An in-depth analysis of the EPIC-MOS instrumental background

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Collaborators

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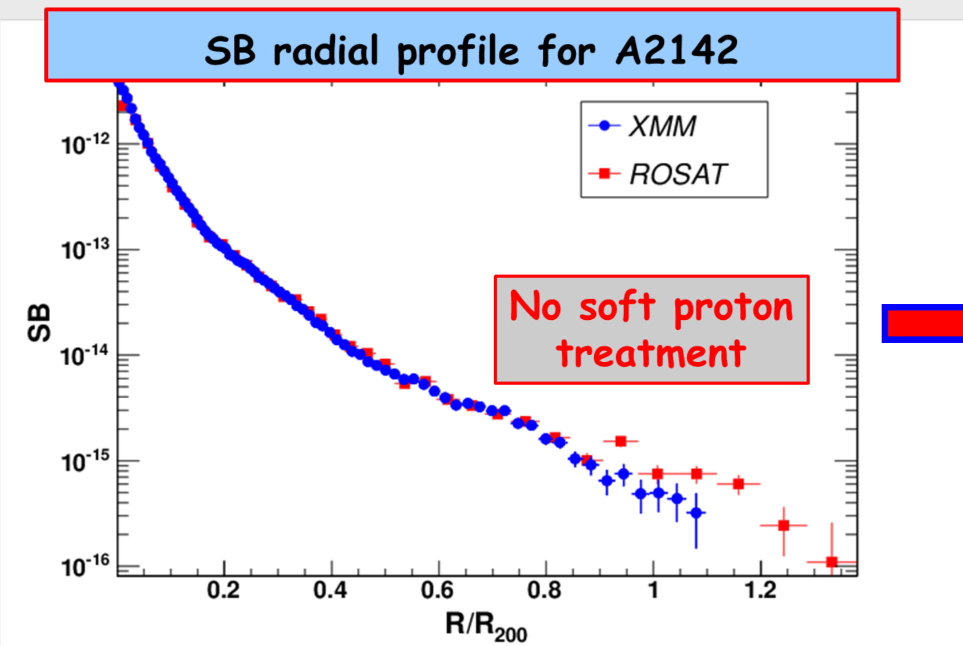
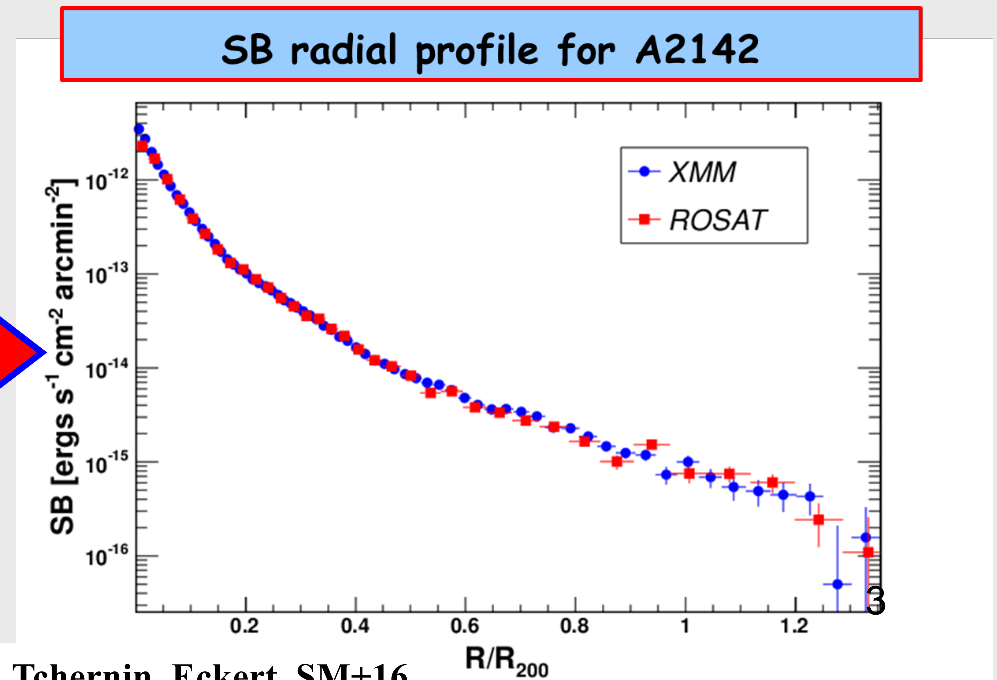
Background: why do we care?

Improved treatment of EPIC background
More effective exploitation of EPIC data

Bkg spatial characterization good to 5%





Tchernin, Eckert, SM+16

Approach

Considerable efforts to achieve an understanding of EPICs bkg.

However:

1) Analysis of "partial" datasets (typically few Ms)
2) Approach almost entirely phenomenological

1) Systematic Analysis of XMM EPIC background data over the full mission timeline
2) Achieve a deeper understanding of how bkg is produced, key to apply what we learn to other missions.

Resources

Significant Resources are required if such an approach is to be followed

Arembes (ATHENA Radiation Environment Models and X-Ray Background Effects Simulators) R&D Activity within ATHENA

EXTraS (Exploring the X-ray Transient and variable Sky)

A project within the EU-FP7 framework

ATHENA Radiation Environment Models and X-Ray Background Effects Simulators	WP1 TN 1.1	Doc No: IASFMi-ATHENA-WP1 Date: 10 February 2017 Page: 1 of 78

AREMBES

ATHENA Radiation Environment Models and X-Ray Background Effects Simulators

ESA's Science Core Technology Programme (CTP)
ESA Contract No. 4000116655/16/NL/BW

WP1 TN 1.1
Radiation Background Data Analysis & Lessons Learned from Previous X-ray Missions

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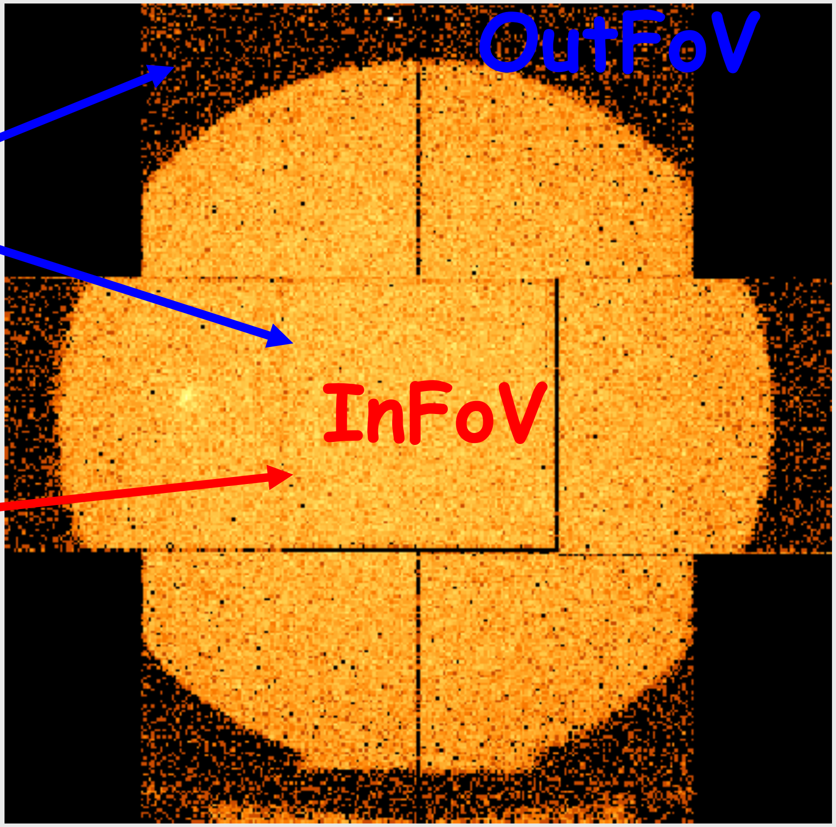
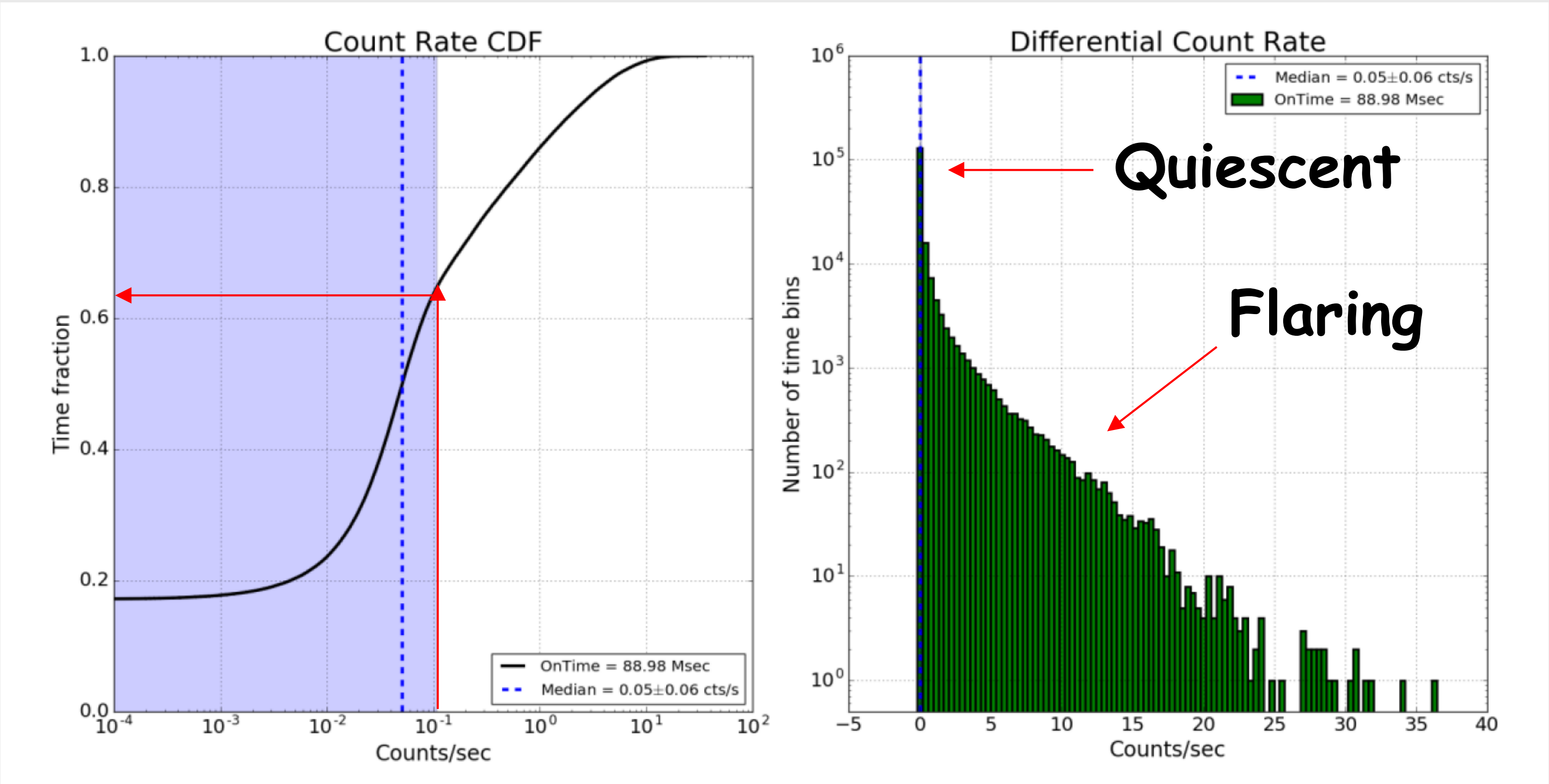
Instrumental bkg

- Secondaries generated by high energy particle (E>100 MeV) mostly Cosmic Rays p+
- Low energy ions (E<100 KeV) concentrated by mirrors



