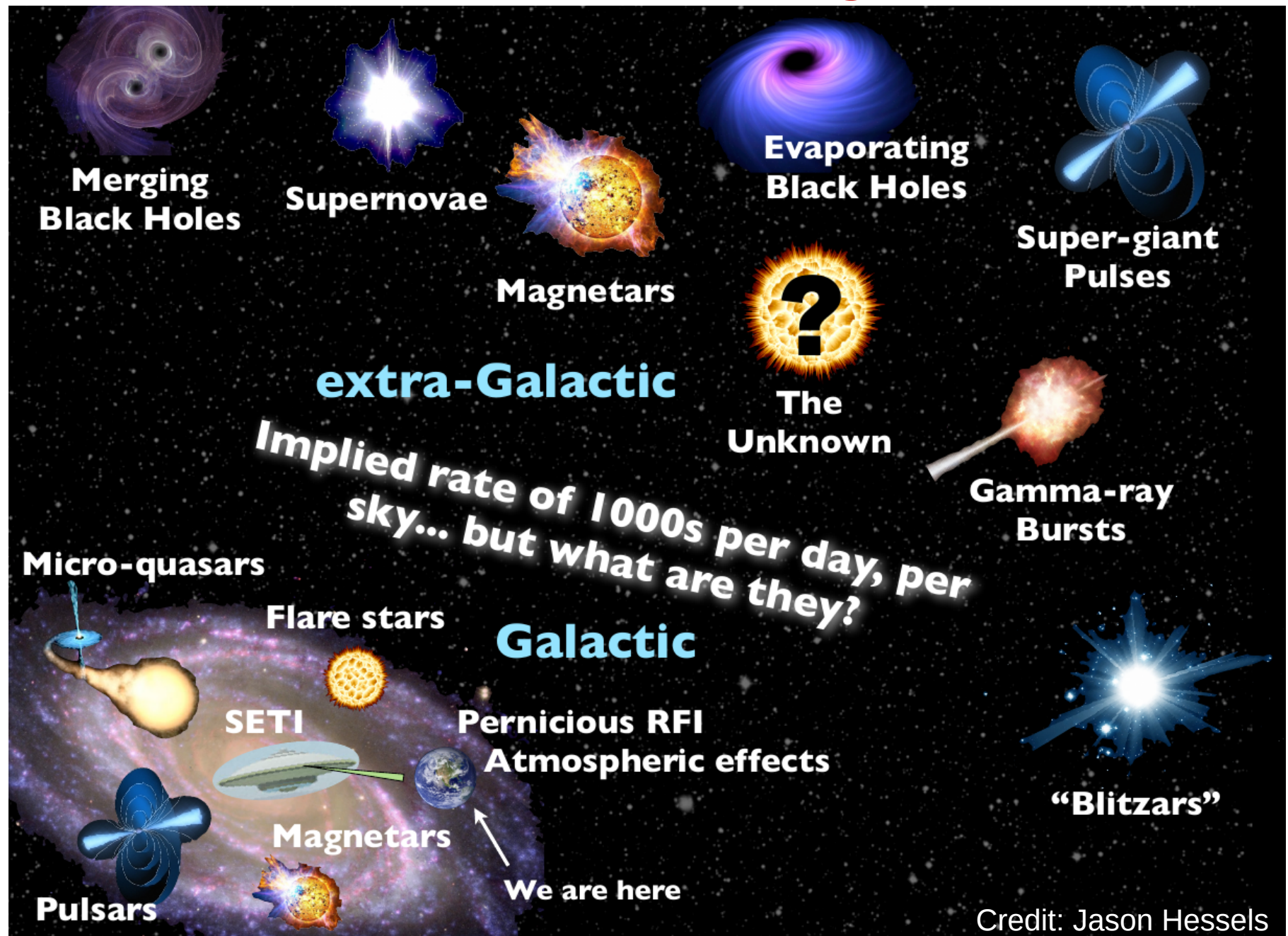
FOV $\sim 200 \text{ deg}^2$

- transient telescope, i.e. no moving parts
- observes the full northern sky each day

Two **classes** of FRBs:

