Gallery of selected galactic supernova remnants

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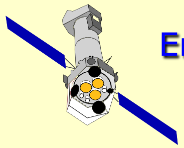
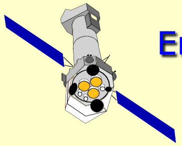
Aims of the project:

- Make an extended source analysis.
- How to treat the background for extended sources in a correct way.
- Make a background correction using blank sky field event files.
- Investigate the difference between the different blank sky fields.
- Create images and spectrums of SNR.



1. **Introduction**
2. **Background components**
3. **Blank Sky Fields**
4. **Results**
5. **Conclusions and next steps**



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1. **Introduction**
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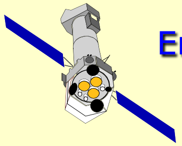
X-ray Multi-mirror Mission - Newton



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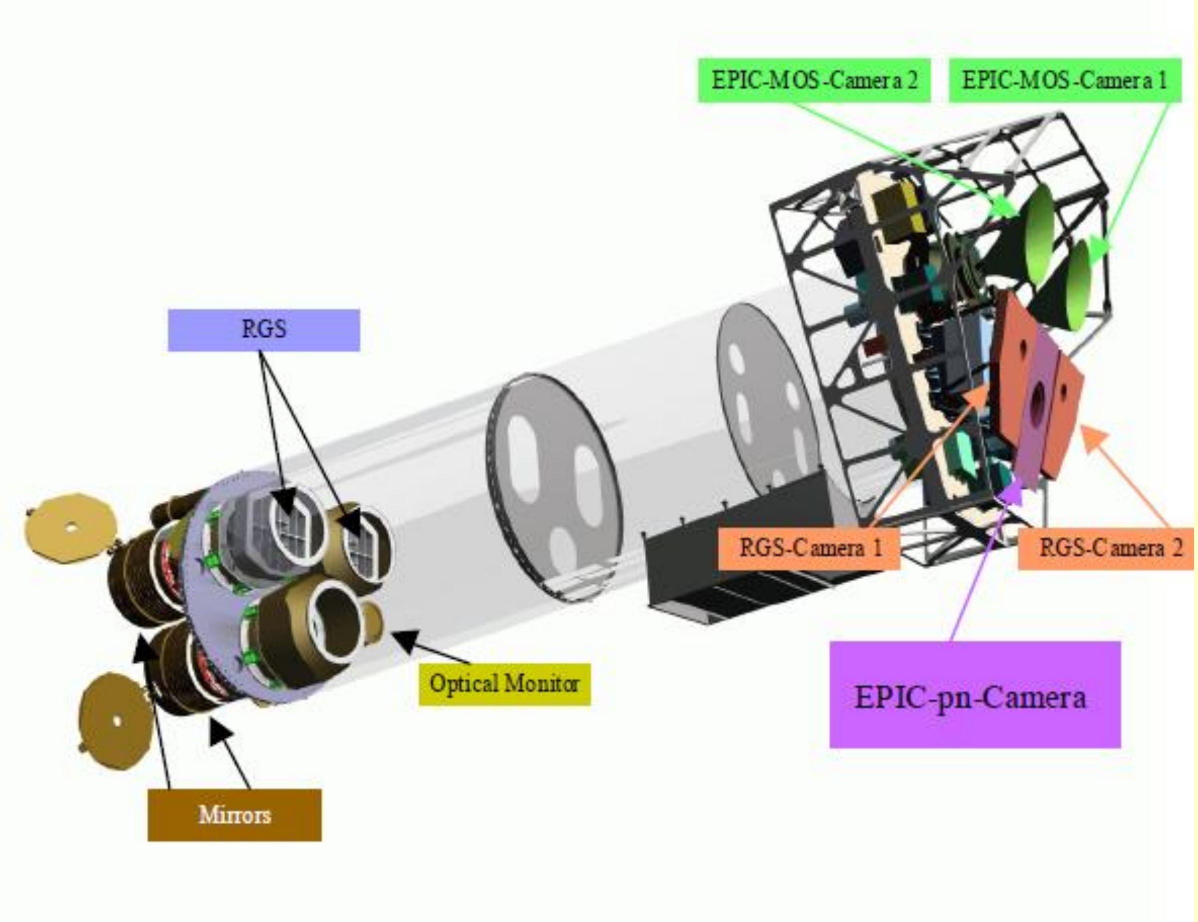
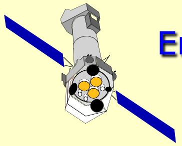
EPIC instrument:

European Photon Imaging Camera



Hardware features:

- Three independent CCD-cameras (two MOS & one PN), observing simultaneously the same field.
- Three different light filters
- Different observation modes



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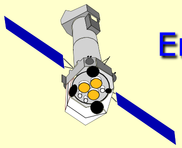

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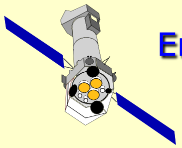
Background components:

- **Astrophysical background**
  - Photons:
    - Cosmic X-ray background
    - Soft proton "flares"
    - Solar wind charge exchange
  - Particles:
    - High energy penetrating (Cosmic Rays) hitting directly the CCD
- **Detector background**
  - Low energy electronic noise
  - Time dependence: detector degrading in space
  - Possition dependence:
    - **Fluorescent emission lines:** strong metal line features (Cu) make background subtraction complex especially for **extended sources**.



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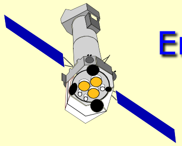
Background components:

More information about background components and their temporal, spectral, spatial properties are summarized at

http://www.star.le.ac.uk/~amr30/BG/BGTable.html



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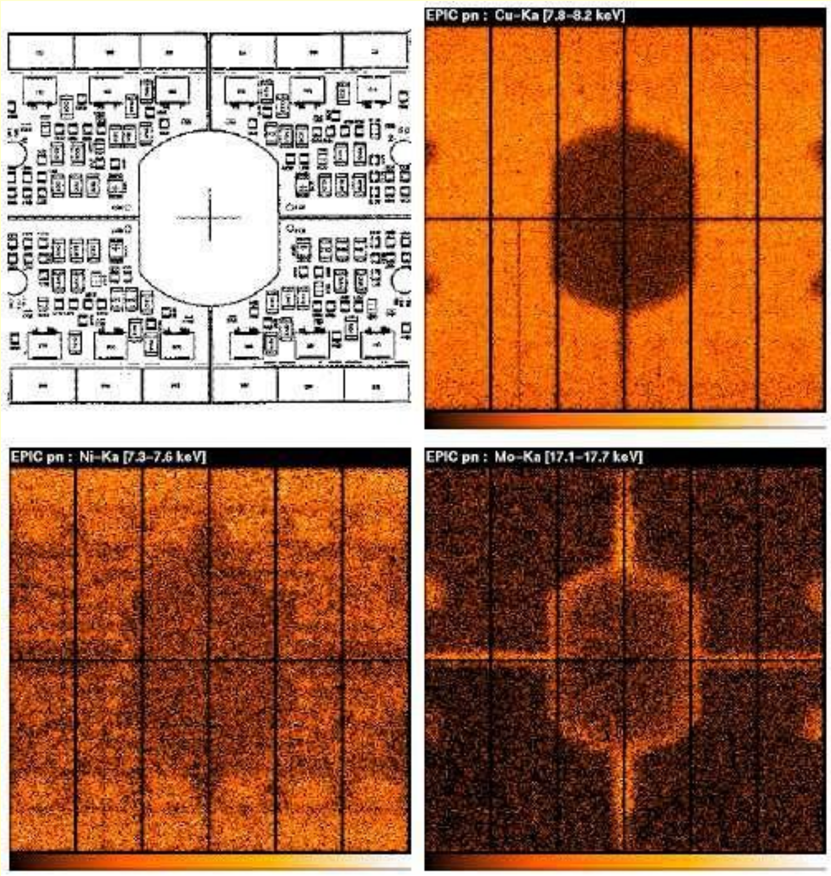
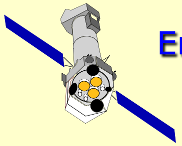
Background components:



Possition
background dependence because
of the electronics of the CCD´s



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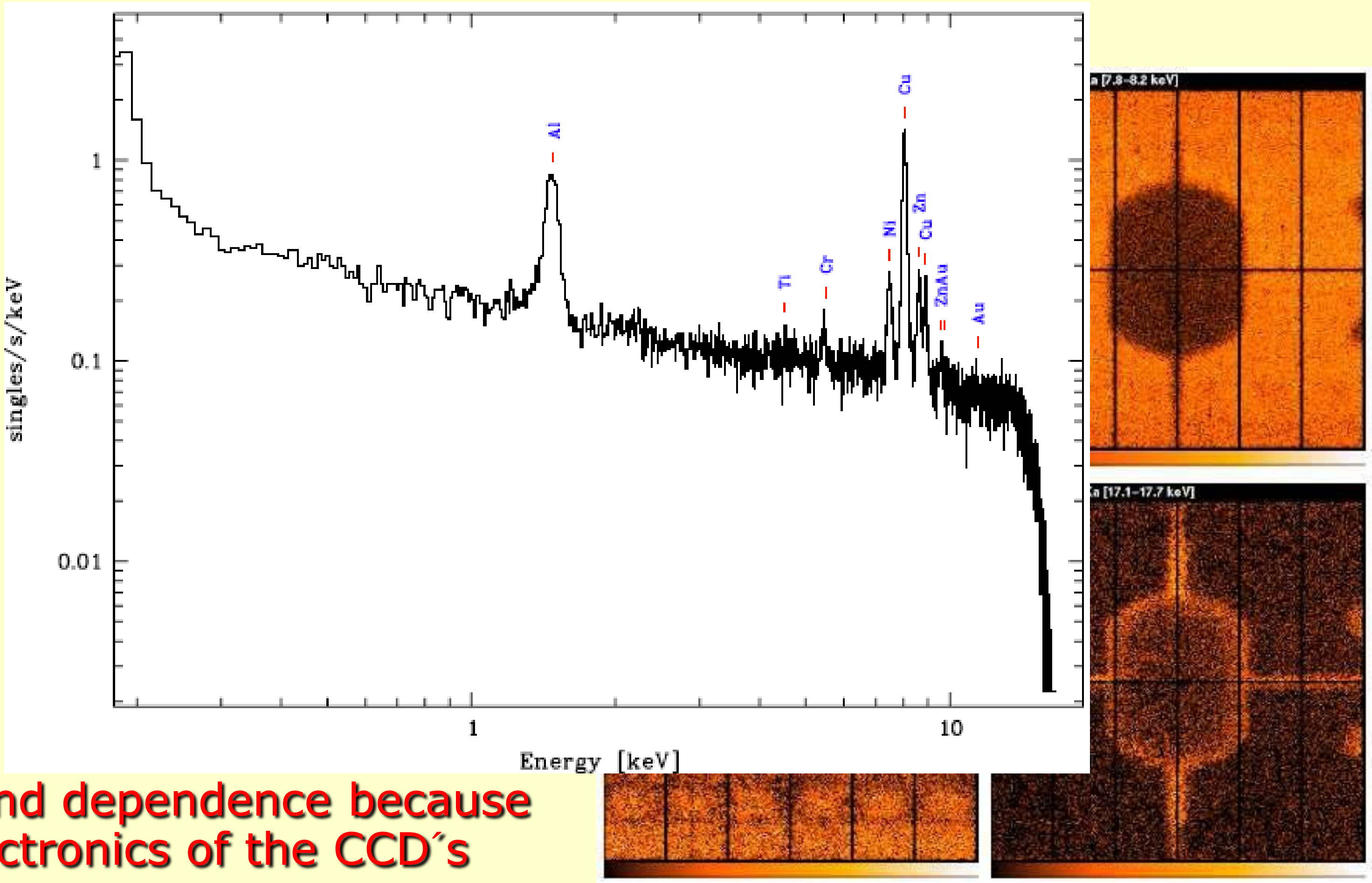
Background components:



Possition
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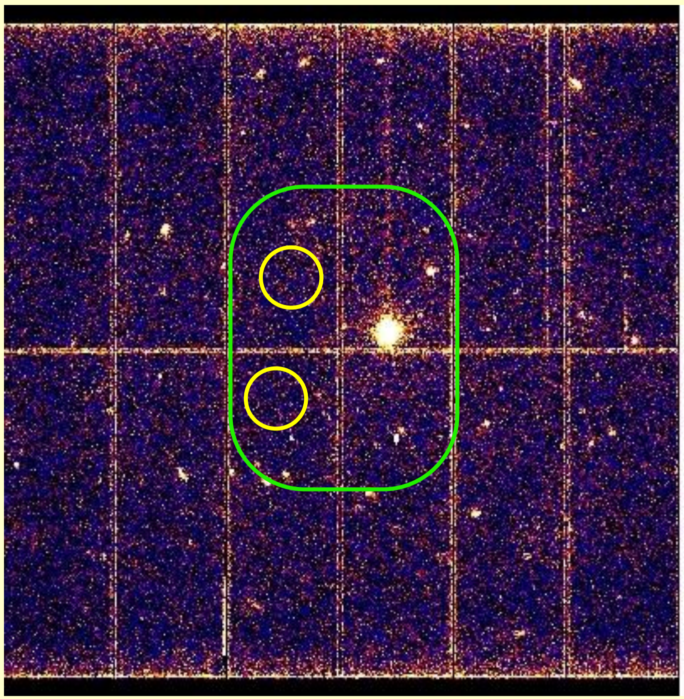
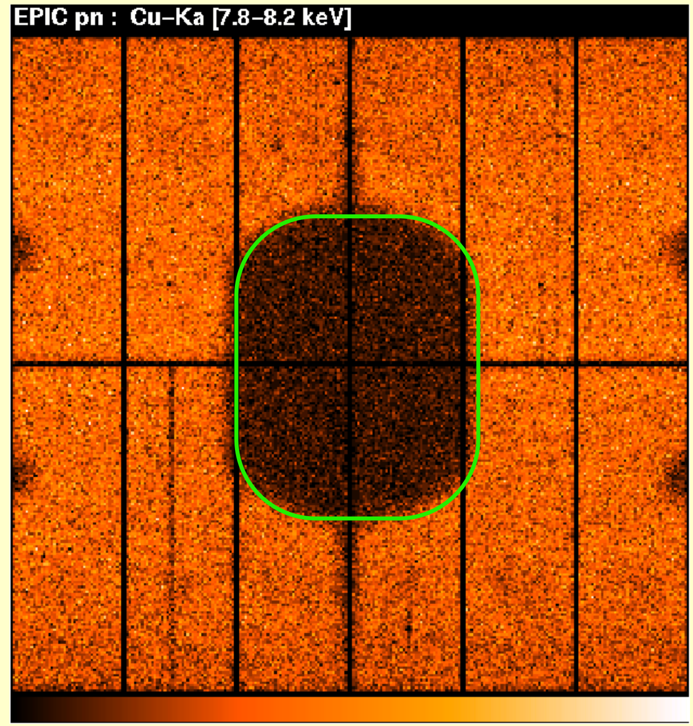
Extracting backgrounds (point sources):





Source: Galaxy Cluster A1795 (full frame mode) – XMM Newton

We can extract the background value from the free electronics region of the detector

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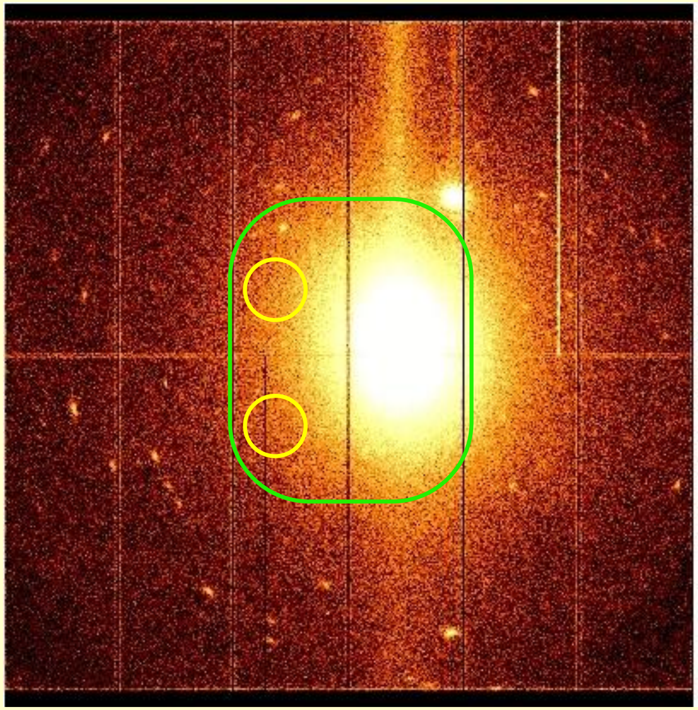
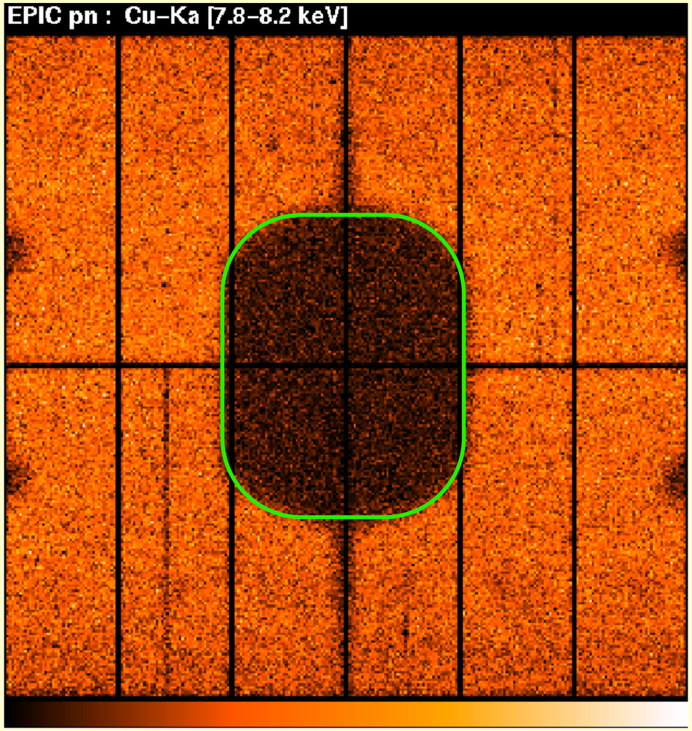
Extracting backgrounds (extended sources):

