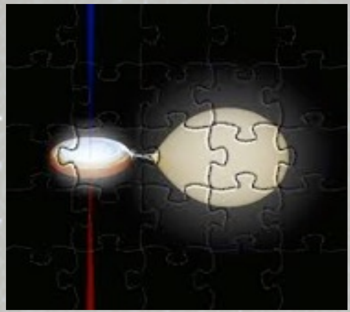


9° Congresso Nazionale
Oggetti Compatti
22 september 2015 – Monte Porzio Catone

New facilities for studying the compact objects in radio band: from SRT to SKA

Andrea Possenti

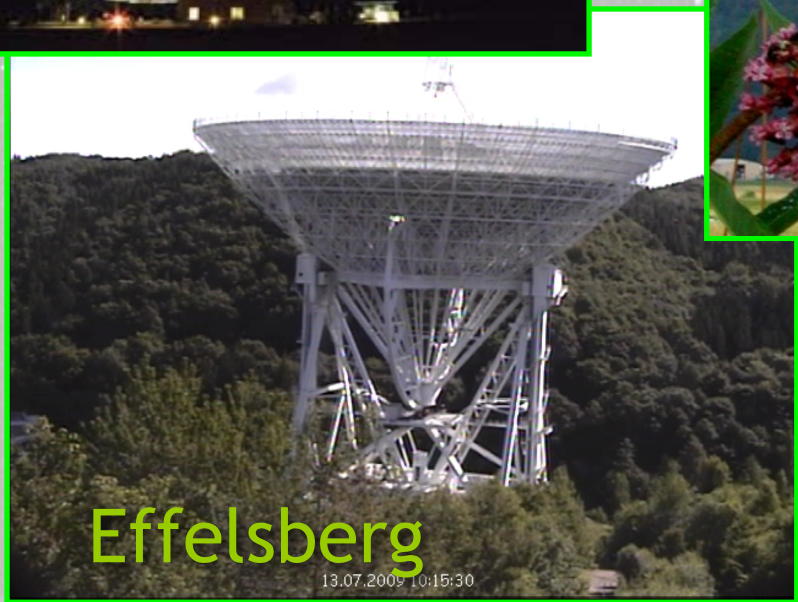
Osservatorio di Radioastronomia – INAF Istituto Nazionale di Astrofisica
OAC Osservatorio Astronomico di Cagliari

SRT

- *Fully steerable, wheel-and-track radio telescope*
- *Frequency coverage: 0.3 - 115 GHz (almost continuously)*
- *Primary mirror diameter: 64 m*
- *Quasi-Gregorian system with shaped surfaces*
- *Active optics: 1116 actuators*
- *6 focal positions (up to 20 receivers): Primary, Gregorian, 4 Beam Wave Guide*
- *Frequency Agility*

Is SRT good for staying at the forefront of the compact object science?

The main competitor telescopes



SRT vs (br)others single dishes: 2011@Bormio

SRT		GBT	PKS	Bonn
Ok	high instantaneous sensitivity (i.e. 64-100 m class dish)	Ok	Ok	Ok
Ok	large bandwidth (i.e. ≈ 20-30% of central freq)	Ok	Ok	Ok
Ok	dual band low freq receiver	No	Ok	No
Ok	digital filter-bank	Ok	Ok	Ok
Ok	base-band recording system	Ok	Ok	Ok
Ok	multi-beam at high frequency	Ok	No	No
No	multi-beam at low frequency	No	Ok	Ok
Ok	good RFI environment	Ok	Ok	No

SRT vs (br)others single dishes: 2015@Mporzio

SRT		GBT	PKS	Bonn
Ok	high instantaneous sensitivity (i.e. 64-100 m class dish)	Ok	Ok	Ok
Ok	large bandwidth (i.e. ≈ 20-30% of central freq)	Ok	Ok	Ok
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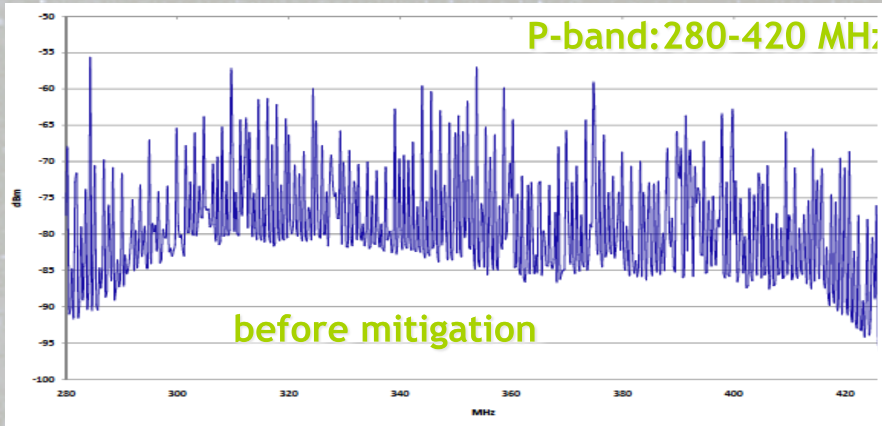
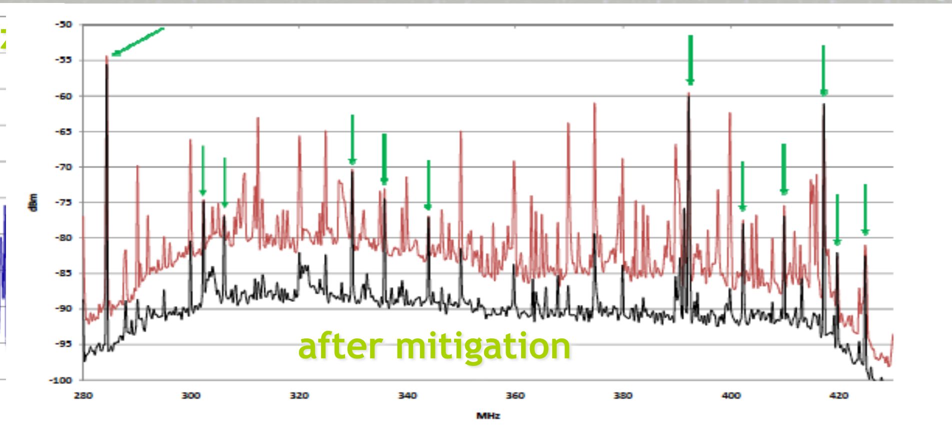
Ok	base-band recording system	Ok	Ok	Ok
Ok	multi-beam at high frequency	Ok	No	No
Ni	multi-beam at low frequency	No	Ok	Ok
Ni	good RFI environment	Ok	Ok	No

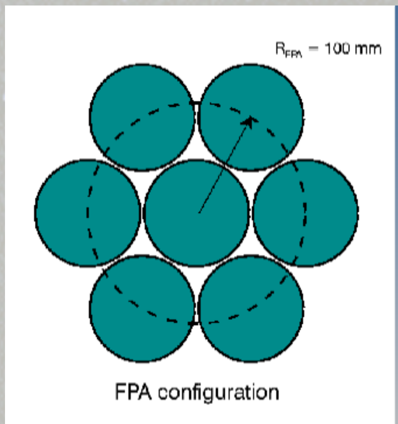
Self induced RFI

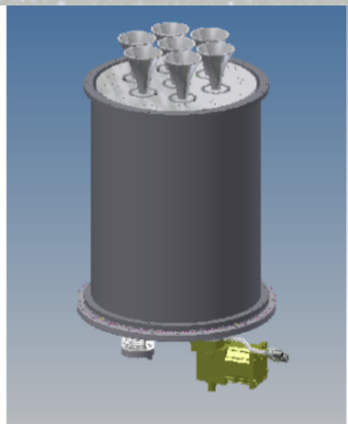


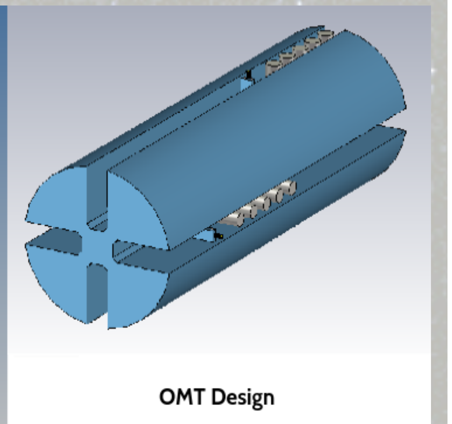


SRT science validation team

The 7-beam 2.3/4.3 GHz receiver







P.I. Noemi Iacolina

Funded by Sardinia Regional Government

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

GW detection from coalescing black-holes

LEAP : ***Large European Array for Pulsars***

(funded by EU grant for 5 years)

