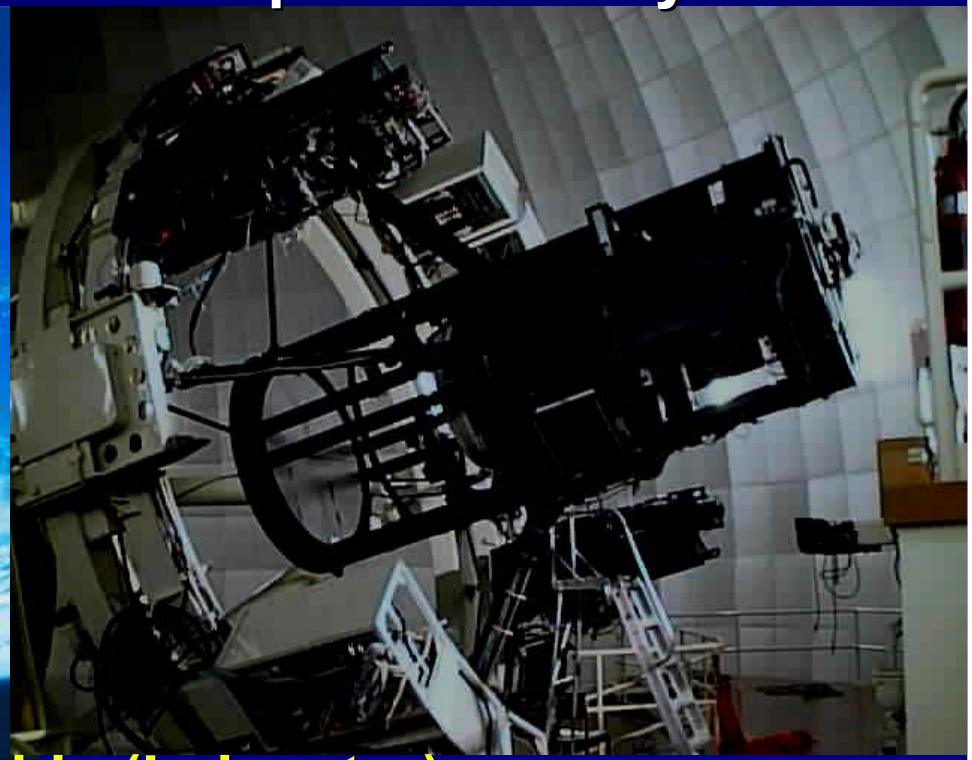
XMM-2dF Wide Angle Serendipitous Survey



Jonathan Tedds (Leicester)

Mat Page (MSSL)

XMM-Newton Survey Science Centre

XMM-Newton SURVEY SCIENCE CENTRE

Jonathan Tedds
Leicester University

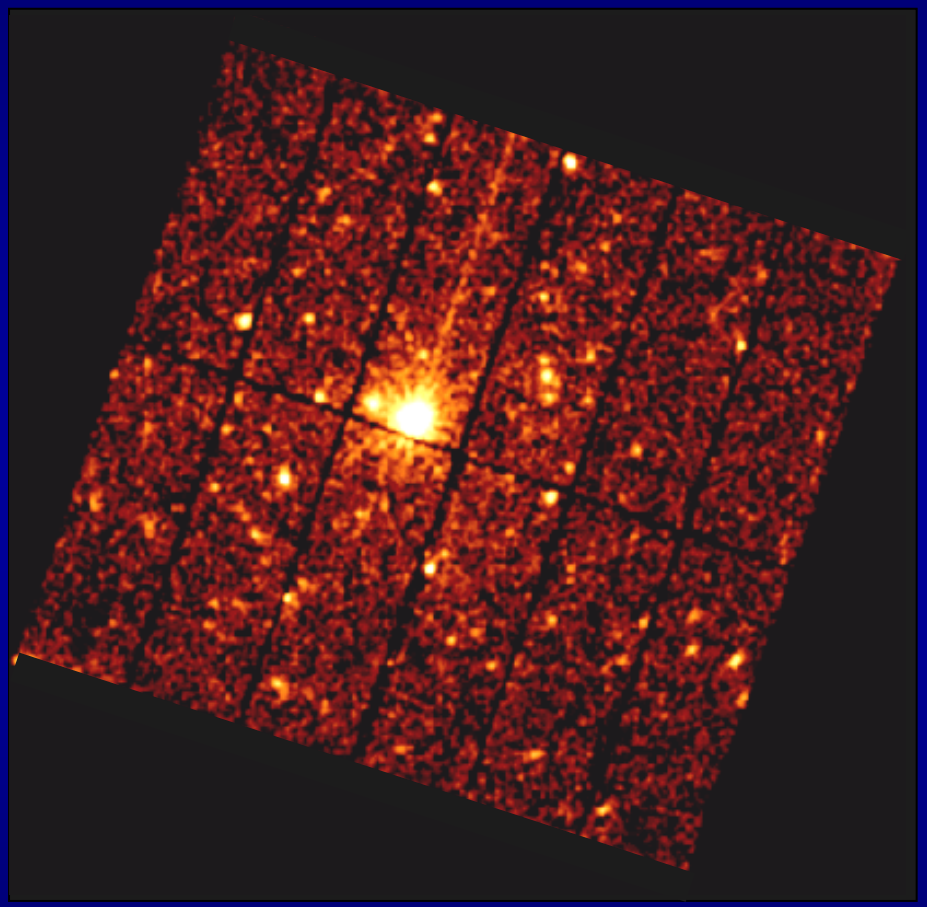
Introduction

- XMM-Newton X-ray serendipitous surveys – XID program
- 2dF optical spectroscopic characterisation of X-ray sample
  - Provisional ID statistics
  - z-distribution
- Unique science examples: rare objects
  - e.g. any BAL QSOs?
- Opt/IR imaging follow-up
  - 1XMM/SDSS/UKIDSS test case
- Summary

Jonathan Tedds
Leicester University

The XMM-Newton serendipitous sky survey

- XMM-Newton with EPIC cameras
  - large FOV
  - large throughput
  - excellent high energy response
- Every new XMM-Newton pointing discovers ~30-150 serendipitous X-ray sources.
- 700 pointings/year ⇒ about 50,000 new X-ray sources/year



Angular resolution worse than Chandra
- depth limited by confusion

($f_x \sim 4 \times 10^{-16}$, T~100 ksec)

