Present and future of pulsar research: the Italian contribute

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OUTLINE

- The Italian Pulsar Group
- Pulsars
- Current Activities
- SRT

The Italian Pulsar Group

Istituto Nazionale di AstroFisica

Università degli Studi di Cagliari

Member of VESF

The Italian Pulsar Group

Head:

Prof. N. D'Amico (OAC Director)

Full time researchers:

Dr. M. Burgay Dr. A. Possenti

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Dr. A. Corongiu

Technical support:

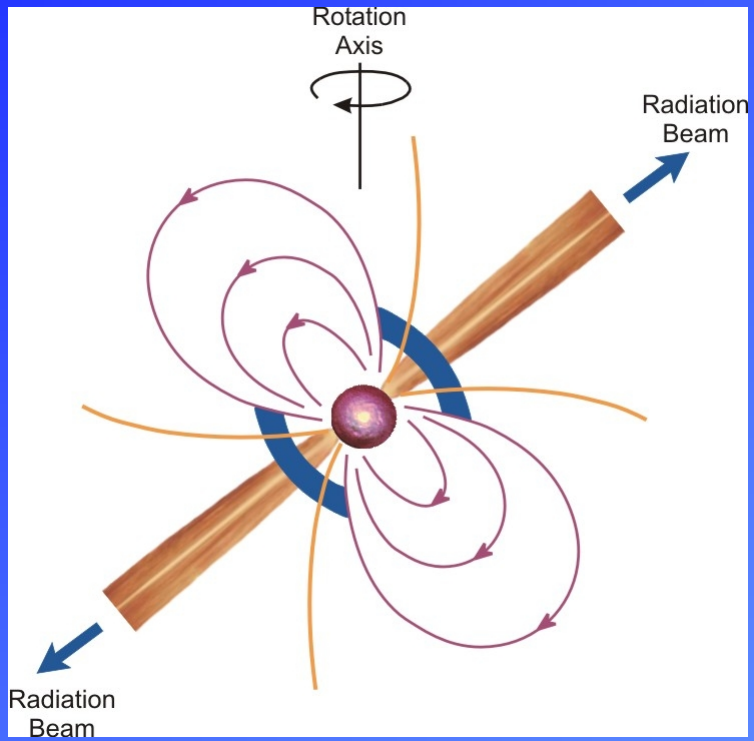
A. Fara

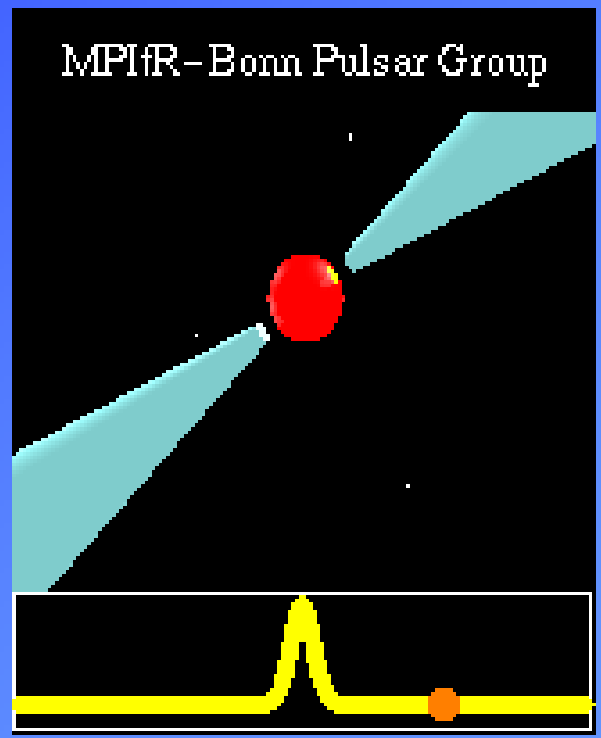
Undergraduate students:

M. Bachetti N. Iacolina M. Pierbattista

Pulsars

Higly magnetised and rapidly rotating neutron stars





Pulsars behave like very precise cosmic clocks!!!!

