



SIGNATURES OF QUASAR FEEDBACK

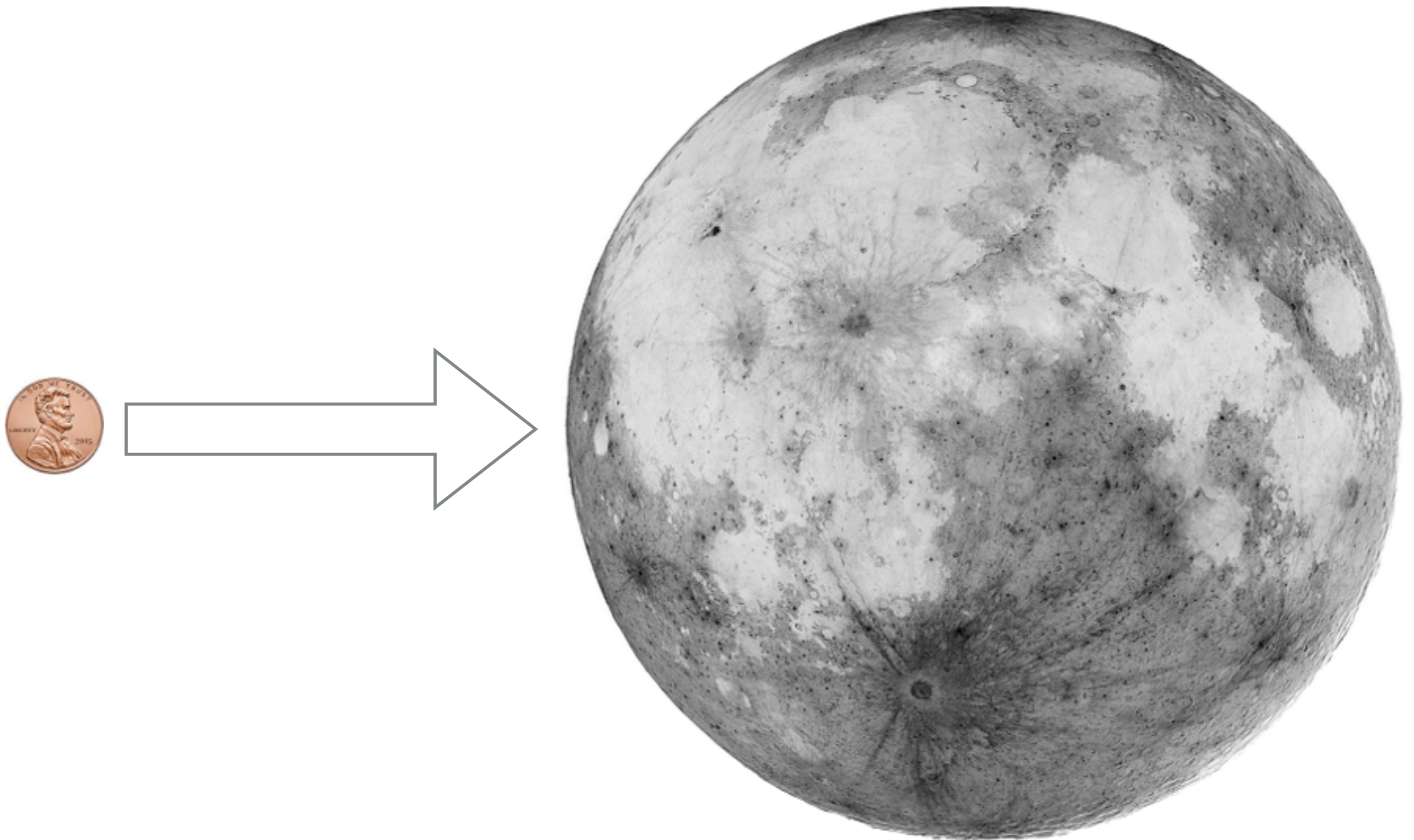
DOMINIKA WYLEZALEK

N. ZAKAMSKA

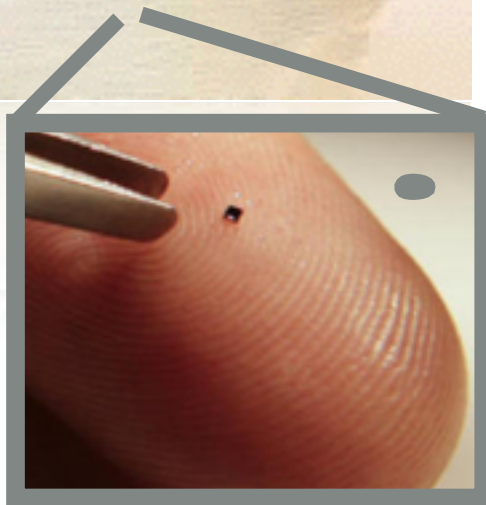
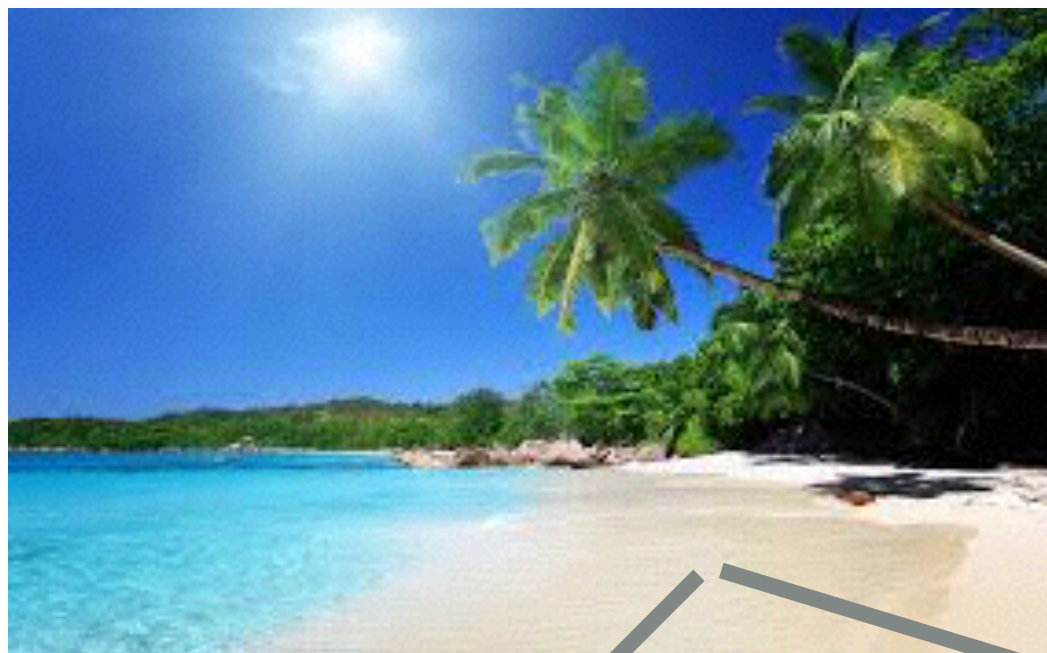


