LOFAR Magnetism KSP meeting

Sant'Antioco, 13 - 17 May 2013

14 may 2013

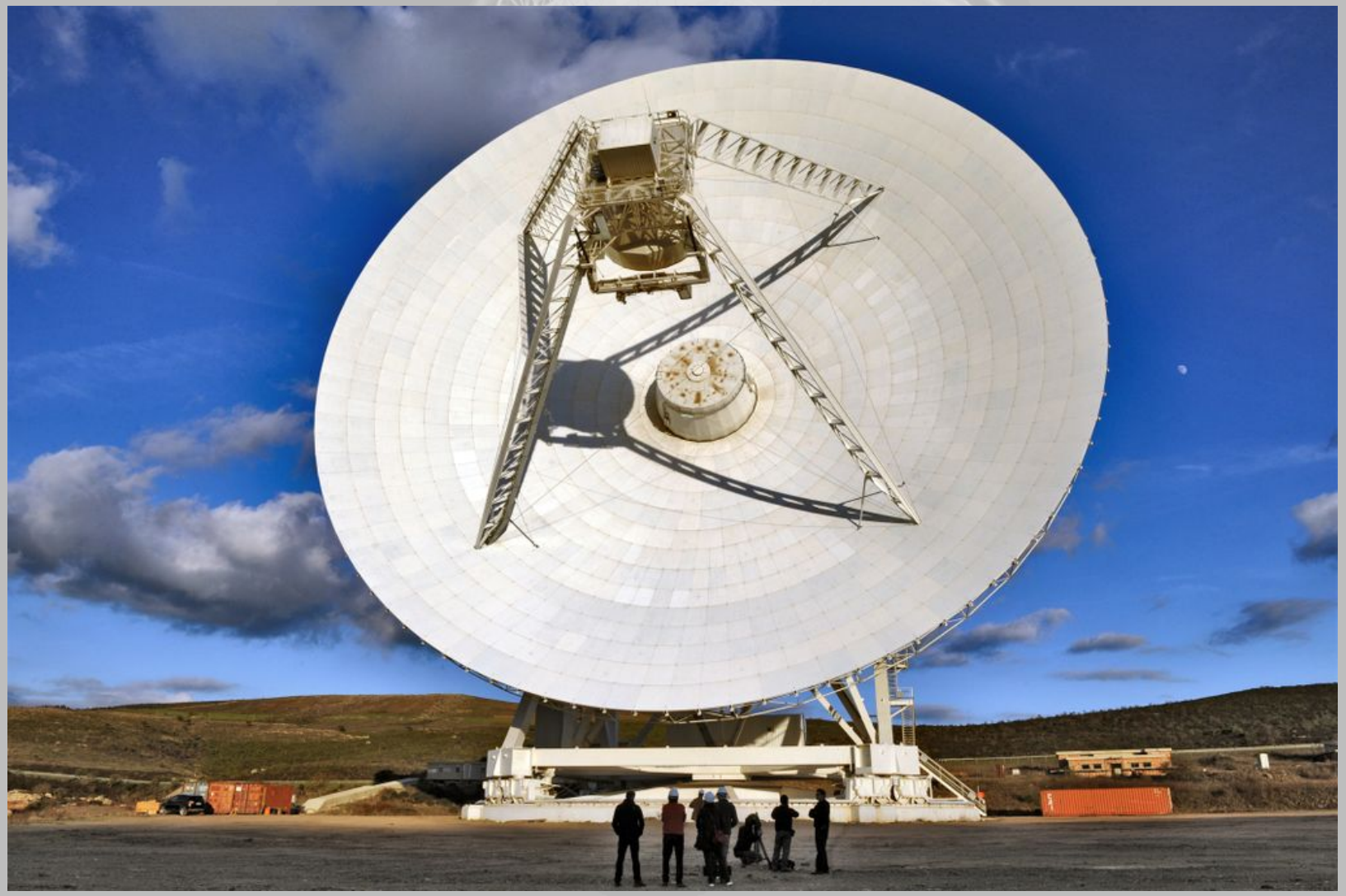
Pulsar experiments at SRT

Andrea Possenti

INAF

OAC Osservatorio Astronomico di Cagliari

Sardinia Radio Telescope



SRT timeline

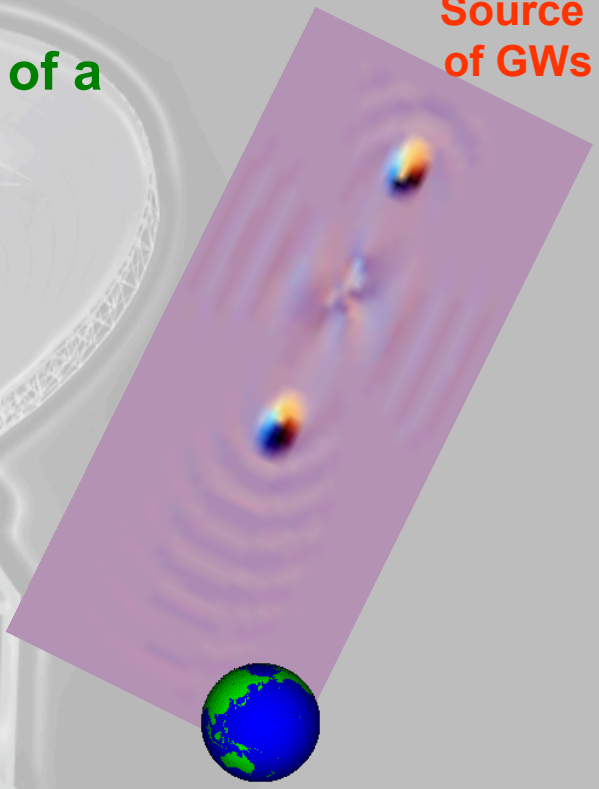
- Technical commissioning ends
  31 may 2013
- Science validation ends
  30 nov 2013
- Early science shared-risk mode ends
  late (??) 2014

Some initial ideas for exploiting SRT in the study of compact objects…

Pulsars as GW detectors

The Pulsar-Earth path can be used as the arm of a huge cosmic gravitational wave detector

Perturbation in space-time can be detected in timing residuals over a suitable long observation time span



