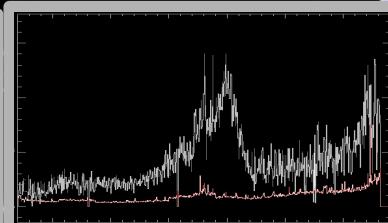
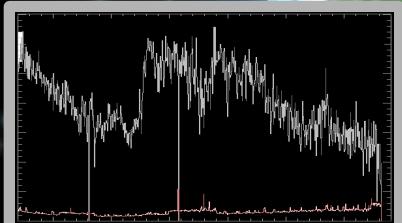


# High Resolution X-Ray Spectra

## A DIAGNOSTIC TOOL OF THE HOT UNIVERSE

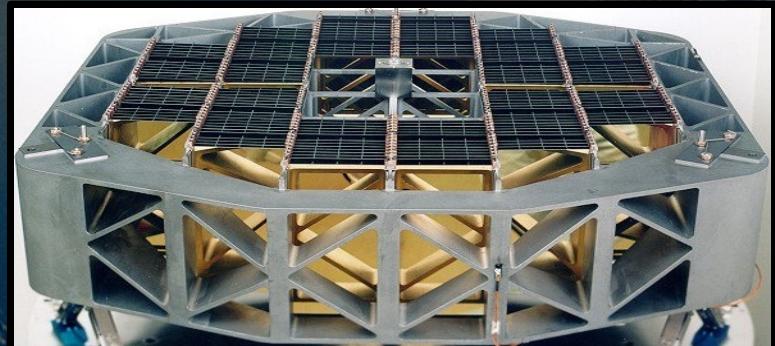


Katarzyna Bensch  
XMM-Newton ESAC



## THE REFLECTION GRATING SPECTROMETER:

- REFLECTION GRATINGS
- DEDICATED CCD DETECTORS
- EACH PHOTON POSITION AND ENERGY ARRIVAL TIME
- HIGH RESOLVING POWER
- RANGE FROM 7 TO 38 Å [~ 0.33 TO 2.5 KEV]



THE REFLECTION GRATING ARRAYS

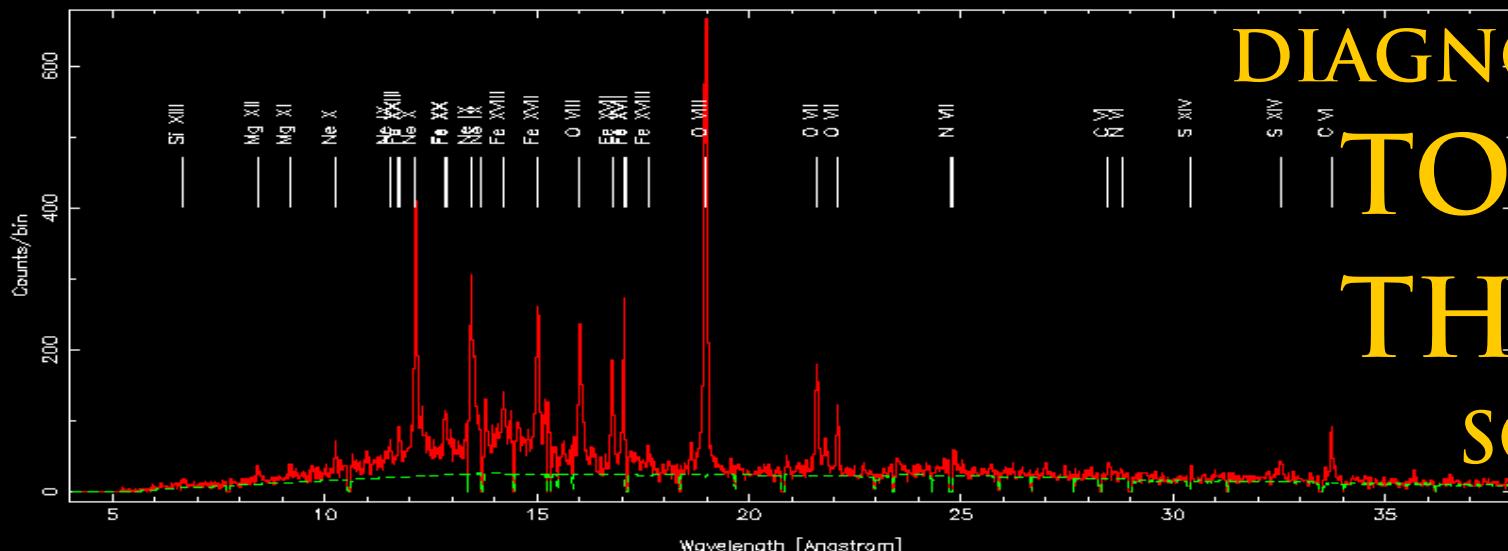
## RGS DESIGNED TO DETECT SEVERAL X-RAY EMISSION & ABSORPTION LINES

- K-SHELL TRANSITION
- HELIUM-LIKE TRIPLETS

CARBON, NITROGEN, OXYGEN, NEON, SILICON, ARGON

- L-SHELL TRANSITION OF IRON

AB Dor XMM/RGS 1 spectrum (rev. 091)



