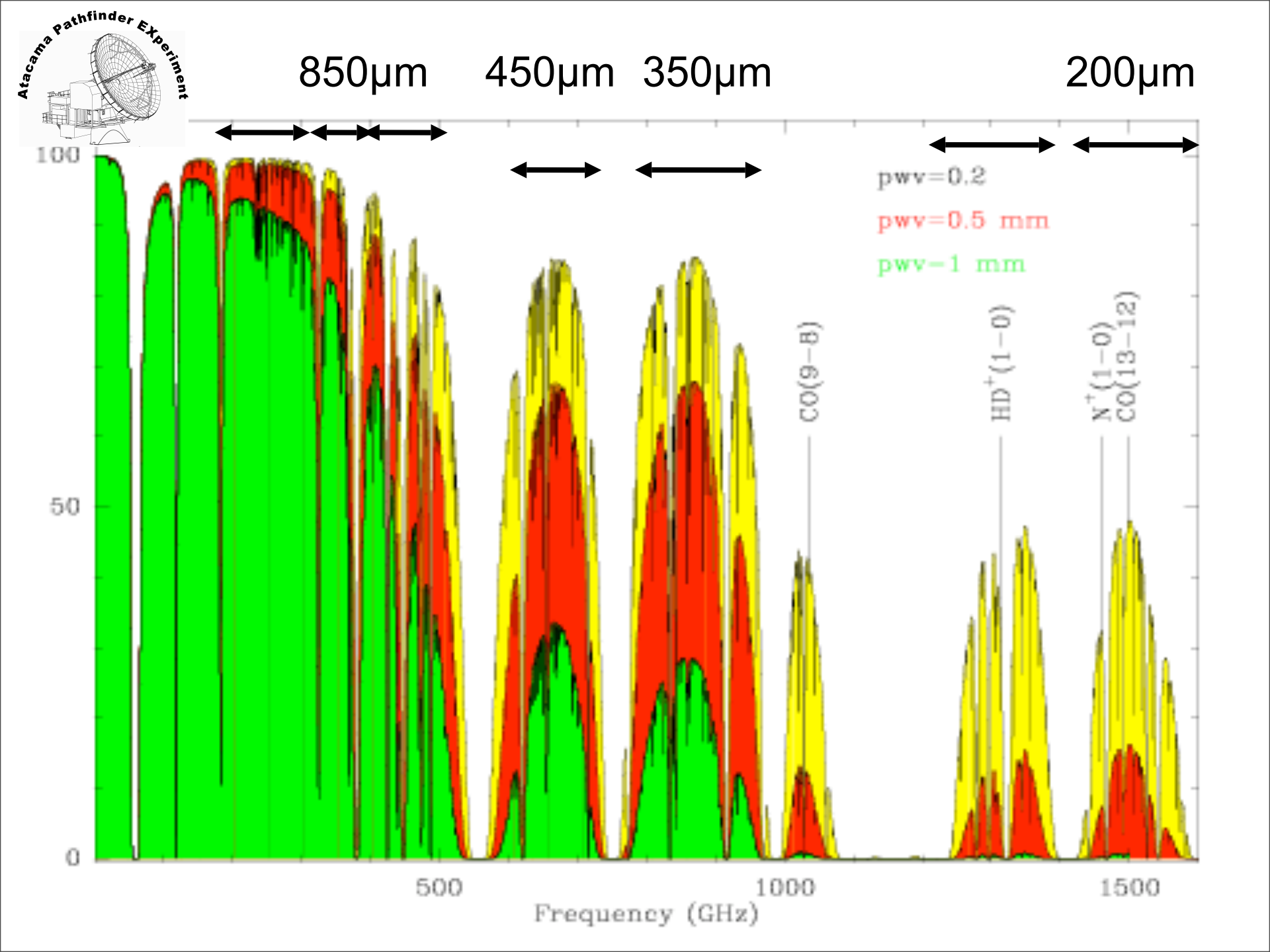
APEX: Atacama Pathfinder Experiment

Carlos De Breuck (ESO APEX project scientist)

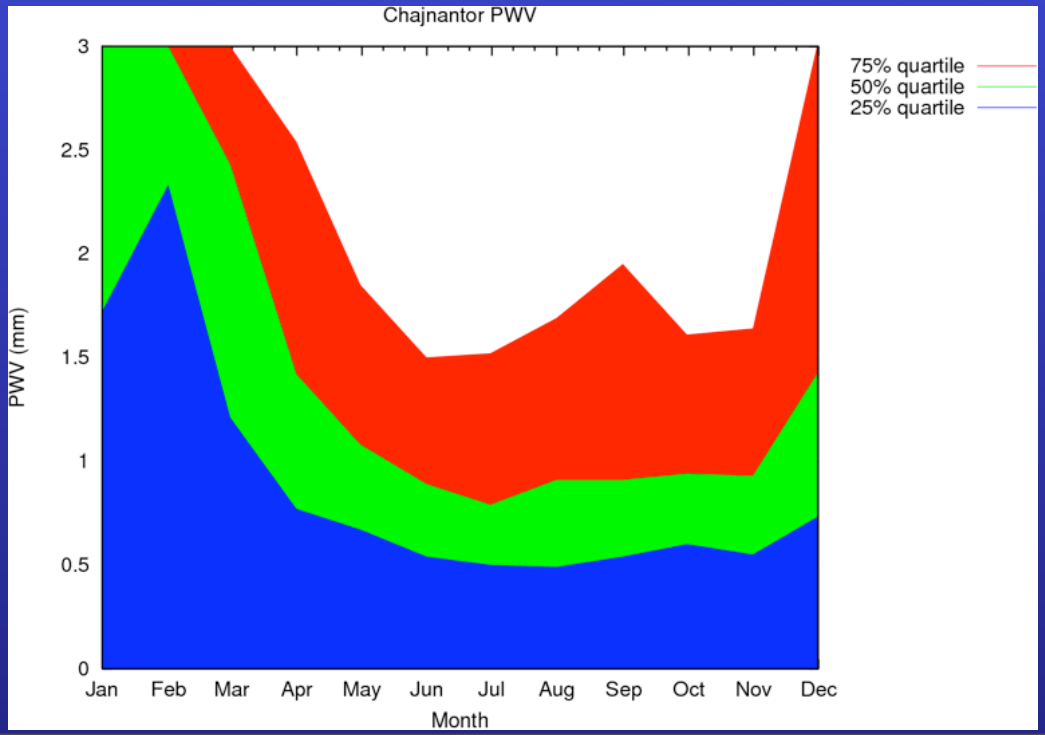
The APEX project

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


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)

