Multi-Mission Study

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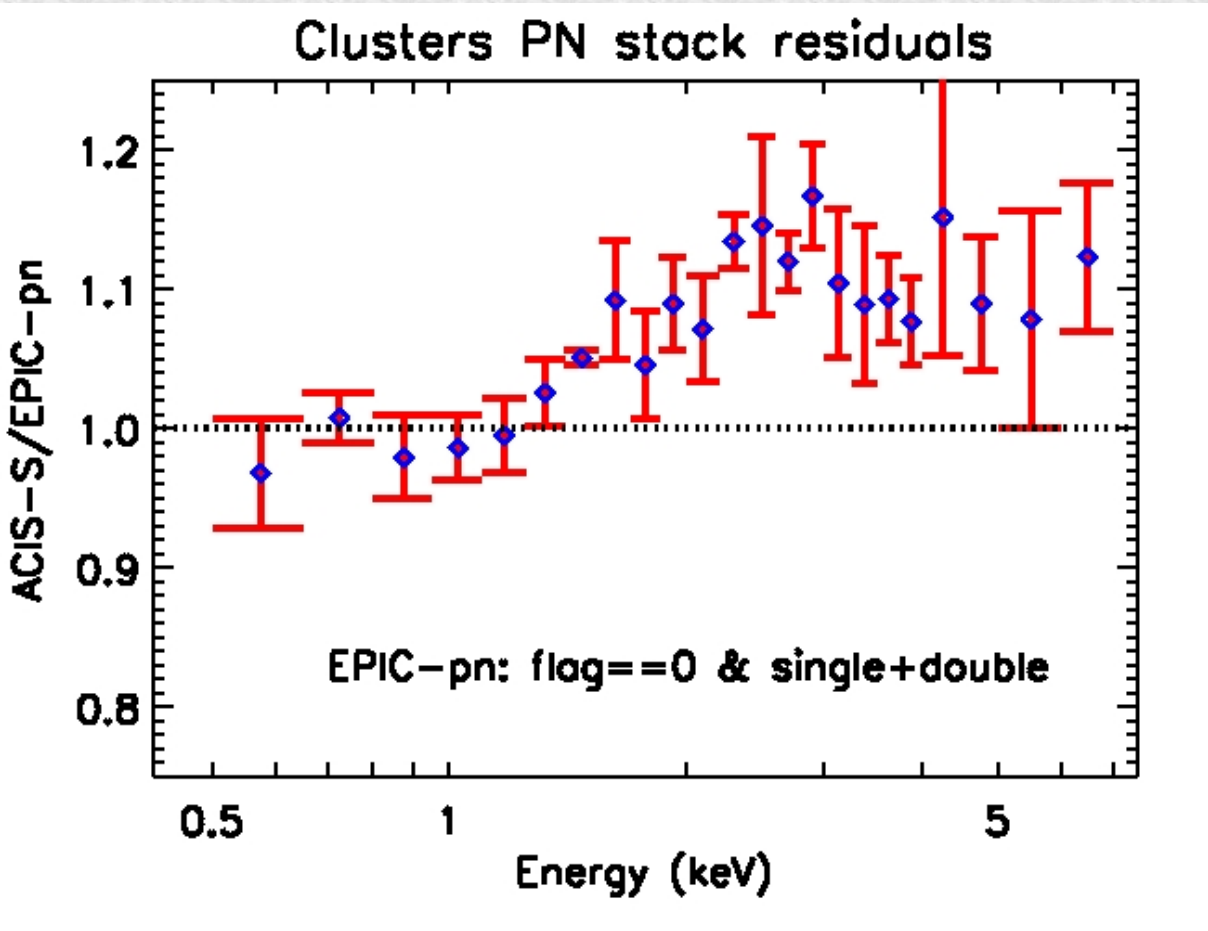
Chandra/XMM

- There are cross-correlation problems between XMM-Newton/EPIC and Chandra/ACIS (Nevalainen et al., 2010):

ACIS-**S** subsample

- ACIS 2-7 keV band flux ~10% higher
- 2-7 keV band effctive area shape calibration OK
- At 2.0- 1.0 keV pn effarea underestimated or ACIS effarea overestimated by 20%



New cans of worms

- We included now Swift/XRT, Suzaku/XIS and ROSAT/PSPC into the comparison work
- We use 3-6 arcmin annulus for the extraction of the spectra, so that
  - we minimise the scatter from the cool core (we are wasting data, but this enables the comparison with Suzaku which has a larger PSF)
  - we minimise the PSF scatter from and to our extraction region (again, dictated by Suzaku)
  - we stay in the bright part of the clusters and thus minimise background systematics (background a few% of the cluster emission)

New cans of worms

- Would be ideal to use a combined mask using the info of the bad pixels and CCD gaps of all instruments, but complicated. At this point areas vary somewhat btw the instruments
- Point sources are variable. We exclude from each instrument the minimal number of point sources required to minimize the point source emission in the 3-6 arcmin annulus

New cans of worms

- For selecting the observations common with the above five missions, we used these criteria:
  - The total exposure time must be at least 10 ks to obtain good enough statistics.
  - The center of the cluster must not be too much offset (< 3 arcmin) from the center of FOV so that we don't fold in instrument effects which are different between the central and outer regions of the FOV (e.g. vignetting).

