SRT as follow up of CMB experiments

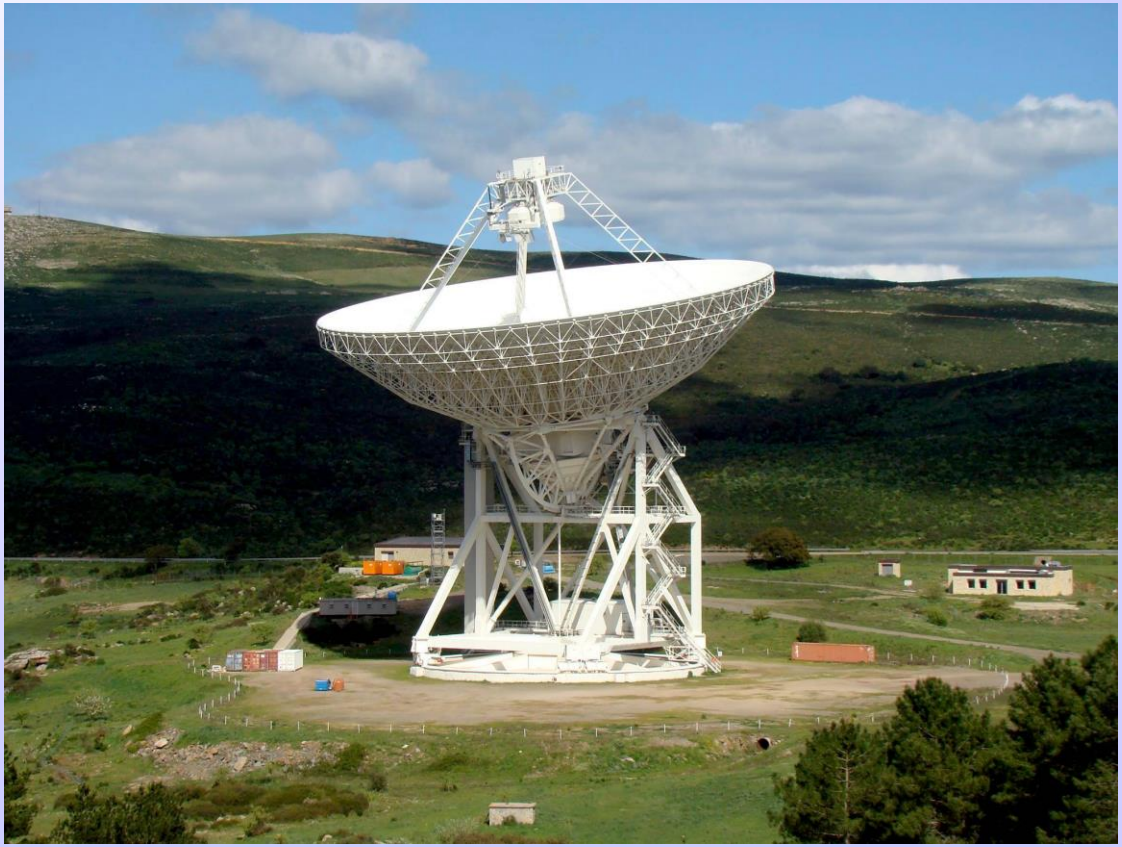
A. Navarrini[1], E. Carretti[2], S. Poppi[1], M. Murgia[1], F. Govoni[1], E. Battistelli[3]

On behalf of the SRT Team

[1] INAF Astronomical Observatory of Cagliari, Cagliari, Italy
[2] INAF Institute of Radio Astronomy, Bologna, Italy
[3]Università la Sapienza, Roma, Italy

SRT
SARDINIA
RADIO
TELESCOPE

INAF
ISTITUTO NAZIONALE
DI ASTROFISICA
NATIONAL INSTITUTE
FOR ASTROPHYSICS



SRT (Sardinia Radio Telescope) Project

64 m diameter fully steerable radiotelescope to cover 0.3-116 GHz:

- Single dish operation
- Part of VLBI network
- Radioastronomy, geodynamical studies, Deep Space Network

Collaboration among three Research Structures of INAF:

- INAF Astronomical Observatory of Cagliari, Cagliari
- INAF Institute of Radio Astronomy, Bologna
- INAF Arcetri Astrophysical Observatory, Florence

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Cost ≈ 60 MEuro

Main Funding Institutions:

- MIUR (Italian Ministry of Education and Scientific Research)
- ASI (Italian Space Agency)
- RAS (Sardinia Regional Government)

REPVBBLICA ITALIANA
Ministero dell'Istruzione dell'Università e Ricerca

asi

SRT site

Altitude a.s.l.	≈600 m
Latitude	$+39^{0}\ 29^{m}\ 50^{s}$

SRT technical specifications

Primary mirror D=64 m; Secondary mirror D=7.9 m

Gregorian configuration with shaped surfaces

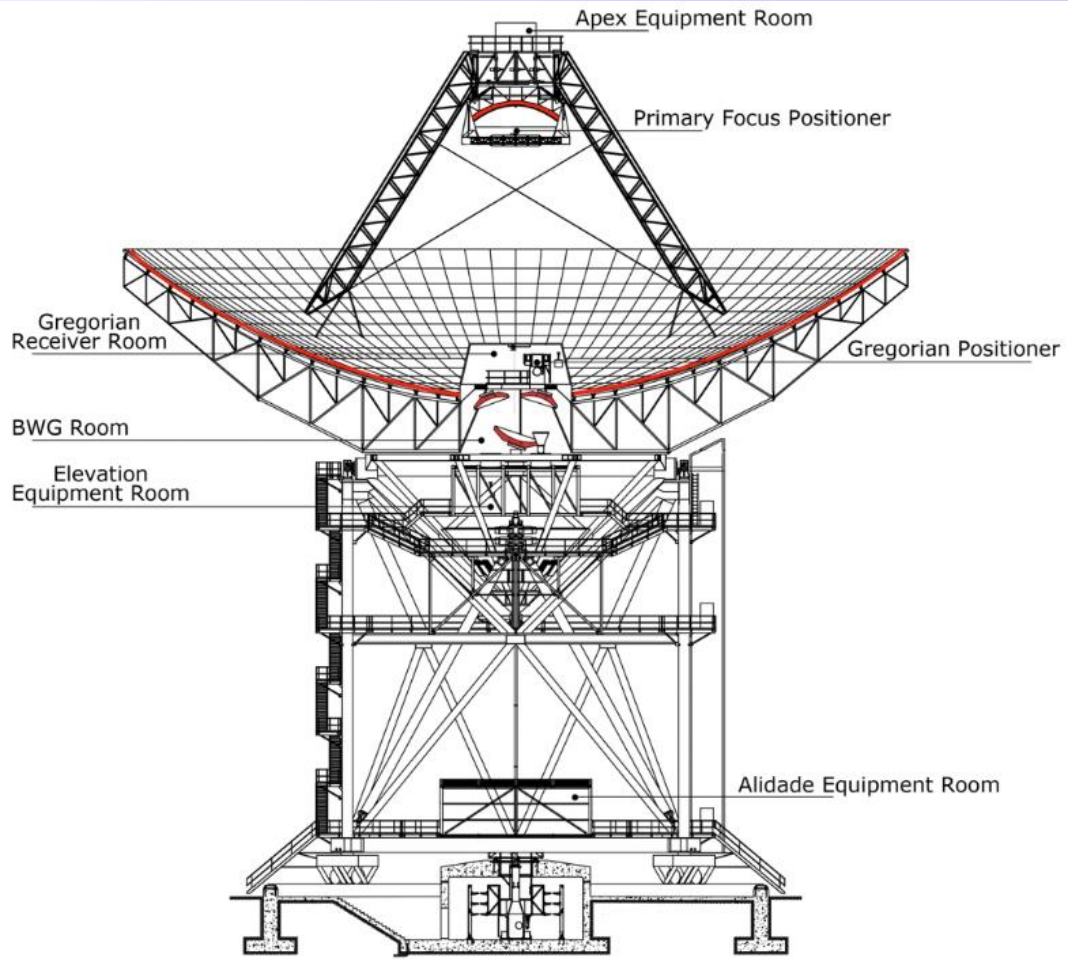
Active Surface on the primary mirror: adjustable with 1116 actuators;

