Image: ESO/S. Guisard

# A physically motivated dense-core extraction technique applied to Herschel/Planck observations


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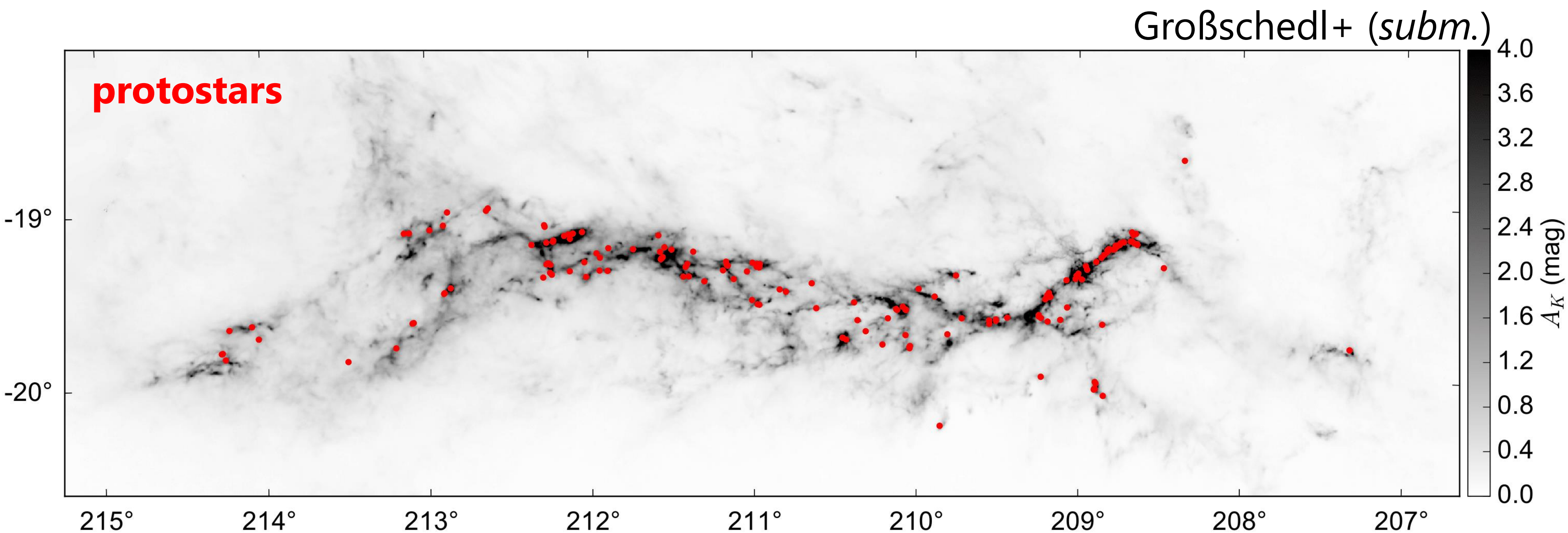
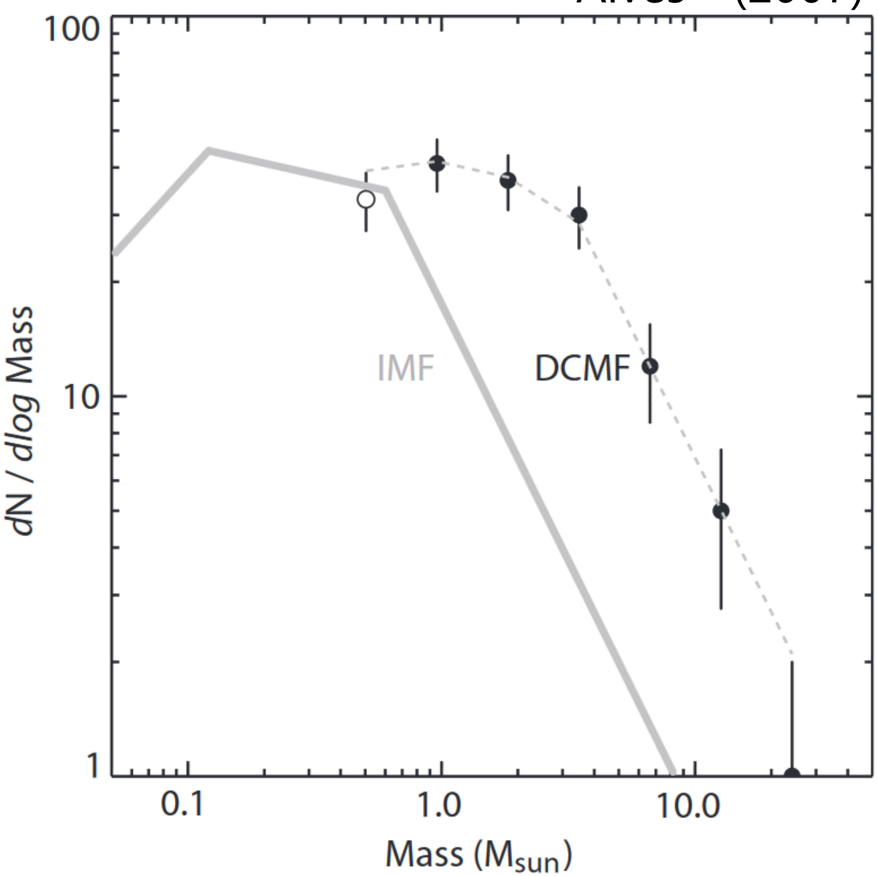
# Dense cores connect cloud structure to star formation.