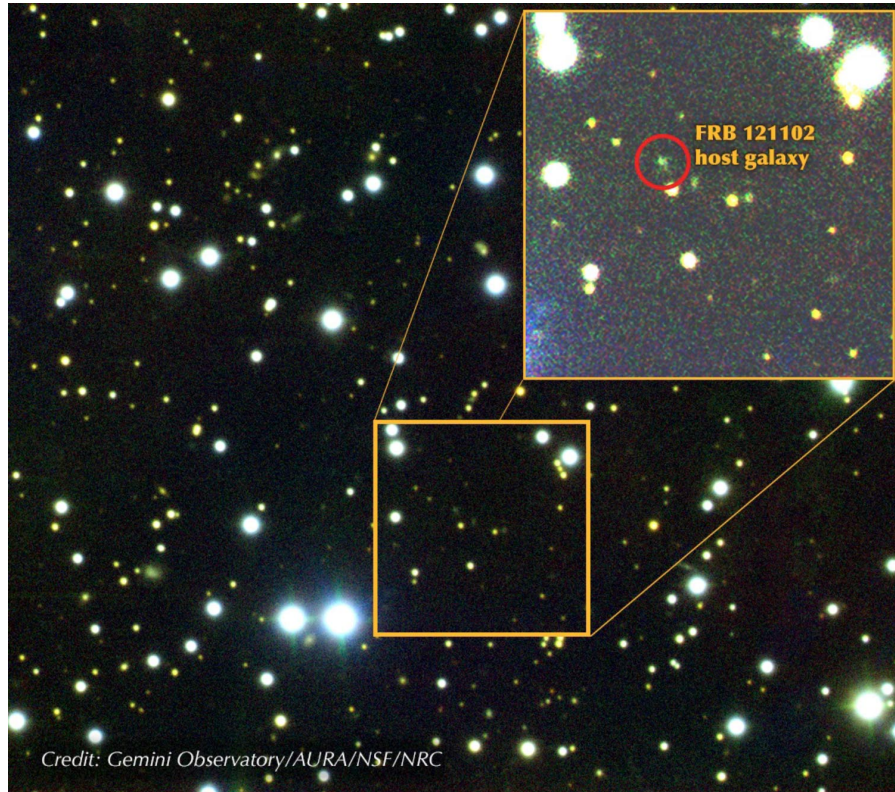
- those that **do not repeat** (~ 800 published, roughly 5000 found)
- Those that **do repeat** (~ 60)

