High Resolution X-Ray Spectra

A DIAGNOSTIC TOOL OF THE HOT UNIVERSE

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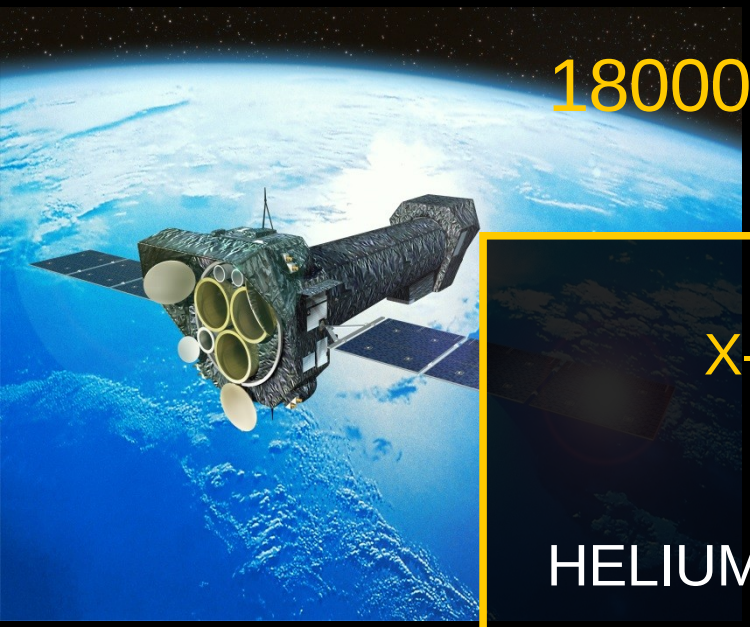
XMM-NEWTON / ESAC

The RGS Instruments

THE REFLECTION GRATING SPECTROMETER

HIGH RESOLVING POWER: 7 TO 38 Å [~ 0.33-2.5 keV]
SIMULTANEOUS OBSERVATIONS WITH EPIC AND OM



18000 RGS SPECTRA 9000 OBSERVATIONS

RGS DESIGNED TO STUDY
X-RAY EMISSION & ABSORPTION

K-SHELL TRANSITION
HELIUM-LIKE TRIPLETS OF C, N, O, Ne, Si, Ar
L-SHELL TRANSITION of Fe

DIAGNOSATIC TOOLS
TO STUDY THE X-RAY SOURCES

Work

1. Identification of useful Spectra

FITTING THE SPATIAL PROFILES

2. Classification of spectra:

QUALITY
TOP QUALITY / LOWER QUALITY

SPATIAL EXTENT
POINT-LIKE SOURCES / EXTENDED SOURCES

BiRD

Browsing Interface for RGS Data

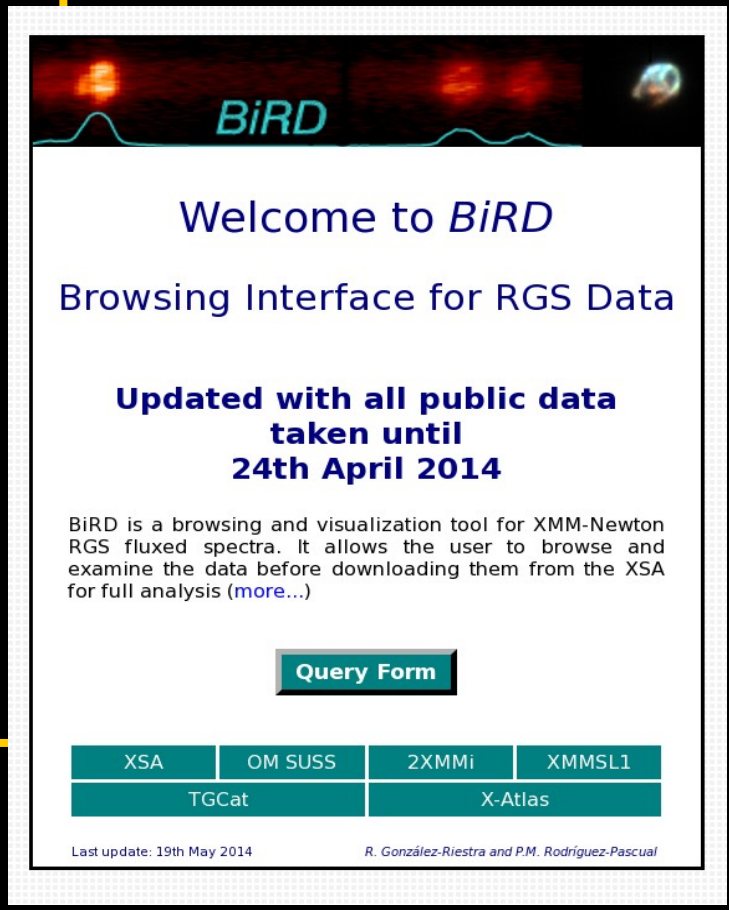
START POINT: BiRD DATABASE

ALL PUBLIC RGS 1 & RGS 2
Events file + spectra

EACH ONE HAS ASSOCIATED:

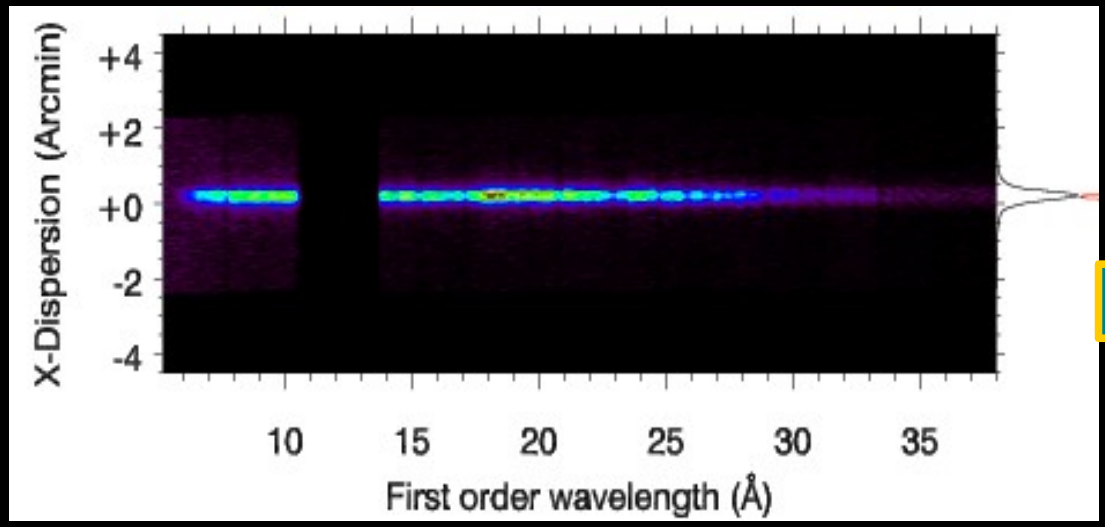
Simbad Object Class, N_h, z / v_{rad}

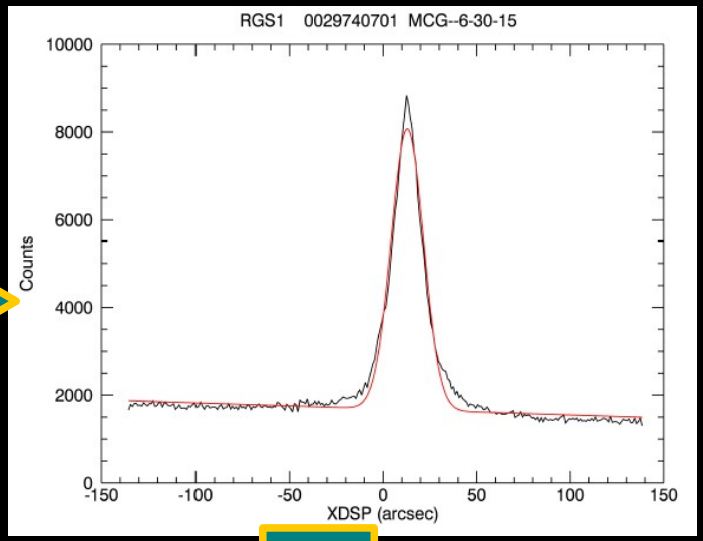
http://xmm.esac.esa.int/BiRD/

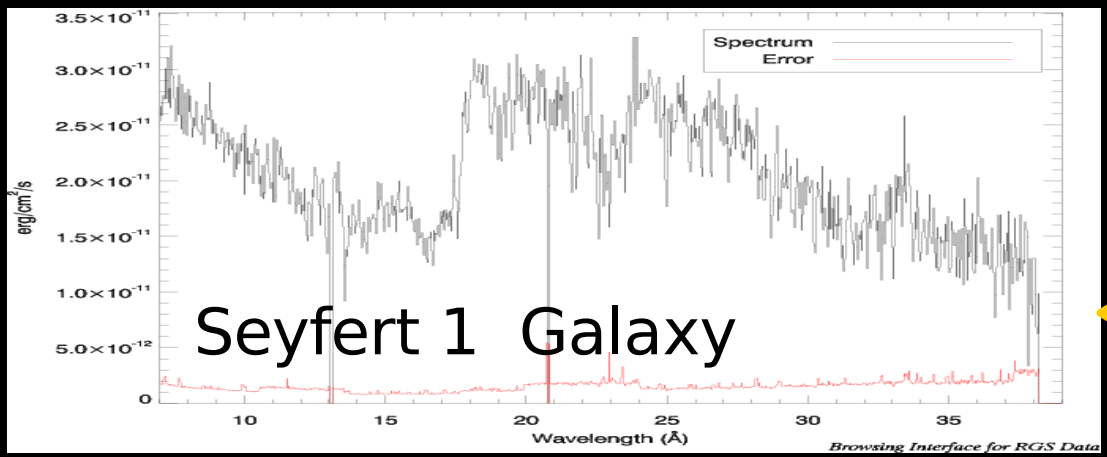


Identification of useful Spectra

Fitting Gaussian function to cross-dispersion profiles







FWHM	20".26
ΔFWHM	± 0".21
PEAK	6409.27 c
ΔPEAK	± 56.20 c
CENTER	12".92
ΔPEAK	± 0".09

Statistically bad fit = discarded | except...

Identification of useful Spectra

FITTING GAUSSIAN TO CROSS-DISPERSION PROFILE
BiRD EVENTS FILES

CALCULATING FLUX & ASSOCIATED ERROR
BIRD SPECTGRA

Defining
“minimum usability”
Parameters

FWHM > 3ΔFWHM
FWHM ≥ INTRINSIC RESOLUTION
INTENSITY > 3ΔPEAK
POSITION ON CCD: -100" : 100"
AREA UNDER GAUSSIAN > 3ΔAREA

$$\frac{FLUX}{ERROR} = \frac{\sum_i F_i \Delta\lambda}{\sqrt{\sum_i \Delta F_i^{\,2}}} > 10$$

Creation of a database with all information

QUALITY classification

All useful observations
5045 (56 % of all)

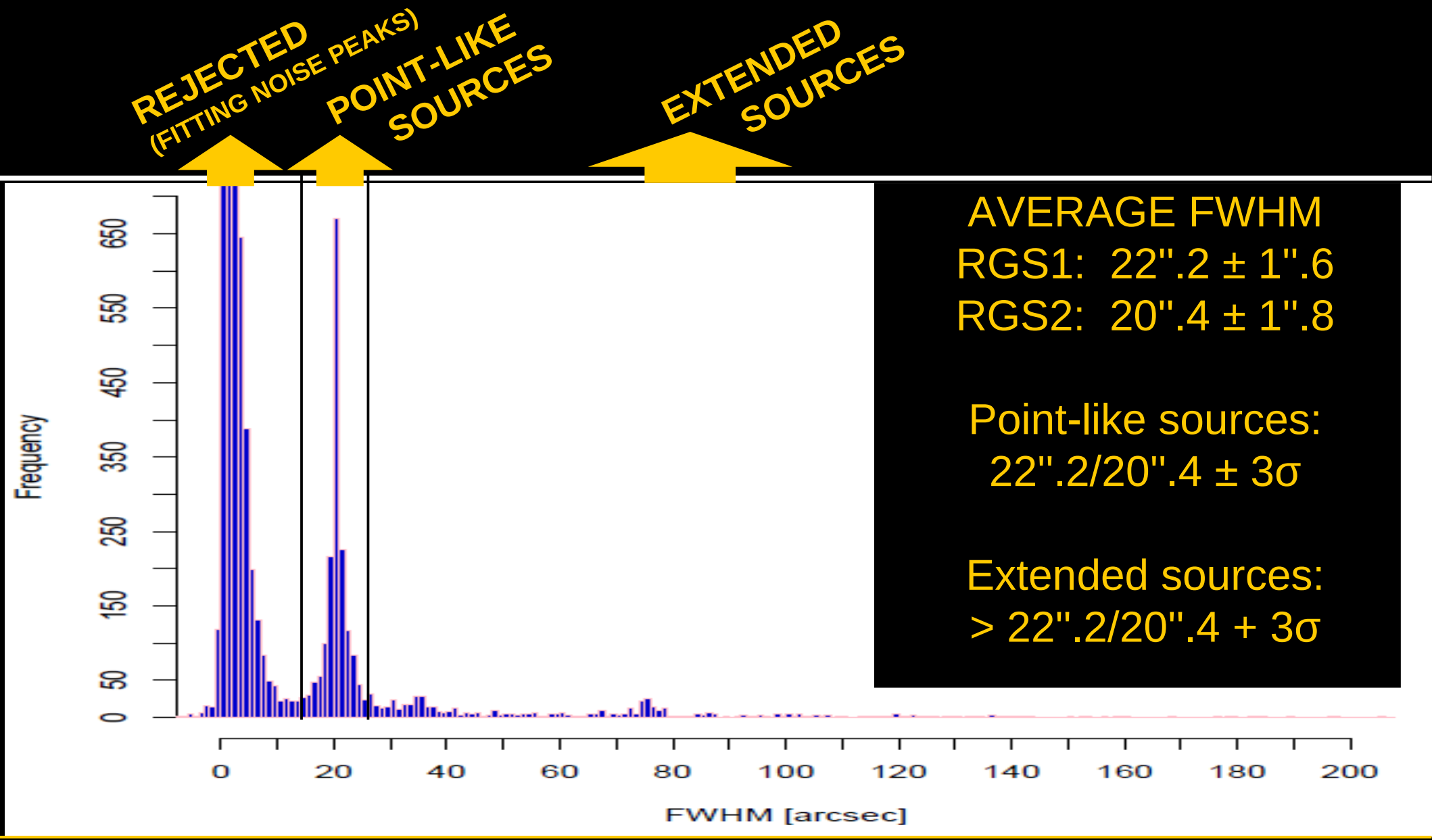
QUALITY:	OBSERVATIONS	% of useful
TOP QUALITY	2421	48
LOWER QUALITY	2624	52

number of useful spectra

Criteria:	RGS1	RGS2	RGS1 or RGS1
The Gaussian parameters	2706	2332	3079
The S/N ratio	3263	4183	4347
All criteria	1796	1915	2259

