"Kinemetry of a sub-sample of local LIRGs using VLT-VIMOS integral-field spectroscopy"

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Main goals:

- 2-D kinematic characterization of local (U)LIRGs sample along with their respective simulated high-z galaxies; look for correlations wrt fundamental properties like Dynamical Status, L_ir, Ionization type, etc.

- Find out kinematic criteria able to distinguish between "disk" or "merger" systems (e.g., Shapiro et al. 2008). This is relevant to constrain different galaxy evolutionary scenarios.

Outline of this work:

i. The sample & sub-sample

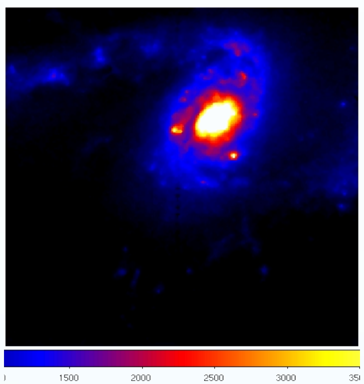
ii. Data reduction *

iii. Data analysis:

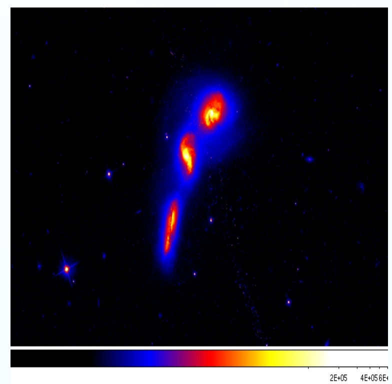
1) Line fitting & Creating maps
2) Kinemetry method (Krajnović et al. 2006)
3) Define different kinematic criteria distinguishing "disk/merger" (e.g., Shapiro et al. 2008)
4) Simulations @ high-z (i.e., NIRSpec resolution)
5) Results

i. The whole sample & VLT/VIMOS IFU observations

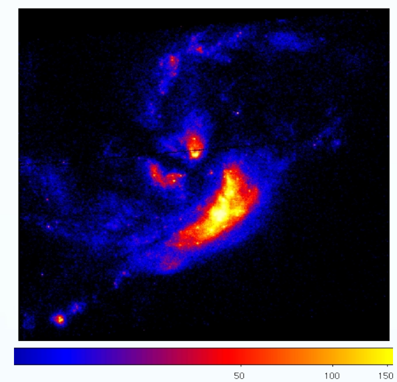
- 38 local (<z> ~ 0.022) (U)LIRGs observed with VIMOS @ VLT (from **RBGS**, Sanders et al. 2003)
- Different ionization types: LINERs, Seyfert, HII
- $L_{IR} = L_{[8-1000\ \mu m]} = 10^{11}\text{-}10^{12.4}\ L_{\odot}$
- Different dynamical phases (morphological types)



Isolated (0)

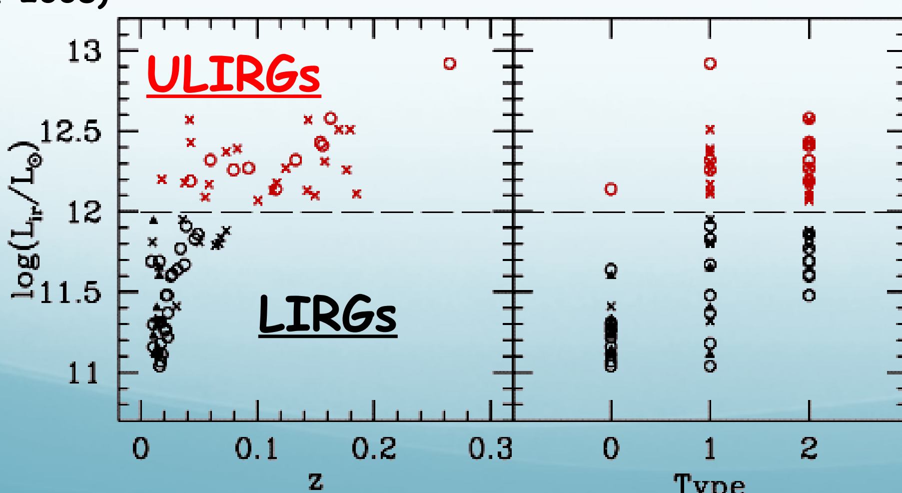


Interacting (1)



Merger (2)

(Arribas et al. 2008)



Our observing mode characterized by

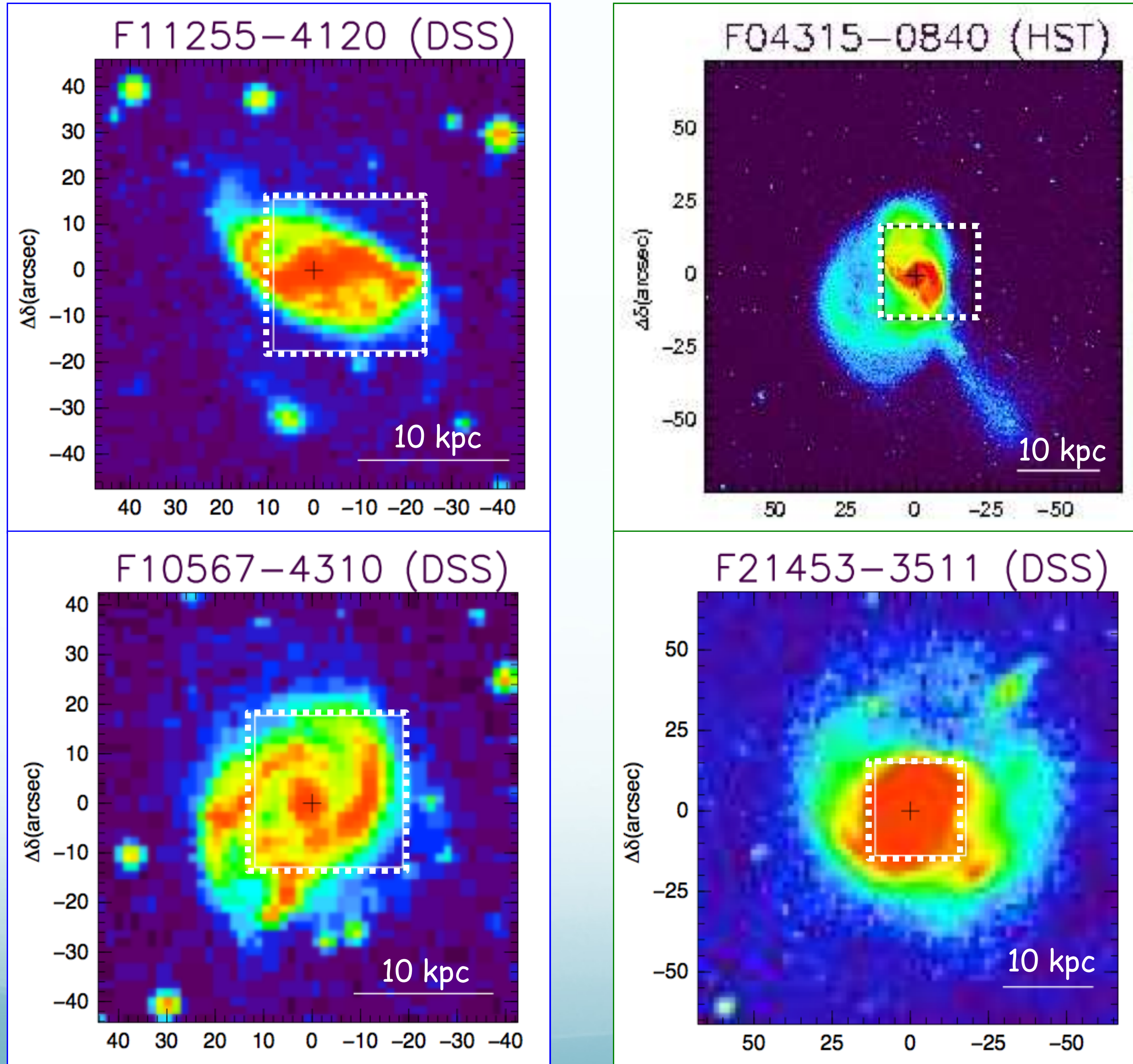
- ✓ FOV = **27x27** arcsec^2 (@ **0.67"**/fiber)
- ✓ Wavelength range: **5250÷7400** Å
- ✓ **1936** spectra/object
- ✓ High resolution: **R ~ 3470**

