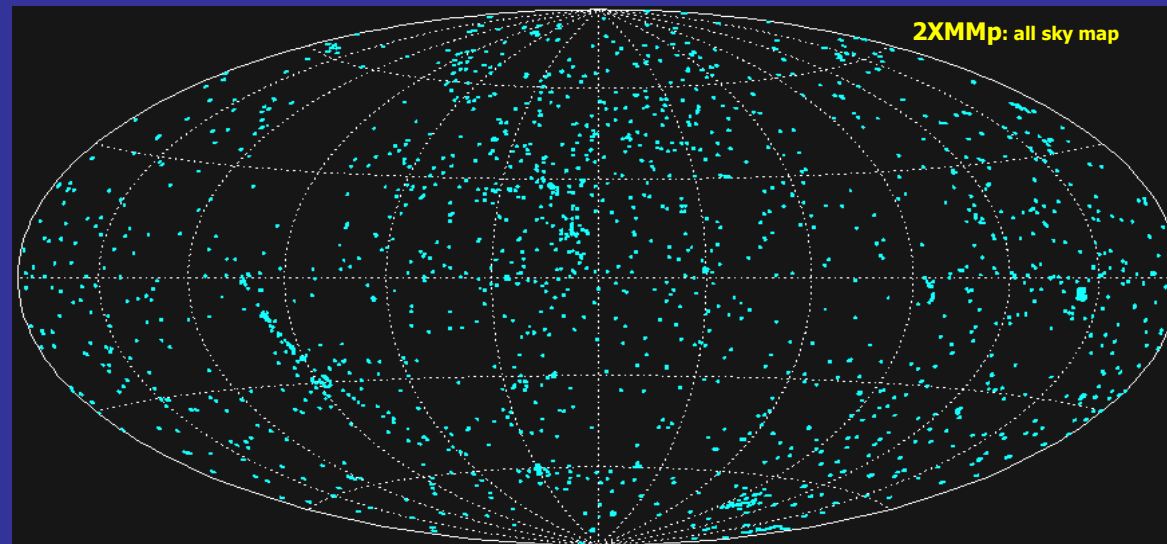


# The 2XMM pre-release Catalogue and Extragalactic variability



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*on behalf of the XMM-Newton Survey Science Centre Consortium*

# THE 2XMMp CATALOGUE

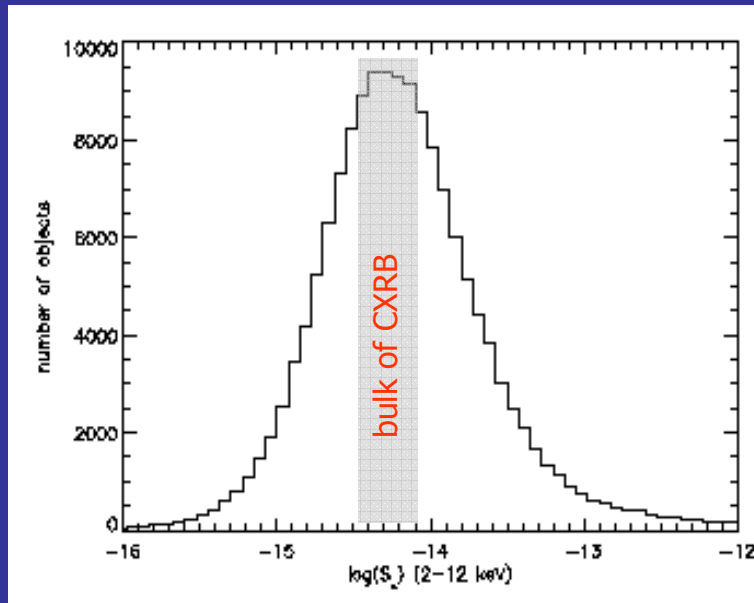
- 2XMM: new serendipitous X-ray source catalogue from XMM
  - EPIC public observations Feb 2000 – April 2006
- 2XMMp: *pre-release* of 2XMM *released July 2006*
  - Filtered subset by field quality
- **Largest X-ray catalogue ever**
  - 150K detections from 2400 observations
    - ~ 117K unique point sources
    - ~ 5K unique extended sources
  - 400 sq.deg. (~280 sq deg overlap corrected)

## 2XMMp ACCESS ONLINE

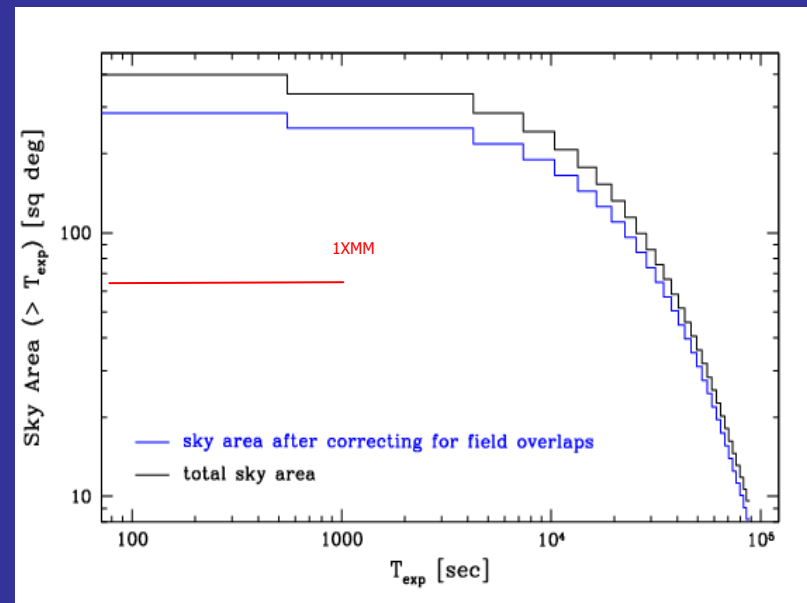
- **Web Page:** <http://xmmssc-www.star.le.ac.uk/>
- **XSA:** <http://xmm.esac.esa.int/xsa/>
- **LEDAS:** <http://www.ledas.ac.uk/>

# THE 2XMMp CATALOGUE

- median flux (0.2 - 12 keV) of sources  $\sim 2.4 \times 10^{-14}$  erg cm<sup>-2</sup> s<sup>-1</sup>
- $\sim 20\%$  have fluxes  $< 1 \times 10^{-14}$  erg cm<sup>-2</sup> s<sup>-1</sup>
- **see M.Watson 2XMMp poster P190**



Distribution of 2-12 keV fluxes for 2XMMp catalogue. The catalogue matches the typical fluxes where most of the Cosmic X-ray Background (CXRB) energy density originates.

