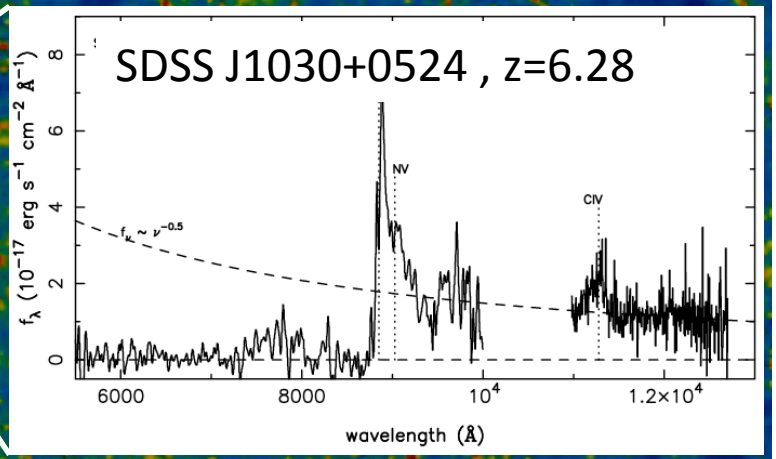
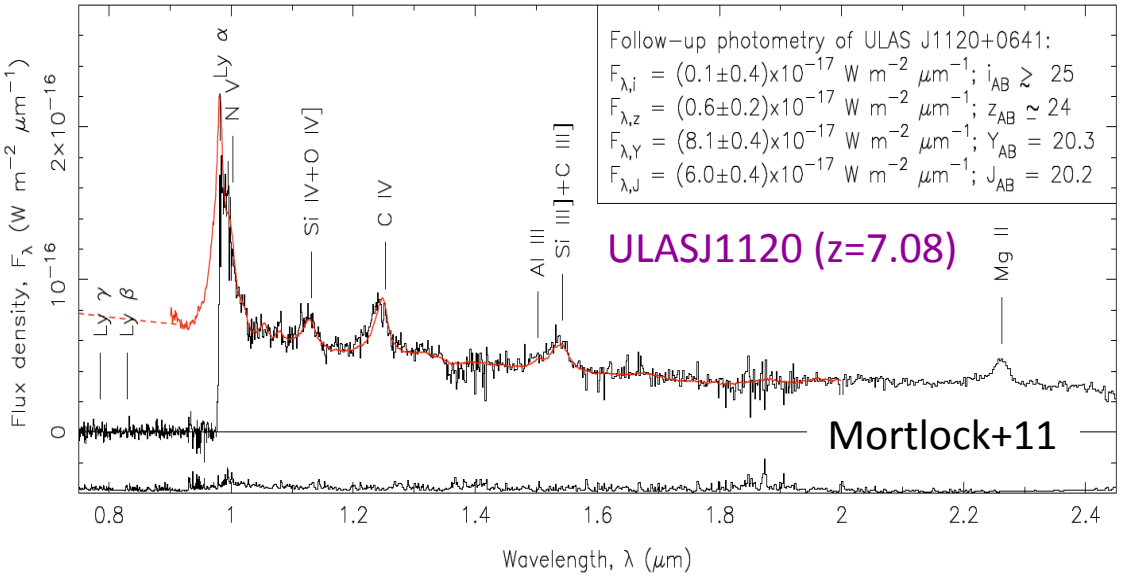
How, when and where did the first SMBHs form?



Roberto Gilli
(INAF – Oss. Astronomico di Bologna)

The persistent challenge of luminous z>6 QSOs

SMBHs grown to 10^9 M_{sun} in less than 1 Gyr



as of May 2016, ~100 QSOs known at z>5.7 (~10 at z>6.5), all from wide-area optical/NIR surveys (SDSS, PanSTARRS, CFHQS, UKIDSS, VISTA)

