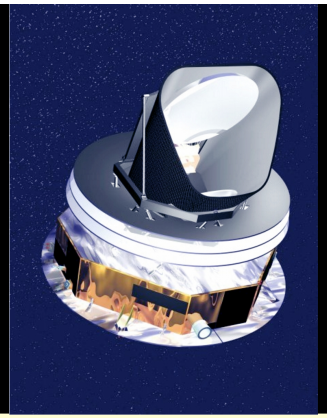
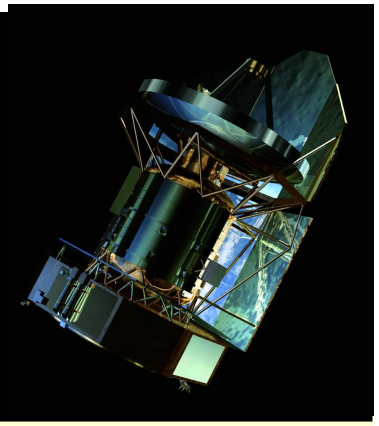
Cold Cores

on Planck[1, 2] and Herschel [1]

on behalf of the Planck collaboration





M. Juvela, **I. Ristorcelli** (coord.)

Planck

Desert, Dupac, Giard, **Harju**, Harrison, Joncas, Jones, Lagache, Lamarre, Laureijs, Lehtinen, Maffei, Martin, **Marshall**, Malinen, Mattila, **McGehee**, **Montier**, Pajot, **Paladini**, **Pelkonen**, Tauber, Taylor, Valenziano, Verstraete, **Ysard**

Abergel, **Bernard**, Boulanger, Cambresy, Davies, Dickinson, Fischera, Macias-Perez, Meny, Miville-Deschenes, Nartallo, Puget, Reach

Herschel

André, Kiss, Klaas, **Krause**, Molinari, Motte, **Pagani**, Schneider, **Toth**, Ward-Thompson, **Zavagno**, Marton, Verebely

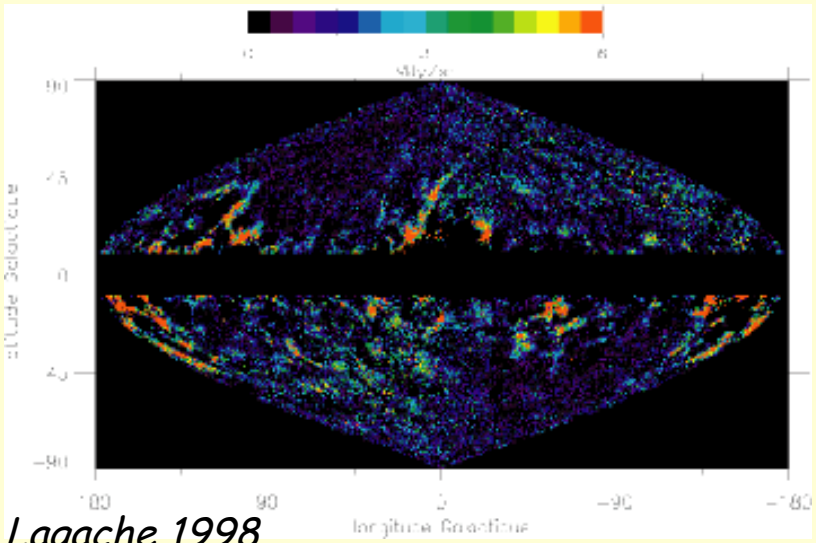
External

Doi, Ueno, Kitamura, Nikeda, Kawamura, Onishi

With acknowledgement to ESA[1] and the Planck HFI & LFI consortia[2]

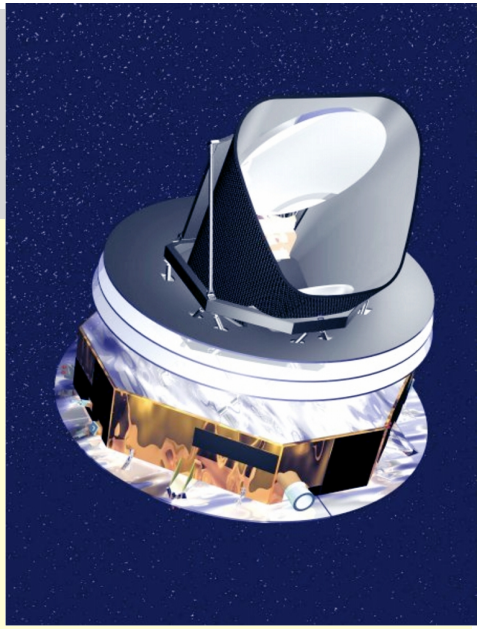
Galactic Cold Cores

- Cold dust: a **tracer** of dense, hidden regions of star-forming clouds
- Access to the **earliest phases of star formation**
  - What generates pre-stellar **cores** and what governs their evolution to protostars and proto-brown dwarfs ?
  - Origin of the global stellar **initial mass function** (IMF)
- Part of the life **cycle of dust**
  - from diffuse medium clouds
- we need large samples of **compact Galactic**



Lagache 1998

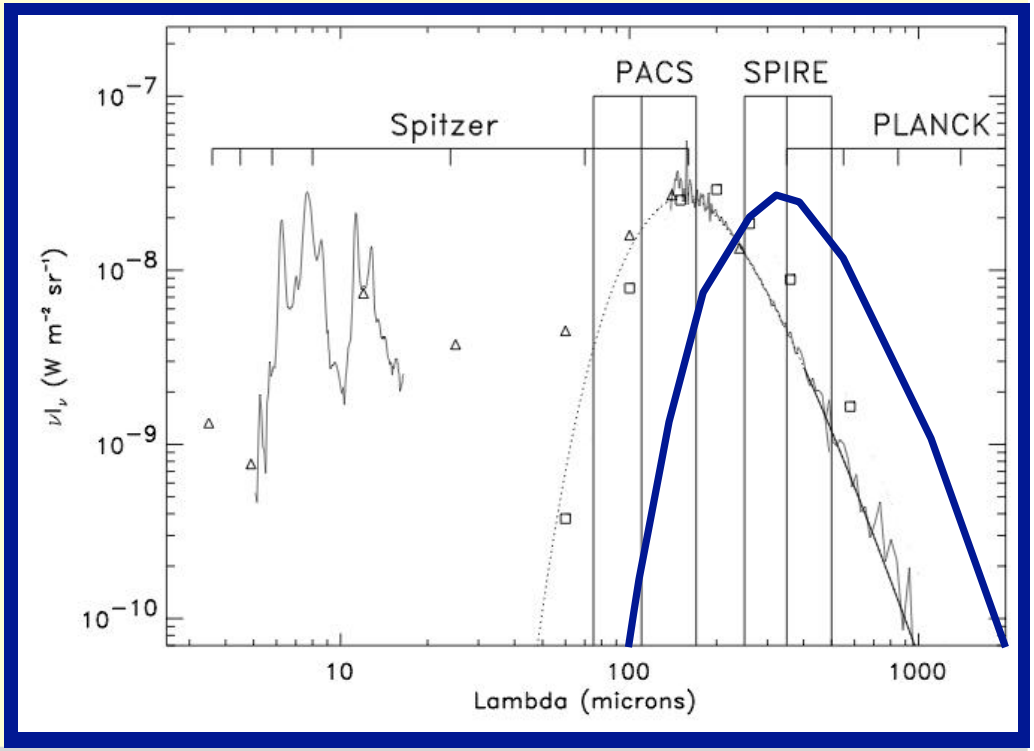
Planck



The Planck satellite is mapping the sky at 9 frequencies between 857GHz and 30 GHz

- main goal: measurement of CMB fluctuations
- provides multiwavelength sub-mm data
  - **350, 550, 850**, 1380, 2100, ...,
  - **5.0, 5.0, 5.0**, 5., 7.1, ...,

This enables the detection of **cold cores**!



