FOLLOWING SUPERMASSIVE BLACK HOLES OVER COSMIC TIME

SPIG2020

Serbia August 2020

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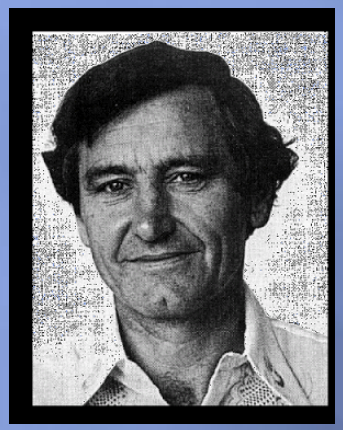
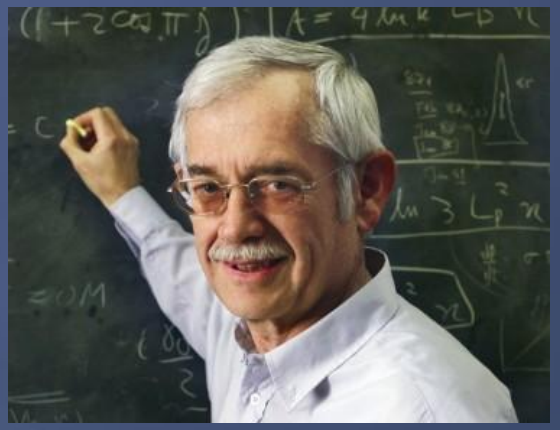
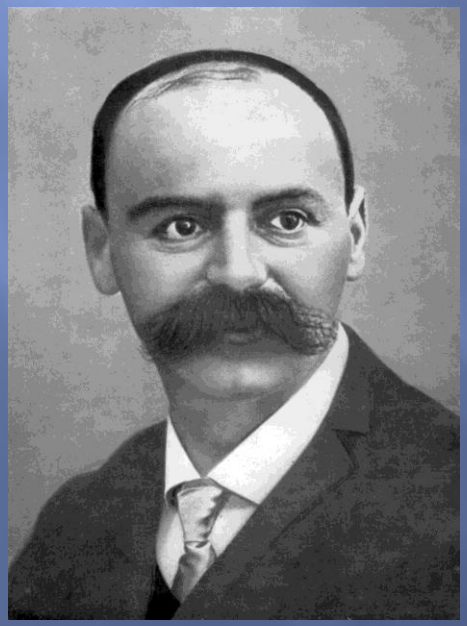
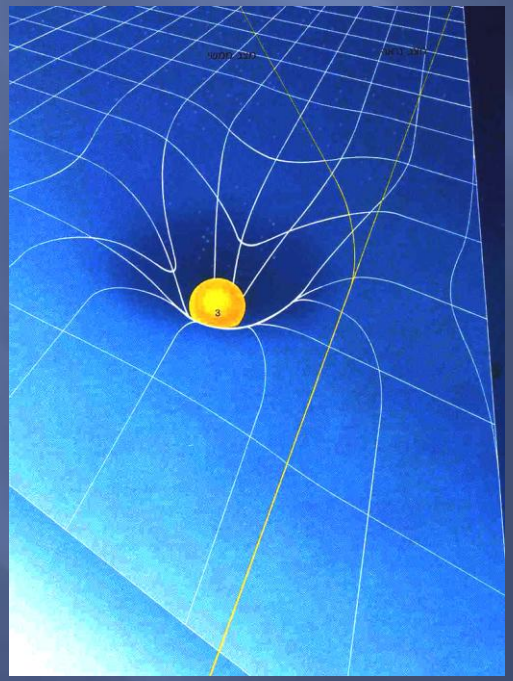
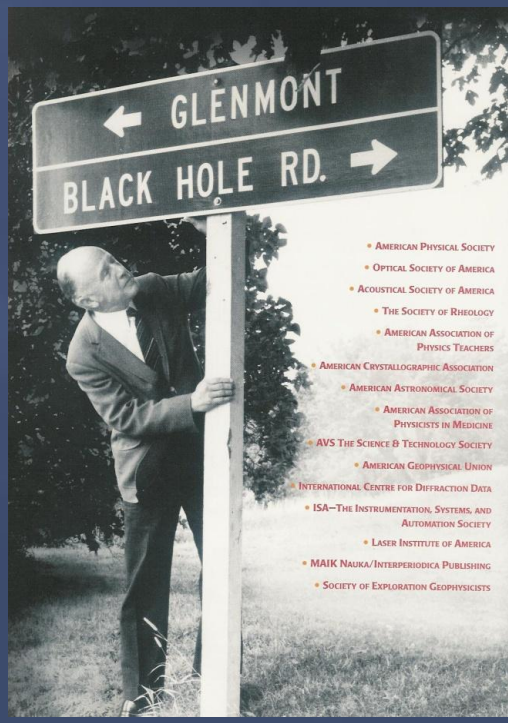
Black hole theory 1916–1974



