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Clusters of galaxies WG session

13th IACHEC meeting, 2018, Italy

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Program

1) Erosita cross-calibration with clusters

2) Multi-mission review from last year

3) Updates on the Multi-Mission Study

1) Erosita cross-calibration with clusters

- Clusters for cross-calibration only and not a high priority
- A1795 and A2029 are in the calibration program
- GO time may yield nearby clusters (with a single pointing far beyond the virial radius)

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2) Multi-mission review from last year

TASK 1: Define the extraction radius

- Statistics requirement and PSF minimisation prefer bigger values
- bkg and vignetting minimisation prefer smaller values

Extraction radius = 6 arcmin

TASK 2: Define a suitable cluster

- Hot enough (minimise 1 keV line emission, better src/to bkg at 7 keV energies)
- Not too distant to yield enough photons
- Preferably low NH... if high, harder to get enough photons at the lowest energies. But we can cut the low energy band and use the rest. **No requirement for NH at the moment**

kT > 6 keV

z < 0.1

TASK 3: Define a suitable observation

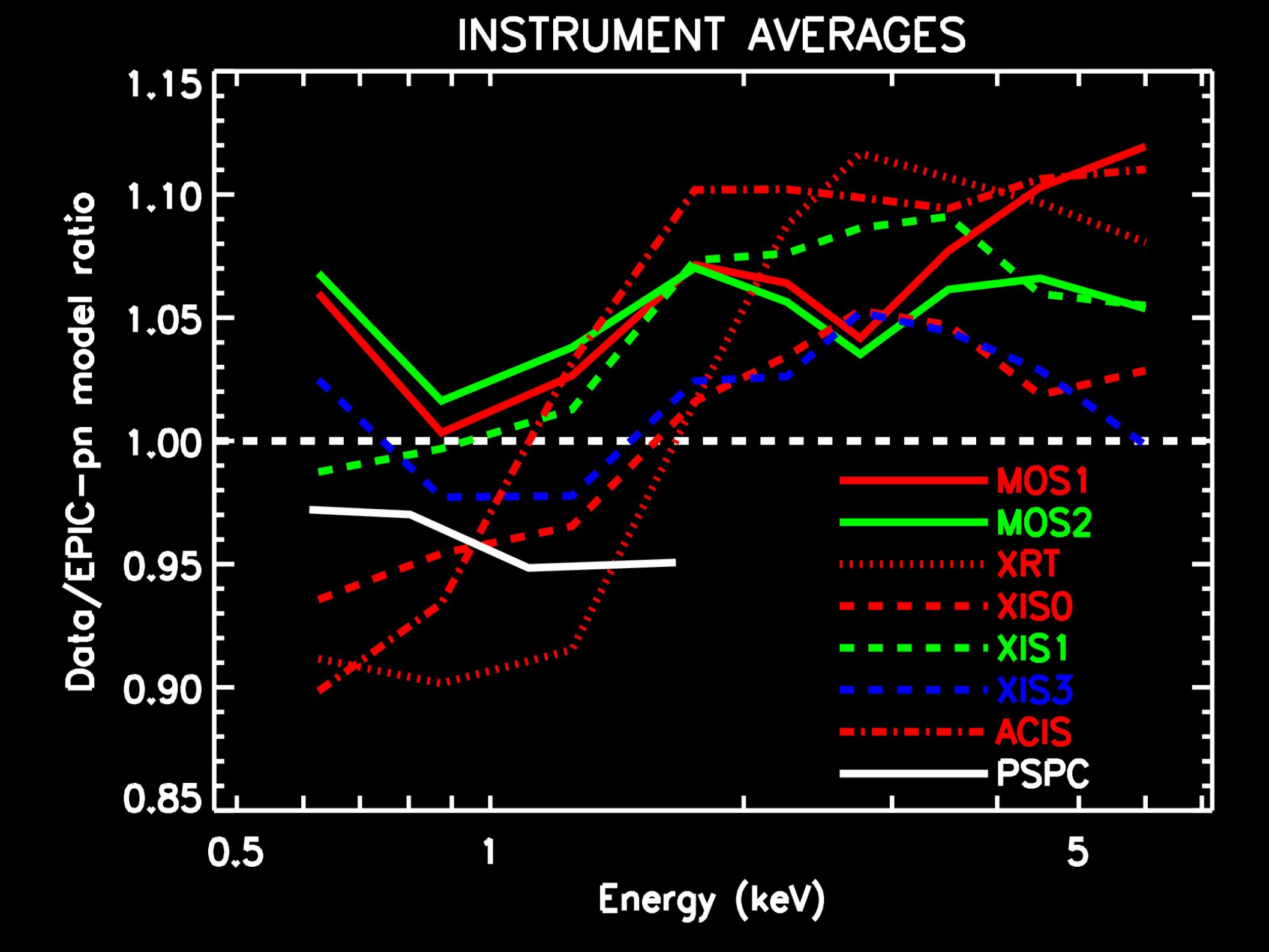
- Long enough for statistics.
- Cluster center – FOV center offaxis minimised
- Proceed with single on-axis observations. If too constraining (not enough clusters with enough counts) we will discuss about merging several observations.

