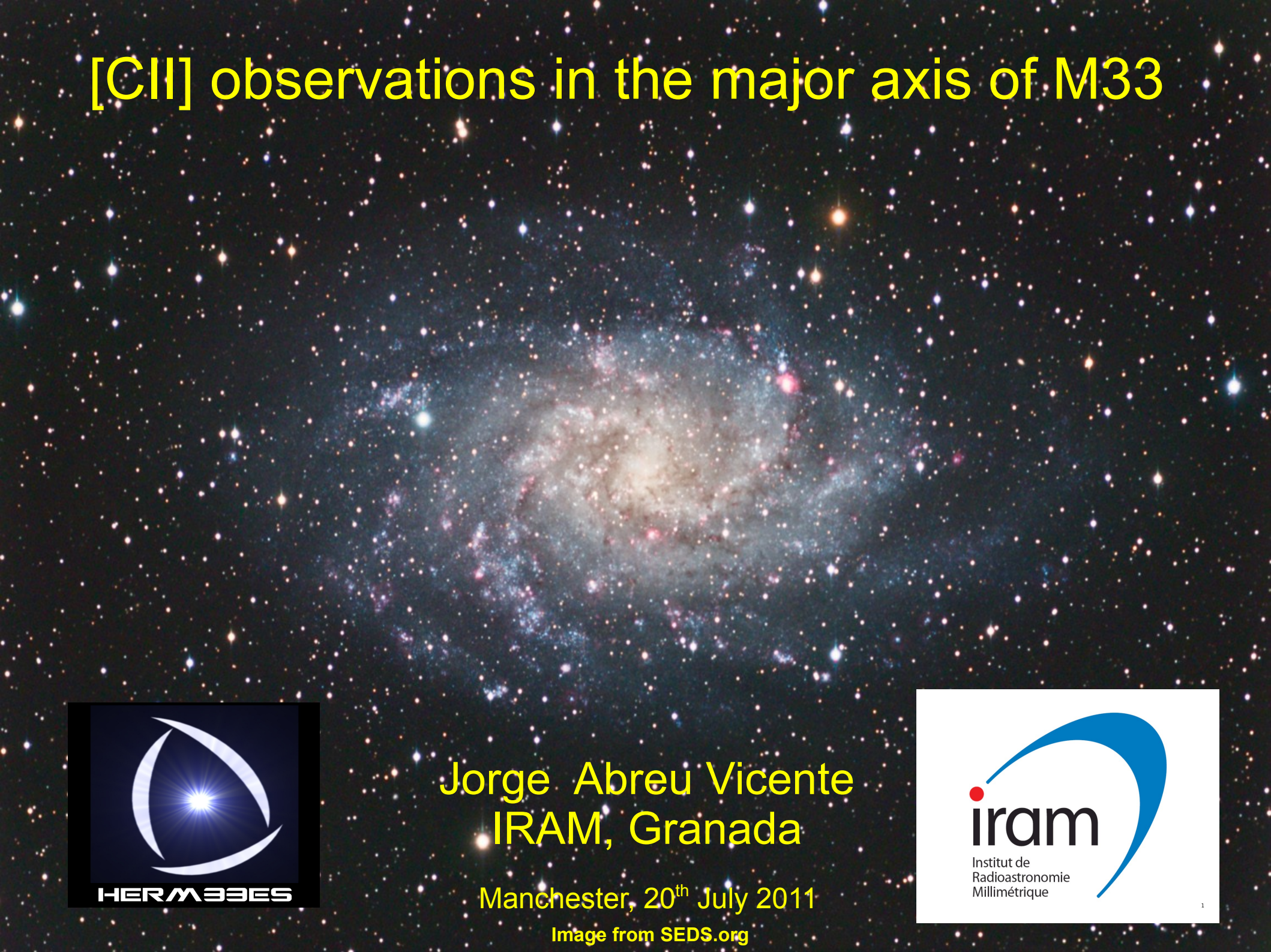
[CII] observations in the major axis of M33



Jorge Abreu Vicente
IRAM, Granada

Manchester, 20th July 2011

Image from SEDS.org

Introduction

The **Her**schel **M33** **E**xtended **S**urvey (**HerM33ES**)

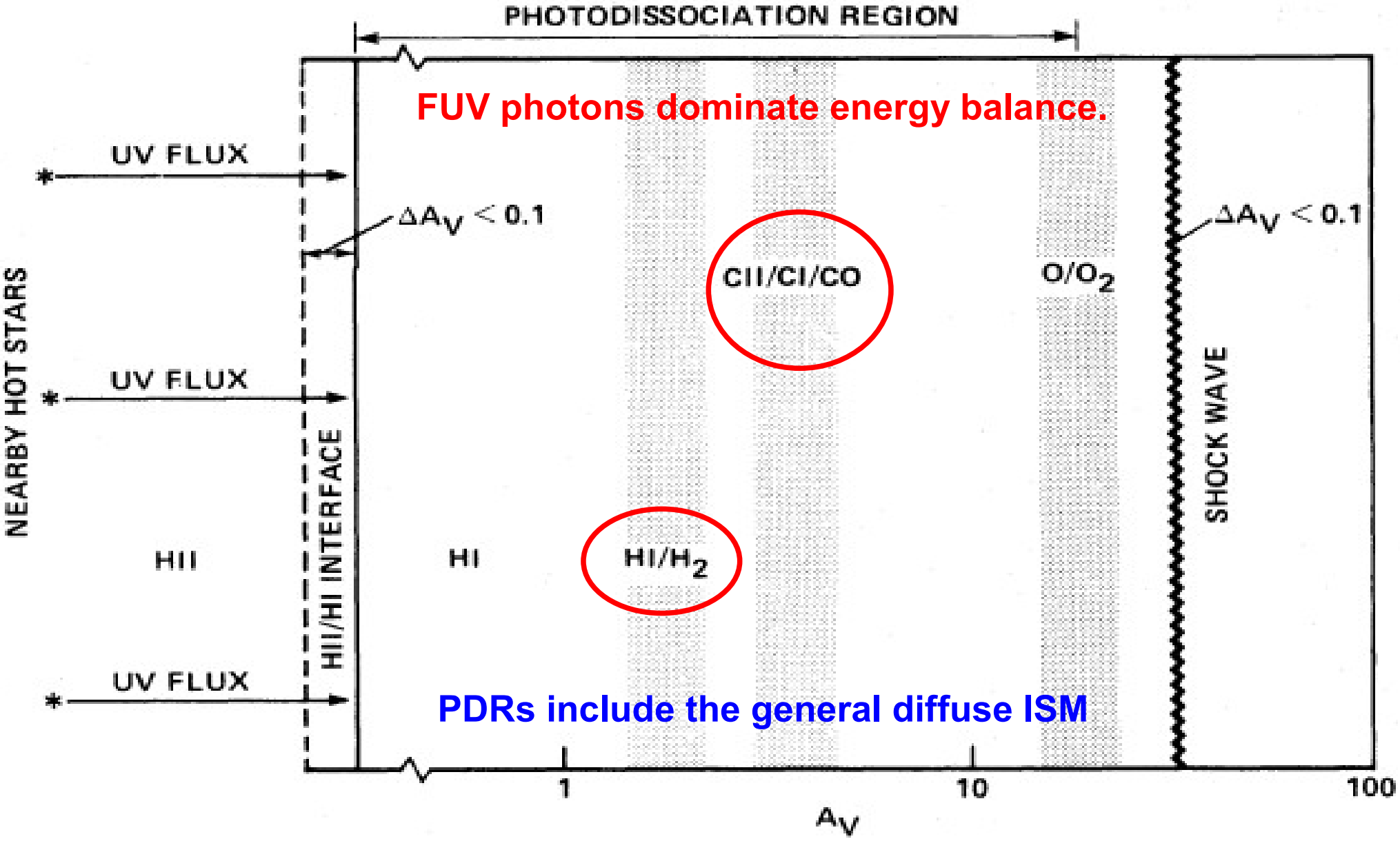
- **Herschel open time key project with almost 200 hours.**
- **High spatial and spectral resolution of:**
  - **Interstellar medium (ISM) cooling lines.**
  - **Far infrared (FIR) dust continuum.**

Key science topics

Energy balance of the ISM as function of galactic environment.