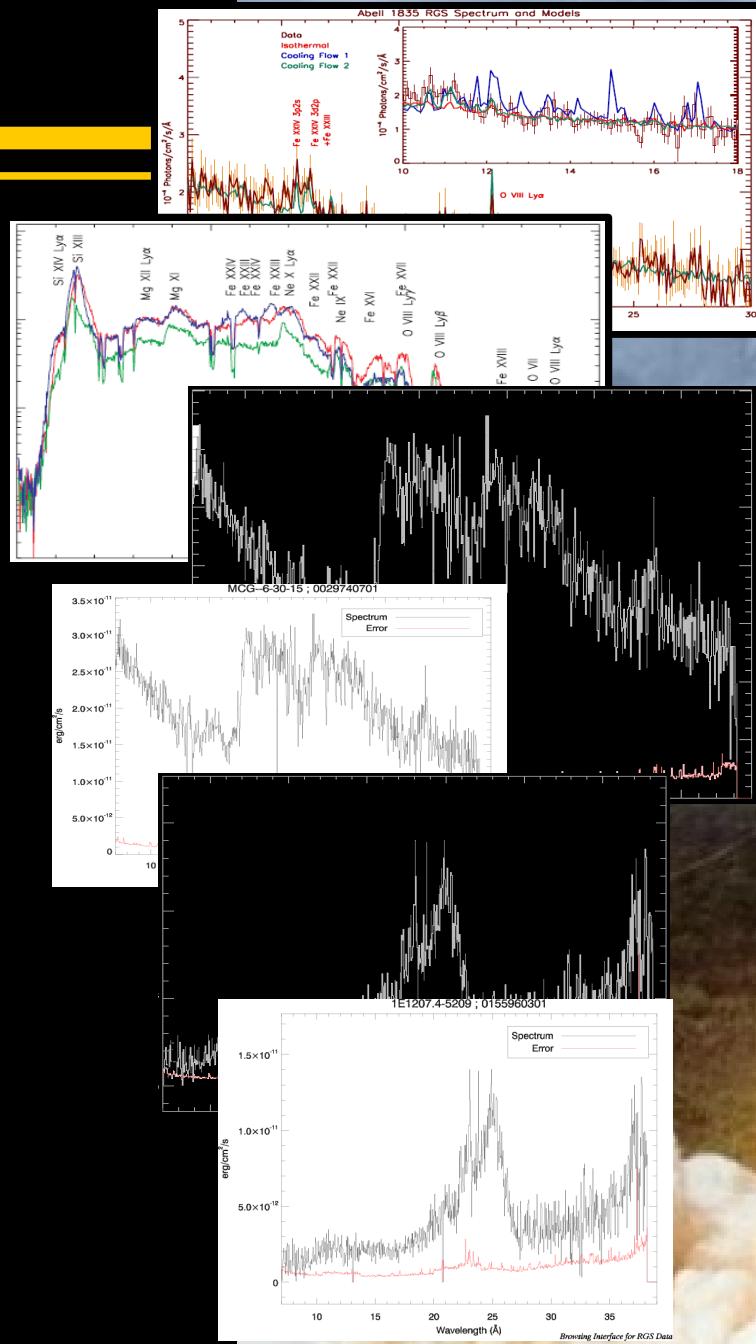
DIAGNOSTIC TOOLS  
TO STUDY  
THE X-RAY  
SOURCES