Cold Cores: The Planck project

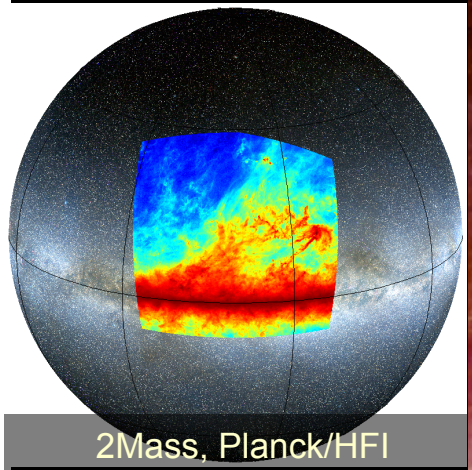
PLANCK will provide the first **unbiased** cold core catalog

- It will include a large list of 'normal' cloud cores
  - Pre-stellar cores in molecular clouds (class –I), isolated globules, dark clouds in the Galactic plane, etc.
  - a large number of new objects at **high Galactic latitudes**
  - many so far undetected objects (**very low T**)
  - possibility for the discovery of **new classes of objects**
    - e.g., Jupiter mass clouds?

We expect to have **>>1000** detections

C3PO = *Cold Cores Catalogue of Planck Objects*

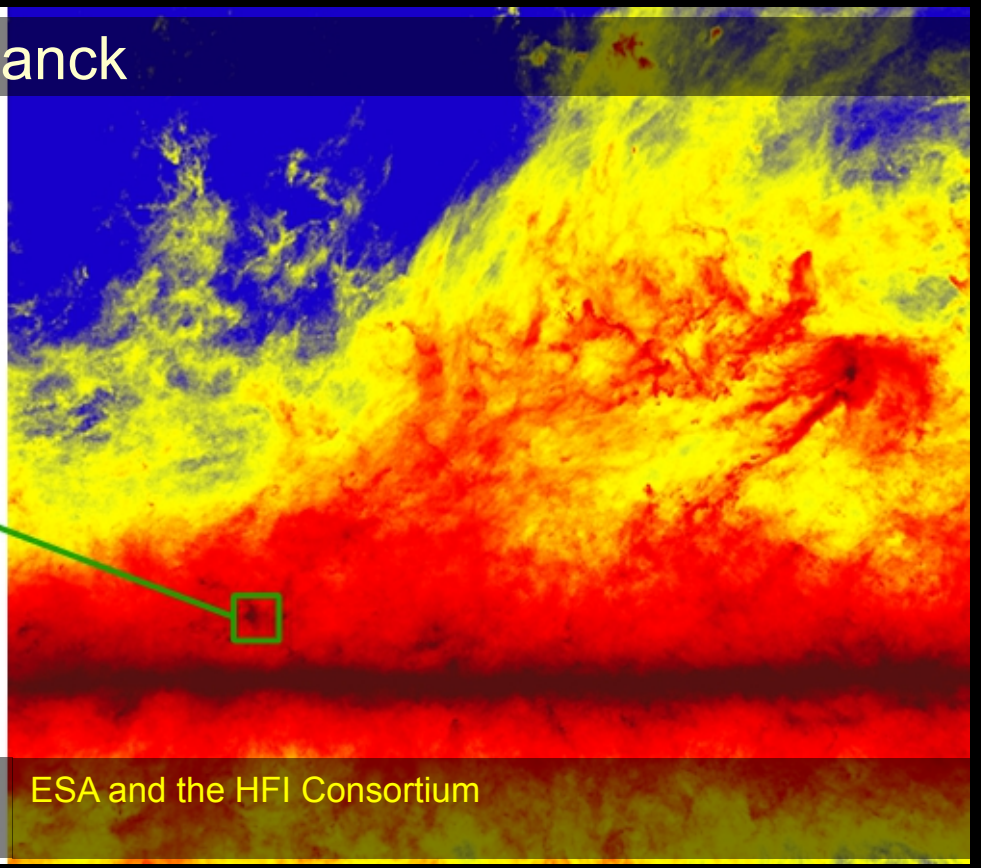
“Planck sees tapestry of cold dust”



2Mass, Planck/HFI

ESA and the HFI Consortium, IRAS
http://www.esa.int/esaMI/Planck/SEMMN9CKP6G_1.html

The Aquila field Herschel ← Planck



ESA and the SPIRE & PACS consortia, P. André (CEA Saclay) for the Gould's Belt KP Consortium

