13th ESAC SAS Workshop
10th – 14th June 2013

The Reflection Grating Spectrometers

Based on presentations given by A. Pollock
with inputs from the RGS team

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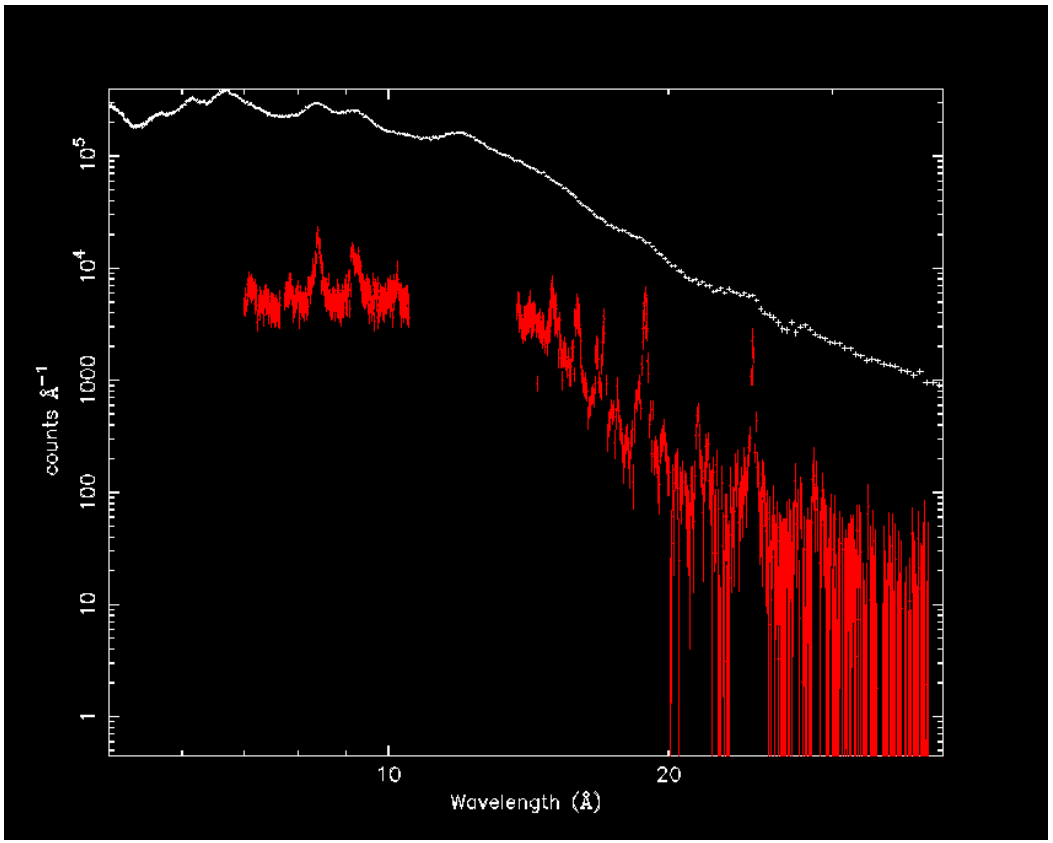
XMM-Newton SOC
ESAC

The Reflection Grating Spectrometers



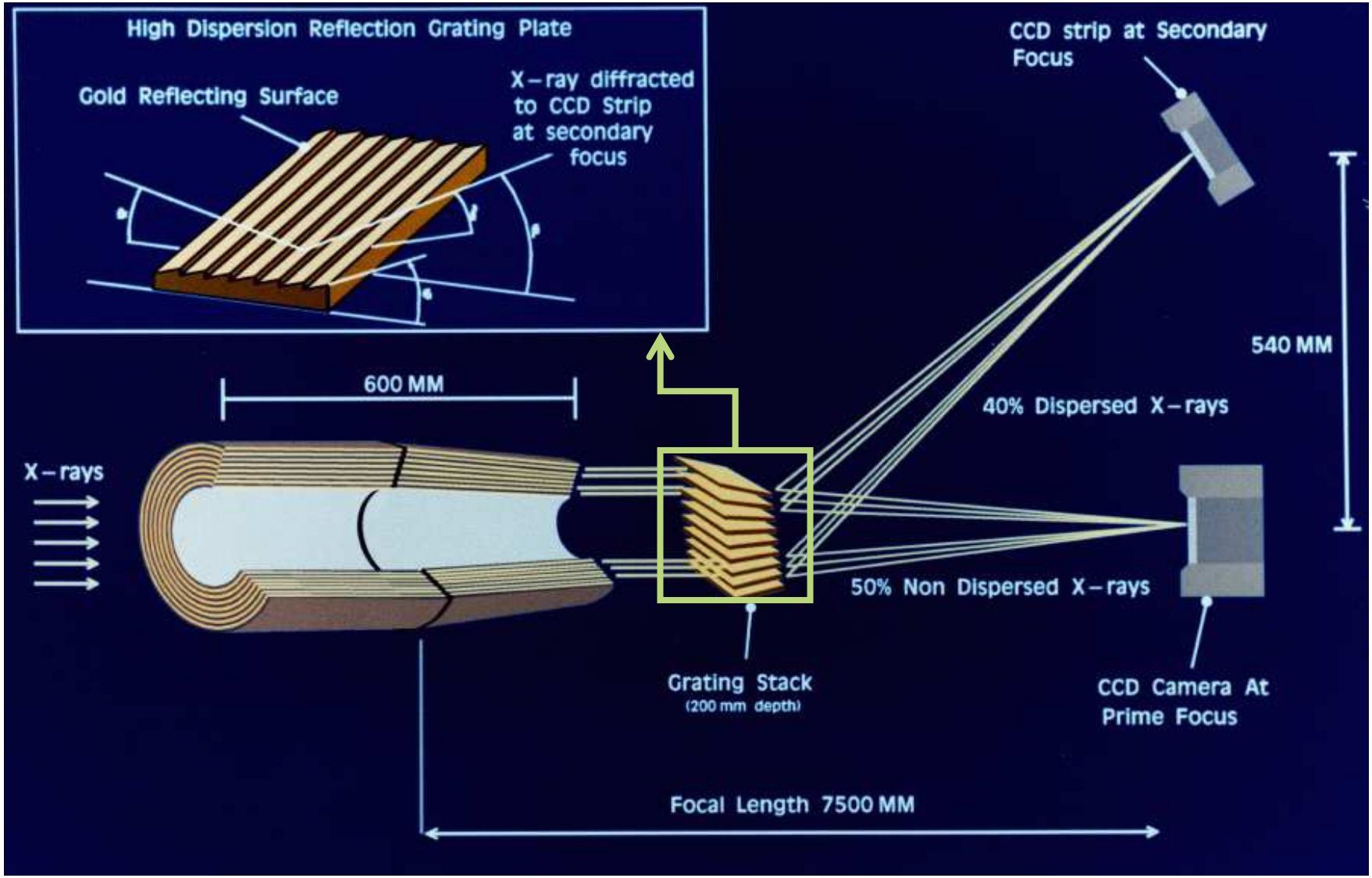
resolution @ 1 keV:

EPIC-pn	10
EPIC-MOS	14

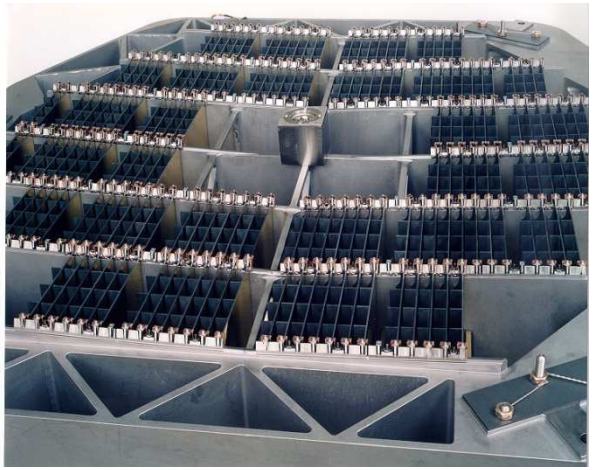
High resolution spectroscopy !