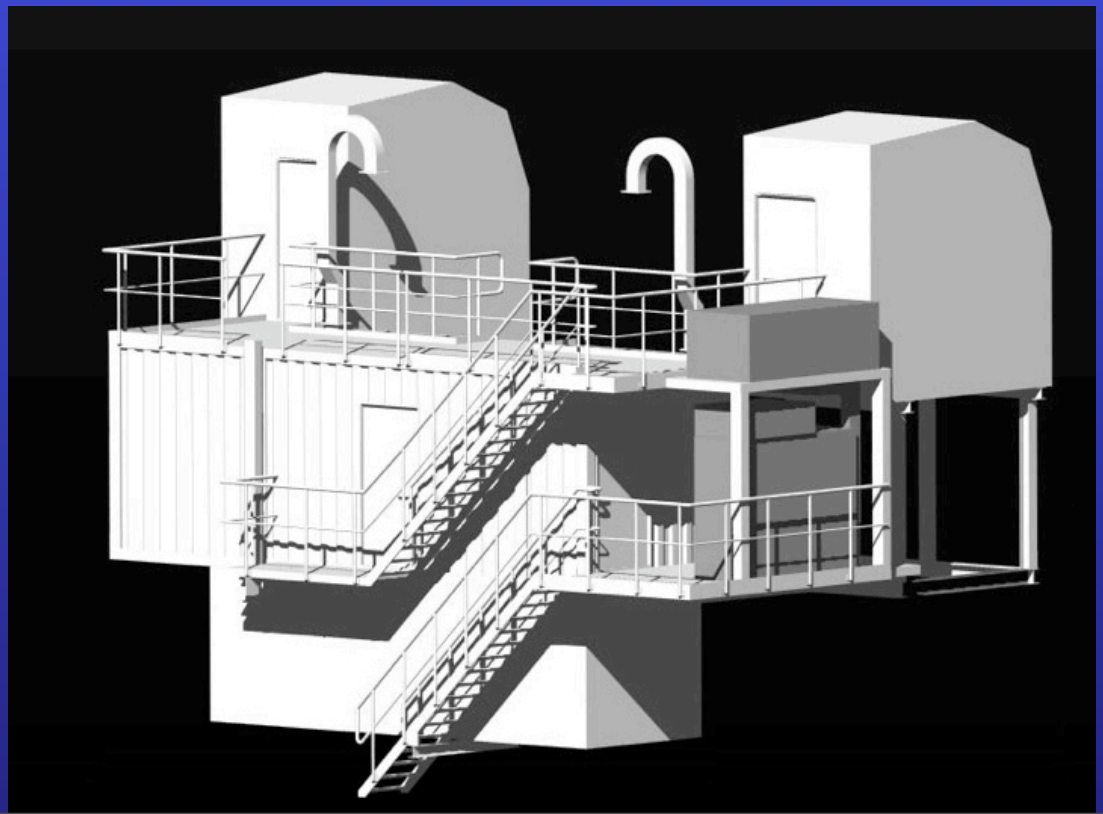
Precipitable Water Vapour statistics

- "Altiplanic 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 service mode observing essential.



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 better than rms 2.5".



Wobbler (moving secondary)

- Allows sky subtraction up to 2 Hz and 150" amplitude (300" between on-off).
- Only azimuthal chops.
- Greatly improves spectral baseline stability.
- Operational since 2007.

APEX operations

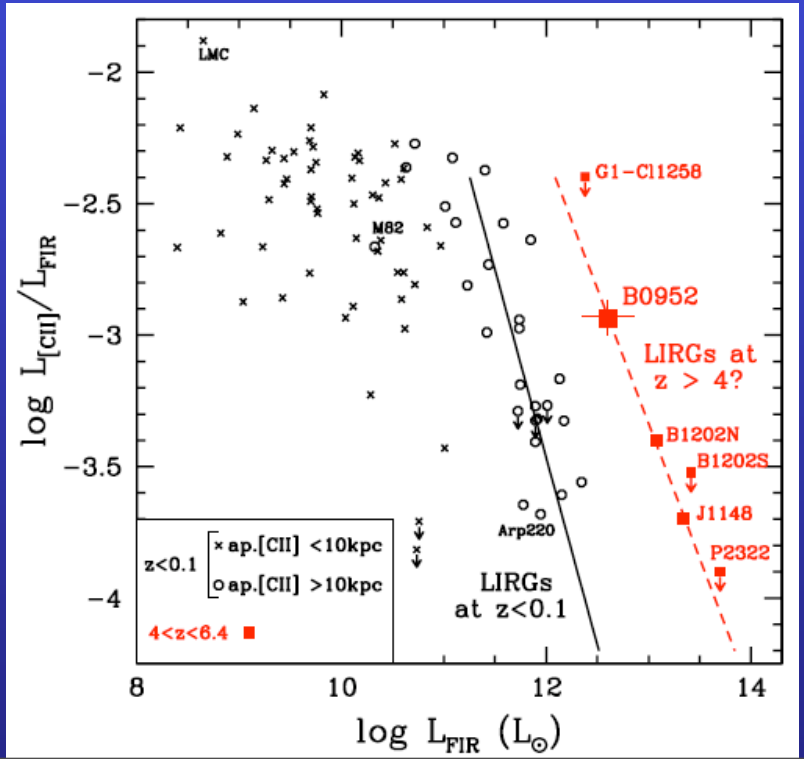
- ESO & Onsala offer APEX only in service mode.
- Observations done by local staff most often with help from external observers per partner.
- Sun avoidance region of 30 degrees.
- Daytime observing only allowed when ≥2 persons are present at the telescope to stow the telescope in case of problems.
- Extra observers allow to extend observations up to 24 hours/day (+60%).