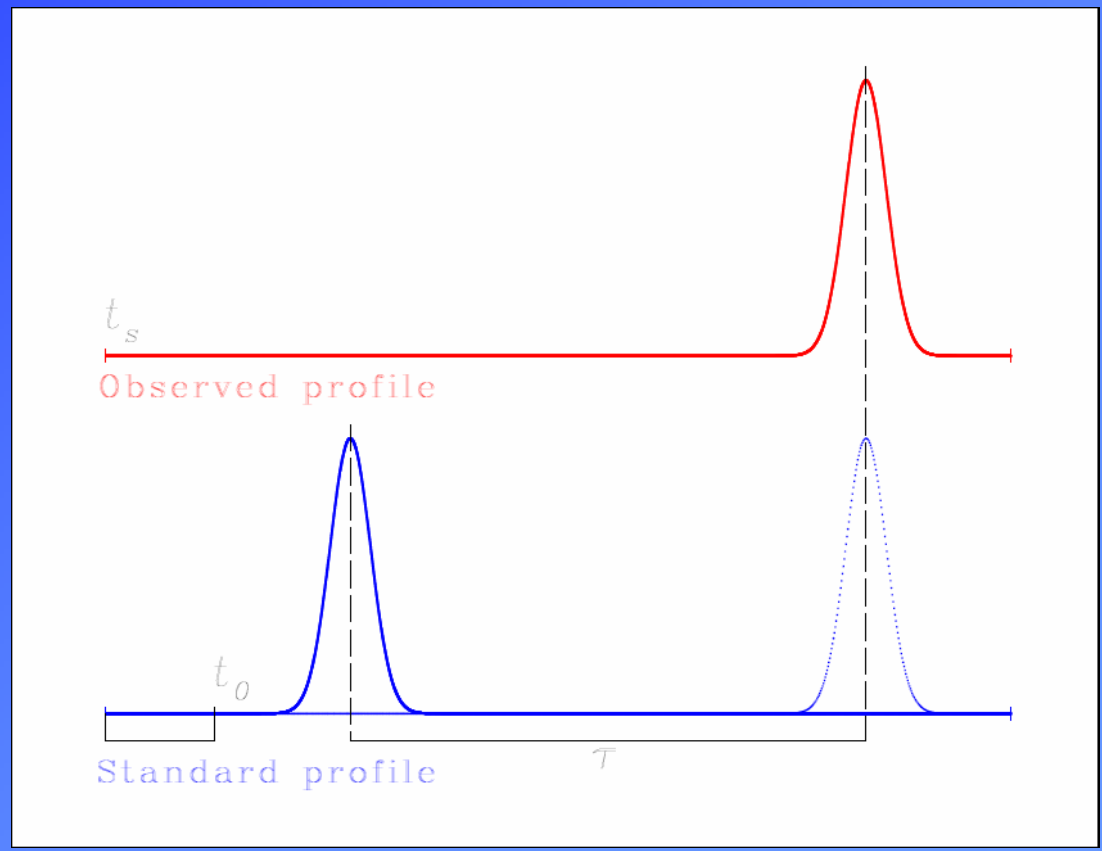
Pulses' time of arrival (ToA)

Times of arrival are determined by the convolution of the observed pulse's profile to a pulse's temlplate.

Typical uncertainties depend on:
- pulsar period
- pulse's width
- signal to noise ratio

For millisecond pulsars ToA's uncertainty can be as small as:

$\sigma \leq 1\ \mu s$



Pulsar timing

Fit procedure of all collected ToAs to a kinematical model.

A timing model is a set of measurable parameters:

- Rotation parameters
- Astrometric parameters
- Keplerian parameters
- Post Keplerian parameters

Pulsar Projects @ Cagliari

Pulsar projects at Cagliari can be grouped in two (obvious) groups:

- Survey Projects, to find out as much pulsar as possible
- Timing Projects, to extract from known pulsars as much informations as possible.

Observations are carried out with the Parkes Radio Telescope (AU).