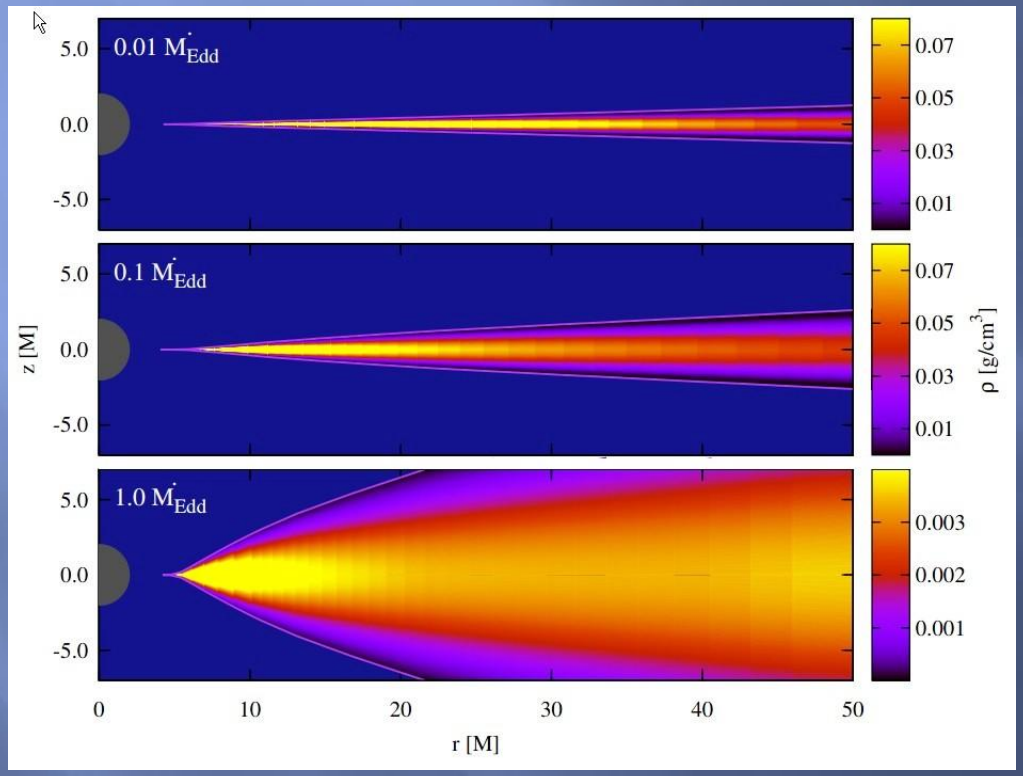








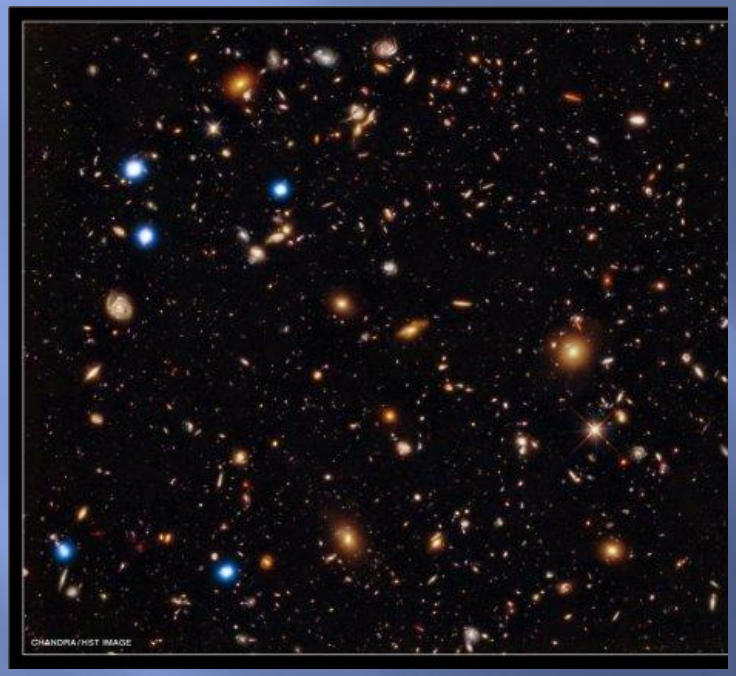
1. Black hole power house: Feeding

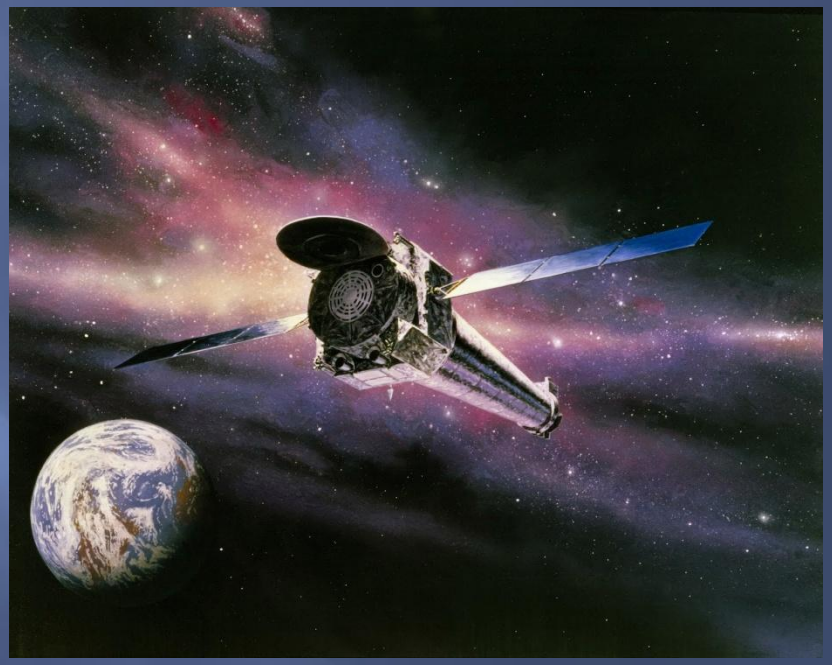


Sadowski 2011

Accretion disks
Mass to energy conversion efficiency
0.038 - 0.42

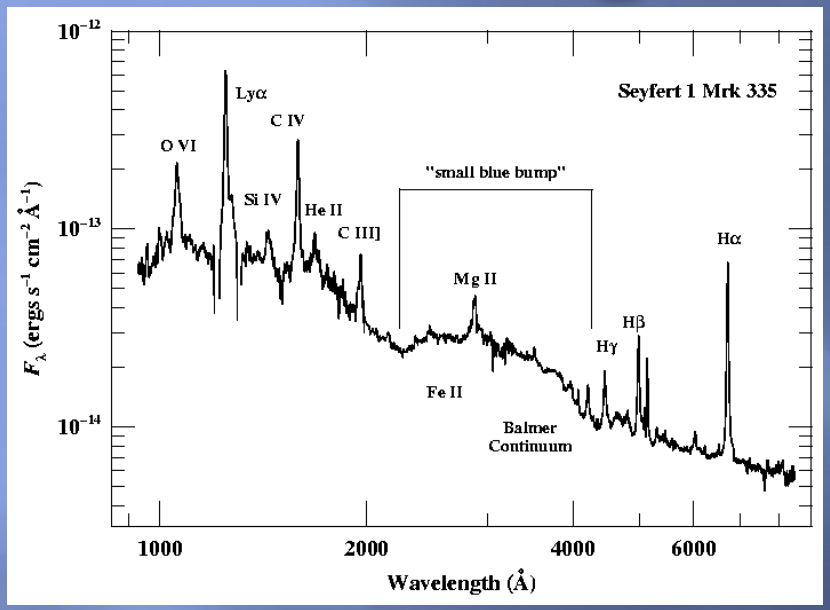
Observing black holes

