

Dust emission in the Small Magellanic Cloud: reviewing excesses

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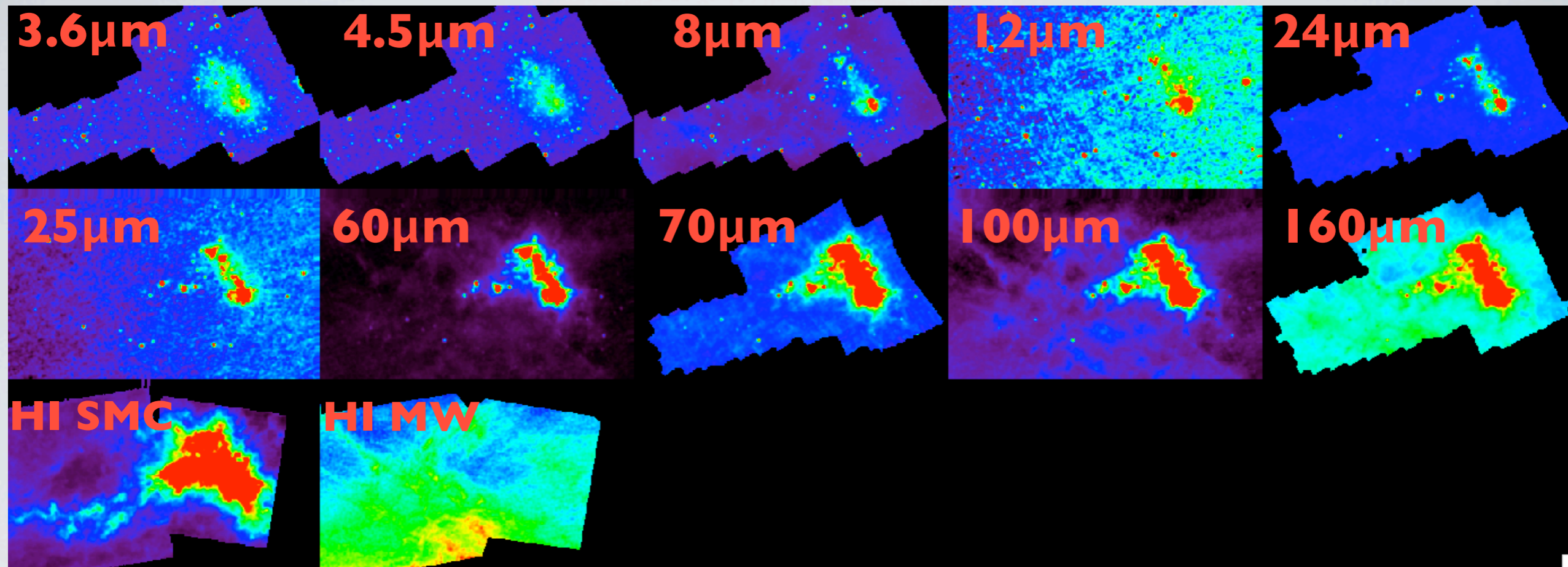
Sub-mm/mm project: M. Rubio, F. Boulanger, M. Albrecht, A. Leroy, A. Bolatto, F. Bertoldi

Mm/cm project: N. Ysard, D. Paradis, J.P. Bernard, G. Lagache, F.P. Israel, W. F. Wall



THE MAGELLANIC CLOUDS

- Some of the most **nearby** galaxies: LMC ~ 50 kpc, SMC ~ 60 kpc
High resolution observations
- **Low metallicity** galaxies (LMC $\sim 1/2$ and SMC $\sim 1/6$ solar)
- Perfect laboratories for dust studies in a very different environment than our Galaxy with access to relatively small scales



SAGE-SMC: SPITZER SURVEY OF THE SMC

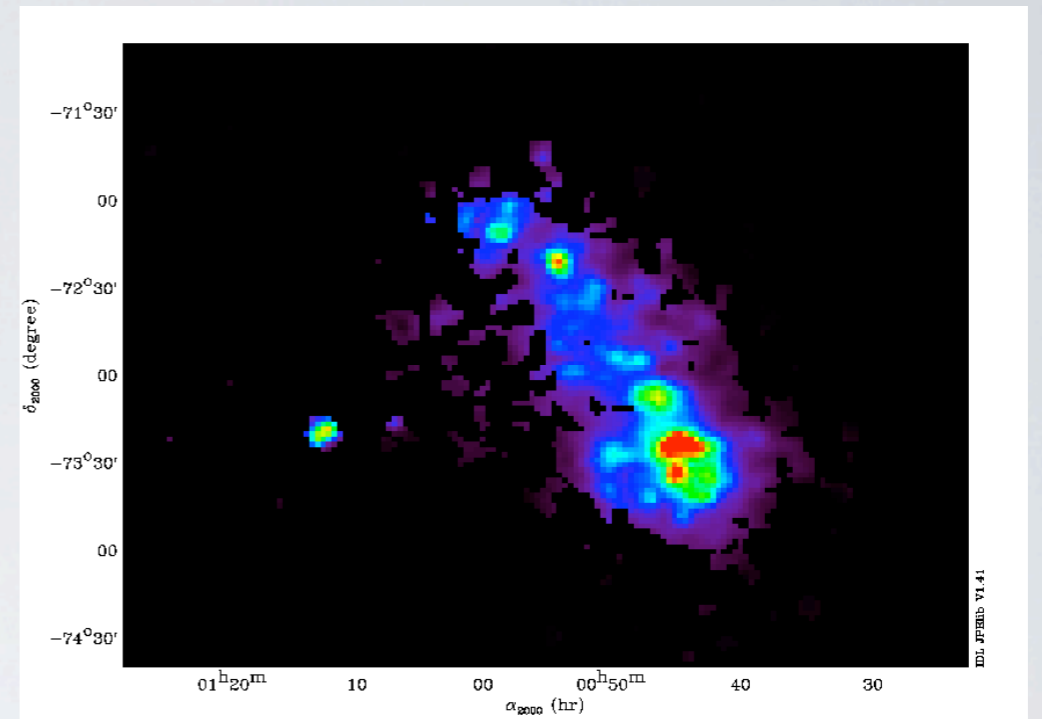
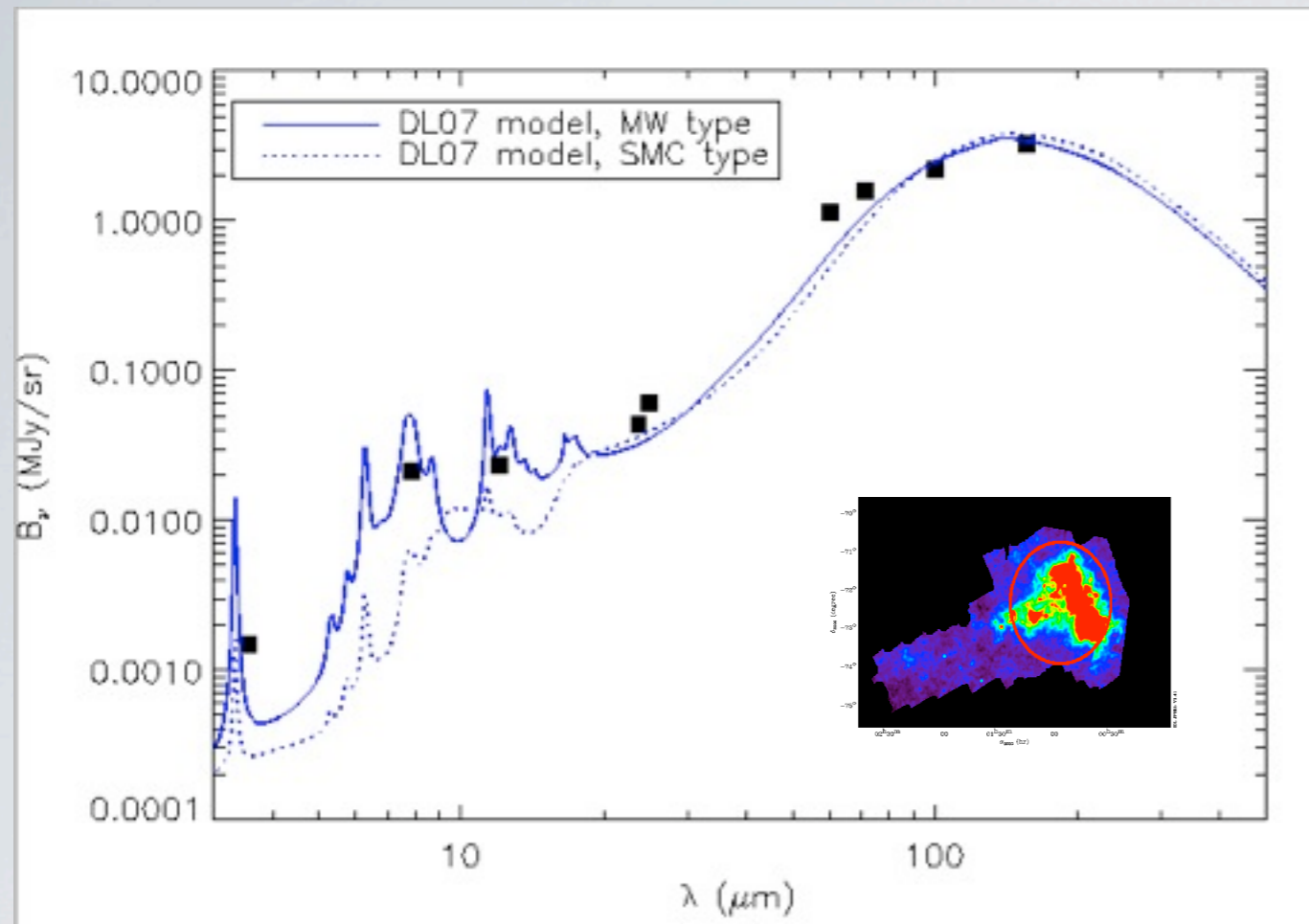
Spitzer + IRAS-IRIS + HI

