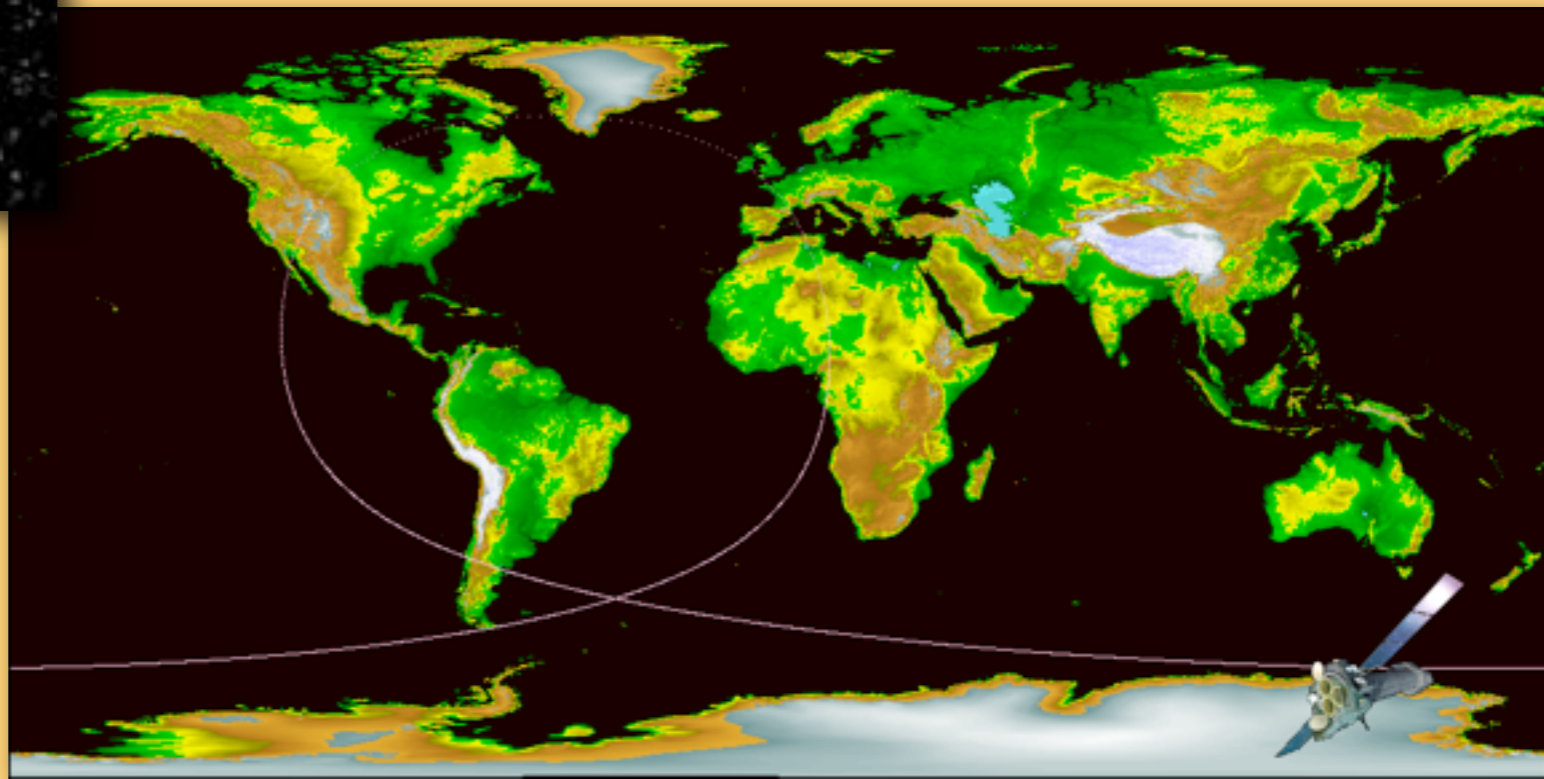


# XMM-Newton Tutorial



Eleonora Torresi

INAF/IASF Bologna

previously from Barbara De Marco

27.11.2013

# OUTLINE

Lab X 2013

□ How to download XMM-Newton data from the public archive

□ PN, MOS1 and MOS2 data reduction:

- selection of *Good Time Intervals (GTI)*
- generation of the cleaned event file
- source and background regions selection
- check for the presence of pile-up
- spectrum extraction (of both source and background)
- creation of the *Response Matrix Function (RMF)*
- creation of the *Ancillary Response Function (ARF)*
- grouping of the spectra

# 1. How to download XMM-Newton data from the public archive

XMM-Newton Science Operations Centre (ESA-Vilspa, Spain)

<http://xmm.esac.esa.int/xsa/>

The screenshot shows the XMM-Newton Science Archive (XSA) website. The browser is Firefox, and the address bar shows [xmm.esac.esa.int/xsa/](http://xmm.esac.esa.int/xsa/). The page features the ESA logo and navigation menus for various mission areas. The main content area is titled "XMM-Newton Science Archive (XSA)" and includes an "Index" section with a list of links:

- Access to XMM-Newton Data and Source Catalogues
- Tools
- Download Full XMM-Newton Catalogues
- Radiation Monitor Data Files
- Documentation
- Notes on the XSA v8.0 release
- Questions, Comments

Below the index is a section titled "Web Interface access to XMM-Newton Data and Source Catalogues" which contains two buttons:

- [Search the XMM-Newton Science Archive \(XSA\)](#)
- [AIO tool for direct access to the XSA database](#)

The page also includes a sidebar with various links such as "Home Page", "News", "General User Support", "Proposers Info", "Observers Info", and "Data Analysis".

# 1. How to download XMM-Newton data from the public archive

XMM-Newton Science Operations Centre (ESA-Vilspa, Spain)

<http://xmm.esac.esa.int/xsa/>

The screenshot shows the XMM-Newton Science Archive (XSA) website in a Firefox browser window. The browser's address bar displays `xmm.esac.esa.int/xsa/`. The website header features the ESA logo and the text "XMM-Newton European Space Agency". A navigation menu includes categories like "Astrophysics Missions", "Planetary Exploration Missions", "Solar Terrestrial Science Missions", "Fundamental Physics Missions", and "Science Faculty". The main content area is titled "XMM-Newton Science Archive (XSA)" and contains an "Index" section with a list of links: "Access to XMM-Newton Data and Source Catalogues", "Tools", "Download Full XMM-Newton Catalogues", "Radiation Monitor Data Files", "Documentation", "Notes on the XSA v8.0 release", and "Questions, Comments". Below the index is a section titled "Web Interface access to XMM-Newton Data and Source Catalogues" which contains two buttons: "Search the XMM-Newton Science Archive (XSA)" and "AIO tool for direct access to the XSA database". A red arrow points to the "AIO tool for direct access to the XSA database" button. The browser's taskbar at the bottom shows various application icons.

# 1. How to download XMM-Newton data from the public archive

XMM-Newton Science Operations Centre (ESA-Vilspa, Spain)

<http://xmm.esac.esa.int/xsa/>

The screenshot shows the XMM-Newton Science Archive search page in a Firefox browser. The browser's address bar shows the URL `nxsa.esac.esa.int/nxsa-web/#search`. The page features a navigation menu with links for HOME, SEARCH, AIO SYSTEM, CATALOGUES AND TOOLS, DOCUMENTATION, USER GUIDE, and CONTACT. The main content area is titled "XMM-Newton Science Archive Search" and includes a search form with the following elements:

- Position and File tabs.
- Radio buttons for Name (selected), Equatorial, Galactic, and Ecliptic.
- Target in options: Field Of View (selected), Circle, and Box.
- Input fields for Name and a dropdown menu for Simbad.
- Expandable sections for "Observation and Proposal filters" and "Display options".
- A "Reset Form" link.
- Buttons for "Catalogue Search >" and "Submit".

The footer of the page contains the text: "Copyright © ESA | ESAC | Science Archives Team v8.0 (23-Jul-2013 10:50)".

# 1. How to download XMM-Newton data from the public archive

XMM-Newton Science Operations Centre (ESA-Vilspa, Spain)

<http://xmm.esac.esa.int/xsa/>

The screenshot shows the XMM-Newton Science Archive search interface. The browser is Firefox, and the page title is "XMM-Newton Science Archive Search". The search form is filled with the following information:

- Position:** Name (selected), Equatorial, Galactic, Ecliptic
- Target in:** Field Of View (selected), Circle, Box
- Name:** NGC6251
- for Simbad:** (dropdown menu)

Below the search form are sections for "Observation and Proposal filters" and "Display options", both with expandable arrows. A "Reset Form" link is located at the bottom right of the form. At the bottom of the page, there are two buttons: "Catalogue Search >" and "Submit". The footer of the page reads: "Copyright © ESA | ESAC | Science Archives Team v8.0 (23-Jul-2013 10:50)".

# 1. How to download XMM-Newton data from the public archive

XMM-Newton Science Operations Centre (ESA-Vilspa, Spain)


<http://xmm.esac.esa.int/xsa/>

The screenshot displays the XMM-Newton Science Archive search interface. The browser window shows the URL `nxsa.esac.esa.int/nxsa-web/#search`. The page title is "XMM-Newton Science Archive Search". The search form includes a "Position" tab with radio buttons for "Name" (selected), "Equatorial", "Galactic", and "Ecliptic". The "Name" field contains "NGC6251". The "Target in" section has radio buttons for "Field Of View" (selected), "Circle", and "Box". Below the search form are sections for "Observation and Proposal filters" and "Display options". A "Submit" button is highlighted with a red arrow. The footer contains the text "Copyright © ESA | ESAC | Science Archives Team v8.0 (23-Jul-2013 10:50)".

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XMM-Newton Science Archive

nxsa.esac.esa.int/nxsa-web/#search

**XMM-Newton Science Archive** 





HOME SEARCH AIO SYSTEM CATALOGUES AND TOOLS DOCUMENTATION USER GUIDE CONTACT Sign in

Back to Search

Results #1

OBSERVATIONS (1)

Add to Basket Columns Save table as Send table to

<input type="checkbox"/>			Obs.ID	EPIC	RGS	Target	RA	Dec	PA	Rev	Distance	Start Date	End Date	Du
<input type="checkbox"/>			0056340201			NGC 6251	16h 32m 31.99s	+82d 32' 16.00"	63.1	420	0	2002-03-26 09:55:45	2002-03-26 23:56:53	5046

Page size: 100

Displaying 1-1 of 1

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XMM-Newton Science Archive

nxsa.esac.esa.int/nxsa-web/#search

# XMM-Newton Science Archive

HOME SEARCH AIO SYSTEM CATALOGUES AND TOOLS DOCUMENTATION USER GUIDE CONTACT

Sign in

Back to Search

Results #1

OBSERVATIONS (1)

Add to Basket Columns Save table as Send table to

<input type="checkbox"/>		Obs.ID	EPIC	RGS	Target	RA	Dec	P	Rev	Distance	Start Date	End Date	Du
<input checked="" type="checkbox"/>		0056340201			NGC 6251	16h 32m 31.99s	+82d 32' 16.00"	63	00	0	2002-03-26 09:55:45	2002-03-26 23:56:53	504

1 of 1 Page size: 100 Displaying 1-1 of 1

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XMM-Newton Science Archive

nxsa.esac.esa.int/nxsa-web/#search

# XMM-Newton Science Archive

esa

HOME SEARCH AIO SYSTEM CATALOGUES AND TOOLS DOCUMENTATION USER GUIDE CONTACT

Sign in

Back to Search

Results #1

OBSERVATIONS (1)

Add to Basket Columns Save table as Send table to

<input type="checkbox"/>		Obs.ID	EPIC	RGS	Target	RA	Dec	PA	Rev	Distance	Start Date	End Date	Du
<input checked="" type="checkbox"/>		0056340201			NGC 6251	16h 32m 31.99s	+82d 32' 16.00"	63.1	420	0	2002-03-26 09:55:45	2002-03-26 23:56:53	504

1 of 1 Page size: 100 Displaying 1-1 of 1

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XMM-Newton Science Archive

nxsa.esac.esa.int/nxsa-web/#search

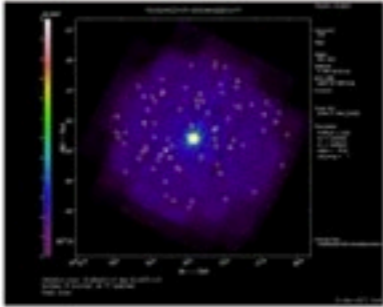
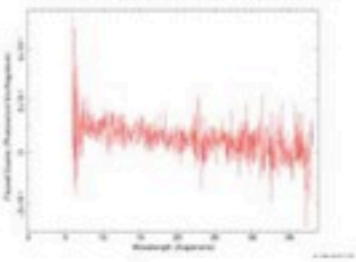
# XMM-Newton Science Archive

HOME SEARCH AIO SYSTEM CATALOGUES AND TOOLS DOCUMENTATION USER GUIDE CONTACT

Back to Search

Results #1

## Details for Observation 0056340201

Summary Exposures Publications

Obs. ID	0056340201
Revolution	420
Target	NGC 6251
Exposures	3 EPIC, 40 OM, 2 RGS

### Proposal Abstract

Most nearby galaxies host supermassive black holes, accreting at low rates in advection-dominated flows, or ADAFs. Depending on accretion rate and mass loss, hard X-ray continua and emission lines at soft and hard X-rays are expected in these systems. We propose XMM observations of the nearby low-power radio galaxies NGC 4261 and NGC 6251, the only radio-loud AGN, along with M87, hosting a supermassive black hole of known mass and where an ADAF may be occurring. Our proposed XMM observations will allow a detailed study of the hard X-ray continua and Fe lines detected in the ASCA data of NGC 4261 and NGC 6251, constraining the ADAF's dynamical and physical properties as a function of black hole mass and luminosity.

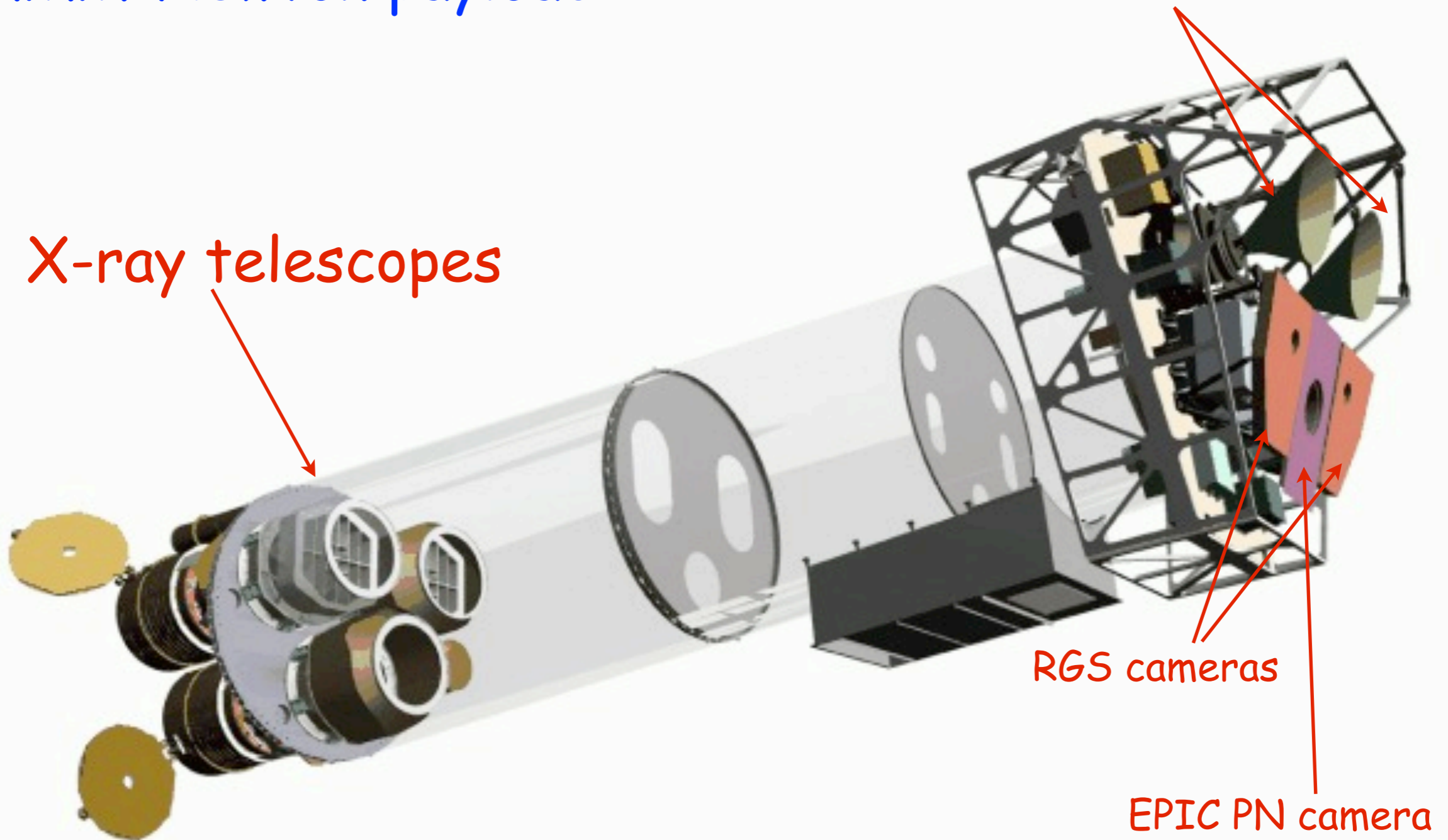
Show Quality Report

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# XMM-Newton payload

EPIC MOS cameras

X-ray telescopes



XMM-Newton payload

Image courtesy of Dornier Satellitensysteme GmbH

European Space Agency

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XMM-Newton Science Archive

Zimbra: In arrivo XMM-Newton Science Archive

nxsa.esac.esa.int/nxsa-web/#search xmm-newton archive

Plù visitati Come Iniziare Ultime notizie Astrophysics Astronomy Pictu... NASA/IPAC Extr... La Repubblica.it SIMBAD HEASARC Web T... METEO