Sample info

	A1795			A2029			Coma		
Center	207.22083, 26.5902			227.7342, 5.7446			194.9447, 27.9326		
	obsid	off-axis (arcmin)	exp (ks)	obsid	off-axis (arcmin)	exp (ks)	obsid	off-axis (arcmin)	exp (ks)
XIS	800012010	0.7	13	804024010	0.5	8	801097010	1.9	179
XRT	00035184002	3.0	13	00035187004	2.0	26	00035172001	1.9	10
ACIS	5289	0.1	15	6101	0.0	10	13996	1.1	125
EPIC	0097820101	0.2	34	0551780401	1.0	47	0300530301	0.5	31
PSPC	RP800105N00	0.5	36	RP800249N00	0.4	13	RP800005N00	2.3	21
	RP800055n00	1.8	26						

- PKS0745-19 also observed by all, but XMM obs badly flared and needs extra care

Method

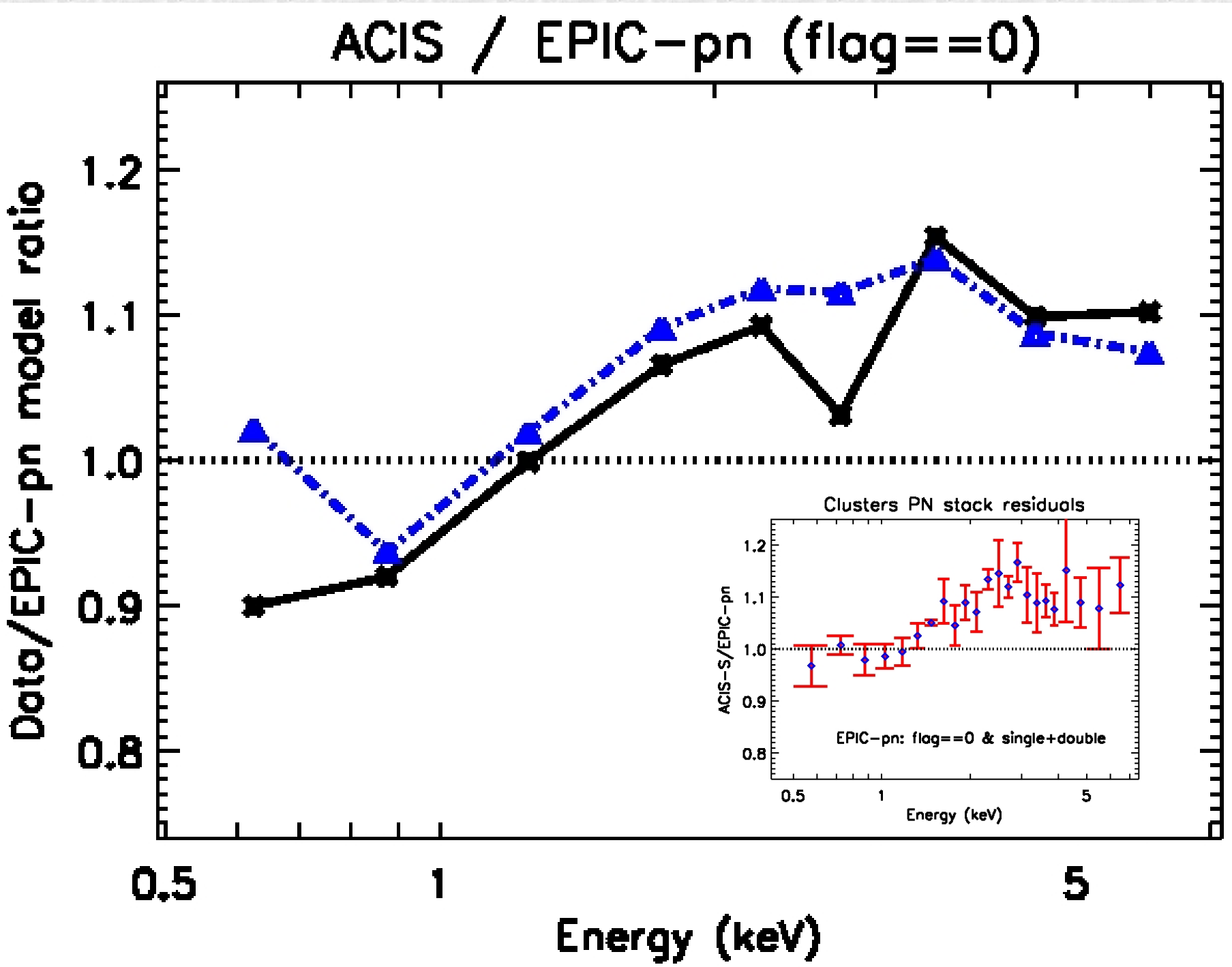
- Stack residuals:
  - We use EPIC-pn as a reference
  - For instrument I we calculate the median and the mean absolute deviation of the ratio

