An ESO/RadioNet Workshop
ESO Garching, 10–14 March 2014

3D2014

Gas and stars in galaxies: A multi-wavelength 3D perspective

Highlight talk session 2
Monday 16:15

- **Jozsa**
- **Opitsch**
- **Morelli**
- **Blasco-Herrera**
- **Zaragoza-Cardiel**
- **Moiseev**
- **Maksym**

ASTRON

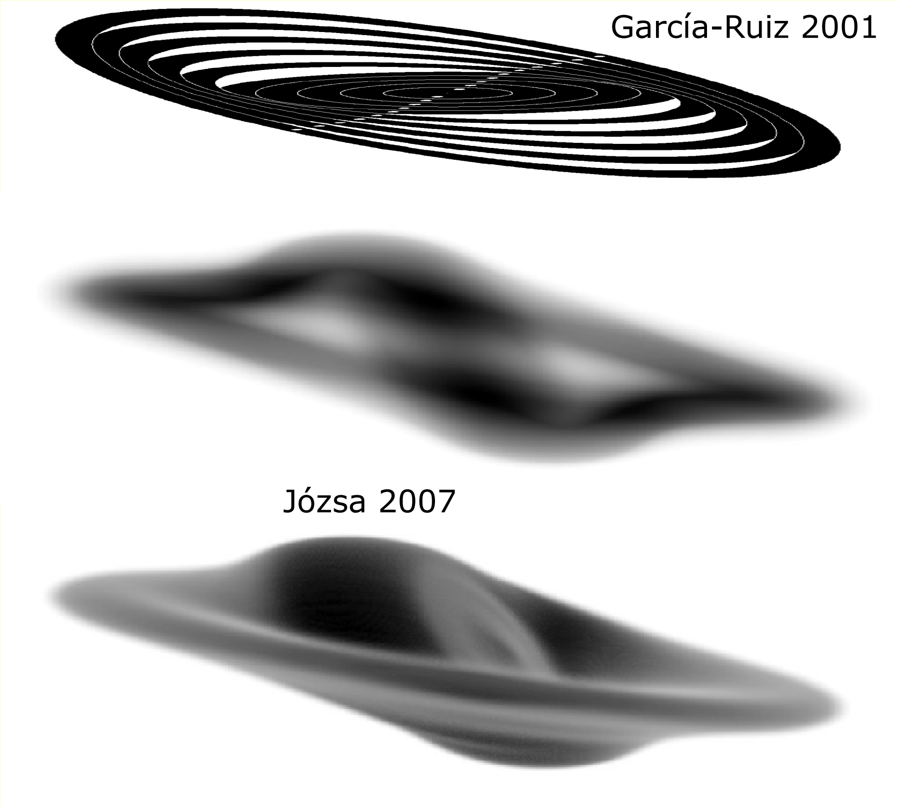
Netherlands Institute for Radio Astronomy

Constraining the 6D structure of galactic H I disks

http://www.astron.nl/~jozsa/tirific/

The tilted-ring model

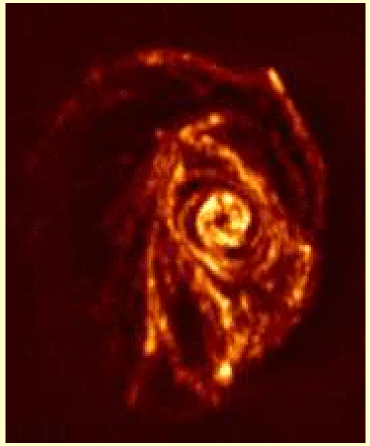
ASTRON



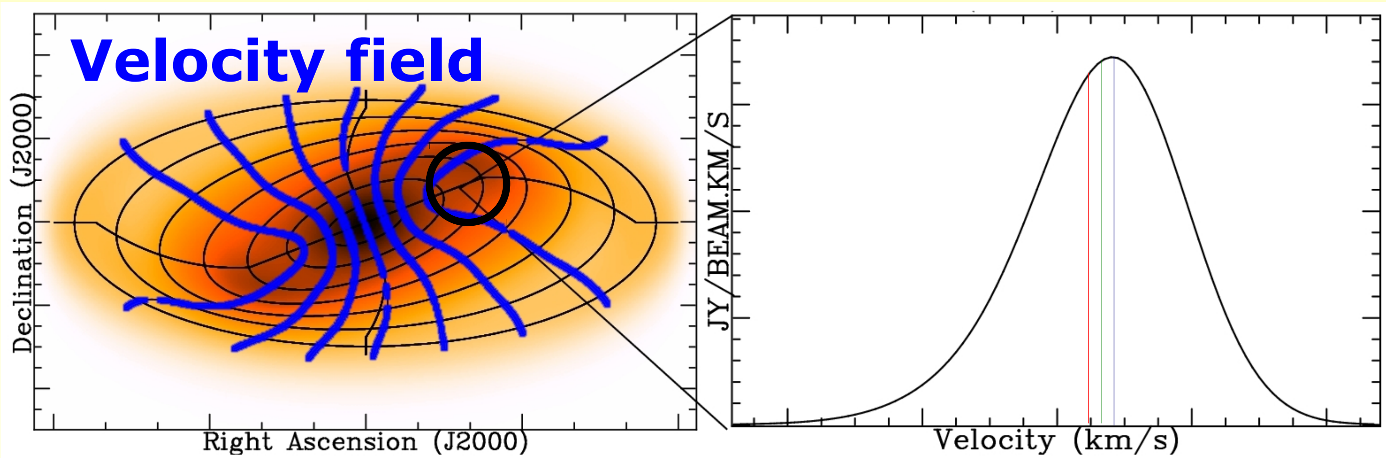
Tilted-Ring-Model
(Rogstad et al. 1974):

parametrise rings at different radii by

- two orientation parameters (i, pa)
- central position
- surface brightness
- rotation velocity



Park et al.

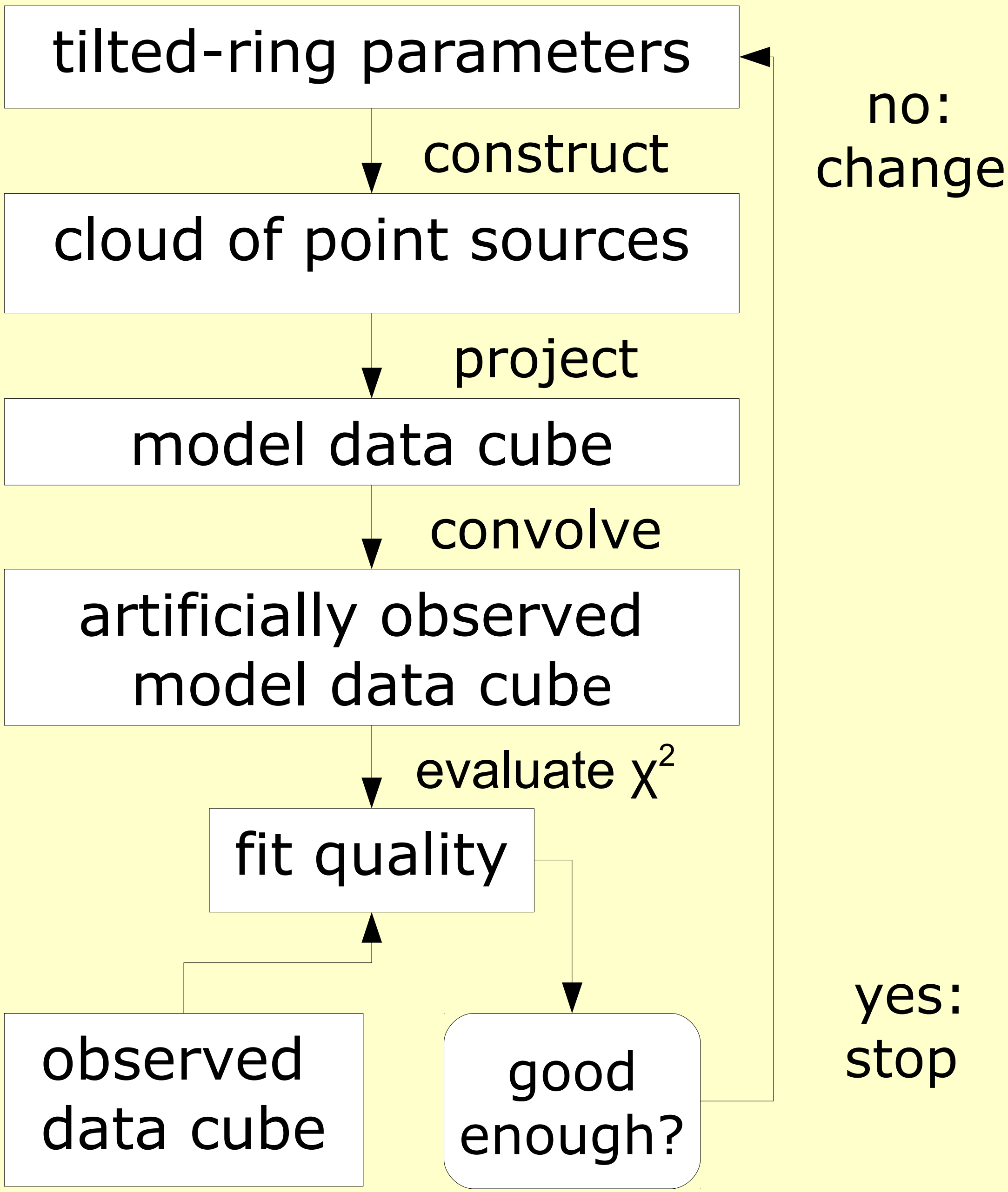


H I data cube:
I(ξ,η,v)

- Fit to a velocity-field restricted to well resolved, thin disk

Tilted Ring Fitting Code

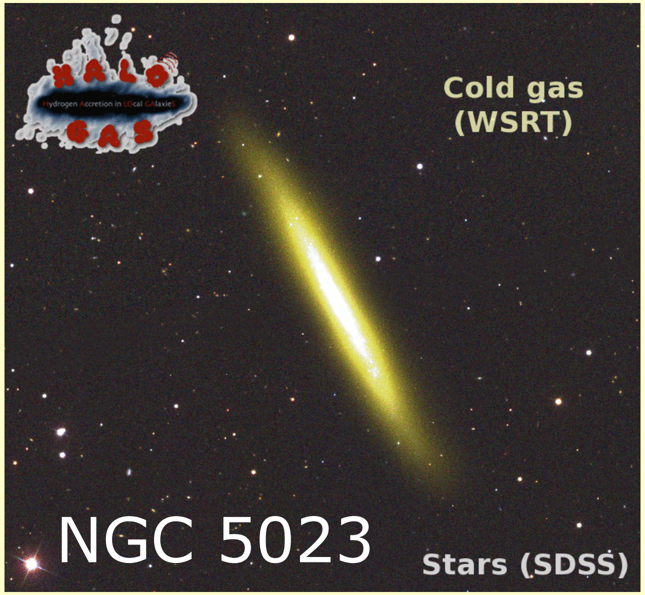
ASTRON



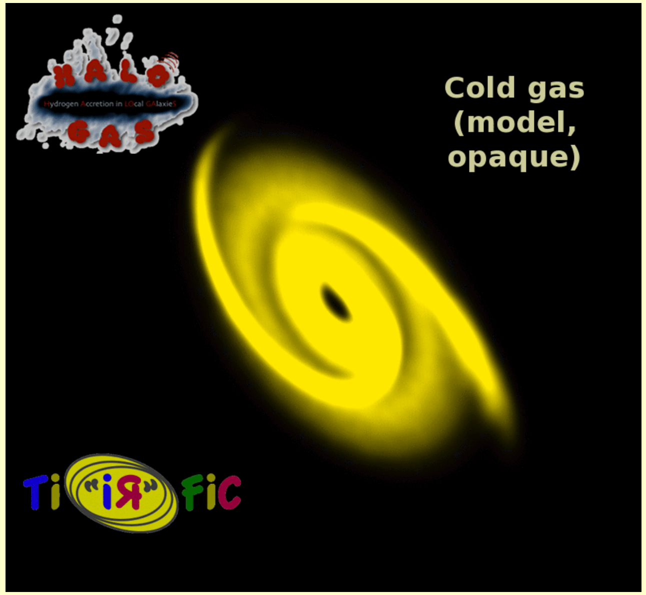
H I data cube: I(ξ,η,v)

- Direct fit to the data cube makes parametrisation of **vertical velocity structure** and **structure along LOS** possible
(first done by Corbelli & Schneider 1997)

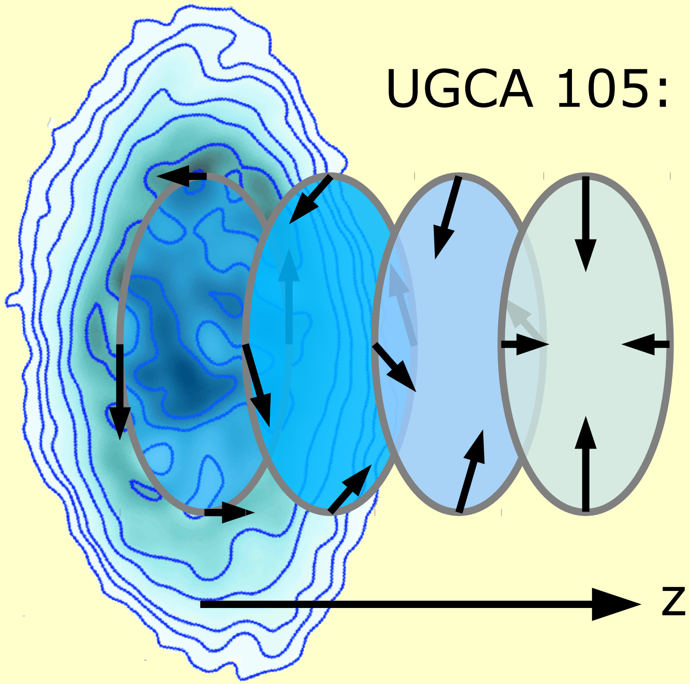
Two Examples



Kamphuis et al. 2013 (for further HALOGAS results see talk Zschaechner)



UGCA 105:



- dV_{rot}/dz = -60 km s^{-1} kpc^{-1}
- No radial motion in central plane
- dV_{rad}/dz = -70 km s^{-1} kpc^{-1}
- Inwards transport 0.05 $M_{\odot}$ y^{-1}
- 40% of gas mass in thick disk
- Fountain or infall?

(Schmidt et al. 2014)

Summary and future

- The tilted-ring model is a useful tool to characterise (galactic) (H I)

- By fitting a tilted-ring model to a spectroscopic (H I) data cube instead of a velocity field
  - it is possible to avoid line-of-sight ambiguities
  - more data points are available to tackle higher complexity (if required)

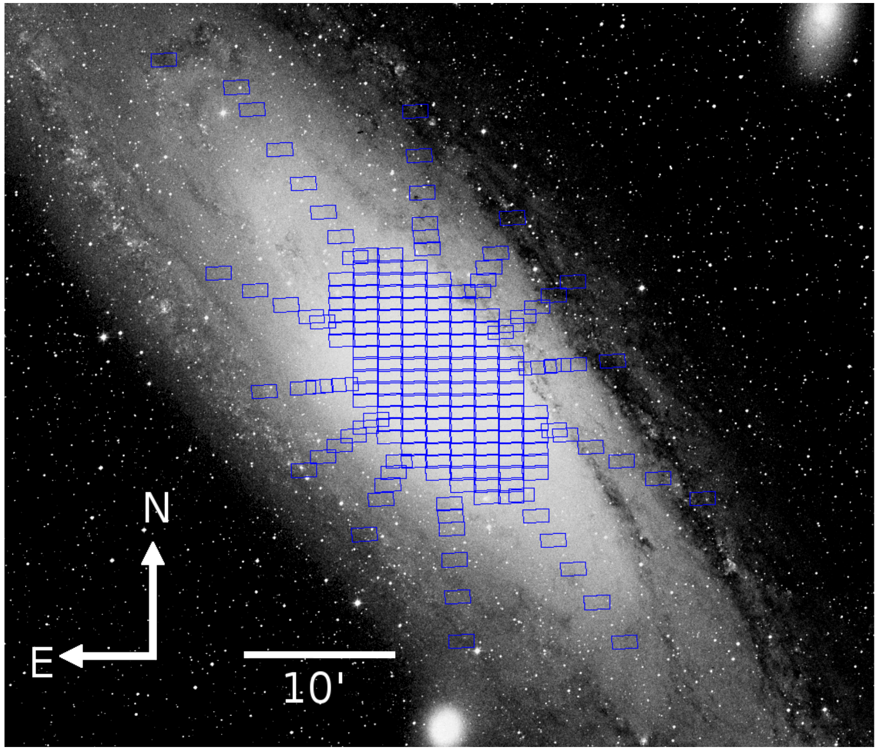
- Direct fitting to a data cube successfully tested using TiRiFiC

