Far-Infrared Spectroscopic Explorer
- FIRSPEX -

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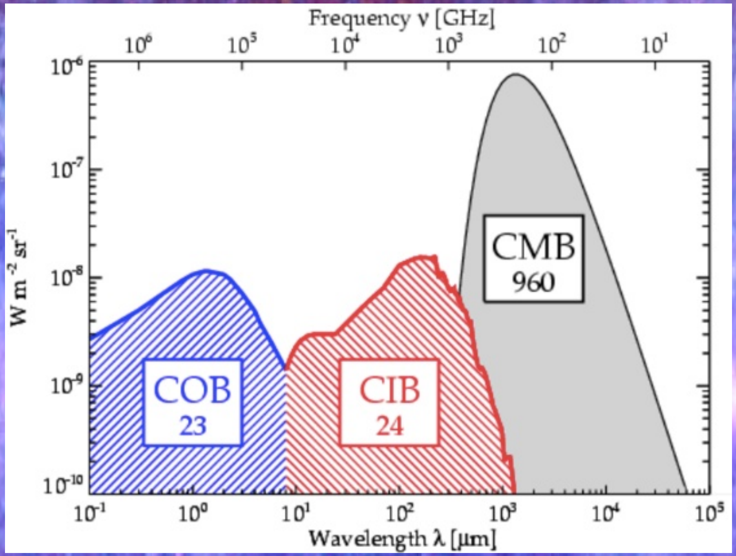
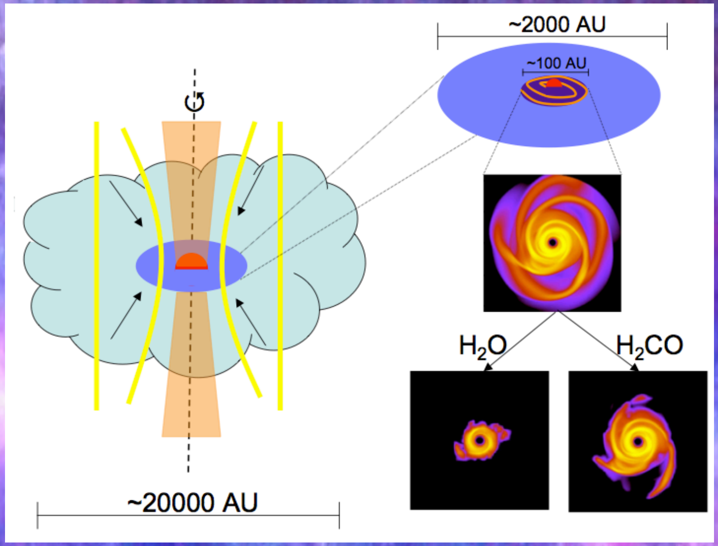
Why far-infrared?