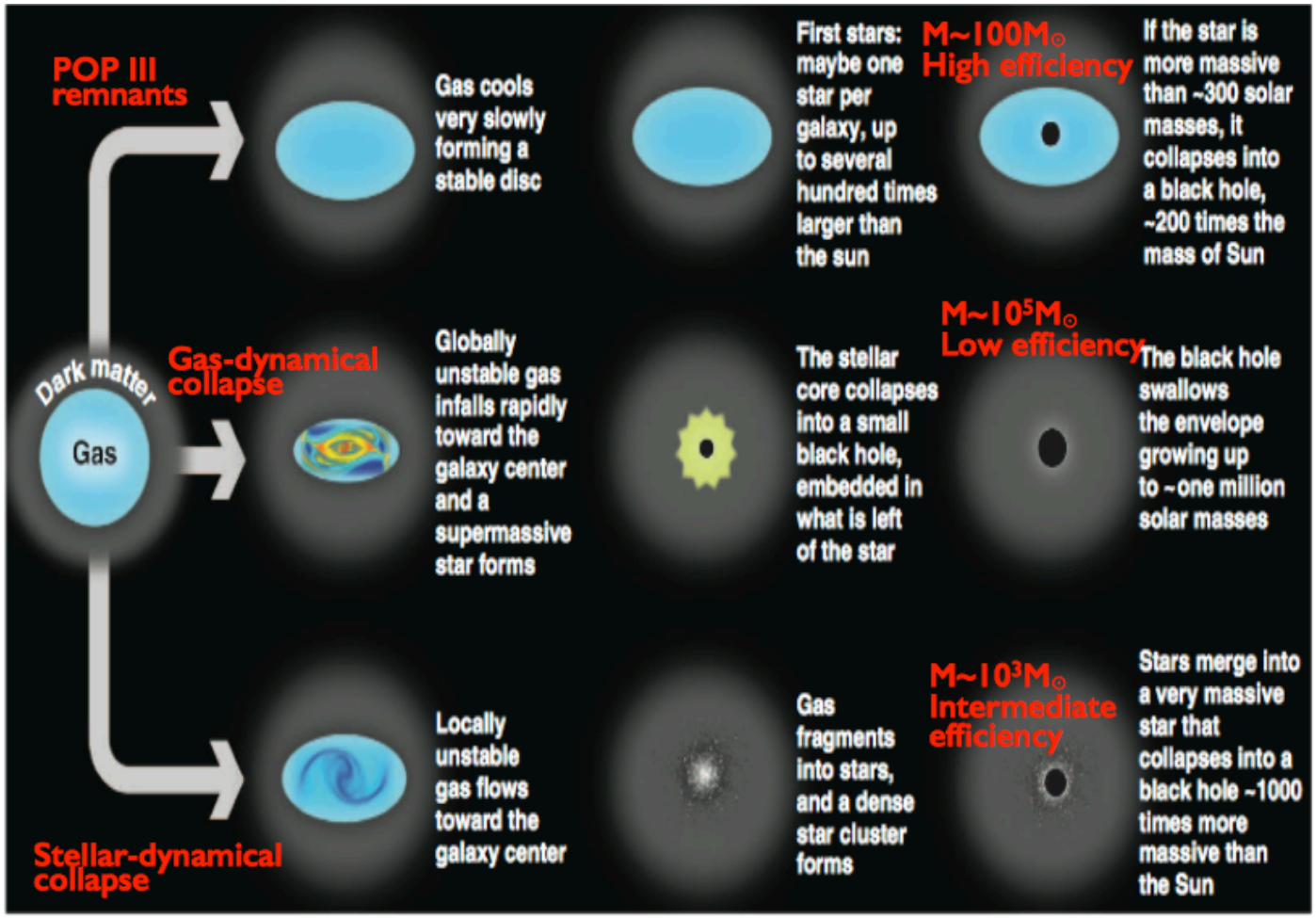
$L_{bol}>10^{13}$ L_{sun}

M_{BH} ~ $10^{8\text{-}10}$ M_{sun}

dN/dV ~ 1/Gpc^3

all broad line, unobscured QSOs

No understanding of BH seeds: theory predicts 10^2-10^6 M_{sun}



from Volonteri10

light, 10^2 M_{sun}
Madau&Rees01
