The Sardinia Radio Telescope

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Evolution of protoplanetary disks seen through the eyes of new-generation high-resolution instruments,
Rome 25-28 June 2018

Outlook

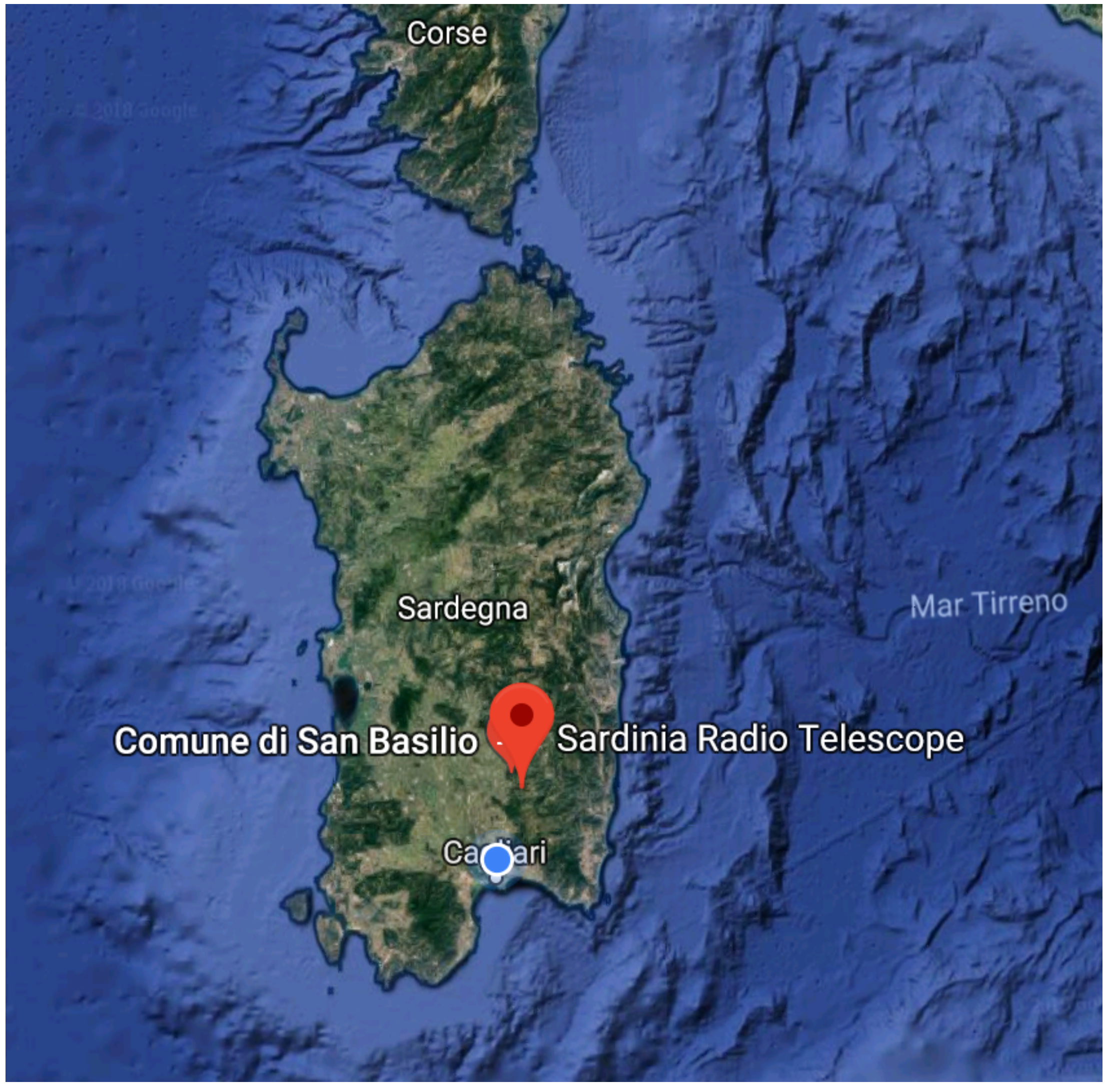
- **Radio single dish telescopes in the ALMA era**
- **The SRT in a nutshell**
- **First light instrumentation**
- **Next future developments**

Single dish telescopes in the ALMA era

Well suited for fast mapping of extended, low surface brightness emission. Especially if equipped with *multifeed array* and with a *broad instantaneous frequency* coverage

- ***Large scale mapping of dense gas in molecular clouds in the Milky Way (e.g. filaments). Chemical inventory of star-forming regions***
- Mapping of molecular gas tracers in nearby galaxies
- Mapping of the radio emission from the Sun and thus space weather applications
- Millimeter VLBI observations to study the physics and masses of supermassive black holes and their associated jets.