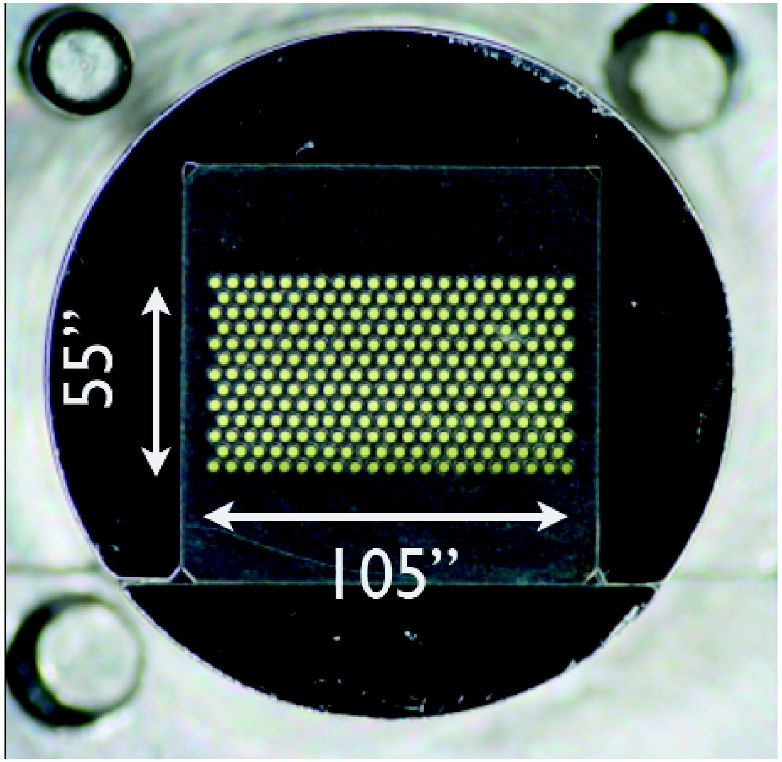
- Next months: better minmizing algorithm, better automisation methods (Kamphuis et al.) for use in future H I surveys (e.g. WNSHS, WALLABY)

http://www.astron.nl/~jozsa/tirific/

Kinematics and dynamics of M31

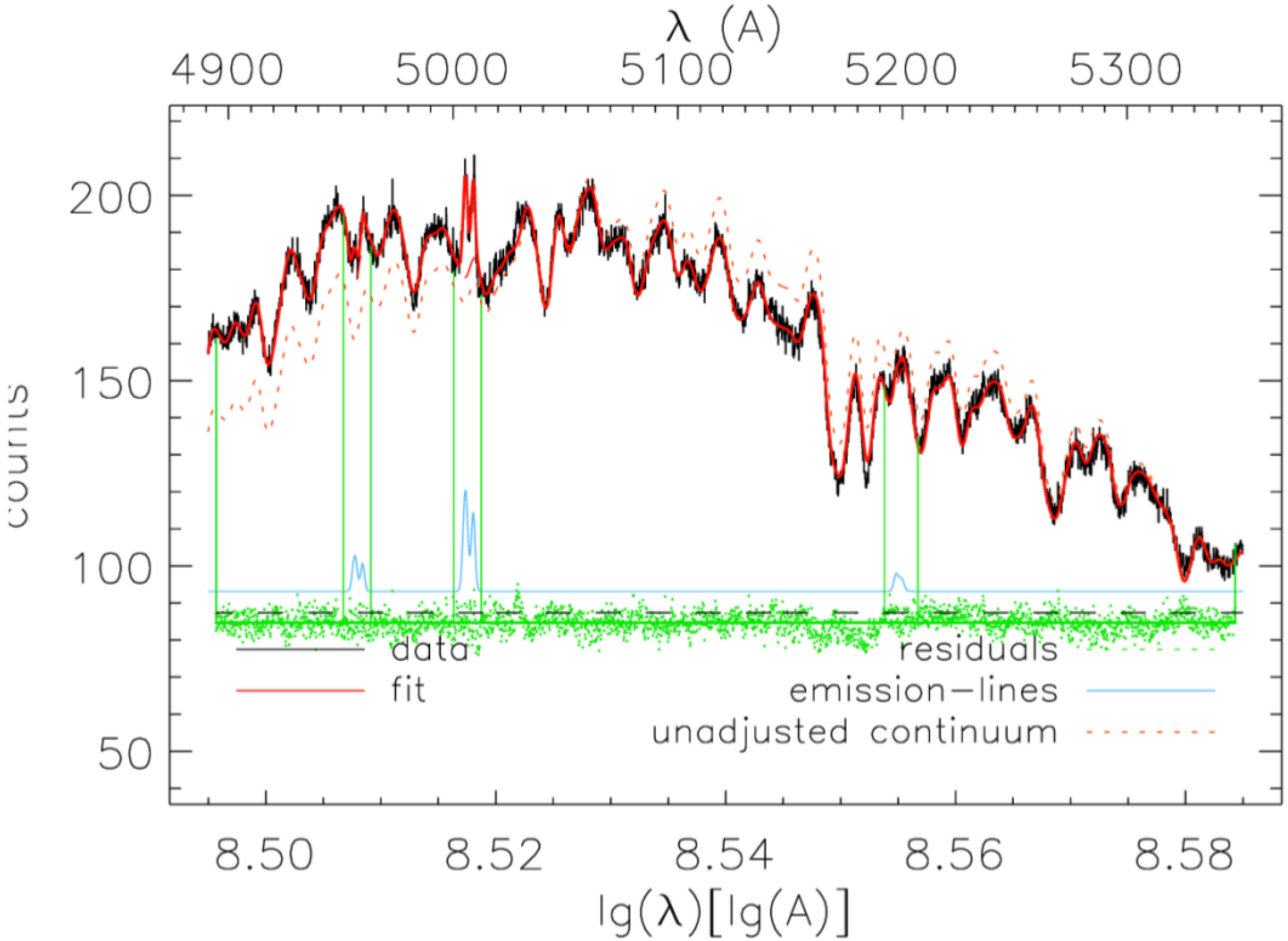
Michael Opitsch (MPE), Roberto Saglia, Ralf Bender, Maximilian Fabricius, Surangkhana Rukdee, Michael Williams





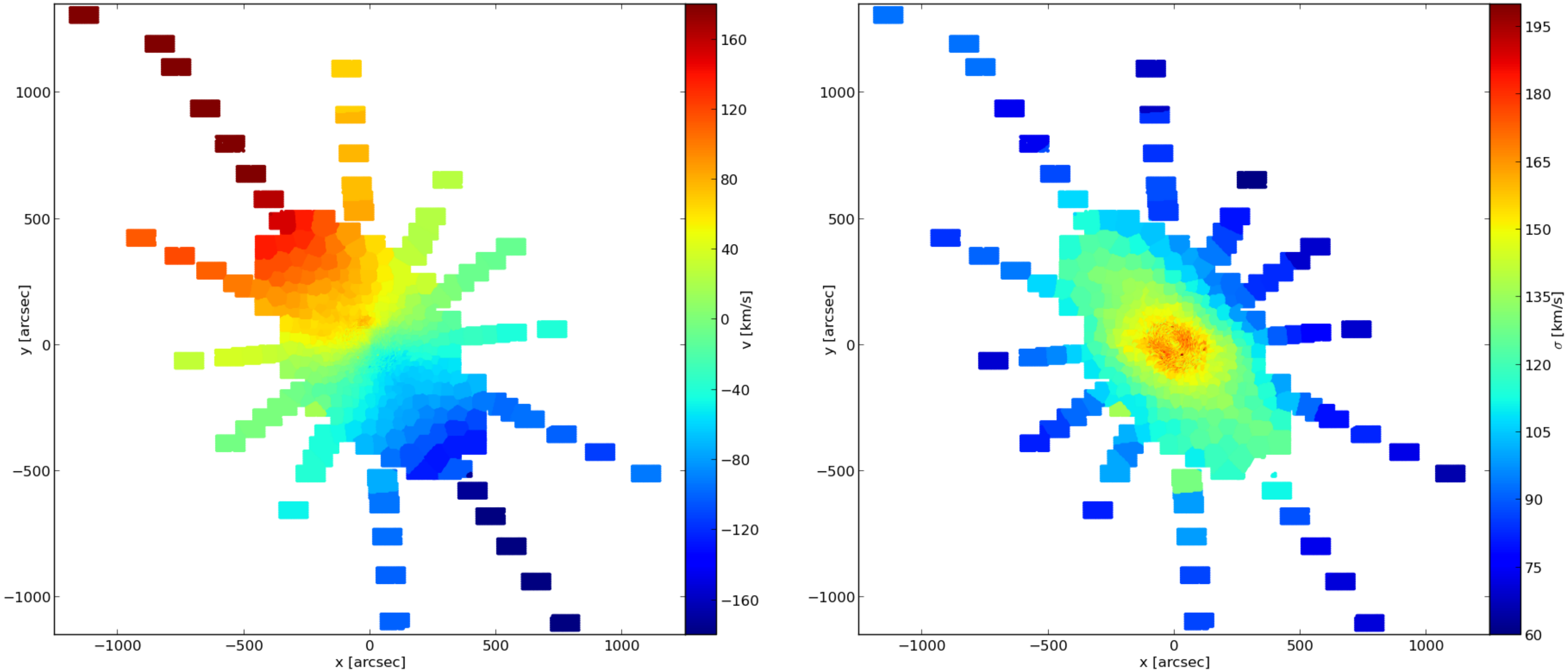
- Open questions: Is there a bar? Is the bulge triaxial? How is the gas distributed?
- long-slit data by Saglia et al, 2010 $\rightarrow \sigma$ higher than in previous measurements
- repetition of these observations with an IFU: VIRUS-W
- VIRUS-W: 267 fibers in rectangular fiberhead, FOV 105" · 55"
- Wavelength range: 4850 Å to 5475 Å, σ_{inst}=14 - 16 km/s

Data reduction and fitting of the kinematics



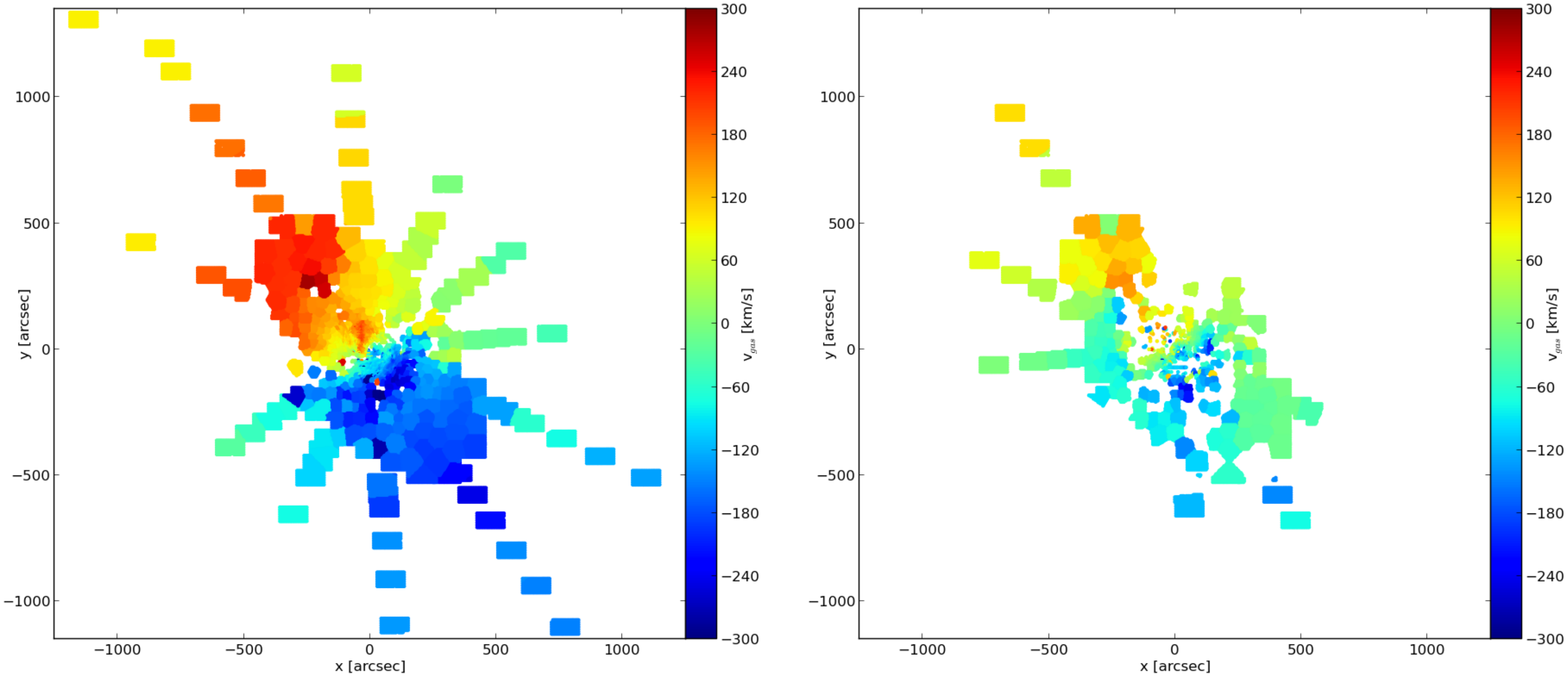
- 190 pointings with 267 spectra each → 50730 spectra
- Voronoi binning → 2393 binned spectra
- Fitting of stellar kinematics with PPXF
- Fitting of emission lines $[OIII]_{\lambda\lambda=4958,5007Å}$ and $[NI]_{\lambda\lambda=5197,5200Å}$ with GANDALF

Stellar kinematics



- No large-scale asymmetries in stellar velocity, small twist along the minor axis
- Velocity dispersion lower in dusty regions in the northwest

Gas kinematics ([OIII]$_{5007\text{Å}}$)



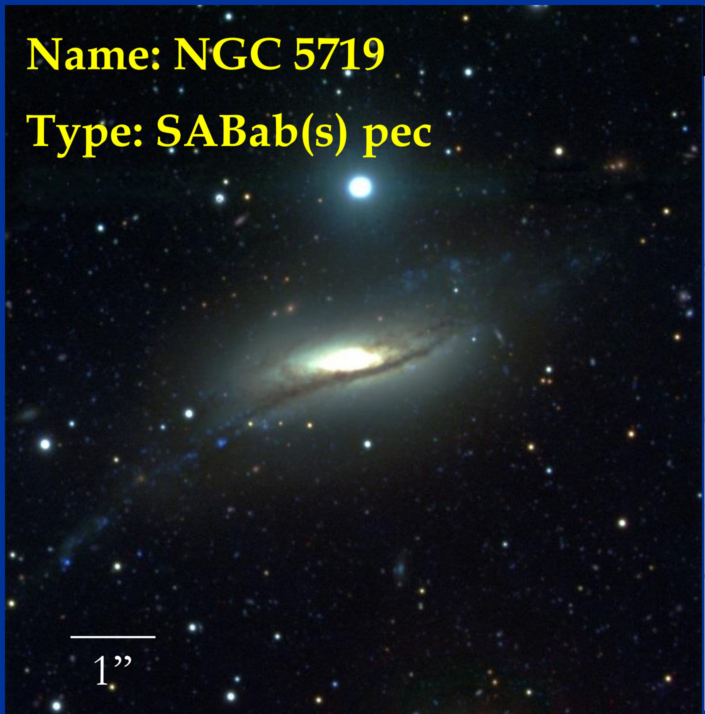
- Two gas components with significantly different velocities
- See my poster (number 29) for further details!