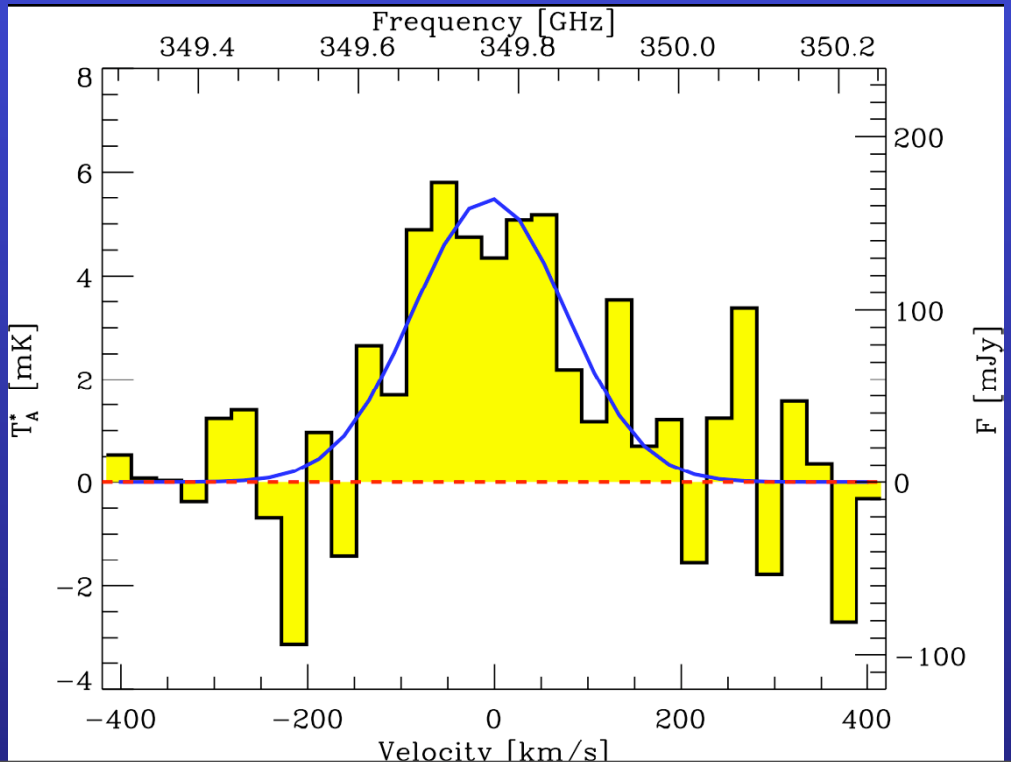
APEX heterodyne instruments

- SHFI: 4-channel single pixel receivers covering 211 to 500 GHz and 1.25 to 1.39 THz. Bands 1, 2 and T2 operational since March 2008. Band 3 (390 to 500 GHz under construction, to be installed in March 2010).
- FLASH 430-492 GHz single pixel (MPIfR PI instrument). See talk by Miguel Requena.
- CHAMP+ 640/810 GHz 7-beam array (MPIfR PI instrument). Operational since 2007. Now also open to ESO users in collaboration with MPIfR. Ideal for large spectral line mapping. See talk by Miguel Requena.

SHFI detection of enhanced [CII]

- Detection of a [CII] line @z=4.4 (Maiolino et al. 2009).
- 5-8 brighter than previous high-z [CII] lines.
- Physical origin of difference unclear (metalicity?), but important impact on observational Cosmology





APEX bolometer instruments

- LABOCA 295 channel array at 870 μm (11.4′ FoV). Operational since 2007. Liquid Nitrogen and Helium cooled to 0.3 K.

