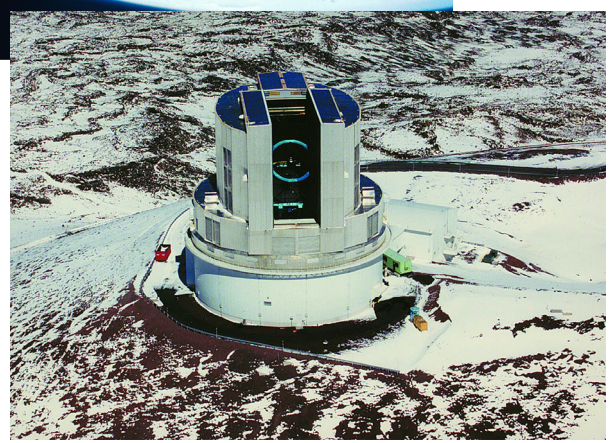
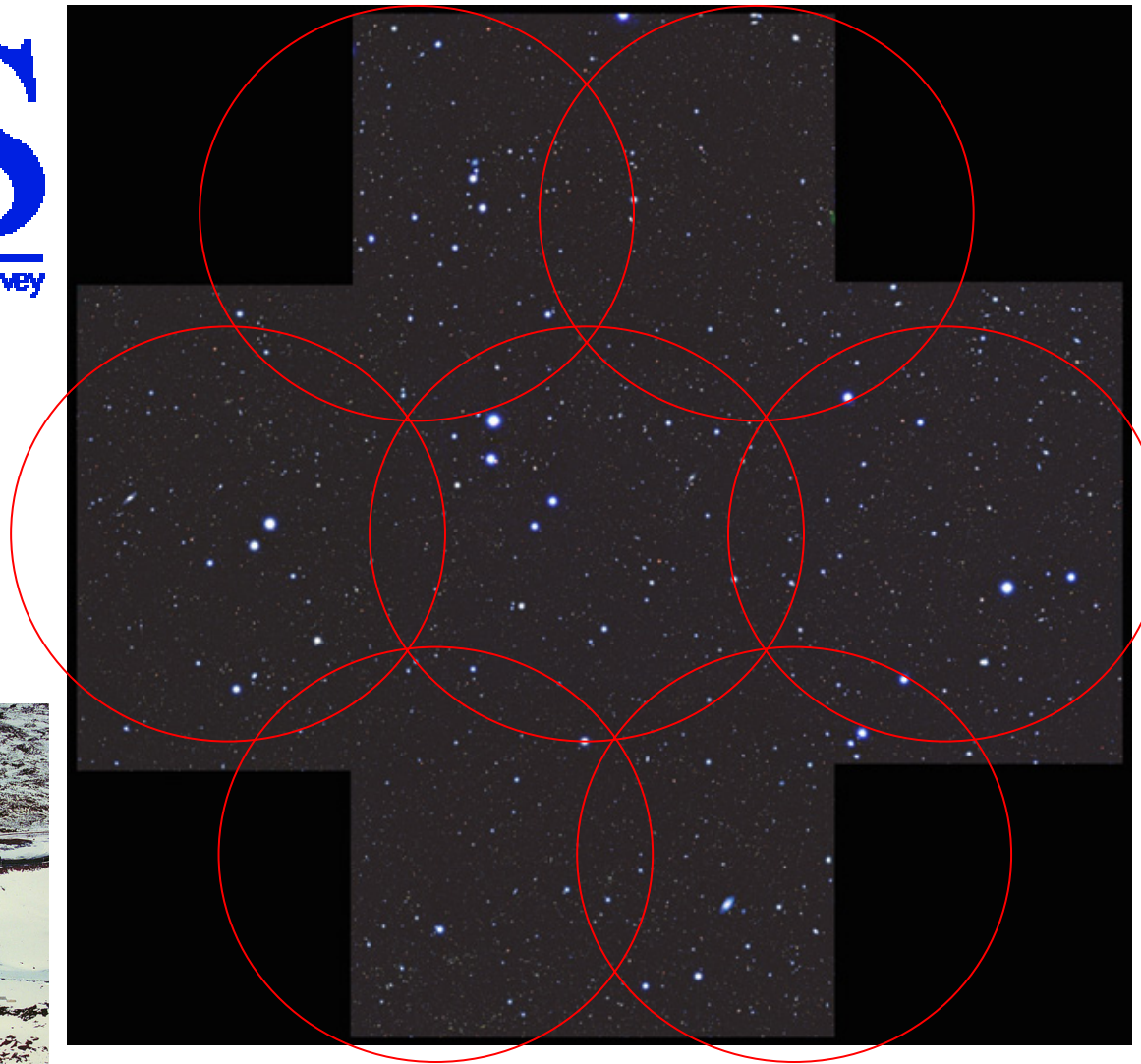
SXDS

Subaru/XMM-Newton Deep Survey





Subaru Telescope Observatory Project

SXDS Team

http://www.naoj.org/science/sxds/index.html

Subaru/XMM-Newton Deep Survey

SXDS

Subaru/XMM-Newton Deep Survey

Today's assignment

1) Background
2) Organization
3) Observations overview
4) Data products
5) Follow-up program
6) Companion program
7) Scientific results

1) Background

A half of the optical observations were taken as a part of Subaru Telescope's "Observatory Key Project".

In 2001, the then-Director of Subaru Telescope, Prof. H. Ando, made the decision to award large fractions of the thelescope time reserved for the people involved in the construction and commissioning of Subaru to large survey projects which would otherwise be unable to receive the amount of telescope time they required.

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.

Also, we hoped the SXDS would be a "seed" for the Further follow-up and extended larger multiwavelength programs.

2) Organization: SXDS Team members

Akiyama M.[1], Aoki K. [1], Doi M.[2], Furusawa H. [1], Furusawa J. [1], Fuse T. [1], Imanishi M. [3], Ishida C. [1], Iye M. [3], Kajisawa K. [1,4], Karoji H. [1], Kobayashi N. [2], Kodama T. [3], Komiyama Y. [3], Kosugi G. [3], Maeda Y. [5], Miyazaki S. [3], Mizumoto Y. [3] Morokuma T[2]. Nakata F. [1,6], Noumaru J. [1], Ogasawara R. [3], Ouchi M. [2,7], Saito T. [2], Sasaki T. [1], Sekiguchi K. [1,3], Shimasaku K. [1], Simpson C. [6,8], Takata T. [3], Tanaka I. [1], Ueda Y. [5,8], Watson M. [9], Yamada T. [1], Yasuda N. [2], & Yoshida M. [10]

[1] Subaru Telescope,
[2] University of Tokyo,
[3] National Astronomical Observatory of Japan,
[4] Tohoku University,
[5] Institute of Space and Astronautical Science
[6] University of Durham
[7] Space Telescope Science Institute
[8] Liverpool John Moores University
[9] University of Leicester (XMM/SSC)
[10] Okayama Astrophysical Observatory

3) Observations overview

The SXDS was initially awarded 15 nights (~90 hours) for four colour (B,Rc,i'&z').

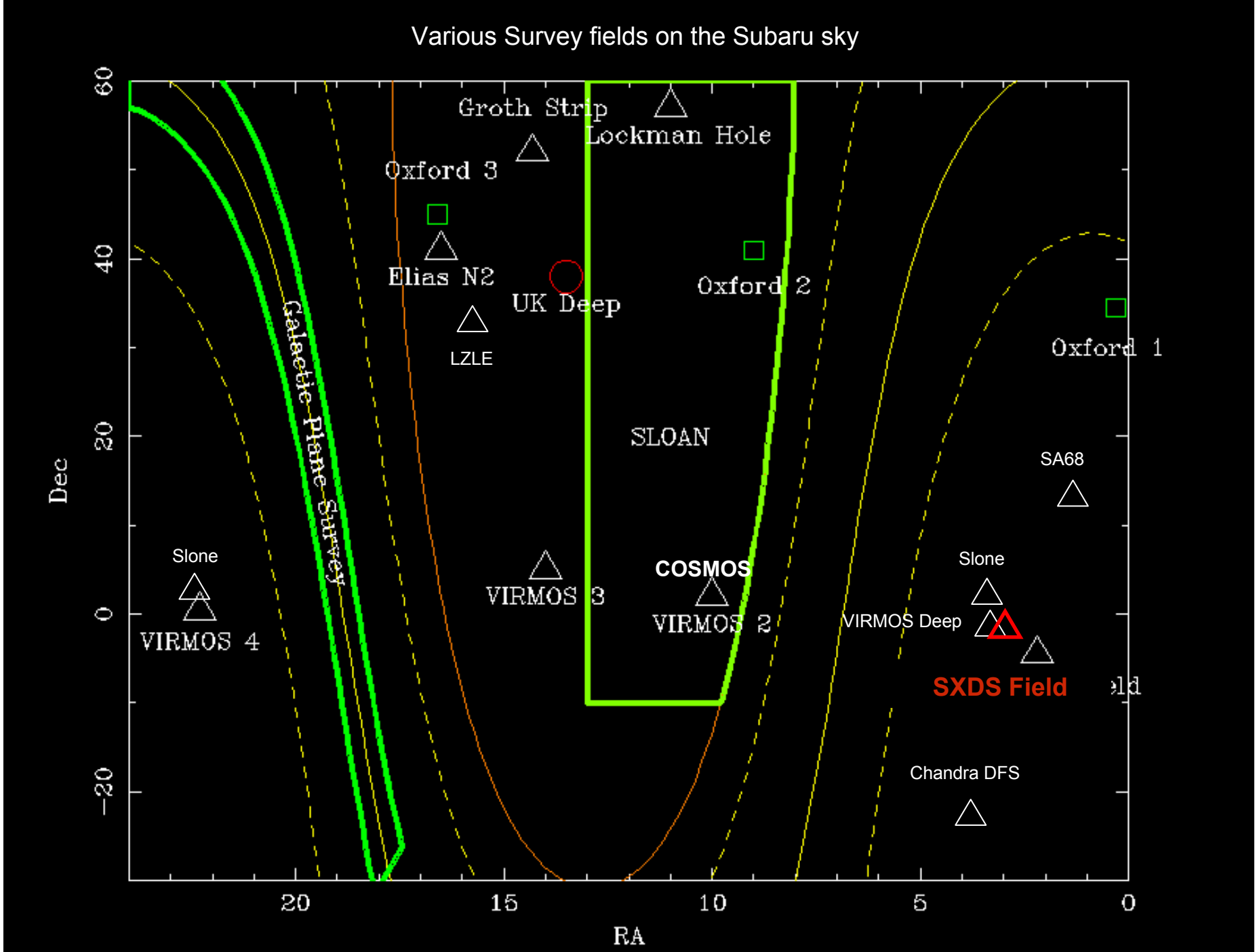
In addition to the Observatory Key Project time, we used various amount of individual observatory staff time, SN Cosmology Project time (Doi et al.:14 hours) and Lyα emitting galaxies program (Ouchi et al.:3 hours) to complete five colour (B,V,Rc,i'&z') imaging.

