



# FEEDBACK AND MERGERS AT $Z=2-5$ AND IN LOCAL E+A GALAXIES

Hagai Netzer

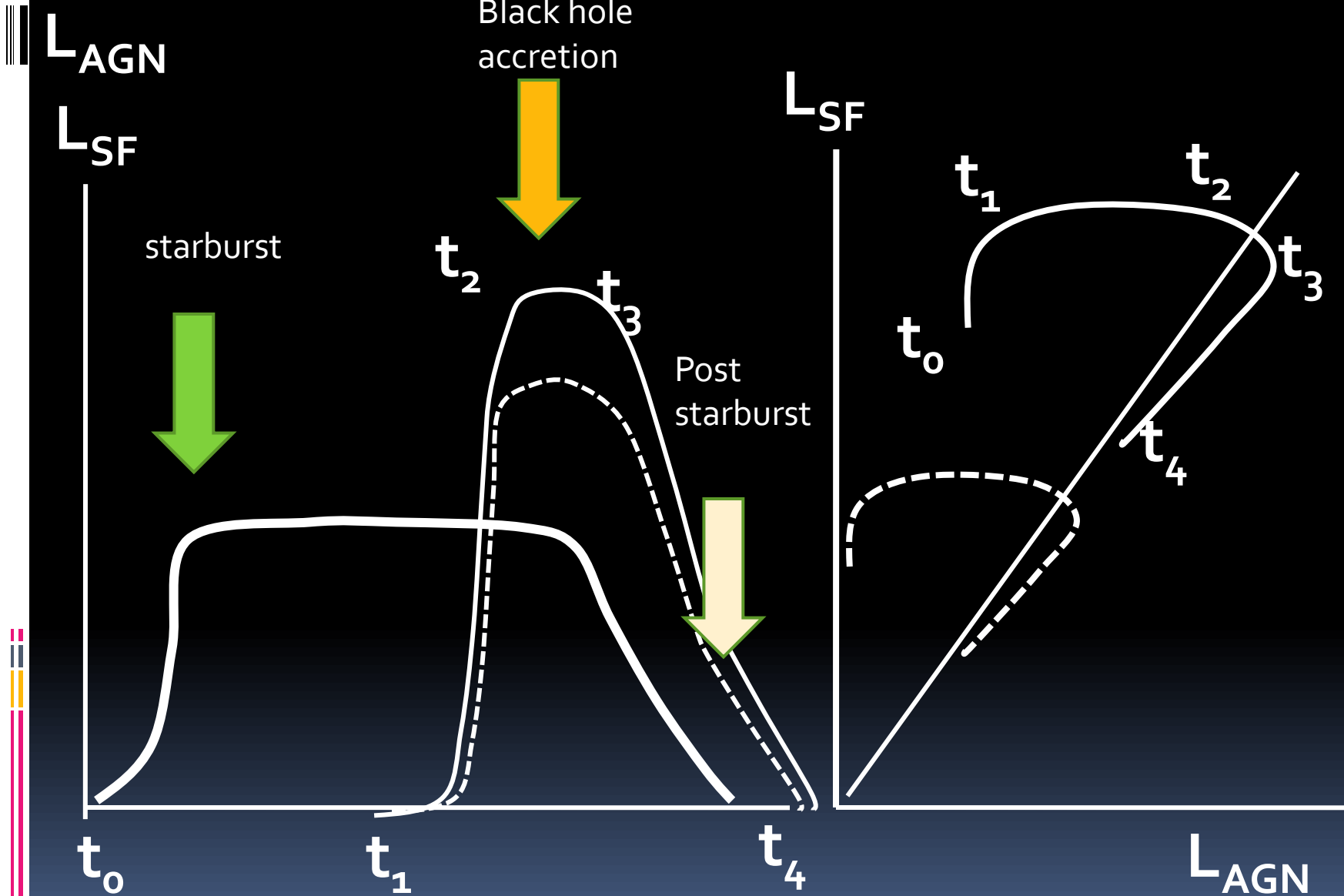


With a LOT of help from  
Benny Trakhtenbrot, Paulina Lira, Dalya Baron

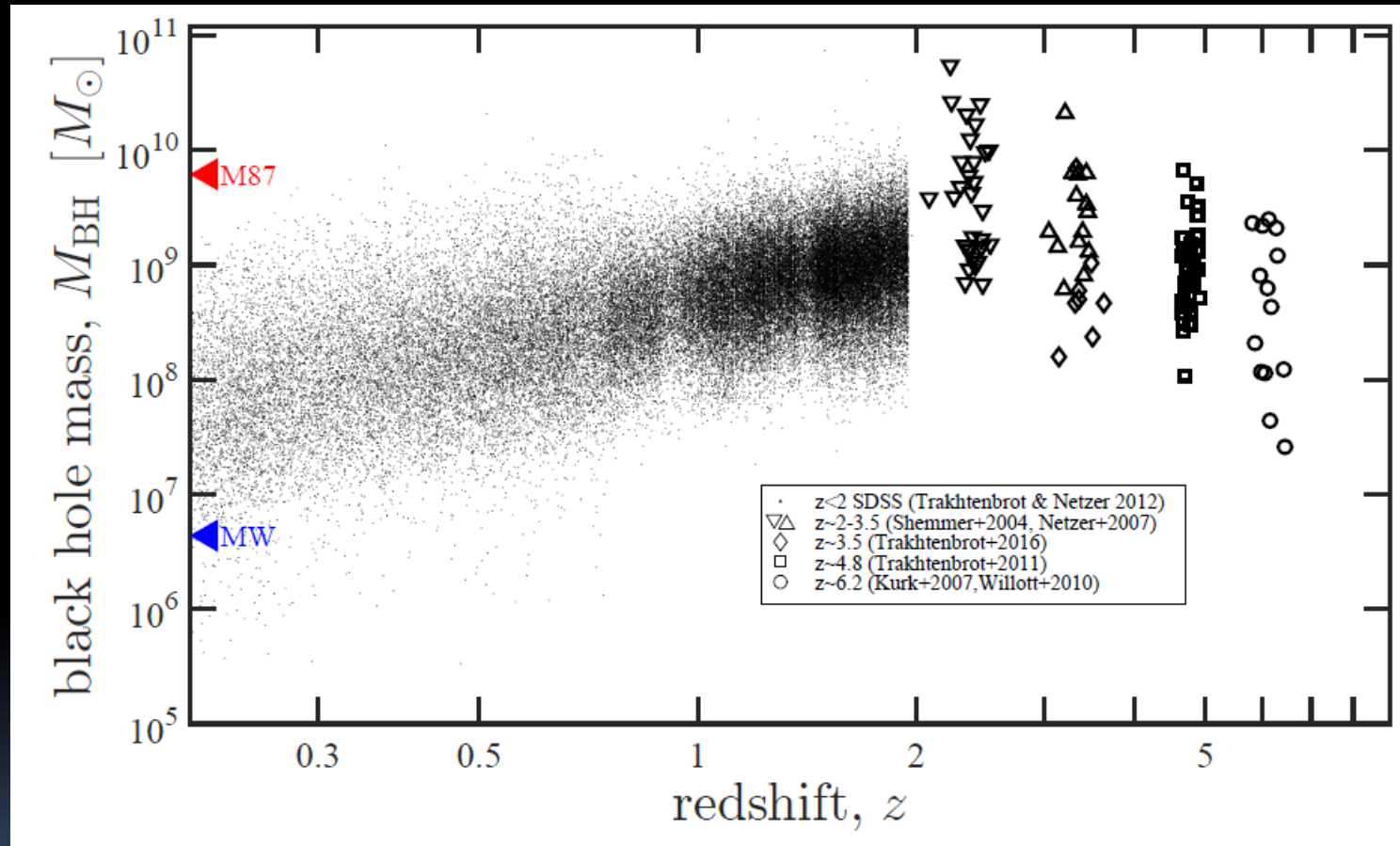
May, 2017

# Main questions

- Have we found evidence for feedback capable of quenching SFR in the most luminous AGN at  $z=2-5$
- Are mergers essential for triggering the most luminous starbursts at high  $z$ ?
- Do we know how ULIRGs end their SF phase (the case of local E+A galaxies)?
- How much can we trust numerical simulations of AGN feedback?



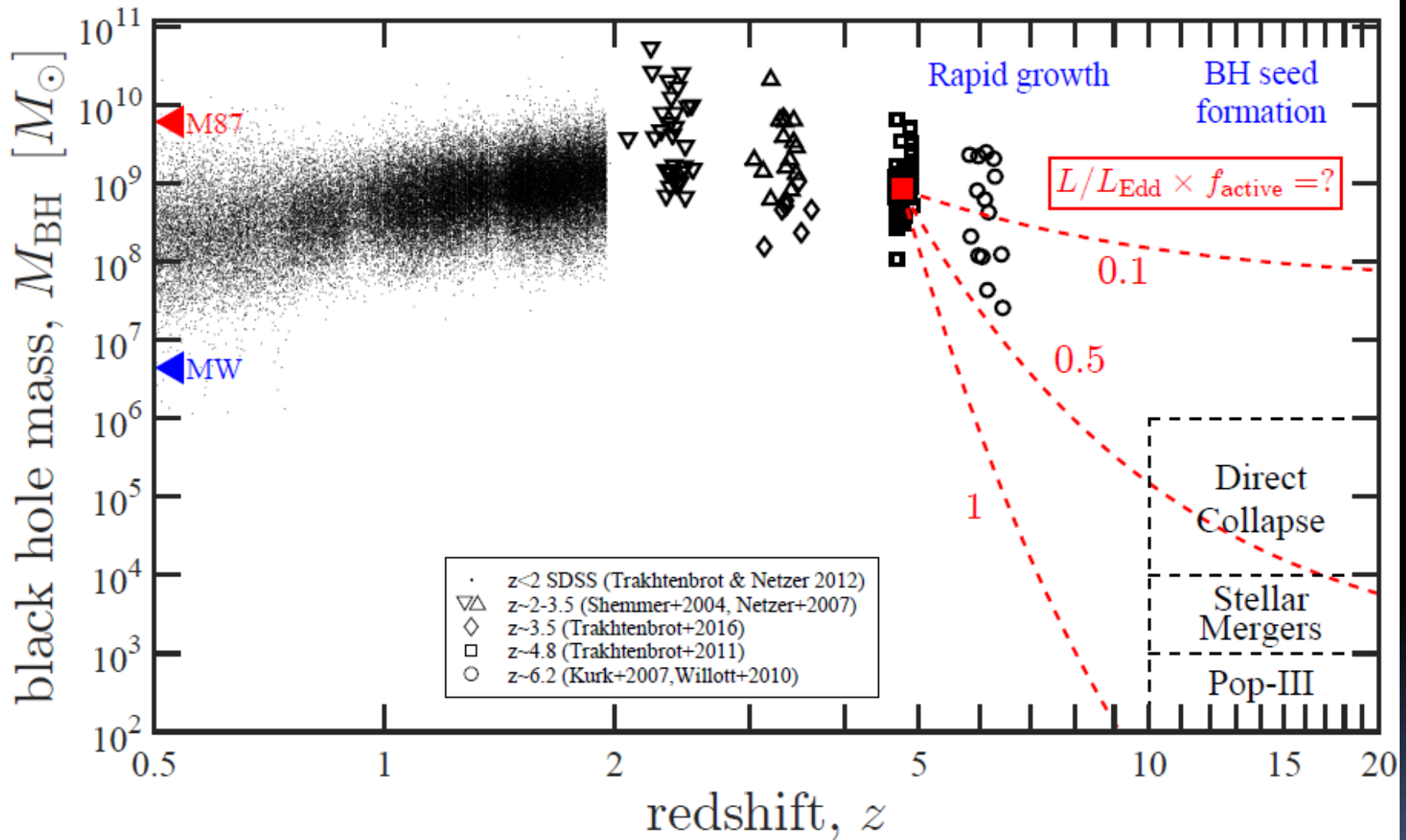
# The most massive and most luminous active BHs