SPATIAL EXTENT classification

Distribution of the widths (FWHM) of the spatial profiles

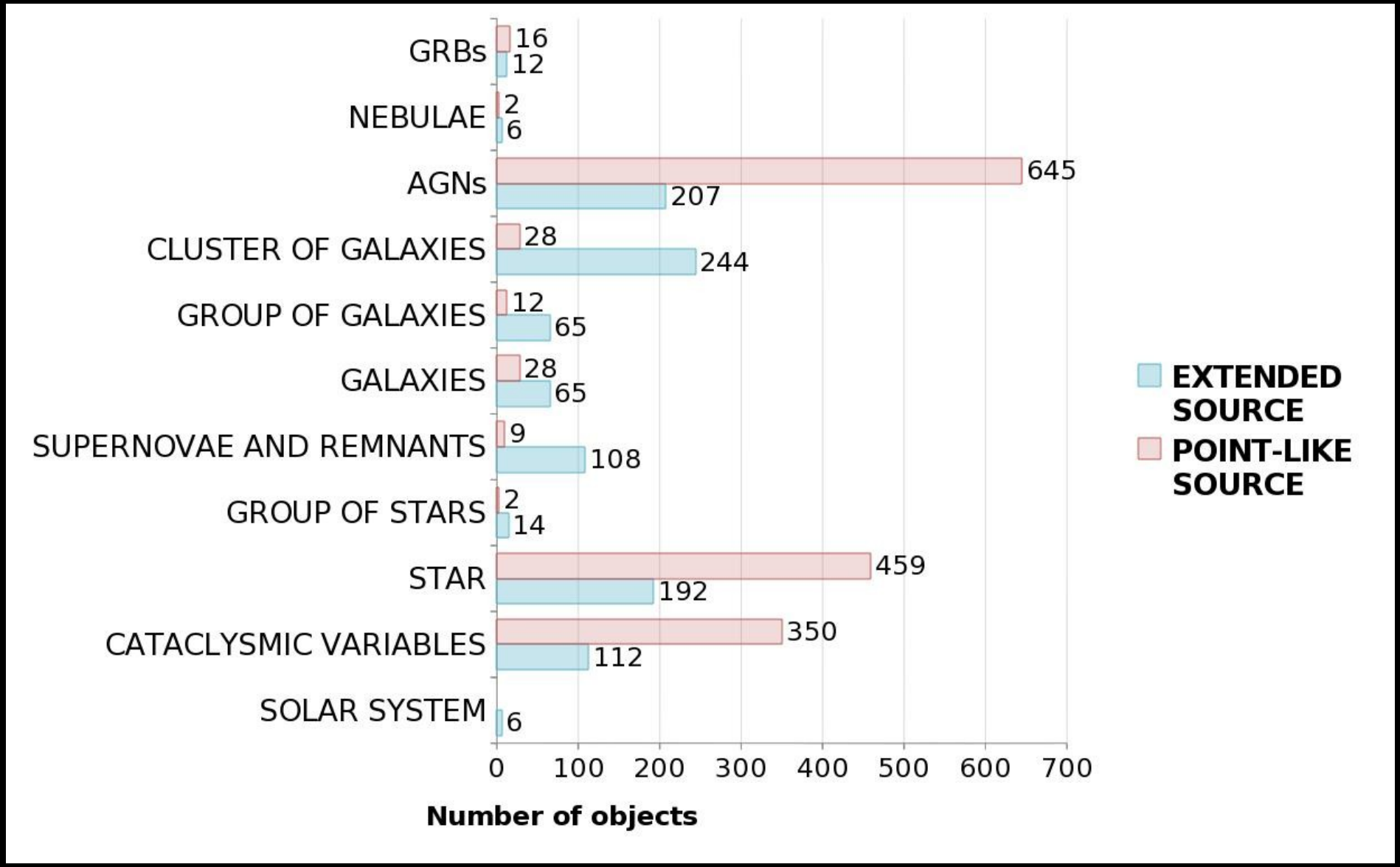


AVERAGE FWHM
RGS1: 22".2 ± 1".6
RGS2: 20".4 ± 1".8

Point-like sources:
22".2/20".4 ± 3σ

Extended sources:
> 22".2/20".4 + 3σ

PROFILE EXTENSION classification