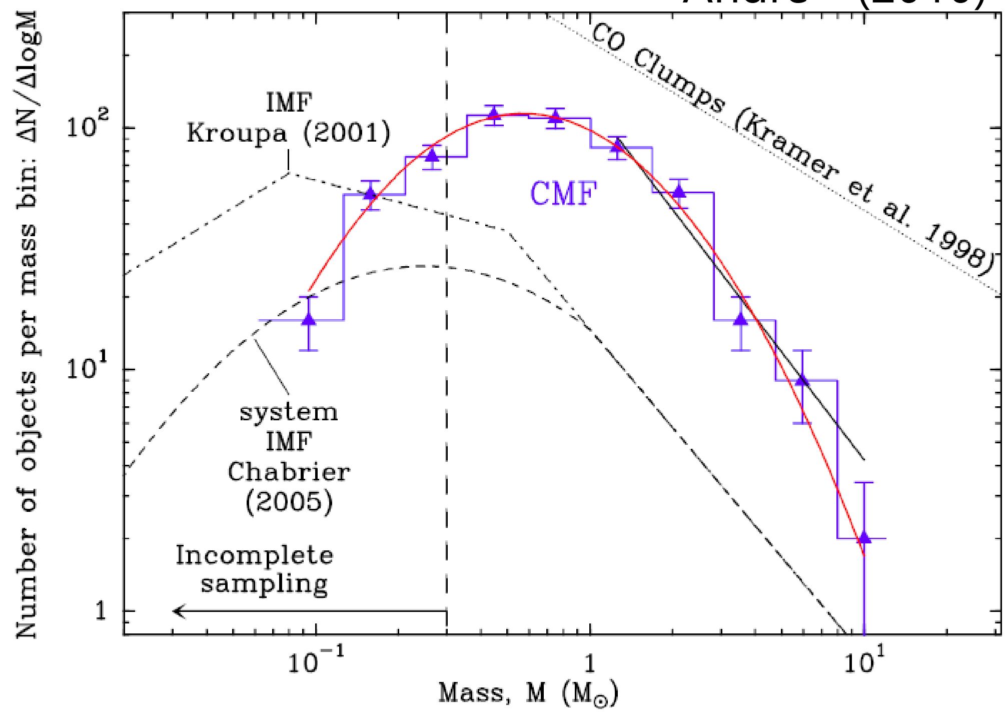


# Dense cores connect cloud structure to star formation.

Alves+ (2007)