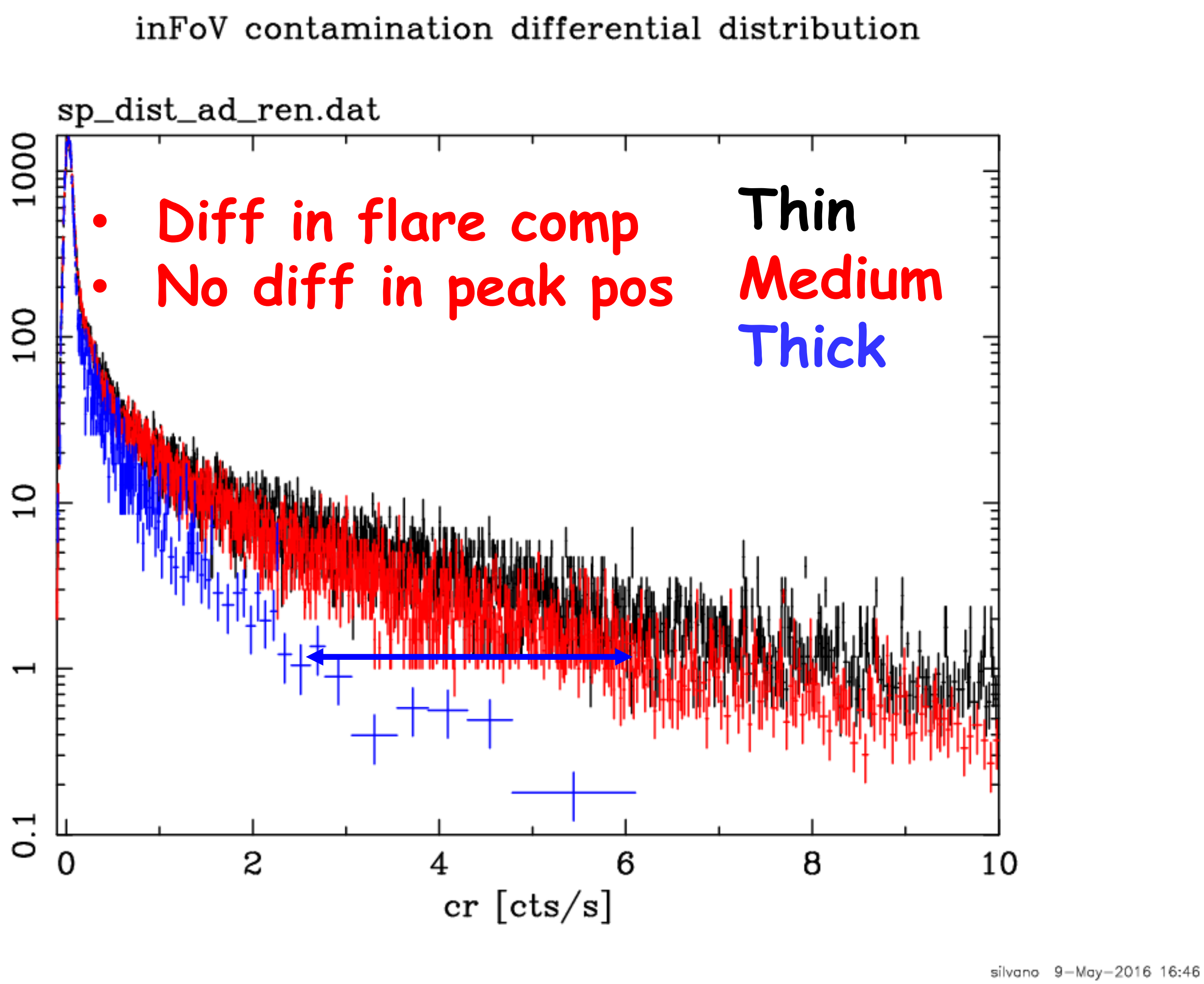
InFoV_excess = InFoV - OutFoV

Soft Proton Distribution



~ 40% of data dominated by flaring component

Soft Protons vs Filters



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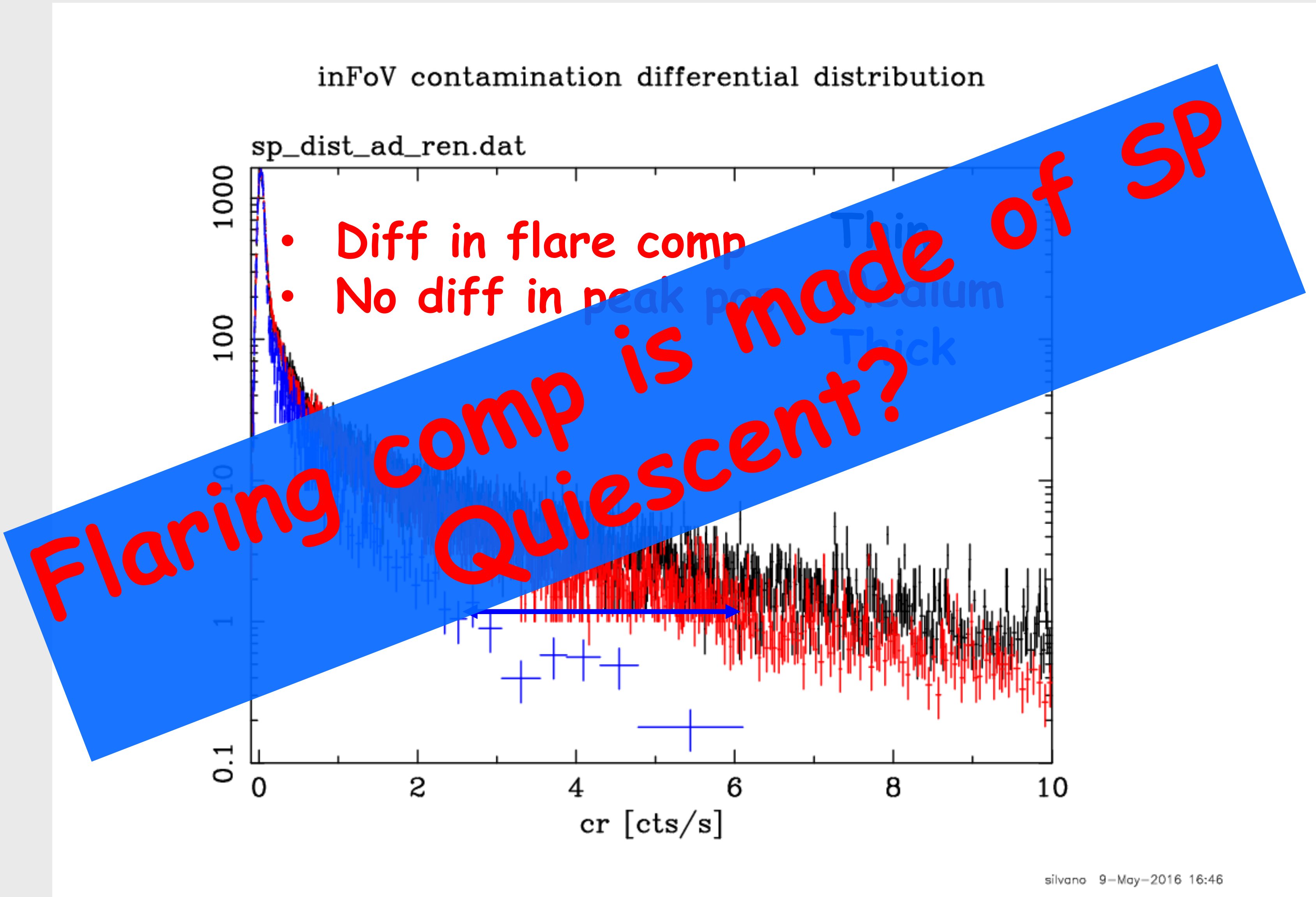
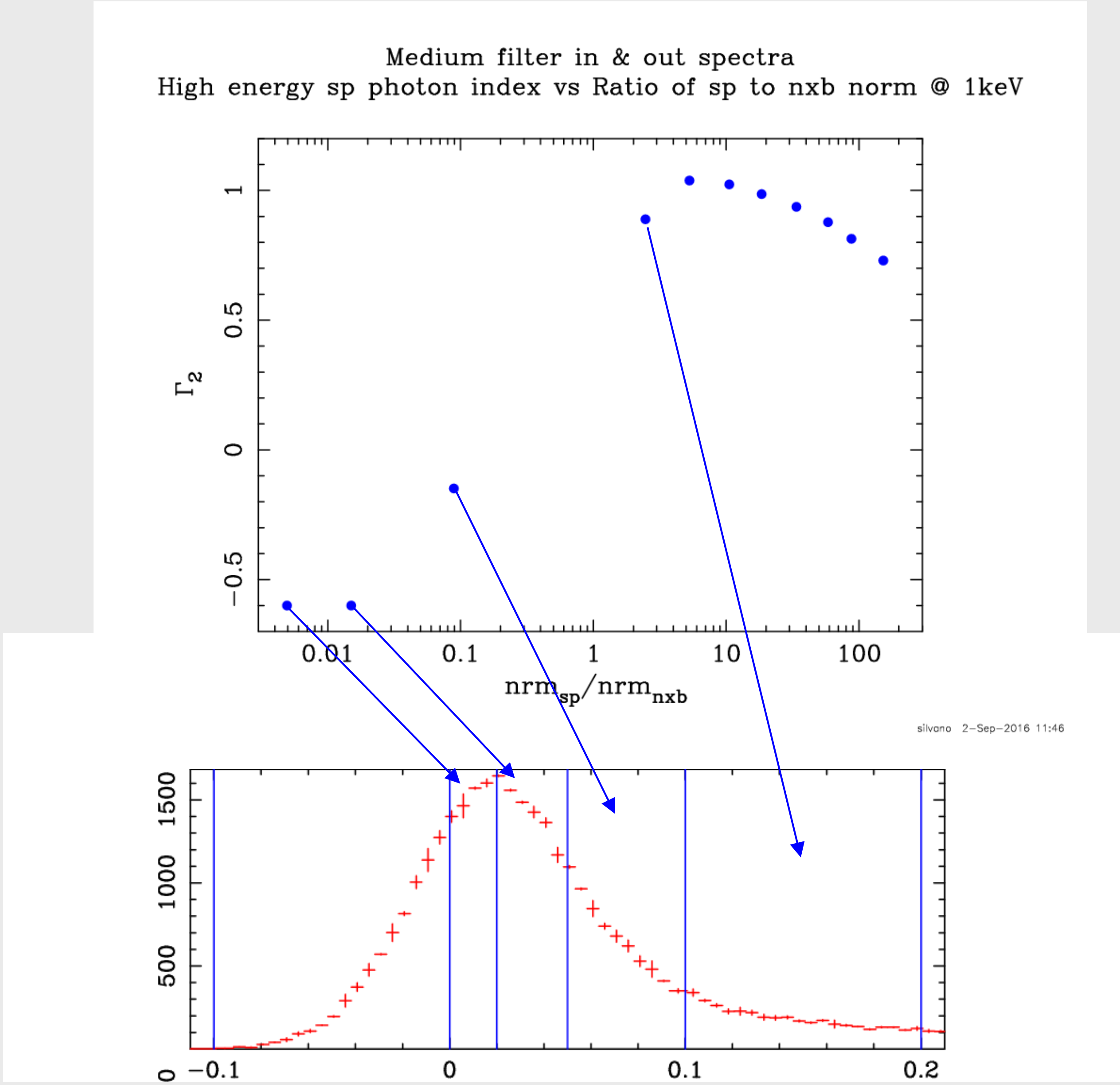


