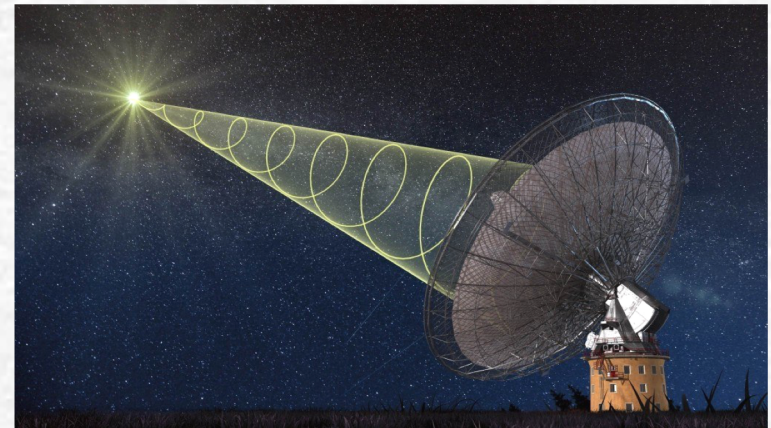


One (of many?) culprits ...

3

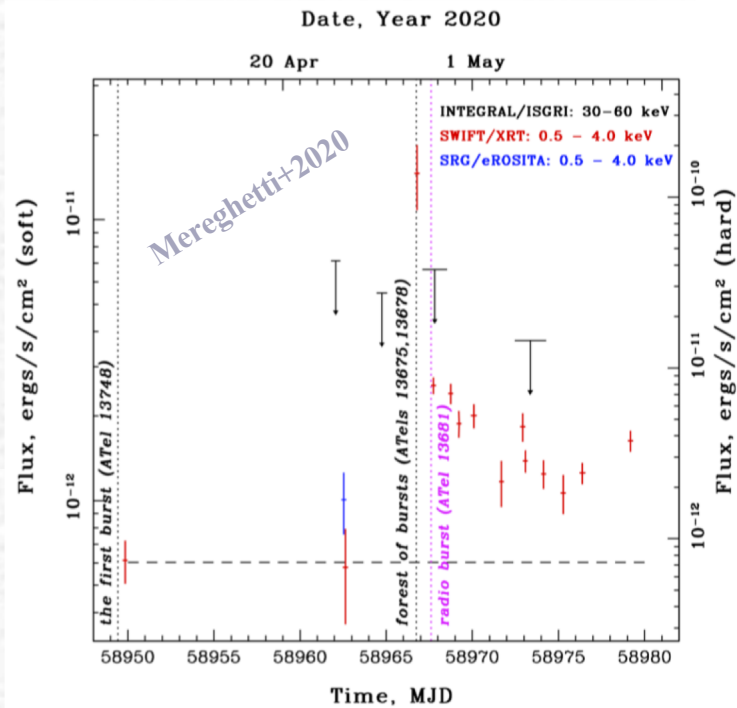
A magnetar-FRB link ?



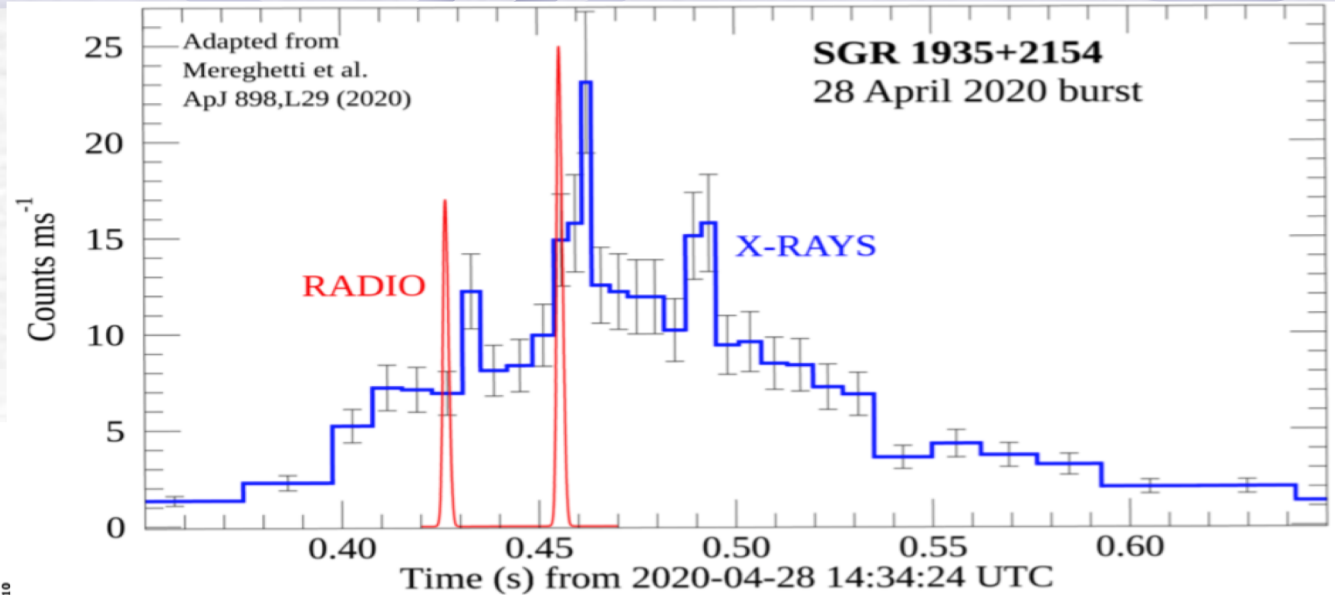
The Galactic FRB from a known “magnetar”