Sub-sample 4 LIRGs @ 70 Mpc

Morphology:

"Disks"

"Mergers"

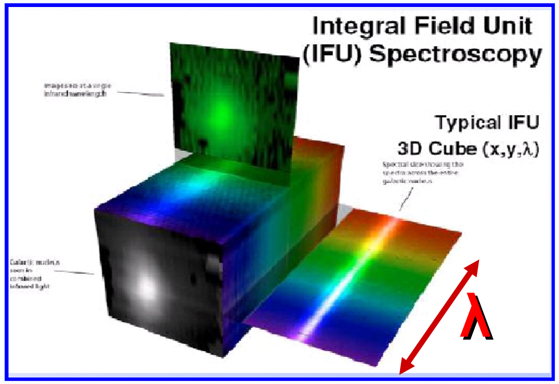


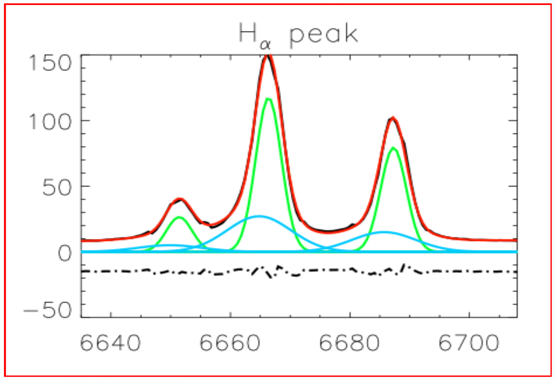
Rodriguez-Zaurin et al. 2010

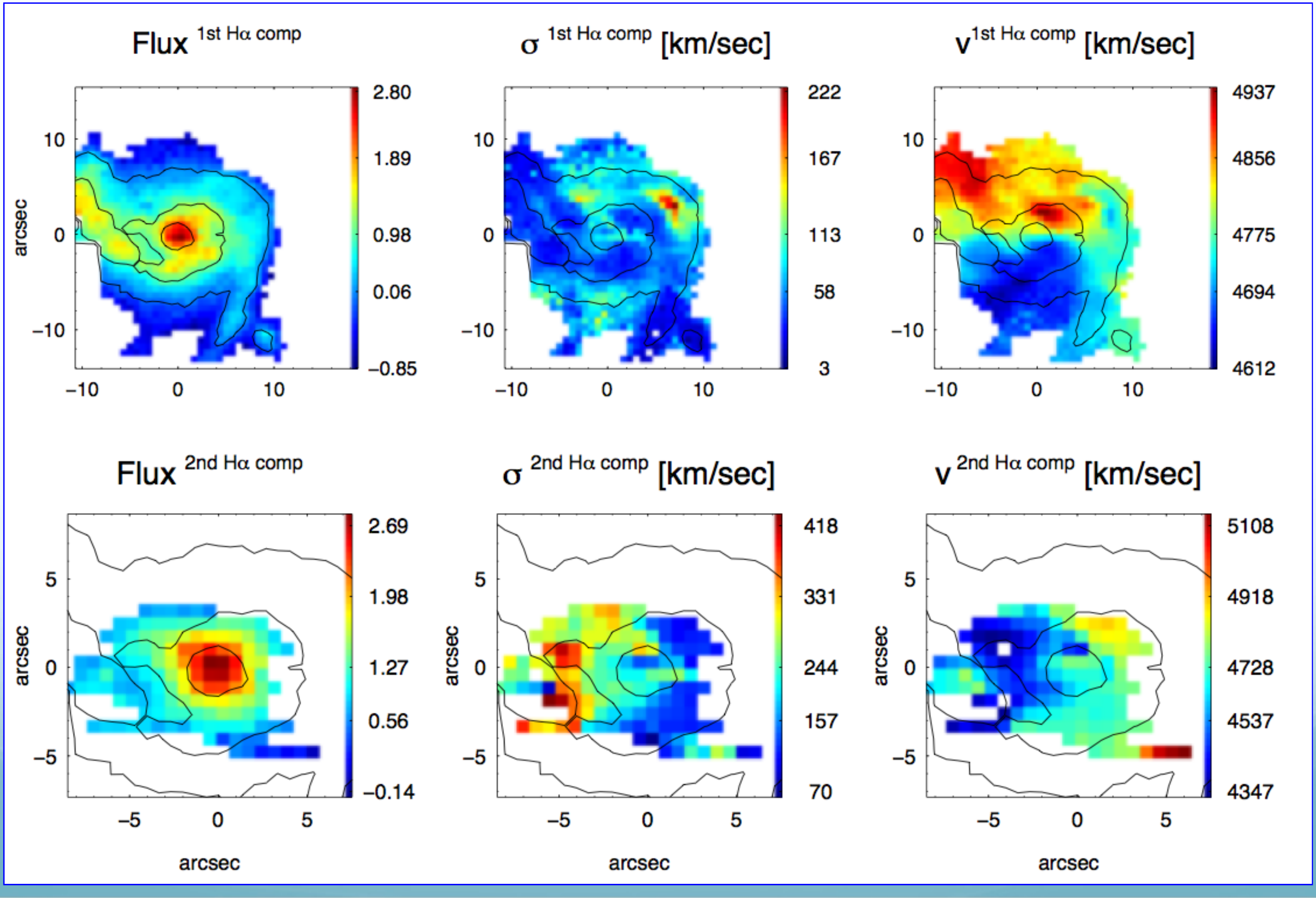
iii. Data analysis

1) Line fitting & relative maps

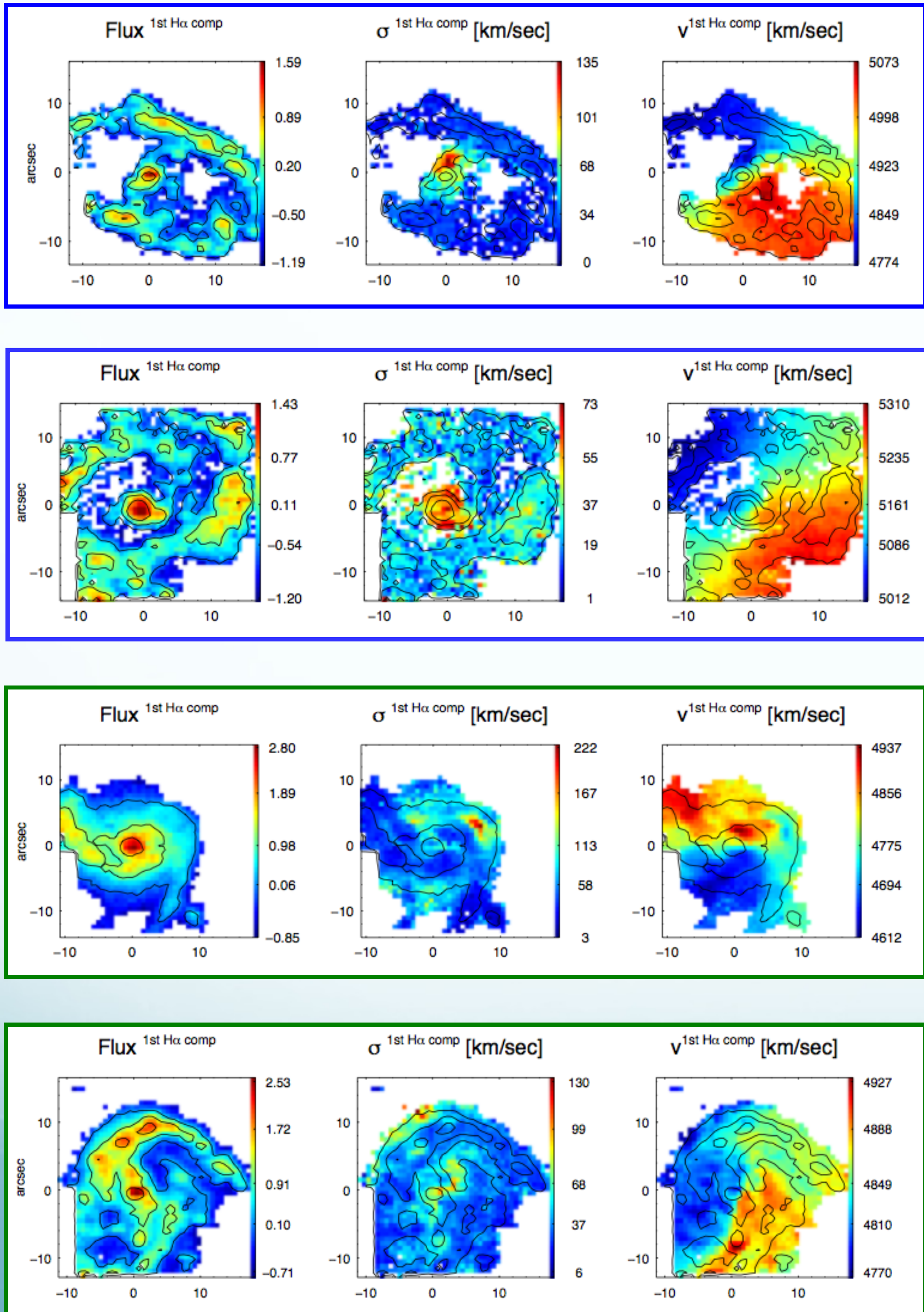
NGC 1614



