Kinematic analysis of luminous infrared galaxies with VLT-SINFONI

Jornadas de Doctorado

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Alejandro Crespo Gómez

Directors:

Javier Piqueras López
Santiago Arribas Mocoroa

UCM tutor:

Nicolás Cardiel López

CENTRO DE ASTROBIOLOGÍA
ASOCIADO AL NASA ASTROBIOLOGY INSTITUTE

UNIVERSIDAD COMPLUTENSE MADRID

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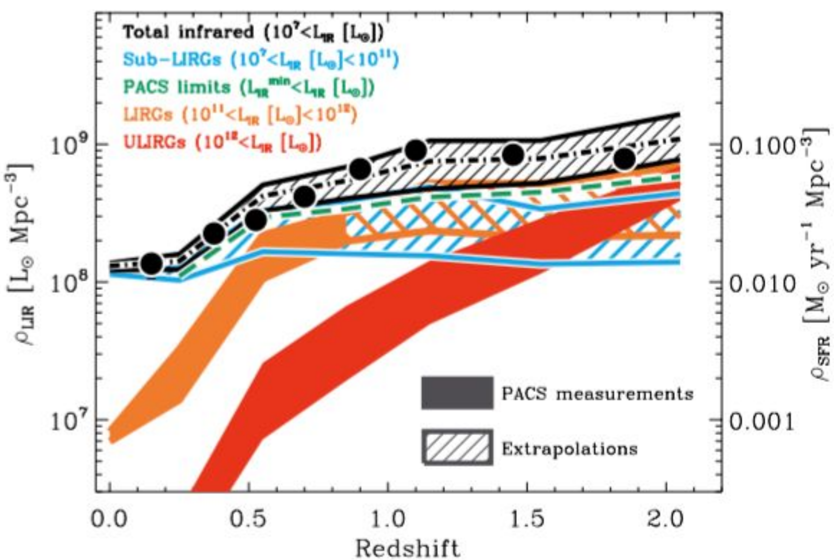
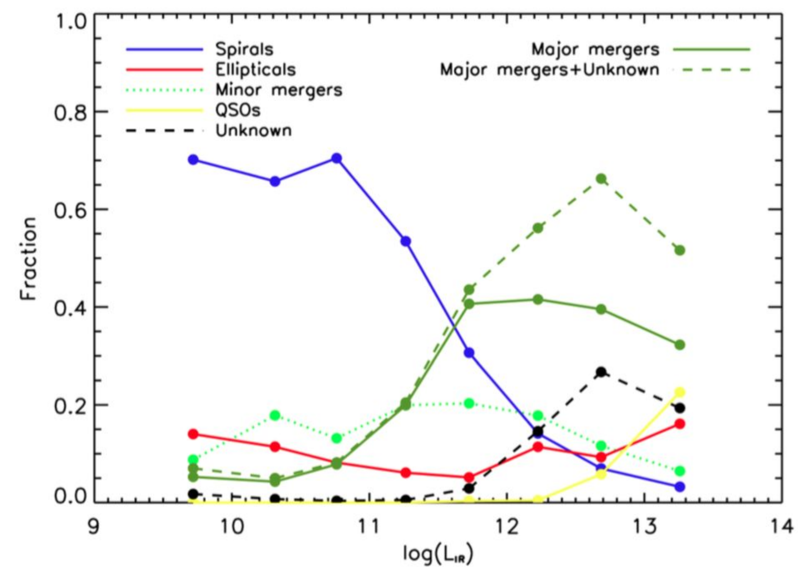
Introduction

- What are the (Ultra)Luminous Infrared Galaxies?
  - (U)LIRGs are galaxies with $(10^{12} < L_{IR} < 10^{13})$ $10^{11} < L_{IR} < 10^{12}$ $L_{\odot}$
  - Dominant component to the energy density at z>2
  - A laboratory for galaxy evolution
    - Coexistent AGN and compact star-formation regions
    - Feedback processes
    - High spatial resolution and S/N

(Magnelli 2013)



(Kartaltepe 2010)

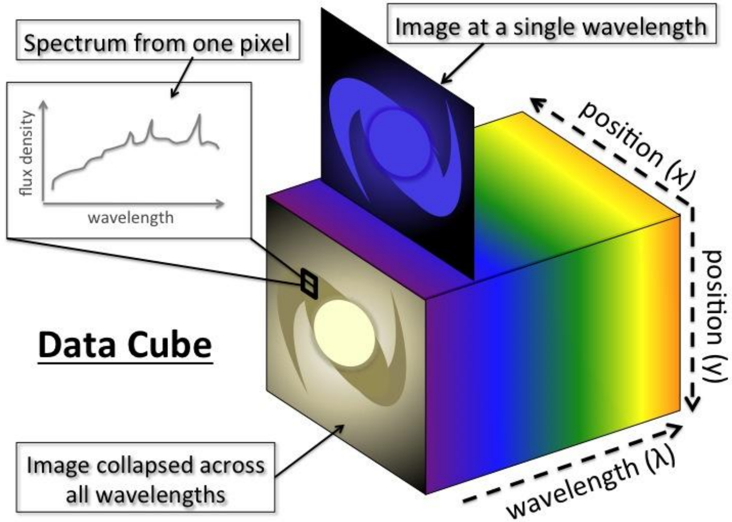


Introduction

- Why IFS?
  - Integral Field Spectroscopy allows us to image and spectroscopic analysis
  - Spectrally and spatially resolved study

