14th ESAC SAS Workshop
2nd – 6th June 2014

The XMM-Newton Reflection Grating Spectrometers

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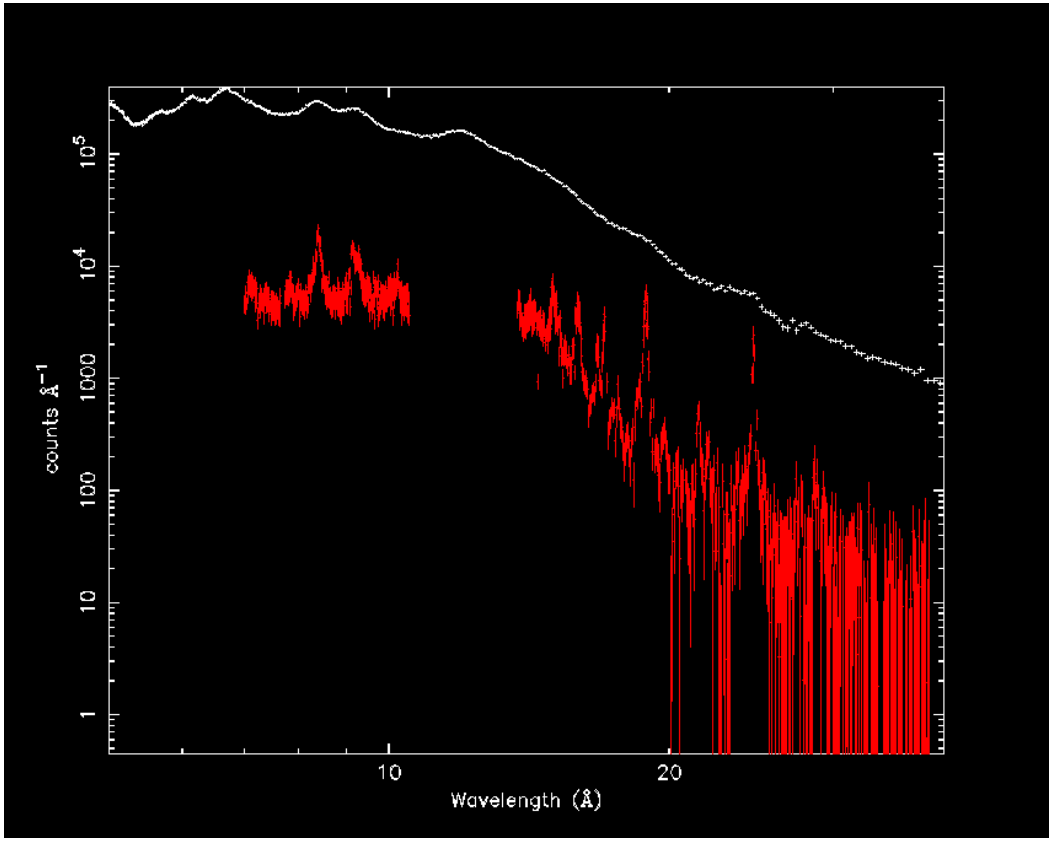
with inputs from the RGS team

XMM-Newton SOC
ESAC

The Reflection Grating Spectrometers



resolution @ 1 keV:

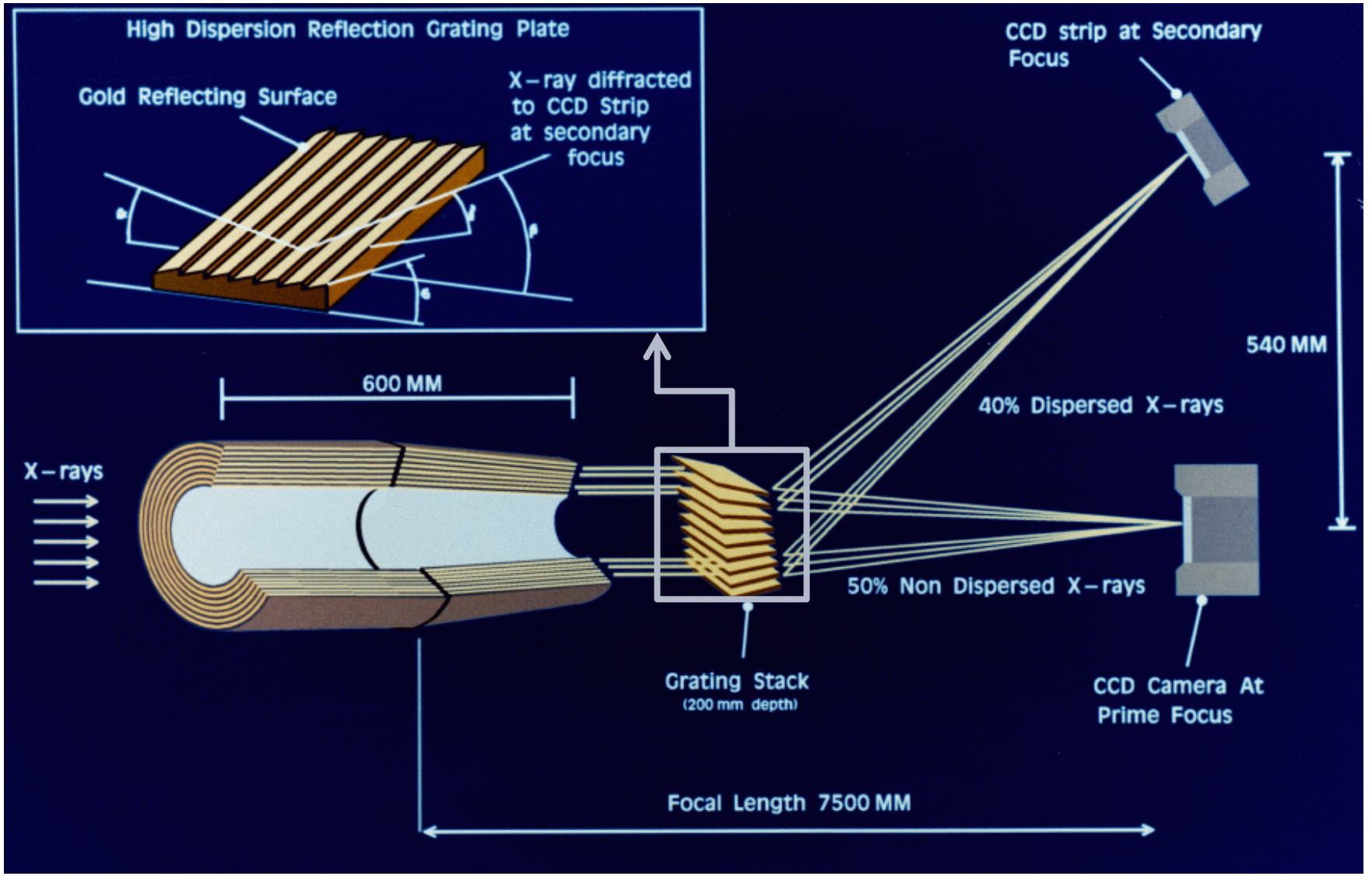
EPIC-pn	10
EPIC-MOS	14

High resolution spectroscopy !

