THE PHYSICAL PROPERTIES OF AGN OUTFLOWS AND THEIR IMPACT ON HOST GALAXIES FROM LOW TO HIGH REDSHIFT

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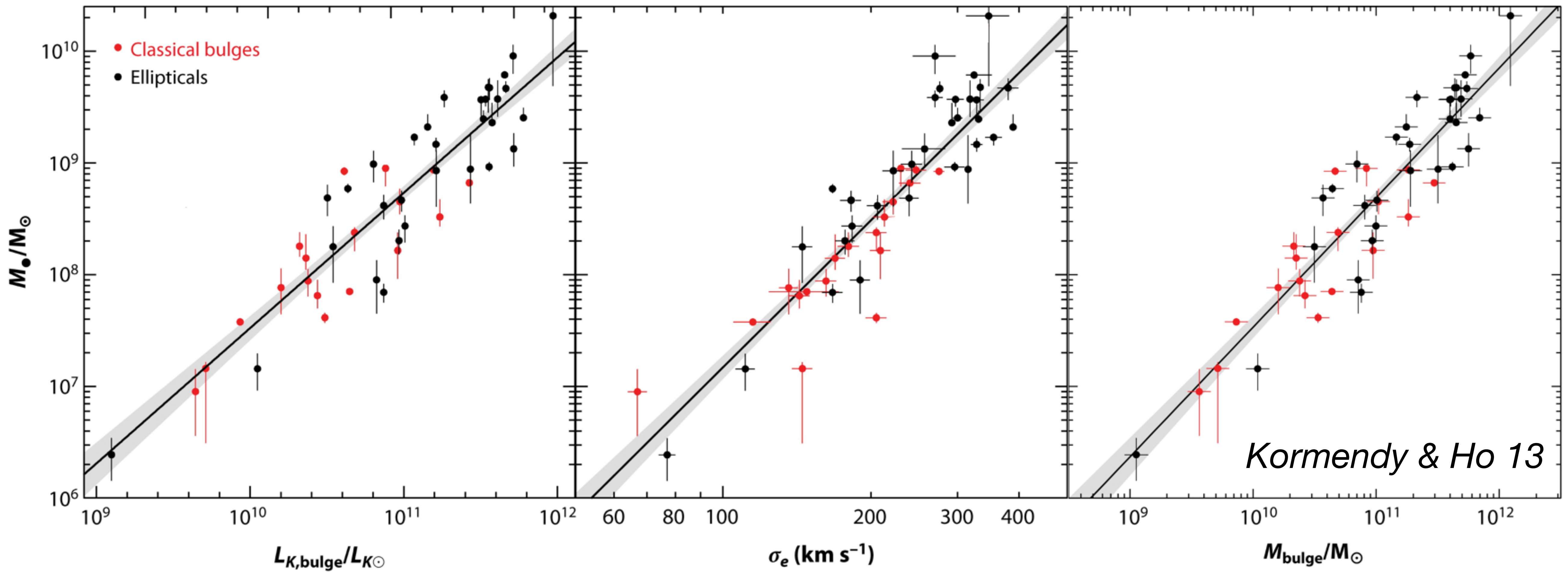
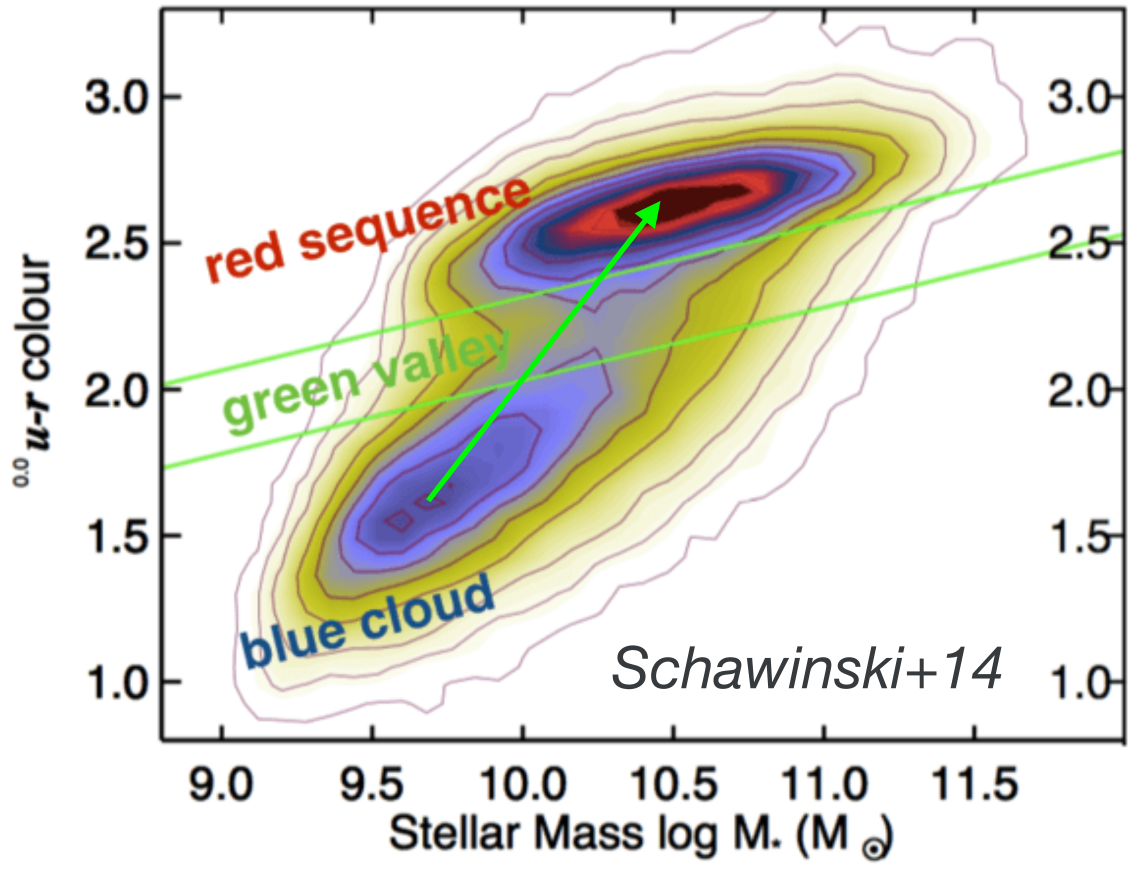
WHY AGN FEEDBACK?

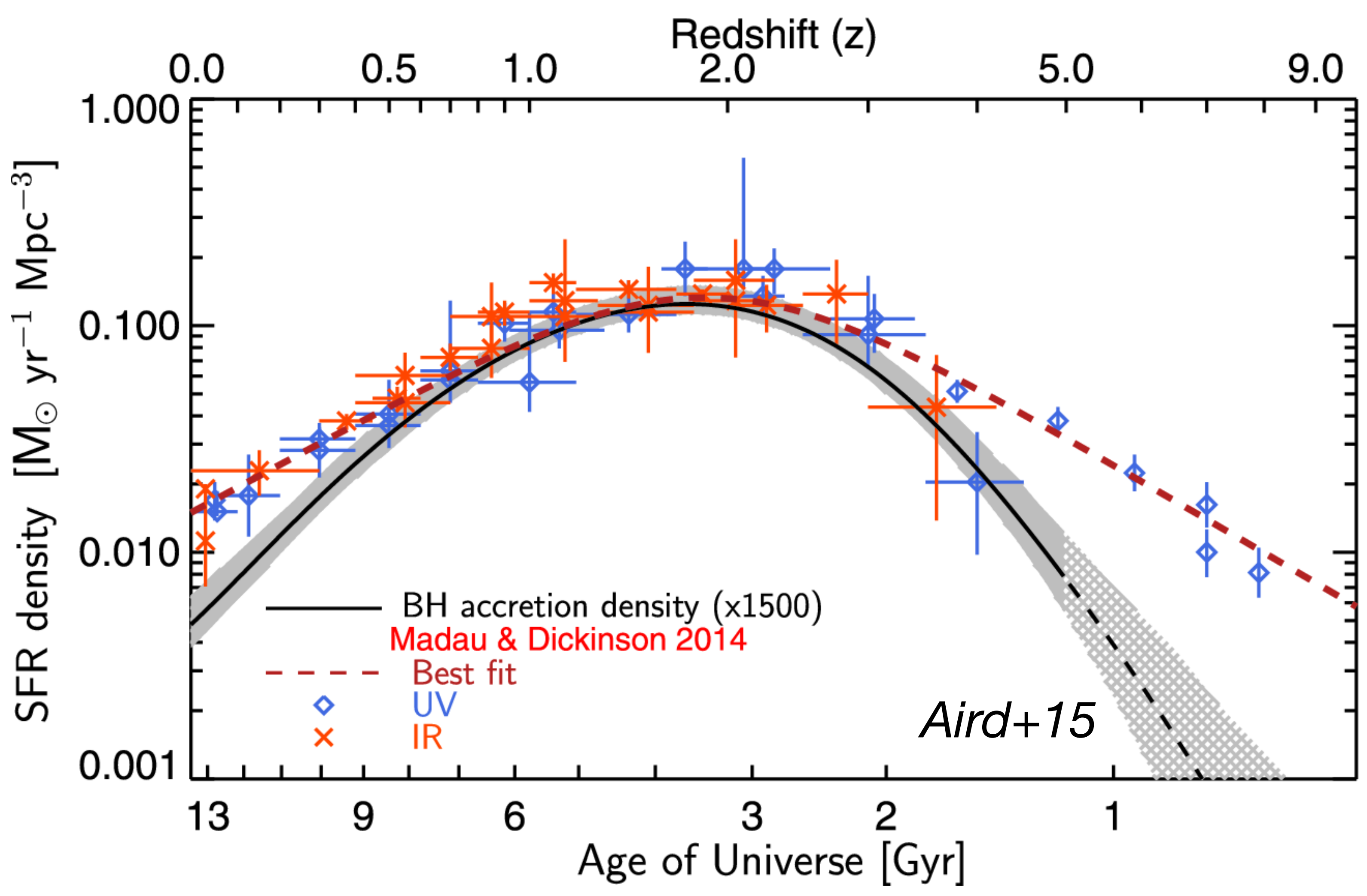
1) M_{BH}-L_{bul}, M_{BH}-σ_{bul}, M_{BH}-M_{bul} scaling relations



2) Galaxy bimodality

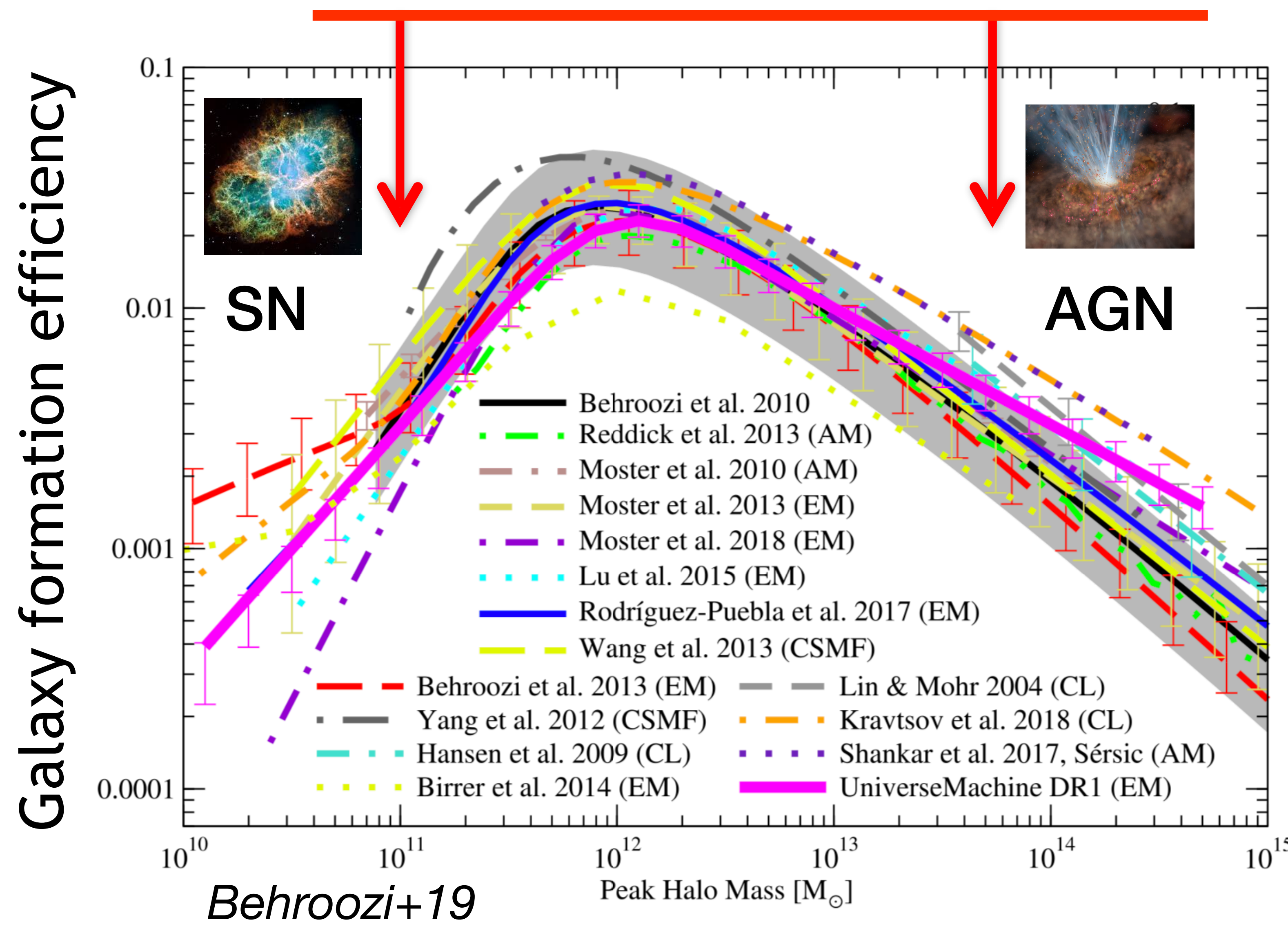


3) SFR similar to BH accretion history



4) Galaxy luminosity function

Cosmic Baryon Fraction (Ω_b/Ω_0 = 0.15 from WMAP)



Stellar feedback cannot explain missing massive galaxies (e.g. Murray+05, Di Matteo+05, Hopkins+06,18, Croton+06, Menci+08, Sijacki+15, Schaye+15 …)

EVIDENCES FOR AGN FEEDBACK?

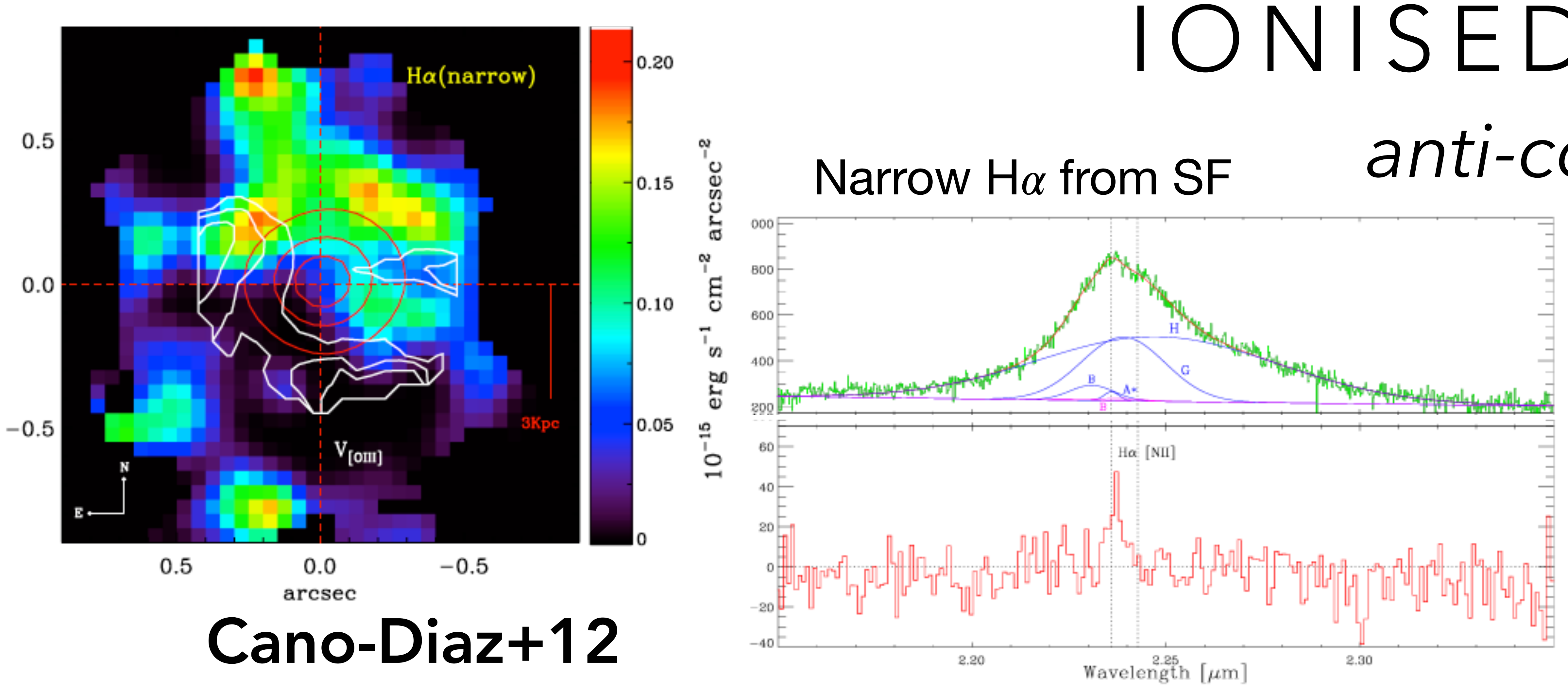
Do we have convincing <u>observational</u> evidence for AGN outflows effectively quenching star formation?

- Outflows at cosmic noon (z~2): AGN outflows during the peak of SF and AGN activity.

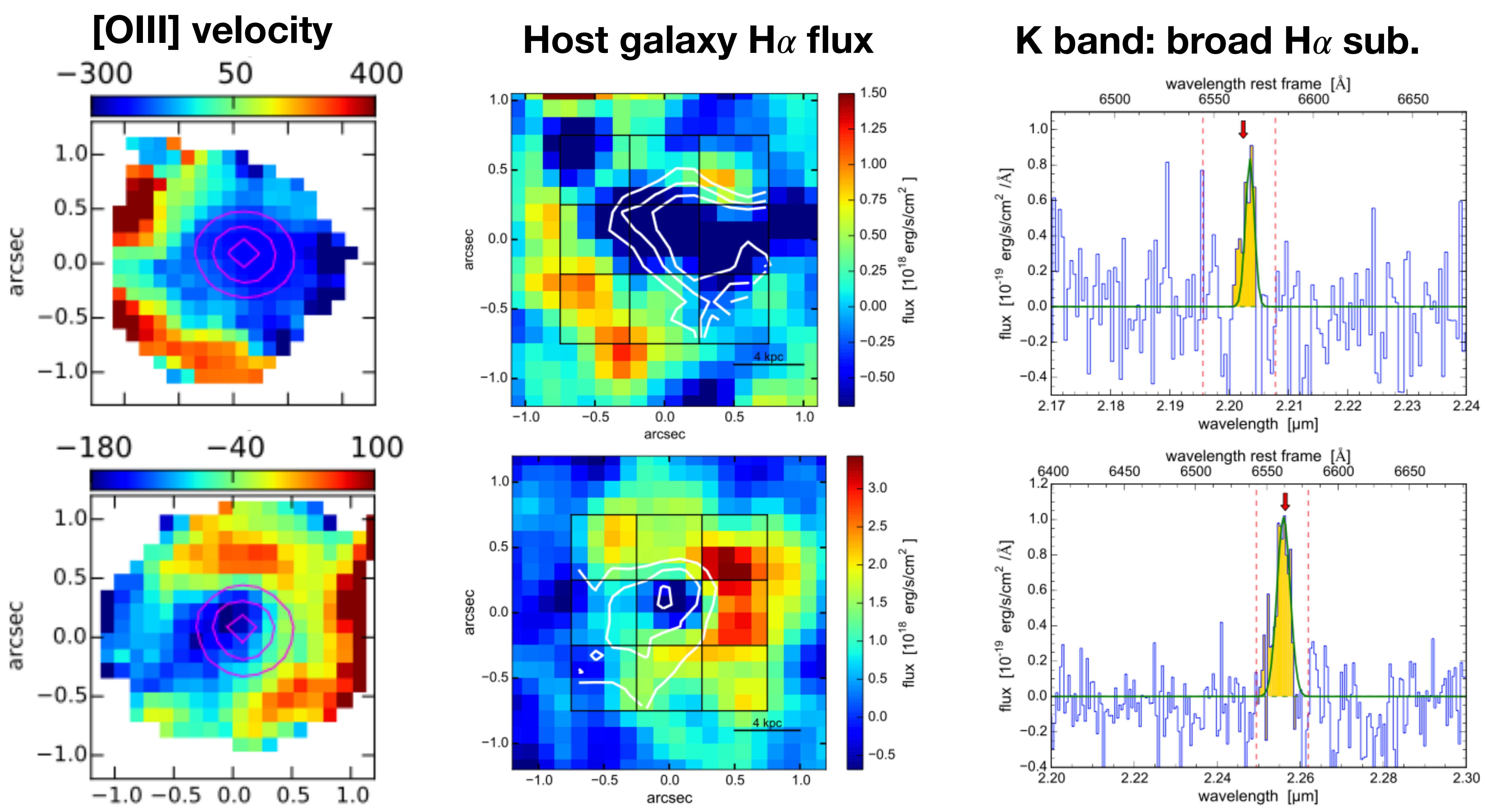
- Outflows nowadays (low z): outflow in nearby AGN as laboratories for the study of high redshift / high L outflows

IONISED OUTFLOWS IN Z~2 QUASARS

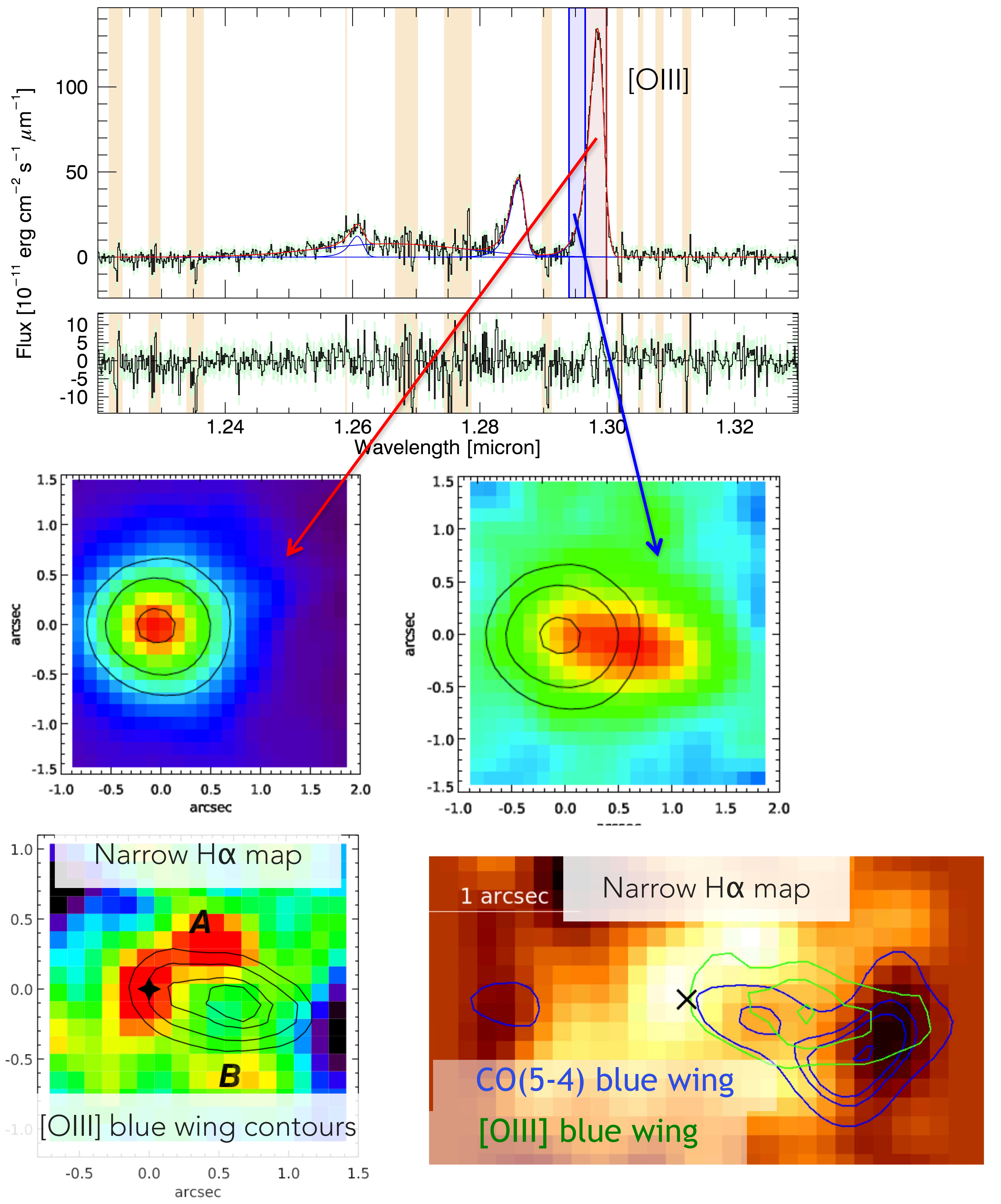
anti-correlation of fast outflows and SF in host galaxies



Cano-Diaz+12



Carniani+15,17



Cresci et al. 2015, Brusa et al. 2018

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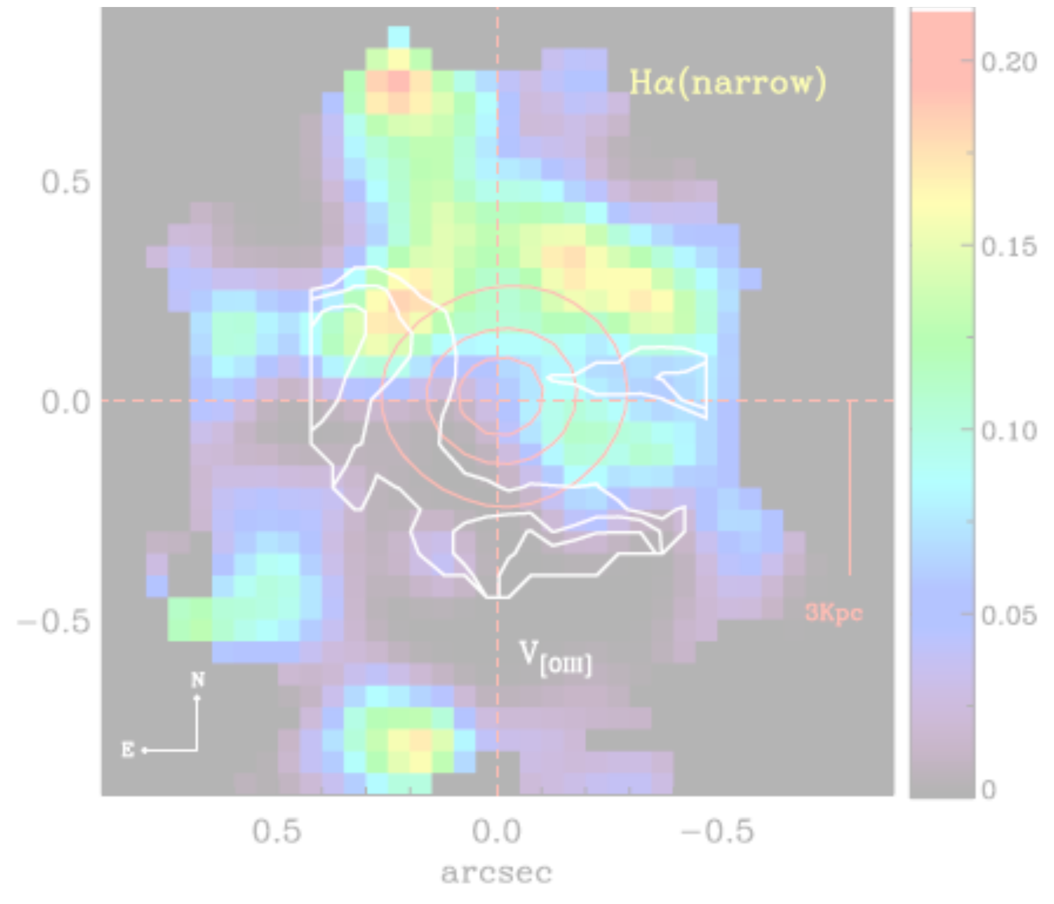
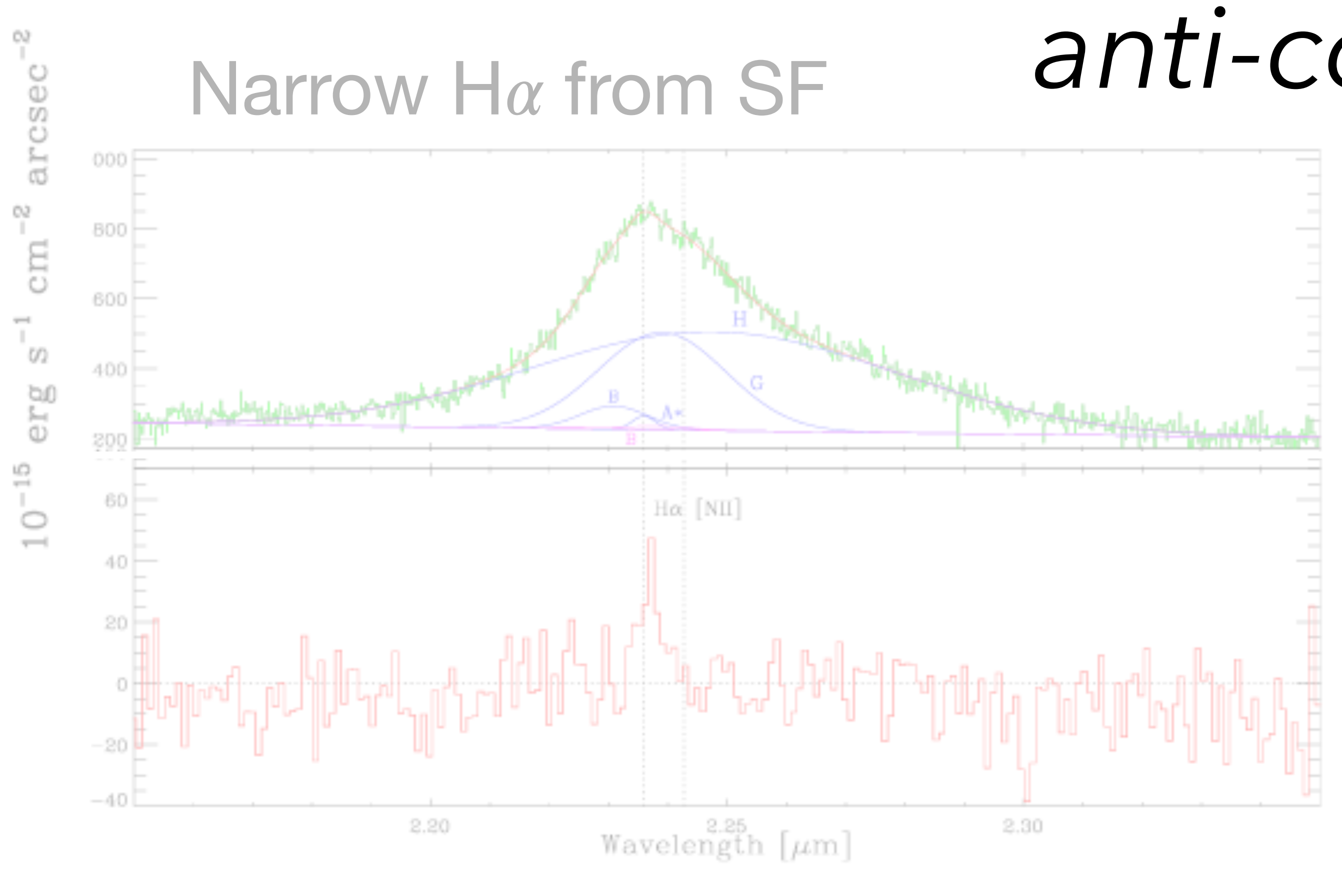
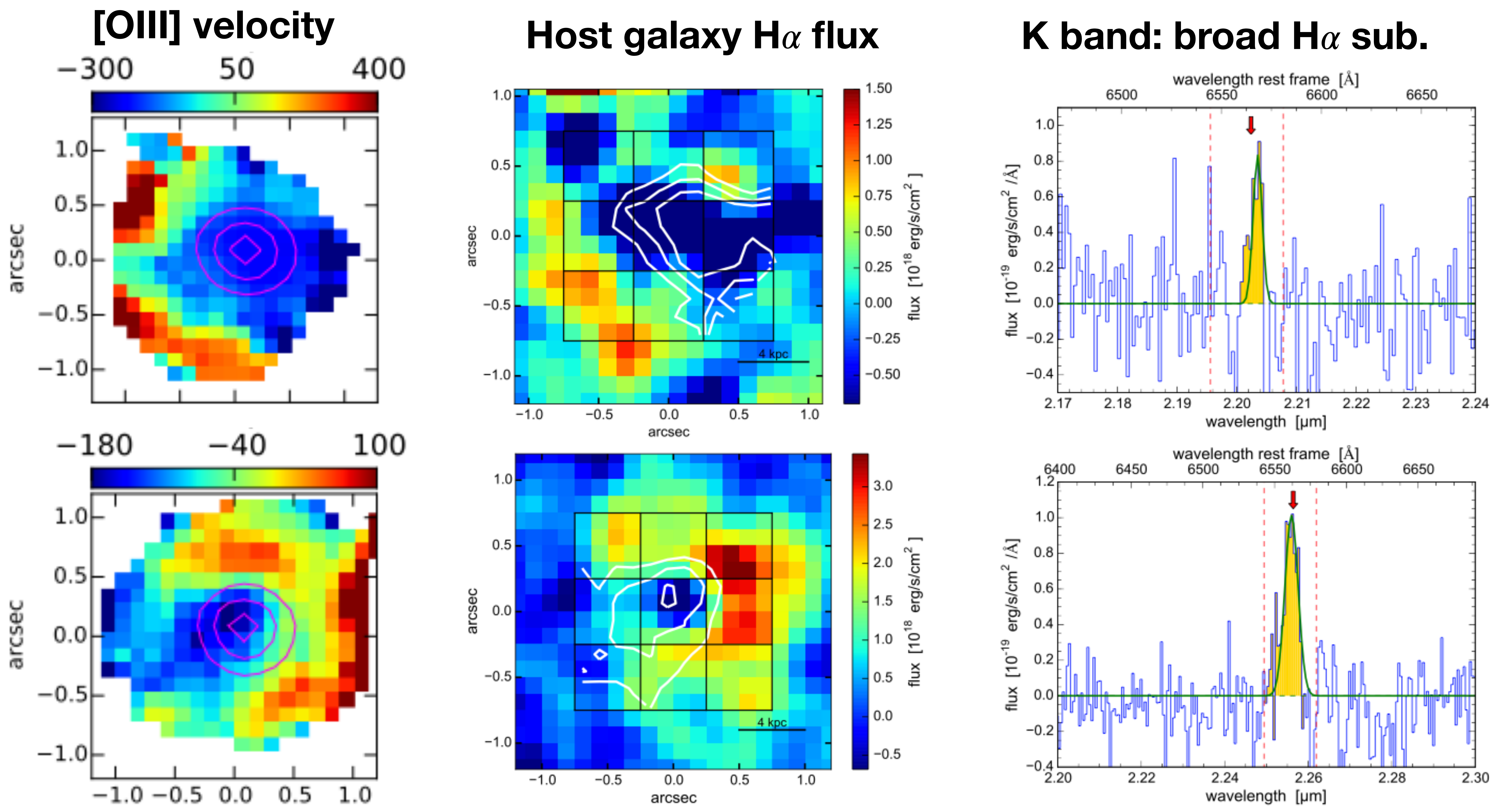