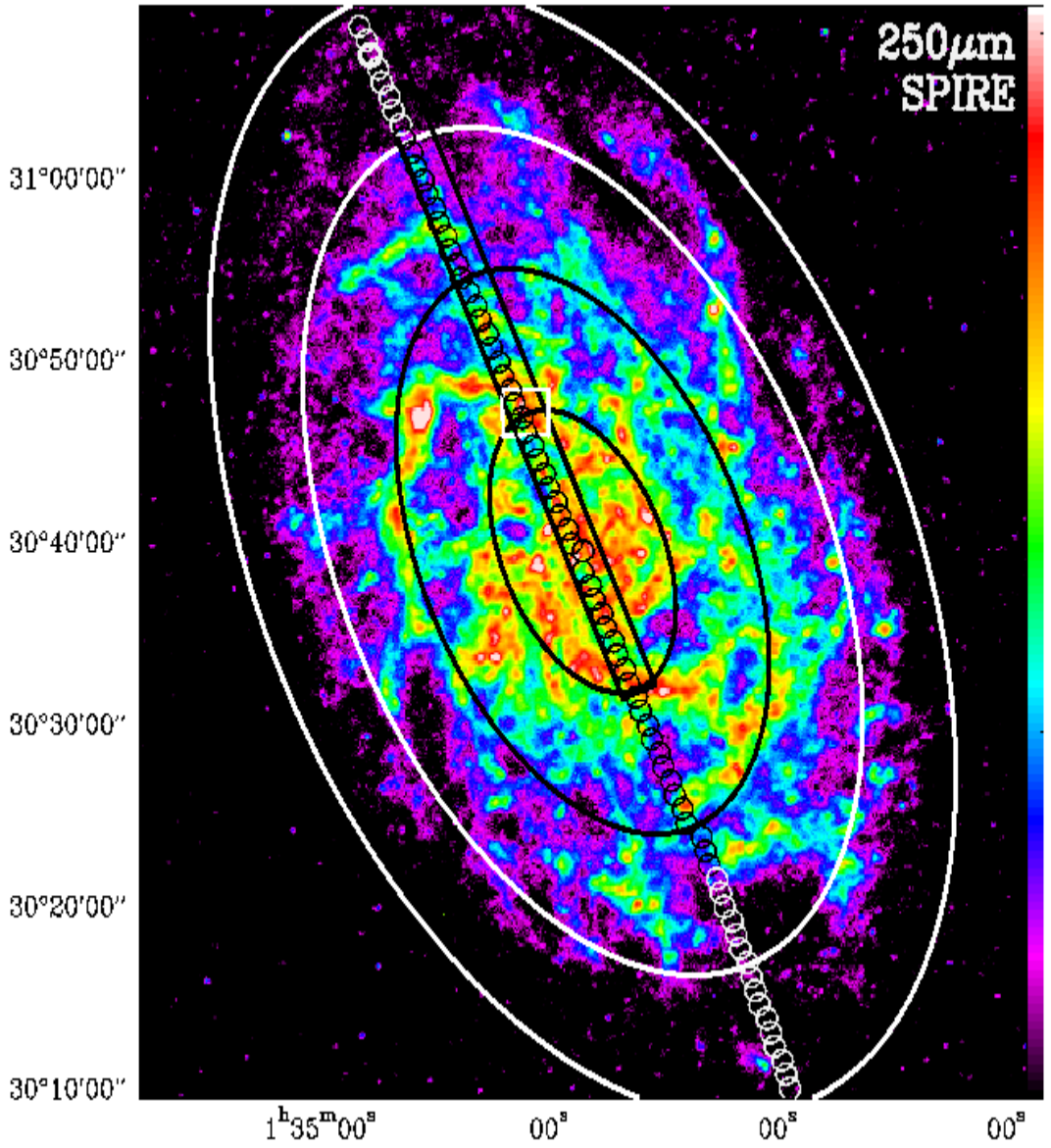
- **Ratio between dust continumm cooling and gas cooling.**
- **Parameters controlling the star formation rate.**
- **Formation of molecular clouds.**
- **[CII] contribution from different ISM phases.**

Photon dominated regions (PDR)



Tielens & Hollenback 1985

Why M33?

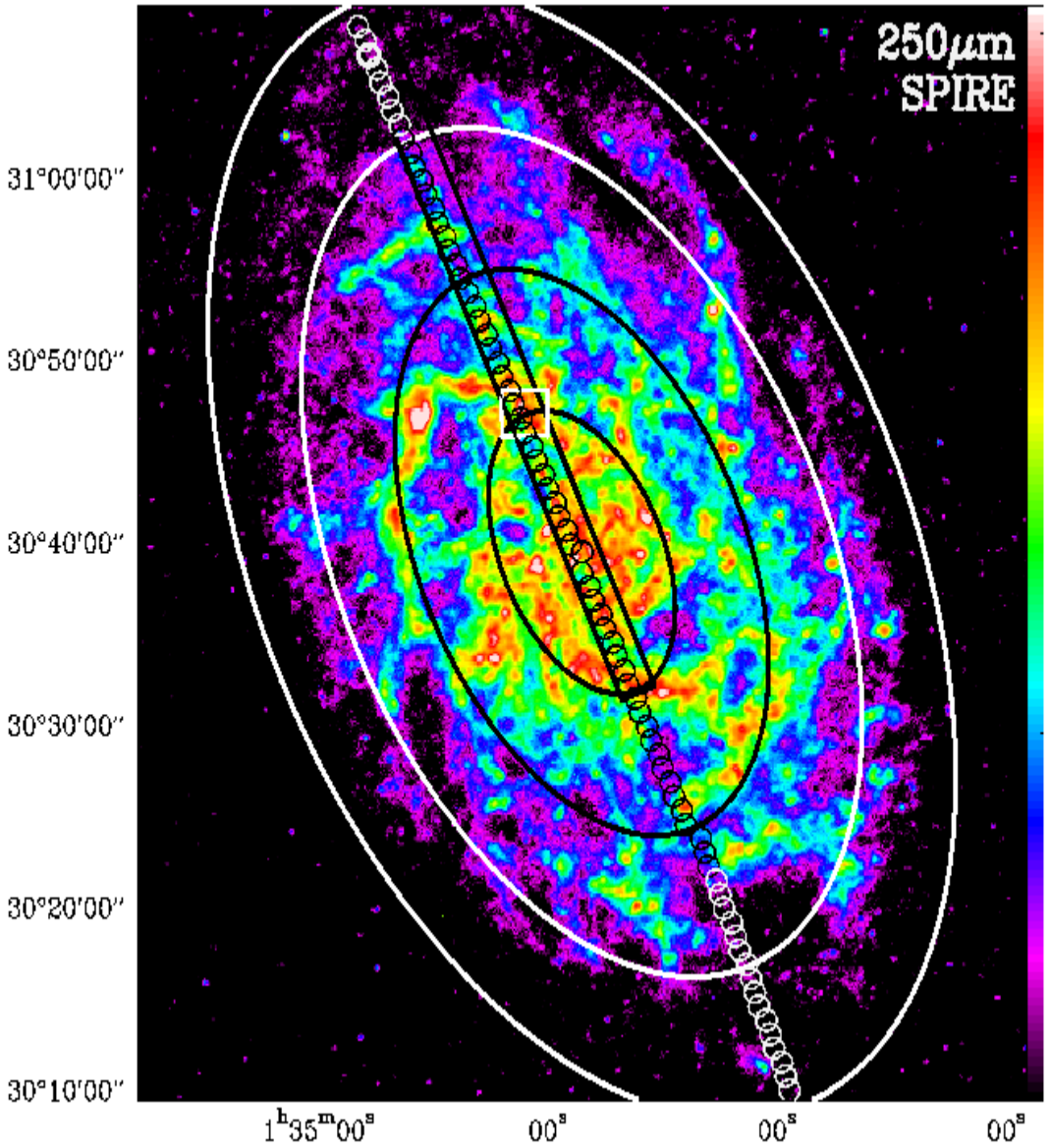


Kramer et al. 2010

- **Very nearby (840kpc) (12" (500μm)=57pc) Resolve individual molecular clouds.**
- **Gas rich galaxy.**
- **Is almost face-on → allow dynamical studies of it disk**
- **It is no perturbed as Magellanic Clouds**
- **It is one of the most studied galaxies. Multiwavelength literature available.**
- **There are no studies in sub-mm or FIR at high angular or spectral resolution.**

