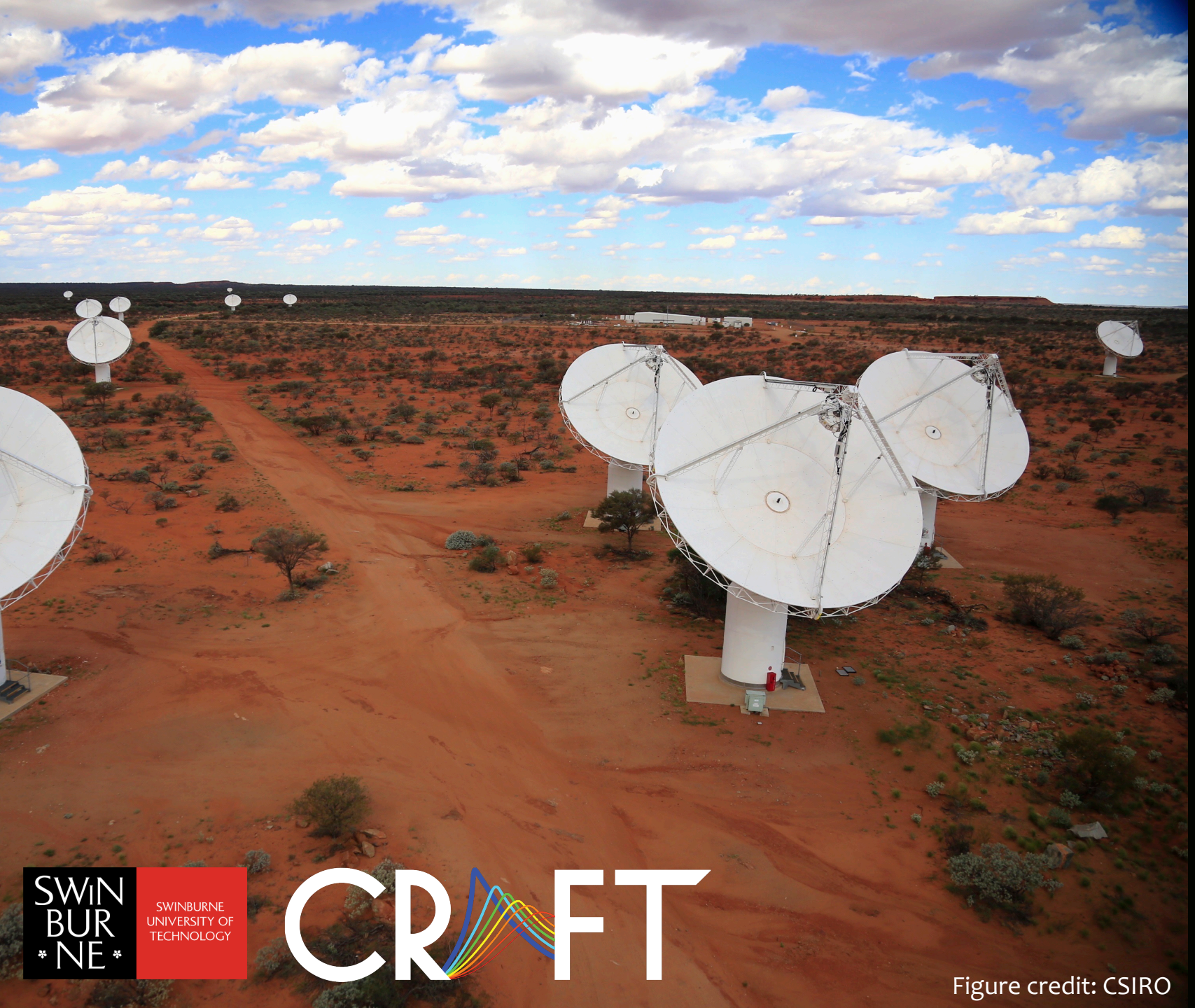


Figure credit: CSIRO

# A highly scattered FRB found with CRACO

Joscha Jahns-Schindler

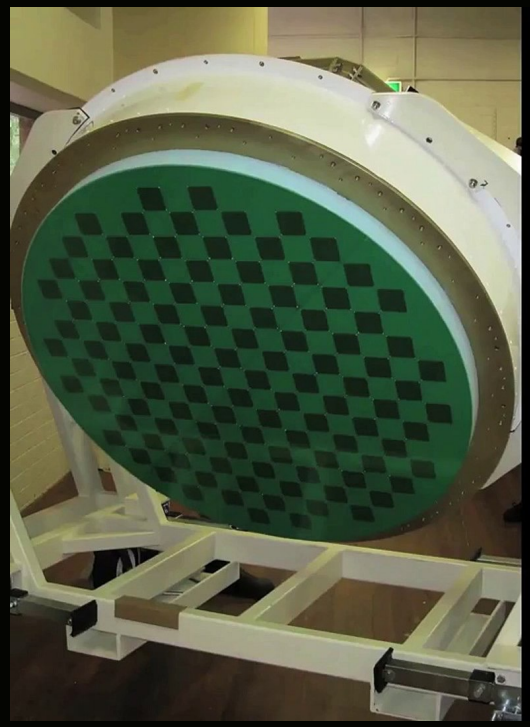
**Akhil Jaini**, **Alexa Gordon**, Adam Deller
Chris Flynn, Keith Bannister, **Lachlan Manoch**, **Pavan Uttarkar**, Ryan Shannon, Stuart Ryder, Vivek Gupta, Yuanming Wang, Ziteng Wang