ESA and the HFI Consortium

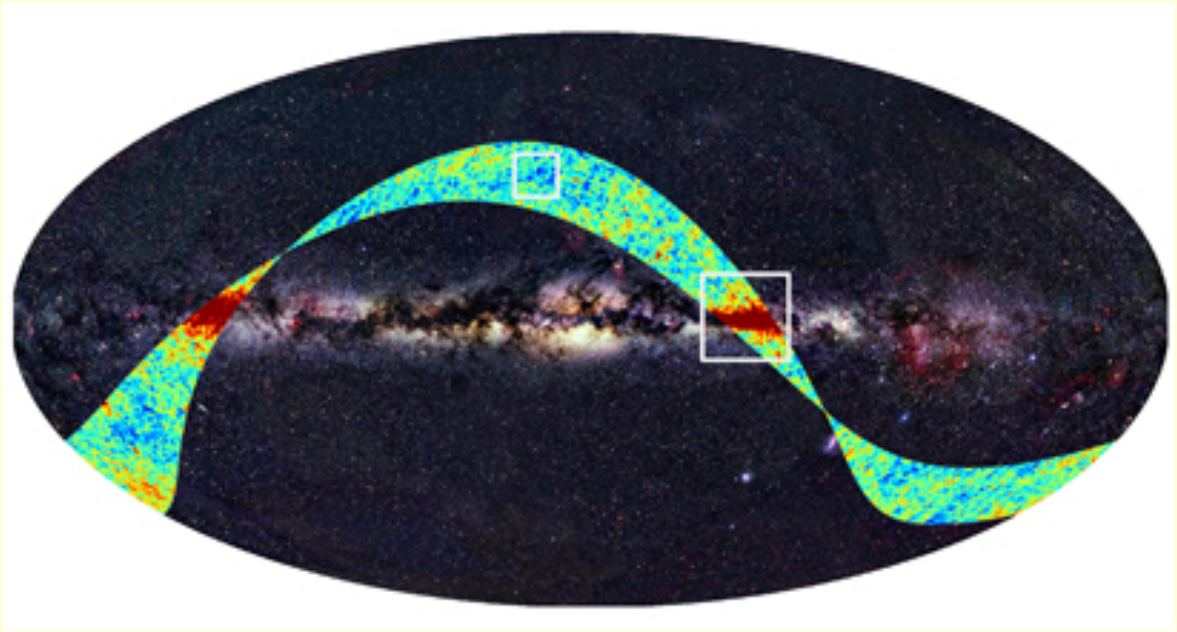
Cold Cores: The Herschel project

- OT KP *Galactic Cold Cores* (150.9h)
- PACS and SPIRE maps of carefully pre-selected cores
  - selection on the basis of Planck and ancillary data
  - a **cross-section** of Galactic cold cores population
  - selection takes into account **physical properties** of the cores (temperature, mass, density, size), their **location** (high/low latitudes, inner/outer Galaxy), **environment** (clustered vs. isolated sources, magnetic fields), **dust properties** (emissivity index, signs of anomalous microwave emission, polarization)
  - special emphasis is put on rare source types (e.g., high latitudes, both ends of the core mass spectrum)
  - 151 hours ~ 100-150 fields

SDP

Analysis of **Planck First Light Survey** resulted in the detection of many new sources.

This enabled us to participate in the **SDP**.



SDP

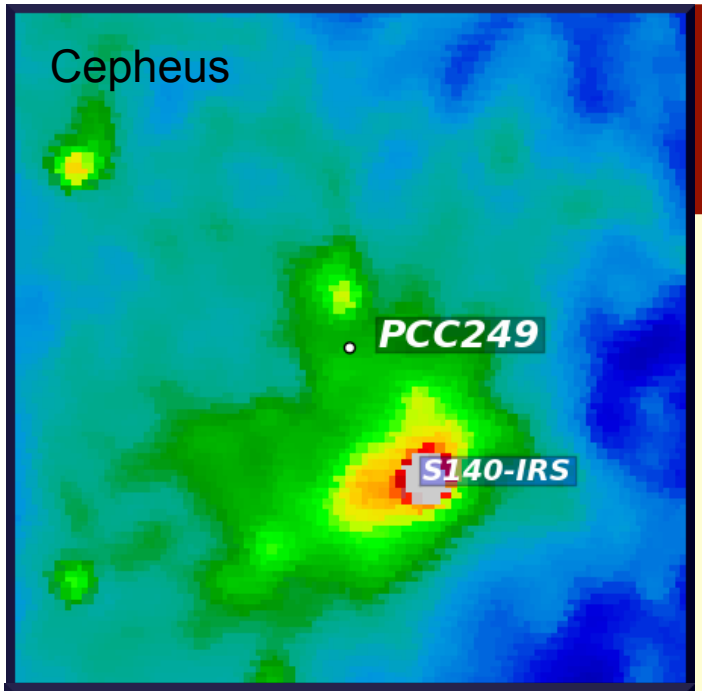
three secure detections of **cold dust excess** from Planck First Light Survey

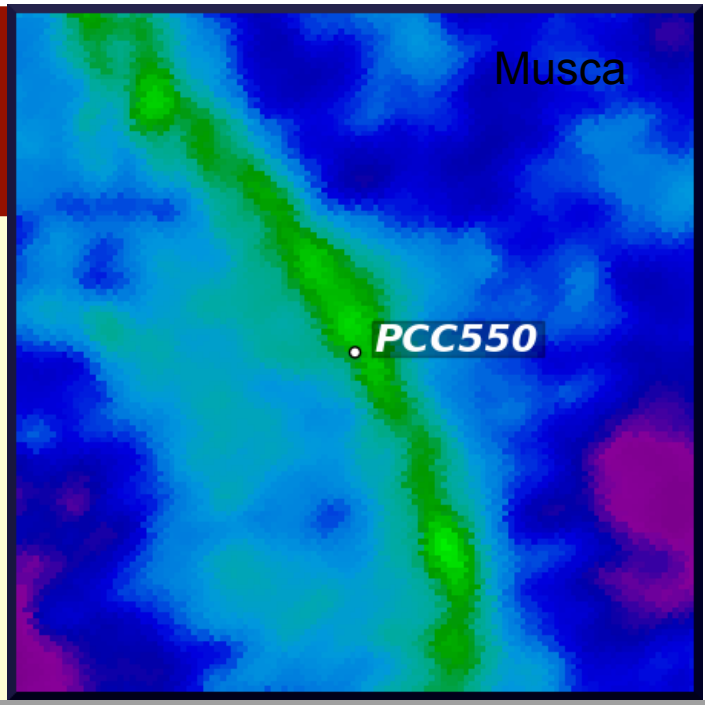
- *after* removing the component traced by IRAS 100μm

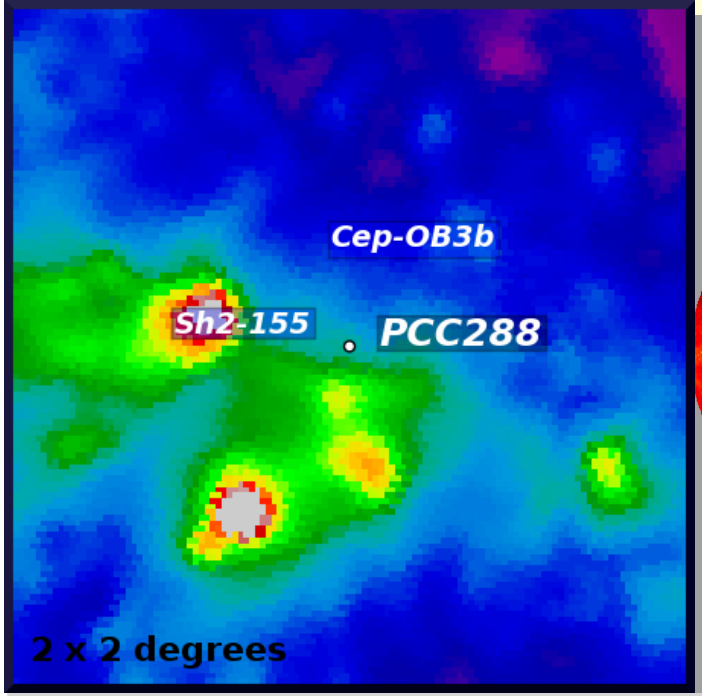
- ***PCC288***
  - PACS: three AORs, total ~0.5 hours; 15 arcmin square, homogeneous coverage
  - SPIRE: 20 arcmin, orthogonal scans
- ***PCC249***
  - parallel mode, orthogonal scans, ~30×30'; ~2 hours
- ***PCC550***
  - PACS: three AORs (0+45+135 deg), 15 arcmin; ~1 hour