RGS	200 1st order
	400 2nd order

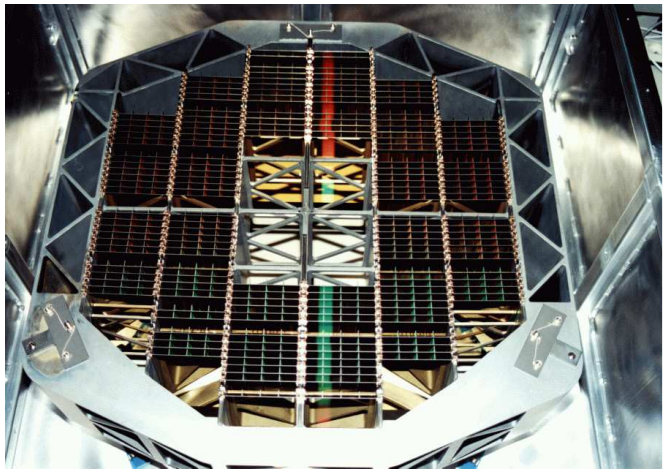
The RGS instrument

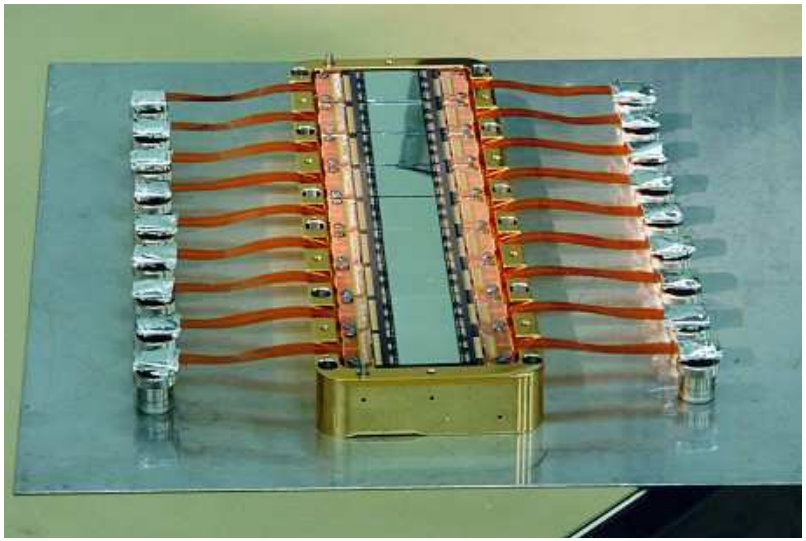


Some views of RGS...



