The optical follow-up of an XMM-Newton large area survey

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Many thanks to:
E. Giallongo, R. Ragazzoni, F. Pedichini, M. Brusa, A. Comastri, N. Menci.

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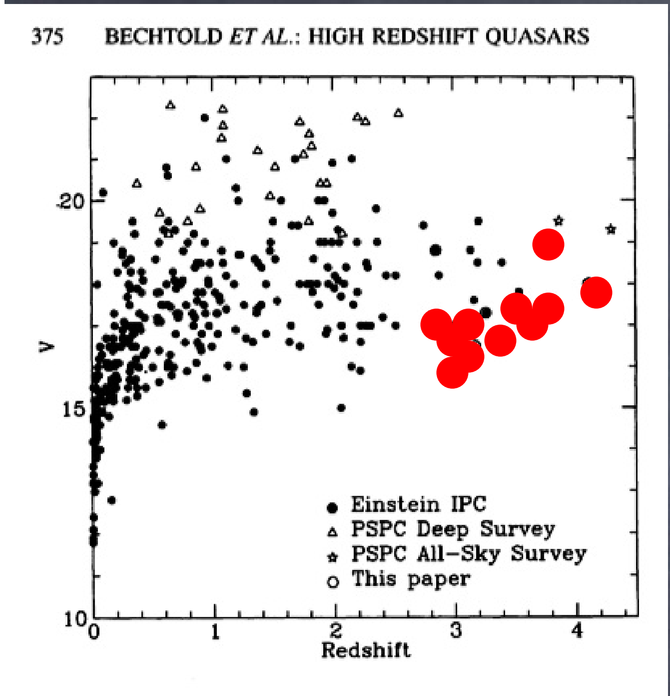
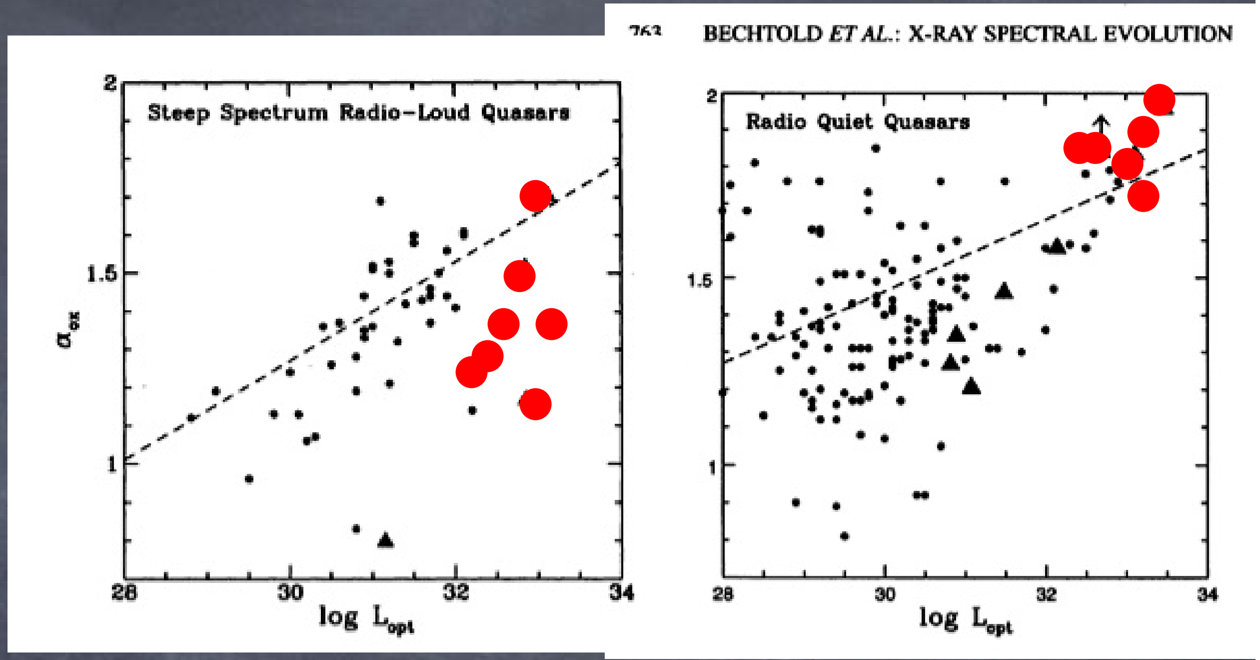
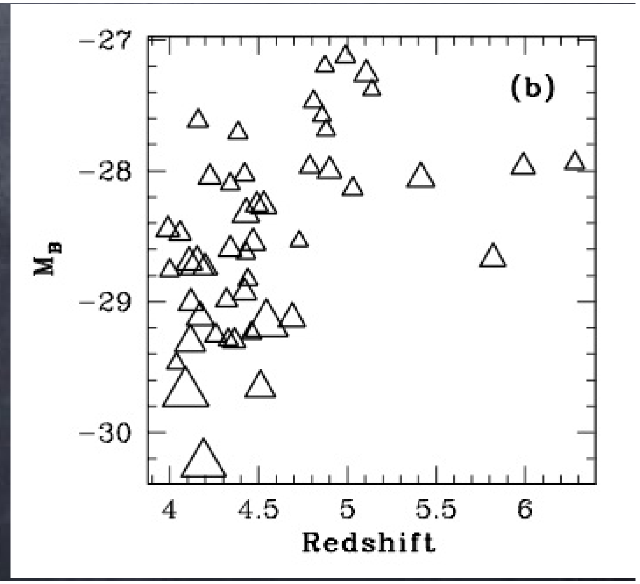
X-rays from High-z QSO