Netzer and Trakhtenbrot 2012

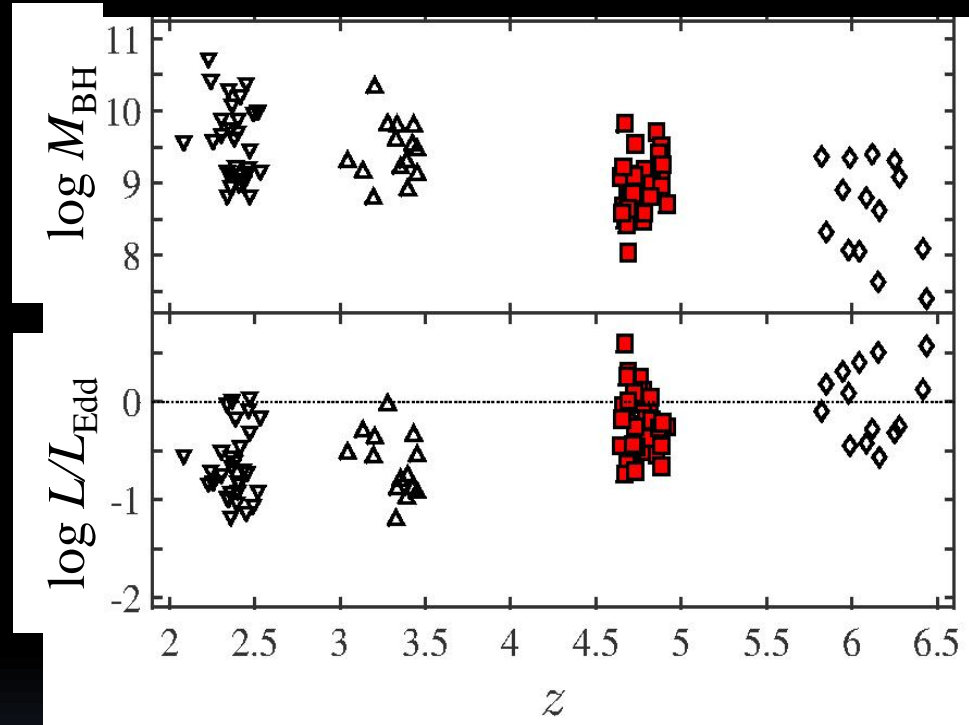
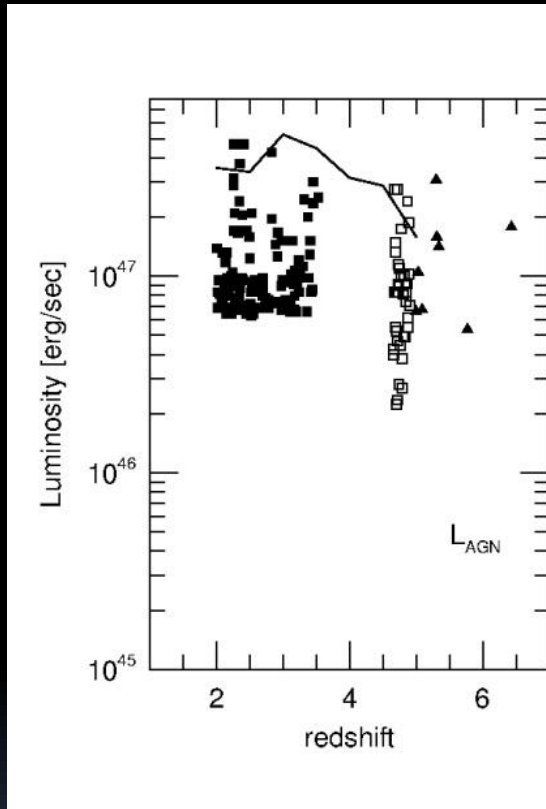
Adapted from Benny Trakhtenbrot presentation

