# Observational Constraints on The Growth of the First SMBHs


Ezequiel Treister

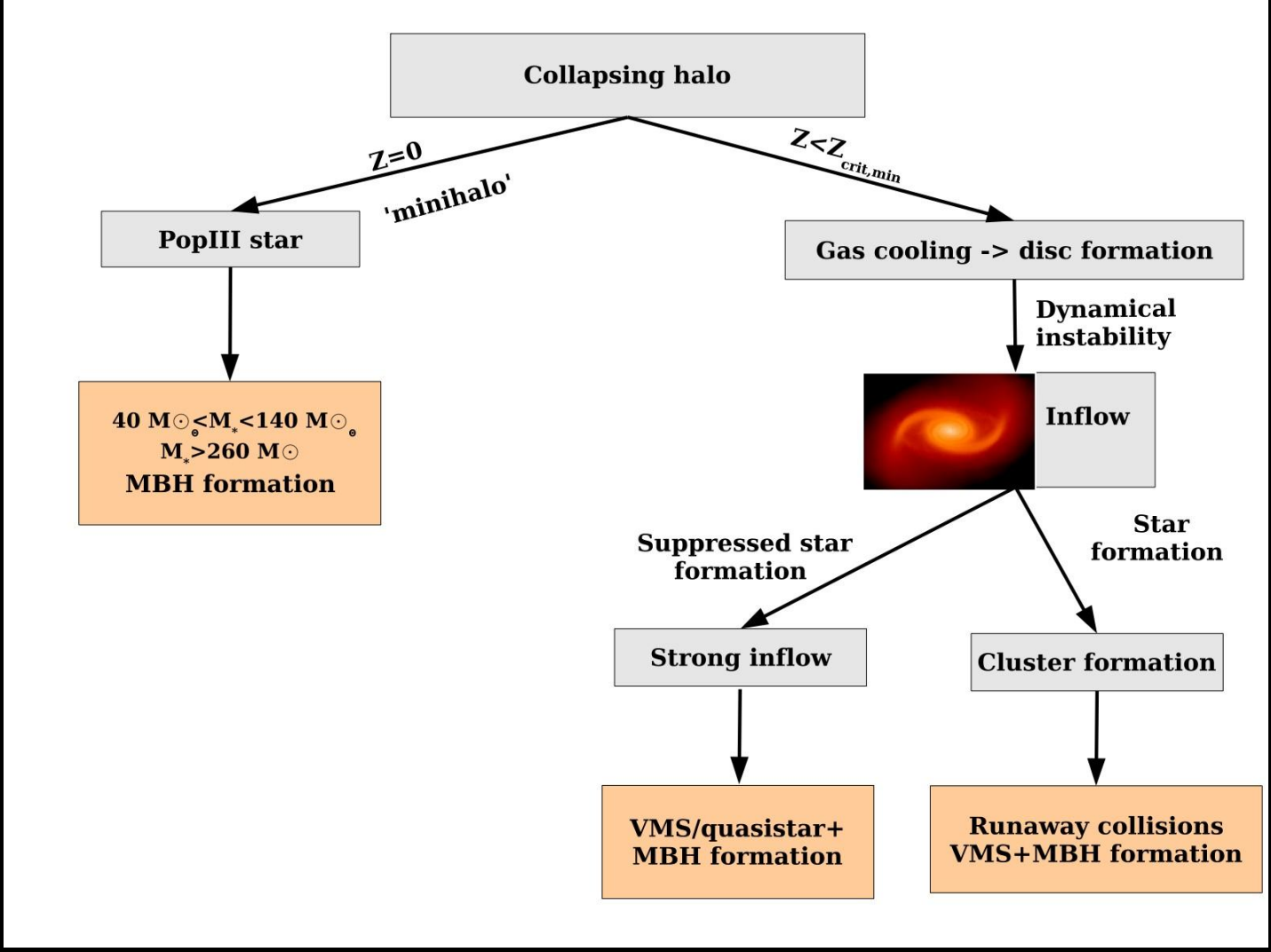
Universidad de Concepción

**Collaborators**: Kevin Schawinski (ETH), Marta Volonteri (IAP), Priya Natarajan and Meg Urry (Yale)

DEPARTAMENTO de ASTRONOMÍA UNIVERSIDAD DE CONCEPCIÓN

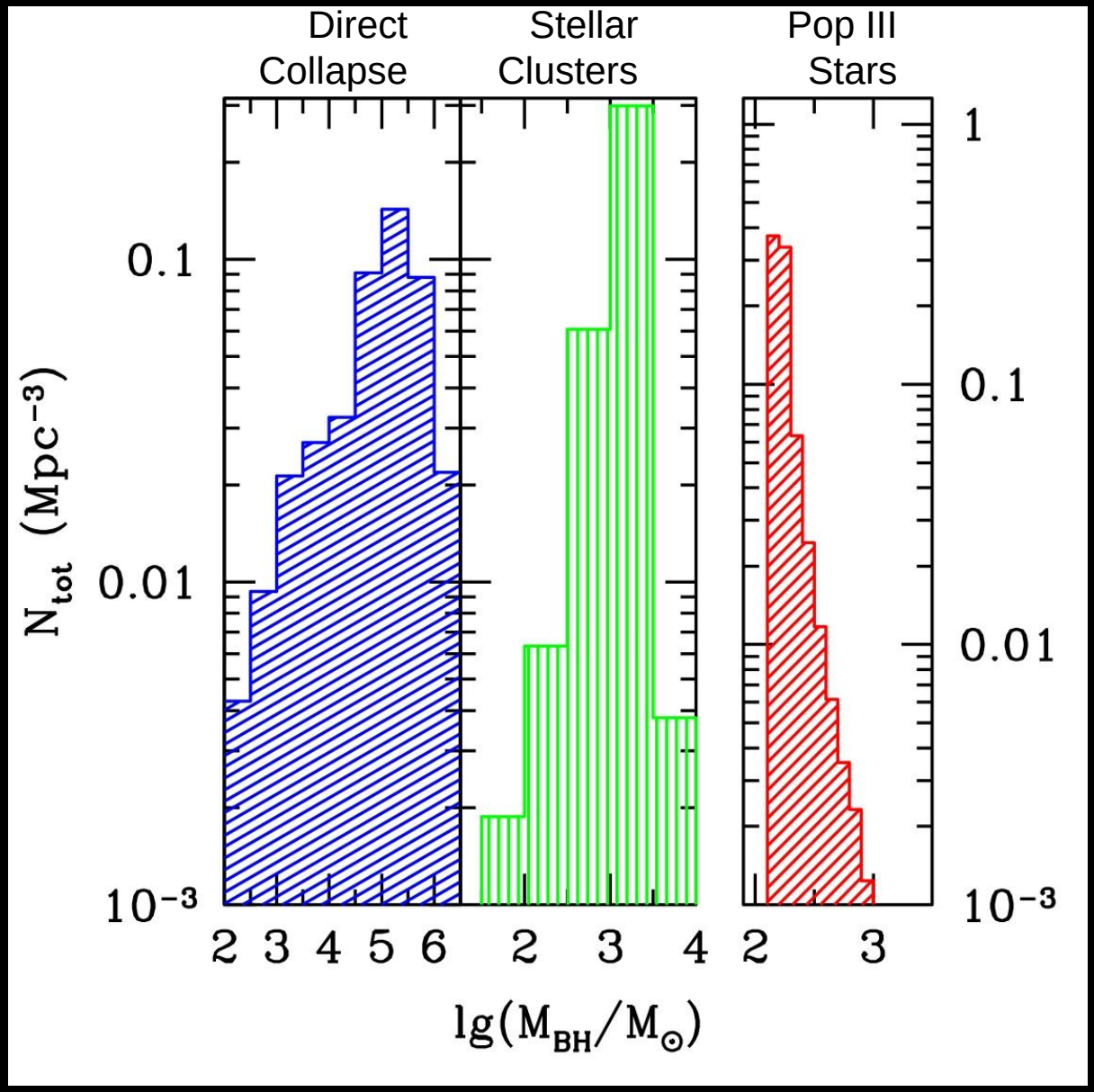
Universidad de Concepción