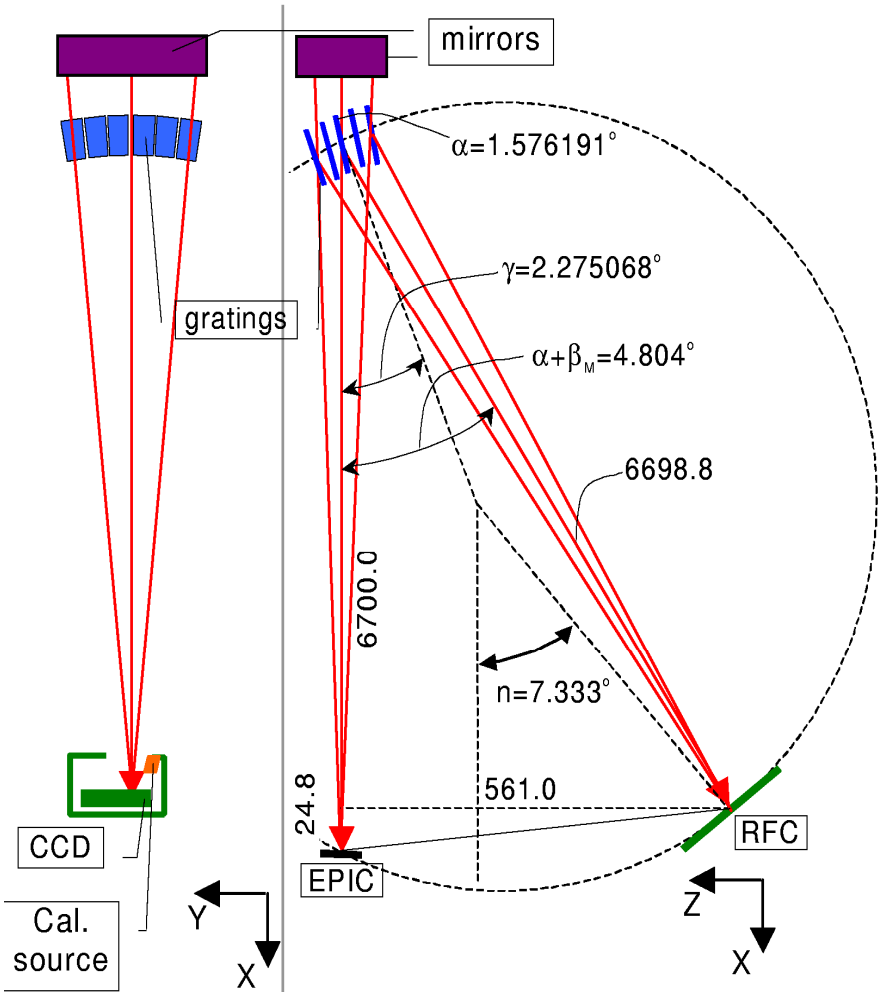
The 182 Gratings

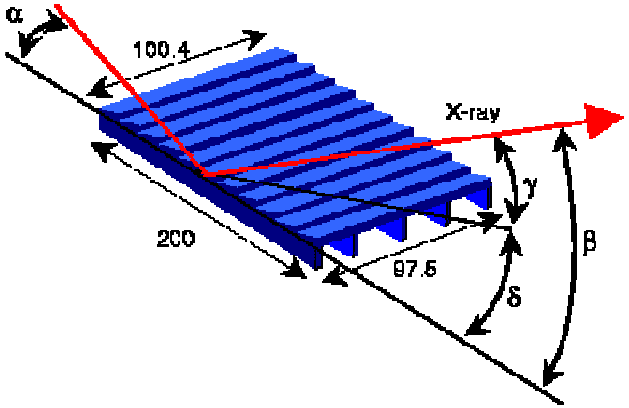




The 9 CCDs

RGS Optical Design

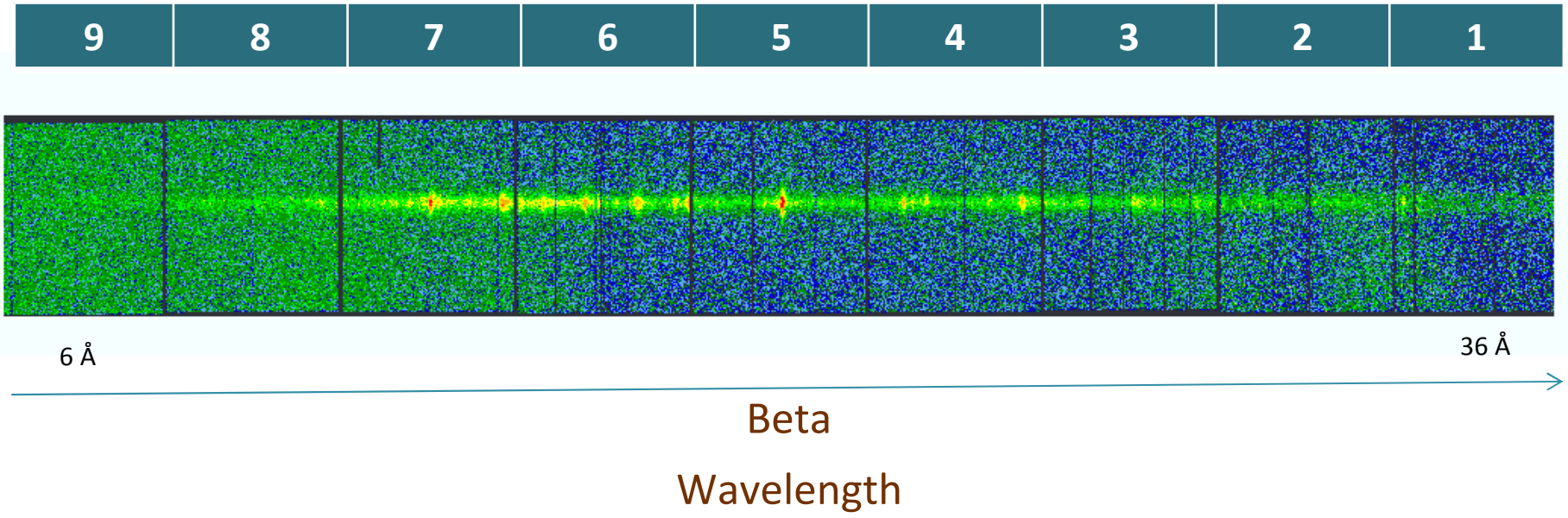




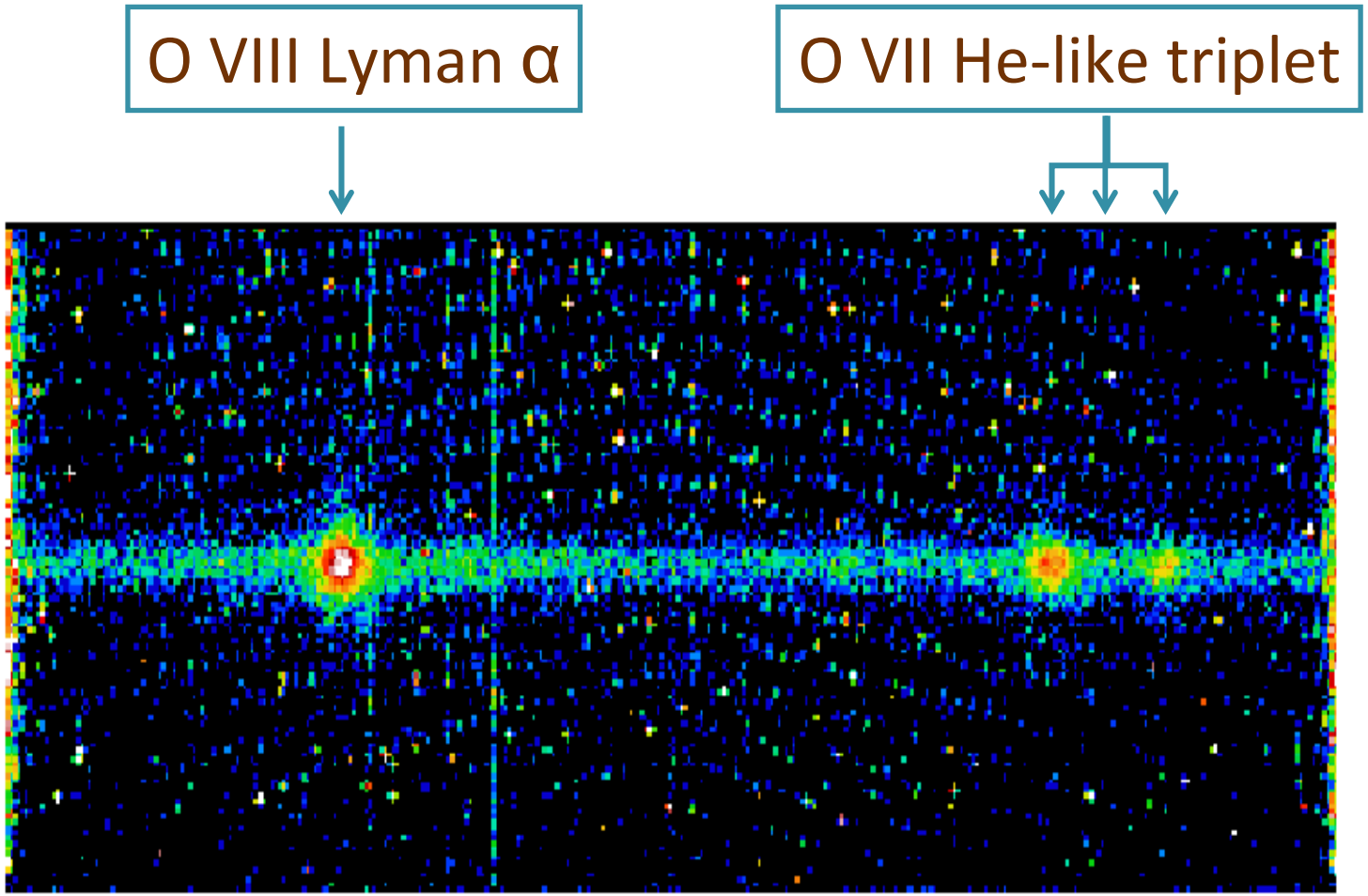
$$\cos\beta = \cos\alpha + m\,\lambda / d$$

