X-ray emission from PTT stars

Giulio Del Zanna

Department of Applied Mathematics and Theoretical Physics
University of Cambridge

Acknowledgements

UNIVERSITY OF CAMBRIDGE

I would like to acknowledge the participation, contribution/support from:

- Gordon Bromage and Hannah Leigh Worters, UCLAN, UK
- Helen Mason, University of Cambridge UK
- Carl Foley, Hilary McKay, MSSL, UK
- Alan Whiting group (CTIO, Chile), in particular Melissa Rice.
- Carlos Alberto, Germano Quast and Ramiro Delareza (Brasil).
- The XMM/SOC at Villafranca, Madrid (Spain), for their professional support. In particular, of Nora Loiseau and Pedro M. Rodriguez Pascual.
- Federico Gonzalez (CASLEO), Argentina

Goals

- determine the physical characteristics of the X-ray emission (during quiescent and flaring state) of PTT stars to help understand the evolution from the T-Tauri phase.
- relate them to the properties of the stellar photospheres.
- in particular in terms of chemical composition
- It is likely that the X-ray emission from CTTS is due to accretion (as proposed by Kastner et al. 2002 for TW Hya)
- the PTTS probably have extended solar-like coronae.
- This is perhaps the first XMM observation. Only one other PTTS (PZ Tel, Argiroffi et al. 2004).
- Multiwavelength multiwavelength multiwavelength

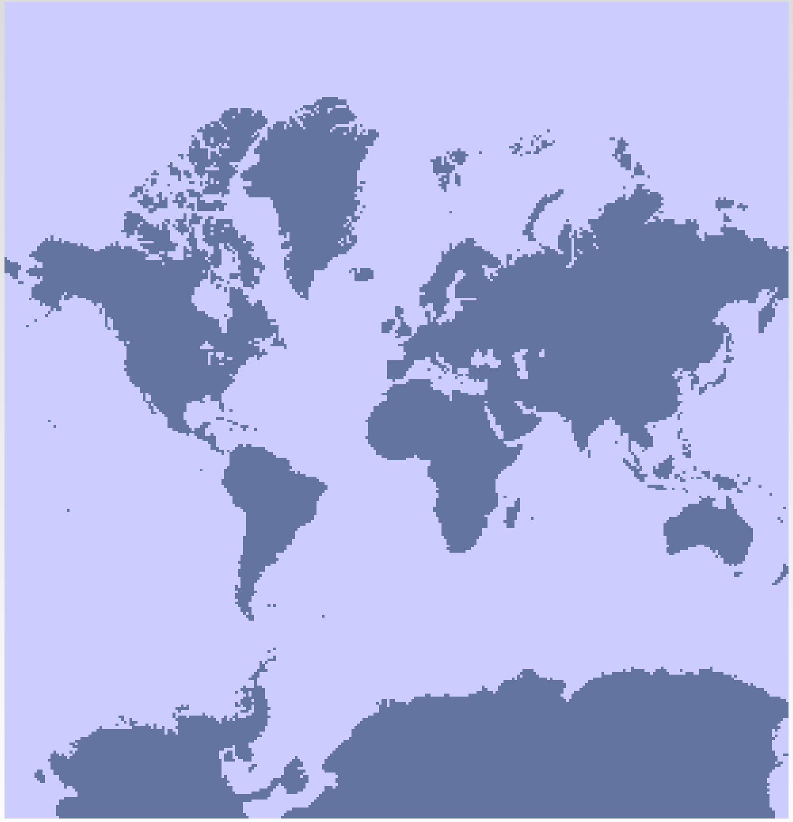
The target

UNIVERSITY OF CAMBRIDGE

- 2RE J0241-53 (nicknamed Horace) is a binary of active X-ray emitting stars, classified as a member of an association of young Post-T-Tauri stars ($\sim$ 30 Myr) by Torres et al. (2000).
- 2RE J0241-53 (EUVE J0241-530) is a bright XUV visual binary, discovered by the ROSAT (Pye et al., 1995) and EUVE (Bowyer et al., 1996) all-sky surveys (see also Jeffries et al. 1996).
- Count rates in the 100 Å bandpassess were comparable to those of the brightest flare stars.
- Both stars have strong chromospheric emission and have recurrent flares (Ball and Bromage 1995).
- dK7e and dM3e fast rotating stars (v sin i=12, 70 km/s). Southern star is Li-rich.

Pushing to the limits

- OM fast mode windows
- angular separation of 22”.
- roll angle
- multi-continent, multi-cultural experience



Ground-based

Spectroscopy

- SAAO 1.9m grating spectrograph with 1 Å resolution and $\simeq$90 s exposures.
- Wavelength range: 3700 - 4360 Å
- 6 consecutive nights

Photometry

- UBV aperture photometry with the SAAO 0.5-m telescope
- 3 nights

On XMM night

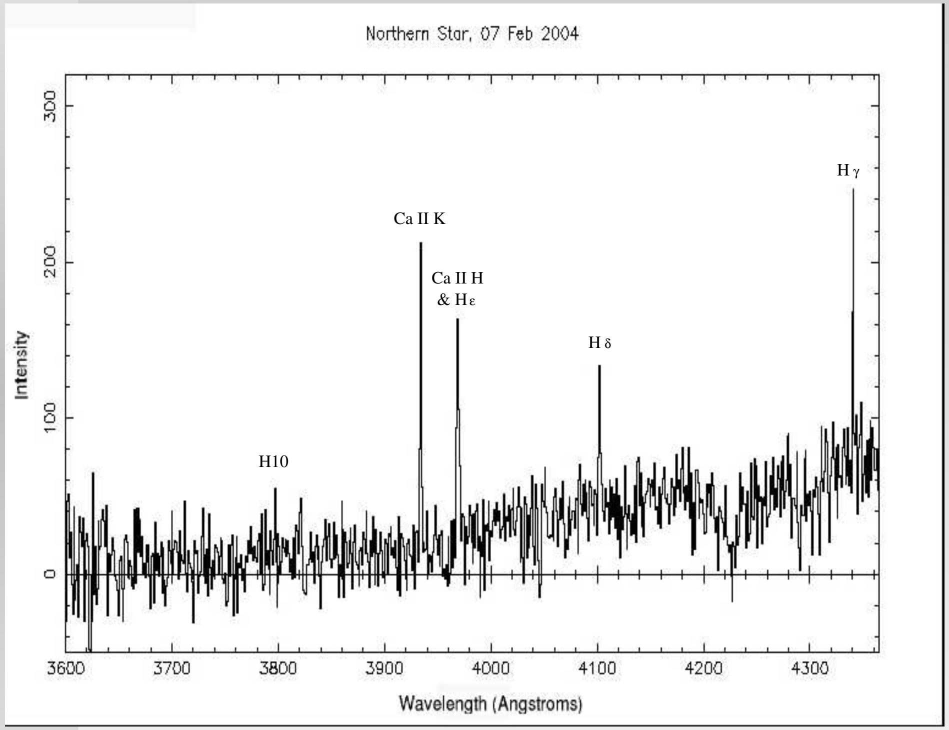
UNIVERSITY OF CAMBRIDGE

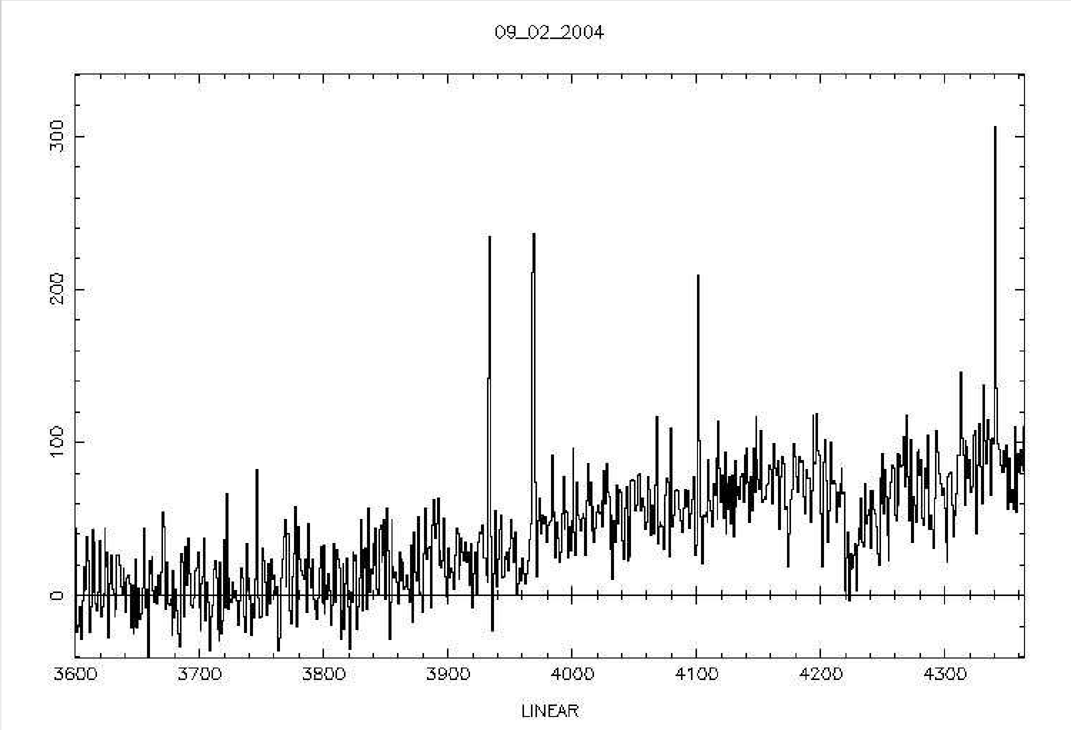
- CASLEO: cloudy
- SAAO 1.9m spectra 18:32 UT – 00:04 UT
- CTIO low-resolution (17.2 Å FWHM) 1.5m spectra
- CTIO CCD B and U band photometry with the 0.9m 01:17 04:40 UT
- SAAO U-band monitoring
- Brasil: B-band monitoring 23:00 – 00:30 UT