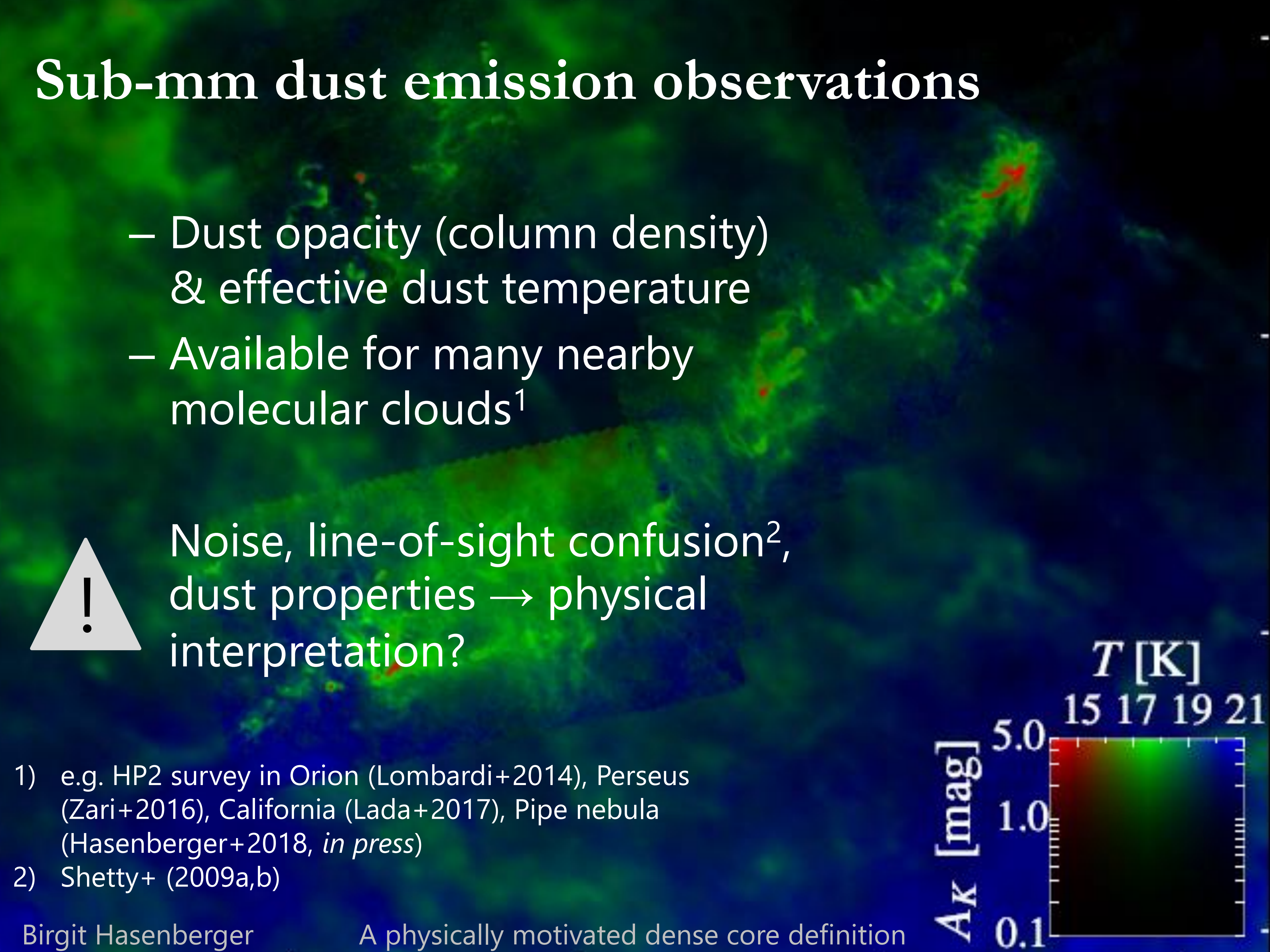

André+ (2010)



# Sub-mm dust emission observations

- Dust opacity (column density) & effective dust temperature
- Available for many nearby molecular clouds[1]

Noise, line-of-sight confusion[2], dust properties → physical interpretation?

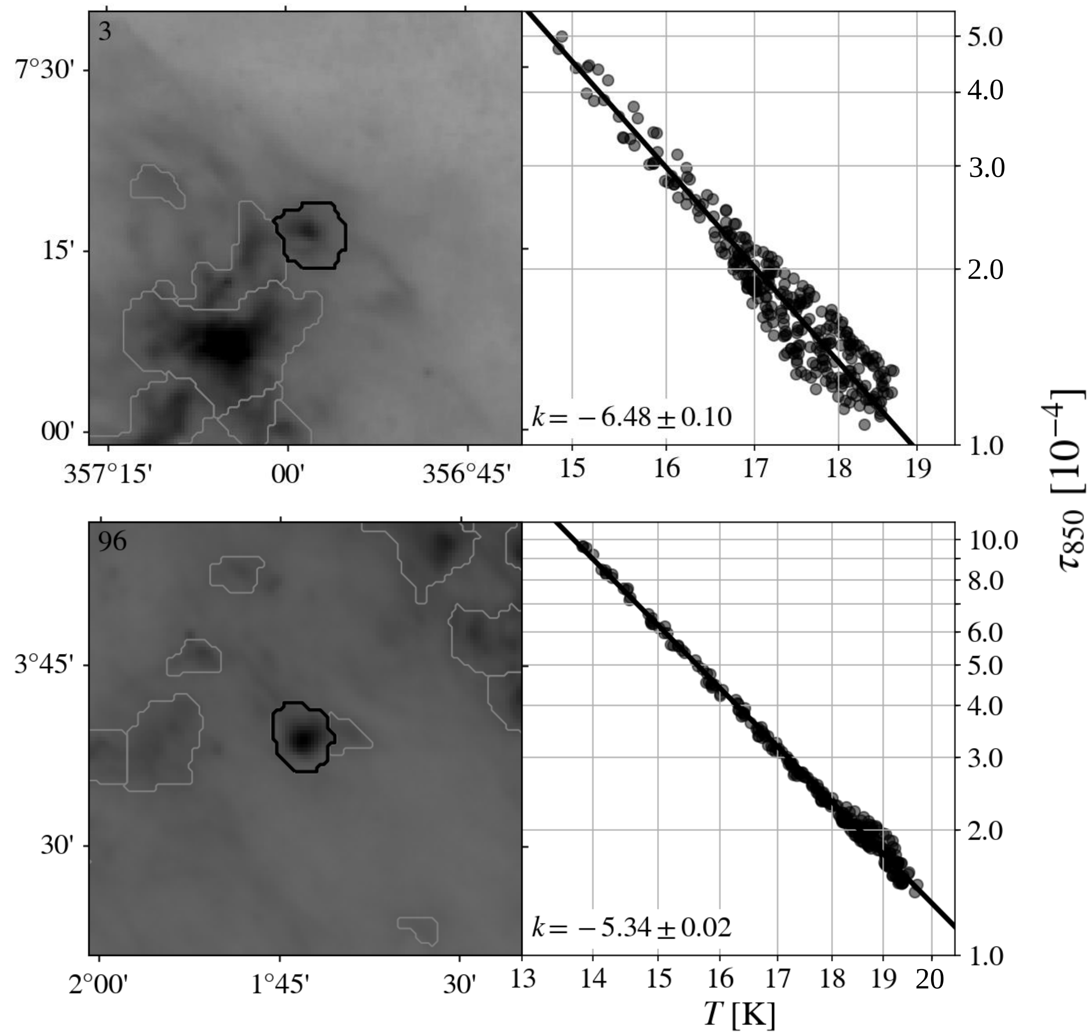



1) e.g. HP2 survey in Orion (Lombardi+2014), Perseus (Zari+2016), California (Lada+2017), Pipe nebula (Hasenberger+2018, *in press*)
2) Shetty+ (2009a,b)

# Effective dust temperatures in cores

- 97% of cores show significant anticorrelation between column density and temperature