0.3-116 GHz frequency coverage

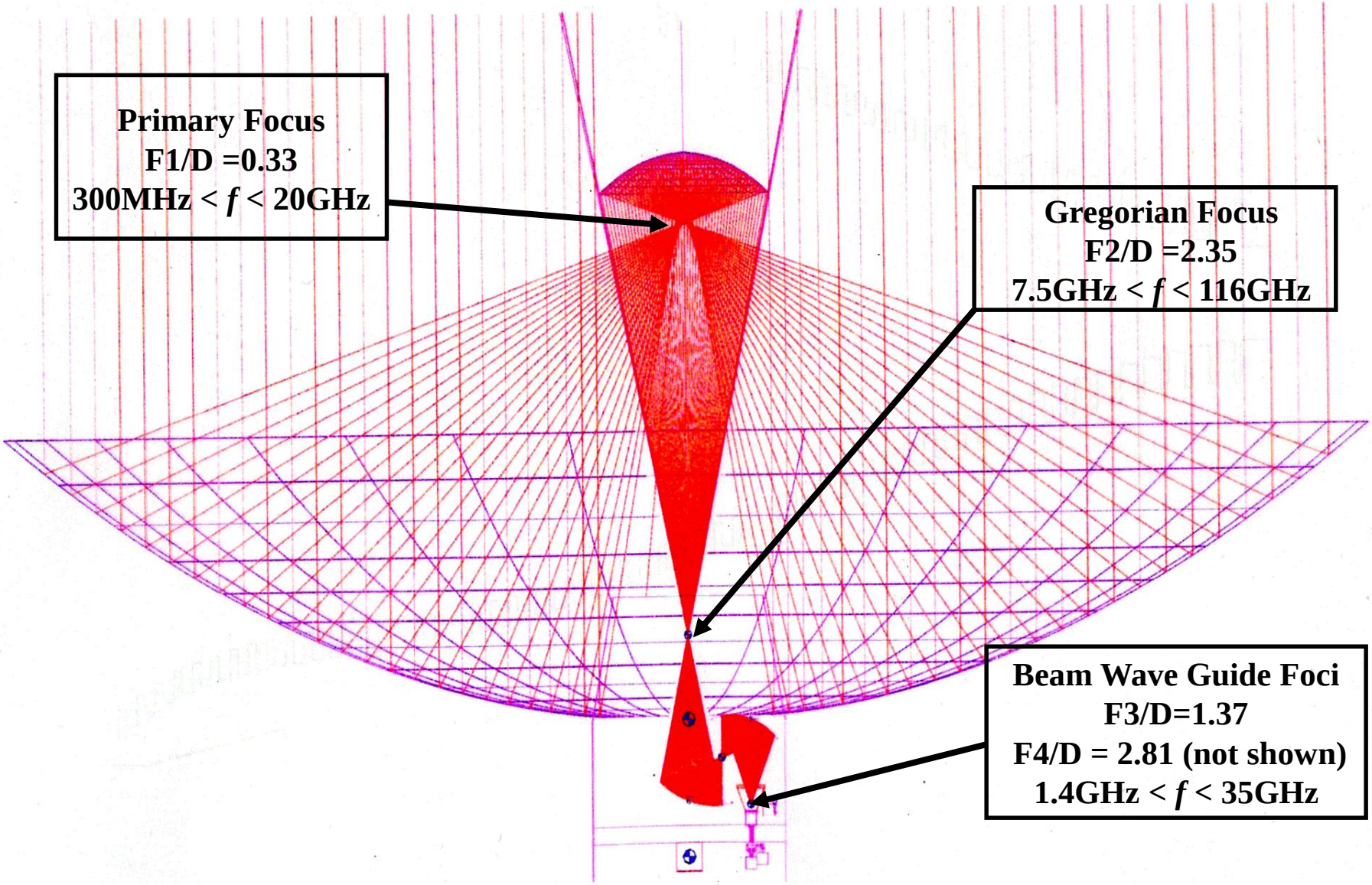
Six focal positions: Primary, Gregorian, & four Beam Wave Guide

Can host over 14 receivers: mono feed, dual frequency, multibeam, phased array feeds