Volonteri+03

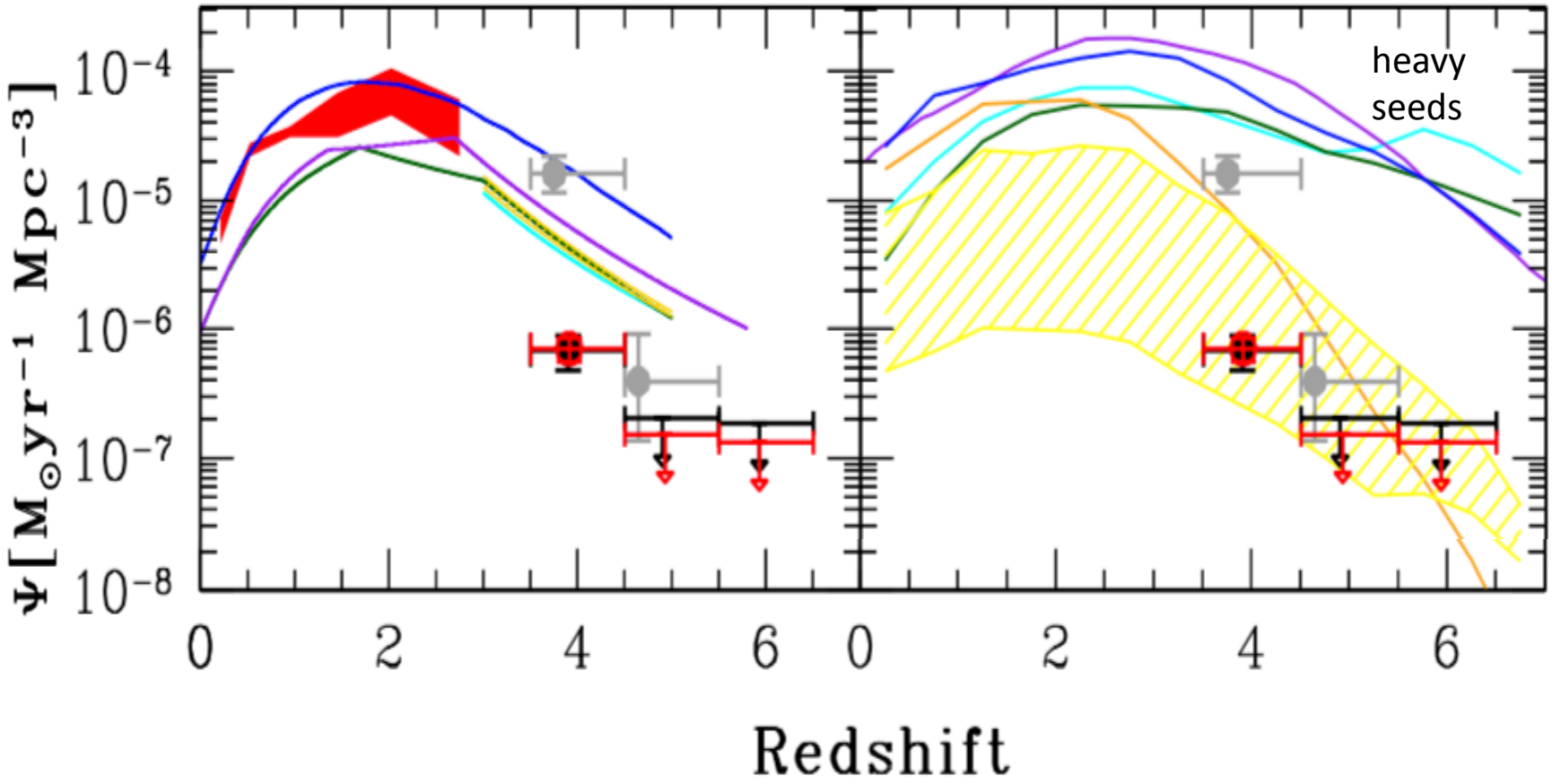
heavy, 10^4-10^6 M_{sun}
DCBHs
Volonteri+08
Agarwal+13
Yue+13

intermediate, 10^3 M_{sun}
Devecchi&Volonteri09

All these individual models have problems:
BH seeding may (probably must) be a mixture of them