Radio Pulsar

Sensitivity (rule of thumb):

$$h_c(f) \sim \frac{\sigma_{TOA}}{T}$$

where

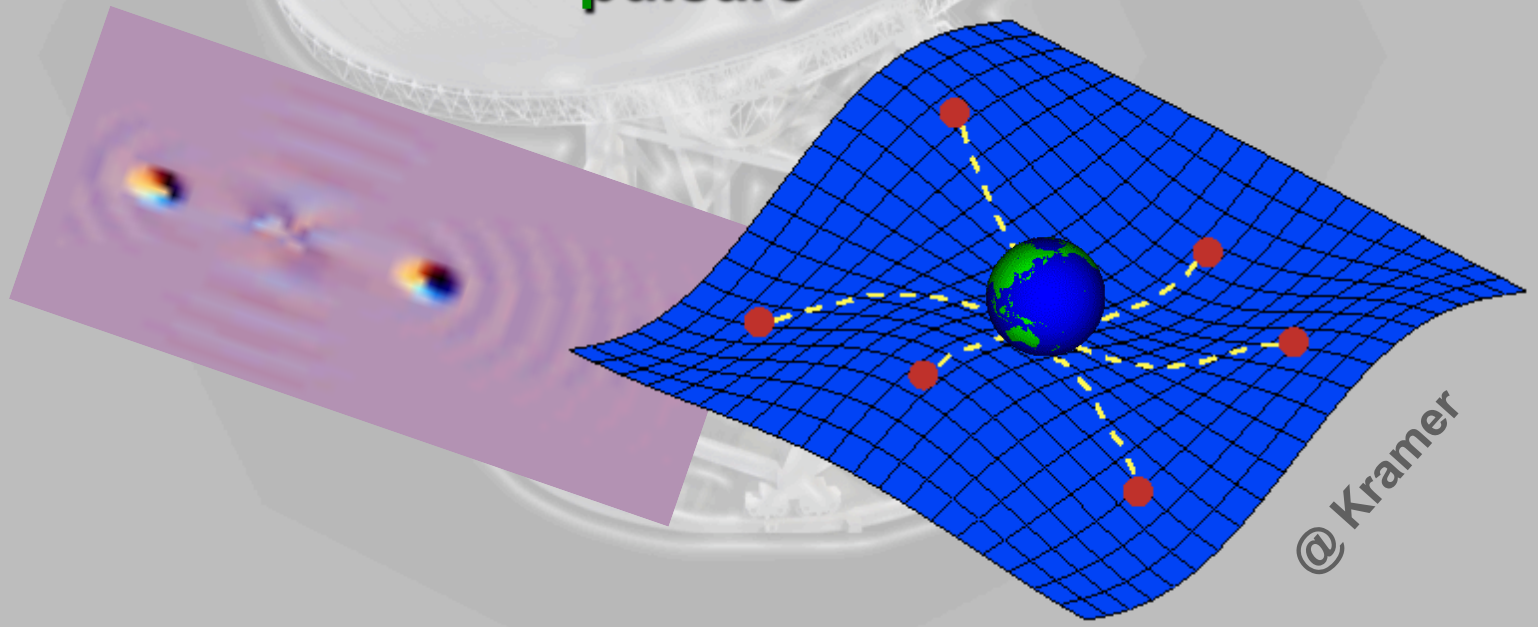
$h_c(f)$ is the dimensionless strain at freq f

σ_{TOA} is the rms uncertainty in Time of Arrival

T is the duration of the dataspan

A pulsar timing array (PTA)

Using a number of pulsars distributed across the sky it is possible to separate the timing noise contribution from each pulsar from the signature of the GW background, which manifests as a local (at Earth) distortion in the times of arrival of the pulses which is common to the signal from all pulsars



GW detection from coalescing black-holes

LEAP : Large European Array for Pulsars
(funded by EU grant for 5 years: PI M.Kramer)

Combining "coherently" all the 5 major european telescopes, SRT will be part of the best available telescope at 20cm-band for timing before SKA era…

+

…unique capability of SRT in removing interstellar medium effects, thanks to the dual band 20+90 cm receiver

Pulsar Front-ends

Dual Band receiver

(L-Band: 1.3-1.8 GHz ; P-Band: 305-425 MHz)

Pulsar Front-ends

Dual Band receiver

Receiver tested on the ground at mid april
and in primary focus since past week

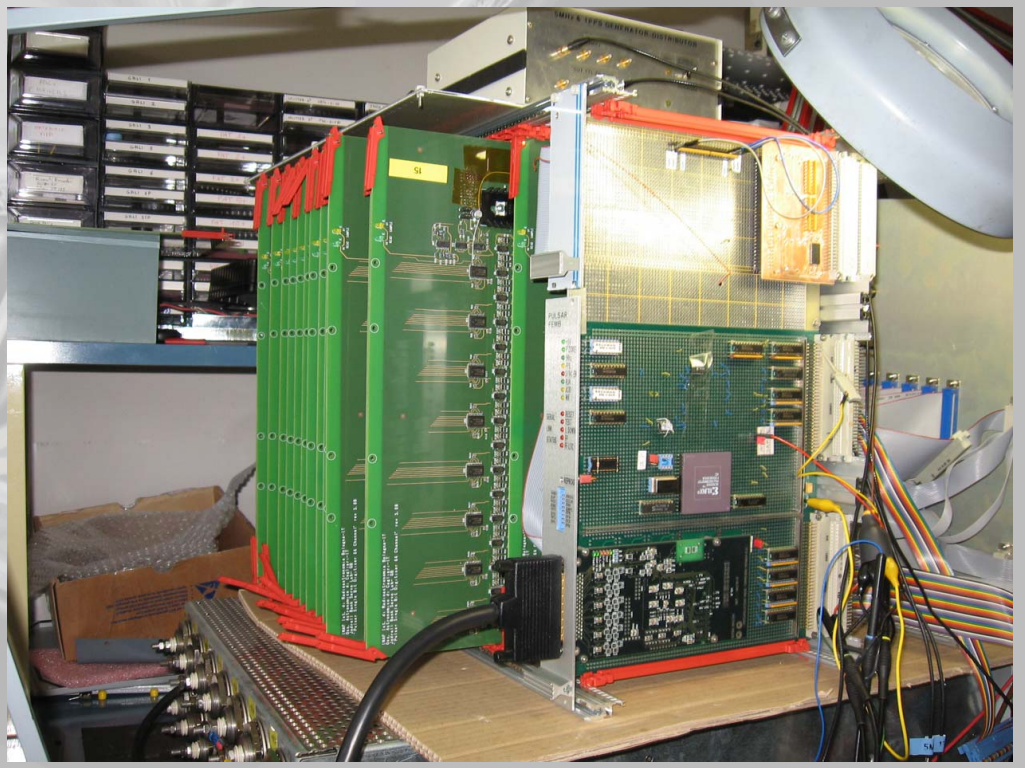
Pulsar Backend # 1

The analogue filterbank

- 512MHz BW, dual polarization
- Analog filter bank 2X1024 channel 512KHz bw/channel
- 1 bit digitizer 1024 channel (the 2 polarizations are added at input)
- Max Sample rate 10 microseconds