The SRT in a nutshell



SRT is located 35km north of Cagliari at ~600m altitude

The SRT in a nutshell

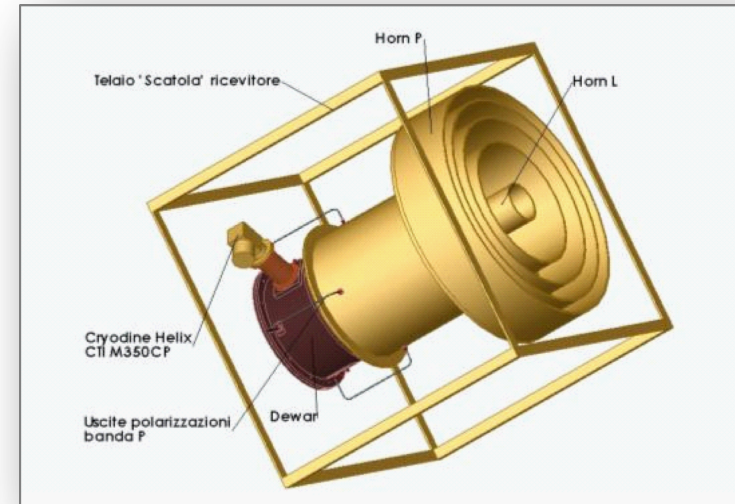
Bolli+2014, 2015; Prandoni+2017

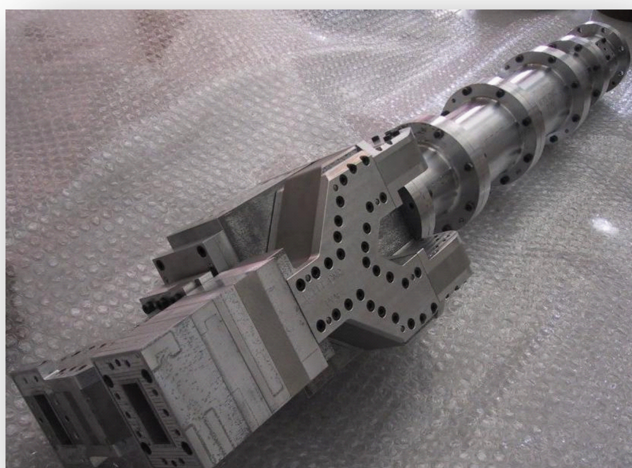
- ***Fully steerable***, 64m diameter, paraboloidal radio telescope;
- ***3 main focal positions*** to allocate up to 20 receivers (3 at first light);
- ***Designed to work up*** to 100GHz;
- ***Equipped with Active Surface to maximize efficiency:*** to correct for deformations induced by gravity. ***Work in progress: corrections for non-systematic errors (e.g. temperature/ wind-related effects);***
- ***Shaping of the primary mirror*** from a shaped configuration to a parabolic profile

First light instrumentation: frontends

L/P Bands Dual frequency (310 ÷ 420 MHz -- 1.3 ÷1.8 GHz) coaxial
Beam= 56.2’ / 12.6’

(primary focus)





C Band

5.7 - 7.7 GHz mono feed,

Beam = 2.8’, Tsys 30K

(BWG)

K Band

18 - 26.5 GHz,

Beam = 50’’, Tsys 40 - 90K

Multibeam (7 feeds)

(Gregorian focus)

http://www.srt.inaf.it/project/front-end/

Osservatorio Astronomico di Cagliari

First light instrumentation: backends

- Total power: for continuum observations with no polarimetric information
- DFB3: Full stokes correlator with large bandwidth. Pulsar search and folding
- Xarcos: full-Stokes narrow band spectrometer with multiple observed bands at different resolutions (max ~ 500kHz). Handle multibeam
- Digital Base Band Converter: mainly for VLBI experiments

SARDARA: wide-band, multi-feed, fully-reconfigurable for continuum, polarimetry, spectroscopy, high-time resolution for pulsars and fast transients.