# RGS Spectra

SIMULTANEOUS  
OBSERVATION  
WITH ALL  
INSTRUMENTS

18000  
RGS SPECTRA

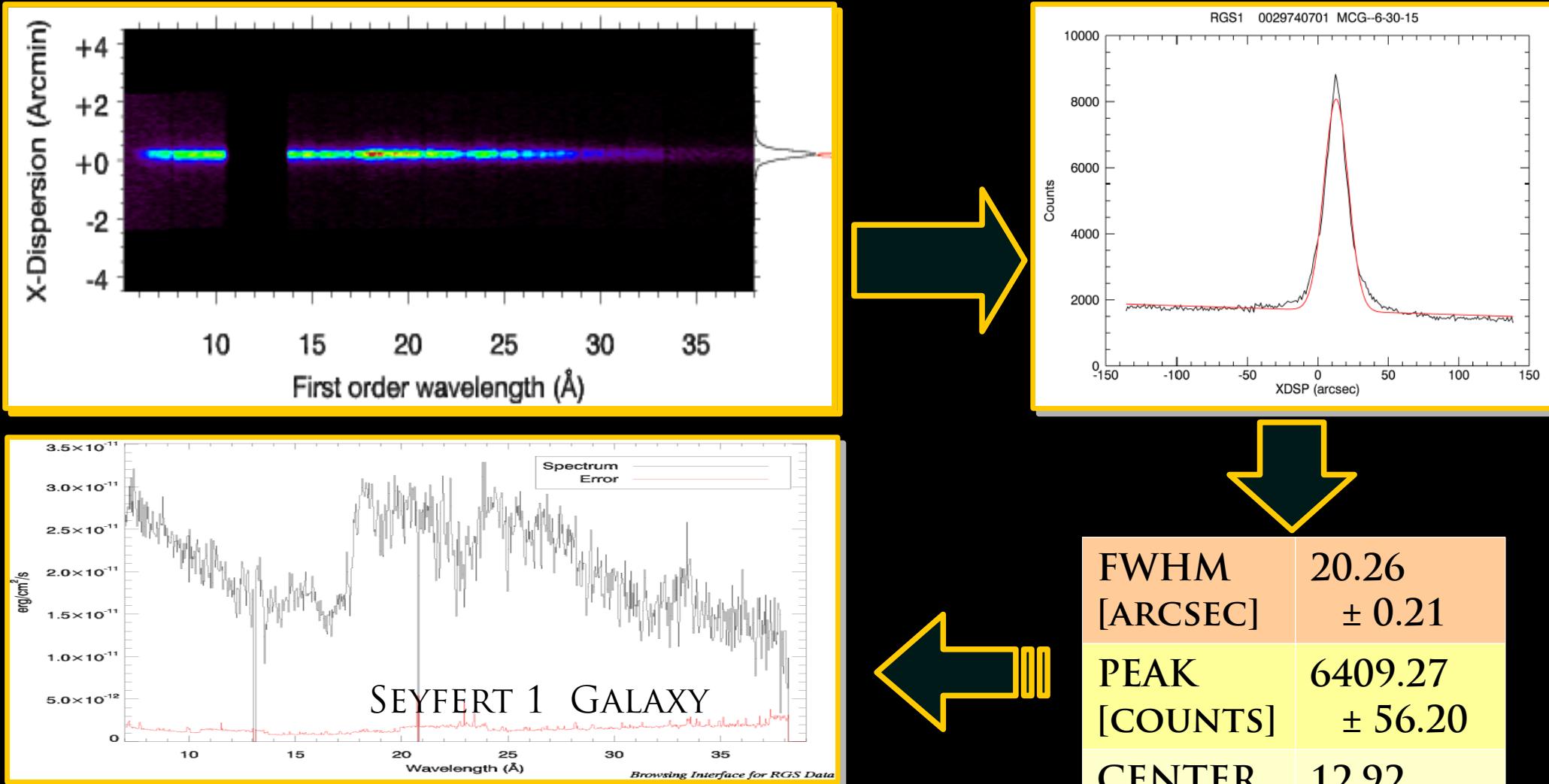
9000  
OBSERVATIONS



1. IDENTIFICATION OF USEFUL SPECTRA
2. CLASSIFICATION OF RGS SPECTRA:  
BASED ON SPECTRAL CHARACTERISTIC
3. INVESTIGATION OF PHYSICAL NATURE OF OBJECTS:  
PHYSICAL CONDITION AND CHEMICAL COMPOSITION
4. DETAILED ANALYSIS OF TYPICAL SPECTRA  
FOR EACH TYPE OF OBJECTS