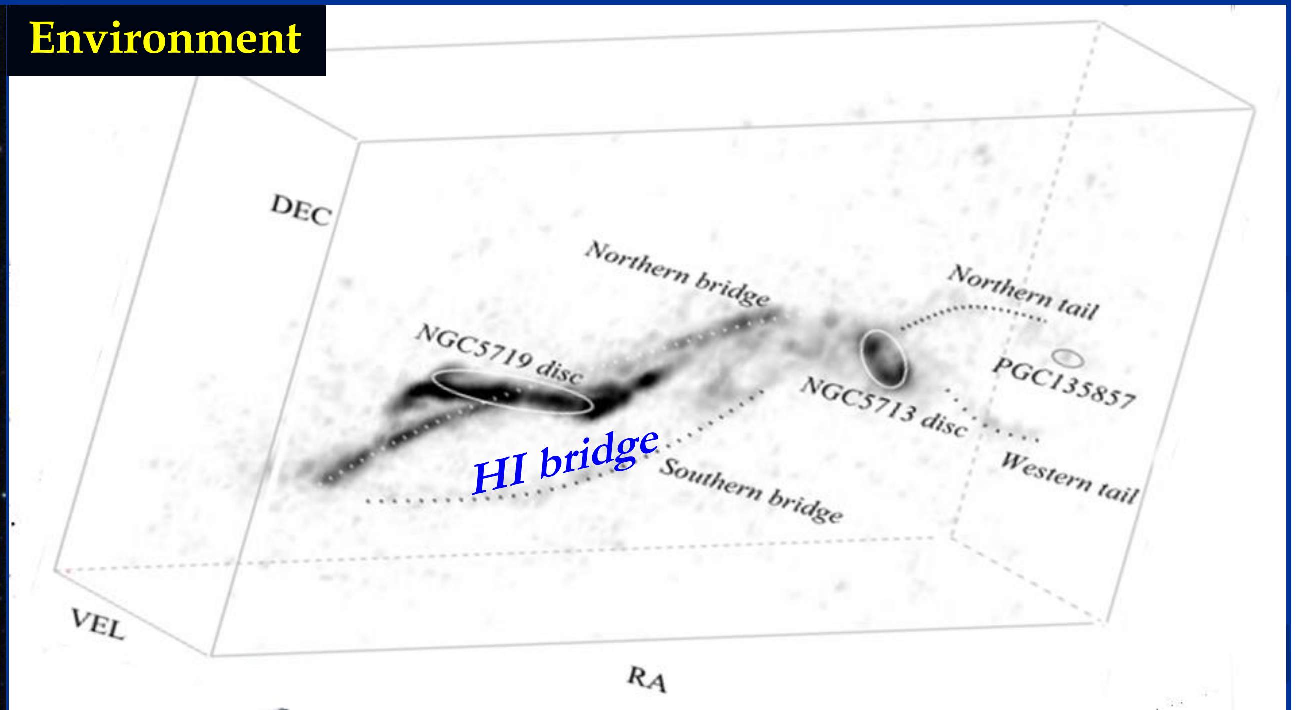
Dating the conter-rotation in NGC 5719

COUNTER-ROTATIONS ➡ presence of stars counter-rotating with respect to other stars and/or gas

FORMATION OF COUNTER-ROTATIONS ➡ gas disk built by retrograde acquisitions or a bar and subsequent star formation in the acquired disk

TARGET





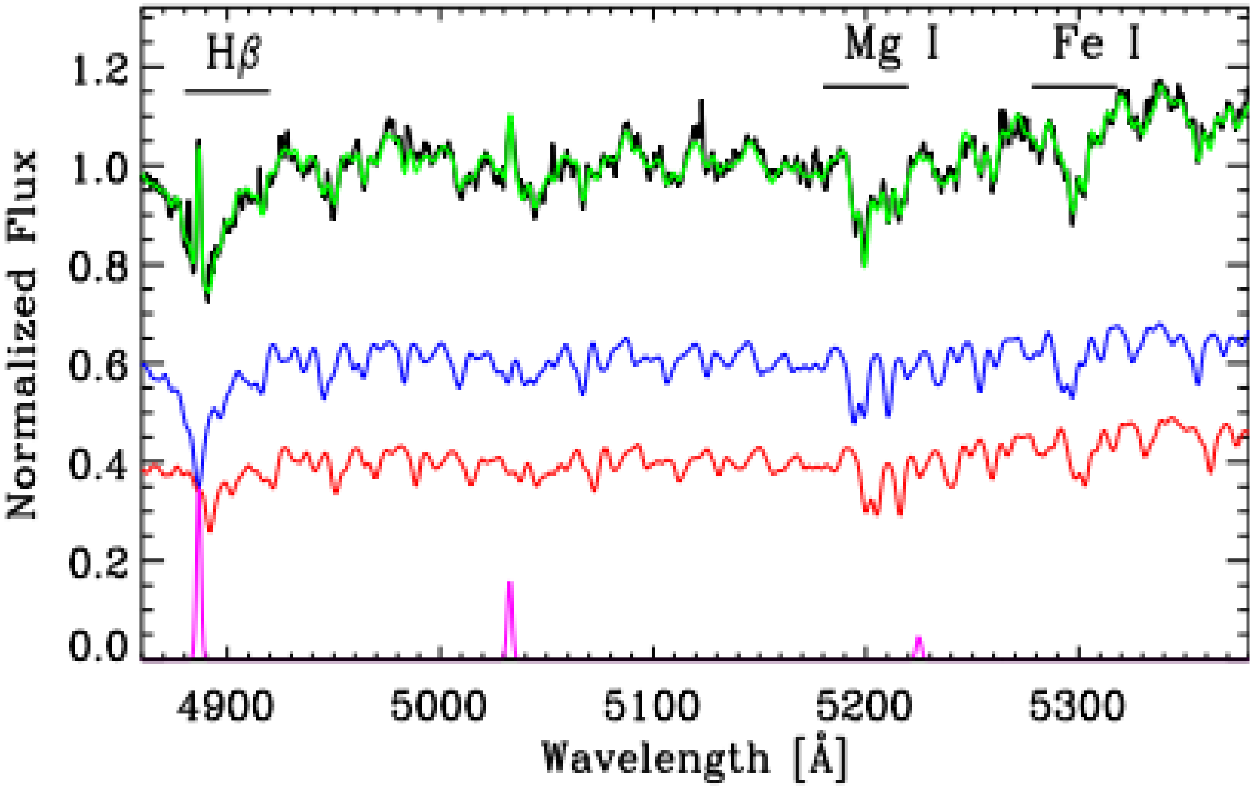
DATA ➡ 3 h at the VLT/VIMOS integral-field spectroscopic observations of the inner 28 × 28 arcsec^2 VIMOS

Disentangling the stellar components

COSPATIAL COMPONENTS ARE CONTAMINATING ONE EACH OTHER

THE METHOD

Modified, penalized pixel fitting code (pPXF; Cappellari et al. 2004) to build two synthetic templates (one for each stellar component) as linear combination of stellar spectra from the MILES (Sánchez-Blázquez et al. 2006) library.



Data + fit

Counter-rotating stellar component

Main stellar component

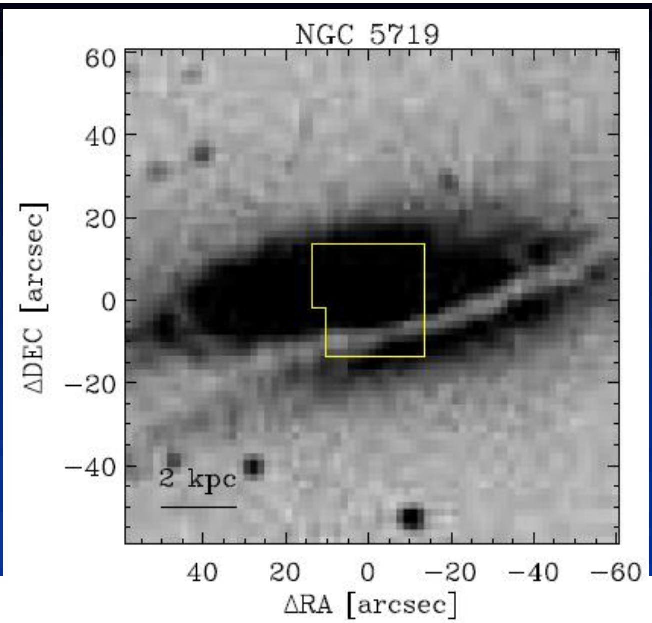
Gas component

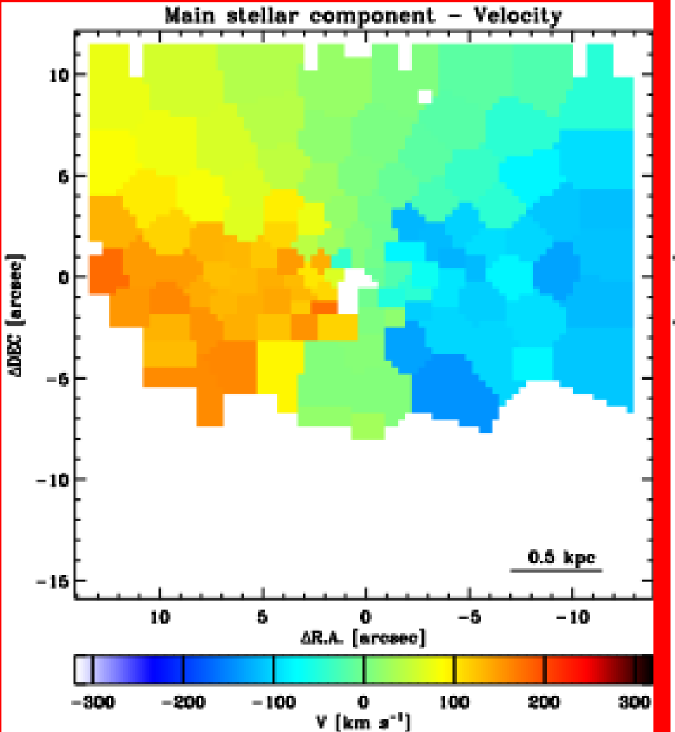
Coccato, Morelli, Corsini et al. 2011

..just a preview, see more details in Coccato talk later today.

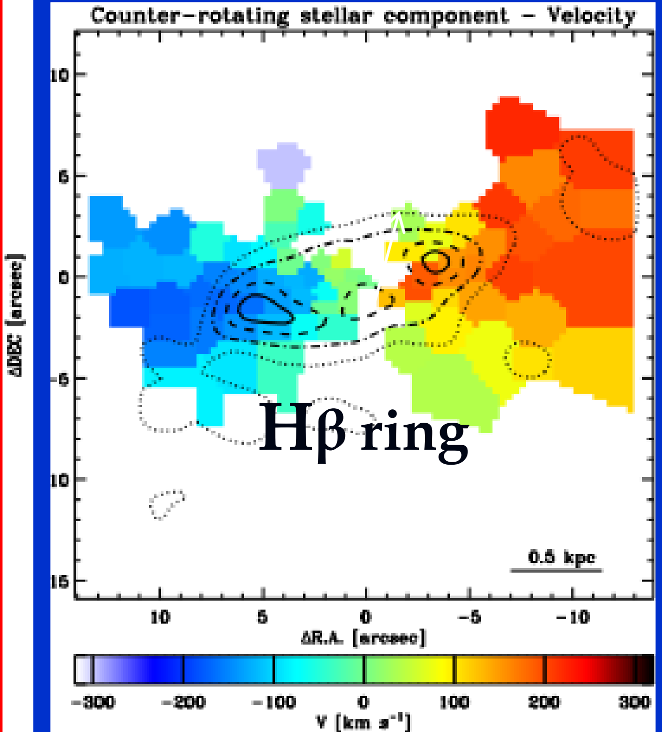
Results (1)

2D STELLAR KINEMATICS

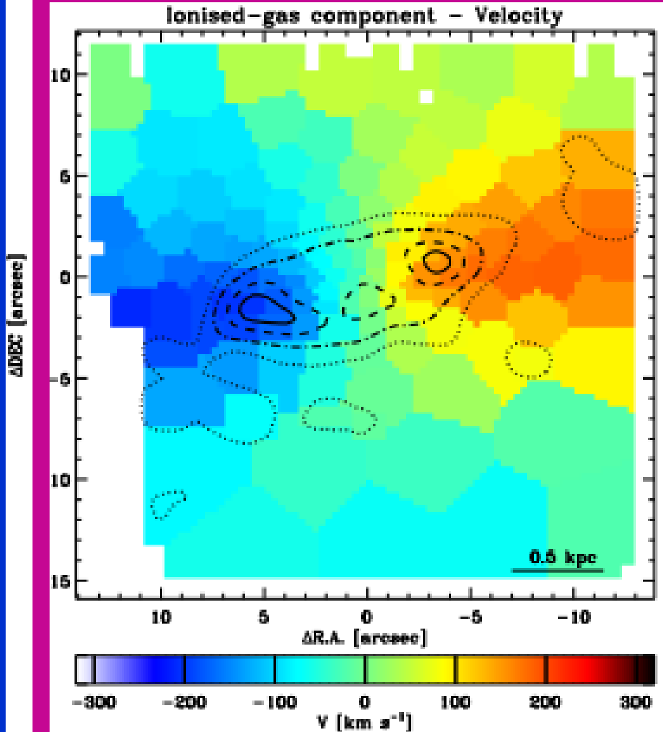




Main stellar component



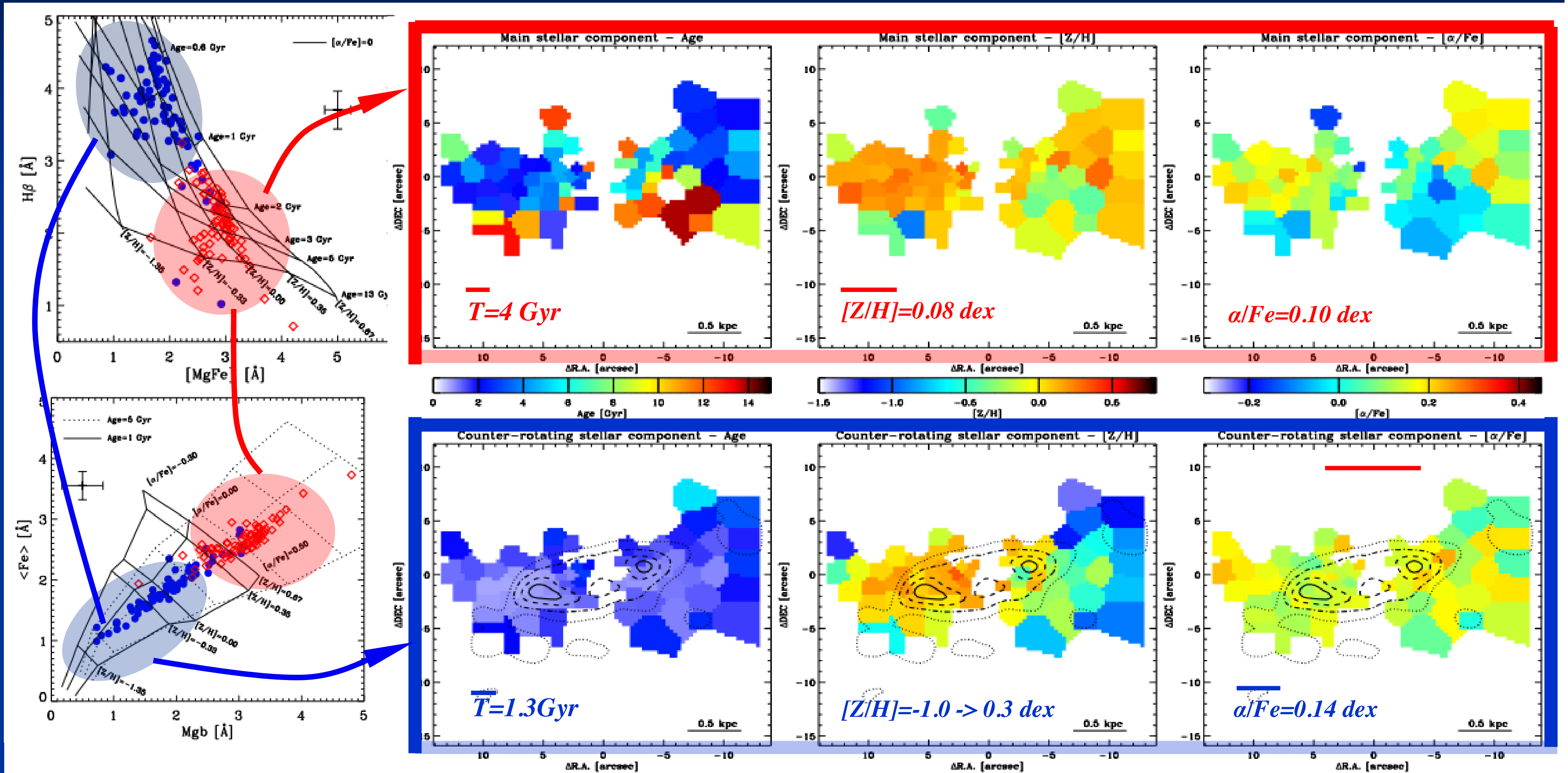
Counte-rotating stellar component



Gas component

Results (2) and Conclusions

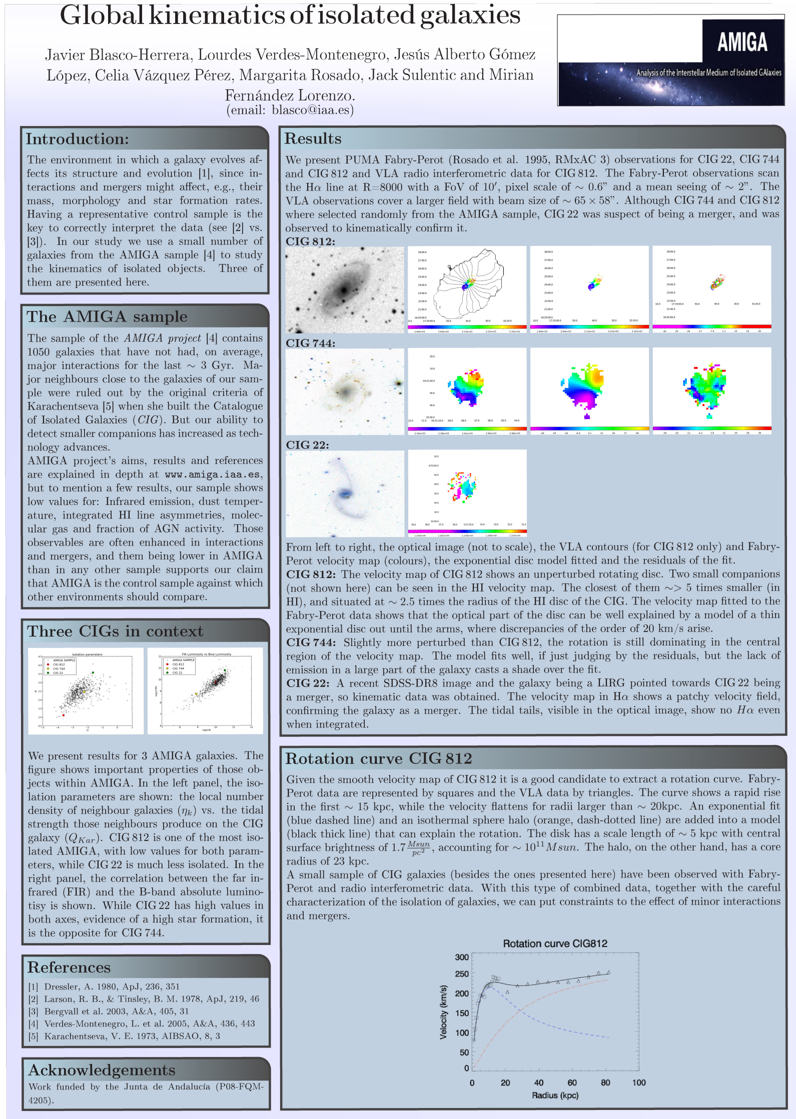
2D STELLAR POPULATIONS



CONCLUSIONS

- We prove that the mean age of the counter-rotating disc, which is associated to the neutral and ionized gas disc, is indeed younger, less rich in metals than the main stellar disc.
- This result shows that counter-rotating disc has been recently assembled.