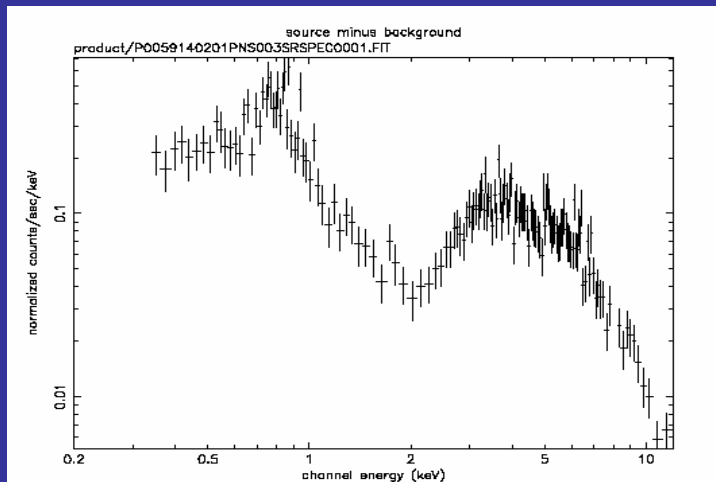


Sky area covered by the 2XMMp catalogue as function of exposure time.

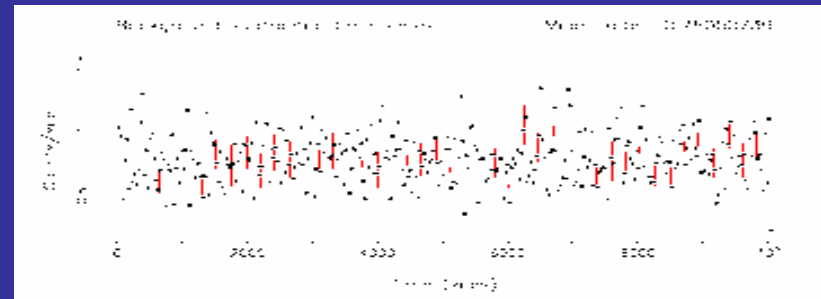
# THE 2XMMp CATALOGUE

## KEY FEATURES

- extended source search and parameterisation
- science grade catalogue:
  - high reliability
  - excellent astrometry and photometry
- spectra & time series for >10% of all 2XMM sources (~15000 sources)



Example X-ray spectrum: automatically extracted as 2XMMp data product



Example X-ray light curve: automatically extracted as 2XMMp data product

## 2XMMp time series and spectra

- **Time Series & Spectra generated if:**
  - Total EPIC > 500 cts (PN:MOS = 3.5:1 assumed)
  - Energy 0.2-12 keV
  - Region
    - 28'' radius circle (source)
    - 60-180'' annulus (background)
    - Exclude DET\_ML > 15 sources at 60'' radius
- **Short term variability - within exposures**
  - SAS task *ekstest*
  - Use  $\chi^2$  probability (based on null hypothesis) that source is constant
    - Pearson's approximation to  $\chi^2$  for Poissonian data
    - Model is used as estimator of it's own variance
  - Flag as variable if  $\chi^2$  probability <  $1e^{-5}$  in at least 1 exposure

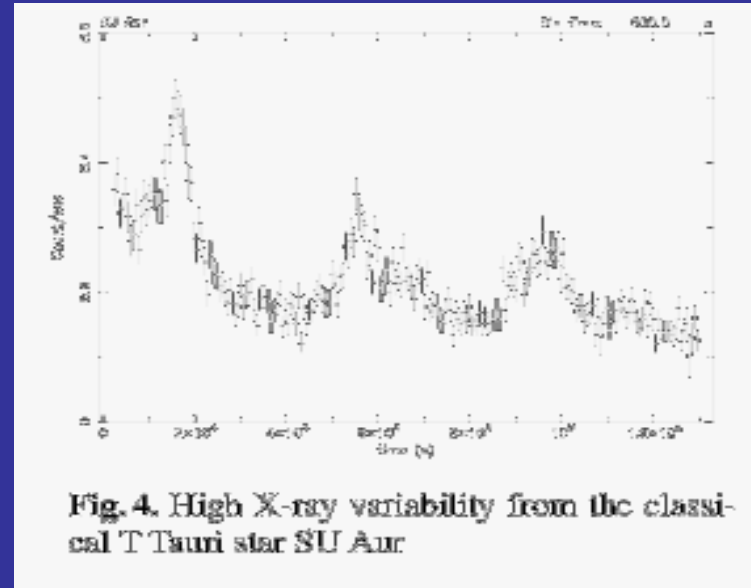
### 2XMMp variables

~15900 sources with lightcurves, spectra

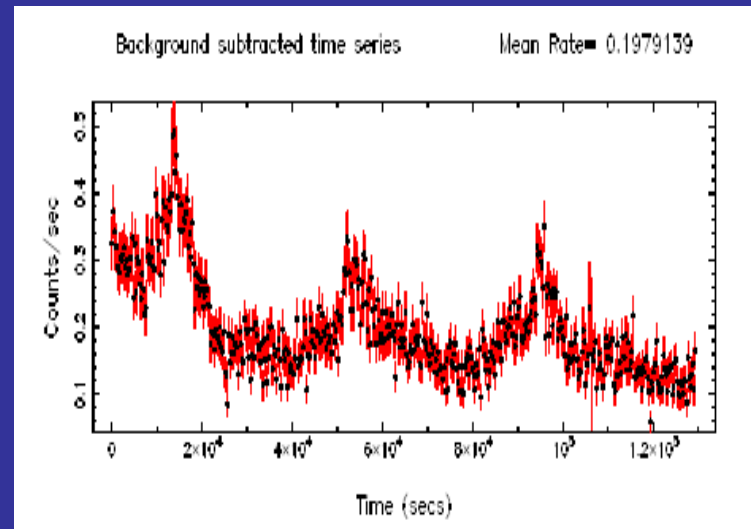
~1100 flagged as variable using  $\chi^2$  test

## Sanity check – known stellar variable

published light curve Pallavicini et al.