- Spectrograph for INtegral Field Observations in the Near Infrared at VLT-4:
  - Gratings (J,H,K,H+K)
  - Seeing-limited and AO
  - Spectral resolutions (2000,3000,4000,1500)
  - Spatial scale (0.25”,0.1”,0.025”)
  - FoV (8”x8”,3”x3”,0.8”x0.8”)

(Wood,C.M. 2015)



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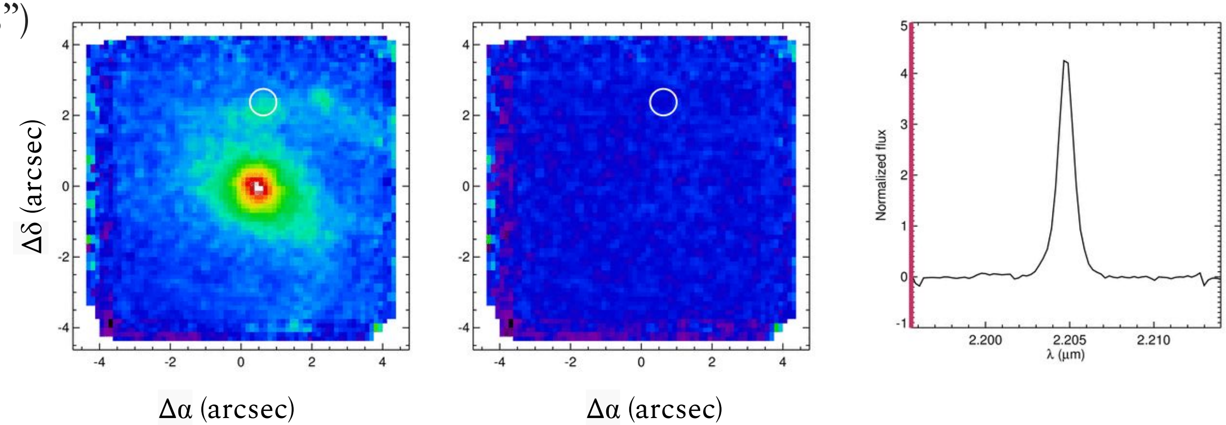
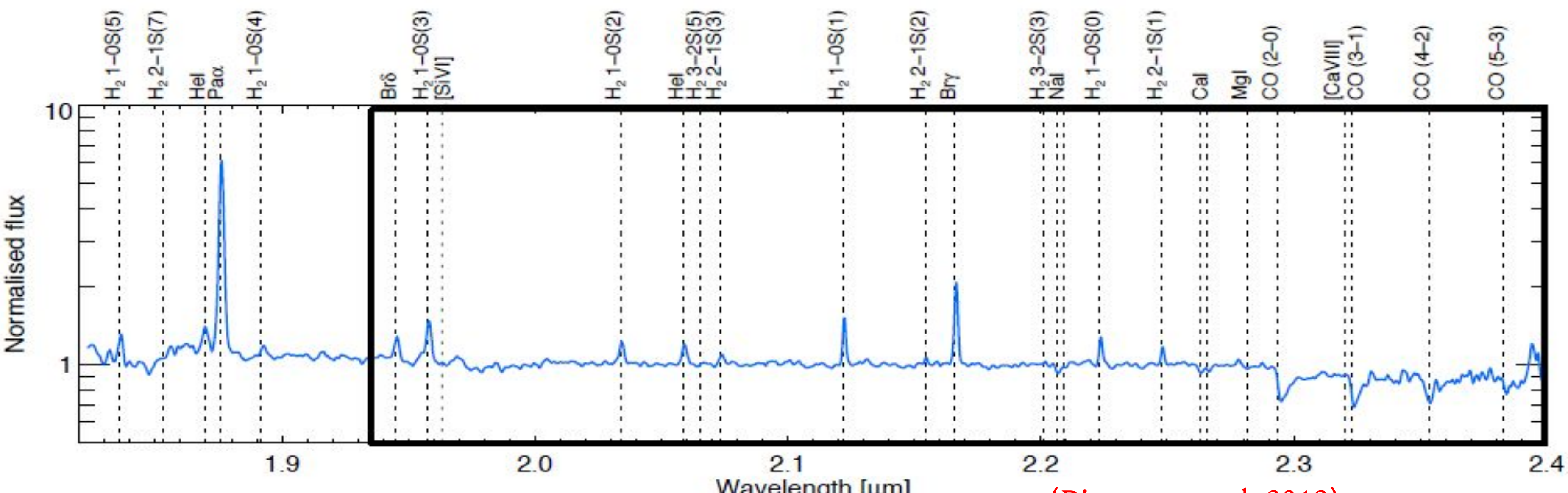


(Piqueras 2015)

