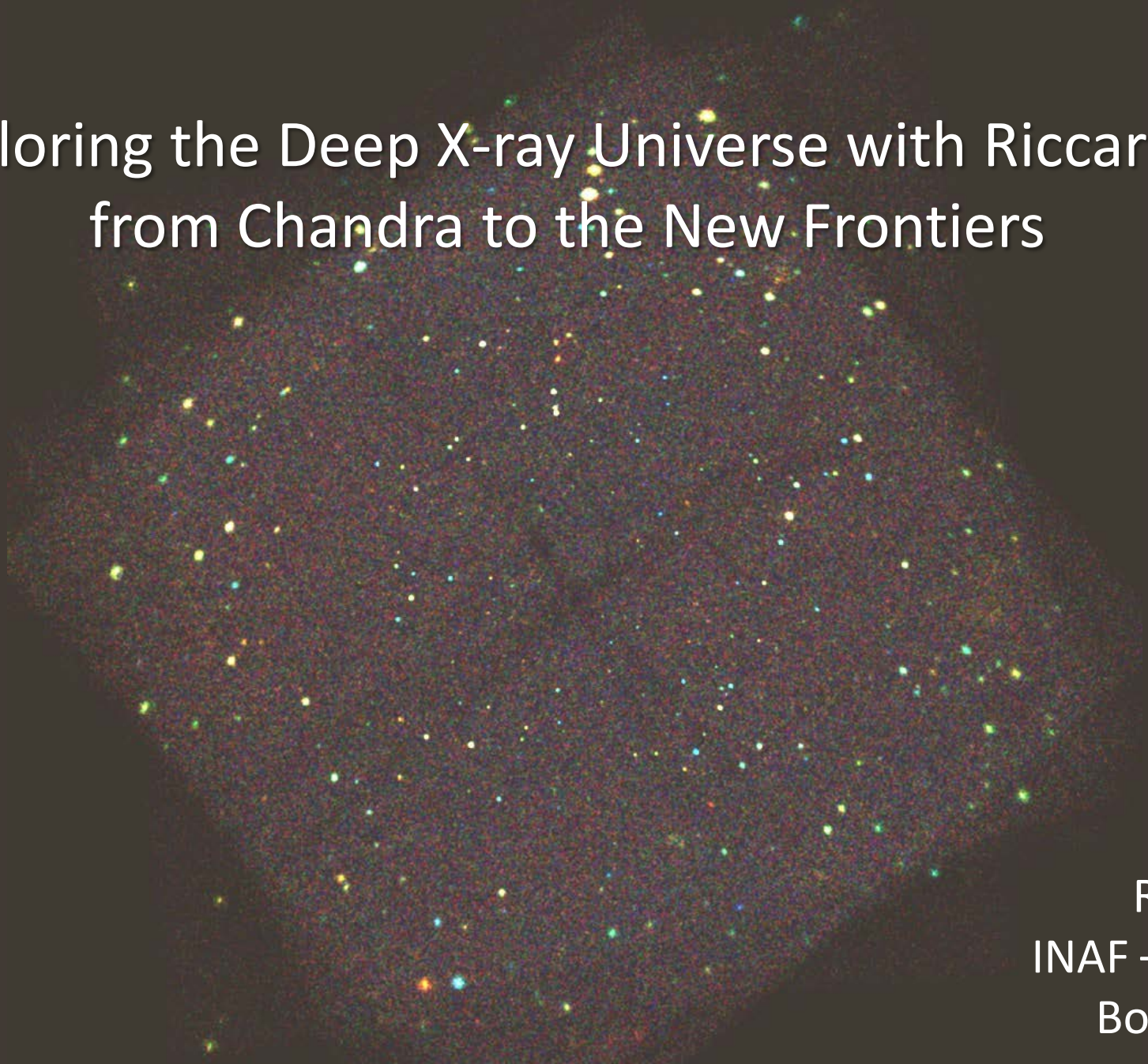
Exploring the Deep X-ray Universe with Riccardo: from Chandra to the New Frontiers



R. Gilli
INAF – OAS
Bologna

The Chandra Deep Field South – 1Ms image

CDFS group at JHU/STScI (2000-2002)

C. Norman

JHU

STScI

E. Schreier

P. Rosati

J.X. Wang

A. Zirm

M. Paolillo

N. Grogin

L. Kewley

P. Tozzi

R. Gilli

W. Zheng

A. Koekemoer

CDFS group at JHU/STScI (2000-2002)

Riccardo calling from Washington..

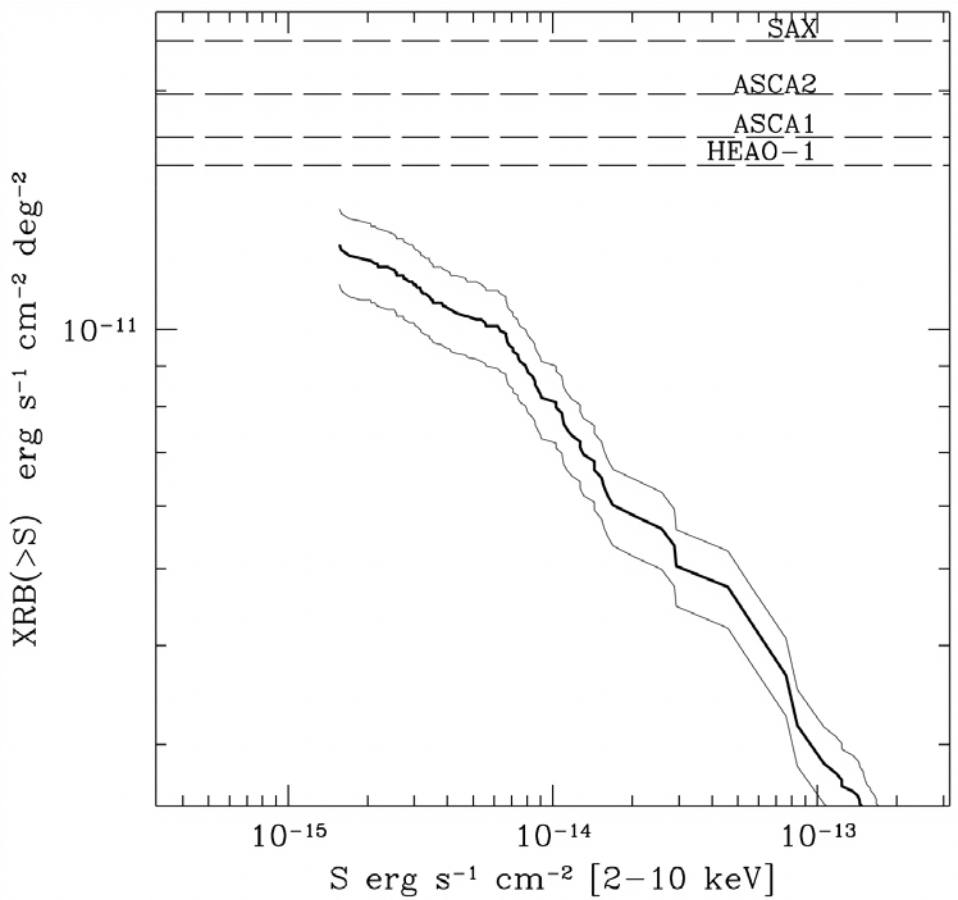
The CDFS: from 120ks to 1Ms

FIRST RESULTS FROM THE X-RAY AND OPTICAL SURVEY OF THE *CHANDRA* DEEP FIELD SOUTH[1]

