Cosmic growth history of supermassive black holes

Subaru Telescope S04b Intensive Program

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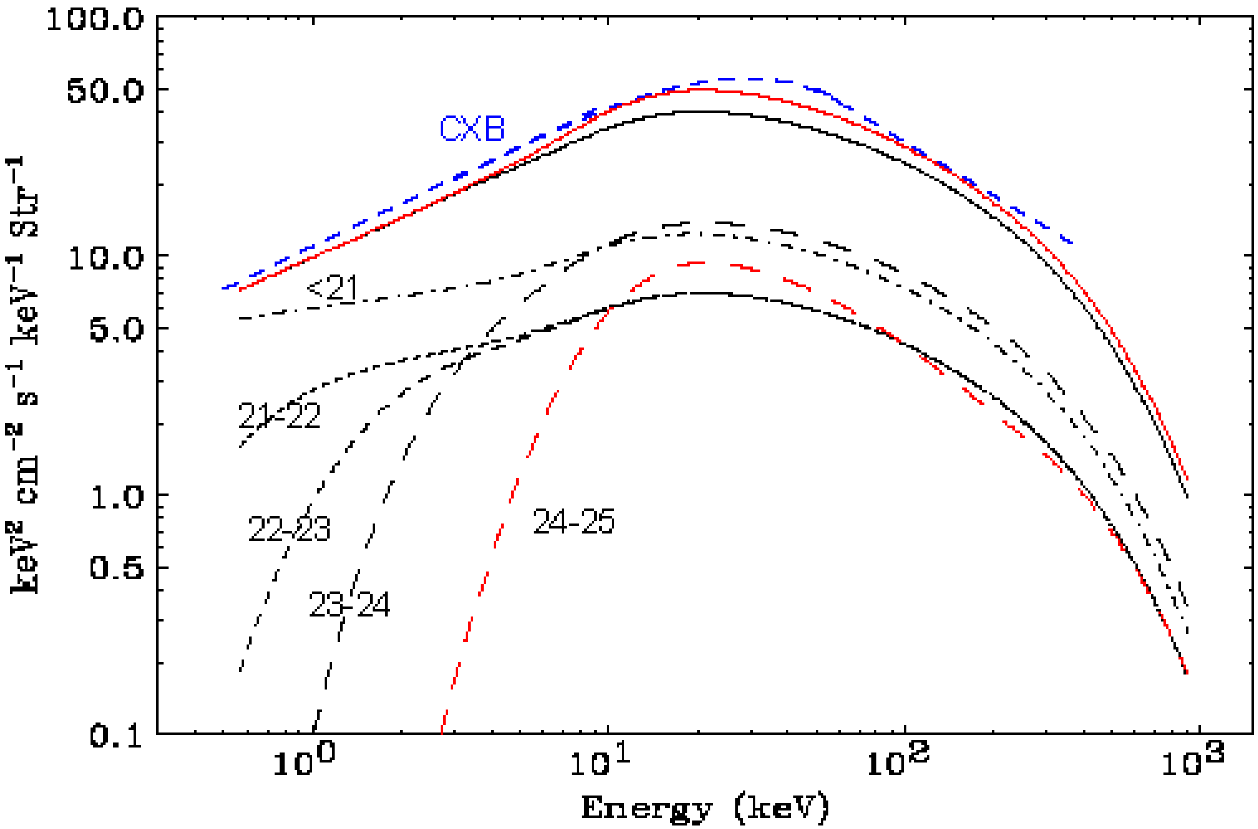
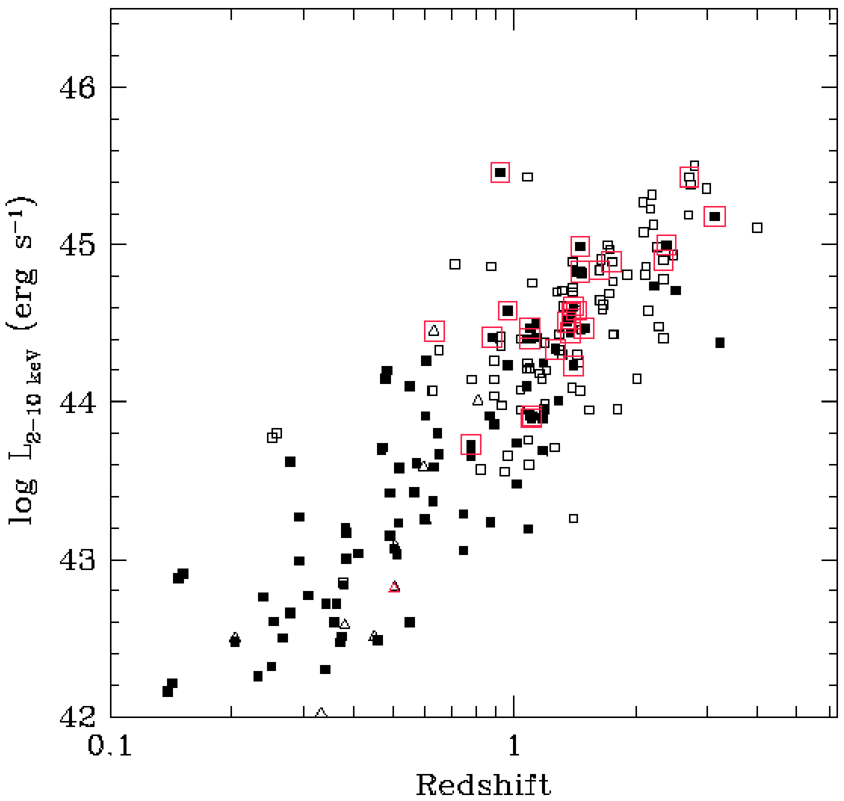
Subaru Telescope Users' Meeting
December 20, 2005 (HST)

The spectrum of the XBG can be explained by the X-ray luminosity function and the absorption. (Ueda et al. 2003)