Study the mid-to-far IR SED of the SMC:

- on a global scale (comparable to more distant galaxies)
- in each point at 3' resolution ($\sim 50\text{pc}$)

to gain informations on q_{PAH} , M_{dust} , dust-to-gas ratio, H_2 without CO...

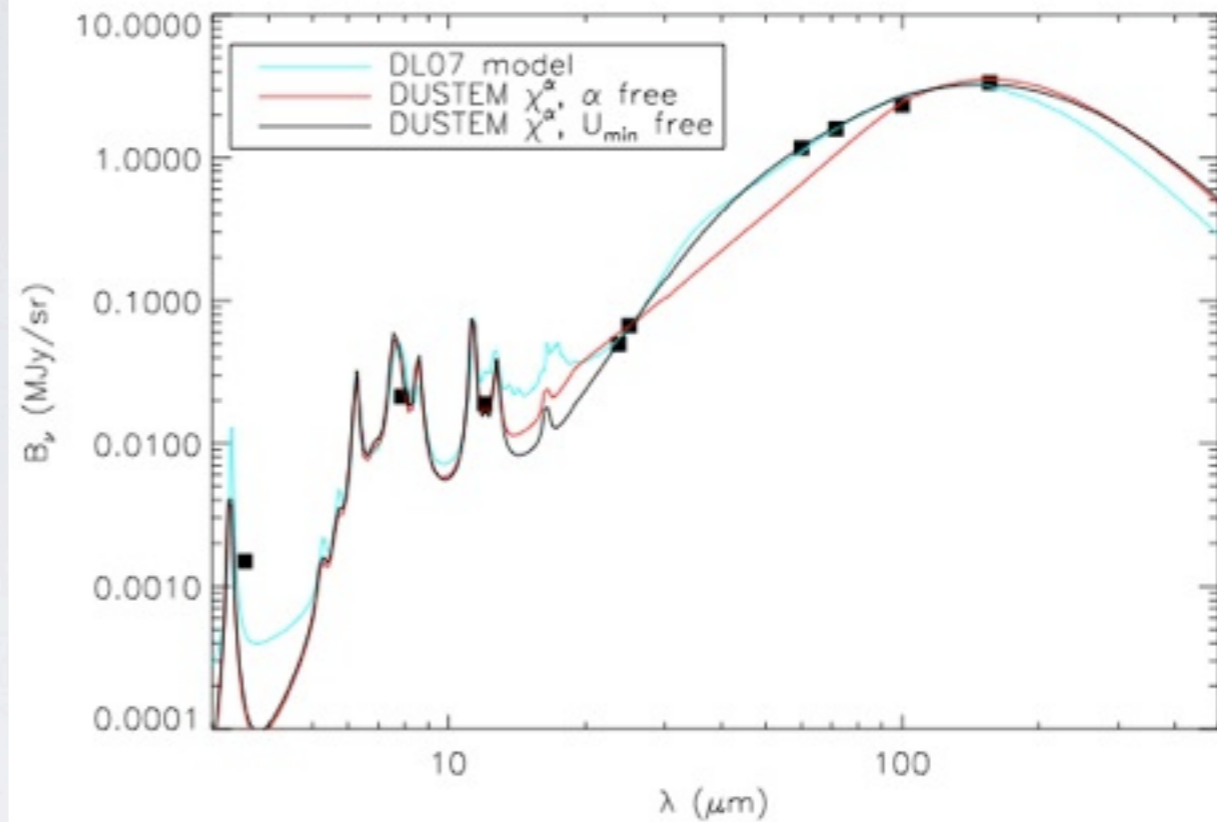
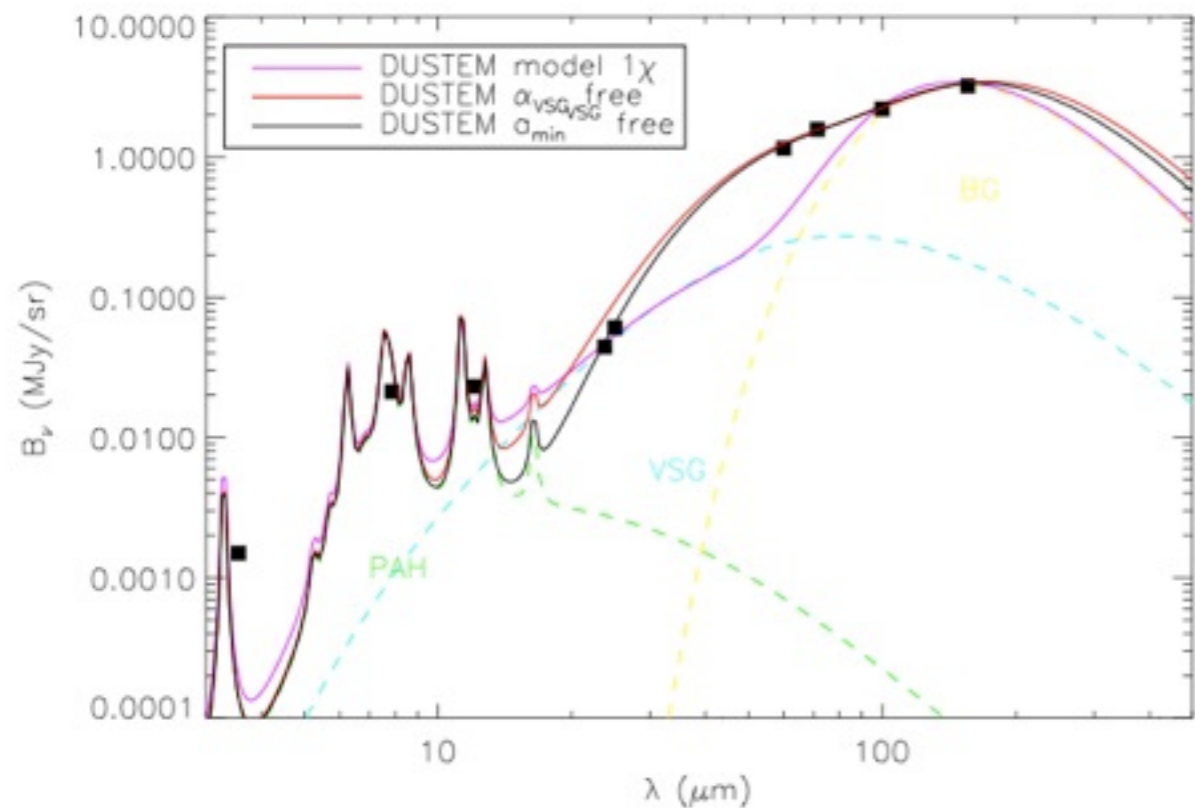
but do we really know how to model the IR SEDs in the SMC?