Global kinematics of isolated galaxies (#8)



Global kinematics of isolated galaxies

Javier Blasco-Herrera, Lourdes Verdes-Montenegro, Jesús Alberto Gómez López, Celia Vázquez Pérez, Margarita Rosado, Jack Sulentic and Mirian Fernández Lorenzo.
(email: blasco@iaa.es)

AMIGA
Analysis of the Interstellar Medium of Isolated GAlaxies

Introduction:

The environment in which a galaxy evolves affects its structure and evolution [1], since interactions and mergers might affect, e.g., their mass, morphology and star formation rates. Having a representative control sample is the key to correctly interpret the data (see [2] vs. [3]). In our study we use a small number of galaxies from the AMIGA sample [4] to study the kinematics of isolated objects. Three of them are presented here.

The AMIGA sample

The sample of the *AMIGA project* [4] contains 1050 galaxies that have not had, on average, major interactions for the last ~ 3 Gyr. Major neighbours close to the galaxies of our sample were ruled out by the original criteria of Karachentseva [5] when she built the Catalogue of Isolated Galaxies (*CIG*). But our ability to detect smaller companions has increased as technology advances.
AMIGA project's aims, results and references are explained in depth at www.amiga.iaa.es, but to mention a few results, our sample shows low values for: Infrared emission, dust temperature, integrated HI line asymmetries, molecular gas and fraction of AGN activity. Those observables are often enhanced in interactions and mergers, and them being lower in AMIGA than in any other sample supports our claim that AMIGA is the control sample against which other environments should compare.

Three CIGs in context

We present results for 3 AMIGA galaxies. The figure shows important properties of those objects within AMIGA. In the left panel, the isolation parameters are shown: the local number density of neighbour galaxies (η_k) vs. the tidal strength those neighbours produce on the CIG galaxy (Q_{Kar}). CIG 812 is one of the most isolated AMIGA, with low values for both parameters, while CIG 22 is much less isolated. In the right panel, the correlation between the far infrared (FIR) and the B-band absolute luminotisy is shown. While CIG 22 has high values in both axes, evidence of a high star formation, it is the opposite for CIG 744.

Results

We present PUMA Fabry-Perot (Rosado et al. 1995, RMxAC 3) observations for CIG 22, CIG 744 and CIG 812 and VLA radio interferometric data for CIG 812. The Fabry-Perot observations scan the Hα line at R=8000 with a FoV of 10′, pixel scale of ~ 0.6" and a mean seeing of ~ 2". The VLA observations cover a larger field with beam size of ~ 65 × 58". Although CIG 744 and CIG 812 where selected randomly from the AMIGA sample, CIG 22 was suspect of being a merger, and was observed to kinematically confirm it.

CIG 812:

CIG 744:

CIG 22:

From left to right, the optical image (not to scale), the VLA contours (for CIG 812 only) and Fabry-Perot velocity map (colours), the exponential disc model fitted and the residuals of the fit.

CIG 812: The velocity map of CIG 812 shows an unperturbed rotating disc. Two small companions (not shown here) can be seen in the HI velocity map. The closest of them ~> 5 times smaller (in HI), and situated at ~ 2.5 times the radius of the HI disc of the CIG. The velocity map fitted to the Fabry-Perot data shows that the optical part of the disc can be well explained by a model of a thin exponential disc out until the arms, where discrepancies of the order of 20 km/s arise.

CIG 744: Slightly more perturbed than CIG 812, the rotation is still dominating in the central region of the velocity map. The model fits well, if just judging by the residuals, but the lack of emission in a large part of the galaxy casts a shade over the fit.

CIG 22: A recent SDSS-DR8 image and the galaxy being a LIRG pointed towards CIG 22 being a merger, so kinematic data was obtained. The velocity map in Hα shows a patchy velocity field, confirming the galaxy as a merger. The tidal tails, visible in the optical image, show no $H\alpha$ even when integrated.

Rotation curve CIG 812

Given the smooth velocity map of CIG 812 it is a good candidate to extract a rotation curve. Fabry-Perot data are represented by squares and the VLA data by triangles. The curve shows a rapid rise in the first ~ 15 kpc, while the velocity flattens for radii larger than ~ 20kpc. An exponential fit (blue dashed line) and an isothermal sphere halo (orange, dash-dotted line) are added into a model (black thick line) that can explain the rotation. The disk has a scale length of ~ 5 kpc with central surface brightness of $1.7\frac{Msun}{pc^2}$, accounting for $\sim 10^{11} Msun$. The halo, on the other hand, has a core radius of 23 kpc.
A small sample of CIG galaxies (besides the ones presented here) have been observed with Fabry-Perot and radio interferometric data. With this type of combined data, together with the careful characterization of the isolation of galaxies, we can put constraints to the effect of minor interactions and mergers.

Rotation curve CIG812
Velocity (km/s)
Radius (kpc)

References

[1] Dressler, A. 1980, ApJ, 236, 351
[2] Larson, R. B., & Tinsley, B. M. 1978, ApJ, 219, 46
[3] Bergvall et al. 2003, A&A, 405, 31
[4] Verdes-Montenegro, L. et al. 2005, A&A, 436, 443
[5] Karachentseva, V. E. 1973, AIBSAO, 8, 3

Acknowledgements

Work funded by the Junta de Andalucía (P08-FQM-4205).

Javier Blasco-Herrera

Lourdes Verdes-Montenegro

Jack Sulentic

Mirian Fernández Lorenzo

(Instituto Astrofísico de Andalucía, Spain)

Jesús Gómez López

Célia Vázquez Pérez

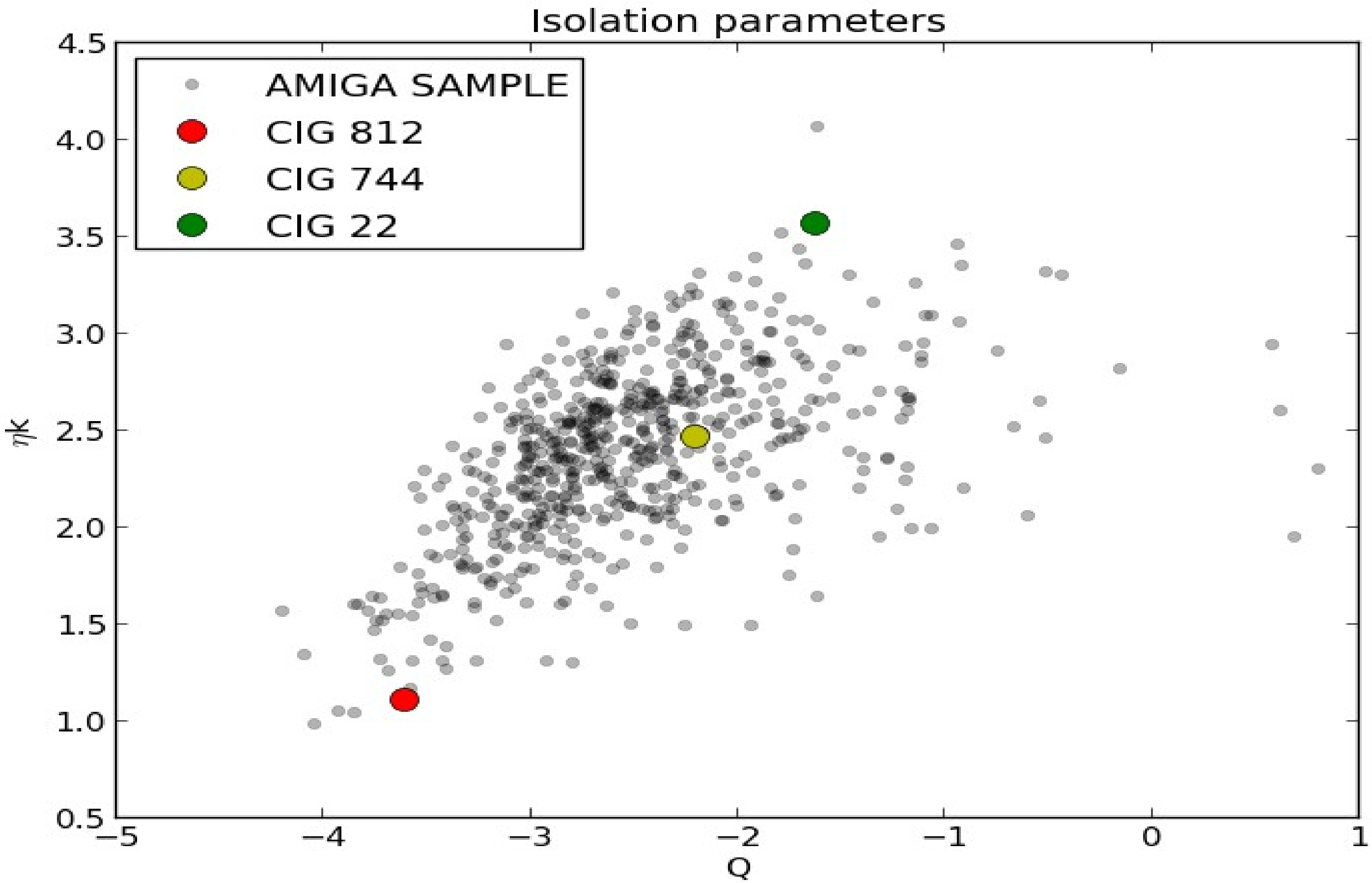
Margarita Rosado

(Universidad Nacional Autónoma de México)

The AMIGA sample of galaxies

www.amiga.iaa.es

- 1050 galaxies with **well characterized isolation criteria**, (Karachentseva 1973, Verley et al. 2007).



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FOR THE RECORD:

“FIELD” IS NOT A VERY ACCURATE DEFINITION !!

The AMIGA sample of galaxies

www.amiga.iaa.es

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- Galaxies with minimized nurturing effects, maximized internal secular evolution.

The AMIGA sample of galaxies

www.amiga.iaa.es

- 1050 galaxies with **well characterized isolation criteria**, (Karachentseva 1973, Verley et al. 2007).

- Galaxies with minimized nurturing effects, maximized internal secular evolution.

- Different **from any other sample**: lower FIR luminosity, lower molecular gas content, lower AGN activity, integrated HI asymmetries...

The AMIGA sample of galaxies

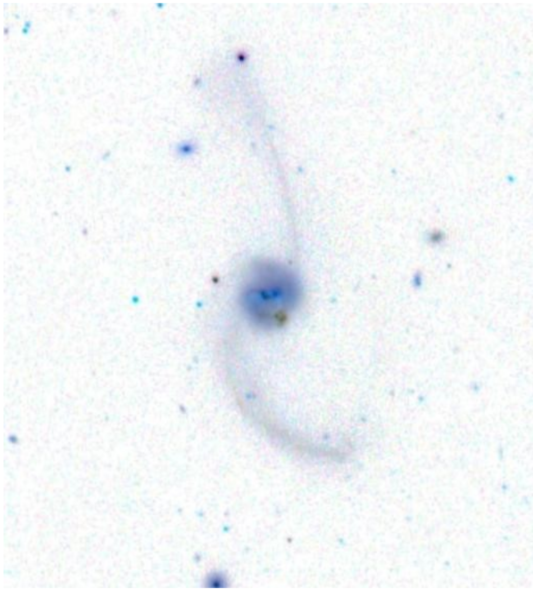
www.amiga.iaa.es

- 1050 galaxies with **well characterized isolation criteria**, (Karachentseva 1973, Verley et al. 2007).

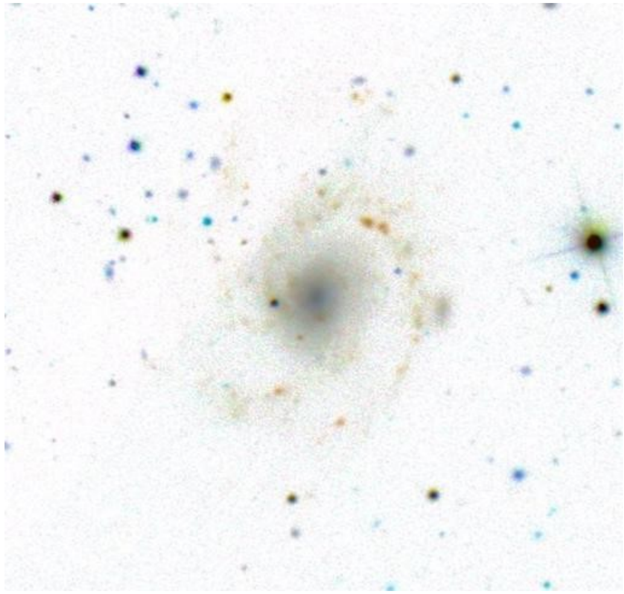
- Galaxies with minimized nurturing effects, maximized internal secular evolution.

- Different **from** ... **mple**: lower FIR luminosity, lower ... ntent, lower AGN activity, integrated HI a... s...

