

X-ray and HSC Selection of Quasars

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Overview

- What can we do by combining HSC opt. + X-ray data?

Contents:

1. Why X-rays?
2. Available X-ray Data
3. Science Cases

1. Why X-rays?

- Good AGN indicator
 - Less affected by stellar light than optical
- Obscured AGN can be found
 - High energy X-rays can penetrate thick matter
- Redshift can be determined if emission line exists
- Probe of the vicinity of central BH
 - Accretion physics/constrain accretion parameters
 - e.g., mass accretion rate

2. Available/Future X-ray Data

- Existing/Future survey data
 - XMM-Large Scale Structure Survey (LSS)
 - XMM Extension of LSS (XLS)
 - COSMOS, SXDS, etc.
- Serendipitous sources
- New data

XMM-LSS, XLS

■ XMM very wide survey

- LSS 10 deg², ~10 ks each

- ◆ $F_{0.5-2, \text{lim}} \sim 5 \times 10^{-15}$ cgs

- http://vela.astro.ulg.ac.be/themes/spatial/xmm/LSS/index_e.html

- ◆ X-ray + Opt. (CFHT-LS) catalog available at

- <http://cosmosdb.iasf-milano.inaf.it/XMM-LSS/>

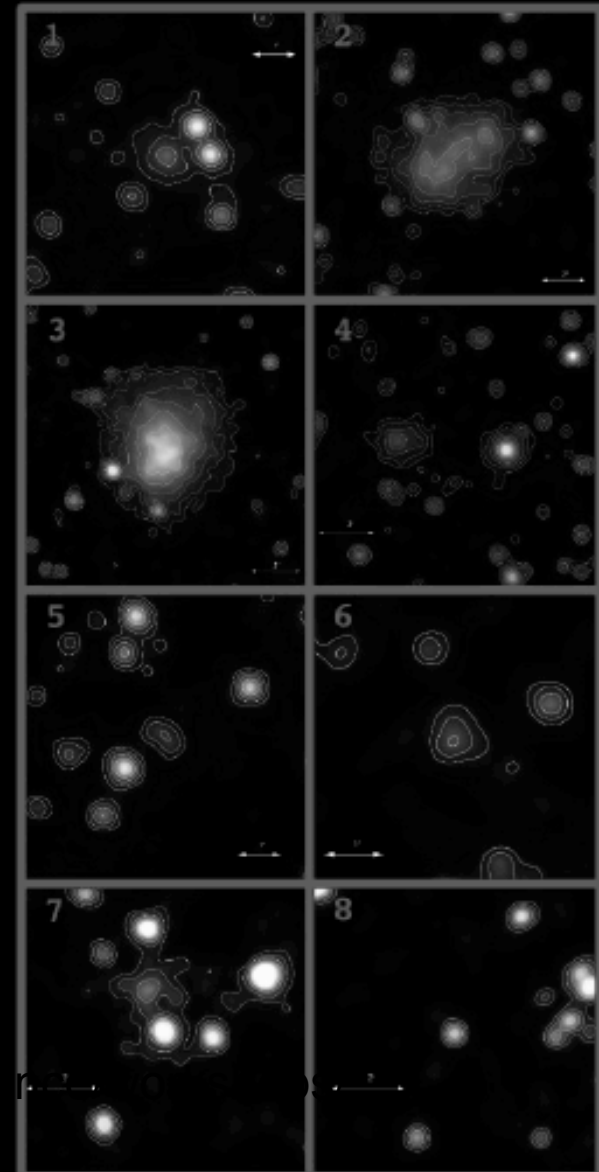
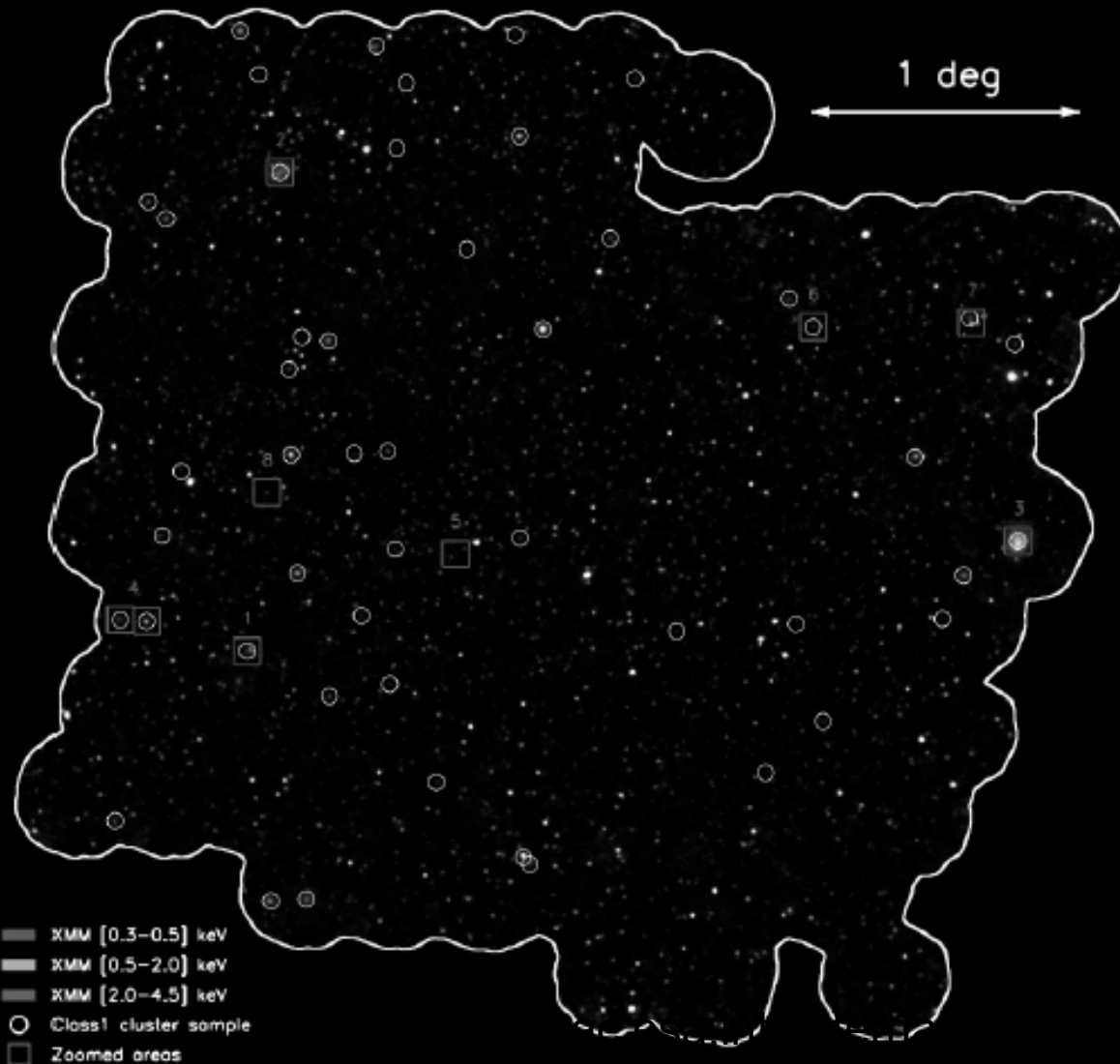
10 deg² catalog: Chiappetti+13