R. GIACCONI,[2,3] P. ROSATI,[4] P. TOZZI,[2,5] M. NONINO,[5] G. HASINGER,[6] C. NORMAN,[2,7] J. BERGERON,[4] S. BORGANI,[8] R. GILLI,[2,9] R. GILMOZZI,[4] AND W. ZHENG[2]

Received 2000 July 17; accepted 2000 December 20

120ks : 159 X-ray sources down to $f_{0.5\text{-}2} \sim 2 \times 10^{-16}$ cgs , $f_{2\text{-}10} \sim 2 \times 10^{-15}$ cgs



The CDFS: from 120ks to 1Ms

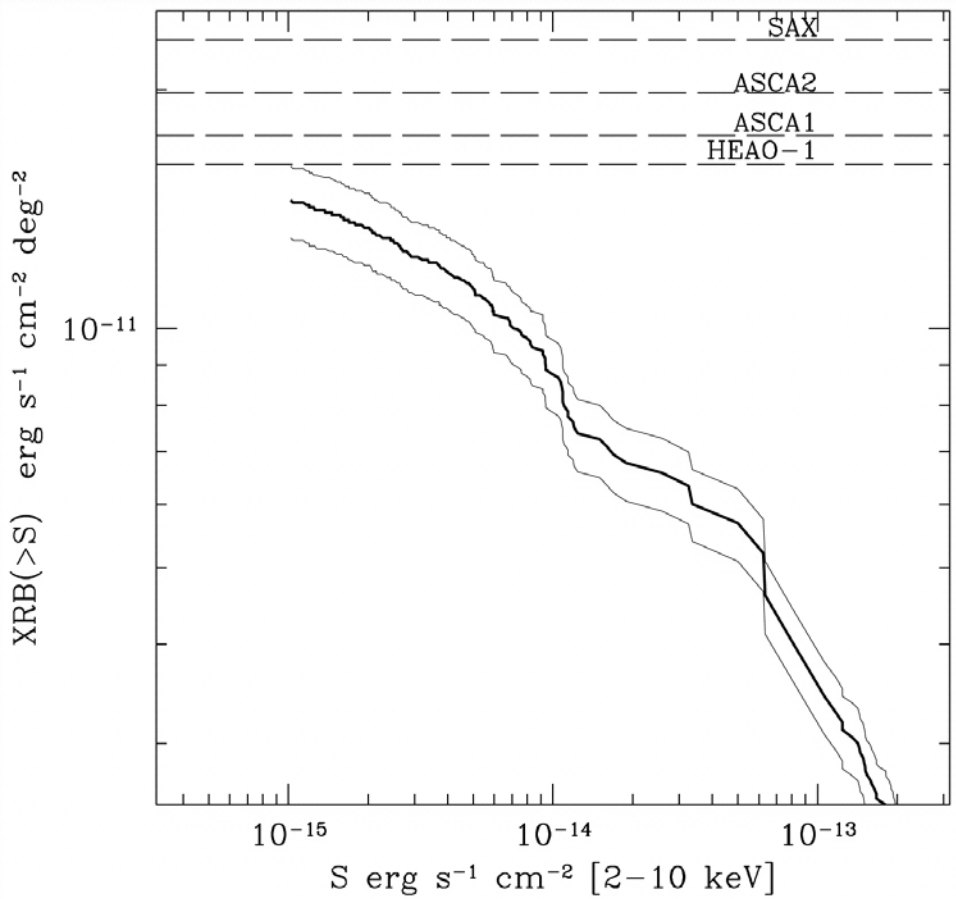
NEW RESULTS FROM THE X-RAY AND OPTICAL[1] SURVEY OF THE CHANDRA DEEP FIELD–SOUTH: THE 300 KILOSECOND EXPOSURE. II.

P. Tozzi,[2] P. Rosati,[3] M. Nonino,[2] J. Bergeron,[3] S. Borgani,[4] R. Gilli,[5] R. Gilmozzi,[3] G. Hasinger,[6] N. Grogin,[7] L. Kewley,[5] A. Koekemoer,[7] C. Norman,[5,7] E. Schreier,[7] G. Szokoly,[6] J. X. Wang,[5,8] W. Zheng,[5] A. Zirm,[5] and R. Giacconi[5,9]

Received 2001 February 28; accepted 2001 July 24

120ks : 159 X-ray sources down to $f_{0.5\text{-}2} \sim 2 \times 10^{-16}$ cgs , $f_{2\text{-}10} \sim 2 \times 10^{-15}$ cgs

300ks : 197 X-ray sources down to $f_{0.5\text{-}2} \sim 1 \times 10^{-16}$ cgs , $f_{2\text{-}10} \sim 1 \times 10^{-15}$ cgs



1Ms CDFS: CXB resolved

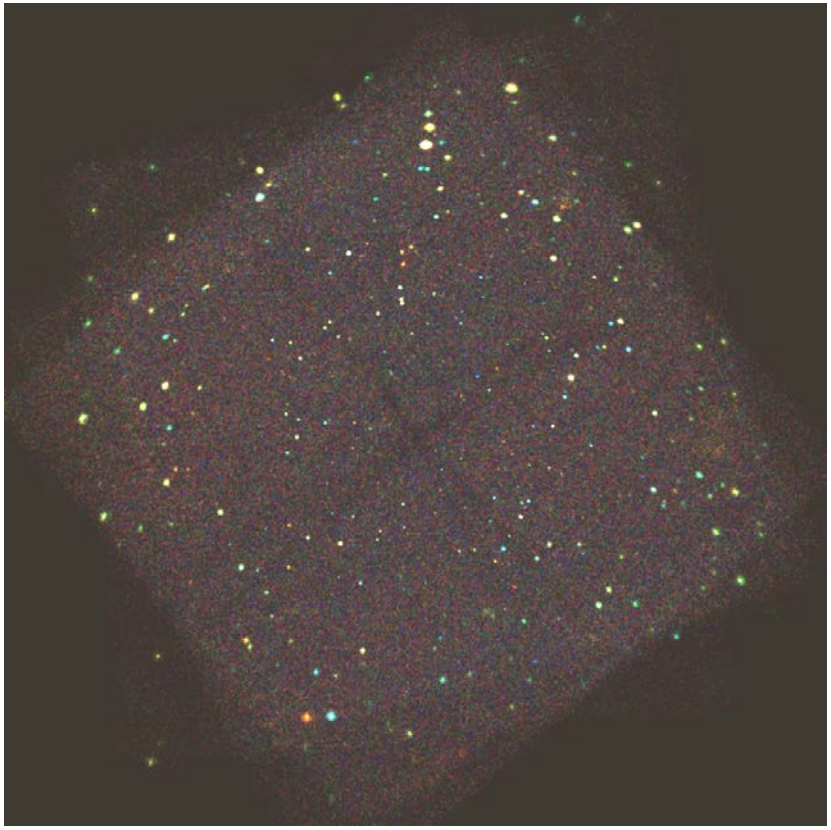
CHANDRA DEEP FIELD SOUTH: THE 1 Ms CATALOG