ISO/LWS[CII] and complementary data

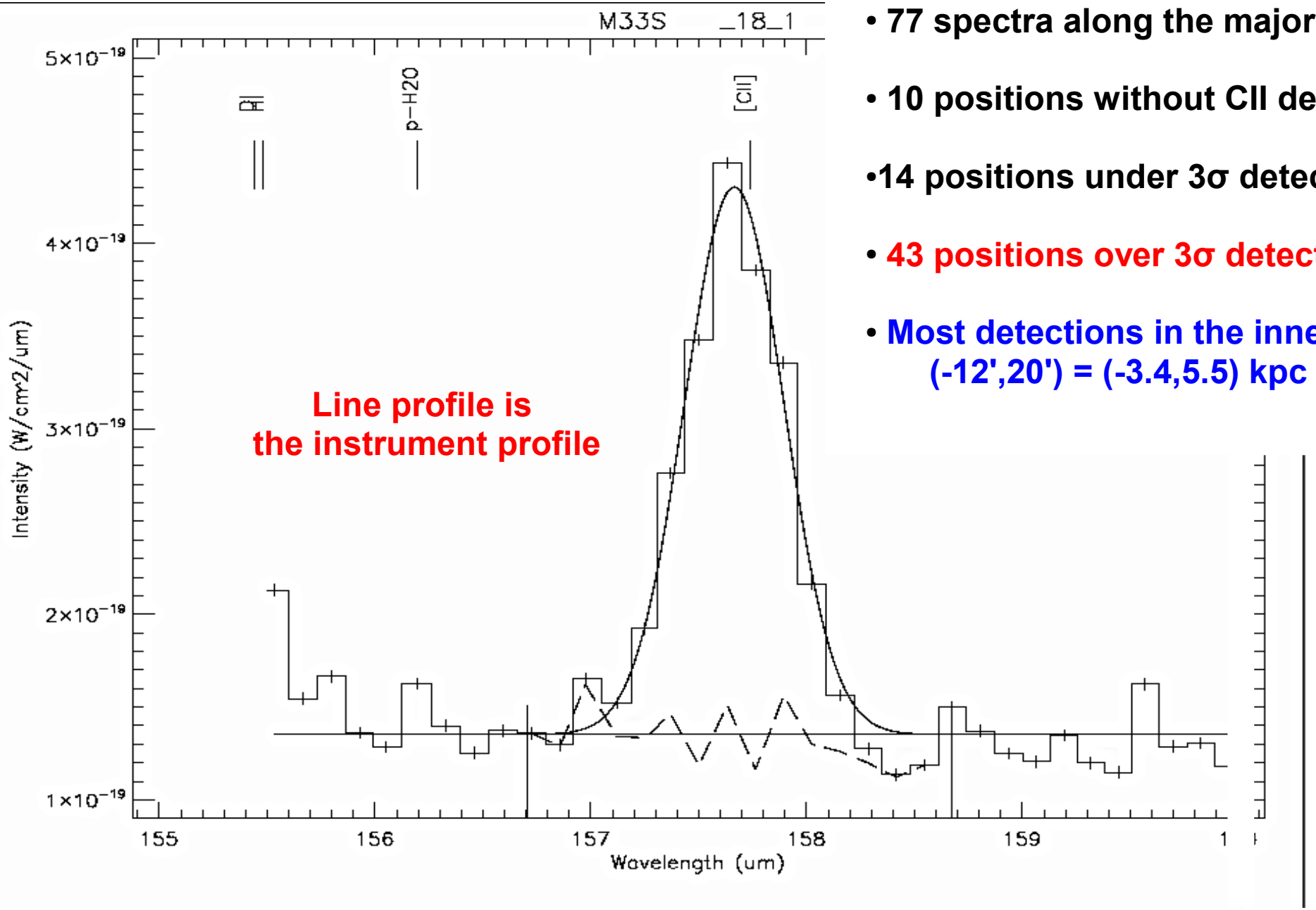
ISO/LWS [CII] (158μm) Data



Kramer et al. 2010

- **ISO/LWS [CII] 158μm from ISO DATA ARCHIVE (IDA)**
- **77 positions along the major axis of M33**
- **69.4“ resolution → 283 pc**
- **Cannot resolve individual clouds → Mixture of ISM phases.**

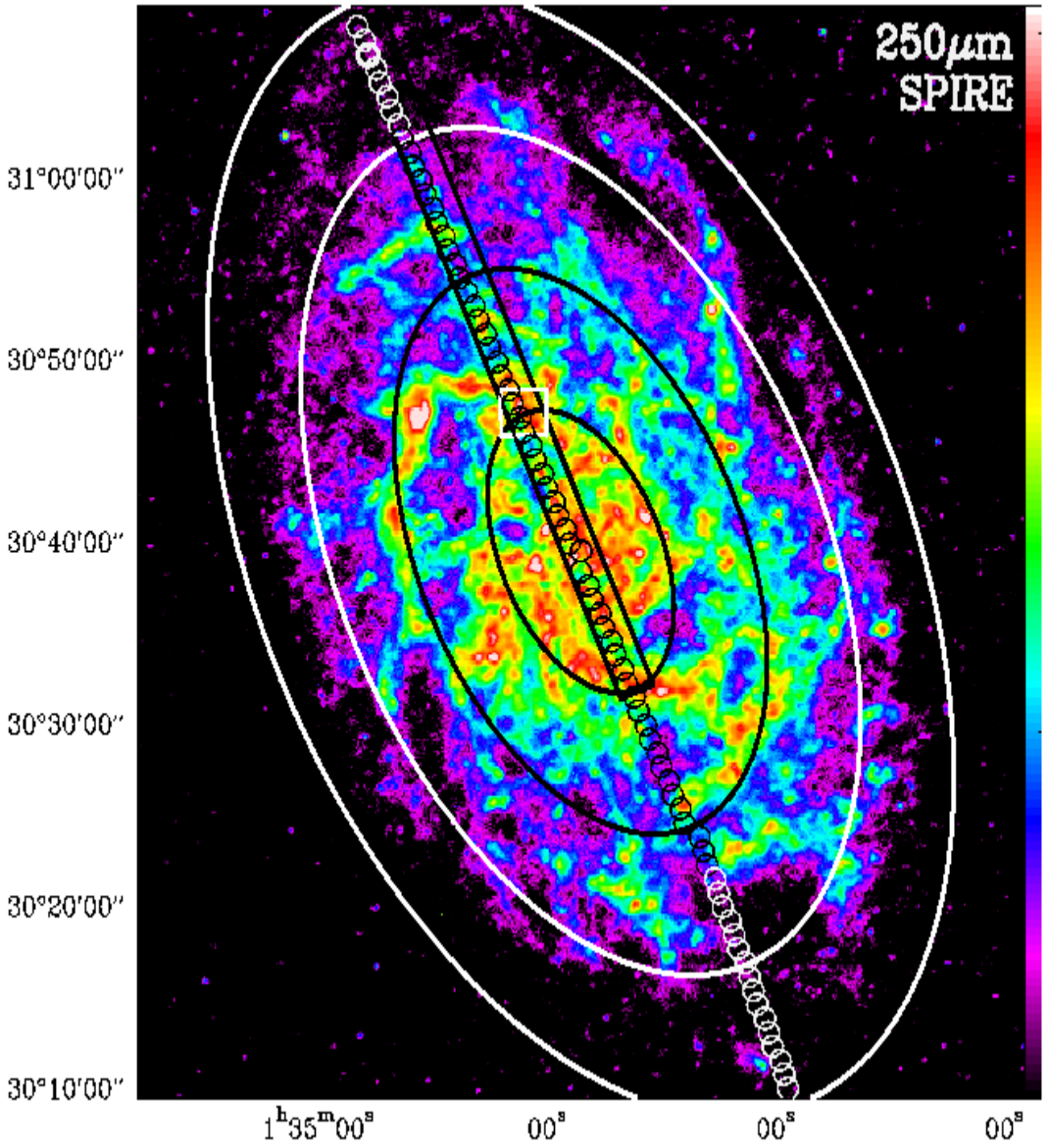
[CII] Spectra



Line profile is the instrument profile

- **77 spectra along the major axis**
- **10 positions without CII detection**
- **14 positions under 3σ detections**
- **43 positions over 3σ detections**
- **Most detections in the inner (-12',20') = (-3.4,5.5) kpc**

