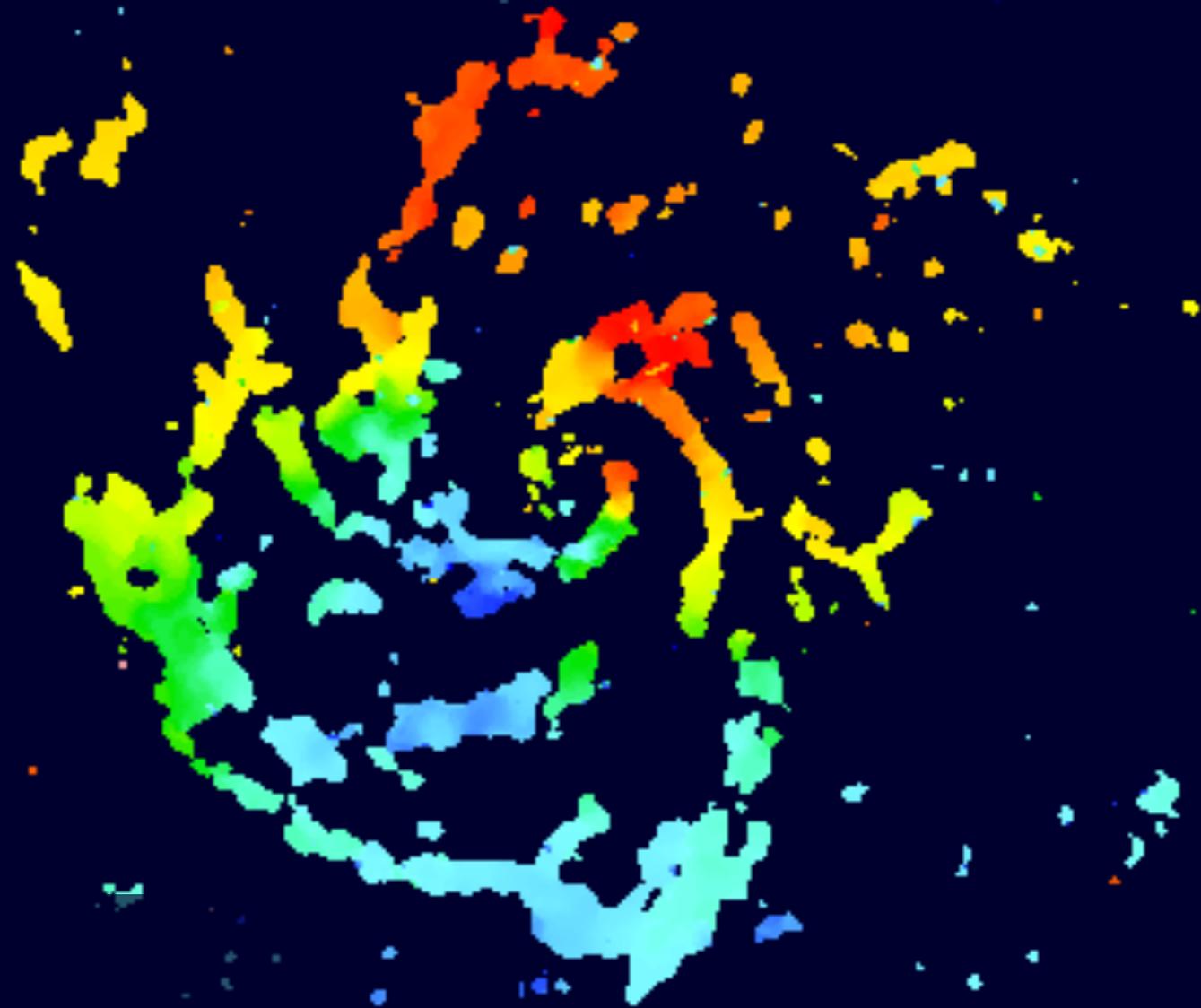


THE COMPLEX GAS KINEMATICS IN THE NUCLEAR REGION OF NGC 7213



PhD student:

Francesco Salvestrini

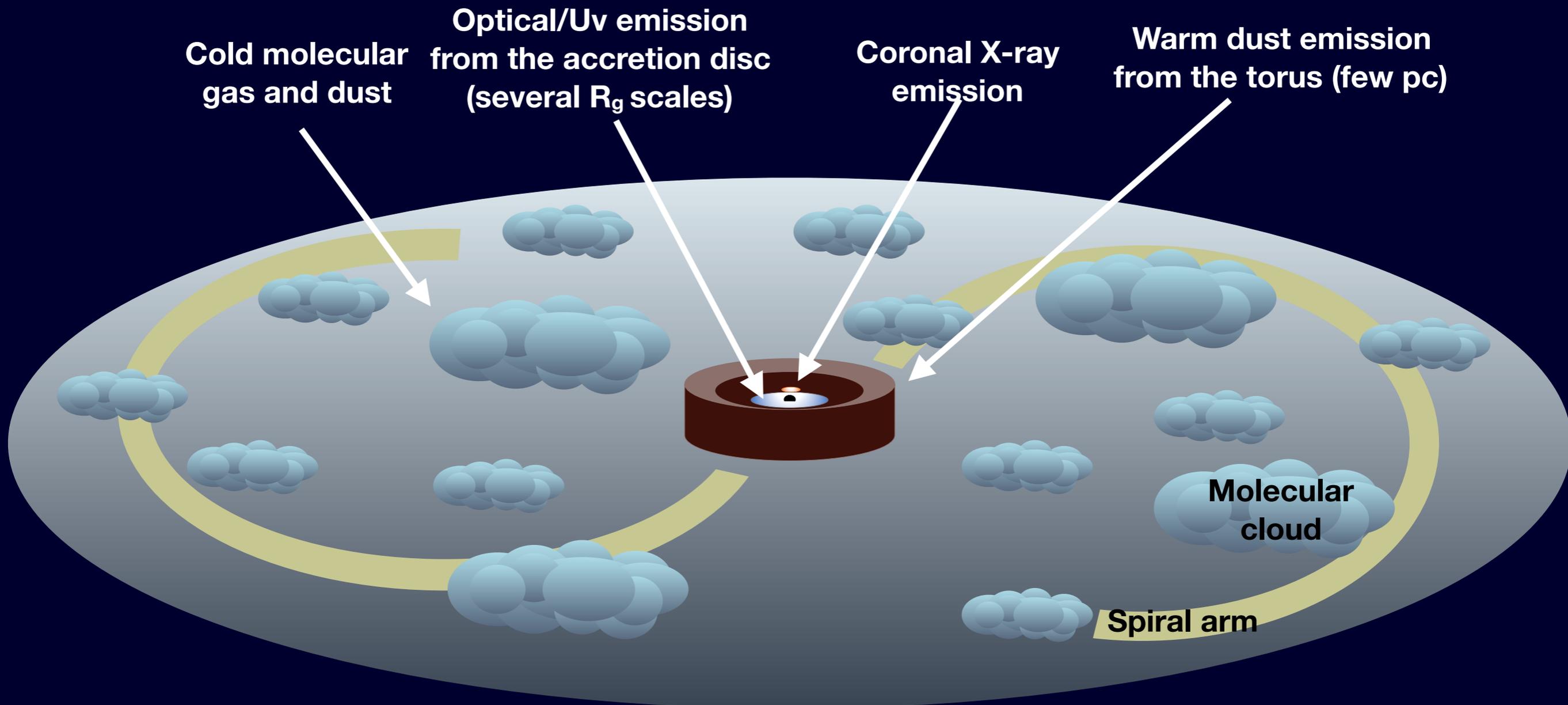
Supervisor: Cristian Vignali

Co-supervisors: Carlotta Gruppioni

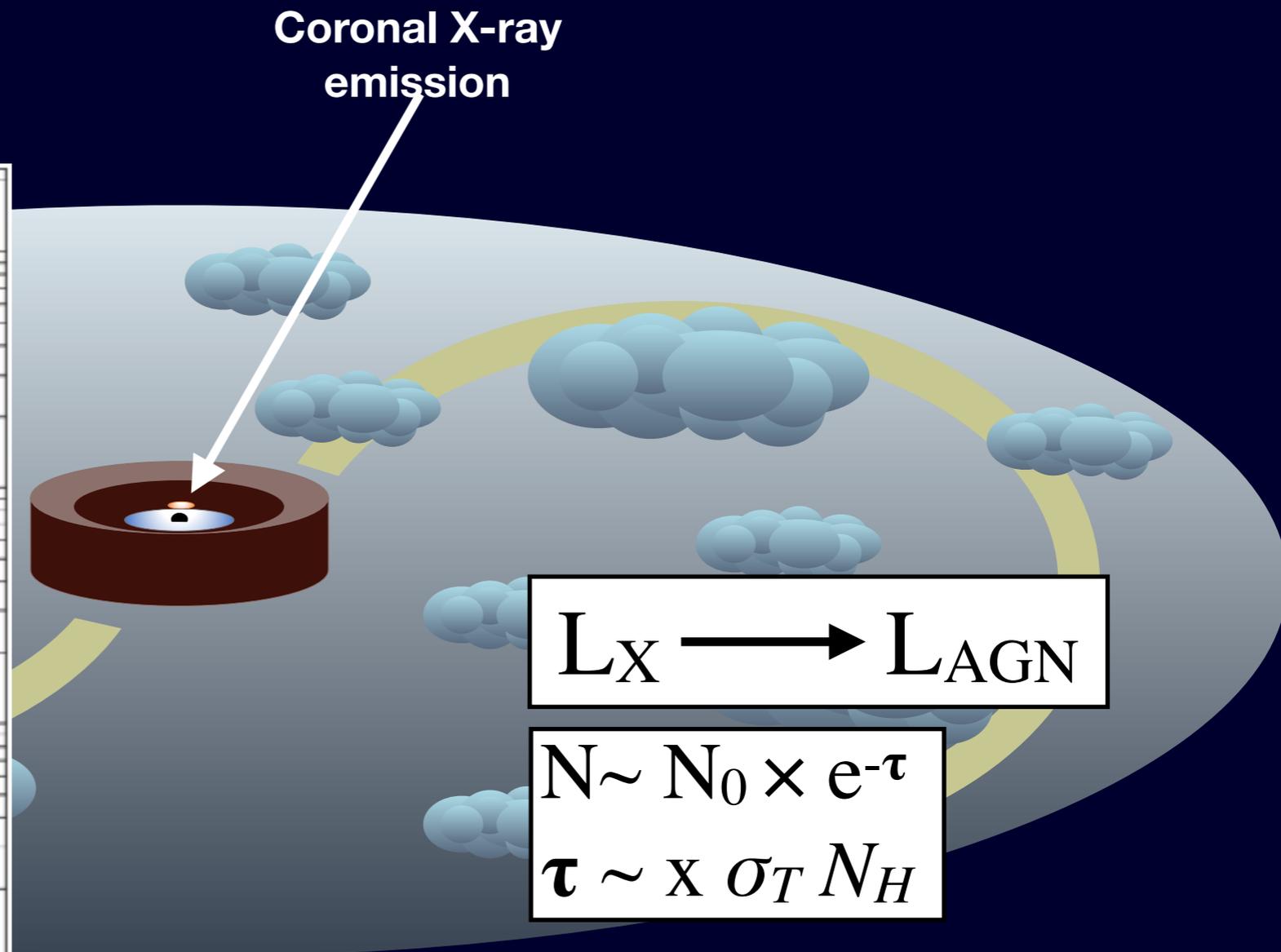
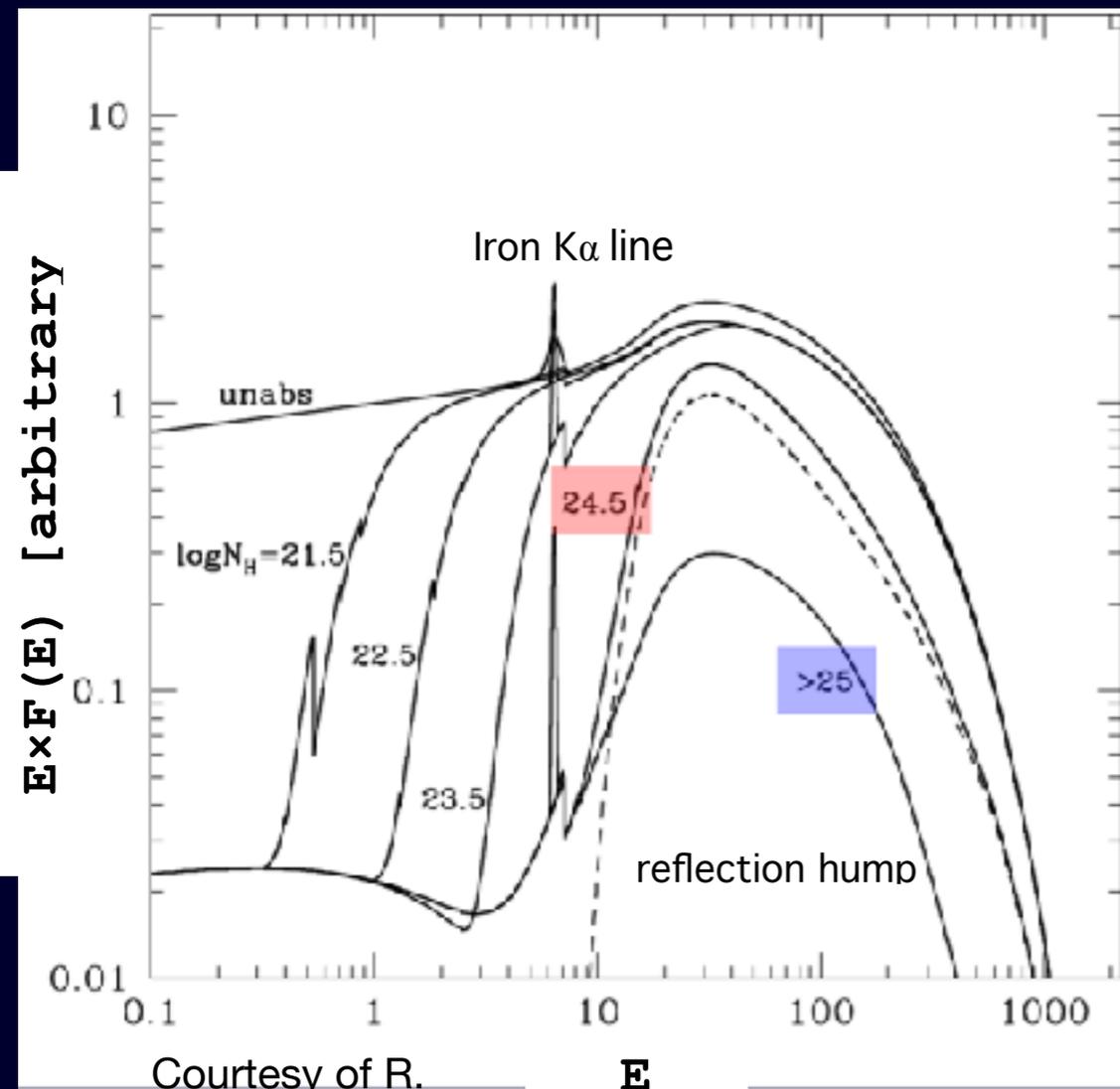
Francesca Pozzi

Collaborator: Rosita Paladino

Different gas components



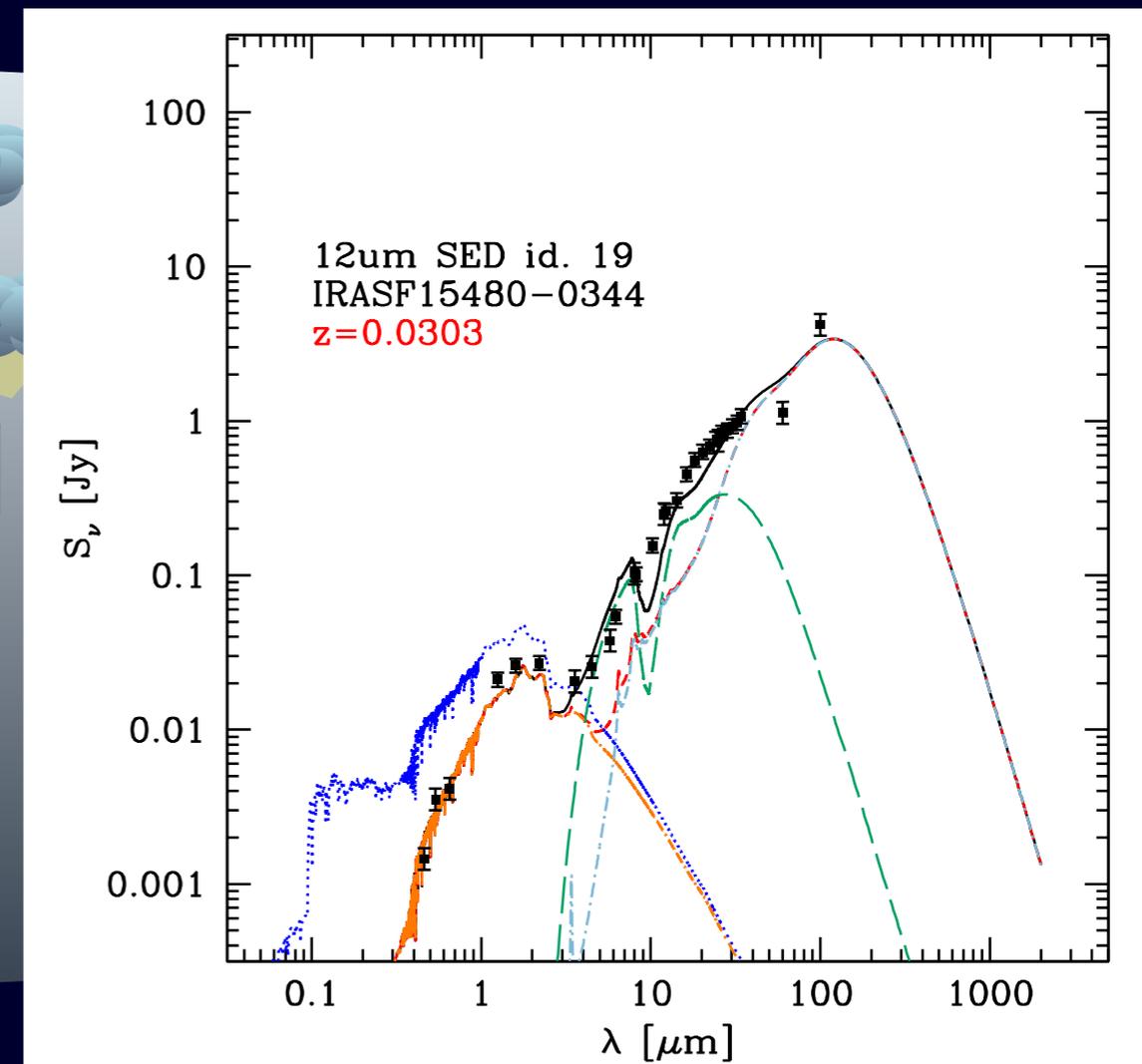
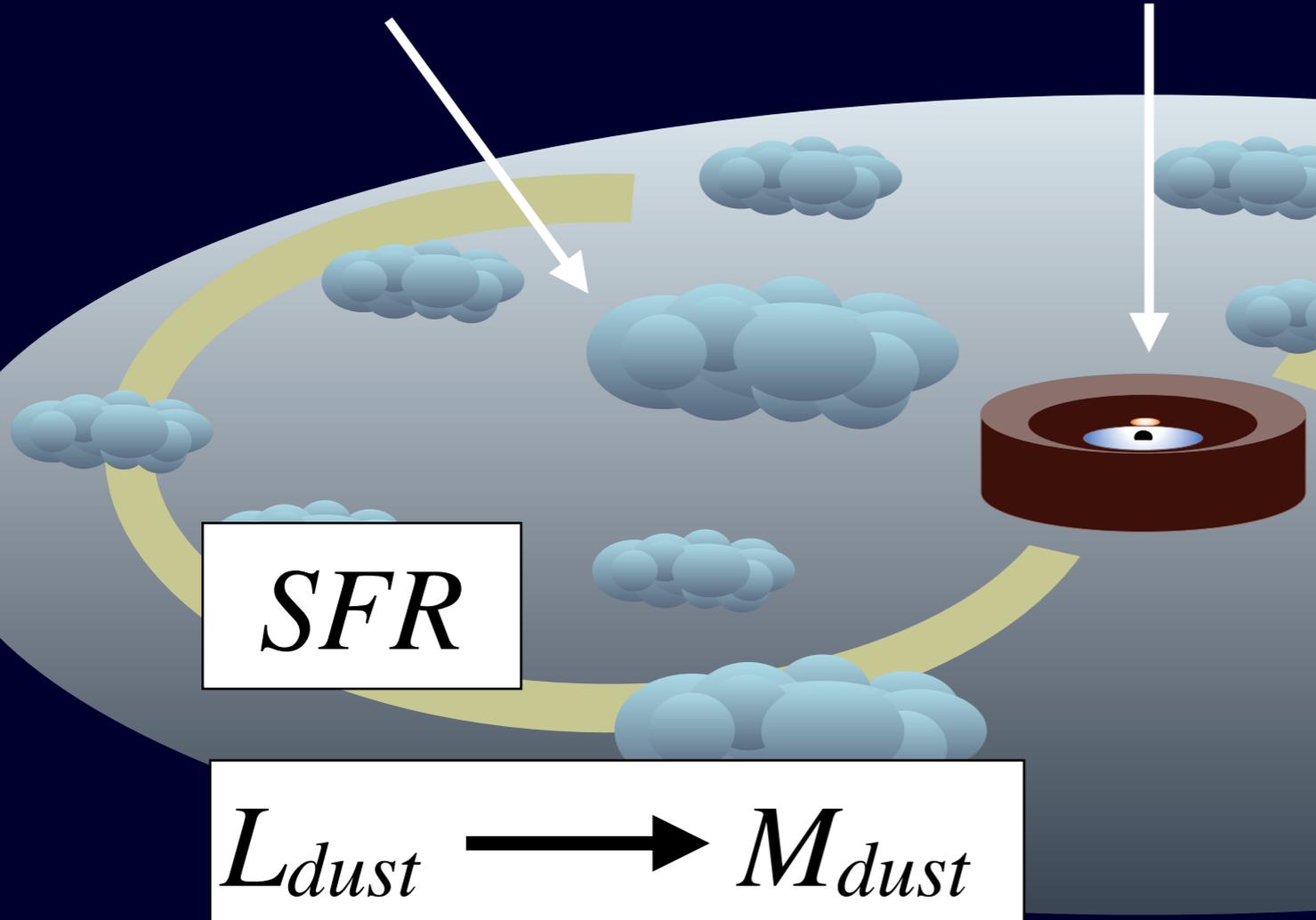
Different gas components