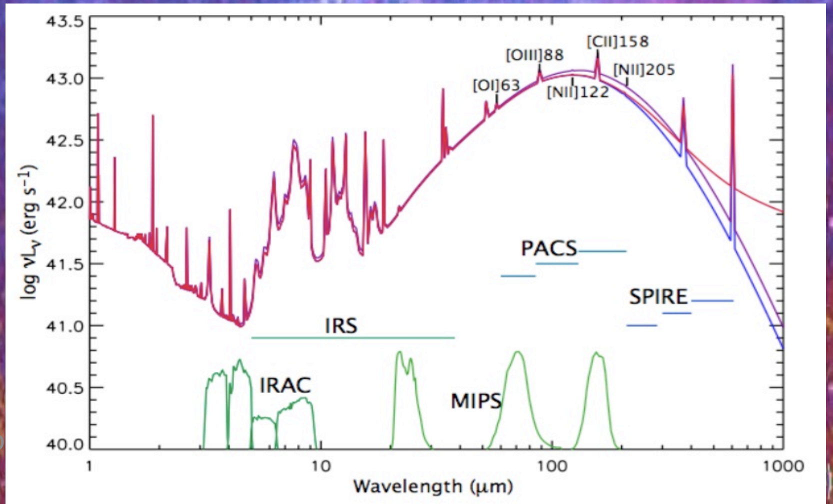
Cosmic Infrared Background



The dawn of protoplanetary disks



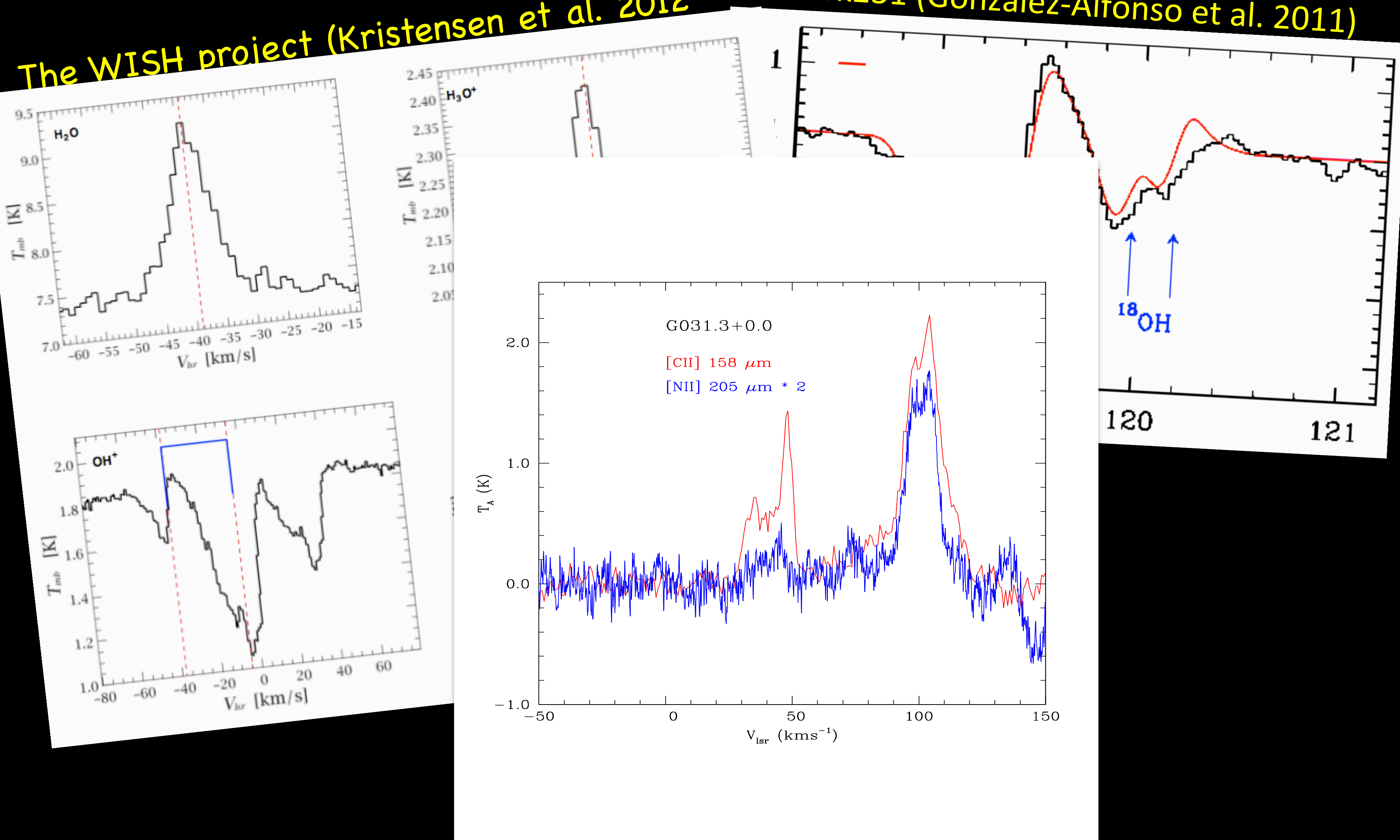
- ✧Study the ISM
- ✧Early stages of star formation
- ✧Cooling processes in galaxies
- ✧Formation of complex molecules
- ✧Gas Grain chemistry



Herschel Heritage

The WISH project (Kristensen et al. 2012

Mrk231 (Gonzalez-Alfonso et al. 2011)



GOT C$^+$ team (Pineda et al. (2013)

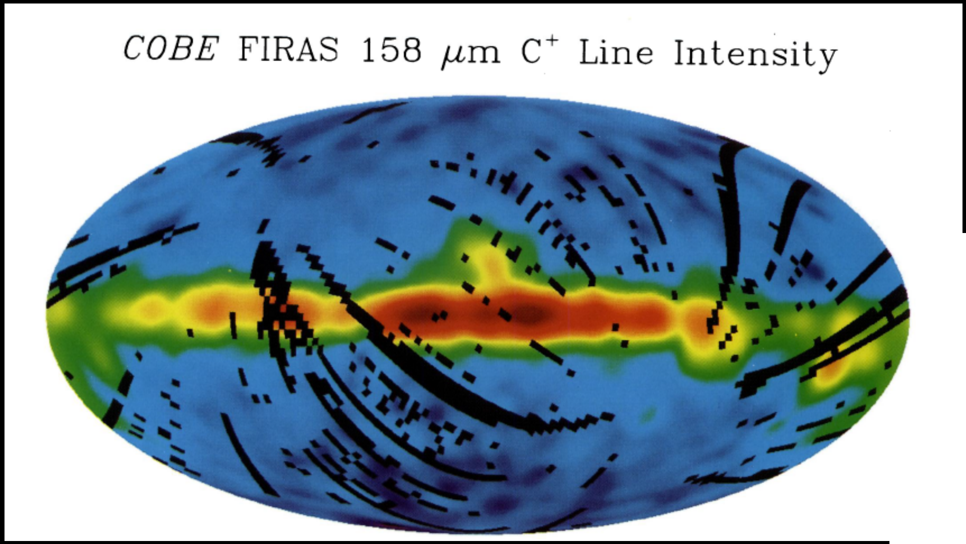
But no spectroscopic equivalent to the Herschel continuum survey of the Galactic Plane

