# Dense gas in the ISM seen by the Sardinia Radio Telescope


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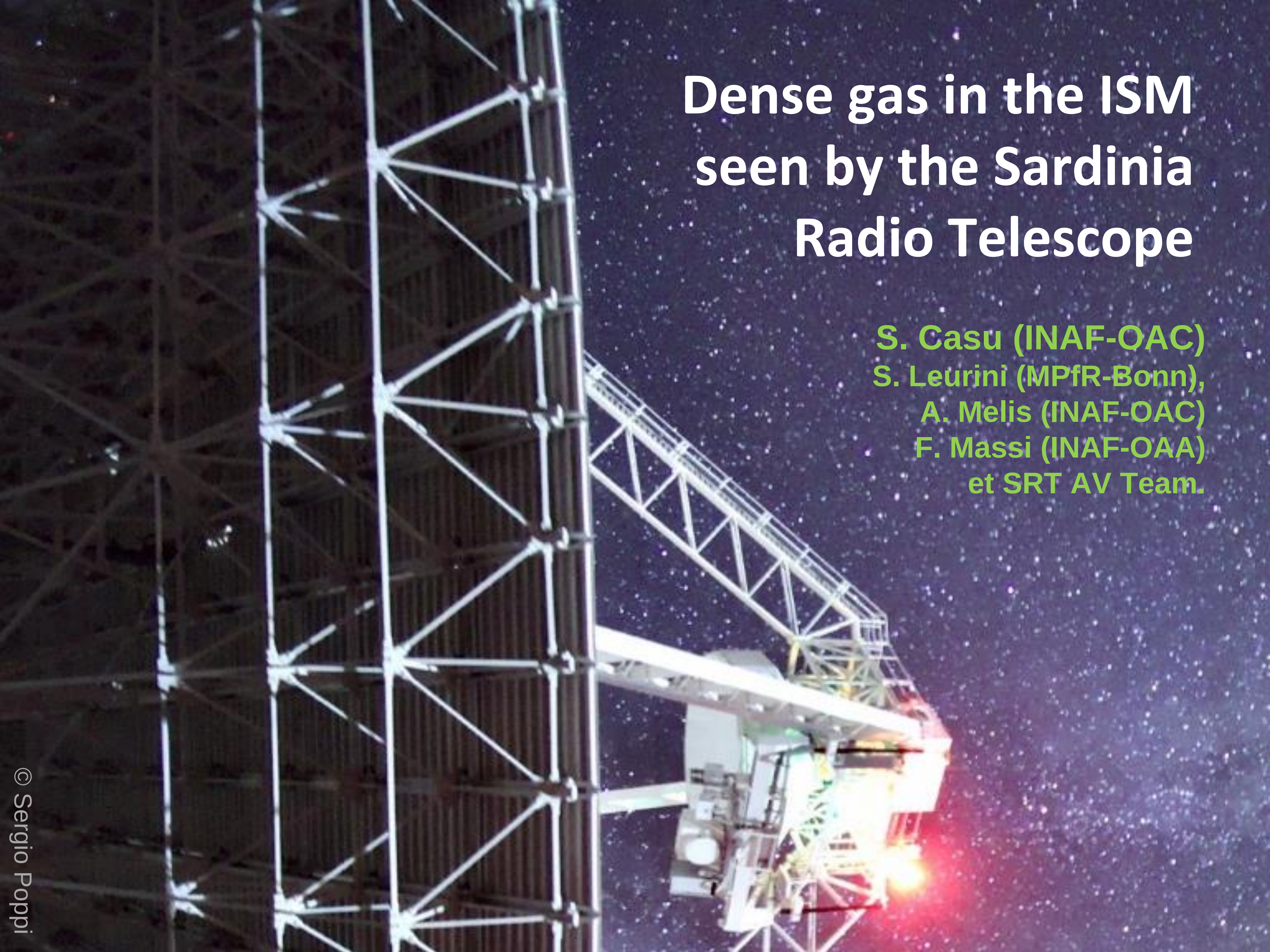
et SRT AV Team.

# Sardinia Radio Telescope (SRT)

**Officer in charge: Ettore Carretti**

Fully steerable, 64m diameter, paraboloidal radio telescope.
3 main focal positions.

Wide frequency range: currently from 300MHz to 26GHz, up to 100GHz

Equipped with Active Surface, to maximize efficiency

Control system: NURAGHE, based on Alma Control Software

Scientific validation almost completed (P.I. Isabella Prandoni)