# How to grow a SMBH in $\sim 1$ Gyr?

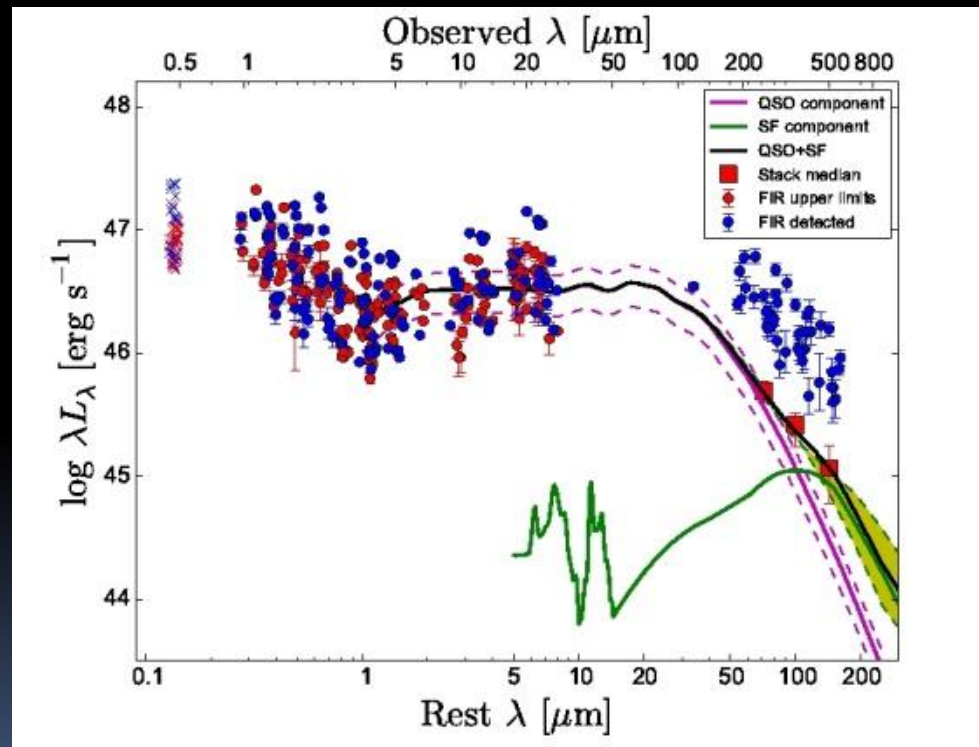


plot adapted from  
Trakhtenbrot & Netzer 12

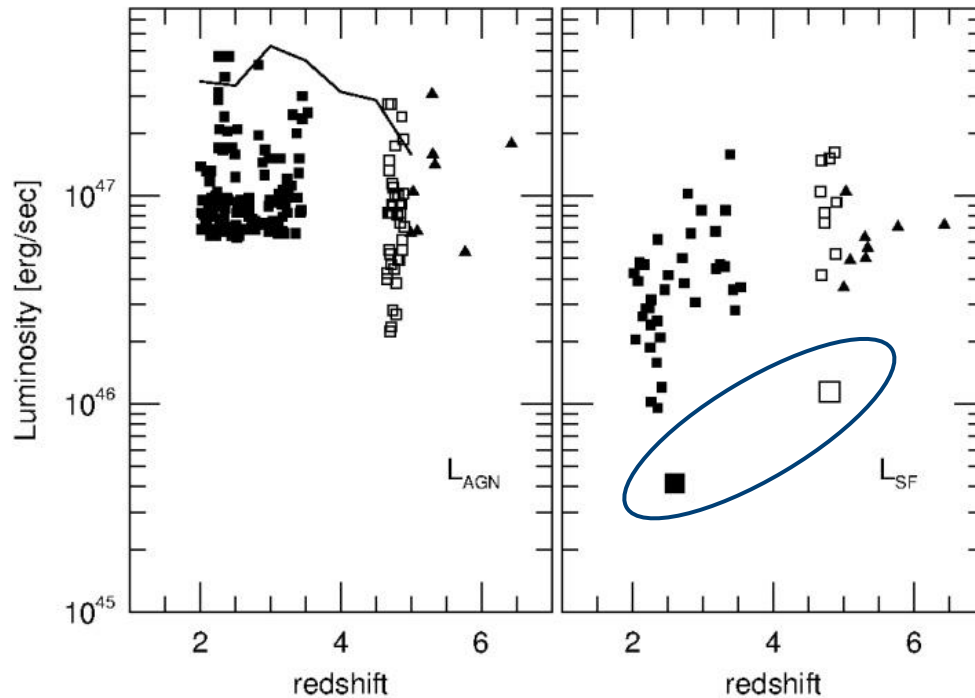
# BH growth rate through cosmic time



# The hosts of the most luminous AGNs at $z=2-3.5$



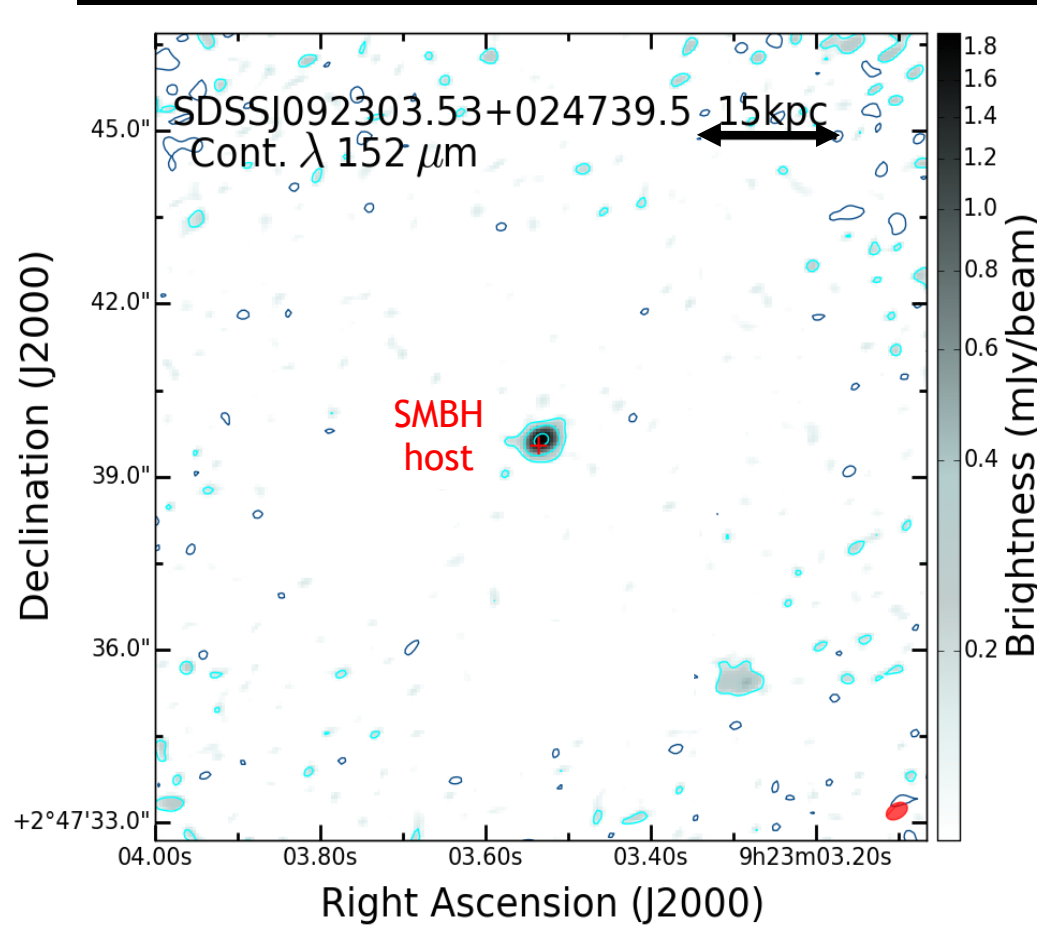