Filter bank rack

Digitizer bank test

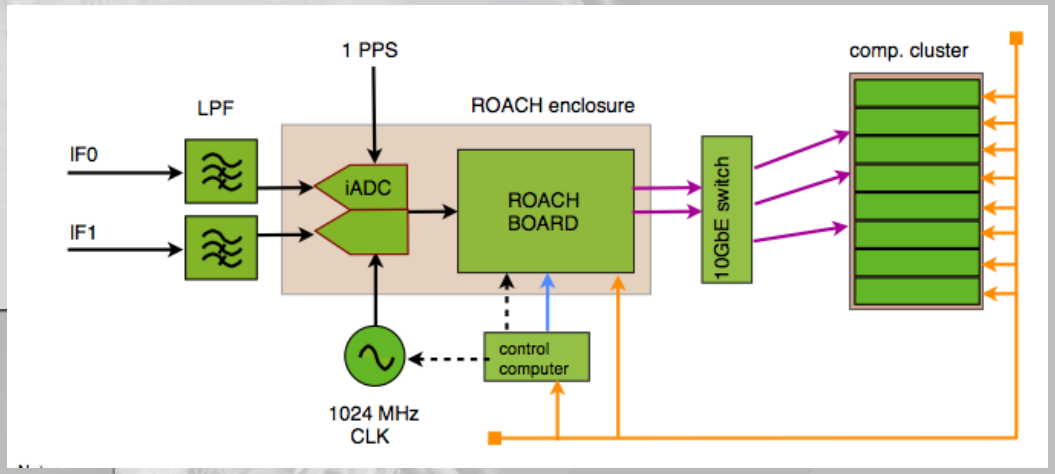


Pulsar Backend 2

Dual Band DFB from ATNF

Pulsar Back-end # 3

Roach 1



ROACH 1 tested in the laboratory with a fake injected pulsar signal: all ok

Pulsar Back-ends location

The DFB3 and ROACH1 systems will be moved next week to the site.

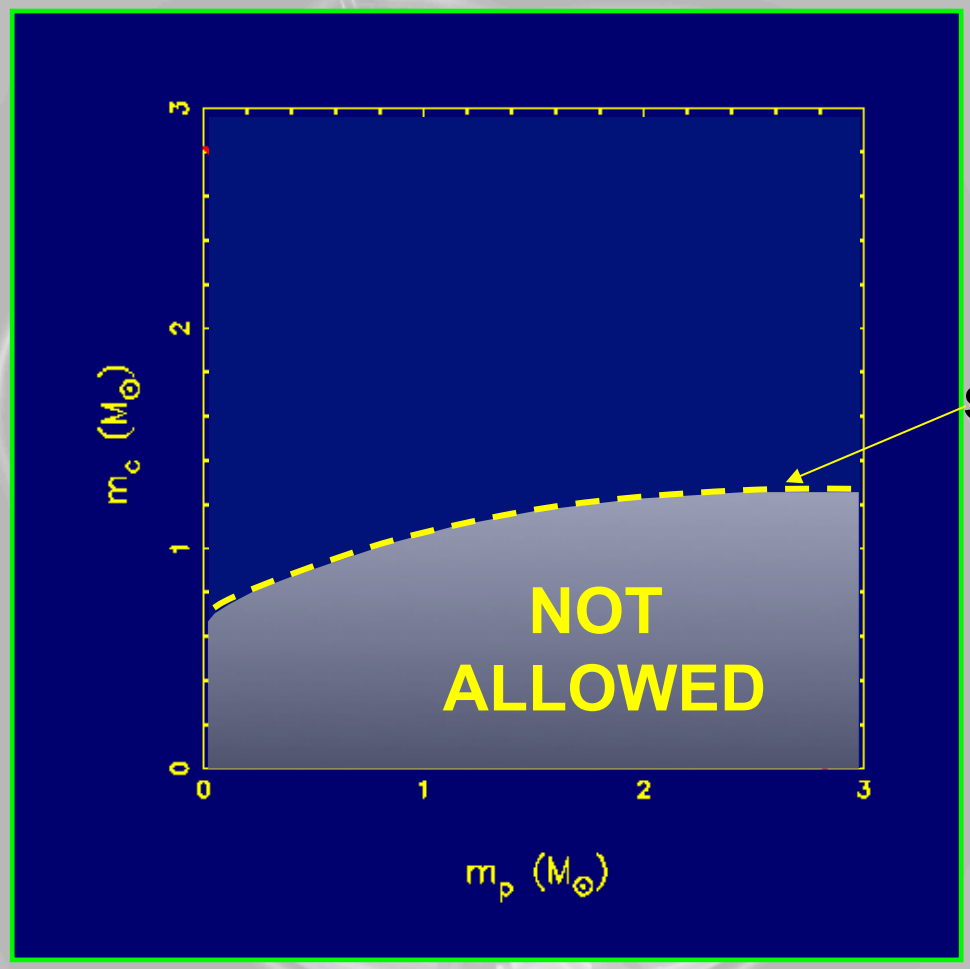
Observing post-keplerian parameters in binary pulsars