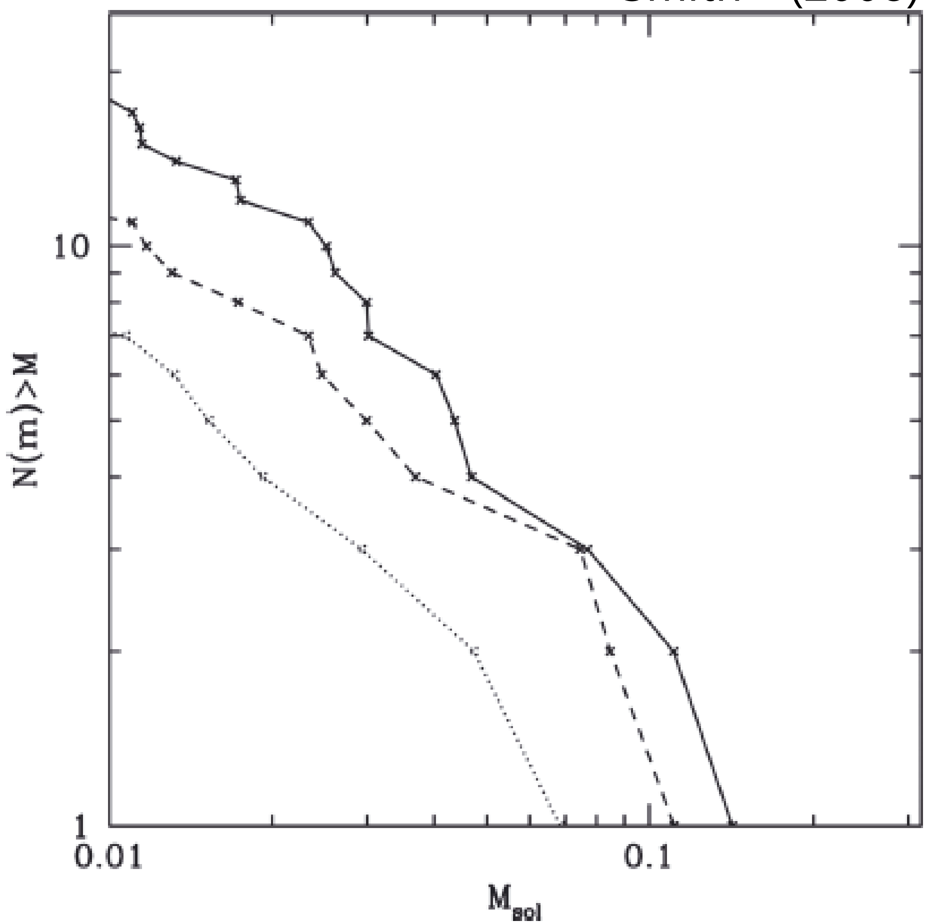
**Thermodynamics of cores:** heating by ISRF & shielding by surrounding medium



# What is a core?

Using algorithms based on morphology only, derived core boundaries potentially depend on the data resolution and chosen input parameters.[3]

Smith+ (2008)




3) Pineda+ (2009), Smith+ (2008)

# What is a core?

Core extraction technique that…

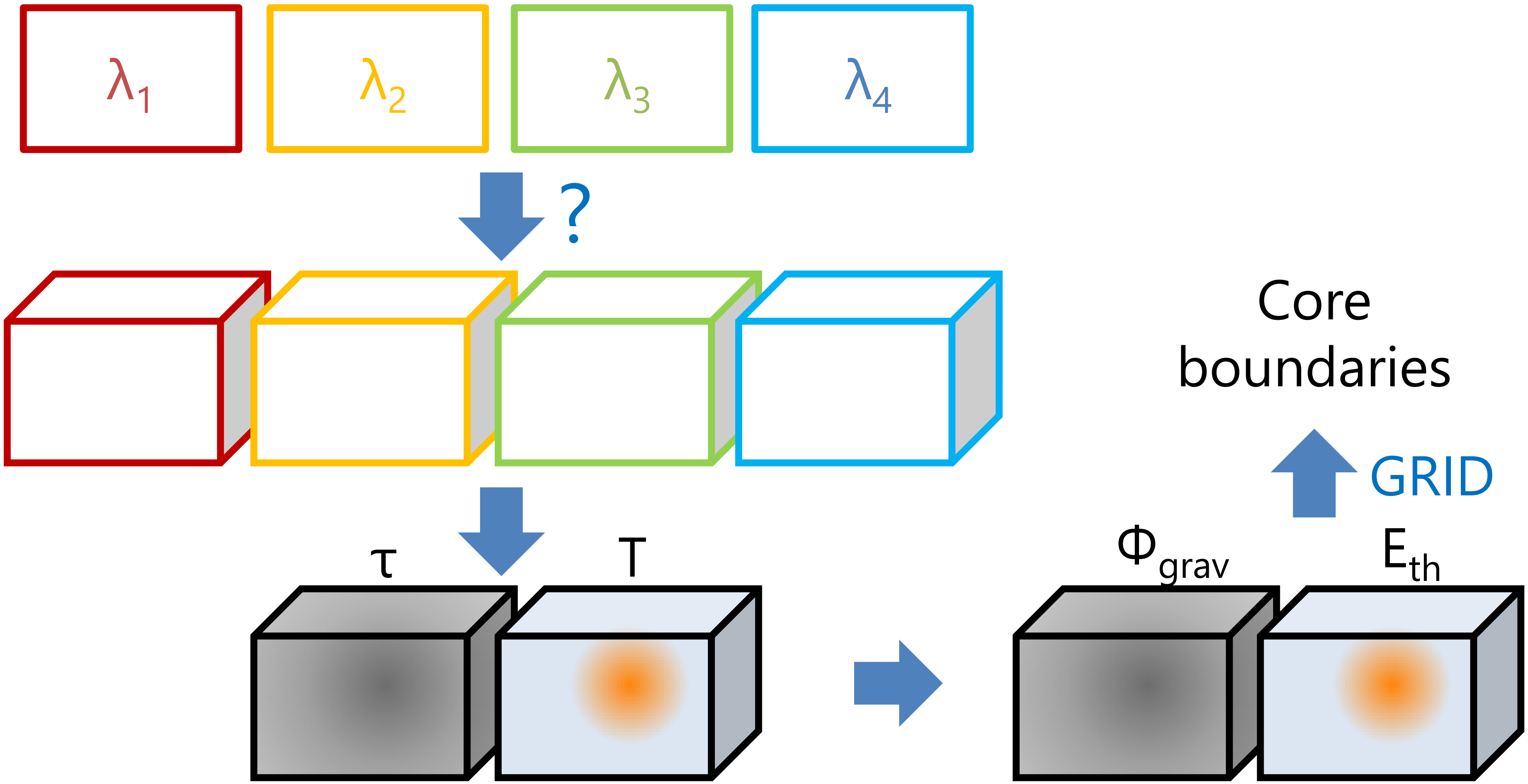
… is based on physical properties of the cloud medium.

