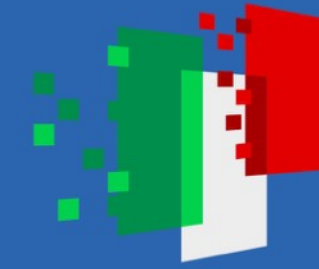




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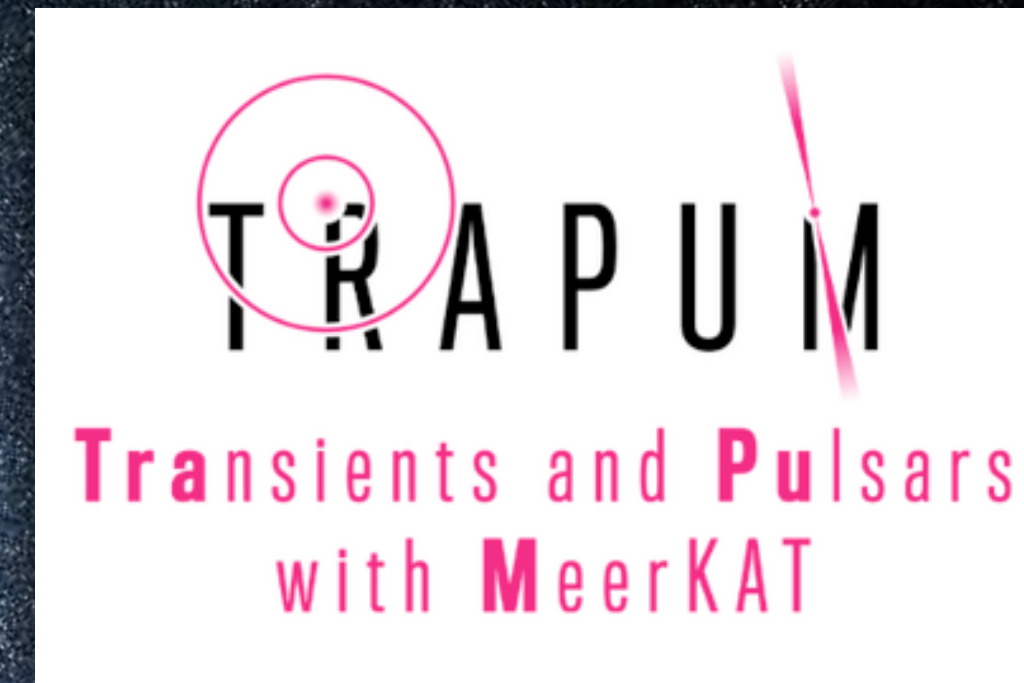
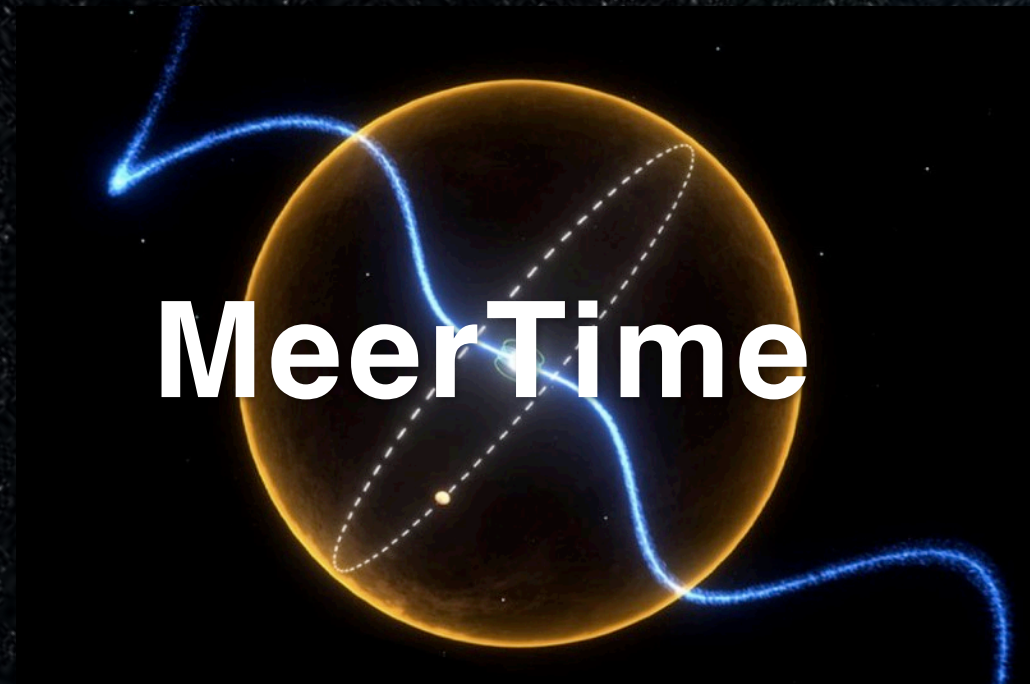
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Recent results of the Large Survey Projects on pulsars at MeerKAT

Federico Abbate

INAF - Osservatorio Astronomico di Cagliari
Max Planck Institut für Radioastronomie Bonn



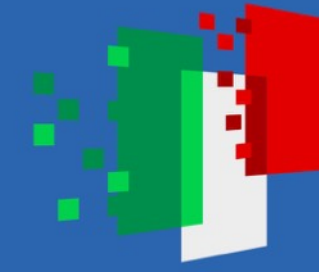
Max-Planck-Institut
für Radioastronomie



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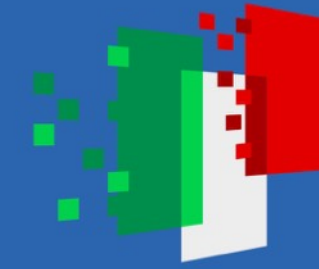
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Small Magellanic Cloud 7 new discoveries

Previously known
pulsars:
34

MeerKAT discoveries:
28

47 Tucanae
11 new discoveries

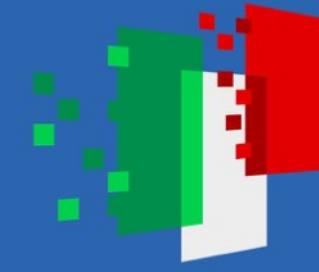
NGC362
10 new discoveries



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MeerKAT radio telescope

64 antennas with a diameter of 13.5 m

Maximum baseline of 8 km

Available frequency bands:
544 - 1088 MHz (UHF-band)
856 - 1712 MHz (L-band)
1.75 - 3.5 GHz (S-band)

Located in South Africa

More than 4x the sensitivity of the
Parkes telescope (Murriyang) and almost
2x that of GBT

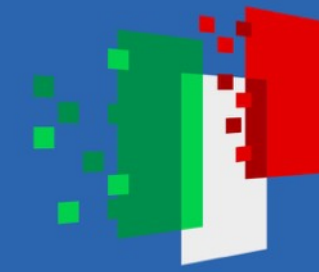




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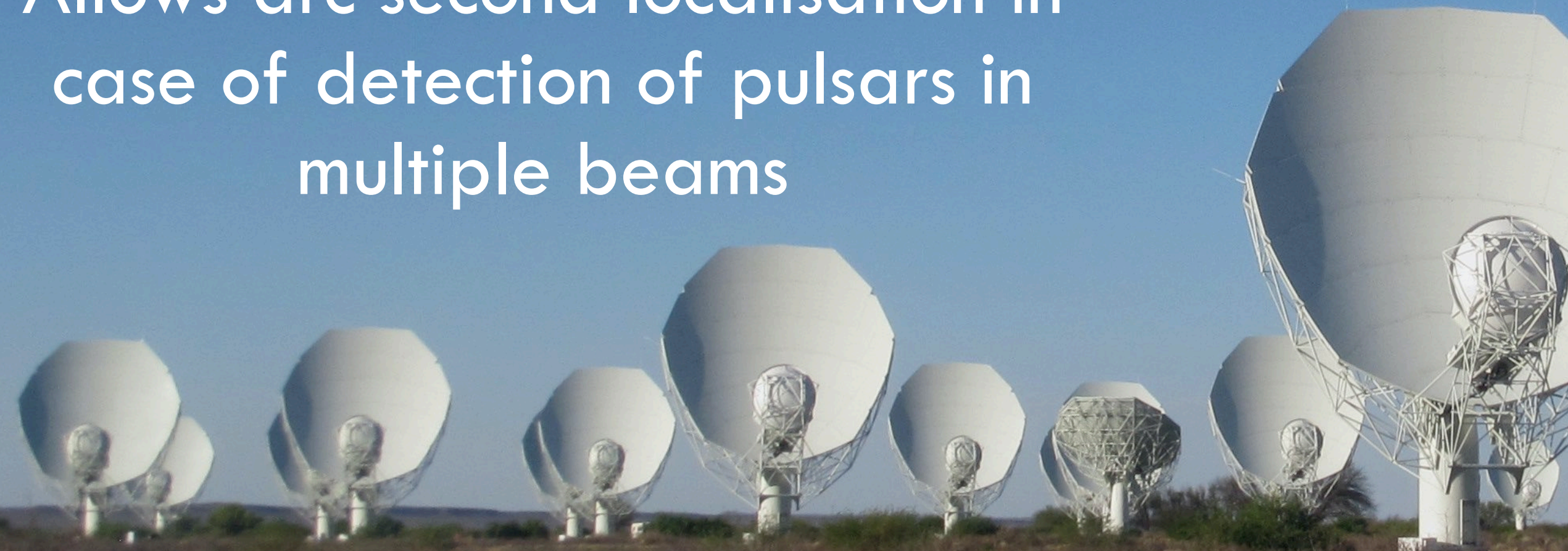
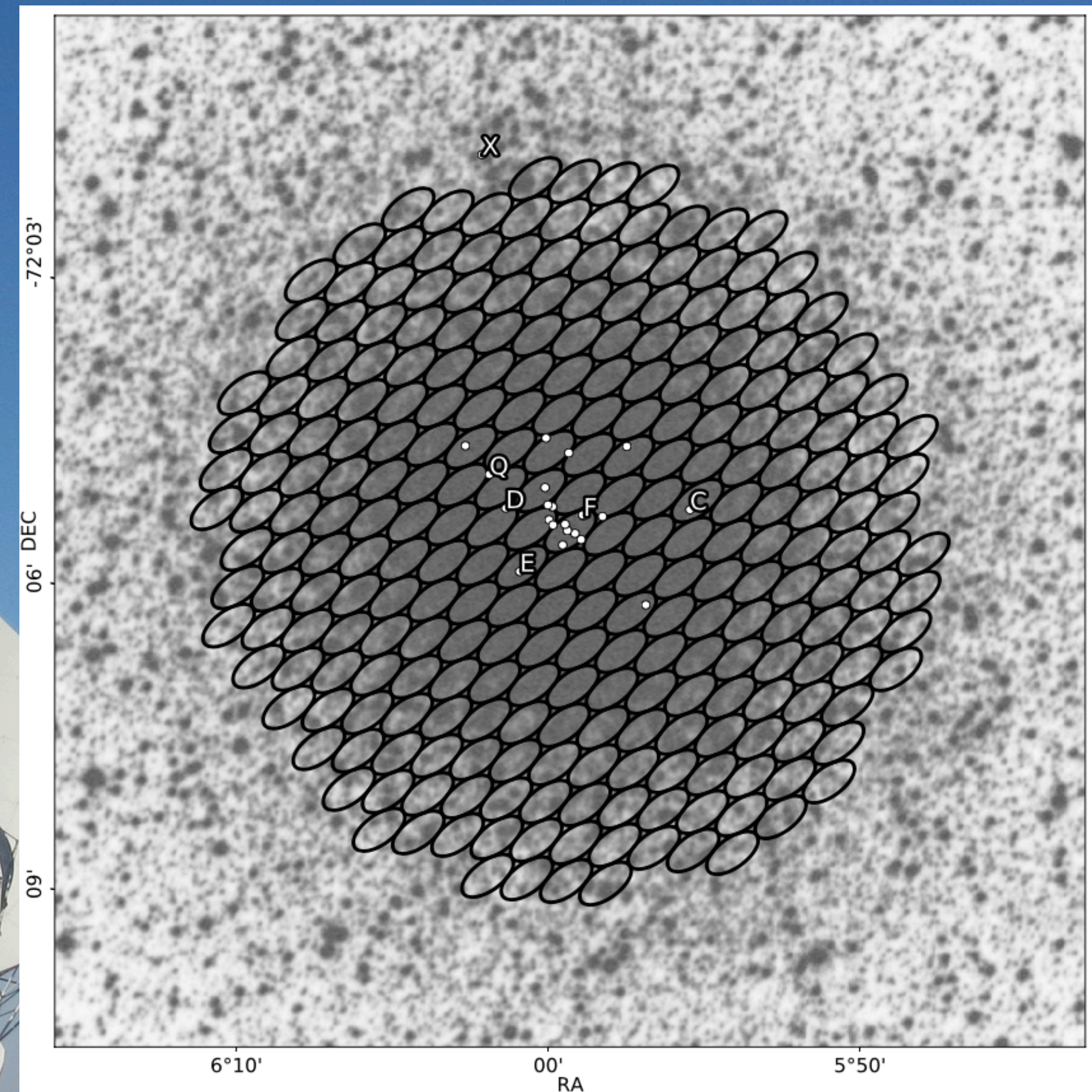
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MeerKAT radio telescope

