

# 13th ESAC SAS Workshop

## 10<sup>th</sup> – 14<sup>th</sup> June 2013

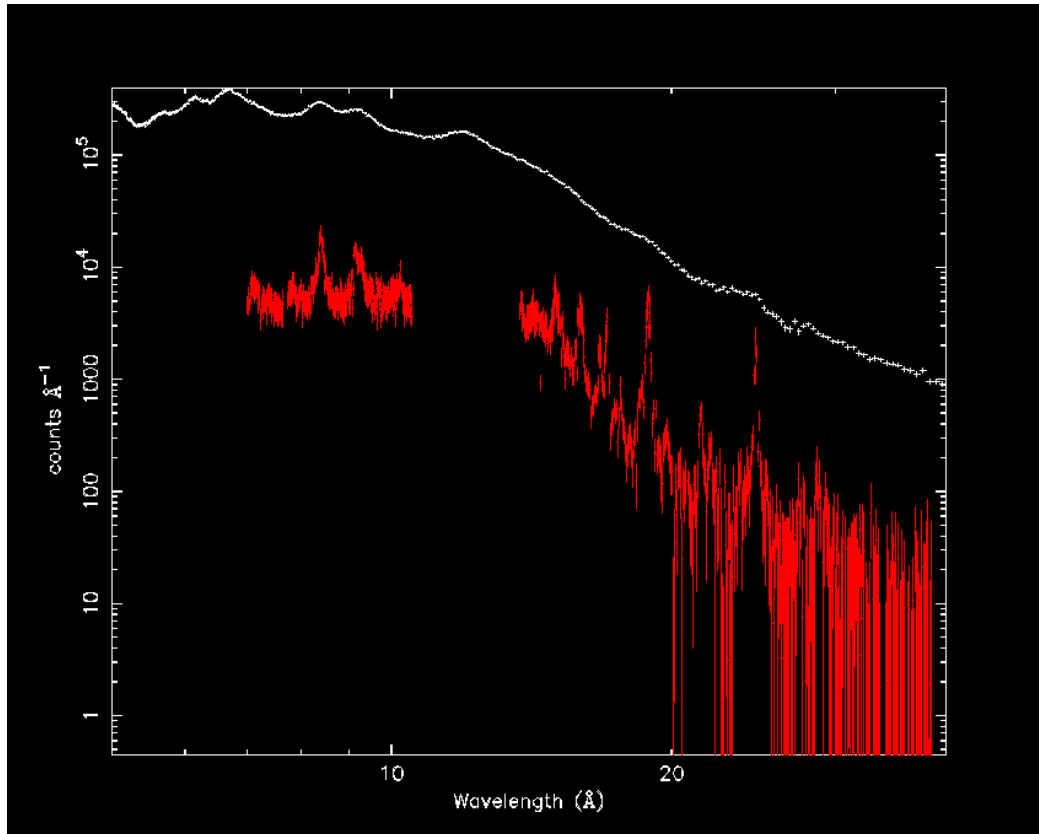
### The Reflection Grating Spectrometers

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

Rosario González-Riestra

XMM-Newton SOC  
ESAC

# The Reflection Grating Spectrometers



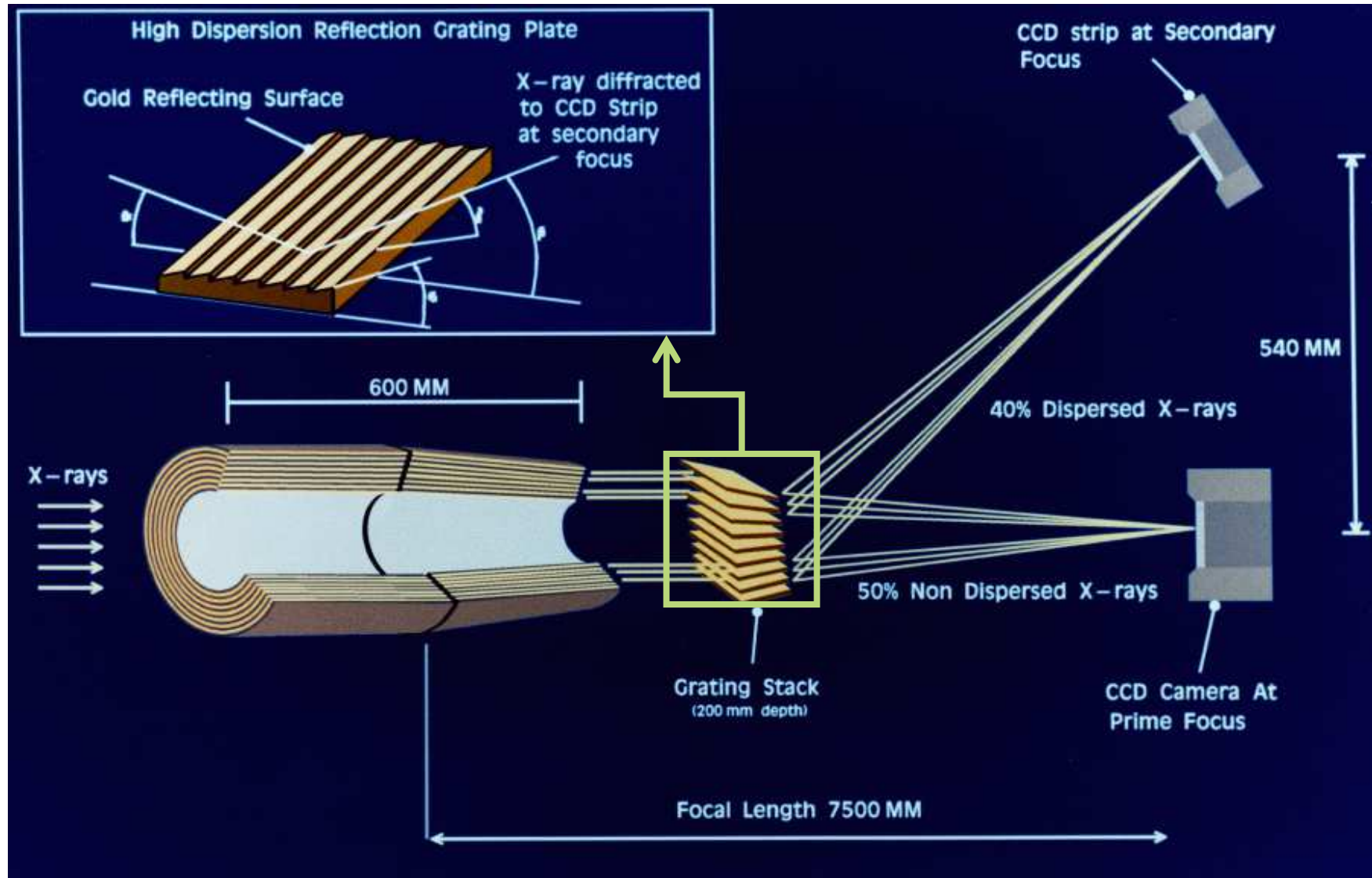
resolution @ 1 keV:

EPIC-pn	10
EPIC-MOS	14

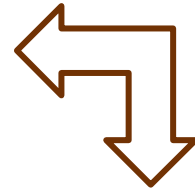
High resolution spectroscopy !

