Sardinia Radio Telescope: status, ongoing and future developments

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Radio telescopes in Italy

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Astronomical Observatory of Cagliari

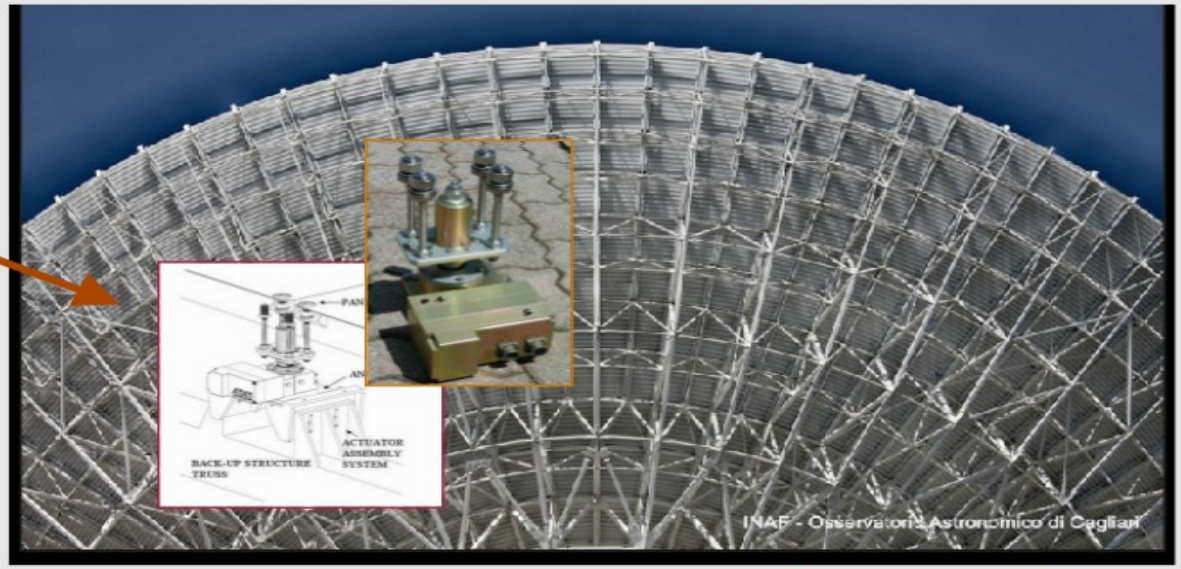
Sardinia Radio Telescope

The Sardinia Radio Telescope is a general purpose fully steerable radio telescope able to function in the range 300 MHz – 115 GHz.

Largest (64-m) Italian radio telescope

Multiple focal position (P, G, 4 BWG):
→up to 20 receivers, frequency agility

Active Surface: 1008 panels, 1116 electro-mechanical actuators with remote control



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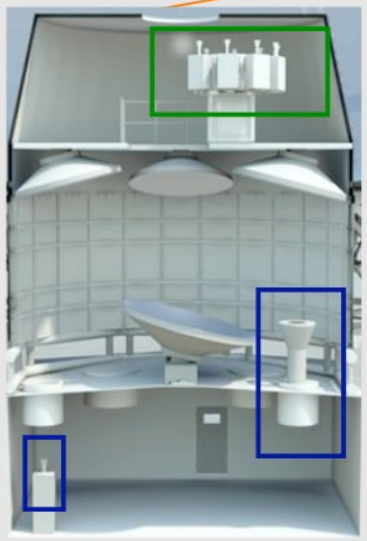
Focal positions

MULTIPLE FOCAL POSITIONS

Primary, Gregorian, 2 Beam Wave Guide:

→ **20 Receivers**

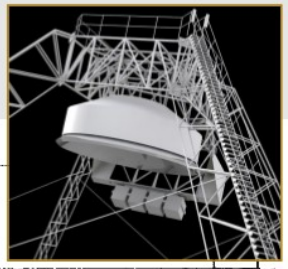
[Frequency agility]



Primary Focus
F/D ratio=0.33
300MHz < f < 20GHz
8 receivers

Gregorian Focus
F/D ratio=2.35
7.5GHz < f < 100GHz
8 receivers

4 BWG Foci
F/D ratio=1.37 & 2.81
1.4GHz < f < 35GHz
2+2 receivers



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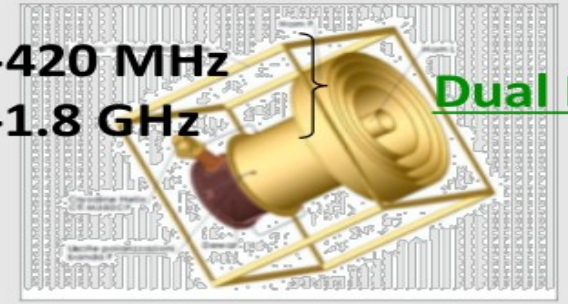
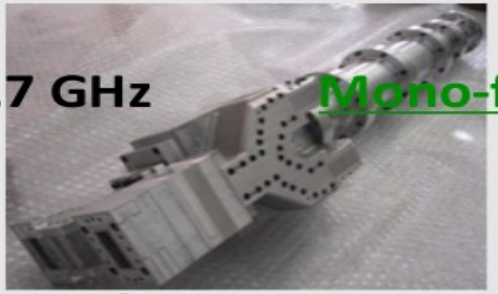
First light receivers

310-420 MHz
1.3-1.8 GHz



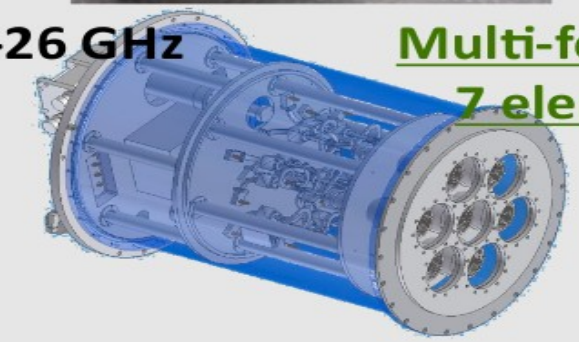
Dual Band

5.7-7.7 GHz



Mono-feed

18-26 GHz



Multi-feed
7 elements

SRT Major revision

May 2017

August 2017

Receivers under development

- *Mono-feed C-low receiver (4.2 - 5.6 GHz)*
- *7-feed S-band receiver (3 – 4.5 GHz)*
- *19-feed Q-band receiver (33 – 50 GHz)*
- *Mono-feed W-band receiver (86-115 GHz) ex IRAM*
- *Phased Array Feed C-band receiver (PHAROS2) in the context of the SKA Advanced Instrumentation Program*

Backends

- ***Total Power:*** 14 IF, 2.1 GHz bandwidth, only continuum
- ***XARCOS:*** 14 IF, 125 MHz bandwidth, full-Stokes spectrometer, high frequency resolution (244 Hz) but limited time resolution (10 s)
- ***Pulsar Digital Filter Bank****:* 4 IF, 1 GHz, pulsar timing and search
- ***Digital Base Band Converter****:* 4 IF, 512 MHz, VLBI & RFI
- ***ROACH****:* 4 IF, 512 MHz, pulsar base-band mode (LEAP)
- ***SARDARA (ROACH2)***: 14 IF, 2.1 GHz, fully reconfigurable