JOHNS HOPKINS
UNIVERSITY

INTRODUCTION



INTRODUCTION



INTRODUCTION



released energy by BH

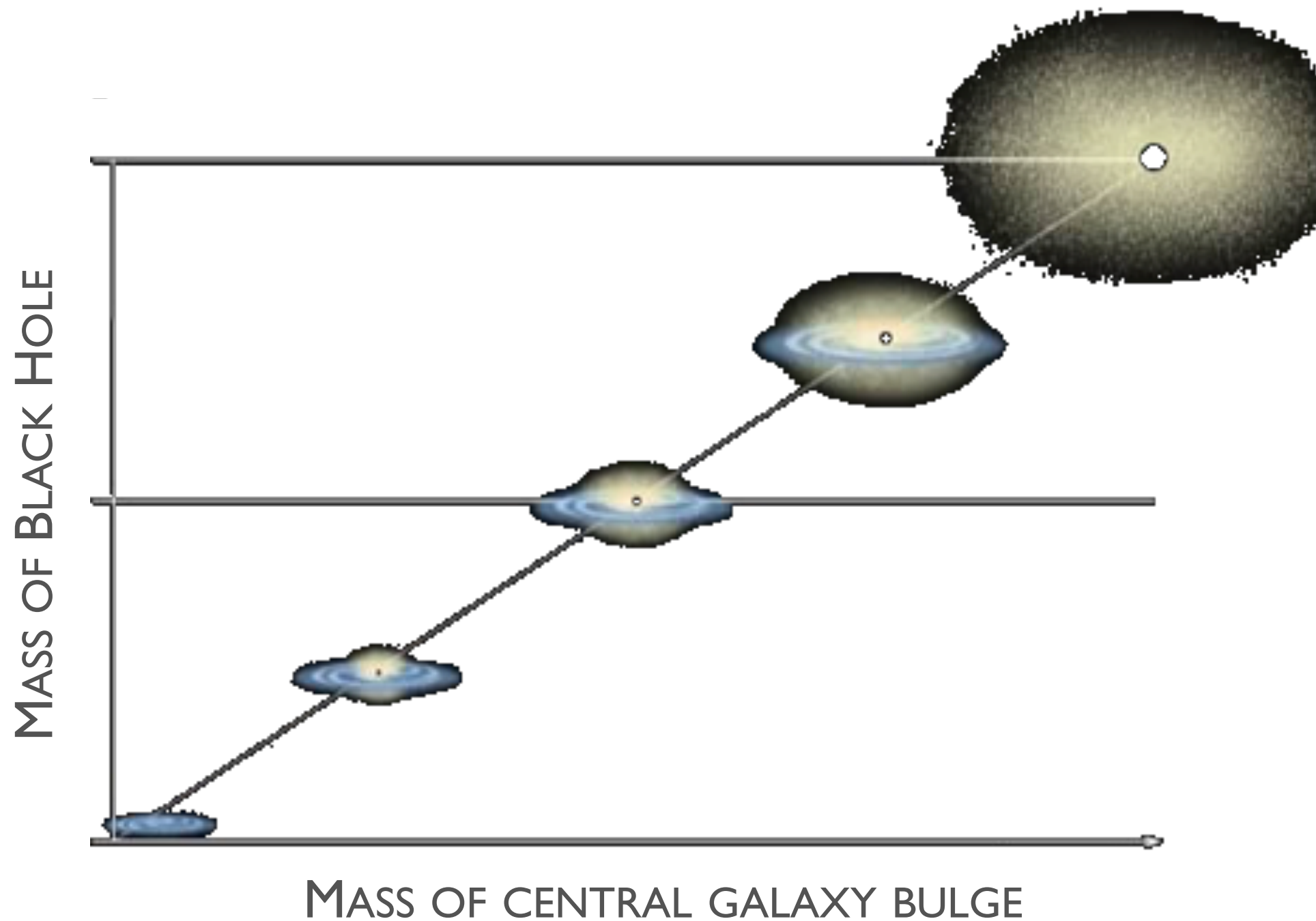
$$0.1 M_{\text{BH}} c^2$$



binding energy of galaxy

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

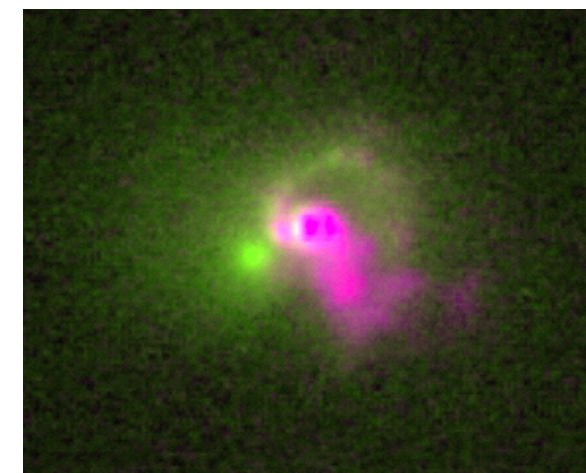
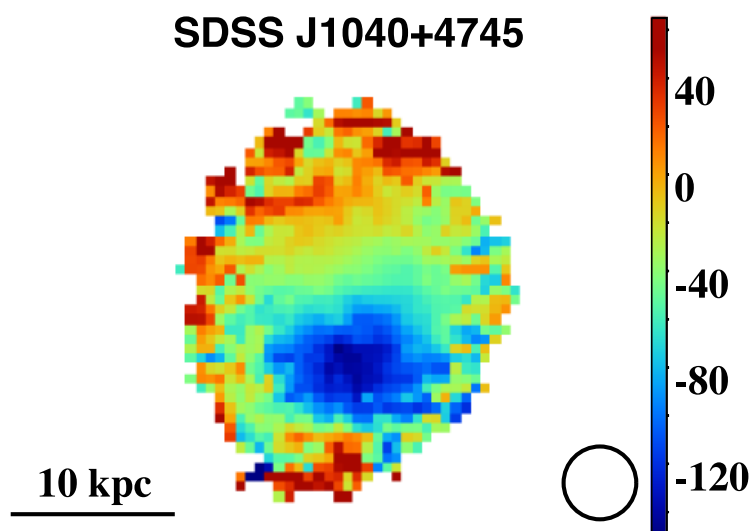
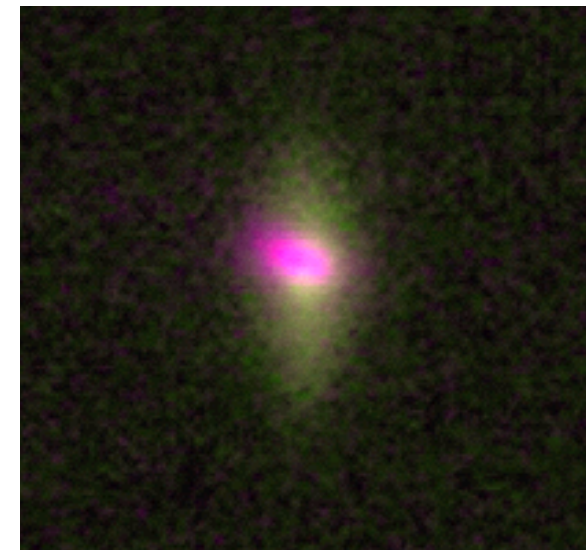
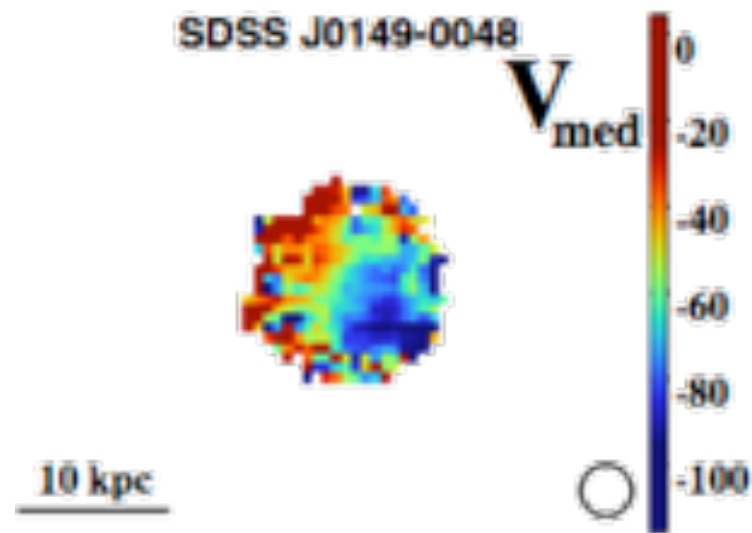
INTRODUCTION