# The most luminous AGNs and the highest luminosity SF galaxies at $z=2-5$



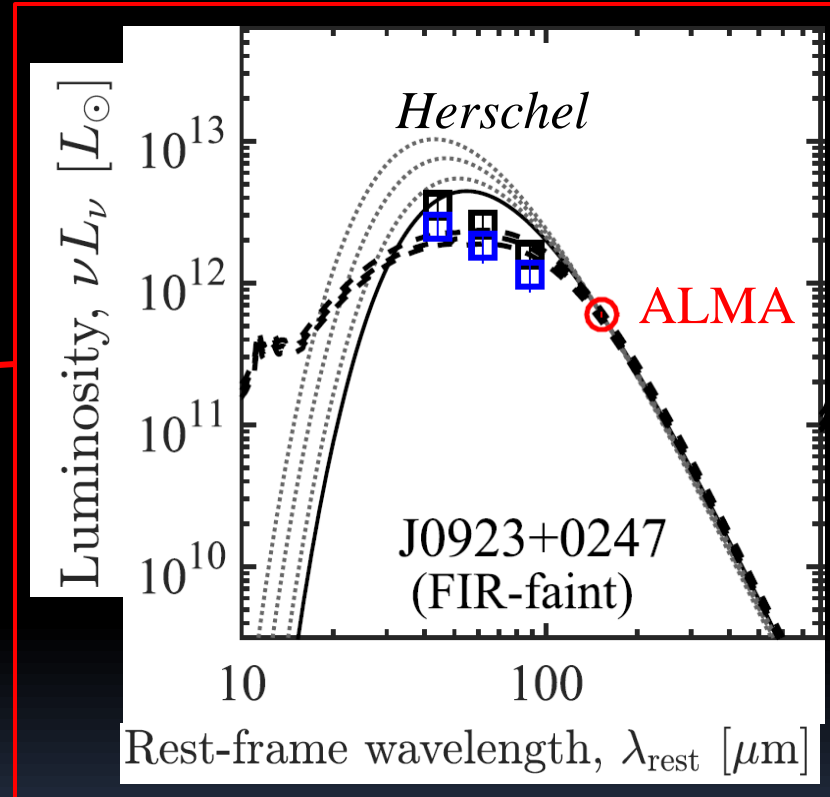
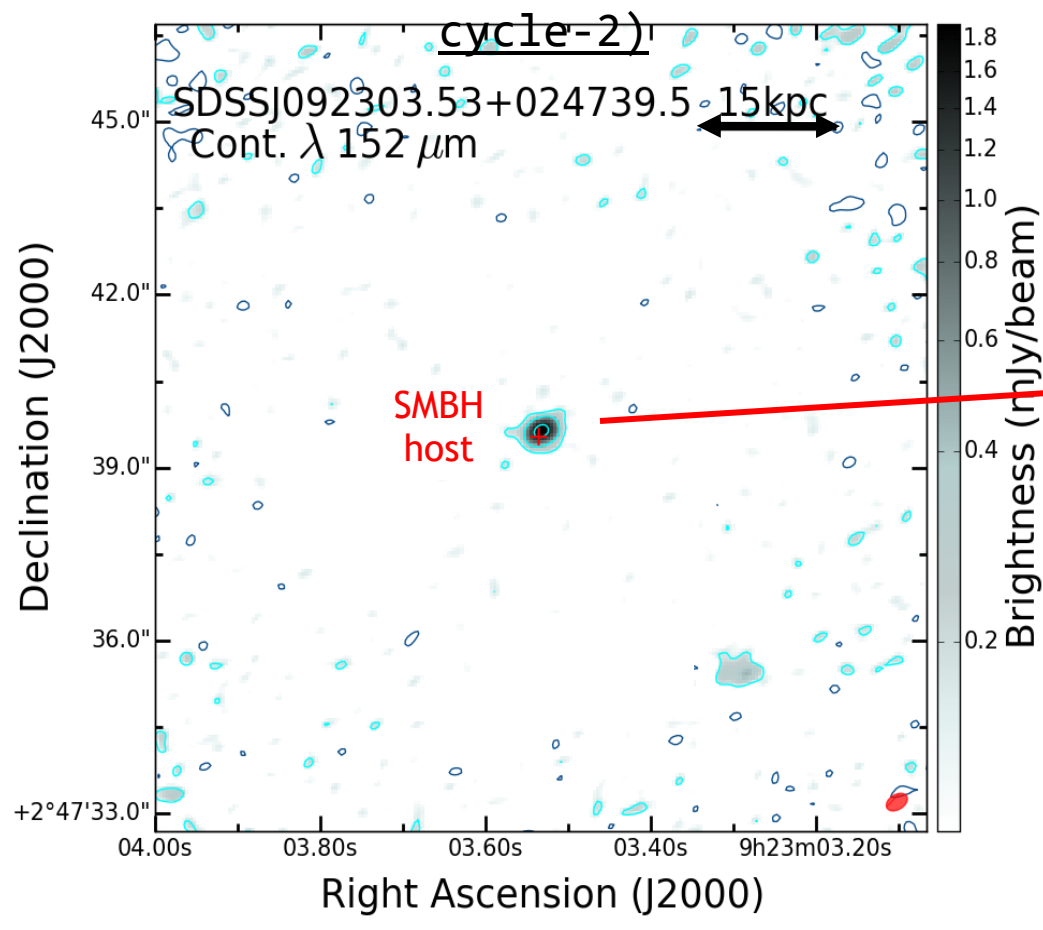
What is the typical SFR in AGN hosts?  
What are the SFRs in the undetected Herschel hosts?  
Is this due to feedback?  
(see R. Maiolino talk)