Spectral Analysis

High energy slope of bkn-pow modeling INFoV Excess



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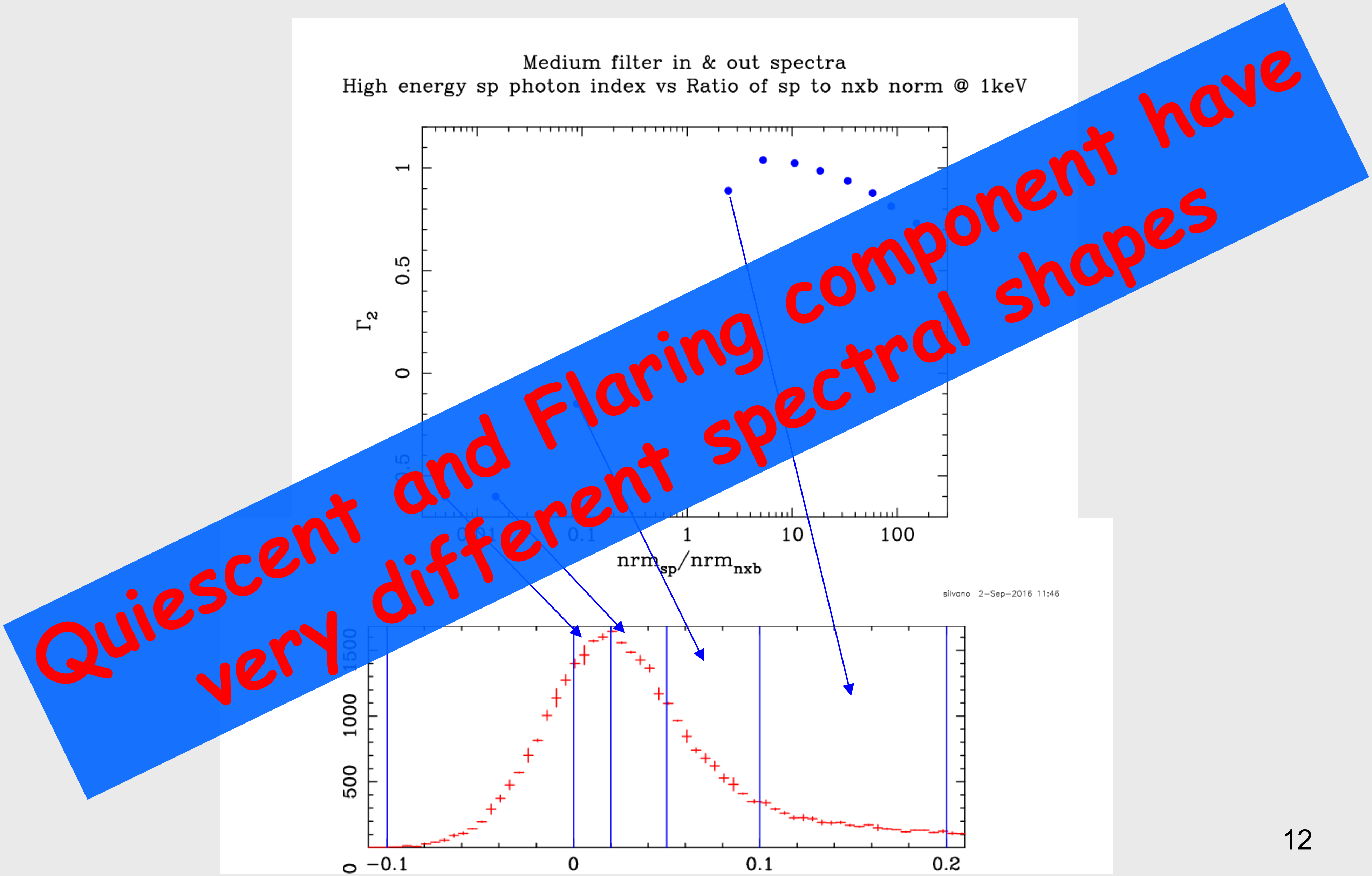
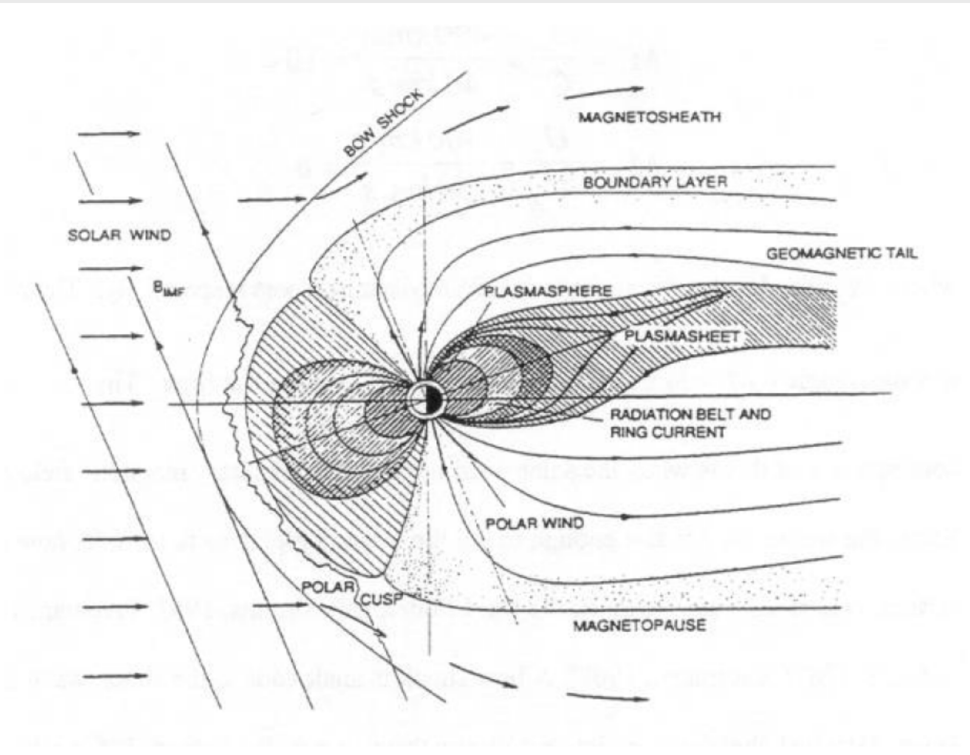
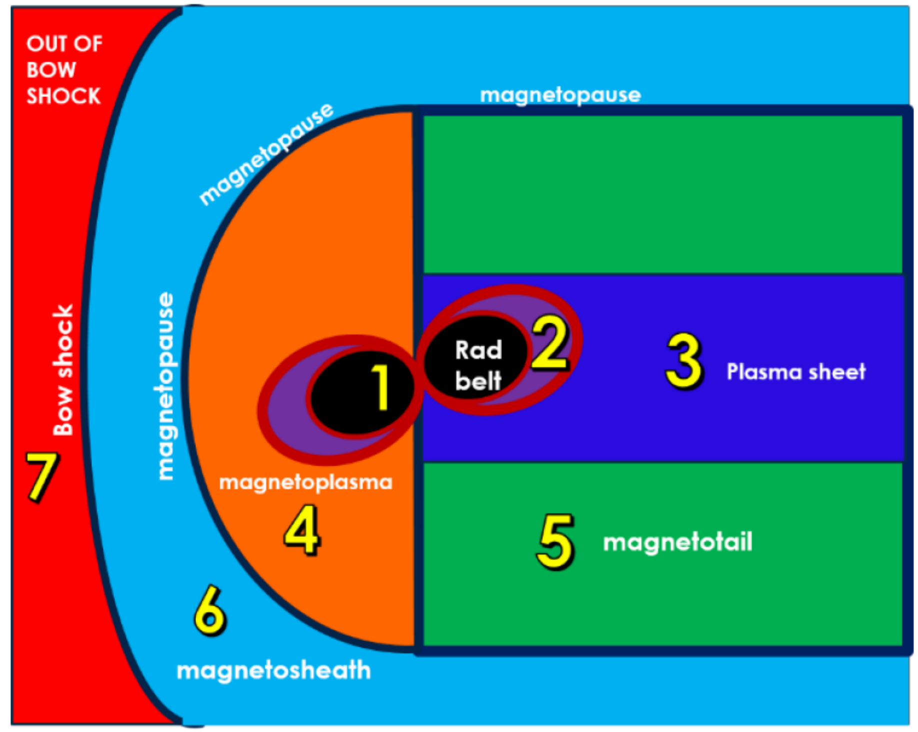


IN - OUT vs. Magneto-Spheric Environment





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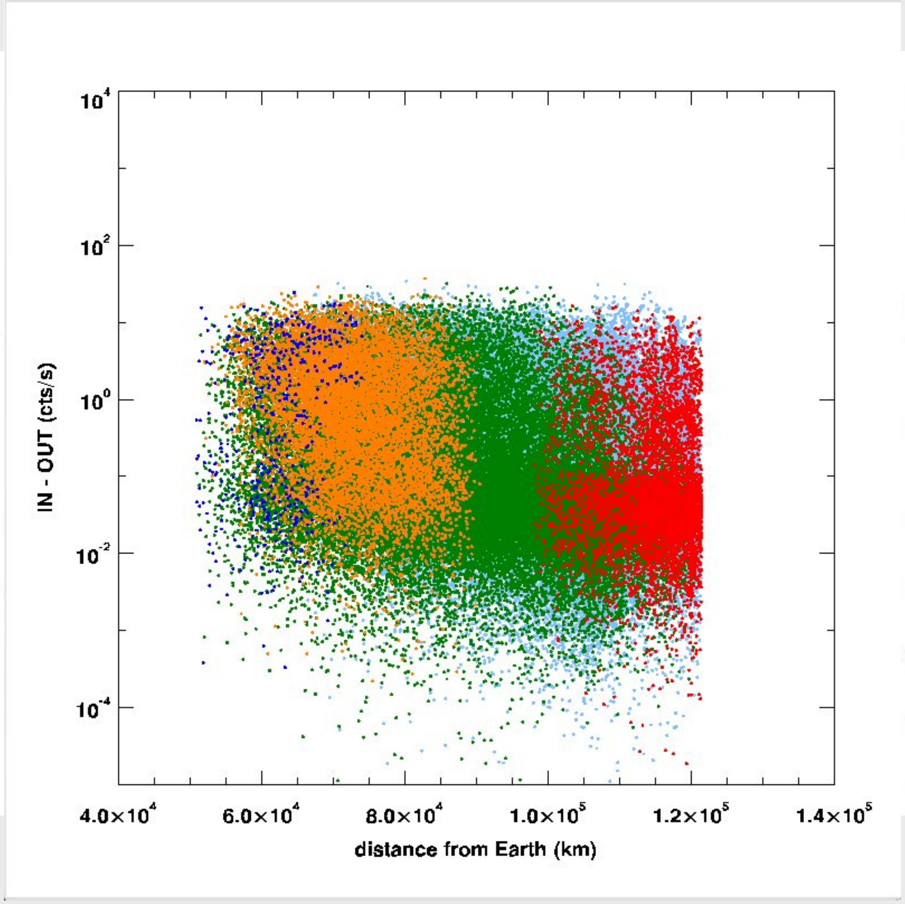
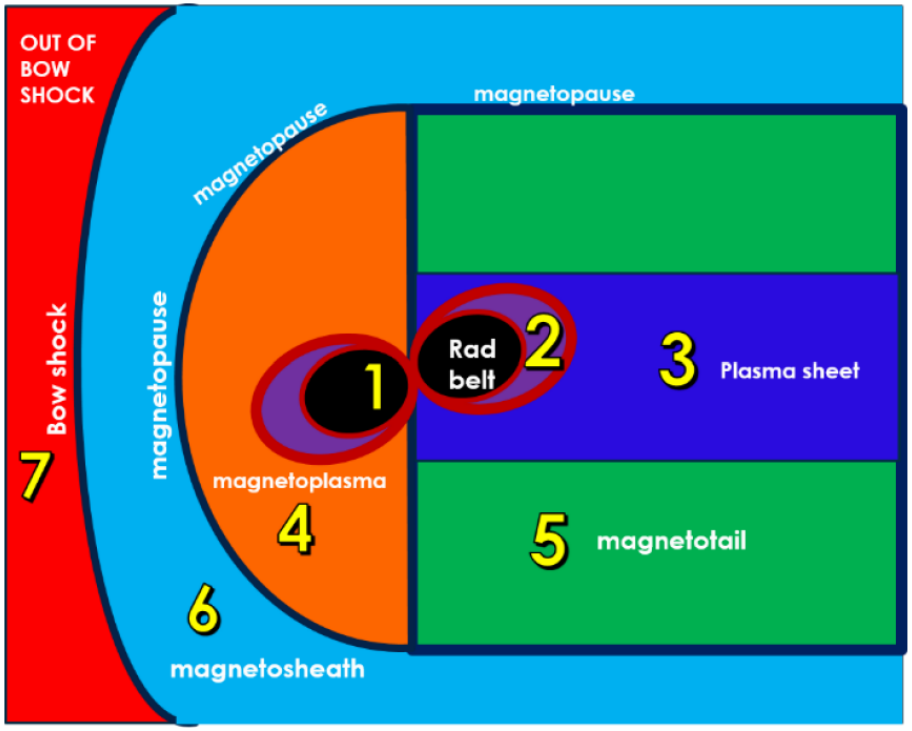
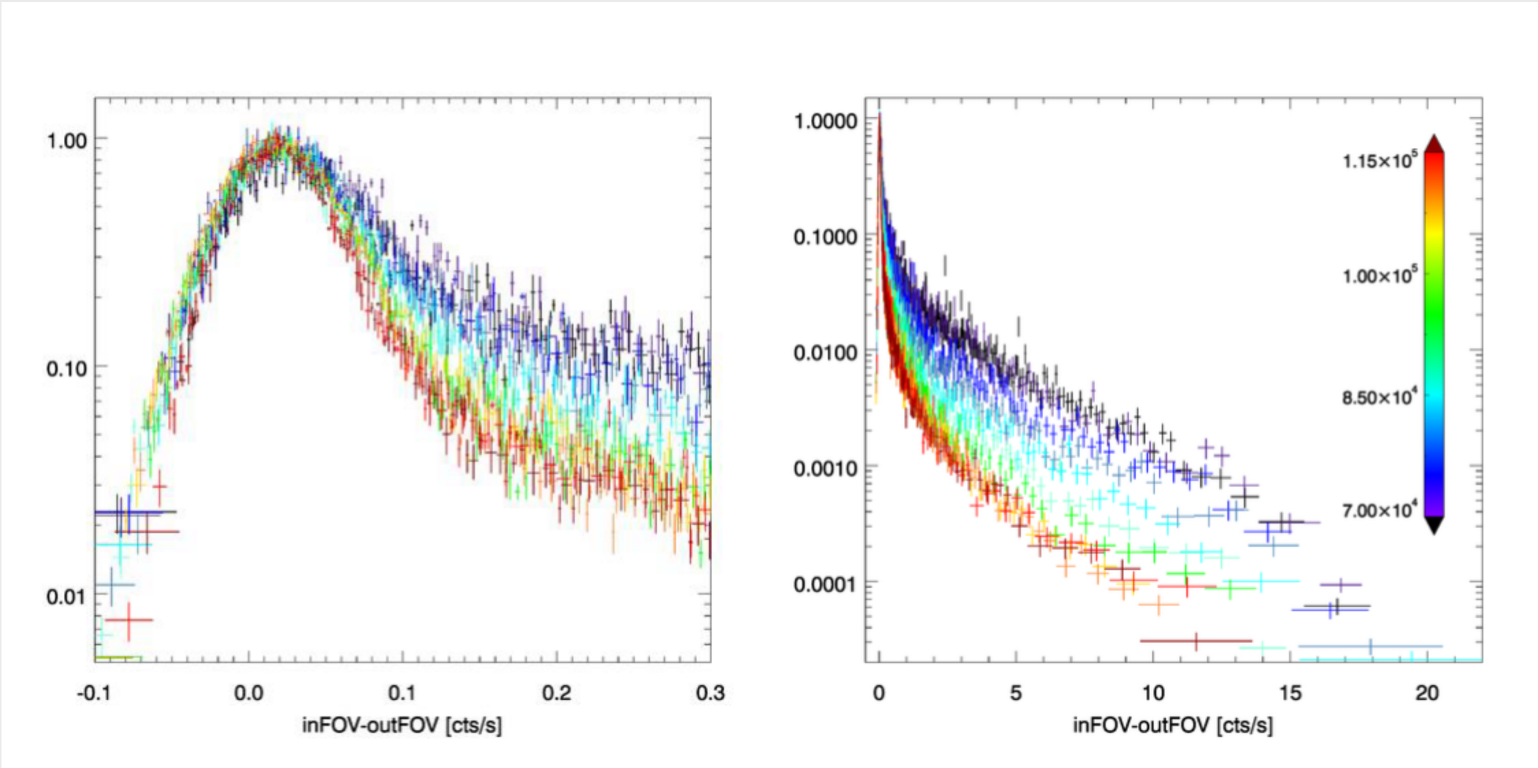