Capable of forming up to 800 tied
array beams in pulsar mode

Allows for large sky coverage
with maximum sensitivity

Allows arc second localisation in
case of detection of pulsars in
multiple beams

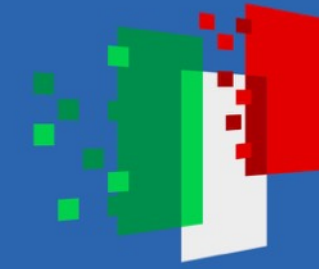




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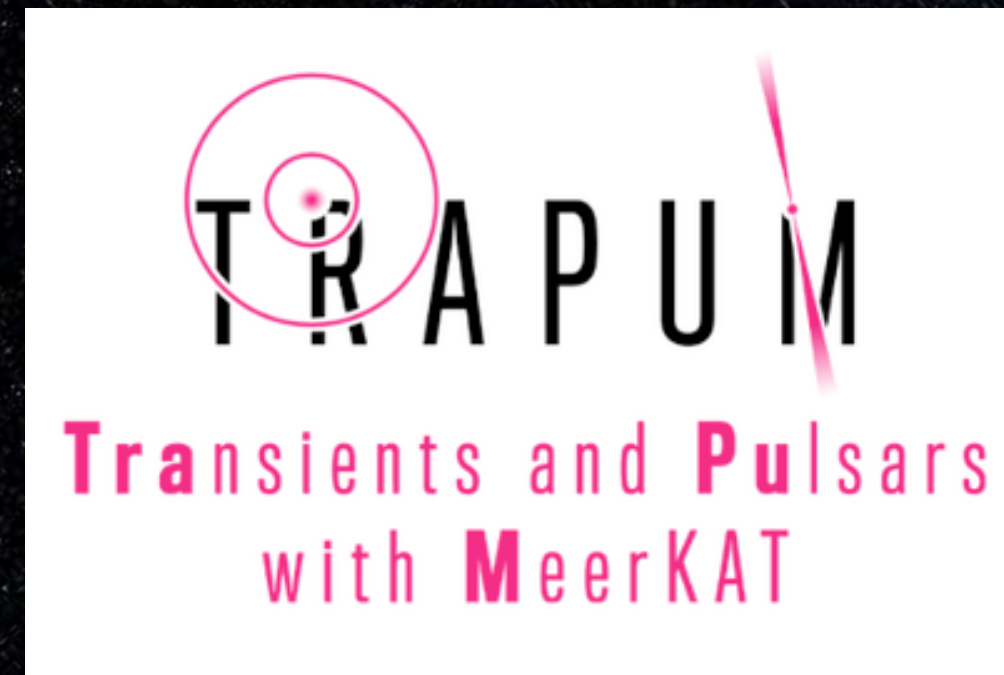
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PIs: Ben Stappers, Michael Kramer

<http://trapum.org/>

Searching for new pulsars

Nearby Galaxies

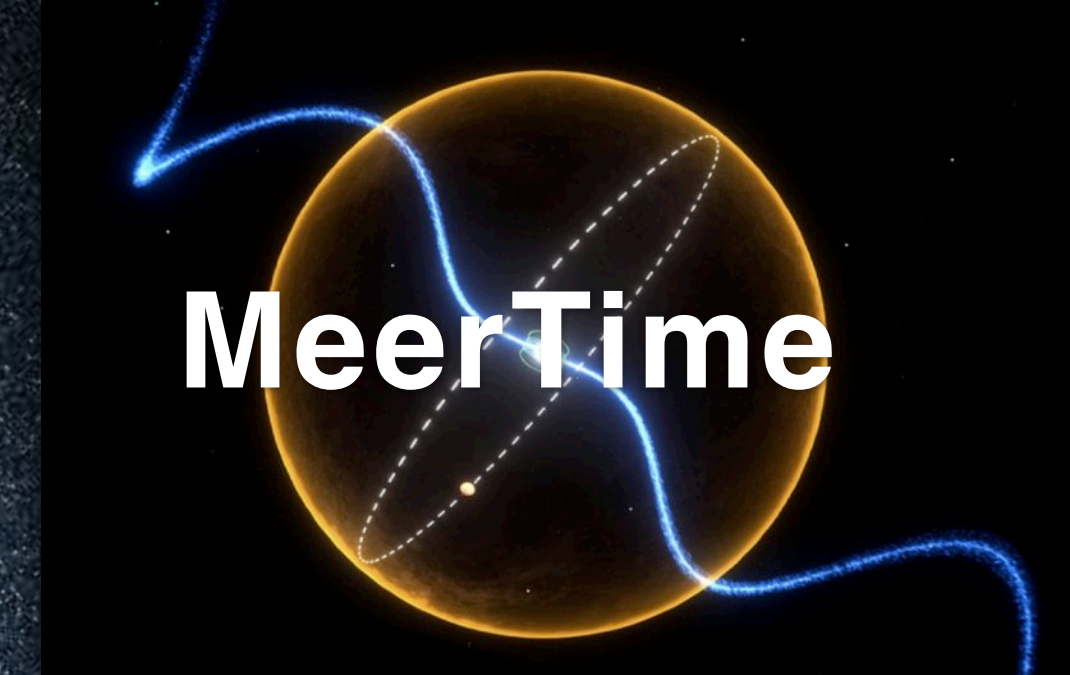
Fermi Sources

Supernova remnants and Pulsar Wind

Nebulae

Globular Clusters

Pulsars at MeerKAT



PI: Matthew Bailes

<http://www.meertime.org/>

Timing known pulsars

Globular Clusters

Thousand Pulsars Array

Relativistic Binaries

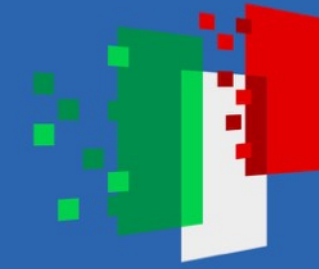
Pulsar Timing Array



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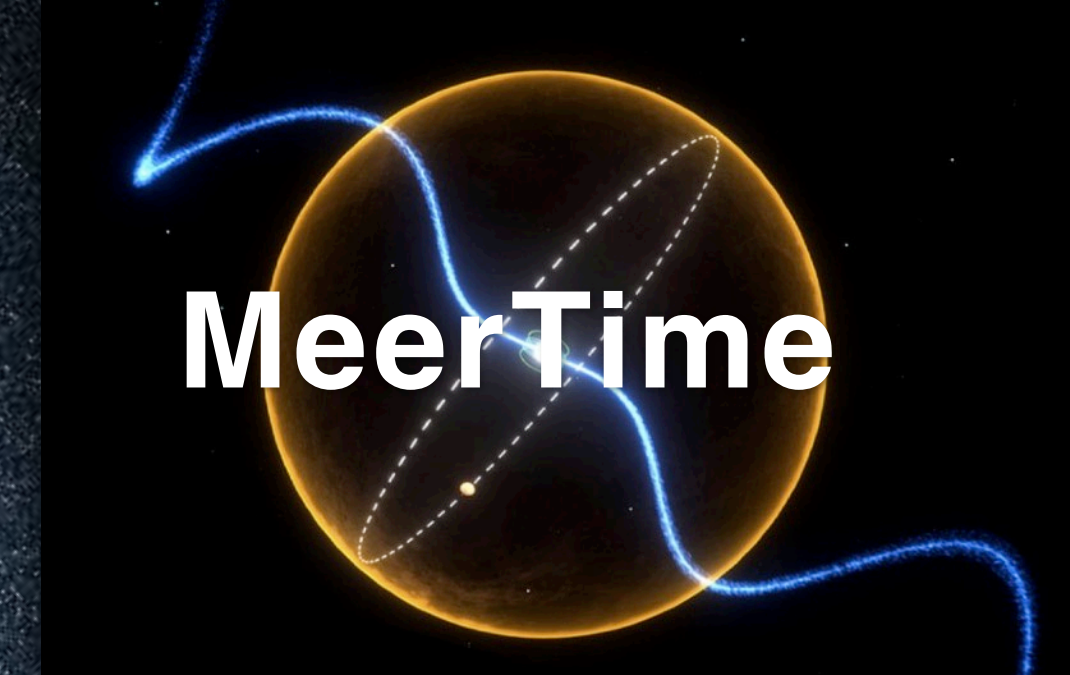
Nearby Galaxies

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Supernova remnants and Pulsar Wind
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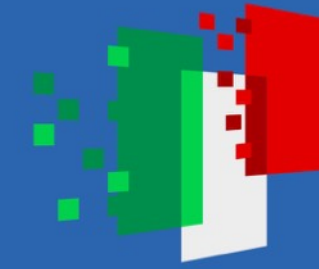
Pulsar Timing Array



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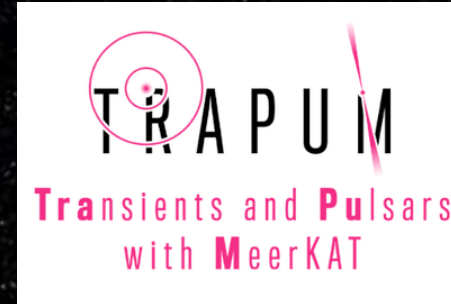
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Pulsar Discoveries: Fermi Sources

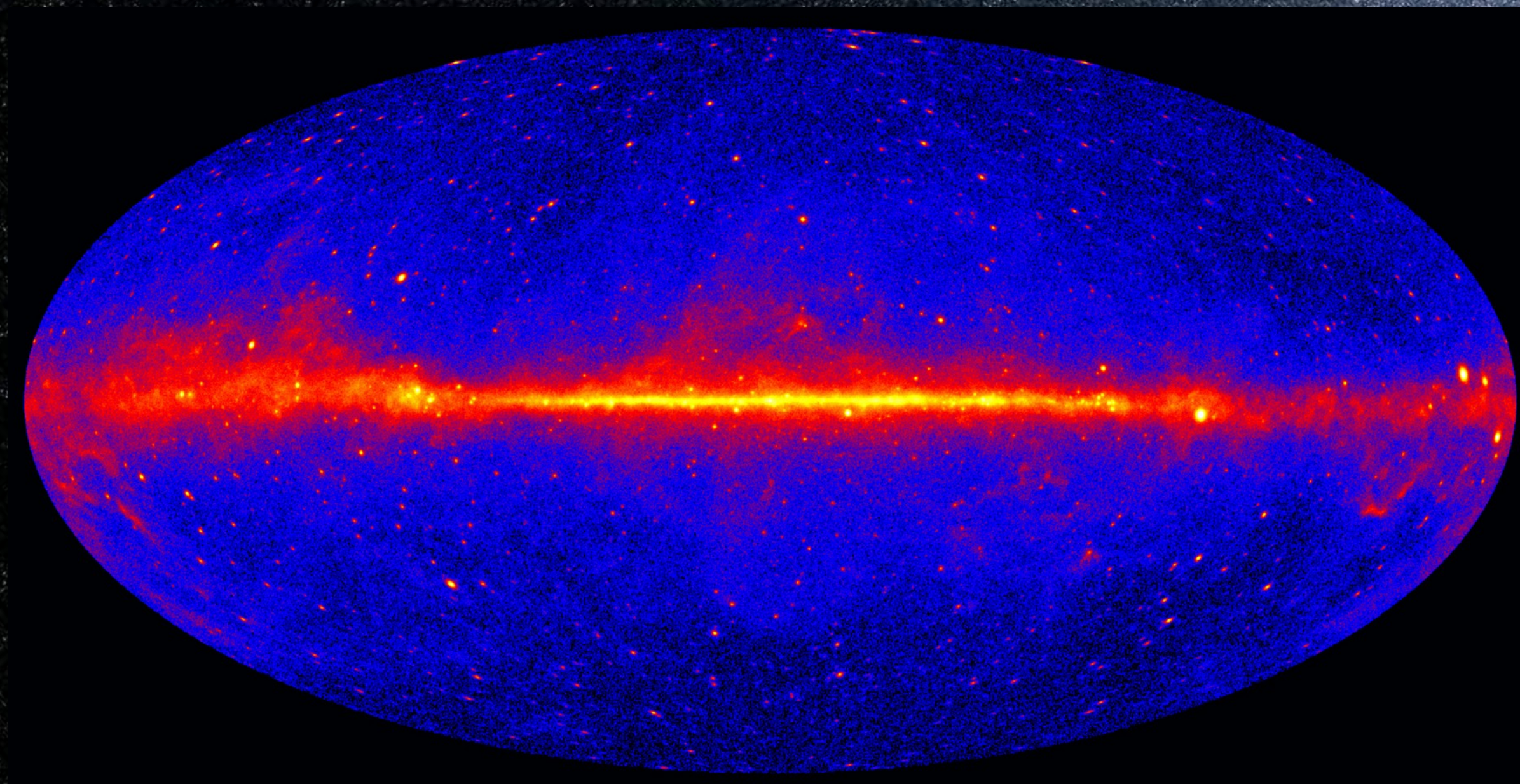
36 new discoveries in total (30 MSPs and 6 slow pulsars)

22 of these discoveries have phase connected solution.

