SARDINIA RADIO TELESCOPE

Project & Scientific Perspectives

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INAF
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NATIONAL INSTITUTE FOR ASTROPHYSICS

SRT
SARDINIA
RADIO
TELESCOPE

SRT PROJECT

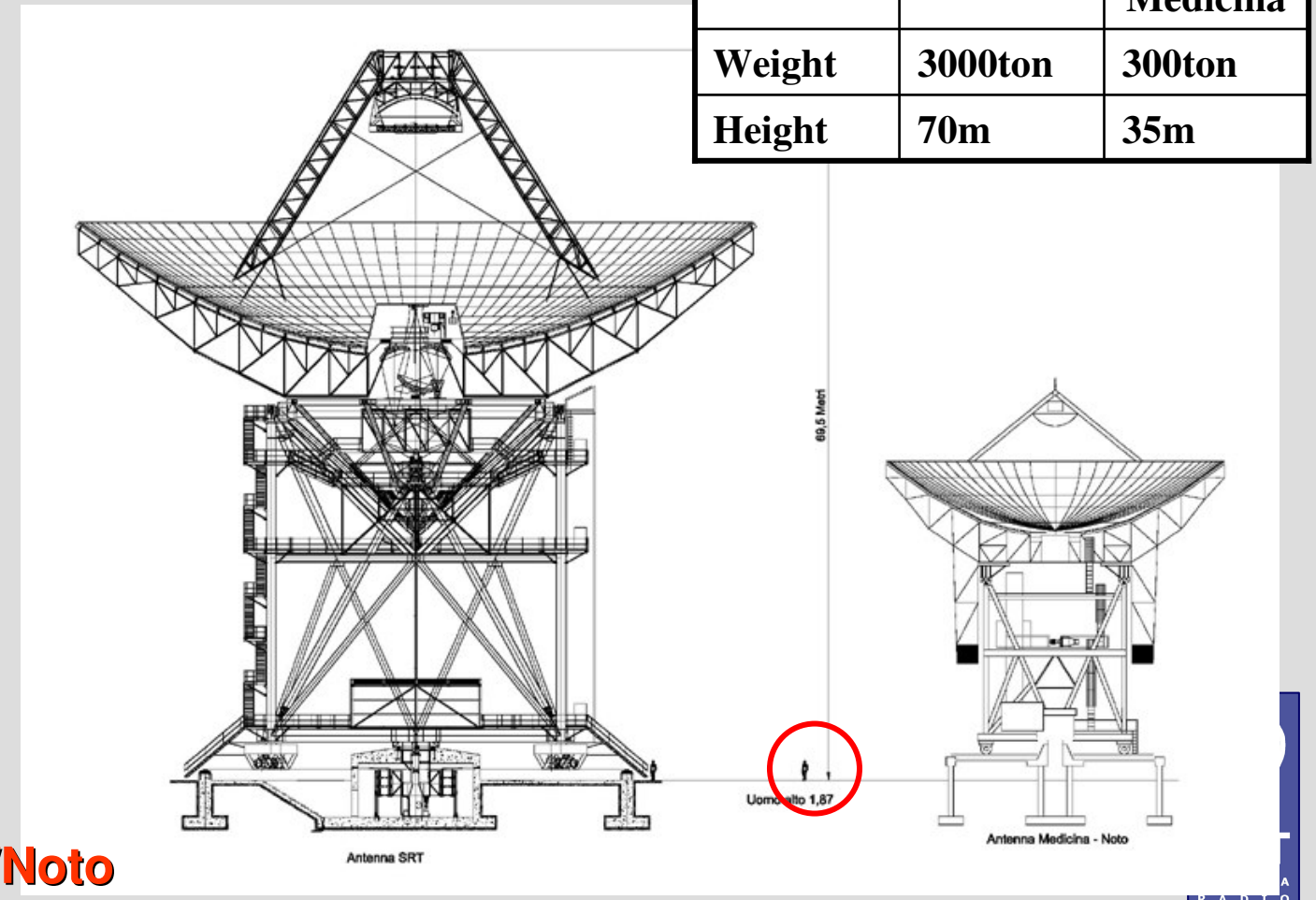
Most powerful Italian radio facility

General purpose fully steerable 64-m diameter radio telescope

High efficiency in a wide frequency range

300 MHz – 100 GHz

	SRT	Noto / Medicina
Weight	3000ton	300ton
Height	70m	35m



SRT vs Medicina/Noto

SRT MOST RELEVANT FEATURES:

- Multiple focal positions (P,G, 2 BWG):

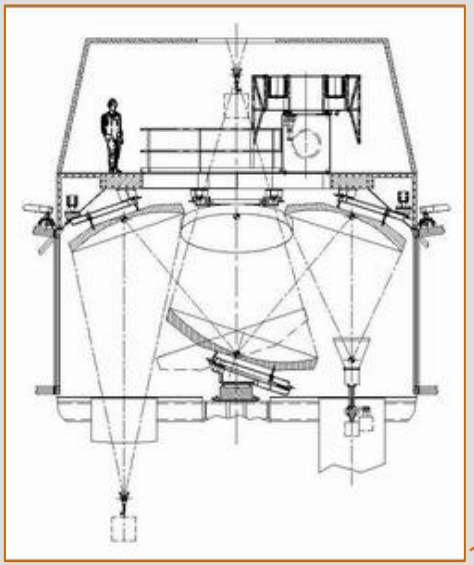
→ 16 Receivers

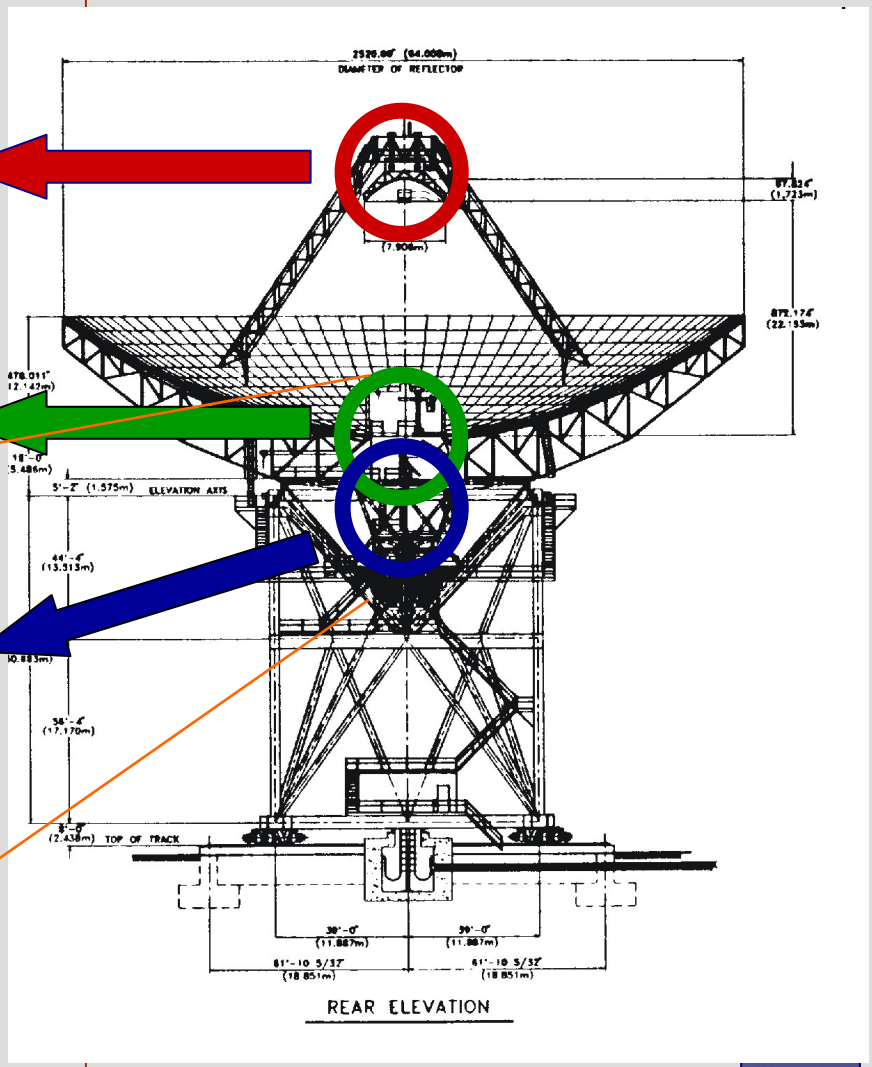
- Frequency agility

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

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

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





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SRT MOST RELEVANT FEATURES:

- Primary and Secondary Mirror *Shaping*:

Basic antenna configuration → gregorian shaped

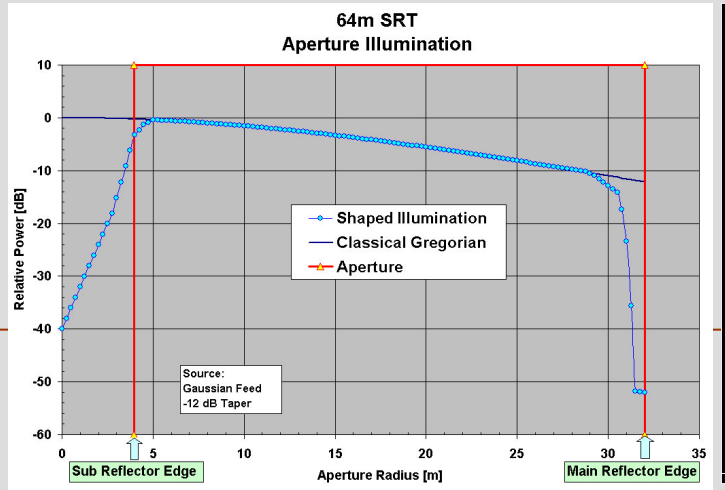
obtained with mirrors "nearly" parabolic and elliptical.