Cano-Diaz+12



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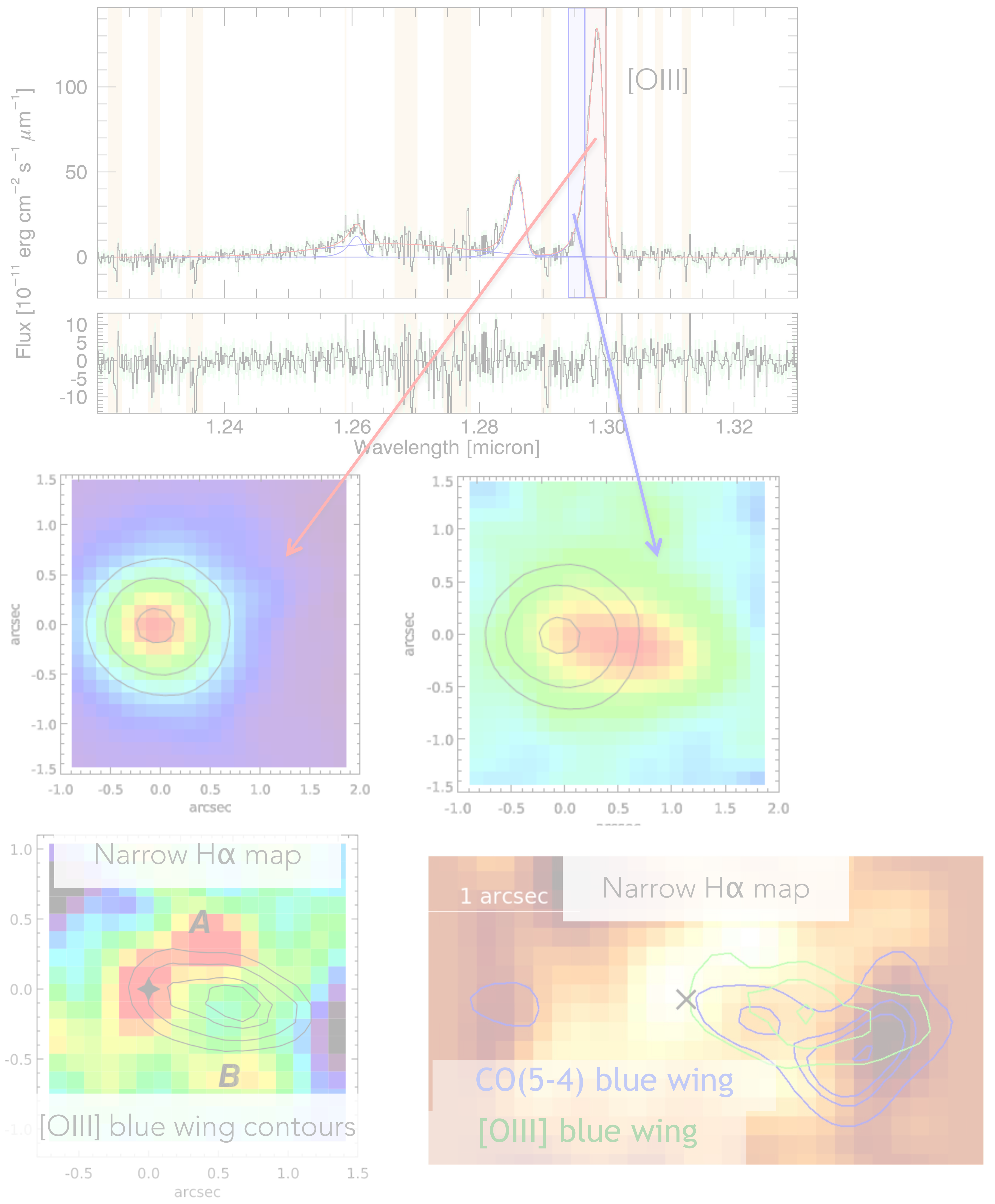

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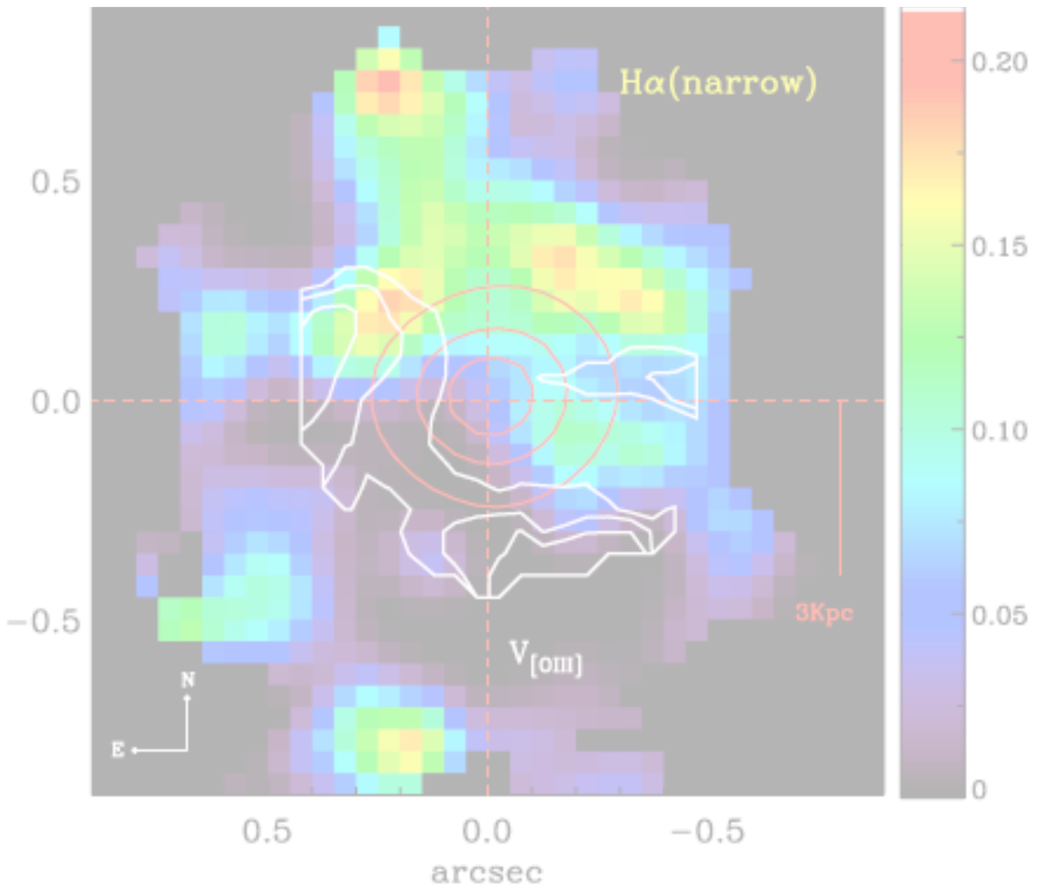
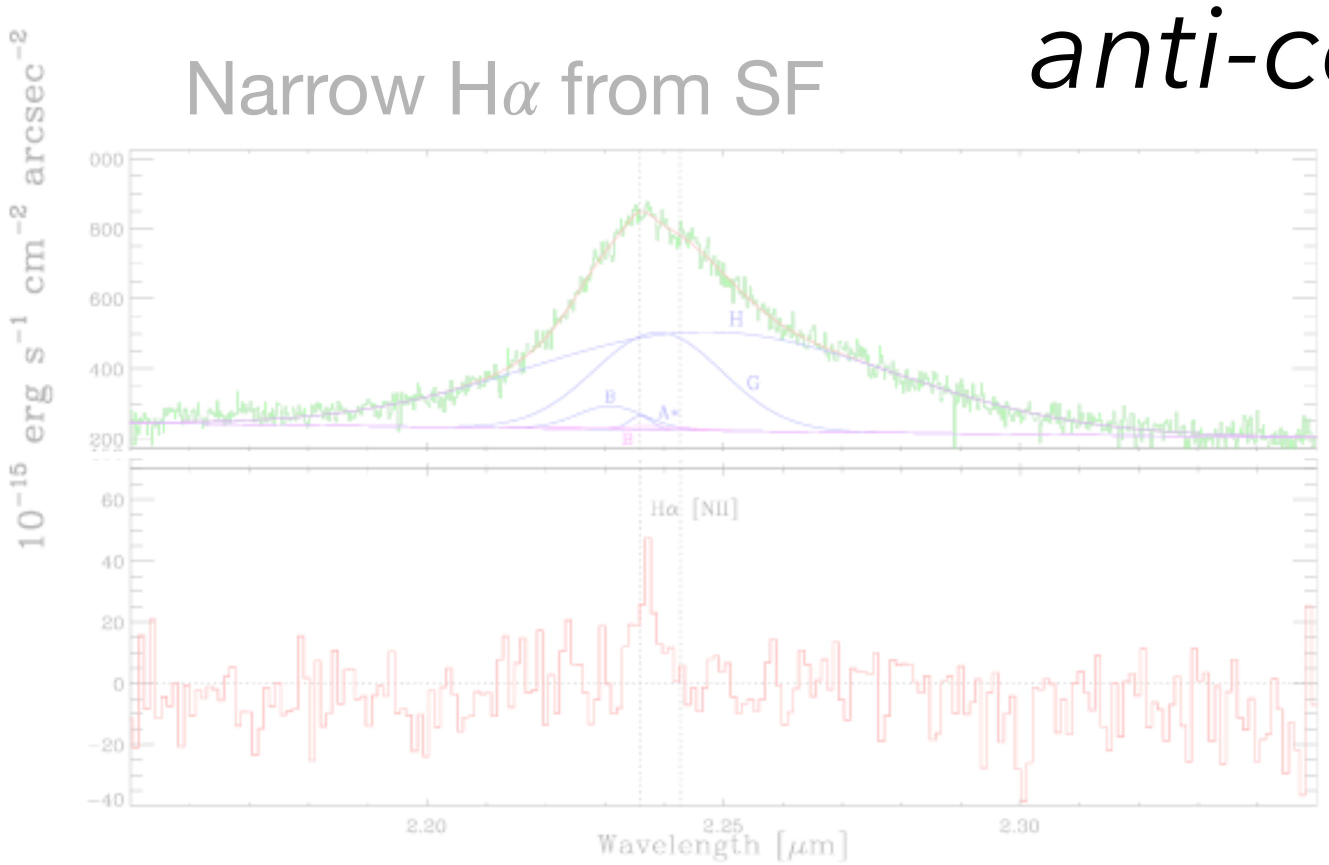
IONISED OUTFLOWS IN Z~2 QUASARS

anti-correlation of fast outflows and SF in host galaxies



Cano-Diaz+12

Narrow Hα from SF

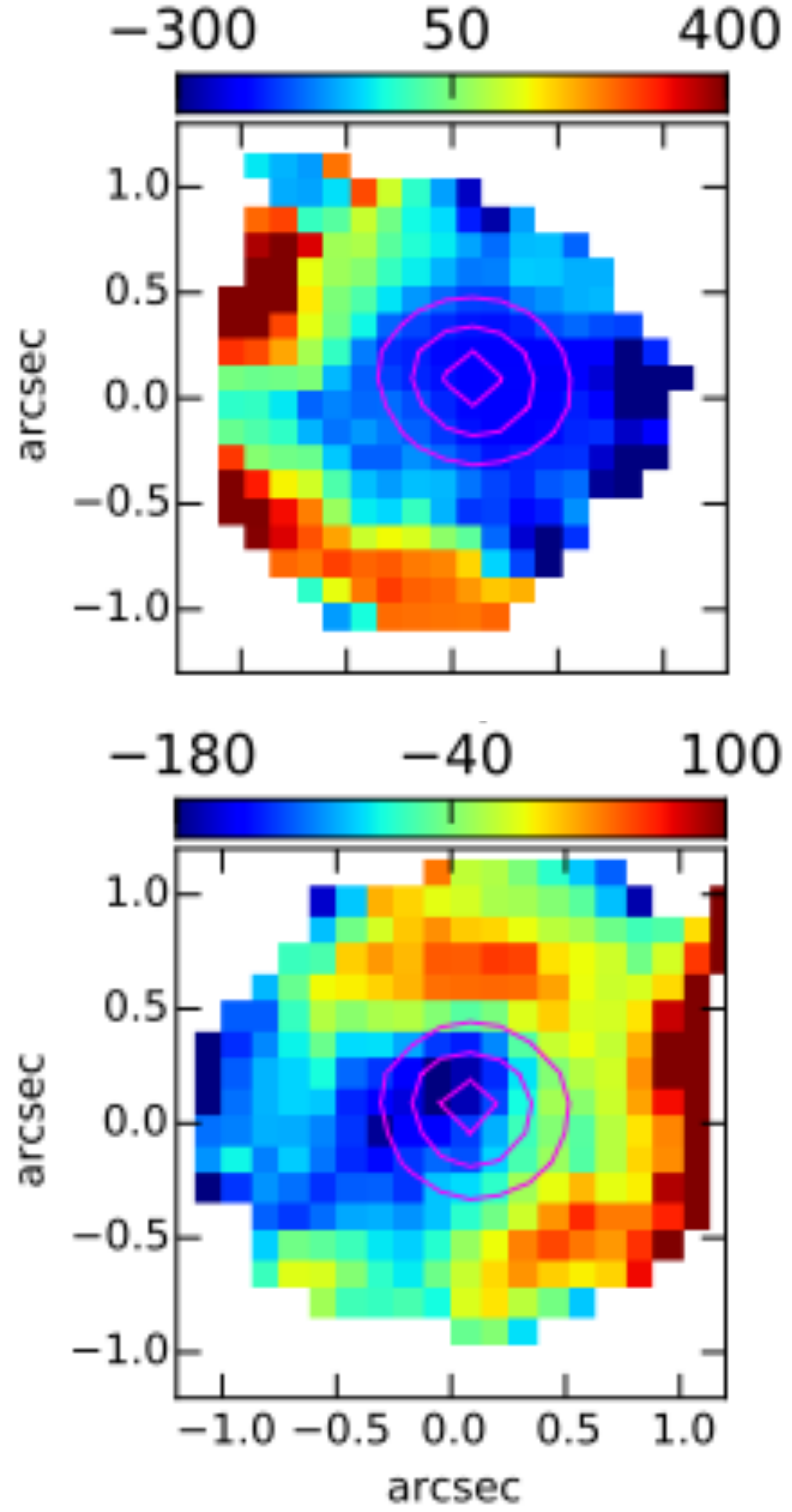


No SF cospatial with fast outflow: "Negative" feedback

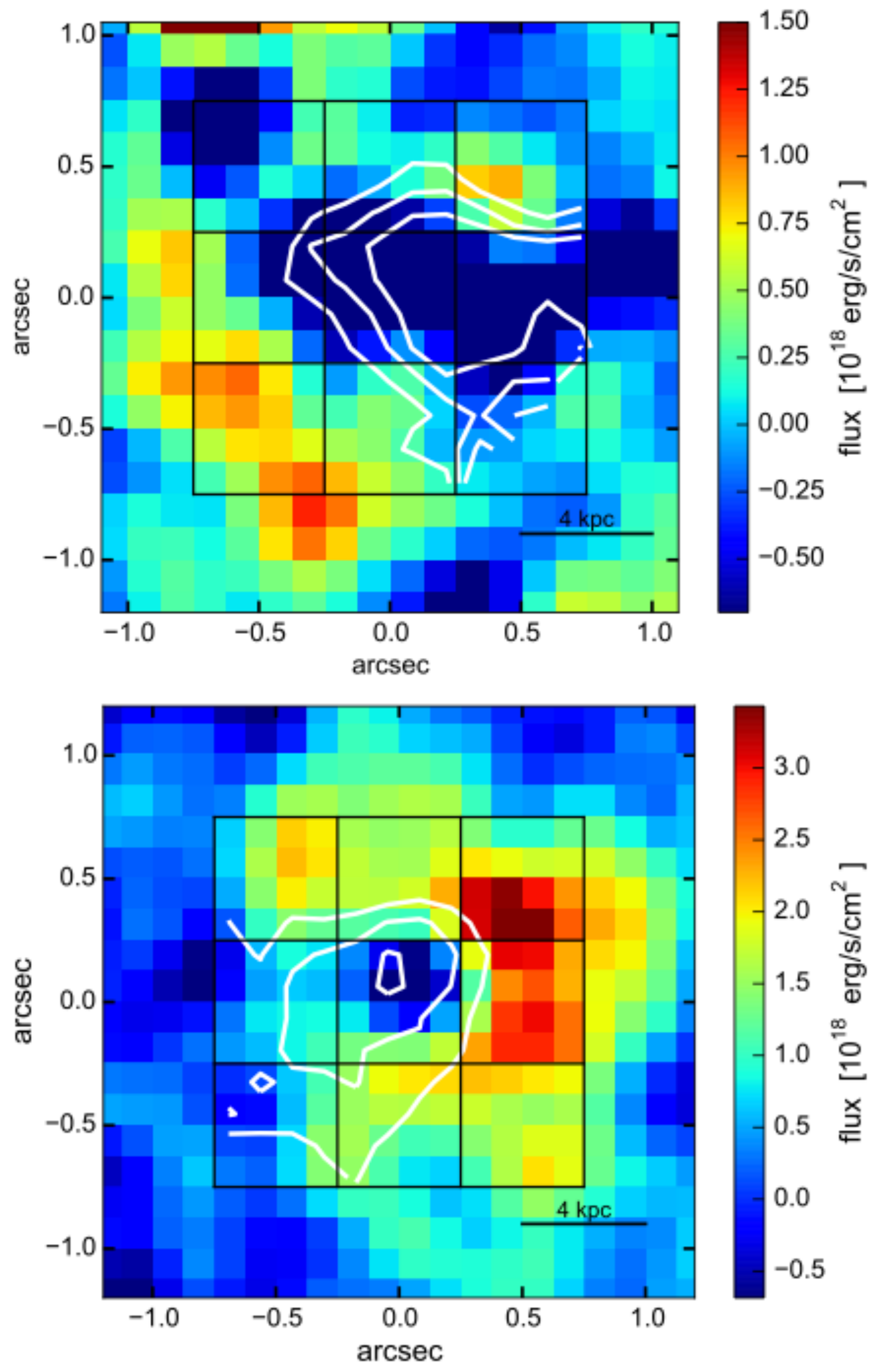
But …

Star formation in the host galaxies is still significant (~100 M⊙/yr)

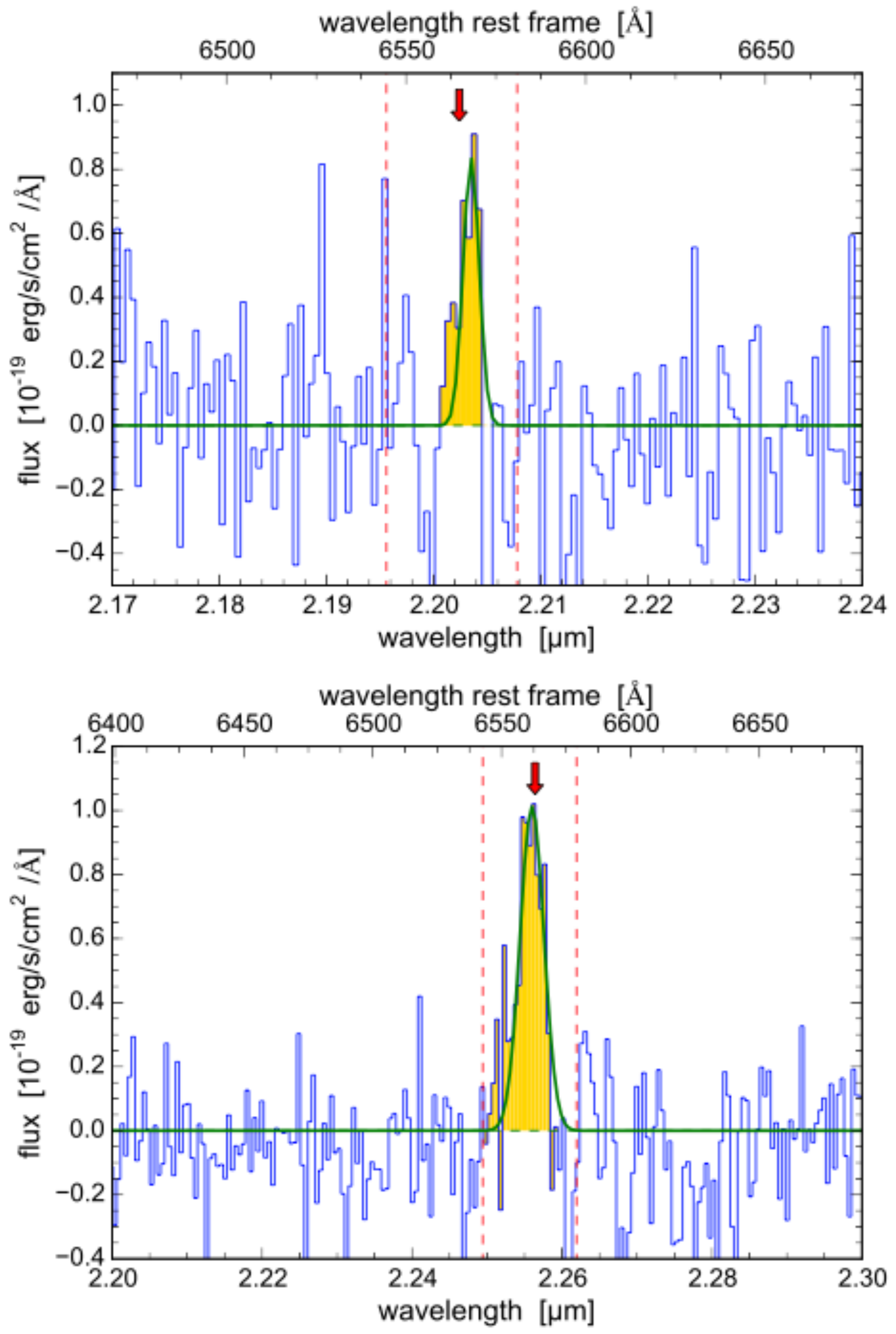
[OIII] velocity



Host galaxy Hα flux



K band: broad Hα sub.



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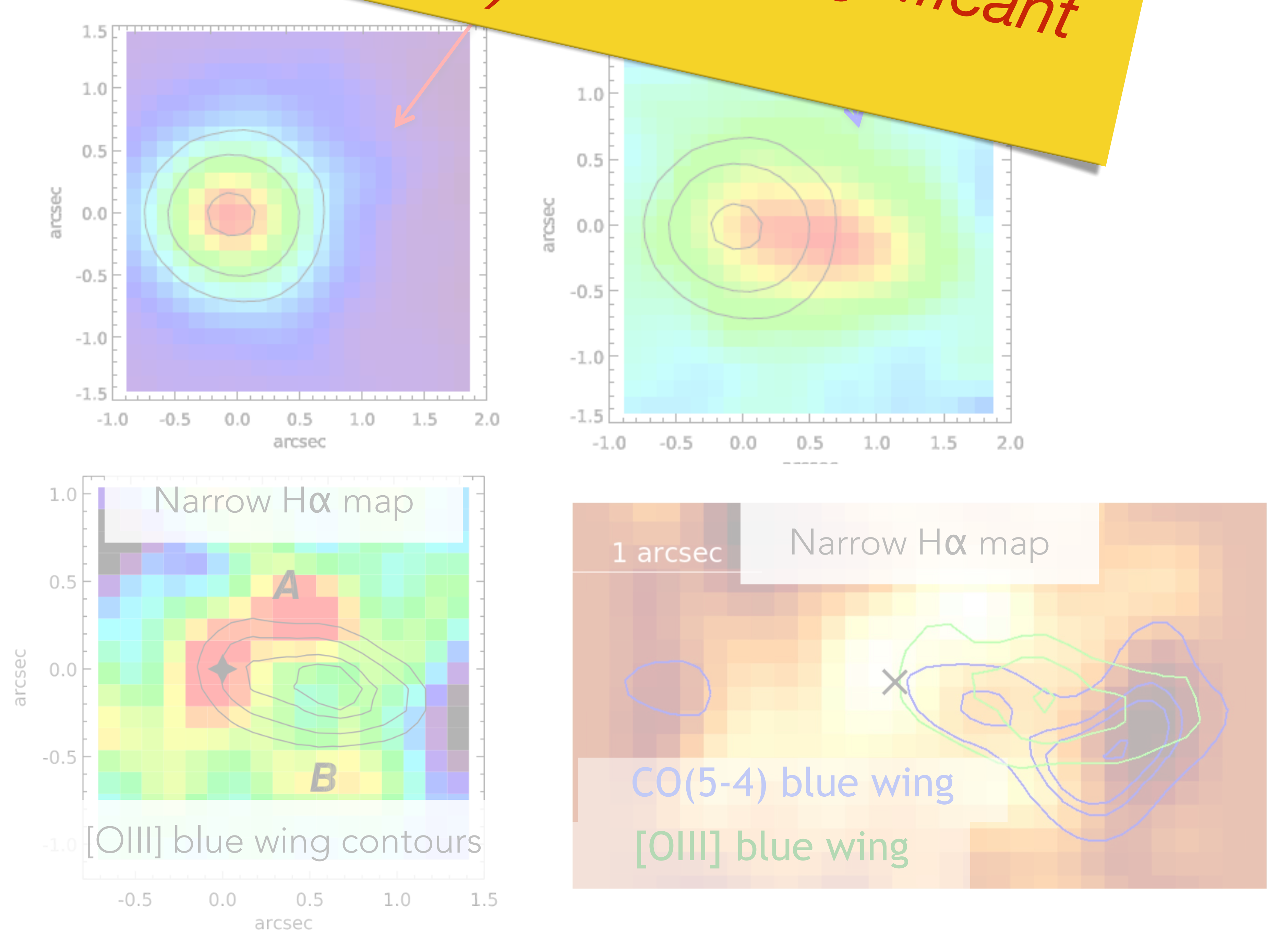
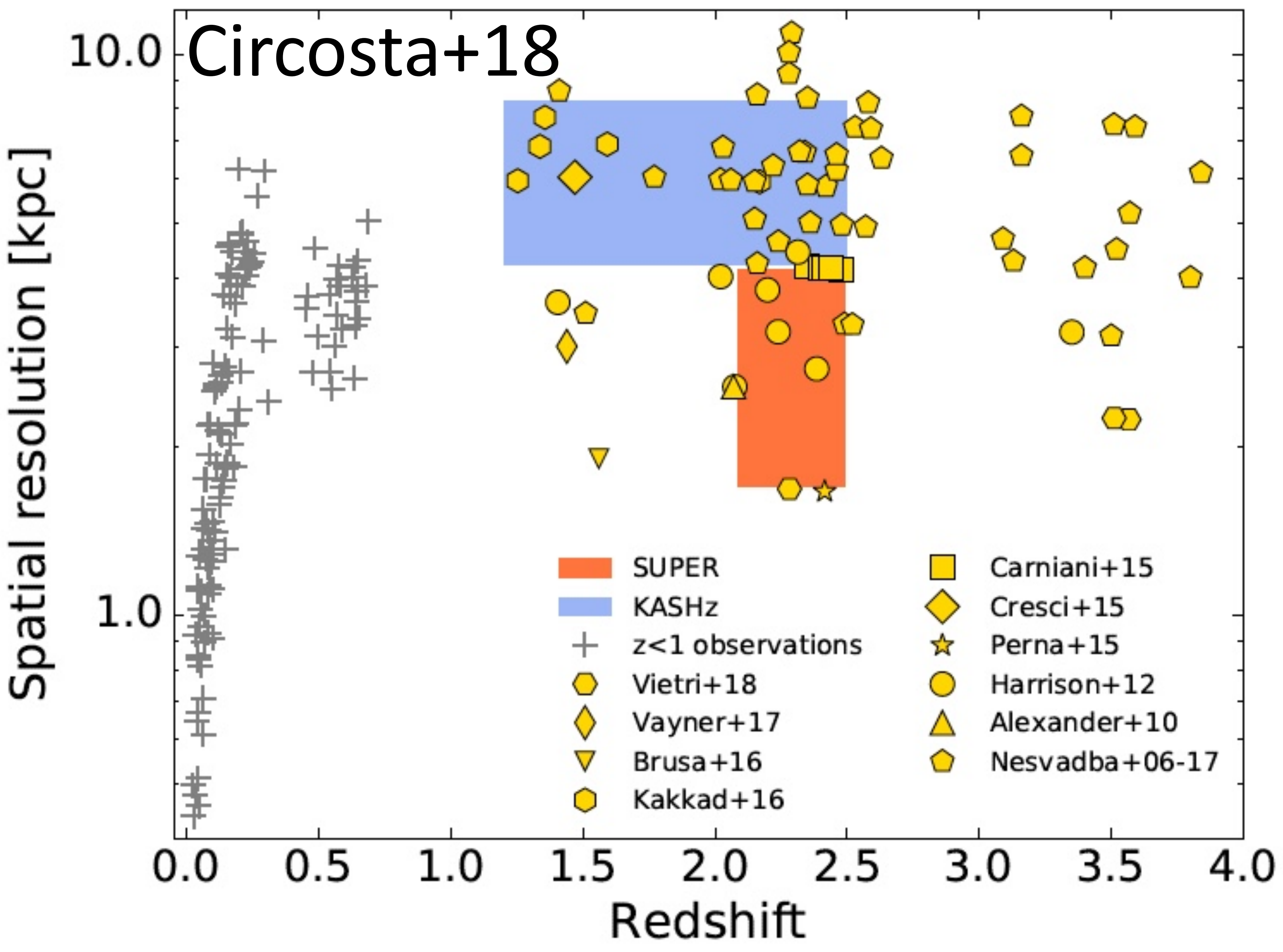