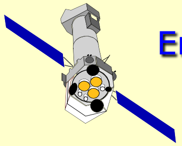




Source: Galaxy Cluster A1795 (full frame mode) – XMM Newton

We see the Cu fluorescence line (an others) in the spectrum

Problem: The source exceeds the "free electronics" region of the detector



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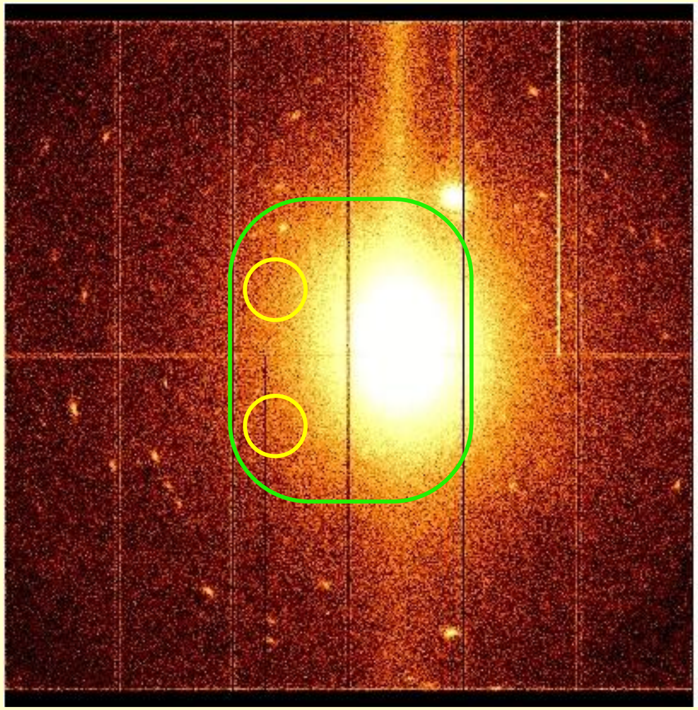

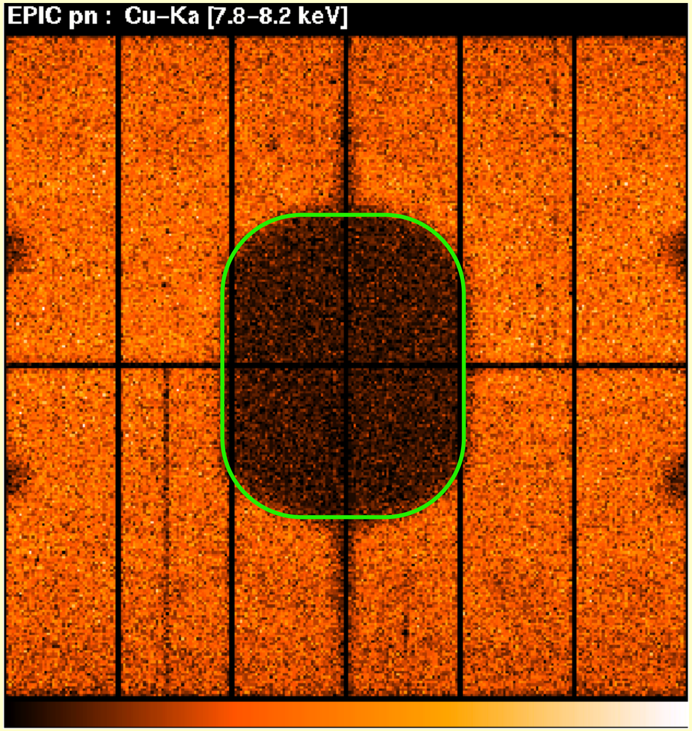

Source: Galaxy Cluster A1795 (full frame mode) – XMM Newton

Solutions? One of them is to use the Blank Sky Fields

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Blank Sky Fields:

Blank Sky Background Event Files

Developed and maintain at Leicester Univ. by the EPIC Blank Sky team based on the work of J. Carter and A. Read (A&A 464, p1155, 2007).

- **All the point sources have been removed**
- **Sky regions free of sources created**

→ **Two different analysis made:**

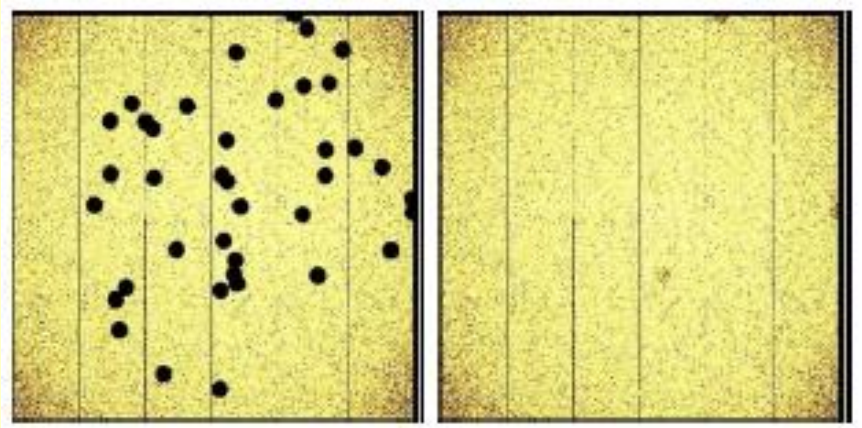
→ ***Time based sky field:***

The detector is degrading with time

→ ***Position based sky field:***

The sky background is not uniform

Each Blank Sky file is constructed from several different event files



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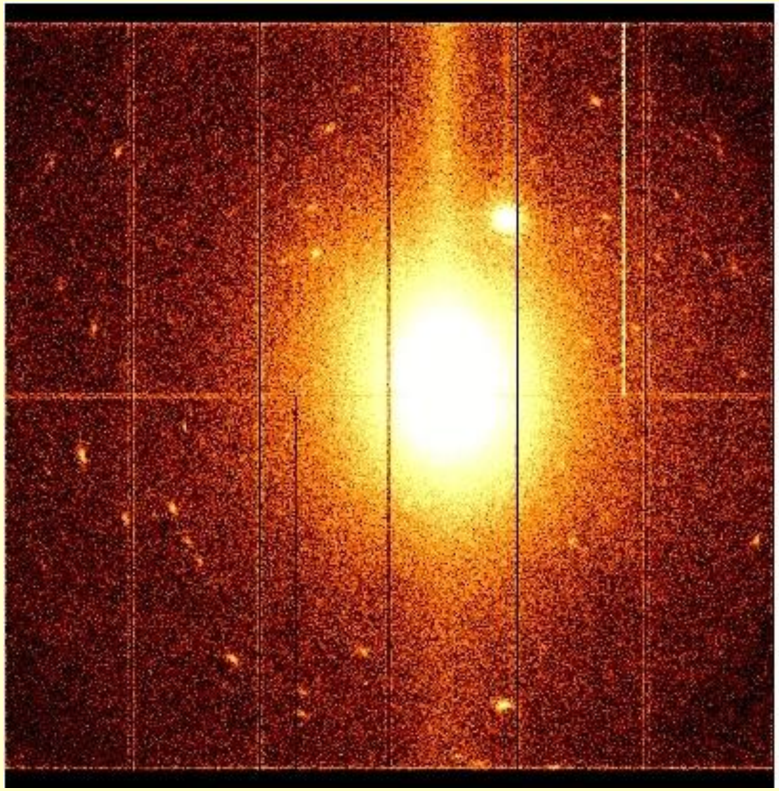
Blank Sky Fields (handling):

Galaxy cluster A1795



Source: Galaxy Cluster A1795 (full frame mode) – XMM Newton

Why?

- High temperature object
- Its spectrum has a more fluxed high energies
- The strongest background feature is Cu flourescence line (~8 keV)

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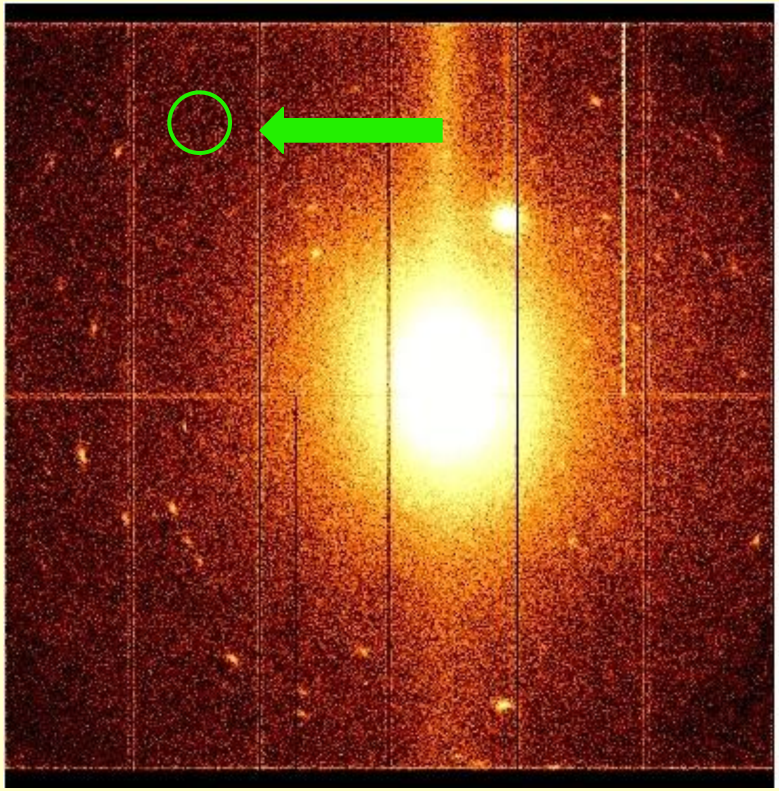
Blank Sky Fields (handling):