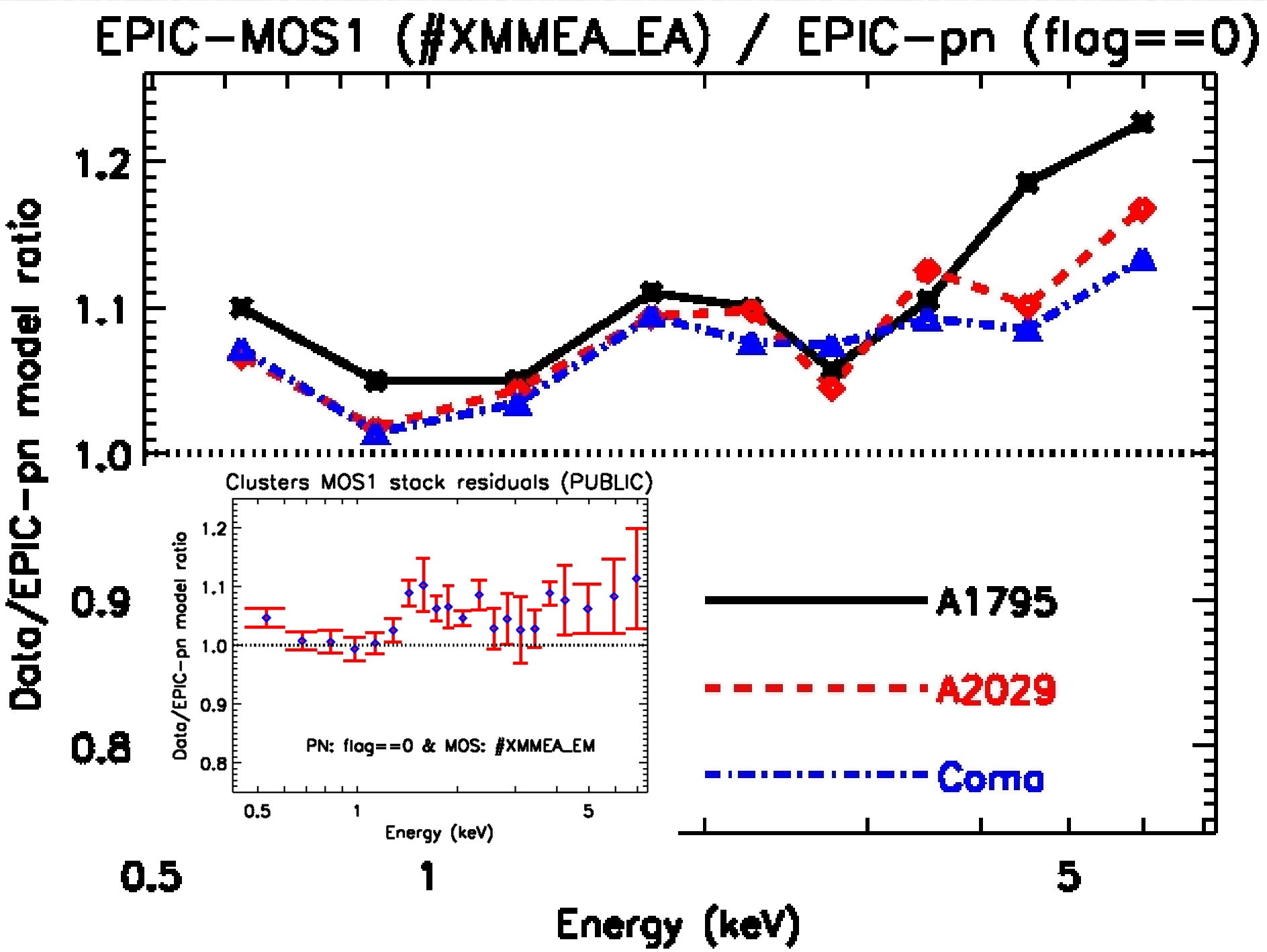
$$R_{I \text{ over } pn} = \frac{data_I}{model_{pn} \otimes resp_I} \times \frac{model_{pn} \otimes resp_{pn}}{data_{pn}}$$