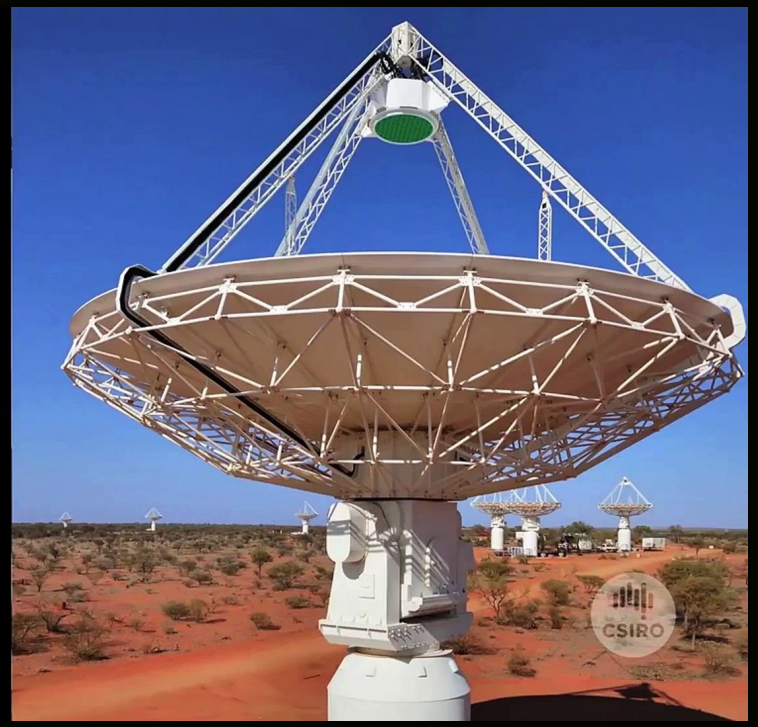
# Summary

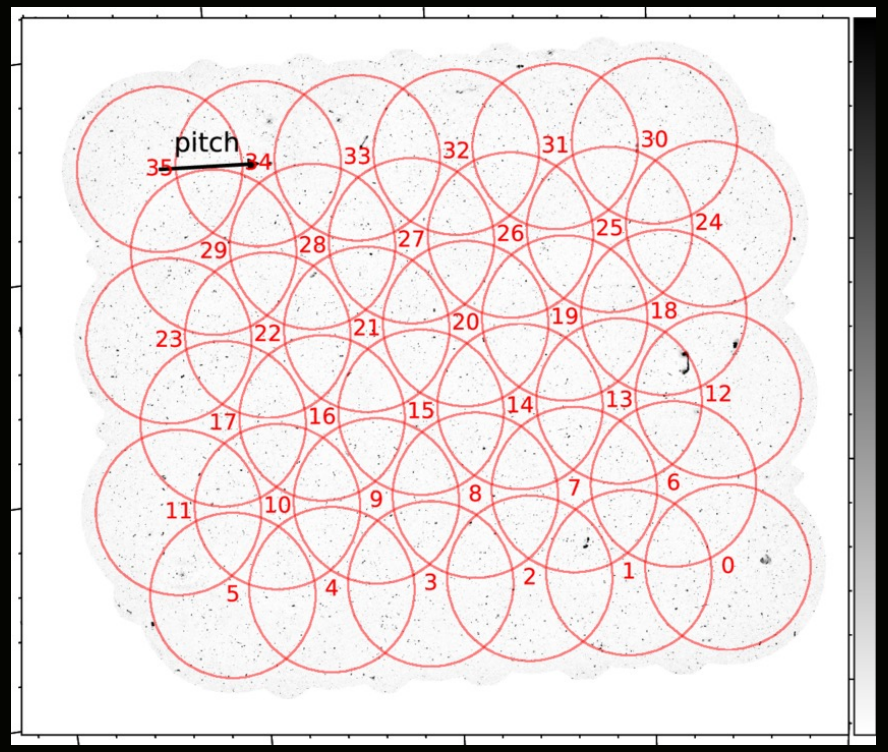
- New coherent search system is great at finding long/scattered FRBs
- A highly scattered FRB shows that high DM and scattering from the circumsource medium are possible
- It also shows the existence of a large population of nsFRBs

# ASKAP

188 Phased Array Feed (PAF) pixels → 36 beams per antenna






FoV = 31 deg²
SEFD = 300 Jy

Y. Wang et al. 2023

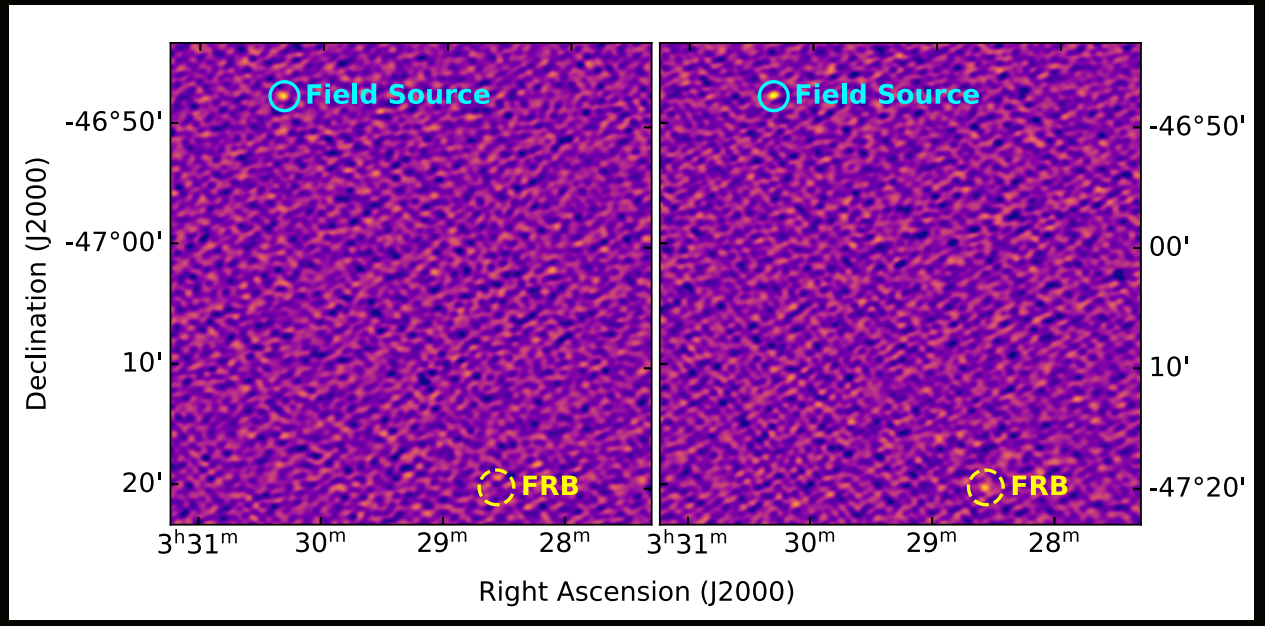
# ASKAP FRB Surveys

- Fly's eye survey (2017-2018)
  - 20 FRBs
  - Bannister et al. 2017: First detection with ASKAP
  - Shannon et al. 2018: FRB brightness distribution
- Incoherent sum survey
  - 43 FRBs
  - Bannister et al. 2019: First localization of a non-repeater
  - Macquart et al. 2020: Census of baryons
  - Shannon et al. 2024: CRAFT-ICS survey

Credit: CSIRO

# The CRAFT Coherent backend (CRACO)

- Image domain search
- 36 beams
- 280 DM trials
- 256x256 pixels
- 30 antennas (435 baselines)
- 13.8 ms resolution
  - 8 boxcars → up to 110 ms width
- 240 channels of 1 MHz
- Details in Z. Wang et al. 2025

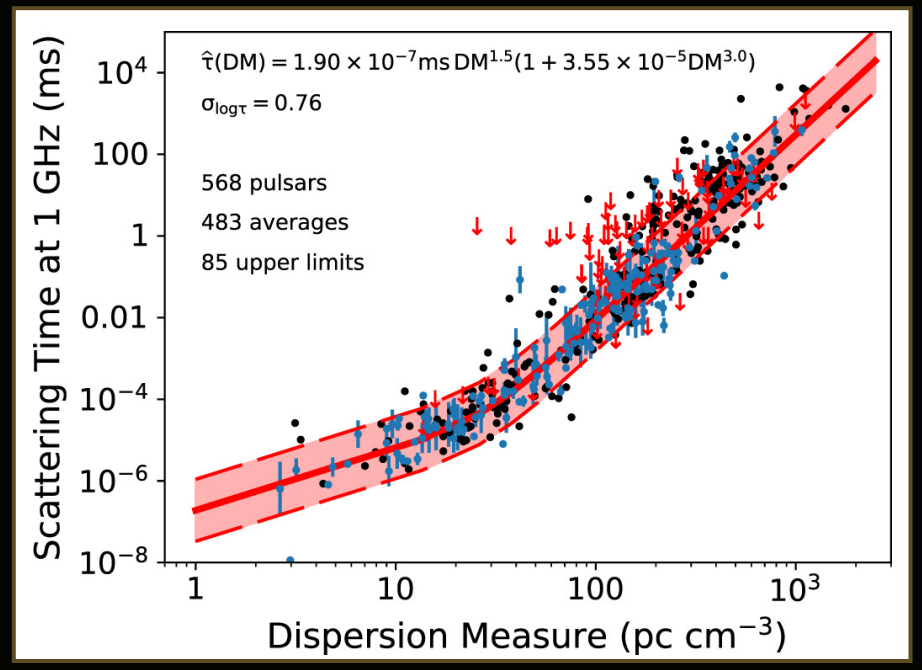


# CRACO early results

- Z. Wang et al. 2024, Nature: LPT with X-ray emission
- Y. Wang et al. 2024: 41 s pulsar
- Lee et al. 2025: LPT with interpulses
- James et al. 2025: Nanosecond pulse from a dead satellite
- Jaini et al. in prep: Order 10 new RRATs