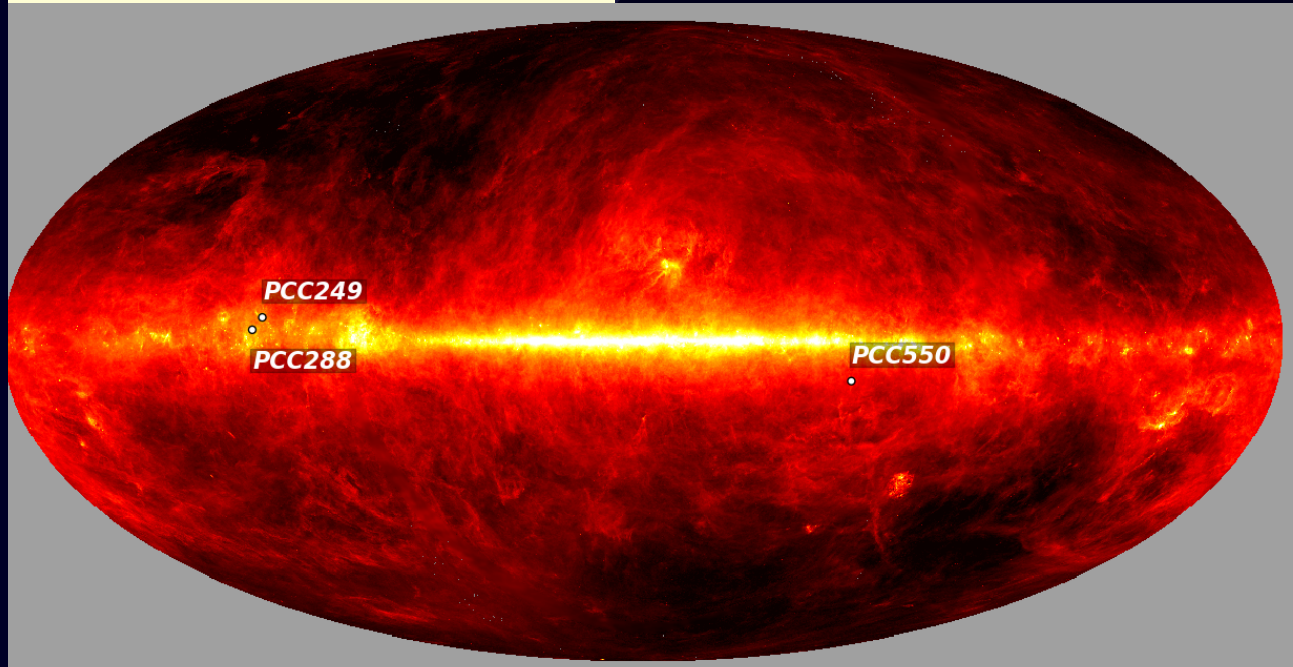
SDP

IRAS 100μm patches around the SDP fields





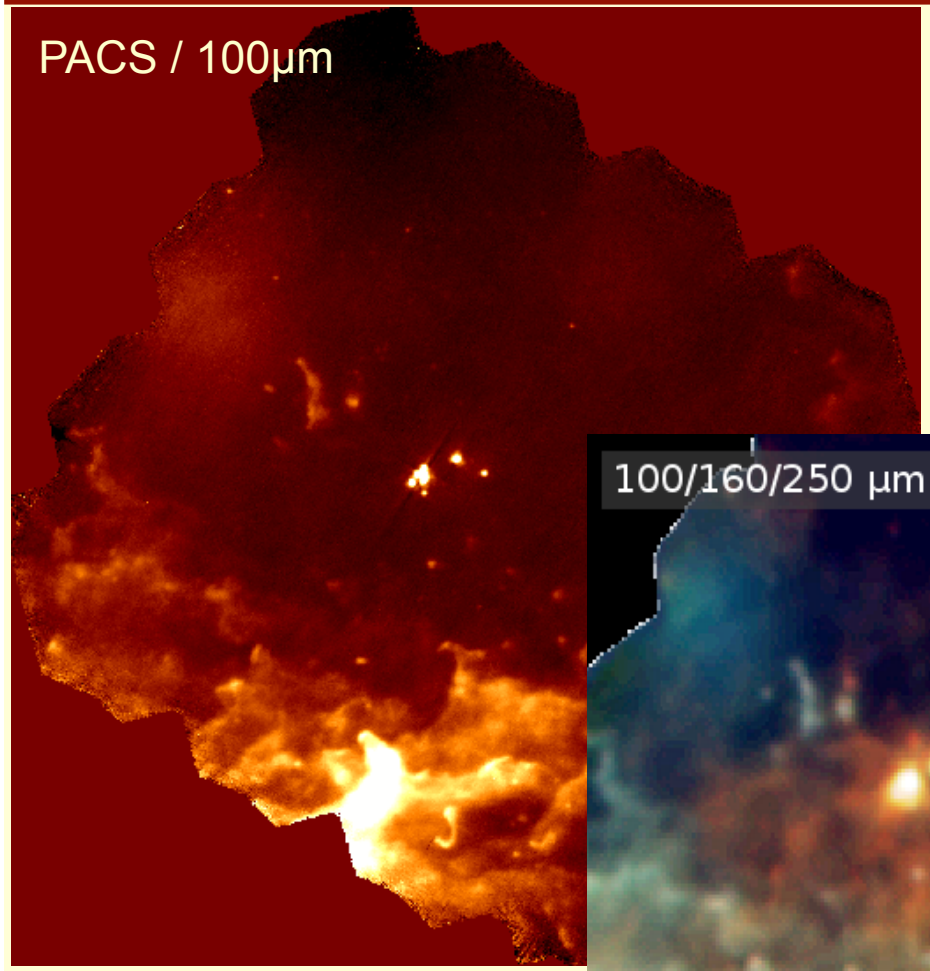


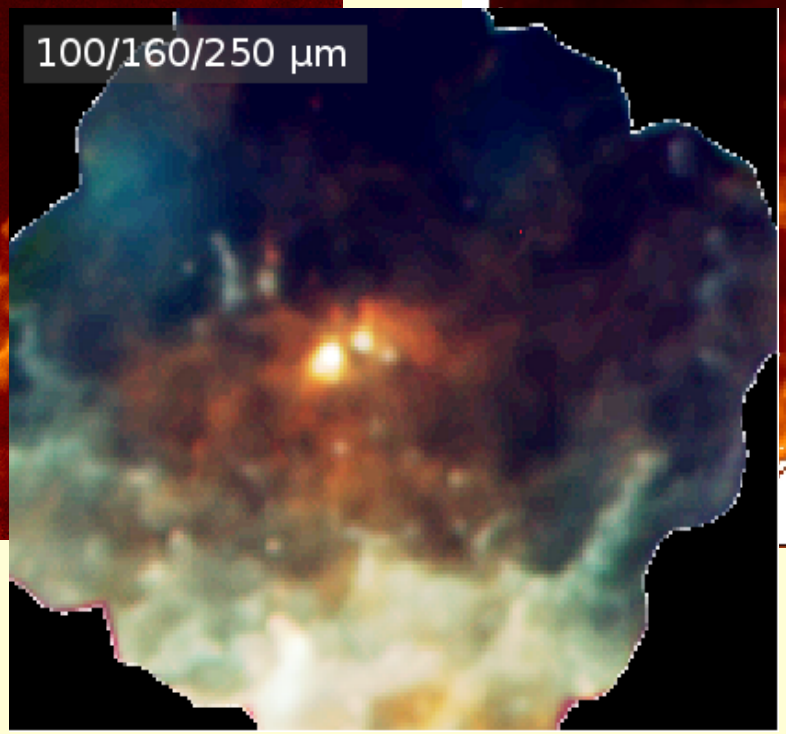


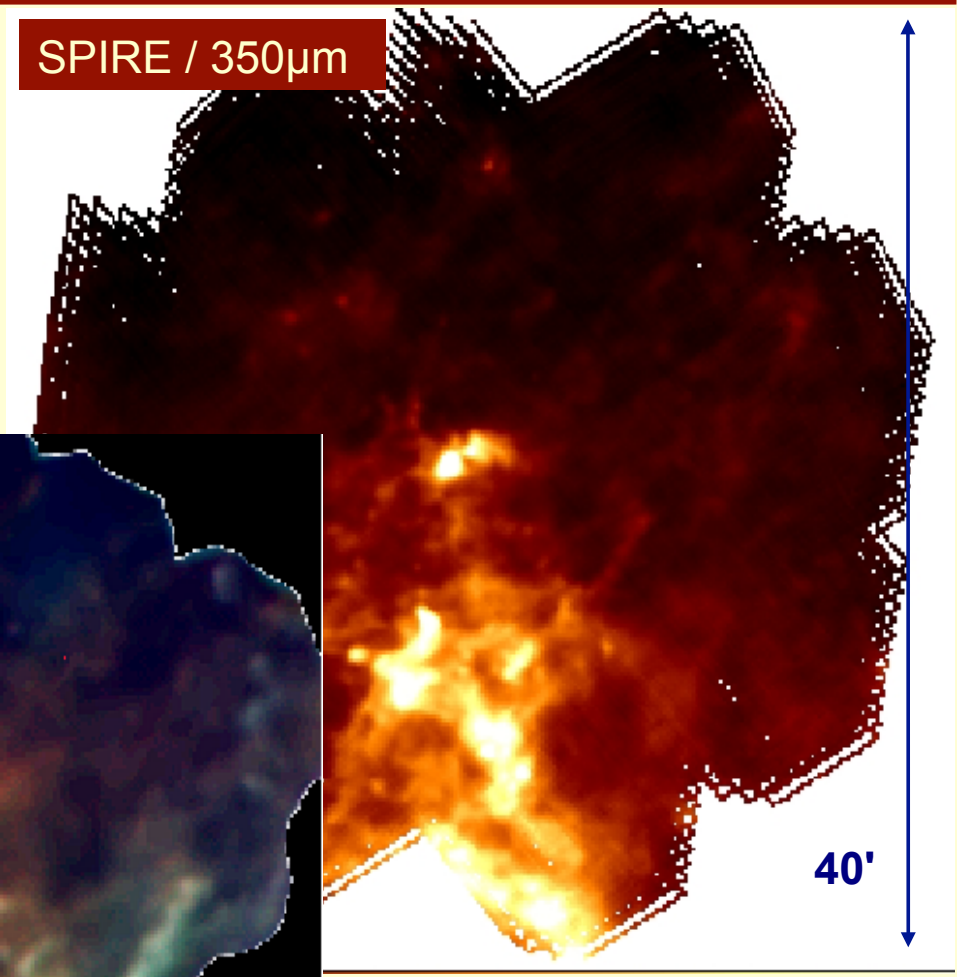
PCC288

- part of L1216 (Cep F) molecular cloud, between the main cloud and the Cep OB association
  - close to Cep OB3b group; one of the youngest nearby stellar groups (~800pc, ~5.5Myr)
- Planck detection corresponds to a cold clump – but one with already some star formation activity
  - three warm embedded sources
  - sub-clump B hosts a Fu Orionis type star and exhibits molecular outflows
- a possible case of sequential, triggered star formation