OBSERVATIONAL EVIDENCE

galaxy-wide
outflows

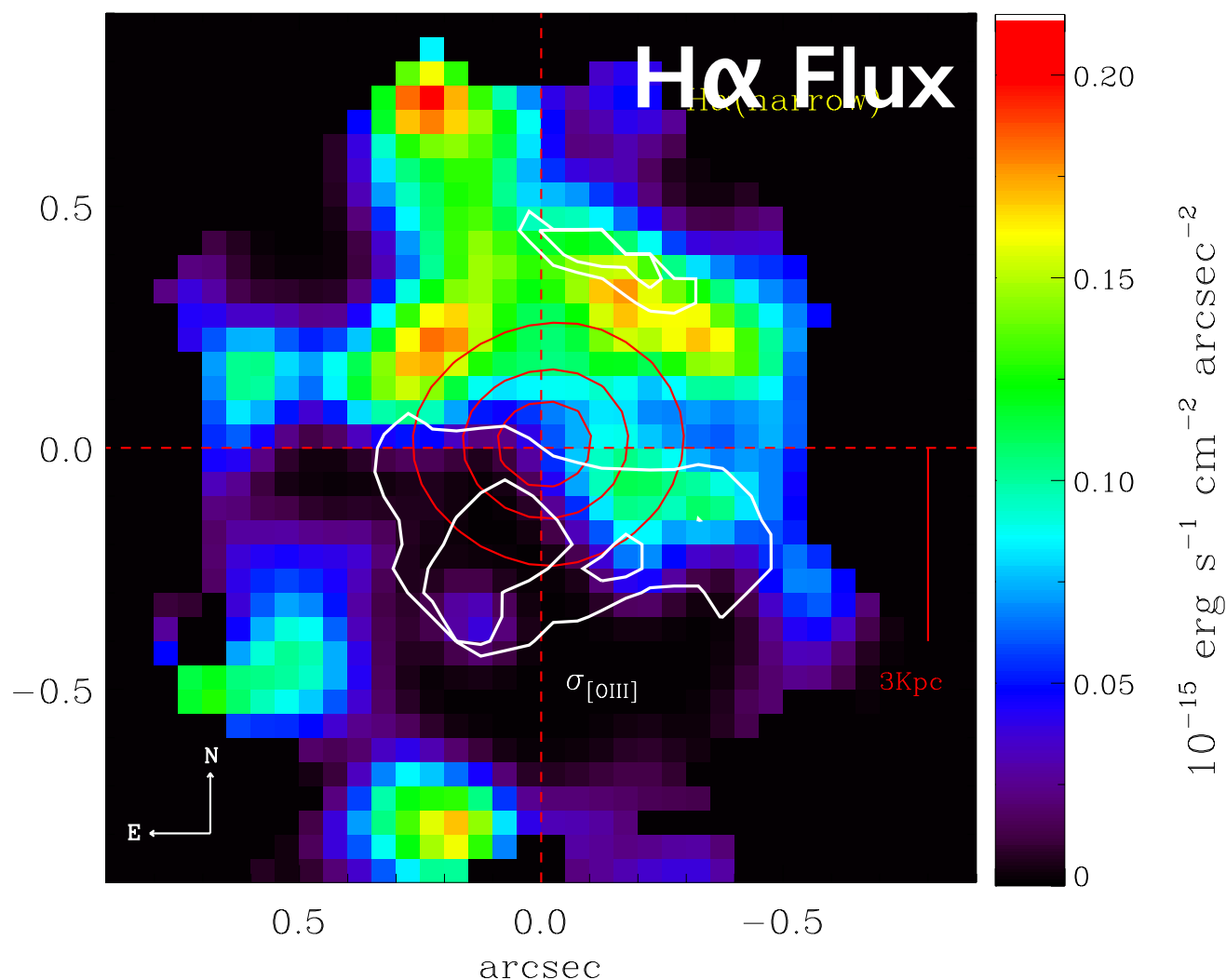
scattering cones



Liu+2013a,b, Wylezalek+2016a, Obied+2016

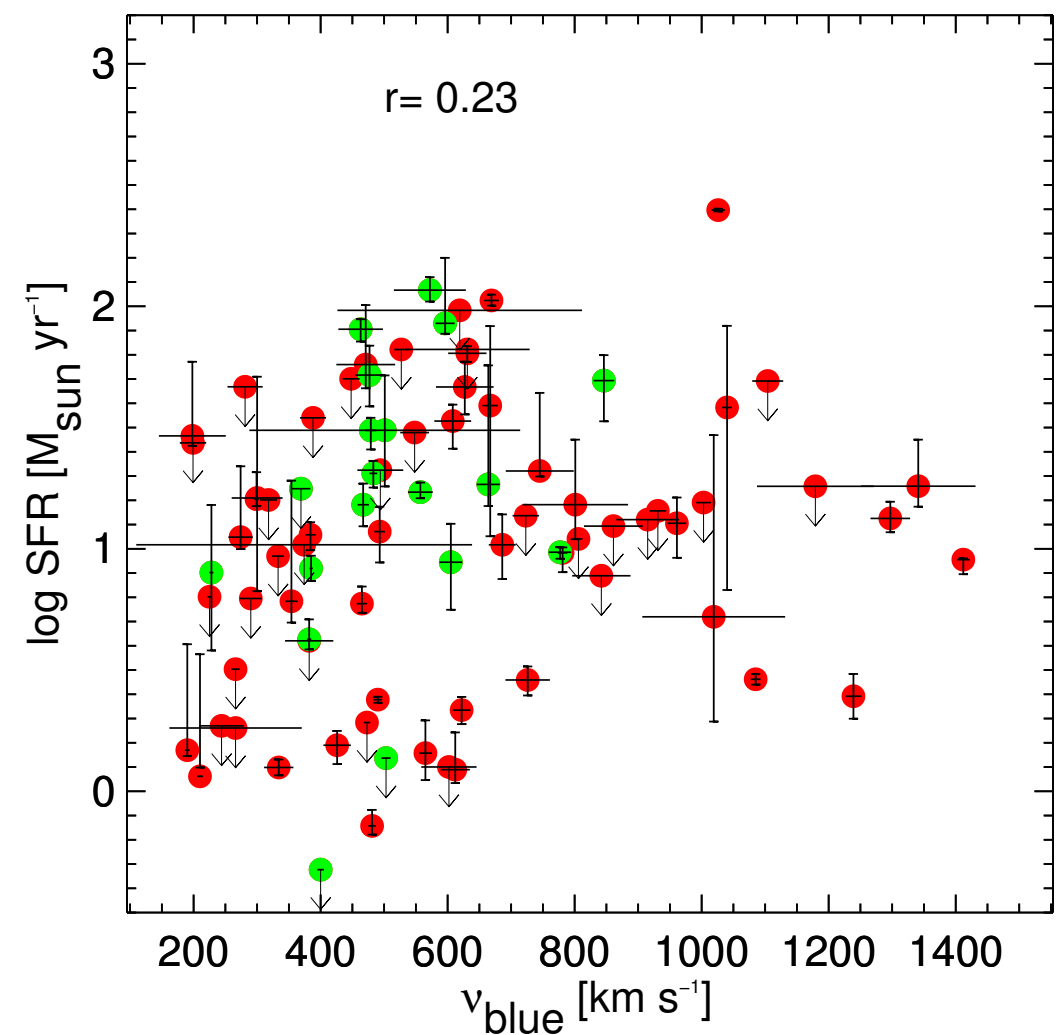
OBSERVATIONAL EVIDENCE

LOCAL EVIDENCE



Cano-Diaz+2012

GLOBAL EVIDENCE?