Results form the deepest X-ray field: 7Ms CDFS

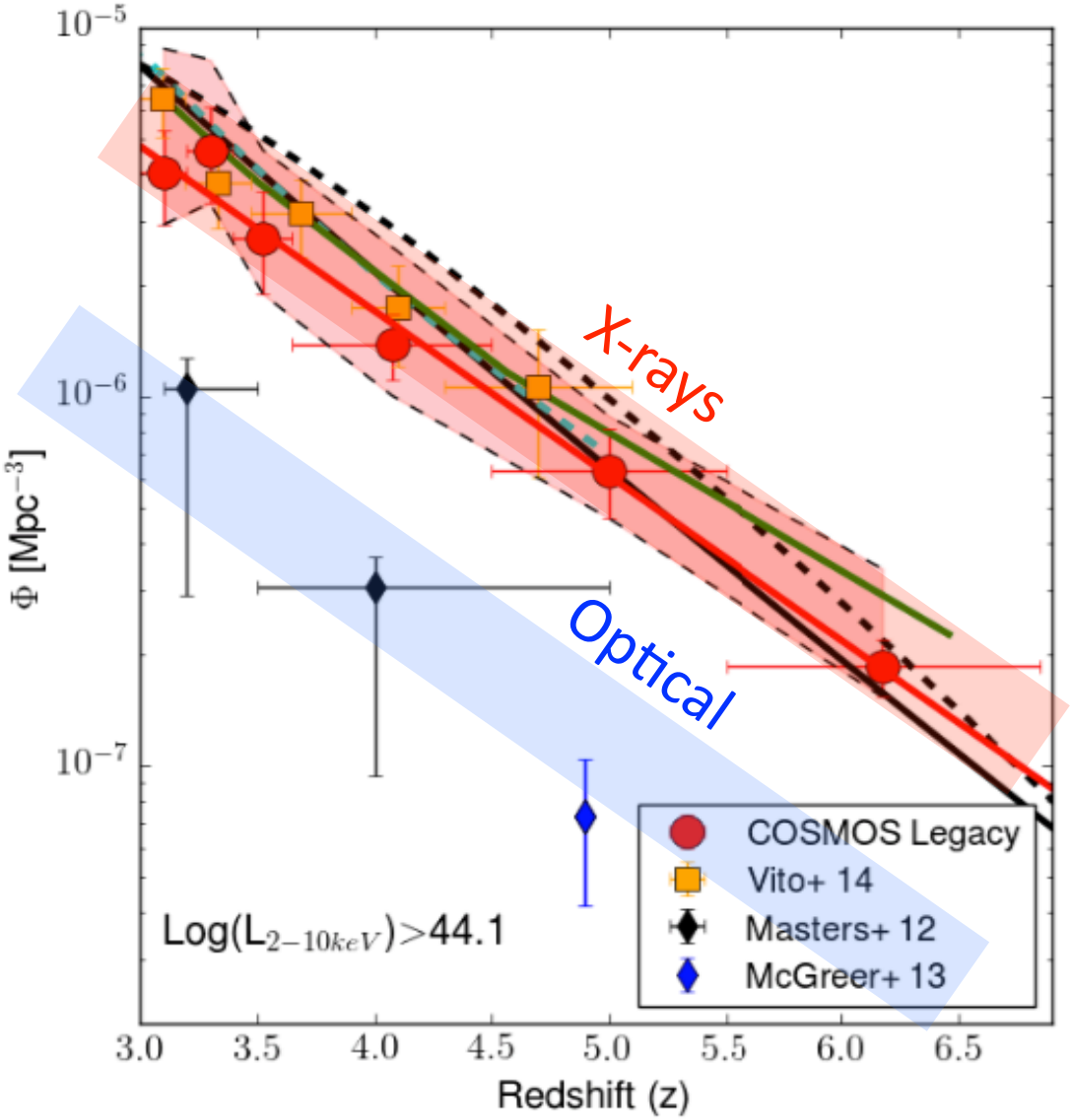
X-ray stacking of CANDELS galaxies



Vito+16

some DCBH models already ruled out

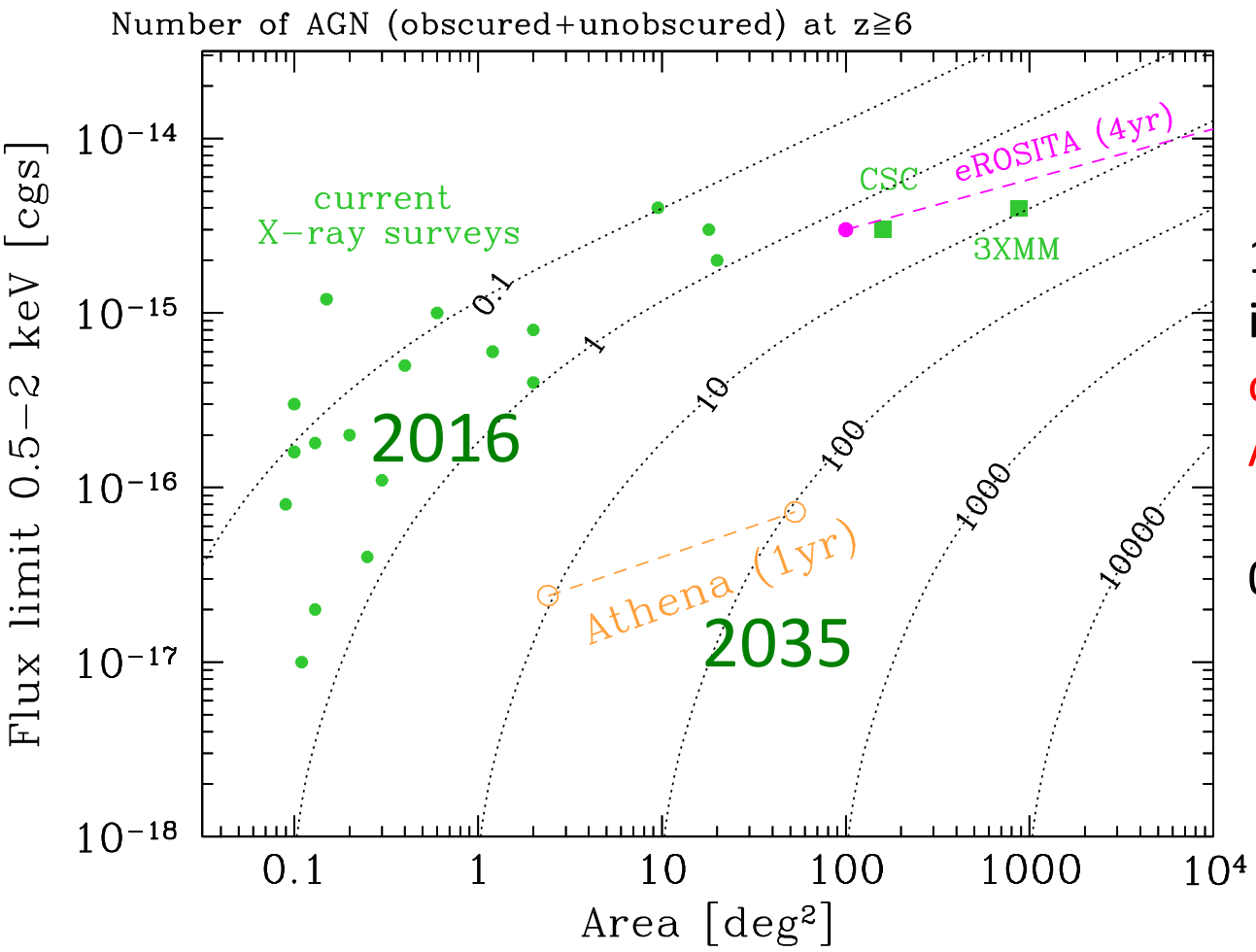
High-z AGN space density