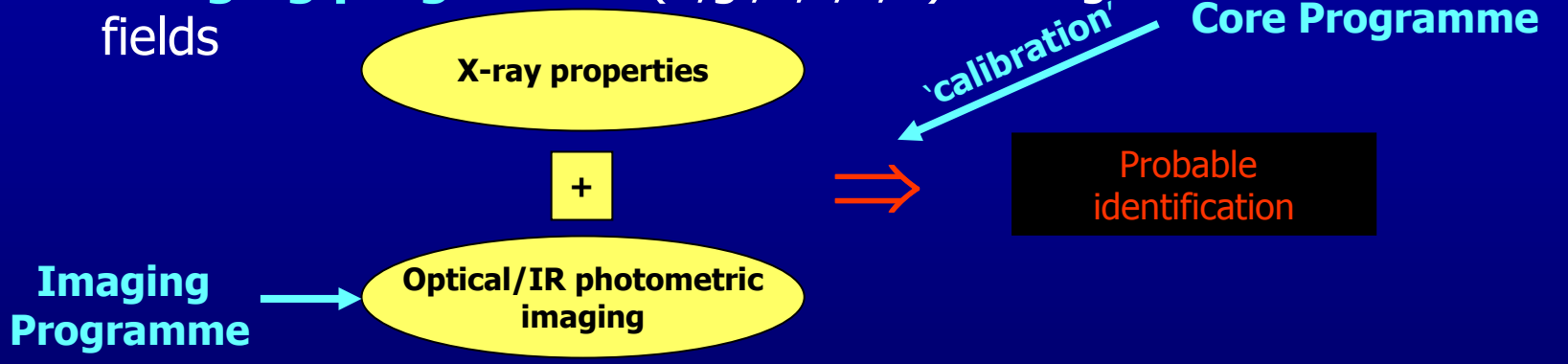
But higher s/n X-ray spectra at medium/faint fluxes

XMM-Newton SURVEY SCIENCE CENTRE

Jonathan Tedds
Leicester University

SSC XID programme

- **statistical identifications for the whole XMM-Newton serendipitous catalogue**
- **Core programme: spectroscopic IDs** (1000 sources/sample):
  - High b faint sample ($\sim 10^{-15}$ erg cm^{-2} s^{-1})
  - High b medium sample ($\sim 10^{-14}$ erg cm^{-2} s^{-1}) => AXIS (PI Barcons) + 2dF
    -> bulk of objects contributing to X-ray background are at fluxes ~ 10^{-14} : depth of XMM serendipitous survey
  - High b bright sample ($\sim 10^{-13}$ erg cm^{-2} s^{-1}) => Della Ceca et al 04
  - Galactic Plane Sample ($\sim 7\ 10^{-15}$ erg cm^{-2} s^{-1}) => PI Motch
- **Imaging programme** (u,g',r',i',Z,H): a large number of XMM-Newton fields

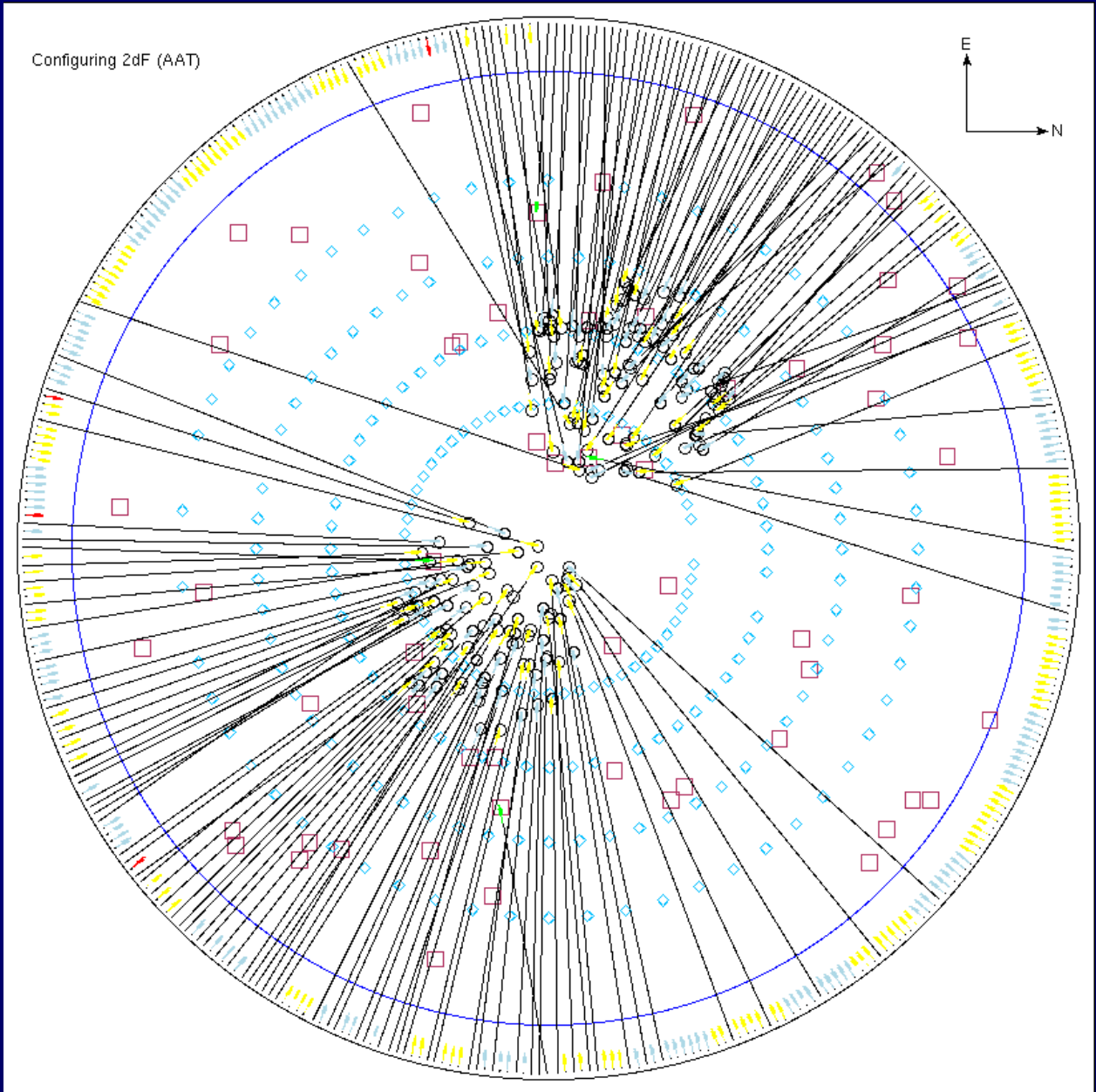


Jonathan Tedds
Leicester University

2df ID Motivation – Characterise X-ray Sky

- AXIS (PI Barcons, IFCA) making a major contribution towards characterising the XMM medium sample in North
- Striving for an unbiased survey with statistical completeness
- But 1000 sources with spectral IDs ambitious!
- Solution: 2dF at the AAT in South
  - Complement AXIS
  - Very high observing efficiency
  - simply aim for the maximum identification rate

What do we get?



