

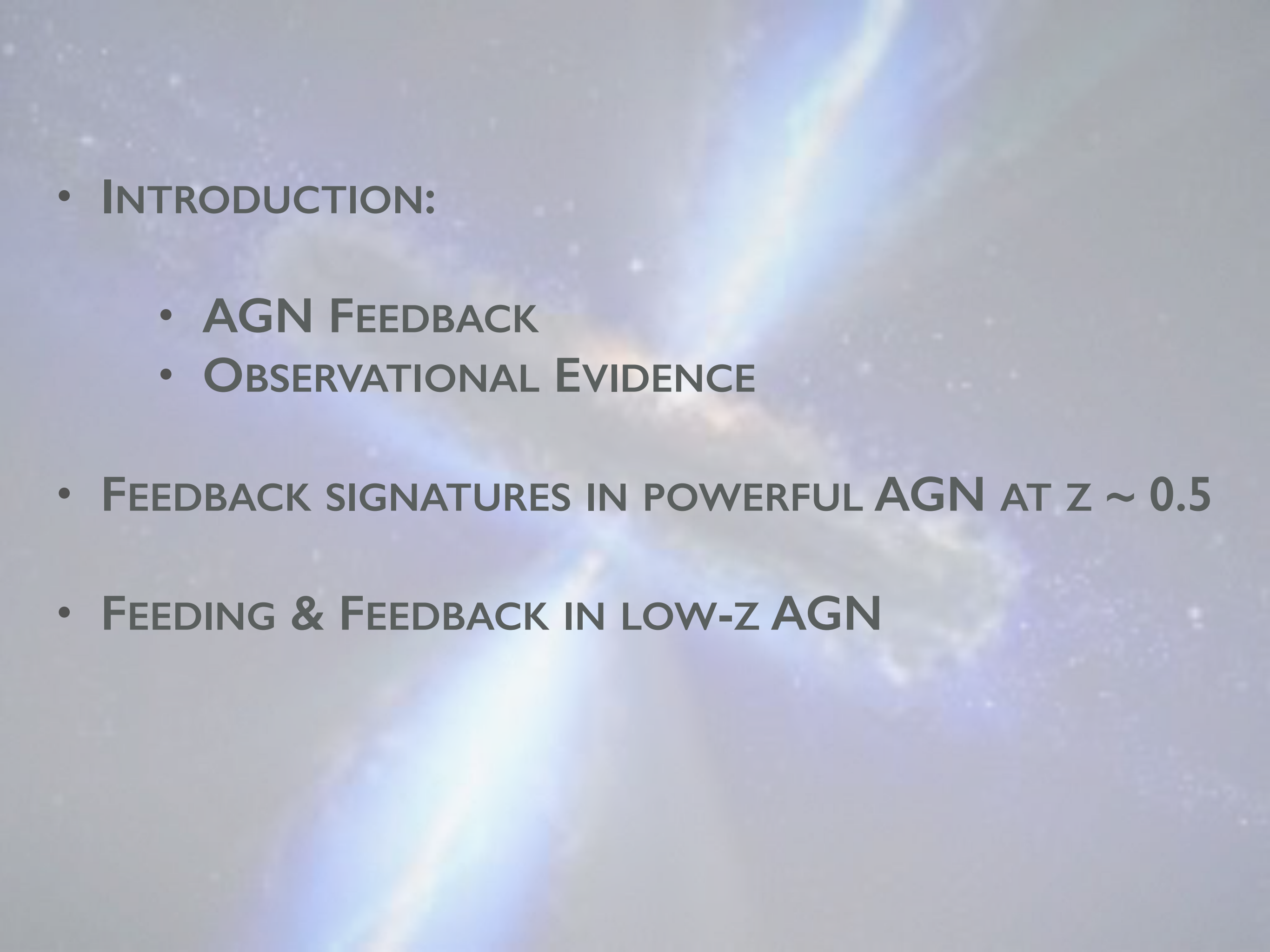


OBSERVATIONAL SIGNATURES OF AGN FEEDBACK

DOMINIKA WYLEZALEK

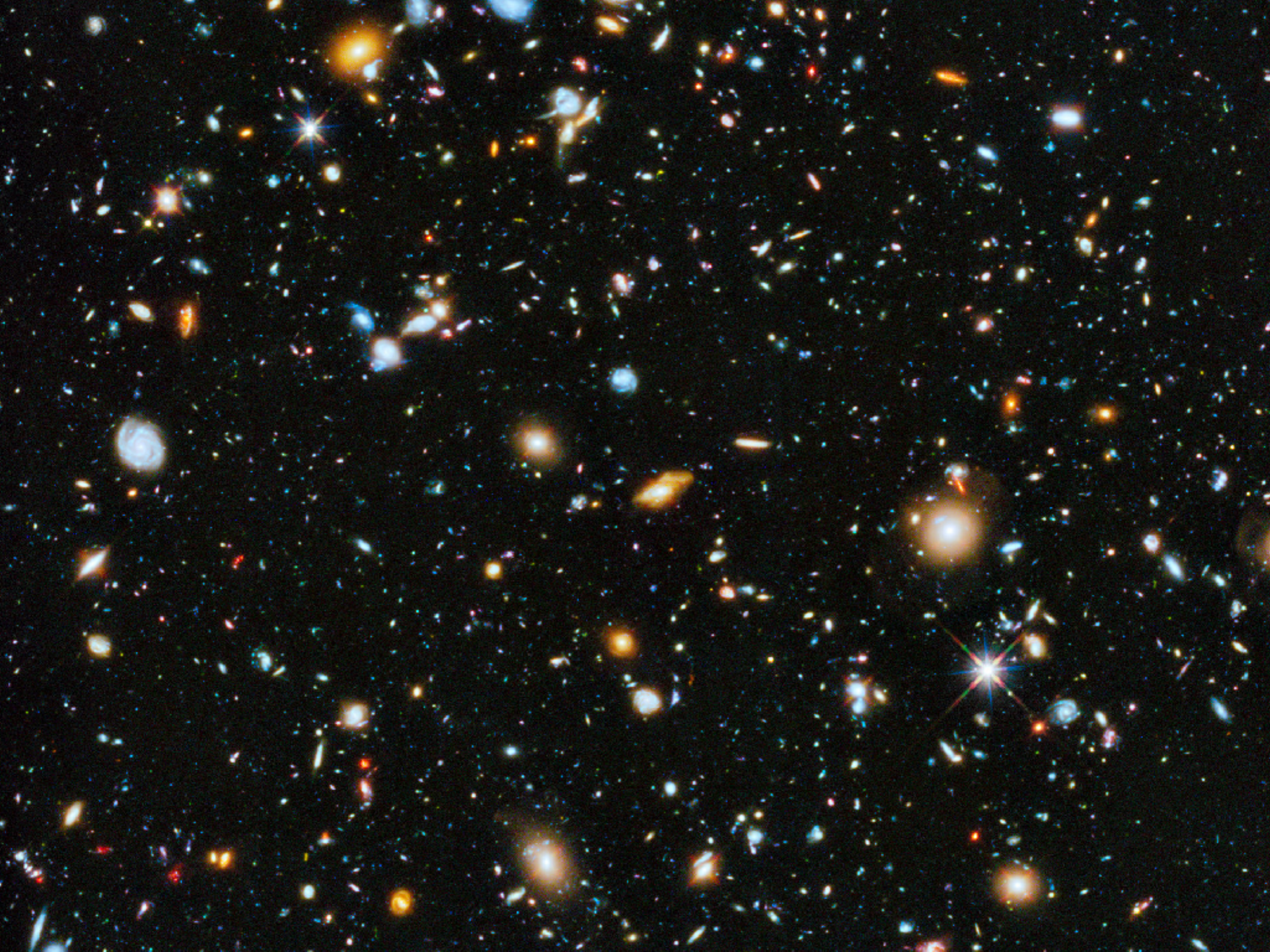


JOHNS HOPKINS
UNIVERSITY

- 
- **INTRODUCTION:**
 - **AGN FEEDBACK**
 - **OBSERVATIONAL EVIDENCE**
 - **FEEDBACK SIGNATURES IN POWERFUL AGN AT $z \sim 0.5$**
 - **FEEDING & FEEDBACK IN LOW-Z AGN**

An astronomical image showing a galaxy with a bright, yellowish-white central region. Two prominent, blue, jet-like structures extend outwards from the center, one towards the top-right and one towards the bottom-left. The background is a dark, starry field.

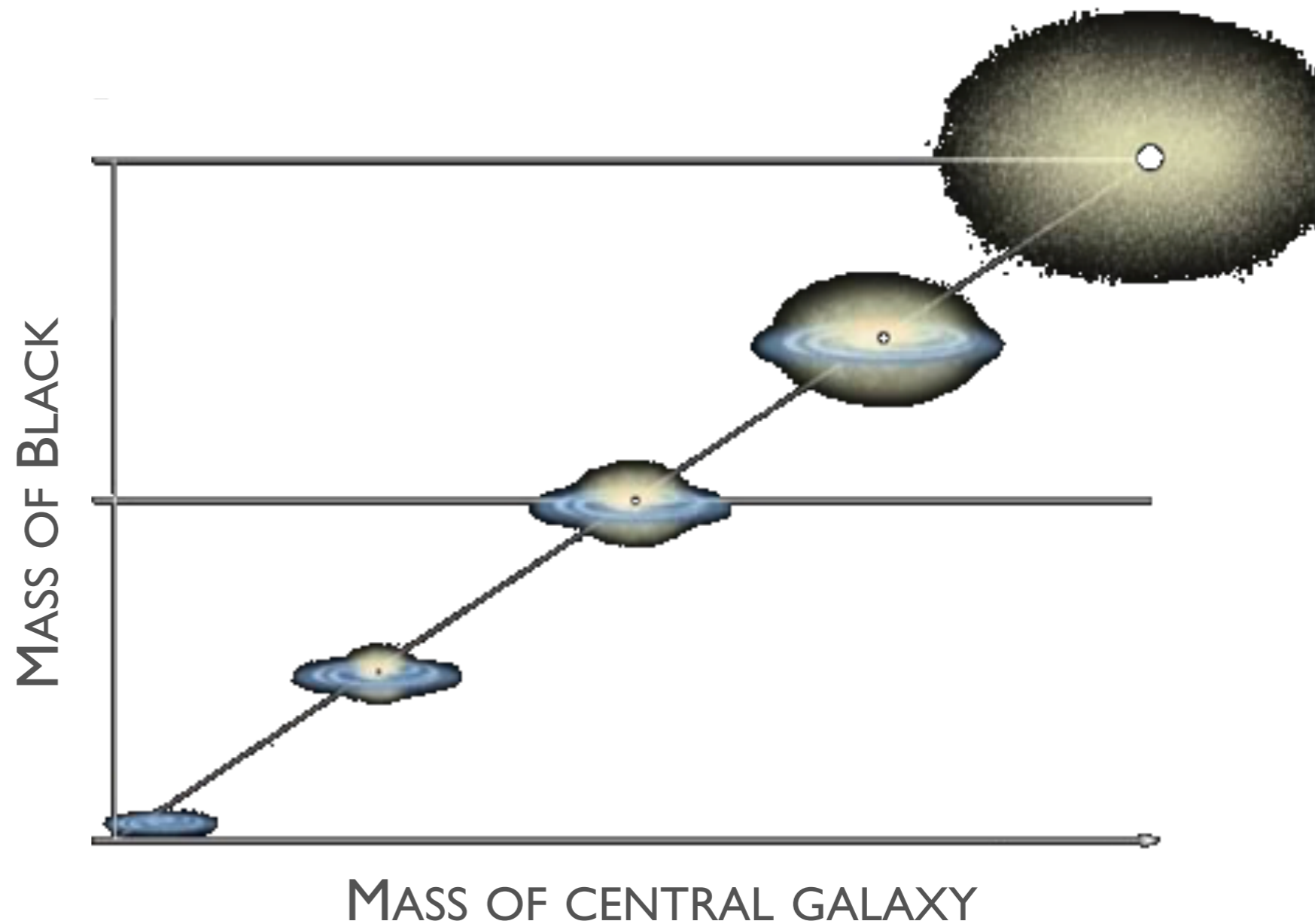
AGN FEEDBACK



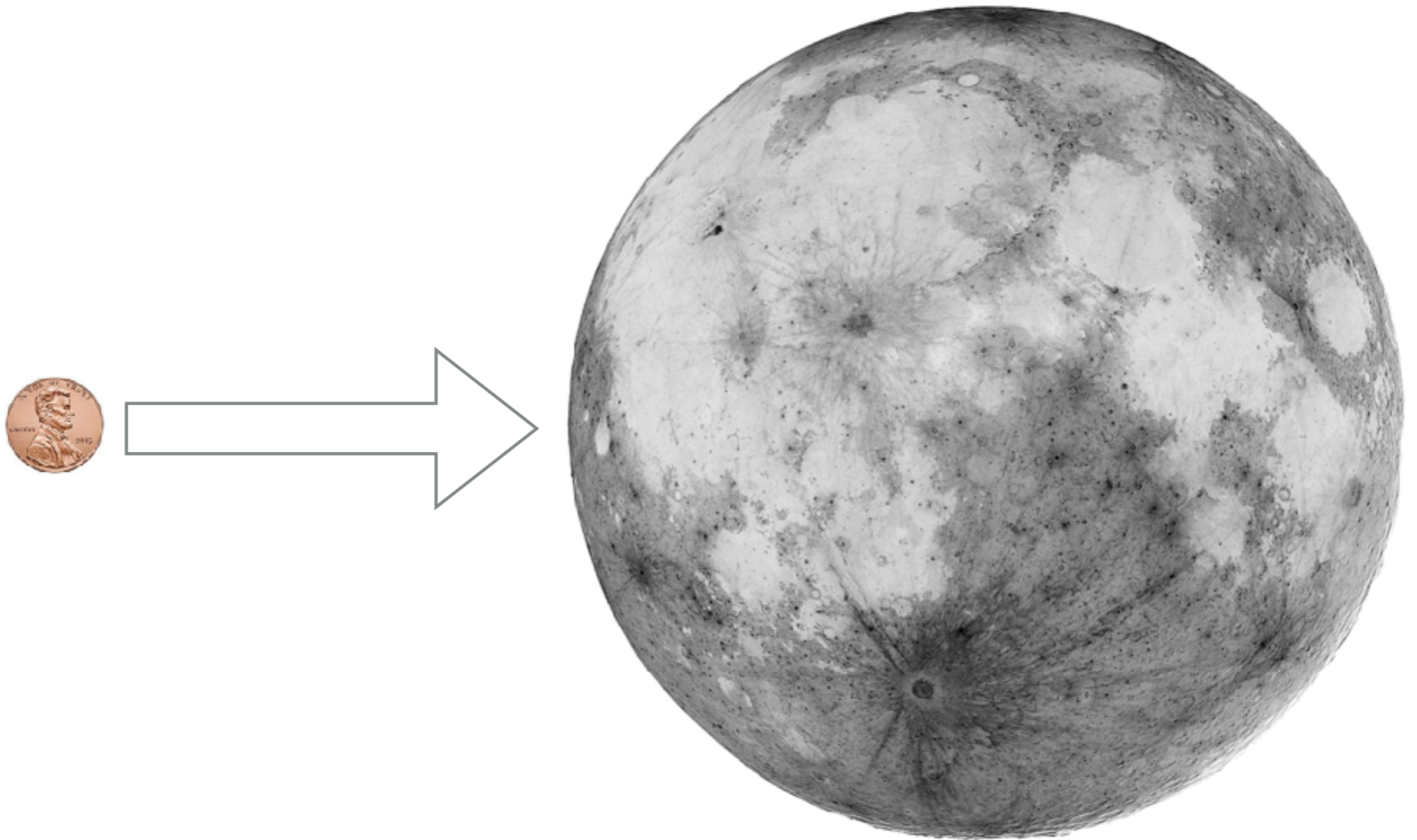
WHY QUASAR FEEDBACK?

Several relations between host galaxy bulge properties and black hole properties

Idea of galaxy/black hole self-regulation



INTRODUCTION



INTRODUCTION



released energy by BH

$$0.1 M_{\text{BH}} c^2$$

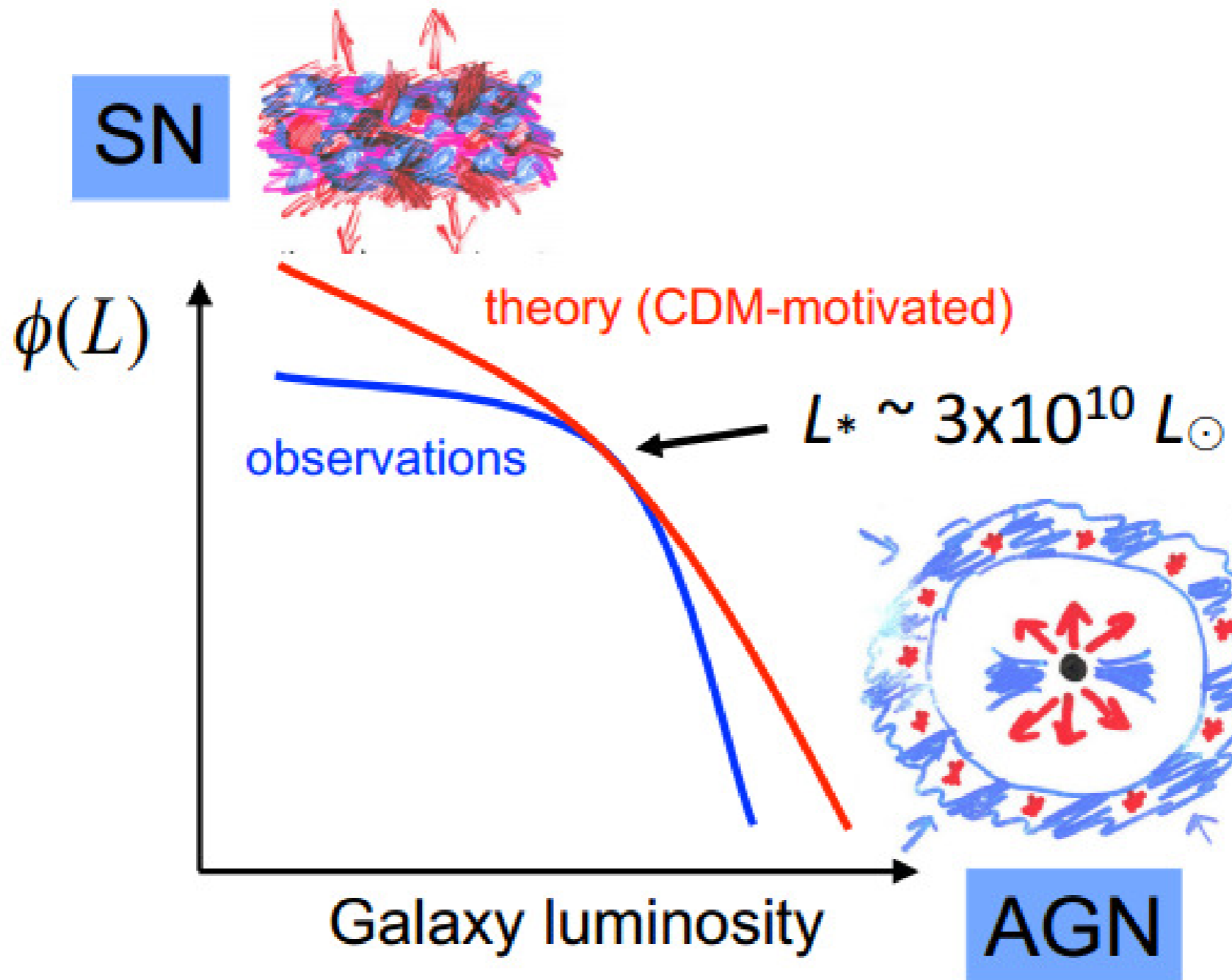


binding energy of galaxy

$$M_{\text{gal}} \sigma^2$$

Lots of binding energy available, efficiencies of 1-5% are sufficient

INTRODUCTION



Silk+2012

INTRODUCTION

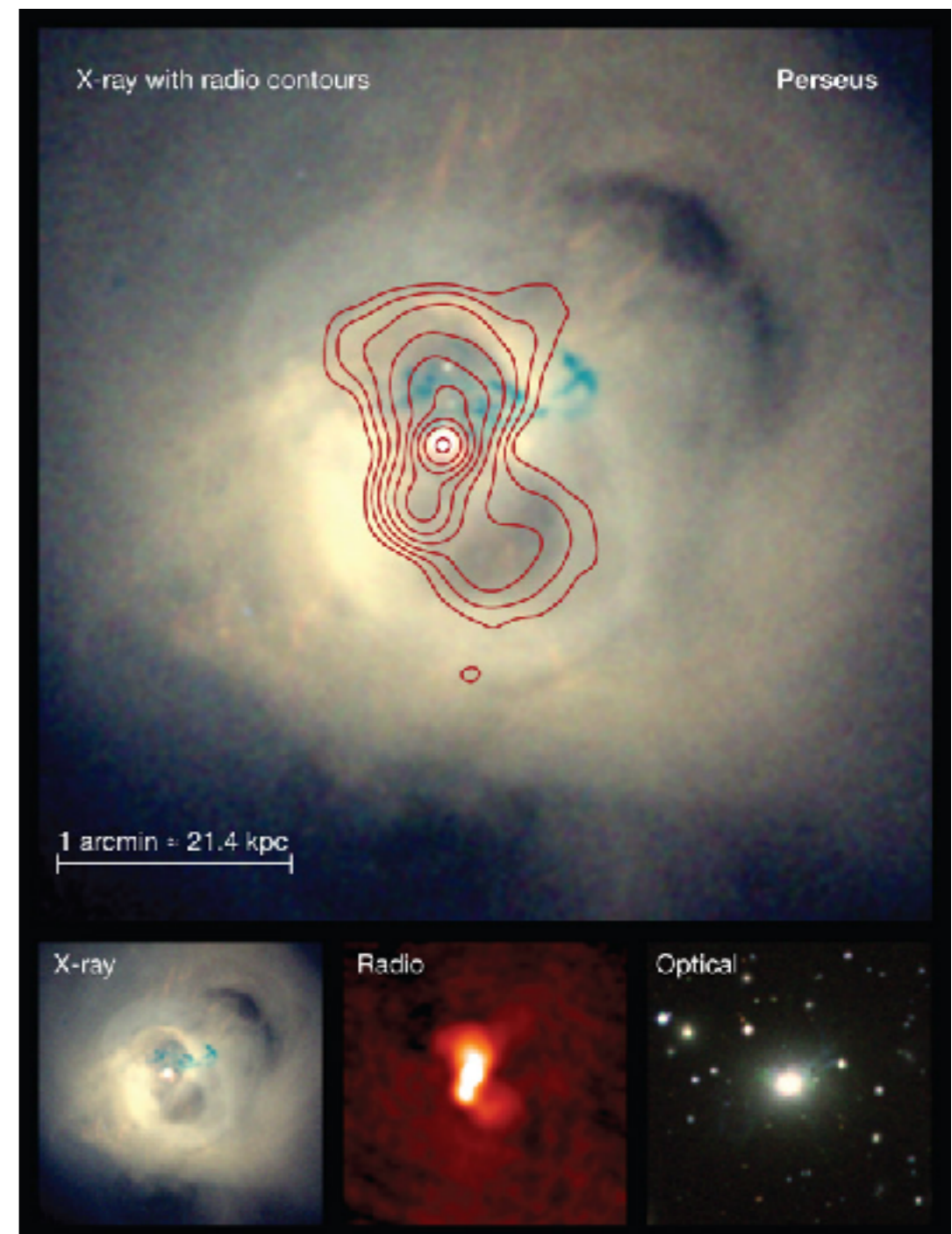
Until recently:

Few observations of quasar feedback

Earliest evidence: radio jets, bubbles

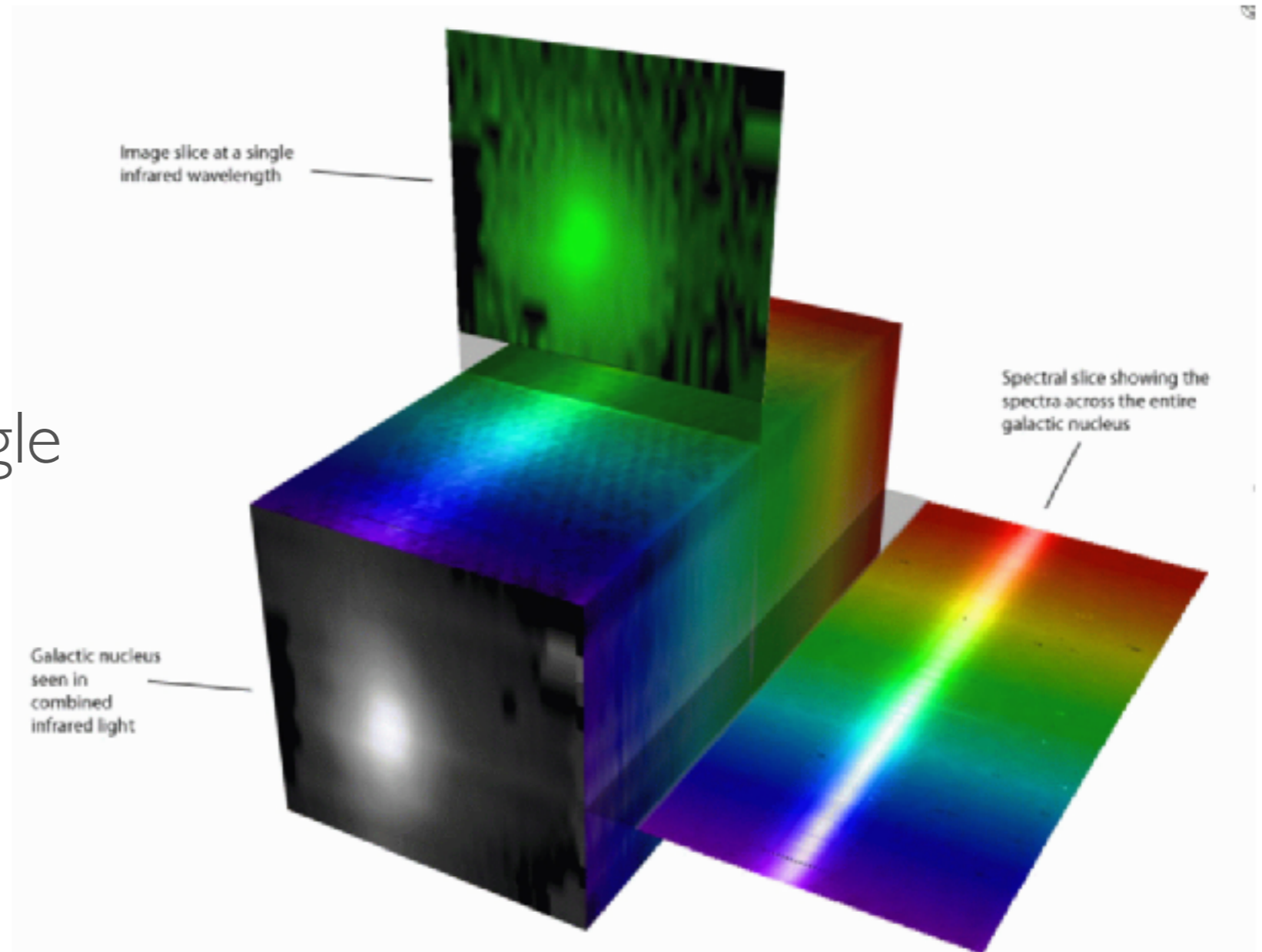
Most quasars: radio-quiet, no powerful jets! Radiatively-driven winds?

Cattaneo+2009



OBSERVATIONS - IFU

Spectrum in every single pixel (spaxel)



credit: S. Todd, D. Pierce-Price

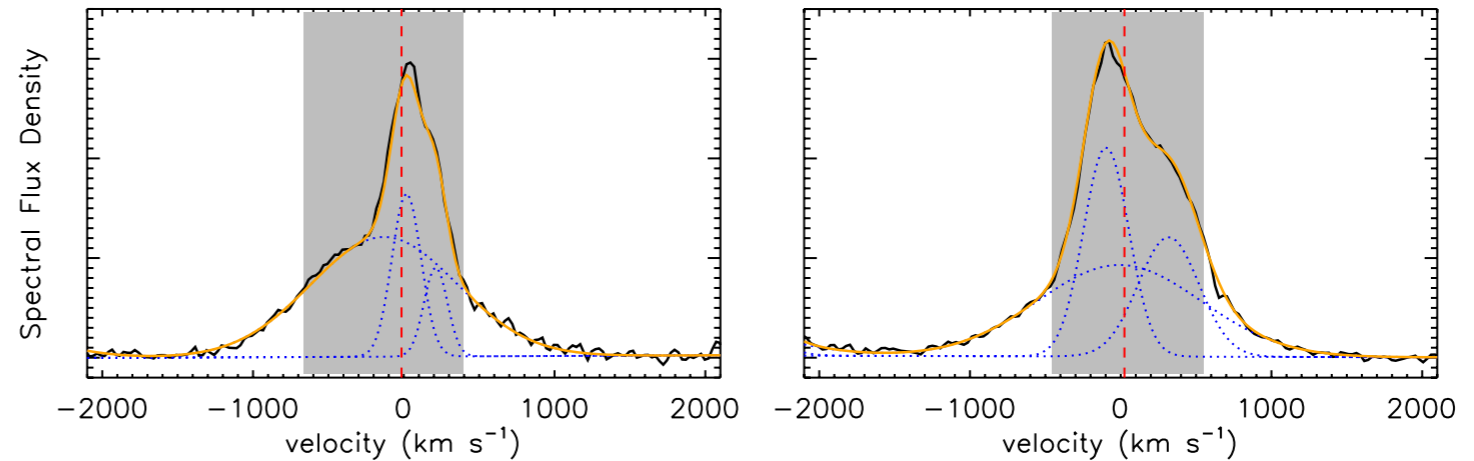


OBSERVATIONAL EVIDENCE

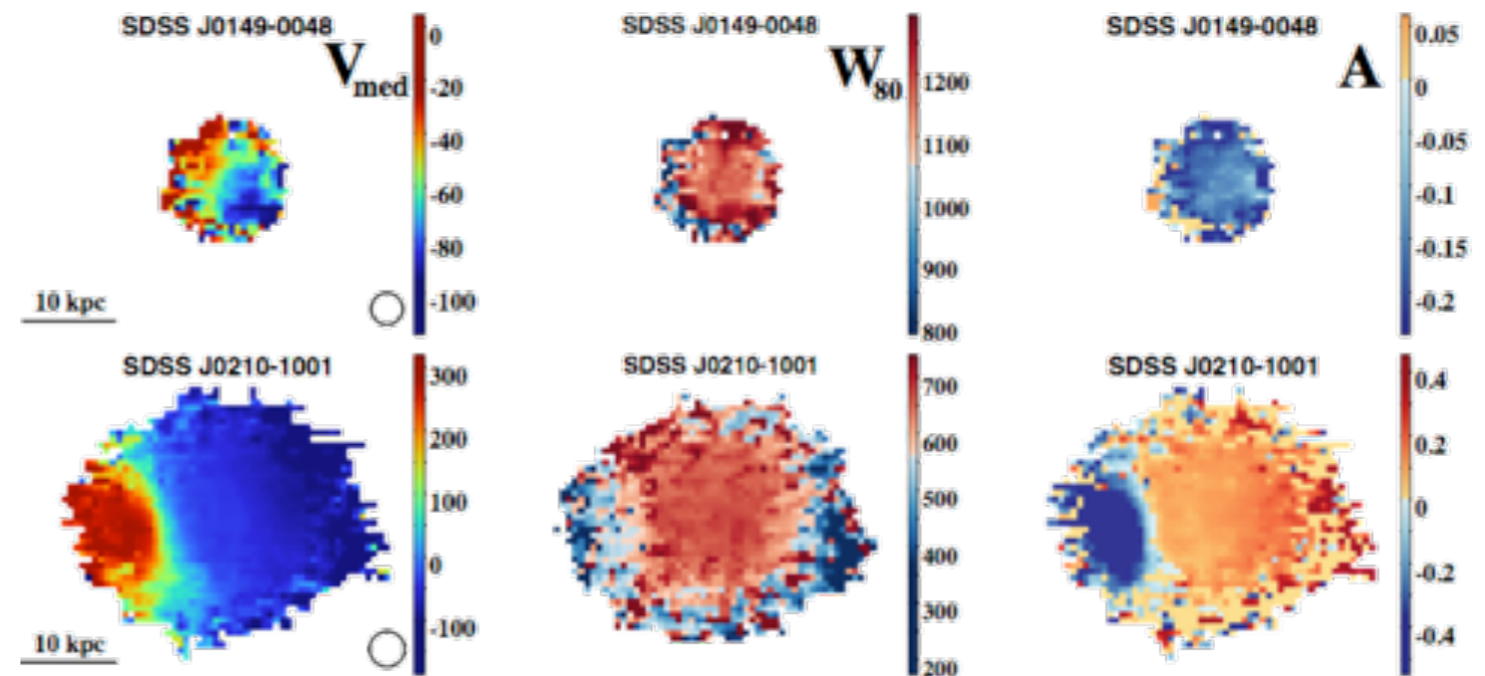
OBSERVATIONAL EVIDENCE

Recent detections of galaxy-wide outflows with high velocity dispersions in luminous quasars

now seen by several groups



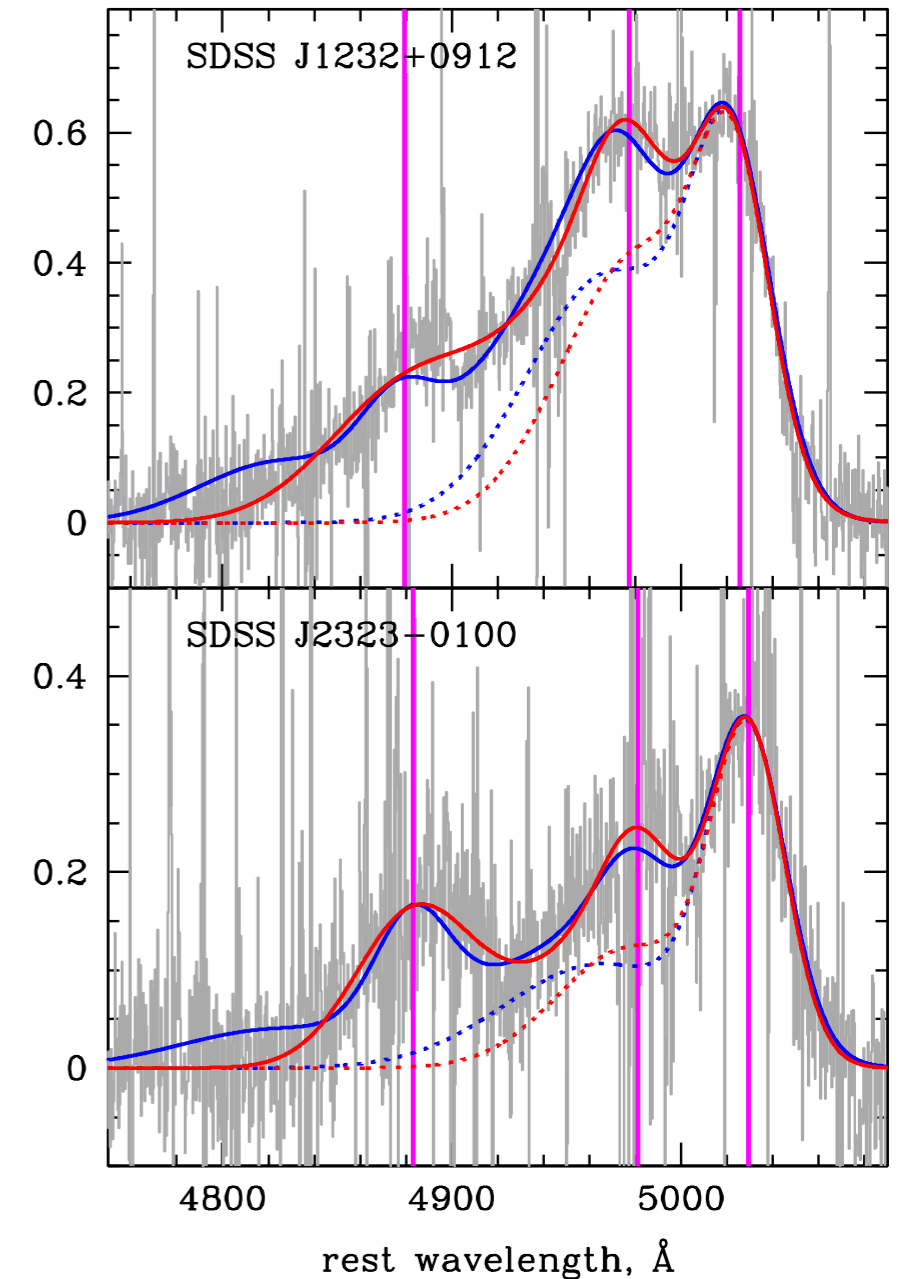
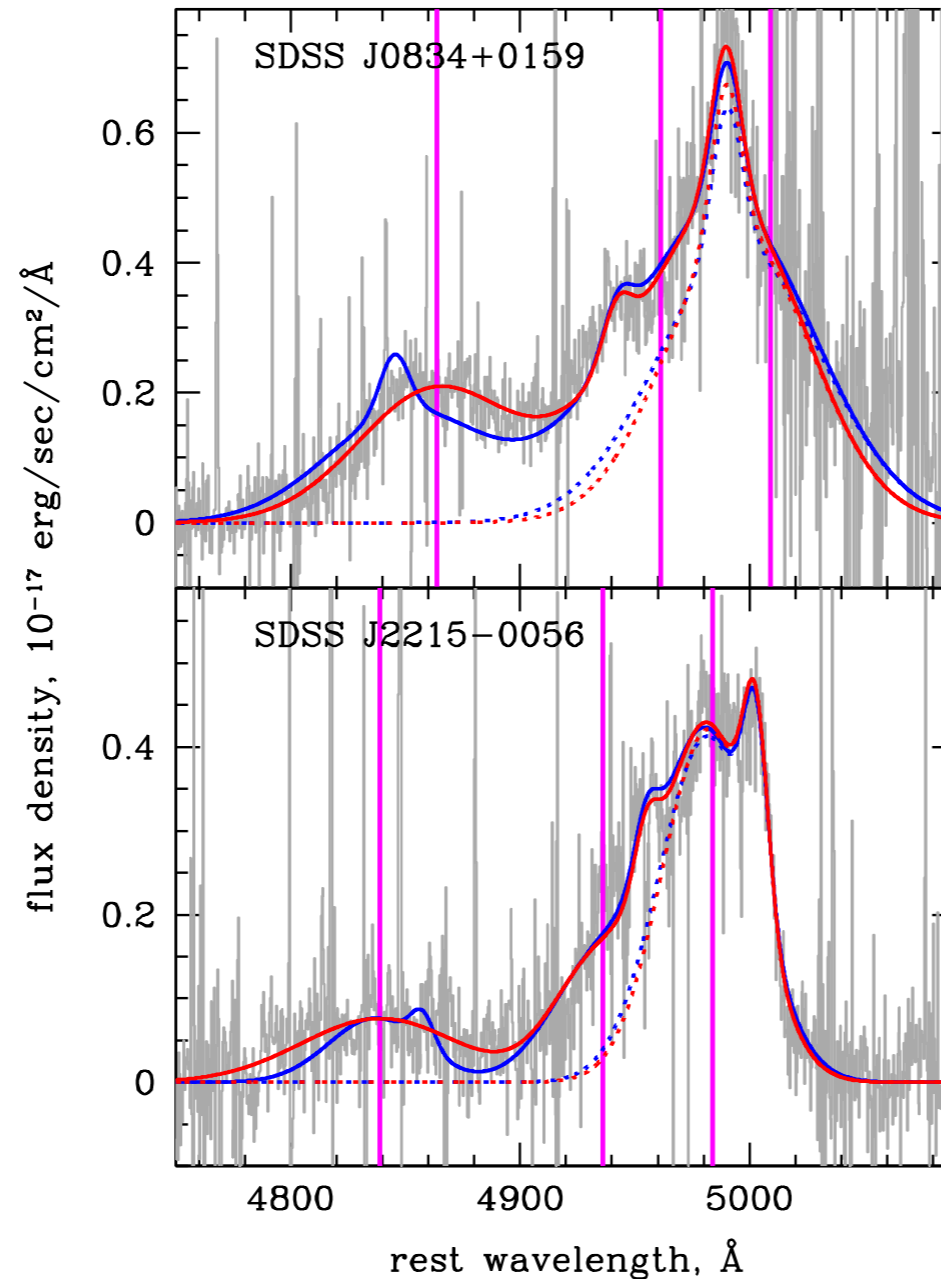
blue/redshifted extreme velocities high negative asymmetries



Liu+2013a,b

OBSERVATIONAL EVIDENCE

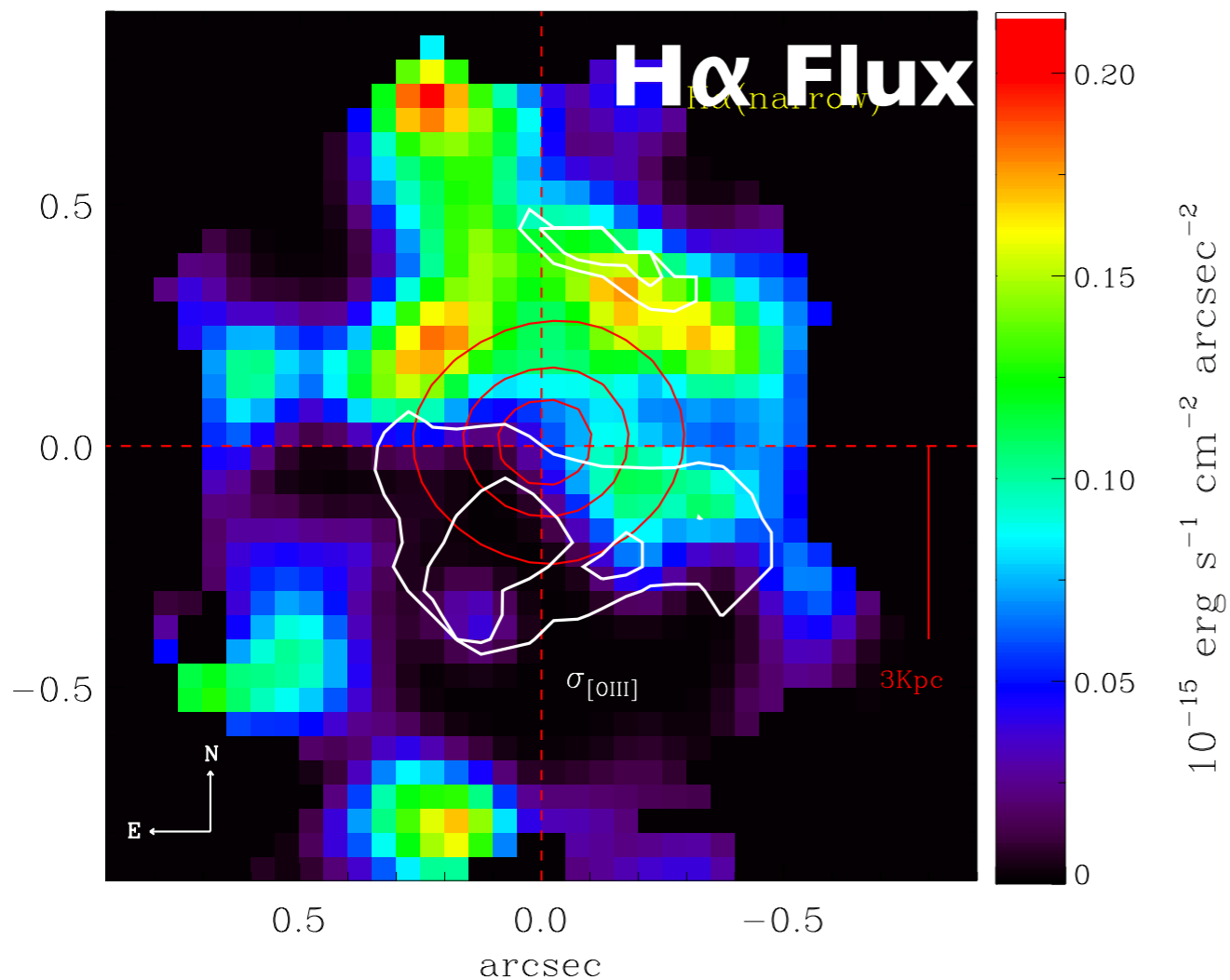
High-redshift
(distant) powerful
quasars with
FWHM $\sim 3000 - 5000$ km/s