LABOCA

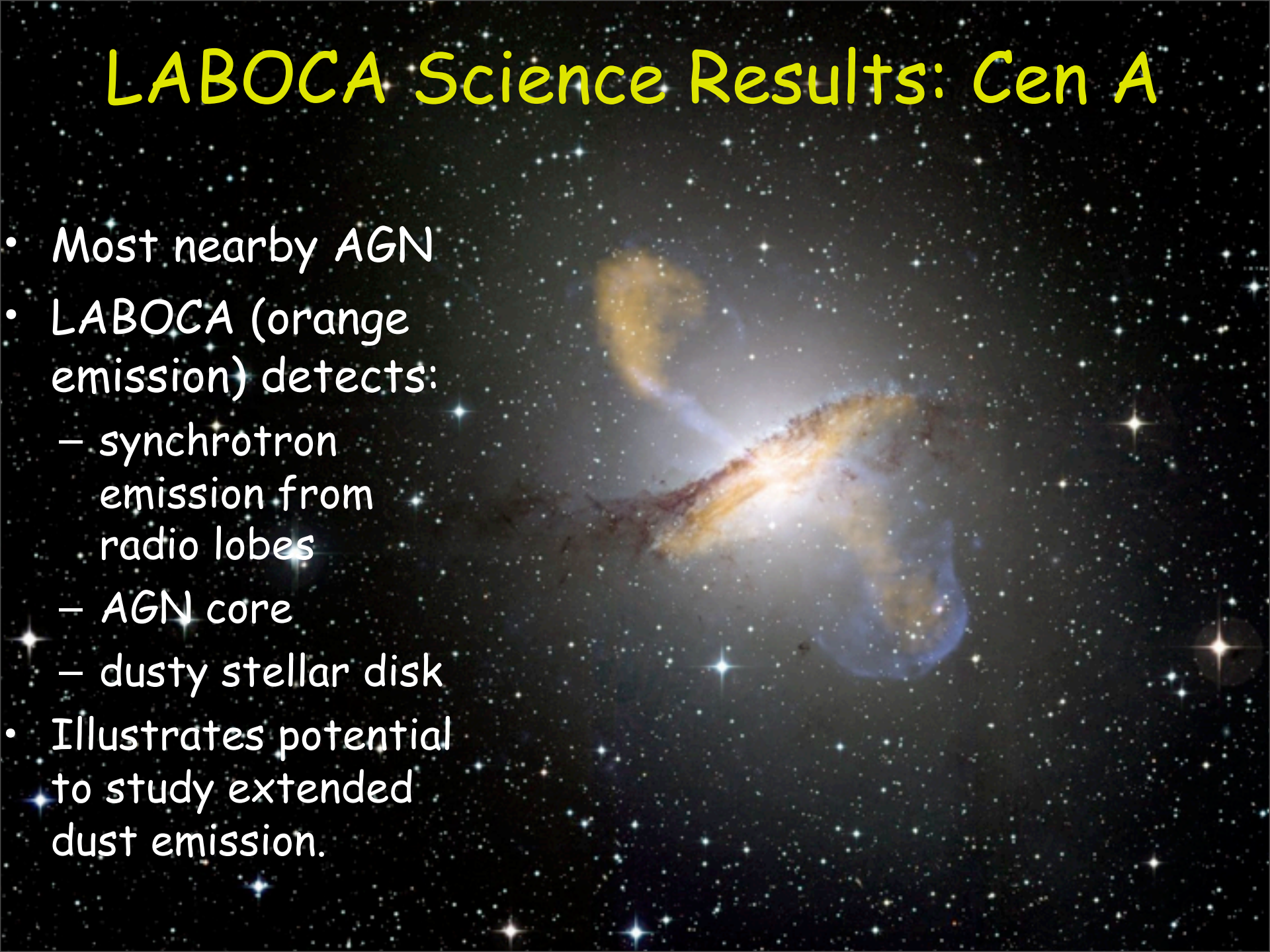
- Liquid He cooled. Hold time is 12h.
- 2 recyclings per He refill.
- Requires 2 persons to fill Helium and Nitrogen at 5100m every day.
- Uses fast scanning instead of wobbler for sky noise subtraction.
- Currently most powerful submm bolometer array.

LABOCA Science Results: RCW120

- HII region.
- Expanding bubble.
- LABOCA detects dust emission in the outer shells (blue).
- Traces the regions where class I stars are formed, triggered by expanding shell
- Dust emission helps to determine mass of concentrations.

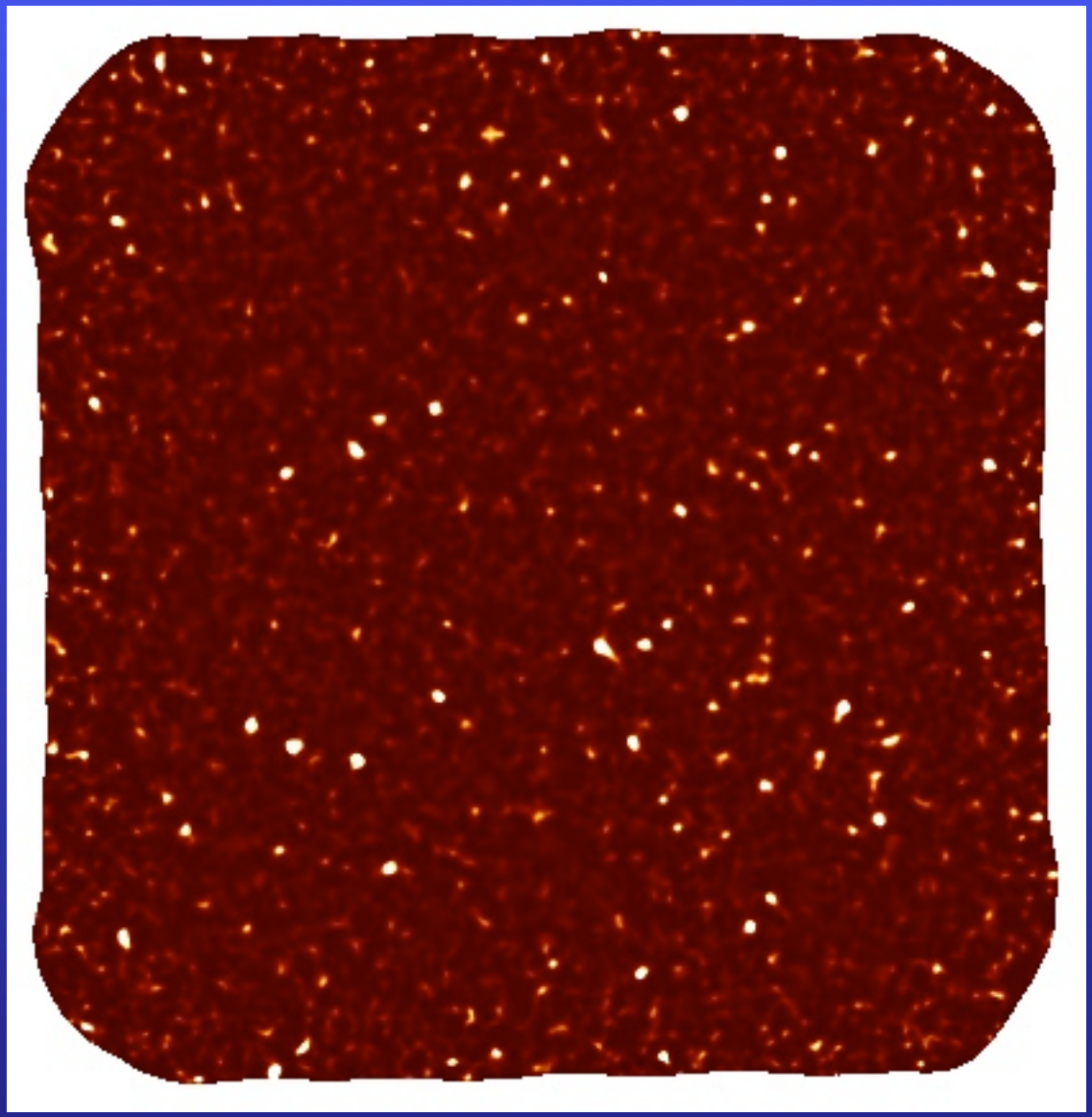
LABOCA Science Results: Cen A

- Most nearby AGN
- LABOCA (orange emission) detects:
  - synchrotron emission from radio lobes
  - AGN core
  - dusty stellar disk
- Illustrates potential to study extended dust emission.