# XMM-Newton Science Archive

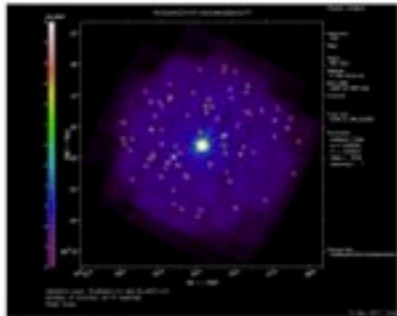
HOME SEARCH AIO SYSTEM CATALOGUES AND TOOLS DOCUMENTATION USER GUIDE CONTACT

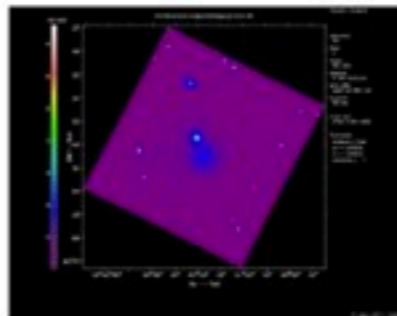
Basket etorresi

Back to Search

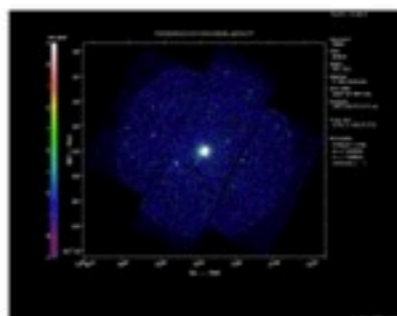
Results #1

## Details for Observation 0056340201

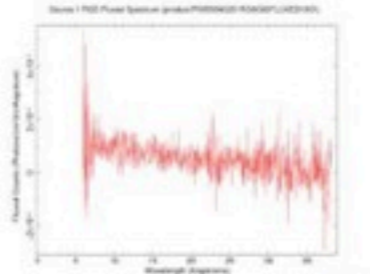




ExposureID	S006
Instrument	OM
Mode	Image
Filter	U



ExposureID	S001
Instrument	EMOS1
Mode	Full Frame
Filter	MEDIUM



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XMM-Newton Science Archive

Zimbra: In arrivo XMM-Newton Science Archive

nxsa.esac.esa.int/nxsa-web/#search xmm-newton archive

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# XMM-Newton Science Archive

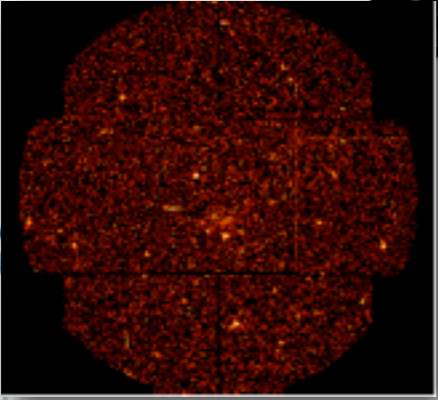
HOME SEARCH AIO SYSTEM CATALOGUES AND TOOLS DOCUMENTATION USER GUIDE CON

Back to Search

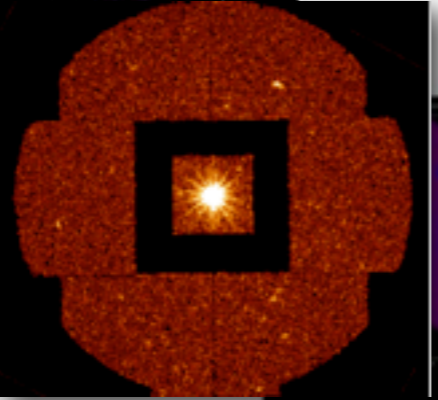
Results #1

Details for Observation

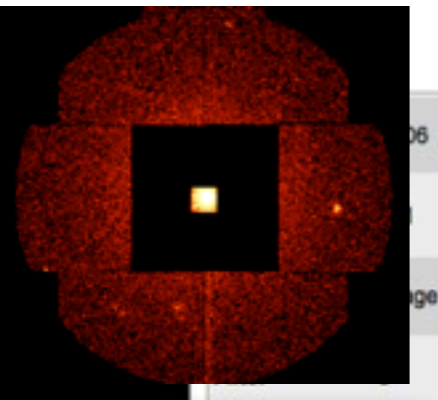
full frame




large window

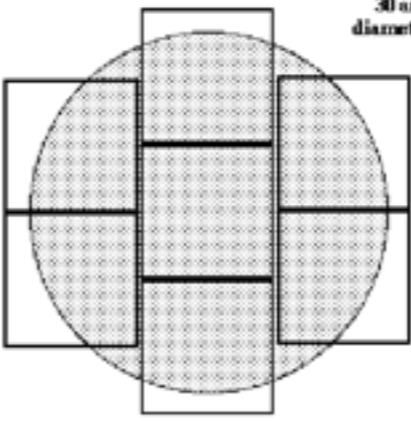


small window

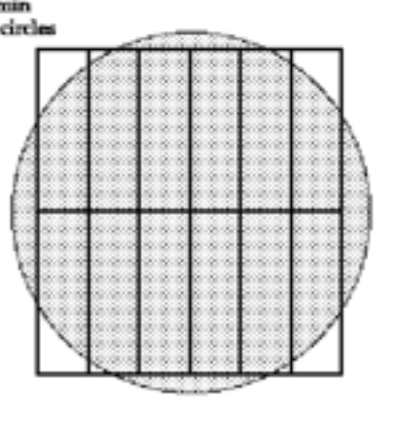


timing mode





EPIC MOS  
7 CCDs each 10.9 x 10.9 arcminutes



EPIC pn  
12 CCDs each 13.6 x 4.4 arcmin

MOS

pn

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XMM-Newton Science Archive

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# XMM-Newton Science Archive

esa

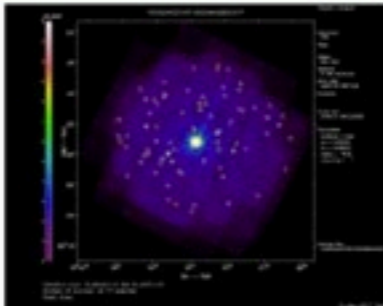
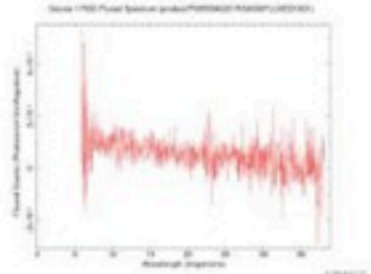
HOME SEARCH AIO SYSTEM CATALOGUES AND TOOLS DOCUMENTATION USER GUIDE CONTACT

Basket etorresi

Back to Search

Results #1

## Details for Observation 0056340201

Summary Exposures Publications

Title	BibCode
Long-Term X-Ray Monitoring of NGC 6251: Evidence for a Jet-dominated Radio Galaxy	2008ApJ...678...78G
An XMM-Newton study of the environments, particle content and impact of low-power radio galaxies	2008MNRAS.386.1709C
The XMM-Newton view of the X-ray halo and jet of NGC 6251	2004A&A...414..885S
The XMM-Newton view of NGC 6251	2004A&A...413..139G
XMM-Newton observations of a sample of gamma-ray loud active galactic nuclei	2006A&A...453..829F

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XMM-Newton Science Archive

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XMM-Newton Science Archive

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Basket etorresi

**Basket**

Type	Observation ID	Download Level	x
OBSERVATION	0056340201	ODF	x

**ODF (Observation Data Files):** row data that need to be reprocessed

**PPS (Processing Pipeline Files):** already reprocessed data using standard pipelines

Shopping Basket contains 1 item(s)

Empty Basket Retrieve data in TAR format Submit

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XMM-Newton Science Archive

nxsa.esac.esa.int/nxsa-web/#shoppingbasket

XMM-Newton Science Archive

HOME SEARCH AIO SYSTEM CATALOGUES AND TOOLS DOCUMENTATION USER GUIDE CONTACT

Basket etorresi

### Basket

Type	Observation ID	Download Level	x
OBSERVATION	0056340201	ODF	x

**ODF (Observation Data Files):** row data that need to be reprocessed


PPS  
Spectra  
Images  
Light curves

**PPS (Processing Pipeline Files):** already reprocessed data using standard pipelines

Shopping Basket contains 1 item(s)

Empty Basket Retrieve data in TAR format Submit

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```
Default
Last login: Mon Nov  5 02:15:04 on ttys000
[leonora@MacBook]~>cd Desktop/ANALISI/labX
[leonora@MacBook]labX>ls
0675400101
[leonora@MacBook]labX>
```

```
Default
Last login: Mon Nov  5 02:15:04 on ttys000
[leonora@MacBook]~>cd Desktop/ANALISI/labX
[leonora@MacBook]labX>ls
0675400101 → Observation ID
[leonora@MacBook]labX>
```

```
Default
Last login: Mon Nov  5 02:15:04 on ttys000
[leonora@MacBook]~>cd Desktop/ANALISI/labX
[leonora@MacBook]labX>ls
0675400101
[leonora@MacBook]labX> cd 0675400101
```

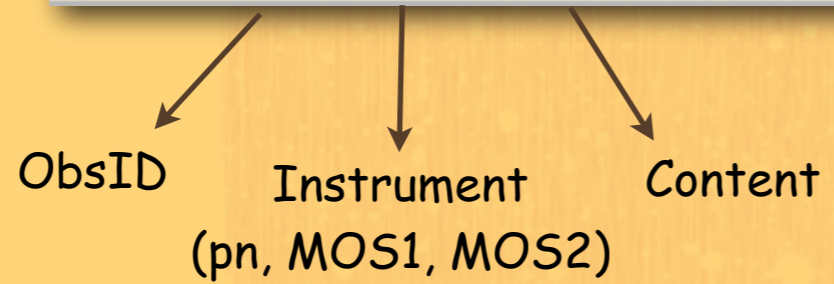
Observation ID

# ODF files

```
Default
[eleonora@MacBook]ODF>ls
2205_0675400101_M1S00100AUX.FIT 2205_0675400101_PNU101120DI.FIT
2205_0675400101_M1S00110IME.FIT 2205_0675400101_PNX00000HCH.FIT
2205_0675400101_M1S00120IME.FIT 2205_0675400101_PNX00000PAH.FIT
2205_0675400101_M1S00130IME.FIT 2205_0675400101_PNX00000PMH.FIT
2205_0675400101_M1S00140IME.FIT 2205_0675400101_R1S00400AUX.FIT
2205_0675400101_M1S00150IME.FIT 2205_0675400101_R1S00401SPE.FIT
2205_0675400101_M1S00170IME.FIT 2205_0675400101_R1S00402SPE.FIT
2205_0675400101_M1U00200AUX.FIT 2205_0675400101_R1S00403SPE.FIT
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```

Revolution  
number ←

FITS files



# FITS files

Data produced by the satellite are stored in **FITS (Flexible Image Transport System)** format.

# FITS files

Data produced by the satellite are stored in **FITS (Flexible Image Transport System)** format.

All the information of your observation are contained in the **header** of the fits file.

You can visualize it by using the FTOOL command **fv**:

```
> fv nomefile.fits
```

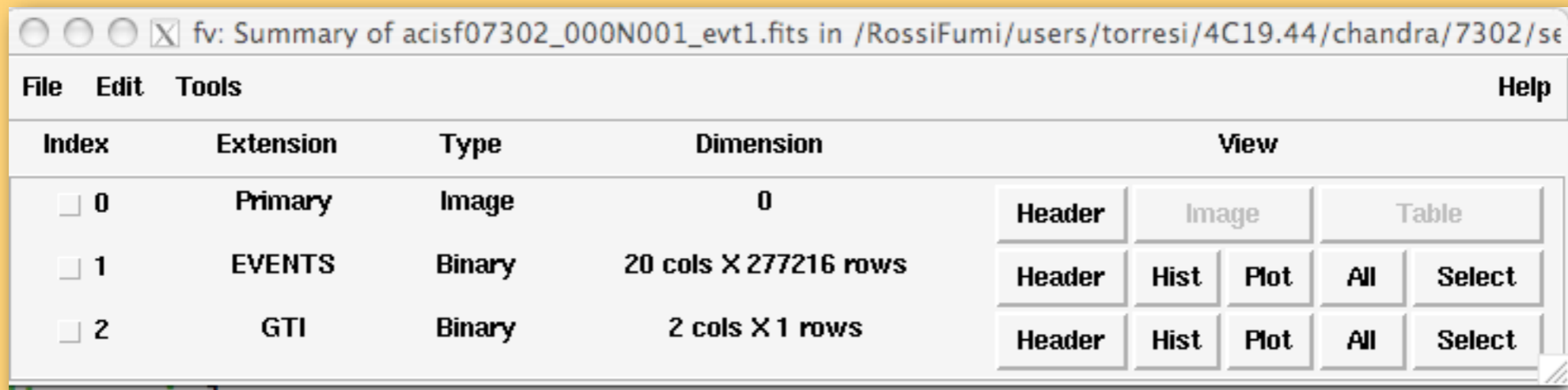
# FITS files

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All the information of your observation are contained in the **header** of the fits file.

You can visualize it by using the FTOOL command **fv**:

> fv nomefile.fits



The screenshot shows a window titled "fv: Summary of acisf07302\_000N001\_evt1.fits in /RossiFumi/users/torresi/4C19.44/chandra/7302/se". The window has a menu bar with "File", "Edit", "Tools", and "Help". Below the menu bar is a table with columns: "Index", "Extension", "Type", "Dimension", and "View".

Index	Extension	Type	Dimension	View
<input type="checkbox"/> 0	Primary	Image	0	Header Image Table
<input type="checkbox"/> 1	EVENTS	Binary	20 cols X 277216 rows	Header Hist Plot All Select
<input type="checkbox"/> 2	GTI	Binary	2 cols X 1 rows	Header Hist Plot All Select



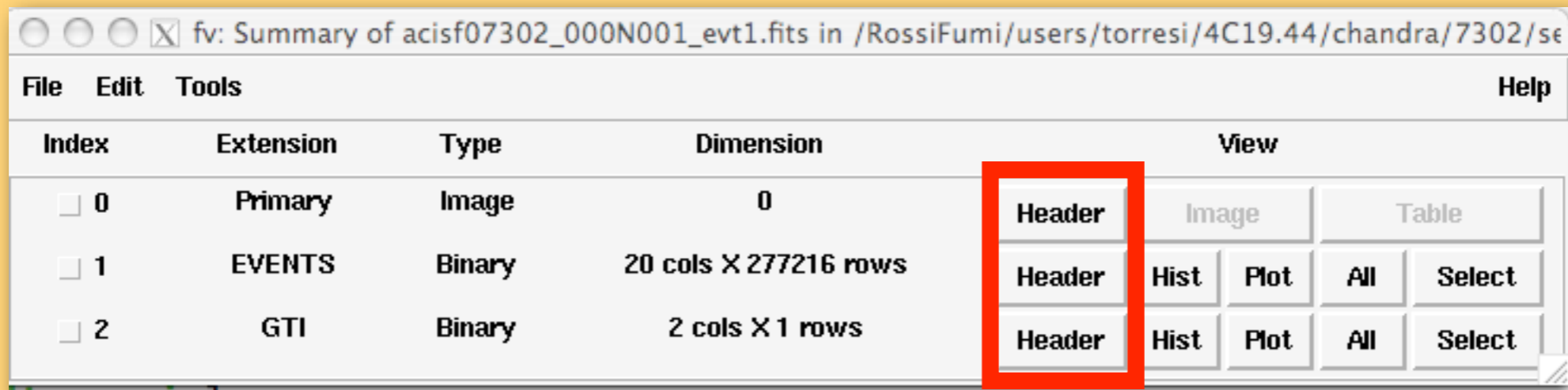
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All the information of your observation are contained in the **header** of the fits file.