RICCARDO GIACCONI,[1,2] ANDREW ZIRM,[1] JUNXIAN WANG,[1] PIERO ROSATI,[3] MARIO NONINO,[4] PAOLO TOZZI,[4] ROBERTO GILLI,[1,5] VINCENZO MAINIERI,[3,6] GUENTHER HASINGER,[7] LISA KEWLEY,[8] JACQUELINE BERGERON,[3] STEFANO BORGANI,[9] ROBERTO GILMOZZI,[3] NORMAN GROGIN,[10] ANTON KOEKEMOER,[10] ETHAN SCHREIER,[10] WEI ZHENG,[1] AND COLIN NORMAN[1,10]

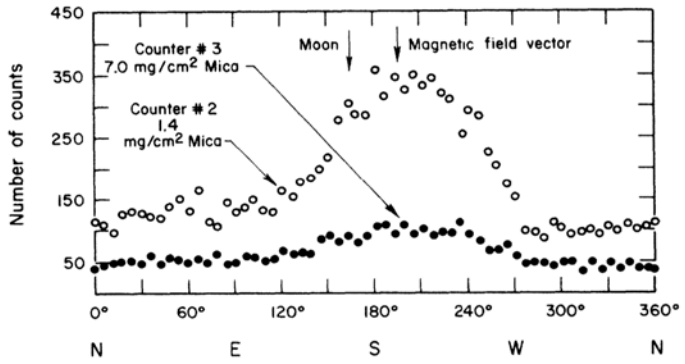
THE CHANDRA DEEP FIELD–SOUTH: THE 1 MILLION SECOND EXPOSURE[1]

P. ROSATI,[2] P. TOZZI,[3] R. GIACCONI[4,5] R. GILLI,[4,6] G. HASINGER,[7] L. KEWLEY,[4] V. MAINIERI,[2,8] M. NONINO,[3] C. NORMAN,[4,9] G. SZOKOLY,[7] J. X. WANG,[4,10] A. ZIRM,[4] J. BERGERON,[2] S. BORGANI,[11] R. GILMOZZI,[2] N. GROGIN,[9] A. KOEKEMOER,[9] E. SCHREIER,[9] AND W. ZHENG[4]

Received 2001 September 18; accepted 2001 October 29



1Ms : 350 X-ray sources down to $f_{0.5\text{-}2} \sim 5 \times 10^{-17}$ cgs , $f_{2\text{-}10} \sim 5 \times 10^{-16}$ cgs



80-90% of the 2-10 keV CXB resolved into single sources, mostly AGN

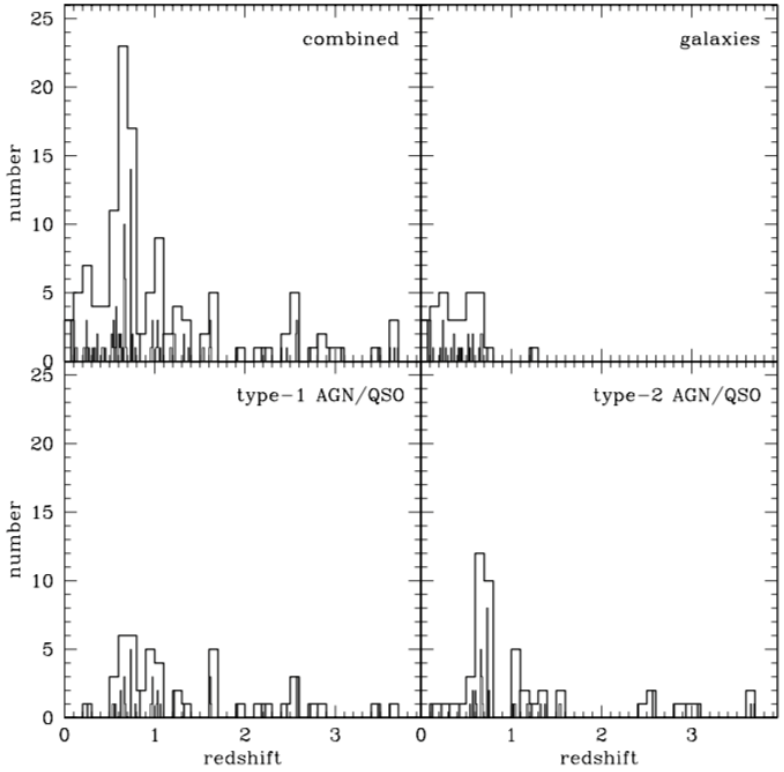
THE CHANDRA DEEP FIELD–SOUTH: OPTICAL SPECTROSCOPY. I.[1]

G. P. Szokoly,[2,3] J. Bergeron,[4] G. Hasinger,[2,3] I. Lehmann,[2] L. Kewley,[5,6] V. Mainieri,[7] M. Nonino,[8] P. Rosati,[7] R. Giacconi,[9] R. Gilli,[10] R. Gilmozzi,[7] C. Norman,[5] M. Romaniello,[7] E. Schreier,[9,11] P. Tozzi,[8] J. X. Wang,[5] W. Zheng,[5] and A. Zirm[5]