The first example:
SGR1935+2154

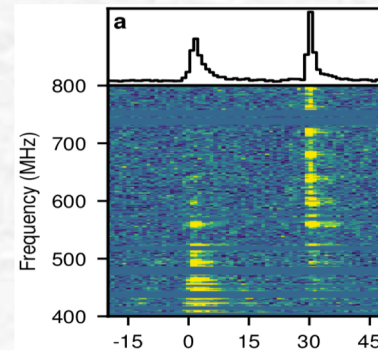
Simultaneous X-ray and
radio bursts: first light on
the nature of FRBs ?



X-ray intense activity towards the
end of Apr 2020

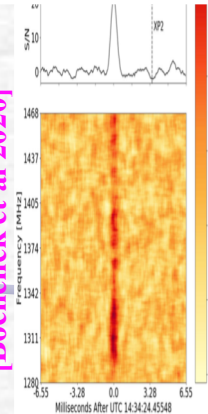


[CHIME/FRB+2020]



CHIME detections in
far side lobes with a
combined fluence of
 ≈ 0.7 MJy ms at 400–
800 MHz band

[Bochenek et al 2020]



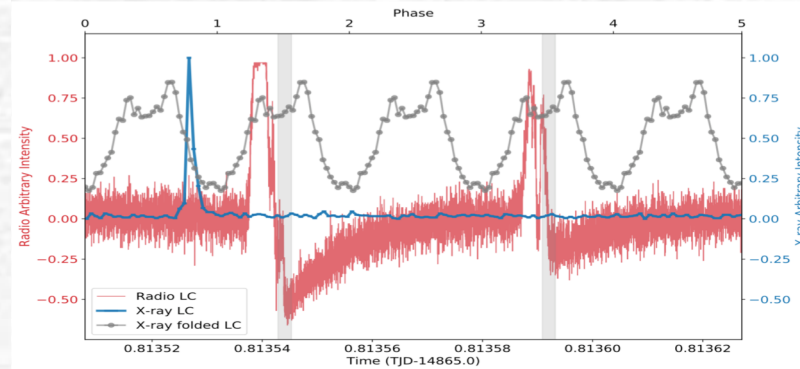
STARE2 detections
with a fluence of
 ≈ 1.5 MJy ms at
1281–1468 MHz

A big boost for the magnetar-based models !

Some other suspicious hints ...

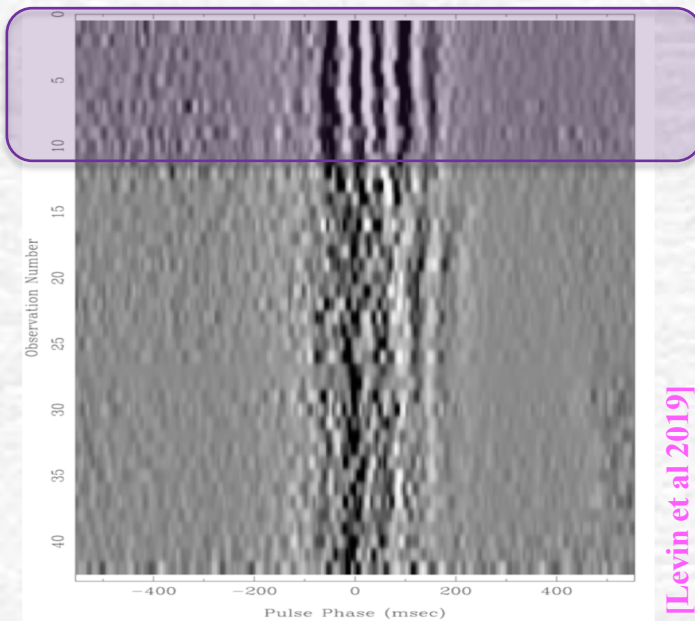
magnetar 1E
J1547-5408

Seen 2 strong radio bursts with a luminosity about 600 times smaller than that of the most powerful ones seen in SGR J1935+2154, the strongest of the two following of ≈ 1 sec a bright X-ray burst