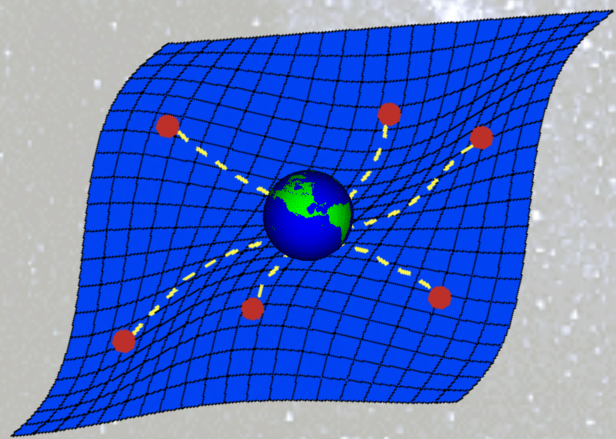
Combining "coherently" all the 5 major european telescopes, SRT will be part of the best available telescope at 20cm-band for timing before SKA era…

+

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

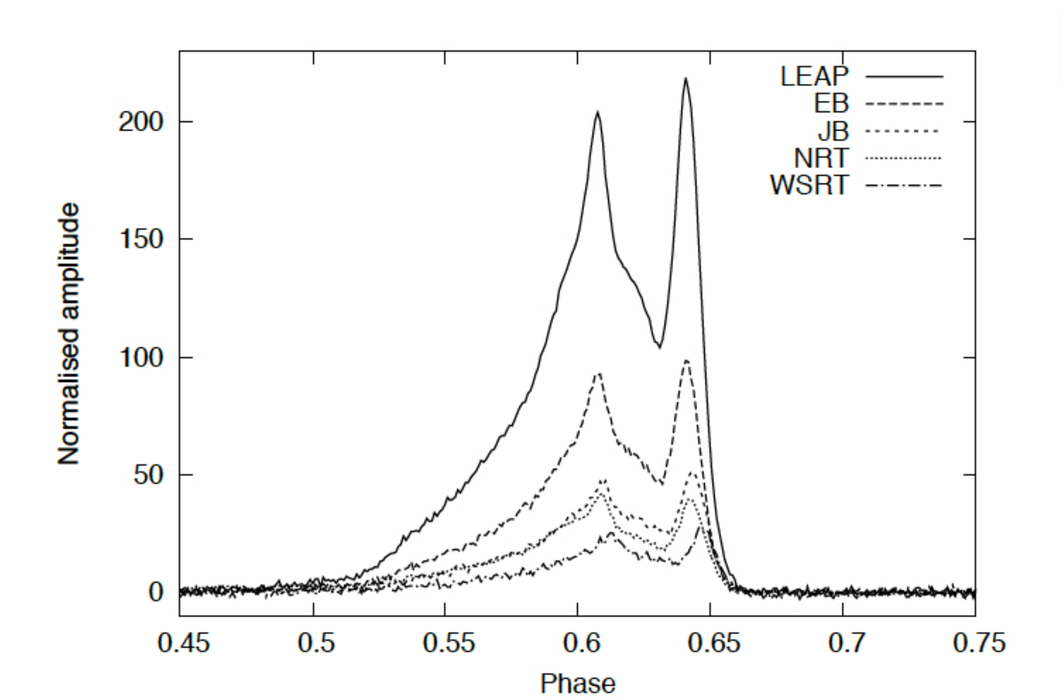
⬇

A world leader experiment for detecting the Cosmological Background of Gravitational Waves (and perhaps some close discrete sources) from the signature on the pulsar timing residuals of the perturbations in the space-time

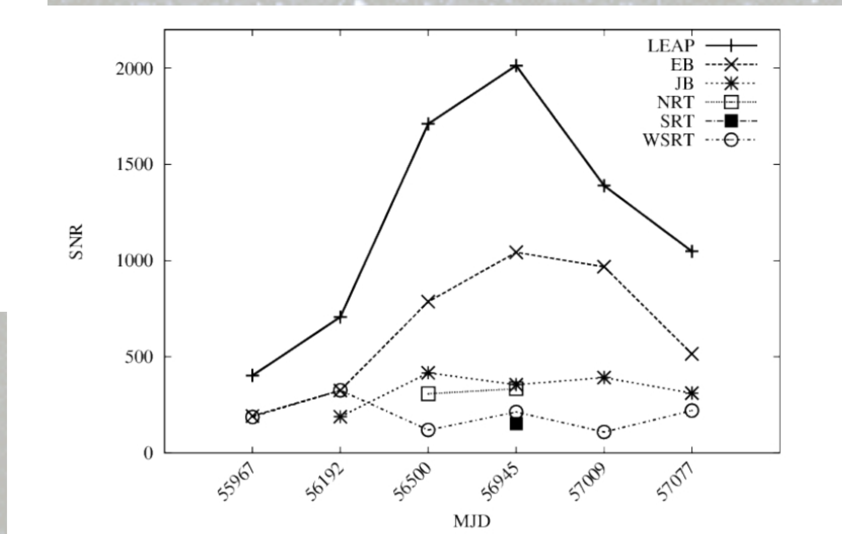


(talks Perrodin, Ricci, Palomba +…)

Some provisional LEAP results



PSR J1022+1001

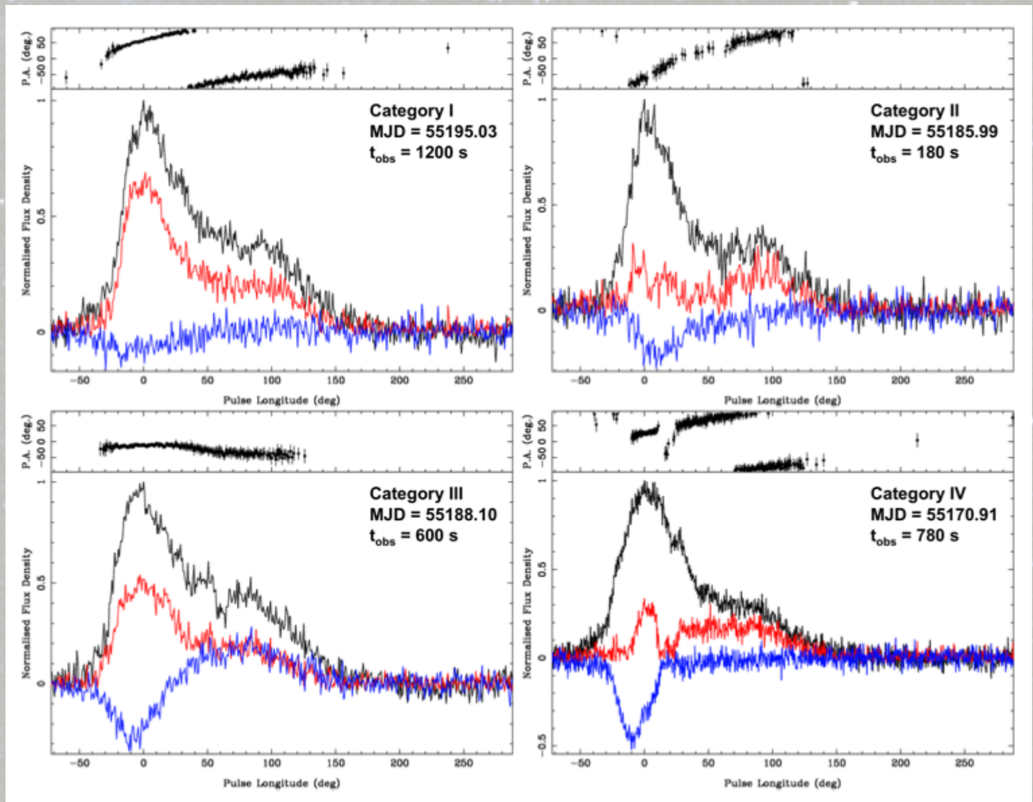


Perrodin & SRT science validation team

Radio vs High Energy Emission properties

Long Term & Prompt Monitoring:

Radio magnetars, X-ray transients, etc…

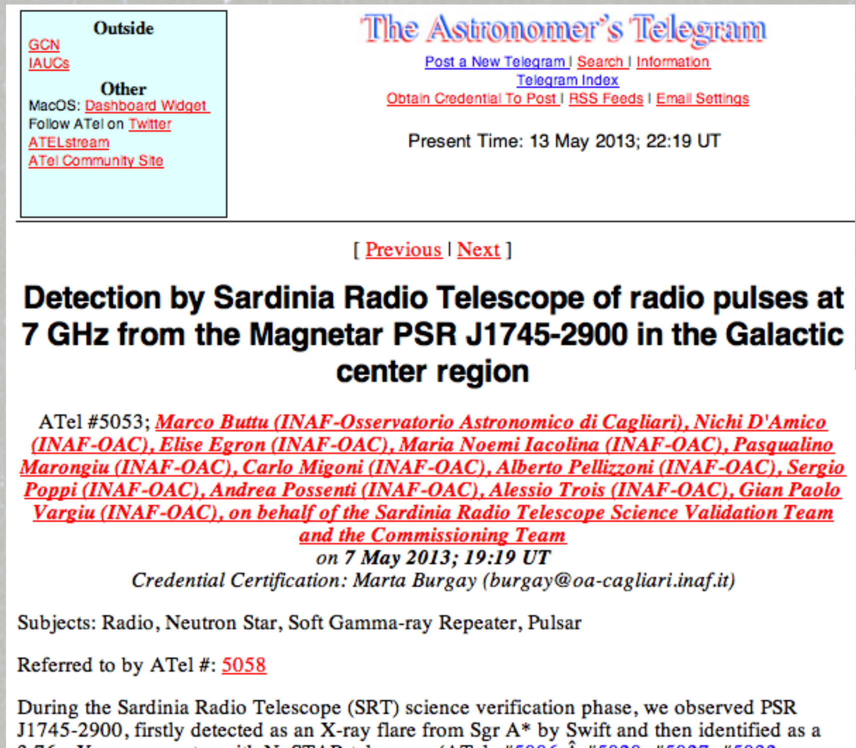


[Levin et al, 2012]

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 …

(talks Turolla, Tiengo, Pili, Taverna, CotiZelati, Cannizzaro, Belloni, Casella, Vincentelli + Baglio…)

The first SRT science observation



Outside
GCN
IAUCs

Other
MacOS: Dashboard Widget
Follow ATel on Twitter
ATELstream
ATel Community Site

The Astronomer's Telegram

Post a New Telegram | Search | Information
Telegram Index
Obtain Credential To Post | RSS Feeds | Email Settings

Present Time: 13 May 2013; 22:19 UT

[Previous | Next]

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

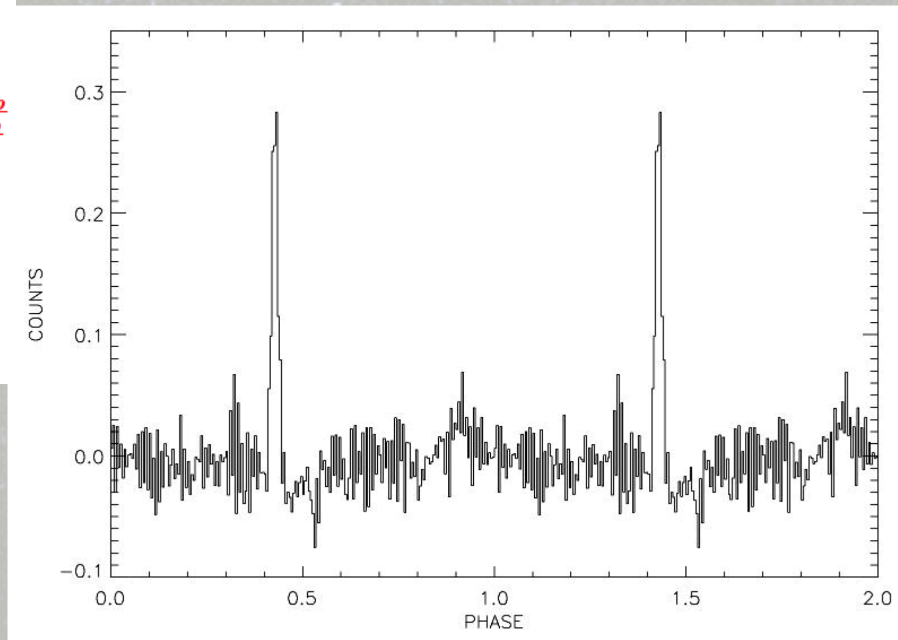
ATel #5053; *Marco Buttu (INAF-Osservatorio Astronomico di Cagliari), Nichi D'Amico (INAF-OAC), Elise Egron (INAF-OAC), Maria Noemi Iacolina (INAF-OAC), Pasqualino Marongiu (INAF-OAC), Carlo Migoni (INAF-OAC), Alberto Pellizzoni (INAF-OAC), Sergio Poppi (INAF-OAC), Andrea Possenti (INAF-OAC), Alessio 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

7 May 2013

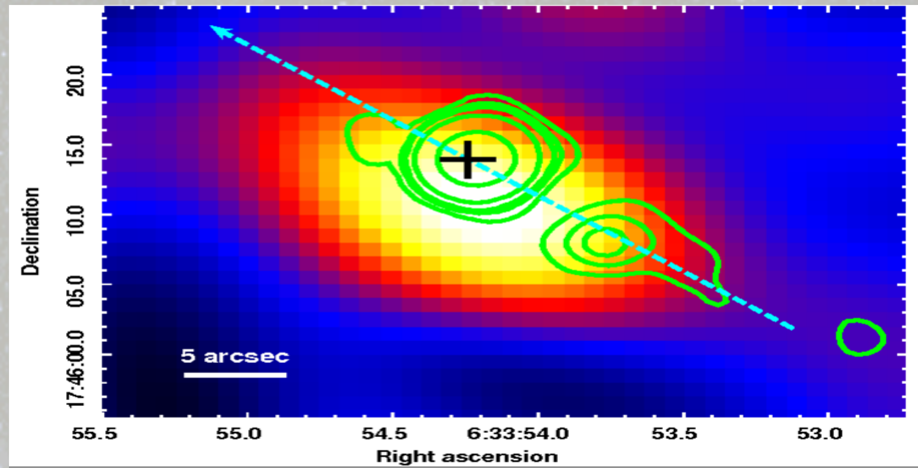


SRT science validation team

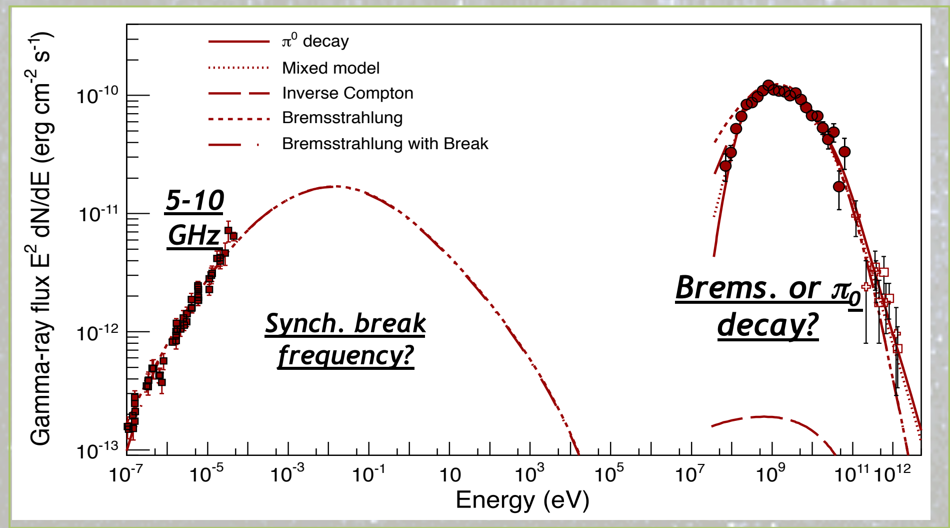
SNR+PWN mapping: space resolved spectral mapping

Exploiting the relatively wide beam and the large spectral coverage, a detailed spatially resolved spectral study of a large sample of SNRs at high radio frequencies, with consequences on the nature (hadrons or leptons?) of the γ-Ray emission and hence on the Cosmic Ray origin problem

(talks Bucciantini, Amato, Olmi, Cardillo, + ...)