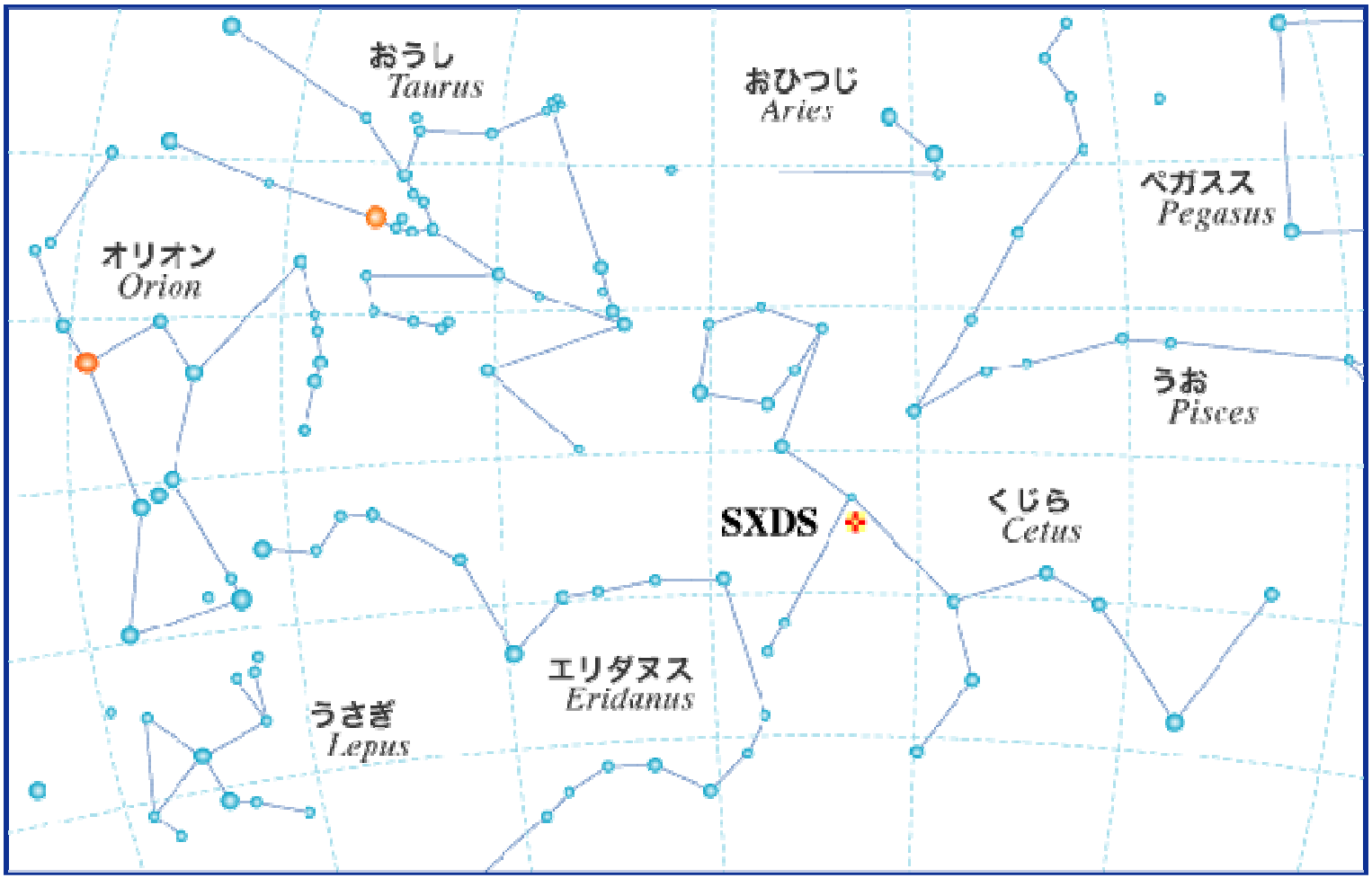
Total allocation was ~177 hours

Of which, 80 hours were lost due to bad weather.

Total usable telescope time for this program was 97 hours.

2002 September – 2005 January


Various Survey fields on the Subaru sky
Groth Strip
Lockman Hole
Oxford 3
Elias N2
UK Deep
Oxford 2
LZLE
Oxford 1
Galactic Plane Survey
SLOAN
SA68
Slone
COSMOS
Slone
VIRMOS 3
VIRMOS 2
VIRMOS Deep
VIRMOS 4
SXDS Field
Chandra DFS
Dec
RA
60
40
20
0
−20
20
15
10
5
0



