XMM-Newton:
The next decade for Cool Stars

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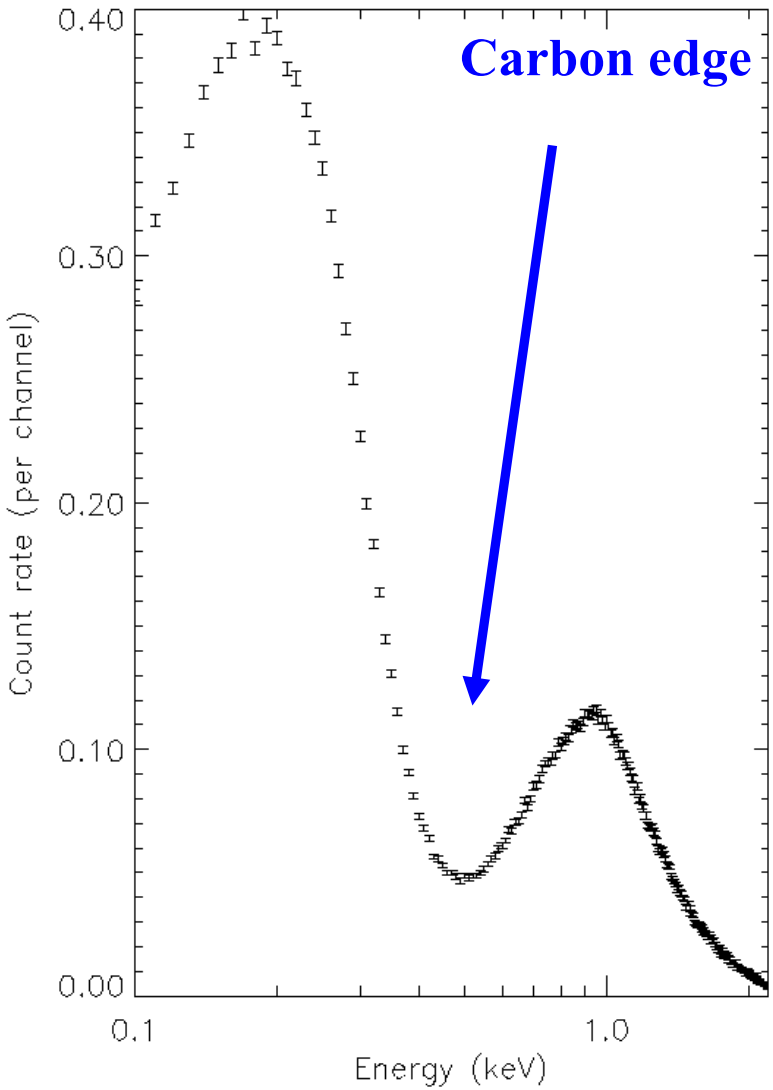
Villafranca June 6 2007

Major XMM-Newton accomplishments:

- High-resolution spectroscopy
- „Long looks“
- Imaging surveys (open clusters, SFRs)

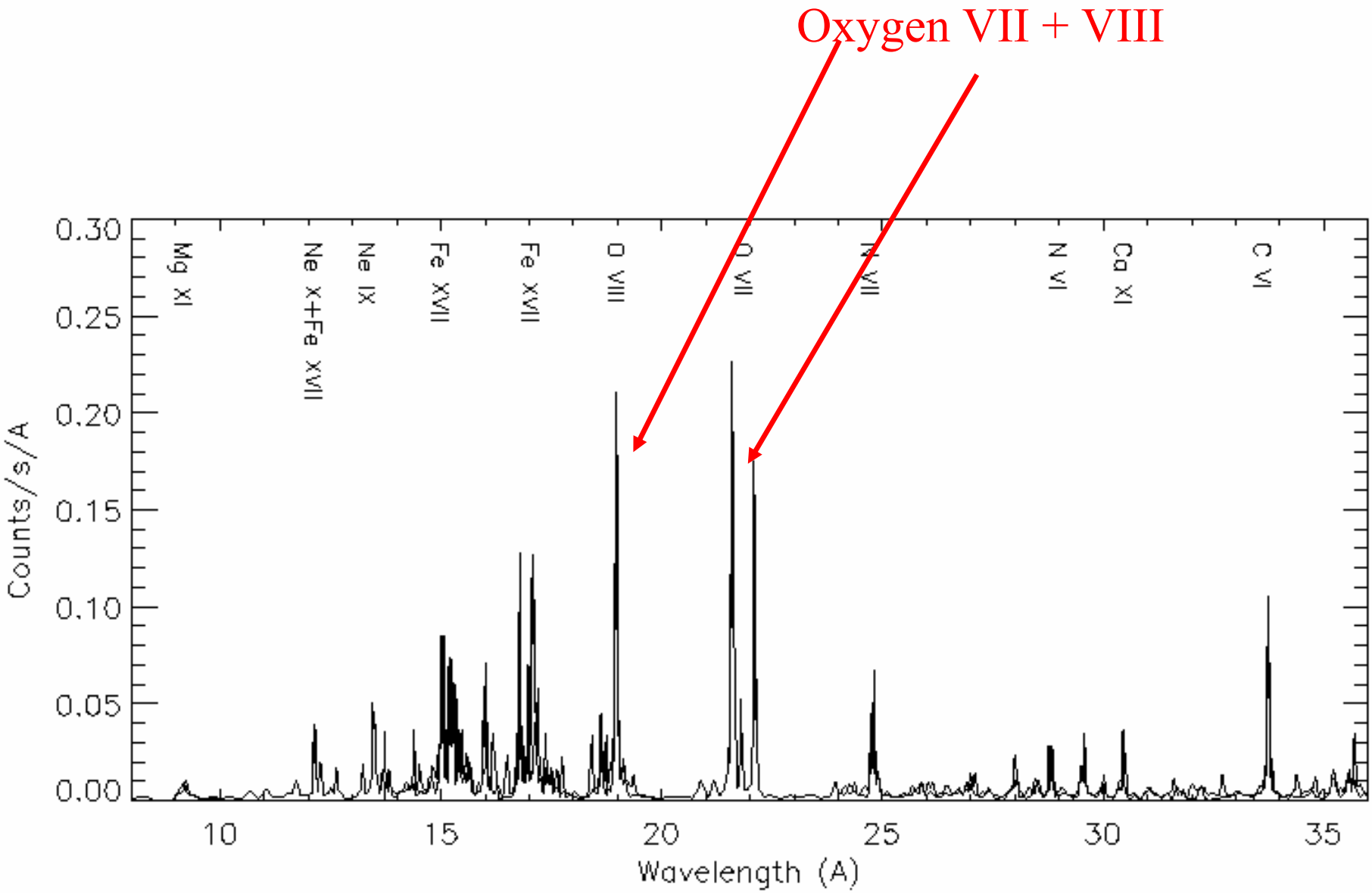
Talks by Güdel, Montmerle, Sciortino

Back in the (good ?) old days ……..



ROSAT PSPC spectrum of Algol

(Proportional counter)



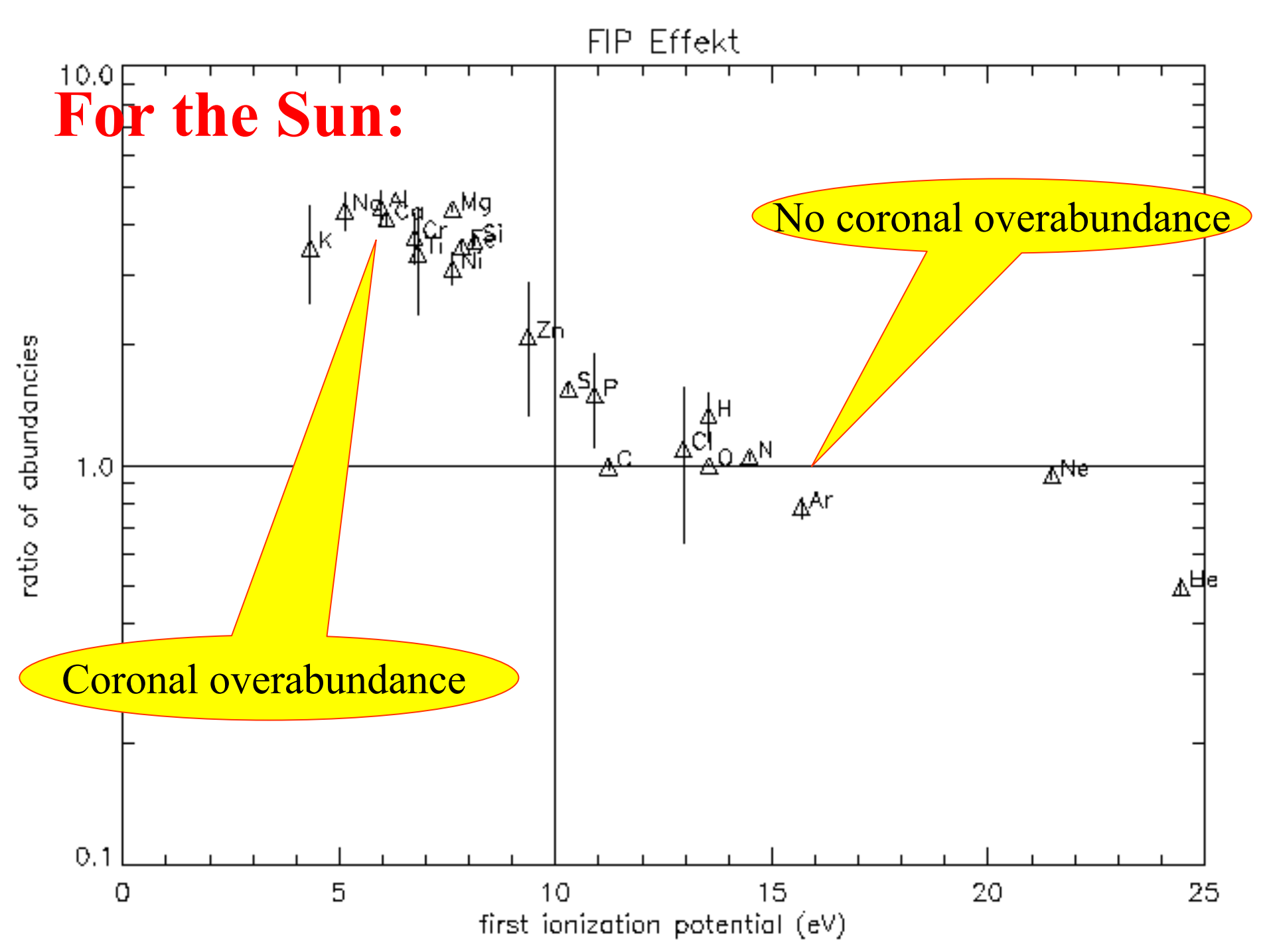
XMM-Newton RGS: α Centauri A+B (Liefke & Schmitt 2006)

High-resolution spectral measurements are used for:

- Abundances
- Densities
- Opacities
- Temperature structure

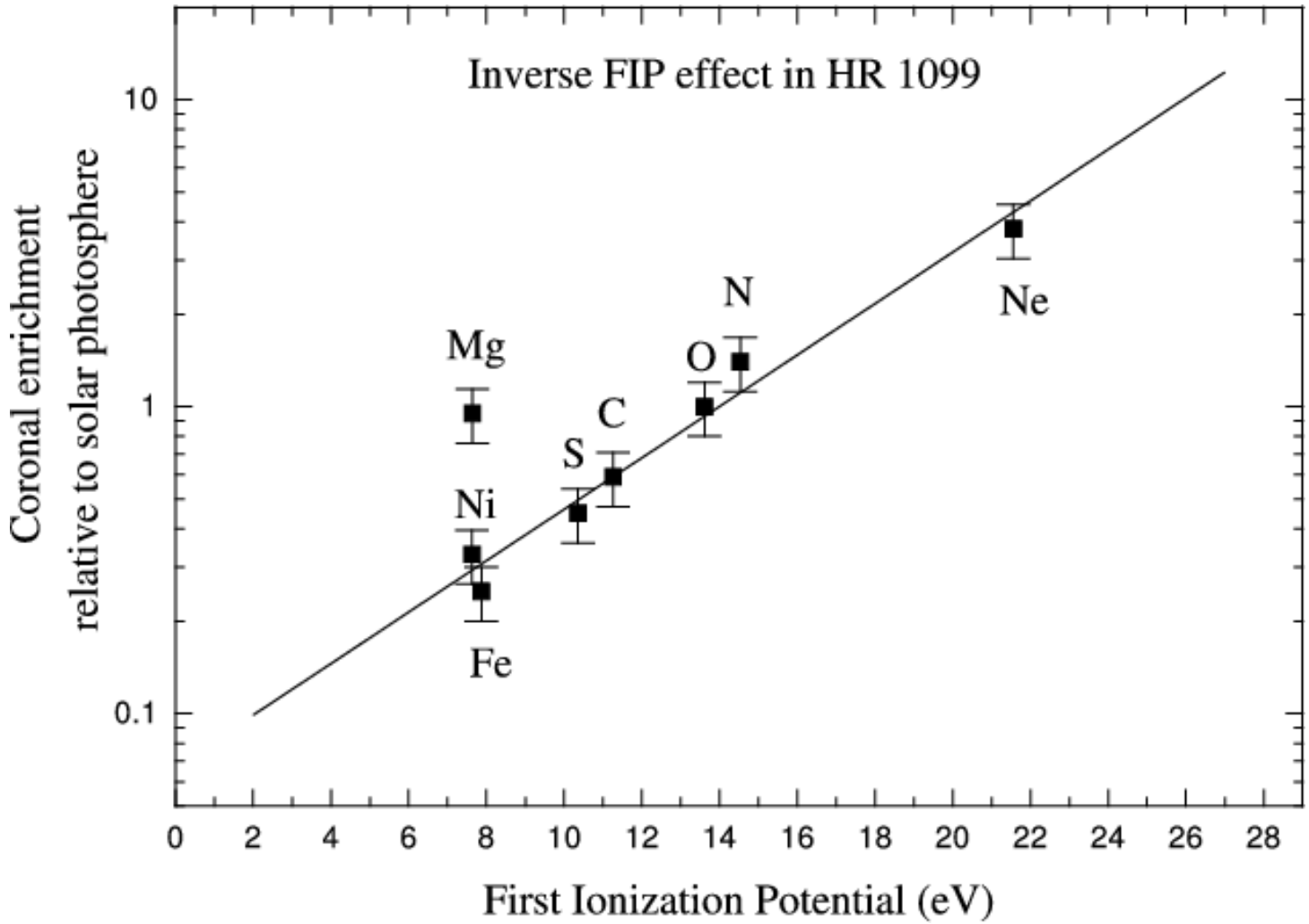
Abundances
Case Study: Cosmic Neon

- FIP- vs. IFIP-effect in stellar coronae
- Neon abundance in local cosmos
- Iron depletion/neon enhancement in classical TTS