So, but **what are they?**

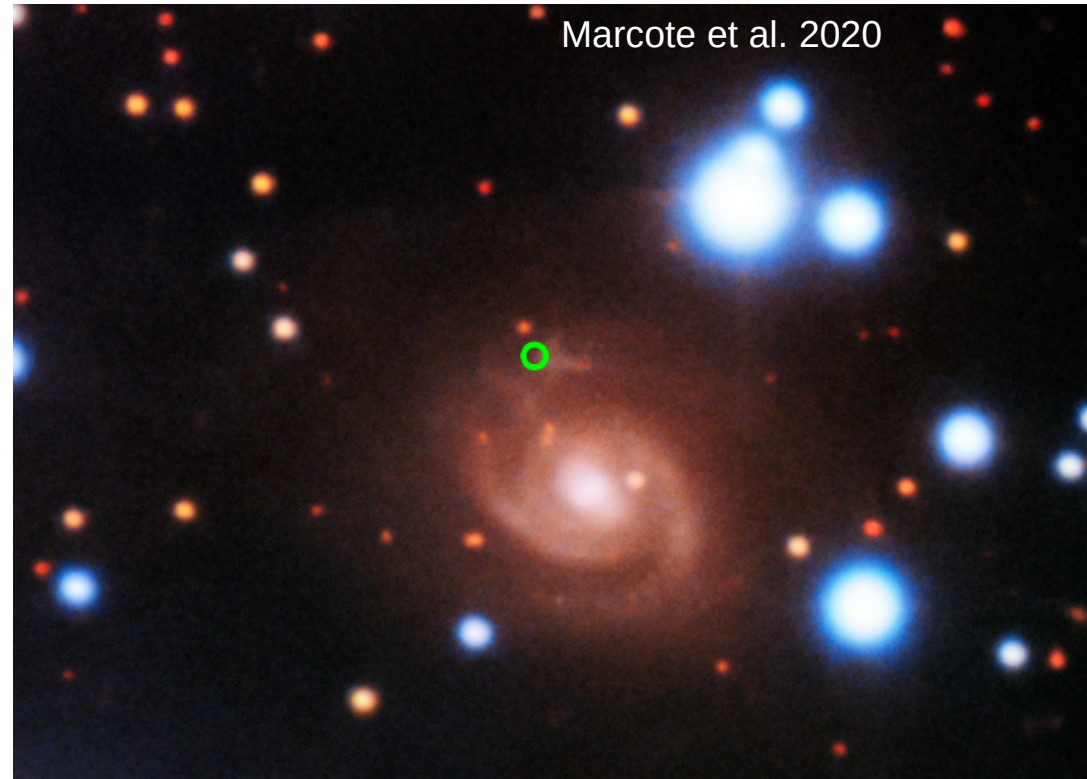


The role of **Localisation** to help **understand FRBs**

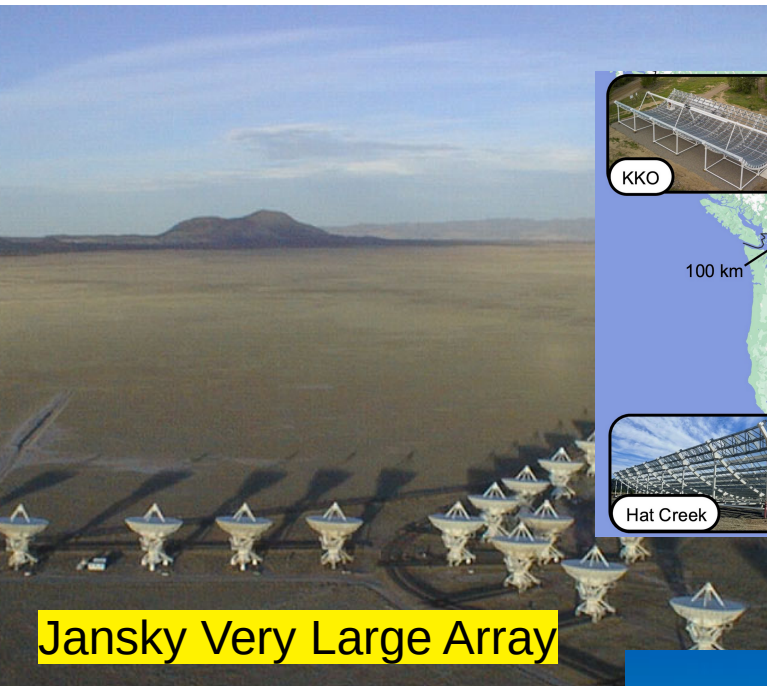
Host galaxies



Local Environment



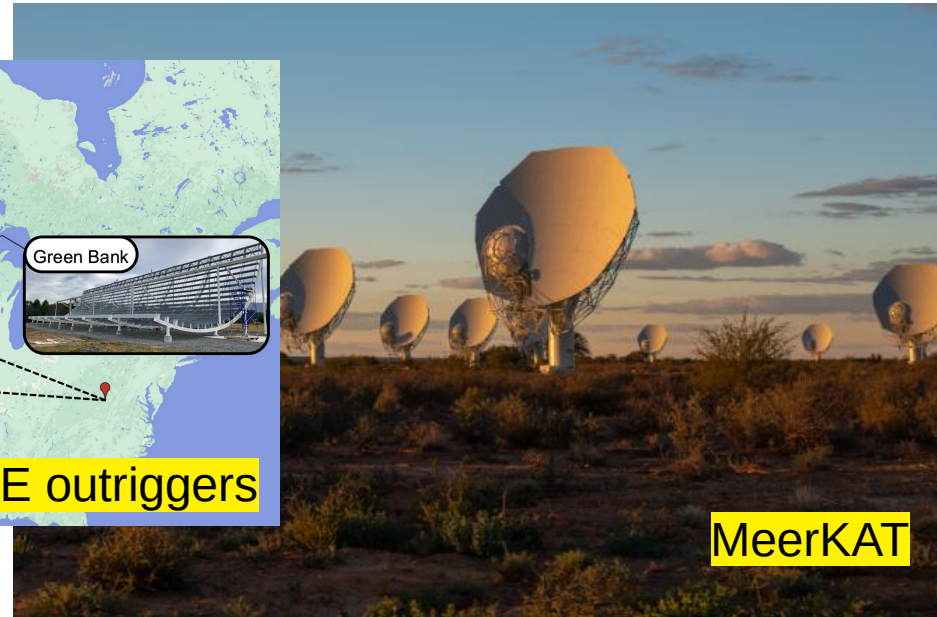
Host galaxies – **arcsecond localisation**