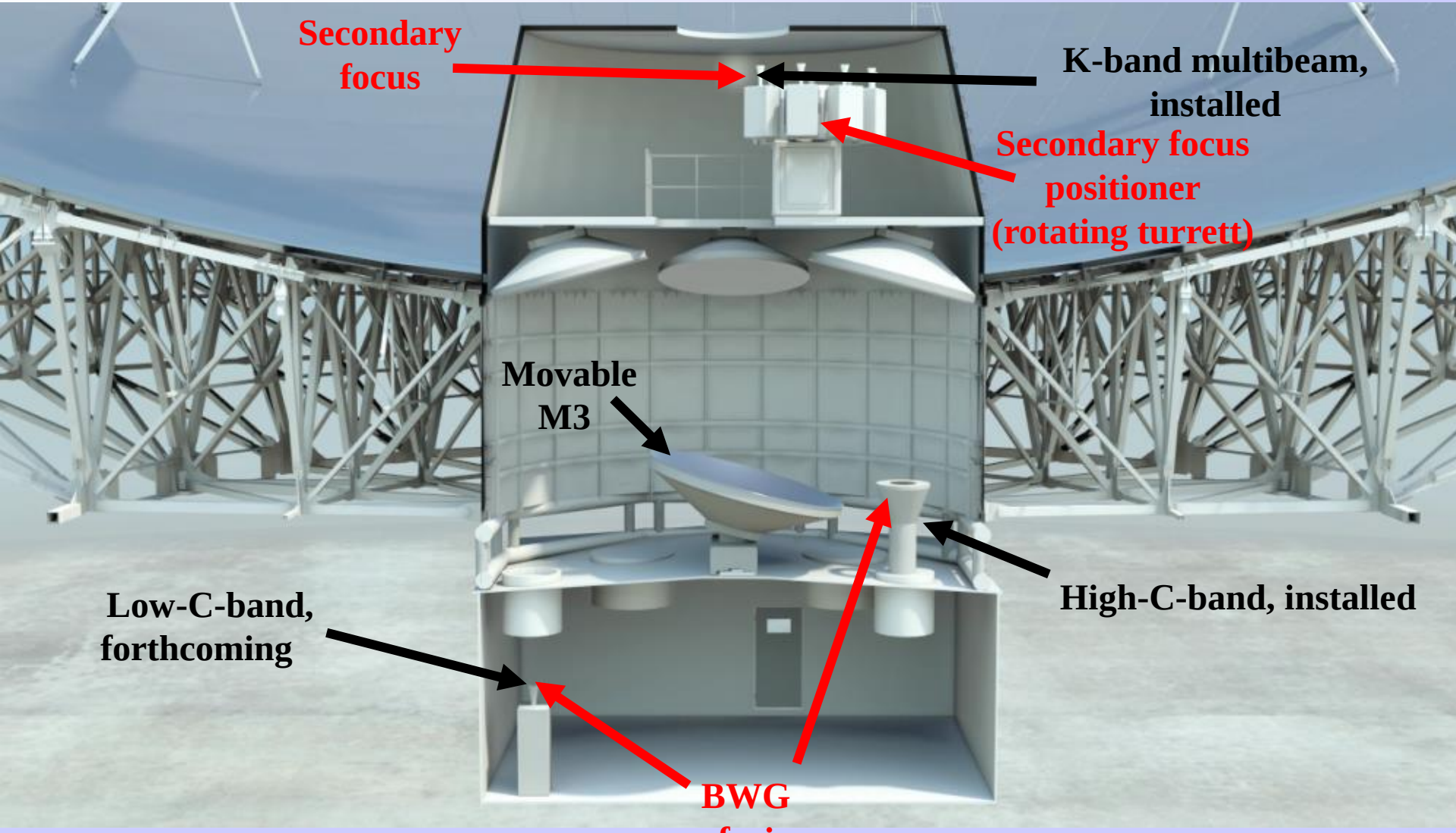
Primary surf. accuracy:≈150 μm RMS



Optical Configuration and Ray Tracing of SRT

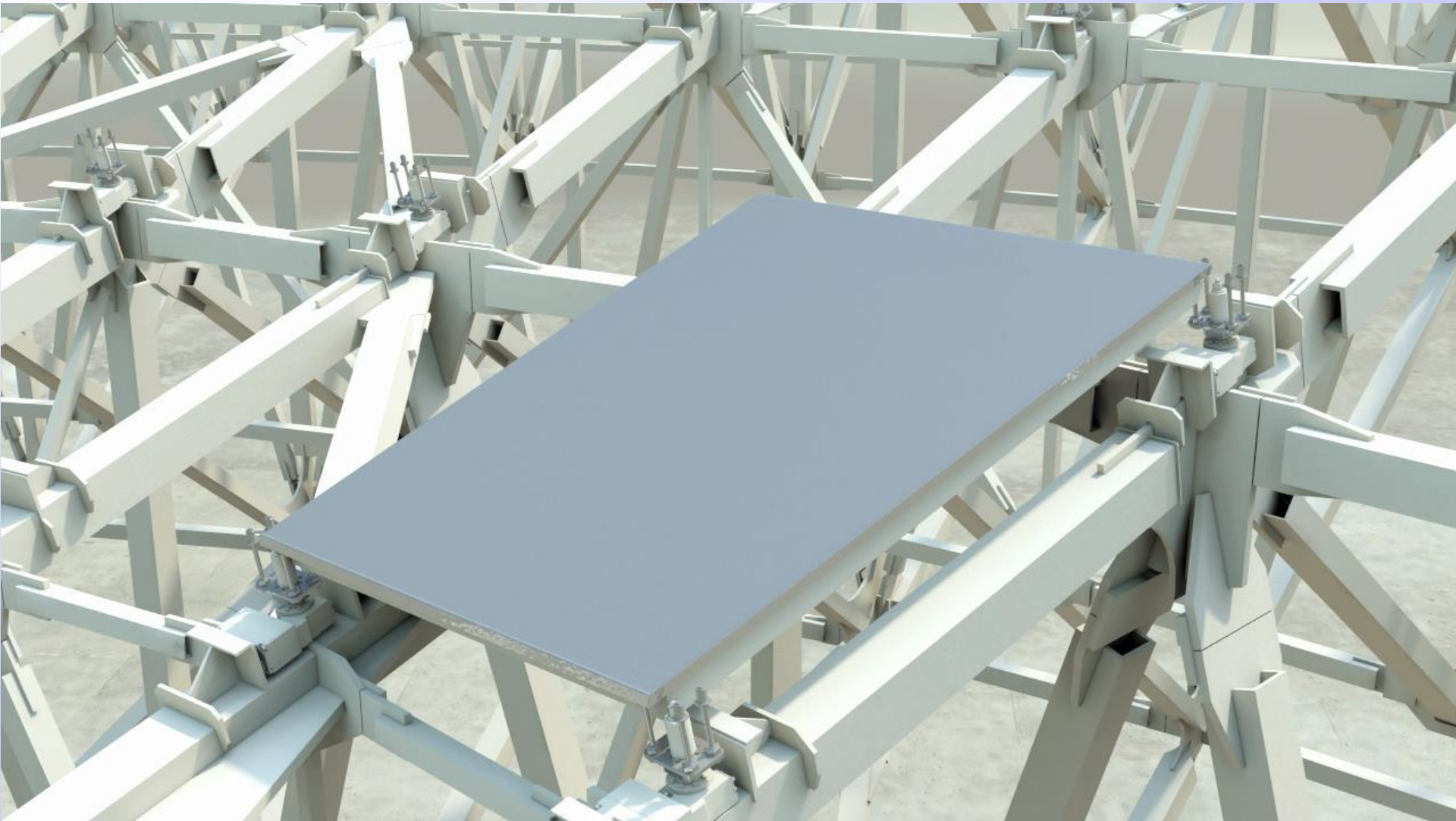


Gregorian and BeamWaveGuide (BWG) rooms



Active surface: shape of primary mirror controlled with actuators

- Compensate deformations of the primary mirror
- Convert shaped profile to a true-parabola (for primary focus)
- Compensate deformations of the secondary mirror



The actuators before installation on the SRT BKS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SRT timeline

June 2012 – October 2013:
Technical commissioning;

February 2012 - January 2016:
Astronomical Validation;

February - August 2016:
Early Science Program;

2017:
Refurbishment of active surface;
Buildings and infrastructures completed;

2018:
Re-commissioning;
First open call (obs.: Dec 2018- May 2019);

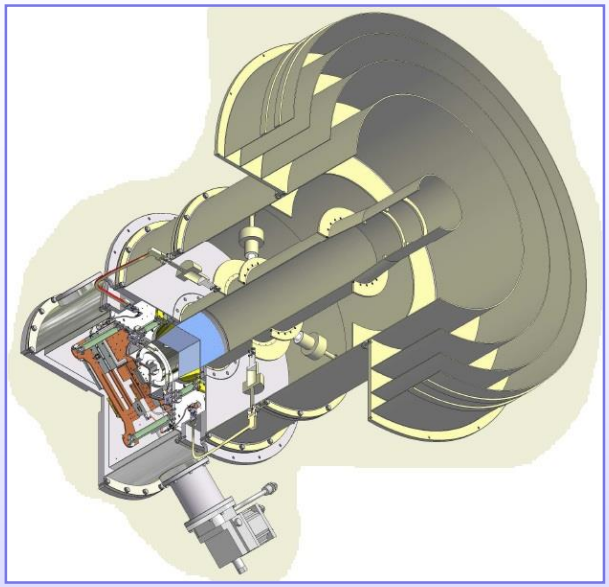
2019:
Deadline of next call: Apr. 2019;

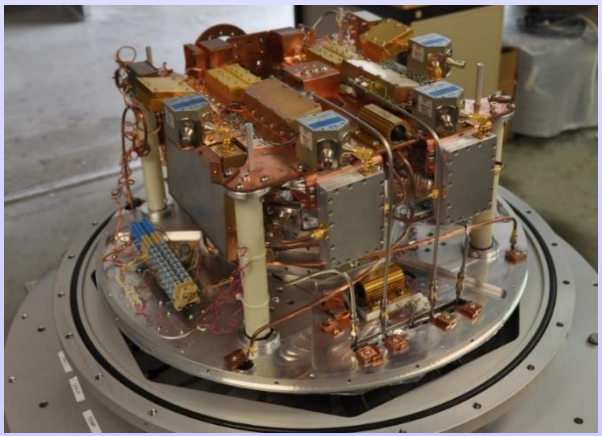
SRT Front-Ends in operation

Front-End	Freq. range [GHz]	Focal position, F/D	N. Pixels × pols	Polarization type	Measured/ receiv. noise temp. [K]
Dual frequency L-P band coaxial	P: 0.305-0.410	Primary, 0.33	1 × 2	H/V or L/R	17-22
	L: 1.3-1.8		1 × 2	H/V or L/R	10-13
High-C-band	5.7-7.7	BWG I, 1.37	1 × 2	L/R	6.5-9
K-band	18-26.5	Gregorian, 2.35	7 × 2	L/R	20-40
X-band (ASI)	8.2-8.6	BWG II, 2.81	1 × 2	L or R	30