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> fv nomefile.fits



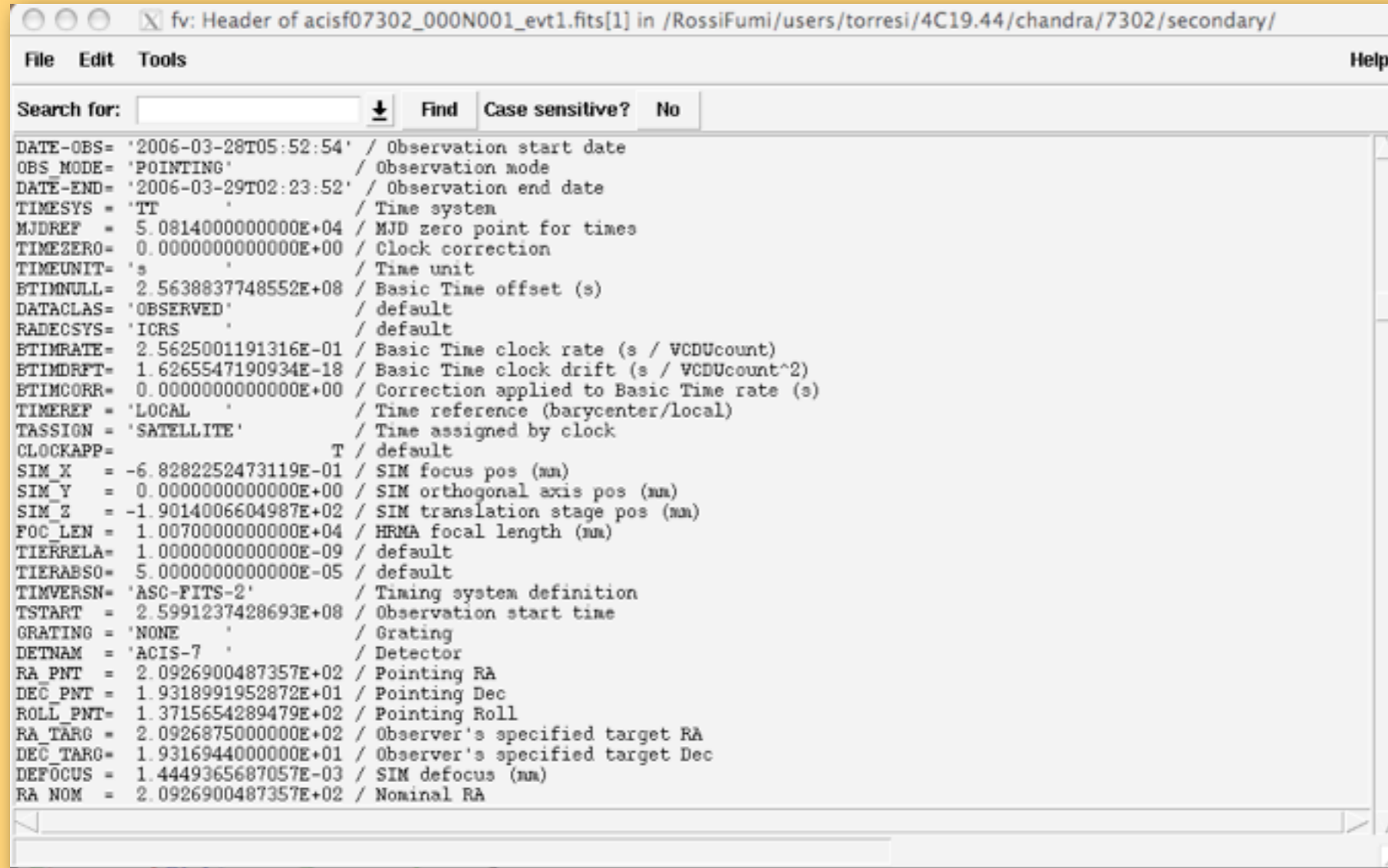
# FITS files

Data produced by the satellite are stored in **FITS (Flexible Image Transport System)** format.

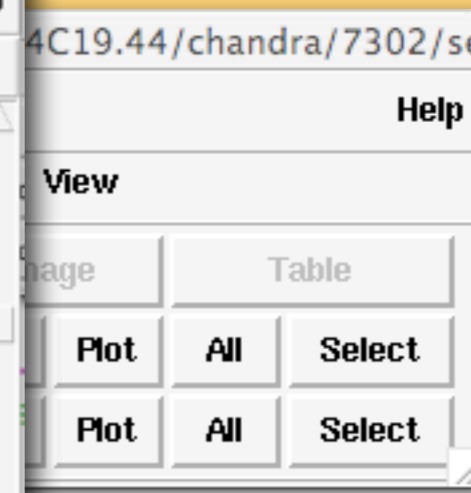
All the information of your observation are contained in the **header** of the fits file.

You can visualize it by using the FTOOL command **fv**:

> fv nomefile.fits



```
fv: Header of acisf07302_000N001_evt1.fits[1] in /RossiFumi/users/torresi/4C19.44/chandra/7302/secondary/
File Edit Tools Help
Search for: [ ] Find Case sensitive? No
DATE-OBS= '2006-03-28T05:52:54' / Observation start date
OBS MODE= 'POINTING' / Observation mode
DATE-END= '2006-03-29T02:23:52' / Observation end date
TIMESYS = 'TT' / Time system
MJDREF = 5.0814000000000E+04 / MJD zero point for times
TIMEZERO= 0.0000000000000E+00 / Clock correction
TIMEUNIT= 's' / Time unit
BTIMNULL= 2.5638837748552E+08 / Basic Time offset (s)
DATACLAS= 'OBSERVED' / default
RADECSYS= 'ICRS' / default
BTIMRATE= 2.5625001191316E-01 / Basic Time clock rate (s / VCDUcount)
BTIMDRFT= 1.6265547190934E-18 / Basic Time clock drift (s / VCDUcount^2)
BTIMCORR= 0.0000000000000E+00 / Correction applied to Basic Time rate (s)
TIMEREF = 'LOCAL' / Time reference (barycenter/local)
TASSIGN = 'SATELLITE' / Time assigned by clock
CLOCKAPP= T / default
SIM_X = -6.8282252473119E-01 / SIM focus pos (mm)
SIM_Y = 0.0000000000000E+00 / SIM orthogonal axis pos (mm)
SIM_Z = -1.9014006604987E+02 / SIM translation stage pos (mm)
FOC_LEN = 1.0070000000000E+04 / HRMA focal length (mm)
TIERRELA= 1.0000000000000E-09 / default
TIERABSO= 5.0000000000000E-05 / default
TIMVERSN= 'ASC-FITS-2' / Timing system definition
TSTART = 2.5991237428693E+08 / Observation start time
GRATING = 'NONE' / Grating
DETNAM = 'ACIS-7' / Detector
RA_PNT = 2.0926900487357E+02 / Pointing RA
DEC_PNT = 1.9318991952872E+01 / Pointing Dec
ROLL_PNT= 1.3715654289479E+02 / Pointing Roll
RA_TARG = 2.0926875000000E+02 / Observer's specified target RA
DEC_TARG= 1.9316944000000E+01 / Observer's specified target Dec
DEFOCUS = 1.4449365687057E-03 / SIM defocus (mm)
RA NOM = 2.0926900487357E+02 / Nominal RA
```



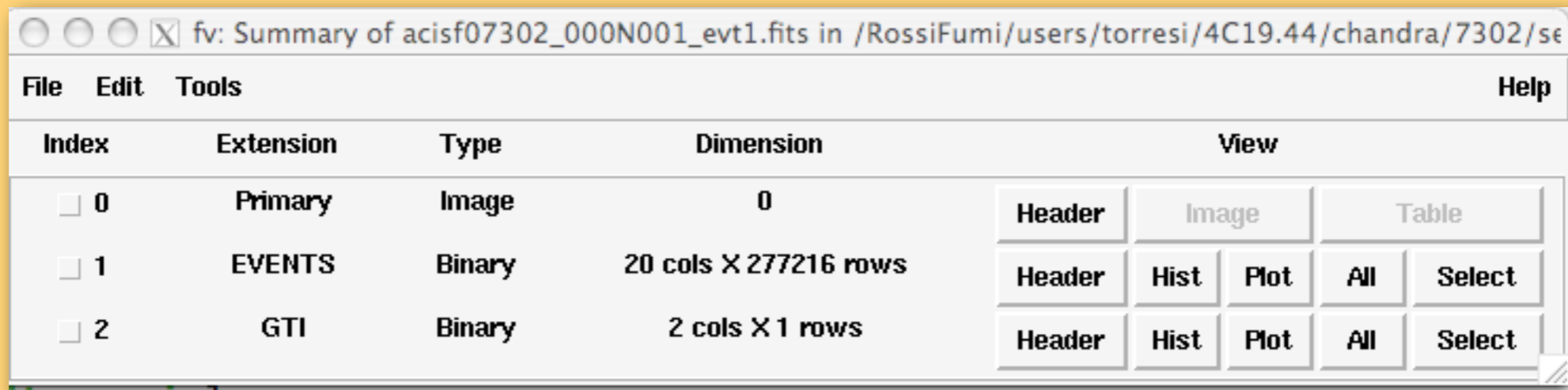
# FITS files

Data produced by the satellite are stored in **FITS (Flexible Image Transport System)** format.

All the information of your observation are contained in the **header** of the fits file.

You can visualize it by using the FTOOL command **fv**:

> fv nomefile.fits



The screenshot shows a window titled "fv: Summary of acisf07302\_000N001\_evt1.fits in /RossiFumi/users/torresi/4C19.44/chandra/7302/se". The window has a menu bar with "File", "Edit", "Tools", and "Help". Below the menu bar is a table with columns: "Index", "Extension", "Type", "Dimension", and "View".

Index	Extension	Type	Dimension	View
<input type="checkbox"/> 0	Primary	Image	0	Header   Image   Table
<input type="checkbox"/> 1	EVENTS	Binary	20 cols X 277216 rows	Header   Hist   Plot   All   Select
<input type="checkbox"/> 2	GTI	Binary	2 cols X 1 rows	Header   Hist   Plot   All   Select

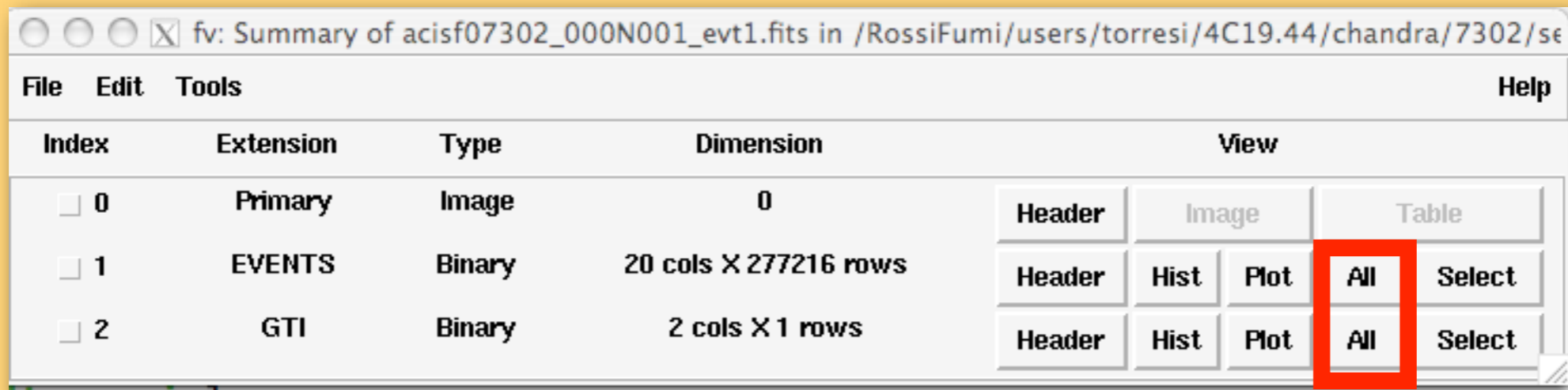
# FITS files

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The screenshot shows a window titled "fv: Summary of acisf07302\_000N001\_evt1.fits in /RossiFumi/users/torresi/4C19.44/chandra/7302/se". The window has a menu bar with "File", "Edit", "Tools", and "Help". Below the menu bar is a table with columns: "Index", "Extension", "Type", "Dimension", and "View". The "View" column contains buttons for different visualization options. The "All" button in the "View" column for the "EVENTS" extension is highlighted with a red box.

Index	Extension	Type	Dimension	View
<input type="checkbox"/> 0	Primary	Image	0	Header Image Table
<input type="checkbox"/> 1	EVENTS	Binary	20 cols X 277216 rows	Header Hist Plot <b>All</b> Select
<input type="checkbox"/> 2	GTI	Binary	2 cols X 1 rows	Header Hist Plot <b>All</b> Select

# FITS files

Data produced by the satellite are stored in **FITS (Flexible Image Transport System)** format.

All the information of your observation are contained in the **header** of the fits file.

You can visualize it by using the **FTOOL** command **fv**:

The screenshot shows a window titled "fv: Binary Table of acisf07302\_000N001\_evt1.fits[1] in /RossiFumi/users/torresi/4C19.44/chandra/7302/secondary/". The window contains a table with 12 columns and 28 rows. The columns are: time (1D), ccd\_id (1I), node\_id (1I), expno (1J), chipx (1I), chipy (1I), tdetx (1I), tdety (1I), detx (1E), dety (1E), x (1E), and y (1E). Each column has a "Modify" button below it. A "Table" menu is open on the right side, showing "Select" and "Select" options. The table data is as follows:

	time	ccd_id	node_id	expno	chipx	chipy	tdetx	tdety	detx	dety	x	y
1	2.599123745351E+08	7	3	293	984	391	4901	2093	4.858813E+03	4.237318E+03	2.541800E+05	-1.430559E+05
2	2.599123745351E+08	7	2	293	591	474	4508	2176	4.466738E+03	4.154643E+03	2.536133E+05	-1.429493E+05
3	2.599123745351E+08	7	3	293	1008	552	4925	2254	4.882676E+03	4.076576E+03	2.541747E+05	-1.428487E+05
4	2.599123745351E+08	7	1	293	387	607	4304	2309	4.262277E+03	4.021737E+03	2.532966E+05	-1.427781E+05
5	2.599123753762E+08	7	0	294	95	431	4012	2133	3.971257E+03	4.197373E+03	2.529332E+05	-1.430042E+05
6	2.599123762172E+08	7	2	295	520	557	4437	2259	4.395667E+03	4.071814E+03	2.534944E+05	-1.428426E+05
7	2.599123770582E+08	7	2	296	541	441	4458	2143	4.416224E+03	4.186880E+03	2.535506E+05	-1.429908E+05
8	2.599123770582E+08	7	2	296	531	474	4448	2176	4.406479E+03	4.154062E+03	2.535292E+05	-1.429485E+05
9	2.599123770582E+08	7	3	296	989	511	4906	2213	4.864095E+03	4.116981E+03	2.541585E+05	-1.429008E+05
10	2.599123770582E+08	7	1	296	471	555	4388	2257	4.346301E+03	4.073634E+03	2.534261E+05	-1.428449E+05
11	2.599123778992E+08	7	0	297	117	493	4034	2195	3.992845E+03	4.135629E+03	2.529486E+05	-1.429248E+05
12	2.599123795813E+08	7	2	299	725	594	4642	2296	4.599758E+03	4.033951E+03	2.537699E+05	-1.427938E+05
13	2.599123795813E+08	7	3	299	858	628	4775	2330	4.733125E+03	4.000127E+03	2.539477E+05	-1.427502E+05
14	2.599123795813E+08	7	0	299	14	639	3931	2341	3.889811E+03	3.989590E+03	2.527703E+05	-1.427368E+05
15	2.599123804223E+08	7	1	300	458	468	4375	2170	4.333020E+03	4.159923E+03	2.534282E+05	-1.429560E+05
16	2.599123804223E+08	7	1	300	461	469	4378	2171	4.336413E+03	4.158963E+03	2.534327E+05	-1.429548E+05
17	2.599123804223E+08	7	2	300	611	604	4528	2306	4.486265E+03	4.024730E+03	2.536094E+05	-1.427820E+05
18	2.599123804223E+08	7	1	300	281	634	4198	2336	4.156607E+03	3.994792E+03	2.531430E+05	-1.427435E+05
19	2.599123804223E+08	7	0	300	169	635	4086	2337	4.044641E+03	3.993877E+03	2.529869E+05	-1.427423E+05
20	2.599123804223E+08	7	0	300	161	636	4078	2338	4.036815E+03	3.992568E+03	2.529757E+05	-1.427406E+05
21	2.599123812634E+08	7	2	301	667	502	4584	2204	4.542446E+03	4.126568E+03	2.537121E+05	-1.429131E+05
22	2.599123812634E+08	7	1	301	439	533	4356	2235	4.314266E+03	4.095672E+03	2.533867E+05	-1.428733E+05
23	2.599123812634E+08	7	1	301	326	633	4243	2335	4.201720E+03	3.995774E+03	2.532060E+05	-1.427447E+05
24	2.599123821044E+08	7	0	302	70	517	3987	2219	3.946417E+03	4.111916E+03	2.528783E+05	-1.428942E+05
25	2.599123821044E+08	7	0	302	102	579	4019	2281	3.978182E+03	4.049786E+03	2.529077E+05	-1.428143E+05
26	2.599123829454E+08	7	0	303	78	434	3995	2136	3.953673E+03	4.194752E+03	2.529081E+05	-1.430008E+05
27	2.599123829454E+08	7	3	303	769	593	4686	2295	4.644235E+03	4.035675E+03	2.538323E+05	-1.427960E+05
28	2.599123829454E+08	7	1	303	476	598	4393	2300	4.351685E+03	4.030826E+03	2.534233E+05	-1.427898E+05

# Creation of event files

ODF

SAS: epproc-emproc-cifbuild



evt



event files | pn.evt  
mos1.evt  
mos2.evt  
CCF | ccf.cif  
calibration index file (CIF)

> pn, MOS1 and MOS2 data reduction

After reprocessing the row data you are ready to start the reduction

## > pn, MOS1 and MOS2 data reduction

After reprocessing the raw data you are ready to start the reduction

1. Extract of a high energy light curve ( $>10$  keV) to identify interval of flaring particle background



# EPIC background

# EPIC background

Cosmic X-ray background

Instrumental background

detector noise  
component  
(important below 300 eV)

second component due to  
the interaction of particles  
with the detectors and the  
structures surrounding  
them  
(important at high energies, e.g.  
above a few keV)

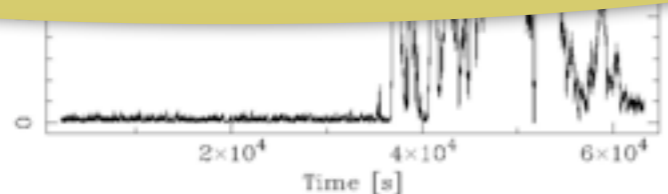
For more information refer to the [XMM-Newton User's Handbook](#)