PCC288

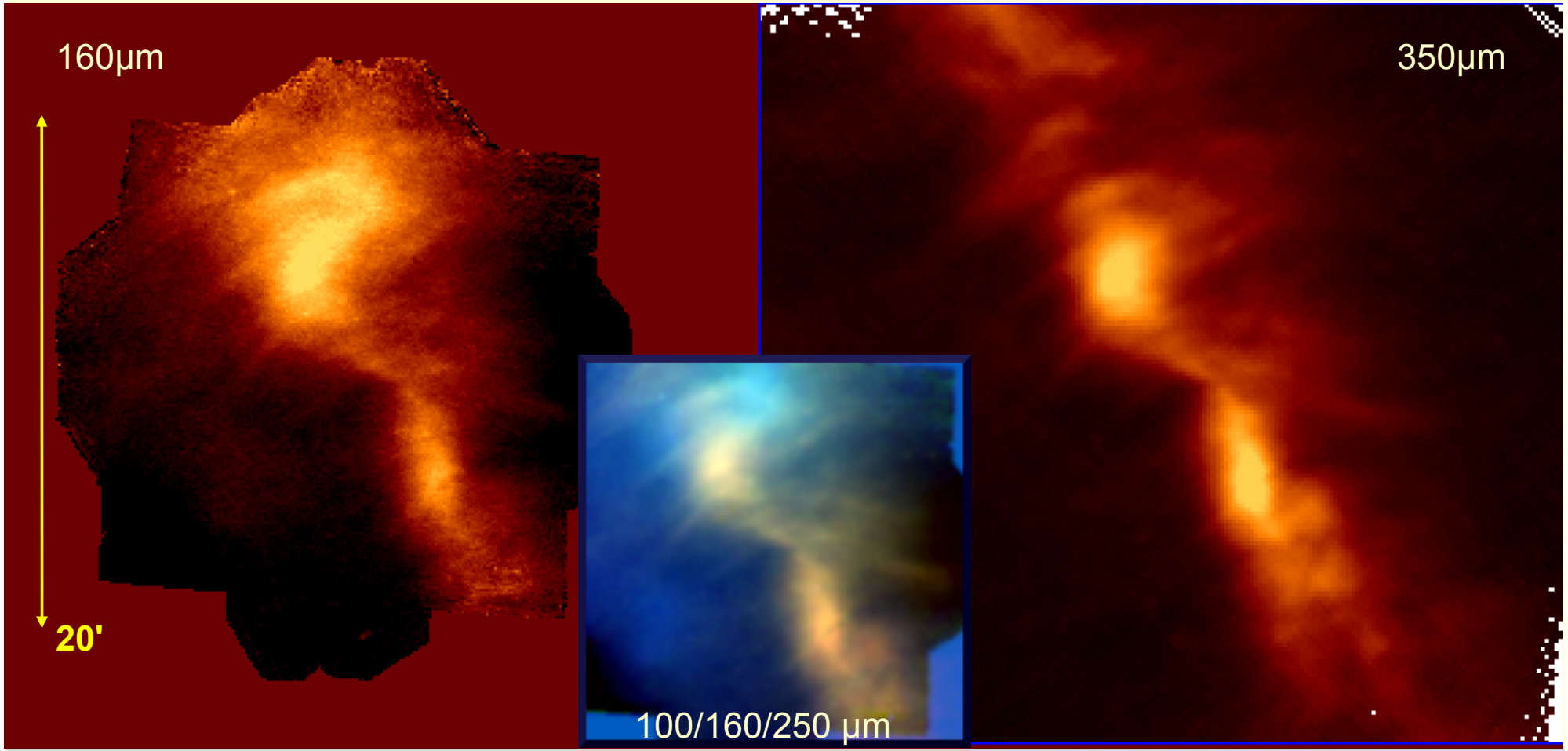






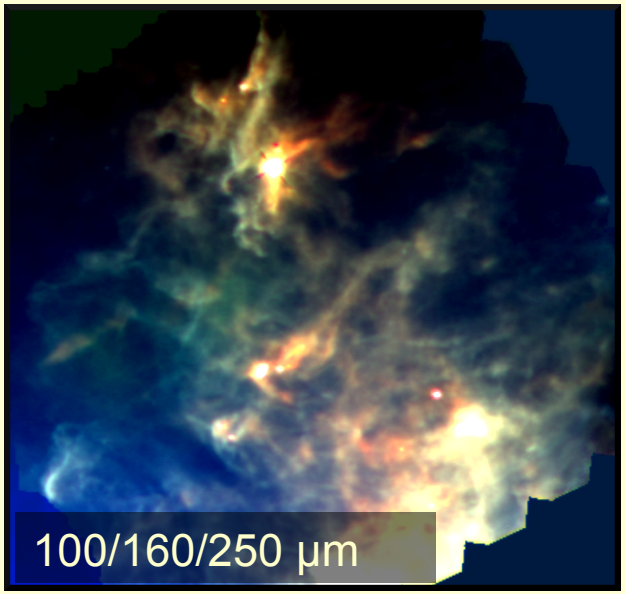
PCC550

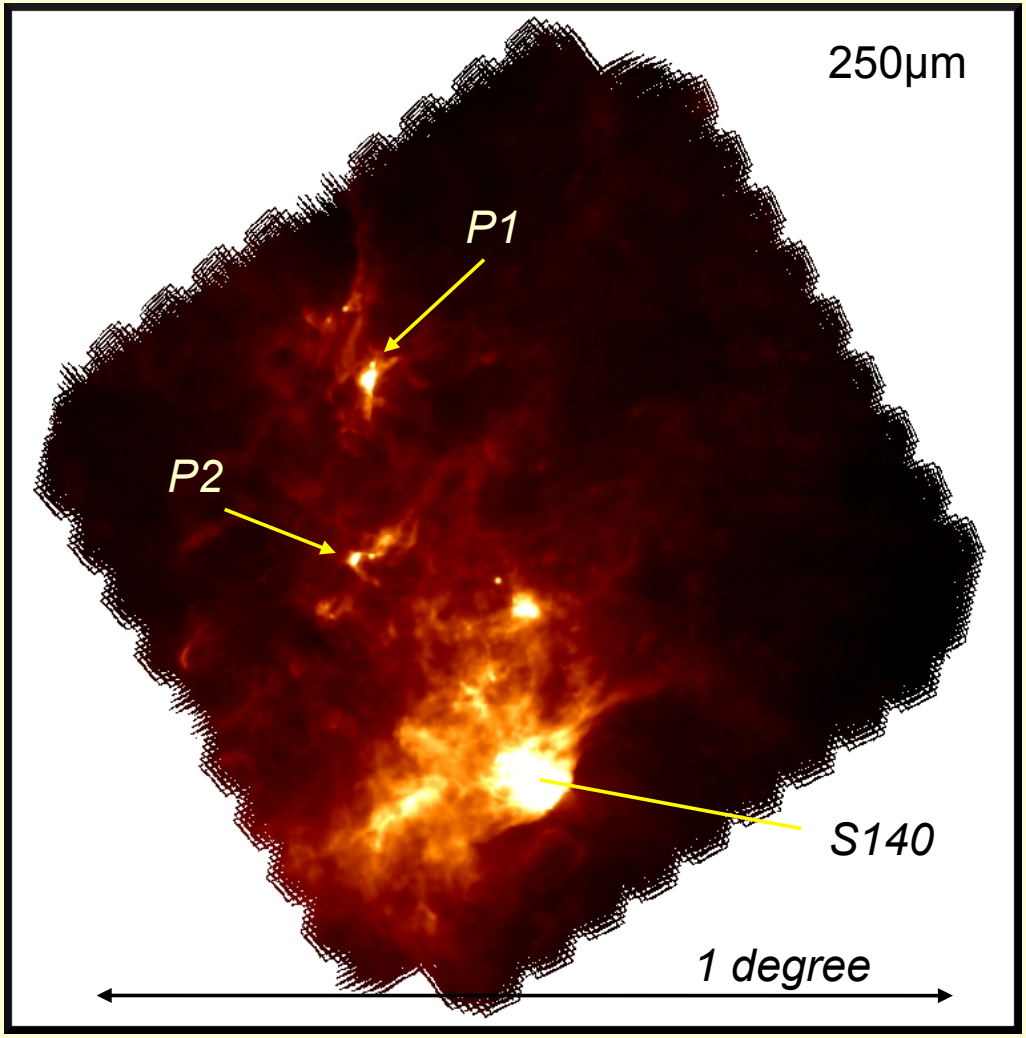
- two quiescent cores within the Musca molecular cloud filament (d~220pc)



PCC249

- active star-formation area
  - three B ZAMS in S140, P1 contains a known YSO
- Planck detection *P2* NE of S140, a second tentative detection *P1* north of this