No strong dependence on magneto-spheric environment

IN - OUT vs. distance from Earth

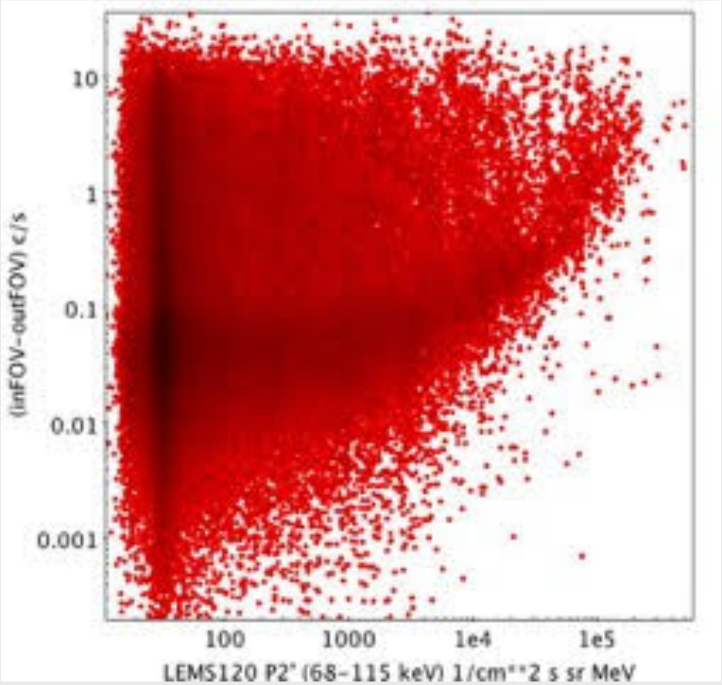


- **Quiescent Component Stable**
- **Flaring component intensity anti-correlated with distance from Earth**

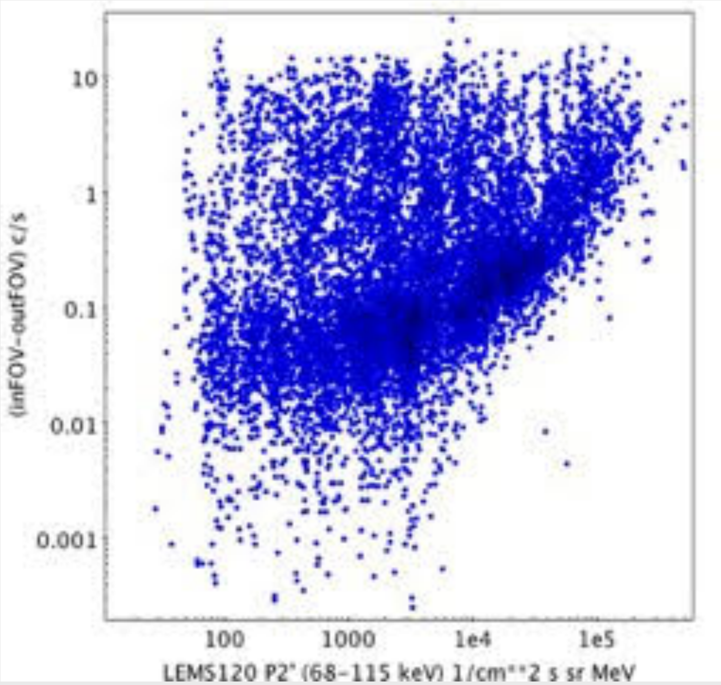
Comparison of XMM with environmental estimates of soft protons

ACE LEMS data (50-100 keV) @ L1

Full dataset



SEP only



- Loose correlation insufficient to calibrate SP Effective Area
- Looking into alternative solutions
- Need to Allocate resources (human & financial) to progress

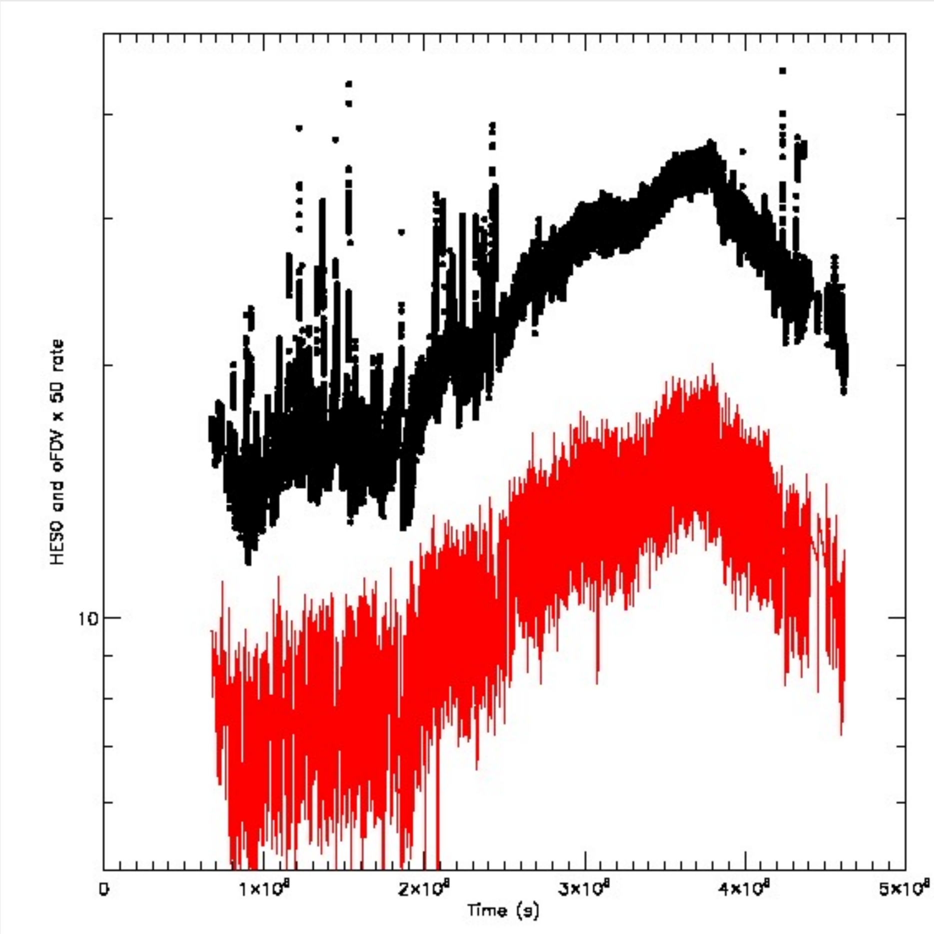
Unfocused Particles bkg

- Particle data from the Standard Radiation Environment Monitor (SREM) to investigate the relationship between particle flux and instrumental background.

Identify the primary mechanism responsible for the generation of the observed instrumental background.