INAF SRT Front-Ends in operation

Dual-frequency L-P band receiver for primary focus

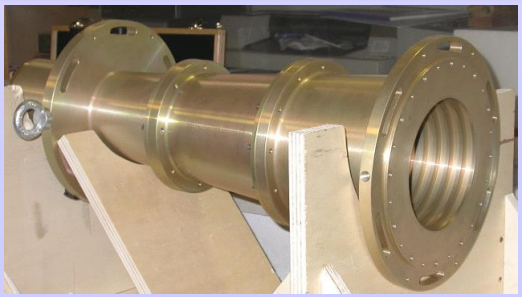




T_{rec} (P band)=17-22 K

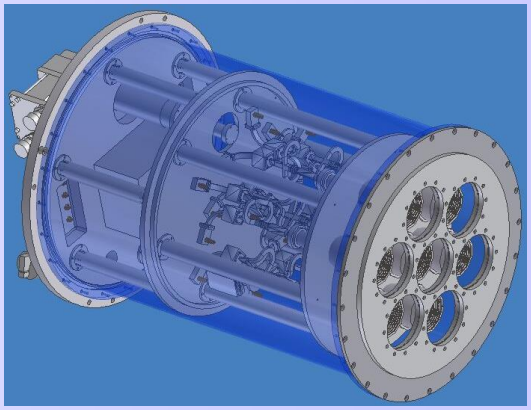
T_{rec} (L band)=10-13 K

High-C-band monofeed receiver for BWGI focus

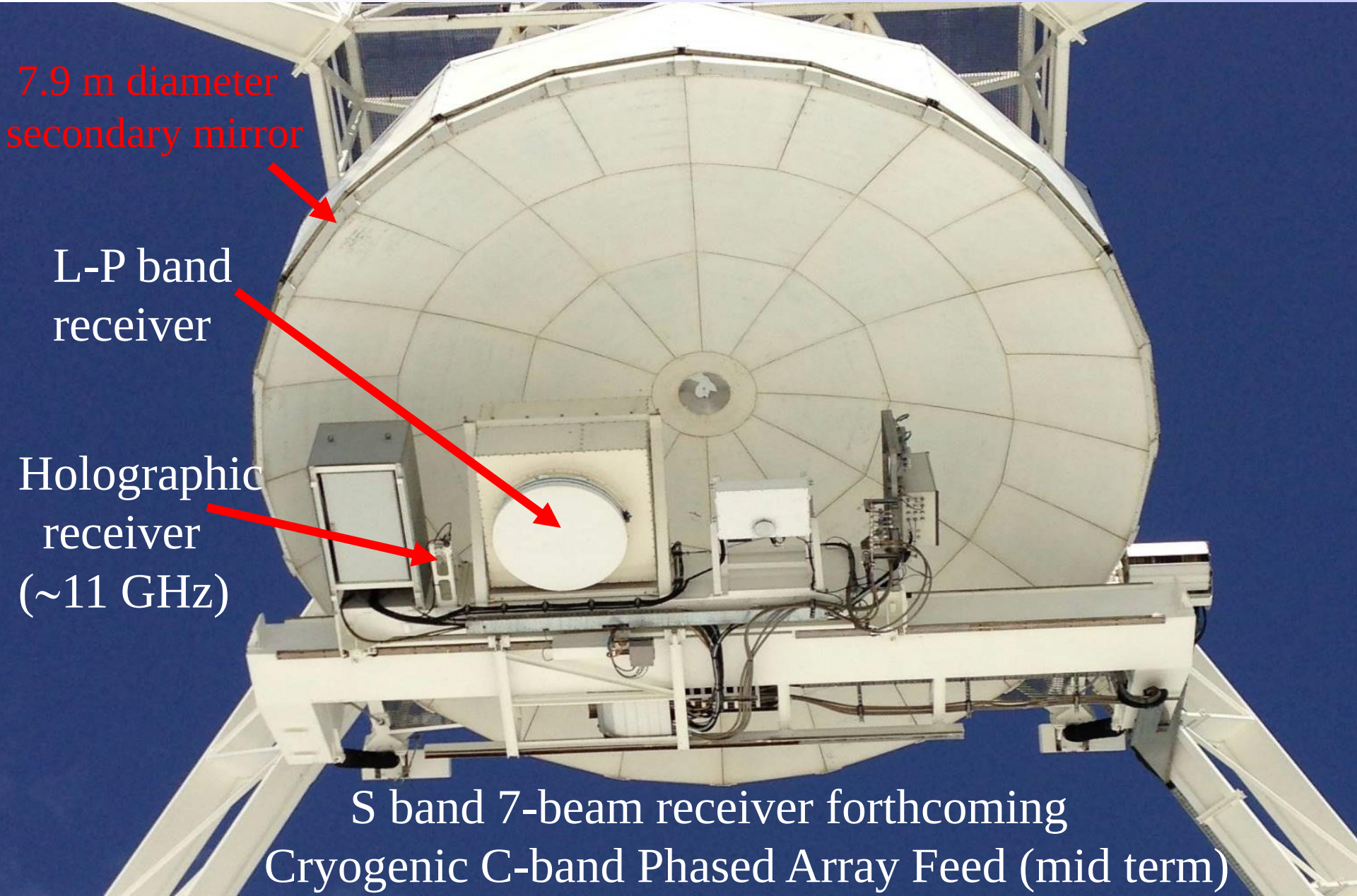


T_{rec}=6.5-9 K

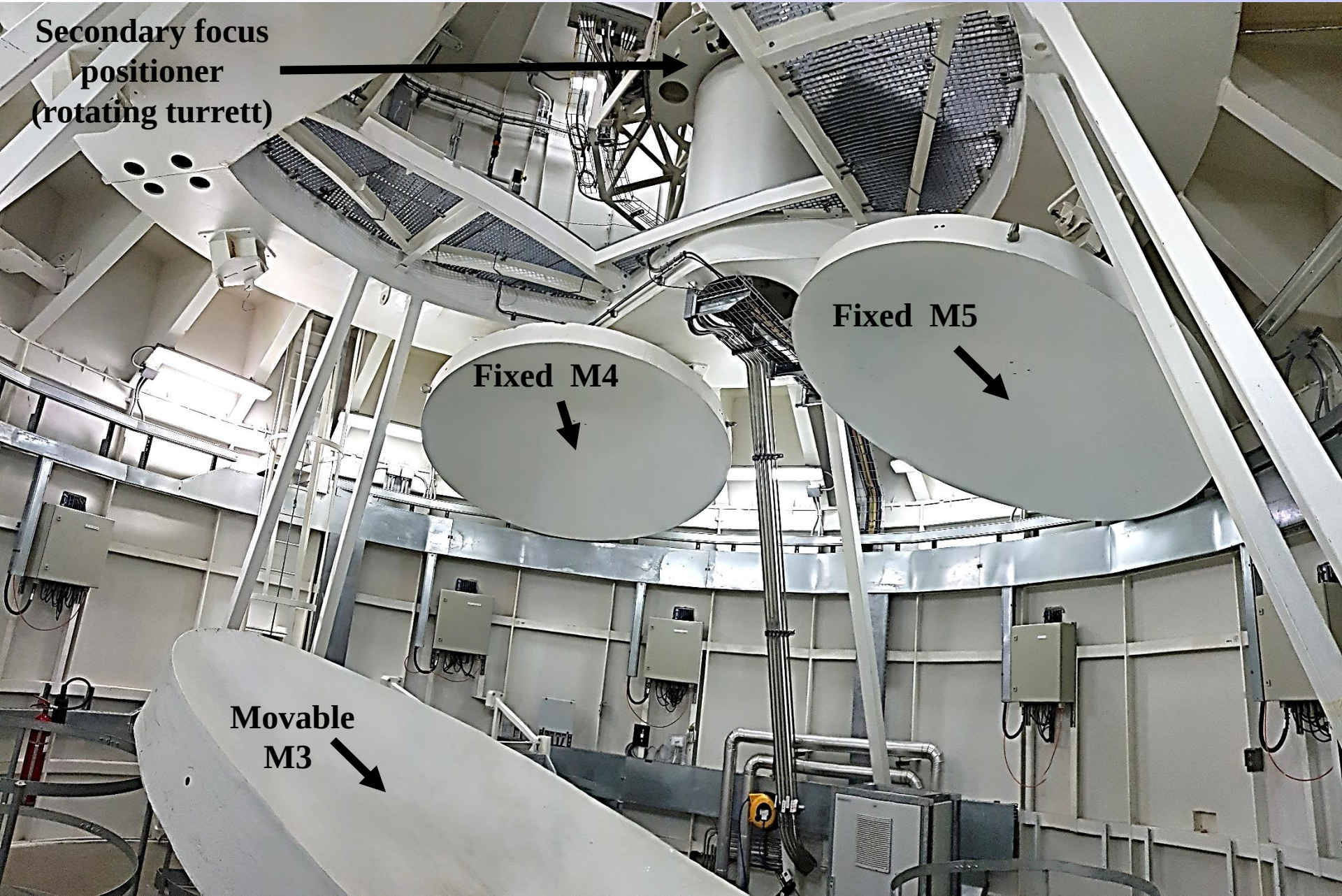
K-band 7-feed receiver for Gregorian focus