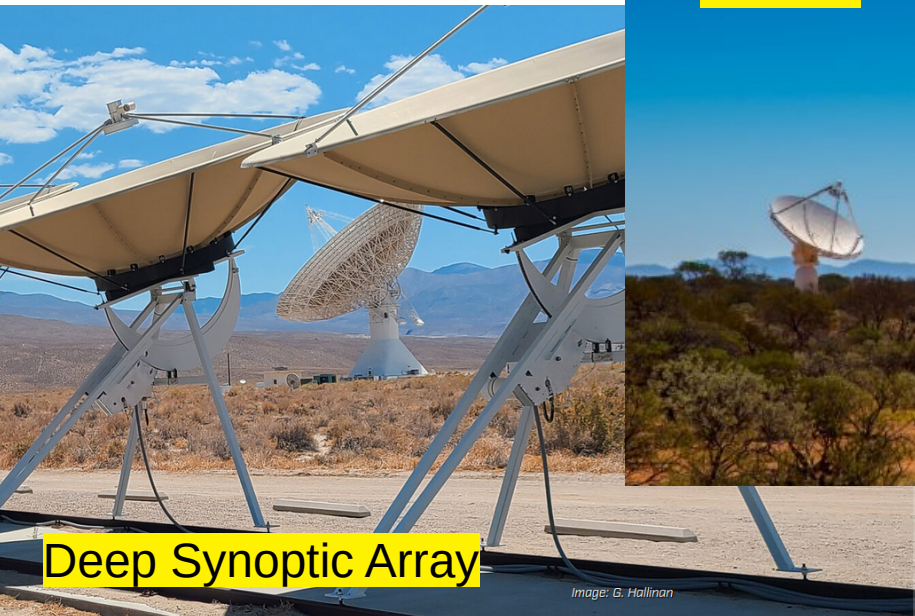
Jansky Very Large Array



CHIME outriggers



MeerKAT



Deep Synoptic Array



ASKAP

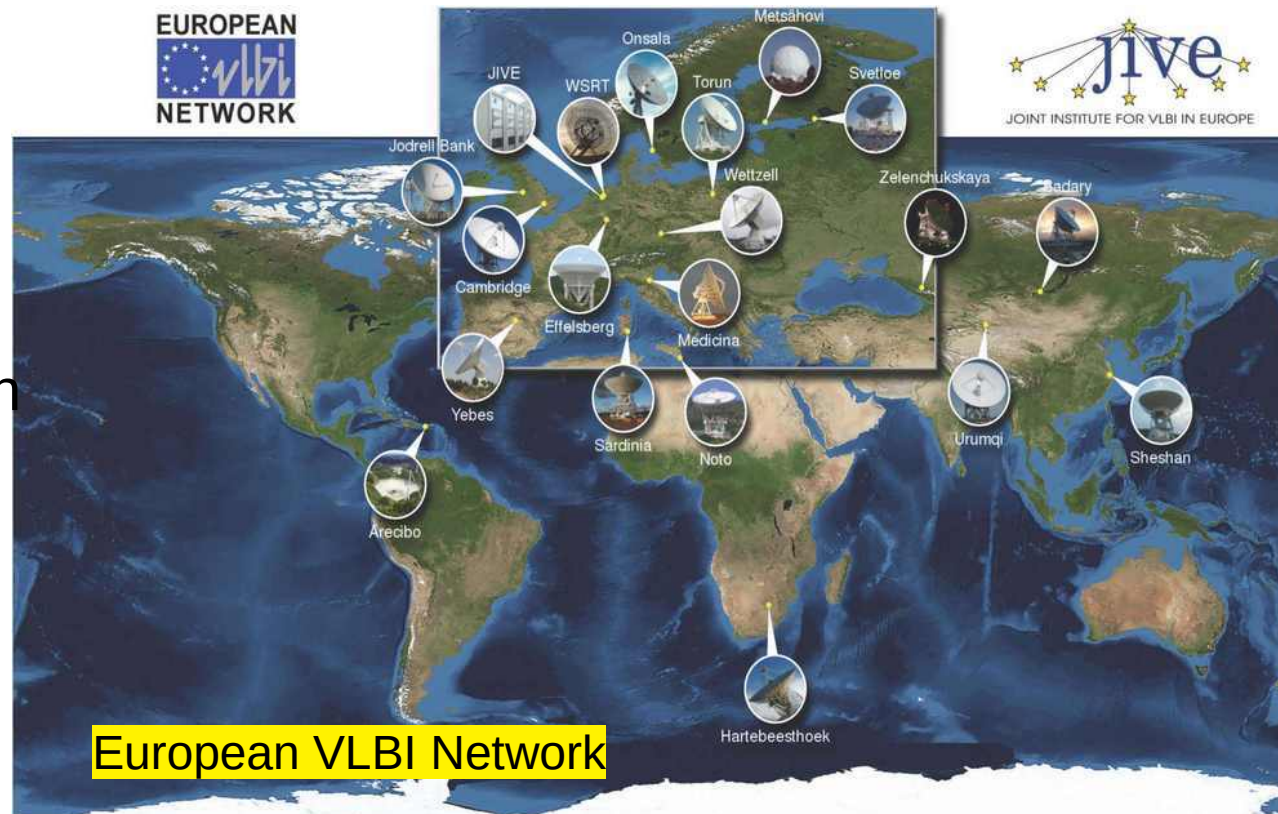


uGMRT

Local environment – **targeted searches** with interferometric arrays

Milliarcsecond accuracy
essential to:

- localise FRBs **within host**
- **Match optical** high-resolution imaging (HST, JWST, ELT...)
- Draw conclusions about **physical environment**
- Assess **compactness** of potential **persistent** radio counterpart



PRECISE

Pinpointing Repeating CHIME-Sources