The 60-70 μm excess

Single ISRF, MW type dust, using either DUSTEM model (Compiègne et al. 2008) or Draine & Li (2007) model

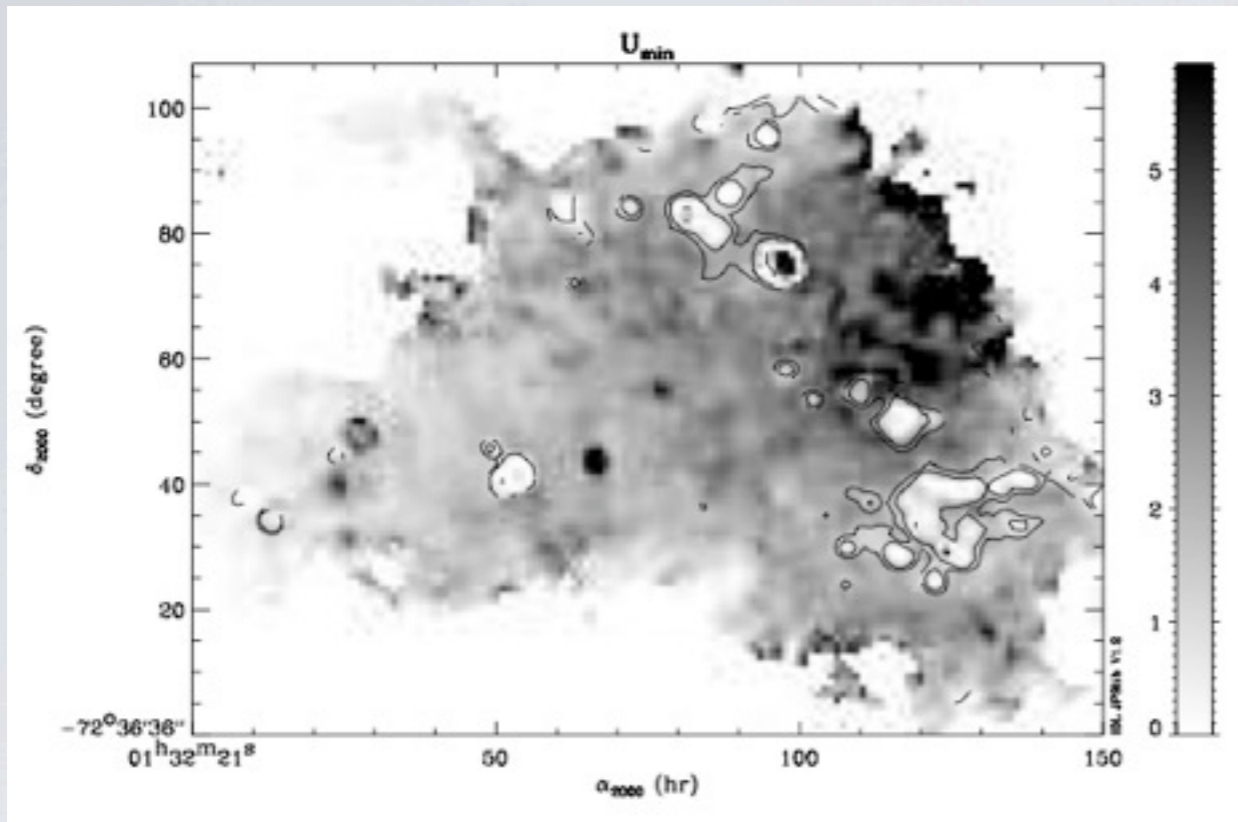
Also observed in the LMC, but higher in the SMC (Bot et al. 2004, Bernard et al. 2008, Paradis et al. 2009)



change of the grain size distribution
 distribution of radiation fields heating the dust
 (Dale et al. 2001, Draine et al. 2007)

$$\int_{U_{min}}^{U_{max}} F_{\lambda}(U, q_{PAH}) U^{-\beta} dU \quad (+ F_{\lambda}(U_{min}, q_{PAH}))?$$

the excess can be explained by a mix of RF with U_{min} free, with
 or without an additional component
 many assumptions have to be made, unclear which are justified
uncertainty on the mass by a factor 2-5