Data

10 LIRGS in K band from SINFONI (1.95-2.45μm)

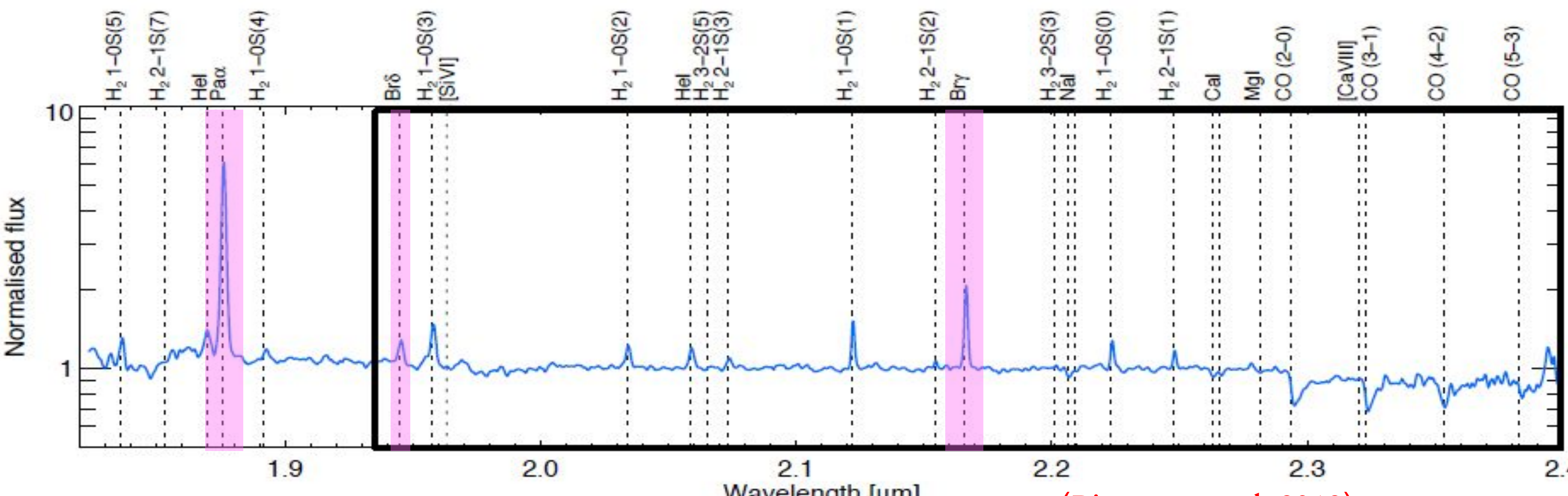
- Plate scale: 0.125/pix
- FoV ~ 10'' x 10'' → 3kpc x 3kpc
- R~ 4000 → 2.45 Å/pix
- Seeing limited 0.62'' → 0.2kpc



(Piqueras et al. 2012)

Data

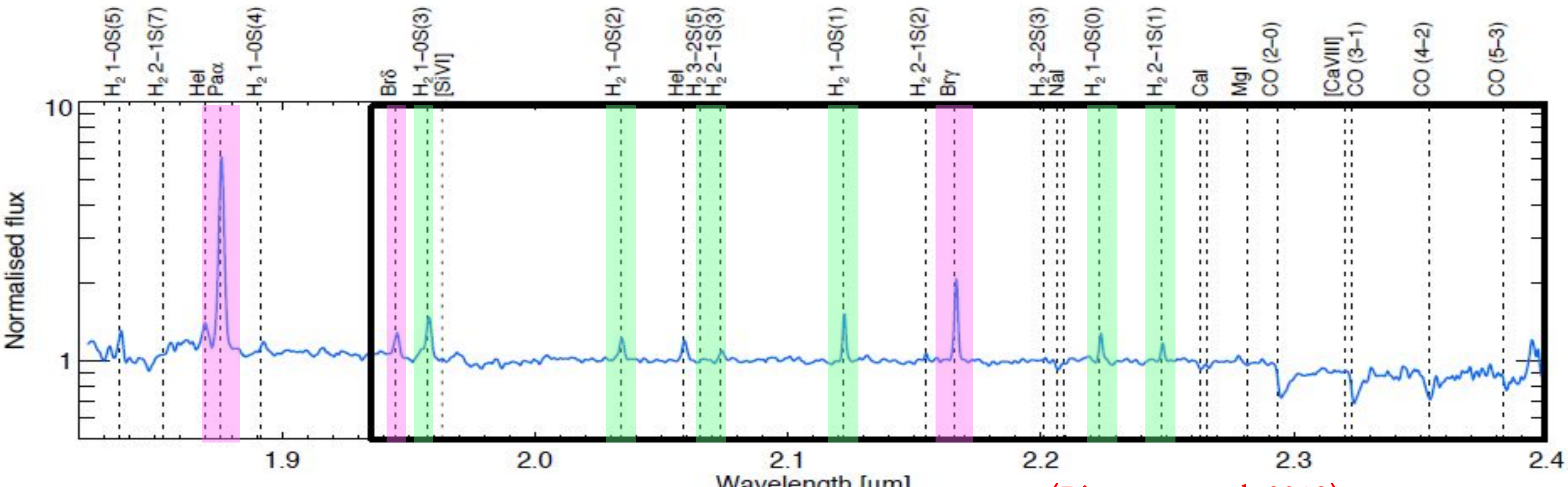
1. Ionised gas → Star-forming regions



(Piqueras et al. 2012)