Early science configurations (2016):

- **SK00(S):** 1.5 GHz band, 16384 nchan ⇒ Δv ~1.2 km/s

First call configurations (Sept. 2018):

- **SK00(S), SK03(S), SK06(S), SK77(S):** 420MHz/ 1.5GHz band, up to16384 nchan ⇒ Δv ~0.1-1.2 km/s

Second call configurations (Spring 2019?):

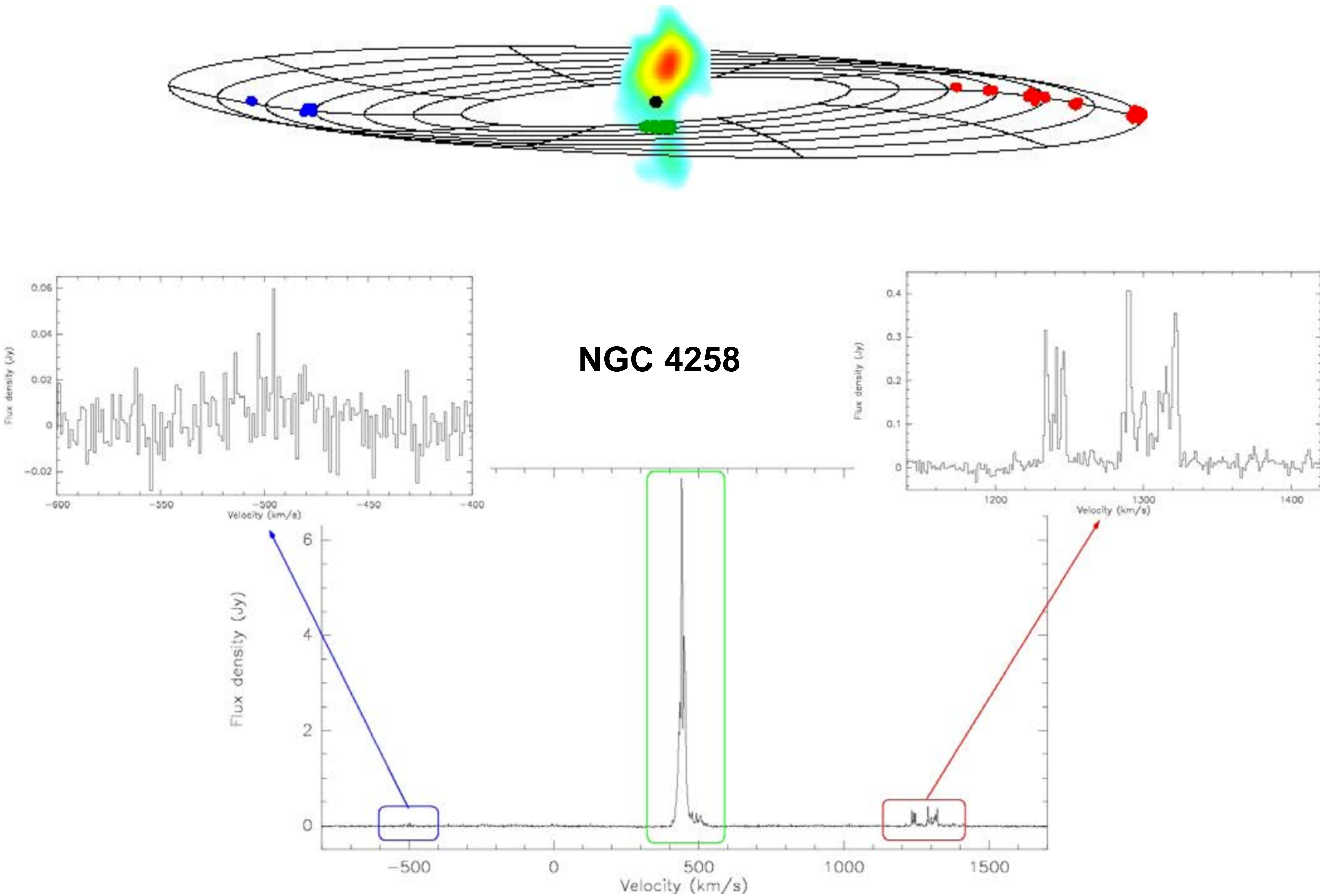
- **7 feeds:** ***NB 150 MHz, up to*** *524k nchan* ⇒ Δv ~ few m/s
  Z four 20 MHz units, up to *131k nchan* ⇒ Δv ~ few m/s
- **1 feed: WBHR2 *1.5 GHz,*** ~2M nchan ⇒ Δv≳10 m/s