# EPIC particle induced background

External 'flaring' component

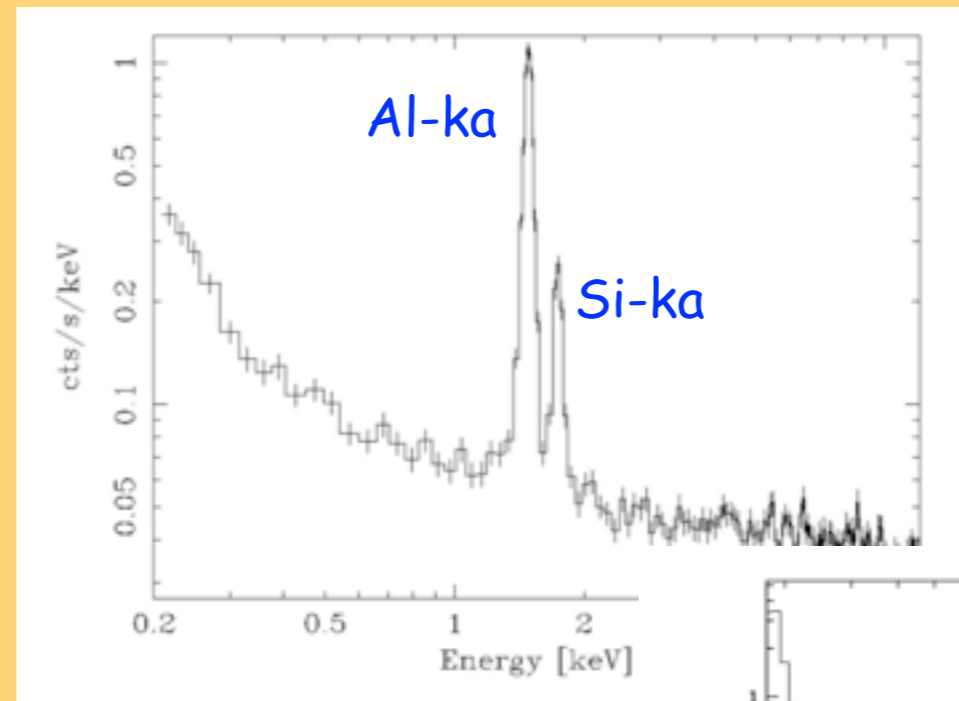
*strong and rapid*

The current understanding is that soft protons are most likely organised in **clouds populating the Earth's magneto-sphere**. The number of such clouds encountered by XMM-Newton in its orbit depends upon many factors, such as the **altitude of the satellite**, its **position with respect to the magneto-sphere**, and the **amount of solar activity**



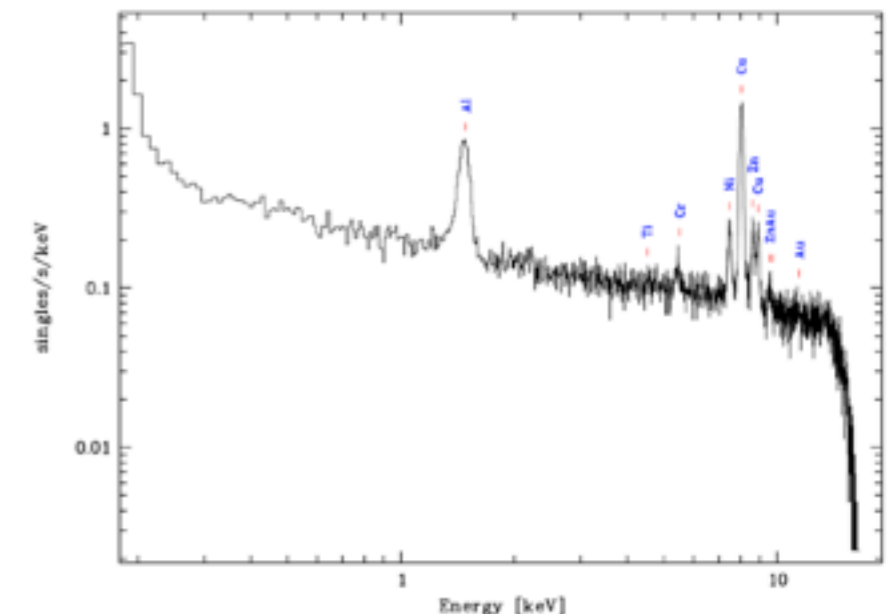
Internal 'quiescent' component

*high energy particles interacting with the structure surrounding the detectors and the detectors themselves*



**MOS1**

**pn**



## > pn, MOS1 and MOS2 data reduction

After reprocessing the raw data you are ready to start the reduction

### 1. Extract of a high energy light curve to identify interval of flaring particle background

```
evselect table=pn.evt energycolumn=PI expression='#XMMEA_EP &&  
(PI>10000) && (PATTERN==0)' withrateset=yes rateset="lcurve_sup10.lc"  
timebinsize=100 maketimecolumn=yes makeratecolumn=yes
```

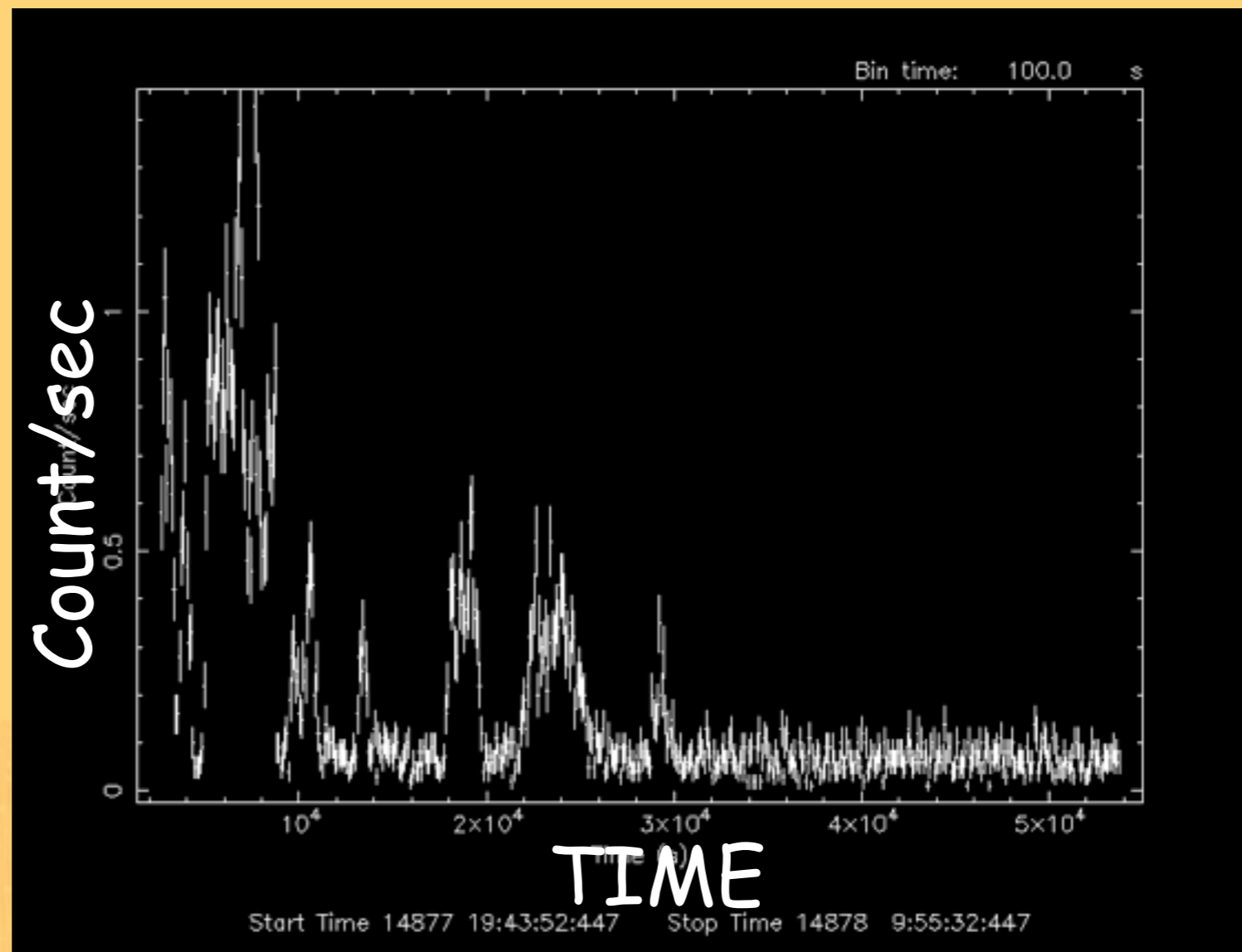
> pn, MOS1 and MOS2 data reduction

After reprocessing the raw data you are ready to start the reduction

1. Check for the presence of soft proton flares above 10 keV

```
evselect table=pn.evt energycolumn=PI expression='#XMMEA_EP && (PI>10000) && (PATTERN==0)' withrateset=yes rateset="lcurve_sup10.lc" timebinsize=100 maketimecolumn=yes makeratecolumn=yes
```

Light curve  
above 10 keV



> pn, MOS1 and MOS2 data reduction

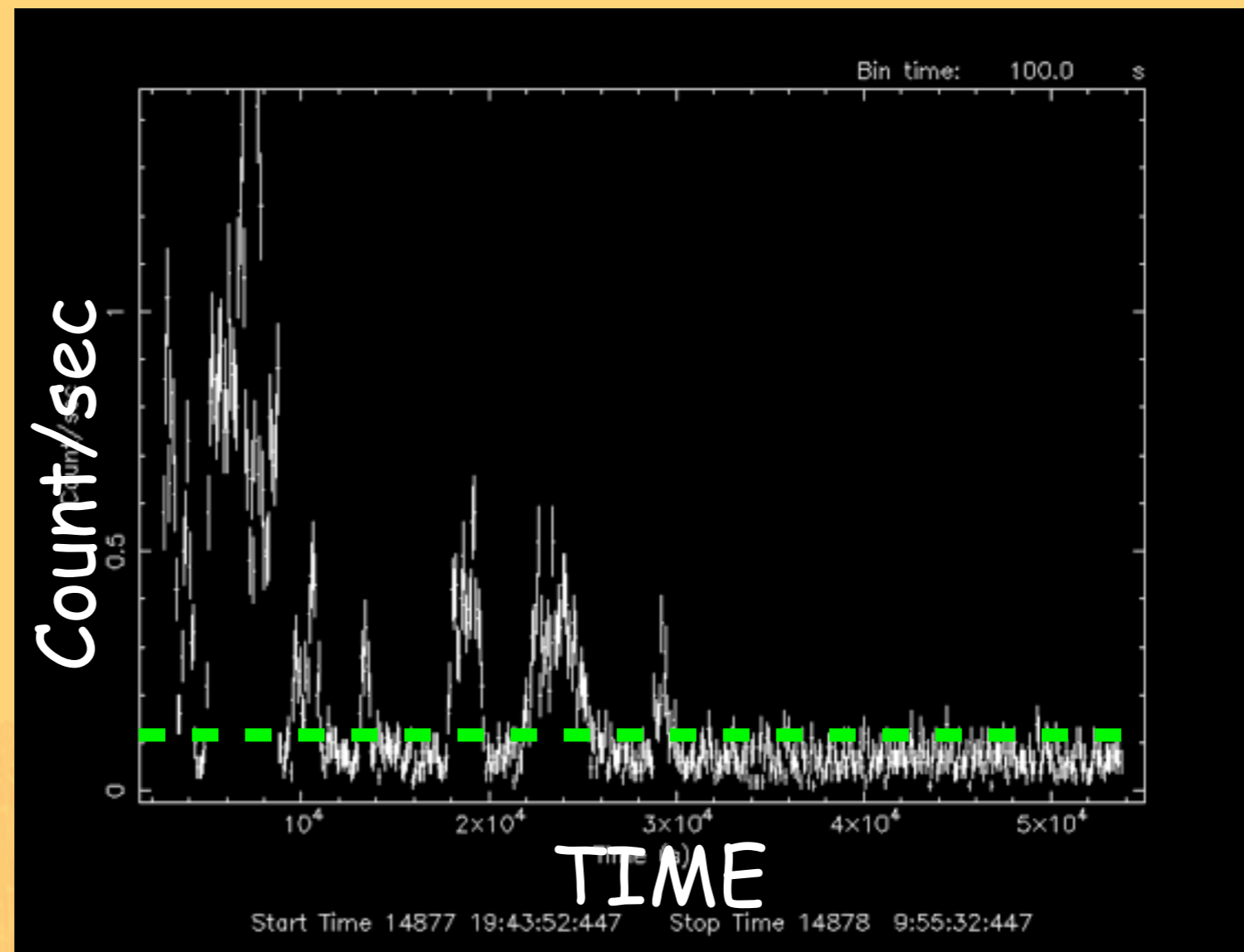
After reprocessing the raw data you are ready to start the reduction

1. Check for the presence of soft proton flares above 10 keV

```
evselect table=pn.evt energycolumn=PI expression='#XMMEA_EP && (PI>10000) && (PATTERN==0)' withrateset=yes rateset="lcurve_sup10.lc" timebinsize=100 maketimecolumn=yes makeratecolumn=yes
```

Light curve  
above 10 keV

pn < 0.4 cts/s  
MOS < 0.35 cts/s



> pn, MOS1 and MOS2 data reduction

## 2. Selection of Good Time Intervals (GTI)

> pn, MOS1 and MOS2 data reduction

## 2. Selection of Good Time Intervals (GTI)

```
tabgtigen table=lcurve_sup10.lc gtiset=good_bkg.gti expression='RATE<
```



> pn, MOS1 and MOS2 data reduction

## 2. Selection of Good Time Intervals (GTI)

```
tabgtigen table=lcurve_sup10.lc gtiset=good_bkg.gti expression='RATE<
```

## 3. Generation of the cleaned event file

```
evselect table=pn.evt expression='#XMMEA_EP (EM) && (PI > 150) &&  
(GTI(good_bkg.gti,TIME))' withfilteredset=yes keepfilteroutput=yes  
filteredset=pn_new.evt(mos1_new.evt)updateexposure=yes cleandss=yes  
writedss=yes
```

> pn, MOS1 and MOS2 data reduction

## 2. Selection of Good Time Intervals (GTI)

```
tabgtigen table=lcurve_sup10.lc gtiset=good_bkg.gti expression='RATE<'
```

## 3. Generation of the cleaned event file

```
evselect table=pn.evt expression='#XMMEA_EP (EM) && (PI > 150) &&  
(GTI(good_bkg.gti,TIME))' withfilteredset=yes keepfilteroutput=yes  
filteredset=pn_new.evt(mos1_new.evt)updateexposure=yes cleandss=yes  
writedss=yes
```



```
pn_new.evt  
mos1_new.evt  
mos2_new.evt
```

> pn, MOS1 and MOS2 data reduction

## 2. Selection of Good Time Intervals (GTI)

```
tabgtigen table=lcurve_sup10.lc gtiset=good_bkg.gti expression='RATE<'
```

## 3. Generation of the cleaned event file

```
evselect table=pn.evt expression='#XMMEA_EP (EM) && (PI > 150) &&  
(GTI(good_bkg.gti,TIME))' withfilteredset=yes keepfilteroutput=yes  
filteredset=pn_new.evt(mos1_new.evt)updateexposure=yes cleandss=yes  
writedss=yes
```



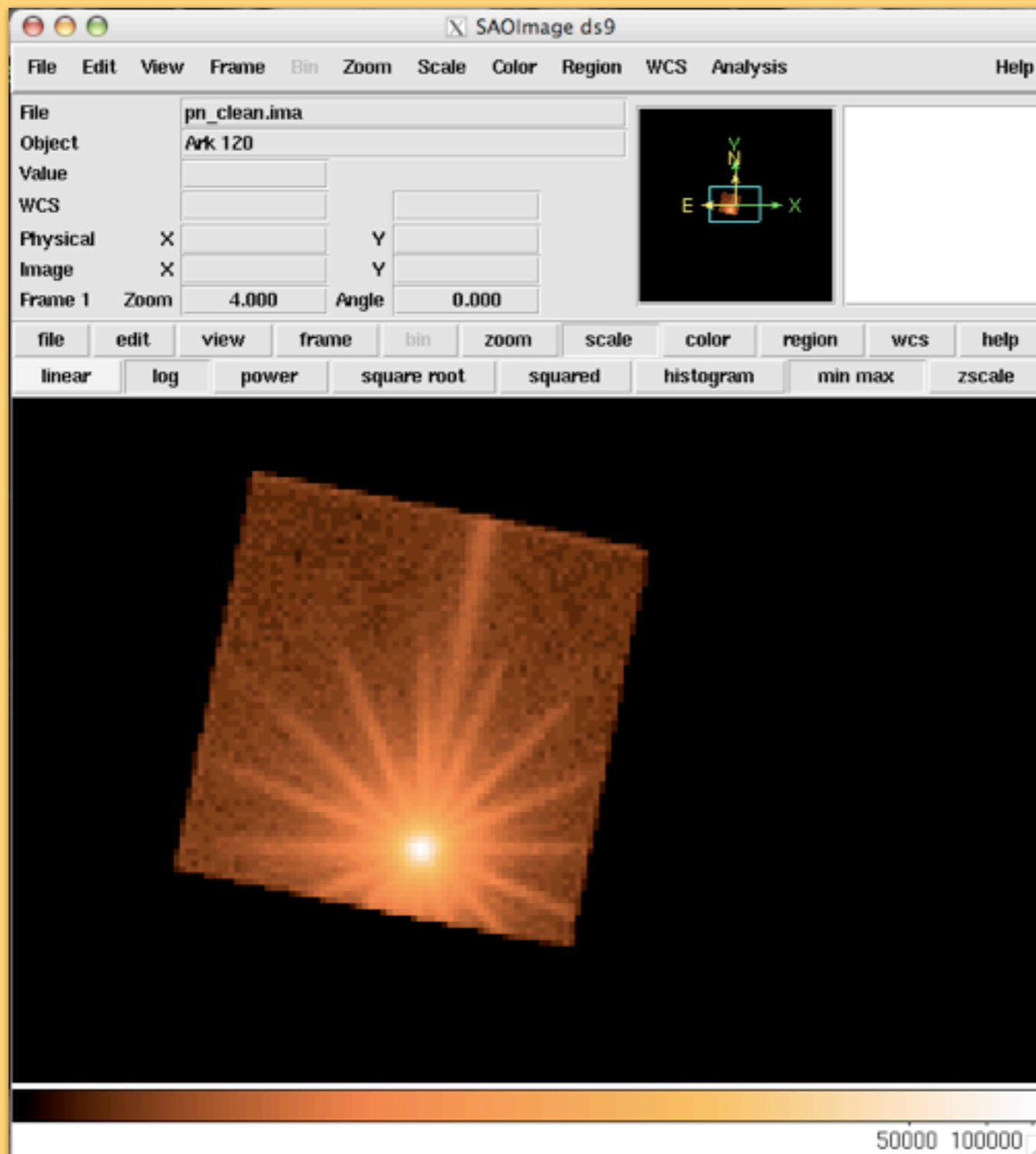
```
pn_new.evt  
mos1_new.evt  
mos2_new.evt
```