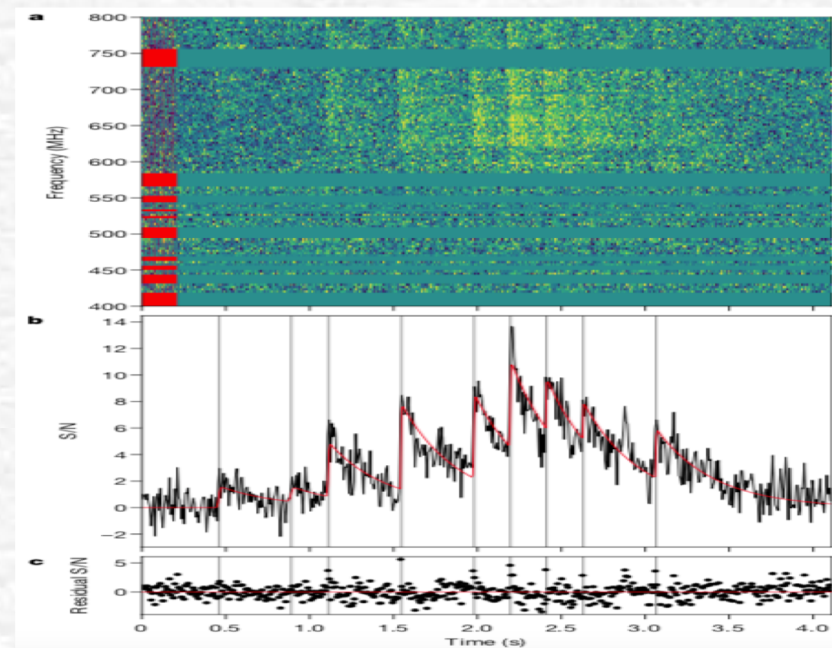
[Israel et al 2020]

magnetar XTE J1810-197



[Levin et al 2019]

≈ 50 ms periodicity in the main pulse during early days after the onset of the X-ray outburst



[Michilli et al 2022]

a ≈ 3 s long burst with 9 components associated to a ≈ 217 ms periodicity

FRB 20191221A

... commonalities/comparisons rFRBs-magnetars

Radio Magnetars single pulses

Often band-limited spectrum
Visible at high frequency ($\lesssim 350$ GHz)
Variable spectral index
Variable pulse profile
Spiky pulse substructure
Variable flux density
No downward drifts in frequency
High % of linear polarization
Often flat PA swing
Some correlation with X-ray