Different gas components

Cold molecular
gas and dust

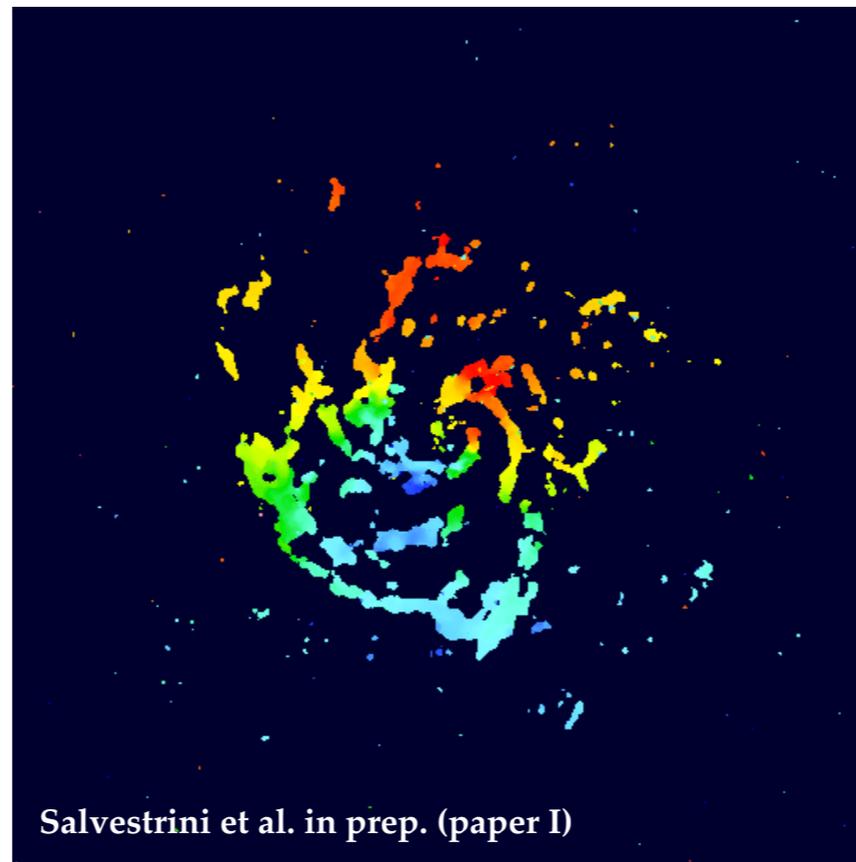
Warm dust emission
from the torus (few pc)



Different gas components

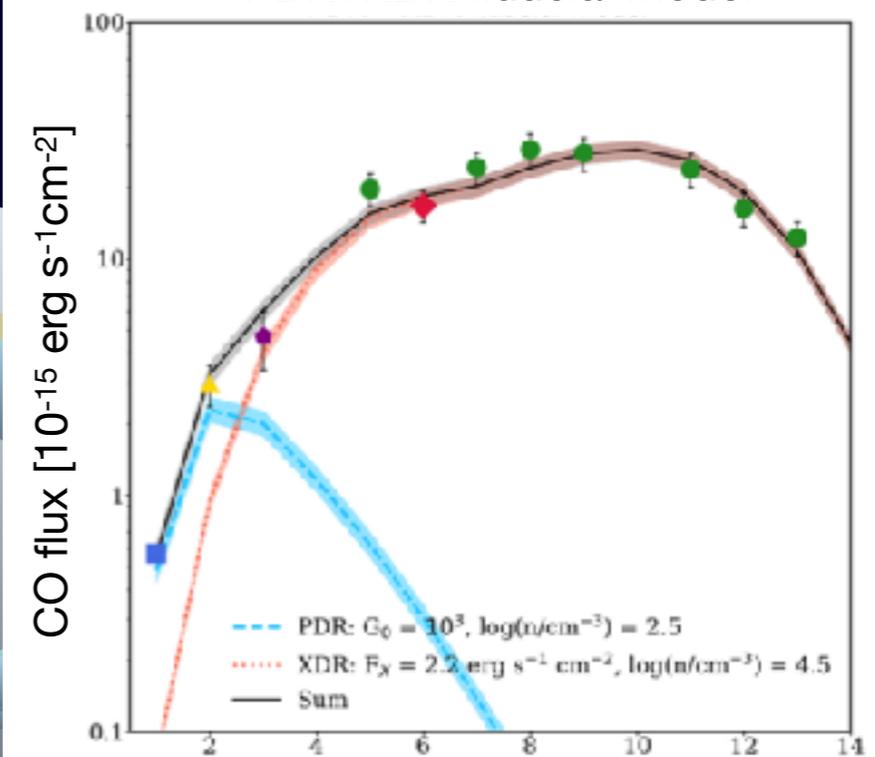
Molecular
gas

Molecular gas kinematic



CO SLED

PDR+XDR fiducial model



Mingozzi et al. 2017 J_{up}

$$\Sigma_{H_2} = \alpha_{CO} I_{CO}$$

NGC 7213

Local **S0 galaxy** ($z=0.005839$, $1'' \sim 120\text{pc}$) spectroscopically classified as **Seyfert** (Phillips 1979) / **LINER** (Filippenko & Halpern 1984).

Available data:

- ▶ X-ray: **NuSTAR** + **XMM-Newton** (+ Suzaku + Chandra)
- ▶ optical: *SALT* spectrum
- ▶ mid-IR: *IRS* spectrum
- ▶ sub-mm: **ALMA Band 6 CO(2-1)**
- ▶ sub-mm: **APEX PI230 (?)**
- ▶ radio: 4.8, 8.4, 20 GHz

NGC 7213

Local **S0 galaxy** ($z=0.0058$, $1'' \sim 120\text{pc}$) spectroscopically classified as **Seyfert** (Phillips 1979) / **LINER** (Filippenko & Halpern 1984)

Available data:

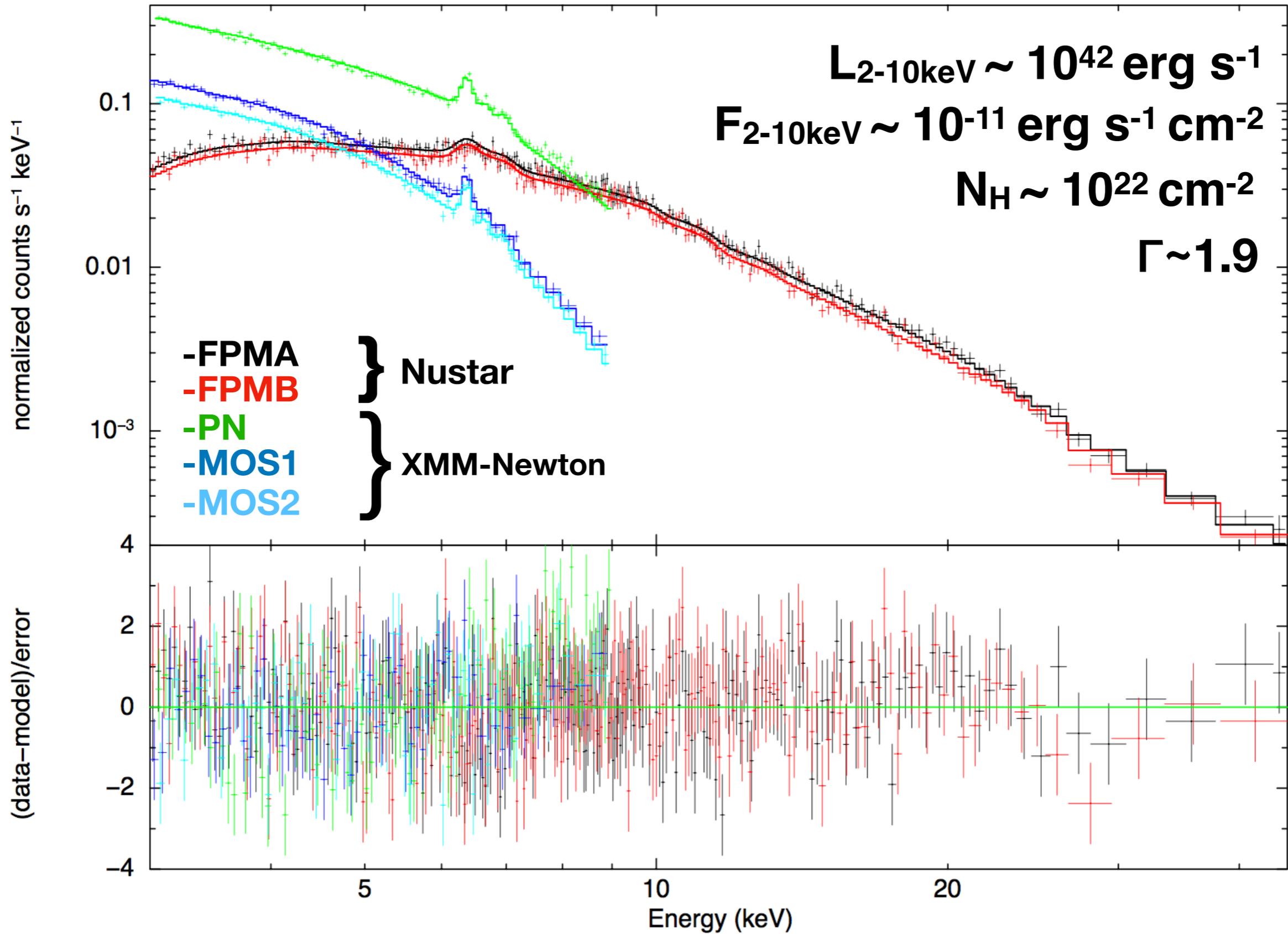
- ▶ X-ray: **NuSTAR + XMM-Newton** (+ Suzaku + Chandra)
- ▶ optical: *SALT* spectrum
- ▶ mid-IR: *IRS* spectrum
- ▶ sub-mm: **ALMA Band 6 CO(2-1)**
- ▶ radio: 4.8, 8.4, 20 GHz

Nustar (3-79 keV)

- ▶ Exp. time: 101.6 ks
- ▶ Angular res.: $16''$ (FWHM)
- ▶ Energy res.: 400 eV at 6 keV

XMM-Newton (3-10 keV)

- ▶ Exp. time: 132.5 ks
- ▶ Angular res.: $6''$ (FWHM, on-axis)
- ▶ Energy res.: 150 eV at 6 keV



NGC 7213

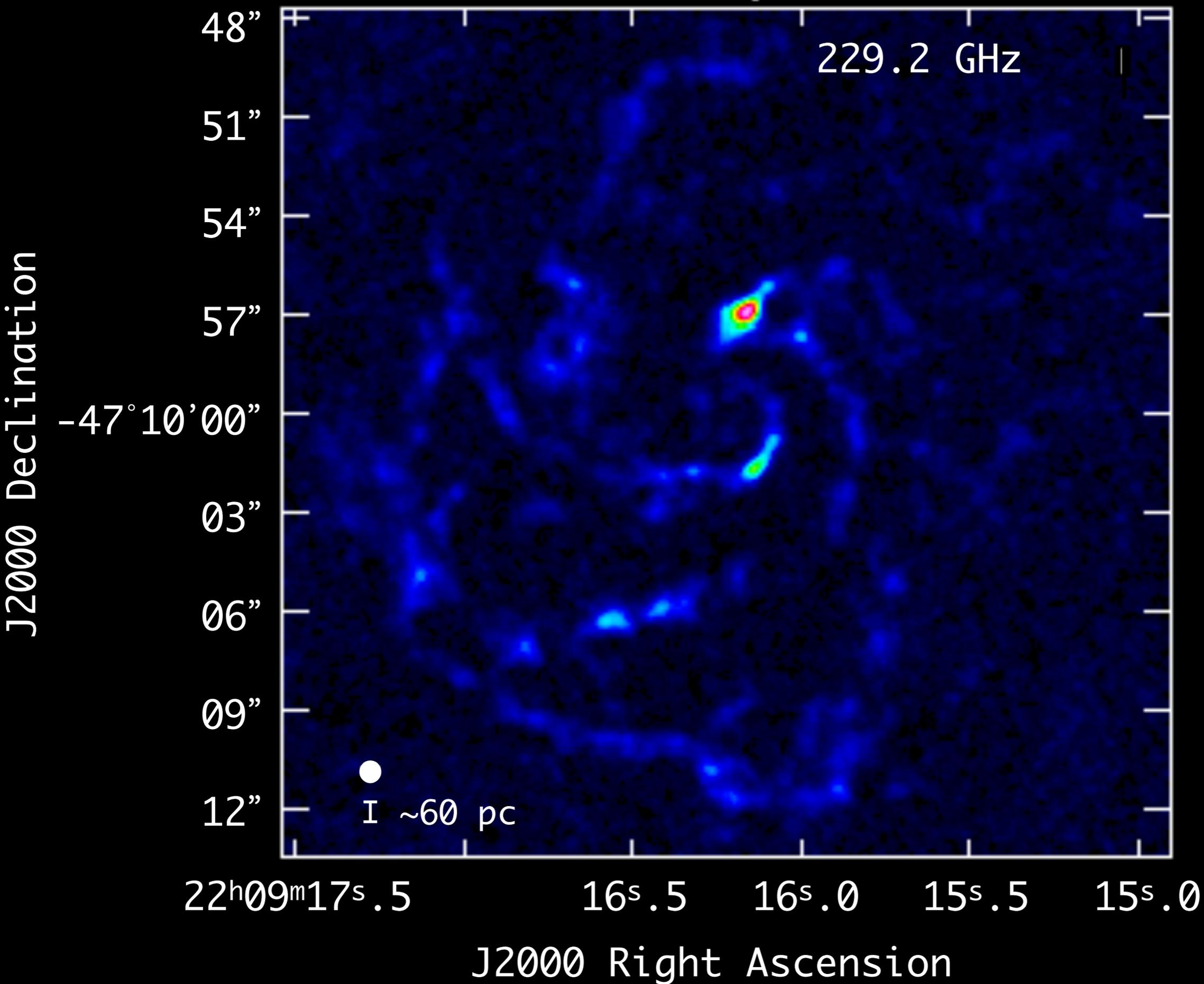
Local **S0 galaxy** ($z=0.005839$, $1'' \sim 120\text{pc}$) spectroscopically classified as **Seyfert** (Phillips 1979) / **LINER** (Filippenko & Halpern 1984)

Available data:

- ▶ X-ray: NuSTAR + XMM-Newton (+ Suzaku + Chandra)
- ▶ optical: *SALT* spectrum
- ▶ mid-IR: *IRS* spectrum
- ▶ **sub-mm: ALMA Band 6 CO(2-1)**
- ▶ radio: 4.8, 8.4, 20 GHz

- ▶ Project_code: 2012.1.00474.S
- ▶ PI_name: Nagar, N.
- ▶ Band: 6
- ▶ Spatial res.: $0.52''$
- ▶ LAS: $6.3''$
- ▶ Spectral res.: 10 km/s

CO (2-1) emission line map



J2000 Declination

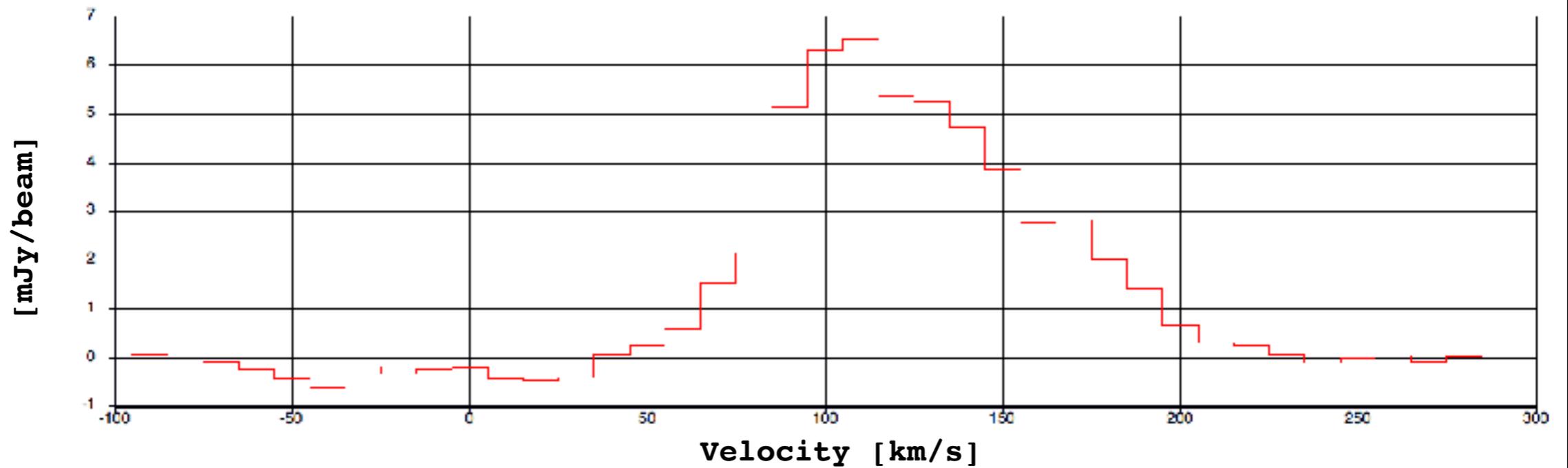
48"
51"
54"
57"
-47° 10' 00"
03"

Region A

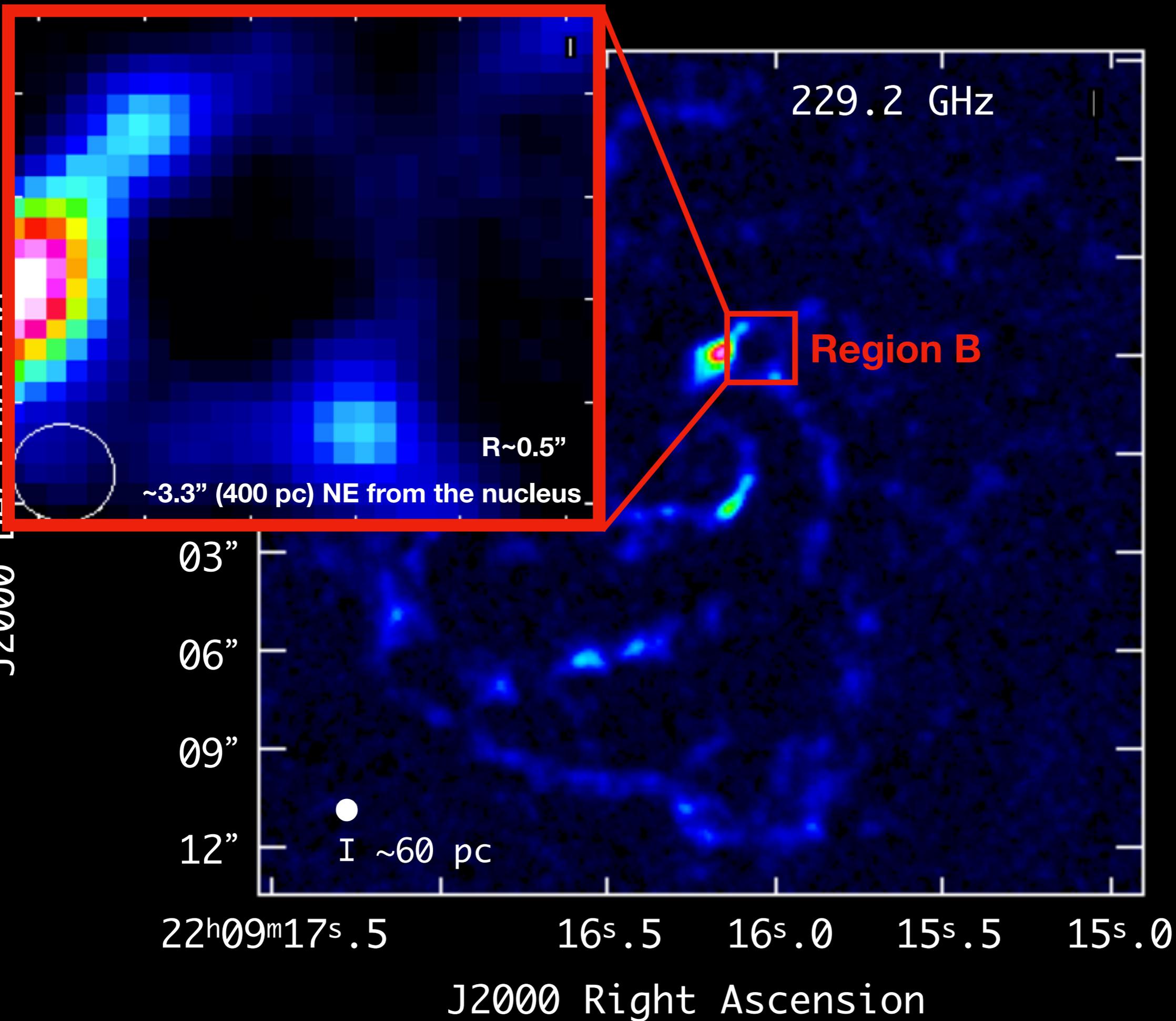
229.