- XLS (2011 May – 2013 April)

- ◆ 25 deg²: extension of LSS --- useful for future work

- ◆ 25 deg²: BCS field (23h30m, -55d00m)

The XMM-LSS survey

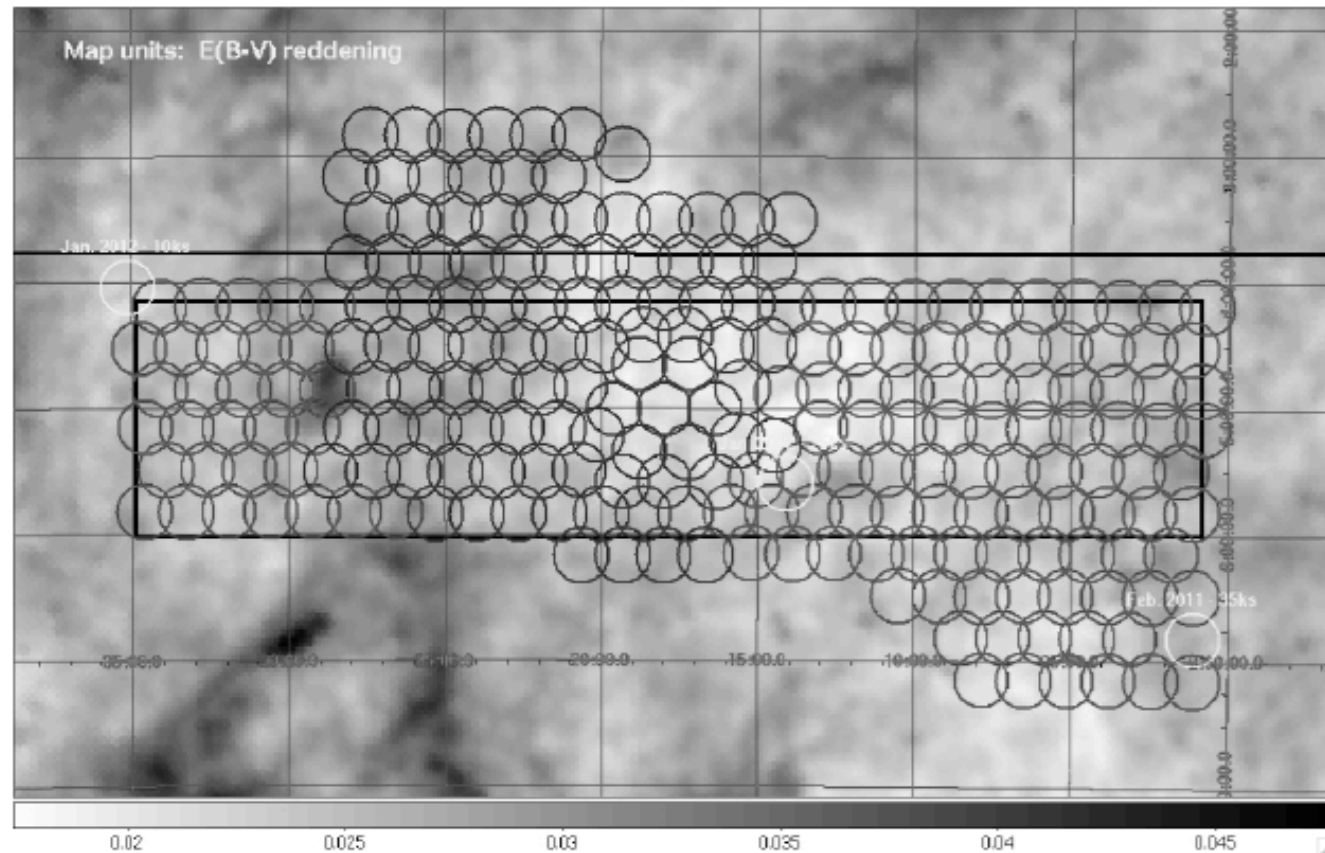


XMM-XLS

25 deg² in CFHTLS-W1

2h23 -5d00

(extension of the XMM-LSS field)