# How to grow a SMBH?
# The seeds:




Volonteri (2010) and refs. therein

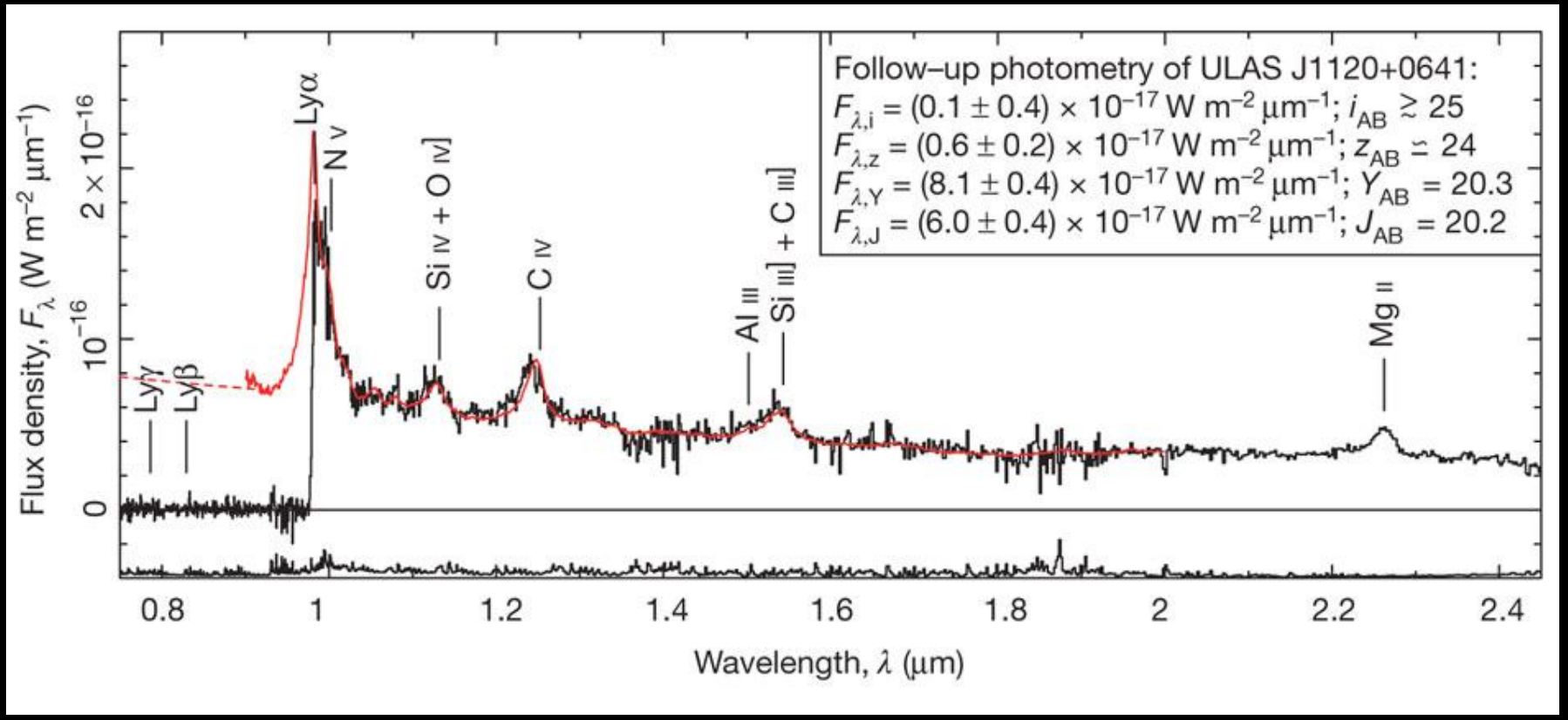
# SMBH Seed Mass Function




Volonteri, Lodato & Natarajan (2008)

# Massive BHs at z~7

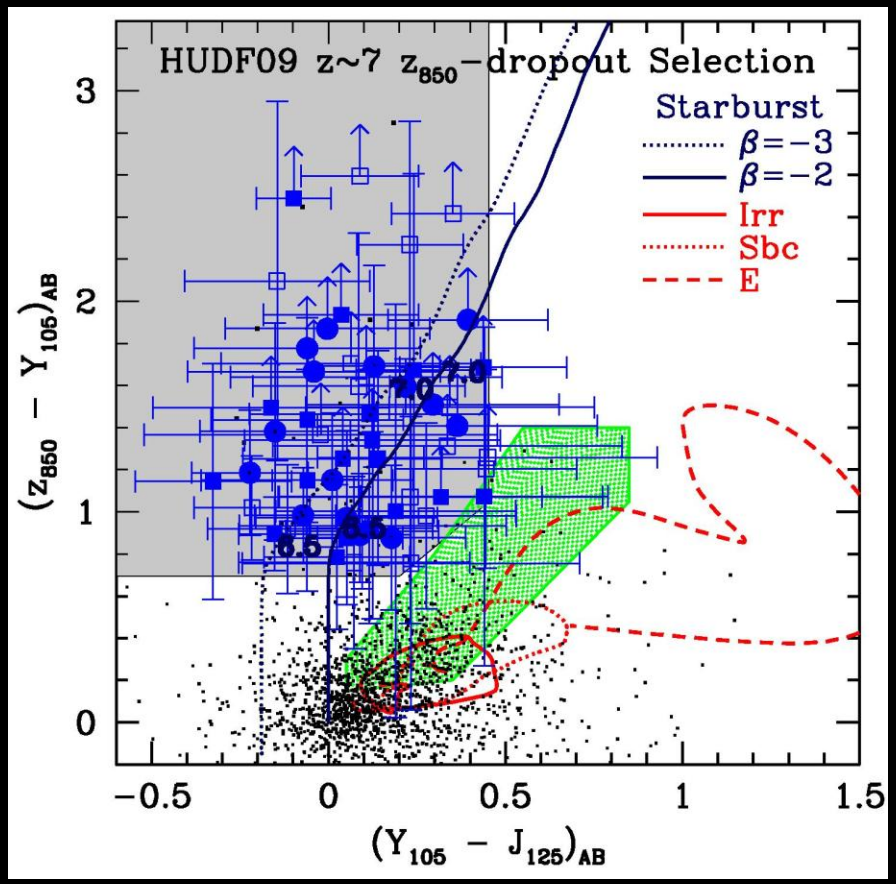
Mortlock et al. 2011




$M_{BH}$~2x10$^9$Msun, only 770 Myrs after Big Bang
Source density extremely low
All BH seed signatures are lost

# Normal SMBH growth at high-z

## Lyman Break Selection at z>6




Undetected in optical bands, but strong optical/near-IR break

Almost completely dust-free

Relatively low stellar mass, ~$10^9$-$10^{10}M_o$, but likely the most massive at these z

Star formation rates ~5-20 $M_o$ $yr^{-1}$, which implies high specific SFR of 2-20 $Gyr^{-1}$