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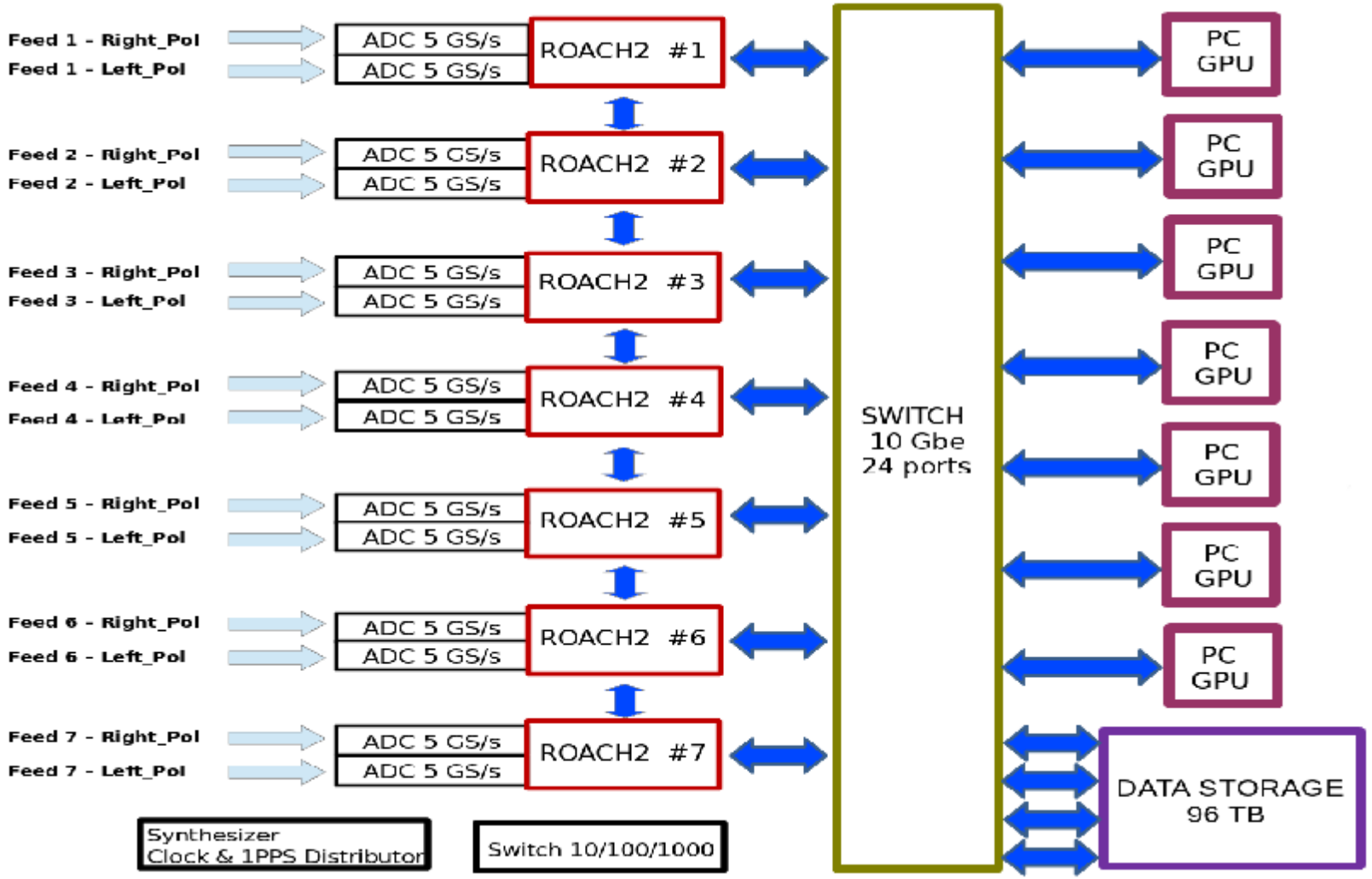
SArdinia Roach2-based Digital Architecture for Radio Astronomy (SARDARA)



SARDARA

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First papers with SARDARA

- M. Murgia et al. "*Sardinia Radio Telescope wide-band spectral-polarimetric observations of the galaxy cluster 3C129*", MNRAS, Volume 461, Issue 4, p. 3516-3532, 2016

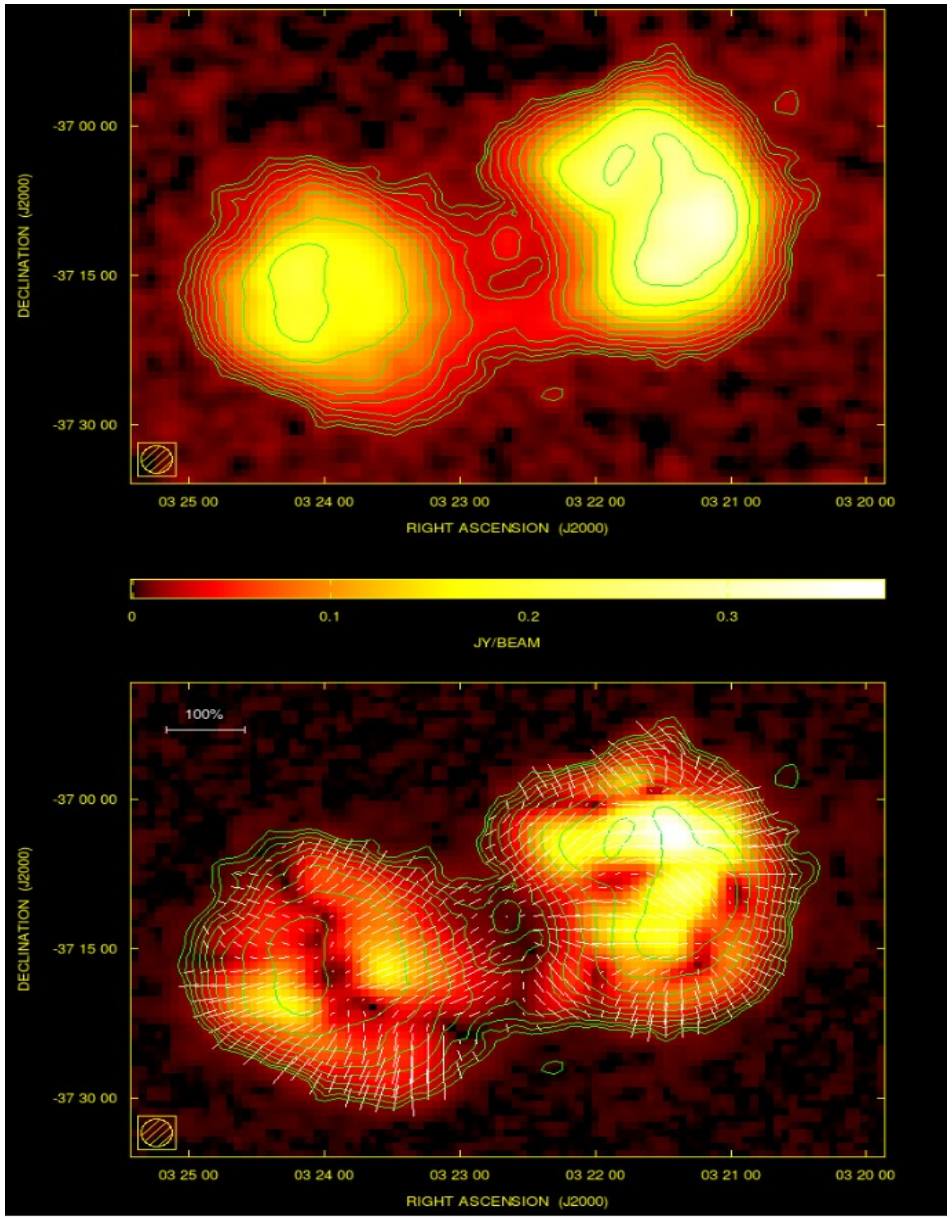
- F. Govoni et al. "*Sardinia Radio Telescope observations of Abell 194. The intra-cluster magnetic field power spectrum*", A&A, 2017, 603, A122