Zakamska+2016

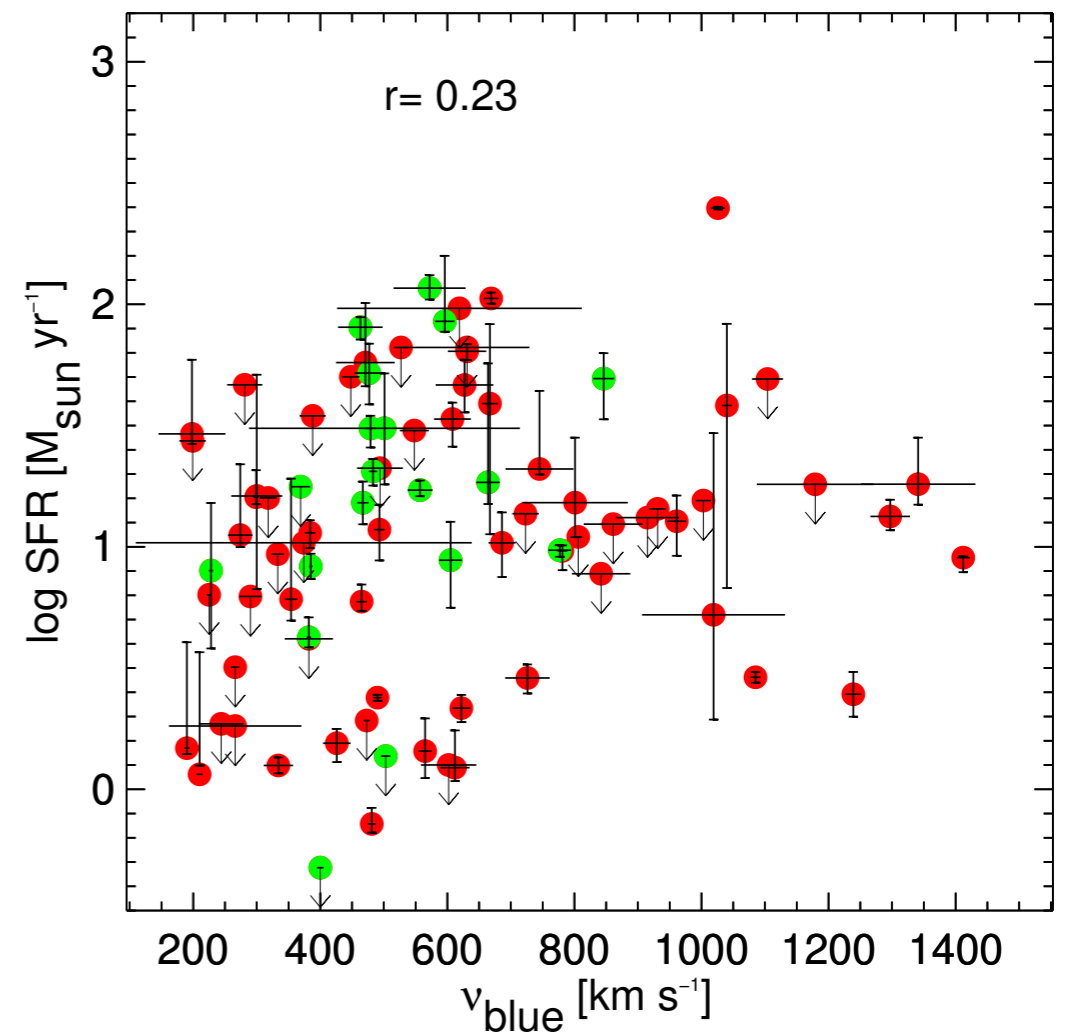
OBSERVATIONAL EVIDENCE

LOCAL EVIDENCE



Cano-Diaz+2012

GLOBAL EVIDENCE?

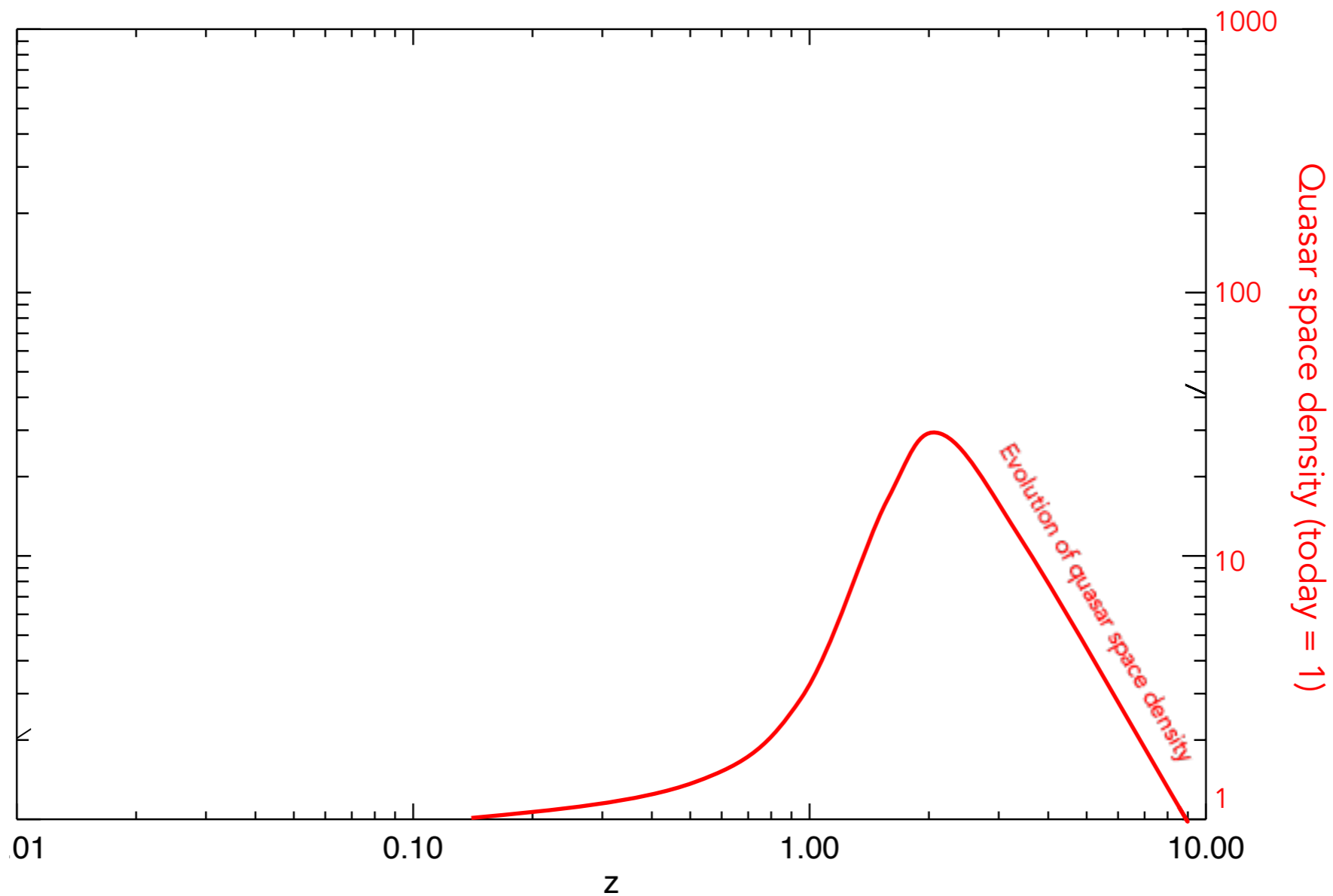


Balmaverde+2015

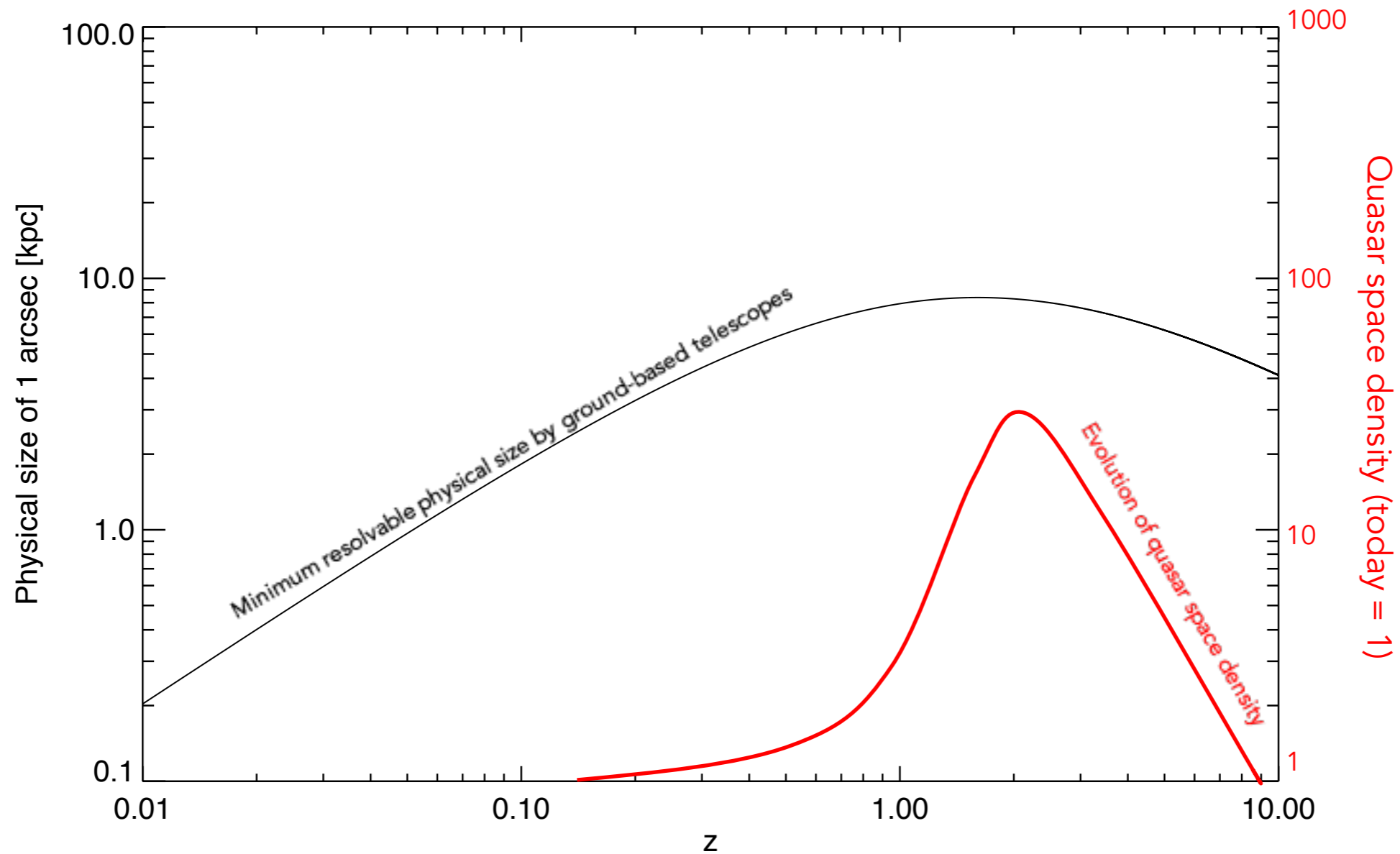


WHERE TO LOOK?

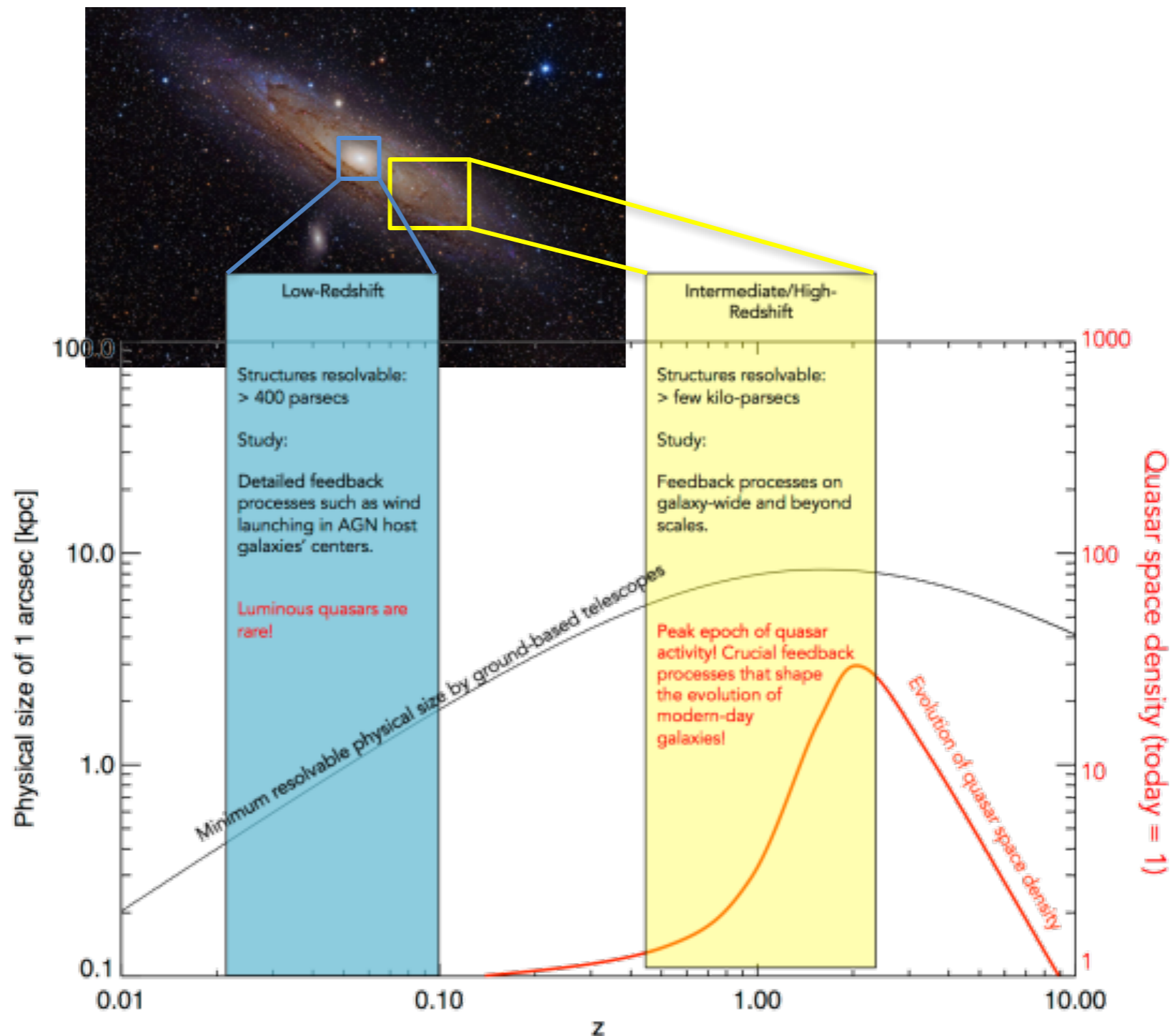
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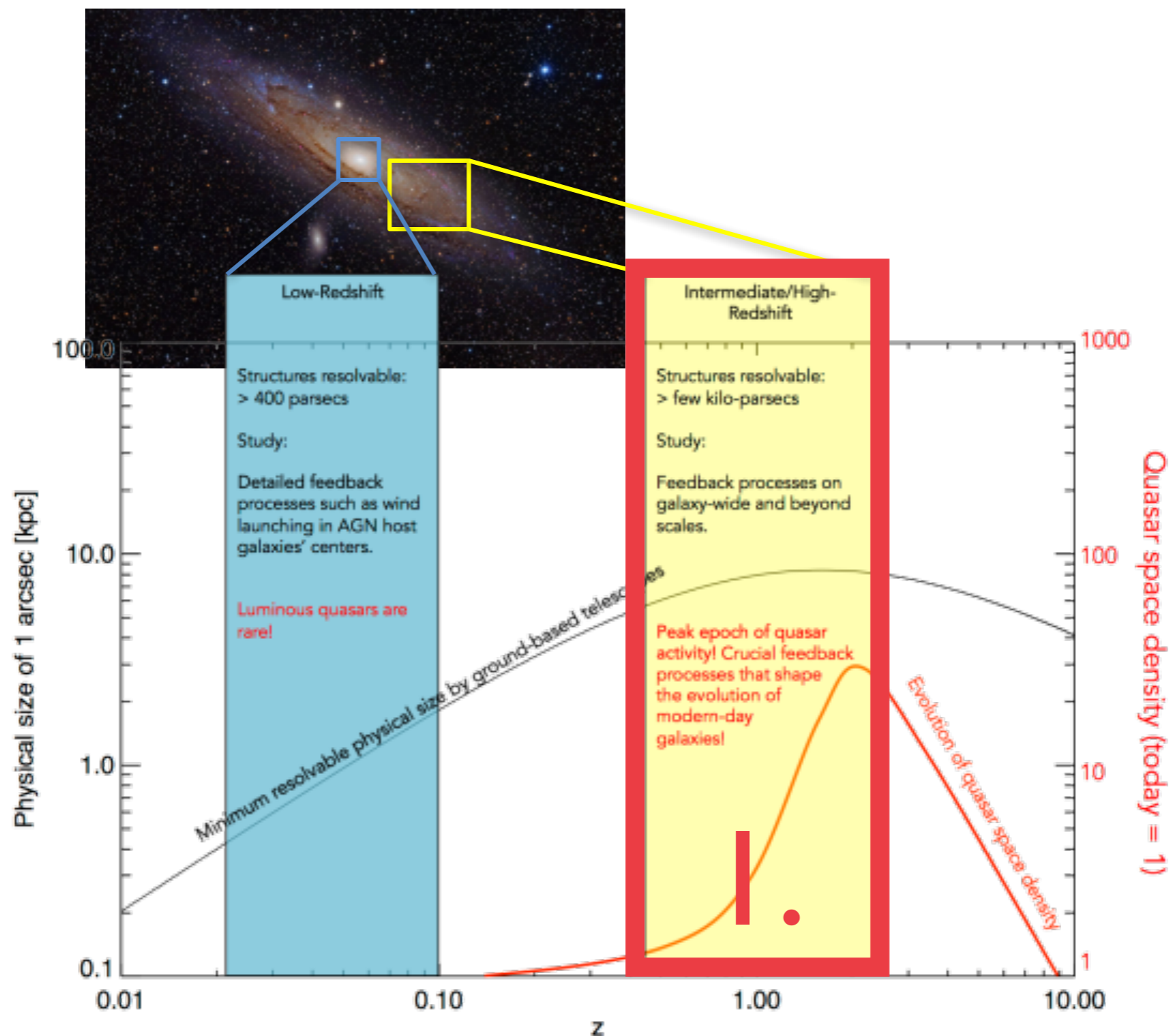
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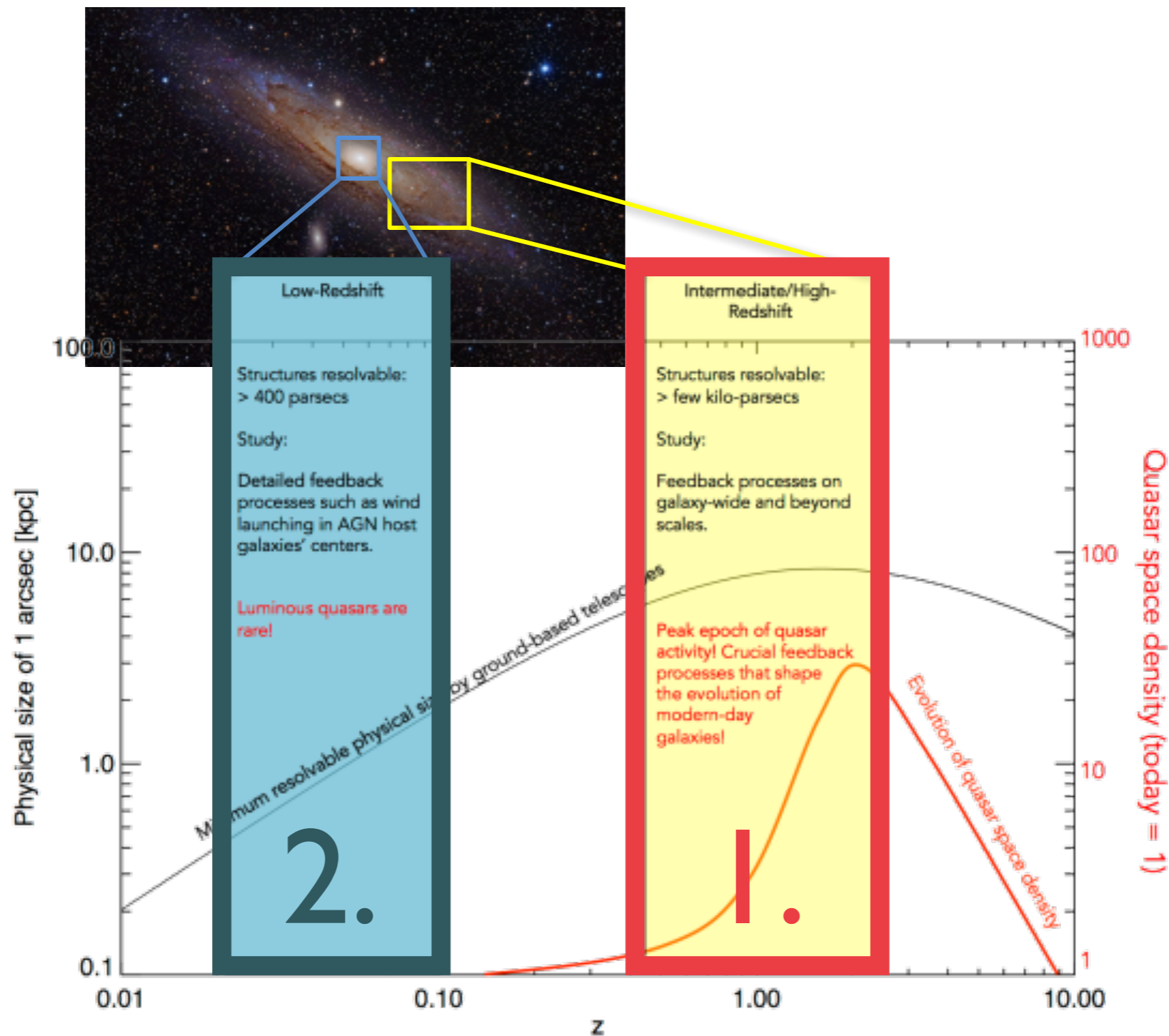
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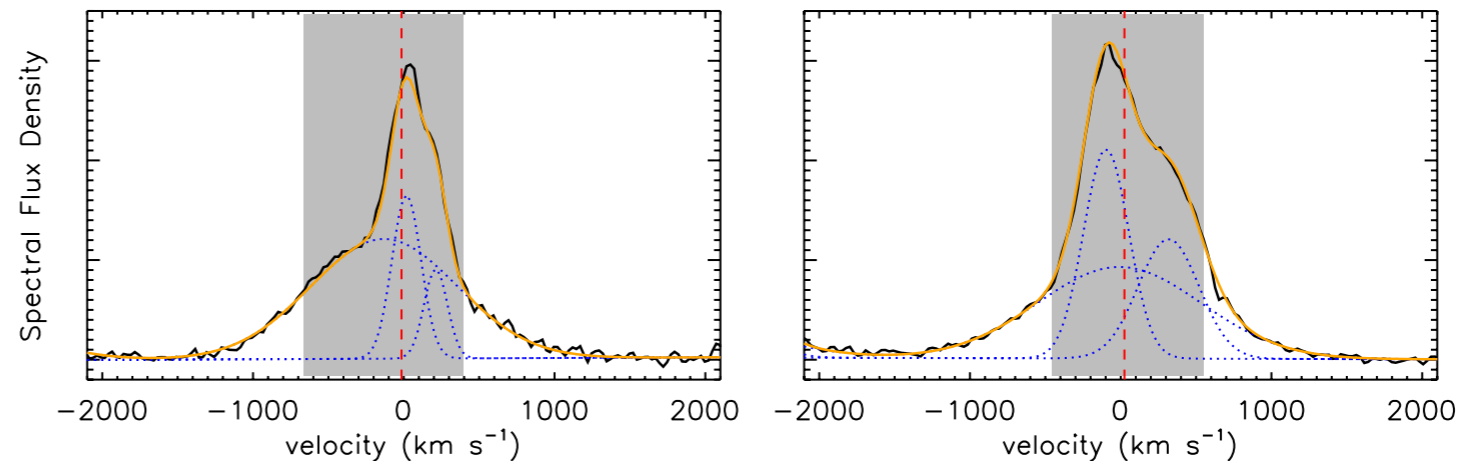