## Shared Risk Early Science program (INAF Community) started on February 1st, 2016

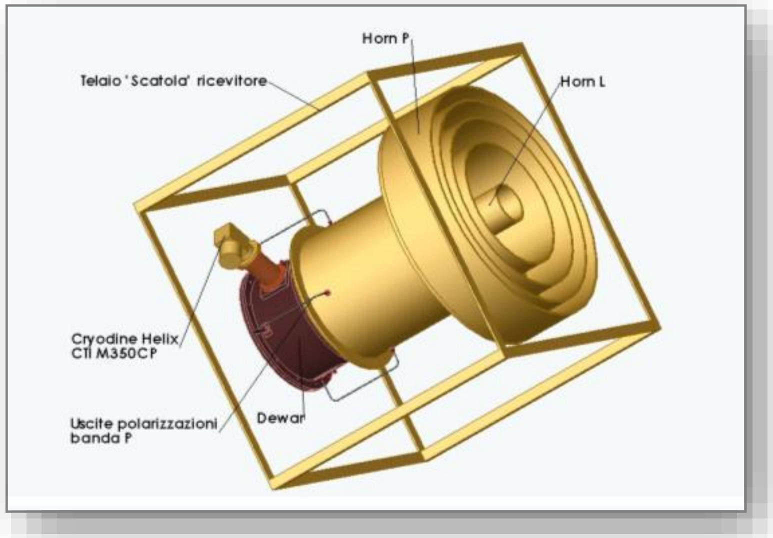
Osservatorio Astronomico di Cagliari

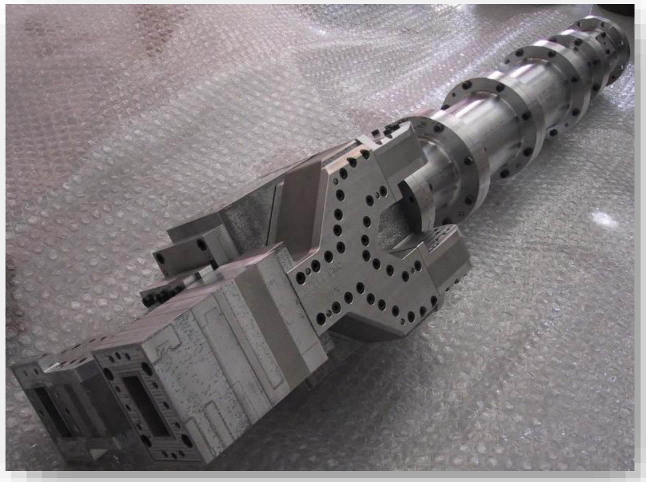
http://www.srt.inaf.it/

# Current SRT frontends

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

*(fuoco primario)*



***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)***

*(fuoco Gregoriano)*

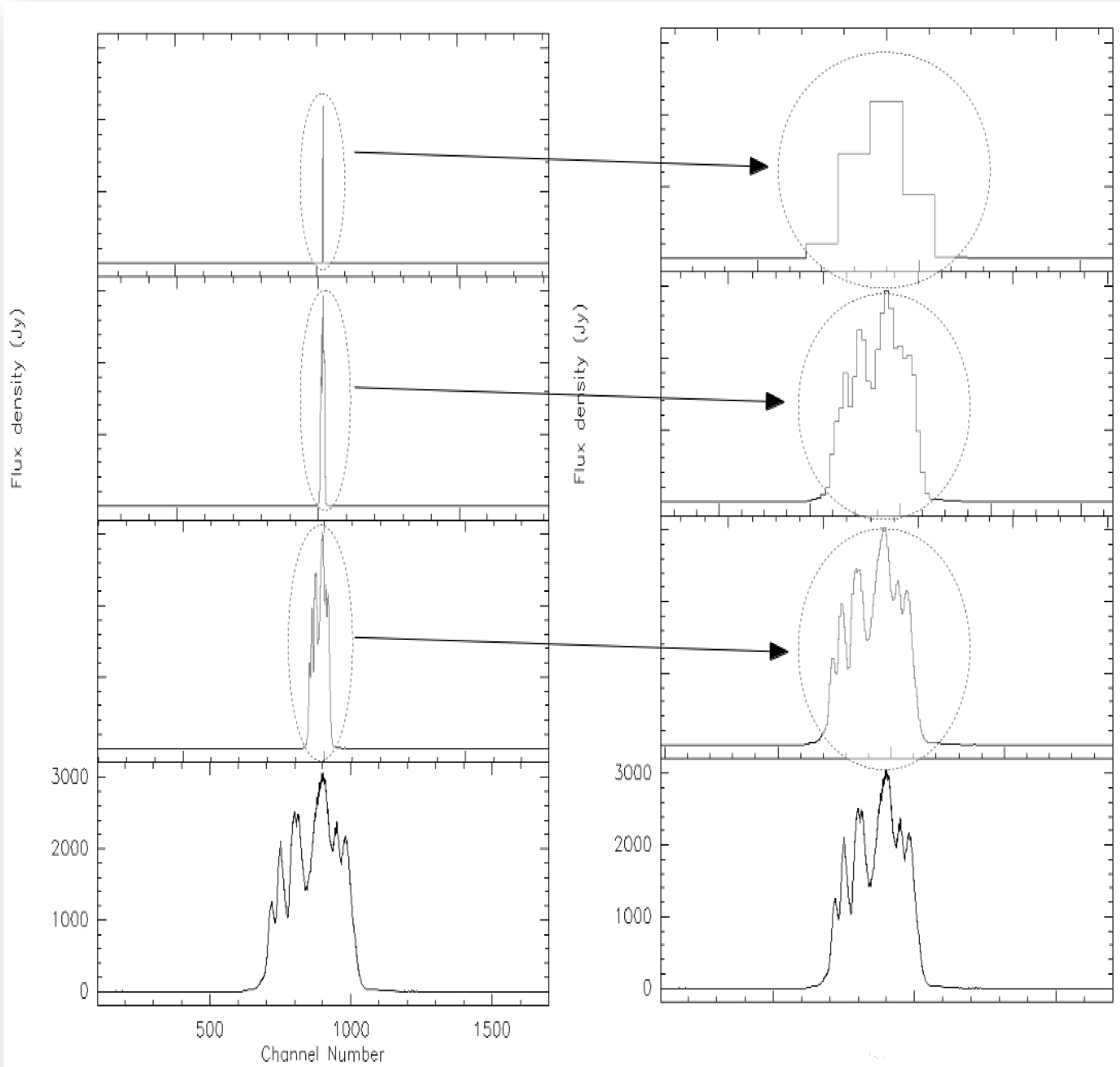


**http://www.srt.inaf.it/project/front-end/**

# Spectroscopic Backends : XArcos

XArcos, full Stokes narrow band spectrometer, 14 IFs,
BW from 0.5 to 125 MHz,
2x2048 channels,
dump time 10 s.
Max effective Res = ~100 Hz
e.g @25GHz Δv~0.01km/s

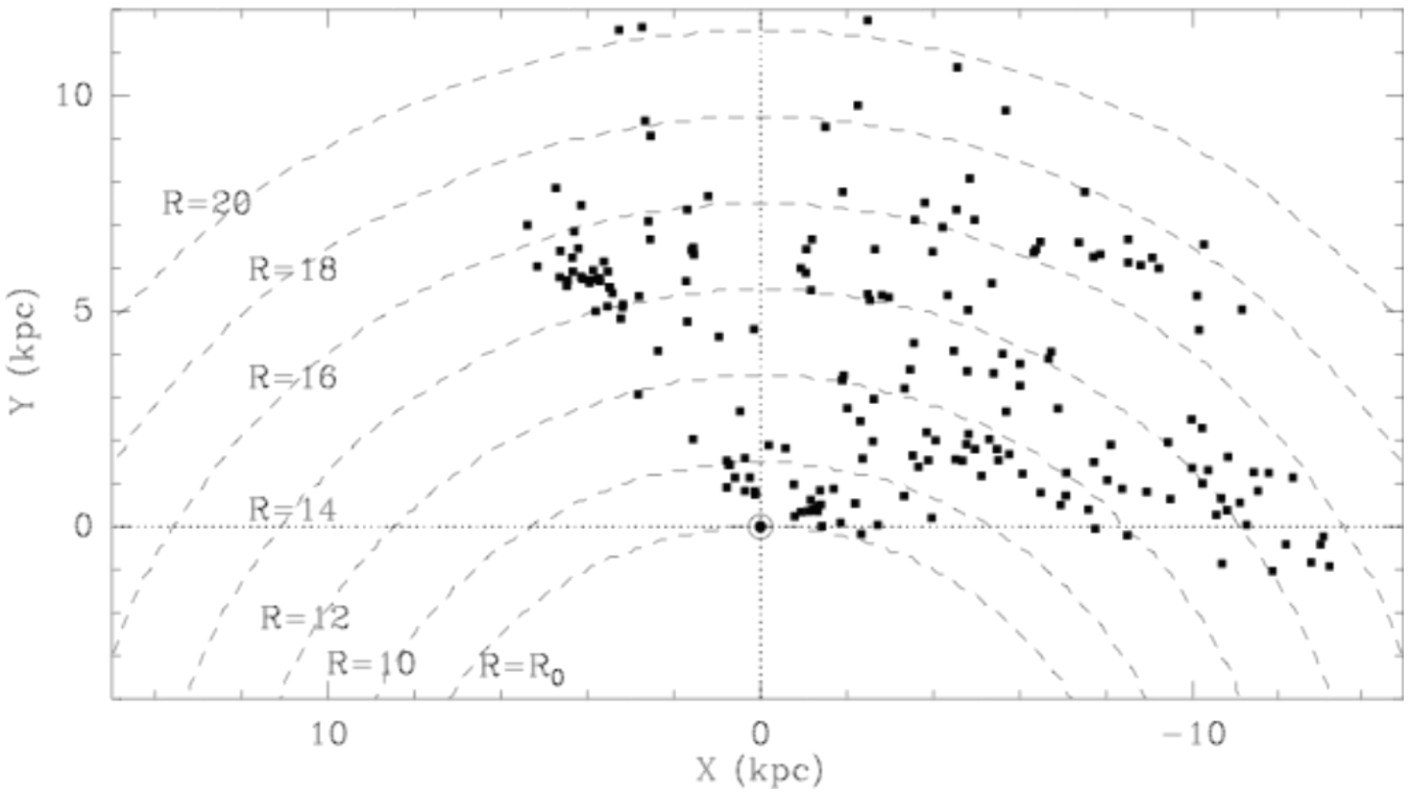
Different configurations for **multi beam** (XK77, single sub-band), **nodding** (XK03,XK06, two sub-bands) and **single beam** (XK00, four sub-bands) use.
No OTF




Credits: Tarchi A., Castangia P., et al

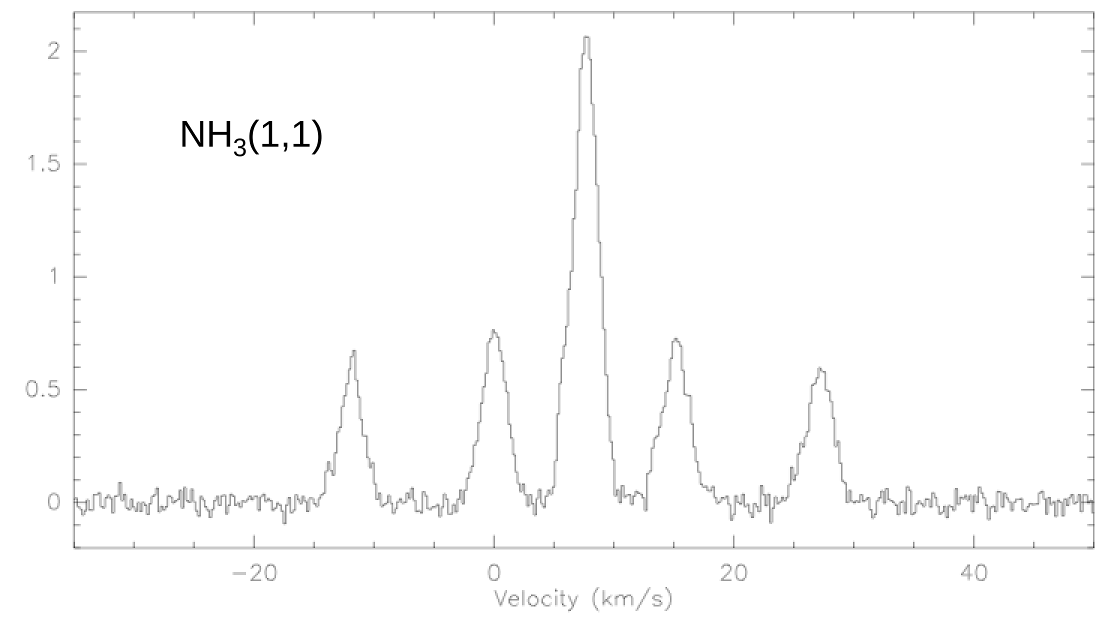
# The temperature of star-forming molecular clouds across the outer galaxy. SRT Early Science Program S011

