CONDOR - a 1.4 THz Heterodyne Receiver

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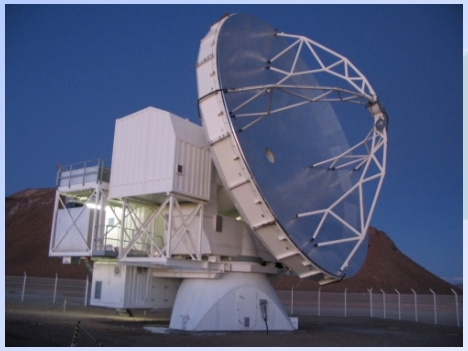
I. Astronomy with CONDOR

CONDOR - CO N^+ Deuterium Observations Receiver

Motivation: Study cores of high and low mass star formation and starburst galaxies

Telescopes: modular Rx, P.I. instrument on **APEX**, low frequency extension of GREAT on **SOFIA**



I. Astronomy with CONDOR

CONDOR - CO N^+ Deuterium Observations Receiver for APEX and low freq. extension of GREAT on SOFIA

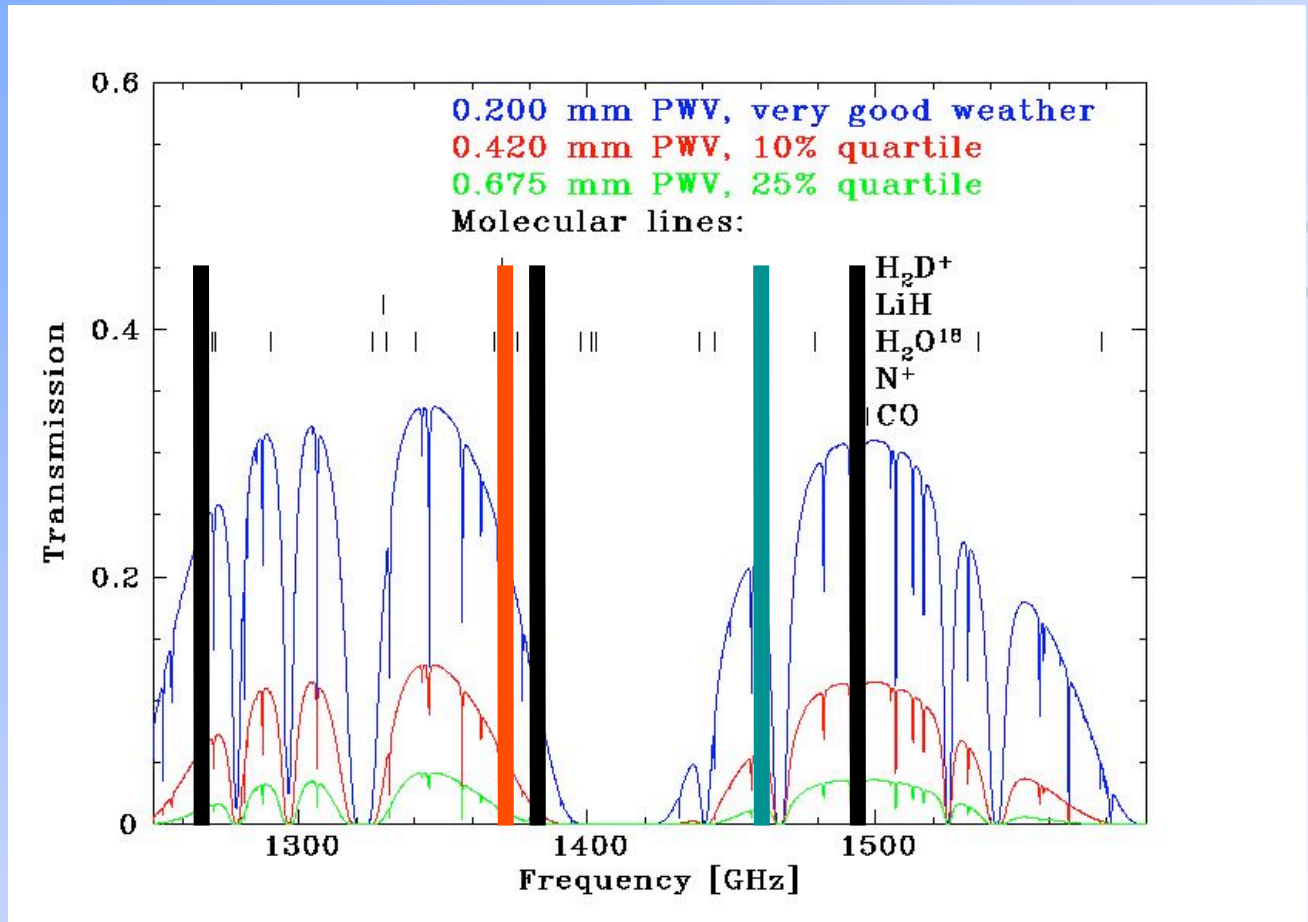
Study cores of high and low mass star formation and starburstgalaxies