# ALMA cycle 2 observations of six fast-growing SMBHs at $z \sim 4.8$

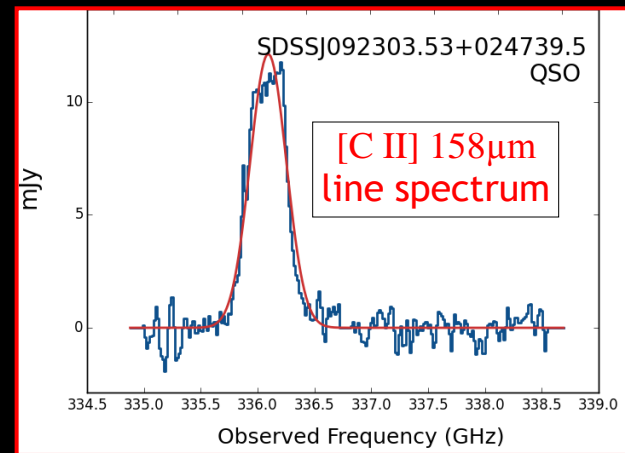
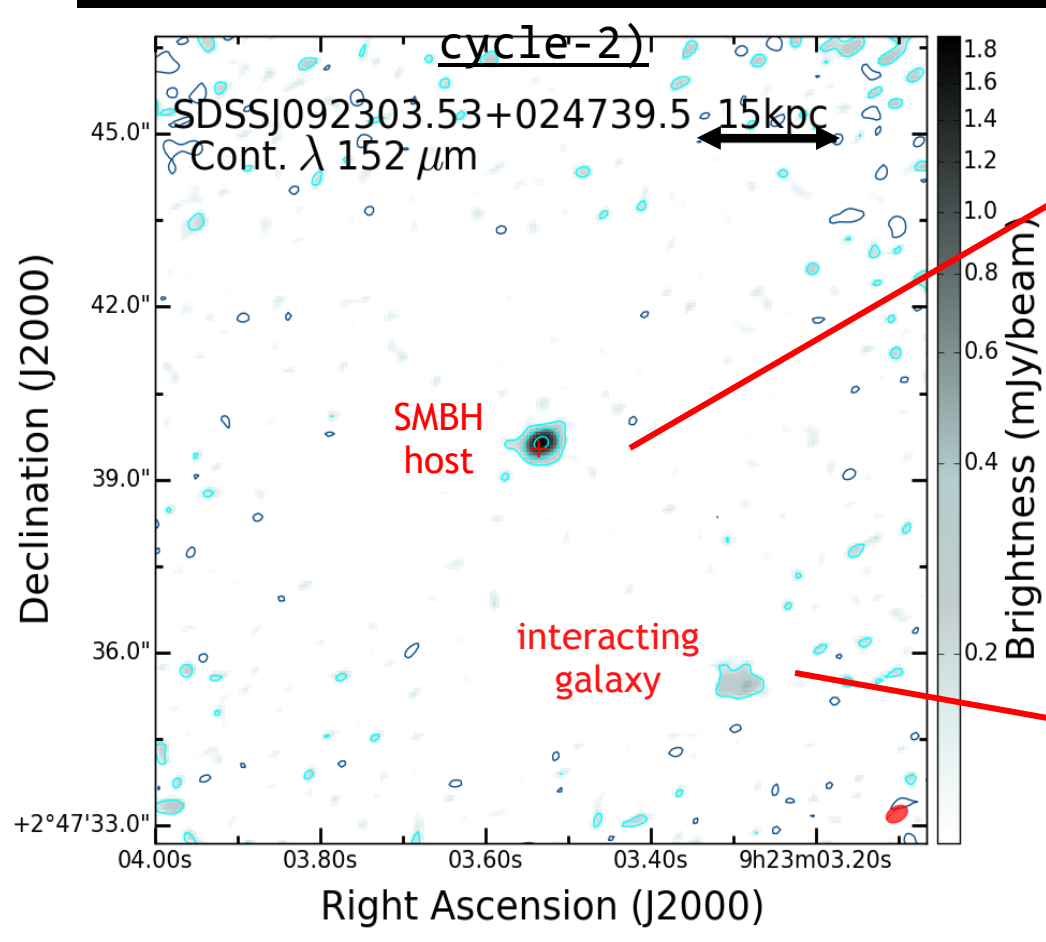