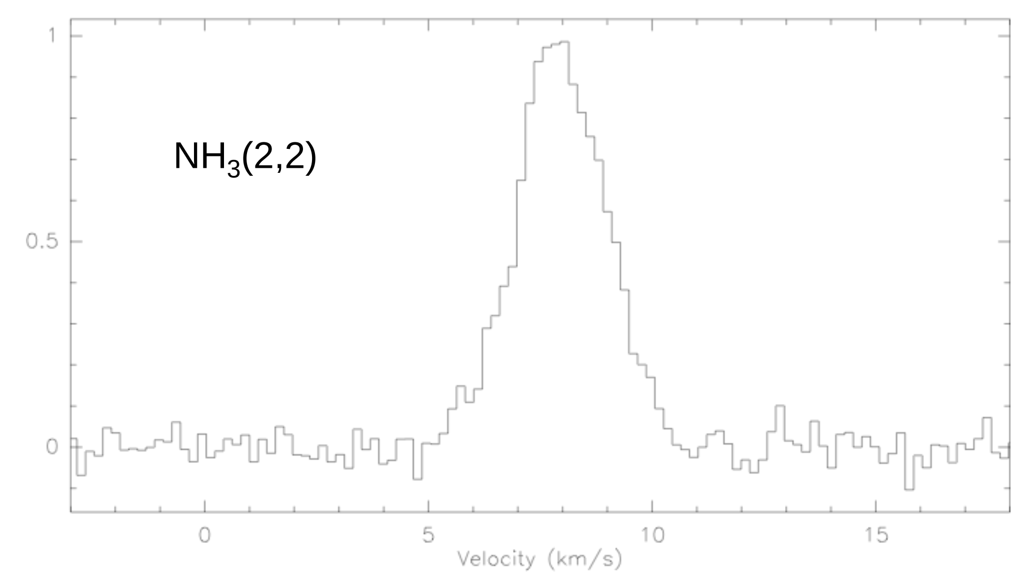
PI Jan Brand (IRA BO), Sergio Poppi (OAC, SRT), Andrea Giannetti (MPIfR, Bonn), Roberto Ricci (IRA BO)
Fabrizio Massi (OAA), Loris Magnani (Univ. Georgia, Athens, USA), Jan Wouterloot (EA Observatory, Hilo Hawaii, USA)




Galactic distribution. Sun is at 0,0. Galactic Centre at 0,-8.5.

WB89-863



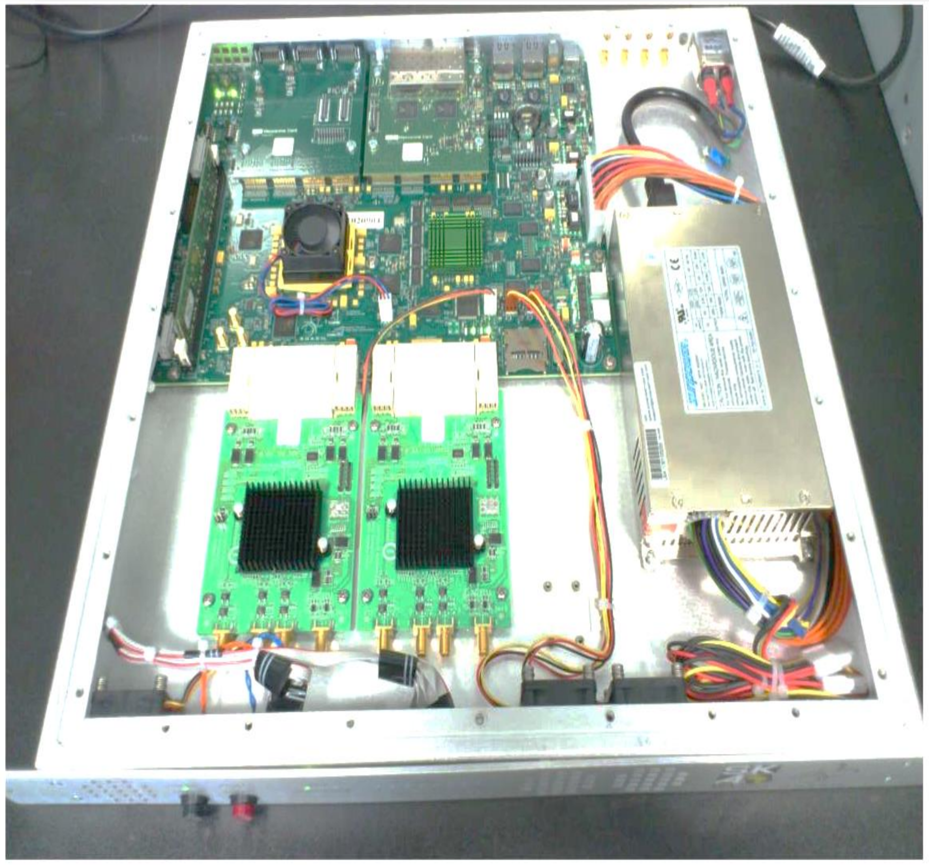




Simultaneous observation of $NH_3(1,1)$ and $(2,2)$ at 23 GHz with XArcos. Line ratio allows derivation of $T_{kin}$.

Sample: 198 targets [IRAS source/CO-cloud].
Observed 144. Detected 53.
Most distant: R=20.3 kpc

Courtesy: Jan Brand

# Spectroscopic Backends: SARDARA



***Sardinia Roach2 Digital Architecture for Radio Astronomy.***

***ROACH2*** *(Reconfigurable Open Architecture and Computing Hardware) stand-alone FPGA-based board*

Base-band data processed via GPU; each node of SARDARA has 2 GPU NVidia GTX 980 TI (2816 CUDA core, RAM 6 GB)

The number of channels can be chosen between **1024 and 2 millions.**

Already available

- **Wide band mode**: instantaneuos BW between 300 MHz and 2 GHz, full-Stokes spectrometer with up to **16384 channels**