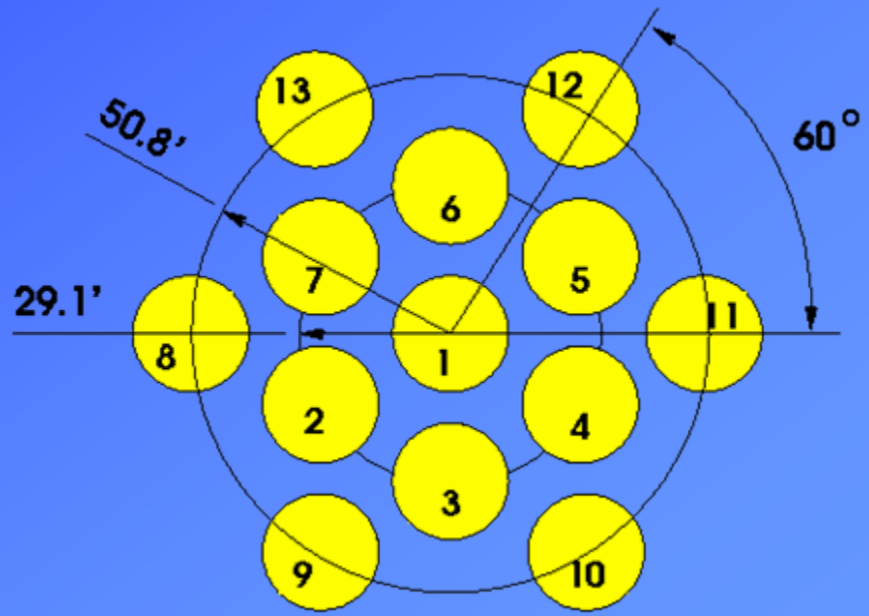
The Parkes Telescope

32° 59' 59".8657 Latitude South
148° 15' 44".3591 Longitude East

391.79 m a.s.l.
64 m diameter

Multibeam receiver

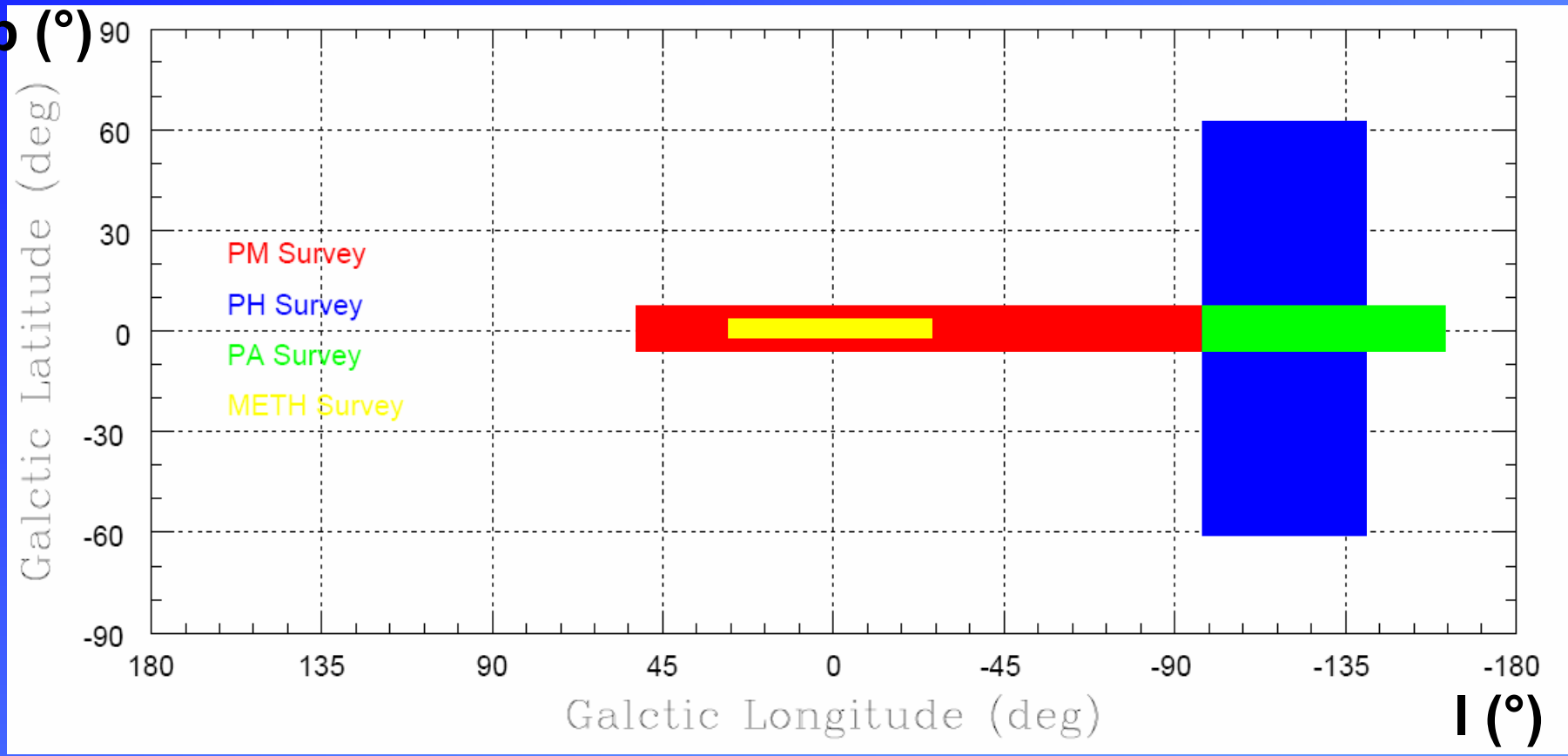
13 receivers in one to observe towards
13 different directions at once
Survey projects become **13** times faster.



