Ionized gas kinematics in local active galaxies: a comprehensive view of inflows and outflows.

Daniel Ruschel Dutra

Thaisa Storchi-Bergmann Allan Schnörr-Müller Roberto Cid Fernandes
Guilherme Couto Rogemar Riffel Davide Lena Andrew Robinson
Bruno Dall'Agnol Daniel Grün Mônica Tergolina

UNIVERSIDADE FEDERAL
DE SANTA CATARINA

Introduction

- Radial motions of the gas are fundamental to our understanding of the AGN phenomenon and for the proposed co-evolution of the SMBH and the bulge of the host galaxy.
- The most powerful outflows are simply too far away to be spatially resolved.
- In order to better constrain large scale outflows we are studying a sample of local AGN (Seyferts) with spatially resolved optical spectroscopy.

The sample

- AGNs (Seyferts) from the Swift/BAT 60 month catalogue limited to observability by GMOS.
- $z < 0.06$
- $L_{2-10\mathrm{keV}} < 10^{44}\ \mathrm{erg\,s^{-1}}$

Some of these galaxies have results individually published by the group: NGC 1365, NGC 1386, NGC 1667, NGC 2110, NGC 3081, NGC 7213 (Lena+2016, 2015; Schnörr-Müller+2017, 2014, 2016, 2014)

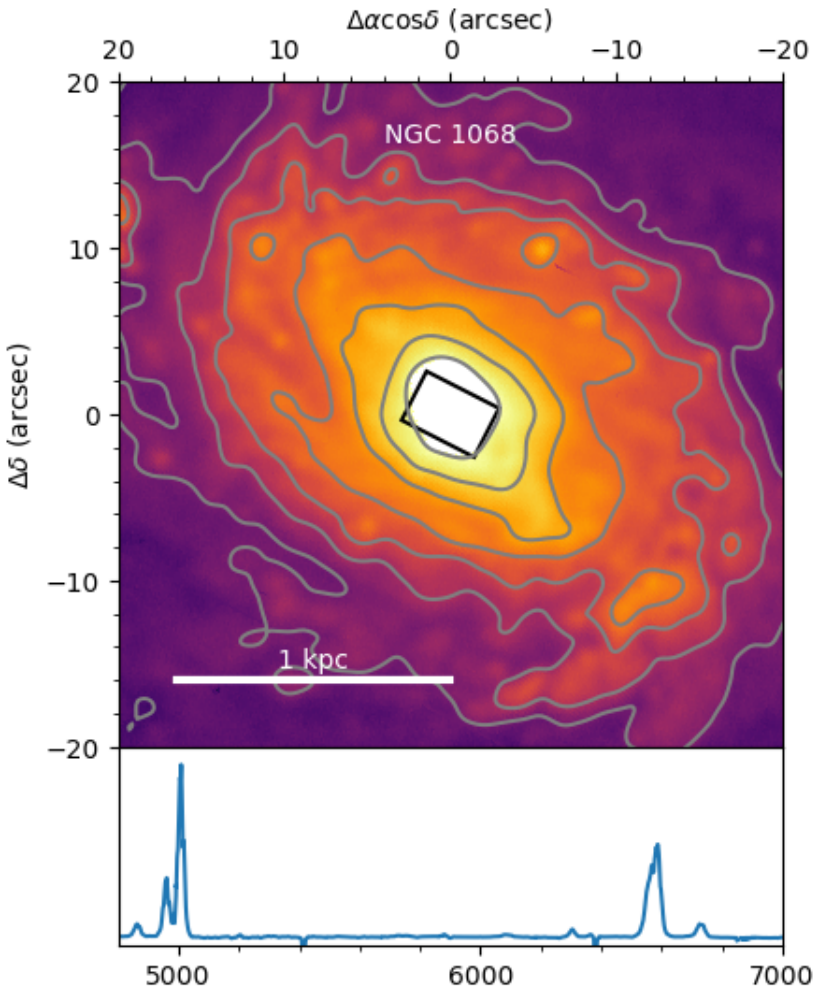
Observations

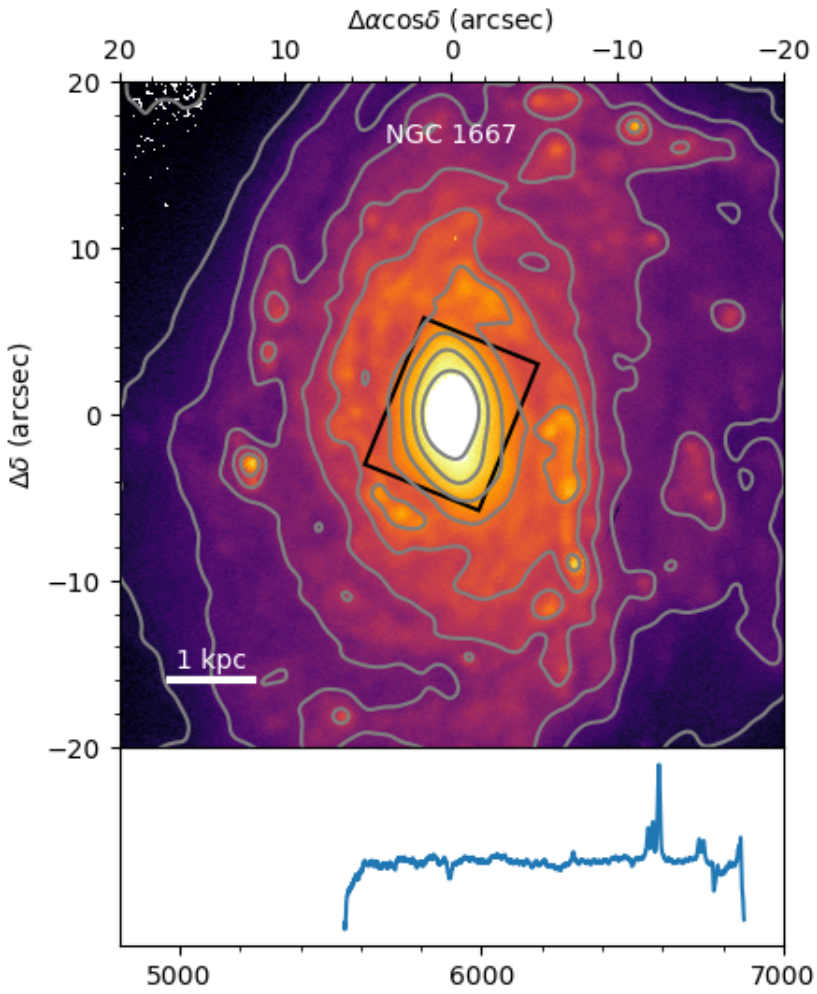
- Data acquired with Gemini's GMOS (N & S)

- Optical IFU
- $R \sim 2000 \rightarrow 50$ km/s
- Spectral coverage roughly $4800\mathring{A} < \lambda < 7200\mathring{A}$
- Seeing limited resolution, with a $0.2''$ sampling.