LABOCA ECDFS (GOODS-S) survey

- 30'x30' survey.
- 350h total observing time.
- Joint ESO + MPIfR project lead by Smail, Walter & Weiß
- Reaches rms~1.2 mJy/beam over a very uniform area.
- 127 sources >3.7 σ
- Raw data public from ESO archive.



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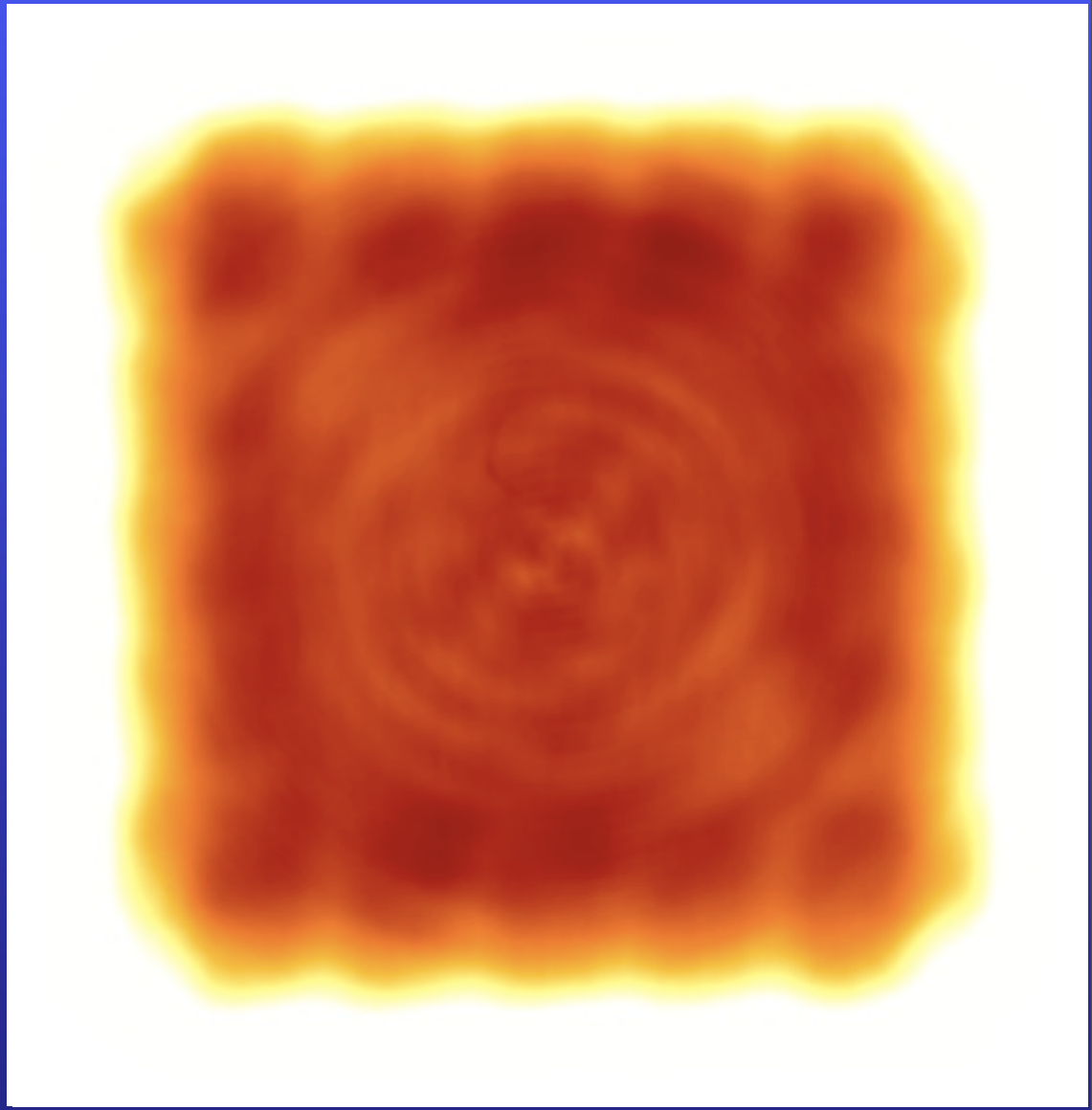