More than half them are in binaries with non degenerate companions.

Optical detection of the companion can give an estimate of the pulsar mass.

In one case the estimated mass is around $2 M_{\text{sun}}$



Clark et al. 2023

Thongmeekom et al. in prep.

Dodge et al. in prep

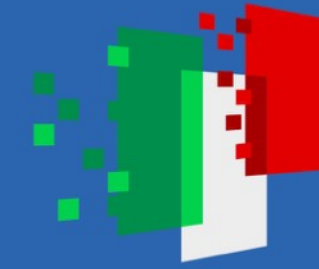
Burgay et al. in prep



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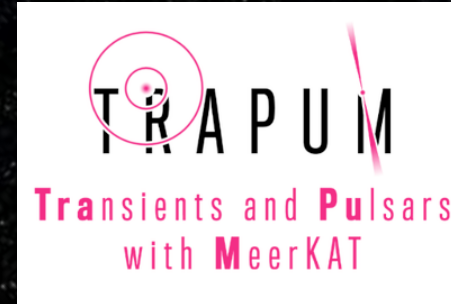
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Pulsar Discoveries: Globular Clusters

89 total discoveries in 15 different GCs (out of a total of 305)

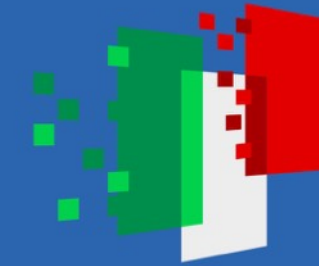
Globular Cluster	# of discoveries	Globular Cluster	# of discoveries
NGC1851	14	M62	4
Omega Cen	13	NGC 6522	3
Terzan 5	11	M22	2
47 Tucanae	11	M28	2
NGC 362	10	NGC 6440	2
NGC 6624	6	NGC 6342	1
NGC6441	5	NGC 6544	1
NGC6752	4		



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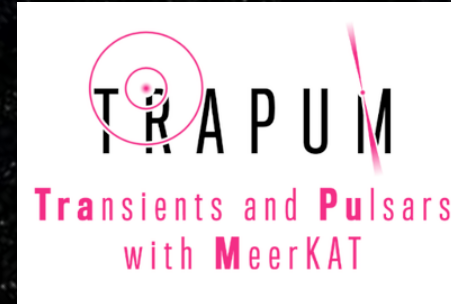
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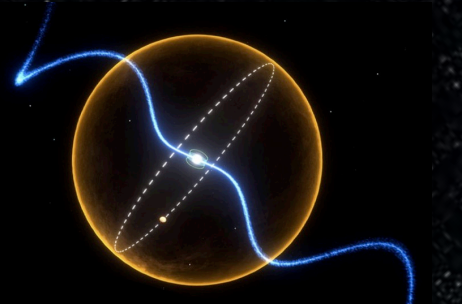
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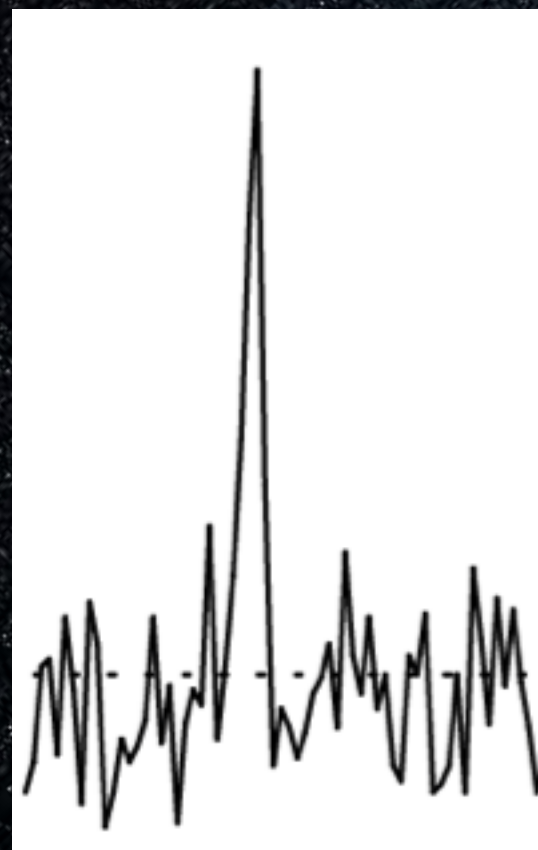
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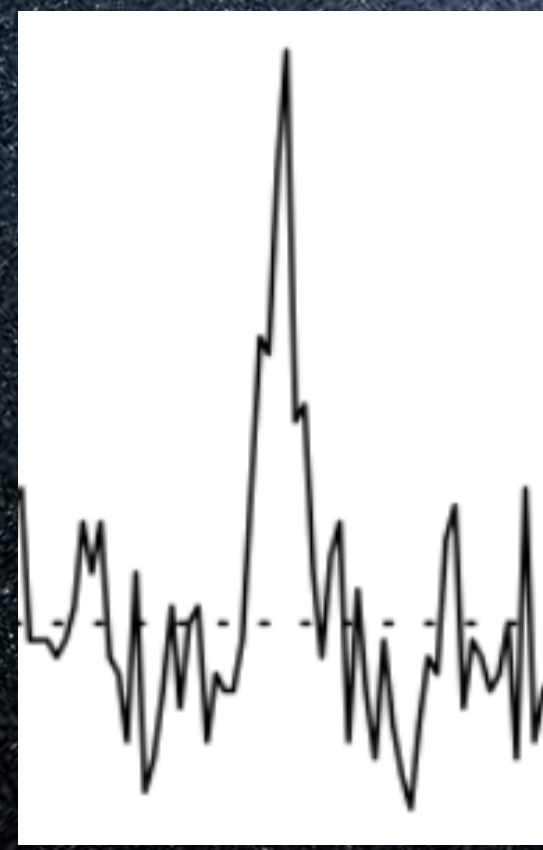
Pulsar Discoveries: Globular Clusters



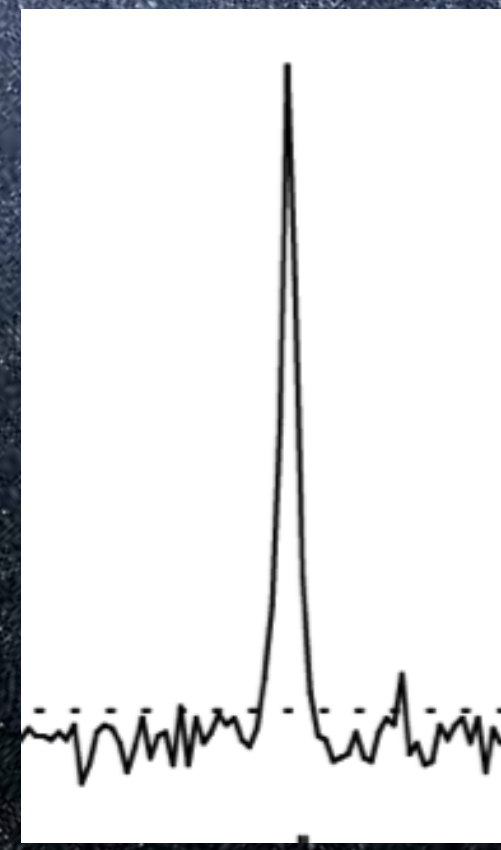
Slow pulsars with periods between 100 ms and 2.5 s