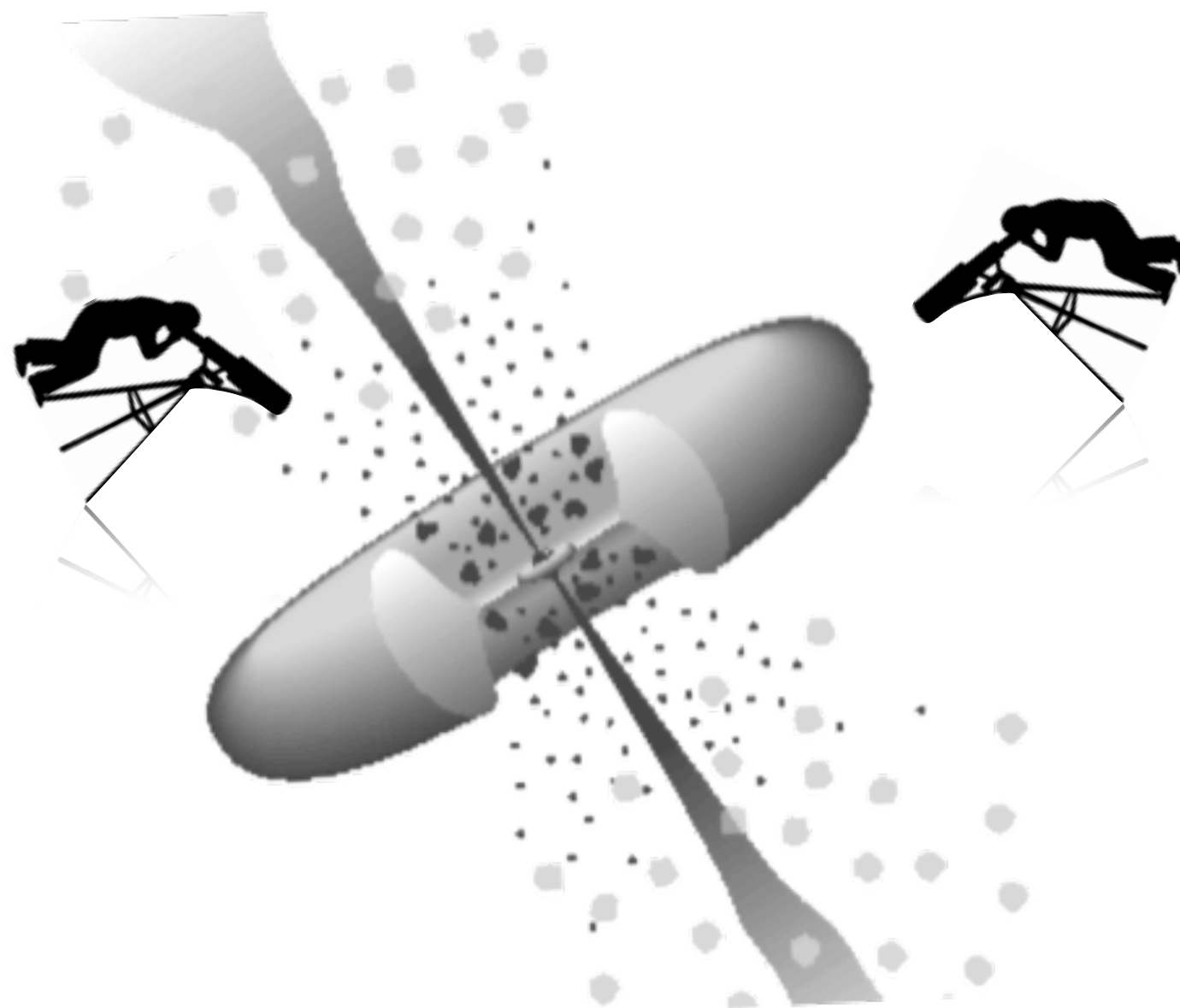
Balmaverde+2015



**WHAT ARE THE OBSERVATIONAL SIGNATURES
OF AGN FEEDBACK?**

HOW CAN WE QUANTIFY AGN FEEDBACK?

SAMPLE SELECTION



type-2 AGN

A cosmic background image featuring a vibrant, multi-colored galaxy (possibly the Carina or Bode Galaxy) with hues of blue, purple, orange, and yellow, set against a dark space filled with distant stars.