Ground-based spectra - northern star

UNIVERSITY OF CAMBRIDGE

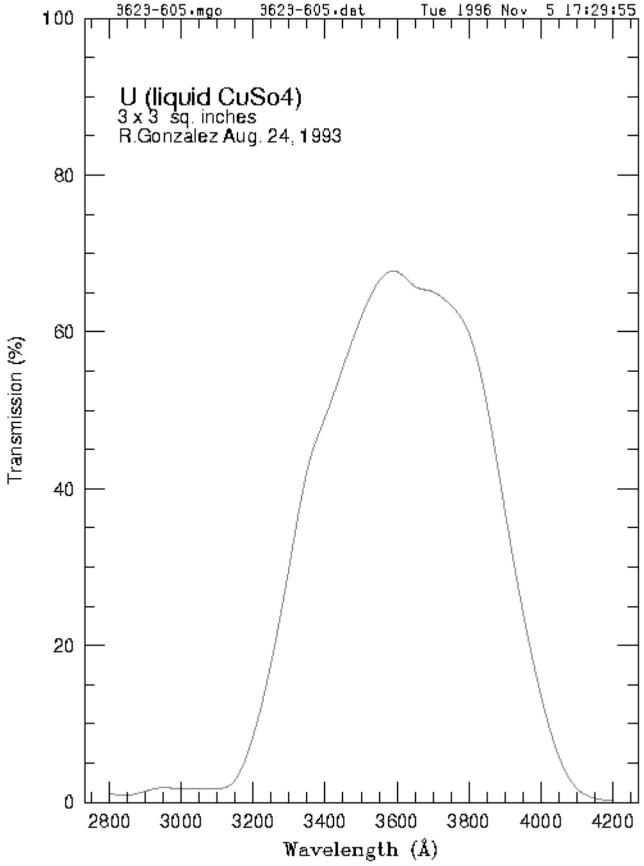
Two spectra on the 7th and 9th Feb 2004:

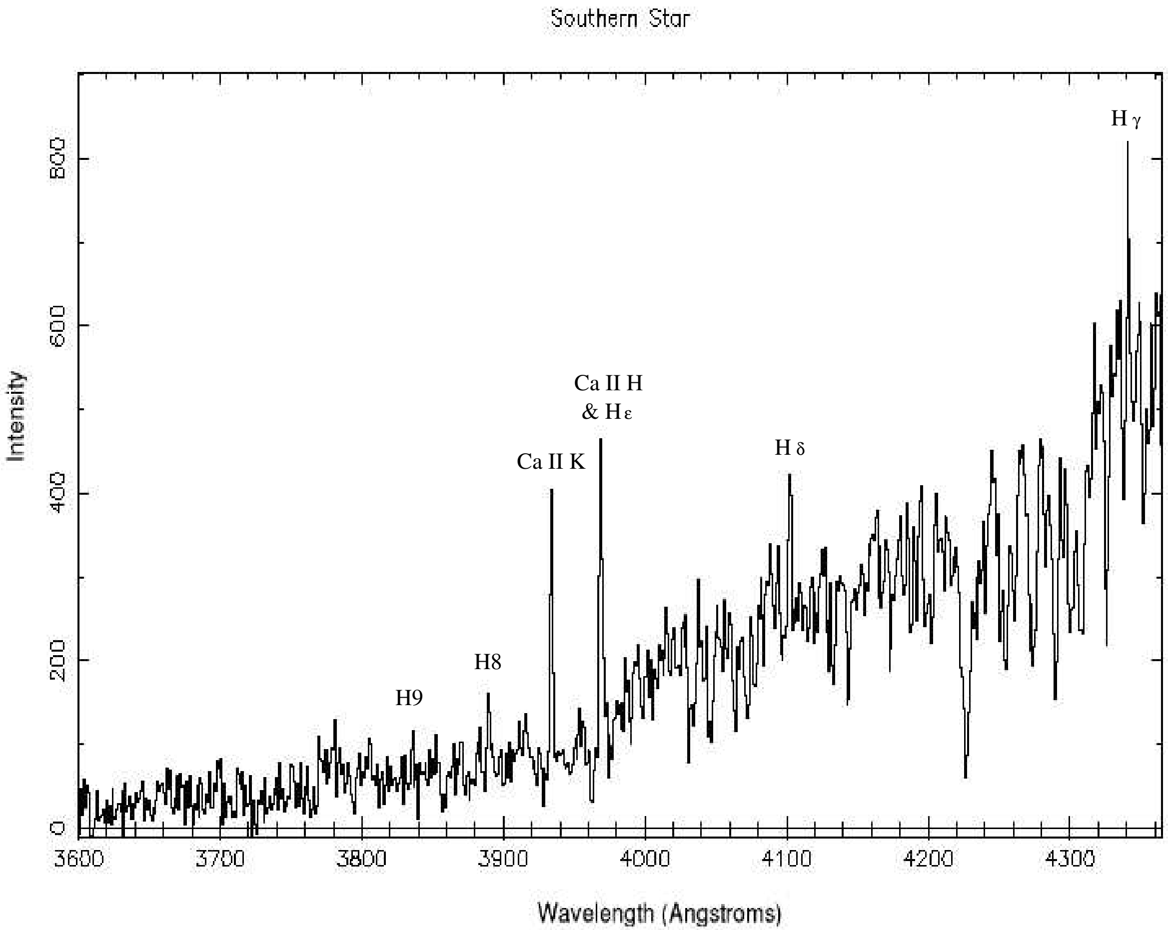




Filters

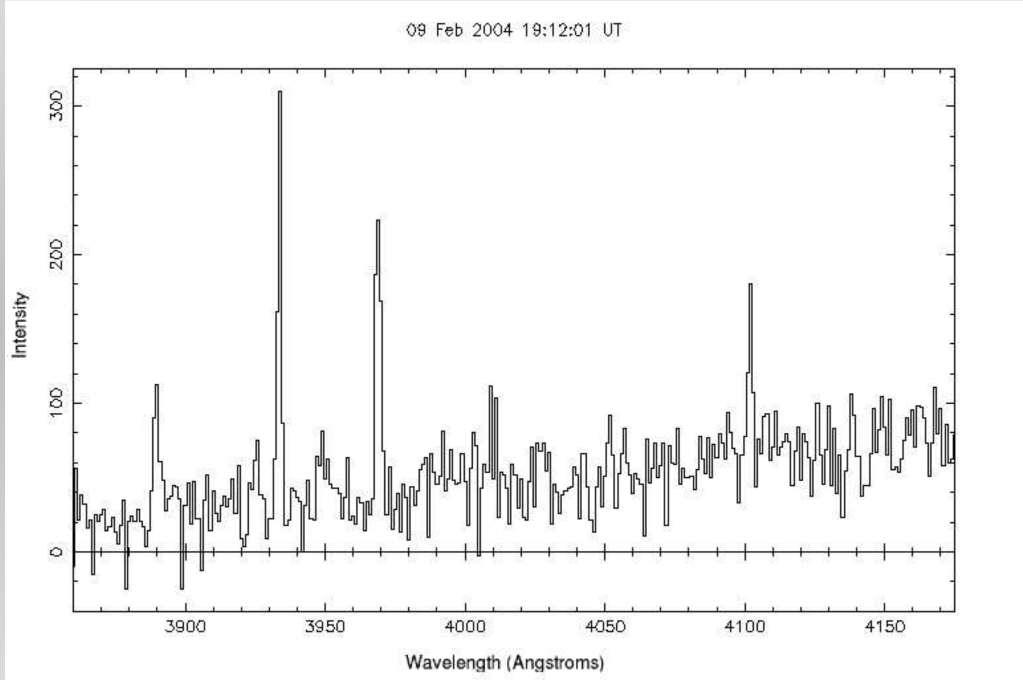
UNIVERSITY OF CAMBRIDGE

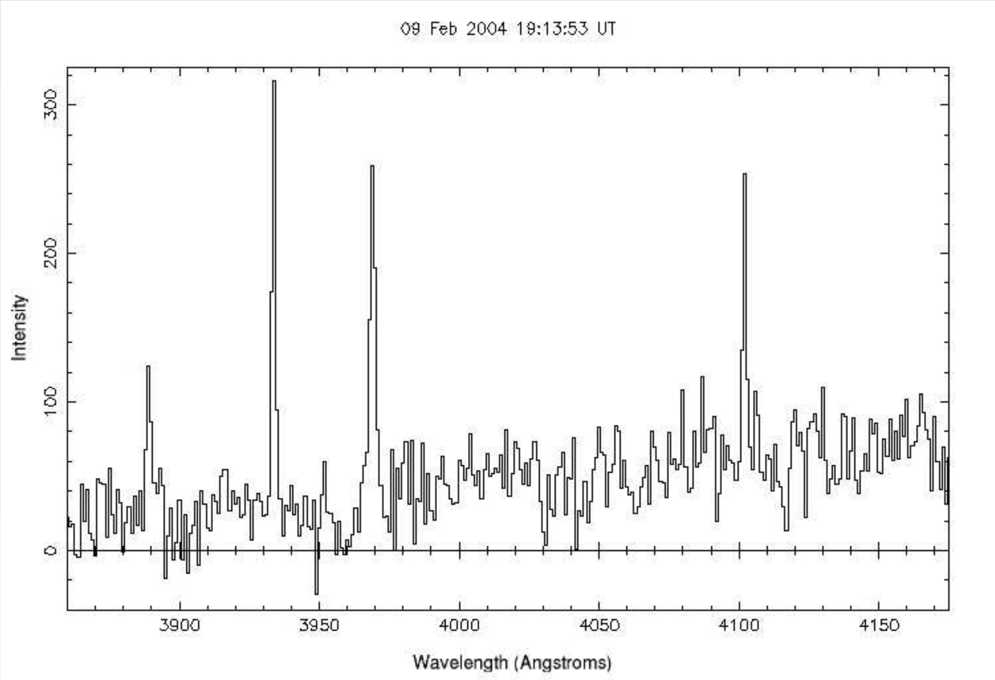




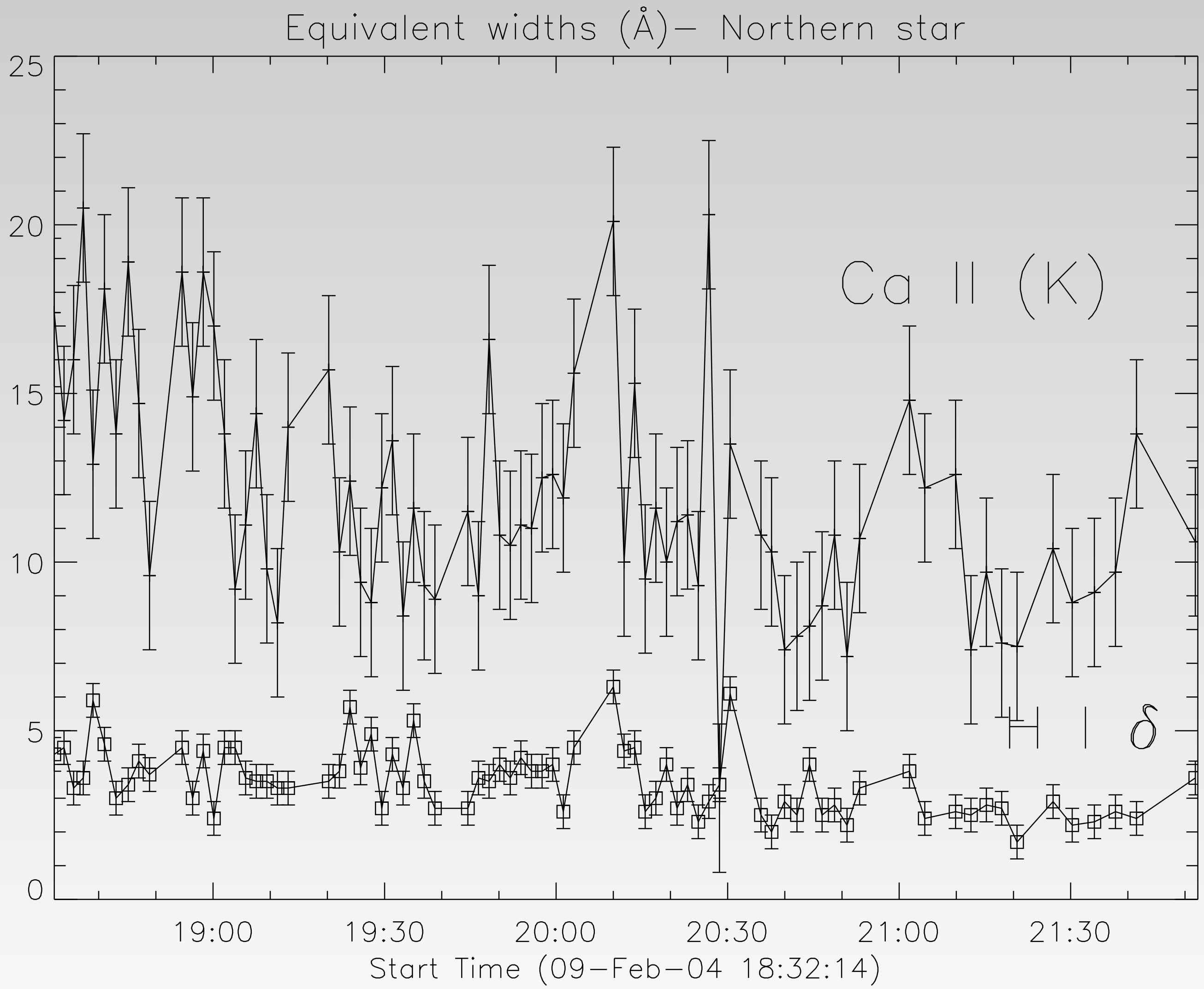
Chromospheric variability

Consecutive 90s exposures from XMM night (19:12,19:14 UT). Notice the variation in the Ca II (H and K) and H δ.