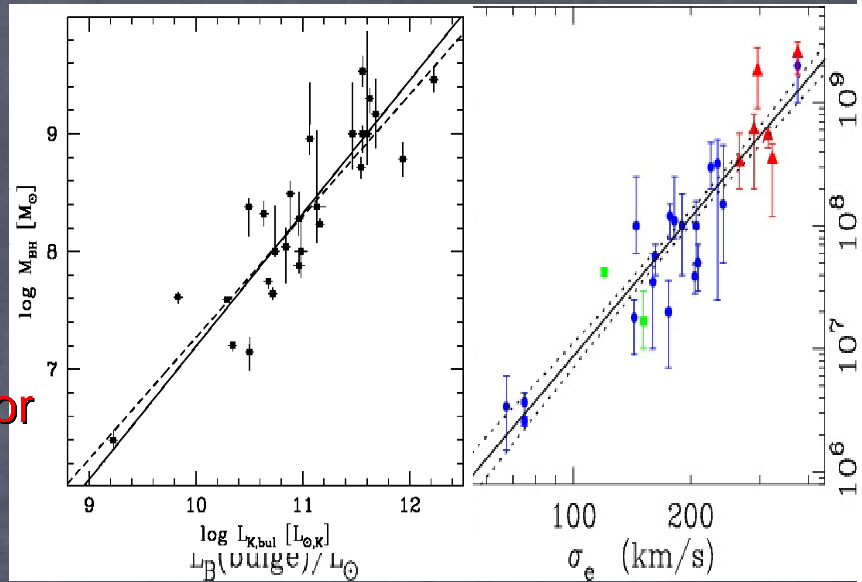
From the pioneering work of M. Elvis, J. Bechtold, B. Wilkes, FF et al. with ROSAT (1994, record z=4)
To Chandra/XMM observations of SDSS QSOs (Vignali, Brandt, Bechtold, Mathur et al. 2002-2005, record z=6.4)

Why high-z AGNs are interesting?

- ***SDSS QSO z>6 => M_{BH}~3-7×$10^{9}M_{Sun}$***

- $\log M_{BH}=(8.2\pm0.1)+(1.1\pm0.1)(\log LK,bul-10.9)$
- $\log M_{BH}=(8.3\pm0.07)+(4.1\pm0.3)(\log\sigma-2.3)$
- M_{BH}~$0.001\times M_{Bulge}$

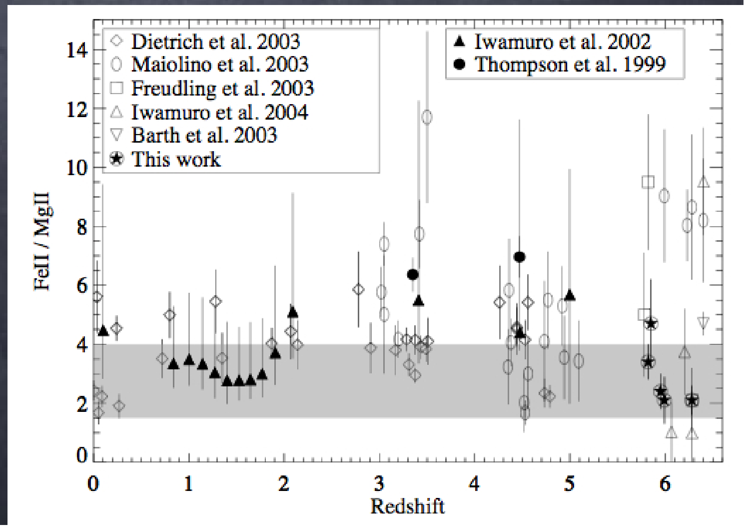
- Either M~$10^{12}M_{Sun}$ bulges are in place at z>6 or the M_{BH}-Bulges-properties relationships must break down at high-z



- Forming (enough) $10^{9-10}M_{Sun}$ BHs and (possibly) $10^{12}M_{Sun}$ Bulges at z>6 can be a challenge for models of structure formation. As well as forming metals and dust.

- But..: downsizing: massive structure grow faster

- Strong constraints on *cosmological models* and *fundamental physics.*



QSOs and fundamental physics

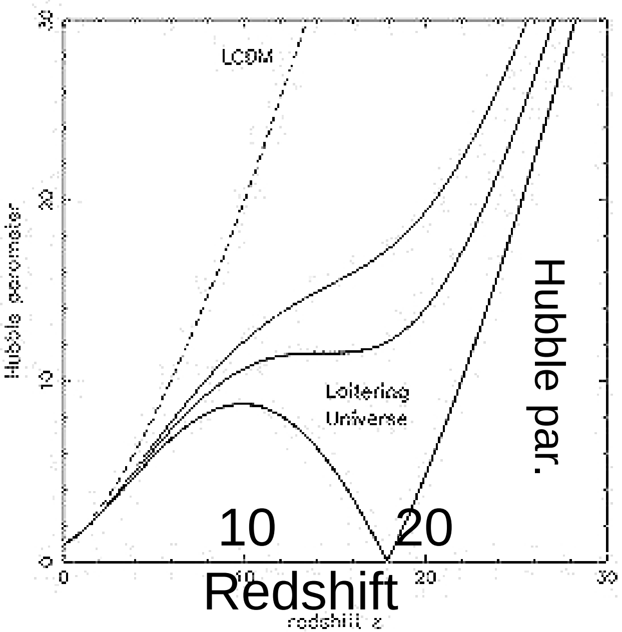
- Z=6 corresponds to ~0.9Gyr in a standard ΔCDM cosmology.
- Is this enough time to form BH-bulges-metals?

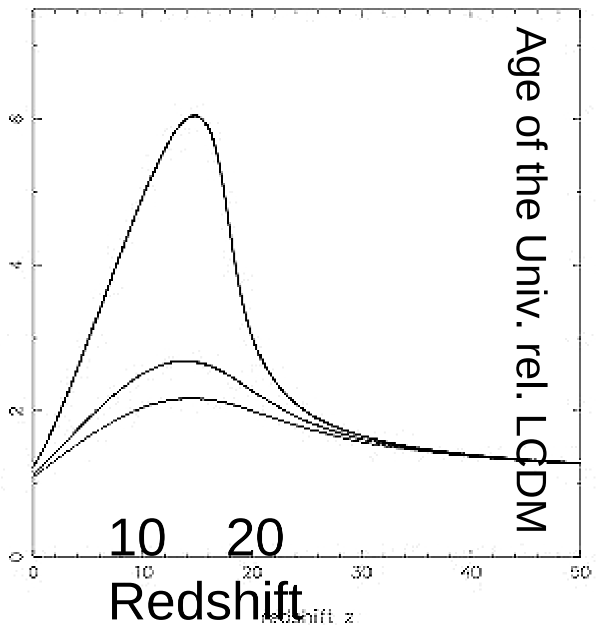
$$t(z) = \int_{z}^{\infty} \frac{dz'}{(1+z')H(z')}$$

$$t(z) \cong \frac{2}{3} H_0 \sqrt{\Omega_m} (1+z)^{-3/2} = 5.38 \times 10^8 (1+\frac{z}{10})^{-3/2} yr \text{ for } \Omega_m = 0.3, h = 0.7$$