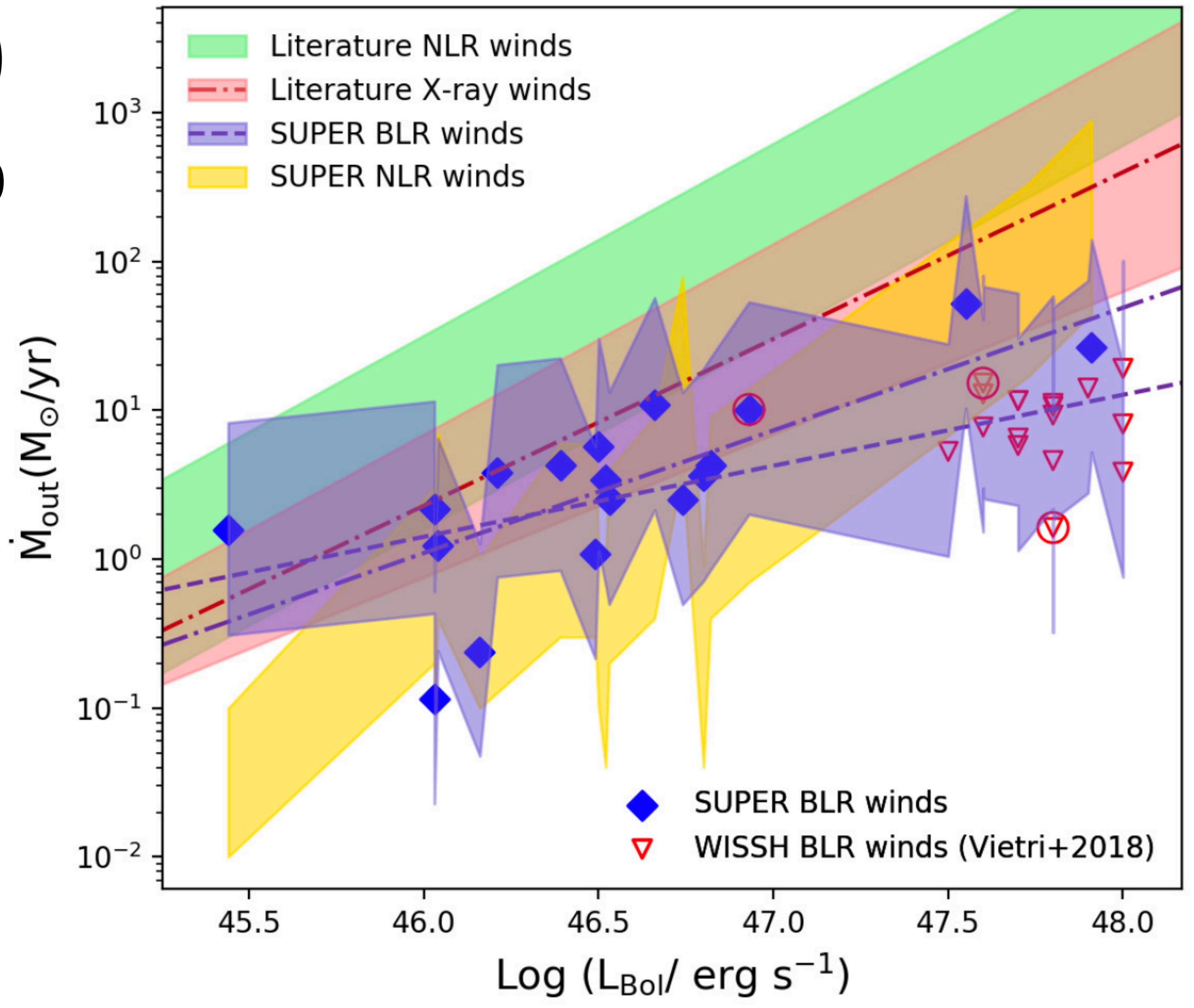
Cresci et al. 2015, Brusa et al. 2018

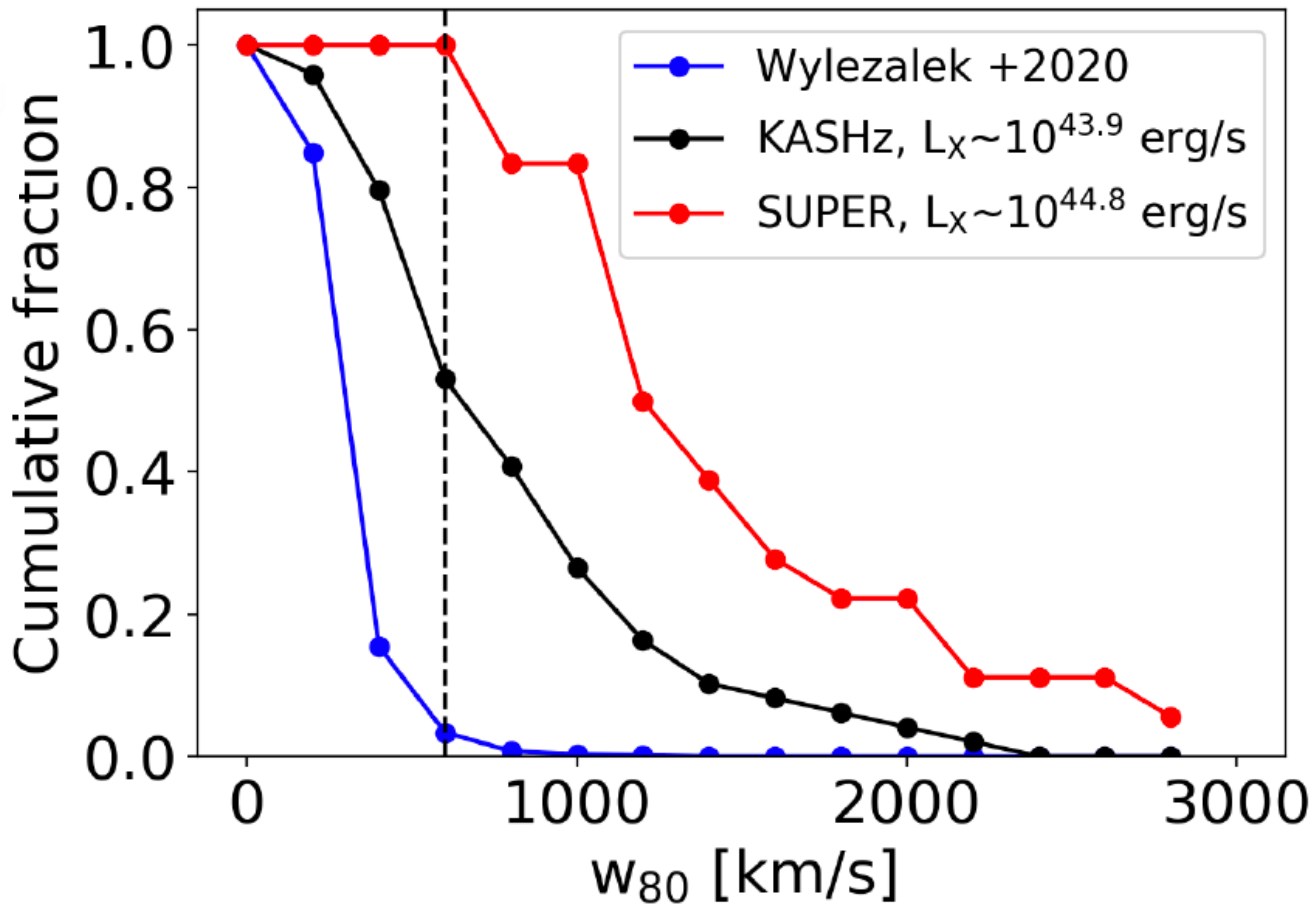
THE SUPER SURVEY



Linking winds in the BLR (<1pc) and NLR (kpc)

Vietri et al. in prep





PI: V. Mainieri

- 280 hours @ VLT/SINFONI (IFS) with AO (~2kpc)
- Blind survey, 40 AGN at z=[2.12-2.49]
- Ionized outflows -> **[OIII] 5007** (H)
- Star formation -> **H** (K)

Demographic of AGN driven outflows at z~2

Kakkad et al. submitted

http://www.super-survey.org

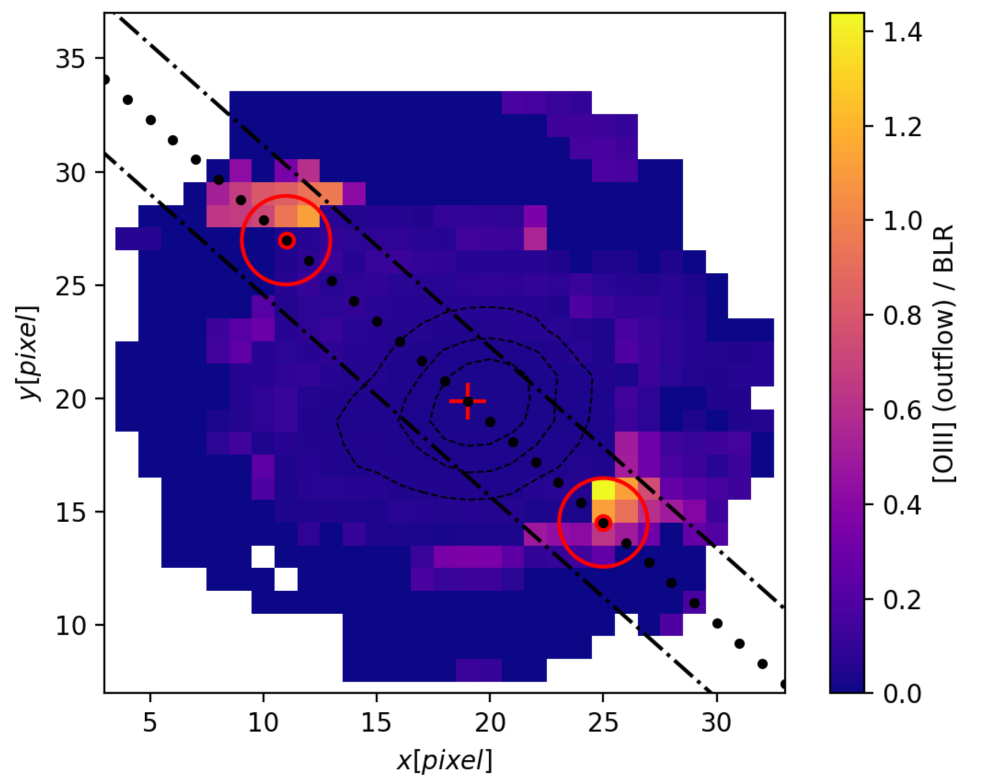
Molecular gas content in AGN host and outflow impact → Circosta et al. submitted

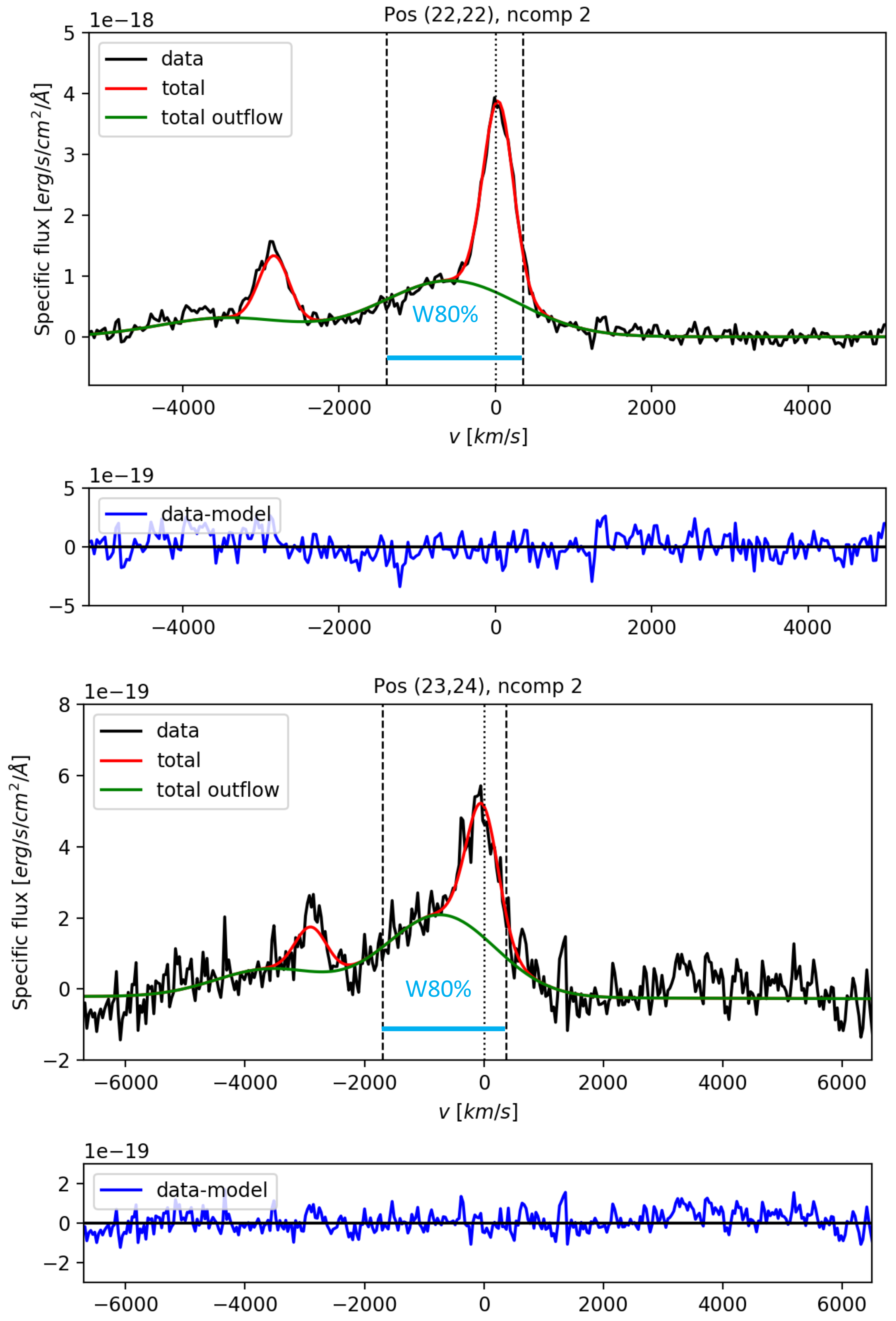
CONNECTING LARGE SCALE WITH NUCLEAR OUTFLOWS AT Z~1.5

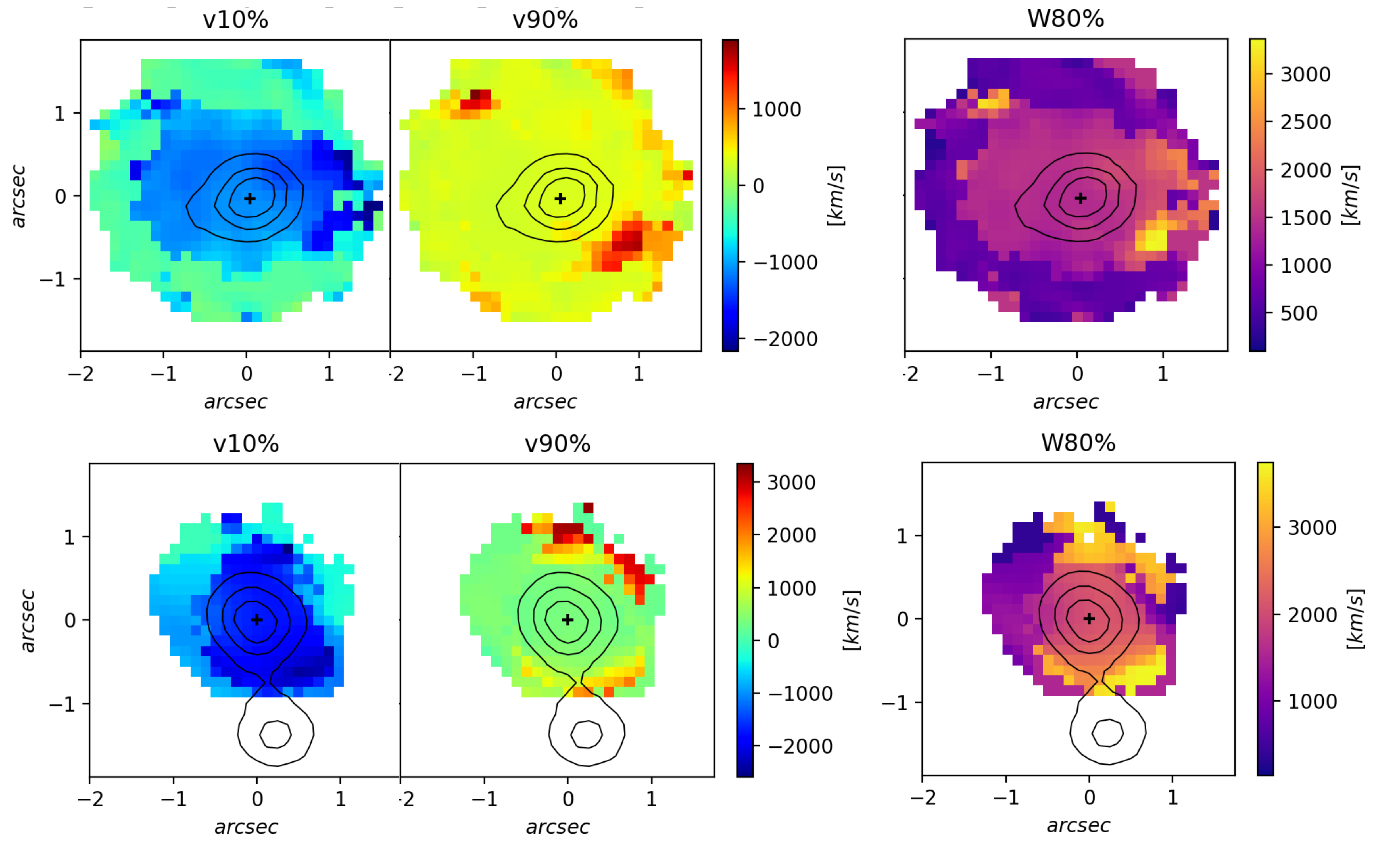
Lensed sources

[OIII] outflow / BLR maps

HS 0810+2554

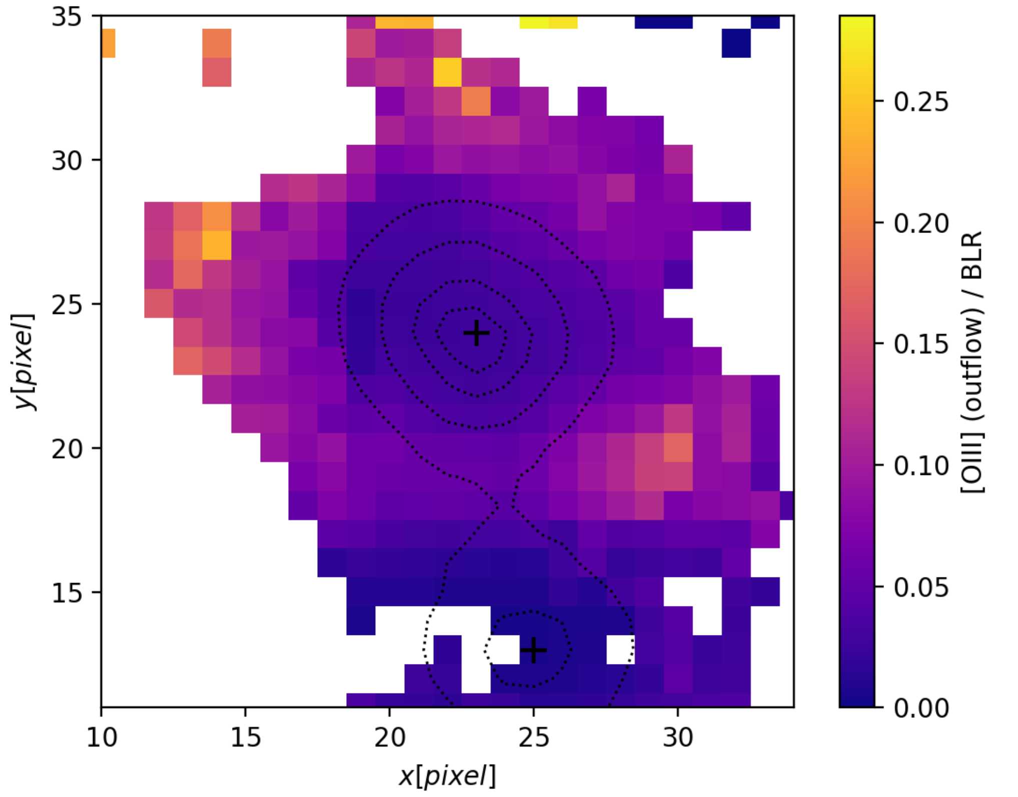


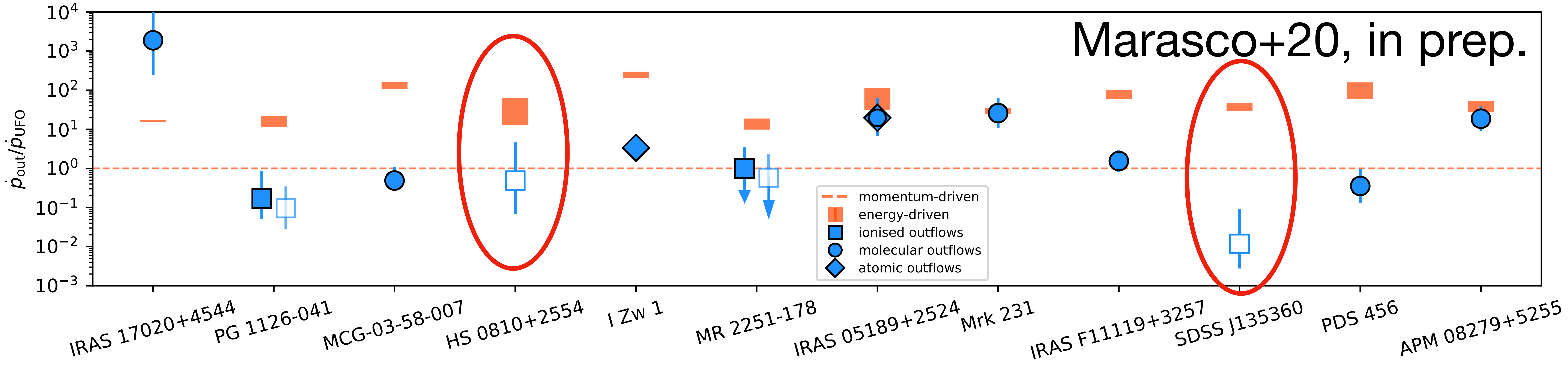




Tozzi+20, in prep.

SDSS J135306

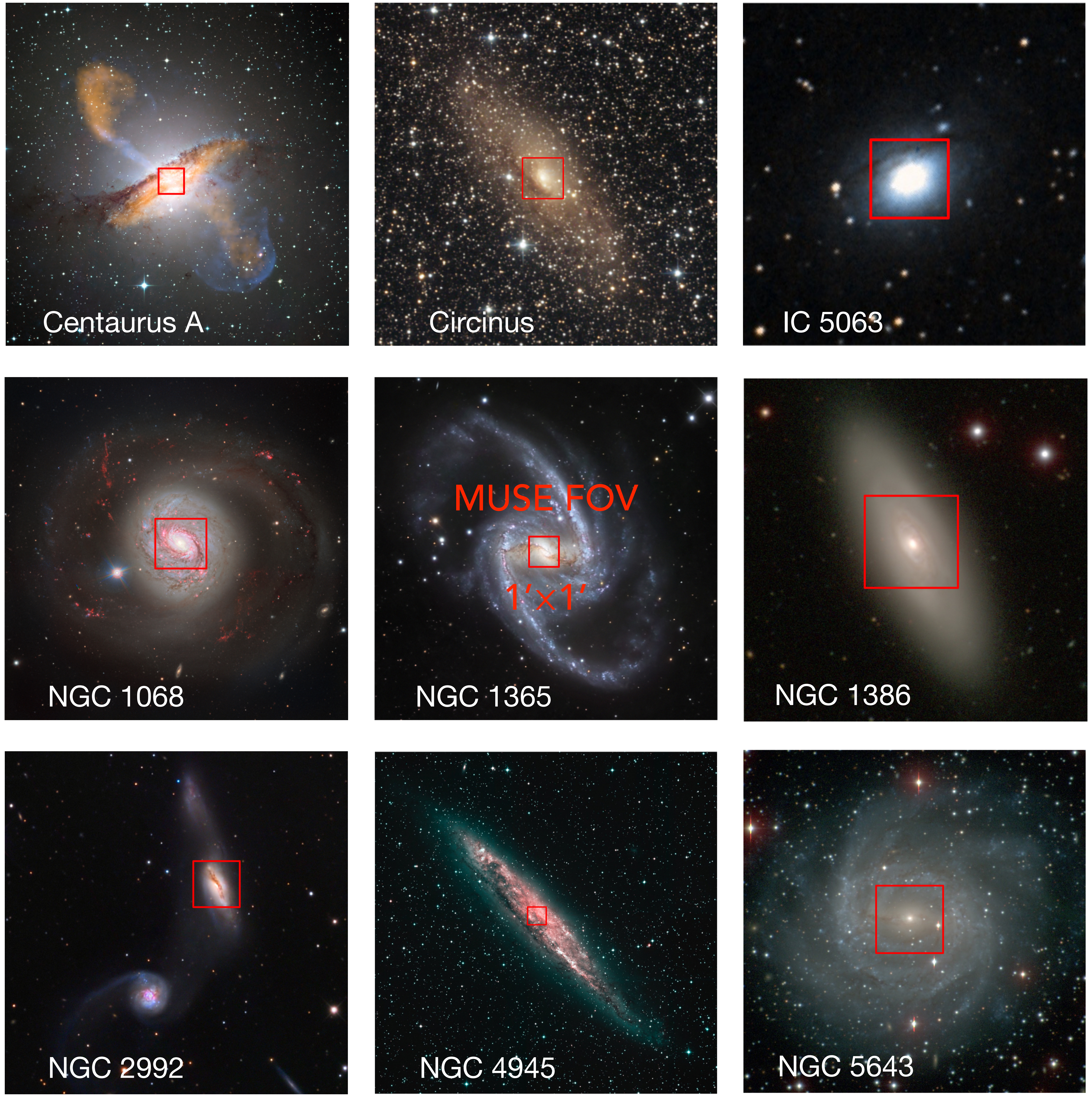




Marasco+20, in prep.

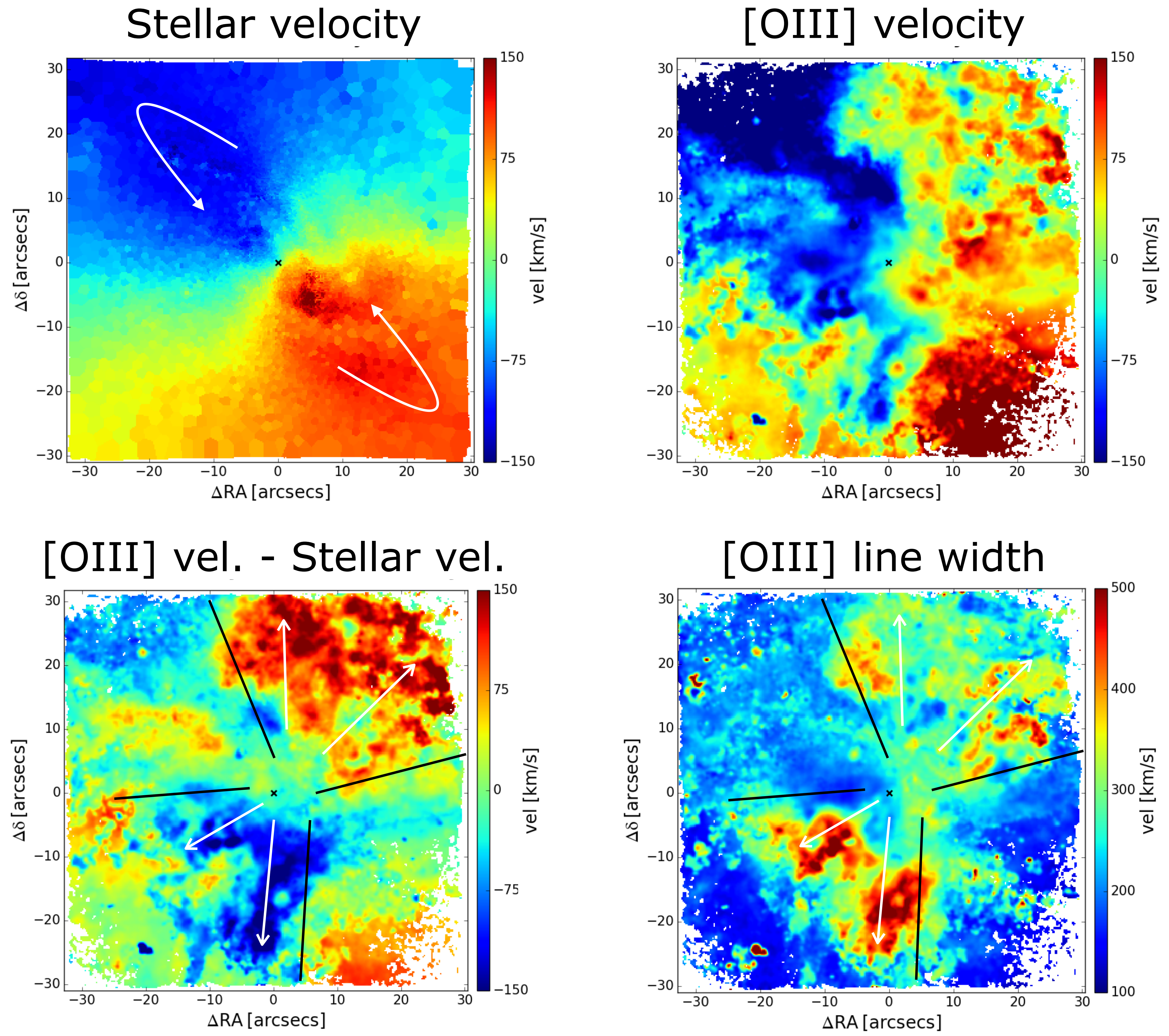
MAGNUM: MEASURING ACTIVE GALACTIC NUCLEI UNDER MUSE MICROSCOPE

- Targeting Nearby AGNs (D < 50 Mpc) with VLT/MUSE
- Seeing limited (~1”):
  15 pc (@4Mpc)
  115 pc (@30Mpc)
- So far 9 objects observed (900,000 spectra!!),
  more to come
- Multi-wavelength data available:
  Chandra, XMM-Newton, Galex, HST, Spitzer, Herschel, ALMA, Radio…