RGS	200 1 <sup>st</sup> order
	400 2 <sup>nd</sup> order

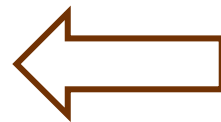
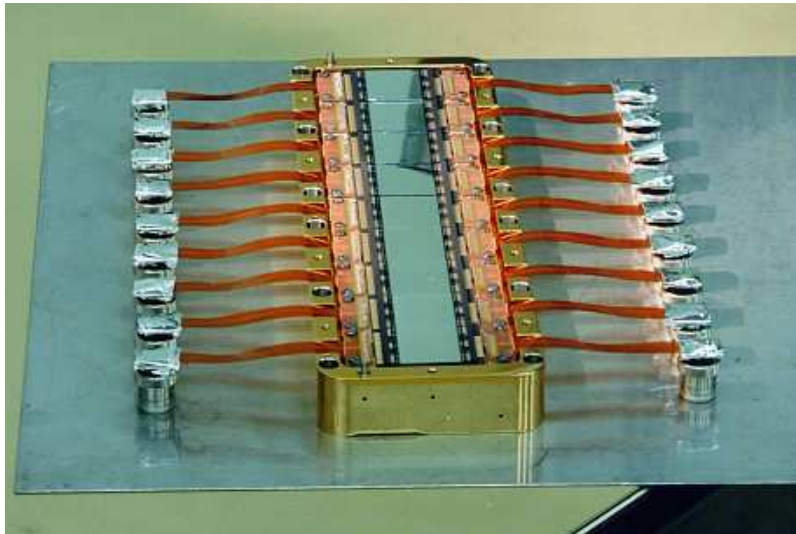
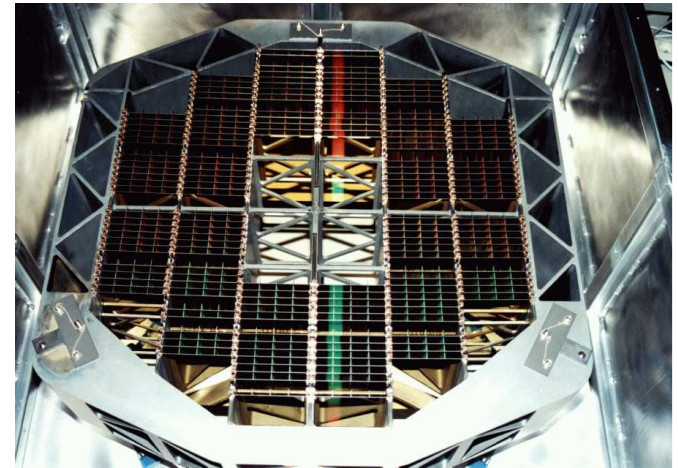
# The RGS instrument



## Some views of RGS...

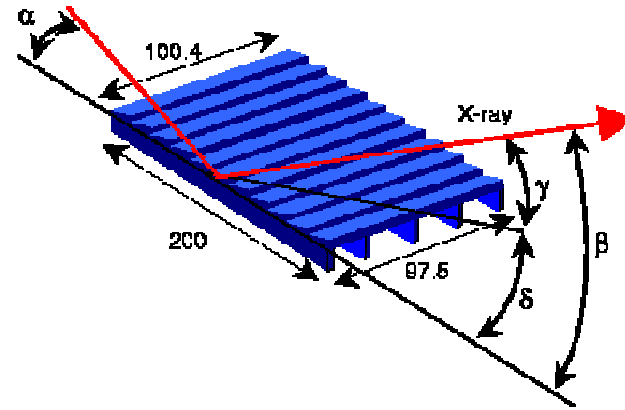
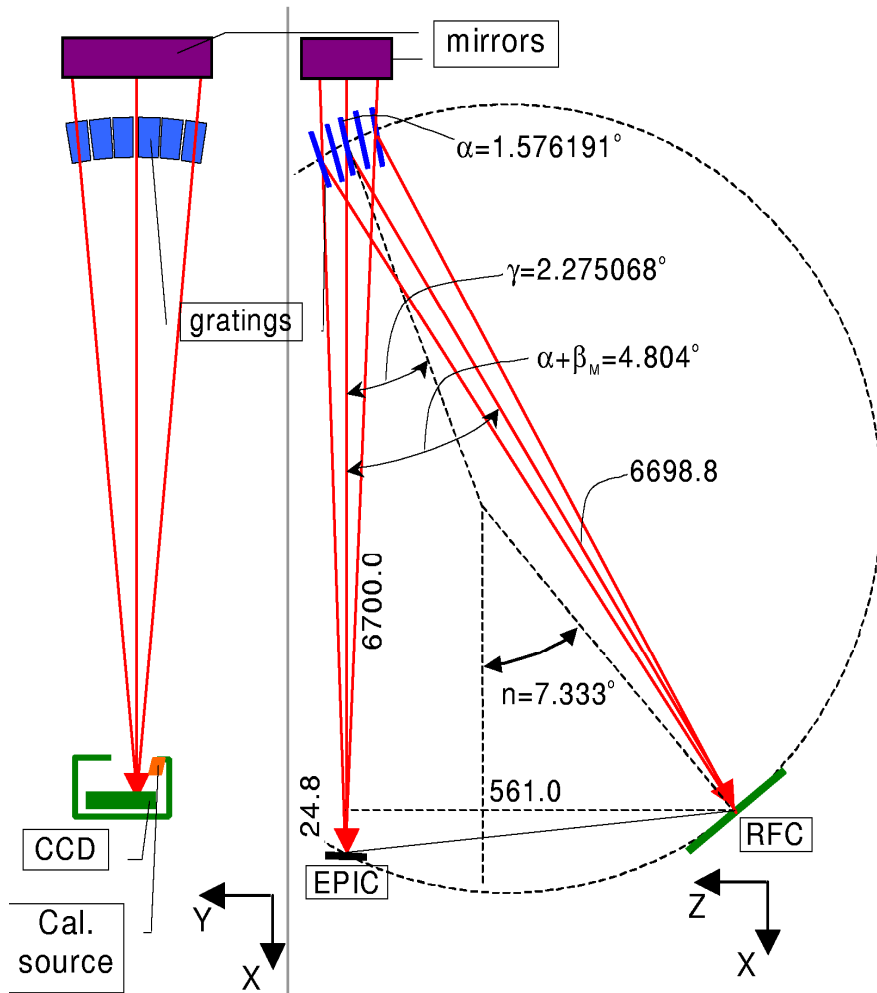