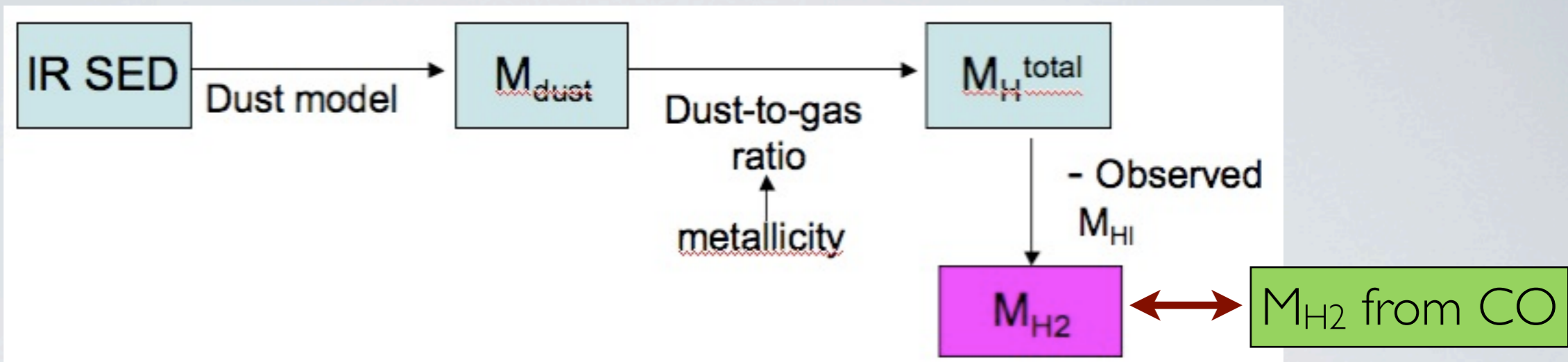


U_{\min} with PDR
fraction contours

change of the grain size distribution
distribution of radiation fields heating the dust
(Dale et al. 2001, Draine et al. 2007)

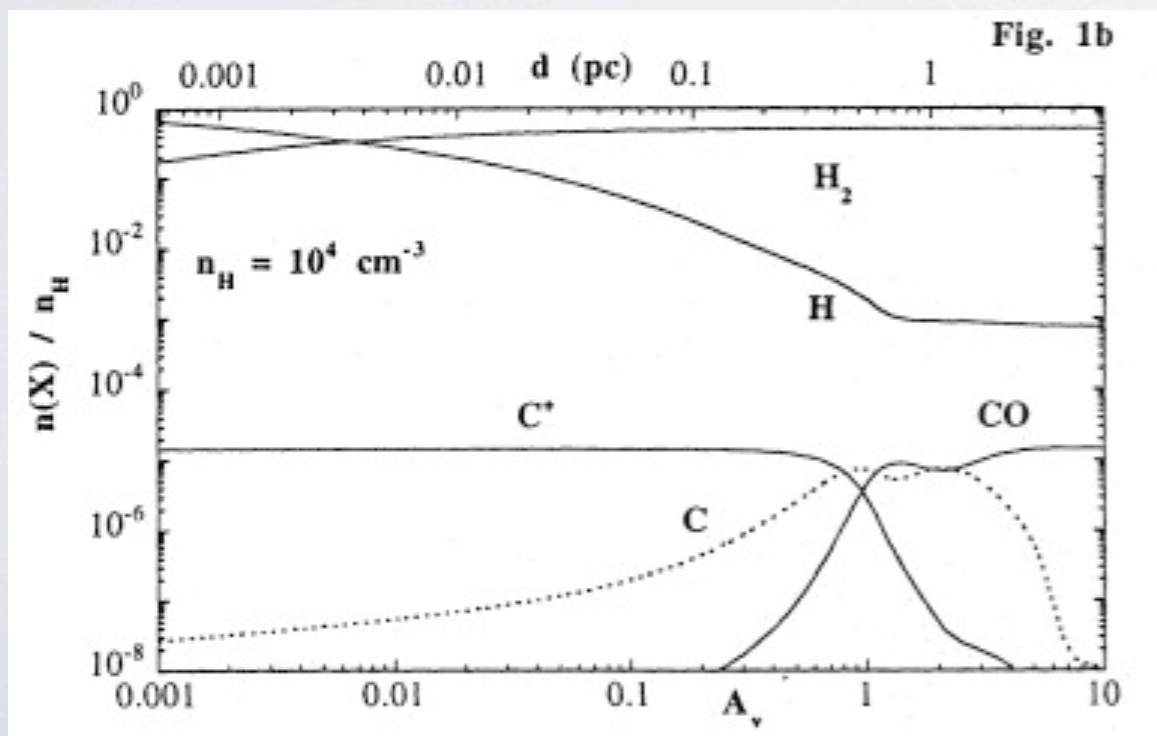
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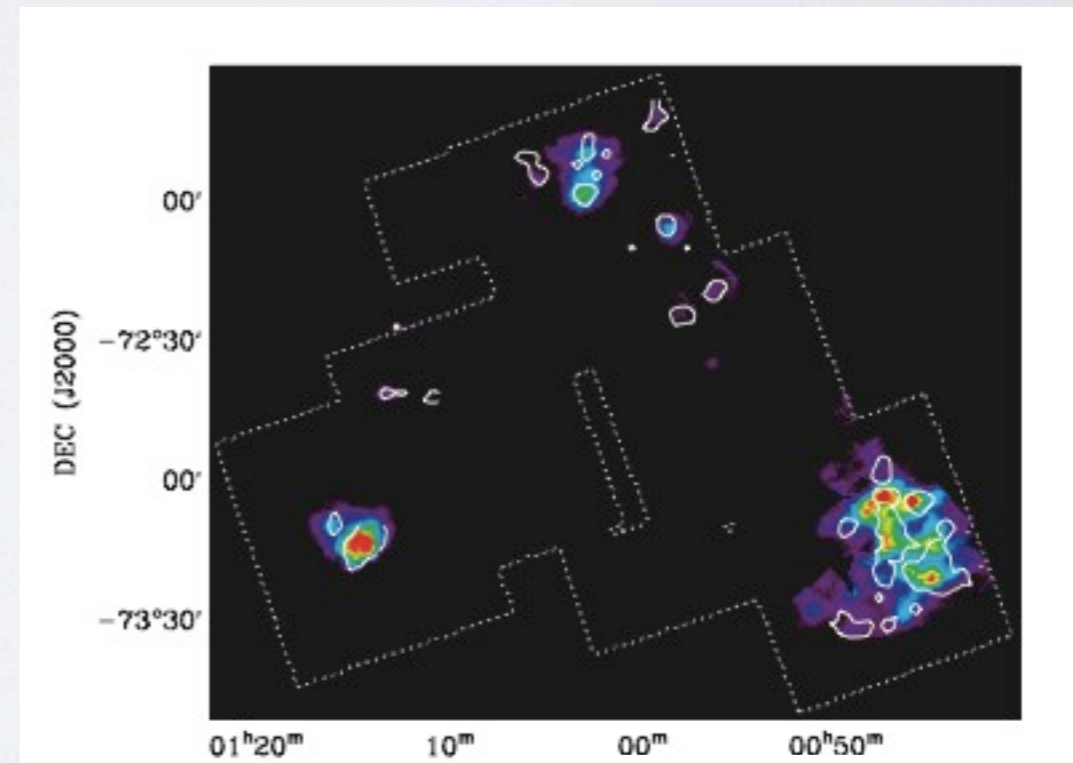