SAMPLE SELECTION

OUTFLOW STRENGTH

STAR FORMATION RATE

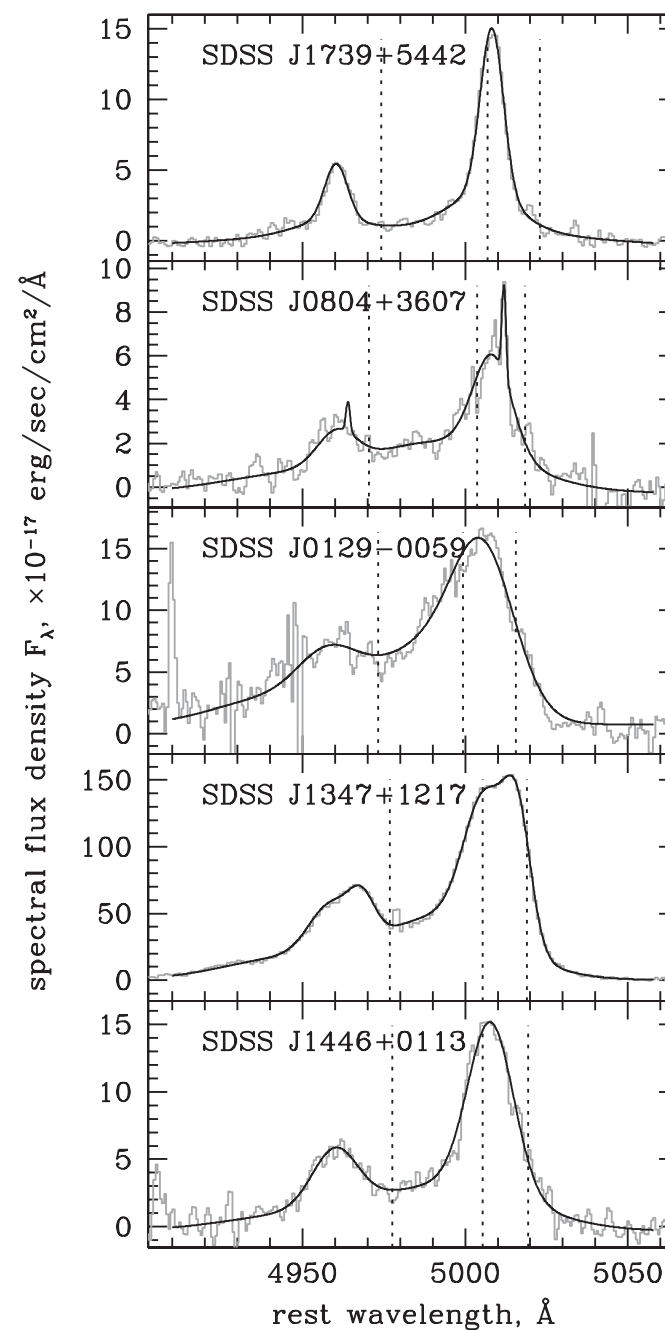
STELLAR MASS

SAMPLE SELECTION

OUTFLOW STRENGTH

[OIII] emission line at
5007Å

velocity width to quantify
outflow strength



SAMPLE SELECTION

OUTFLOW STRENGTH

STAR FORMATION RATE

[OIII] emission line at
5007Å

far-IR emission

velocity width to quantify
outflow strength

SAMPLE SELECTION

OUTFLOW STRENGTH

STAR FORMATION RATE

STELLAR MASS

[OIII] emission line at
5007Å

far-IR emission

NEAR-IR IMAGING
DATA

velocity width to quantify
outflow strength

SAMPLE SELECTION

Spectra & Kinematics

Reyes+2008
887 sources

Good kinematics
568 sources

BOSS Objects
2707 sources

Good kinematics
2706 sources

Stellar Masses from near-IR

UKIDSS
239 sources

UKIDSS
843 sources

SFR

Far-IR

Zakamska+2015
47 sources
(23 upper limits)

HerS
6 sources

H-ATLAS SDP
2 sources

PAHs from
Zakamska+2015

12 sources
(8 upper limits)

L_{IR} from Artificial
Neural Network
(Ellison+2016)

16 sources

Far-IR

HerS
23 sources
(19 upper limits)

H-ATLAS SDP
2 sources
(1 upper limit)

L_{IR} from Artificial
Neural Network
(Ellison+2016)

0 sources

SAMPLE SELECTION

OUTFLOW STRENGTH

STAR FORMATION RATE

STELLAR MASS

[OIII] emission line at
5007Å

far-IR emission

NEAR-IR IMAGING
DATA

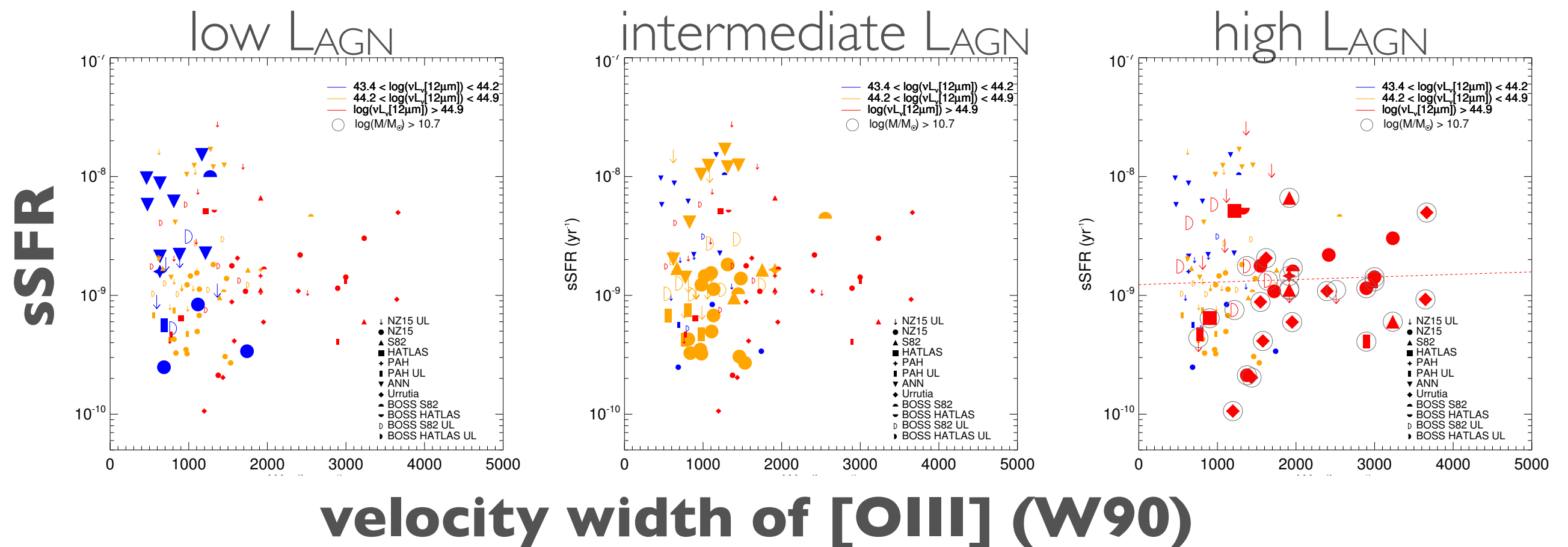
velocity width to quantify
outflow strength



specific star formation rate sSFR

sSFR vs. VELOCITY WIDTH

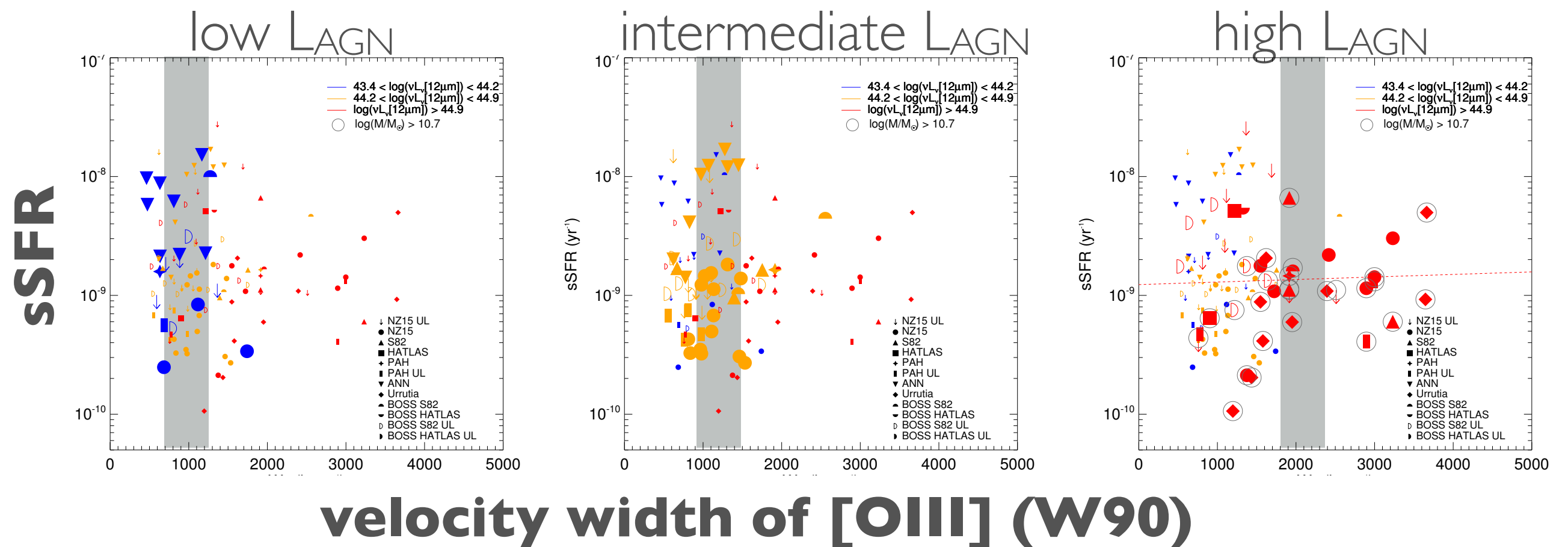
No dependence of sSFR as a function of [OIII] velocity width
(i.e. outflow strength)