The 182 Gratings



The 9 CCDs

# RGS Optical Design

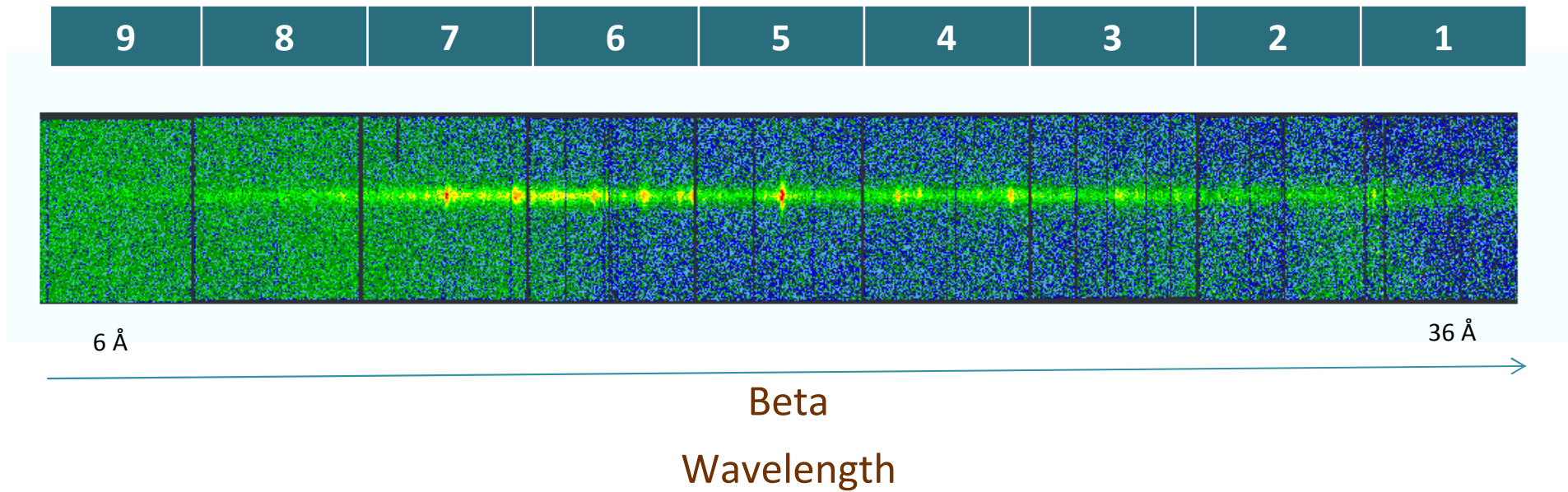


$$\cos \beta = \cos \alpha + m \lambda / d$$



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

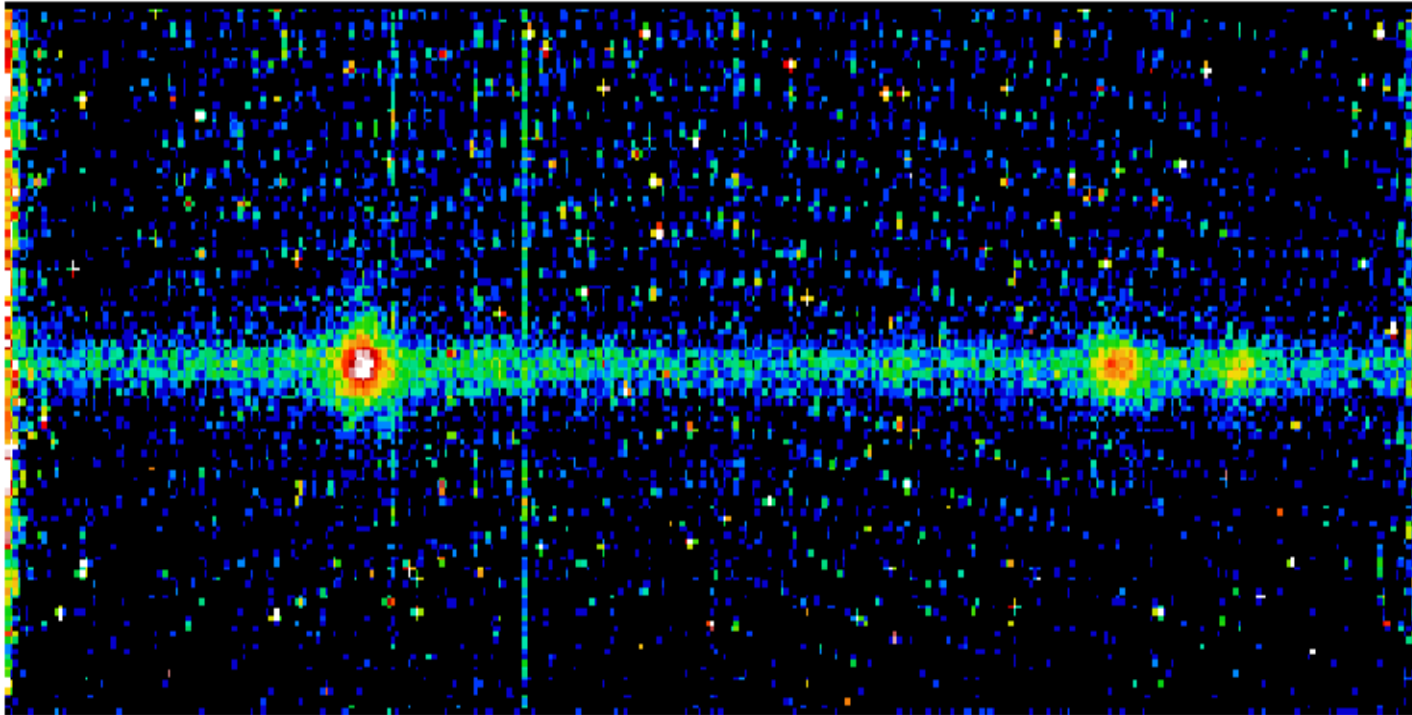
# The RGS CCDs



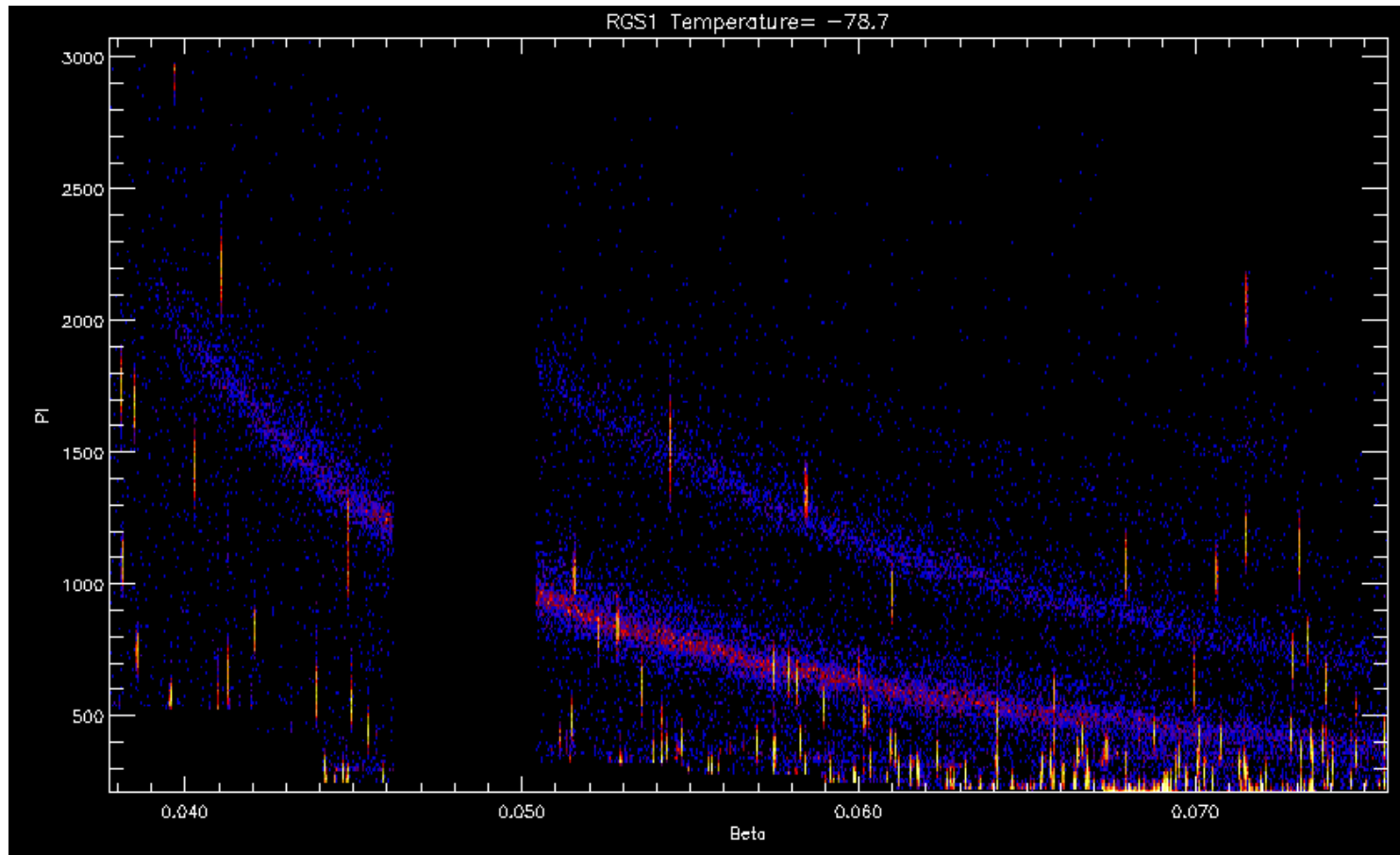
# One of the RGS CCDs

O VIII Lyman  $\alpha$

O VII He-like triplet

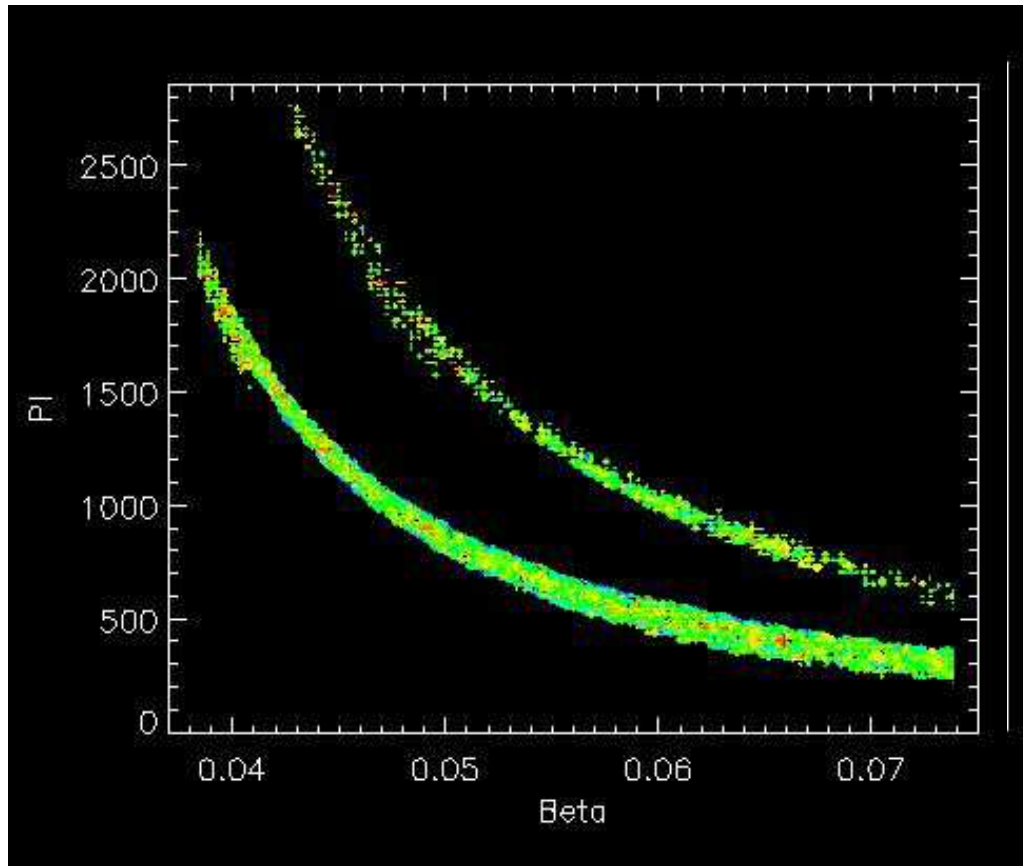


# RGS Cooling in November 2002





# RGS modes



Two modes:

- Spectroscopy (+ Q)
- Small Window  
(for very bright objects,  
reading only  $\frac{1}{4}$  of the FOV)

For each event:

- Time
- Position on the detector
- Energy

# RGS performance

	RGS 1 1 <sup>st</sup> order	RGS 2 1 <sup>st</sup> order	RGS 1 2 <sup>nd</sup> order	RGS 2 2 <sup>nd</sup> order
Effective area @15 Å (cm <sup>2</sup> )	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  $\sim 2 \cdot 10^{-10} \text{ erg cm}^{-2} \text{ s}^{-1}$ .

Only  $\sim 20$  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:

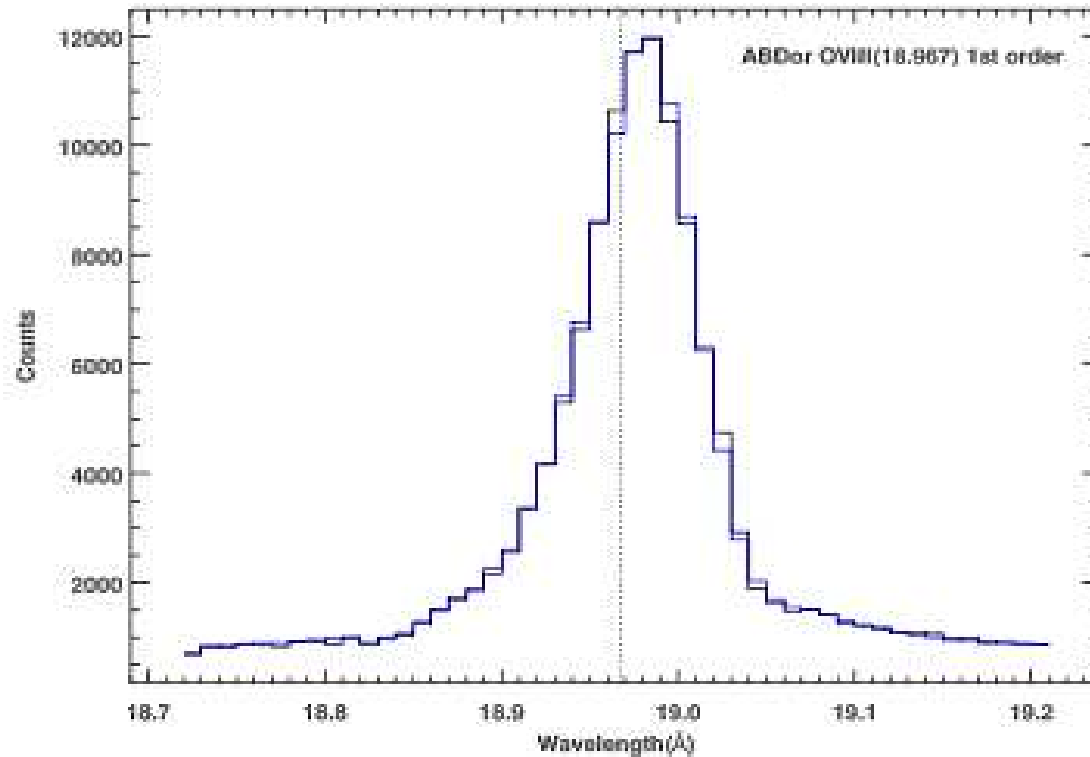
- reading fewer CCDs
- reading the most brightly illuminated CCDs more often
- using the RGS Small Window mode
- a combination of these

# The Instrumental Response

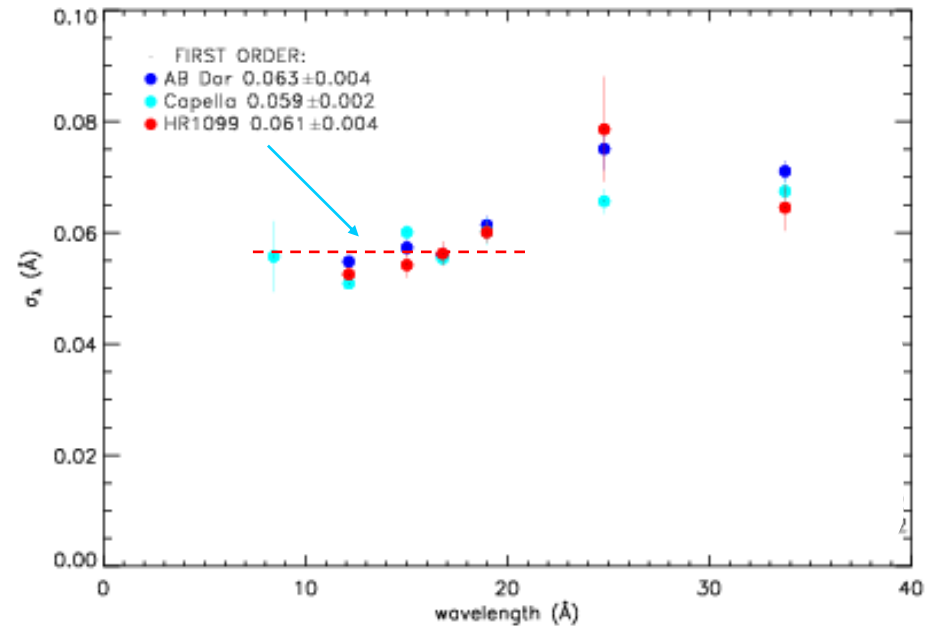
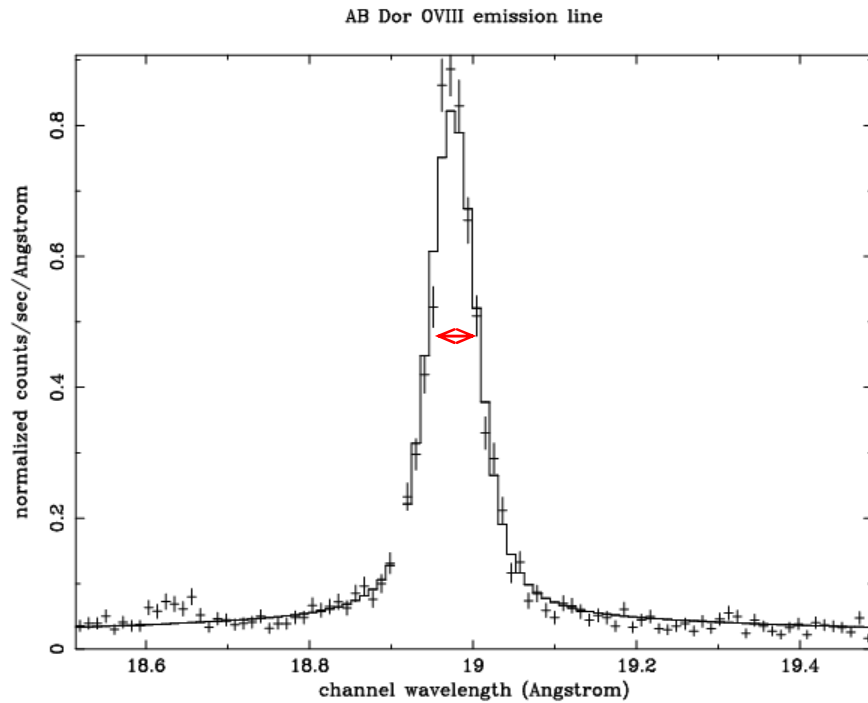
- Mirror
  - Grating
  - CCD
- } pre launch
- + empirical corrections ← in flight
- The line spread function and the wavelength scale
  - The effective area