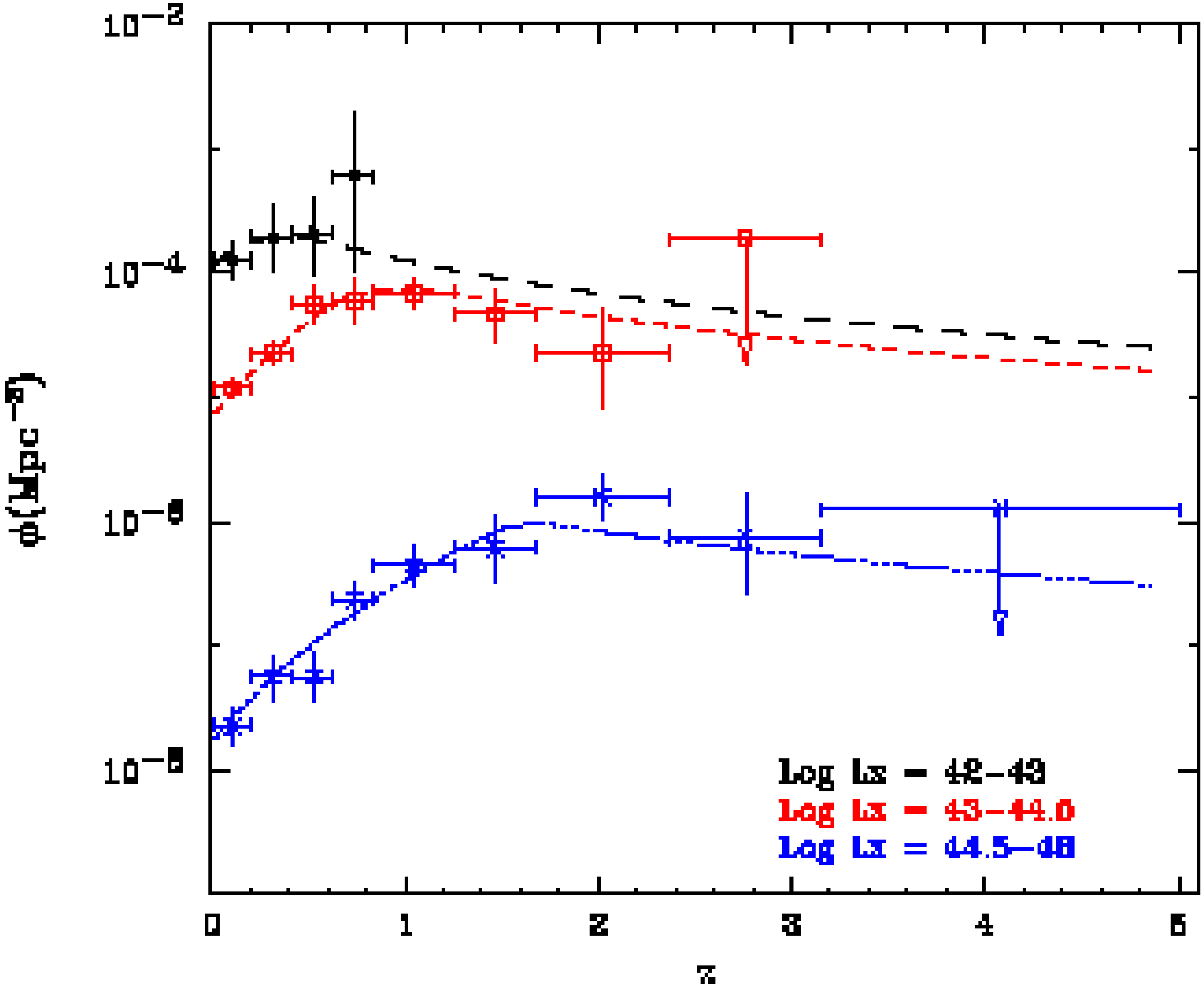


X-ray Luminosity - Redshift Distribution



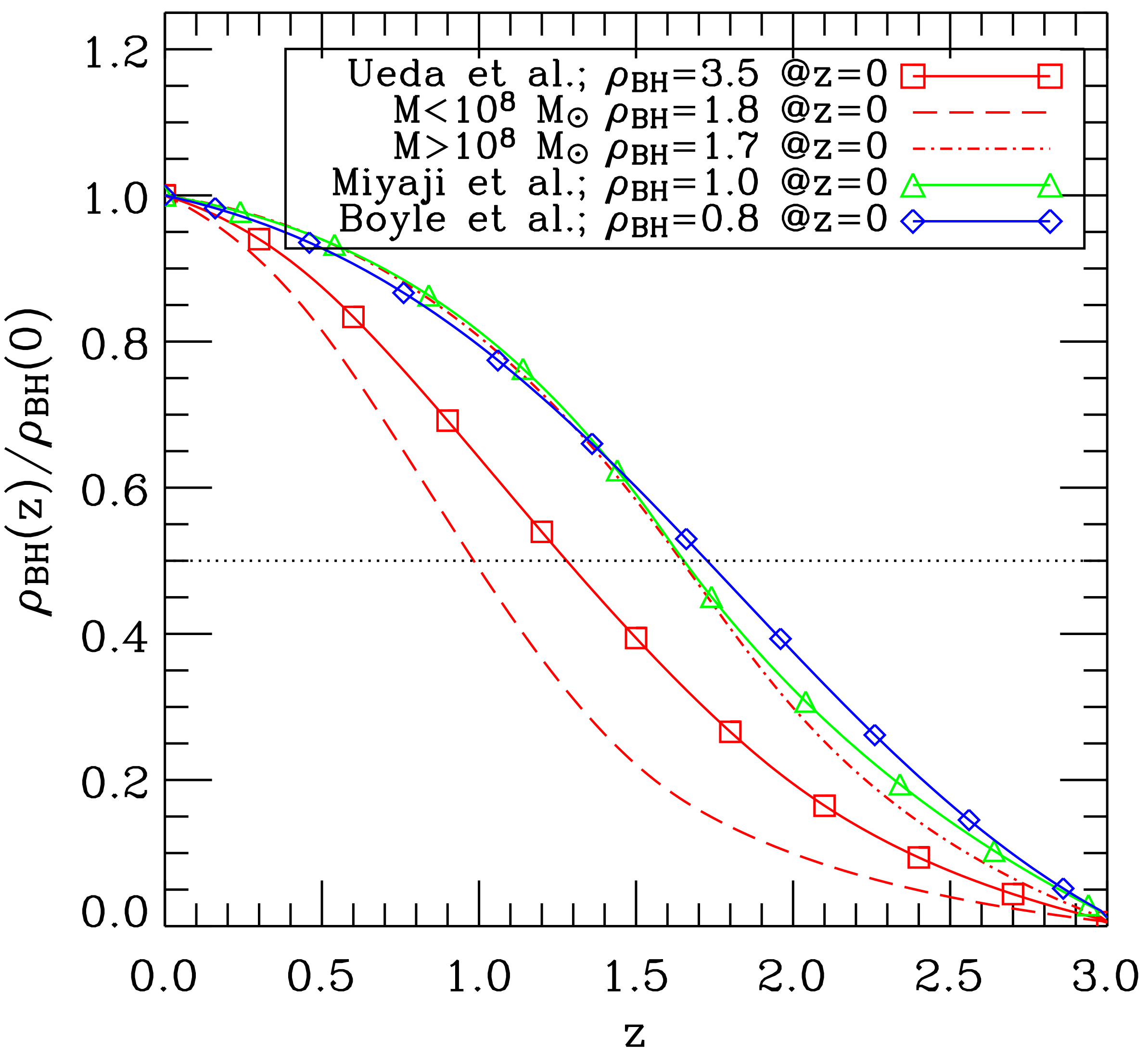
Most of them have hard X-ray luminosity comparable to QSOs.

Luminosity (or mass) dependent density evolution.



Number density of the AGNs

The BH mass growth curve



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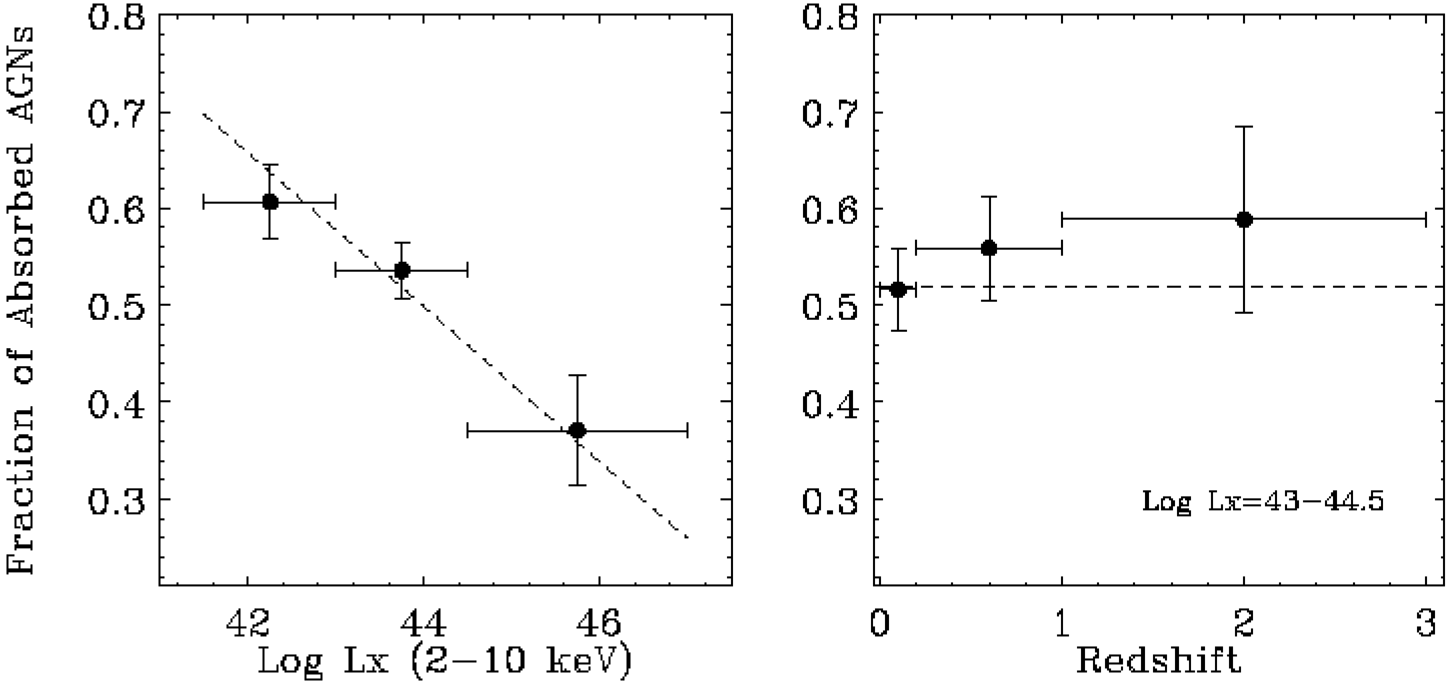
SXDS Subaru/XMM-Newton Deep Survey

Background : ASCA+Chandra Results
Lack of Obscured QSOs



Ueda et al. 2003

Luminosity dependence

- Lack of obscured QSOs

No significant redshift dependence

- But the number of the high-redshift luminous AGN is limited

Questions:

1) QSO number density @ z>2

2) Nature of the optically faint Hard X-ray sources (?).