The easiest to observe post-keplerian parameters

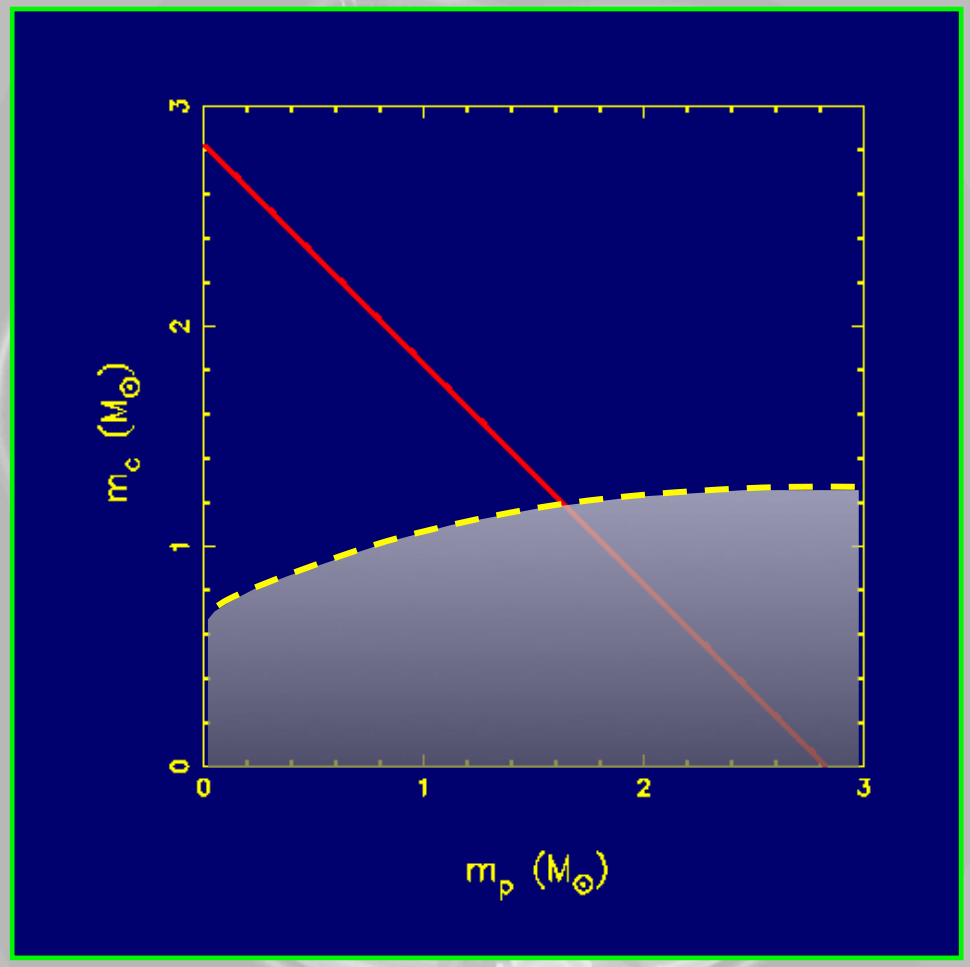
- $\dot{\omega}$: Periastron precession
- γ : Time dilation and gravitational redshift
- **r** : Shapiro delay “range”
- **s** : Shapiro delay “shape”
- $\dot{P}_b$: Orbit decay due to Gravitational Wave emission

$$f(m_p, m_c) = \frac{4\pi^2}{G}\frac{(a_p \sin i)^3}{P_{orb}^2} = \frac{(m_c \sin i)^3}{(m_p + m_c)^2}$$