The Herschel infrared Galactic Plane Survey (Hi-GAL)
PI: S. Molinari

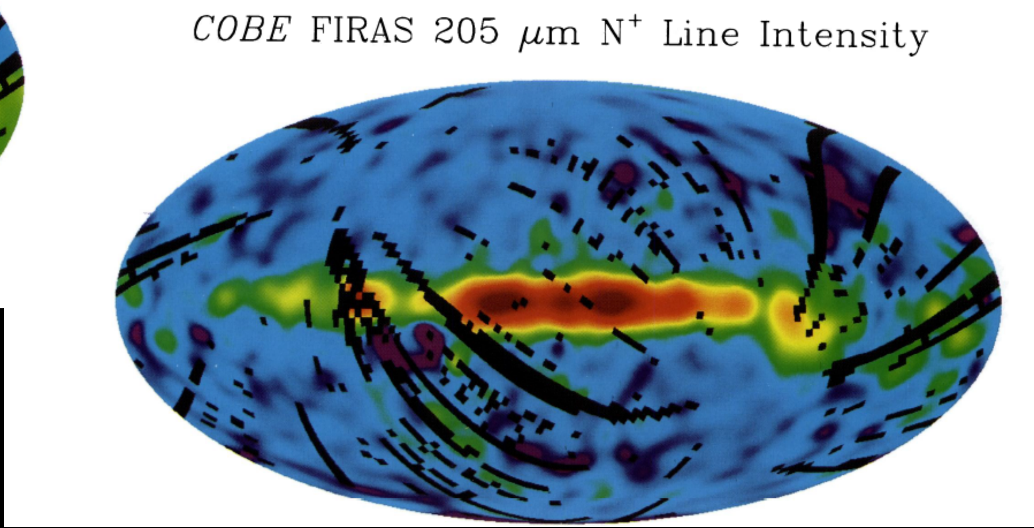
Heritage

COBE/FIRAS low resolution map in [CII],[NII] Bennett et al '94

probe the CNM (Bennet et al 94), WIM (Heiles et al 94)
PDRs (Cubick et al. 08)

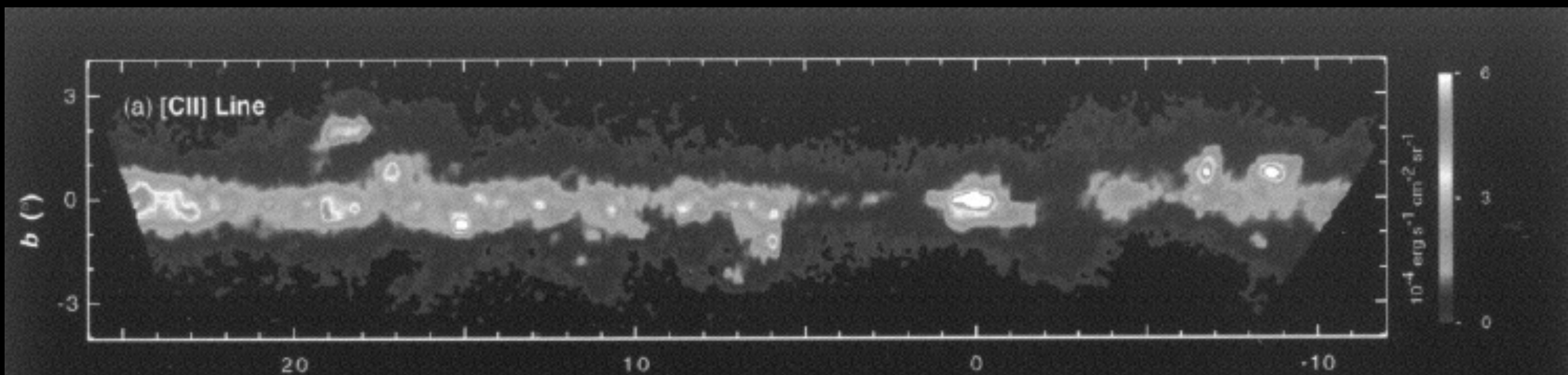


Spatial resolution 7°



Spectral res: 1000 km/sec

Balloon-borne Infrared [CII] Explorer (BICE)



Galactic Longitude in degrees

angular resolution: 15 arcmin
spectral resolution : 175 km/sec

Nakagawa et al. (1998)

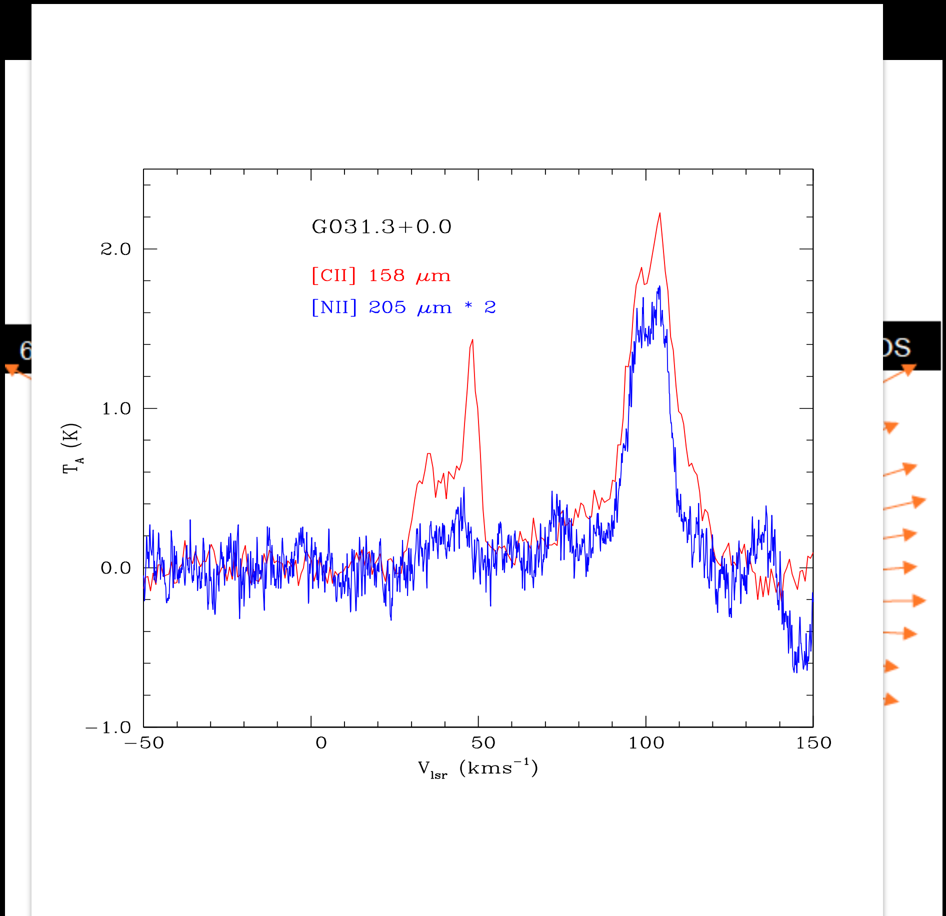
The Herschel-HIFI survey of [CII] in the Galaxy (the GOT C^+ team)