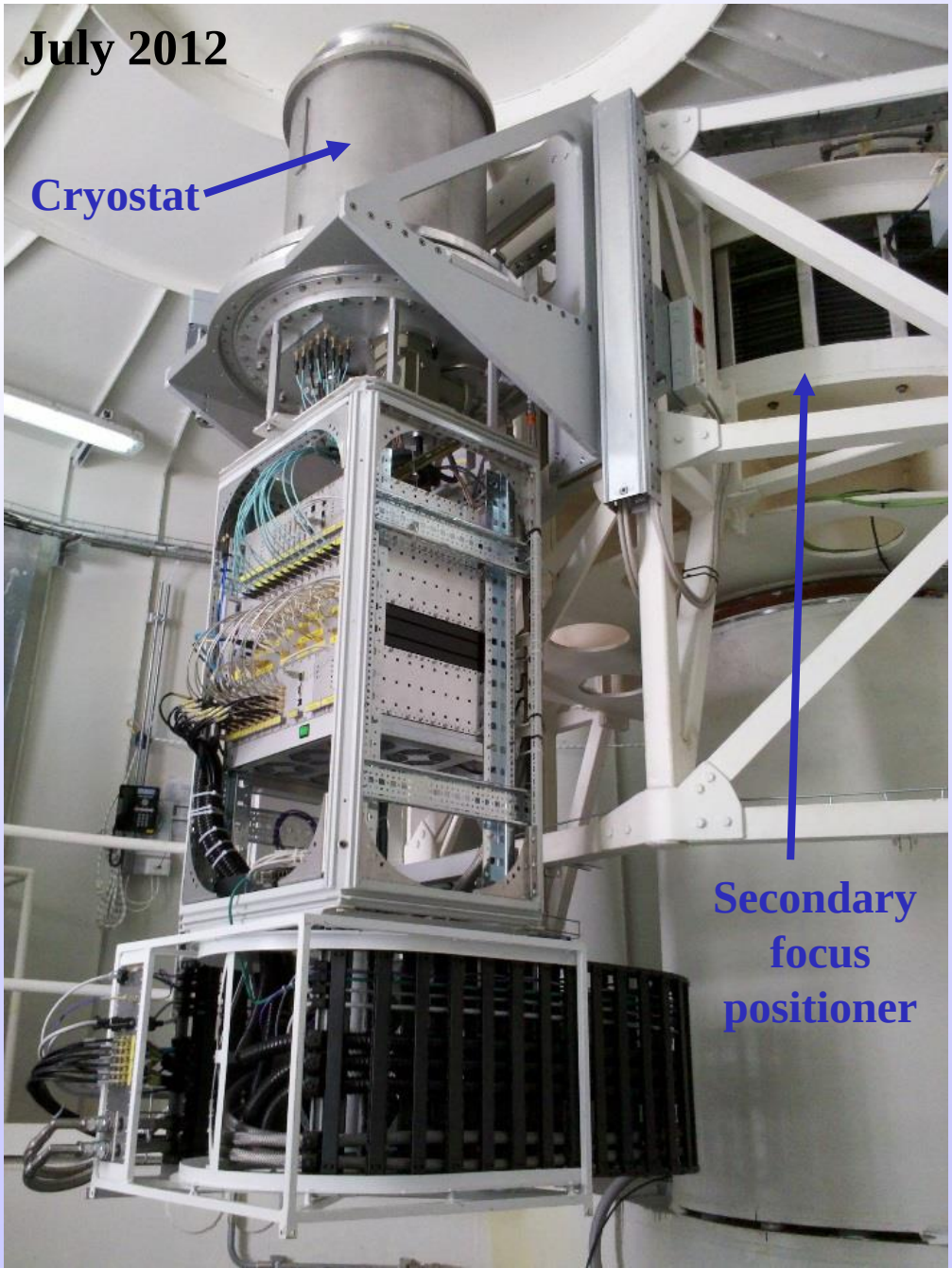
Front-Ends installed at the SRT primary focus



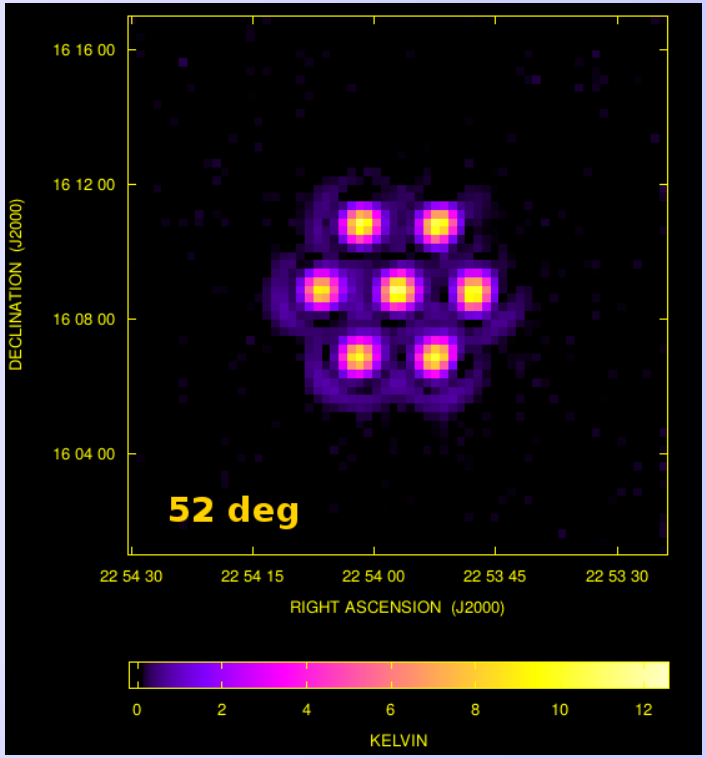
SRT Beam Waveguide Room



K-band multibeam receiver installed on SRT Gregorian focus



Instantaneous sky coverage



M. Murgia et al., in prep.

Freq [GHz]	HPBW [arcsec]
18	58.5
22	50.1
26	44.3

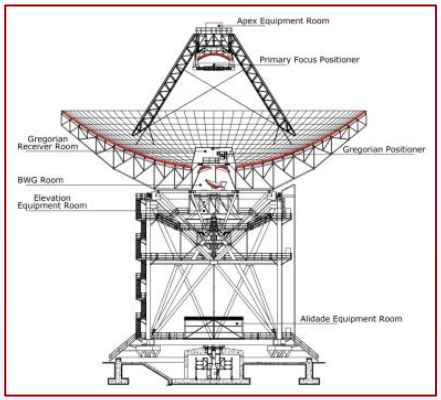
Separation between contiguous beams: 137.6”

Backends currently in operation at SRT

- ATNF PDFB (Pulsar Digital Filter Bank): 1 GHz BW full-Stokes; up to 2048 ch., folding and search mode (Pulsars);
- ROACH1: 512 MHz BW, sw correlation - CPU cluster (Pulsars);
- XARCOS: 62.5 MHz, 7 beams dual pol., 2048 ch., freq. res. down to 0.25 KHz (spectroscopy);
- SARDARA (ROACH2-based): 2 GHz BW, 7 beams full-Stokes, f/w: up to 16 kch., (pulsars, spectroscopy, continuum, spectropolarimetry);
- VLBI backend: DBBC2 + MK-V recorder; RFI monitoring;
- Total Power (TP): up to 7 beams dual pol., 2 GHz BW;

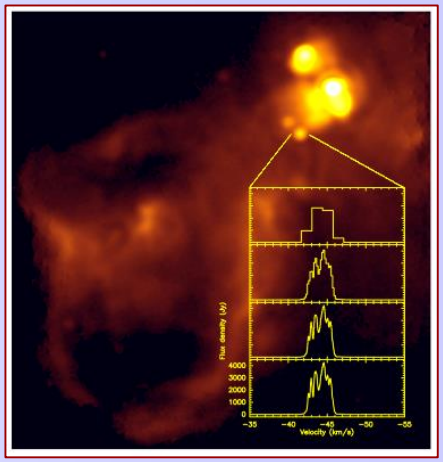
Science with SRT

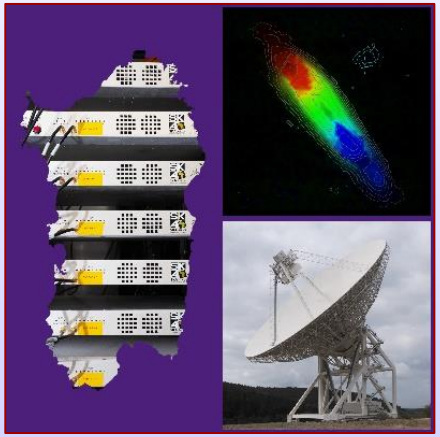
(technical commissioning and astronomical validation)



Bolli et al. (2015)
Sardinia Radio Telescope: General Description, Technical Commissioning and first Light

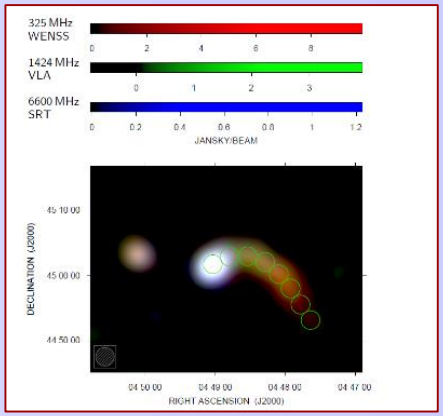
Prandoni et al. (2017)
The Sardinia Radio Telescope : From a technological project to a radio observatory





Melis et al. (2018)
Sardinia Roach2-based Digital Architecture for Radio Astronomy (SARDARA)

Murgia et al. (2016)
Sardinia Radio Telescope wide-band spectral polarimetric observations of the galaxy cluster 3C129