Survey projects

- Parkes Multibeam Pulsar Survey (completed)
- Parkes High Latitude Pulsar Survey (completed)
- Perseus Arm Pulsar Survey (in progress)
- Parkes Methanol Pulsar Survey (just started)
- Globular Clusters' Pulsars Search (in progress)

Parkes Surveys: Sky coverage



Survey projects

	l (deg)	b (deg)	Freq. (MHz)	Bandwidth (ch x chwidth x npol)	Sampl rate (ms)	Int Time (min)
PM	-100 < l < 50	-5 < b < 5	1374	288 (96 x 3 x 2)	0.25 (1 bit)	35
PH	220 < l < 260	-60 < b < 60	1374	288 (96 x 3 x 2)	0.25 (1 bit)	35
PA	200 < l < 260	-5 < b < 5	1374	288 (96 x 3 x 2)	0.125 (1 bit)	35
METH	*-25 < l < 25*	*-1 < b < 1*	*6410*	*576 (192 x 3 x 2)*	*0.25 (1 bit)*	*70/140*

MANGUSTA

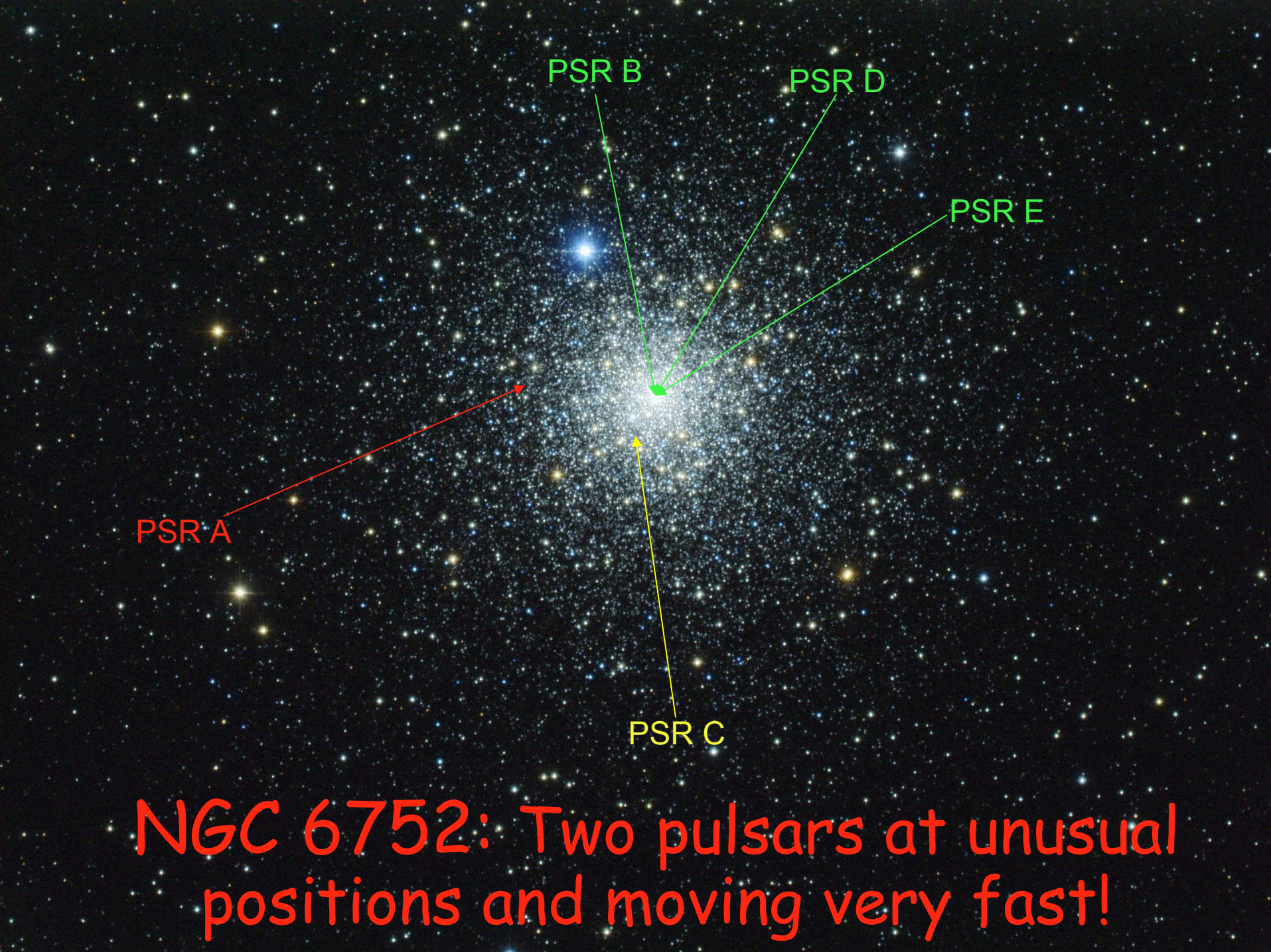
Multiprocessor
Array for
New
Generation
p**U**lsar
Searched and
Timing
Analysis