- **100000 c in central 6 arcmin (40000 for PSPC)**
- **Offaxis < 3 arcmin**

Stack residuals spectra

- Sample of 4 clusters

$$R_{i\,/\,ref} = \frac{data_i}{model_{ref} \otimes resp_i} \times \frac{model_{ref} \otimes resp_{ref}}{data_{ref}}$$


INSTRUMENT AVERAGES
Data/EPIC−pn model ratio
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.5
1
5
Energy (keV)
MOS1
MOS2
XRT
XIS0
XIS1
XIS3
ACIS
PSPC

More clusters

- This needs to be done carefully with the definitions we agreed on today
- **Task 4:** Compile a list of available clusters and obs. ID:s fulfilling our criteria: Larry (Chandra), Eric (Suzaku), Andy B. (Swift), Steven Snowden (ROSAT), Jukka (XMM) ***Deadline end of April***
- **Task 5:** Extract and process data with May 2017 calibration information. ***Deadline end of June***
- **Task 6:** Jukka will do the stack residuals ratio analysis.

3) Updates on the Multi-Mission Study

Extraction radius

- In order to optimise the data, we experimented with r_ext = 3,4,5 and 6 arcmin
- Today only 6 arcmin results
- And only for EPIC-pn / ROSAT-PSPC pair

Counts criterium

- Same – epoch observations co-added (PSPC only)
- Had to lower the count criteria to get enough clusters:
- 10000 c in central 6 arcmin in the 4 PSPC channels 0.5-0.7-0.9-1.3-2.0 keV
- Statistical uncertainties ≈ 2% per channel

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Updates from last year

- More clusters...
- Here only pn – PSPC
- r_extr = 6 arcmin only
- NH free, abund equiv 0.3 Solar
- Unnormalised blank sky

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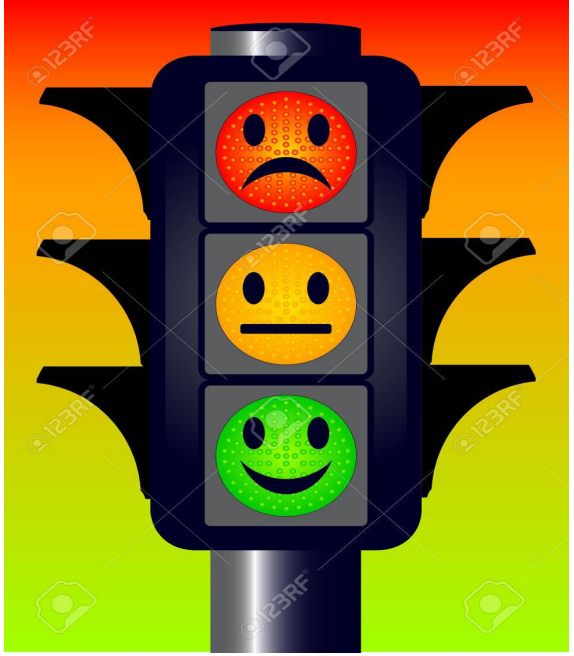
- 12 clusters observed with XMM-Newton/EPIC-pn and ROSAT/PSPC having
  - bkg < 10% of the source in the 0.5-2.0 keV band
  - Number of counts > 10^4 in the 0.5-2.0 keV band
- Possibly 14 additional clusters (TBD)