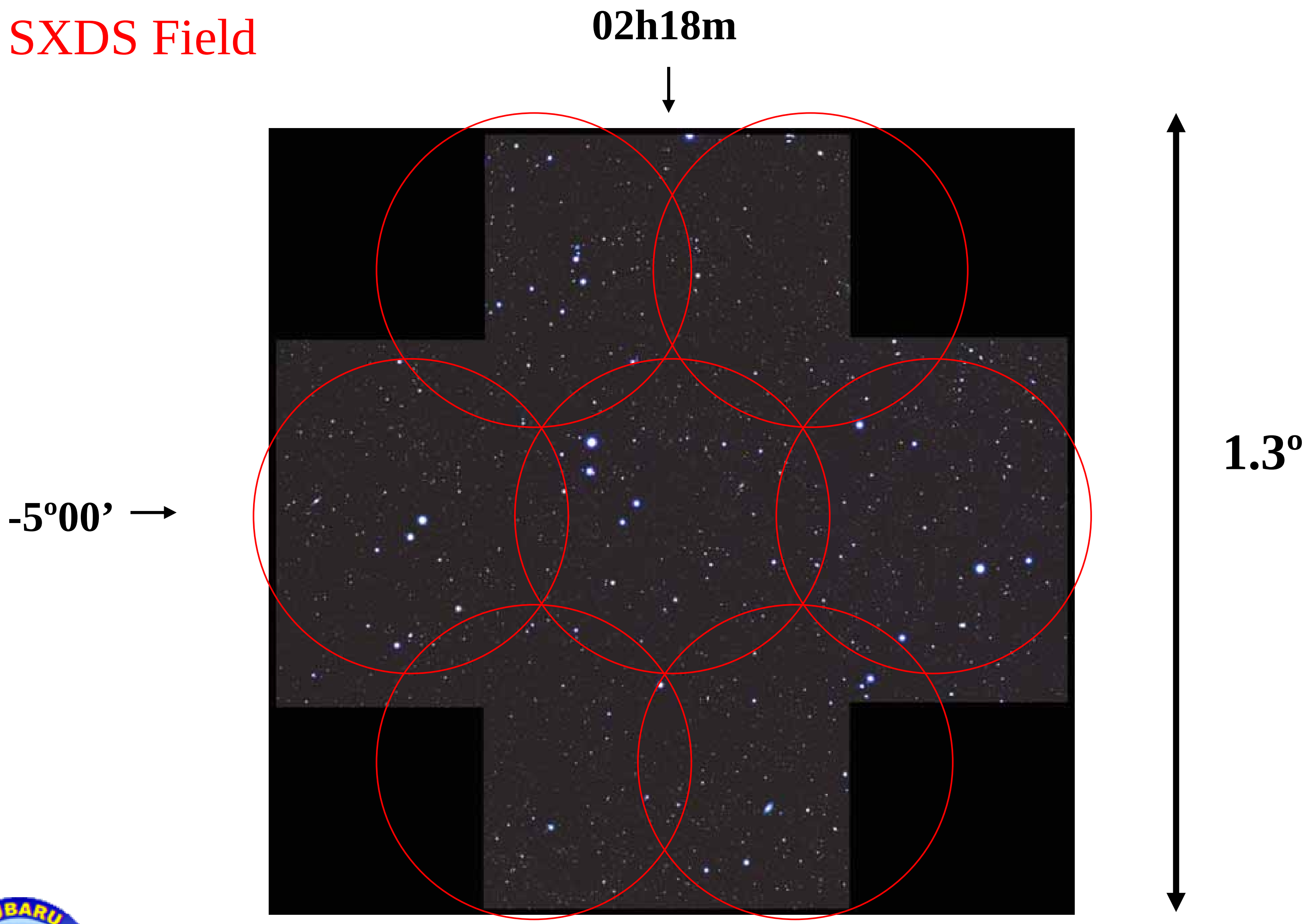
Number density of the obscured AGNs @ *z>1*

The Subaru/XMM-Newton Deep Survey (SXDS) is a deep optical / X-ray survey covering more than one square degree.

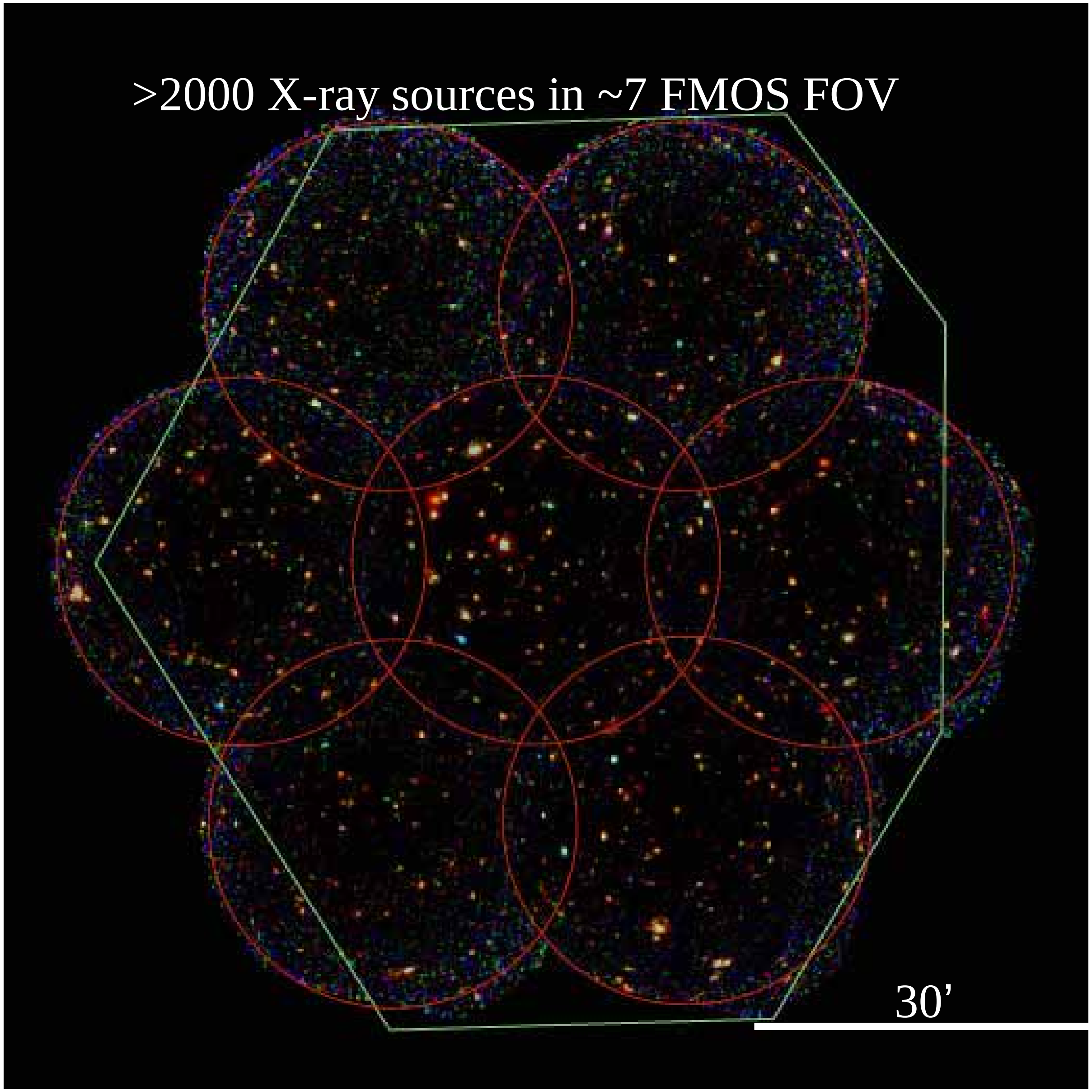
The goal of the SXDS is to provide an accurate census of objects in the early Universe, by imaging to very faint magnitudes over a sufficiently large region to be relatively immune to cosmic variance.

The core of the survey consists of optical imaging with Suprime-Cam on Subaru Telescope and X-ray imaging with the EPIC camera on the ESA XMM-Newton satellite.