Galactic Plane and Galactic Central Regions Survey

[CII] emission in the Galaxy mostly related to spiral arms, tracing clouds transiting from atomic to molecular.

But to fully trace properties of ISM we need large scale [CII] , [NII], [OI] maps of the Galaxy and Nearby Galaxies

FIRSPEX survey



GOT C^+ team (Pineda et al. (2013)

Far-Infrared Spectroscopic Explorer (FIRSPEX)

A proposed ESA-CAS mission to perform an all-sky survey and targeted observations in:

(OI) 63 μ m, OH 119 μ m, [CII] 158 μ m, H_2O 179.531μm [NII] 205 μ m

4.75 THz 2.51 THz 1.90 Thz 1.67 THz 1.46 THz

Top level Science Goal: Perform "all-sky" survey (equivalent of the IRAS/AKARI mission) in order to:

- trace the transition from atomic to molecular clouds
- investigate the formation of stars within high density regions,
- understand the radiative feedback from newly formed stars and AGN
- explore the termination of star formation

The choice of spectral lines

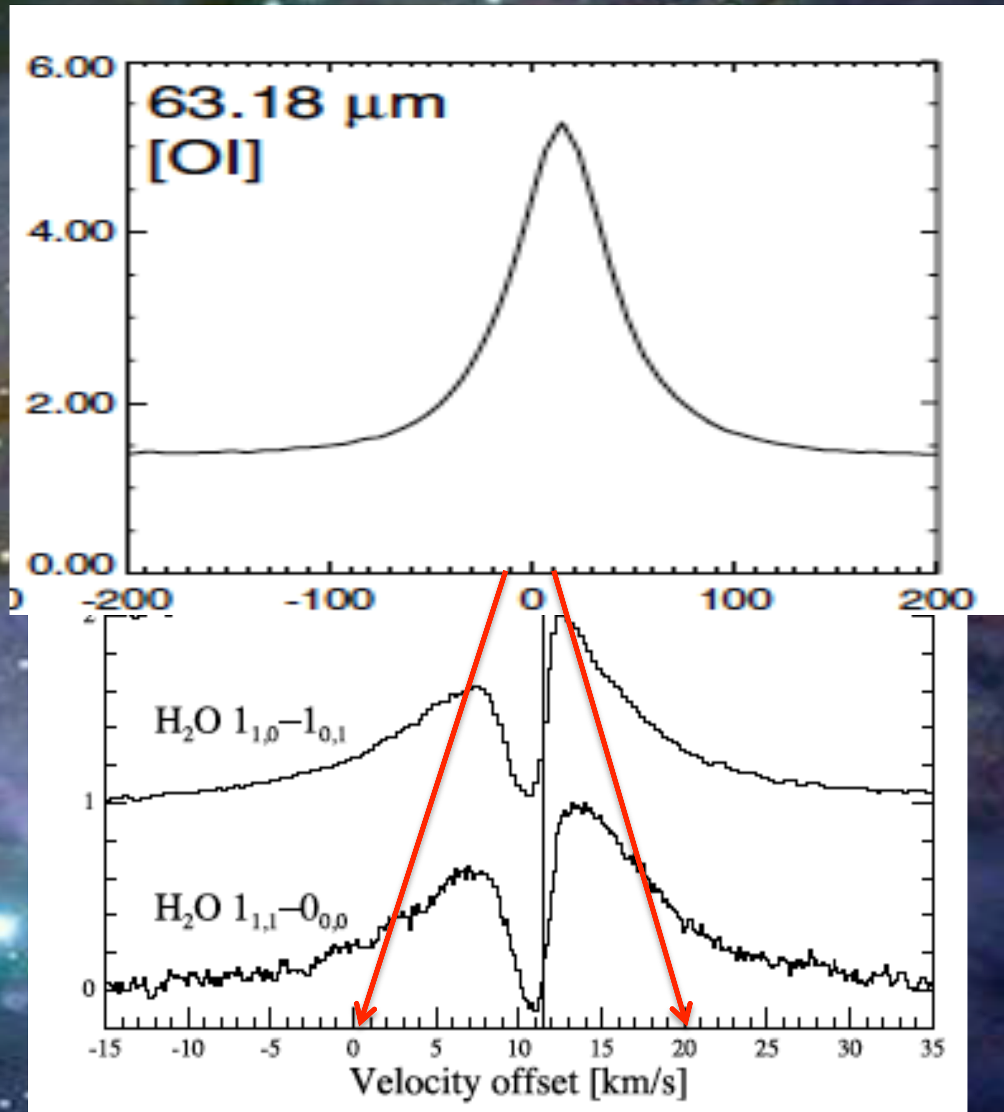
- [OI] (63µm), [CII] (158 µm), [NII] (205 µm) Cooling mechanism in galactic and extragalactic environs properties of Interstellar Medium (ISM) and its microphysics

- H_2O (179 µm)
  important for the formation of complex molecules on ices. Controls gas/grain chemistry.