# Scattering for FRB applications

- Scattering makes detections more difficult and causes biases
- Could constrain host DM (Cordes et al. 2022)
- Can constrain the turbulence in intervening halos (Prochaska et al. 2019, Mas-Ribas et al. 2024)




Cordes et al. 2022

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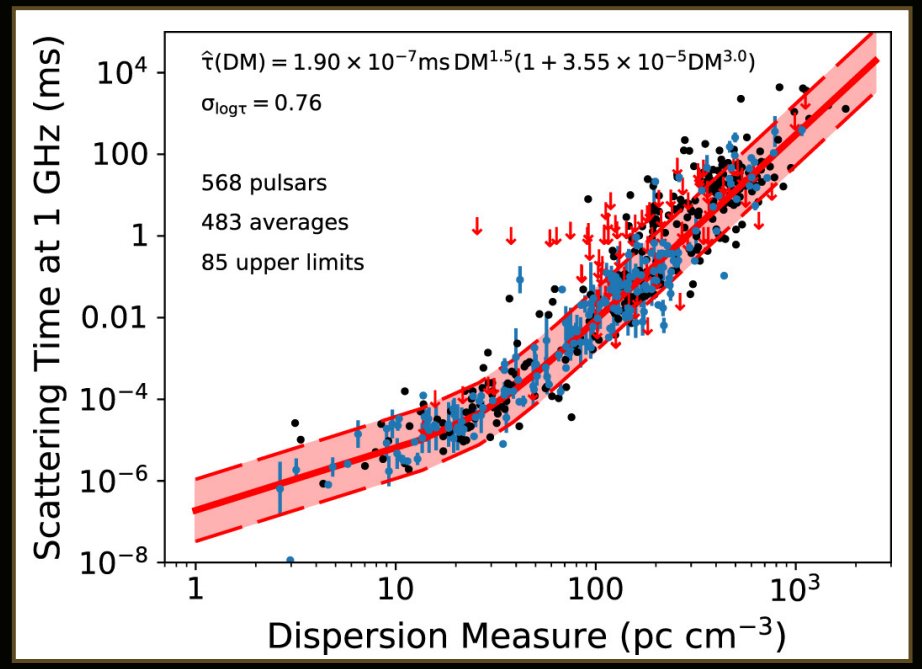
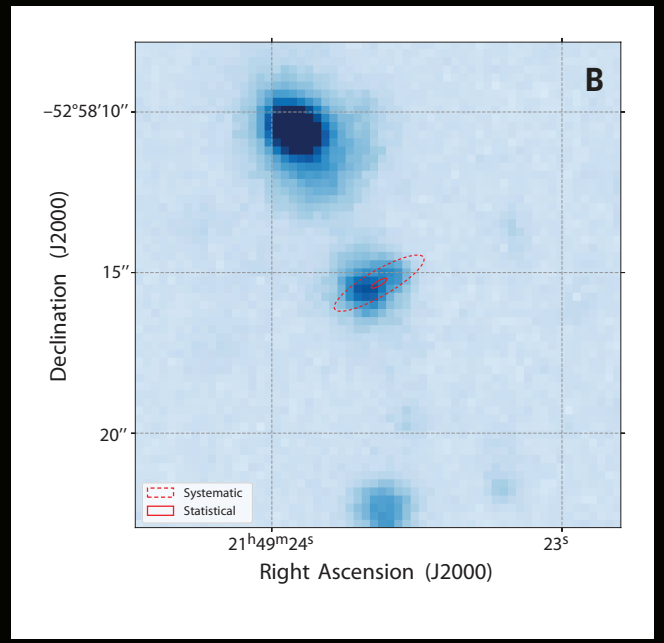