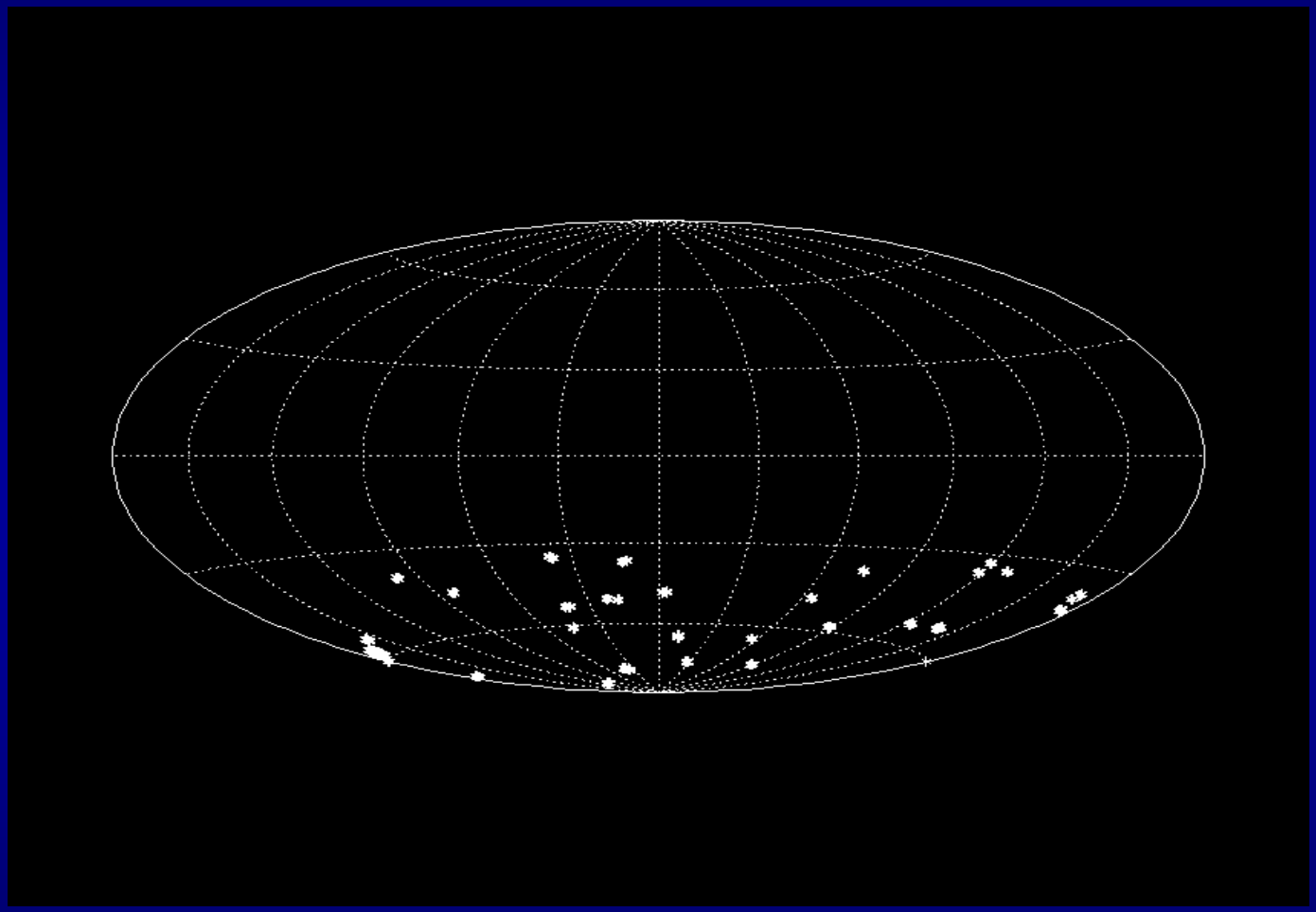
How much have we observed?

- 27 pointings with 2dF
- 68 XMM fields including LSS fields – some multiple exposures
- Typically 1hr exposures
  - **any** X-ray source with an optical counterpart that could be allocated a fibre
  - Prioritise according to X-opt offset
  - 1/2 of fields have WFC/WFI multiband opt imaging

- **In total > 3000 X-ray sources observed and reduced**
  - **Identification stage almost complete and we have certainly beaten the barrier of 1000 sources brighter than $F_{0.5\text{-}4.5} > 10^{-14}$ erg cm^{-2} s^{-1}**
    - *Opens up unique areas of parameter space*