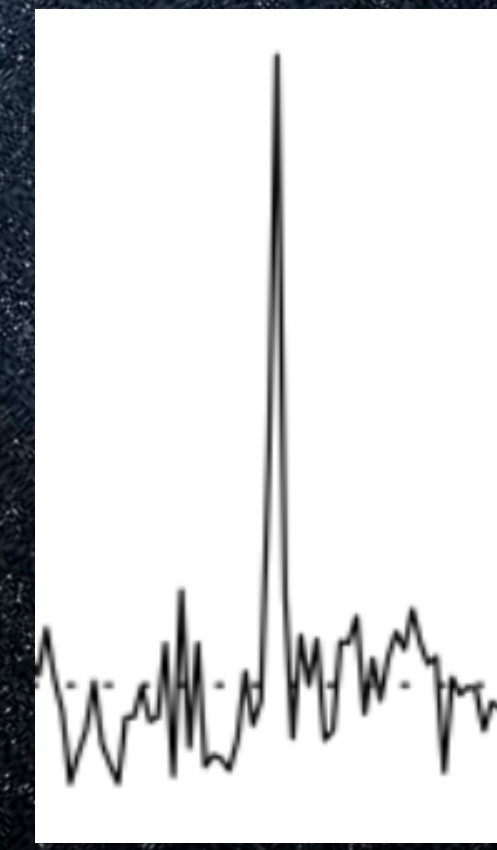
NGC 362E
P= 104 ms



NGC 6522F
P= 148 ms



NGC 6441E
P= 251 ms



J1823-3022
P= 2.5 s

Abbate et al. 2022,2023

Ridolfi et al. in prep

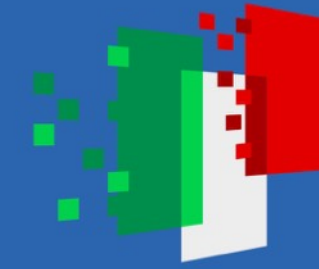
Venkatraman Krishnan et al. in prep



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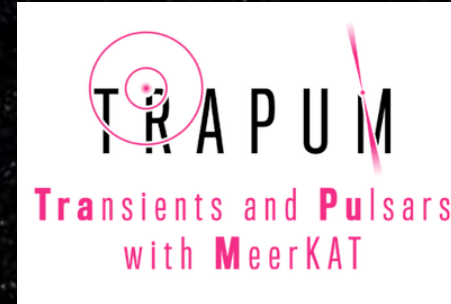
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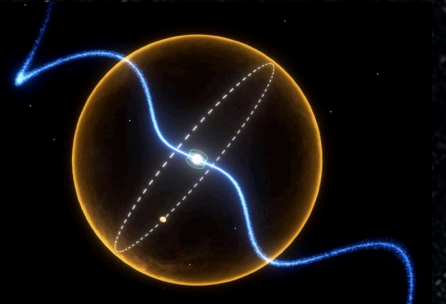
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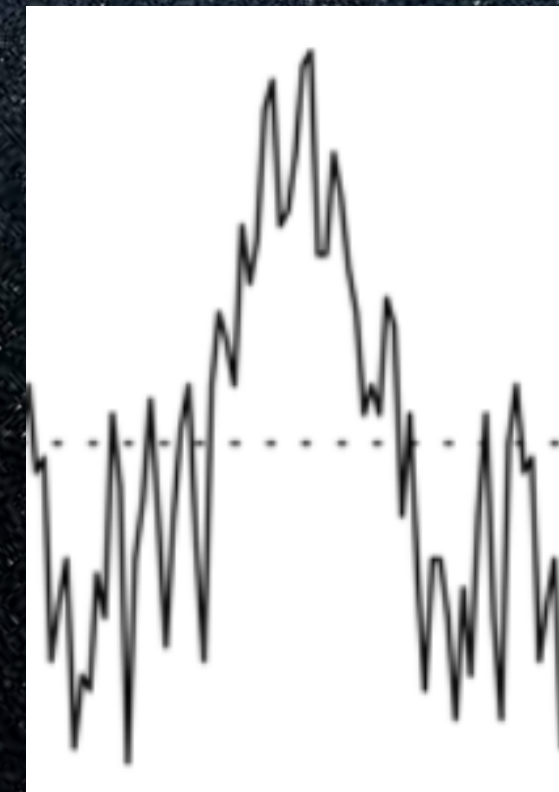
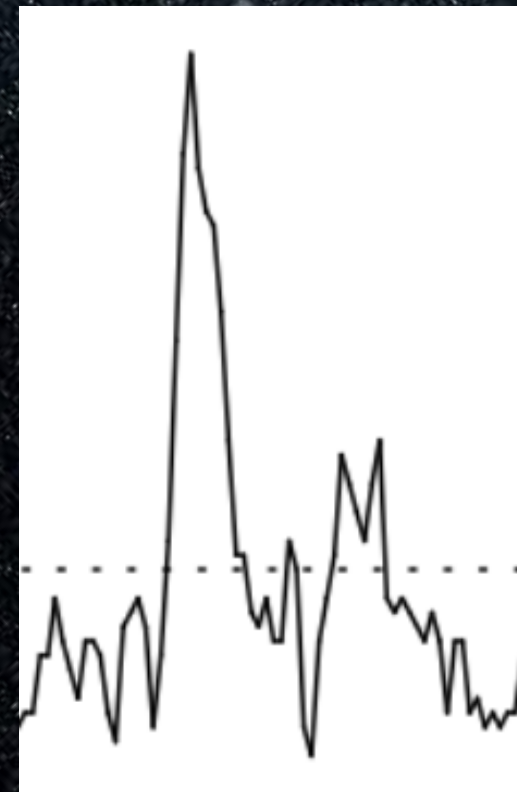
Pulsar Discoveries: Globular Clusters



Slow pulsars with periods between 100 ms and 2.5 s

Binary systems with planet mass companions

NGC 6440H
Median companion
mass: $7 M_J$



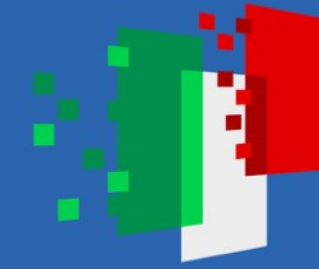
M62 H
Median companion
mass: $3 M_J$



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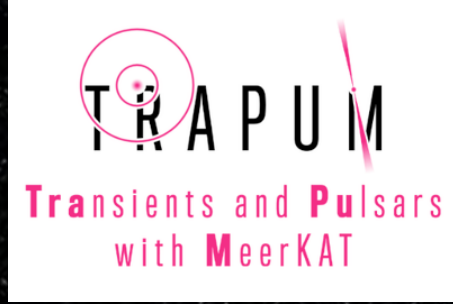
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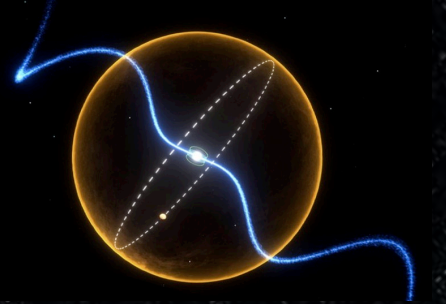
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Pulsar Discoveries: Globular Clusters



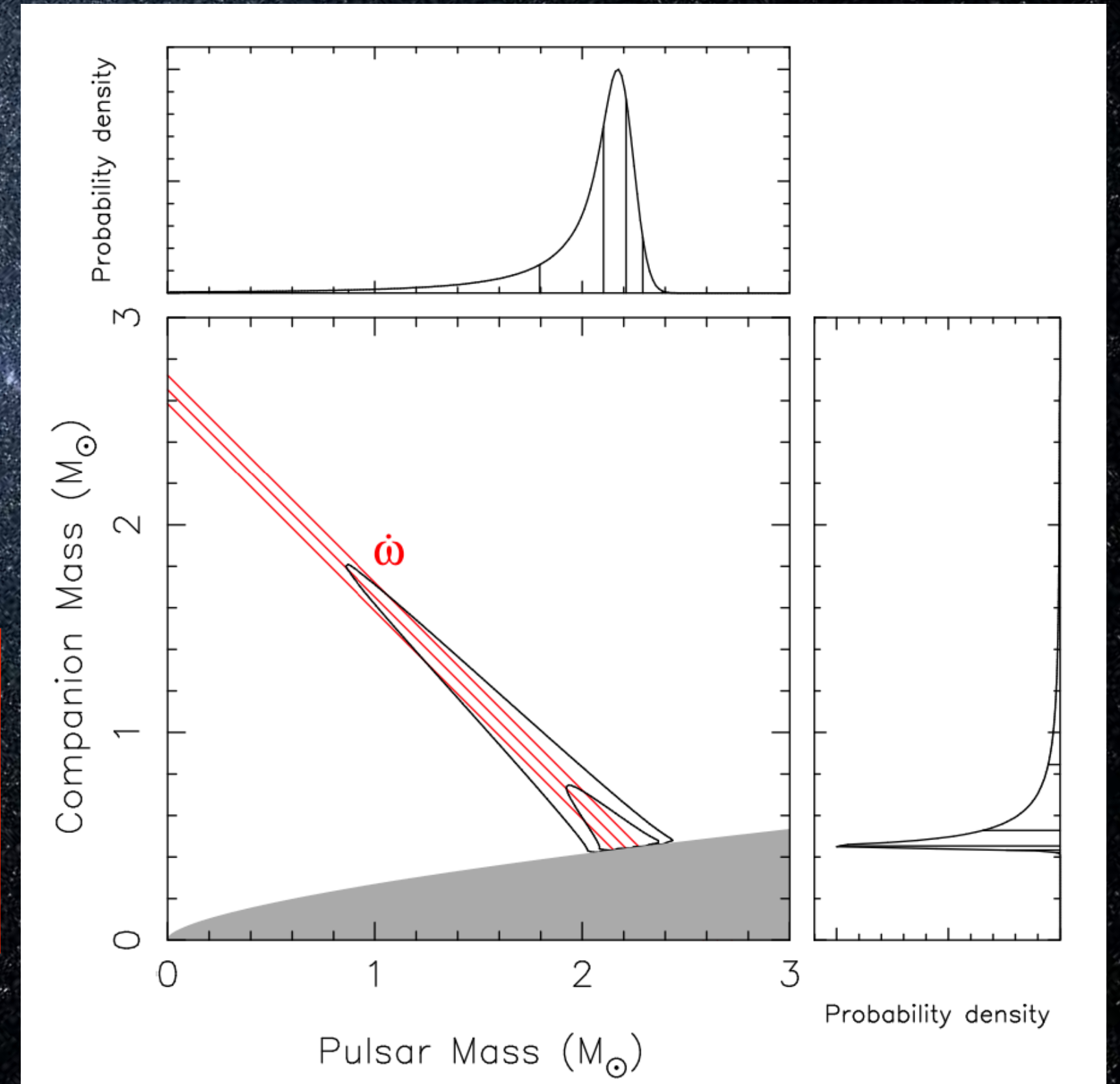
Slow pulsars with periods between 100 ms and 2.5 s

Binary systems with planet mass companions

Massive binary systems

NGC6624 G
Median pulsar mass
 $2.1 M_{\text{sun}}$

Likely double neutron star
system in Terzan 5

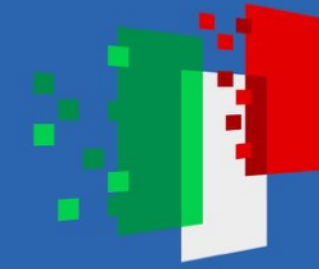




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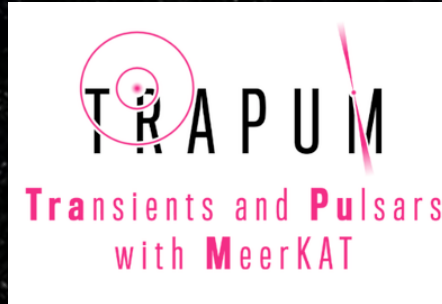
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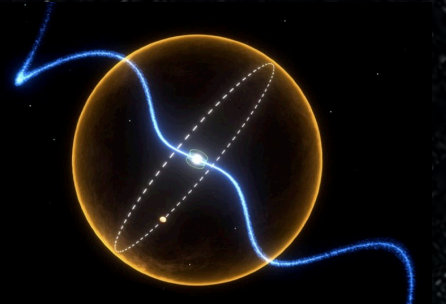
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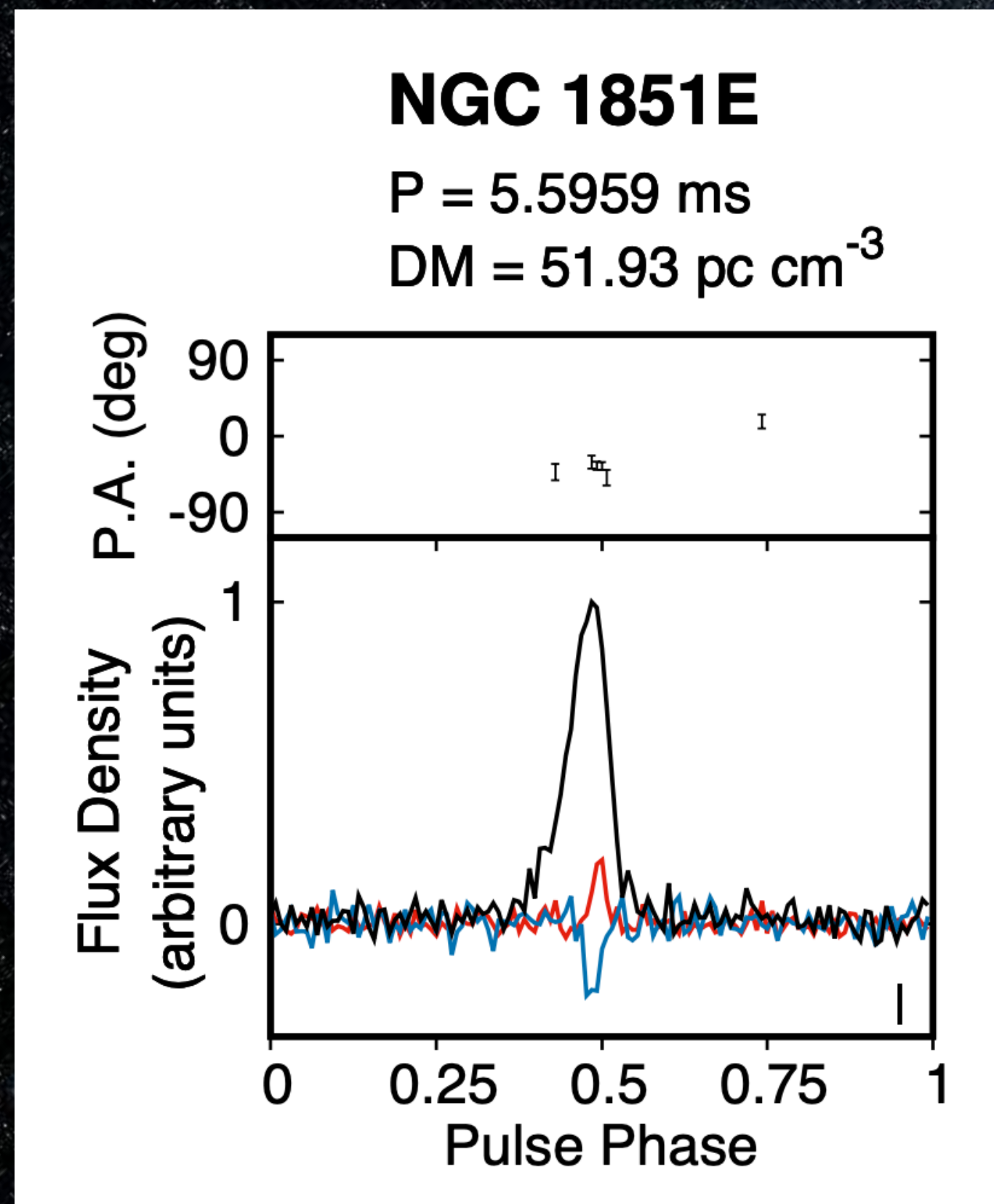
Pulsar Discoveries: Globular Clusters