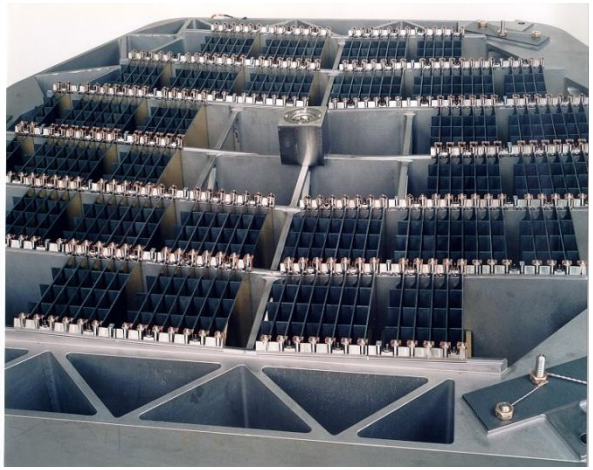
RGS	200 1st order
	400 2nd order

"The Reflection Grating Spectrometer on board XMM-Newton"
den Herder et al., 2001, A&A 365, L7
"Calibration and in-orbit Performance of the Reflection Grating Spectrometer on board XMM-Newton"
de Vries et al., submitted to A&A

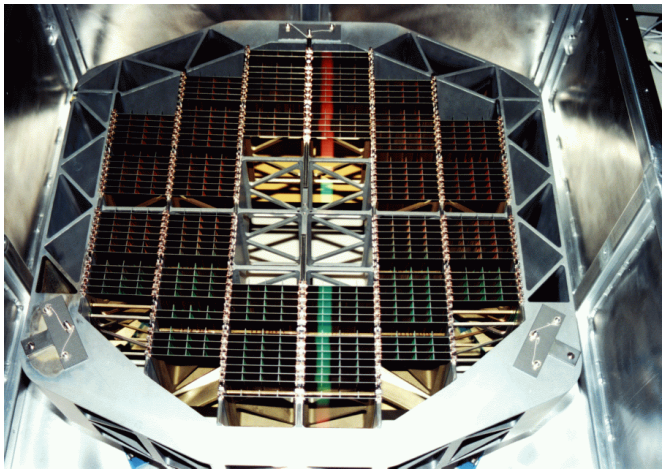
The RGS instrument

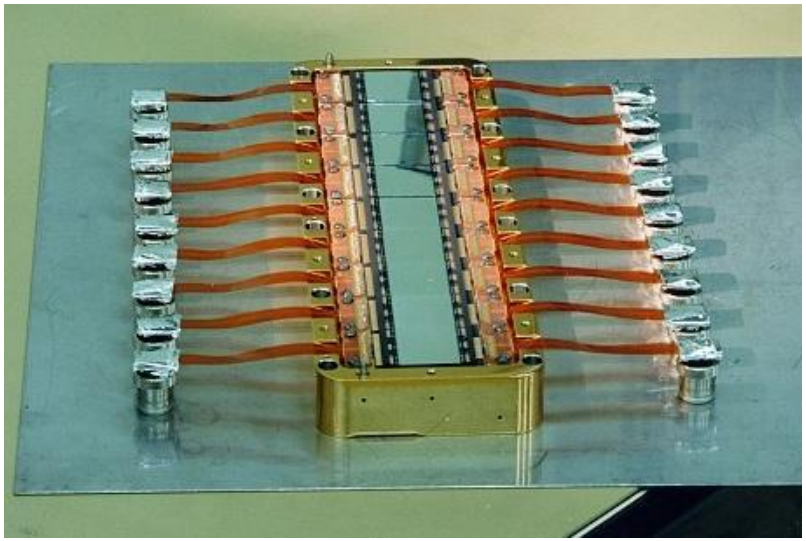


Some views of RGS...