Prochaska et al. 2019

Cordes et al. 2022

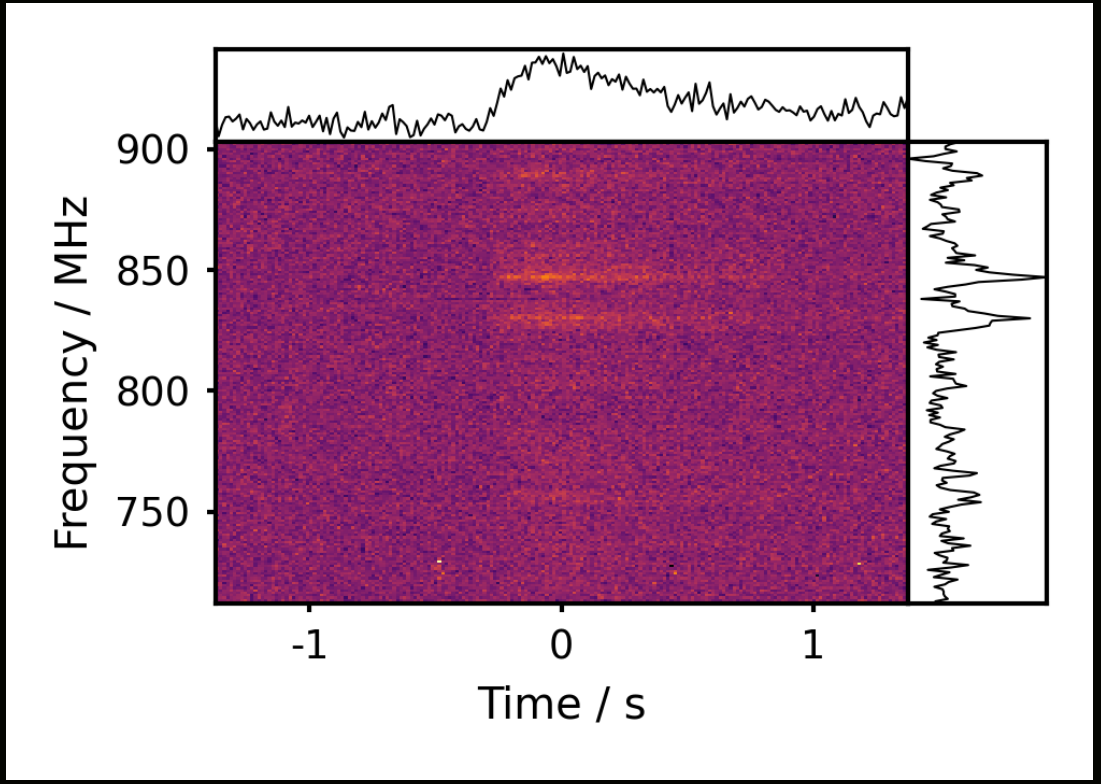


# FRB 240312

$$\mathrm{DM} = 334 \pm 4\,\mathrm{pc\ cm^{-3}}$$

$$\tau_{807\,\mathrm{MHz}} = 688 \pm 31\,\mathrm{ms}$$

$$\tau_{1\,\mathrm{GHz}} = 300 \pm 48\,\mathrm{ms}$$



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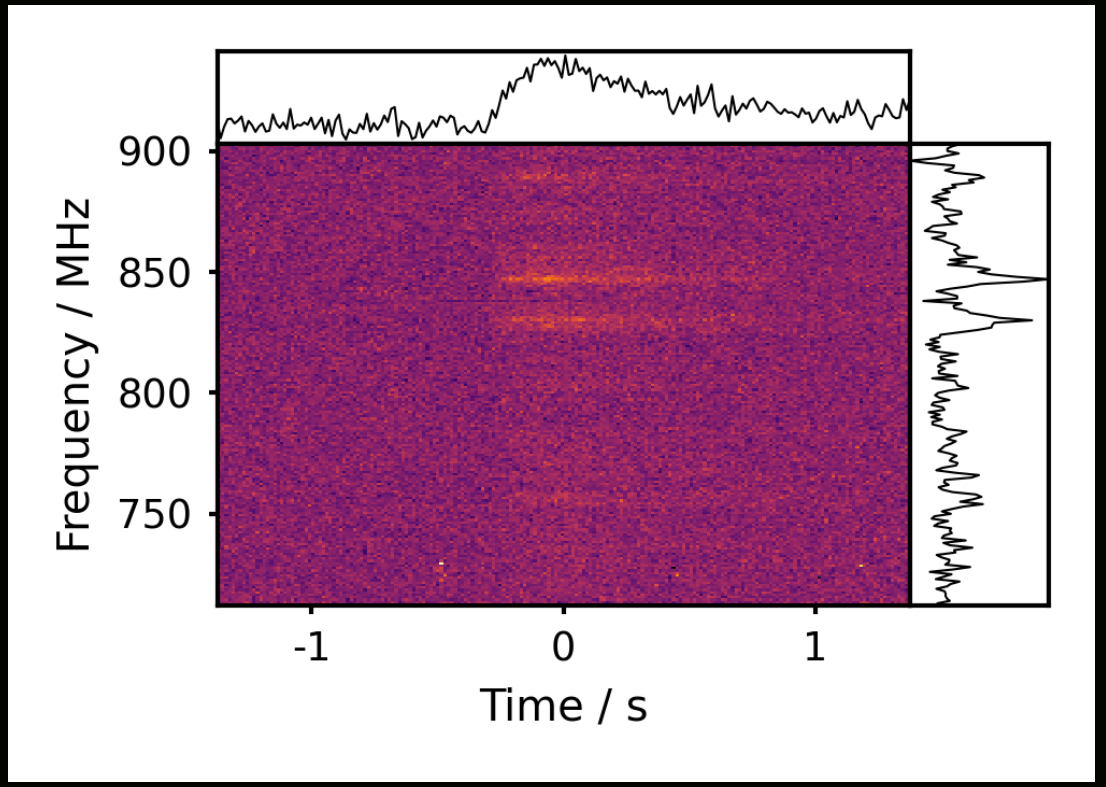
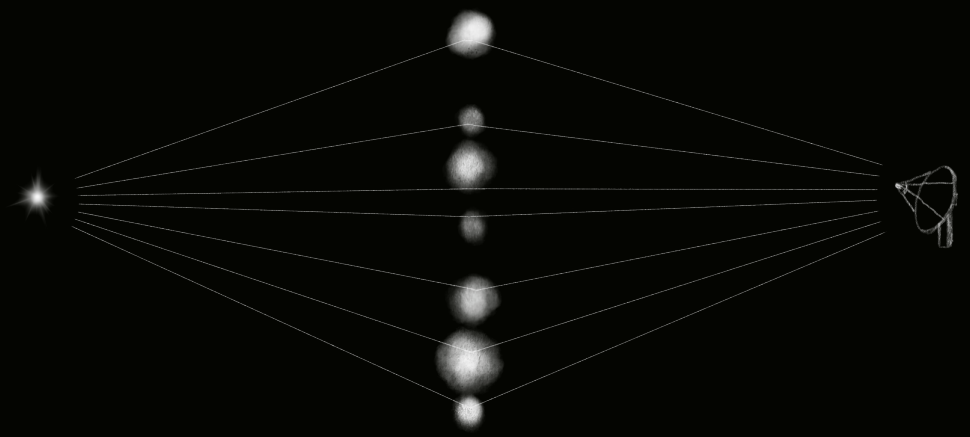



Consistent with MW scintillation

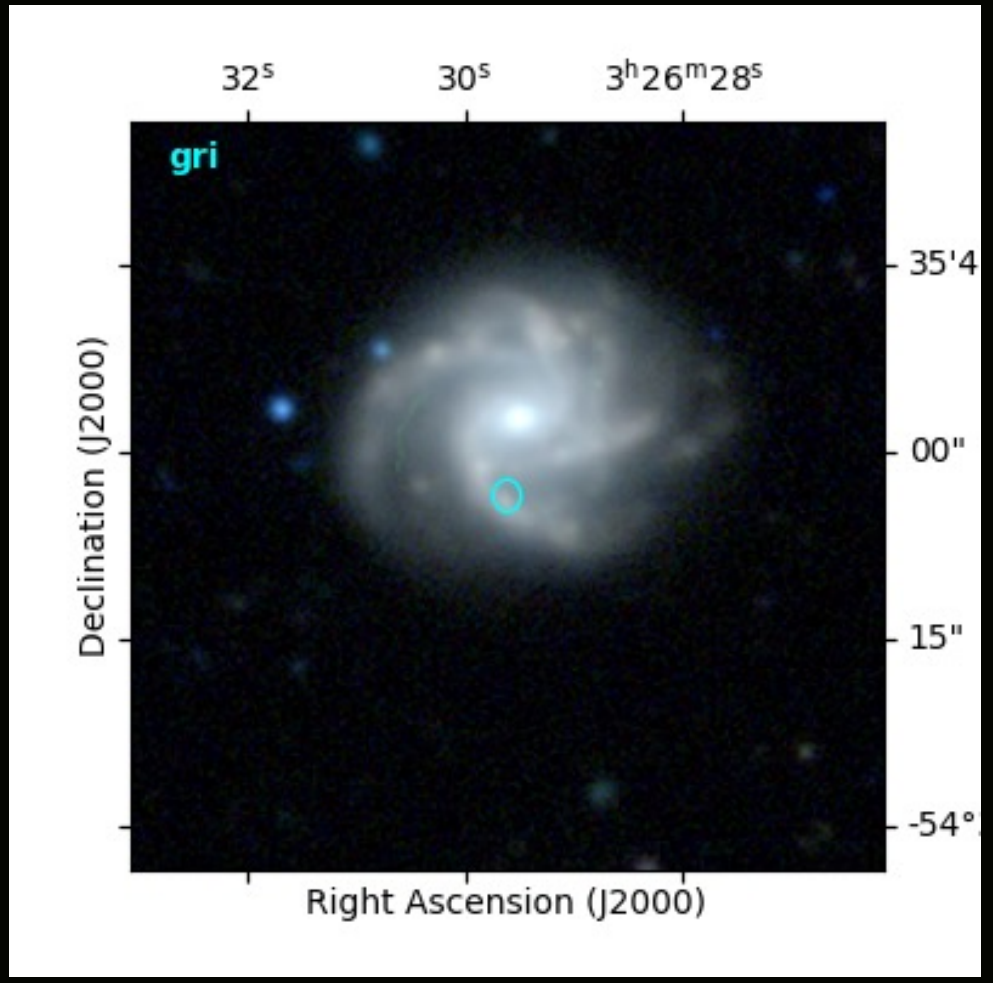
- Scattering much larger
- Scattered image appears as a point source to the MW screen
- $D_{\mathrm{host,source}} D_{\mathrm{MW}} \lesssim 0.008\,\mathrm{kpc}^2$



# Host galaxy

- Covered by DES
- $z = 0.04973(15)$
  $(D_L = 228.6 \pm 0.7\ \mathrm{Mpc}\ )$
- Redshifts obtained with SOAR