X-ray surveys trace the bulk (80-90%) of active SMBHs

2deg^2 Chandra COSMOS-Legacy; Marchesi+16

The future of X-ray surveys (Athena) is bright but far away



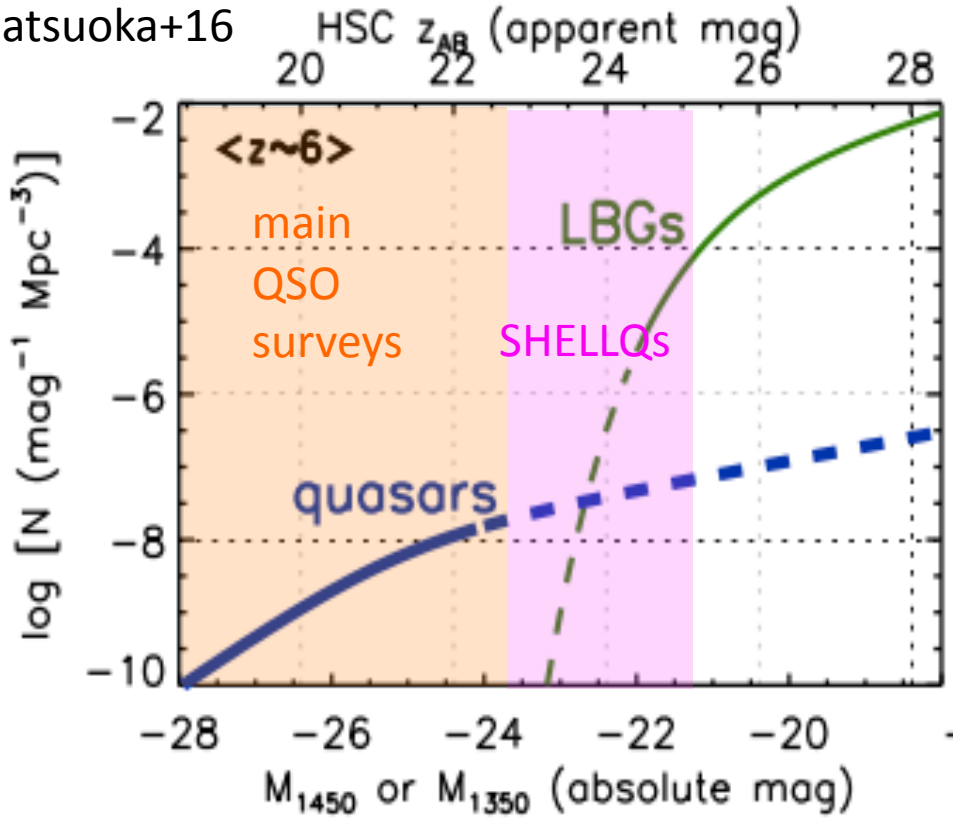
100-400 z>6 X-ray AGN in Athena surveys: obscured/unobscured AGN XLF and clustering