Data

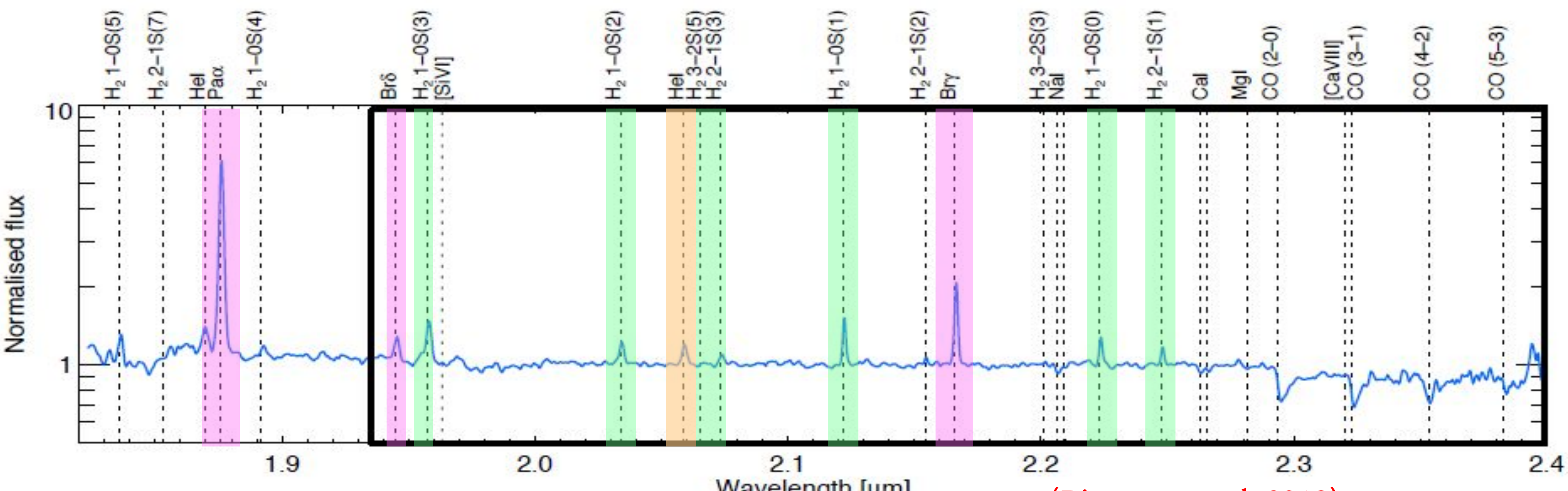
1. Ionised gas → Star-forming regions
2. Molecular lines → Molecular warm gas



(Piqueras et al. 2012)

Data

1. Ionised gas → Star-forming regions
2. Molecular lines → Molecular warm gas
3. HeI



(Piqueras et al. 2012)

Data

1. Ionised gas → Star-forming regions
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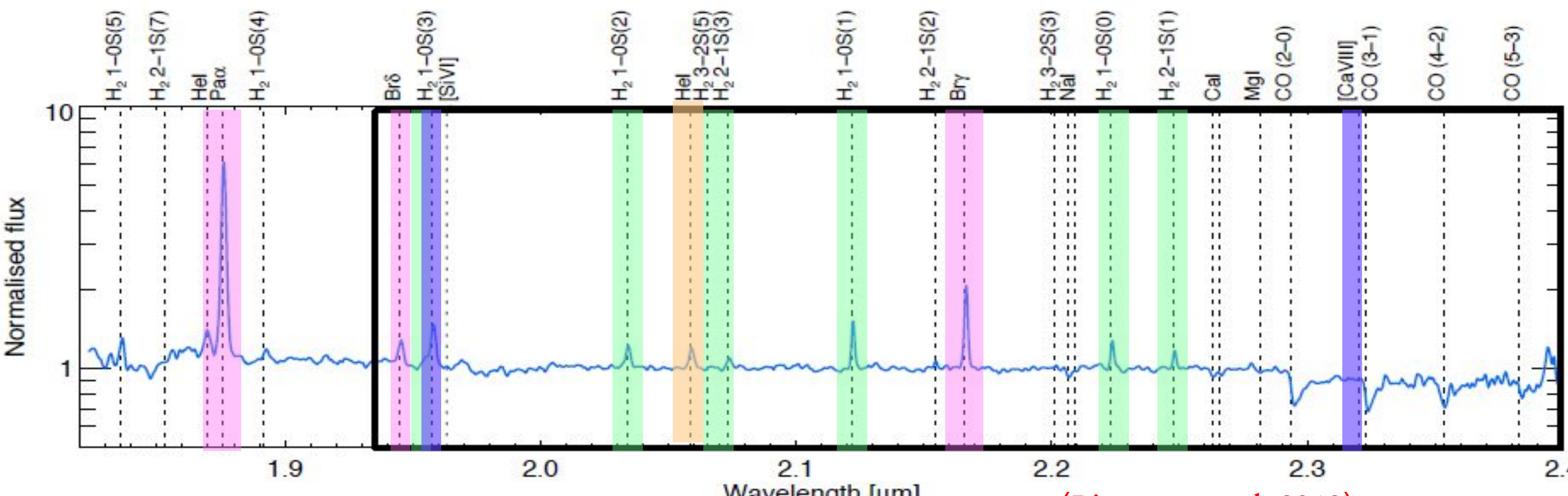
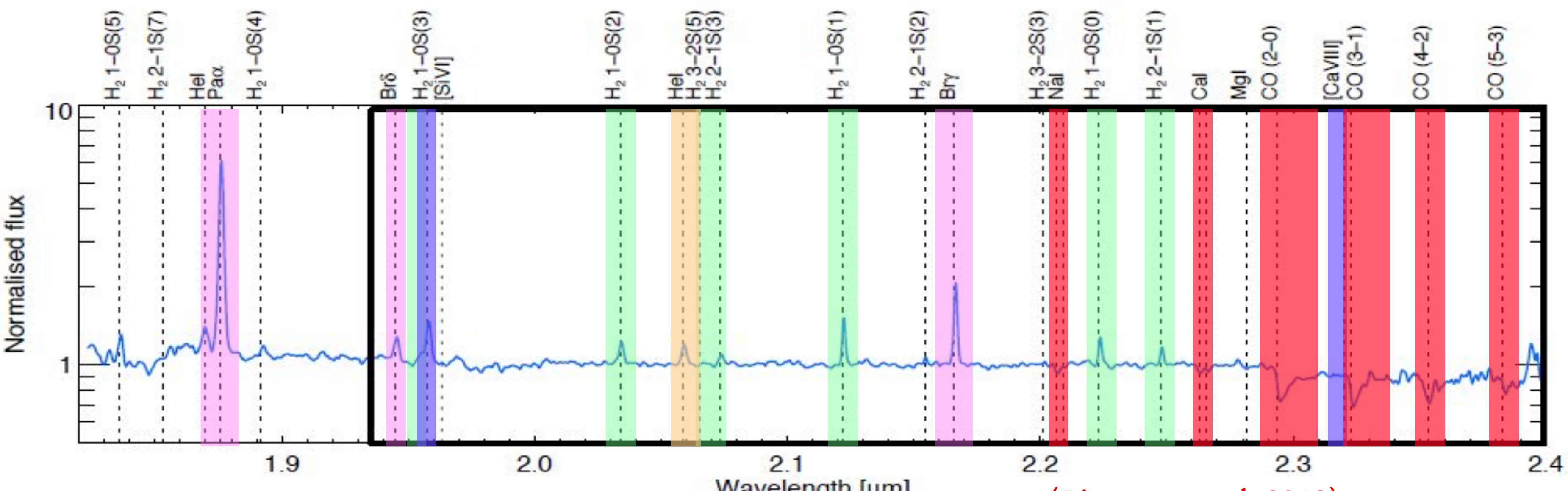
4. Coronal lines → AGN