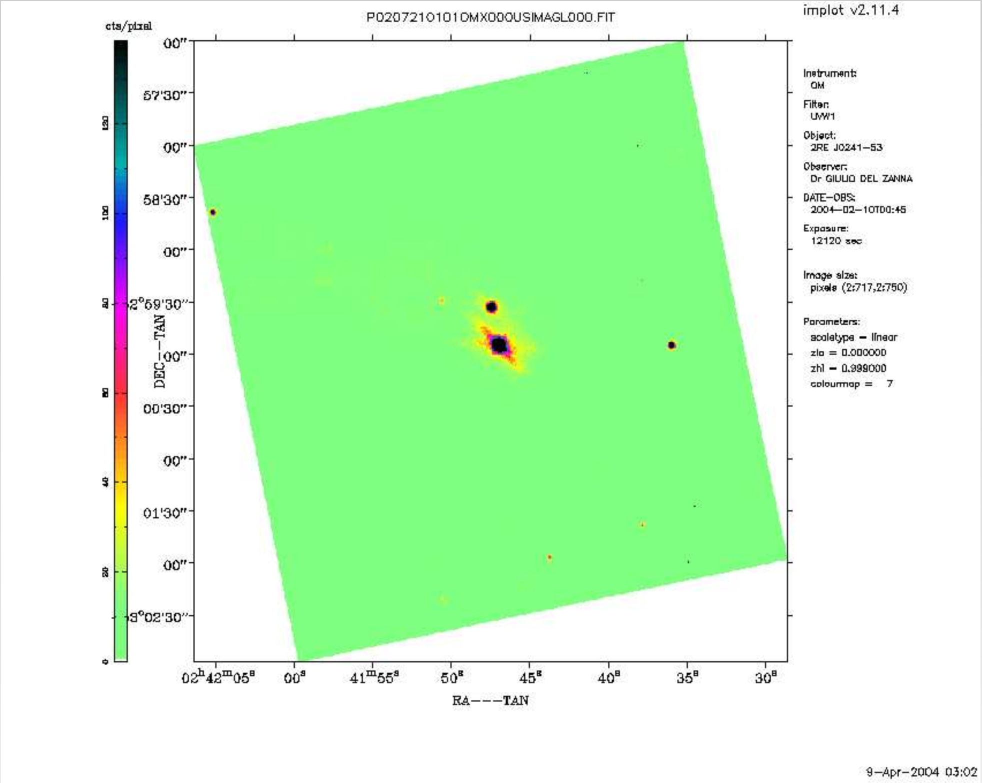


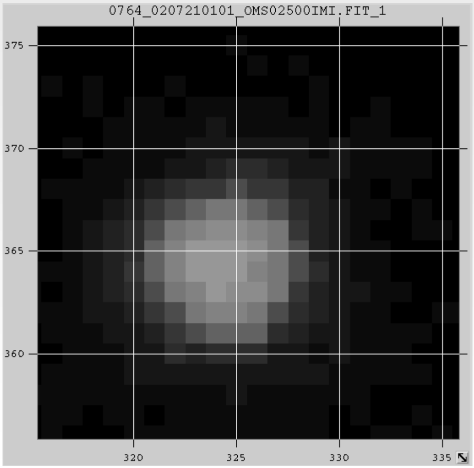


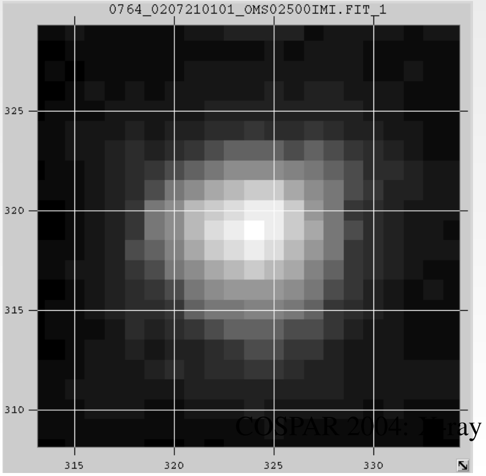
Equivalent widths for the Northern star



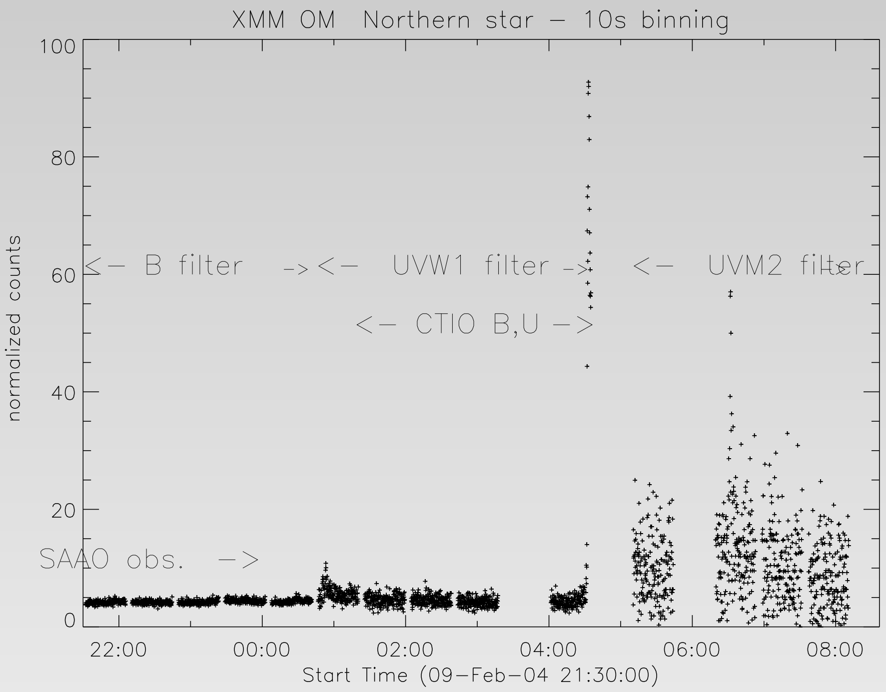
XMM OM

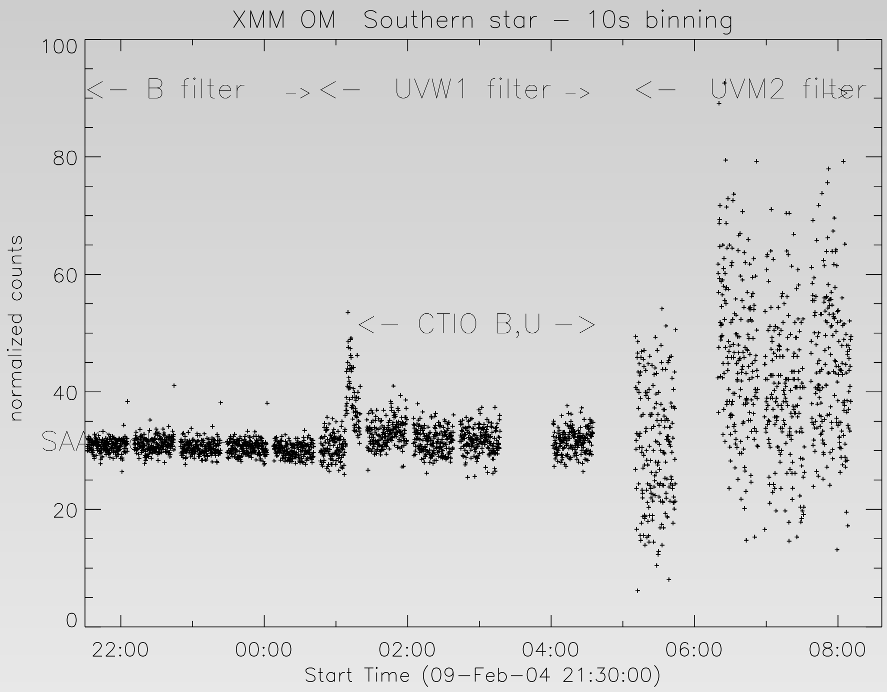

P0207210101OMX000USIMAGL000.FIT
implot v2.11.4
cts/pixel
Instrument:
OM
Filter:
UVW1
Object:
2RE J0241-53
Observer:
Dr GIULIO DEL ZANNA
DATE-OBS:
2004-02-10T00:45
Exposure:
12120 sec
Image size:
pixels (2:717,2:750)
Parameters:
scaletype = linear
zlo = 0.000000
zhi = 0.999000
colourmap = 7
DEC--TAN
RA---TAN
9-Apr-2004 03:02