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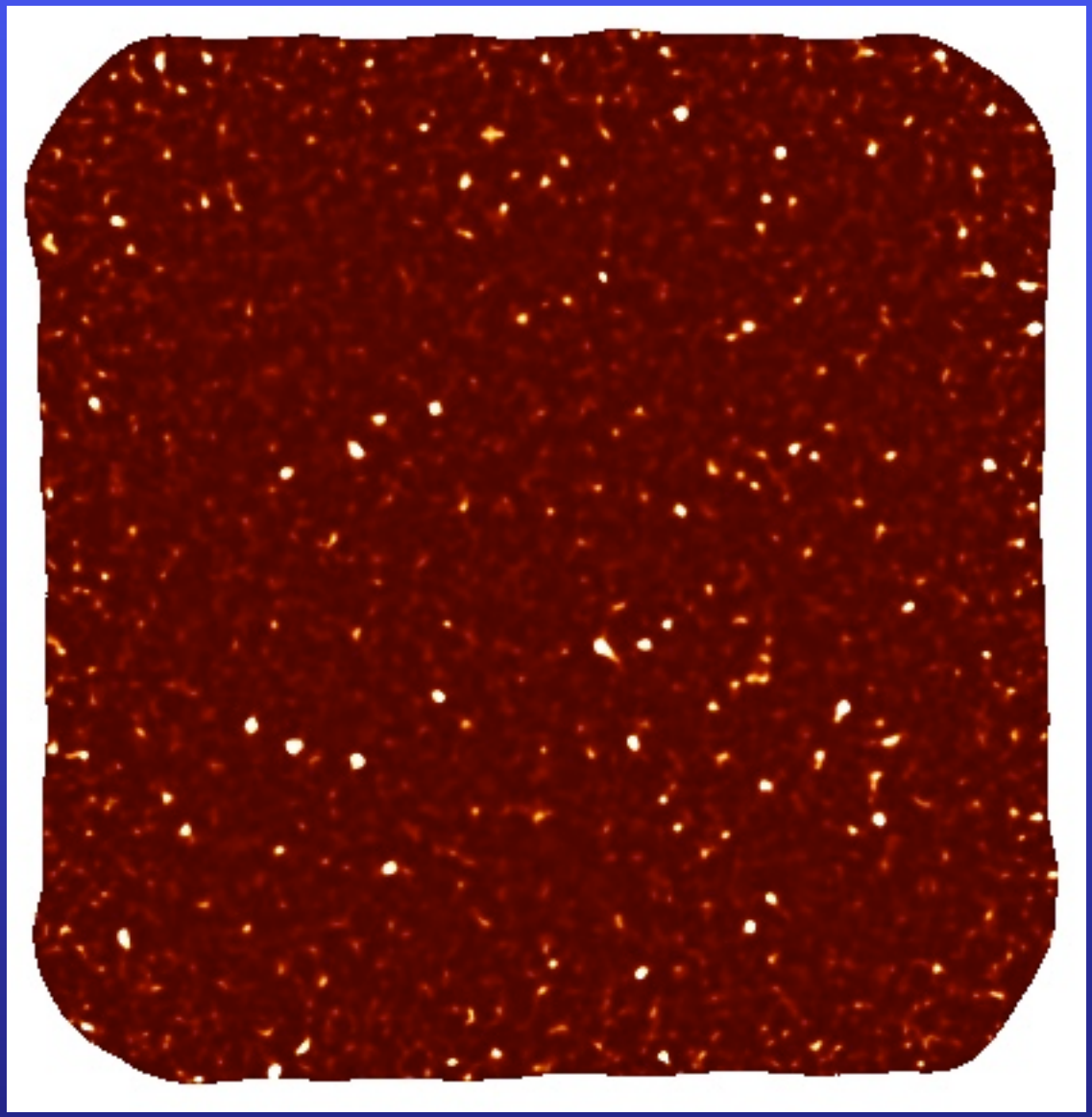
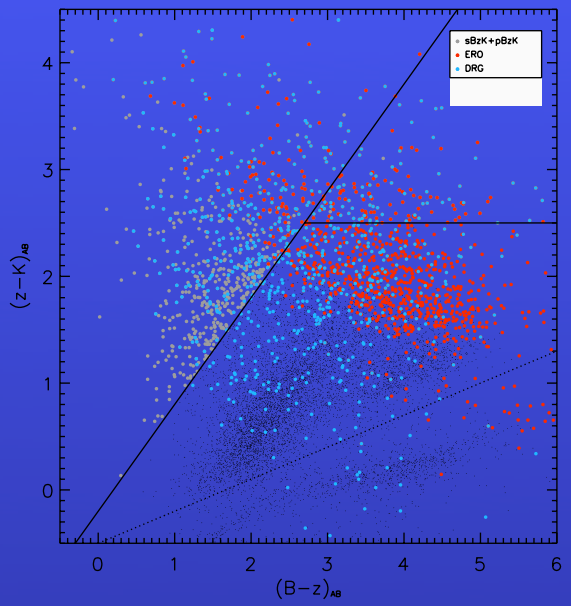
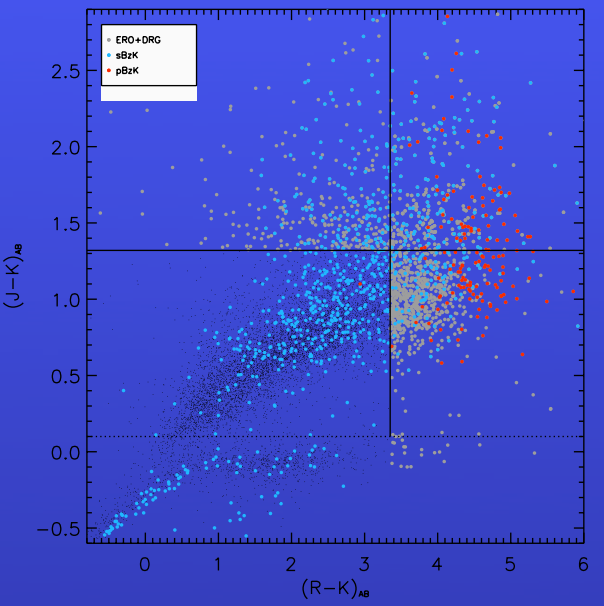
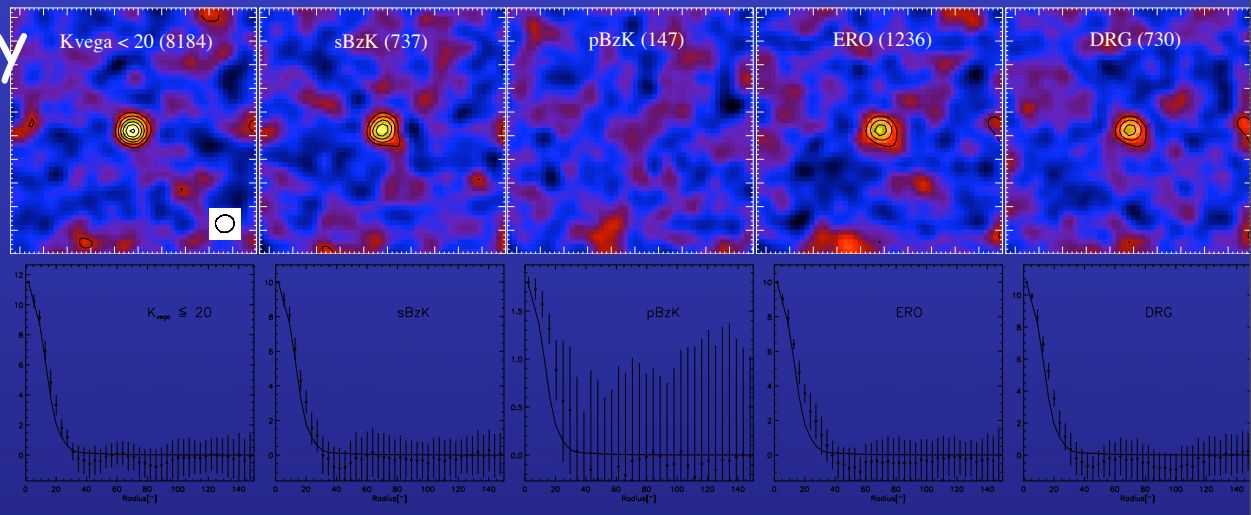