LETTER TO THE EDITOR

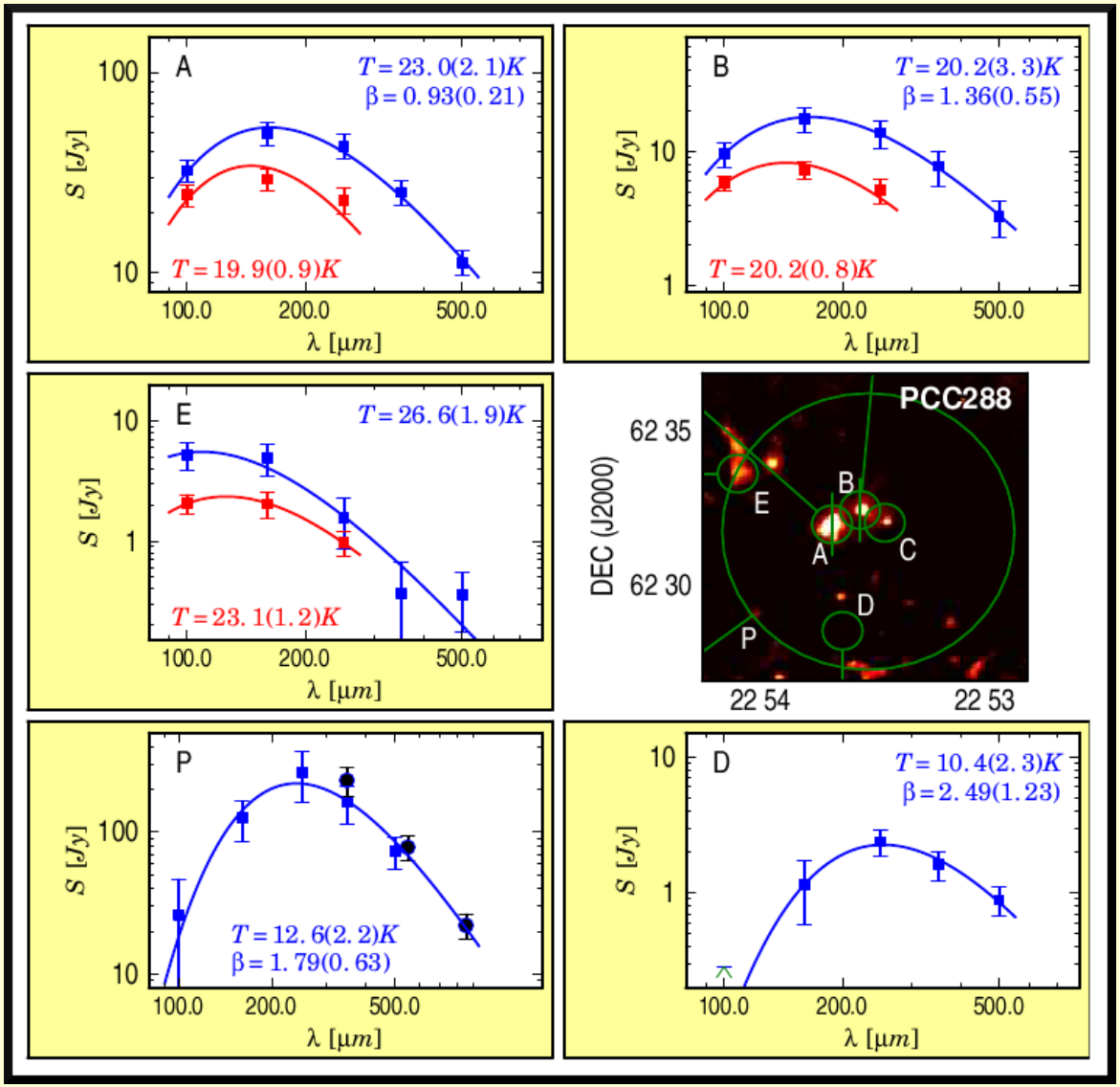
Galactic cold cores: *Herschel* study of first *Planck* detections ⋆ ⋆⋆

M. Juvela[1,2], I. Ristorcelli[3], L.A. Montier[3], D.J. Marshall[3], V.-M. Pelkonen[2,5], J. Malinen[1,2], N. Ysard[1,2], L.V. Tóth[6], J. Harju[1,2], J.-P. Bernard[3], N. Schneider[8], E. Verebélyi[6], L. Anderson[7], P. André[8] M. Giard[3], O. Krause[4], K. Lehtinen[1,2], J. Macias-Perez[12] P. Martin[10], P.M. McGehee[5], C. Meny[3], F. Motte[8], L. Pagani[9], R. Paladini[5], W. Reach[5], L. Valenziano[11], D. Ward-Thompson[12], A. Zavagno[7]

[1] Department of Physics, FI-00014, University of Helsinki, Finland
[2] Observatory, University of Helsinki, Finland
[3] CESR, Observatoire Midi-Pyrénées (CNRS-UPS), Université de Toulouse, BP 44346, 31028 Toulouse Cedex 04, France
[4] Max-Planck-Institut für Astronomie, Königstuhl 17, 69117, Heidelberg, Germany
[5] IPAC, Caltech, Pasadena
[6] Loránd Eötvös University, Department of Astronomy, Pázmány P.s. 1/a, H-1117 Budapest, Hungary (OTKA K62304)
[7] Laboratoire d'Astrophysique de Marseille, 38 rue F. Joliot-Curie, 13388 Marseille Cedex 13, France
[8] Laboratoire AIM, CEA/DSM - INSU/CNRS - Université Paris Diderot,IRFU/SAp CEA-Saclay, 91191 Gif-sur-Yvette, France
[9] LERMA & UMR 8112 du CNRS, Observatoire de Paris, 61 Av. de l'Observatoire, 75014 Paris, France
[10] University of Toronto, CITA, Canada
[11] INAF/IASF, Bologna, Italy
[12] LPSC, Université Joseph Fourier Grenoble I, CNRS/IN2P3, Institut National Polytechnique de Grenoble, 53 Avenue des Martyrs, 38026 Grenoble Cedex
[13] School of Physics and Astronomy, Cardiff University, Cardiff, UK