- OH (119 µm)
  Star forming regions in the Galaxy AGN feedback

Physical conditions in Star forming regions

Resolution is key ….



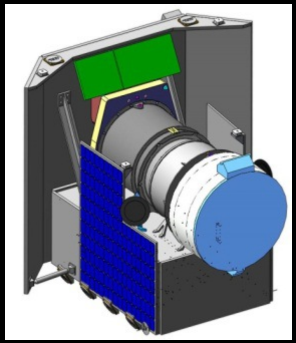
[OI] in Orion -KL
ISO-LWS
Lerate et al. 2006

Water in Orion-KL
HIFI
Kama et al. 2013

Payload

- Small mission provides excellent science opportunity.
- Limited payload resources – low power, low mass, and small volume.
- Cryogenic cooling to 4K too demanding with present technology, but ~20-50 K is viable.
- Semiconductor (Schottky) mixer technology compliant with higher ambient temperature operation
- Schottky offers good sensitivity and wide IF bandwidth.
- **Quantum Cascade Laser (QCL)** Technology provides sufficient mixer LO power.
- Proposed concept has the advantage of low cost cooling and relatively rapid mission deployment

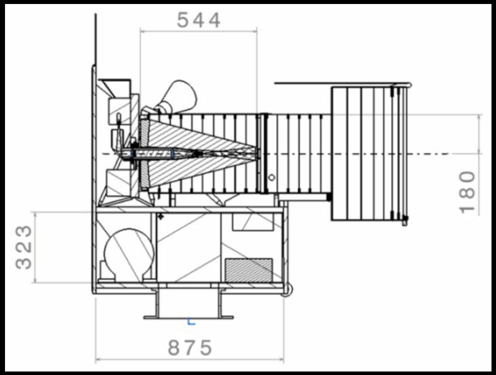
System Overview

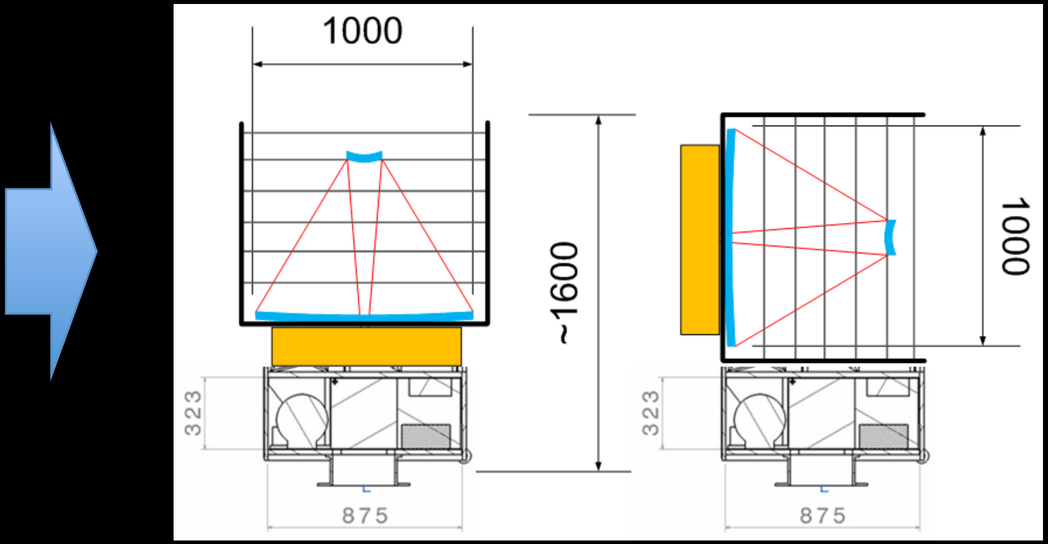


Start from SSTL concept for CHEOPS (35 cm optical telescope)