FIP Effekt
For the Sun:
No coronal overabundance
Coronal overabundance
ratio of abundancies
first ionization potential (eV)
10.0
1.0
0.1
0
5
10
15
20
25
K
Na
Al
C
Mg
Cr
Ti
Si
Fe
Ni
Zn
S
P
C
H
Cl
O
N
Ar
Ne
He

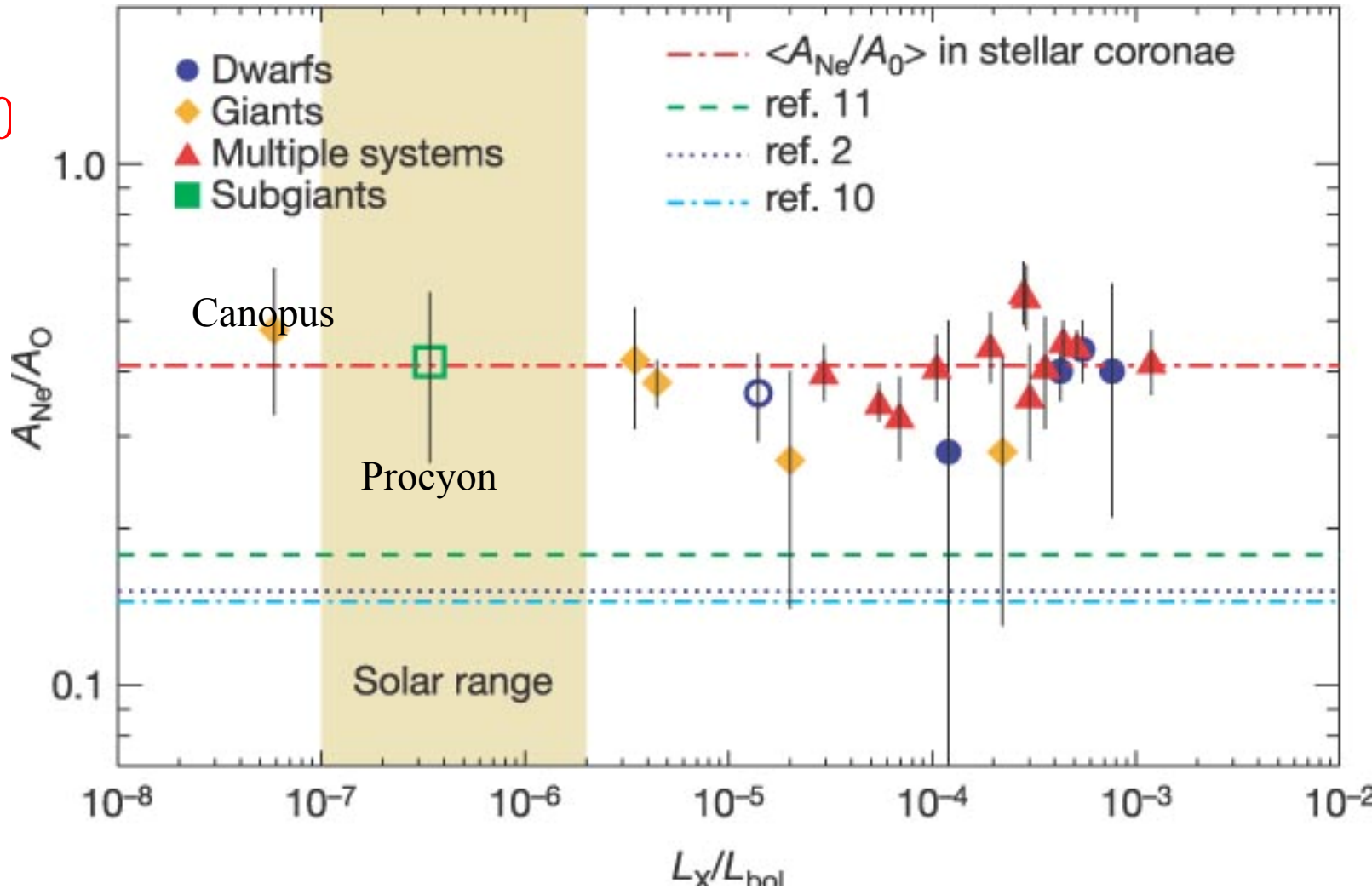
For the Stars:

IFIP-Effect in HR 1099



Brinkmann et al. (2001)

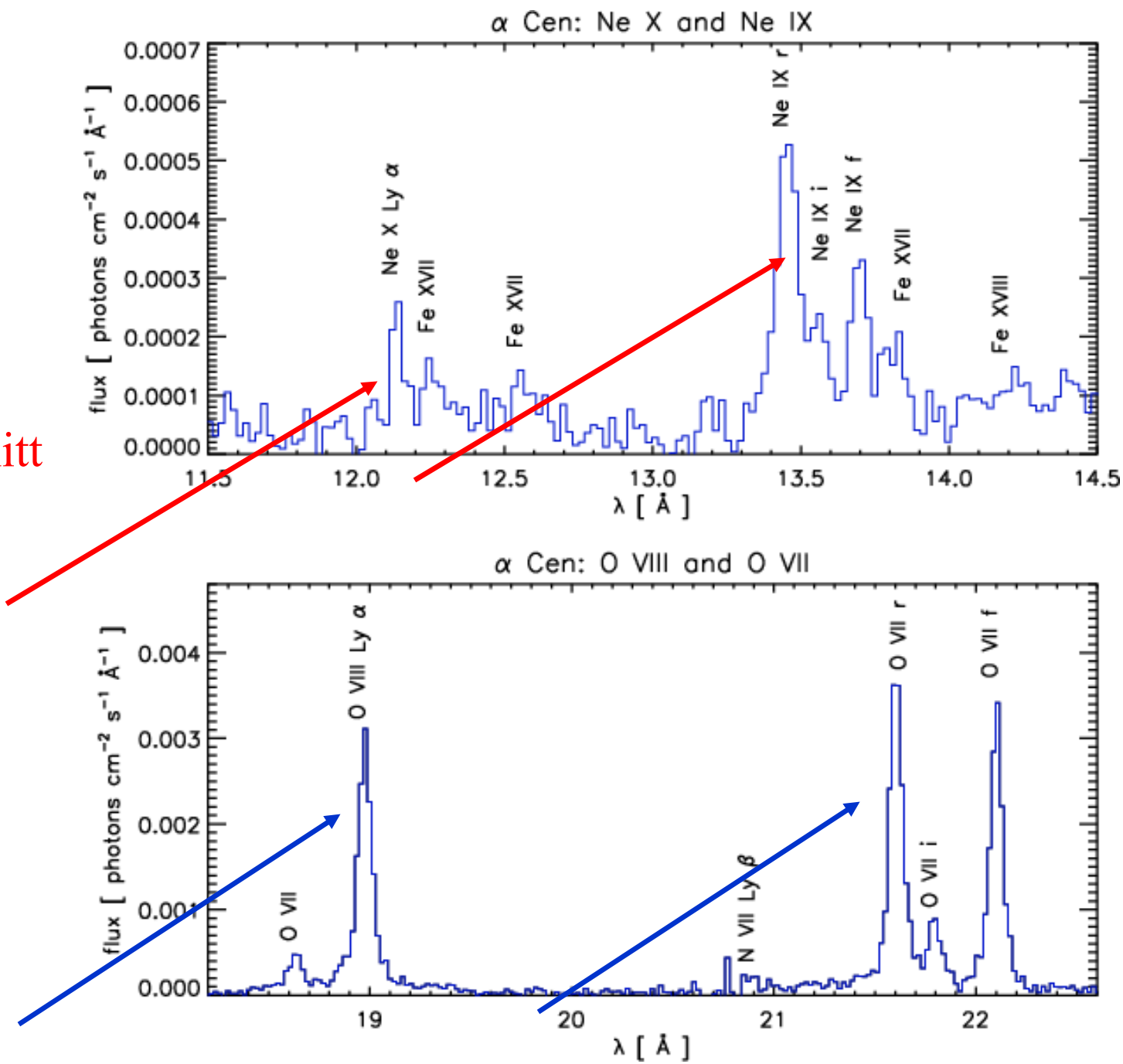
Drake &
Testa (20



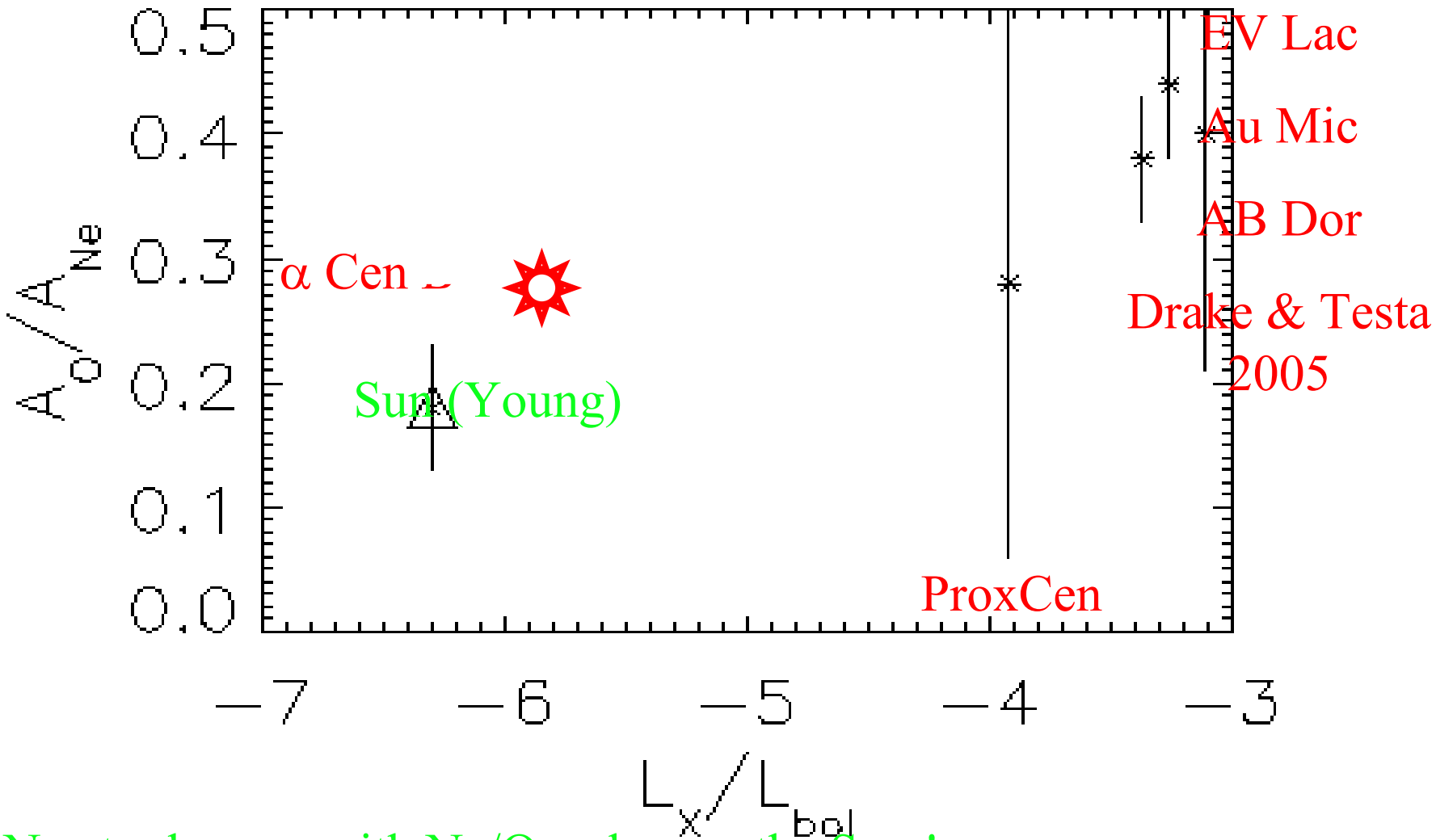
Suggestion: **Increased neon abundance**

typical for local cosmos at large

Liefke & Schmitt (2006)



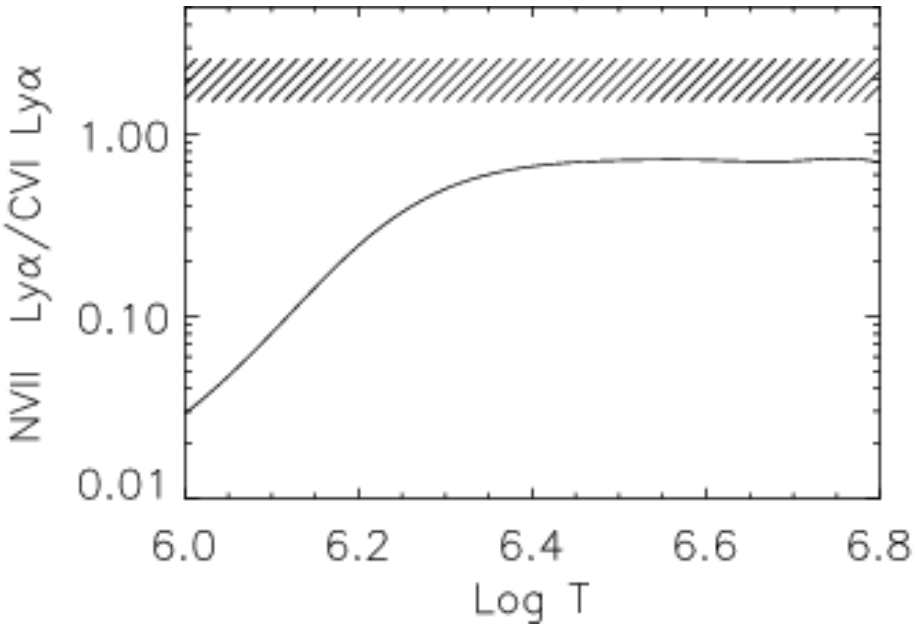
Neon/oxygen abundances for dwarf stars



No star known with Ne/O as low as the Sun !