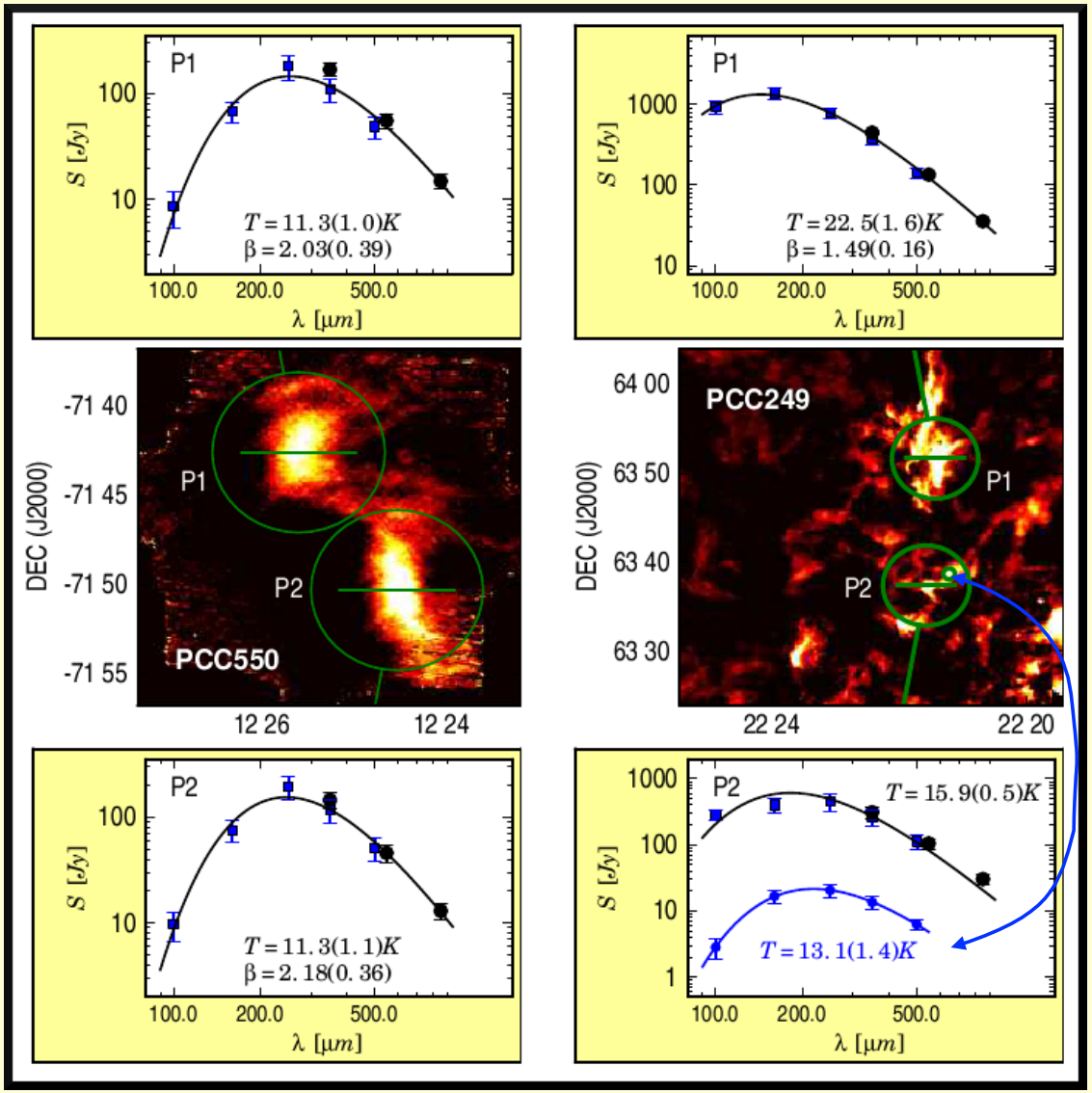
Compact sources: PCC288

- the average temperature over 9 arcmin aperture is 13K
- the sources A-C are warmer, 20K
- in the surrounding clump and the filament towards south *T*~10-12K
- spectral index decreasing with temperature?
- *M* ~140 M_0 (9', 800pc)



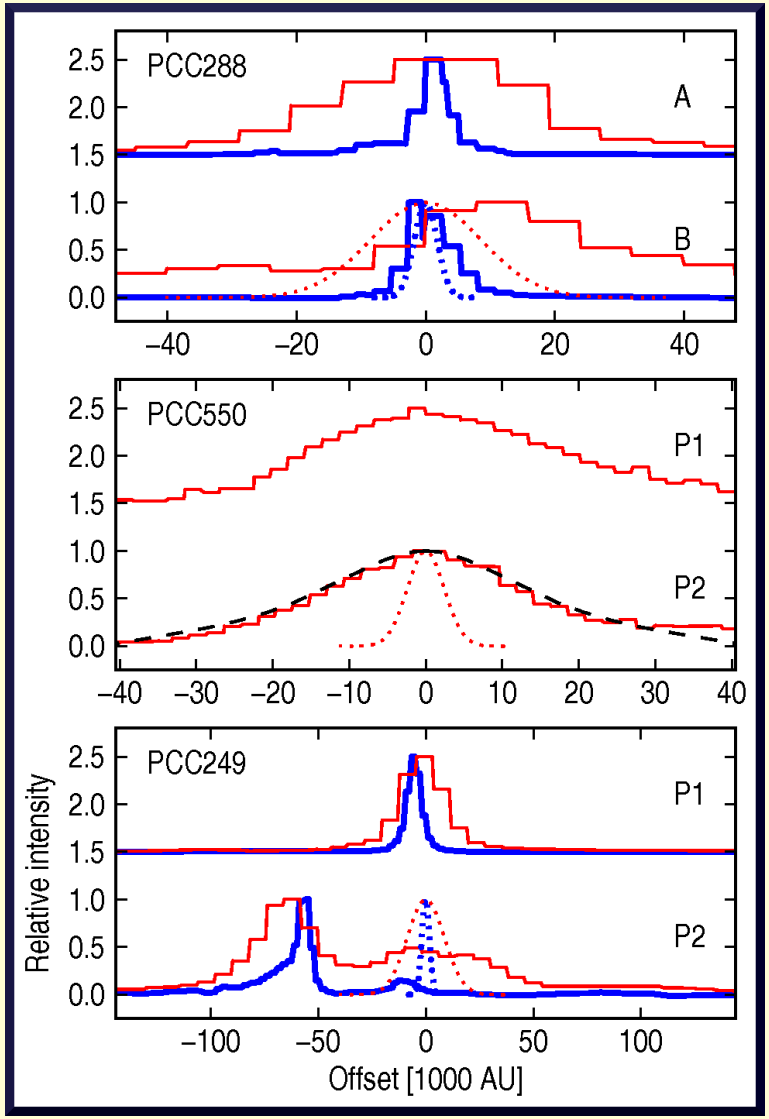
Sources: PCC550, PCC249

- the PCC550 (Musca) cores both have ~9 solar masses and are at ~11K
- PCC249 (Cepheus) sources are warm, both ~100M_O; P2 is colder but still not a *real* cold core
- Planck detection was not for *cold temperature* but for *excess of cold emission*
- within P2, one can find structures at ~13K



Sources: Intensity profiles

- the warm sources are still barely resolved with PACS
- longer wavelengths / cold dust emission is more extended
- the intensity profiles of Musca cores (PCC550) seem to be consistent with the density profile of a Bonnor-Ebert sphere
  - to confirm this, one needs to model the emission



Summary

Herschel has confirmed the Planck detections of cold dust. However, only the Musca cores are still in pre-stellar phase.

Significant amounts of cold dust are found around and between starforming clumps.

The study of SDP observations continues with the analysis of diffuse emission and the modelling of the sources.

Planck is providing large numbers of new detections of compact, cold dust clouds. Selected sources will be followed up in our Herschel OTKP within the next year.