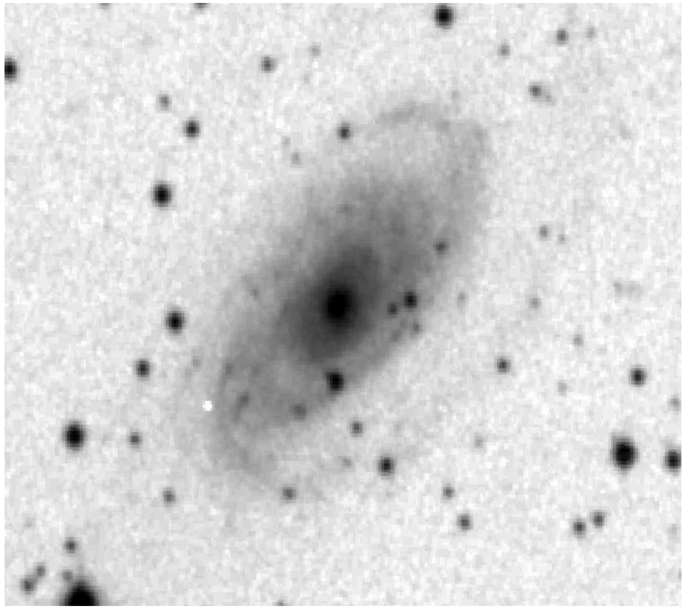
Three galaxies within AMIGA



CIG 22

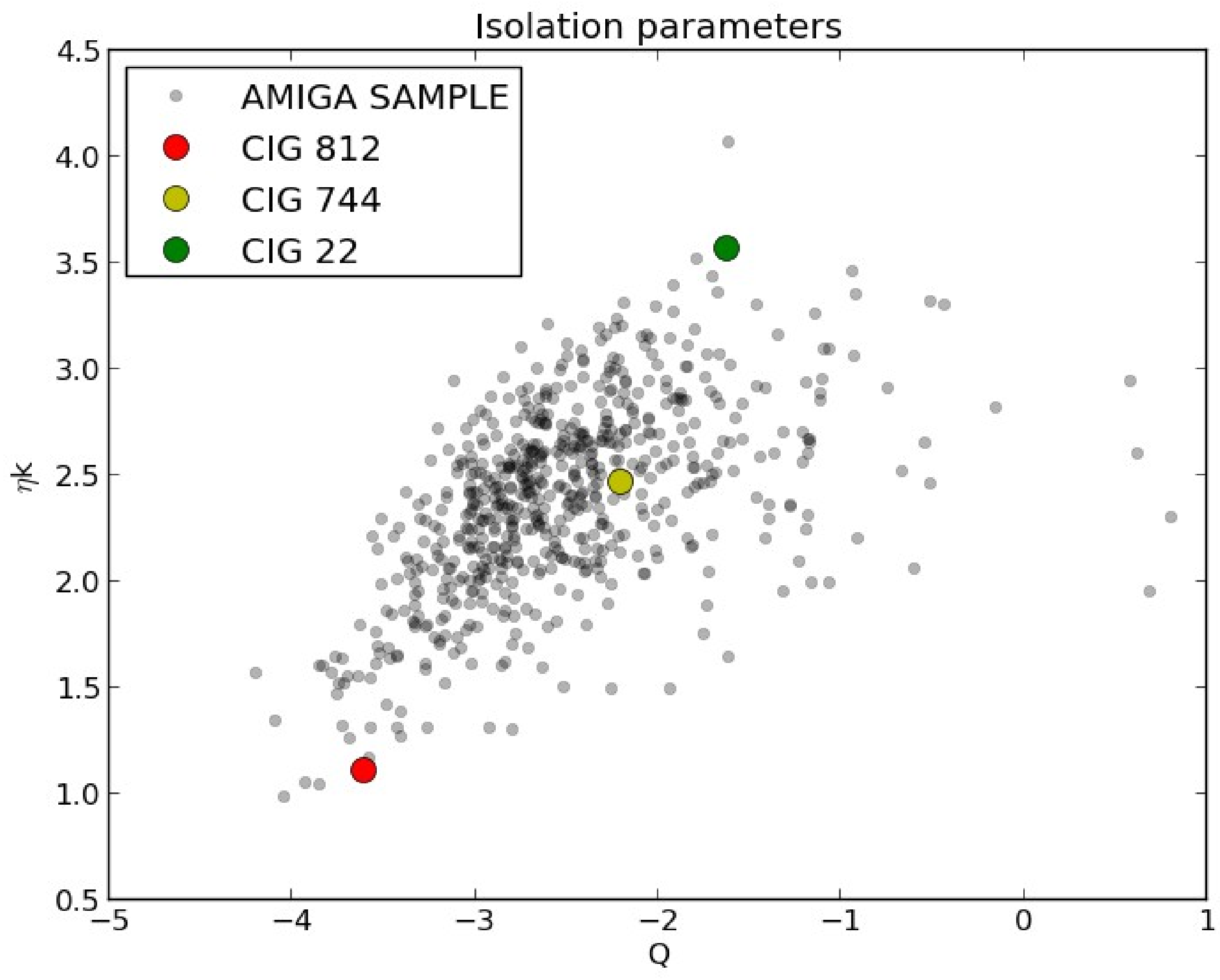


CIG 744



CIG 812

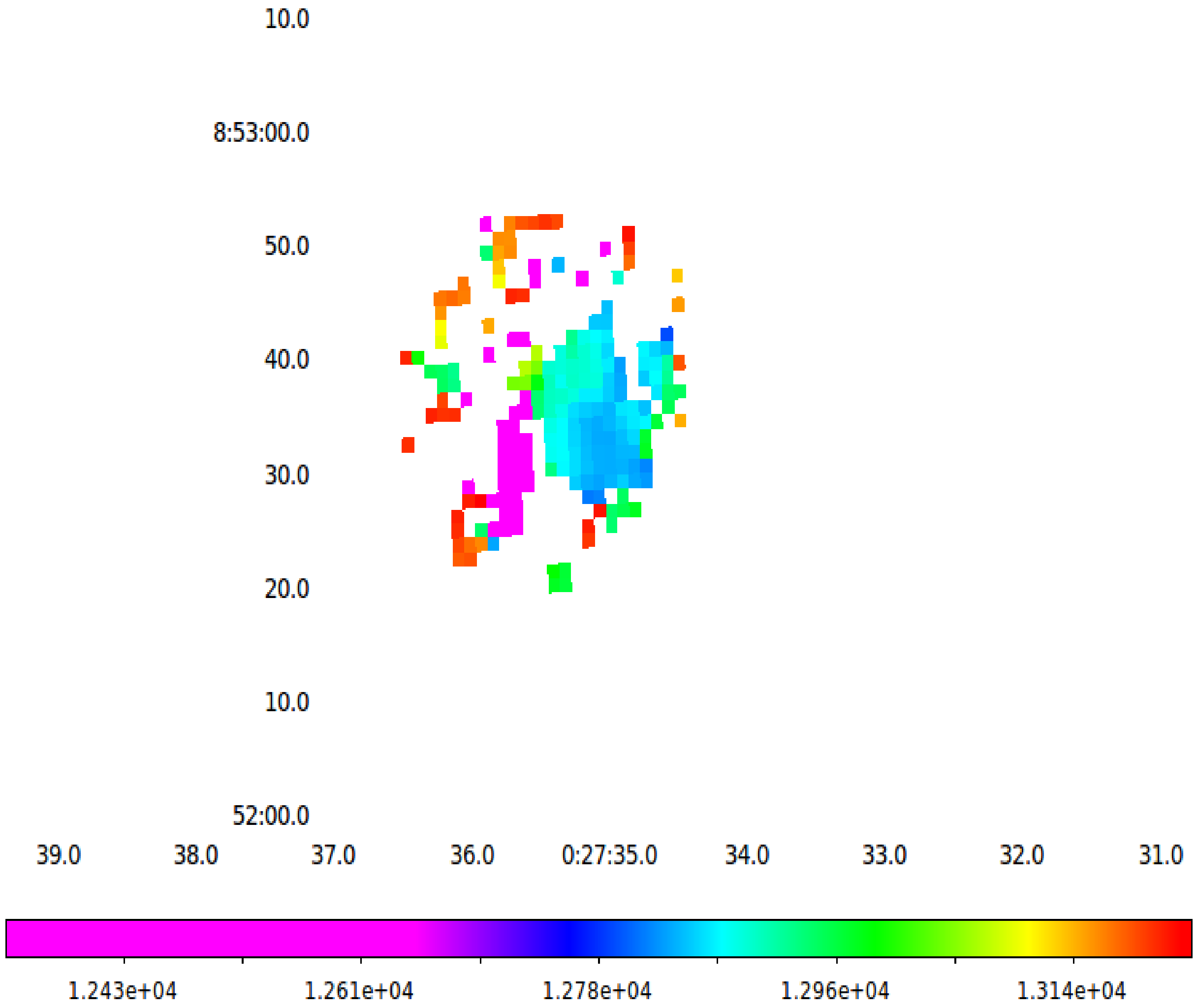
Three galaxies within AMIGA



PUMA Fabry-Perot data

- PUMA Fabry-Perot
- R ~ 8000 at Halpha
- 10' FoV

PUMA Fabry-Perot data

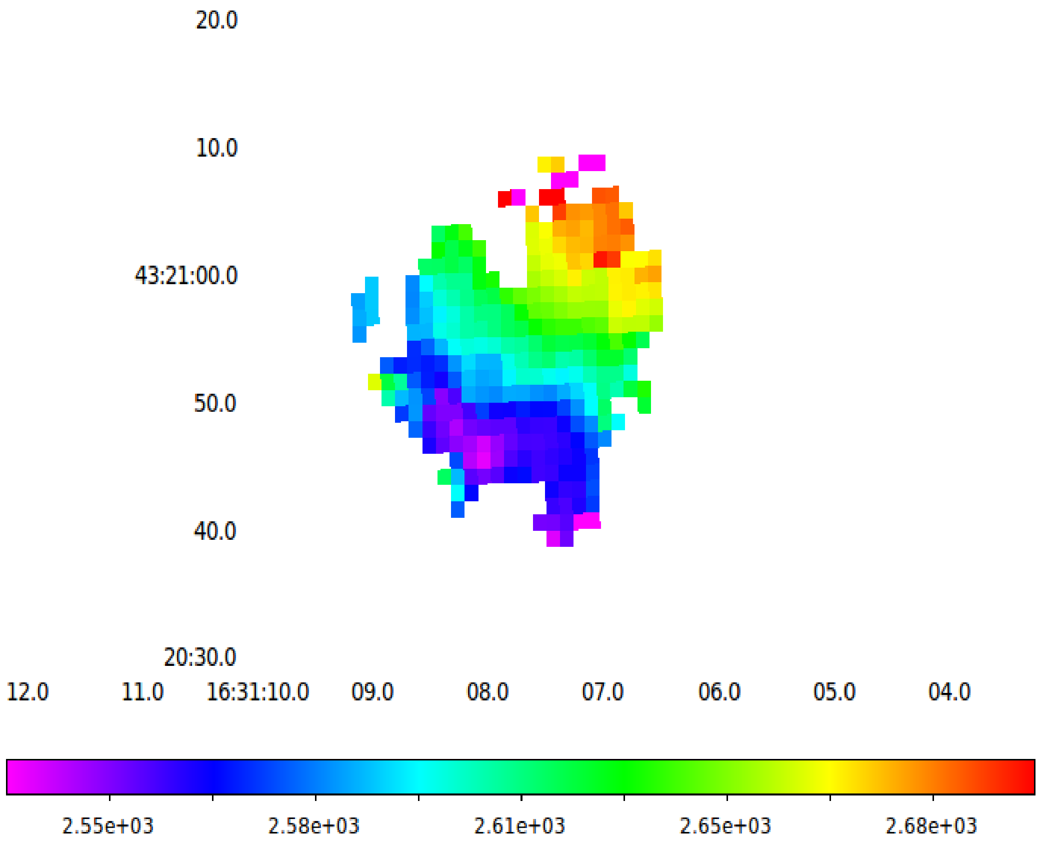


CIG 22:

Clearly a merger.

No Halpha in arms

PUMA Fabry-Perot data



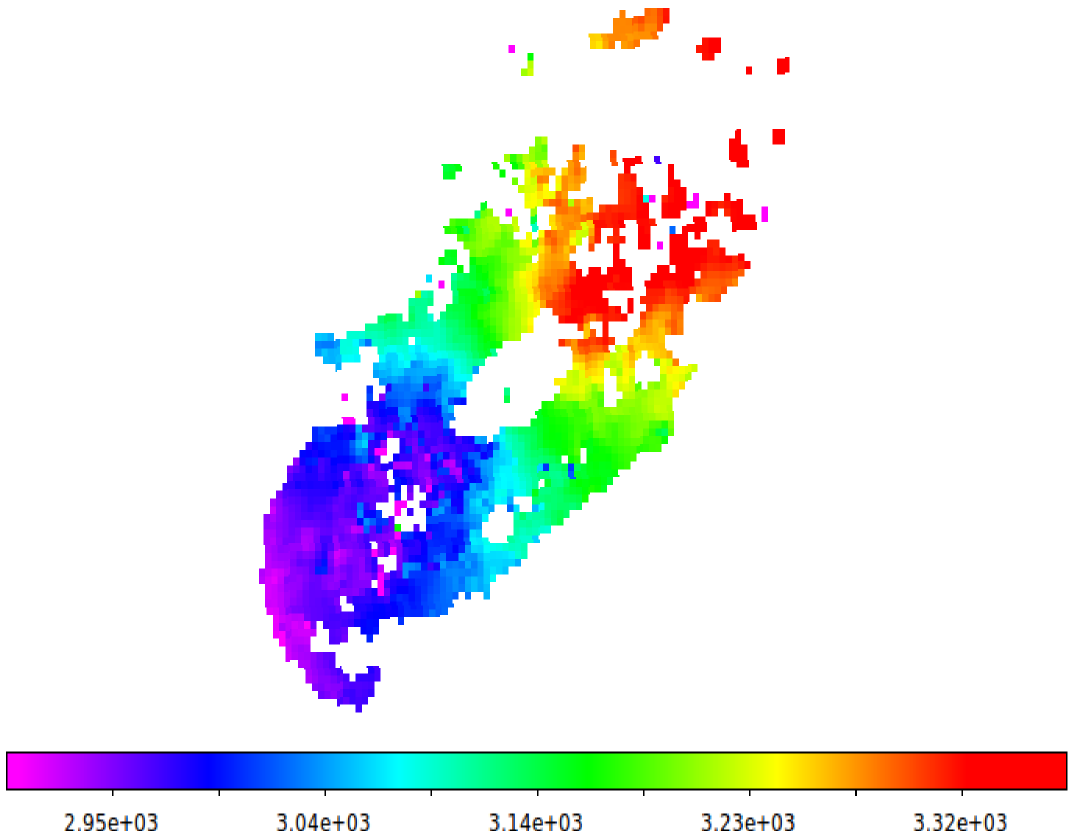
CIG 744:

Rotating galaxy, (~150 km/s velocity range)

Halpha not extender beyond the very centre.

Work still in progress!

PUMA Fabry-Perot data



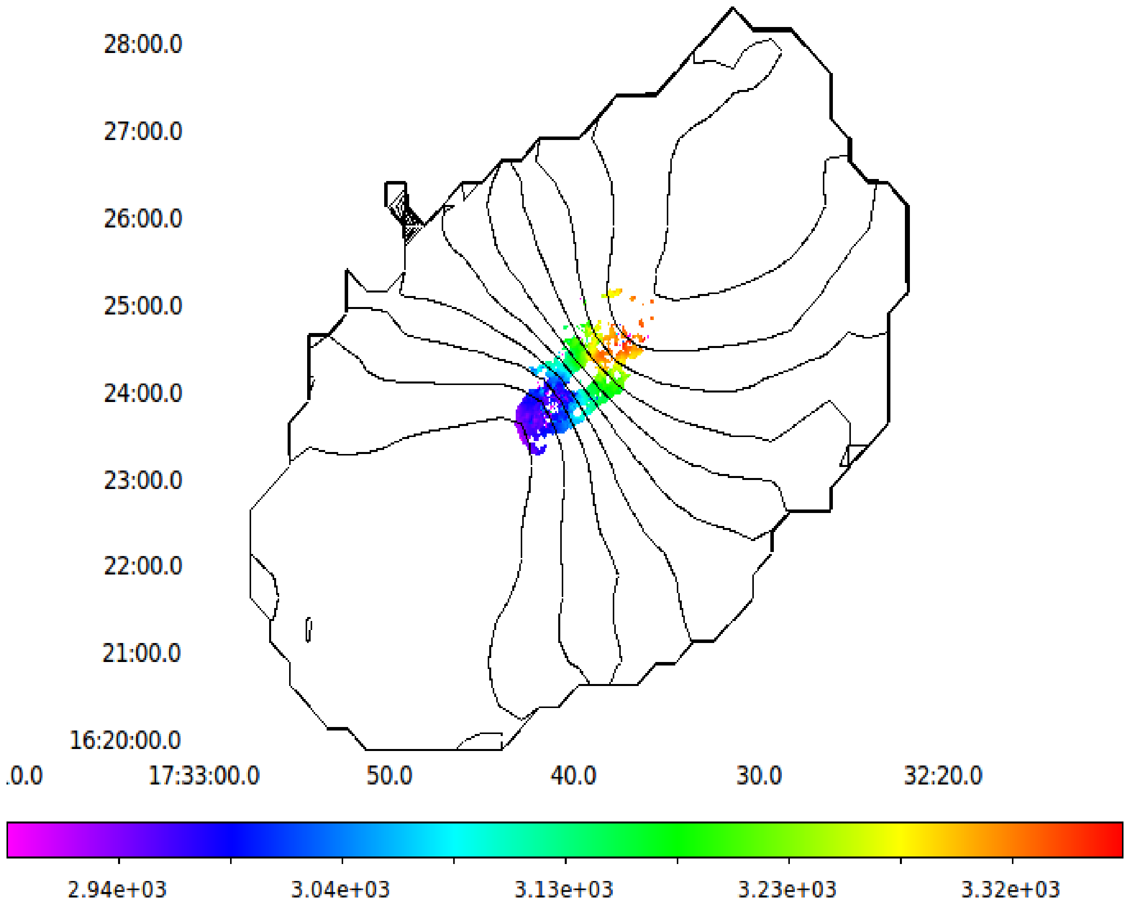
CIG 812:

Smooth rotation curve (~380 km/s velocity range)

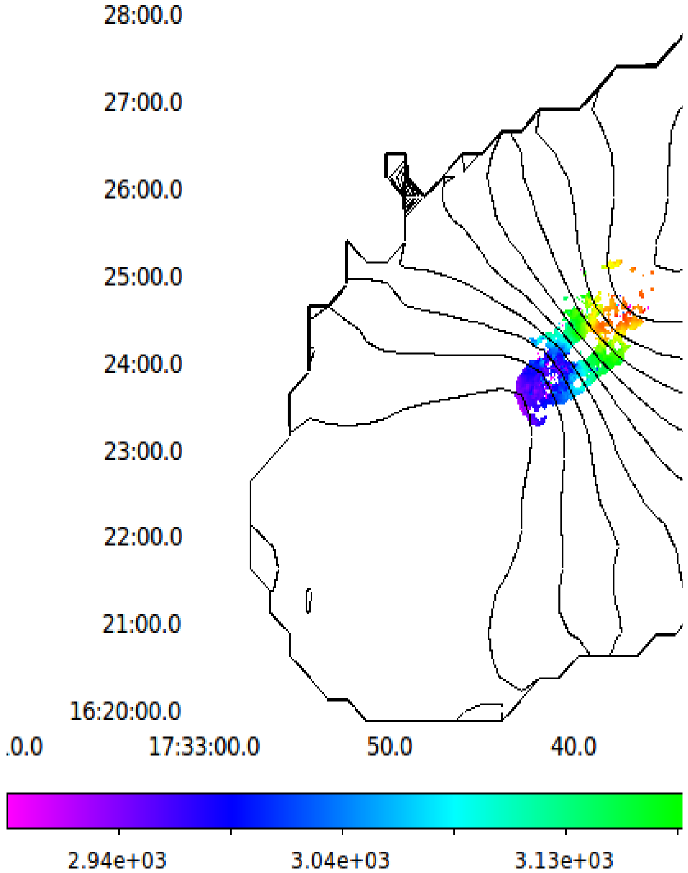
Halpha extends to the start of arms.