Bouwens et al. 2006, 2011 and many others

# Normal SMBH growth at high-z

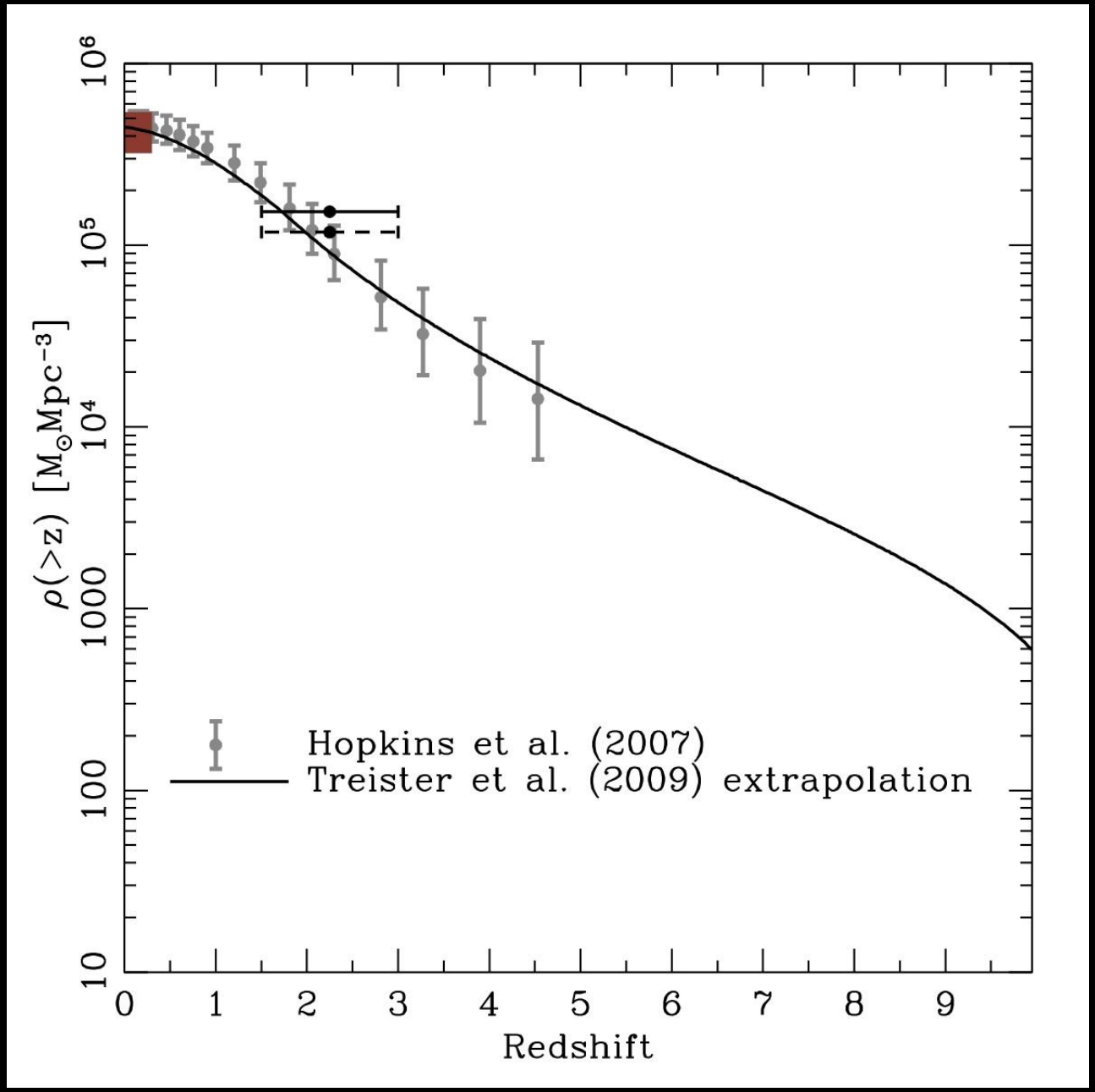
Chandra X-ray stacking of z>6 Lyman Break Galaxies

Treister et al., ApJ sub.