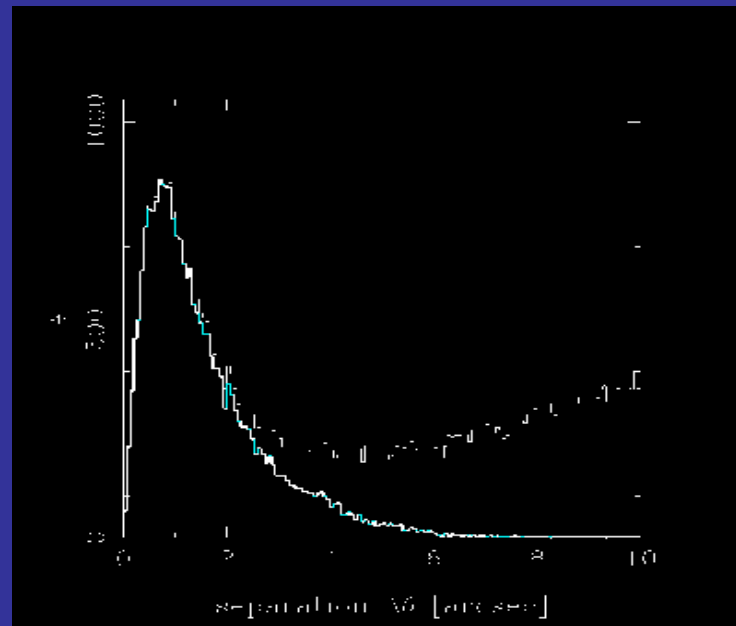
automatically generated time series plot from 2XMMp reprocessing pipeline



# 2XMMp – SDSS DR5 CROSS-CORRELATION

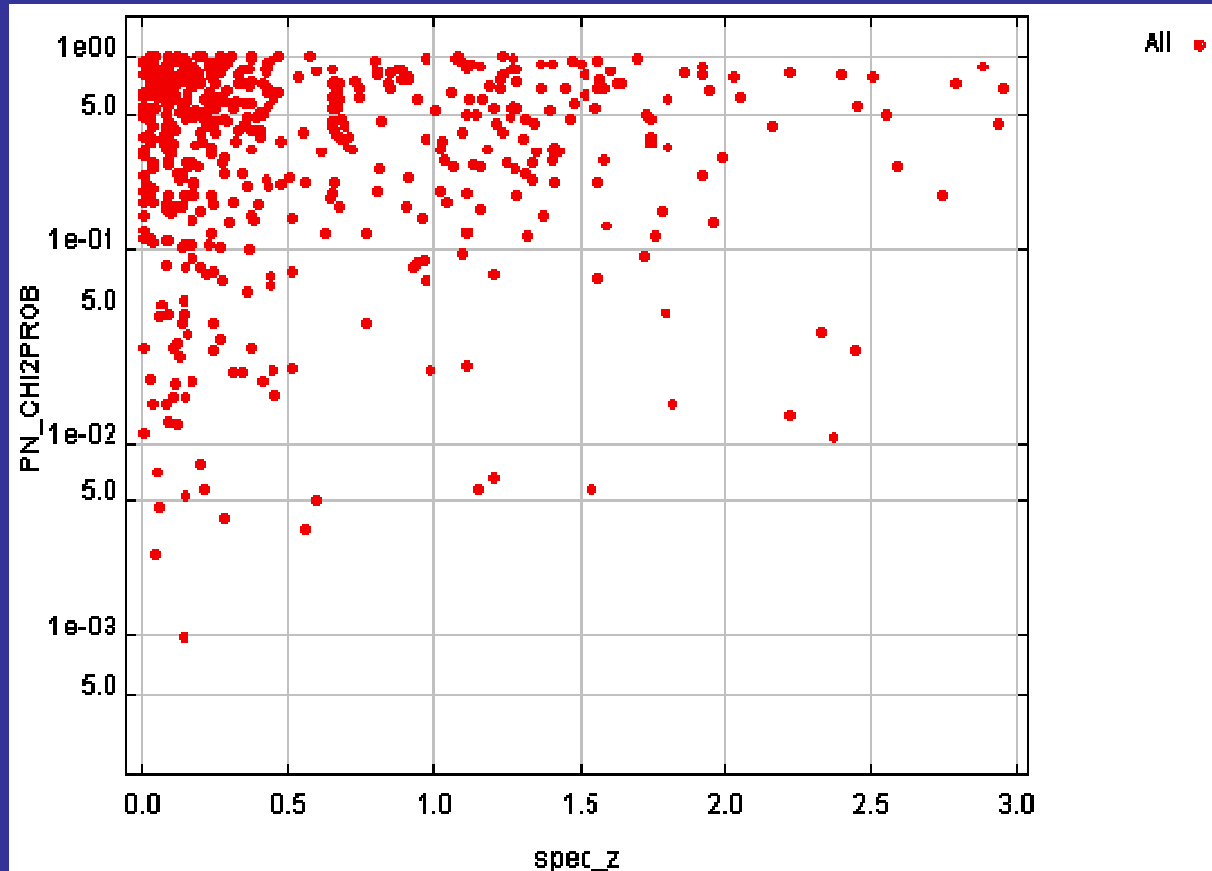
see M.Watson 2XMMp poster P190

- ~ 25% overlap by sky area
- ~ 20,000 secure matches (using *likelihood ratio* analysis)
- ~ 60% of 2XMMp sources in overlap region have SDSS match
- ~ 1200 matched XMM sources SDSS spectra (~1% of 2XMMp)



