APEX: Atacama Pathfinder Experiment

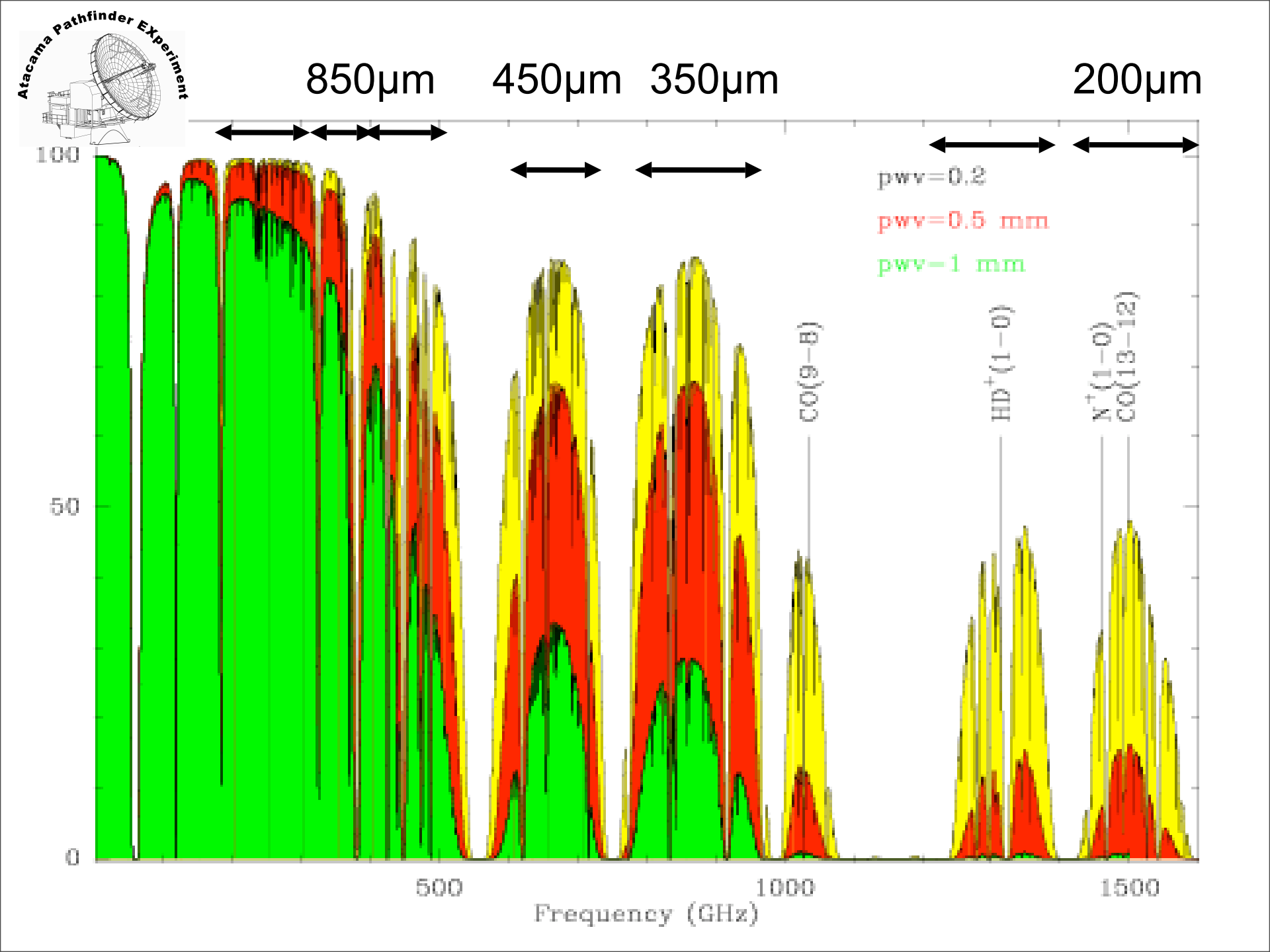
Carlos De Breuck (ESO)

The APEX project

- Collaboration 50% MPG (MPIfR Bonn), 27% ESO, 23% Sweden (Onsala).
- Observing time follows contributions with 10% to host country Chile.
- MPIfR built telescope and bolometer arrays.
- Onsala built heterodyne instruments.
- ESO responsible for infrastructure and operations.

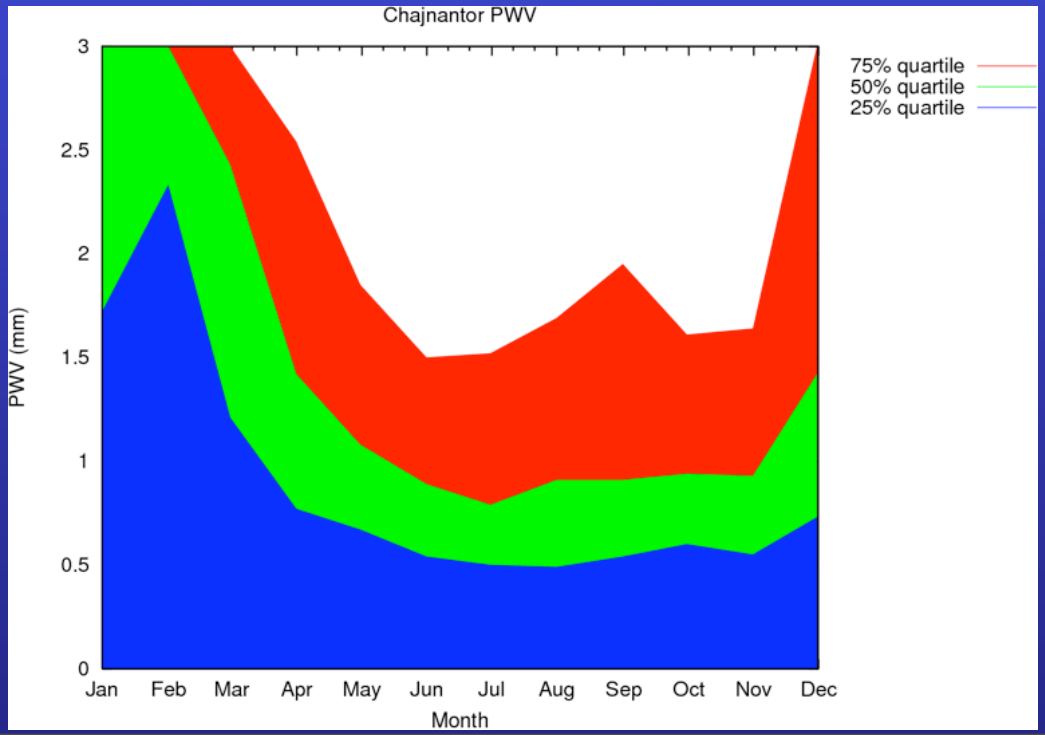
Where is APEX ?