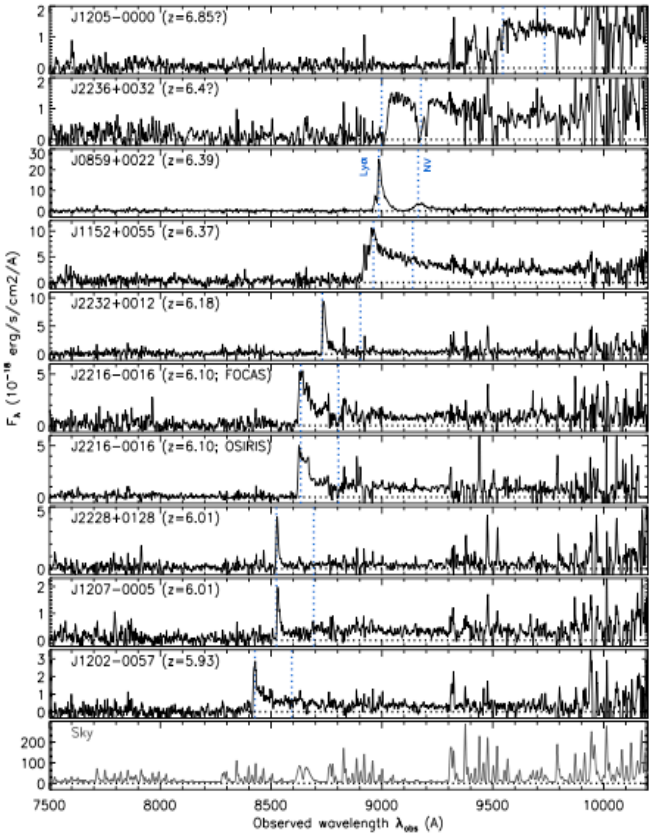
0 known at the moment

#1 – Need to fill the 20yrs temporal gap and prepare for Athena

Discovery space of wide-and-deep optical surveys: HSC - SHELLQs

Matsuoka+16

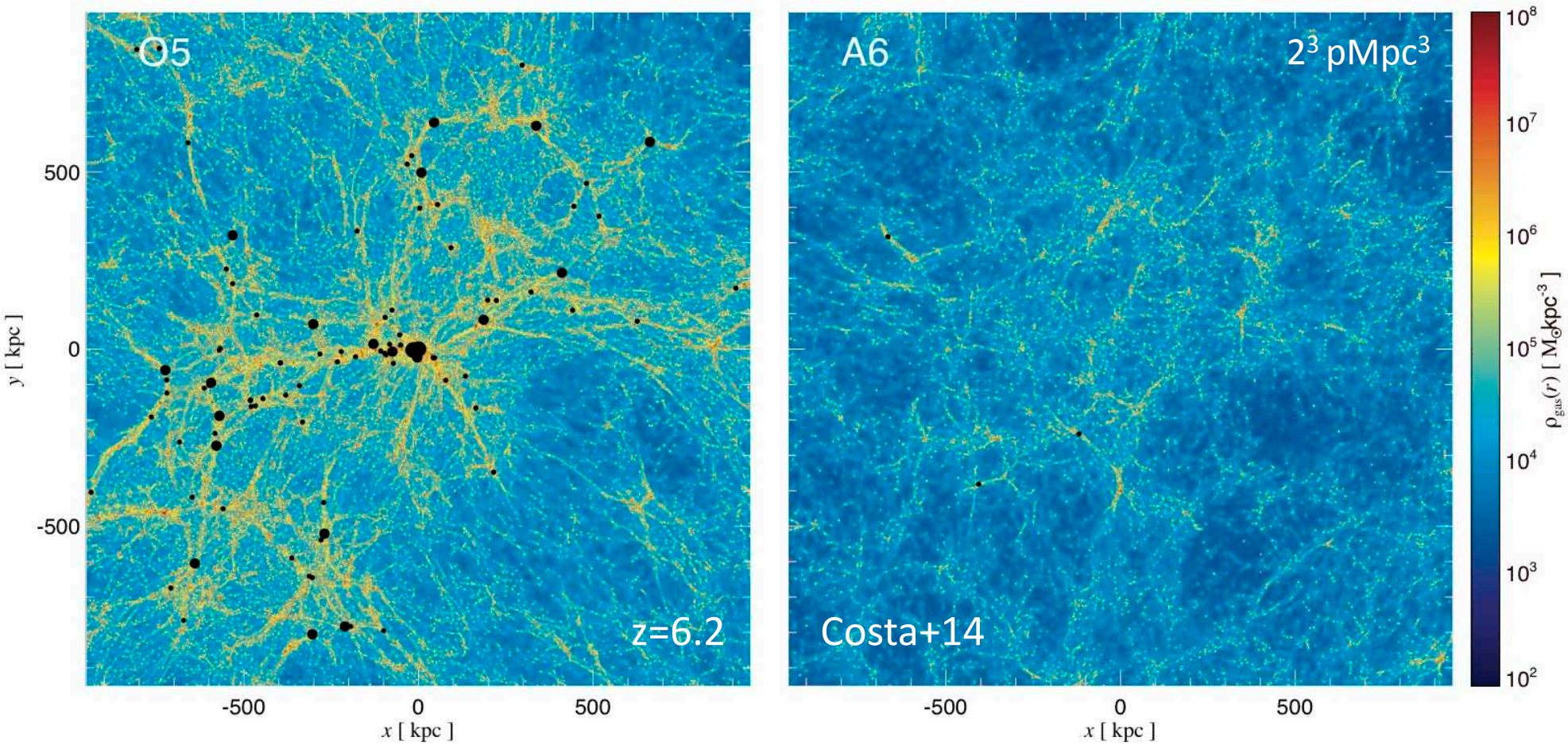




15 new QSOs & LBGs in 80 deg^2 ➔ 250-300 in the final 1400 deg^2 : faint end of QSO LF

LBC etendue = 1/5 x HSC ➔ LBT slower but probably second best
Dedicated survey effort? (discovery rate ~ 1 faint z=6 QSO every 10 nights)