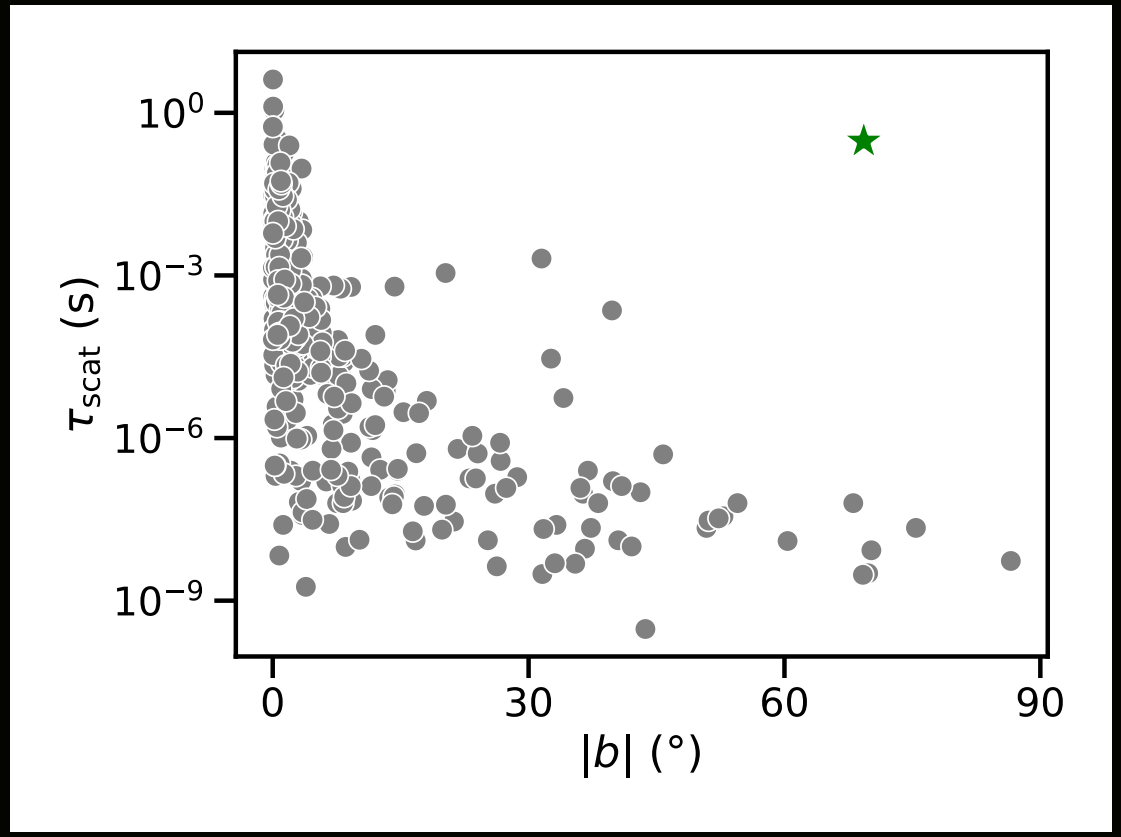
- MW-like spiral
- Inclination of $20.7 \pm 0.3\ \mathrm{deg}$
  - ➢ Almost face-on
- Significantly offset from centre

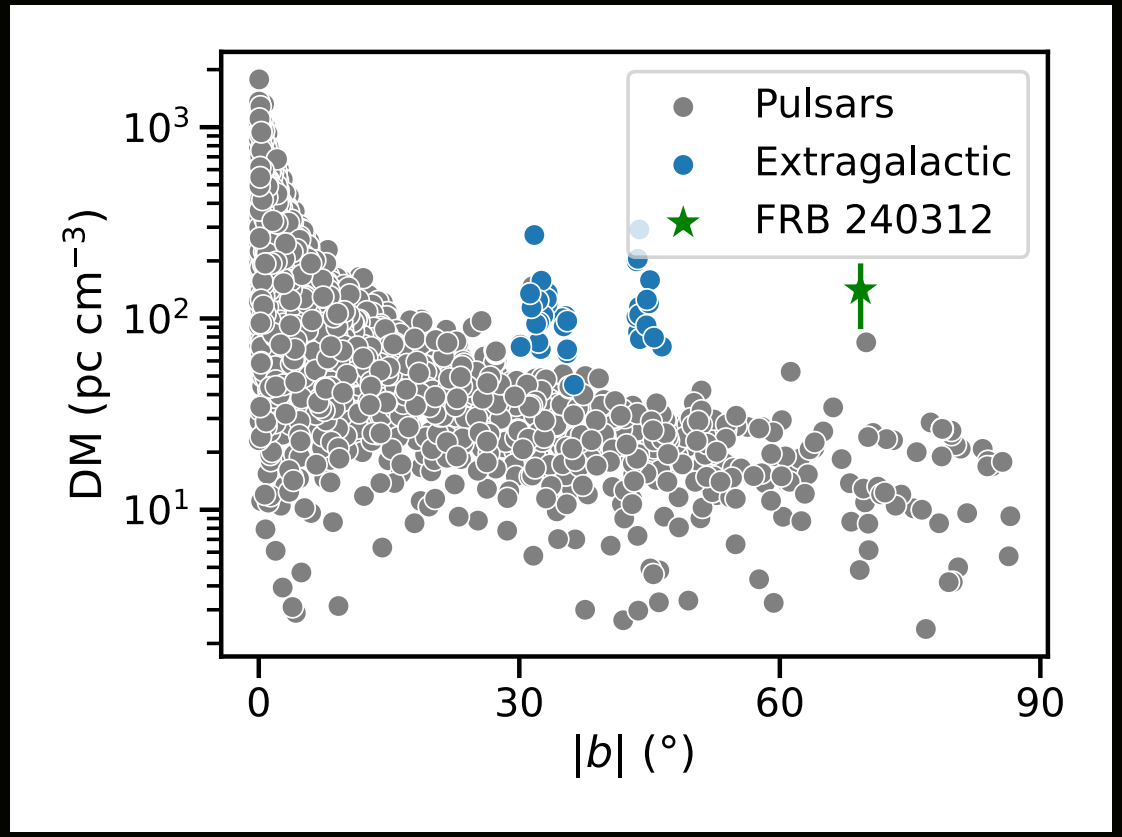


# Comparison to the Milky Way

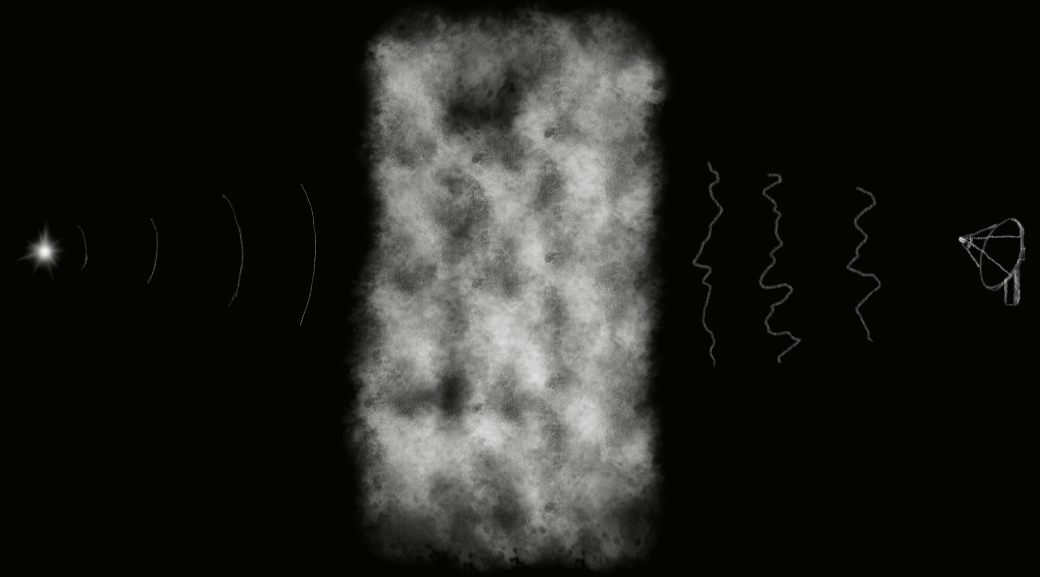
- Scattering and DM much higher than allowed by the host inclination