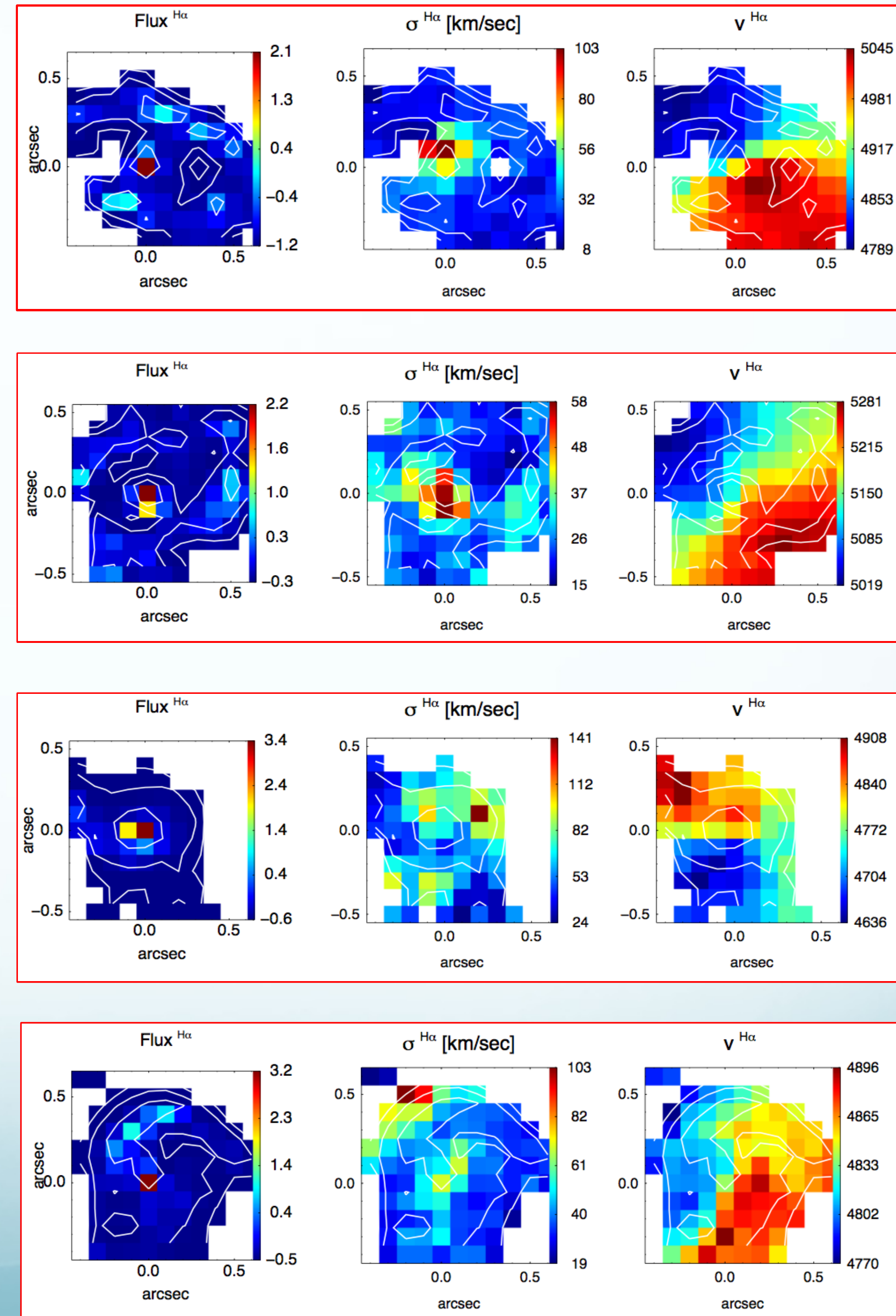




Local Observed data



z = 3 Simulated data



2) "Kinemetry" method

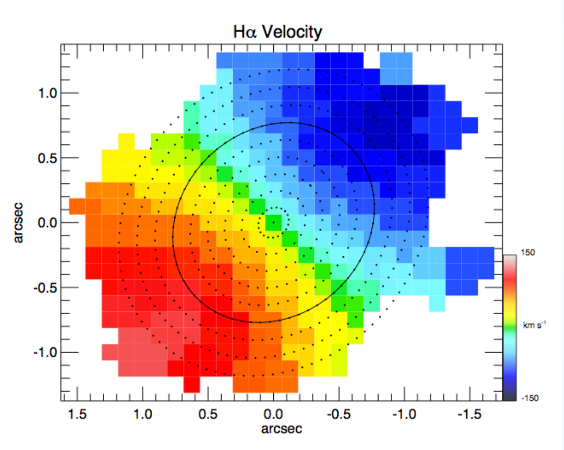
- Harmonic expansion of 2D maps of observed moment along the best fitting ellipses: along each ellipse the moment as a function of angle is extracted and decomposed into the Fourier series