0764_0207210101_OMS02500IMI.FIT_1


0764_0207210101_OMS02500IMI.FIT_1

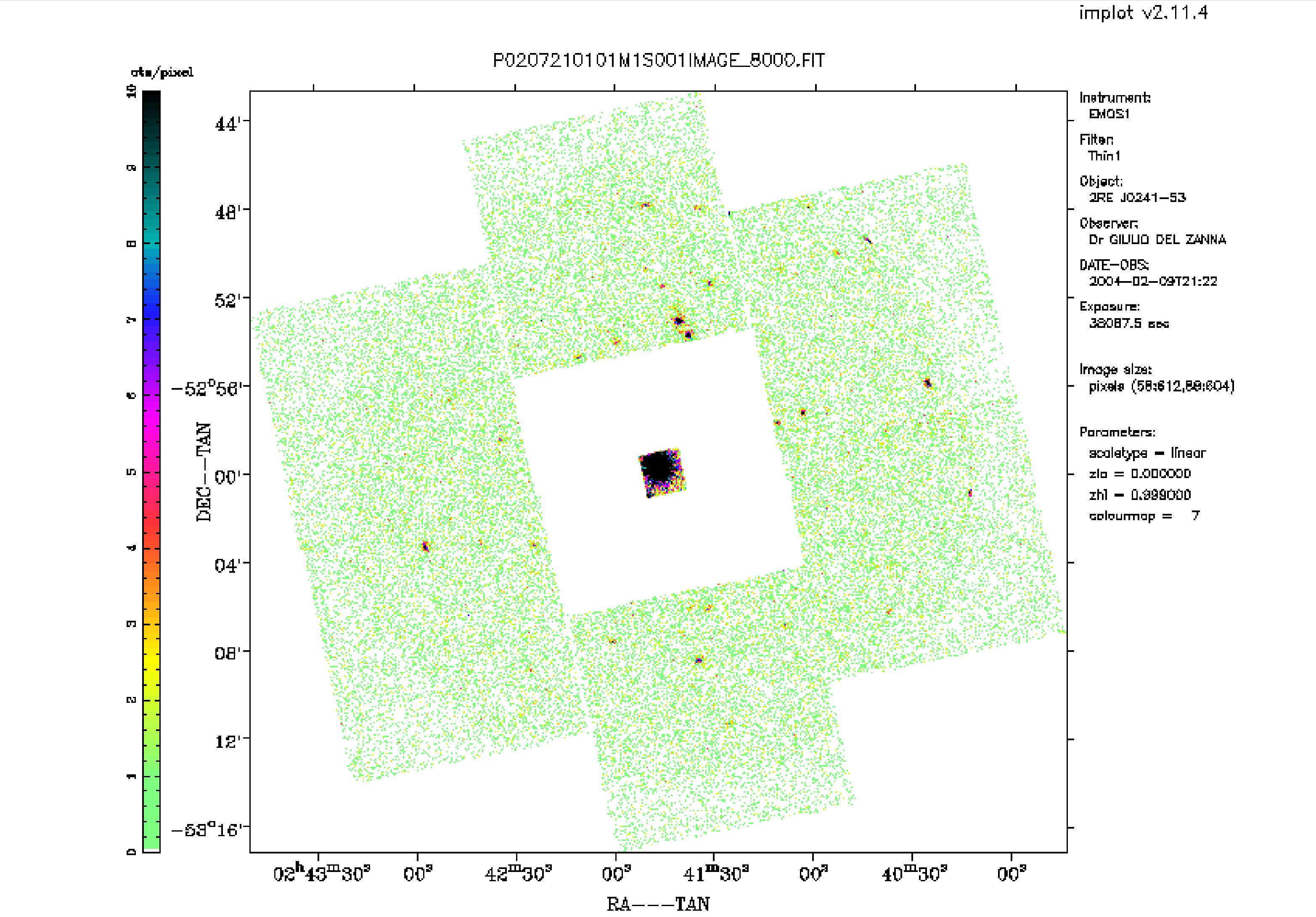
OM light curves





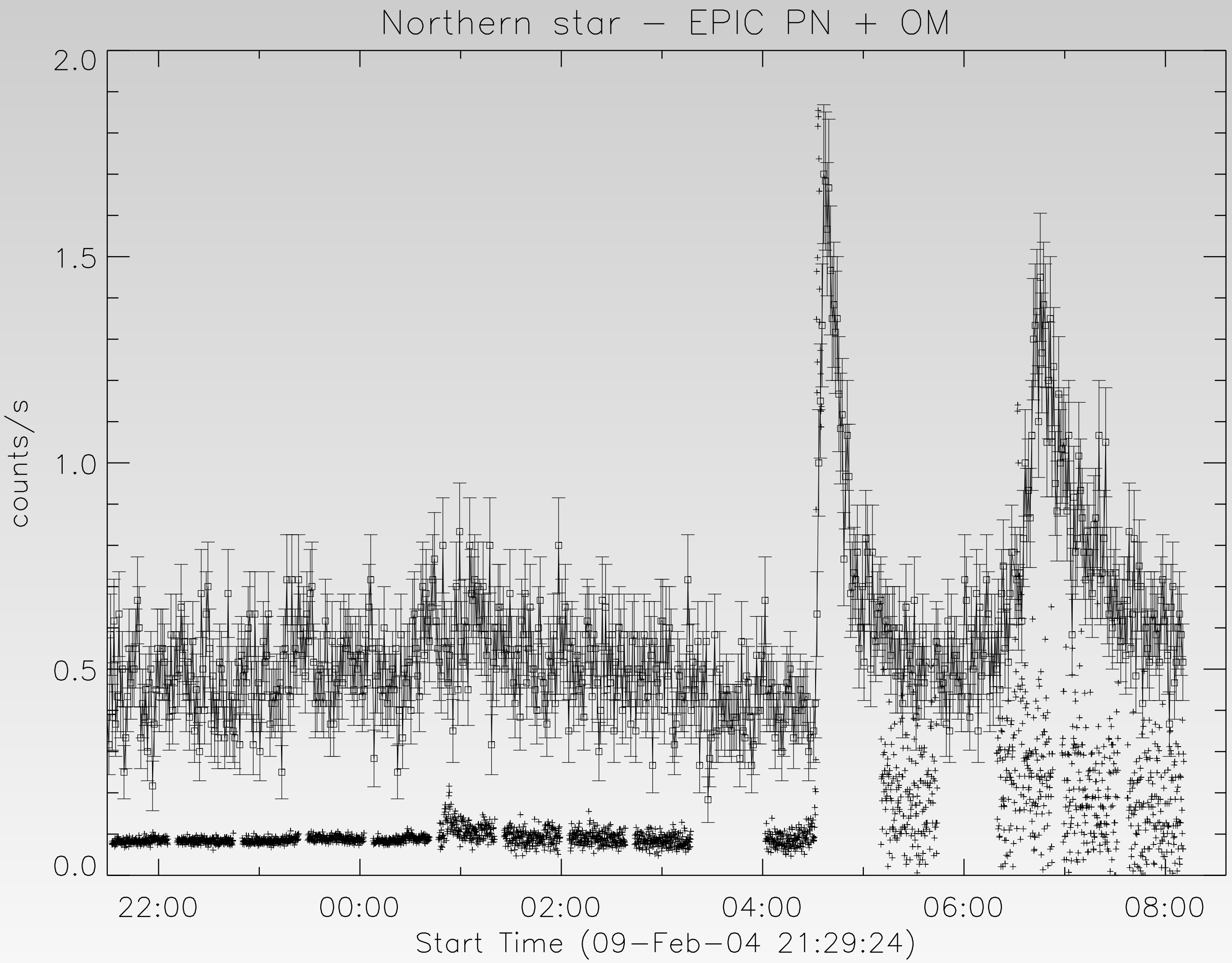
EPIC MOS 1 image

UNIVERSITY OF CAMBRIDGE



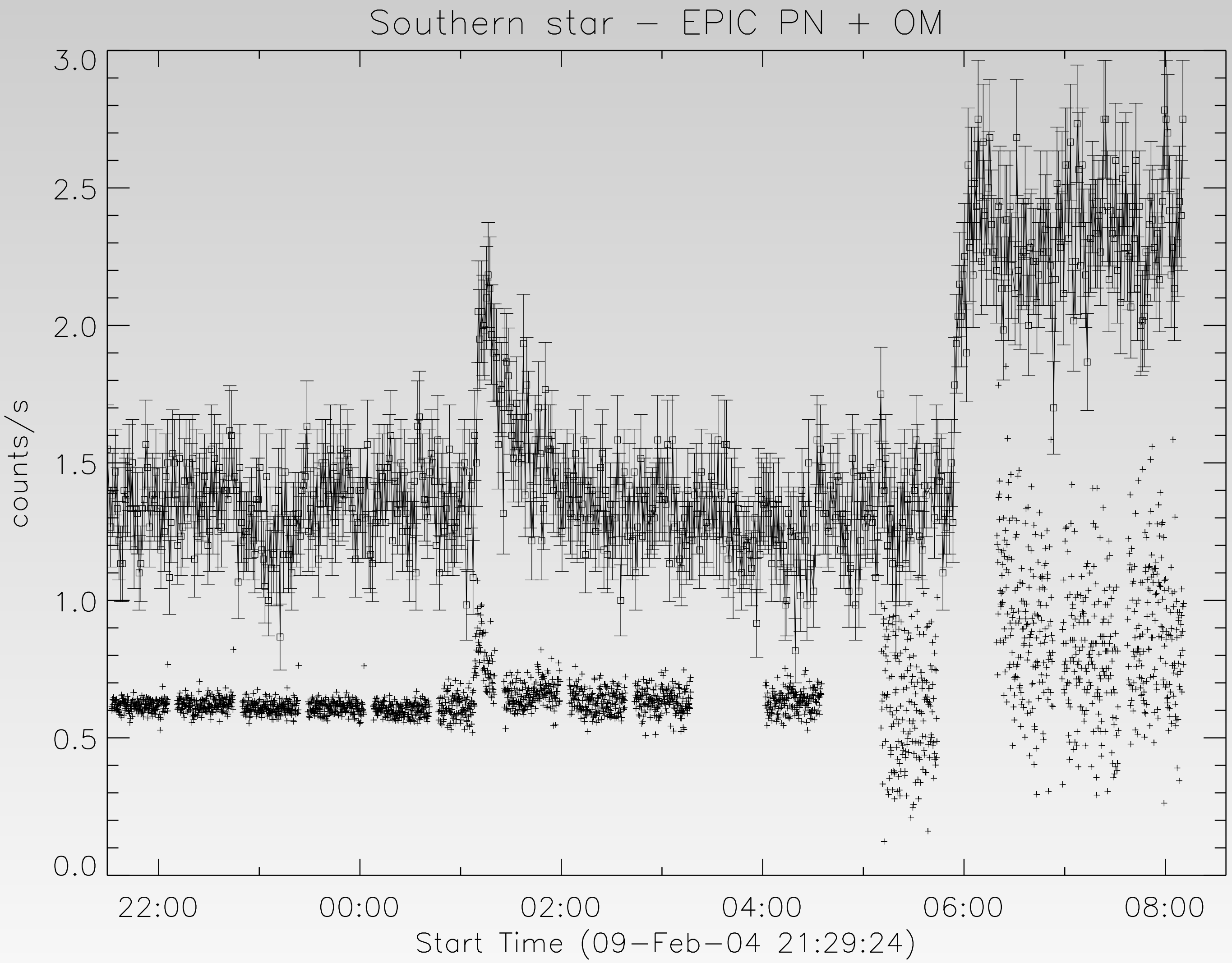
EPIC PN light curves

UNIVERSITY OF CAMBRIDGE