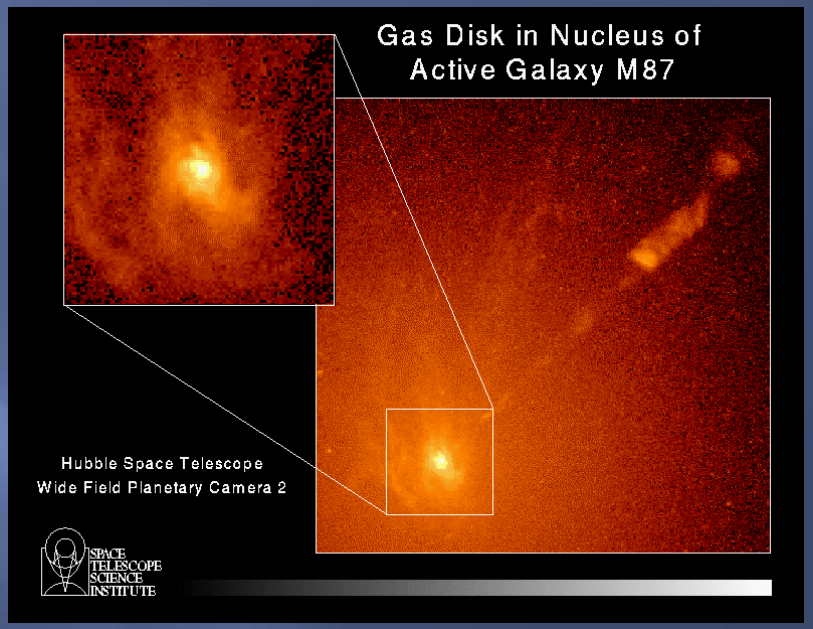


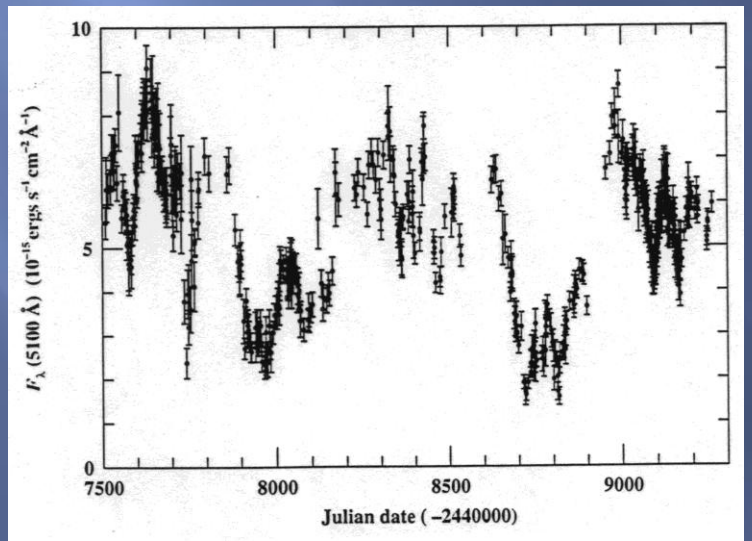


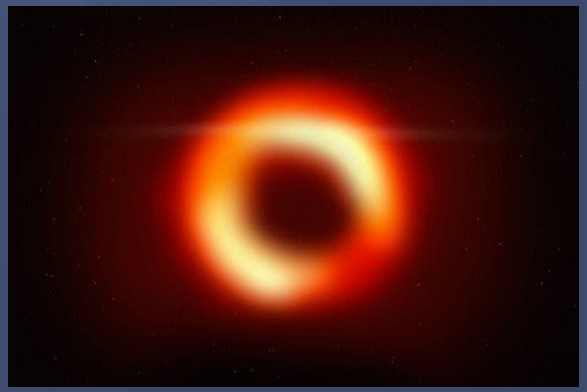
- X ray observations – Chandra
- 0.11 square degrees , 4 million seconds, 1000 detections translated to more that a billion sources all over the sky.
- About 1% of all galaxies