**You start here!**

> pn, MOS1 and MOS2 data reduction

#### 4. Source and background regions selection

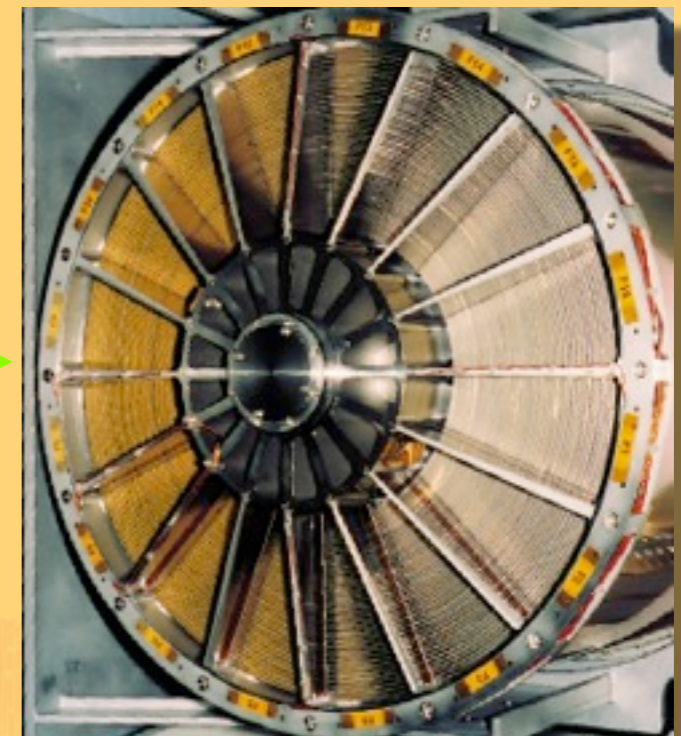
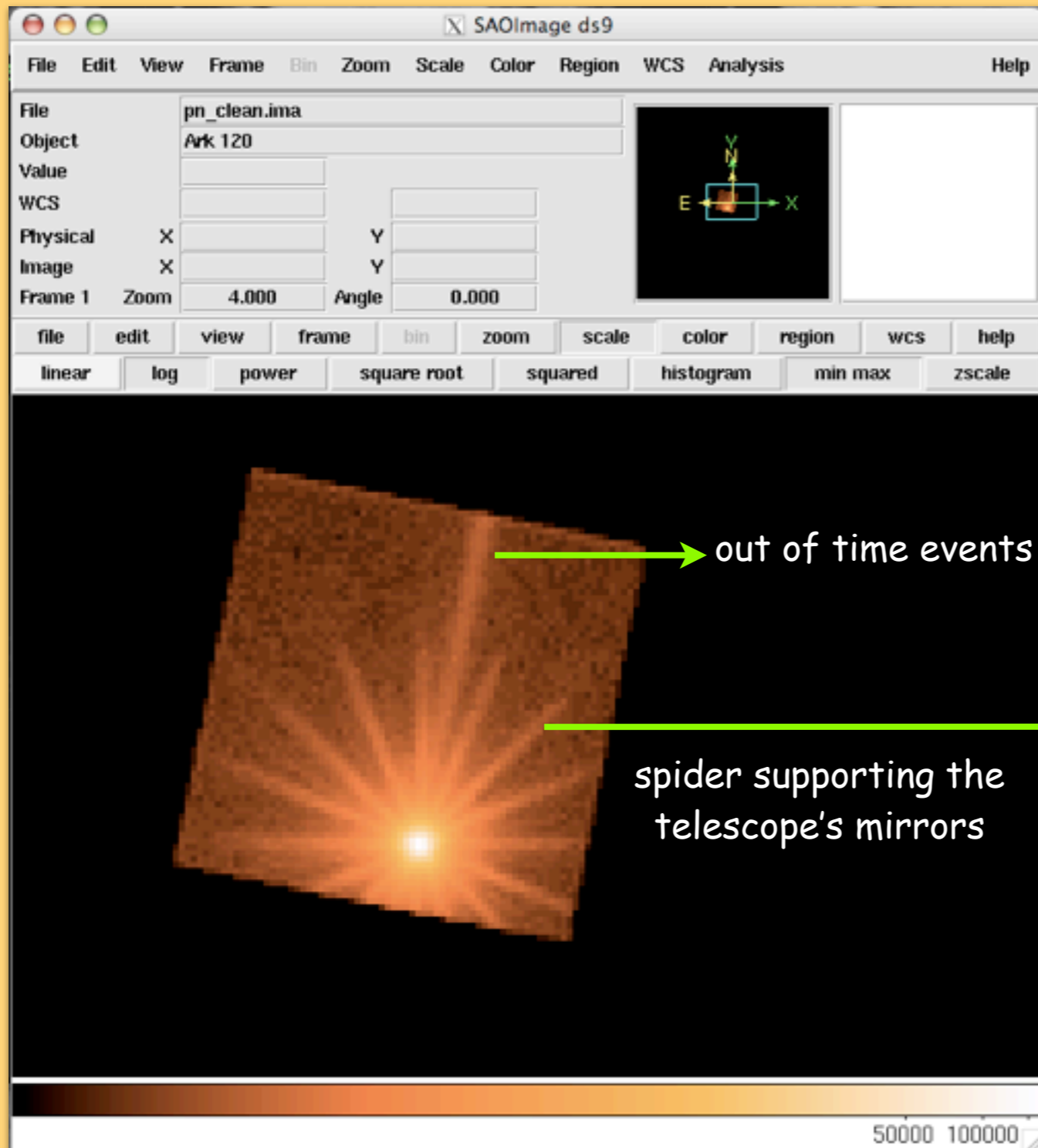
open event list file with ds9 > ds9 pn\_new.evt



> pn, MOS1 and MOS2 data reduction

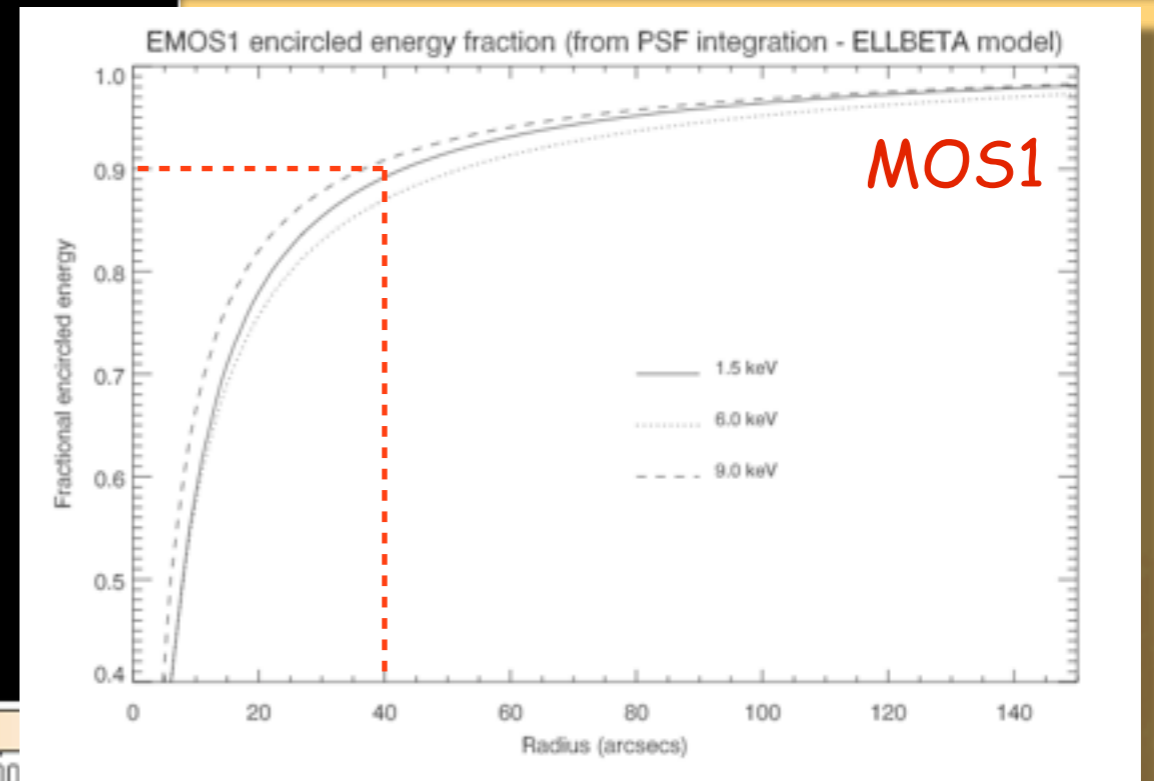
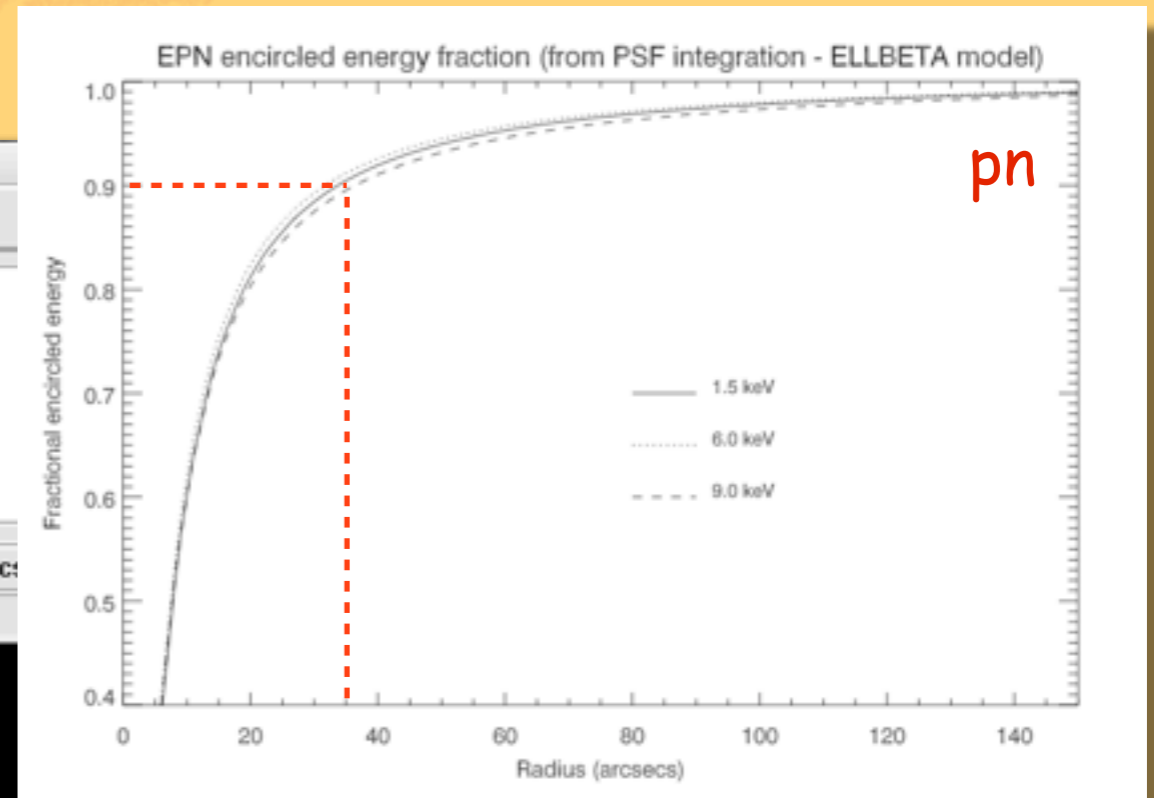
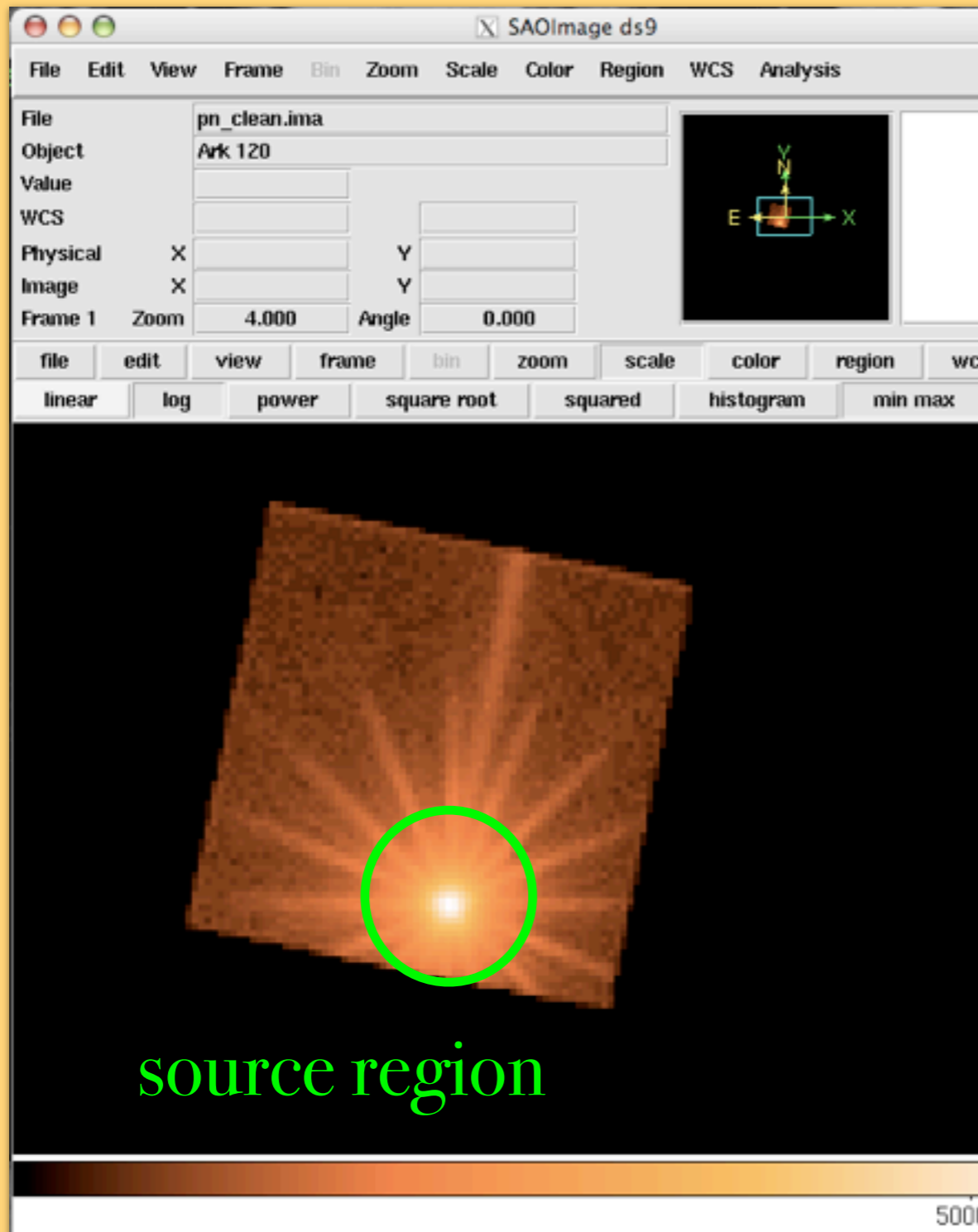
#### 4. Source and background regions selection

open event list file with ds9 > ds9 pn\_new.evt



> pn, MOS1 and MOS2 data reduction

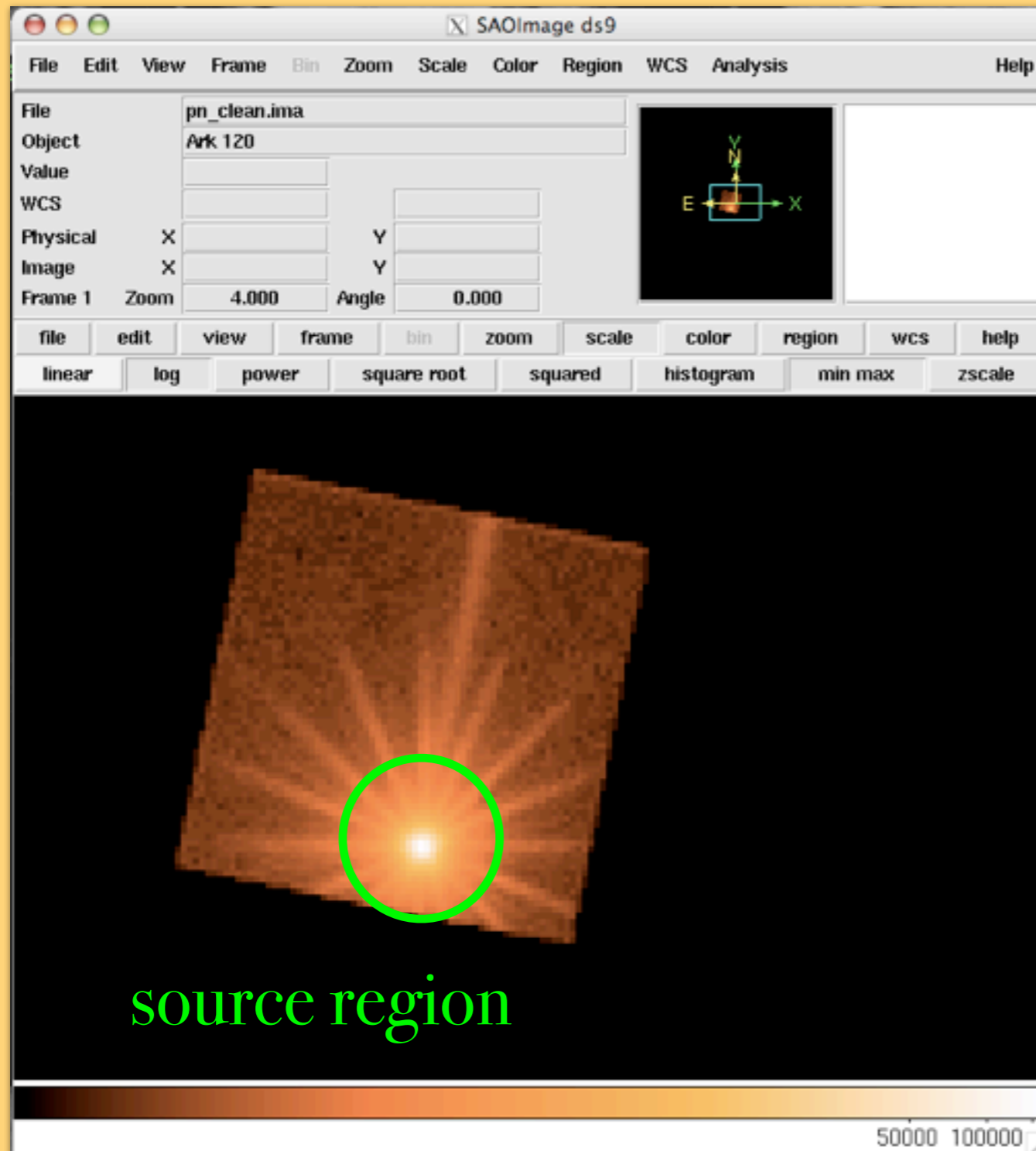
## 4. Source and background regions selection