NGC 1365: DOUBLE-CONICAL OUTFLOW

Outflow spatially traced by motions deviating from rotation



Venturi et al. 2018

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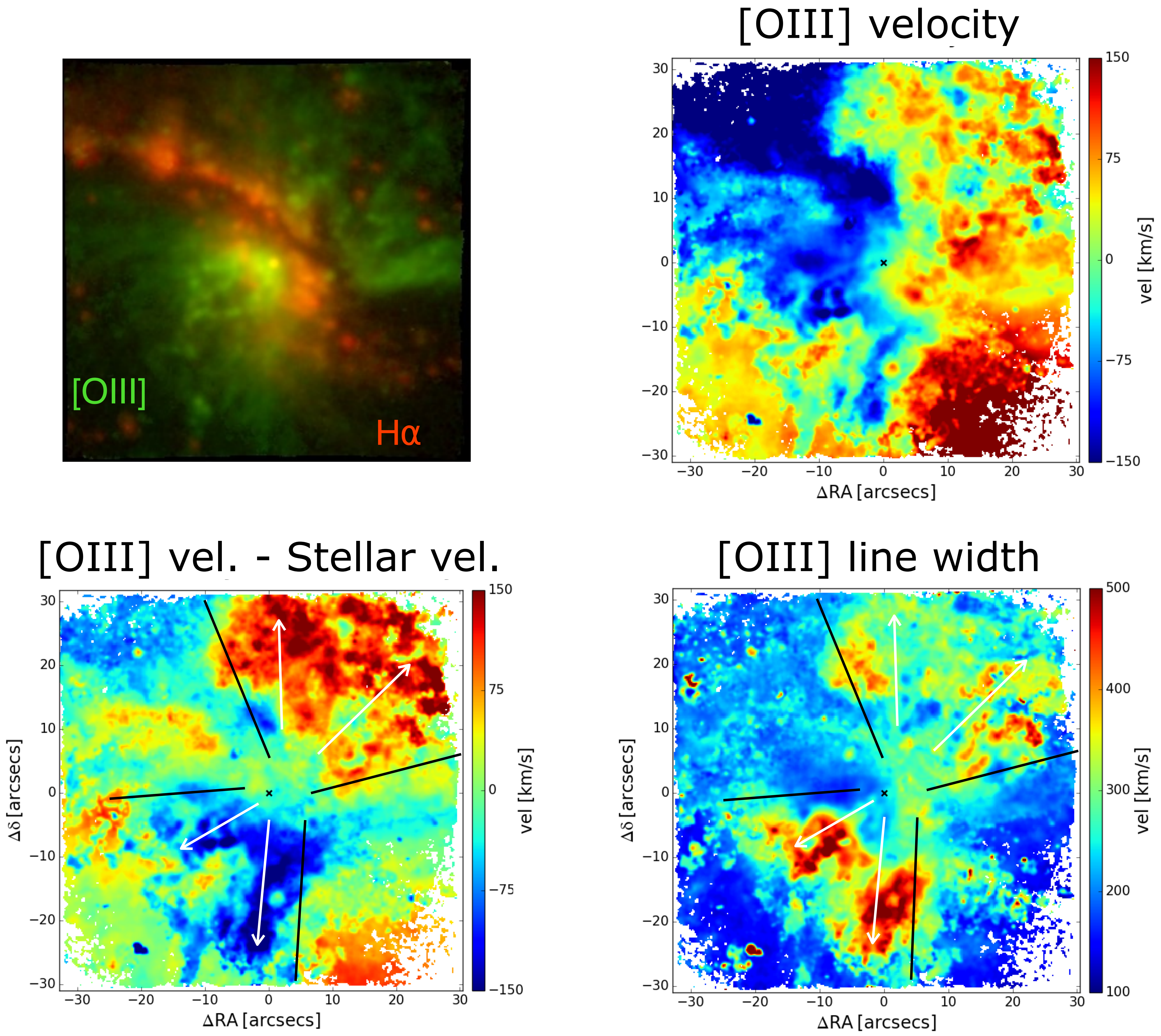

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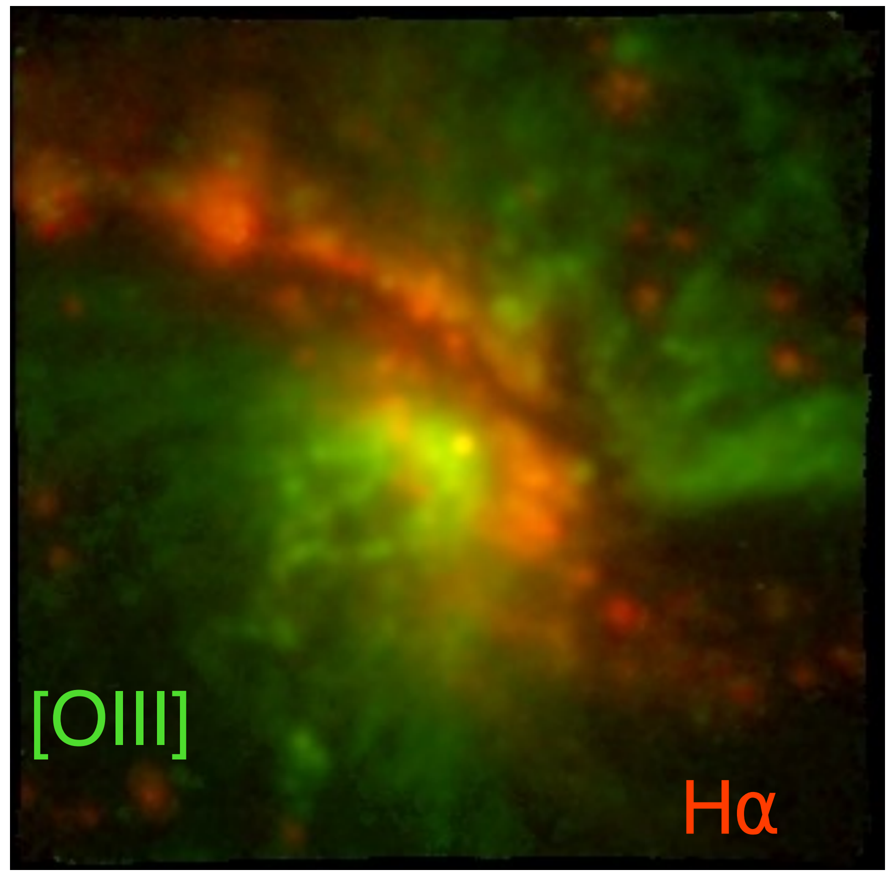
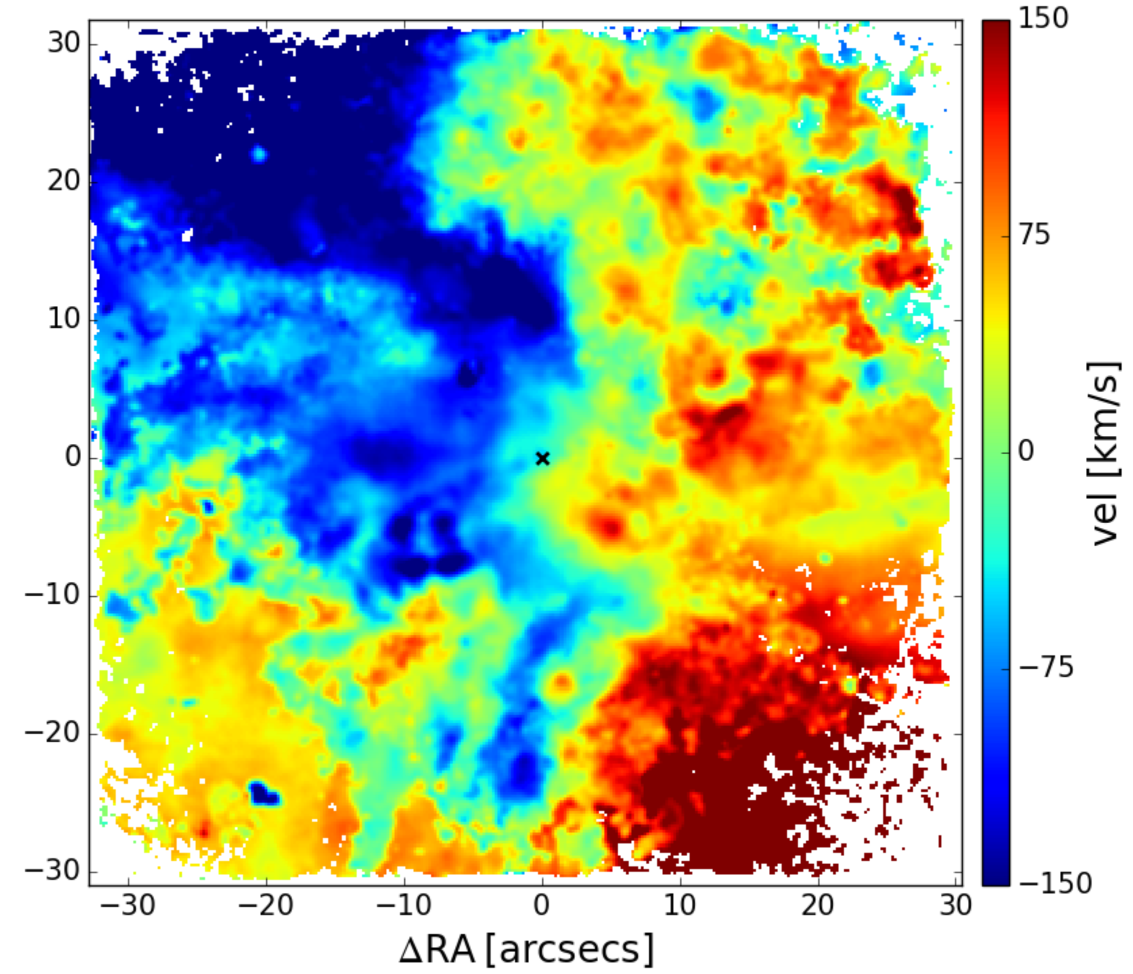
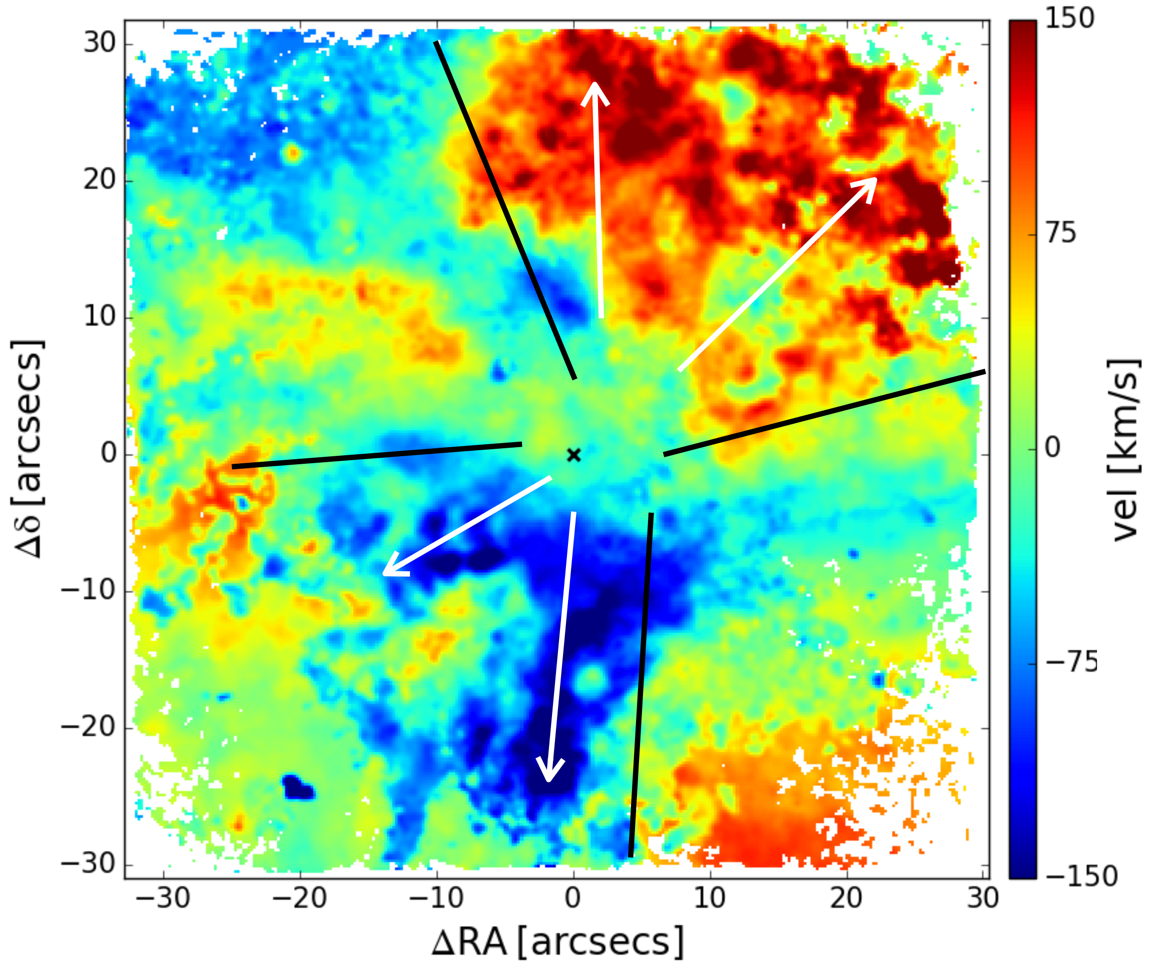


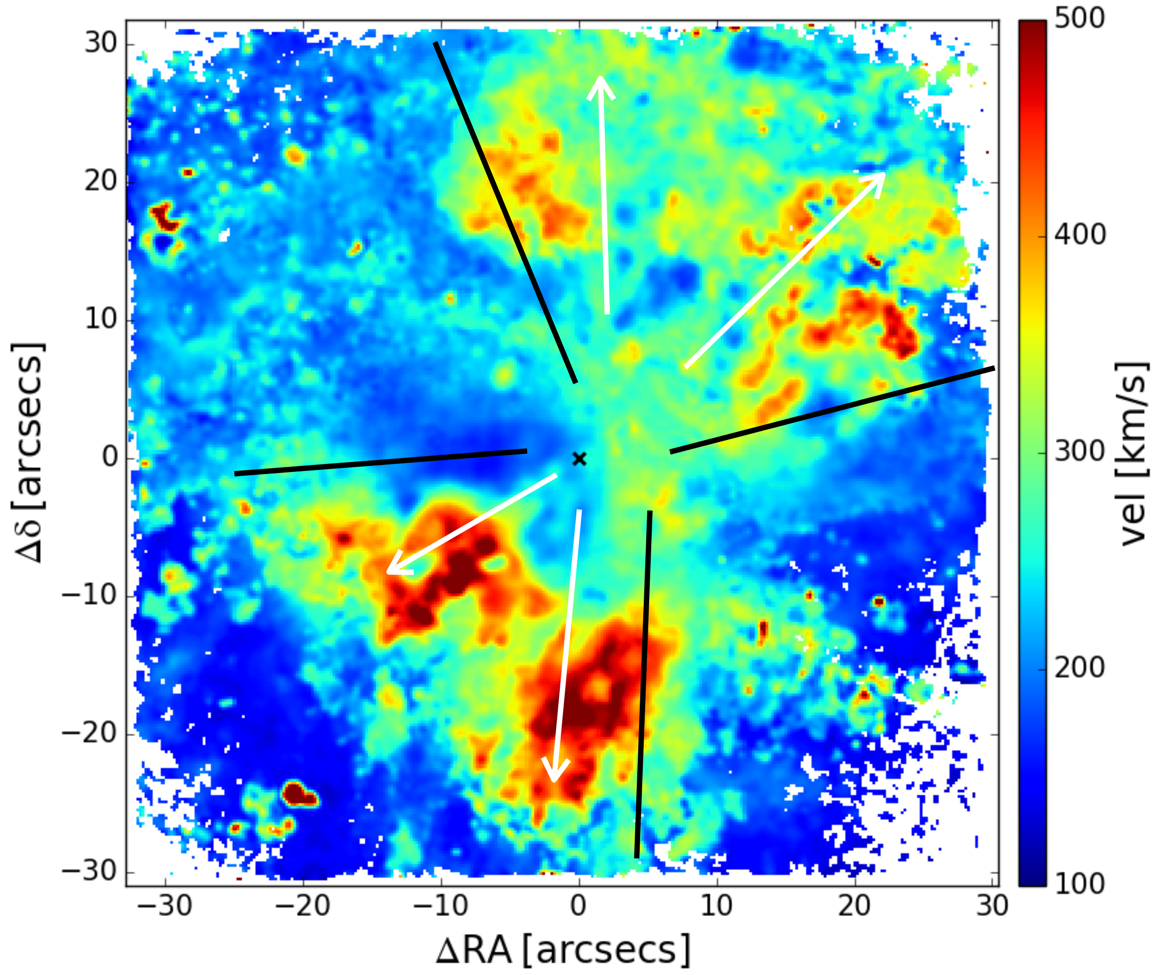
[OIII] velocity

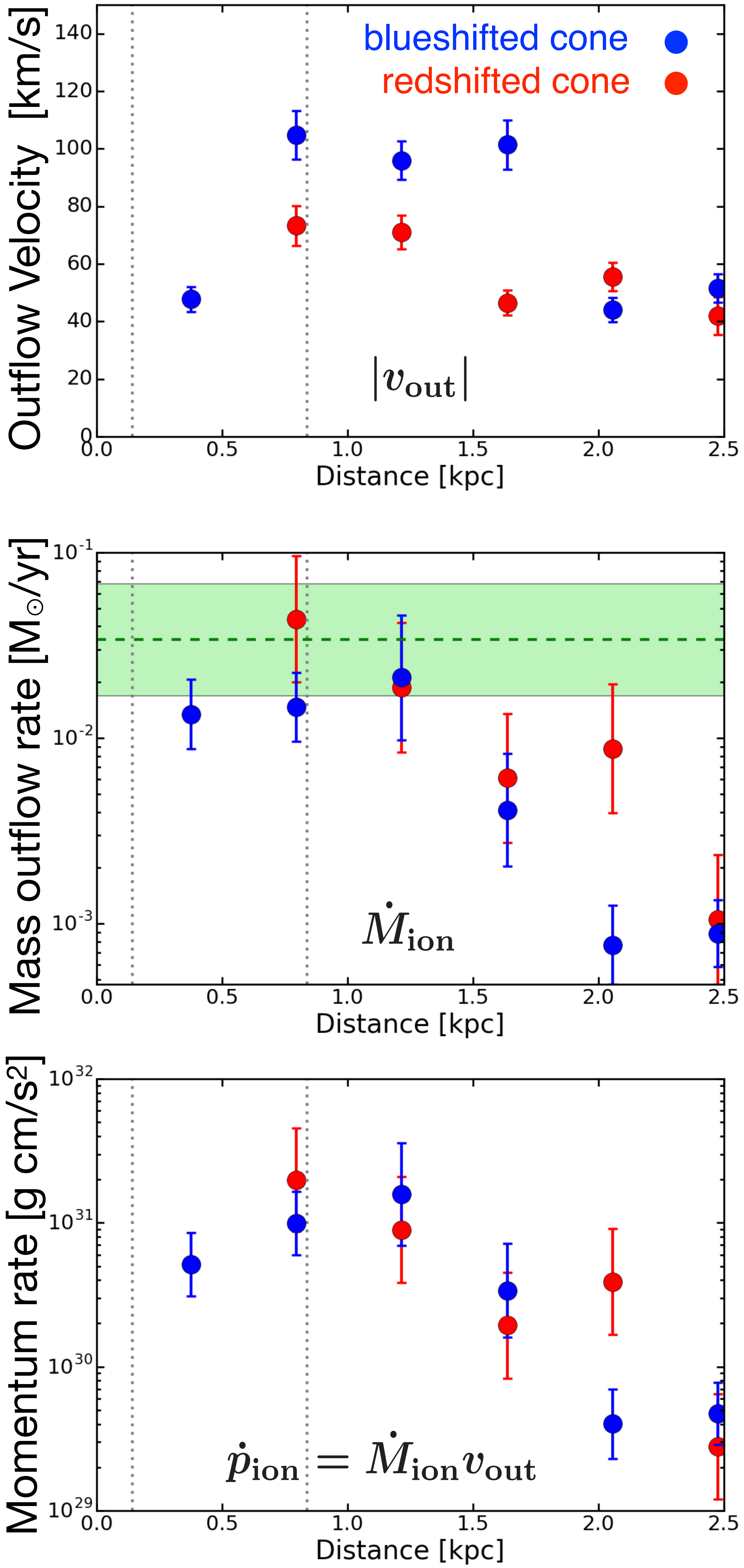


[OIII] vel. - Stellar vel.



[OIII] line width





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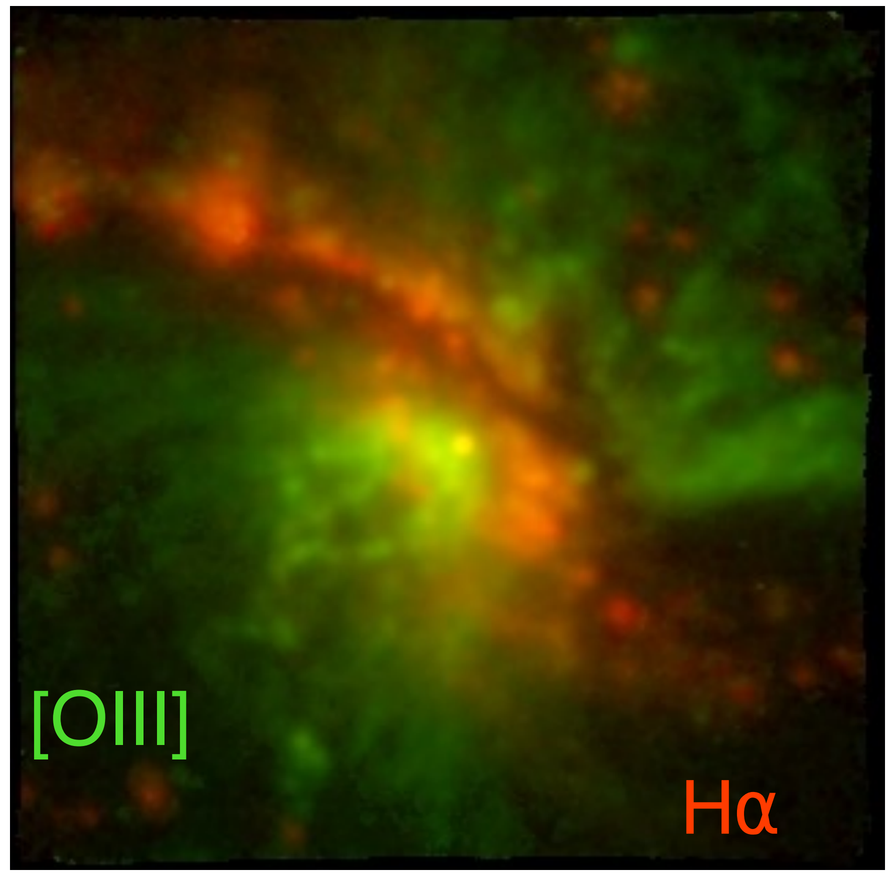

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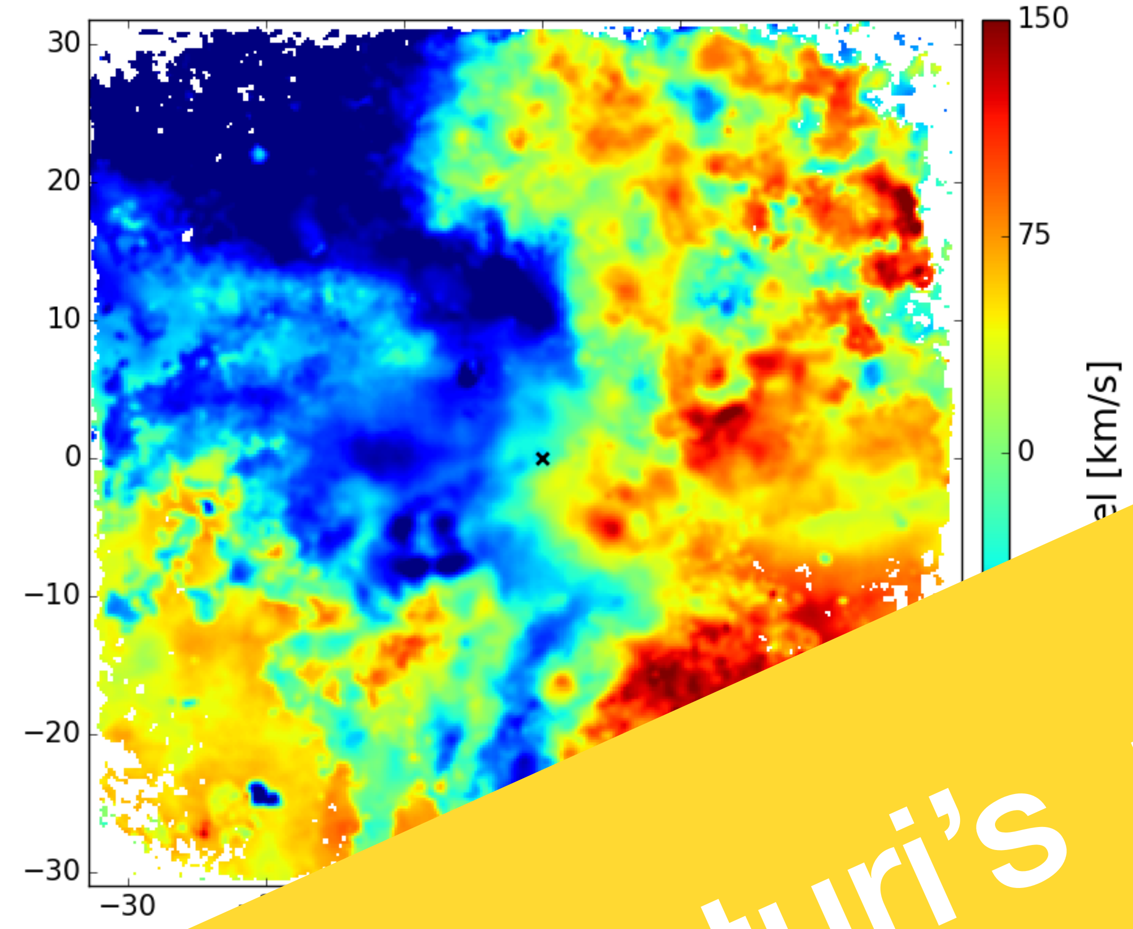

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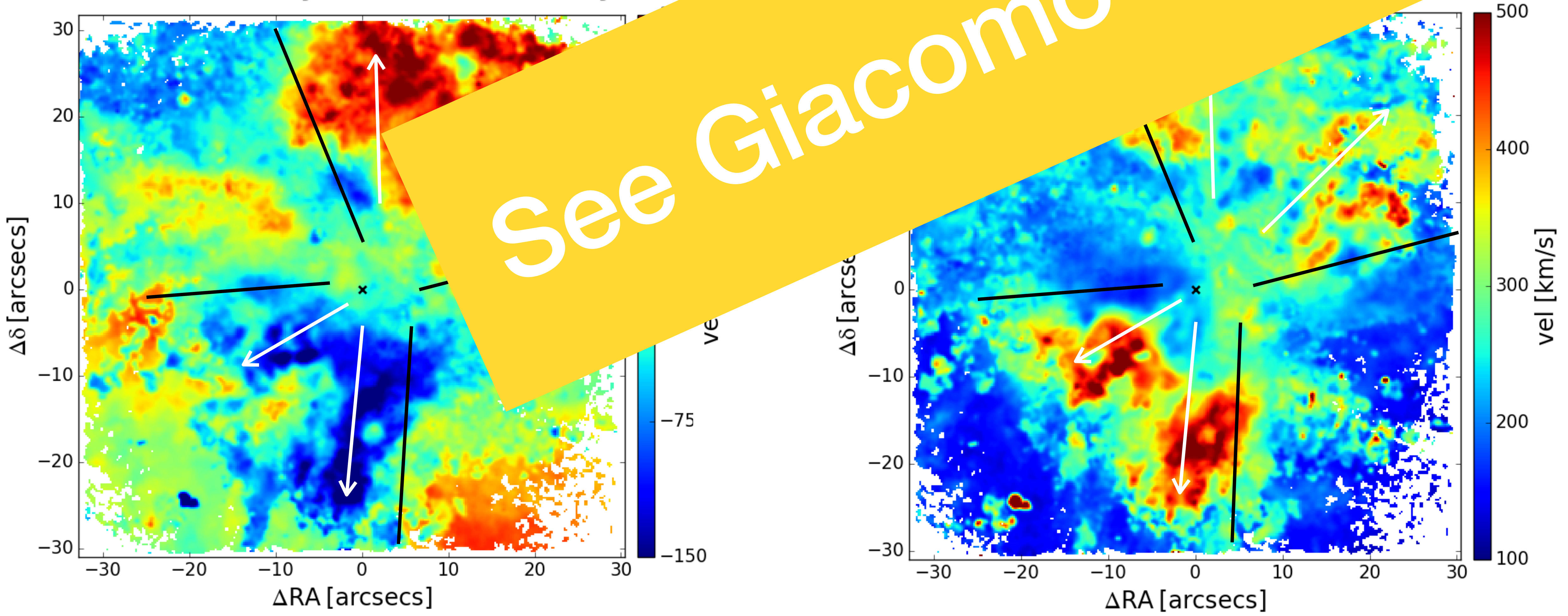
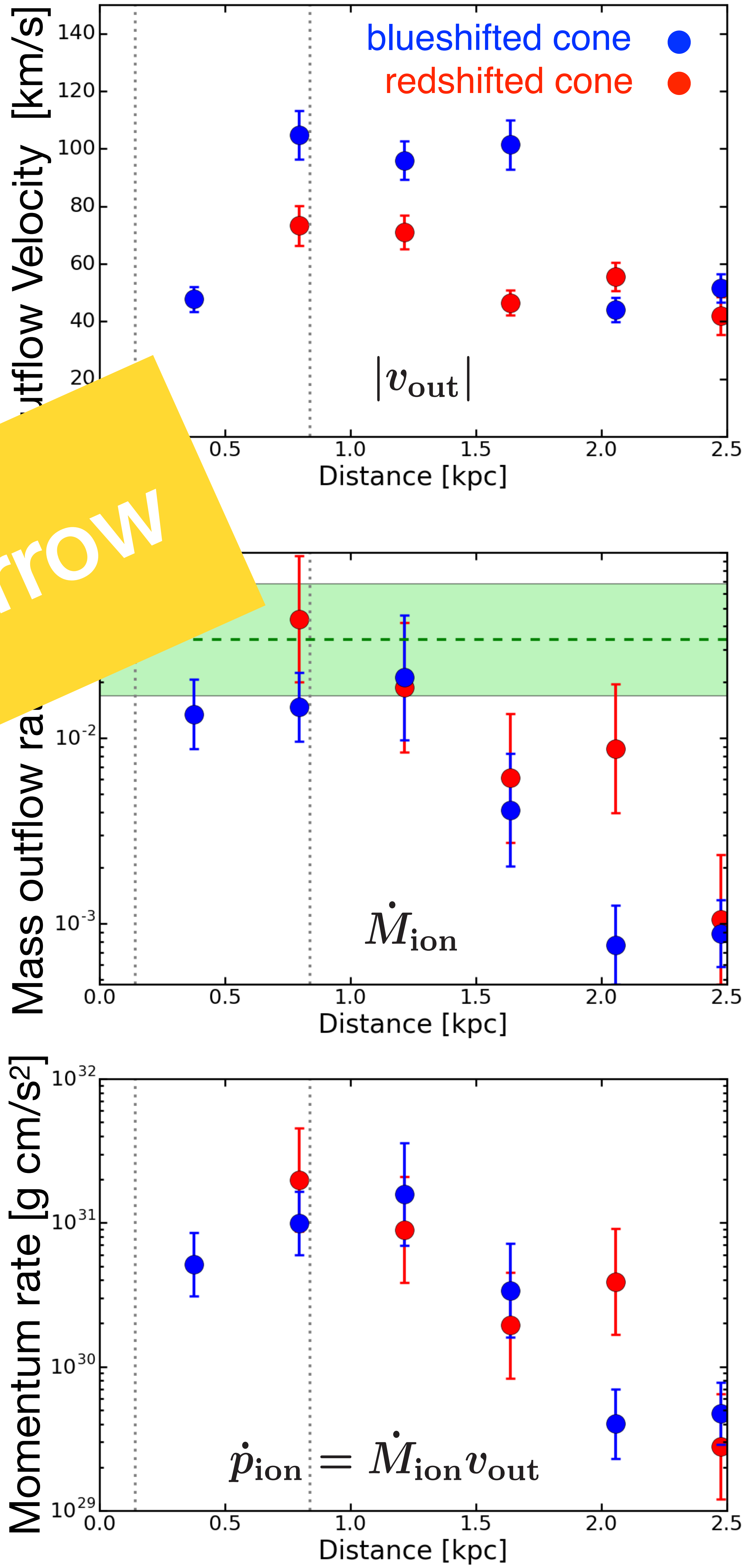


See Giacomo Venturi's talk tomorrow

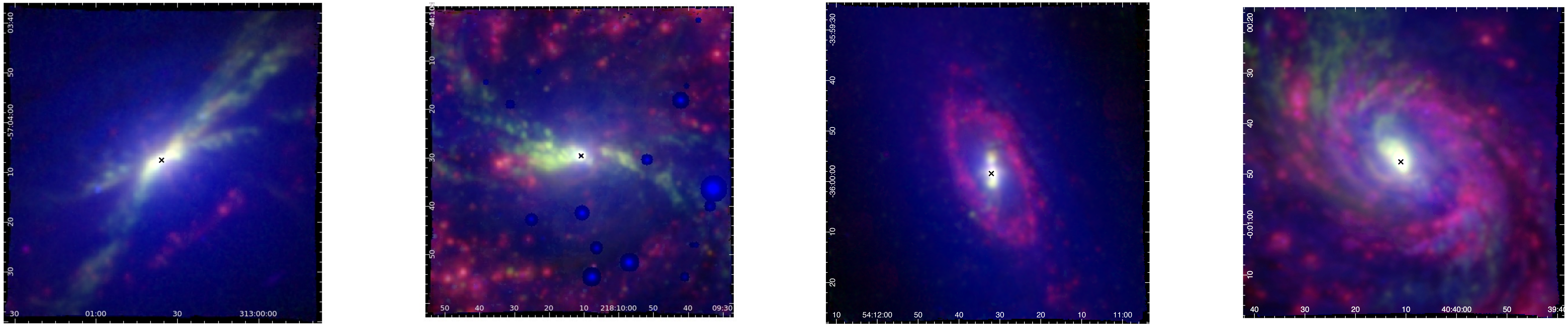


Venturi et al. 2018

OUTFLOWS VS JETS

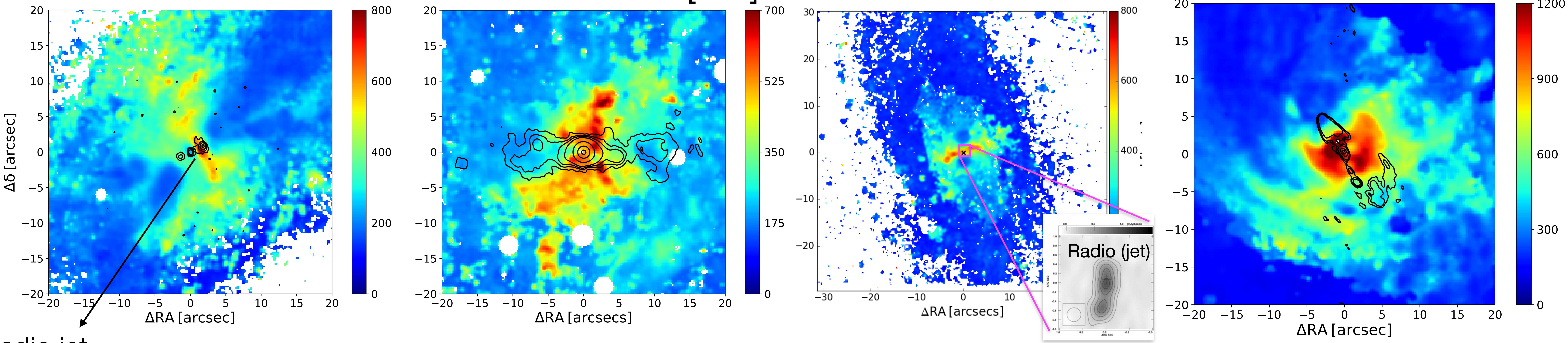
Green: [OIII] Red: Hα Blue: stars

IC 5063 FOV ~ 14 kpc **NGC 5643** FOV ~ 5 kpc **NGC 1386** FOV ~ 5 kpc **NGC 1068** FOV ~ 3.3 kpc



[OIII] W70

Venturi et al. 20, in prep.