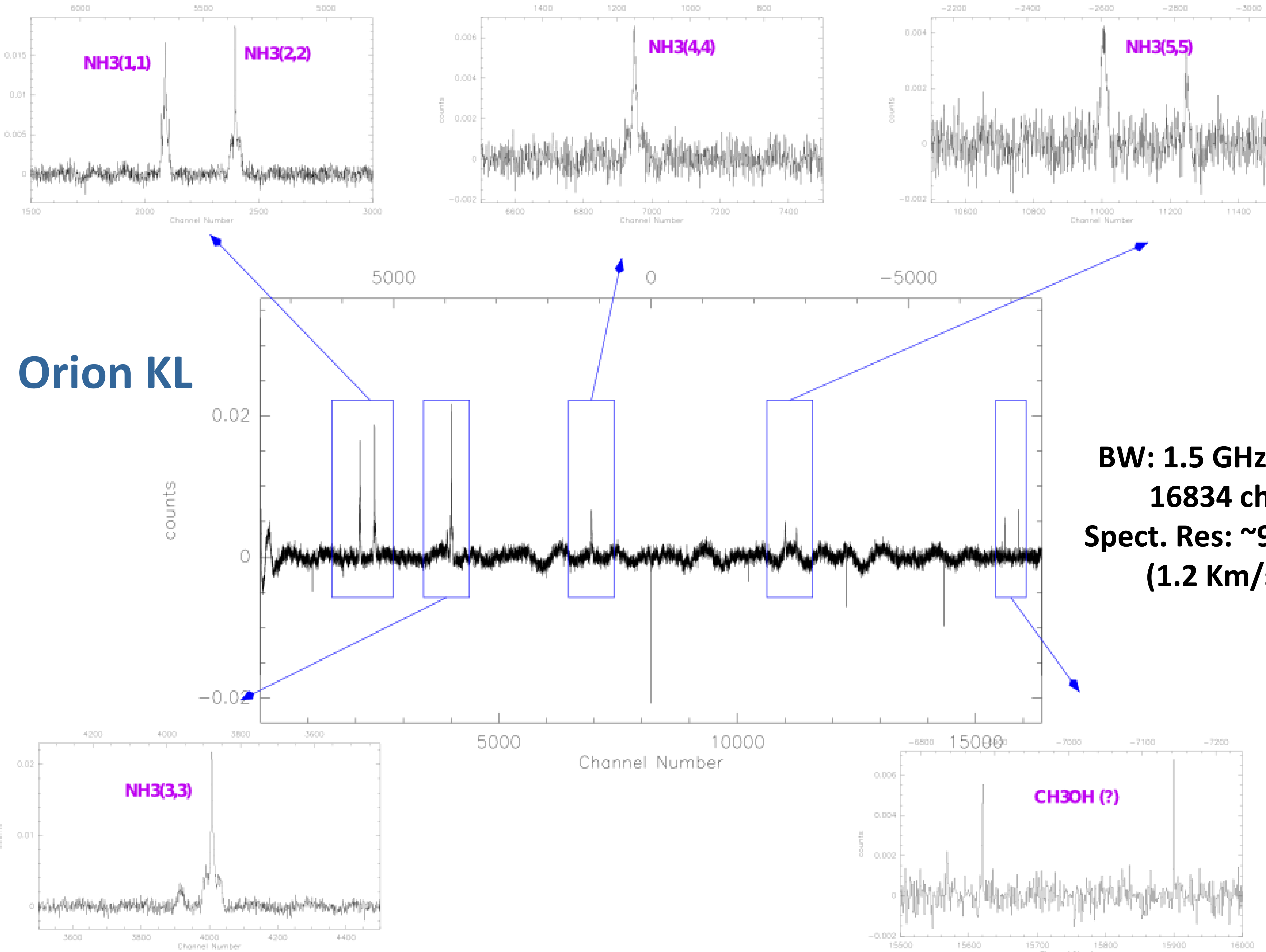
Available in a few weeks

- **Single zoom mode**: instantaneuos BW between 50 MHz and 200 MHz, full-Stokes spectrometer with up to 1 million channels

Under development:

- **Multi-zoom mode**: 8 tunable sub-bands, 20 MHz each, number of channels to be determined