the FIR excess

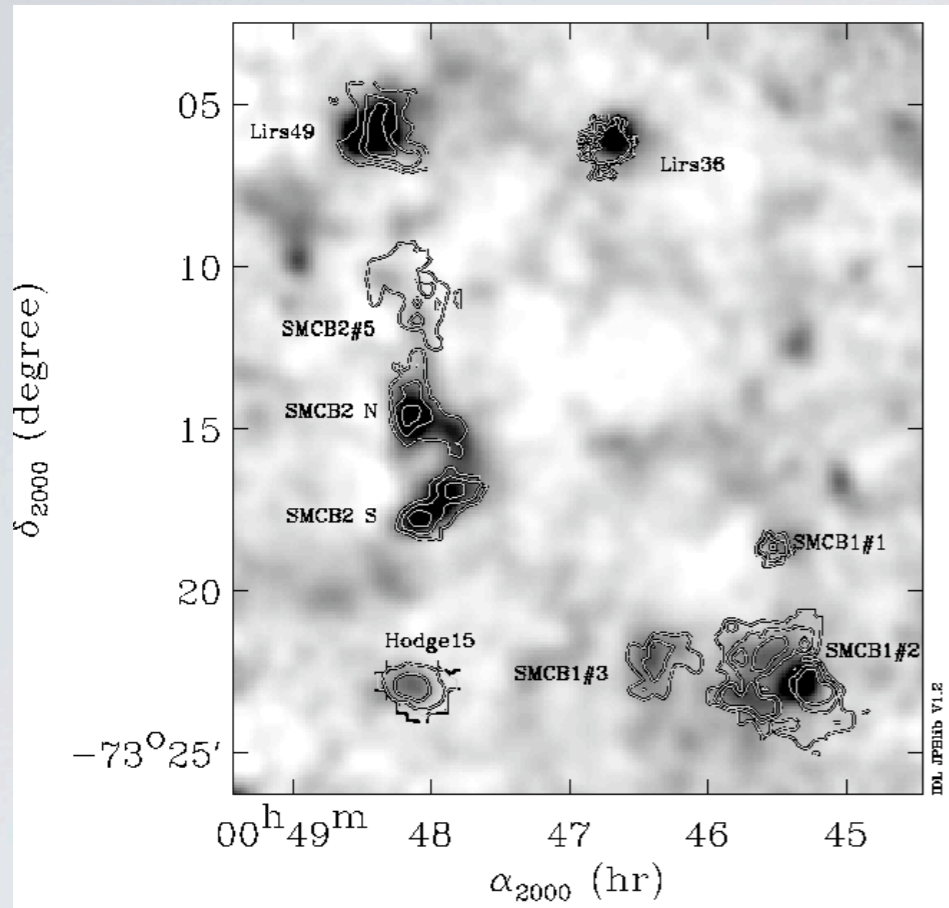
depending on the assumed dust/gas ratio, dust model, ...:
 M_{H_2} from dust = $[3-100] \times M_{H_2}$ from CO (Mizuno et al. 2001)
 H_2 from the envelopes of molecular clouds = "dark H_2 "



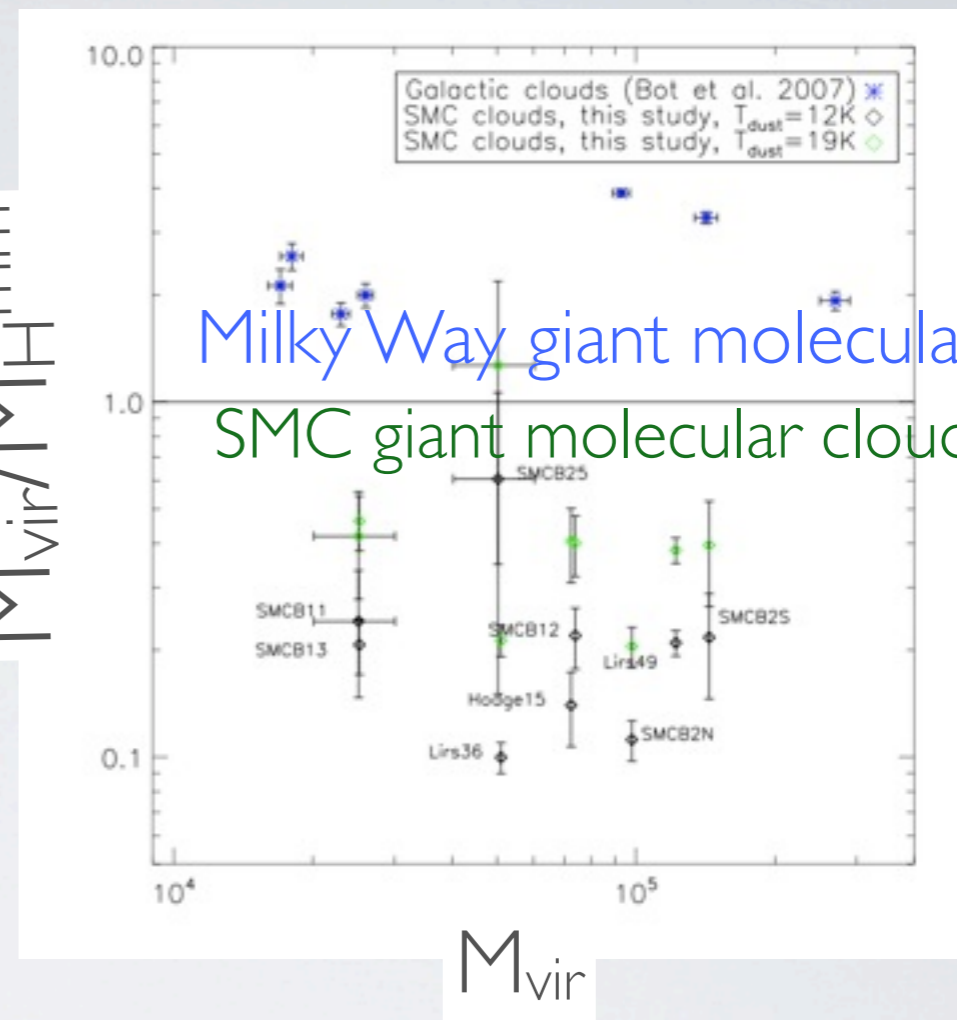
Lequeux et al. 1994



Leroy et al. (2007)