Pulsar Population

- 1627 Pulsars known
- 101 in Globular Clusters
- 20 in Magellanic Clouds
- 11 RRATS
- 124 Binaries
  - 8 Double neutron star binaries
    - 1 Double pulsar binary

Timing projects

- Timing of pulsars discovered in all aforementioned surveys.
- Timing of pulsars in globular clusters.



NGC 6752: Two pulsars at unusual positions and moving very fast!

NGC 6752: Open questions

- The high value for the line-of-sight acceleration for the central pulsars indicates a cluster core with a very high mass-to-light ratio.

- The high values for the transverse velocity of the outher pulsars indicate a cluster whose global mass-to-light ratio is too high for a globular cluster.

- There is a hint for the presence of an intermediate mass binary balck hole (10 and 50 $M_{\odot}$), which may be a source of detectable GWs.

PSR J1740-5340 in NGC 6397

- PSR J1740-5340 is a newly born millisecond pulsar.
- Radio and X-ray observations allow to investigate the physics of neutron star in accreting binaries.

PSR J1740-5340 in NGC 6397

- Binaries that produce millisecond pulsars in globular clusters are formation through casual encounters in the cluster's core.

- Some of such systems are very close and are not observable as radio pulsar because of eclipses due to the accreting matter. They may be sources of detectable GW.

PSR J0737-3039A/B

a.k.a. : the double pulsar

- It is the most relativistic binary pulsar known to date. Its discovery increased of a factor 5-10 the expected rate of coalescing binaries.
- Three years of regular timing observations have lead to the measure of 5 post-keplerian parameters… and with the highest precision!
- Within reasonable time second order PK parameters are espected to be measured.

The mass-mass diagram

Each PK parameter identifies a curve in the mass-mass diagram.

1 line:	a relation between the two masses.
2 lines:	the masses of the stars are determined **accordingly to the adopted gravity theory**
3 lines or more:	**gravity theories can be tested!**