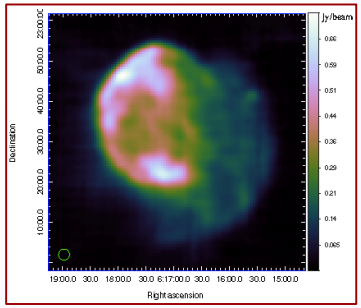
~50 Technical notes and Internal Reports **http://www.oa-cagliari.inaf.it/area.php?page_id=10**

For a complete descriptions of the scientific articles and of the 6 Astronomers's Telegrams see:

http://www.srt.inaf.it/astronomers/science_srt/

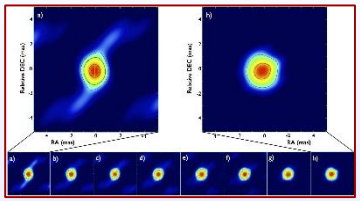
Science with SRT

(Early Science Program 2000 hours)



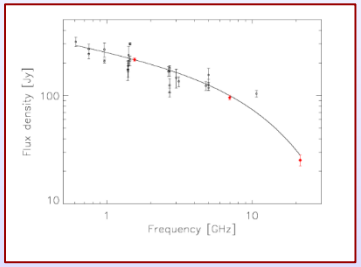
Egron et al. (2017a)

Imaging of SNR IC443 and W44 with the Sardinia Radio Telescope at 1.5 GHz and 7 GHz



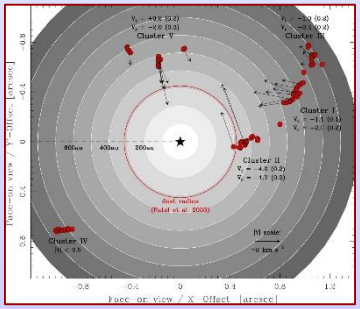
Egron et al. (2017b)

Single-dish and VLBI observations of Cygnus X-3 during the 2016 giant flare episode



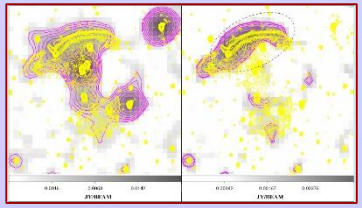
Loru et al. (2018)

Investigating the high-frequency spectral features of SNRs Tycho, W44, and IC443 with the Sardinia Radio Telescope



Sanna et al. (2017)

Planar infall of CH3OH gas around Cepheus A HW2

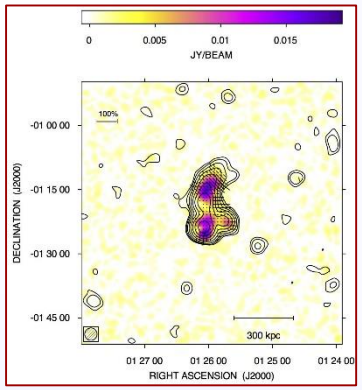


Loi et al. (2017)

Observations of the galaxy cluster CIZA J2242+5301 with the Sardinia Radio Telescope.

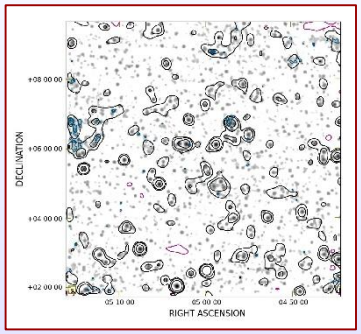
Science with SRT

(Early Science Program 2000 hours)



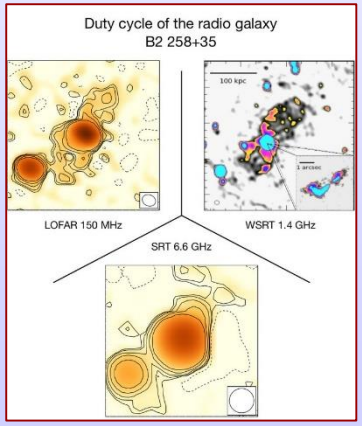
Govoni et al. (2017)

Sardinia Radio Telescope observations of Abell 194 - the intra-cluster magnetic field power spectrum.



Vacca et al. (2018)

Observations of a nearby filament of galaxy clusters with the Sardinia Radio Telescope

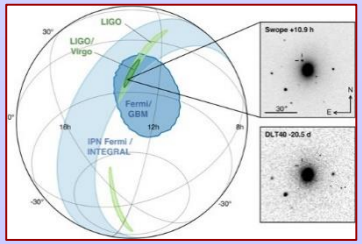


Brienza et al. (2018)

Duty cycle of the radio galaxy B2 0258+35

Science with SRT

(Re-commissioning)



Abbott et al. (2017)

Multi-messenger Observations of a Binary Neutron Star Merger

Future perspectives:
PON grant (Programma Operativo Nazionale)

Call for proposals for grants aimed to enhance research infrastructures
National Operative Programme – Research and Innovation 2014-2020

Ministero dell'Istruzione dell'Università e della Ricerca
Dipartimento per la Formazione Superiore e per la Ricerca
Direzione Generale per il coordinamento, la promozione e la valorizzazione della ricerca
PON Ricerca e Innovazione 2014-2020
(CCI: 2014IT16M2OP005)

Enhancement of the Sardinia Radio Telescope for the study of the Universe at high radio frequencies

Total requested budget (for 9 Work Packages) 18.7 MEuro, to spend within 32 months from notification

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PON grant

March 2019: Expected notification from Ministry about funding request;

Goals of PON grant and Work Packages:

WP1: W-band (75-116 GHz) heterodyne multibeam receiver for SRT Gregorian focus;

WP2: 19-beam Q-band (33-50 GHz) heterodyne receiver for SRT Gregorian focus;

WP3: 3 mm band KID detectors bolometric camera for SRT Gregorian focus;

WP4: Simultaneous tri-band K-Q-W band receivers for mm-VLBI (KVN) with SRT, Medicina and Noto antennas;

WP5: Backends for new W-band and Q-band multibeams and tri-band VLBI receivers;

WP6: Upgrade of servo-systems and telescope infrustracuture;

WP7: Upgrade of metrology system for high-efficiency high-frequency operation;

WP8: Upgrade of HPC (high performance computing) and data archiving;

WP9: Upgrade INAF-OA Cagliari laboratories;

SRT Front-Ends: current and future

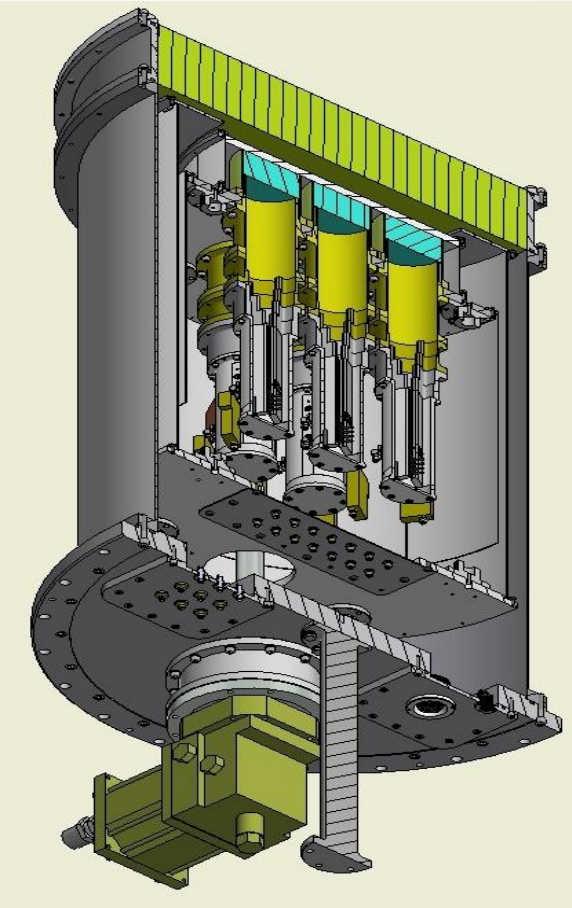
Front End	Frequency range [GHz]	Beams × polarizations	Polarization type	Status
Dual frequency L-P band coaxial feed	0.305-0.410	1 x 2	H/V or L/R	Operational
	1.3-1.8	1 x 2	H/V or L/R	Operational
C_{high}	5.7-7.7	1 x 2	L/R	Operational
K	18-26.5	7 x 2	L/R	Operational
X-ASI	8.2-8.6	1 x 1	L or R	Operational
S-band	3.0-4.5	7 x 2	H/V	Under construction
C_{low}	4.2-5.6	1 x 2	L/R	Under construction