Pellizzoni et al, 2011



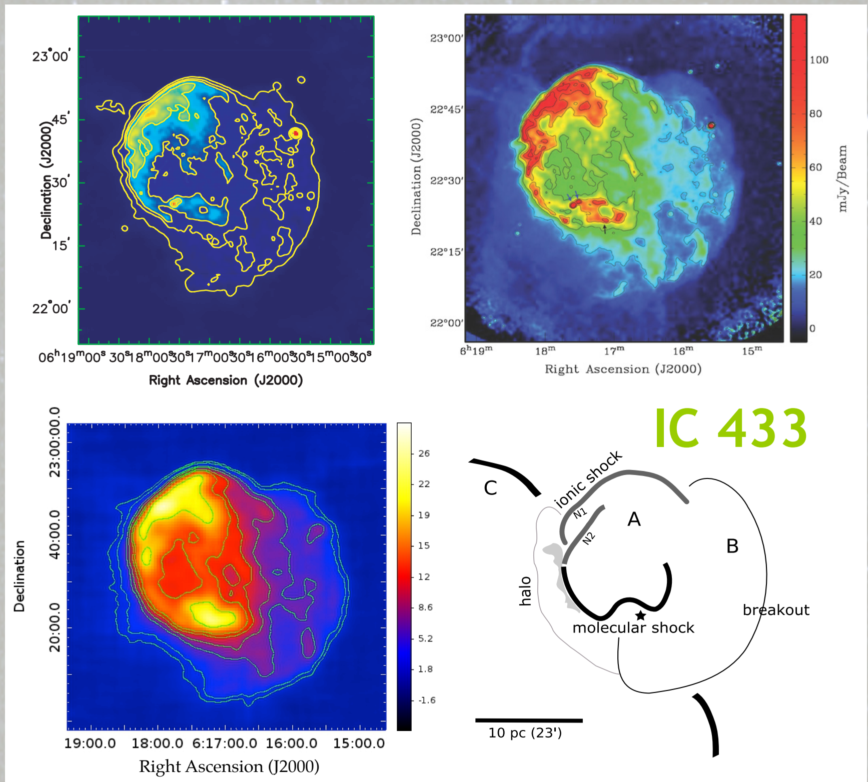
Ackermann et al., 2013

Some commissioning observations

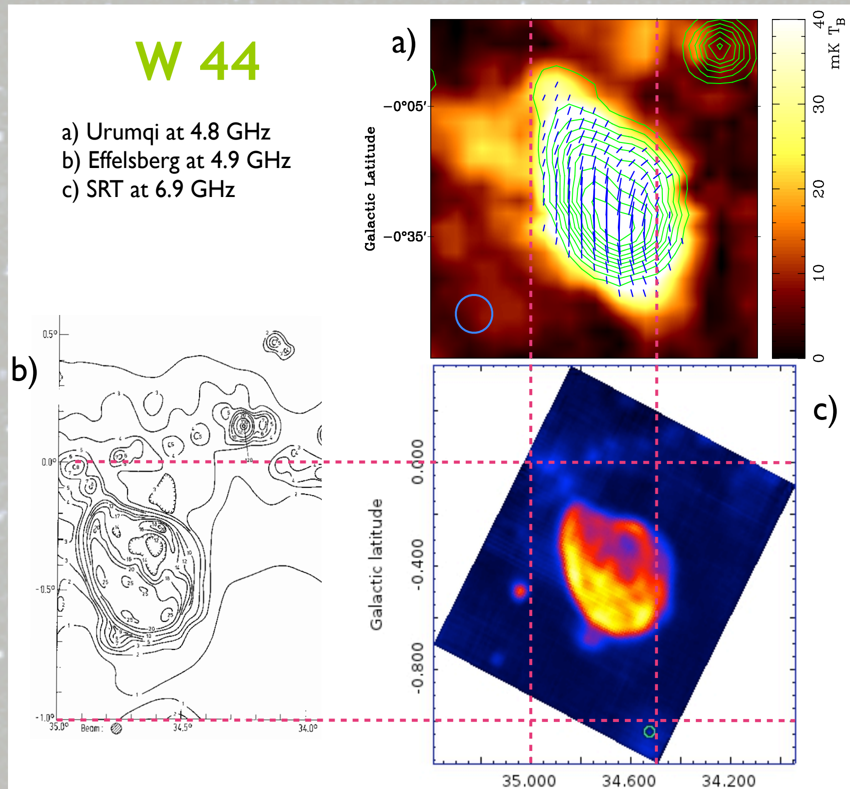
VLA 330 MHz, Hewitt et al. 2006

VLA+Arecibo, Lee et al. 2008

SRT@7GHz



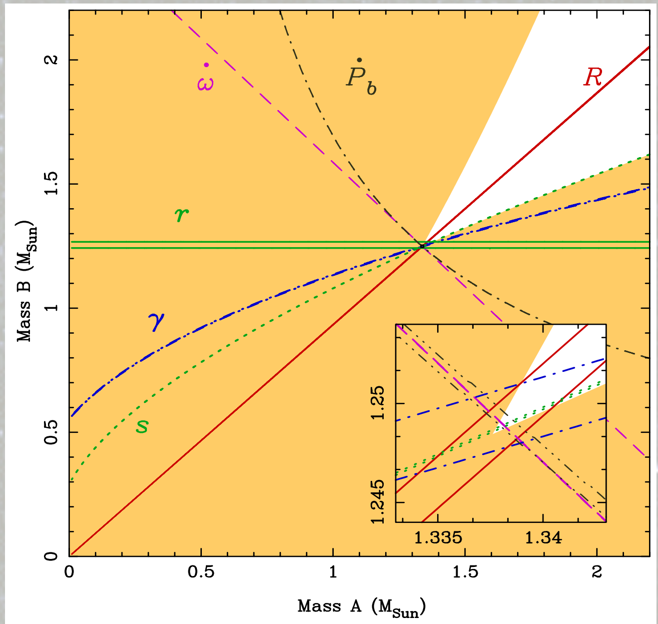
Urumqi at 5 GHz



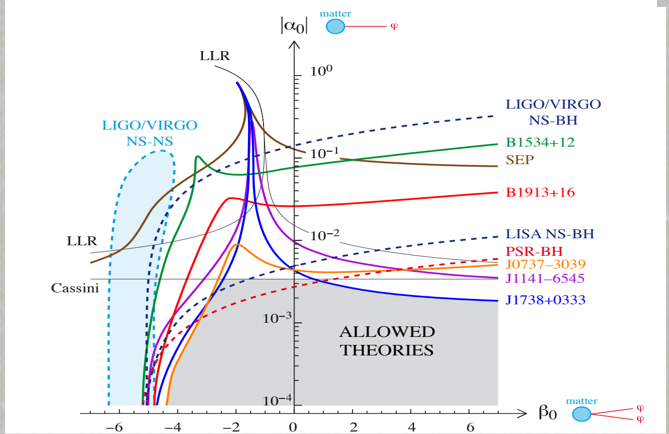
Effelsberg at 5 GHz
Altenhoff et al., 1978

SRT@7GHz

Exploiting the Double Pulsar and other MSPs as fundamental gravity-physics Laboratories



[Kramer et al 2016 (in prep.)]

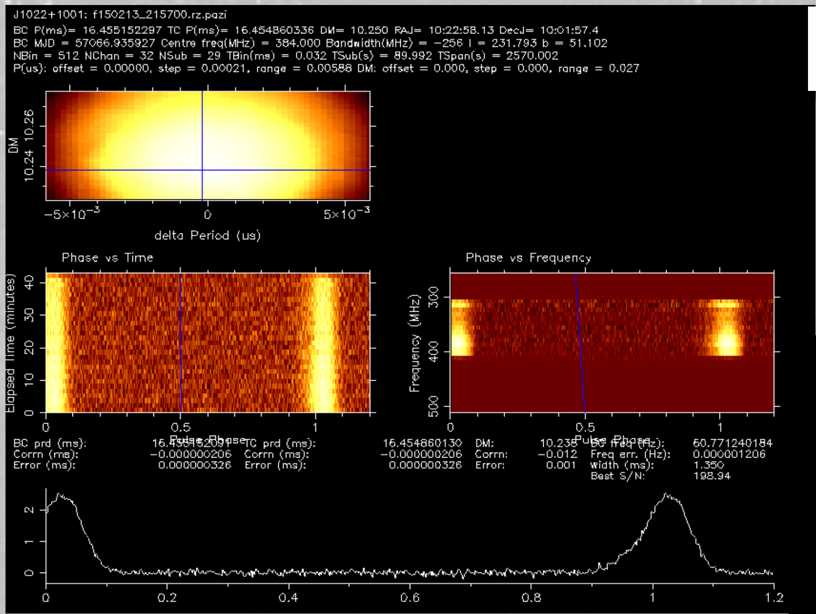


[Freire et al 2012]

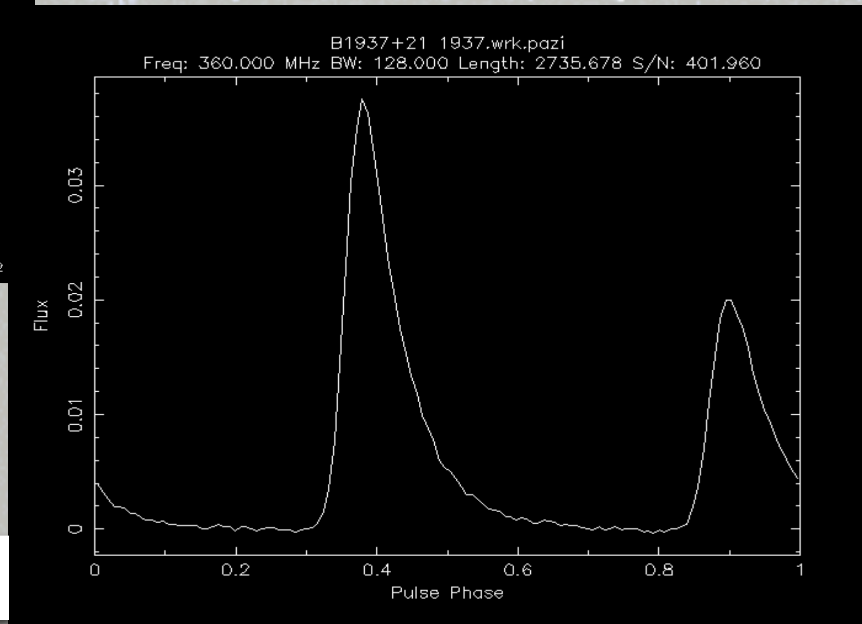
The unique 20+90 cm receiver, coupled with a state-of-art Digital Backend (ATNF-DFB3), can be exploited for improving the quality of the ongoing tests of General Relativity and for performing additional unprecedented tests of the magnetosphere of pulsar B

(talk Burgay, Ricci, Palomba +....)