~ 180pc x 300 pc

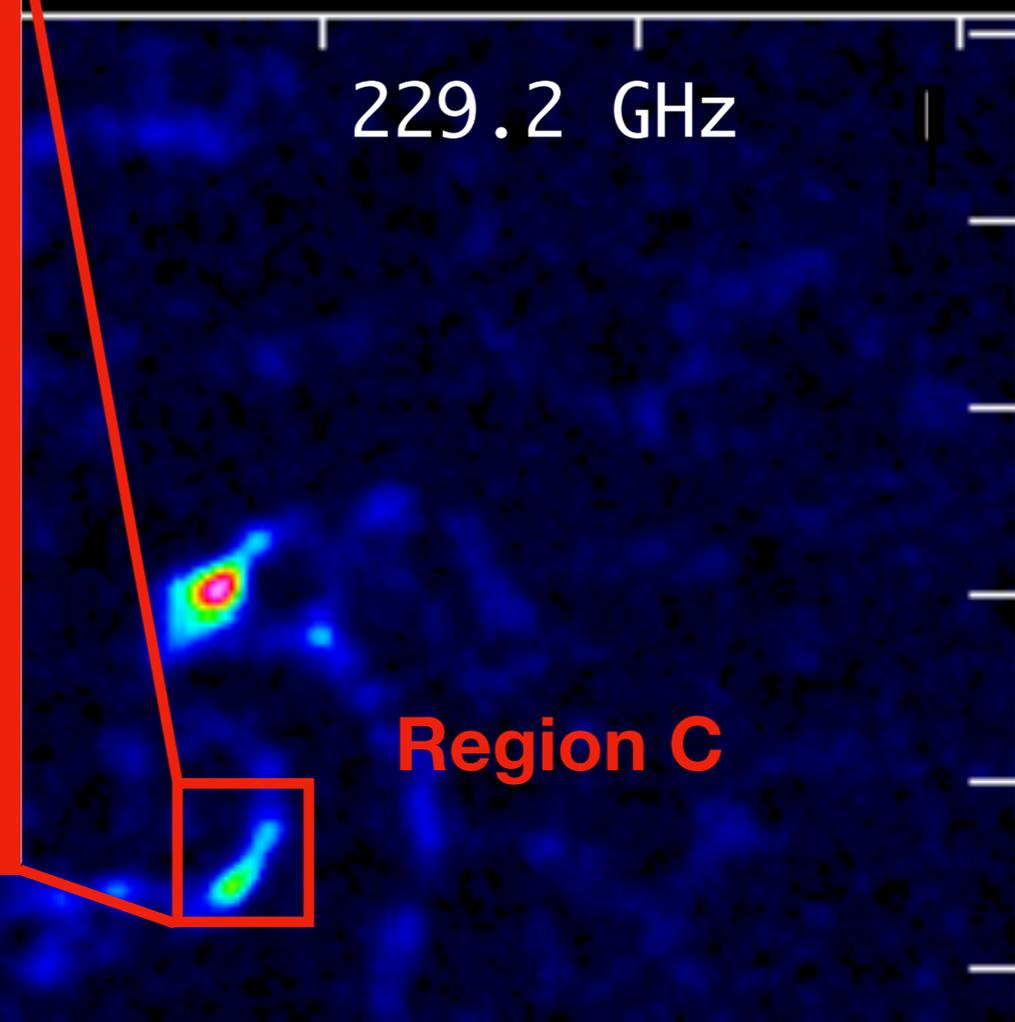
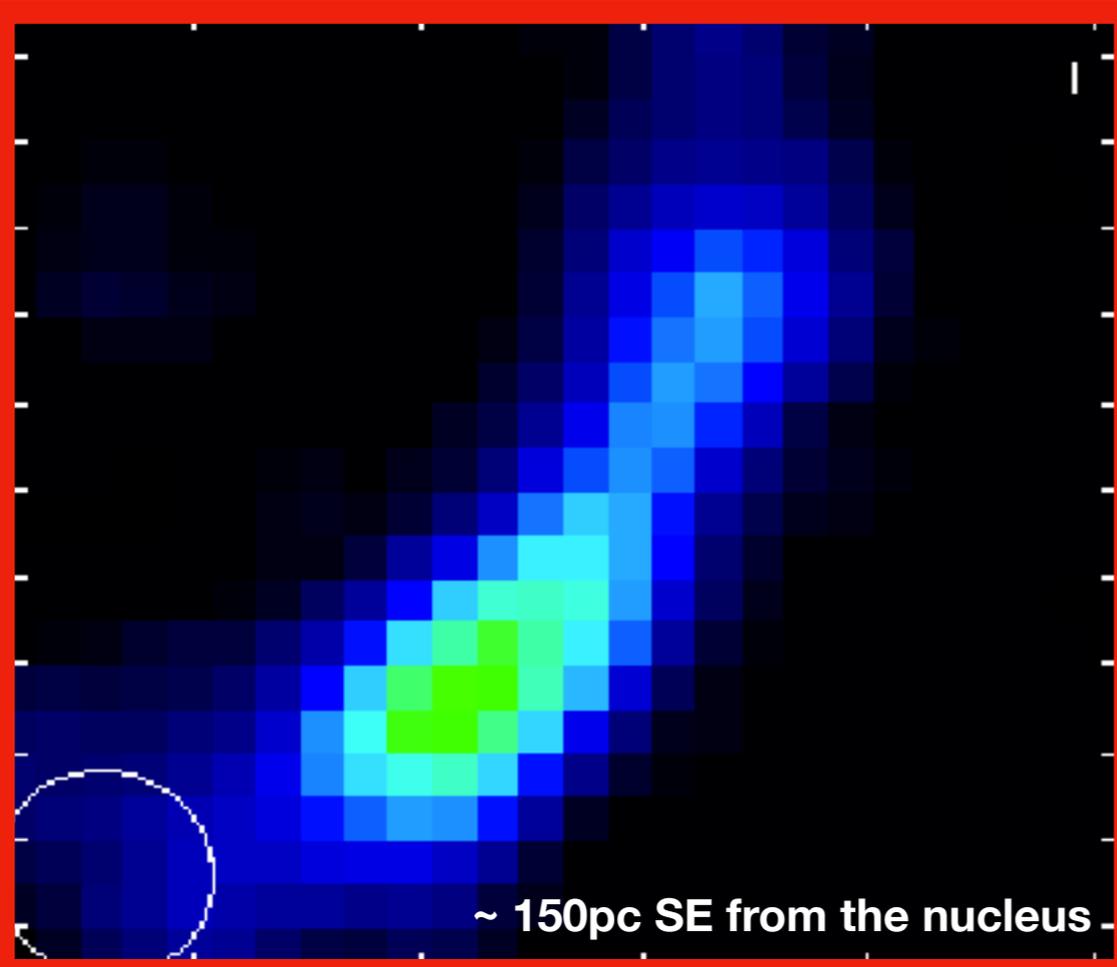
Region A



J2000 Declination



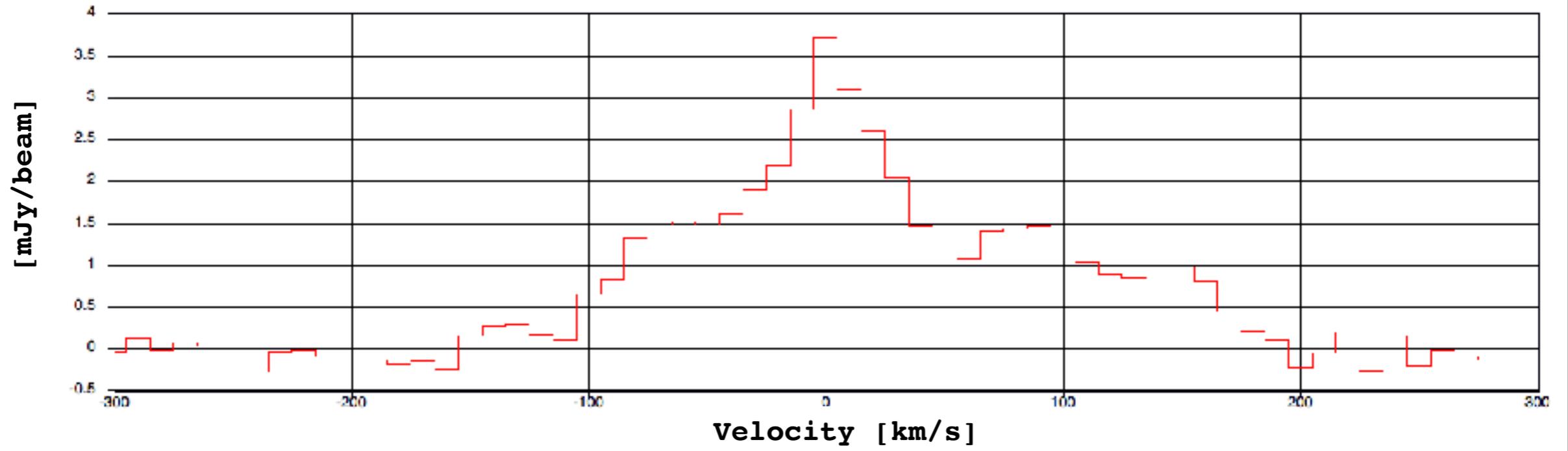
J2000 Declination



03"

Region C

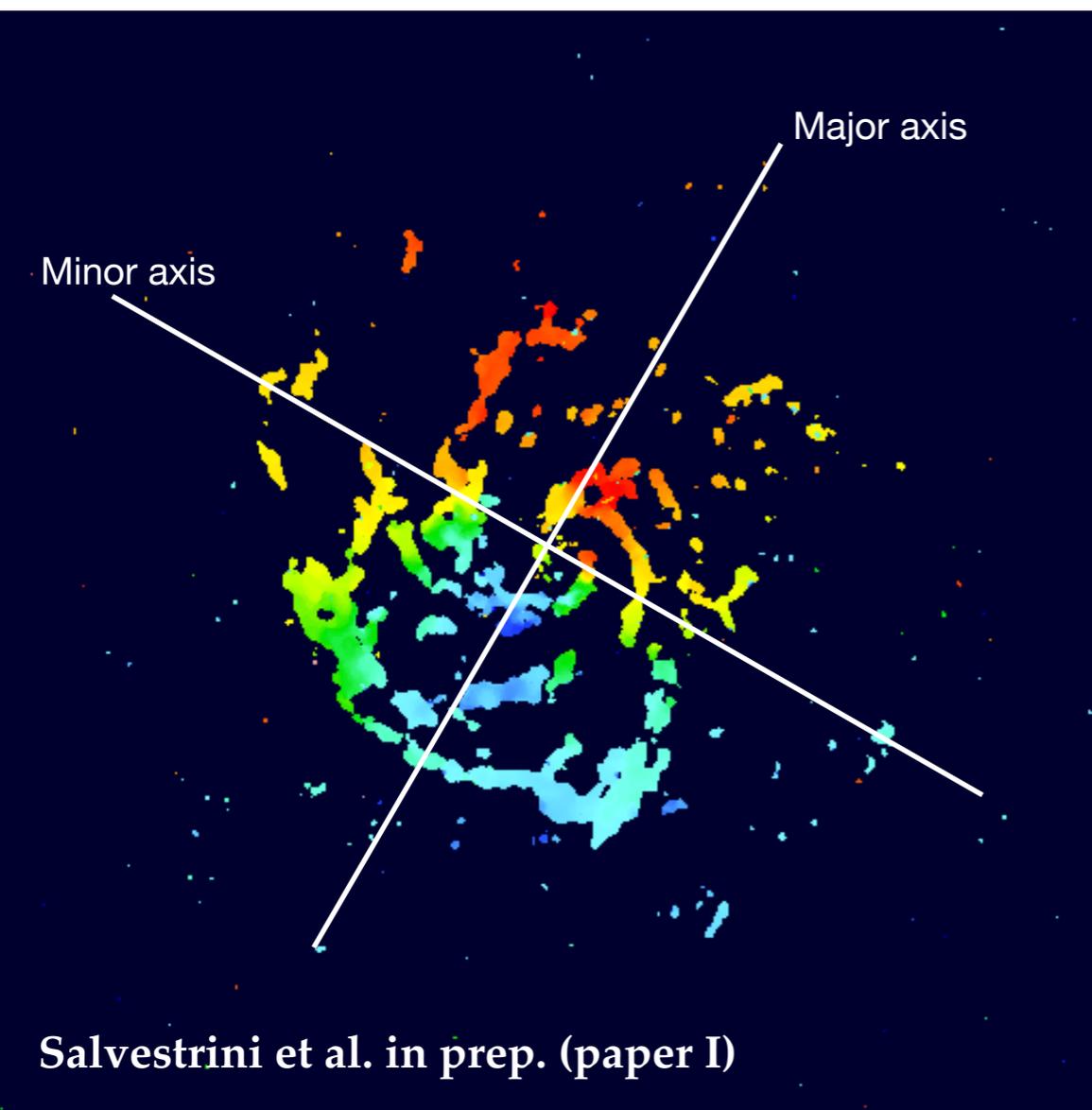
See PV diagram later!



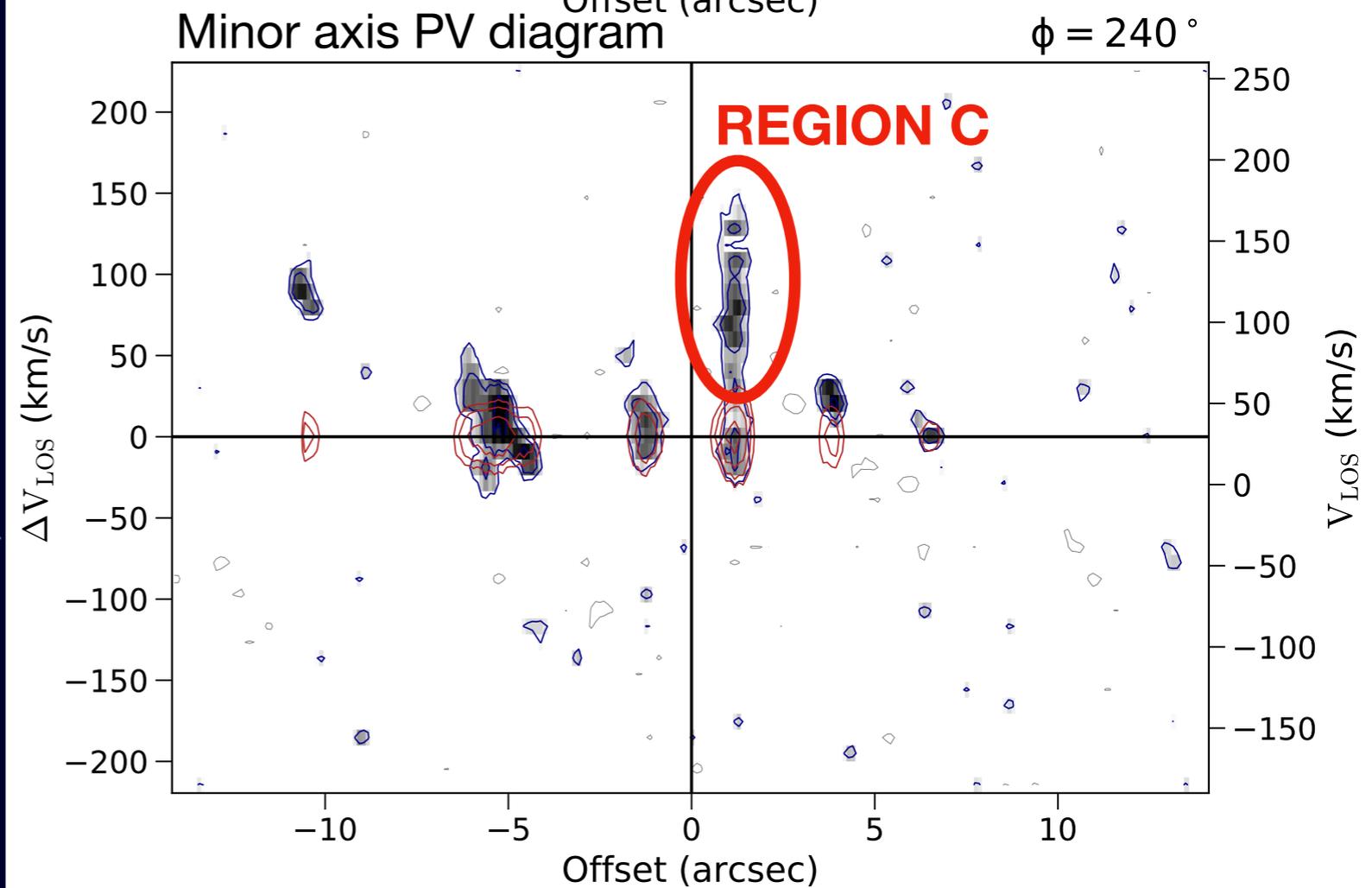
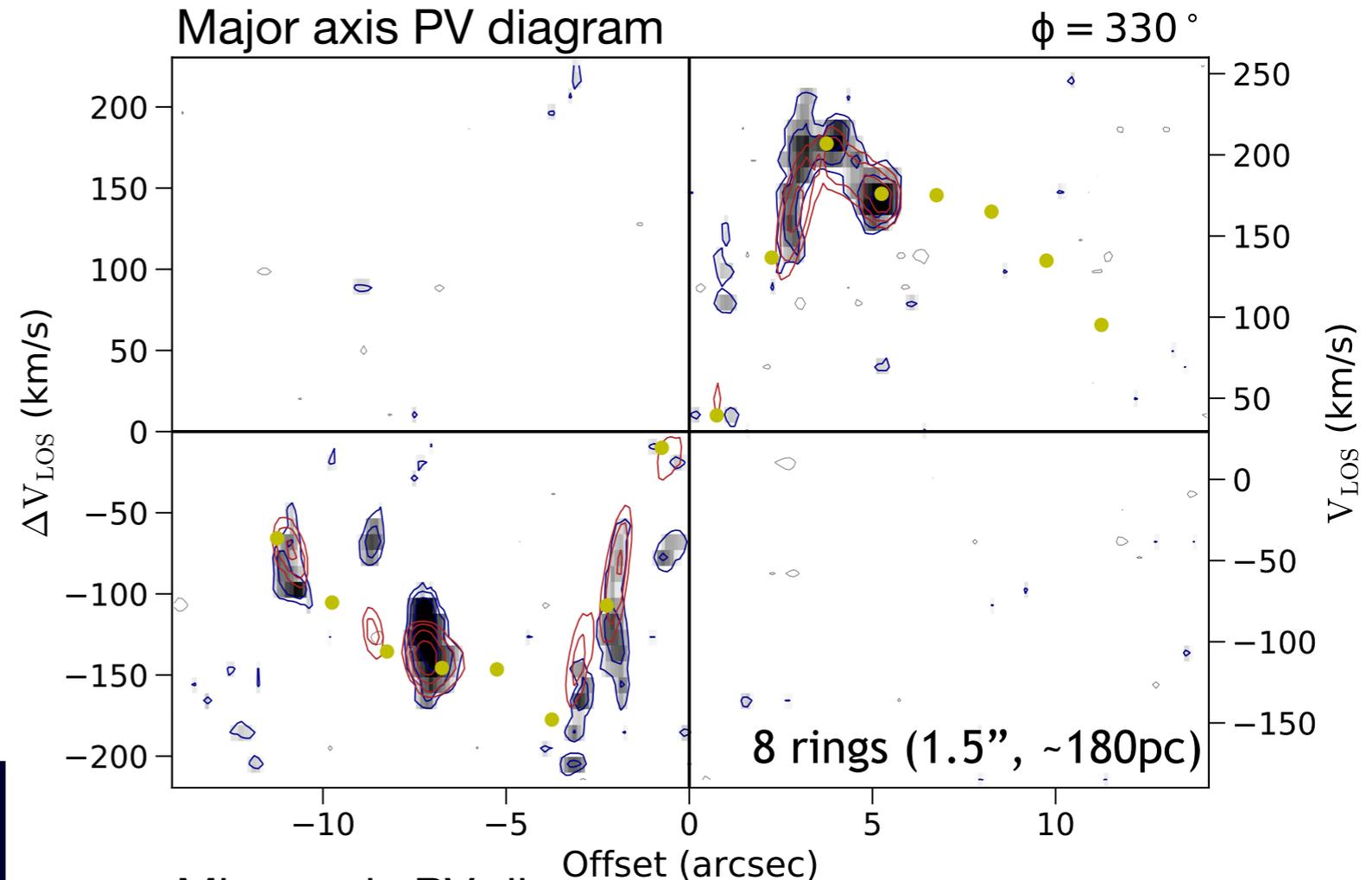
BBAROLO