Brainworlds models: our observable Universe is a (3+1)-brane in a (4+1)-dimensional bulk space

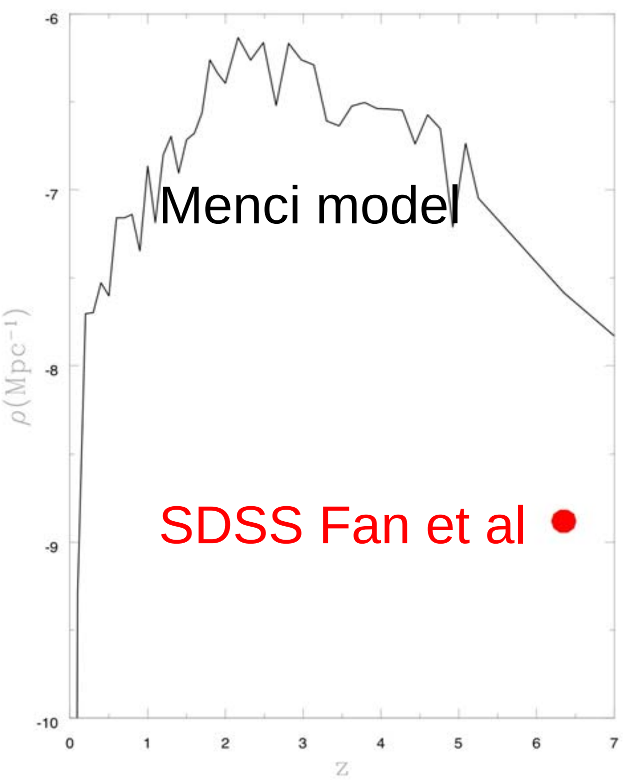
Sahni 2005

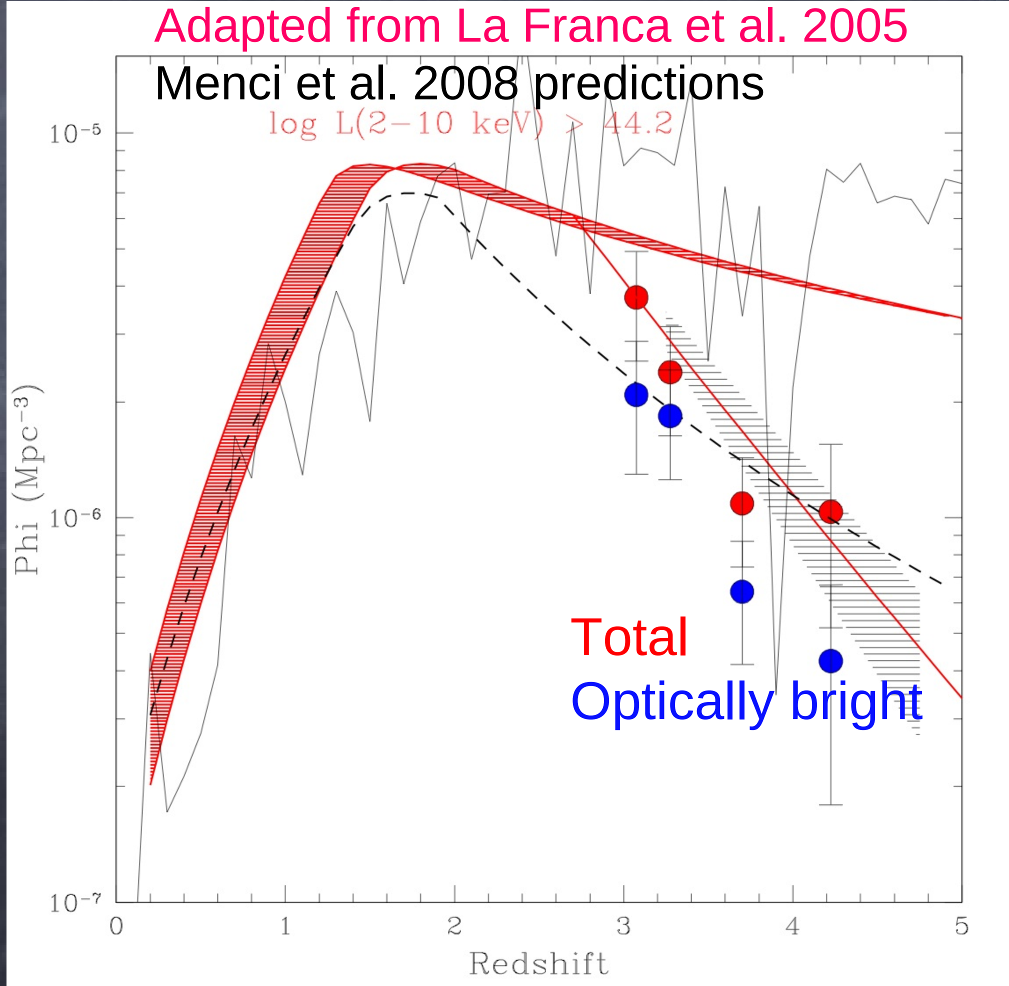




High-z QSOs, why X-rays?

- The best survey of high-z QSOs: COSMOS 2deg² (Brusa et al. 2008)
- F(0.5-2keV)>10^{-15} 40 QSOs z>3 4 QSOs z>4
- F(0.5-2keV)>3×10^{-15} 11 QSOs 3>z>4
- All logL(2-10keV)=44-45