- Data reduction was carried out by fully automated pipeline based on Gemini's IRAF routines.

FOV and spectra

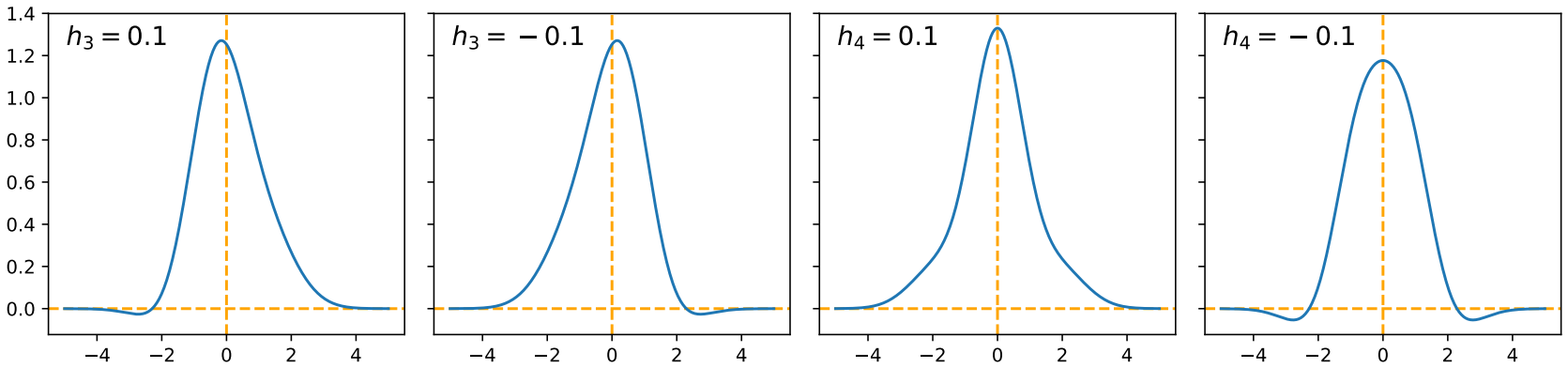




Modeling emission lines

Gauss-Hermite polynomials

$$f(\lambda) = \frac{A}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(\lambda-\lambda_0)^2}{2\sigma^2}\right) \times \left\{ \frac{h_3}{\sqrt{6\pi}} \left[2\sqrt{2}\left(\frac{\lambda-\lambda_0}{\sigma}\right)^3 - 3\sqrt{2}\left(\frac{\lambda-\lambda_0}{\sigma}\right) \right] + \frac{h_4}{\sqrt{24}} \left[4\left(\frac{\lambda-\lambda_0}{\sigma}\right)^4 - 12\left(\frac{\lambda-\lambda_0}{\sigma}\right)^2 + 3 \right] \right\}$$