$$DM_{\mathrm{host,ISM}} = 141 \pm 53\,\mathrm{pc\,cm^{-3}}$$



# Scattering diffractive or refractive?





Sprenger et al. 2022

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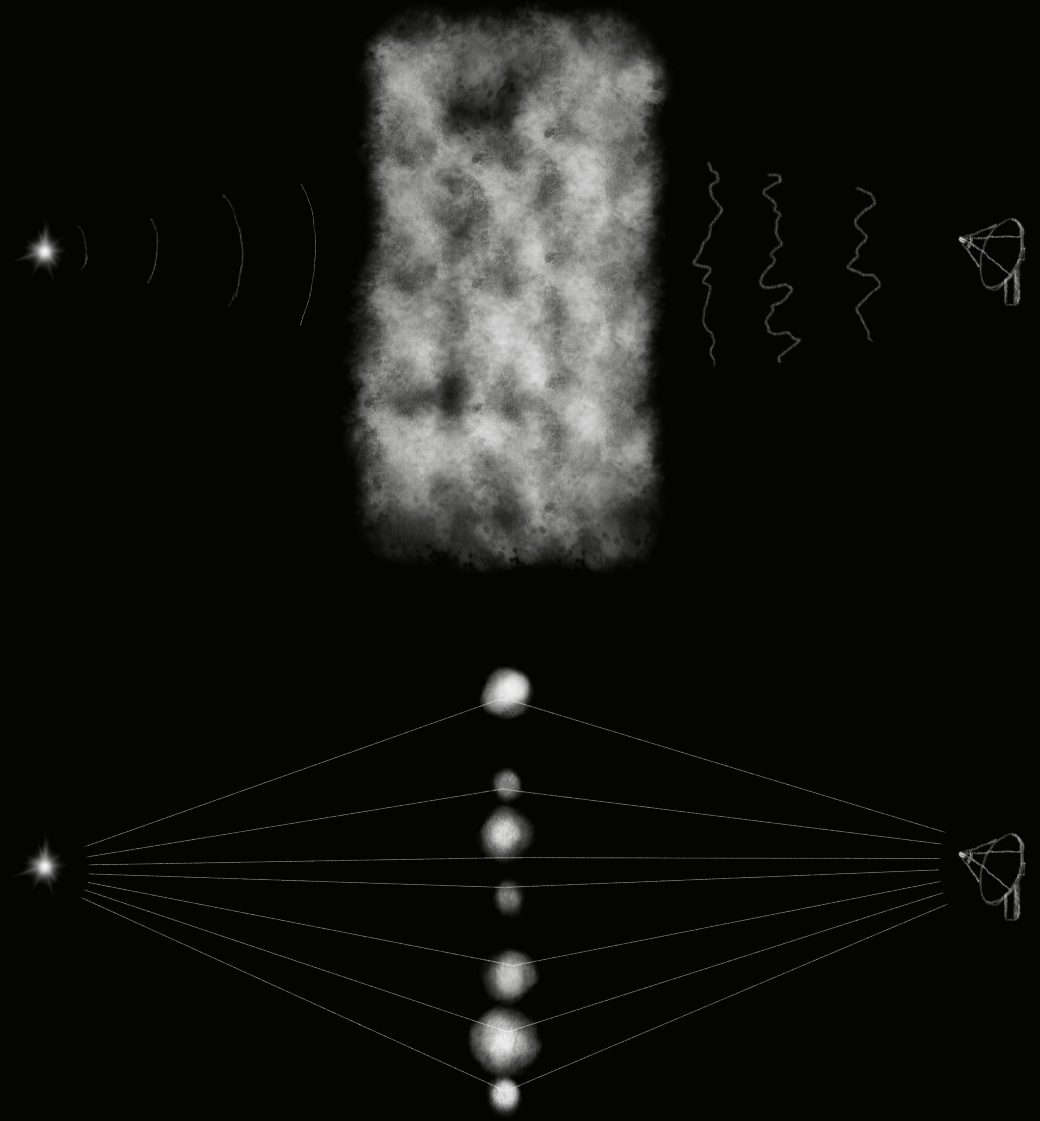



Sprenger et al. 2022

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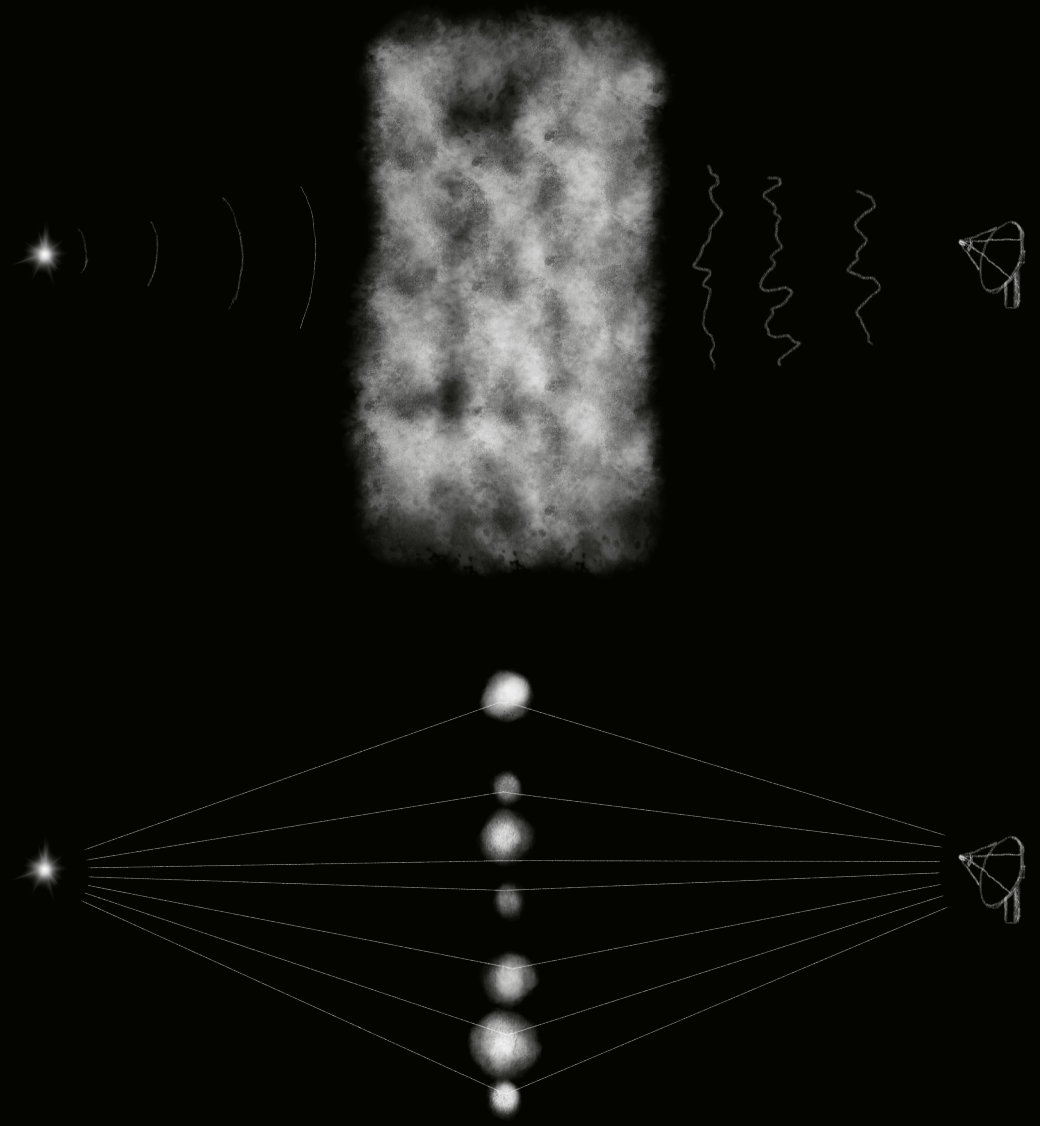