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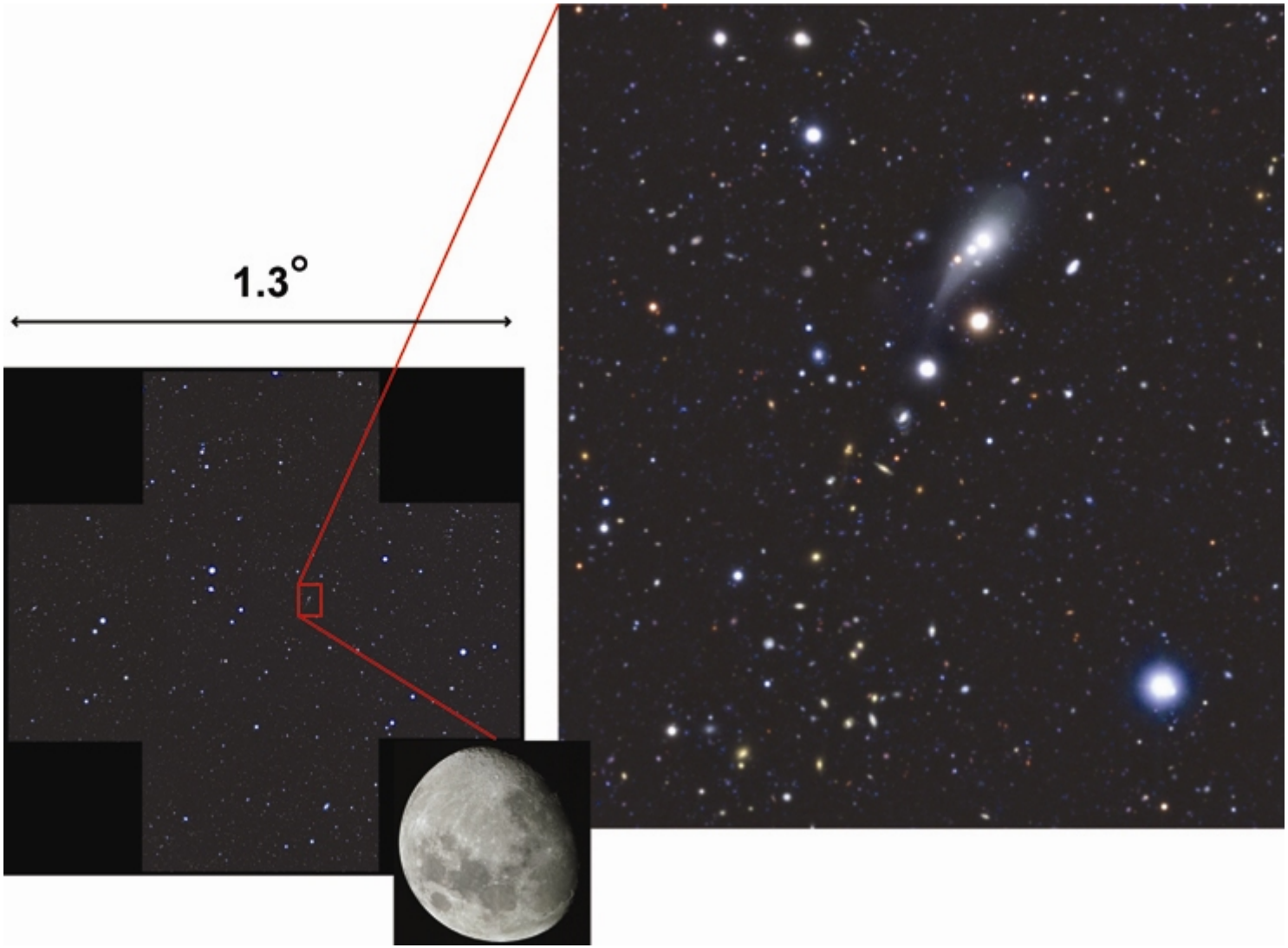
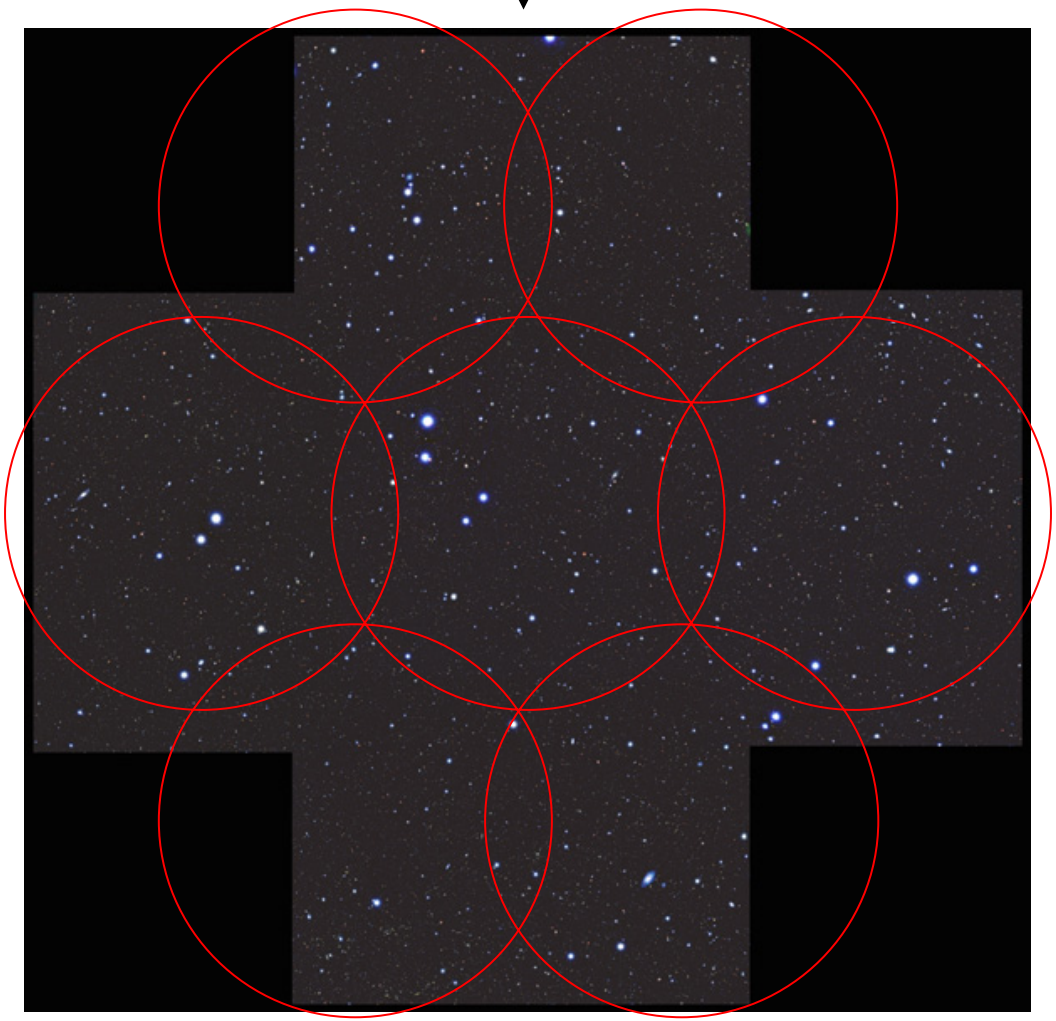