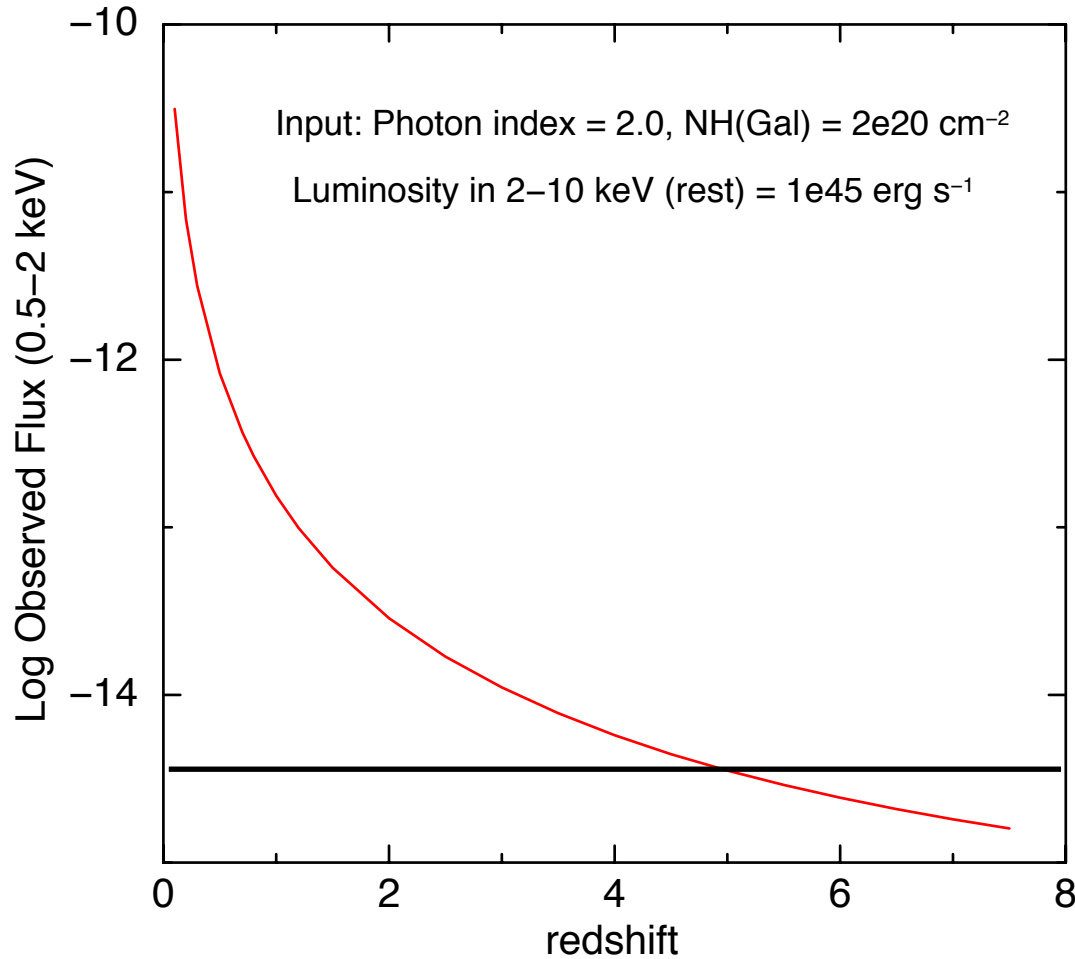


In red: the new observations (126)

$\Delta\alpha = \Delta\delta = 20'$ everywhere

http://xmm.esac.esa.int/external/xmm_science/workshops/2011symposium/talks/Pierre_Topici.pdf

Flux vs Luminosity



XMM-LSS

Detectable down to

$L_{2-10} = 2.8 \times 10^{44} \text{ erg s}^{-1}$	at $z=3$
4.1×10^{44}	$z=3.5$
5.0×10^{44}	$z=4$
1.0×10^{45}	$z=5$

* Boundary between Seyfert and quasar $L_{2-10} = 1 \times 10^{44} \text{ erg s}^{-1}$

← XMM-LSS detection limit

Deeper fields



COSMOS

Cappelluti+09

2.1 deg²

Mean exposure ~68 ks

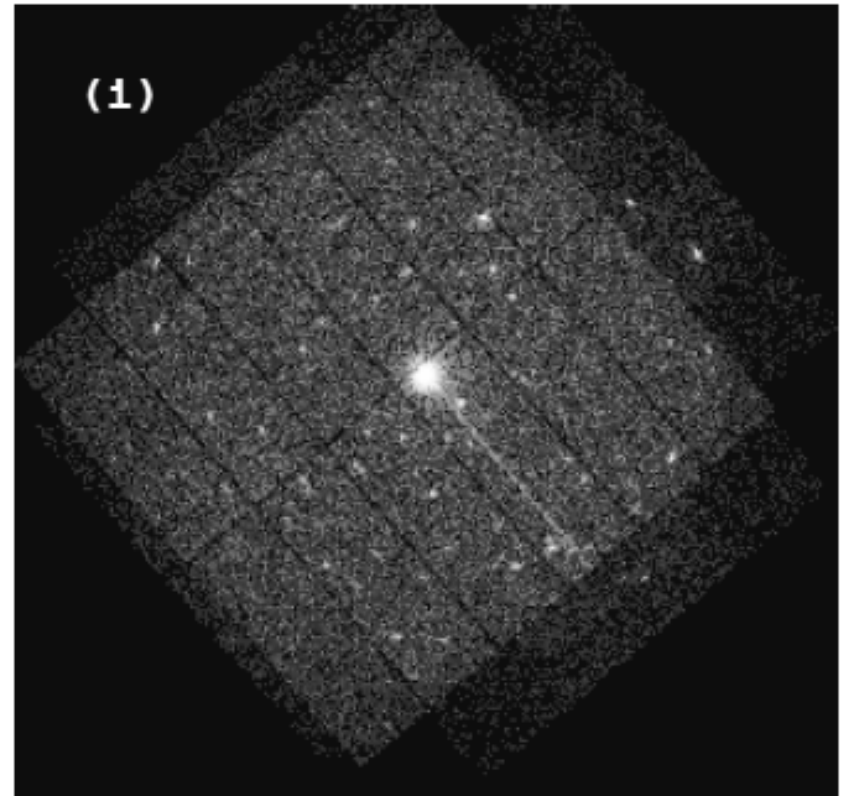
$F_{\text{lim}, 0.5-2} = 1.7 \times 10^{-15}$ cgs

$F_{\text{lim}, 2-10} = 9.3 \times 10^{-15}$ cgs

Serendipitous Sources

- XMM serendipitous source catalogue
 - 262902 unique sources in DR3
 - ◆ <http://xmmssc-www.star.le.ac.uk/Catalogue/>

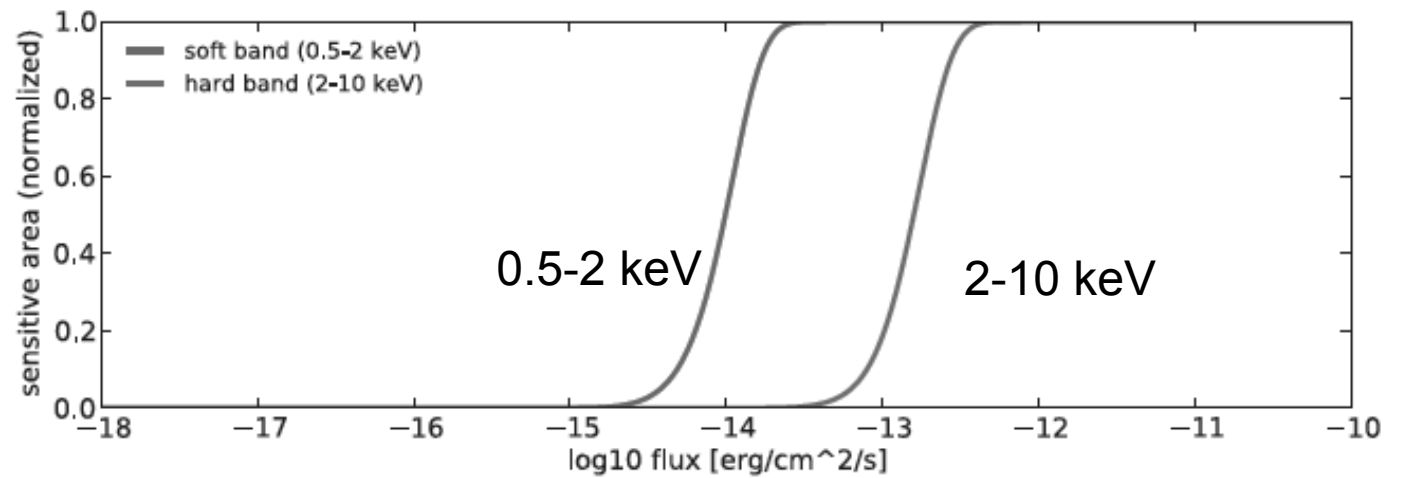
- Chandra Source Catalog
 - 136000 sources
 - ◆ <http://cxc.harvard.edu/csc/index.html>



