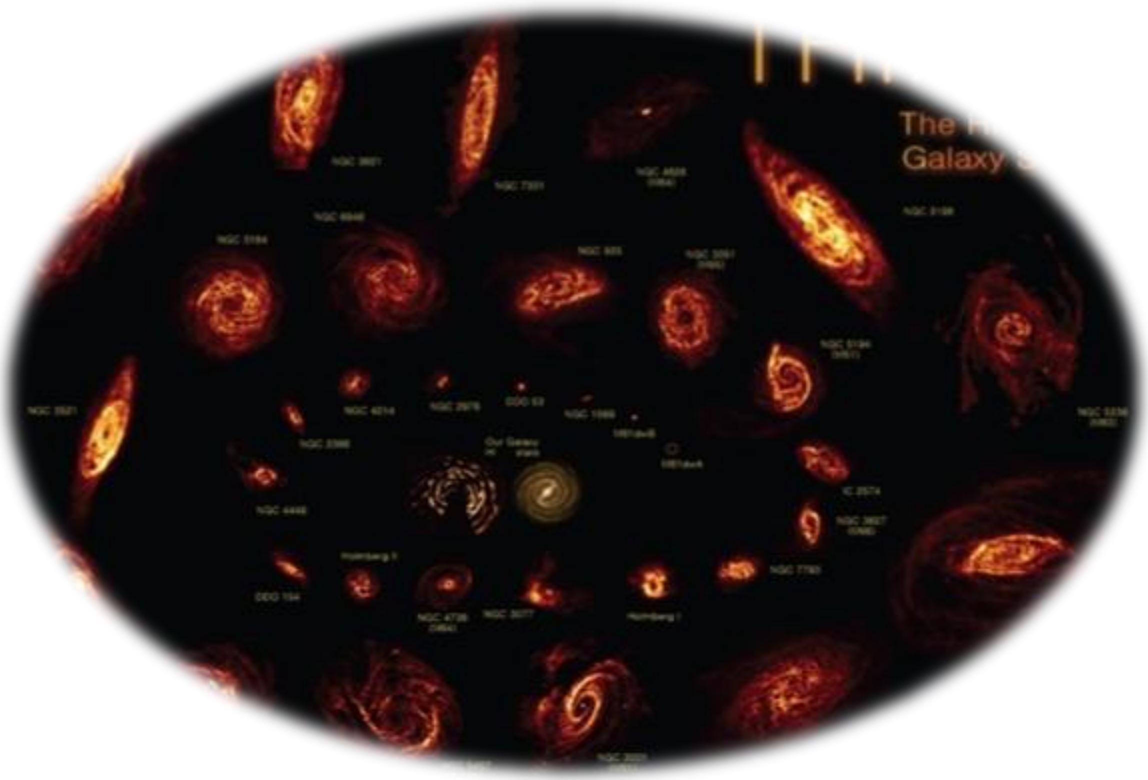
The HI super profiles of the THINGS galaxies



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Goals of the project

Study the HI velocity profiles of the entire THINGS samples and relate the shapes of the profiles to e.g:

- ✓ the phase structure of the ISM
- ✓ the energy sources of the ISM
- ✓ the mechanisms that regulate the star formation activity of a galaxy
- ✓ gas content and star formation activity of galaxies : compare the properties of the neutral gas (HI) to molecular gas (H2) as traced by CO emission line

The HI Nearby Galaxy Survey

Number of surveyed galaxies : 34

Telescope used : VLA

Spectral resolution: < 5.2 km/s

Spatial resolution: ~6’’

Samples properties:

Morphologies: dwarfs & spirals

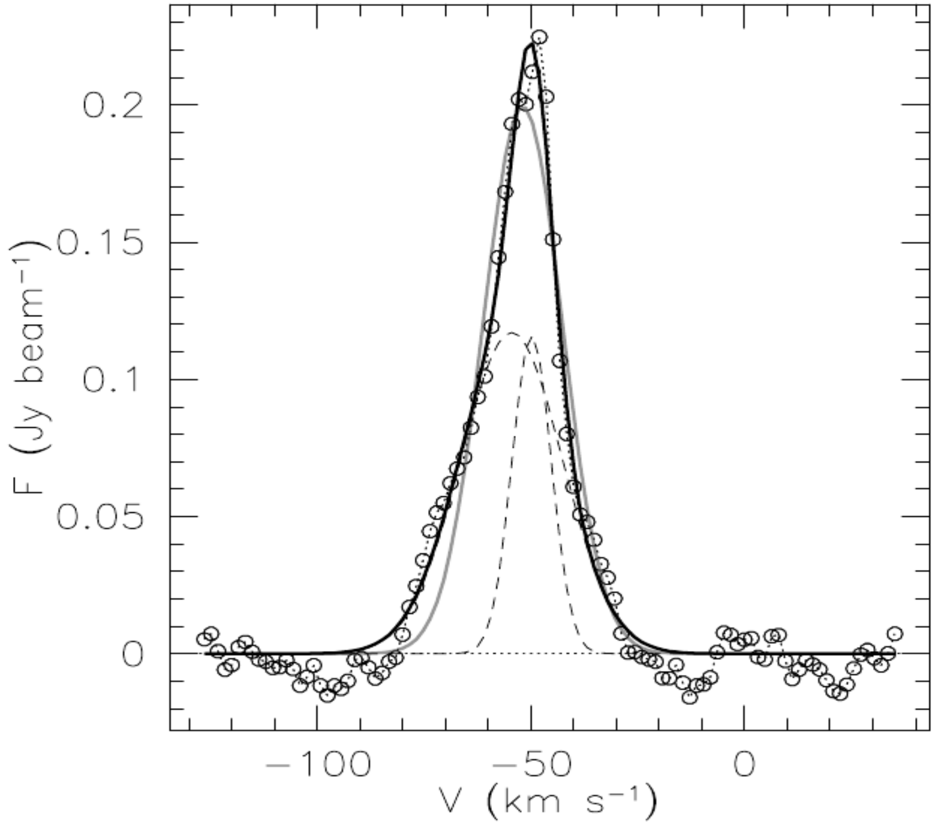
Distances: between 2 Mpc and 15 Mpc

Metallicities: 7.5 to 9.2 (12 + log[O/H])

SFR : 0.001 to 6 solar mass per year

M_B : -12.5 to -21.7 mag

HI velocity profiles and the two phases ISM



de Blok and Walter 2006

example of an HI line profile fitted with two Gaussian components

Neutral ISM: has two phases Known as the CNM and WNM. The two can be detected via HI profile decomposition

Method: decompose the profiles into Gaussian Components and analyze their spatial distribution

Results : broad ($\sigma \approx$ 8km/s) and narrow ($\sigma \approx$ 3-5 km/s) components .

HI velocity profiles and the two phases ISM

Properties of the components (e.g Young and Lo 1996):