At 5100m, on Chajnantor plateau, 2 km from the ALMA Array Operations Site technical building.


Atacama Pathfinder EXperiment
850μm
450μm
350μm
200μm
pwv=0.2
pwv=0.5 mm
pwv=1 mm
CO(9–8)
HD+(1–0)
N+(1–0)
CO(13–12)
100
50
0
500
1000
1500
Frequency (GHz)

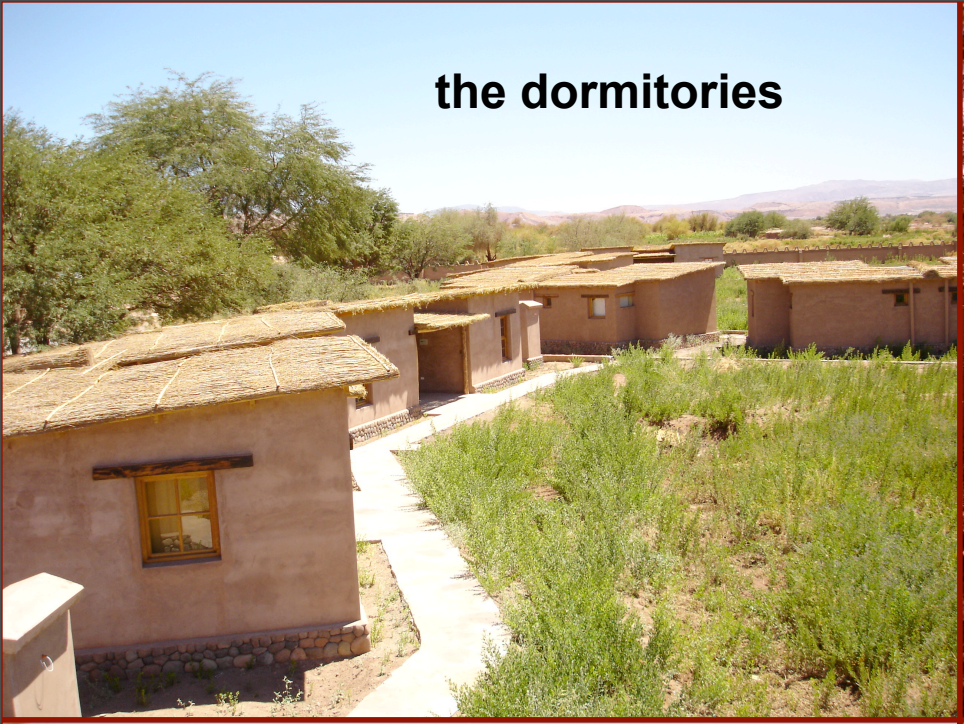
Precipitable Water Vapour statistics

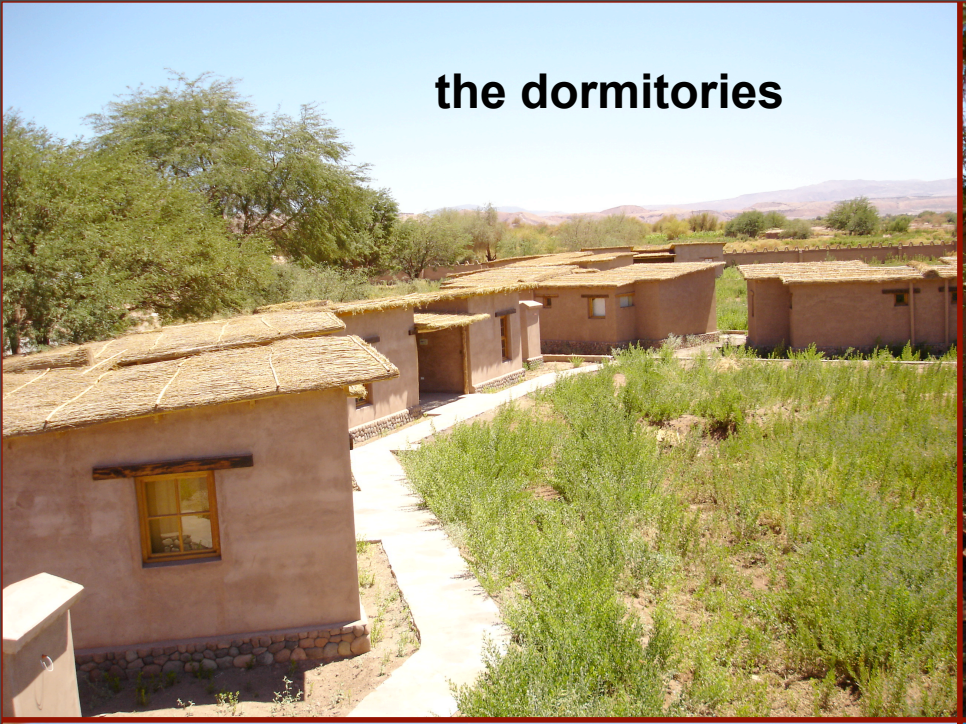
- "Bolivian winter" (January to March) is not suited for submm observations.
- λ<450 μm observations require PWV<0.5mm.
- PWV<0.5mm conditions ~25% at Chajnantor
  ⇒ flexible observing essential.