Mass (S/C + payload) ~ 200 kg

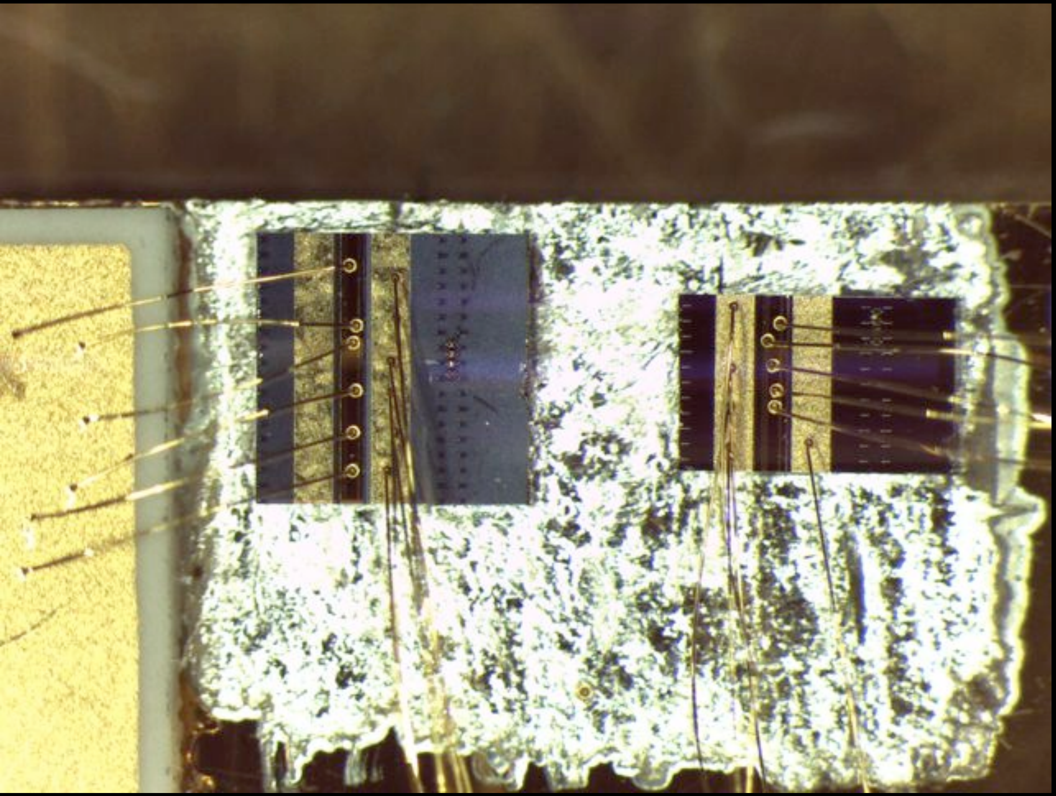
Take this "bus" and add 1m fast FIR telescope in tube





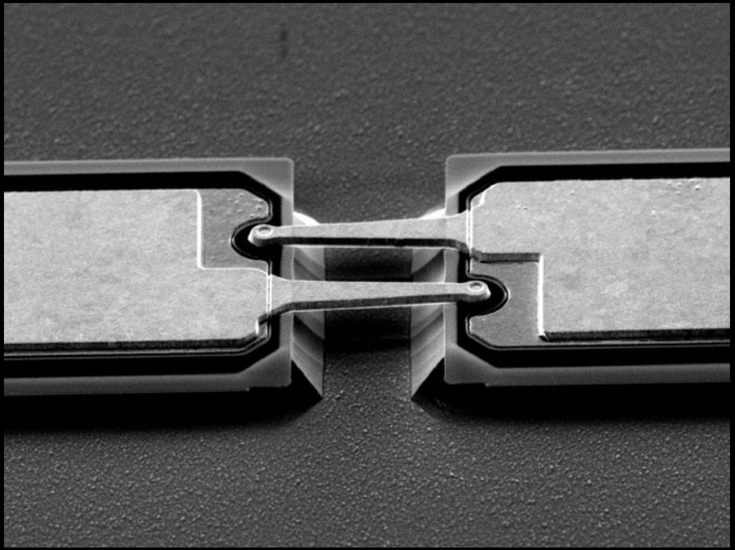
Mass ~250-300 kg (S/C + payload) assuming SiC mirror @25 kg/m^2

Lighter weight CFRP telescope possible?



QCL FIR Laser device developed at Leeds University

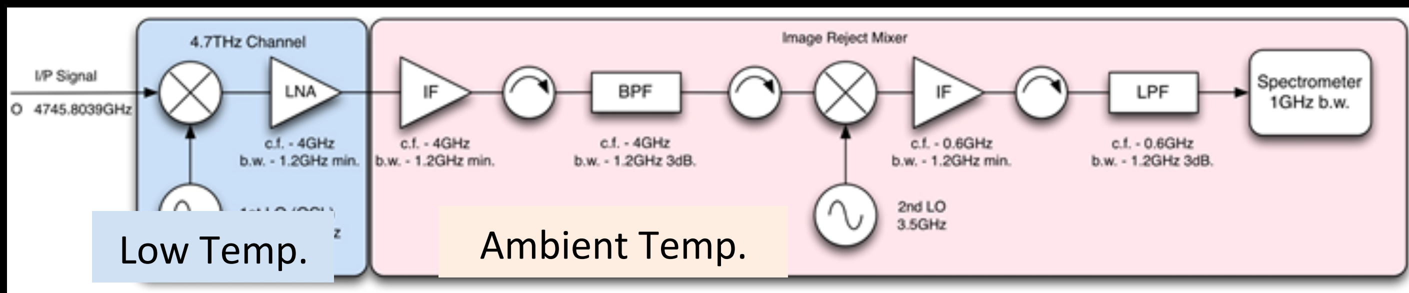
Planar Schottky mixer diode developed at RAL-Space



Exploring alternatives in collaboration with Purple Mountain Observatory colleagues

Receiver

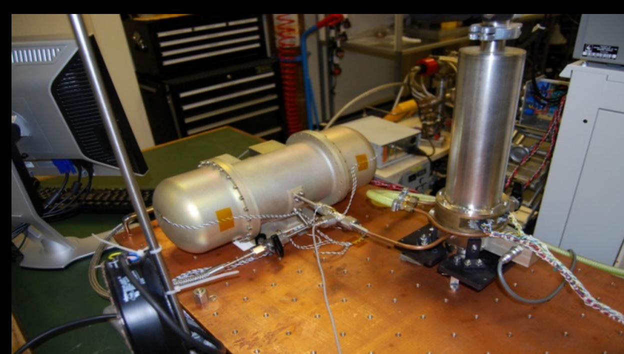
Five receiver channels arranged with separation between cold mixer/LO assembly and warm IF and backend digital spectrometer