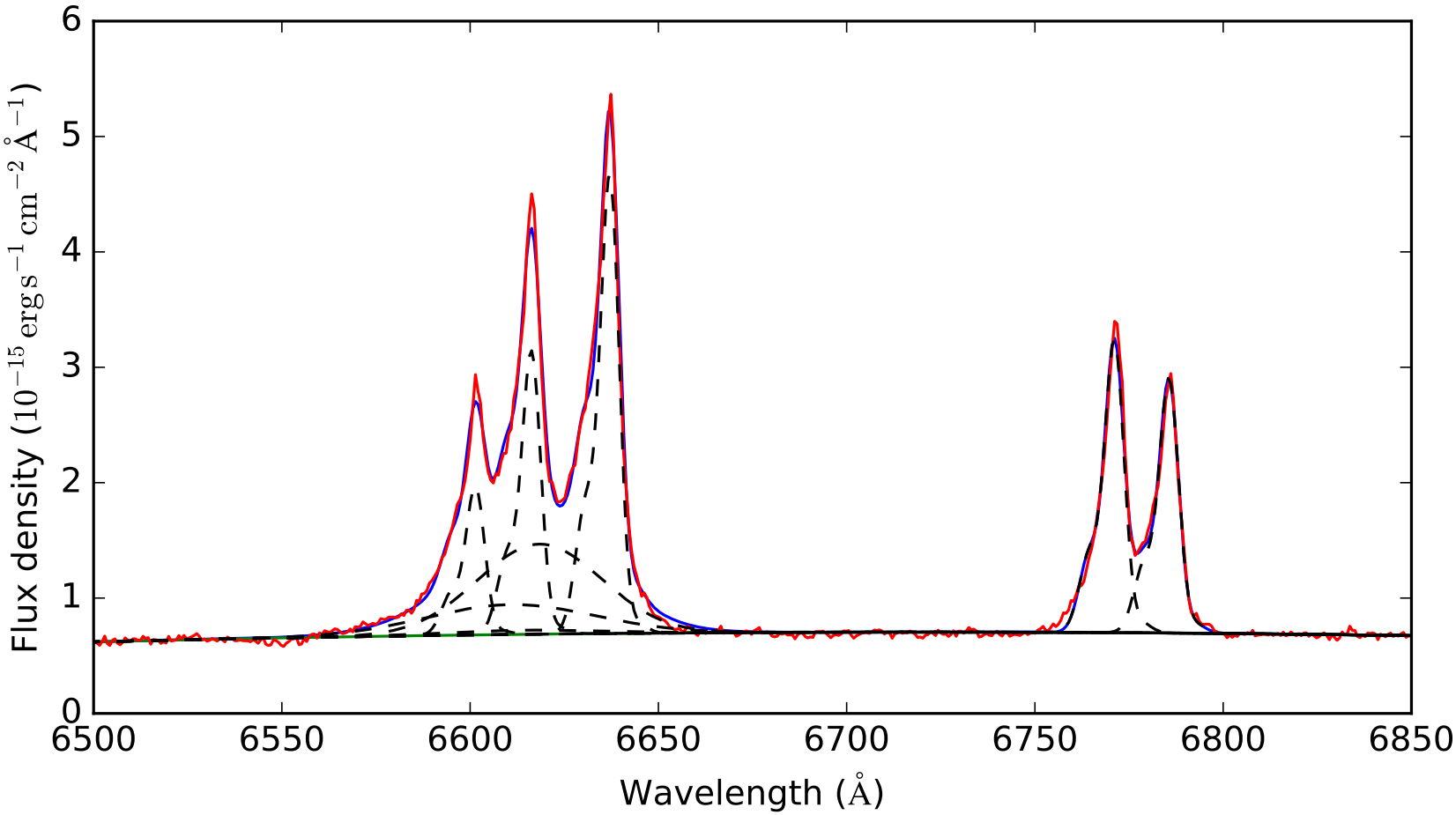


Modeling emission lines

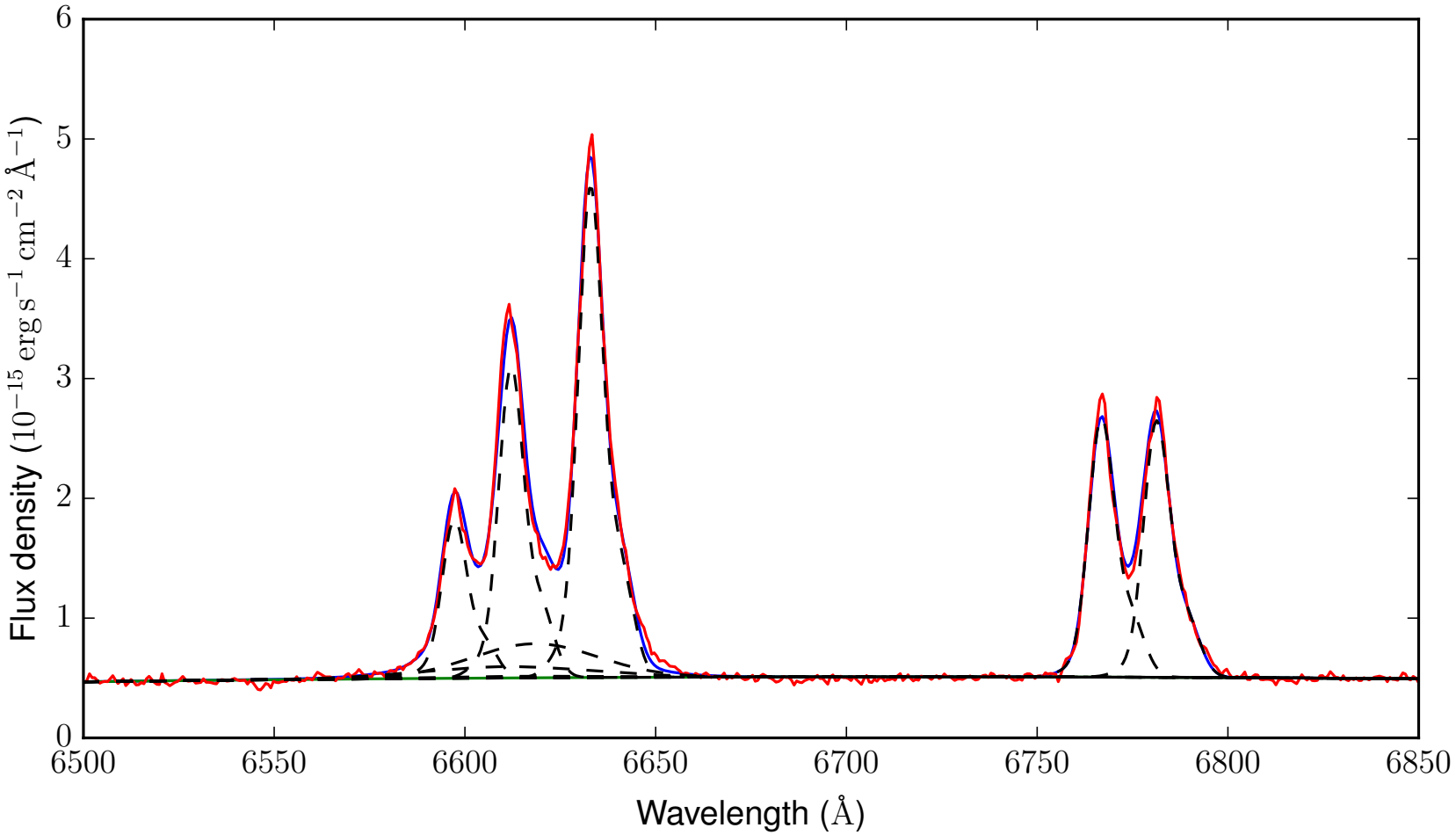
- The broad component profile of Sy1's is fitted only once, and only the total flux is subject to fitting in each spaxel.

- IFS line fitting code available at https://bitbucket.org/danielrd6/ifscube. Contributions are welcome!