Radio jet contours

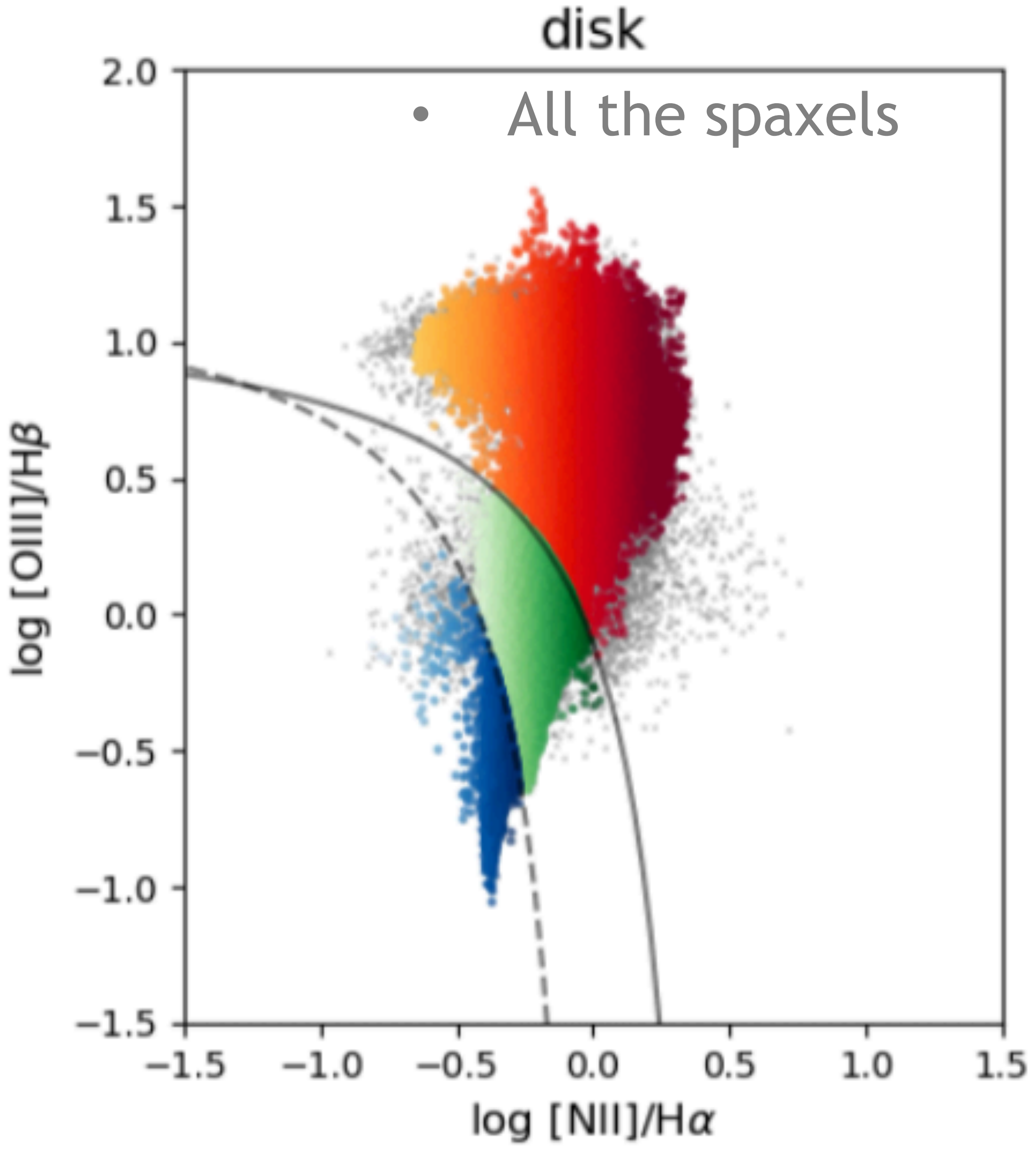
Broad linewidths (outflows/turbulence) perpendicular to AGN cones and radio jet!

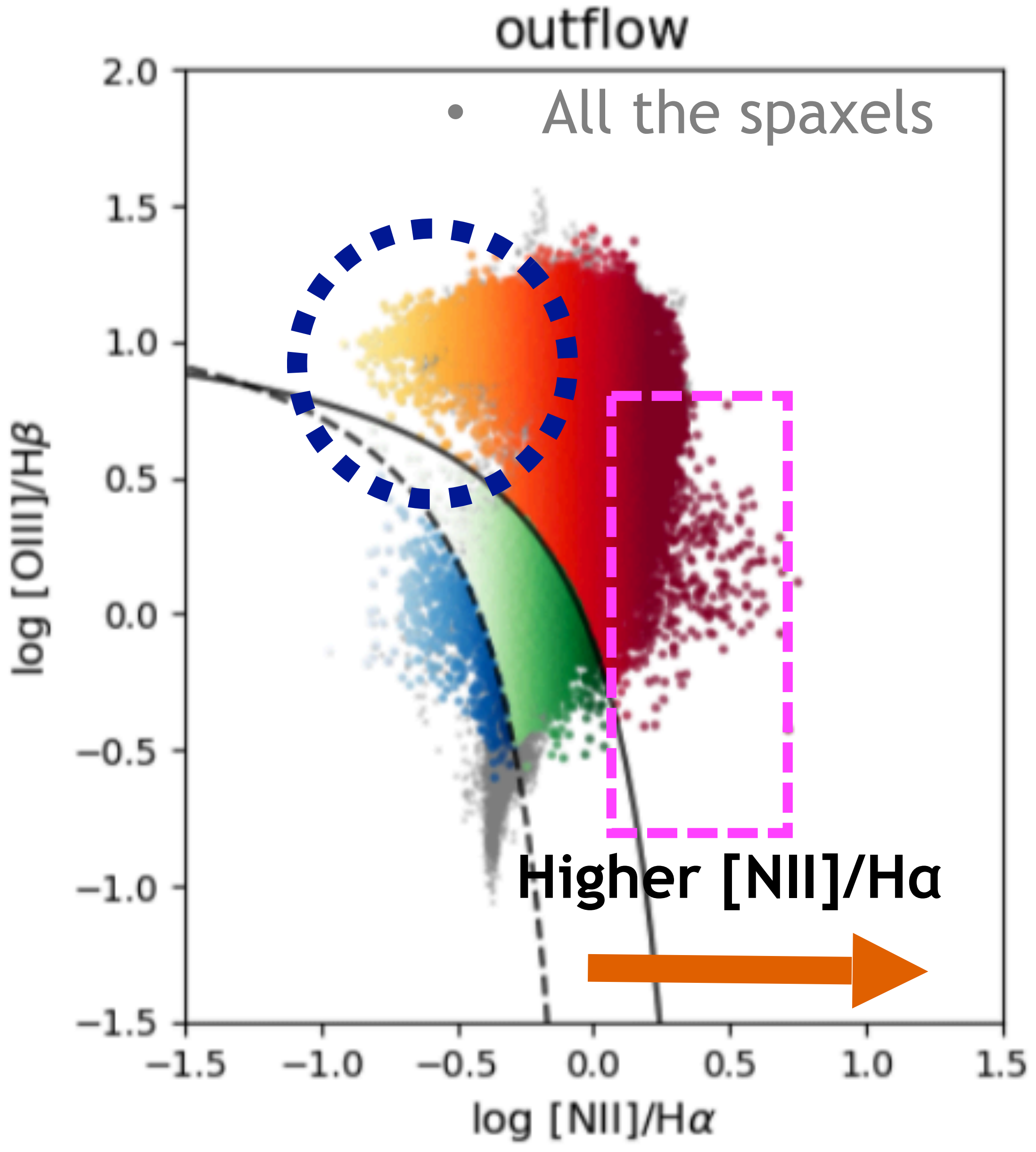
OUTFLOWS VS JETS

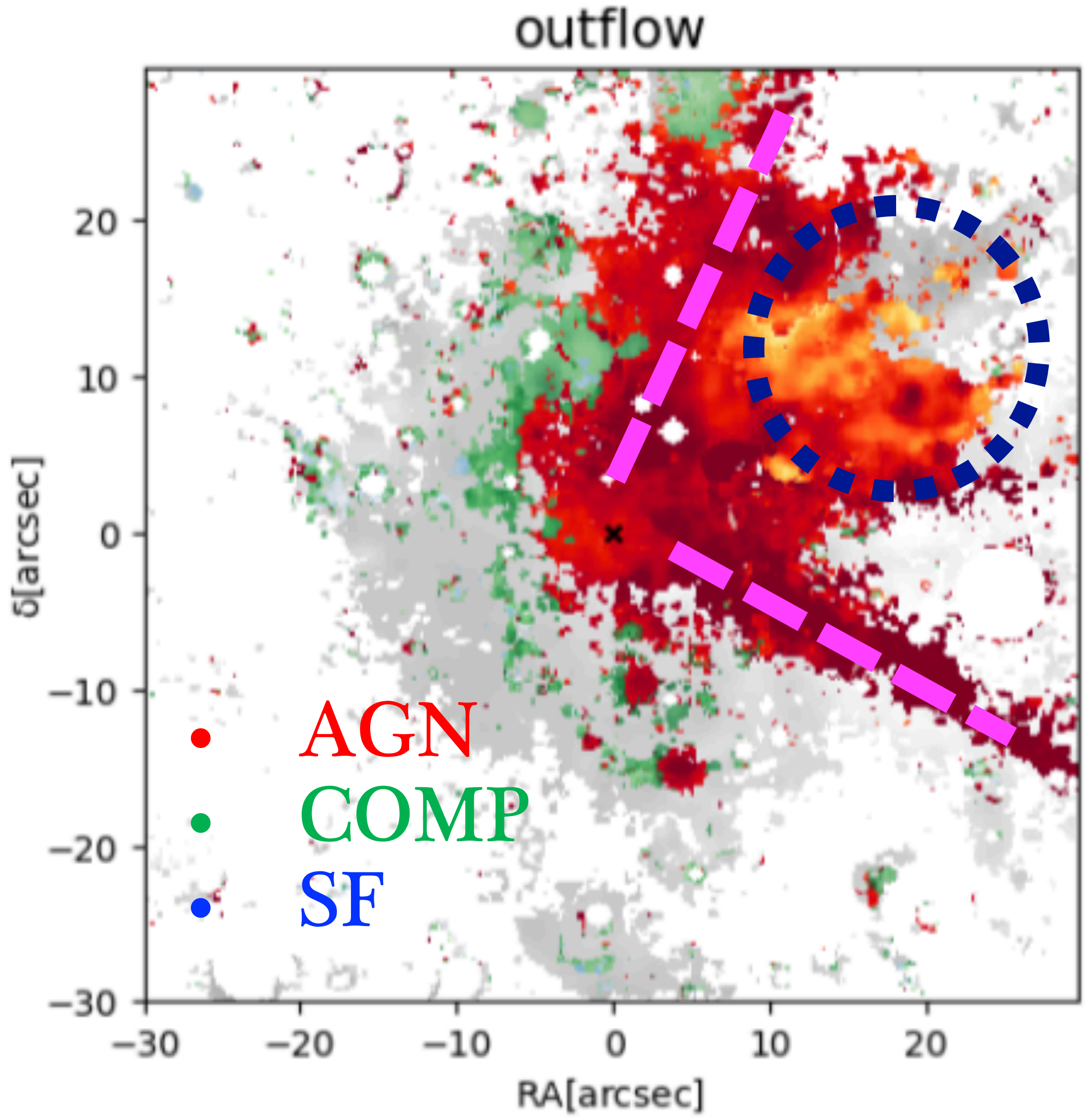
Green: [OIII] Red: Hα Blue: stars

Broad linewidths (outflows/turbulence) perpendicular to AGN cones and radio jet!

DISENTANGLING OUTFLOW AND DISK PROPERTIES

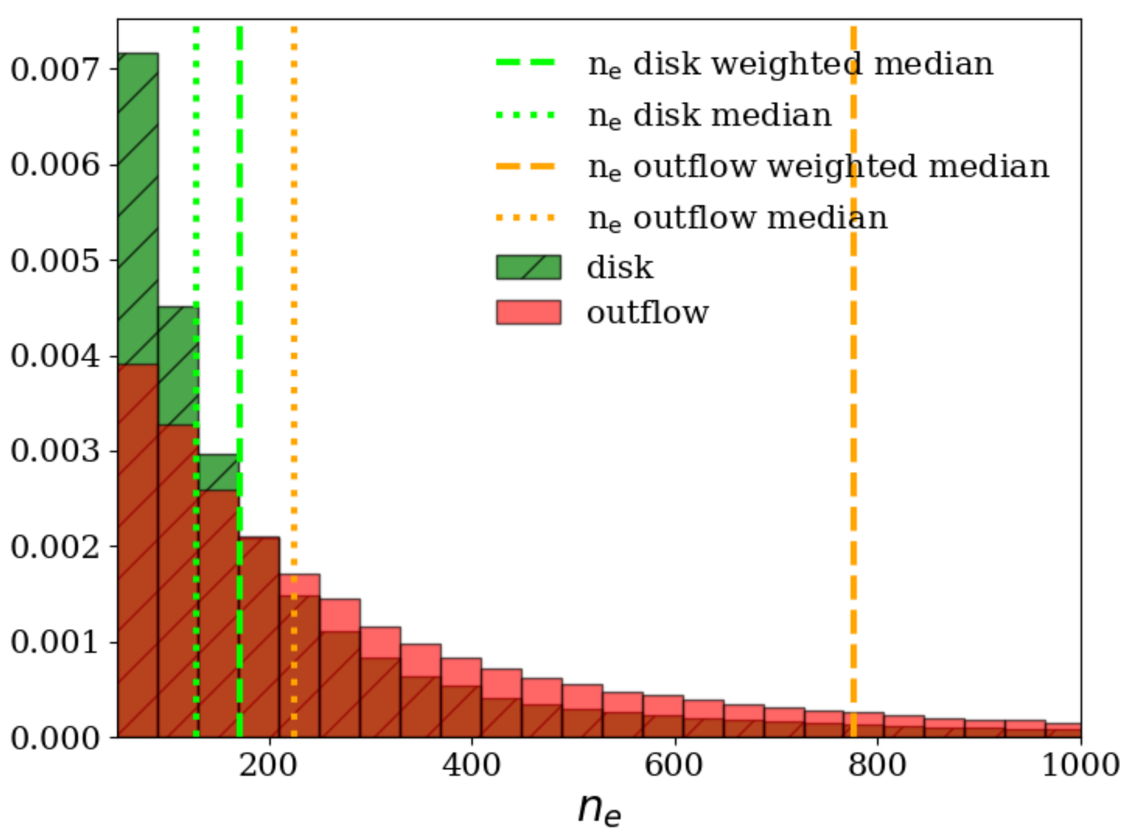




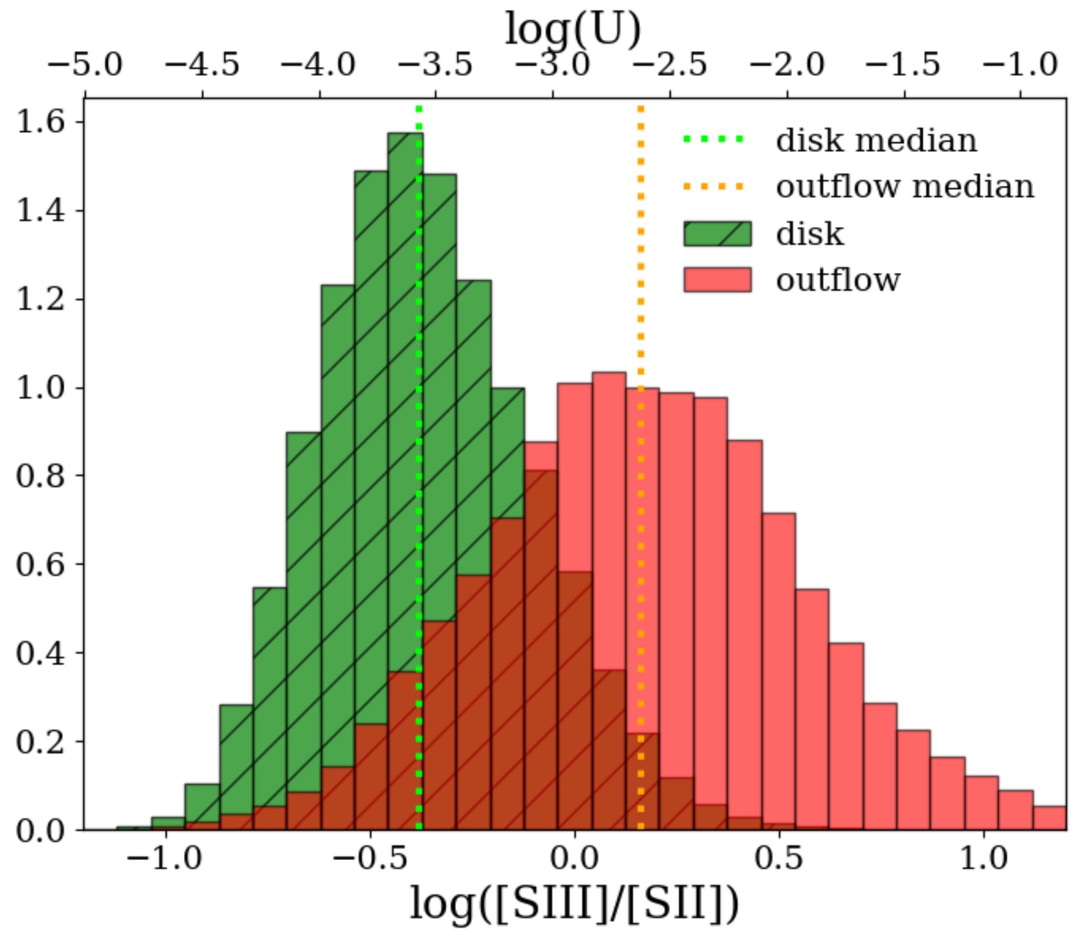


Velocity-resolved BPT diagrams

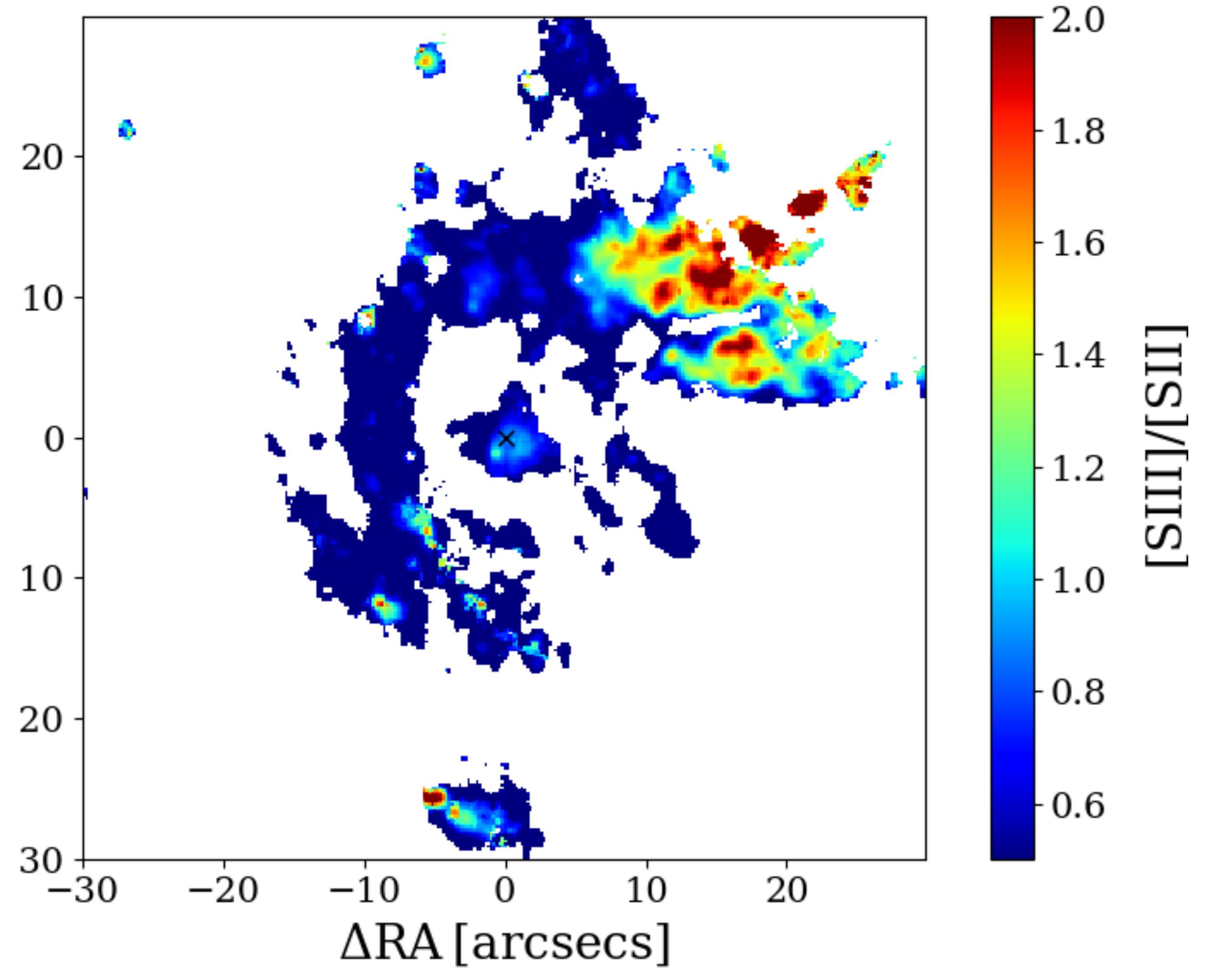
ELECTRON DENSITY n_e



IONISATION PARAMETER



Circinus: [SIII]/[SII]



Lowest [NII]/Hα corresponds to Highest [SIII]/[SII]