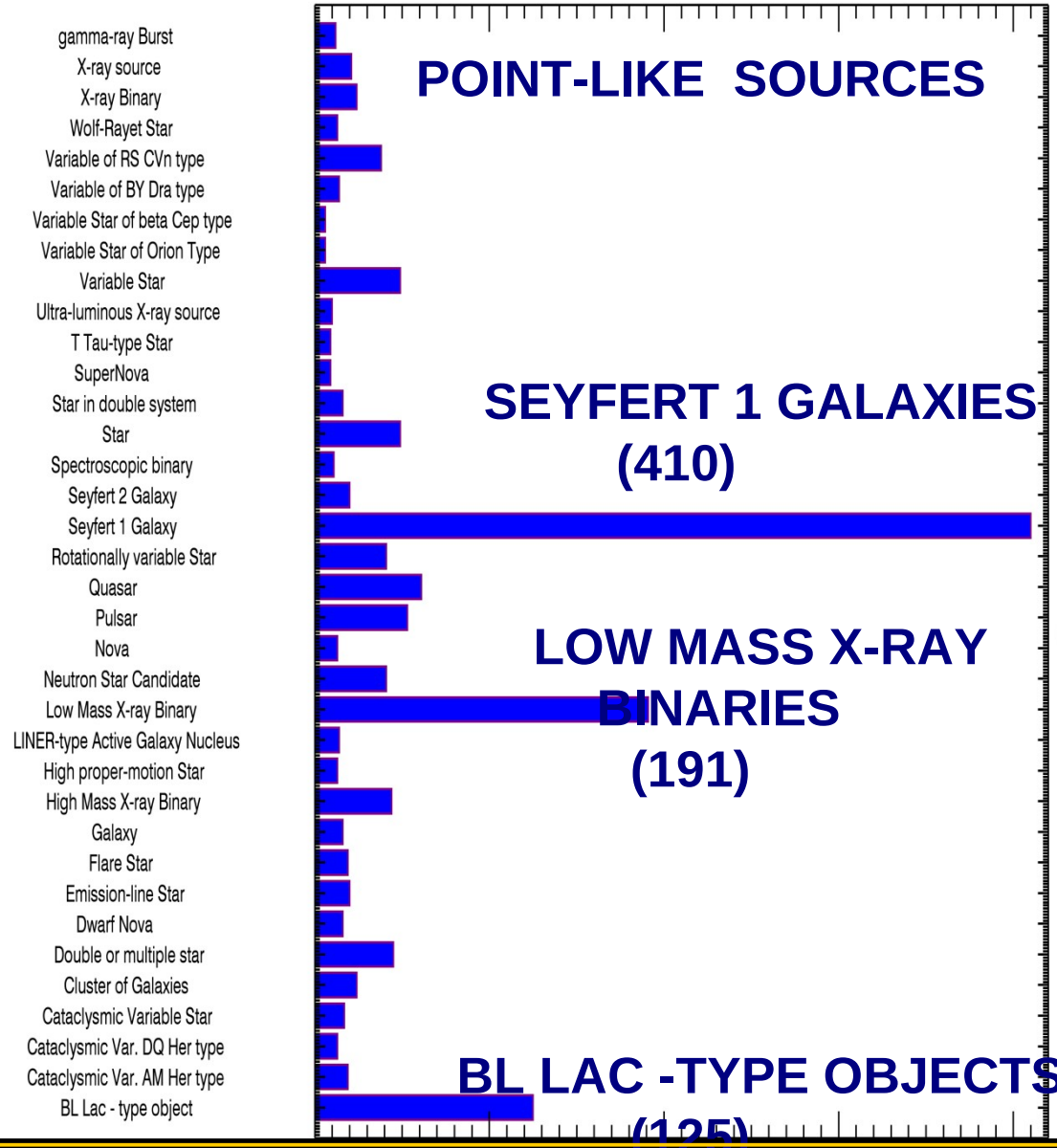


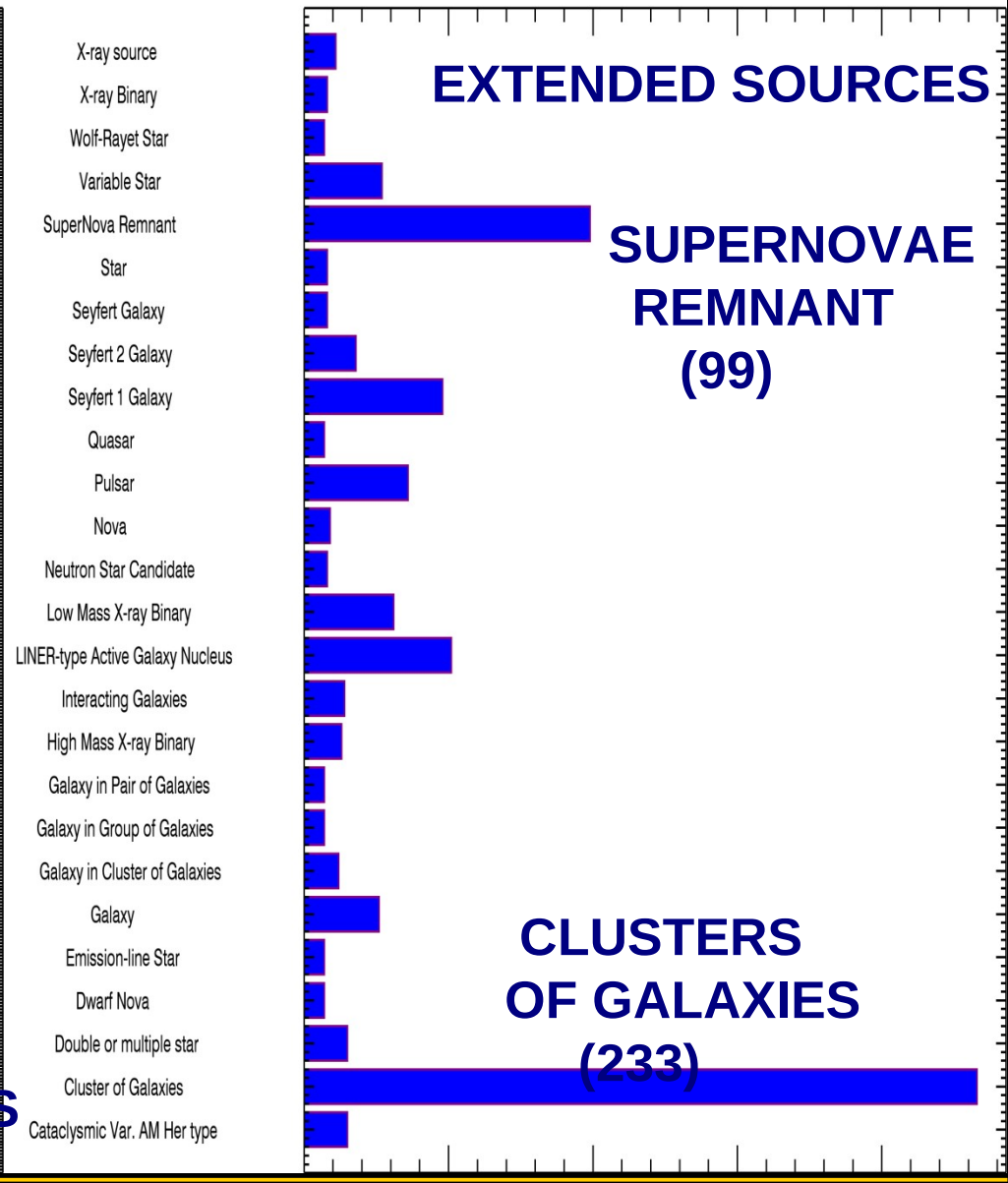
(RGS1)
ALL USEFUL SPECTRA

Object types distribution

TOP QUALITY

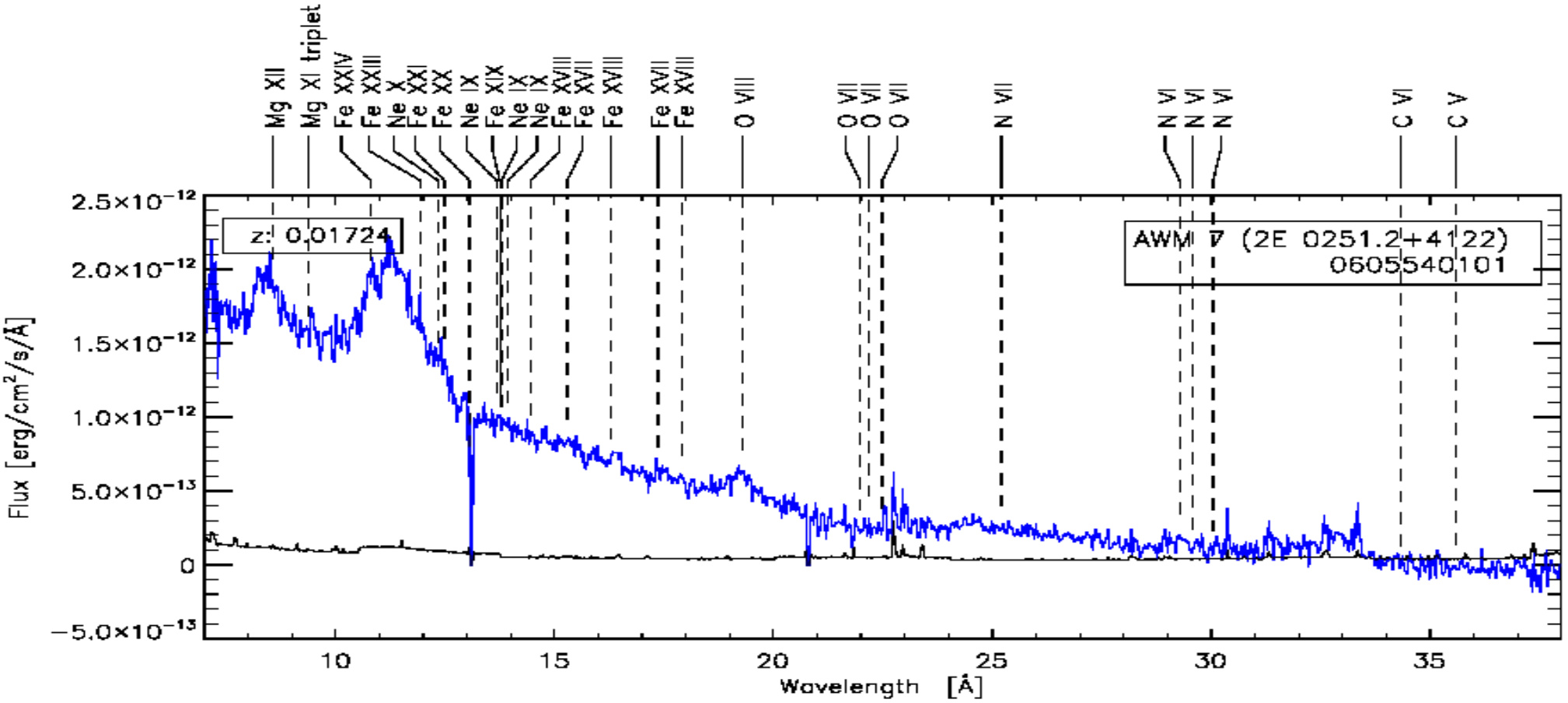
MOST FREQUENT OBJECTS



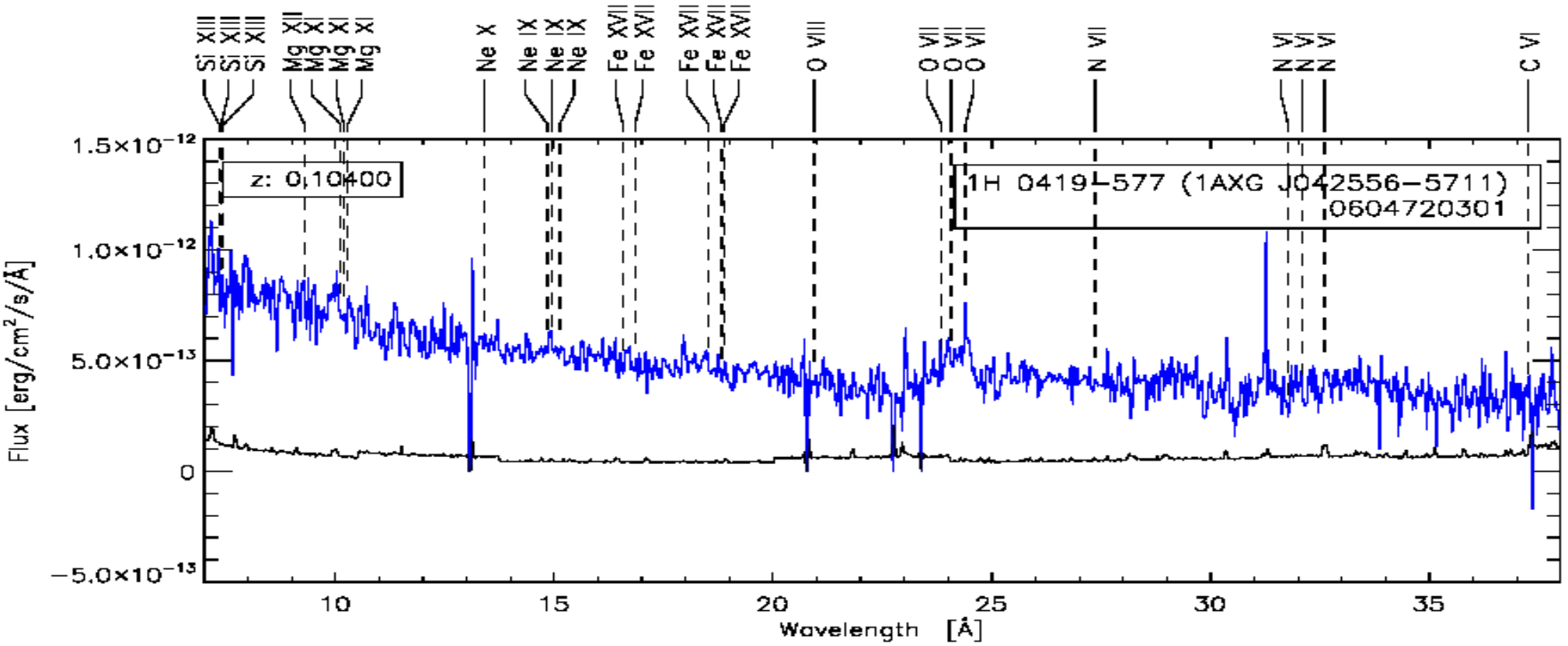


SPECTRA

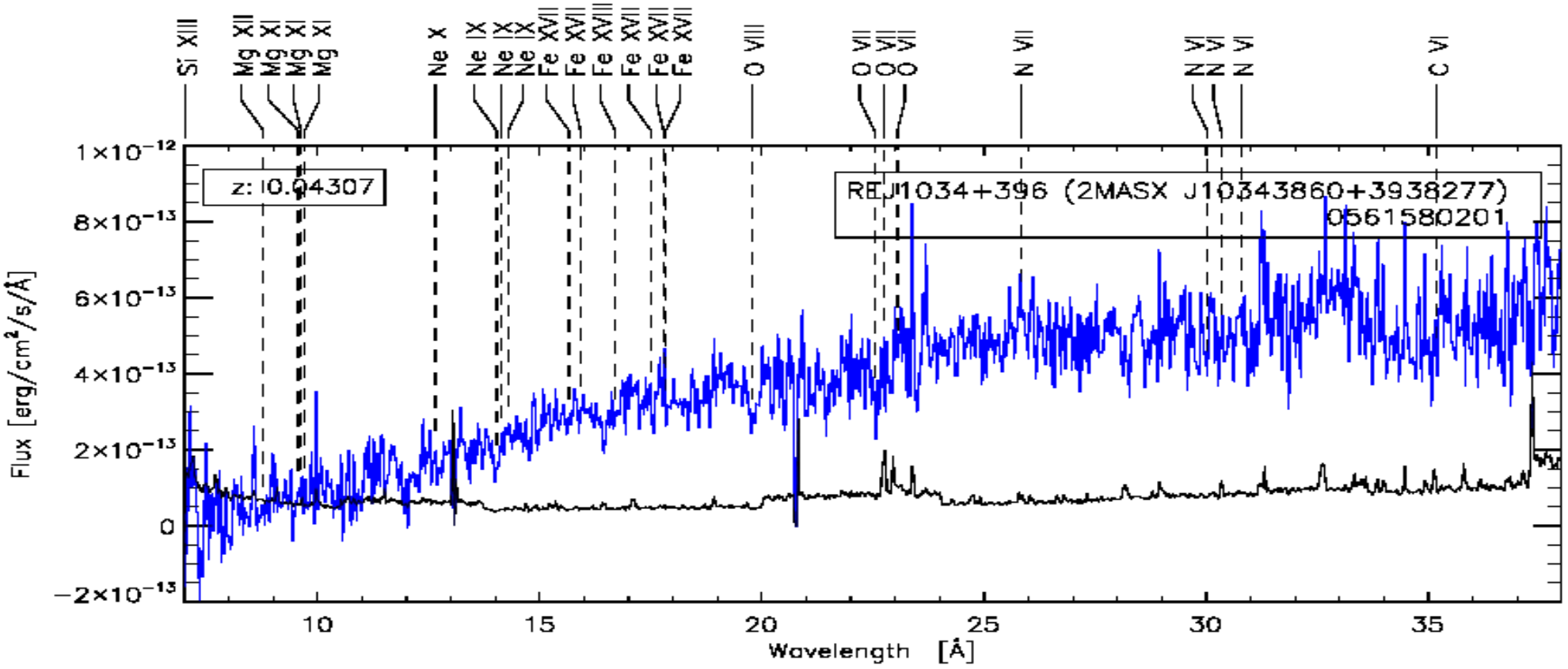