FEEDBACK IN POWERFUL QUASARS AT $z \sim 0.5$

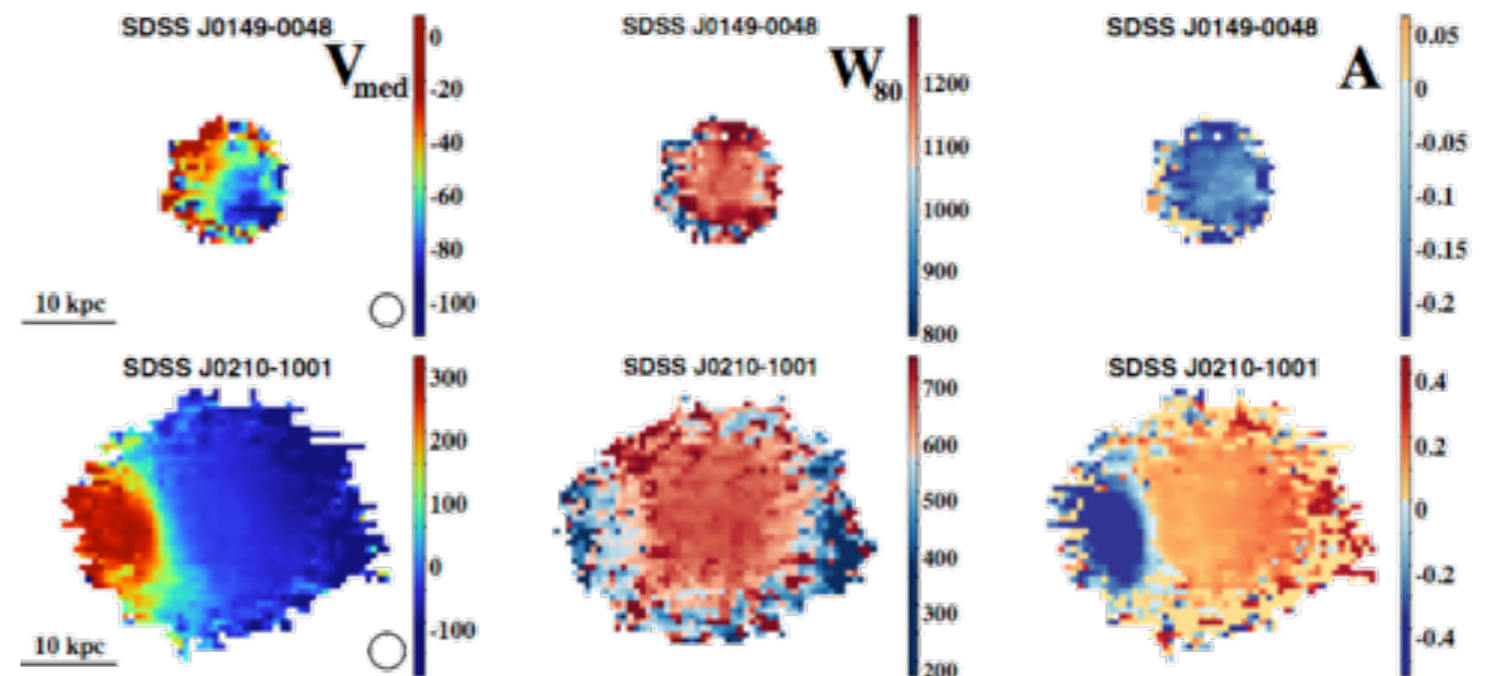
OUTFLOWS IN POWERFUL QUASARS

Recent detections of galaxy-wide outflows with high velocity dispersions in luminous quasars

now seen by several groups



blue/redshifted extreme velocities high negative asymmetries



Liu+2013a,b

QUASAR HOST GALAXIES

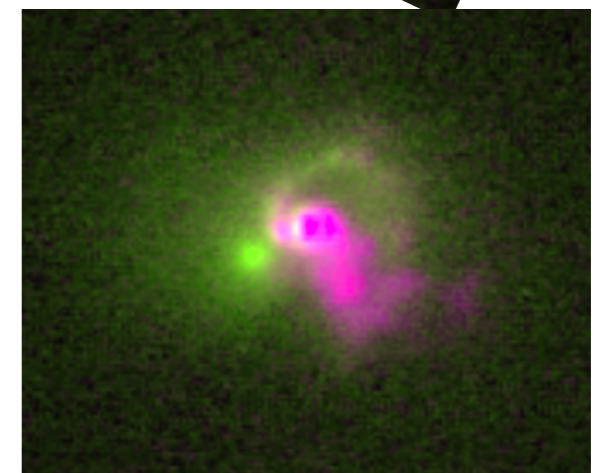
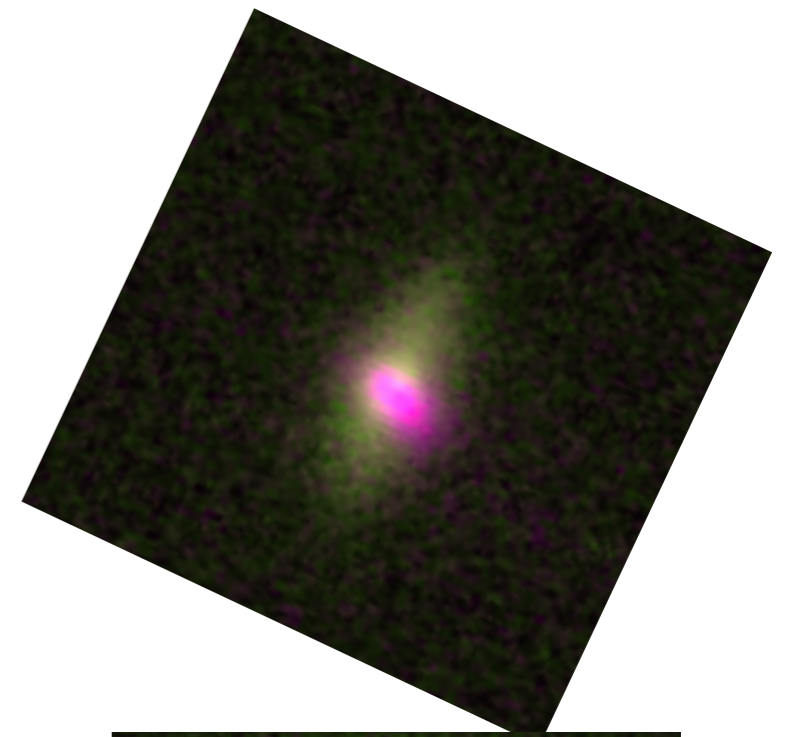
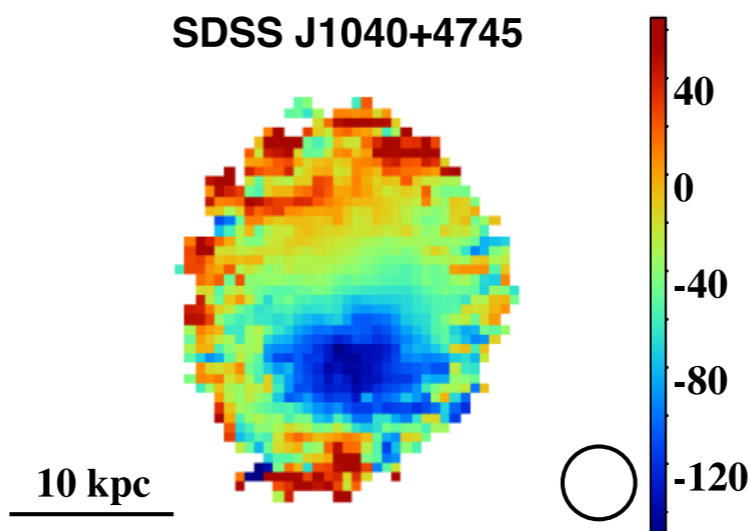
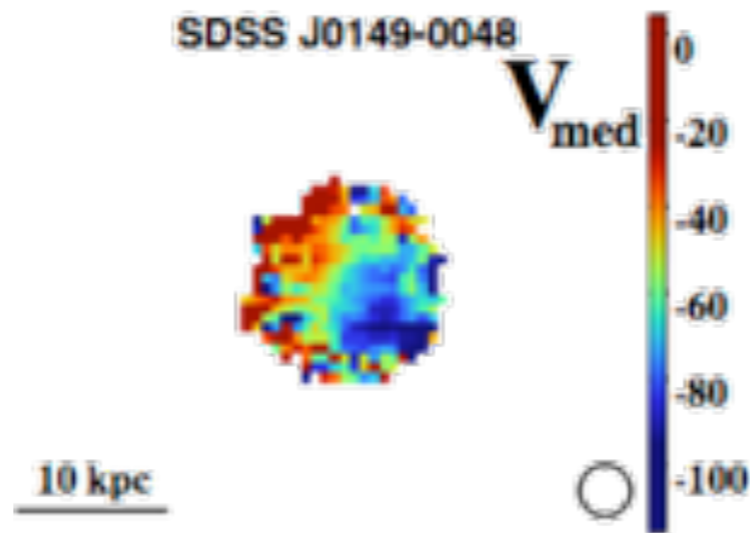
Galaxy-wide outflows

Scattering cones

Luminous quasar host galaxies are bulge-dominated galaxies

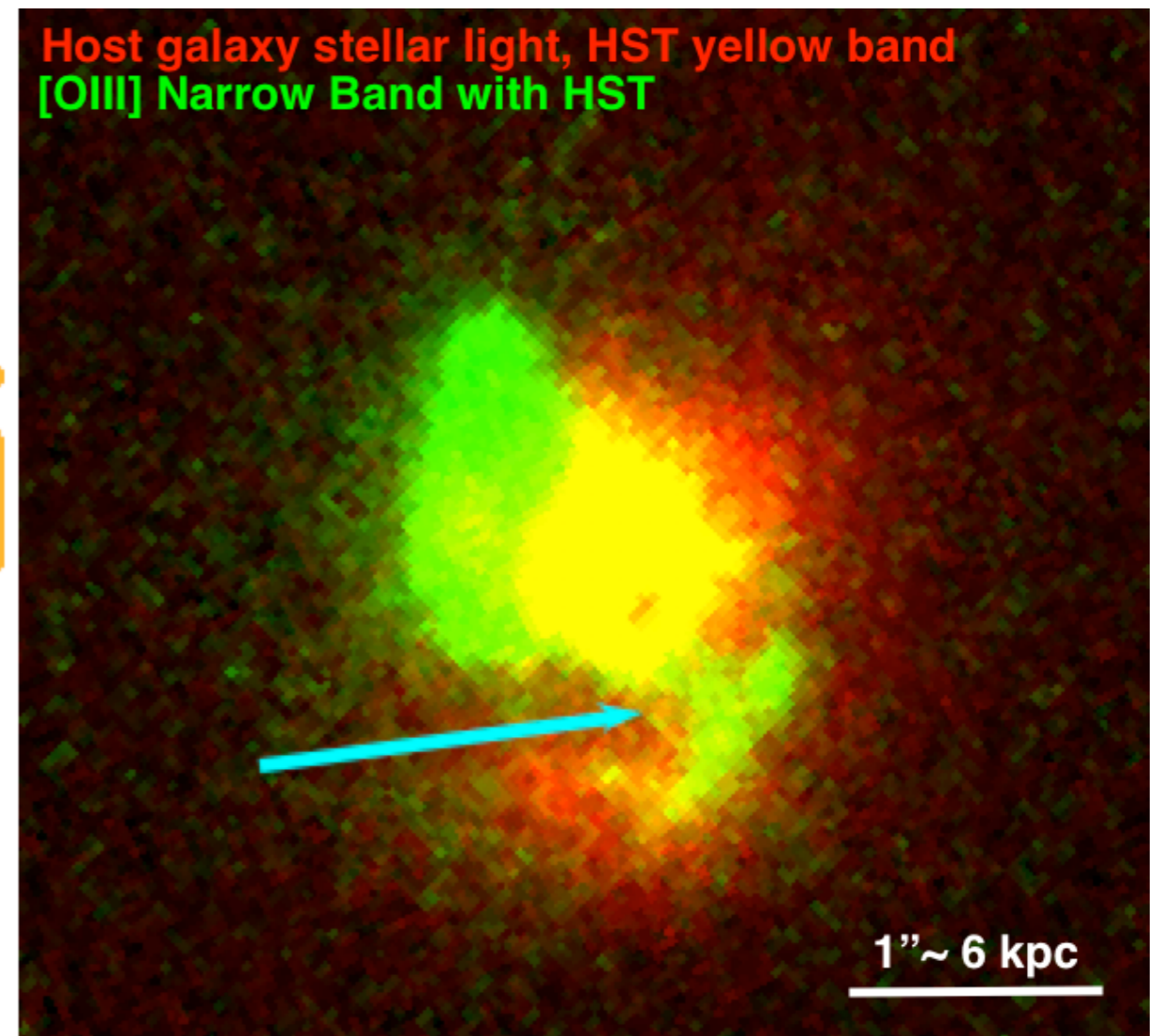
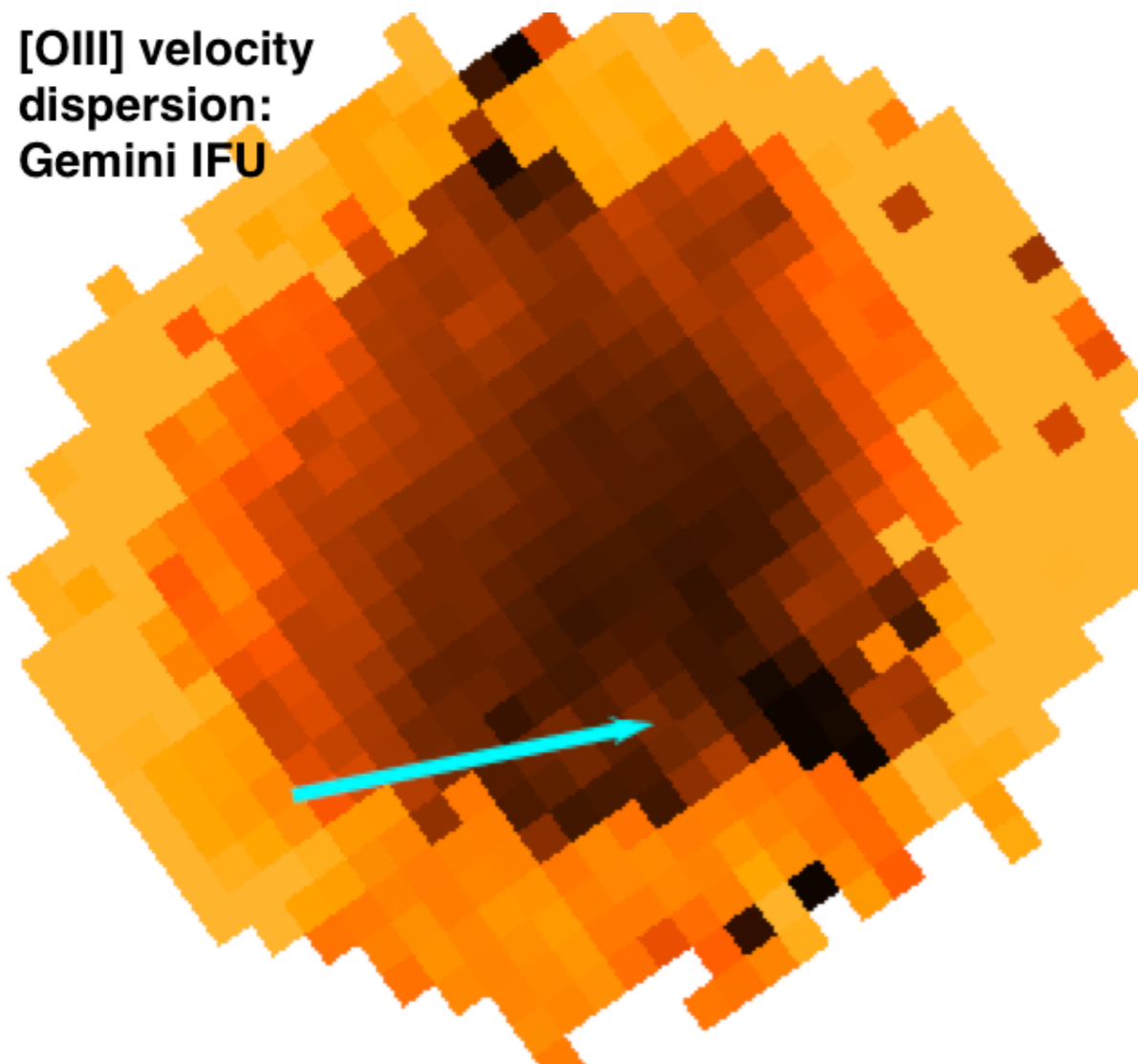
High merger fraction