Some MSP commissioning observations



PSR J1022+1001

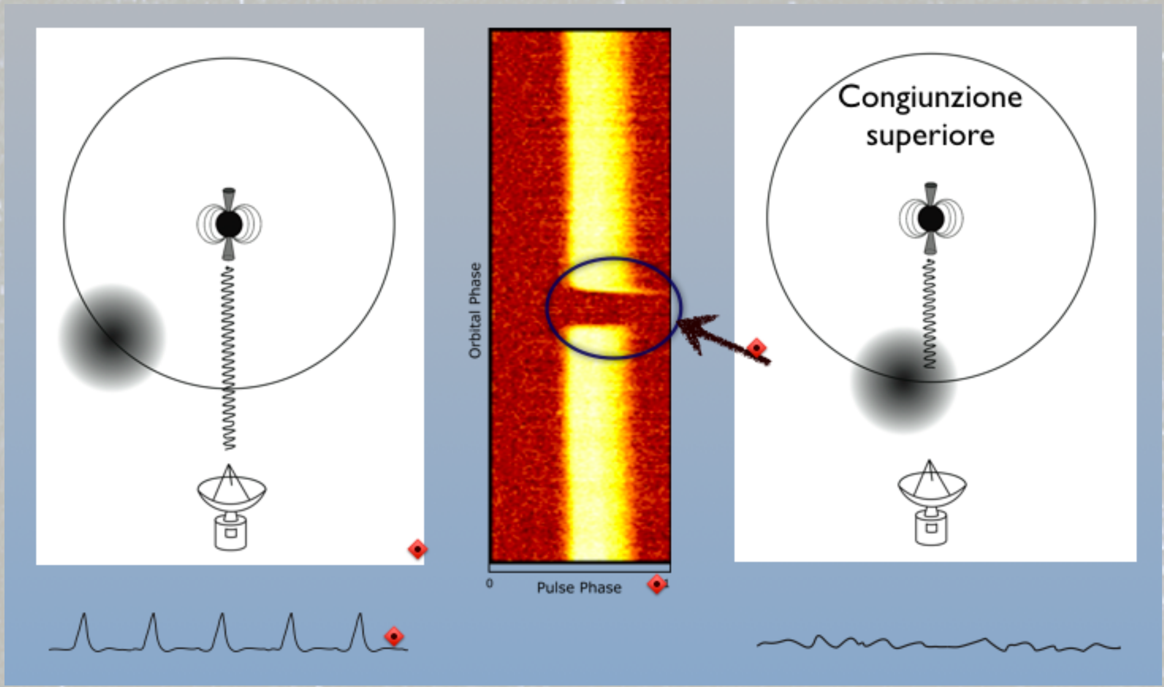


PSR B1937+21

SRT science validation team: 13 February 2015

Observing Eclipsing and Transitional Pulsars

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



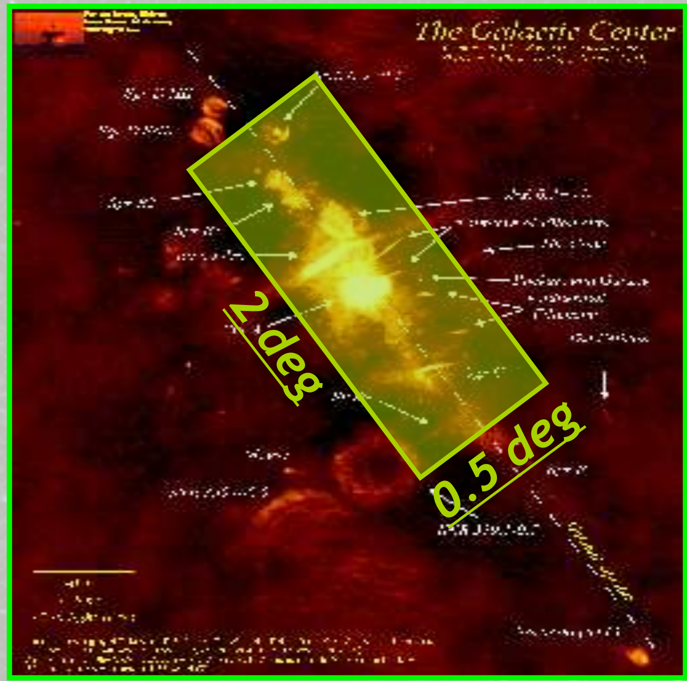
[© A. Ridolfi]

(talks Cadelano, Patruno, D'Avanzo, De Martino, Pintore, Sanna + ..-)

Coming soon…

Large search for pulsars at unprecedently used radio frequencies

PSR22 : *a Galactic Center survey for Pulsars at 22 GHz*



As soon as the new 9cm 7-beam receiver will be ready

PSR03 : *a large scale targeted surveys (e.g. Fermi sources, Globular Clusters, Open Clusters), for Pulsars at 3 GHz*

(talk Burgay, Sabatini, Baglio + ...)

Coming soon...

High resolution mapping in the EVN context: e.g. ULXs, BH binaries, etc

- Extragalactic X-ray sources with luminosity > Eddington limit for 10 M_{sun} BHs: IMBHs? Super-Eddington accretion?

- Radio - X correlation hints to "standard" accretion states, possible probe of IMBHs - used in *hyper* luminous X-ray sources (HLX) (Lx>10^{42} erg/s). Few Interesting works [Mezcua+15]

- Jet observed in one ULX [Cseh+15] with the EVN

- Few detections, only with interferometers (VLA and EVN included)

- SRT can improve the effectiveness of EVN, mostly when operating at medium-high frequency)

(talk Zampieri, Bachetti + ...)

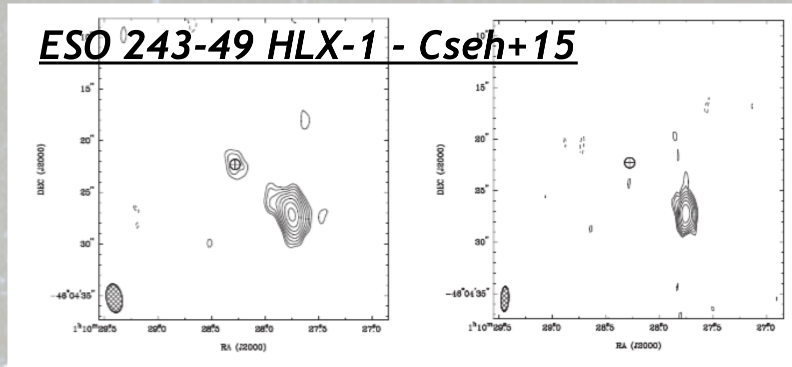


Figure 2. Left: the combined ATCA image of HLX-1 during the X-ray hard state at 6.8 GHz central frequency. The circle with a cross shows the 95 per cent

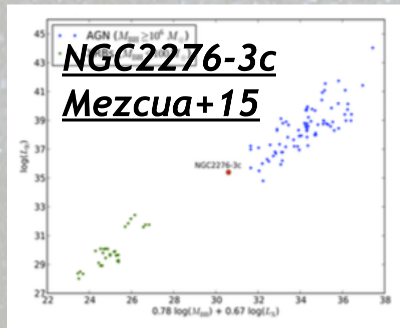
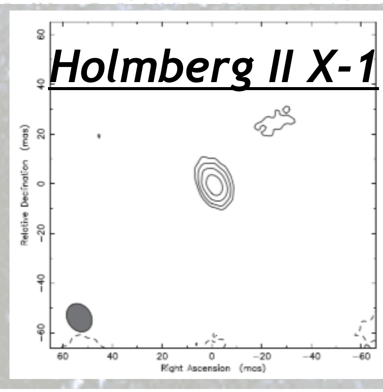


Figure 2. Fundamental Plane of BH accretion from Gültekin et al. (2009) extending from XRBs hosting stellar-mass BHs (green dots) to AGN



Unveiling recurrent jets of the ULX Holmberg II X-1: evidence for a massive stellar-mass black hole?