## Identify Extragalactic sample with 2XMMp lightcurves

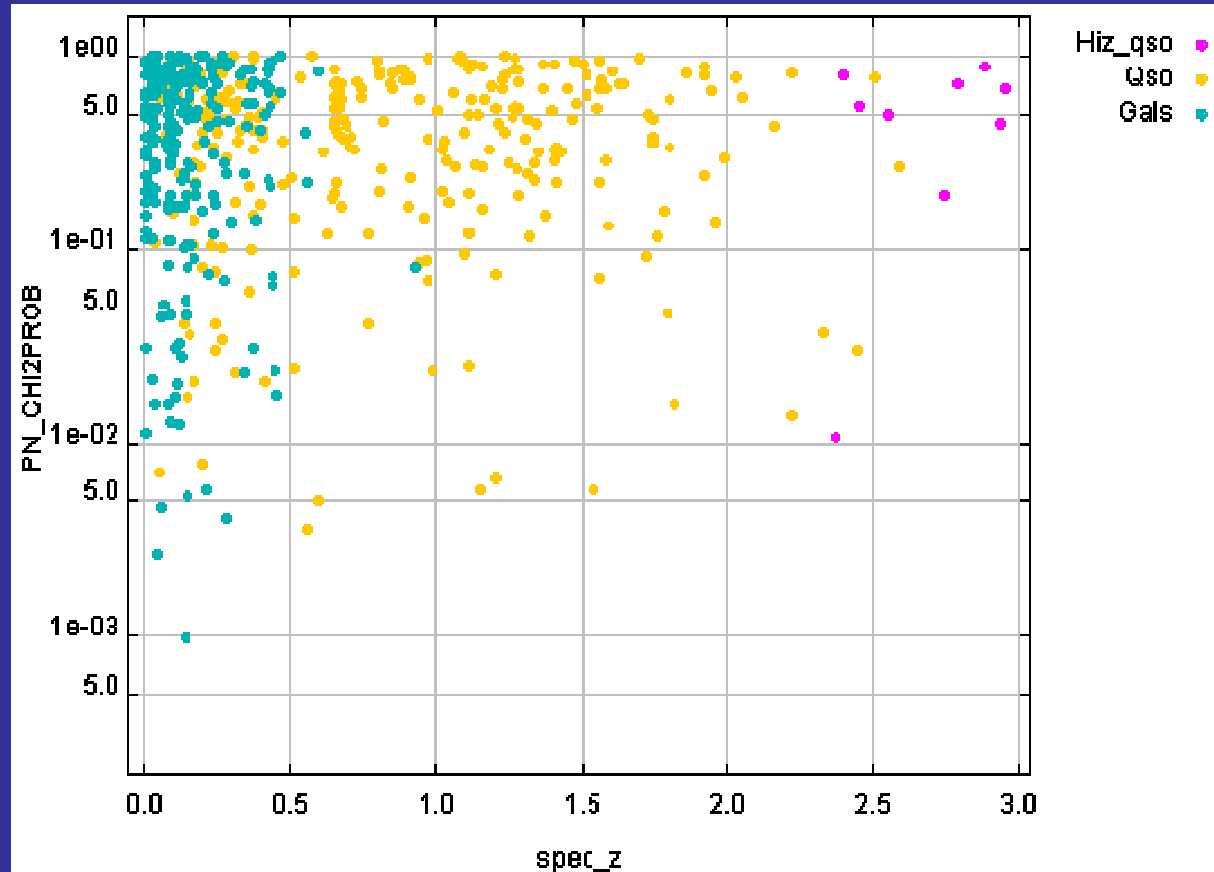
- Use SDSS DR5 confirmed spectroscopic IDs = extragalactic
- 683 unique objects (301 gals, 370 qso's, 12 hiz\_qso's)



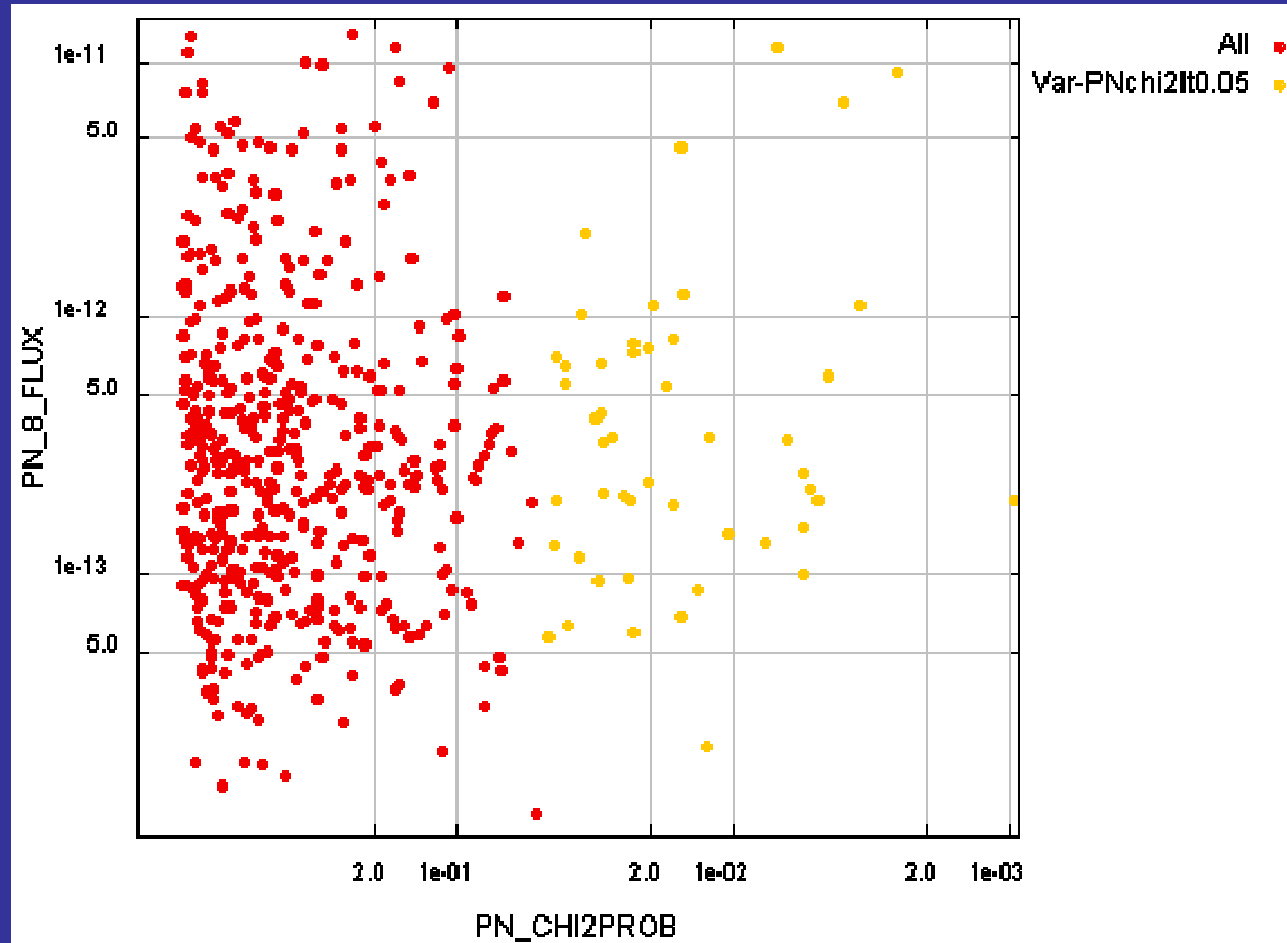


# Extragalactic variability in 2XMMp

- by SDSS DR5 sub-class (gals, qso, hiz\_qso)