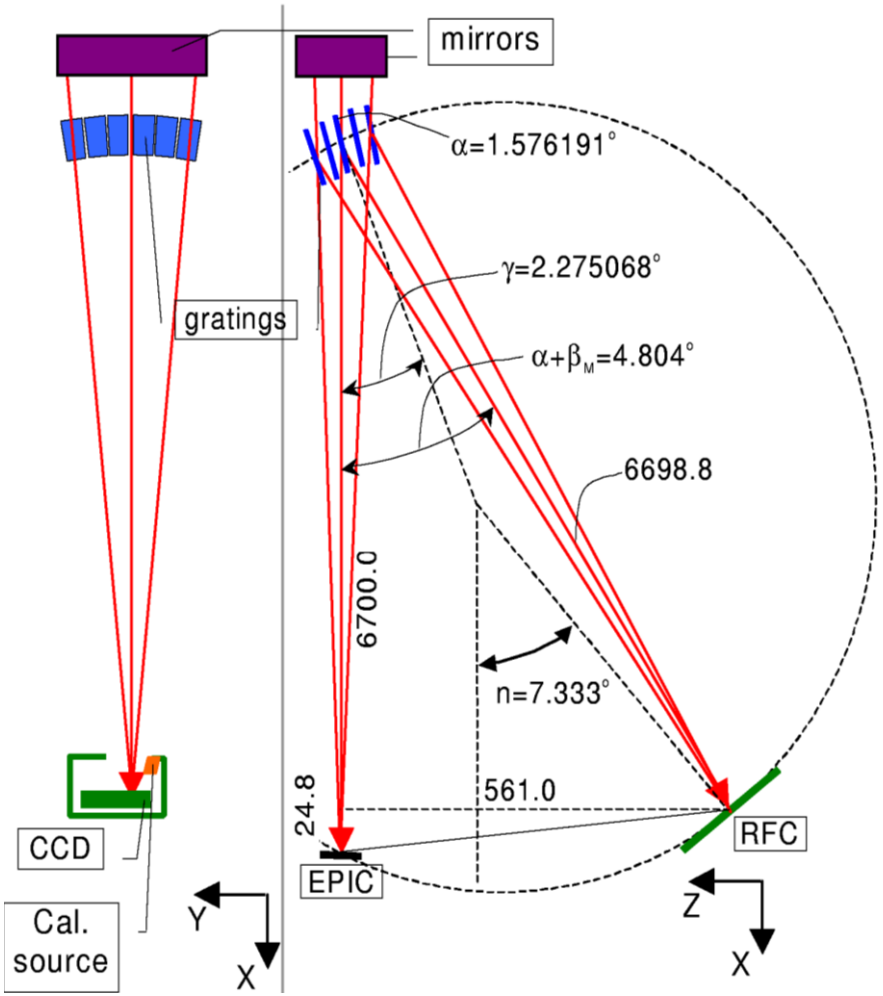
The 182 Gratings

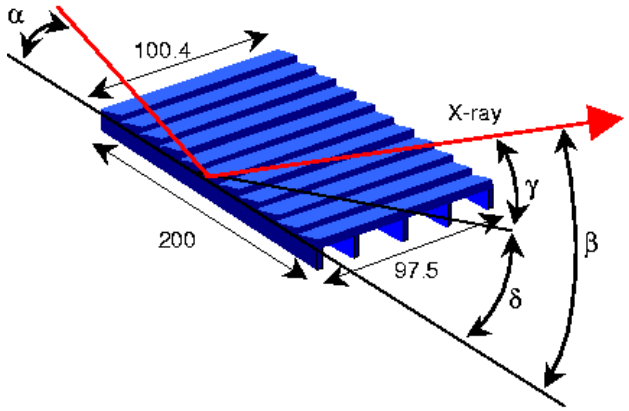




The 9 CCDs

Optical Design

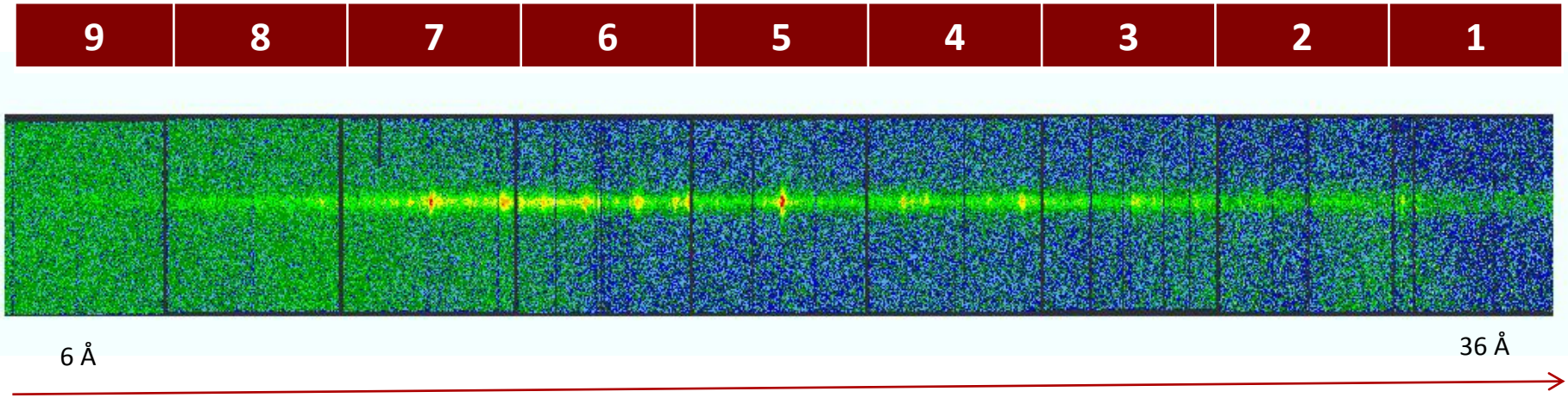




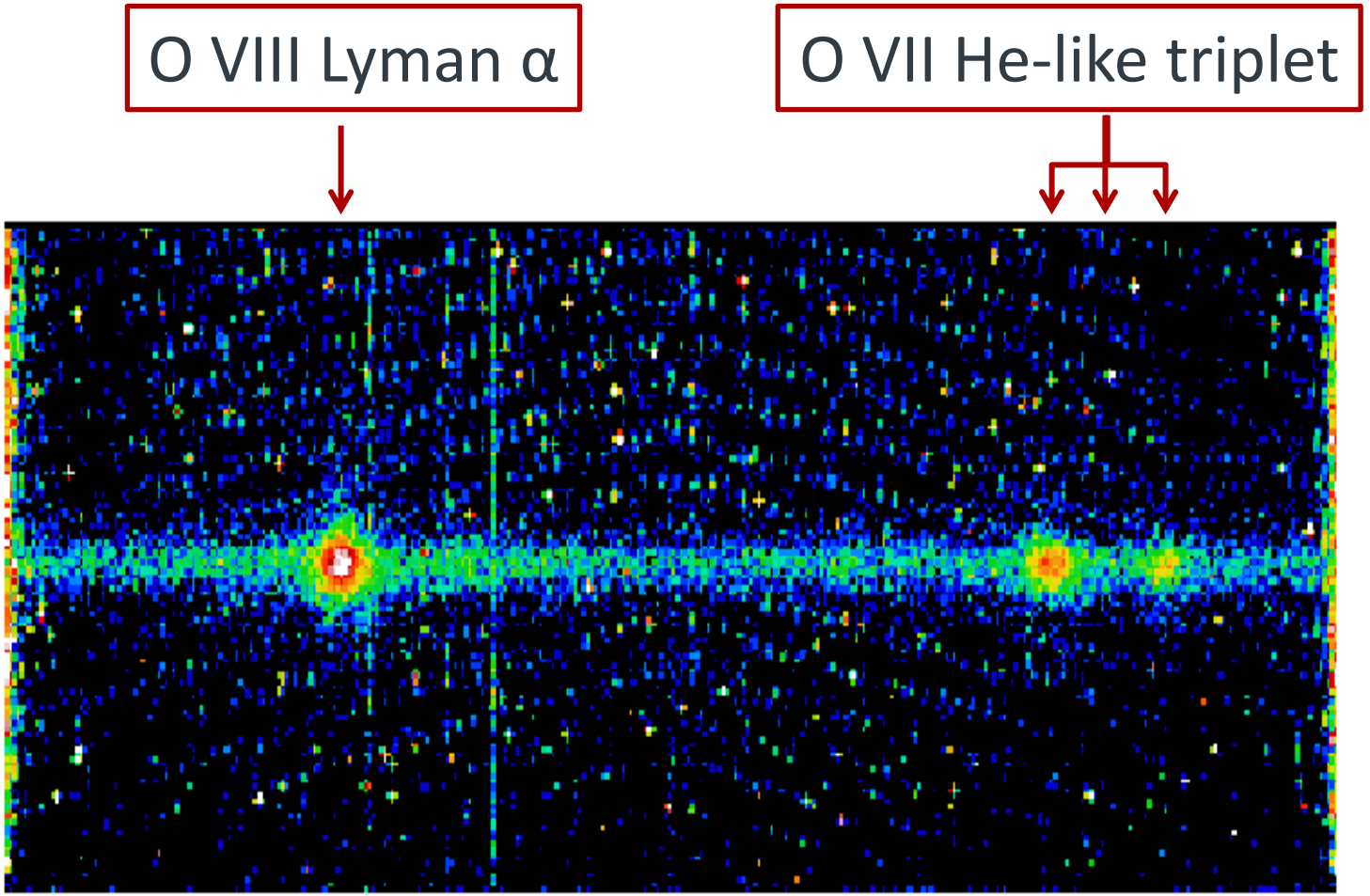