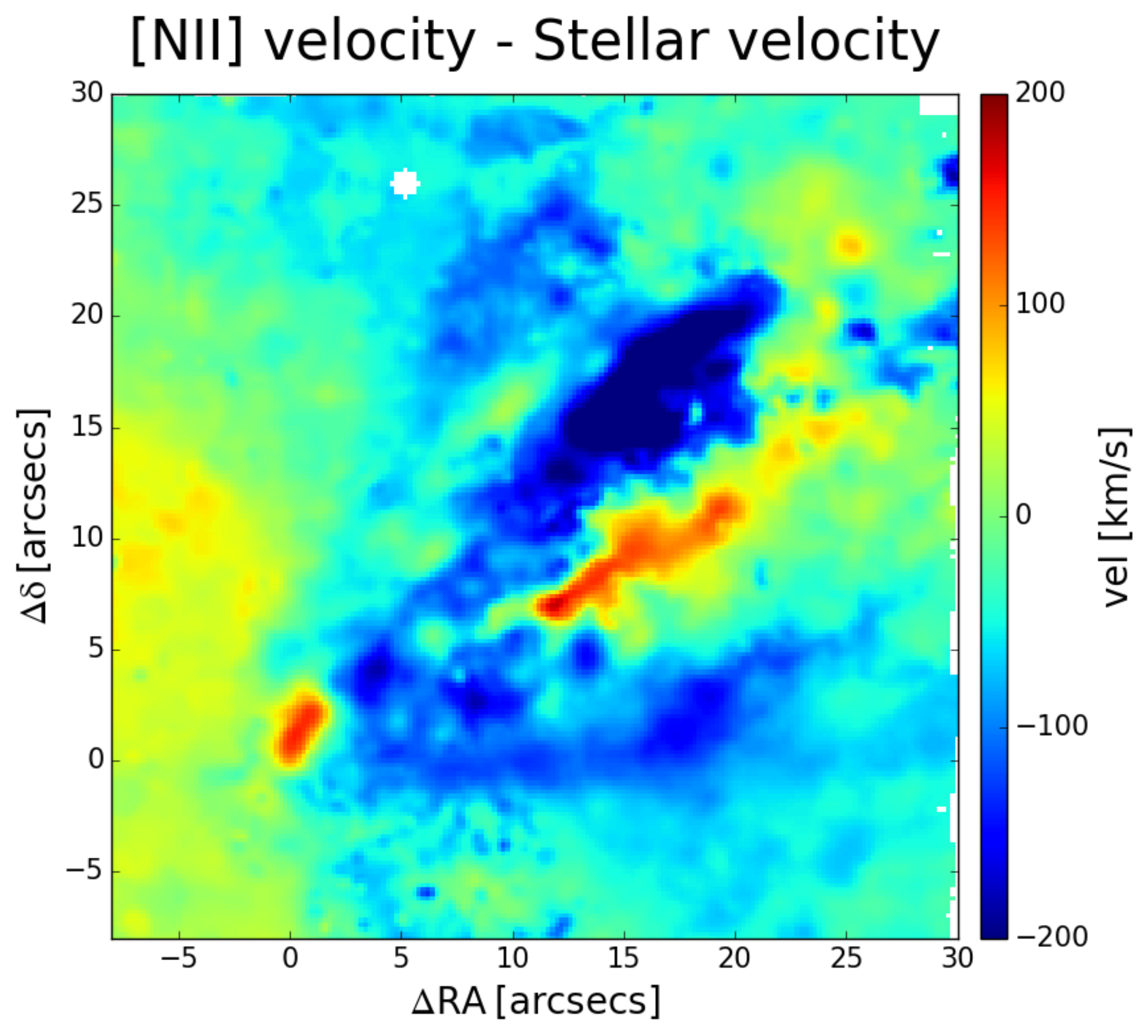
⇓

Highest ionisation in the inner regions of the outflow

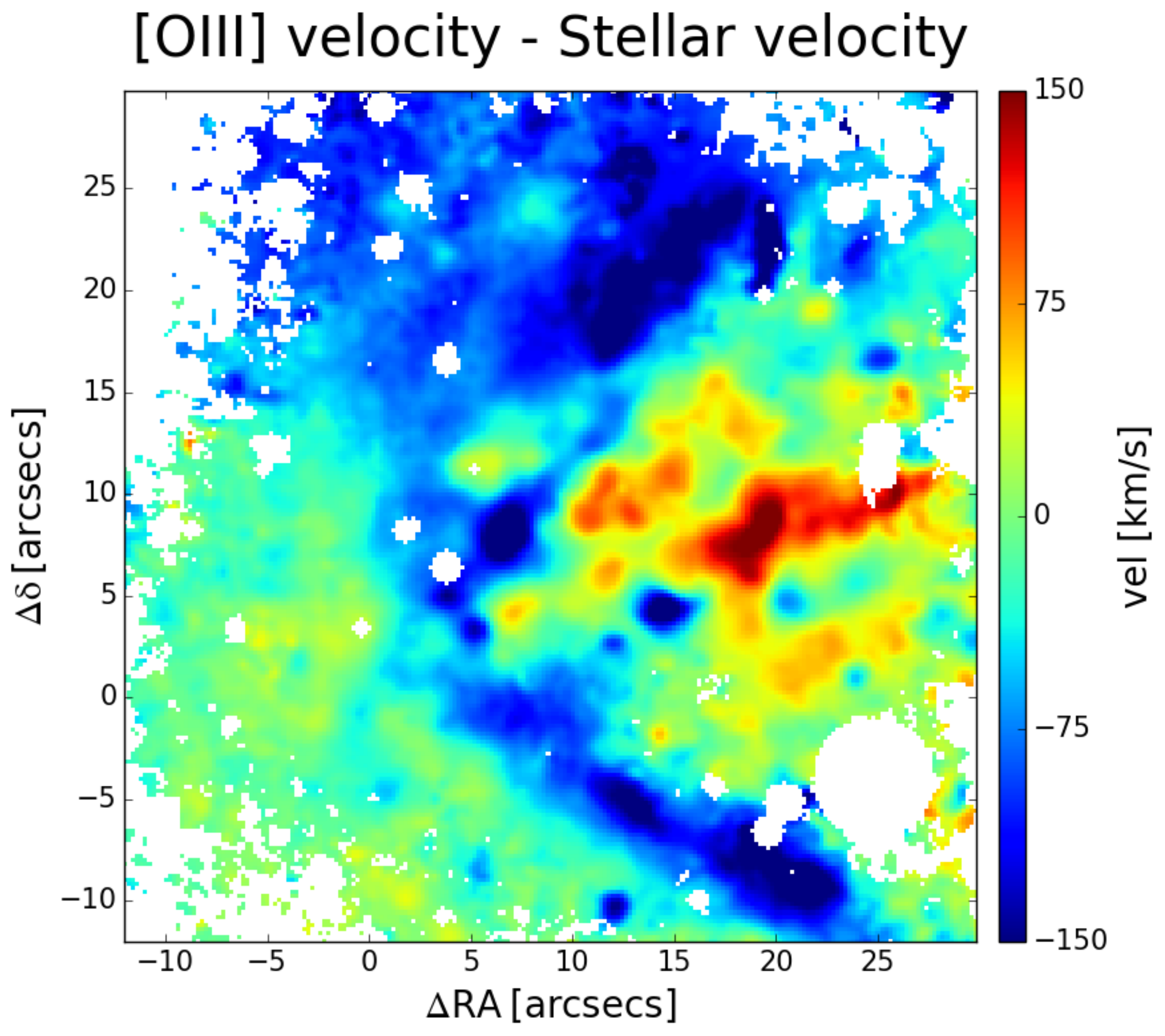
Mingozzi et al. 2019

MAGNUM SURVEY: OUTFLOW STRUCTURE

NGC 4945



Circinus



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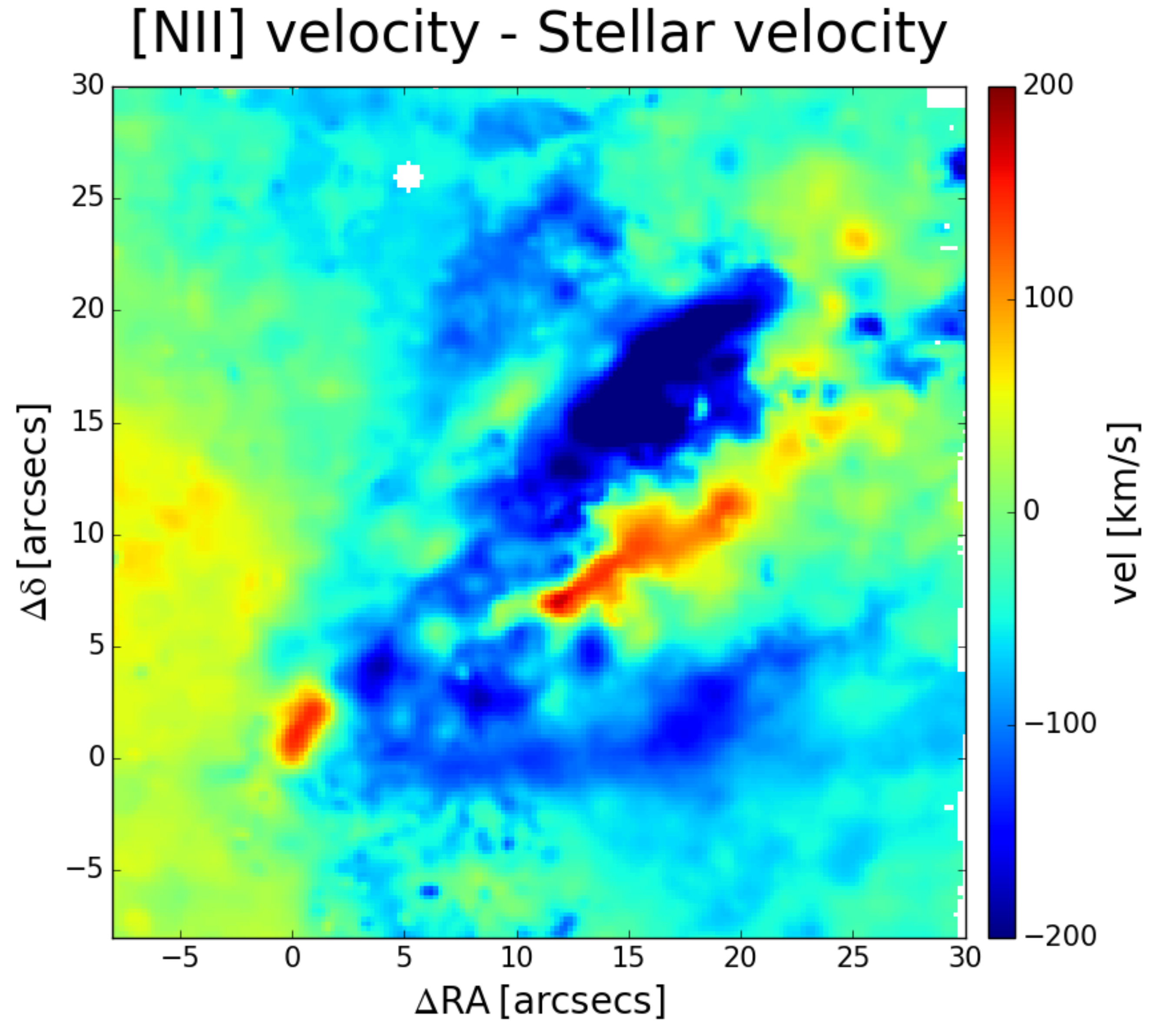
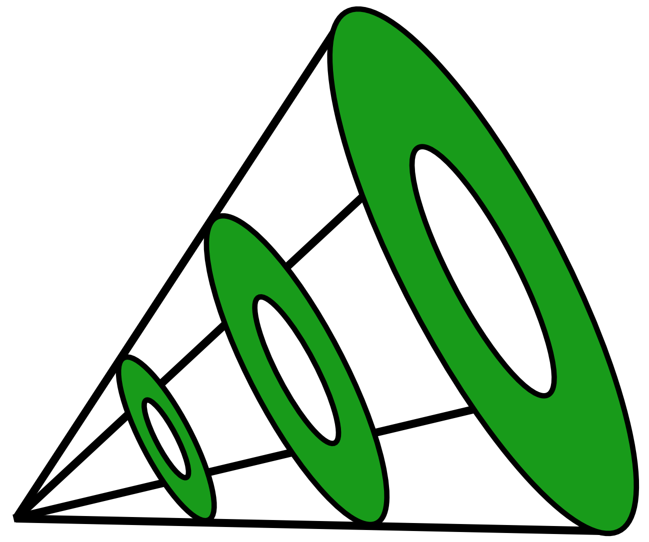
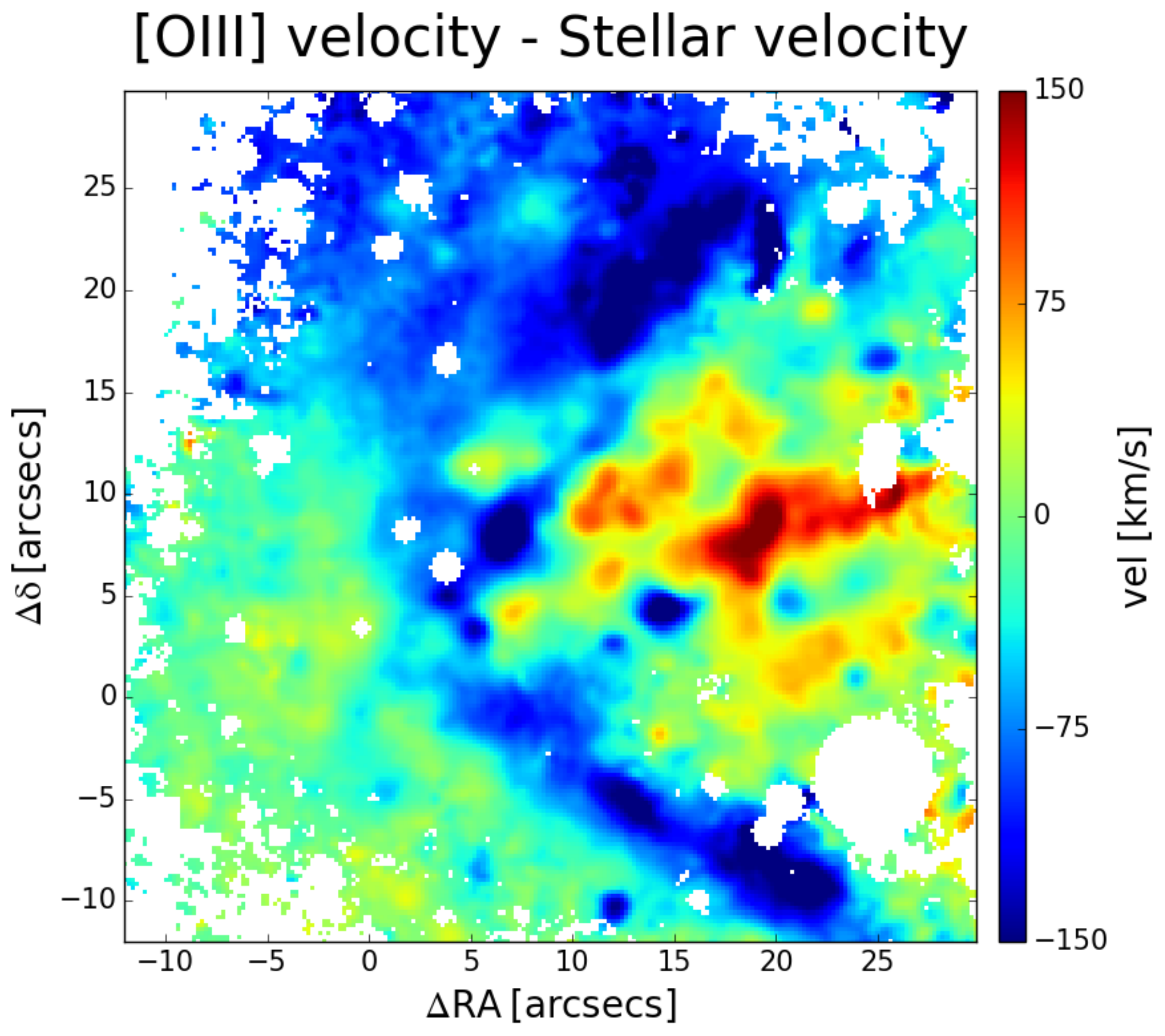


A hollow conical outflow?



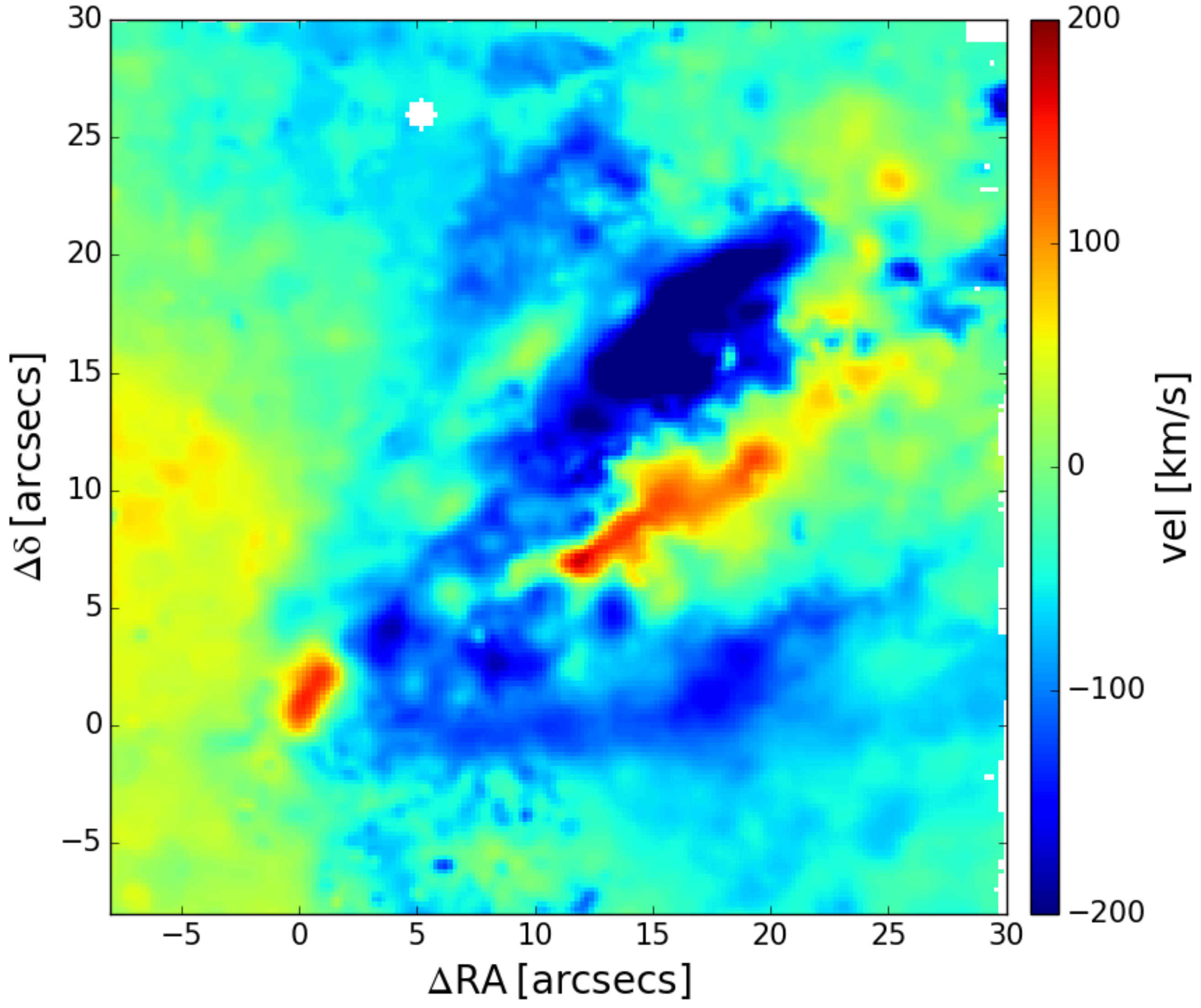
Circinus



MAGNUM SURVEY: OUTFLOW STRUCTURE

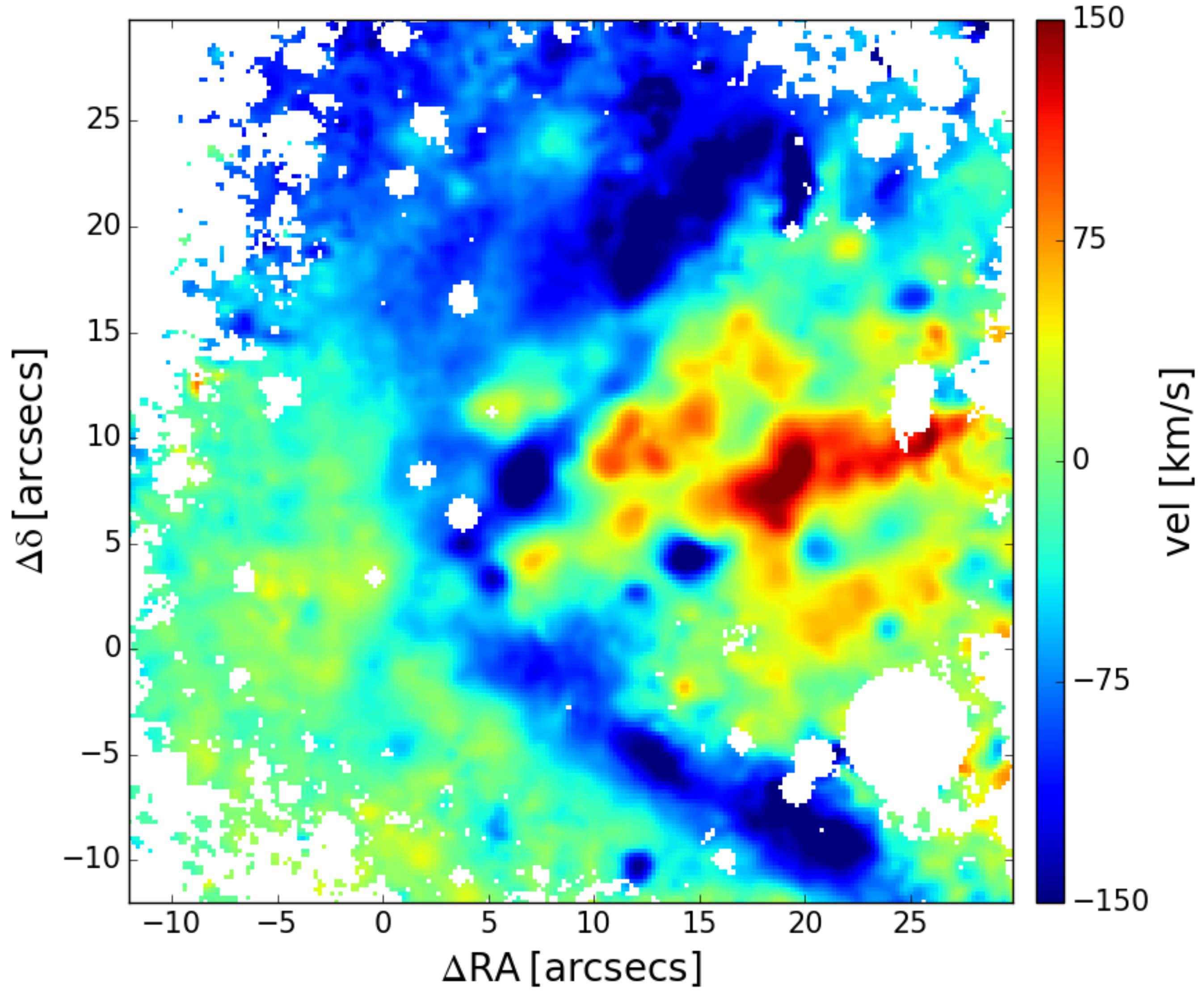
NGC 4945

[NII] velocity - Stellar velocity



Circinus

[OIII] velocity - Stellar velocity



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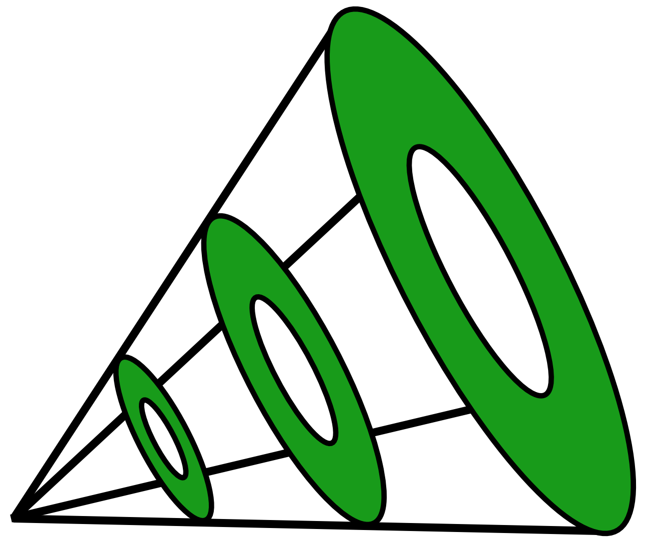
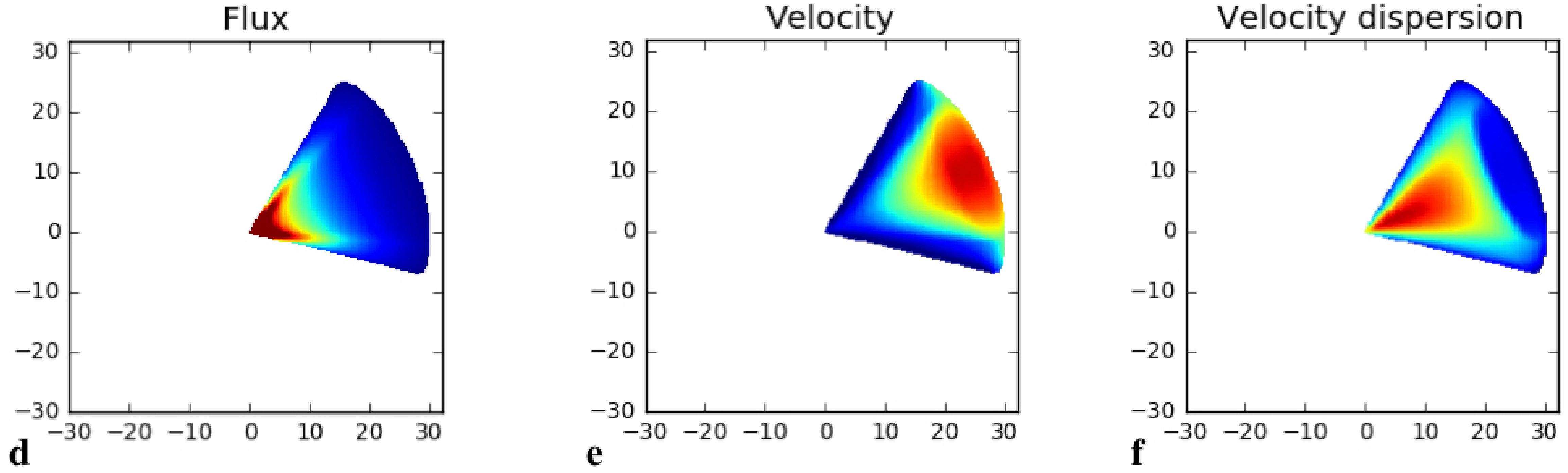


A simple kinematical model: hollow cone



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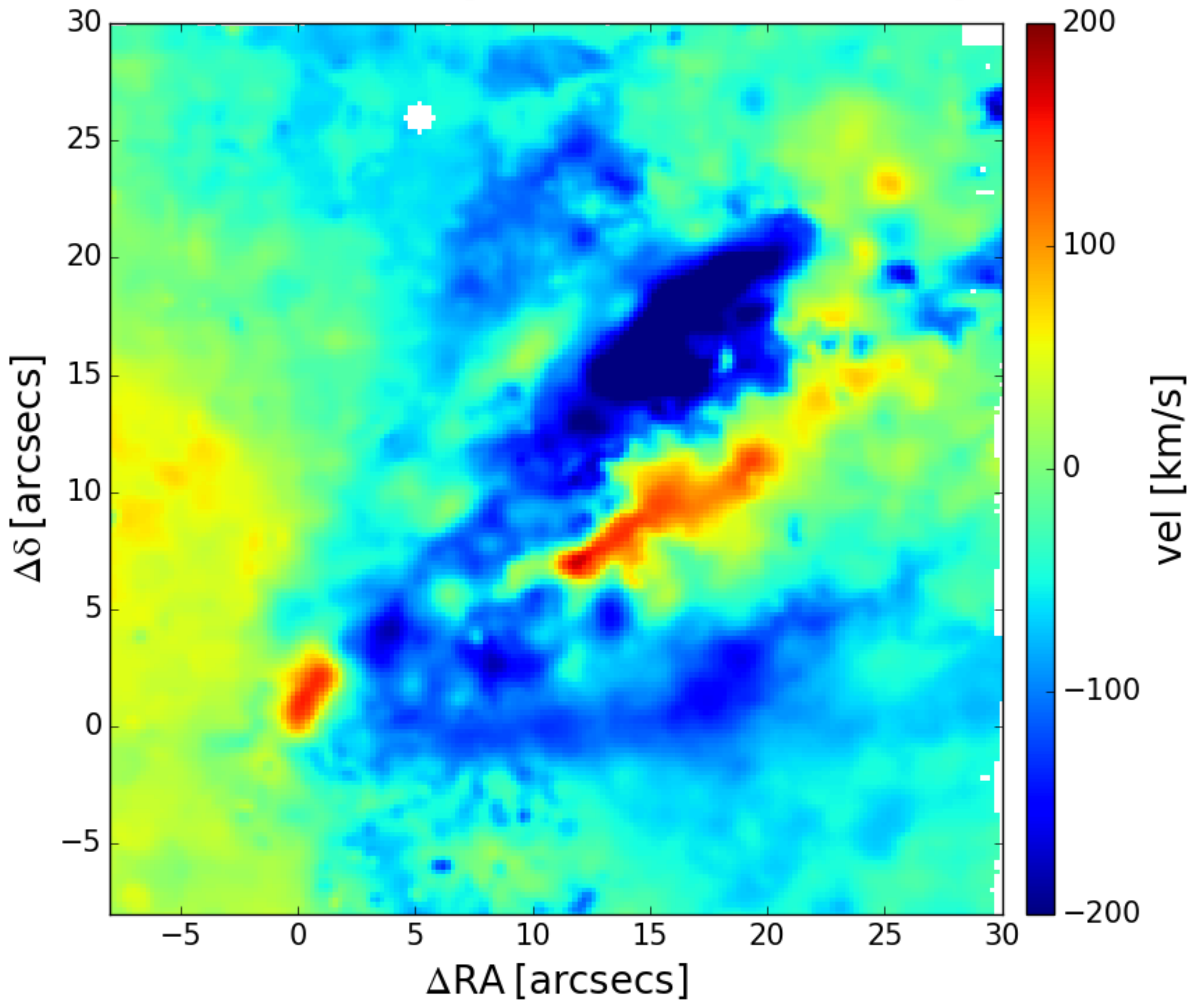
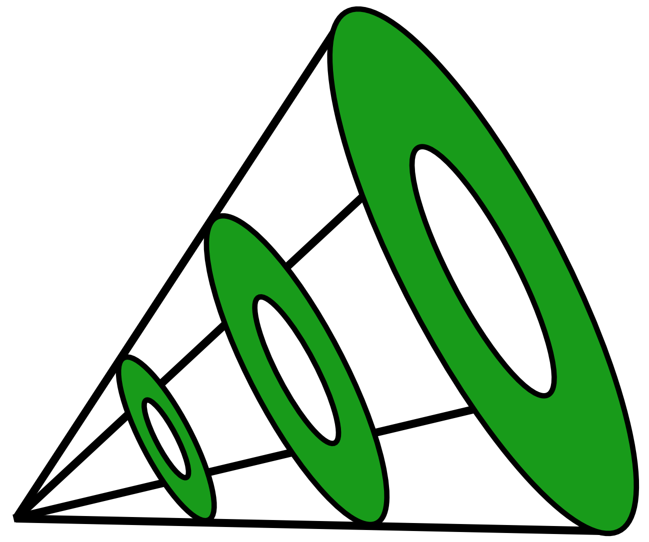


But velocity fields are complex: real motions or effect of clumpy line emission?

A hollow conical outflow?



Circinus

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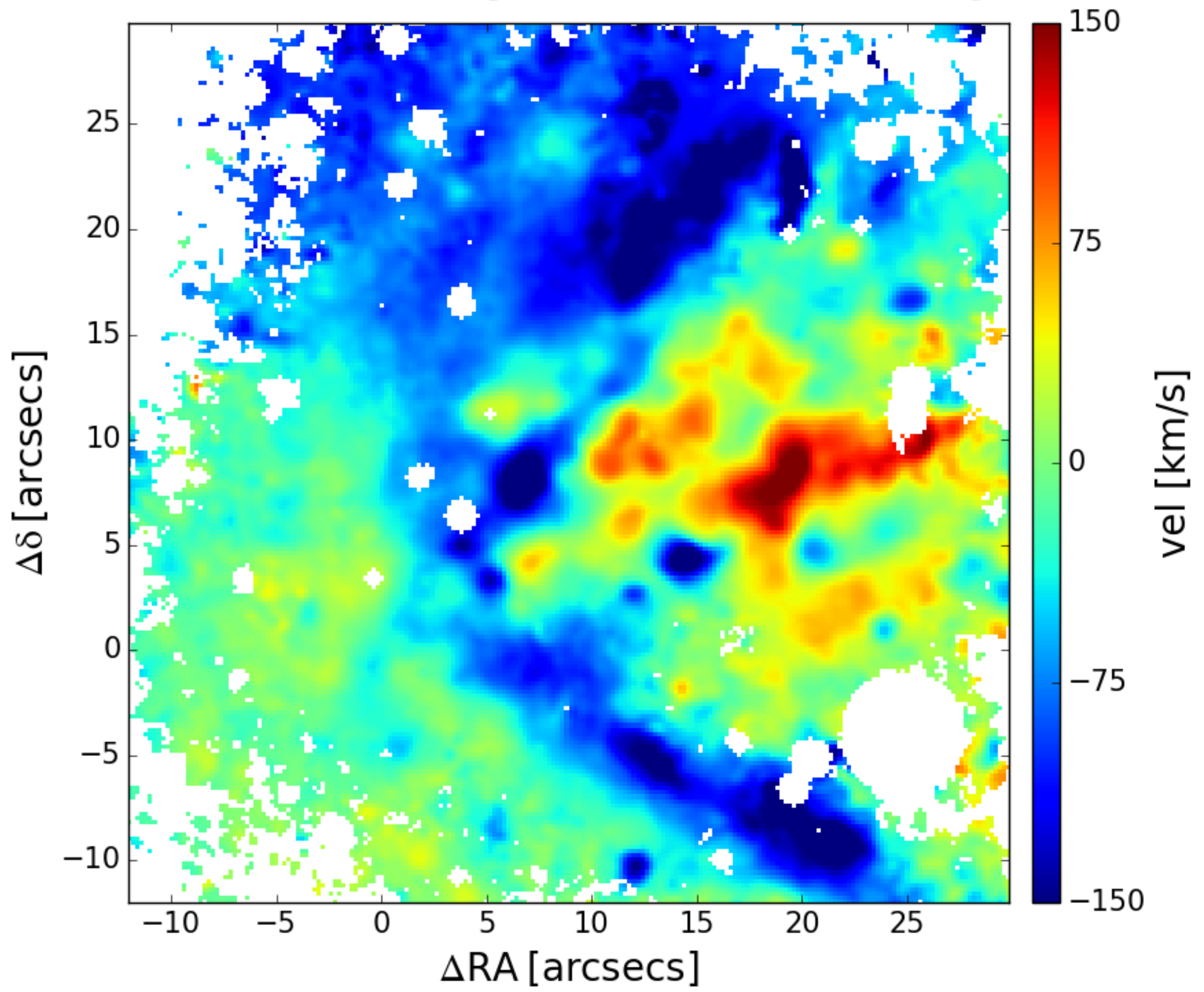