Wylezalek+2016b (in prep.)

sSFR vs. VELOCITY WIDTH

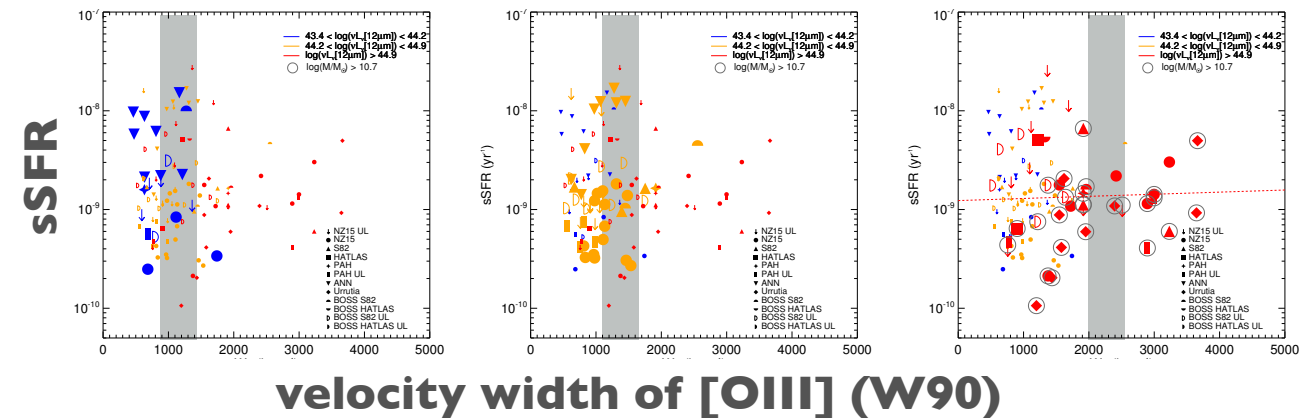
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Wylezalek+2016b (in prep.)

sSFR vs. VELOCITY WIDTH

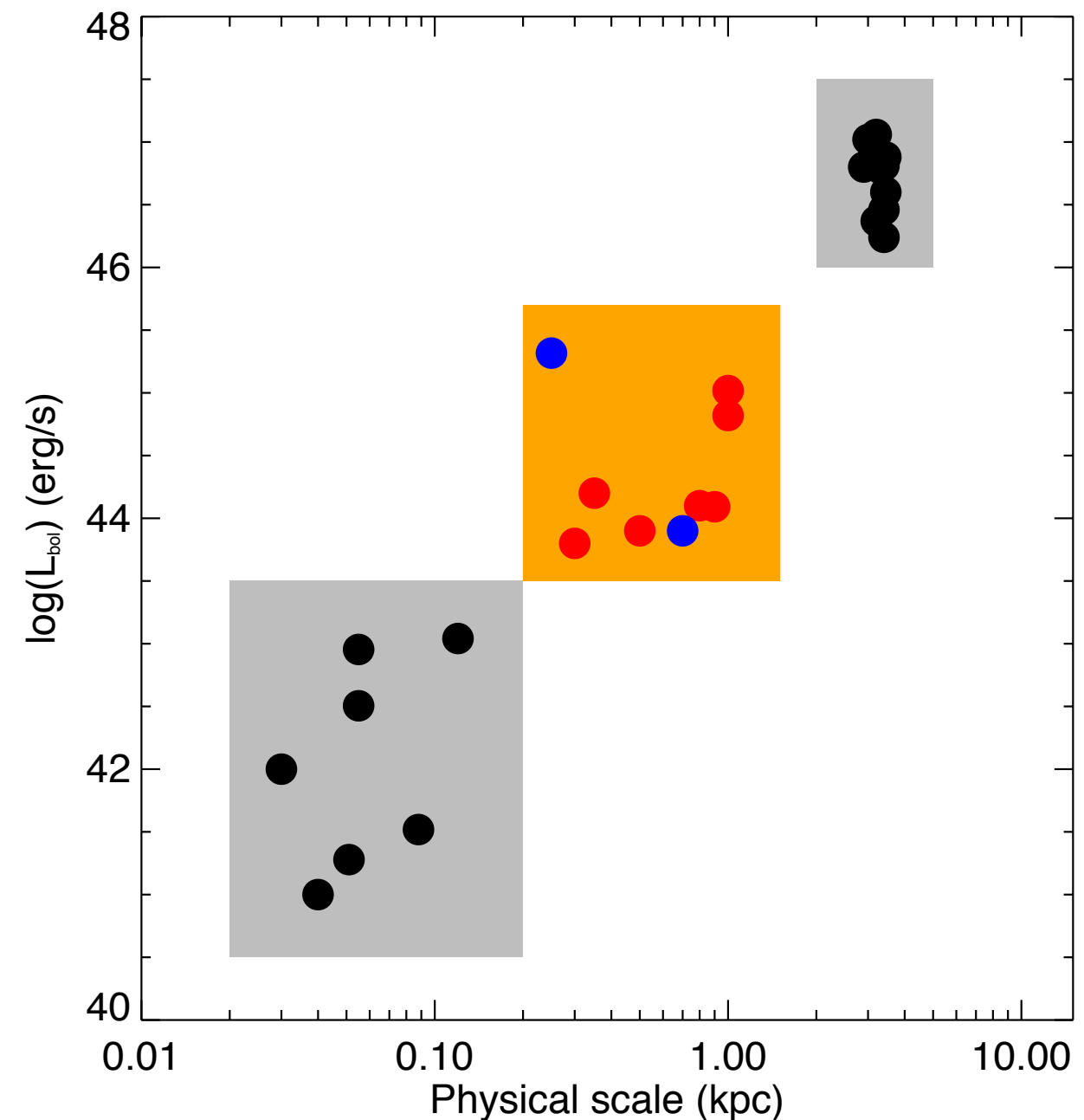
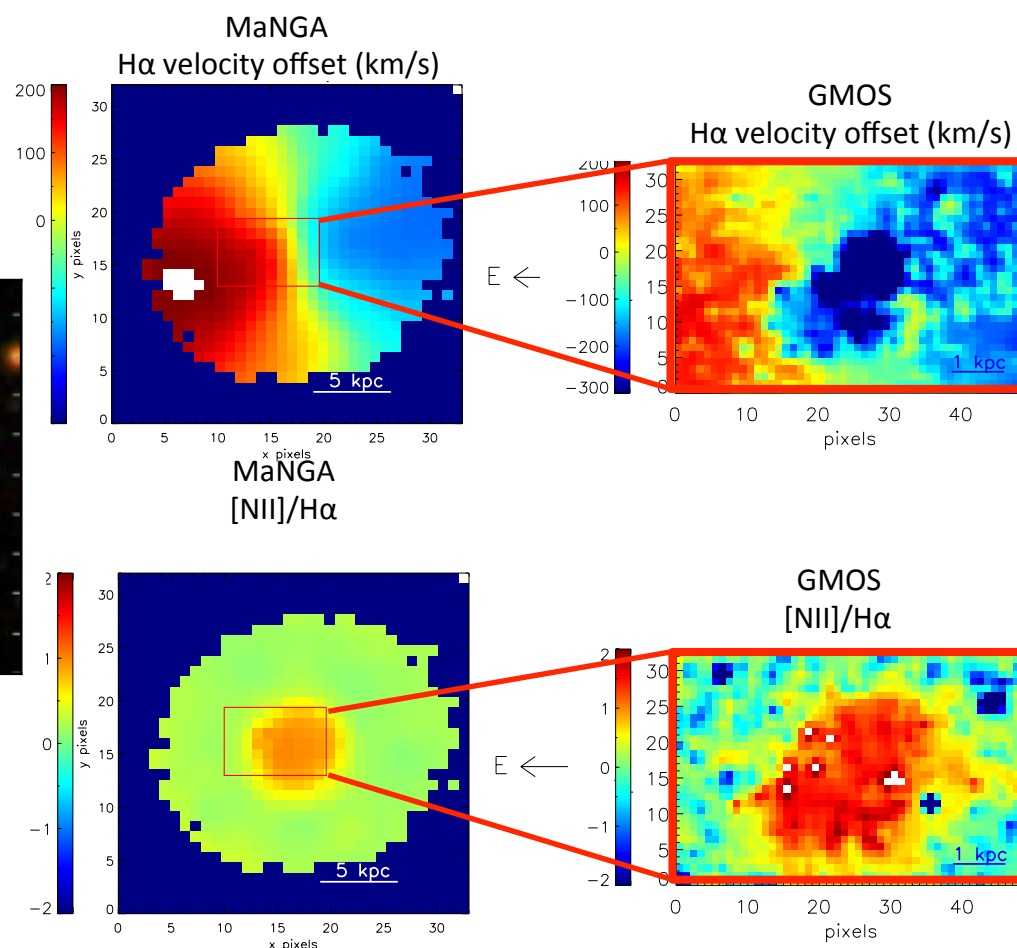
- No dependence of sSFR as a function of [OIII] velocity width (i.e. outflow strength)
- Increase of velocity width with AGN power
- threshold for AGN feedback (need enough power to launch wind that can overcome the galaxy potential)