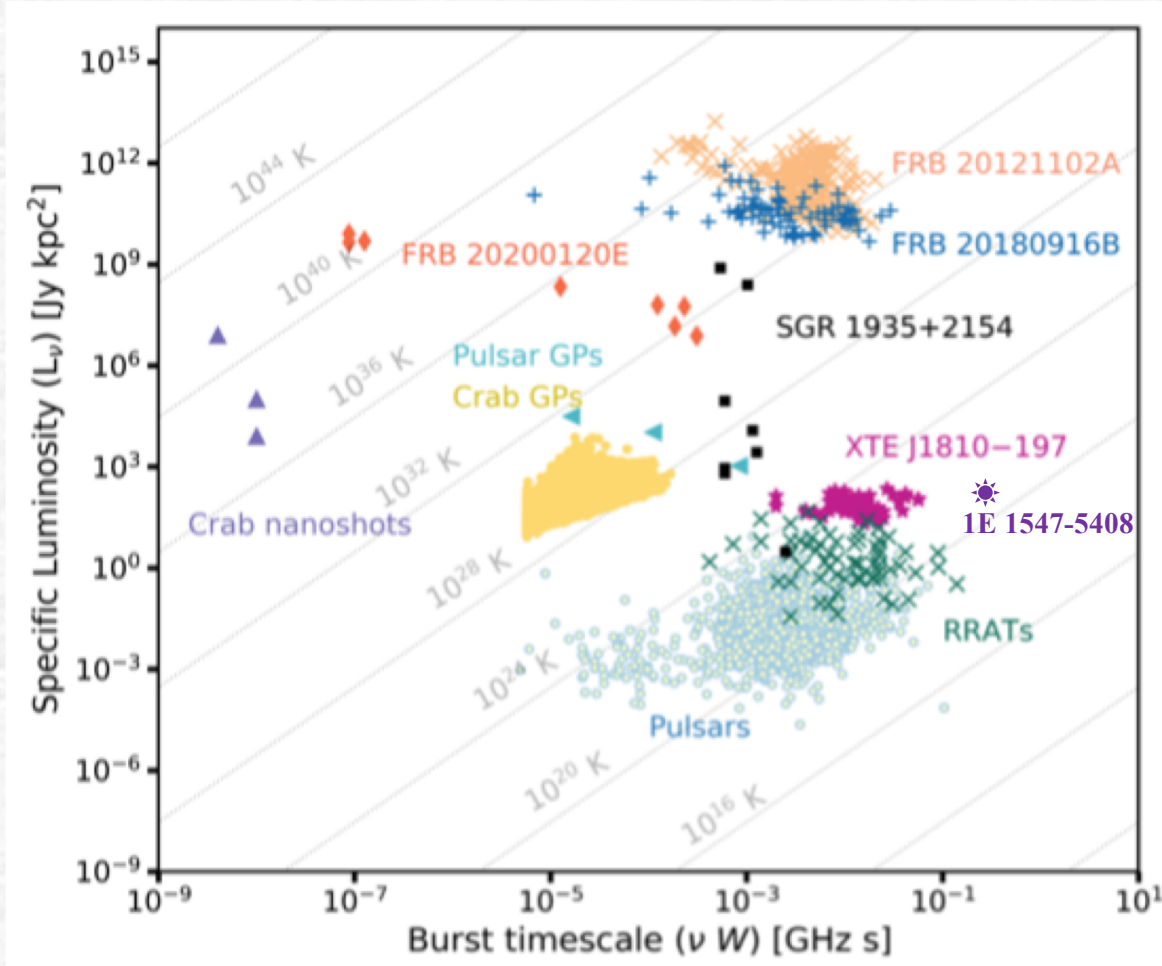
Repeating FRBs

Always band-limited spectrum
Not seen at high freq ($\gtrsim 10$ GHz)
Variable spectral index
Variable pulse profile
Spiky pulse substructure
Variable flux density
Sad-trombone structure
High % of linear polarization
Often flat PA swing
Some correlation with X-ray

The phenomenology is rich in exceptions ...

A pulsar - magnetar - rFRB connection?

Adapted from [Caleb & Keane 2021]



Energy reservoirs:

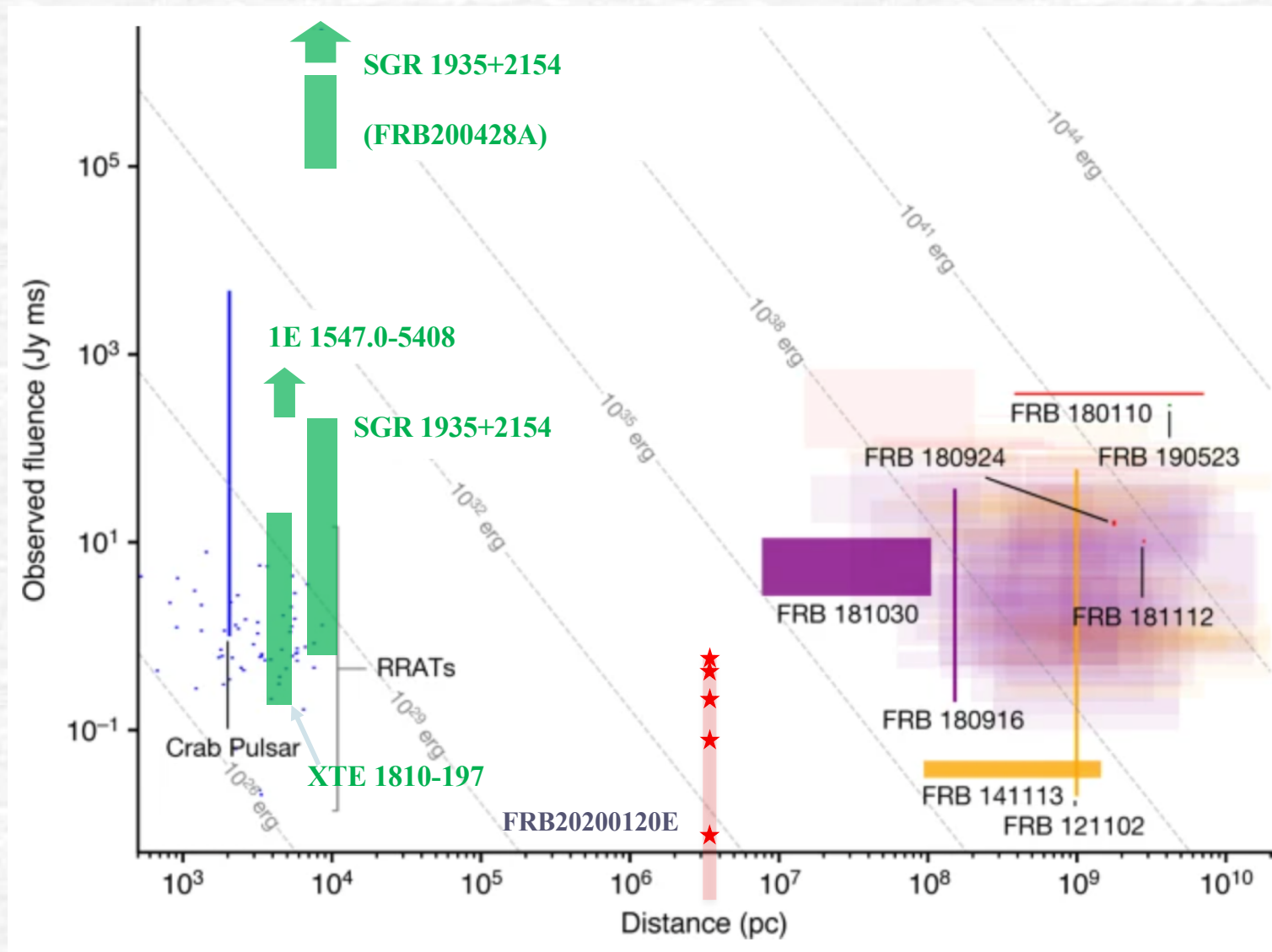
- magnetic energy
- rotational energy

A strong suggestion for the common energy reservoirs expressing at different levels under different conditions and thus providing an enormous range of manifestations in Brightness Temperature

$$10^{15} \lesssim T_B \lesssim 10^{43} \text{ K}$$

A pulsar - magnetar - rFRB connection?