Subaru/XMM-Newton Deep Survey

SXDS Field

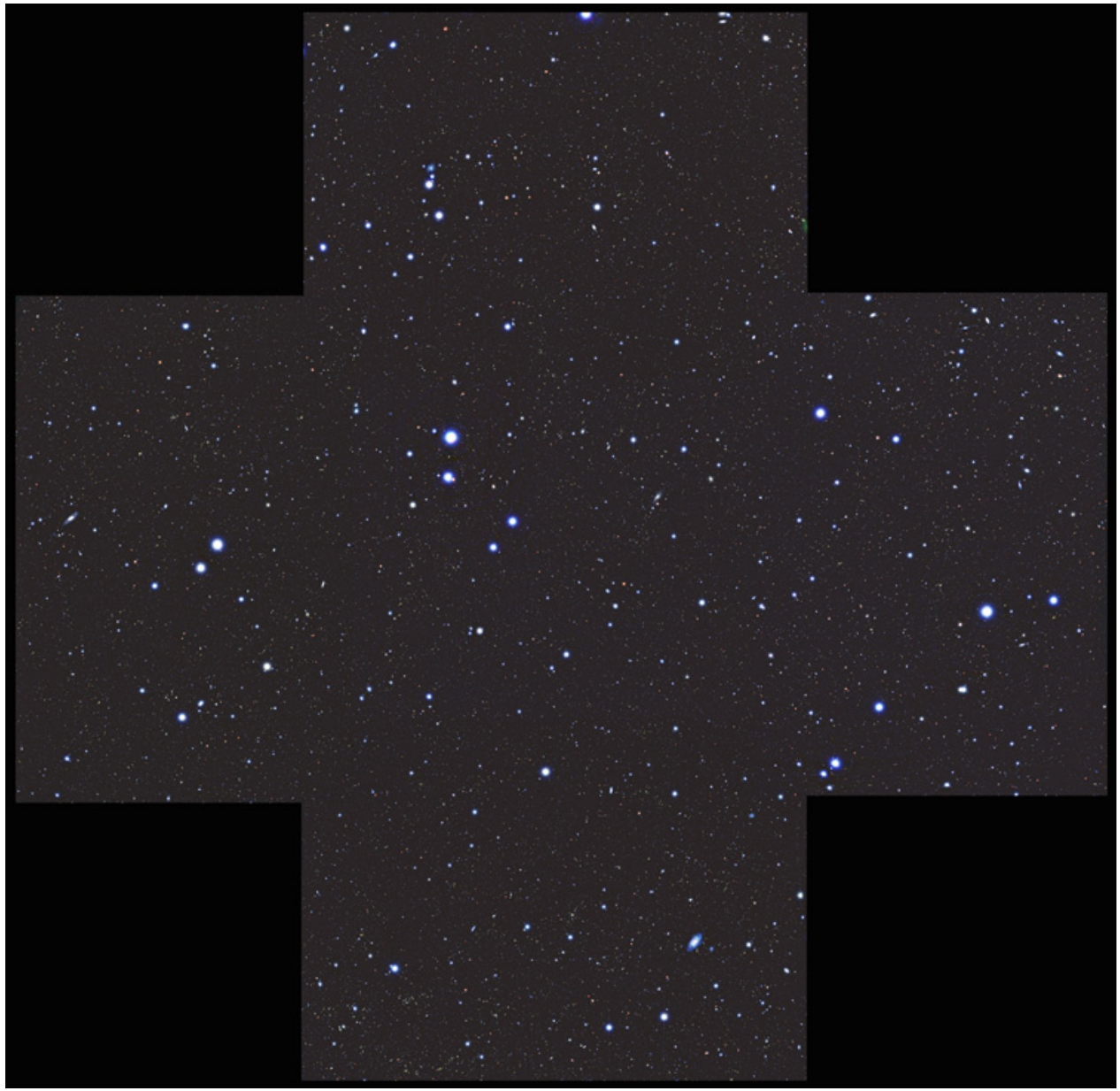
02h18m



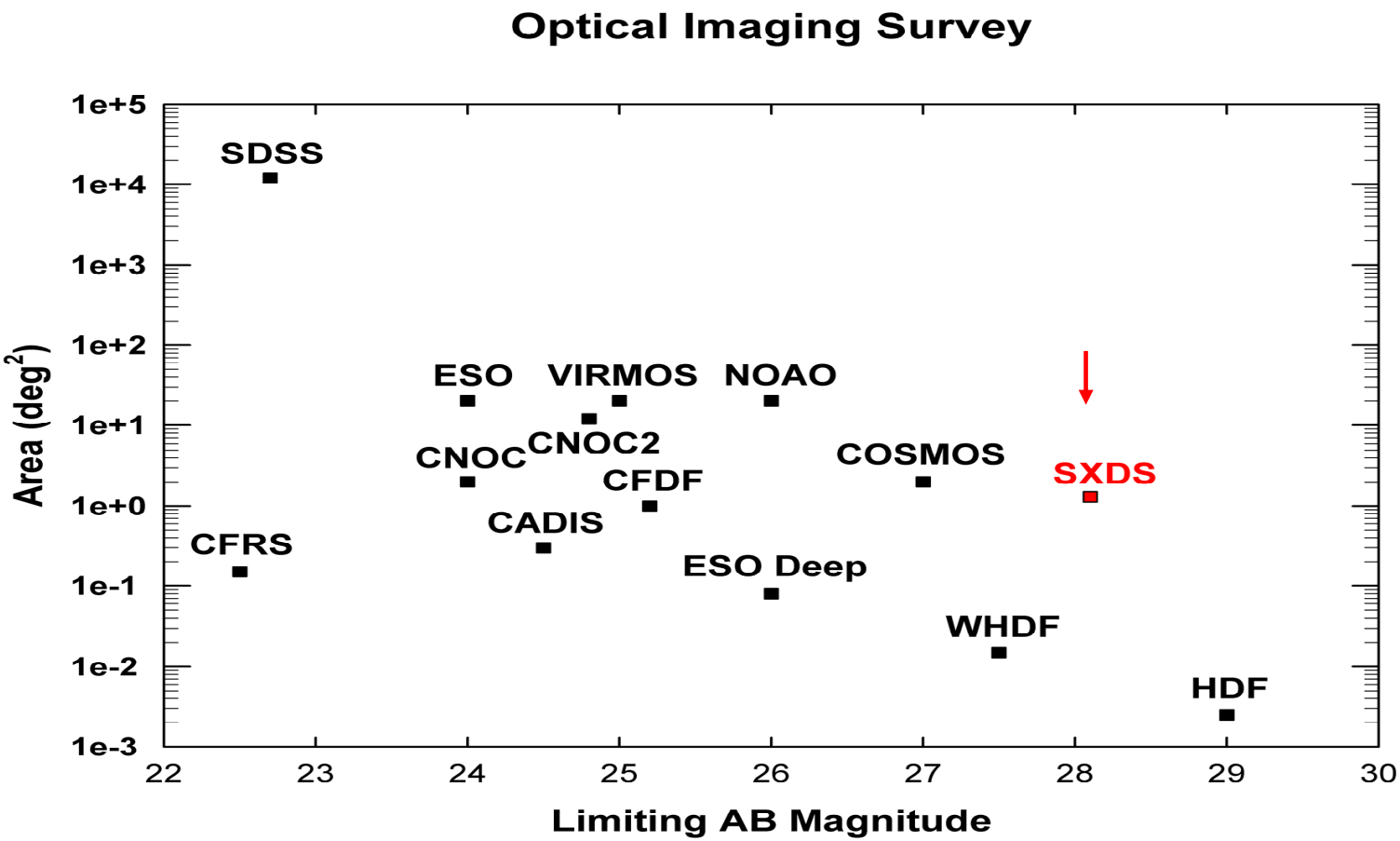
-5°00’ →

1.3°

Subaru/XMM-Newton Deep Survey



Subaru/XMM-Newton Deep Survey



Subaru/XMM-Newton Deep Survey

Major features:

- **Large area -- 1.3 deg^2**

  => cover large scale structures

  transverse dimention of ~ 75 Mpc (comoving) @ z~1
  (~145 Mpc @ z~3)
  covers a volume of ~3.8^{7}Mpc^3 to z~3

- **Deep imaging (B_{AB} = 28.2 mag, K'_{AB} = 24.9 mag, 5σ)**

  => L* galaxies at z < 3

  => ~10^6 galaxies. A statistically sound, large volume and large number of high redshift sample of various different classes of objects.
  (Do not suffer from limited source statistics and cosmic variance, also by low detectability of rare objects like the luminous high z AGNs.)

Subaru/XMM-Newton Deep Survey

Major features (2):

- **Deep X-ray (by XMM/Newton) and VLA Imaging**

  => cover the obscured AGNs

  Unbiased tracers of SMBH/Host Galaxy to study "Co-evolution"

- **Sub-mm Imaging by SCUBA (SHADES) and BLAST**

  => Cosmic history of massive dust enshrouded star-formation activity.

  => Investigate the clustering properties of sub-mm galaxies to determine whether they could be progenitors of present-day massive ellipticals.

  => Investigate the fraction of sub-mm galaxies that harbour AGN

Subaru/XMM-Newton Deep Survey

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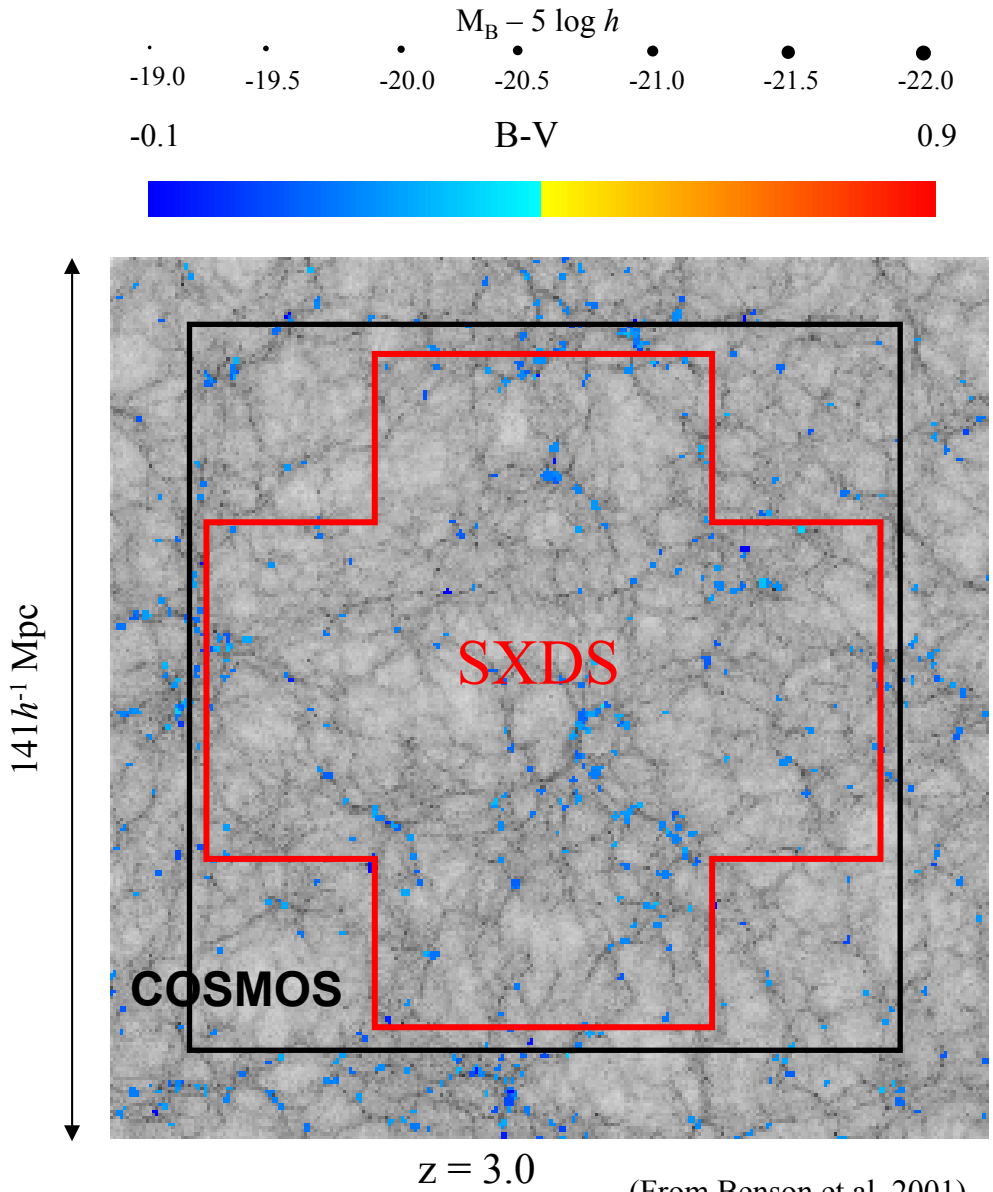


(From Benson et al. 2001)

Subaru/XMM-Newton Deep Survey

Optical Imaging by Subaru Suprime-Cam

The SXDS covers 5 Suprime-Cam pointings (1.3 deg^2) to the exposure time (estimated depth) :