APEX base camp Sequitor @2500m (near San Pedro de Atacama)

- Remote night time observing from Sequitor is the default.
- Connection to Chajnantor with 34 Mbit/s microwave link.
- Travel time to telescope is 1.5 hours.
- Remote observing from Europe is possible, but requires backup solution in Chile.


the dormitories


the dormitories

footpath to office building

offices/laboratories

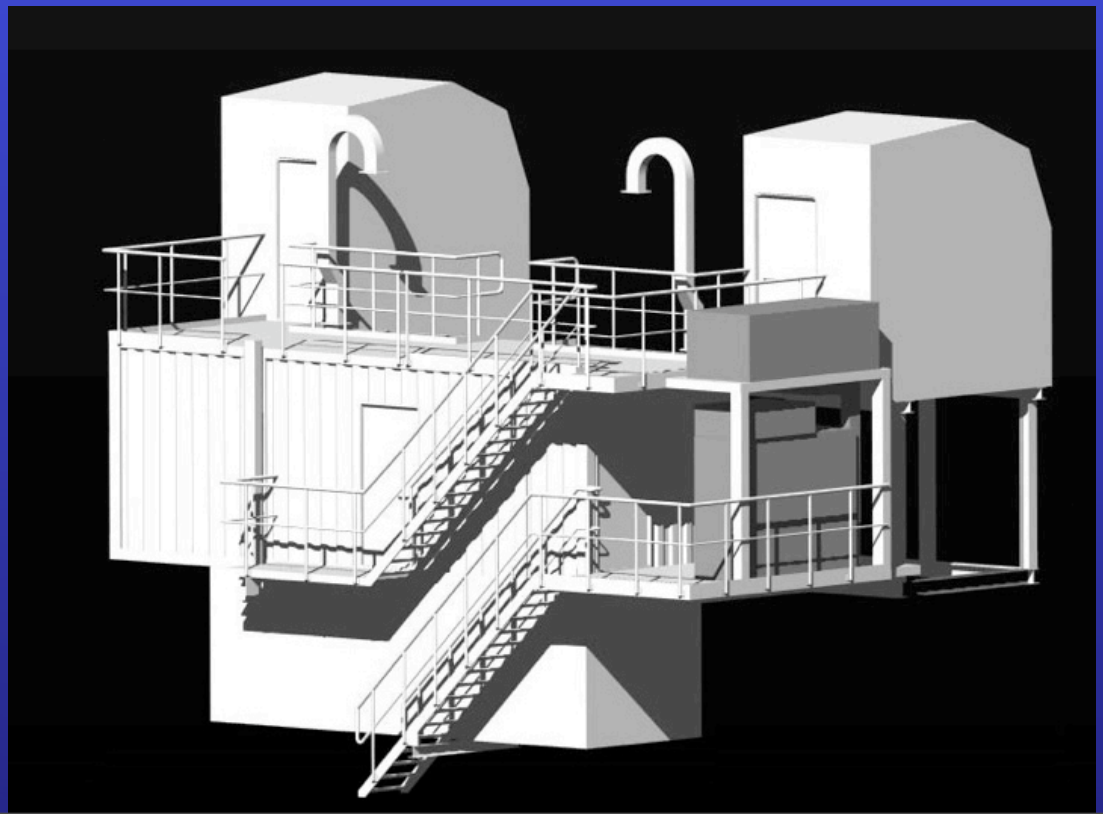
meeting rooms

Telescope @ Chajnantor 5100m

- Containers (control room, laboratory, kitchen, 3 storage containers) including oxygenated control room/dormitory container.
- 2 (soon 3) generators inside a power house.

The APEX telescope

- Based on ALMA proto-type antenna (Vertex).
- Adapted to add 2 Nasmyth cabins.
- 12m diameter, 15 μm rms surface accuracy.
- Pointing model rms 2.5" or better.



Wobbler (chopper)

- Allows sky subtraction up to 2 Hz and 150".
- Will greatly improve baseline stability.
- Succesfully installed, and available for standard operations from late 2007.

APEX operations

- ESO & Onsala offer APEX only in service mode.
- Observations done by local staff sometimes with help from external observers per partner.
- Sun avoidance region of 30 degrees.
- Daytime observing only allowed when ≥2 persons are present at the telescope to stow the telescope in case of problems.
- Extra observers allow to extend observations to ~16 hours/day (+50%).