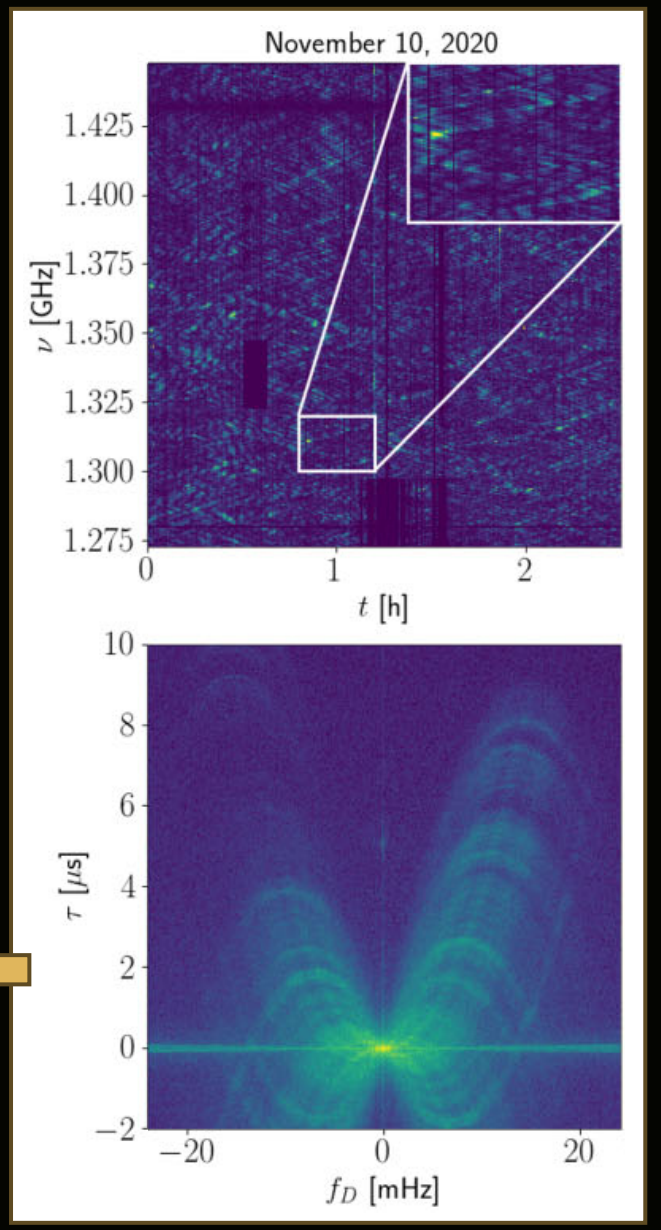


Sprenger et al. 2022

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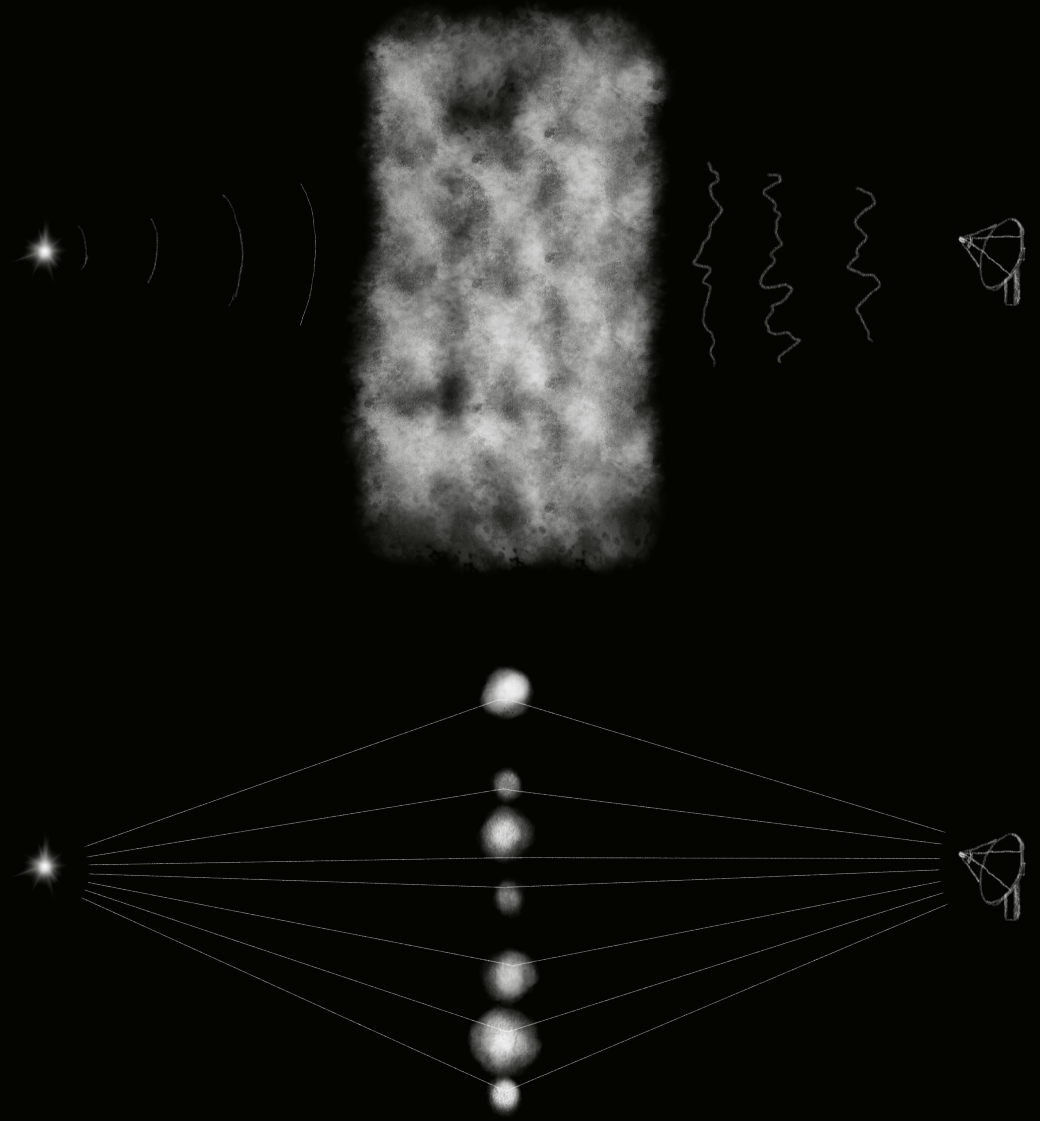