The mass-mass diagram

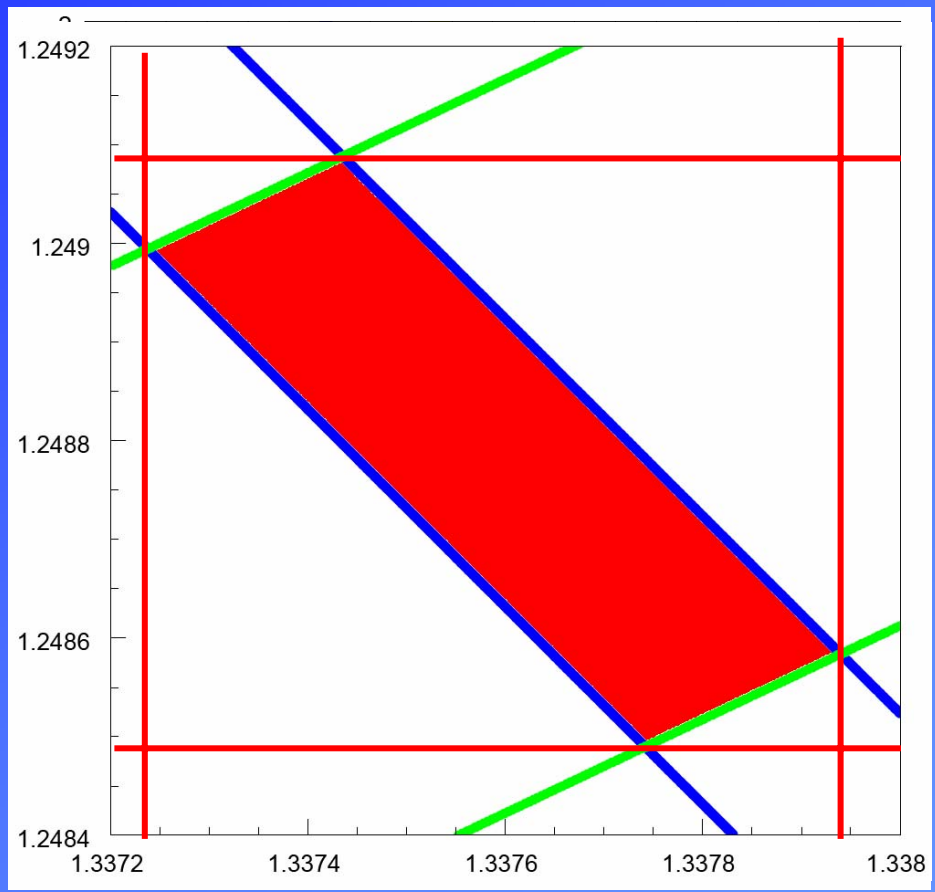
The mass-mass diagram for the double pulsar contains:

- 5 curves from the measured PK parameters

- The mass ratio line (bonus!!!): orbit's semimajor axis has been measured for both pulsars. Their ratio provides the system's mass ratio, **without calling into play any gravity theory!**

The mass-mass diagram

Confidence level: 2σ



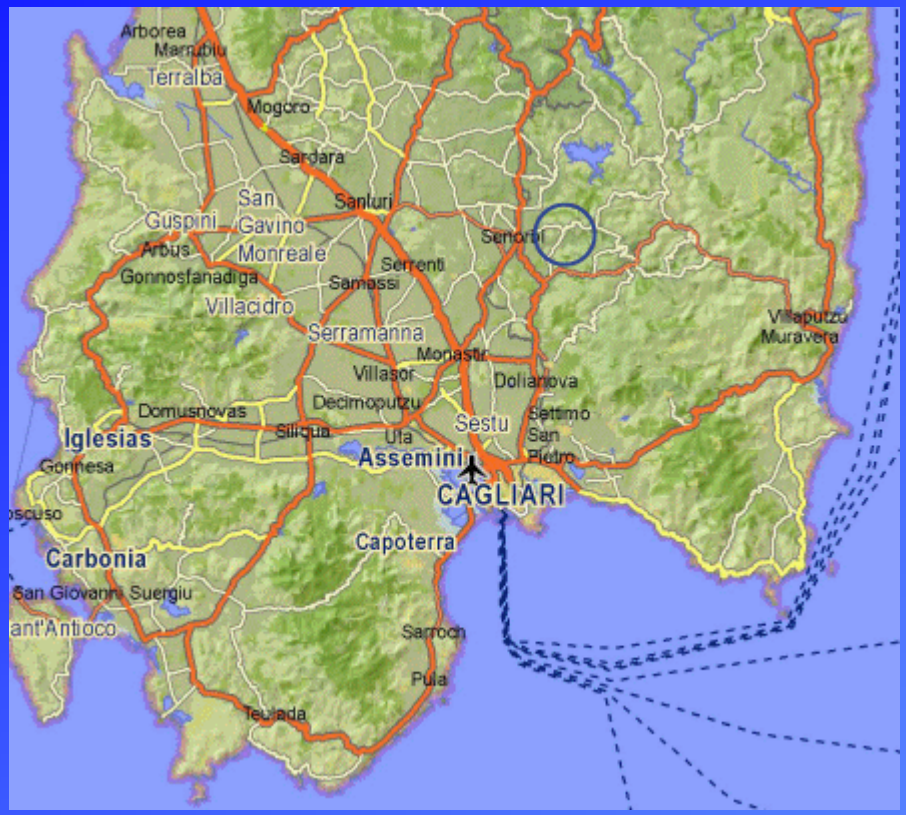
PSR A MASS ($M_\odot$)