# RGS line-spread function components

Response to monochromatic radiation

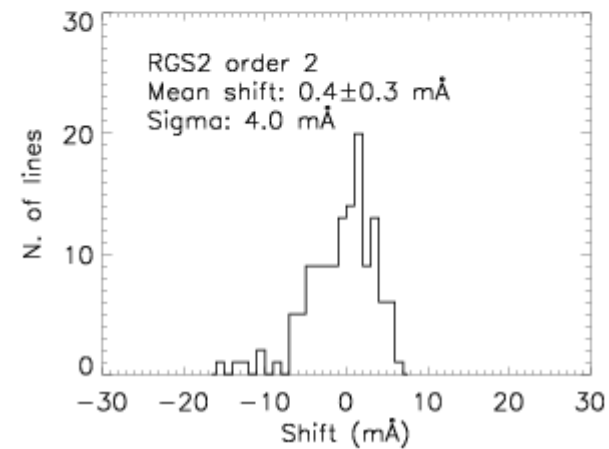
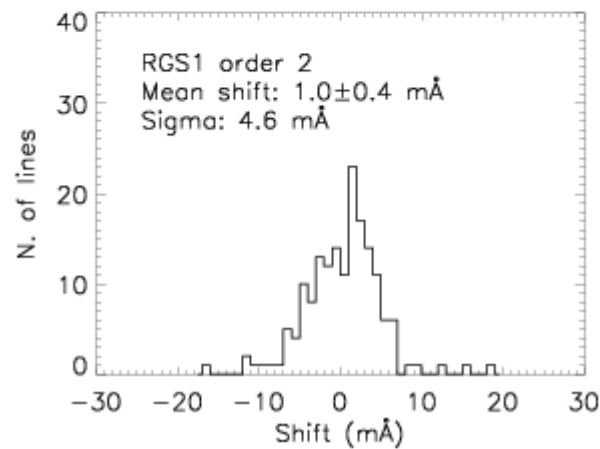
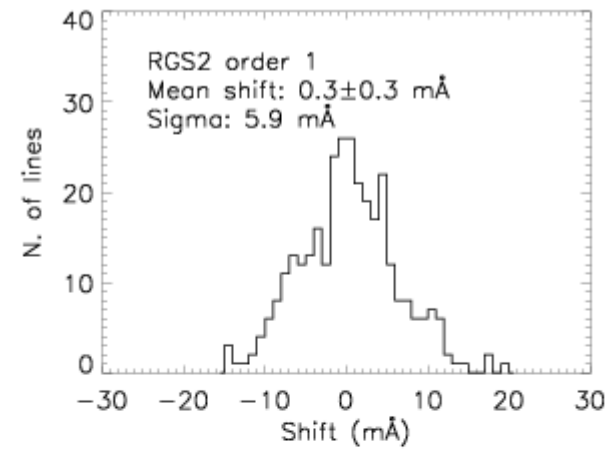
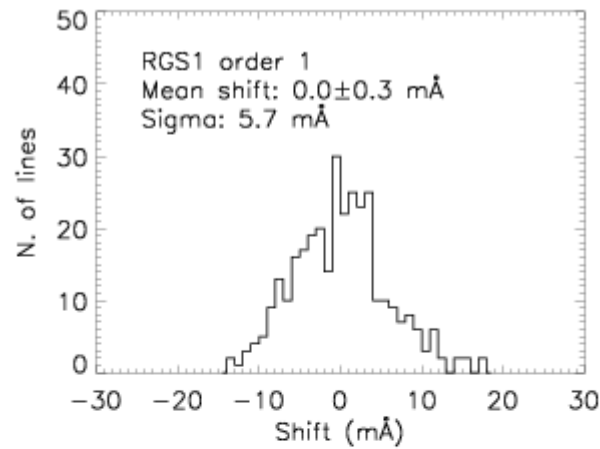


# RGS observed LSF and resolving power



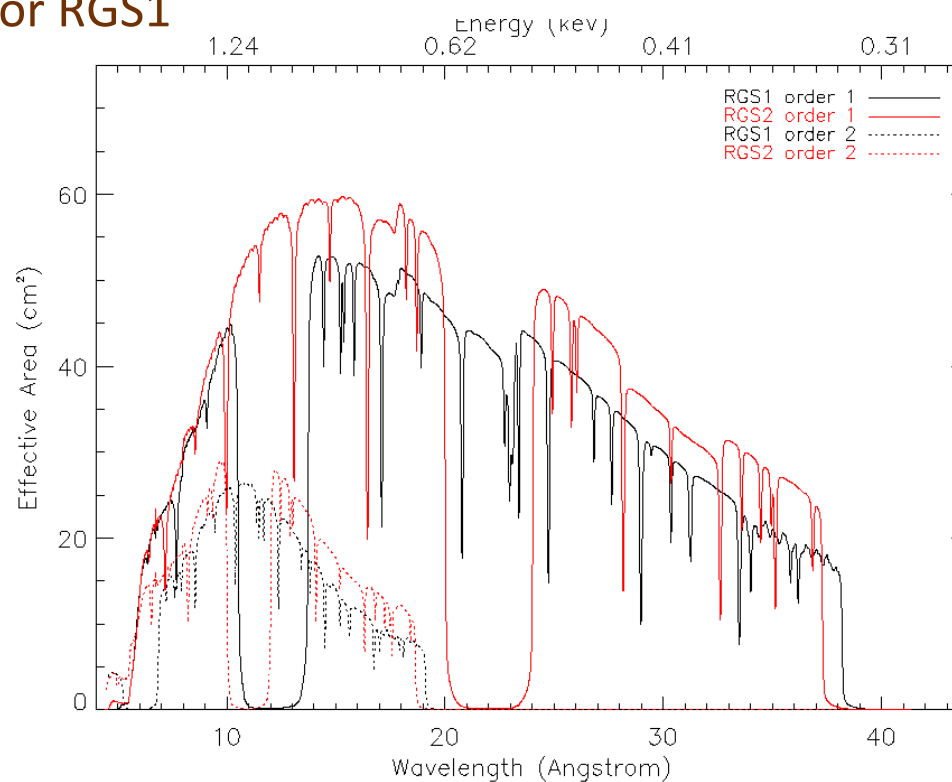
# RGS wavelength scale ( $\sigma \sim 6$ mÅ)

Corrections for Solar Angle dependence and Heliocentric velocity



# The Effective Area

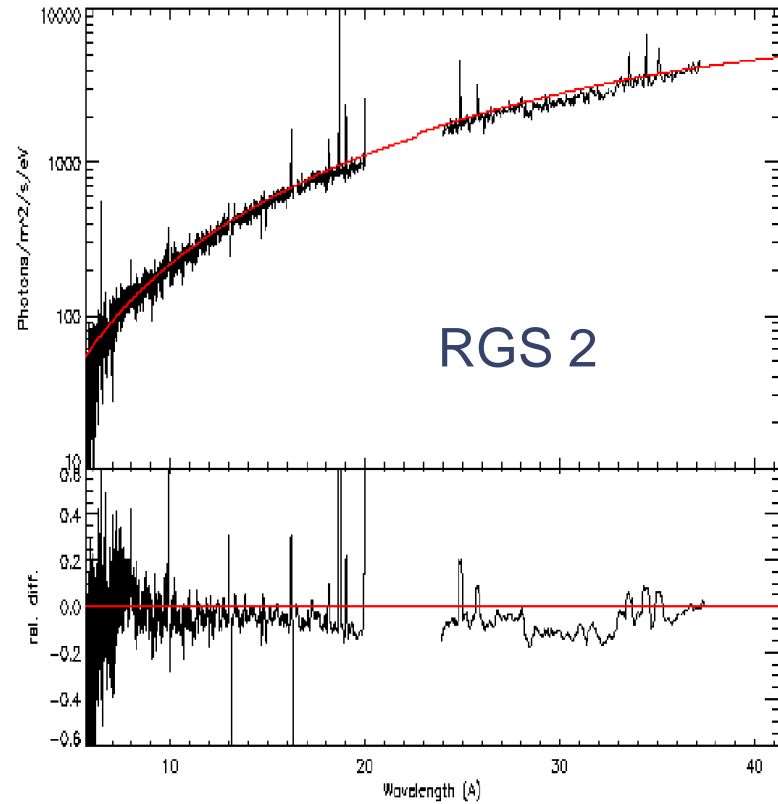
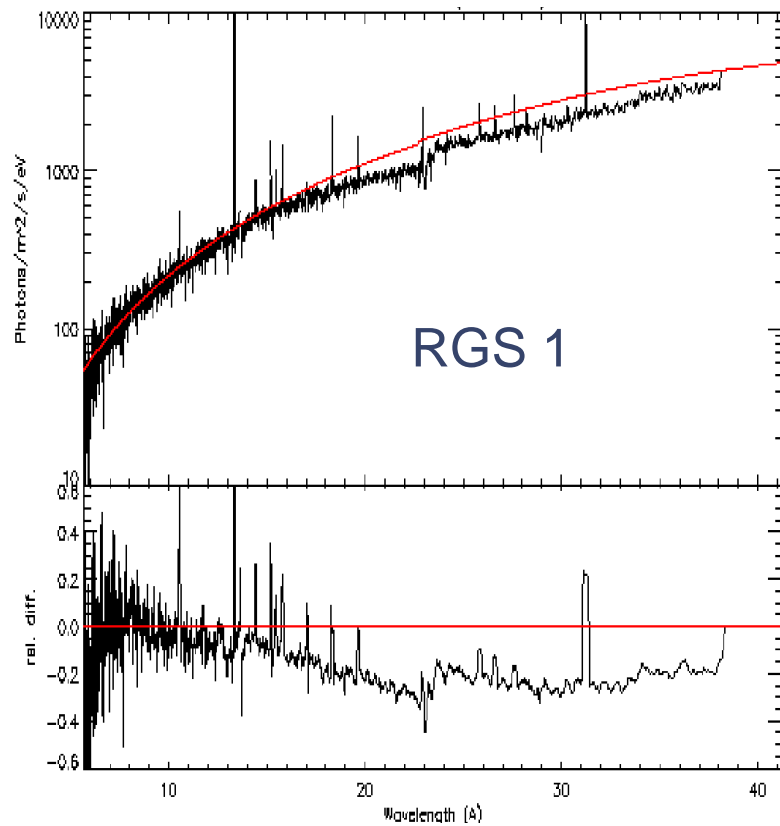
- Pre-launch and in flight measurements
- Empirical corrections:
  - Beta dependent correction for RGS1
  - High orders correction
  - Time correction
  - Instrumental edges:
    - Al (8.3 Å)
    - Mg (9.5 Å)
    - F (18.3 Å)
    - Mg<sub>2</sub>F (17.9 Å)
    - O (23.5 Å)