Cooling based on long heritage in Stirling Cycle coolers in Europe

New generation "Large scale cooler" will lift ~3 W at 50 K

120 W input power and 7 kg mass



Sensitivities

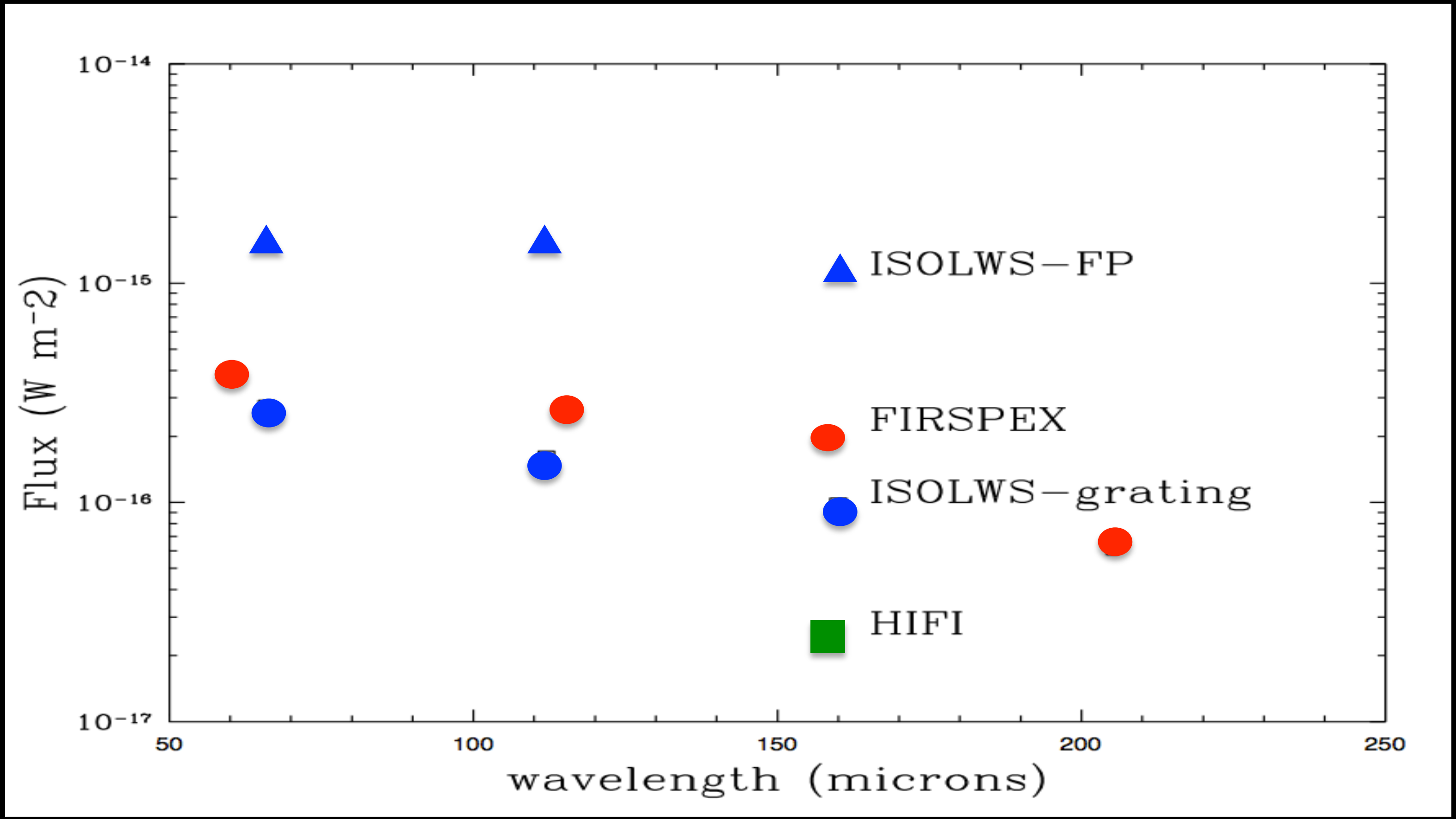
Assumptions: 1 K in 5 sec @ 1.5 THz (conservative)
30 K in 5 sec @ 5 THz (based on LOCUS)
1 MHz resolution

Telescope: effective 1.0 m diameter

Antenna theorem: $A_e\Omega_a=\lambda^2$
$A_e = \eta_a A_p$
where, $\eta_a = 0.5$, $A_p=\pi (0.5)^2$