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

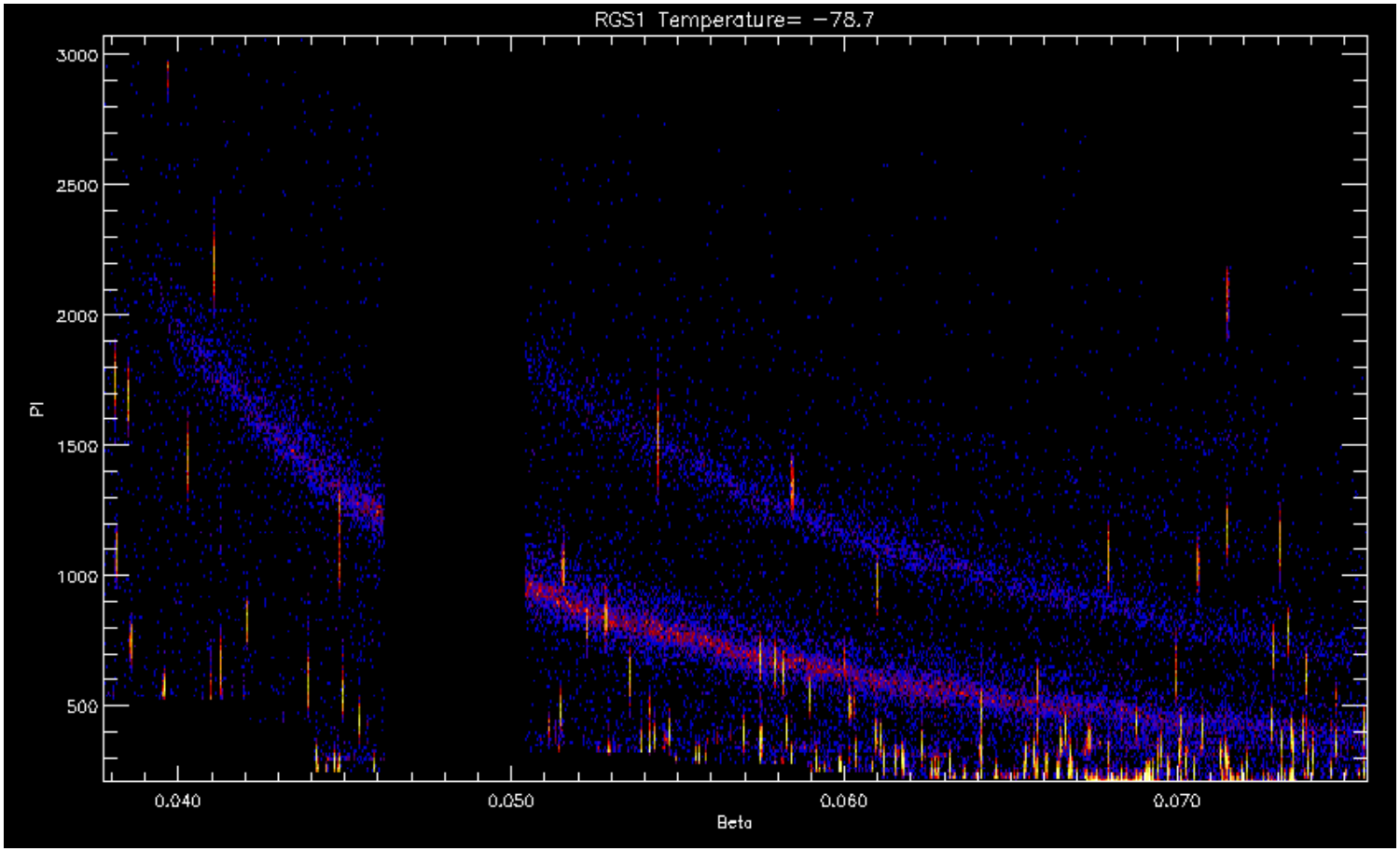
The RGS CCDs



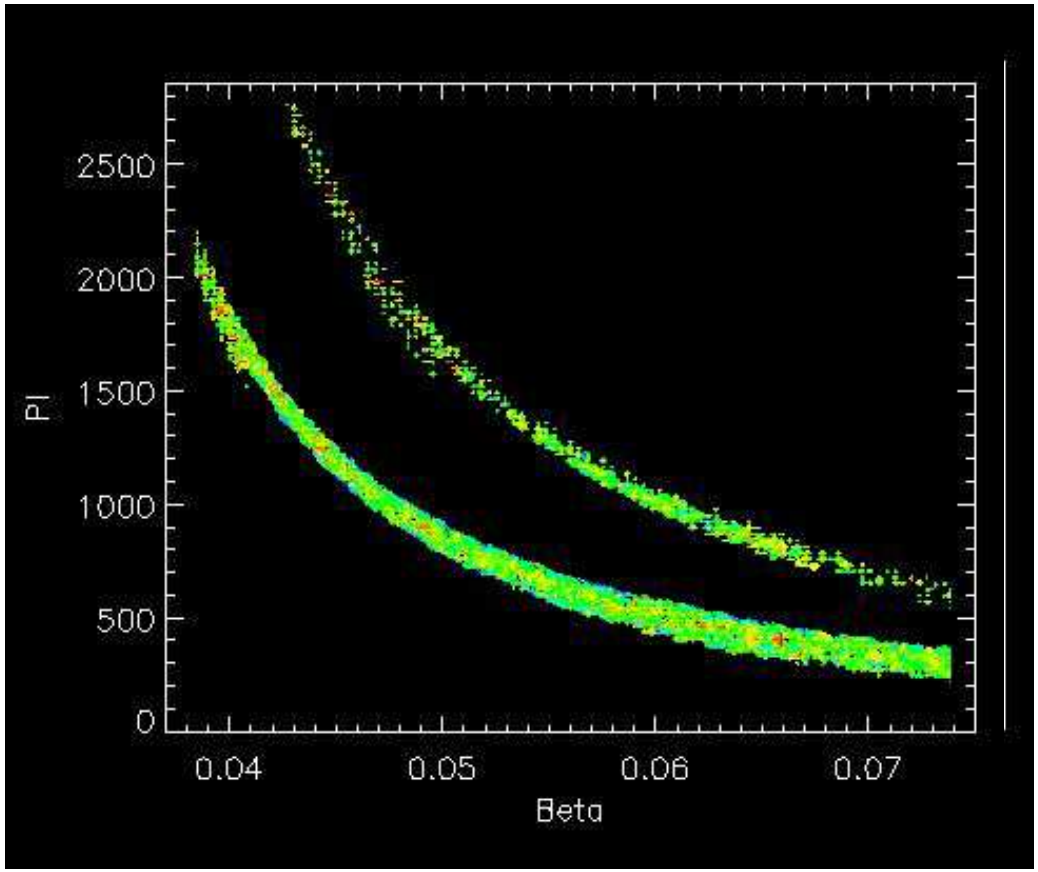
One of the RGS CCDs



RGS Cooling in November 2002



RGS 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

RGS performance

	RGS 1 1st order	RGS 2 1st order	RGS 1 2nd order	RGS 2 2nd order
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 range	5 – 38 Å		5 - 20 Å	
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 (SW, 8 CCDs)	1.2 s	2.4 s	1.2 s	2.4 s

Pile-up in RGS

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 s ~ 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 acute in RGS2, due to the longer readout time.

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
- a combination of these

The Instrumental Response

- Mirror
- Grating
- CCD

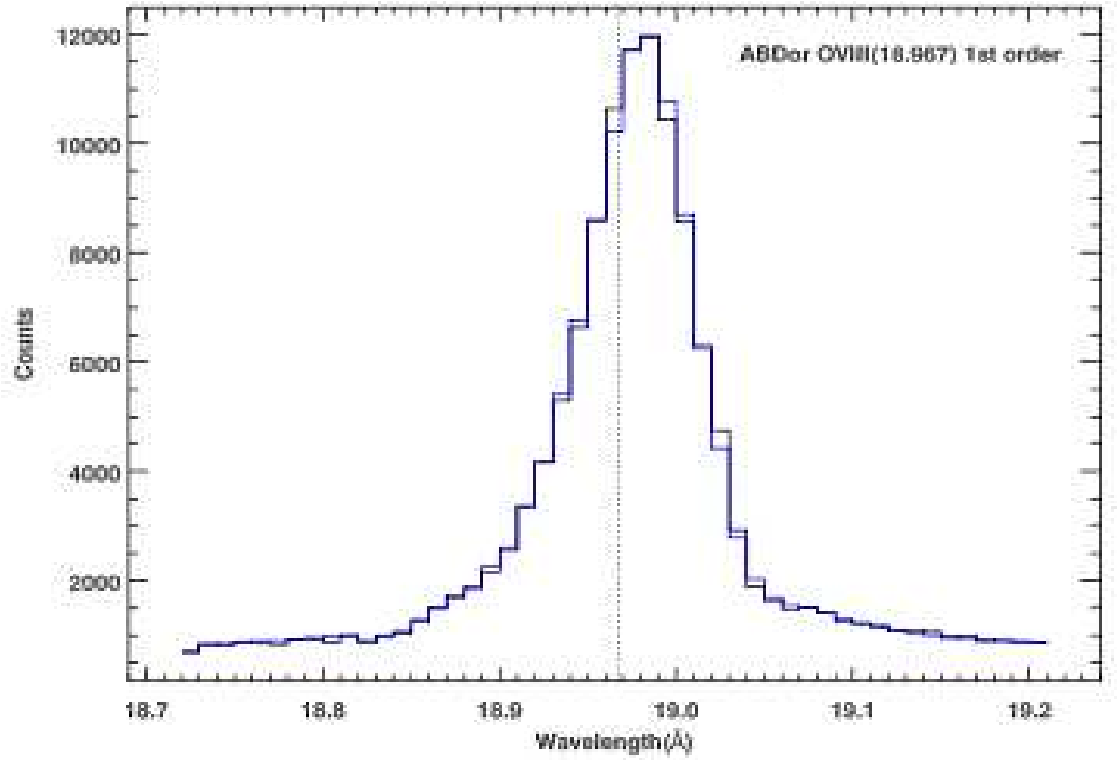
} pre launch

- + empirical corrections ⇦ in flight

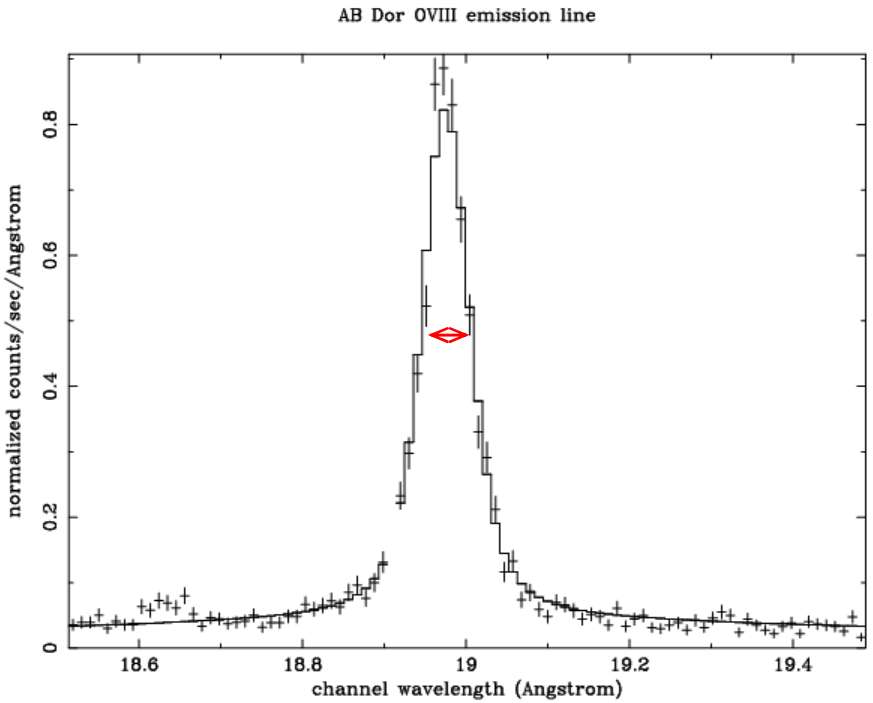
  - The line spread function and the wavelength scale
  - The effective area