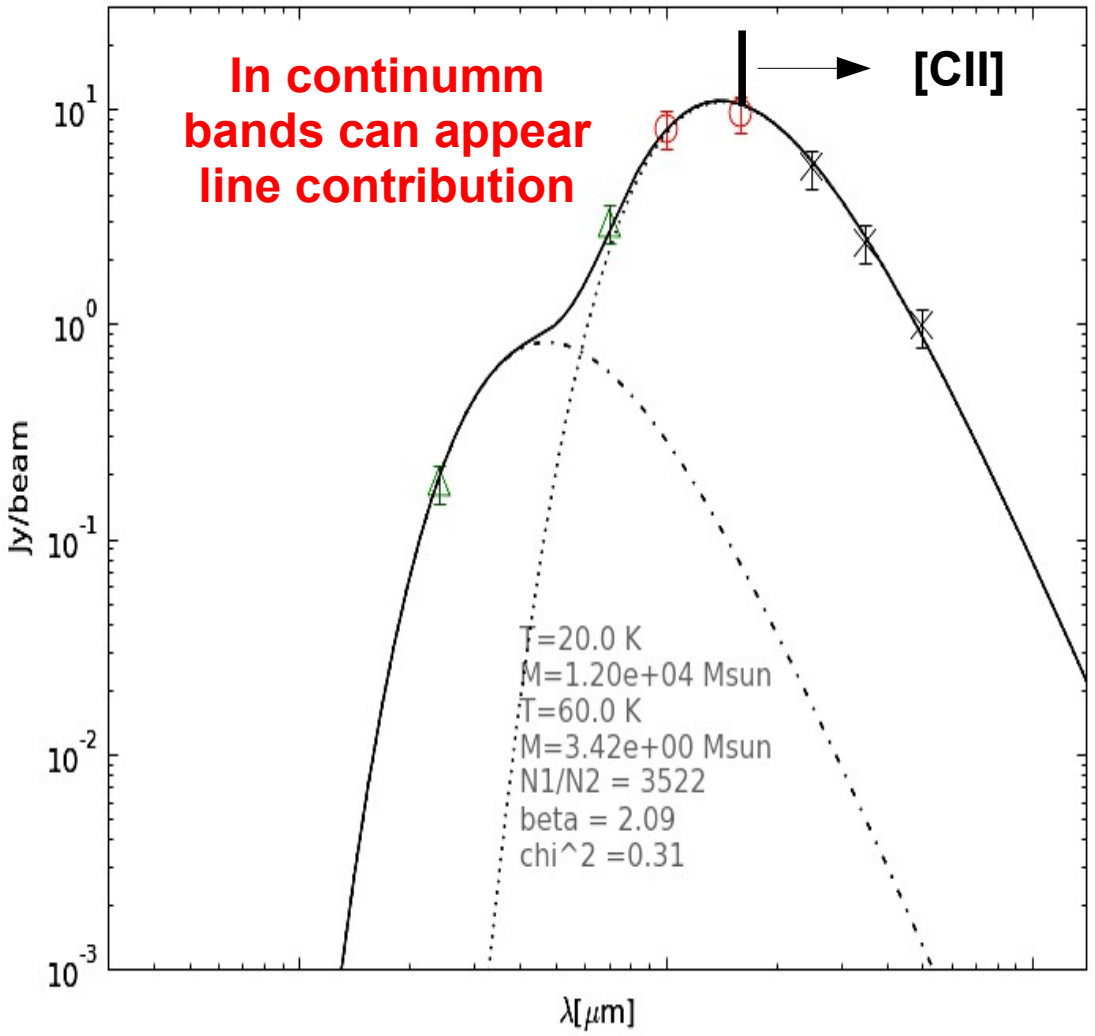
Complementary data



Far Infrared (FIR) continuum

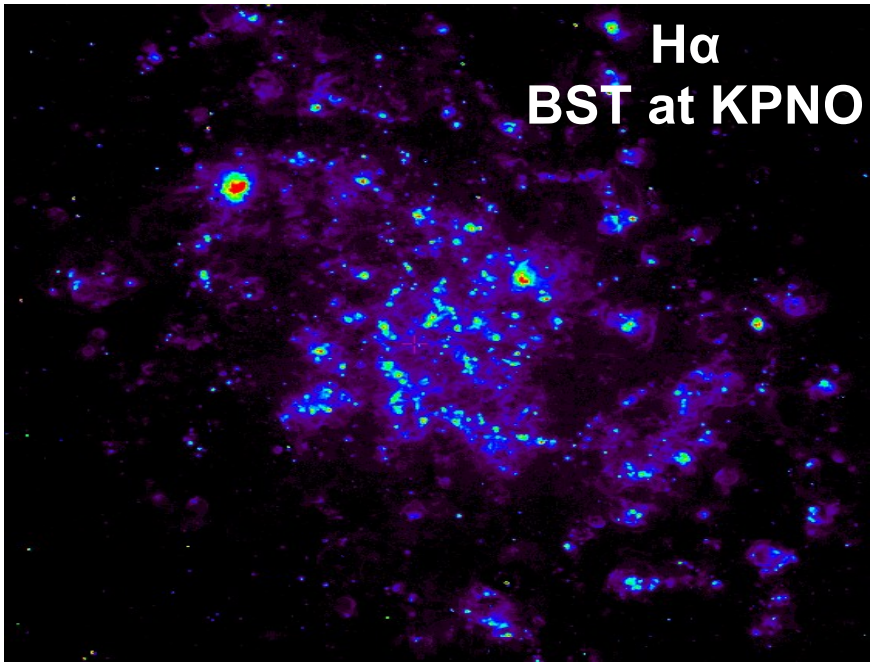
- **MIPS/Spitzer 24 and 70μm (Tabatabaei et al. 2007)**
- **PACS/Herschel 100(3.2“) & 160(6.4“)μm (Kramer et al. 2010)**
- **SPIRE/Herschel 250, 350 & 500μm (Kramer et al. 2010)**

Total Infra Red (TIR) calculation

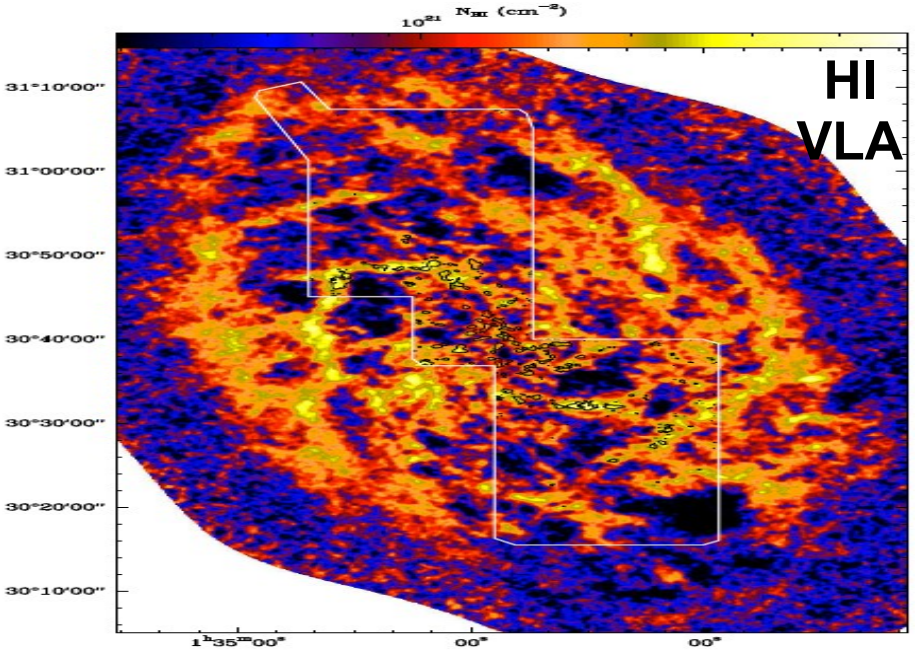


- **SPIRE, PACS and MIPS data used. (24, 70, 100, 160, 250 350 & 500 μm)**
- **24μm is used to estimate warm component**
- **2 isothermal components greybody fit**
- **Integrate between 1μm – 1100μm**
- **X^2 = (1,3) in positions studied (-12',20') = (-3.4,5.5) kpc**

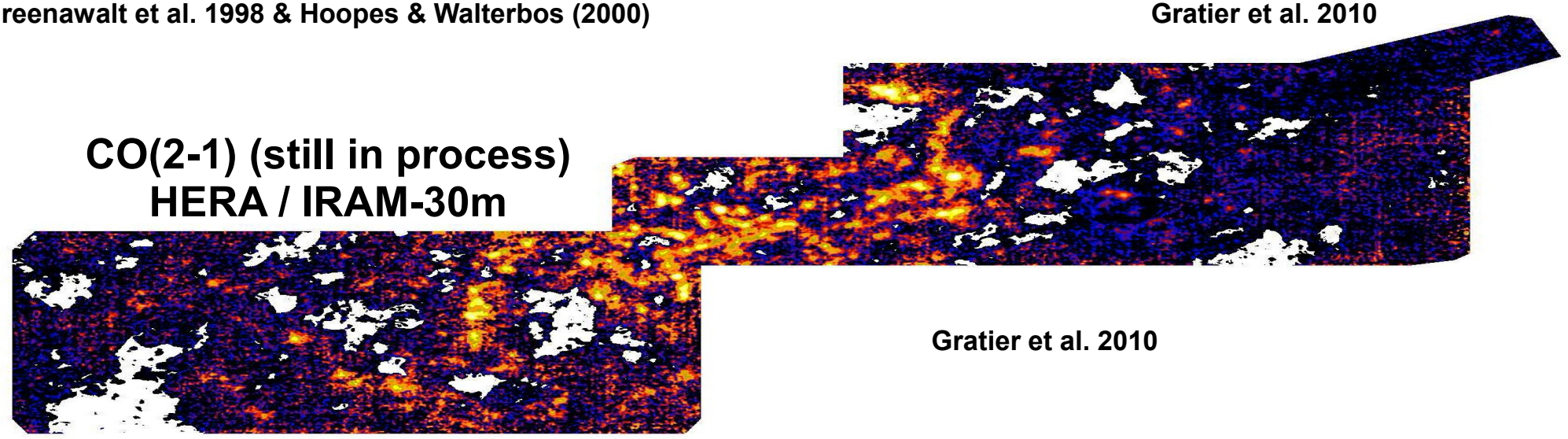
Complementary data



Greenawalt et al. 1998 & Hoopes & Walterbos (2000)