narrow: tend to be found in the vicinity of star forming regions

broad : ubiquitous

Conclusion: The two components represent the CNM and WNM

Problem: Individual profiles are noisy

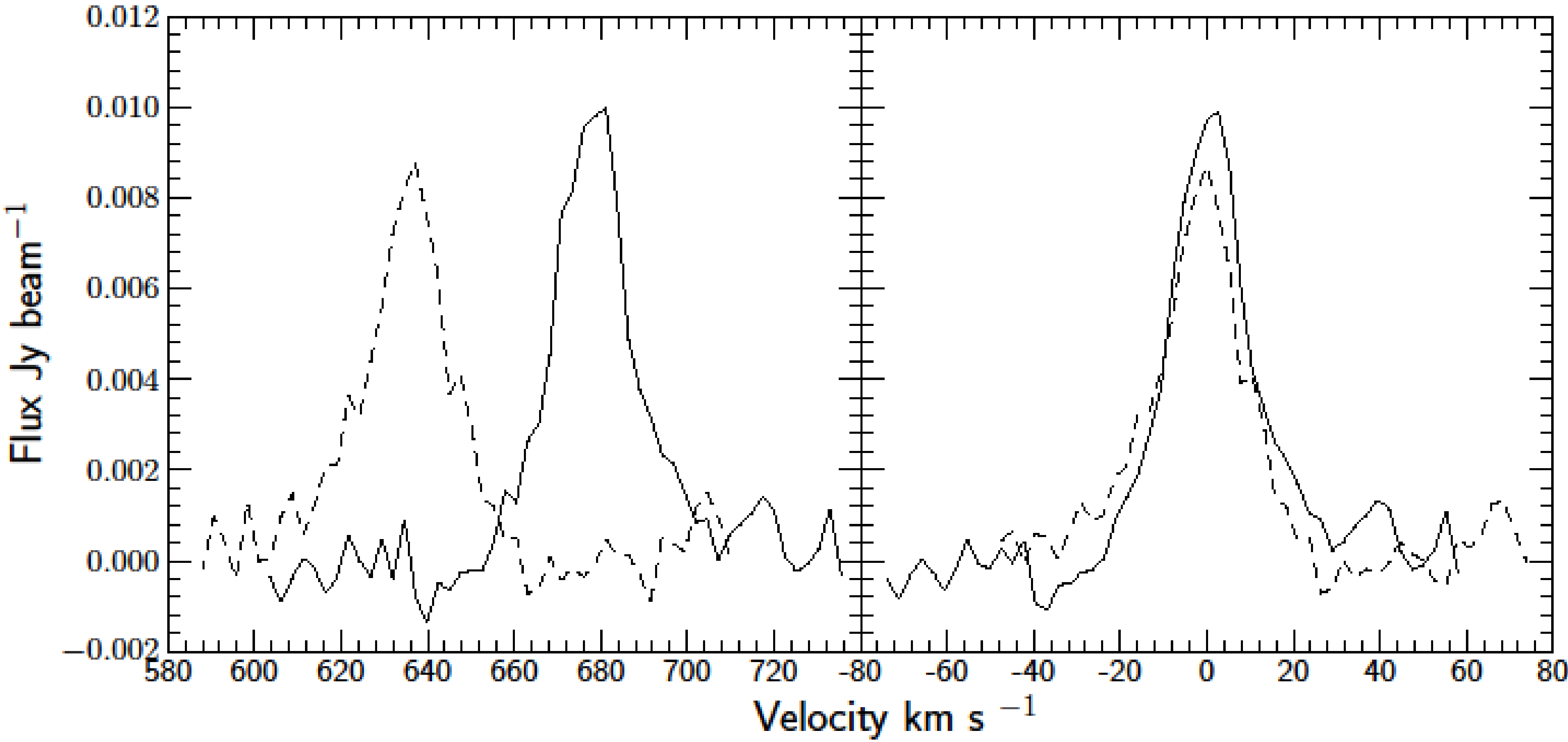
Solution: Need work on high S/N spectra

The super profiles of the THINGS galaxies

Method: Sum the line profiles to get high S/N

Problem: Different profiles have different velocities

Solution: Shift them to the same reference velocities

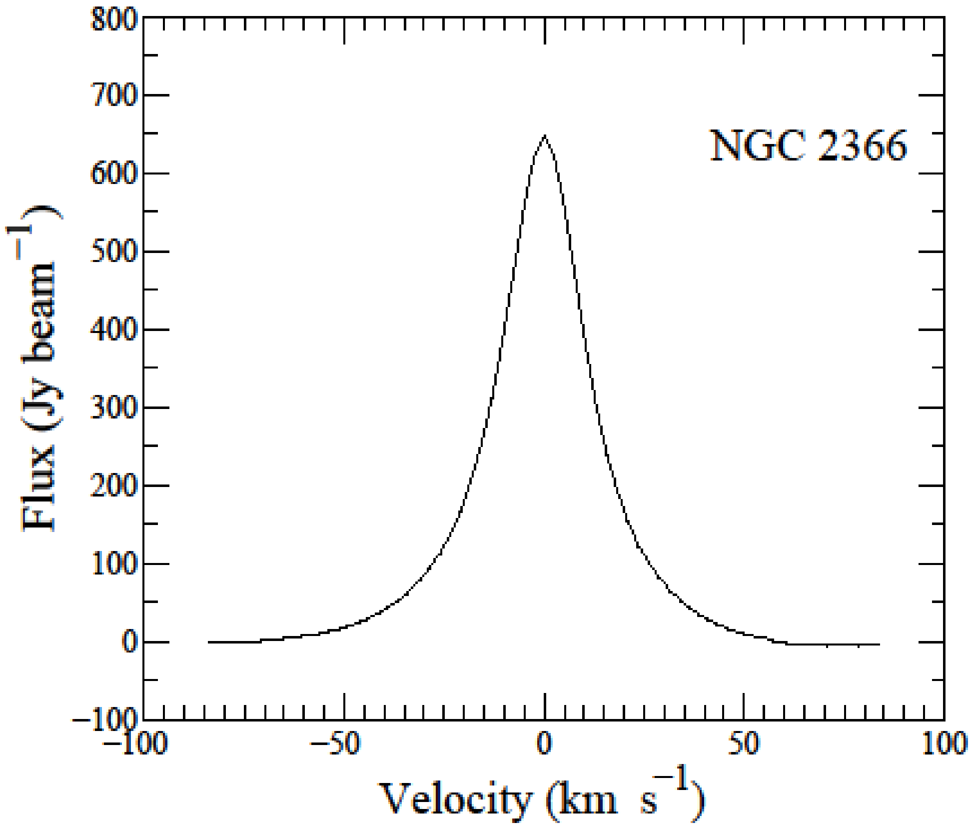


Left panel: examples of two individual profiles of NGC 628 extracted at different positions in a data cube before the shifting in velocity.

Right panel: The individual profiles after shifting them to the same reference velocity

Super profiles: Sum of the shifted individual profiles (“stacking”)

The super profiles of the THINGS galaxies



Higher S/N profile

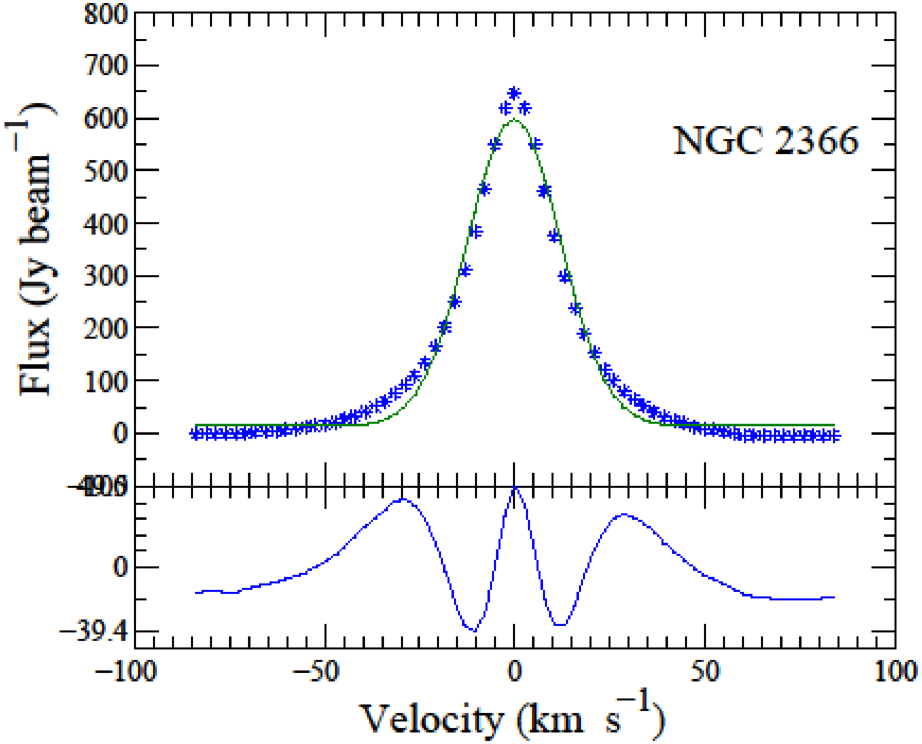
Broader wing and narrower peak than a pure Gaussian profile

Next step: Fit the super profiles both with one Gaussian and two Gaussian components

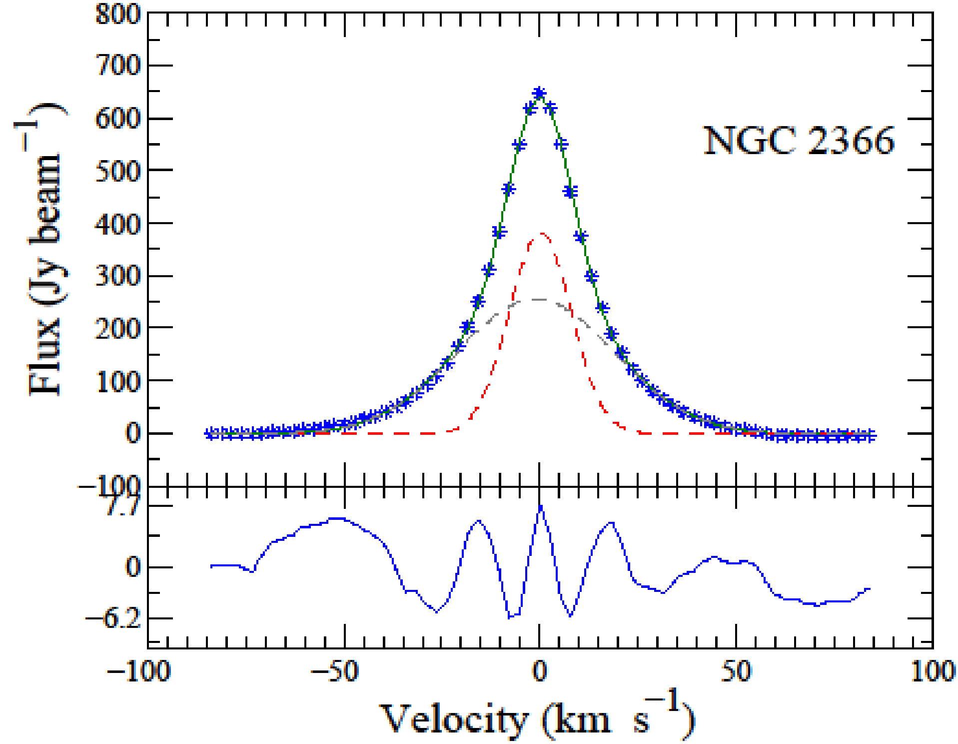
Example of the resulting profile after the shifting and summing, which we call *Super profile*