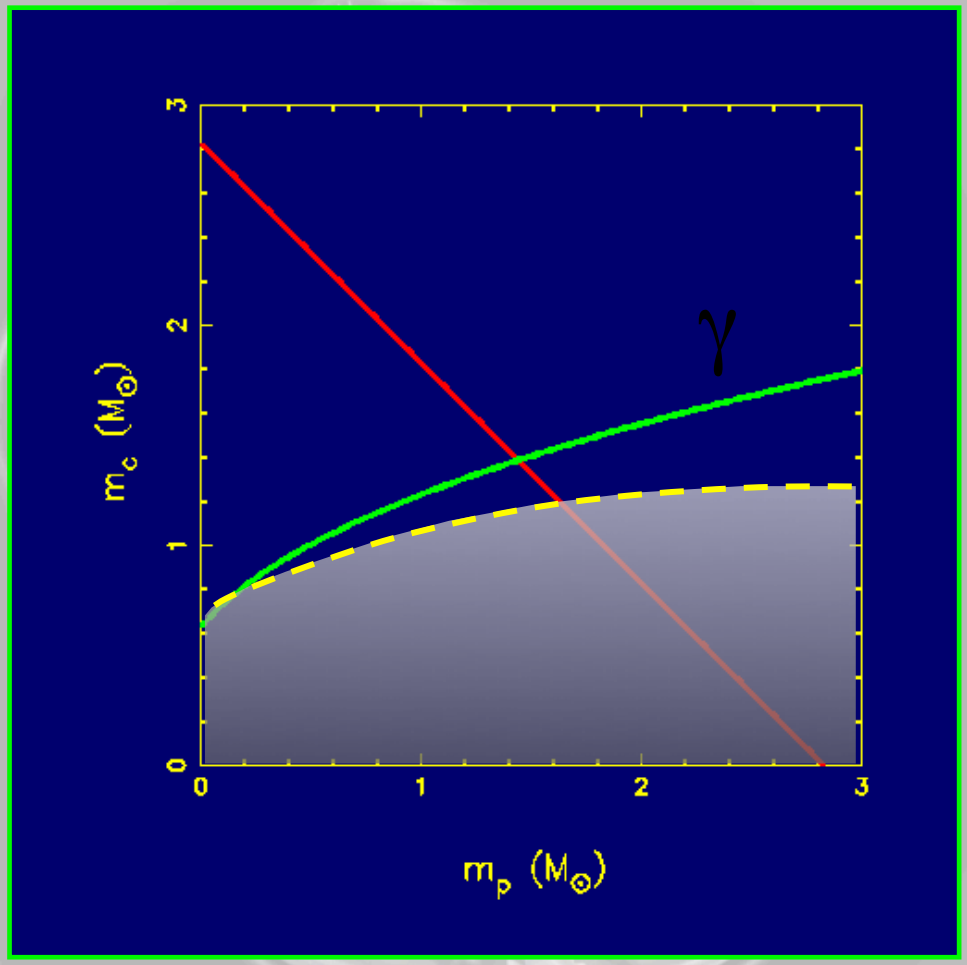
Mass Function constraint



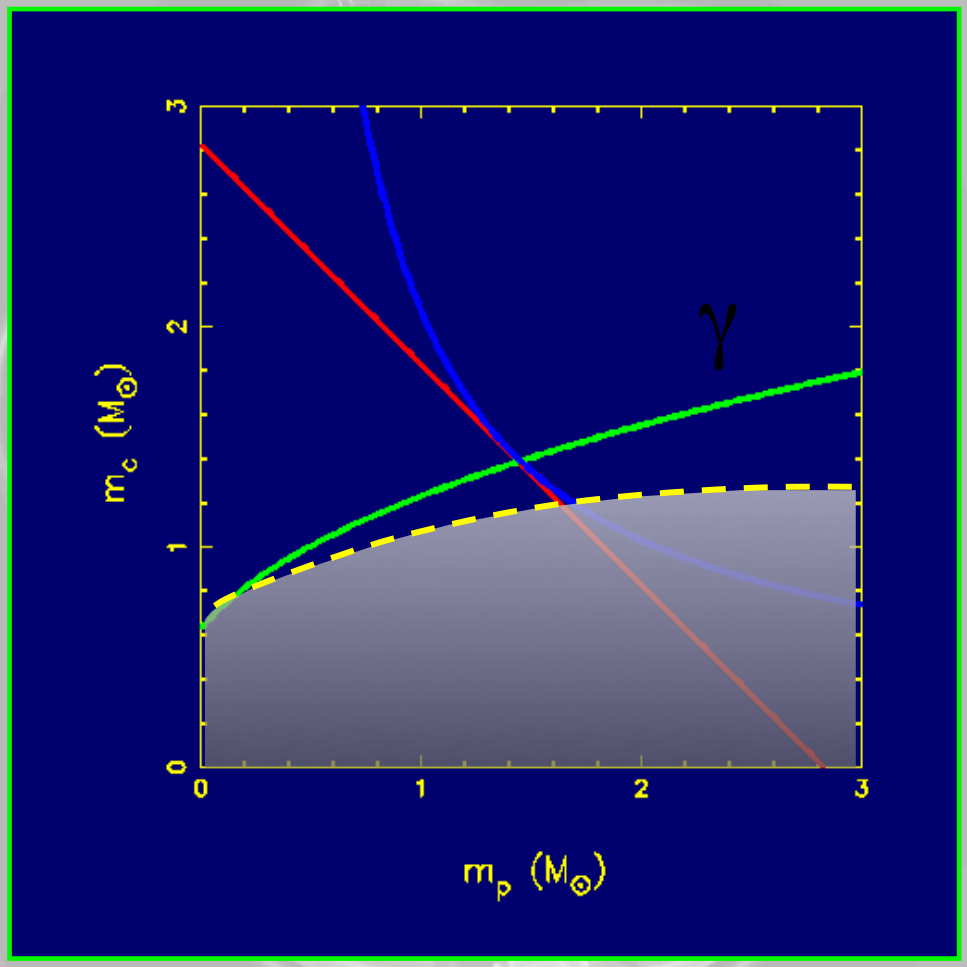
The pulsar and companion star masses are unconstrained



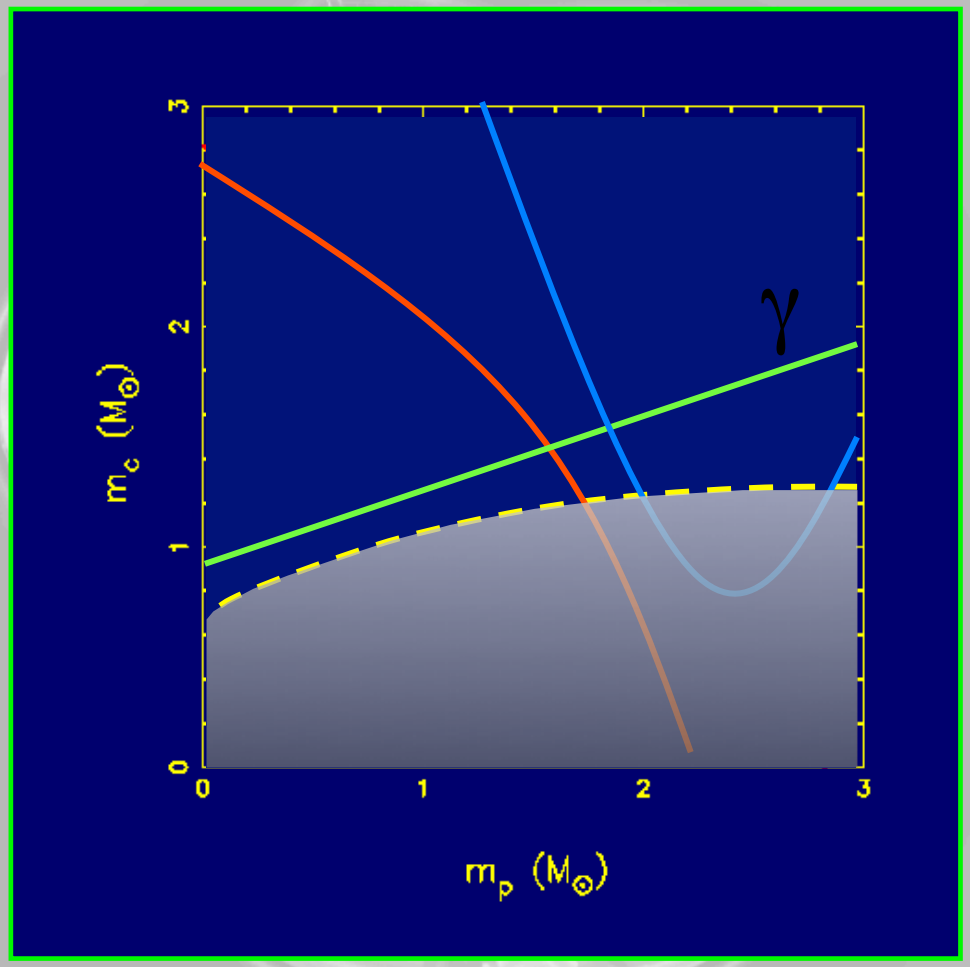
One PK-parameter: constraining mass



Two PK parameters: mass determined within a theory



Three PK parameters: in correct theory lines meet !