Correlate OFoV data with SREM data

RM AND OUTFOV DATA



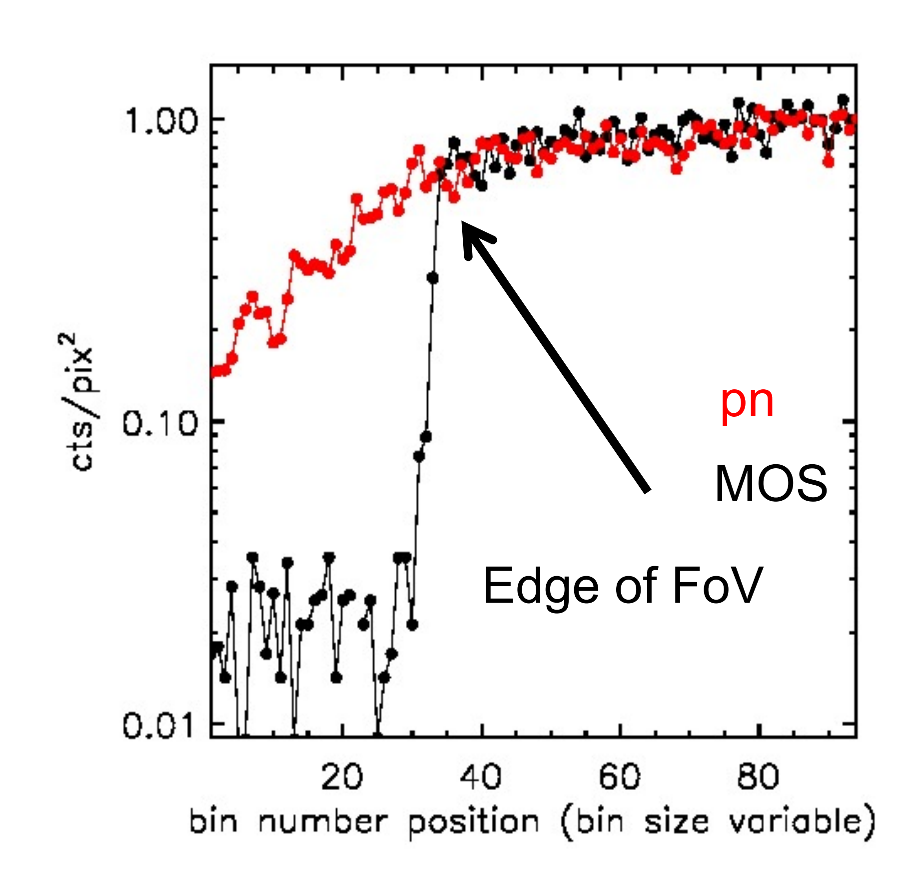
- OUTFOV data correlates with Radiation Monitor data
- Both modulated by solar cycle

STRONGLY SUPPORT HYPOTHESIS OF HIGH ENERGY COSMIC RAY PROTONS AS ULTIMATE SOURCE OF THIS BKG COMPONENT

MOS vs pn

- EPIC MOS has outFoV
- EPIC pn does not

Confirmation from analysis of ~500 blank fields (in/out diagnostic)



Summary

Contrary to what previously believed, the low intensity component is not associated to soft protons! This amounts to a shift in paradigm in our understanding of the EPIC background with significant consequences both for XMM-Newton & Athena.

Dependence of the soft proton rate on magnetospheric environment is modest if any. Conversely we find evidence of an anti-correlation of soft proton intensity with distance from the Earth

Loose correlation between SP measurements in L1 and with XMM, insufficient to provide useful constraints on XMM SP collecting area

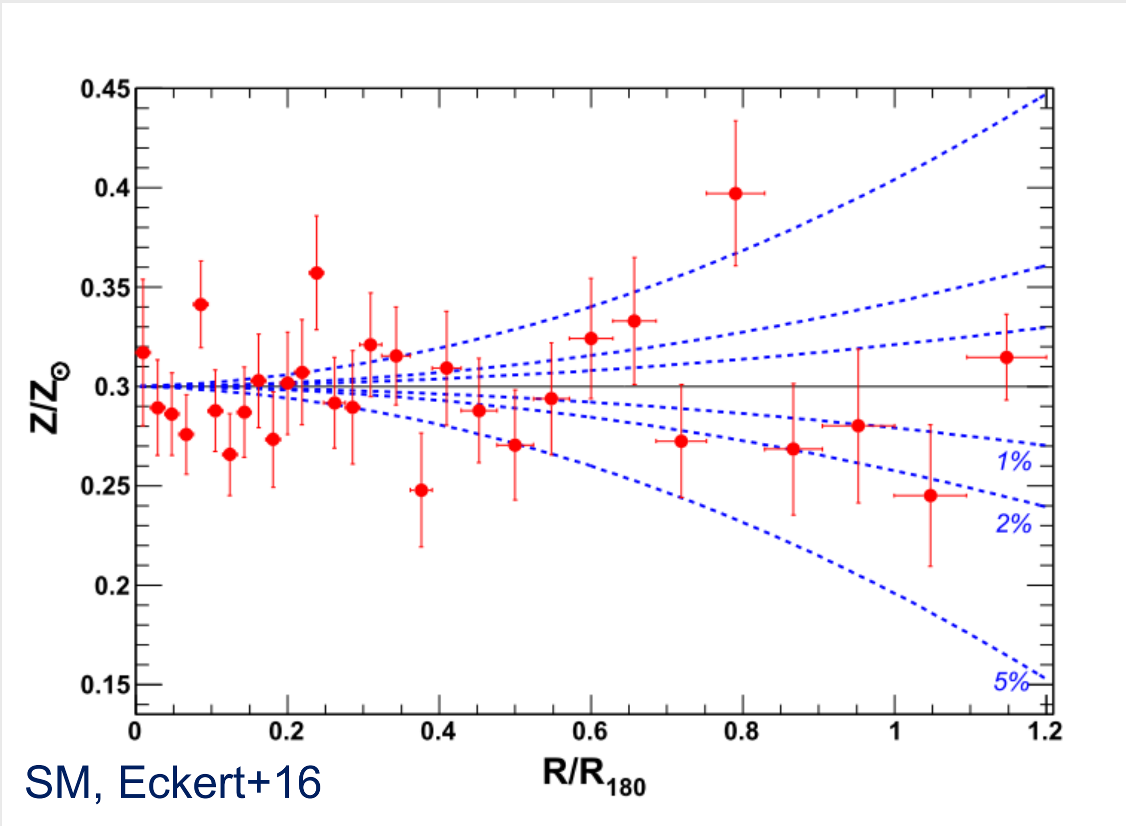
Next Steps

- What is the origin of the quiescent component?
- What about the pn?
- How do we measure SP effective area?
- Where do we find resources to do all this?

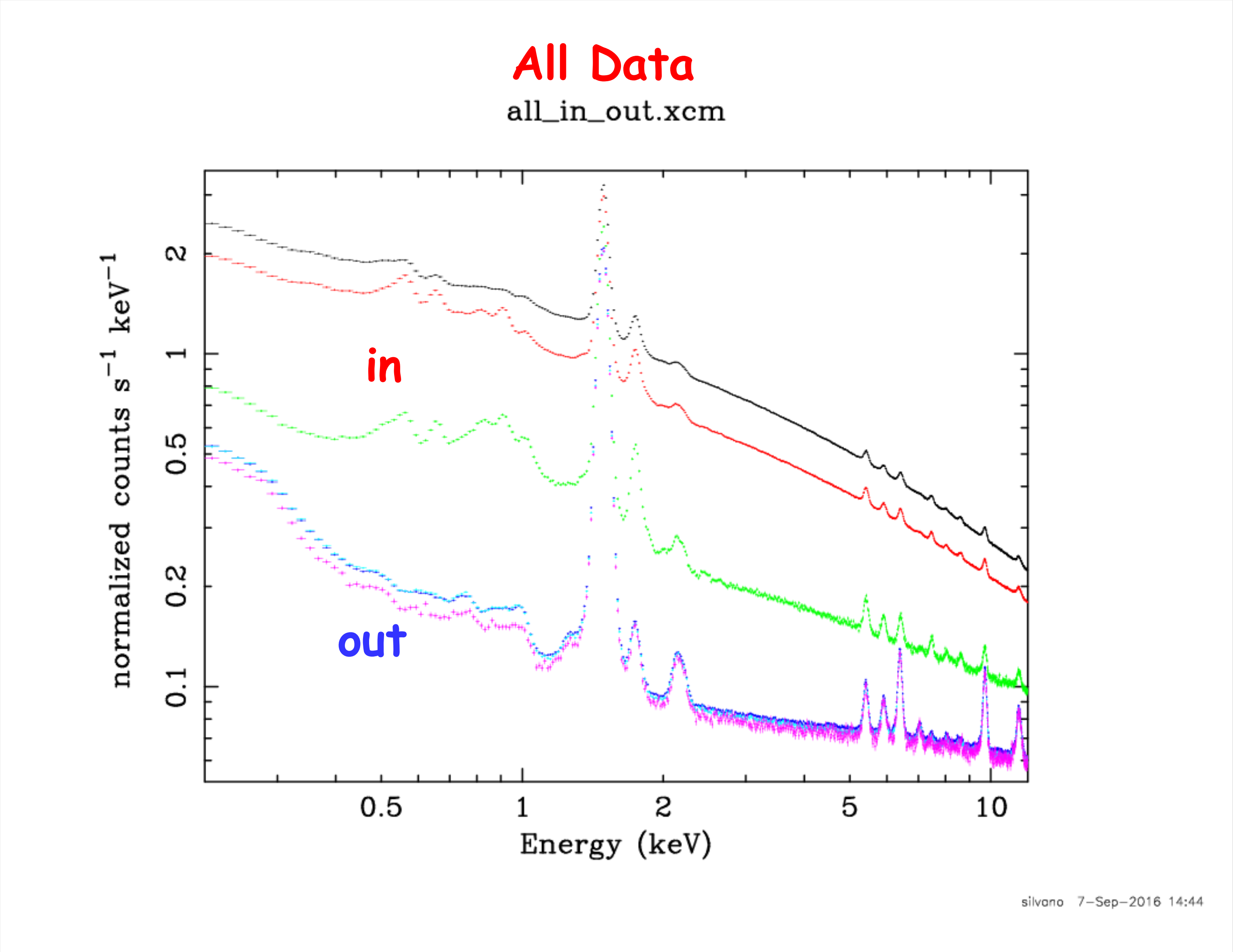
Long Term Goal

Reach understanding of EPIC bkg good to few % level

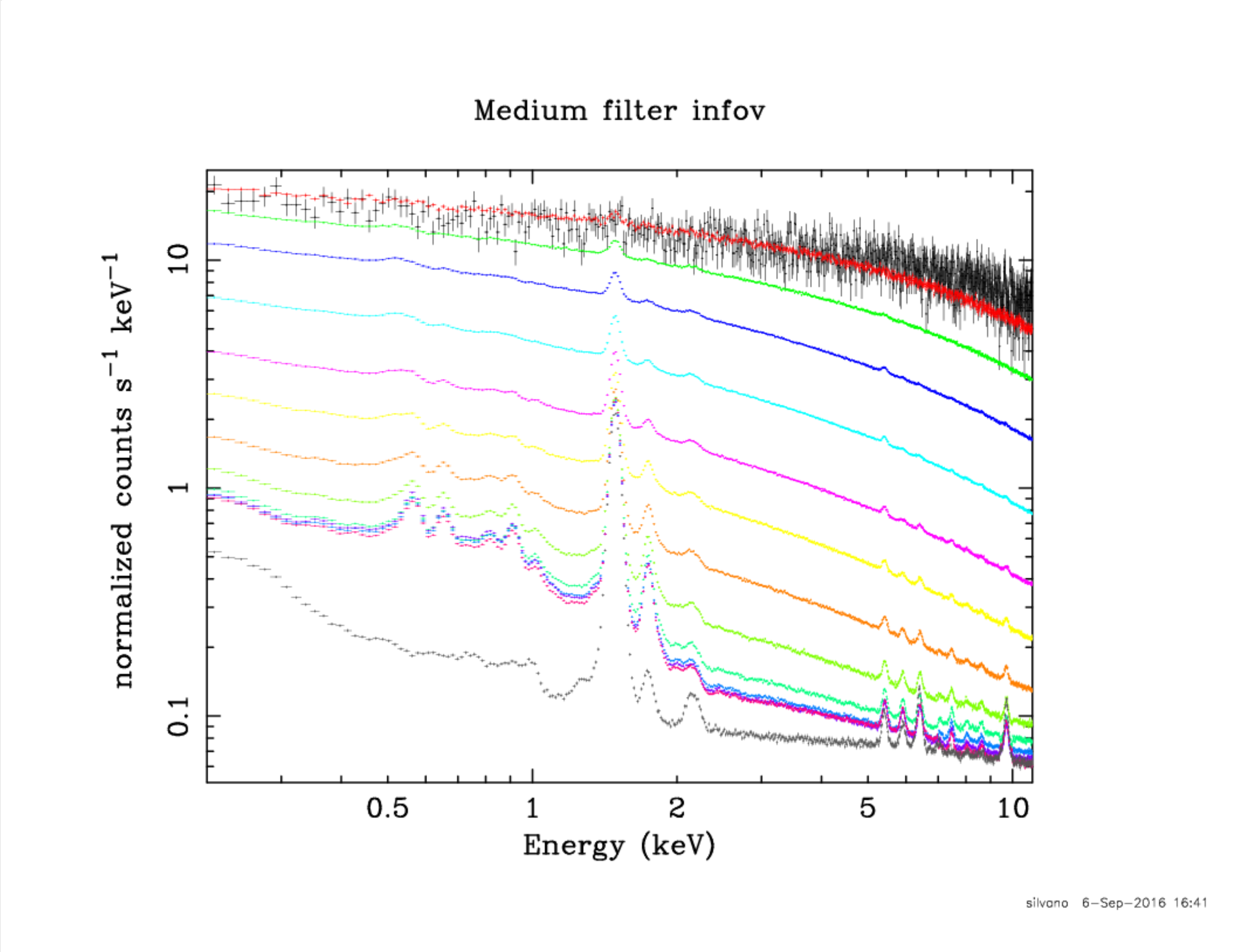
Important not only for XMM but also for future missions