- E. Egron et al. " *Observations of SNR IC443 and W44 with the Sardinia Radio Telescope at 1.5 GHz and 7 GHz*", MNRAS, Volume 470, Issue 2, p. 1329-1341, 2017

- F. Loi et al. "*Observations of the galaxy cluster CIZA J2242+5301 with the Sardinia Radio Telescope*", MNRAS, 2017, arXiv:1708.07125

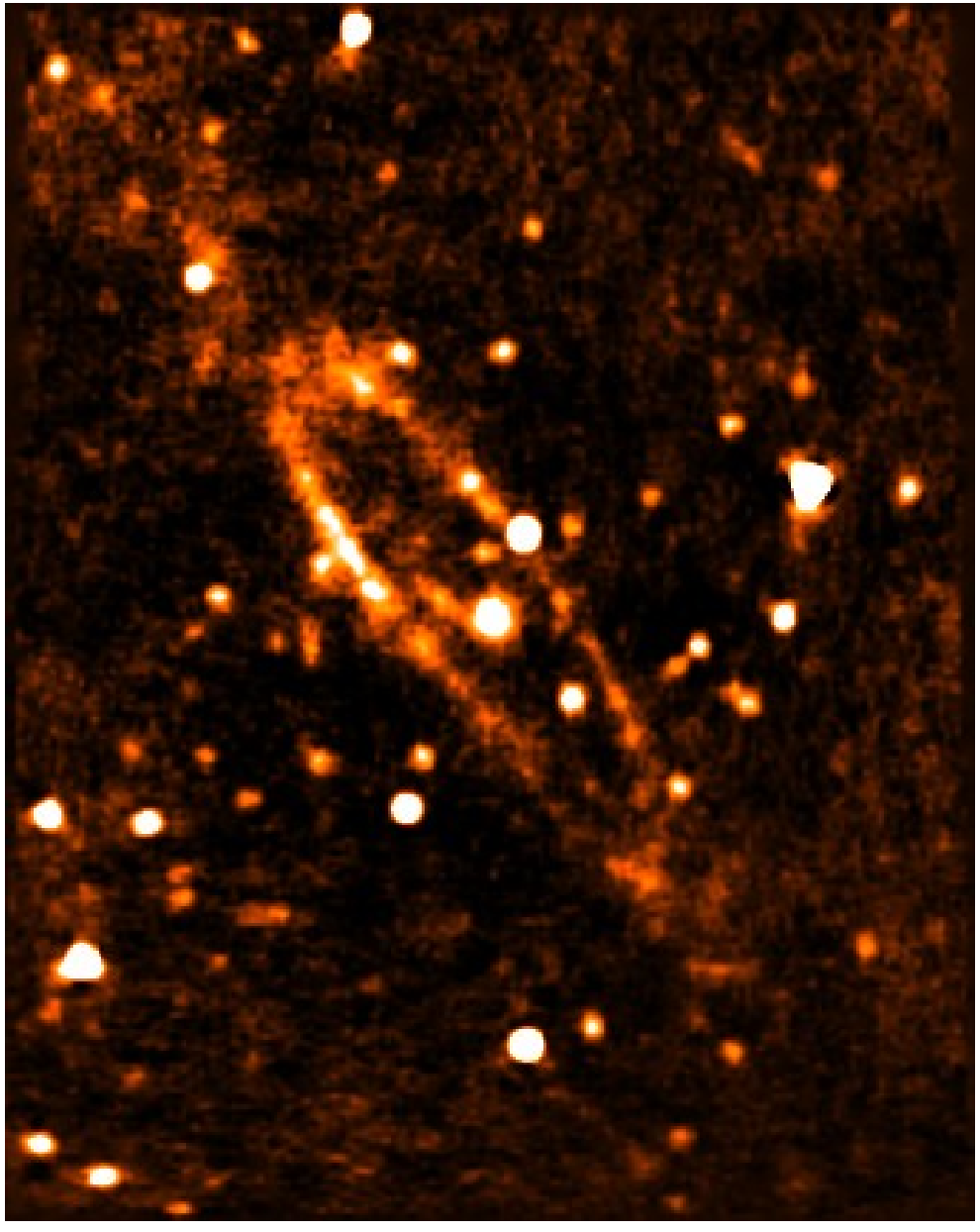
Fornax A with SARDARA at SRT

Credits: M. Murgia



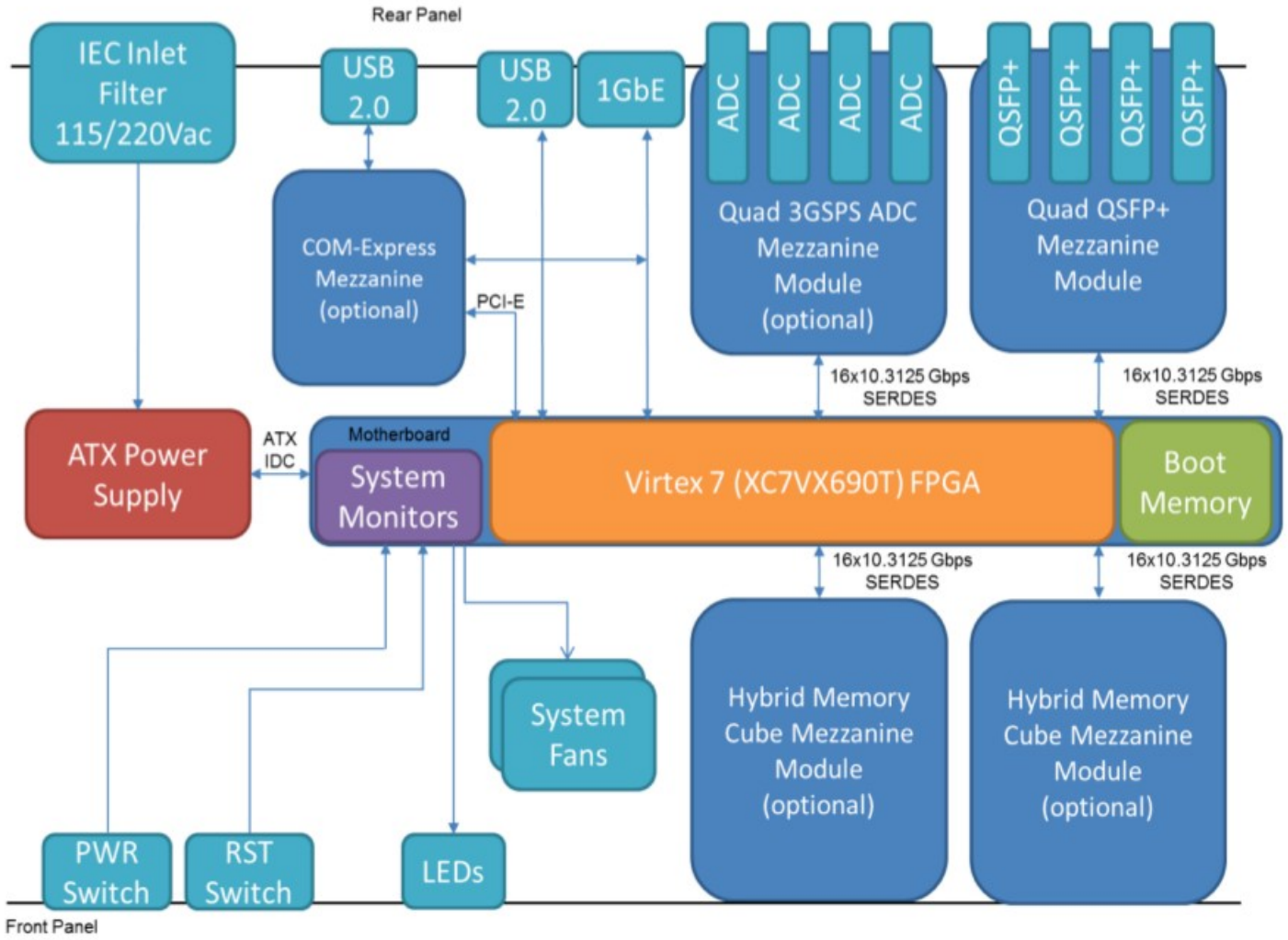
M31 with SARDARA at SRT

Credits: E. Battistelli, M. Murgia