… can be applied to a variety of nearby molecular clouds.

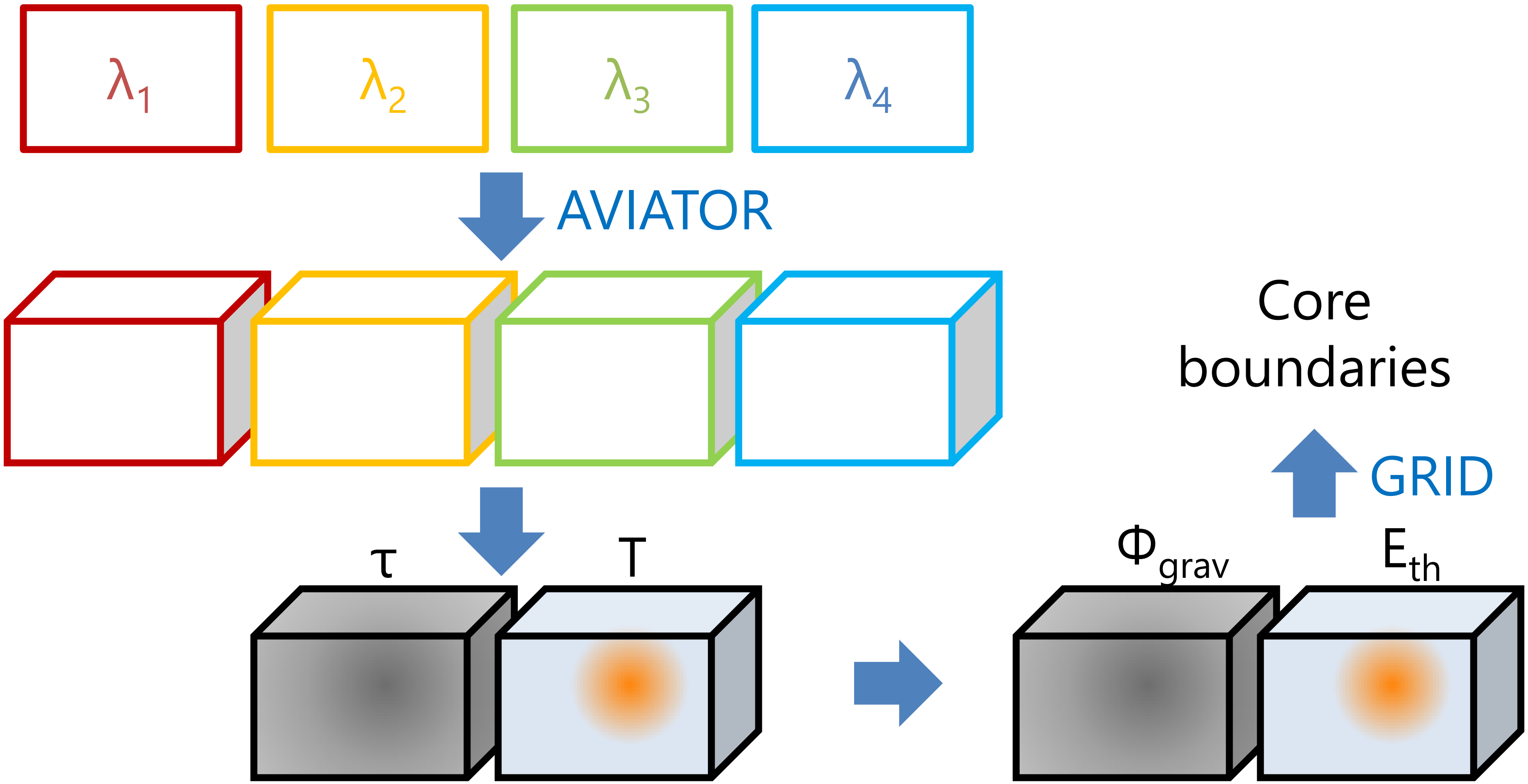
→ **GRID core-finding technique**[4] (isocontours of the gravitational potential and balance between $E_{grav}$ and $E_{th}$) on dust emission observations

4) Gong+ (2011)

# From flux maps to cores



# From flux maps to cores



# Estimating 3D flux distributions: AVIATOR

A Vienna Inverse-Abel-Transform based Object Reconstruction algorithm

Abel transform[5]:

$$F_{2D}(x,y) = F_{2D}(\rho) = \int g_{3D}(r)\, dz$$

Inverse Abel transform (spherical geometry):