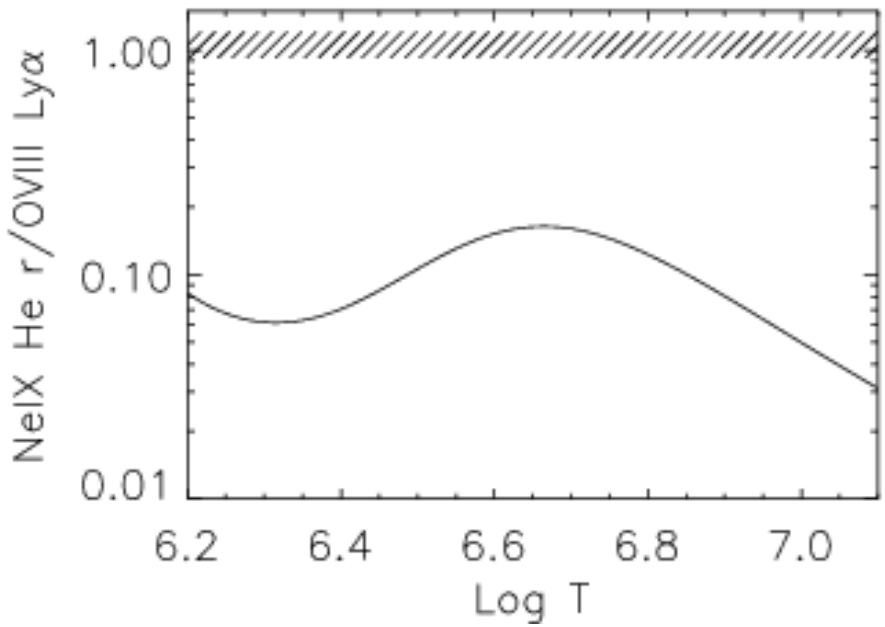
TW Hya

N/C enhancement



N/C >> solar

Ne/O enhancement



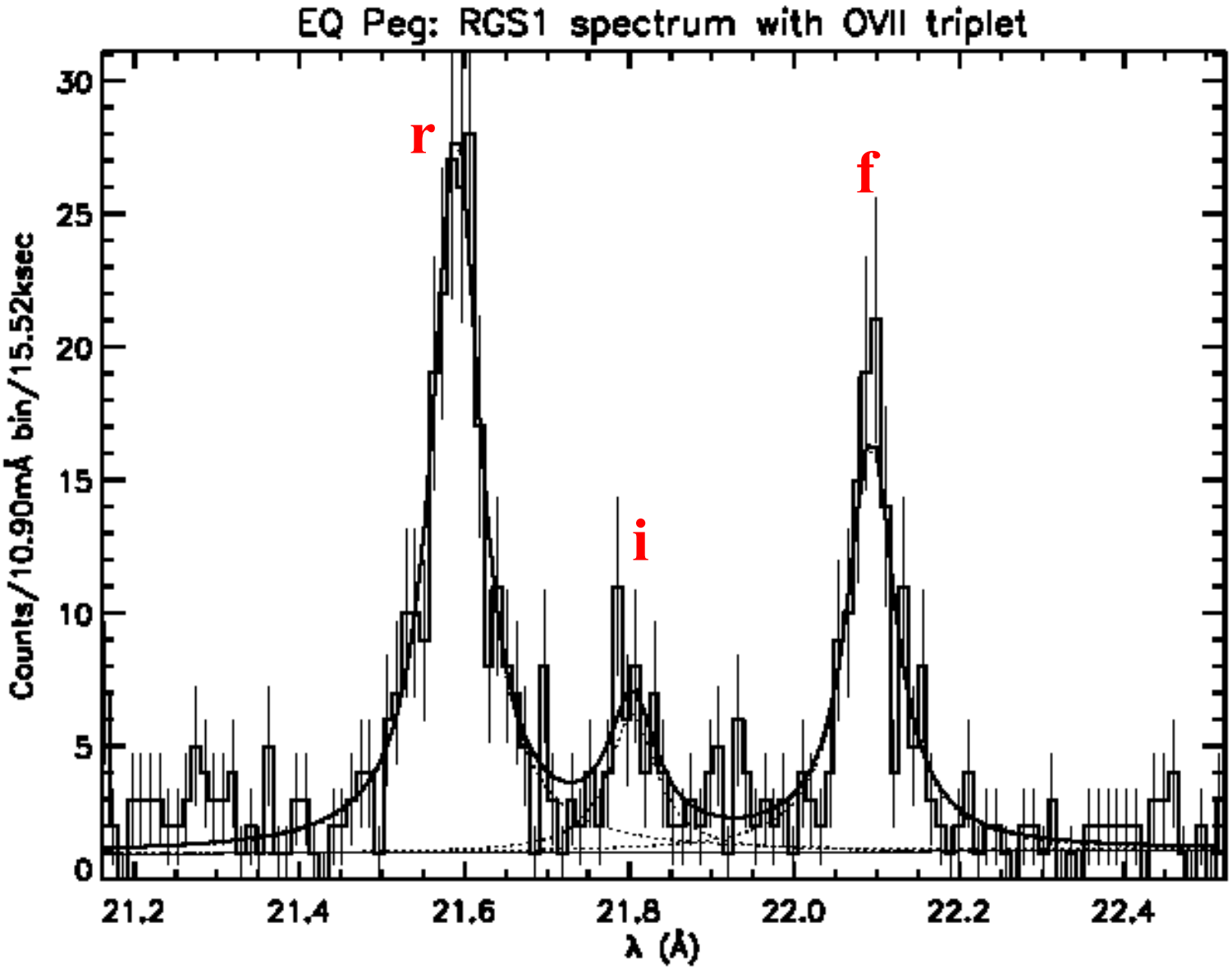
Ne/O >> solar

Stelzer & Schmitt (2004)

Densities

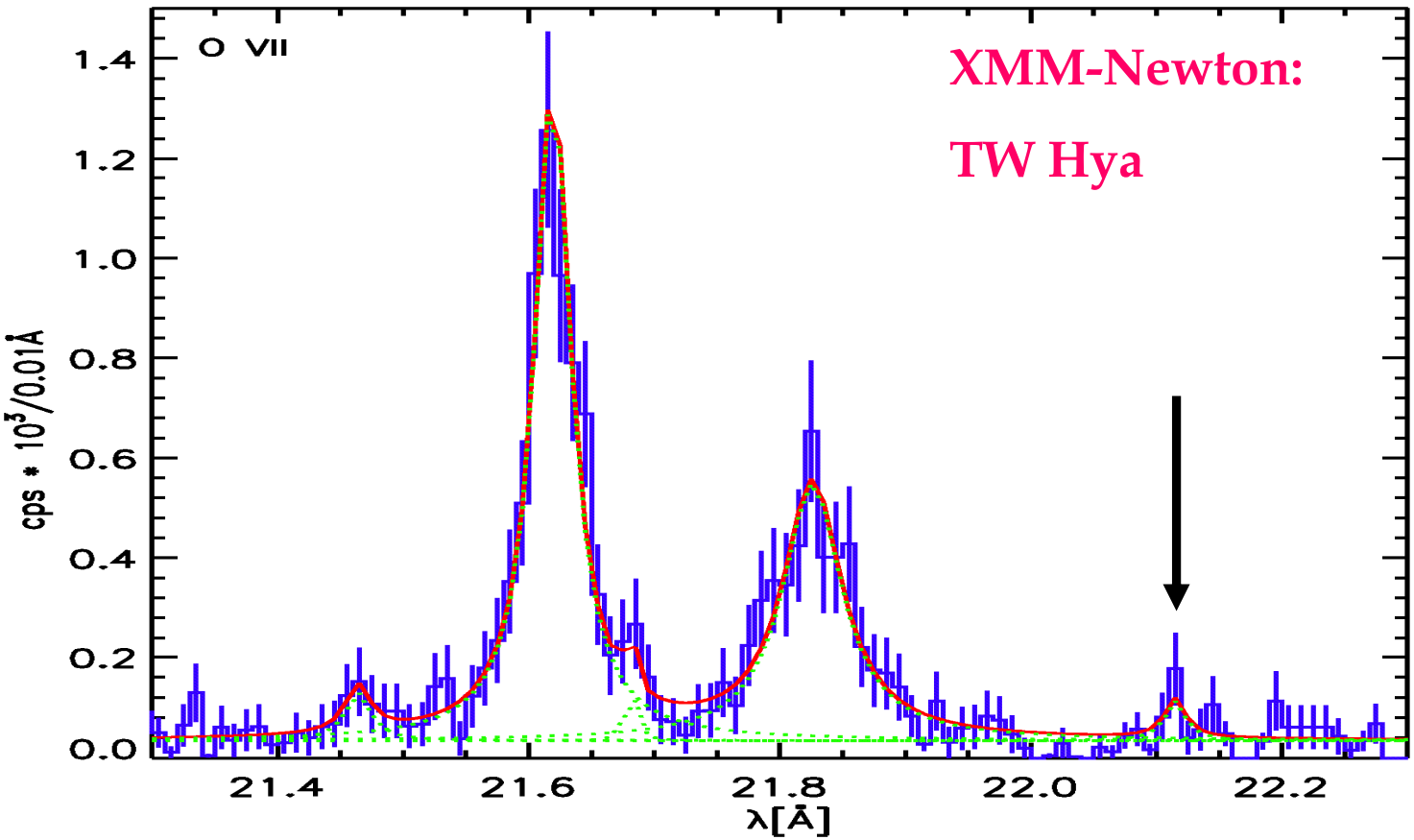
OVII triplett

XMM-Newton EQ Peg



Robrade & Schmitt (2005)

X-ray spectrum of TW Hya (CTTS): OVII triplet



forbidden line almost absent !

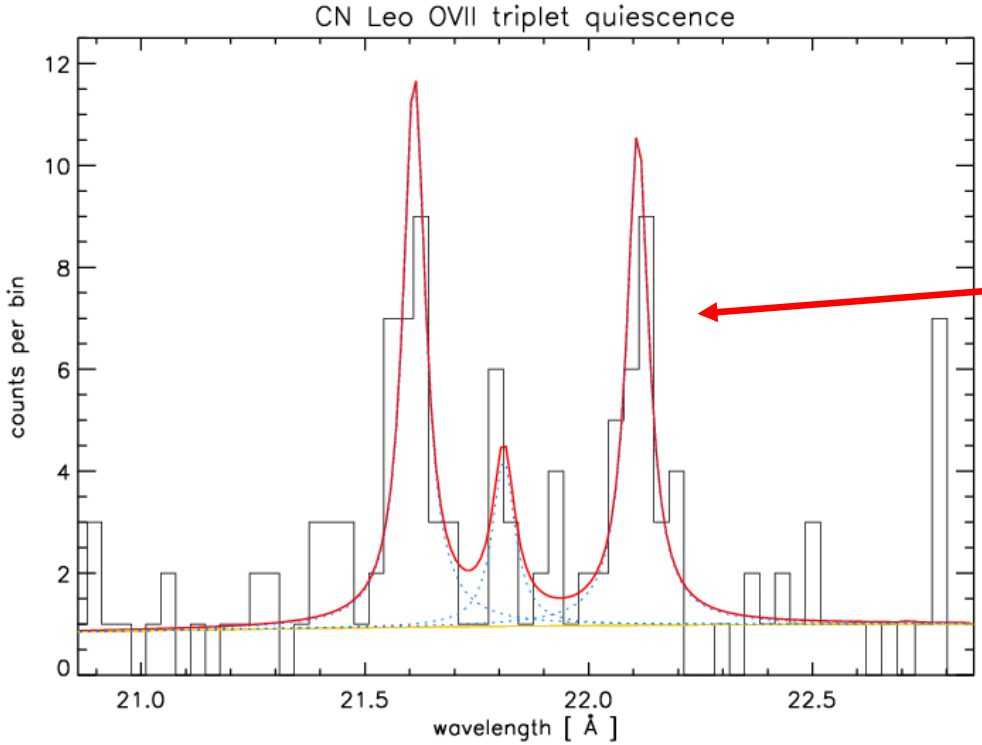
$n_e \geq 10^{13}\ cm^{-3}$

$T \approx 2.8\ 10^6\ K$

$L_X \approx 10^{30}\quad erg/\sec$

Stelzer & Schmitt (2004)

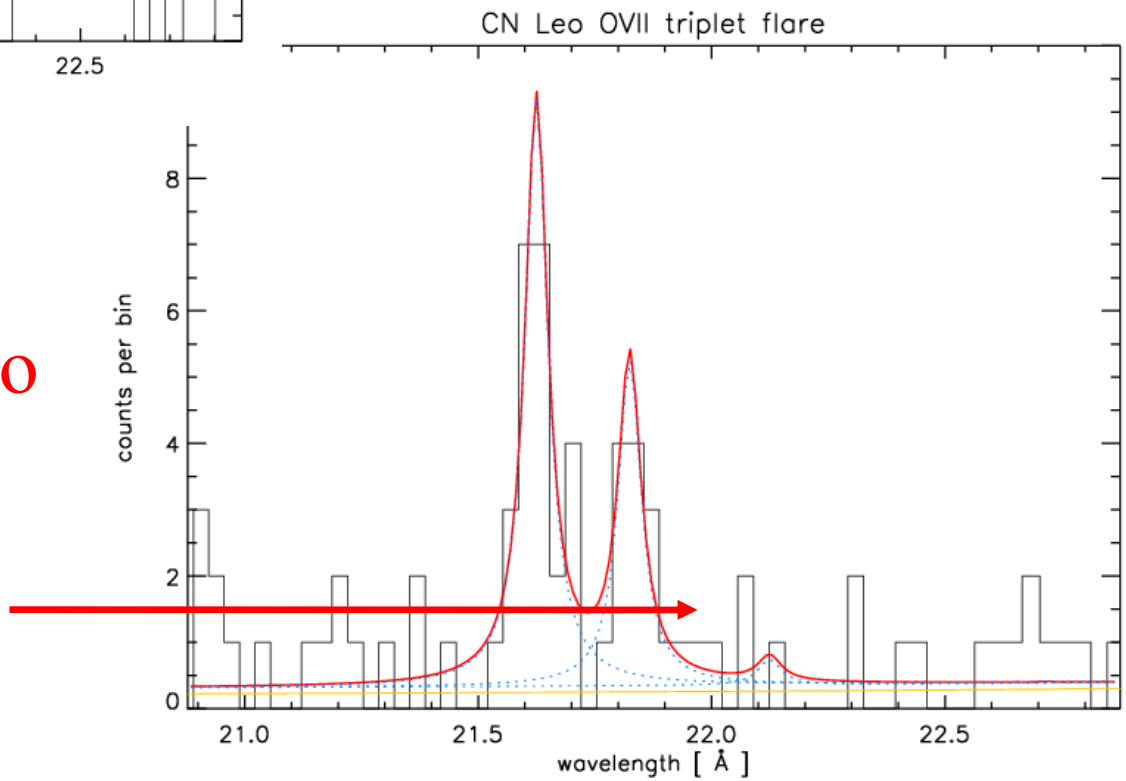
see also Kastner et al. (2002)