3D Based Analysis of Rotating Objects via Line Observations

Di Teodoro & Fraternali 2015



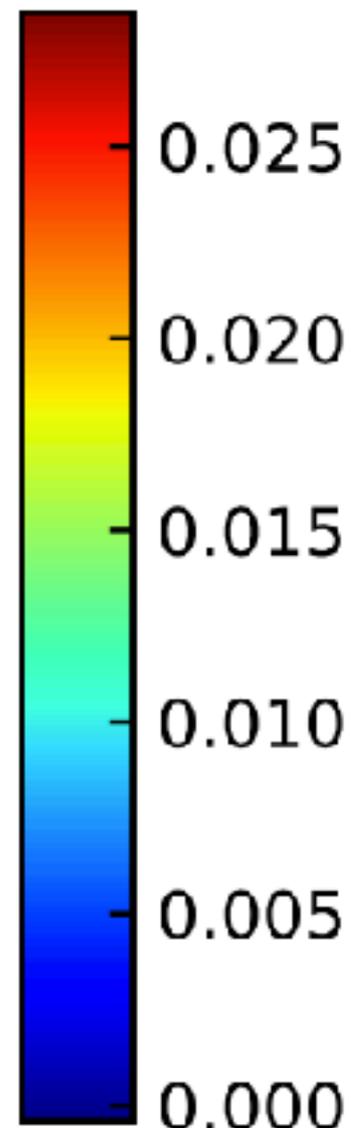
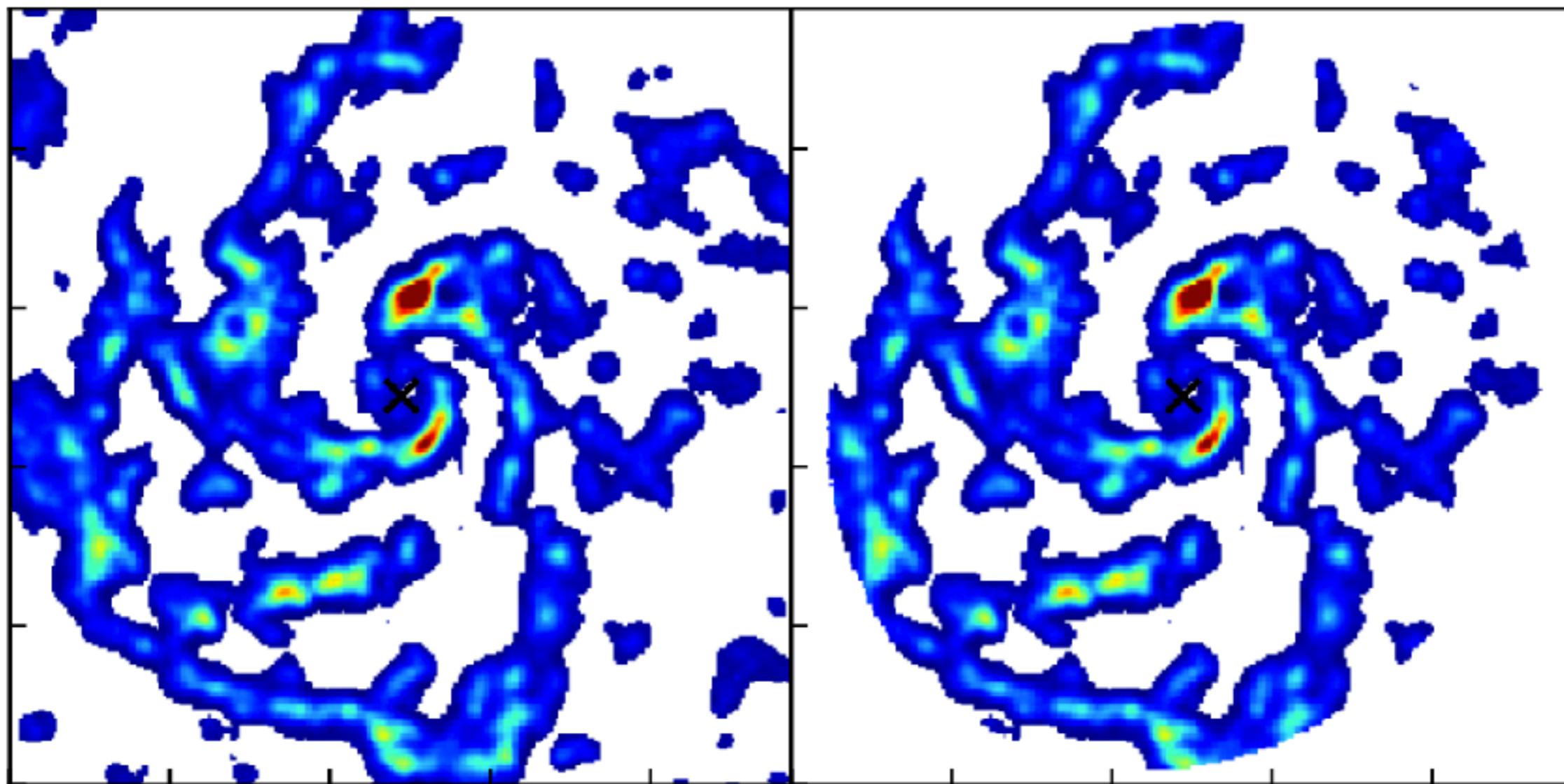
Salvestrini et al. in prep. (paper I)



DATA

MODEL

INTENSITY



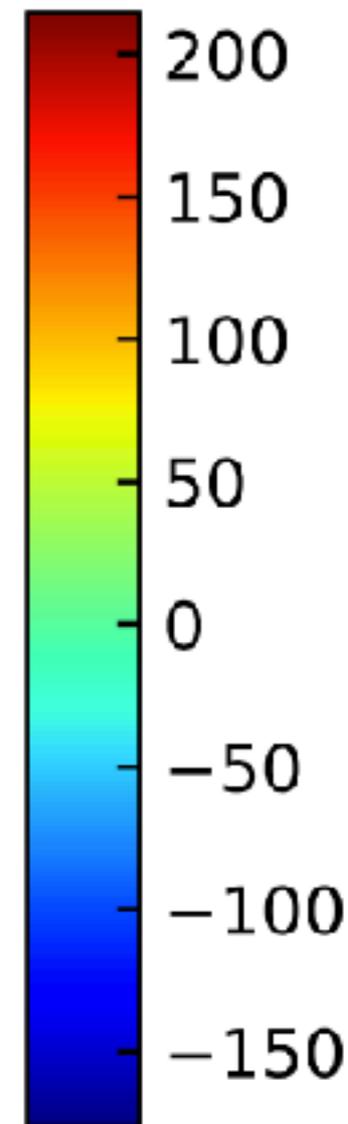
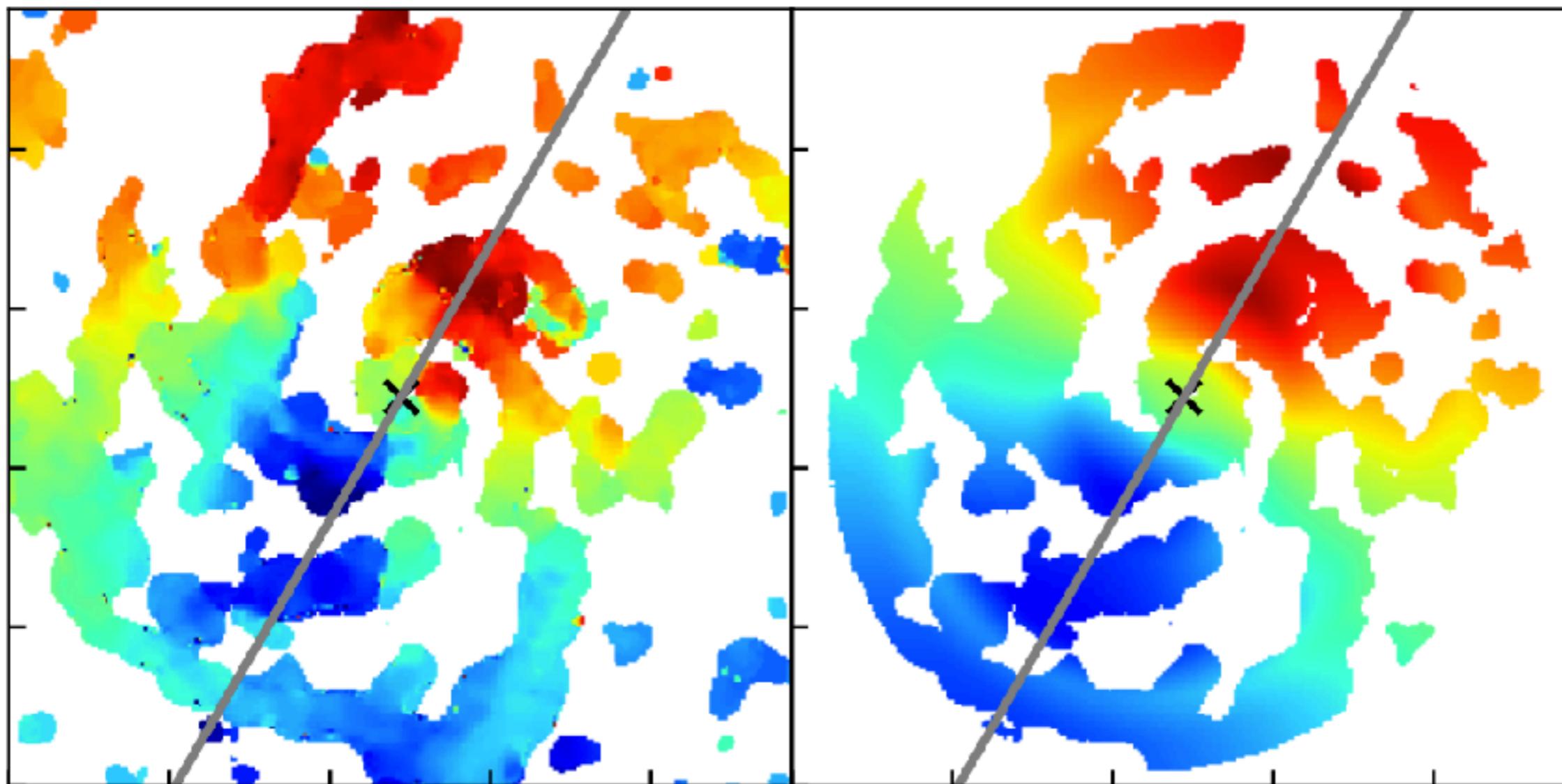
Intensity
[Jy km/s]



DATA

MODEL

VELOCITY



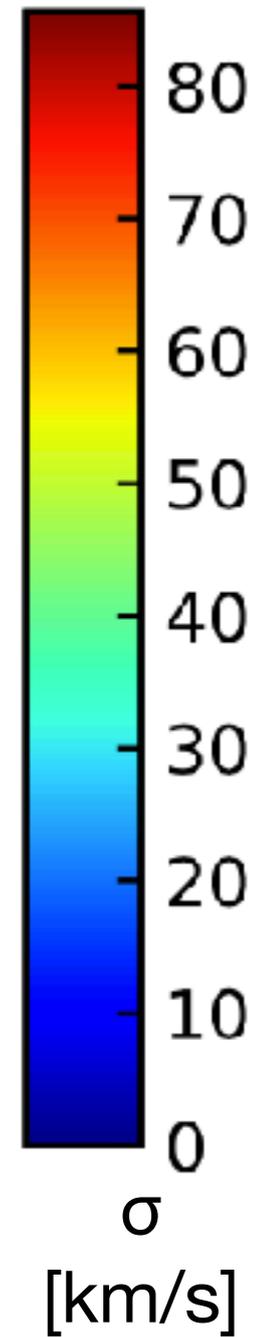
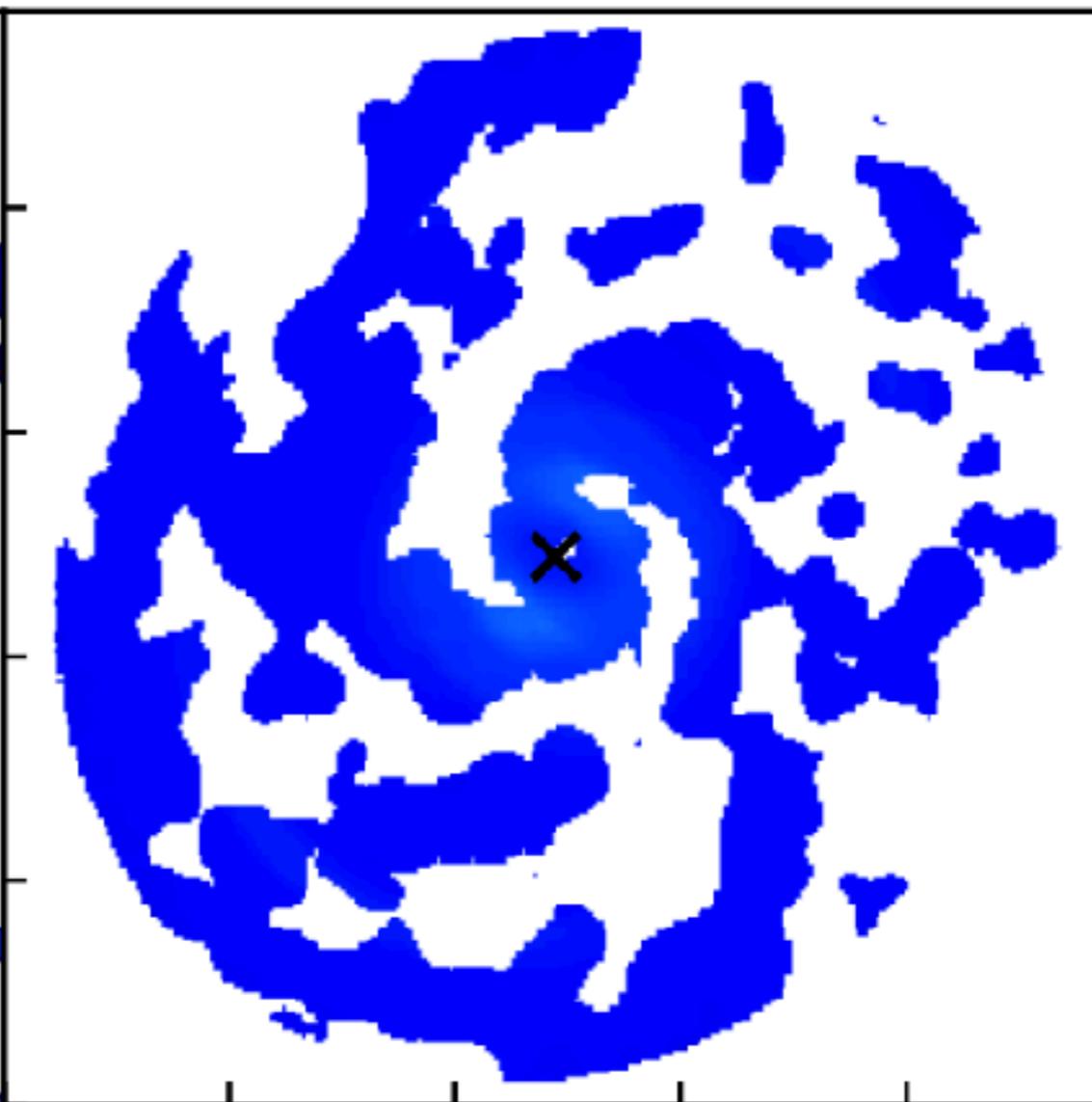
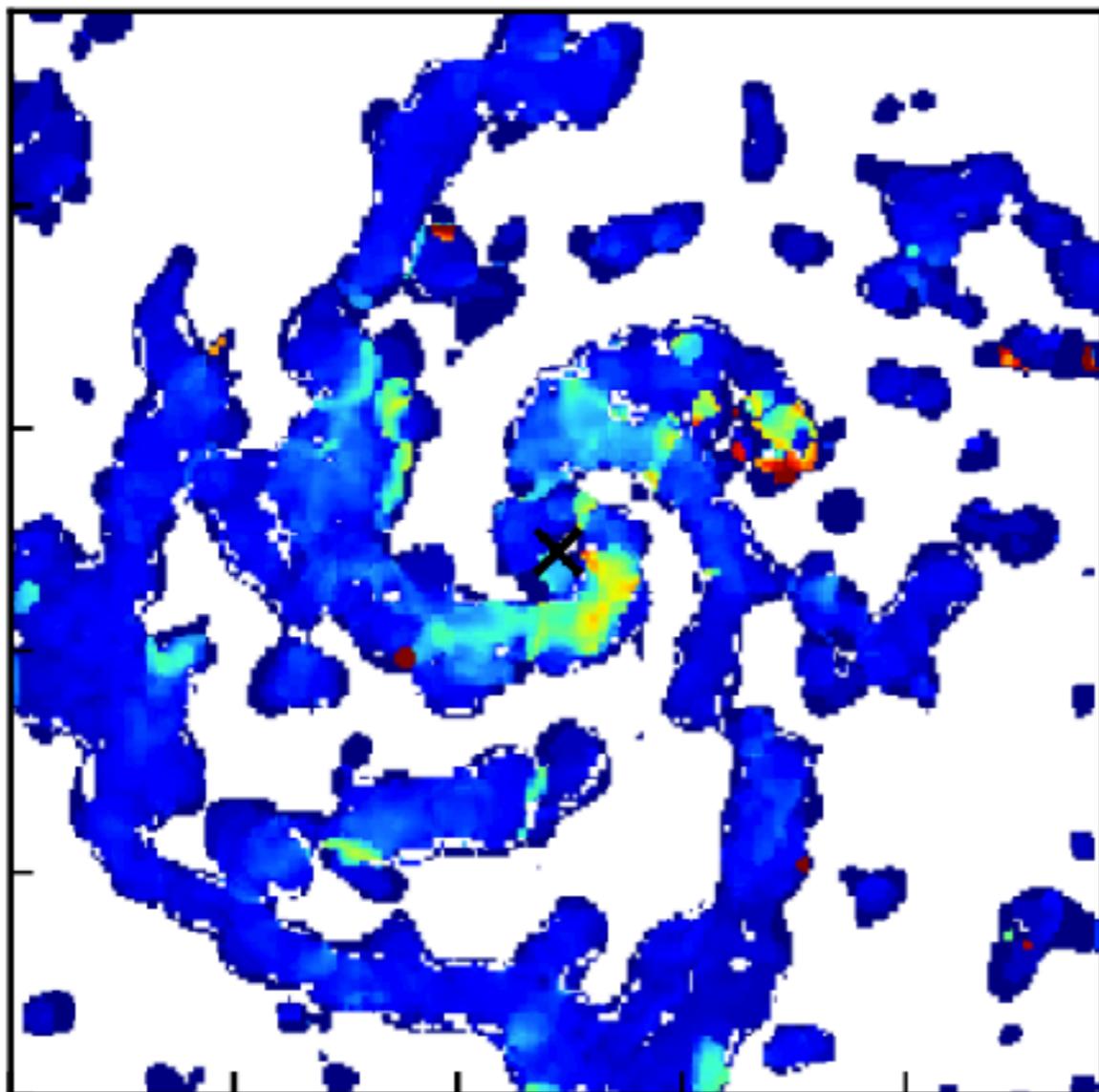
V_{LOS}
[km/s]