# Orion KL



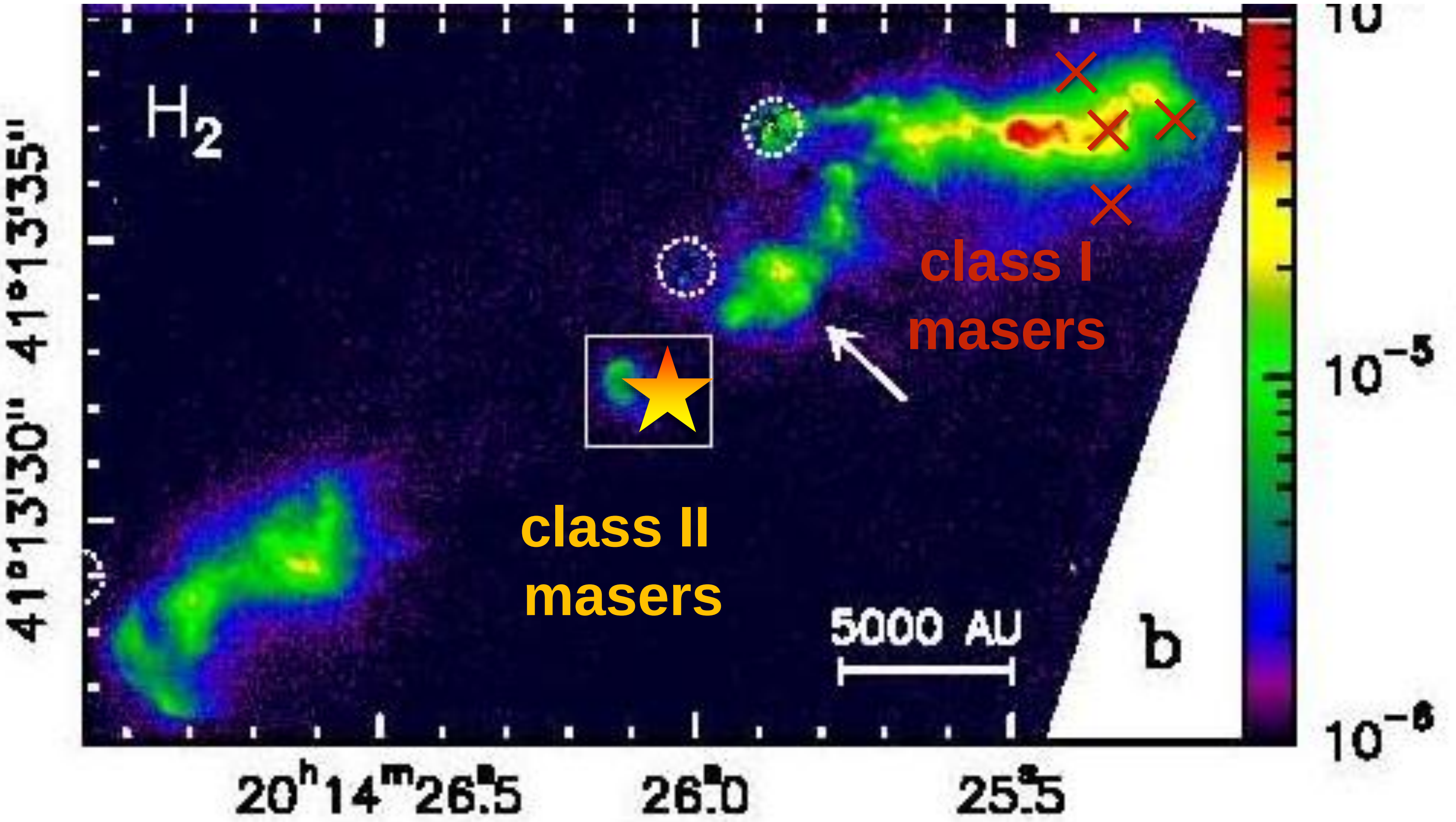

**BW: 1.5 GHz with 16834 chs**
**Spect. Res: ~90 KHz (1.2 Km/s)**

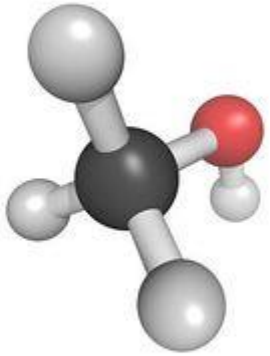
Credits: Poppi, Tarchi, & SRT AV Team

# A case study: Methanol masers in high mass star forming regions

**IRAS 20126+4104**

**Cesaroni+2013; Kurzt+2004**



**Class I methanol ($CH_3OH$) masers (CIMMs)**

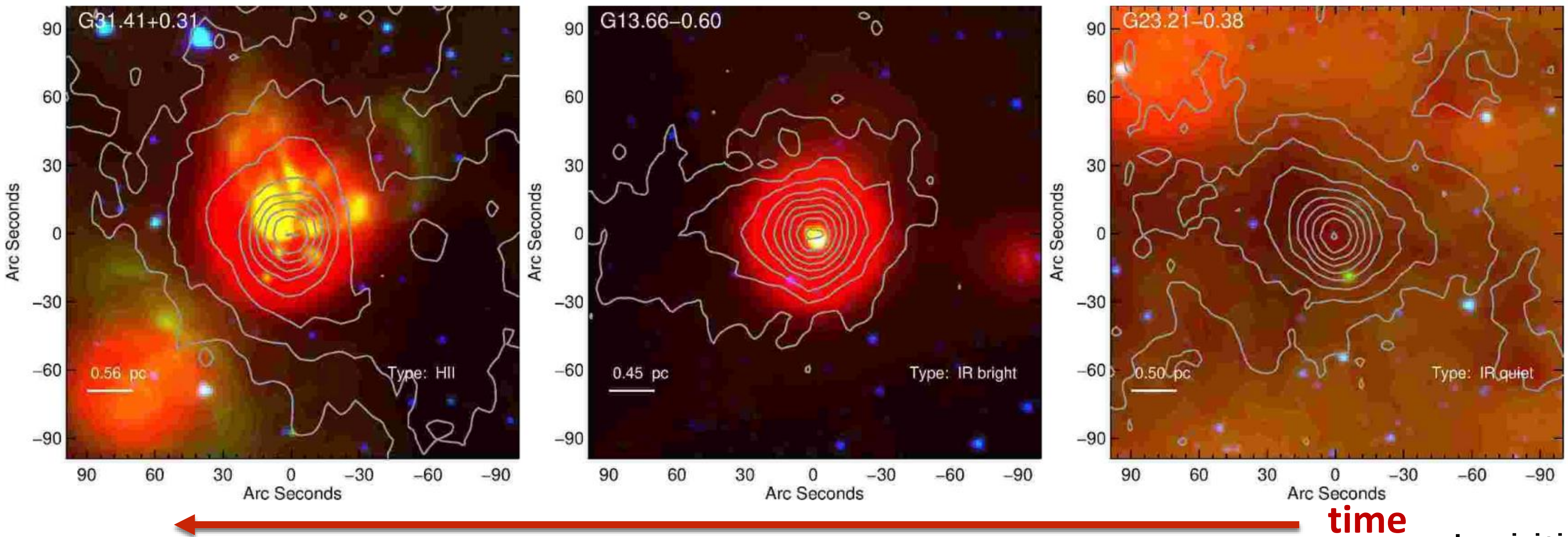
- Scattered around YSOs (up to a parsec)
- Collisional excitation (e.g. by shocks)
- Regions of star formation (high & low mass)

**Class II methanol ($CH_3OH$) masers**

- Located in the nearest vicinity of YSOs
- Radiative excitation (by infrared from YSO)
- Regions of high mass star formation only

# CIMMs in ATLASGAL survey: the selected sample

**Spitzer 3.6μm (blue), 8μm(green), and WISE 22μm (red)**




**Leurini+in prep.**

**Multilines CIMMs observations could provide important constraints on the shocked gas physics.**

**(Leurini et al, 2016 in press)**

**CIMMs surveys in 200 targets in different evolutionary phases:**

1. Presence of outflows in clumps ⇒

   a) are IR-dark clumps *really* pre-stellar?

   b) are Class I masers associated with a particular phase?

2. Definition of a sample of targets to follow up with interferometric obs

(**25 GHz** - 44 GHz JVLA;  84 GHz - 95 GHz NOEMA+ALMA)

# CIMMs in ATLASGAL selected high mass star forming regions

## SRT Early Science Project S0004

P.I. S. Leurini, K. Menten, MPfRi, Bonn;
S.Casu, A.Melis, C.Migoni, A. Trois, C. Migoni, P. Castangia, R.Concu, A. Tarchi, INAF-OAC;
F. Massi, L. Moscadelli, L. Olmi, M. Walmsley INAF-OAA

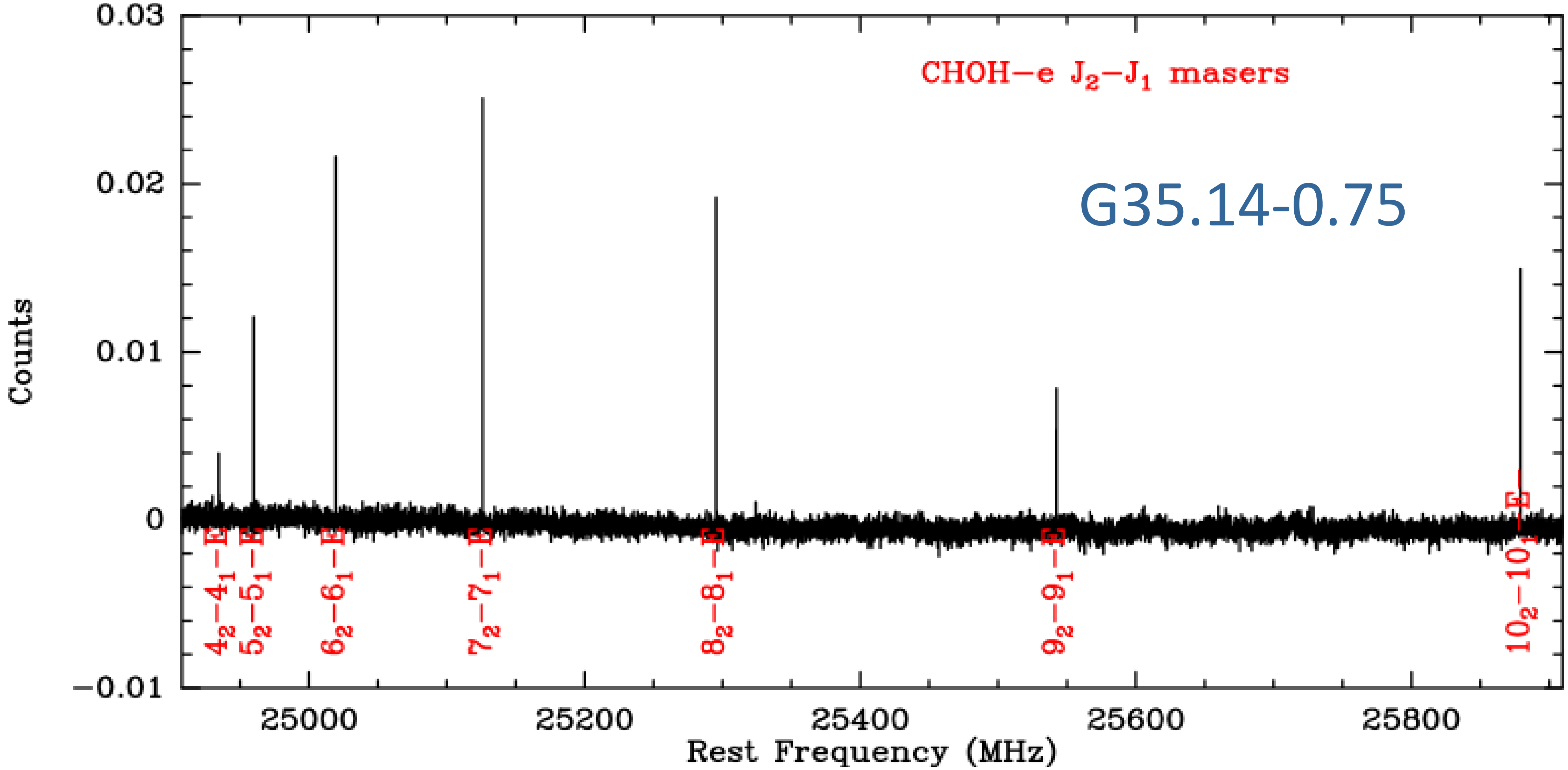
## 25 GHz series (higher density tracers)

| Transition | Frequency (MHz) |
|---|---|
| $3_2 \rightarrow 3_1$-$E$ | 24 929 |
| $4_2 \rightarrow 4_1$-$E$ | 24 933 |
| $2_2 \rightarrow 2_1$-$E$ | 24 934 |
| $5_2 \rightarrow 5_1$-$E$ | 24 959 |
| $6_2 \rightarrow 6_1$-$E$ | 25 018 |
| $7_2 \rightarrow 7_1$-$E$ | 25 125 |
| $8_2 \rightarrow 8_1$-$E$ | 25 294 |
| $9_2 \rightarrow 9_1$-$E$ | 25 541 |