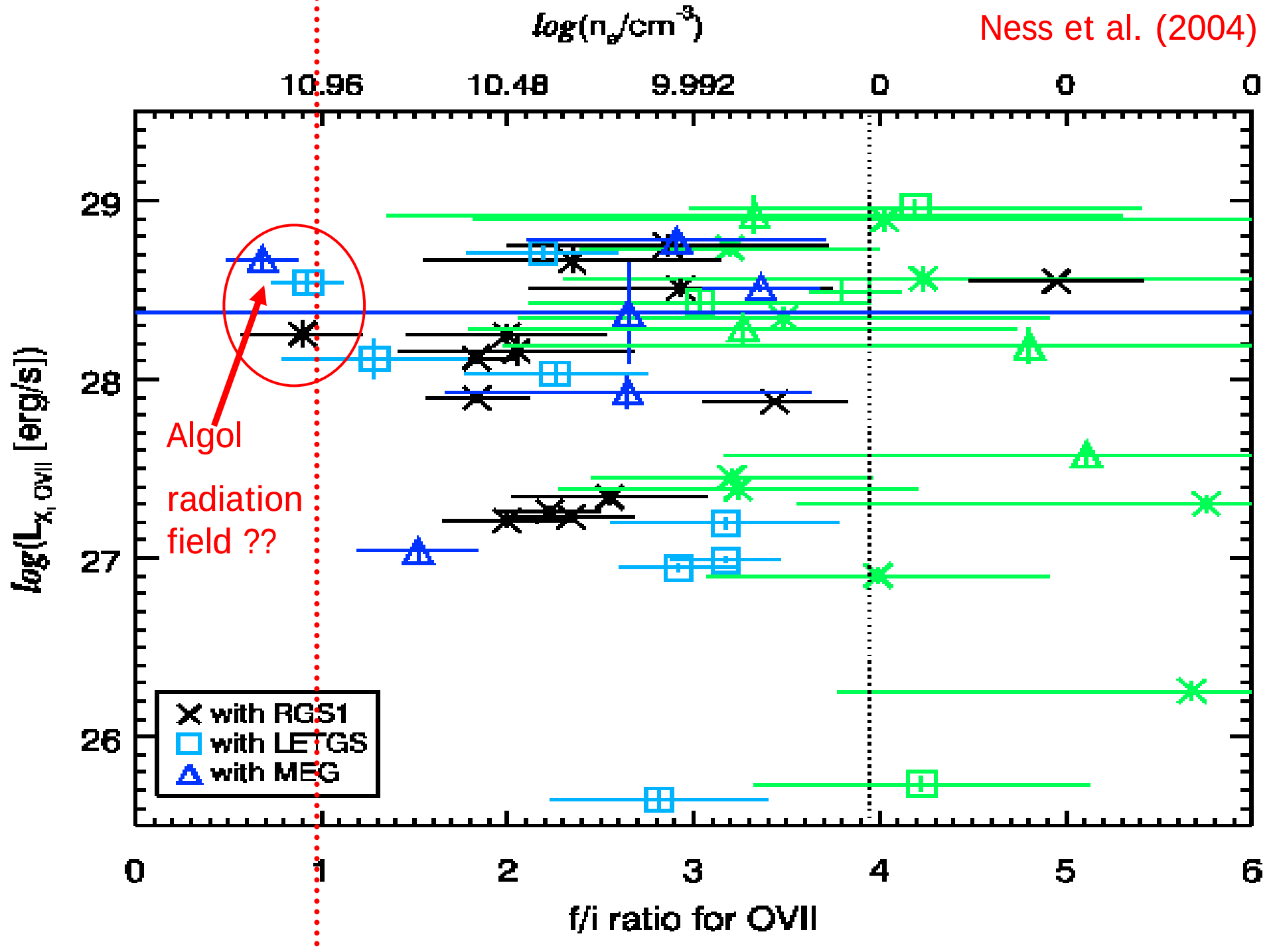


quiescence

XMM Newton: CN Leo

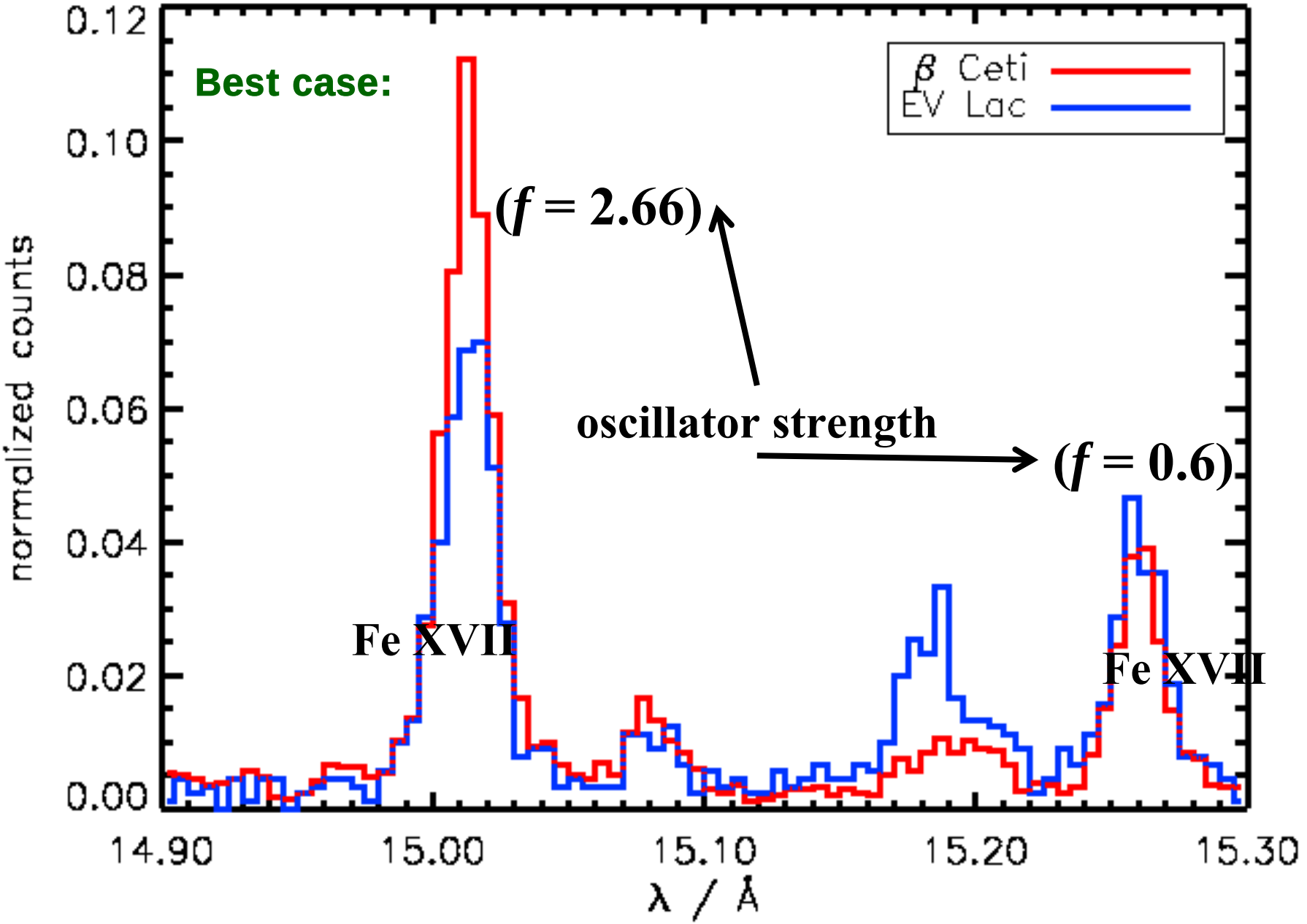
flare



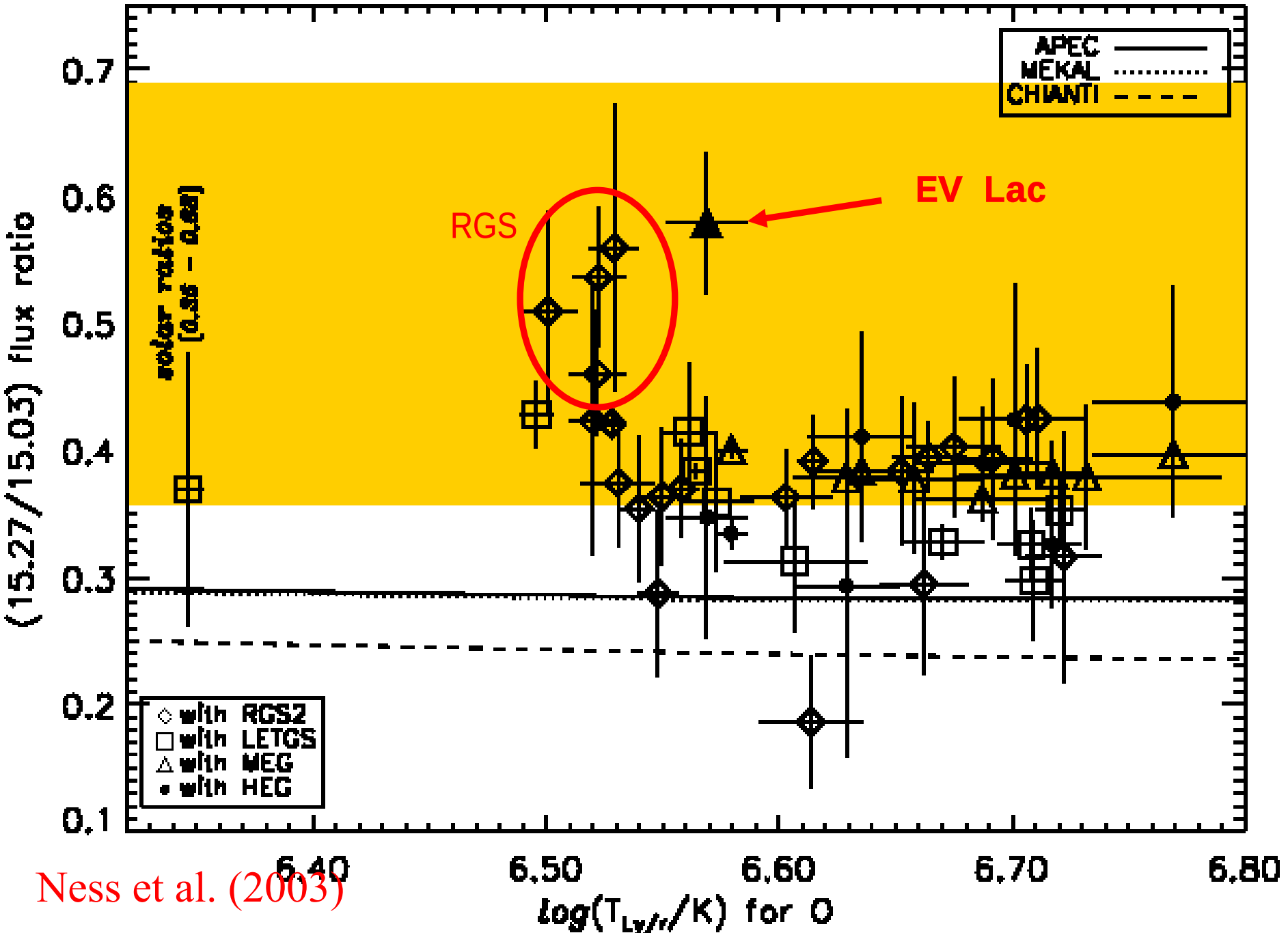

log(n_e/cm^-3)
10.96
10.48
9.992
0
0
0
Ness et al. (2004)
29
28
27
26
log(L_X, OVII [erg/s])
Algol
radiation
field ??
with RGS1
with LETGS
with MEG
0
1
2
3
4
5
6
f/i ratio for OVII

Opacities

Fe XVII 15.03/15.27 Å



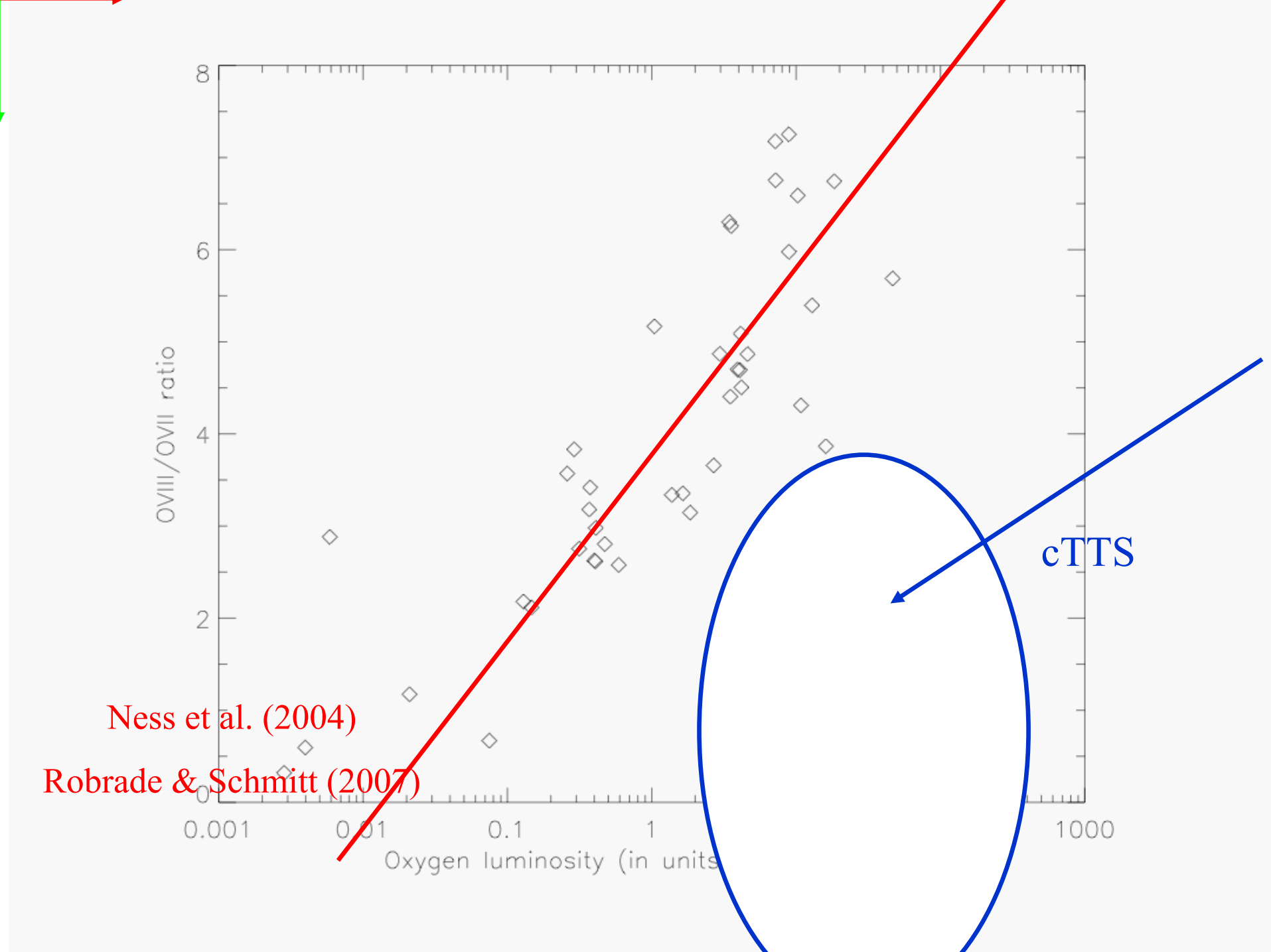
Ness et al. (2003)