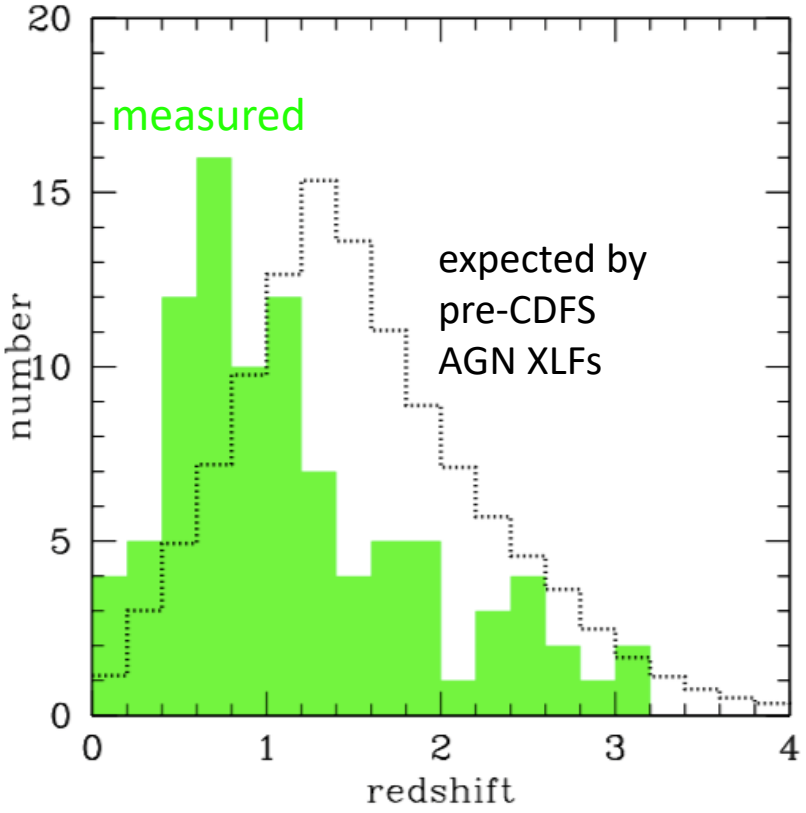
Received 2003 August 18; accepted 2004 July 7

Optical identification: AGN redshift distribution

Peak at z<1 and evidence for prominent LSSs



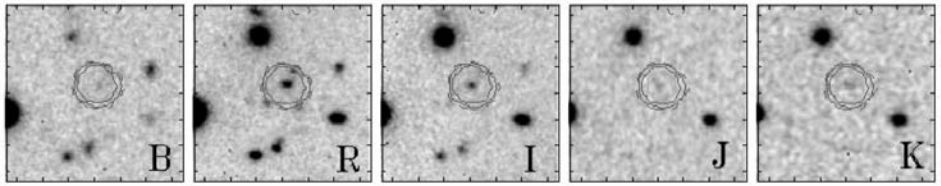
First manifestation of AGN downsizing

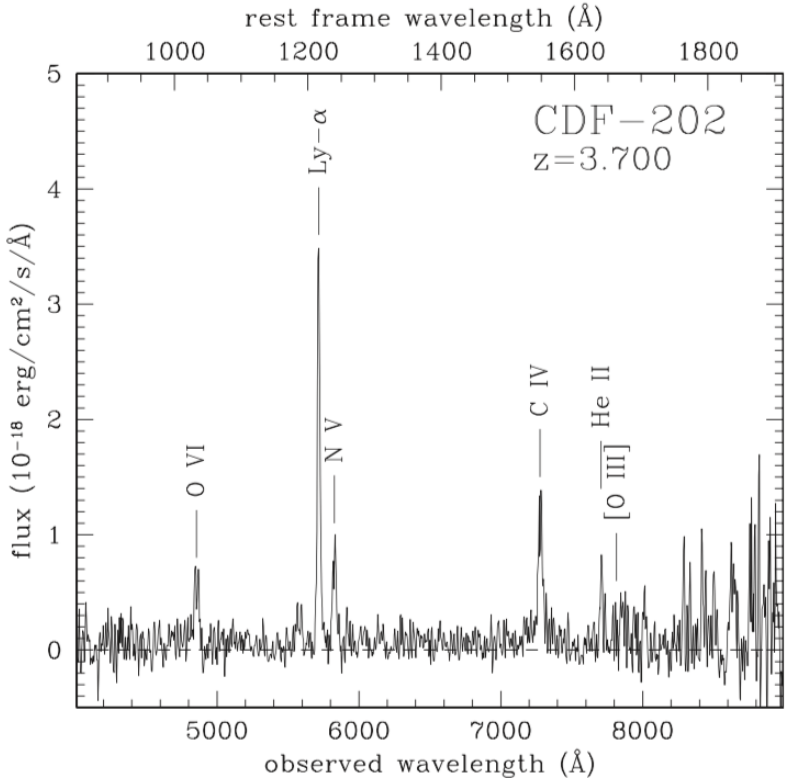


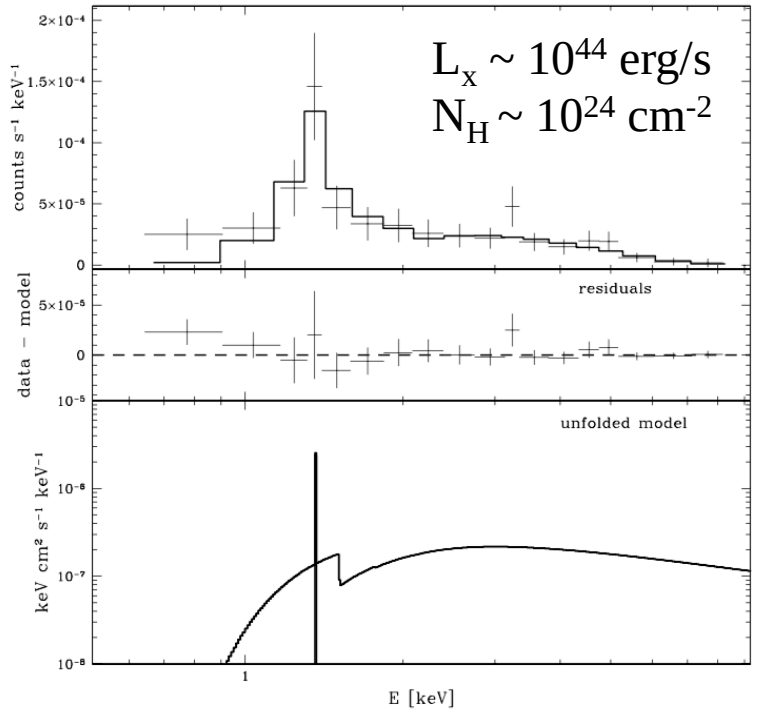
A CLASSIC TYPE 2 QSO

COLIN NORMAN,[1,2] GUENTHER HASINGER,[3] RICCARDO GIACCONI,[1,4] ROBERTO GILLI,[1,5] LISA KEWLEY,[1,6] MARIO NONINO,[7] PIERO ROSATI,[1,8] GYULA SZOKOLY,[3] PAOLO TOZZI,[7] JUNXIAN WANG,[1] WEI ZHENG,[1] ANDREW ZIRM,[1] JACQUELINE BERGERON,[8] ROBERTO GILMOZZI,[8] NORMAN GROGIN,[2] ANTON KOEKEMOER,[2] AND ETHAN SCHREIER[2]