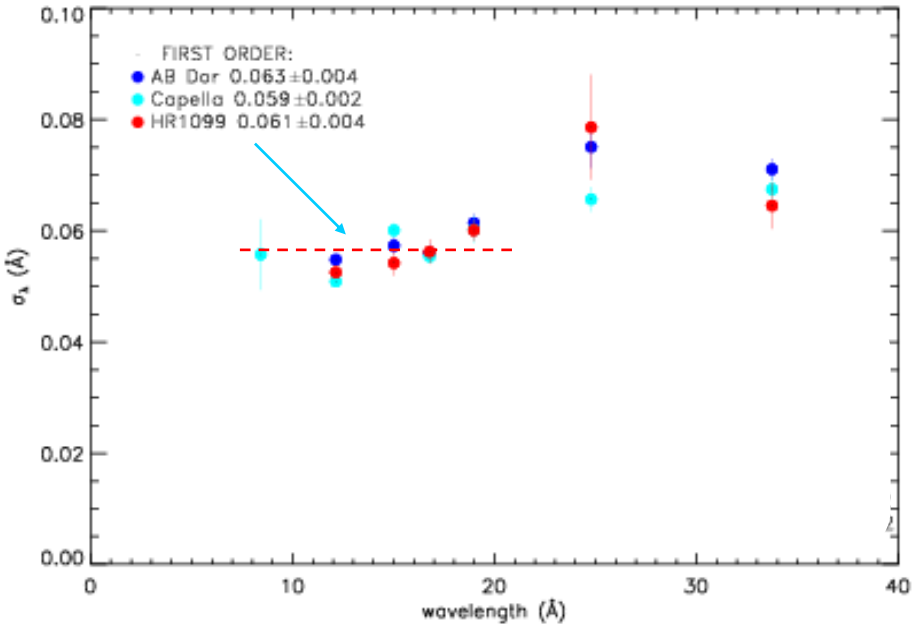
RGS line-spread function components

Response to monochromatic radiation



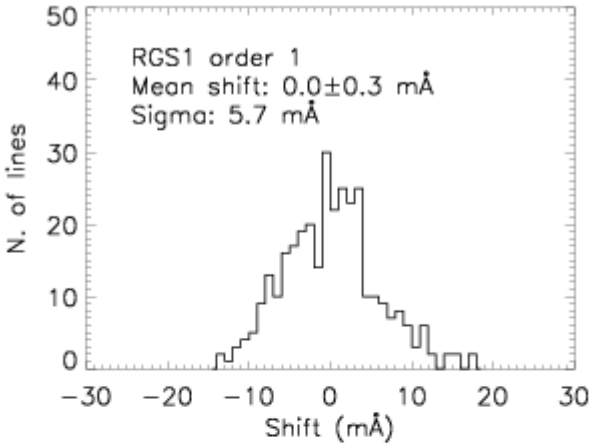
RGS observed LSF and resolving power

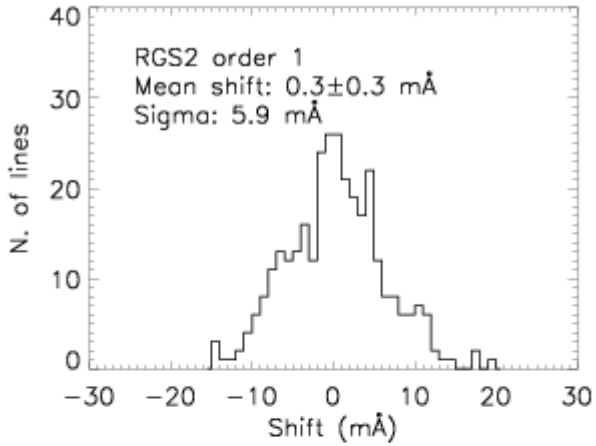


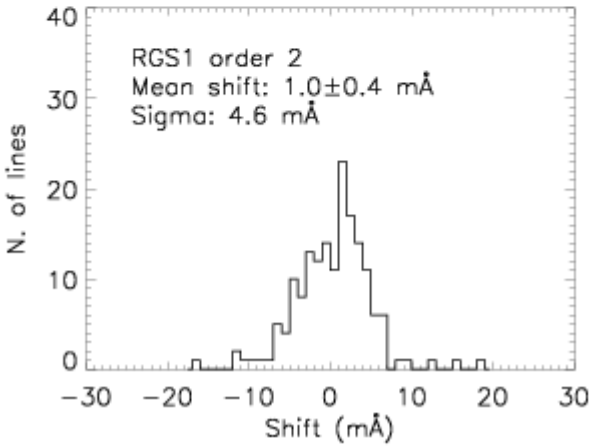


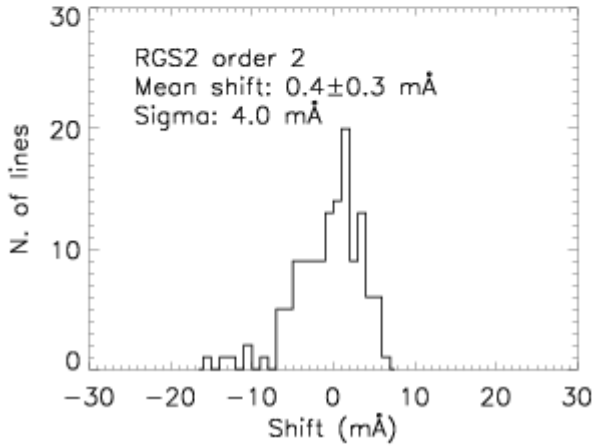
RGS wavelength scale (σ~6 mÅ)