in **CO** – hot (several 100K), dense mol. gas, CO 11-10, 12-11
CO 13-12 E_{up}=503K, ρ_{crit} =10^7 cm^{-3}

in **N+** – WIM prob. created by SNe, 3rd strongest line in MW fine structure trans. 205µm, 3P1→3P0 Eup=70K

in **H_2D^+** – cold (5-20K) mol. gas, last kinematic tracer, key to deuterium chem, chemically interesting o/p-ratios
para-H_2D^+ $1_{(01)}$→$0_{(00)}$ E_{up}=66K

Atmospheric Transmission



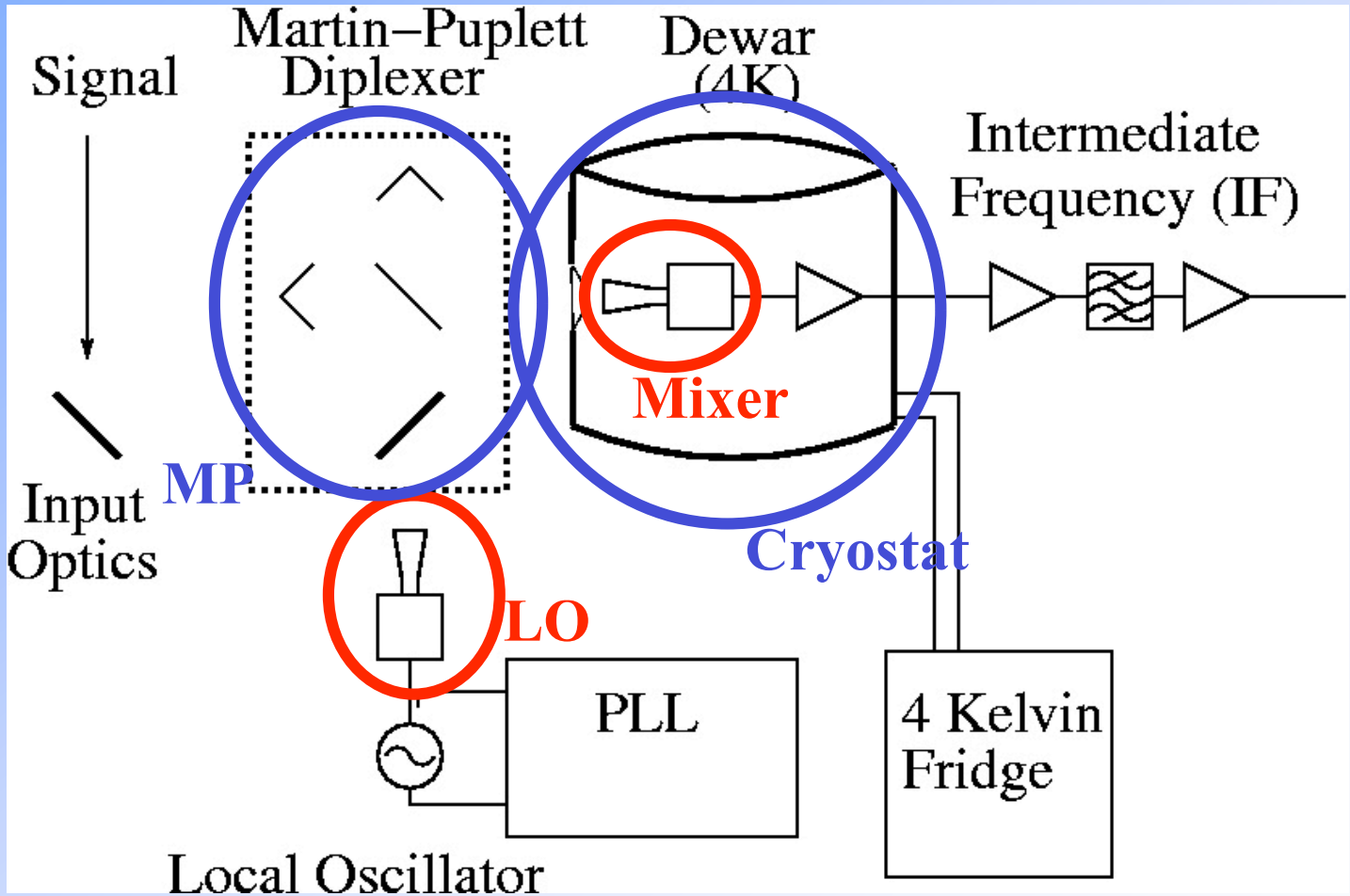
CO

N^+

H_2D^+

Pardo et al. 2005, Pardo et al. 2005, Wiedner et al. 2004, Pardo et al. 2004

The Receiver



Mixer: Hot Electron Bolometer

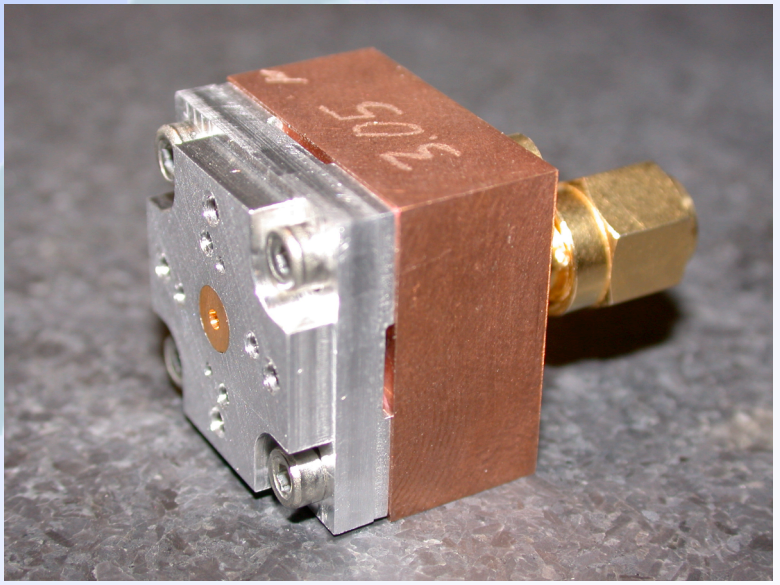
Fabricated by **K. Jacobs**, **C. E. Honingh** and their group

NbTiN HEB

on thin membrane substrate

in **waveguide** mixer

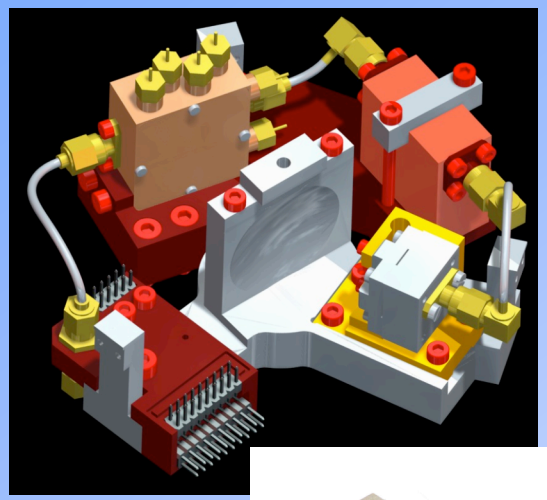
corrugated feed horn (RPG)