Jonathan Tedds
Leicester University

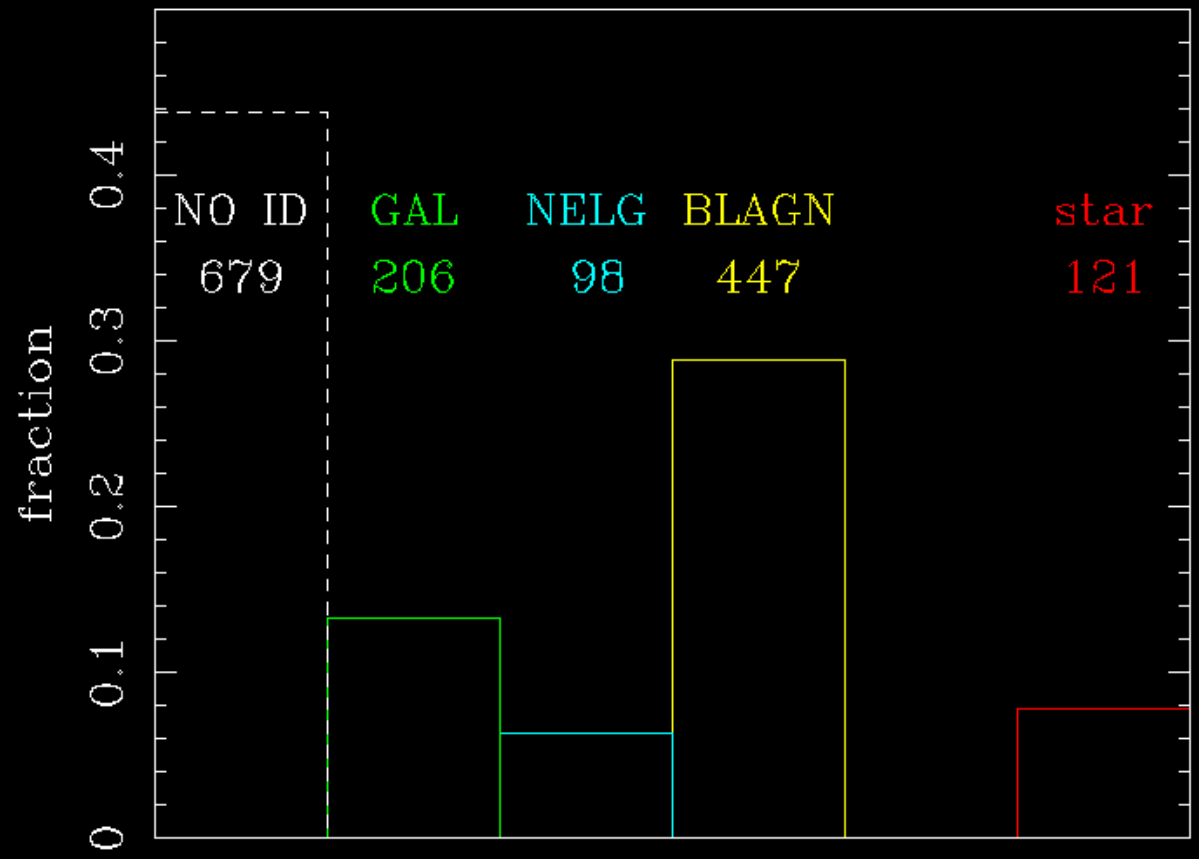
Distribution of 2dF fields on sky



XMM-Newton SURVEY SCIENCE CENTRE

Jonathan Tedds
Leicester University

Provisional 2dF ID statistics

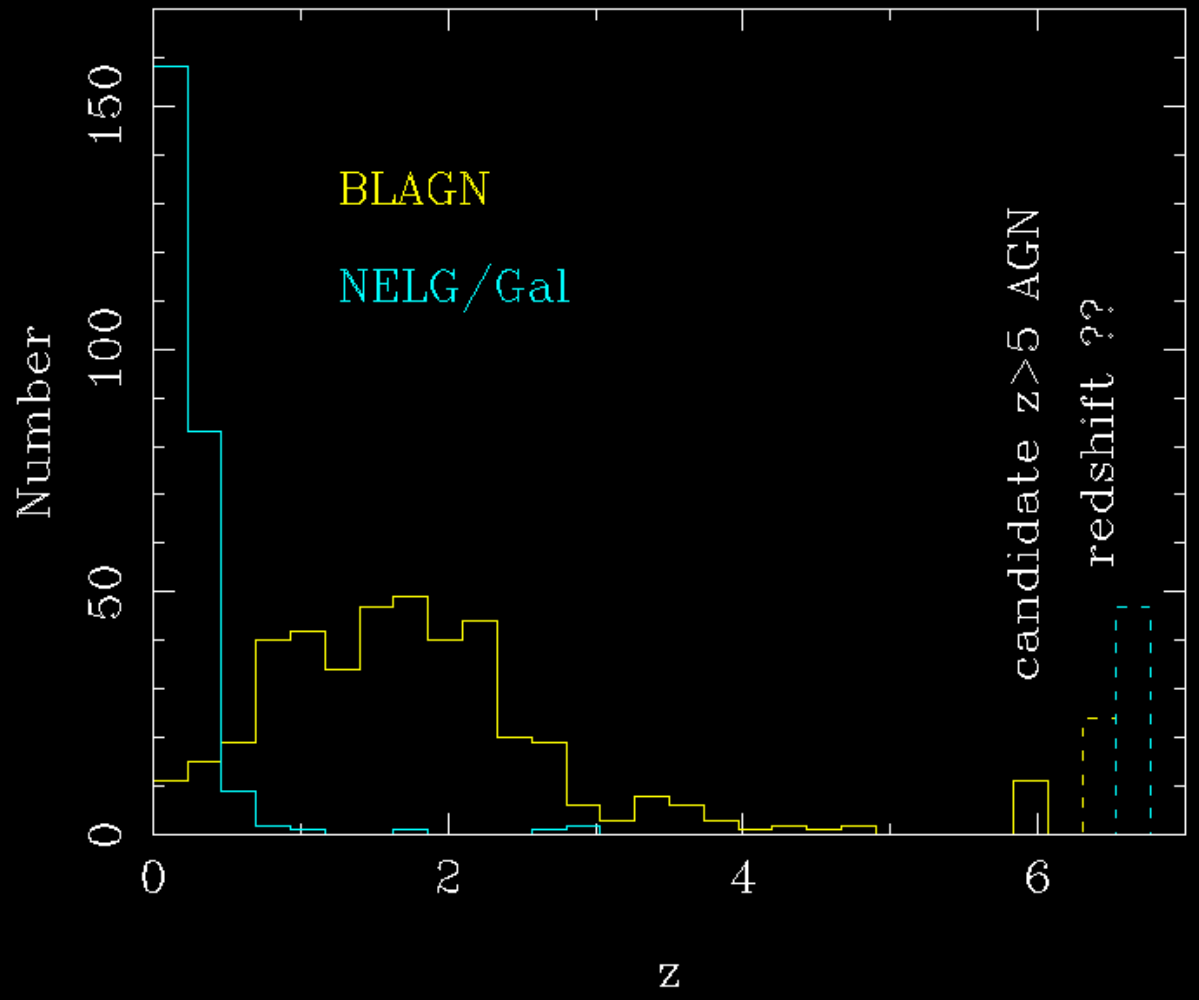


area~8 deg^2 , >50% ID rate, ~50% final sample

XMM-Newton SURVEY SCIENCE CENTRE

Jonathan Tedds
Leicester University

Provisional 2dF ID statistics



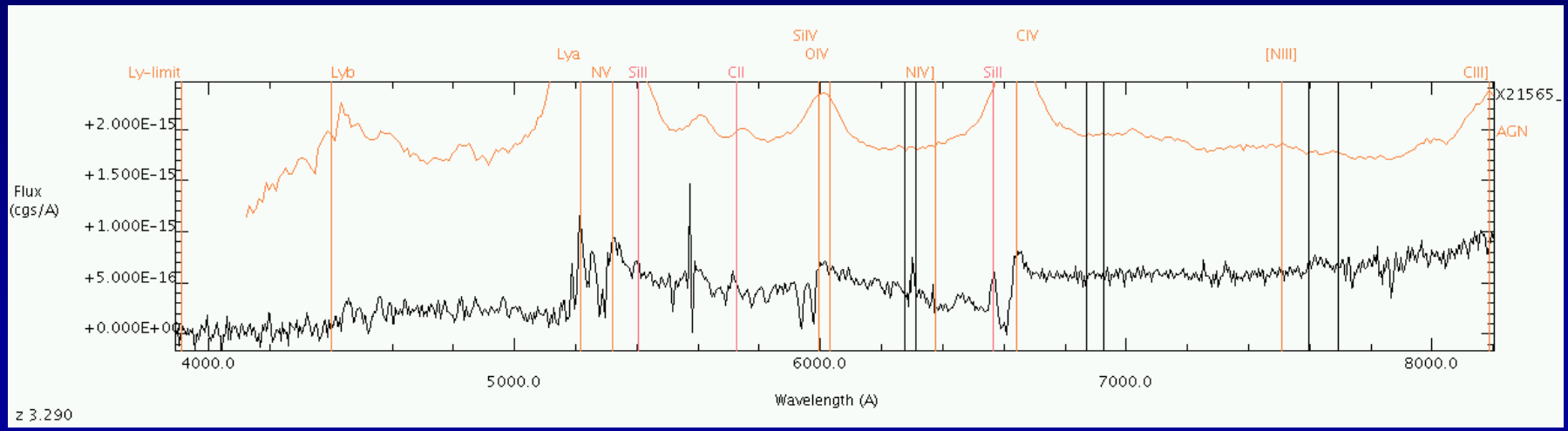
XMM-Newton SURVEY SCIENCE CENTRE

Jonathan Tedds
Leicester University