Modeling examples

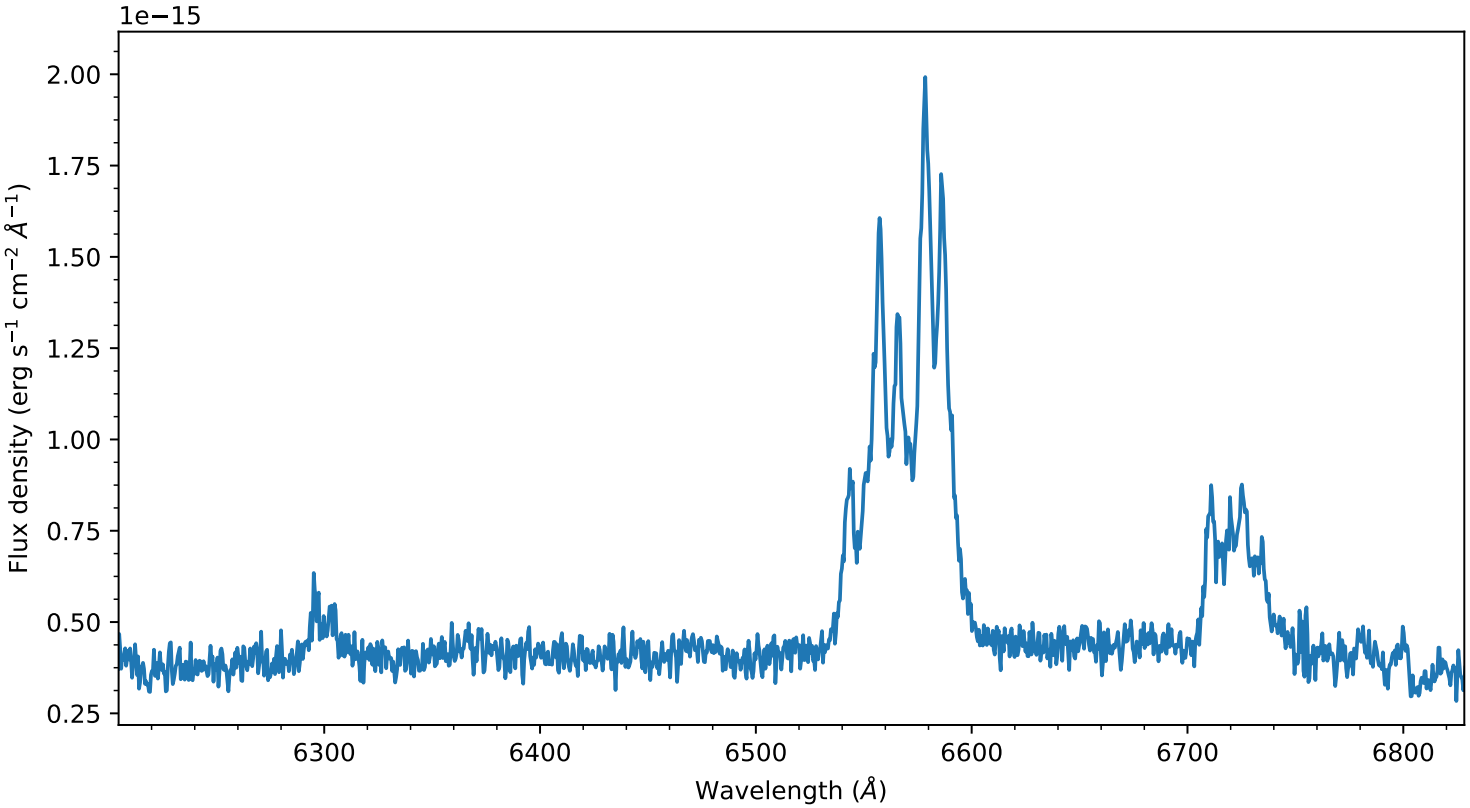


Modeling examples

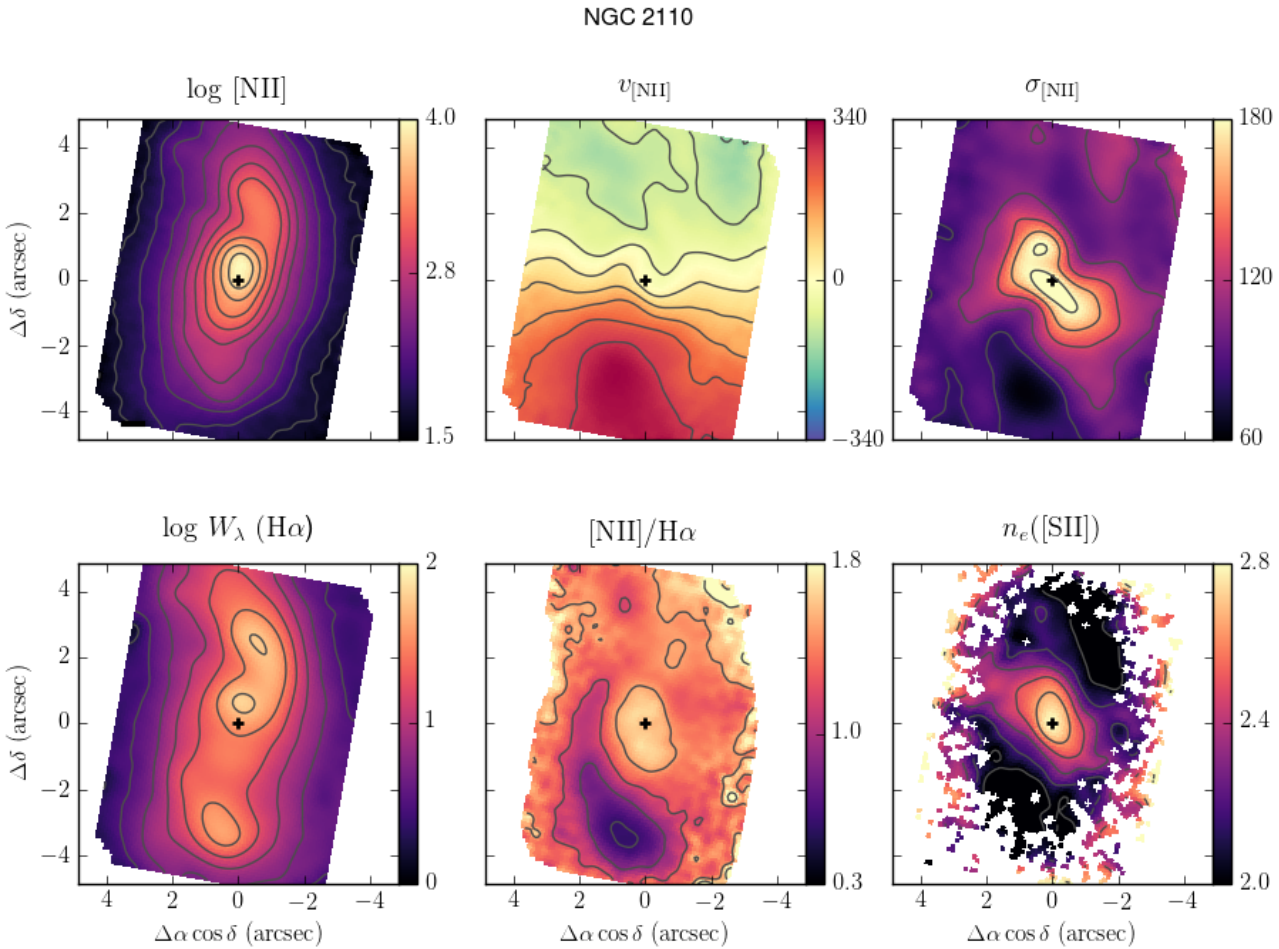


Model limitations

- Not all galaxies can be modeled with such a simple model.
- Spectroscopically resolved components have to be modeled separately.
- NGC 1068 and NGC 5728 temporarily left out.