eROSITA

Launch in 2014

Sensitivity limit for full 4 yrs survey
All sky coverage, shallower than LSS



3. Science Cases

- By combining optical. and X-ray...
 - (1) Selecting interesting/peculiar objects
potential targets for follow up spectroscopy

 - (2) More reliable quasar selection

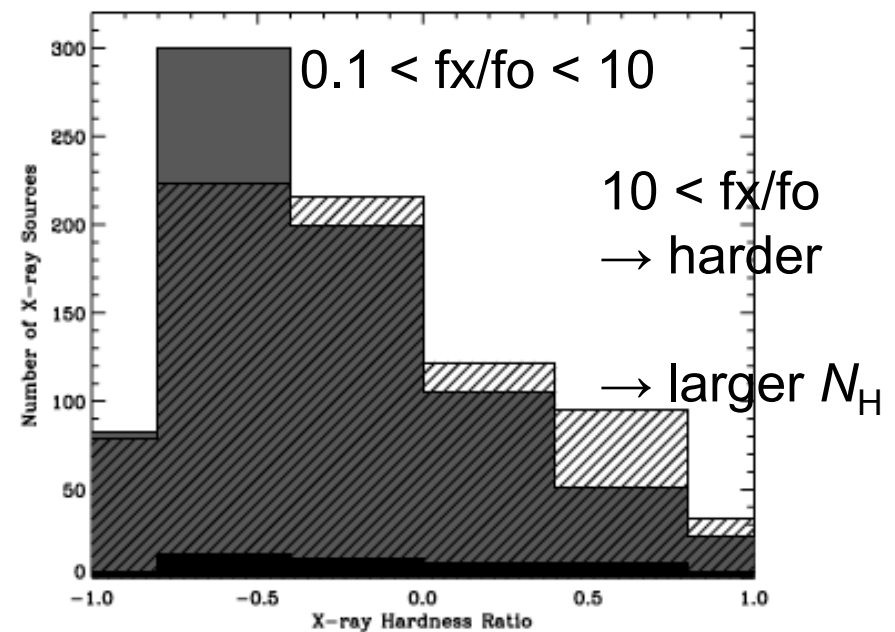
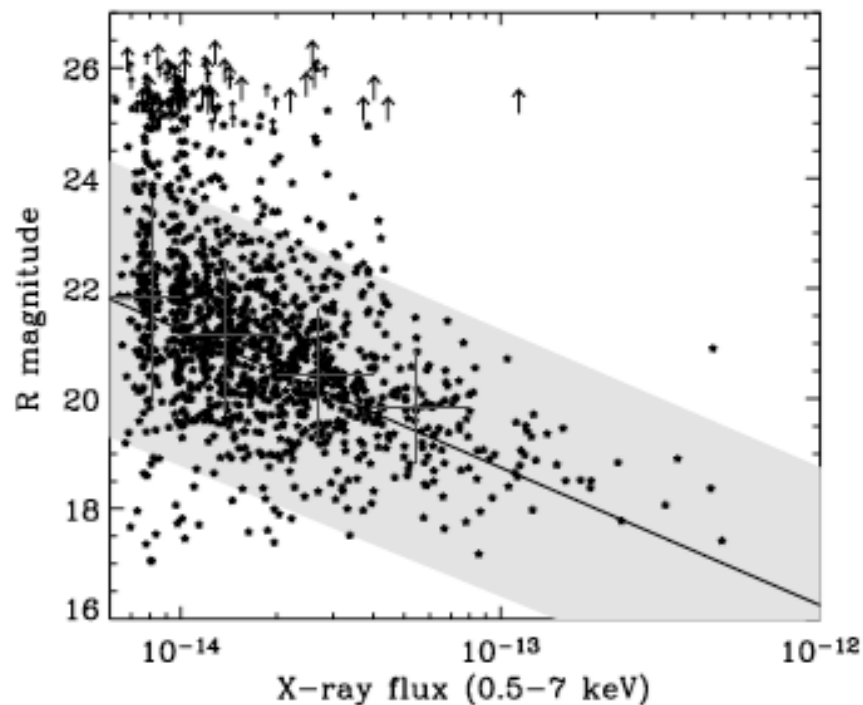
(1) Selecting interesting/peculiar objects