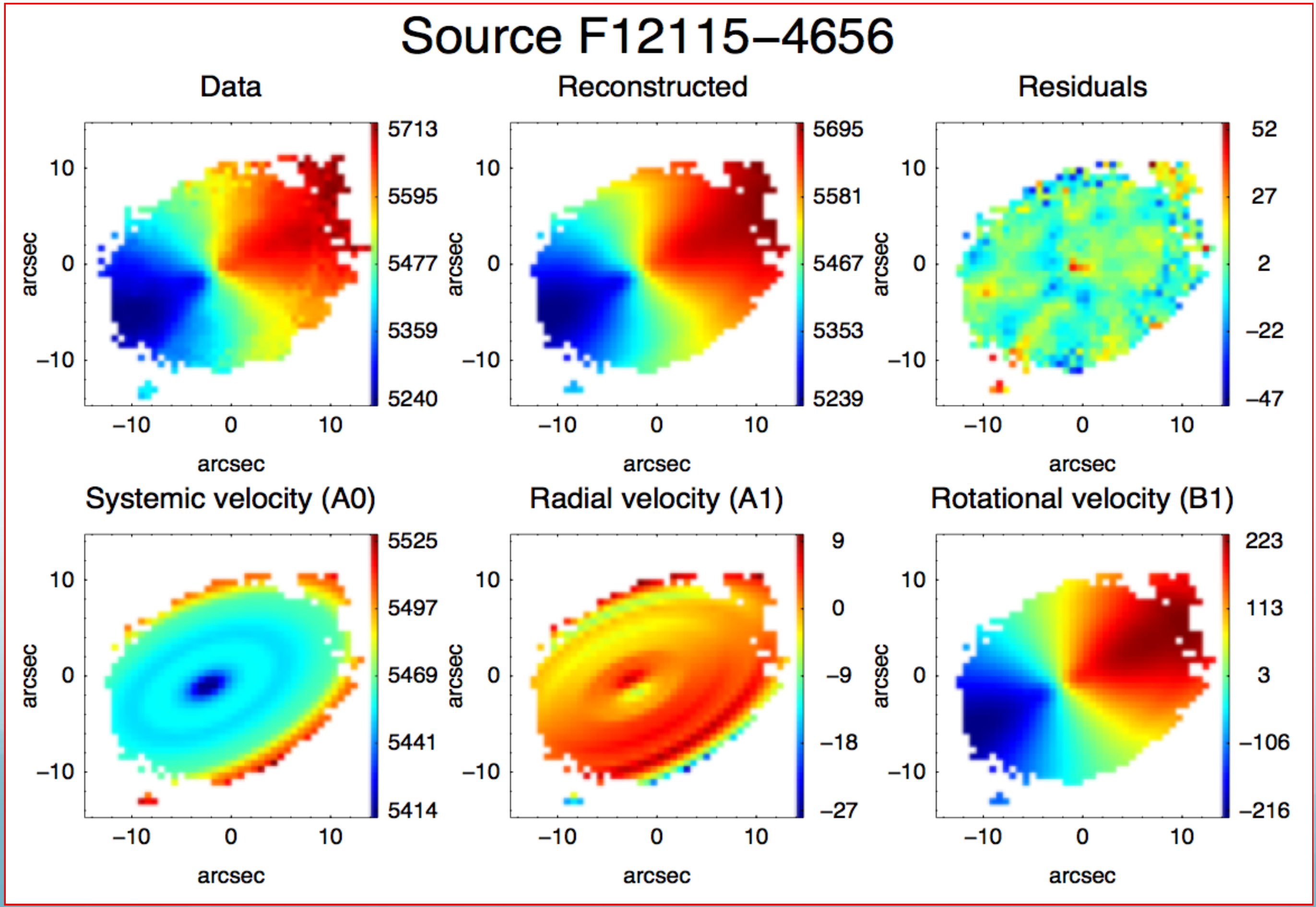
$$K(\psi, r) = A_0(r) + \Sigma_i\, A_i(r)\sin(i\cdot\psi) + B_i(r)\cos(i\cdot\psi)$$

where Ψ is the azimuthal angle in the plane of the galaxy

→ The results are the Fourier coefficients (A_i, B_i)

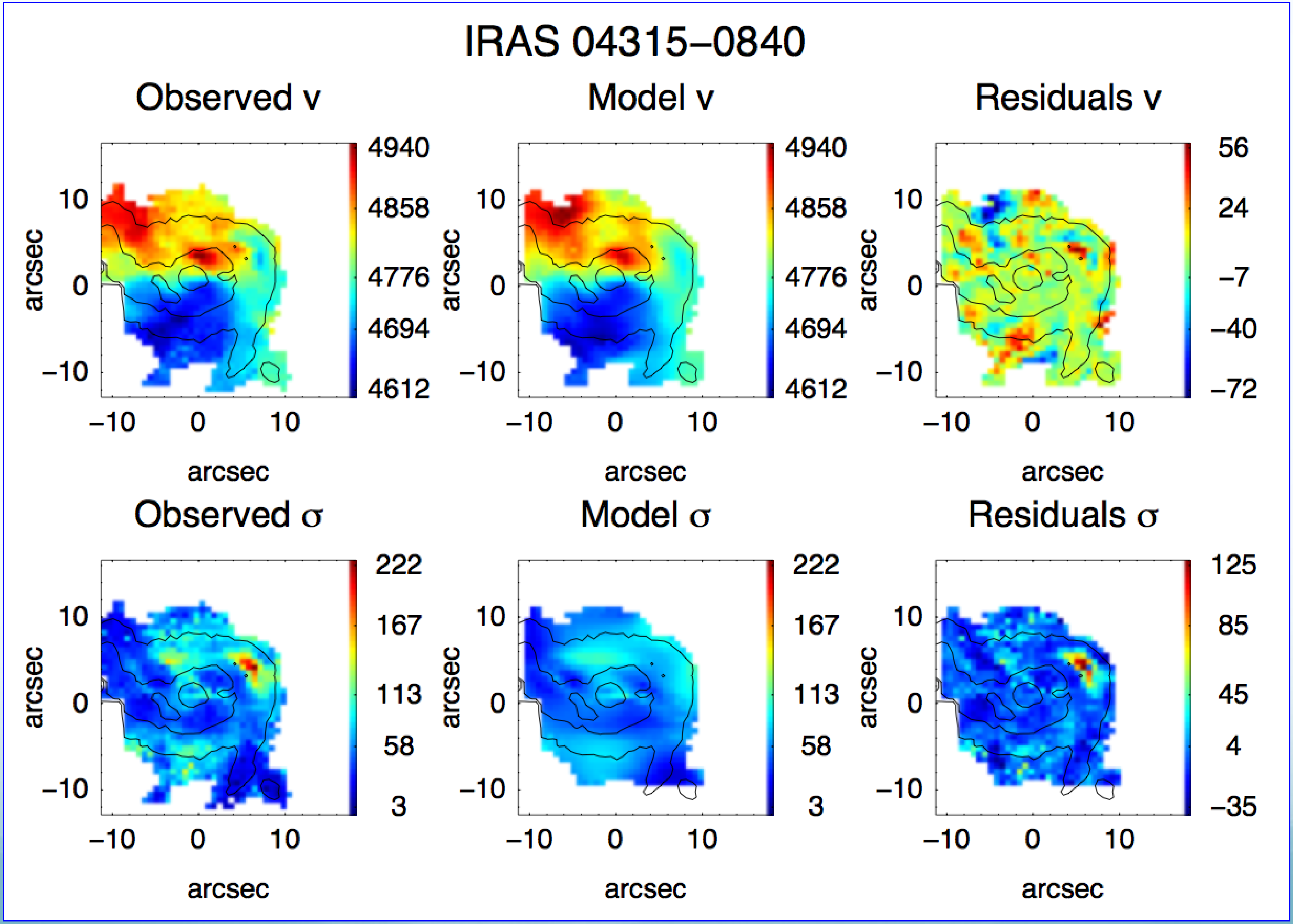
and reconstructed kinematic moment maps !