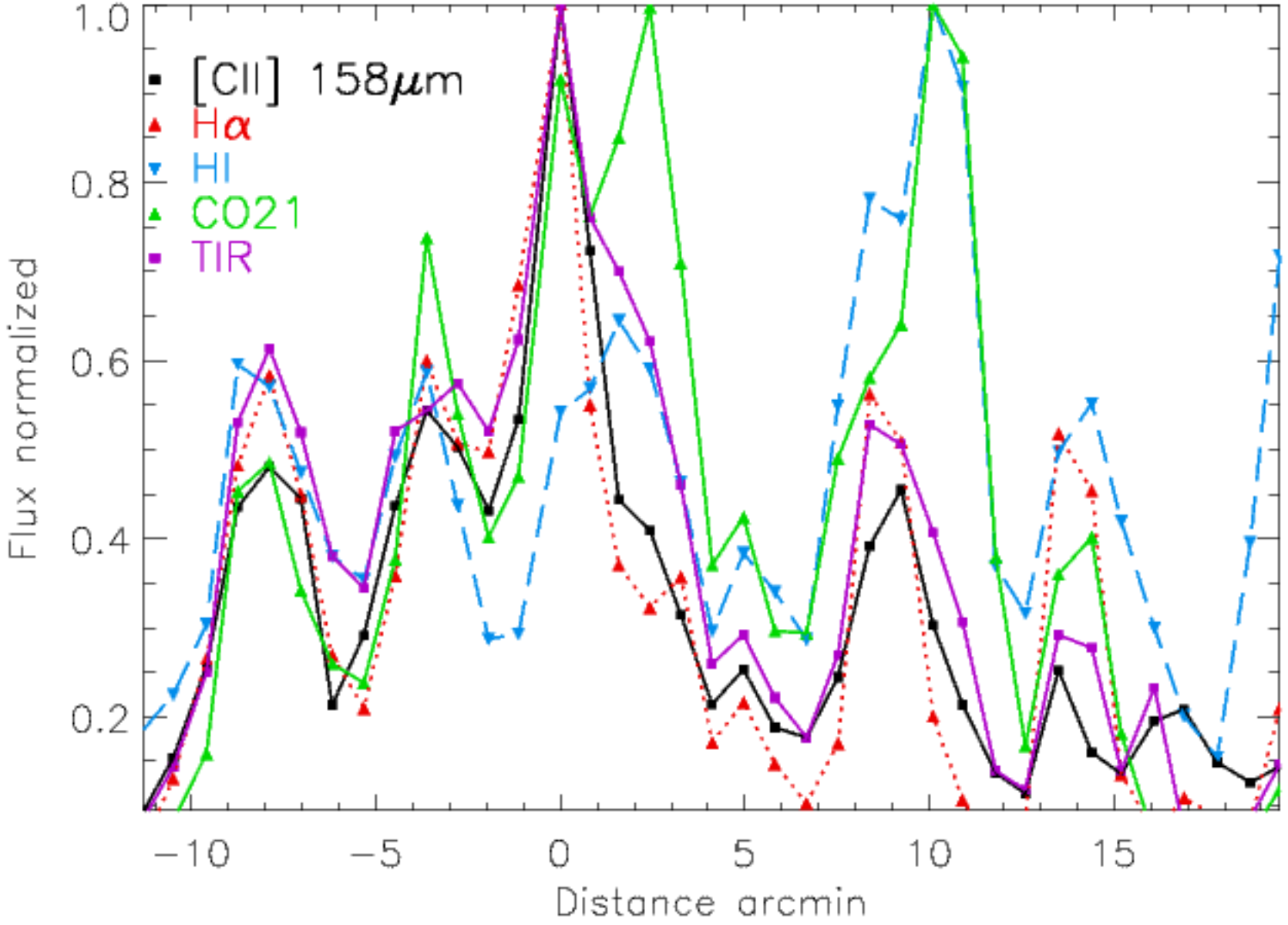
Gratier et al. 2010



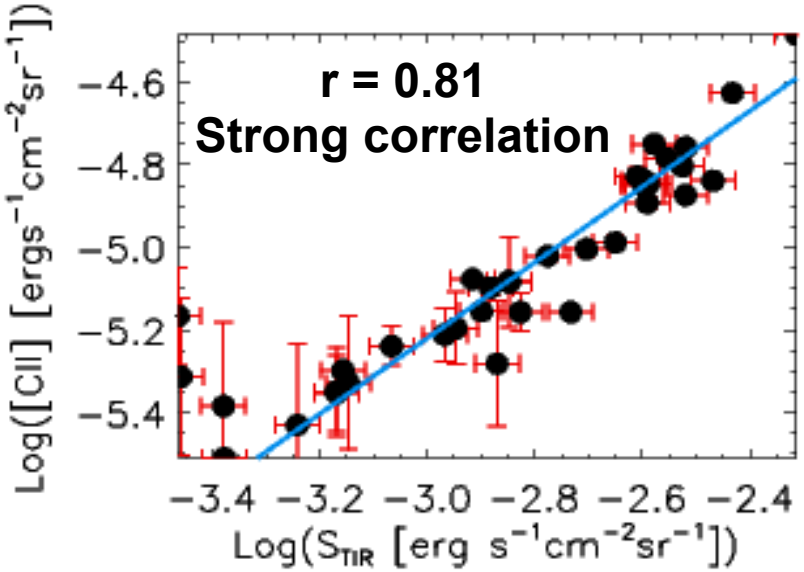
Gratier et al. 2010

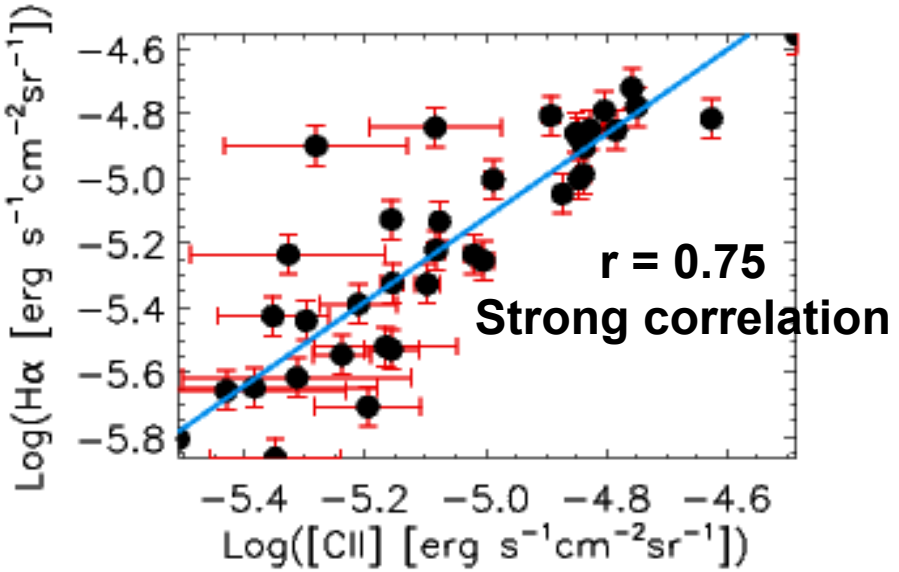
Results

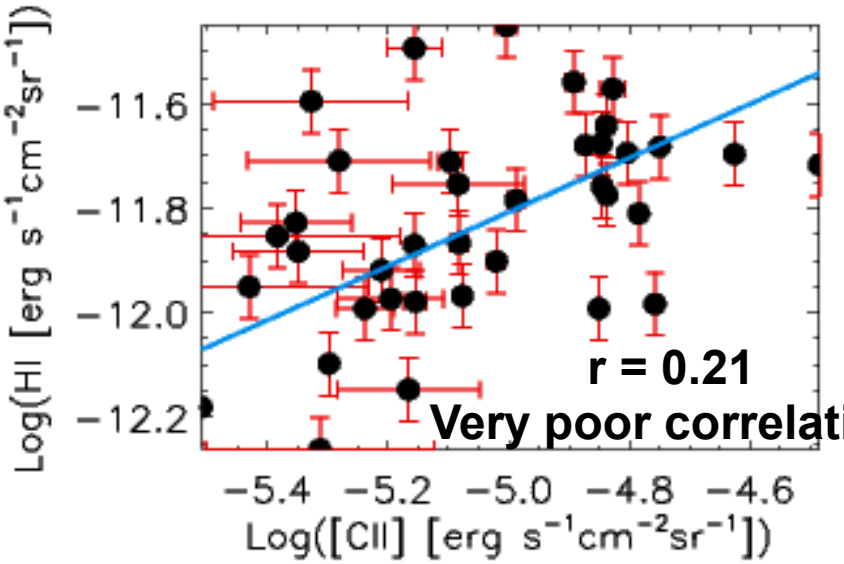
Continuum and lines distribution along major axis