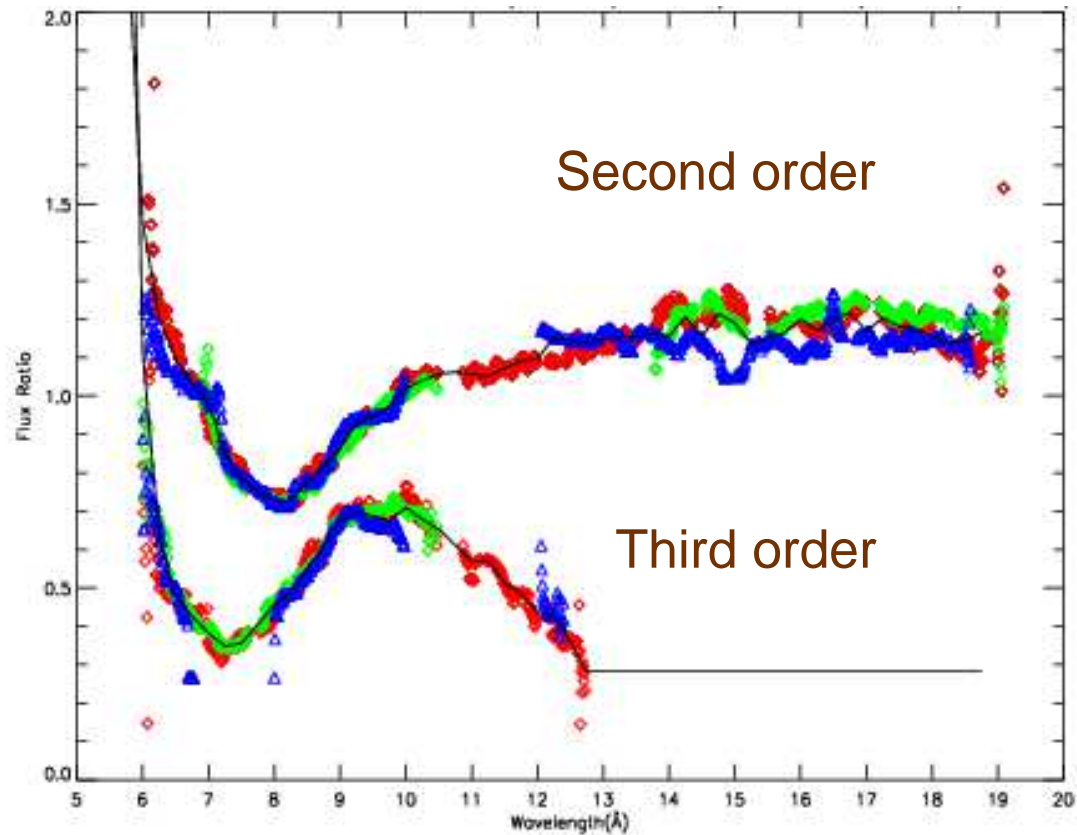
# RGS1 - RGS2 broadband comparison

## Systematic differences between instruments



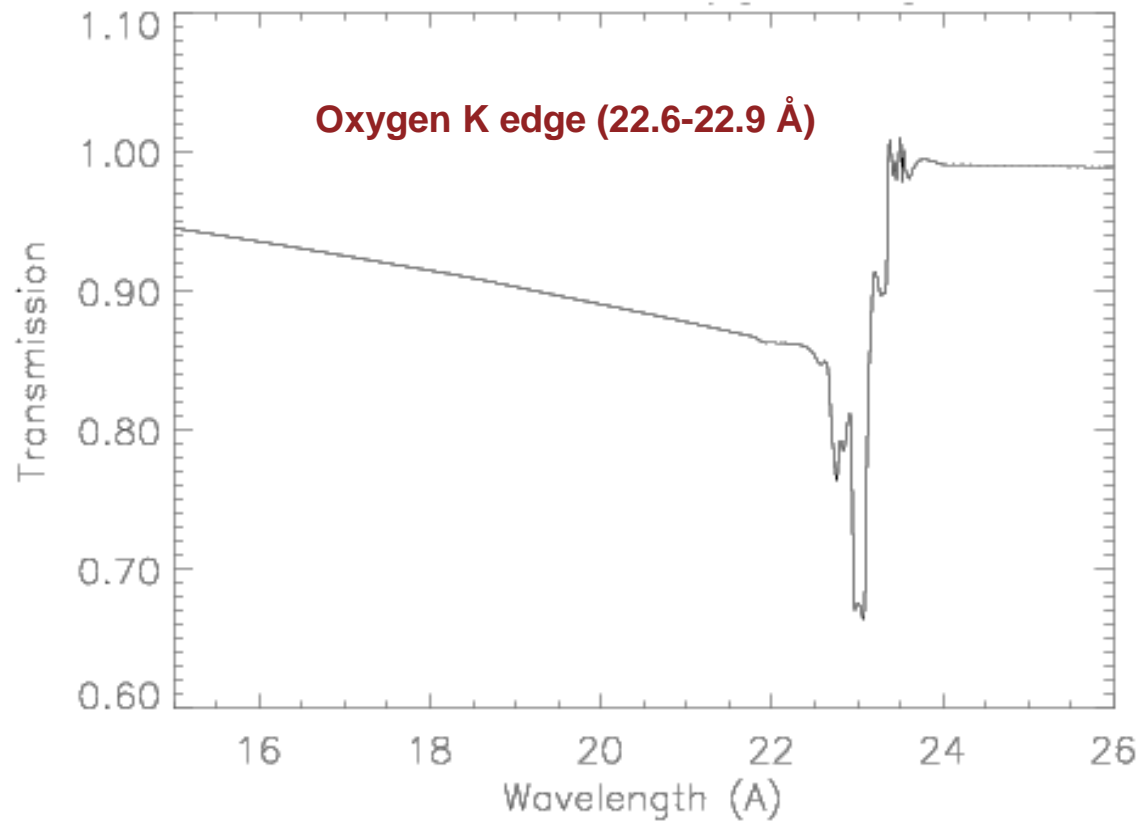
# RGS order-to-order correction

Systematic differences between orders



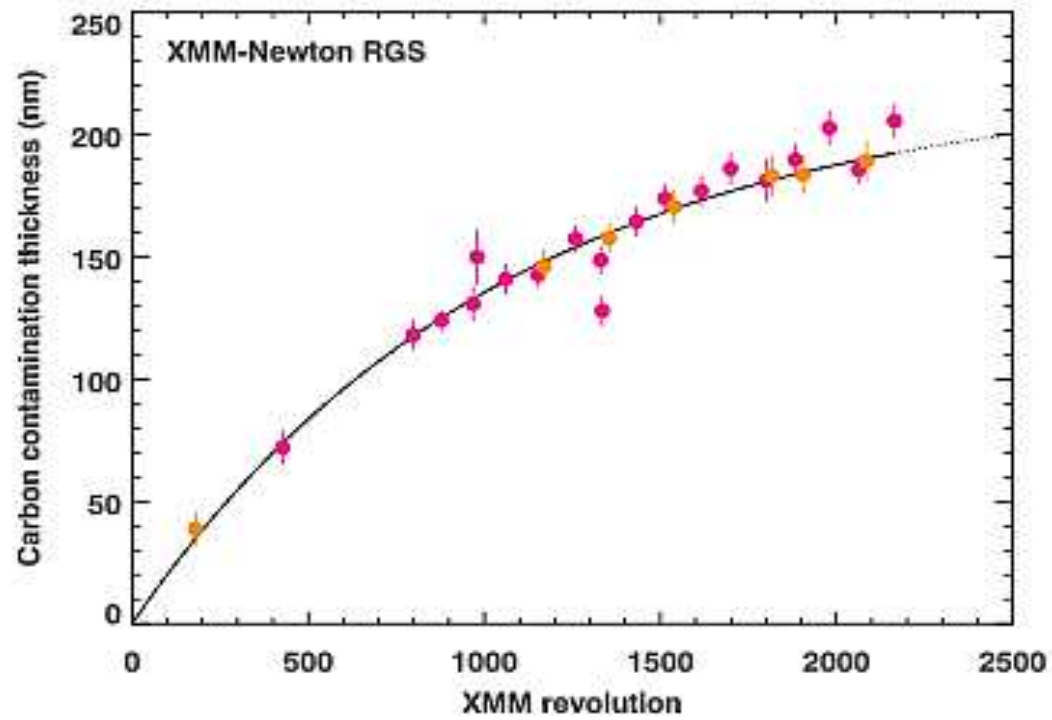
# RGS instrumental Oxygen edge

Additional Oxygen layer on the detectors