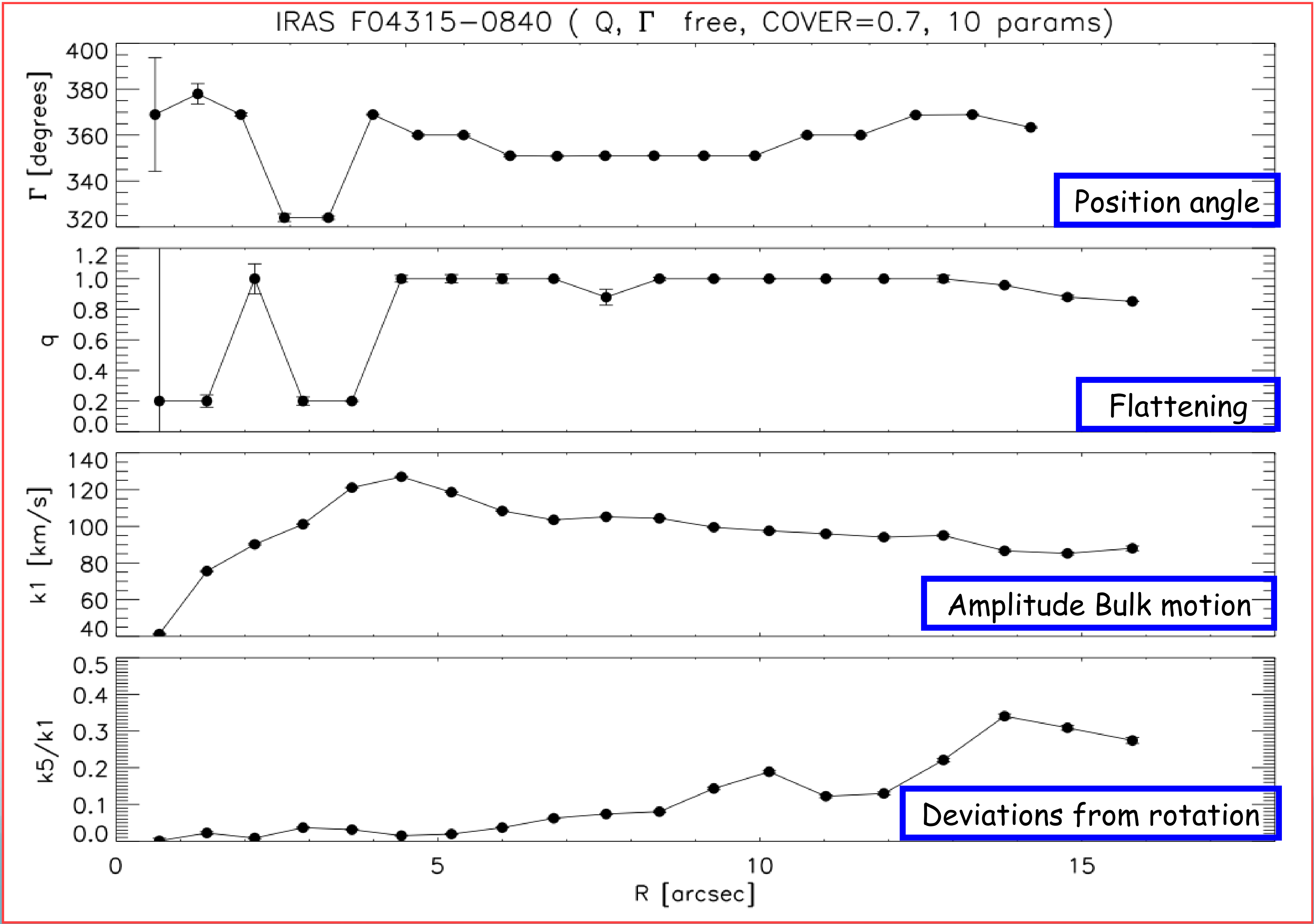


Rotational Curve !

Kinemetry outputs (I)



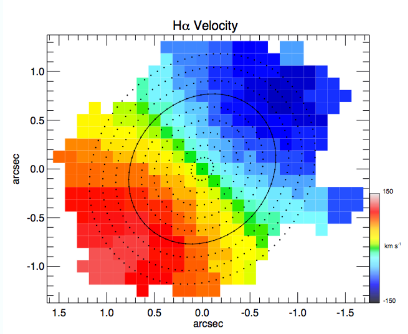
Kinemetry outputs (II)



3) Kinematic criteria

a) Shapiro et al. 2008

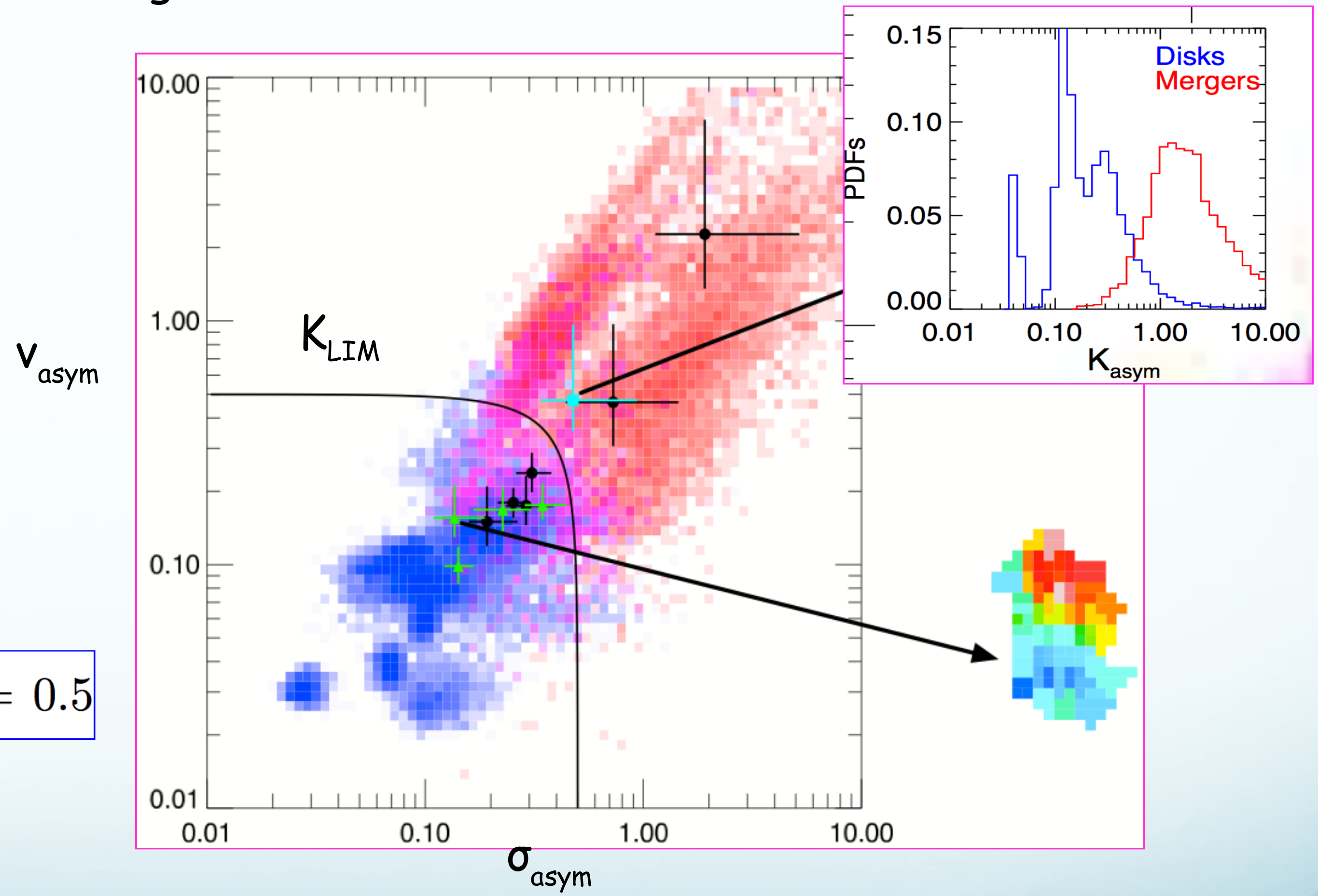
To quantify asymmetries of a system (e.g., v_{asym}, σ_{asym}) wrt an *ideal rotating disk*, to differenciate it between "disk" or "merger"