From pulsar timing the binary
parameters tell us that:

Minimum companion mass
(from mass function):
 $> 1.4 M_{\text{Sun}}$

Eccentricity:
0.7

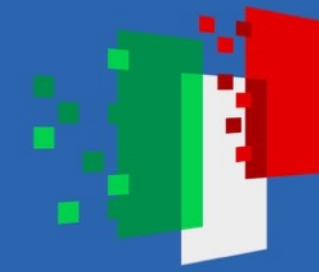




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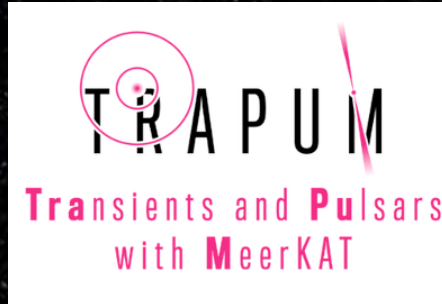
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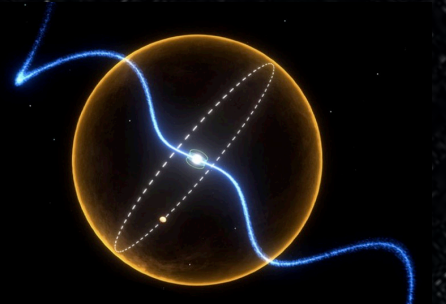
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Pulsar Discoveries: Globular Clusters



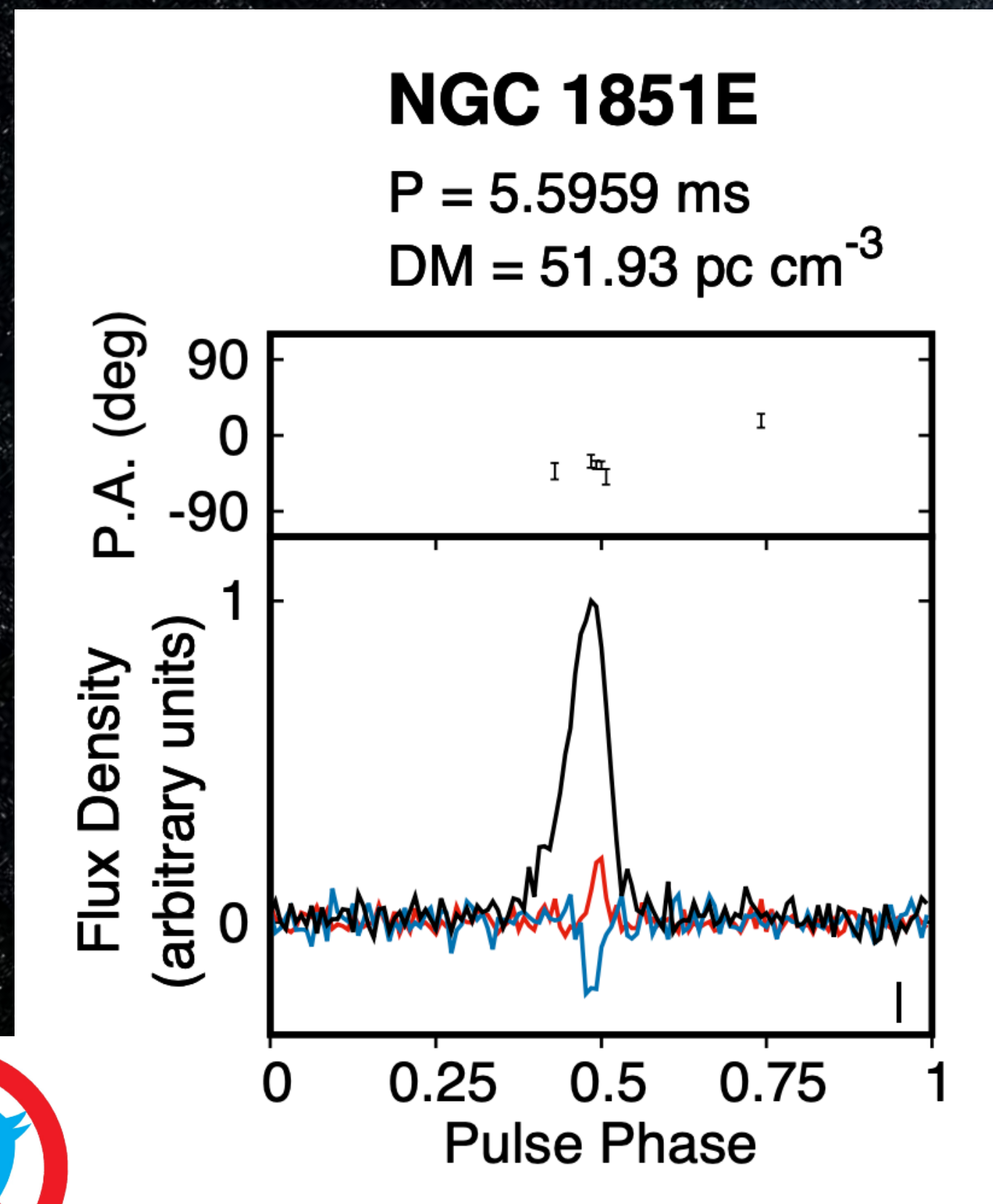
From pulsar timing the binary parameters tell us that:

Minimum companion mass
(from mass function):
 $> 1.4 M_{\text{Sun}}$

Eccentricity:
0.7

Total mass of the system (from
relativistic advance of periastron):
 $3.9 M_{\text{Sun}}$

Estimated companion mass:
 $> 2 M_{\text{Sun}}$



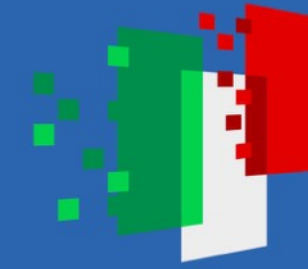
Ridolfi et al. 2022
Barr et al. submitted



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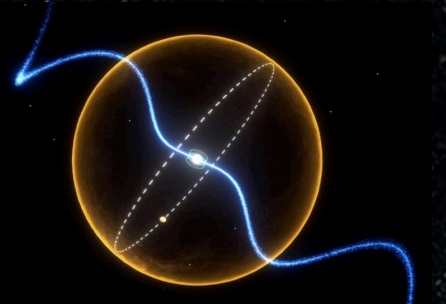
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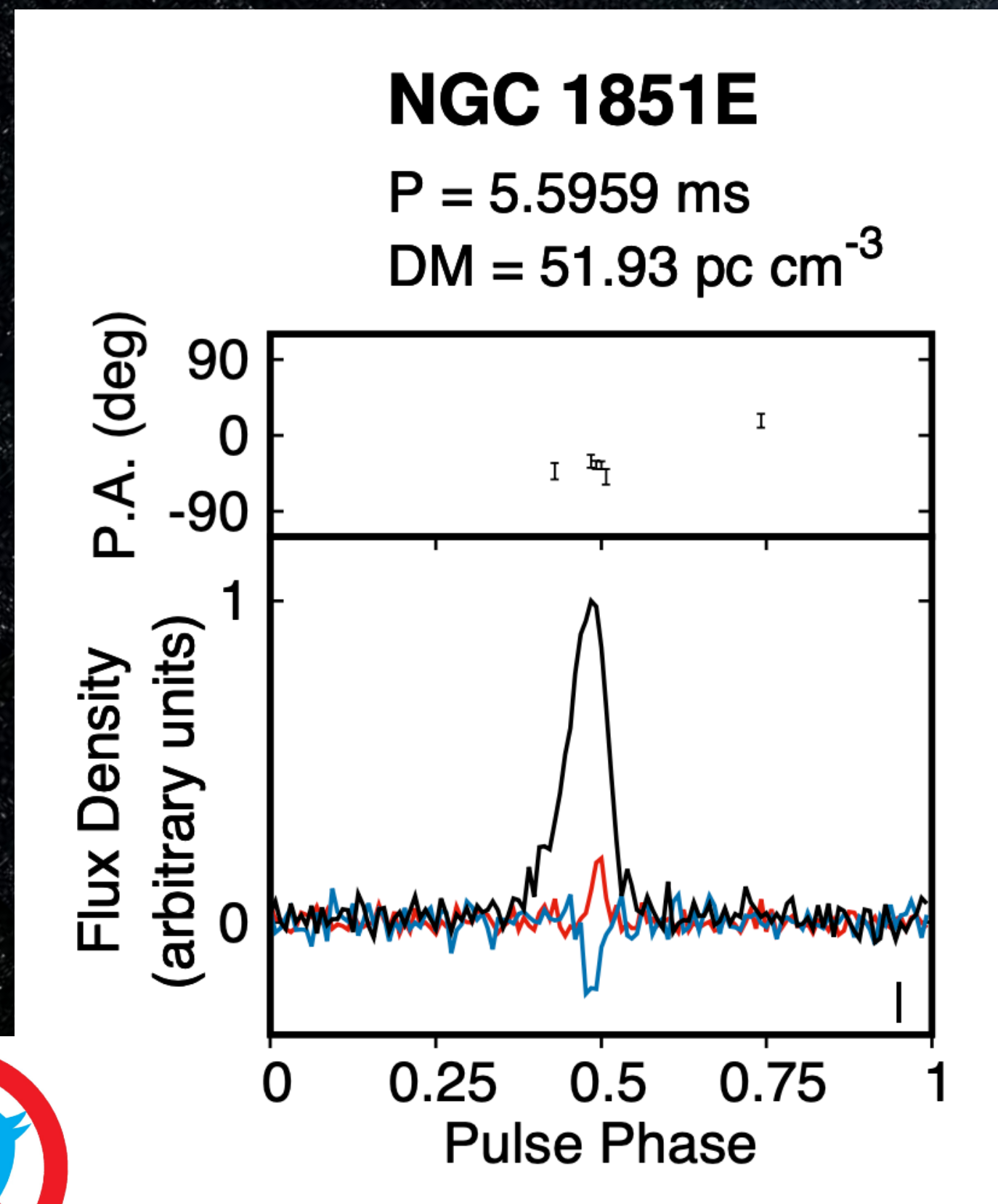
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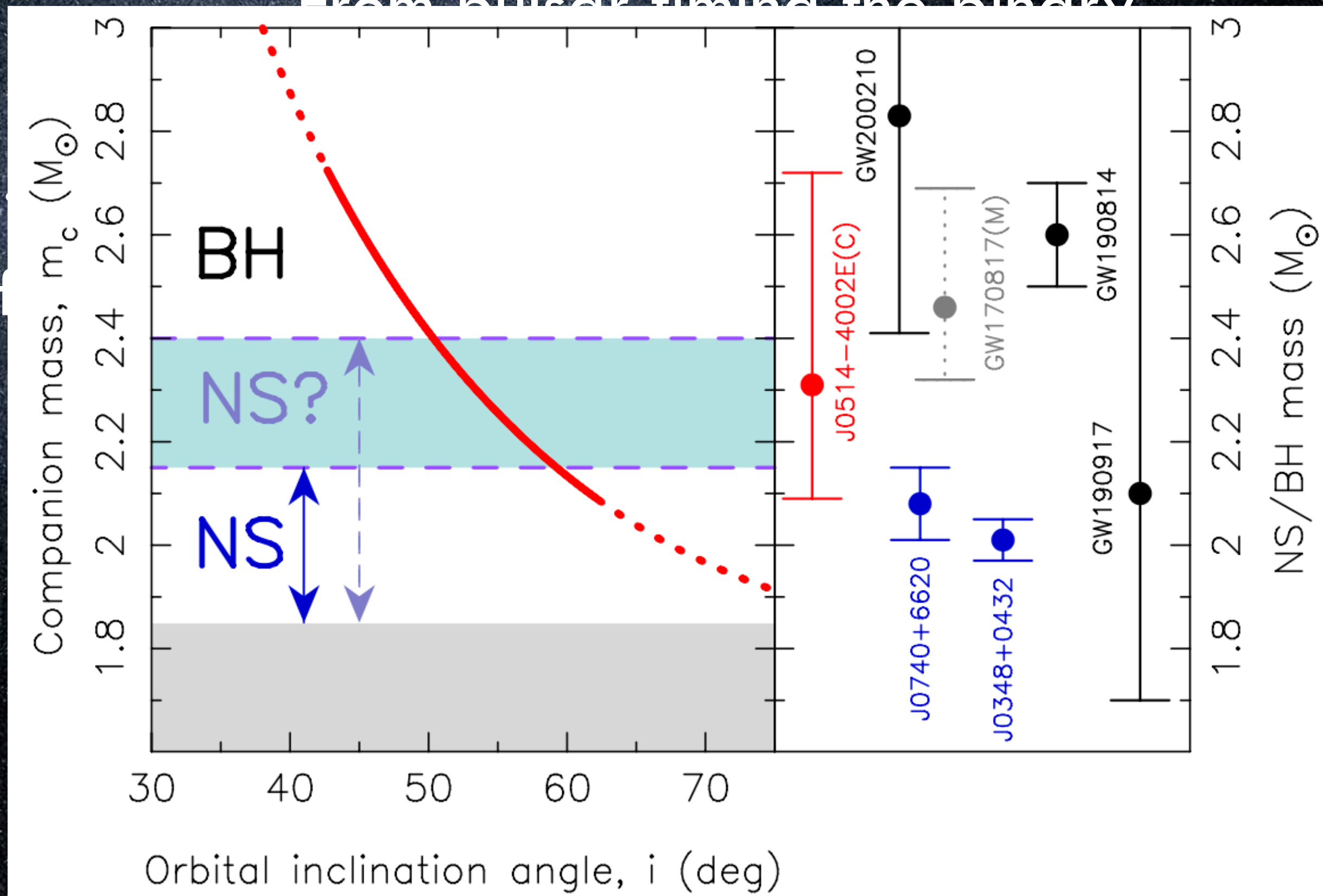
Pulsar Discoveries: Globular Clusters