SKARAB

SKARAB and ADCs



- Dual-Channel, 14-Bit, 3.0-GSPS ADC
  - Input Full-Scale: 1.35 VPP
  - RF Input Supports Up to 4.0 GHz
  - On-chip 50 Ohm Input Termination
- On-chip Digital Down-Converters:
  - Up to 4 DDCs (Dual-Band Mode)
  - Up to 3 Independent NCOs per DDC

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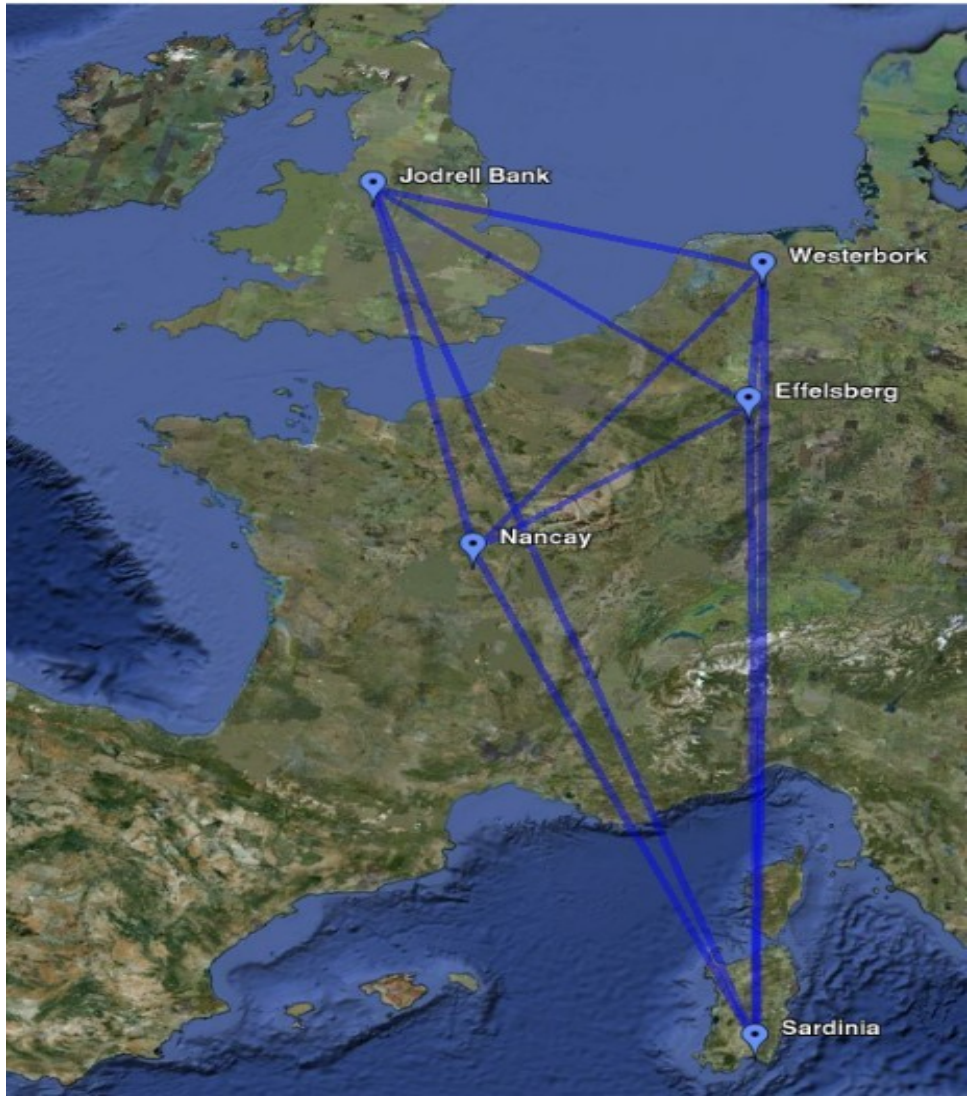
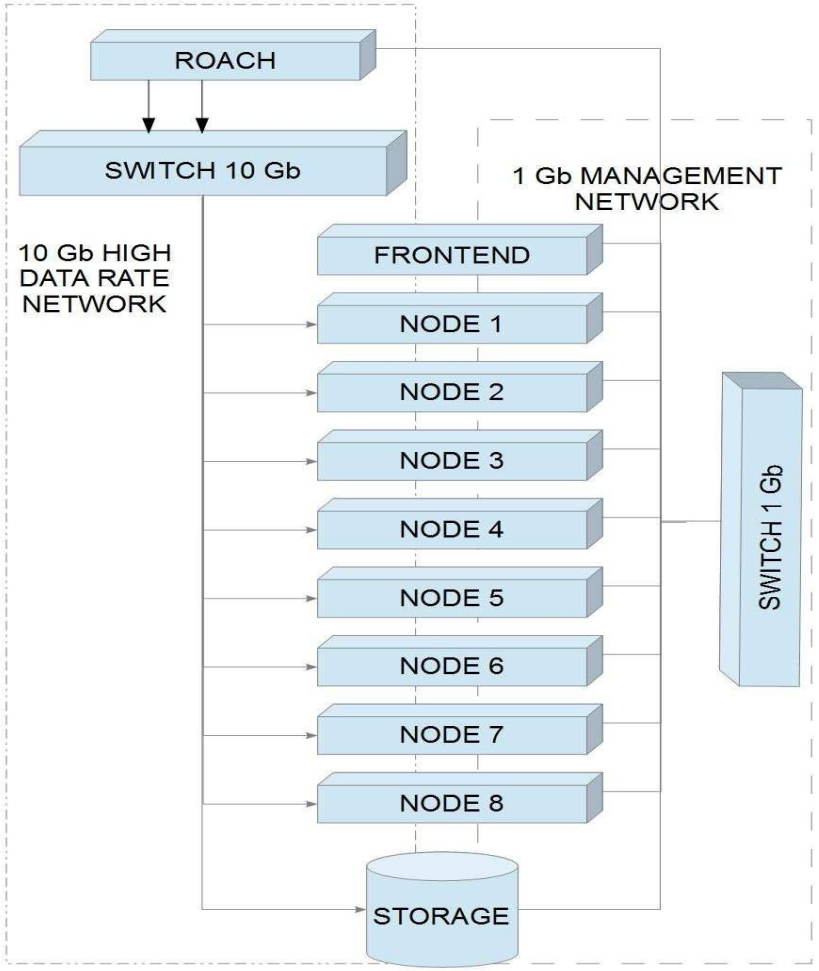
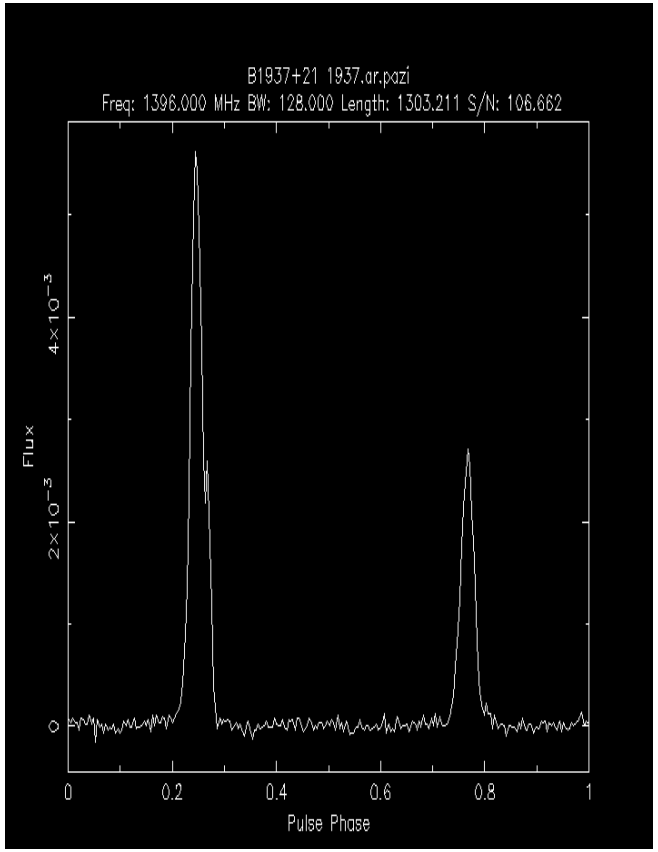
Large European Array for Pulsars