with EVN-dishes

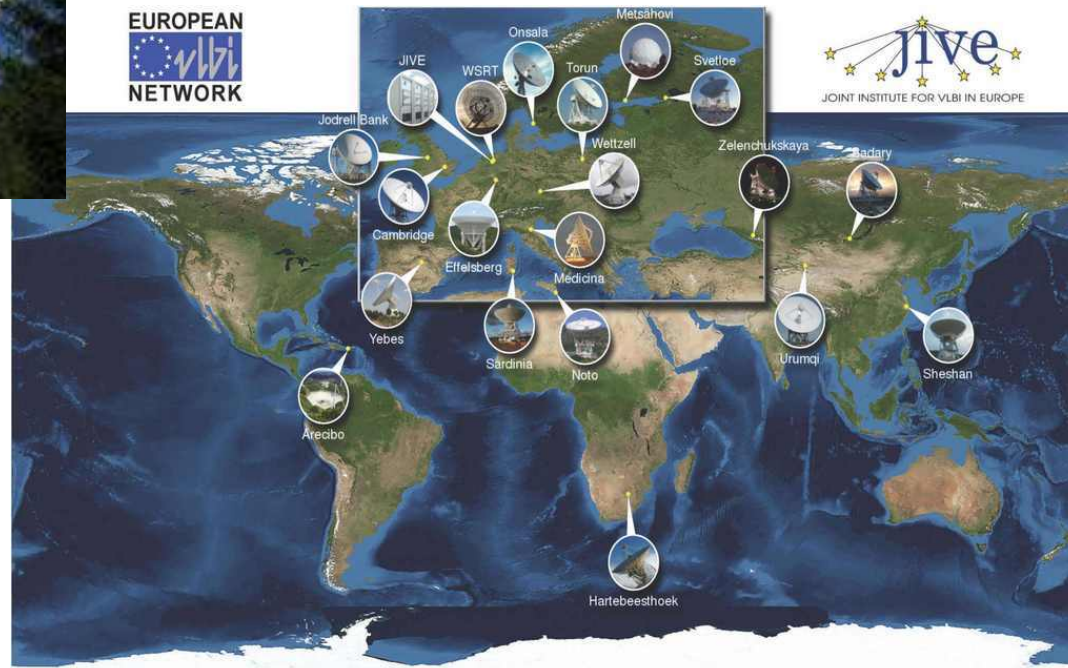
PRECISE

Pinpointing Repeating CHIME-Sources with EVN-dishes

Quick facts

- We're and EVN-Lite project focusing on repeating FRBs only
- Weekly 10h-observations with 5-12 dishes, including e-MERLIN
- Data from Effelsberg are searched for bursts – correlation only in case of a detection (hence the “Lite”)
- Correlation is done at JIVE; first step is typically “delay mapping” – Aard will tell you all about it
- Since we started in Jan 2020, localised 7 repeaters