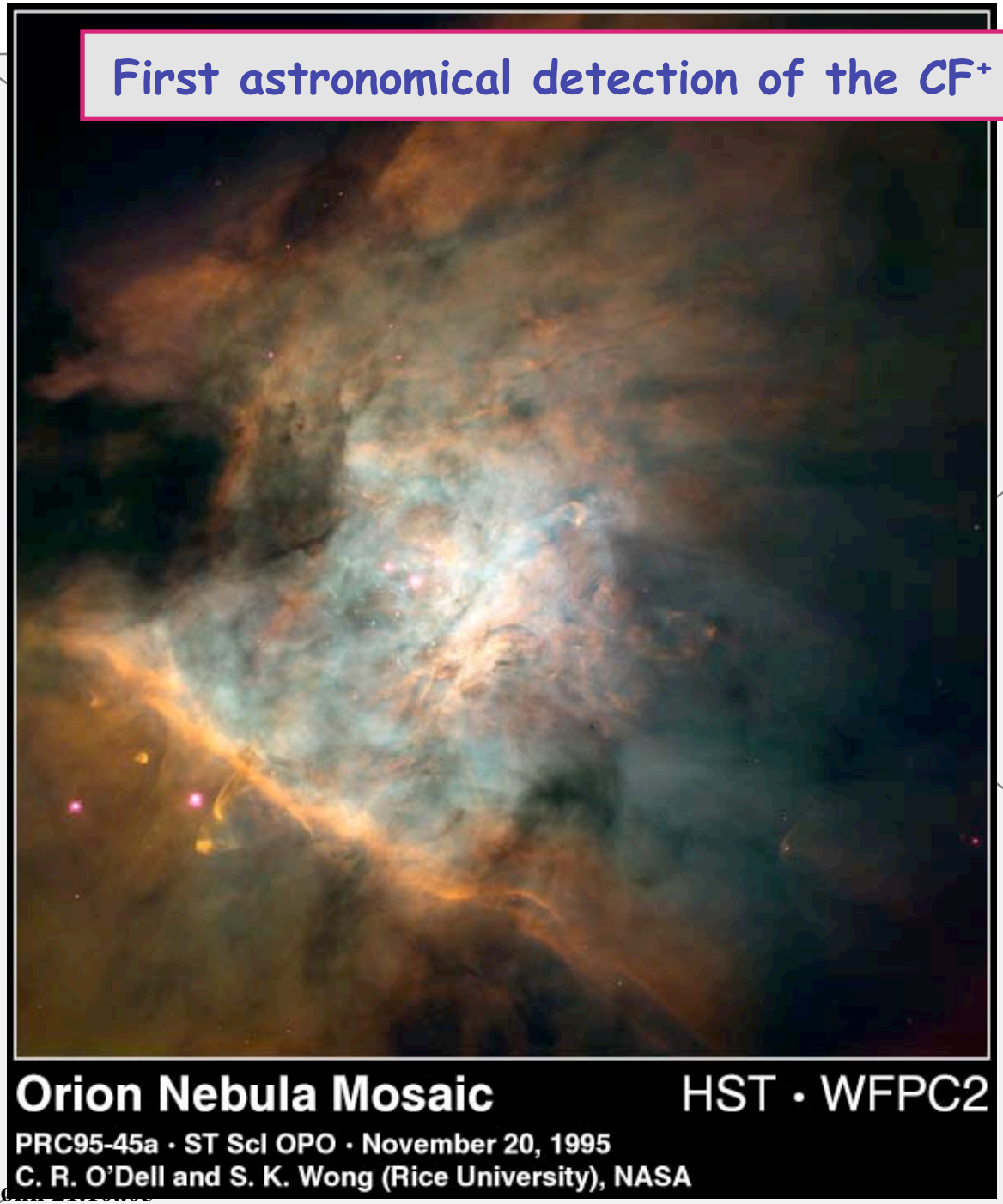
APEX heterodyne instruments

- APEX-2A: double side band receiver covering 279 to 381 GHz (18" beam). Operational since 2005.
- FLASH: dual-beam receiver covering 460 to 492 GHz and 780 to 887 GHz simultaneously (MPIfR PI instrument). Operational 2005 to 2007.
- CHAMP+ 460/610 GHz 7-beam heterodyne array (MPIfR PI instrument).
- Future instrumentation: 4 facility heterodyne receivers covering 211 to 500 GHz and 1.25 to 1.39 THz

Heterodyne science results

- New molecular lines:
  - CF^+ detection (Neufeld et al): molecules other than H, C, N, O, Si, S are rare.
  - unbiased line surveys (Schilke et al, Leurini et al).
- Dense proto-stellar cores.
- Molecular outflows.
- Molecular exitation in the Eagle Nebula's fingers.
- Molecules in circumstellar envelopes.
- High-order CO lines in nearby galaxies.

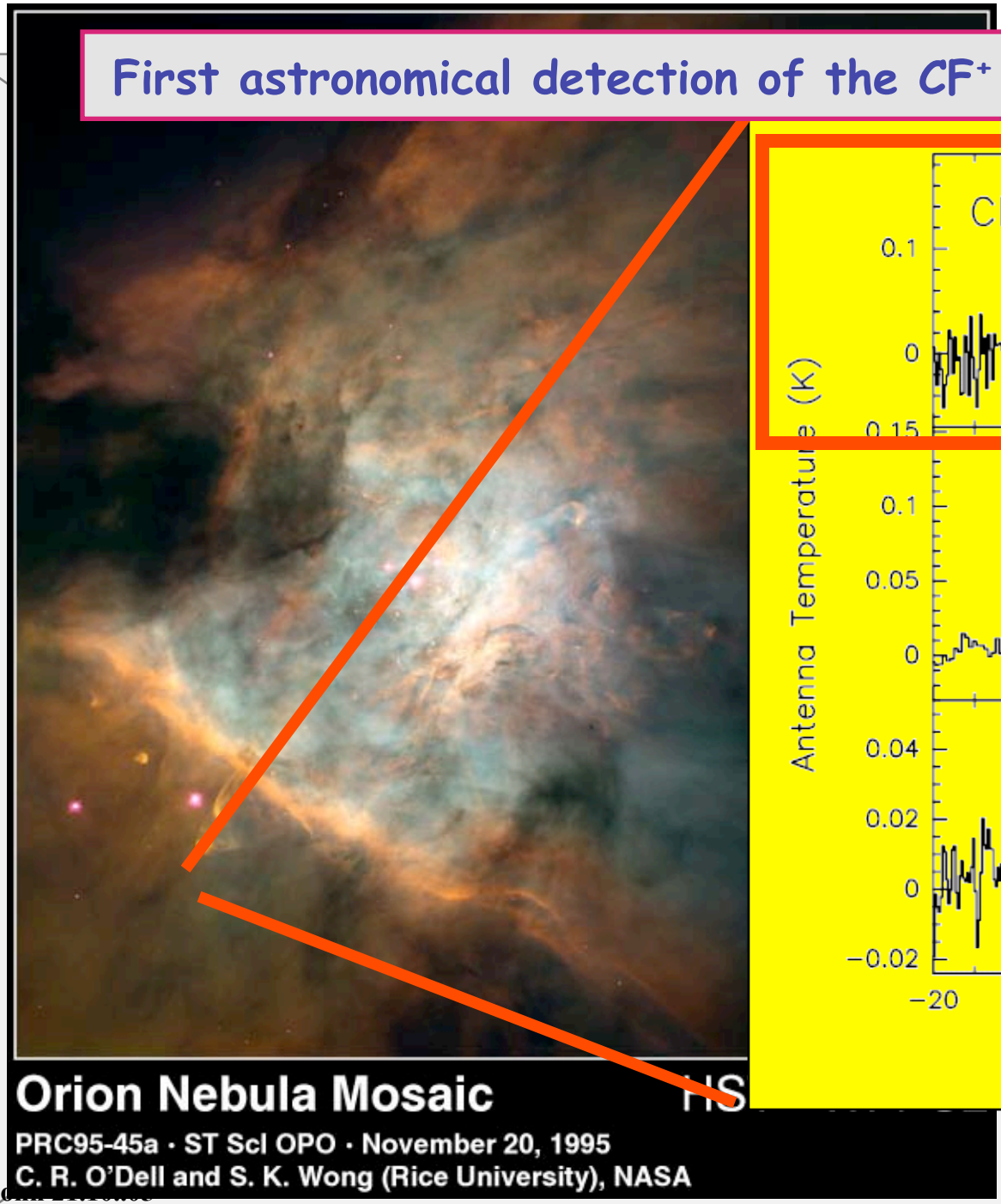
First astronomical detection of the CF^+ ion (Neufeld et al.)