The super profiles of the THINGS galaxies

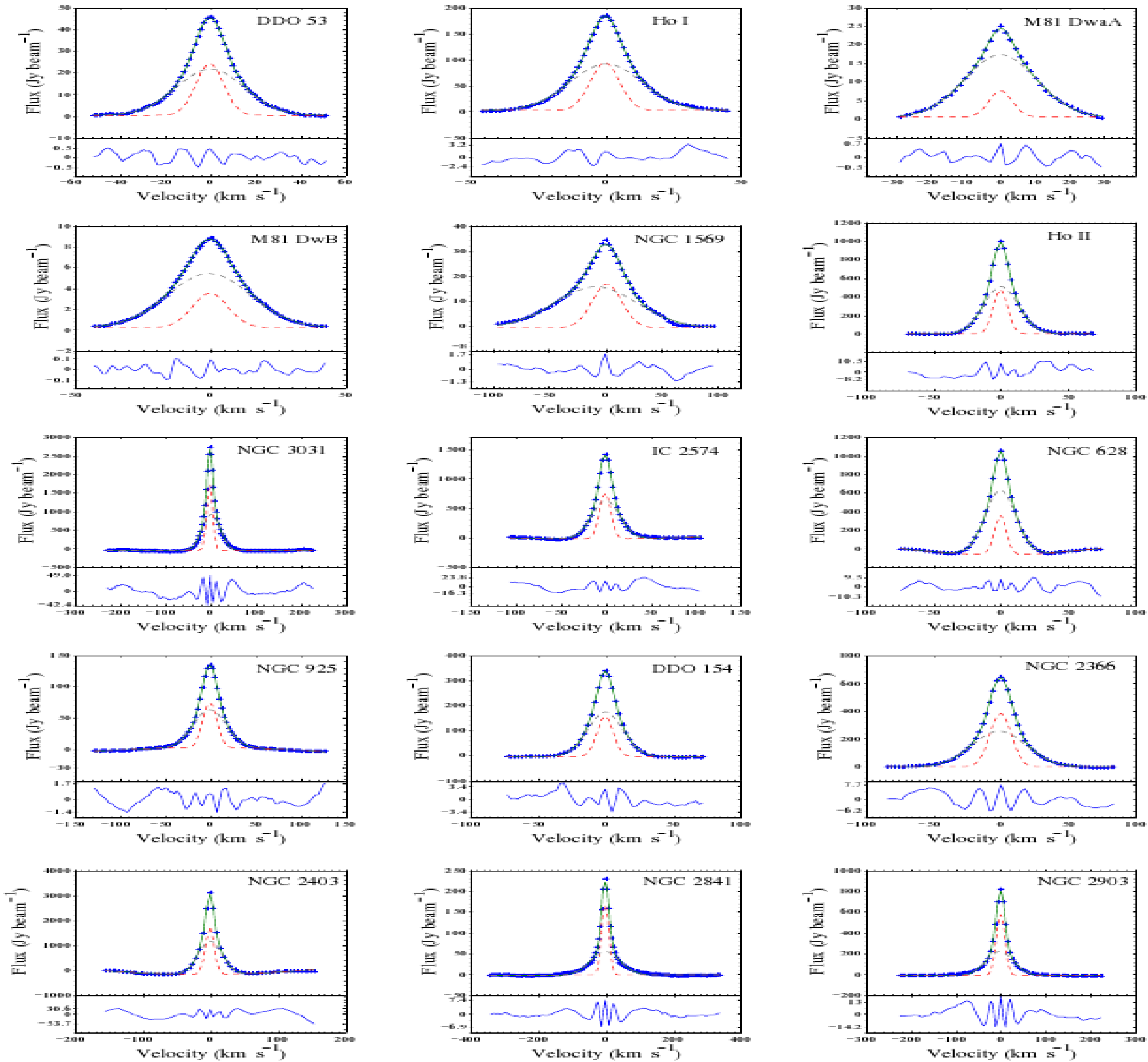
Profile samples



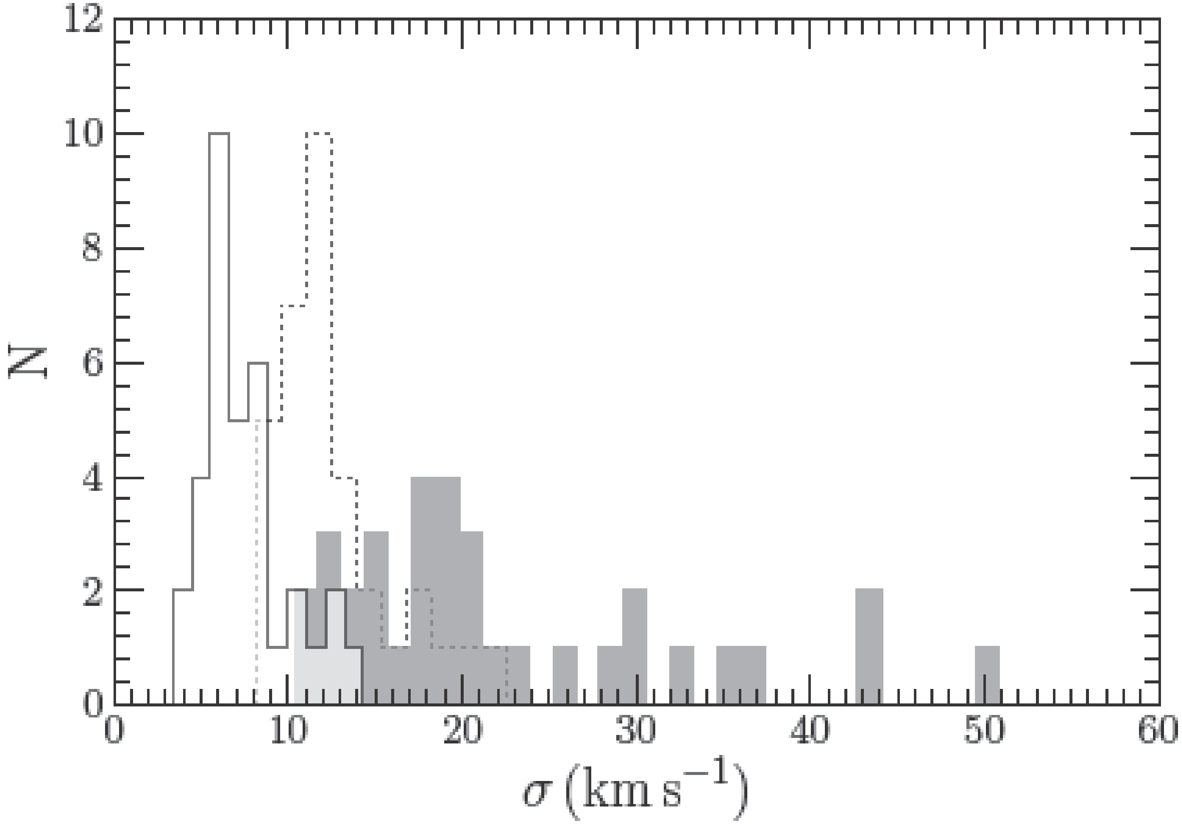
One Gaussian fit



Two Gaussian components fit
the dotted lines represent the
broad and narrow components


DDO 53
Ho I
M81 DwaA
M81 DwB
NGC 1569
Ho II
NGC 3031
IC 2574
NGC 628
NGC 925
DDO 154
NGC 2366
NGC 2403
NGC 2841
NGC 2903
Flux (Jy beam^{-1})
Velocity (km s^{-1})