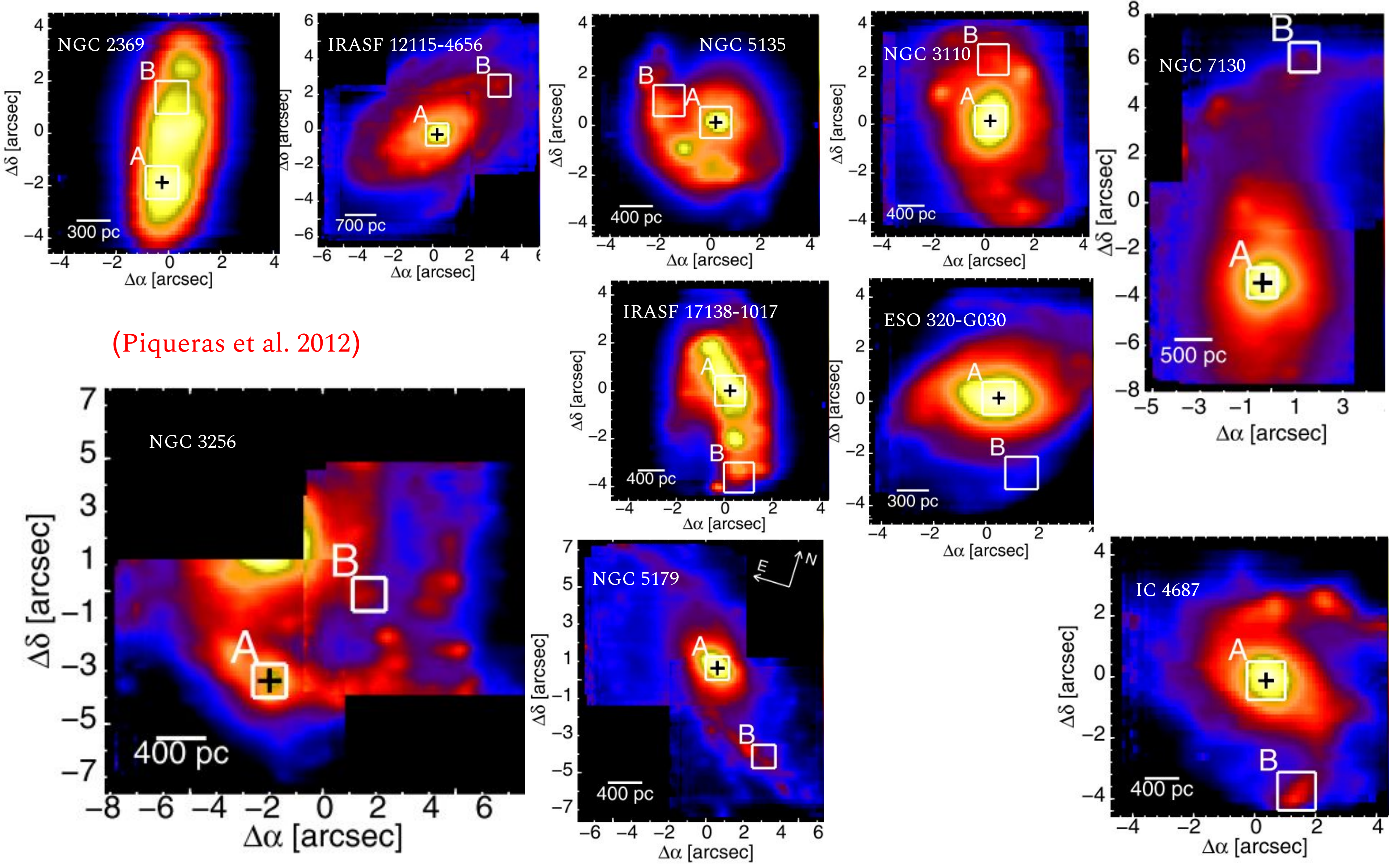
(Piqueras et al. 2012)