Adapted from [CHIME/FRB 2020]

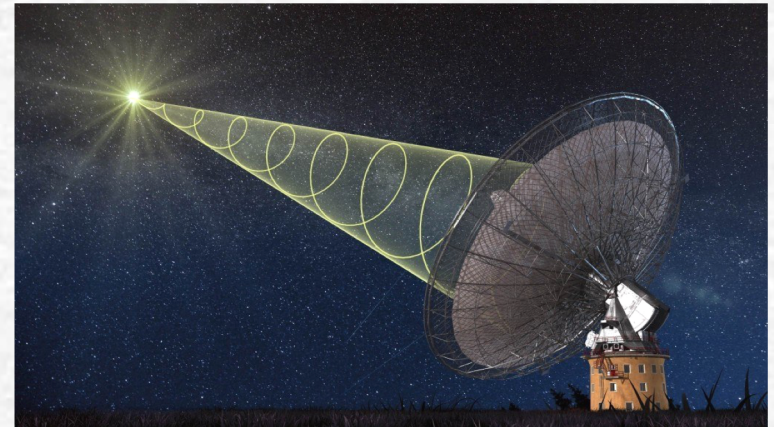


Also continuity in radio burst Energetics from 10^{43} erg to 10^{26} erg

Some major mysteries ...

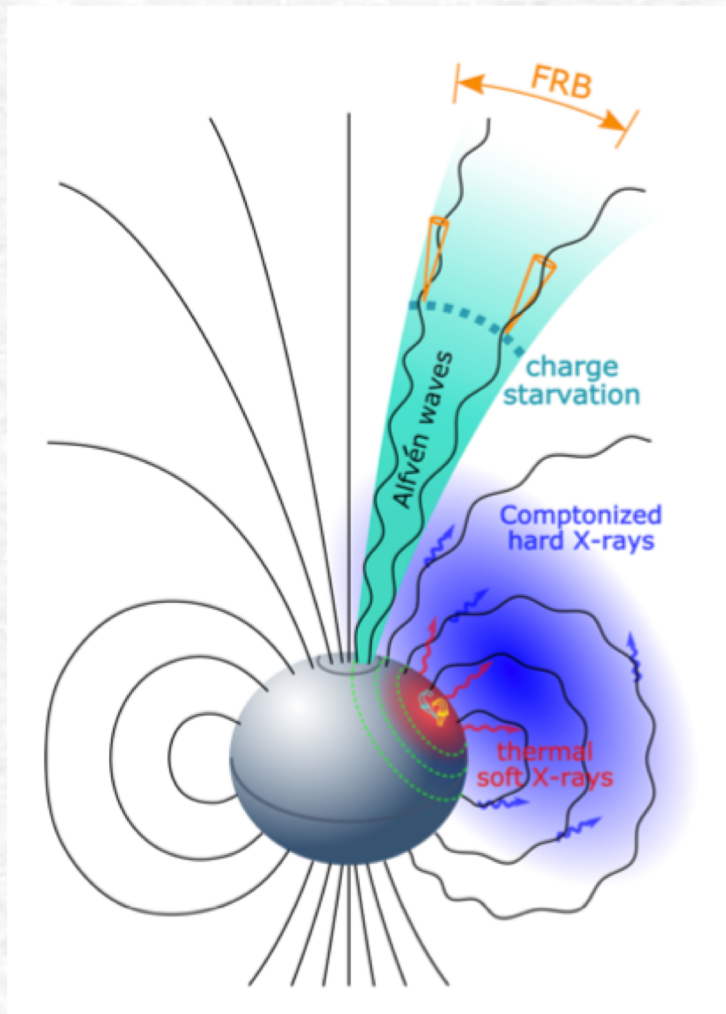
④

Which emission process(es) ?



Magnetar framework: emission processes

[credit Wenbin Lu 2020]



magnetospheric emission

(aka pulsar-like models)

[Lu, Kumar & Zhang 2020]

[Lyutikov 2020]

[Popov & Postnov 2010]

via magnetic pulses triggering magnetic reconnection

[Lyutikov 2020] [Mahlmann et al 2022]

via curvature radiation by bunches of charges

[Ghisellini & Locatelli 2017]