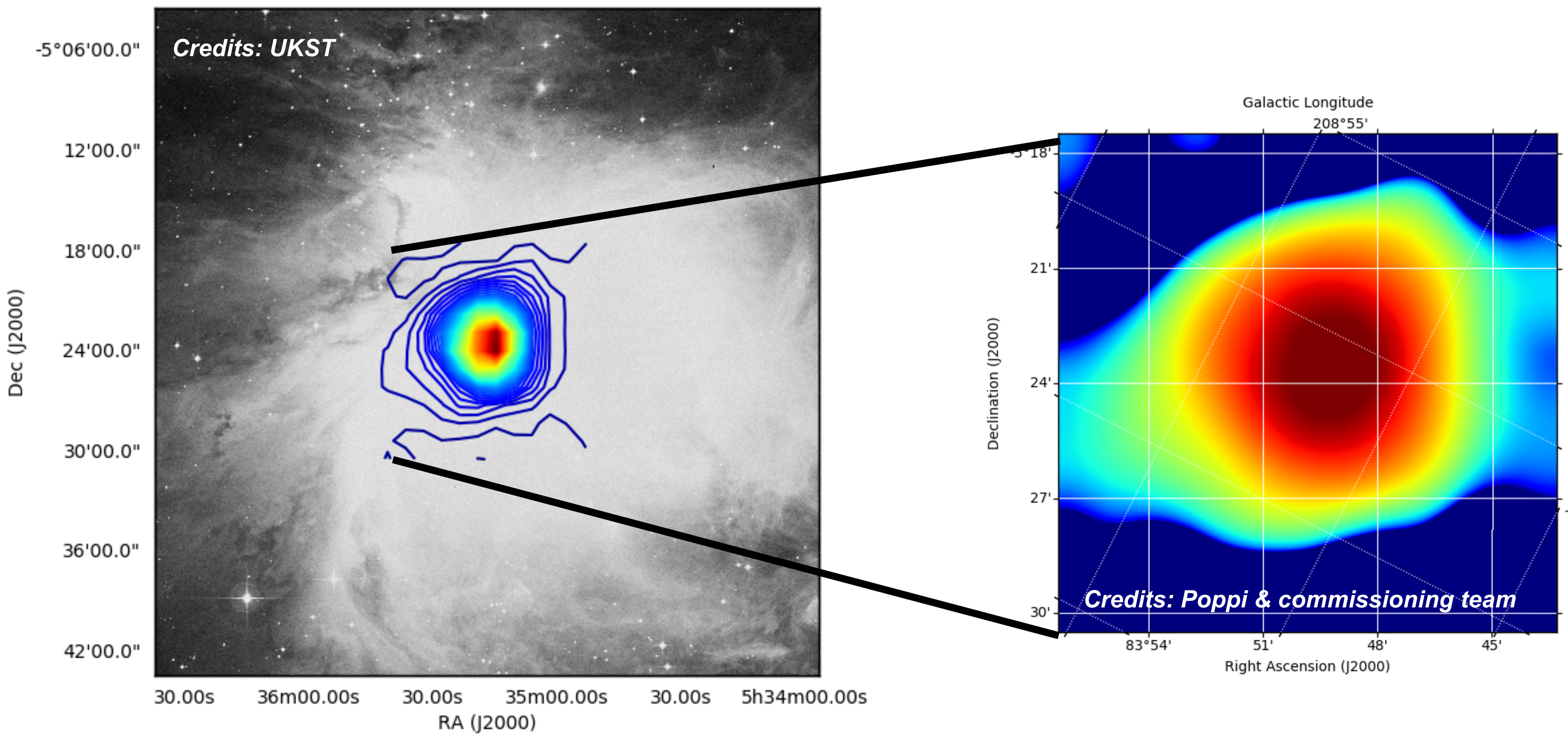
Melis+2018

K-band 7-feed receiver (22 GHz reference)