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Search for ExtraTerrestrial Intelligence (SETI)

Technological activities:

- Mathematical algorithms: FFT, Wavelet, KLT
- Phased Array Feed study

Scientific activities:

- Test SETI detection software on Breakthrough Listen's data (GPU baseband data from GBT)

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Breakthrough Listen program

- 100 millions of dollars in ten years for dedicated SETI observations

- Green Bank Telescopes & Parkes offer ~20% of telescope time

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SERENDIP VI

- Collaboration with UC Berkeley to make a porting of the SERENDIP VI in Sardinia.
- One ROACH2-GPU chain will be dedicated to piggy-back SETI, others can be made available, depending on ongoing observations
- The same system will be used for FRB and pulsar searching in coherent observing mode
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- The system should be ready and operative by mid 2018

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Breakthrough Listen at SRT?

A possible participation of the Sardinia Radio Telescope in the BL program is under evaluation.

At the beginning of 2018 we will organize a meeting in Cagliari to discuss this possibility.

Leaders of BL (Pete Worden, Jamie Drew, Andrew Siemion) manifested strong interest.

Phased Array Feed

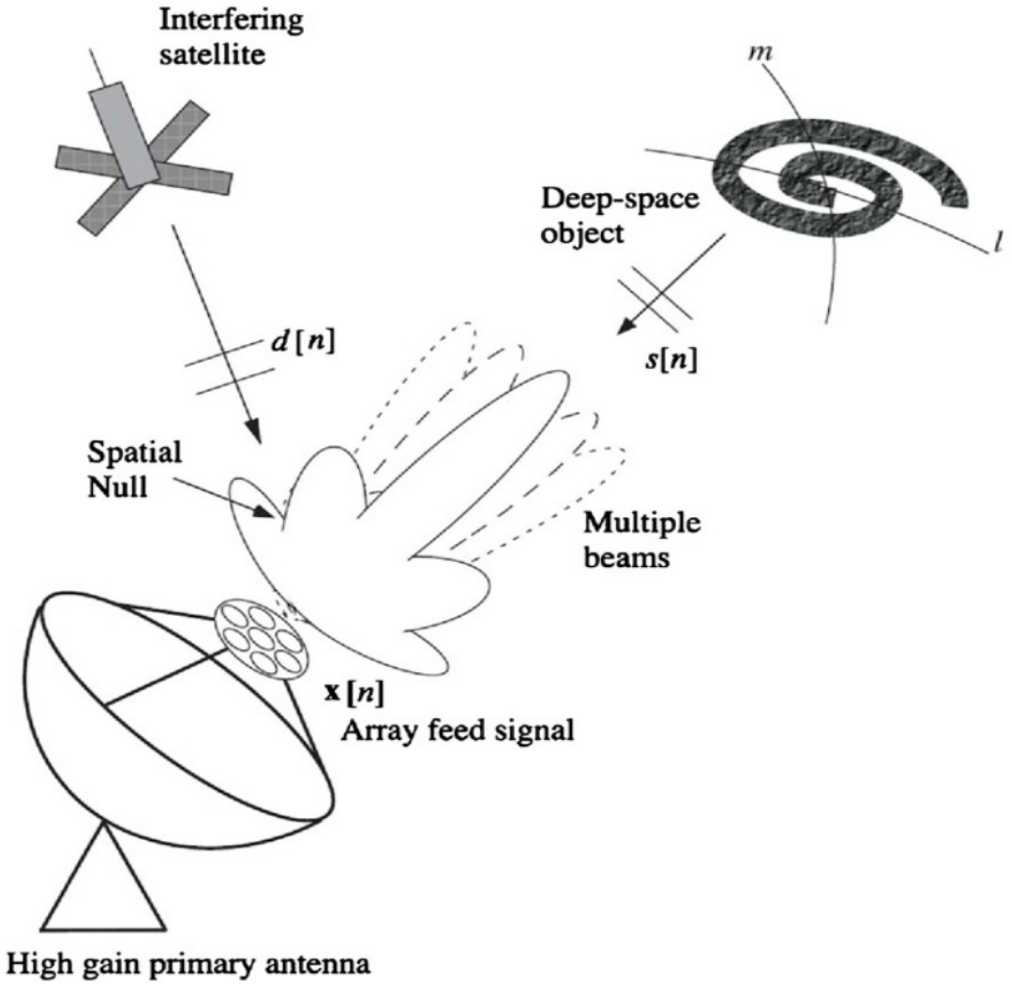

Image taken from Elmer et al.,
The Astronomical Journal, 145:24 (11pp), 2013 January

Main advantages of PAF

- Simultaneous beams on the sky for complete coverage for the available FoV
- Full sampling of the sky
- Increased antenna efficiency
- Improved radiation pattern
- Correction of the reflector surface defects
- Reduction of baseline ripple
- Interference cancellation
- One of more PAF beams could be dedicated to SETI activities