B=28.4 (AB, s/n=3 σ , ϕ =2")

V=27.8

Rc=27.7

***i*'=27.7**

***z*'=26.6**

4) Data products

Data Release

2003/04/05 Beta-version released to Subaru project members
(*on http://www1.naoj.org/science/sxds/public or http://sbrprj.dc.nao.ac.jp/sxds/web/index.html*)
2003/06 Beta-version released to Japanese astronomers
2003/10 Beta-version release to world wide (on access policy)
2005/03 Ver. 1.0 released to Japanese astronomer
2007/02 Ver. 1.0 released to world wide
(no access restriction)

5) Follow-up program

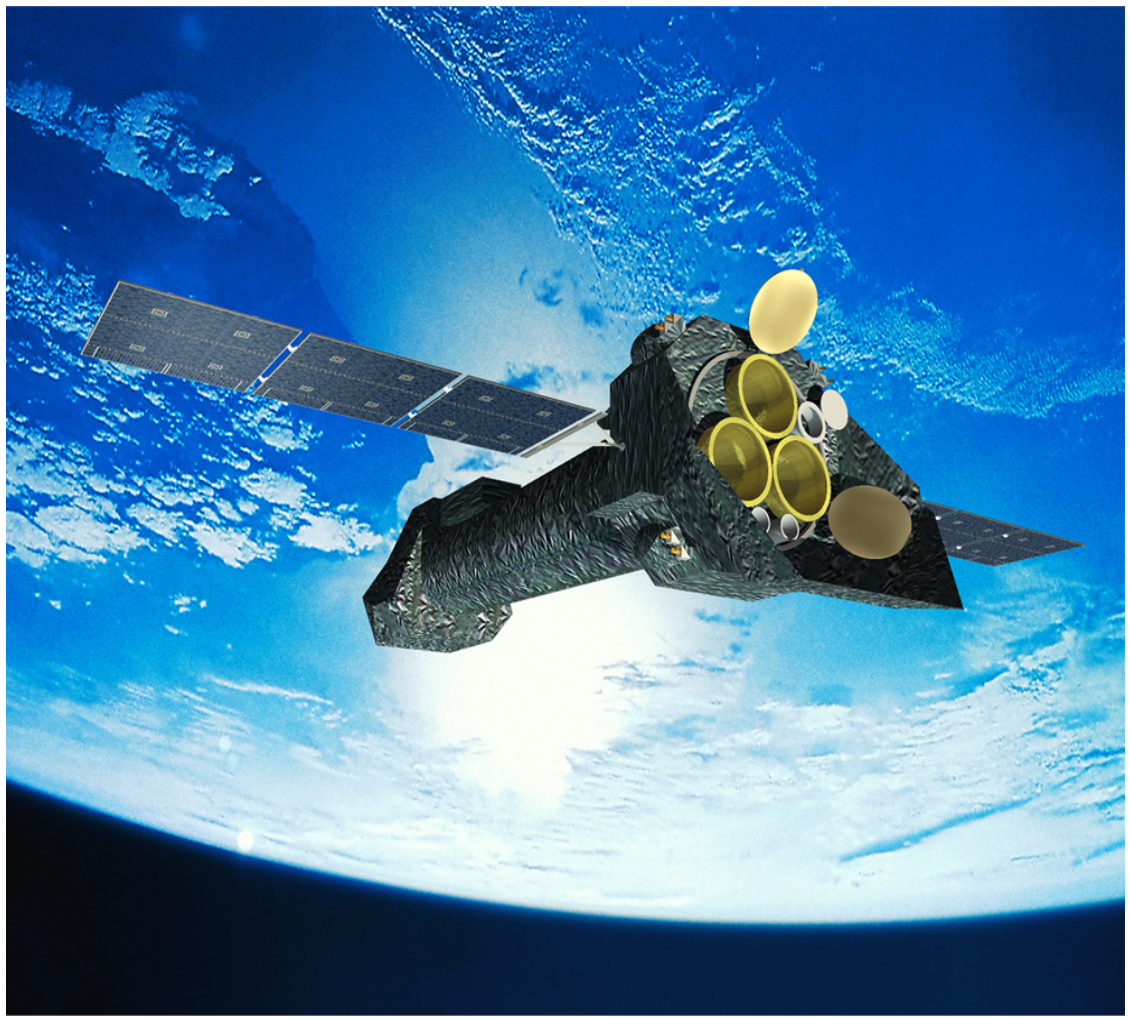
- Subaru FOCAS & AAT 2dF Spectroscopy
  2,000 objects spanning 0.0< z <5.7
  (Akiyama, Simpson, Sekiguchi, Saito, et al.,)

- Subaru narrow-band NB815 and NB921 imaging to isolate Lyman-emitters at z ' 5.7 and z ' 6.6 (Ouchi et al 2005)

- High-resolution VLA mosaic, reaching 1.4GHz = 6 μJy beam-1 at 1.4 GHz, (Simpson et al. 2006)

- Deep 610-MHz image from GMRT(Rawlings, et al.)

6) Companion program



XMM-Newton X-ray Observatory

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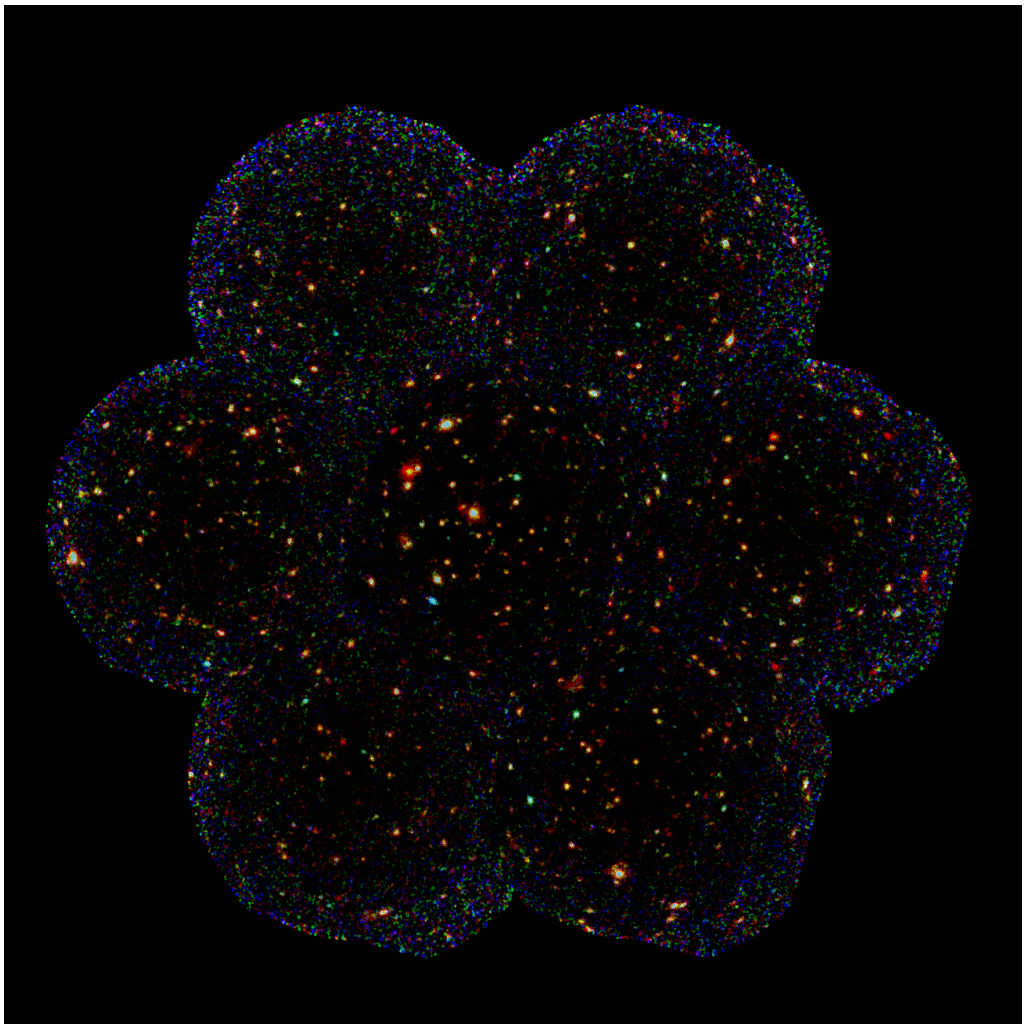
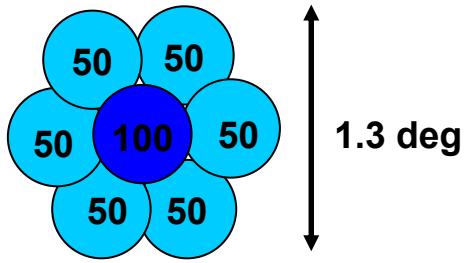
x-ray





400 ksec of EPIC data from XMM/Newton:

100 ksec on central field

50 ksec on 6 flanking fields

Subaru/XMM-Newton Deep Survey

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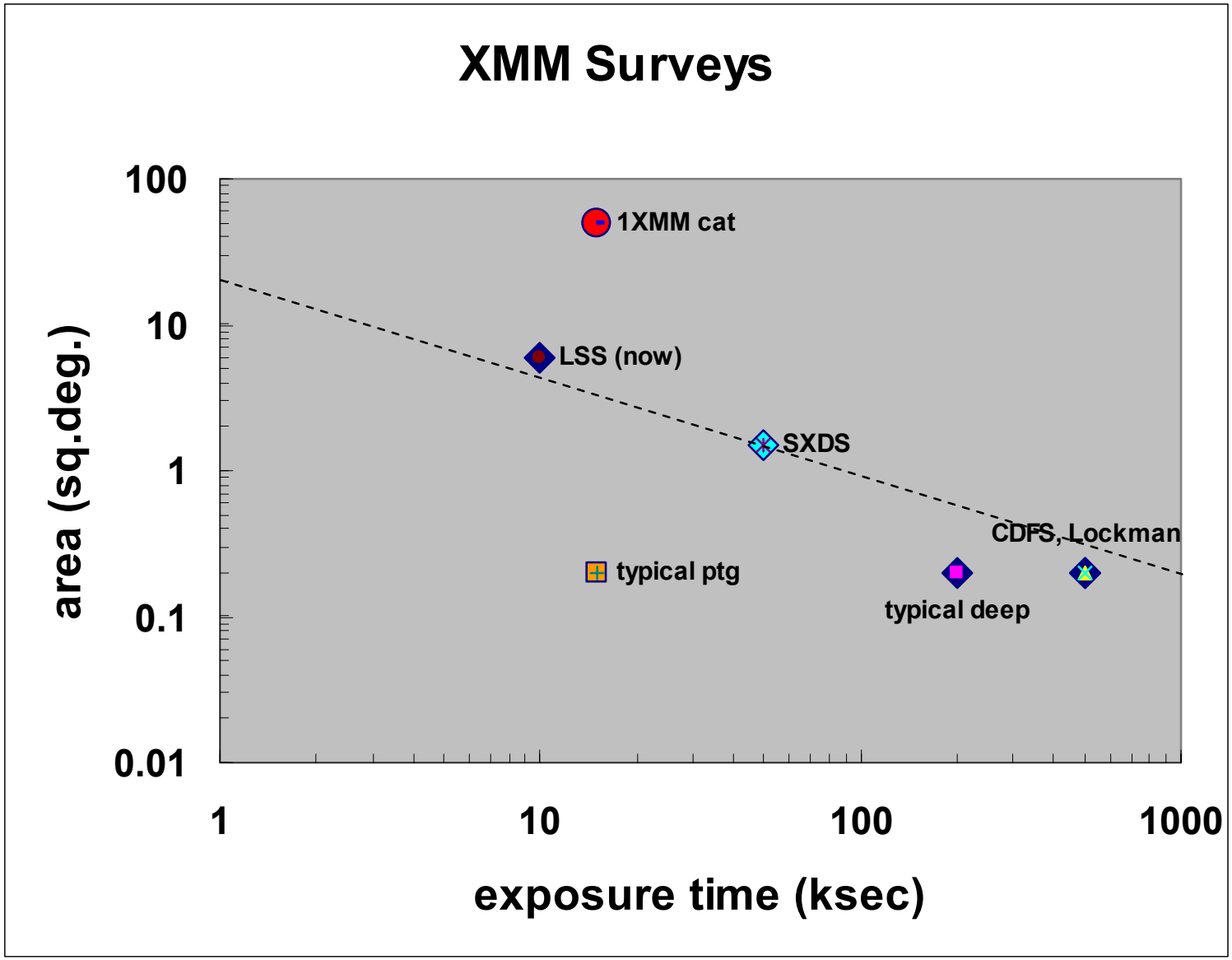

Subaru/XMM-Newton Deep Survey

Multiwavelength Observations

- XMM-Newton (XMM/SSC)

1×10^{-18} W/m^2 (0.5 – 2 keV)

- UKIRT/WFCAM (UKIDSS/UDS)

296 nights of UKIRT/WFCAM time

DR1: 0.77 deg^2 JHK (K=24, AB 5σ)

This is already as deep as the GOODS CDFS VLT-ISAAC data-set, but cover an area 20 times larger.

The final depth will be J=26.5, H=25.5 and K=25 (AB 5σ)

Matching the deepest near-IR surveys (Franx et al. 2003) but a 1,000 x in area by 2010.

c.f. The Ultra-VISTA Survey of the COSMOS field cannot reach this depth until 2013.

Subaru/XMM-Newton Deep Survey

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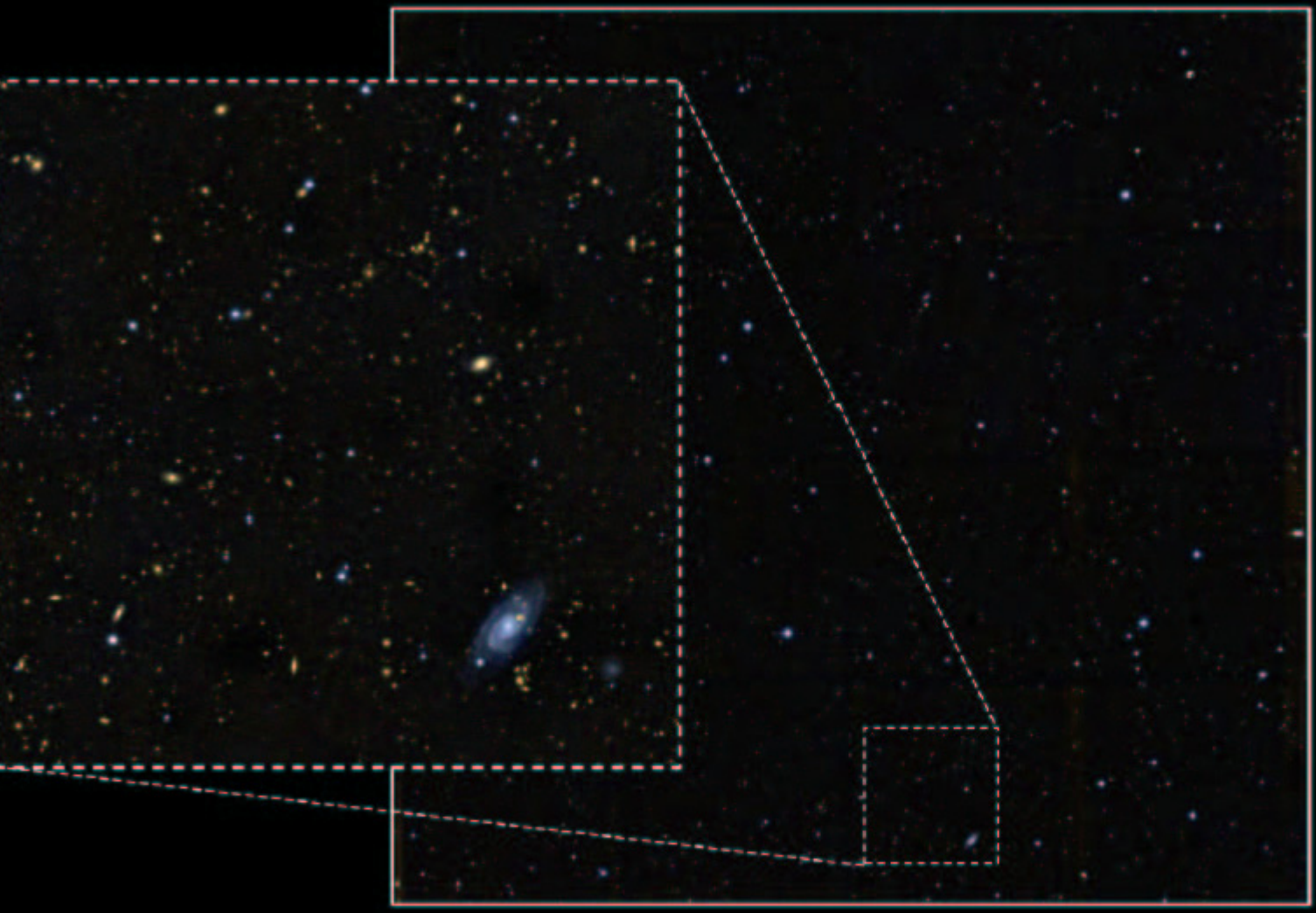
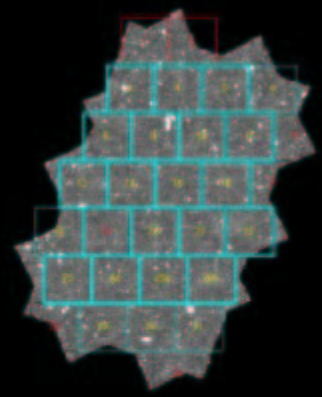
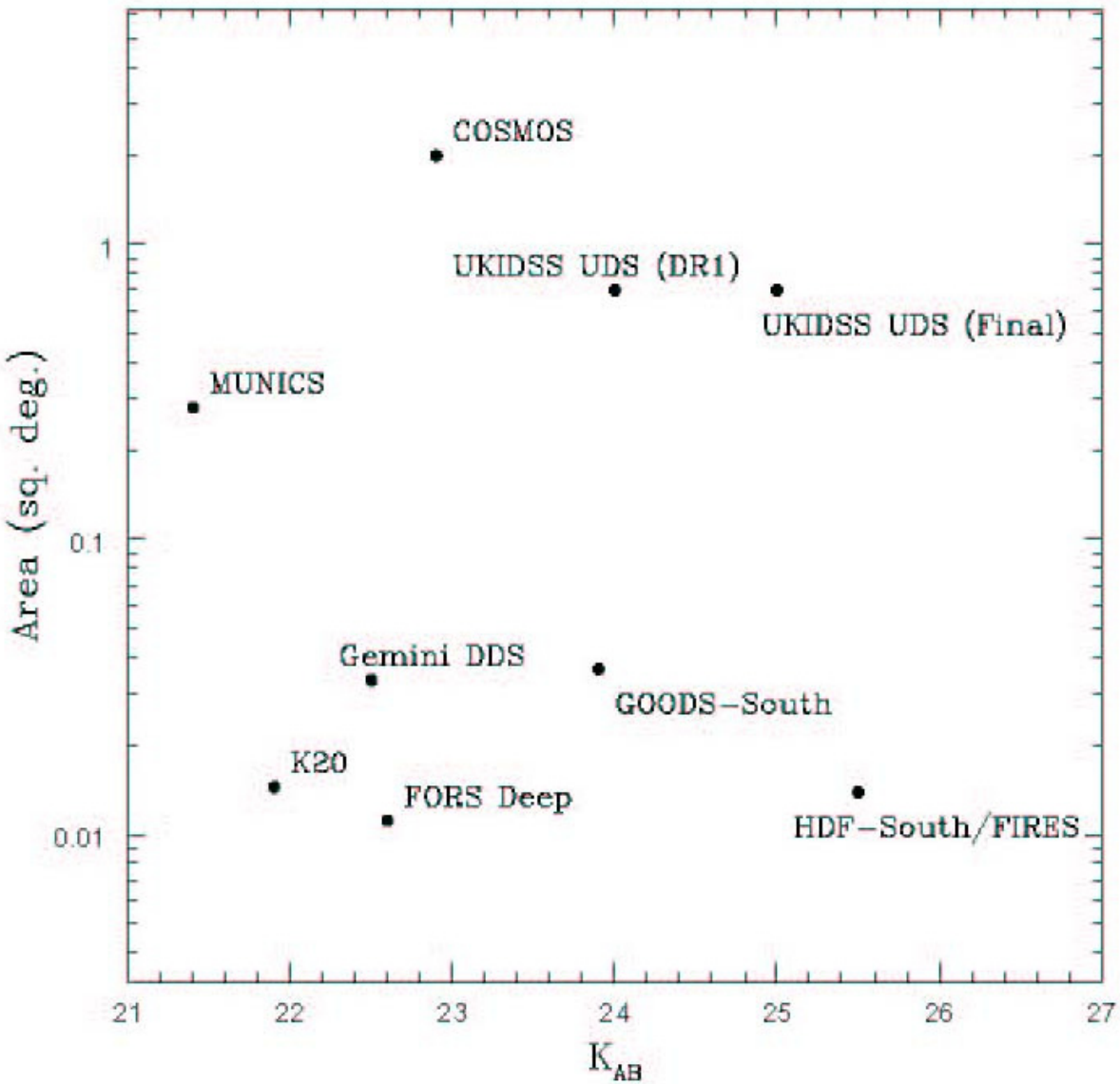