$$\cos \beta = \cos \alpha + m \lambda / d$$

$$\lambda = (\cos \beta - \cos \alpha)\ d / m$$

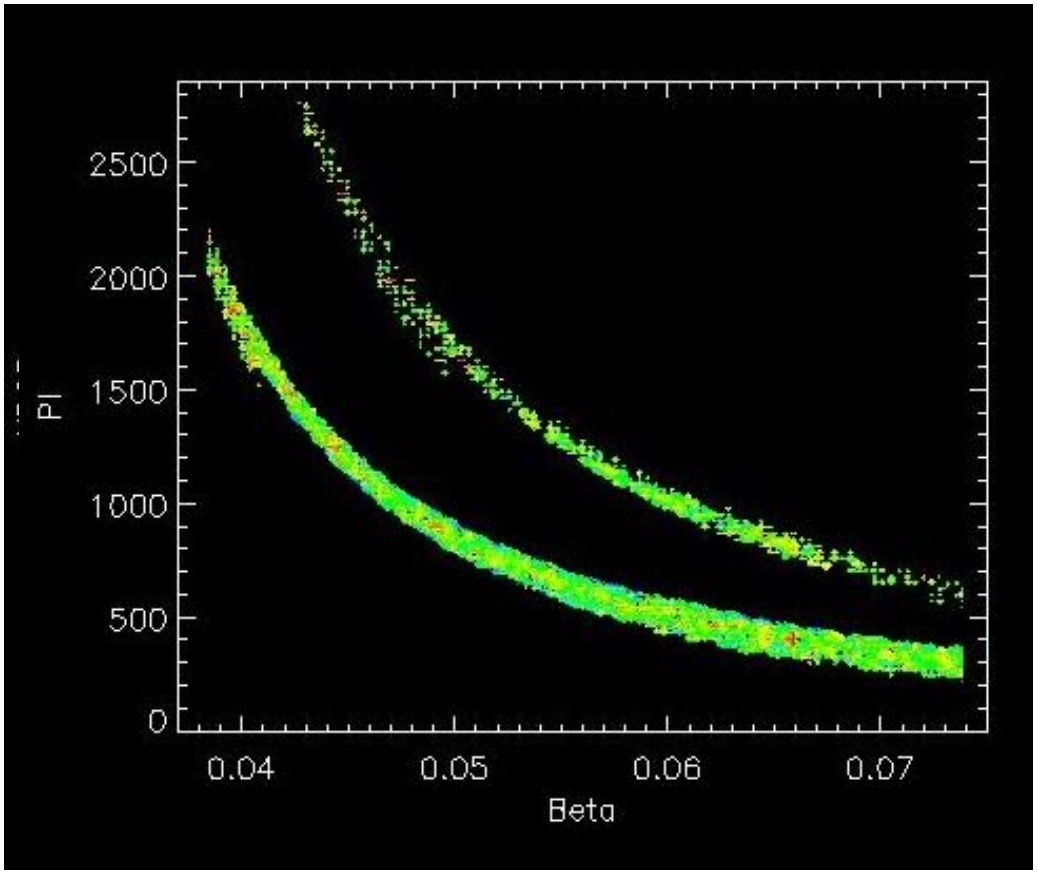
The CCDs



One of the CCDs



Observing Modes



Two modes:

- Spectroscopy (+ Q)
- Small Window

(for very bright objects, reading only ¼ of the FOV)

For each event:

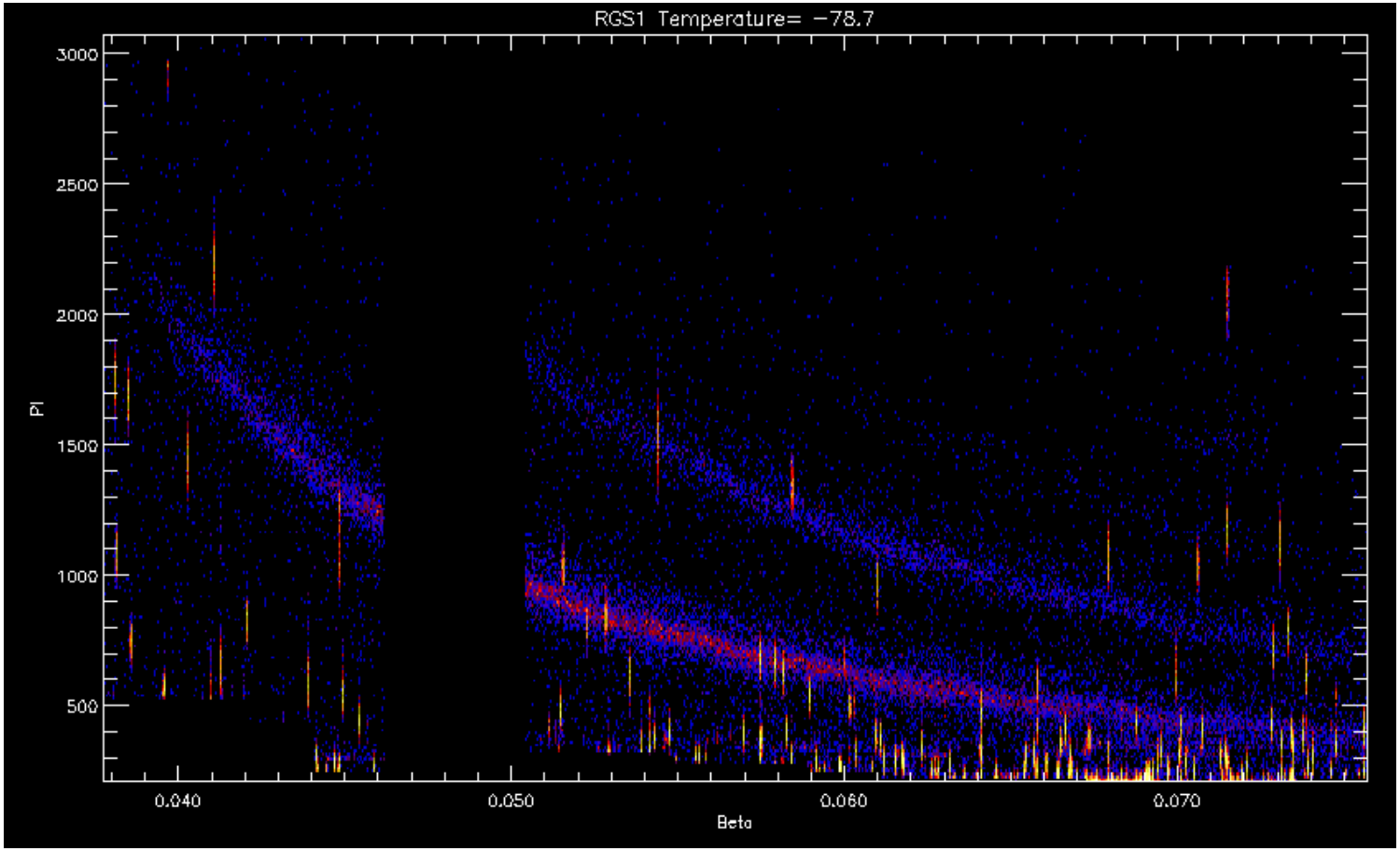
- Time
- Position on the detector
- Energy

Instrument Performance

	RGS 1 1st order	RGS 2 1st order	RGS 1 2nd order	RGS 2 2nd order
Wavelength range	6 - 38 Å		6 - 20 Å	
Effective area @15 Å (cm^2)	61	68	15	19
Resolution @15 Å	250 1200 km/s 60 mÅ	215 1400 km/s 70 mÅ	430 700 km/s 35 mÅ	375 800 km/s 40 mÅ
Wavelength accuracy	6 mÅ		5 mÅ	
Time resolution (Spec, 8 CCDs)	4.8 s	9.6 s	4.8 s	9.6 s
Time resolution (Spec, 1 CCD)	0.6 s	1.2 s	0.6 s	1.2 s
Time resolution (SW, 8 CCDs)	1.2 s	2.4 s	1.2 s	2.4 s
Time resolution (SW, 1 CCD)	0.15 s	0.3 s	0.15 s	0.3 s

up-to-date information always available in
"Status of the RGS Calibration"
http://xmm2.esac.esa.int/docs/documents/CAL-TN-0030.pdf

Cooling in November 2002



Pile-up

RGS observations of **very bright** sources may show the effects of **pile-up**, the arrival of more than one X-ray photon in one pixel before it is read out.

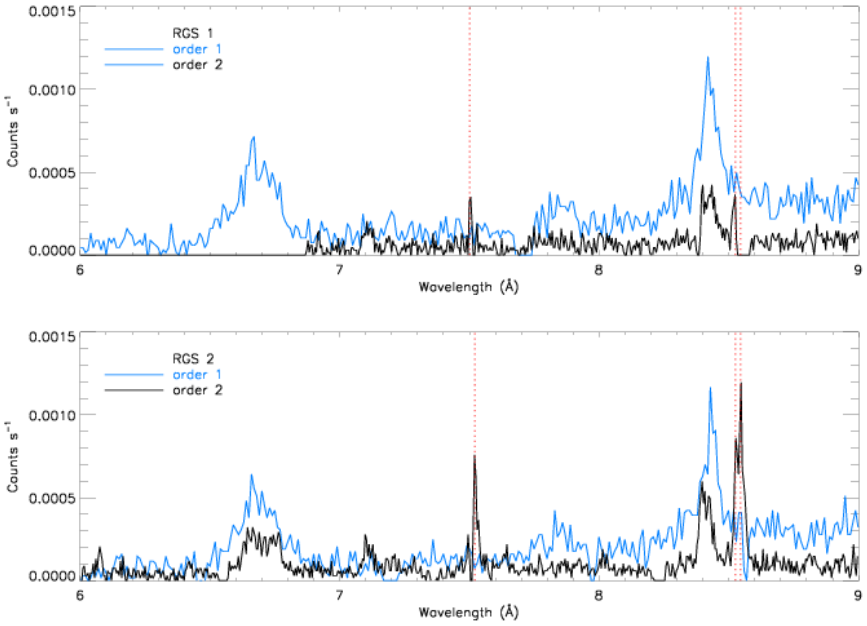
Pile-up effects in bright continuum sources is important for cases with integrated fluxes within one CCD **above ~ 2 10^{-10} erg cm^{-2} s^{-1}**.

Only ~ 20 objects with fluxes higher than that are identified in the ROSAT All Sky Survey.

The effects of pile-up on spectra are :

- migration of photons from first to higher orders.
- rejection of events with complicated patterns by the on-board processing.
- the effects of pile-up are more severe in RGS2 due to the longer readout time.