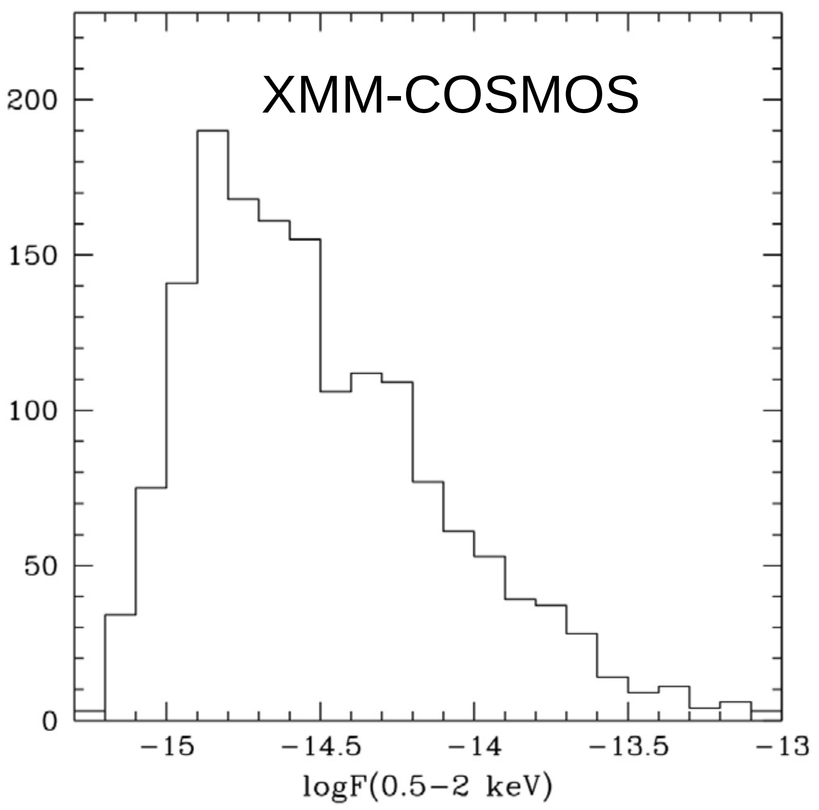


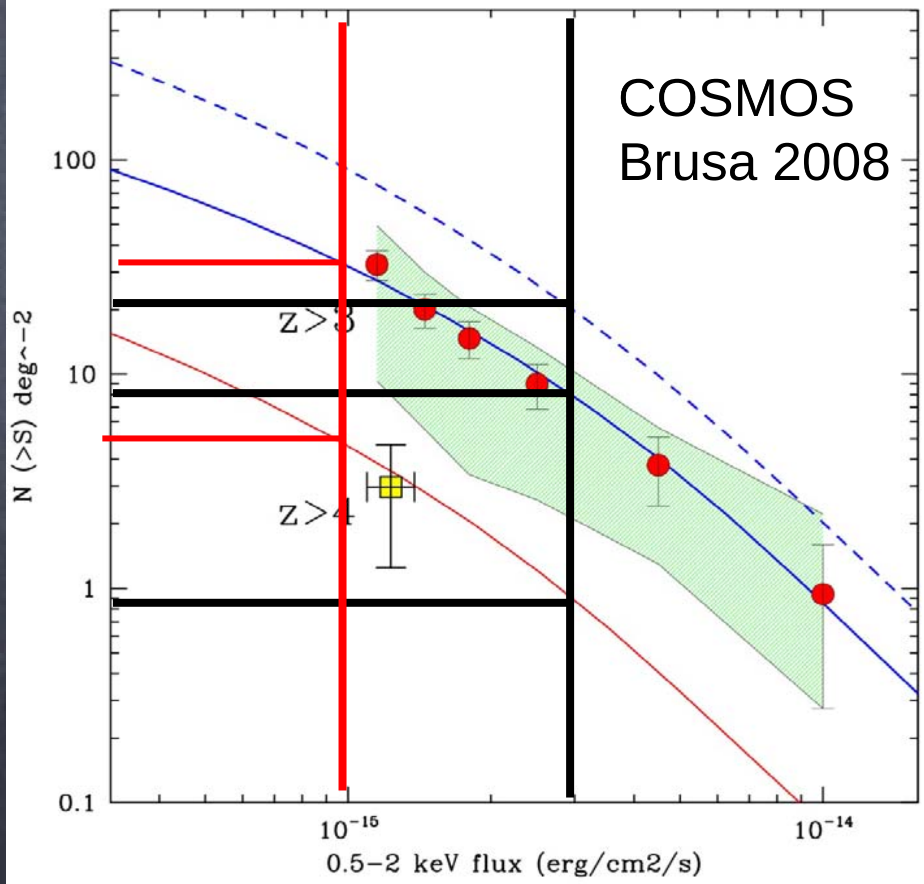
High-z QSOs number counts

- @ F(0.5-2keV)>3×10^{-15} ~8 QSO/deg^2 z>3 ~1 z>4
- @ F(0.5-2keV)>10^{-15} ~30 QSO/deg^2 z>3 ~5 z>4