Corrections for Solar Angle dependence and Heliocentric velocity





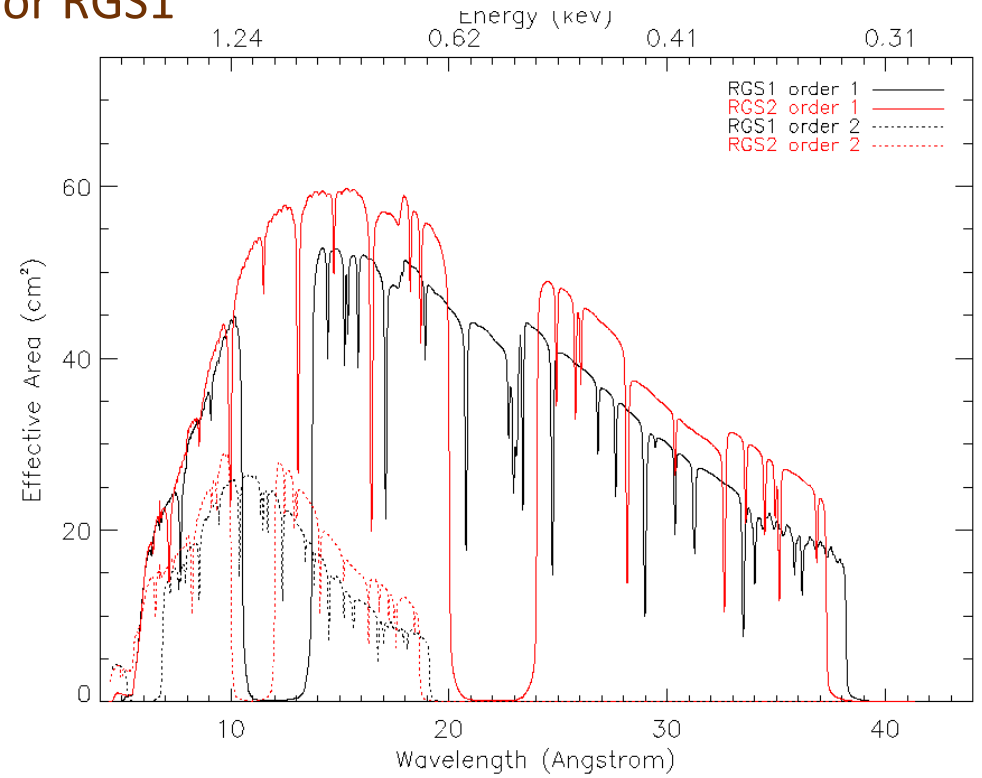




The Effective Area

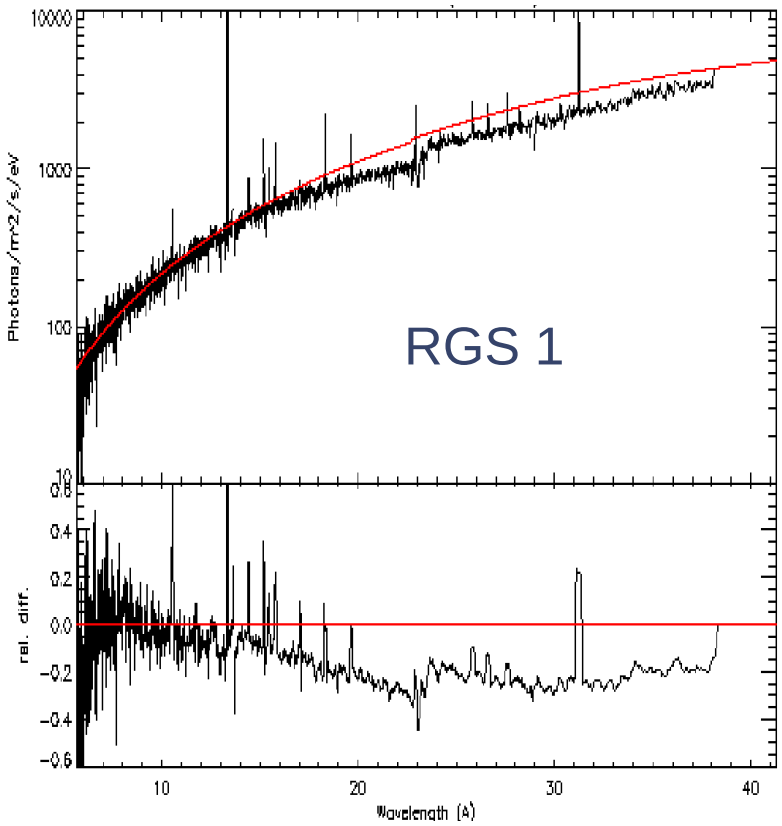
- Pre-launch and in flight measurements

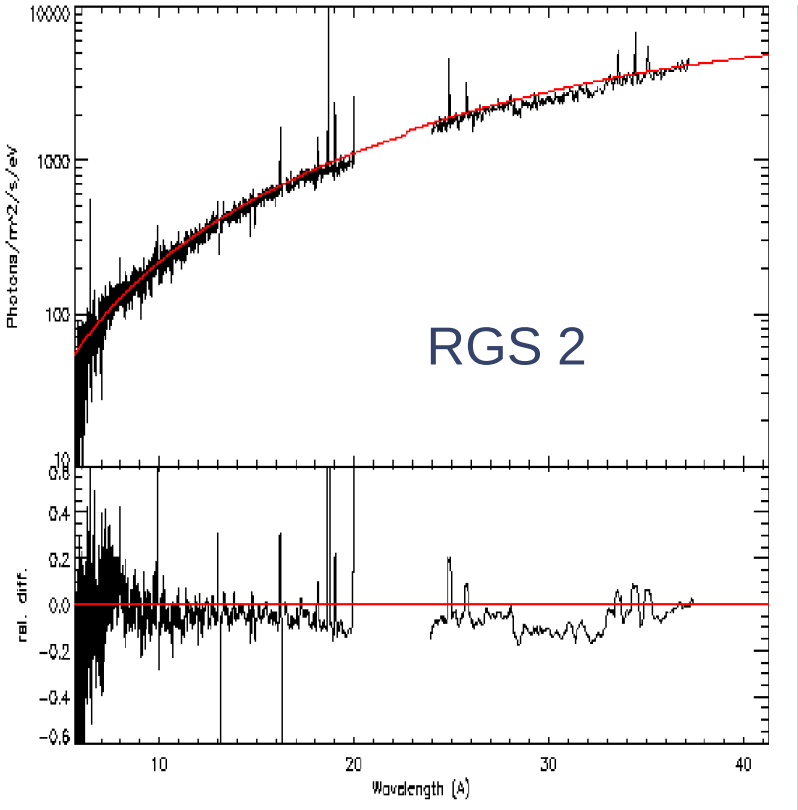
- Empirical corrections:
  - Beta dependent correction for RGS1
  - High orders correction
  - Time correction
  - Instrumental edges:
    - Al (8.3 Å)
    - Mg (9.5 Å)
    - F (18.3 Å)
    - Mg_2F (17.9 Å)
    - O (23.5 Å)



RGS1 - RGS2 broadband comparison

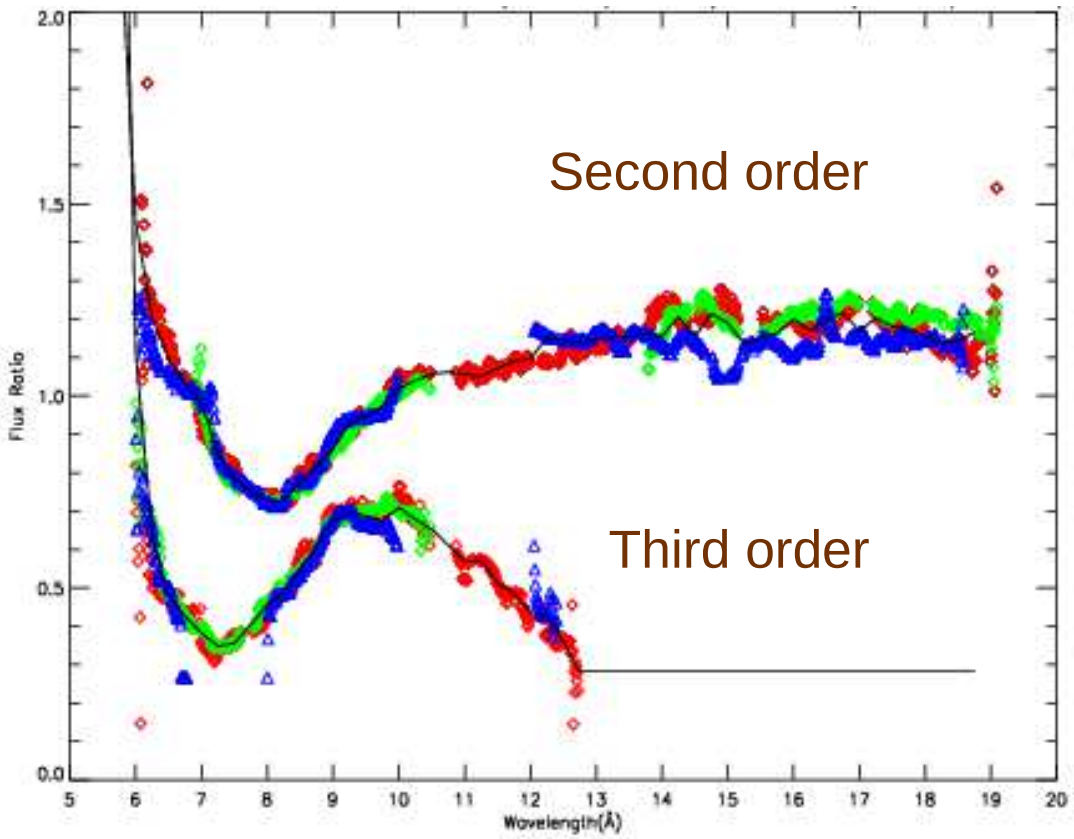
Systematic differences between instruments