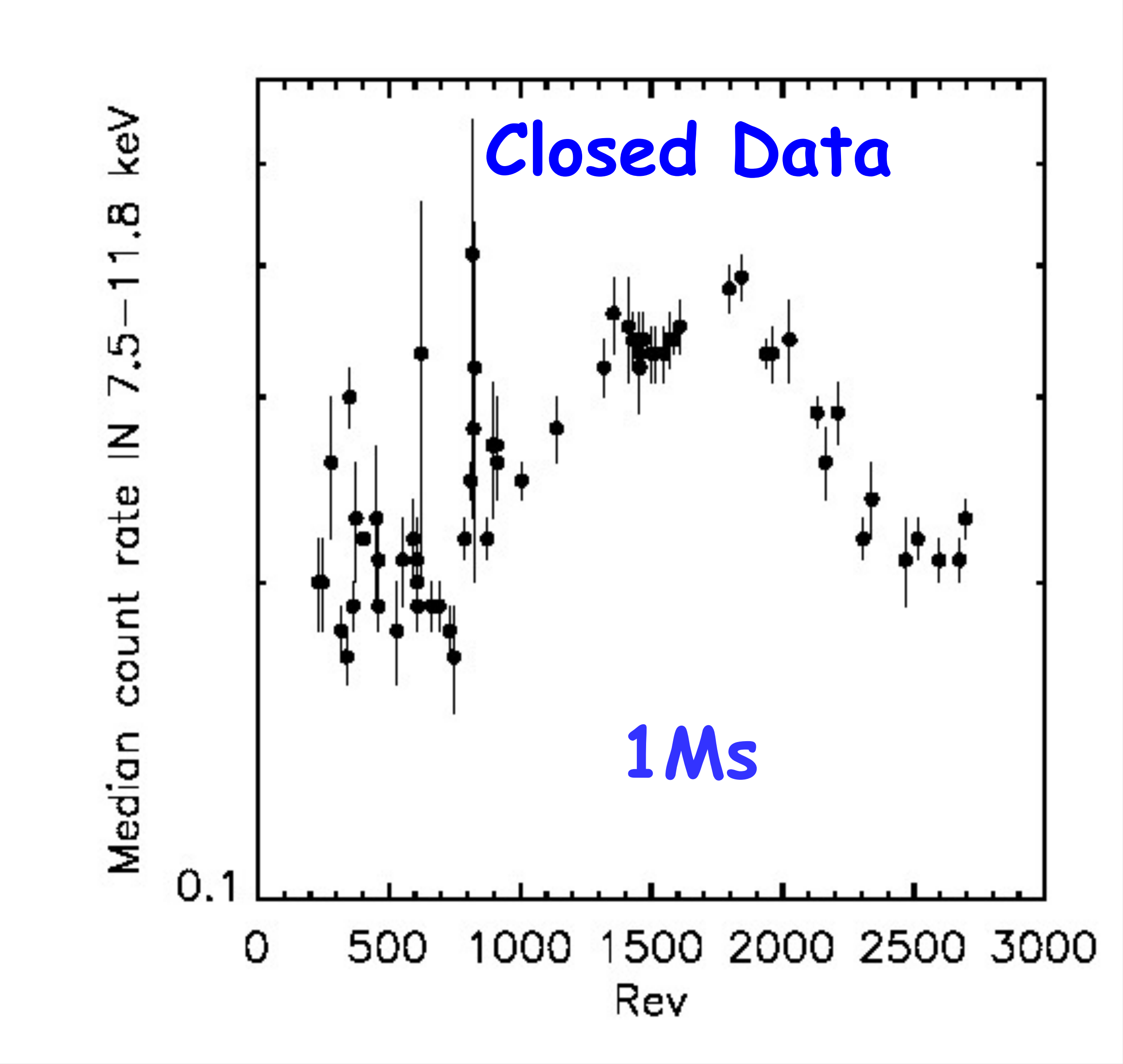
Soft Protons vs Filters

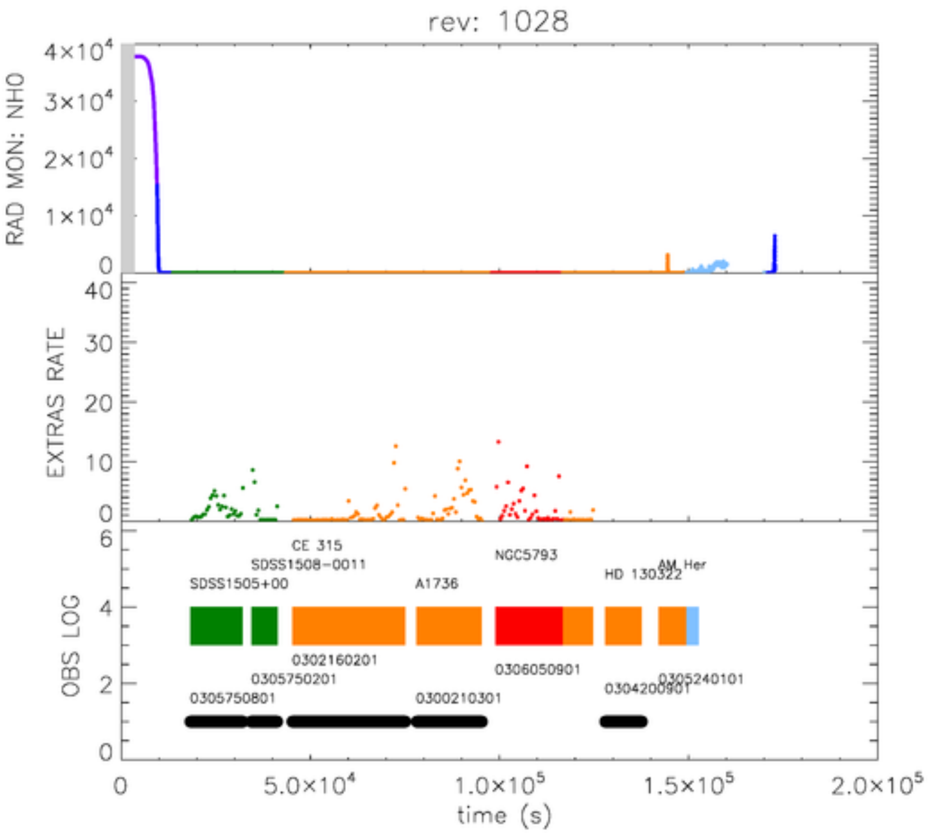


Selection wrt in-out distribution



High Energy induced bkg

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CE 315
A1736
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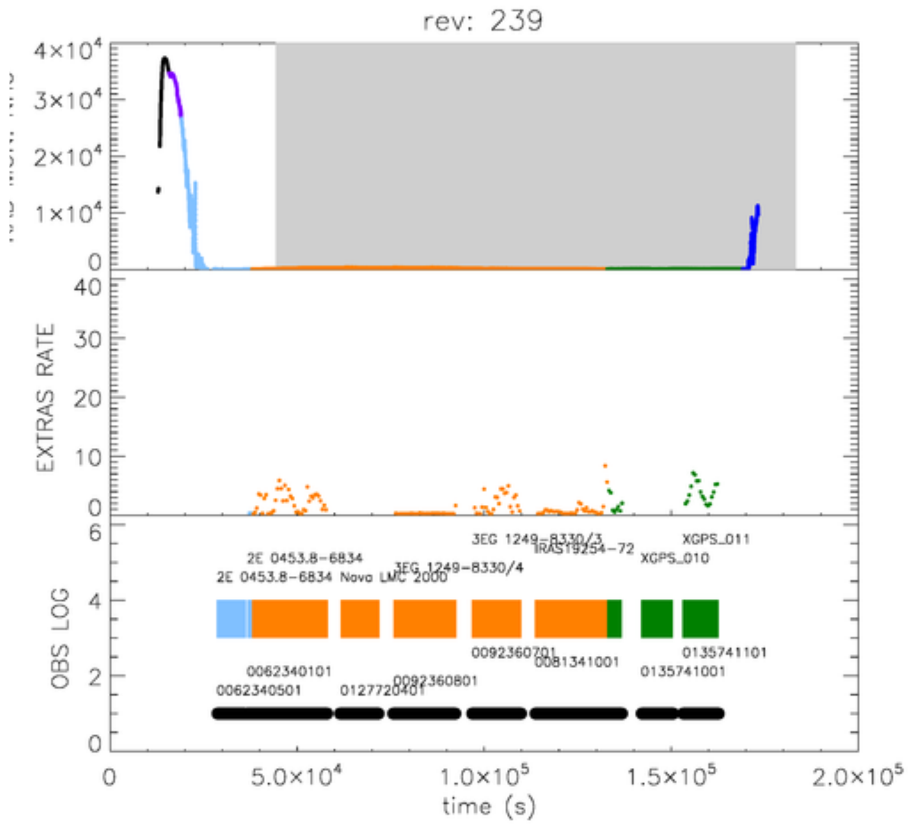
time (s)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IRAS19254-72
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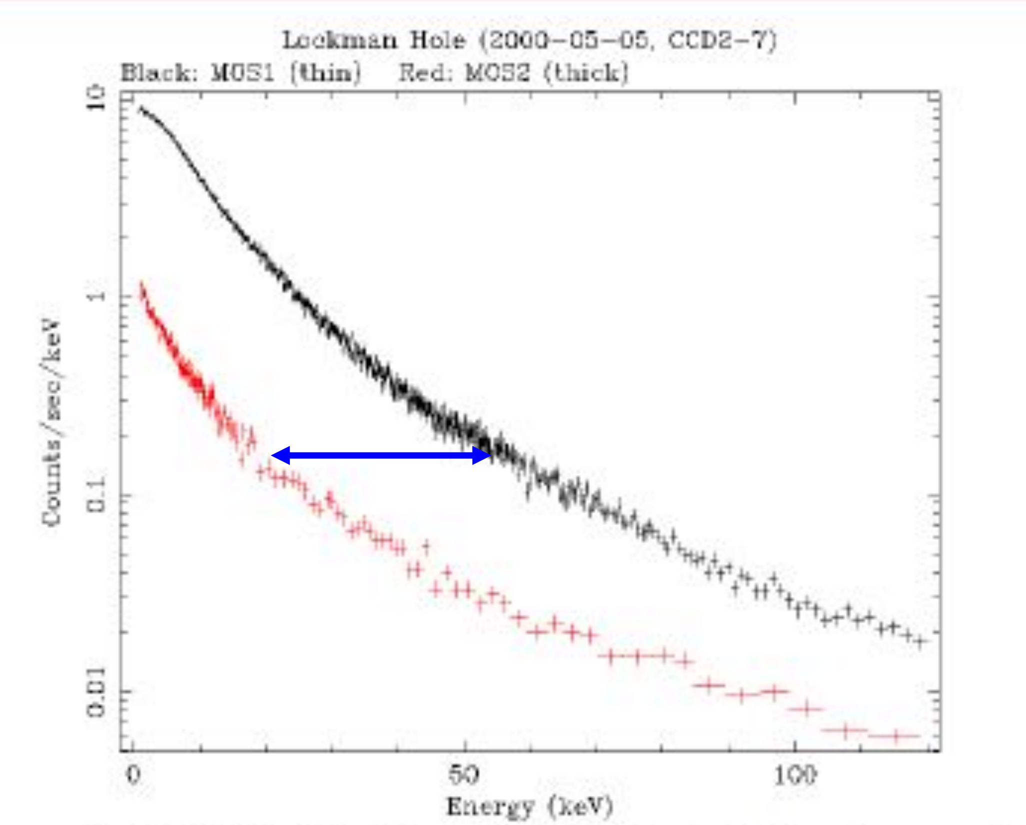
time (s)