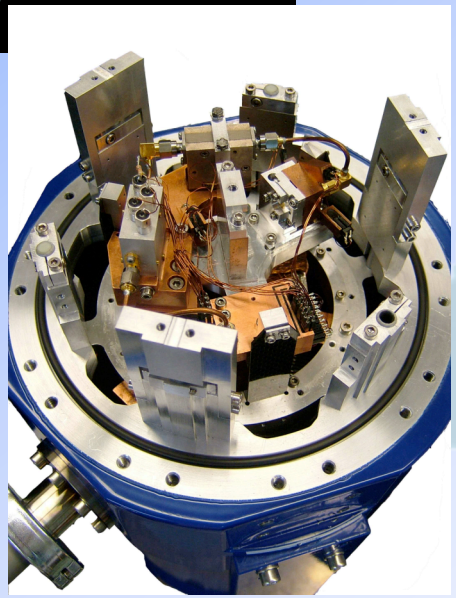
RF: 1300 – 1500 GHz

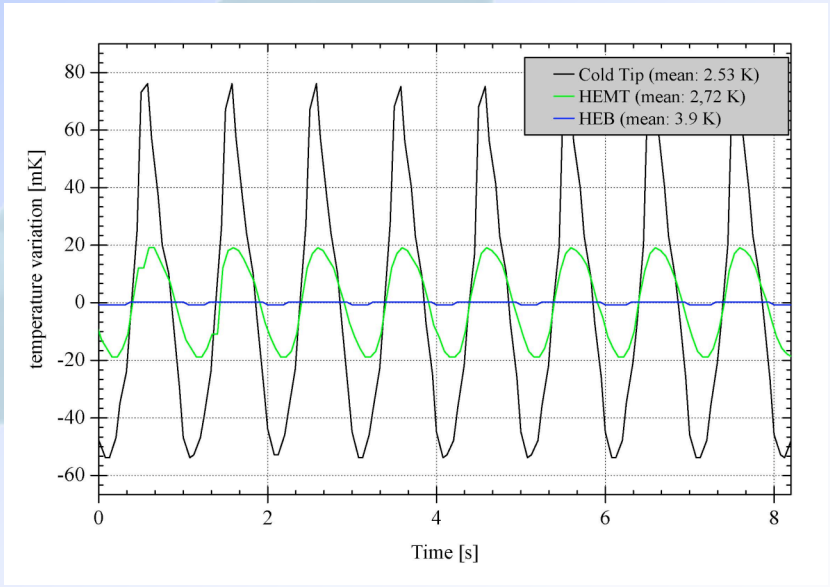
IF : 0 →2 GHz

Cryostat



Pulse Tube Cooler
! Small vibrations
! Small temperature variations

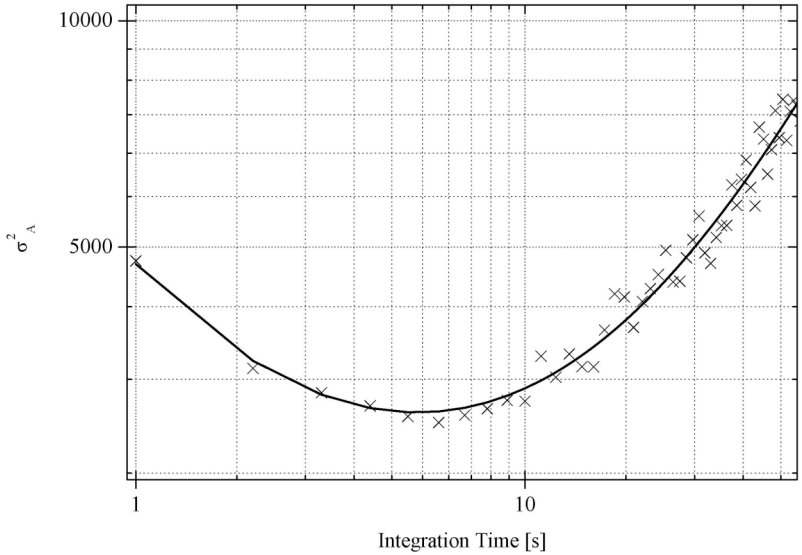




Allan Variances

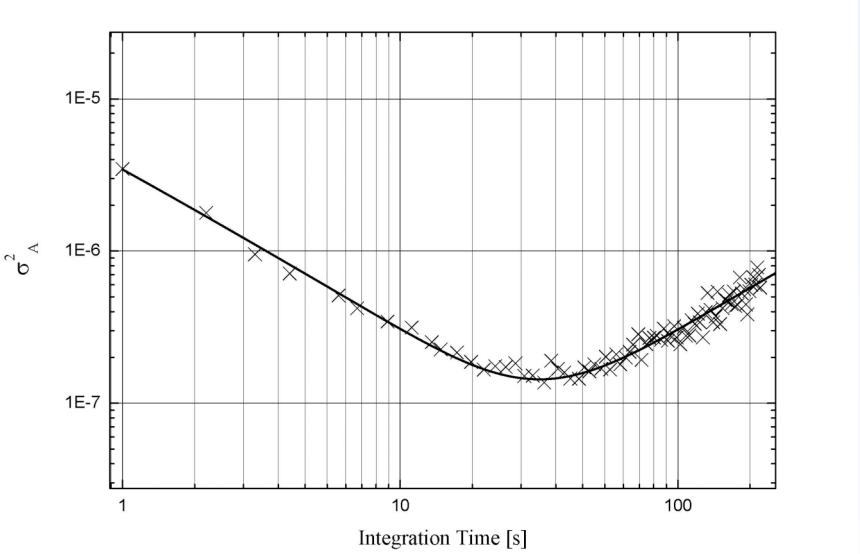
Total Power

min ~6 sec



Spectroscopic

min ~35 sec



Performance of CONDOR

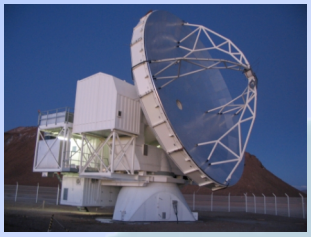
Receiver: Heterodyne THz Receiver with HEBs

Frequency Range: 1.25 – 1.53 THz

IF width: current 0.7 GHz (140km/s), soon 2 GHz (400km/s)

T_{rx}: 1500 K (DSB)

APEX



T_{mb} = 4.”5

T_{rms} = 13K (meas.)

@ 10min, 1km/s

SOFIA

T_{mb} = 15”

T_{rms} = 0.1K (theo)