L(2-10keV)=45-45.5 Lbol~46.85-47.4 M_{BH}~5×10^8-2×10^9 M_{Sun}

- L=45-46 z=3-4 expected ~6/deg^2





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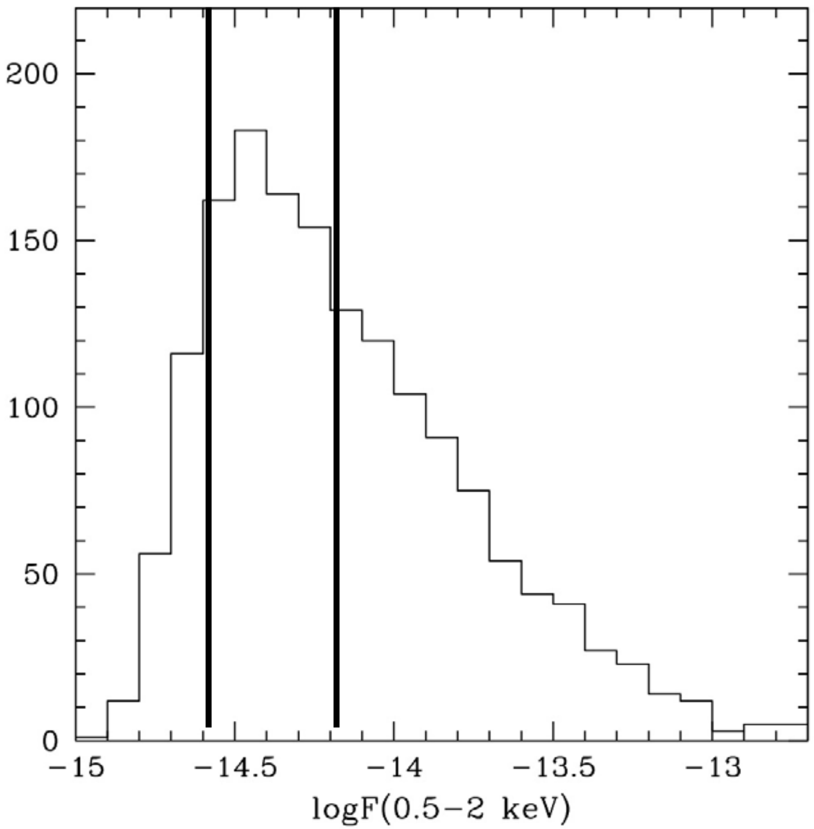
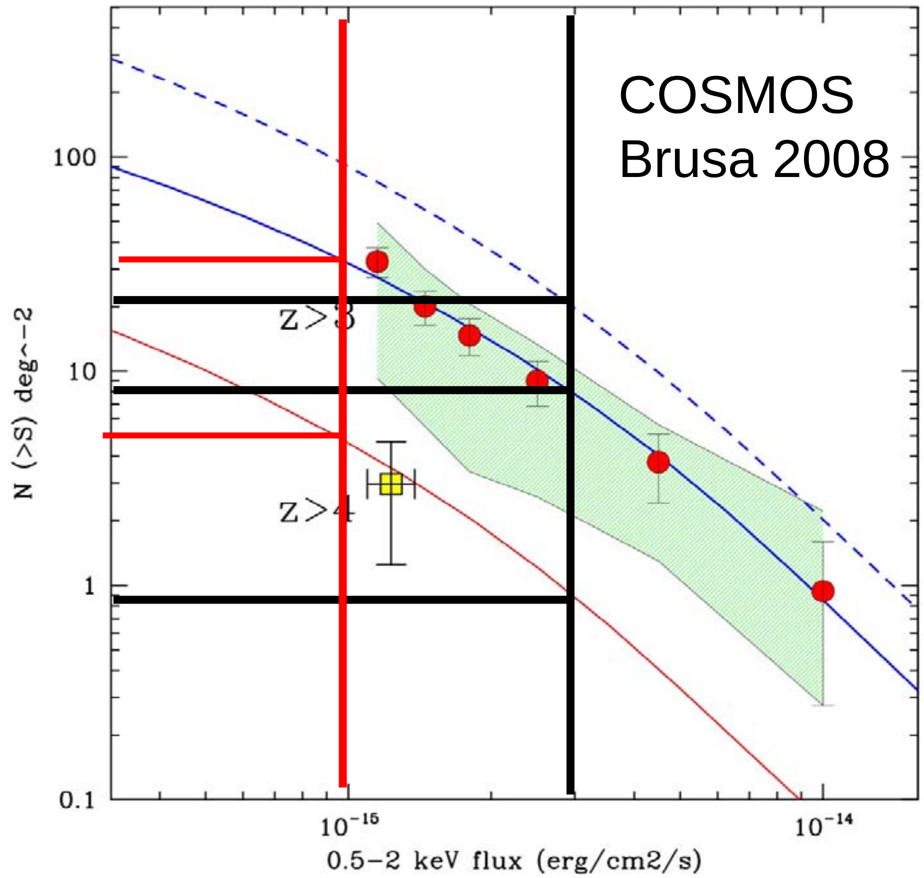
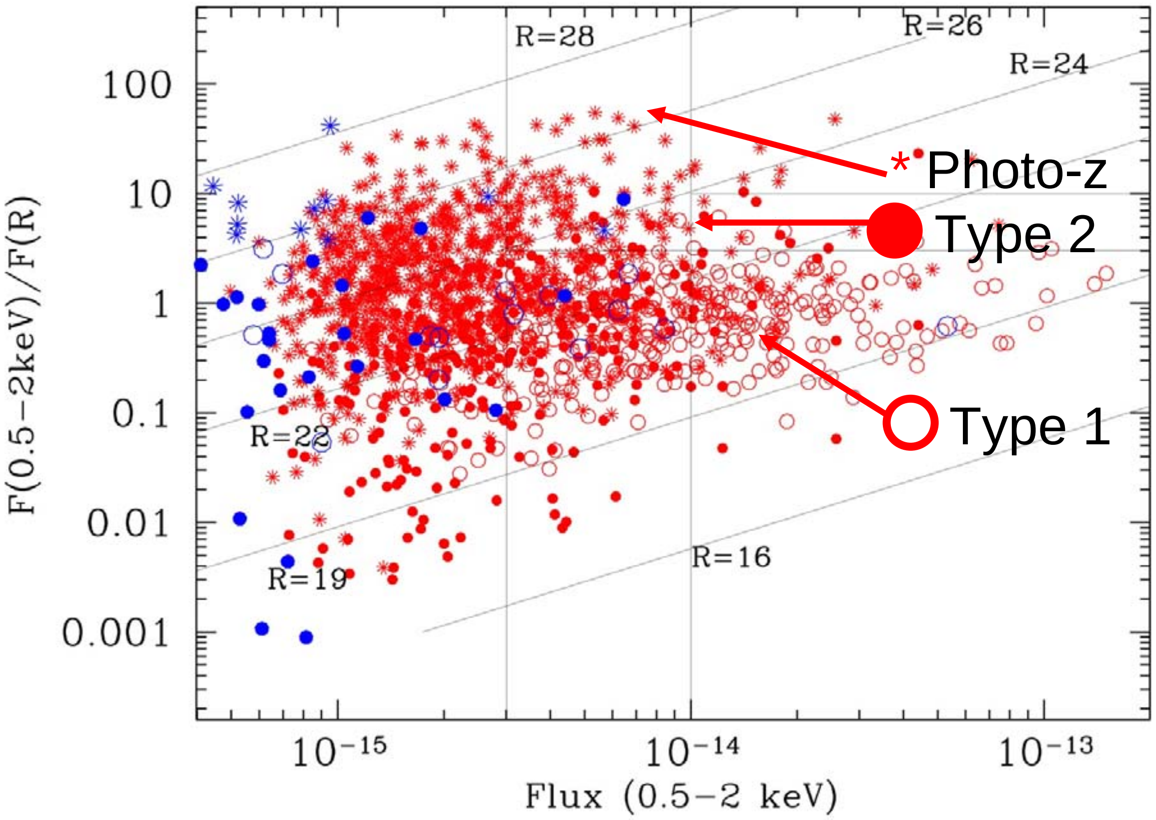