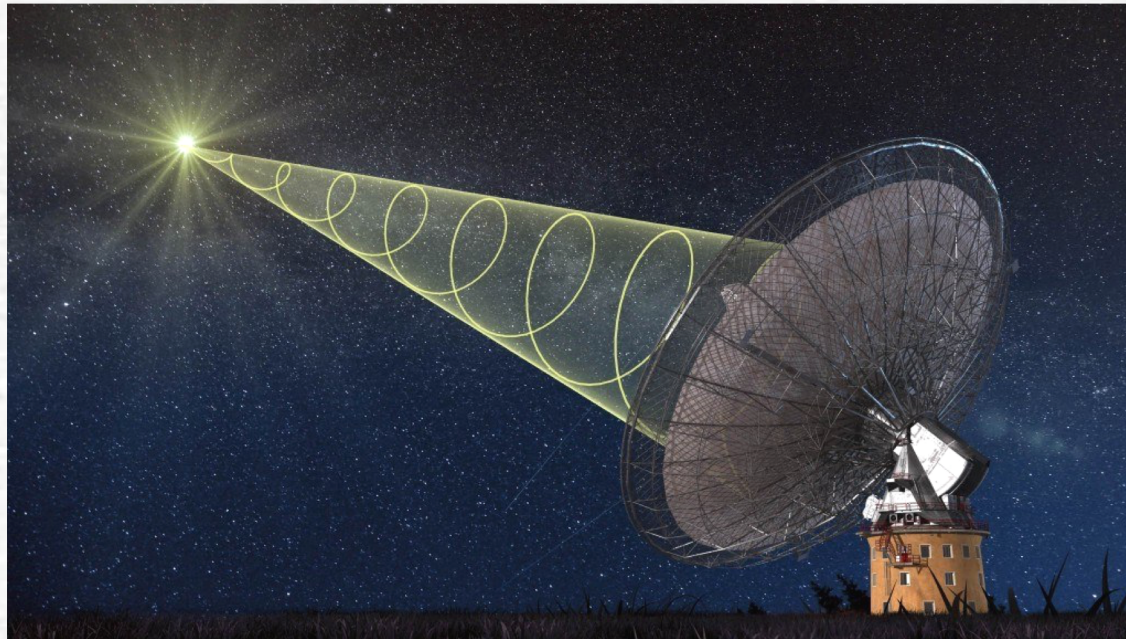
[Kumar, Lu & Bhattacharya 2018]

via magnetic twist, i.e. pair cascades created by dislocations and oscillations of the magnetic field at the neutron star surface

[e.g. Wadiasingh & Timokhin 2019]

Very promising in view of rapid variations and short time scale events seen in several FRBs

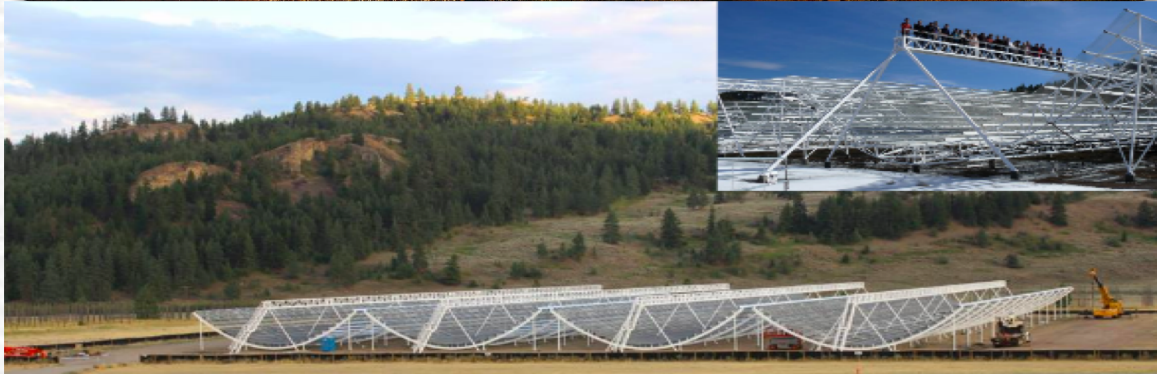
Major running experimental investigations and perspectives



Major running experimental investigations ...



ASKAP: 1400 MHz, in “fly’s-eye” mode, 12 dishes x 30 sq deg
FoV = 360 sq deg



CHIME: 400-800 MHz, 4 x
20m x 100m cylindrical
antennae $\approx$ 180 sq deg FOV

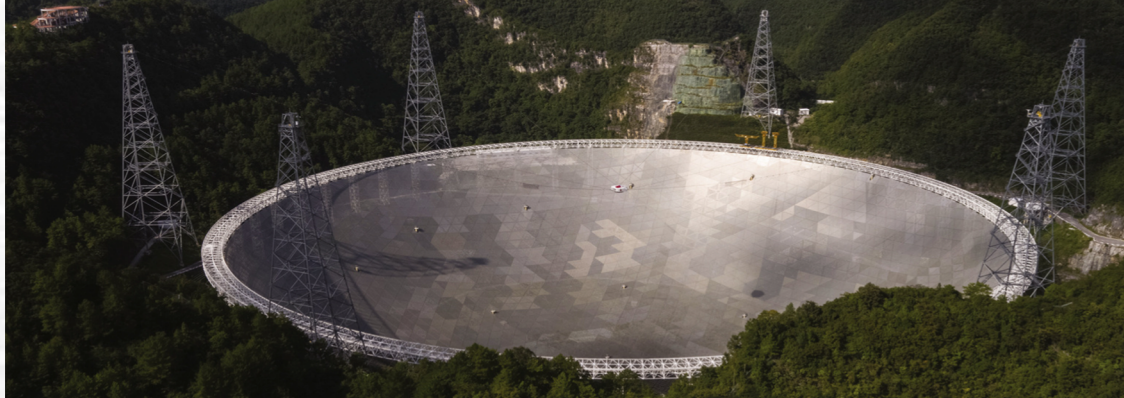


MEERKAT: 800 or 1400 MHz,
piggybacking most of the regular
observation with MeerTRAP

other major running experimental investigations ...