SRT Front-Ends: current and future

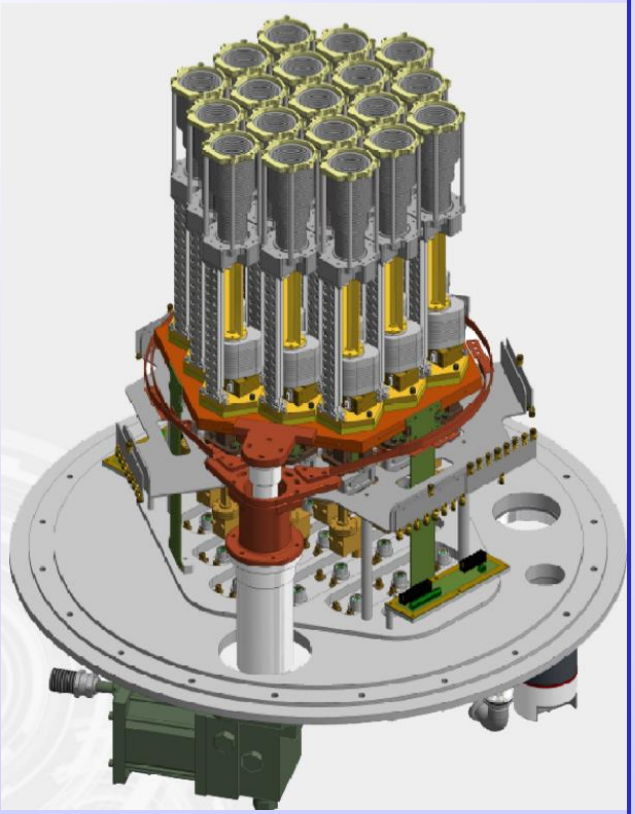
Front End	Frequency range [GHz]	Beams × polarizations	Polarization type	Status
Dual frequency L-P band coaxial feed	0.305-0.410	1 x 2	H/V or L/R	Operational
	1.3-1.8	1 x 2	H/V or L/R	Operational
C_{high}	5.7-7.7	1 x 2	L/R	Operational
K	18-26.5	7 x 2	L/R	Operational
X-ASI	8.2-8.6	1 x 1	L or R	Operational
S-band	3.0-4.5	7 x 2	H/V	Under construction
C_{low}	4.2-5.6	1 x 2	L/R	Under construction
Q-band	33-50	19 x 2	L/R	PON
W-band	75-116	16 x 2 or 9 x 2	H/V or L/R, TBD	PON
Tri-band (K/Q/W)	18-26 / 33-50/ 80-116	1 x 2	L/R	PON
W-band KID detector bolometer	80-115	≈300	Polarization insensitive	PON

Future SRT Front-Ends

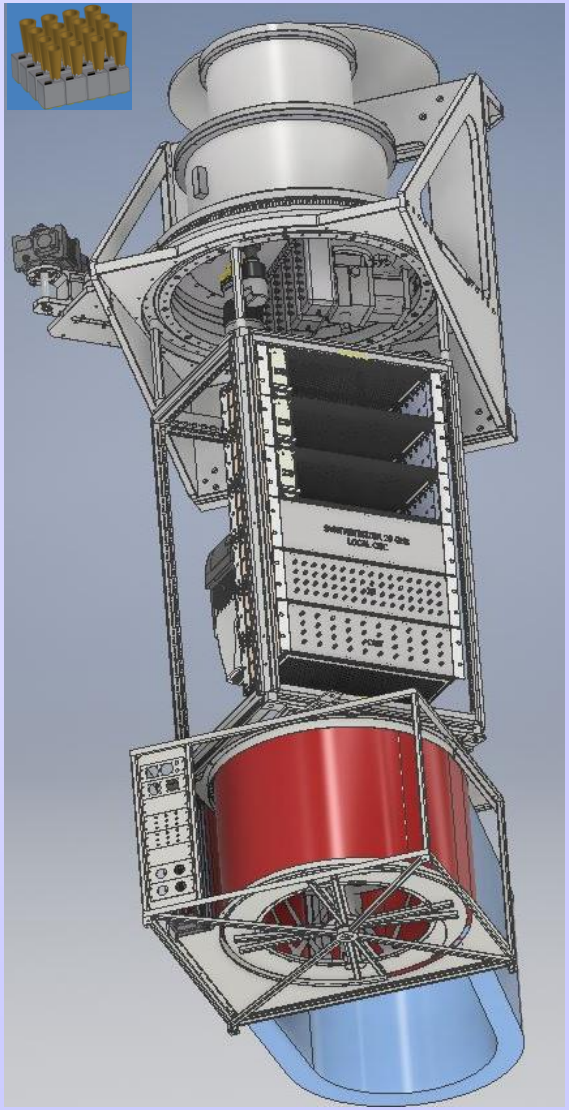
S-Band (3.0-4.5 GHz)
7-beam receiver for primary focus



Q-Band (33-50 GHz)
19-beam receiver for Gregorian focus



W-Band (75-116 GHz)
multibeam receiver for Gregorian focus



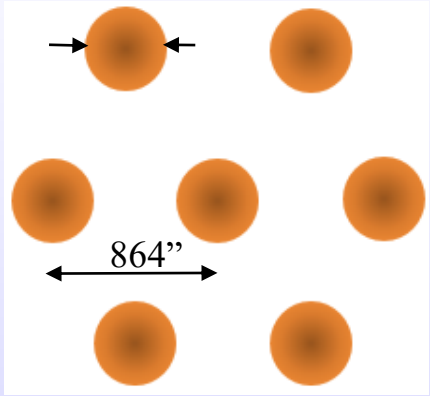
Instantaneous sky coverage with SRT heterodyne multibeam receivers

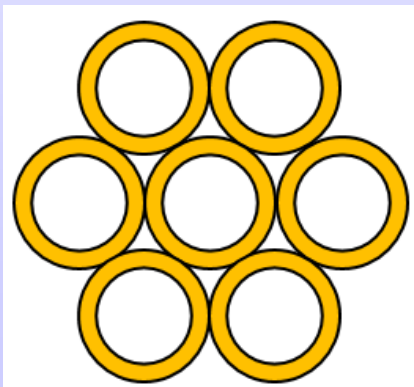
On the sky

Focal plane

7-pixel S-band (3-4.5 GHz)

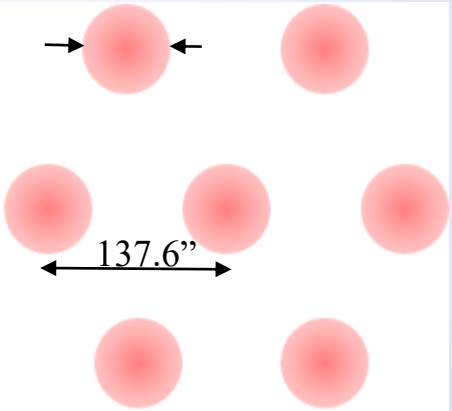
HPBW
317”@3.75GHz

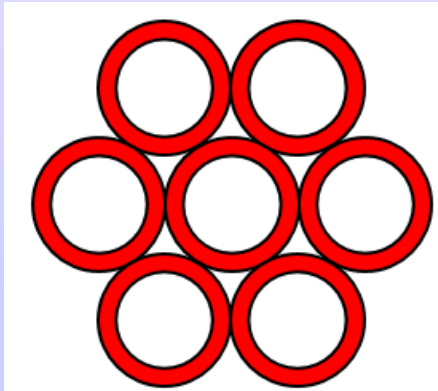




7-pixel K-band (18-26.5 GHz)

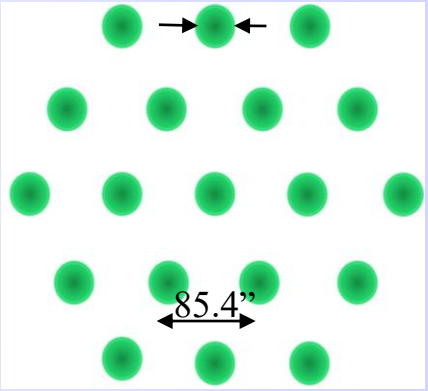
HPBW
50”@22GHz

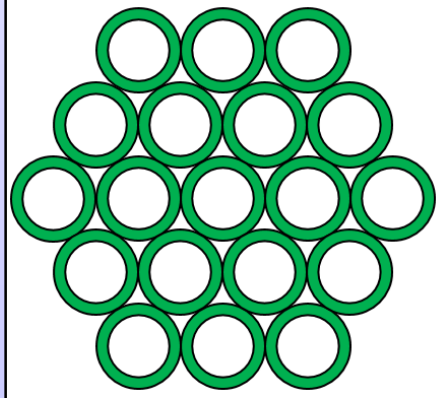




19-pixel Q-band (33-50 GHz)