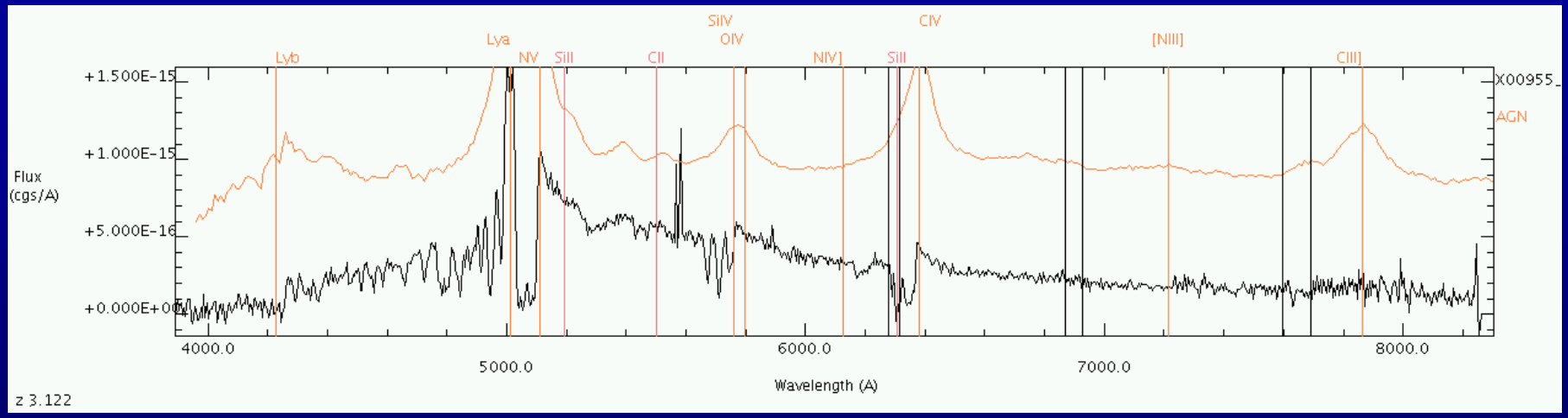
Unique science example: Broad Absorption Line QSOs

- 3-5% of optically selected QSOs (SDSS ~10-15%?)
- Virtually absent in previous X-ray surveys because of absorption
  - None in ROSAT surveys!
- But are there any which are *transmissive* enough to be picked up in current X-ray surveys?
  - Certainly will require a large survey to have a hope of detecting more than one or two
  - Not heavily obscured in the optical - perfect area to be addressed by 2dF medium survey