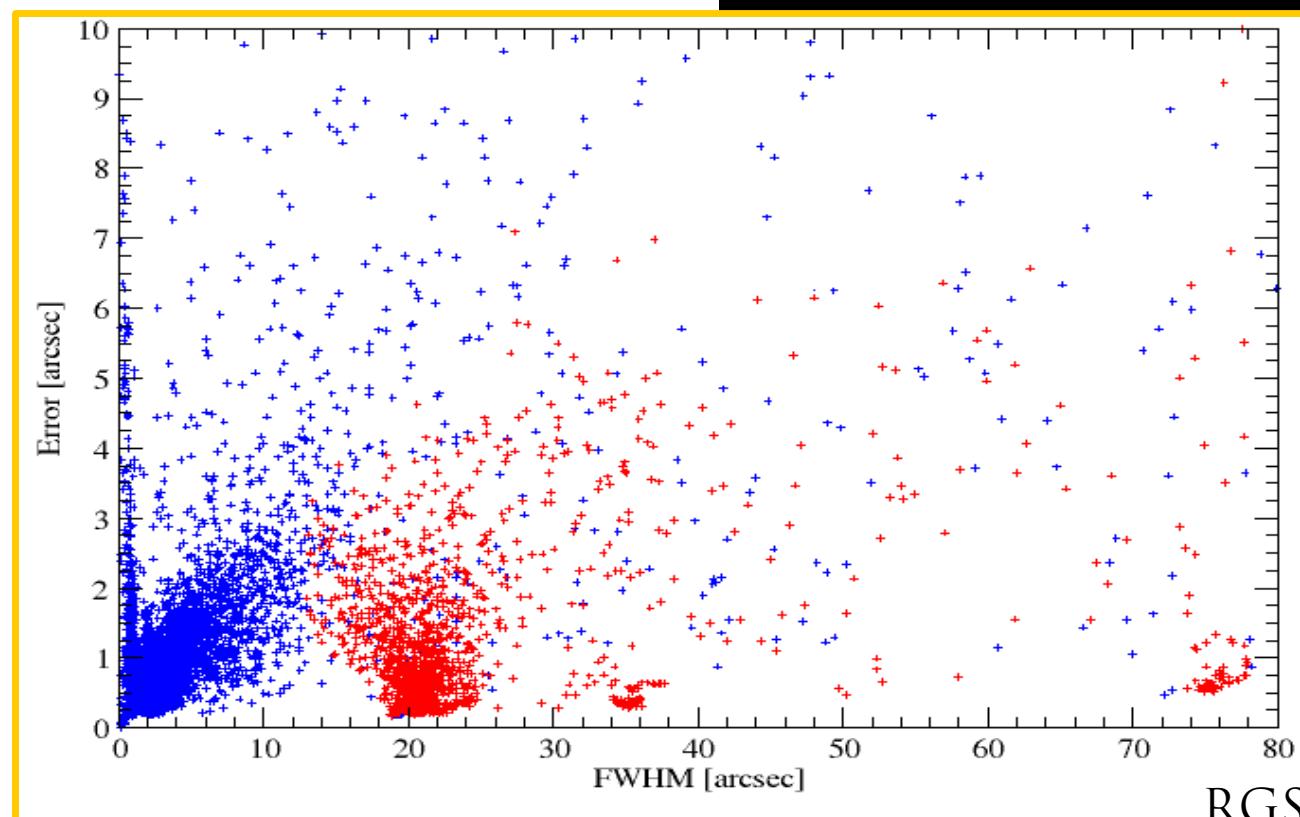
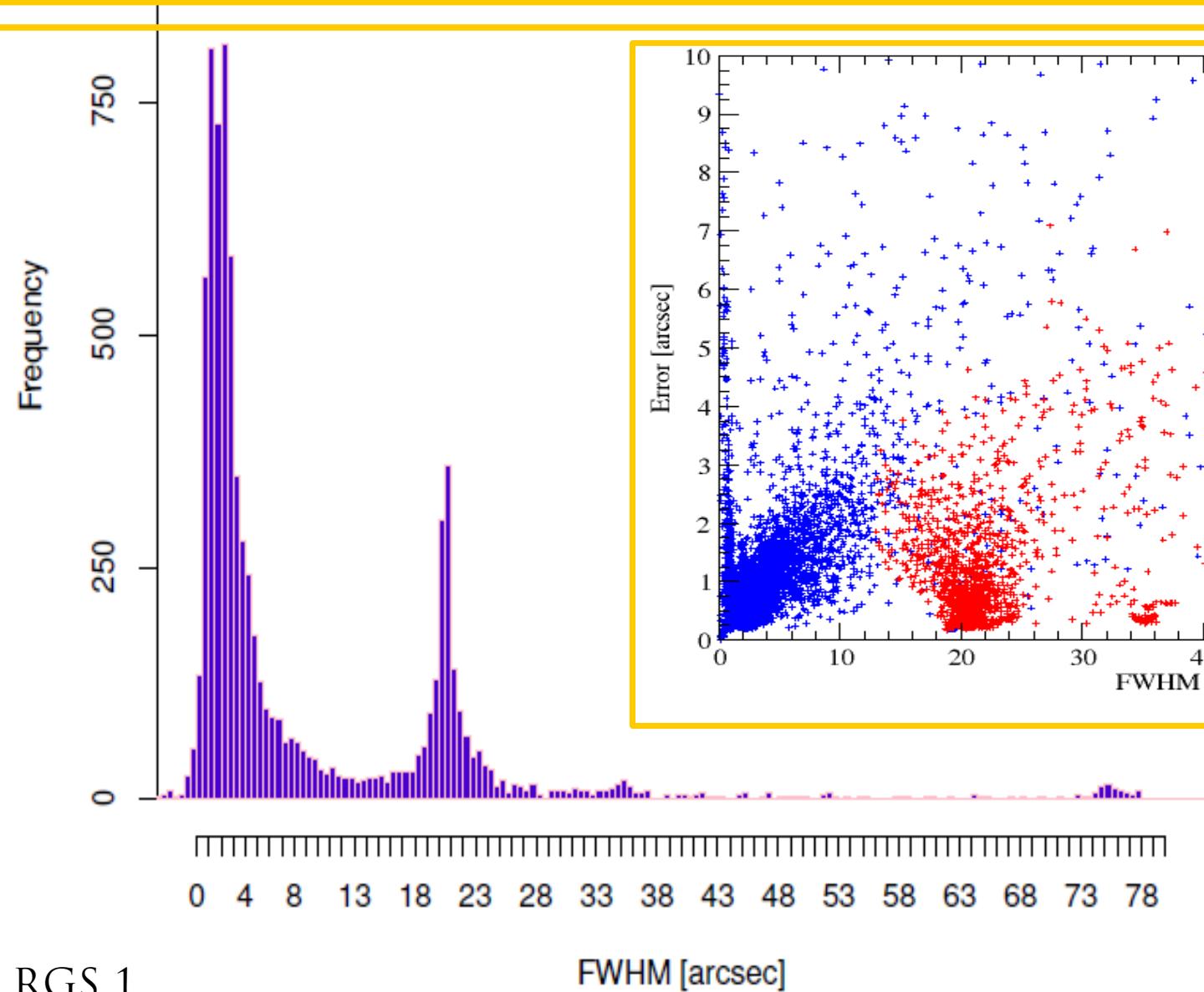
# Method: DEFINING USEFUL SPECTRA