a. Elusive/Obscured AGNs

“NOAO Wide + Chandra match” Xbootes field Brand et al. 2006

X-ray Bright Optical Normal/Faint Galaxies

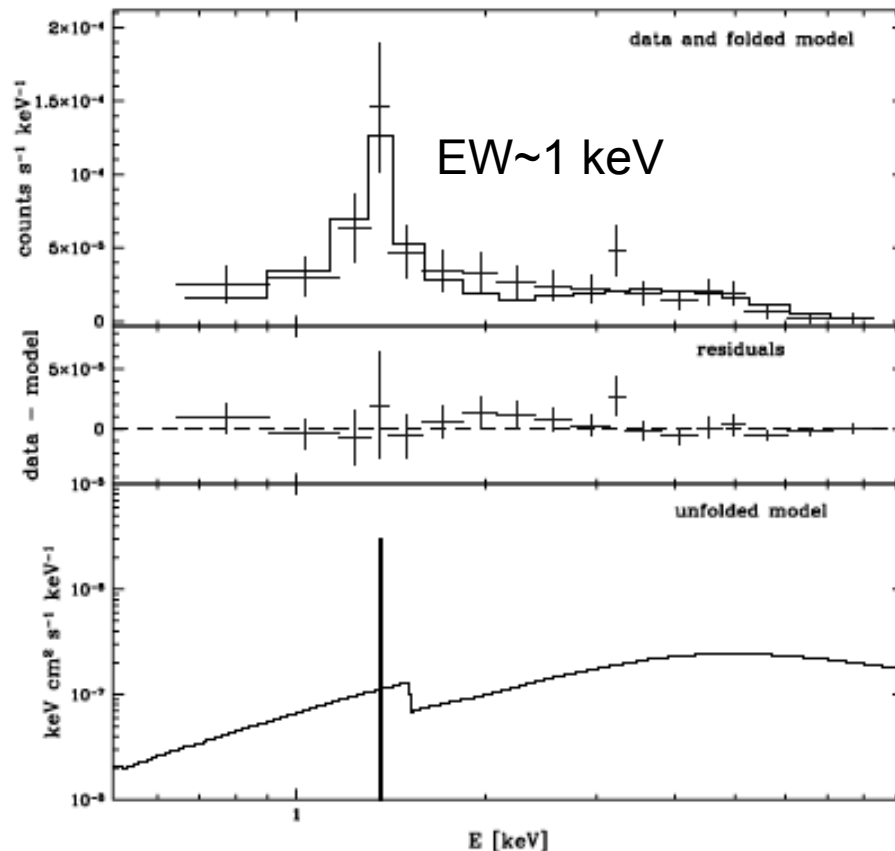
Obscured Sources



Science done w/out opt. spectroscopy

Redshift Measurements with Fe-K Line

- Obscured AGNs show strong Fe-K line
 - Redshift can be determined w/out opt. spectroscopy



CDF-S 202 (Norman+02)
Chandra 1 Ms

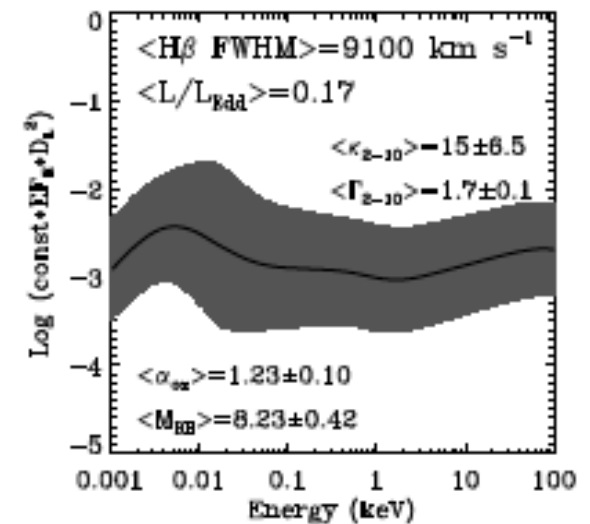
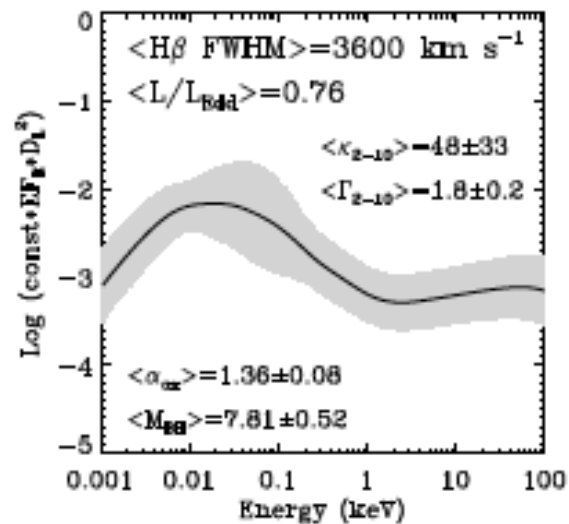
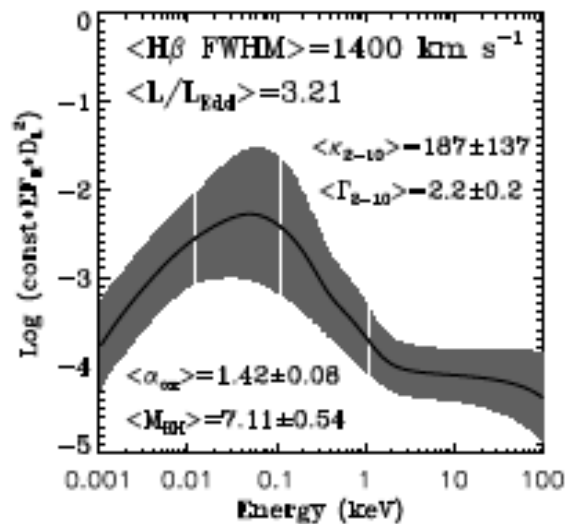
Type 2 quasar at $z=3.7$

Fe-K line (6.4 keV)
redshift to 1.4 keV

(1) Selecting interesting/peculiar objects

b. Growing AGNs

SDSS + XMM L/L_{Edd} Sorted SED



Large L/L_{Edd} object

→ steeper α_{OX} and X-ray photon index

Jin+11

α_{OX} + Photon index give crude estimate of L/L_{Edd}

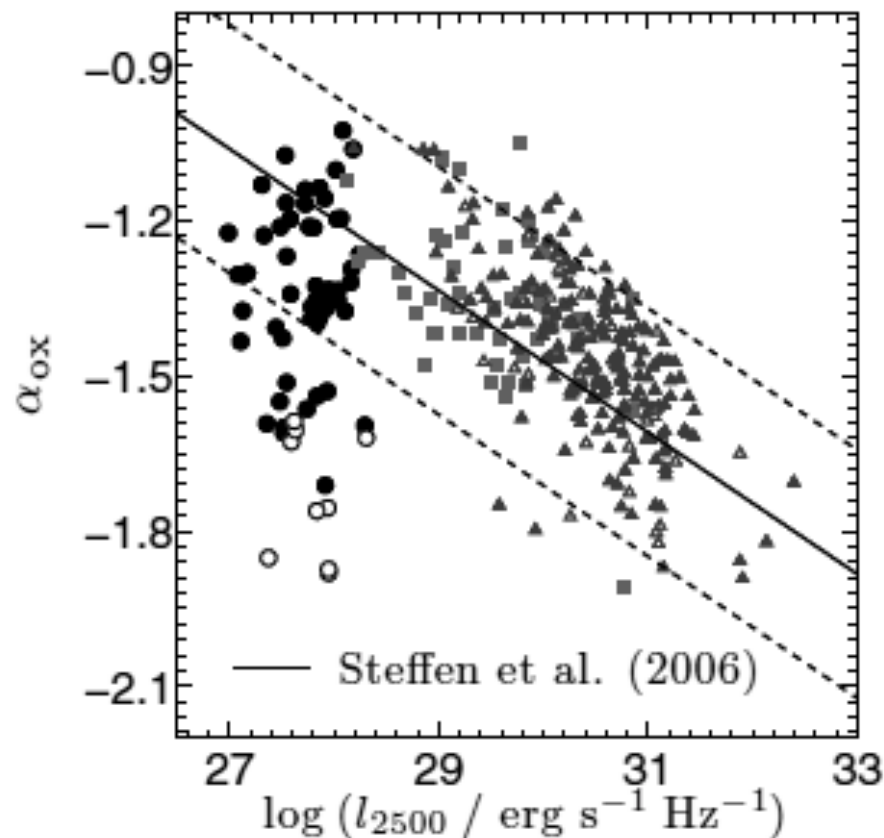
(1) Selecting peculiar objects

b. Growing AGNs

Dong+12

Red: Jin+12 quasars; Blue: Wu+12 quasars

Black: SDSS selected IMBH ($<2 \times 10^6 M_{\text{solar}}$)