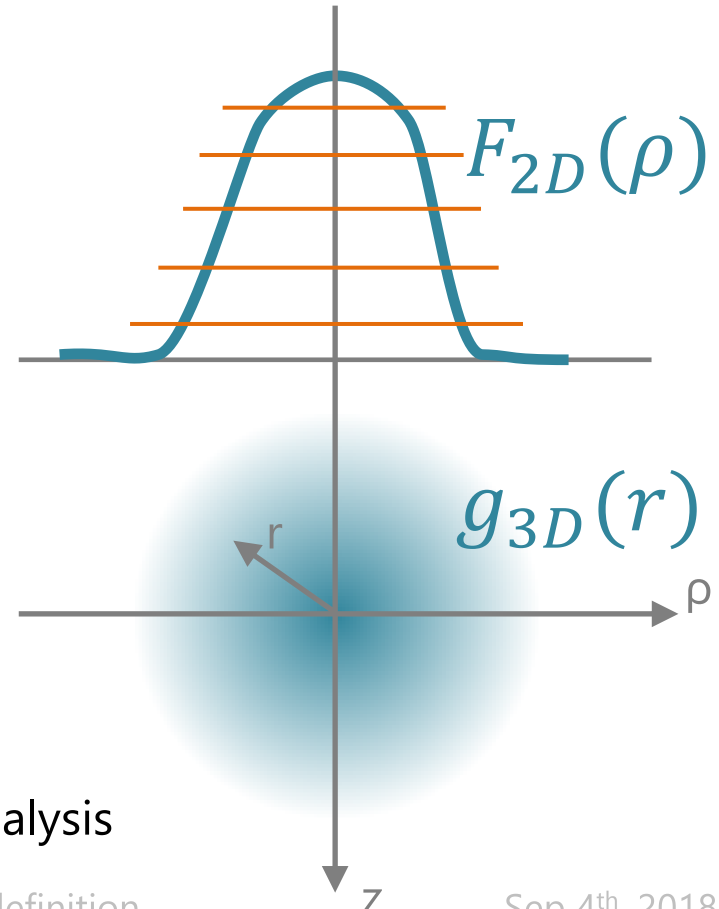
$$g_{3D}(r) = -\frac{1}{\pi}\int_r^{\infty} \frac{dF_{2D}(\rho)}{d\rho}\frac{d\rho}{\sqrt{\rho^2-r^2}}$$

Our scheme:

- Decompose 2D flux images into flux levels
- Apply variant of inverse Abel transform

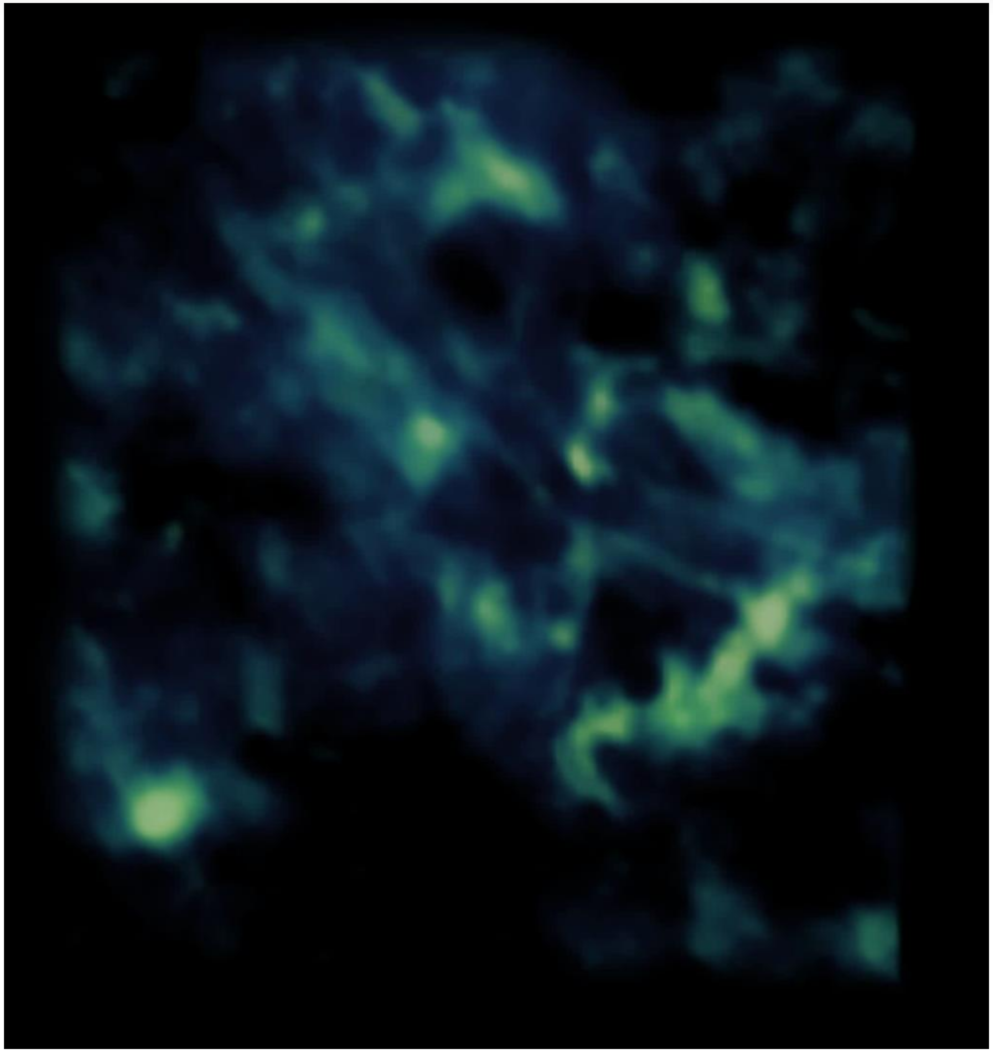
$$g_{3D}(r) = \sum_i \frac{1}{\pi}\frac{1}{\sqrt{R_i^2-r^2}}$$