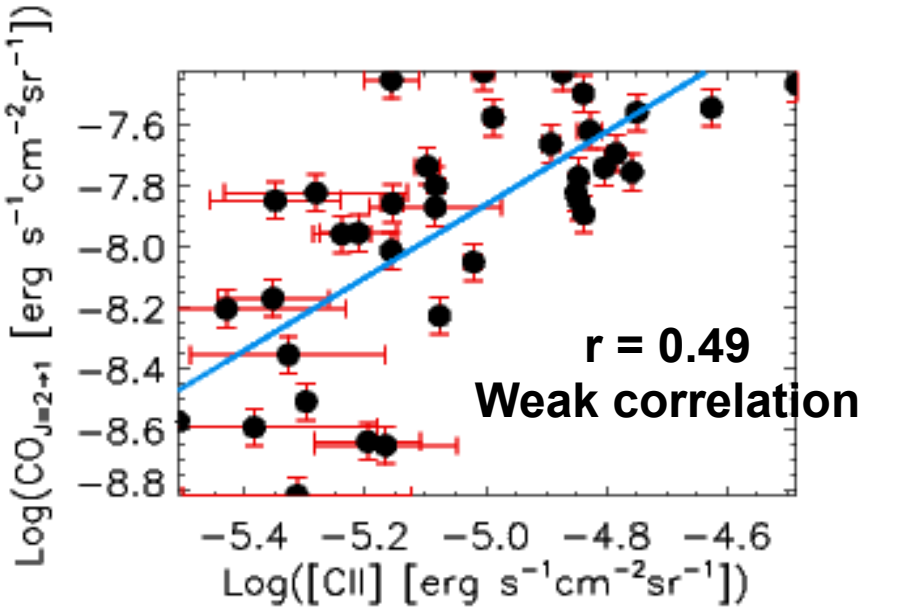


[CII] Correlations

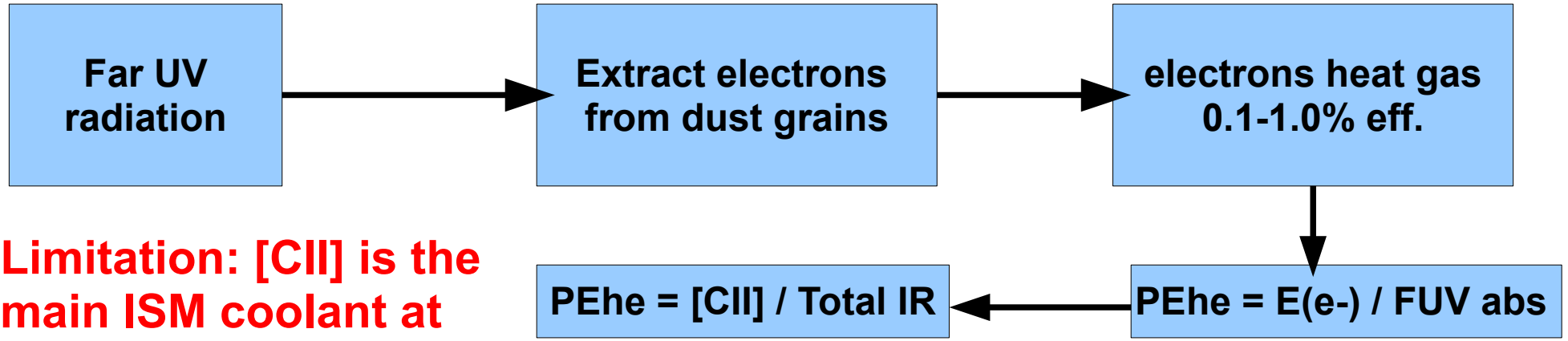




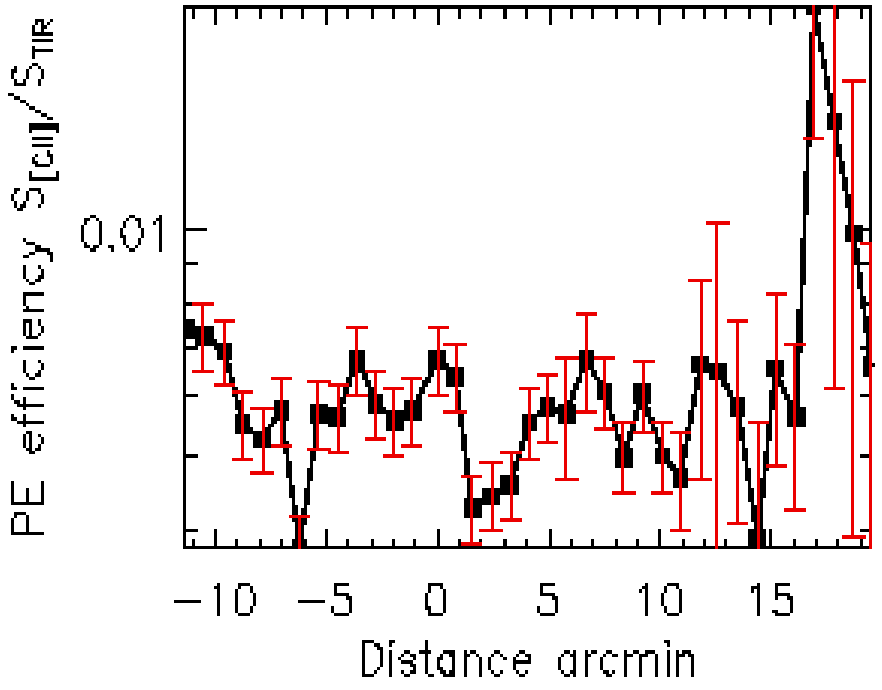


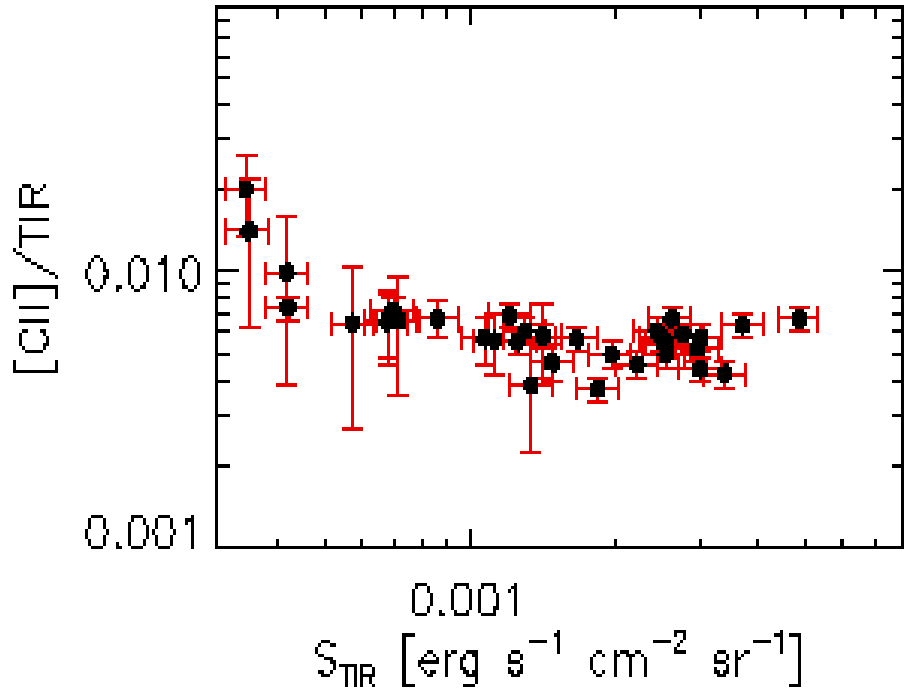


Photoelectric heating efficiency (PEhe)

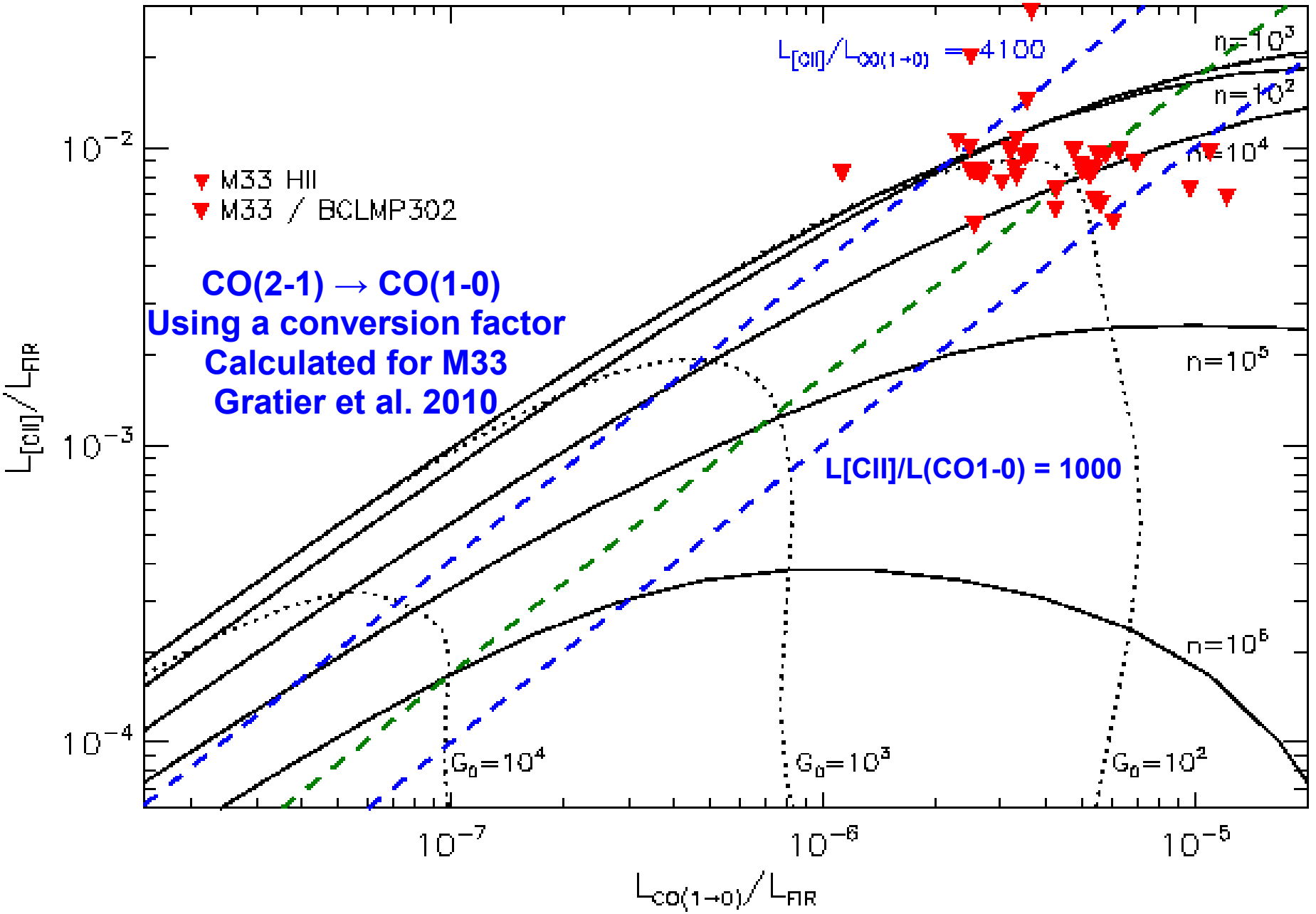


Limitation: [CII] is the main ISM coolant at T~91K and n<3000cm^-3.