## Observing Strategy:

1. **SARDARA: Low spectral resolution Survey (~1 kms$^{-1}$) on targets observed @44GHz presenting S/N>5**
2. **Xarcos: deep integrations (~30 min ON+OFF; Spectral resolution: 0.02/0.05 kms$^{-1}$) on the most intense line detected with SARDARA.**

# Preliminary Results: SARDARA

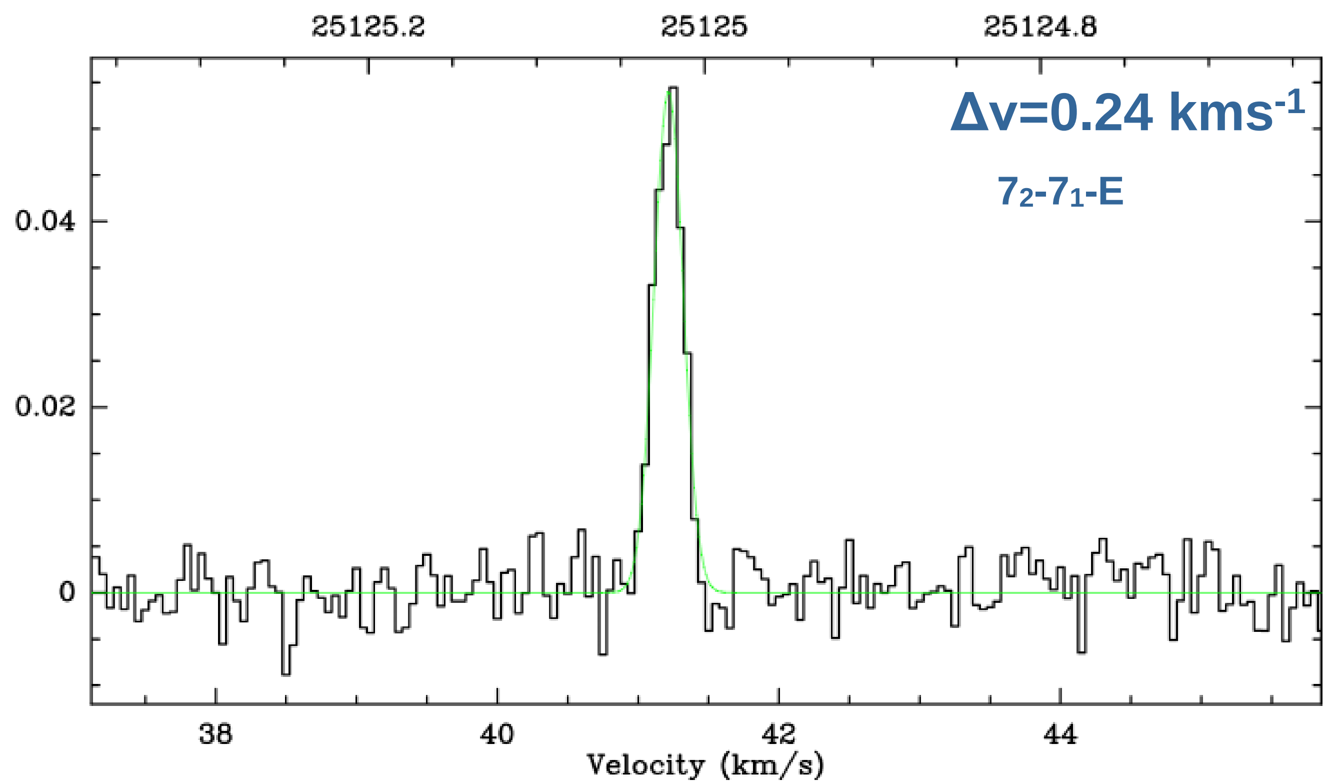


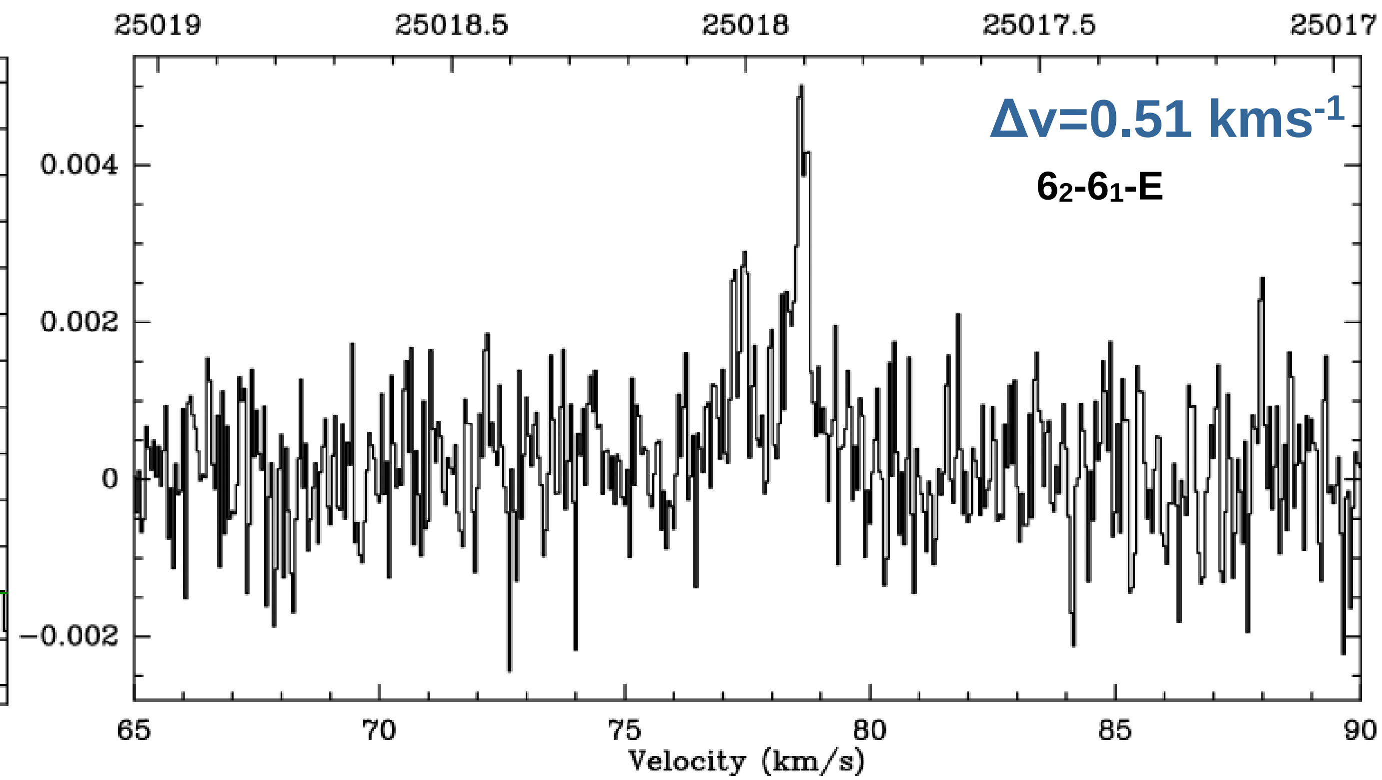

- 22 (over ~60 observed) detections in at least one line in the $J_2$-$J_1$-E serie
- Statistics on the relative intensity