Received 2001 February 21; accepted 2002 January 25



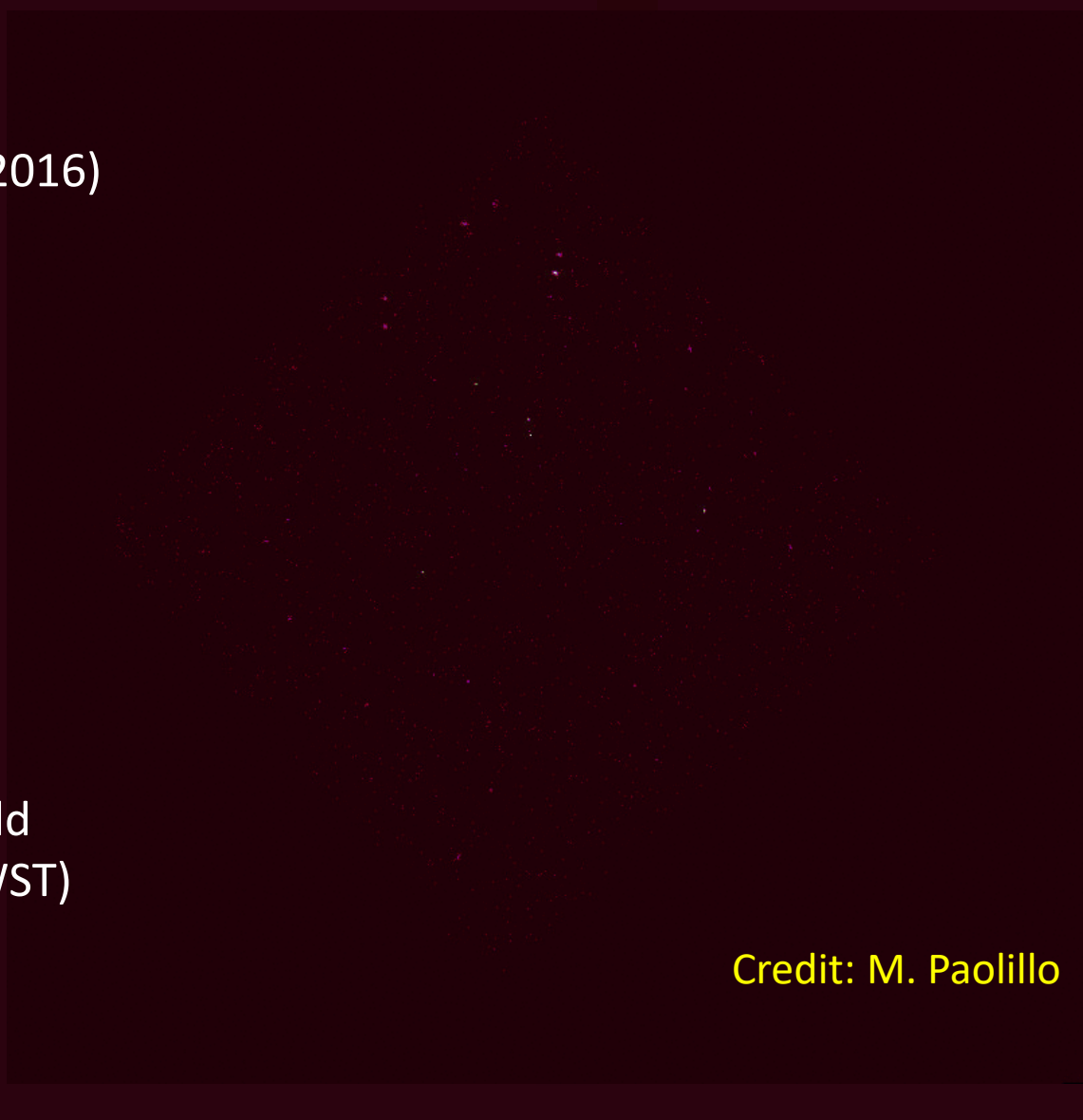




First example of a distant, heavily obscured QSO

From 1Ms to 7Ms : the deepest X-ray field

1Ms GTO/DDT	Giacconi/Tananbaum	(1999-2000)
1Ms DDT	Tananbaum	(2007)
2Ms DDT	Tananbaum	(2010)
3Ms GO	Brandt	(2014-2016)



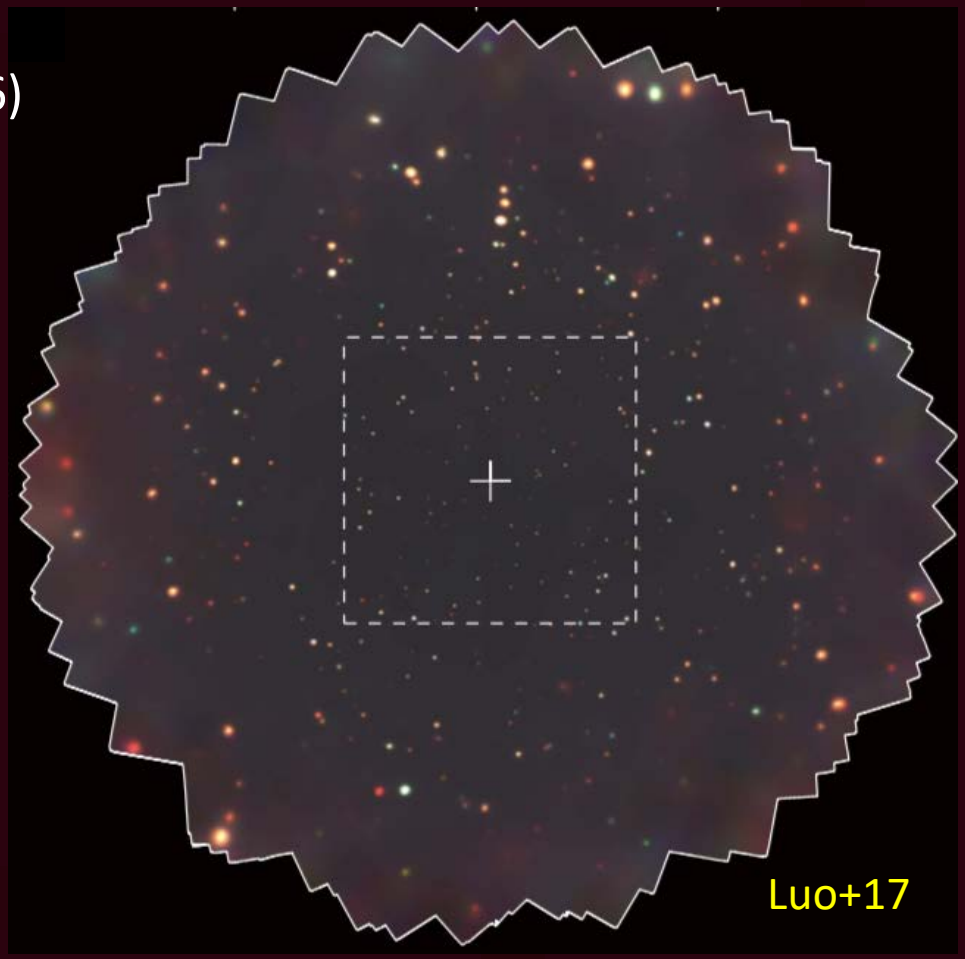
7Ms : 102 ACIS-I pointings
1000 sources down to
$f_{0.5-2} = 7 \times 10^{-18}$ cgs
$f_{2-10} = 3 \times 10^{-15}$ cgs