Active galaxies – AGN



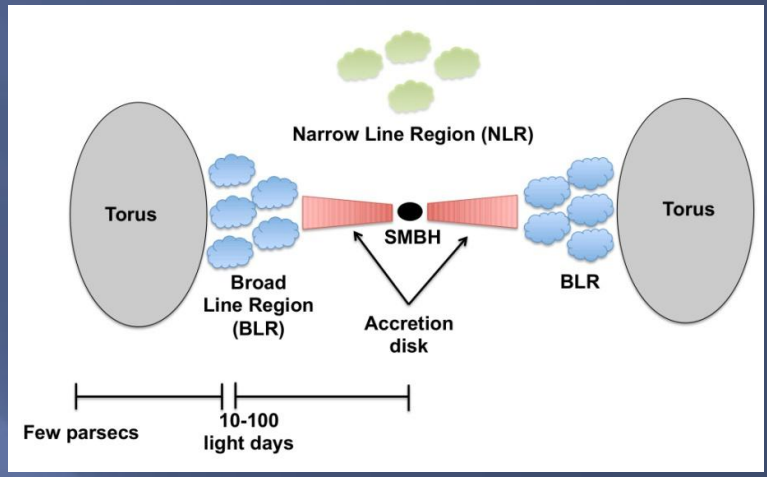


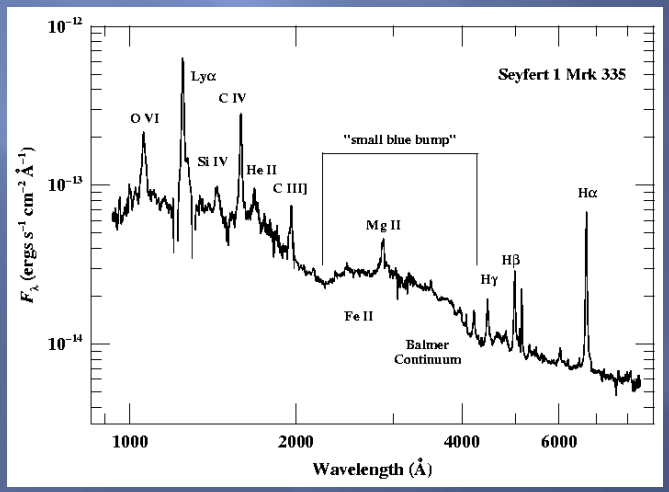




Measuring black hole mass here and here

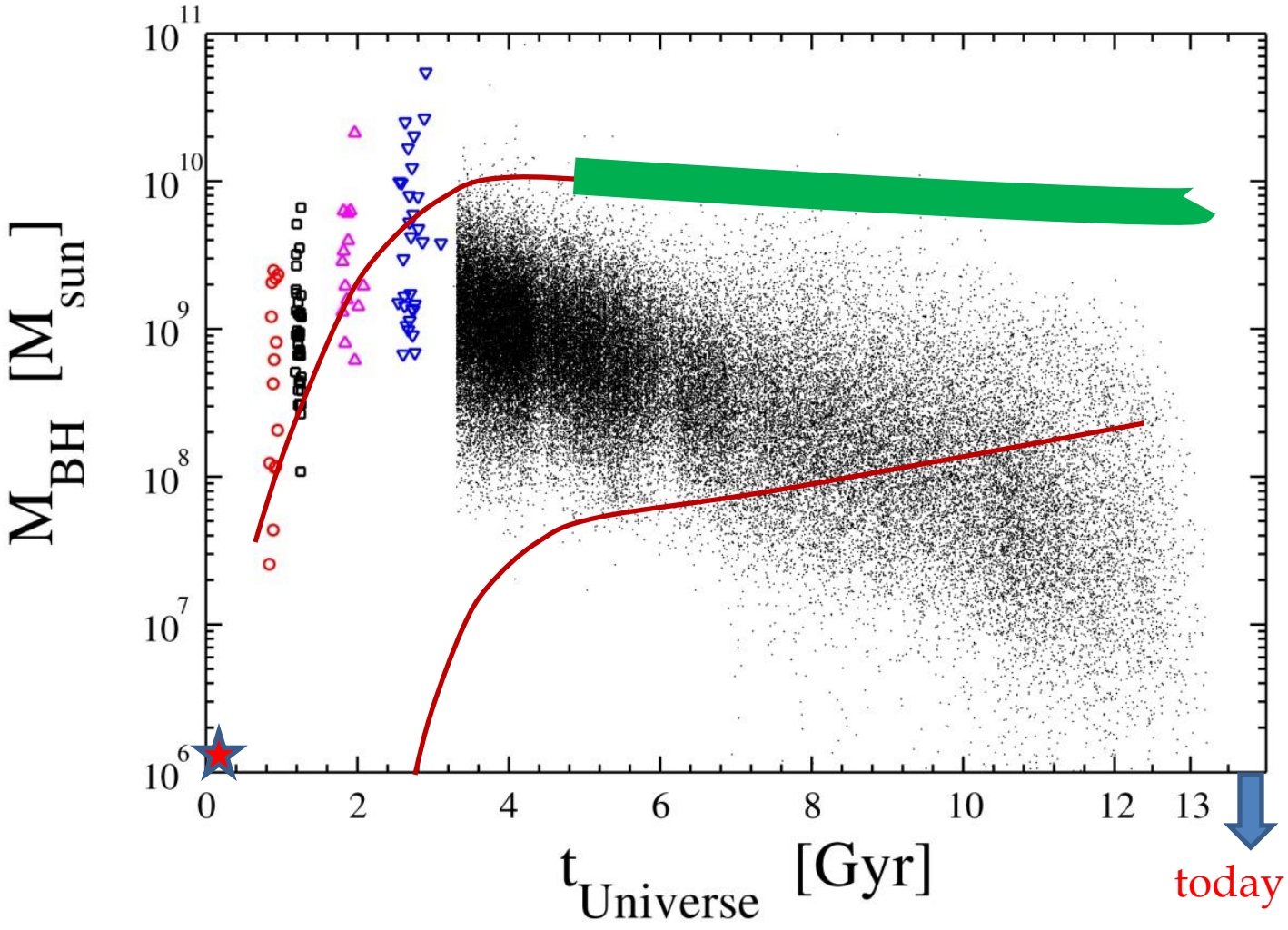
$M=V^2R/G$

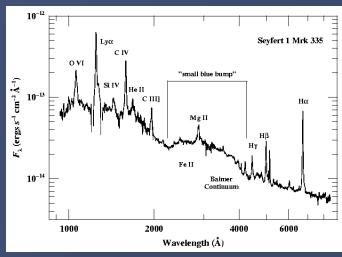




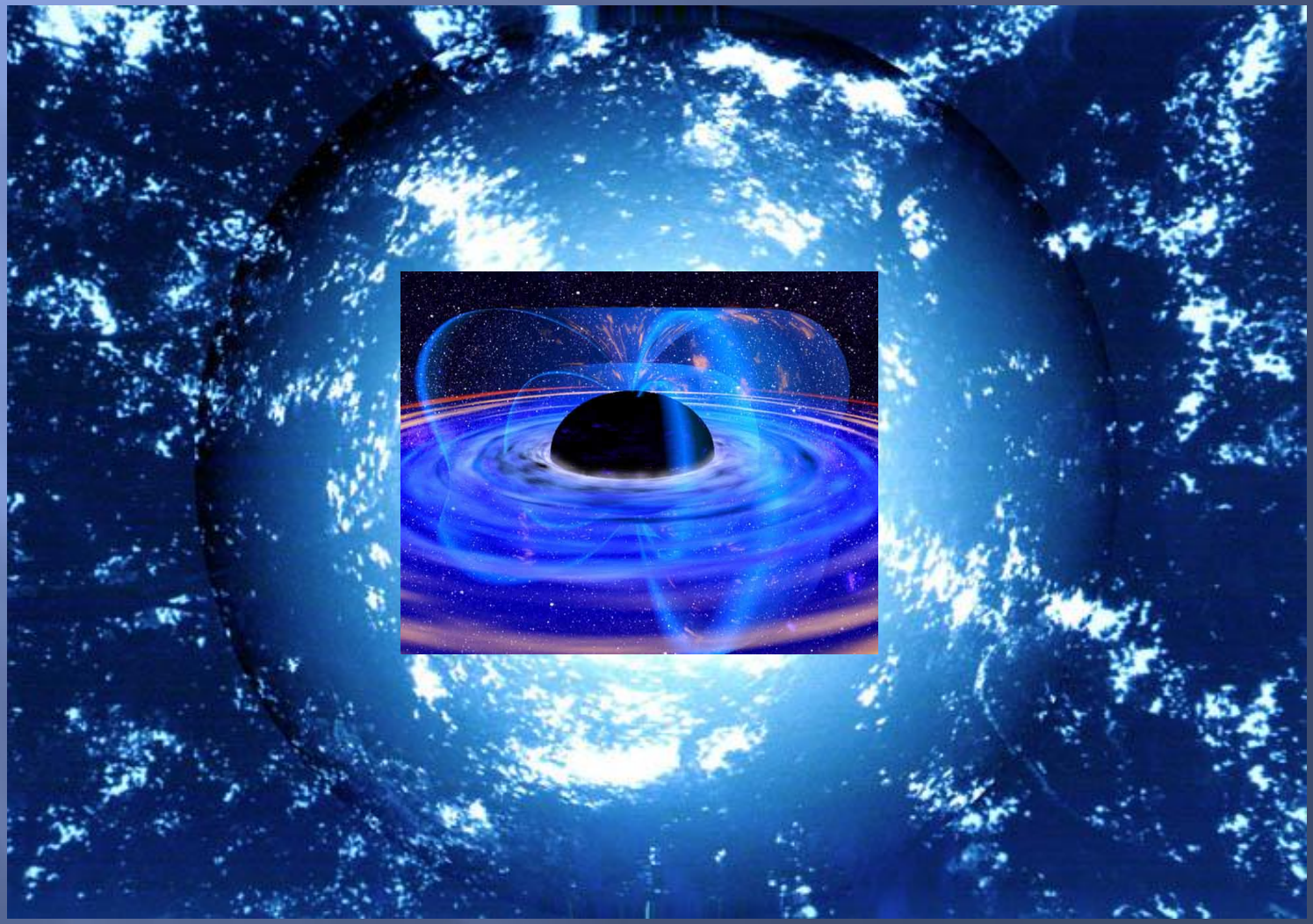
Here (Serbia) and here (Tel Aviv)