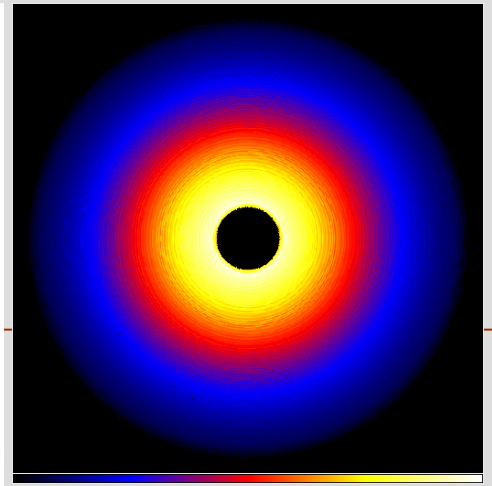
"non classical" curves → better illumination of gregorian/BWG focus compared to standard configuration

Shaping generates **null field in** primary mirror **central region**, blocked by secondary mirror

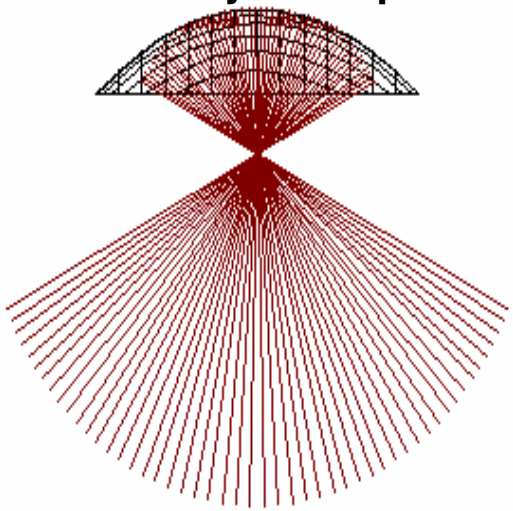
Field redistributed throughout unblocked region, **increasing illumination efficiency**

In addition, the *shaping* causes **under-illumination of the reflector edge**



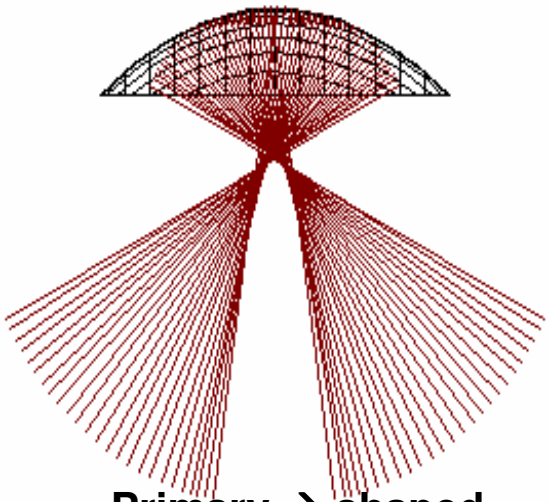


Secondary → Elliptical



Primary → parabolic

Secondary → *shaped*



Primary → shaped

SRT *Shaping:*

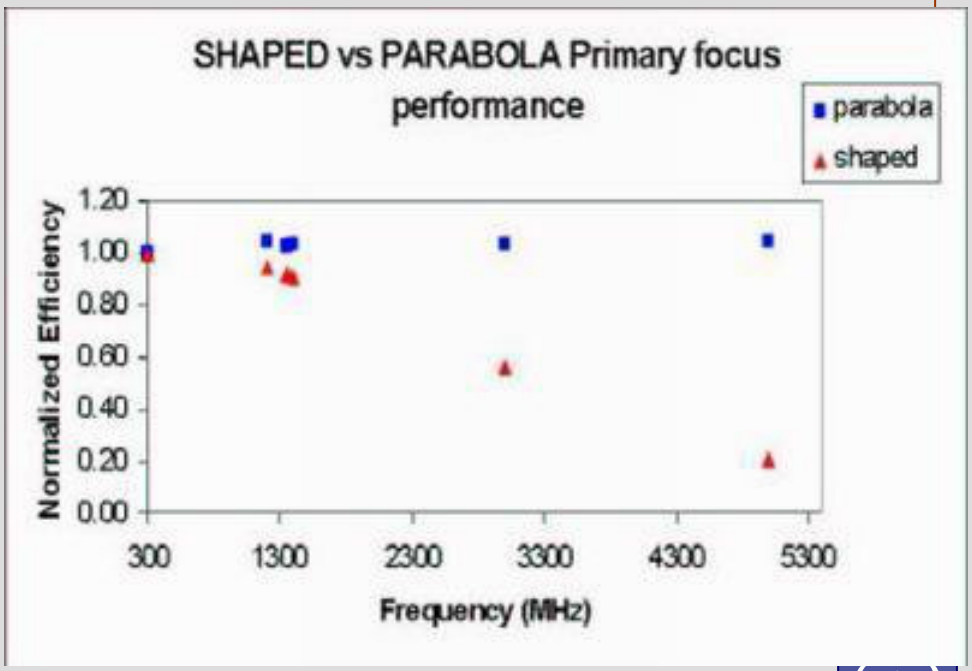
This choice **optimizes gregorian/BWG foci observations**, despite some loss in FoV → **no standing waves, no spillover ➔ high efficiency spectroscopy**

But it reduces the primary focus efficiency, as those observations uses the primary reflector only

For observations in primary focus classical parabolic profile has to be preferred

➔ Max eff. & FOV ≤ 20 GHz

NB: It is possibile to modify the primary reflector's geometry through **active surface techniques**



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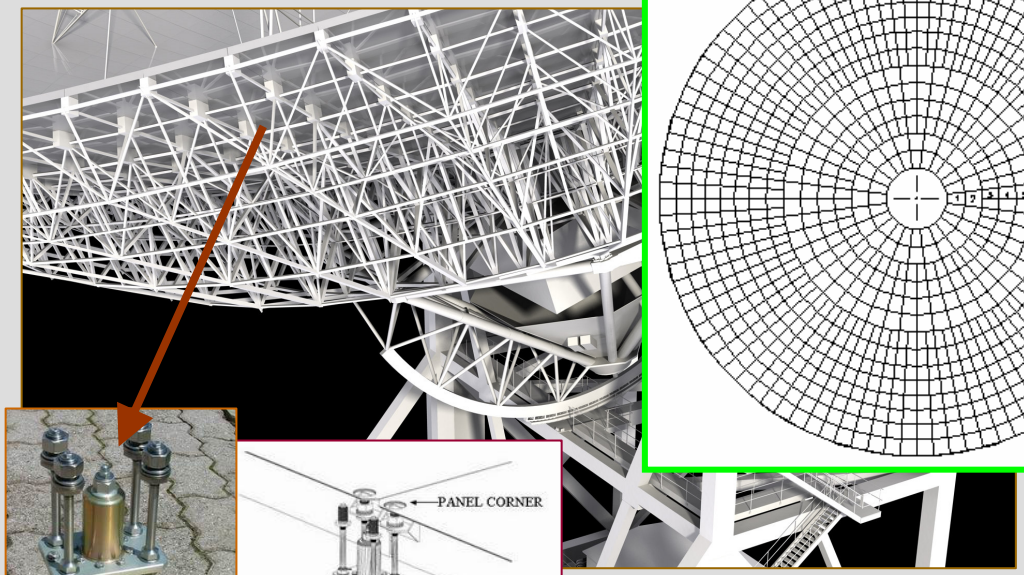
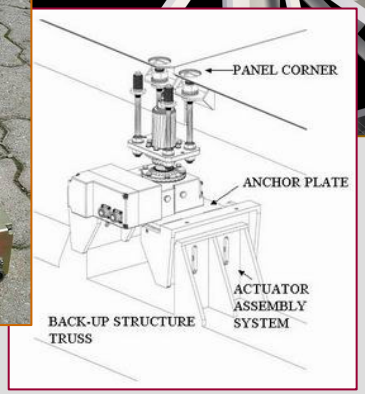
SRT MOST RELEVANT FEATURES:

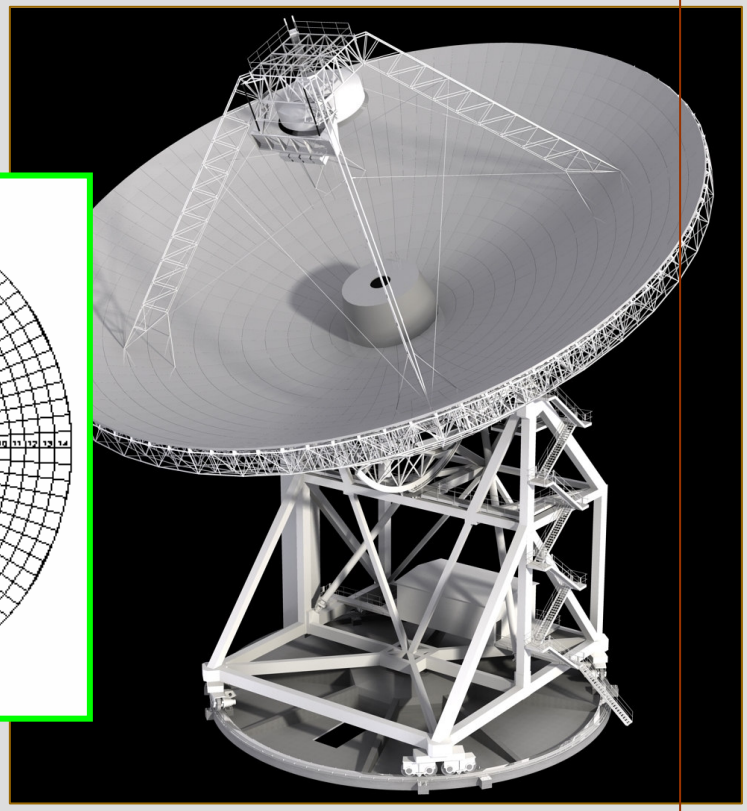
- Active surface of primary mirror

1008 panels supported by 1116 electro-mechanical actuators digitally controlled





Antenna rendering



- **change geometry** from *shaped* to classical paraboloid

➔ **max eff. & FOV at primary focus (≤ 20 GHz)**

- **Correct for deformations** of primary mirror *backup structure* **due to gravity, wind pressure , temperature gradients**

➔ **guarantee optimal performances at frequencies 20 ÷ 100 GHz**

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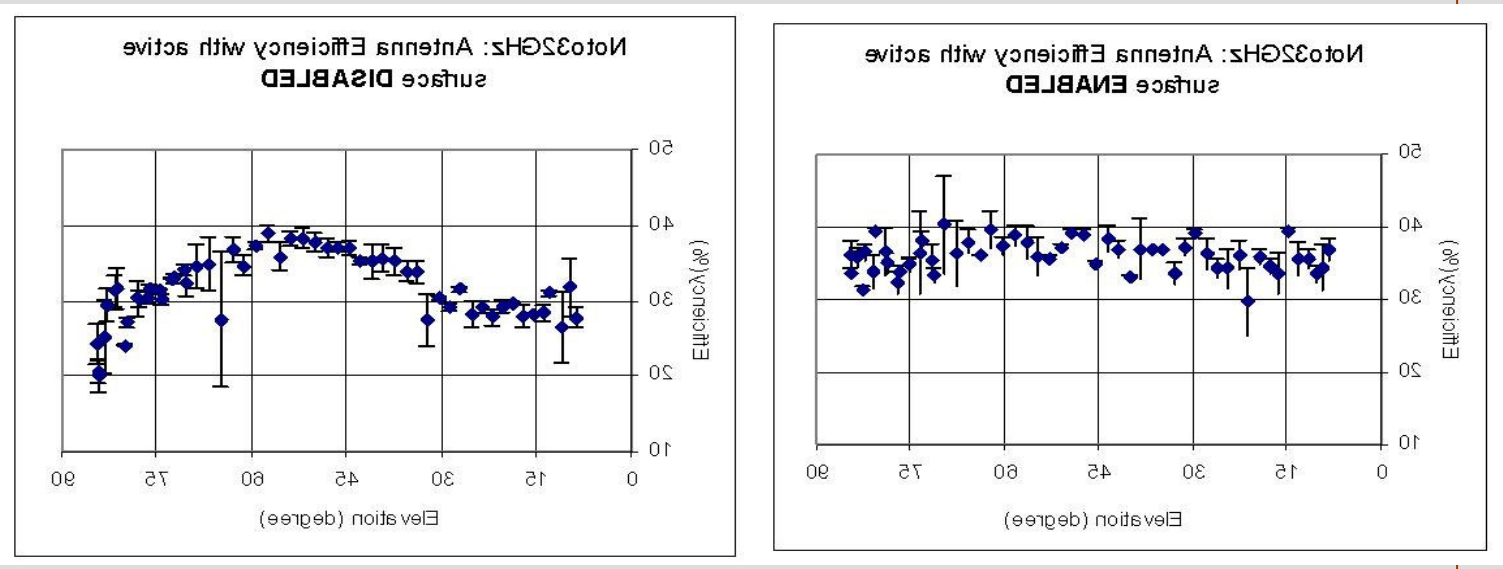
SRT Active Surface:

Gravitational deformations:

A structural analysis (FEA – Finite Element Analysis) allows to define, **for each elevation, variations in antenna's geometry due to its own weight.**

A control system, made of one or two couple of inclinometers will allow **real time measures and corrections of antenna's geometry**.

➔ **flat gains vs elevation**



Wind and thermal gradients:

On mirror surface pressure sensors installed. **On alidade and quadrupod temperature sensors**. Using data from all sensors possible to study antenna's behaviour under the effects of thermal gradients and wind pressure.

With a second FEA, it will be possible to **link reflector deformations to climatic conditions and recover surface accuracy**.

SRT General Specifications

	Up to 22GHz	Up to 100GHz
Configuration	EL over AZ	
Elevation angular travel	from 5° to 90°	
Azimuth angular travel	± 270°	
Azimuth angular velocity	51deg/min (if wind speed < 60 km/h)	
Elevation angular velocity	30deg/min (if wind speed < 60 km/h)	
Global Surface accuracy (global rms from specifications of single structural elements)	630μm (sup. passiva)	185 μm (Phase 1) 119 μm (Phase 2)
Pointing accuracy (rms) – Normal Conditions	11 ÷ 2.7 arcsec	
Pointing accuracy (rms) – Precision Conditions	5 ÷ 1.8 arcsec	

80-100 GHz obs → only in normal/precision conditions

Observing Conditions

Parameters	Precision	Normal
Wind (km/h)	< 15	< 40
Solar	Absent	Clear sky
Precipitations	Absent	Absent
Temperature	da – 10°C a 30°C	da – 10°C a 40°C
Temperature drift	< 3°C/h	< 10°C/h
Humidity	< 85%	< 90%

Active Surface:

Phase 1: End of antenna's assembly

(**OPEN LOOP→ Finite Element Analysis**).

Phase 2 : End of olographic campaign (measure of primary reflector panels' alignment).

Metrology technics are under evaluation (**CLOSED LOOP**).

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SRT MOST RELEVANT FEATURES:

- **Fast Wobbling of secondary mirror** (wobbling time ≤ 1 sec for f ≥ 20 GHz)

- **State-of-the-art Receivers/Backend** (Wide Band/Multibeam)

- **Site quality** → low RFI; wind speed (<v> = 4m/s); low content of water vapor

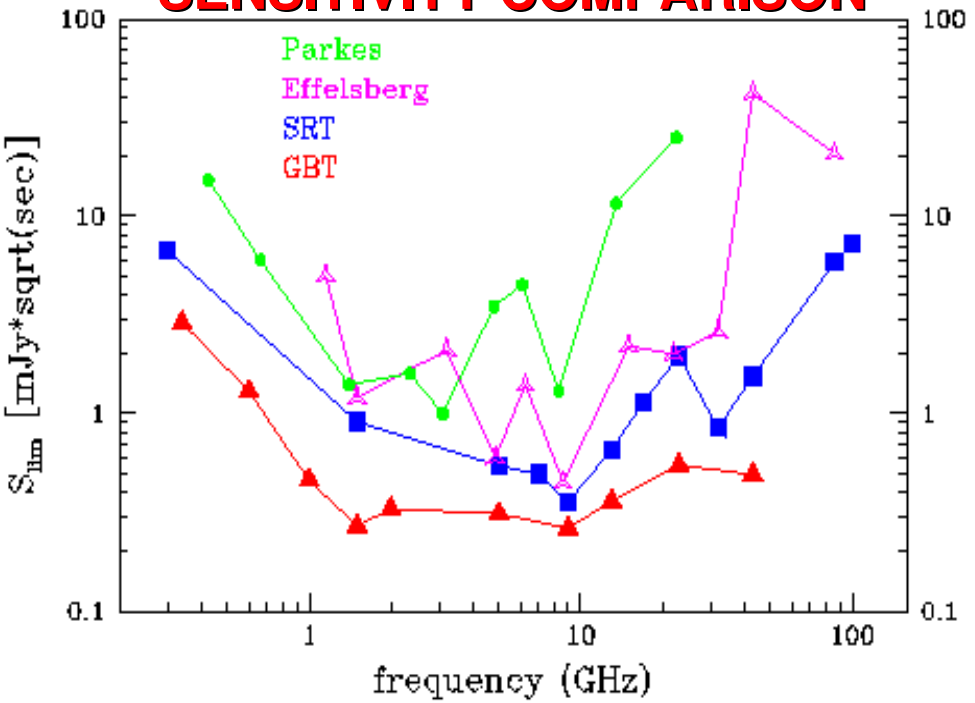
- **SRT used also in Transmission**

→ radar techniques: tracking experiments (ESA/ASI, NASA);

Space science

-**Both SD and VLBI operations**

SENSITIVITY COMPARISON*



E. Cenacchi, 2005

(*) includes site quality, instrumentation

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SRT SITE:

Located in "Pranu Sanguni" close to a village named San Basilio, 35 km North of Cagliari.