Ness et al. (2003)

Temperature structure

OVIII/OVII line ratio


8
6
4
2
0
OVIII/OVII ratio
0.001
0.01
0.1
1
1000
Oxygen luminosity (in units
cTTS
Ness et al. (2004)
Robrade & Schmitt (2007)

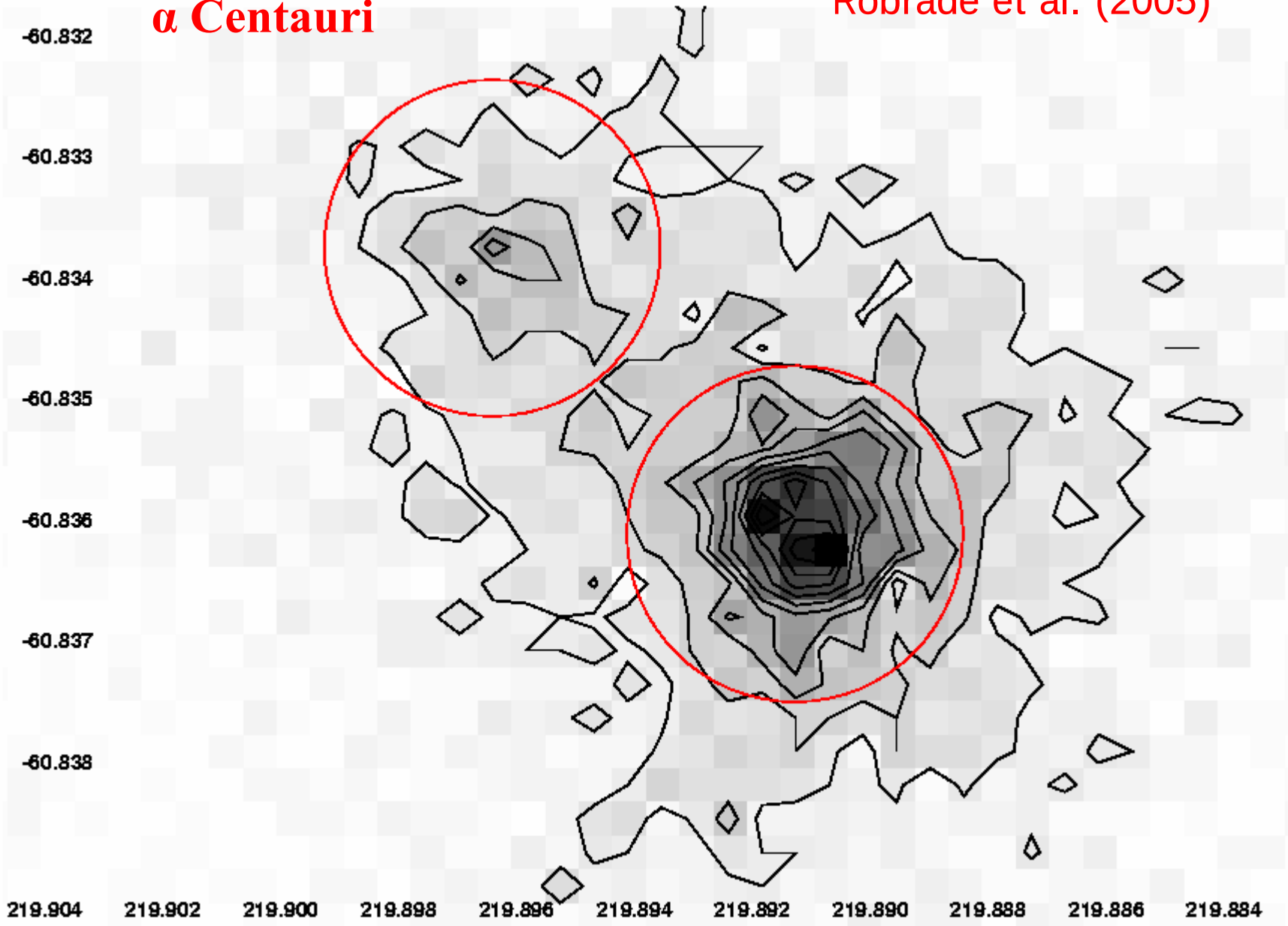
Long Looks

- Long term cycles
- Flares
- Eclipse studies/Structure

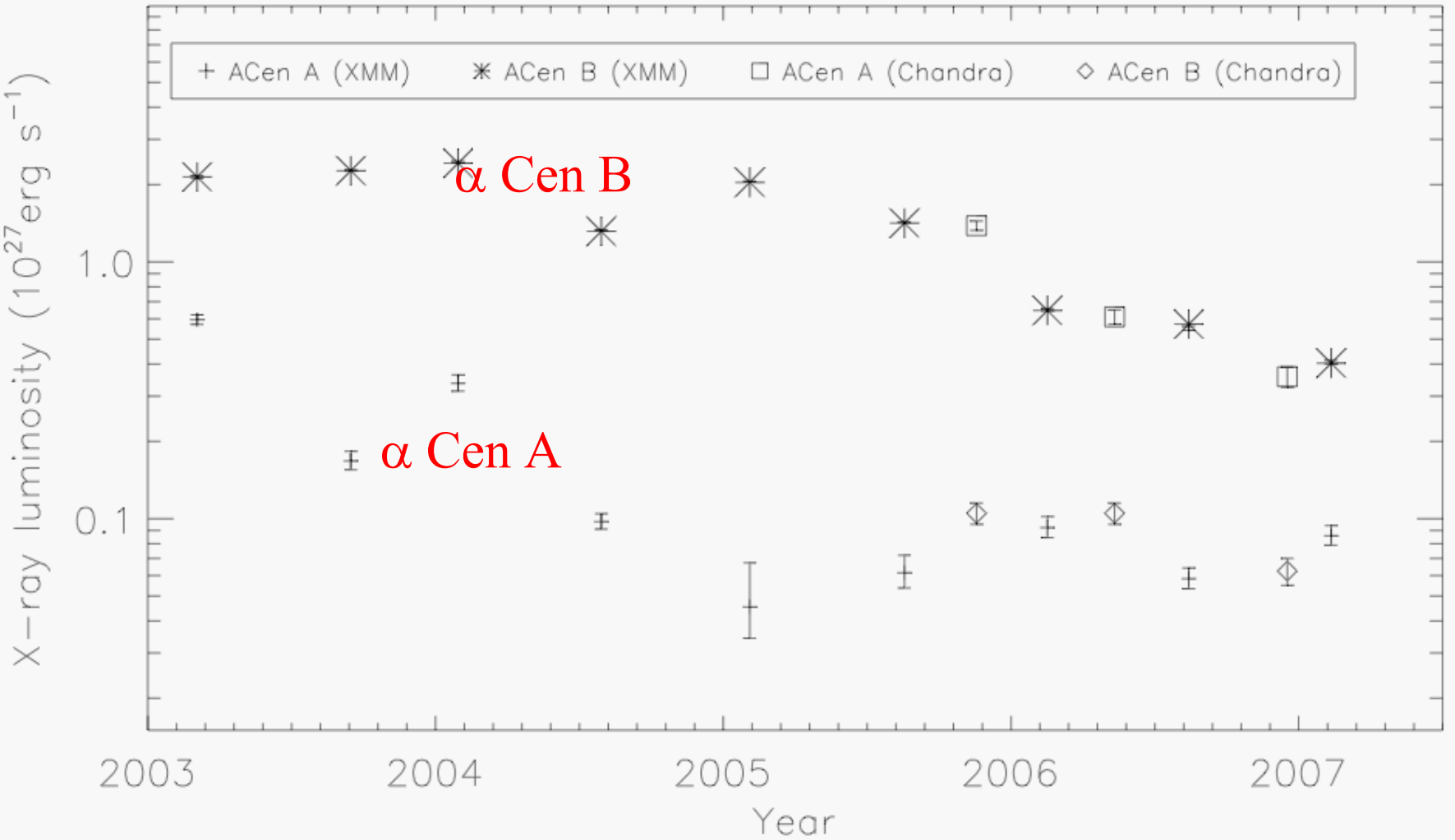
X-ray cycles

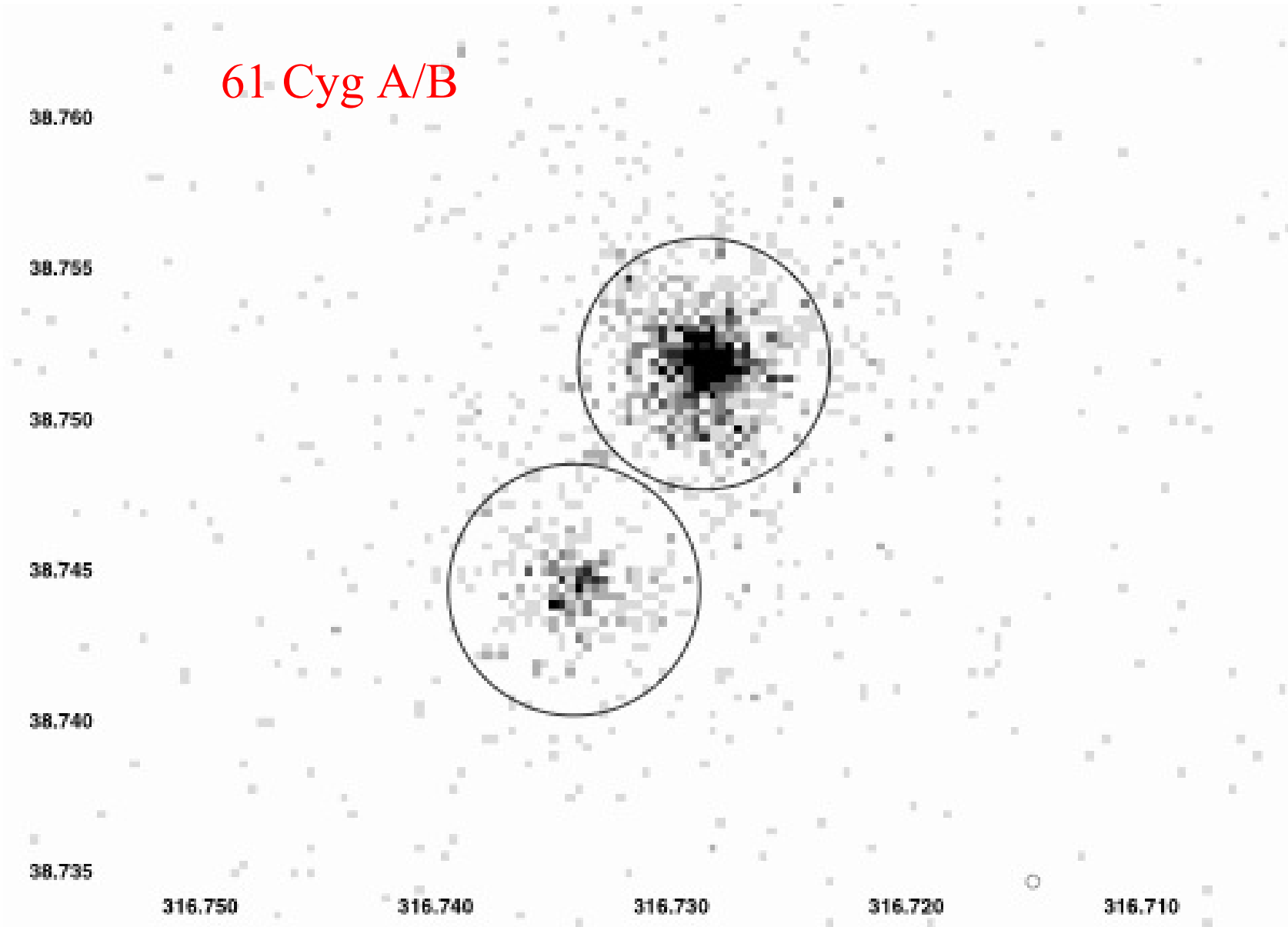
α Centauri

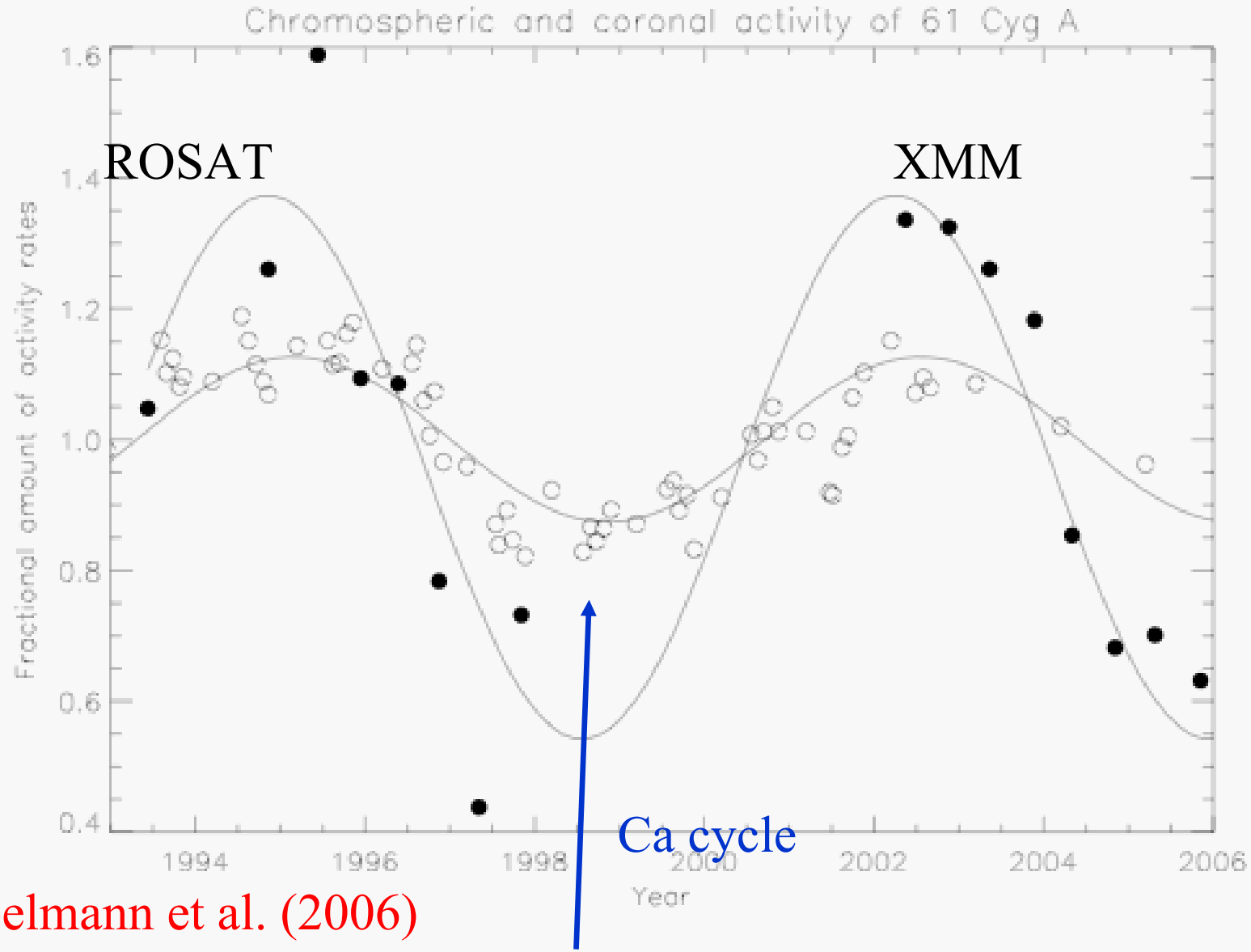
Robrade et al. (2005)