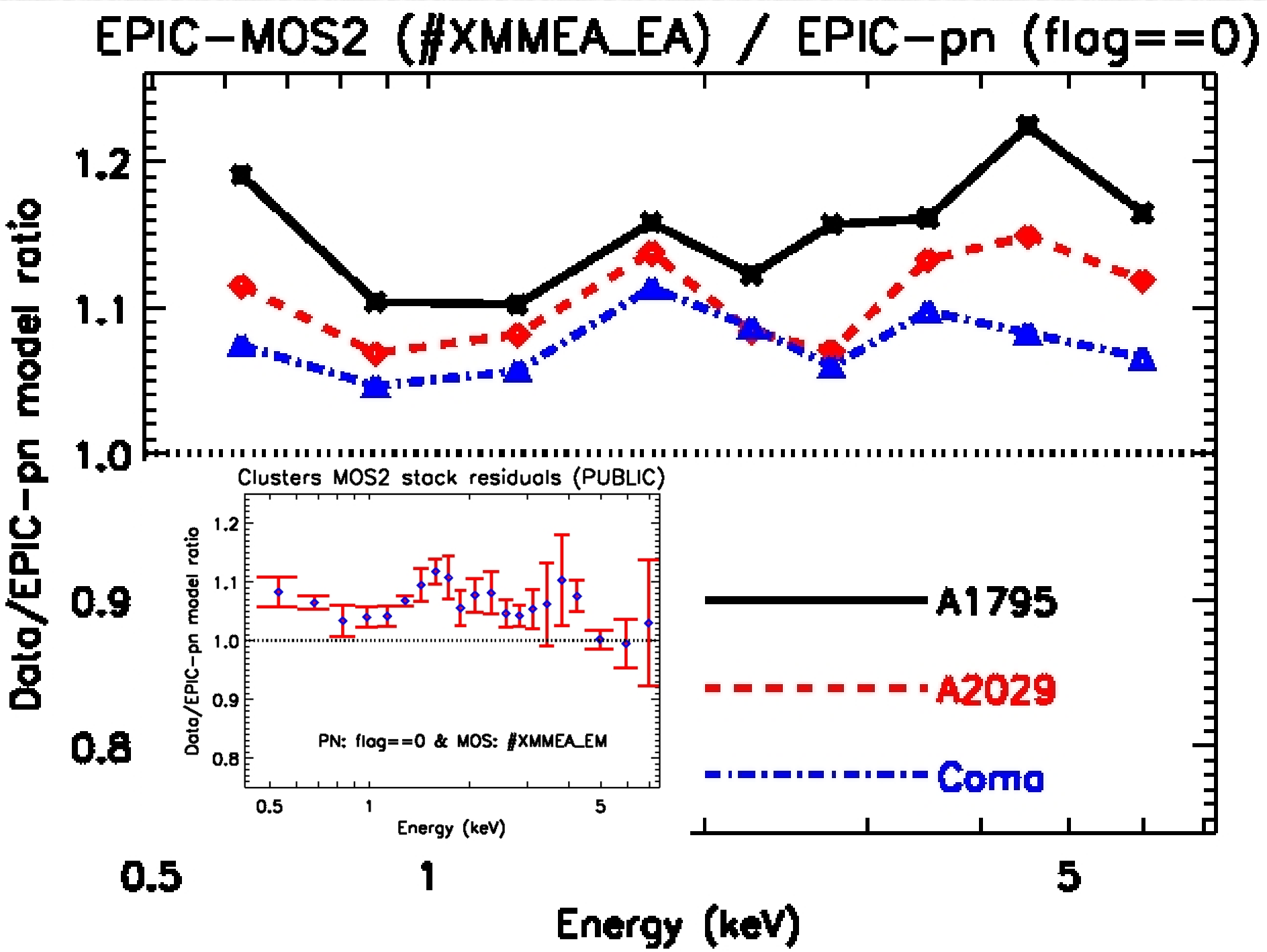
- The latter term corrects for deviations btw. pn model and pn data which cannot be produced by the model (no point in comparing other data with a model which does not fit pn data)