Capella



Pile-up can be mitigated by reducing the accumulation time:

- reading fewer CCDs,
- reading the most brightly illuminated CCDs more often,
- using the RGS Small Window mode,
- or a combination of these

The Instrumental Response

- Mirror
- Grating
- CCD

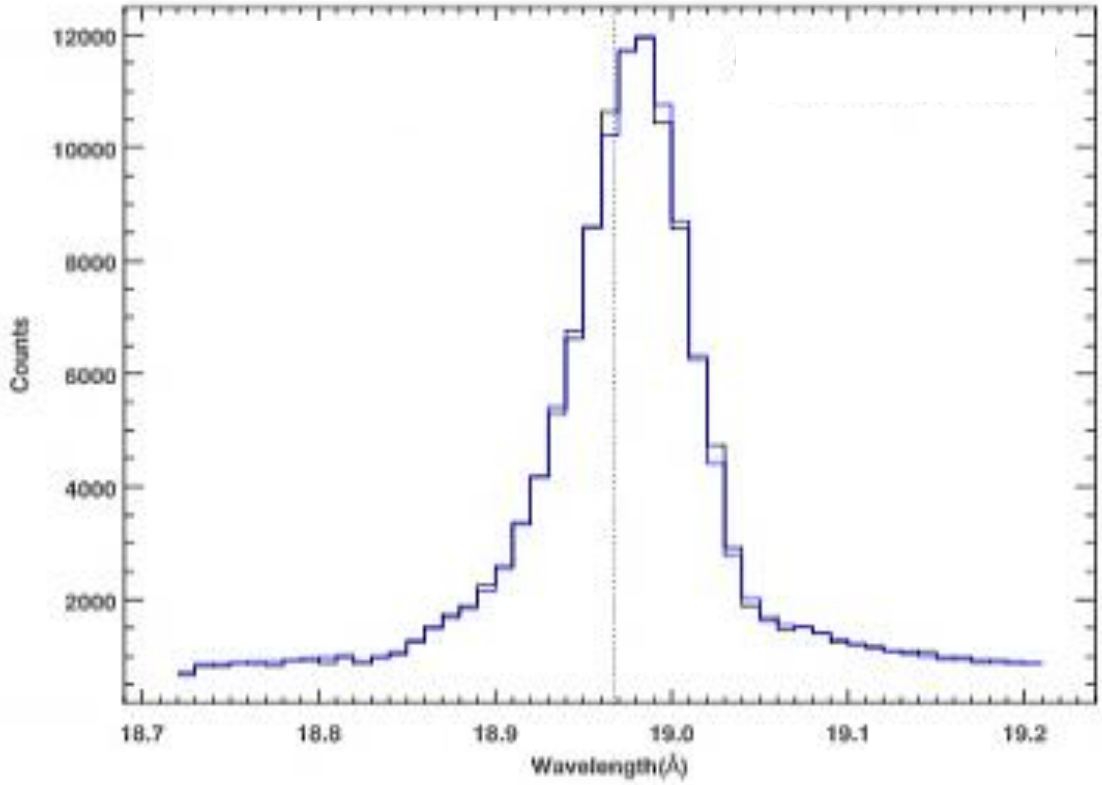
} **pre launch**

- \+ empirical corrections ⇦ **in flight**

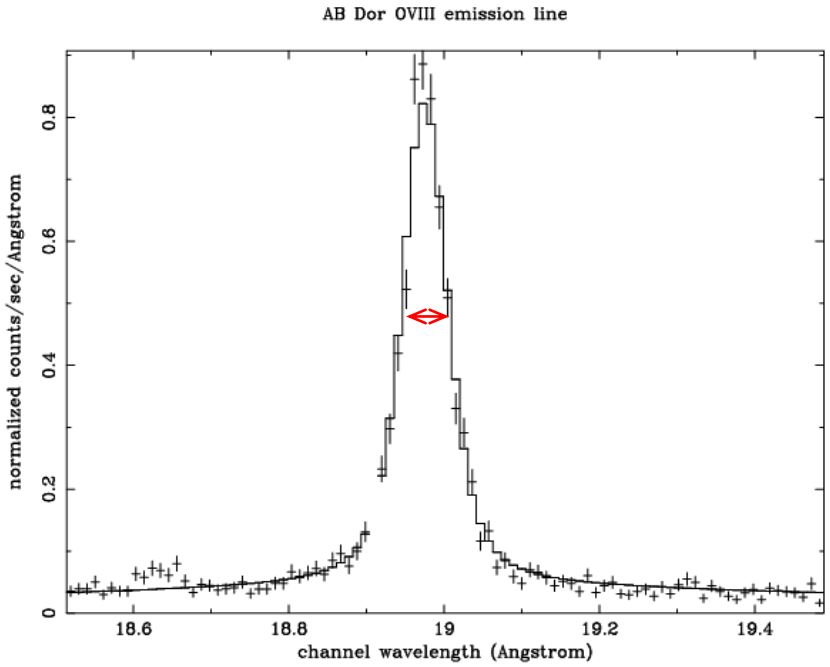
  - The line spread function and the wavelength scale
  - The effective area

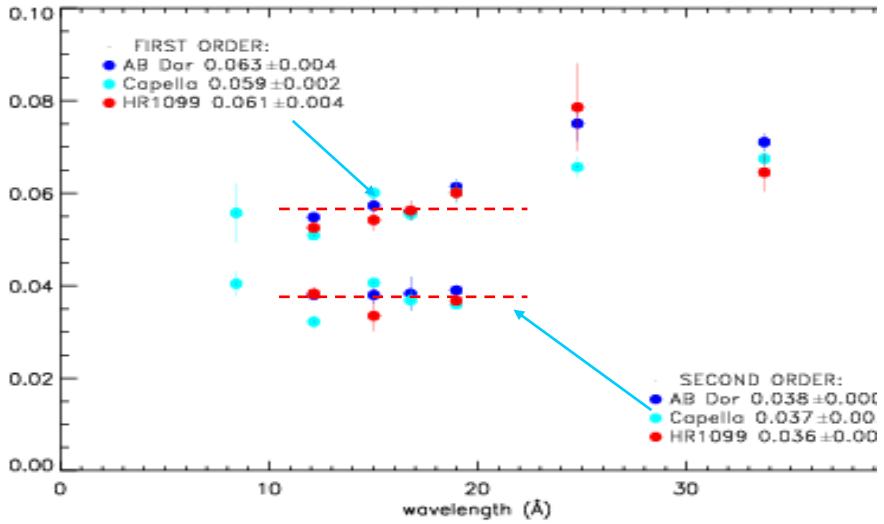
The Line-Spread Function

Response to monochromatic radiation



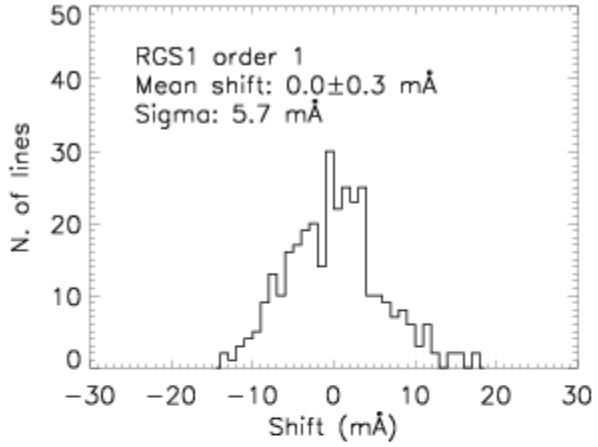
The Observed LSF and the Resolving Power