PSR A MASS ($M_\odot$)

Some 10^{-4} $M_\odot$!

The Sardinia Radio Telescope

The Sardinia Radio Telescope



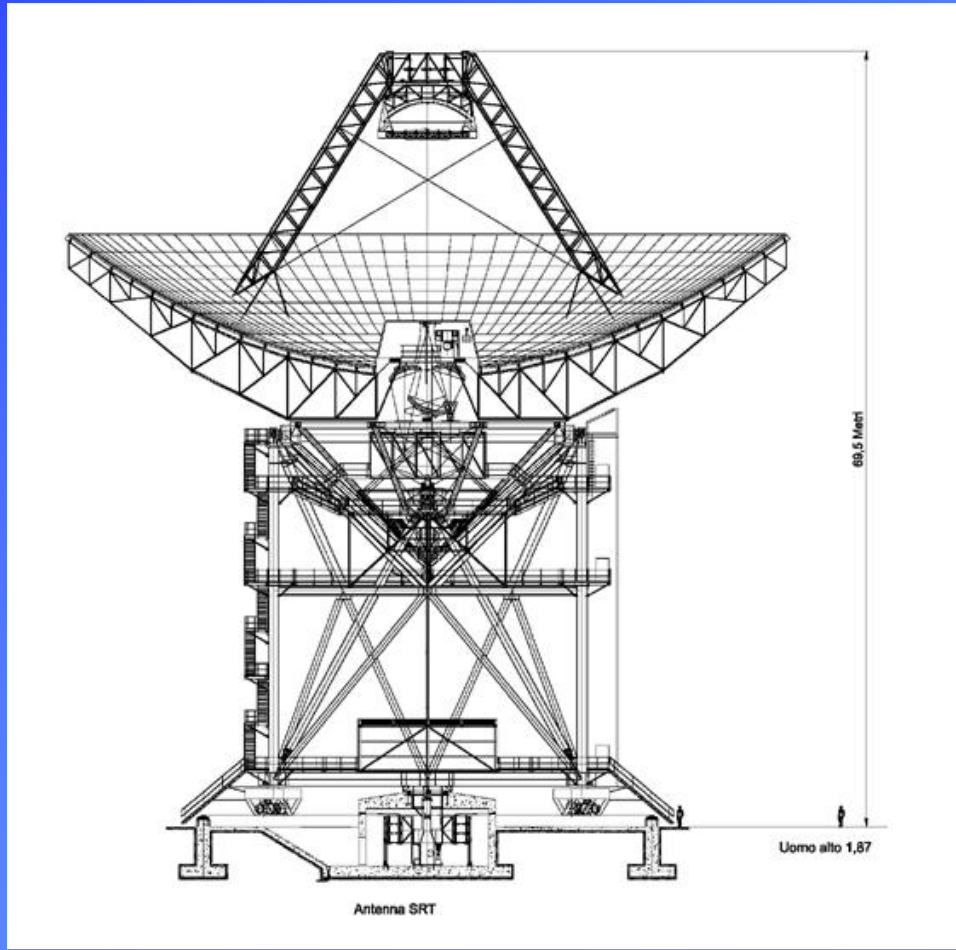
Location: San Basilio (CA) - Loc. Pranu Sanguni
Position: Lat. 39°29'50" N - Long. 09°14'40" E

The Sardinia Radio Telescope

64 m single dish antenna

Active control of the surface shape

Receivers in either primary and Gregorian focus.