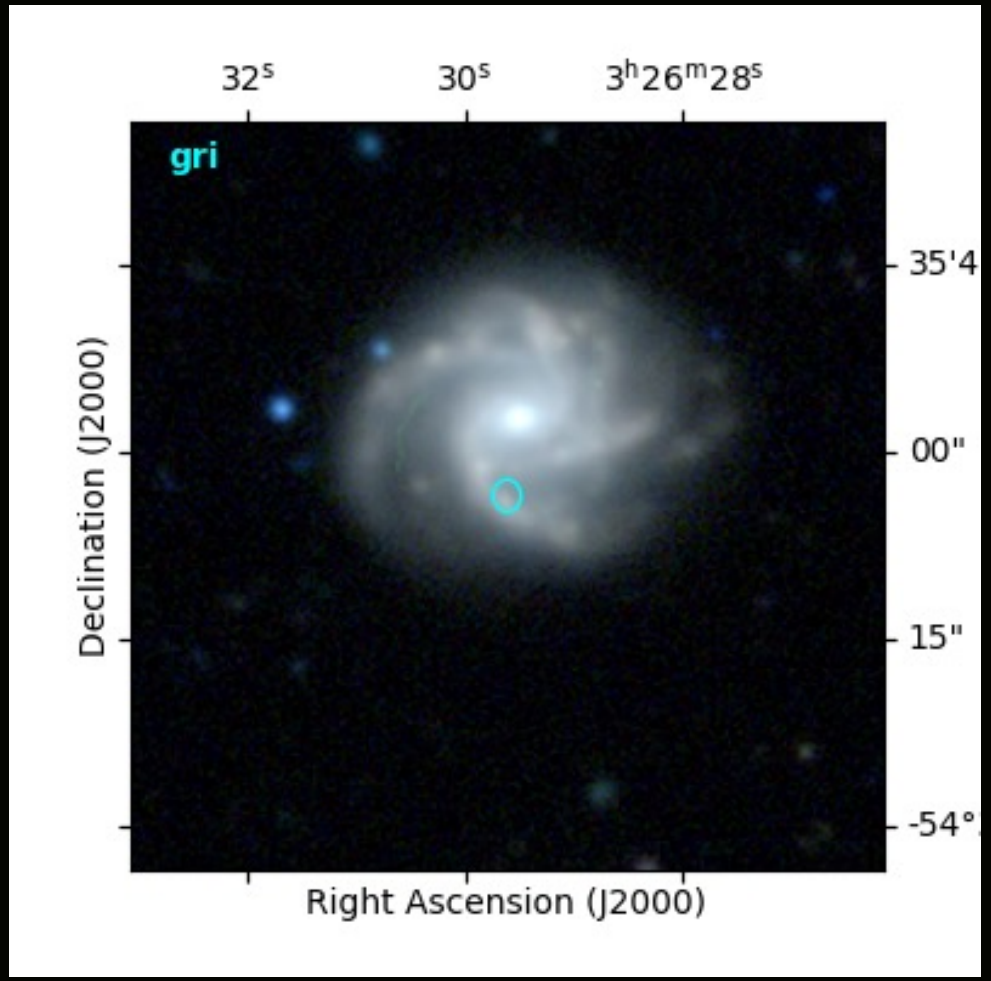
- $r_{\mathrm{diff}}$ = 500 m
- $r_{\mathrm{diff}}$ > Ion inertial scale implies $n > 2 \times 10^5\ \mathrm{cm}^{-3}$
- Combined with DM this yields e.g. a SN with age~0.7 yr

- Only gradient matters
- $\langle |\partial_x \mathrm{DM}| \rangle = 9\,\mathrm{pc\,cm^{-3}\,au} \left( \frac{D_{\mathrm{host,source}}}{1\,\mathrm{pc}} \right)^{-1/2}$

# Possible Sources

Dense ionized medium with large variations

- Supernova remnant
- HII region
- Offset BH

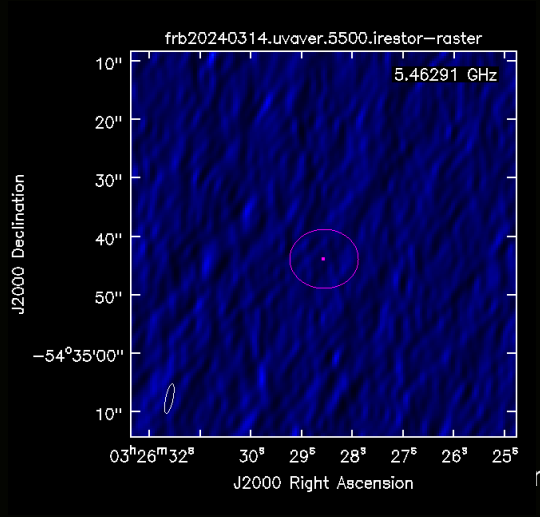


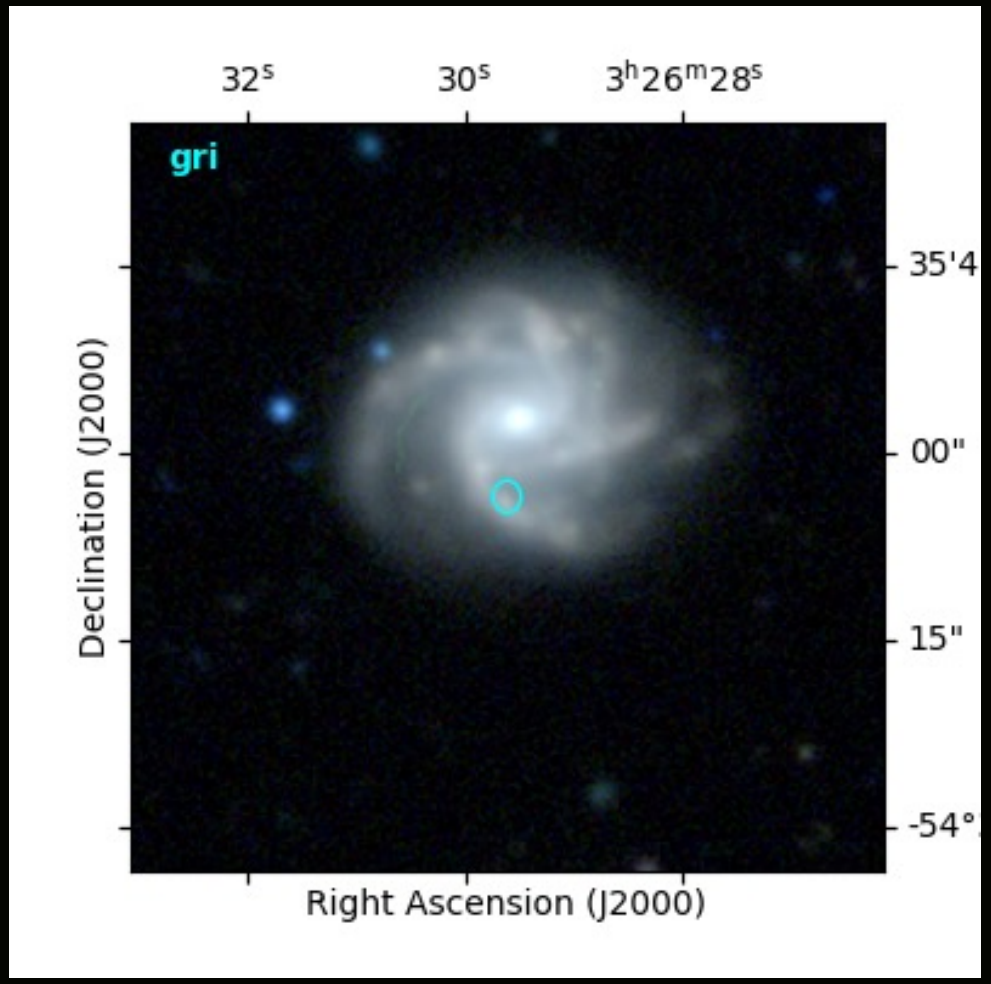
# Possible Sources

Dense ionized medium with large variations

- Supernova remnant
- ~~HII region~~
- Offset BH
- PRS like (younger version of FRB 121102?)
- < 1/70 x PRS of FRB 121102
- < 1/120 x PRS  of FRB 190520B

$L < 2.6\times10^{27}\ \mathrm{erg\,Hz^{-1}\,s^{-1}}$



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