$M_{\text{vir}}/M_{\text{H}2\text{mm}}$



Milky Way giant molecular clouds
SMC giant molecular clouds

FIR excess confirmed by sub-mm observations

South-west region of the SMC

SIMBA @1.2mm

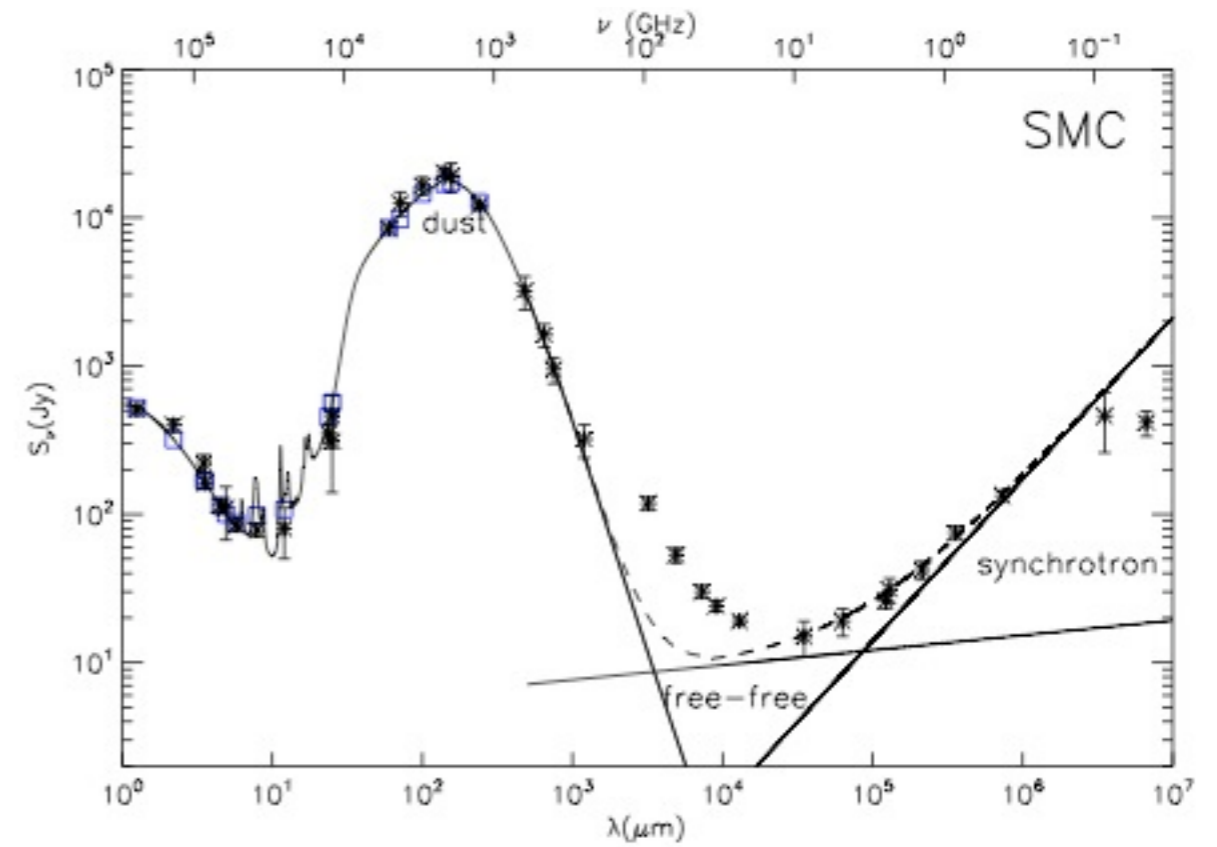
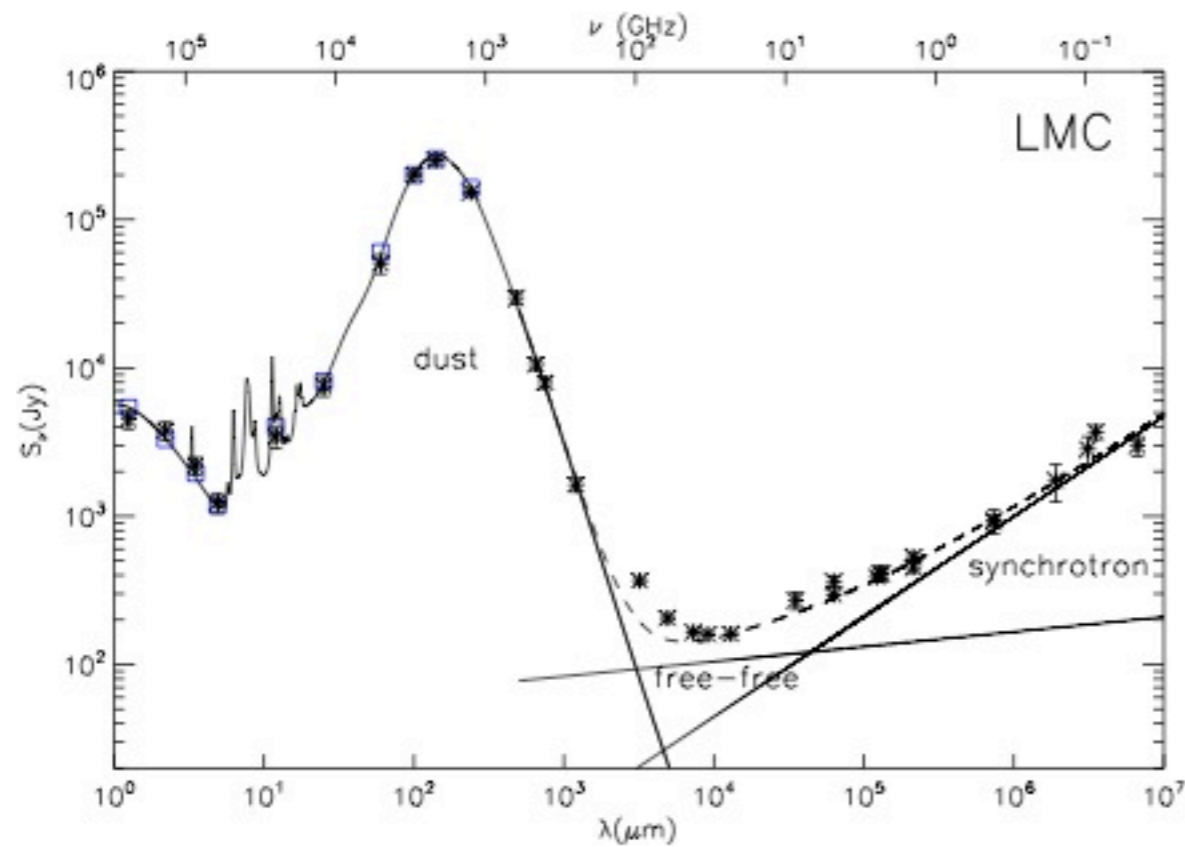
LABOCA/APEX @870μm

free-free removed

$M_{\text{H}2}$ from dust = $4 \times M_{\text{virial}}$ from CO data

but is this all cold dust?