From pulsar timing the binary



Min



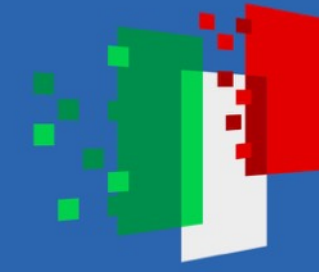
Ridolfi et al. 2022
Barr et al. submitted



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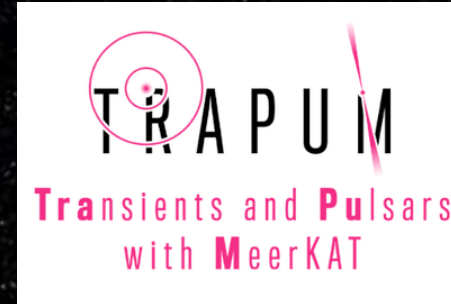
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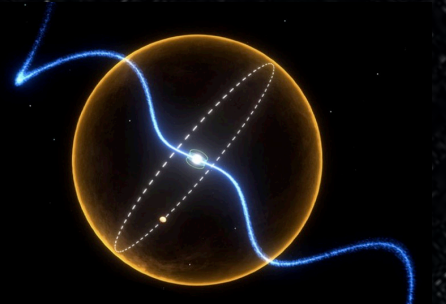
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Pulsar Timing: Globular Clusters

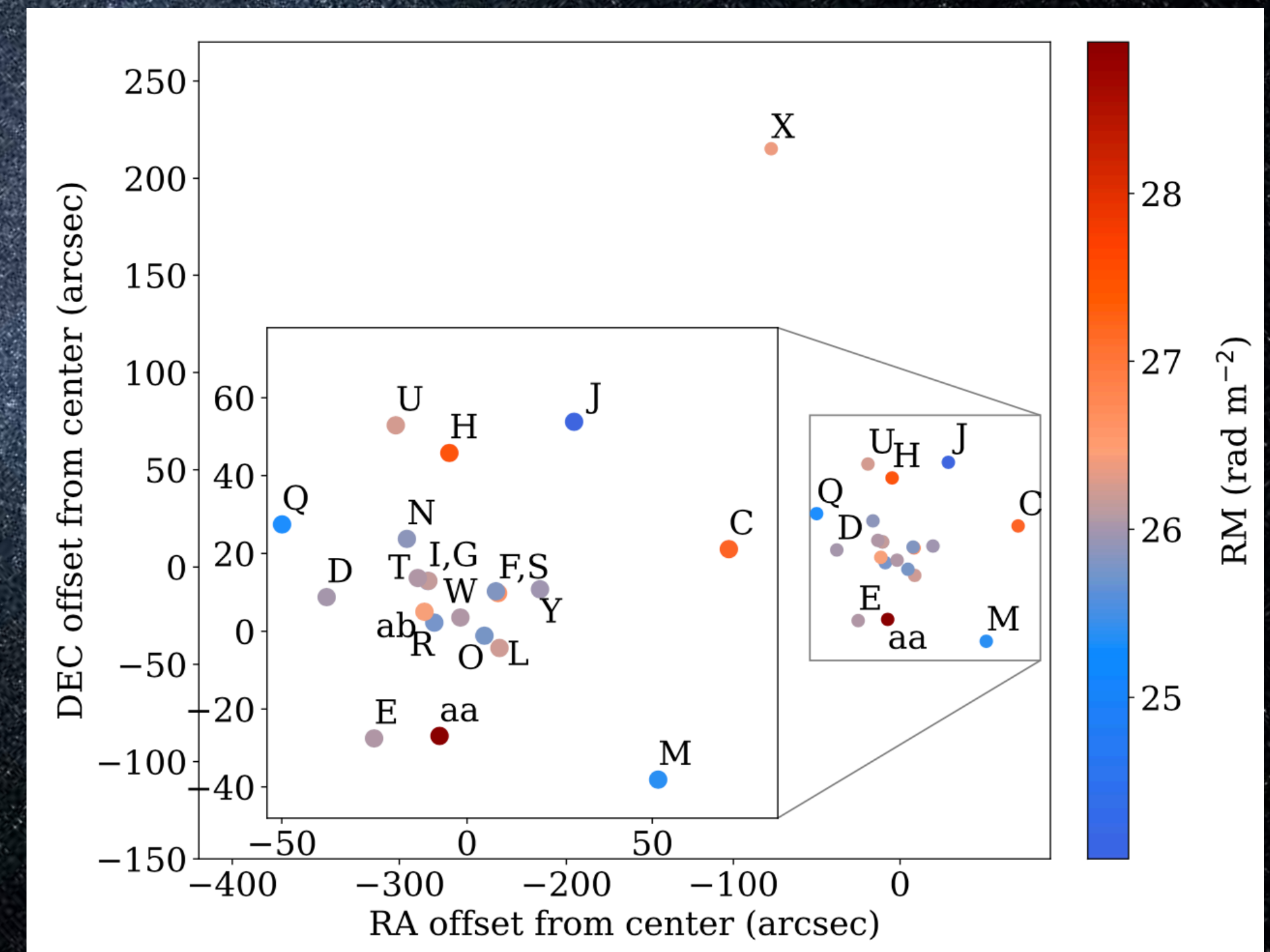
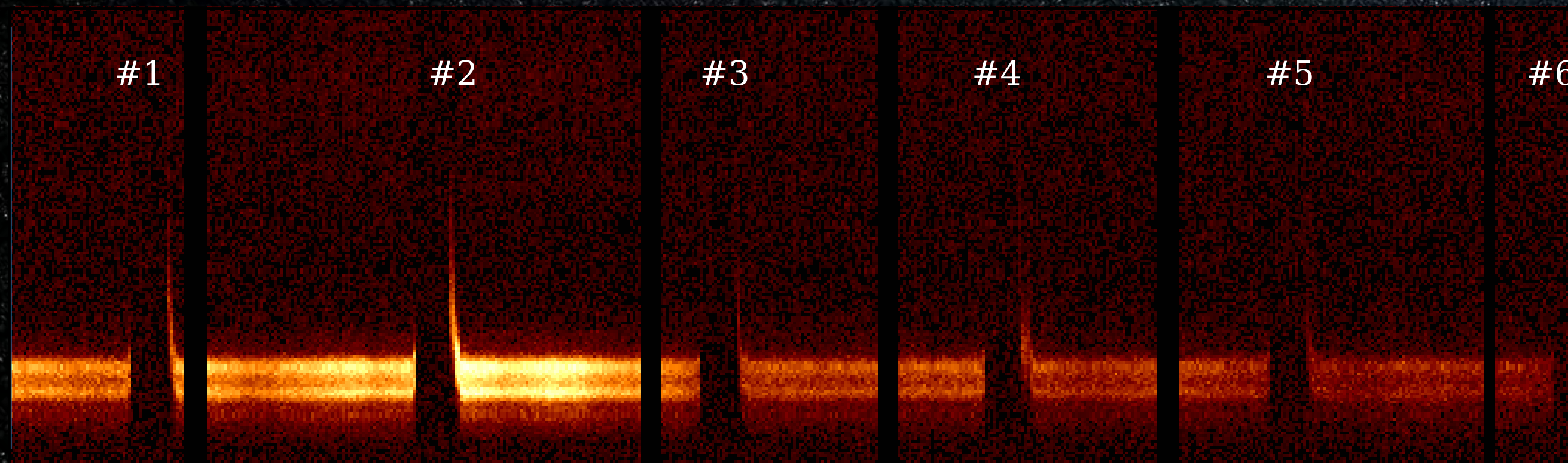


Search for non-luminous mass in NGC 6752

Search for internal magnetic field in 47Tuc

Determination of the mass of NGC 6440B

Consecutive eclipses of 47Tuc O



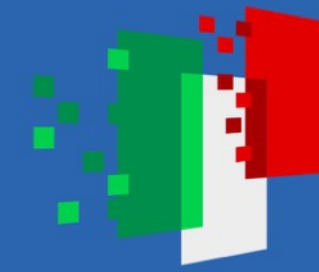
Abbate et al. 2023, in prep
Corongiu et al. submitted
Venkatraman Krishnan et al. in prep



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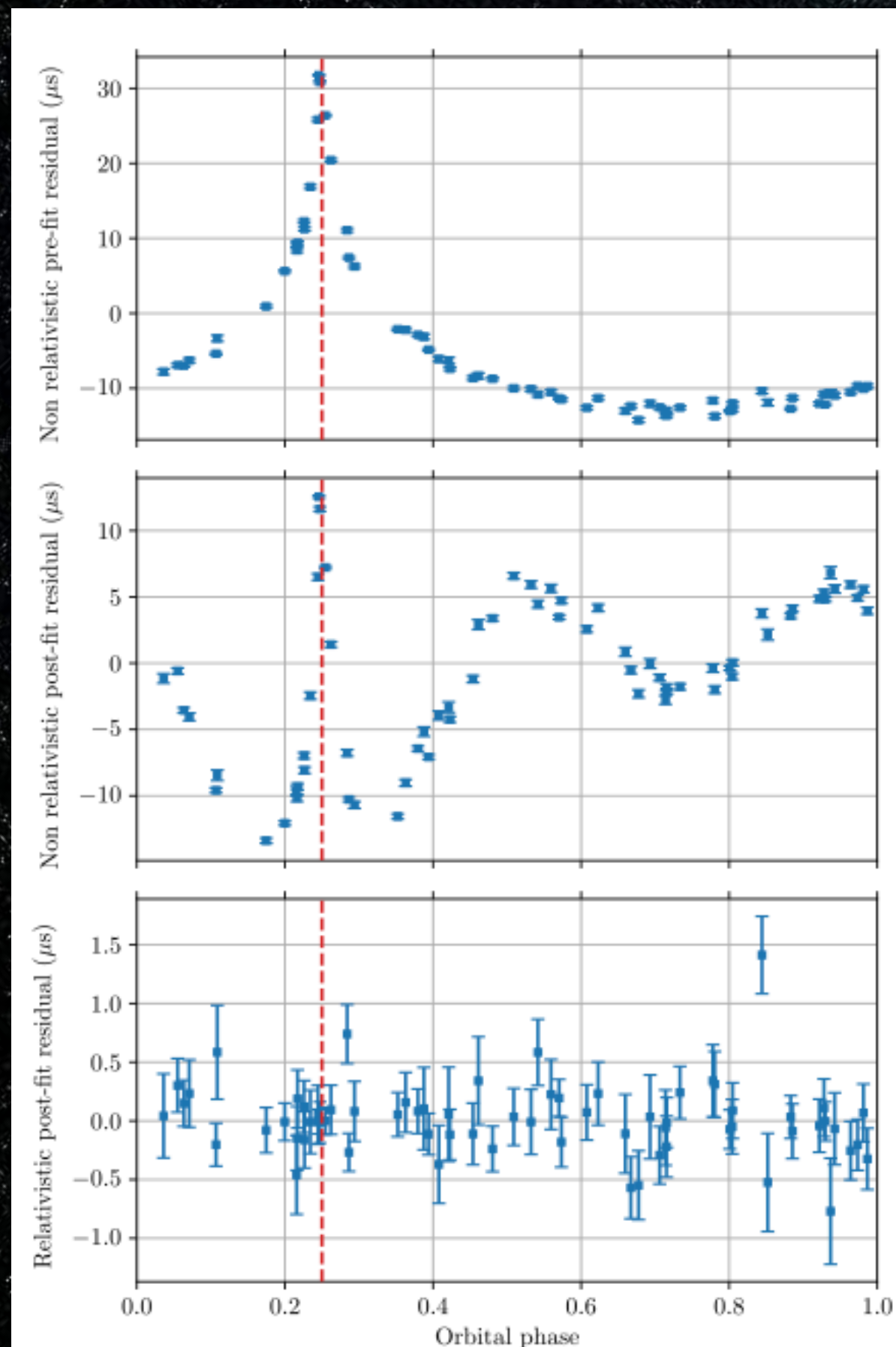
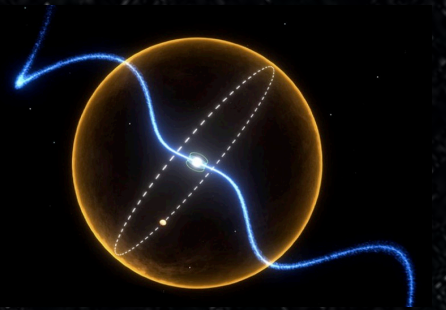