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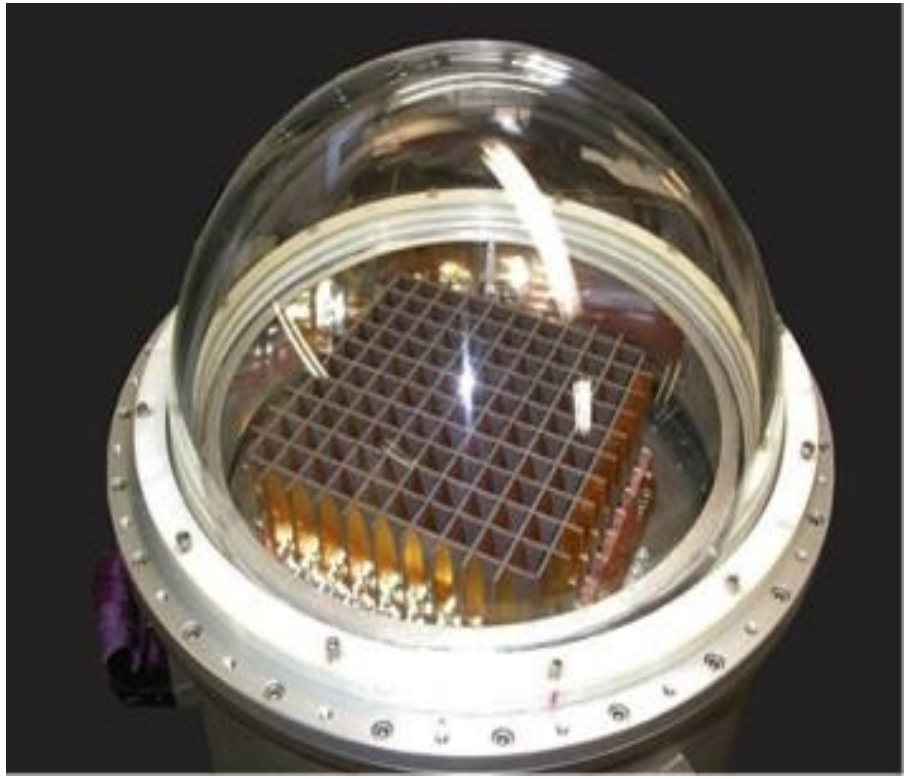
PHAROS (PHased Arrays for Reflector Observing Systems) PAF

- C-band (4-8 GHz) cryogenic PAF based on Vivaldi antennas (11x10x2 pols) with cryogenic analog beamformer



- *European technology demonstrator; collaboration of INAF, U. Manchester, ASTRON, Chalmers and U. Malta*

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PHAROS2

- Re-use some of existing PHAROS hardware;

- New cryogenic LNAs with state-of-the-art performance to replace the existing ones;

- Downconversion of part of RF band to IF using a tunable LO;

- IF over Fiber (IFoF) analog signal transportation;

- Digital backend (at room temperature) to replace existing analog beamformer.

- This project involves: OA Cagliari, IRA Bologna, OA Arcetri, OA Catania, University of Malta, Jodrell Bank

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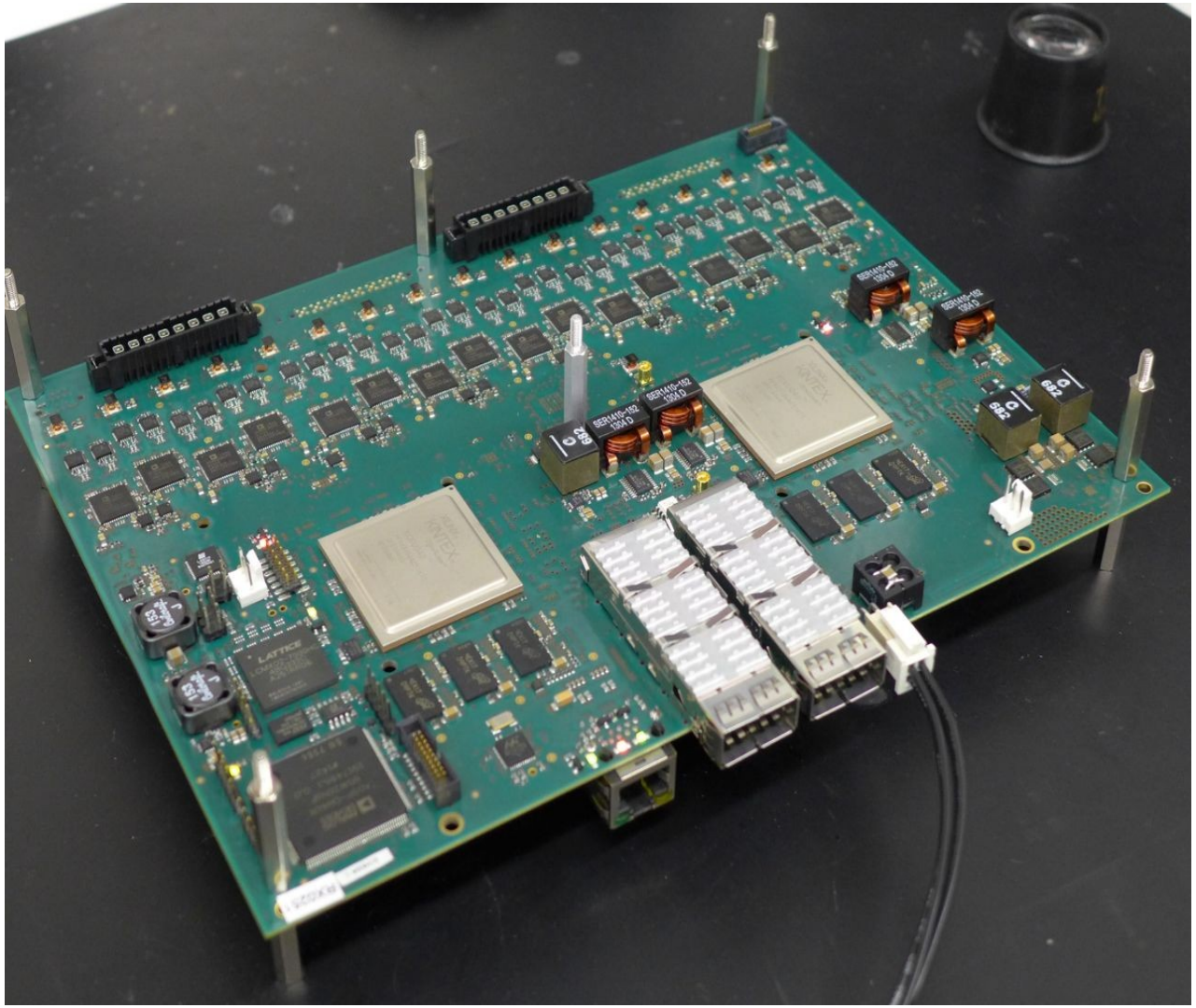
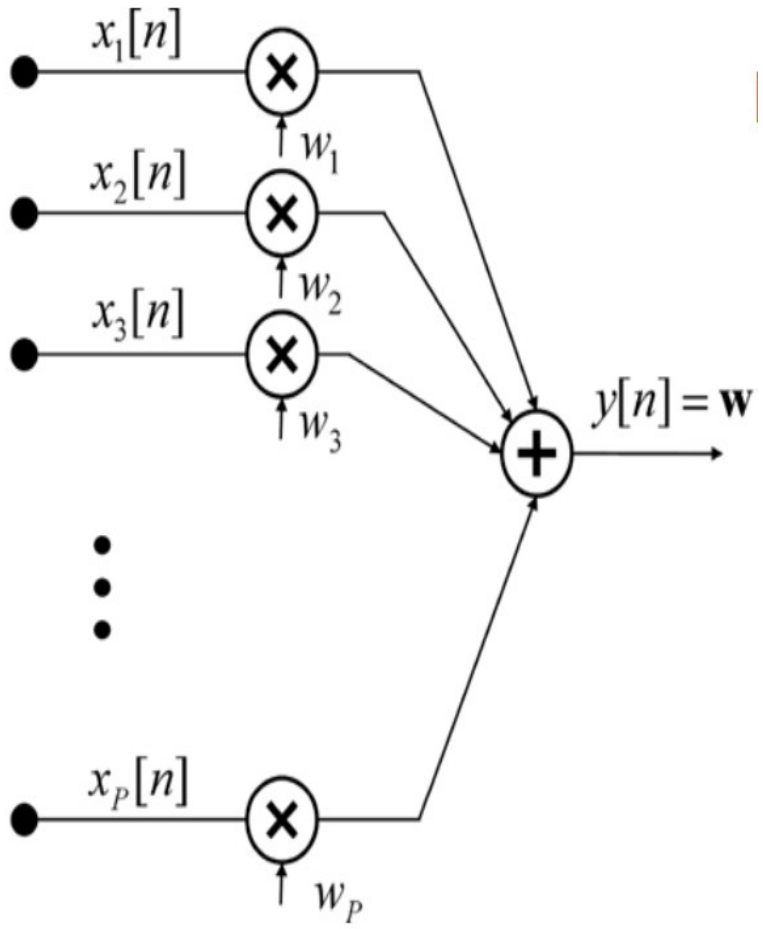
Italian Tile Processing Module (ITPM)