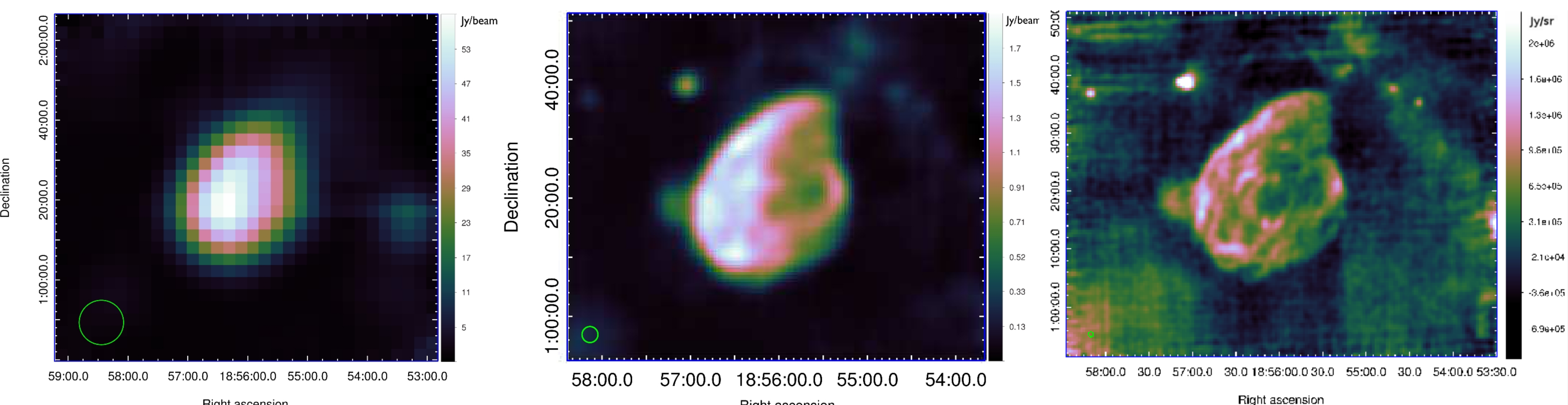
NH_3	$(1,1)$	23694.4955
NH_3	$(2,2)$	23722.6336
NH_3	$(3,3)$	23870.1296
HC_5N	$9-8$	23963.9010
HC_7N	$21-20$	23687.8974(6)
HC_7N	$22-21$	24815.8772(6)
C_2S^a	2_1-1_0	22344.030(1)

SK00(S): 1.5 GHz band, 16384 nchan ⇒ Δv ~1.2 km/s





ORI-A continuum @ 20 GHz, recommissioning test



SNR W44 continuum at 1.55 GHz, 7.0 GHz and 21.4 GHz (Egron+2017, Soru+2018)

Future developments

INAF review on Receivers for Radio Astronomy: current status and future developments at the Italian radio telescopes (2017)

Status	RT	Receiver	2017	2018	2019 and beyond
Receivers under dev	SRT	S-band	OAC	OAC	
	SRT	Clow-band	IRA OAC OAA		
	SRT	Q-band	IRA OAC	IRA	
	SRT	ALMA 2+3 Band	IASF	IASF	
New receivers	SRT	Multi-feed W-band			OAC
	SRT	PAF C-band			OAC
	MED	Simultaneous frequency K/Q/W-bands			IRA

Table 11.I – Proposed scheme for receiver development in the next years

Massi+
Casasola+

Giroletti+

Future developments (ERC-2018-SyG)

ALMA 2+3 band: convert ALMA receiver in a (dual beam?) 67-116 GHz receiver, at least 8 GHz instantaneous bandwidth

P.Is. Hennebelle, Molinari, Testi, Klessen
first step of evaluation passed! soon more news…

- ability of tracing ground state rotational lines of deuterated species (DCO+, DCN, DNC, CCD, N2D+, orto-NH2D)
- chemical inventory of (star forming) clumps, and their evolution

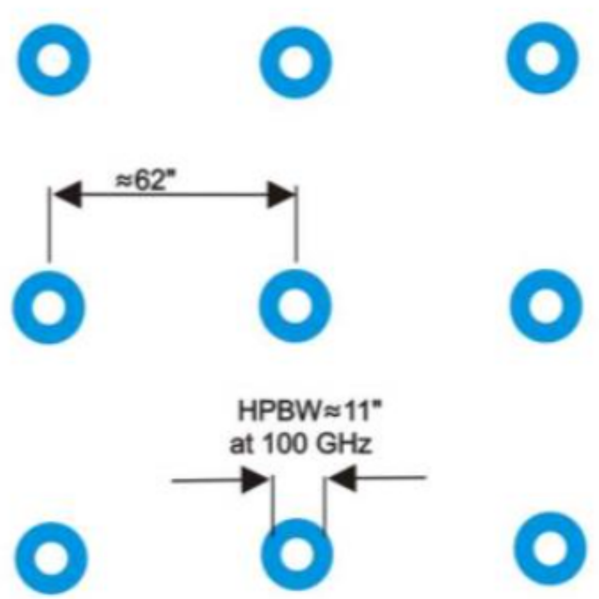
Future developments (PON Ricerca e Innovazione 2014-2020)