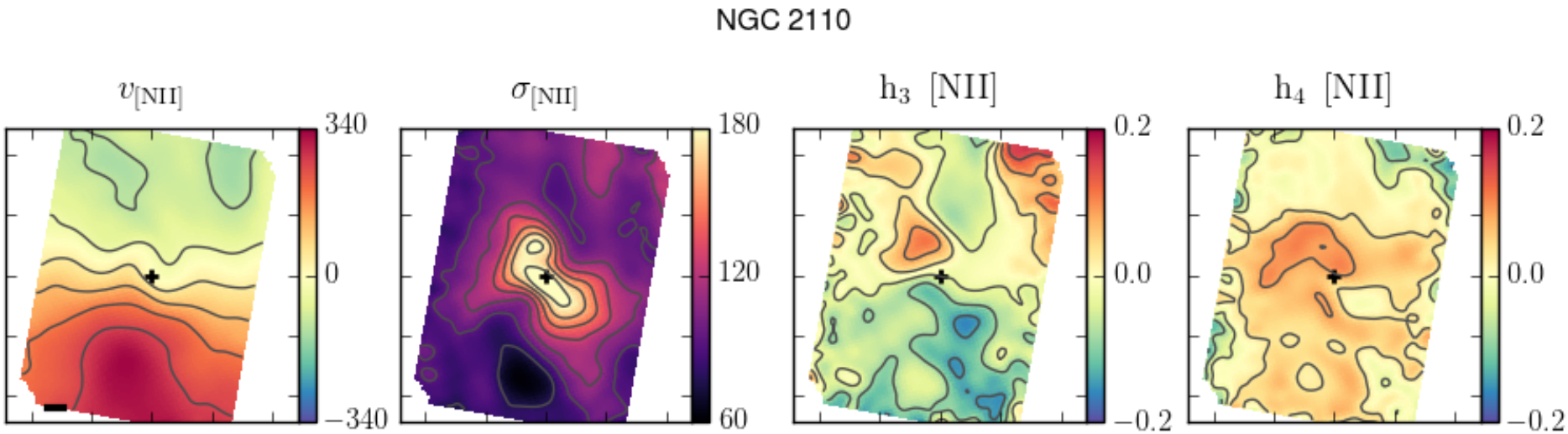
Some examples. . .



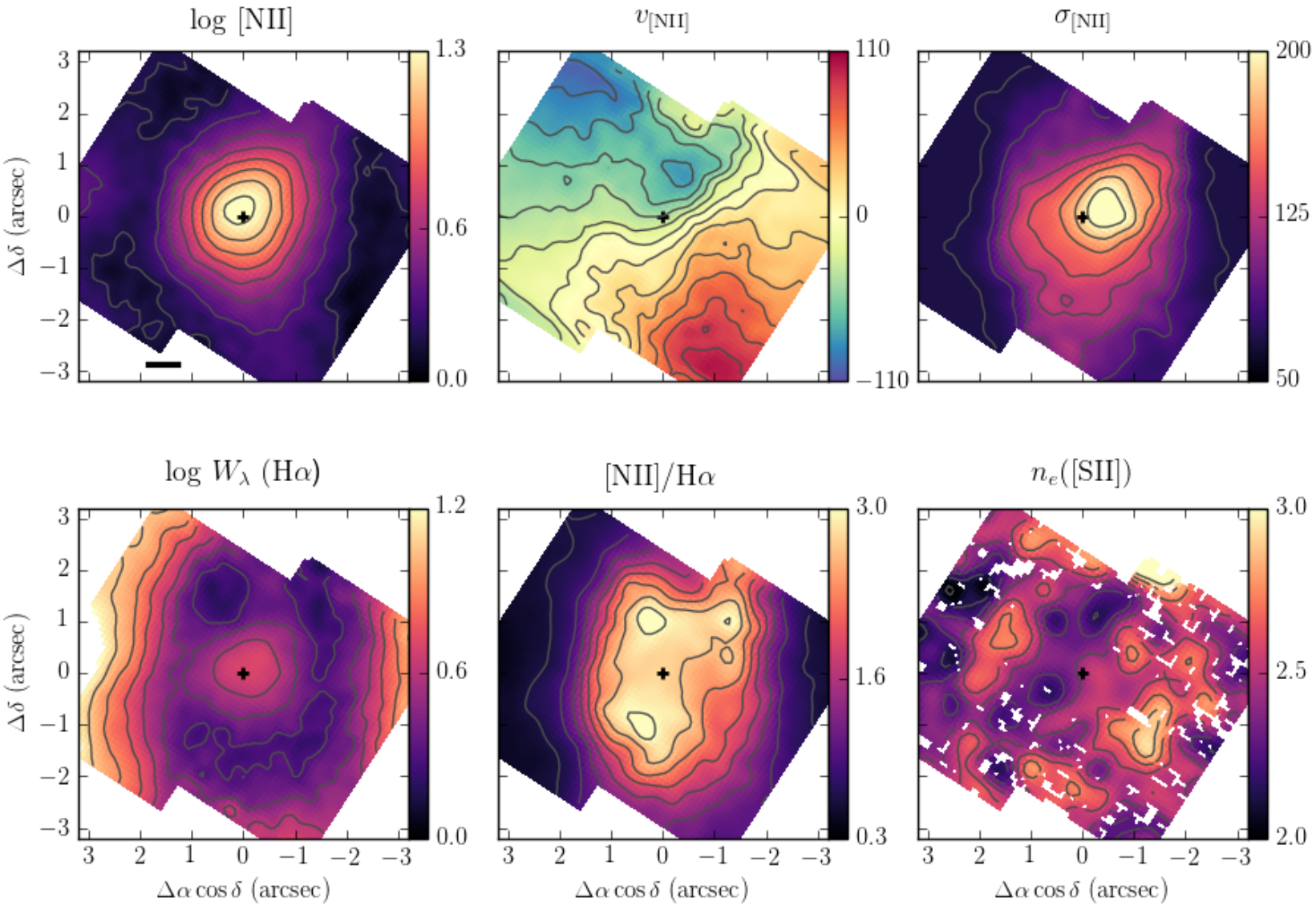
Units: velocities in km/s, fluxes in 10^{-15} $\mathrm{erg\,s^{-1}}$ and equivalent width in *Å*

Some examples...