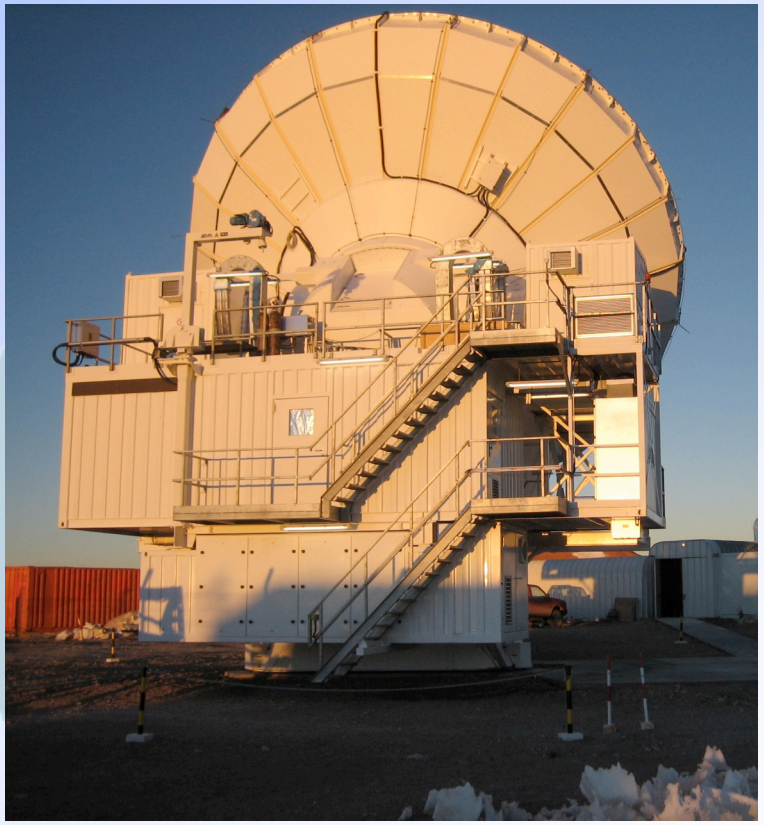
@ 10min, 1km/s

Observations at APEX

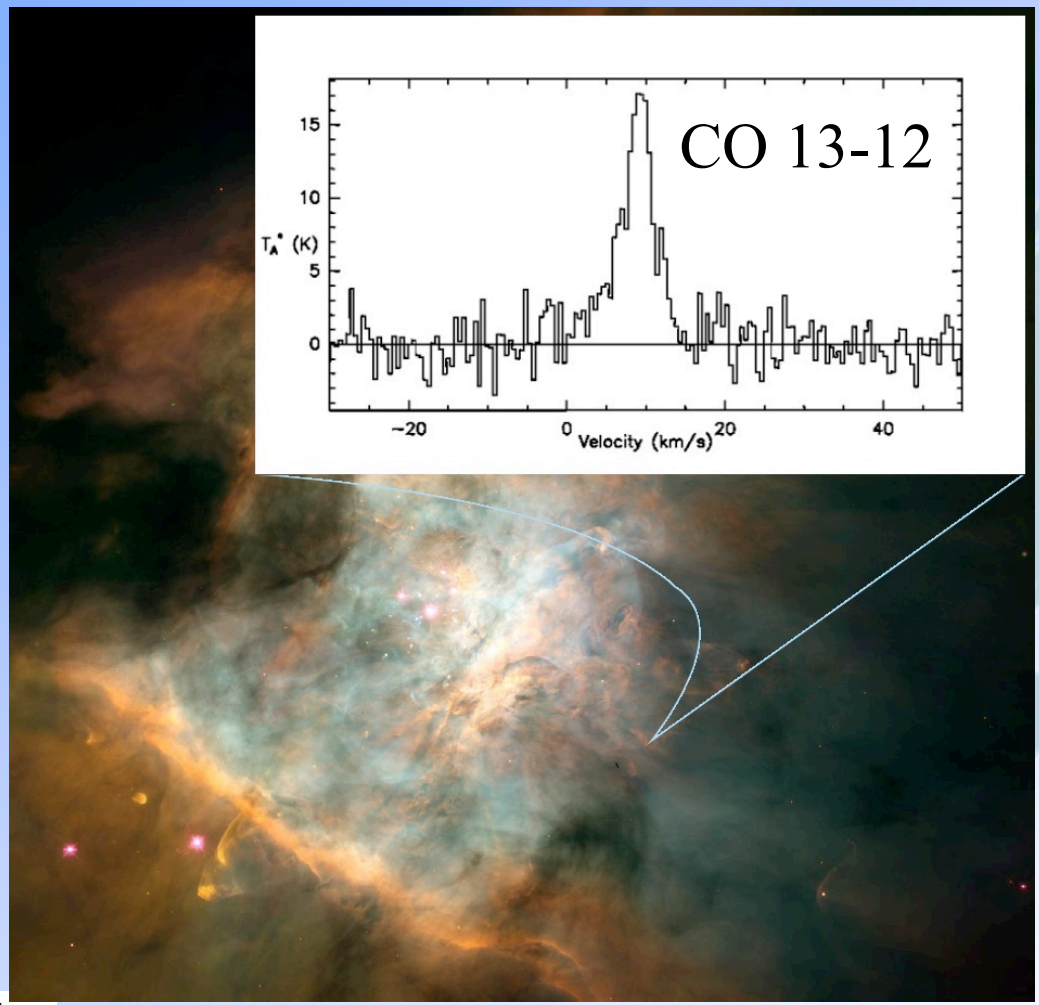
First observations with CONDOR on APEX in Nov. 2005

Observing not easy, but possible!