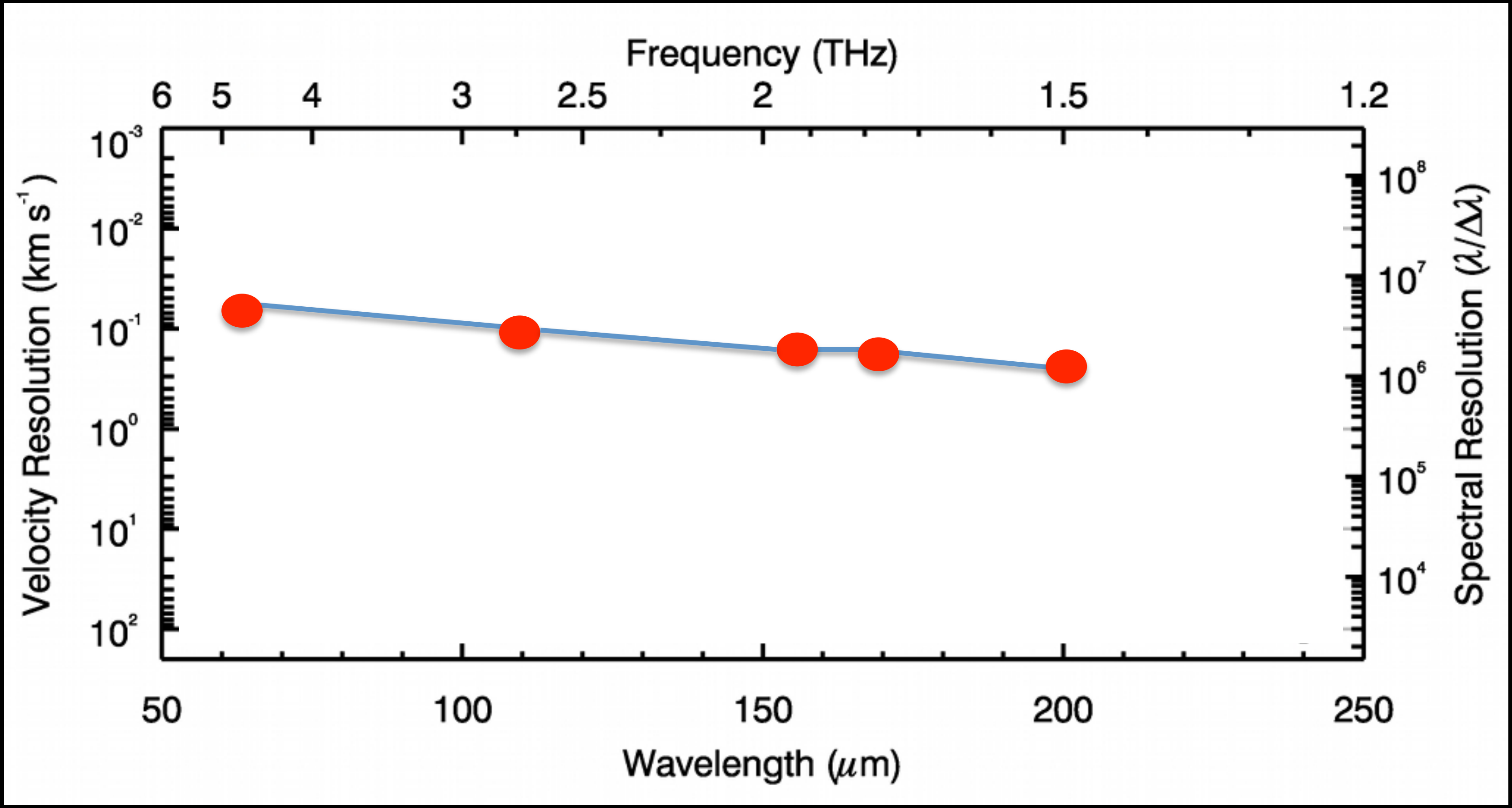
Conversion K to Jy : $K/Jy = A_e/2k$

Sensitivities



Assuming 1 MHz resolution @ 1.5 THz

Achievable Spectral Resolution



Mission

Orbit is proposed as sun synchronous

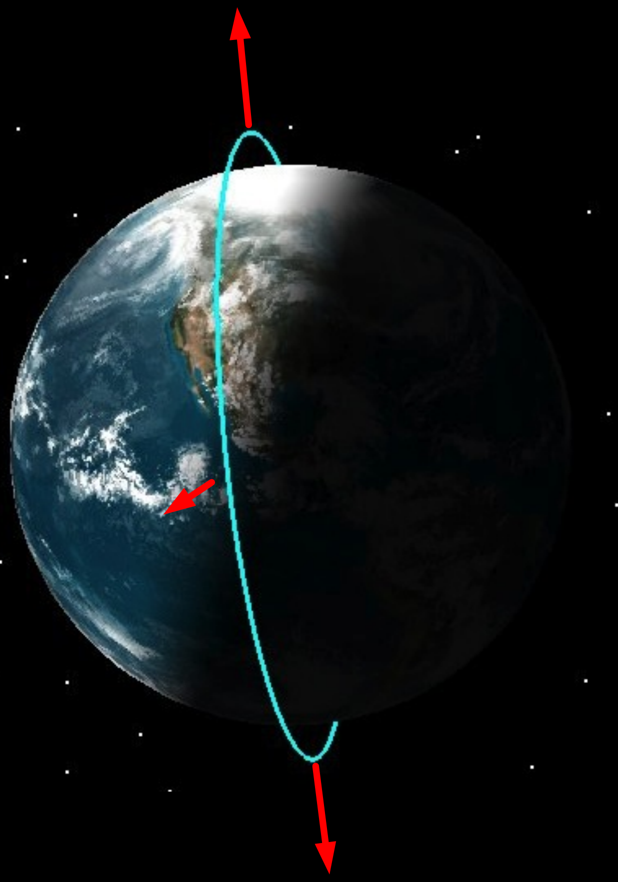
Viewing direction is anti-Earth

Solar panels constantly illuminated

Radiators constantly face deep space

Full survey in 6 months with multiple passes over sky “bins”

Followup targeted observations



Concluding remarks

- We propose the implementation of a high spectral resolution Terahertz (THz) heterodyne receiver system for astronomical research.

- The instrument will consist of 5 detection bands covering key atomic and molecular transitions in the far-infrared at high spectral/spatial resolution.

- Our goal is to observe simultaneously at the 5 bands covering the IR sky

- Our mission has great synergistic value with China Antarctica Dome A TeraHertz Telescope (DATE5) and ALMA

Thank you

謝謝你