Requirements on optical follow-up

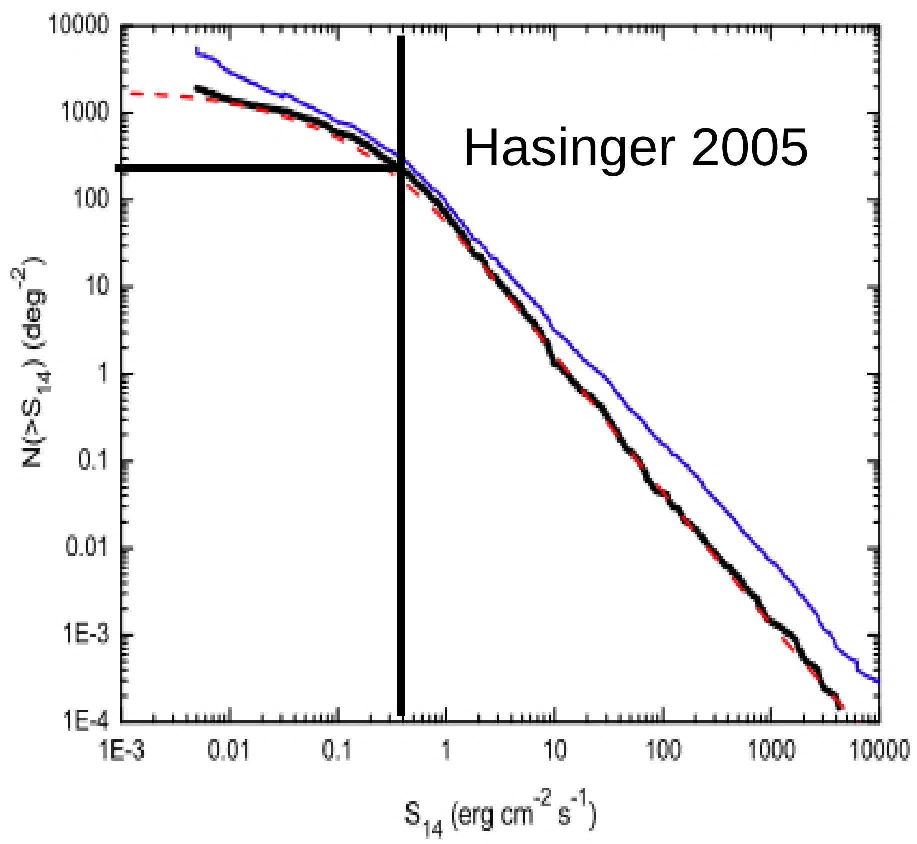


- F(0.5-2keV)>3×10^{-15}
  - ~85% of counterparts have R<24
  - ~95% R<25
- Most objects with R>24-25 type 2 AGN
  - Optical-IR SED dominated by the galaxy (no simple power law), photo-z more relialble
- High-z QSOs
  - I,z dropouts
  - Would benefit of deep IR coverage, Y, IRAC

Requirements on optical followup

F(0.5-2keV)=3×10^{-15} ~200-300 X-ray sources/deg^2

~2-3 per 6×6 arcmin FOV ~2000 per 9deg^2 FOV



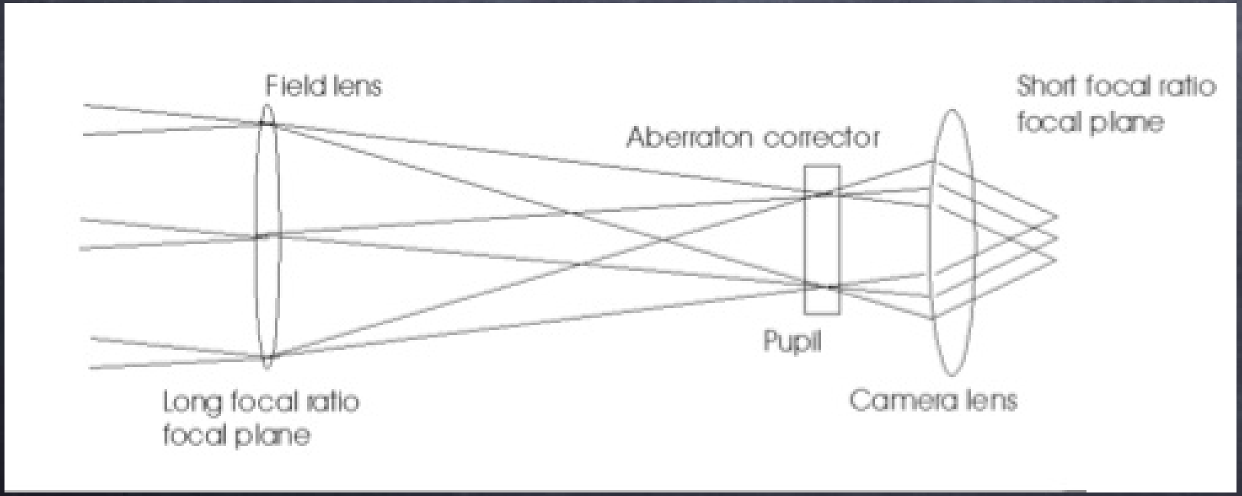
1-10/deg^2 high-z QSOs

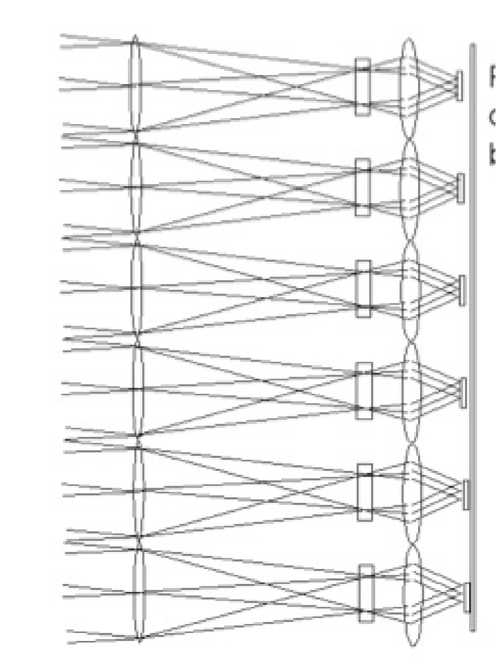
0.01-0.1 per 6×6 arcmin FOV

9-90 per 9deg^2 FOV

A 3°×3° imager spectrograph

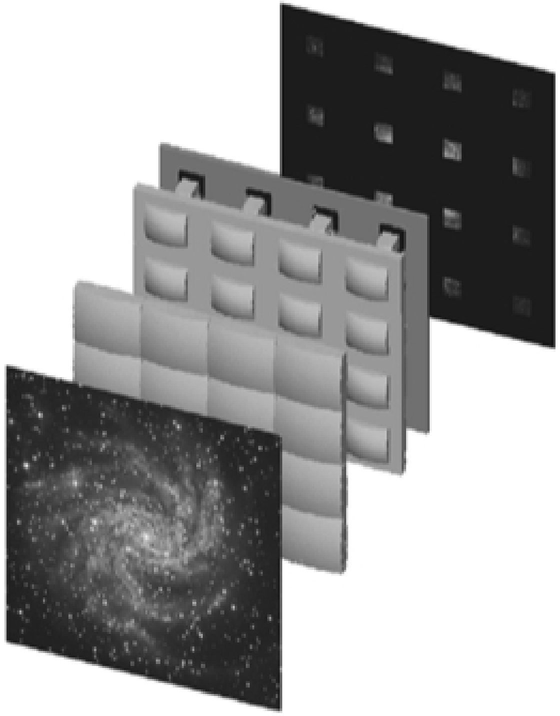
- "Smart" fast camera concept
- Modular approach: instead of a single, large optical system reducing aberration of full FOV, many (~1000), small, compact systems reducing aberrations on mini-FOVs