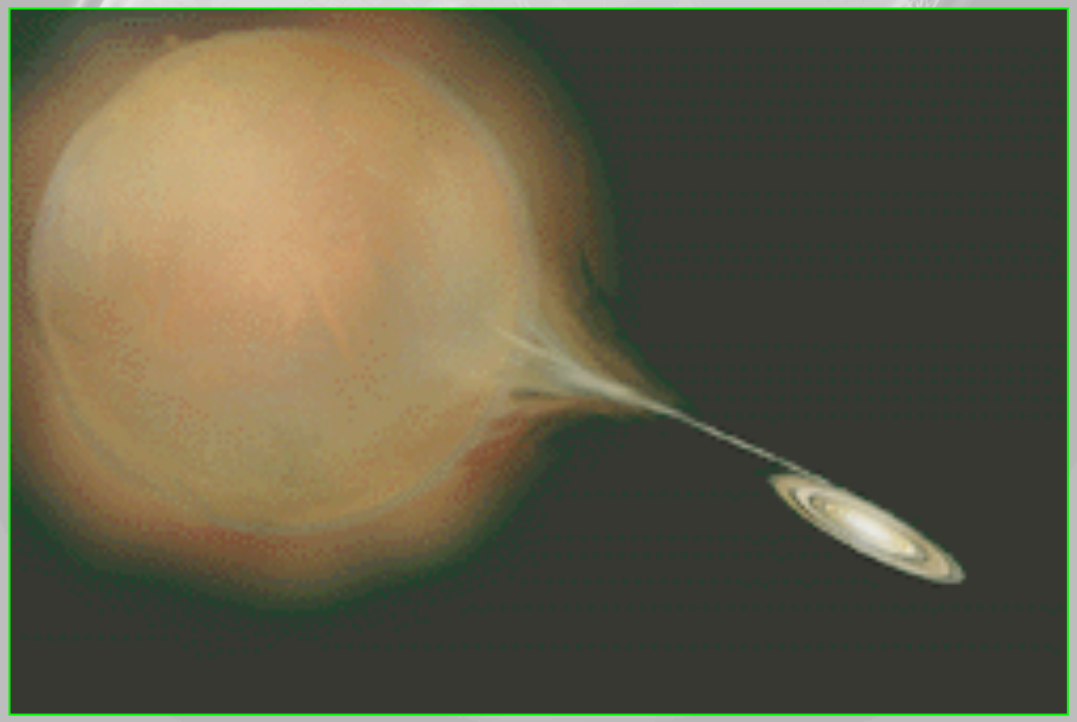


But not in a wrong theory !!!

The Millisecond Pulsar formation paradigm

Recycling scenario: Millisecond pulsars are old neutron stars spun up by accretion of matter and angular momentum from a companion star in a multiple system

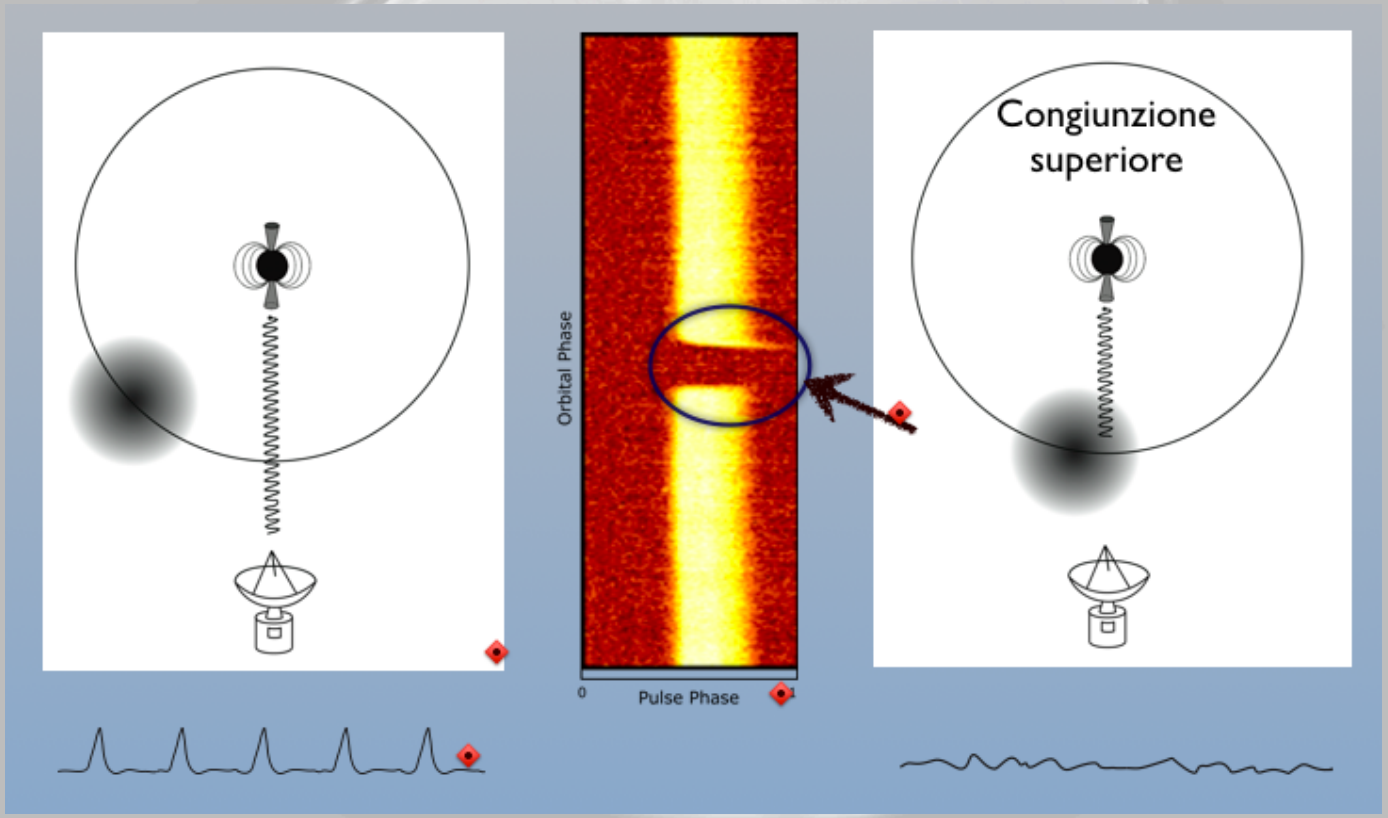
(Bisnovati-Kogan & Kronberg 1974, Alpar et al. 1982)



But what about the isolated Millisecond pulsars ?