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Pulsar Timing: Relativistic Binaries



Shapiro delay signature of
J1614-2230

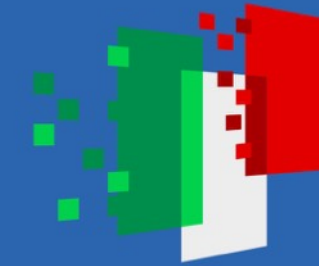
Mass of the pulsar:
 $1.94 \pm 0.03 M_{\text{Sun}}$



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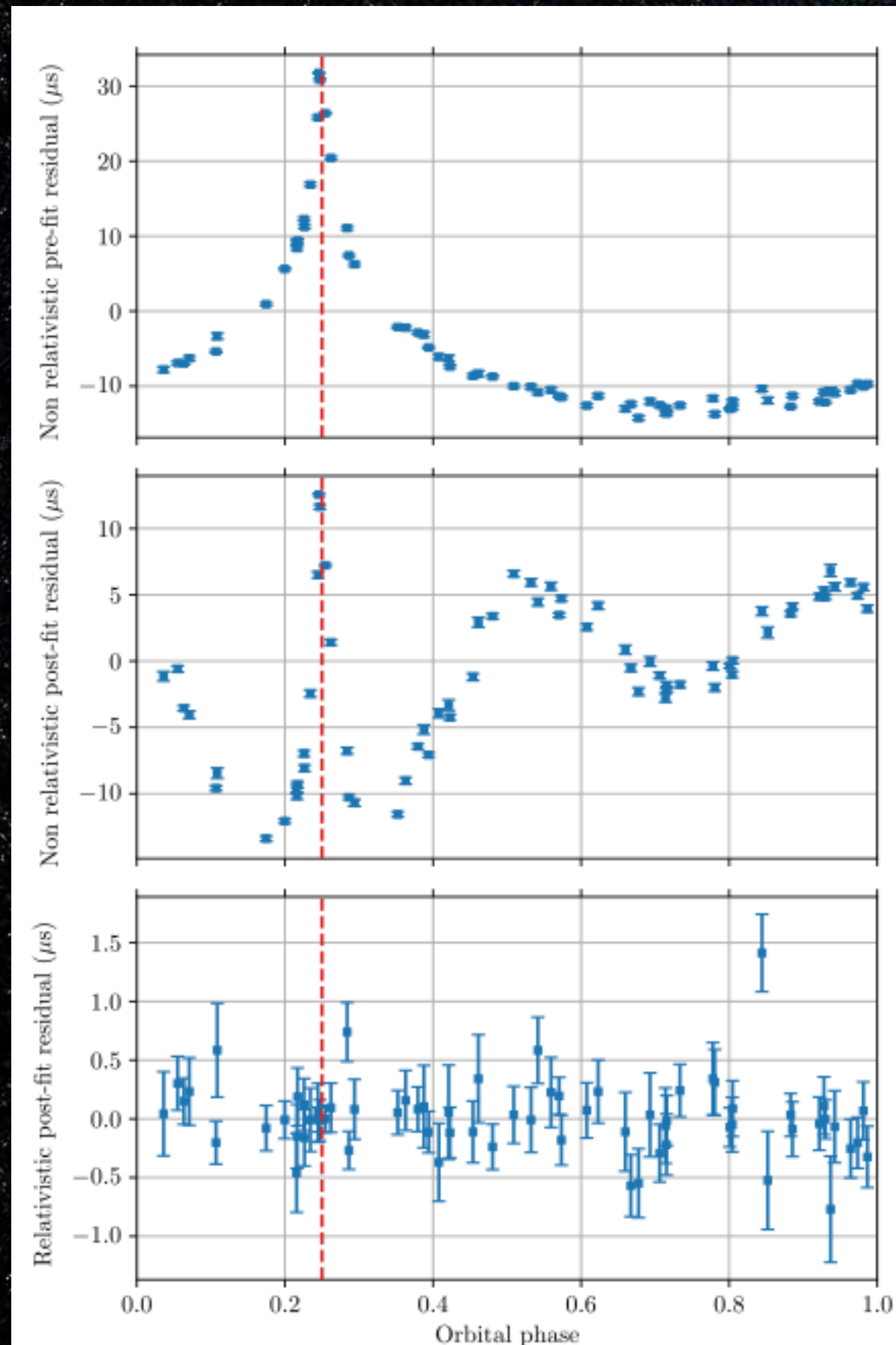
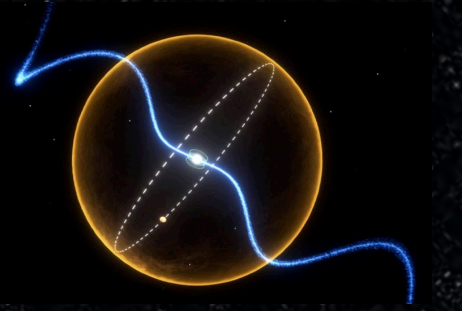


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Pulsar Timing: Relativistic Binaries



Shapiro delay signature of
J1614-2230

Mass of the pulsar:
 $1.94 \pm 0.03 M_{\text{Sun}}$

Shapiro delay detection and
masses of 11 pulsars

Potential detection of a pulsar
with mass $> 2 M_{\text{Sun}}$

Tests of gravity with the Double
Pulsar and study of eclipses

Hu et al. 2022

Shamohammadi et al. 2023

Geyer et al. in 2023

Corongiu et al. 2023

Jang et al. 2023

Grunthal et al. submitted

Gautam et al. submitted

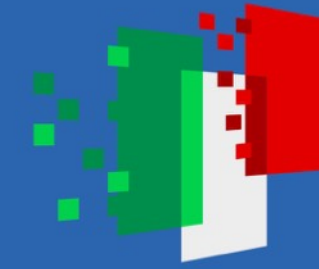
Lower et al. submitted



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Future perspectives

Pushing the mass limit of neutron stars above $2 M_{\text{Sun}}$

Finishing ongoing surveys: lots more of discoveries
awaiting

S-band surveys and observations: discoveries and
mass measurements

Further PTA data releases

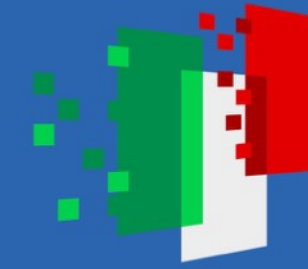




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A little further down the road:

MeerKAT+ upgrade: 80 antennas

New observing band:
Band 5 (8-15GHz)

Ideal for searches in the
Galactic Center

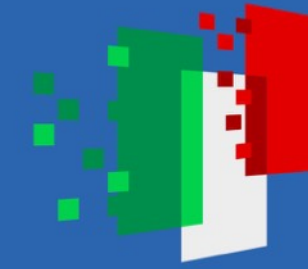




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Thank You!

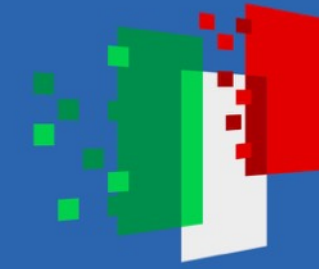




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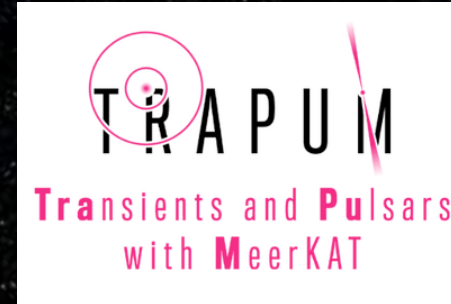
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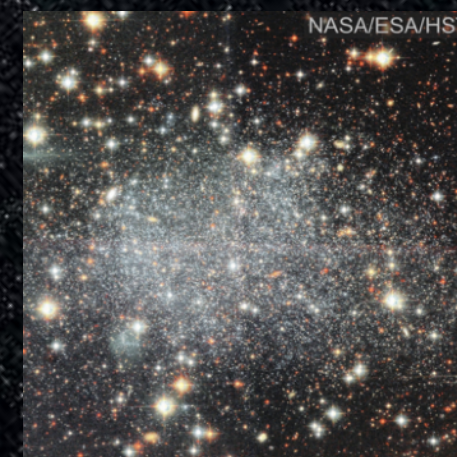
Pulsar Discoveries: Nearby Galaxies

14 new discoveries in total (32 previously known)

7 in the Large Magellanic
Cloud

7 in the Small Magellanic
Cloud
including 3 glitching pulsars

Other galaxies observed still without discoveries: Sextant A and B, Sagittarius
Dwarf Spheroidal galaxy and NGC 253



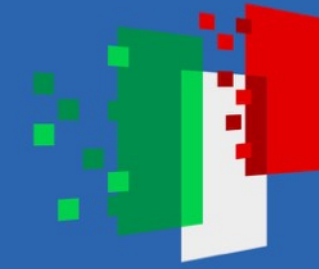
Carli et al. in prep.
Prayag et al. in prep
Hurter et al. in prep