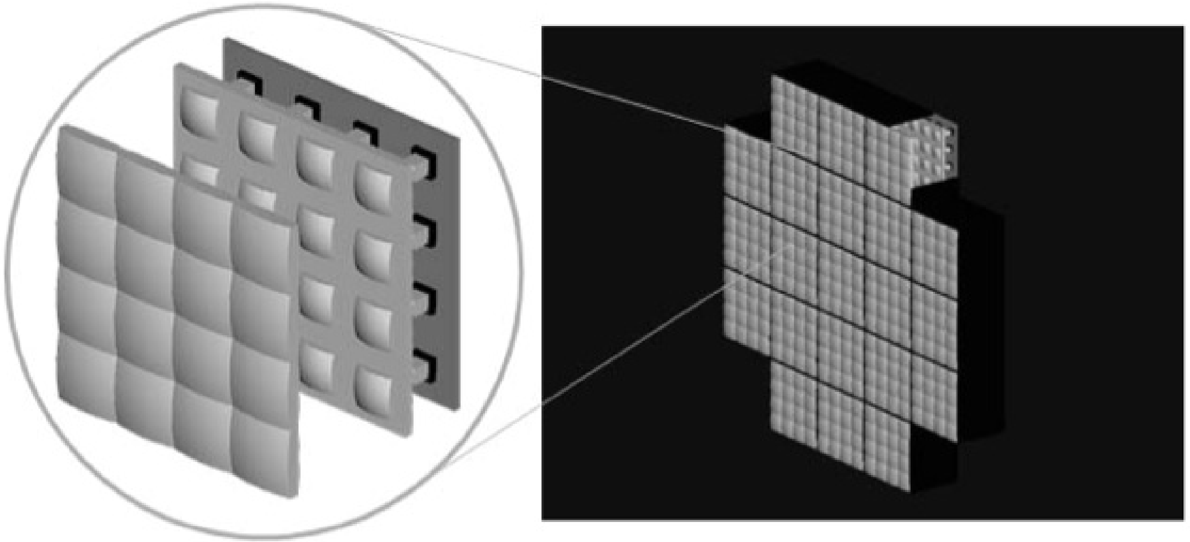
Ragazzoni et al. SPIE 2006

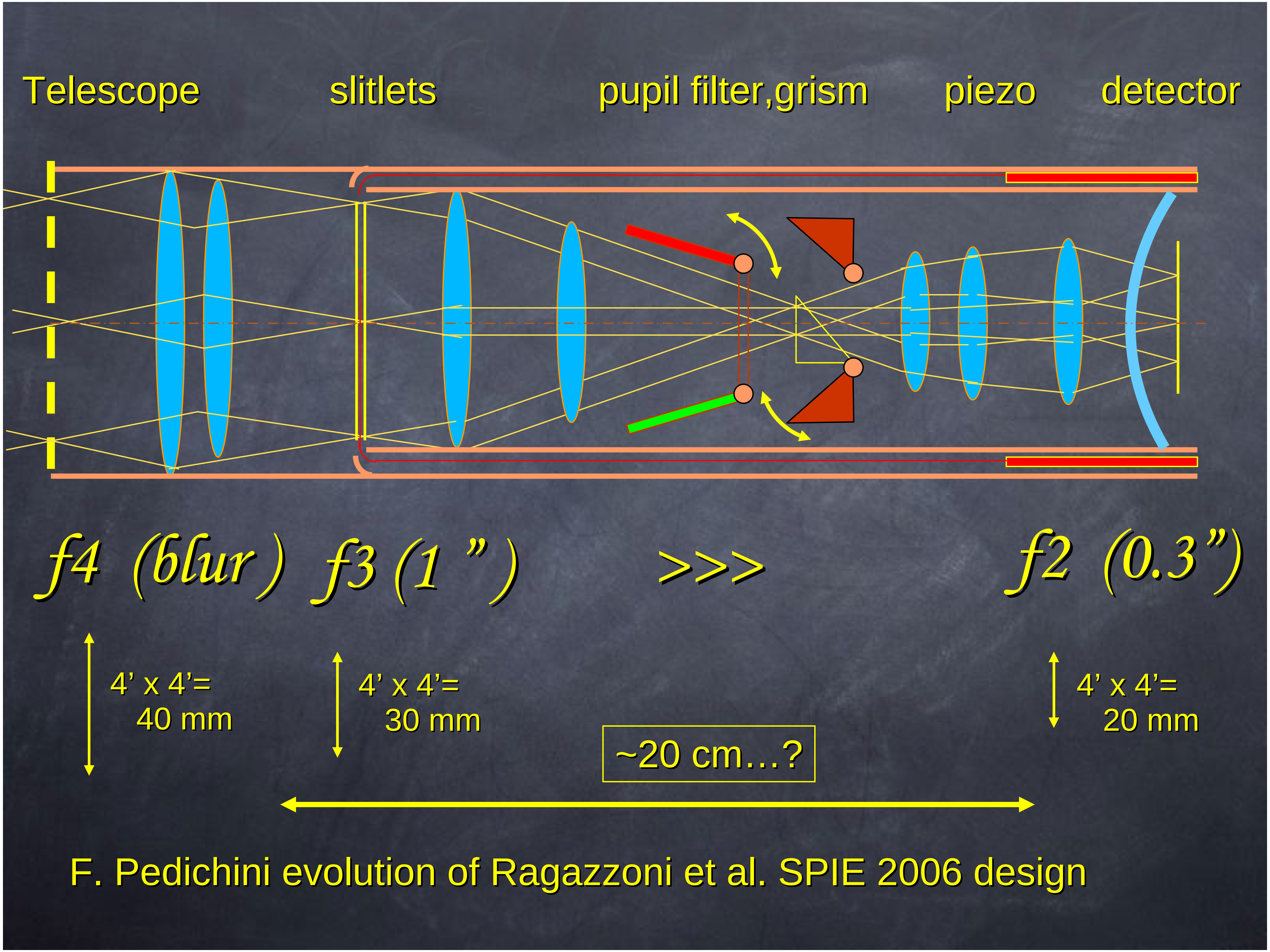
A 3°×3° imager spectrograph

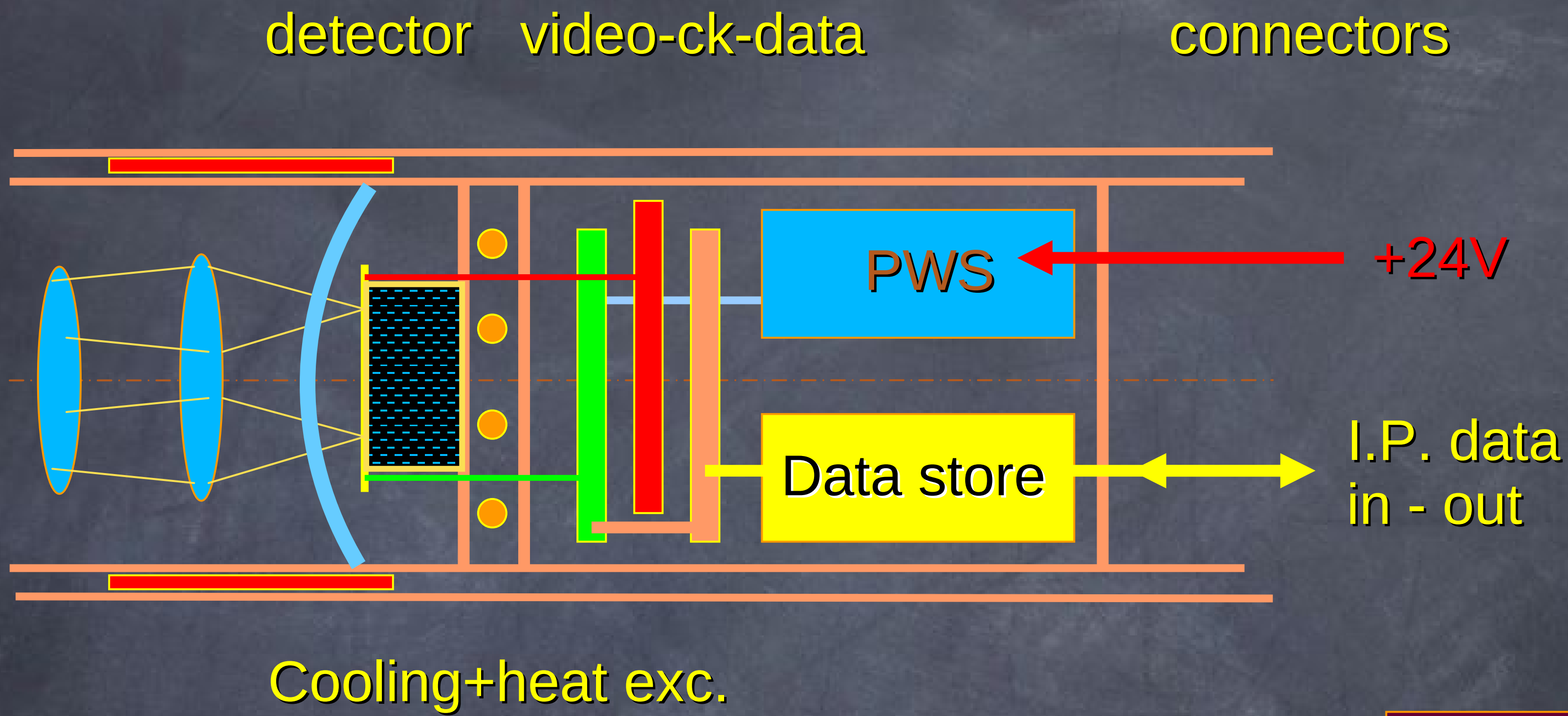


- Image with large plate scale is projected onto a lenslet array whose elements are single focal reducers.
- Portions of the image are imaged with a smaller plate scale onto an array of small detectors.

A large FOV can be populated with virtually identical modules

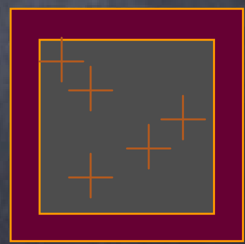



Telescope
slitlets
pupil filter,grism
piezo
detector
f4 (blur) f3 (1") >>> f2 (0.3")
4' x 4'= 40 mm
4' x 4'= 30 mm
~20 cm…?
4' x 4'= 20 mm
F. Pedichini evolution of Ragazzoni et al. SPIE 2006 design

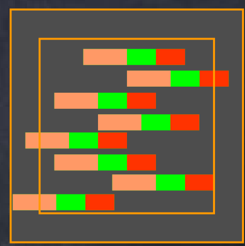


CCD o C-MOS da 1000 x 1000 pix
20 micron pixel = 0.3”
2-8 Slitlets 15”-20”
RON 10^{-2} e^{-} >> ROT 2-15 sec
On Board Data Store

Imaging mode



Spectro mode



Summary

- ~100 deg^2 survey at F(0.5-2keV)=3×10^{-15} will find 10000-20000 AGN
- Extrapolating COSMOS results:
  - 10 QSO z>3 deg^2 1 QSO z>4 deg^2
  - ~10 z>5 QSOs in the full survey
- ΔCDM models more optimistic
- More exotic gravity models even more optimistic
- IR coverage mandatory
- Most (80-95%) counterparts of X-ray sources accessible to 8m class telescope spectroscopy
- Source density low:
  - 2-3 per 6×6 arcmin FOV (0.01-0.1 z>3 QSOs)
  - ~2000 per 9deg^2 FOV (10-100 z>3 QSOs)
- Modular approach: a smart fast camera to cover a $3^o\times3^o$ FOV
  - ~1000 nearly identical imager spectograph
- Trapped Cassegrain foci of LBT (one instrument optimized for red/NIR and the other for UV/blue)