Data

1. Ionised gas → Star-forming regions
2. Molecular lines → Molecular warm gas
3. HeI
4. Coronal lines → AGN
5. Stellar absorption bands → Stellar component



(Piqueras et al. 2012)



(Piqueras et al. 2012)

Goals

- Kinematic and dynamic analysis of Luminous infrared galaxies using VLT-SINFONI
  - Derive v, σ, EW and flux maps
  - Extract rotation curves
  - Calculate dynamical masses and comparison with stellar and gas masses
  - Compare gas and stellar phases

- Similar studies based on others Integral field units:
  - Analysis of first light JWST-NIRSpec data
  - Scientific simulations related with the development of ELT-HARMONI

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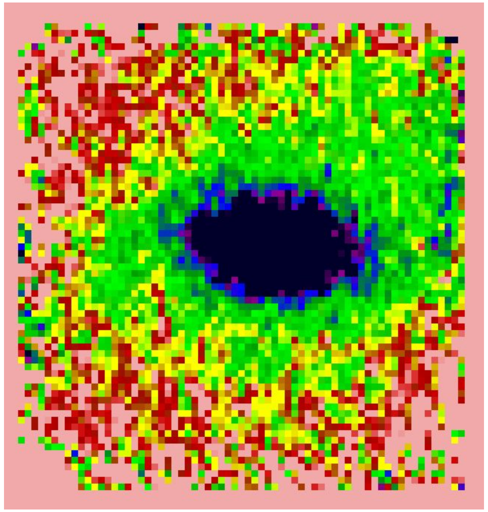
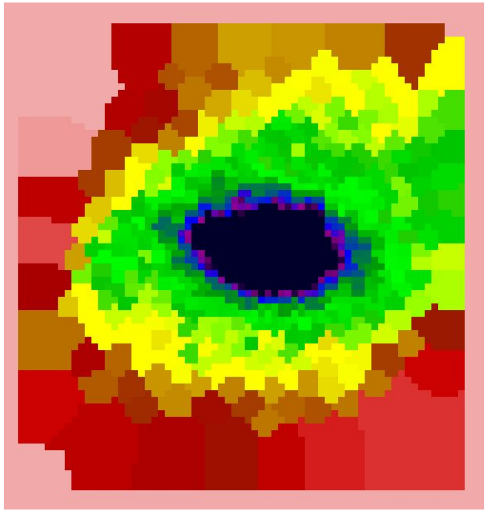
Data analysis: derivation of kinematic maps

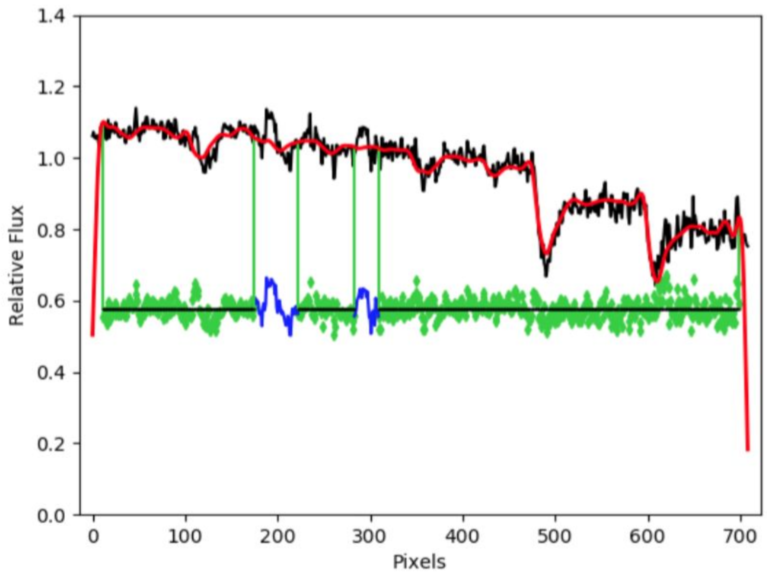
- Reduction made using the ESO pipeline (REFLEX v2.8.5) and python scripts
- Python code based on Voronoi binning (Cappellari & Copin 2003) to achieve a more homogeneous S/N distribution.
- Penalized Pixel-Fitting (Cappellari & Emsellem 2014) code using PHOENIX synthetic spectra templates (Husser et al. 2013)
  - Velocity and velocity dispersion maps