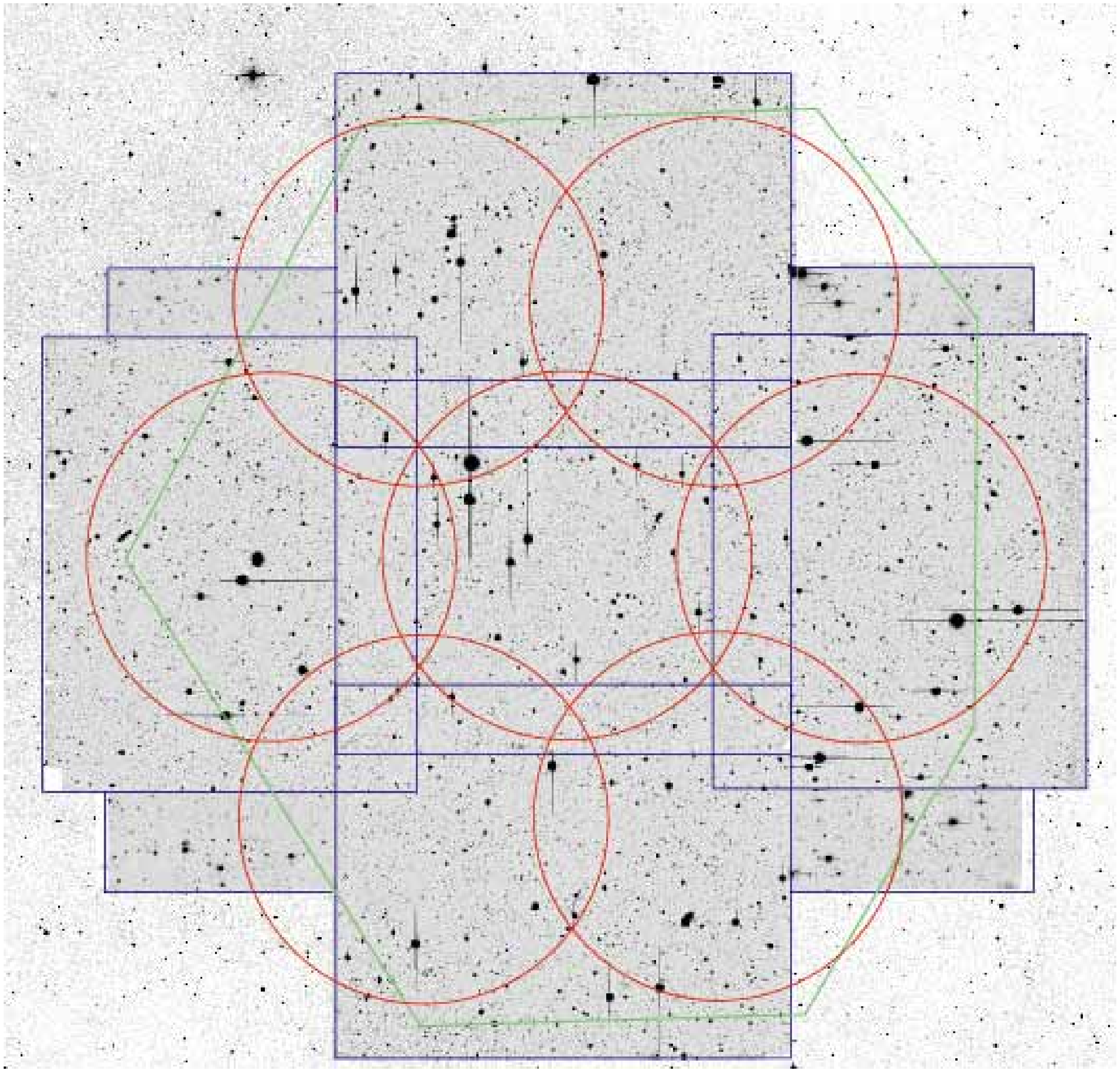
SXDS Field



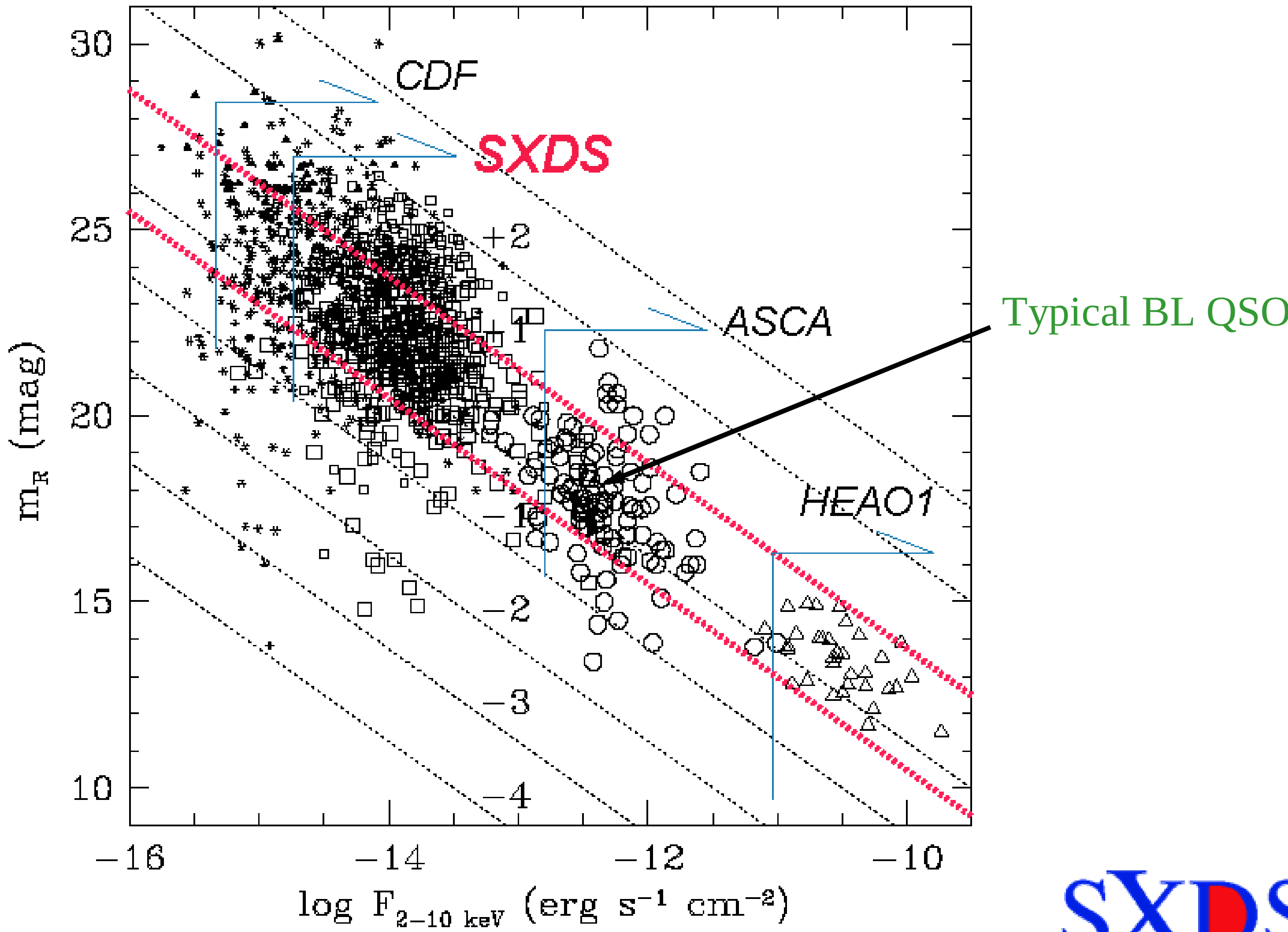
X-ray image



Optical image



Large number of "optically-faint" (f_X / f_R > +1) X-ray sources appear in the deep X-ray surveys.