## FITTING GAUSSIAN FUNCTION TO CROSS-DISPERSION PROFILE



Defining „minimum usability” parameters

# Results: FWHM Distribution

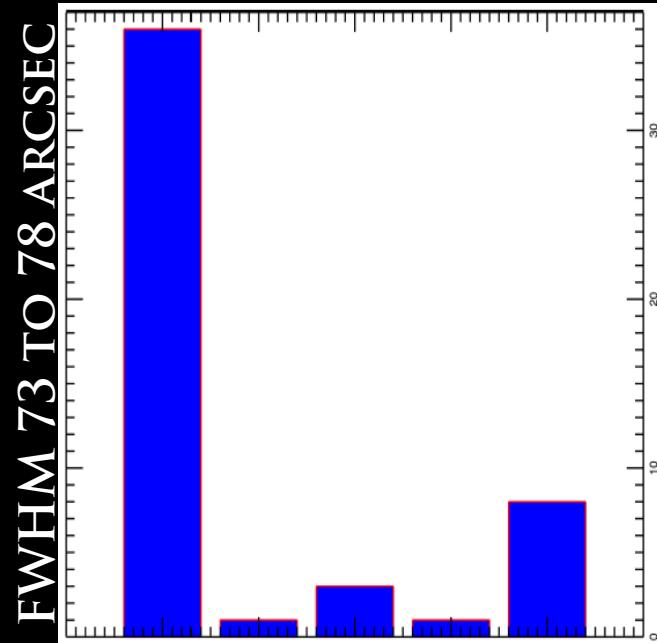
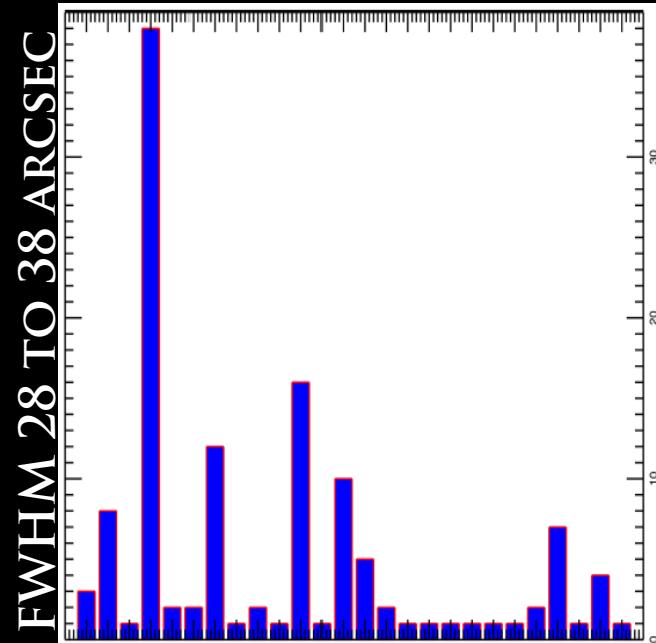
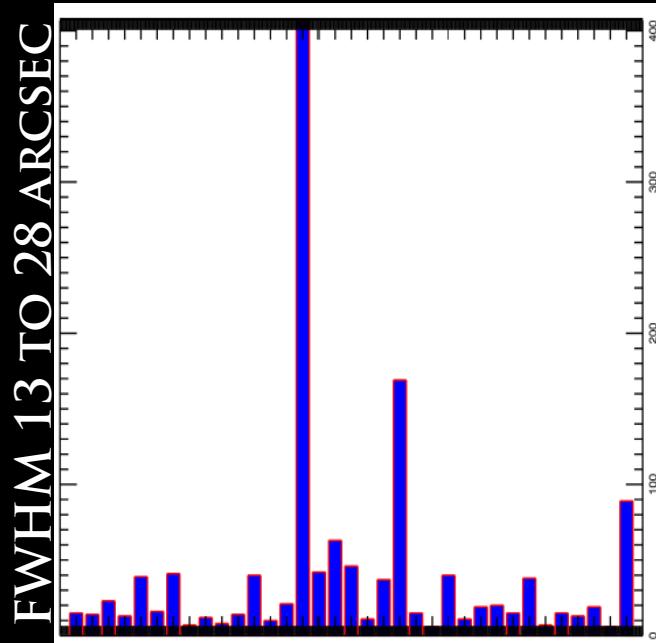