CDFS has become THE deep field
also for HST, VLT, ALMA, + .. (JWST)
(see talk by P. Rosati)

Credit: M. Paolillo

From 1Ms to 7Ms : the deepest X-ray field

1Ms GTO/DDT Giacconi/Tananbaum (1999-2000)
1Ms DDT Tananbaum (2007)
2Ms DDT Tananbaum (2010)
3Ms GO Brandt (2014-2016)



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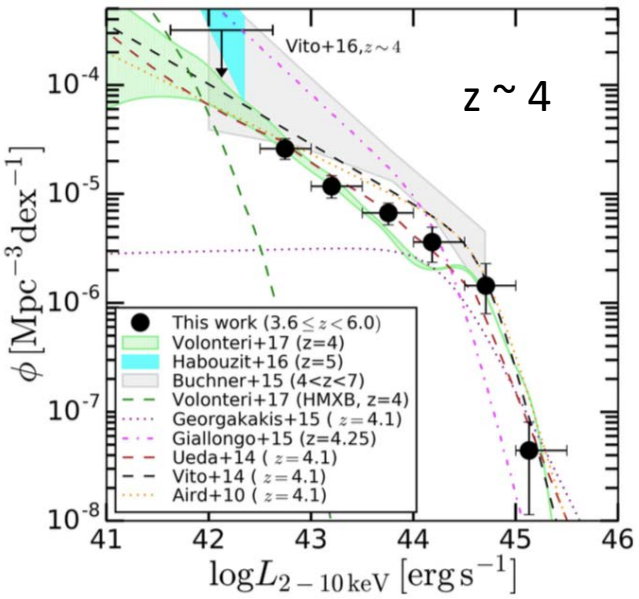
also for HST, VLT, ALMA, + .. (JWST)
(see talk by P. Rosati)

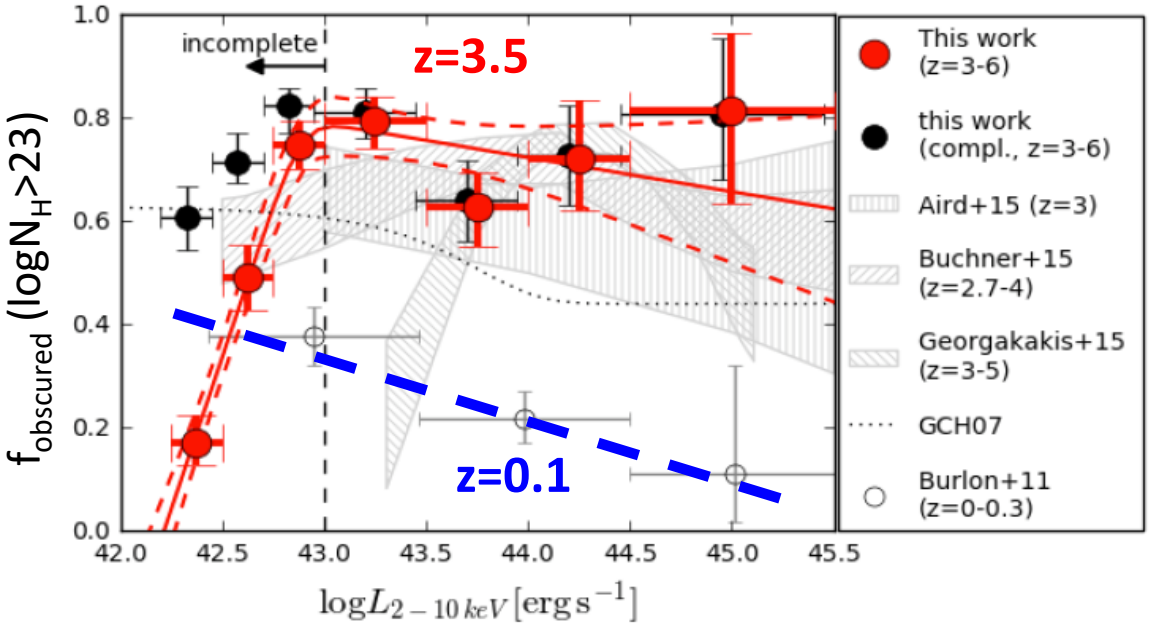
A key resource for AGN evolution studies

AGN XLF



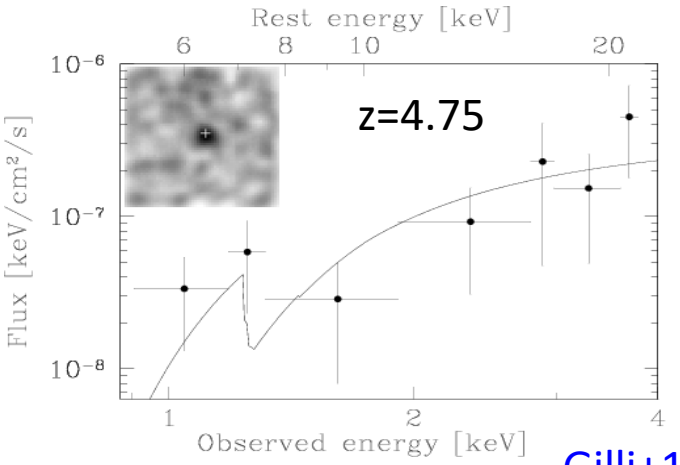
Vito+18

History of nuclear obscuration



high-z nuclei hidden because of denser ISM? Circosta+19

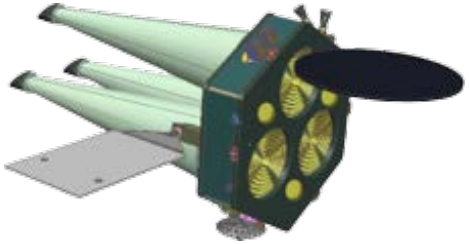
Most distant obscured QSO



Gilli+11

All in 0.1 deg^2 of the sky...