High star formation rates

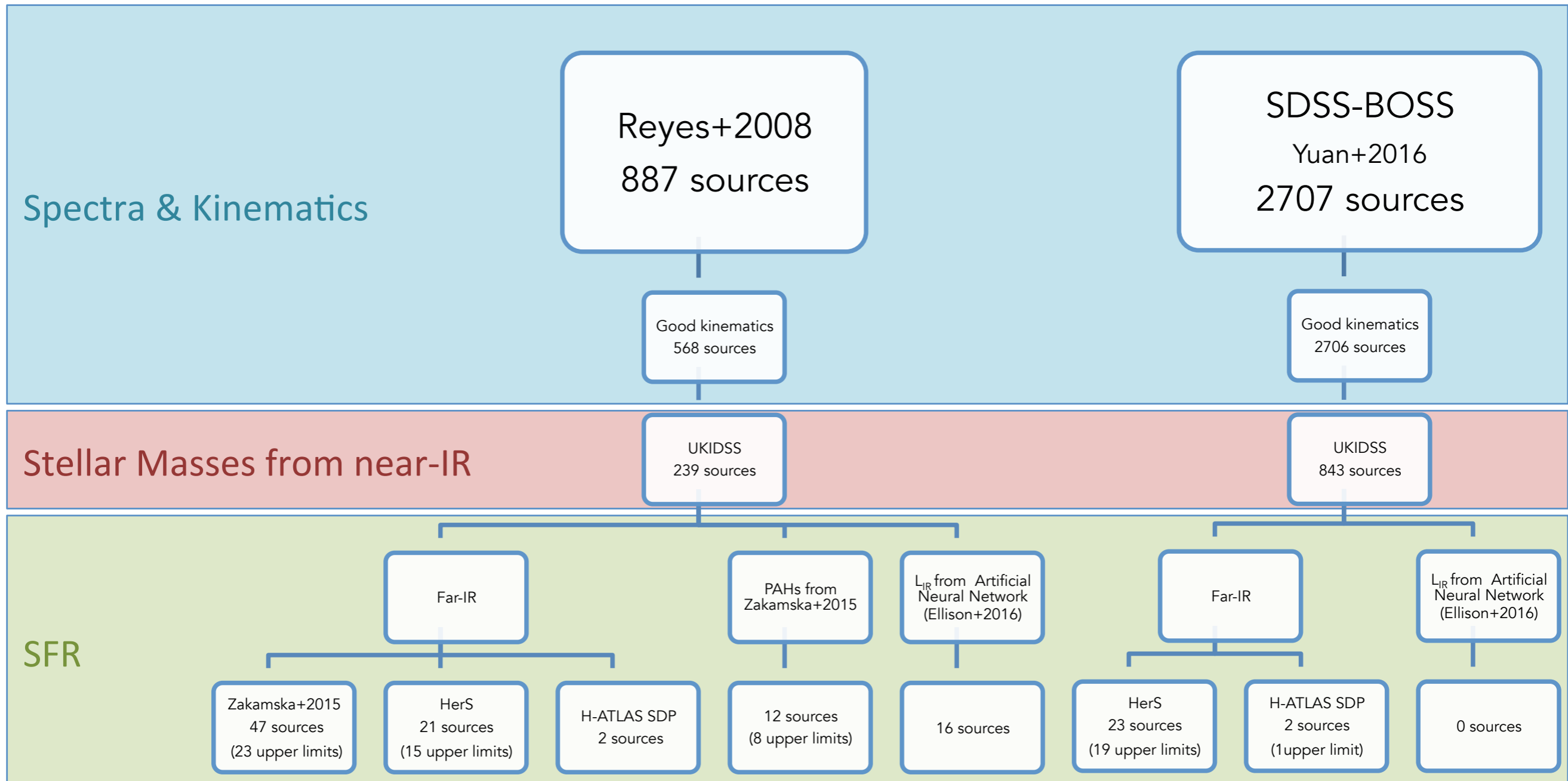


Liu+20 | 3a,b, Wylezalek+20 | 6a, Obied+20 | 6

FAST IONIZED GAS ON LARGE SCALES

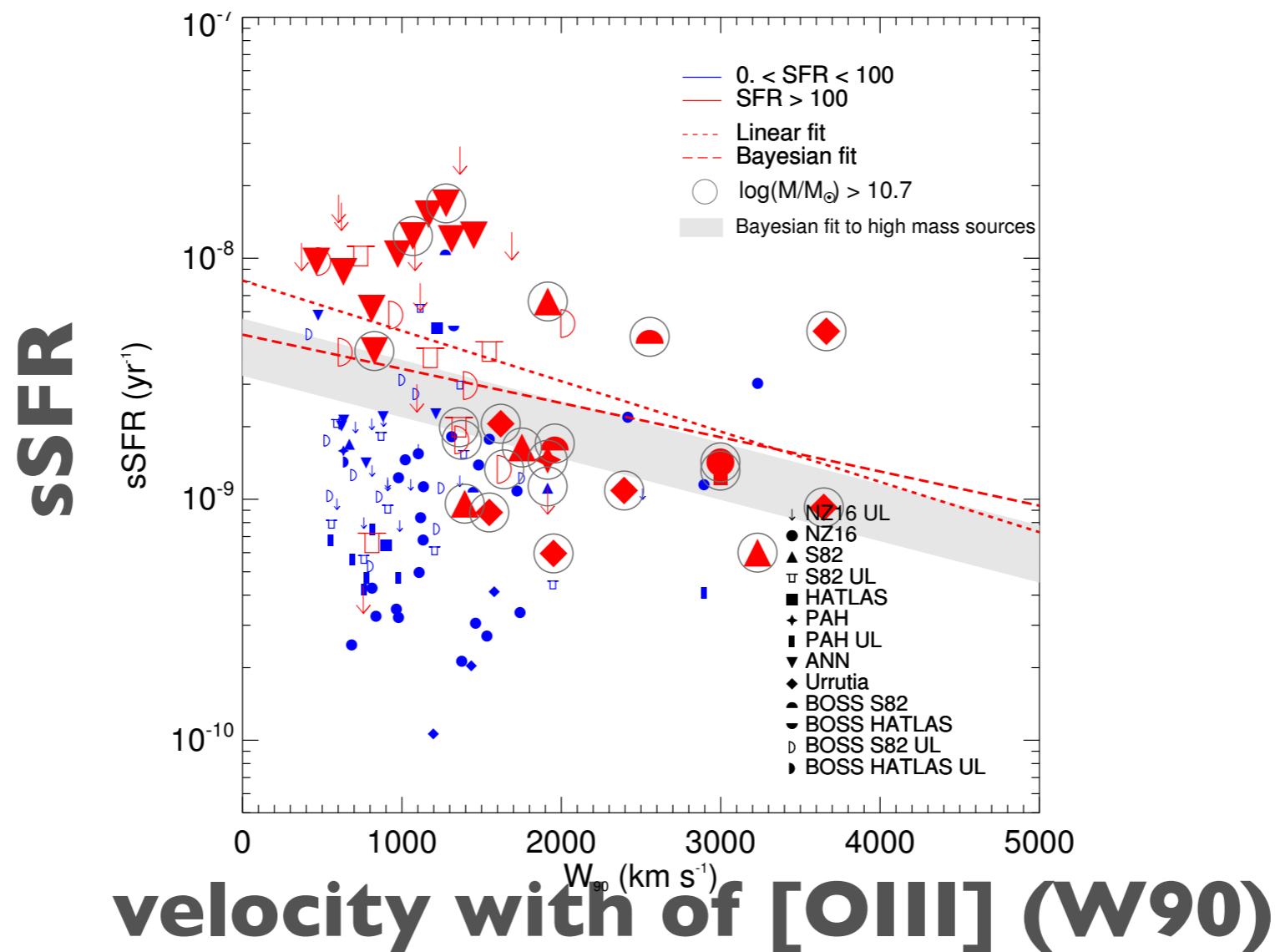


LARGER SAMPLES NEEDED



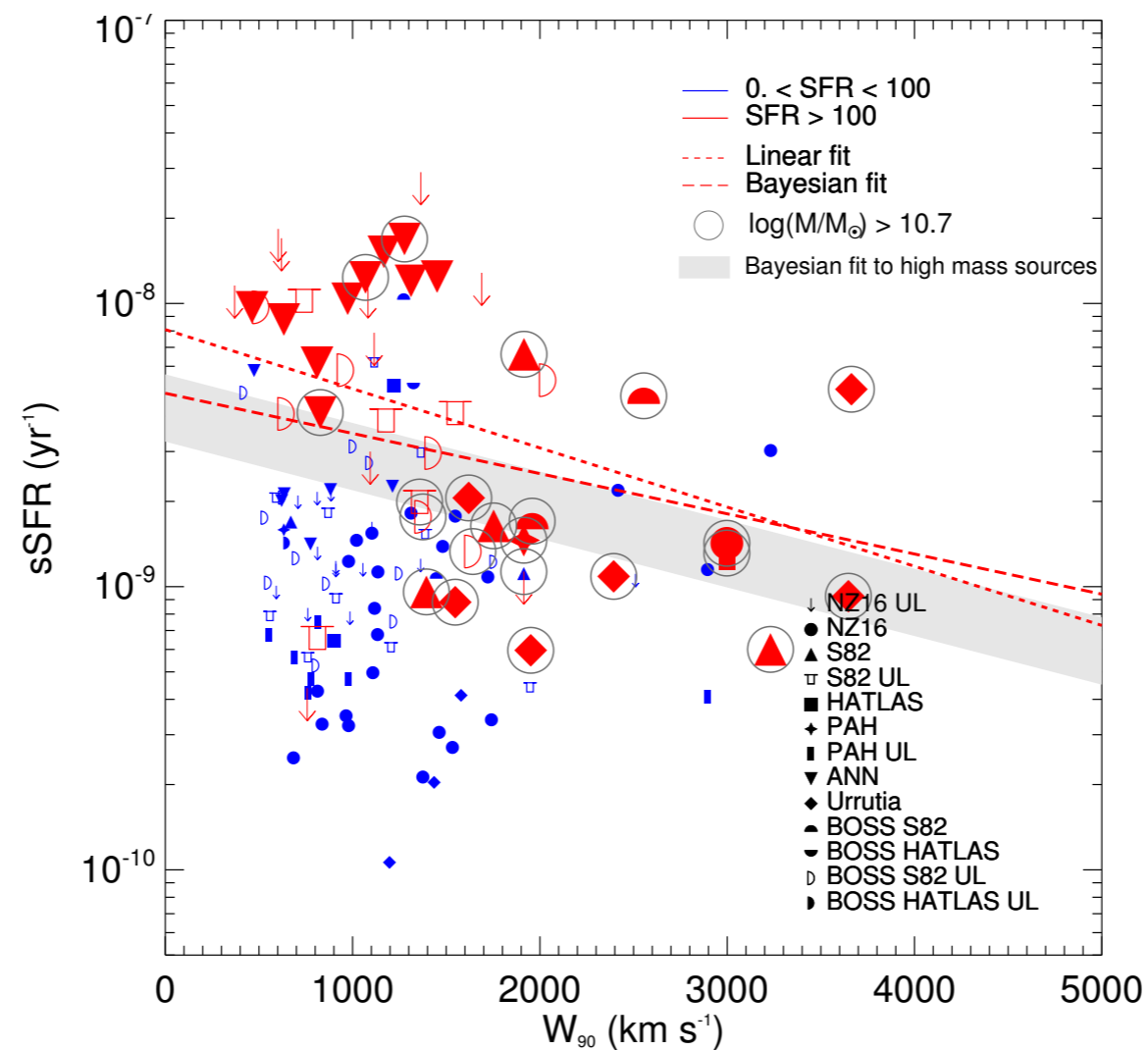
sSFR vs. VELOCITY WIDTH

Strong negative correlation between sSFR and velocity width at high SFRs



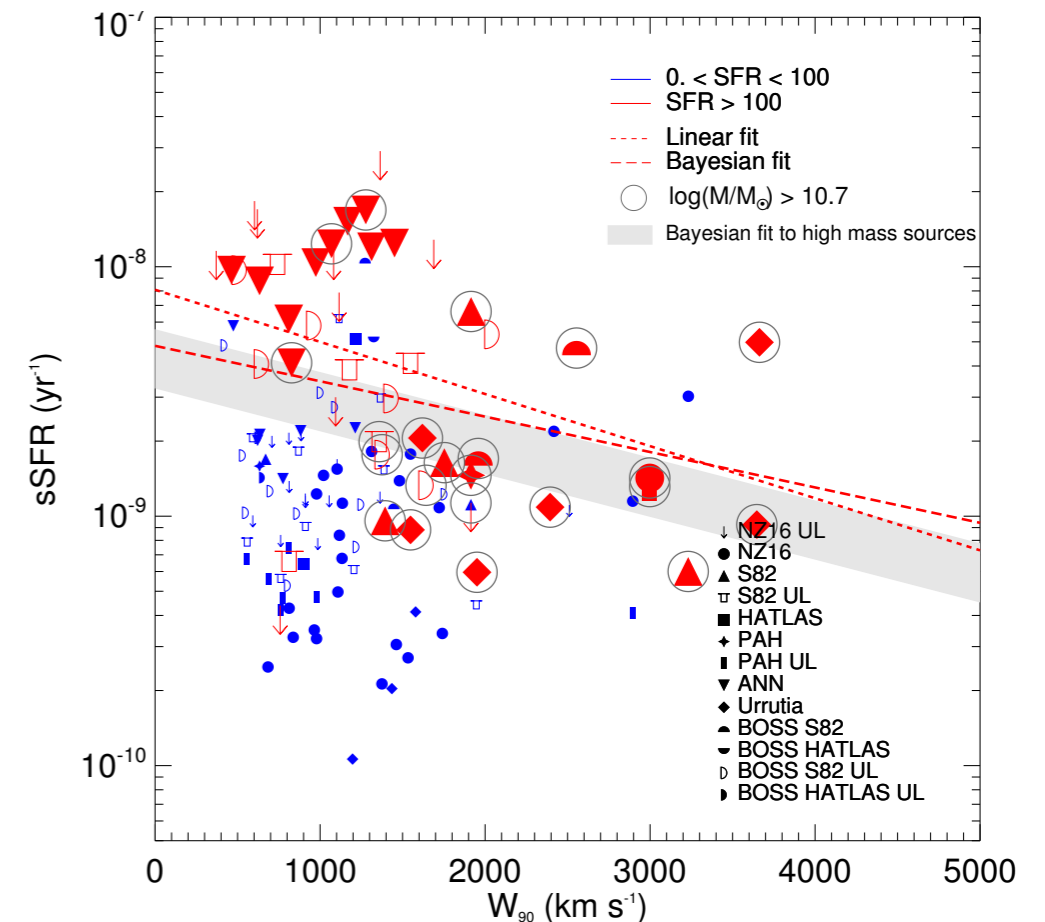
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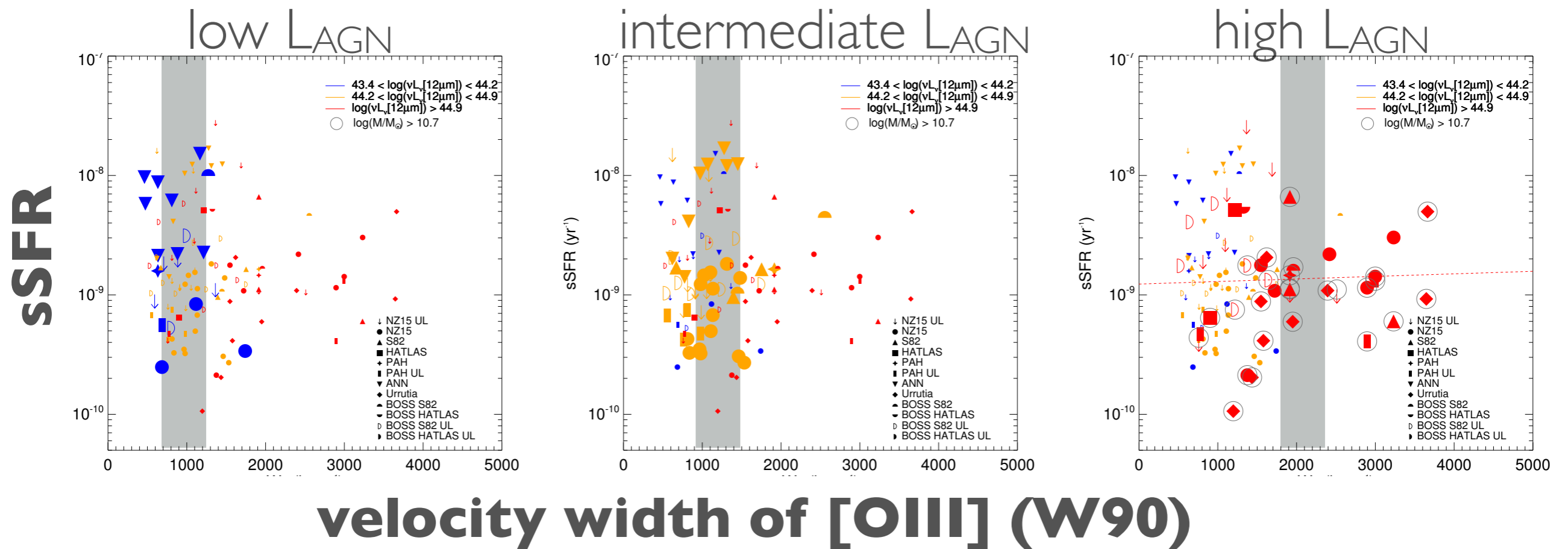


sSFR vs. VELOCITY WIDTH

- negative correlation between sSFR and velocity width at high SFRs
- coupling between wind+gas is potentially strongest
- relative signatures of AGN feedback
- decrease of sSFR driven by increase in stellar mass
- effect of galaxy potential negligible

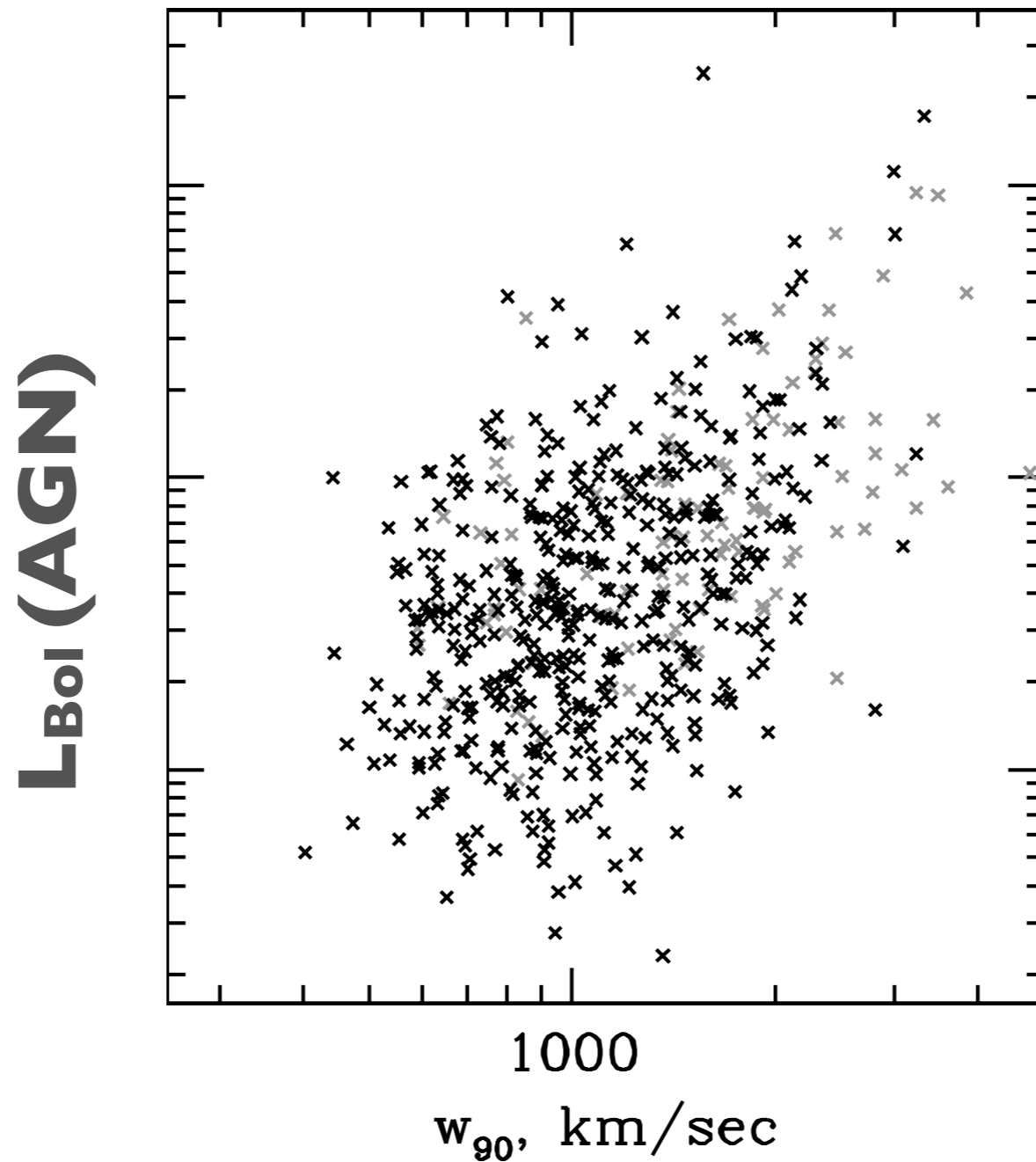


sSFR vs. VELOCITY WIDTH



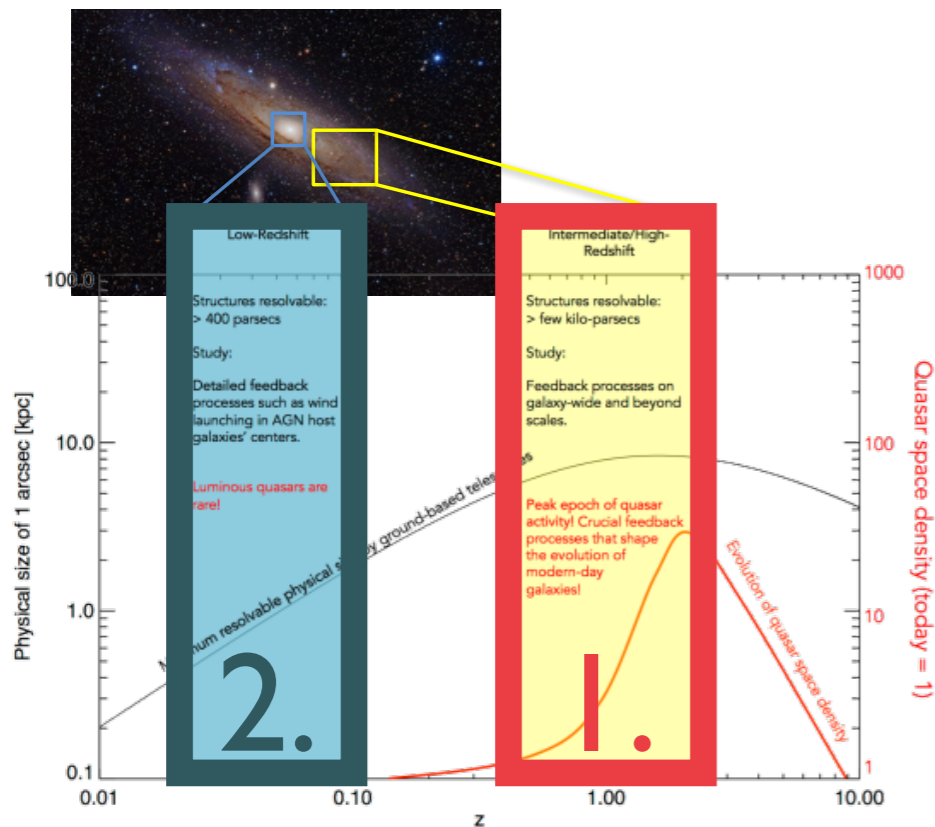
Wylezalek+2016b

FEEDBACK THRESHOLD?