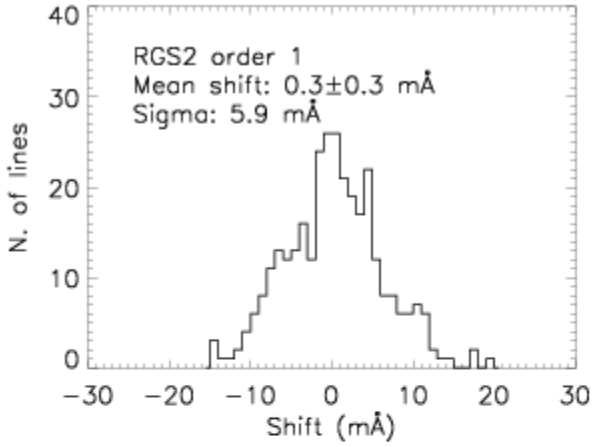


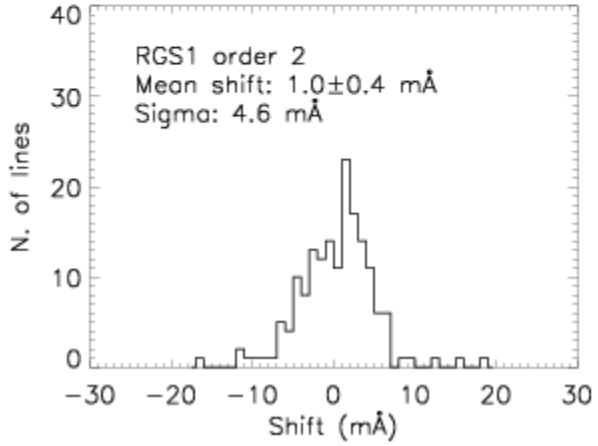


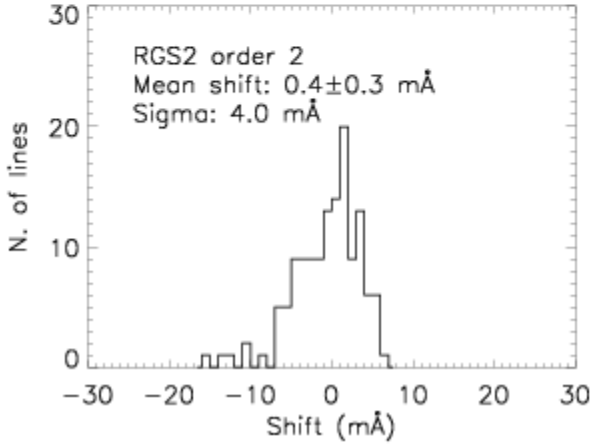
The Wavelength Scale

Corrections for Solar Angle dependence and Heliocentric velocity





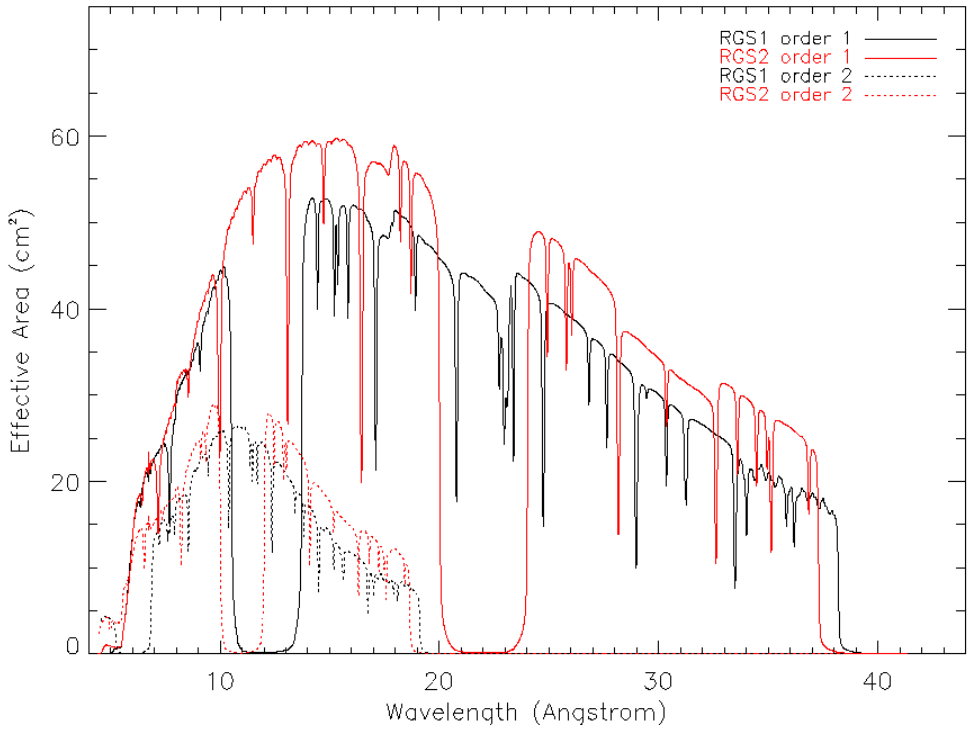




The Effective Area

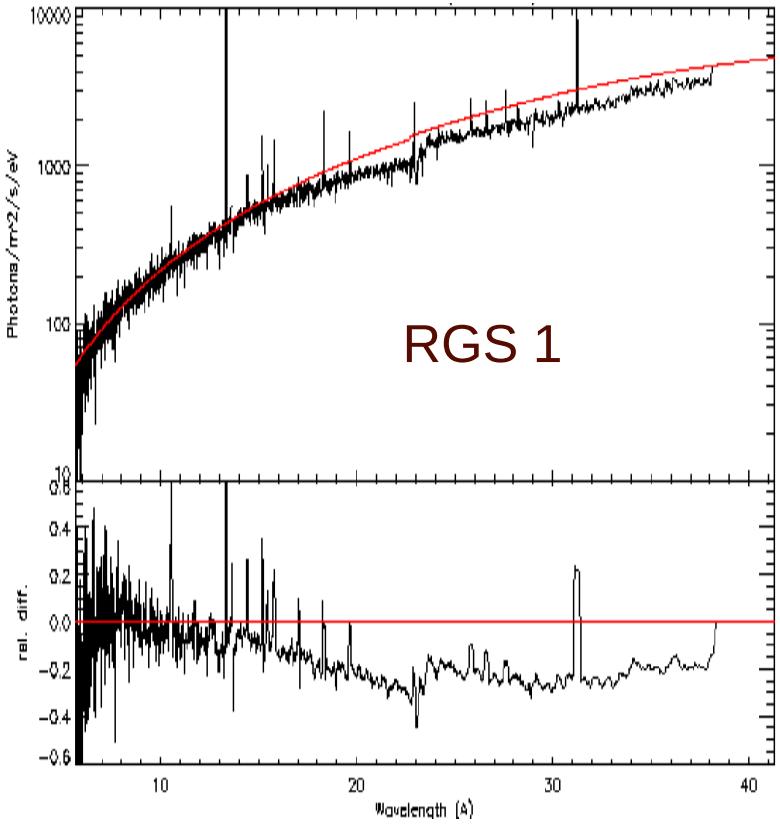
- Pre-launch and in flight measurements

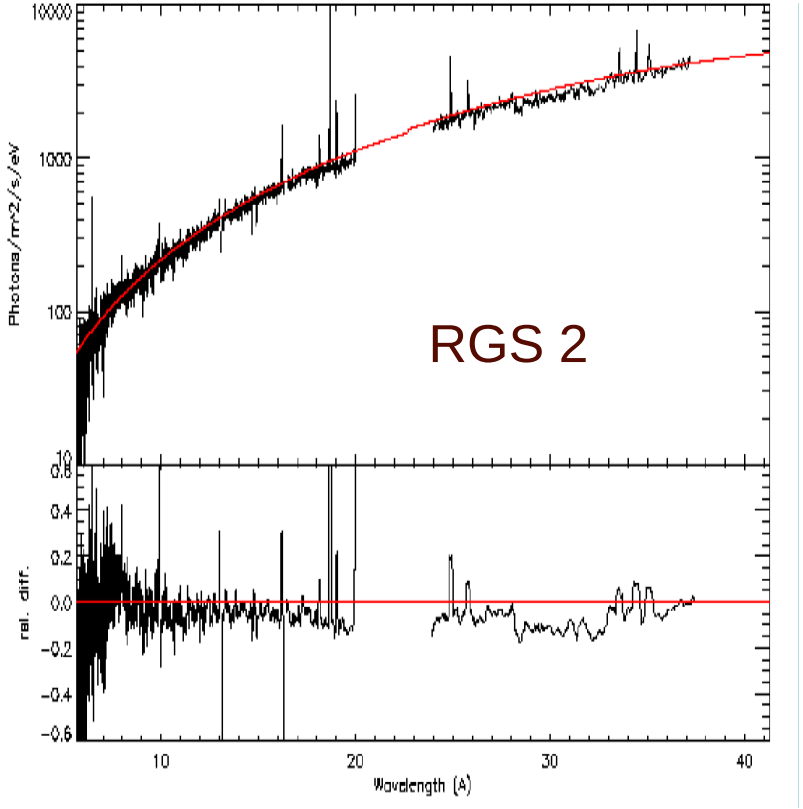
- Empirical corrections:
  - Beta dependent correction for RGS1
  - High orders correction
  - Time correction
  - Instrumental edges



RGS1 - RGS2 Comparison

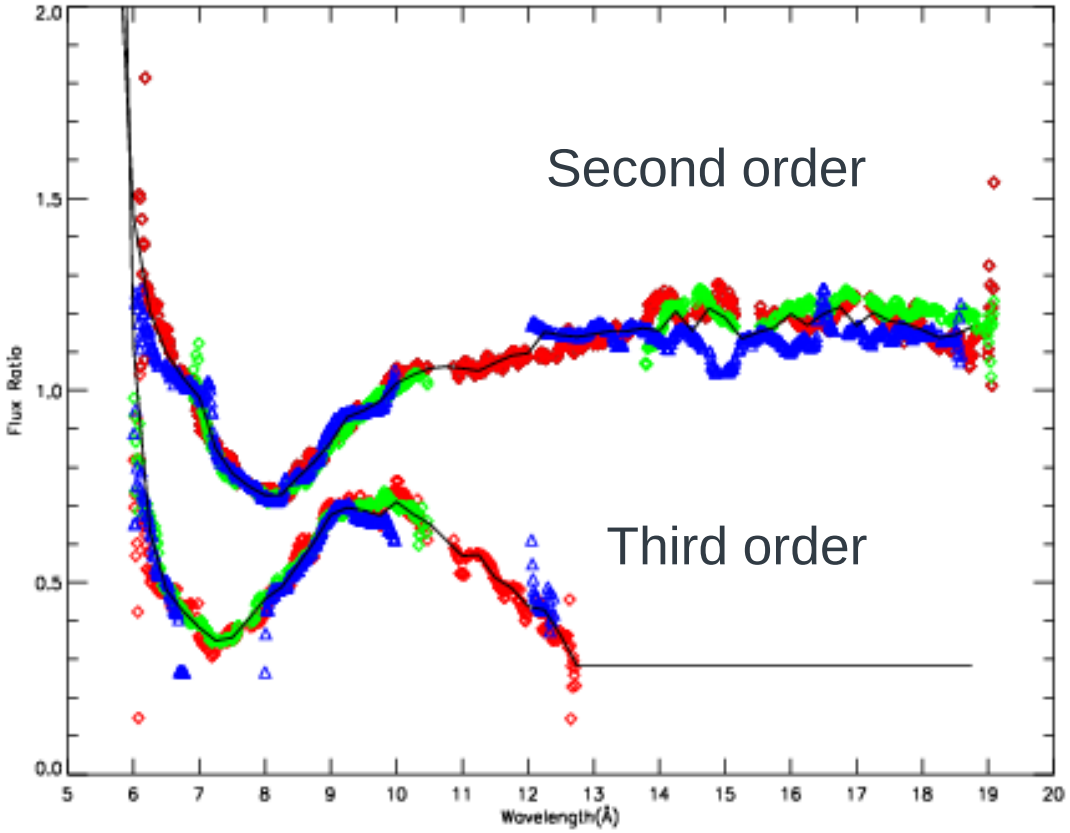
Systematic differences between instruments