Clusters of Galaxies



Seyfert 1 Galaxies

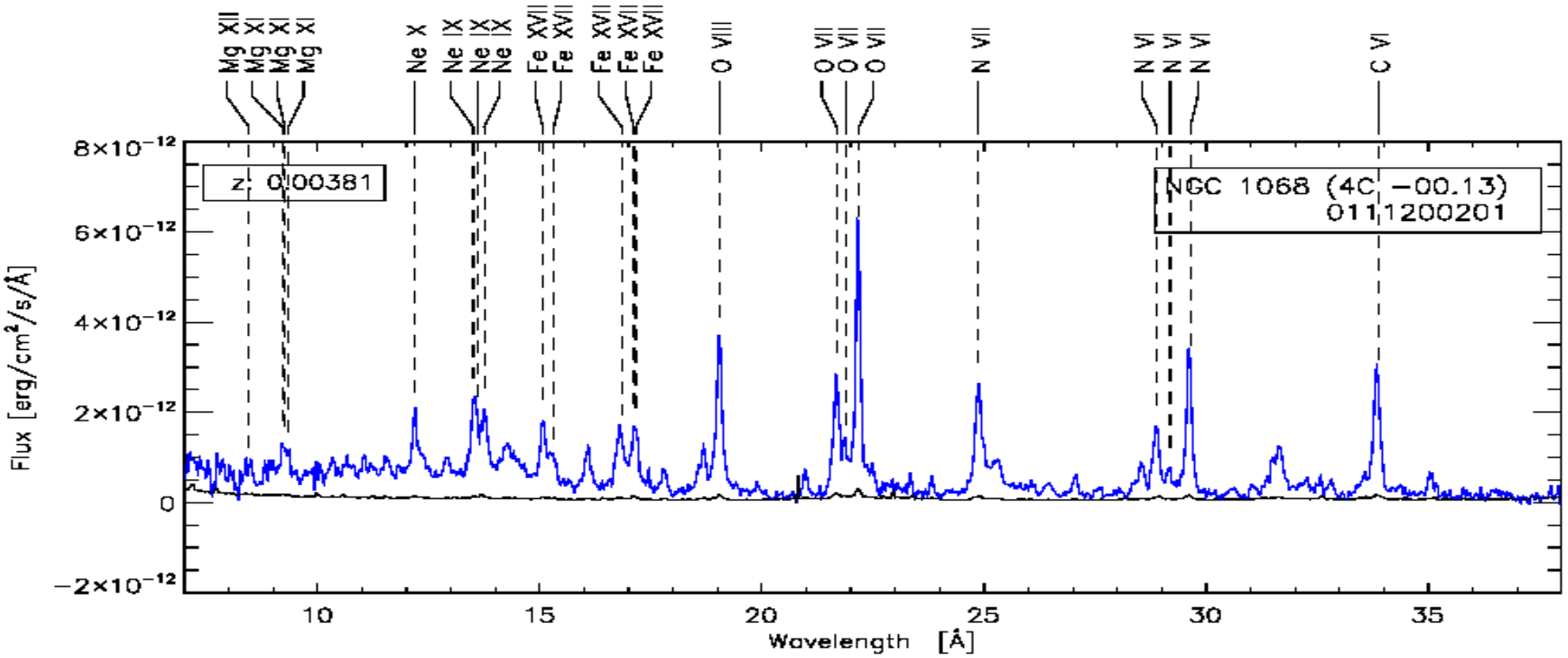


Seyfert 1 Galaxies

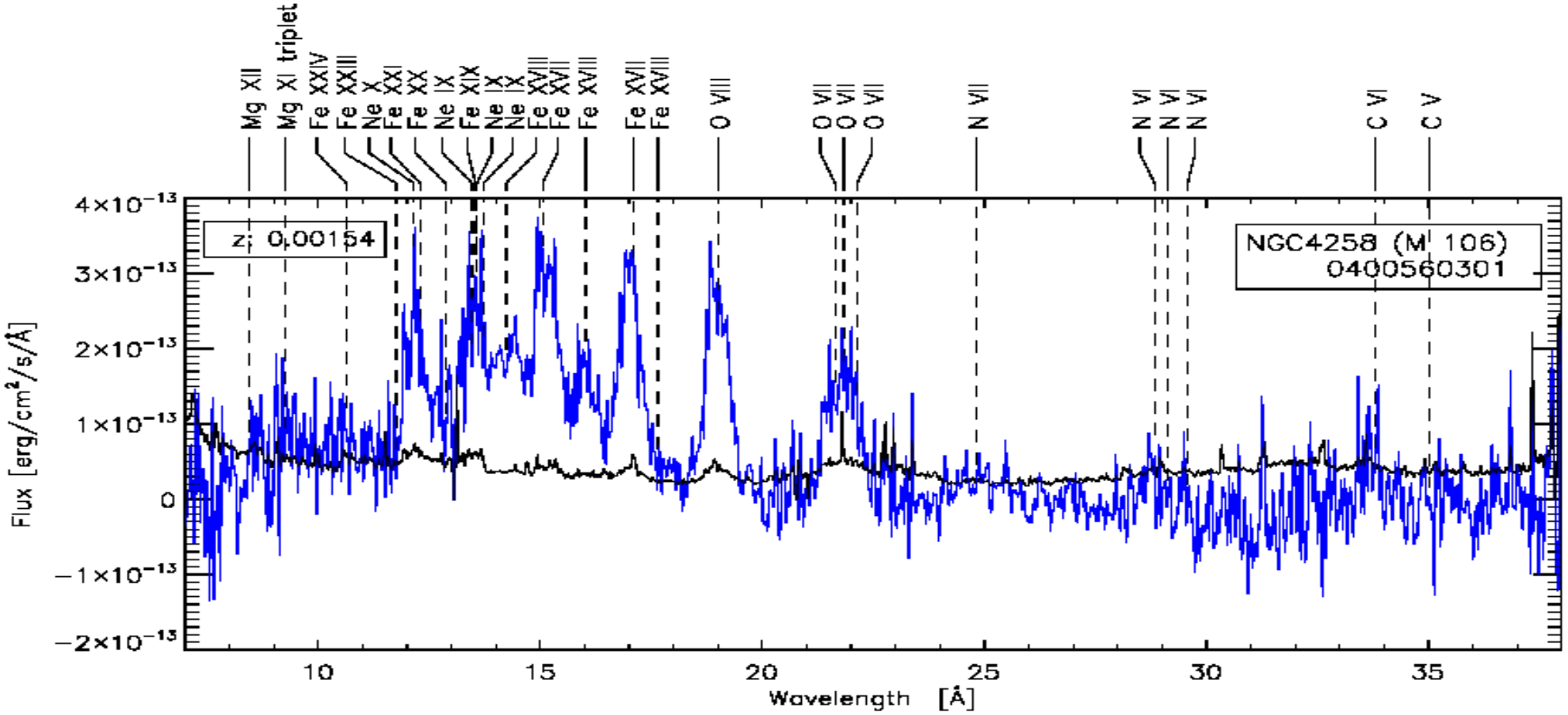


High state / Low state

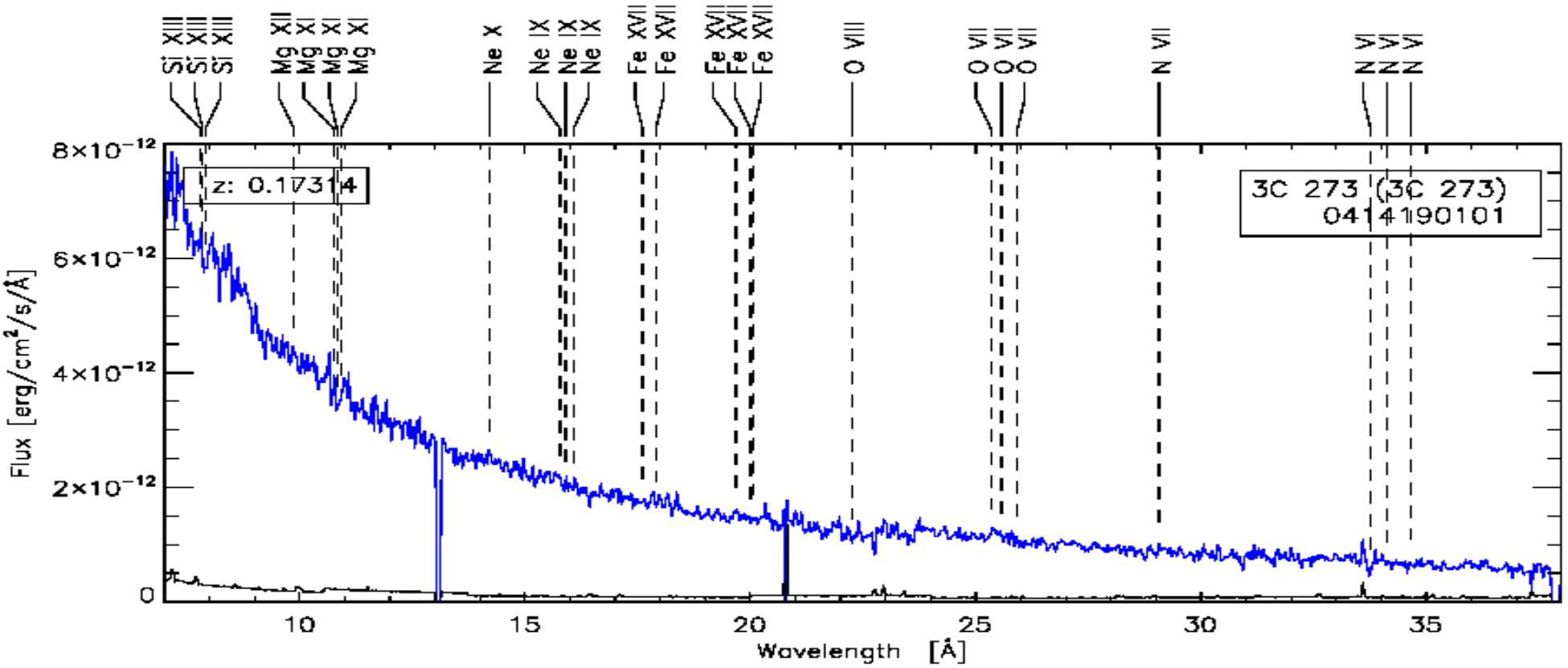
Seyfert 2 Galaxies



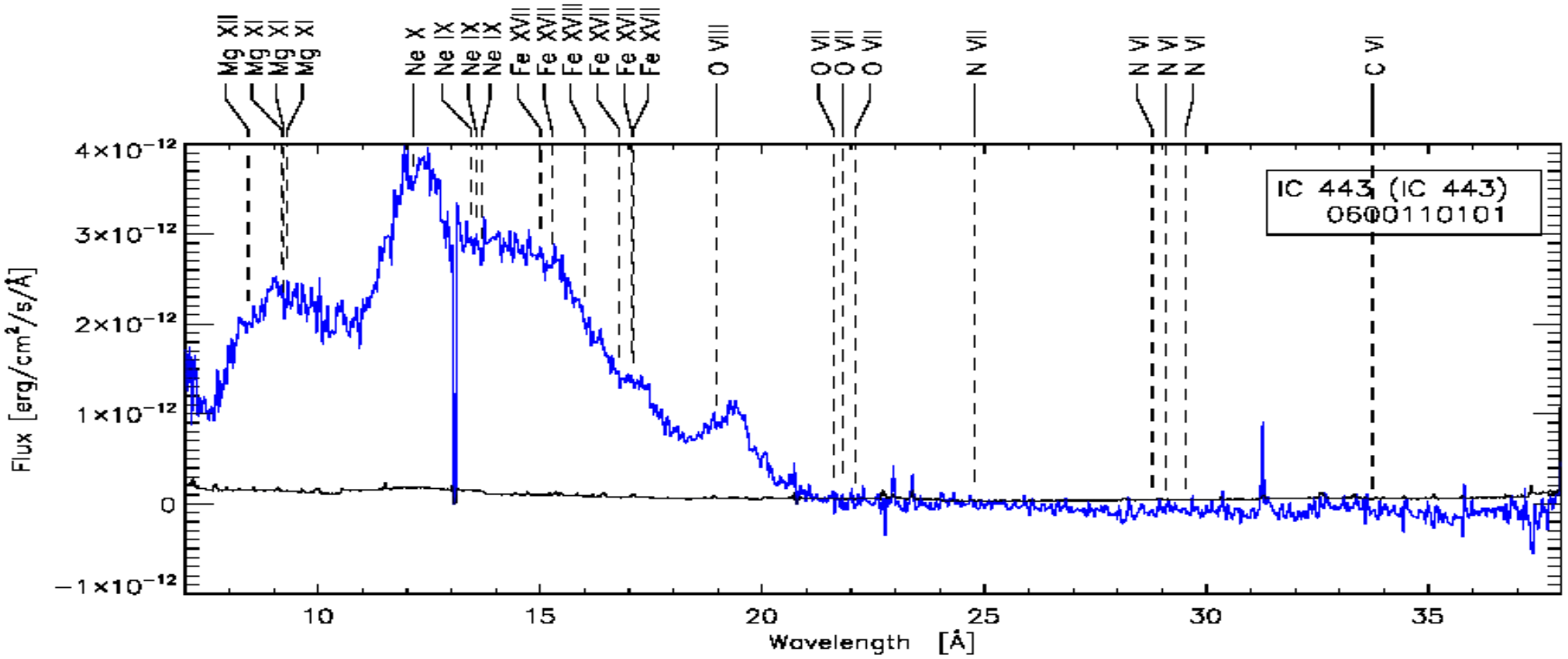
LINERs


Mg XII
Mg XI triplet
Fe XXIV
Fe XXIII
Ne X
Fe XXI
Fe XX
Ne IX
Fe XIX
Ne IX
Ne IX
Fe XVIII
Fe XVII
Fe XVIII
Fe XVII
Fe XVIII
O VIII
O VII
O VII
O VII
N VII
N VI
N VI
N VI
C VI
C V
z: 0.00154
NGC4258 (M 106)
0400560301
Flux [erg/cm²/s/Å]
4×10⁻¹³
3×10⁻¹³
2×10⁻¹³
1×10⁻¹³
0
−1×10⁻¹³
−2×10⁻¹³
10
15
20
25
30
35
Wavelength [Å]