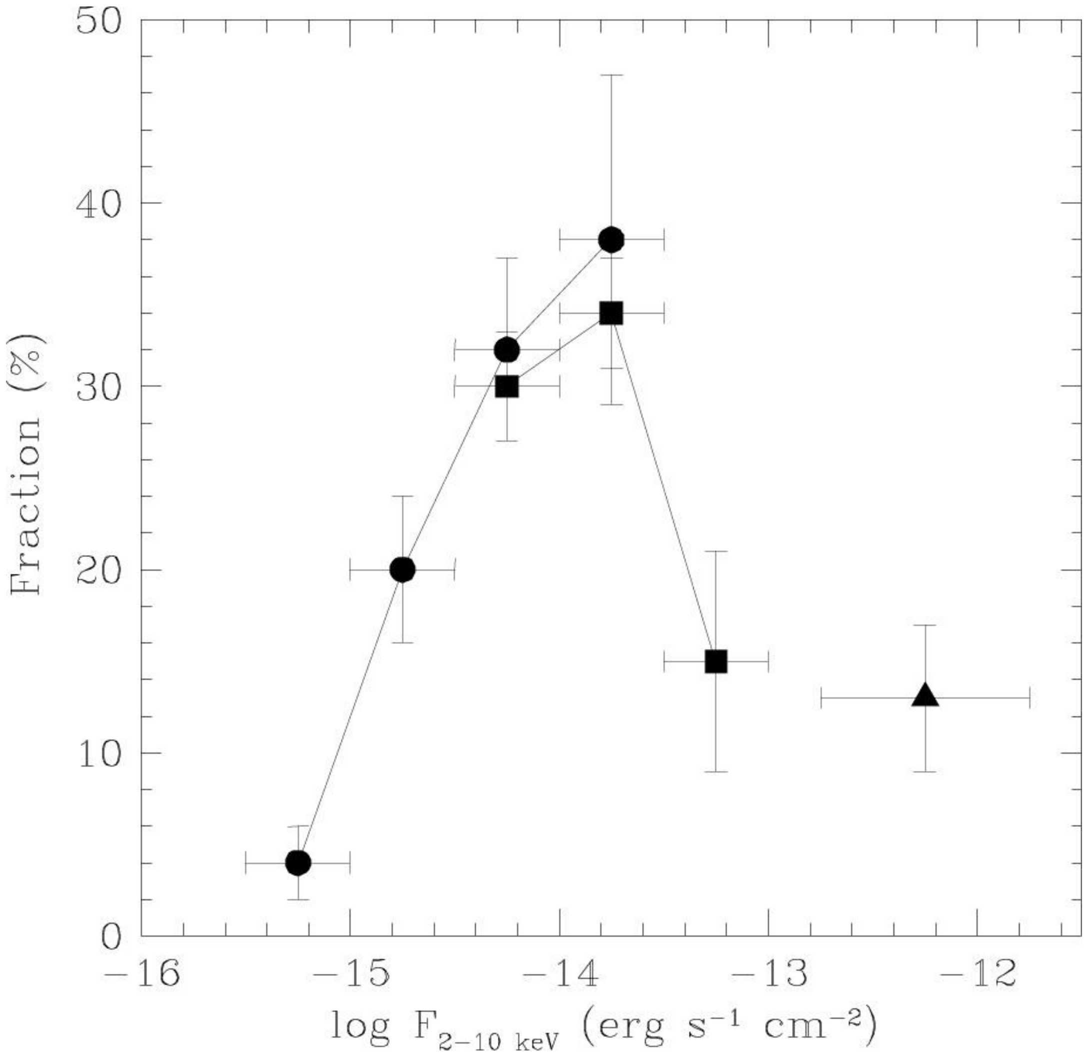


Fraction of the "optically-faint" X-ray sources

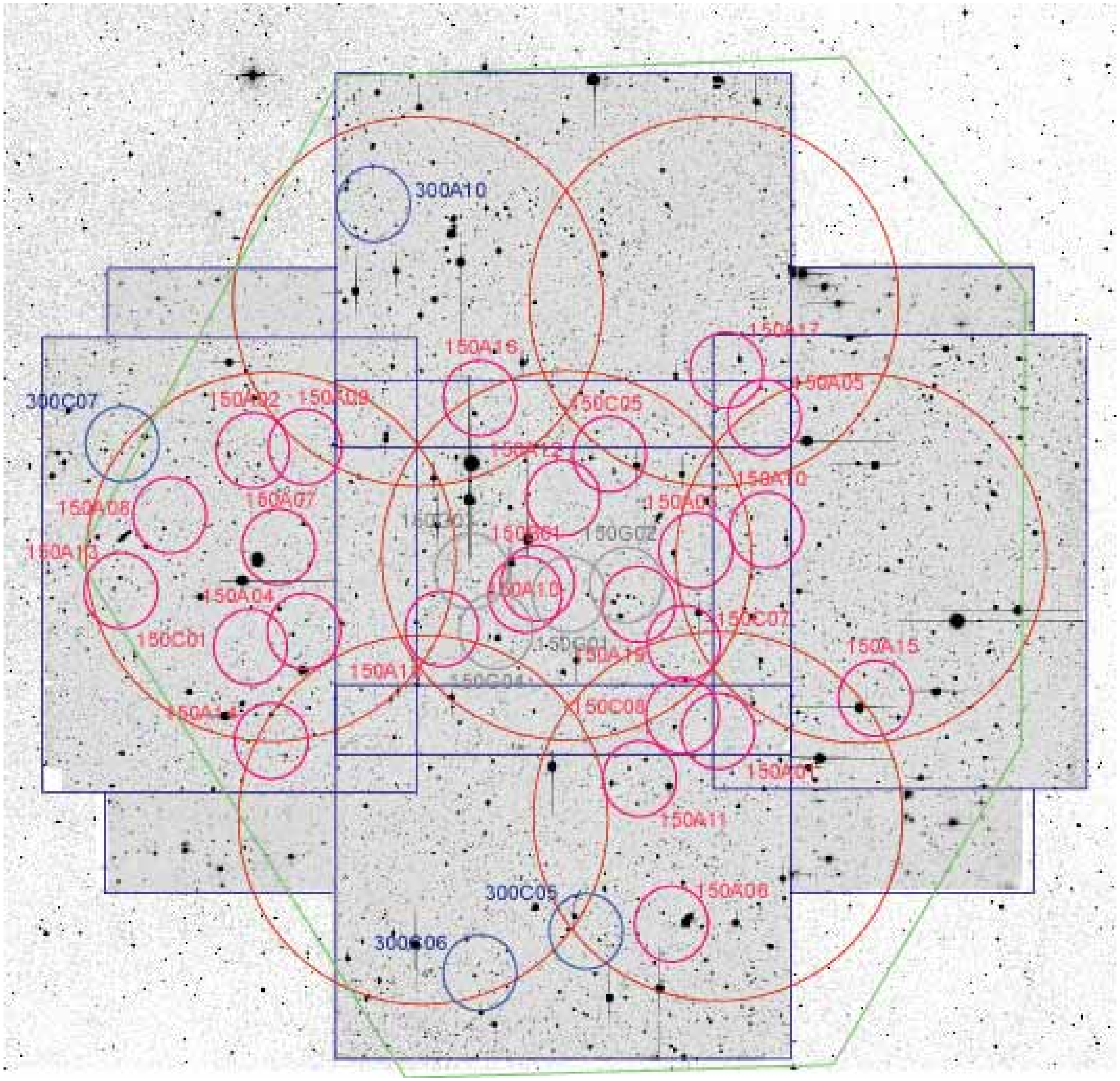
> 30 %

at 10^{-14} erg s^{-1} cm^{-2}

Contribute ~20% of the CXB



Spectroscopic follow-up of the X-ray sources



FOCAS/Subaru observations (small circles)

2dF/AAT observations (entire area)

FOCAS/MOS spectroscopy

S03B: **SX (SXDS), YO (Yamada Open-use), SA (Sekiguchi + Akiyama Obs. Time)**

150+Y47 25 Masks, 300B+Y47 4(+1) Masks

Day		# of Masks Obs.		
Oct. 06, 22:00-28:00	Clear	2	2 x 150	SA
Oct. 27, 23:00-29:00	Cirrus	2	1 x 150, 1 x 300	YO
Oct. 28, 23:45-29:00	Clear	3	3 x 150	YO
Oct. 29, 23:45-29:00	Clouds	2	2 x 150	YO
Oct. 30, 21:00-29:00	Cloud Out			YO
Nov. 26, 23:00-26:00	Cloud Out			SX
Nov. 27, 19:00-26:00	Cloud Out			SX
Nov. 28, 19:00-26:00	Cloud Out			SX
Nov. 29, 19:00-26:00	Cloud Out			SX
Nov. 30, 19:00-26:00	Cloud Out			SX
Dec. 18, 19:00-24:30	Clear	3	3 x 150	SX
Dec. 19, 19:00-24:30	Clear	4	4 x 150	SX
Dec. 20, 19:00-24:30	Clear	3	2 x 150, 1 x 300	SX
Dec. 21, 19:00-24:30	MOS Trouble			SX
Dec. 22, 19:00-24:30	Clear	4	4 x 150	SX
Dec. 23, 19:00-24:30	Clear	3	2 x 150, 1 x 300	SX
Dec. 25, 19:00-24:30	Clear	3	2 x 150, 1 x 300	SA
		(29)		

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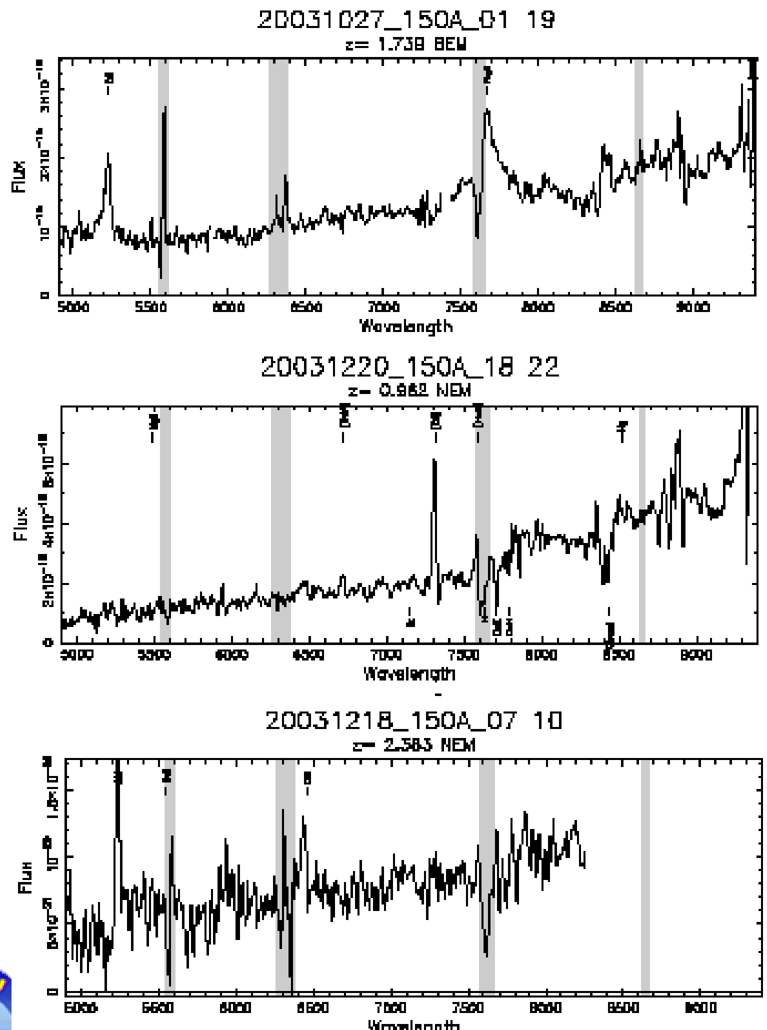
SXDS Subaru/XMM-Newton Deep Survey

Total of 29 masks (+1 FOCAS/MOS pilot obs.)

815 objects are observed, 517 are identified.