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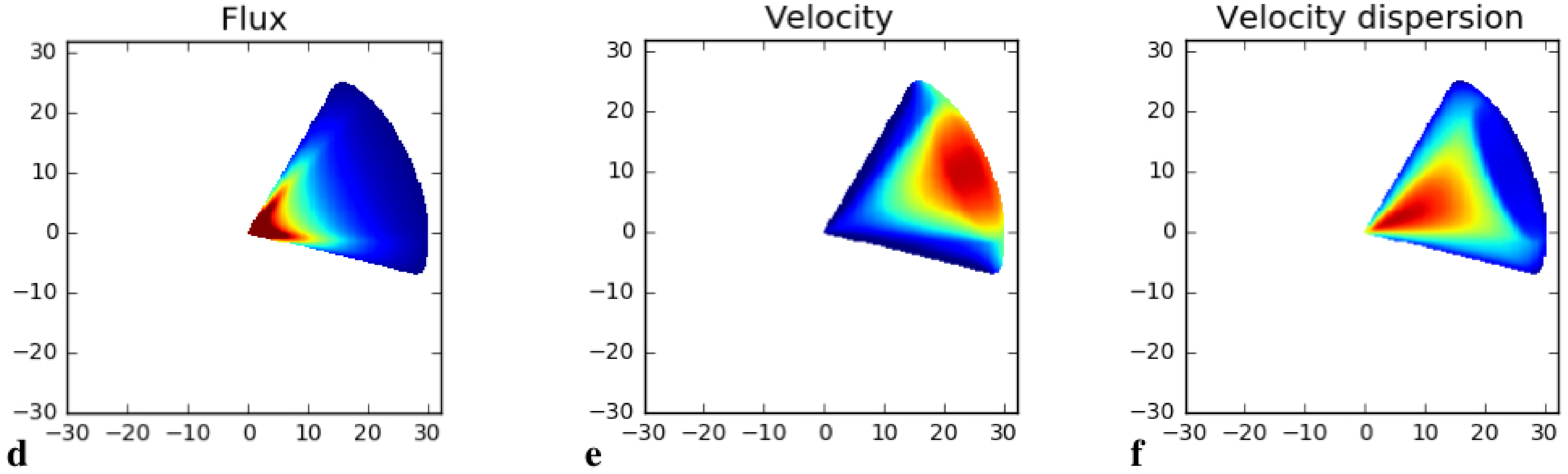
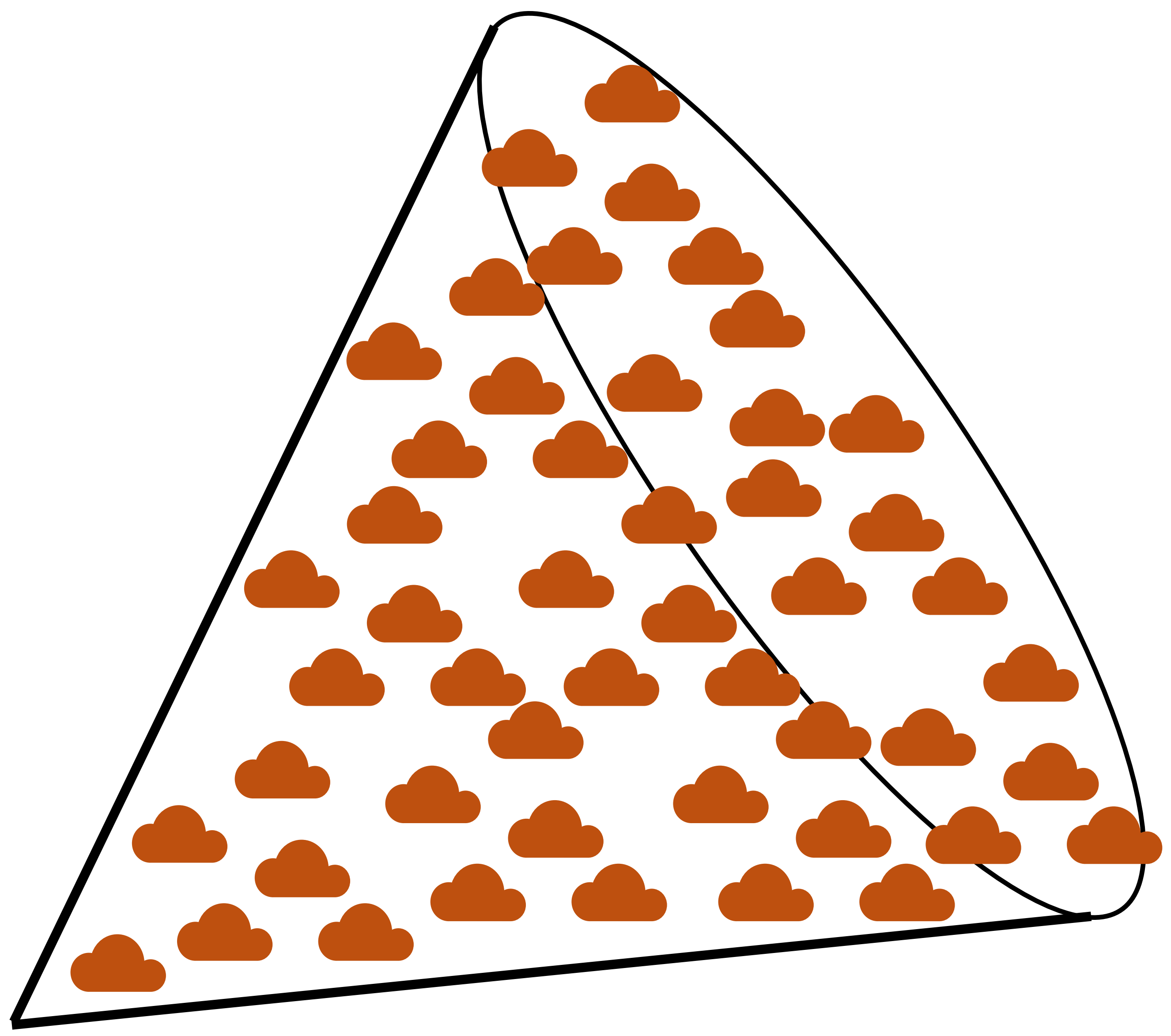
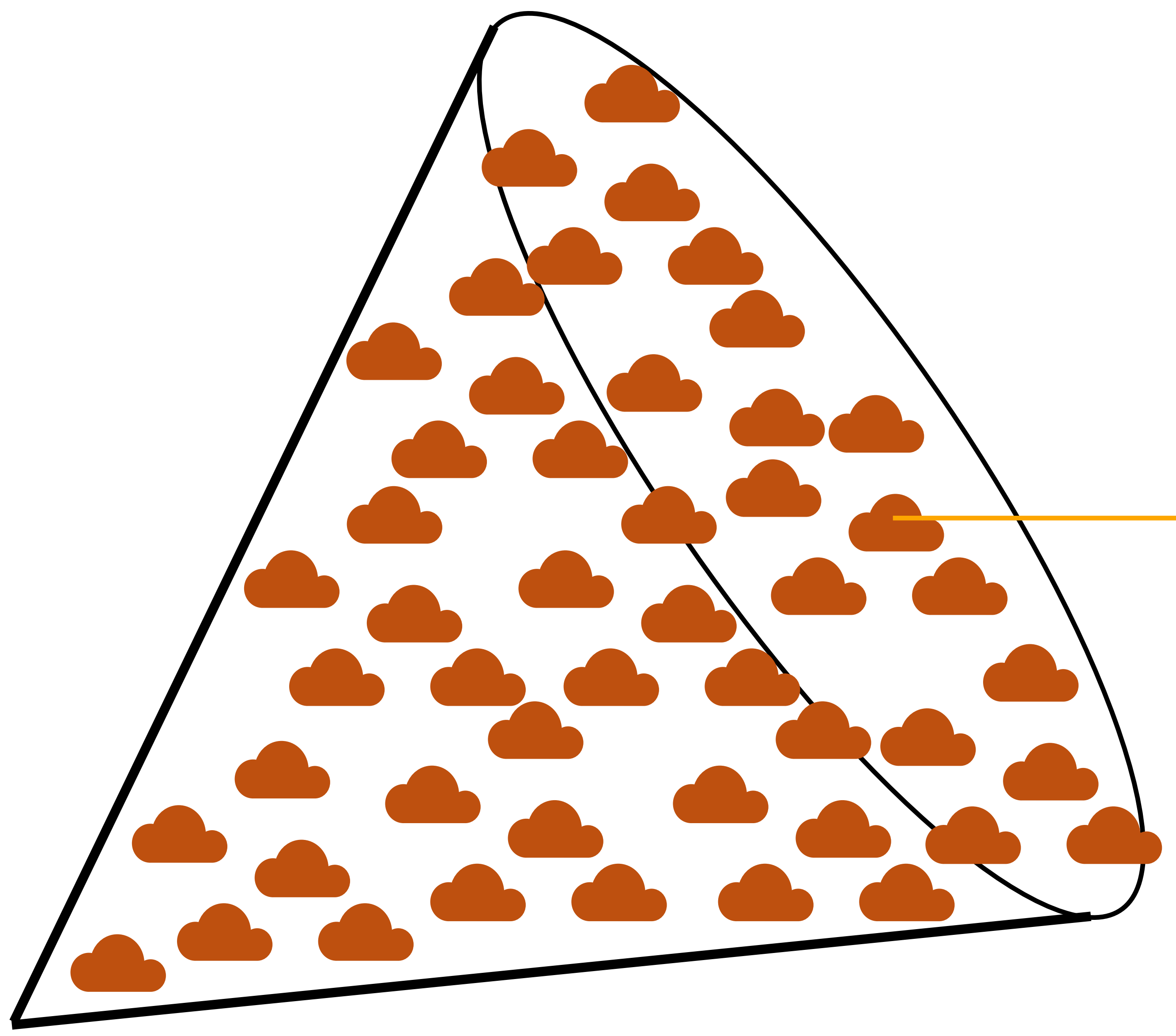


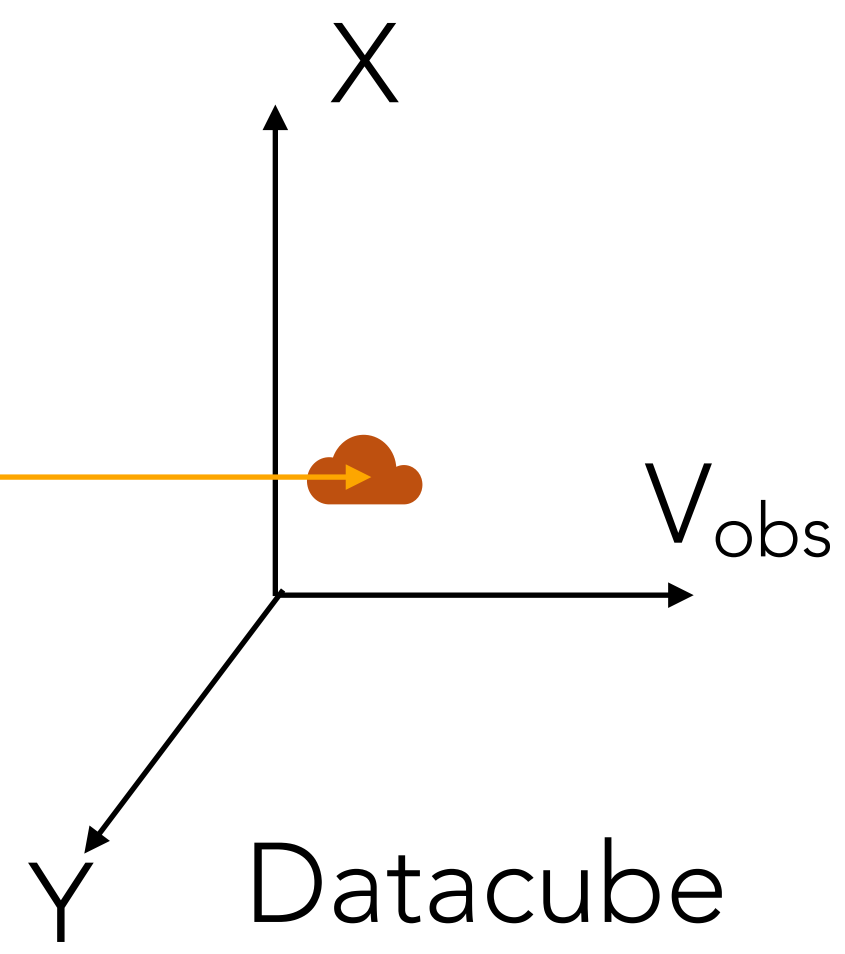
NEXT GENERATION KINEMATICAL MODEL



- Montecarlo “cloud” model, assumed velocity field
- Takes into account all geometrical projection effects and observational effects (e.g. beam smearing, binning, etc.)
- Weigh clouds according to measured flux in spaxel where cloud is “observed”
- Extremely versatile: allow tomographic reconstruction of 3D structure following assumption of velocity field

NEXT GENERATION KINEMATICAL MODEL

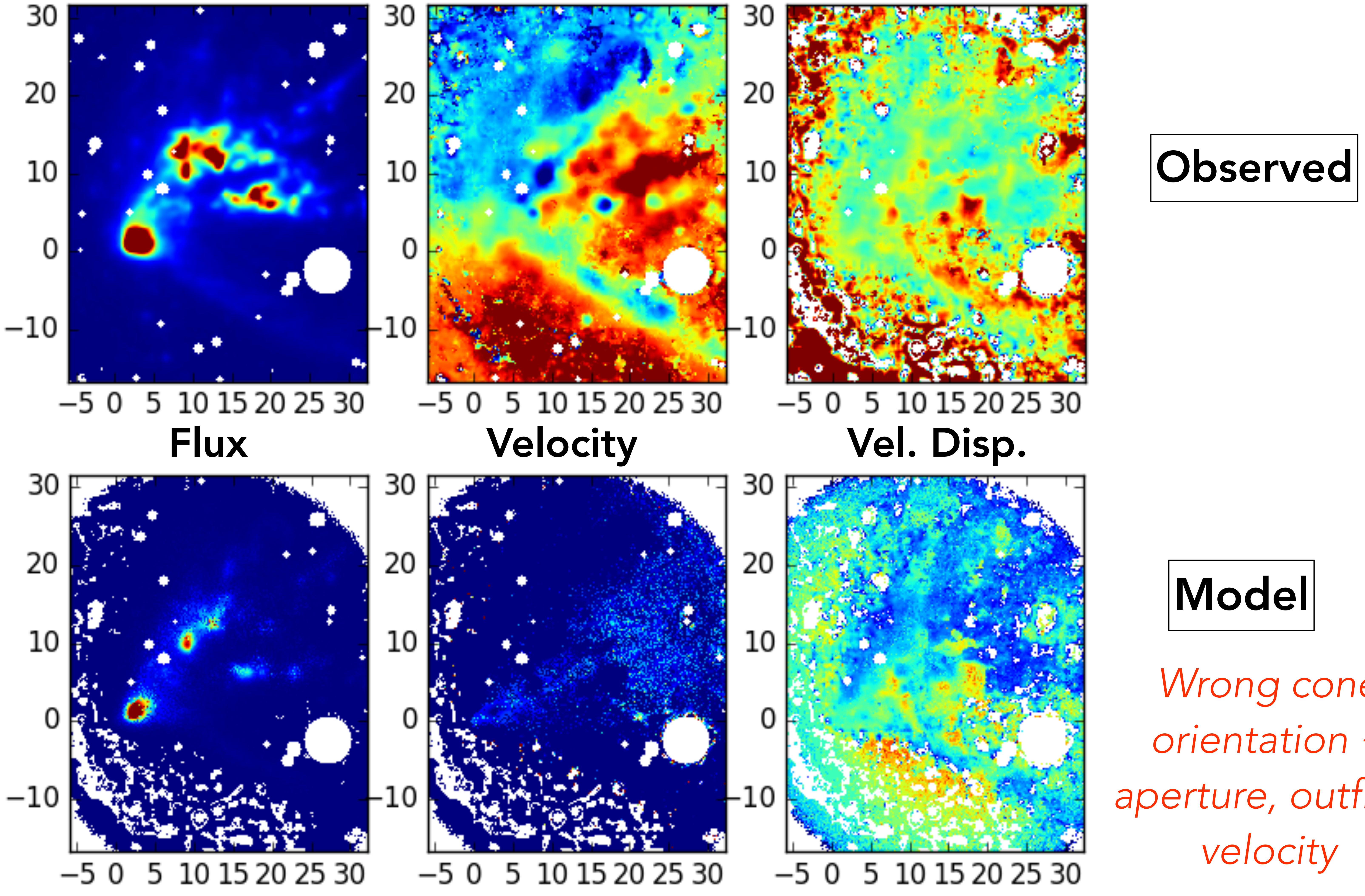




- Montecarlo "cloud" model, assumed velocity field
- Takes into account all geometrical projection effects and observational effects (e.g. beam smearing, binning, etc.)
- Weigh clouds according to measured flux in spaxel where cloud is "observed"
- Extremely versatile: allow tomographic reconstruction of 3D structure following assumption of velocity field

NEXT GENERATION OF KINEMATICAL MODELS

Circinus galaxy - MUSE observations, MAGNUM survey

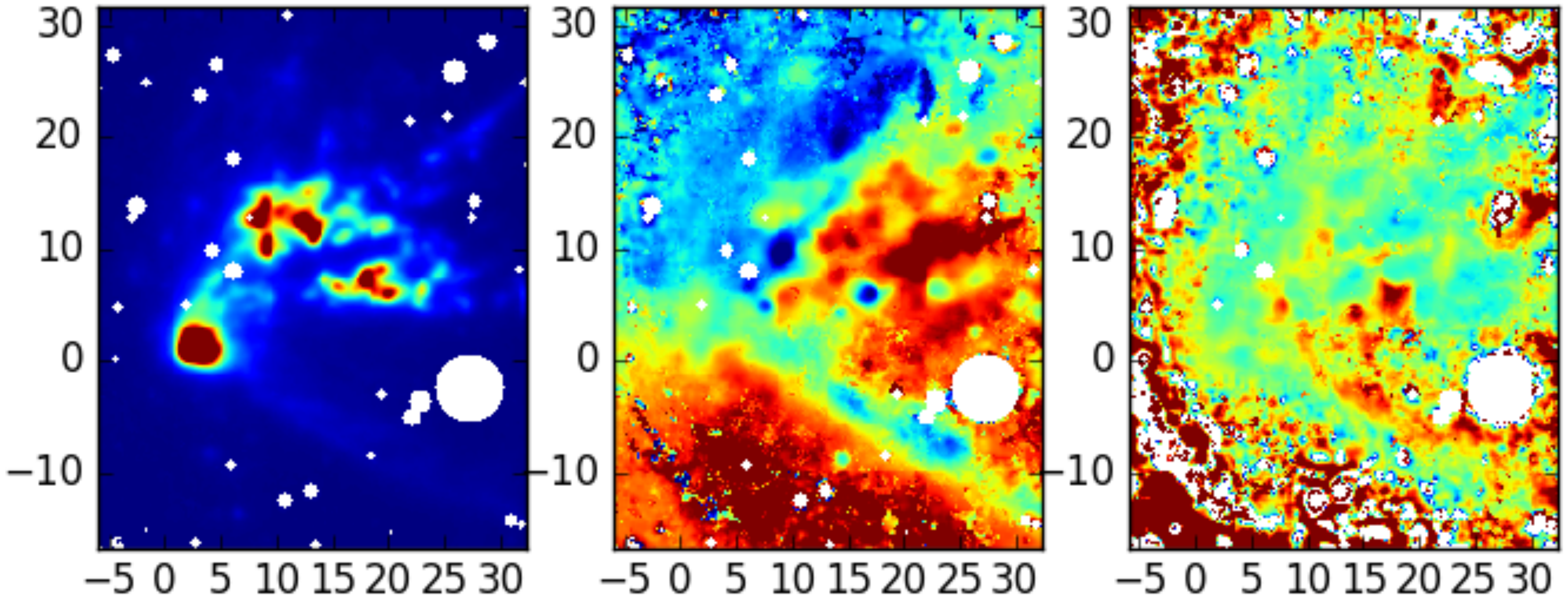


Wrong cone orientation + aperture, outflow velocity

Marconi et al., in prep.

NEXT GENERATION OF KINEMATICAL MODELS

Circinus galaxy - MUSE observations, MAGNUM survey



Observed

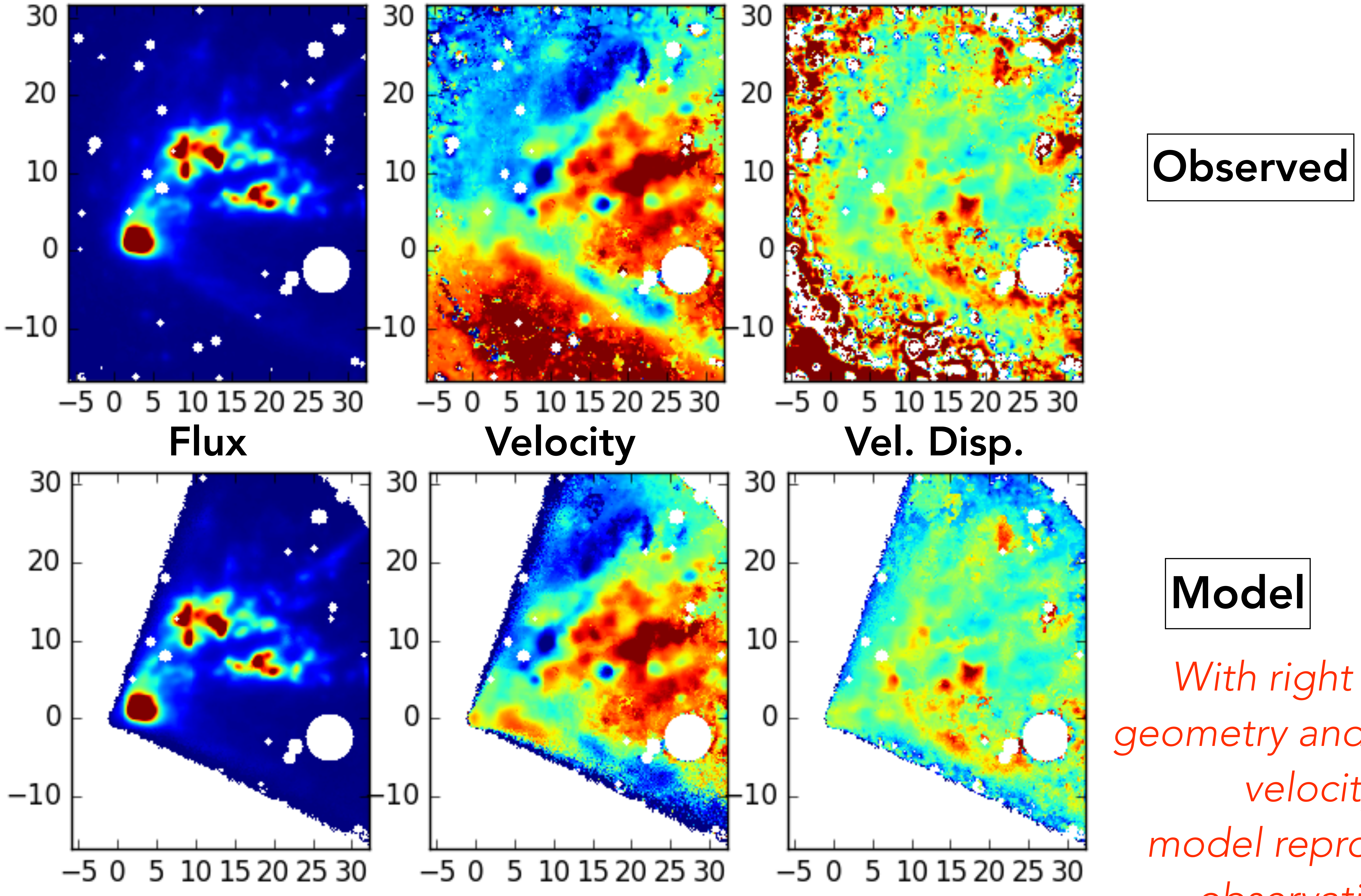
Model

With right cone geometry and outflow velocity model reproduces observations

Marconi et al., in prep.

NEXT GENERATION OF KINEMATICAL MODELS

Circinus galaxy - MUSE observations, MAGNUM survey



With right cone geometry and outflow velocity model reproduces observations

Marconi et al., in prep.