Difficulties:
- atm. transmission
- telescope surface accuracy
- pointing, lack of THz pointing sources
- calibration (atmosph., tel eff., Rx stability)



Orion South – FIR 4



- Hot core in OMC-1
- Near or at interface between HII and compact mol. gas
- Hot gas component (300 – 500K)
- At vertex of system of outflows.
- Narrow line (5.4km/s) → unlikely to be shock heated

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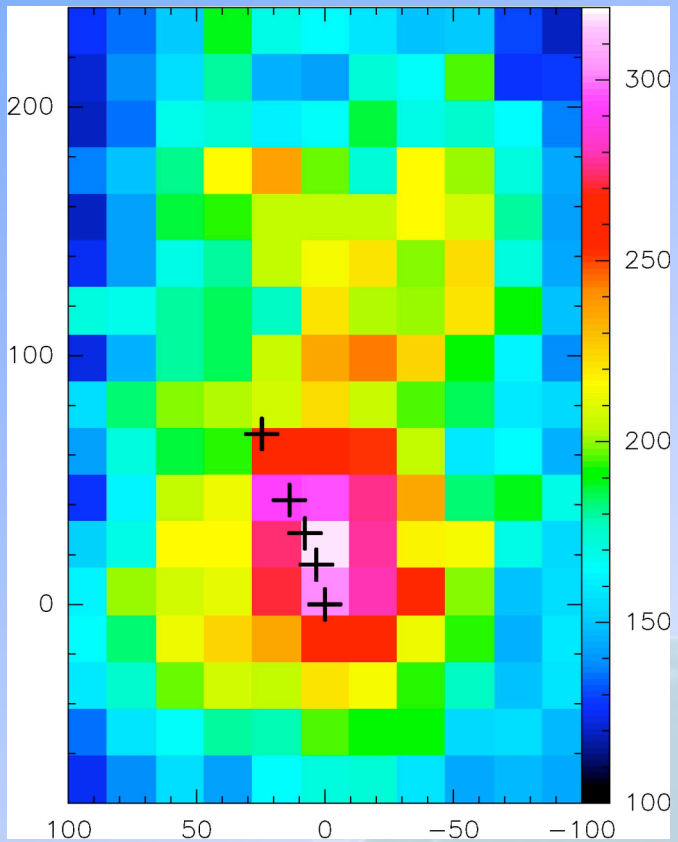
CONDOR, Wiedner et al.

NGC 2024



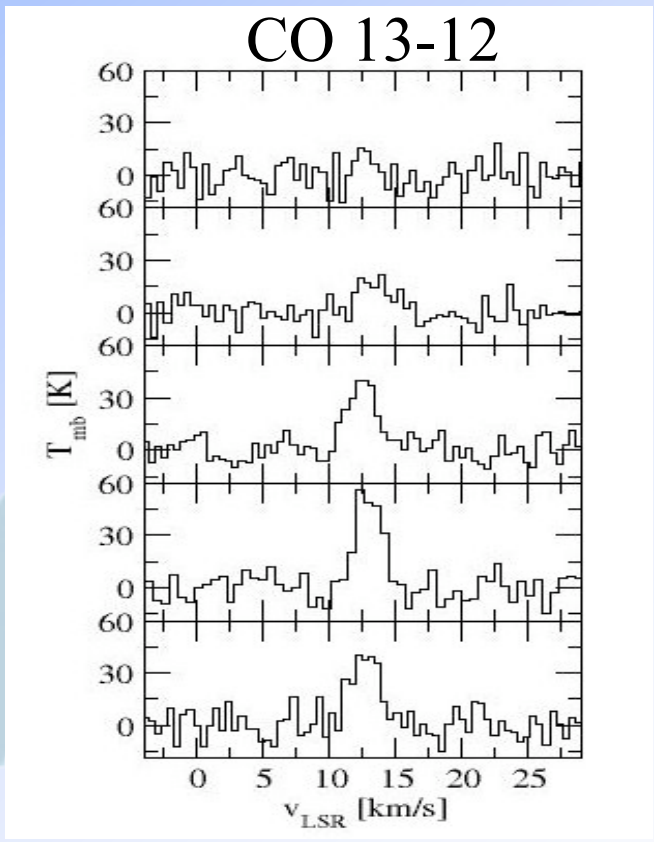
IRS2

30” S

45” S

IRS3

FIR5



^{12}CO 6-5 map, observed with the KOSMA telescope.