ROSAT PSPC:

Bkg always < 10%

Not always data available

pc: min. 10^4 pn 0.5-2.0 keV band counts?

pb: pn bkg/src < 10% ?

Rd: ROSAT data exists?

Rc: min. 10^4 ROSAT 0.5-2.0 keV band counts?

cluster	pc	pb	Rd	Rc
A85	☺	☺	☺	☺
A119	😐	😐	☺	😐
A399	😐	😐	☺	😐
A401	☺	☺	☺	☺
A478	☺	☺	☺	☺
A754	☺	☺	☹	
A644	☺	☺	☺	☺
A1413	☺	😐	☺	😐
A1650	☺	😐	☹	
A1651	☺	☺	☺	☺
Coma	☺	☺	☺	☺
A1689	😐	😐	😐	😐
A1795	☺	☺	☺	☺
A1914	😐	😐	😐	😐
A2029	☺	☺	☺	☺
A2065			☹	
A2142	☺	☺	☺	☺
A2163			☹	
A2204	☺	☺	☺	😐

cluster	pc	pb	Rd	Rc
A2244	☺	😐	☺	😐
A2255	☺	😐	😐	😐
A2256	😐	😐	😐	😐
A2319	☺	☺	☺	😐
A3112	☺	☺	☺	☺
A3158	☺	☺	☹	☹
A3266	off			
A3391	☺	☺	☺	😐
A3558	☺	☺	☺	☺
A3571	☺	☺	☺	😐
A3627	?	?	😐	😐
A3667	off			
A3827	☺	😐	☹	
A3888	☺	☺	☺	😐
Ophiu	☺	☺	☺	
Perse	☺	☺	☺	☺
PKS0745	☺	☺	☺	☺
RXCJ1504	?	?	?	☹
Triang	☺	☺	☹	
ZwCl1215	☺	☺	☹	