	Secure ID (+Less secure ID) / Observed in total
***X-ray Source* :**	**103 (+5) / 119**
***Optical Faint X-ray Source* :**	**43 (+11) / 73**

“optically-faint” X-ray sources = “obscured QSOs”



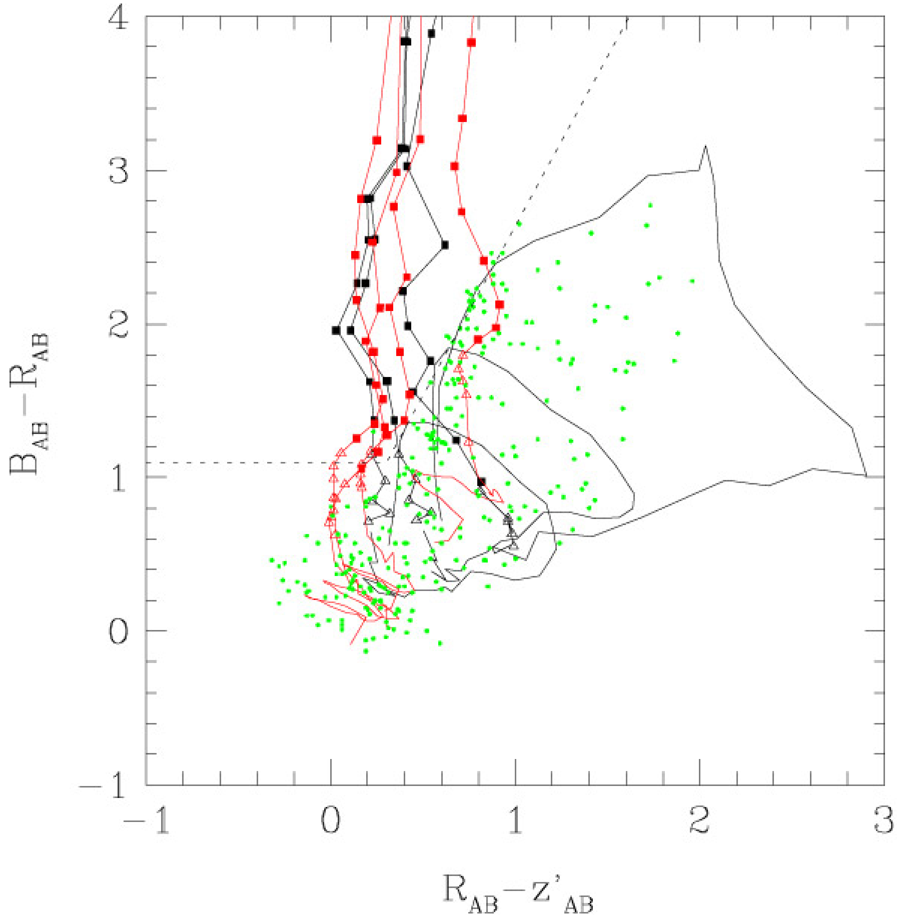
Half of them are identified with obscured QSOs !

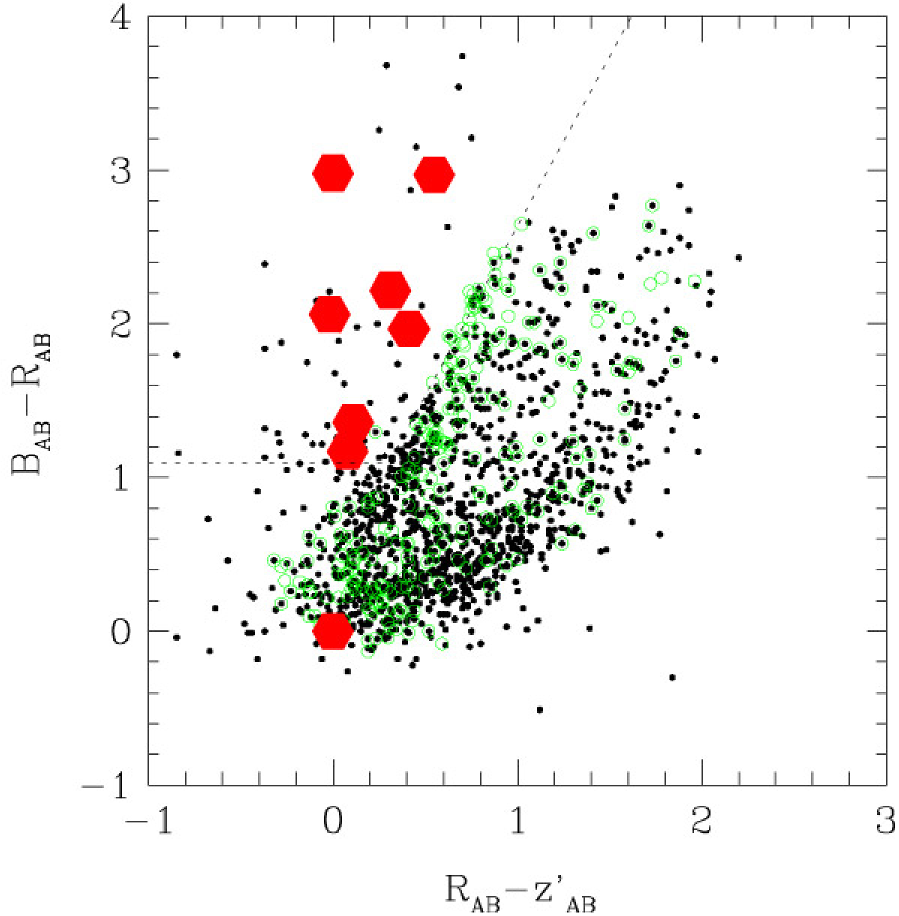
Rest of them could not be identified, because they do not show emission line in the optical band.

SXDS

Are there many obscured AGNs exist
in the early Universe?

z>3 AGN candidates





FOCAS/MOS spectroscopy

S04B: Intensive Program (300 lines/mm)

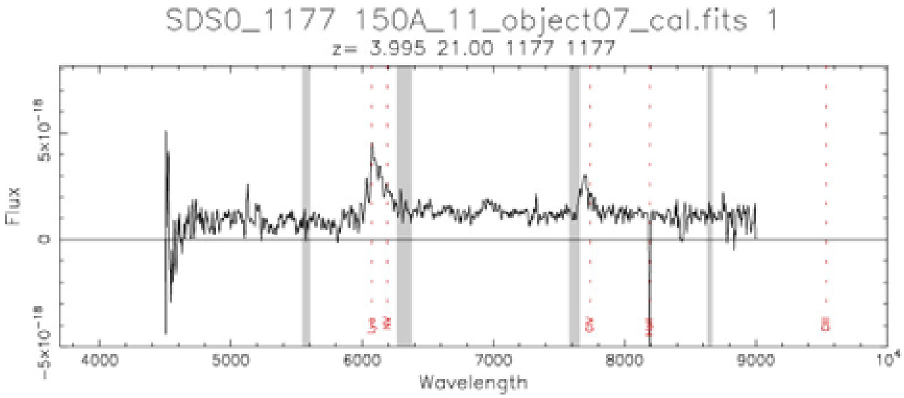
Day		# of Masks Obs.	
Oct. 15	Clear	1	8 x 1,800 sec
Oct. 16	Clear	2	5 x 1,800 sec
			6 x 1,800 sec
Nov. 09	Clear	2	6 x 1,800 sec
			6 x 1,800 sec
Nov. 10	Clear	3	5 x 1,800 sec
			4 x 1,800 sec (150 lines/mm)
			3 x 1,800 sec (150 lines/mm)
Nov. 11	Clear	2	6 x 1,800 sec
			6 x 1,800 sec
Dec. 5	Clear	2	5 x 1,800 sec
			4 x 1,800 sec

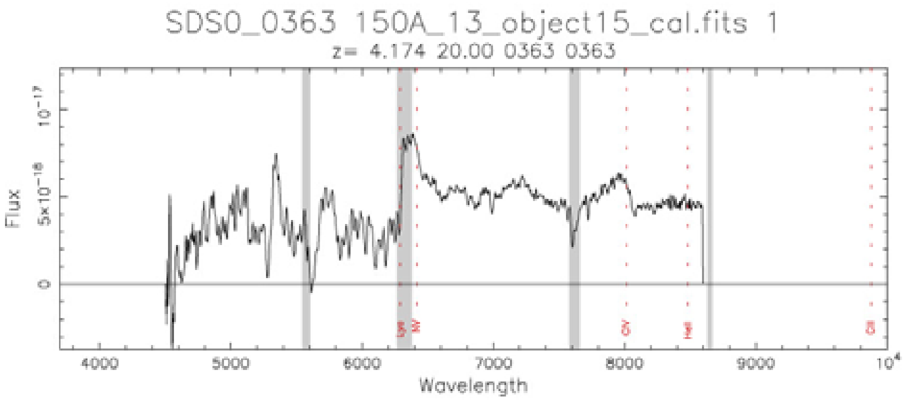
Total of 10 masks (+2 repeat from the previous year)

Plus 5 nights during S05B (Akiyama et al.)
to obtain 12 more masks.