2. Cosmic evolution of black holes

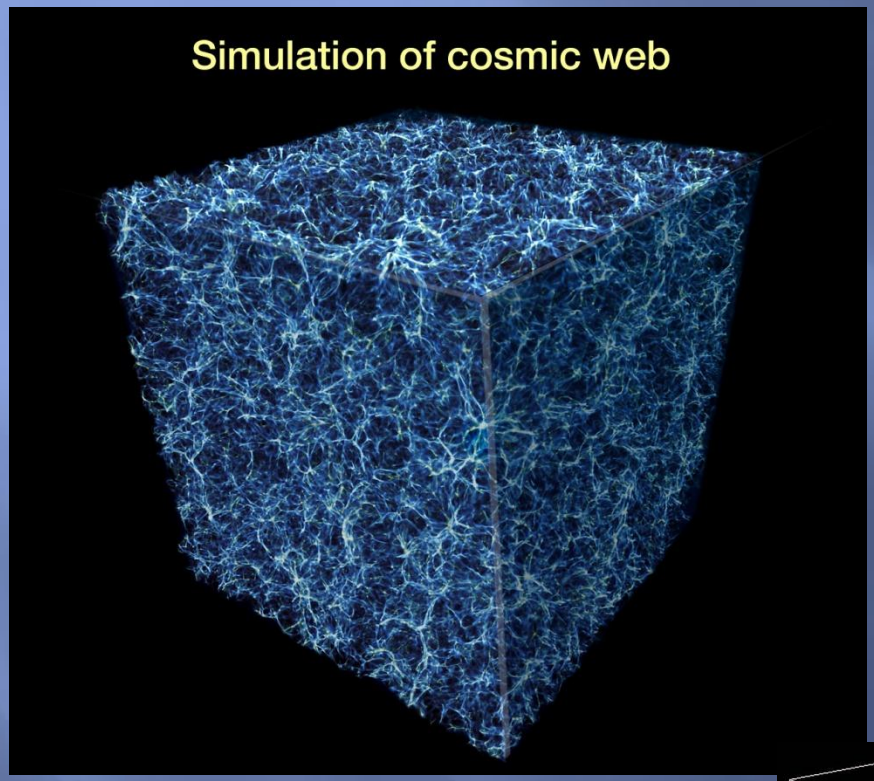


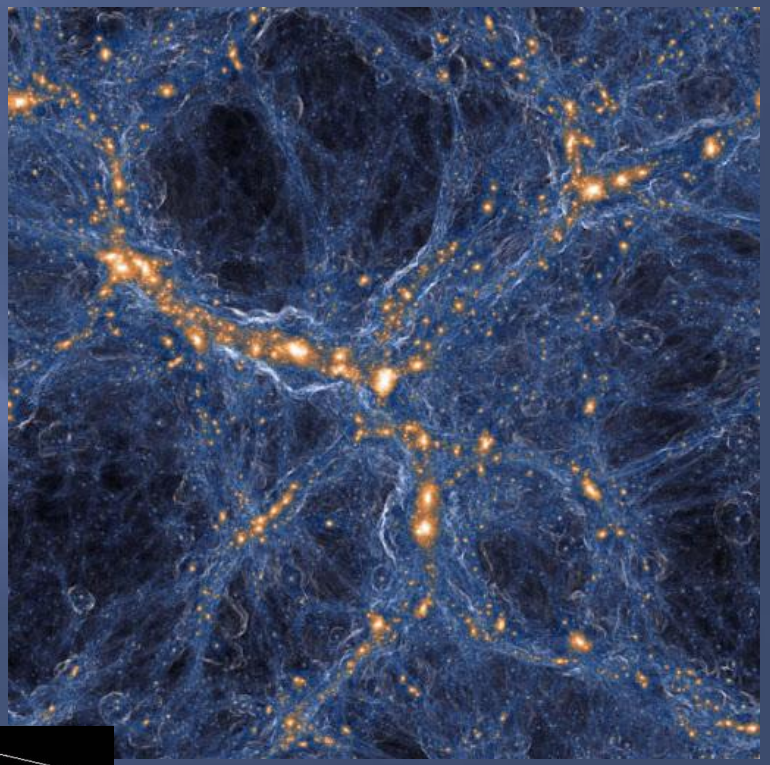


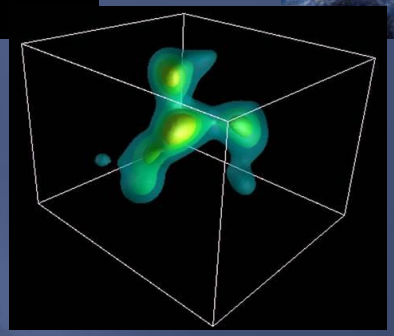
3. The first black holes



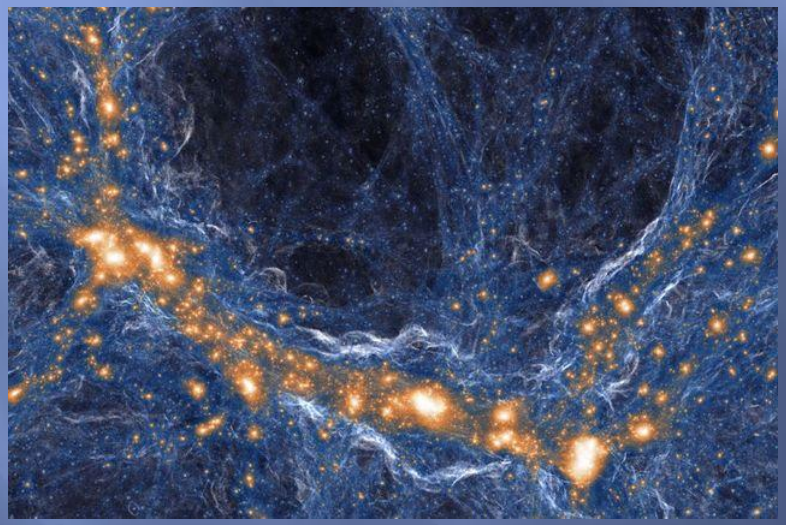
Black hole and galaxy environment at early times