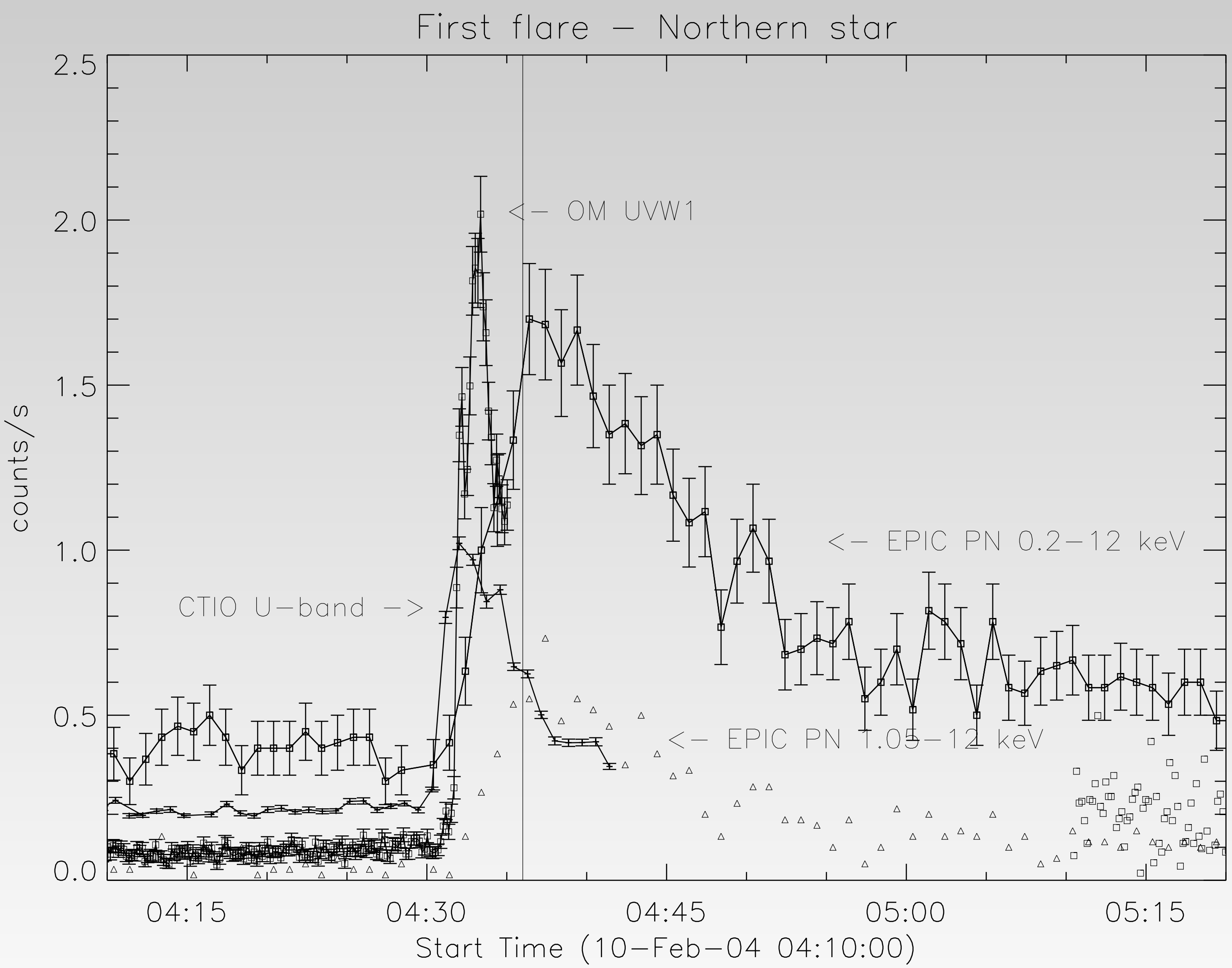
EPIC PN light curves

UNIVERSITY OF CAMBRIDGE

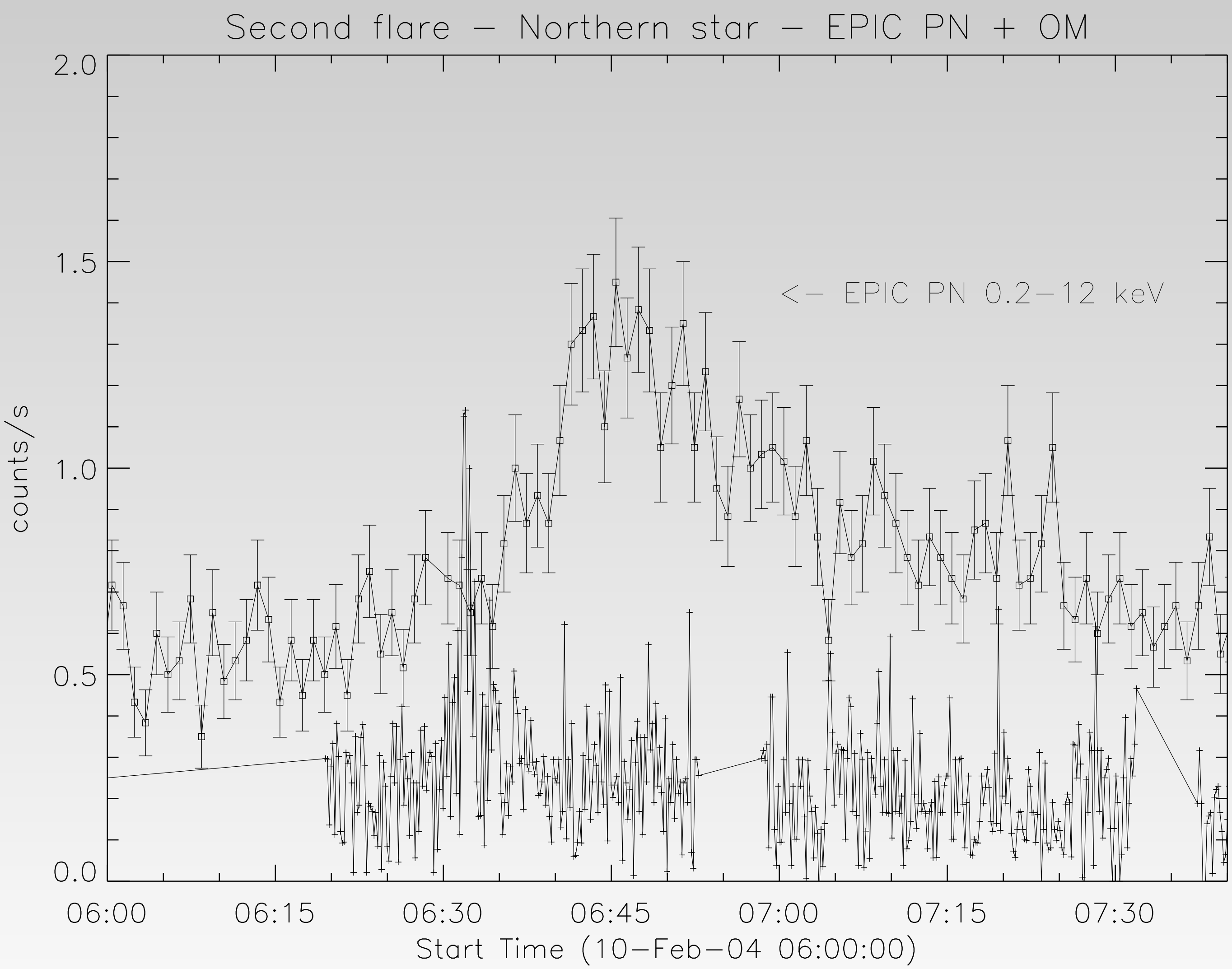


Flares on Northern star

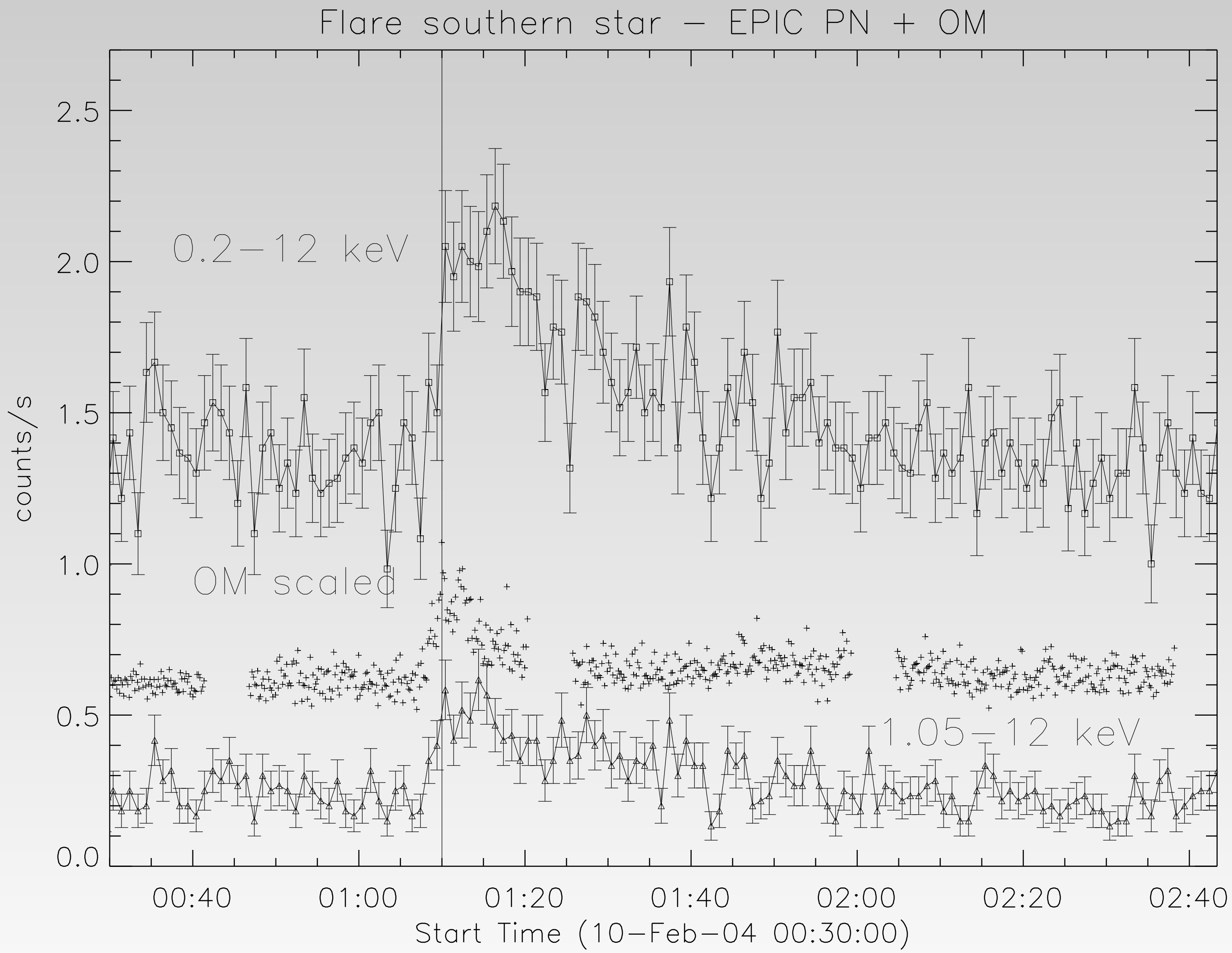
UNIVERSITY OF CAMBRIDGE



Flares on Northern star

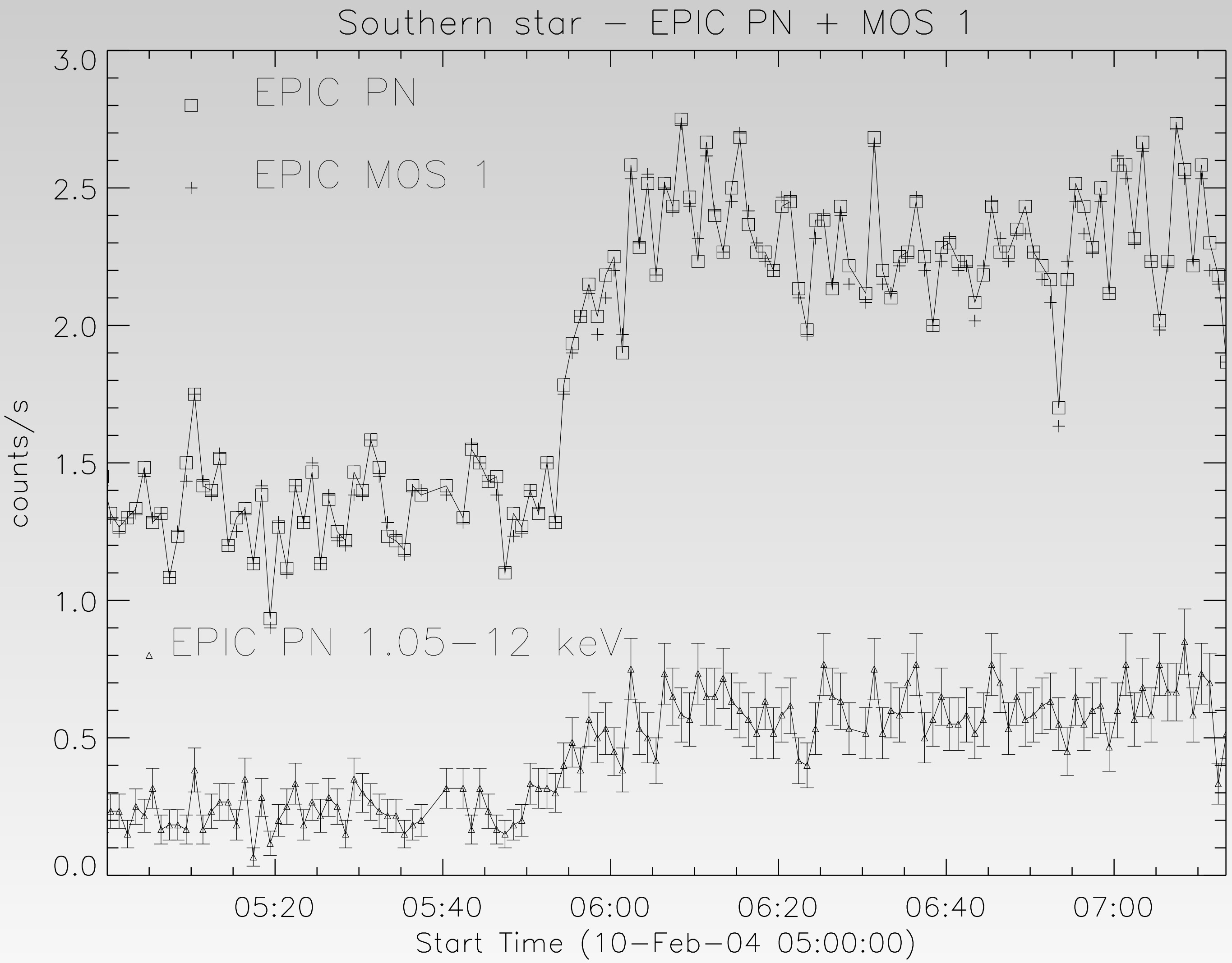


Flares on the Southern star.