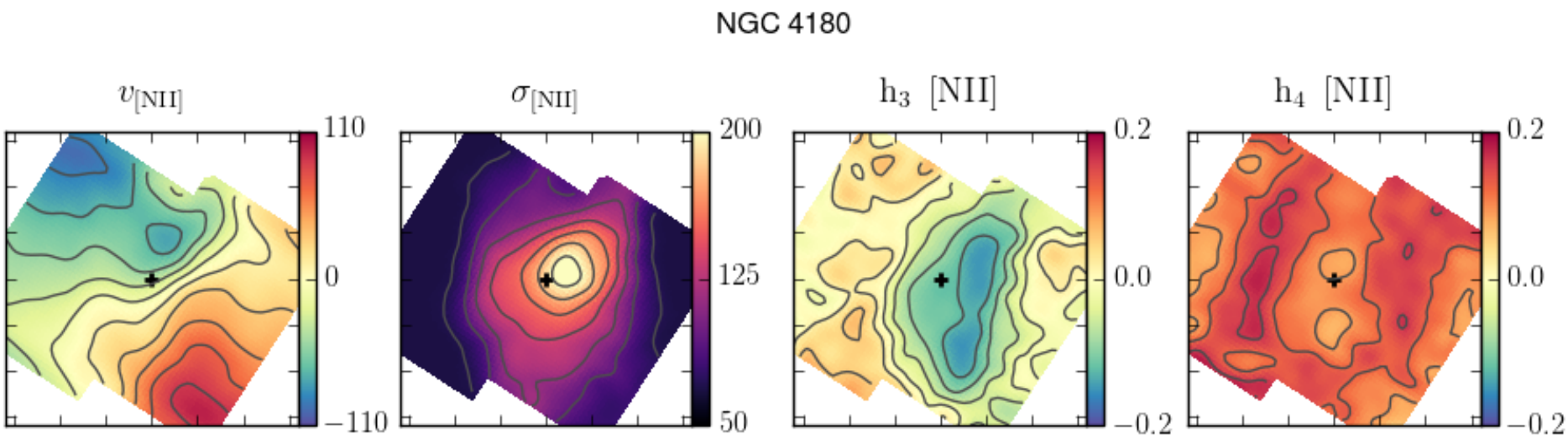
- The h_3 coefficient reveals the presence of a component lagging behind the disk rotation. (8/19 galaxies)
- Positive values of h_4 indicate two components of similar σ instead of one broad and one narrow component.