- In 3 sources we detect 20-40 kpc companions: One Herschel detected and 2 not-detected
- Some very powerful starburst galaxies do not have (clear) companions
- The observed companions are SMGs. They allow us to confirm the median Herschel SFR - i.e. hosts are on the Main Sequence of SF galaxies

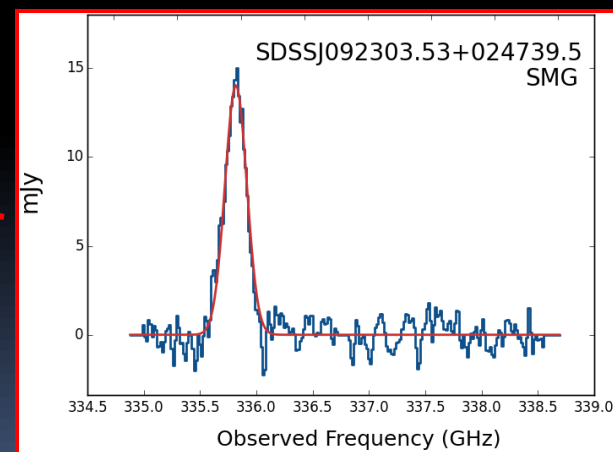


SMBH host galaxy at  $z=4.8$   
 $\text{SFR} = 360 M_\odot / \text{yr}$

Trakhtenbrot+17



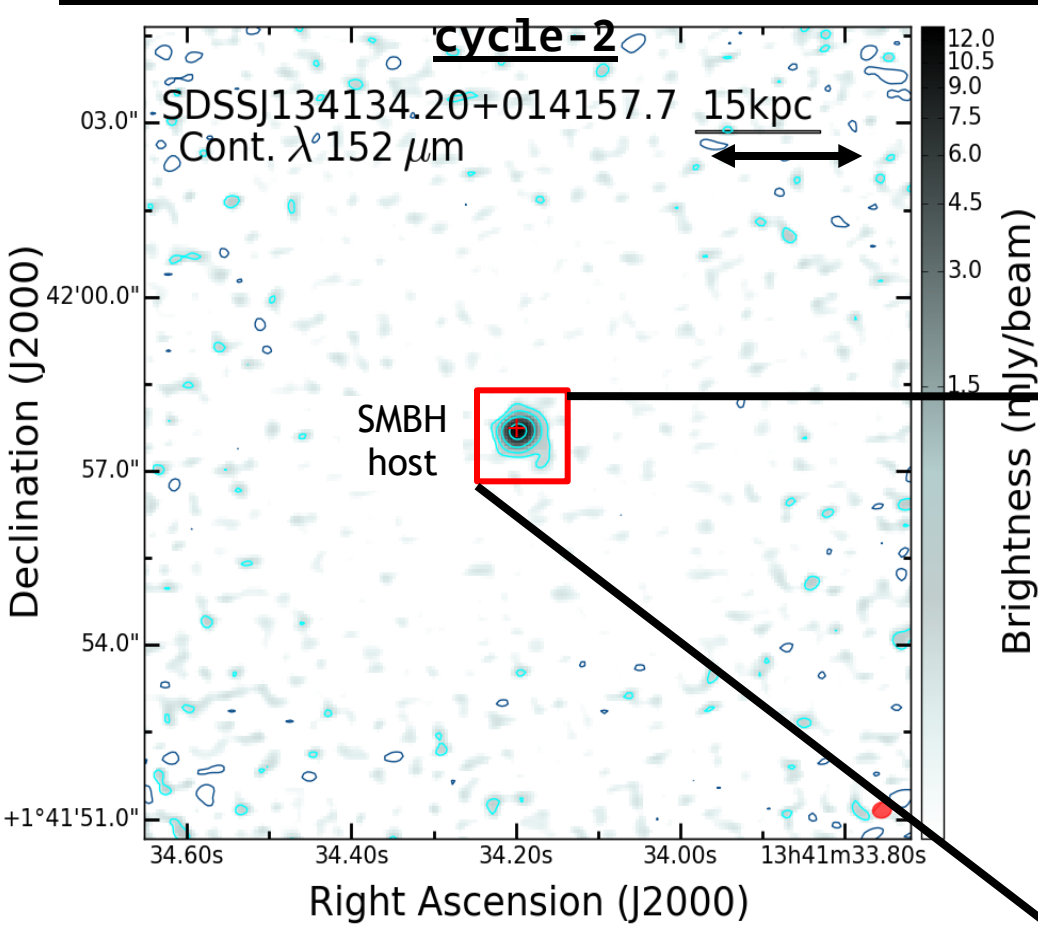
SMBH host galaxy at  $z=4.8$   
 $M_{\text{Host}} \approx 7 \times 10^{10} M_{\odot}$ ,  $\text{SFR} = 360 M_{\odot} / \text{yr}$



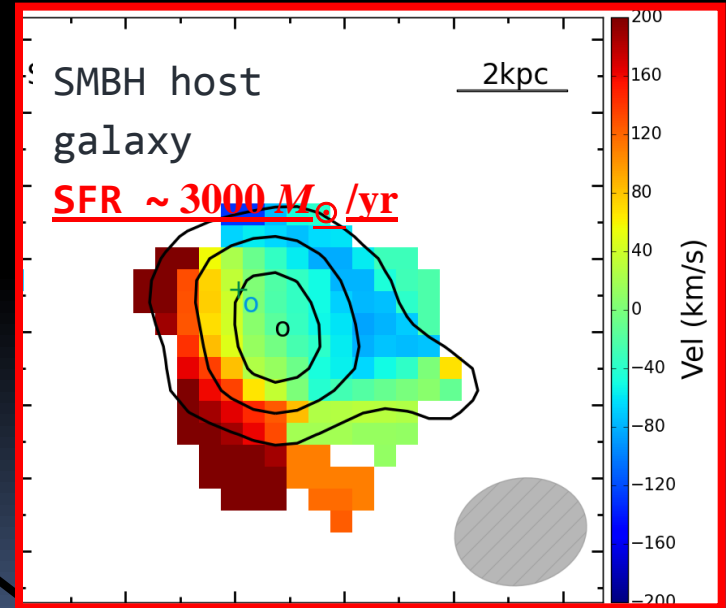
interacting galaxy  
 $M_{\text{SMG}} \approx 2 \times 10^{10} M_{\odot}$ ,  $\text{SFR} = 150 M_{\odot} / \text{yr}$