Source: Galaxy Cluster A1795 (full frame mode) – XMM Newton

Galaxy cluster A1795

Three background corrections compared:

1. Background spectrum (*local bkg*)
2. Background spectrum from BlankSky field 1 (*Position based*)
3. Background spectrum from the BlankSky field 2 (*Time based*)

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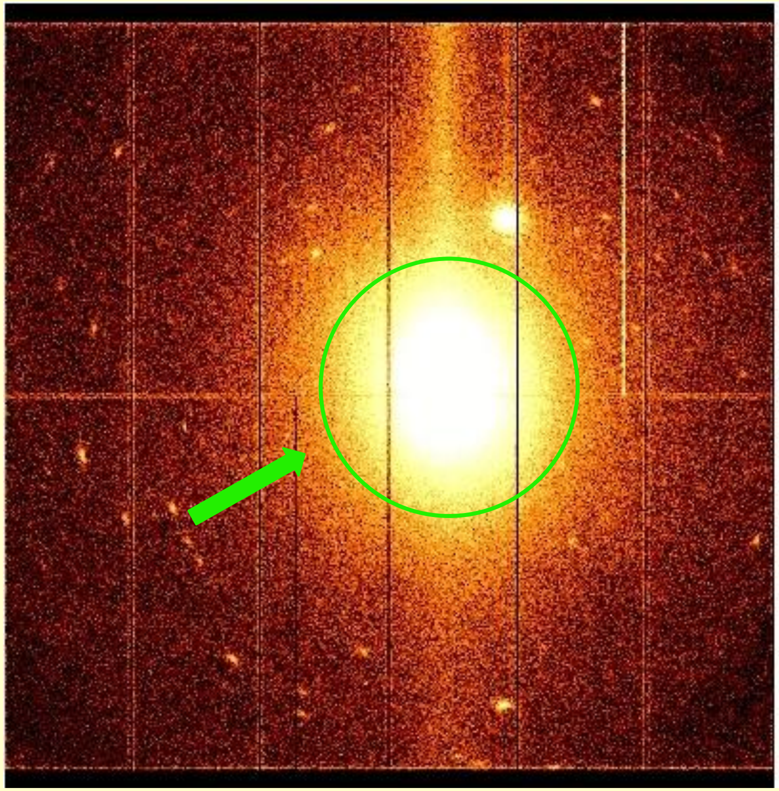
Blank Sky Fields (handling):



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…applied in two regions:

- Full cluster region

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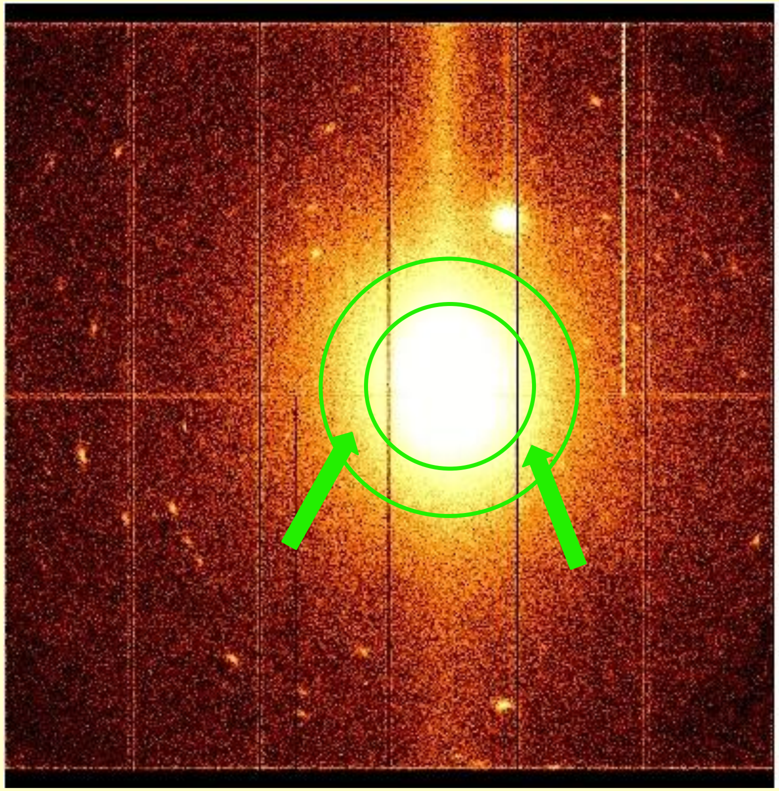

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Galaxy cluster A1795

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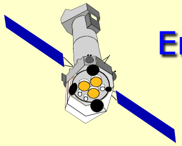
…applied in two regions:

- Full cluster region
- Annular region



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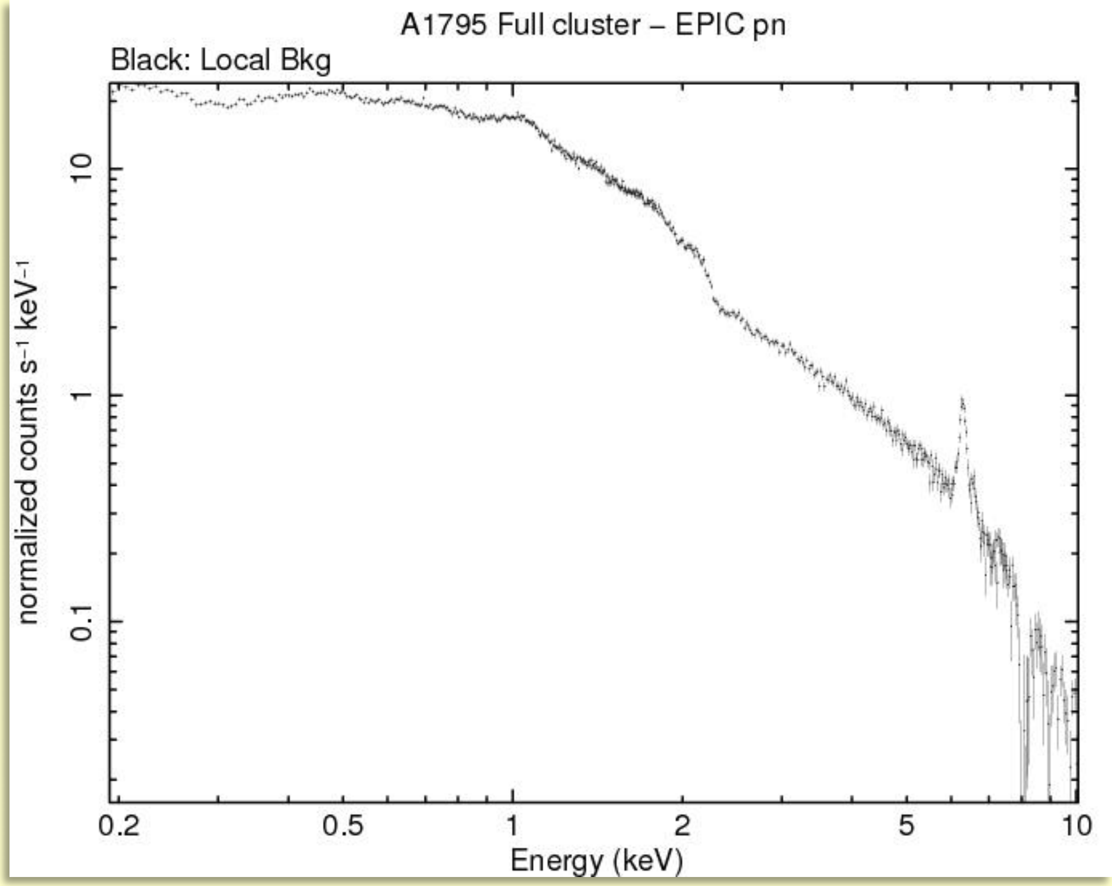
Results:

Galaxy cluster A1795



Background corrections applied?

1. Bkg spectrum (*local bkg*)

Regions:

- **Full cluster region**

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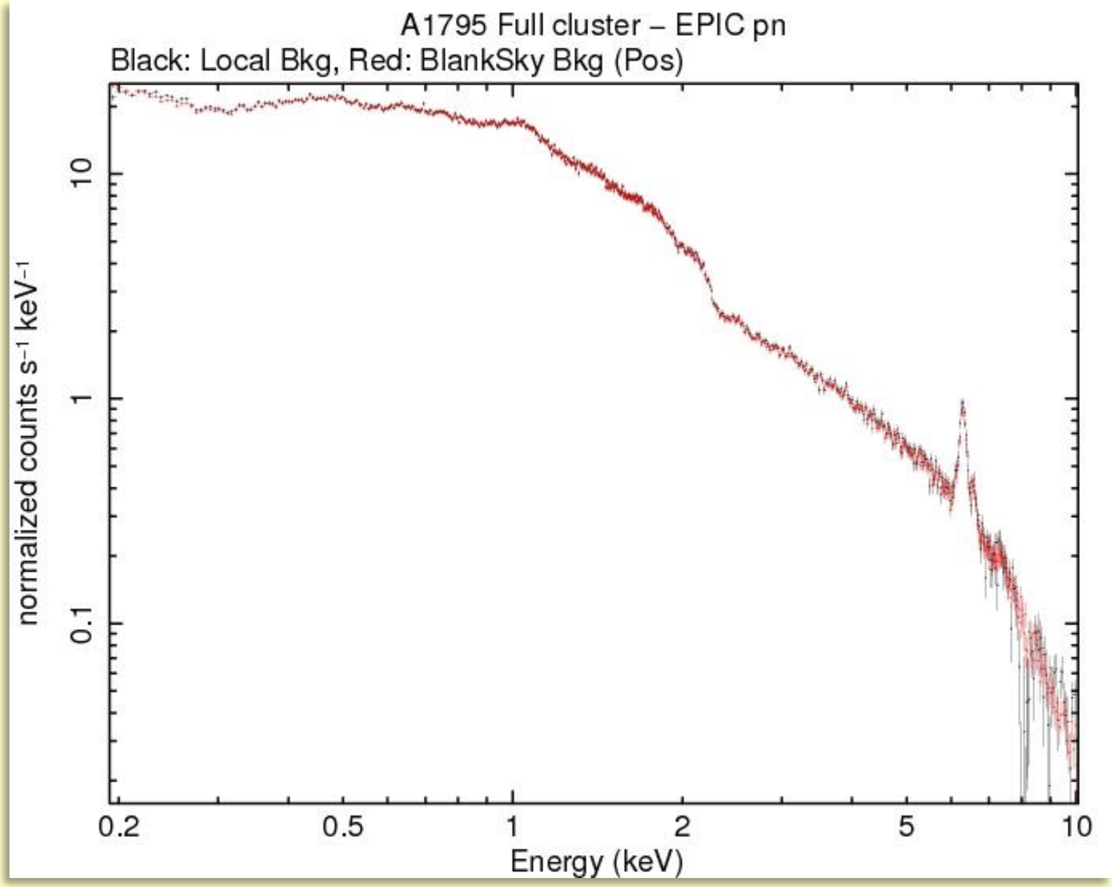
Results:

EPIC ESAC

Galaxy cluster A1795



Background corrections applied?

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2. Bkg spectrum from BlankSky field 1 (*Position based*)

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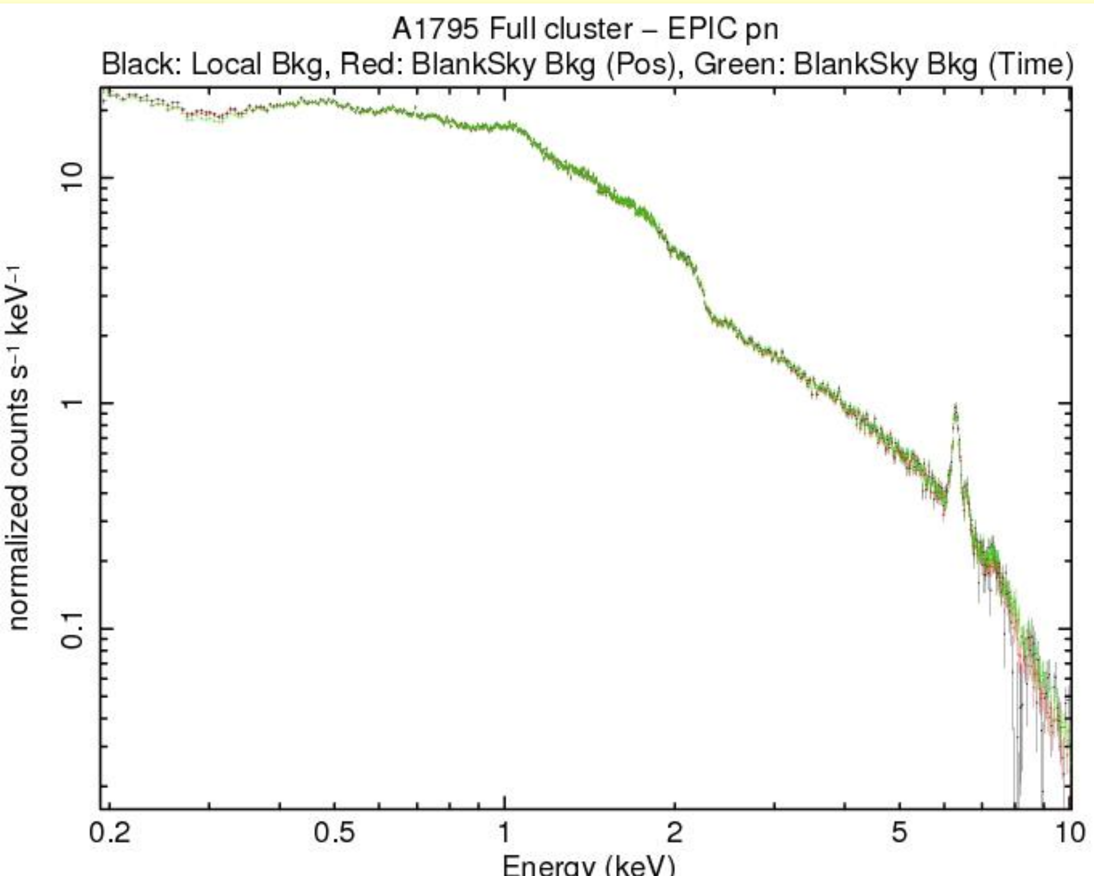
Results:

Galaxy cluster A1795



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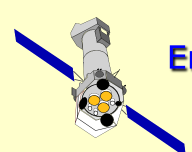

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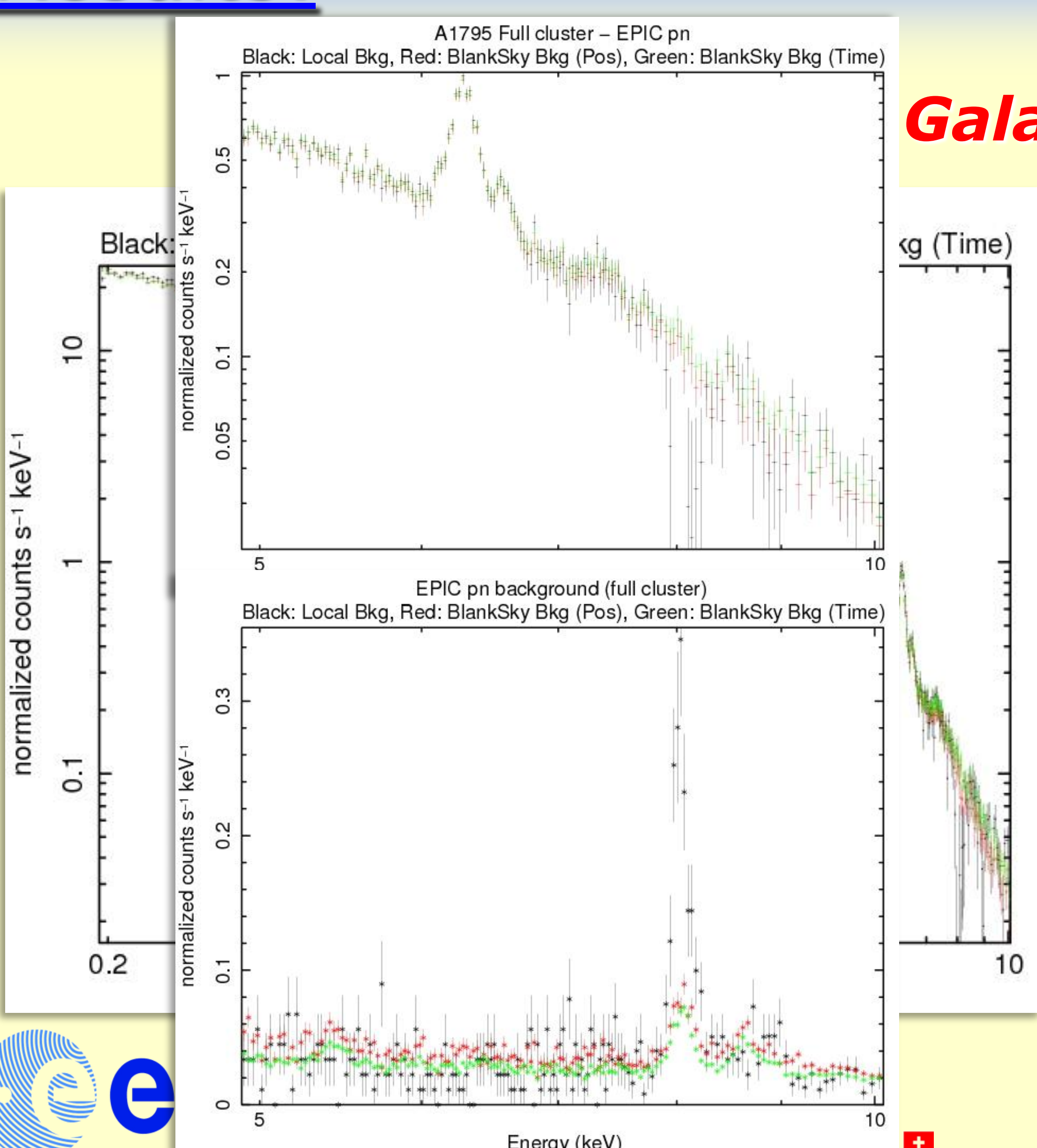