Example BALQSOs found with 2dF



XMM: $F_{0.5\text{-}4.5}=9.4\text{x}10^{-15}\text{ergs}^{-1}\text{cm}^{-2}$



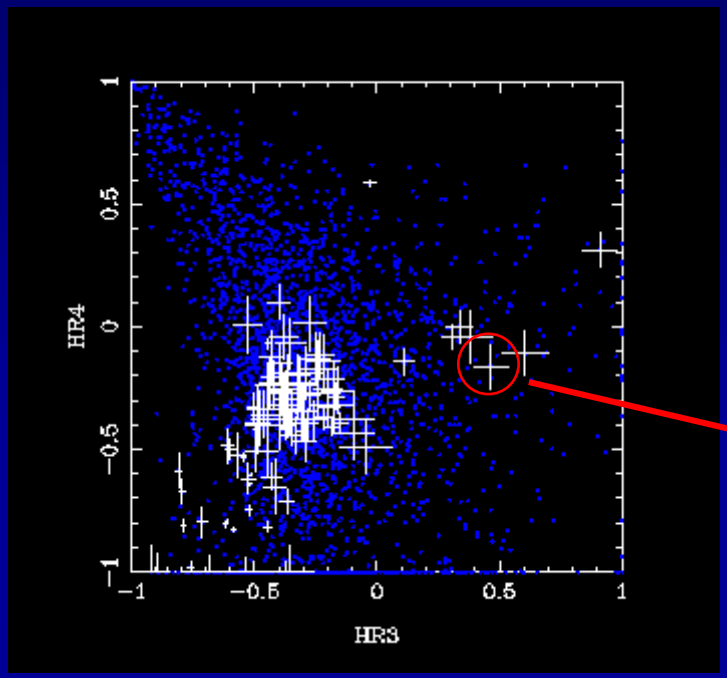
XMM-Newton SURVEY SCIENCE CENTRE

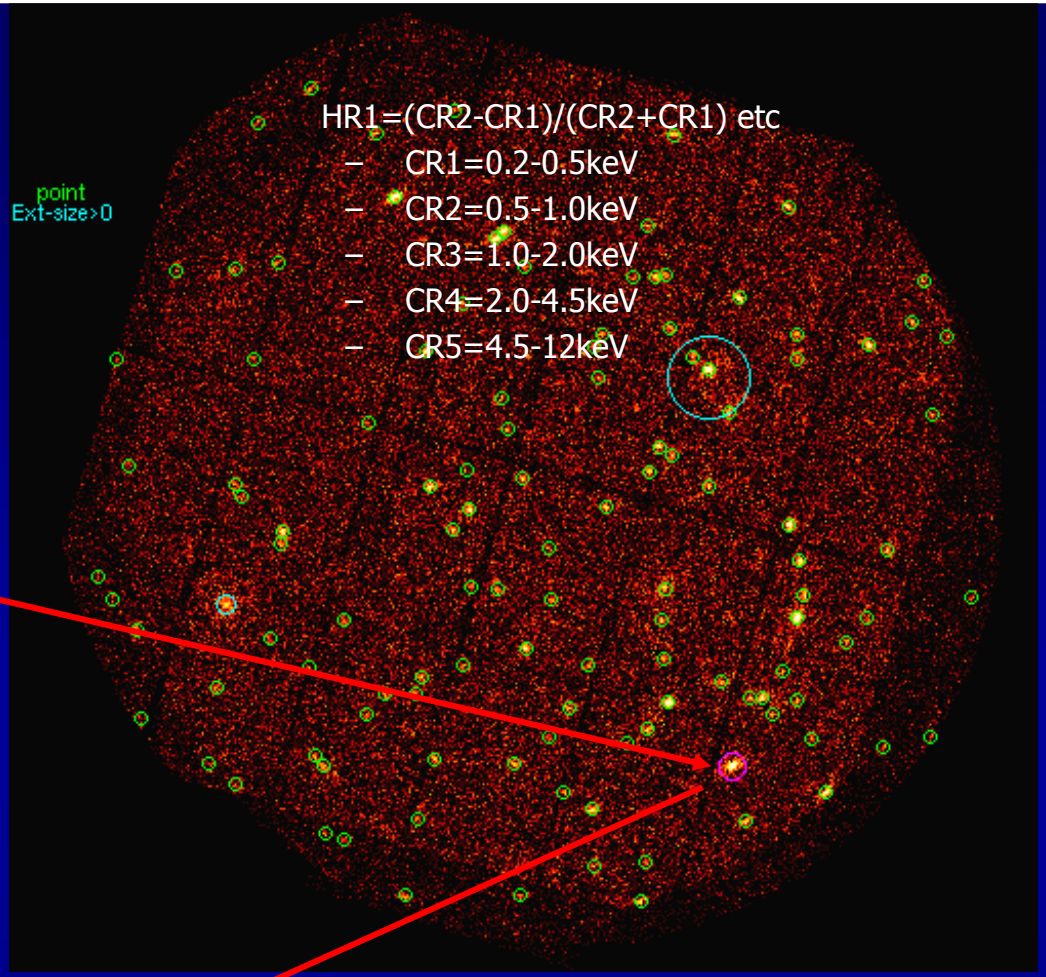
Jonathan Tedds
Leicester University

Results: Broad absorption line QSOs

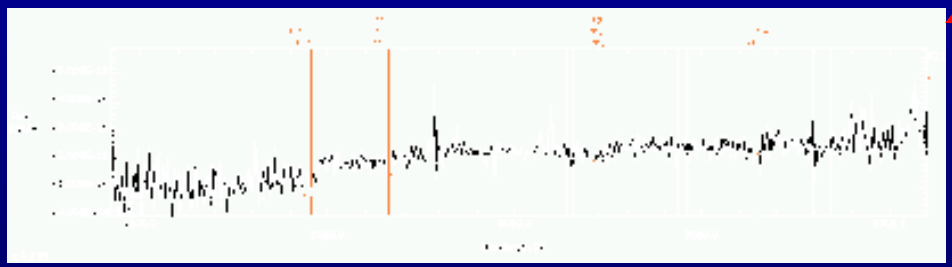
- ~10-20 BALQSOs found cf ~1000 QSOs
  - 1-2% of the X-ray QSO population
  - 1/3 the fraction found in past optical surveys
    - this is suprisingly large… but new SDSS result?
    - ~15% optical QSO population, 1.7<z<3.5 (Reichard et al 03)
- The X-ray selected ones will have the lowest X-ray absorption of the BALQSO population
  - Are their optical absorption lines typical of the optically selected population?
  - What are their X-ray column densities?
    - Homogeneous reprocessing of all 2dF XMM data completed
      - Current public pipeline
      - 2XMM test pipeline

ROE IR Surveys Workshop, 10th Nov 2005





with Silvia Mateos, Mike Watson



X-ray colour selection → obscured source → ID with NELG z=0.23

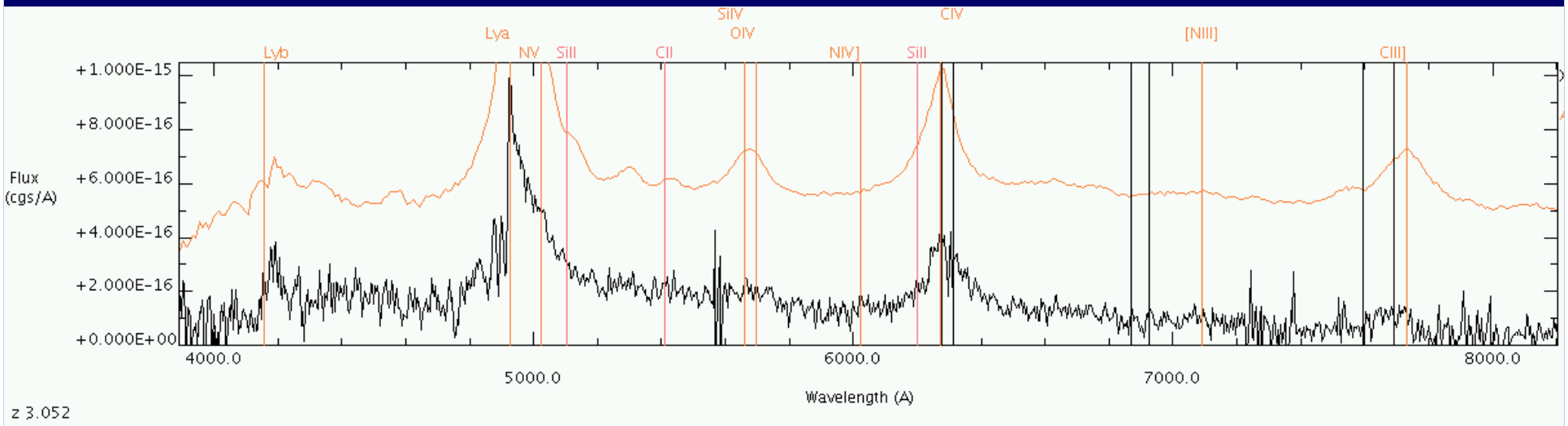
XMM-Newton SURVEY SCIENCE CENTRE

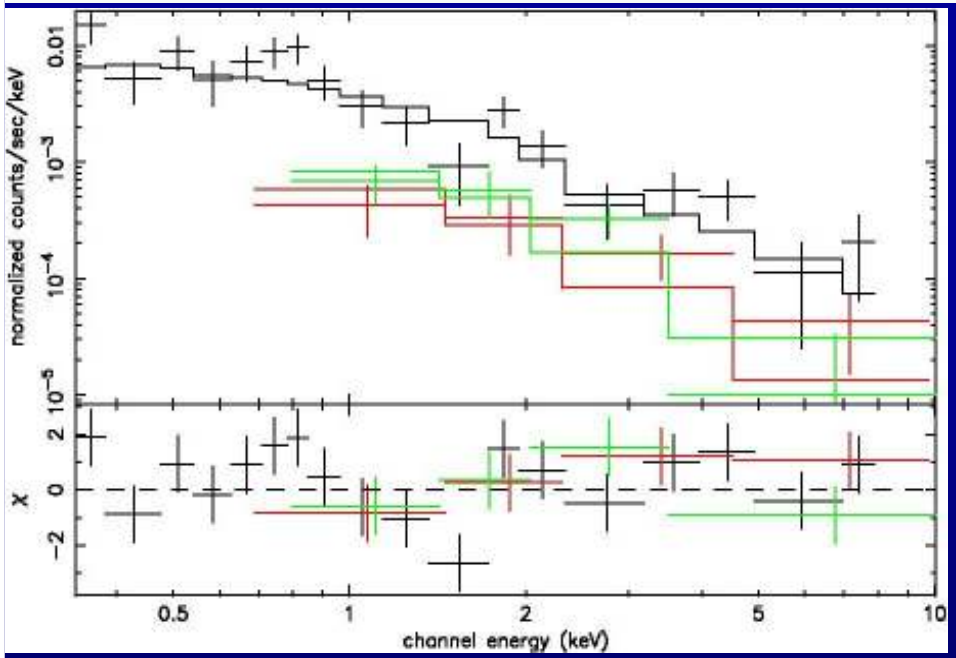
Jonathan Tedds
Leicester University

BLAGN

- What are their X-ray spectra? => XMM reprocessing complete
  >150 BLAGN spectra EPIC counts >200
  e.g. stack, bin spectra - Fe line?
- What is the space density of z~4 QSOs in X-ray surveys - do they decline at z > 2 in the same way that optical QSOs do?
- How common is X-ray absorption?
- Ly-alpha in optical red, relatively easy objects to identify spectroscopically, but fairly rare on the sky - 2dF survey ideal
- WFC,ESO mags for some fields – photo-z (Astrogrid VO tools), dropouts
- Supercosmos, Sloan correlations via AstroGrid, Vizier etc

Jonathan Tedds
Leicester University





Z=3.052 BLAGN

F_X=5x10^{-15} cgs, power law = 1.66, N_H=10^{20}
Bj=22.46

broad Lyb, Lya/NV/SiII + weak abs, broad CII
SiIV/OIV CIV [NIII] CIII]