Q-band multi-feed receiver: 19 feed, 33-50 GHz with integrated continuum backend and dedicated spectroscopic backend ***(P.I. Orfei)***

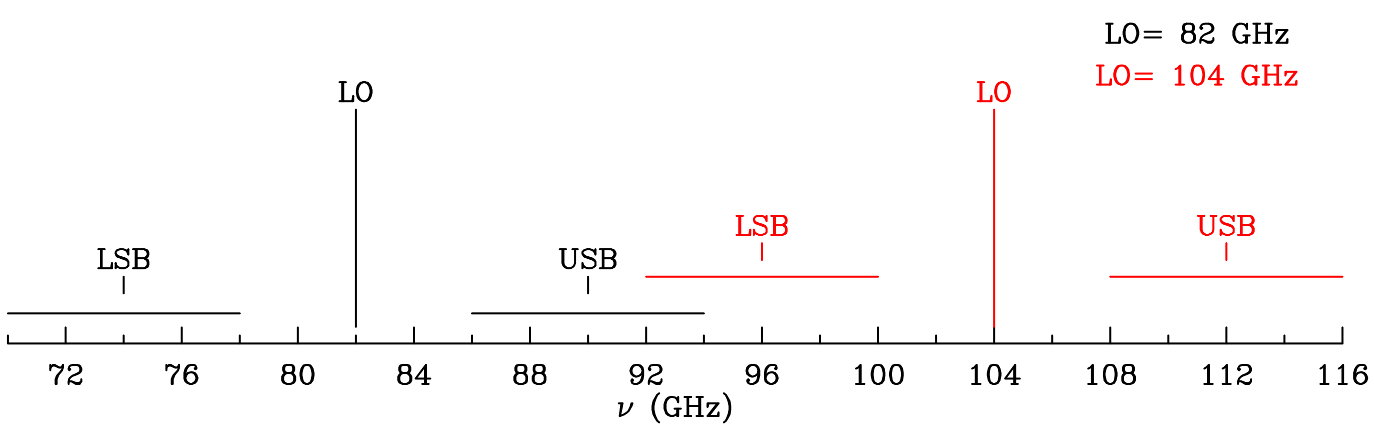
W-band multi-feed receiver: 9 feed, 70-116 GHz with dedicated spectroscopic backend ***(P.I. Navarrini)***

Simultaneous K/Q/W band receiver for VLBI (P.I. Bolli)

P.I. Govoni, submitted on June 15th



W-band multi-feed receiver



Credits: A. Navarrini

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New generation digital backend based on *SKARAB cards* *(P.I. Comoretto)*

- **Q-band multi-feed receiver:** 2 GHz per polarization per feed, 440*k nchan* ⇒ Δv ~ 50 m/s, **HC3N, HC5N, HC7N…, CS, SiO, CH3OH**
- **W-band multi-feed receiver:** 6 GHz per polarization/SB per feed, 1**2CO, 13CO, C18O, C17O (1-0) simultaneously;**

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plus other receivers, new holographic system, temperature sensors, inclinometers….

timescale: 32 months after positive proposal evaluation!