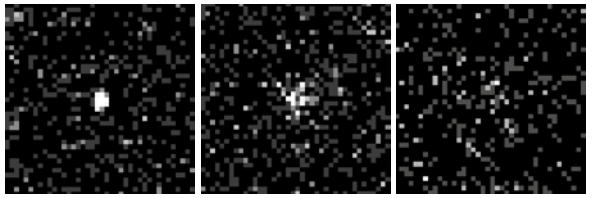
The Wide Field X-ray Telescope



Original concept in Burrows, Burg & Giacconi 1992

Basics: 1m^2 @ 1 keV, 5" HEW flat over 1 deg^2 FoV
(Chandra av. 3" over 0.1 deg^2)

7Ms CDFS sources



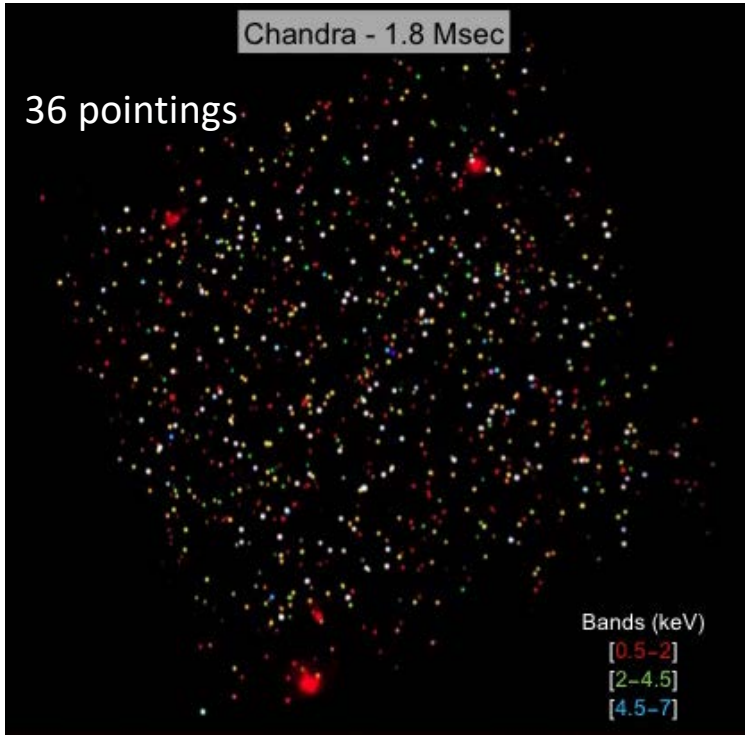
1 arcmin 6 arcmin 9 arcmin

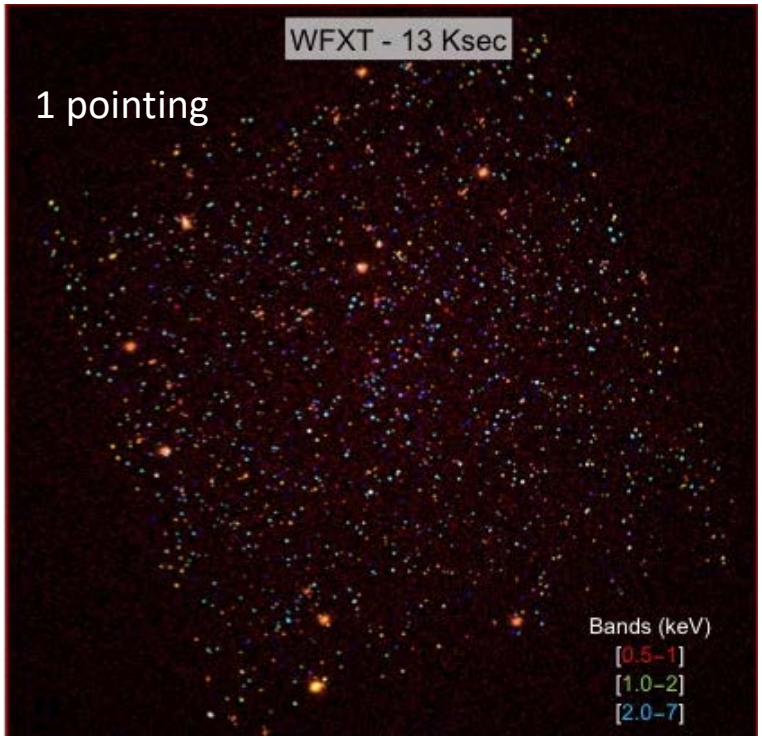
White papers submitted to the NASA Decadal Survey 2010
Giacconi+09, Vikhlinin+09, Murray+09, Ptak+09
RFIs submitted in 2009 and 2011
http://www.wfxt.eu

PI Steve Murray

X-ray surveys over 100s-1000s deg^2 down to Chandra deep fields depth
Immense discovery space: incarnation of Riccardo's mantra "listen to Nature"

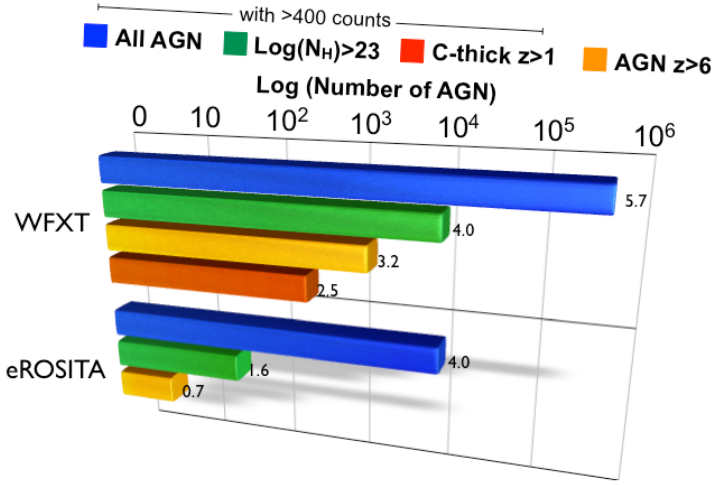
WFXT simulation of the 1 deg^2 Chandra-COSMOS field