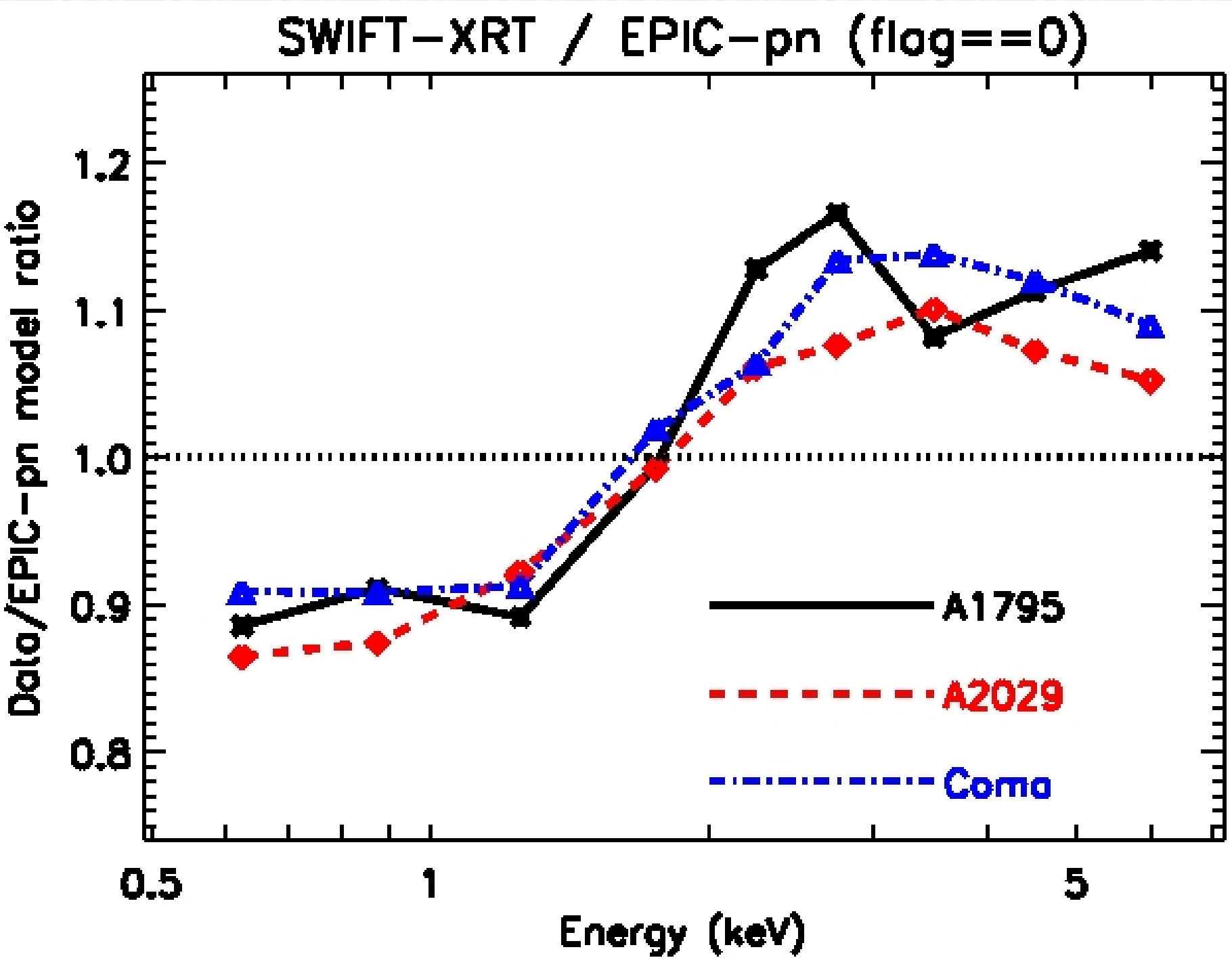
Preliminary results

(ROSAT and Suzaku not yet done, sorry


ACIS / EPIC-pn (flag==0)
Data/EPIC-pn model ratio
1.2
1.1
1.0
0.9
0.8
0.5
1
5
Energy (keV)
Clusters PN stack residuals
ACIS-S/EPIC-pn
EPIC-pn: flag==0 & single+double
Energy (keV)


EPIC−MOS1 (#XMMEA_EA) / EPIC−pn (flag==0)
Data/EPIC−pn model ratio
1.2
1.1
1.0
0.9
0.8
0.5
1
5
Energy (keV)
A1795
A2029
Coma
Clusters MOS1 stack residuals (PUBLIC)
Data/EPIC−pn model ratio
PN: flag==0 & MOS: #XMMEA_EM
Energy (keV)