**Galaxy samples**
B06: Bouwens et al. 2006
B11: Bouwens et al. 2011
F12: Finkelstein et al. 2012

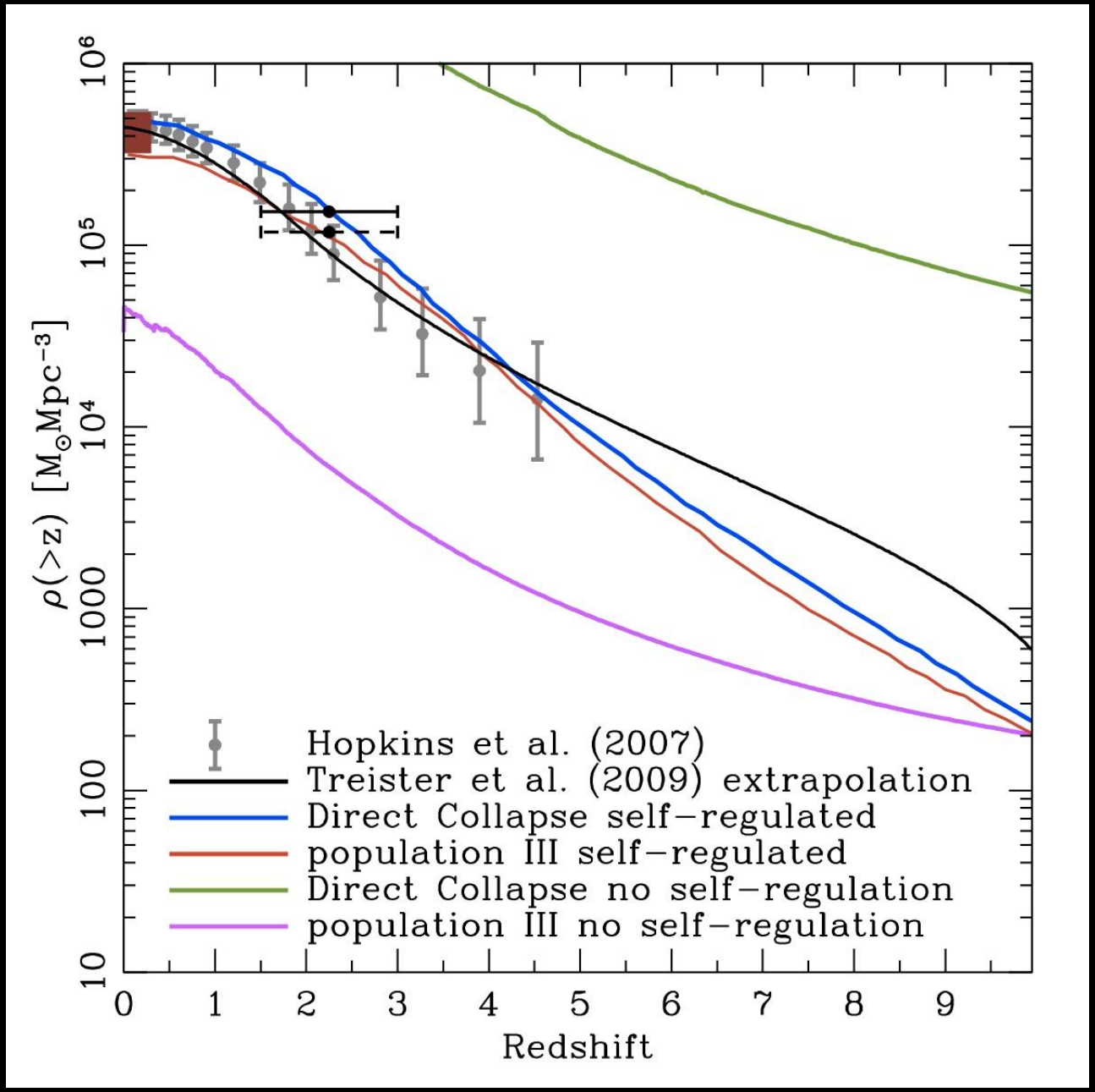
Total of 360 galaxies at z~6, 56 at z~7 and 31 at z~8.