The super profiles of the THINGS galaxies

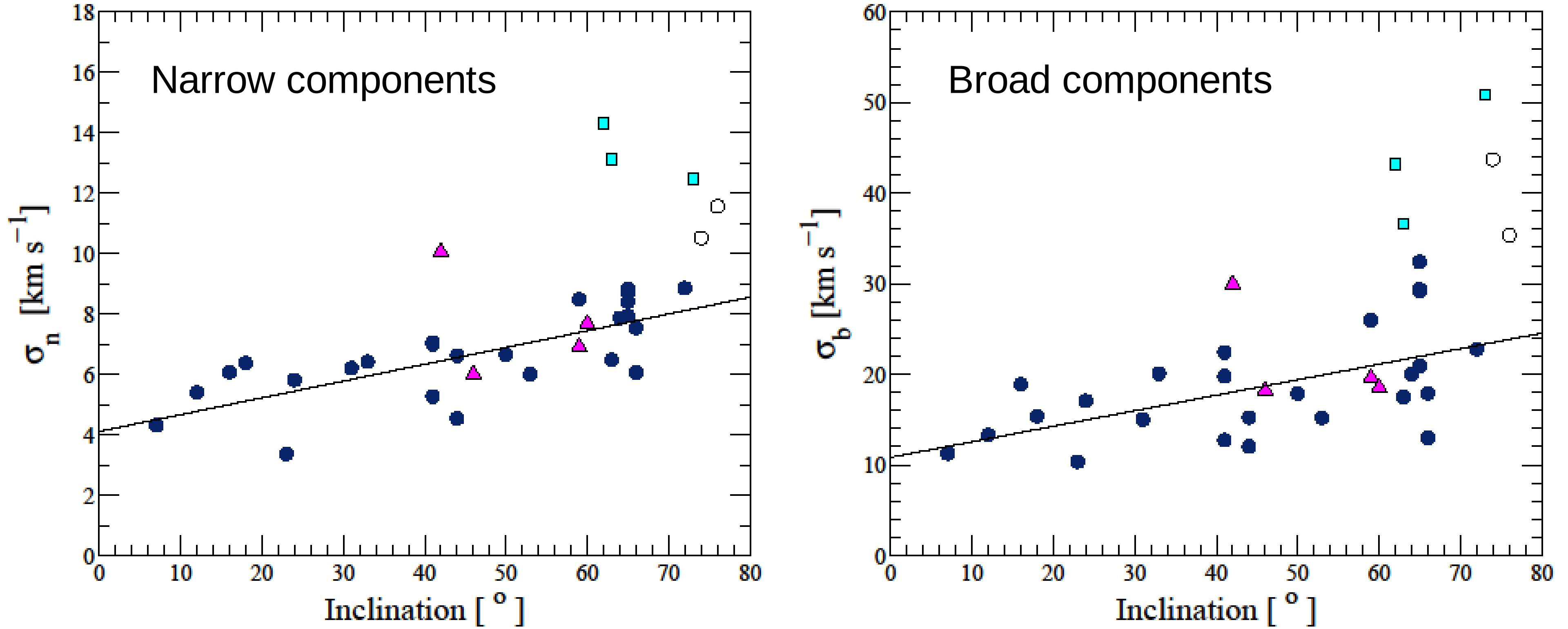


Dotted histogram: velocity dispersion from simple Gaussian fit

Solid histogram: velocity dispersion of the narrow components

Gray histogram: velocity dispersion of the broad components

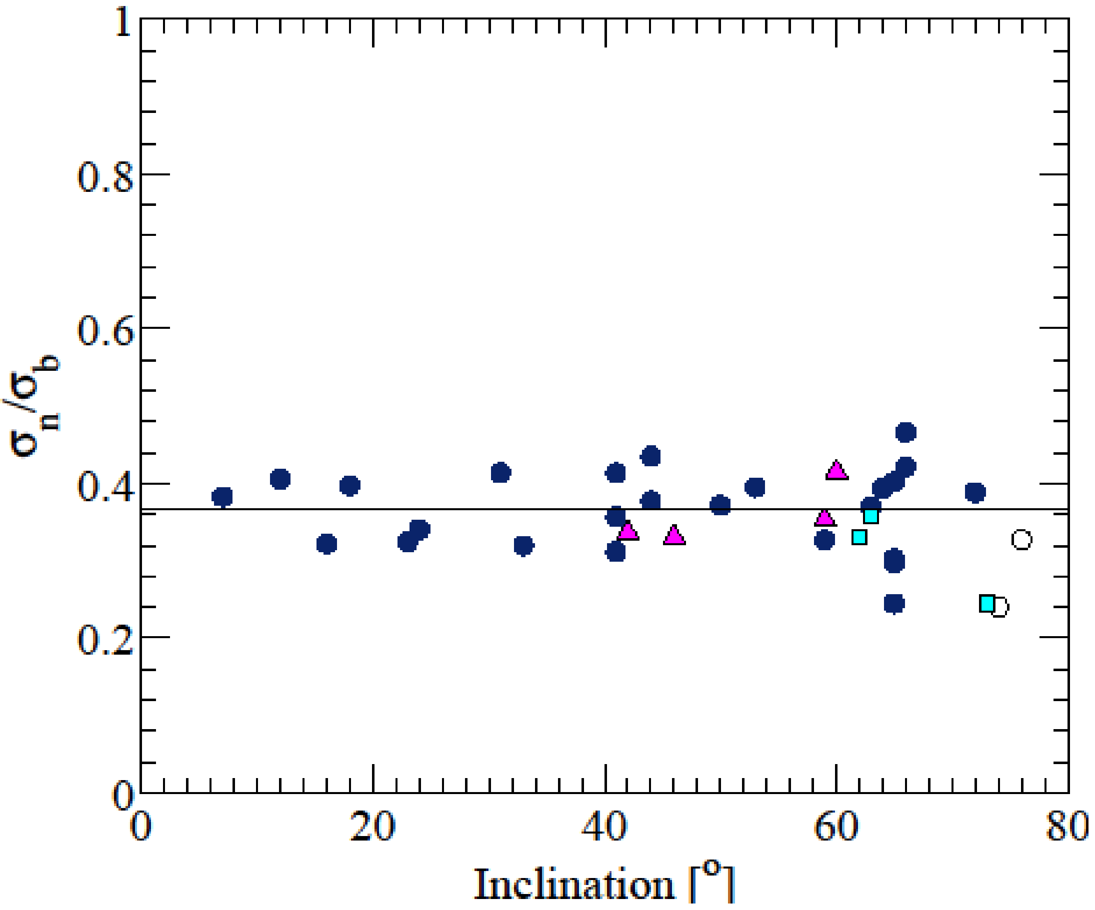
Histograms of the derived velocity dispersions from both the one Gaussian and two components Gaussian fits



Effect of inclination on the shapes of the super profiles

Some galaxies do not follow the trend between inclination and profile shapes, these are interacting and kinematically disturbed galaxies

- • Non interacting Galaxies
- △ Interacting galaxies
- ○ Non interacting but having significantly high velocity dispersion
- ■ Kinematically disturbed galaxies



The broad and narrow components have the same projection effect so, the effect of inclin-ation can be cancelled by taking the ratios of the velocity dispersion of the narrow and bro-ad components

Constant ratios of velocity dispersion against inclination

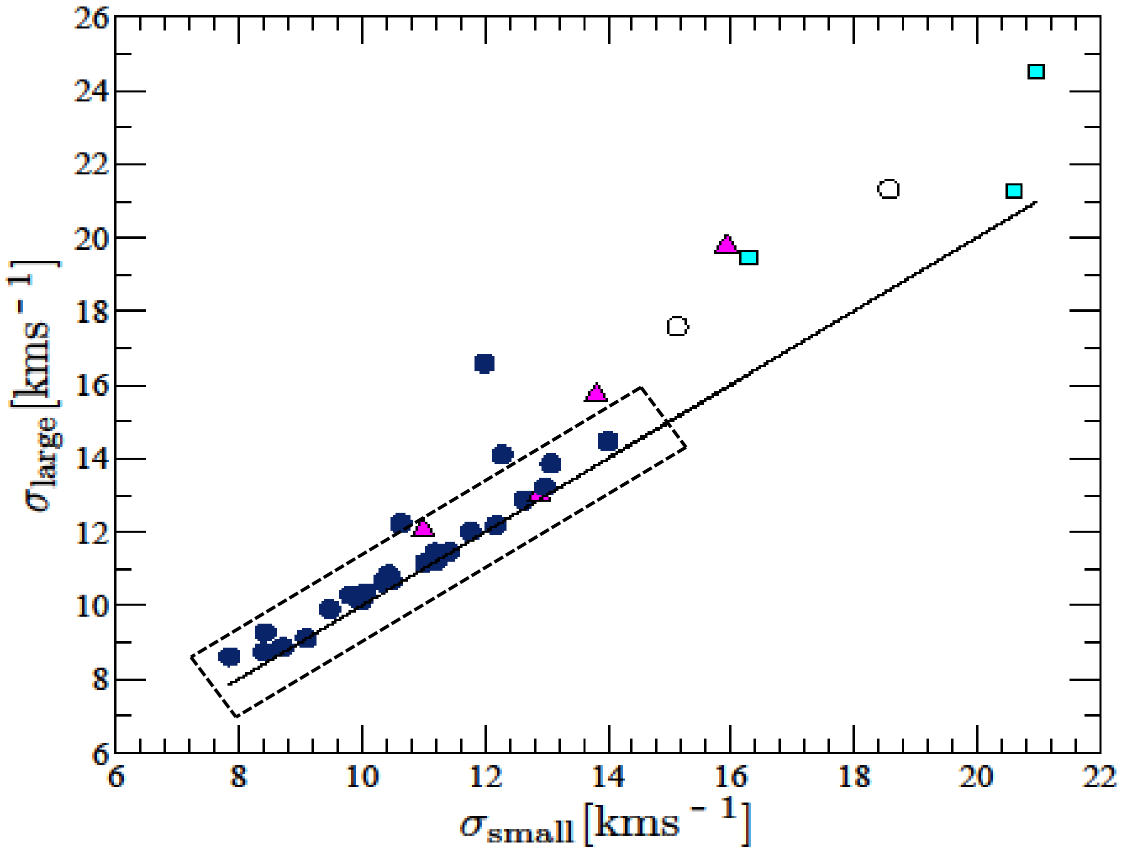
Are the super profiles intrinsic or systematic ?

- Is the non-Gaussianity of the super profiles caused by:

  1-the effect of a few high intensity profile?

  2-the presence of a thick disk ?
- Does the shape of the super profiles depend on galaxy asymmetry?
- How does the resolution affect the shapes of the super profiles?