EPIC−MOS2 (#XMMEA_EA) / EPIC−pn (flag==0)
Data/EPIC−pn model ratio
1.2
1.1
1.0
0.9
0.8
0.5
1
5
Energy (keV)
A1795
A2029
Coma
Clusters MOS2 stack residuals (PUBLIC)
Data/EPIC−pn model ratio
PN: flag==0 & MOS: #XMMEA_EM
Energy (keV)


SWIFT−XRT / EPIC−pn (flag==0)
Data/EPIC−pn model ratio
1.2
1.1
1.0
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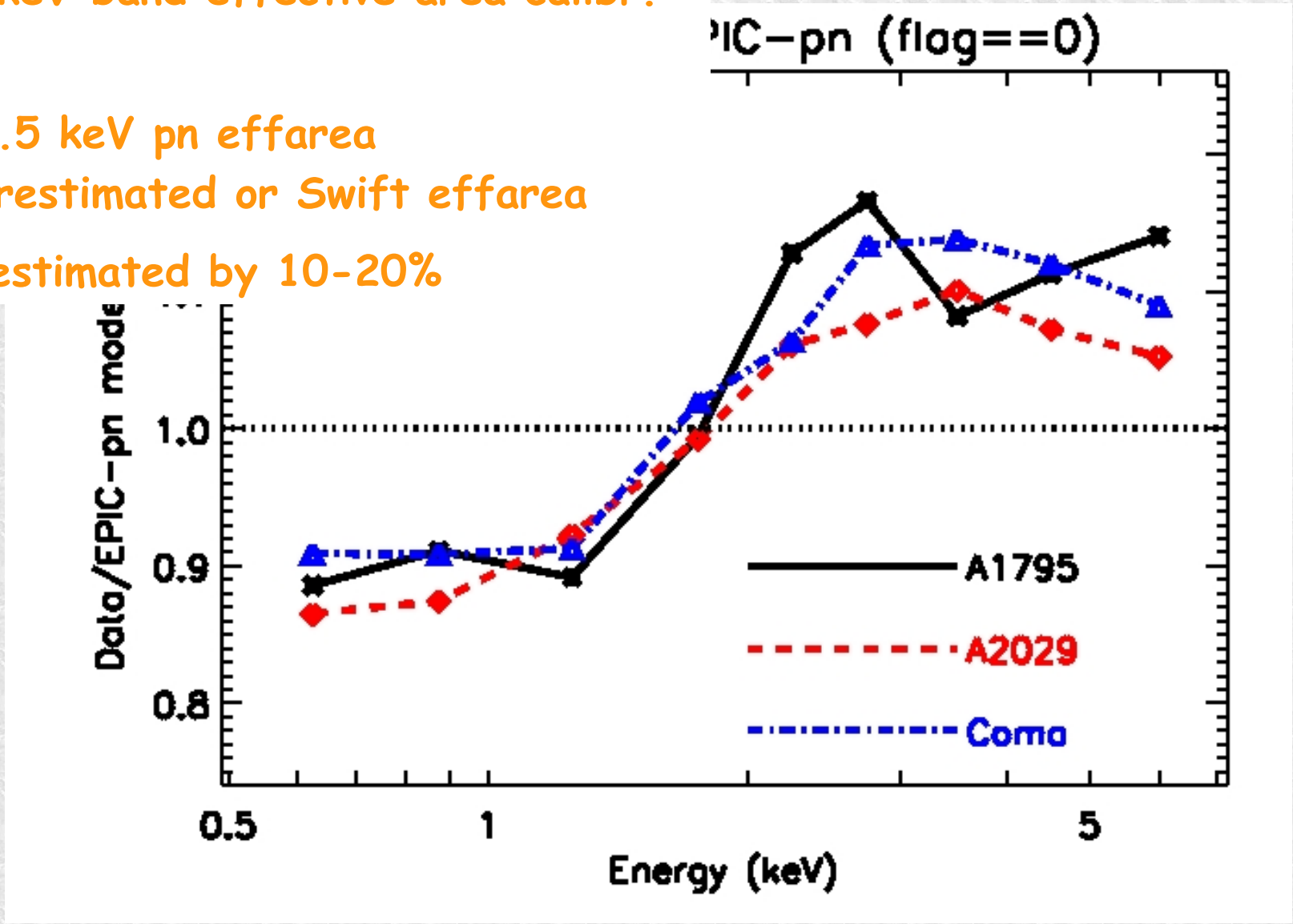
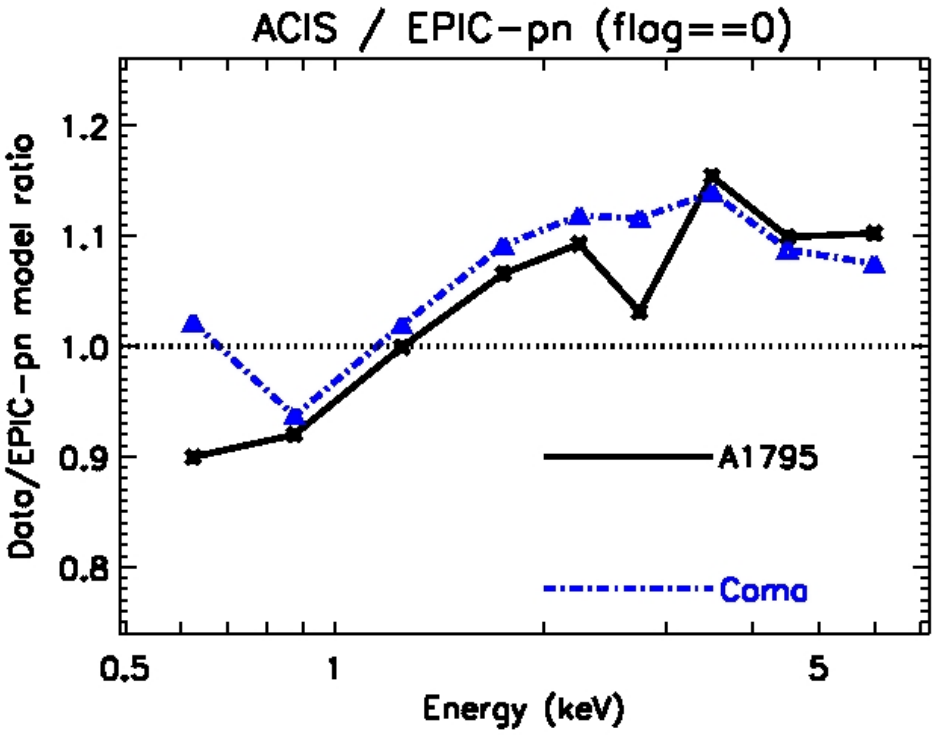
0.8
0.5
1
5
Energy (keV)
A1795
A2029
Coma