Wylezalek+2016b (in prep.)

FEEDBACK THRESHOLD WITH MANGA/GMOS

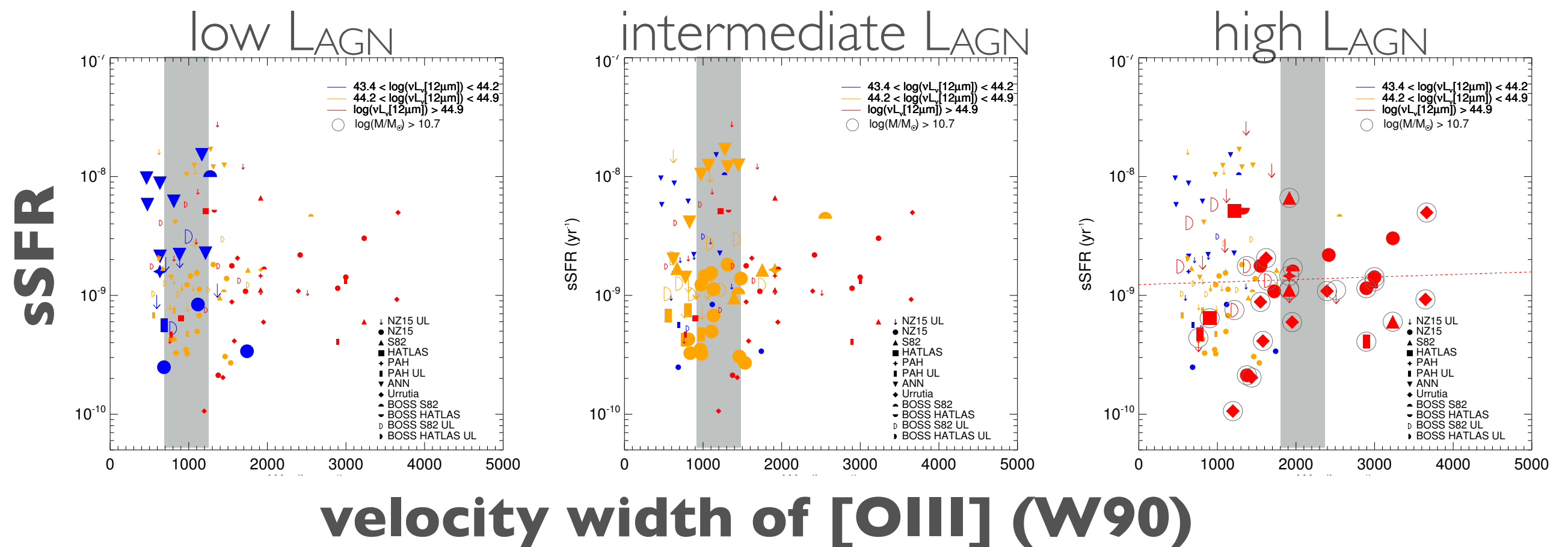
Object 1



Wylezalek, Zakamska, Schnorr Müller,
Storchi-Bergmann+ in prep.

sSFR vs. VELOCITY WIDTH

No dependence of sSFR as a function of [OIII] velocity width
(i.e. outflow strength)



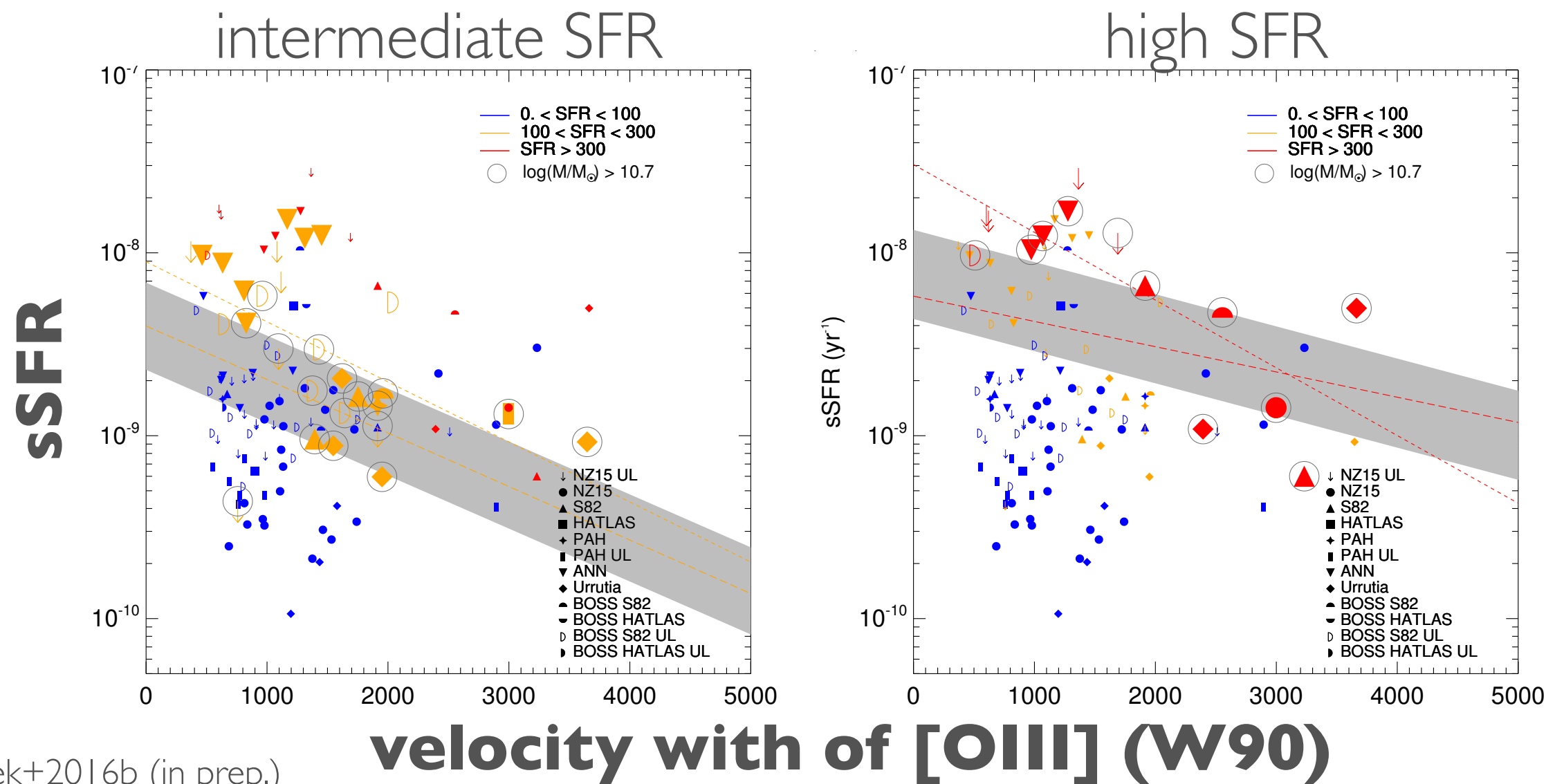
Wylezalek+2016b (in prep.)