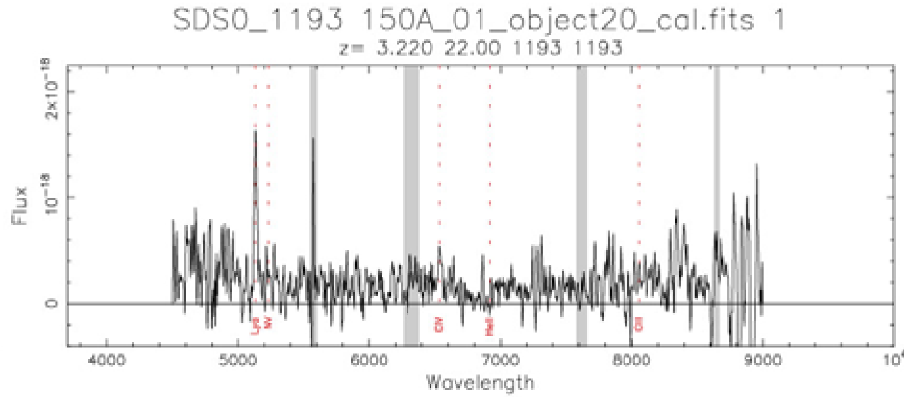
Preliminary results

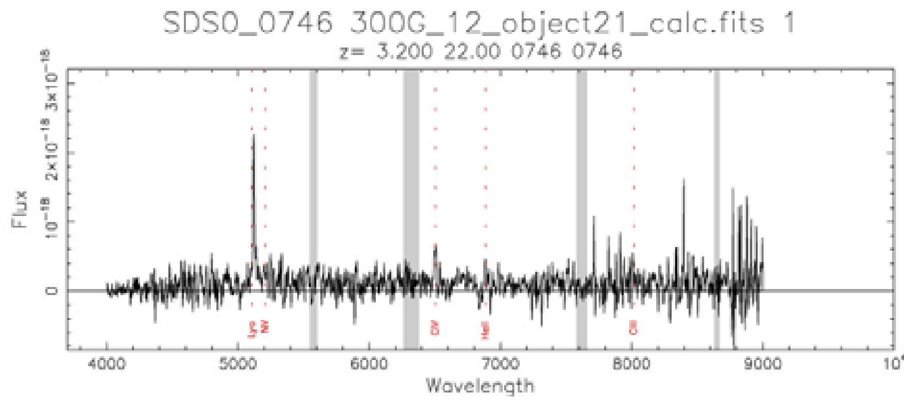
Broad-line AGN





Narrow-line AGN





Preliminary Results

Subaru/FOCAS Spectroscopy of 25 B-drop AGN s
(2003/09 – 2005/11)

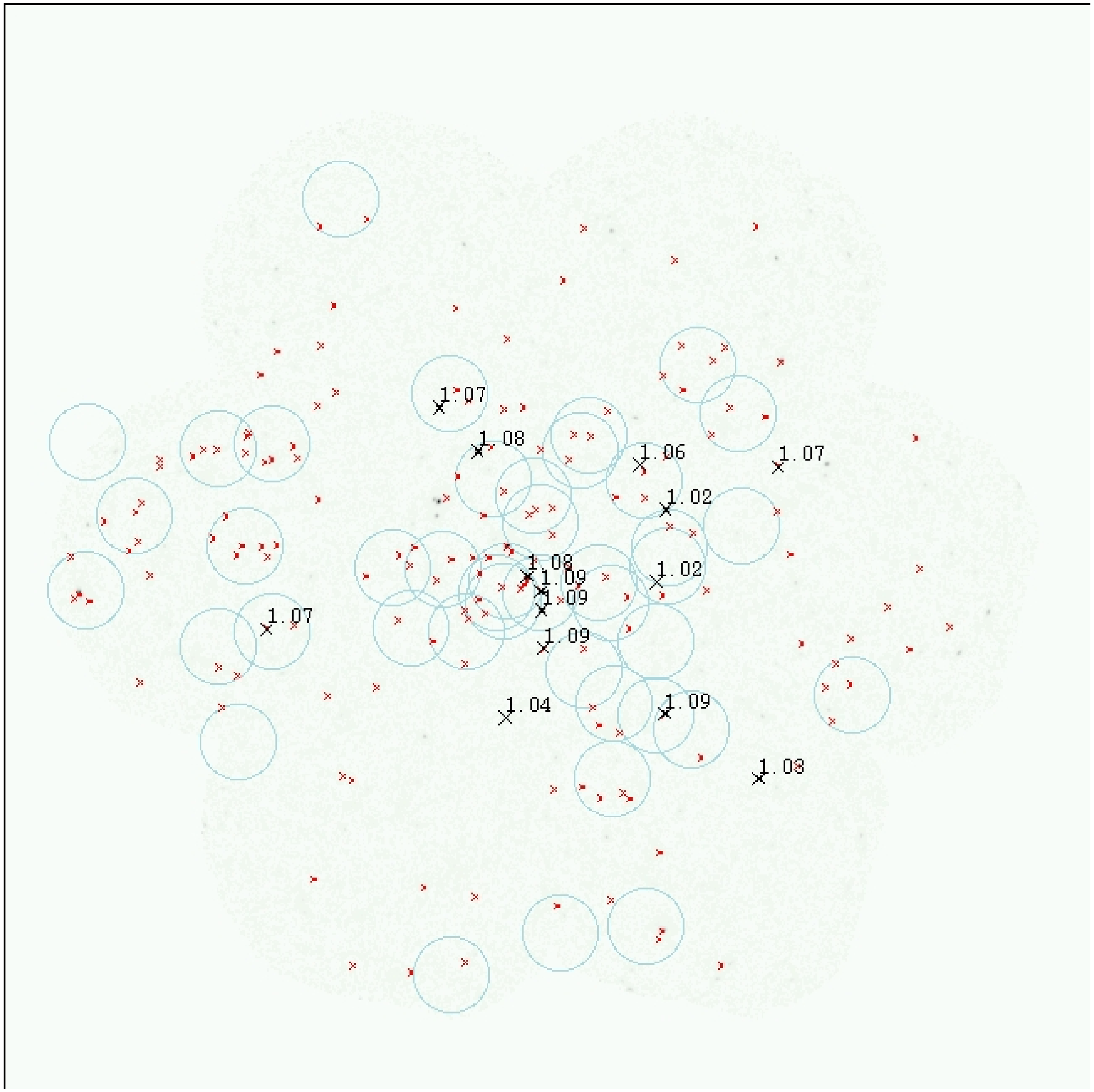
Class A1 : z>3 & Spitzer/IRAC detection	**10**
Class A2 : z>3 & No Spitzer/IRAC detection	**1**
Class B1: Spitzer/IRAC detection (too faint to Obs.)	**2**
Class B2: Spitzer/IRAC detection (ID ? : too faint to Obs.)	**3**
Class C1 : B-drop No EL、Spitzer/IRAC detection	**1**
Class C2 : B-drop No EL、No Spitzer/IRAC detection	**3**
Class D : B-drop foreground object	**3**
Class E : AGN (not the B-drop object)	**2**

Firm z>3 sample = Class A12 = 11 objects
Possible z>3 sample = Class A12 + Class B1 = 13 objects
Maximal = Class A12 + Class B12 + Class C12 = 20 objects

- Redshift distribution shows some peaks.

(Clustering of the AGNs ?)