- Swift/pn similar as ACIS/pn:
  - XRT 2-7 keV band flux ~10% higher
  - 2-7 keV band effective area calibr. OK
  - At 0.5 keV pn effarea underestimated or Swift effarea overestimated by 10-20%



Is pn a freak?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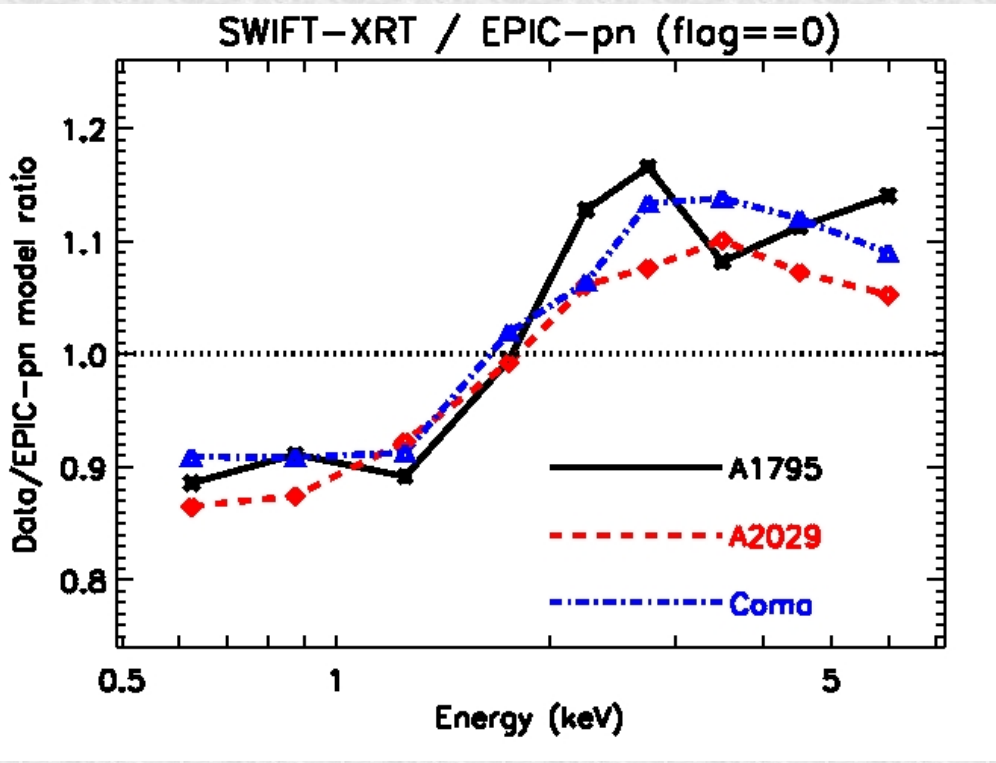
A1795
Coma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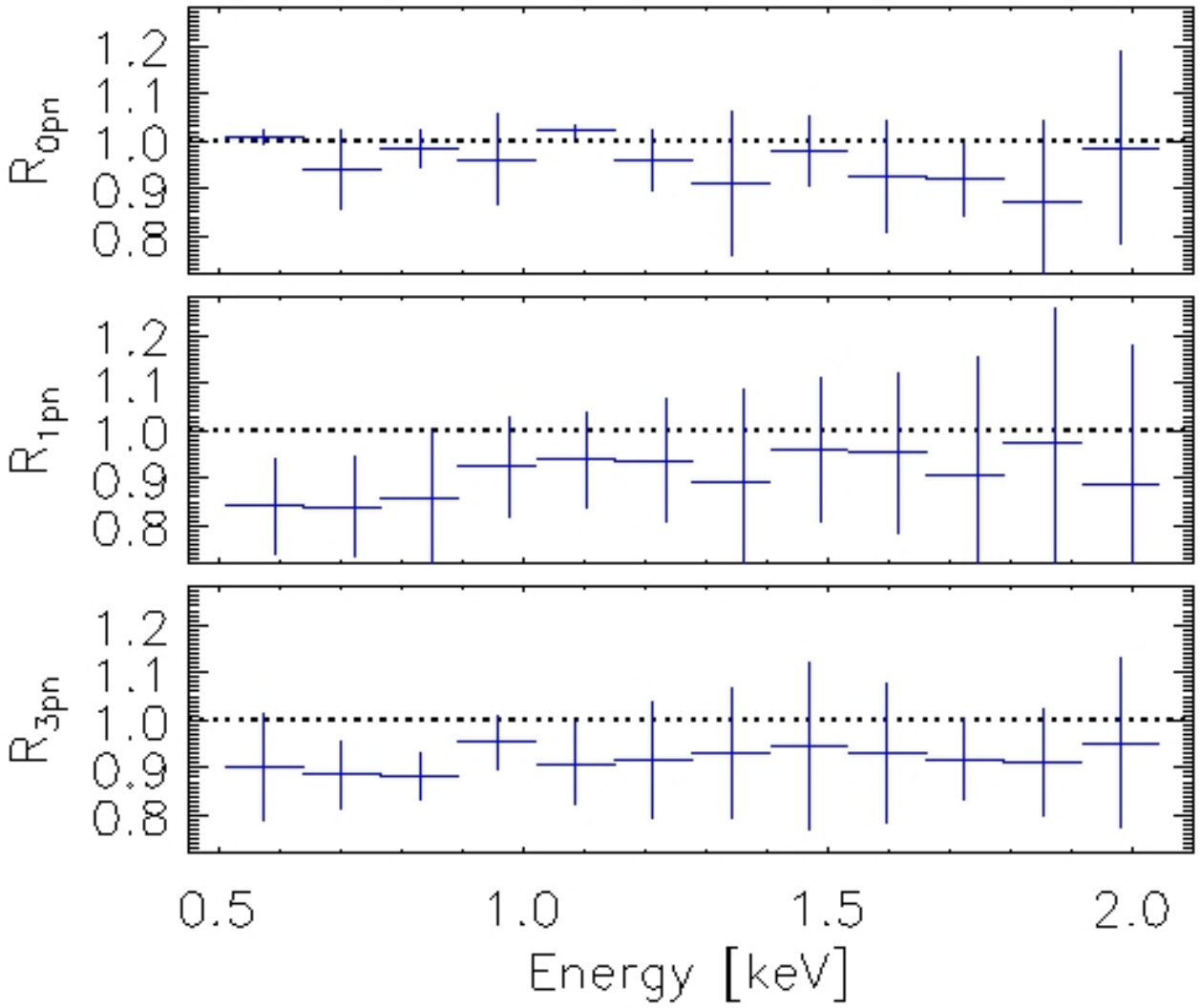
A2029
Coma

Not quite: Suzaku-XIS / pn soft band

- XIS/pn do not show the steep feature btw 1 and 2 keV (Kettula et al, 2013)



Conclusions

- XMM-Newton-EPIC and Suzaku-XIS in rough agreement
- Chandra-ACIS and Swift-XRT in rough agreement
- The two pairs in clear disagreement ➔
- Grand Calibration Scheme (M. Guainazzi)