Trakhtenbrot+17

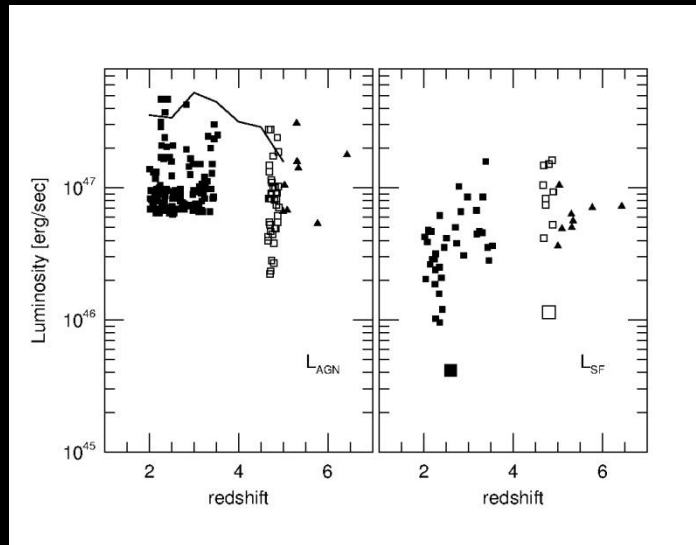
# ALMA Observations of fast-growing SMBHs at $z \sim 4.8$



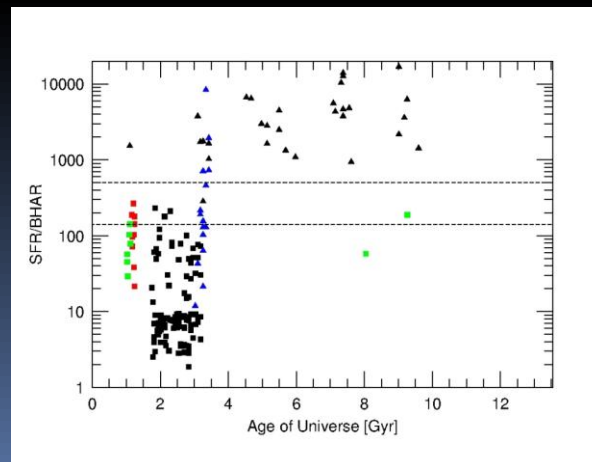
- Mergers are not essential for triggering SF in the highest SFR galaxies at  $z=2-5$



# The fraction of starbursting systems quenched by feedback at high redshift



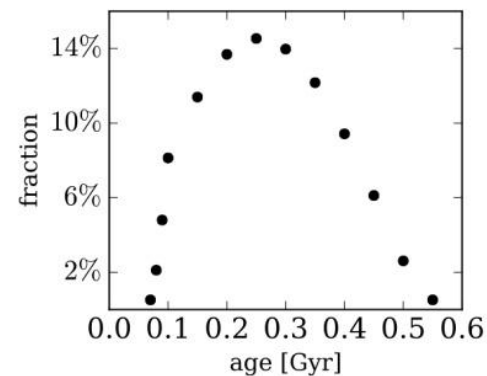
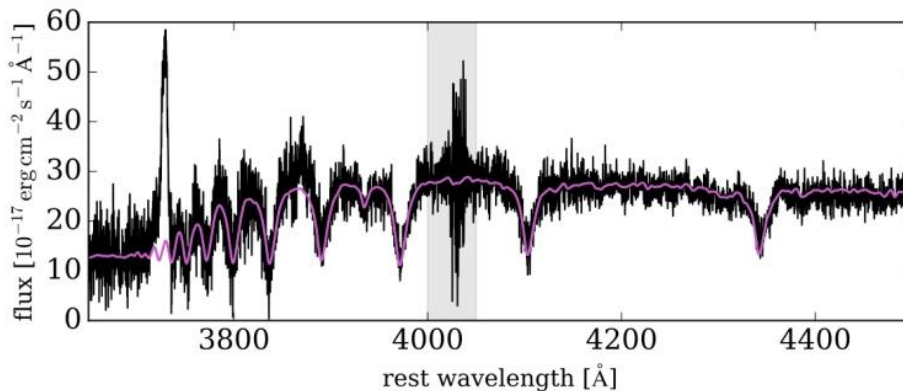
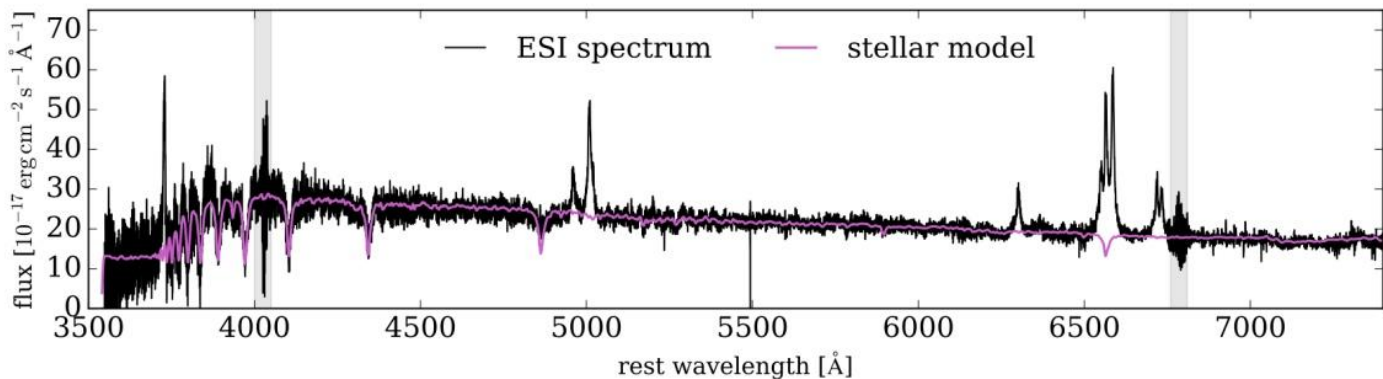
At  $z=4.8$  ~0%  
At  $z=2-3.5$  33-66%