PRECISE – burst finding in a nutshell



PRECISE – burst finding in a nutshell

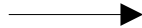


E-transfer to “ebur”

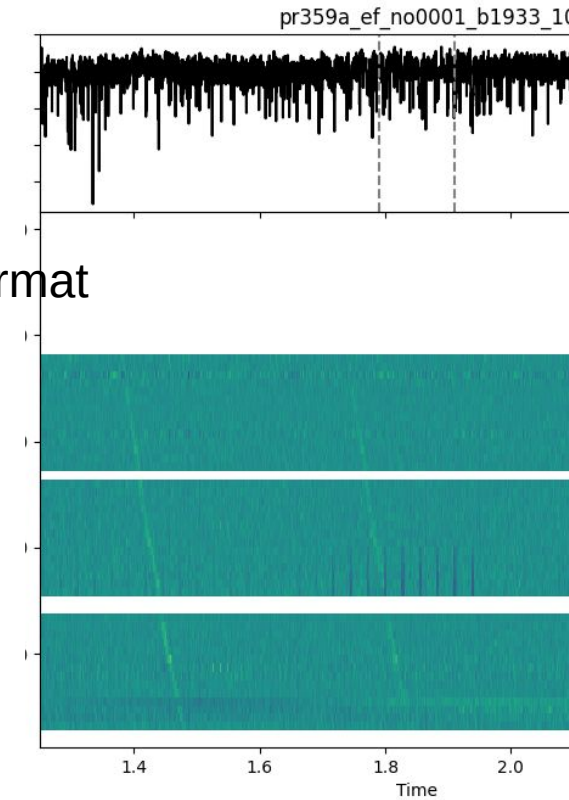
at Onsala via
m5copy/jive5ab



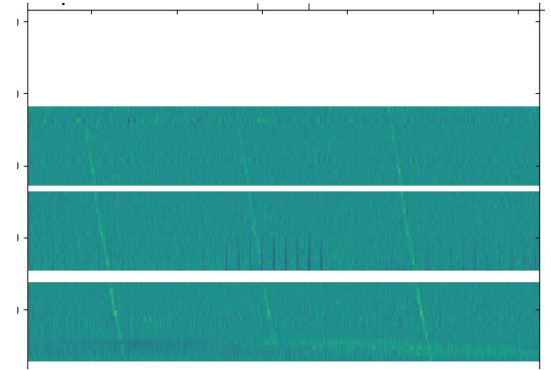
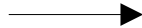
PRECISE – burst finding in a nutshell



Convert to
filterbank format



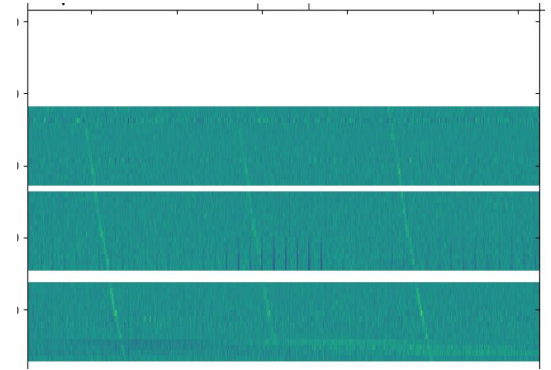
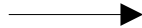
PRECISE – burst finding in a nutshell



Dedispersion and
Burst searching



PRECISE – burst finding in a nutshell

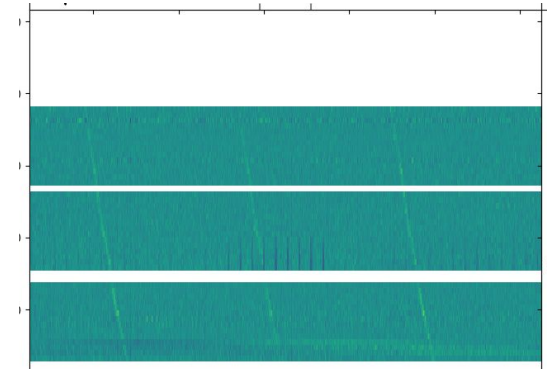
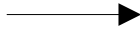