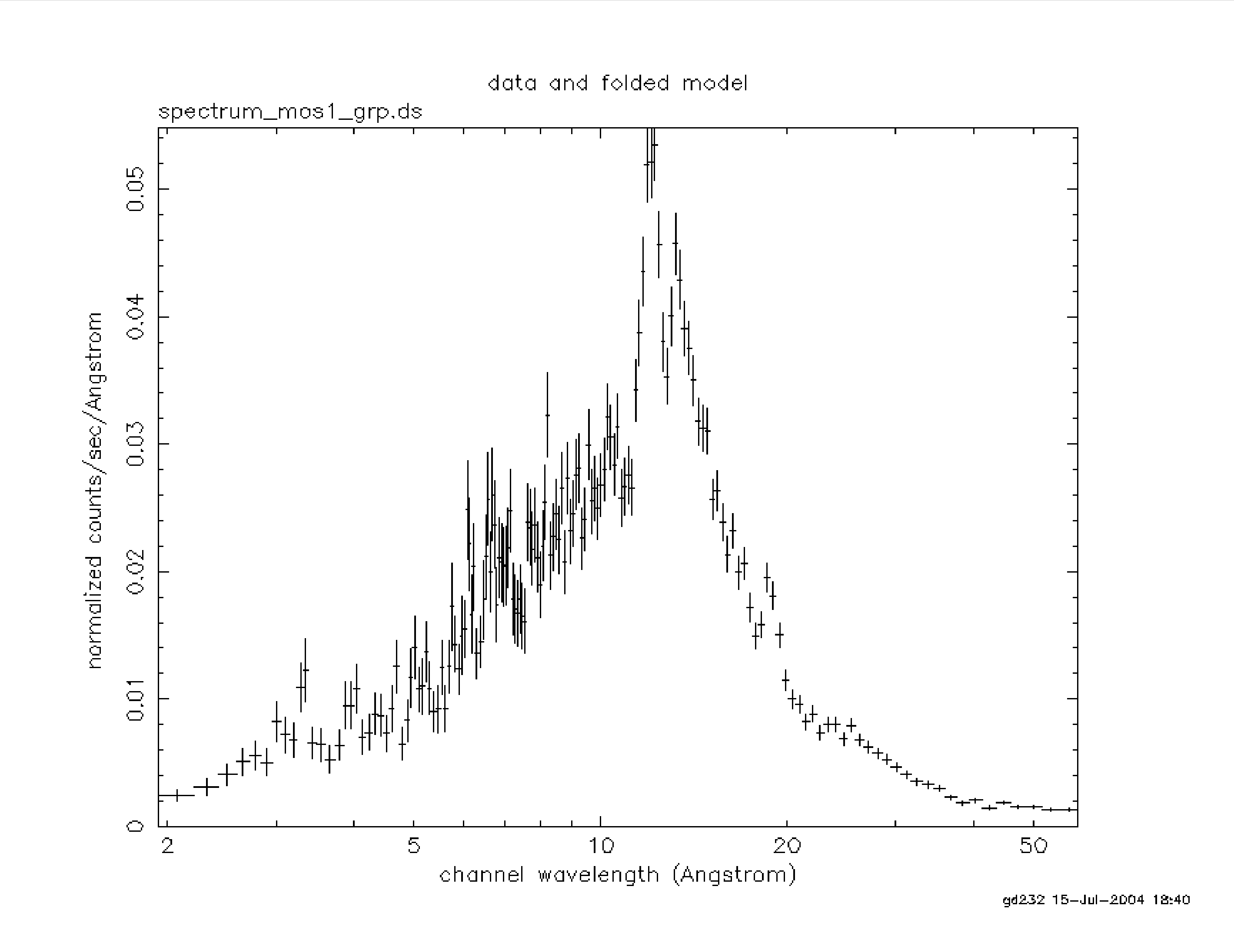
Flares on the Southern star.

UNIVERSITY OF CAMBRIDGE



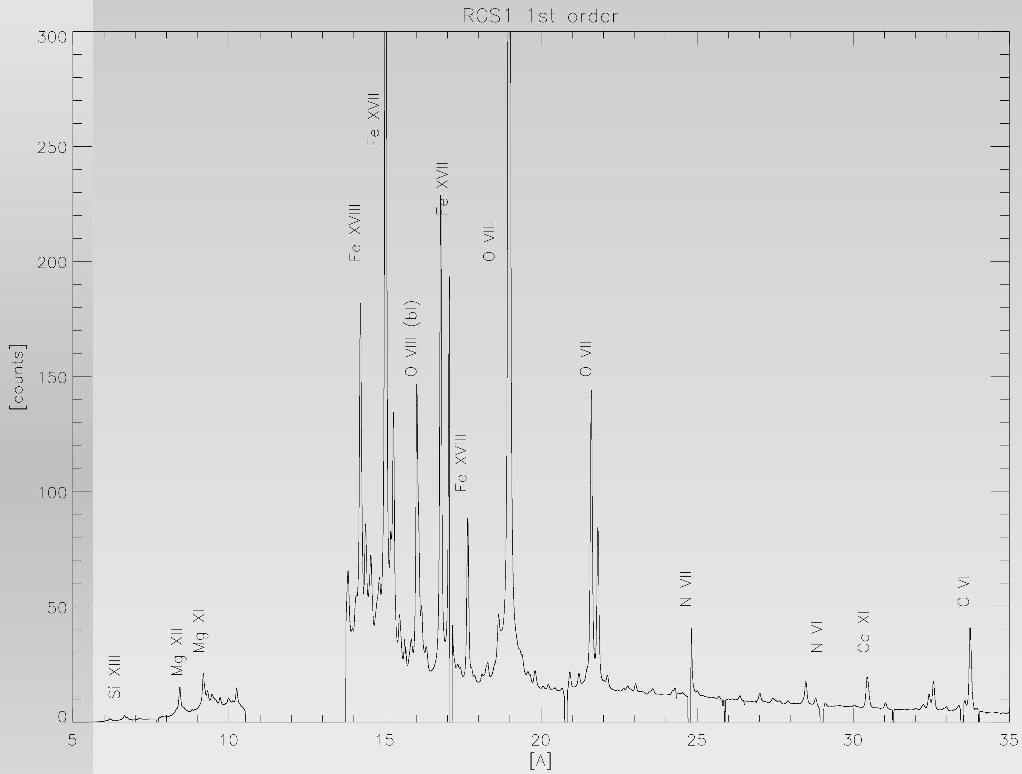
EPIC MOS 1 spectrum of the Southern star

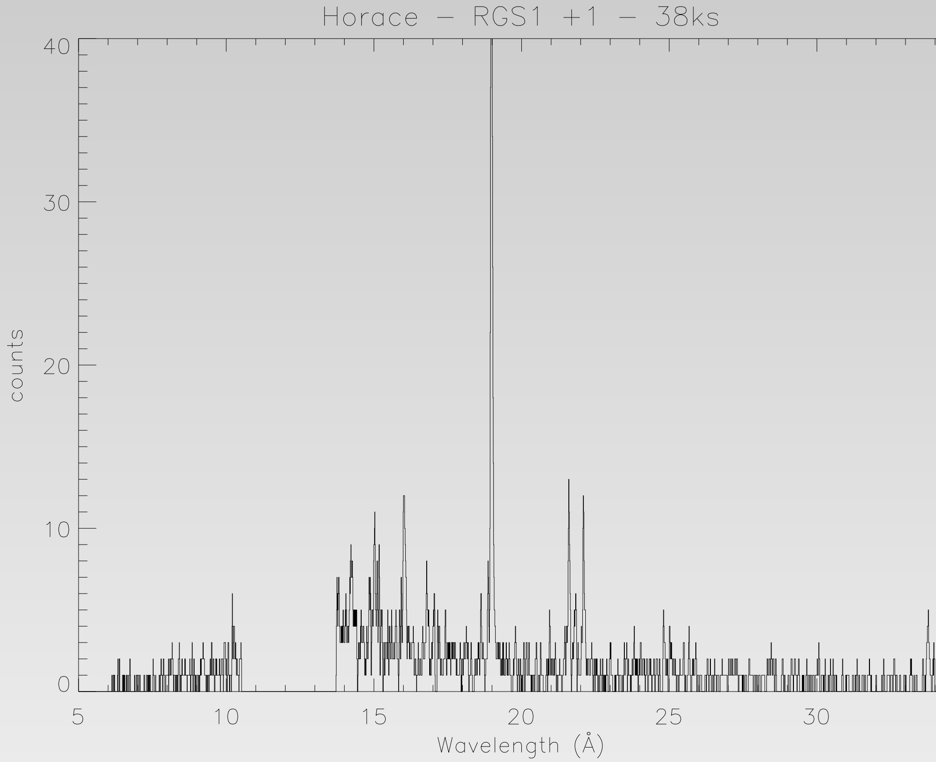
UNIVERSITY OF CAMBRIDGE



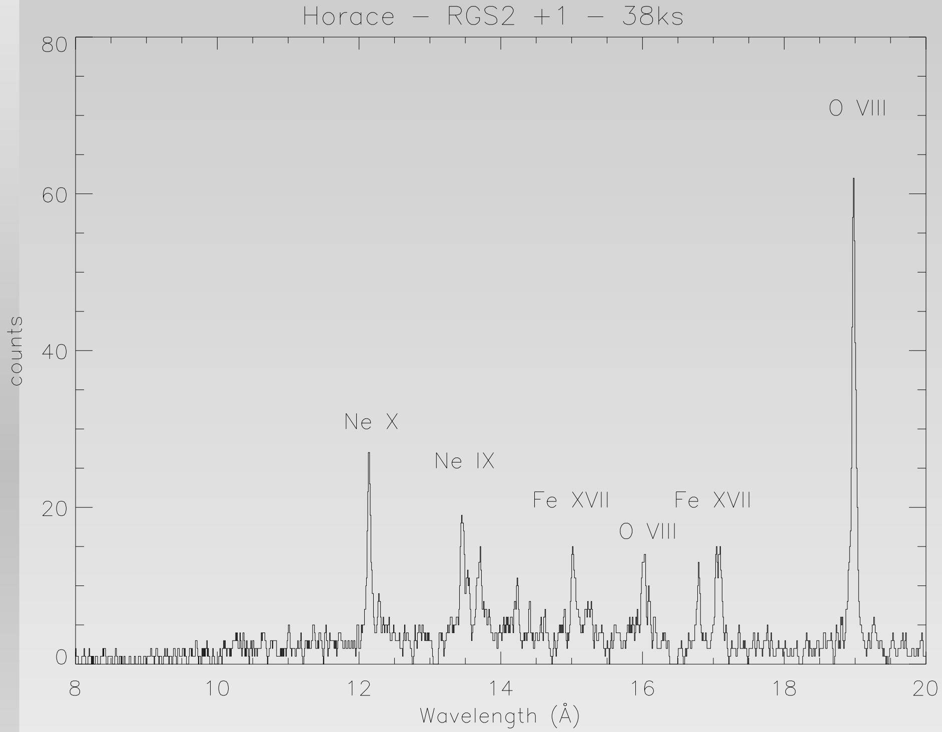
RGS - Where is all the Iron gone ?