QSOs

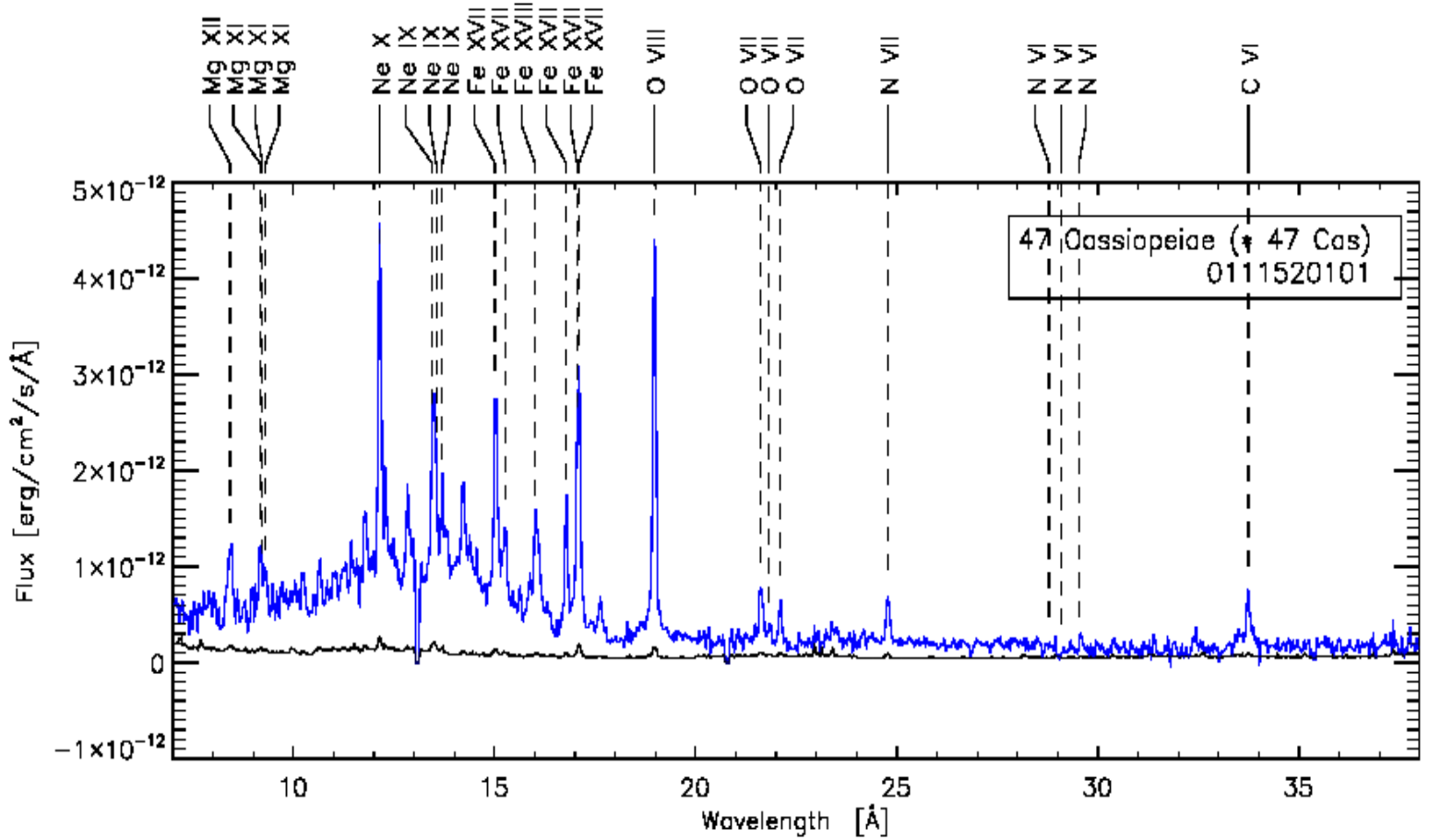

Si XIII
Si XIII
Si XIII
Mg XII
Mg XI
Mg XI
Mg XI
Ne X
Ne IX
Ne IX
Ne IX
Fe XVII
Fe XVII
Fe XVII
Fe XVII
Fe XVII
O VIII
O VII
O VII
O VII
N VII
Ni XX
Ni XX
Ni XX
z: 0.173114
3C 273 (3C 273)
0414190101
8×10⁻¹²
6×10⁻¹²
4×10⁻¹²
2×10⁻¹²
0
Flux [erg/cm²/s/Å]
10
15
20
25
30
35
Wavelength [Å]

SNRs

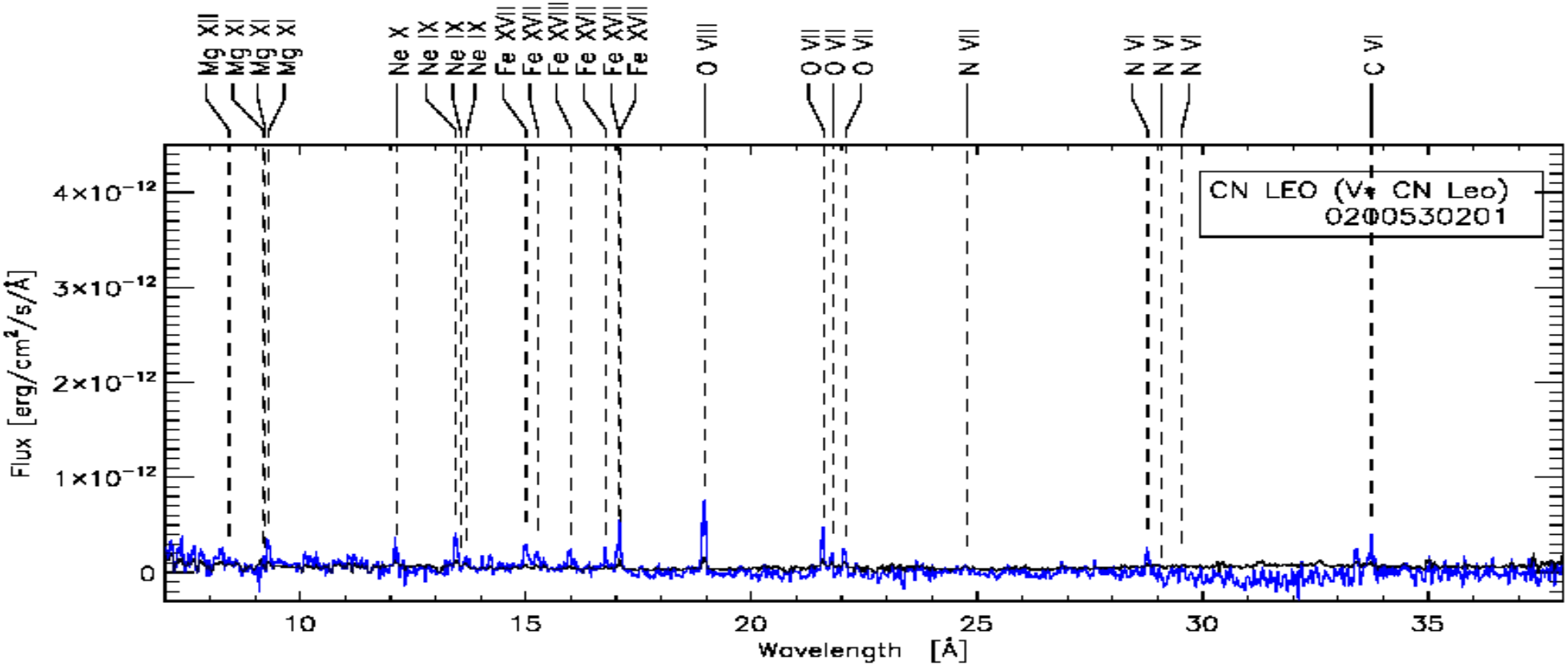

Mg XII
Mg XI
Mg XI
Mg XI
Ne X
Ne IX
Ne IX
Ne IX
Fe XVII
Fe XVII
Fe XVIII
Fe XVII
Fe XVII
Fe XVII
O VIII
O VII
O VII
O VII
N VII
N VI
N VI
N VI
C VI
IC 443 (IC 443)
0600110101
4×10⁻¹²
3×10⁻¹²
2×10⁻¹²
1×10⁻¹²
0
−1×10⁻¹²
Flux [erg/cm²/s/Å]
10
15
20
25
30
35
Wavelength [Å]