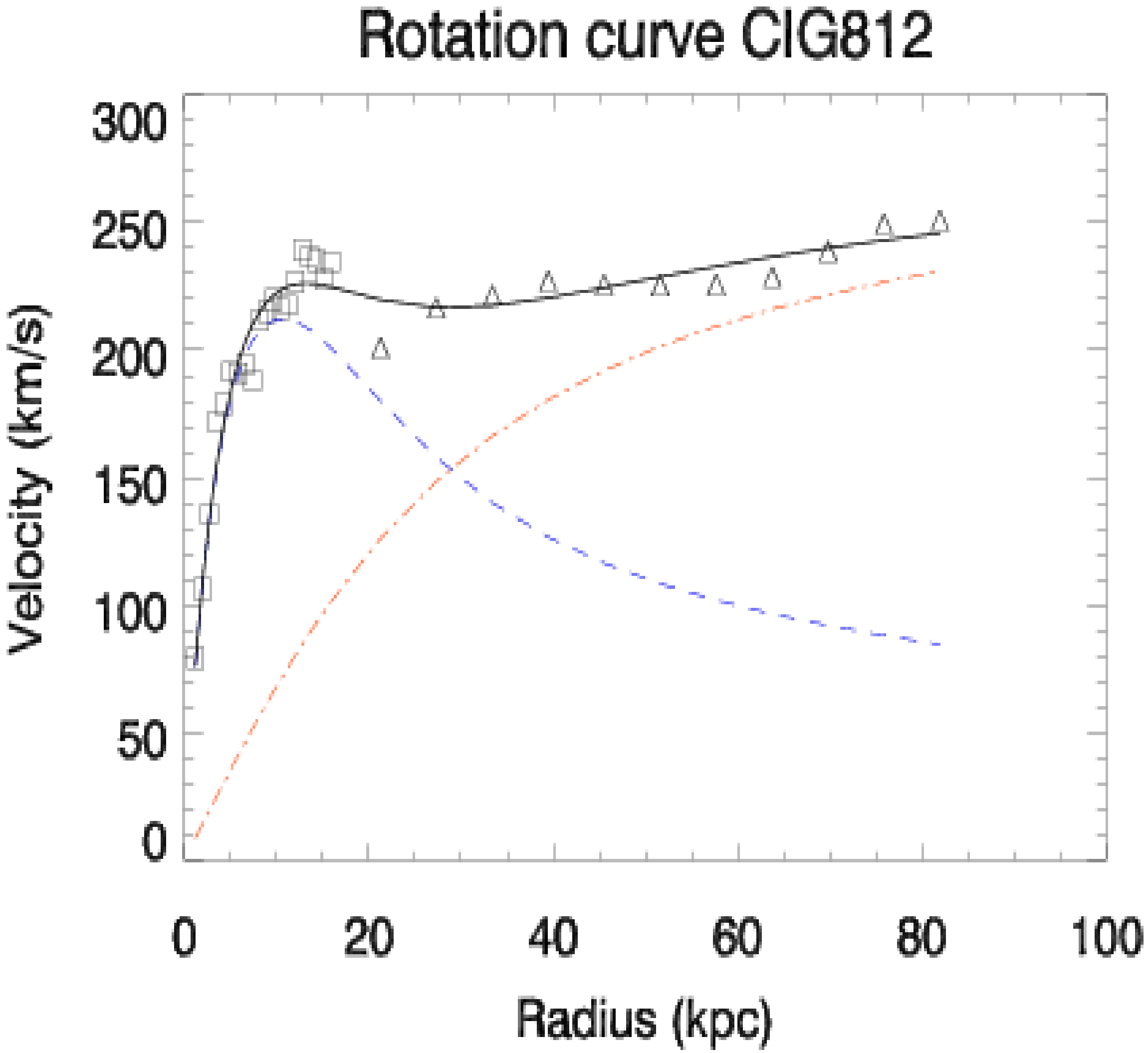
Work still in progress!

PUMA + VLA for CIG 22



PUMA Fabry-Perot data

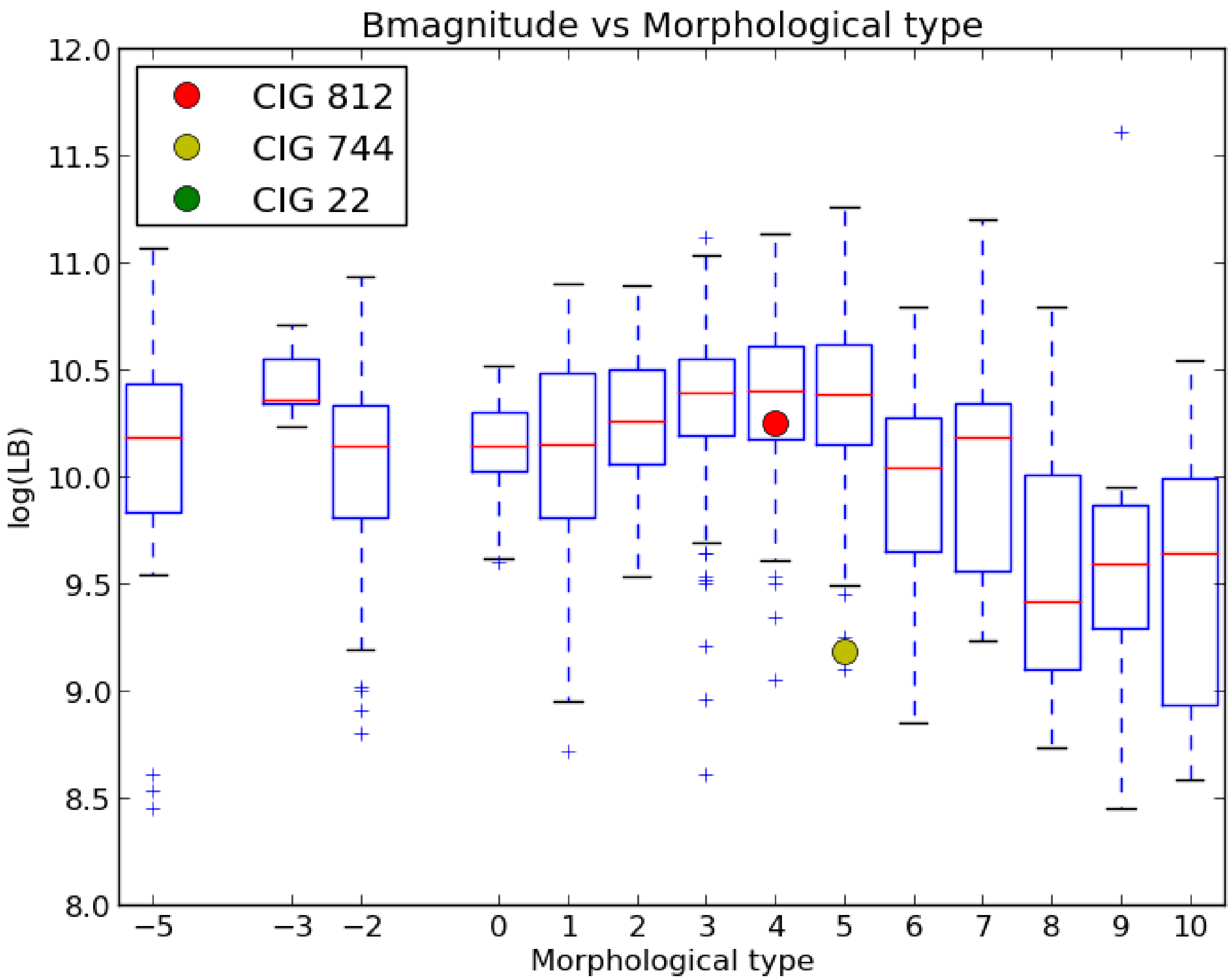




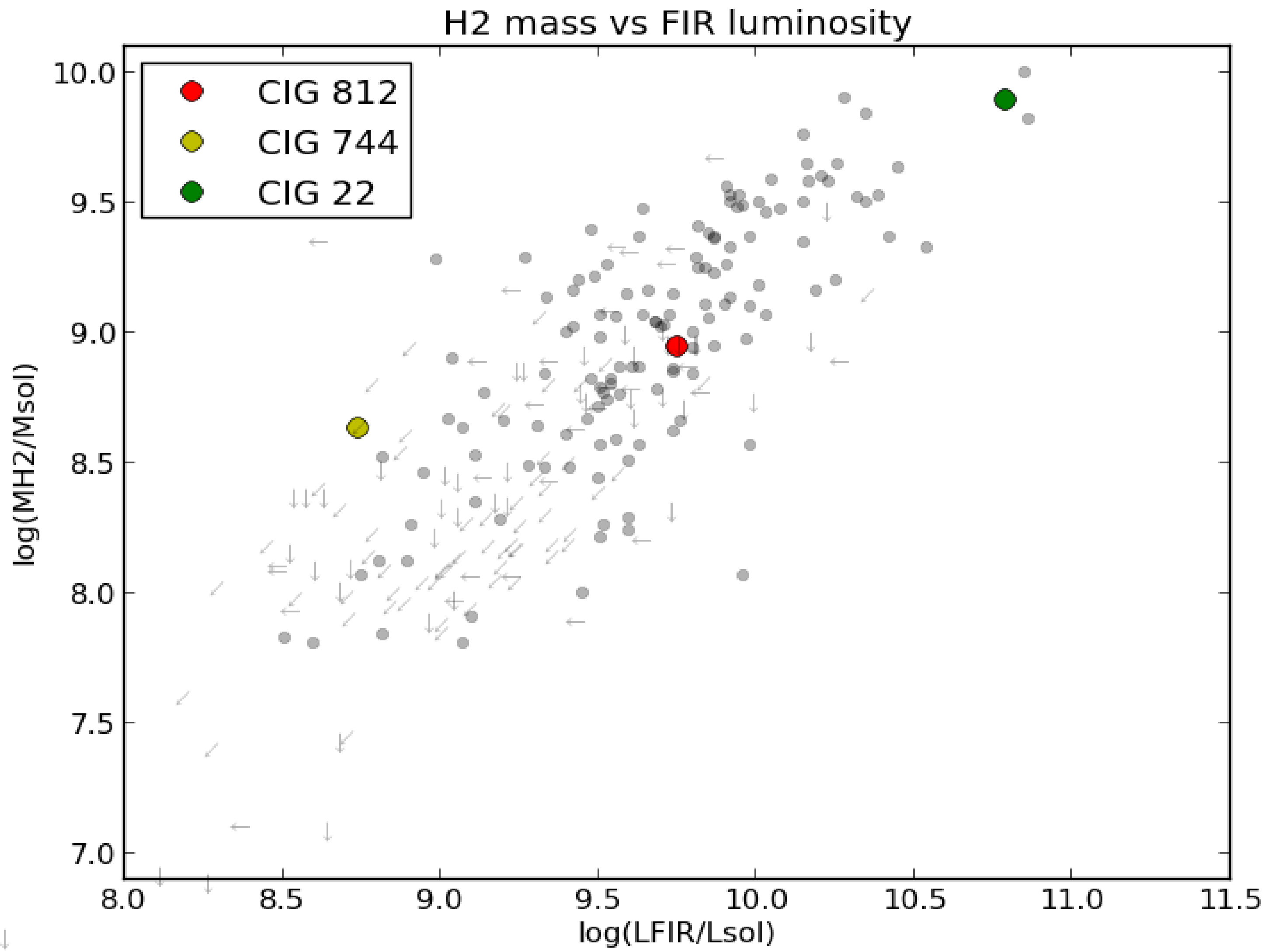
Thanks!

(and visit the poster!)

Three galaxies within AMIGA



Three galaxies within AMIGA

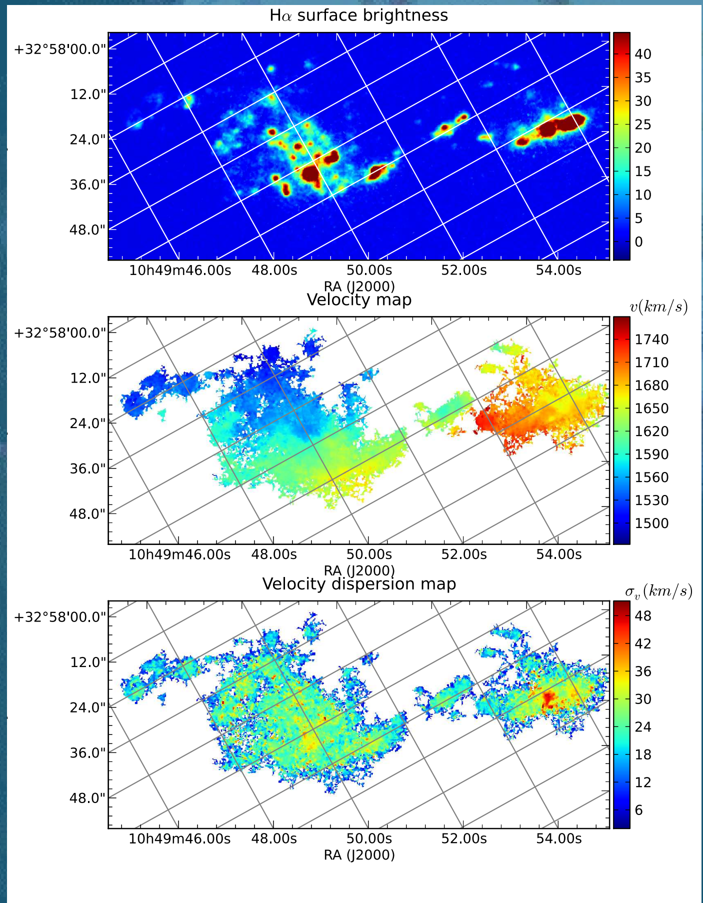


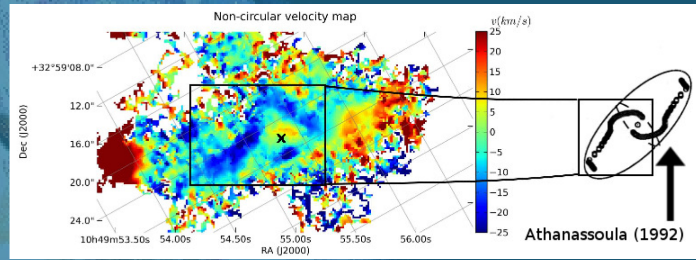
Condition for star formation triggering in interacting galaxies
Poster 46

Javier Zaragoza Cardiel • IAC • jzc@iac.es
Joan Font, John E. Beckman, Javier Blasco Herrera, Begoña García Lorenzo

- Galaxy Hα Fabry-Perot System
- FOV$\sim$ 3.4$'$x3.4$'$
- Spatial resolution seeing limited $\rightarrow$ pixel size 0.2“
- Spectral range $\Delta\lambda \sim 8\AA \rightarrow$ $\Delta v \sim 390 km/s$
- Spectral resolution $\delta\lambda \sim 0.17\AA \rightarrow$ $\delta v \sim 8 km/s$
- Best optical system to derive kinematical maps

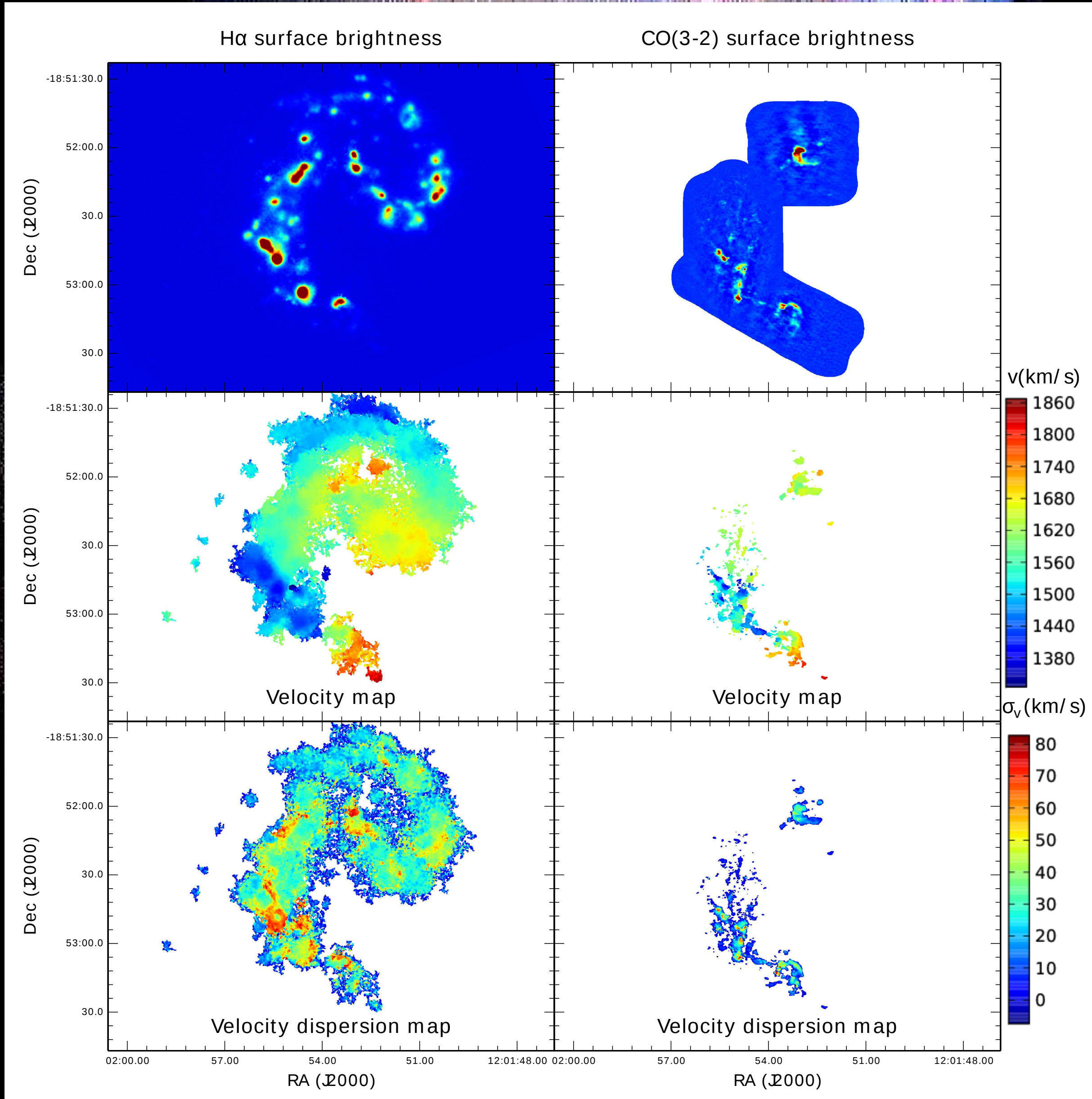
Kinematics of Arp 270 (Zaragoza-Cardiel et al., 2013)