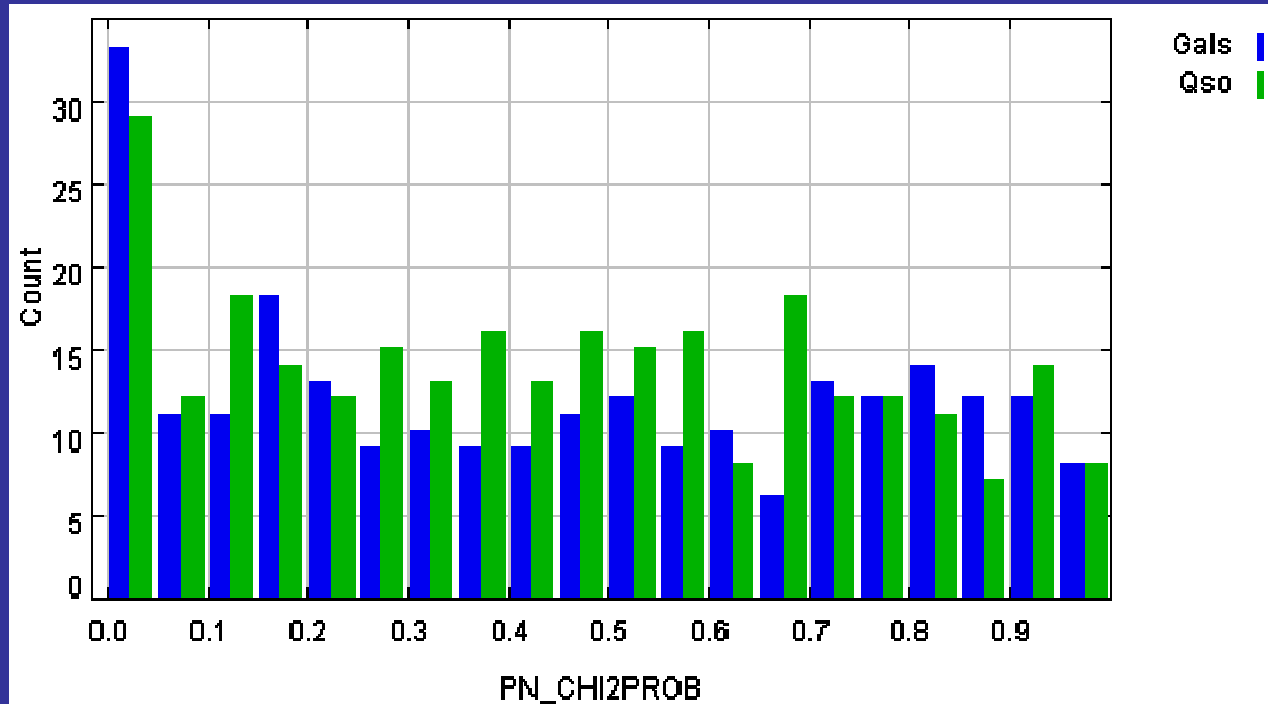


## 0.2-12keV Flux & variability in 2XMMp



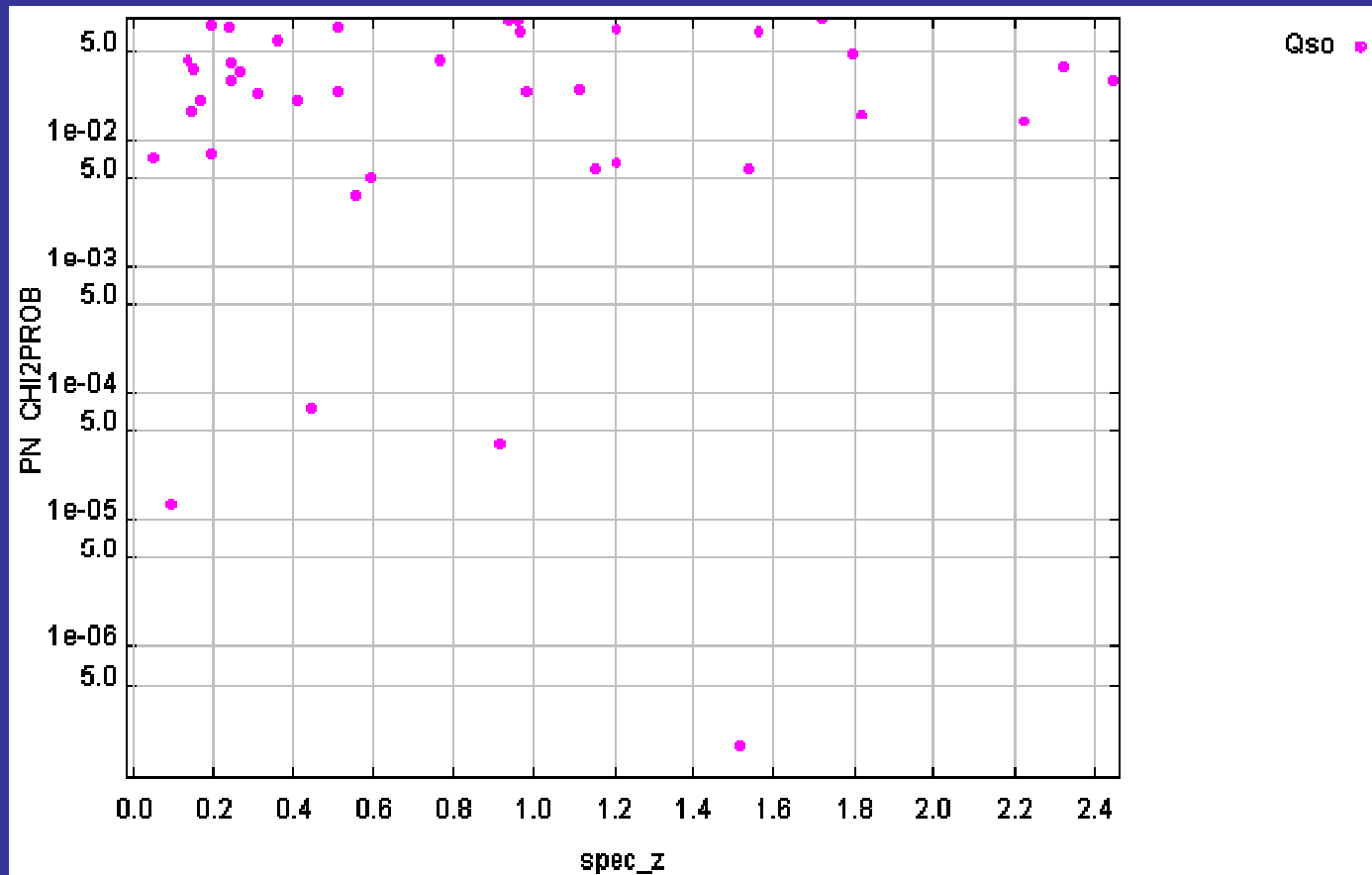
# Extragalactic variability in 2XMMp

- Histogram by SDSS DR5 sub-class (Gals, QSOs)