$$\sigma_{asym} = \left\langle \frac{k_{avg,\sigma}}{B_{1,v}} \right\rangle_r$$

$$v_{asym} = \left\langle \frac{k_{avg,v}}{B_{1,v}} \right\rangle_r$$

$$K_{asym} = \sqrt{v_{asym}^2 + \sigma_{asym}^2} = 0.5$$

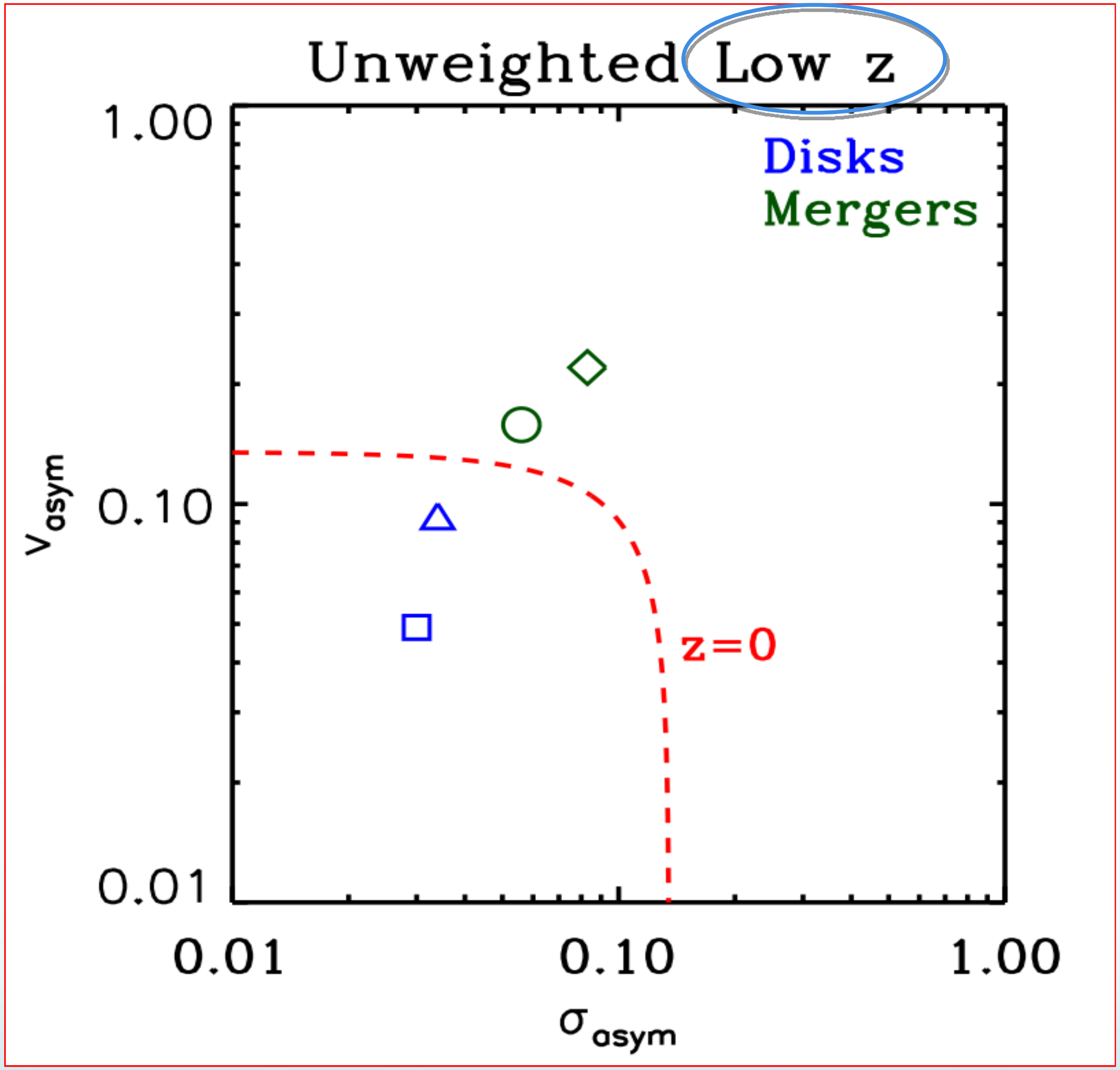


→ k_{avg} = high-order deviations

→ $B_{1,v}$ = Rotational Curve

- "Disks" → low values of v_{asym} & σ_{asym}
- "Mergers" → high values of v_{asym} & σ_{asym}