D. Cseh,[1★] P. Kaaret,[2] S. Corbel,[3] F. Grisé,[4,5] C. Lang,[2] E. Körding,[1] H. Falcke,[1] P. G. Jonker,[1,6,7] J. C. A. Miller-Jones,[8] S. Farrell,[9] Y. J. Yang,[10] Z. Paragi[11] and S. Frey[12]

[1]*Department of Astrophysics/IMAPP, Radboud University Nijmegen, PO Box 9010, NL-6500 GL Nijmegen, the Netherlands*

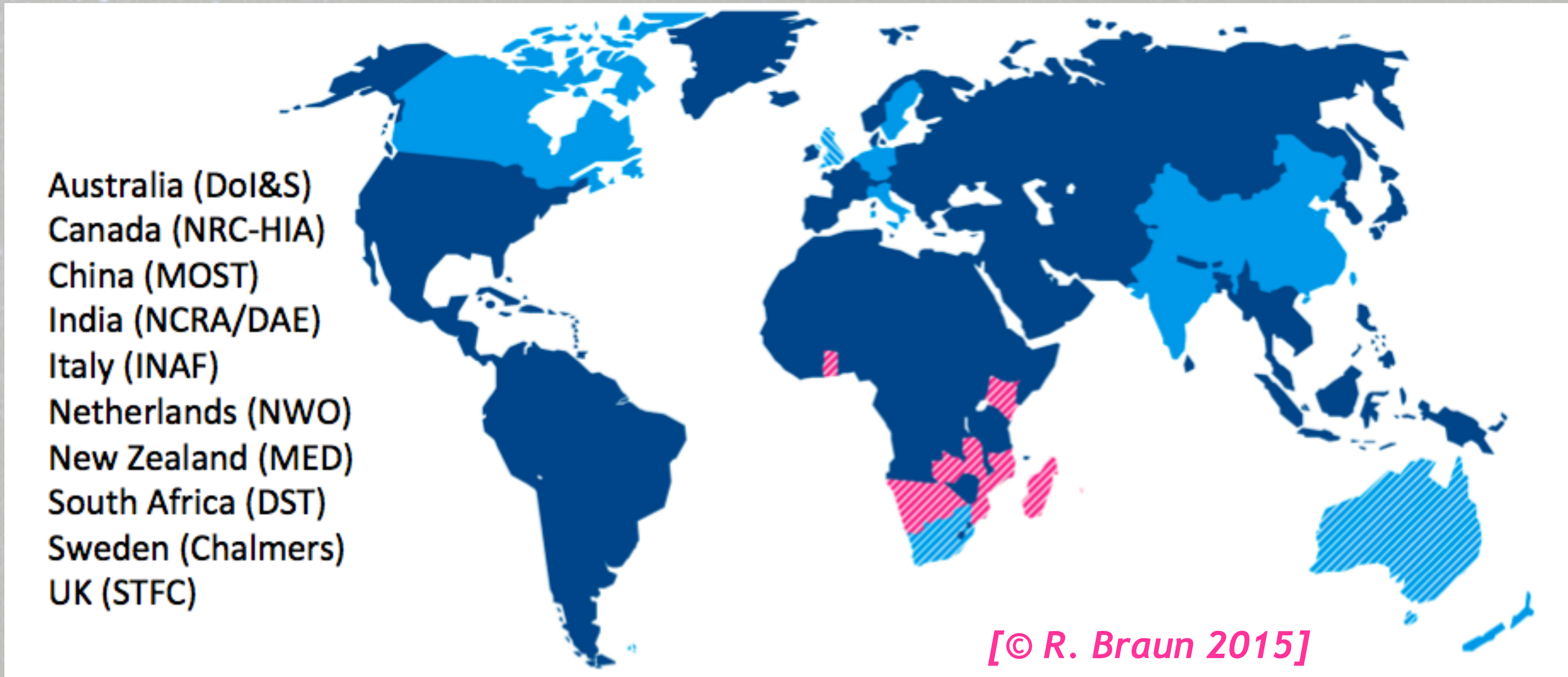
When the SRT will be ready for guest observers?

SRT timeline

- Technical commissioning DONE
- Opening official ceremony: 30 sett 2013
- Science validation will run until ≈ autumn 2015
- Early science shared-risk mode will likely run since early 2016


SKA
SQUARE KILOMETRE ARRAY
Exploring the Universe with the world's largest radio telescope

SKA organization and funds



The SKA Board instructs the SKA Office to proceed with the design phase assuming a cost ceiling for SKA1 capital expenditures of € 650 Million [2013 value].

€150 Million design effort – fully funded

SKA: some numbers of a transformational instruments

Element	SKA1 scale	SKA2 scale
Dishes, feeds, receivers	~200	~2500
Aperture arrays	~130,000	~1,000,000
Signal transport	~1 Pb/s	~10 Pb/s
Signal processing	~exa-MACs	~exa-MACs
High performance computing	~100s tera-flops	~exa-flops
Data storage	Exa-byte capacity	Exa-byte
Power requirements	~10MW	~50MW

[© R. Braun 2015]

SKA: the two sites

SKA1-LOW, Murchison, Australia:

130,000 dipoles (512 stations x 256 antennas); 50–350 MHz
~80km baselines; large areal concentration in core

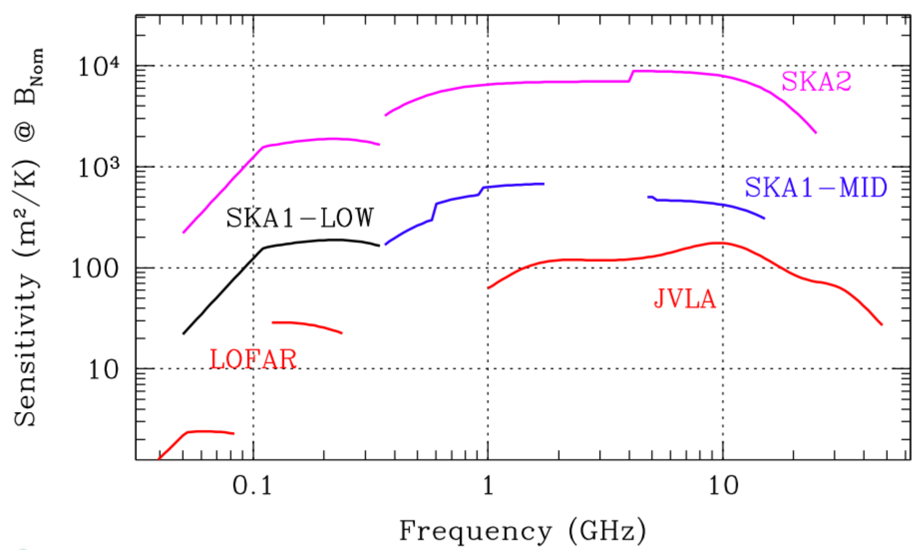
[© R. Braun 2015]

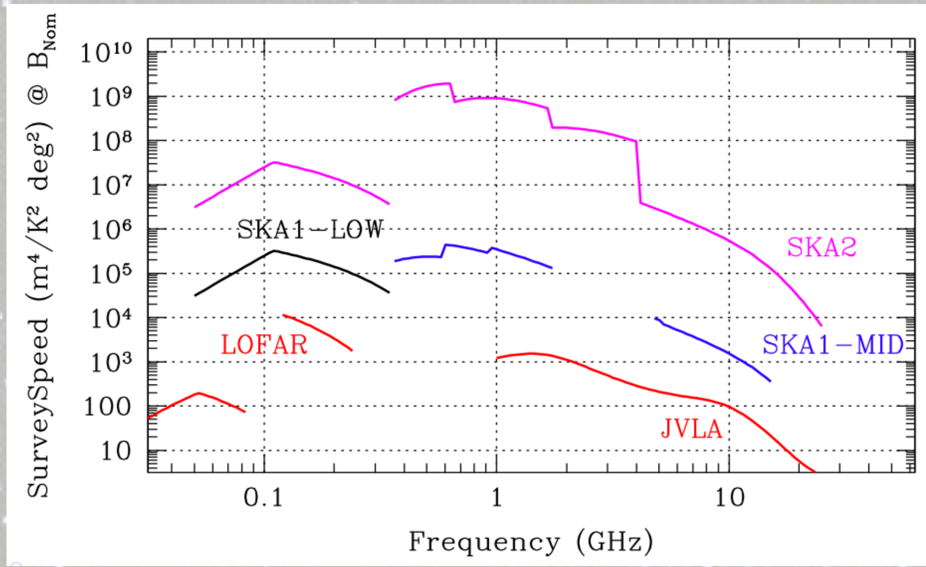
SKA1-MID, Karoo, South Africa:

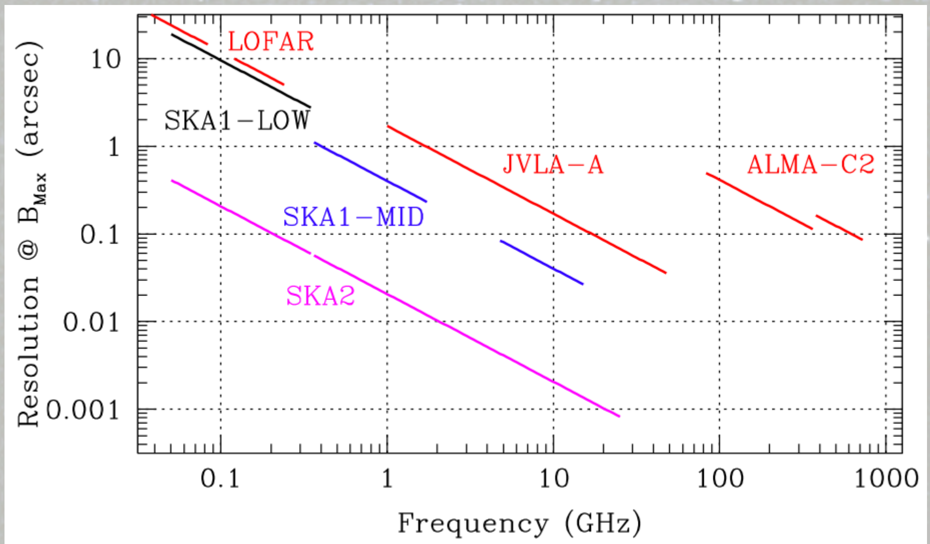
133 SKA1 + 64 MeerKAT dishes. Max baseline ~150km
Bands: 2 (0.95–1.76 GHz), 5 (4.6–14(24) GHz), 1 (0.35–1.1 GHz)

[© R. Braun 2015]

SKA: comparisons



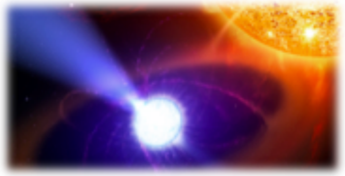
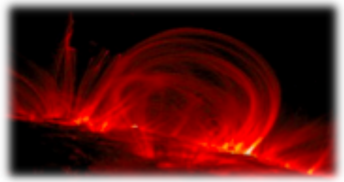
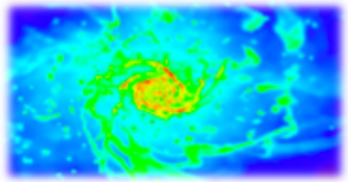




[© R. Braun 2015]

Flagship science

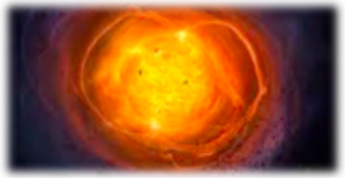
	SKA1	SKA2
The Cradle of Life & Astrobiology	Proto-planetary disks; imaging inside the snow/ice line (@ < 100pc), Searches for amino acids.	Proto-planetary disks; sub-AU imaging (@ < 150 pc), Studies of amino acids.
	Targeted SETI: airport radar 10^4 nearby stars.	Ultra-sensitive SETI: airport radar 10^5 nearby star, TV ~10 stars.
Strong-field Tests of Gravity with Pulsars and Black Holes	1st detection of nHz-stochastic gravitational wave background.	Gravitational wave astronomy of discrete sources: constraining galaxy evolution, cosmological GWs and cosmic strings.
	Discover and use NS-NS and PSR-BH binaries to provide the best tests of gravity theories and General Relativity.	Find all ~40,000 visible pulsars in the Galaxy, use the most relativistic systems to test cosmic censorship and the no-hair theorem.
The Origin and Evolution of Cosmic Magnetism	The role of magnetism from sub-galactic to Cosmic Web scales, the RM-grid @ 300/deg2.	The origin and amplification of cosmic magnetic fields, the RM-grid @ 5000/deg2.
	Faraday tomography of extended sources, 100pc resolution at 14Mpc, 1 kpc @ z ≈ 0.04.	Faraday tomography of extended sources, 100pc resolution at 50Mpc, 1 kpc @ z ≈ 0.13.
Galaxy Evolution probed by Neutral Hydrogen	Gas properties of 10^7 galaxies, <z> ≈ 0.3, evolution to z ≈ 1, BAO complement to Euclid.	Gas properties of 10^9 galaxies, <z> ≈ 1, evolution to z ≈ 5, world-class precision cosmology.
	Detailed interstellar medium of nearby galaxies (3 Mpc) at 50pc resolution, diffuse IGM down to N_H < 10^17 at 1 kpc.	Detailed interstellar medium of nearby galaxies (10 Mpc) at 50pc resolution, diffuse IGM down to N_H < 10^17 at 1 kpc.

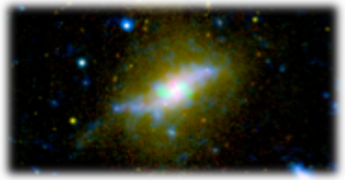





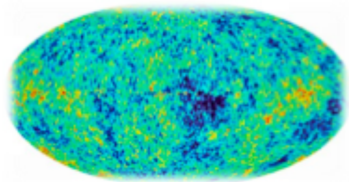
[© R. Braun 2015]

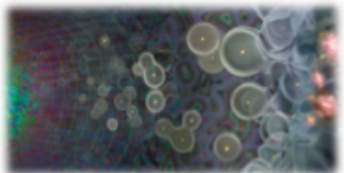
Flagship science (cont'ed)

	SKA1	SKA2
The Transient Radio Sky	Use fast radio bursts to uncover the missing "normal" matter in the universe.	Fast radio bursts as unique probes of fundamental cosmological parameters and intergalactic magnetic fields.
	Study feedback from the most energetic cosmic explosions and the disruption of stars by super-massive black holes.	Exploring the unknown: new exotic astrophysical phenomena in discovery phase space.
Galaxy Evolution probed in the Radio Continuum	Star formation rates (10 M_Sun/yr to z ~ 4).	Star formation rates (10 M_Sun/yr to z ~ 10).
	Resolved star formation astrophysics (sub-kpc active regions at z ~ 1).	Resolved star formation astrophysics (sub-kpc active regions at z ~ 6).
Cosmology & Dark Energy	Constraints on DE, modified gravity, the distribution & evolution of matter on super-horizon scales: competitive to Euclid.	Constraints on DE, modified gravity, the distribution & evolution of matter on super-horizon scales: redefines state-of-art.
	Primordial non-Gaussianity and the matter dipole: 2x Euclid.	Primordial non-Gaussianity and the matter dipole: 10x Euclid.
Cosmic Dawn and the Epoch of Reionization	Direct imaging of EoR structures (z = 6 - 12).	Direct imaging of Cosmic Dawn structures (z = 12 - 30).
	Power spectra of Cosmic Dawn down to arcmin scales, possible imaging at 10 arcmin.	First glimpse of the Dark Ages (z > 30).









The impact of SKA1 on neutron star science in the radio band

from SKA Science book (Sicily 2014)

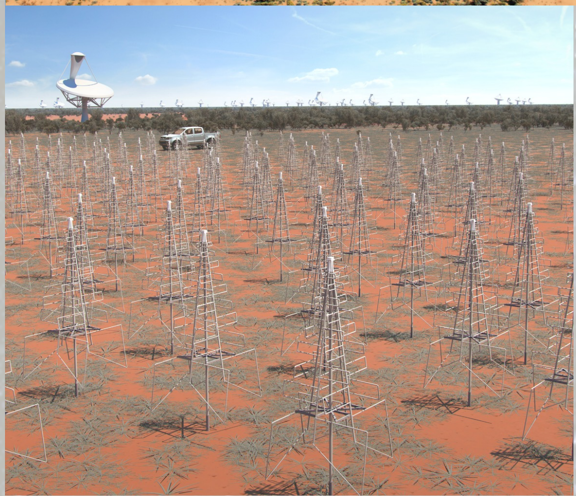
- *Cosmic census* *(Keane et al. 1501.00056)*
- *Testing Gravity* *(Shao et al. 1501.00058)*
- *GW astronomy* *(Janssen et al. 1501.00127)*
- *Understanding PSR Magnetospheres* *(Karastergiou et al 1501.00126)*
- *Understanding NS population* *(Tauris et al. 1501.00005)*
- *Galactic & Intergalactic medium* *(Han et al. 1412.8749)*
- *NS Equation of State* *(Watts et al. 1501.00042)*
- *Pulsars in the Galactic centre* *(Eatough et al. 1501.00281)*
- *Pulsars in Globular clusters* *(Hessels et al. 1501.00086)*
- *Pulsar wind nebulae* *(Gelfand et al. 1501.00364)*