SRT at high frequencies

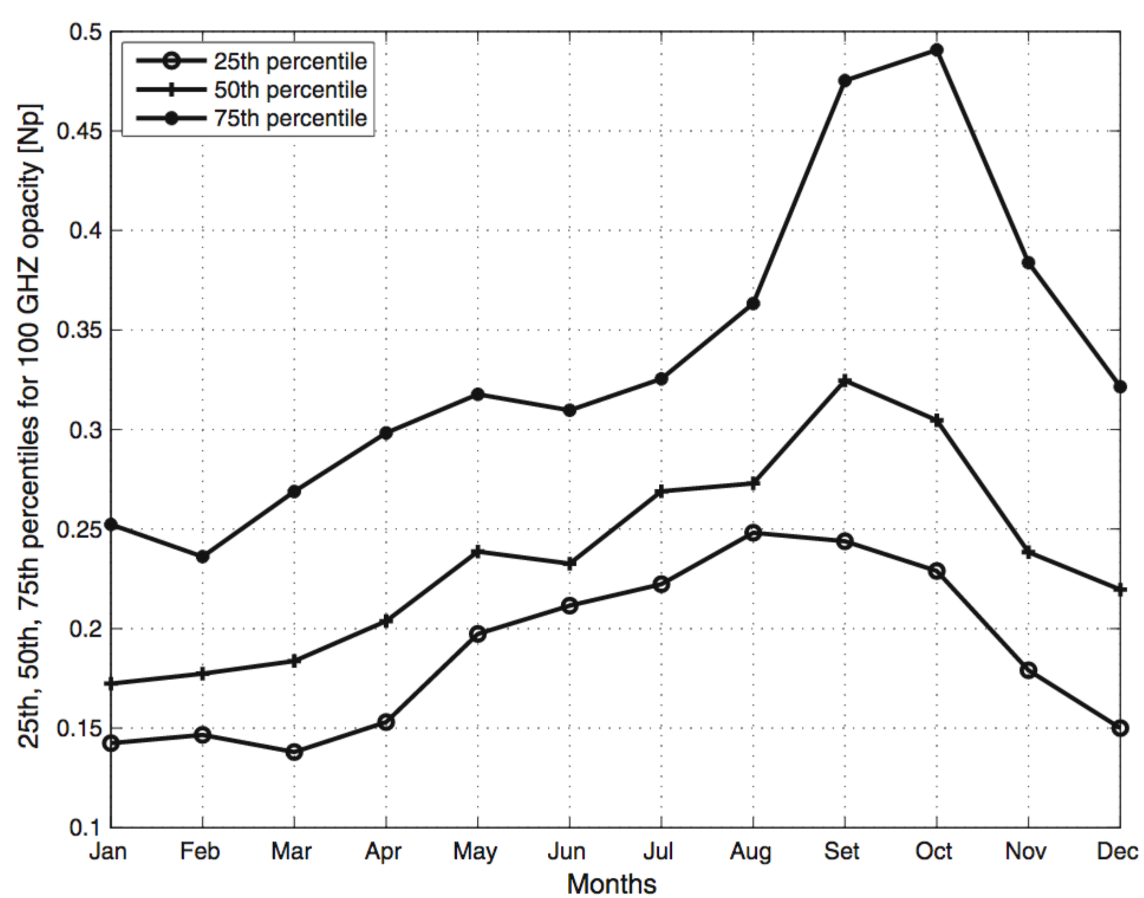
Metrology: error budget of the surfaces

	Phase 1	Phase 2	Phase 3
Error source	RMS surface error [mm]		
Main reflector panels manufacturing	0,07	0,07	0,07
Main reflector alignment (**Photogr** , Hologr , Hologr)	**0,39**	0,2	PON 0,145

Monthly percentage probability (January-June): IWV <10 mm, τ<0.15 Np

Quantity	Jan	Feb	Mar	Apr	May	Jun
IWV	45	49	43	30	10	5
ILW	54	59	64	59	67	77
τ (0.3)	100	100	100	100	100	100
τ (1.4)	100	100	100	100	100	100
τ (6.7)	100	100	100	100	100	100
τ (10)	100	100	100	100	100	100
τ (15)	100	100	100	100	100	100
τ (18)	100	100	100	100	100	100
τ (22)	94	94	92	86	70	59
τ (22.12)	93	93	90	85	66	56
τ (22.23)	91	91	89	82	63	51
τ (23.69)	97	98	95	90	82	76
τ (23.72)	97	98	95	91	83	77
τ (23.87)	98	98	96	92	85	81
τ (30)	100	100	100	99	96	97
τ (42.82)	83	86	85	78	77	82
τ (43.12)	81	85	83	76	75	80
τ (88.63)	47	48	49	35	17	12
τ (90.66)	46	47	48	34	17	11
τ (100)	34	35	35	25	9	6

Nasir, Buffa, Deiana 2011



Monthly quartile plots for 100 GHz opacity at SRT

SRT at high frequencies

Receiver	Freq [GHz]	Beam size [arcsec]
L-band	1.7	667
C-band	7.35	155
K-band	23	48
Q-band (under construction)	45	27
W-band	100	12