# Accreted BH Mass Density




Treister et al., ApJ sub

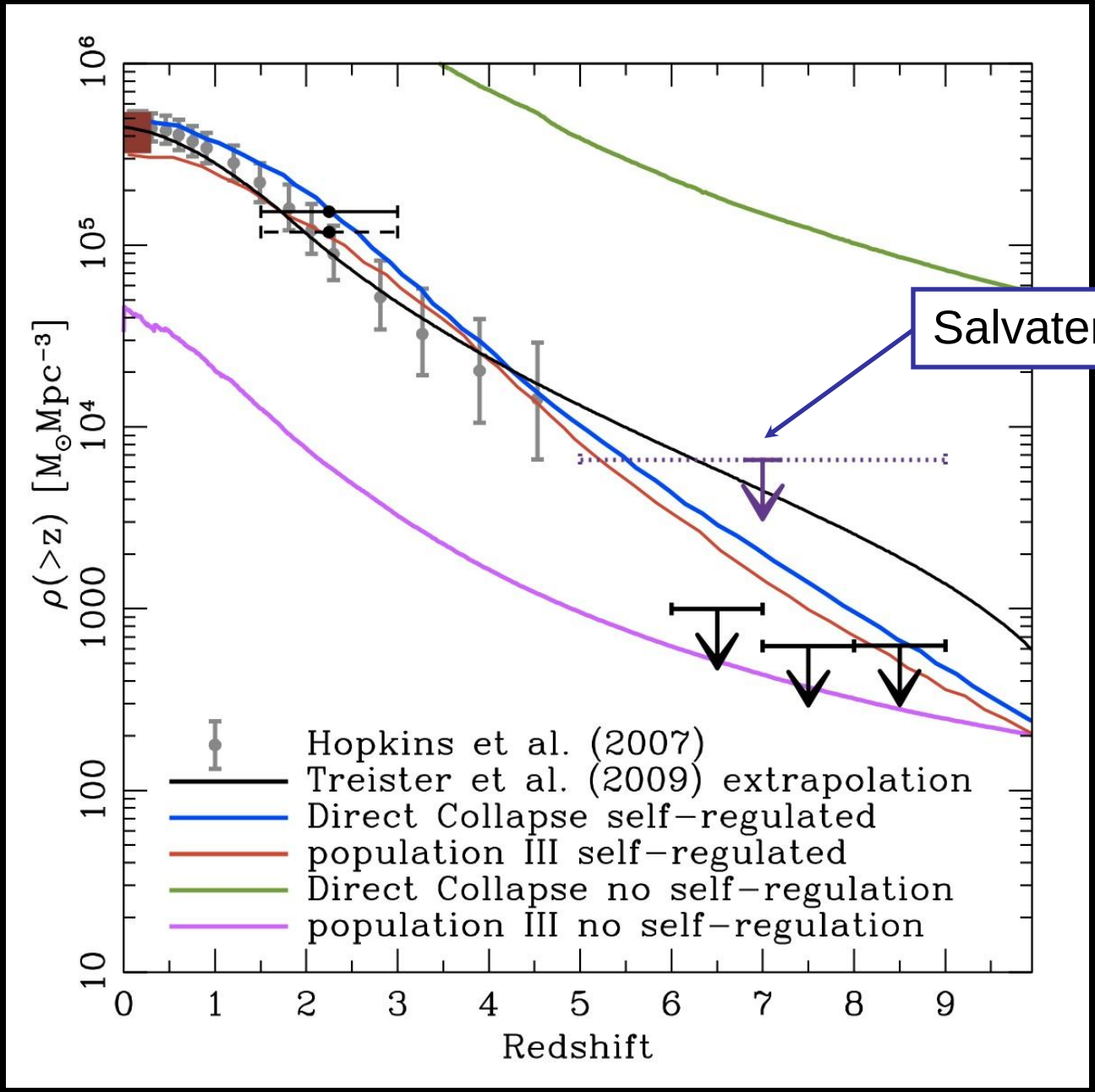
# Accreted BH Mass Density




Models by
**Marta Volonteri**

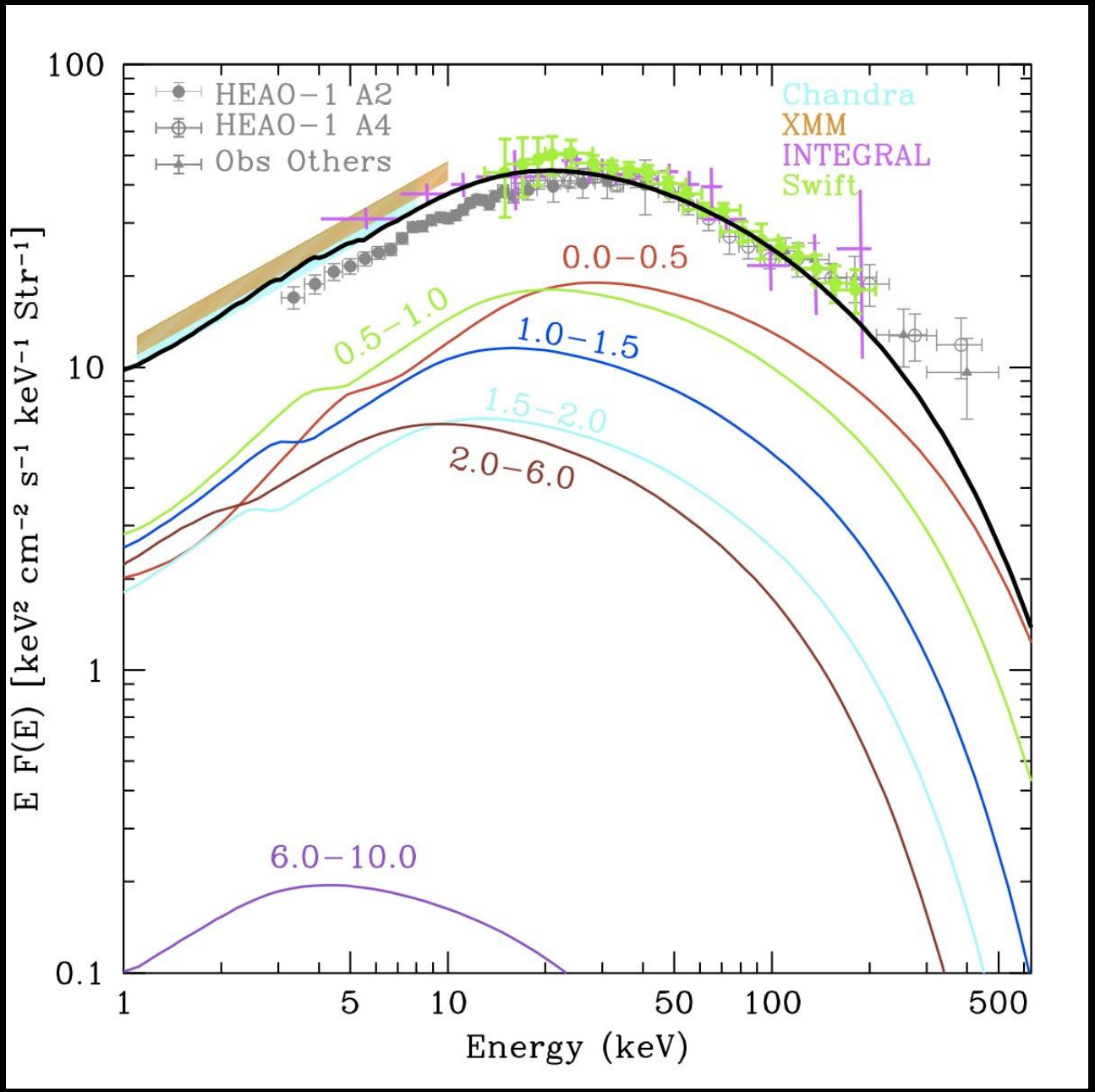
Treister et al., ApJ sub

# Accreted BH Mass Density




Treister et al., ApJ sub

# XRB as a Function of Redshift




Treister & Urry (2005)
Urry & Treister (2007)
Gilli et al. (2007)
Treister et al. (2009)
and others…