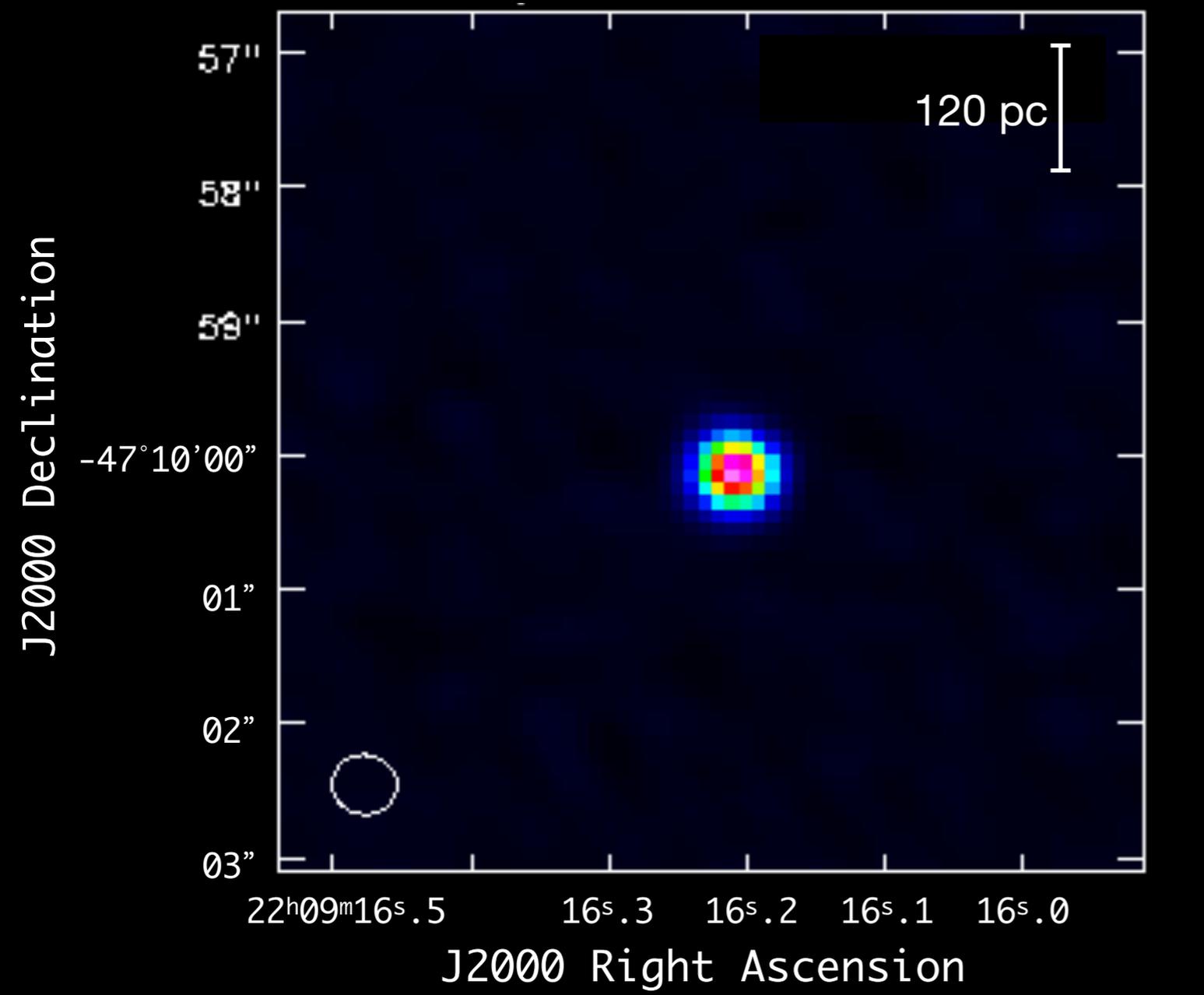
DATA

MODEL

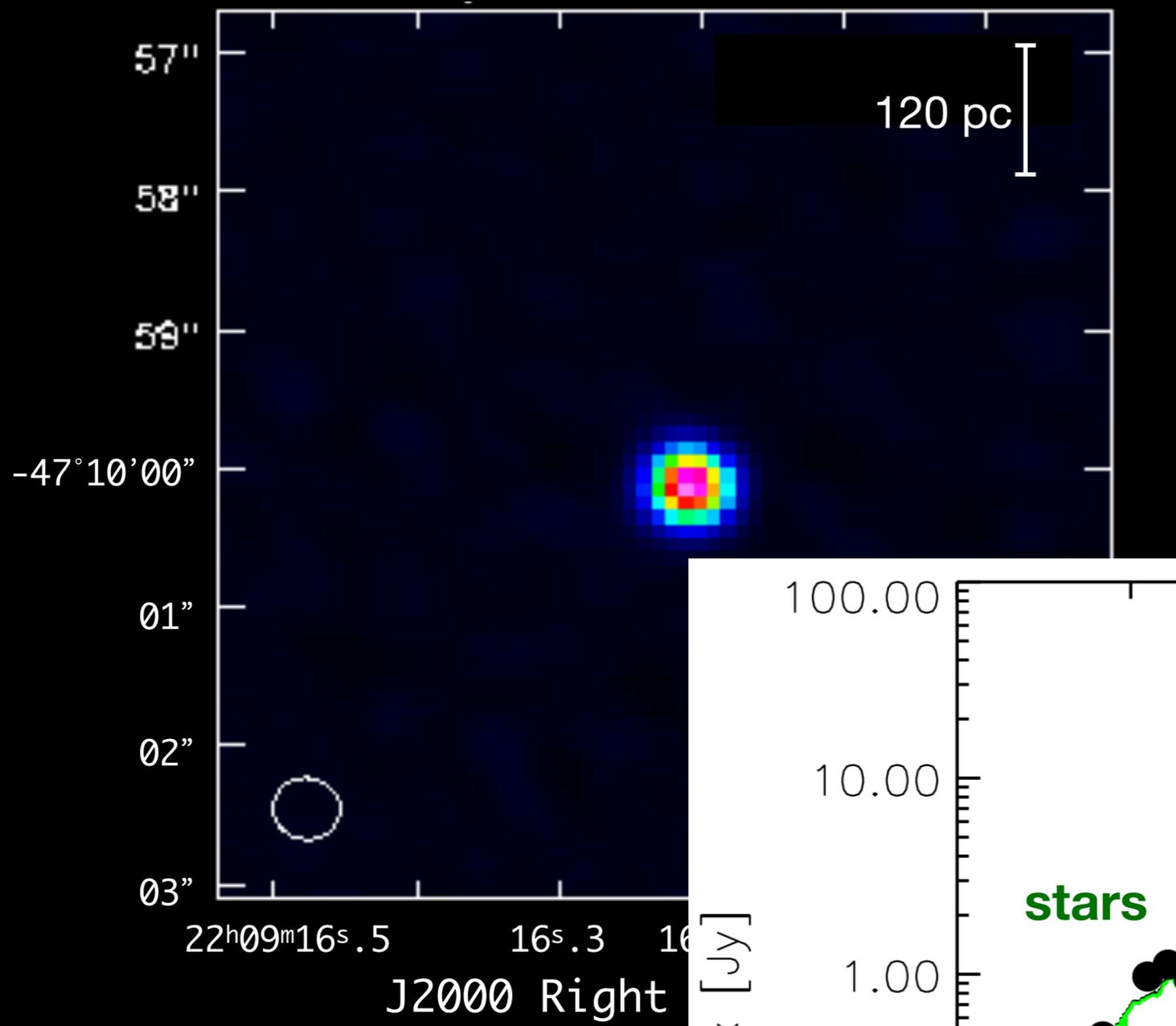
DISPERSION



**ALMA Band 6 continuum:
point-like source**

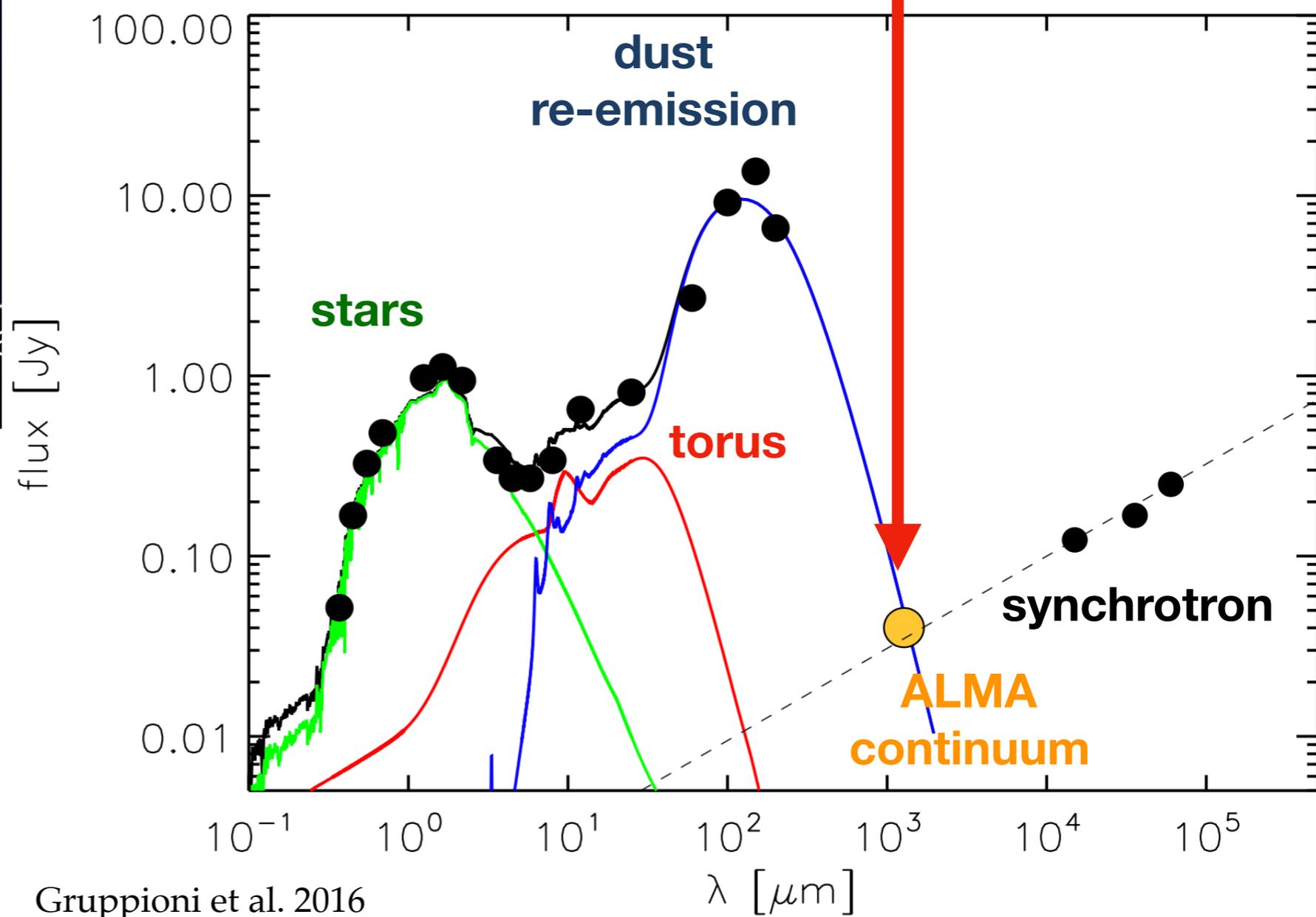


J2000 Declination



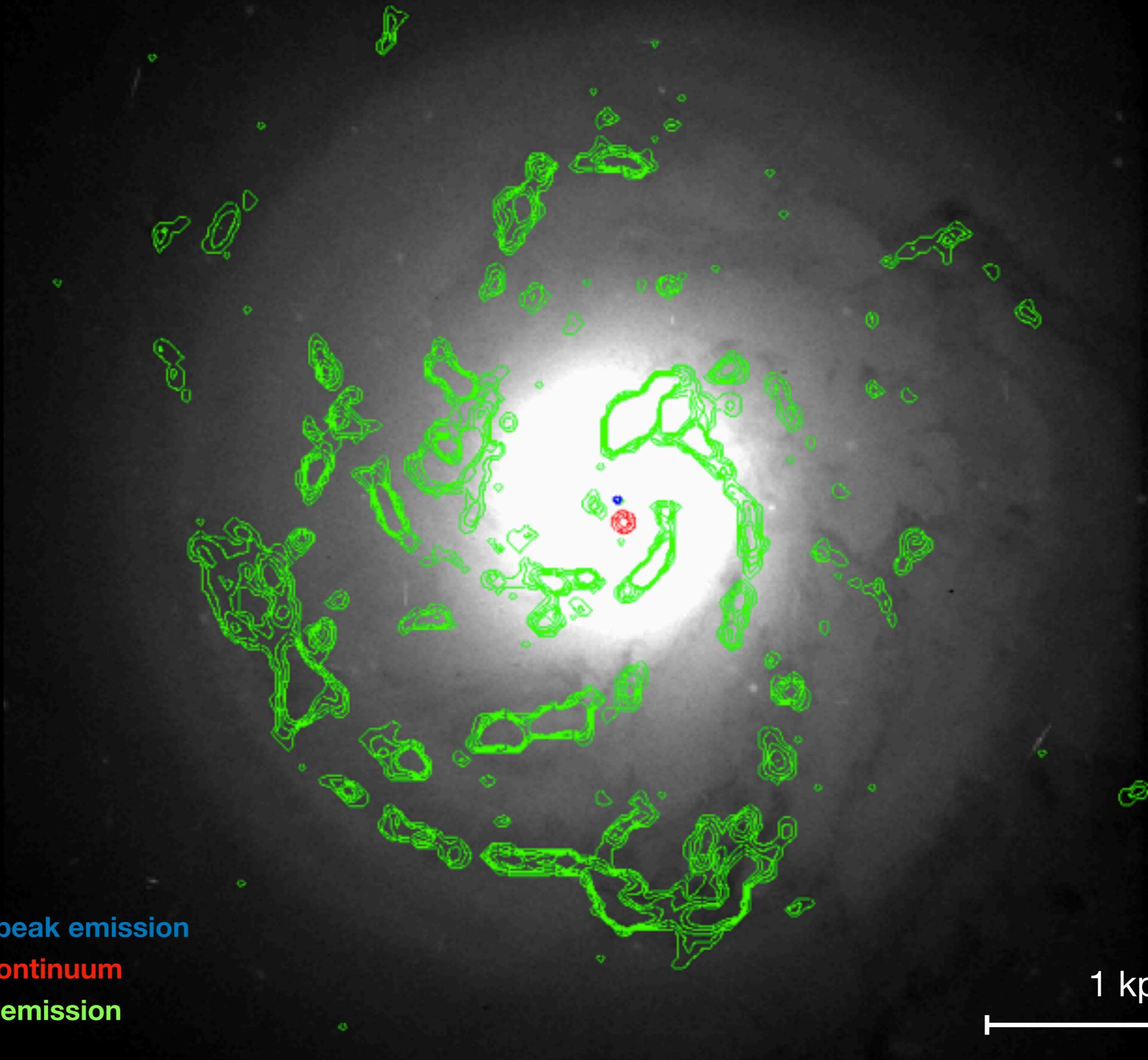
ALMA Band 6 continuum:
point-like source

Synchrotron radiation?



- Optical peak emission
- ALMA continuum
- CO(2-1) emission

1 kpc



Conclusions

- ▶ Relatively weak AGN not affecting the ISM.
- ▶ Kinematical modelling of the molecular gas component.
- ▶ Potential outflow?

... and more to do!

- ▶ M_{dust} from detected continuum
- ▶ M_{gas} from APEX PI230 (?)
- ▶ New optical classification on proprietary SALT data

More details in *Salvestrini et al. in prep.*



Thank you!



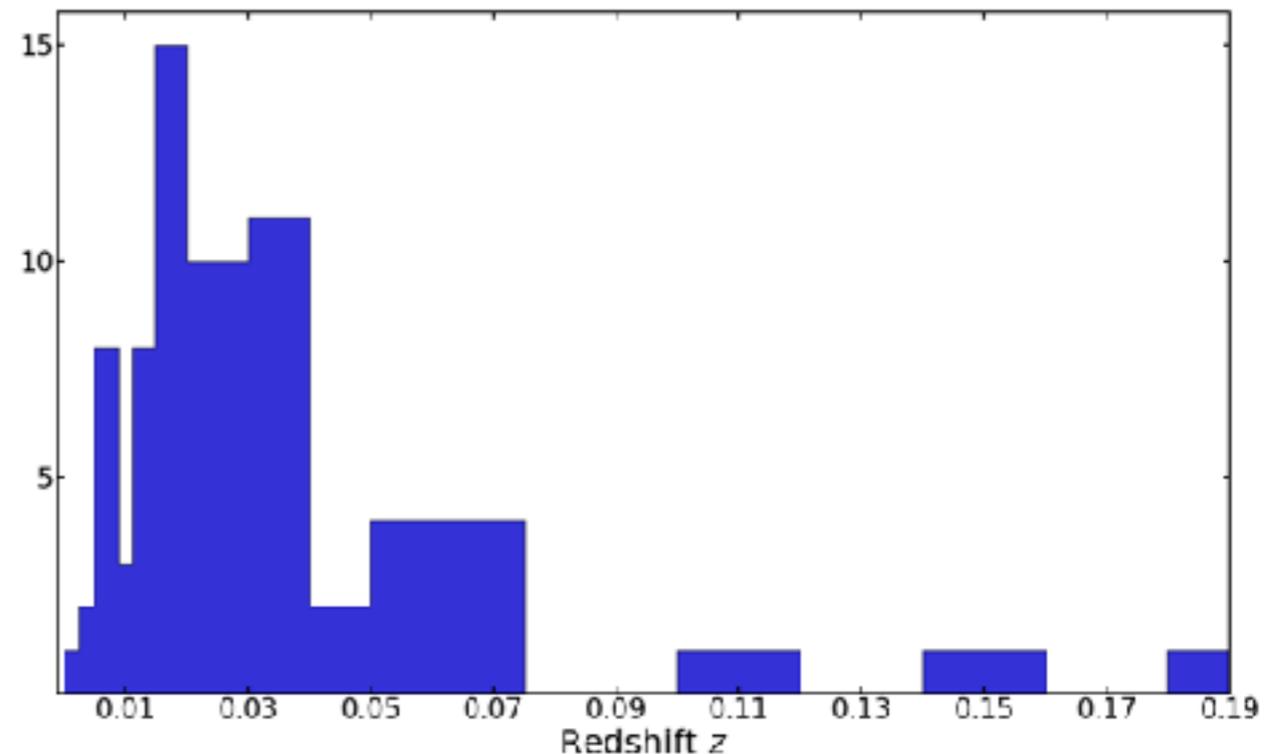
BACKUP SLIDES



The sample

The sample

- ▶ 12MGS is a mid-IR selected sample ($F_{12\mu\text{m}} > 0.22 \text{ Jy}$) consisting of 893 galaxies. \longrightarrow 118 classified as AGN
- ▶ Our sample consists of **76 galaxies** having mid-IR spectra ($5.5\text{--}35 \mu\text{m}$ & $10\text{--}37 \mu\text{m}$).
- ▶ 26/76 galaxies having far-IR *Herschel*-PACS ($\sim 60\text{--}200 \mu\text{m}$) and -SPIRE ($\sim 200\text{--}600 \mu\text{m}$) spectra.
- ▶ Galaxies are classified as Seyfert 1, 2 (35/76, 38/76) and LINER (3/76).
- ▶ $0.0023 < z < 0.1849$