Reliability of the super profiles shape parameters

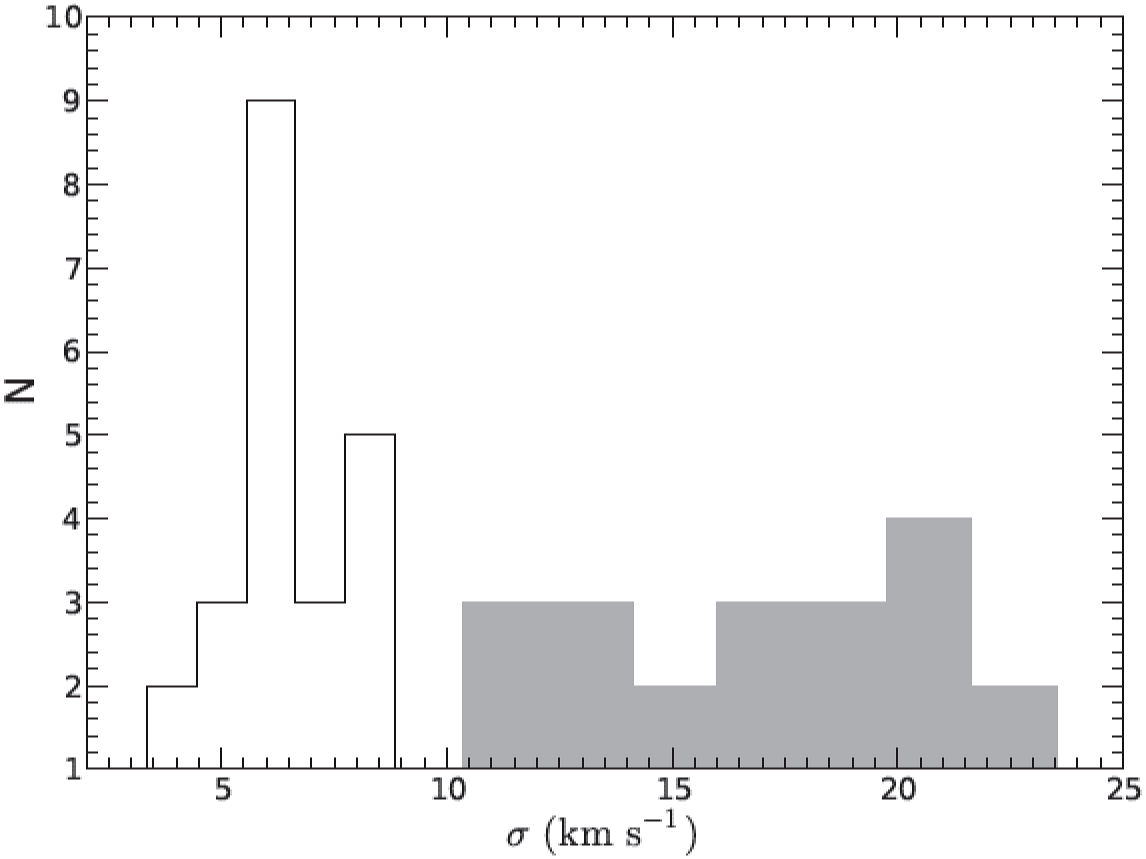


- Non interacting galaxies
- Interacting galaxies
- Non Interacting galaxies but having significantly high velocity dispersion
- Kinematically disturbed galaxies

Comparison of the super profiles derived from both halves of the galaxies to check asymmetry

Making subsamples

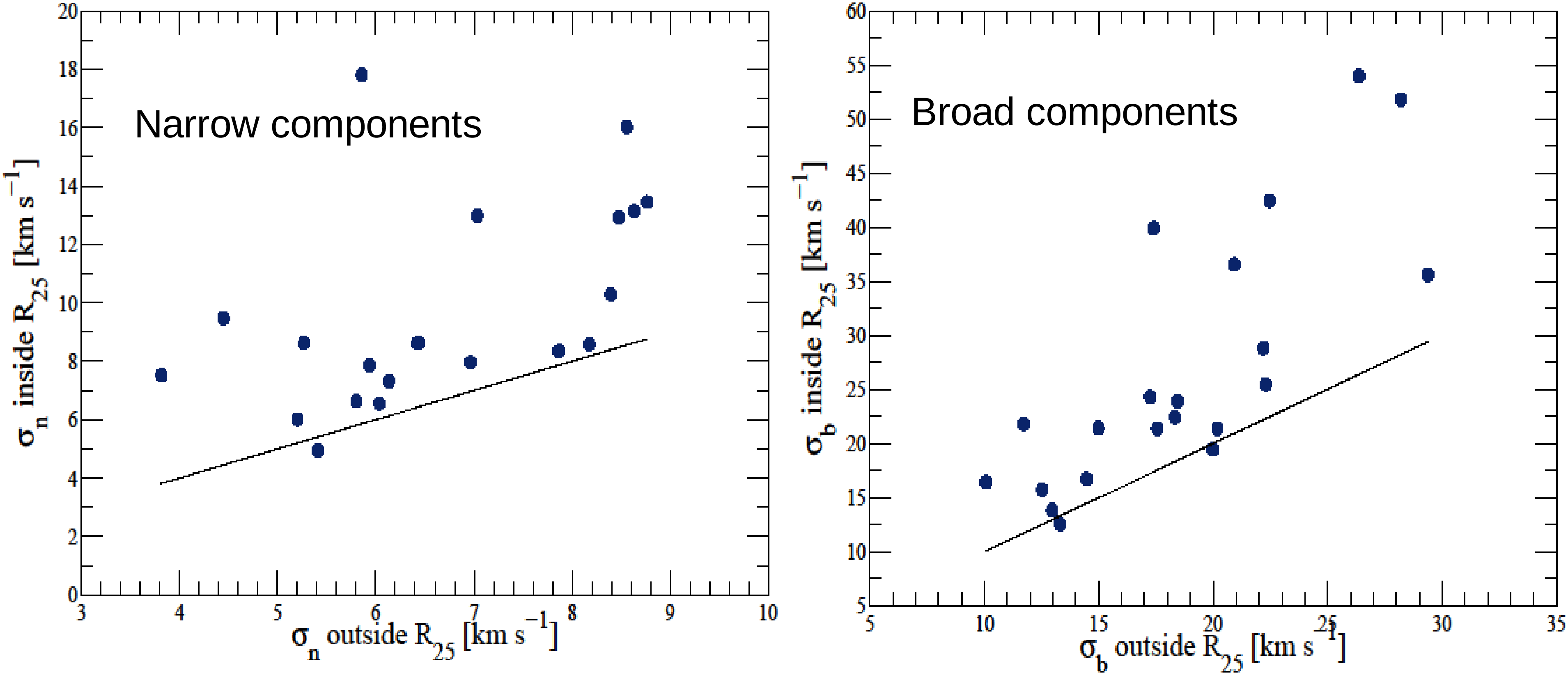
- Clean samples:
  - Non interacting
  - followed the trend between inclination and velocity dispersion
  - having super profiles similar in both halves (their derived velocity dispersion differ by < 1 km/s
- The rest of the analysis will only focus on the clean samples



Solid Histogram: narrow components velocity dispersion of the clean sample

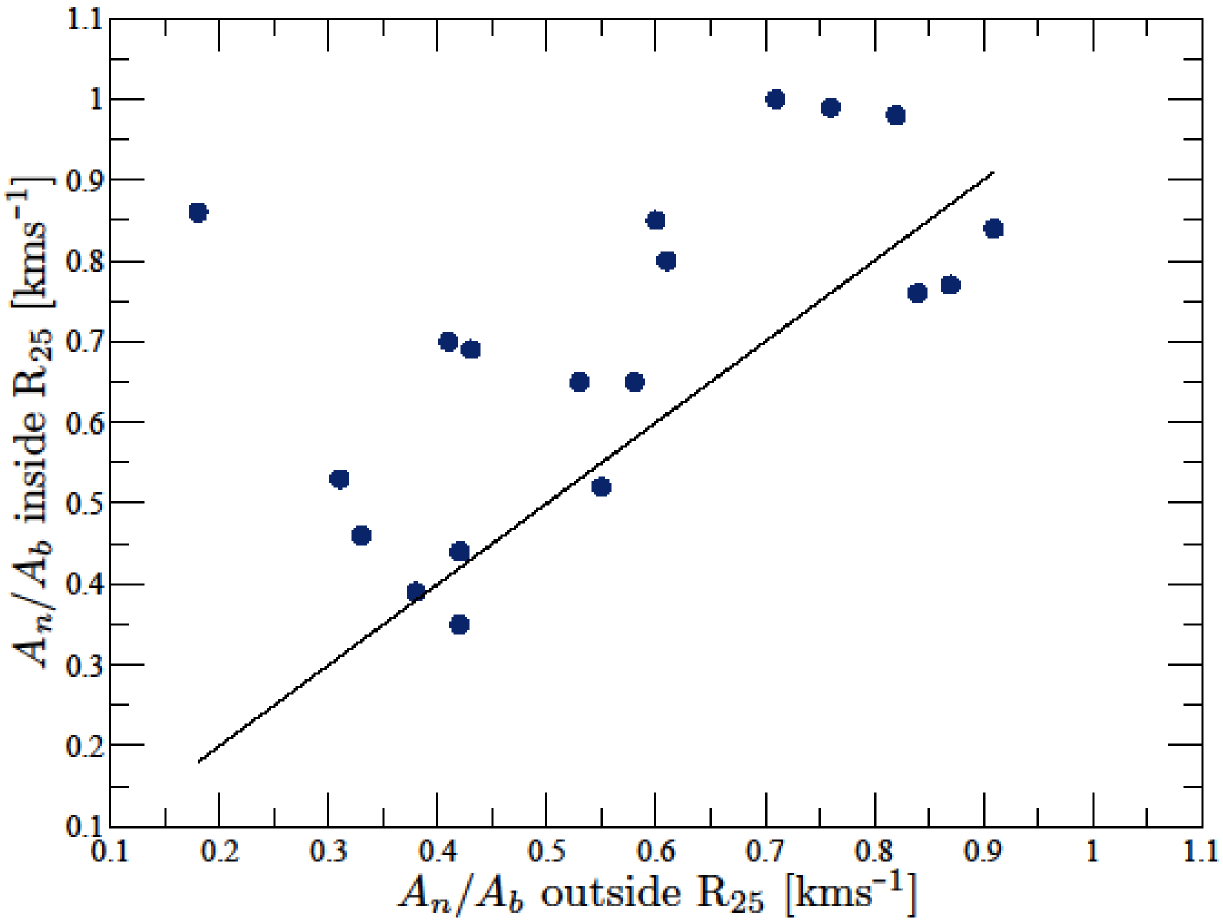
Gray Histogram: Broad components velocity dispersion of the clean sample.