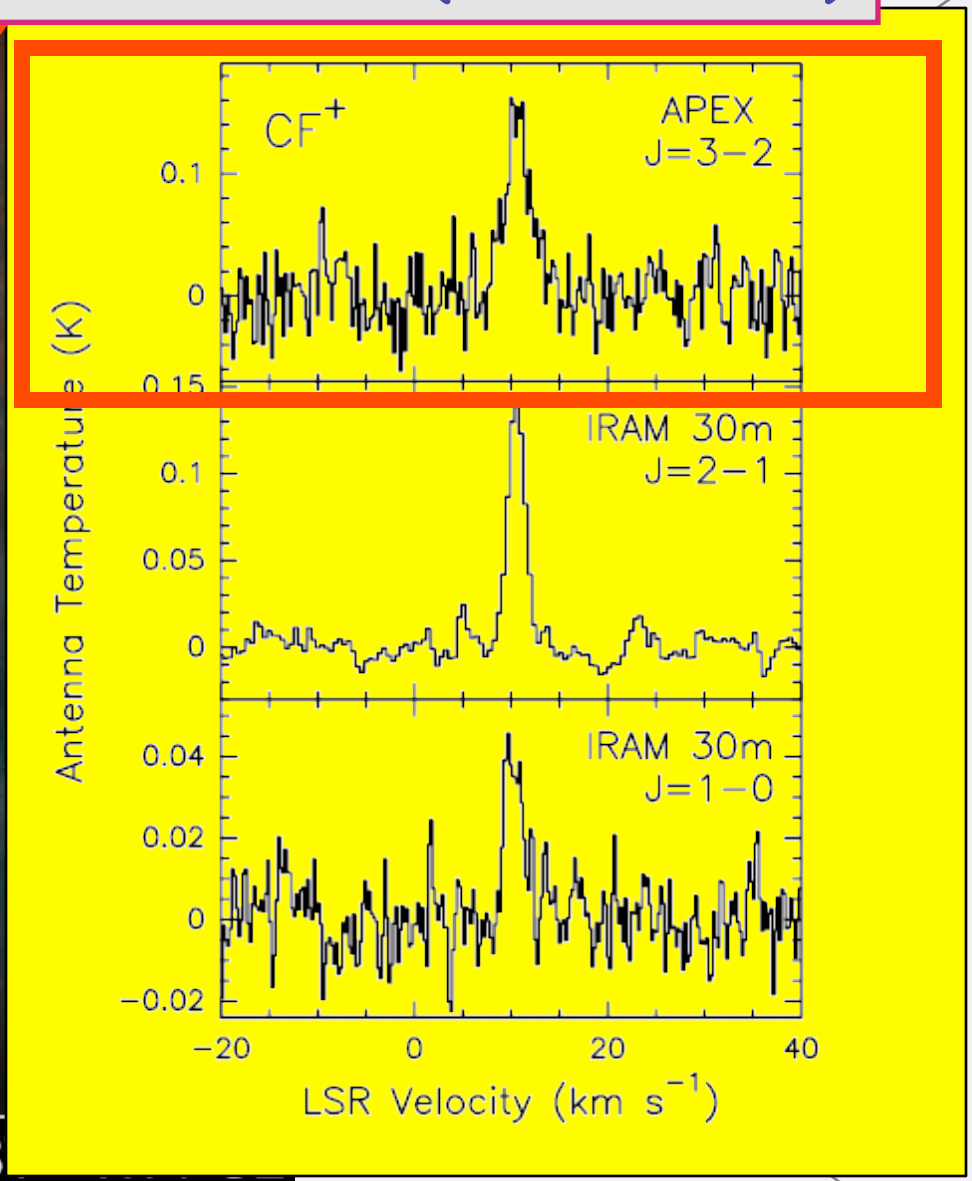


CF^+: fluoromethylidynium

APEX-2a with FFTS

First astronomical detection of the CF^+ ion (Neufeld et al.)