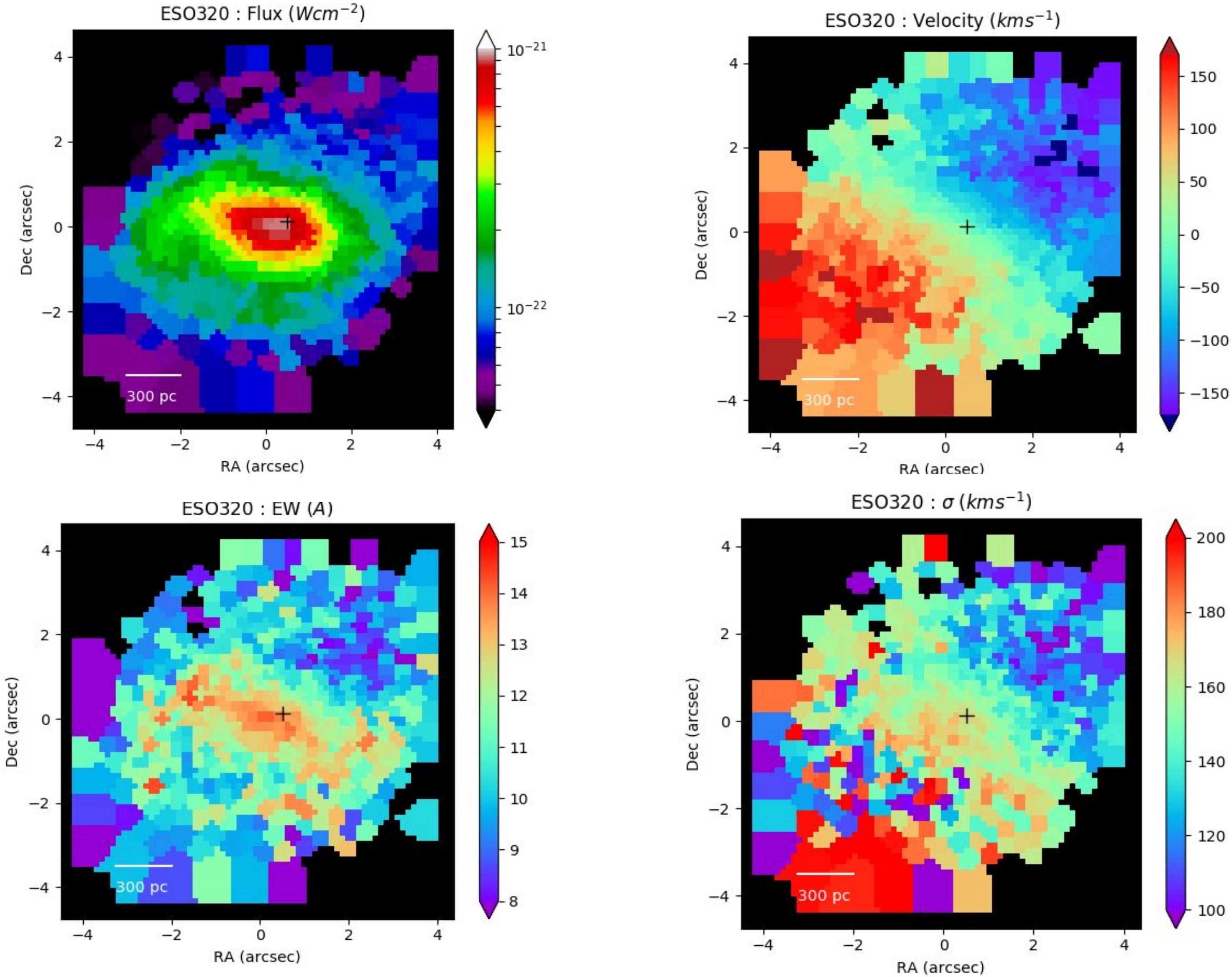


Pixel by pixel CO(2-0) band



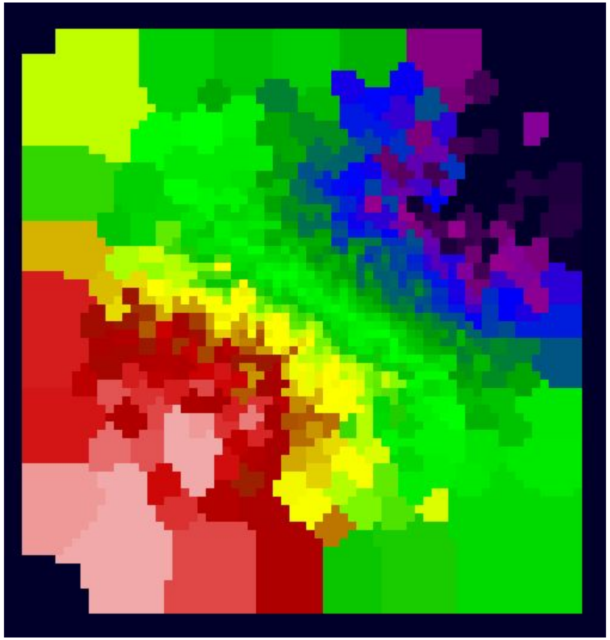
Binned CO(2-0) map

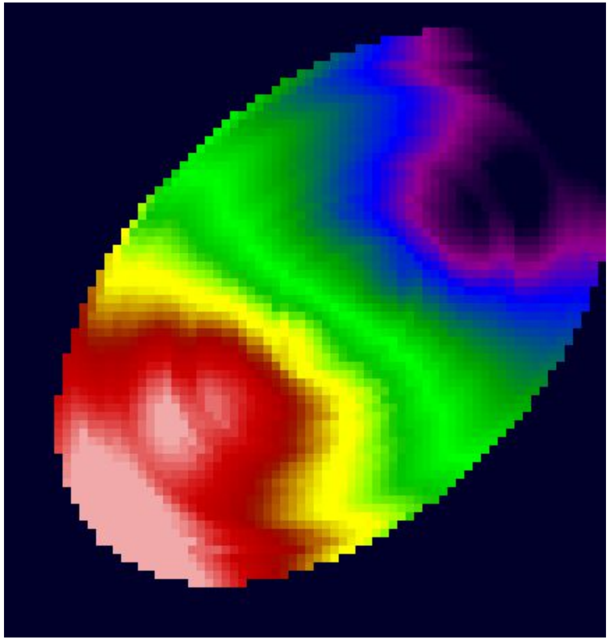


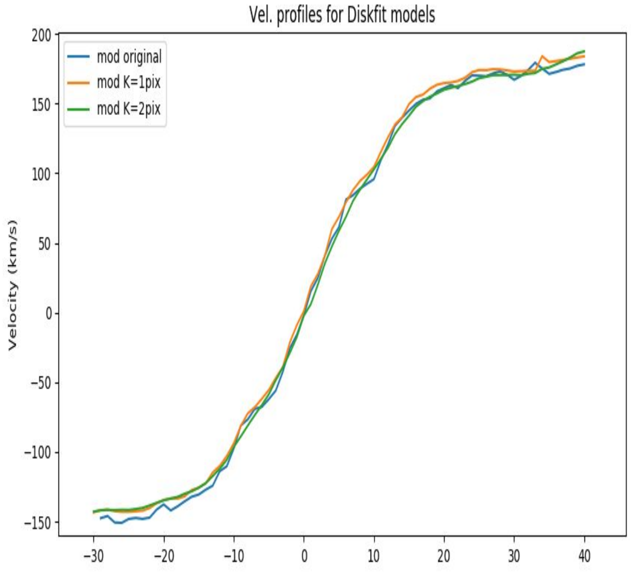

ESO320 : Flux (Wcm^{-2})
10^{-21}
10^{-22}
300 pc
Dec (arcsec)
RA (arcsec)
ESO320 : Velocity (kms^{-1})
150
100
50
0
−50
−100
−150
300 pc
Dec (arcsec)
RA (arcsec)
ESO320 : EW (A)
15
14
13
12
11
10
9
8
300 pc
Dec (arcsec)
RA (arcsec)
ESO320 : σ (kms^{-1})
200
180
160
140
120
100
300 pc
Dec (arcsec)
RA (arcsec)

Data analysis: derivation of rotation curves