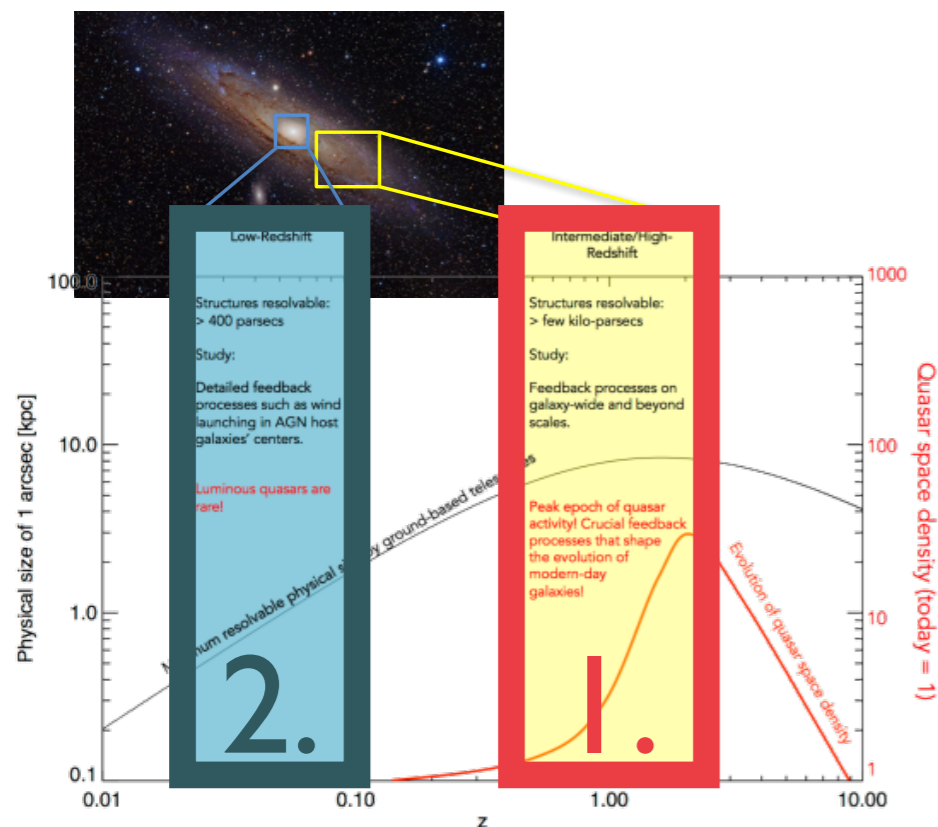
Zakamska+Greene 2014

SUMMARY I



- one of the first direct observational proofs of AGN having a “negative” impact on galaxy evolution
- effect of wind-gas coupling important, at high SFRs can be neglected

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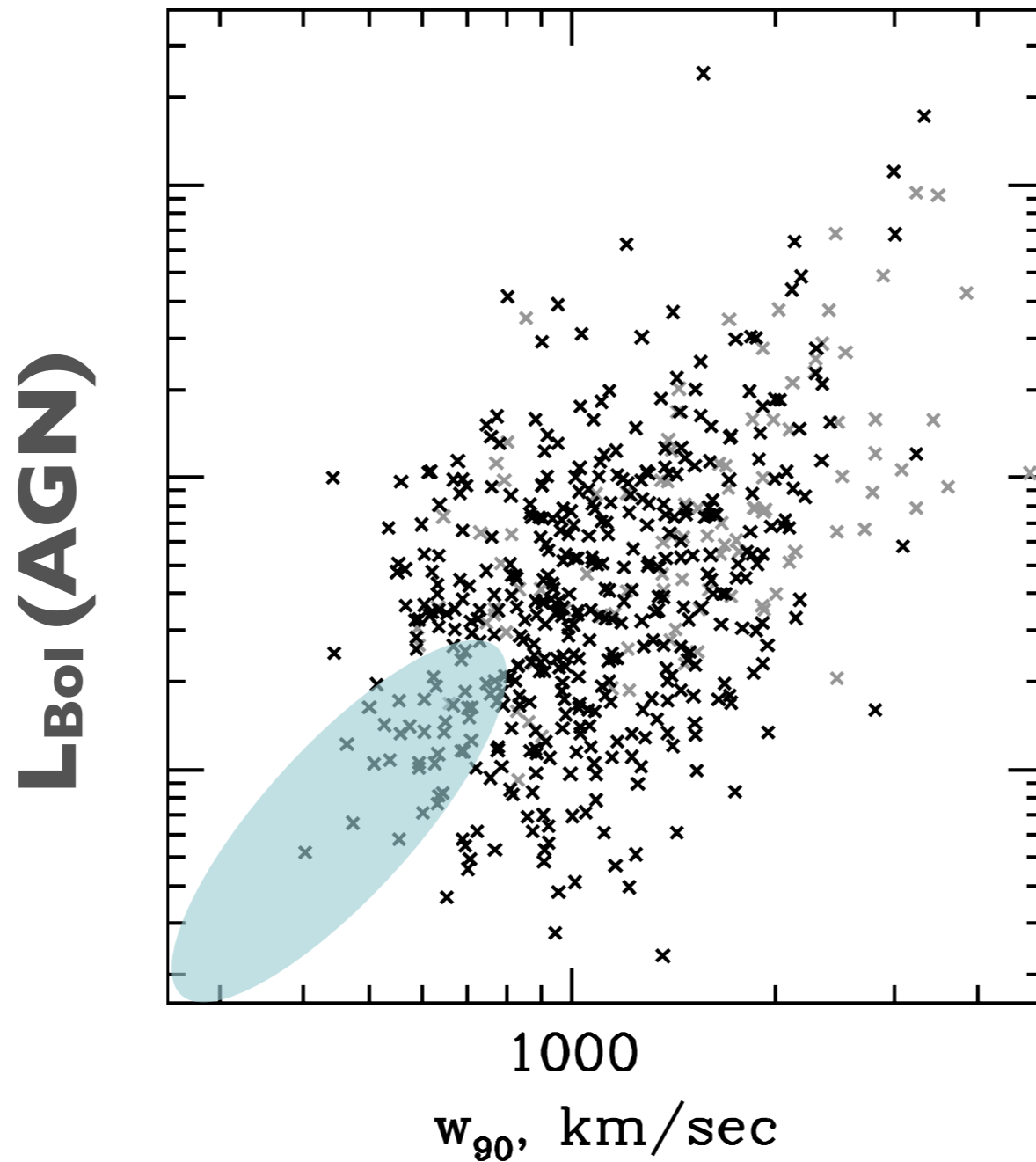
Luminosity threshold for AGN feedback



HOW ARE OUTFLOWS LAUNCHED?

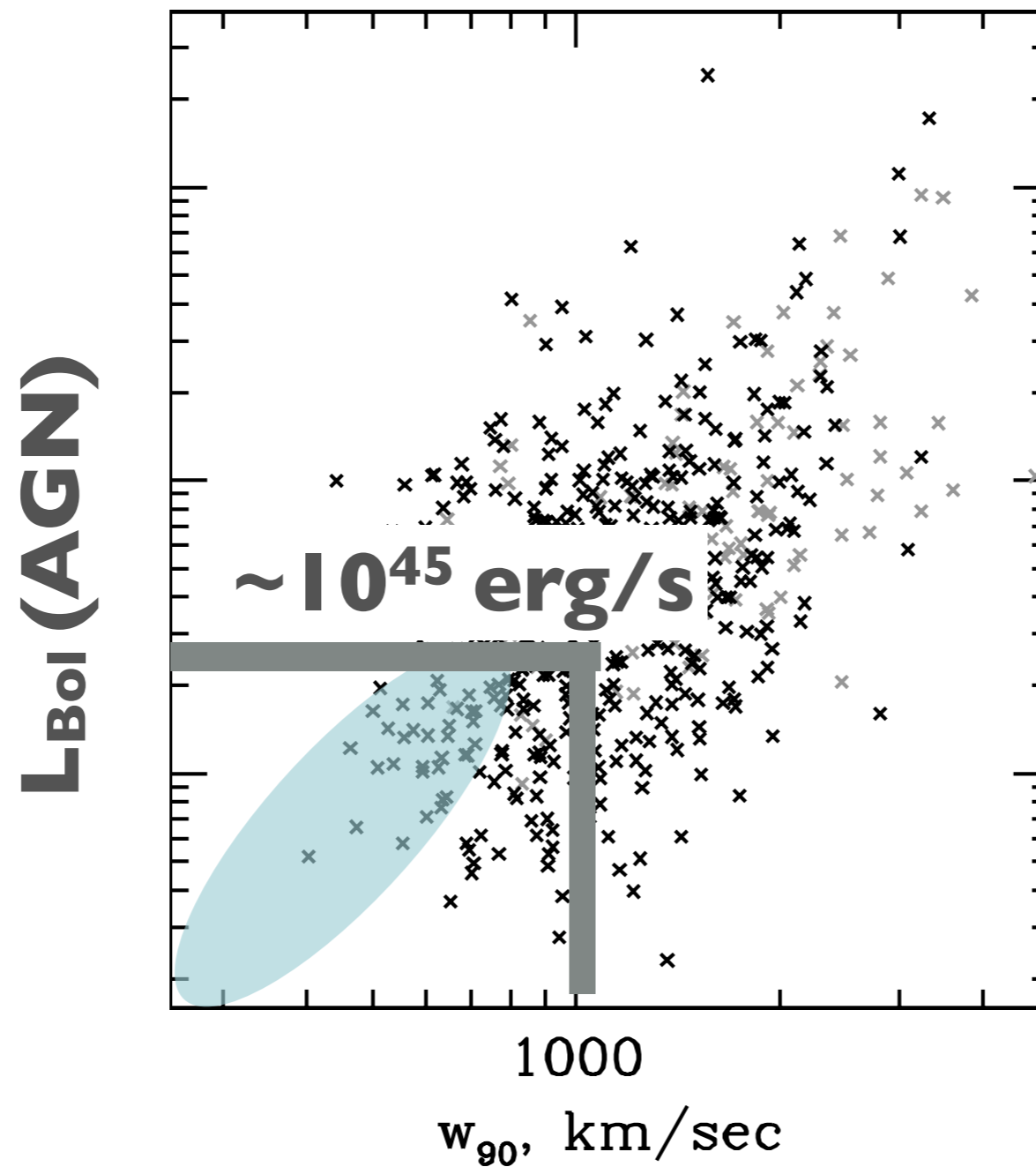
WHAT IS THEIR CONTRIBUTION TO GALAXY EVOLUTION?

FEEDBACK THRESHOLD?



Zakamska+Greene 2014

FEEDBACK THRESHOLD?



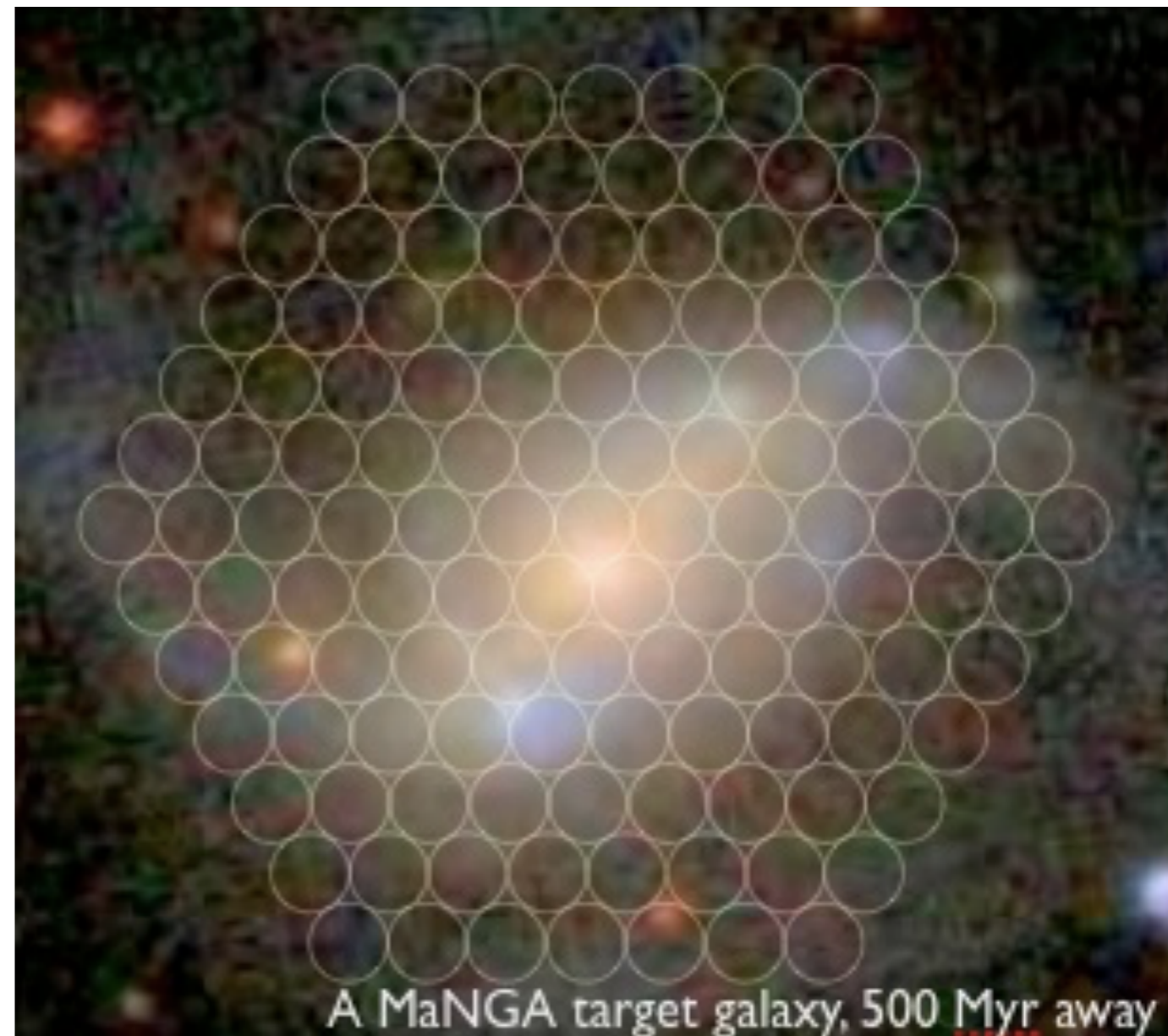
Zakamska+Greene 2014

FEEDBACK THRESHOLD WITH MANGA/GMOS

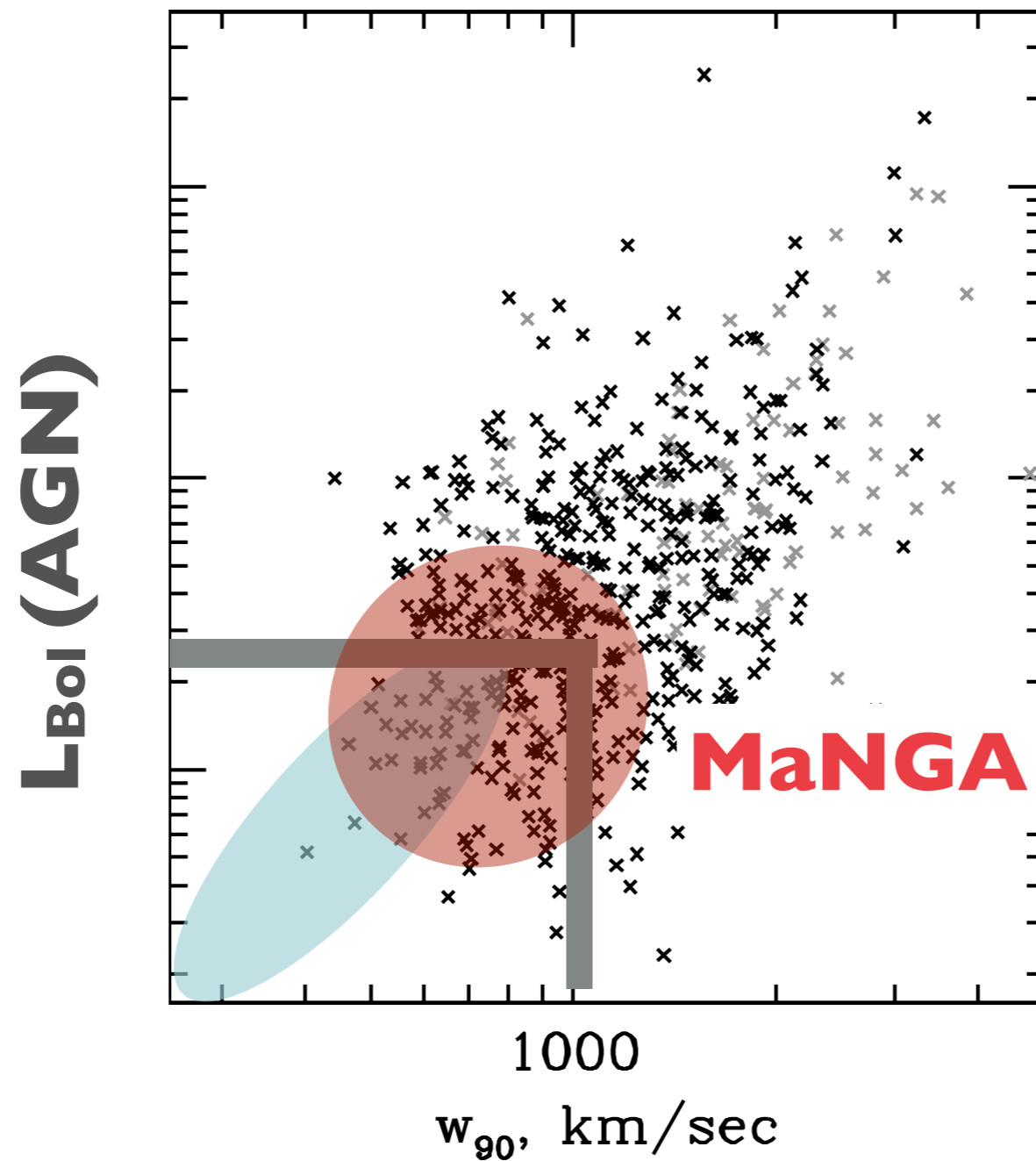
MaNGA - SDSS IV:

10 000 galaxies
group fibers to bundles - IFU

What about the AGN in this
sample?

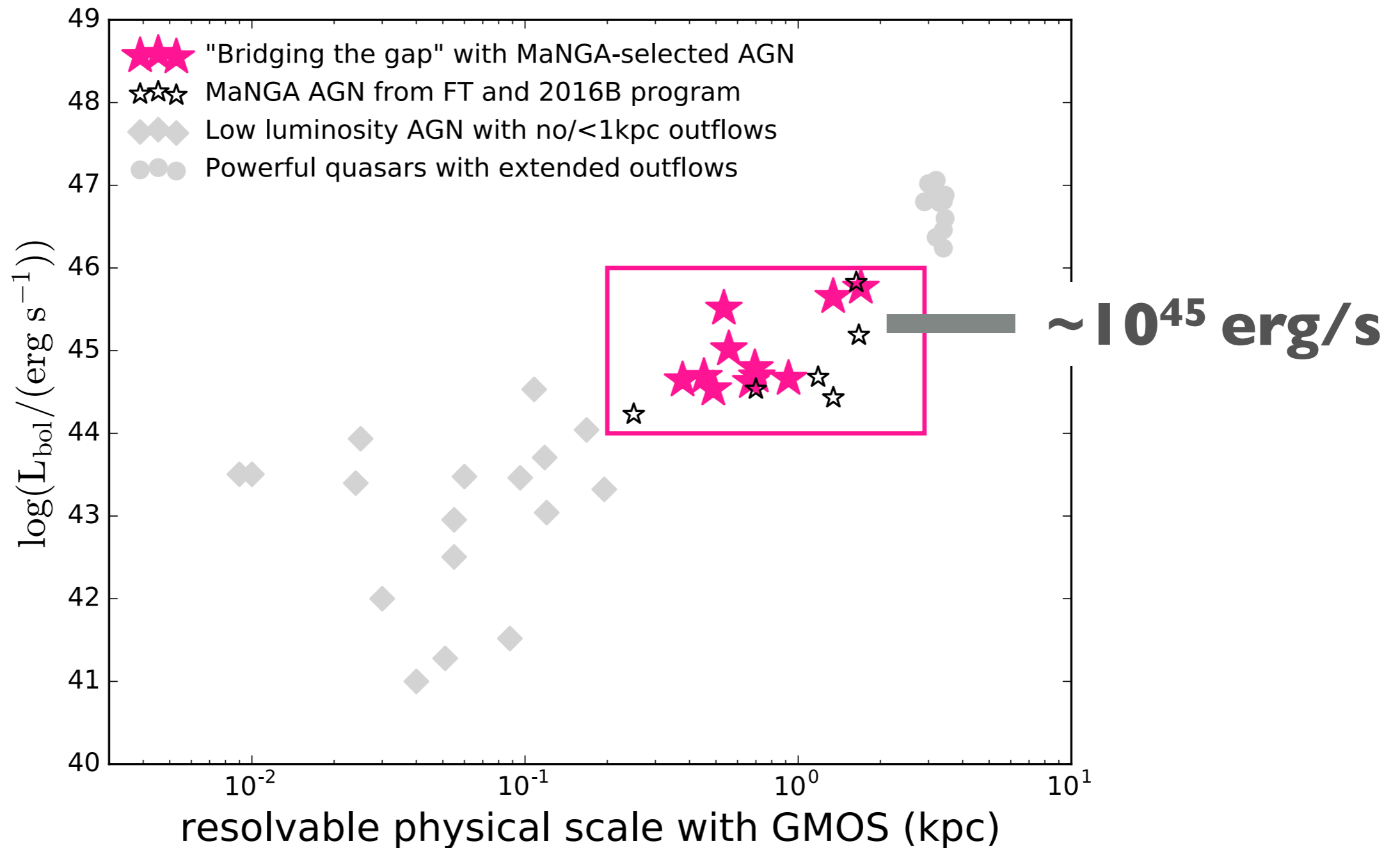


FEEDBACK THRESHOLD?