BUT

sSFR vs. VELOCITY WIDTH

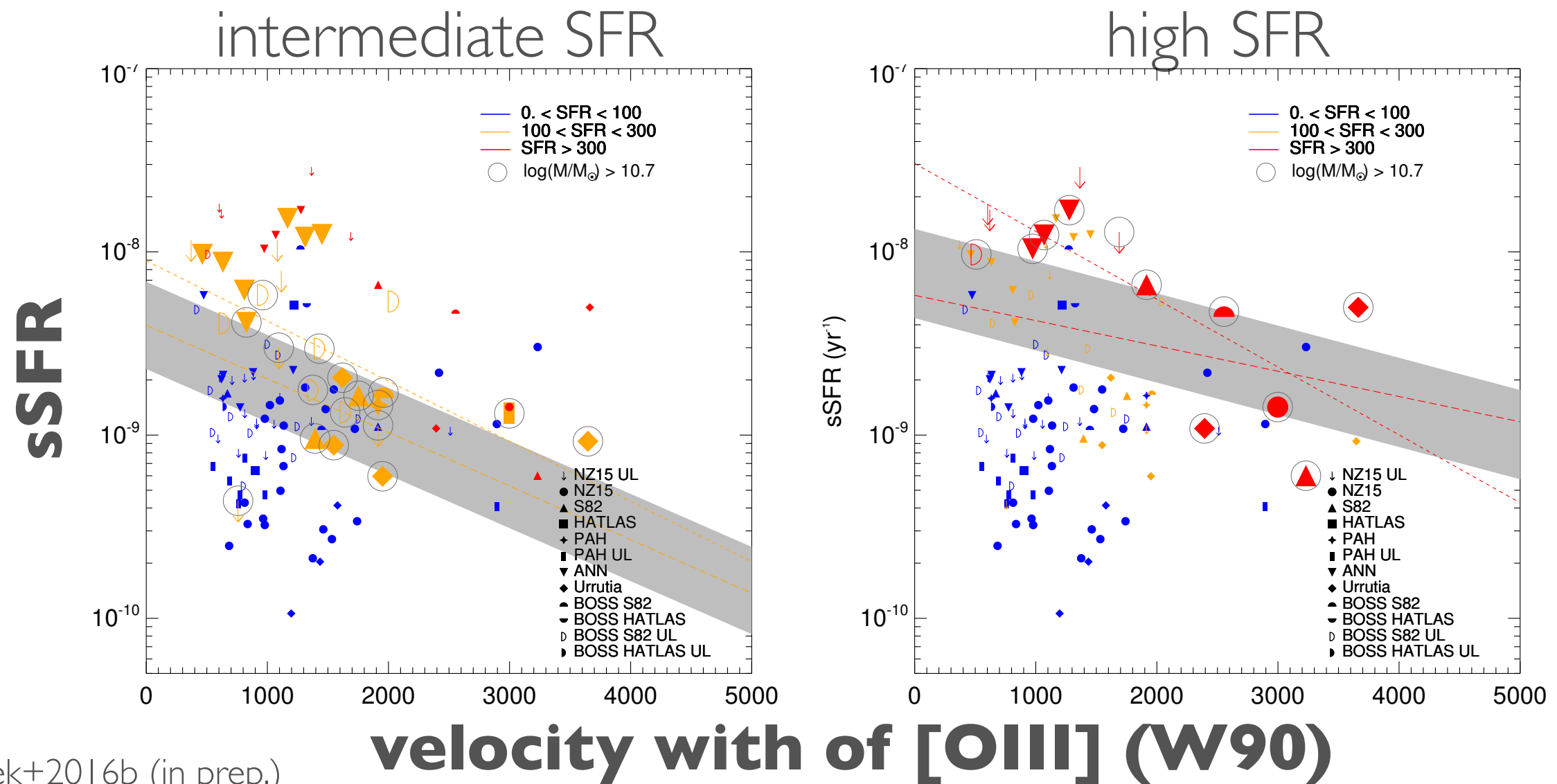
Strong negative correlation between sSFR and velocity width at high SFRs



Wylezalek+2016b (in prep.)

sSFR vs. VELOCITY WIDTH

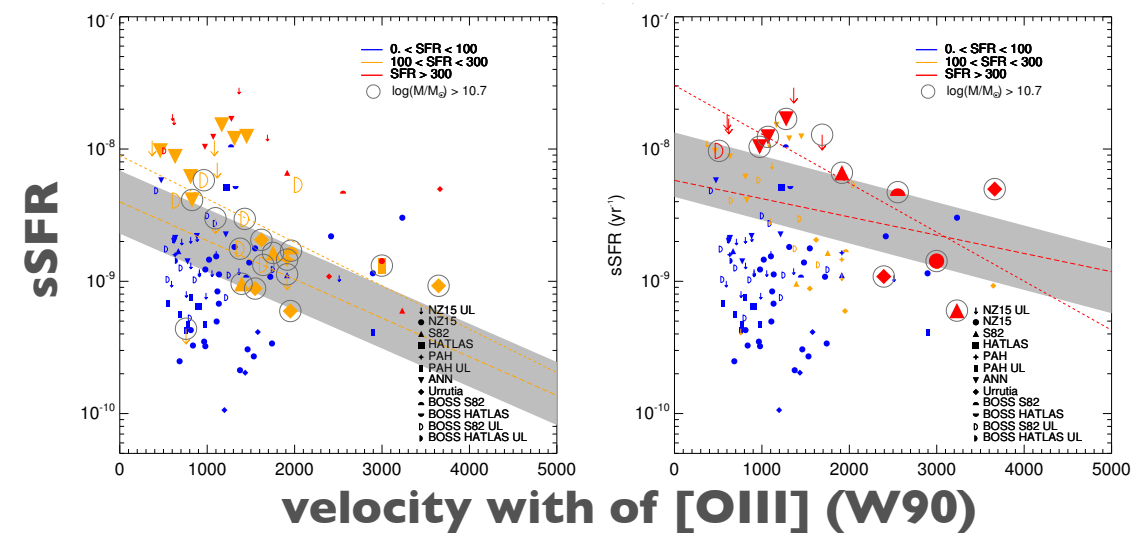
Strong negative correlation between sSFR and velocity width at high SFRs



Wylezalek+2016b (in prep.)

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



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
- large, uniform samples needed

THANK YOU!

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