SOFT PROTONS vs Filters

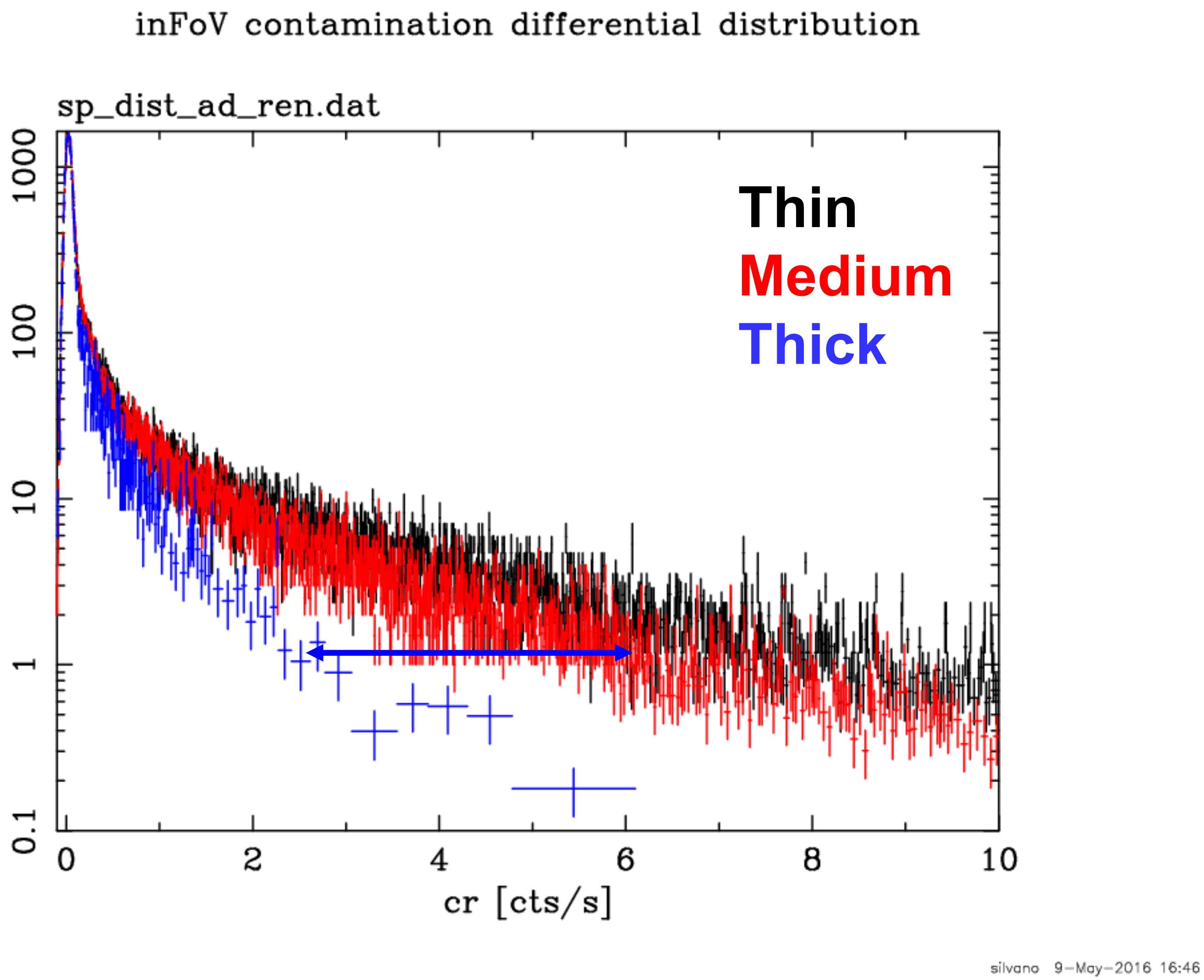


Tiengo 07

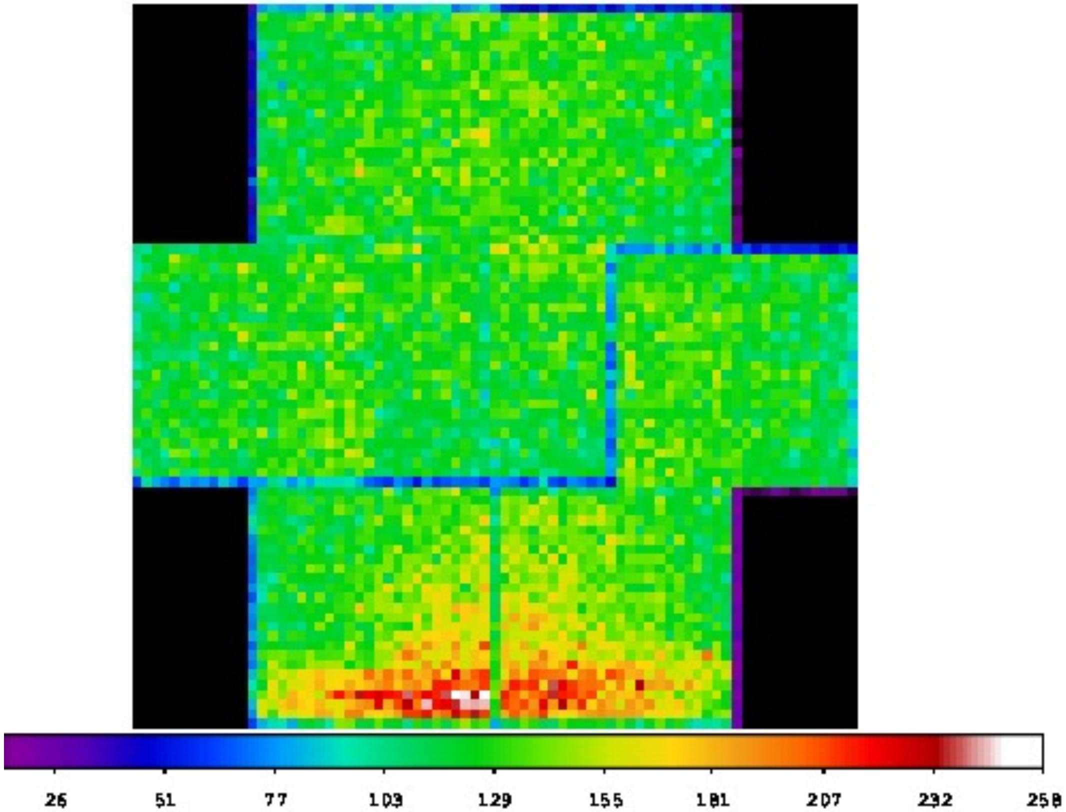
MOS detectors operated in reduced gain mode
MOS1 thin filter
MOS2 thick filter

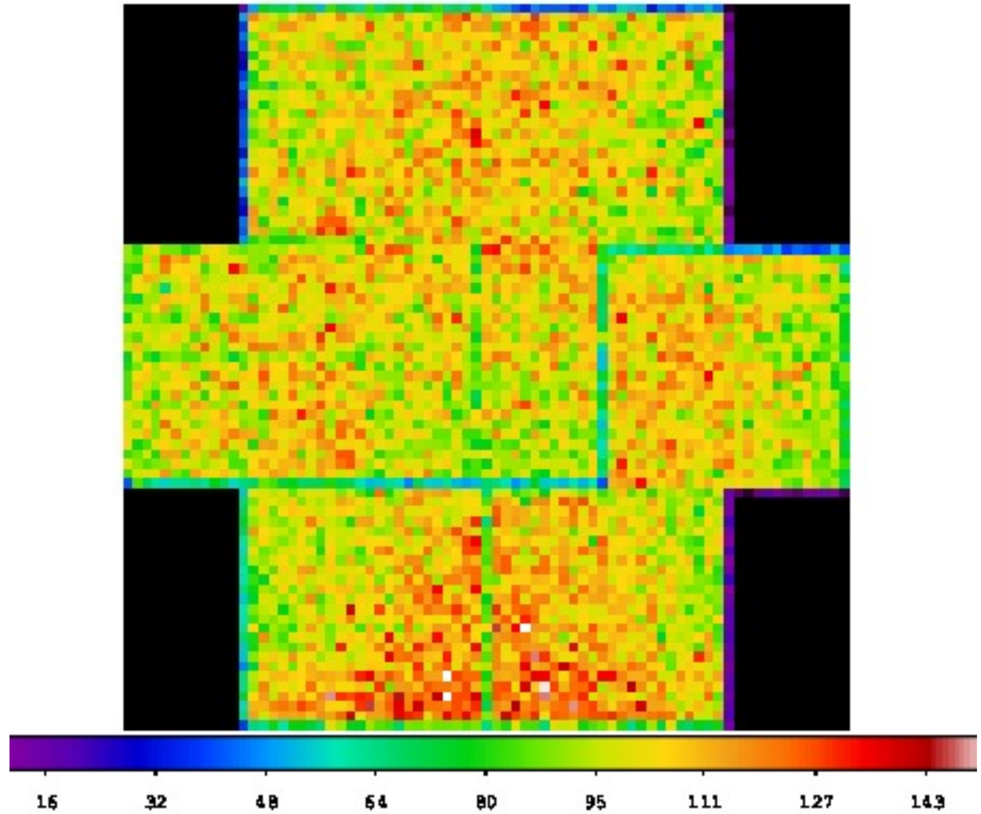
Constant difference in energy btwn 2 detectors consistent with difference in energy loss expected for SP going through thin and thick filter

Soft Protons vs Filters



GOLD FLUORESCENCE





7.5-11.8 keV

7.0-9.4 & 10-11 keV

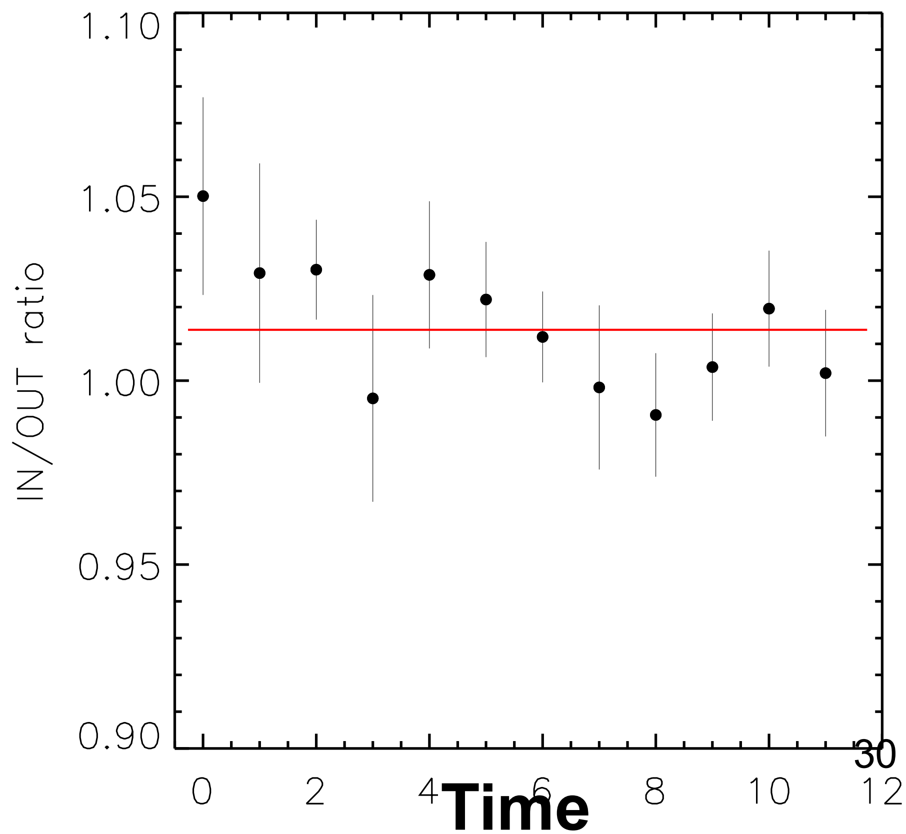
After line removal significant variations still there
Characterization limited by statistics

High Energy P.Bkg Reproducibility

Measurement of bkg in corner regions used to estimate contribution within FoV.
Spatial distribution of bkg across detector known