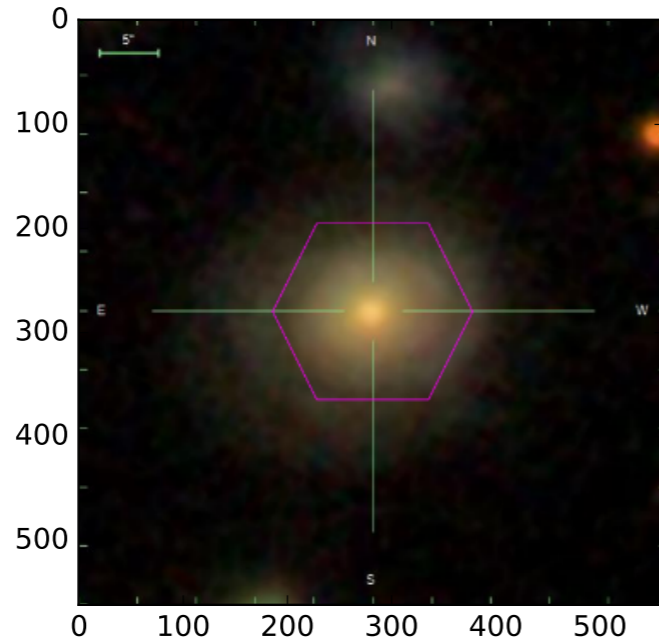


Zakamska+Greene 2014

FEEDBACK THRESHOLD WITH MANGA/GMOS



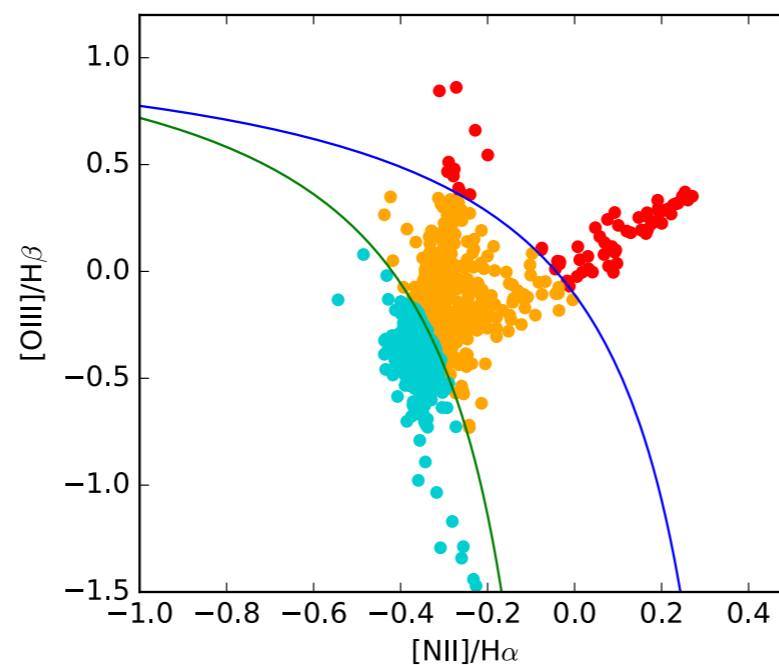
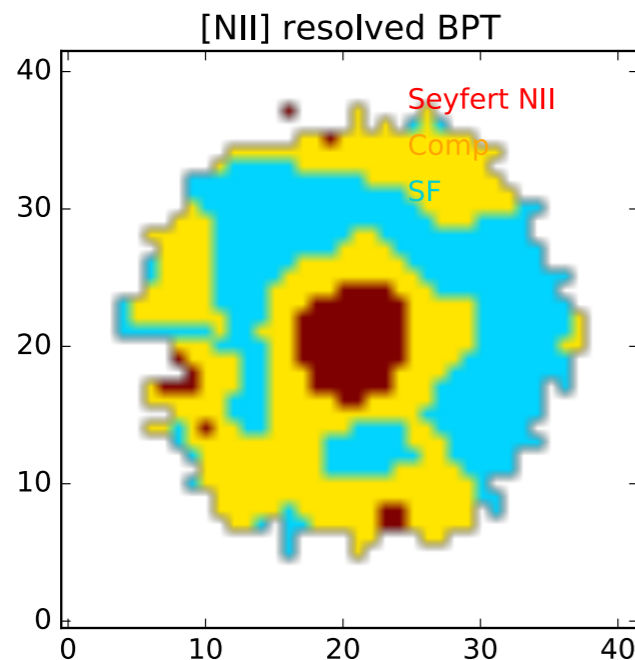
FEEDBACK THRESHOLD WITH MANGA/GMOS



Emission Line Ratios used as diagnostic for different ionization mechanisms

“BPT diagrams”: Baldwin, Phillips & Terlevich

lines are close in wavelength space (same extinction, can be observed together)

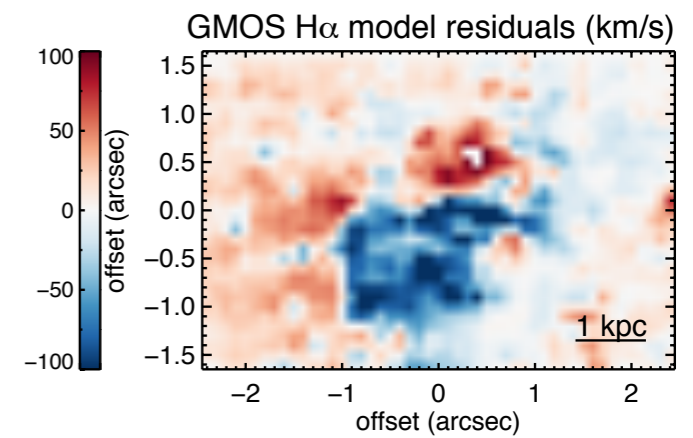
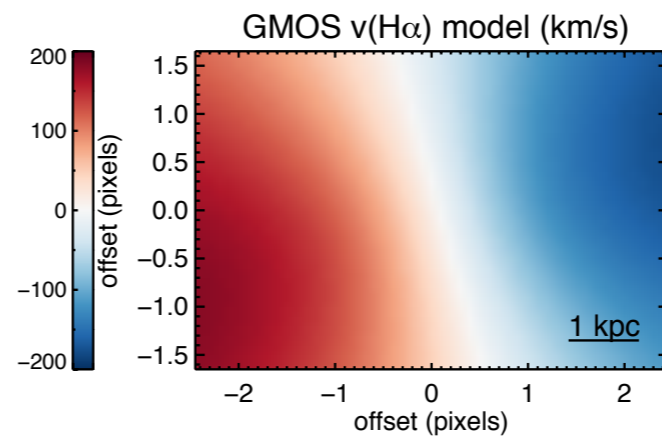
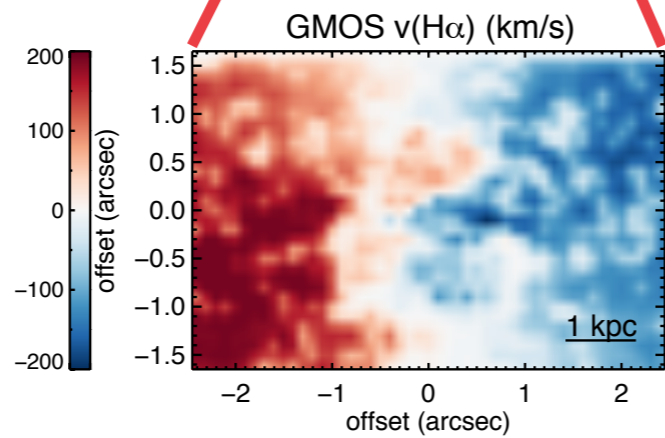
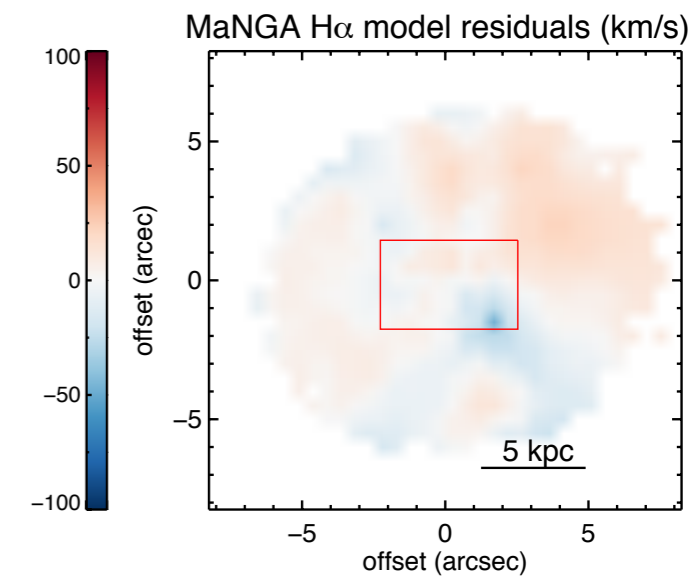
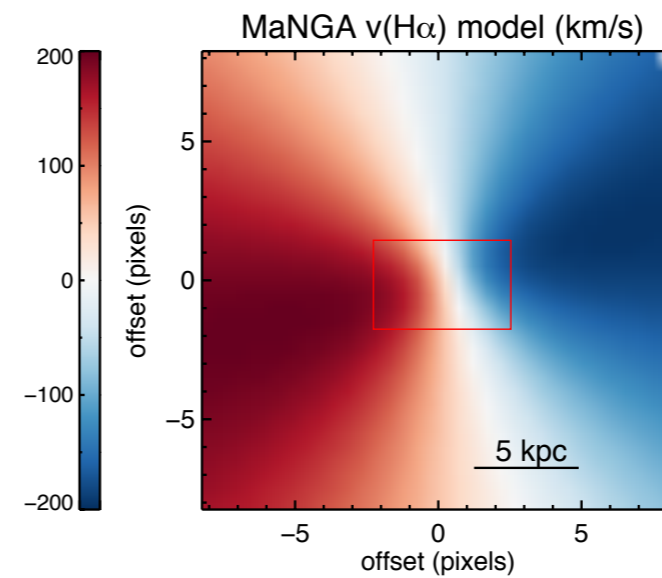
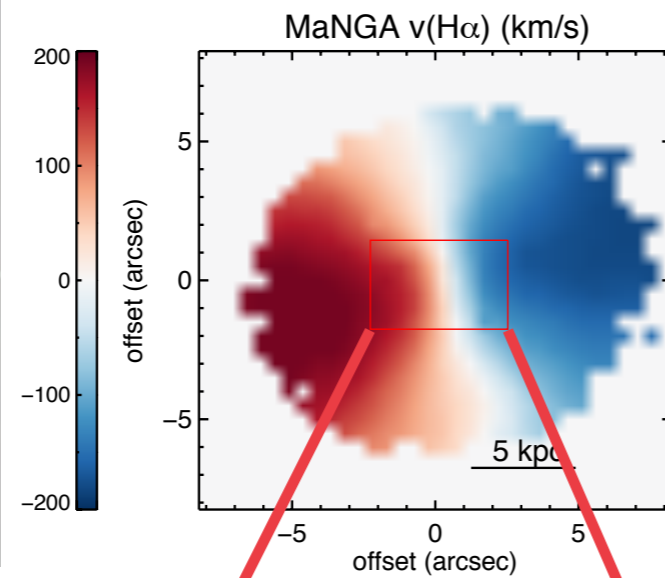
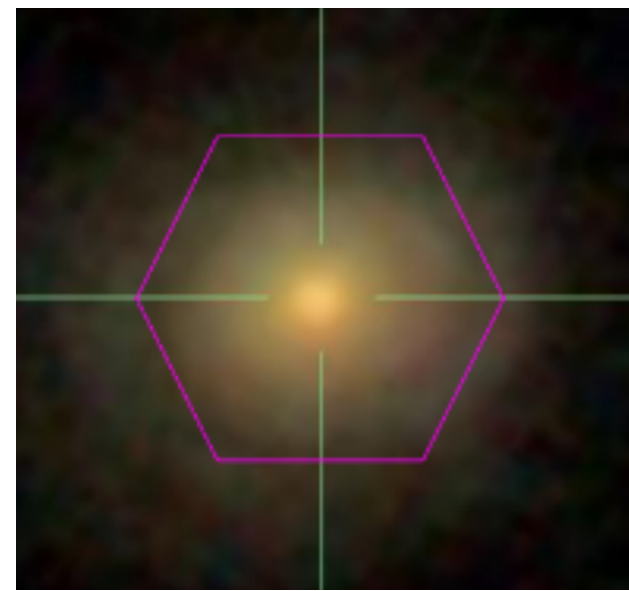


Pilot Project: 2 sources

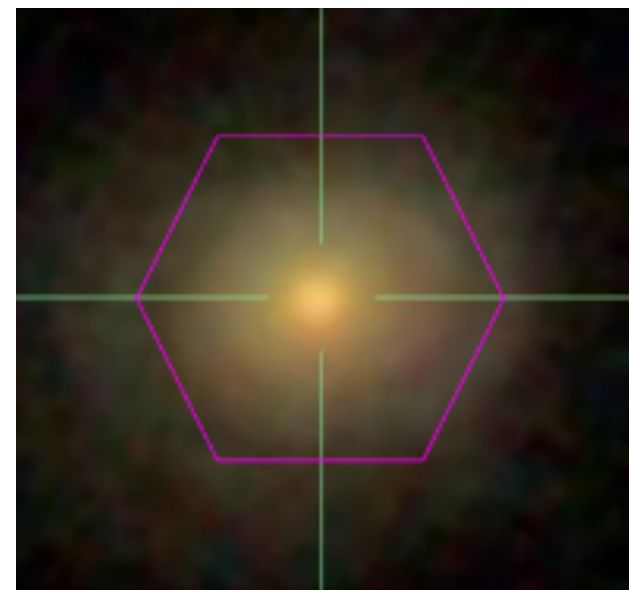
- **1 bona-fide AGN**
- **1 AGN-candidate**