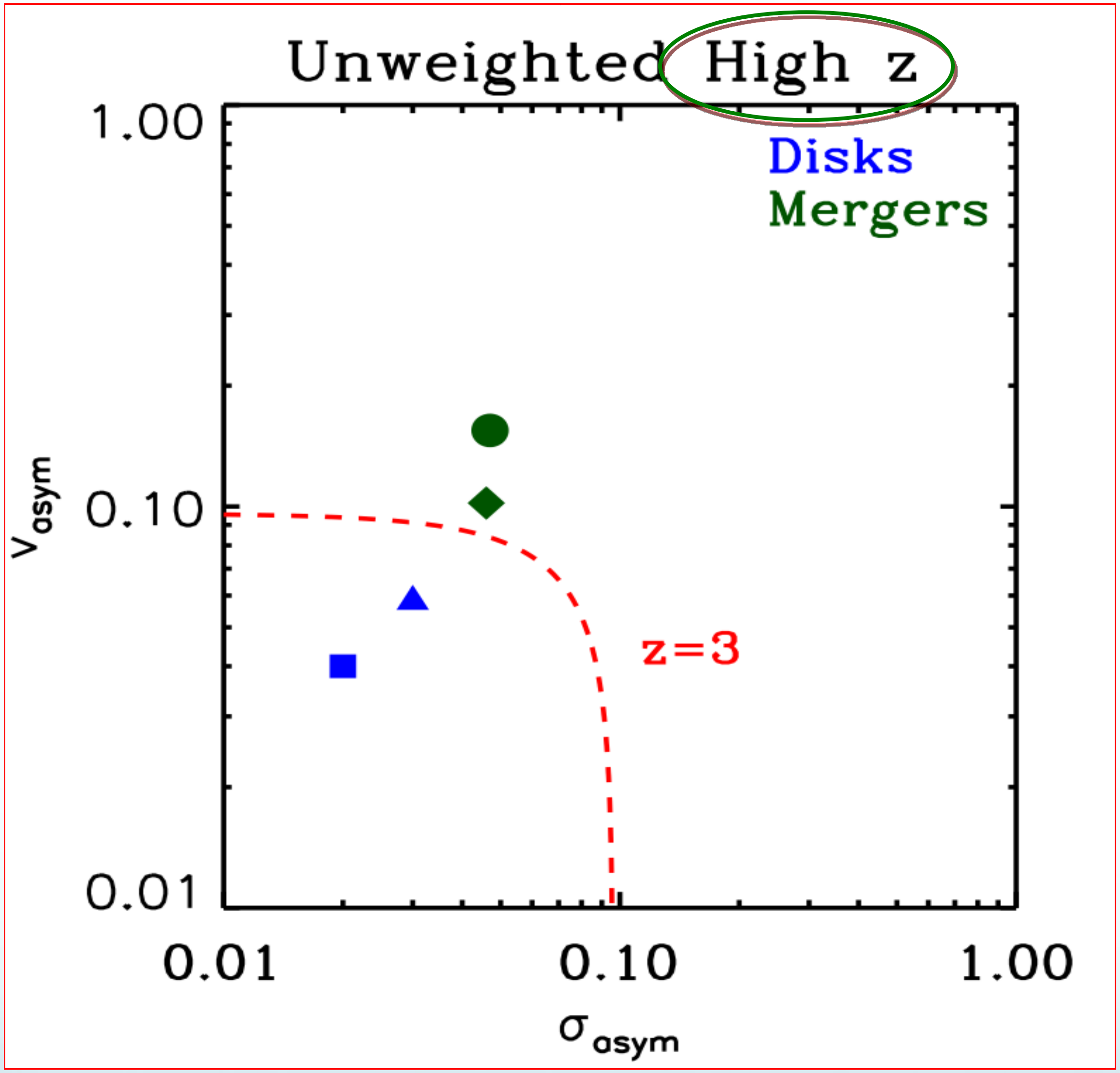
Our results @ low -z



→ Consistency between morphology & kinematics

→ $\langle K_{LIM} \rangle = 0.135$

Our results @ high-z



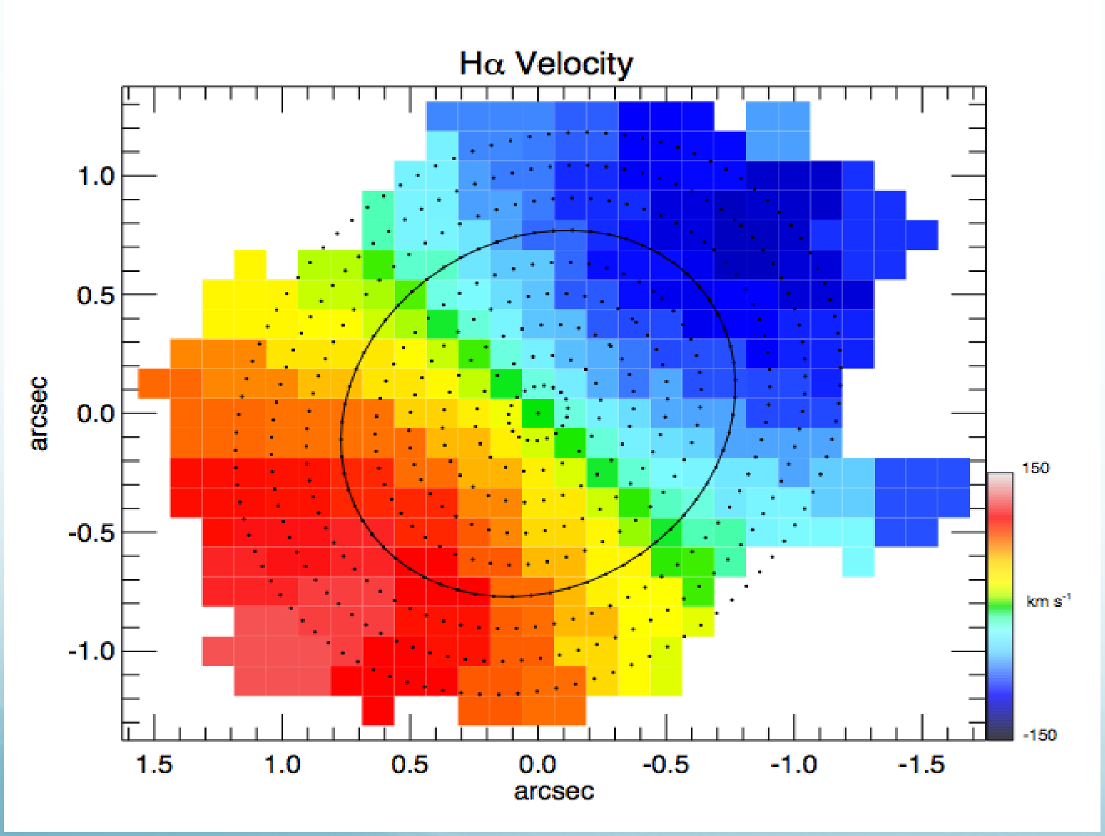
- Distorsions are smeared out @ high-z
  → objects appear more symmetric than they are! $\langle K_{LIM} \rangle = 0.096$ (lower!)

b) NEW CRITERIA

(Bellocchi et al. 2011 submitted)

Instead of averaging the deviations for the number of RADII we use the number of DATA POINTS (in each ellipse) !!!

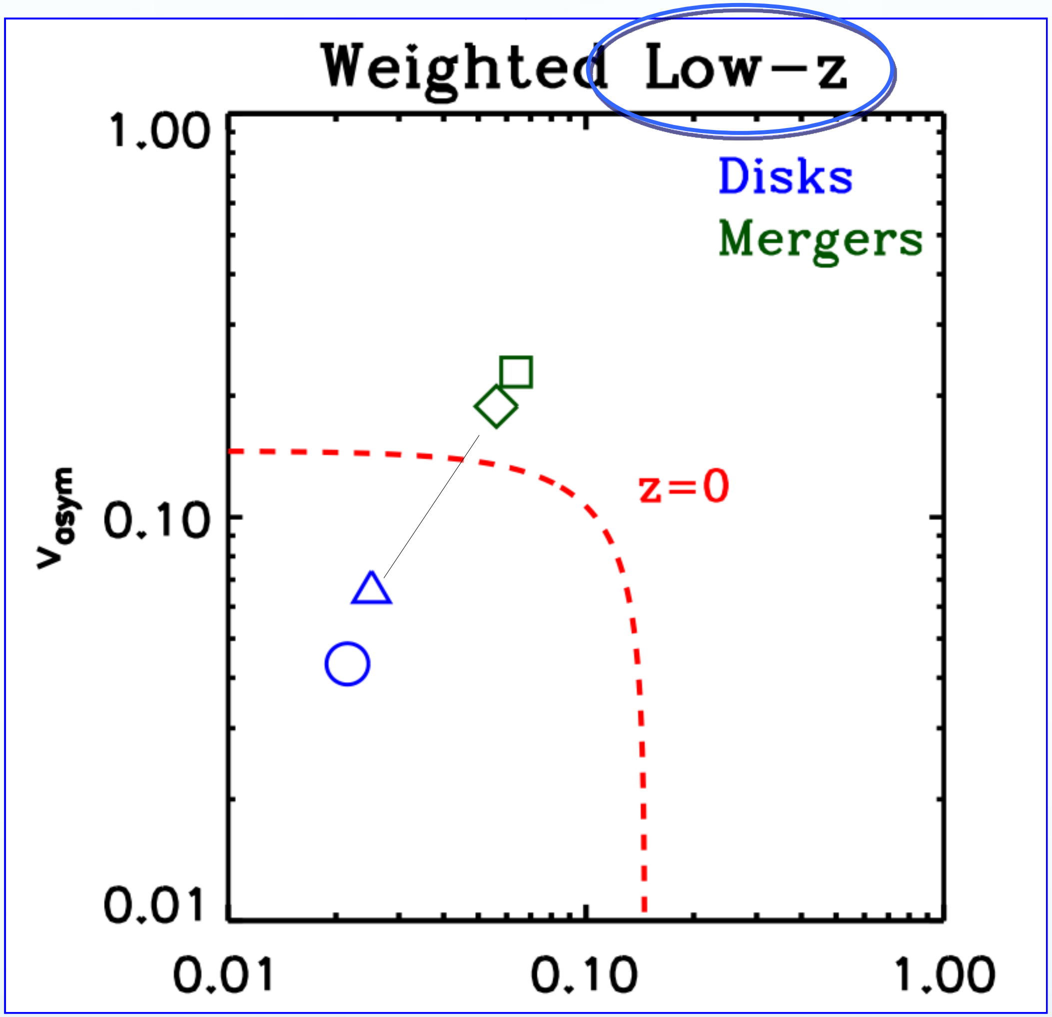
More points → more weight!