Stacking of galaxy populations in CDFS

- Greve et al, in prep.
- 8184 near-IR detected sources in LABOCA map.
- Large numbers allow to separate galaxies in different populations (BzK, DRG, ERO) and study their submm properties as function of e.g. z.
- Clear detections of stacked populations.







APEX bolometer instruments

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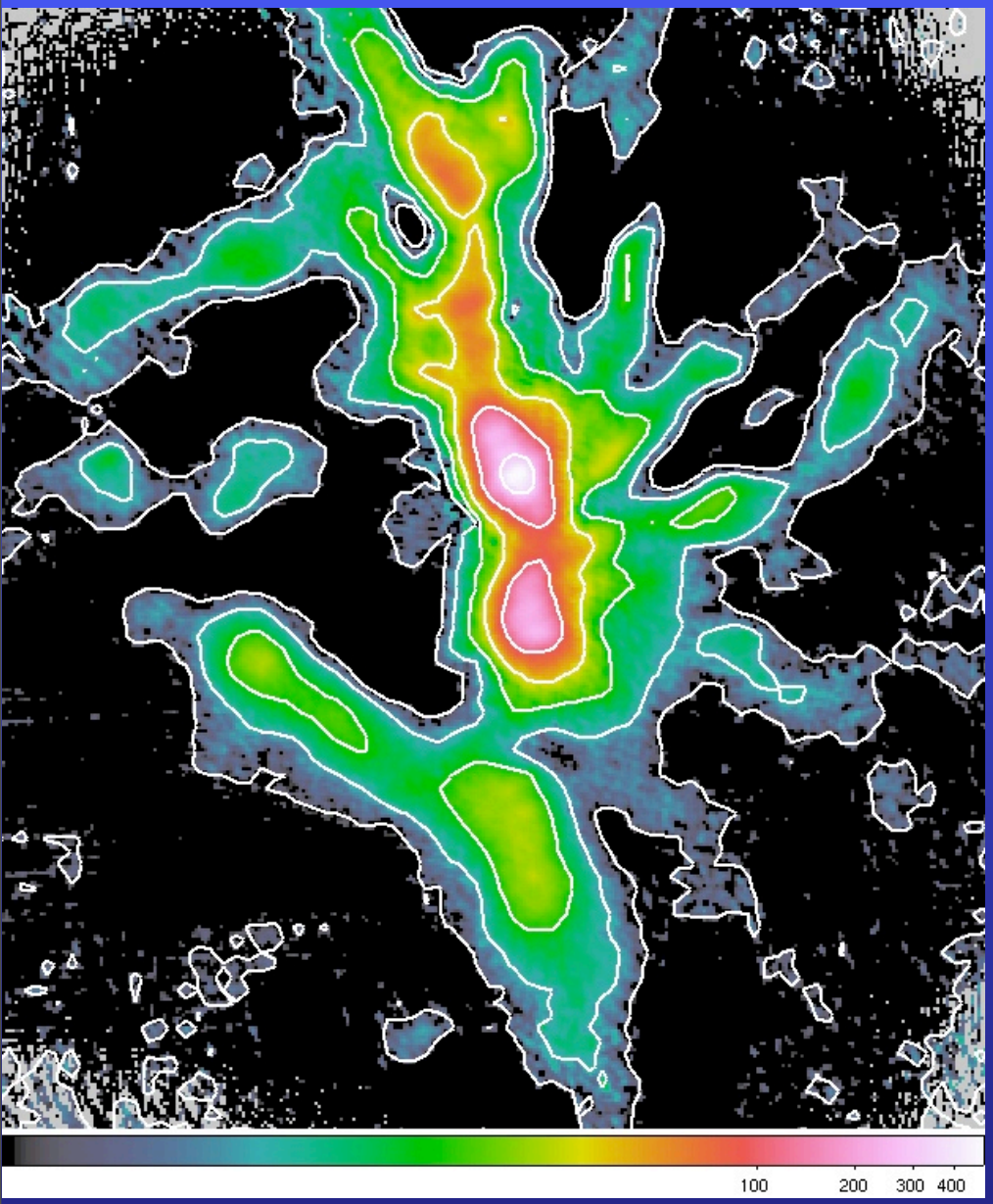
- SABOCA array of 37 TES bolometers at 350 μm. Commissioned end of 2008.

SABOCA



- 350 μm array of 37 TES detectors with SQUID readout.
- Requires PWV<0.8mm
- Sensitivity ~200 mJy.$\sqrt{s}$ (without atmosphere).
- Offered to ESO community since P83.