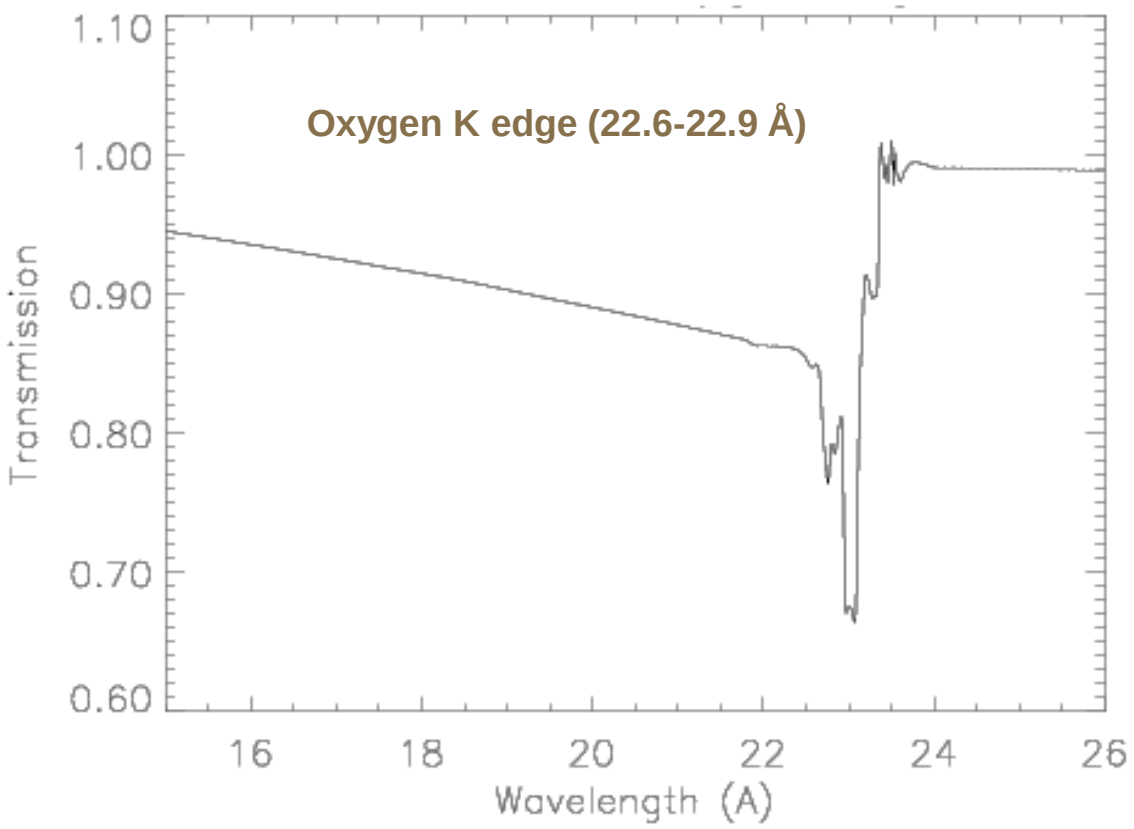
Order to Order Correction

Systematic differences between orders



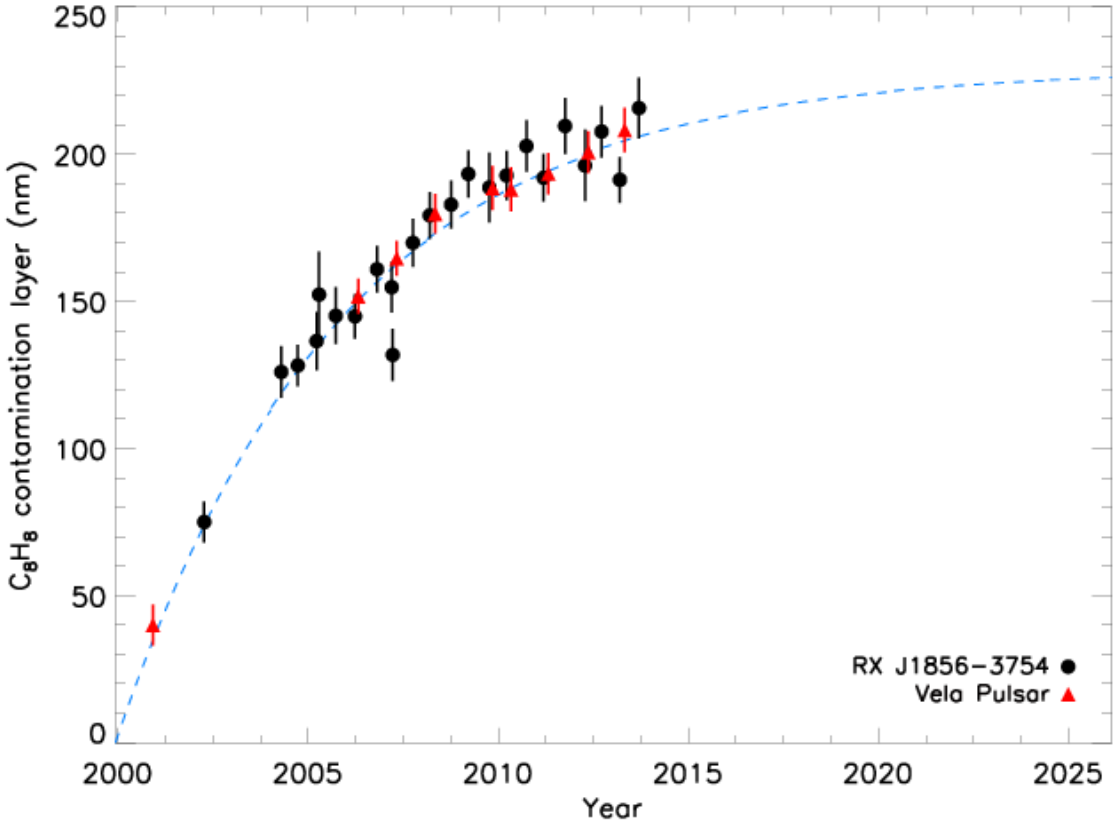
The Instrumental Oxygen Edge

Additional Oxygen layer on the detectors



The Contamination

Increasing Carbon contamination



RGS SAS and the CCF components

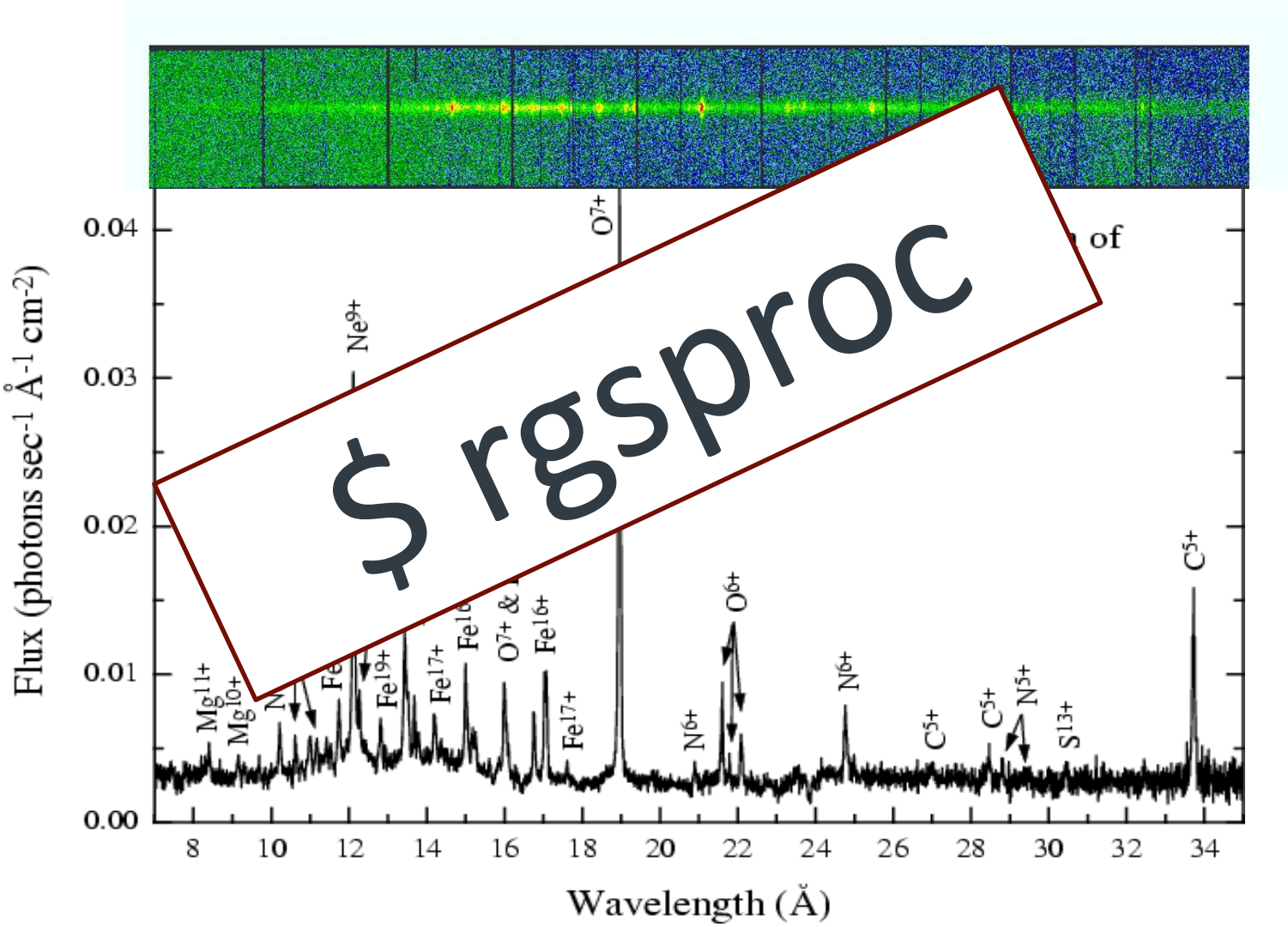
Current Calibration Files

BORESIGHT
MISCDATA
ADUCONV
BACKGROUND
BADPIX
CALSOURCEDATA
CLOCKPATTERNS
COOLPIX
CROSSPSF
CTI
DARKFRAME
EFFAREACORR
EXAFS
HKPARMINT
LINCOORD
LINESPREADFUNC
MODEPARAM
QUANTUMEF
REDIST
SAACORR
TEMPLATEBCKGND

SAS (rgsproc) tasks

atthkgen
attfilter
hkgtigen
rgsoffsetcalc
rgssources
rgsframes
rgsenergy
rgsbadpix
rgsevents
evlistcomb
rgsangles
rgsfilter
rgsregions
rgsspectrum
rgsbkgmodel
rgsrmfgen
rgsfluxer
rgslccorr

What's next ?


$ rgsproc
Flux (photons sec^{-1} Å^{-1} cm^{-2})
Wavelength (Å)
0.00
0.01
0.02
0.03
0.04
8
10
12
14
16
18
20
22
24
26
28
30
32
34
O^{7+}
Ne^{9+}
Mg^{11+}
Mg^{10+}
Fe^{19+}
Fe^{17+}
O^{7+} &
Fe^{16+}
Fe^{17+}
N^{6+}
O^{6+}
N^{6+}
C^{5+}
C^{5+}
N^{5+}
S^{13+}
C^{5+}