Elevation	585 m
Longitude	$-09^{0}\ 14^{m}\ 40^{s}$
Latitude	$+39^{0}\ 29^{m}\ 50^{s}$

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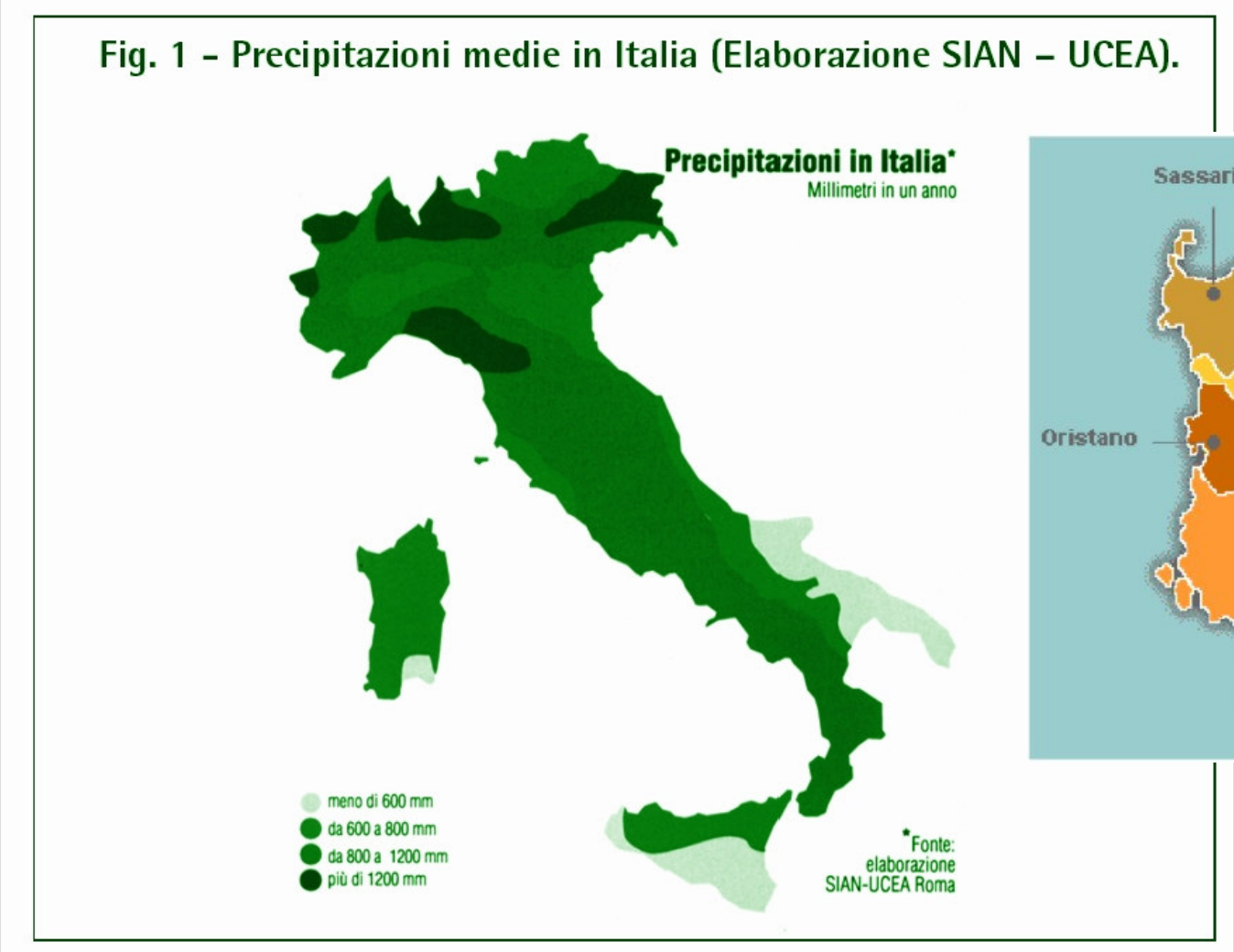
SRT SITE:

One of lowest precipitation regions in Italy and Europe



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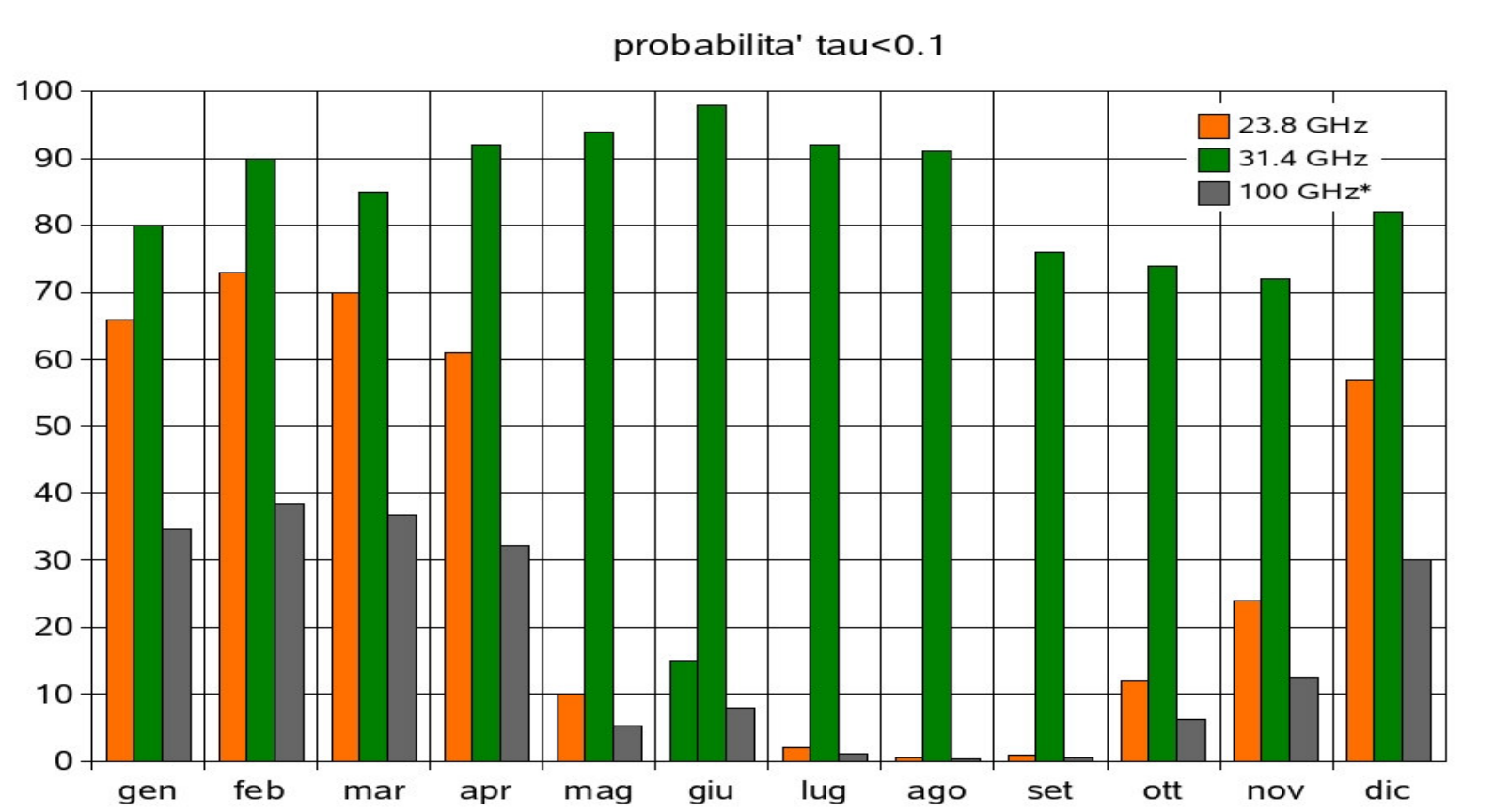
SRT SITE:

Probability of measuring atmospheric opacity $\tau<0.1$ along the year



23.8 GHz **31.4 GHz** measuring campaign 1999 (Ambrosini et al.)
100 GHz simulation based on realistic atmospheric model

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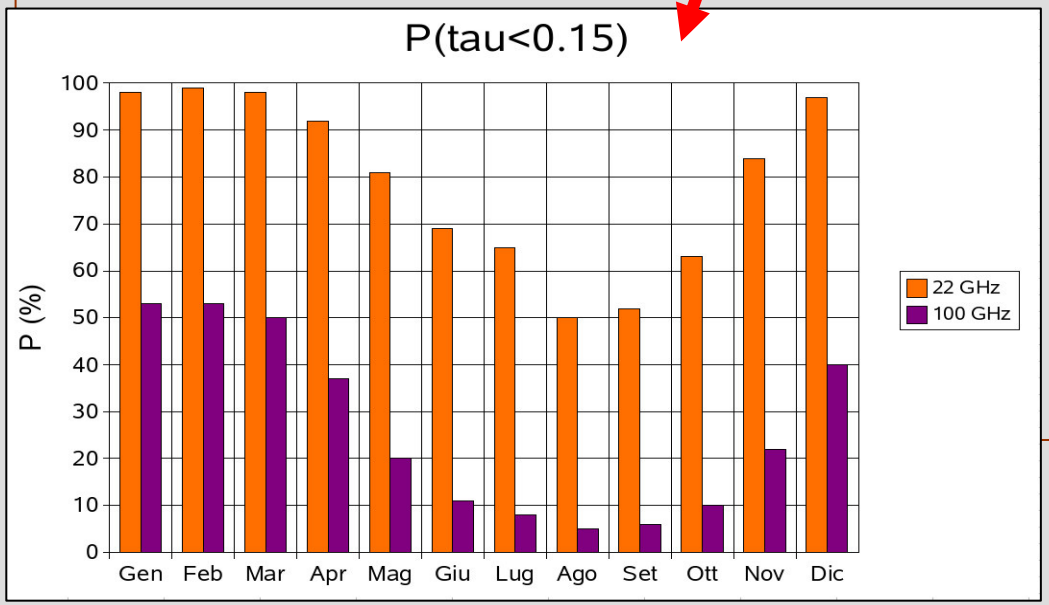
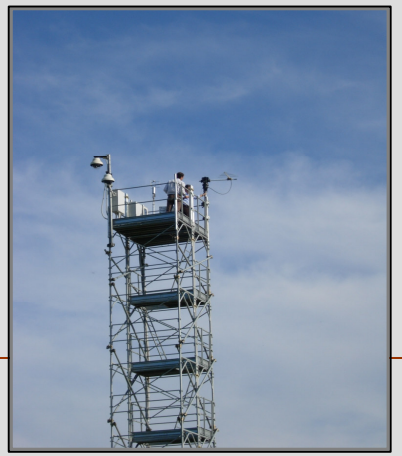
SITE MONITORING:

Monitoring campaign for both RFI and atmospheric transparency is on-going

Transparency at high frequencies monitored with GPS and radiometers





RFI monitoring

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RECEIVER SET: 0.3 – 100 GHz

Banda (Sigla)	ν_0 (GHz)	λ (cm)	N° Ricevitore	ν_{Lsky} (GHz)	ν_{Hsky} (GHz)	$\Delta\nu/\nu_c$ (%)	Banda ricevitore (MHz)	Temperatura di rumore (K)	Configurazione
P	0.3	90	1P	0.31	0.42	12	2X110	30	Coassiale a 1.5 GHz
L	0.6	50	1P	0.58	0.62	7	2X40	25	
L	1	30	1P	0.70	1.30	60	2X600		
L	1.5	18-21	2P	1.30	1.80	32	2X500	5	Coassiale a 0.3 GHz
S	2	13	2P	2.20	2.36	7	2X160		Coassiale a 8 GHz
S	3	10	3P	2.36	3.22	27	2X860		
S	4	7.5	3P	3.22	4.30	32	2X1080		
C	5	6	1B	4.30	5.80	32	2X1500	15	Monofeed
C	7	5	2B	5.70	7.70	30	2X2000	15	Monofeed
X	8	3.6	2P	8.18	8.98	9	2X800		Coassiale a 2 GHz
X	9	3.3	1G	7.50	10.40	32	2X2000	10	
Ku	13	2.3	2G	10.30	14.40	33	2X2000	14	
Ku	17	1.8	3G	14.40	19.80	32	2X2000	18	
K	23	1.3	4G	19.00*	26.50	33	2X2000	21	Multifeed (7 elementi)
Ka	32	0.9	5G	26.00	36.00	32	2X2000	25	
Q	43	0.7	6G	35.00	50.00	31	2X2000	40	
E	86	0.4	7G	70.00	90.00	25	2X2000	90	
W	100	0.3	8G	90.00	115.00	25	2X2000	100	

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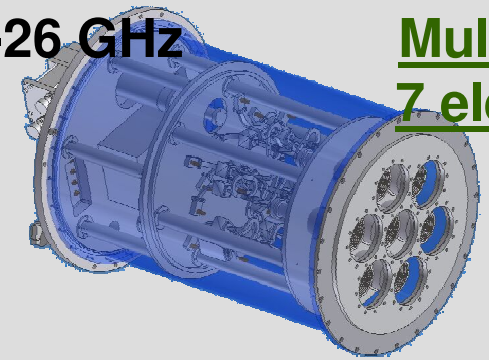
FIRST LIGHT INSTRUMENTATION

1ST 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



1ST LIGHT BACK-END

Digital Spectrometer for
Pulsar observations
1 GHz BW, 1024 channels

Spectrometer
60 MHz BW

l Power
BW
er
6 channels

SRT: only antenna with multi-beam available in K-band

V_{map} ~ 10 V_{map} Effelsberg/GBT

Large surveys of e.g. Ammonia and H_2O masers

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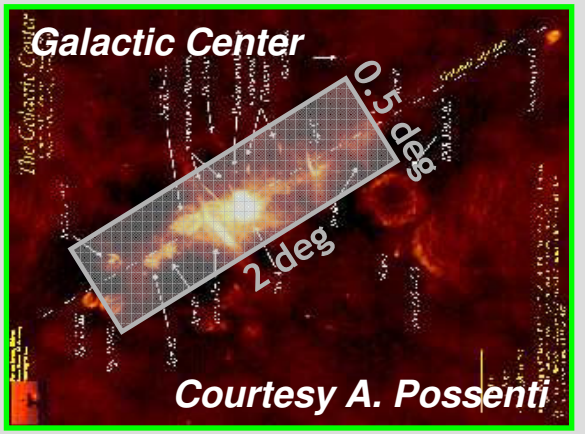
18-26 GHz

Multi-feed

K-band Surveys



- Pulsar Research:

- Search for Recycled/msec pulsars in Galactic Center → new binary systems

  msec pulsar/BH → gravitational tests

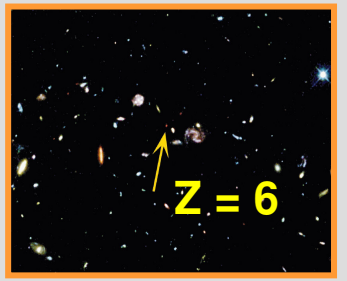
- Continuum Surveys:

- Free-free emission mapping of the Galactic Plane

  → Ultra-Compact HII Regions

- Deep Fields [SRT confusion limit: 50-70 μJy (rms)]

  →adding information @ ≥ 10 GHz → high-z/low lum. AGNs



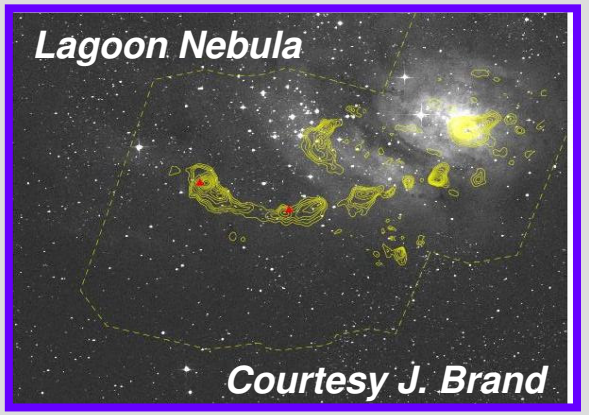
- Line Surveys:

- Search of H_2O masers in Local Group

  → Distance & 3D kinematics → Dark Matter & Cosmology

- Unbiased Mapping NH_3 in Galactic Plane

  → Astrochemistry of Star formation Regions



18-26 GHz

Multi-feed

ASTROCHEMISTRY with SRT

Unbiased Mapping of Ammoniaca in star formation regions

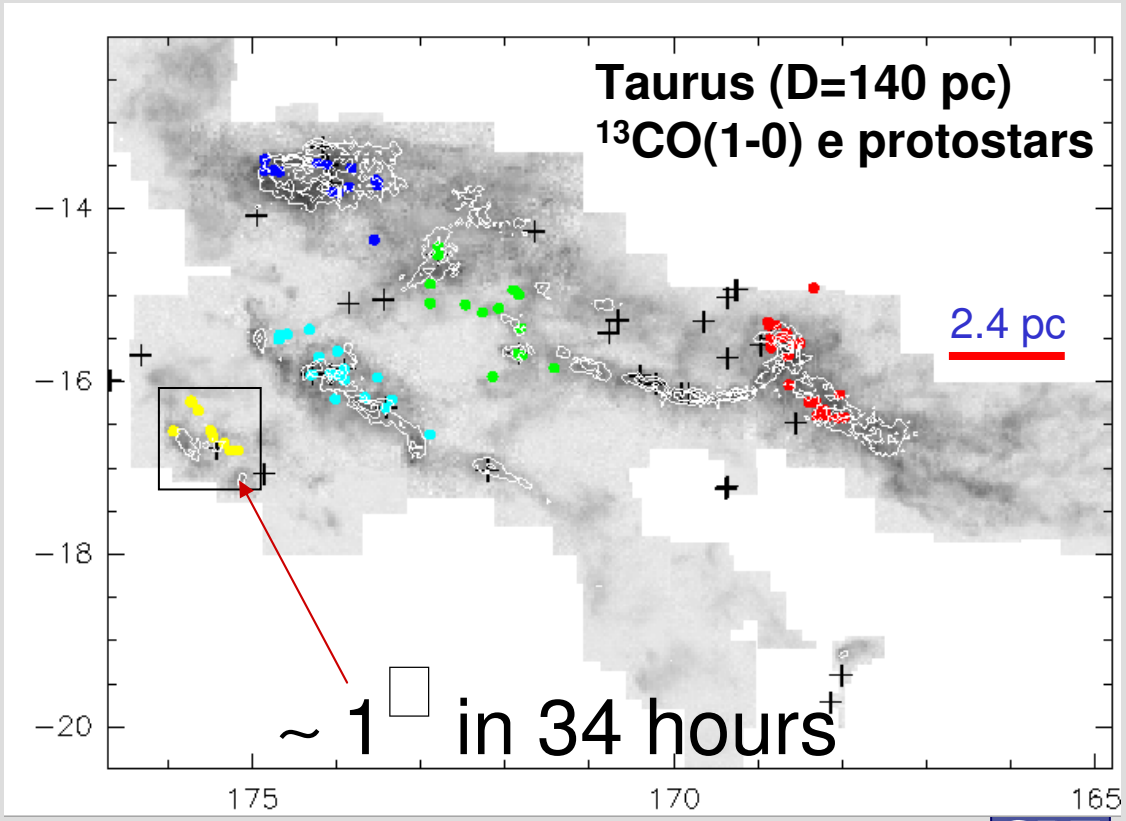
NH_3(1,1) & (2,2) at ~23.7 GHz + hyperfine transitions [τ]

➔ T of molecular clouds

In sinergy with JCMT, Herschel/Spitzer, APEX, ALMA

➔ Find *pre-stellar cores*

➔ Study of physical and chemical properties of various components: gas, dust, stars



Courtesy P. Caselli & J. Brand

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20/90 cm

Dual Band

PULSARS with SRT

LEAP: Large European Array for Pulsars

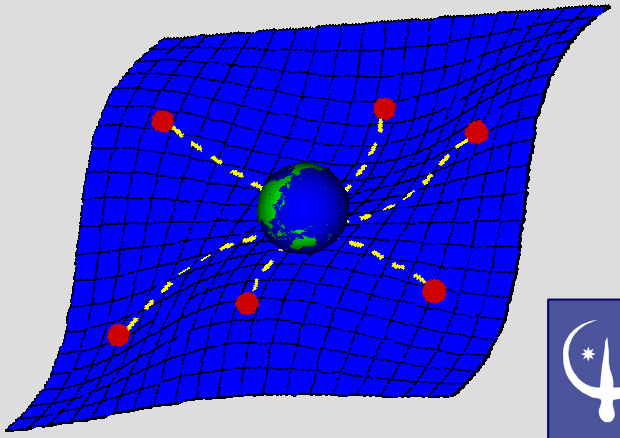
(UE grants for 5 years)

- **Combining coherently the 5 major European telescopes**

➔ **best telescope in L-band for timing before SKA**

- **dual band 20+90 cm receiver mounted on SRT ➔ unique capability in removing interstellar medium effects**

➡ **Ultra precise Timing of Pulsar: Detection of space-time perturbations in residual timing analysis**



Leader Experiment for detection of Gravitational Waves from Cosmological Background and/or from SMBH in local merging galaxies

Courtesy A. Possenti

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18 - 26 GHz

Dual Feed

EXTRA-GALACTIC CO

CO(1-0) → K band at 3.5<z<5.5

GBT/Effelsberg: **20hr on source**

Wide band (1-2 GHz), Tsys →20-25 K

Future:

90 - 115 GHz

70 - 90 GHz

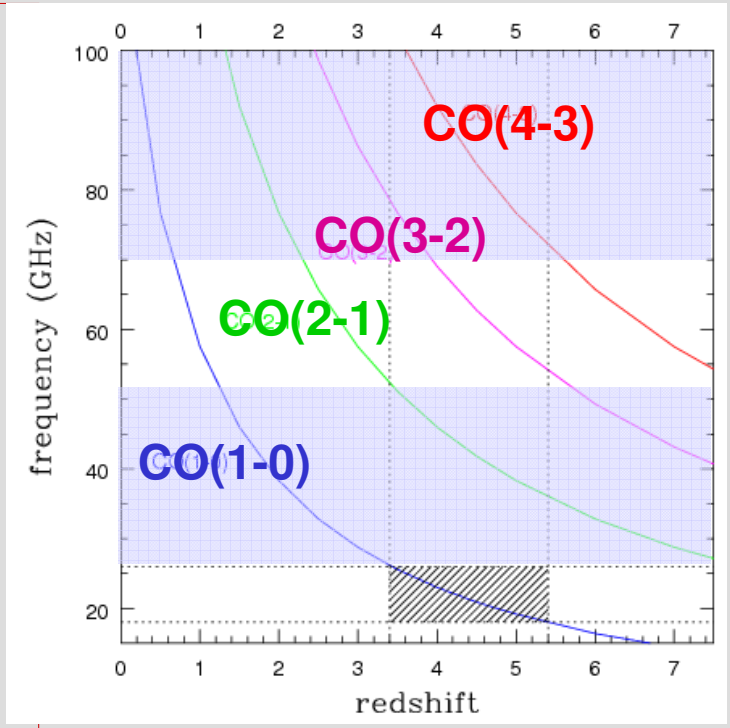
35 - 50 GHz

26 - 36 GHz

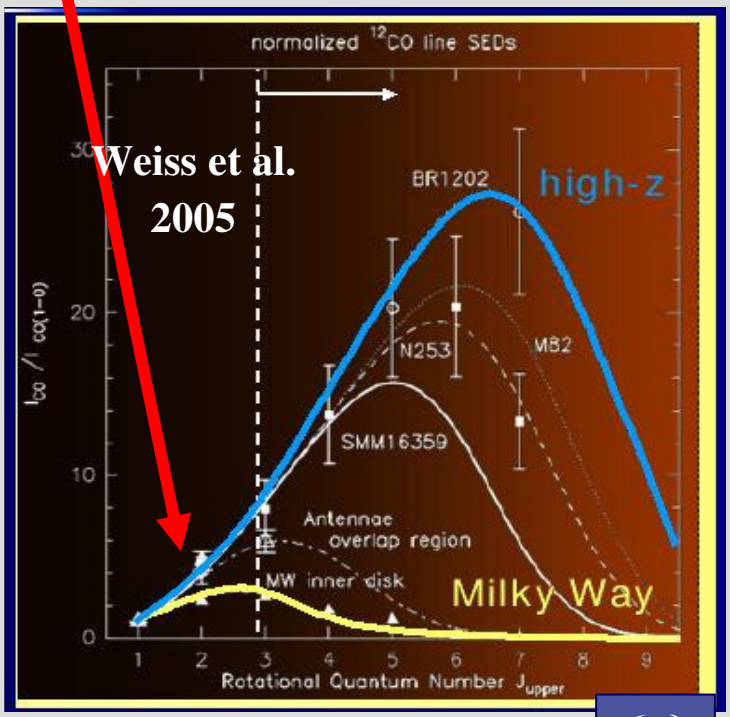
Redshift Machines:

***eg* 14 GHz BW**

@ 26-40 GHz



Cold Comp. Of molecular gas in high-z galaxies



→redshifted CO

1<z<7 J→J-1 J≤4

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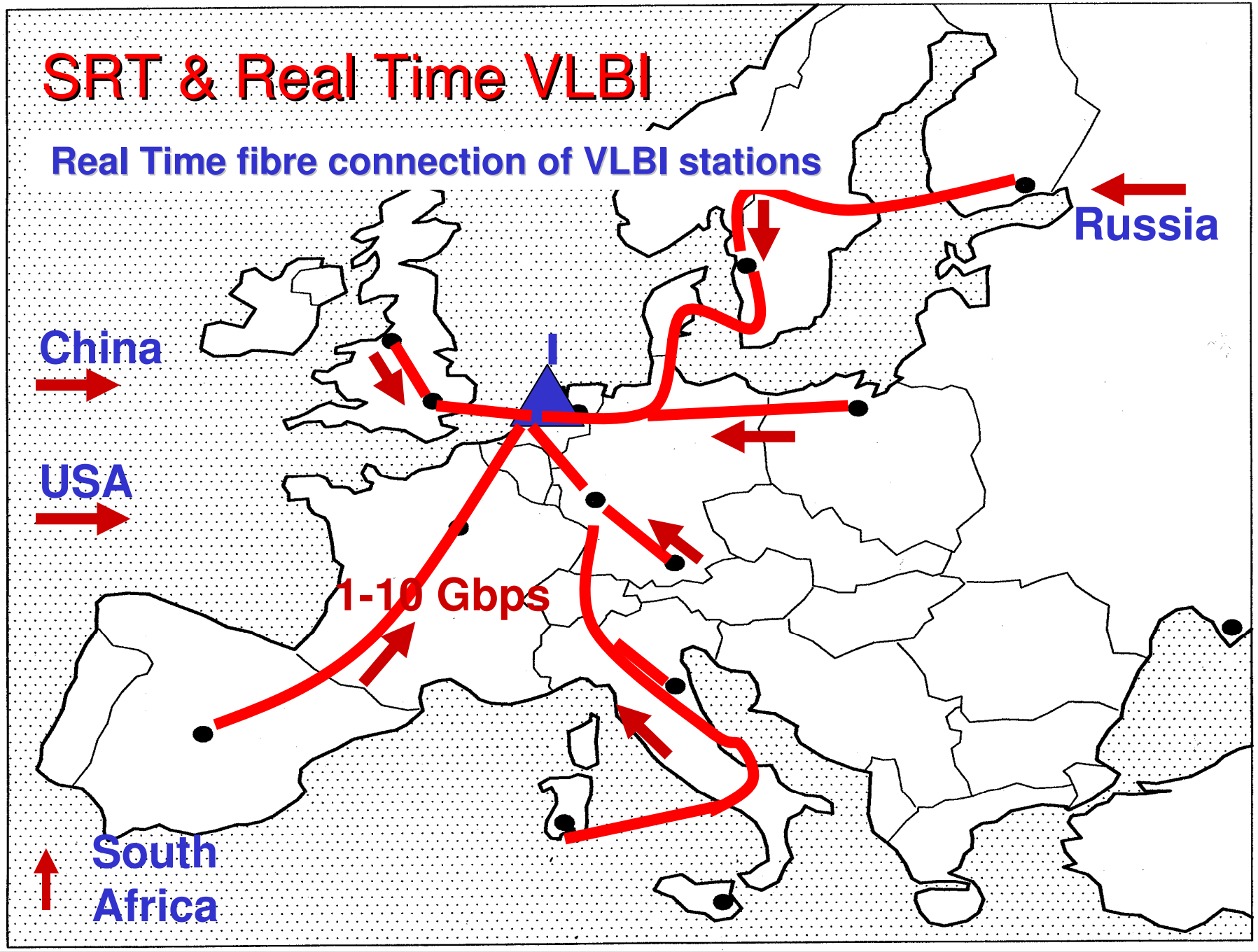
I. Prandoni. IRA – INAF. ITALY

SRT & Real Time VLBI

Real Time fibre connection of VLBI stations



PROGRESS STATUS

ANTENNA FOUNDATIONS

Completed beginning 2006

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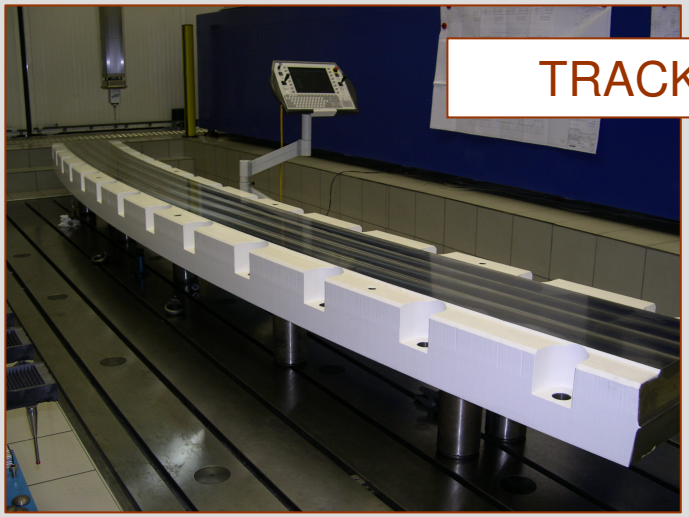
AZIMUTH TRACK



TRACK

Azimuth wheels

Az Track final measurements → September 2008

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ALIDADE AND ACTUATORS

Alidade

Alidade assembling and welding → October 2008

Actuators

Designed by IRA

Tested and stored in Medicina

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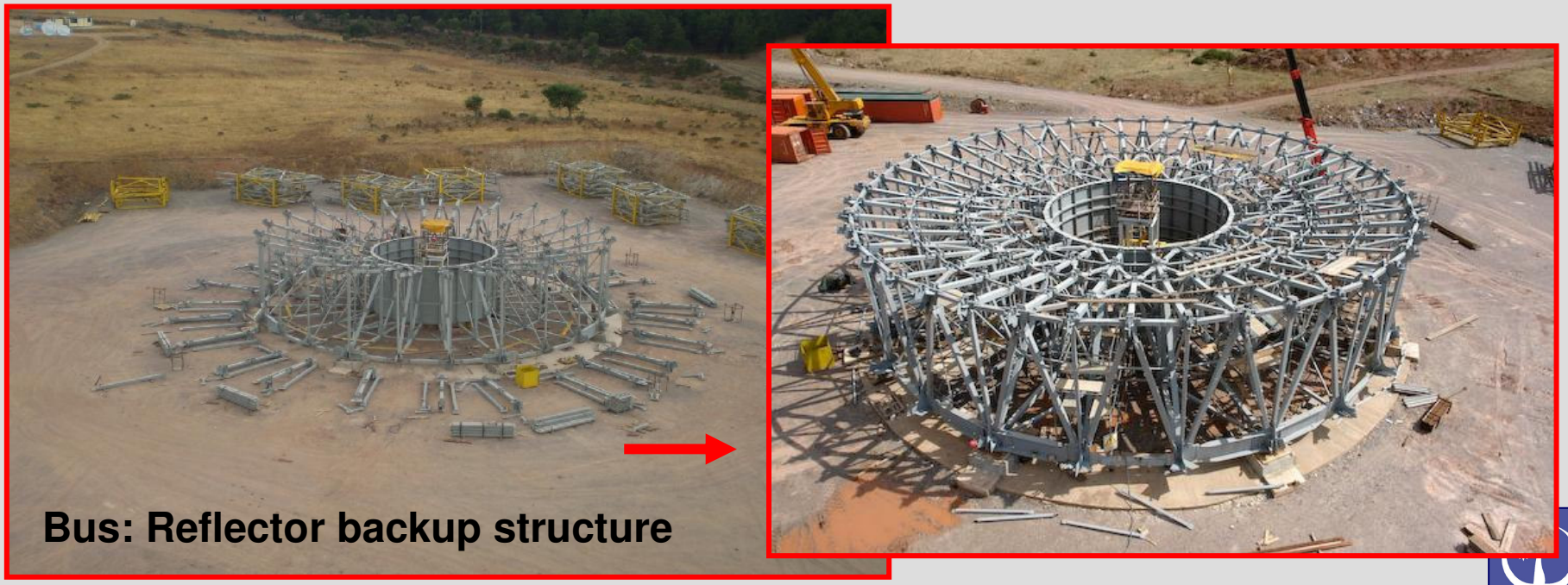
REFLECTOR BACKUP STRUCTURE

Bus assembling on ground → December 2008



Bus: Reflector backup structure

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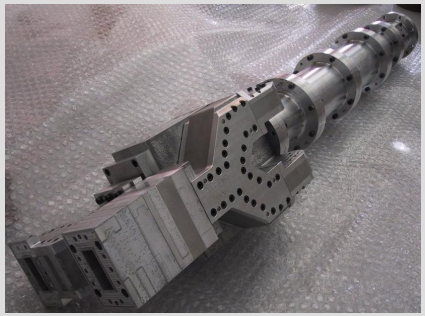
INSTRUMENTATION: 1st LIGHT RECEIVERS

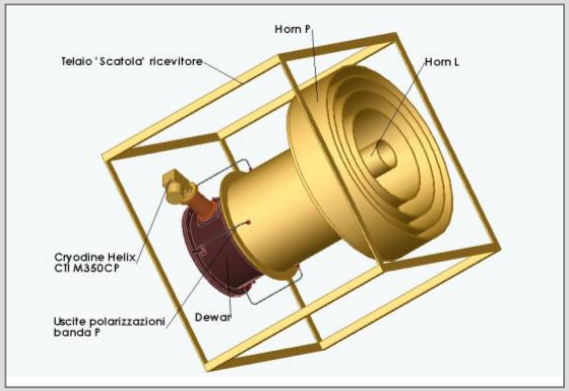
22 GHz multibeam receiver

Mounted on 32 m in Medicina



6.7 GHz mono feed receiver

Dual frequency (300 MHz / 1400 MHz) coaxial receiver



higher frequency receivers are on the agenda !