Large scale (60Mpc) clustering of AGNs @ z~1.0



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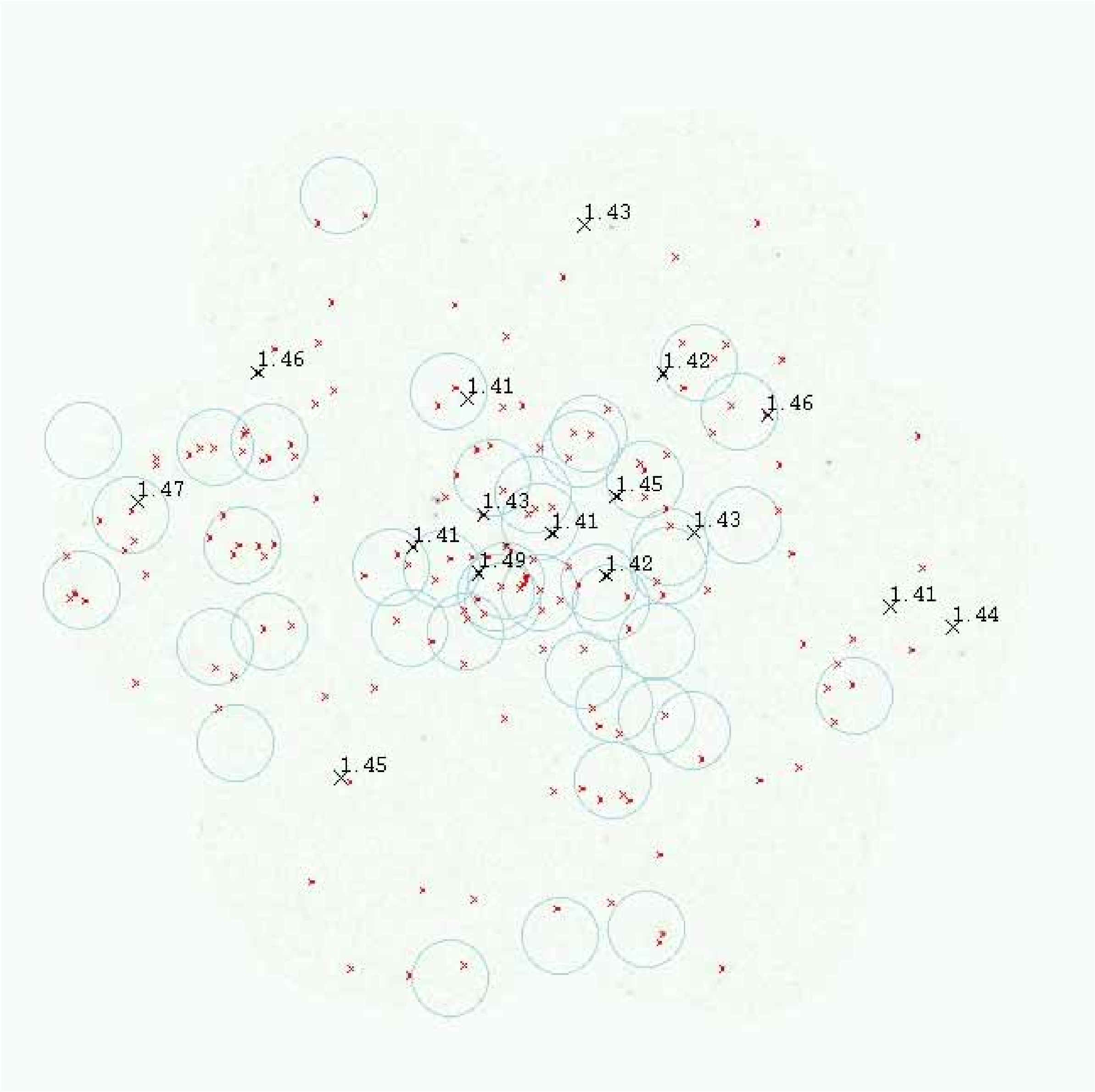
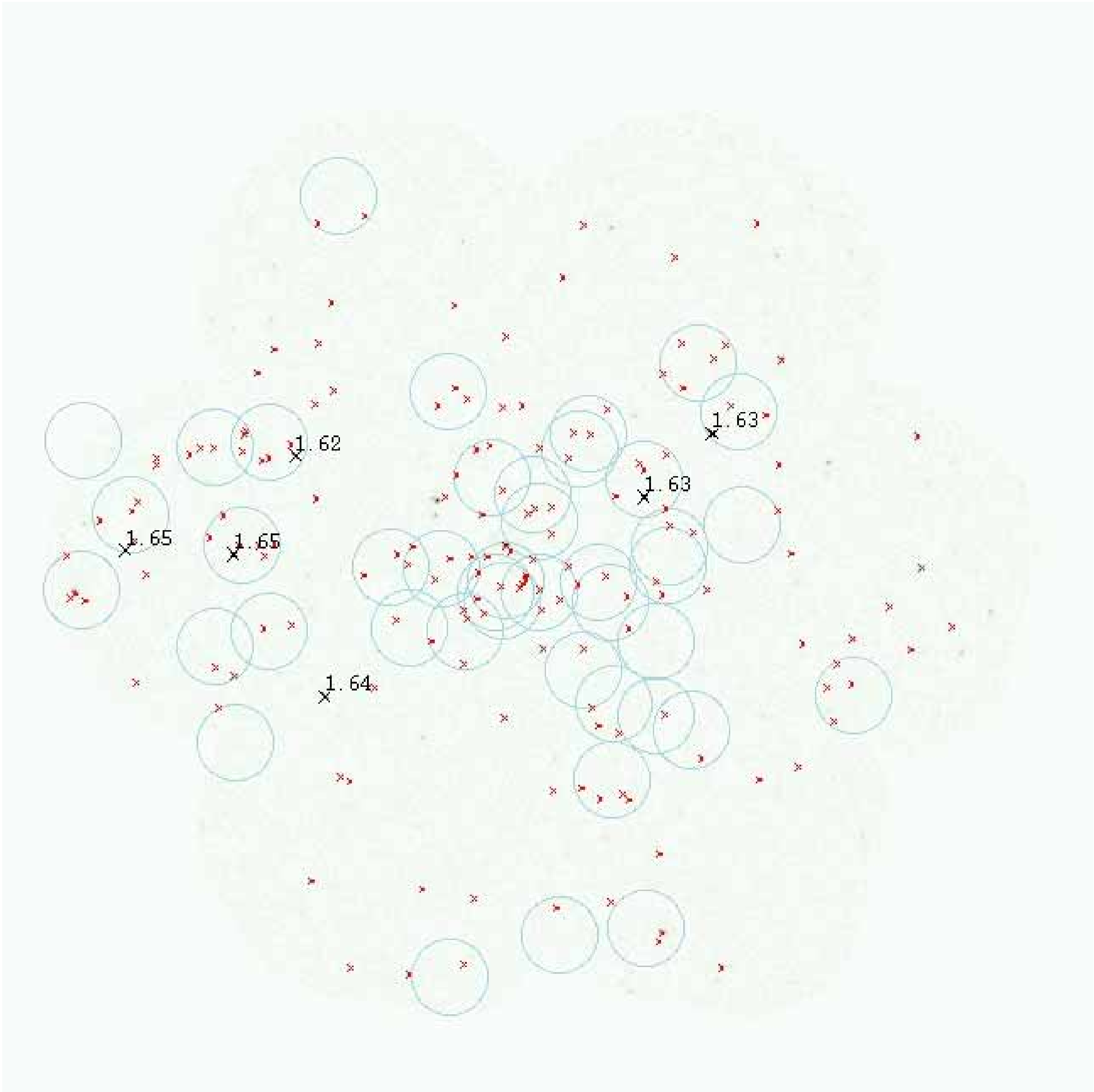
Large scale (60Mpc) clustering of AGNs @ z~1.4



SXDS

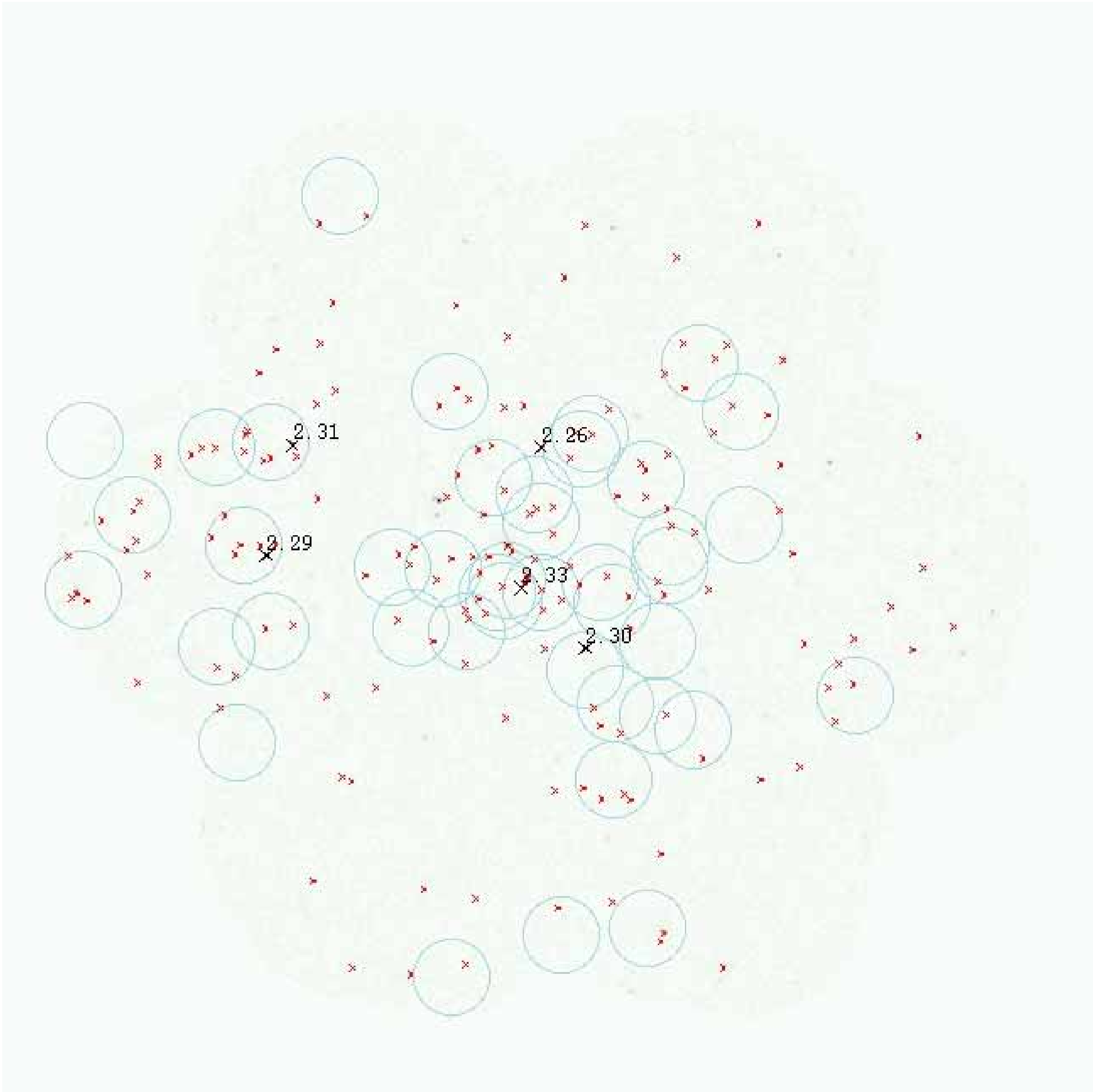
Subaru/XMM-Newton Deep Survey

Large scale (60Mpc) clustering of AGNs @ z~1.6



SXDS

Large scale (60Mpc) clustering of AGNs @ z~2.3



Next step:

VLT/VIMOS Spectroscopy (~60 hours)
Covers entire SXDF

Quantitative analysis on the AGN clustering