- We have used DISKFIT (Spekkens & Sellwood 2007) for fitting non-axisymmetric kinematic maps
  - Model obtained (inclination, Positional Angle, bars?,..)
  - Rotation curve derived from model







Data analysis: calculation of dynamical masses

Velocity map

Vel. Dispersion map

Continuum map

NFW map

Jeans Anisotropic Models (JAM)

Solving Jeans equations
Axisymmetric assumption
Constant M/L across the galaxy
Constant anisotropy

(Cappellari 2008)

$$\beta_z = 1 - \sigma_z^2/\sigma_R^2$$

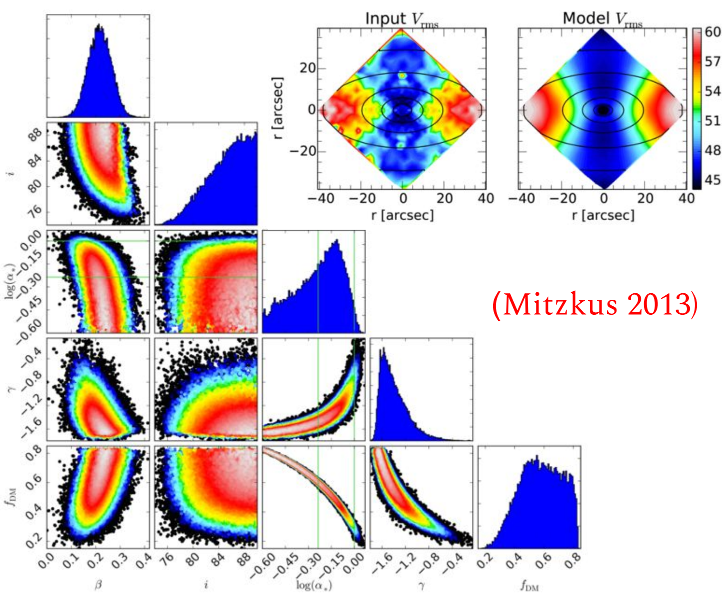
MCMC

Inclination

Anisotropy parameter

M/L ratio

NFW parameters



(Mitzkus 2013)


Thanks for your attention!