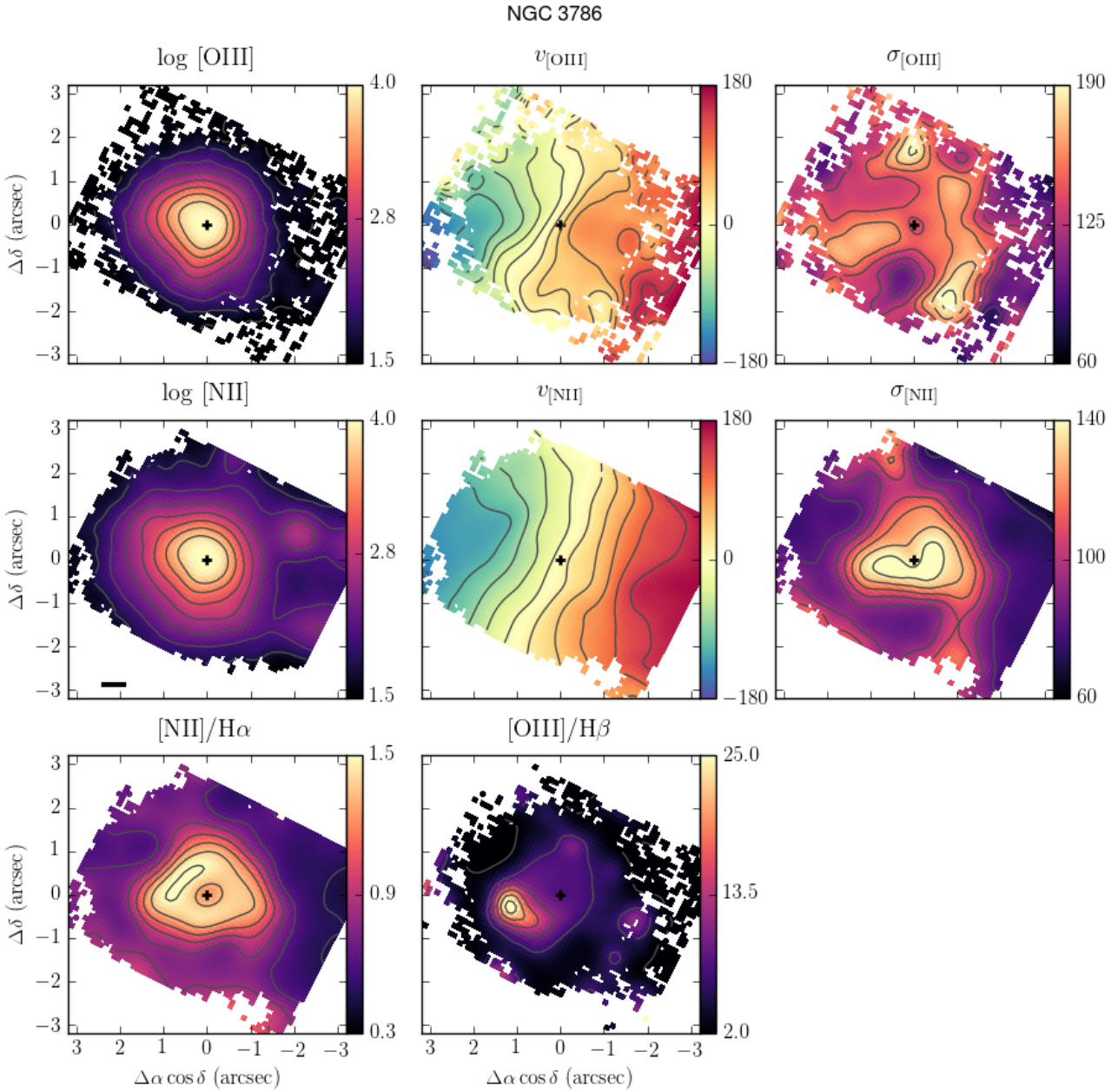


NGC 4180

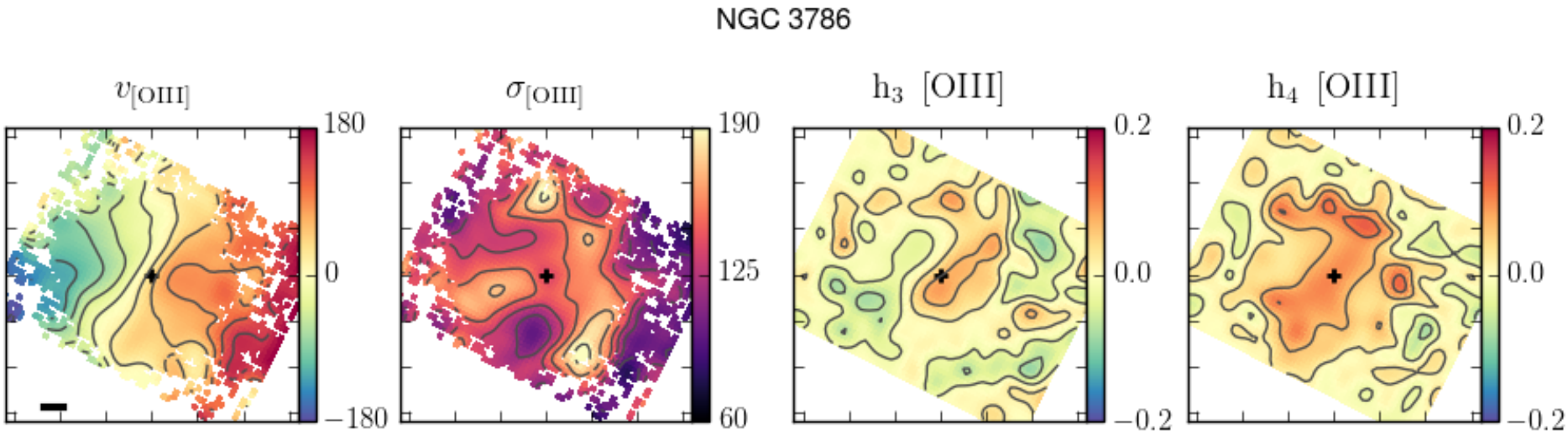

log [NII]
$v_{[NII]}$
$\sigma_{[NII]}$
log W_λ (Hα)
[NII]/Hα
n_e([SII])
$\Delta\delta$ (arcsec)
$\Delta\alpha \cos\delta$ (arcsec)

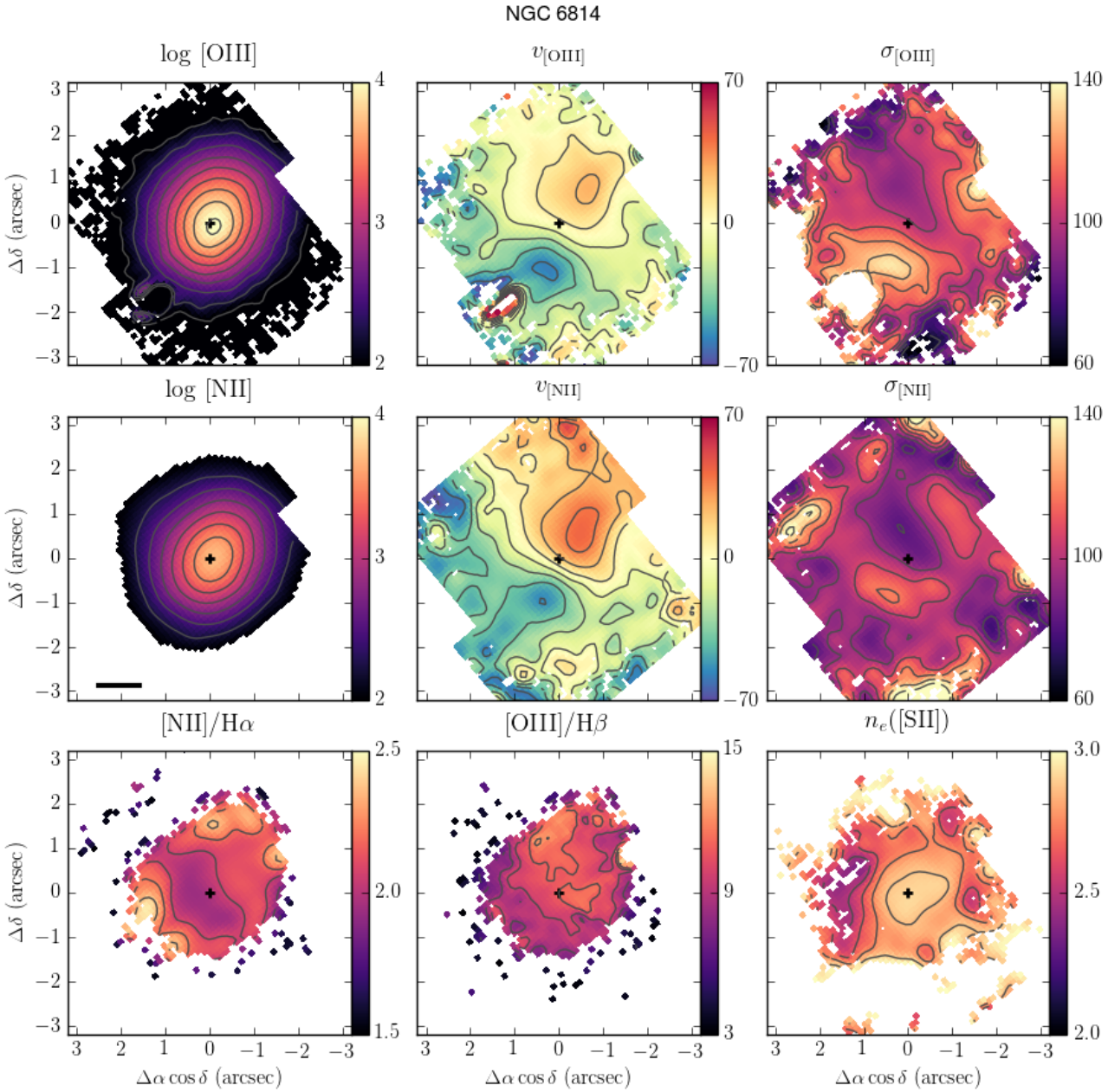
- In 5/19 galaxies the assymetry in line profiles is not co-planar with the disk rotation.