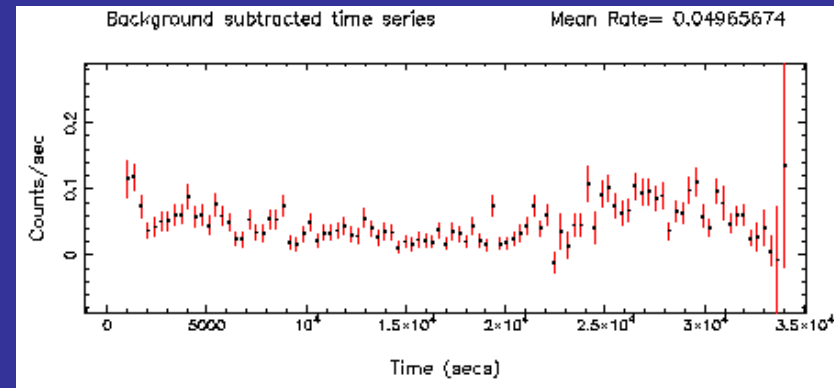
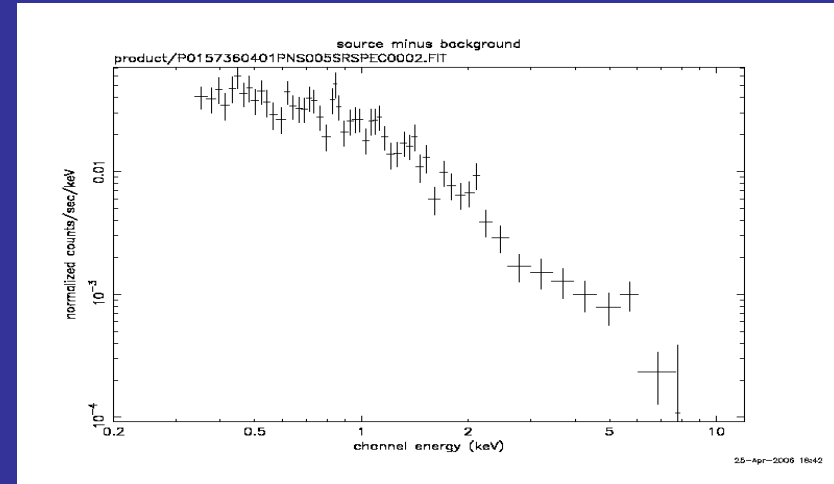
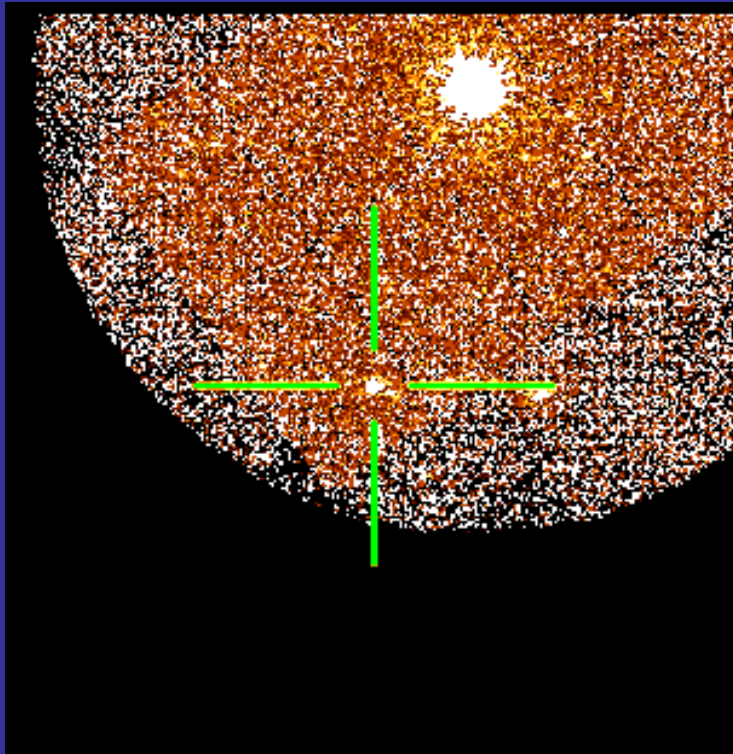
# Extragalactic variability in 2XMMp-DR5