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VLBI

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A bit of history (1)

- 2013: first test (hardware and software setup, FS procedure optimization, etc)

- 2014: first fringes during an I-VLBI test (January)

- 2014: first fringes at L-band and K-band during the first EVN session (February)

- 2014: first fringes at C-band during the second EVN session (June)

- 2014: first RADIOASTRON experiments

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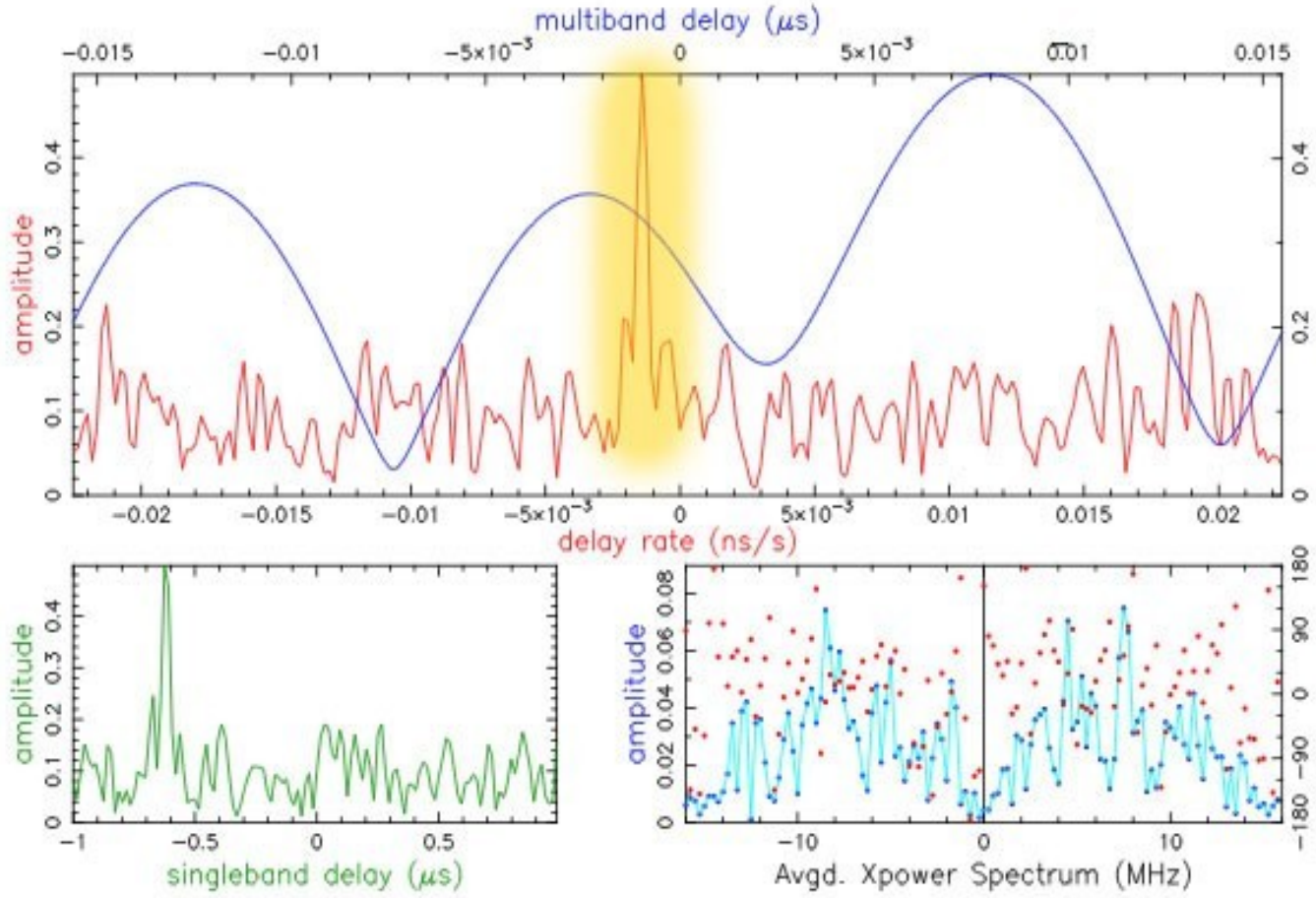
First fringe SRT-Medicina