Histogram of the velocity dispersion of the clean sample. The narrow components velocity dispersion has a mean of 6.6 km/s, whereas that of the broad components has a mean of 18.3 km/s



Comparison of the derived velocity dispersions inside R_{25} and outside R_{25}.

The super profiles inside R_{25} tend to be broader than those outside R_{25} .

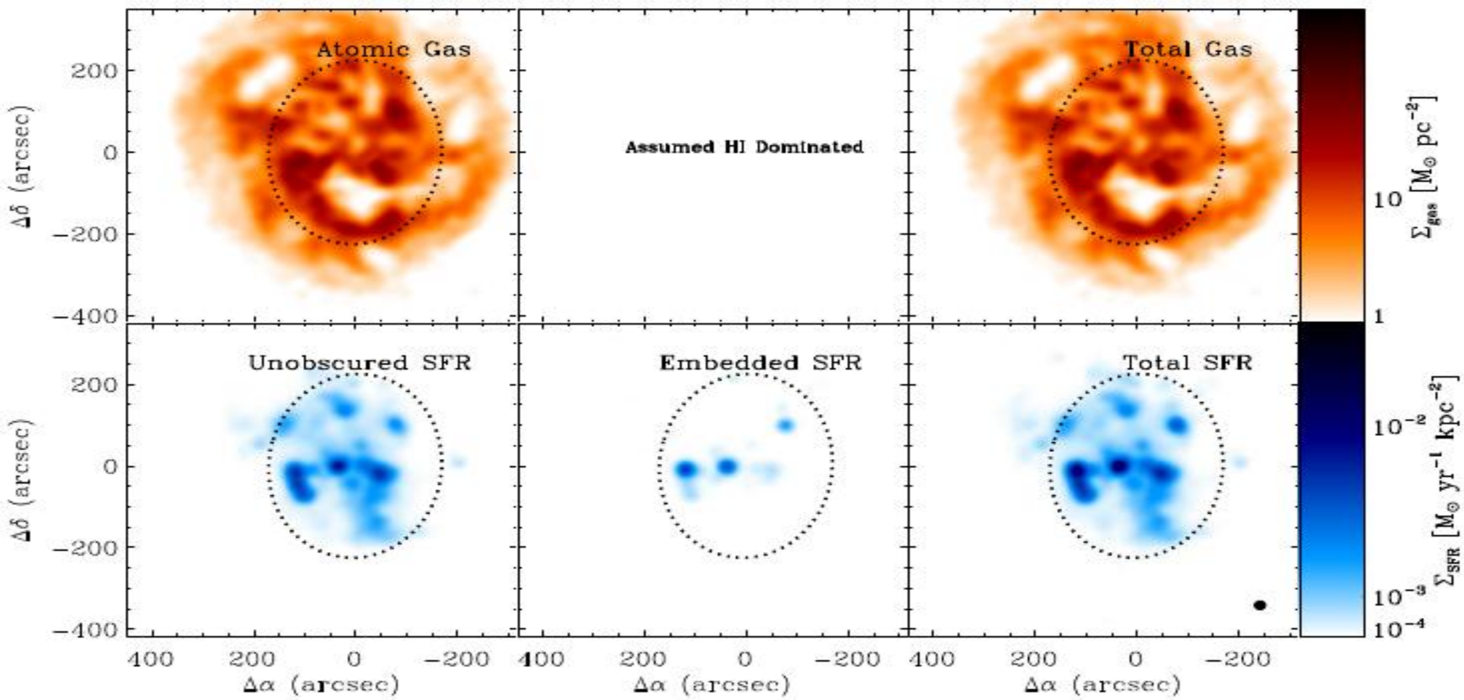


Ratios of the mass of the broad and narrow components inside and outside R_{25}.

This figure suggests that the CNM tend to be more dominant inside than outside R_{25}

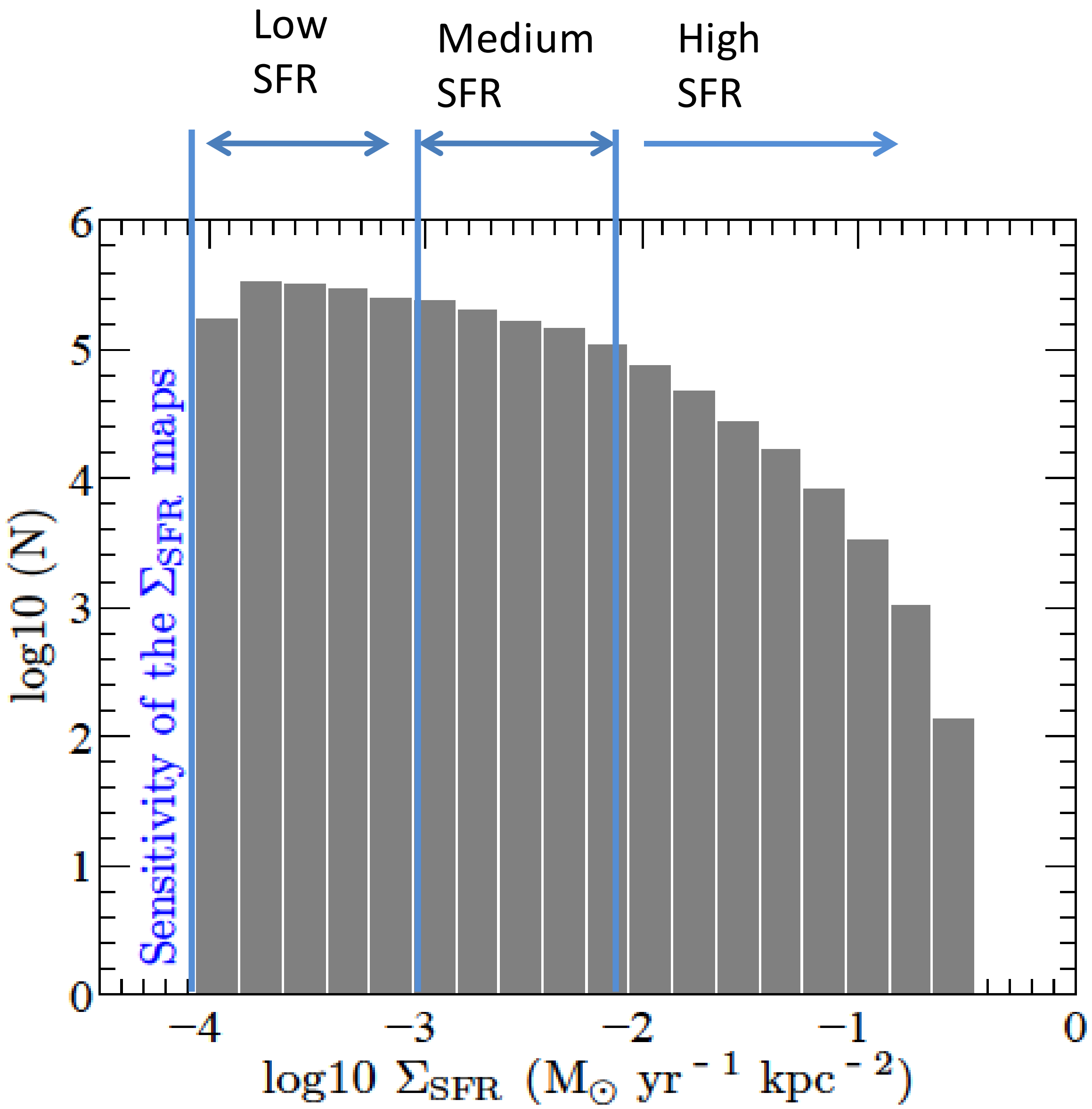
Star formation and profile shapes

An example of a SFR map



$$\Sigma_{SFR} = 8.1 \times 10^{-2} I_{FUV} + 3.2^{+1.2}_{-0.7} \times 10^{-3} I_{24}$$