WSRT-APERTIF: 1400 MHz, with PAF technology, 40 beams, and FoV of 6-10 deg²



FAST: 1400 MHz, 19 beams, the highest instantaneous sensitivity available to date



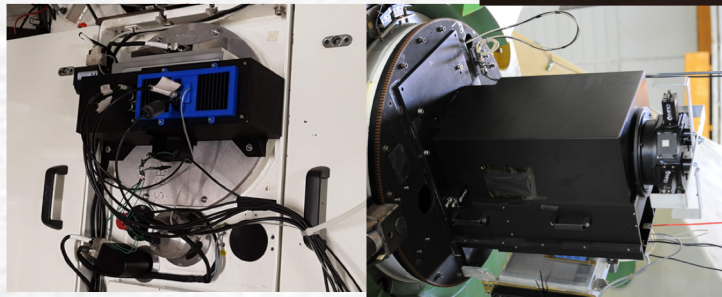
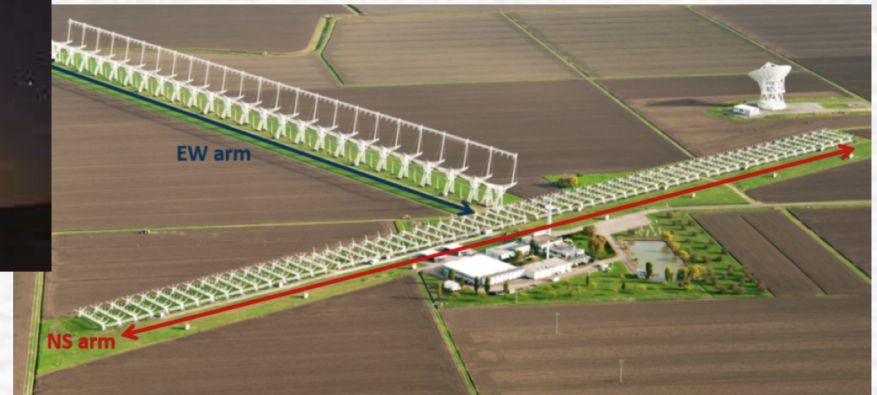
LOFAR: 110-190 MHz, with capability to look at a large fraction of the entire sky

other major running investigations (by Italian teams)

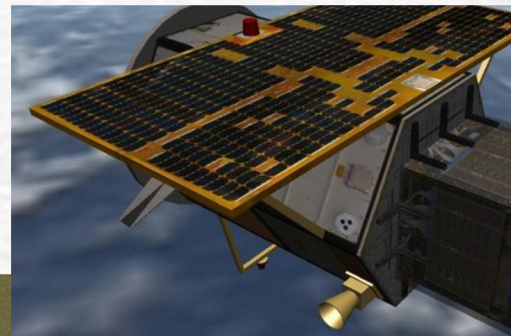
SRT: 300 MHz, 1.4 GHz,
6 GHz



Northern Cross: 408 MHz



SiFAP2@TBG, AQUEYE+@Copernicus:
ultrafast optical photometers



**AGILE, HXMT, and all
suite of X-ray and Y-ray
telescopes:** study of (upper
limits to) prompt and
afterglow emission



VLA, EVN: radio localization and host characterization

Large MWL campaigns organized: ~ 50 people involved

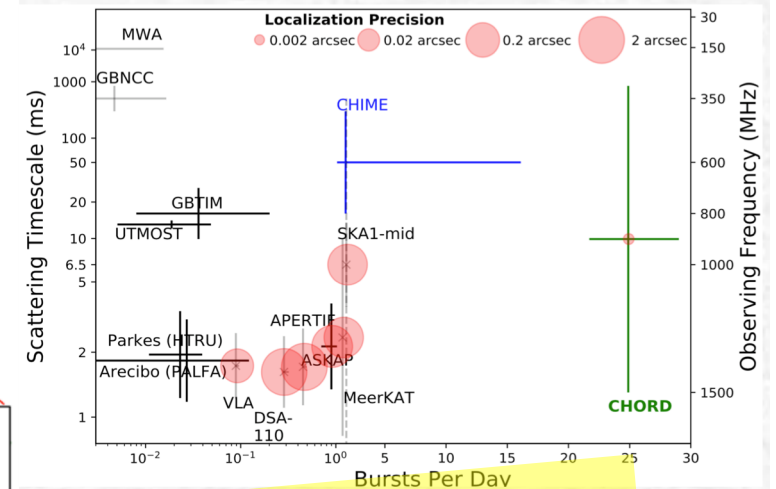
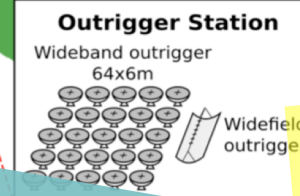
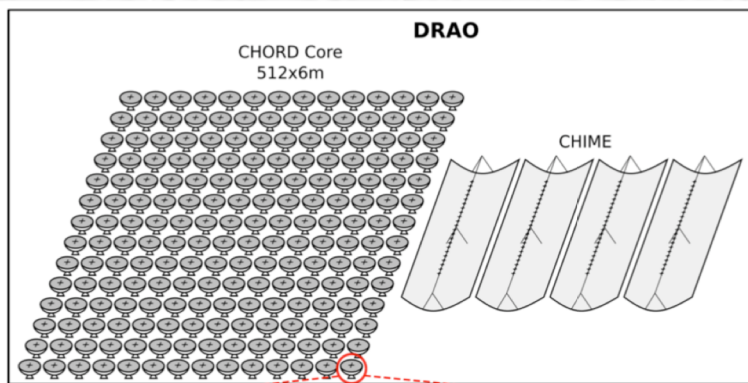
[e.g. Pilia et al 2020, Zampieri et al 2022, Trudu et al 2022 in prep]