High-L, steep α_{OX} objects are candidates for growing quasars

Low-L objects are candidates for IMBHs

N.B.,

- Massive BHs with low L/L_{edd} have low-L and flat α_{OX}

- LSS depth not sufficient.

 - Deeper X-ray obs.

- Contribution from host galaxy is not negligible.

Spectroscopic confirmation needed

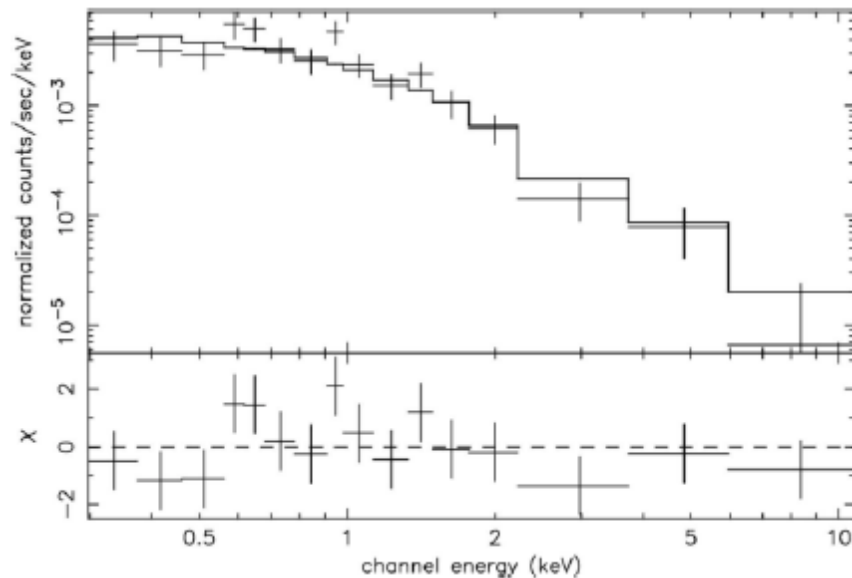
(1) Selecting peculiar objects

c. Highest-z quasar

X-ray follow up observations of highest-z quasars at $z \sim 7$
(e.g., request for director time)

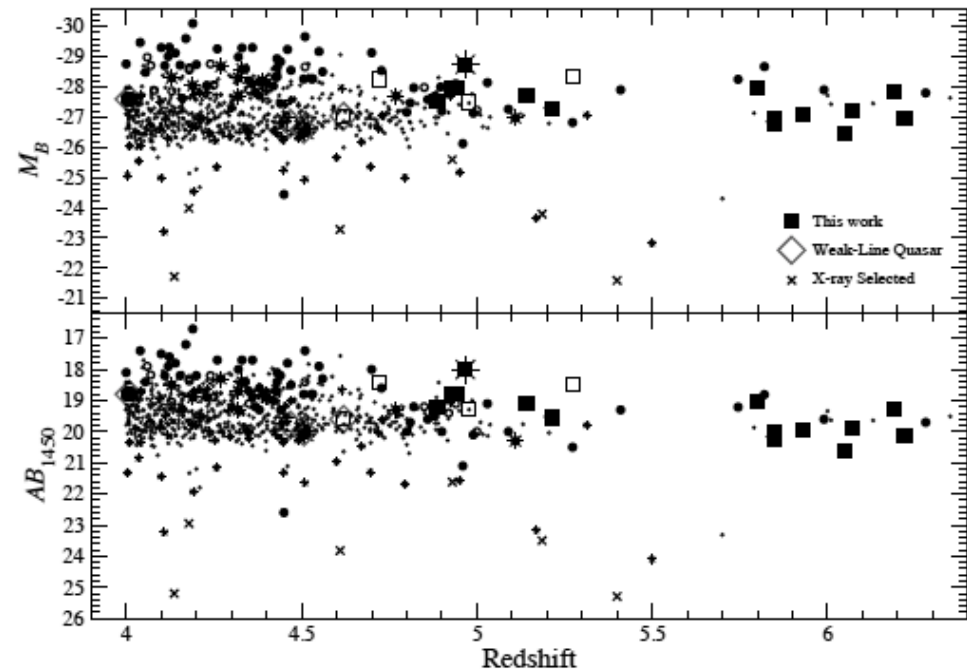
- Constraint on bolometric luminosity
- L/LEdd estimation from X-ray spectra
- Intervening absorption