Leroy et al 2008

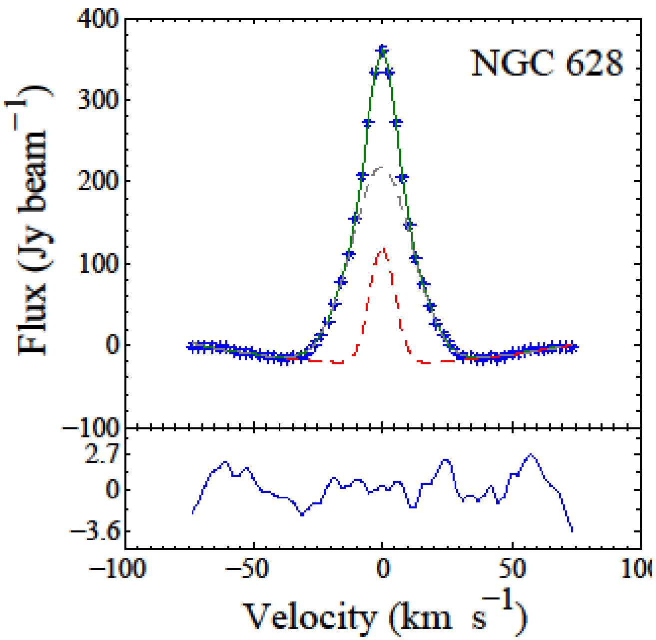


Classify the star formation activity of different regions of galaxies according to their SFR values

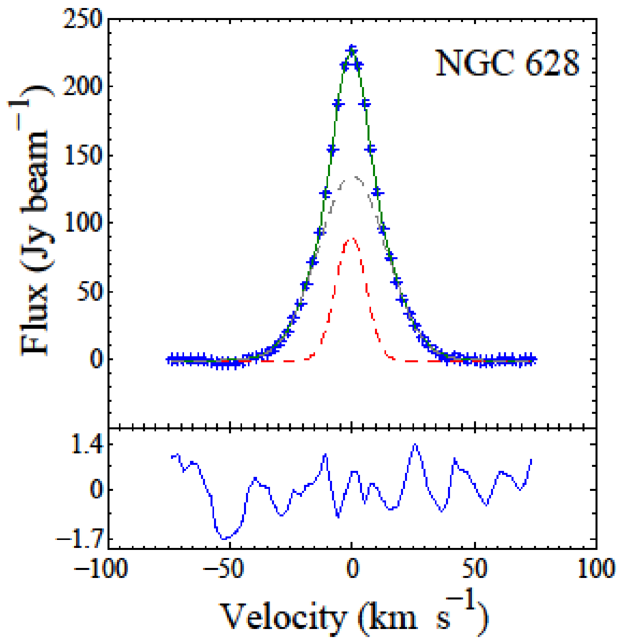
Studies the shapes of the profiles in low and high SFR regions of galaxies

Histogram of the SFR of the entire THINGS samples

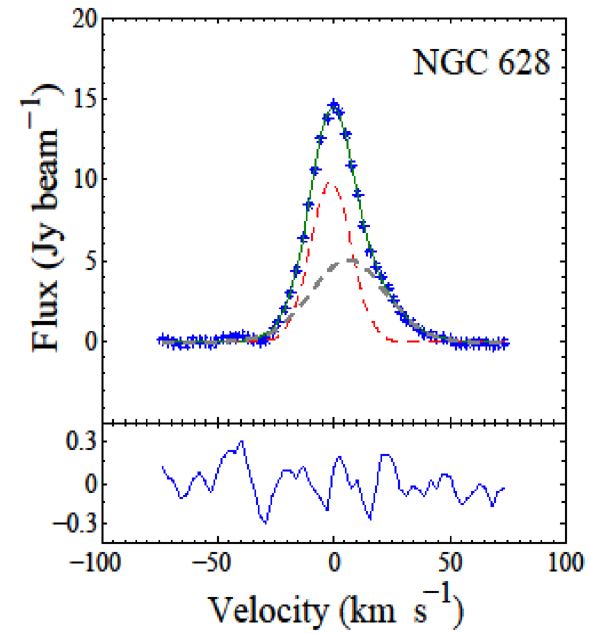
Star formation and profile shapes



Low SFR regions



Medium SFR regions



High SFR regions

The shapes of the super profiles in different SFR regions

Note the asymmetry of the super profiles in active SFR regions, which is a result of turbulence and streaming motions of gas induced by stellar feedback (mostly by SNe)

CONCLUSION

- The shapes of the super profiles depend on the star formation activity of galaxies
- We found strong evidence of the presence of CNM/WNM in the THINGS galaxies using super profile shape analysis
- The importance of the narrow components (CNM) increase with increasing SFR
- Profiles in high SFR area tend to be asymmetric

Future works

- Relating the shapes of the super profiles to the energy budget of the ISM
- Analyzing the individual line profiles of

  the THINGS galaxies
- Investigating whether the distribution of the narrow components is consistent to that of CO measurement.

REFERENCES

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- [4] Young, L. M.; Lo, K. Y. 1997, ApJ, 490, 710
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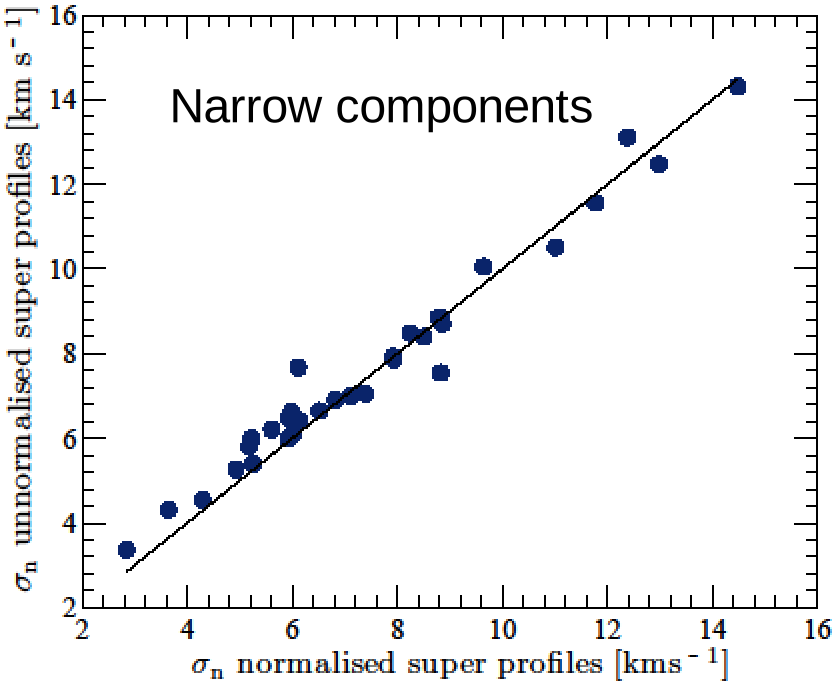
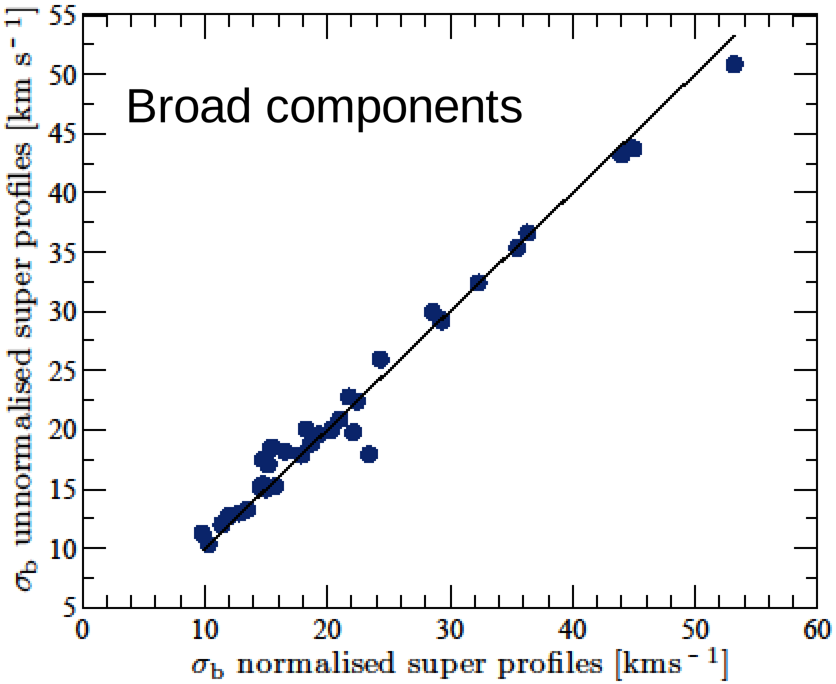
Reliability of the super profile shape parameters