UKIDSS UDS



GOODS

FIRES


COSMOS
UKIDSS UDS (DR1)
UKIDSS UDS (Final)
MUNICS
Gemini DDS
GOODS−South
K20
FORS Deep
HDF−South/FIRES
Area (sq. deg.)
1
0.1
0.01
21
22
23
24
25
26
27
K_AB

Multiwavelength

- Spitzer (SWIRE)

IRAC and MIPS data, but they are very shallow (120s & 80s)
There is a plan to go deeper (see below).

- CSO : 350μ Obs. Just started
- JCMT/SCUBA (SHADES)

850 & 450 micron, 400 sq arcmin
60 sub-mm objects.
SCUBA-2 Legacy Survey (see below)

- AzTEC 1.1μm, 0.2 sq deg^{-1}, 1.3 mJy

25 objects

- VLA

1.4 GHz, σ=6μJy beam^{-1}

- GMRT

610-MHz, deepest mapping ever made

Subaru/XMM-Newton Deep Survey

SXDS
Subaru/XMM-Newton Deep Survey

Multiwavelength: (Planned)

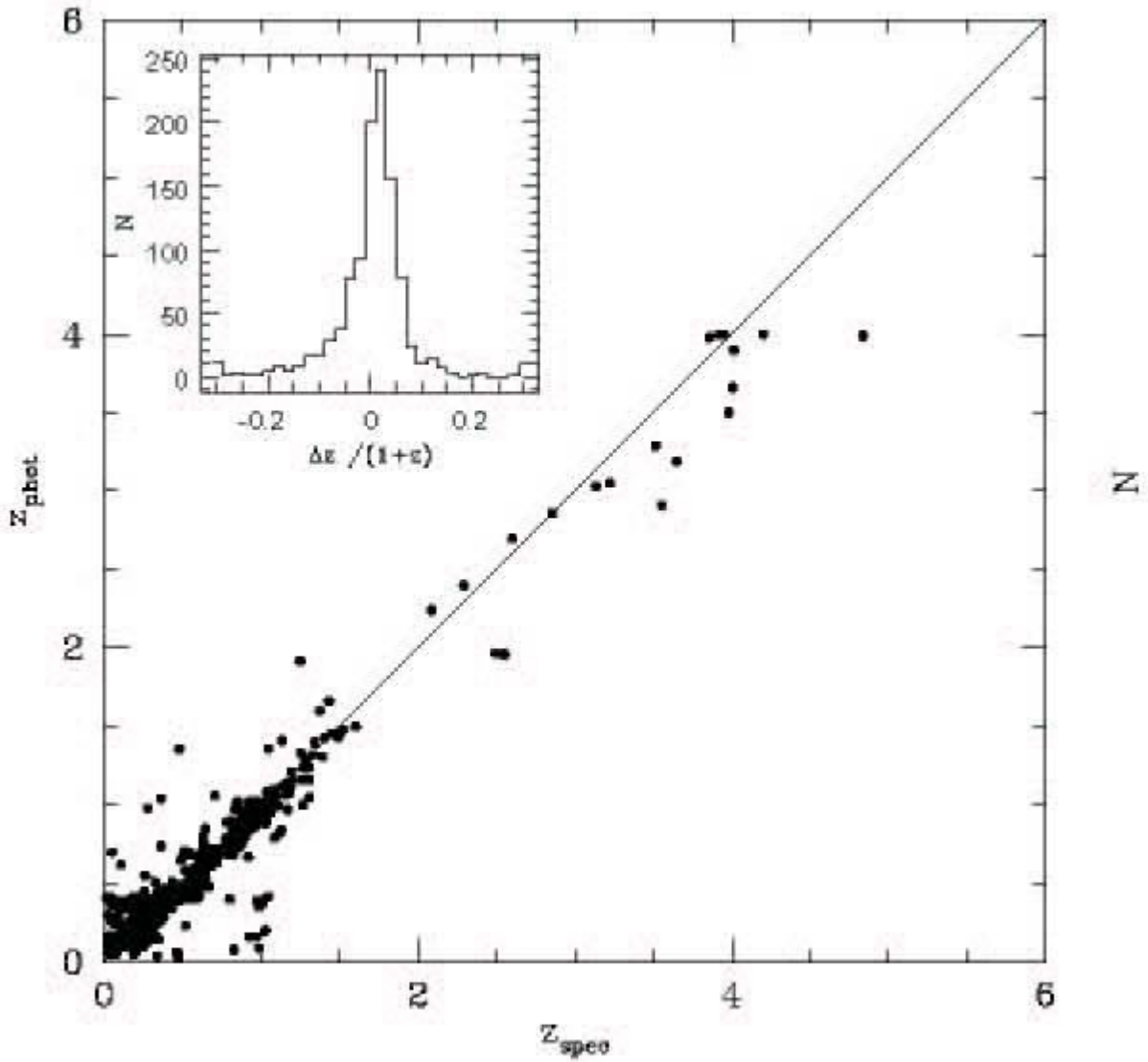
- JCMT/SCUBA2 (Cosmology Legacy Survey)
0.77 sq deg-1 to 5mJy (Aproved!)