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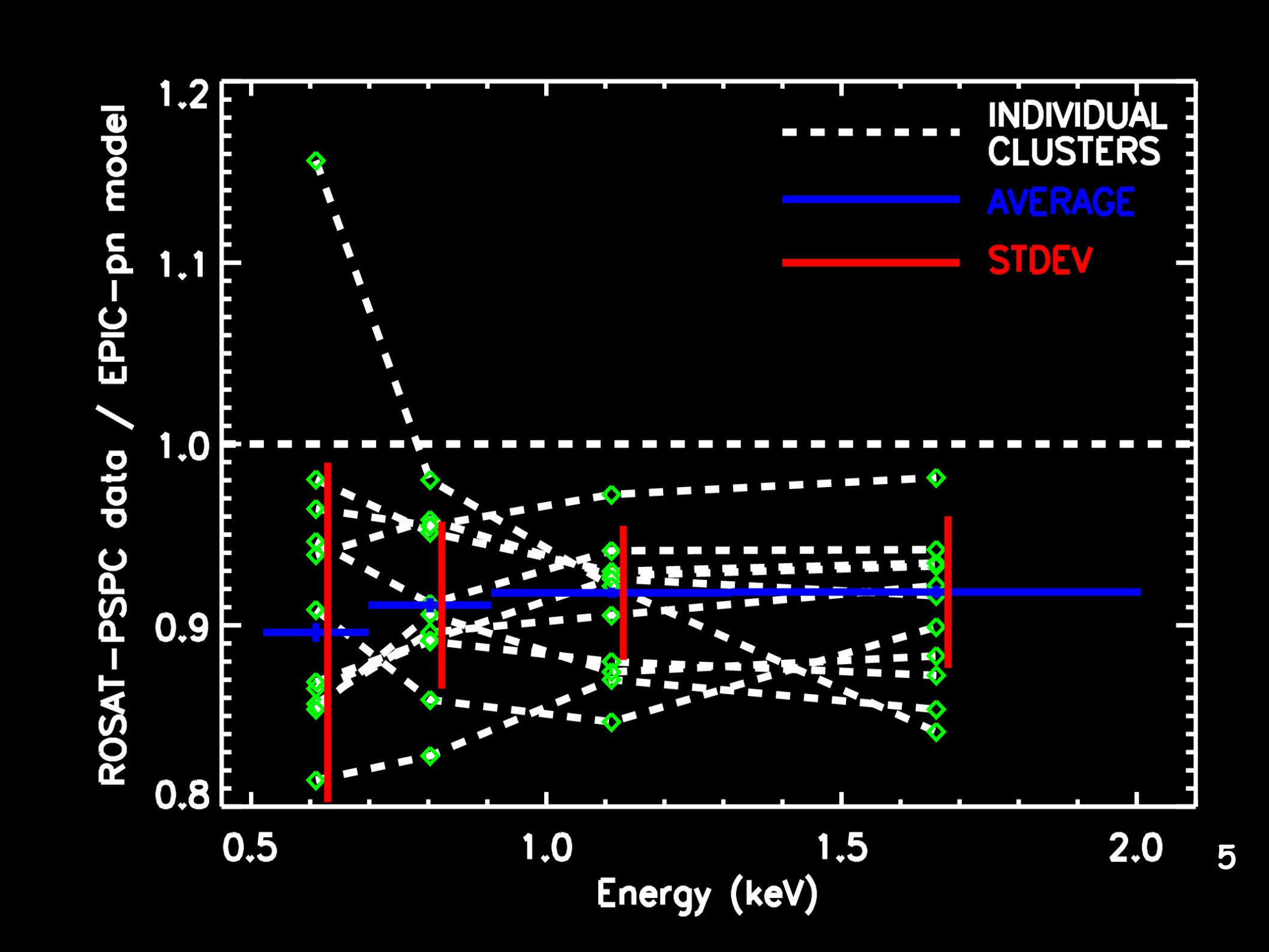
- Stack residuals spectrum calculated

$$R_{i\,/\,ref} = \frac{data_i}{model_{ref} \otimes resp_i} \times \frac{model_{ref} \otimes resp_{ref}}{data_{ref}}$$


INDIVIDUAL CLUSTERS
AVERAGE
STDEV
ROSAT-PSPC data / EPIC-pn model
1.2
1.1
1.0
0.9
0.8
0.5
1.0
1.5
2.0
Energy (keV)