> pn, MOS1 and MOS2 data reduction

#### 4. Source and background regions selection

open event list file with ds9

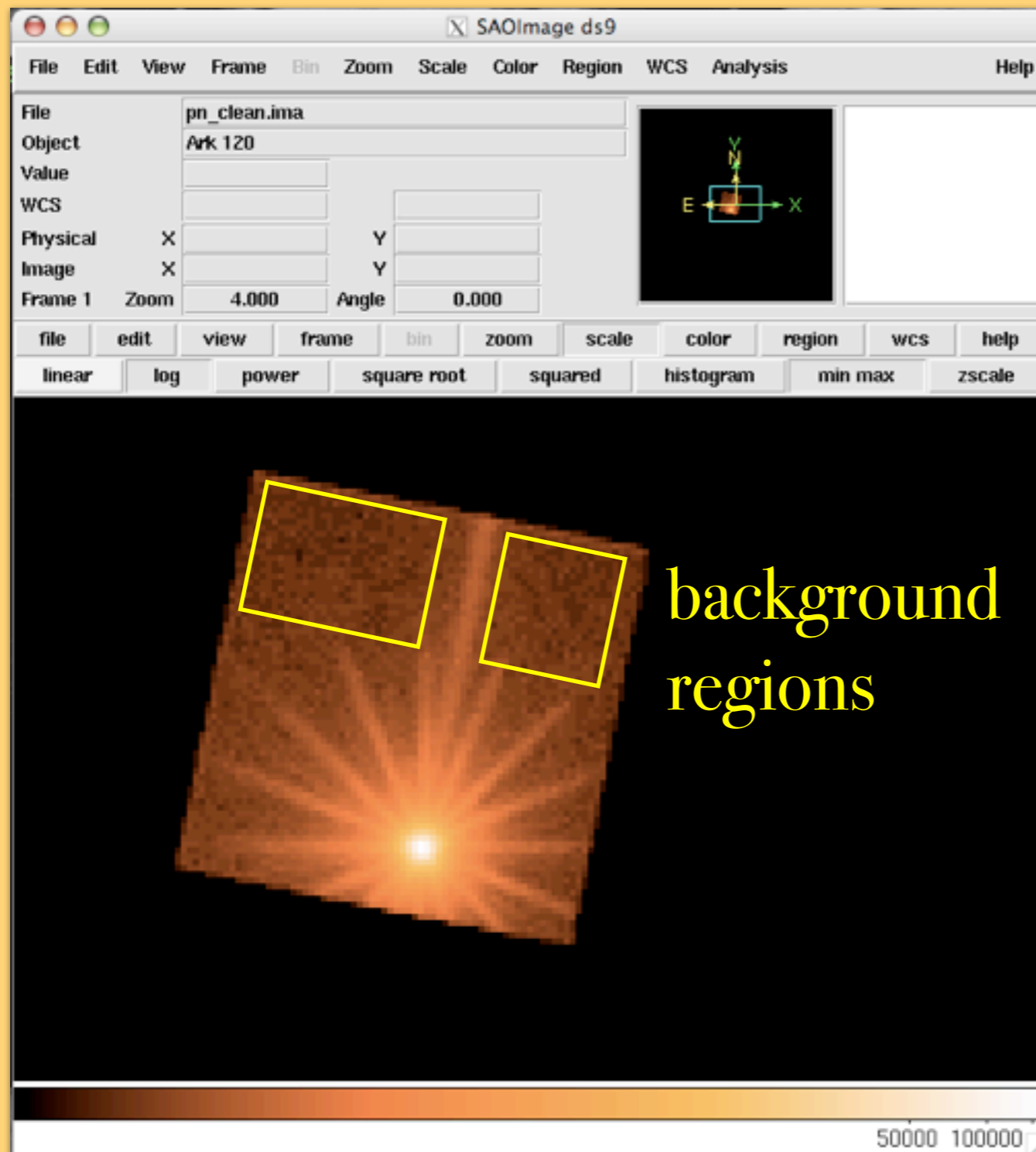


Region ->  
save region ->  
file format 'ds9' ->  
coordinates 'physical' ->  
source.reg

> pn, MOS1 and MOS2 data reduction

#### 4. Source and background regions selection

open event list file with ds9



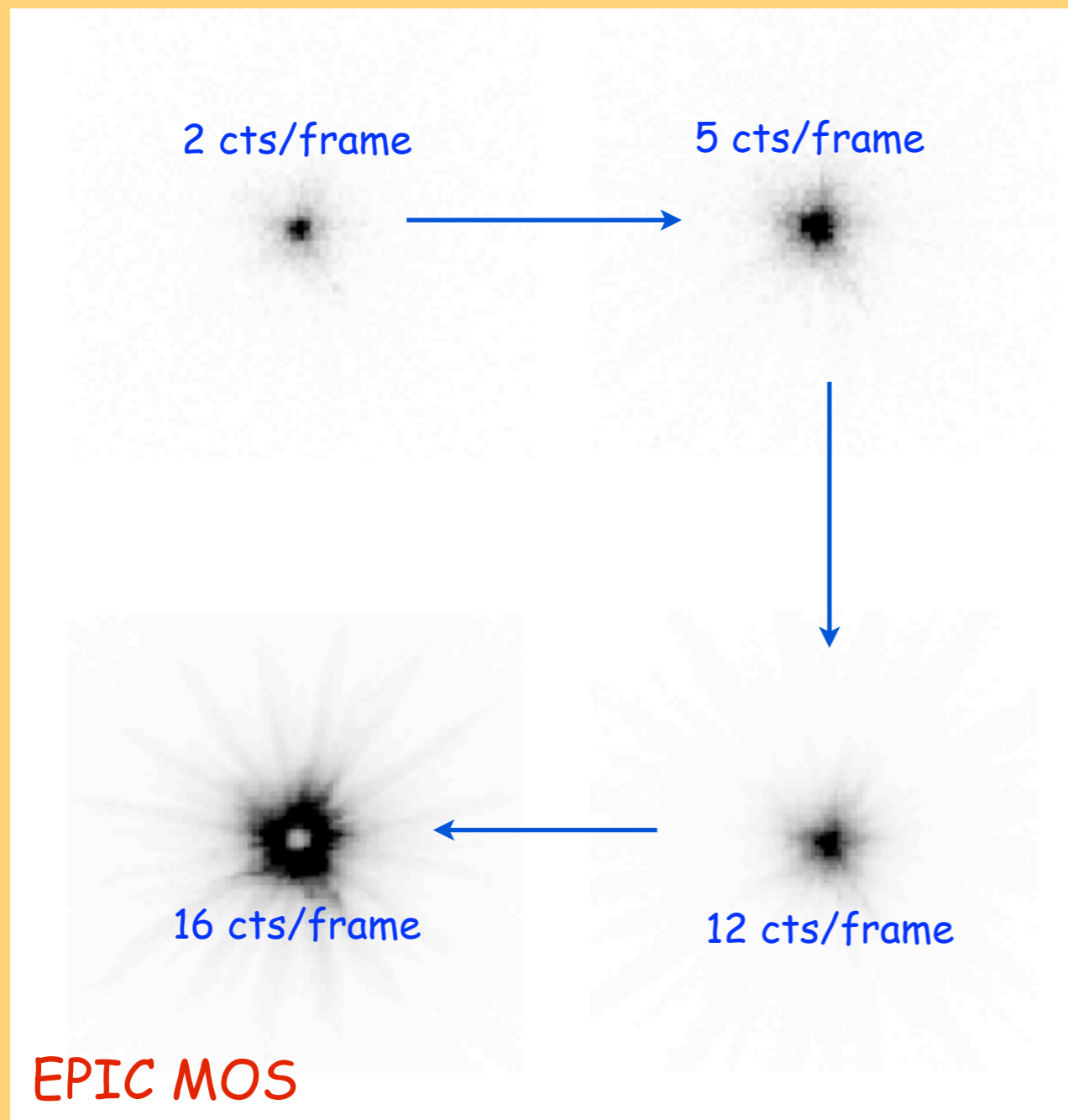
Region ->  
save region ->  
file format 'ds9' ->  
coordinates 'physical' ->  
back.reg



> pn, MOS1 and MOS2 data reduction

## 5. Check for the presence of photon pile-up

Arrival of more than one X-ray photon in one camera pixel or in an adjacent pixel before it is read out



Can affect the PSF (in its core many photons arrive at almost the same time) and the EPIC spectral response (artificial "hard" X-ray photons are created where there have been two or more soft photons)

> pn, MOS1 and MOS2 data reduction

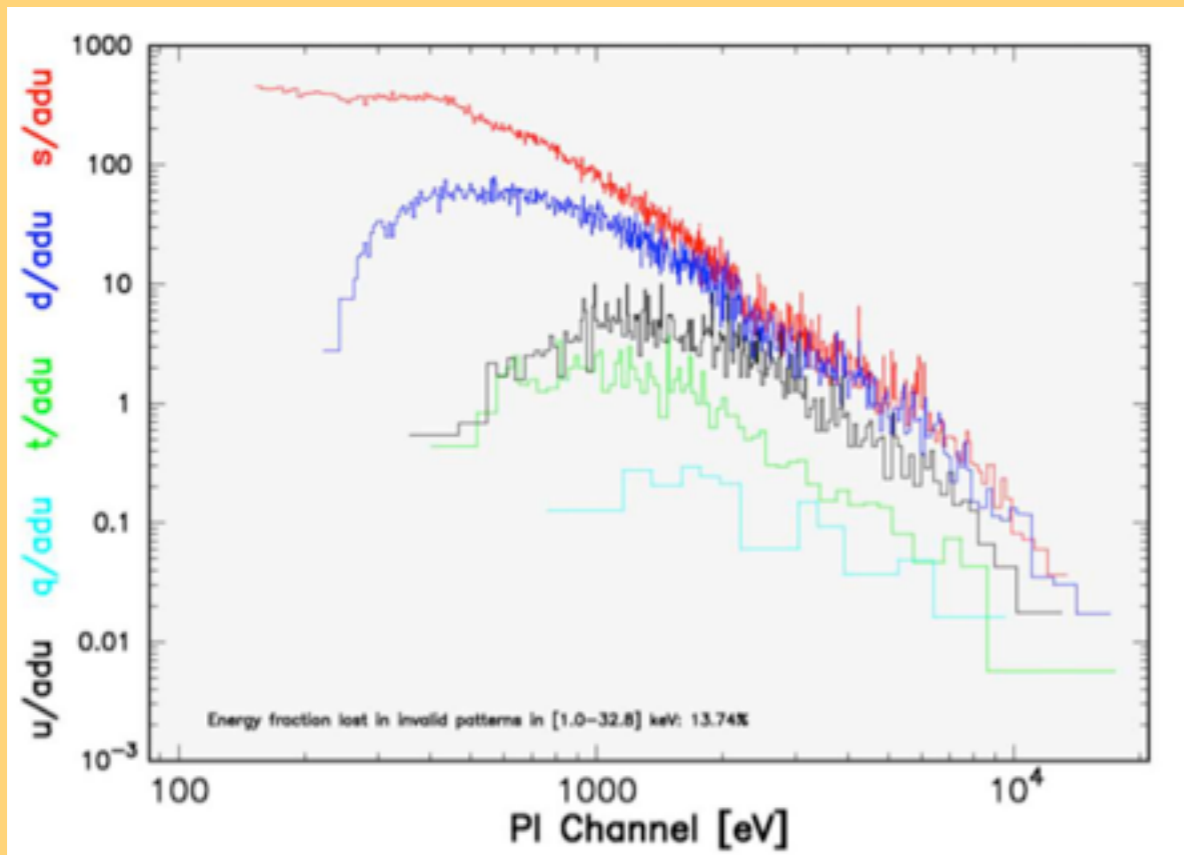
5. Check for the presence of photon pile-up (the epatplot task)

```
evselect table=pn_new.evt withfilteredset=yes  
filteredset=pnf.evt keepfilteroutput=yes expression="(X,Y)  
IN circle (source region)"
```

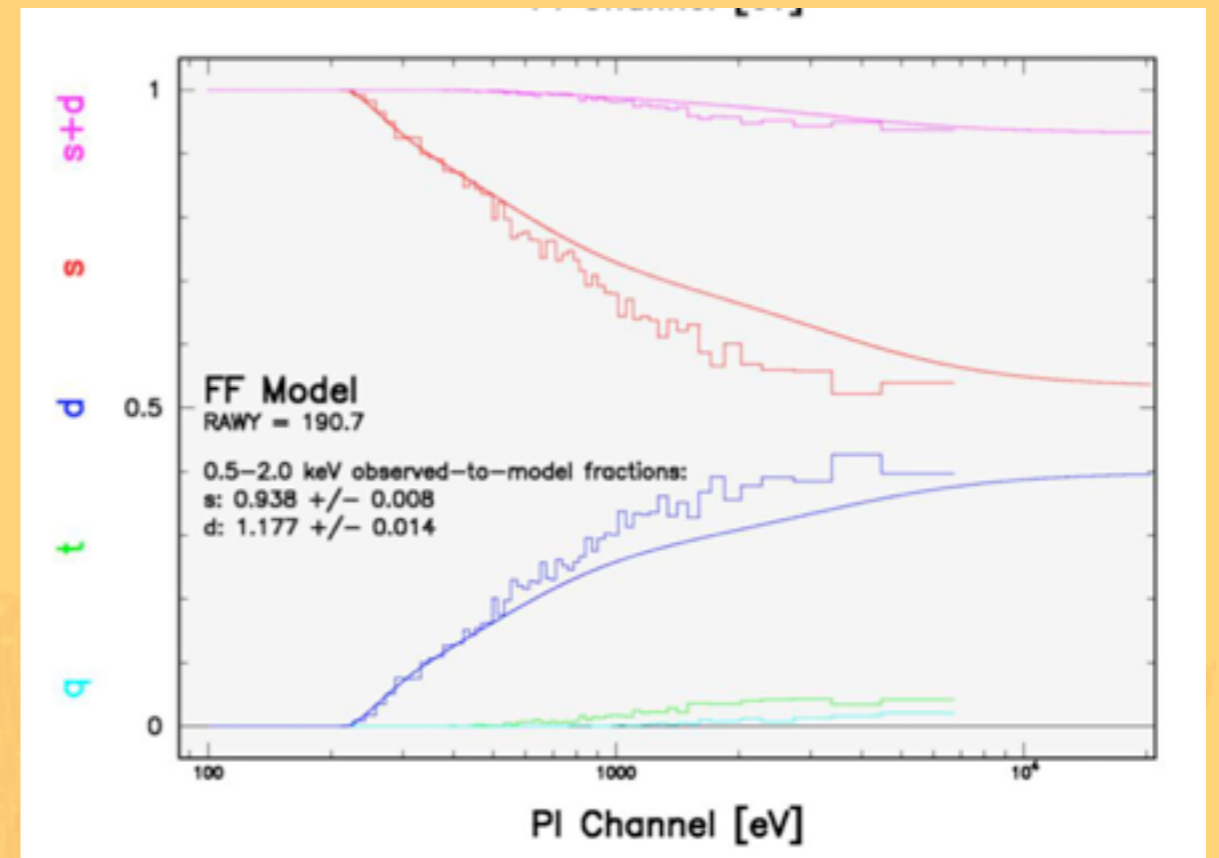
```
epatplot set=pnf.evt device="/CPS" plotfile="pnf_pat.ps"
```

```
gv pnf_pat.ps
```