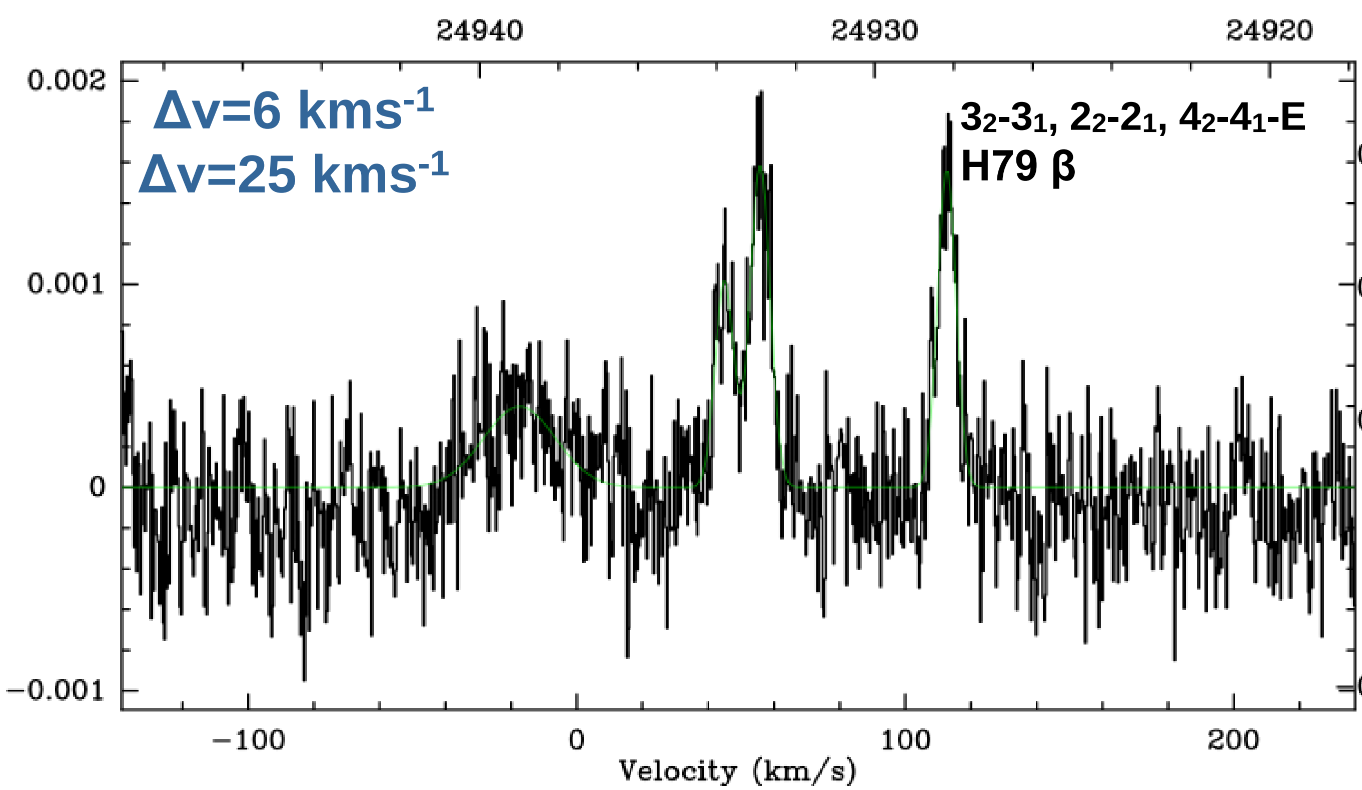
In several lines of sight, simultaneous observations of recombination lines (H64 α, H80 β, H91 γ, H100 δ, H63 α, H79 β) and ammonia $NH_3$(6,6)