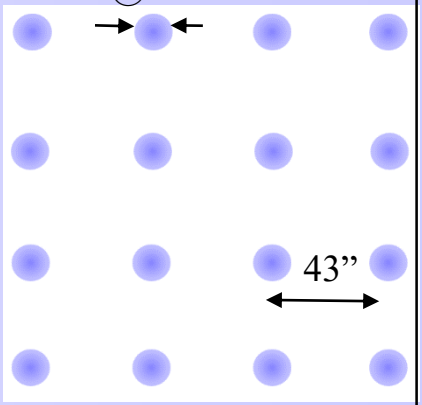
HPBW
27”@41.5GHz

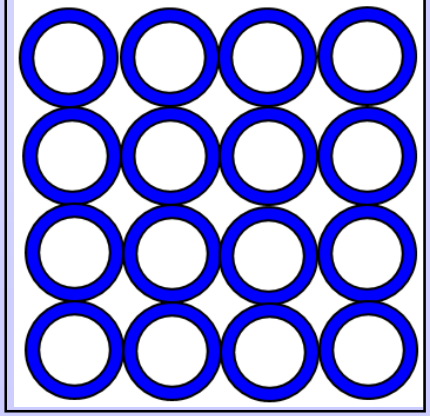




16-pixel W-band (75-116 GHz)

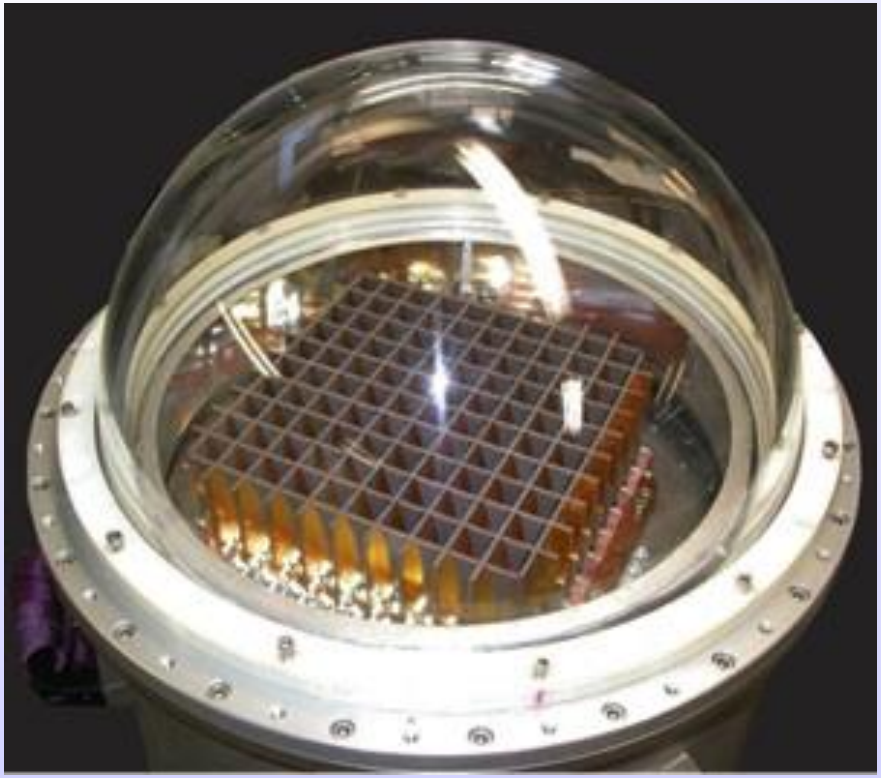
HPBW
12”@95.5GHz

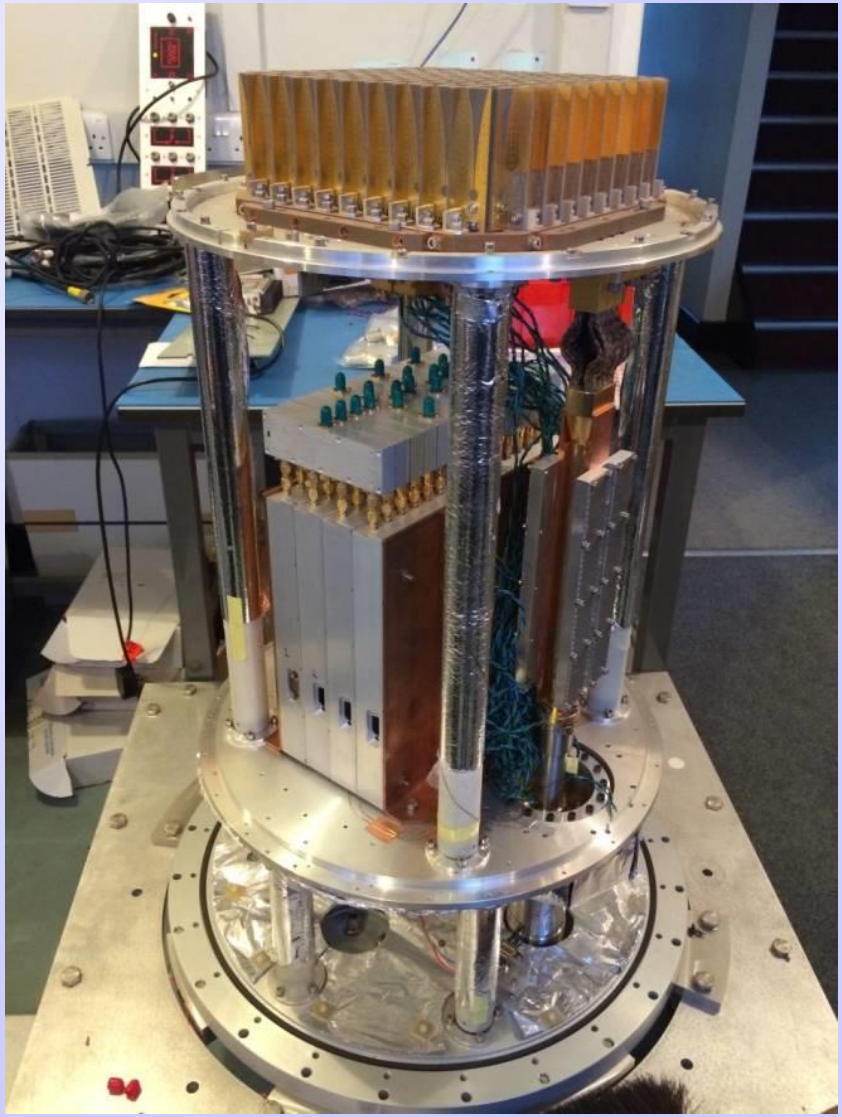




Beyond the PON grant: Phase Array Feed for SRT primary focus

Currently developing PHAROS2, a technology demonstrator of cryogenic C-band (4-8 GHz) PAF of Vivaldi antennas with digital beamformer (in the framework of the PAF Advanced Instrumentation Program for SKA)





Current demonstrator:

- 220 elements Vivaldi array;
- 24 Low Noise Amplifiers;
- 20 K cooling;
- 24 elements to digitally form four beams;

SRT as follow up of CMB experiments: (non-comprehensive) list of science possibilities

- (AME) Anomalous Microwave Emission as an astrophysical source and as a foreground for the CMB: maximum emission expected in the 20-40 GHz range. Already observed with SRT in C-band (S007 ESP) and K-band (current call). Future Q-band observations.

- Study of synchrotron foreground emission with high spatial resolution;

- High spatial resolution (12”@100 GHz) Sunyaev-Zeldovich effect: to study the physics of galaxy clusters, out of equilibrium galaxy cluster systems, interacting galaxy clusters and filamentary structures (baryonic dark matter and WHIM, Warm-Hot Intergalactic Medium). Follow up of clusters found by SPT, Planck, ACT, CARMA (now dismissed).

- Provide high angular resolution to complement the information of LSPE (that will be missing angular resolution);

- Within the current SRT call: L, C, and K-band observations of the Crab nebula to measure its polarization angle; useful for CMB polarization calibration (proposal by R. Genova-Santos, M. Murgia, E. Carretti, S. Poppi, E. Battistelli);

SRT is an open sky facility

Observational infrastructure that grants scientists of the international community access to the telescope through calls for proposals every six months. No restrictions on origin of proposers. Observing time is assigned on a competitive basis, by scientific merit, by a TAC of experts.

http://www.radiotelescopes.inaf.it

See also http://www.srt.inaf.it

You are welcome to apply for observing time!