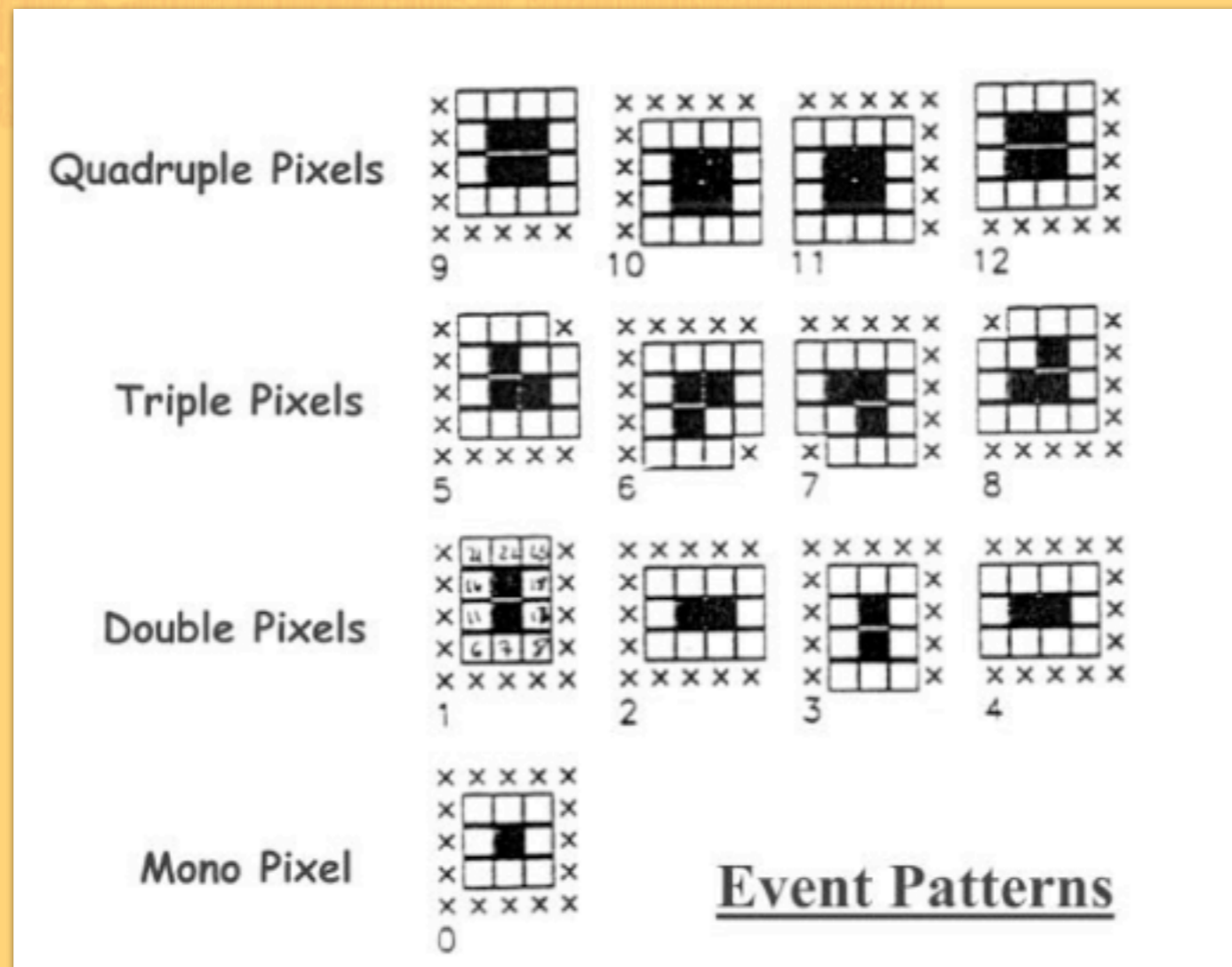
spectral distributions as function of PI channels for single-  
double- triple- and quadruple- events



fraction of the four valid event types



Single- double- triple- quadruple- events are the four types of valid events which can be created by an X-ray photon



Double events can be produced only if the energy of both events is above the event threshold. Triple (quadruples) events start at 3 (4) times the event threshold.

> pn, MOS1 and MOS2 data reduction

## 6. Spectrum extraction (source)

pn:

```
evselect      table=pn_new.evt      withspectrumset=yes
spectrumset=source_spectrum.fits    energycolumn=PI
spectralbinsize=5    withspecranges=yes    specchannelmin=0
specchannelmax=20479 expression='(FLAG==0) && (PATTERN<=4) &&
((X,Y) IN circle (27874.528,26645.58,699.99999))'
```

mos:

```
evselect      table=mos1_new.evt    withspectrumset=yes
spectrumset=source_spectrum.fits    energycolumn=PI
spectralbinsize=15    withspecranges=yes    specchannelmin=0
specchannelmax=11999 expression='(FLAG==0) && (PATTERN<=12) &&
((X,Y) IN circle (28090.5,24221.5,775.48791))'
```

PATTERN==0 (single events); PATTERN==[1-4] (double events); PATTERN==[5-12] (triple and quadruple events)

> pn, MOS1 and MOS2 data reduction

## 7. Spectrum extraction (background)

pn:

```
evselect table=pn_new.evt withspectrumset=yes  
spectrumset=back_spectrum.fits energycolumn=PI  
spectralbinsize=5 withspecranges=yes  
specchannelmax=20479 expression=  
((X,Y) IN circle (27874.528,26645.528,1500))
```

mos:

```
evselect table=mos1_new.evt withspectrumset=yes  
spectrumset=back_spectrum.fits energycolumn=PI  
withspecranges=yes specchannelmax=20479  
expression='(FLAG==0) && (PATTERN<=4) && ((X,Y) IN circle(28090.5,24221.5,775.48791))'
```

If you have more than one detector

```
evselect table=pn_new.evt withspectrumset=yes  
spectrumset=back_spectrum.fits spectralbinsize=5  
withspecranges=yes specchannelmax=20479  
expression='(FLAG==0) && (PATTERN<=4) && ((X,Y) IN circle( ) ) || ((X,Y) IN circle( ))'
```

FLAG > encoding of various event conditions, e.g. near hot pixels or outside the field of view.  
Setting FLAG==0 is the most conservative screening criteria and should be applied when serious spectral analysis is done

> pn, MOS1 and MOS2 data reduction

8. Calculate the area of source and background regions used to make the spectral files

```
backscale spectrumset=source_spectrum.fits badpixlocation=pn_new.evt
```

```
backscale spectrumset=back_spectrum.fits badpixlocation=pn_new.evt
```

The backscale task takes into account any bad pixels or chip gaps and writes the result into the **BACKSCAL** keyword of the spectrum table

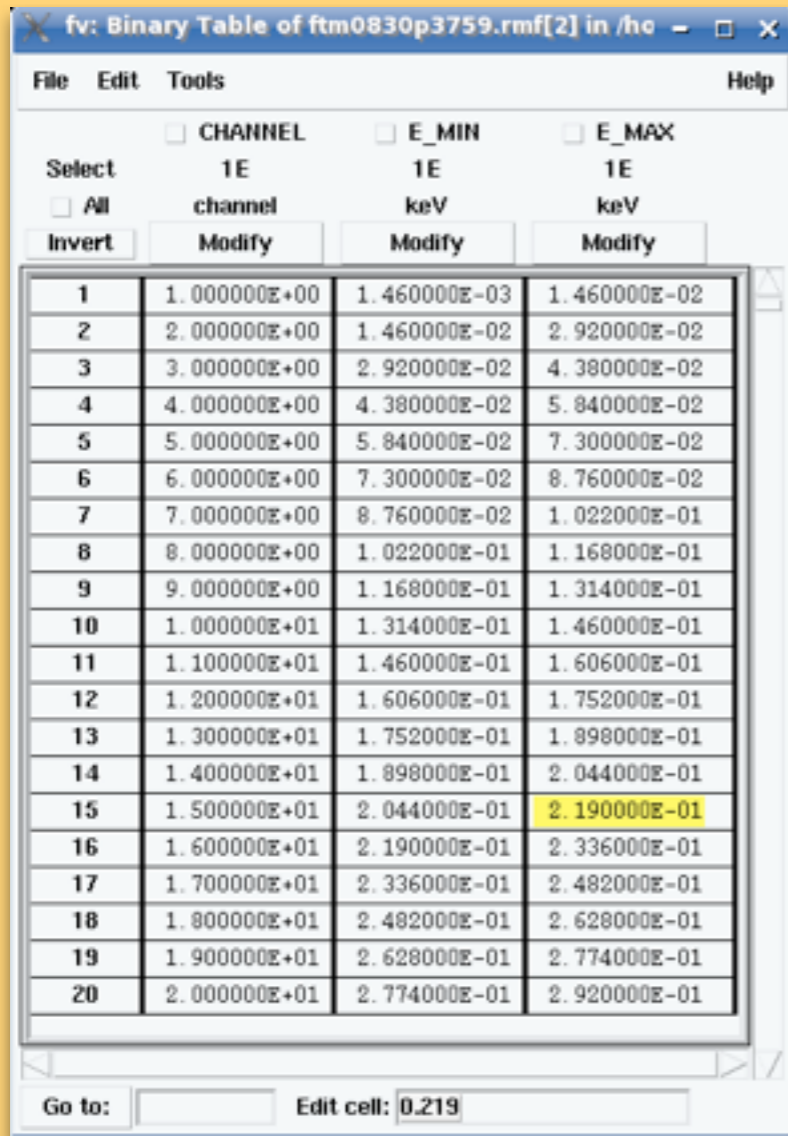
> pn, MOS1 and MOS2 data reduction

## 9. Creation of the Response Matrix Function (RMF)

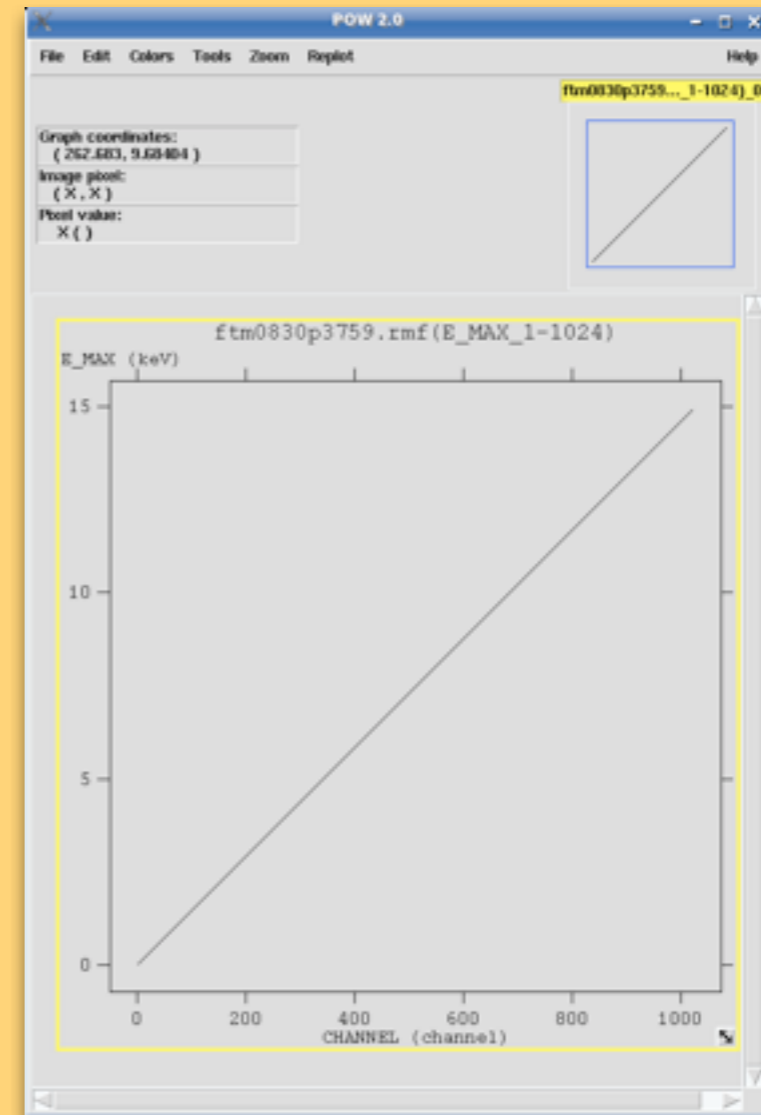
> pn, MOS1 and MOS2 data reduction

## 9. Creation of the Redistribution Matrix File (RMF)

The Redistribution Matrix File (RMF): associates to each instrument channel (I) the appropriate photon energy (E)



CHANNEL	E_MIN (keV)	E_MAX (keV)
1	1.000000E+00	1.460000E-02
2	2.000000E+00	2.920000E-02
3	3.000000E+00	4.380000E-02
4	4.000000E+00	5.840000E-02
5	5.000000E+00	7.300000E-02
6	6.000000E+00	8.760000E-02
7	7.000000E+00	1.022000E-01
8	8.000000E+00	1.168000E-01
9	9.000000E+00	1.314000E-01
10	1.000000E+01	1.460000E-01
11	1.100000E+01	1.606000E-01
12	1.200000E+01	1.752000E-01
13	1.300000E+01	1.898000E-01
14	1.400000E+01	2.044000E-01
15	1.500000E+01	2.190000E-01
16	1.600000E+01	2.336000E-01
17	1.700000E+01	2.482000E-01
18	1.800000E+01	2.628000E-01
19	1.900000E+01	2.774000E-01
20	2.000000E+01	2.920000E-01



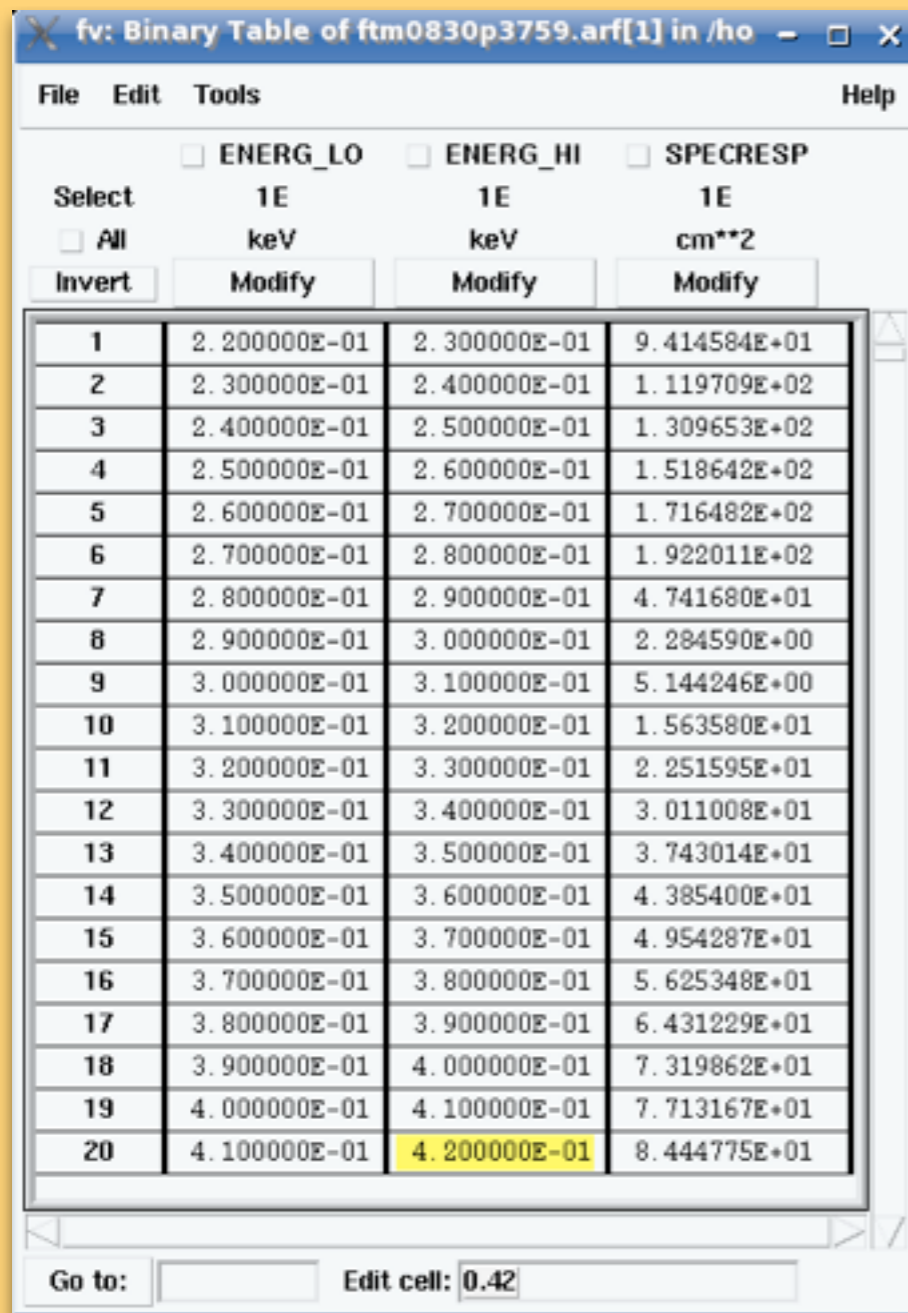
```
rmfgen spectrumset=source_spectrum.fits rmfset=pn.rmf
```