SDSS J1030+0524 at $z=6.30$
XMM 75 ks



Farrah+04

Chandra detections of SDSS quasars



Shemmer+06

(2) More Reliable Quasar selection

Case Study: XMM-LSS + CFHT-LS

■ Limit mag

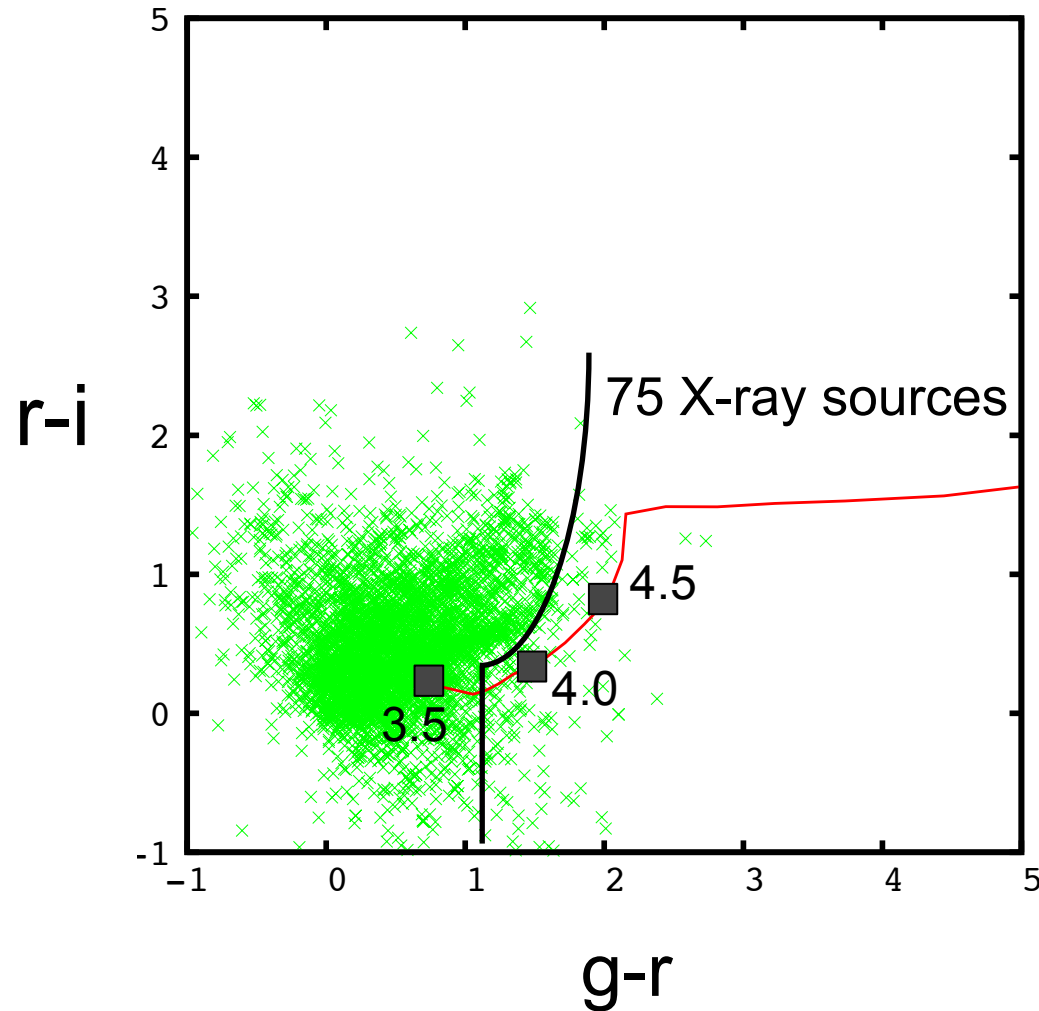
- CFHT-LS: u 25.5, g 25.6, r 25.7, i 25.5, z 24.0
- HSC-wide g 26.5, r 26.1, i 25.9, z 25.1, y 24.4

■ LSSOPT catalog (Pierre+07)

- All the optical sources within 6 arcsec of XMM sources are listed
 - 3385 X-ray sources in 5.5 deg²
 - ◆ 2208 at least 1 opt. candidate
 - 472 1 counterpart
 - 613 2 counterparts
 - Rest more
 - ◆ 106 No opt. association
 - ◆ 1071 area w/out CFHT coverage as of Pierre+07
- many wrong counterparts are also contained in the catalog.

Optical Color Selection

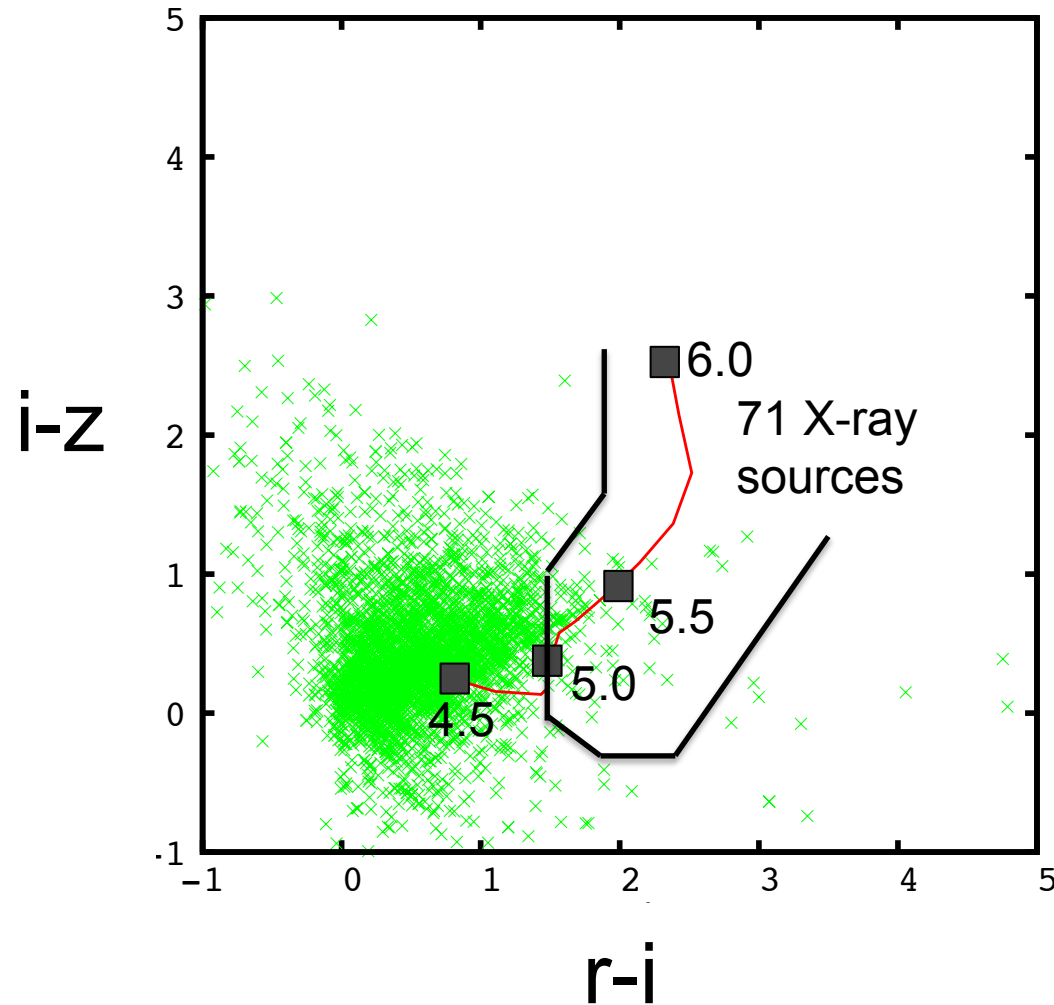
$z \sim 4$ quasars



Quasar color track
(Telfer+02 UV SED)

Calculated by
Ikeda-san.