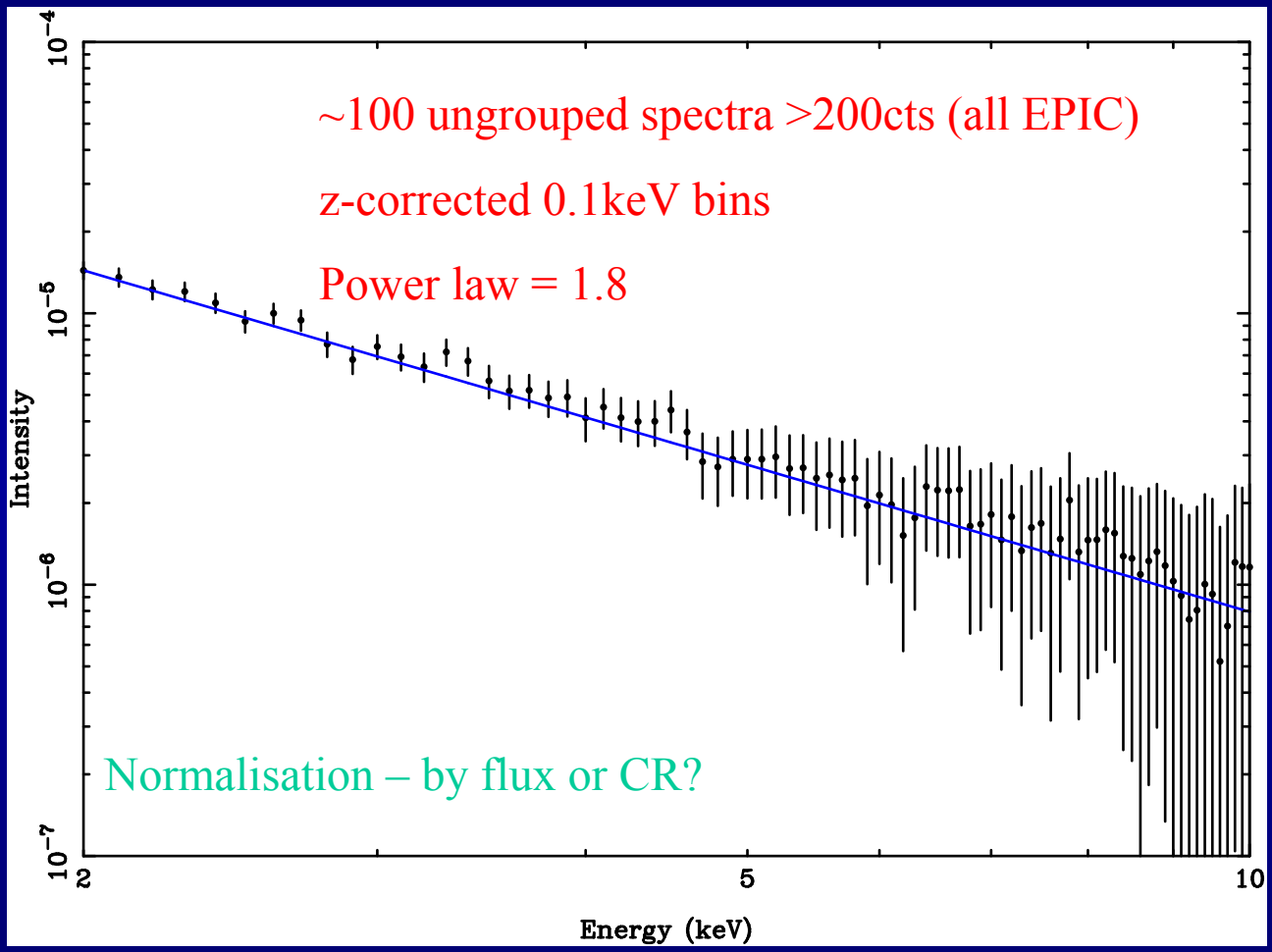
with Pam Derry

XMM-Newton
SURVEY SCIENCE CENTRE

Jonathan Tedds
Leicester University

Stacked BLAGN spectra

with
Pam Derry
Silvia Mateos
Mike Watson
Gordon Stewart



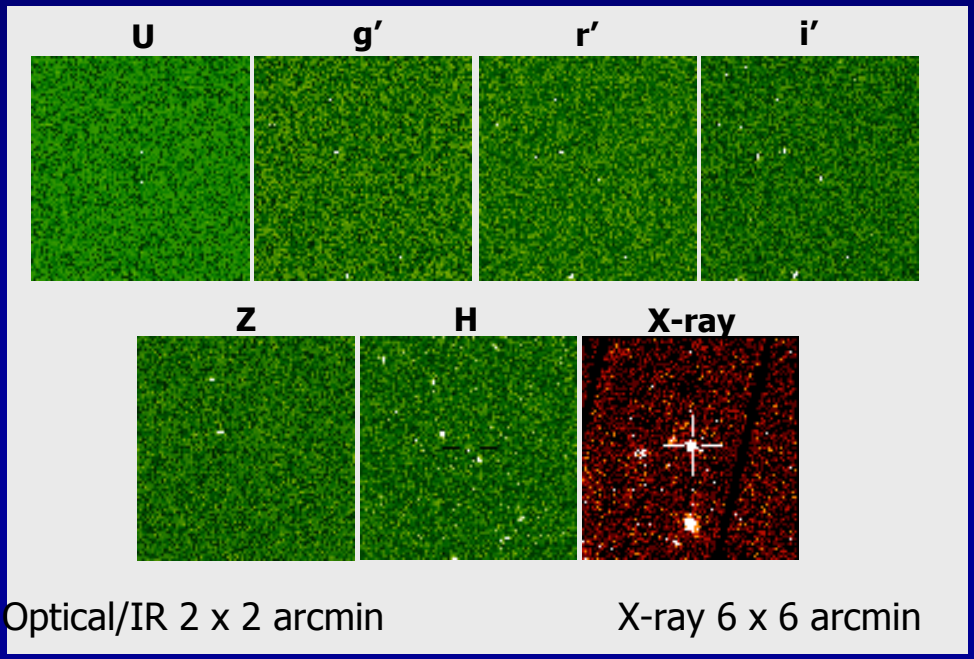
XMM-Newton SURVEY SCIENCE CENTRE

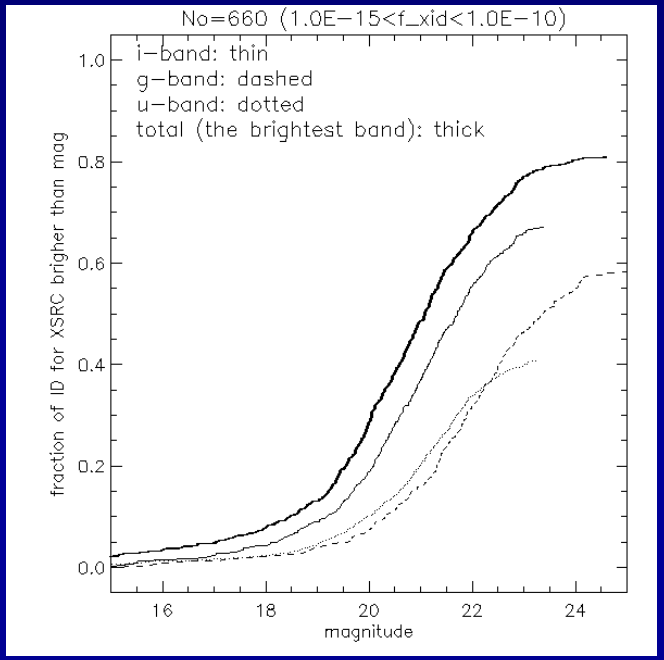
Jonathan Tedds
Leicester University

XID Imaging Programme

With McMahon, Yuan (IoA); Watson; Schwope (AIP)