RGS 1

FWHM > 3 ERROR  
FWHM > 13 [arcsec]  
PEAK > 3 ERROR  
- 100 < CENTER < 100

USEFUL SPECTRA ~ 20 %

# Object Types Distribution



MOST FREQUENT OBJECTS IN THE SAMPLE

3124 SPECTRA

RGS1 & RGS2

SEYFERT 1 GALAXIES

232 SPECTRA

RGS1 & RGS2

SUPERNova Remnants

102 SPECTRA

RGS1 & RGS2

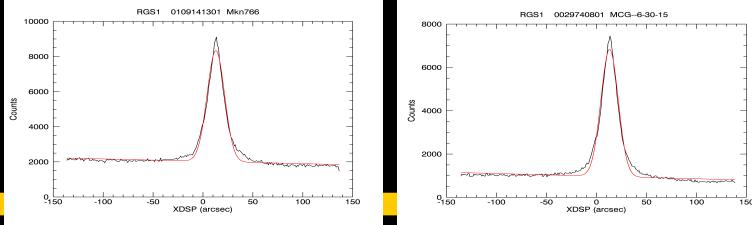
SUPERNova Remnants

LMXB

PULSARS

CLUSTERS OF GALAXIES

# Point Sources



## NARROW LINE SEYFERT 1 GALAXIES:

### MCG -6-30-15 & MRK 766

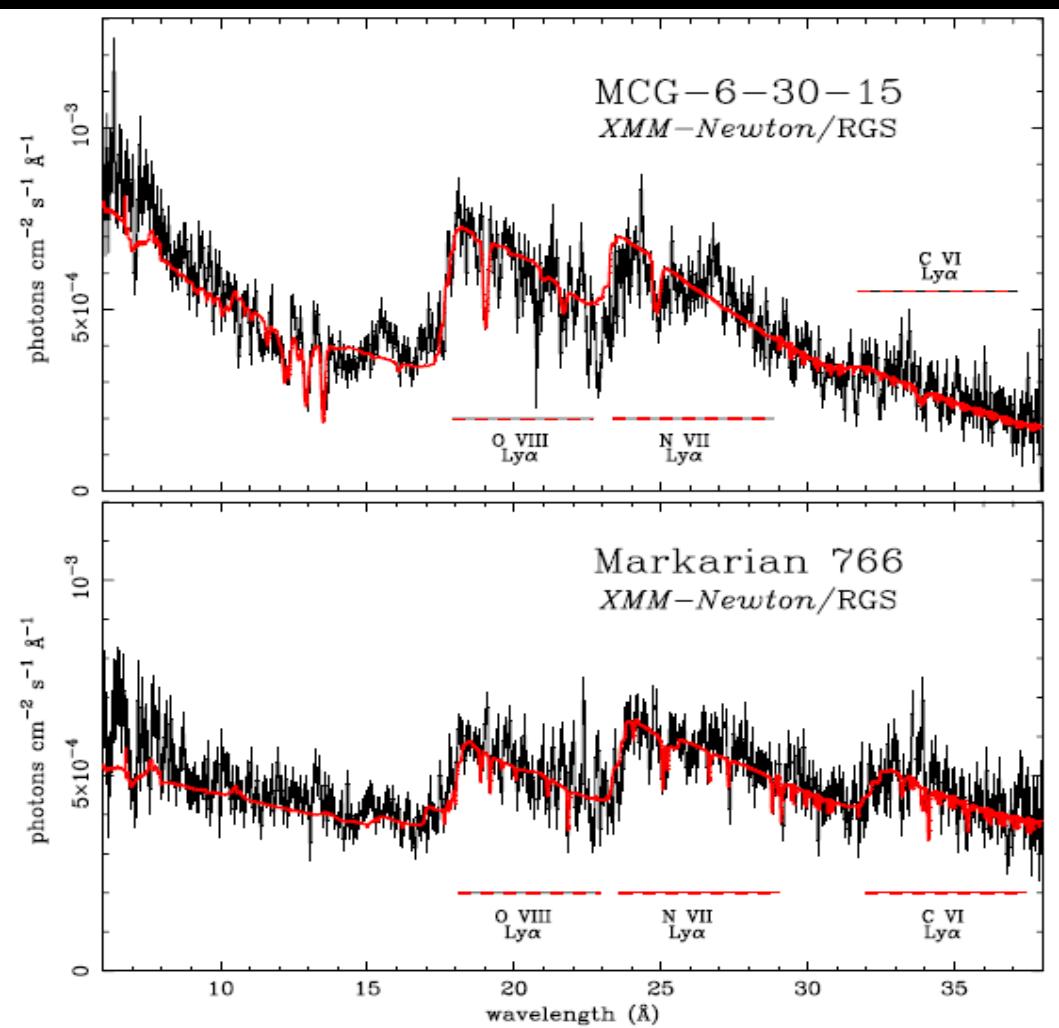
#### DISK-LINE EMISSION INTERPRETATION

MODEL CONSISTING OF:

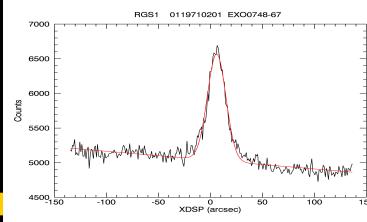
- absorbed power-law
- emission lines  
(gravitationally redshifted and broadened by relativistic effects in a medium of a black hole)
- components of narrow absorption