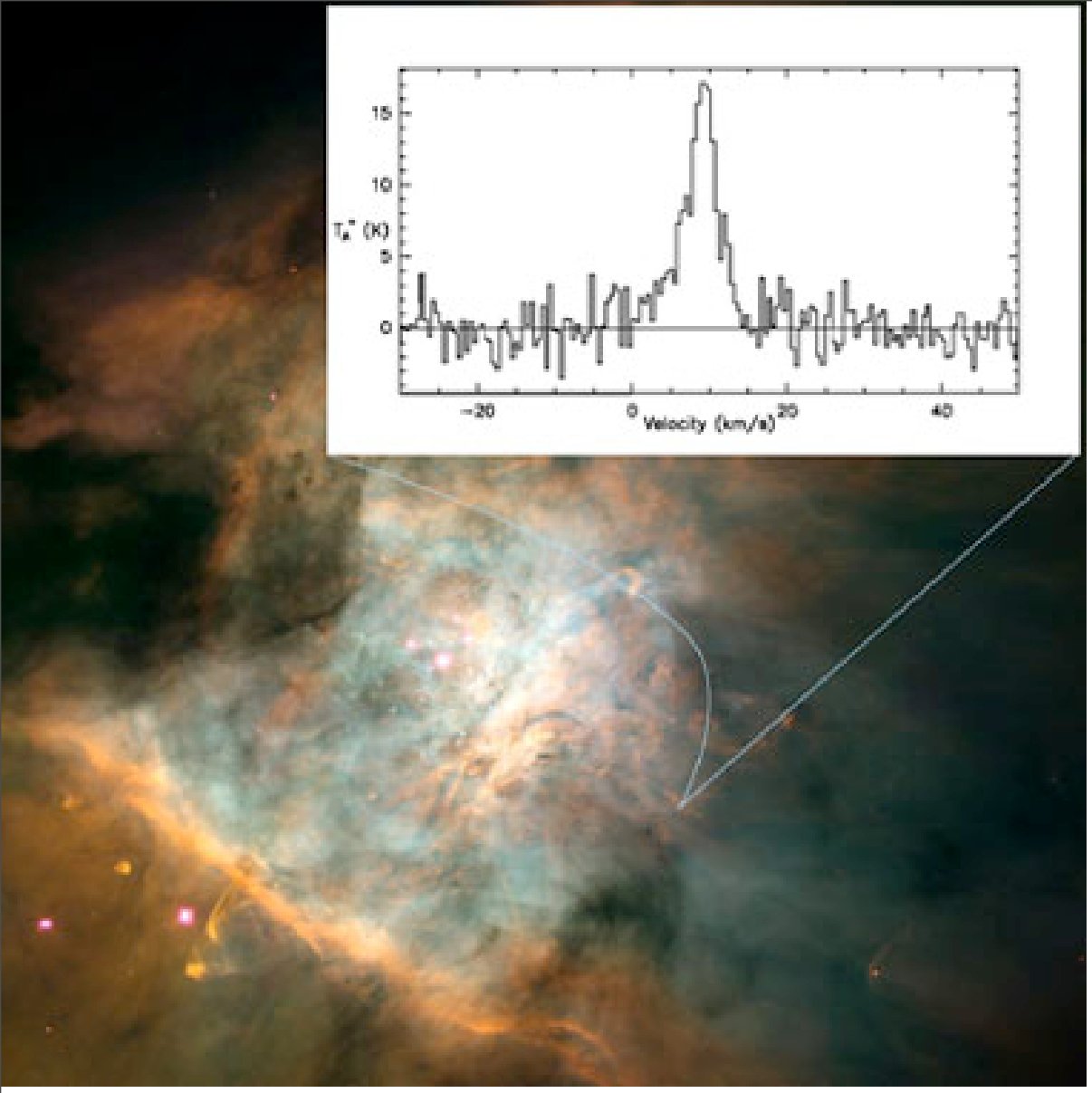




APEX-2a with FFTS

Heterodyne science results

- New molecular lines (CF+, unbiased surveys).
- Dense proto-stellar cores: non-depleted molecules in coldest regions:
  - H_2D^+, ND_2H, $C^{18}O$(3-2), CO(13-12)
- Molecular outflows.
- Molecules in circumstellar envelopes.
- High-order CO lines in nearby galaxies.



CONDOR

CO(13-12) at 1.5 THz in Orion FIR4

Wiedner et al.

Heterodyne science results

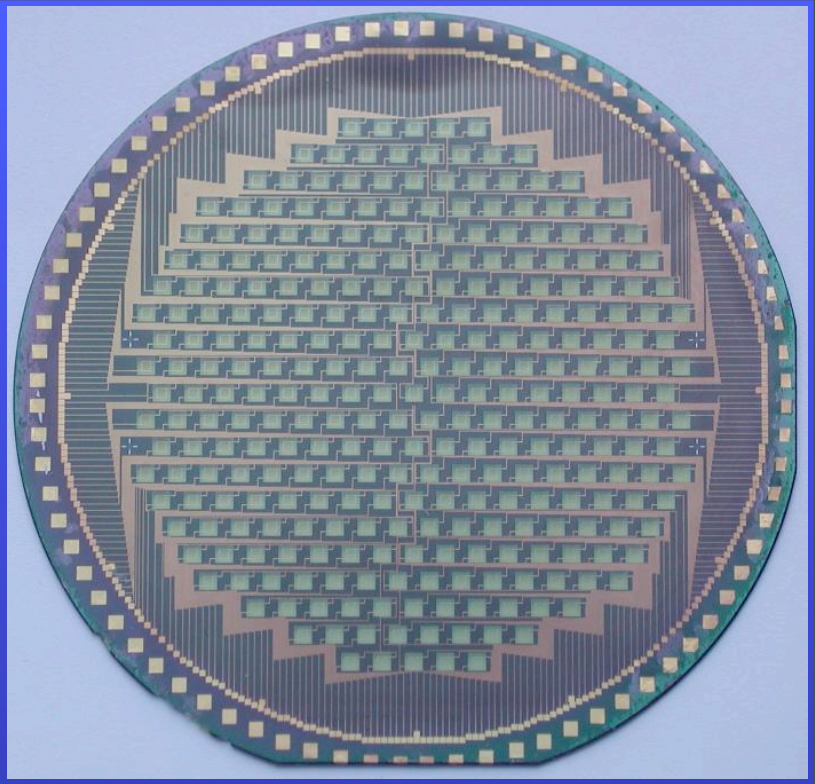
- New molecular lines (CF+, unbiased surveys).
- Dense proto-stellar cores (non-depleded molecules in coldest regions).
- Molecular outflows: higher-order transitions allow to constrain the densities and temperatures much better than before.
- Molecules in circum-stellar envelopes.
- High-order CO lines in nearby galaxies.