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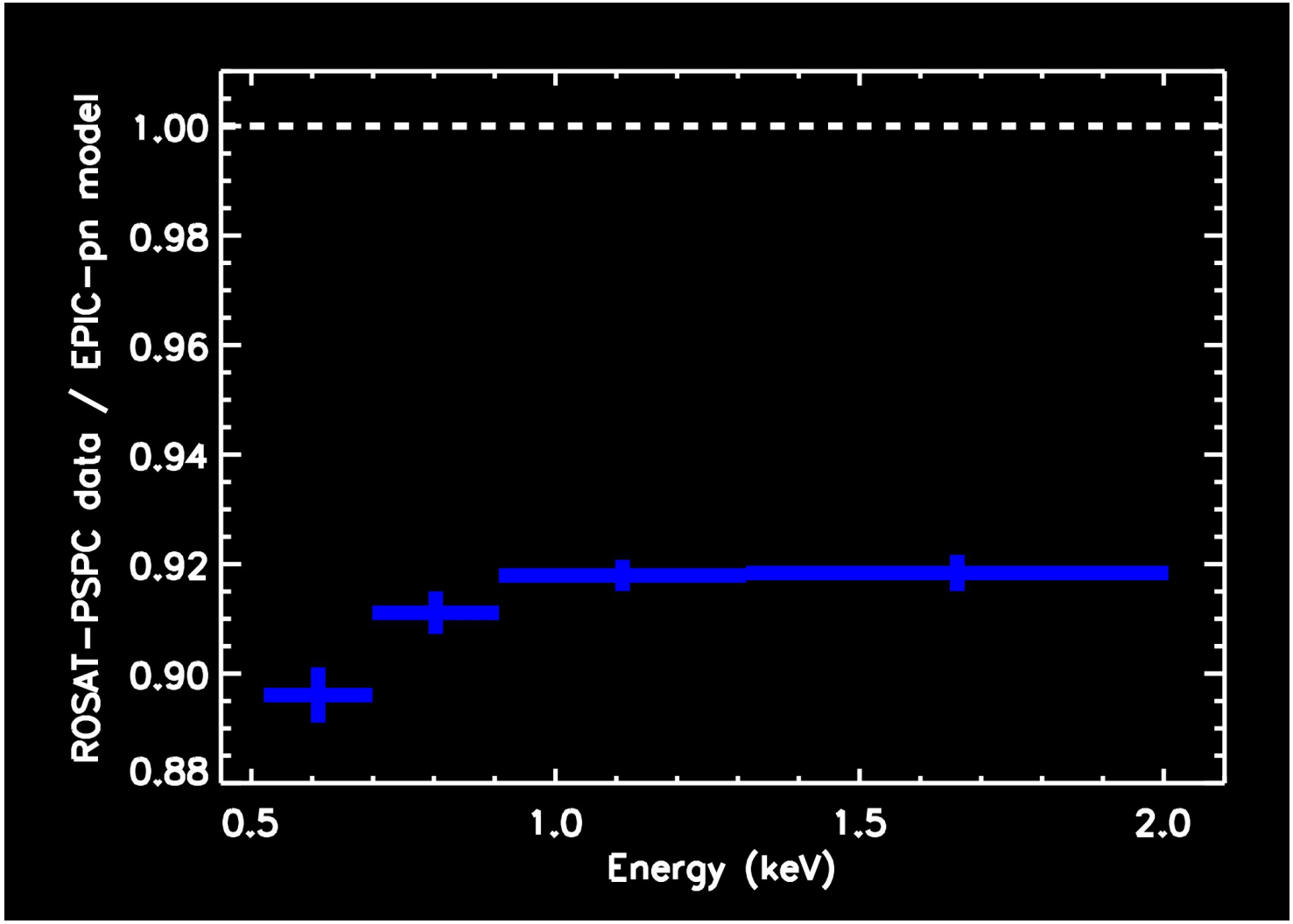