Optical Color Selection $z \sim 5$ quasars



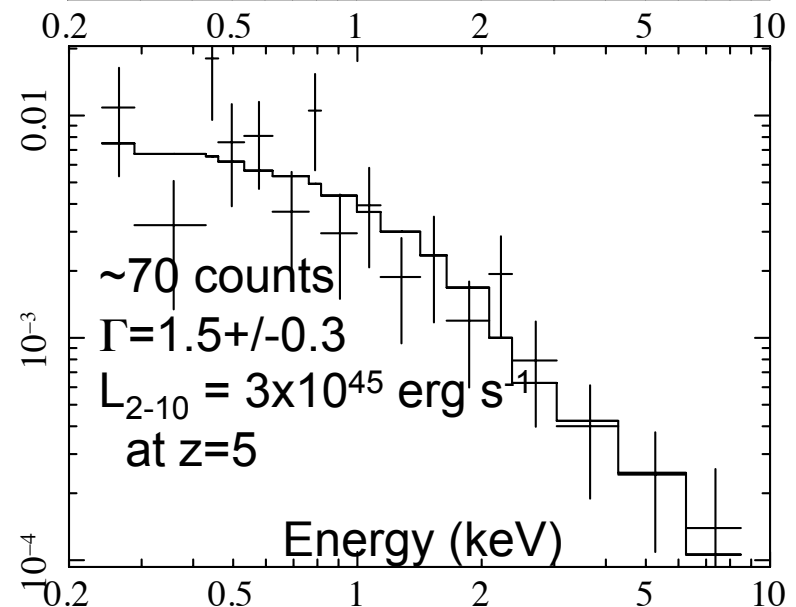
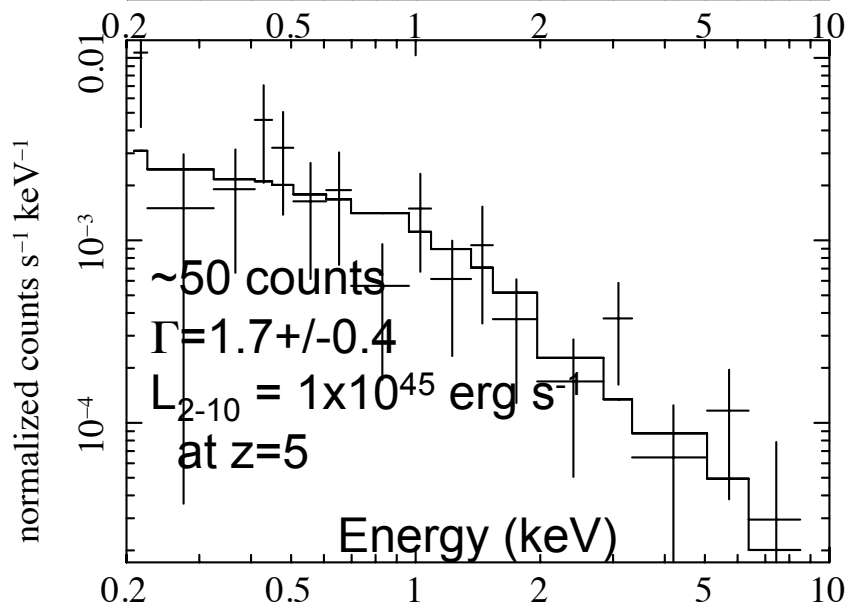
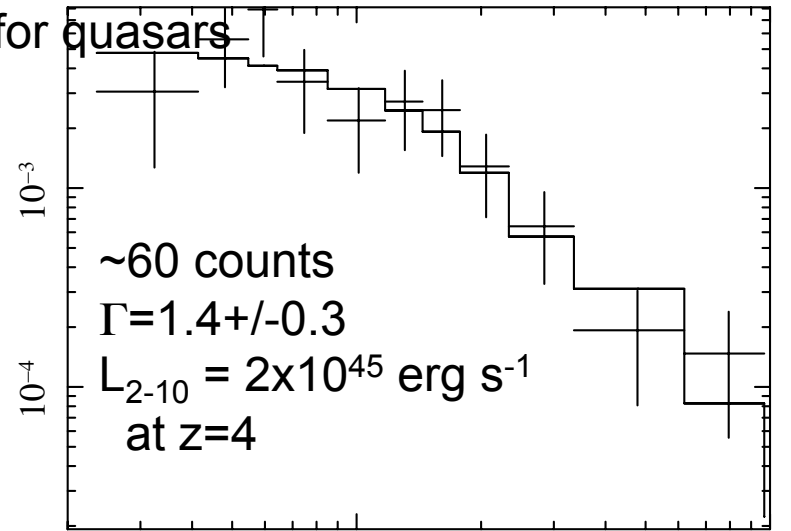
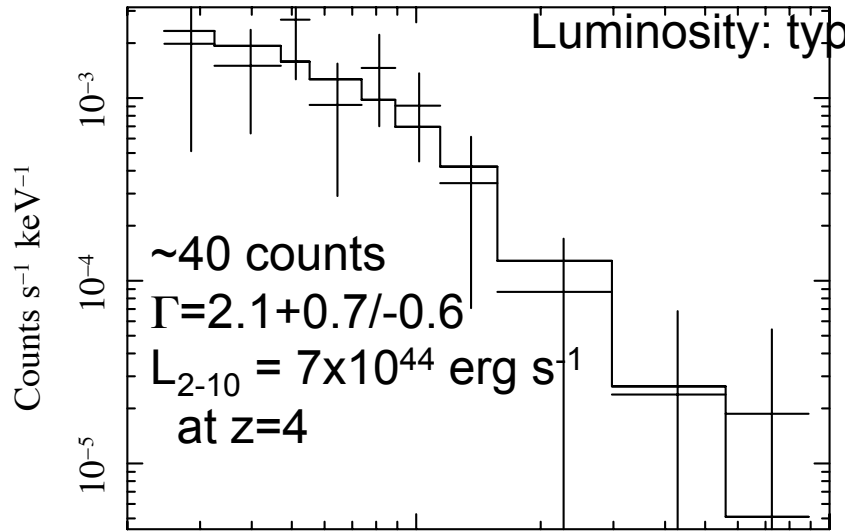
Quasar color track

Calculated by
Ikeda-san.

X-ray Spectra

Photon index: typical for AGNs

Luminosity: typical for quasars



Summary

- XMM-LSS, XLS, serendipitous data are available
- New observations can be proposed
(e.g., highest-z quasars)
- By combining Opt. and X-ray data
 - Interesting classes of objects can be selected
 - ◆ Obscured/Elusive AGNs
Redshift can be measured from Fe-K line
if heavily obscured and bright enough
 - ◆ AGN in growing phase
 - ◆ High-z quasars
 - More reliable identification of quasars is possible