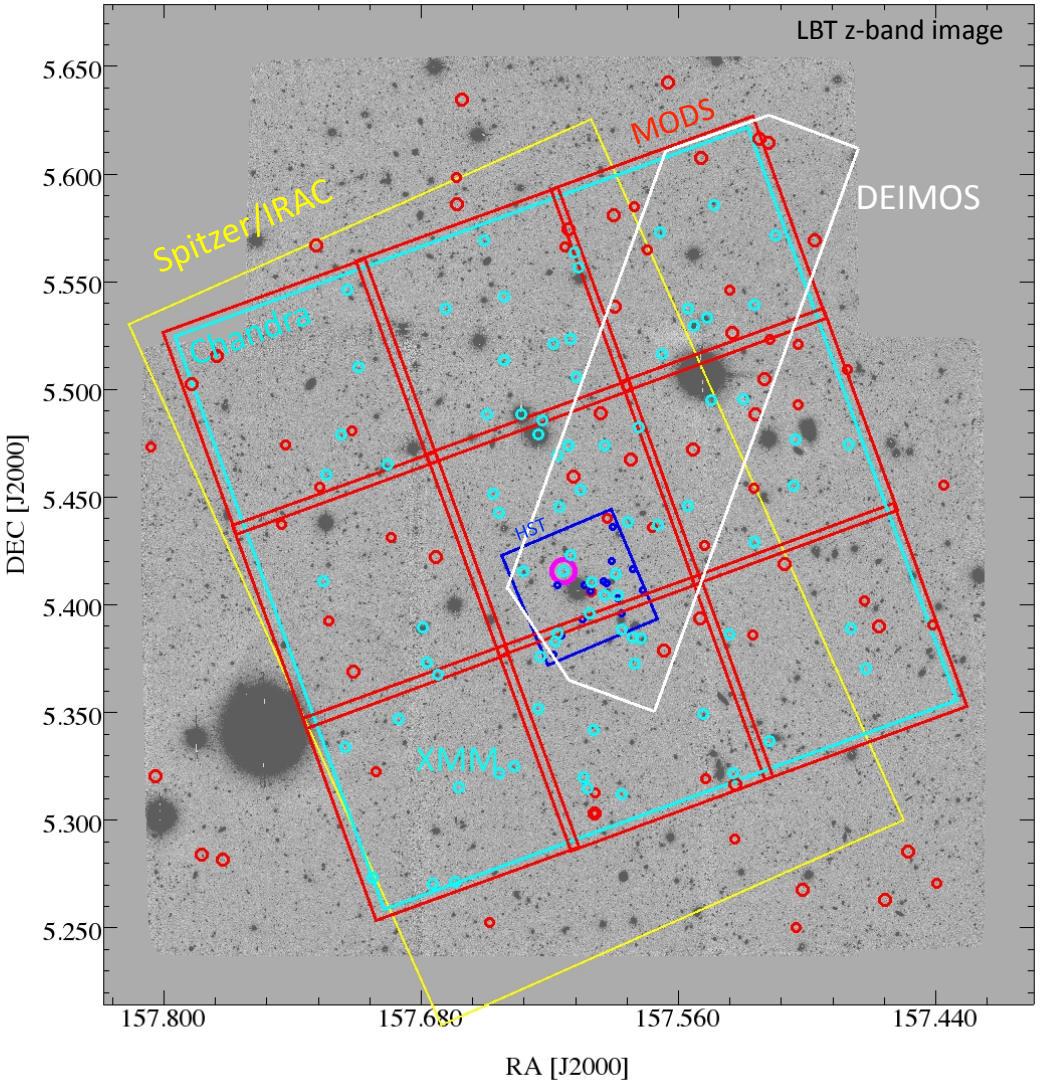
LSSs around early SMBHs



(Most) simulations show that early SMBHs only form in overdense environments - indirectly supported by their abundance and mass

Observational searches for LBG overdensities inconclusive so far

LBT + deep multi-λ survey in the SDSS J1030 field



Entire field covered by

LBC

riz (Morselli+14)

*

MUSYC

UBVRIzJHK (Gawiser+06)

*

WIRCAM

YJ (Balmaverde+ in prep.)

*

Subaru

rizNB$_{CIV}$ (Diaz+14,15)