Observing Eclipsing Pulsars

The unique 20+90 cm receiver will be a unique instrument for investigating the radio eclipse phenomenology simultaneously at various frequencies

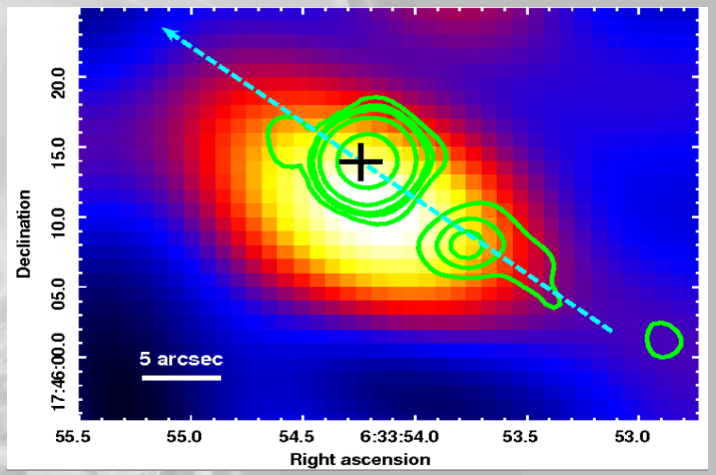


@ A. Ridolfi

Due to eclipse irregularities, this is the best kind of observations for constraining eclipse mechanisms and the physics and geometry of last stage of mass transfer

SNR+PWN mapping: space resolved spectral mapping

Exploiting the relatively wide beam and the large spectral coverage, a detailed spectral study of a large sample of SNRs at high radio frequencies with consequences on Cosmic Ray origin problem



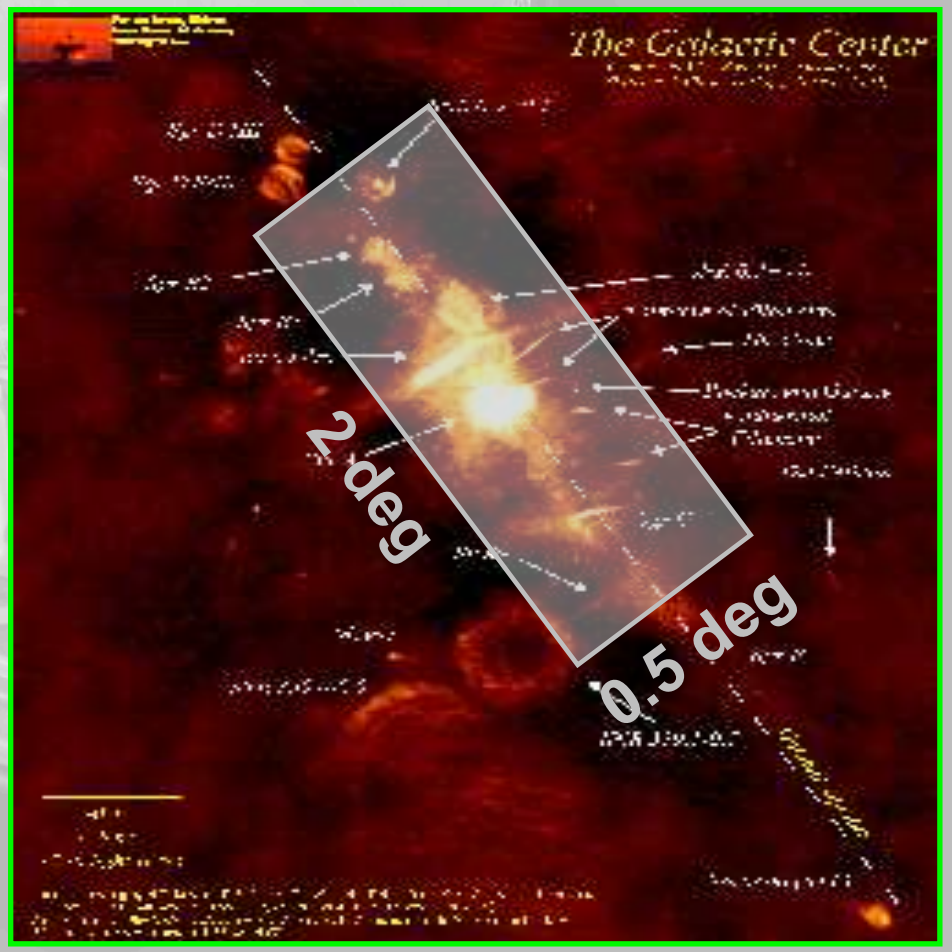
Pellizzoni et al, 2011

Search for pulsars in unassociated Fermi Sources or other intriguing sources

Searching a pulsar orbiting SGR A*

PSR22 : a Galactic Center survey for Pulsars at 22 GHz

The availability of a multi-feed receiver at 22 GHz open the possibility of performing the best survey ever for recycled pulsars in the Galactic Center