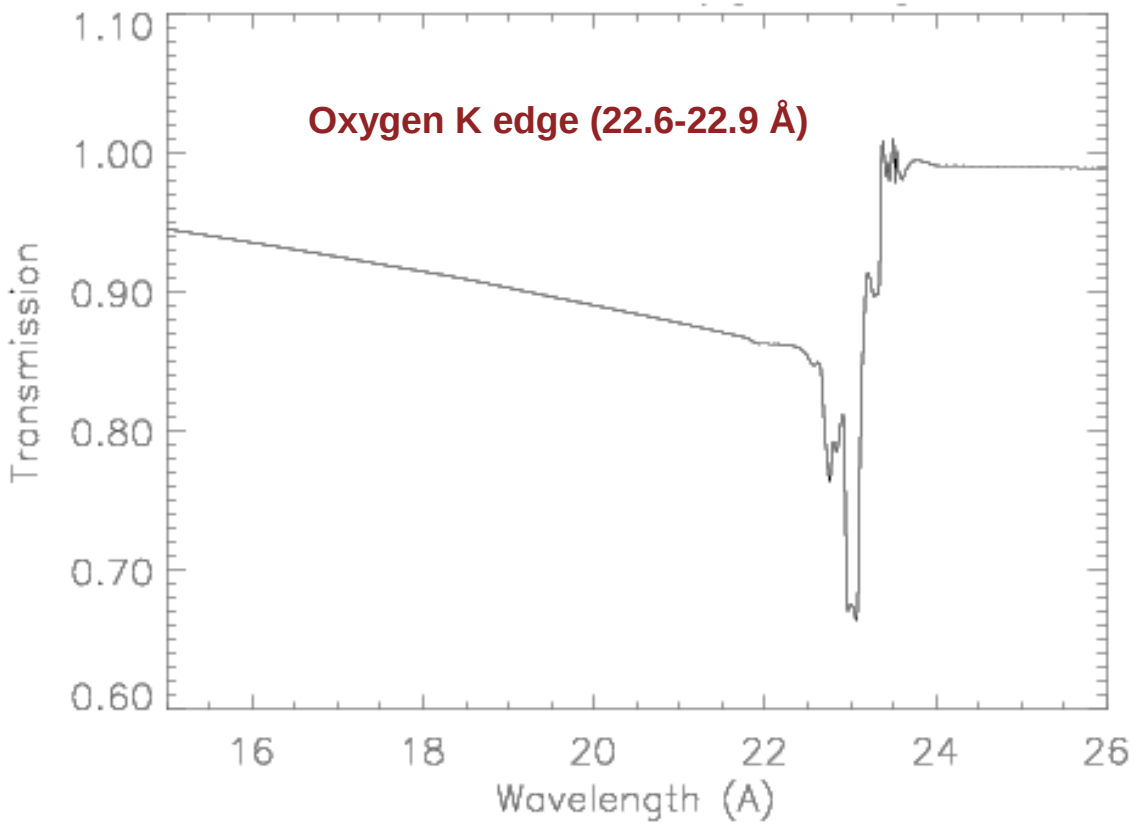
RGS order-to-order correction

Systematic differences between orders



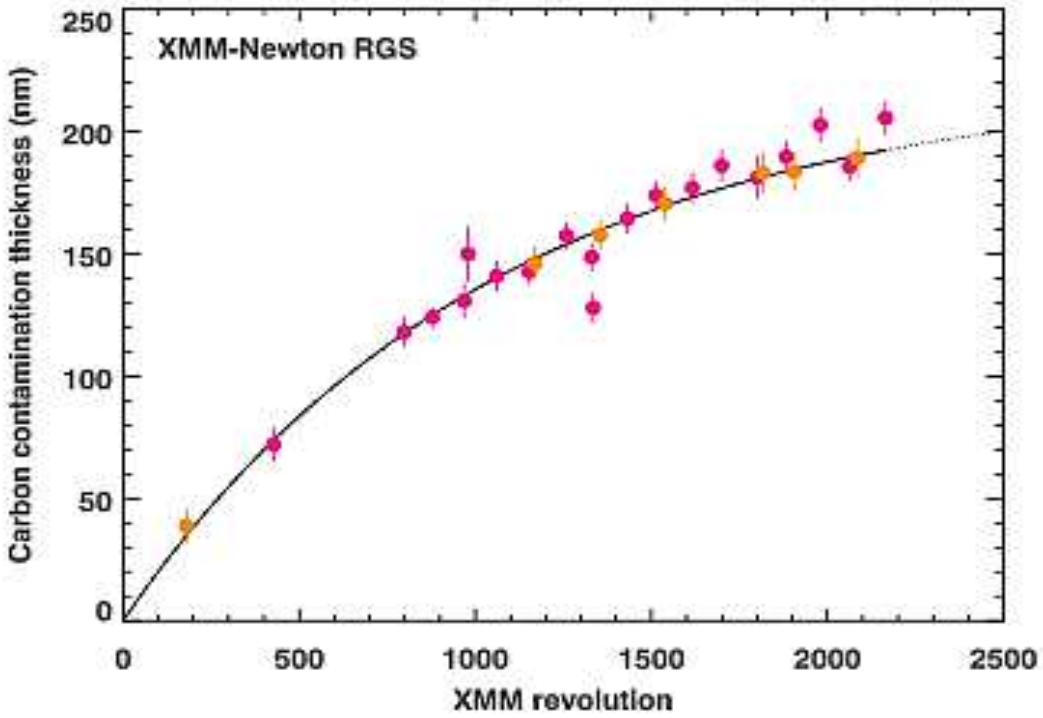
RGS instrumental Oxygen edge

Additional Oxygen layer on the detectors



RGS contamination

Increasing Carbon contamination



RGS SAS and the CCF components

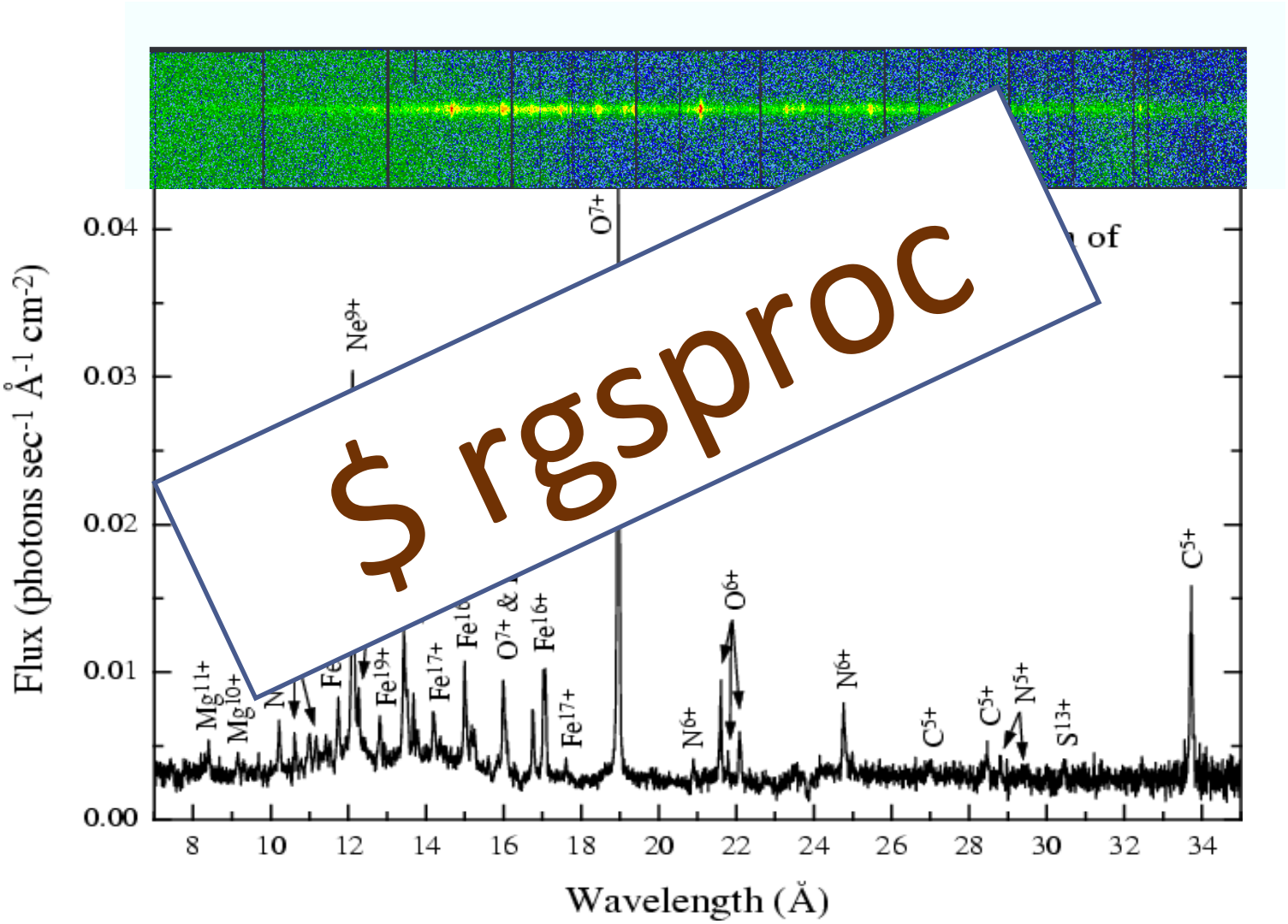
Current Calibration Files

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

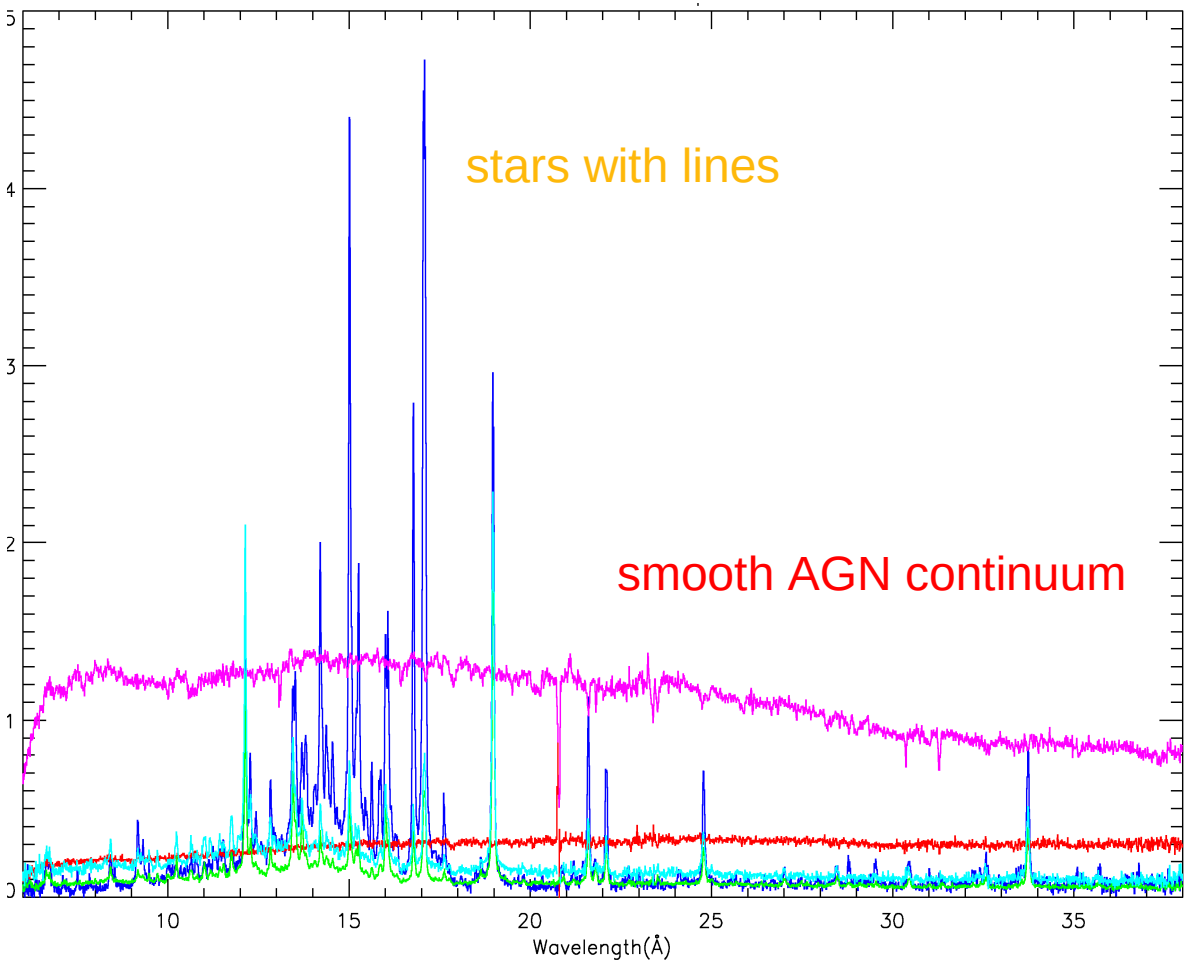
SAS (rgsproc) tasks