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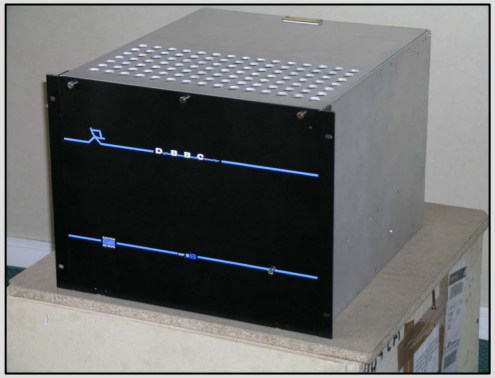
INSTRUMENTATION: BACK-ENDS

Analogic Total power Backend 7x2 outputs

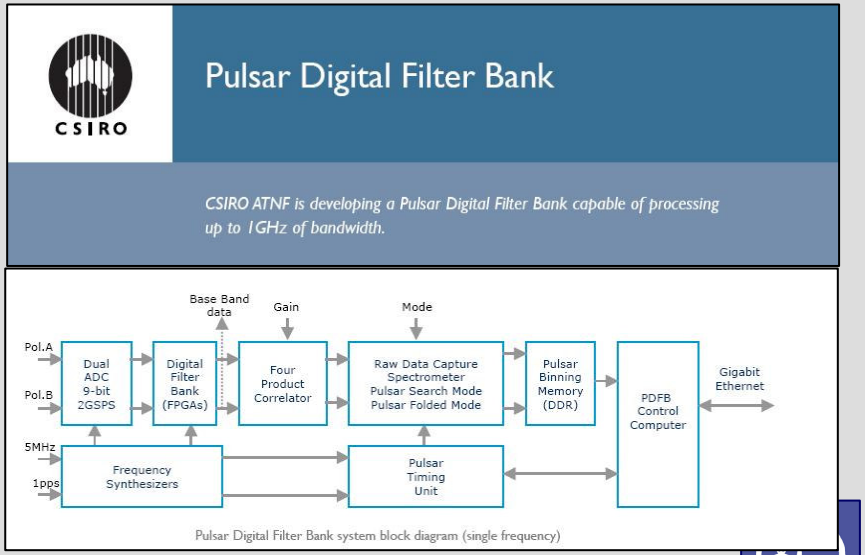
Multipurpose digital spectrometer

ATNF Pulsar Digital Filterbank



DBBC system + MARK 5 C

Software Correlator



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SRT_ SCHEDULE PLAN FABRICATION, TRANsPORT , Erection, Panel Installation & Plants

SRT-PI

2008 2009

Title	Duration	Start	Finish
ERECTION	1019 dys	Mon 08/02/06	Thu 31/12/09
Track preweldng and preparation	72 dys	Mon 06/02/06	Tue 16/05/06
Site transfer	56 dys	Wed 17/05/06	Wed 02/08/06
Track, assembly and welding	185 dys	Thu 03/08/06	Wed 18/04/07
Grease remove and conorete restoration	75 dys	Thu 19/04/07	Wed 01/08/07
Track,grouting, hardening, prestress	56 dys	Thu 02/08/07	Thu 18/10/07
Track Machining, Final measurement	47 dys	Mon 07/07/08	Tue 09/09/08
Track final acceptance	0 dys	Tue 09/09/08	Tue 09/09/08
Pintle Bearing and Az. Cable wrap, hardening	130 dys	Mon 16/04/07	Fri 12/10/07
Alidade	225 dys	Thu 22/11/07	Wed 01/10/08
Erection	105 dys	Thu 22/11/07	Wed 16/04/08
Welding	150 dys	Thu 20/12/07	Wed 16/07/08
Alignment upper part, welding	43 dys	Thu 17/07/08	Mon 15/09/08
Measurement, weighting	12 dys	Tue 16/09/08	Wed 01/10/08
Alidade acceptance	0 dys	Wed 01/10/08	Wed 01/10/08
El. Wheel, pillow block, drive	195 dys	Mon 20/10/08	Fri 17/07/09
Partial Preassembly on ground, partial welding	40 dys	Mon 20/10/08	Fri 12/12/08
Erection on Alidade	55 dys	Mon 10/11/08	Fri 23/01/09
Welding	70 dys	Mon 26/01/09	Fri 01/05/09
ballast concrete	5 dys	Mon 04/05/09	Fri 08/05/09
El.Wheel Acceptance	0 dys	Fri 08/05/09	Fri 08/05/09
remaining works	50 dys	Mon 11/05/09	Fri 17/07/09
BUS	380 dys	Mon 12/05/08	Fri 26/08/09
Assembling on ground, adjusting	150 dys	Mon 12/05/08	Fri 05/12/08
welding on ground	80 dys	Mon 08/12/08	Fri 27/03/09
Geometrical Acceptance on ground	0 dys	Fri 27/03/09	Fri 27/03/09
Lifting, connecting,welding	50 dys	Mon 11/05/09	Fri 17/07/09
BUS acceptance inner	0 dys	Fri 12/06/09	Fri 12/06/09
BUS Final acceptance	0 dys	Wed 26/08/09	Wed 26/08/09
remaining works	50 dys	Mon 20/07/09	Fri 25/09/09
Quadripod	202 dys	Tue 16/12/08	Wed 29/09/09
Erection Apex on ground	15 dys	Tue 16/12/08	Mon 05/01/09
Erection Apex incl. SR,PFP on BUS	12 dys	Mon 15/06/09	Tue 30/06/09
Erection Quadripod legs	8 dys	Mon 20/07/09	Wed 29/07/09
Quadripod Acceptance	0 dys	Wed 29/07/09	Wed 29/07/09
remaining works	40 dys	Thu 30/07/09	Wed 23/09/09
Rest of works	260 dys	Mon 22/12/08	Fri 18/12/09
beamguide	165 dys	Mon 22/12/08	Fri 07/08/09
Beam guide acceptance	0 dys	Fri 07/08/09	Fri 07/08/09
painting	100 dys	Thu 18/06/09	Wed 04/11/09
servo cabling	20 dys	Mon 31/08/09	Fri 25/09/09
servo installation, El/Az	35 dys	Mon 24/08/09	Fri 09/10/09
servo, final commissioning	50 dys	Mon 12/10/09	Fri 18/12/09
Servo main movement tests	5 dys	Thu 05/11/09	Wed 11/11/09
Servo acceptance	0 dys	Wed 11/11/09	Wed 11/11/09
Subreflector	181 dys	Mon 01/09/08	Mon 18/04/09
Design, Fabrication, erection site installation frame	80 dys	Mon 01/09/08	Fri 19/12/08
Erection Subreflector on ground	30 dys	Tue 16/12/08	Mon 26/01/09
Installation Apex, SR Pos.,SR into site frame	20 dys	Tue 27/01/09	Mon 23/02/09
Panel installation, prealignment	20 dys	Tue 24/02/09	Mon 23/03/09
Panel alignment 45°	15 dys	Tue 24/03/09	Mon 13/04/09
Main Reflector	234 dys	Mon 09/02/09	Thu 31/12/09
Installation of actuator pads,prealignment	25 dys	Mon 09/02/09	Fri 13/03/09
Alignment of actuator pads	35 dys	Thu 09/07/09	Wed 26/08/09
Installation of actuators, cabling	25 dys	Thu 13/08/09	Wed 16/09/09
Panel installation	28 dys	Thu 17/09/09	Mon 26/10/09
Panel alignment for 45°	20 dys	Tue 27/10/09	Mon 23/11/09
Alignment main-sub-reflector; look up table	28 dys	Tue 24/11/09	Thu 31/12/09
Plants	250 dys	Mon 17/11/08	Fri 30/10/09
cable trays	180 dys	Mon 17/11/08	Fri 24/07/09
power distribution	65 dys	Mon 29/06/09	Fri 25/09/09
cooling system installation	25 dys	Mon 28/09/09	Fri 30/10/09
Inst., cabling minor syst. Control	20 dys	Mon 14/09/09	Fri 09/10/09
ballast cover, design fabrication, erection	60 dys	Mon 09/03/09	Fri 29/05/09
Taking over	0 dys	Thu 31/12/09	Thu 31/12/09

Antenna assembling → End 2009

SRT in 2010

Beginnning 2010: Commissioning

Science obs. soon afterwards

Be ready to submit your proposal!

http://srtproject.ca.astro.it

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