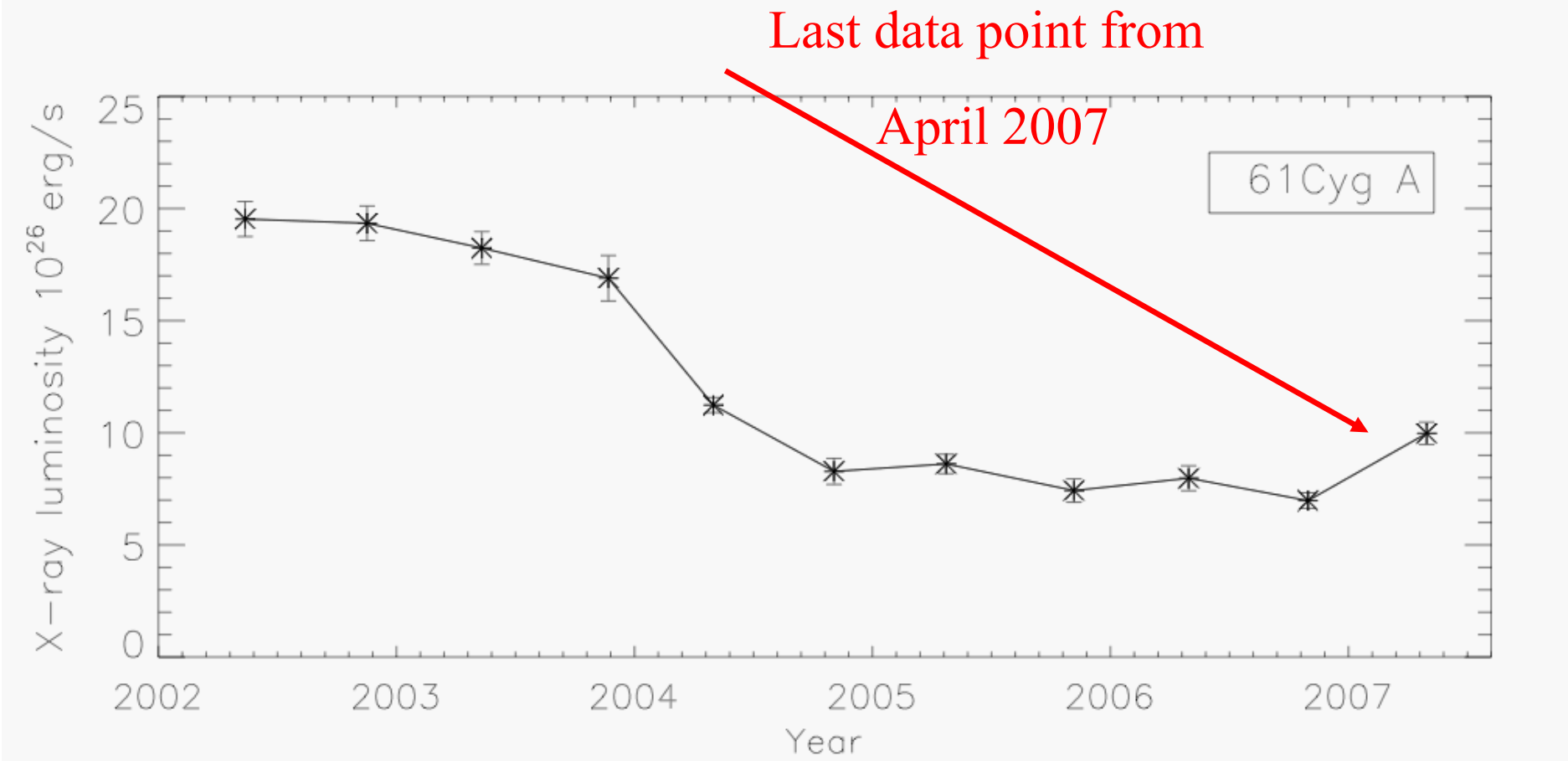
α Cen: A solar-like star is disappearing ?




61 Cyg A/B
38.760
38.755
38.750
38.745
38.740
38.735
316.750
316.740
316.730
316.720
316.710



Hempelmann et al. (2006)

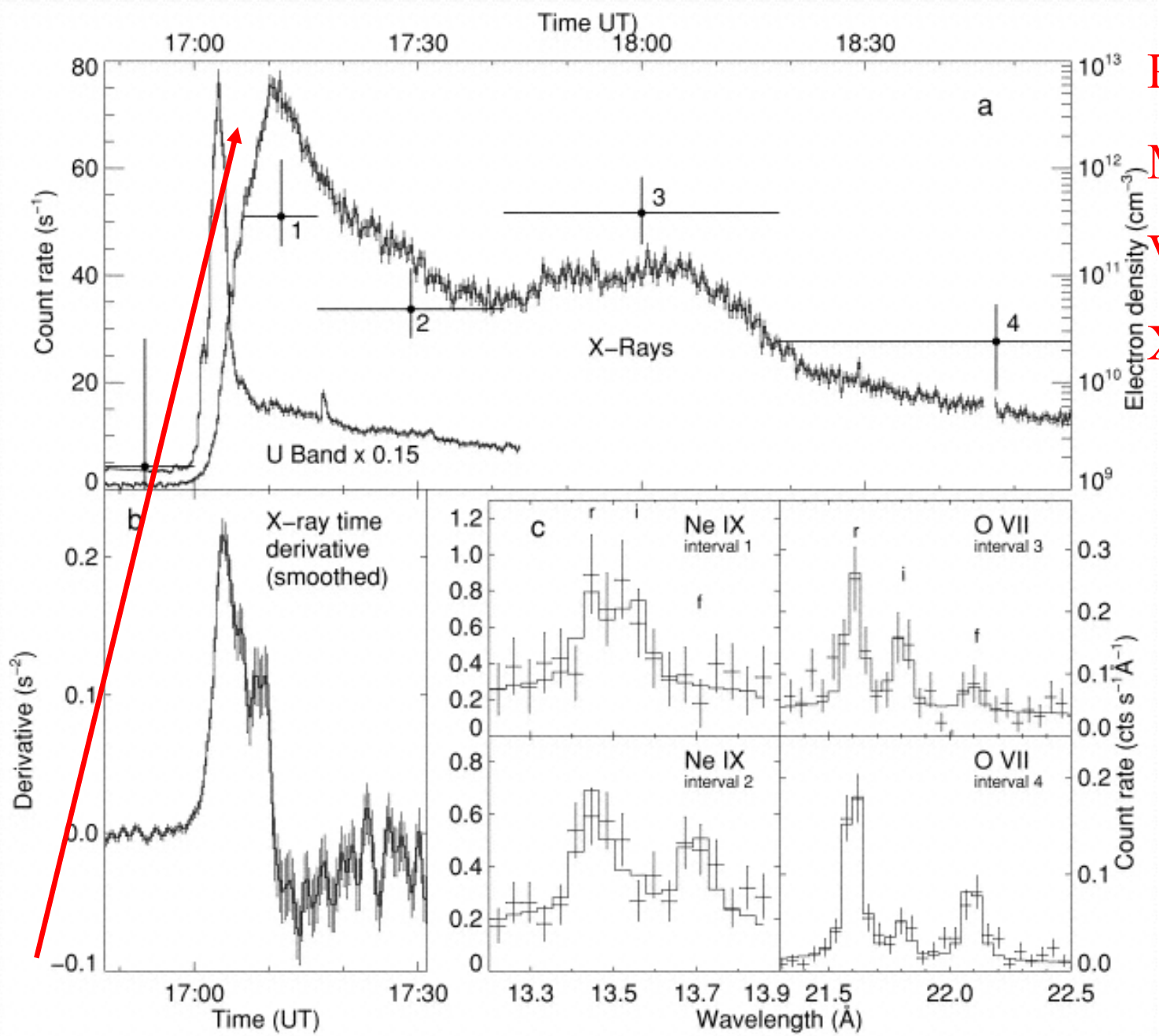

Last data point from
April 2007
61Cyg A
X−ray luminosity 10^{26} erg/s
0
5
10
15
20
25
2002
2003
2004
2005
2006
2007
Year

Flares with OM coverage

Proxima Centauri

LPS 412-31

CN Leo



Prox Cen

M5.5V

V = 11.05

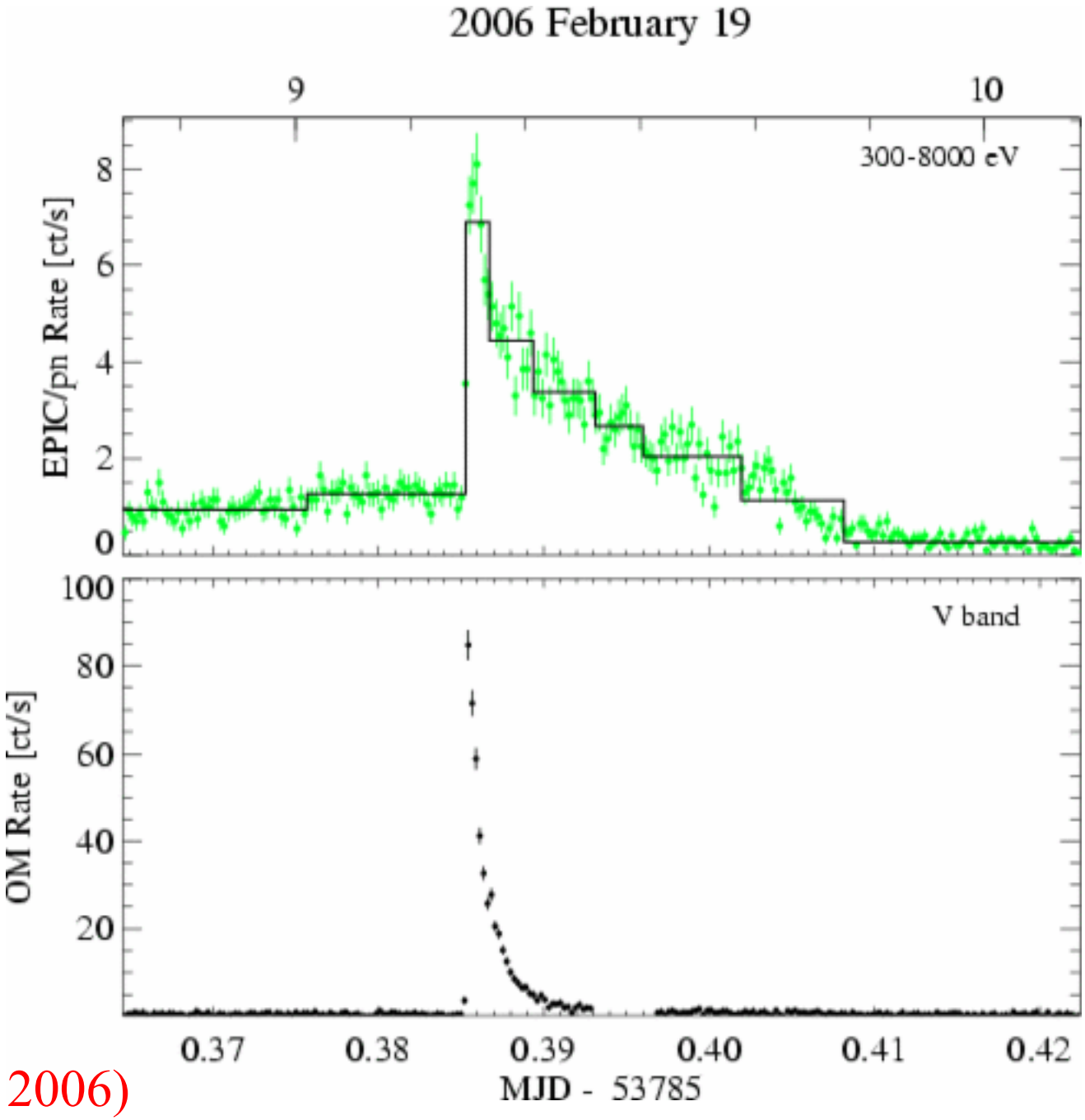
XMM-Newton

Güdel et al. (2002)