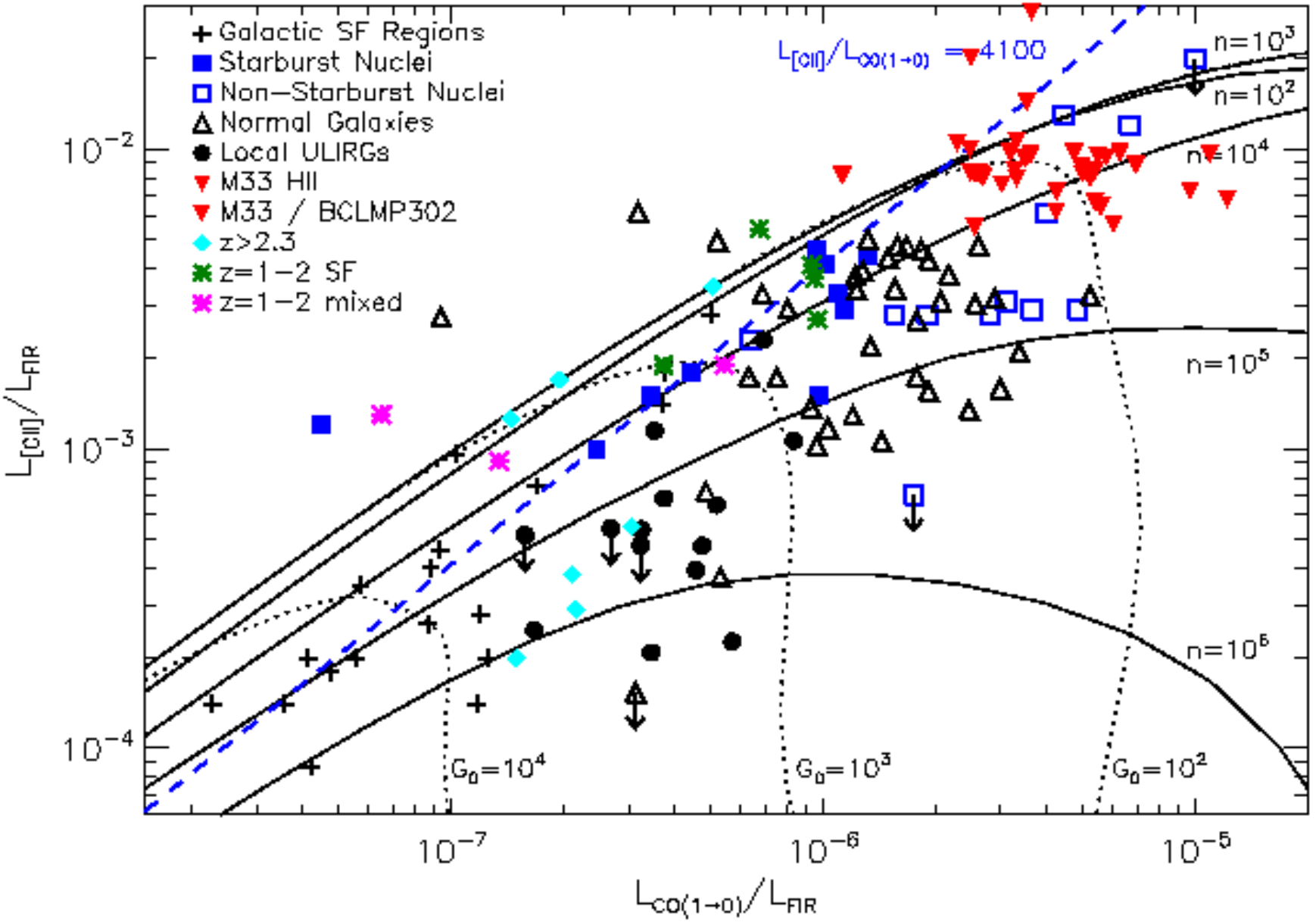




Gas conditions in M33

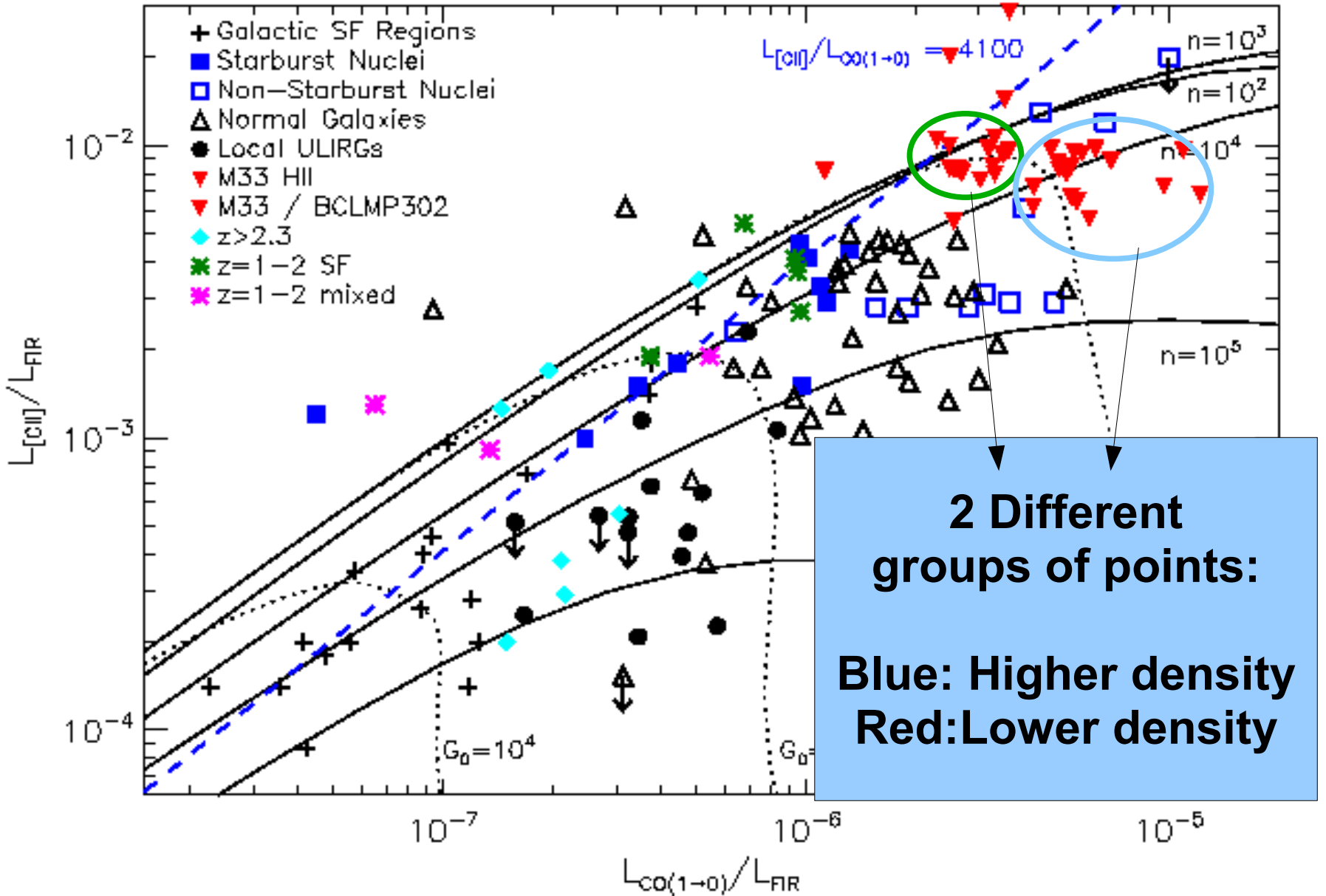


Gas conditions in different environments



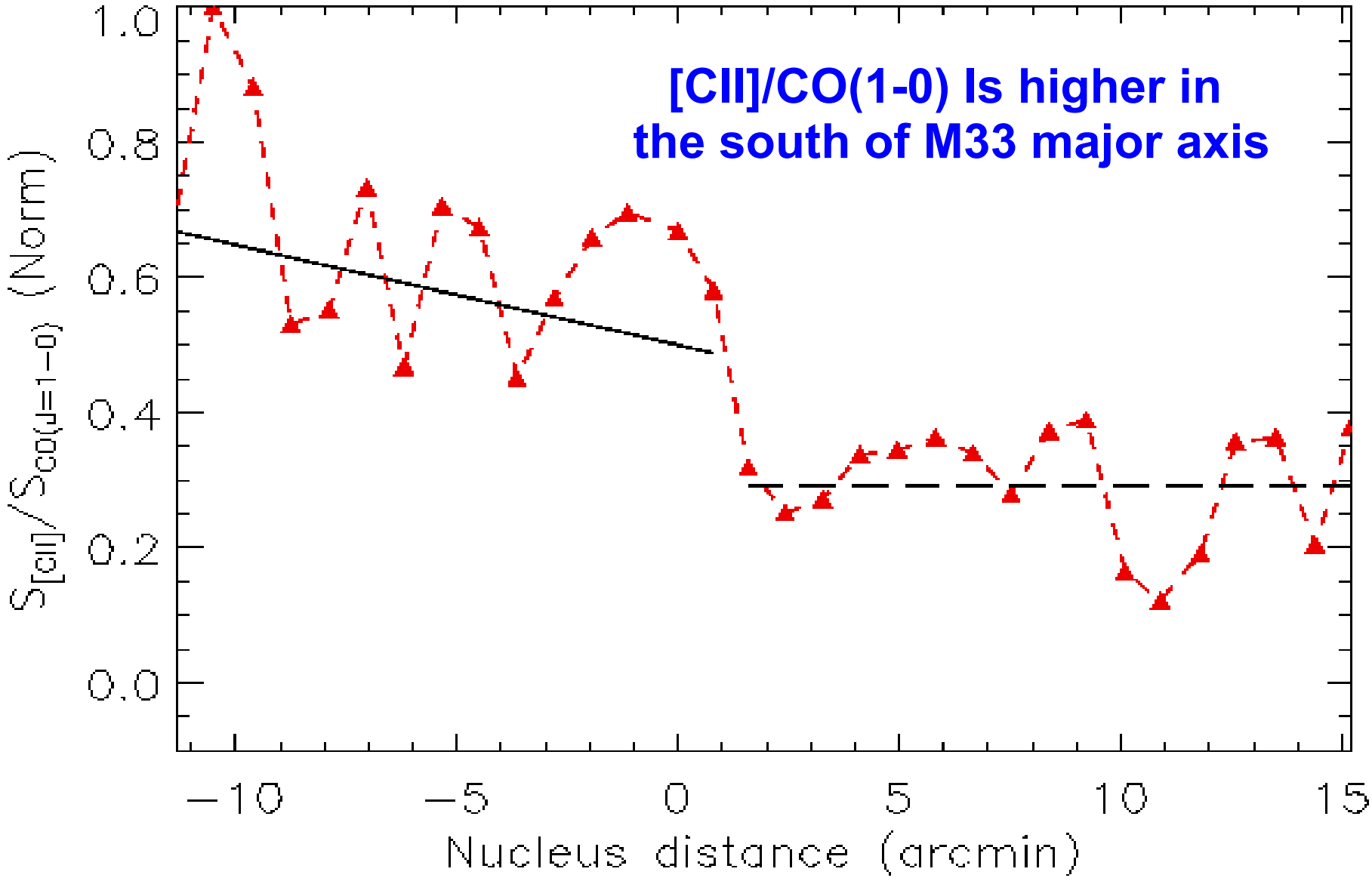
Data compilation from: Stacey et al. 1991, Hailey-Dunsheath et al. 2010, Stacey et al. 2010, Gracia-Carpio et al. 2011