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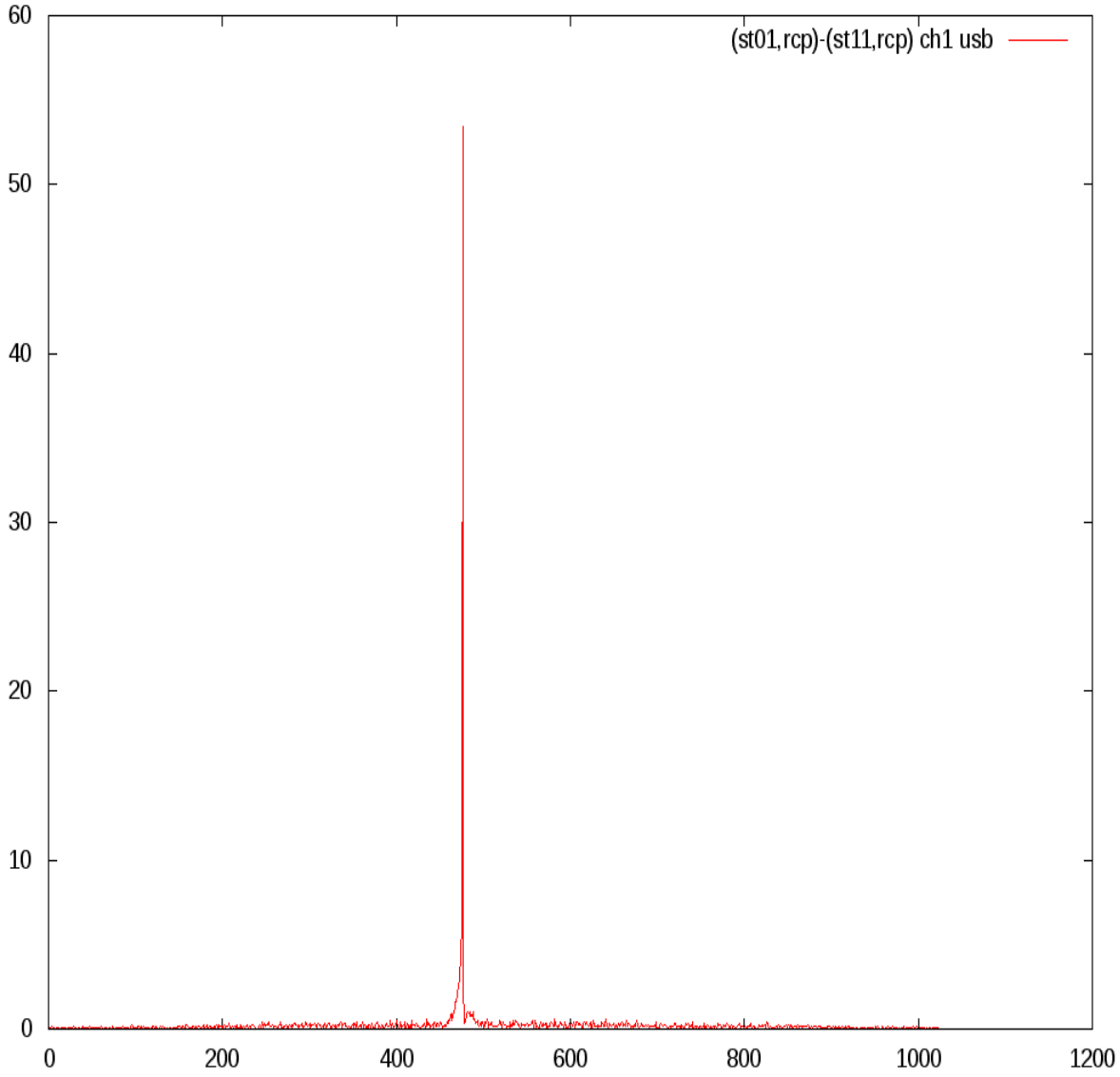
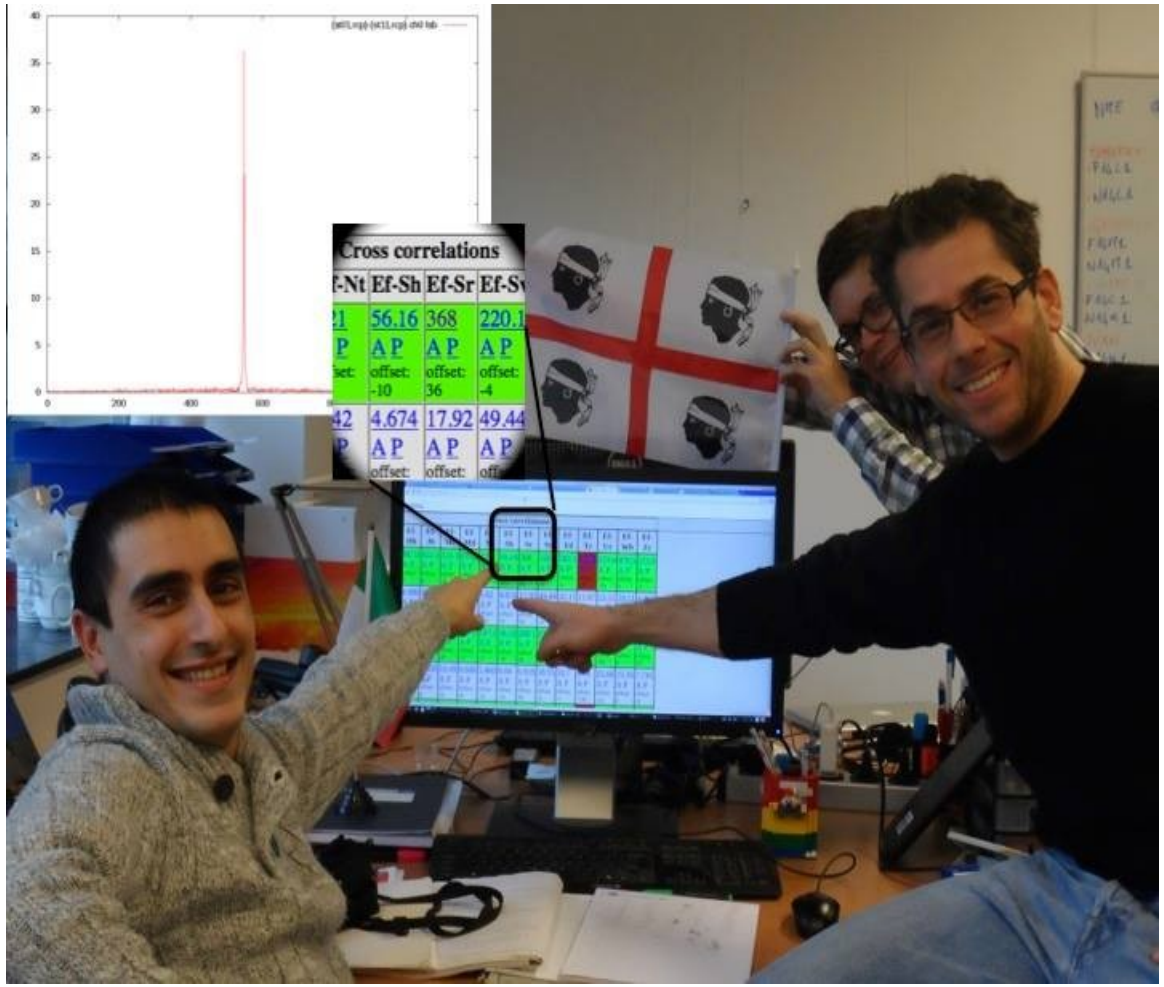
First EVN fringes (SRT-Effelsberg)





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A bit of history (2)

- 2014: Technical and Operational Group meeting in Cagliari (Oct)

- 2015: Officially into EVN network, SRT joins most of all the experiments at the three its available bands

- 2015: Officially into RadioAstron network

- 2015: Experiments and tests with Japanese VLBI Network (VERA)

- 2016: Experiments and tests with

    - Korean VLBI Network (KVN)
    - Chinese Tianma 65-m radio telescope

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VLBI instrumentation

DBBC2
4 Core2 boards
Fila10G

Mark5B+

Mark5C

DBBC2
2 Core2 boards
No Fila10G

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DBBC3

- Instantaneous bandwidth: **4 GHz**

- Sampling representation: **10 bit**

- Compatibility with DBBC2 environment

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Current status of SRT

- After the refurbishment of its actuators, SRT observed successfully the Cassini's splash

- A quick technical & scientific commissioning will start in November

- Participation to next EVN sessions: 70%

- Early Science: September 2018

- Call for Proposal: June 2019

THANKS FOR YOUR ATTENTION!