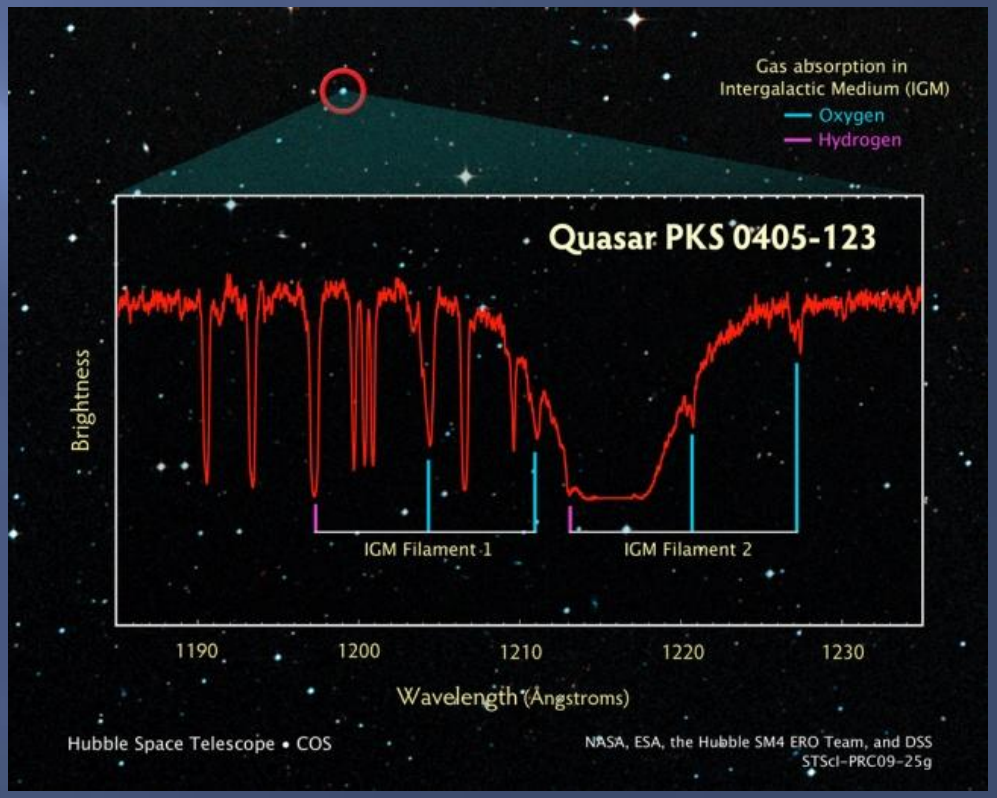






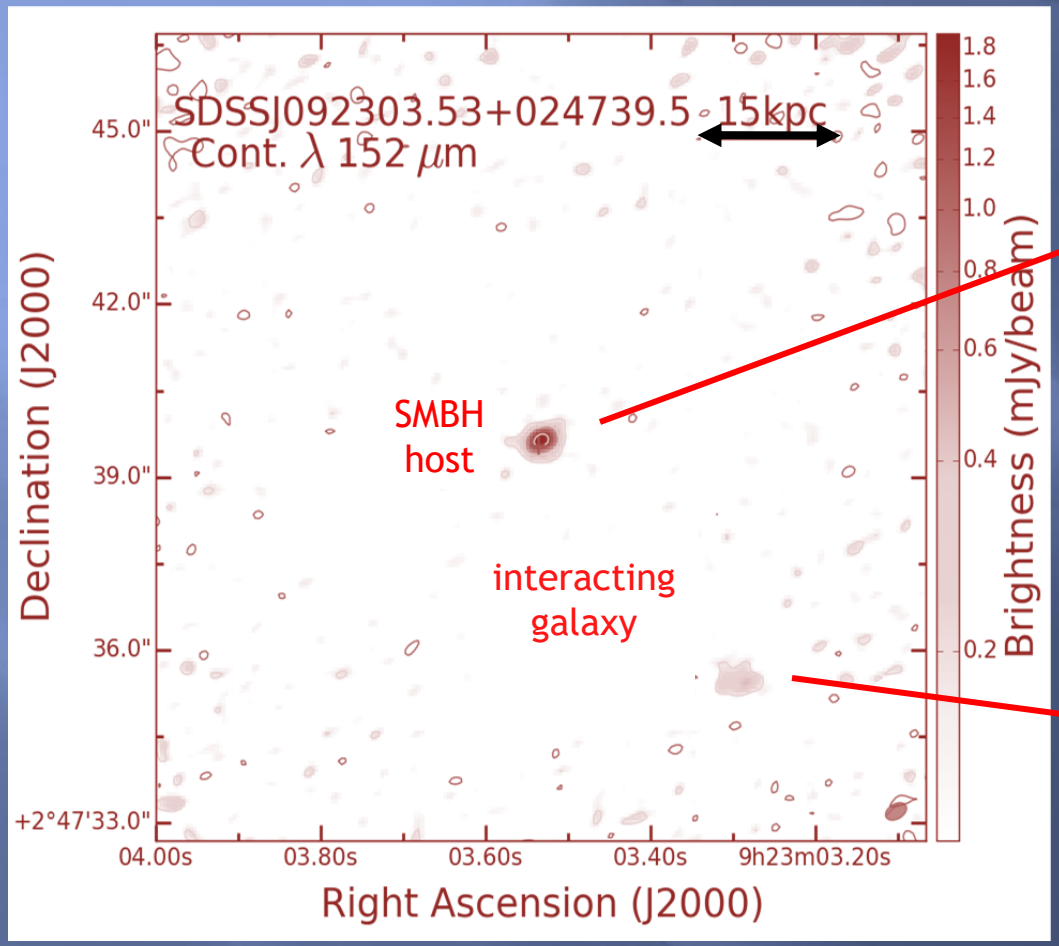
Probing the cosmic web with high redshift lamp-posts

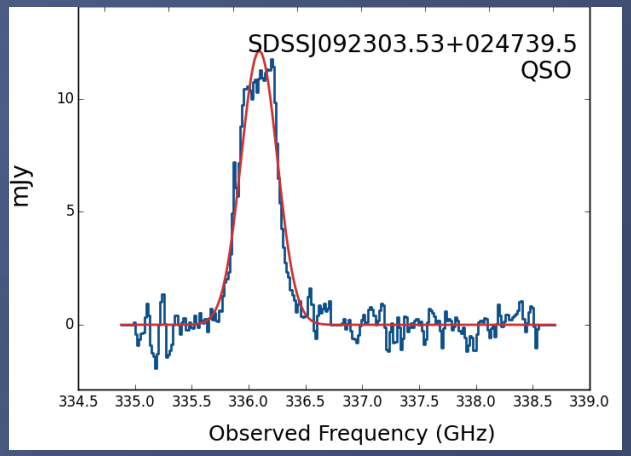




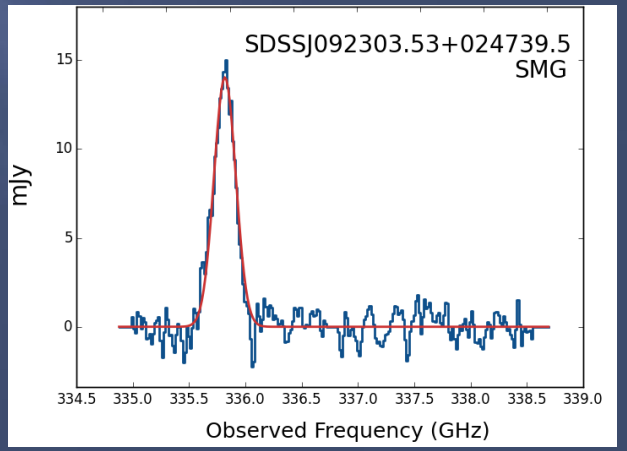
Black holes and their companion galaxies at z=5 ($t_{universe}$=1.2X10^9 yr)