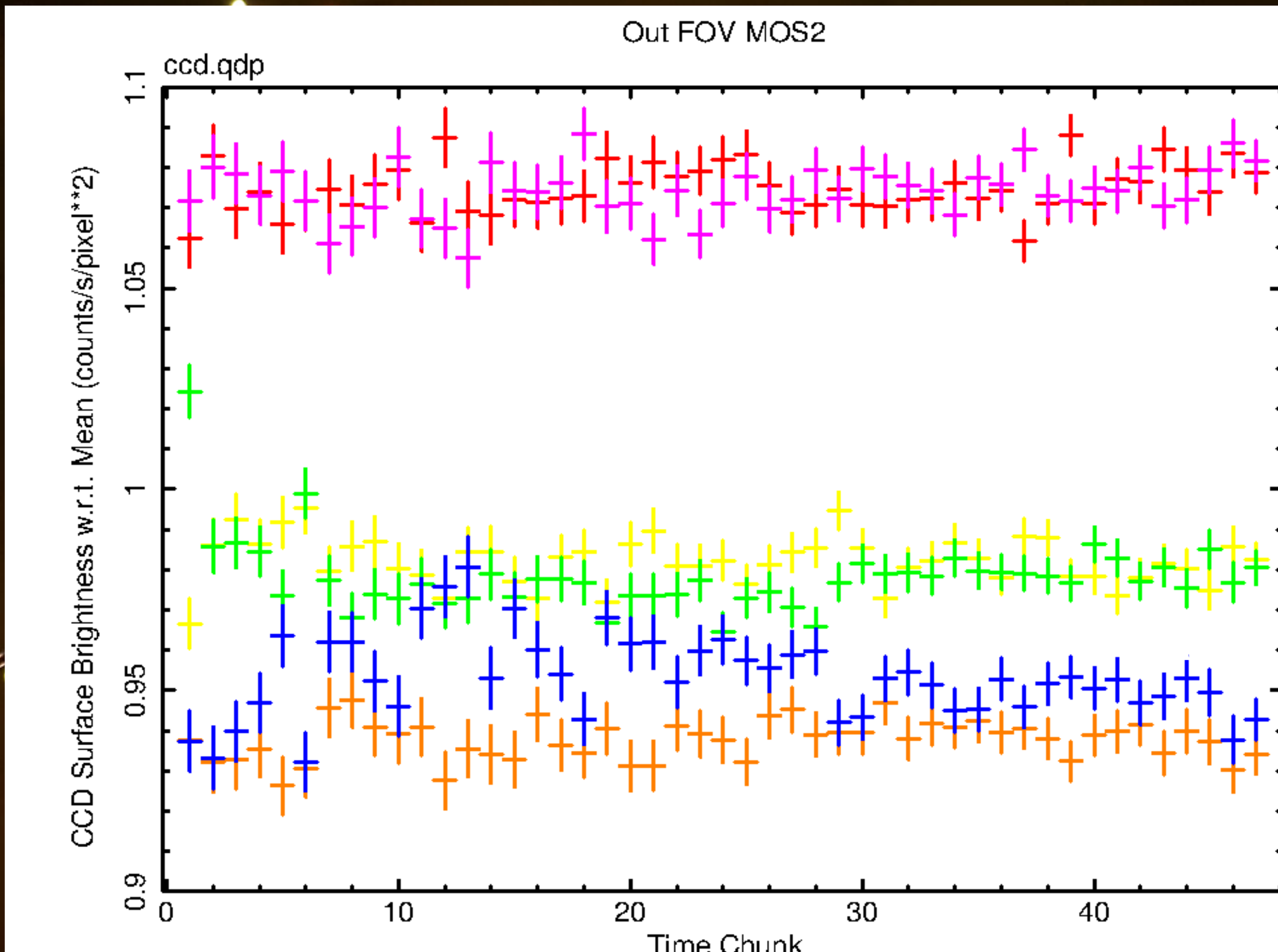
Good stability, intrinsic scatter only 2-3%

Total systematic error in sub. process < 3-4%



VERIFICATION OF THE DATASET AND CUTS

(a first look at spatial inhomogeneities and their temporal variation)

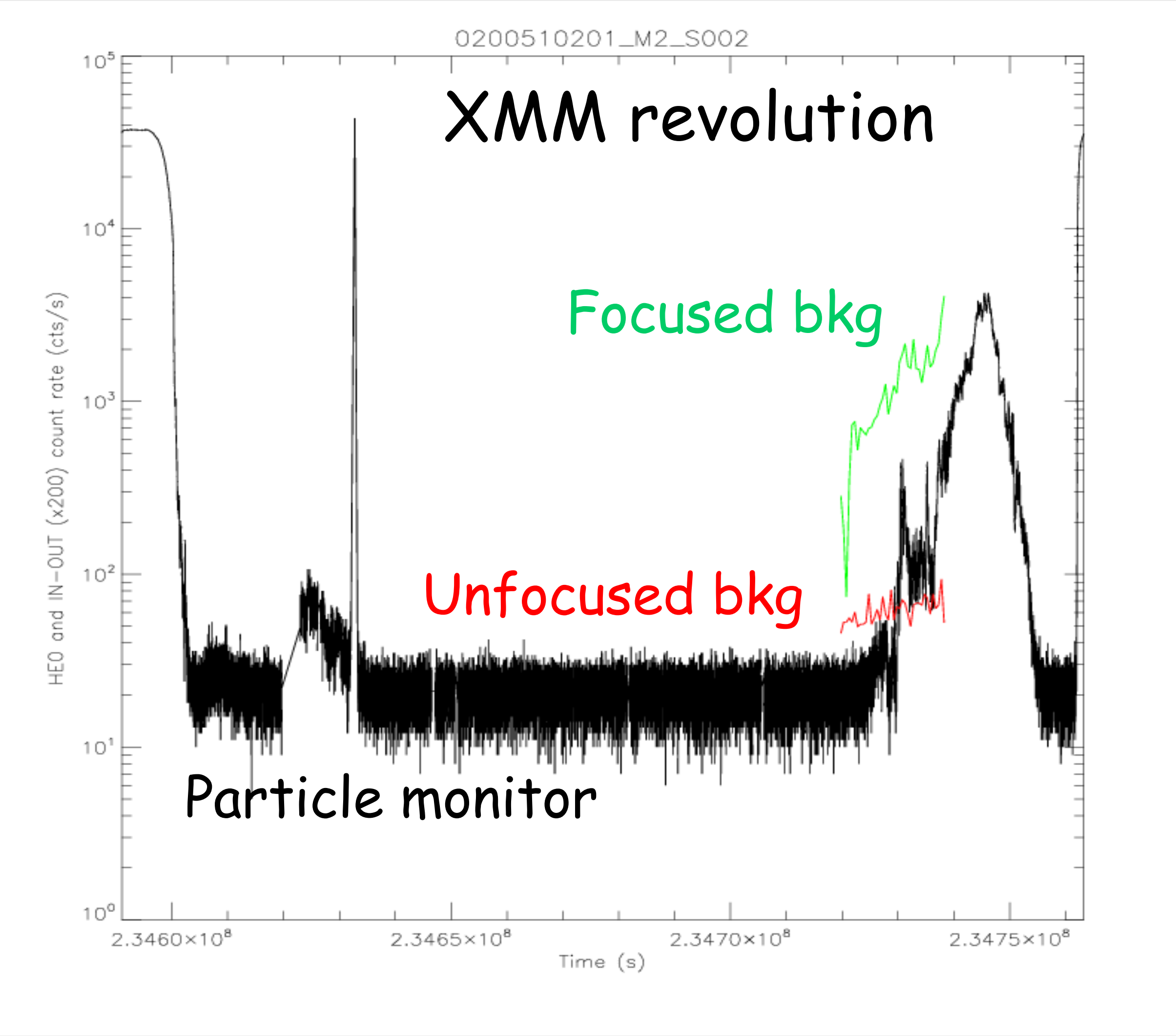


CCD 2
CCD 3
CCD 4
CCD 5
CCD 6
CCD 7

ccd5-6 vary with

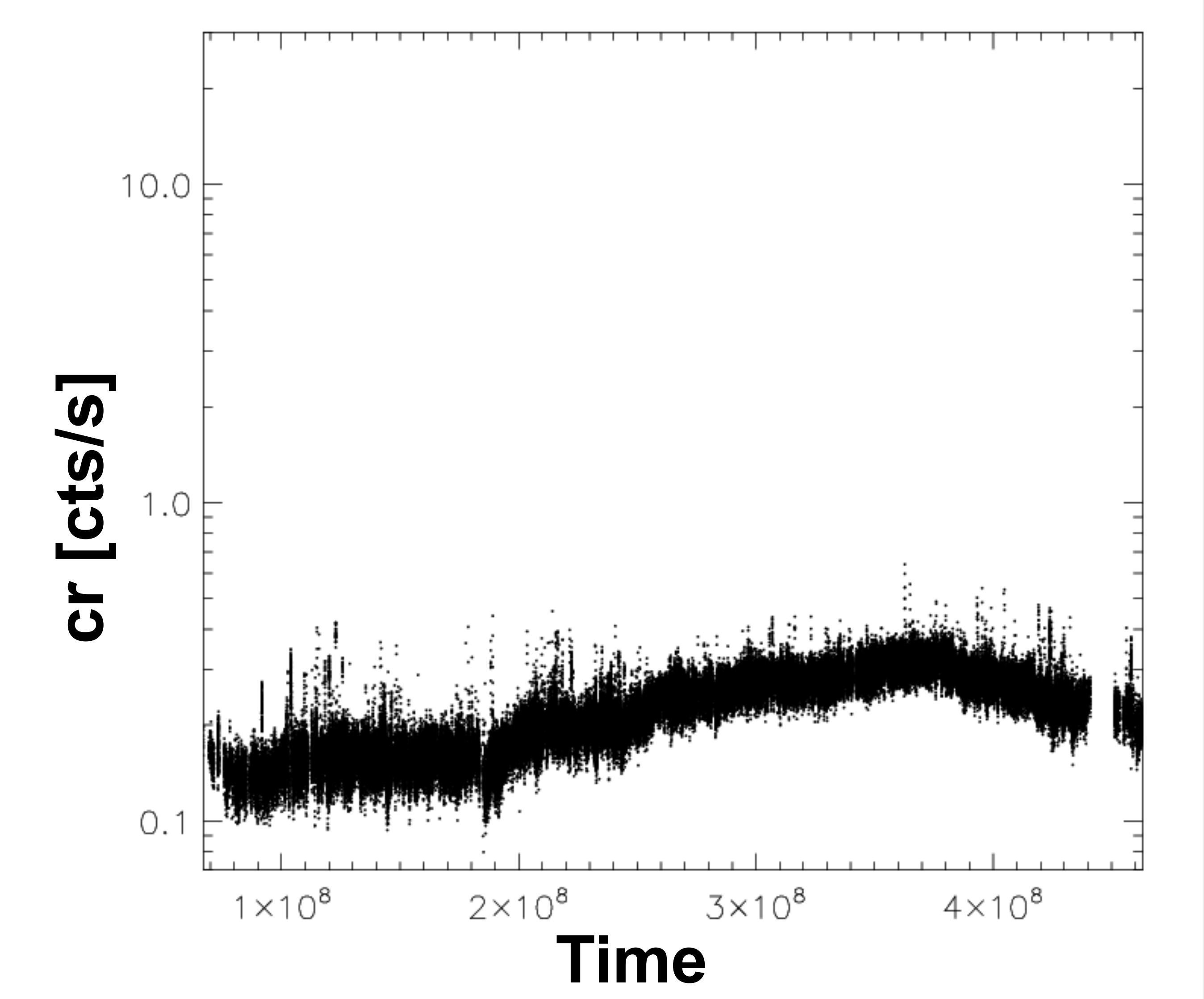
of different CCD is consistent within ~10% and show only little variations with time (bri
nyway.. future analysis are needed to verify spatial differences between IN and OUT-FOV

Spectral variations



EPIC, like WFI is only sensitive to particles with E>200 MeV, at these energies the dominant contribution is from CR protons, occasionaly emission from belts and SEP, rare. It is only at these times that we have evidence of spectral changes.

High Energy induced bkg



High Energy induced bkg

Soft protons
highly variablie