BOTH GALAXIES  
IDENTICAL SPECTRAL STRUCTURE

Emission lines:  
H-like Ly $\alpha$  lines of  
O VIII, N VII, C VI

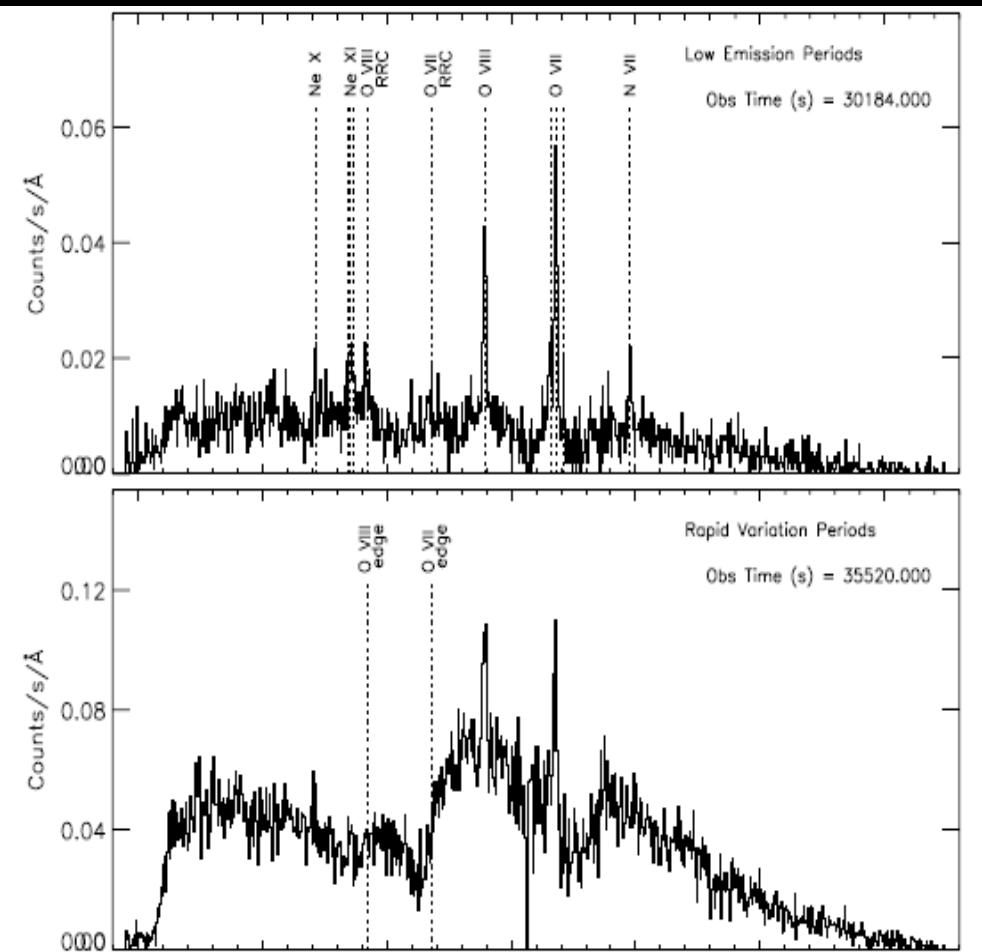


# Point Sources



## LOW-MASS X-RAY BINARY: EXO 0748-67

HIGHLY VARIABLE - DEEP ECLIPSES - 3.82 HOUR ORBITAL PERIOD -  
INCLINATION  $75^\circ$ - $82^\circ$  - NEUTRON STAR



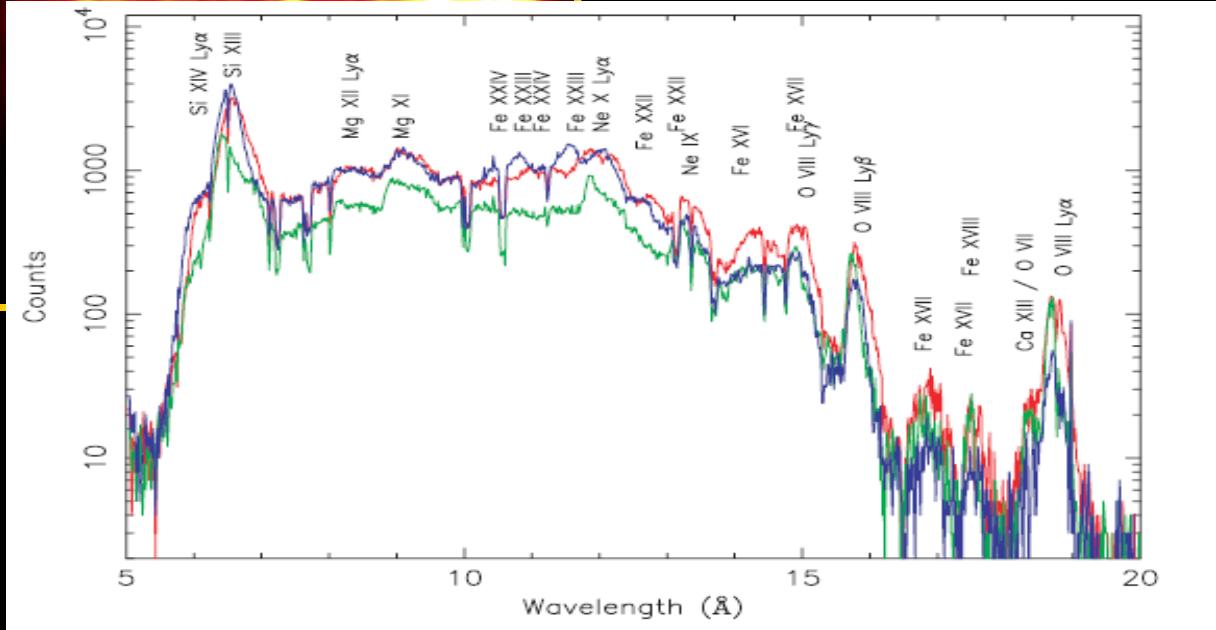
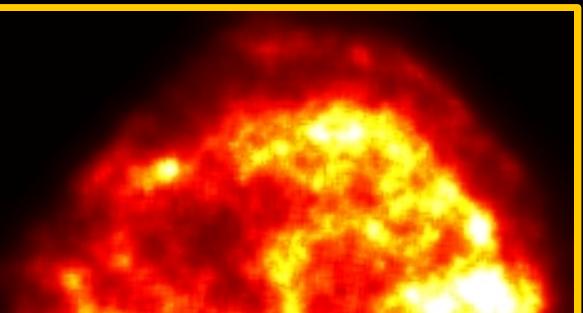
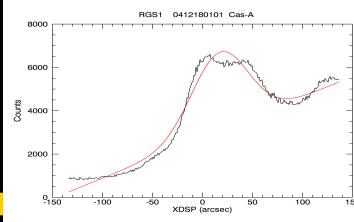
Previous observation - limited spectral resolution  
The RGS spectrum - absorption and emission

Bright emission lines:  
O VIII Ly $\alpha$ , O VII He-like complex

Weaker emission lines  
(the periods of low emission):  
Ne X Ly $\alpha$ , Ne IX He-like complex, N VII Ly $\alpha$

Photoelectric absorption edges  
(periods of rapid variation):  
O VIII, O VII

# Extended Sources



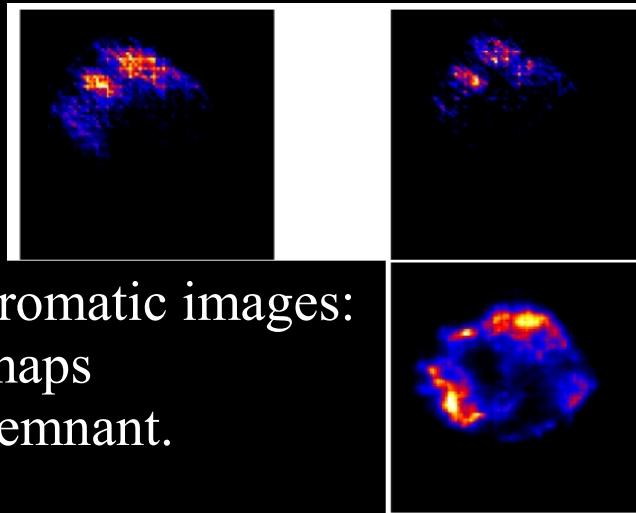
Spectra from three regions  
the N, NE and SE.