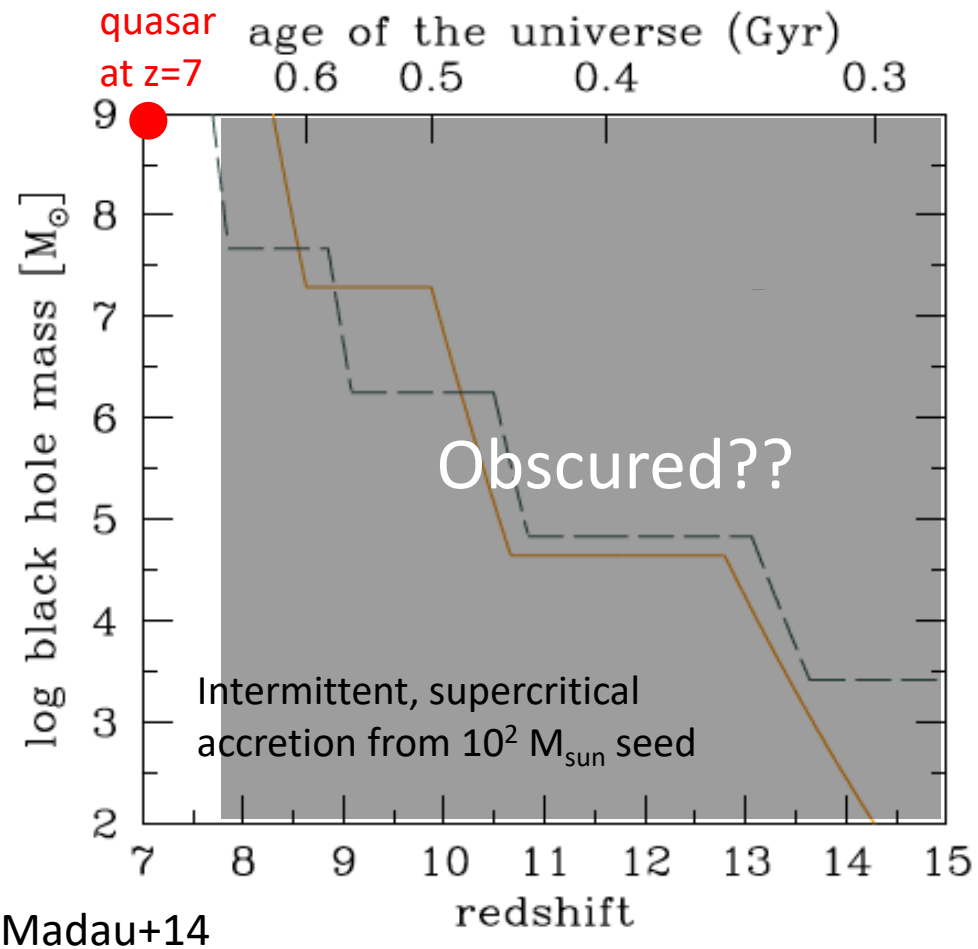
WFXT surveys =

1000x 1Ms-CDFS +
1000x C-Cosmos +
1000x XBootes



Quasars at z > 6 : little time to grow

BH seed models span the full mass spectrum $10^{2\text{-}6}$ M_{sun} …
that is, we have no idea of what they are



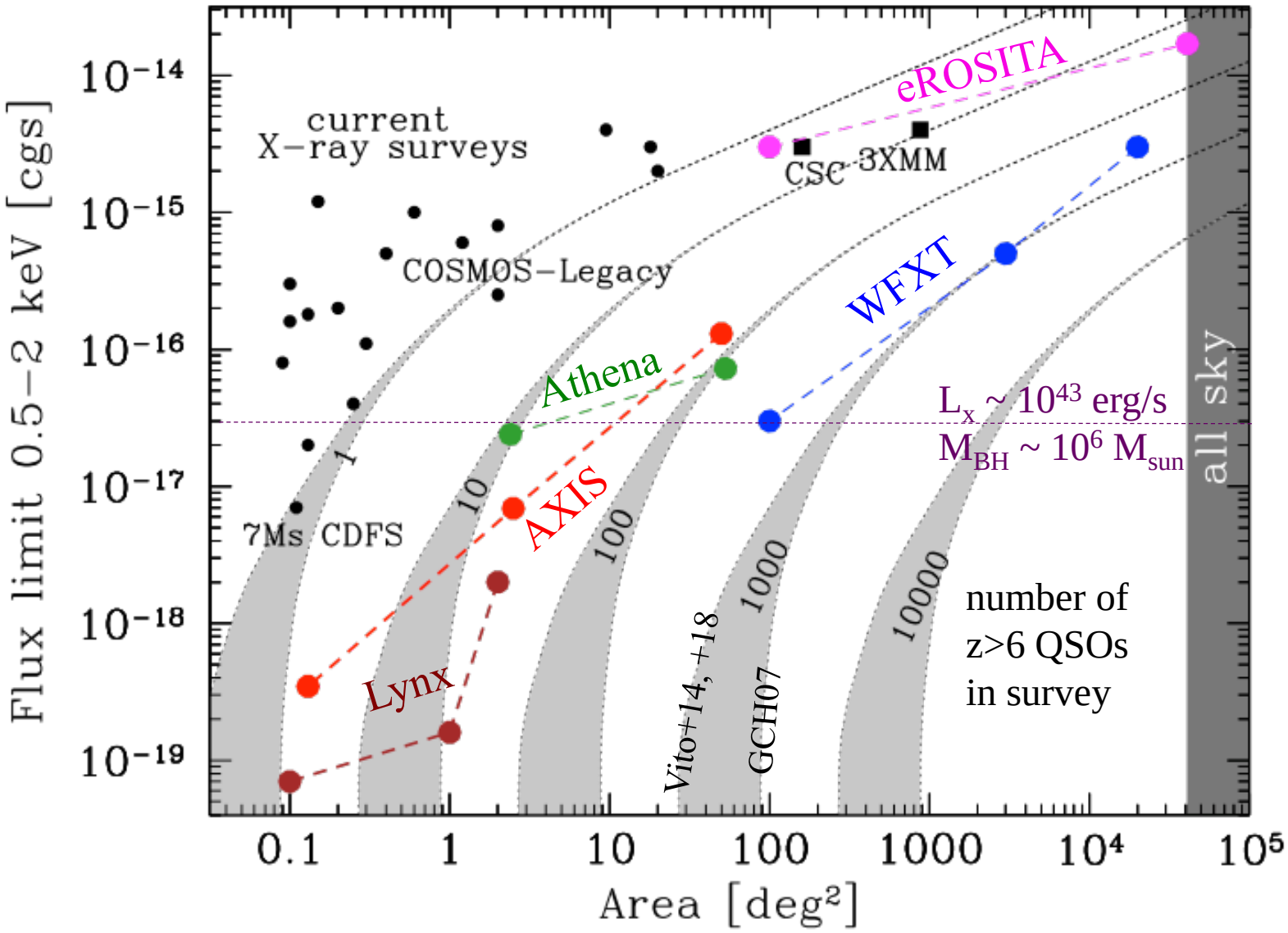
Madau+14

200 QSOs known at z>6, 3 at z>7
All of them unobscured (by selection)

In WFXT
surveys:1800 AGN
at z>=6, 70 at z>8

mostly obscured??

Discovery space for SMBHs at z > 6



Another example of Riccardo's vision: WFXT concept compelling even in the 2030s

From the foreword to the proceedings of the meeting: "The Wide Field X-ray Telescope", Bologna Nov 25-16, 2009

Important discoveries in all branches of Astronomy and in particular in X-Ray Astronomy have often come about by a combination of physical intuition, technological improvements, and a boundless faith in the richness of Nature. It is clear that theories about the Universe only go so far as can be achieved given our current knowledge and our mathematical skills.

Nature has no such limitations and has already solved the questions we are asking; very simply Nature is. This perhaps is why so many discoveries in Astronomy are real discoveries rather than verifications. The existence of binary X-ray sources, of efficient energy production by in fall of matter on collapsed objects, the existence of an extragalactic X-ray background, and the existence of intergalactic plasmas were revealed in most cases by unexpected discoveries from broad surveys in the X-ray domain.

While faith in the bounty of Nature is justified, it is also important to realize that understanding Nature requires skill in providing discovery space and care in listening to its replies.

Riccardo Giacconi, September 2010

http://sait.oats.inaf.it/MSAIS/17/PDF/5.pdf