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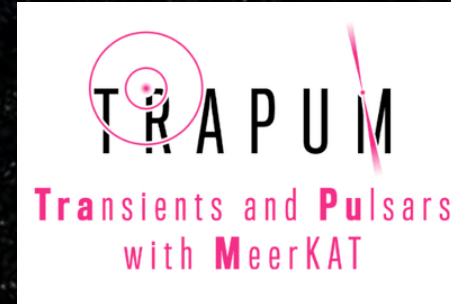
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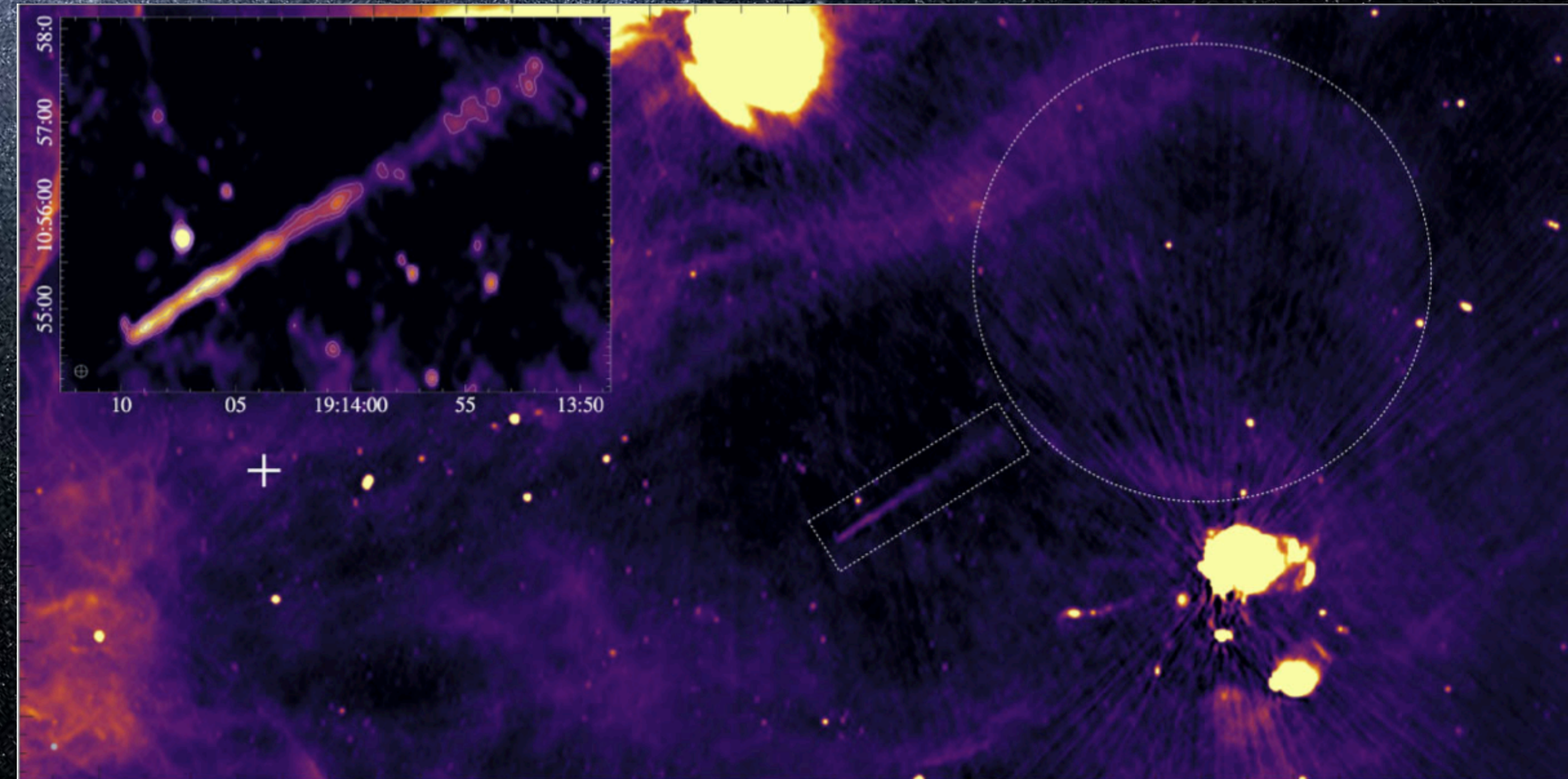
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Pulsar Discoveries: Supernova remnants and Pulsar Wind Nebulae

2 new discoveries but only one associated with a PWN



Discovery a new radio nebula found to
be associated with a previously known
(but not localised) pulsar

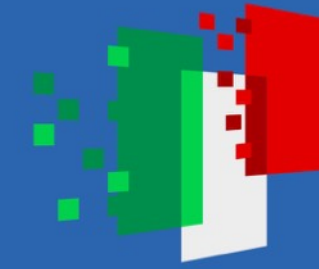




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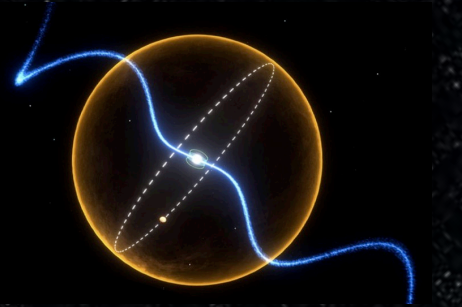
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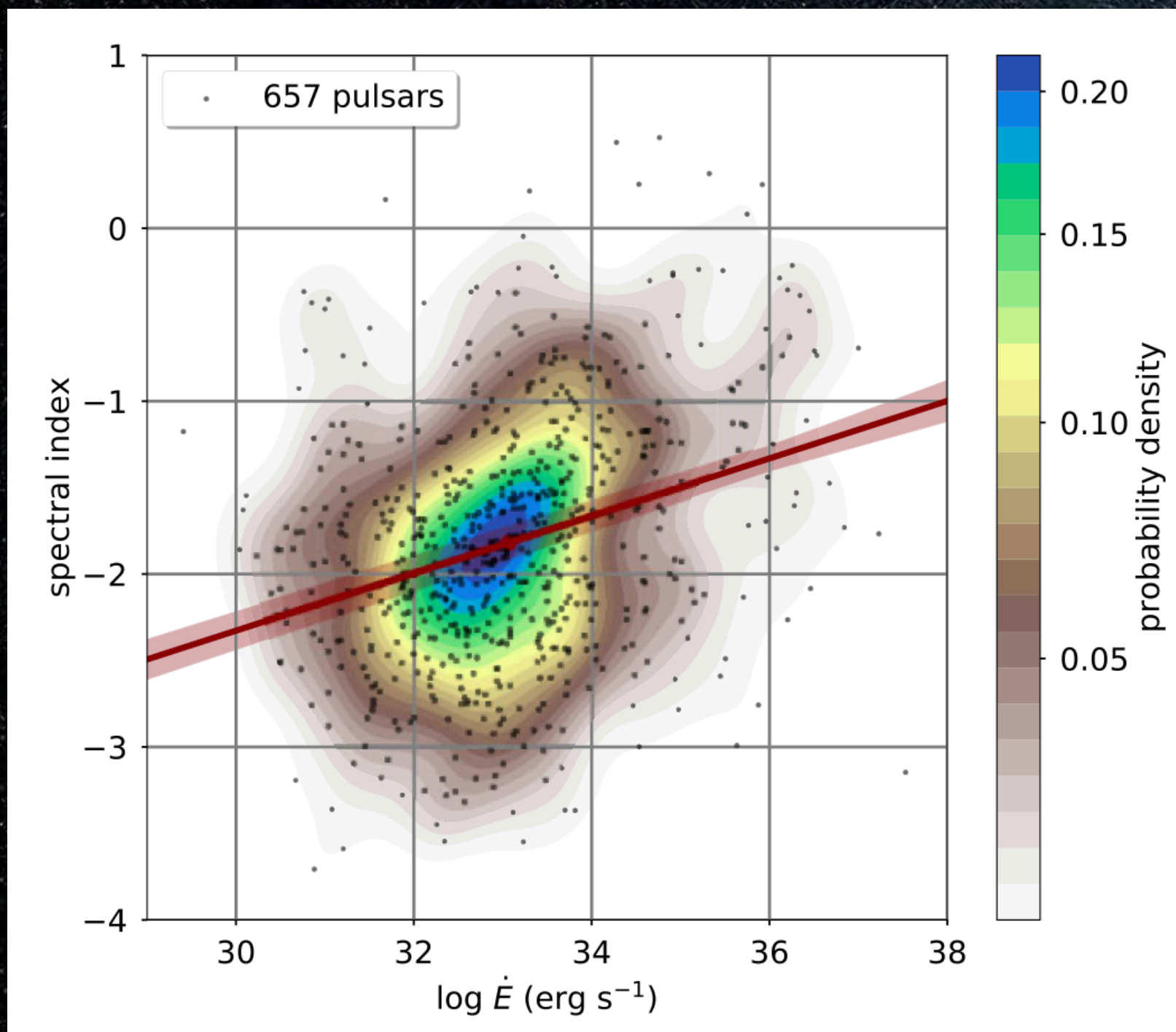
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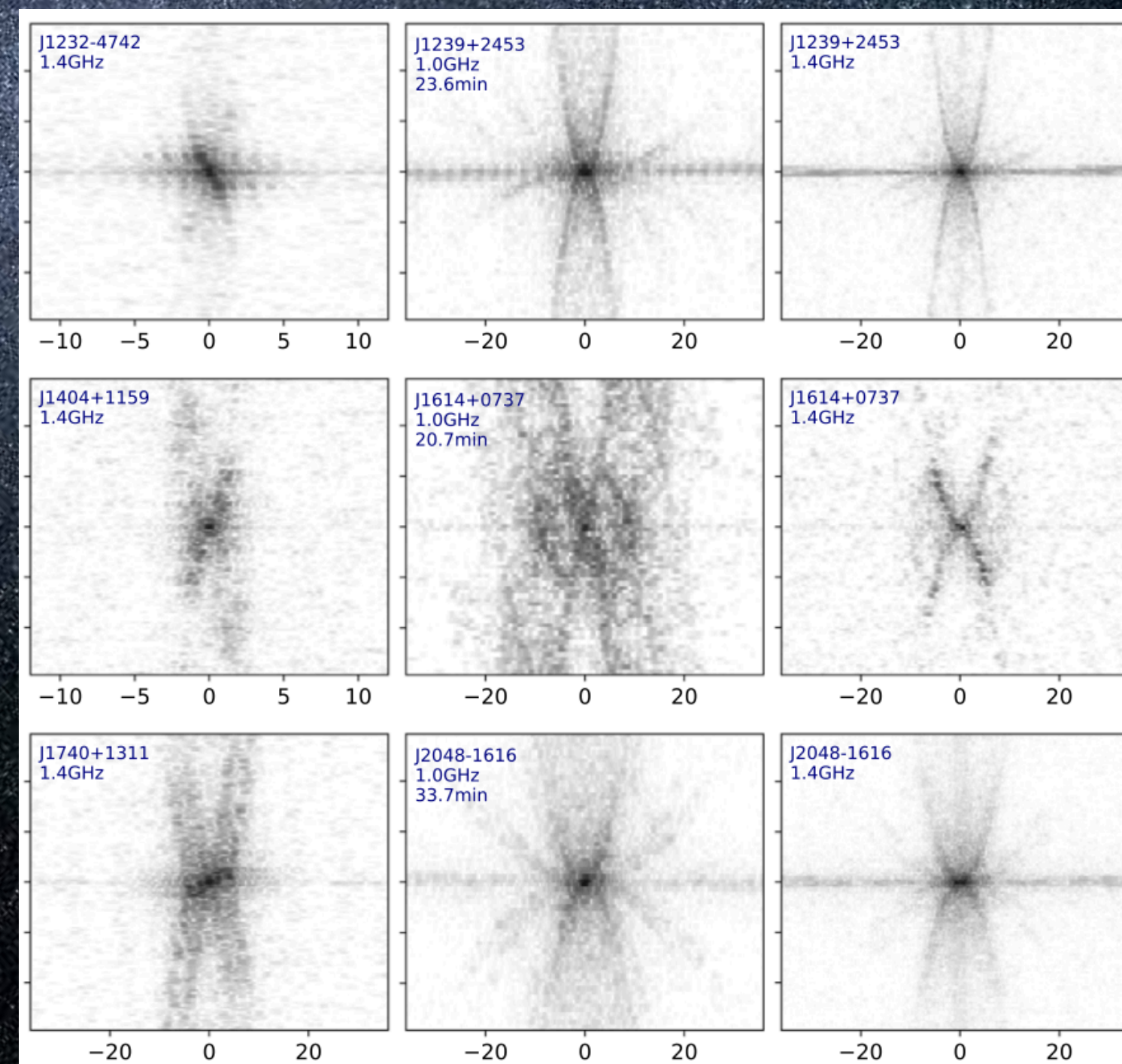
Pulsar Timing: Thousand Pulsar Array



Population studies



Study of 107 scintillation arcs



Subpulse
modulation

Study of glitches

Galactic
magnetic field

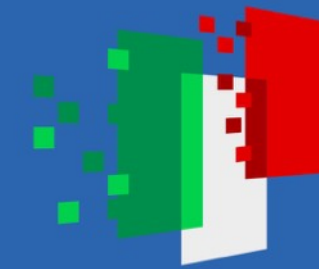
Song et al. 2023
Main et al. 2023
Posselt et al. 2023
Keith et al. in prep
Oswald et al. in prep.



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Pulsar Timing: Pulsar Timing Array

First MPTA data release with 2.5 years of data

78 pulsars observed in L-band with a cadence of 2 weeks

On course to becoming the most sensitive PTA in the Southern sky