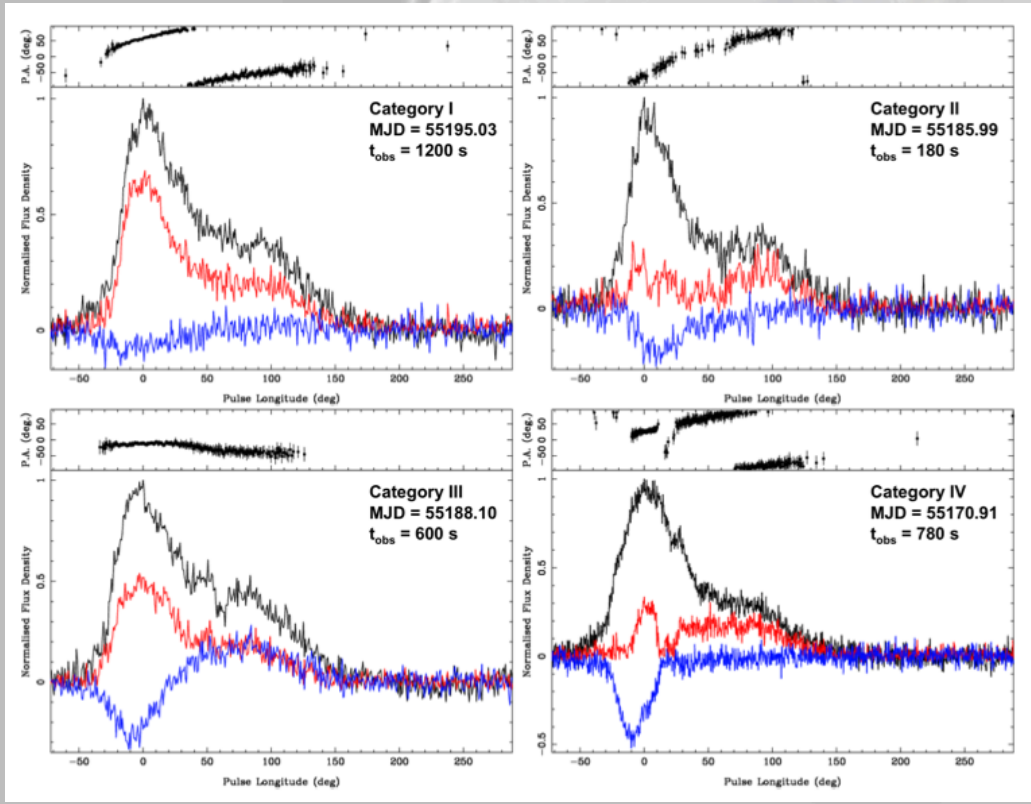
SRT Multi-beam Receiver

7 beam operating btw 18 and 26 GHz

Radio vs High Energy Emission properties and Transients

Long Term & Prompt Monitoring:

Radio magnetars, transients, etc…



Levin et al, 2012,

Good sensitivity and likely rapid response time will allow the NS community to be at the front line in the follow up in the radio band of transients in the high energy bands …

...a magnetar and transient has been the first target of a scientific investigation with SRT

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Present Time: 13 May 2013; 22:19 UT

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Detection by Sardinia Radio Telescope of radio pulses at 7 GHz from the Magnetar PSR J1745-2900 in the Galactic center region

ATel #5053; *Marco Buttu (INAF-Osservatorio Astronomico di Cagliari), Nichi D'Amico (INAF-OAC), Elise Egron (INAF-OAC), Maria Noemi Iacolina (INAF-OAC), Pasqualino Marongiu (INAF-OAC), Carlo Migoni (INAF-OAC), Alberto Pellizzoni (INAF-OAC), Sergio Poppi (INAF-OAC), Andrea Possenti (INAF-OAC), Alessio Trois (INAF-OAC), Gian Paolo Vargiu (INAF-OAC), on behalf of the Sardinia Radio Telescope Science Validation Team and the Commissioning Team*
on 7 May 2013; 19:19 UT
Credential Certification: Marta Burgay (burgay@oa-cagliari.inaf.it)

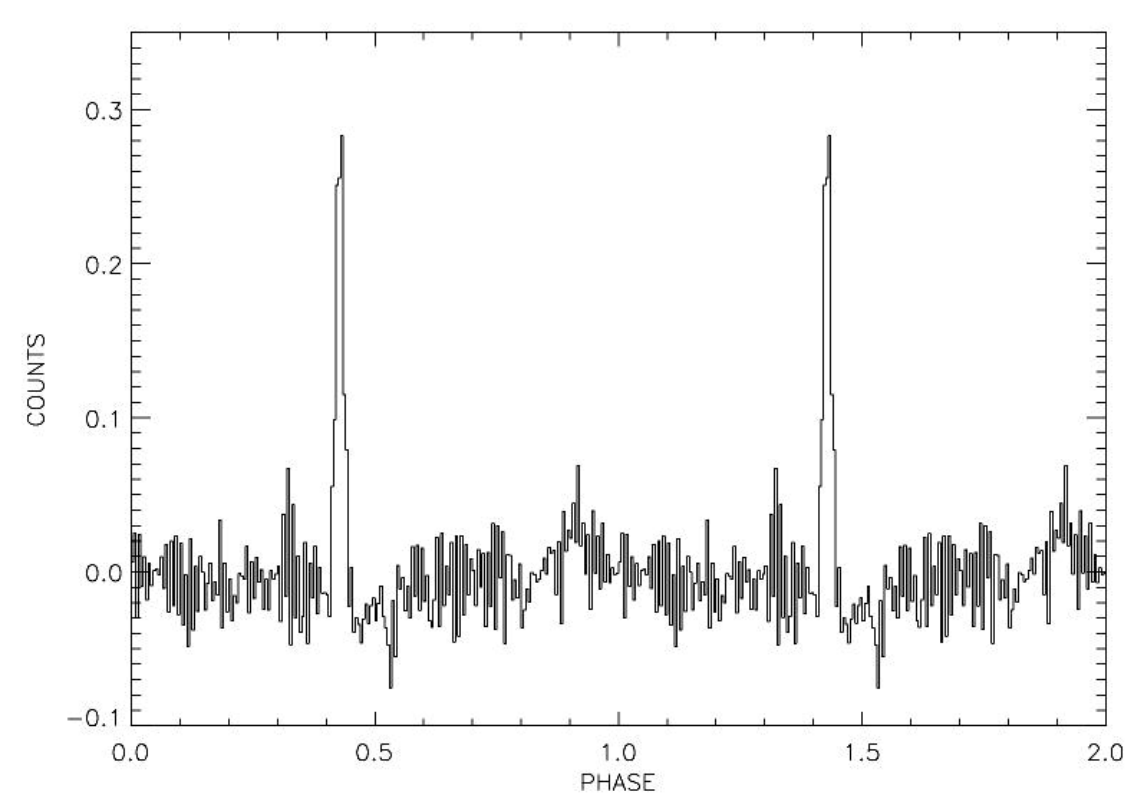
Subjects: Radio, Neutron Star, Soft Gamma-ray Repeater, Pulsar

Referred to by ATel #: 5058

During the Sardinia Radio Telescope (SRT) science verification phase, we observed PSR J1745-2900, firstly detected as an X-ray flare from Sgr A* by Swift and then identified as a

SRT 6-7 GHz Receiver

1 beam



PSR J1745-2900: a 3.7 sec magnetar a 3” from the position of SgrA*


Thank you!