Future experimental investigations ...

A blossom of experiments are entering the scene ... two most remarkable



DSA-2000: in Nevada, 2000×5-m dishes in the 0.7-2 GHz range and a FoV of about 10 deg²



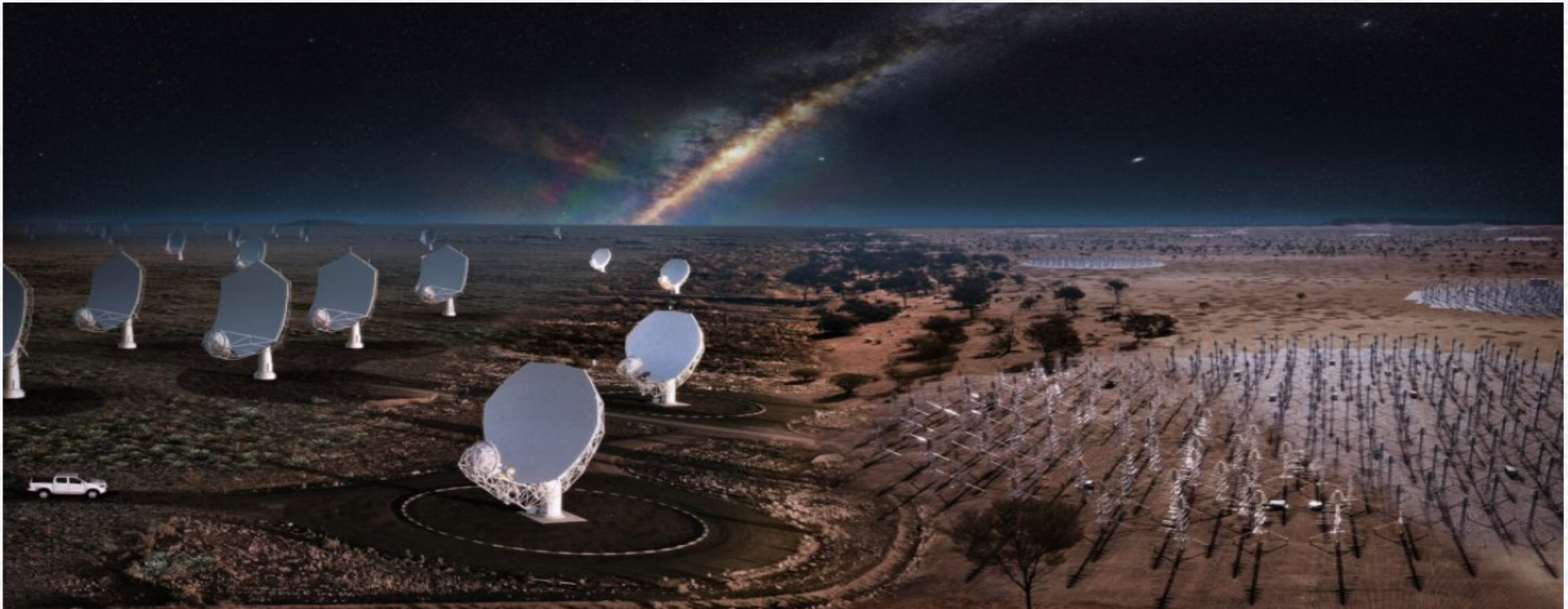
CHORD: Canada+outriggers,
3 M€ + 4 TD positions since 2023
512 beams on sky, 160×130 deg²

INAF 2nd member

PNRR funded: Great opportunity for all italian community !

Future experimental investigations ...

A blossom of experiments are entering the scene ... the longest term one



SKA mid: South Africa, 197×15 -m dishes in the 0.35-2 GHz, 1500 on sky beams

SKA low: West Australia, 131000 antennas, 0.05-0.35 GHz, 500 on sky beams

Thanks for the rediscovery of the **rLEBs** ...



repeating Long Eating Bursts