# RGS contamination

Increasing Carbon contamination



# RGS SAS and the CCF components

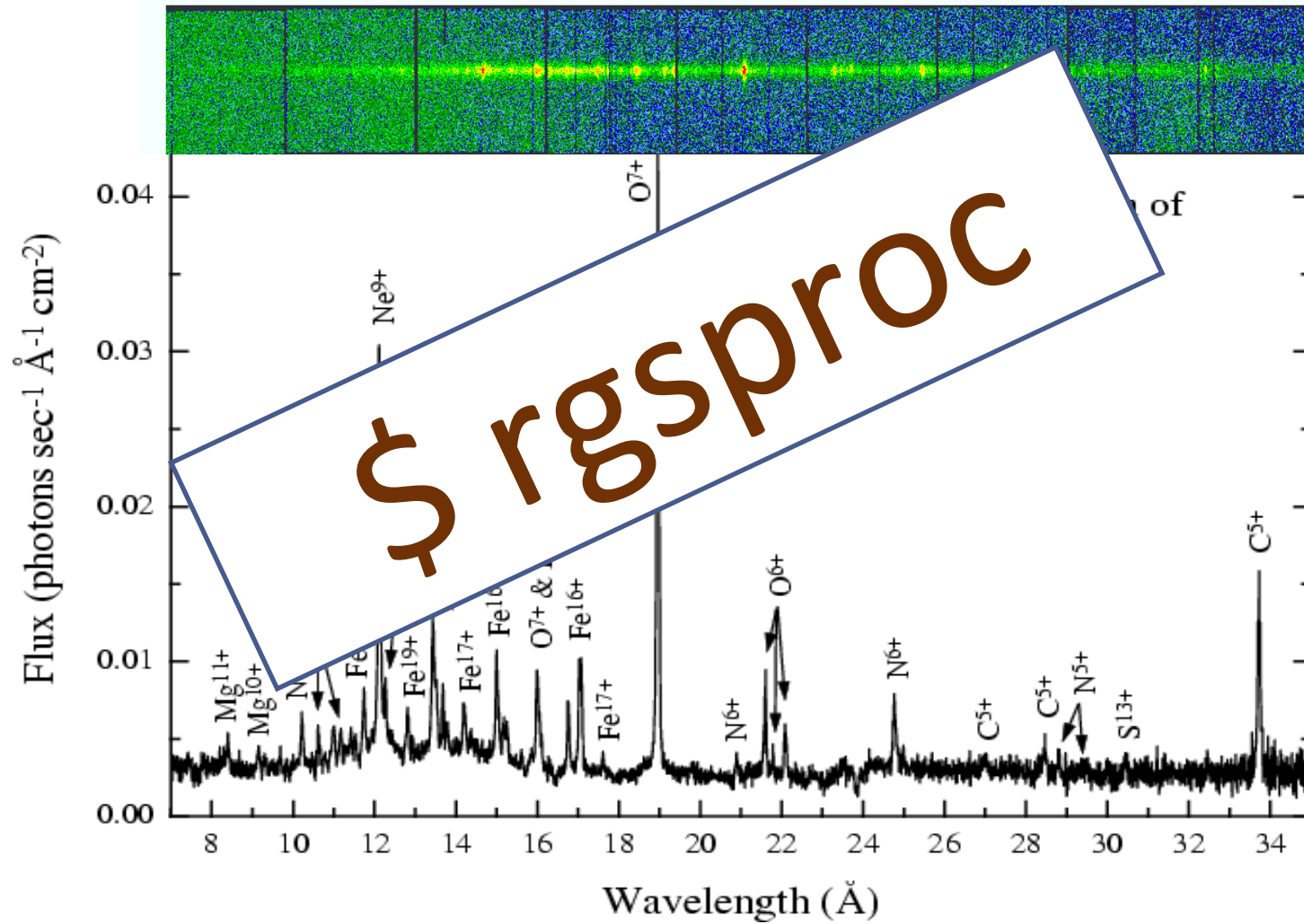
## Current Calibration Files

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

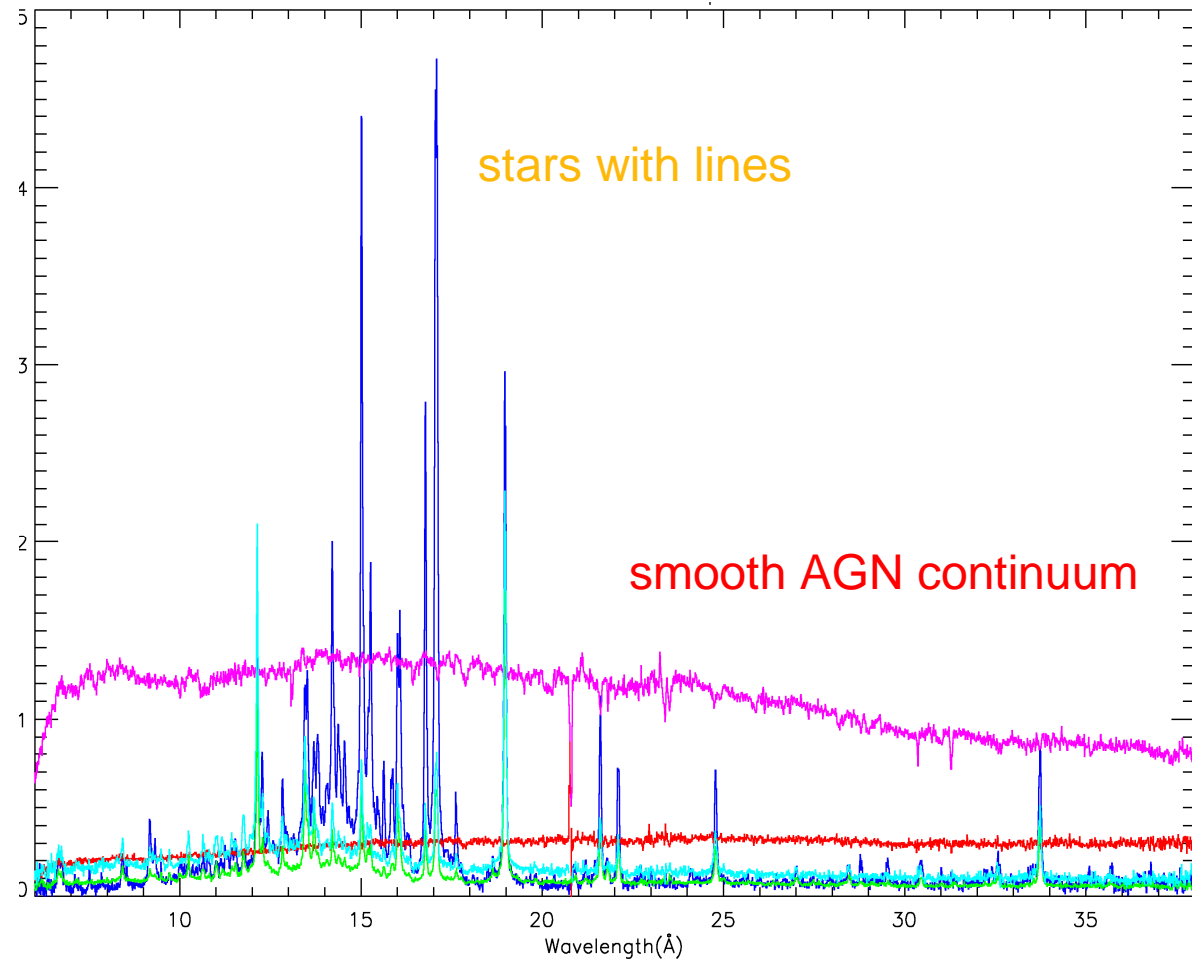
## SAS (rgsproc) tasks

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

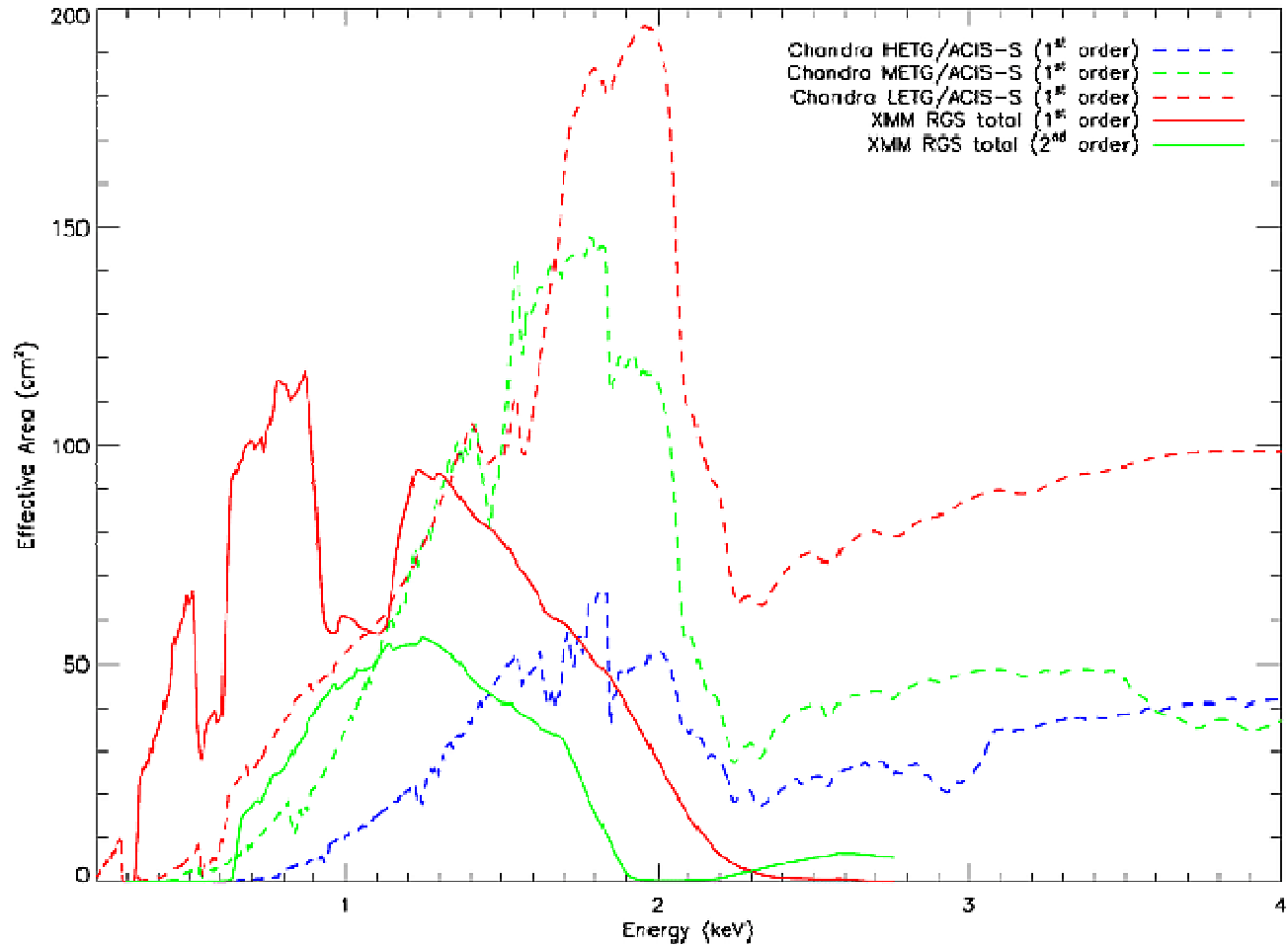