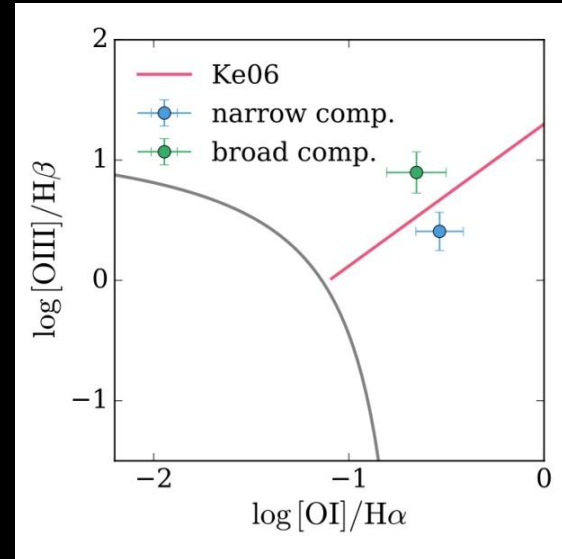
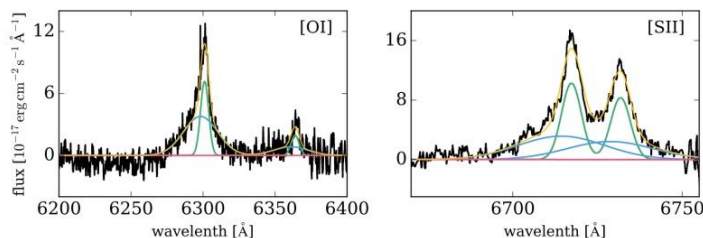
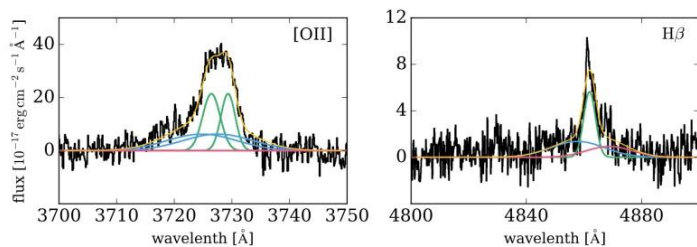
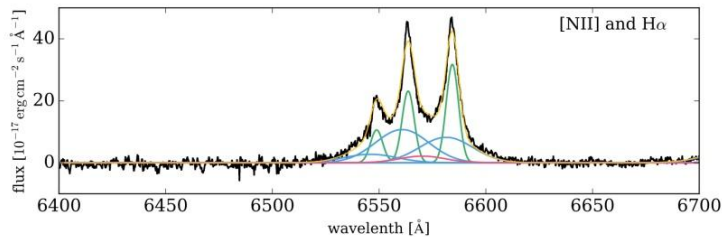
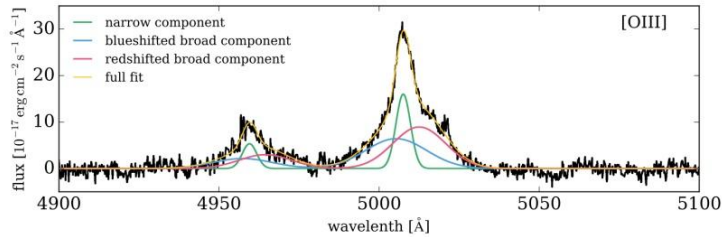
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# The most accurately timed AGN feedback: ULIRGs and E+A galaxies



# E+A galaxies: NLR, outflow or both?



Outflow signature in several emission lines:

$$\text{Mass outflow rate} = M/\dot{t} \sim (L(\text{H}\alpha)/n)/(R/v) \sim 1/nR$$

$$\text{Emission line (blue wing) ratios} \sim L/nR^2$$

$$\text{Mass outflow rate} \sim LR$$

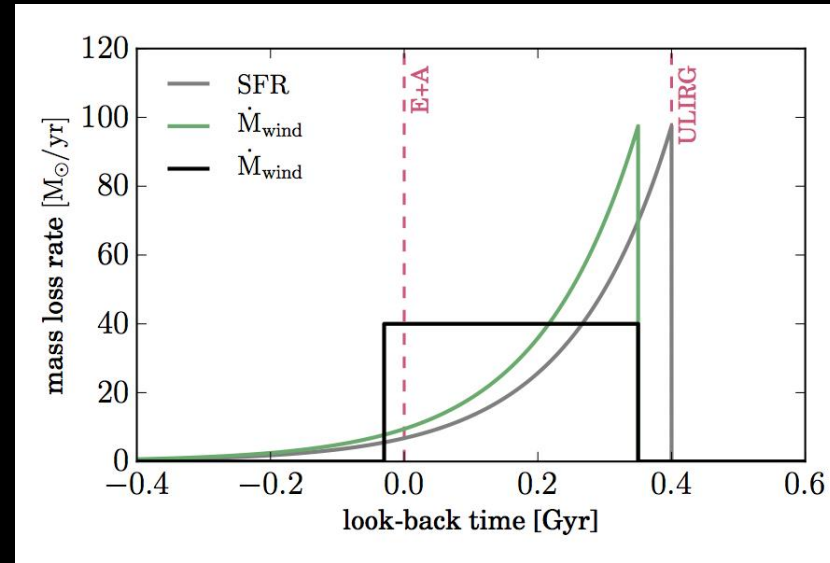
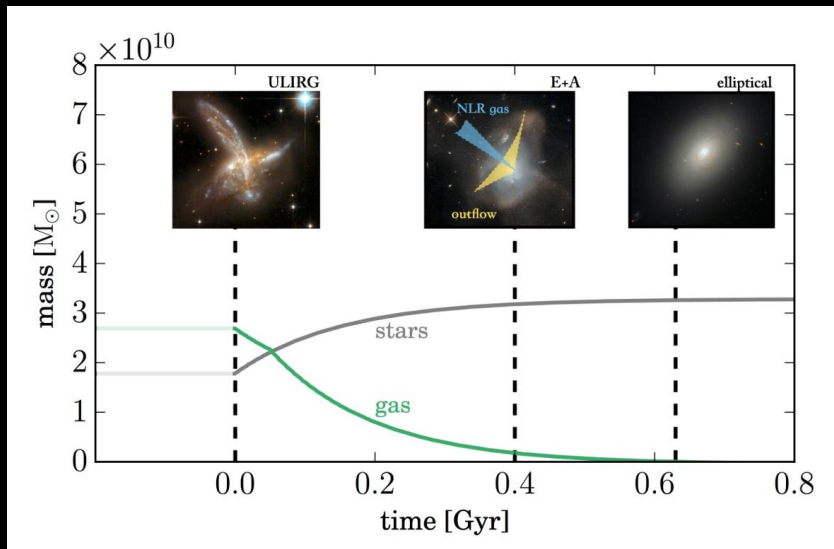
Example :

$$\text{Mass outflow rate} = 83 R_{\text{kpc}} \text{ Msun/yr}$$



# Timing feedback

## A toy model with real masses




Questions:

Is this a continuous  $\sim 100$  Myr-long feedback?

Can such an outflow shut off, abruptly, SF in ULIRGs?

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# Thank you – תודה רבה

- Thank you Ari and Ehud
  - Thank you Reuma and the Technion
  - We will visit you again when we know how to simulate AGN feedback
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