deduced from morphological analysis

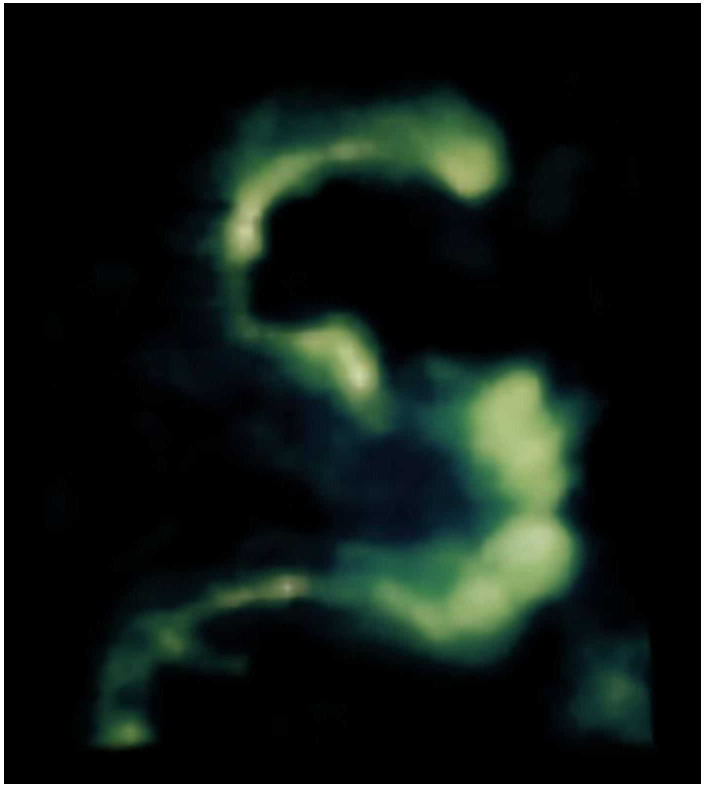



5) Abel (1826)