# What's next ?



# Some nice RGS spectra

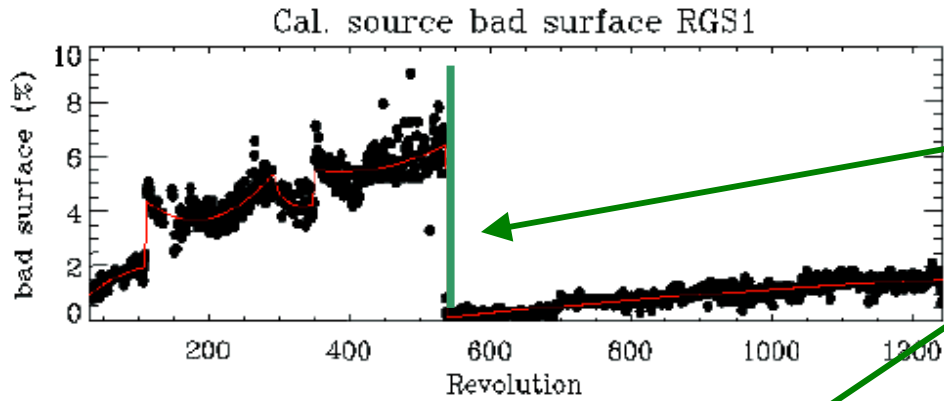


# Comparison with Chandra gratings

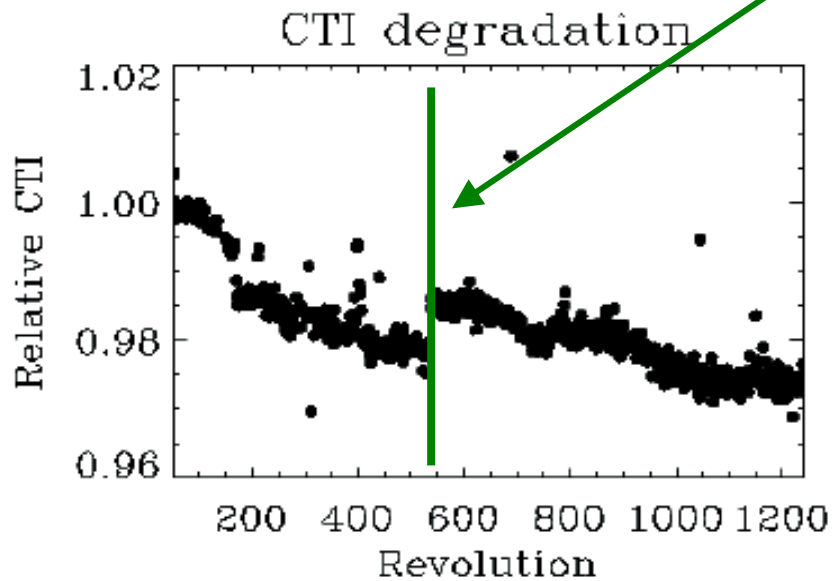




# Instrumental Trends



RGS cooling: Nov 2002  
Operating temperature from  $-80^{\circ}\text{C}$  to  $-110^{\circ}\text{C}$



Oxygen layer building up  
somewhere in the optical path