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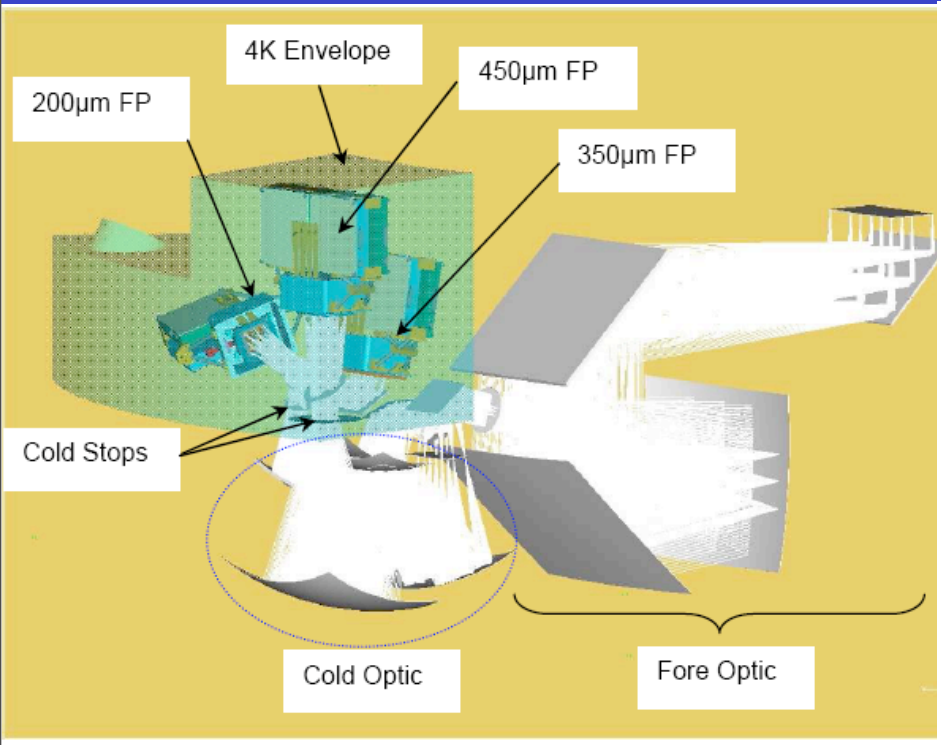
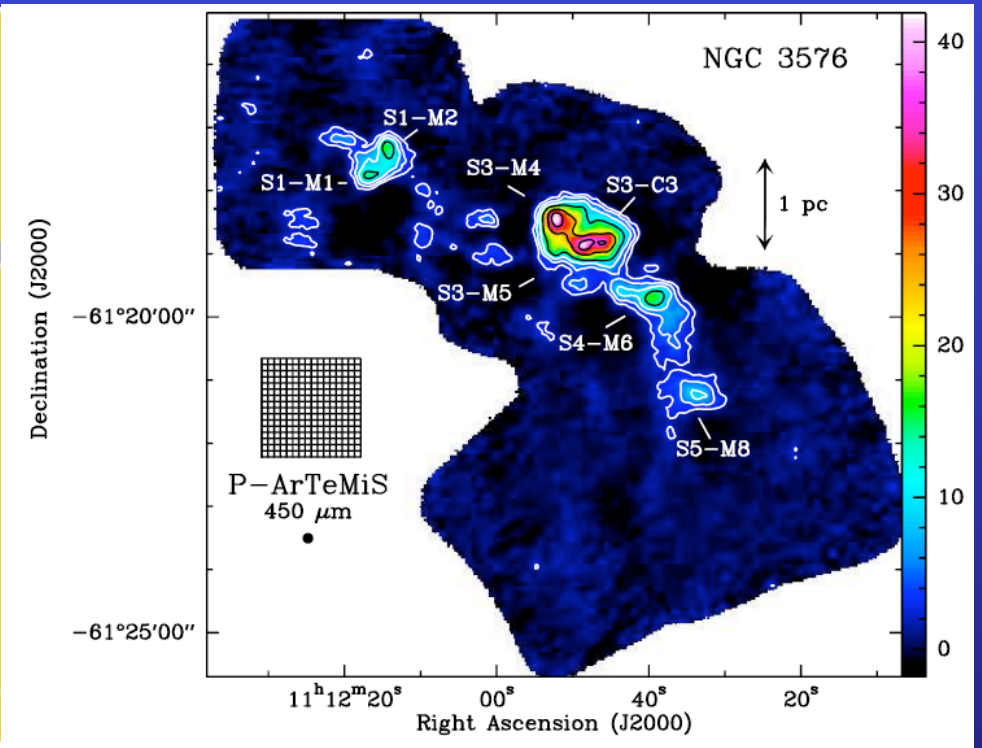
Artemis

- Built by CEA/Saclay, based on Herschel/PACS technology.
- Simultaneous 450/350/200 μm imaging in 2.6'x4.7' (1'x1' @200 μm) with 5760 fully sampled pixels.
- Prototype has produced science results in 2007+09, main instrument available in 2011 (ESO visitor instrument).





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- APEX-SZ array for S-Z cluster studies (MPIfR/ UC Berkeley PI instrument). Operational since 2007. Pulse-tube closed-cycle cooled instrument. See talk by Miguel Requena.

APEX archive at ESO

- All ESO and Onsala data is observed in service-mode, validated by 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/

Complementarity APEX-IRAM

- Access to southern hemisphere.
- Better atmospheric transparency than Pico Veleta allows work at higher frequencies → higher order transitions in compared to

  30m allow detailed CO ladder studies, probe denser regions, new molecules, ...
- 30m still wins in collecting area.
- MAMBO and LABOCA have similar architecture, but 1.2 mm vs. 870 μm.

Hints on APEX proposals

- Contact MPIfR well in advance before submitting a proposal on PI instrument.
- LST pressure is not uniform. Galactic Plane is often more highly oversubscribed.
- PWV>2mm conditions (SHFI/APEX-1) are less demanded. Larger proposals welcome.
- 24h observations allow submissions in both periods, though for high frequency work, try to submit when sources are observable during night + morning hours.
- Joint APEX+VLT(I) proposals welcome!