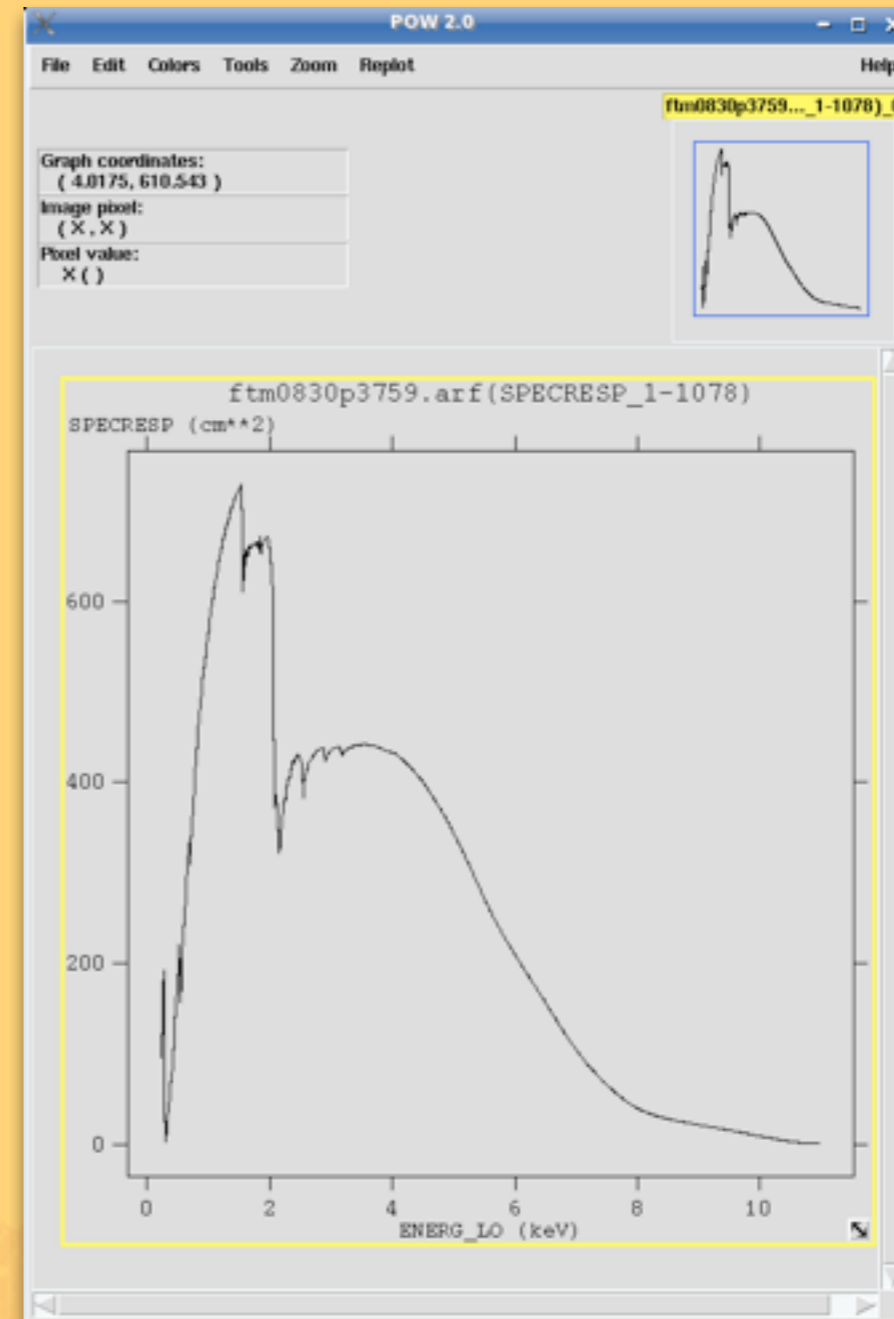
## > pn, MOS1 and MOS2 data reduction

### 9. Creation of the Auxiliary Response File (ARF)

The Auxiliary Response File (ARF) includes information on the effective area, filter transmission and any additional energy-dependent efficiencies, i.e. the efficiency of the instrument in revealing photons.

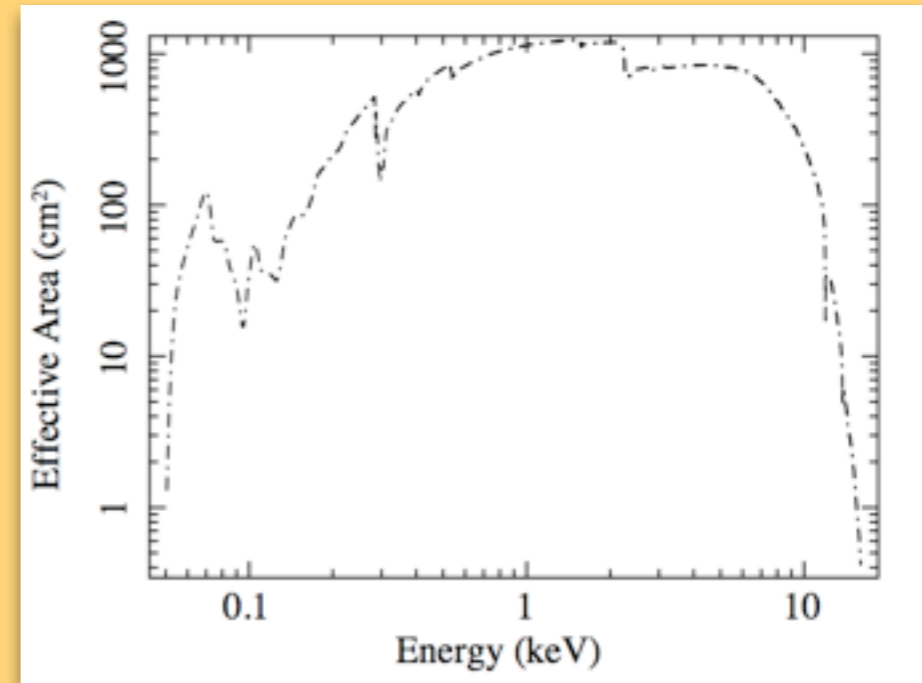
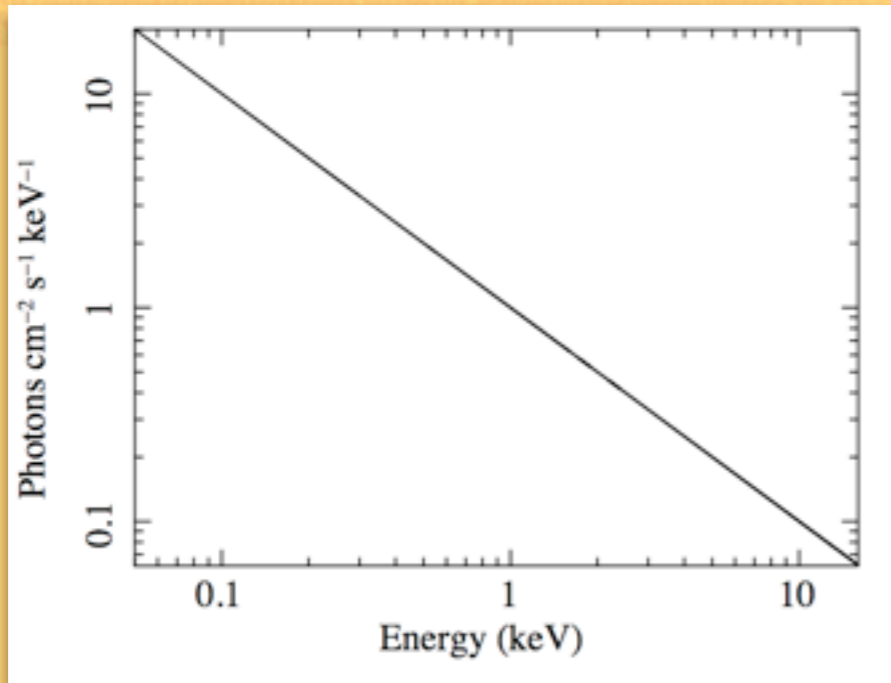


	1E keV	1E keV	1E cm**2
1	2.200000E-01	2.300000E-01	9.414584E+01
2	2.300000E-01	2.400000E-01	1.119709E+02
3	2.400000E-01	2.500000E-01	1.309653E+02
4	2.500000E-01	2.600000E-01	1.518642E+02
5	2.600000E-01	2.700000E-01	1.716482E+02
6	2.700000E-01	2.800000E-01	1.922011E+02
7	2.800000E-01	2.900000E-01	4.741680E+01
8	2.900000E-01	3.000000E-01	2.284590E+00
9	3.000000E-01	3.100000E-01	5.144246E+00
10	3.100000E-01	3.200000E-01	1.563580E+01
11	3.200000E-01	3.300000E-01	2.251595E+01
12	3.300000E-01	3.400000E-01	3.011008E+01
13	3.400000E-01	3.500000E-01	3.743014E+01
14	3.500000E-01	3.600000E-01	4.385400E+01
15	3.600000E-01	3.700000E-01	4.954287E+01
16	3.700000E-01	3.800000E-01	5.625348E+01
17	3.800000E-01	3.900000E-01	6.431229E+01
18	3.900000E-01	4.000000E-01	7.319862E+01
19	4.000000E-01	4.100000E-01	7.713167E+01
20	4.100000E-01	4.200000E-01	8.444775E+01

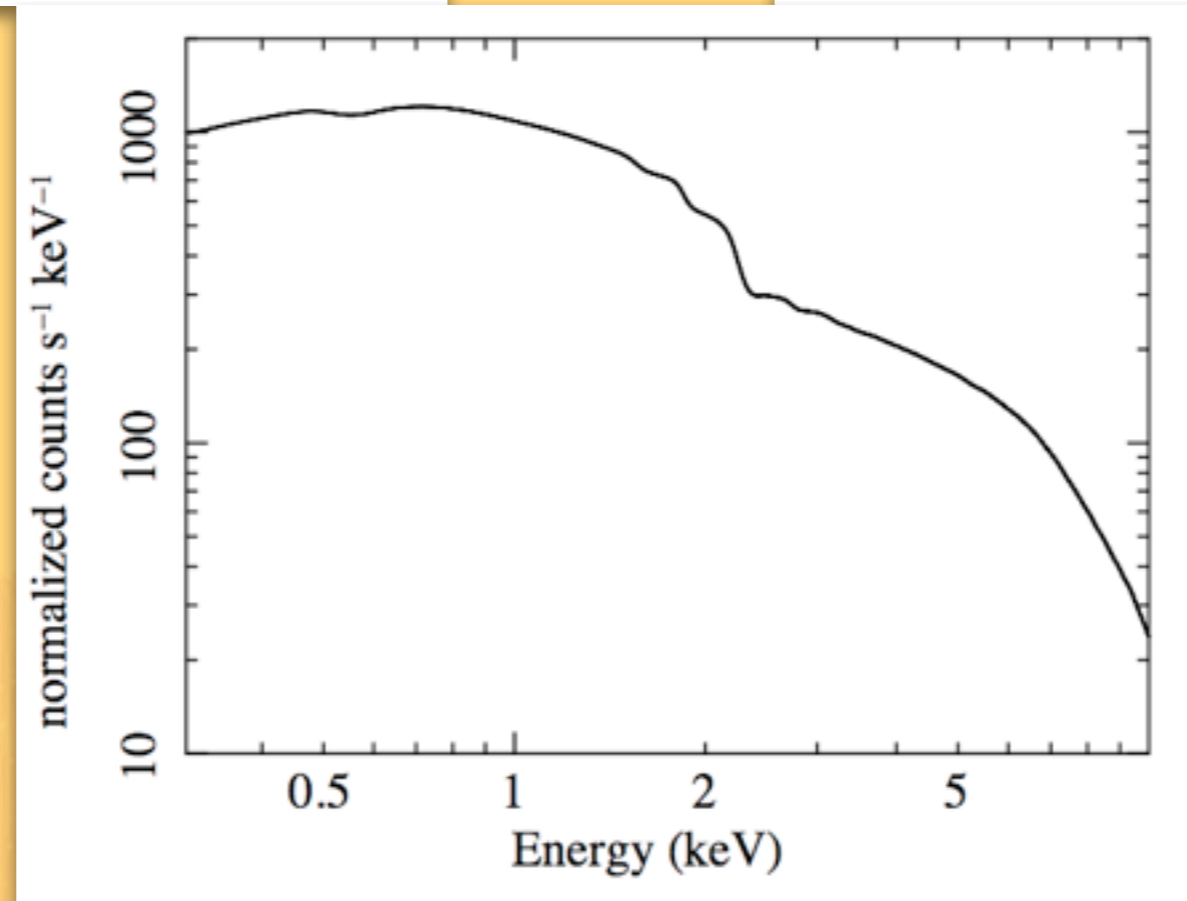
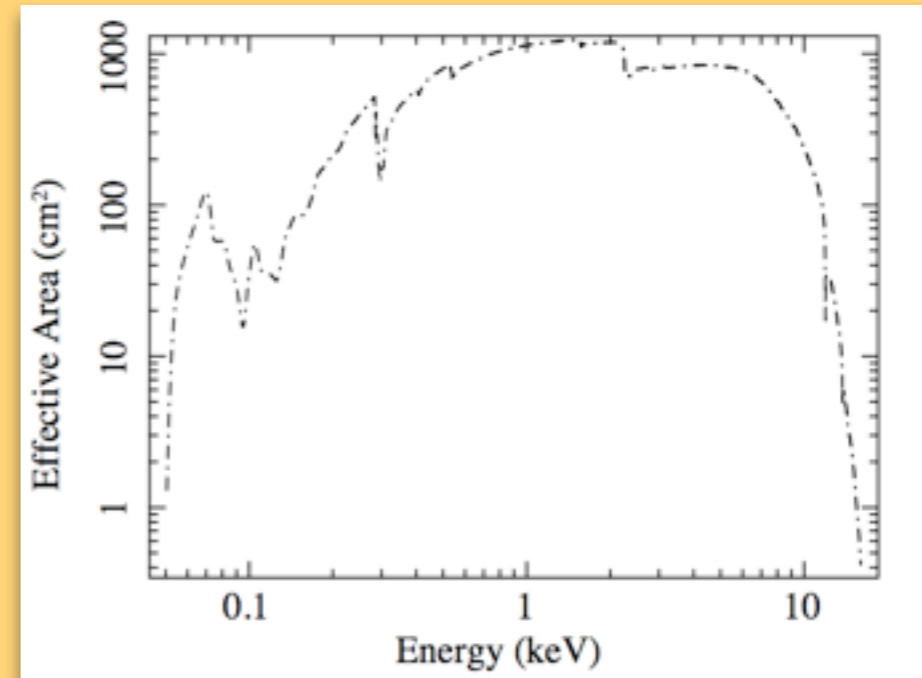
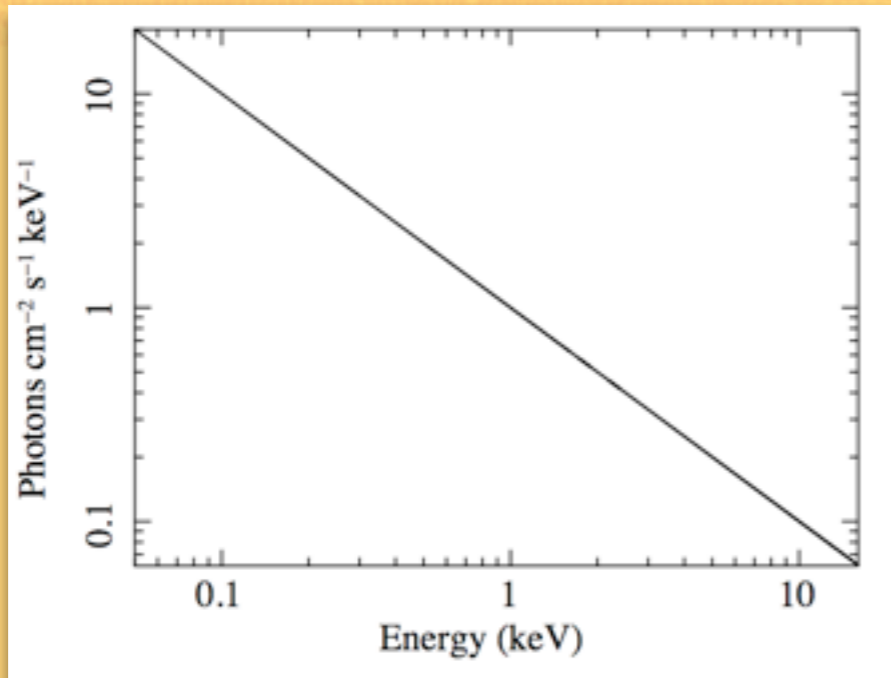


```
arfgen spectrumset=source_spectrum.fits arfset=pn.arf withrmfset=yes  
rmfset=pn.rmf badpixlocation=pn_new.evt detmaptype=psf
```

The combination of RMF and ARF produces the input spectrum weighted by telescope area and detector efficiencies versus energy.



The combination of RMF and ARF produces the input spectrum weighted by telescope area and detector efficiencies versus energy.



> pn, MOS1 and MOS2 data reduction

## 10. Grouping of the spectra

In order to apply the chi2 statistics (Gaussian distribution) you need to have at least 25 counts in each bin of your spectrum. Otherwise Cash statistics (Poisson distribution) is preferred (see also Statistics Tutorial).

```
grppha source_spectrum.fits pn_25.grp comm= "chkey RESPFILE  
pn.rmfi & chkey ANCRFILE pn.arf & chkey BACKFILE  
back_spectrum.fits & group min 25 & exit"
```

> pn, MOS1 and MOS2 data reduction

## 10. Grouping of the spectra

In order to apply the chi2 statistics (Gaussian distribution) you need to have at least 25 counts in each bin of your spectrum. Otherwise Cash statistics (Poisson distribution) is preferred (see also Statistics Tutorial).

```
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pn.rmf & chkey ANCRFILE pn.arf & chkey BACKFILE  
back_spectrum.fits & group min 25 & exit"
```