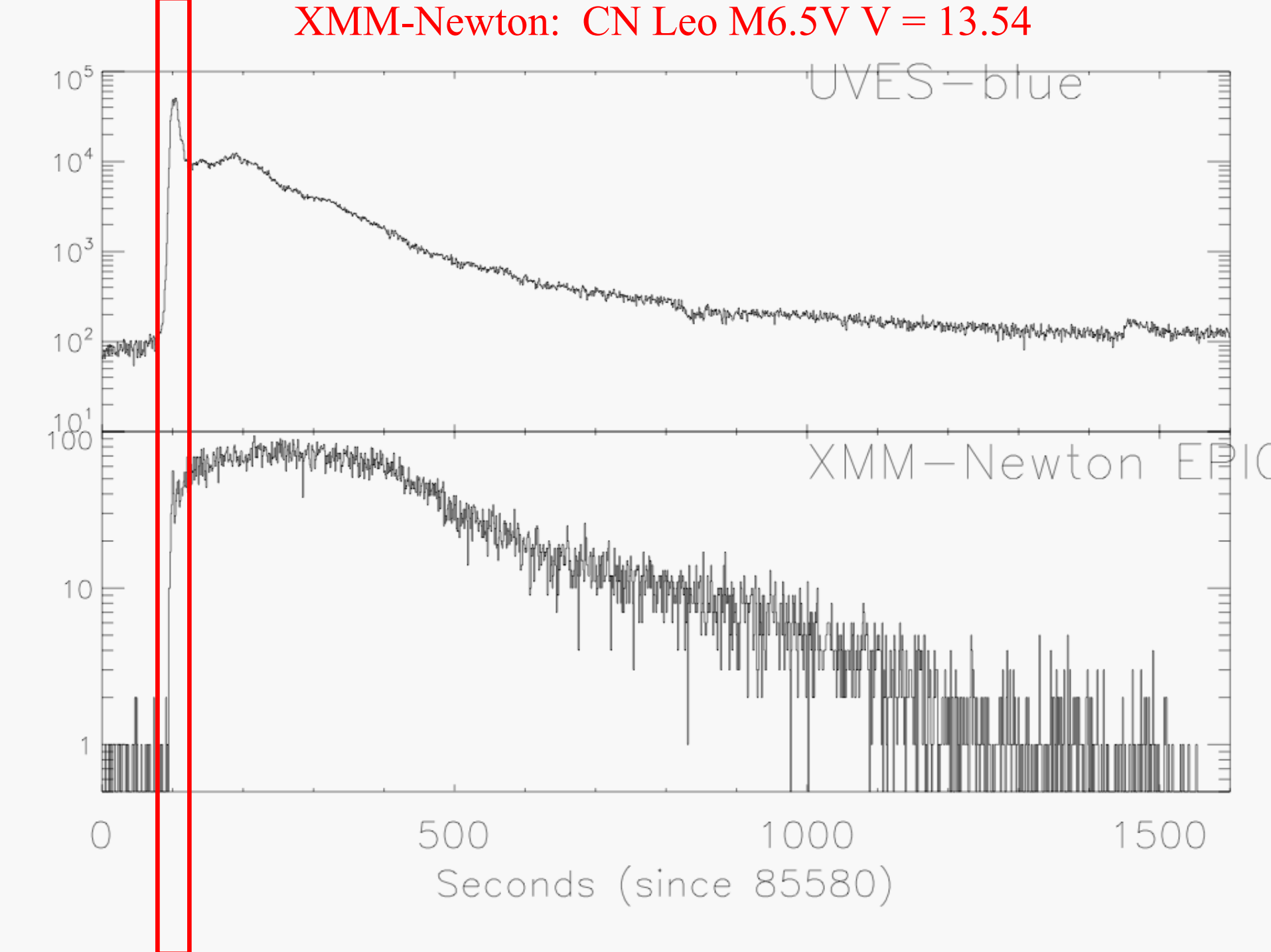
LP 412-31

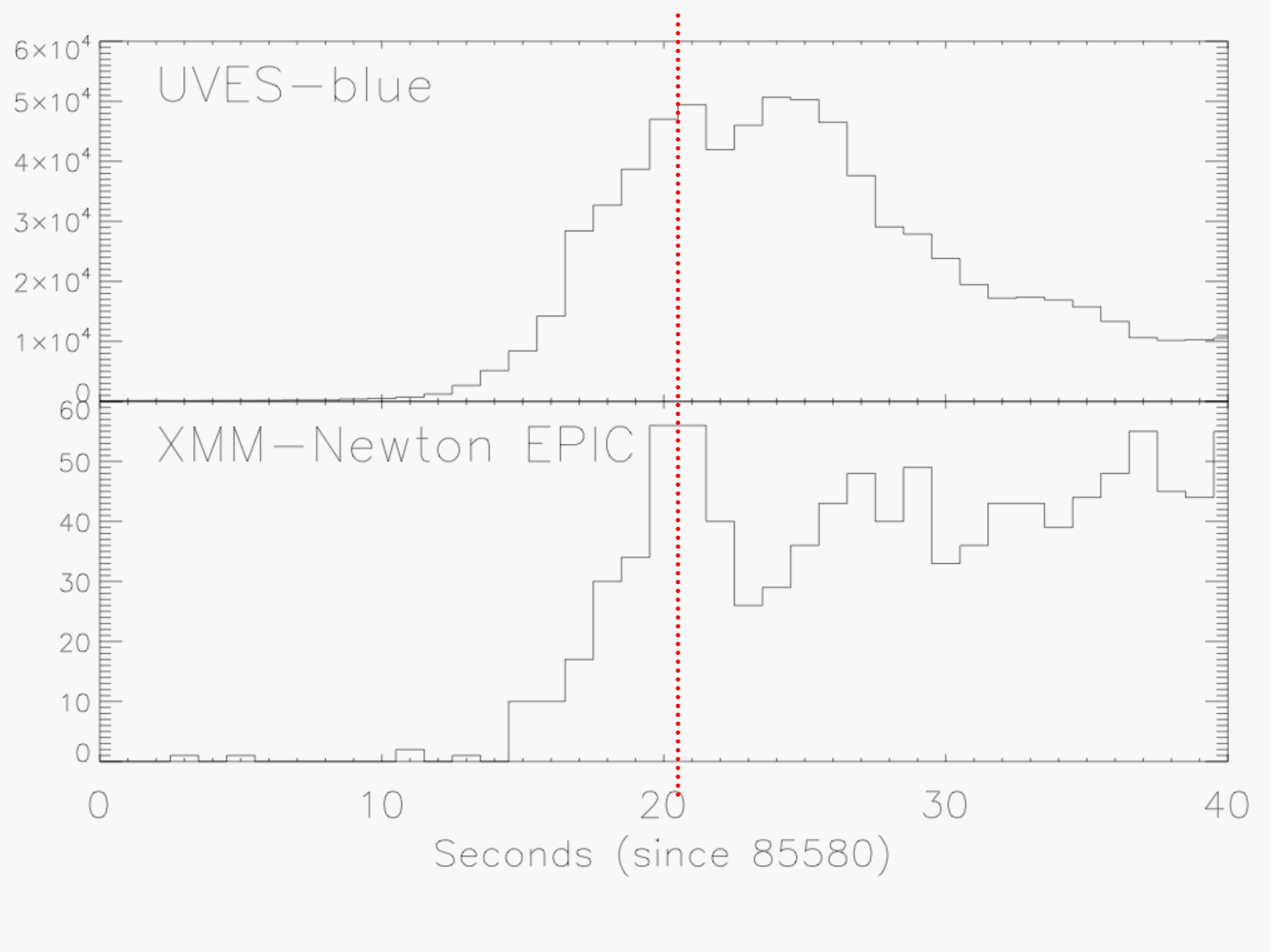
M8V

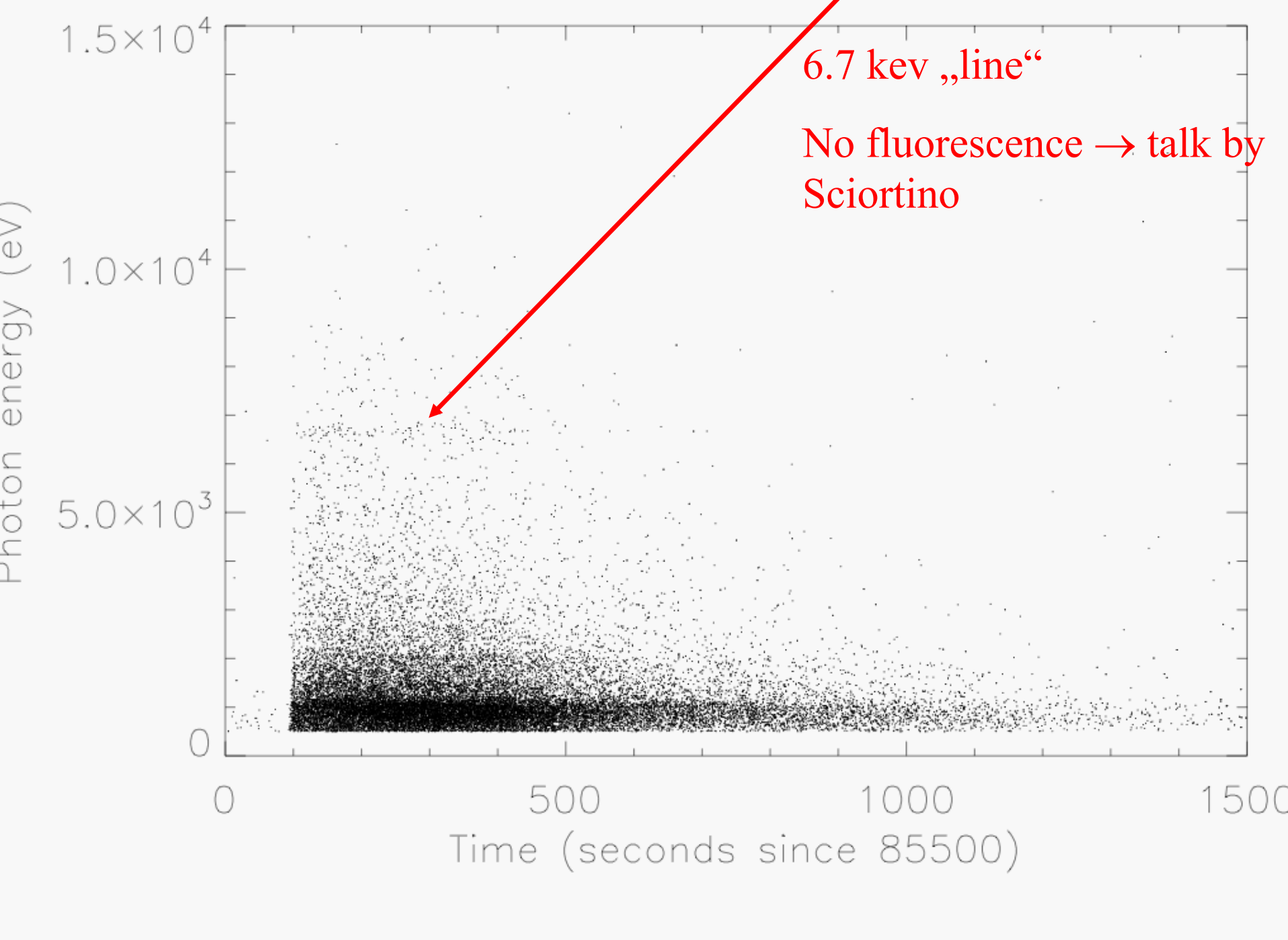
V=19.21



Stelzer et al. (2006)


XMM-Newton: CN Leo M6.5V V = 13.54
UVES−blue
XMM−Newton EPIC
10^5
10^4
10^3
10^2
10^1
100
10
1
0
500
1000
1500
Seconds (since 85580)


UVES−blue
6×10^4
5×10^4
4×10^4
3×10^4
2×10^4
1×10^4
0
XMM−Newton EPIC
60
50
40
30
20
10
0
0
10
20
30
40
Seconds (since 85580)


6.7 kev „line“
No fluorescence → talk by Sciortino
Photon energy (eV)
1.5×10^4
1.0×10^4
5.0×10^3
0
0
500
1000
1500
Time (seconds since 85500)

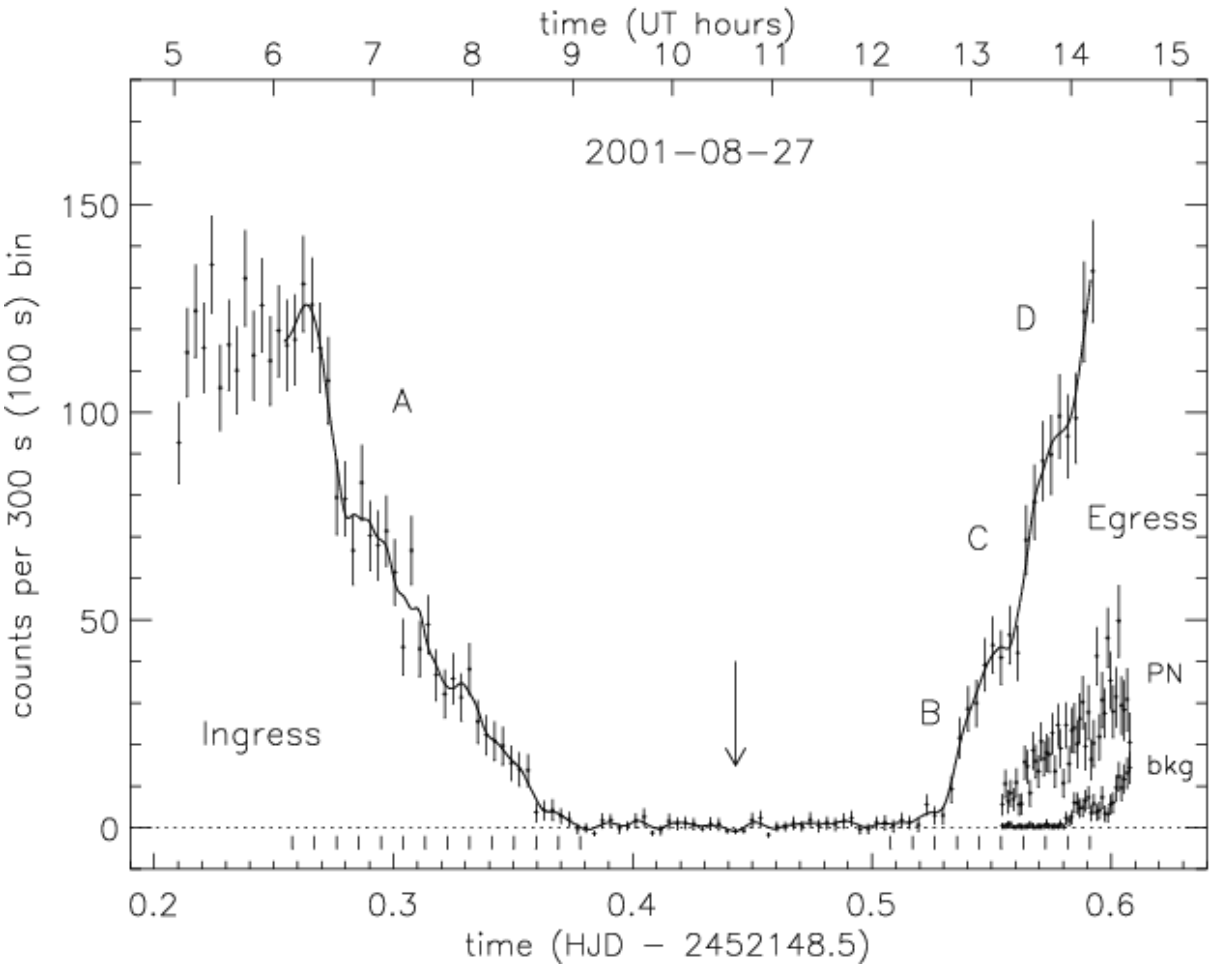
Structure

α CrB

Algol (flare)