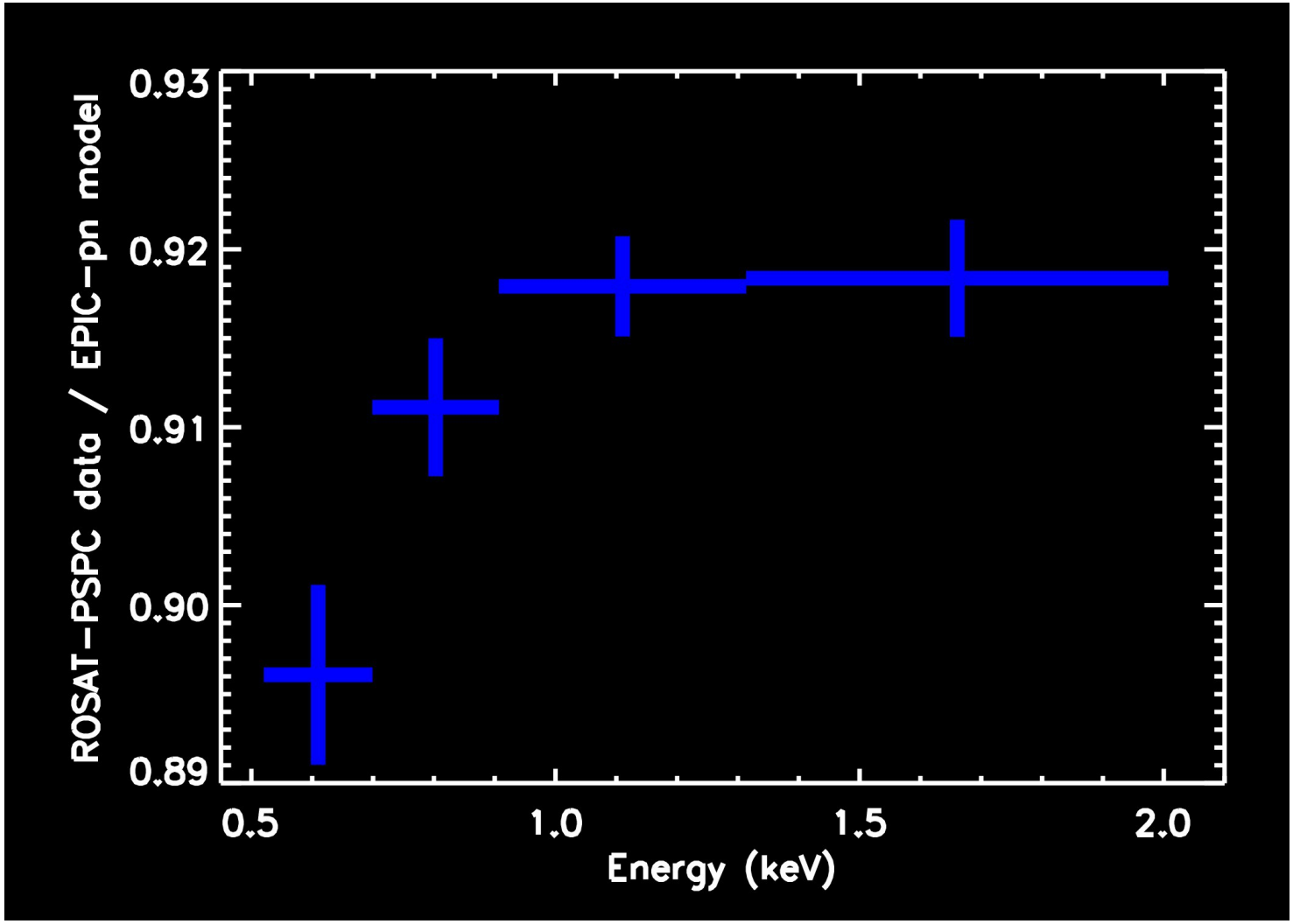
- Scatter much bigger than the statistical uncertainties. Why?
- Cool cores do not stand out