- Subaru/FMOS: Galaxy Survey of 1.0 < z
100,000 galaxies

- HST+Spitzer Legacy program
HST/ACS F850LP, z' < 26
Spitzer/IRAC 3.6, 4.5 & 8 μm
" /MIPS 24 μm to 20 μJy

- ALMA : high spatial resolution mm imaging

7) Scientific results



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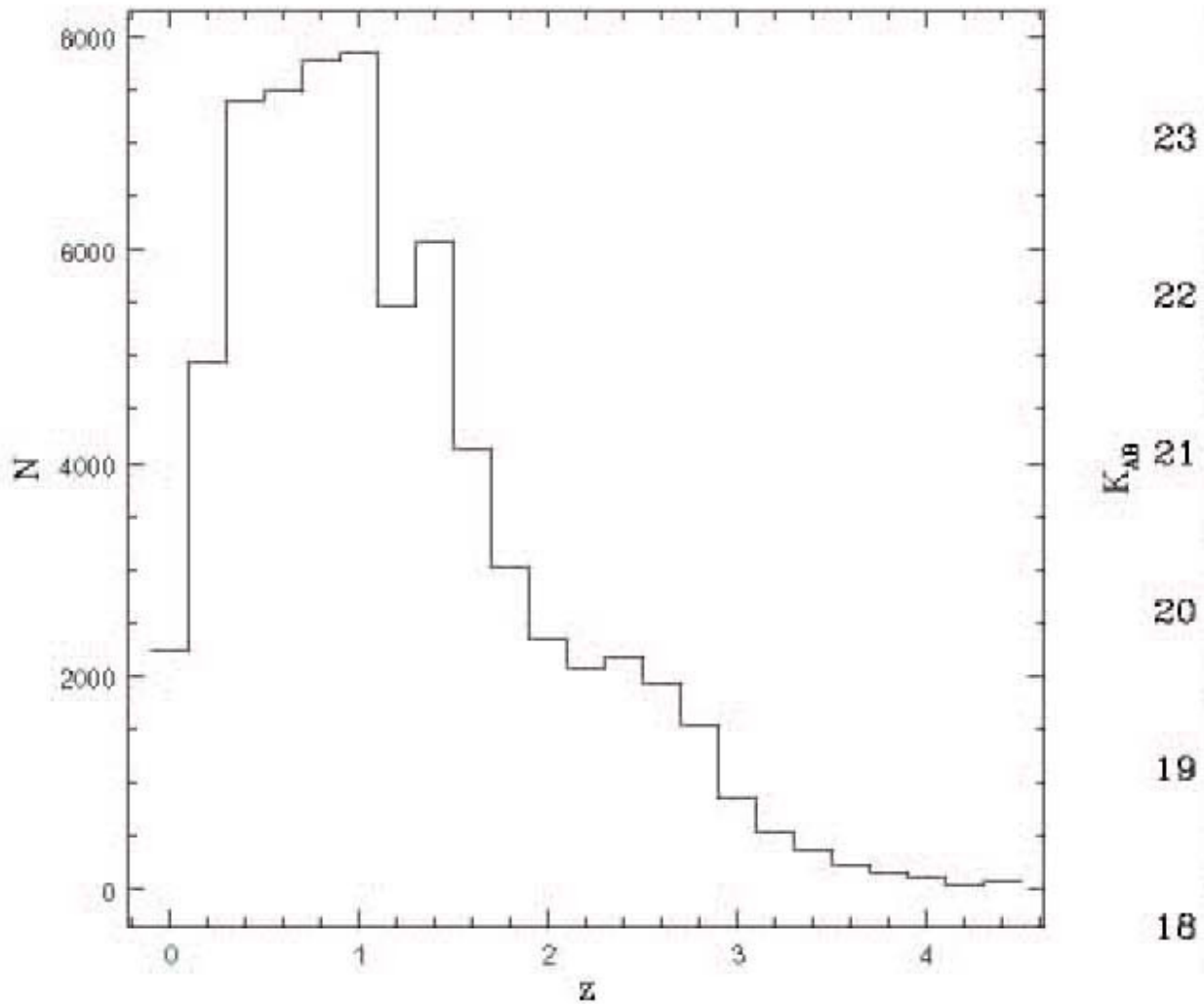

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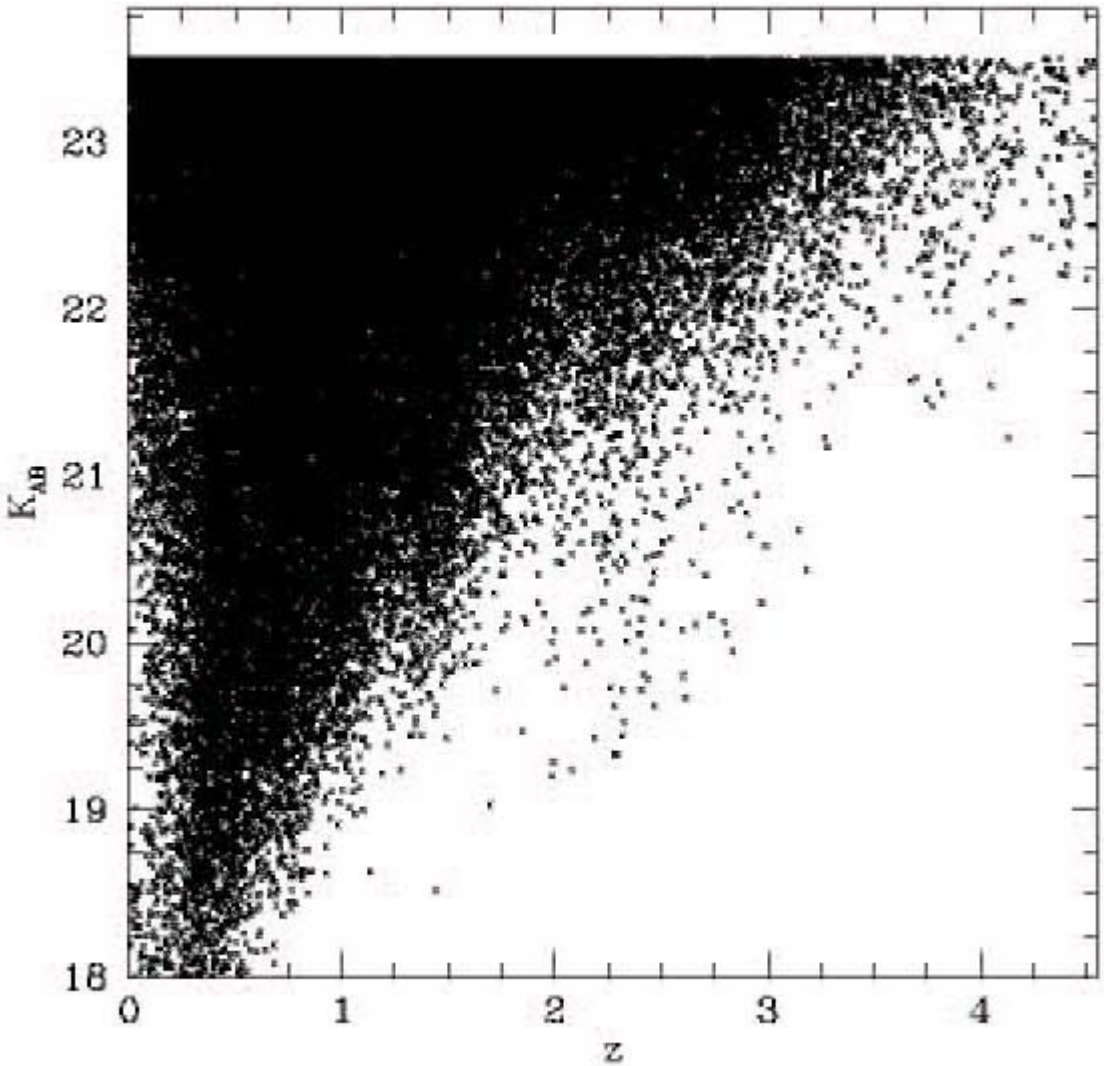
23
22
21
20
19
18
K_{AB}
0
1
2
3
4
z

- AGN in apparently normal galaxies

  (Severgnini, et al., 2003 A & A, v.406, 483)

- Down-sizing in galaxy formation at z~ 1

  (Kodama, et al., 2004, MNRAS, 350, 1005)

- Number Density of Old Passively Evolving Galaxies at z=1

  (Yamada, et al, 2005, ApJ, 634, 861)

- Primeval Large-Scale Structures with Forming Clusters at Redshift 6

  (Ouchi, et al., 2005, ApJ, 620, L1)

- Transition between Small- and Large-Scale Clustering for Lyman Break Galaxies

  (Ouchi, et al., 2005, ApJ, 635, L117)

- Extended Lyα Sources over z~3-5

  (Saito, et al., 2006, ApJ, 648, 54)

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- SHADES (Mortier et al. 2005; Coppin et al. 2006)
- EROs (Simpson et al. 2006)
- Massive galaxies at redshifts $5 < z < 6$ (McLure et al. 2006)
- Galaxy clusters (van Breukelen et al. 2006)
- Galaxy colour bimodality (Cirasuolo et al. 2007)
- AGN population (Martinez-Sansigre et al. 2007)

So far a total of 30 refereed and 16 other papers on SXDF