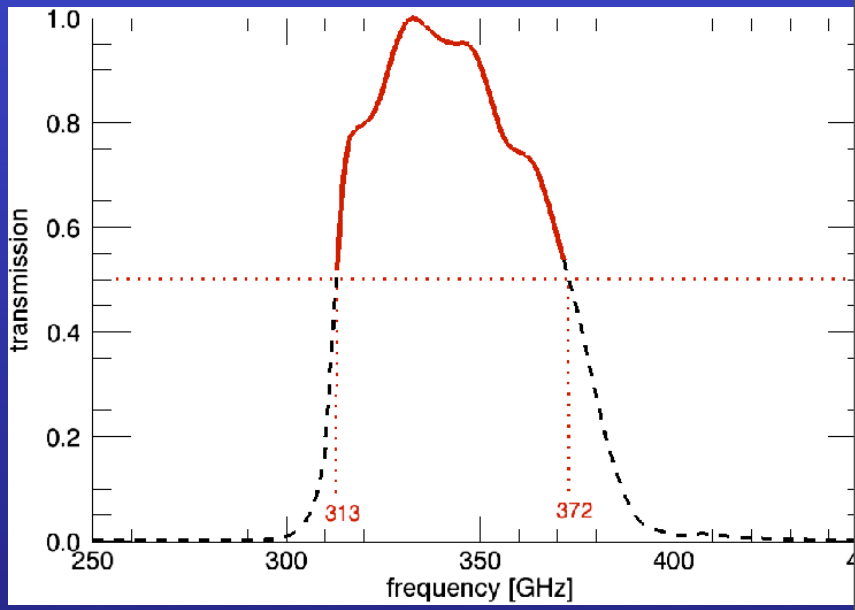
APEX bolometer instruments (1)

- LABOCA array of 295 bolometers at 870 μm.
- Field of view 11.4′
- Beam size 18.6″.
- NEFD = 120 mJy √s.
- Ideal for mapping large regions.
- Complicated optics in Cassegrain cabin.
- Operational since May 2007.

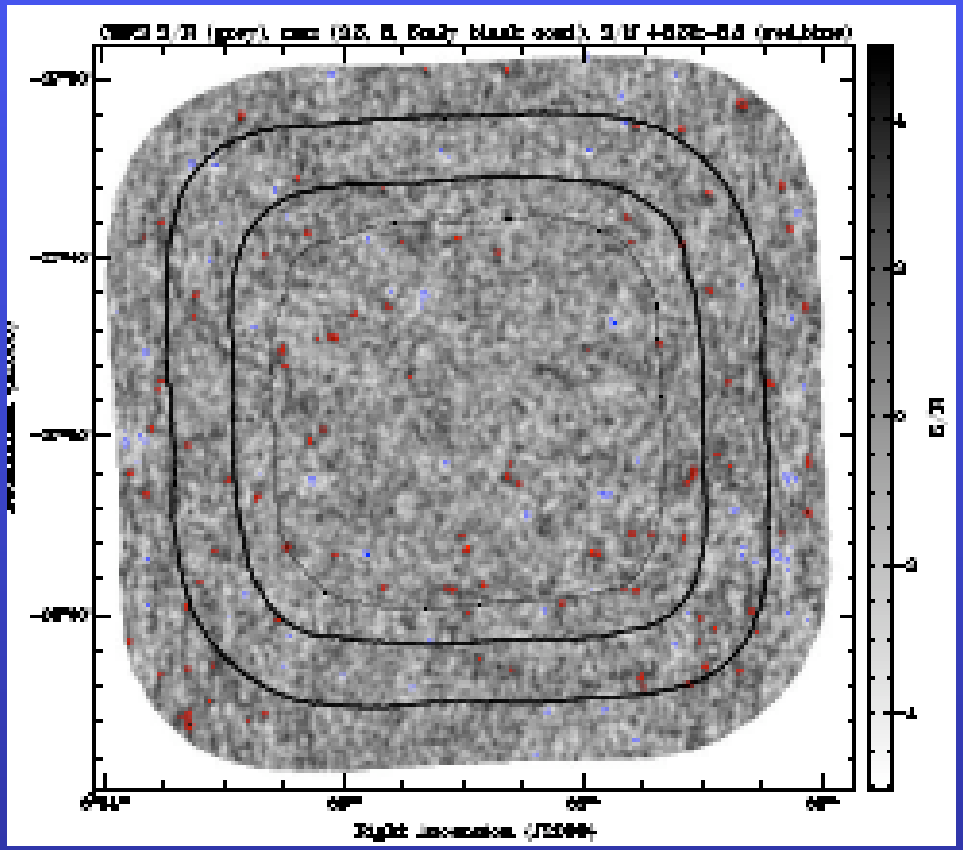
LABOCA

- Classical 3-stage N, He4, He3 cooling system.
- 248 operational bolometers.
- After skynoise filtering, NEFD = 75 mJy √s.
- OTF and innovative spiral raster mode mapping.
- Data reduction with dedicated software BoA.
- See talks by Frederic Schuller and Attila Kovacs.