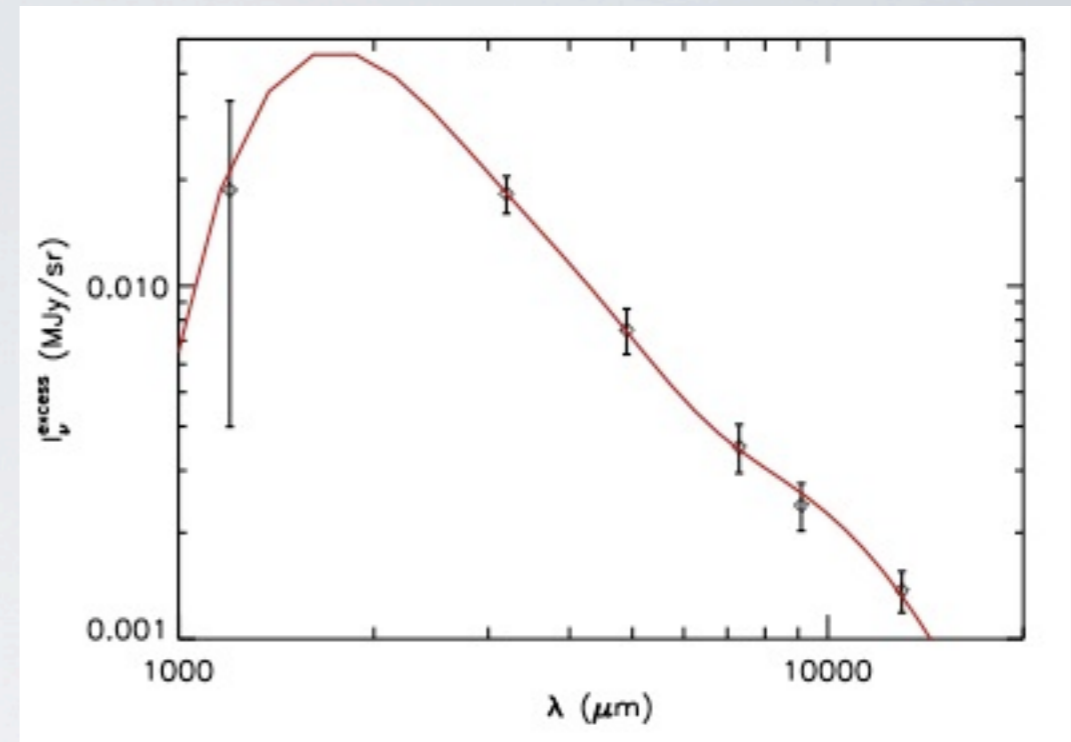
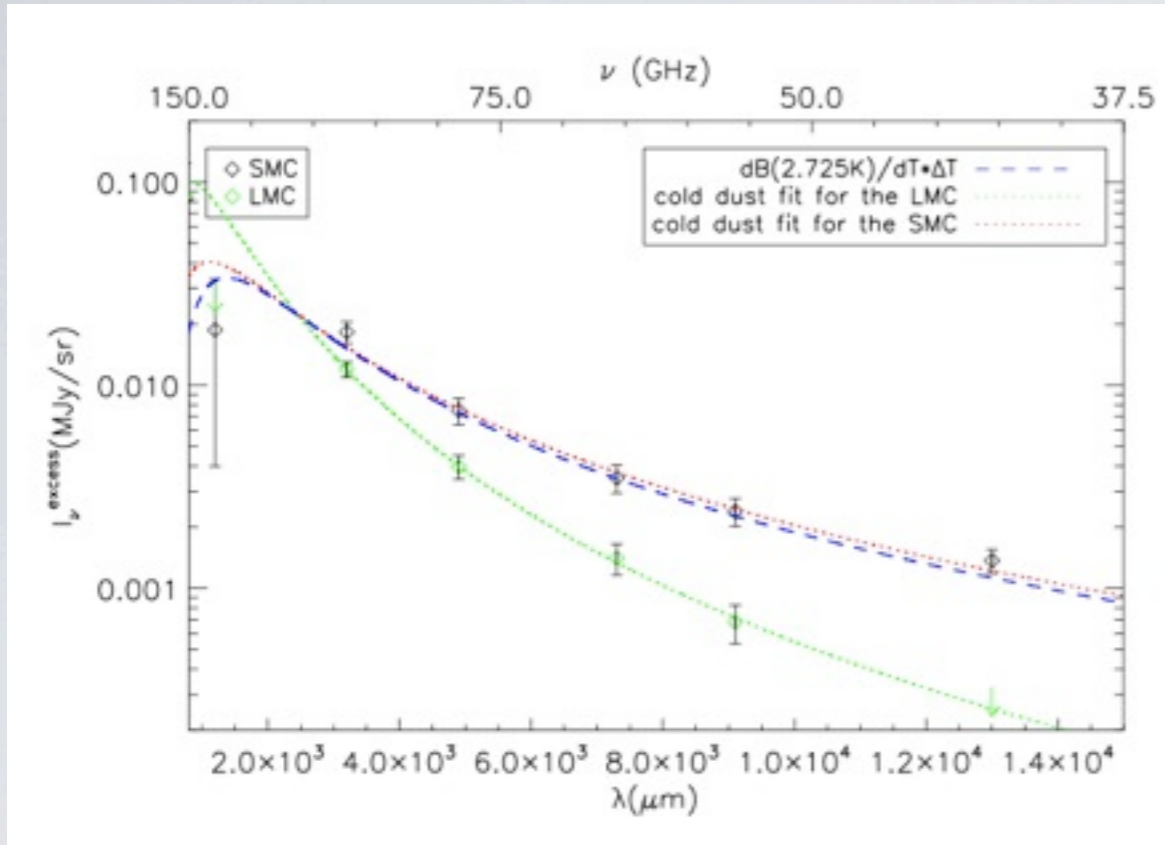
Rubio et al. 2004
Bot et al. 2007
Bot et al. 2010b