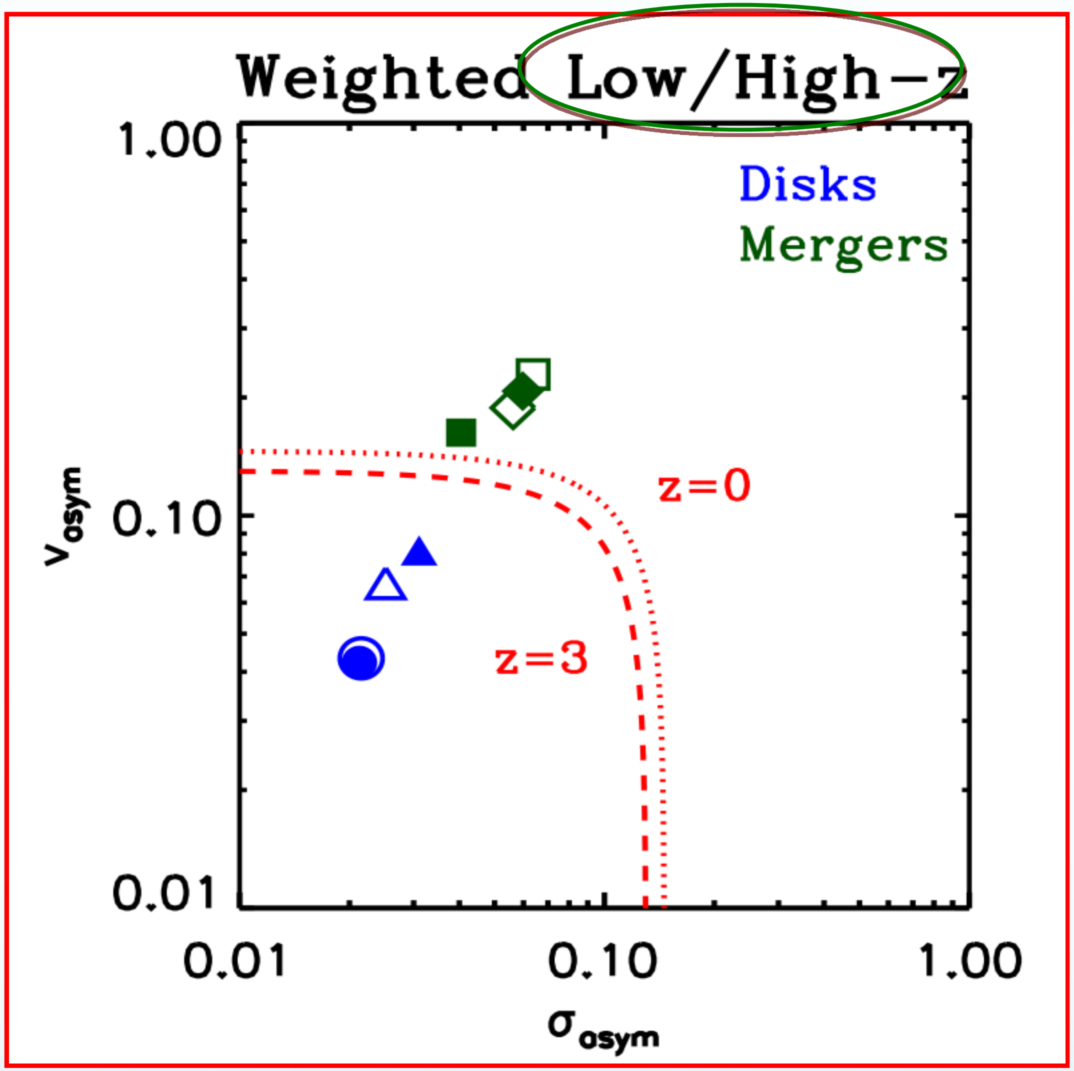
$$v_{asym} = \sum_{n=1}^{N} \left(\frac{k^{v}_{2,n} + k^{v}_{3,n} + k^{v}_{4,n} + k^{v}_{5,n}}{4 \cdot B^{v}_{1,n}} \cdot P_n \right) \cdot \frac{1}{\sum_{n=1}^{N} P_n}$$

$$\sigma_{asym} = \sum_{n=1}^{N} \left(\frac{k^{\sigma}_{1,n} + k^{\sigma}_{2,n} + k^{\sigma}_{3,n} + k^{\sigma}_{4,n} + k^{\sigma}_{5,n}}{5 \cdot B^{v}_{1,n}} \cdot P_n \right) \cdot \frac{1}{\sum_{n=1}^{N} P_n}$$

Weigthed results @ low -z



→ WEIGHTED plane differenciates better the 2 classes LOCALLY
(larger separation <K_{LIM} = 0.146>)



Results:

→ WEIGHTED plane differenciates better the 2 classes

→ LESS dependent from RESOLUTION effects: *more stable!*

Other kinematic results for the 4 LIRGs

1. The kinematic properties are consistent with their morphology ("disks" reveal quite regular velocity field and centrally peaked velocity dispersion maps consistent with a single rotating disk interpretation while "mergers" show departures from this behaviour);

2. 1-D kinematic based criteria (e.g., v_c/σ_c, v_{shear}/Σ parameters) seems to be more uncertain discriminator "disks/mergers";

3. 2-D kinematic based criteria:

- more powerful tool to discriminate between "disks/mergers"
- We proposed new method (WEIGHTED) that seems to work better!
- K_{LIM} value could depend on the kind of systems considered.

4. - Broad ($\sigma \approx$ 70–450 km/sec) and blue-shifted (i.e., $\Delta v \approx$ 50–150 km/s) peaked component is found in their inner regions (e.g., IRAS F04315-0840 has an outflow of 5.5 kpc^2, likely due to star-formation activity in a dusty environment)

Future work

✓ Extend this analysis to the whole sample (locally and for simulated high-z objects)

✓ Derivation of dynamical masses & discuss its consistency with the stellar masses derived in collaboration with IAP (S. Charlot)