FEEDBACK THRESHOLD WITH MANGA/GMOS

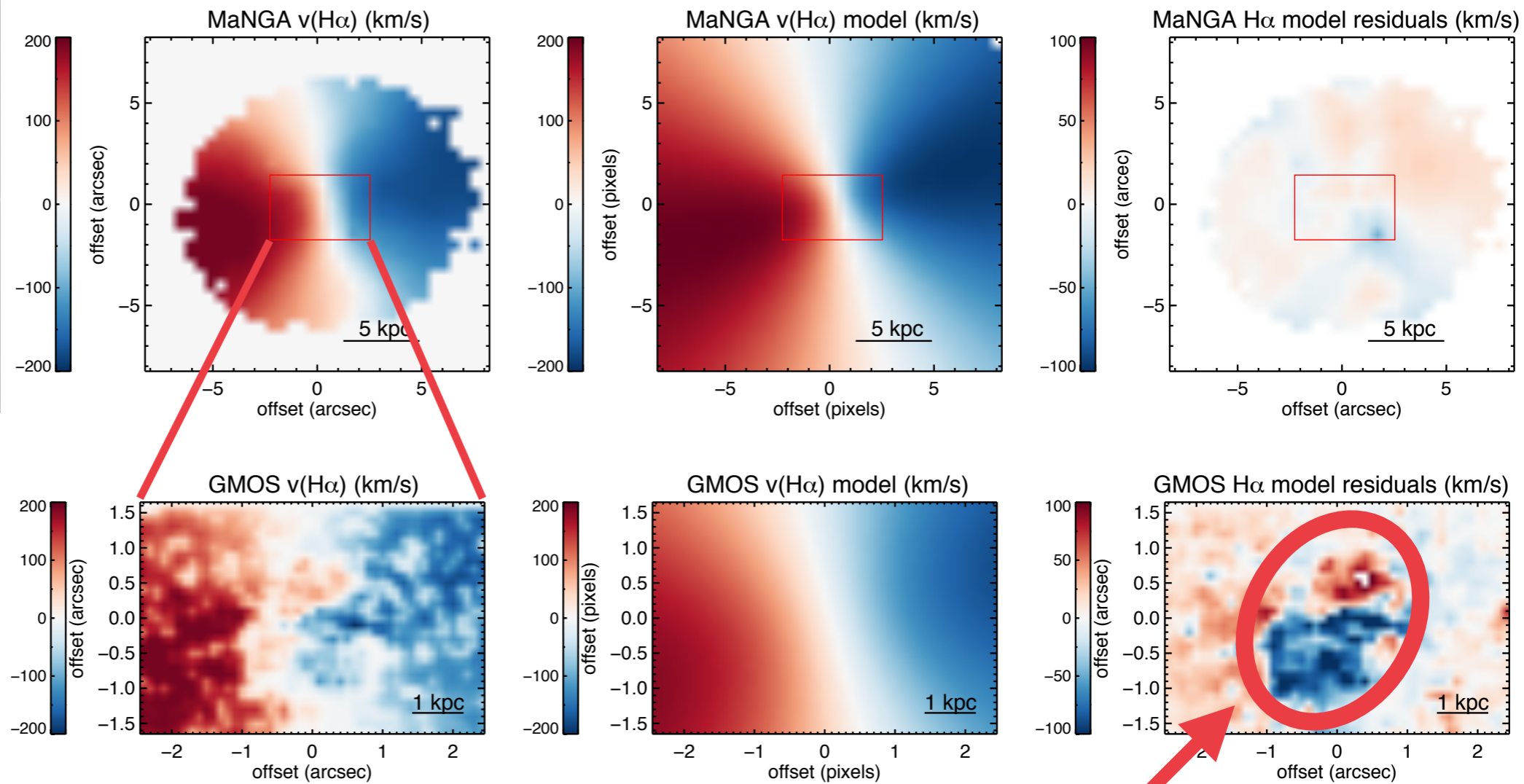
Blob Source



FEEDBACK THRESHOLD WITH MANGA/GMOS



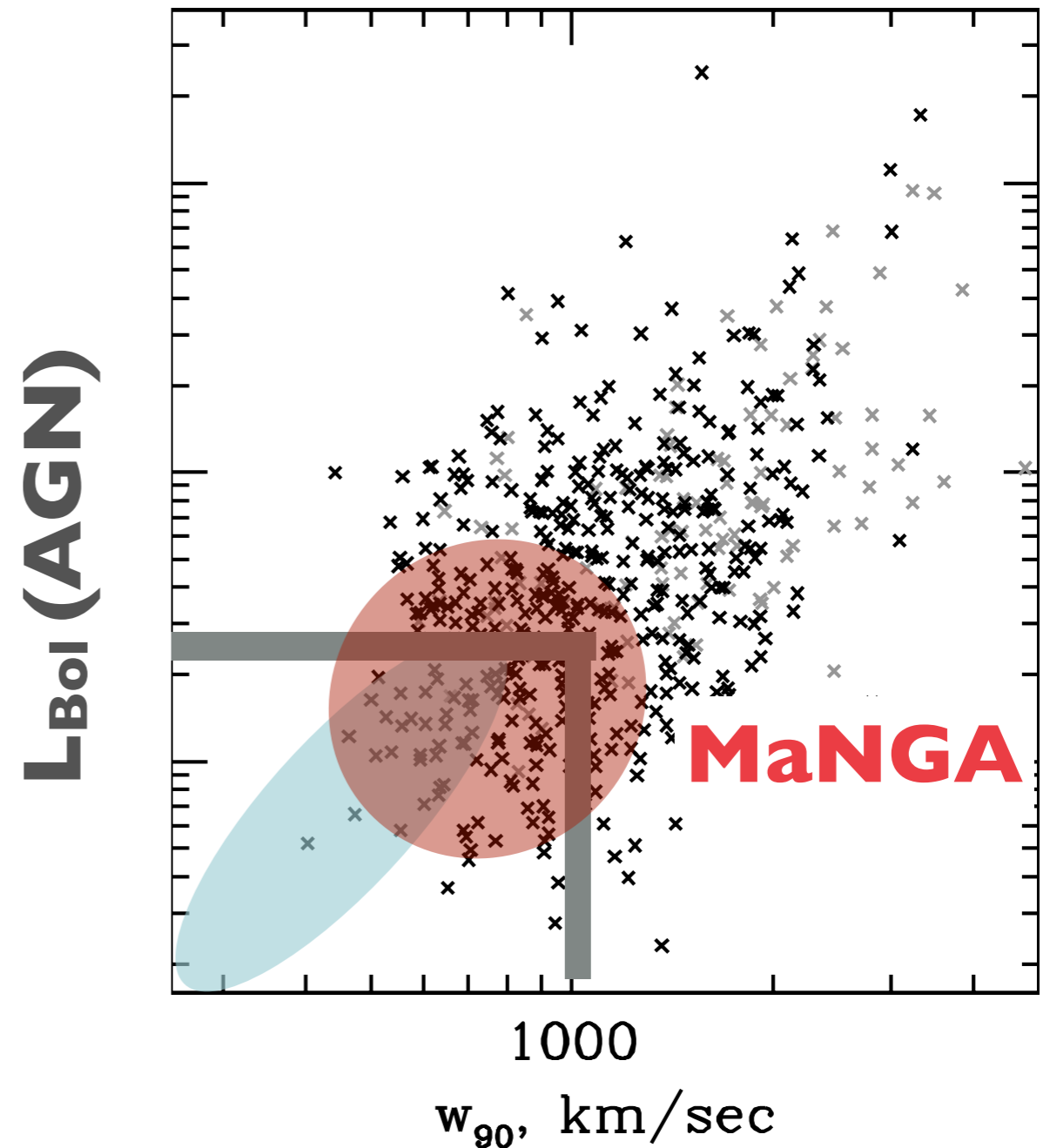
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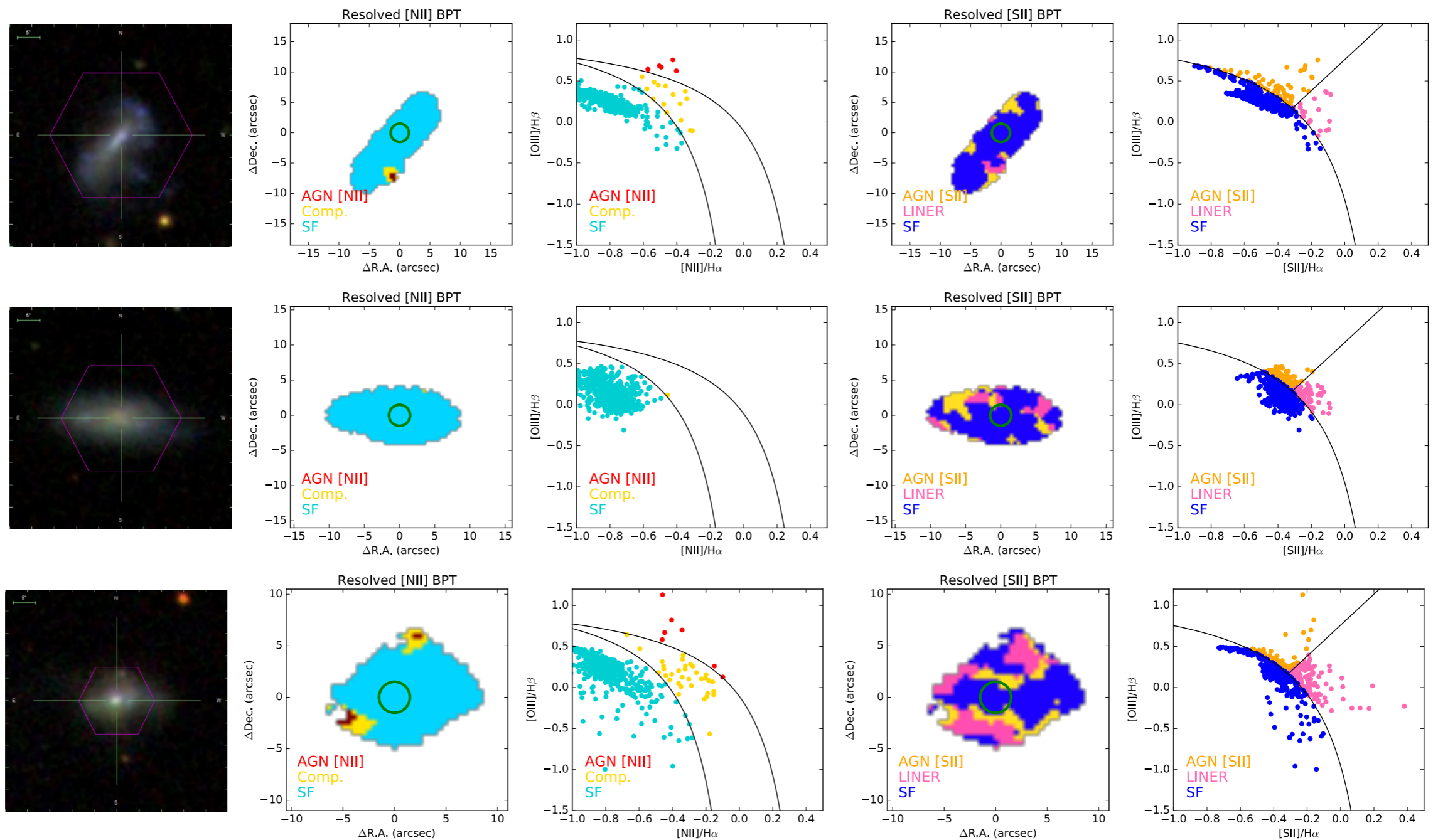
Outflow Signature!

FEEDBACK THRESHOLD?

Unbiased selection, large sample of AGN in MaNGA allows systematic analysis of outflow properties in relation to AGN properties, galaxy potential, environment

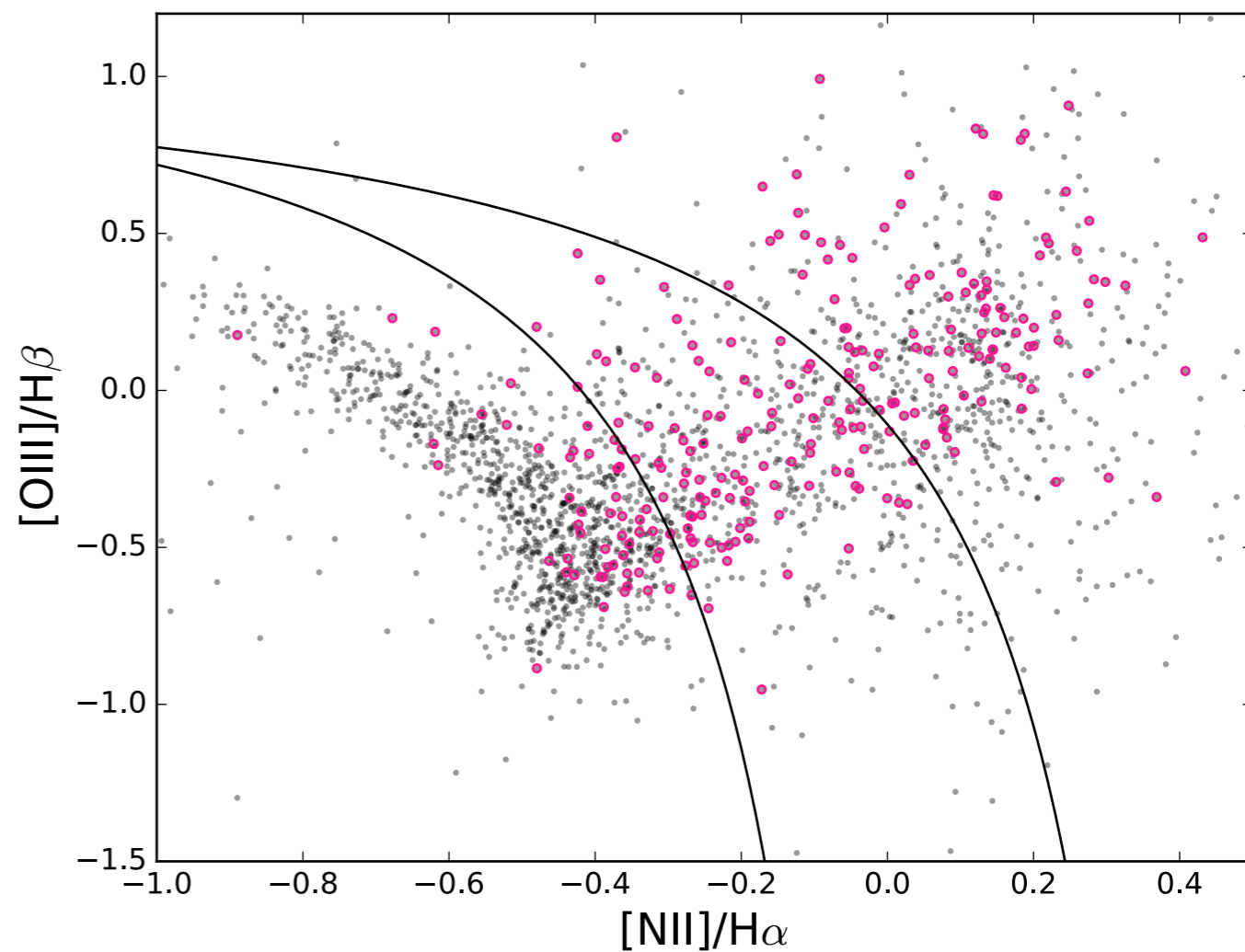
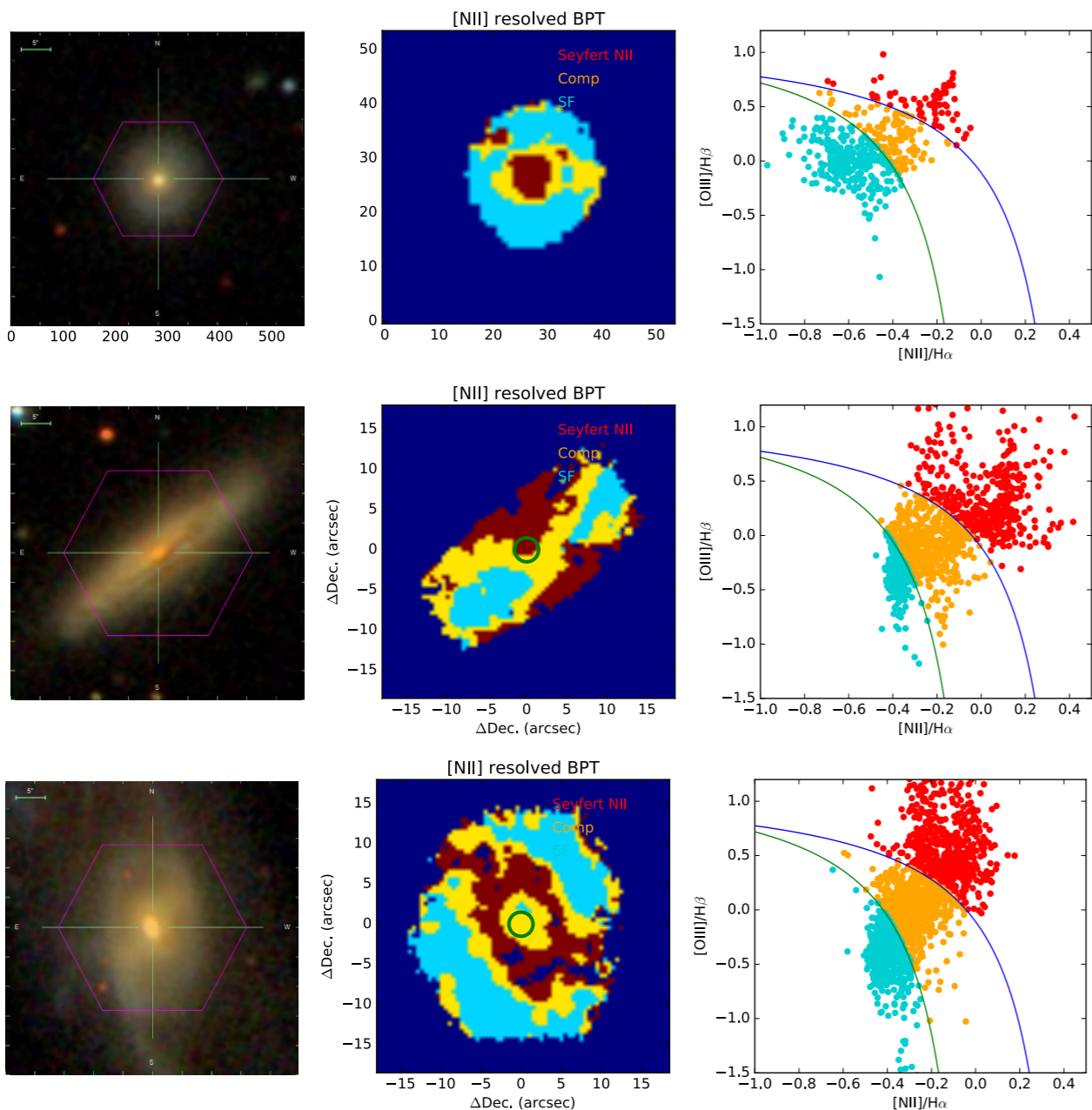


CLASSIFYING AGN IN IFU DATA IS DIFFICULT!



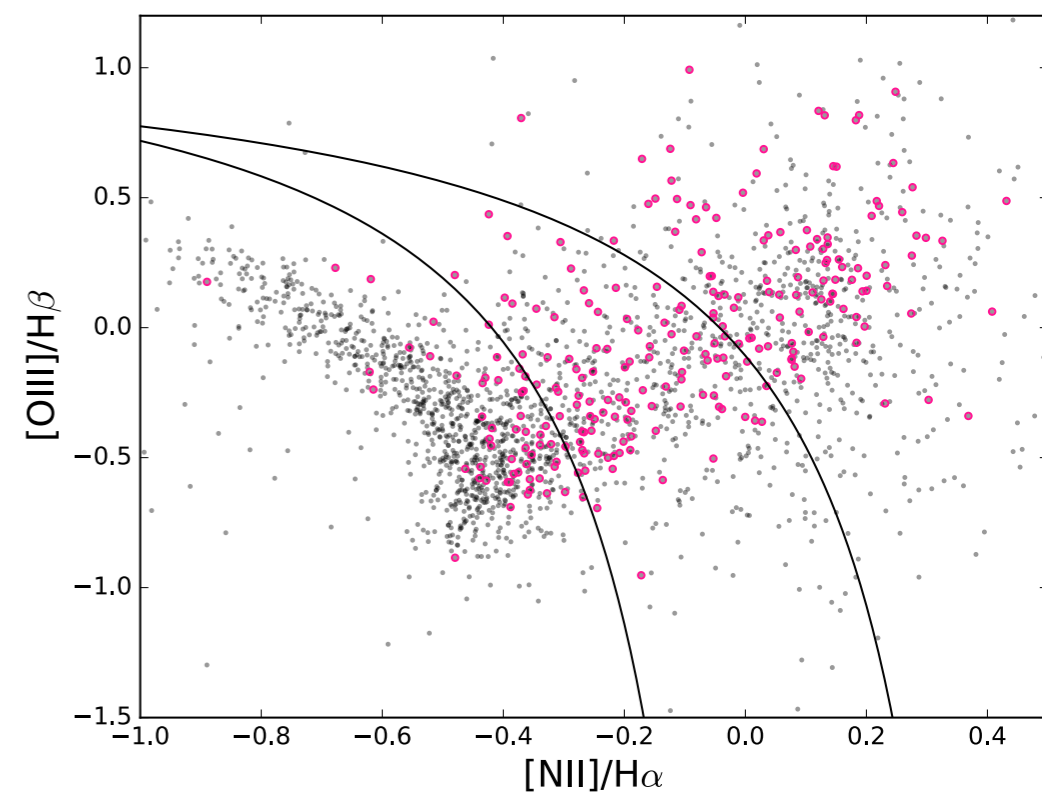
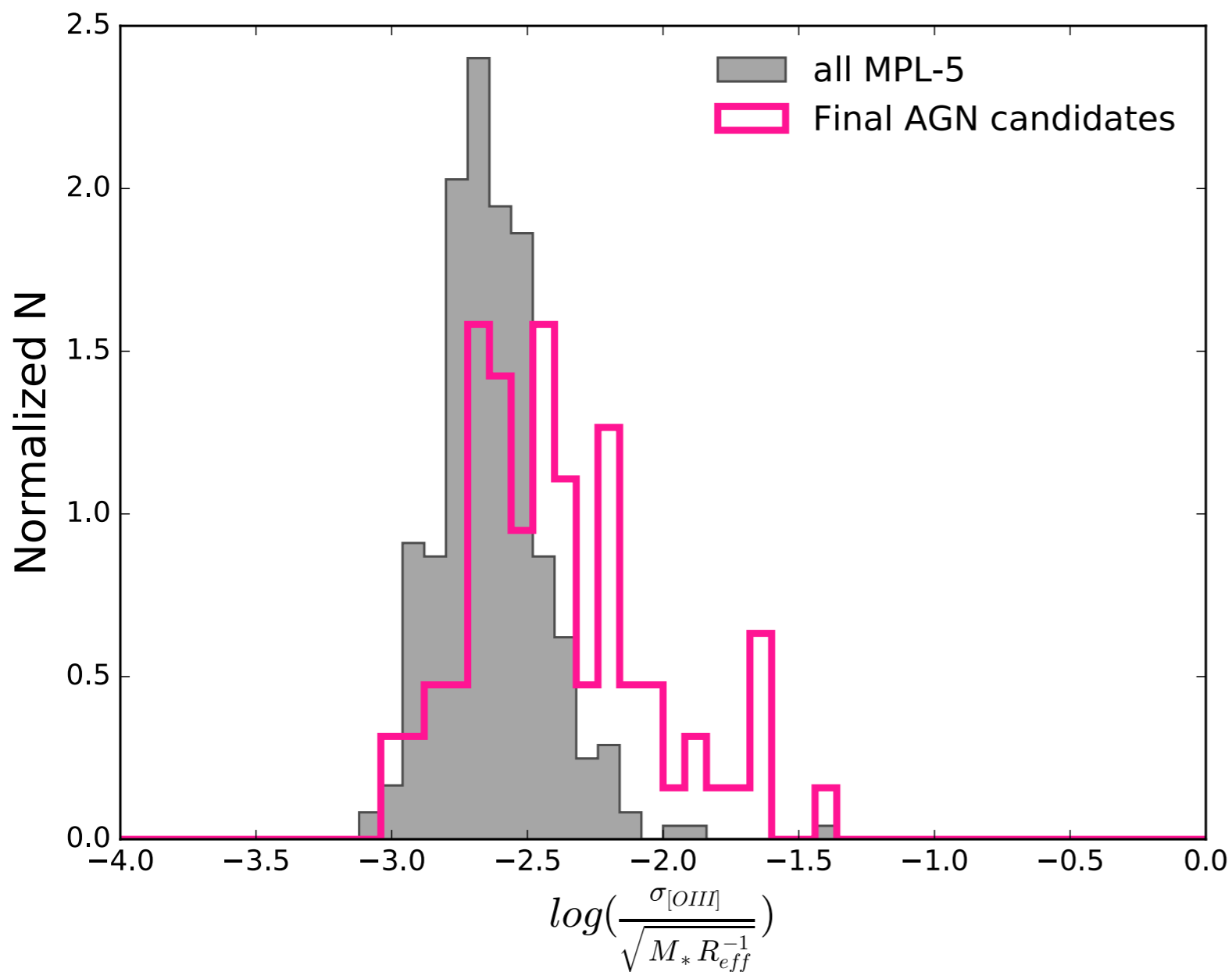
Wylezalek+submitted

HOW MANY AGN HAVE WE BEEN MISSING?



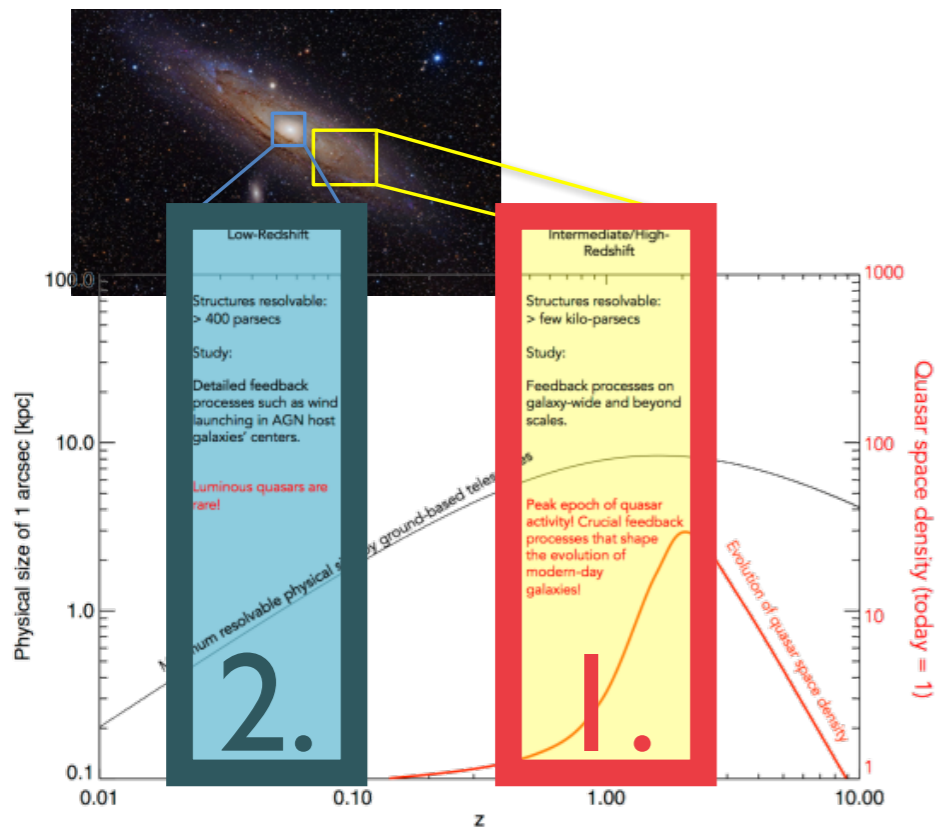
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HOW MANY AGN HAVE WE BEEN MISSING?



Wylezalek+submitted

SUMMARY



- one of the first direct observational proofs of AGN having a “negative” impact on galaxy evolution
- effect of wind-gas coupling important, at high SFRs can be neglected

- Evidence for AGN activity and outflows in previously unknown AGN
- How classify AGN in large resolved IFU surveys? Have we been missing an important component in galaxy evolution?

Luminosity threshold for AGN feedback, to be explored using unique combination of MaNGA + GMOS