CO 13-12 spectra obtained with CONDOR

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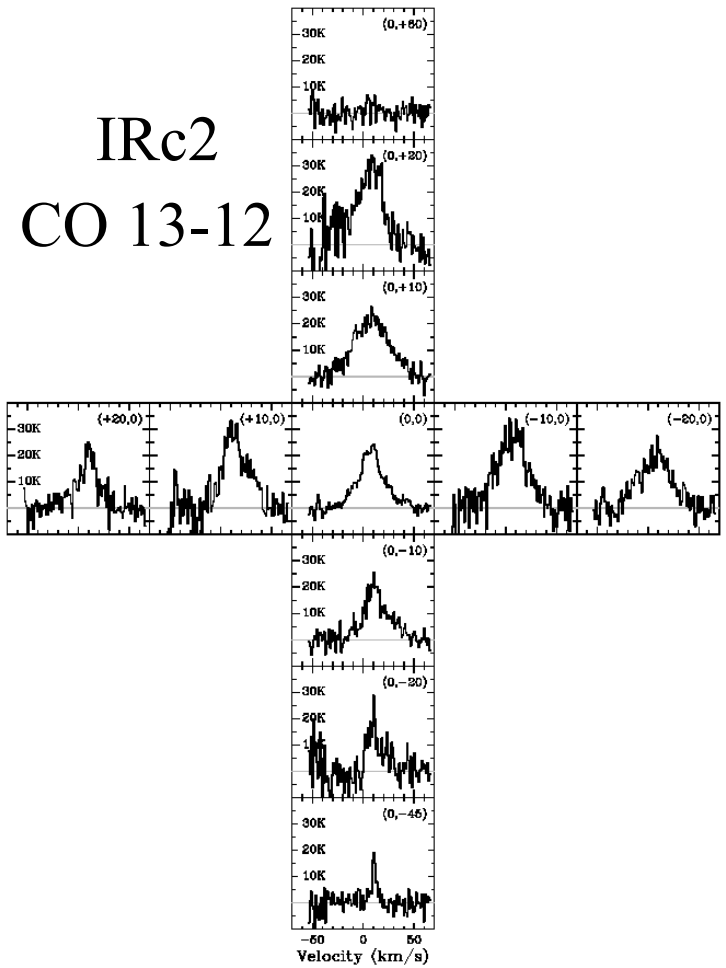
CONDOR, Wiedner et al.

Observations: Orion KL



Main Results:

Spectral res. → decompose

Spike: extended PDR

→ v-gradient

→ PDR model underestimate high-J CO intens.

Hot core: hot gas close to protost.

Plateau: outflow

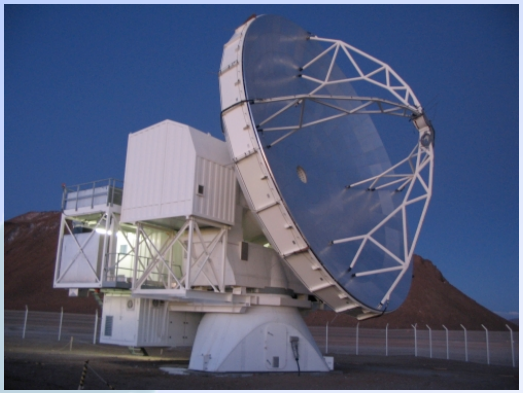
Volgenau et al. in prep.

Summary & Outlook

CONDOR operational:
RF: 1.25 – 1.53 THz,
IF: 140km/s → 400km/s

APEX observations:
suitable for bright lines,
e.g. high-J CO, (N^+)

SOFIA: Trms=0.1K in 10 min,
high-J CO, H_2D^+, N^+
End 2008/ Beginning 2009



CONDOR–offspring: to Antarctica?

Heterodyne THz Receivers

- ~1980s – KAO, Boreiko & Betz, Shottky Diode Mixers, IR Laser Lo
- ~2000s – HHT, Blundell, Kawamura et al., HEB, Solid State LO, 1 THz
- 2001-now – RLT, Blundell, Marone et al., HEB, Solid State LO, 0.8, 1.1, 1.5 THz
- 2005 – CONDOR @ APEX, Wiedner et al. HEB in closed-cycle cooler, Solid State Lo, 1.25 – 1.5 THz, soon @ SOFIA
- Soon – 1.5 THz Rx for APEX, Belitsky et al. 2-HEBs for LO noise supression
- Soon – Herschel up to 1.3THz SIS, 1.5 THz Rx HEB, solid state multiplier chains