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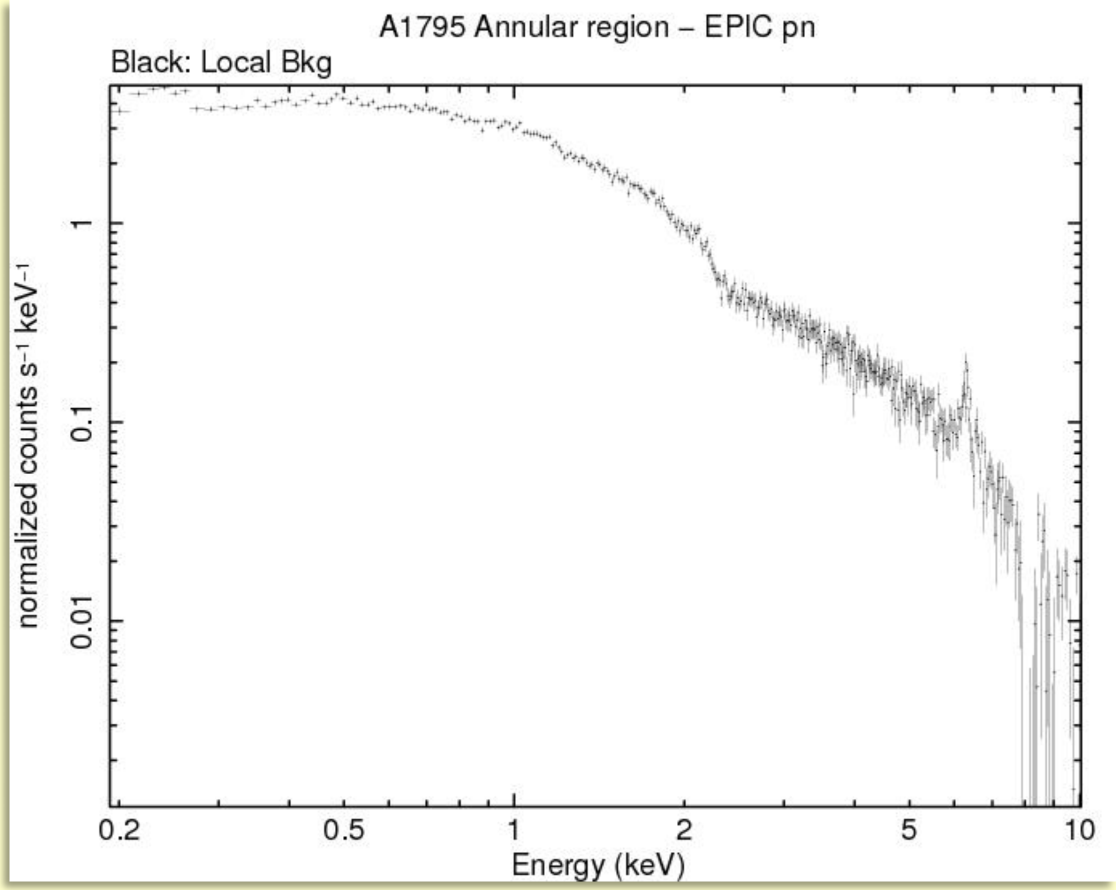

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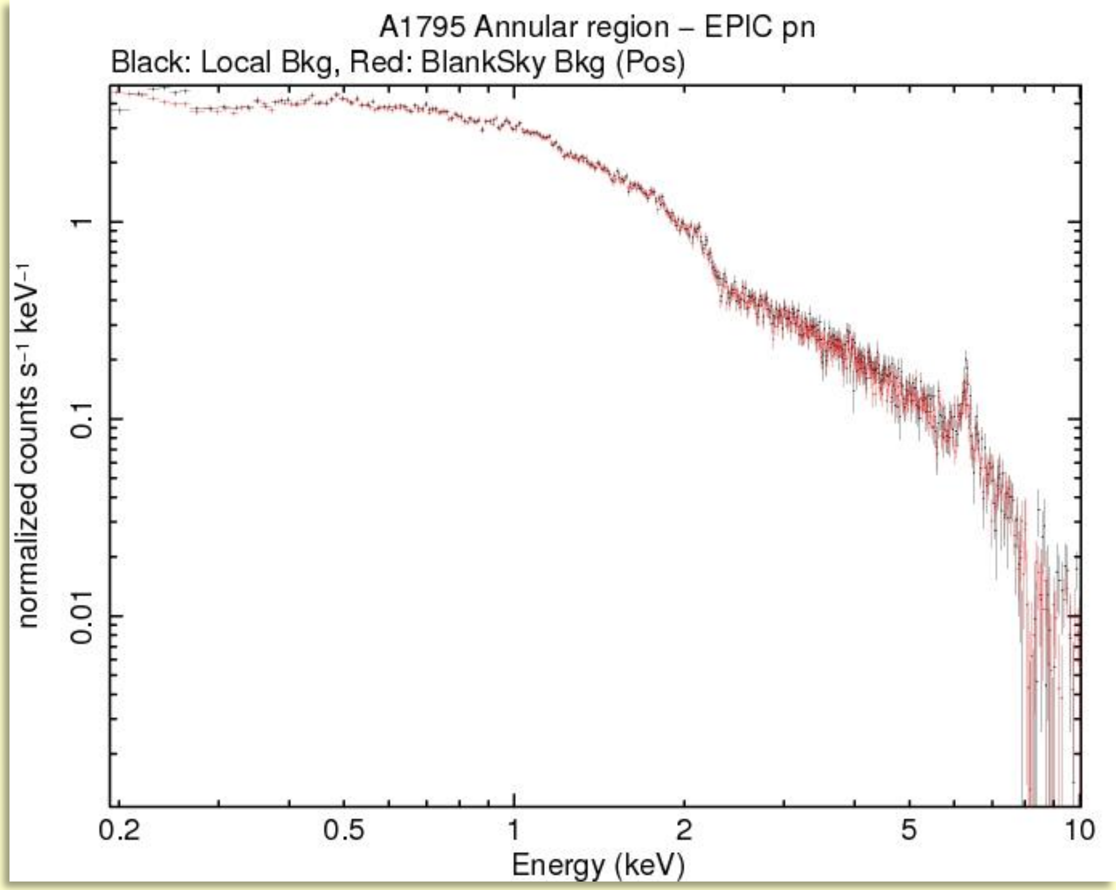

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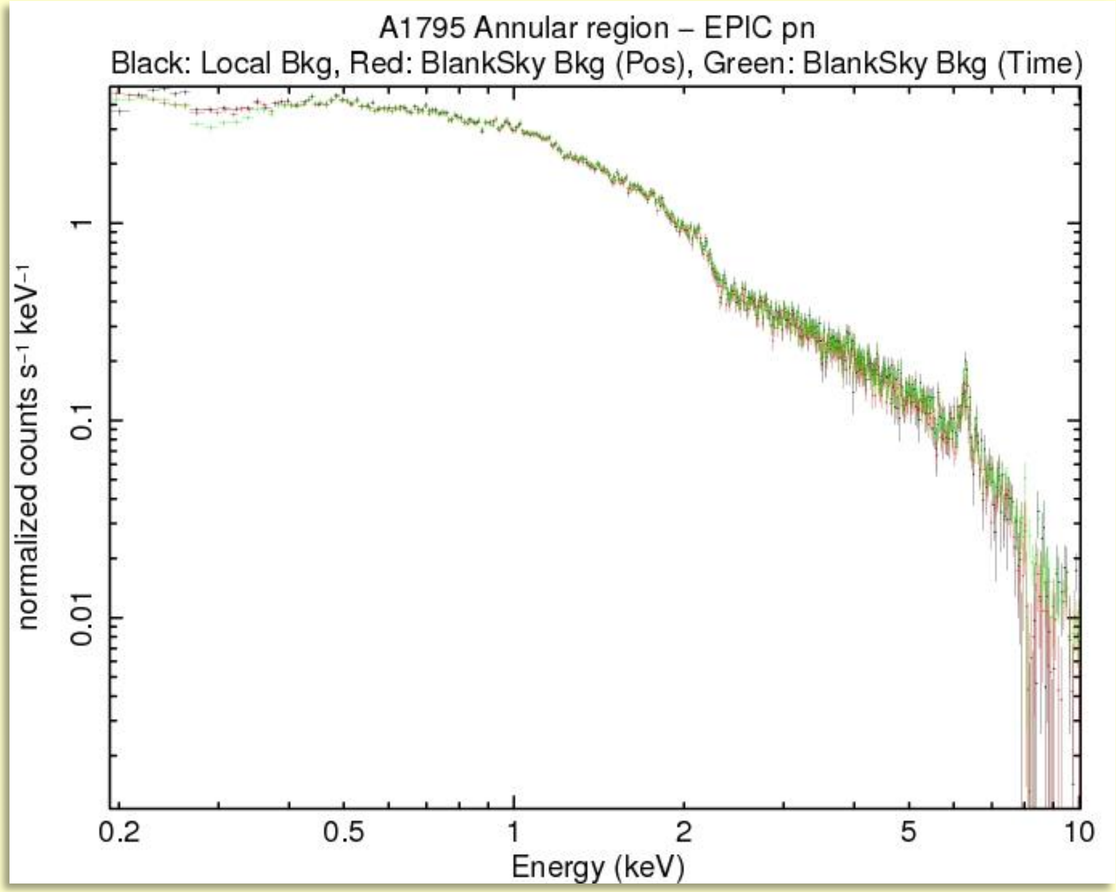