# Some Possible Explanations

1.- Fraction of (active) massive black holes in z>6 galaxies is low, <20%, and so galaxy seeding is inefficient.

2.- Most BH growth happens in lower mass and/or dustier, yet undetected, galaxies.

(but we know that LBGs at z>6 have high sSFR and thus are gas rich)

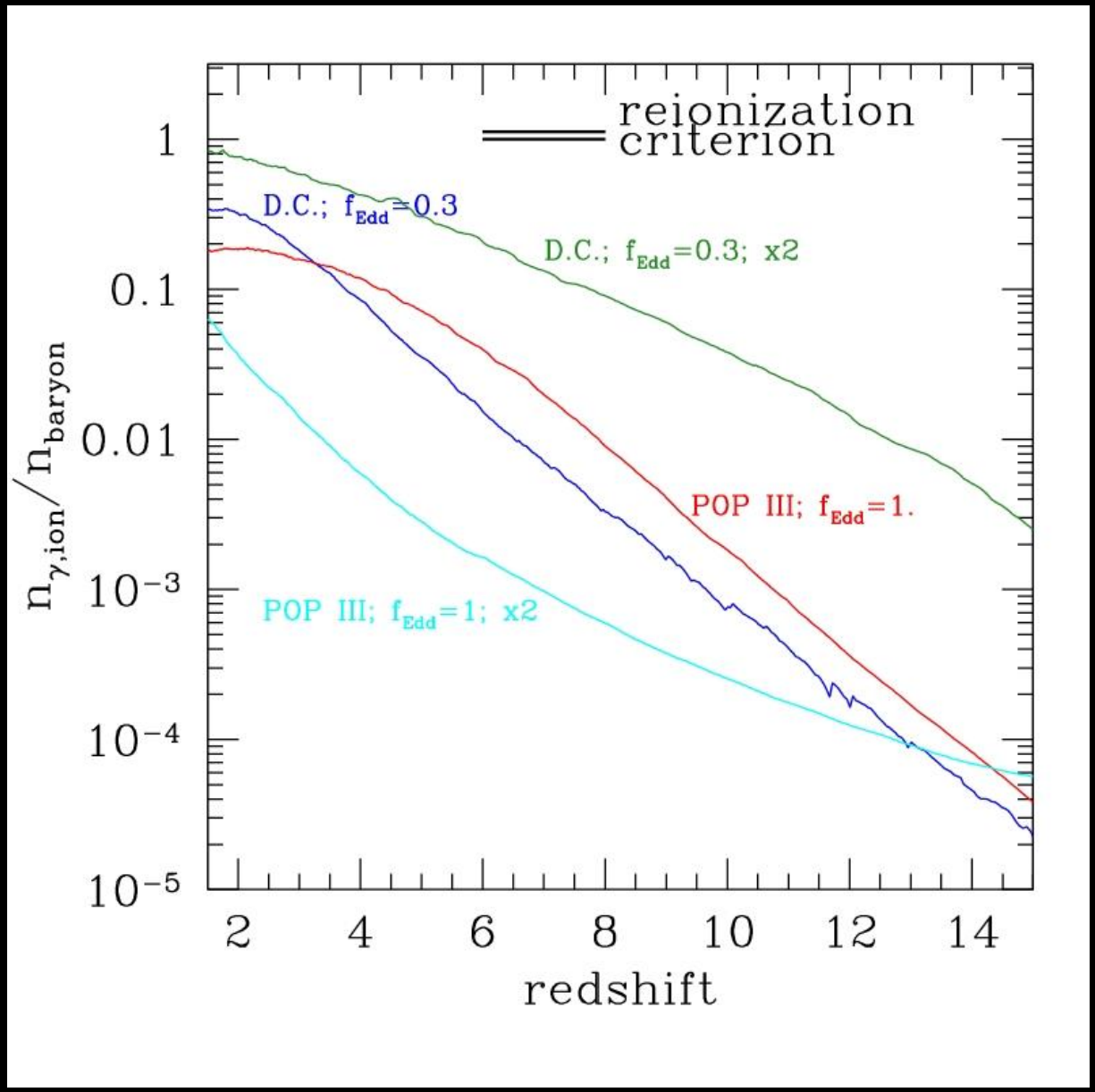
3.- Fraction of low-z interlopers in the LBG samples are z>6 is higher than expected.