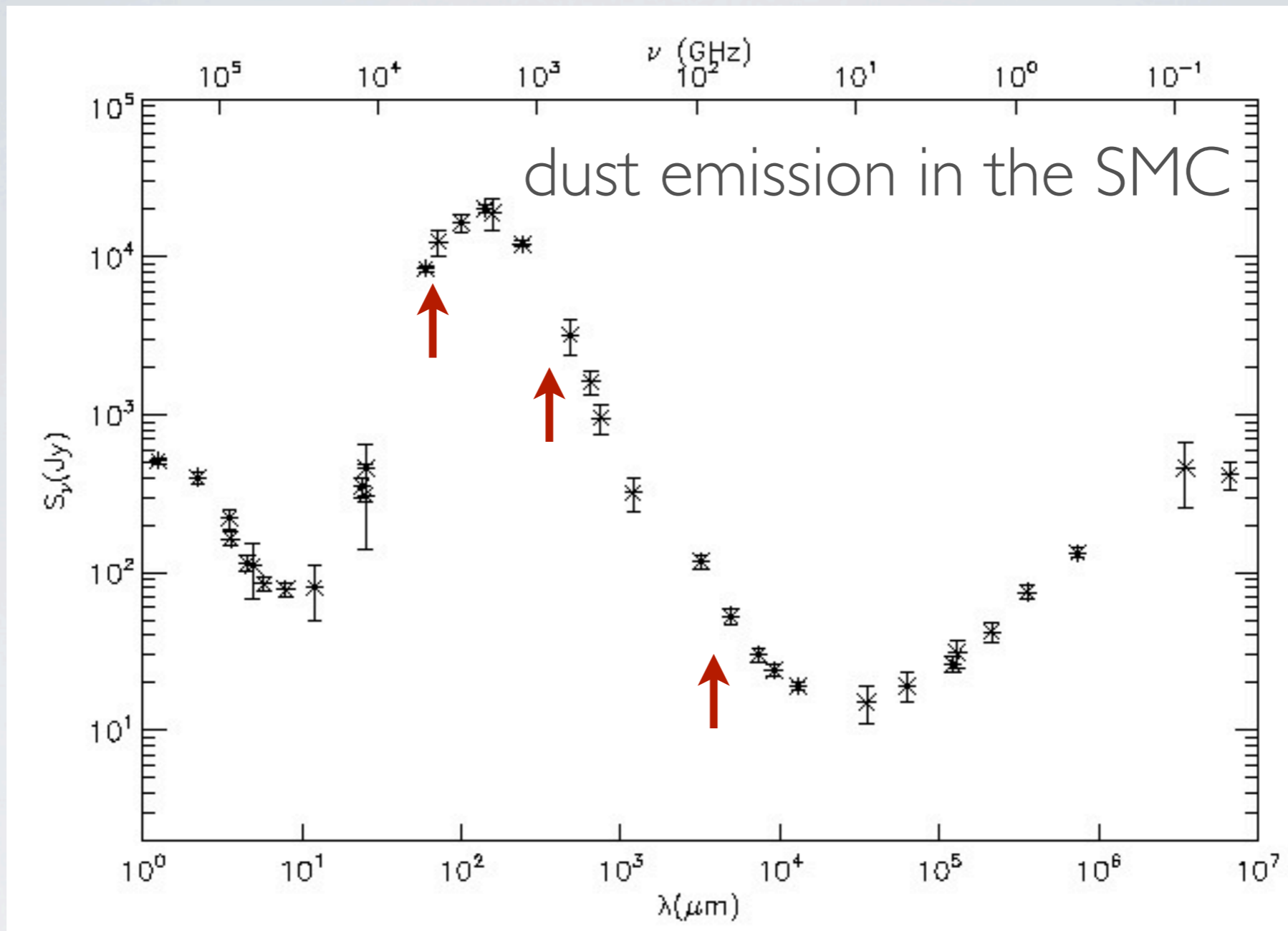
The mm-cm excess

integrated SED of the SMC and the LMC
 combining IRAS, DIRBE, TopHat, WMAP and radio data
 Draine & Li (2007) dust model + free-free + synchrotron
 small excess in the LMC, clear cm excess in the SMC!

Israel et al. 2010
 Bot et al. 2010



- cold dust is rejected ($\sim 3\text{K}$)
- CMB fluctuations?
right SED but 5% probability and also in LMC
- TLS/DICD effects for amorphous grains?
not flat enough for the SMC excess, works for LMC
- anomalous/spinning dust grains?
works but w/ 3 components (diffuse, $n_{\text{H}} = 10^3$ & 10^5cm^{-2} PDRs)



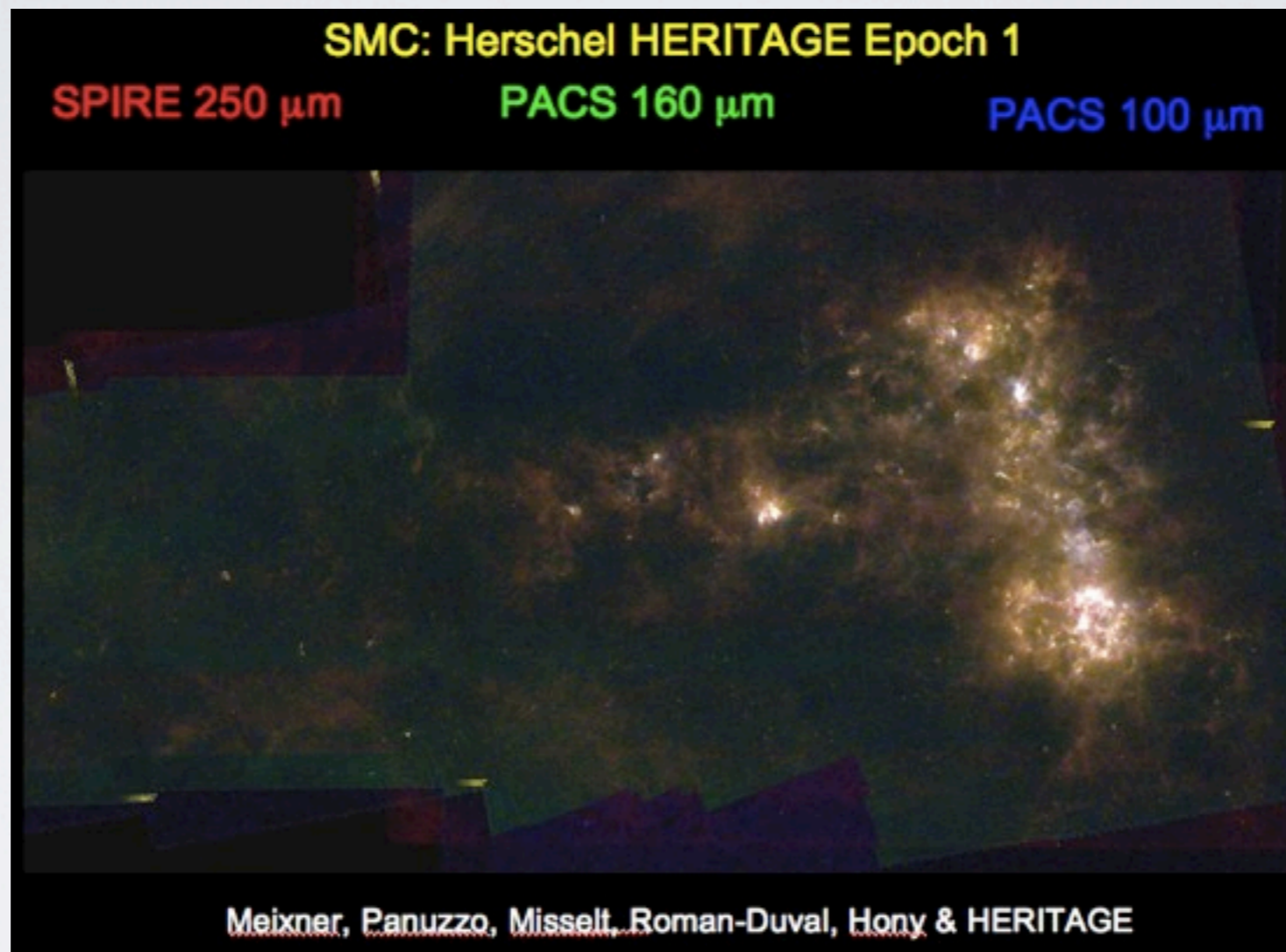
60-70 μm excess: mix of radiation field, change of size distribution

FIR excess: "dark" molecular gas

cm-mm excess: CMB, spinning dust, amorphous dust effects

do we need to reconsider dust models at low Z ?

Adding Herschel and Planck data will help to probe the spatial distributions with respect to other tracers, constrain the dust masses,...



HERITAGE: (Herschel inventory of the Agents of Galaxy Evolution, Meixner et al.) Herschel key project on the Magellanic Clouds