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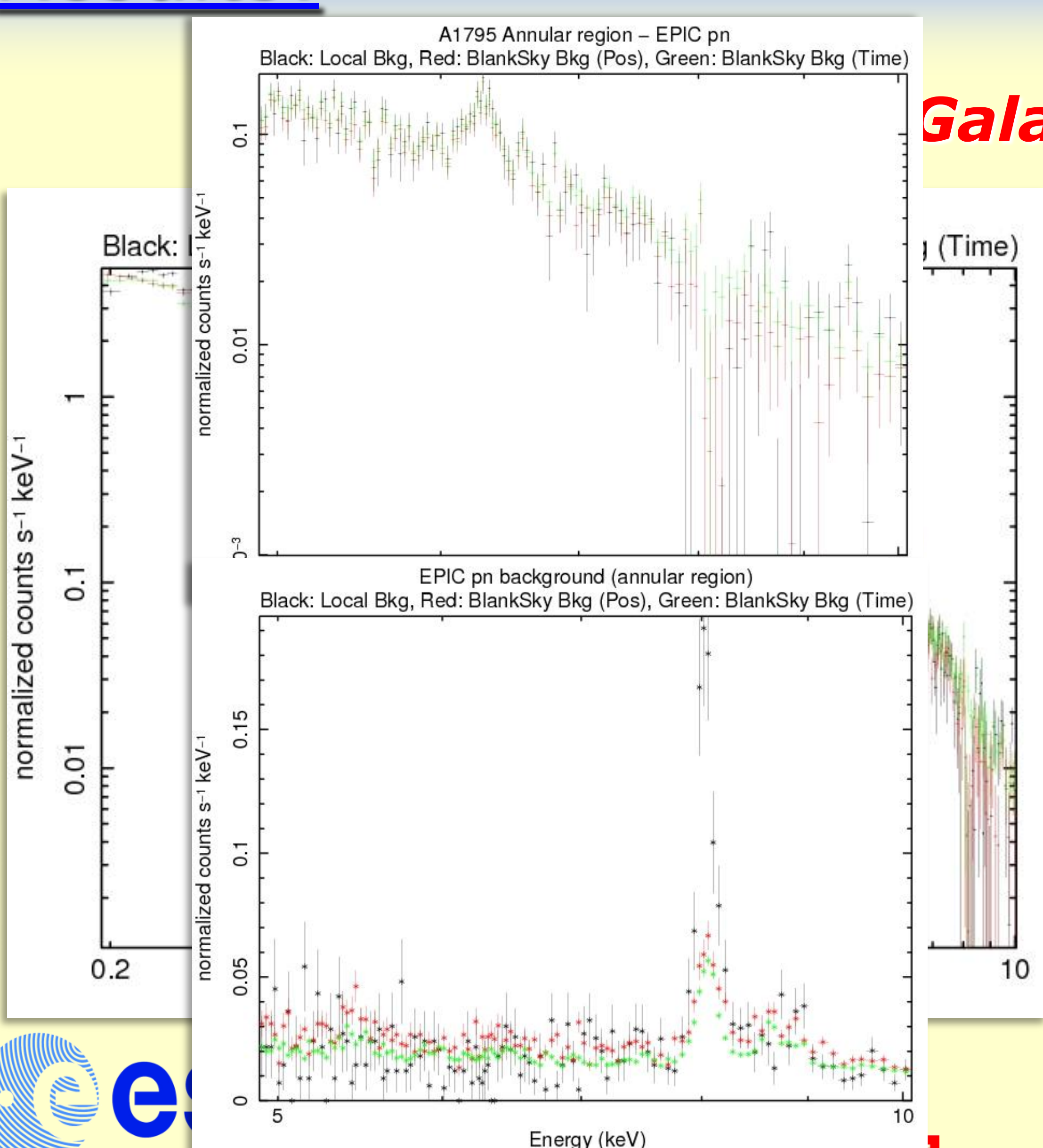

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Regions:

- **Annular region**

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Conclusions:

- Results for the full galaxy cluster are as we expected:
  - Background features disapeared.
  - No significant difference between the two blank sky fields.
  - As SNR analysis is equivalent, applying blank sky field backgrounds is succesful.

- However, for the annular region using blank sky fields there still remain background issues.
  - We don´t know yet why.

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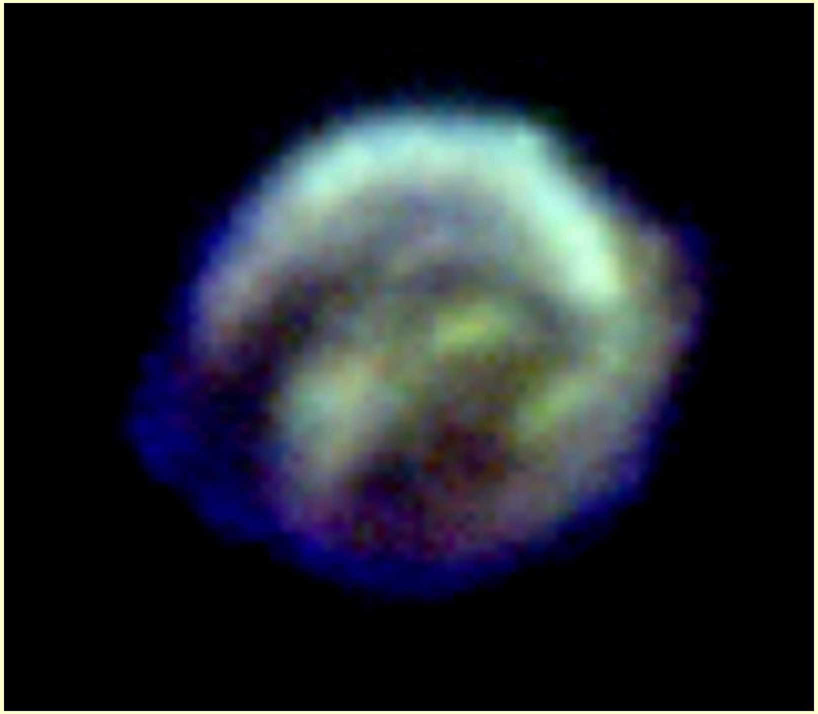
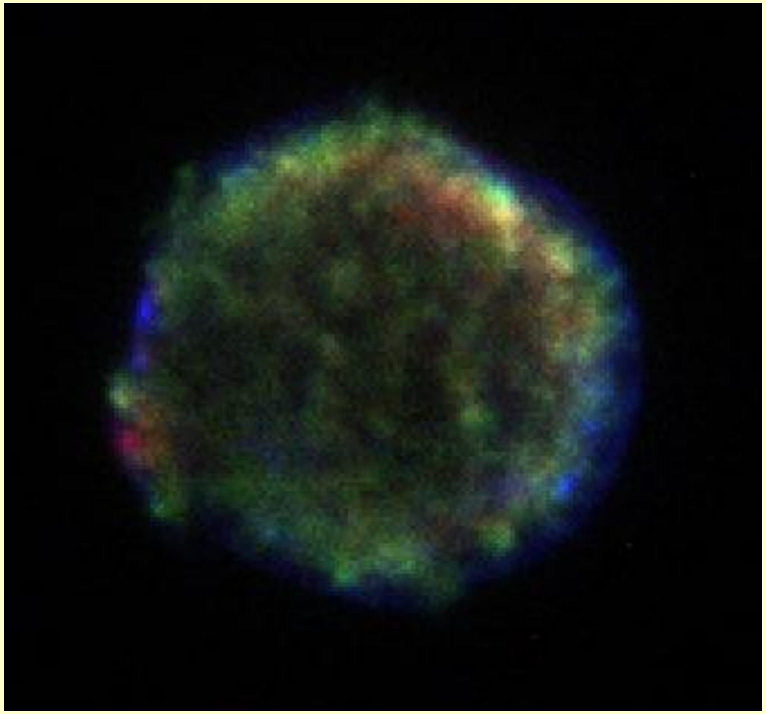
Next steps:

- Create an spectra of SNR using this process: blank sky background correction.
- Create image gallery of galactic SNR.



Kepler SNR – XMM Newton EPIC MOS



Tycho SNR – XMM Newton EPIC MOS

Courtesy of Martin Stuhlinger

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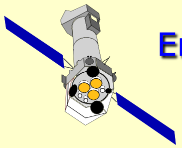
Acknowledgements:

Thanks to:

Martin Stuhlinger, I. de la Calle and Deborah Baines and my trainee mates.



Questions please…

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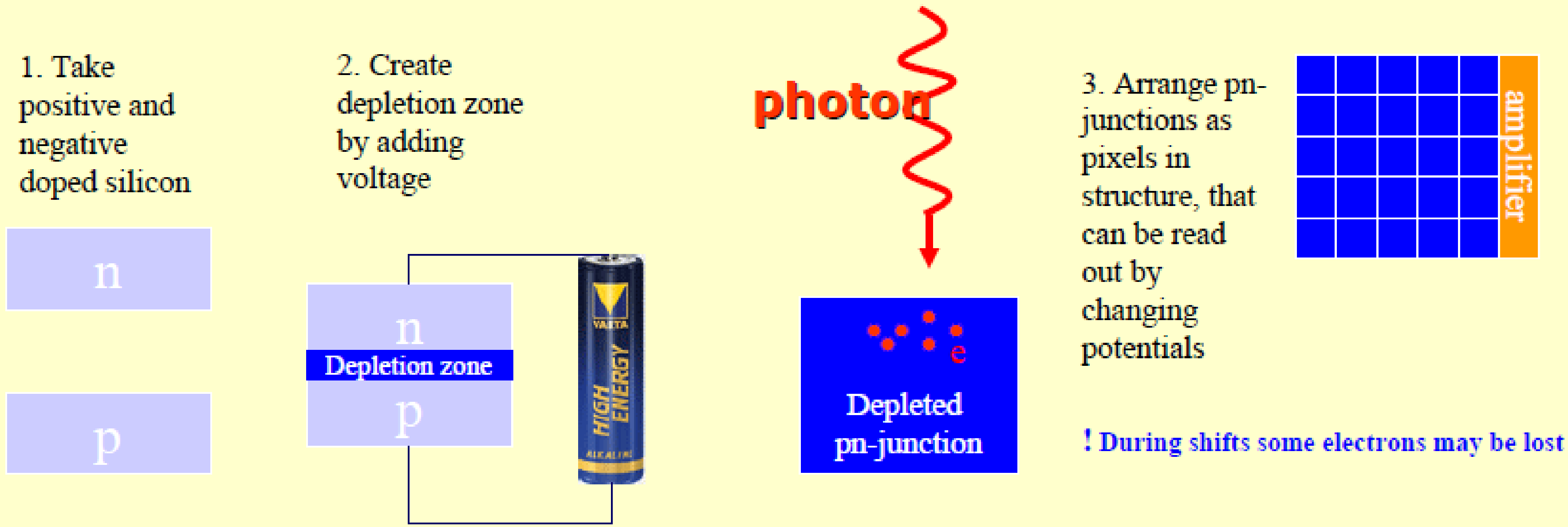
Additional material (1):

EPIC ESAC

What is a CCD?