80% IDs with INT WFC data



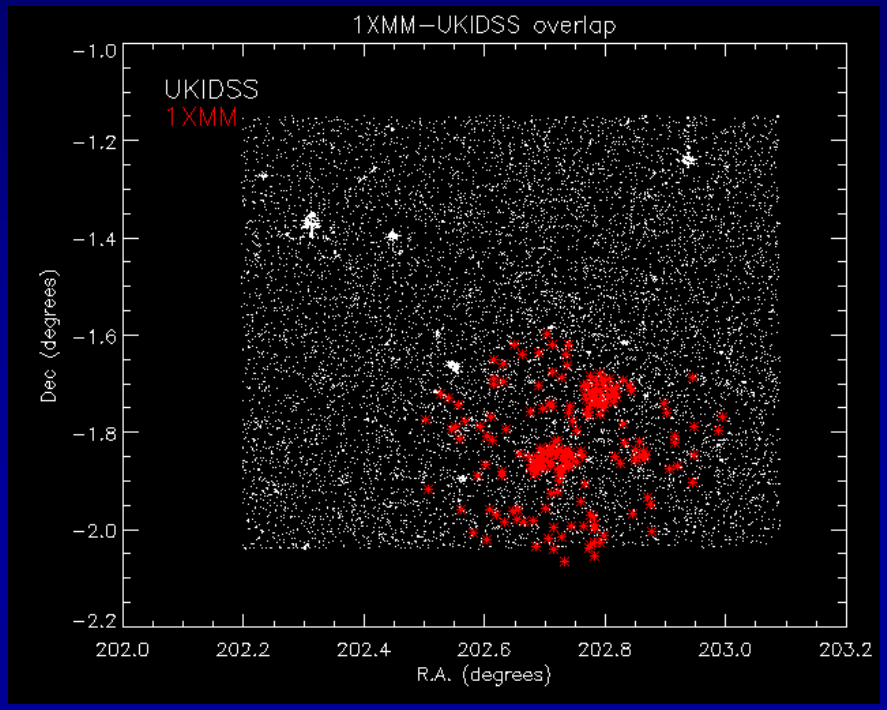


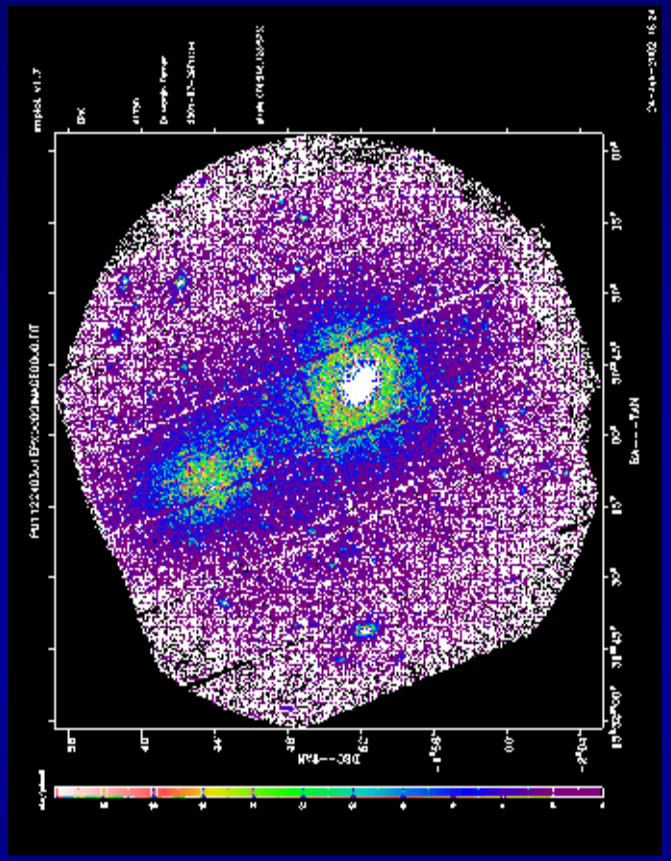
- multicolour optical data for 33/68 2dF XMM fields (WFC+ESO)
  - magnitudes, colours, morphology, redshifts
- 2 mag. deeper than SDSS (INT WFC $i' \approx 23^m$; SDSS $i' \approx 21^m$)
- *photometric* IDs for ~1500 XMM sources !

XMM-Newton SURVEY SCIENCE CENTRE

Jonathan Tedds
Leicester University

UKIDSS LAS and the XMM Serendipitous Catalogue





- Single UKIDSS Tile
  - 4 point mosaic
  - SV target L/T dwarf?
- XMM pointing on Abell 1750 cluster (redshift z=0.085)

XMM-Newton SURVEY SCIENCE CENTRE

Jonathan Tedds
Leicester University

UKIDSS LAS and the XMM Serendipitous Catalogue

- One 1XMM field 'by chance' overlapped with the UKIDSS LAS Science Verification observations
  - UKIDSS Target was a L/T dwarf
  - XMM target was Cluster Abell 1750 (z=0.075)
    - non-ideal XMM field but illustrative

- 50 sources with Fx>2x10-14cgs

- UKIDSS/SDSS Identification statistics
  - Search radius 5"; ~2sigma radius for 1XMM sources
  - 40 1XMM sources have ids in SDSS DR4 (id rate=80%)
  - Normal blank 'field' ID rate is 30% so maybe ids associated with cluster of galaxies
  - No 'new' UKIDSS LAS ids i.e. all SDSS blank fields were blank in LAS
  - 26 of SDSS ids have UKIDSS LAS detections (65%)

Conclusions:

LAS will provide YJHK photometry for 65% of 1XMM SDSS identifications

- 20% of all XMM sources in LAS

- 10% of all 2XMM sources will lie within LAS region(4000deg2) after 2yrs
  - Assuming 20% LAS ID rate
  - 2% of all XMM sources will have both SDSS and LAS photometry
  - 3000 sources from 2XMM catalogue

Jonathan Tedds
Leicester University

Summary

- **2dF ID >1000 sources brighter than $F_{0.5\text{-}4.5} > 10^{-14}$ erg cm^{-2} s^{-1}**
  - Homogeneous X-ray data reprocessing completed
    - Current public pipeline + test 2XMM
  - Characterise XRB source population
  - Optical multiband imaging complete for 1/2 fields (WFC,ESO…)
    - Opt mag dropouts?
    - 2 mags deeper than SDSS
  - Excellent statistical ID training sample
- XMM serendipitous survey = WIDE coverage!
  - Larger no of rare objects than deep, narrow surveys to date, e.g.
    - X-ray selected BAL QSOs => SDSS agreement?
    - High-z AGN

Jonathan Tedds
Leicester University