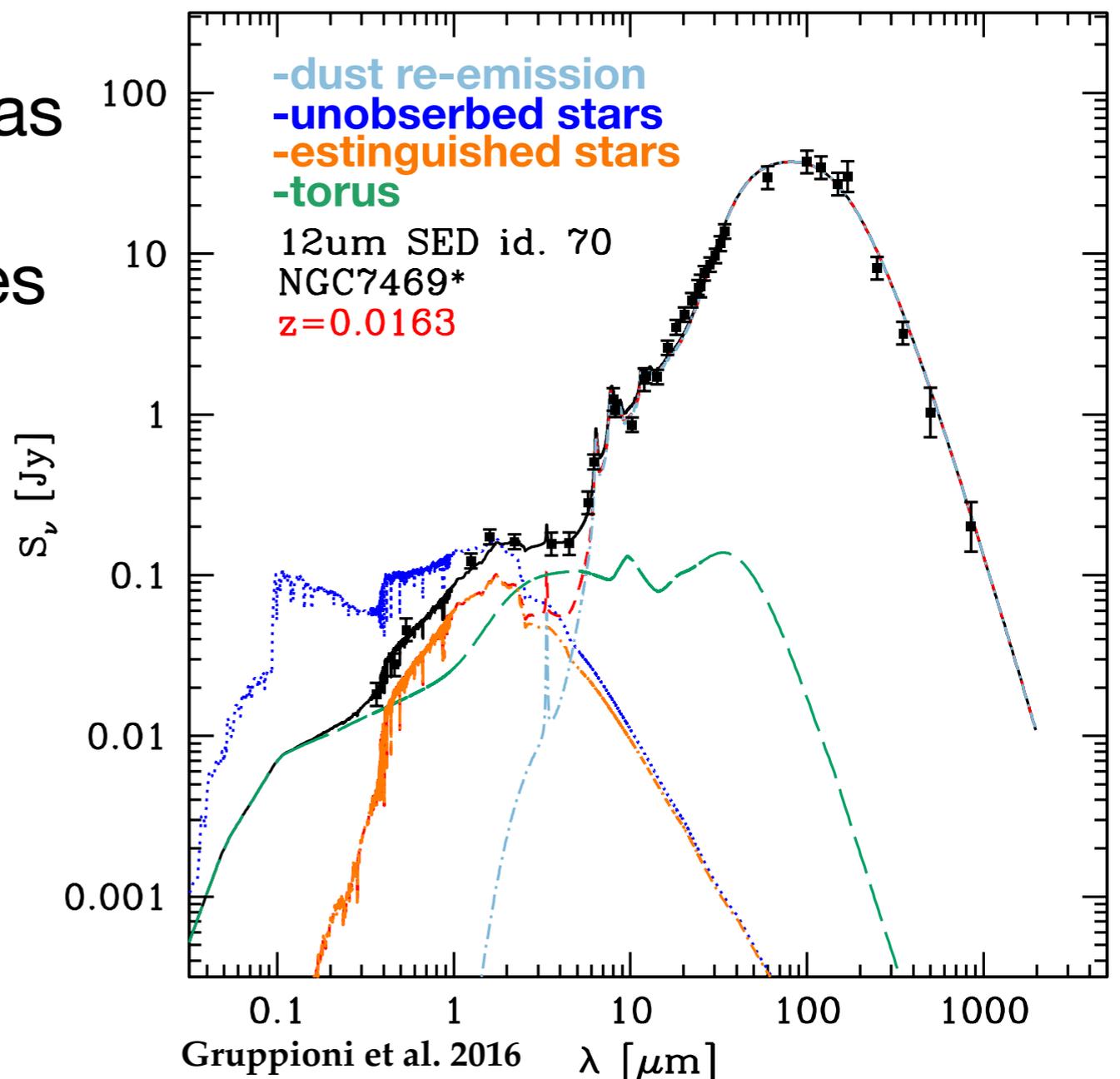


The sample

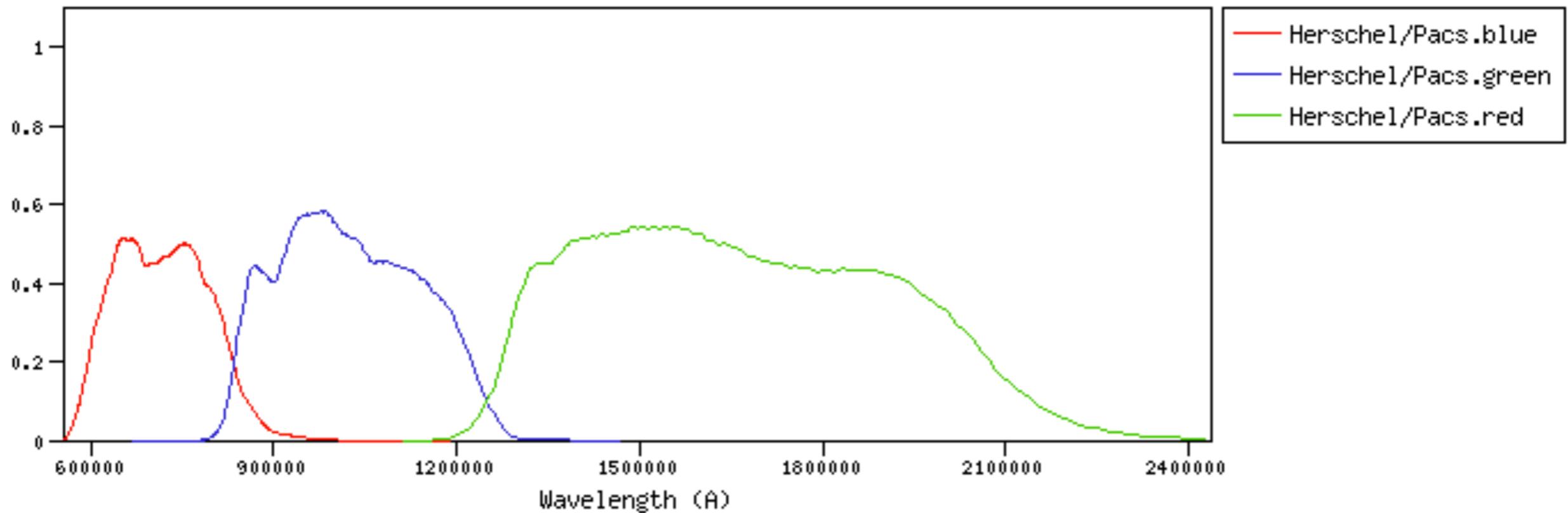
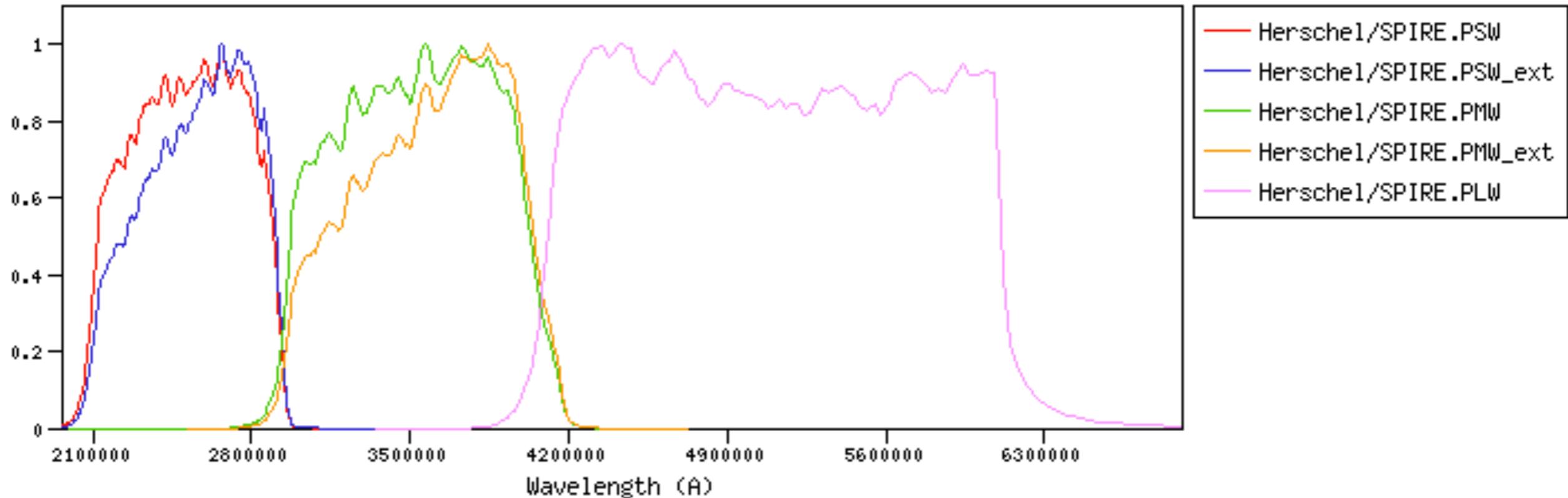
- ▶ 12MGS benefits from an extensive data set, from X-ray to radio frequencies from different observational campaigns spread over the past 20 years.
- ▶ The SED decomposition has been performed over the entire sample of 76 galaxies (Gruppioni et al. 2016).

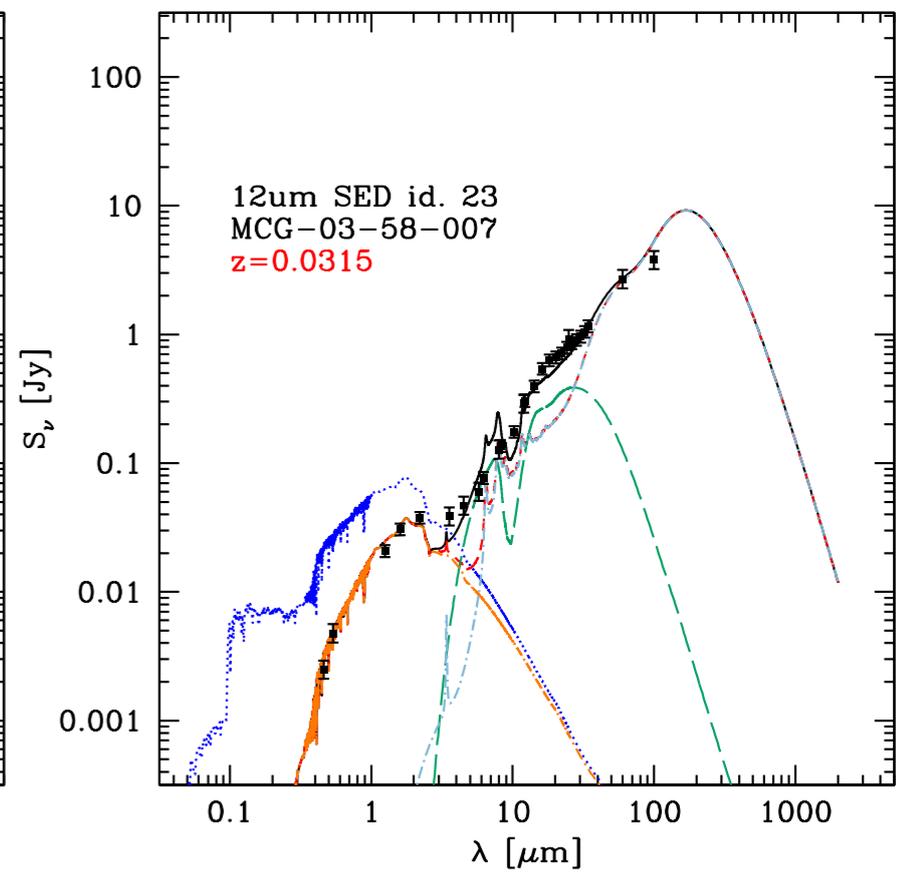
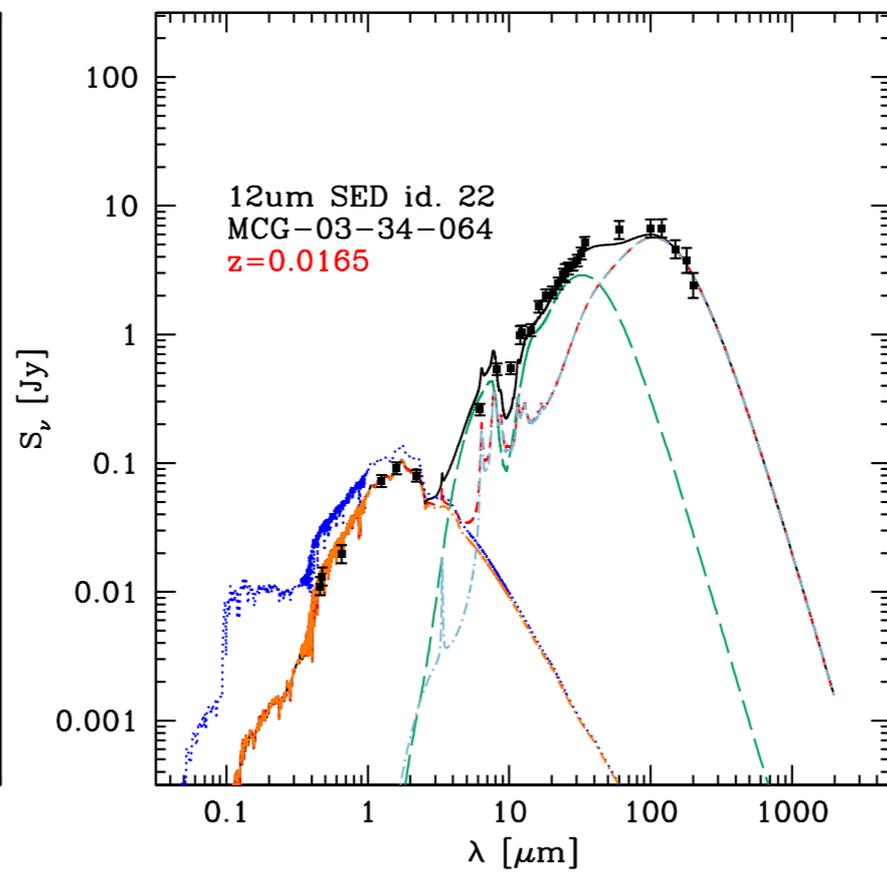
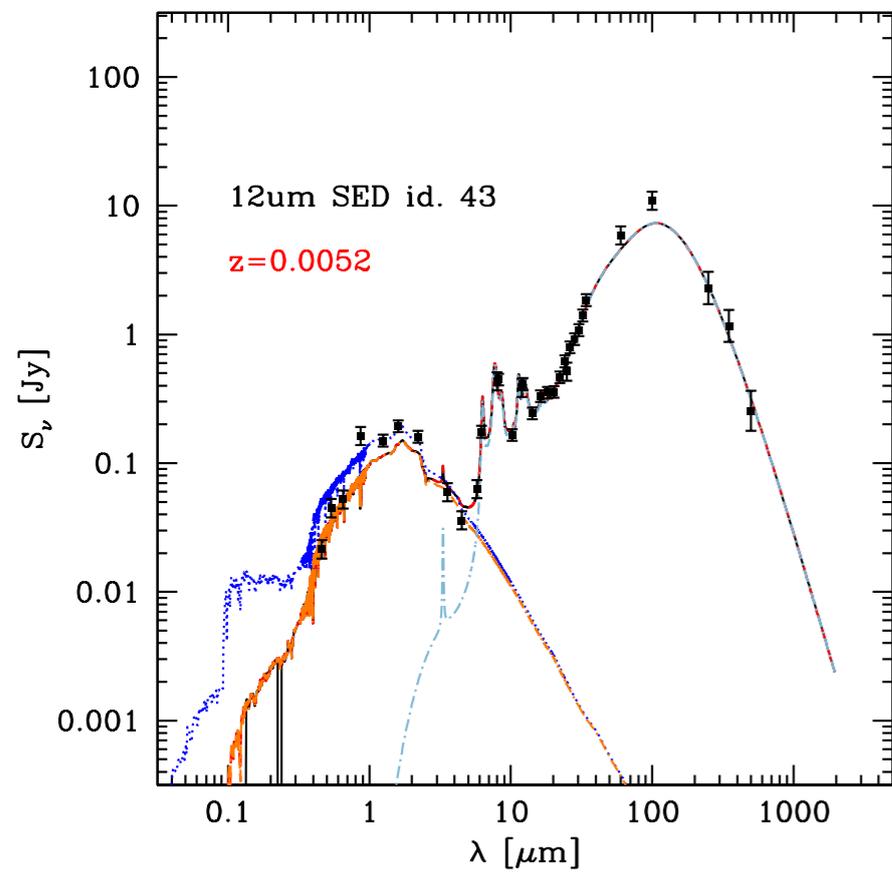
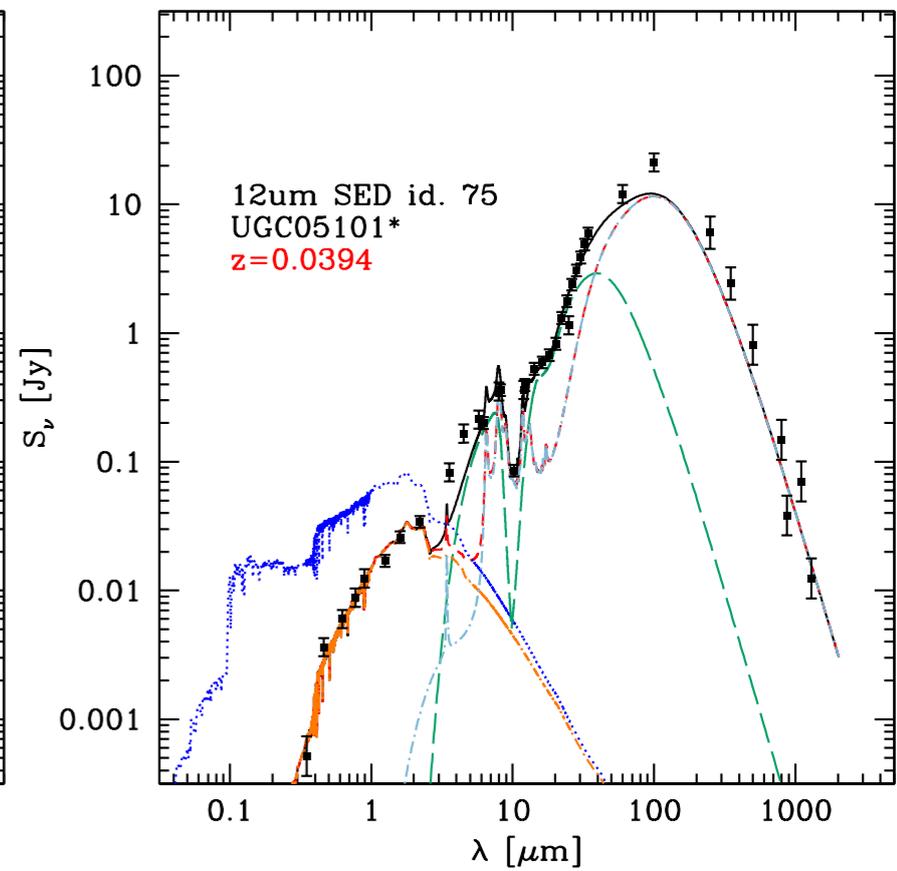
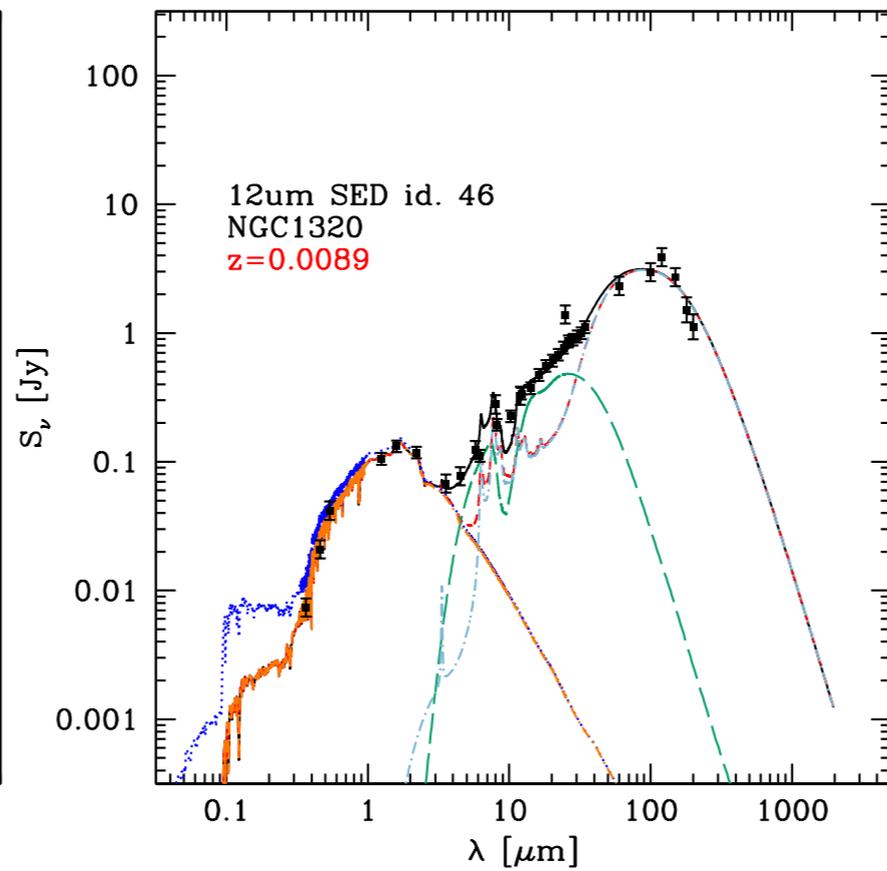
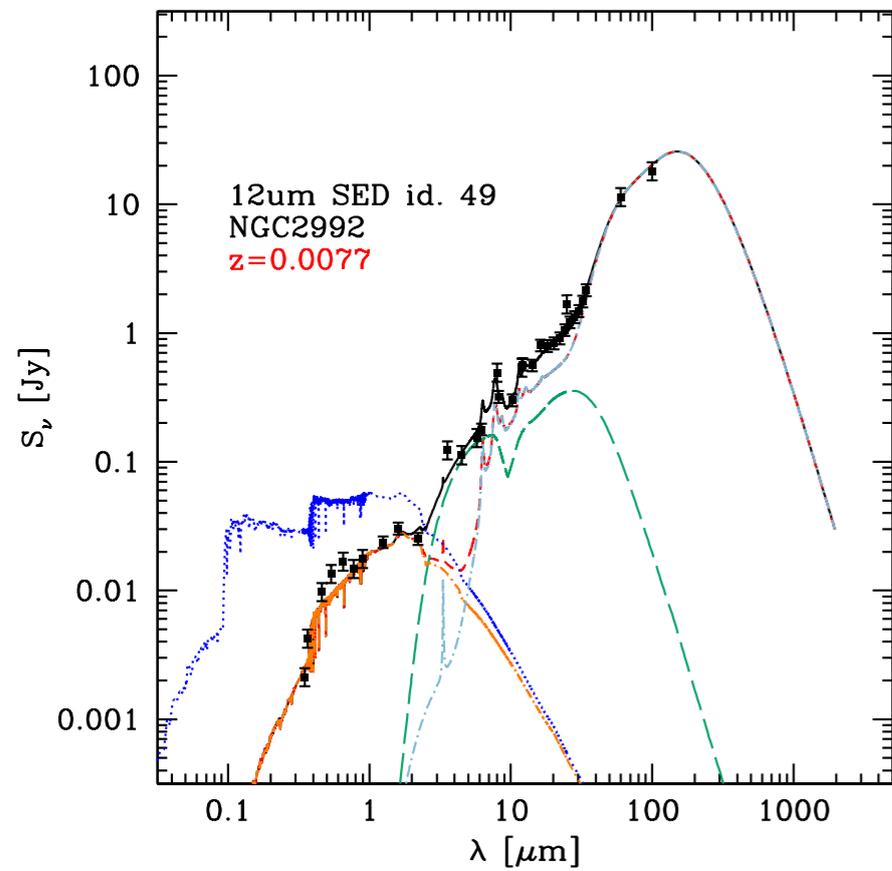
↓