- QSOs - PN  $\chi^2$  probability  $< 0.05$



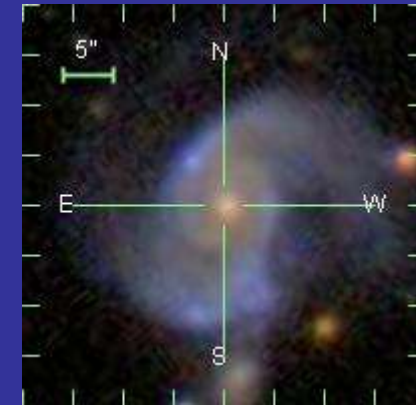
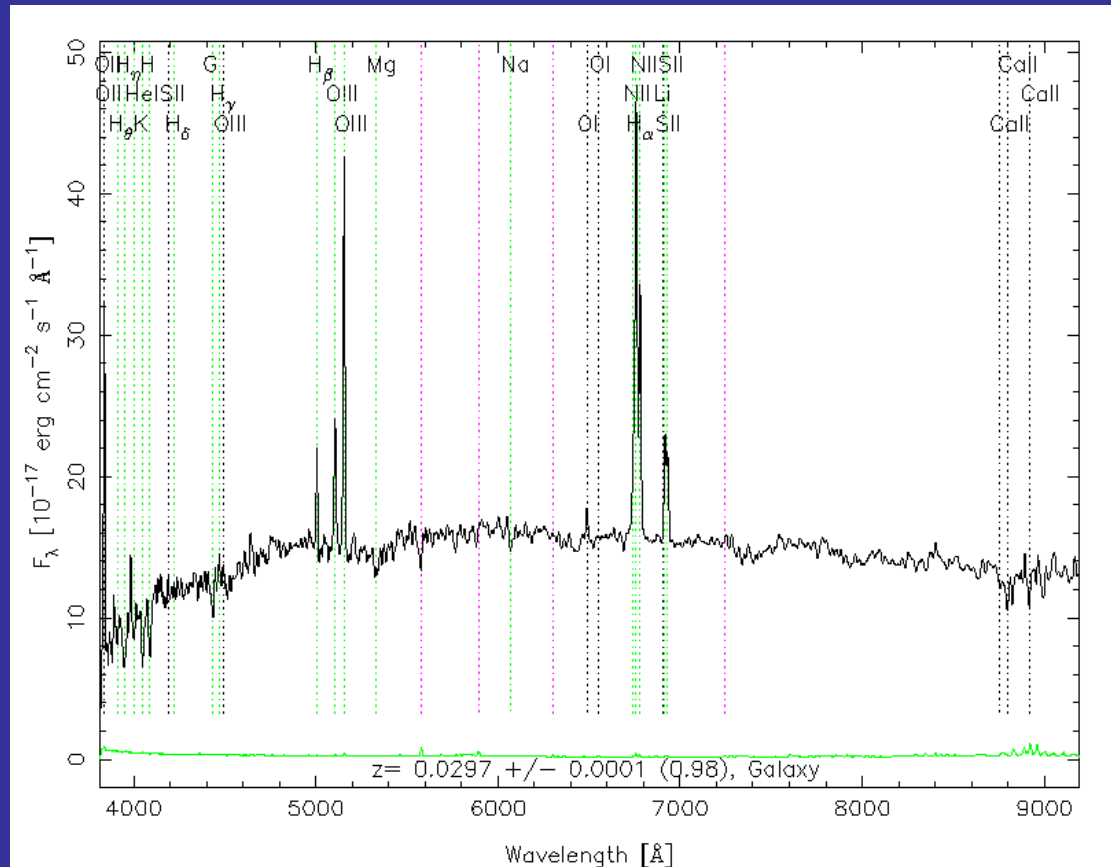
# Extragalactic short-term variable example

- PN  $\chi^2$  probability  $\sim 10^{-18}$
- $F_x = 3 \times 10^{-13}$  cgs (0.2-12keV)

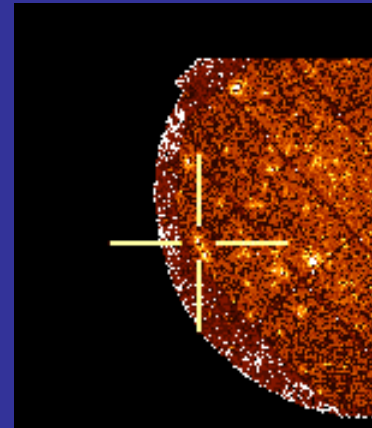
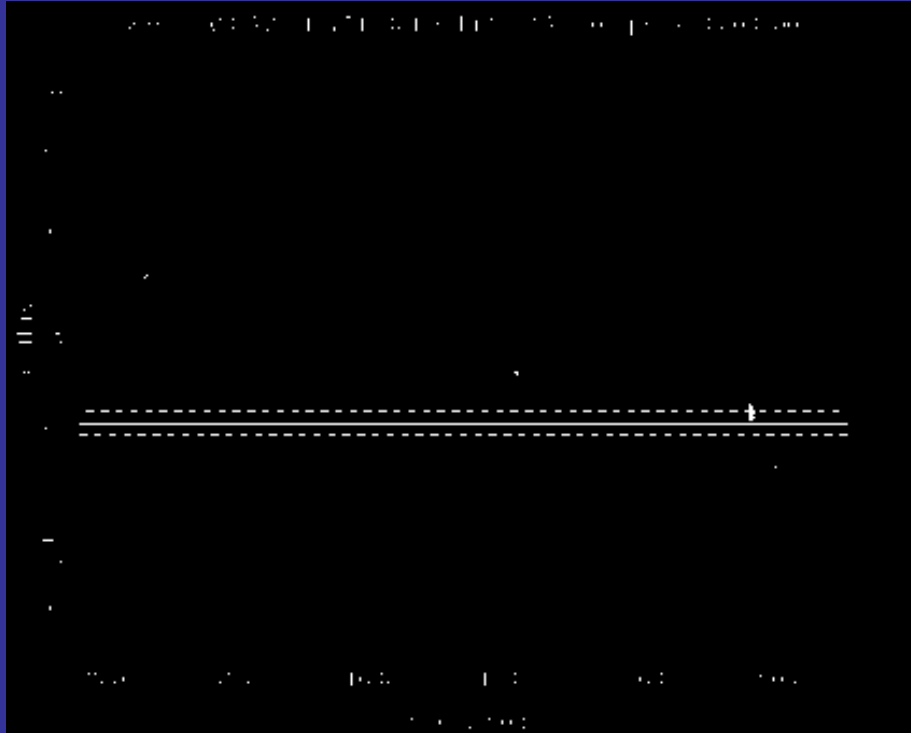


# Extragalactic short-term variable example

– NELG,  $z=0.03$



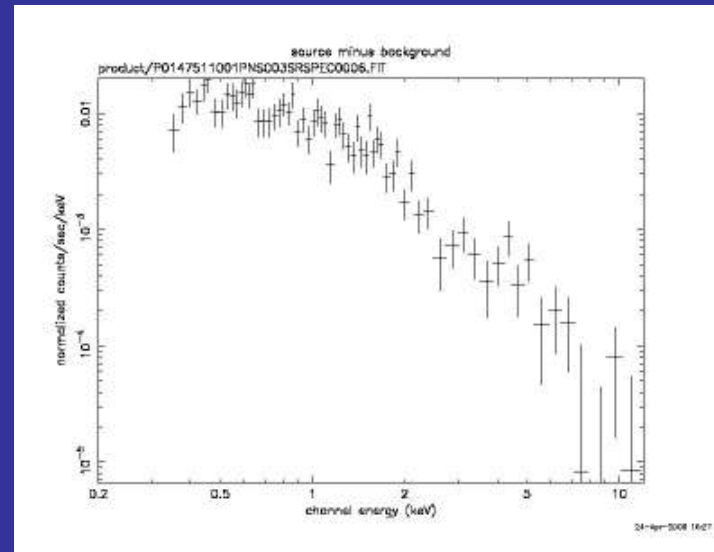
# Extragalactic long-term variable example