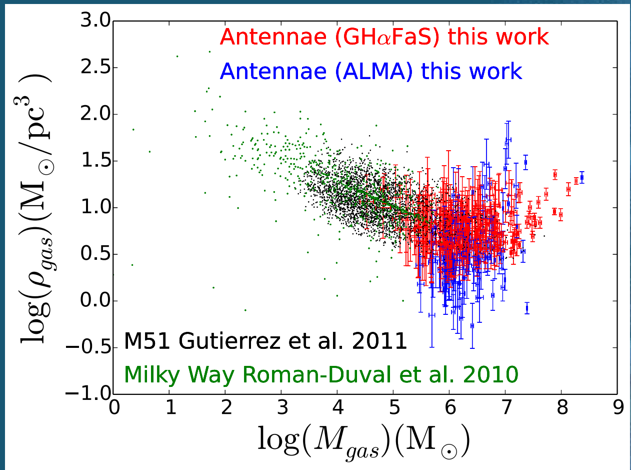
- Removing the rotation curve we obtain the non-circular motions
- The non-circular velocity morphology is similar to the dust lane model from Athanassoula (1992)

Antennae galaxies (Zaragoza-Cardiel et al., 2014, submitted)

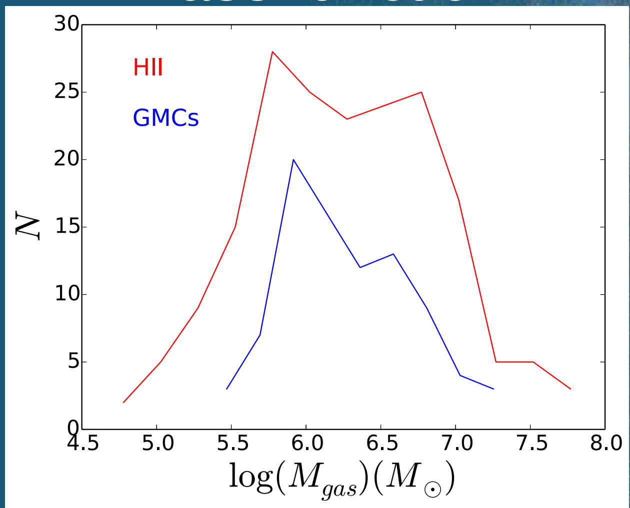


Physical properties of HII regions and GMCs

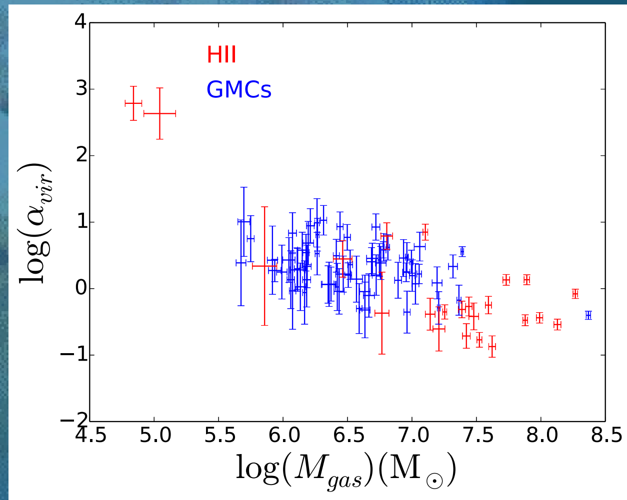
Density



Mass function



Virial parameter



- Two populations of HII regions and GMCs
- Virial parameter decreases with gas mass
- The more gas, the more important is the self gravity of the region instead of the external pressure

Ionized gas kinematics of dwarf galaxies: 3D spectroscopic view with scanning FPI.

(Alexei Moiseev, *Special Astrophysical Observatory, Russia*)

The sample:

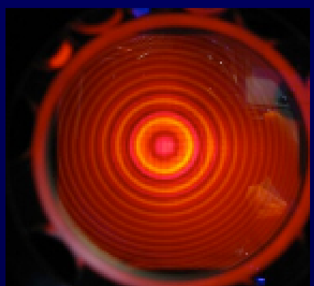
35 Local Volume dwarf galaxies (D<10 Mpc): Lozinskaya et al. (2003-2008) , Moiseev & Lozinskaya (2012), Moiseev (2014)

11 eXtremely Metal-Deficient galaxies: Moiseev et al (2010).

12 Blue Compact Dwarf Galaxies: Martinez-Delgado et al. (2007)

In total: 58 galaxies with M_B=-11...-22

SCORPIO multi-mode focal reducer with scanning Fabry-Perot interferometer (Afanasiev & Moiseev, 2005, 2012)



Field of view: 6.1x6.1 arcmin

Spectral range: Hα emission line

Spatial sampling: 0.35-0.70 "/px

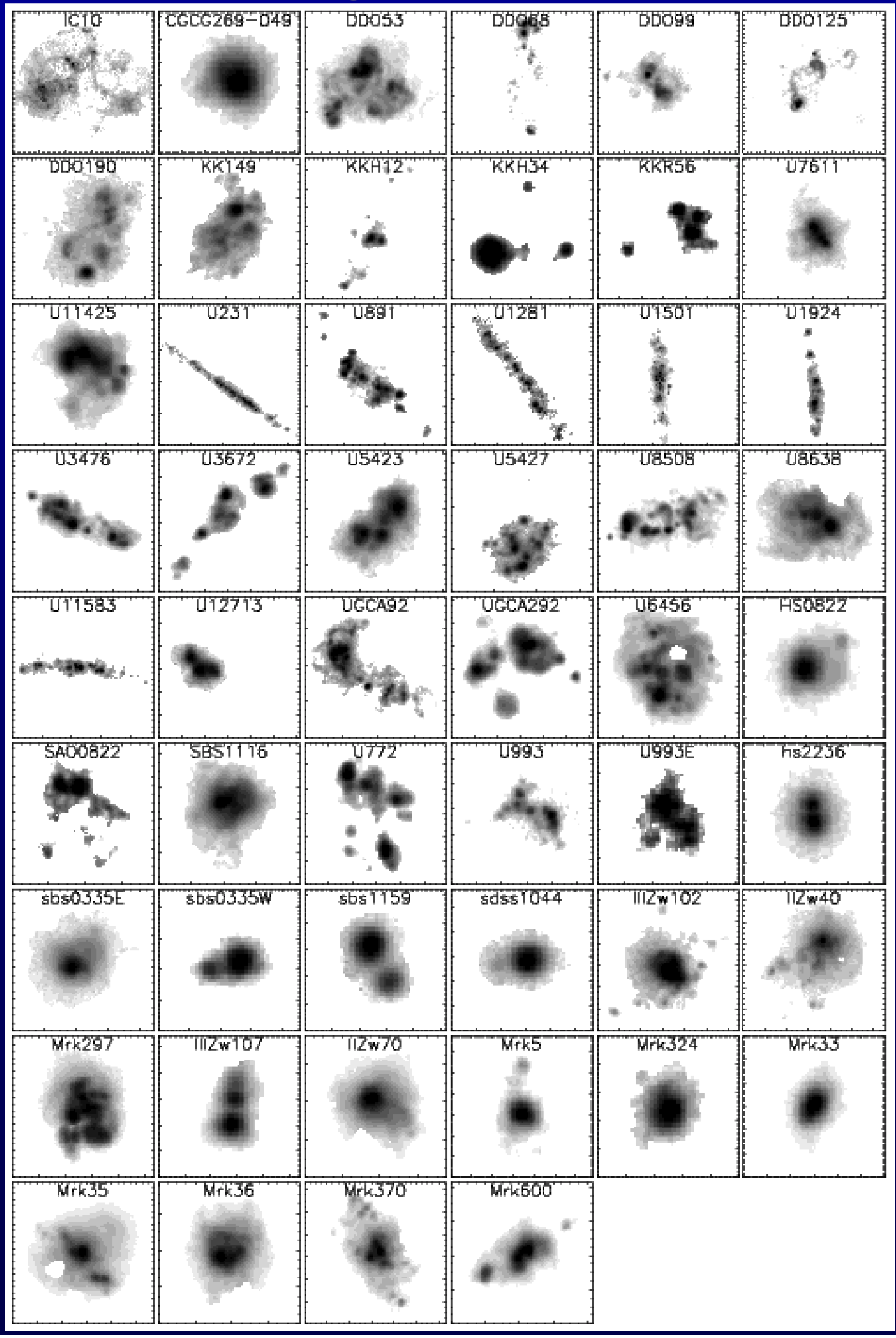
Spectral resolution:

R=9000 & 14600

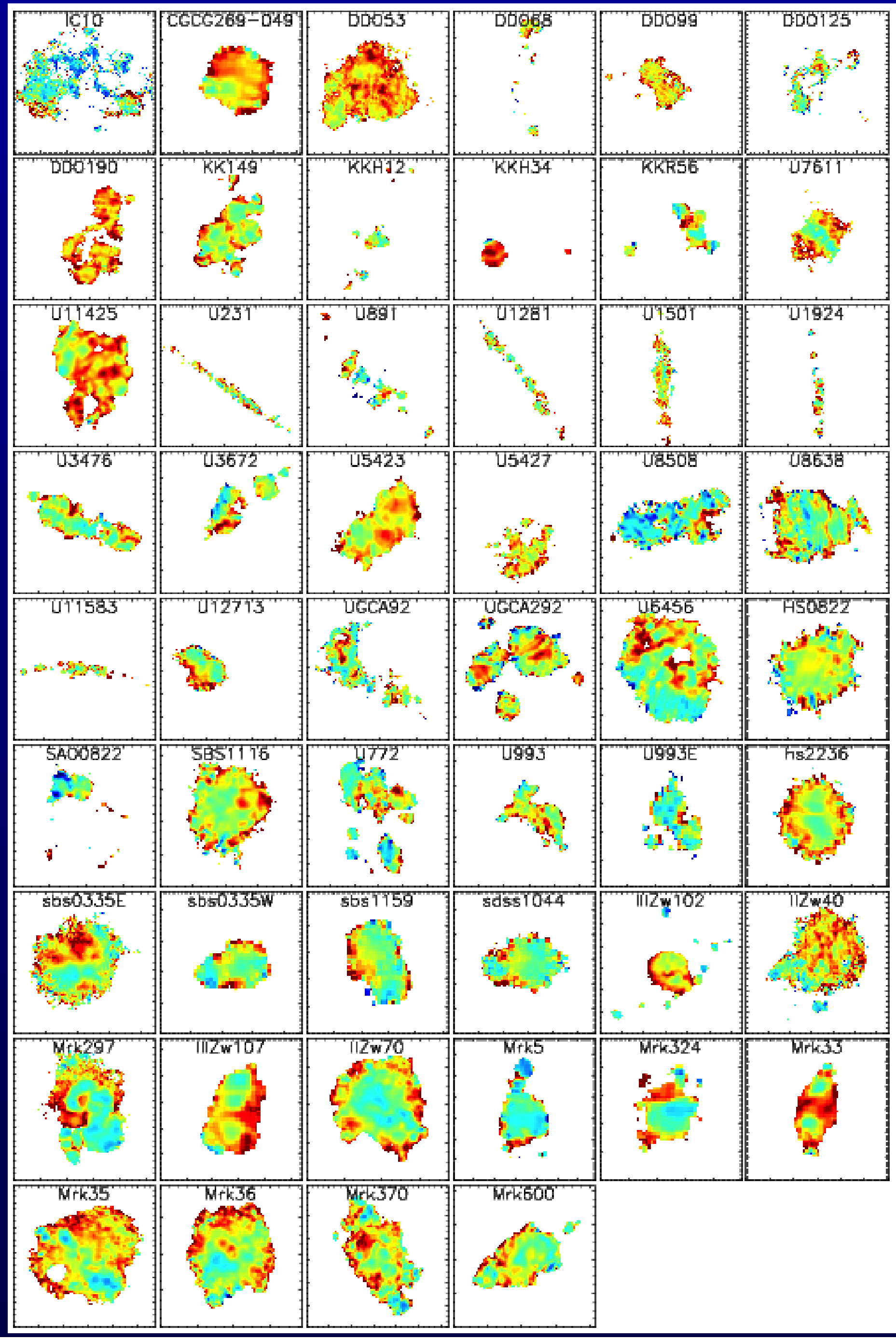
σ= 8.5 & 14.0 km/s

SAO RAS 6-m telescope: www.sao.ru

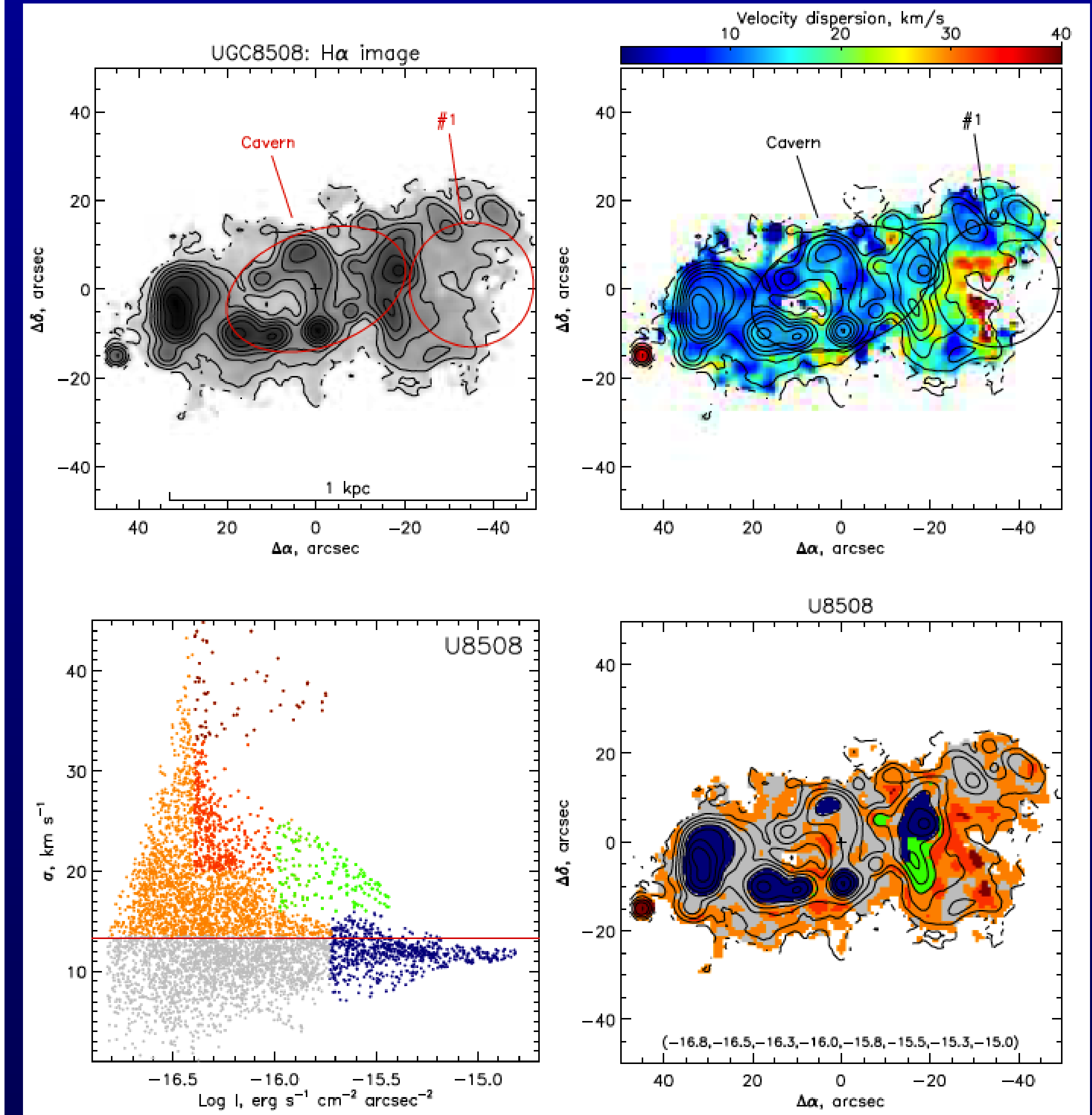
Hα images



Velocity dispersion fields



Velocity dispersion vs line intensity (I-σ diagram)