ALMA observations of fast growing z=5 black holes and their companion galaxies





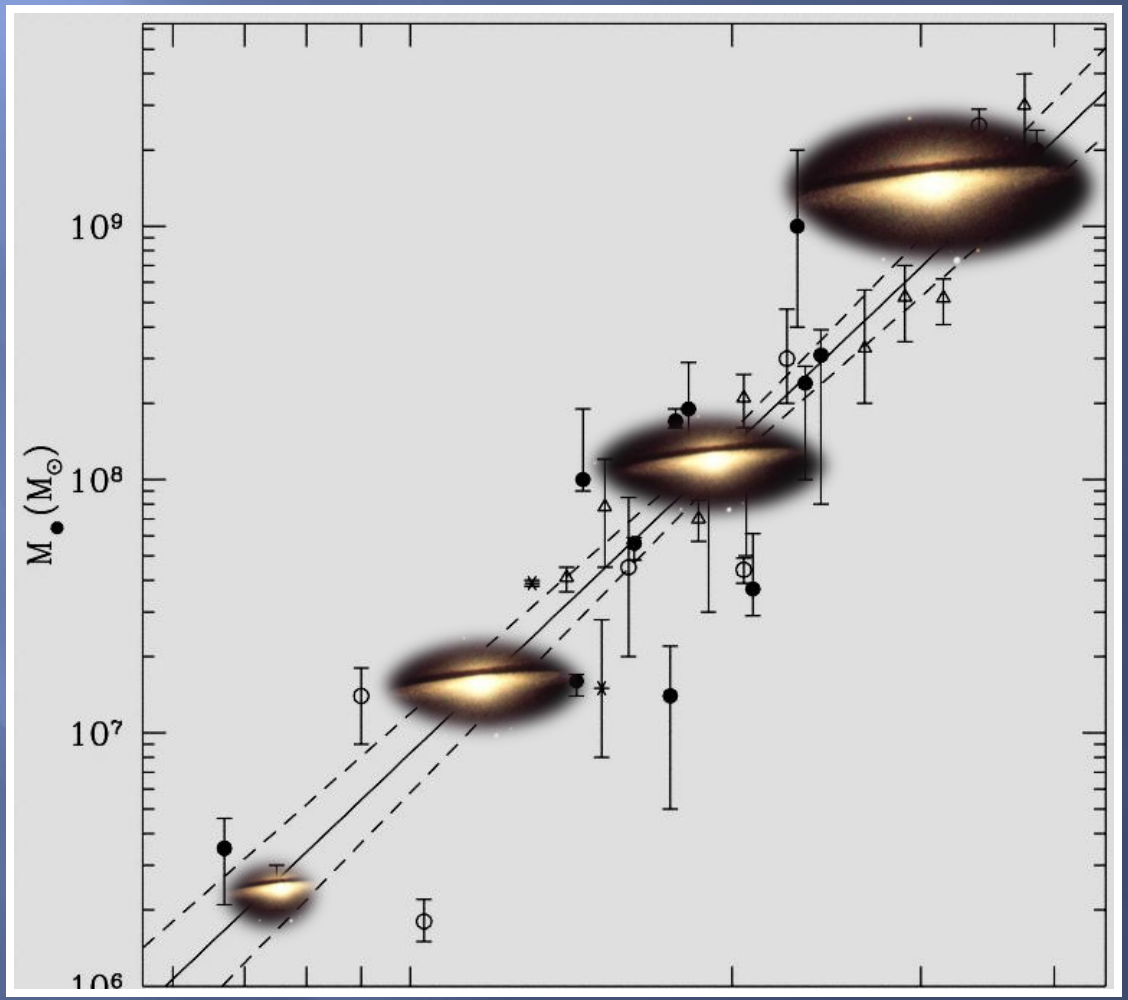
host galaxy of SMBH



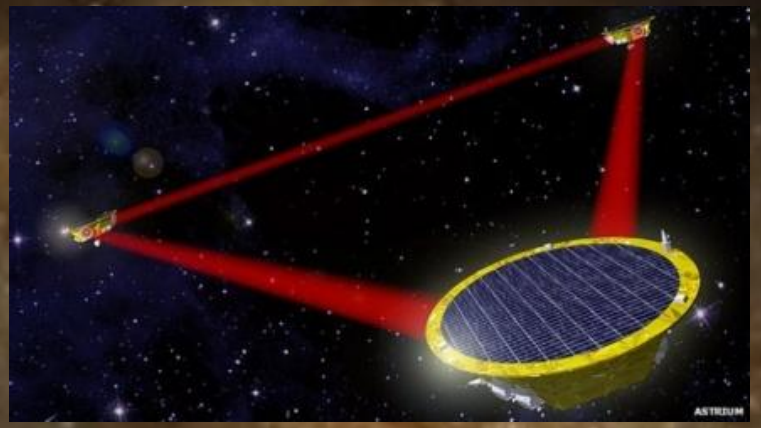
companion galaxy

Trakhtenbrot, Netzer, Lira .. 2017-2020

4. Parallel evolution of black holes and their host galaxies

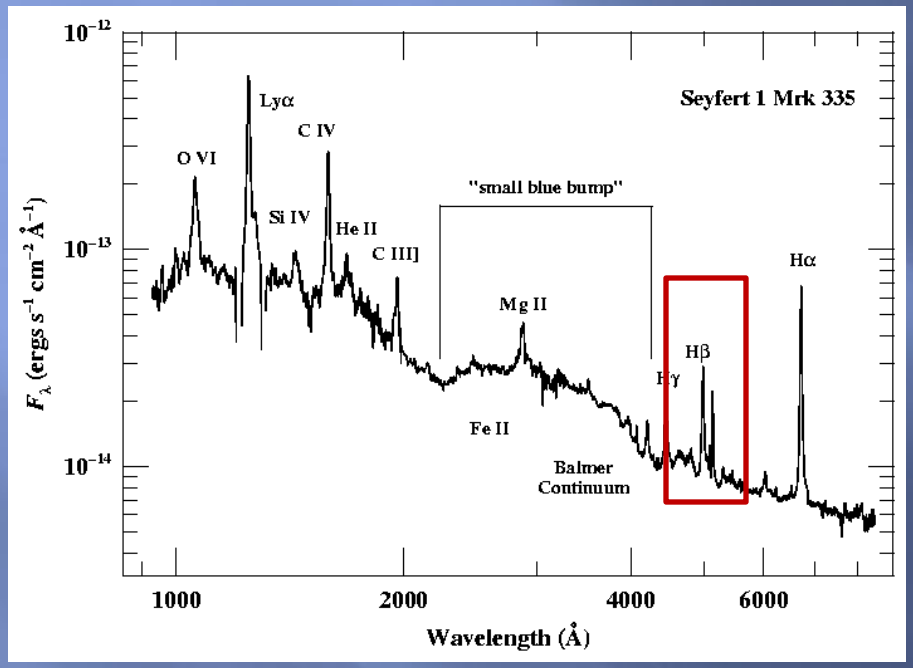


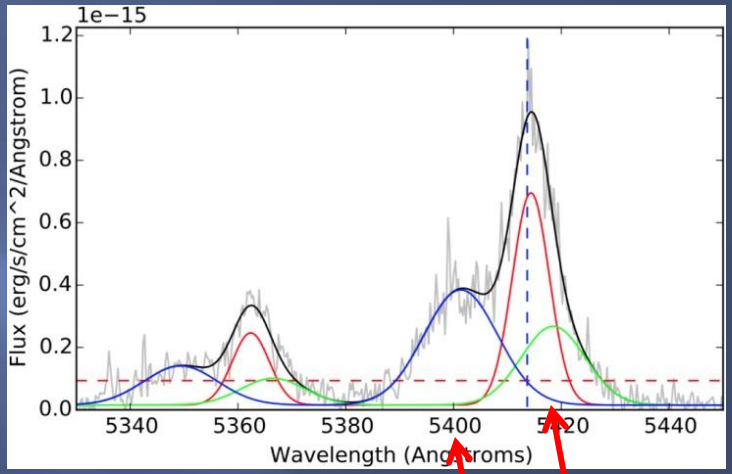
Black hole and galaxy mergers



LISA will observe it “soon”