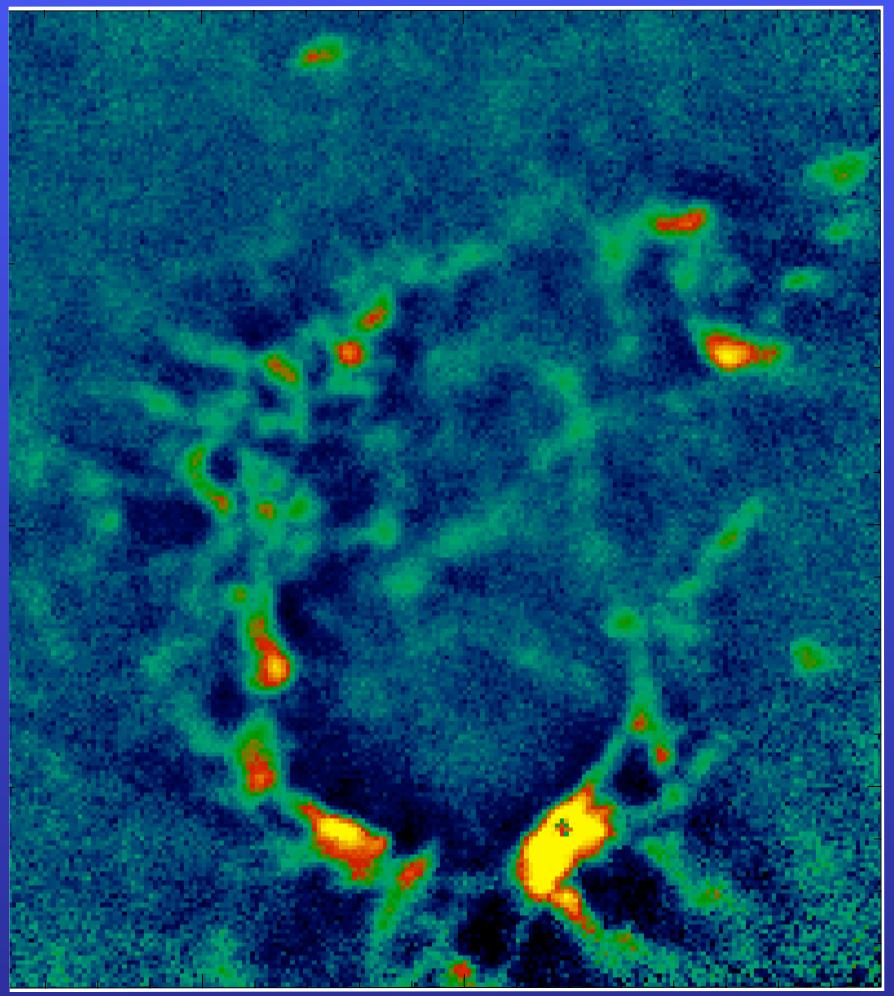


LABOCA Science Verification



CDFS: 22'x22' map to σ=2.8 mJy. Dozen of >4σ sources detected. Will be continued.

Smail, Walter, Weiß et al.

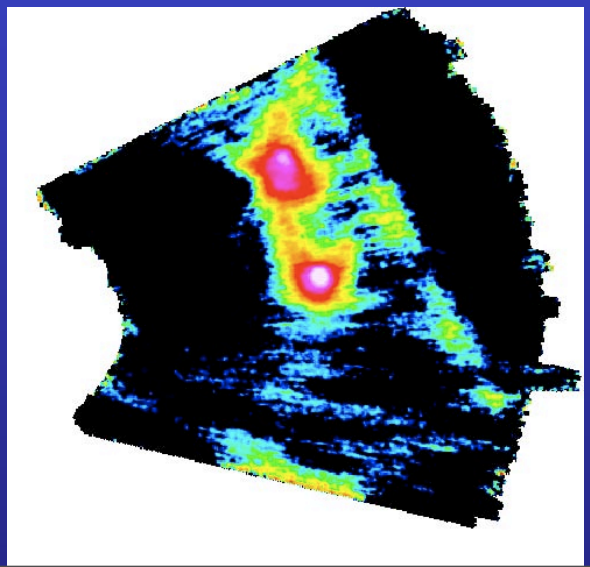


RCW120 star forming region

Zavagno et al.

APEX bolometer instruments (2)

- SABOCA array of 37 pixels at 350 µm to be installed later in 2007.
- APEX-SZ array for S-Z cluster studies (MPIfR PI instrument).
- Artemis 64x64 pixels, fully sampled array operating at 450/350/200 microns. Test run in Nov 2007.



NGC6334 with P-Artemis @ 450µm

APEX archive at ESO

- All ESO and Onsala data is observed in service-mode, validated by local APEX staff in Chile, and sent to PI's after archiving in ESO Garching.
- ESO and Onsala data become public after 1 year proprietary period.
- Science verification data are publicly available from http://www.eso.org/sci/activities/apexsv/

APEX Large Programmes

- As time per APEX partner is very limited, it is likely that many large surveys will be done jointly between the partners.
- For ESO, large programmes can start in 2008, i.e. deadline end of Sept 2007.
- To coordinate the efforts, we will have an informal meeting on Thursday 6 September, afternoon (just after the "Surveys for ALMA" meeting).
- If you have plans for a large APEX project, please contact me, Peter Schilke or Hans Olofsson.

Goals of the APEX meeting

- Inform other APEX partners of plans for large programmes to avoid duplication.
- Potentially create new collaborations through partners.
- Inform about different rules, deadlines, proprietary periods, etc per partner.
- Look at initial technical feasibility of the future proposals.

ESO access to APEX

- ESO time is open to scientists from all ESO member states.
- Worldwide access for top-level science proposals.
- Data proprietary period of 1 year maximum. Can be waived (which would increase your chances).
- Possibility to submit large programmes:
  - cover up to 4 periods (2 years).
  - require progress report after 1 year.
  - requirement to provide advanced data products after end of large programme.
- ESO deadlines: 1 October and 1 April.
- Period 80 oversubscription: 6.7

MPIfR access to APEX

- See Peter Schilke's presentation

Onsala access to APEX

- See Hans Olofsson's presentation.

APEX coordination

- APEX Board has appointed an APEX Program Review Committee (APRC) .
- APRC checks for duplications of proposals from different APEX partners.
- Informs PI's of duplicate proposals, but does not enforce collaborations.
- Total time per semester: ~150 days of science: ~67 MPIfR, ~36 ESO, ~32 Sweden, ~15 Chile.
- Assuming average 16 hour observing per day, corresponds to ~1100h MPIfR, 600h ESO, 500h Sweden, 250h Chile. Not considering weather downtime!

Chilean access to APEX

- Open to Chilean scientists.
- Unlike other ESO proposals, Chile has a separate APEX TAC.
- Deadlines flexible
- Data remains proprietary.
- No provision for large programmes yet.
- Contact person: Leonardo Bronfman.

Plans for APEX "large" programmes

- ECDFS (Smail, Walter, Weiss)
- COSMOS (Bertoldi)
- ATLASGAL (Schuller, Walmsley, Bronfman)
- Chamaeleon and Lupus III (Belloche, Hatchell)
- SMC/LMC (Madden)
- Galaxy lensing clusters (Boone, Schaerer, Smail)
- CO in nearby galaxies (van der Werf, ?)
- S-Z (Bertoldi, Horellou).
- Main sequence stars in moving groups (Liseau)
- ...