Emission lines Stars

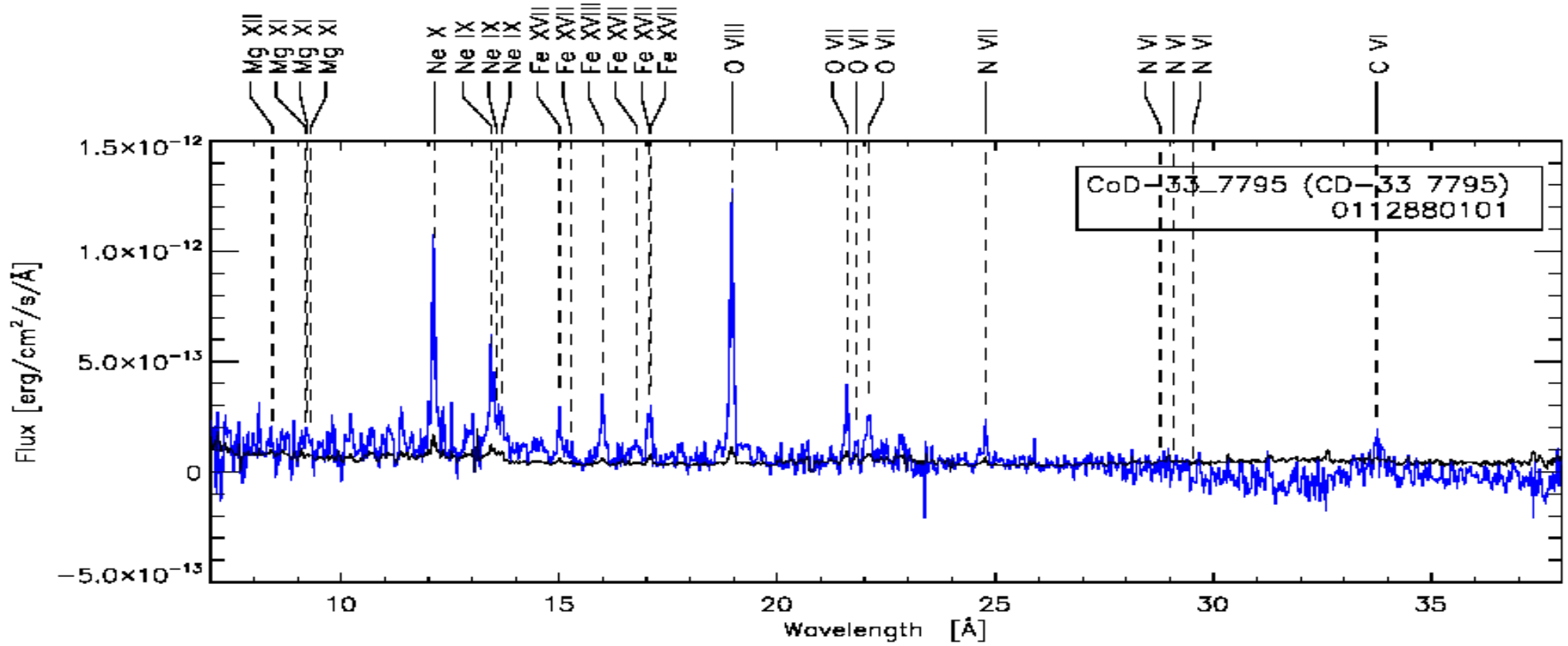
Star
Flare Star
Variable Star
-of BY Dra
-of RS CVn
-of BY Dra
-of Orion Type
-of beta Cep type
-Rotationally
T Tau-type Star
Eclipsing binary
-of Algol type
-of W Uma type
Spectroscopic binary
Star in double system
Double or multiple star
High proper-motion Star
Pre-main sequence Star



Flare Stars

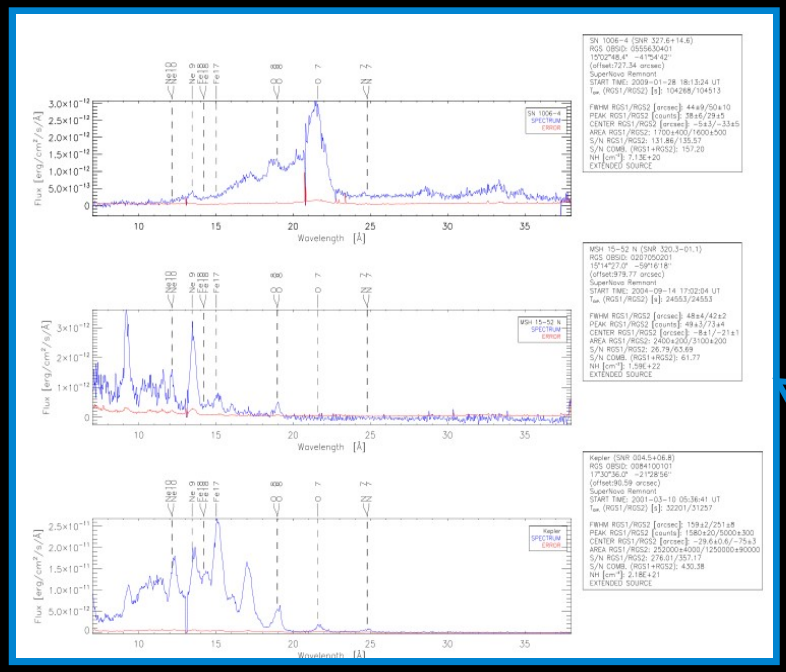

Mg XII
Mg XI
Mg XI
Mg XI
Ne X
Ne IX
Ne IX
Ne IX
Fe XVII
Fe XVII
Fe XVIII
Fe XVII
Fe XVII
Fe XVII
O VIII
O VII
O VII
O VII
N VII
N VI
N VI
N VI
C VI
CN LEO (V* CN Leo)
0200530201
Flux [erg/cm²/s/Å]
4×10⁻¹²
3×10⁻¹²
2×10⁻¹²
1×10⁻¹²
0
10
15
20
25
30
35
Wavelength [Å]

T Tau-type Stars



Web page

Catalogue & atlas of useful RGS spectra



WILL BE AVAILABLE THROUGH THE BIRD WEB PAGE

http://xmm.esac.esa.int/BiRD/

ANNOUNCED IN THE XMM-NEWTON NEWSLETTER

The RGS Spectral Atlas - Mozilla Firefox

Firefox | The RGS Spectral Atlas

The RGS Spectral Atlas

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María Santos-Lleó
Rosario González-Riestra
XMM- Newton Science Operations Centre

Introduction ->

1. Solar System ->
2. Stars ->
3. Groups of stars ->
4. Cataclysmic Variables ->
5. Supernovae and Remnants ->

Type	Top Spectra	Other Spectra	All spectra
SuperNova Remnant	Download PDF	Download PDF	Download PDF
SuperNova	Download PDF	Download PDF	Download PDF
SuperNova Remnant Candidate	N/A	Download PDF	Download PDF

All Supernovae and Remnants	Download PDF	Download PDF	Download PDF

6. Nebulae ->

Conclusions:

Atlas shows:

Great potential of RGS data in archive
+ 5000 useful observations
+ 2400 very good quality

→ **Some object classes show:**
similar spectral properties
(continuum shape/emission lines)

→ **While at the same time some object classes show:**
great diversity in spectral properties
(continuum shape/emission lines)

→ **Some object types show significant changes in:**
Spectral properties and flux

→ **Some object types show:**
constant properties

What can be done in future

The interpretation of the observations in terms
of physical properties and mechanisms

For instance:

Different abundances for different objects in same class / different classes
eg. SNR with or without Fe

Different ionization eg. Fe XXIV in some objects

Intrinsic variability eg. Flare Stars

Environment eg. Absorption due to cloud crossing the line of sight in some AGNs