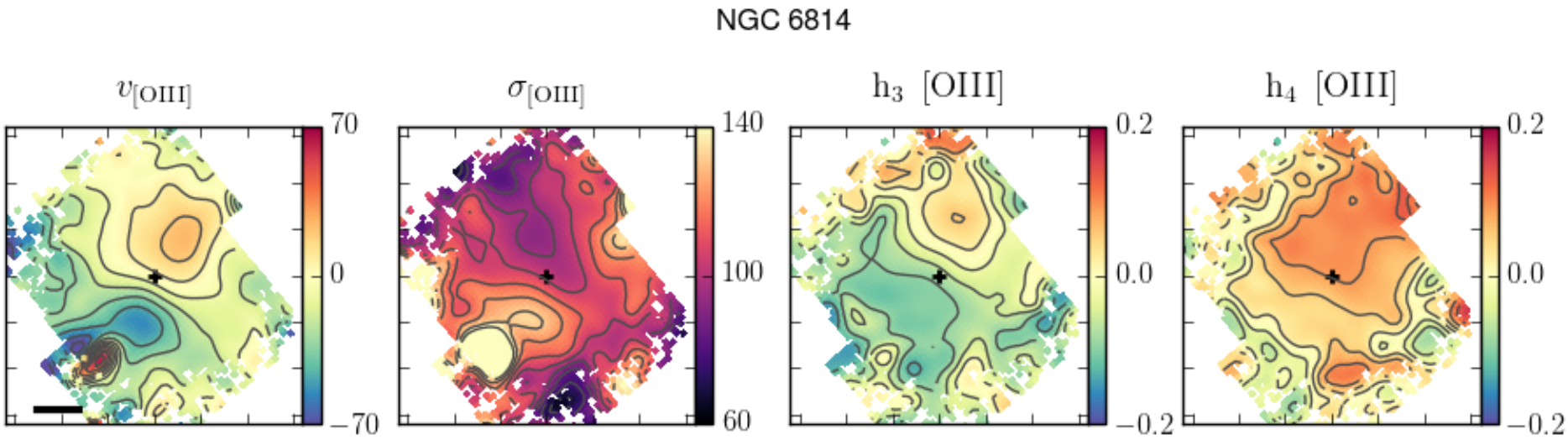

NGC 3786
log [OIII]
$v_{[OIII]}$
$\sigma_{[OIII]}$
log [NII]
$v_{[NII]}$
$\sigma_{[NII]}$
[NII]/Hα
[OIII]/Hβ
$\Delta\delta$ (arcsec)
$\Delta\alpha \cos\delta$ (arcsec)

- 4/19 galaxies display no clear pattern of h_3 and h_4 coefficients with respect to the general rotation.

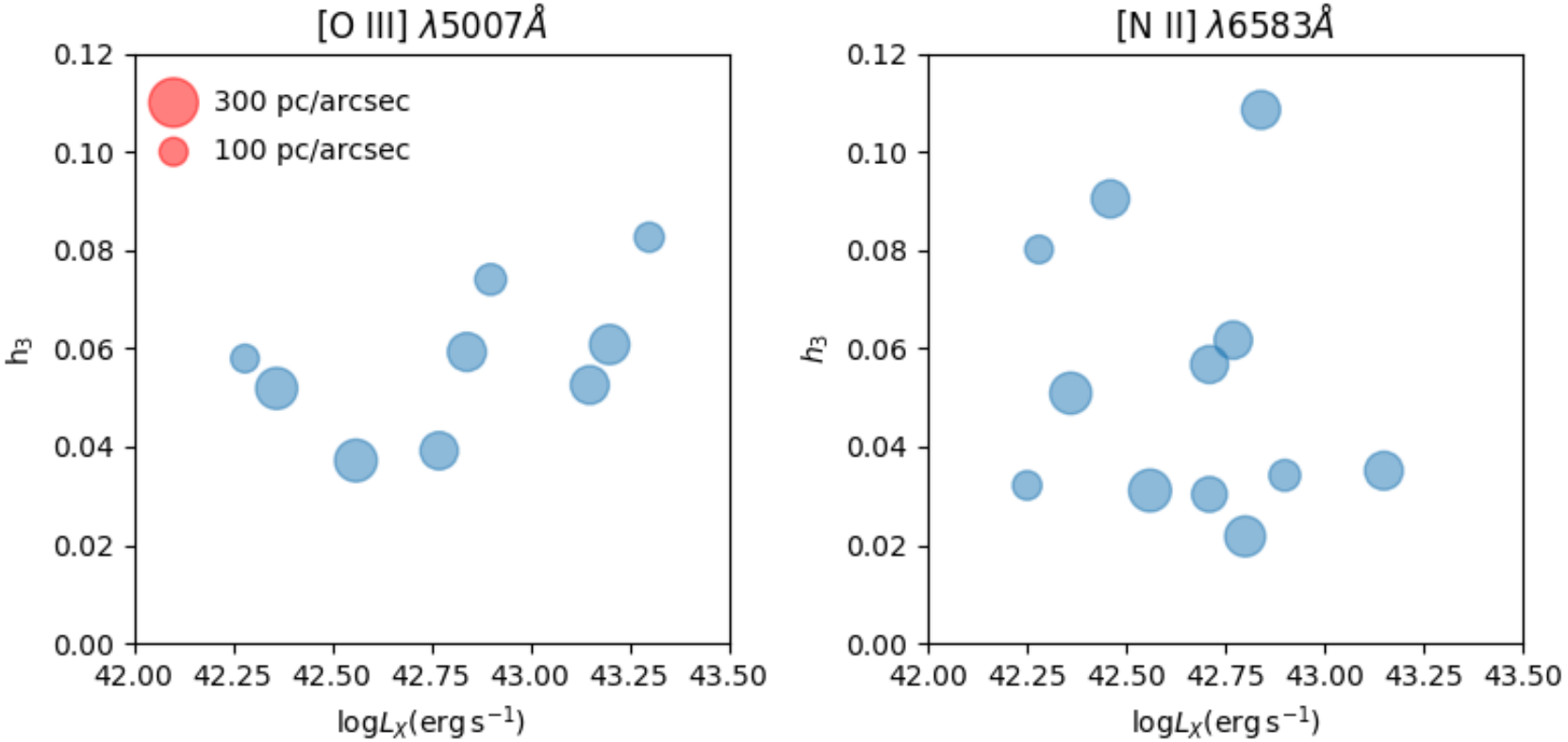



NGC 6814
log [OIII]
$v_{[OIII]}$
$\sigma_{[OIII]}$
log [NII]
$v_{[NII]}$
$\sigma_{[NII]}$
[NII]/Hα
[OIII]/Hβ
n_e([SII])
$\Delta\delta$ (arcsec)
$\Delta\alpha \cos\delta$ (arcsec)

- Only 2 galaxies show wings in the same direction of the rotation.



Assymetry and x-ray luminosity (PRELIMINARY!)



Median of the h_3 coefficient.

Sizes are proportional to the projected scale of the galaxies.

Summary

- We have compiled a sample of IFS cubes for 23 local AGNs focusing on the inner few hundred parsecs.

Summary

- We have compiled a sample of IFS cubes for 23 local AGNs focusing on the inner few hundred parsecs.
- Radial motion (i.e. not rotation) is detected in 3/4 of the galaxies in our sample.

Summary

- We have compiled a sample of IFS cubes for 23 local AGNs focusing on the inner few hundred parsecs.
- Radial motion (i.e. not rotation) is detected in 3/4 of the galaxies in our sample.
- The majority of radial motion is contrary to the disk rotation

Summary

- We have compiled a sample of IFS cubes for 23 local AGNs focusing on the inner few hundred parsecs.
- Radial motion (i.e. not rotation) is detected in 3/4 of the galaxies in our sample.
- The majority of radial motion is contrary to the disk rotation
- Assymetry in the line profiles of [O III] weakly correlated with the X-Ray luminosity

Future and ongoing work

- Quantify the inflow/outflow rates
- Fit disk rotation models.
- Compare the ionized gas kinematics to the stellar population history of the galaxies.