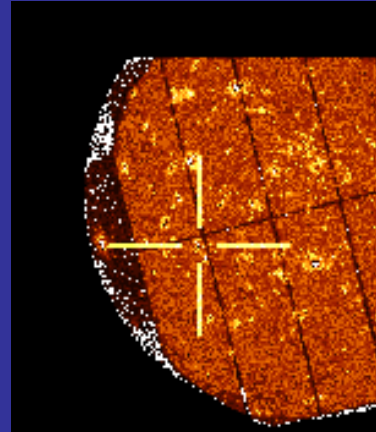
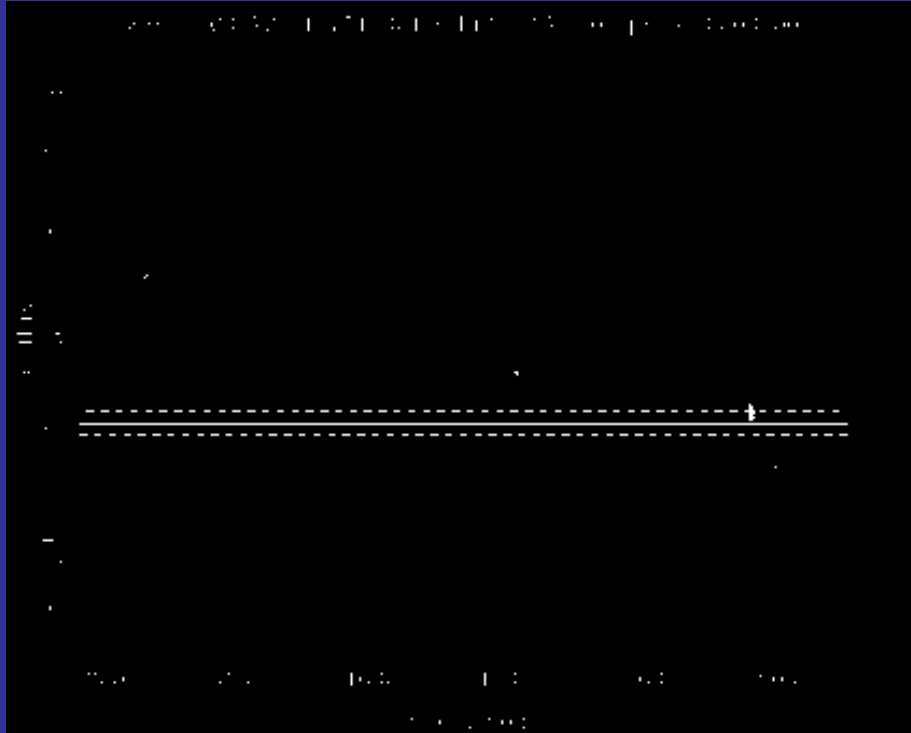
SDSS DR5



- Known QSO in LH
  - Clear long term decline over XMM lifetime
  - No obvious change in spectrum or short term variability



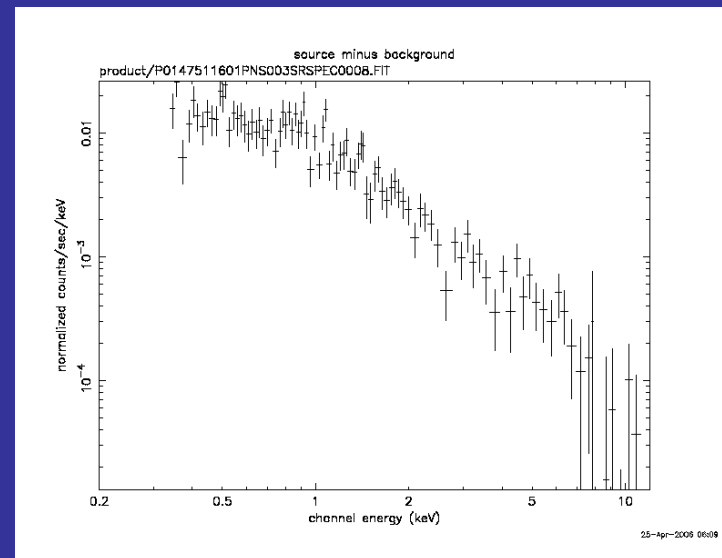
# Extragalactic long-term variable example



SDSS DR5



- Known QSO  $z=0.78$  in LH
  - Clear long term decline over XMM lifetime
  - No obvious short term variability





# Summary

- 2XMMp a unique resource to study X-ray variability
- Extragalactic variable candidates are rare and as likely to be QSOs as galaxies?
  - 683 unique 2XMMp sources in SDSS DR5
    - XMM lightcurves, spectra
    - optical spectroscopic IDs, spectral-z, linewidths
  - ~10% show  $\chi^2$  probability  $< 0.05$ 
    - No clear correlation of variability with  $F_x$  or z for gals or QSOs
- Clear serendipitous discovery potential of extragalactic variability in 2XMMp!
  - Short-term - e.g use  $\chi^2$  probability  $< 0.05$  for gals and QSOs
  - Long-term - compare multi-epoch XMM and Chandra, ROSAT
- Future work
  - need larger samples
    - Extend to include XMM-2dF wide angle survey (S.Mateos, Y.Xu talks)
    - Use much bigger statistically ID'd samples next?

# Credit

- The production of the XMM catalogue is a collaborative project involving the whole SSC Consortium:
  - University of Leicester, UK
  - Mullard Space Science Laboratory, University College London, UK
  - Institute of Astronomy, Cambridge, UK
  - Max-Planck Institut für extraterrestrische Physik, Germany
  - Astrophysikalisches Institut Potsdam, Germany
  - Service d'Astrophysique, CEA/DSM/DAPNIA, Saclay, France
  - Centre d'Etude Spatiale des Rayonnements, Toulouse, France
  - Observatoire Astronomique de Strasbourg, France
  - Instituto de Fisica de Cantabria, Santander, Spain
  - Osservatorio Astronomico di Brera, Milan, Italy
- 
- The SSC team is pleased to acknowledge the contributions to the SAS software, on which the catalogue processing is based, made by ESA's Science Operations Centre staff. Significant contributions to the production of the catalogue were also made by NASA Goddard Space Flight Centre HEASARC staff resident for much of the project at the University of Leicester