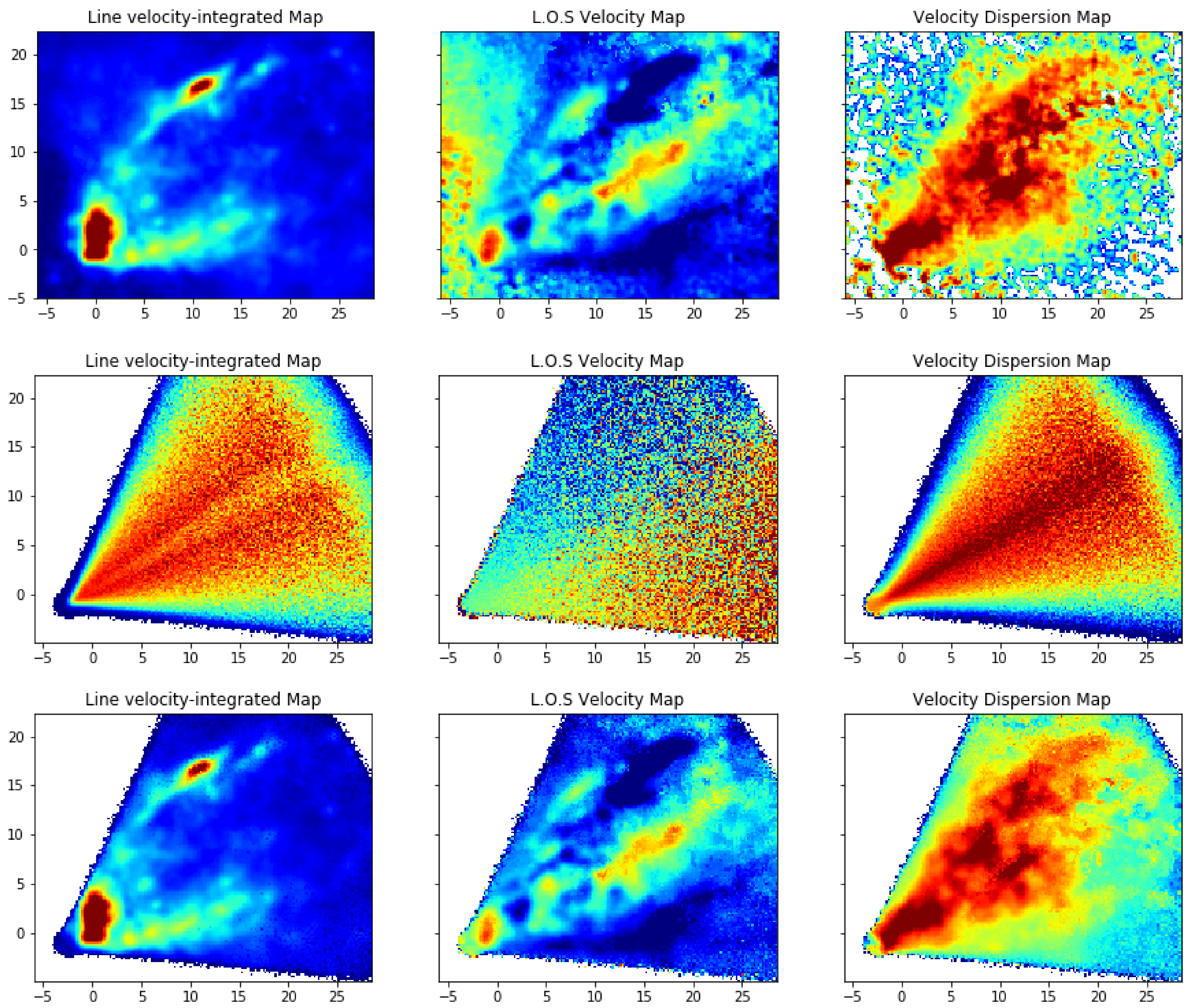
NEXT GENERATION OF KINEMATICAL MODELS

NGC4945 MUSE observations, MAGNUM survey

Observed

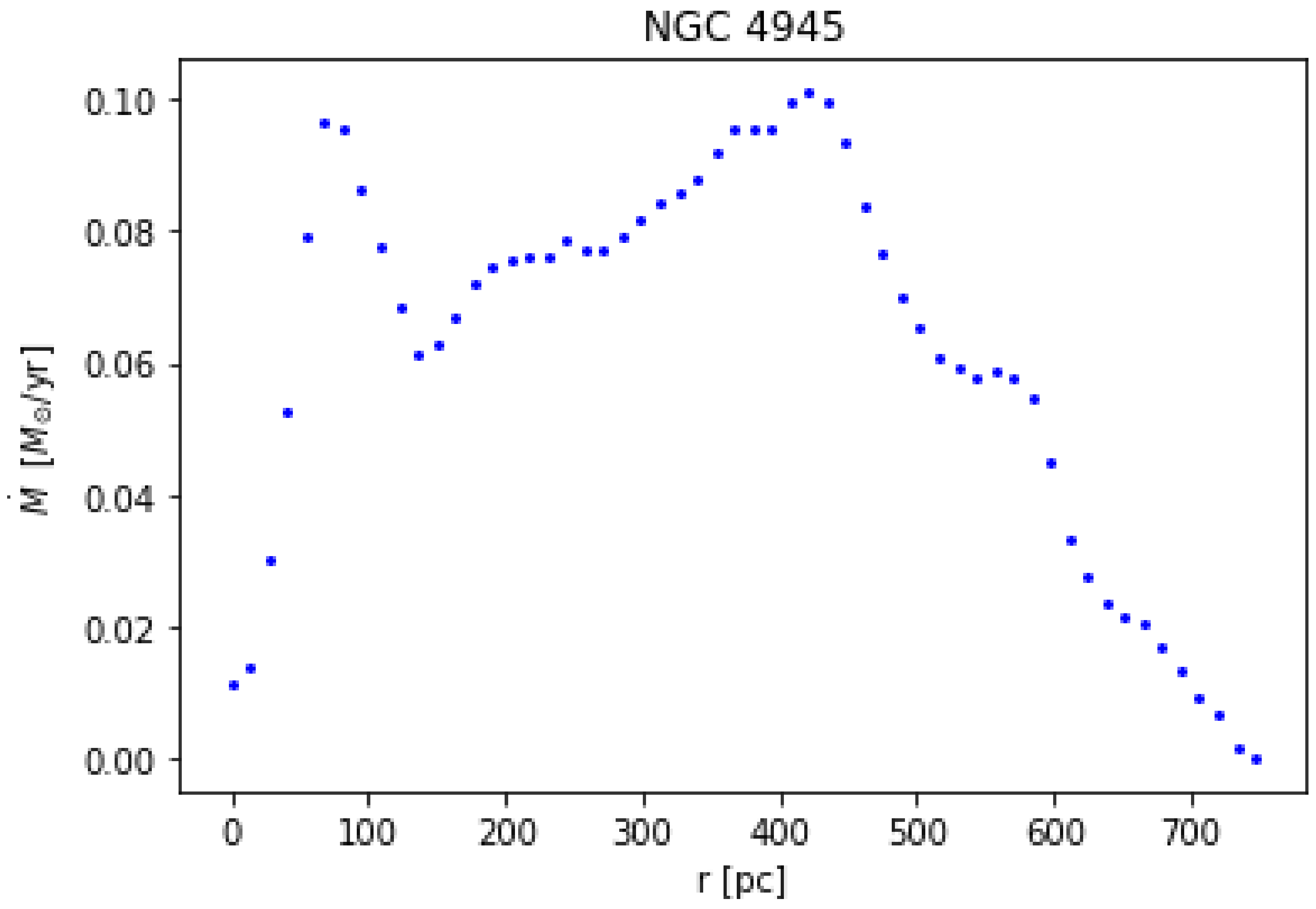
Model Unweighted

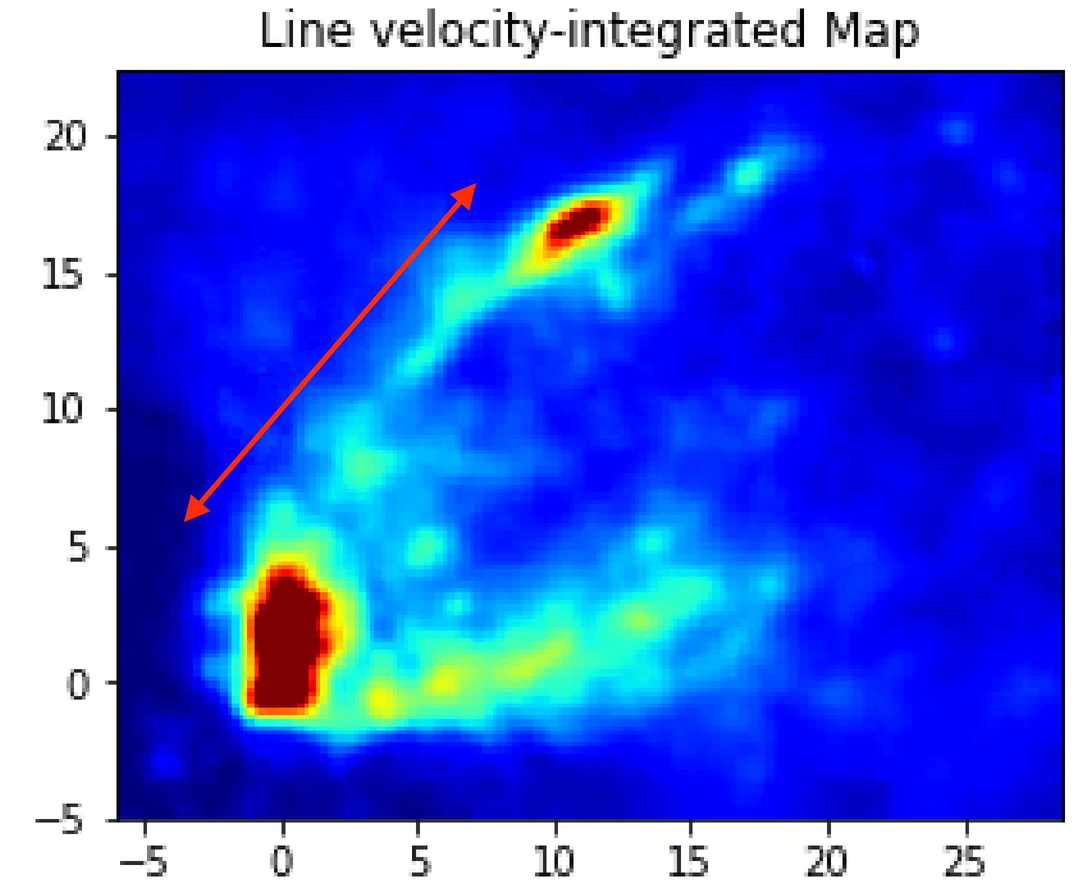
Model Flux Weighted

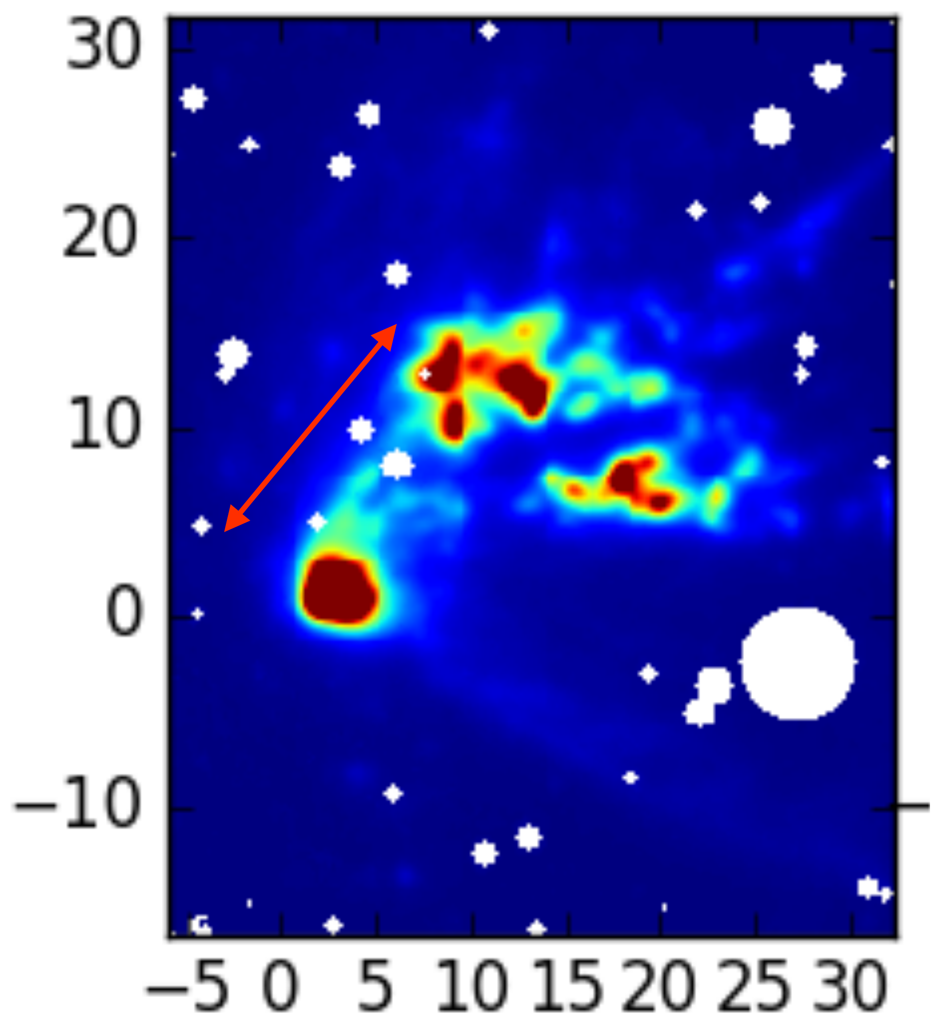


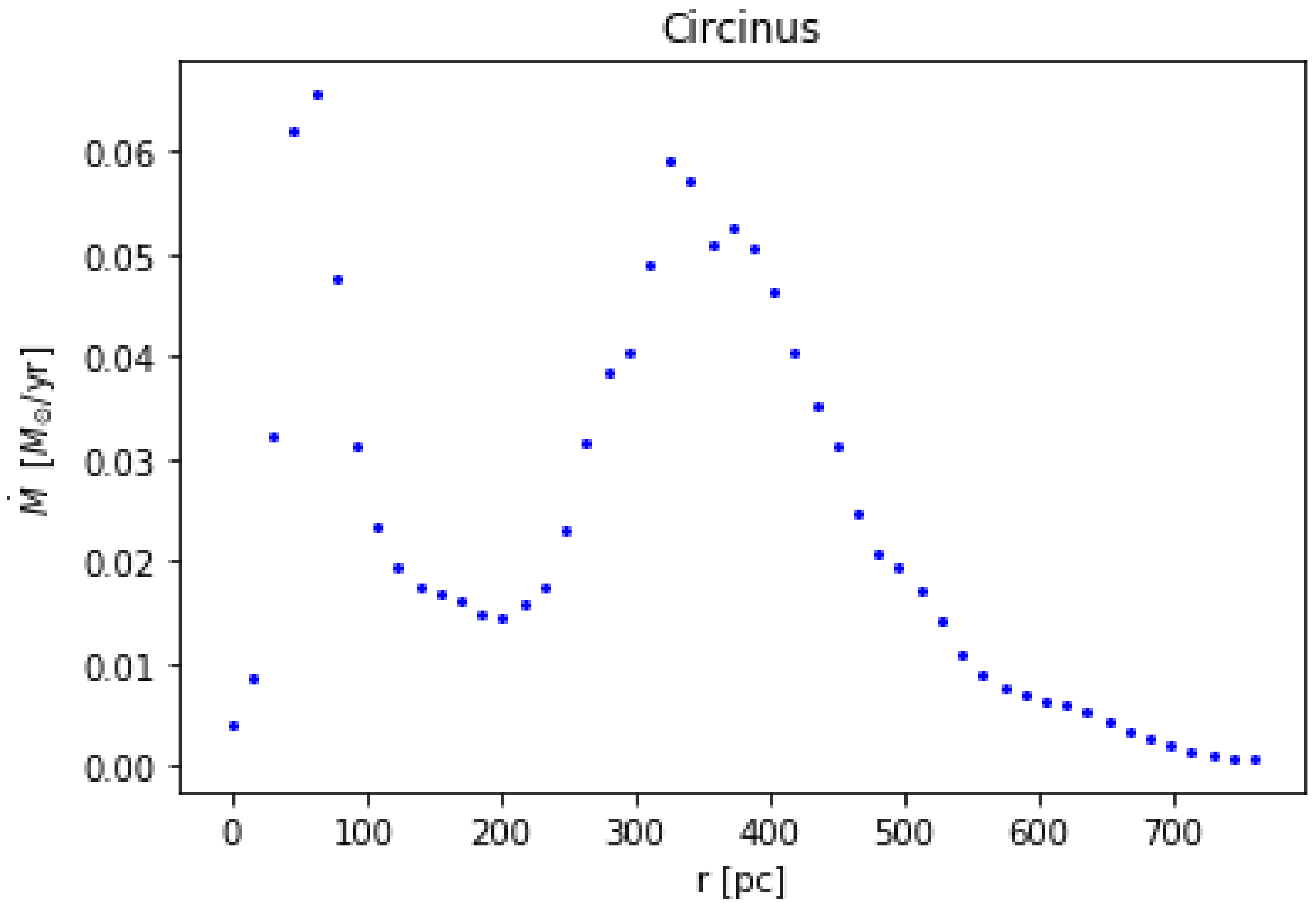
NEXT GENERATION OF KINEMATICAL MODELS

Models feature constant velocity field, complexity is given by clumpiness!



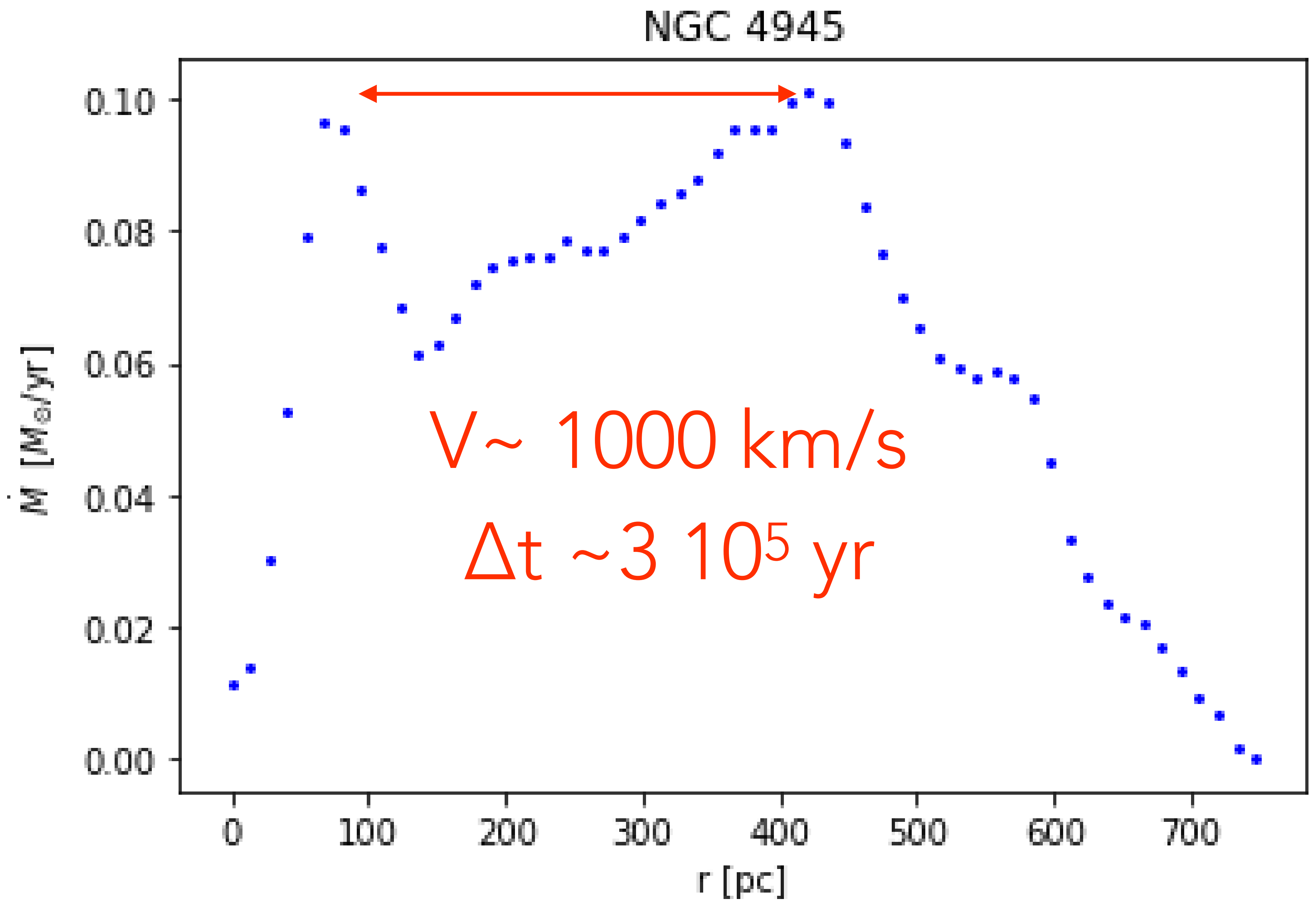


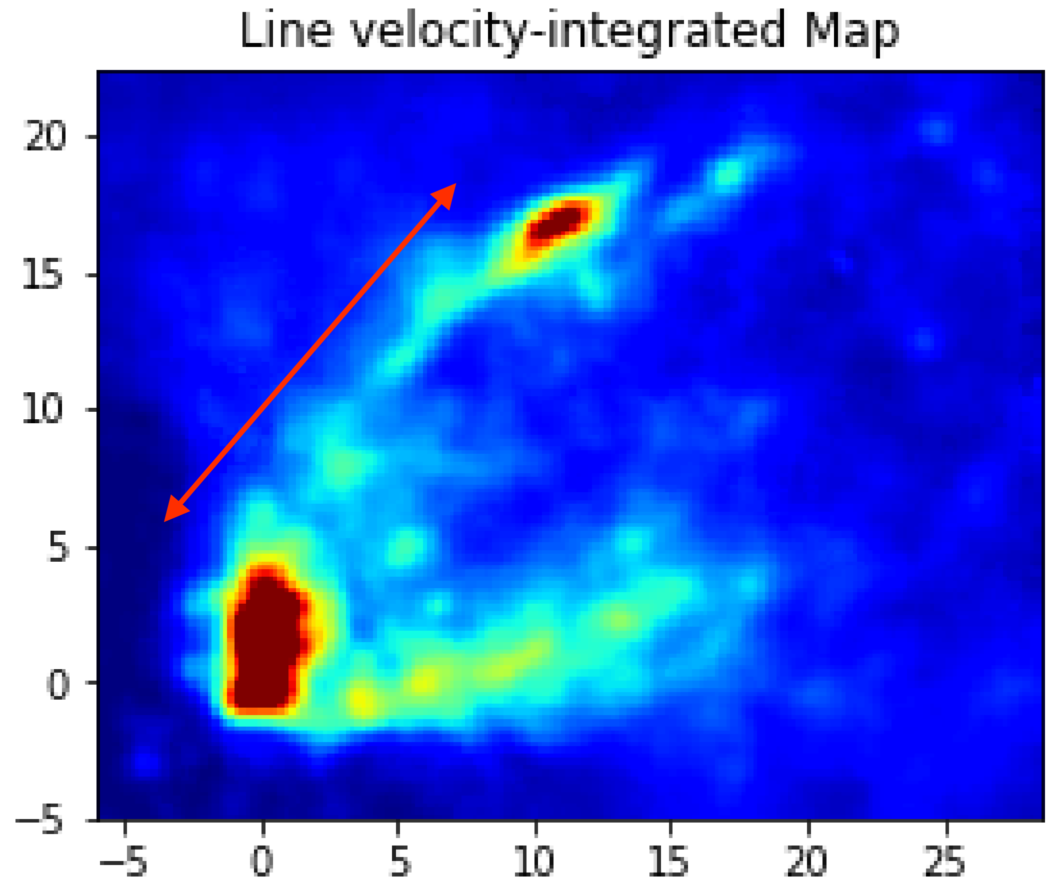


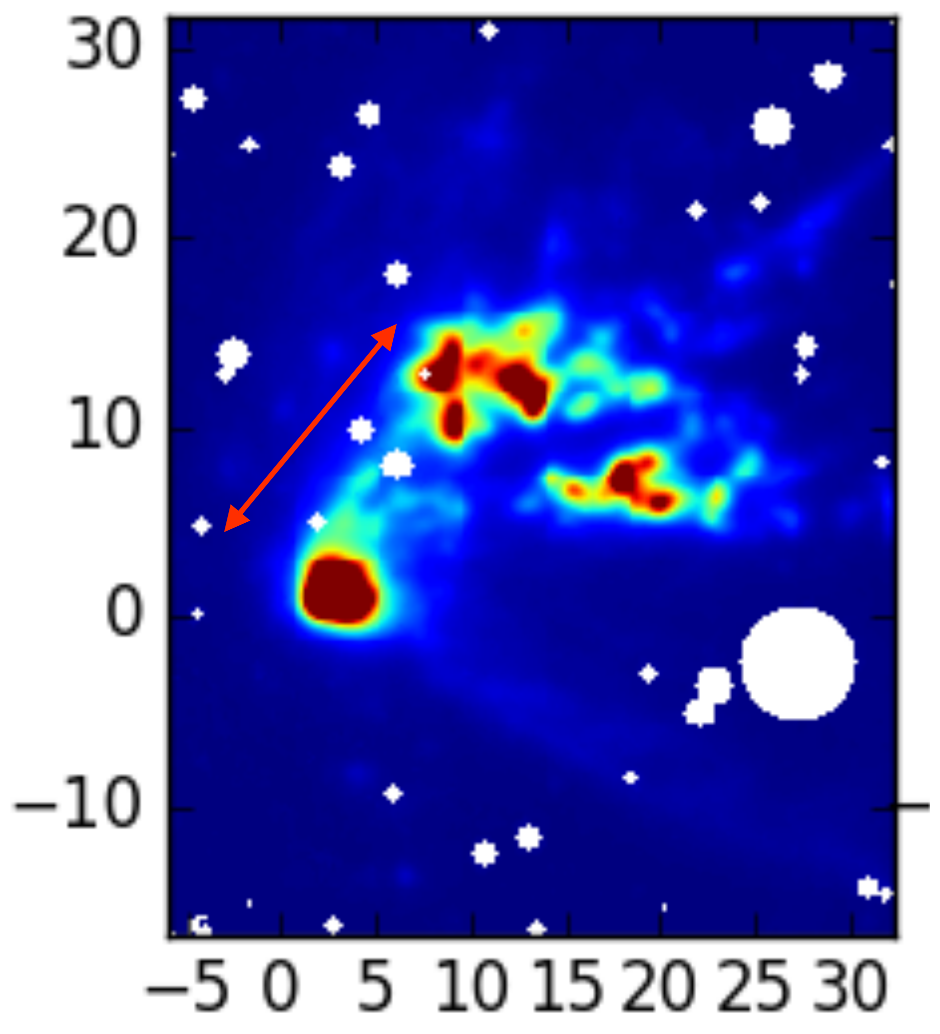


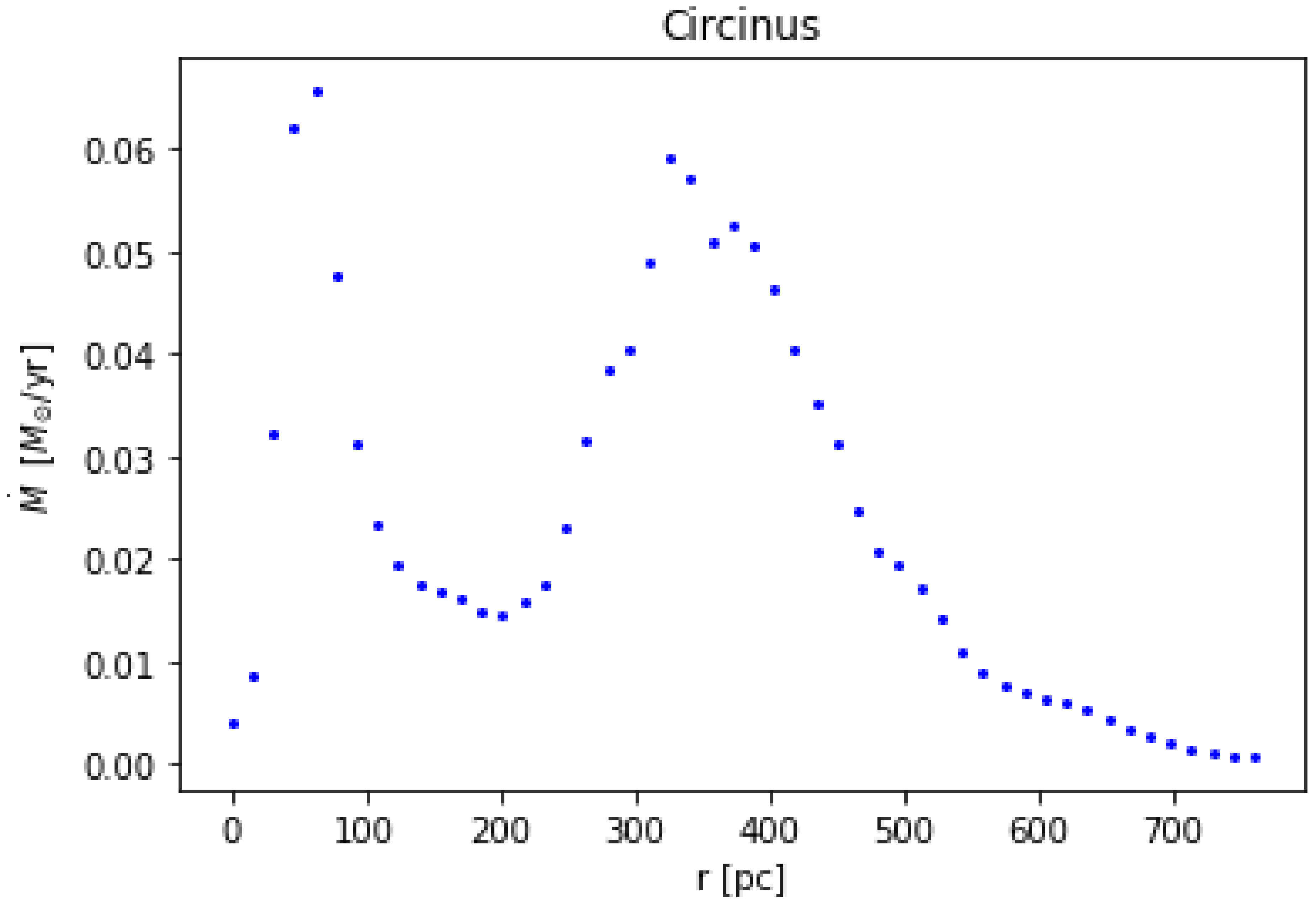
NEXT GENERATION OF KINEMATICAL MODELS

Models feature constant velocity field, complexity is given by clumpiness!



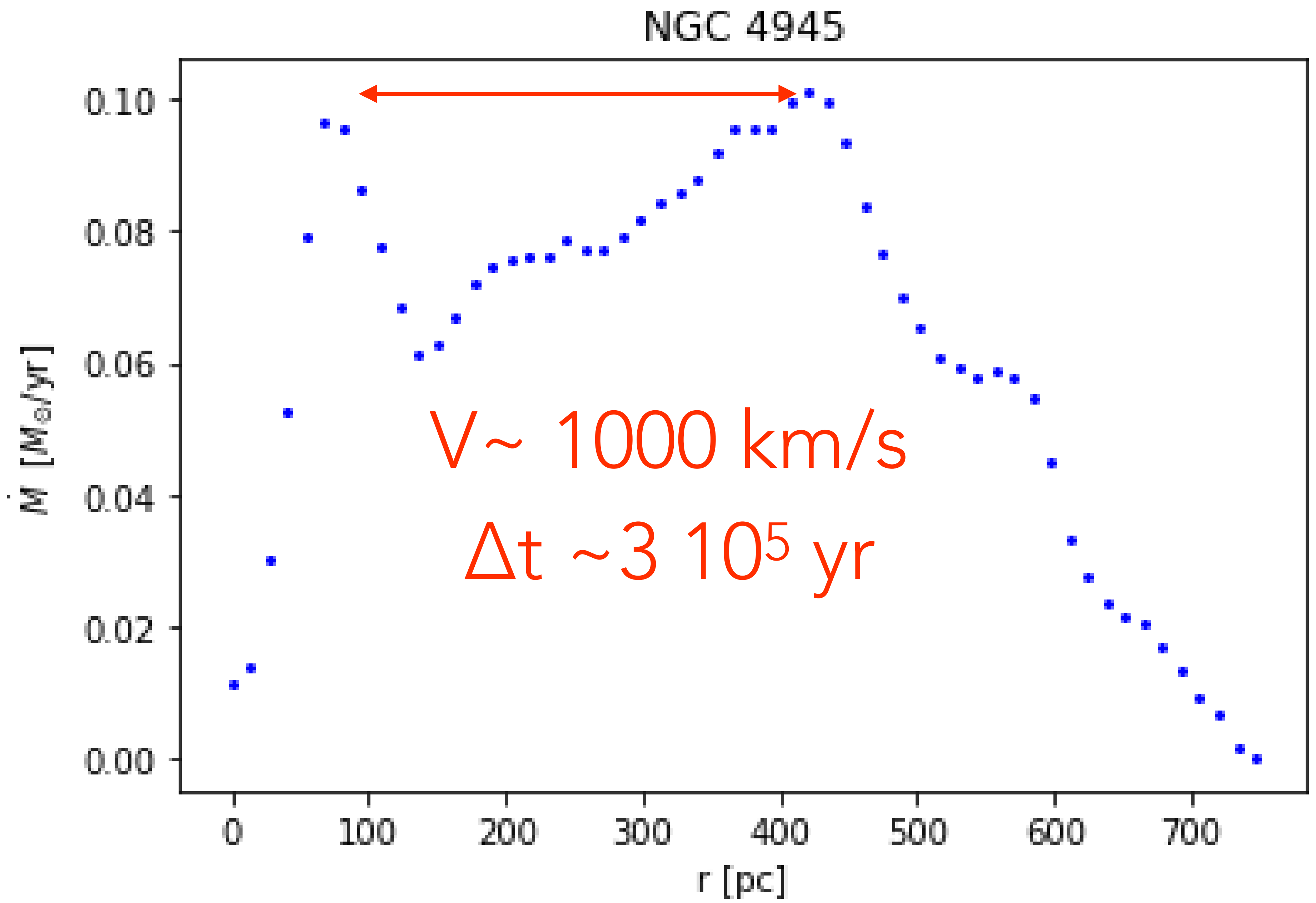


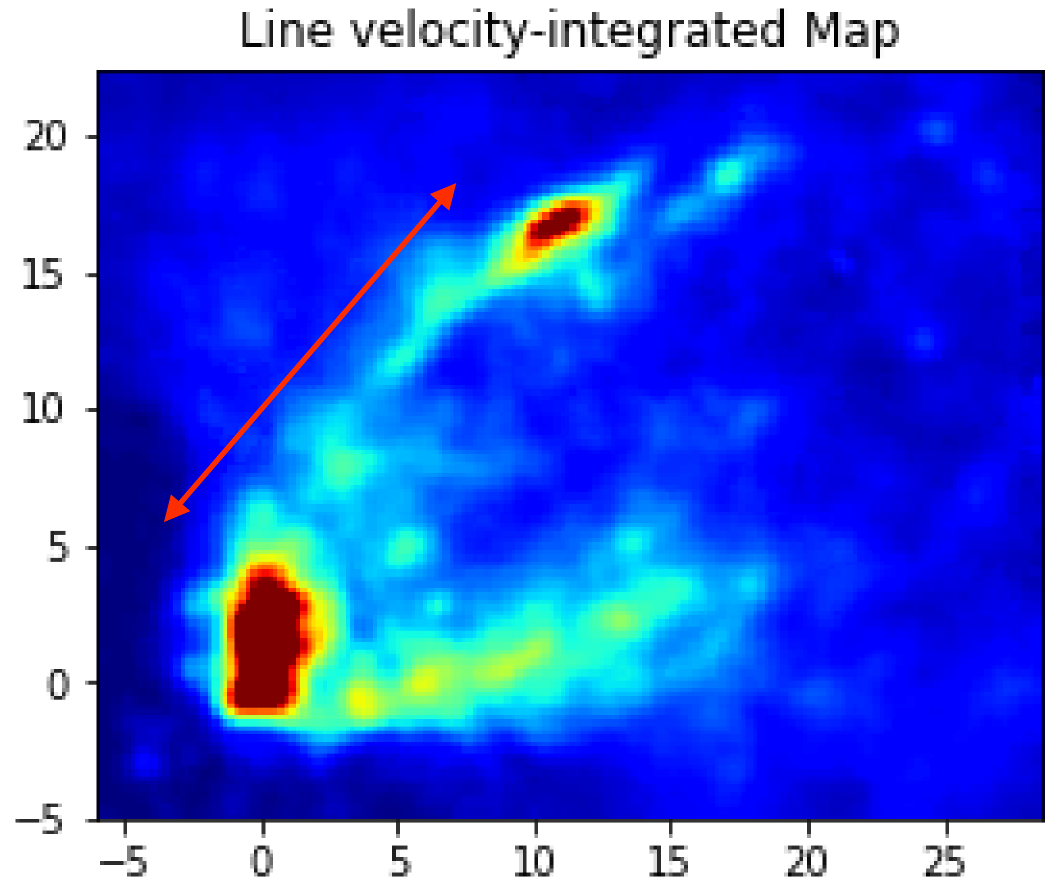


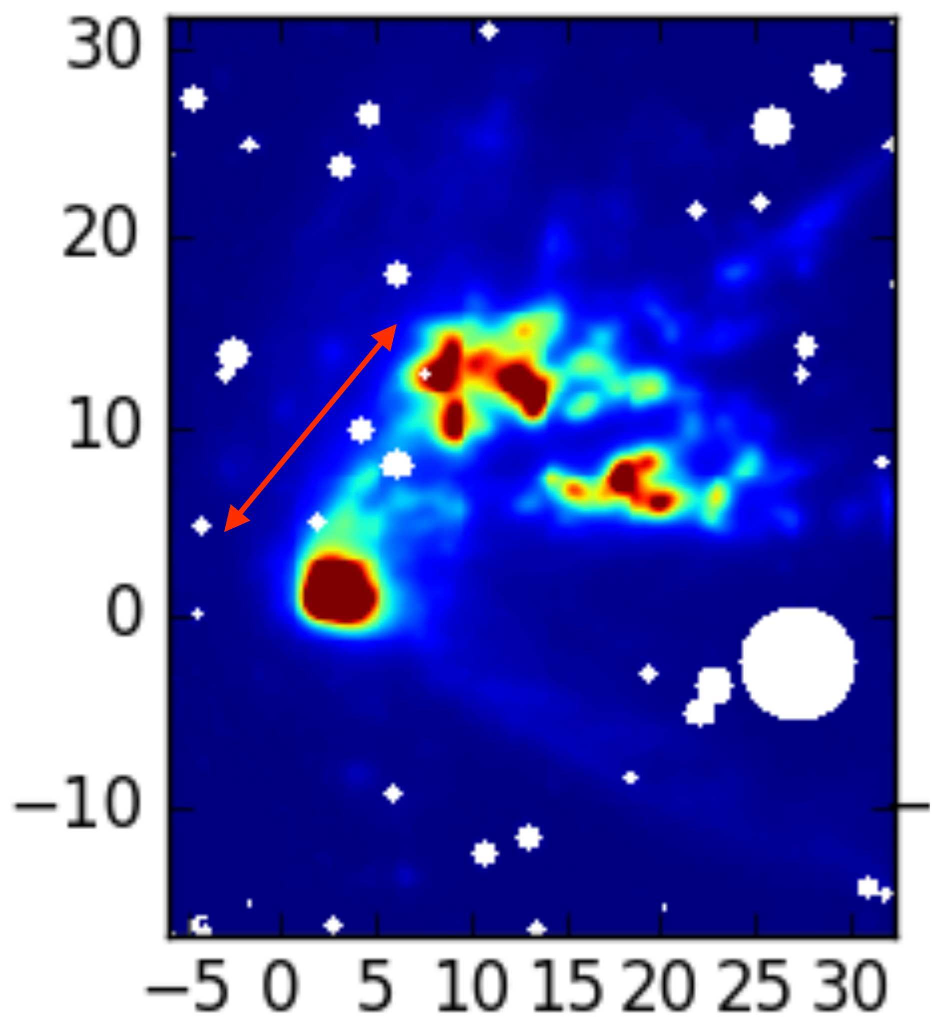


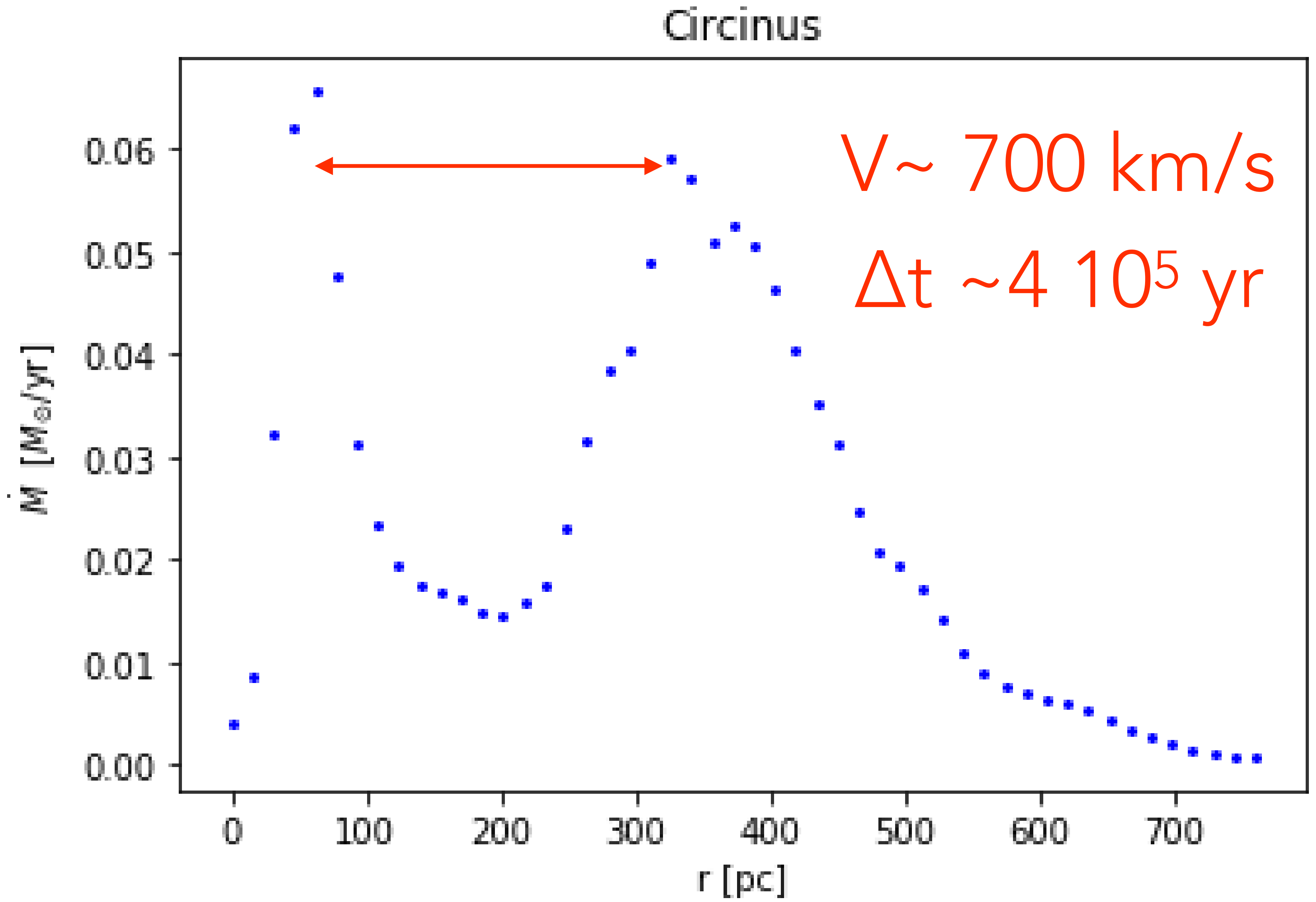
NEXT GENERATION OF KINEMATICAL MODELS

Models feature constant velocity field, complexity is given by clumpiness!









CONCLUSIONS

- Outflows are impacting host galaxies (disturbed kinematics, filaments, cavities, positive and negative feedback)
- But overall effects are not significant: we are missing the evidence that AGN outflows are significantly quenching SF
  → may work slowly on long timescales …
- Complexity and spatial resolution of new IFU data require a new approach to model kinematics and to infer outflow properties