The Sardinia Radio Telescope

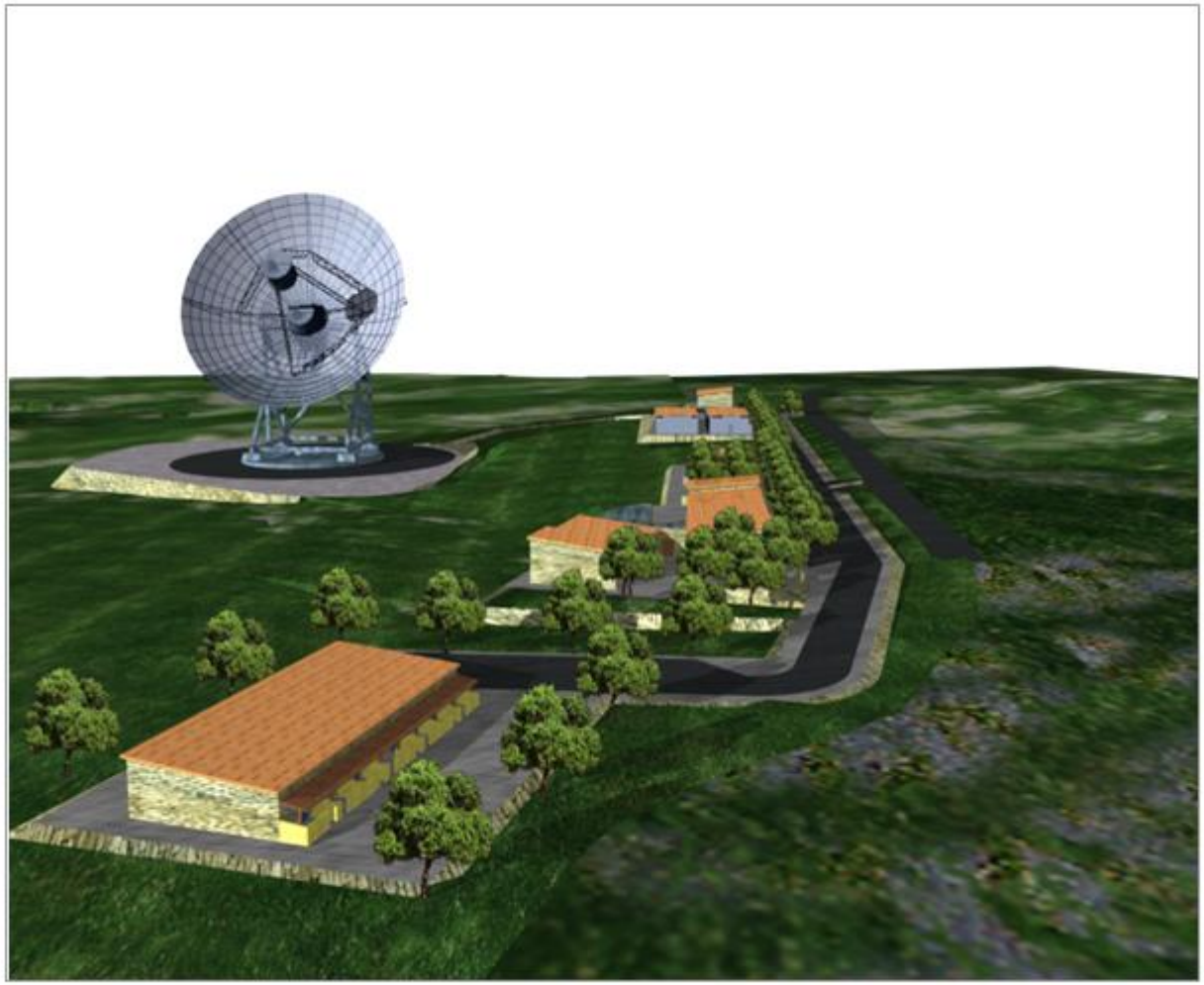
The active surface allows:

- corrections due to wind and gravity deformations.

- surface control to perform very high frequency observations up to 100GHz.

- best performances for both primary focus and Gregorian focus observations.

The Sardinia Radio Telescope



Plans for SRT

- Northern Sky Survey for young pulsars and coalescing binaries.
- Timing of young pulsars, millisecond pulsars and coalescing binaries.

Pulsar Timing Array

Pulsars discovered in Galactic Census also provide a network of arms of a huge cosmic gravitational wave detector.

Perturbations in space-time can be detected in pulsars' timing residuals.