RGS extracted dispersed monochromatic images:  
The O VIII Ly $\alpha$  and Ly $\beta$  lines – maps  
Three blobs: E and N rim of the remnant.

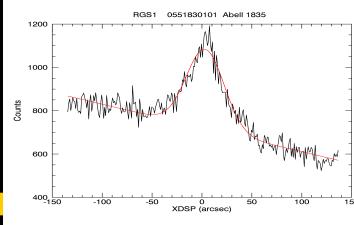
SUPERNOVA REMNANTS: CASSIOPEIA A

Detected lines in the spectrum:

Highly ionized species of  
Si, Mg, Ne, Fe L, O

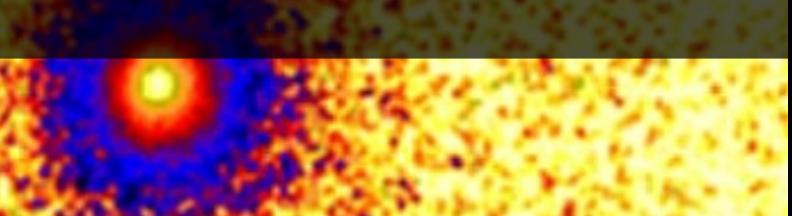


# Extended Sources

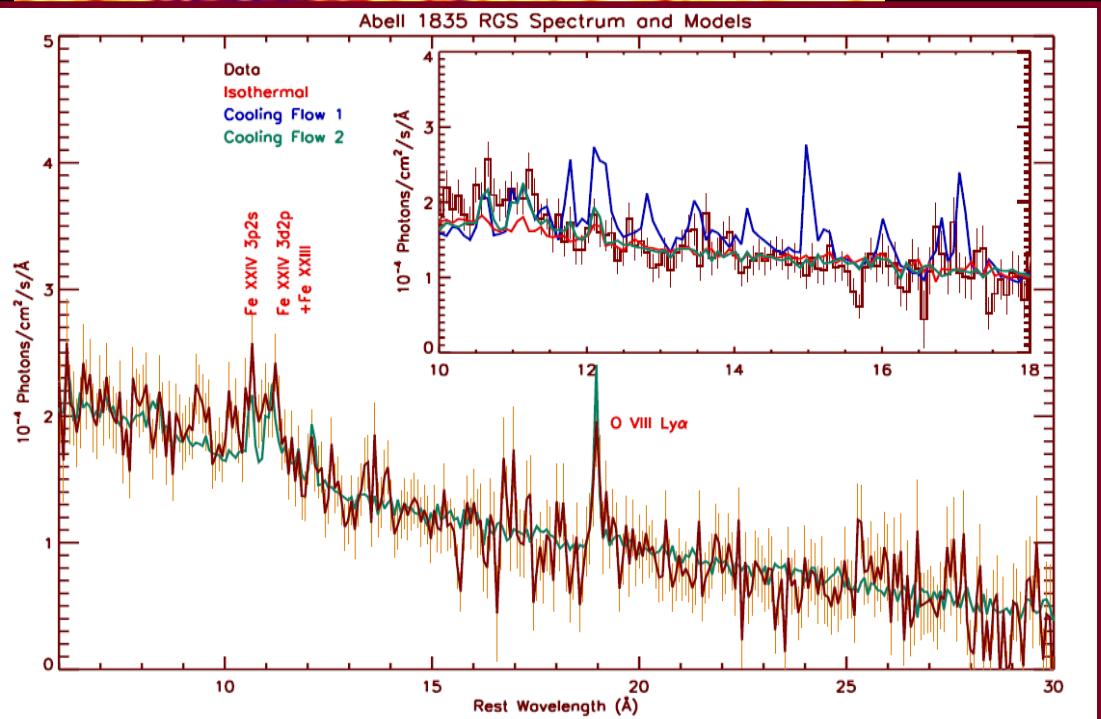


## CLUSTERS OF GALAXIES: ABELL 1835

A LUMINOUS X-RAY EMITTING CLUSTER OF GALAXIES –  
WITH MEDIUM REDSHIFT ( $Z = 0.2523$ )



Studying the RGS spectrum:  
→ the relative emission measure of cold gas  
→ the spectral properties of the cooling flow



DETECTED ABOVE THE BREMSSTRAHLUNG CONTINUUM:  
- 2 Fe L complexes (Fe XXIV lines)  
- O VIII Ly  $\alpha$

Fe XXIV ion → cool gas (1 and 3 keV)  
O VIII → both cool (1 keV) and hot gas (10 keV)  
No other Fe L shell ions → cooling-flow models

# Expected Output



CATALOGUE OF USEFULL RGS SPECTRA

FOR DIFFERENT TYPES OF OBJECTS

ATLAS CHARACTERISTIC OF:

SPECTRA

IMAGES

LIGHT CURVES

(ACCESSIBLE THROUGH THE WEB)

THANK YOU FOR YOUR ATTENTION!