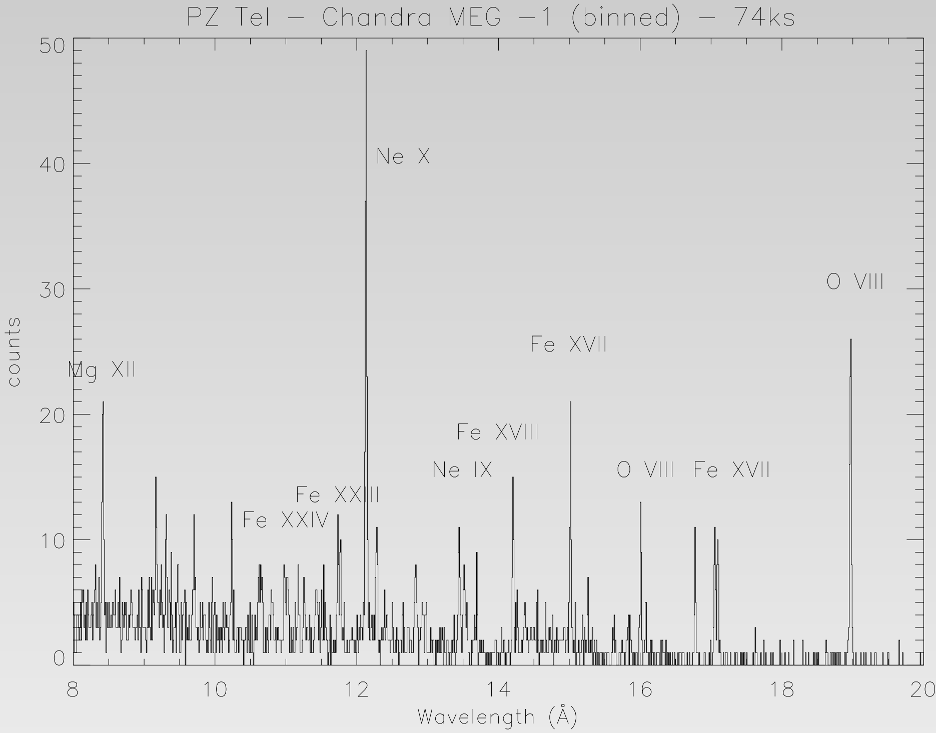
UNIVERSITY OF CAMBRIDGE





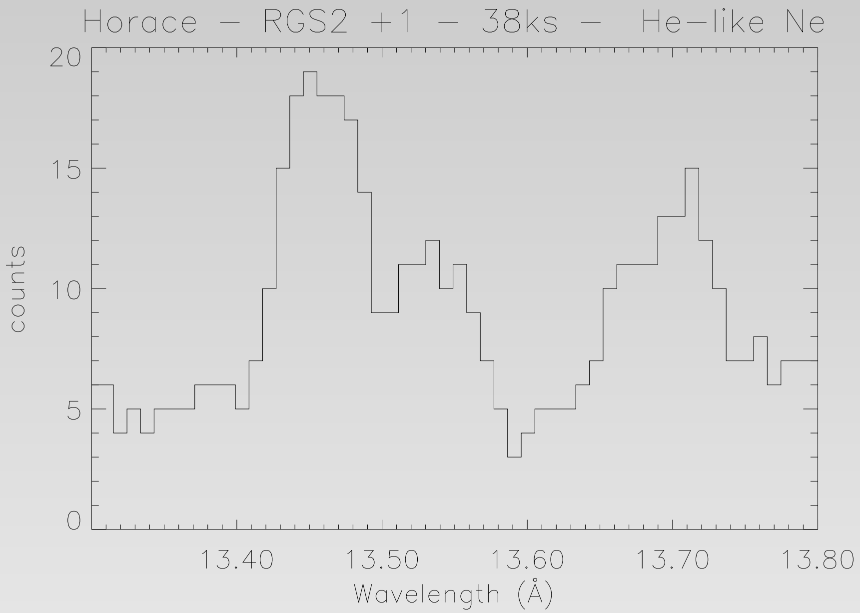
Horace vs. PZ Tel

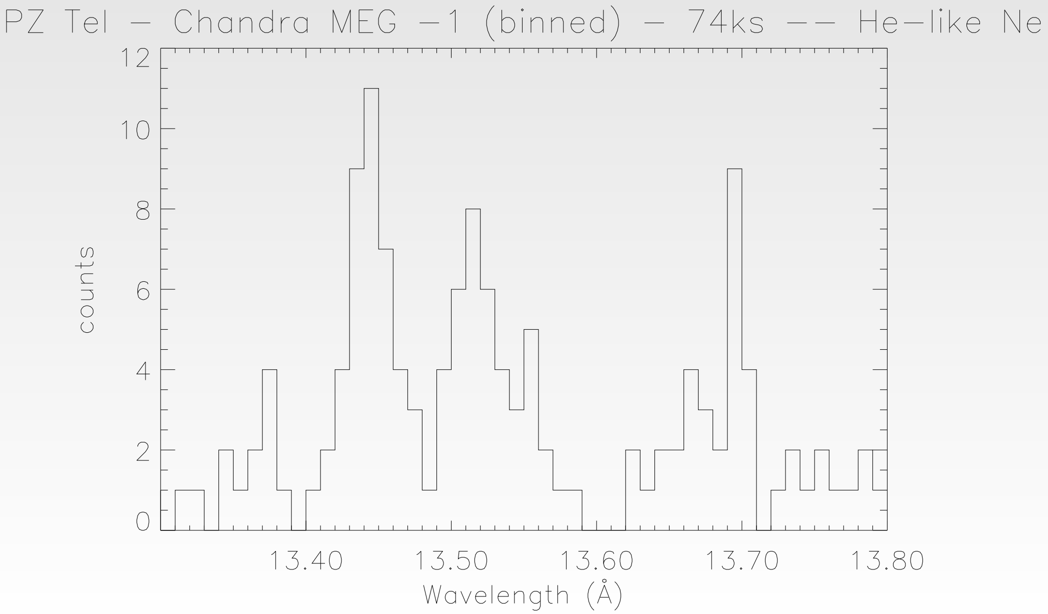




Ne IX

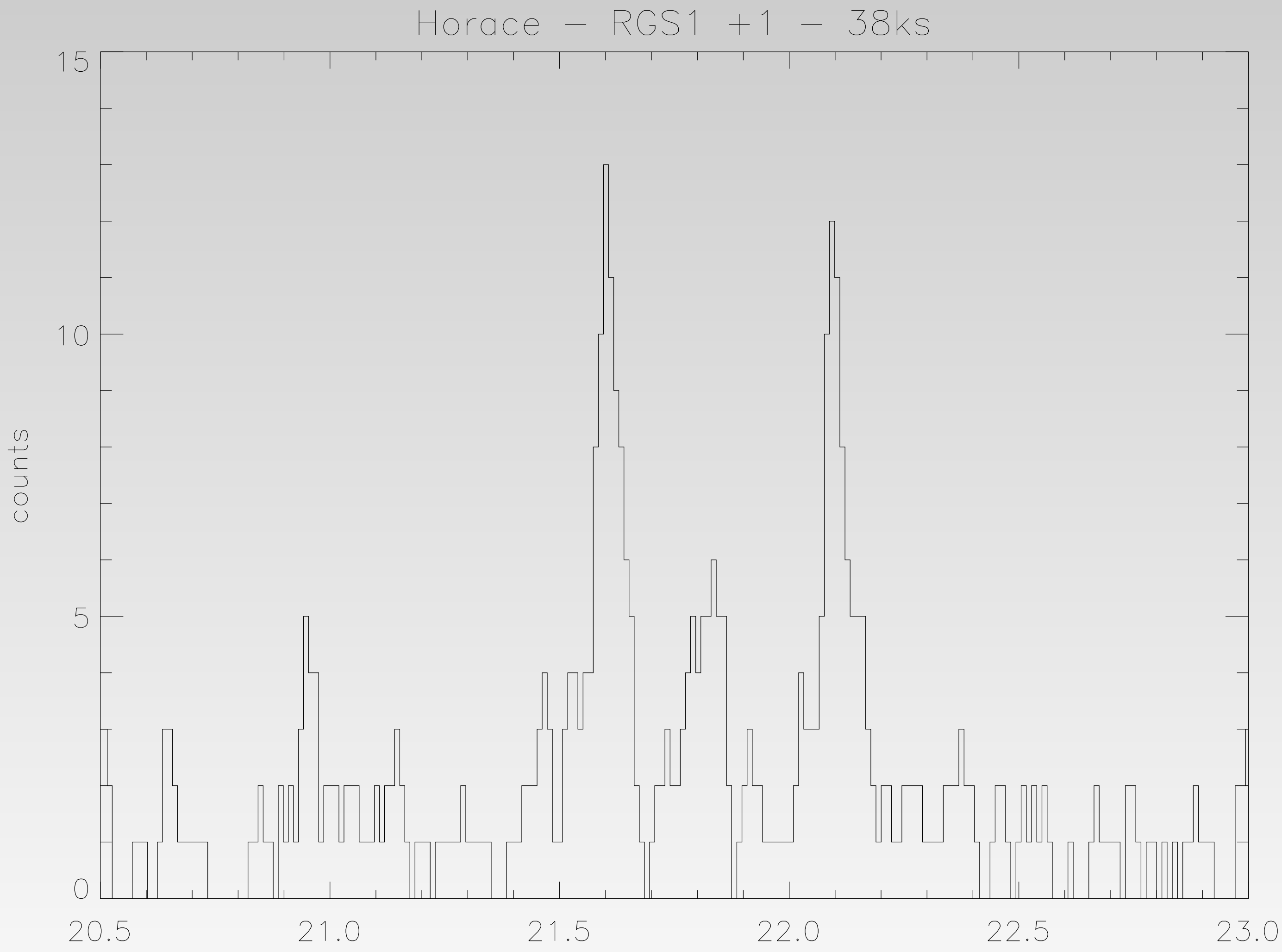
UNIVERSITY OF CAMBRIDGE





O VII

UNIVERSITY OF CAMBRIDGE



Summary of preliminary results

UNIVERSITY OF CAMBRIDGE

- This is one of the few (two ?) X-ray observations of PTT stars.
- The XMM/OM fast-mode windows worked very well but data are missing.
- Both stars confirmed to be active, with flares.
- Ground-based SAAO and CTIO observations are nicely complementary.
- The coronae are mostly abundant in Ne,O.
- Compared to other young stars and PZ Tel, these stars have no ‘hot’ emission. They were in a remarkably quiescent state (stellar cycles?).
- We confirm Linsky’s law (the most interesting events occurr at the end of the observation).