- Charge Coupled Device
- You know that from your digital cam or mobile phone
  - our CCDs however work also for X X-ray photons
- Silicon device to measure photons energy, position and time



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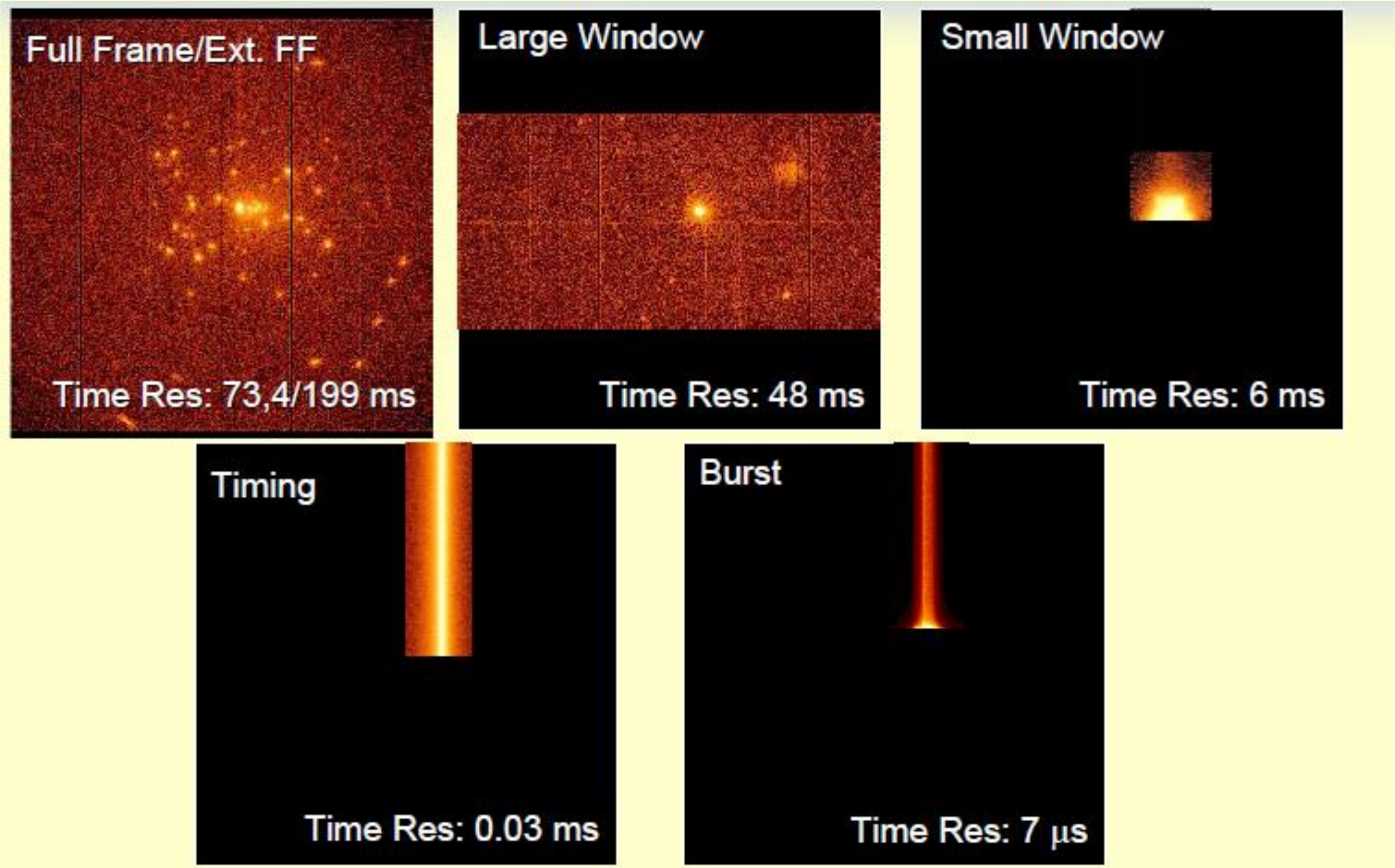
Additional material (2):

PN operating modes



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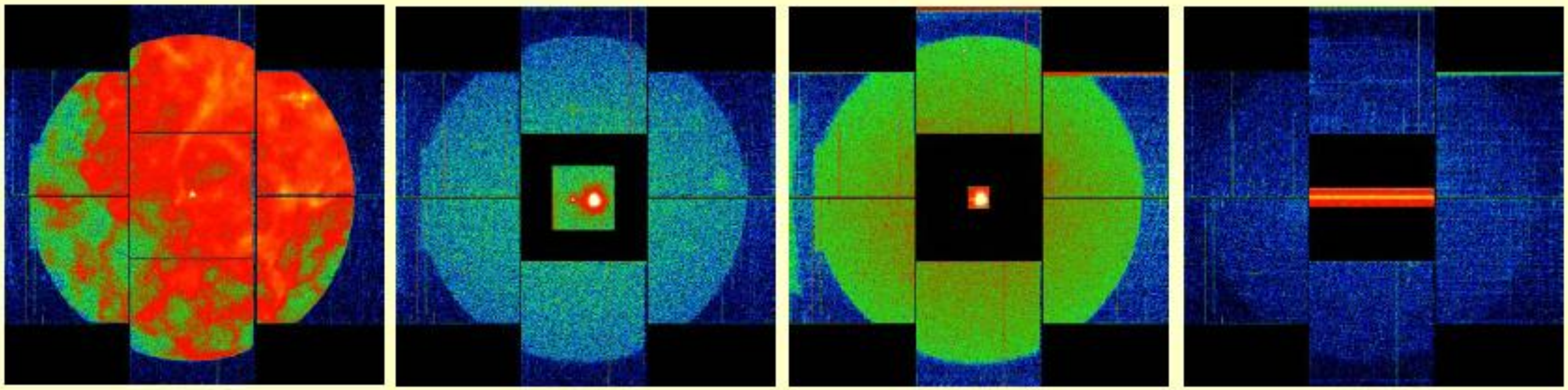
Additional material (3):

MOS operating modes



Full Frame	Large Window	Small Window	Timing
Time Res.: 2.6 s	Time Res: 0.9 s central CCD 2.7 s outer CCDs	Time Res.: 0.3 s central CCD 2.7 s outer CCDs	Time res. : 1.8 ms central CCD 2.6 s outer CCDs

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Additional material (4)

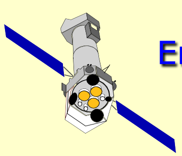
Summary of modes properties

Table 3: *Basic numbers for the science modes of EPIC*

MOS (central CCD; pixels) [1 pixel = 1.1"]	**Time resolution**	**Live time [1] [%]**	**Max. count rate [2] diffuse [3] (total) [s^{-1}]**	**Max. count rate [2] (flux) point source [s^{-1}] ([mCrab] [4])**
Full frame (600 × 600)	2.6 s	100.0	150	0.70 (0.24)
Large window (300 × 300)	0.9 s	99.5	110	1.8 (0.6)
Small window (100 × 100)	0.3 s	97.5	37	5 (1.7)
Timing uncompressed (100 × 600)	1.75 ms	100.0	N/A	100 (35)
pn (array or 1 CCD; pixels) [1 pixel = 4.1"]	**Time resolution**	**Live time [1] [%]**	**Max. count rate [2] diffuse [3] (total) [s^{-1}]**	**Max. count rate [2] (flux) point source [s^{-1}] ([mCrab] [4])**
Full frame [5] (376 × 384)	73.4 ms	99.9	1000(total)	6 (0.7)
Extended full frame [5,6] (376 × 384)	199.1 ms	100.0	370	2 (0.25)
Large window (198 × 384)	47.7 ms	94.9	1500	10 (1.1)
Small window (63 × 64)	5.7 ms	71.0	12000	100 (11)
Timing (64 × 200)	0.03 ms	99.5	N/A	800 (85)
Burst (64 × 180)	7 μs	3.0	N/A	60000 (6300)

This table is extracted from the source of any wisdom as far as XMM-Newton instruments are concerned: the *XMM-Newton Users Handbook:*

http://xmm.esac.esa.int/external/xmm_user_support/documentation/uhb/index.html



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