Gas conditions in different environments

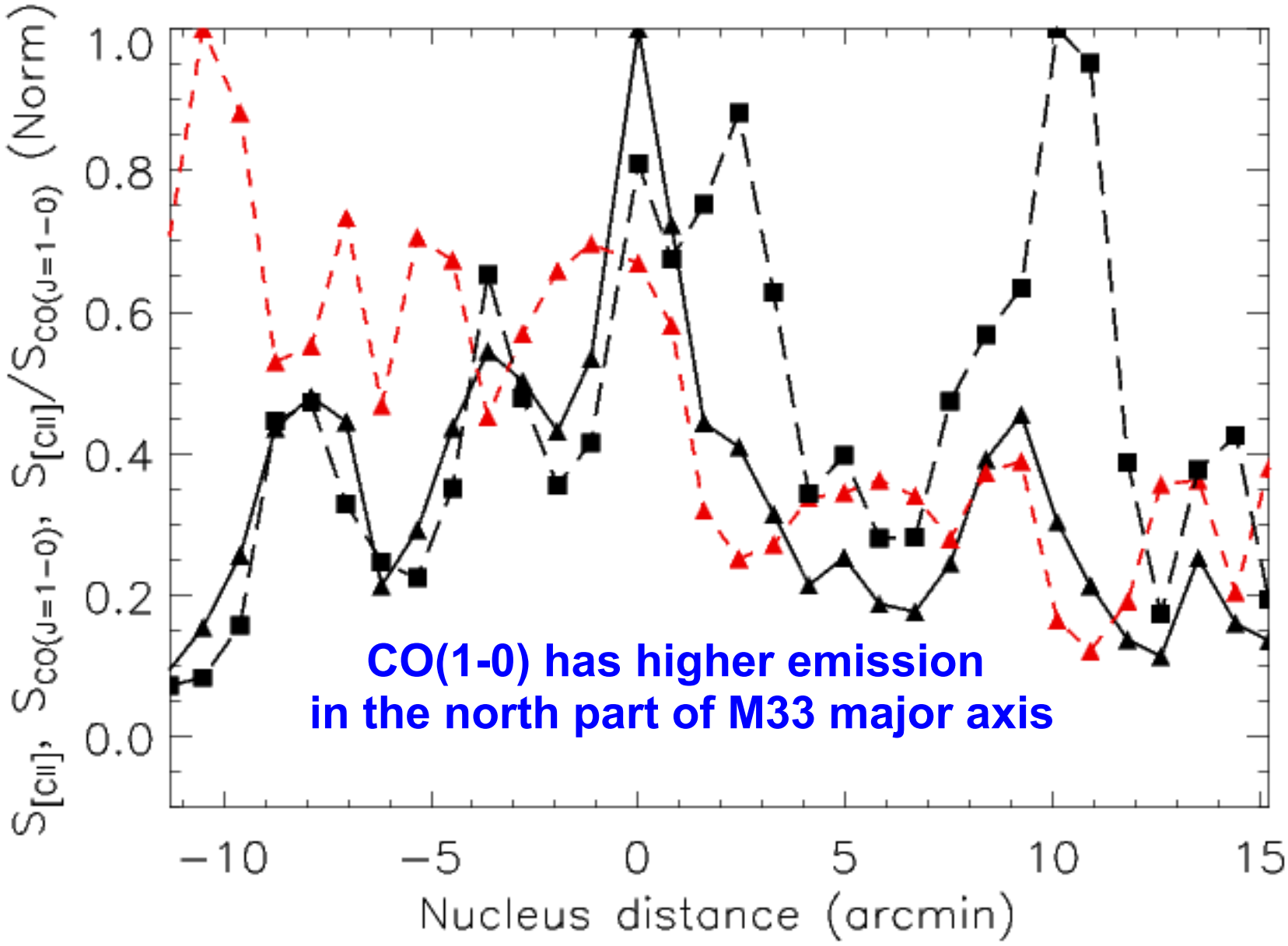


Data compilation from: Stacey et al. 1991, Hailey-Dunsheath et al. 2010, Stacey et al. 2010, Gracia-Carpio et al. 2011

[CII]/CO(1-0) as galactocentric distance function



[CII]/CO(1-0) as galactocentric distance function



Conclusions

Conclusions

- **CII correlates well with SF tracers as total IR and Hα**
- **PE heating typical efficiencies ~0.5%**
  (a bit higher than in MW ~0.3%)
- **PE heating efficiency has radial distribution**
- **Densities higher in the north**
- **[CII]/CO(J=1-0) higher in the south**
- **More CO(J=1-0) emission in the north**

Thanks for your attention

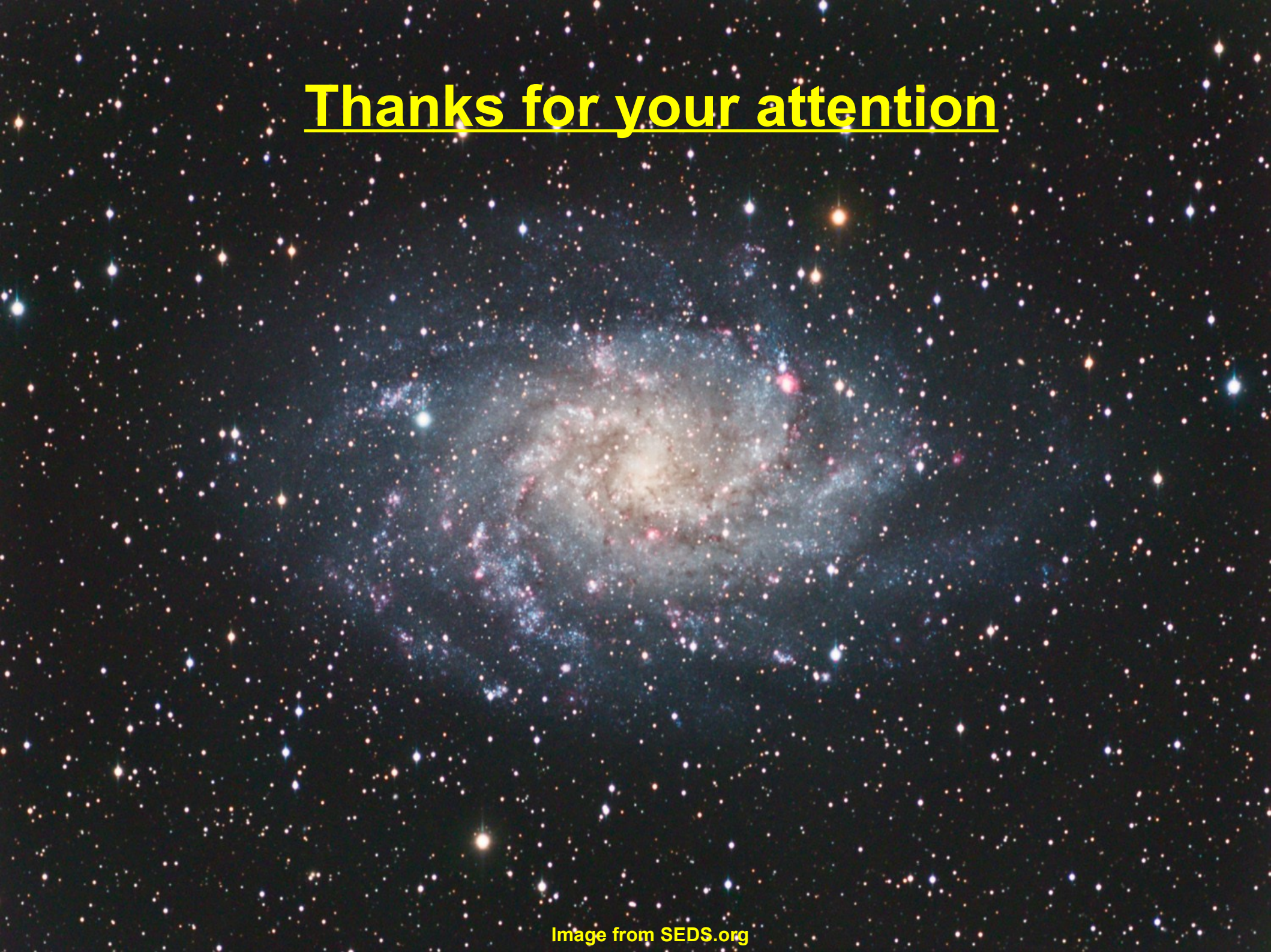


Image from SEDS.org