*

500ks Chandra in Jan 2017

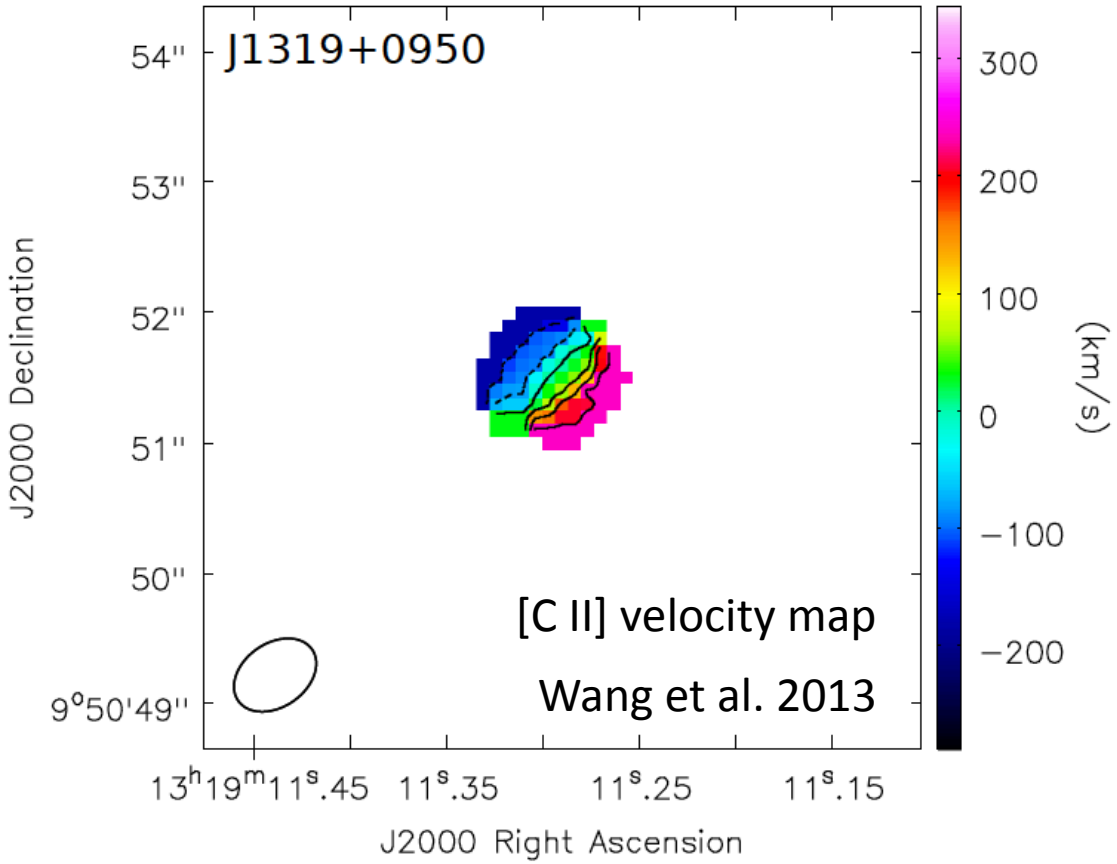
QSO is being pointed by

MUSE + ALMA

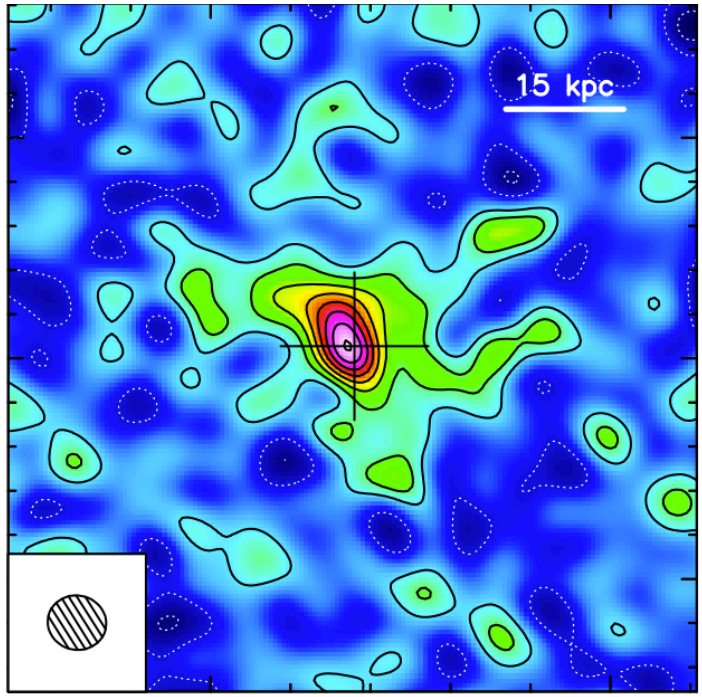
#2 - Need to exploit unique LBT features

The submm breakthrough with ALMA

measure of mass (dynamical, gas, dust),
kinematics, morphology of z>6 QSO hosts
~40-50 such measurements by 2017-2018



BH feedback at high-z



gas outflows in SDSSJ1148 at z=6.42
(Cicone+15) with PbBI → NOEMA

#3 – need to enter into the discovery space opened by ALMA

Summary and mid-term (<5-10 yr) programmatics

X-rays surveys : Make plans for the 20 yrs before Athena surveys:

1) intensive exploitation of Chandra/XMM through large programs (XMM workshop last May, Chandra is Aug 16)
2) join proposals for mid-term survey missions (e.g. NASA MIDEX)

Wide-and-deep optical surveys: exploit LBT; exploit VST/KIDS; join LSST?

Submm follow-up: reinforce ARC and enlarge submm community, even through participation to facilities other than ALMA

Current INAF Vision document does not really provide priorities: do this in the revised version, based on FTEs per project

Exercise for MA1 (and not only): think how to distribute our working time in the next few years and look at the total FTE distribution