Candidate
←
classification

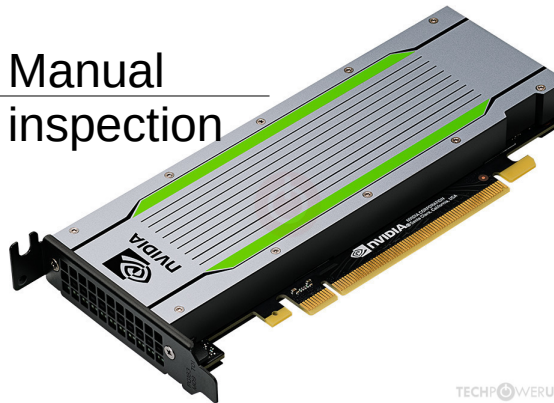


TECHPOWERUP

PRECISE – burst finding in a nutshell

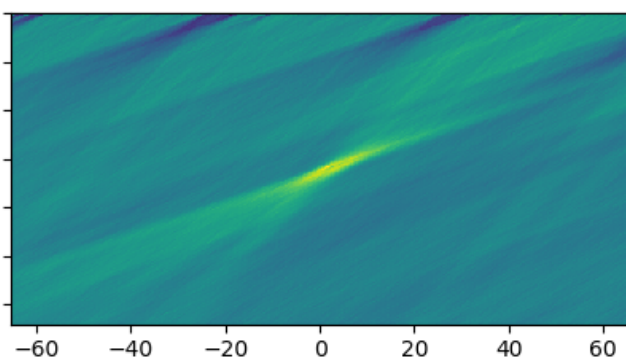
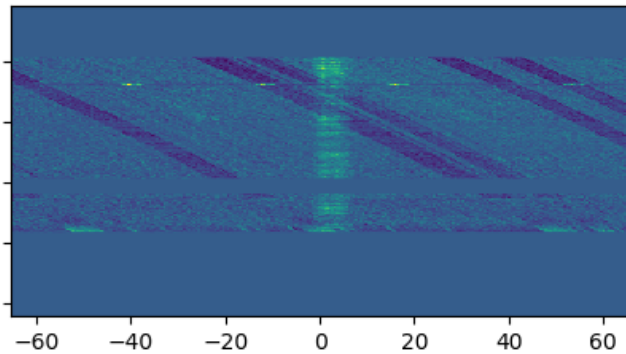
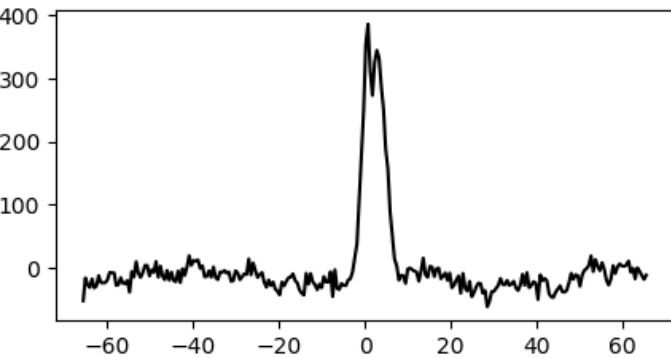