Average PSPC/pn SRS



Average PSPC/pn SRS



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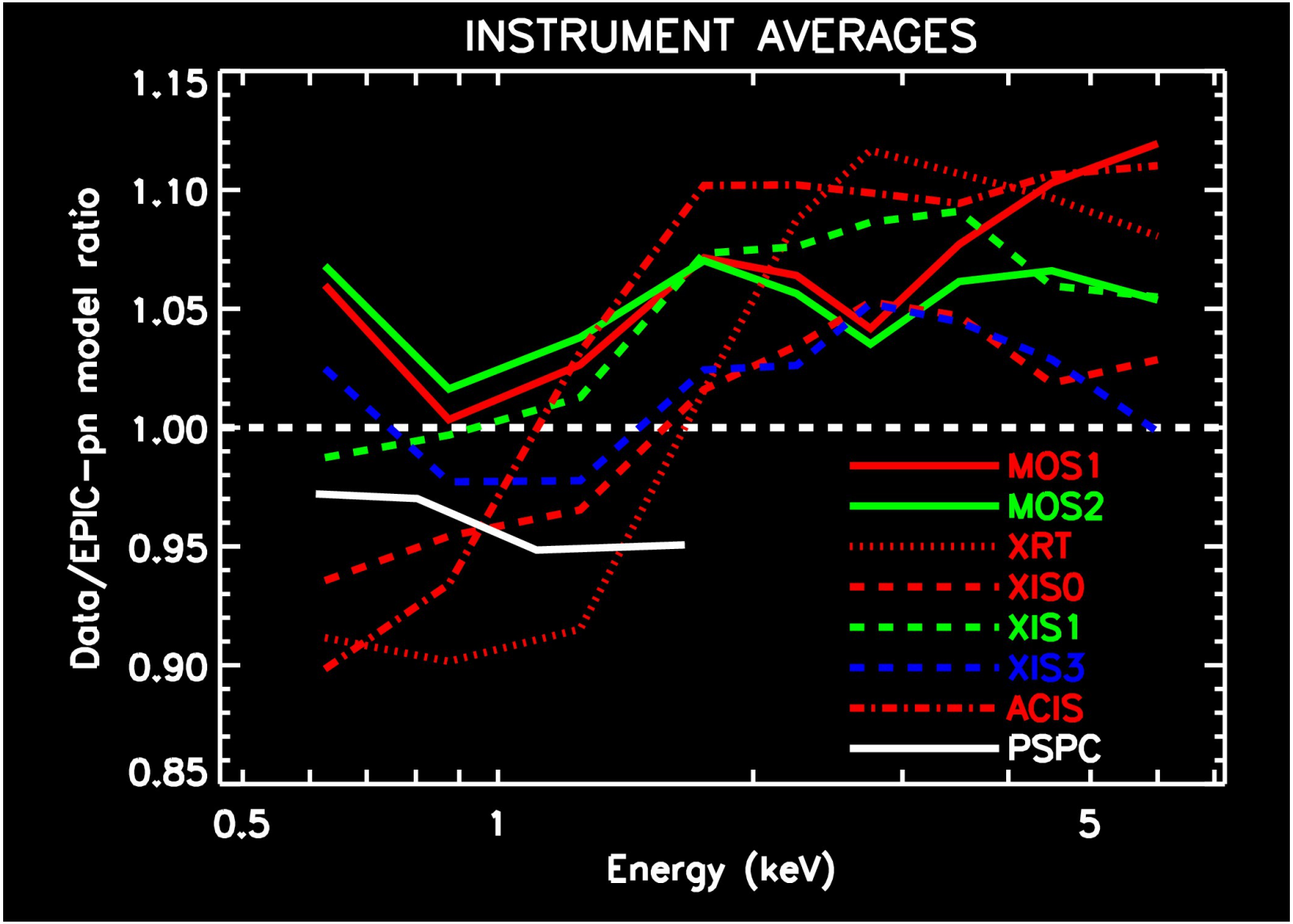
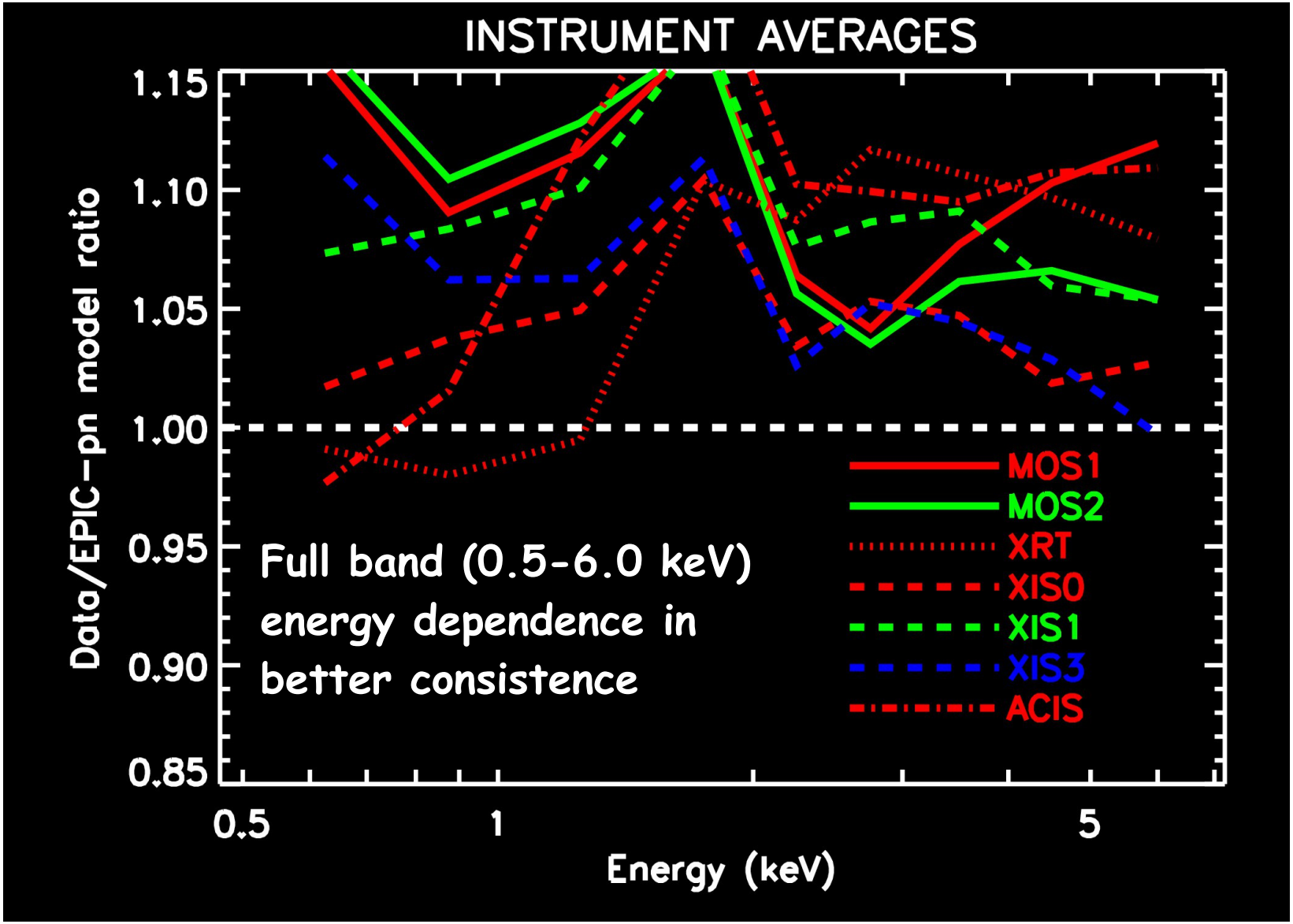
- If PSPC absolutely correct, pn 0.7-2.0 keV band model prediction too high, i.e. effarea too low by 8-9%, not energy dependently
- Assuming this, the last year instr / pn model should be increased by 8-9% in the 0.7-2.0 keV band...

Old 4 clusters sample



Old 4 clusters sample corrected with PSPC info



Action items

- TASK 1: Check ROSAT PSPC calibration using one of our clusters (Jukka & M. Freyberg)
- TASK 2: Check one cluster with Konrad's methods. Needs isothermal region for simple and accurate modelling.
- TASK 3: Swift XRT flux weighting of ARF:s