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

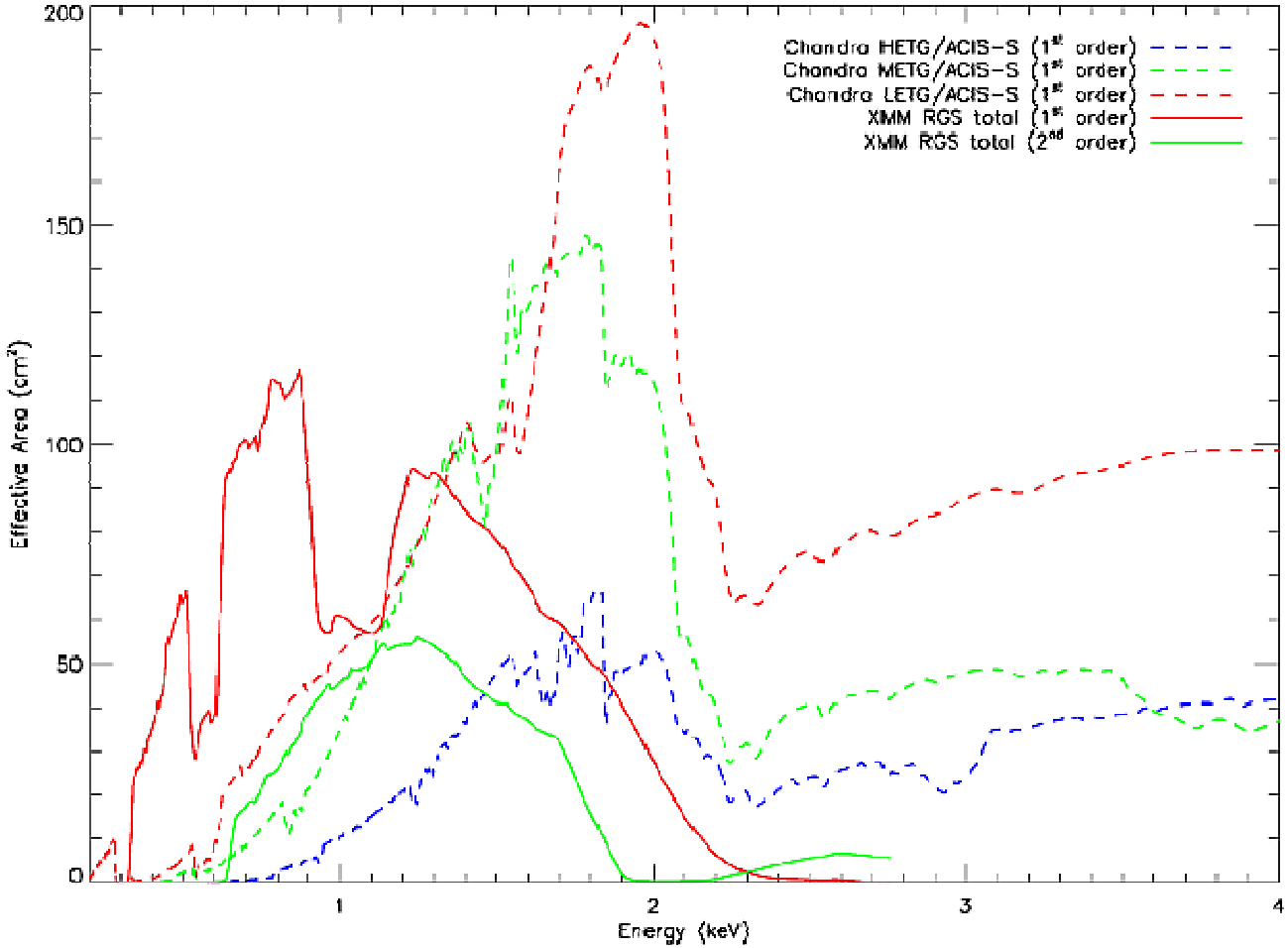
What's next ?


$ 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
O7+
Ne9+
Mg11+
Mg10+
Fe17+
Fe19+
Fe16+
O6+
N6+
C5+
N5+
S13+

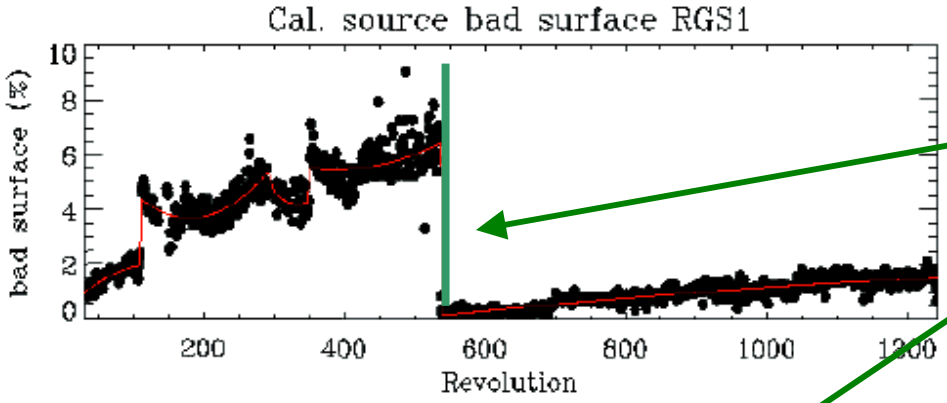
Some nice RGS spectra



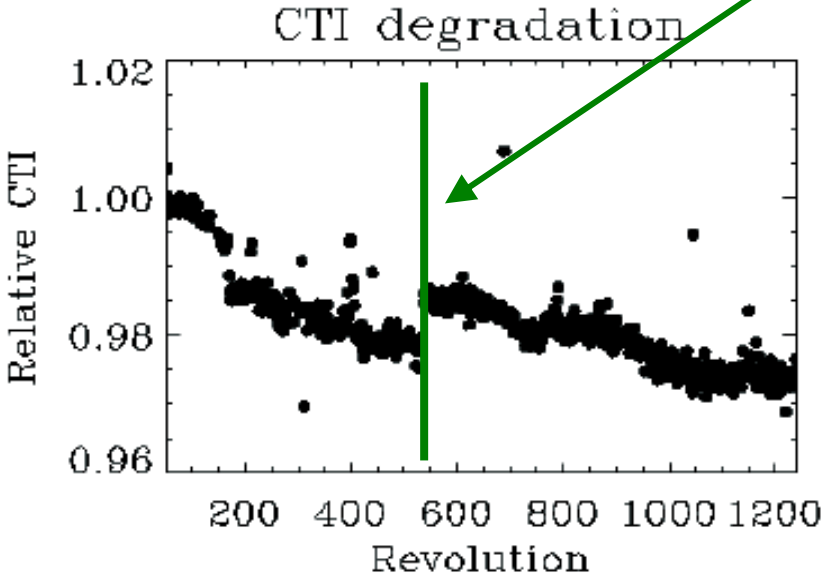
Comparison with Chandra gratings



Instrumental Trends



RGS cooling: Nov 2002
Operating temperature from -80ºC to -110ºC



Oxygen layer building up
somewhere in the optical path