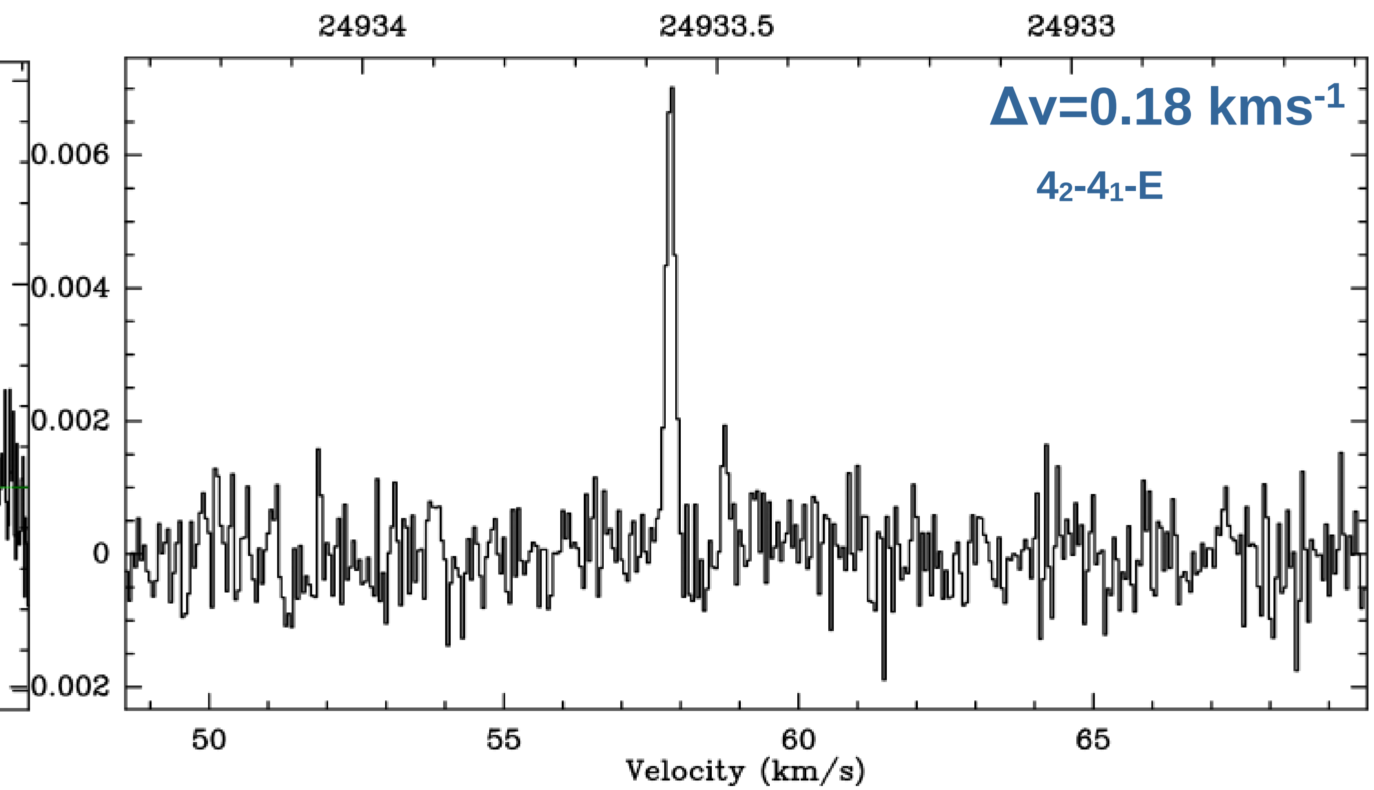
Casu et al., in prep

# Preliminary Results: XArcos



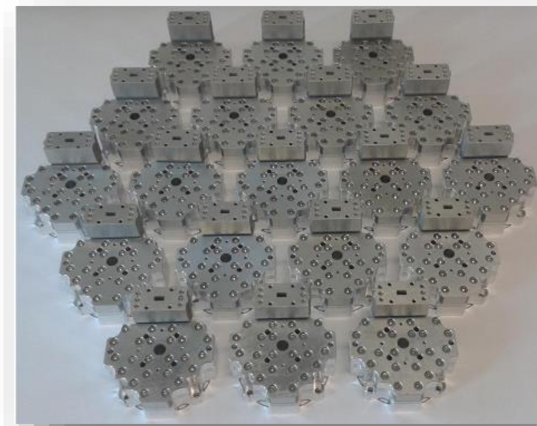



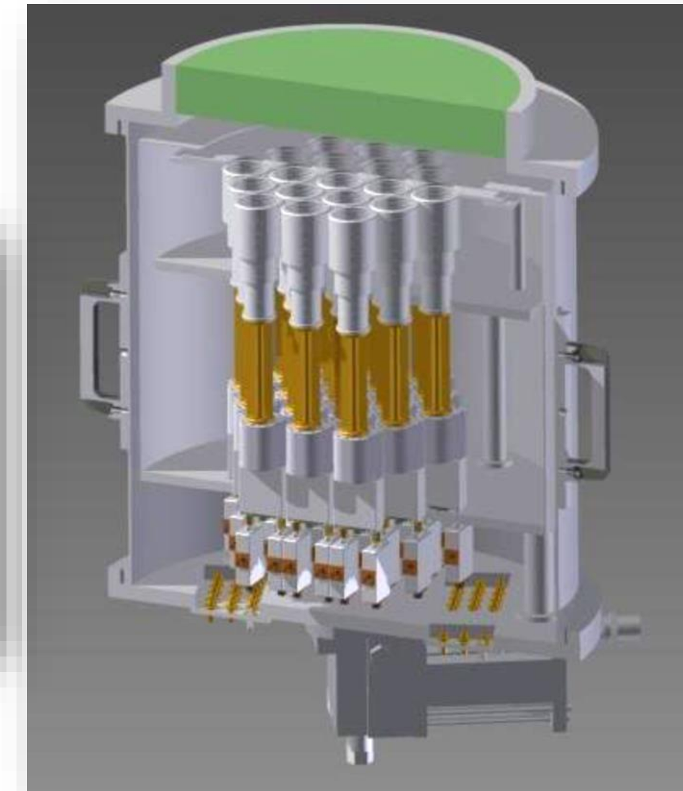



# Astrochemistry and star formation with SRT: a future perspective

**Q BAND – 7 mm receiver under development**
(**33-50 GHz, BW: 17 GHz**) multi beam receiver,
**19 feeds. Beam ~30''**
Dual polarization for each horn, full Stokes
With SARDARA up to 131Kchannels over BW =2GHz
Spectral resolution = 15KHz (0.1km/s @ 43GHz)





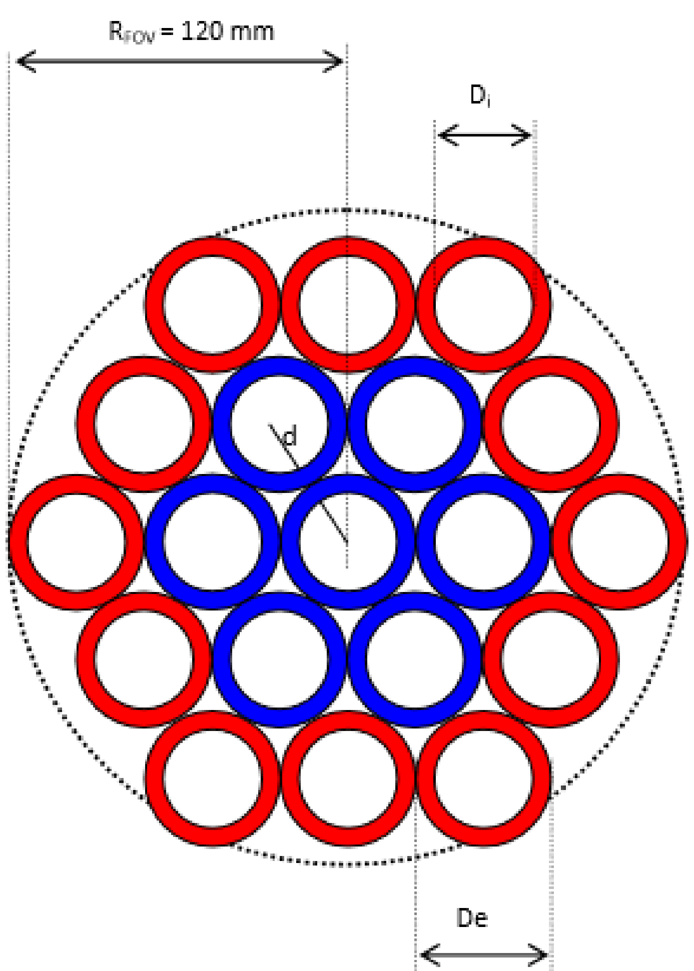


Fig. 2.5 Disposizione a 19 horn

Examples of possible programs:

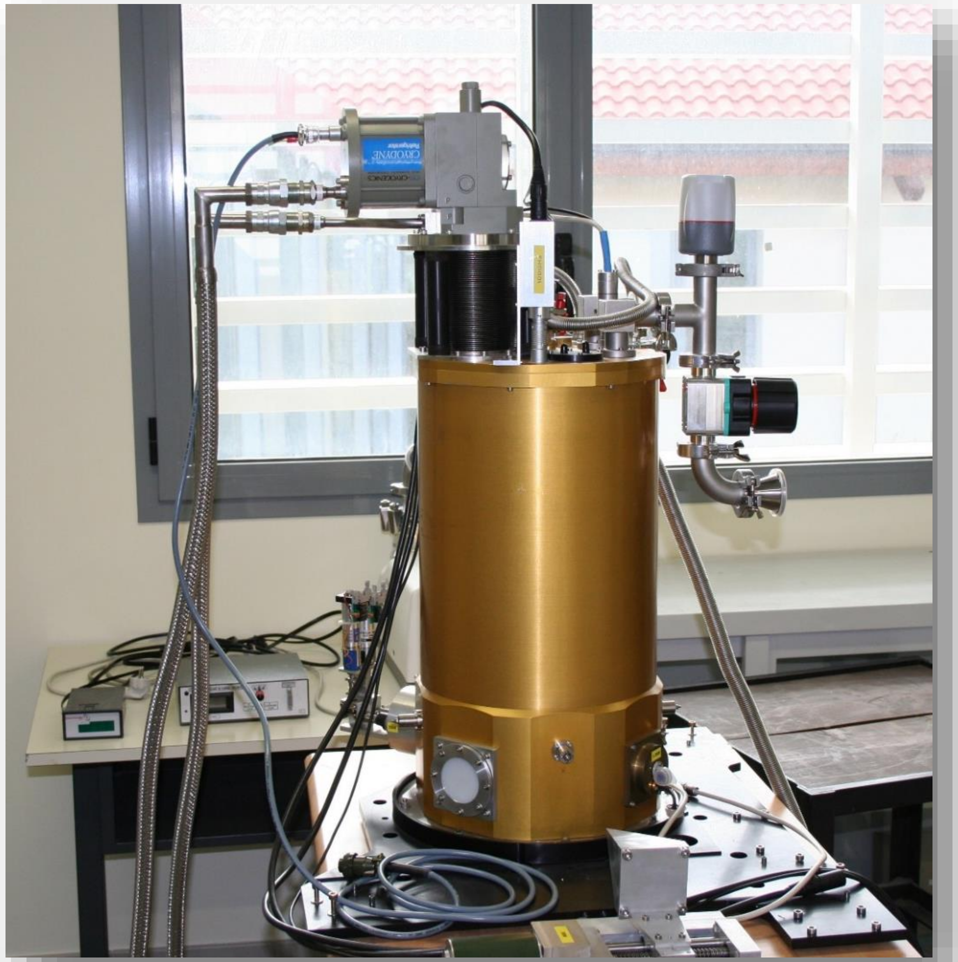
- Survey of **methanol lines** (@36 and 44GHz) in galactic Plane (see Yusef-Zadeh, 2012)
- **SiO (1-0)** maps of IRDCs filaments (together with **$CH_3OH$** masers), using central 7 beams (fov ~4'). See Jimenez-Serra, 2010
- Multi line survey of **complex organic molecules** (COMs), Cyanopolyynes $HC_nN$, formaldeheide,...
- ...

A. Orfei (INAF-IRA), R. Nesti (INAF-OAA)

# Astrochemistry and star formation with SRT: a future perspective

**W BAND – 3 mm SIS receiver**
(A. Ladu, T. Pisanu, INAF-OAC)

Purchased from the IRAM to **test the performances** of the antenna (namely the active surface) at mm frequencies (**84-110 GHz**).
IF signal: BW 500MHz
**Beam ~10''**



Ready for dynamic schedule (high precision weather forecast, max reliability)

Examples of possible programs:

- Surveys of **molecular ions (hydrogenated and deuterated):** $DCO^+$ (1-0) , $N_2D^+$ (1-0), $HCO^+$ (1-0), $N_2H^+$ (1-0)
- Multi line survey of **complex organic molecules** (COMs), eg. higher transitions of Cyanopolyynes
- …

# Conclusions

## A single dish in the interferometers era?

SRT could be an useful facility for astrochemistry and star formation studies.

Its current receveirs and backends allow to perform molecular surveys ($NH_3$, $CH_3OH$, OH and $H_2O$ masers) and large scale simultaneous maps of different chemical species (e.g. $NH_3$ e $C_2S$).

Interesting future equipments in Q and W bands.

Is there a INAF interested community?