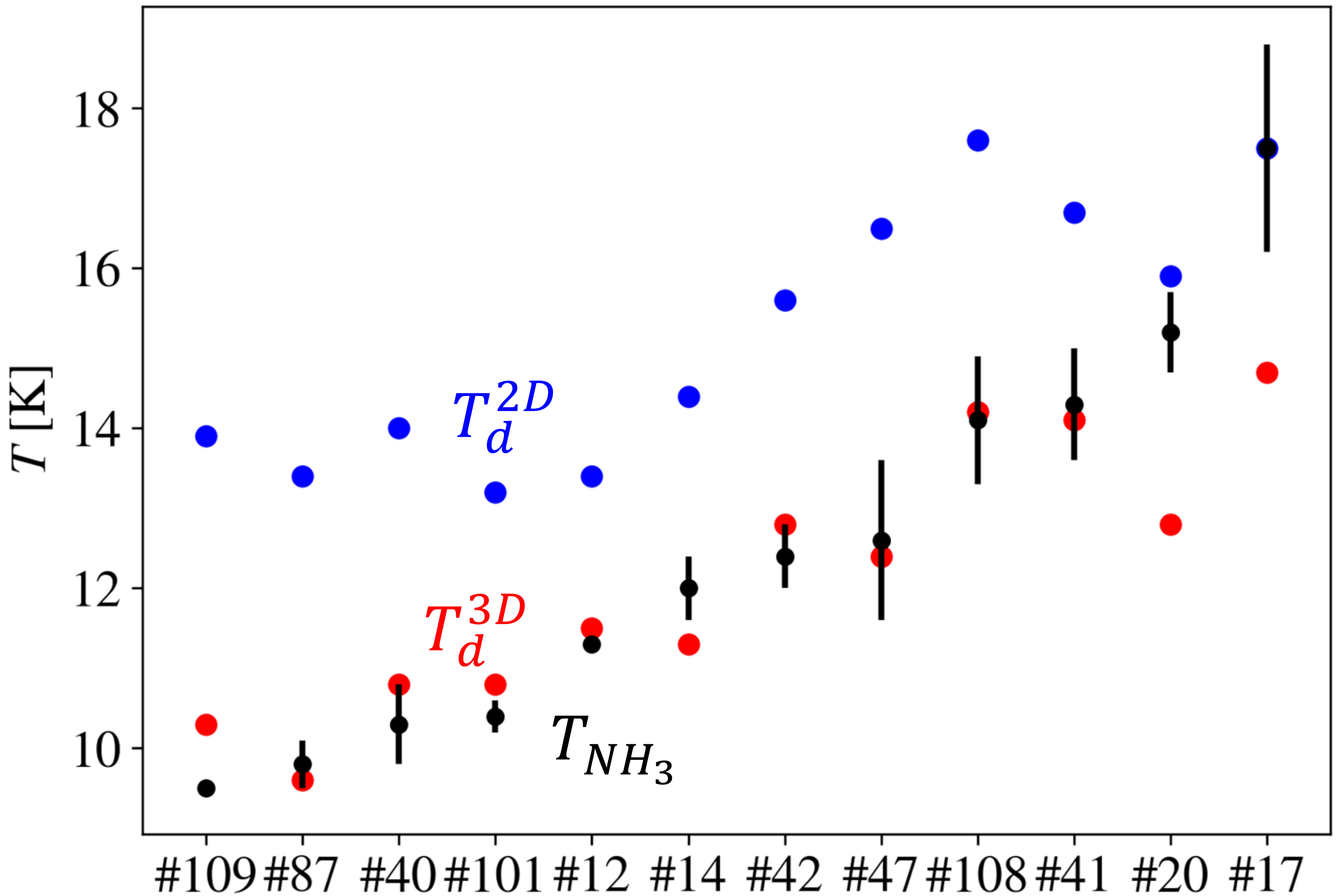
# Examples for 3D flux estimates



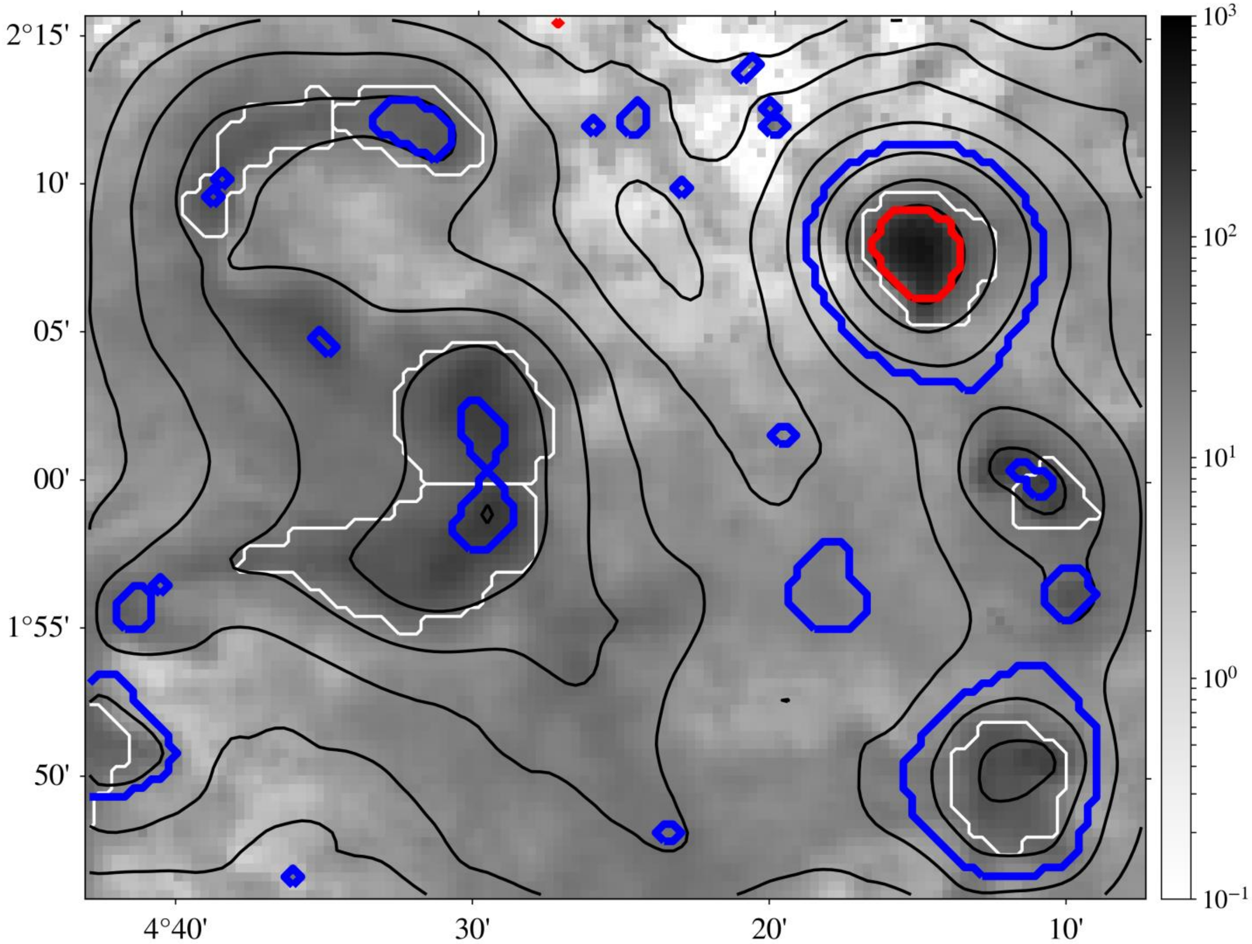
Extent along LoS ~
Extent in plane of the sky



# Validation of estimated 3D temperatures



# AVIATOR/GRID cores in a Pipe nebula subregion




gravitational potential

cores (GRID definition)

bound cores (GRID definition)

cores (clumpfind, Rathborne+2009)

# Summary

- **Dust emission observations allow us to investigate the thermodynamics of dense cores:** In the Pipe nebula, the dominant processes are heating by the ISRF and shielding by the surrounding medium.

- **The AVIATOR algorithm is an innovative tool to estimate 3D flux distributions from observations:** Estimates of dust temperature using the AVIATOR algorithm are in good agreement with molecular line measurements of $NH_3$ for most cores in the Pipe nebula.

- **The AVIATOR/GRID-core technique allows us to define physically motivated core boundaries and yields results different from morphology-based algorithms:** In the Pipe nebula, only few individual gravitational wells contain bound material, and the relation to cores derived by clumpfind is generally not straight-forward.