4.- Most (all?) growing SMBHs at high-z are heavily obscured.

5.- BHs at high redshifts are growing by radiation-inefficient processes such as mergers and not by accretion.

Treister et al., ApJ sub

# Early Hydrogen Re-ionization

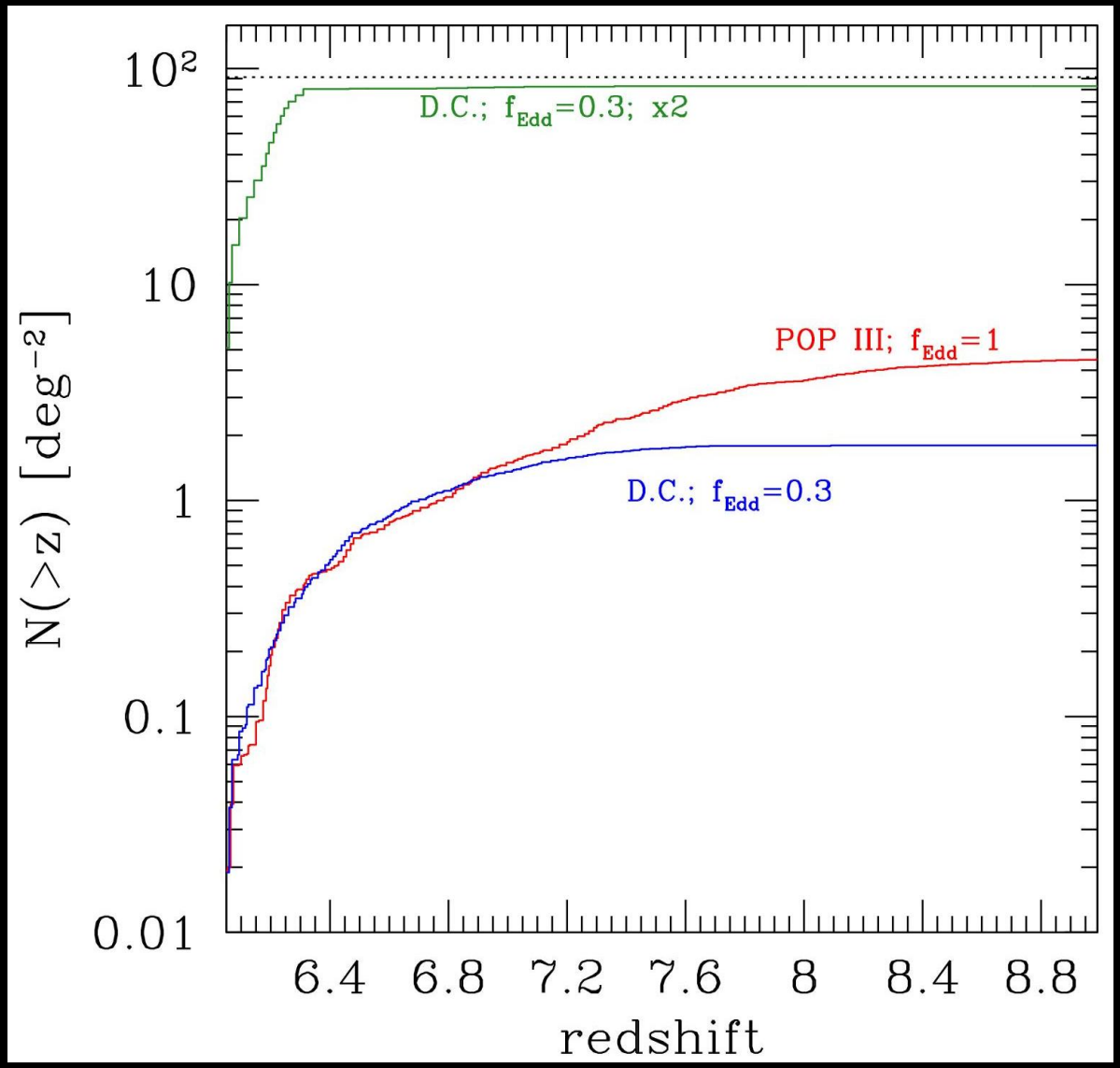



**AGN cannot re-ionize the Universe at z>6**

**Regardless of the reason for X-ray non-detection, this implies not enough UV photons either.**

Treister et al. 2011

# Critical Observational Test




**Finding individual sources will allow to separate BH seed models and test scenarios.**

**Fiducial number: >1 deg$^2$ at 1 Msec for Chandra observations**

Treister et al., 2011

# Summary

Constraining the nature of the first SMBH seeds requires detecting moderate luminosity AGN on galaxies at z>6

X-ray stacking on the CDF-S 4 Msec field of 400+ Lyman-break galaxies at z>6 yields a non-detection.

This poses interesting problems for models of early black Hole growth. However, several ways out exist.

Growing SMBHs do not contribute much to hydrogen re-ionization in the early Universe.

Only a wide AND deep X-ray survey can find the first “normal” SMBHs at high-z, and hence understand the black hole seed formation.