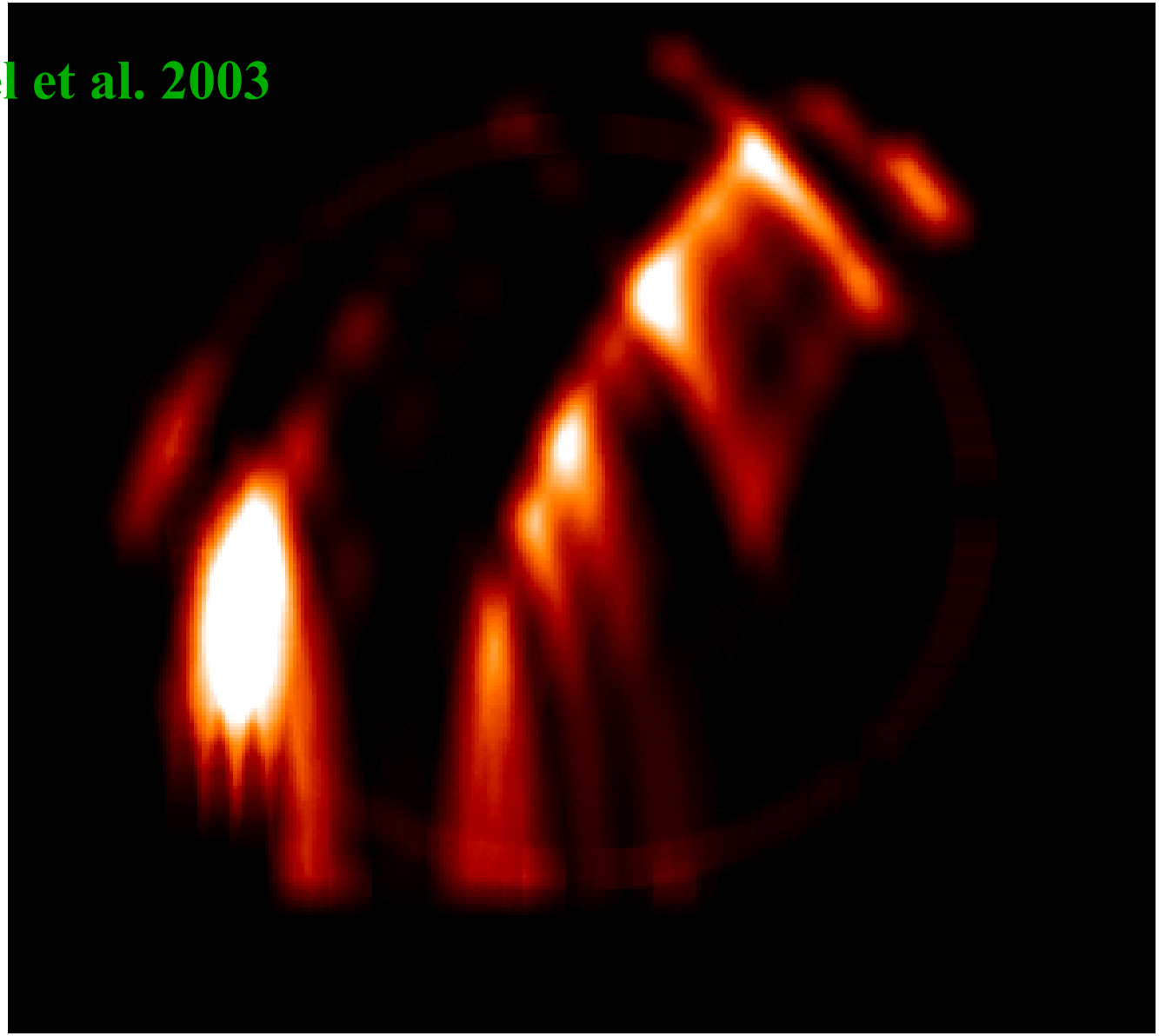
α CrB: Reconstruction of intensity structures from eclipse

Güdel et al. 2003



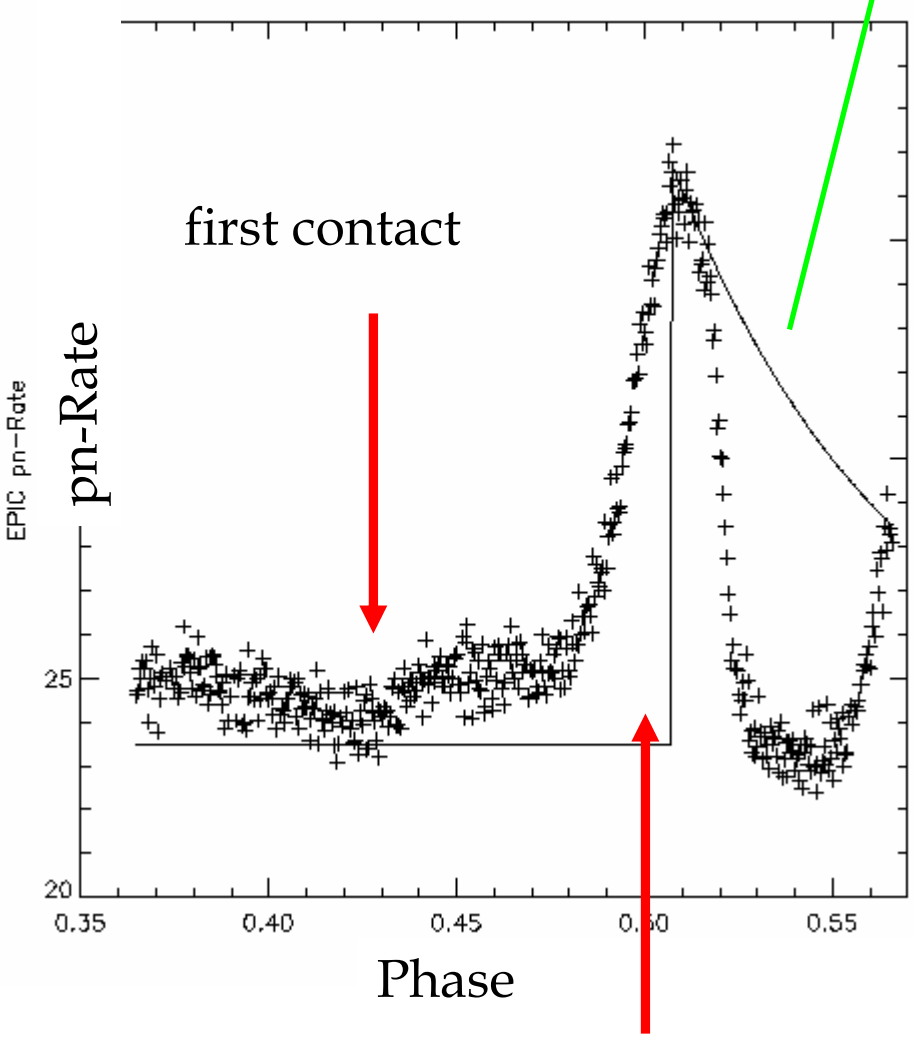
α CrB: Reconstruction of intensity structures from eclipse

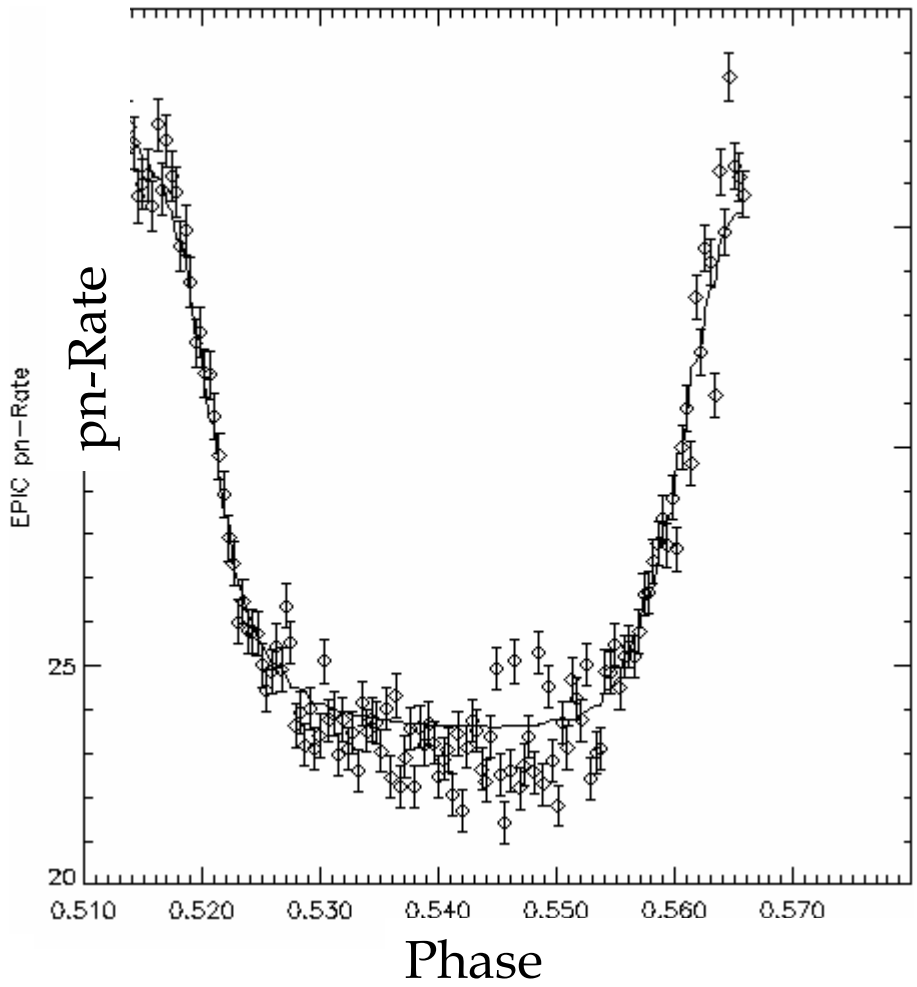
Güdel et al. 2003



XMM-Newton : Algol B

$$B + A_0 e^{-\frac{t}{\tau_{decay}}}$$





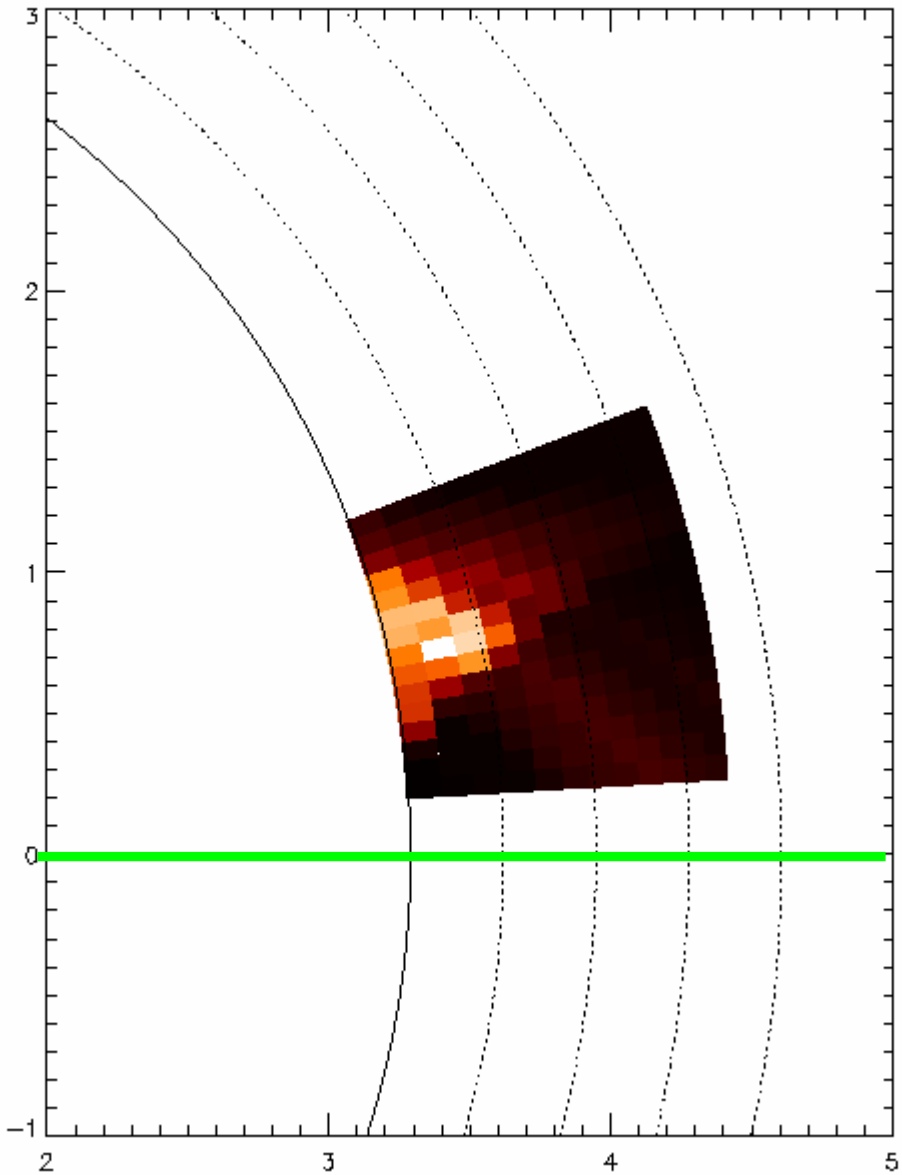
Schmitt et al. (2003)

optical mid-eclipse

Rectified light curve !

Limb flare on Algol B !

Eclipse mapping on rectified light curve (Lucy-Richardson iteration)



Schmitt et al. (2003)

What should XMM-Newton do for cool stars in the next decade ?

Cool stars successfully observed with XMM-Newton RGS

(excluding calibration targets)

RS CVn	14	942 ksec
Active MS	14	920 ksec
dMe	11	701 ksec
Algol type	3	287 ksec
Contact binary	2	63 ksec
cTTS/HAeBe	6	575 ksec
wTTS	4	327 ksec
Giants	4	237 ksec
Low activity	4	340 ksec
	62	4392 ksec

What should XMM-Newton do for cool stars in the next decade (I)?

X-ray spectroscopy of selected types of stars:

- Giants (hybrid stars)
- Low activity objects
- CTTs
- WTTs

What should XMM-Newton do for cool stars in the next decade (II)?

X-ray emission from „extreme stars“ in the HR-diagram:

- Brown dwarfs
- Magnetic B/A-type stars (see also talk by G. Rauw)
- Low-activity stars (see talk by A. Pollock)
- Dividing line

My personal wishlist of what XMM ought to do:

Goal	Objects	Time (Msec)
CTTs spectra	5	1.0
WTTs spectra	5	0.5
Low activity spectra	5	0.8
Hybrid spectra	2	0.5
„Old“ BDs	5	0.6
LCs of magnetic Bp and Ap stars	3	0.6
Giants beyond the DL	4	0.3
λλ XMM OM	5	0.5
Activity survey of planet bearing stars	~ 100	1.0
	Sum	5.8