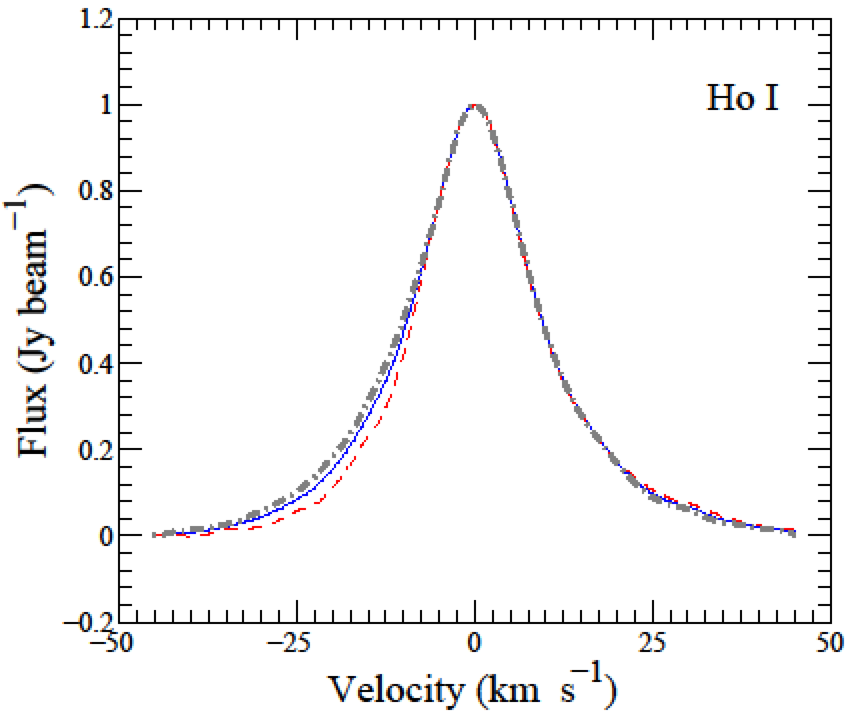




Comparison between normal super profiles and super profiles normalised by peak flux.

There is no major difference between the normalised and the unnormalised super profiles

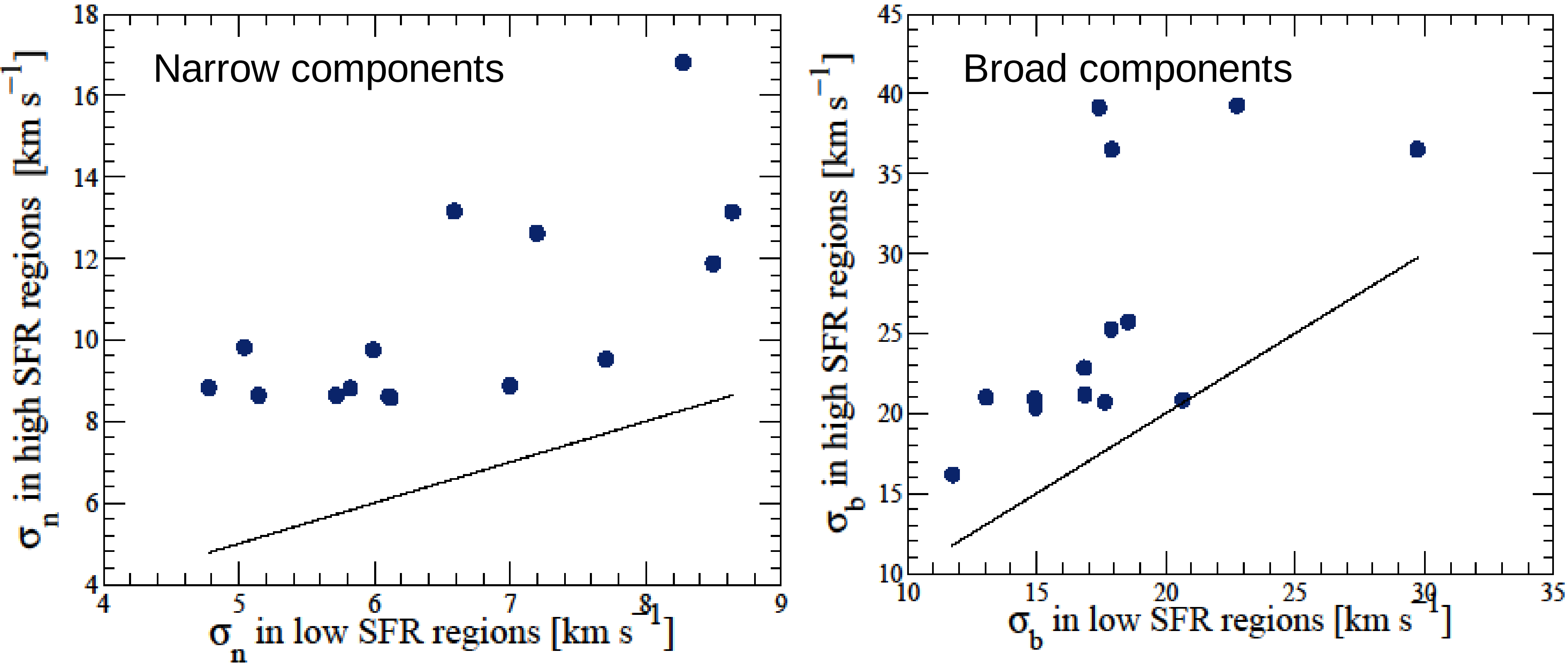
Reliability of the super profiles shape parameters



Solid line: original super profiles
Dashed lines: super profiles from the two halves of the galaxy.

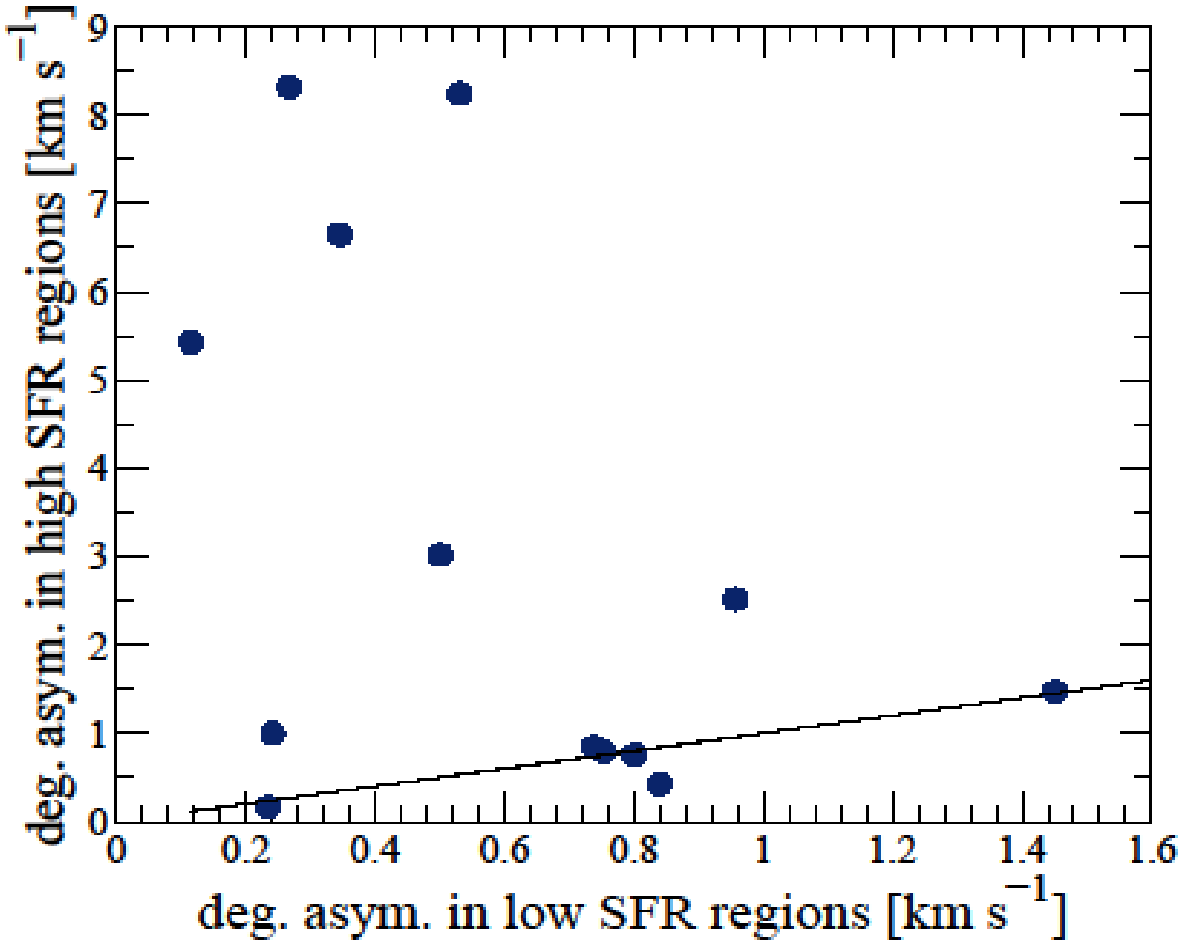
The super profiles in the two sides of the galaxies are symmetrical which confirm that the non-Gaussianity of the super profiles are not caused by the presence of a thick disk

Comparison the super profiles in the two halves of the galaxies and the overall super profiles



Comparison of the derived velocity dispersion from low and high SFR regions.

Super profiles in high SFR regions tend to be broader than those in low SFR regions.



Comparison of the degree of asymmetry (offset between peak velocity) of the super profiles in low and high SFR regions.

Super profiles in high SFR regions tend to be more asymmetric than those in low SFR regions. This could be a result of injection of kinetic energy in the ISM by young massive stars.