- L_{AGN}
- $f(\text{AGN})$
- SFR
- M_{\star}



Herschel SPIRE & PACS spectrographs



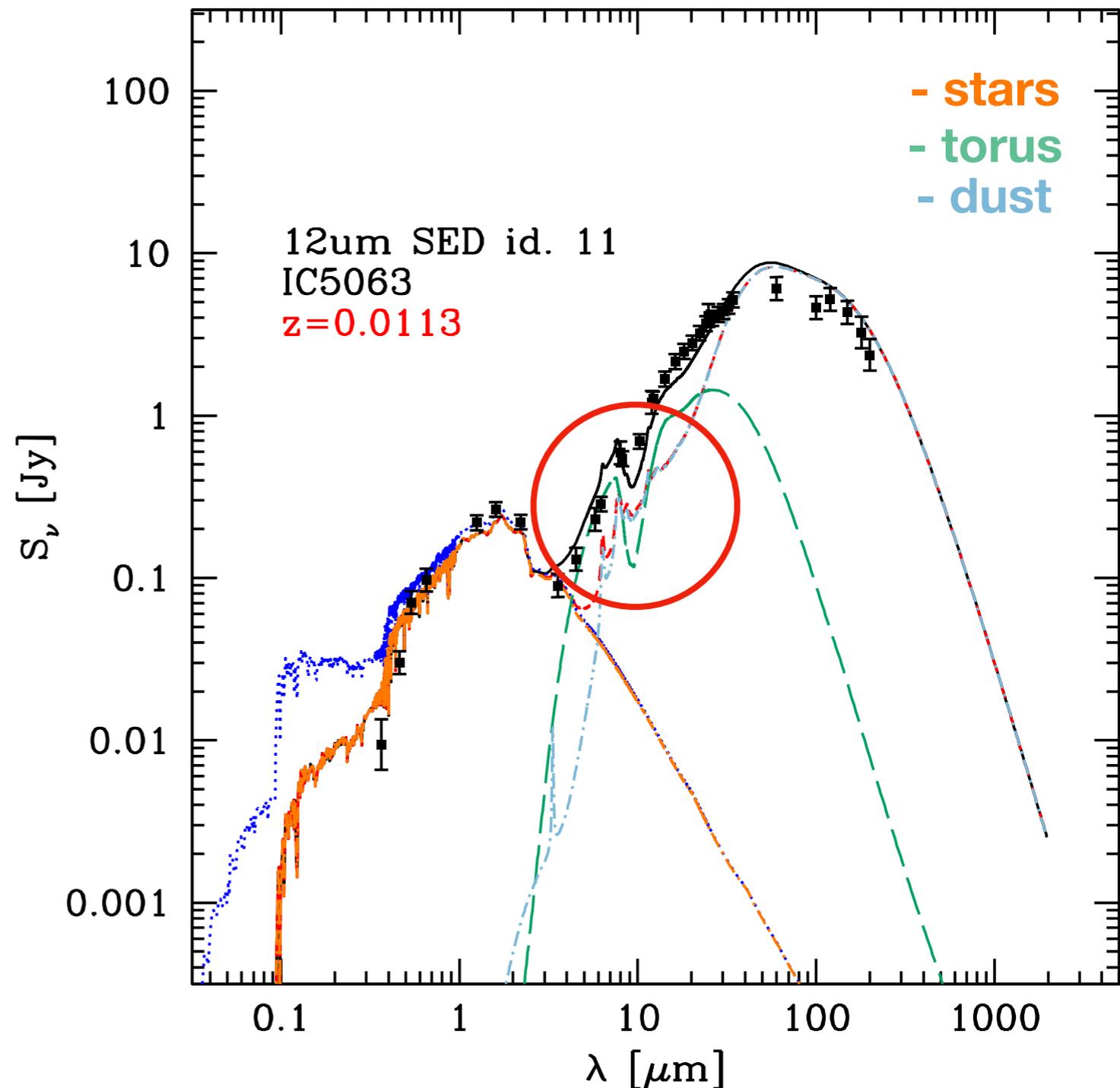


N_H from the $9.7\mu\text{m}$ feature

$$\tau_{los}^{sm}(9.7) = \tau_{eq}(9.7) \cdot e^{-\gamma|\cos(\pi/2-\beta)|}$$

$$\tau_{los}^{sm}(9.7) = 0.042 \cdot \tau_{Vlos}$$

$$N_H \sim 2 \cdot 10^{21} \tau_{Vlos} \text{ cm}^{-2}$$



Compton depth

$$\tau_s(E_0) = x\sigma_{\text{KN}}(E_0) \left[\frac{\int_0^{2\pi} \int_0^\pi P(E_0, \theta, \phi) N_{\theta, \phi} \sin \theta \, d\theta \, d\phi}{\int_0^{2\pi} \int_0^\pi P(E_0, \theta, \phi) \sin \theta \, d\theta \, d\phi} \right]$$

$$\tau_s \sim x \sigma_T N_H$$

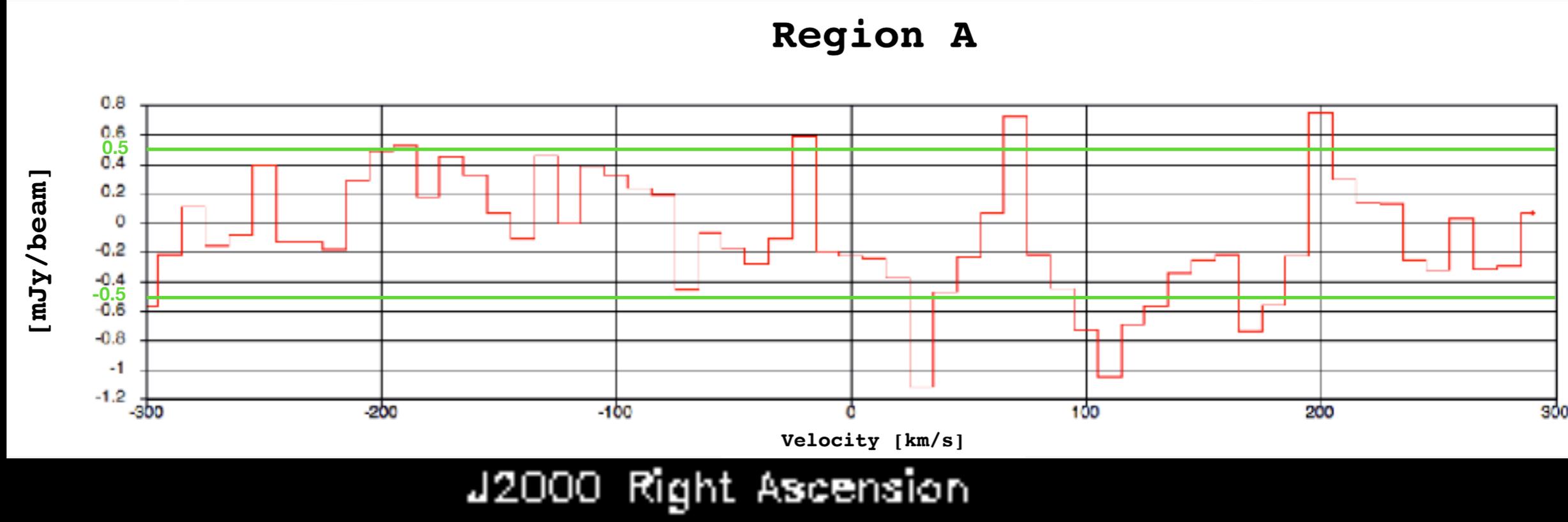
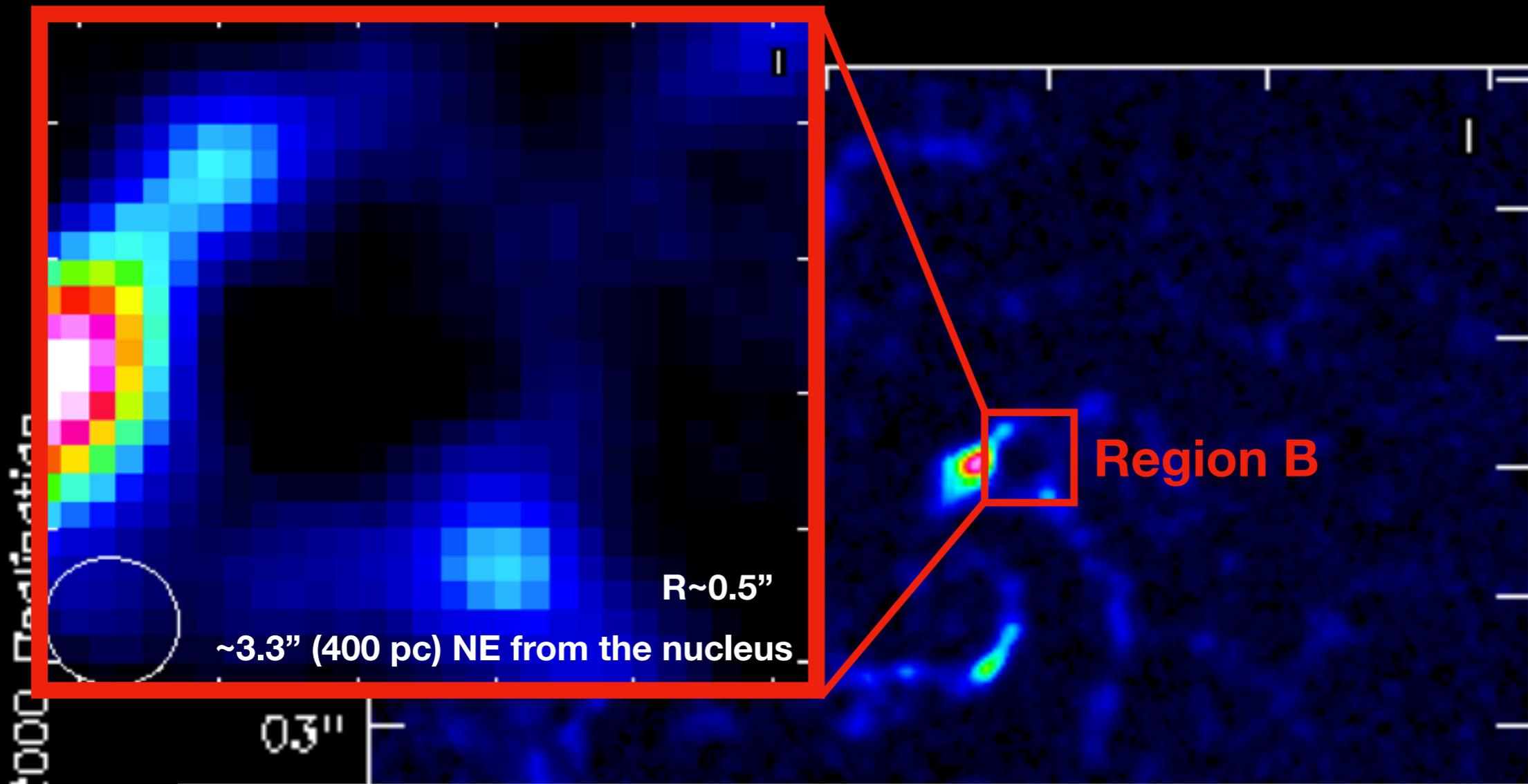
$$\tau_s \sim 0.8090 N_{24}$$

Compton depth is defined as the *Thomson depth* of the medium *regardless of the energy spectrum of the incident photons*

- X-ray source is isotropic
- Column-density distribution is spherically-symmetric



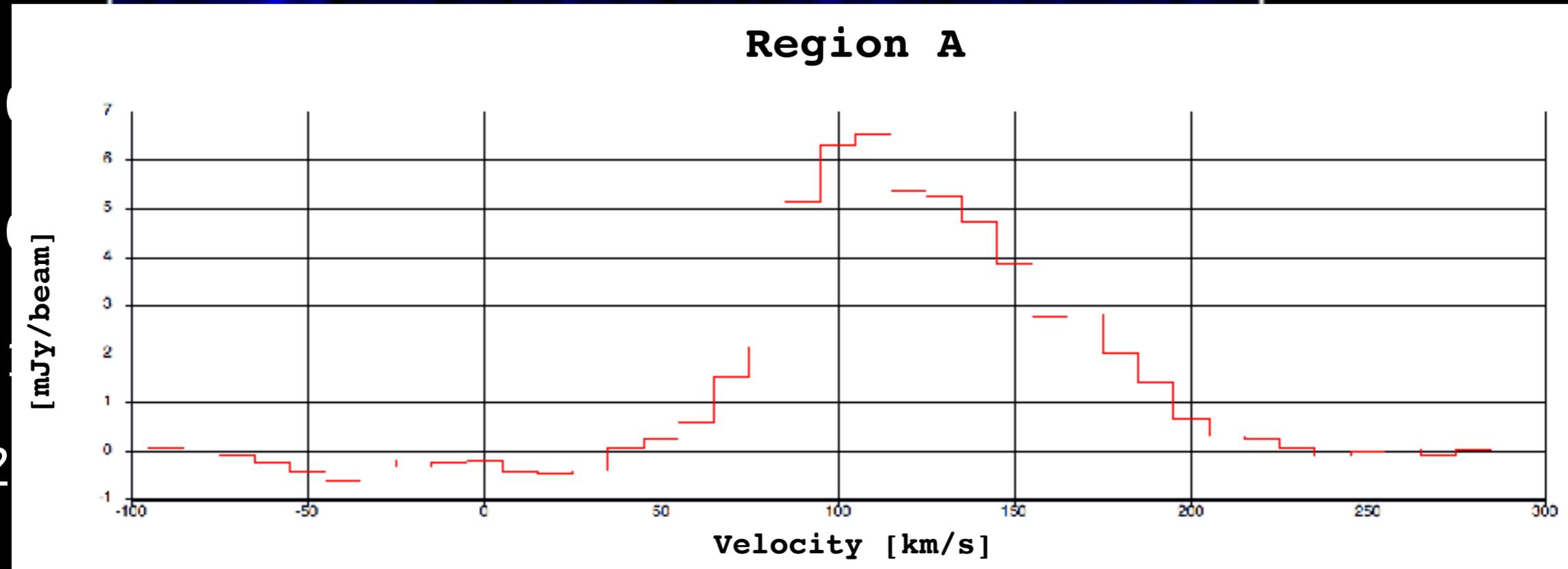
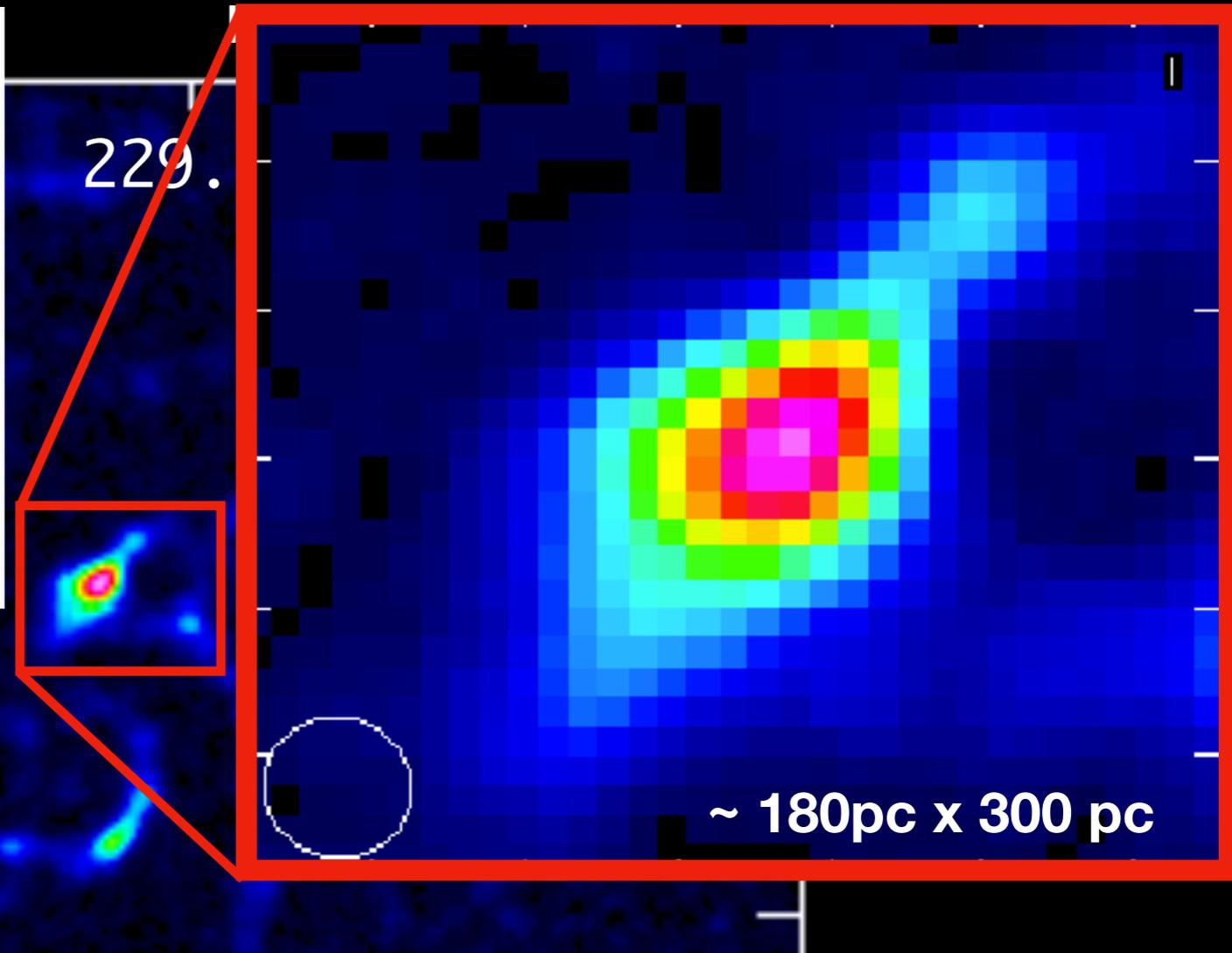
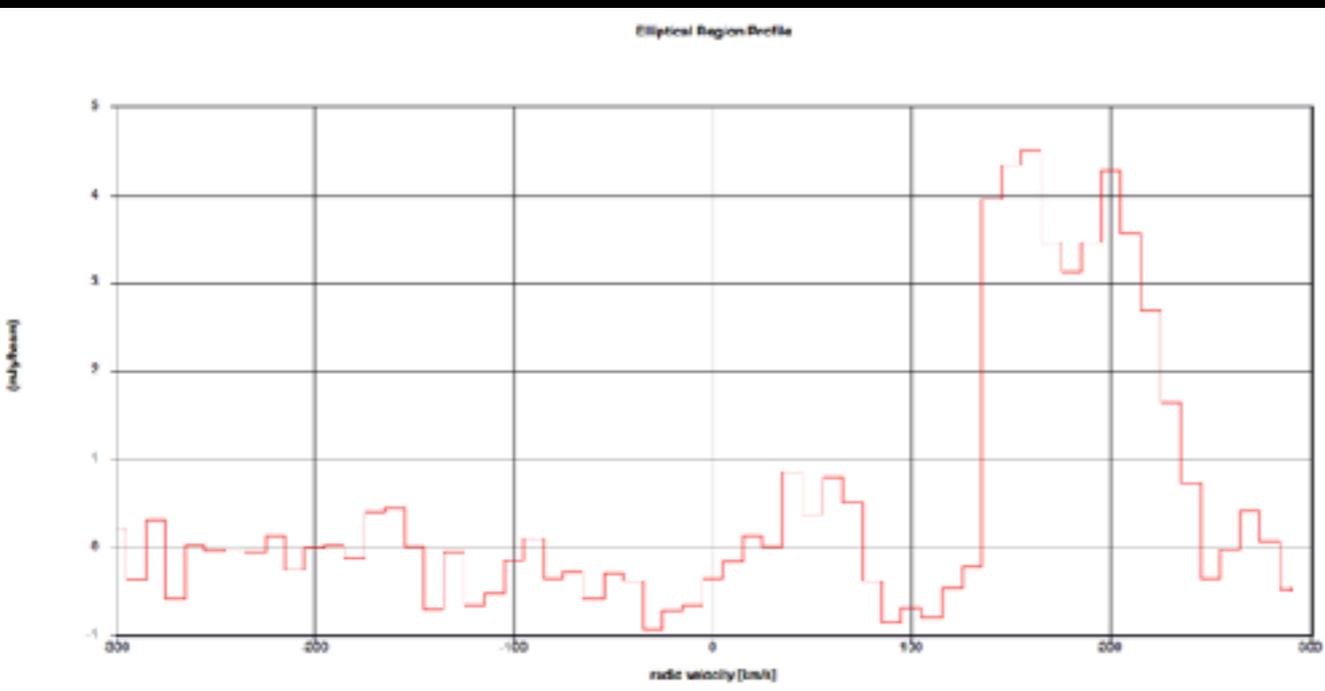
NGC 7213