Overview *(Kramer & Stappers 1507.04423)*

The impact of SKA1 on pulsar population

The *current* pulsar population ≈ 2400 (with ≈ 300 MSPs)

The post-*SKA1*-searches pulsar population ≈ 12000 and in particular a population of Millisecond pulsars ≈ 1500



The impact of SKA1 on gravity theories studies

The current relativistic pulsars population ≈ 20-30

The SKA1 relativistic pulsar population ≈ 100-200 and a timing precision better by a factor ≈ 10-100

Some of the promises of SKA…

FINDING AND TIMING A PSR-BH BINARY (AND MAYBE A PSR-MSP BINARY IN A GLOBULAR CLUSTER [Clausen et al. 2014])

From the ordinary PK parameters — BH mass with precision $< 0.1\%$

From precessional effects on semi-major axis and longitude of periastron — BH spin S with precision $< 1\%$

From M & S $\chi \equiv \frac{c}{G}\frac{S}{M^2}$ — $\chi \leq 1$ Test of "Cosmic Censorship Conjecture" [Penrose 1969]

FINDING AND TIMING A PSR CLOSELY ORBITING SGR A*

From only 1 PK parameter — BH mass with precision $< 0.001\%$

From BH oblateness — BH quadrupole moment Q with precision $\sim 1\%$

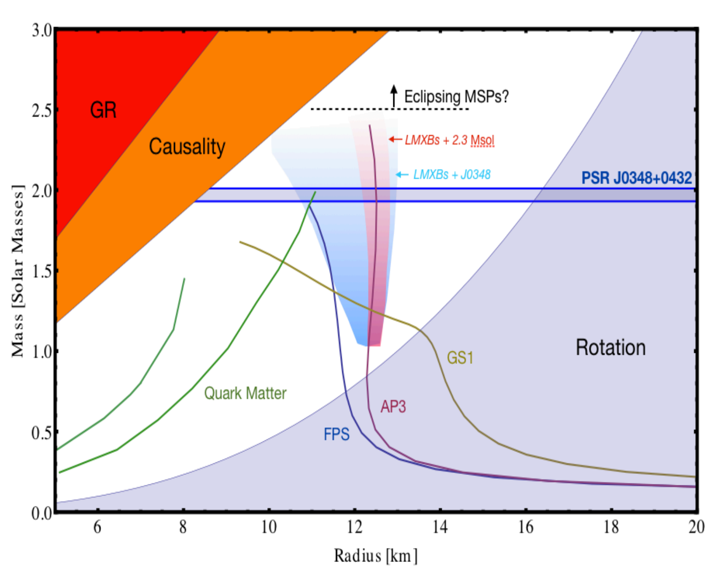
From M & Q $q \equiv \frac{c^4}{G^2}\frac{Q}{M^3}$ — $q = -\chi^2$ Test of "No Hair theorem"

Equation of State for Nuclear Matter

The EoS of nuclear matter uniquely determine several NS observables: M-R relation, moment of inertia I, cooling rate, minimum spin period P_{min} and maximum mass M_{max} above which NSs collapse to black holes.

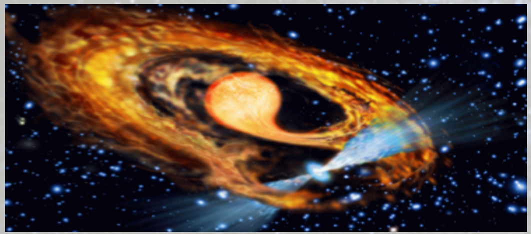
Most quantities will be precisely determined in a wide sample of NSs with SKA1-MID (M for ≈100 pulsars + enhanced capabilities to observe very small P_{min}, and I at least for J0737-3039) E-ELT (WD mass and radius) and Athena (cooling rates)

Best constraints expected from a combination of radio optical and X-ray constraints



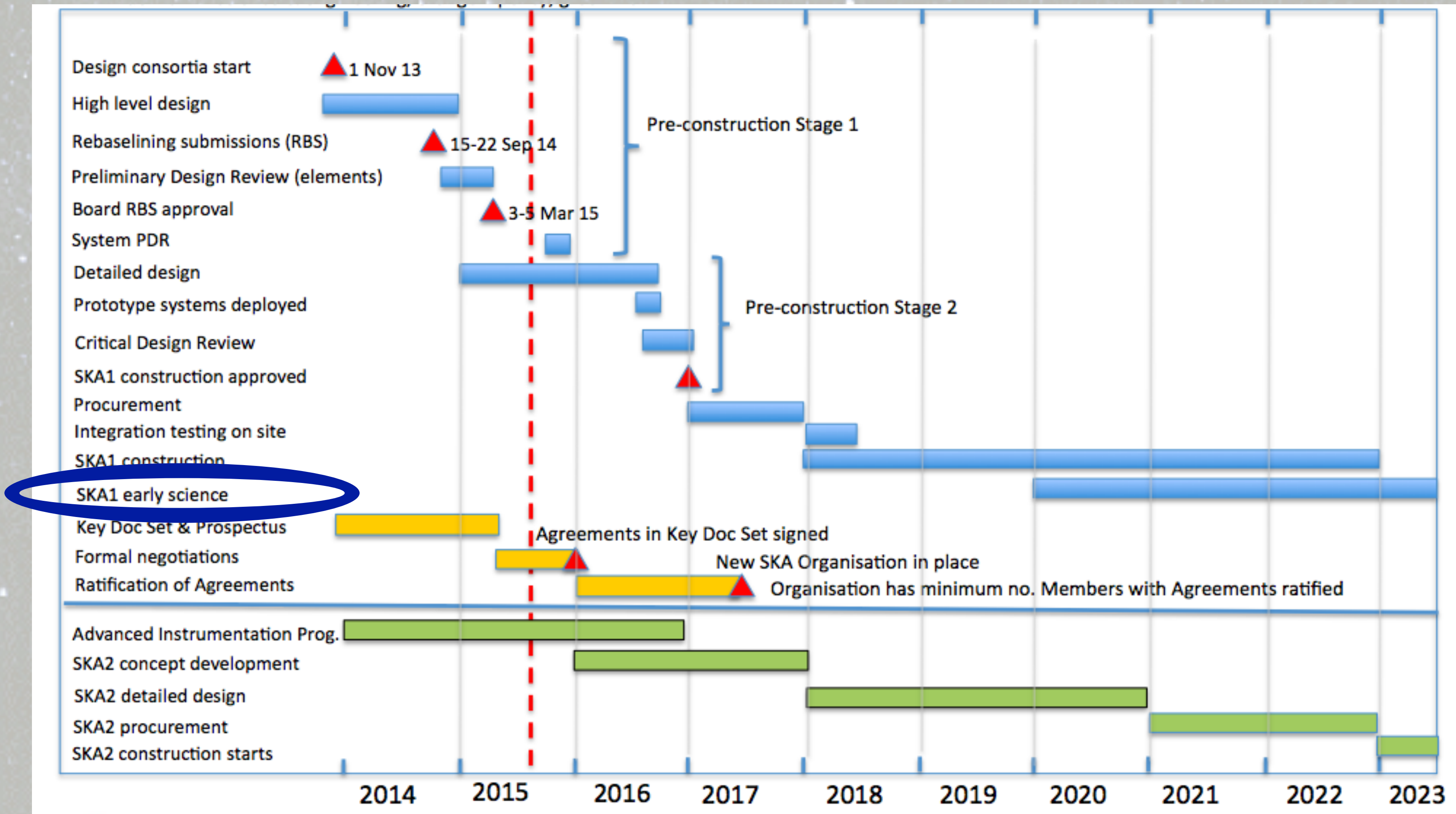
[© Antoniadis]

"Black widow" and "redback" binary pulsars might host massive NSs, whose mass can be precisely determined with the combination of SKA-mid and E-ELT



[© ESO]

Timeline



Design consortia start
1 Nov 13
High level design
Rebaselining submissions (RBS)
15-22 Sep 14
Preliminary Design Review (elements)
Board RBS approval
3-5 Mar 15
System PDR
Pre-construction Stage 1
Detailed design
Prototype systems deployed
Critical Design Review
SKA1 construction approved
Pre-construction Stage 2
Procurement
Integration testing on site
SKA1 construction
SKA1 early science
Key Doc Set & Prospectus
Formal negotiations
Ratification of Agreements
Agreements in Key Doc Set signed
New SKA Organisation in place
Organisation has minimum no. Members with Agreements ratified
Advanced Instrumentation Prog.
SKA2 concept development
SKA2 detailed design
SKA2 procurement
SKA2 construction starts
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023


Thank you!