Outflows: basic spectroscopy





[OIII] λλ4959,5007A

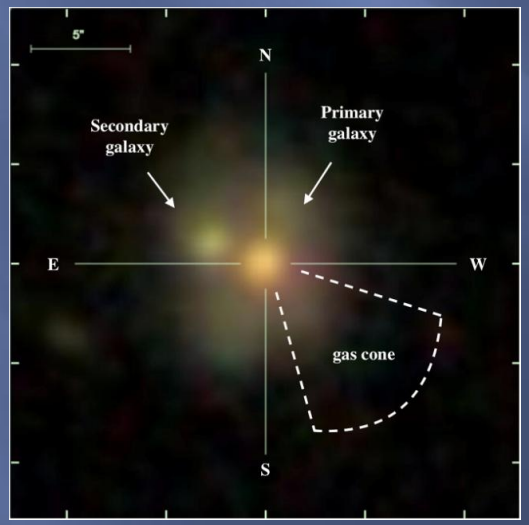
Line core

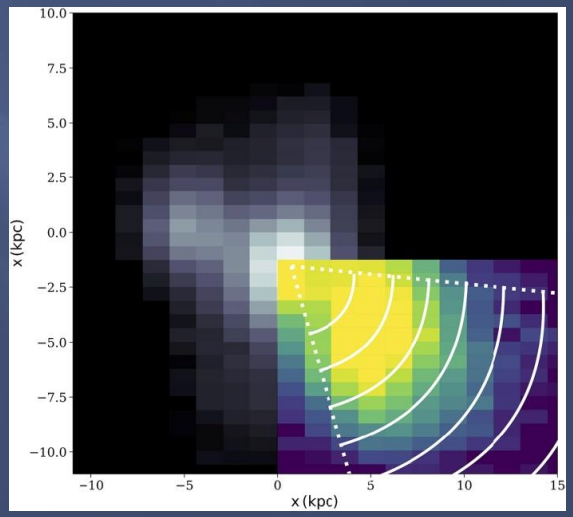
Blue wing

Outflow and Feedback

- Outflows are clearly observed in many AGN hosts at all redshifts
- Outflow can clear up gas from the galaxy thus stop star formation and stellar mass growth

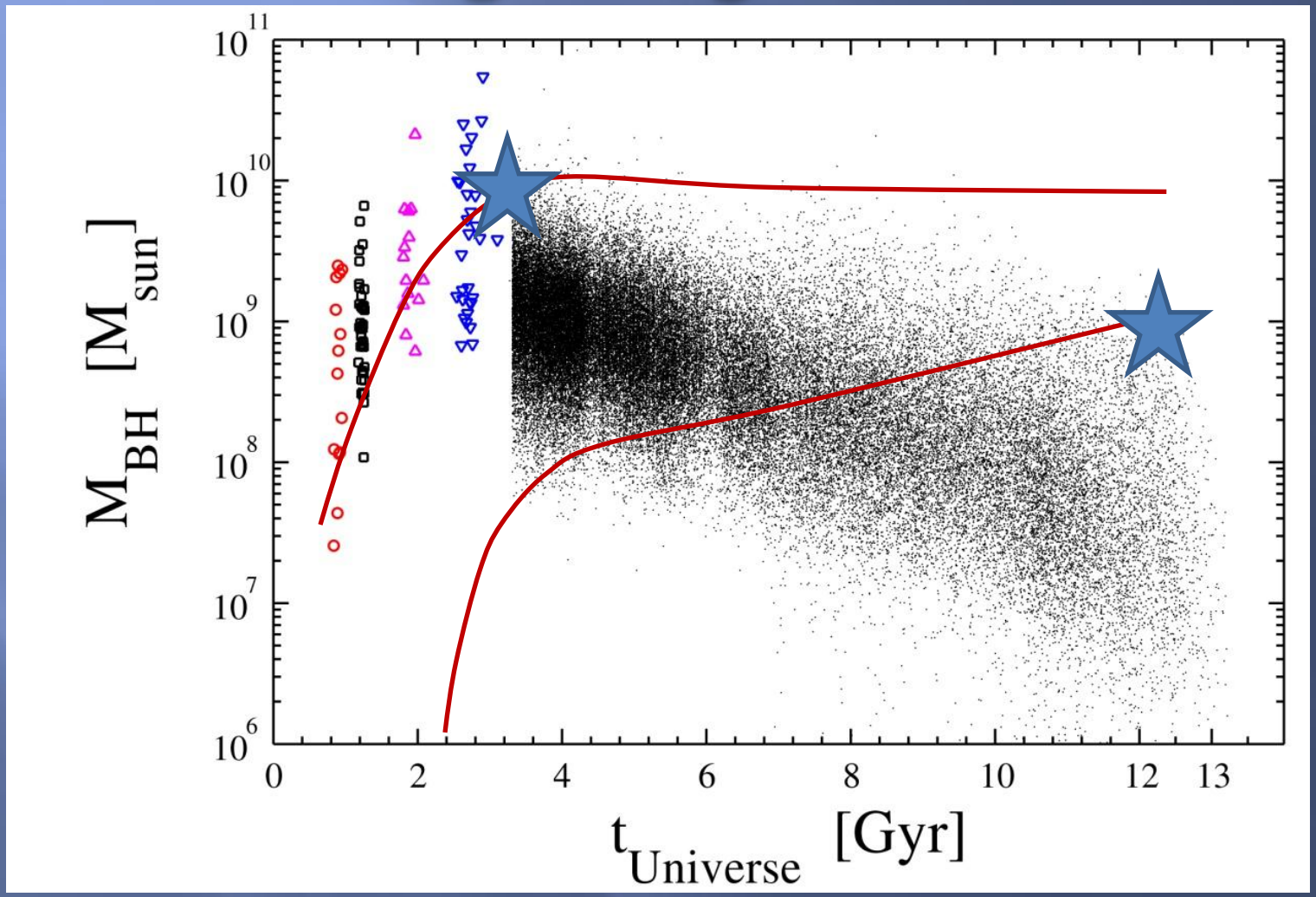
Star Formation Feedback

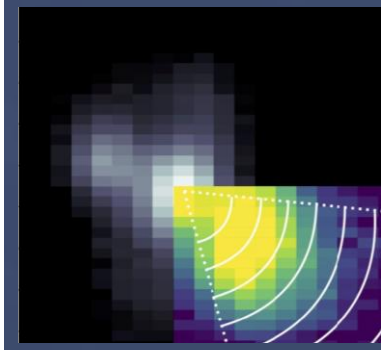




Black Hole Feedback
Baron, Netzer, Prochaska , Davies… 2018

Cosmic evolution of black holes including mergers and feedback





FOLLOWING SUPERMASSIVE BLACK HOLES OVER COSMIC TIME – 2020 VIEW

The power house of black holes

The cosmic evolution of black holes

Black holes in the early universe

Parallel evolution of black holes and their host galaxies

Thank You