Manual
inspection

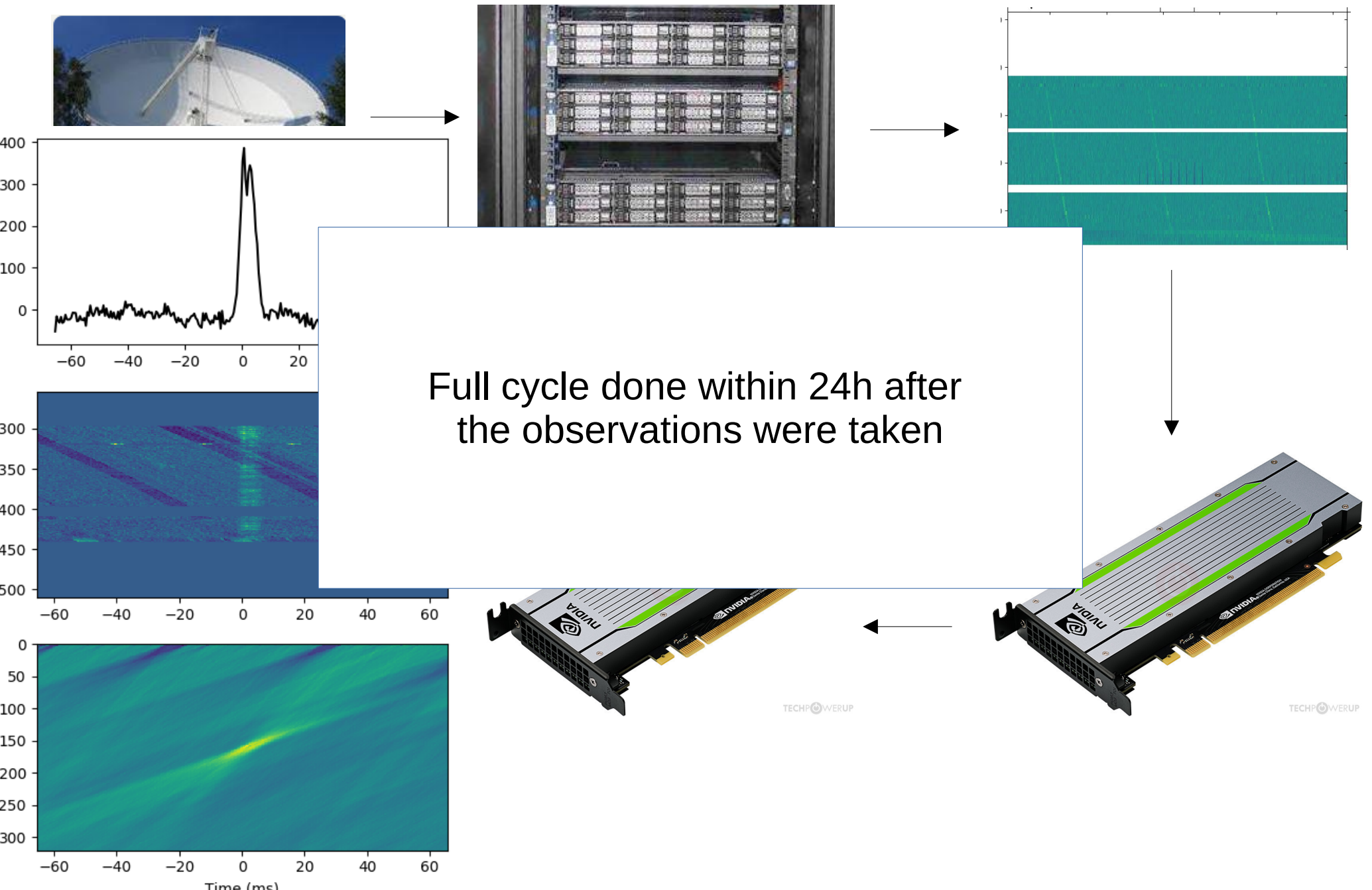


TECHPOWERUP

TECHPOWERUP



PRECISE – burst finding in a nutshell



PRECISE – burst finding in (some) detail

Conversion to filterbank

- Done with
 - jive5ab: splitting VDIF files into one file per subband (both polarisations)
 - digifil: detection and conversion to filterbank (part of dspsr)
 - splice: stitching filterbanks per IF back together into one file

Dedispersion and burst searching

- Done by Heimdall
 - searches around known DM of the source (speed up processing)
 - applies different boxcar filter widths
 - Final output is a list of candidates with ToAs and DMs

Candidate classification

- Done by FETCH
 - machine learning classifier that was trained on simulated data
 - Based on probability calculation tells RFI from astrophysical candidates
 - “real” candidates are plotted and sent to a dedicated Slack channel

Manual inspection

- Done in Slack

PRECISE – Live demo burst finding!



PRECISE – delay mapping (if time permits)

- A priori, the exact position of the FRB-source within the observed field is not known.
- Imaging the entire FOV at mas-resolution is unfeasible – well, mostly just crazy inefficient
- Thus, the initial search for the FRB position is done via “delay mapping”.