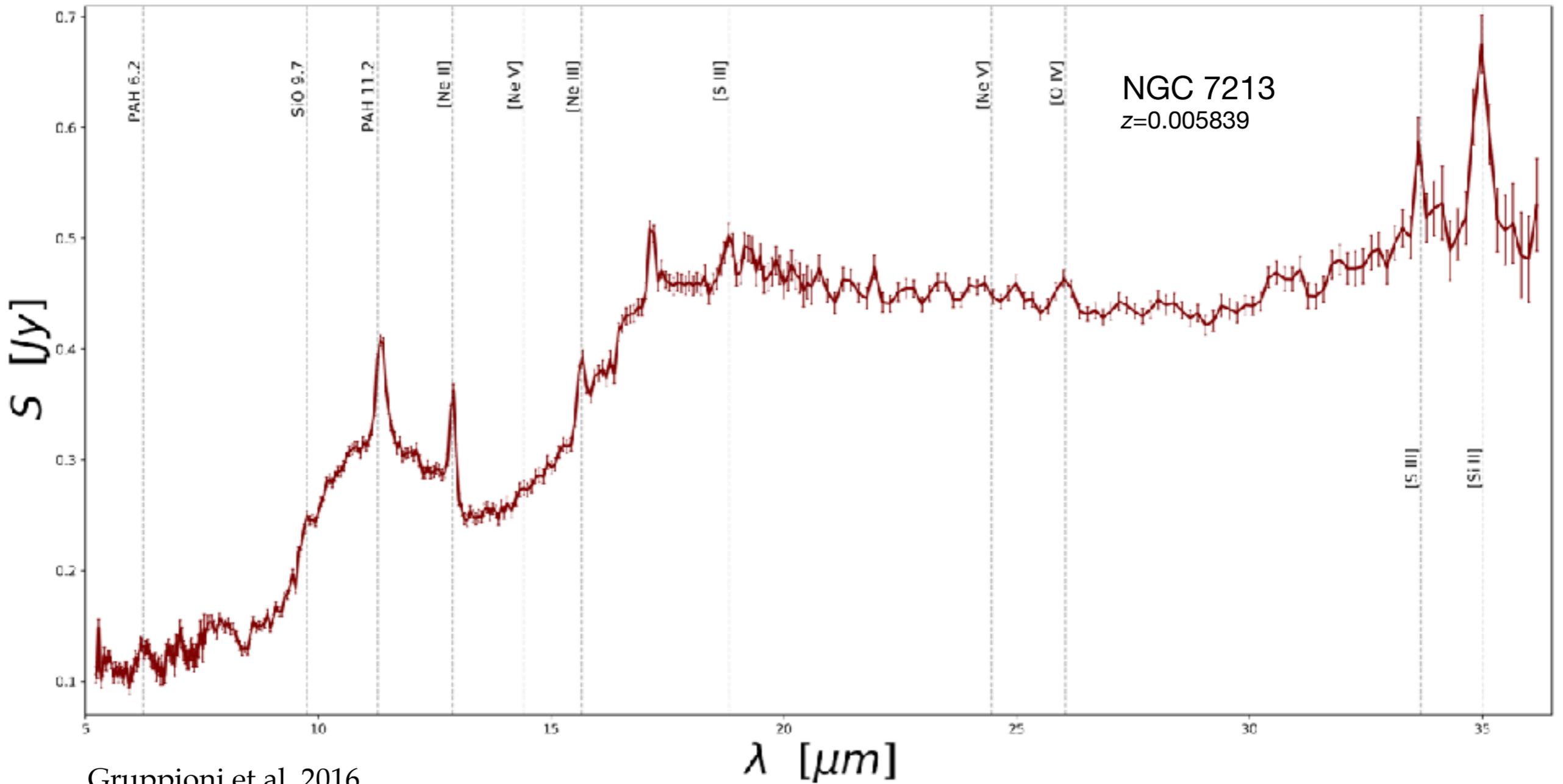
J2000 Declinat

$-47^{\circ}10'00''$

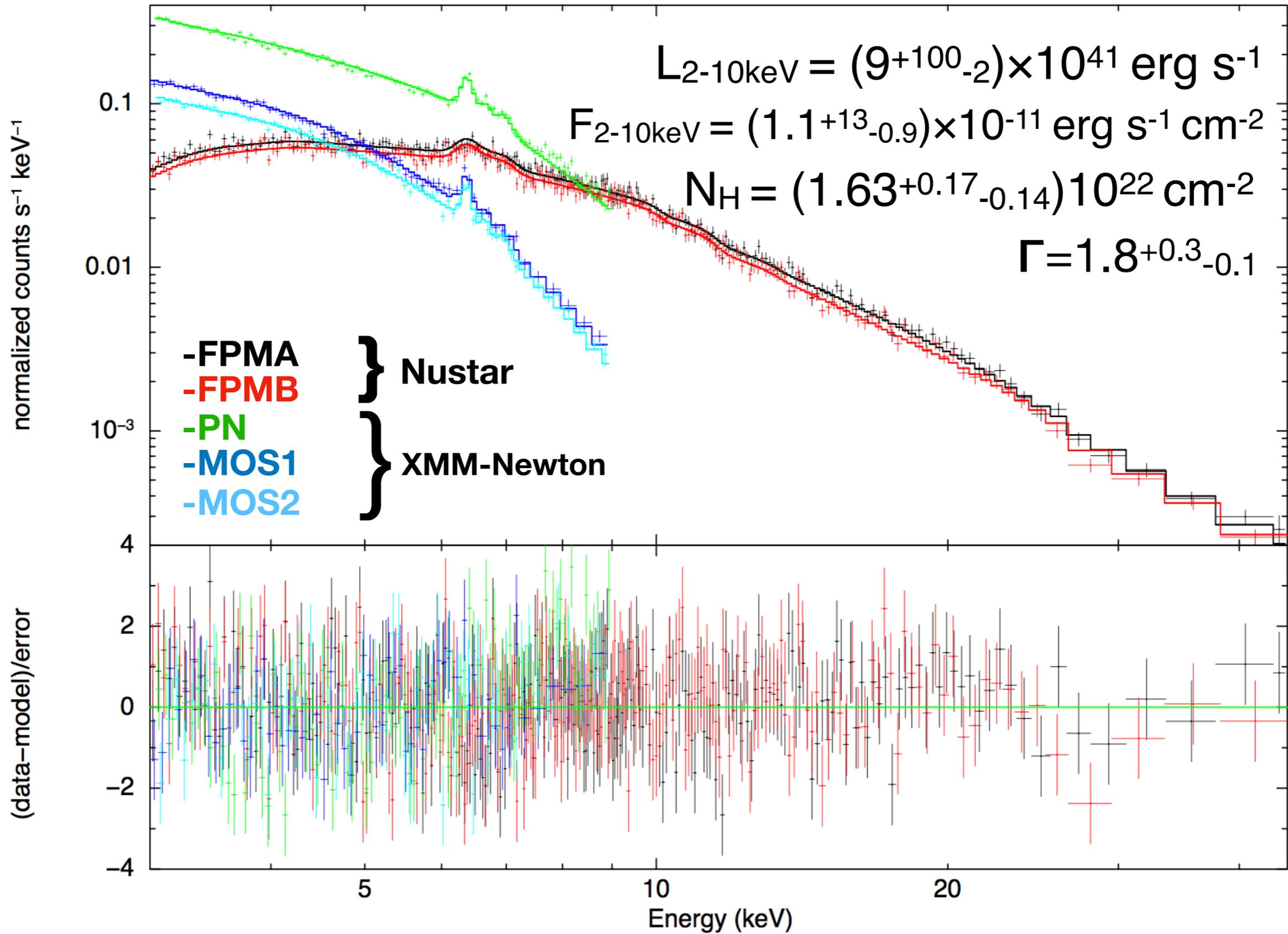
$03''$



Spettro IR NGC7213



Gruppioni et al. 2016

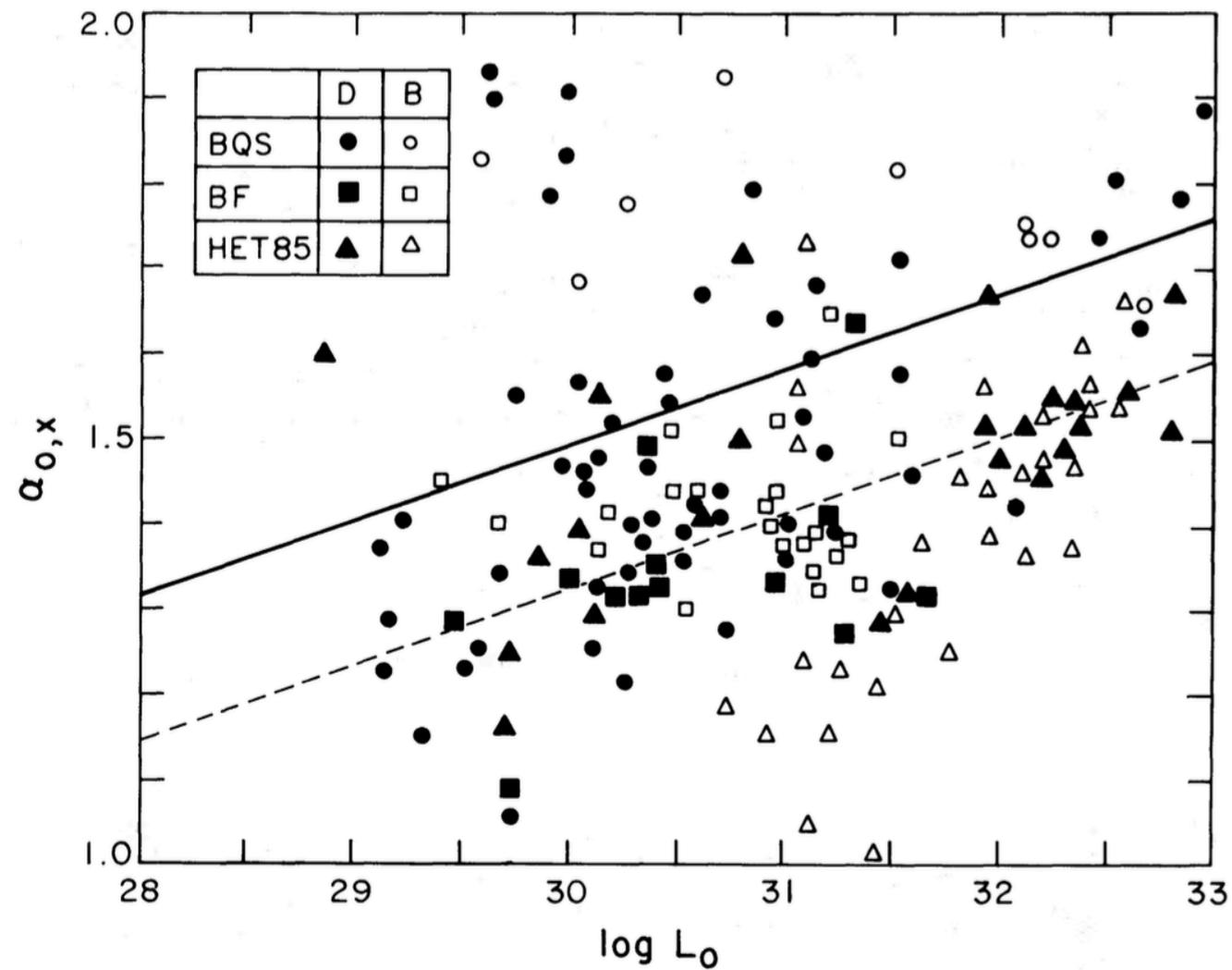


Quasar as High-Redshift Standard Candles

The L_x - L_{UV} relation at high redshift

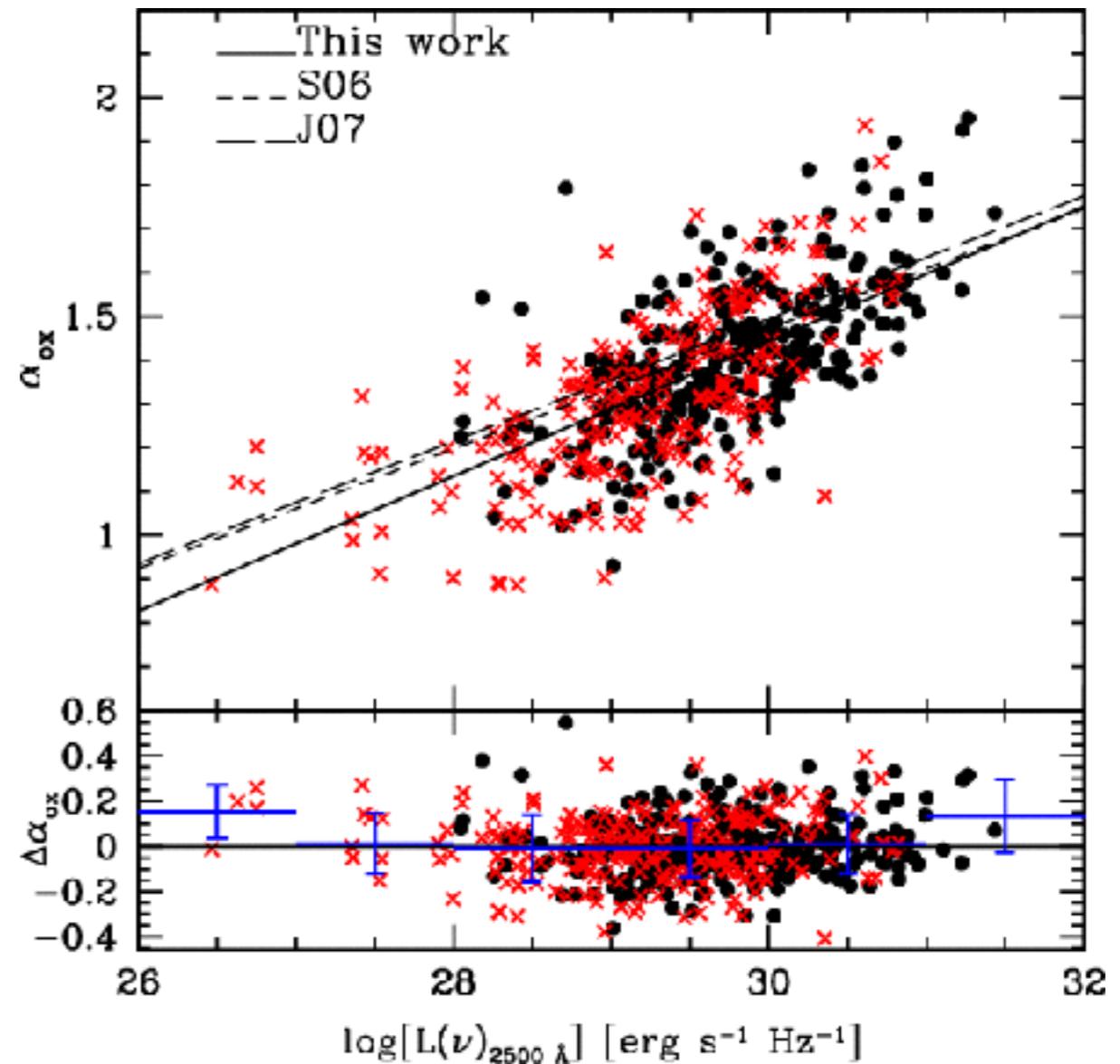
Co-authors: G. Risaliti, S. Bisogni, E. Lusso

The L_X-L_{UV} relation



Avni and Tananbaum (1986)

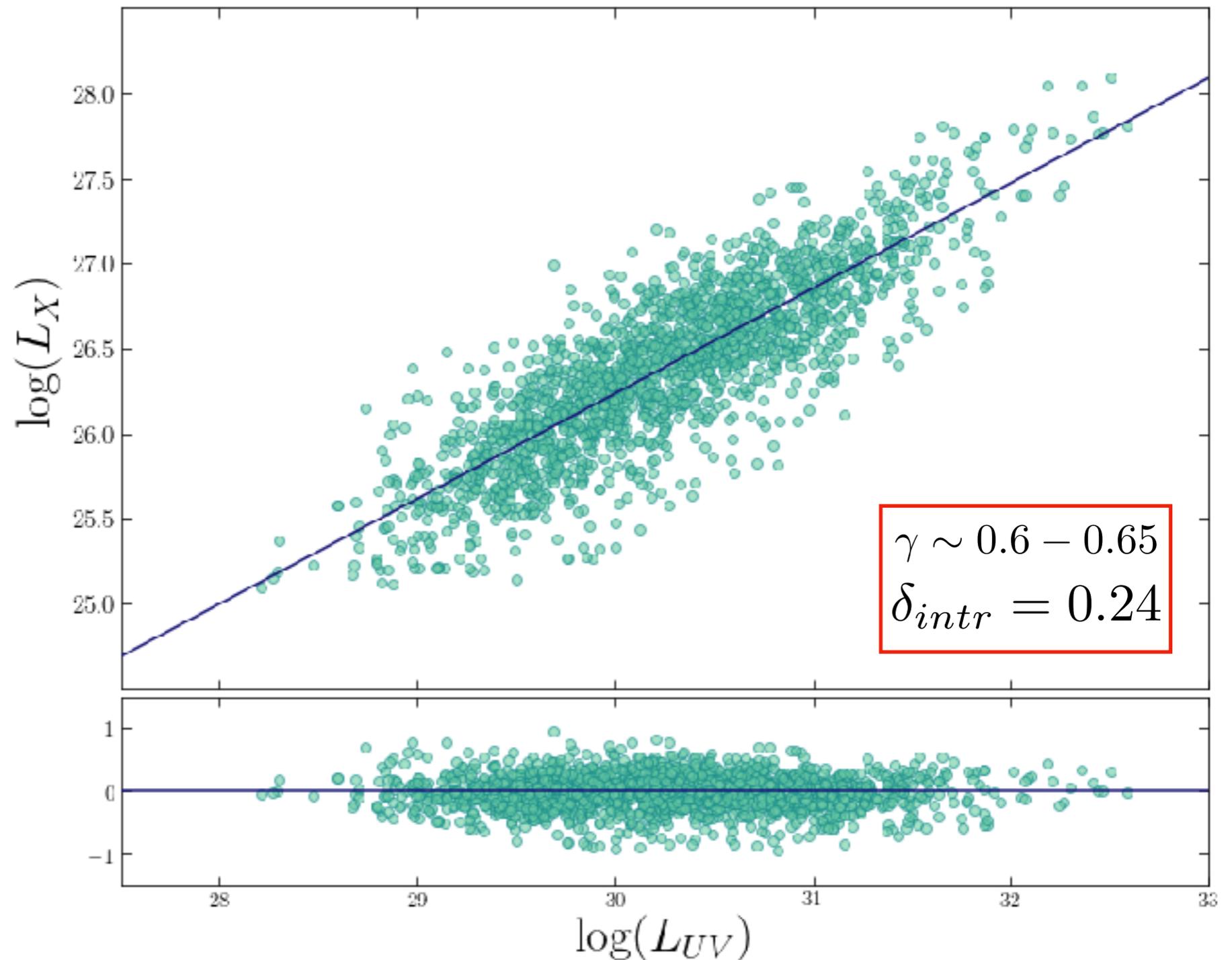
$\delta_{intr} \sim 0.35-0.40$ dex



Lusso et al. (2010)

The L_X - L_{UV} relation

- ▶ SDSS DR7
(Shen et al. 2011)
- ▶ 3XMM-DR5
- ▶ No BAL sources
- ▶ Radio Quiet
- ▶ $1.6 < \Gamma_X < 2.8$
- ▶ 2153 sources
- ▶ $0.065 < z < 4.925$



Lusso and Risaliti (2016)

The sample

- ▶ SDSS DR7 (Shen et al. 2011) & DR12 (for $z < 5.3$)
 - ▶ No BAL sources
 - ▶ Radio Quiet
 - ▶ Archival *Chandra* and *XMM-Newton* observations
 - ▶ No X-ray flux upper limit
 - ▶ $4.0 < z < 7.08$
- Accurate selection
- Accurate X-ray analysis
- Evolution with redshift?
-

More details in: Salvestrini et al. in prep.

$$\log(L_X) = \gamma \log(L_{UV}) + \beta$$