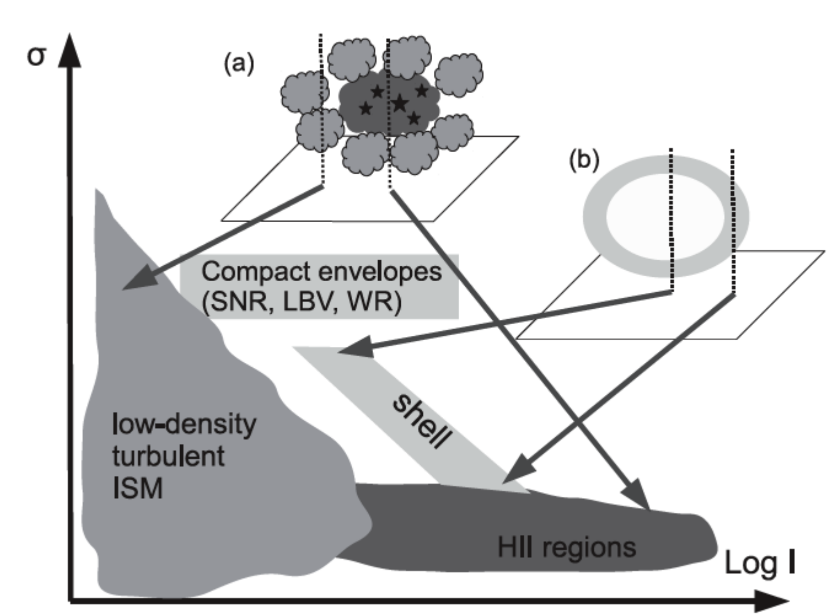


Figure 6. The scheme illustrating the location of points on the $I-\sigma$ diagram. The insets show how we projected on to the sky plane the surface brightness distribution and velocity dispersion (a) from dense H II regions, surrounded by low-density gas with considerable turbulent motions, and (b) from the expanding shell within the model by Muñoz-Tuñón et al. (1996). The dotted line shows the lines of sight passing through different spatial

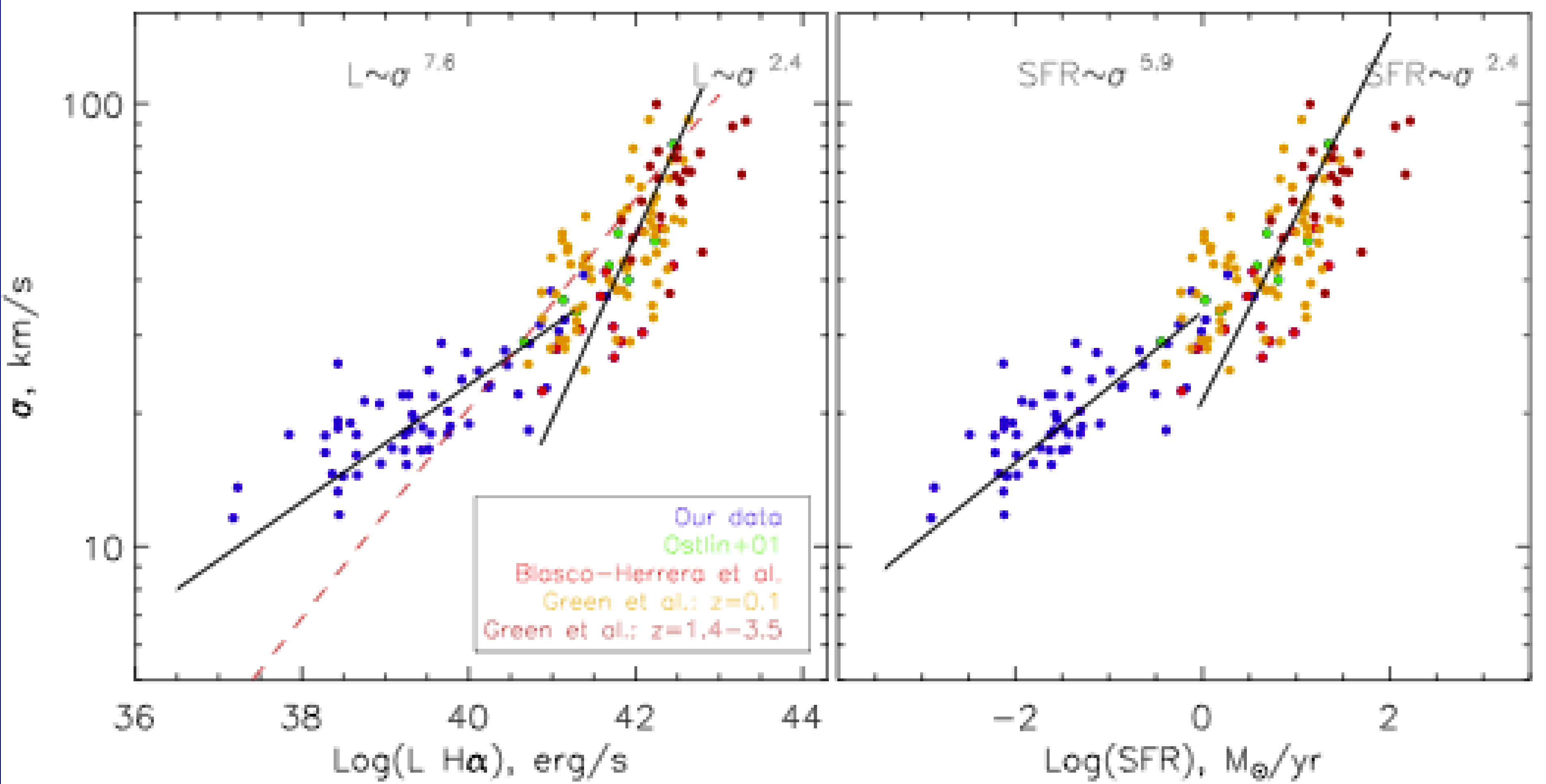
What controls the brightness-weighted velocity dispersion of the ionized gas:

- virial motions
- stellar feedback

?

Moiseev & Lozinskaya (2012)

L-σ relation → SFR-σ



The ionized gas turbulent motions is determined mainly by the energy injected to the ISM from the ongoing star formation (both in the form of ionizing radiation pressure, and by the winds of young stars and supernova explosions).

For more details see the poster #26

A 3D Perspective on Extended Emission Line Regions from the Galaxy Zoo

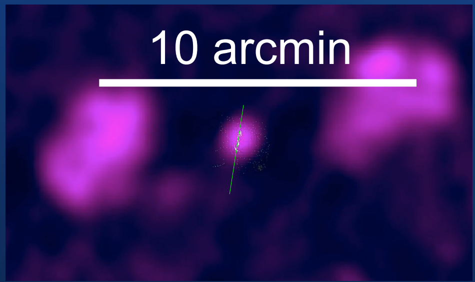
Peter Maksym
(University of Alabama)
wpmaksym@bama.ua.edu, @StellarBones

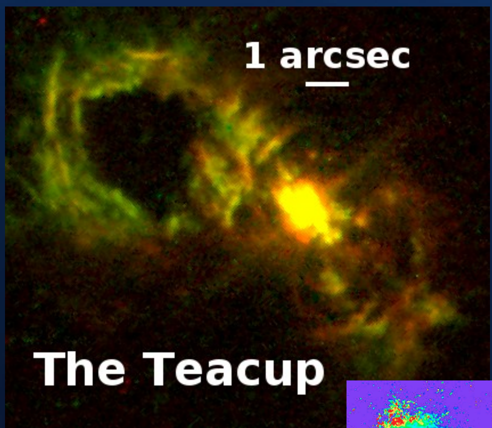
W.C. Keel (U. Alabama), C. Lintott (Oxford), K. Schawinski (ETH Zürich), V.N. Bennert (California Polytechnic SLO), A. Moiseev (SAO Russia), M. Urry (Yale), D. Chojnowski (U. Virginia), M. Schirmer (Gemini)

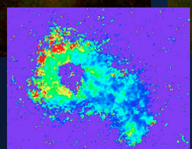
and hundreds of Galaxy Zoo citizen-scientists!

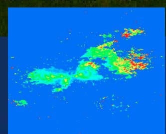
The Voorwerpjes:
a Zoo of the Bizarre

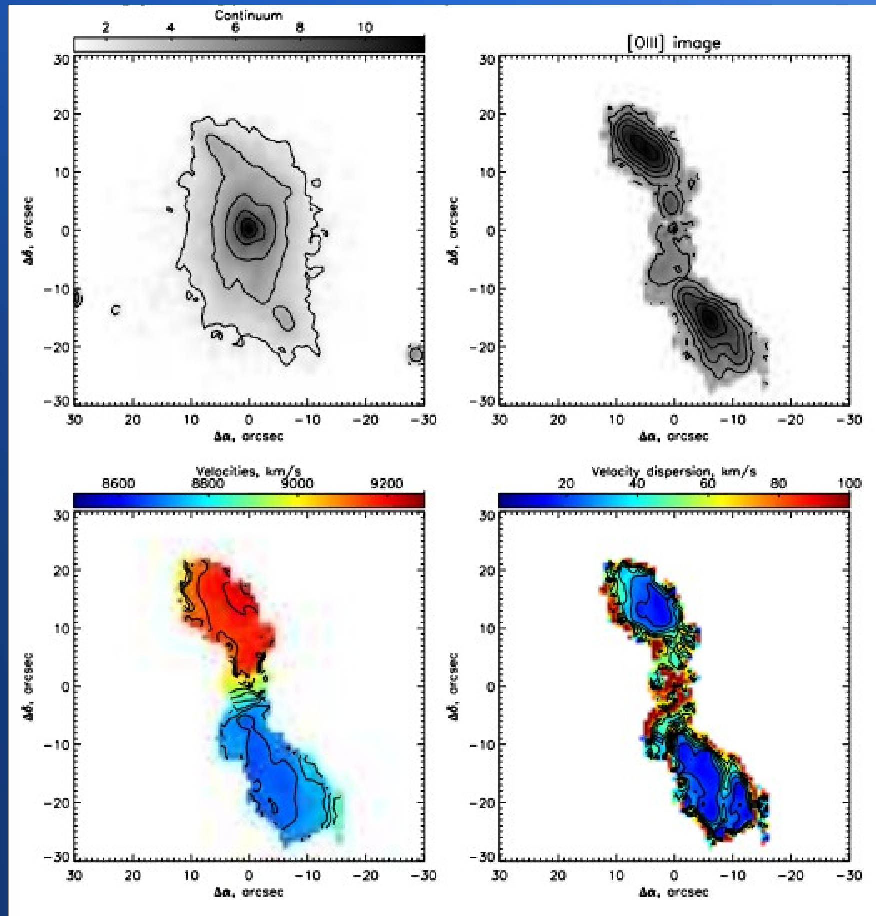
NGC 5972



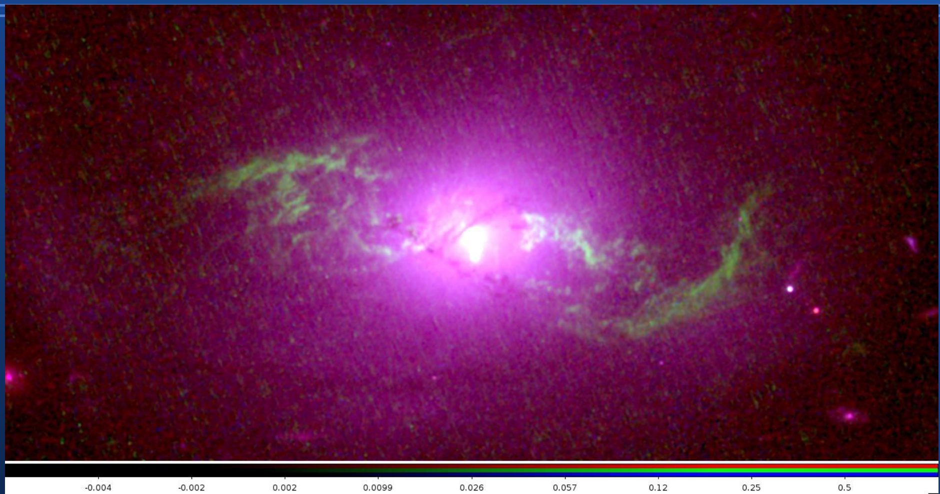


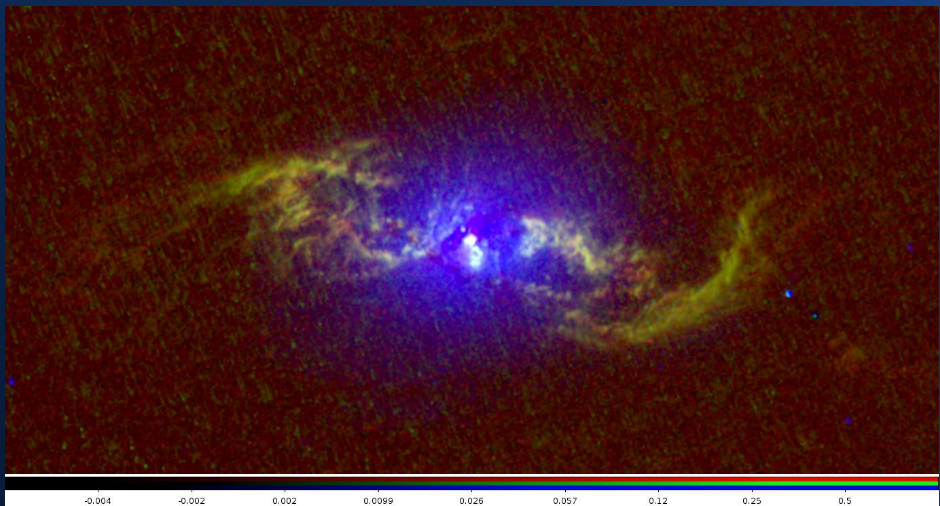


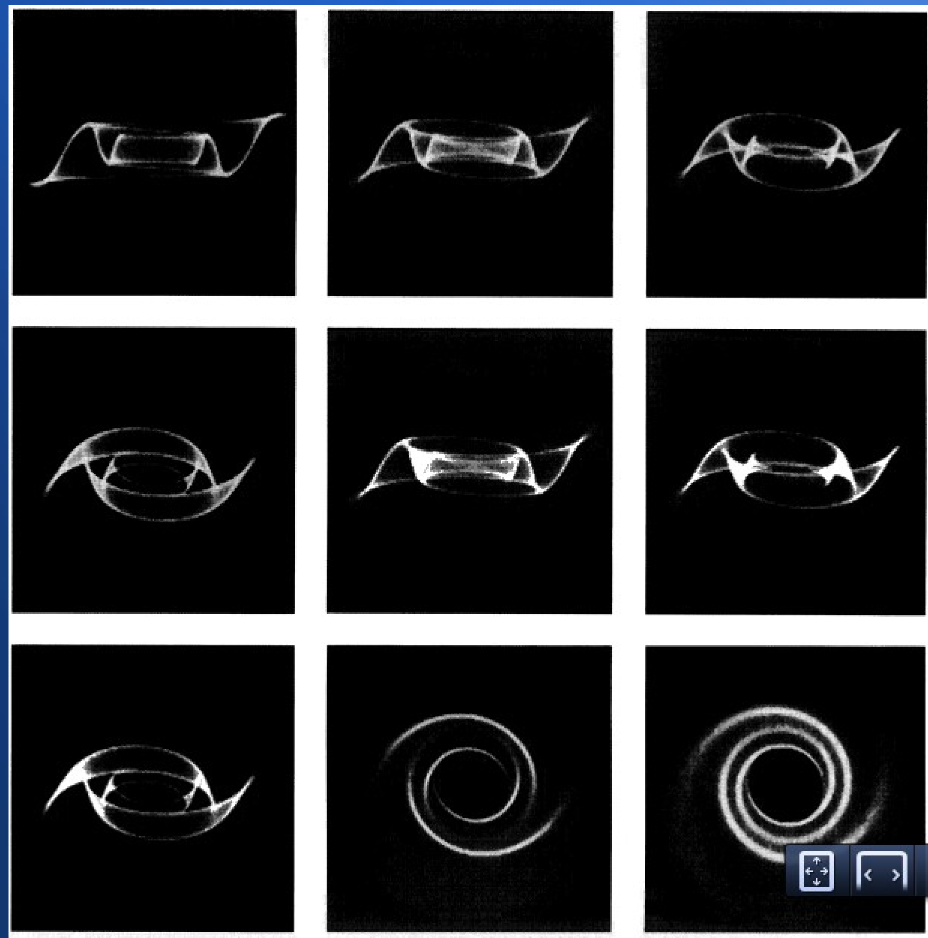




Ionization and Interactions







Left: NGC 5972, Right: Steiman-Cameron et al., 1992

Gemini Observations: in Hand and Ongoing