# Galaxy Clusters WG

## Review of WG activities and action items

IACHEC meeting 2013, Theddingworth

1) HIFLUGCS extension

2) Multi-Mission Study

3) SZ, Grav lensing

} Today 9:00-12:30 and possibly continued in the afternoon

4) NuSTAR

5) Suzaku paper

} Wed 14:00-17:30

# 1) HIFLUGCS extension

G. Shellenberger et al.

IACHEC meeting 2013, Theddingworth

# BACKSCAL

- 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)

- To account for different sizes of the extraction regions due to CCD gaps, we scale the spectra with the BACKSCAL value:

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

$$\frac{BACKSCAL_{pn}}{BACKSCAL_I} \times \frac{data_I}{model_{pn} \otimes resp_I} \times \frac{model_{pn} \otimes resp_{pn}}{data_{pn}}$$

- Linear scaling not exact, because brightness drops with radius
- BACKSCAL not correctly calculated for ACIS-I? CCD gaps and bad pixels not excluded from BACKSCAL?
- Larry has a tool for it. Gerritt should learn this. **TASK1**

# Suggestions for Gerrit

- Group the data according to
  - Epochs
    - Possible time dependence of effective area uncertainties. Multiple observations of same objects useful. Are there enough?
  - Patterns
    - No effect in EPIC-XCAL work, though
  - #XMM_EM(P) v.s. flag==0
    - flag==0 excludes more area. BACKSCAL does not fully recover the lost flux compared to #XMM_EP
  - Filters
    - No effect in EPIC-XCAL work, though

# Suggestions for Gerrit

- tbabs

# 2) Multi-Mission Study

J. Nevalainen, L. David, S. Snowden, A. Beardmore, K. Kettula

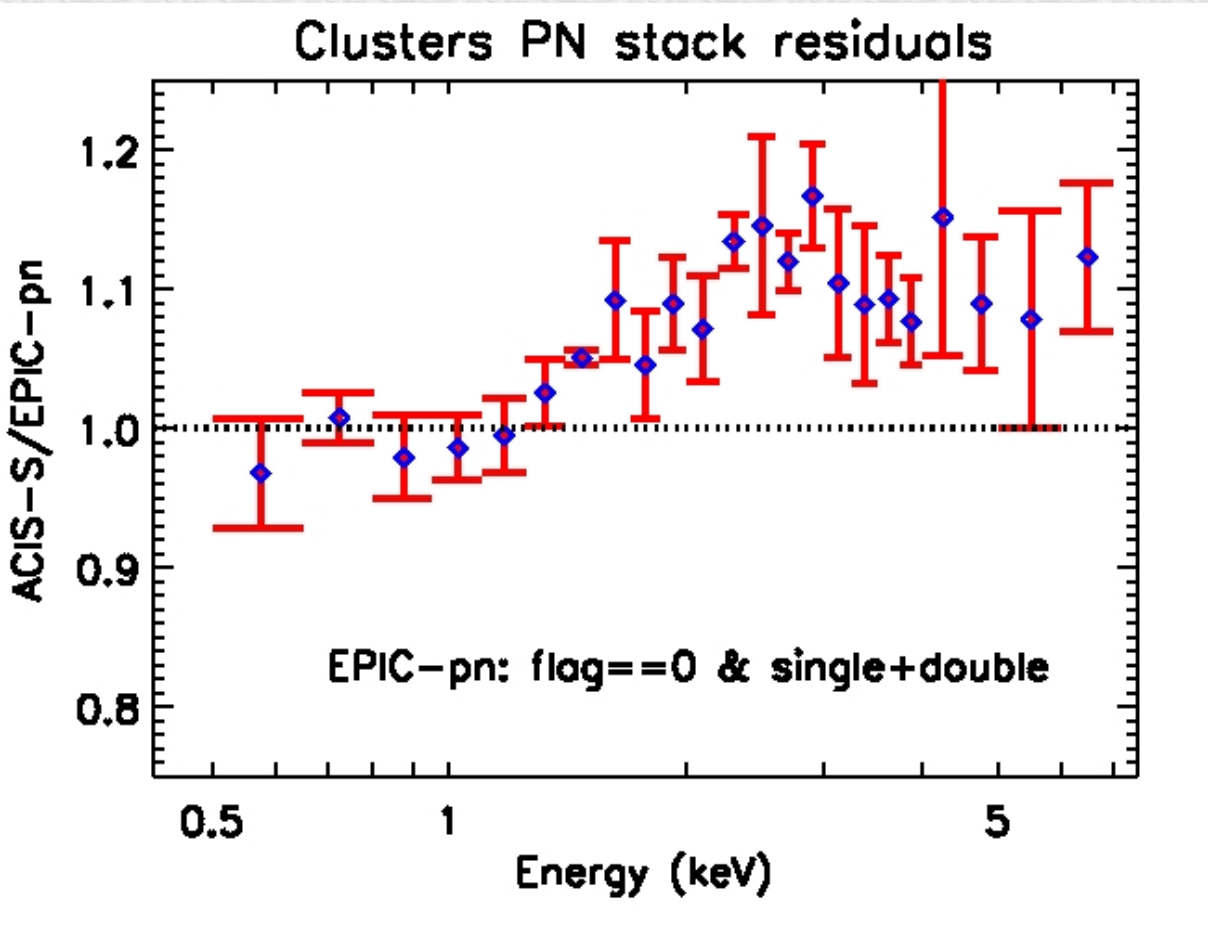
IACHEC meeting 2013, Theddingworth

# 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 effective 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). **Perhaps OK to use center?**
  - 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. **Rather minimum number of counts.**
  - 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).

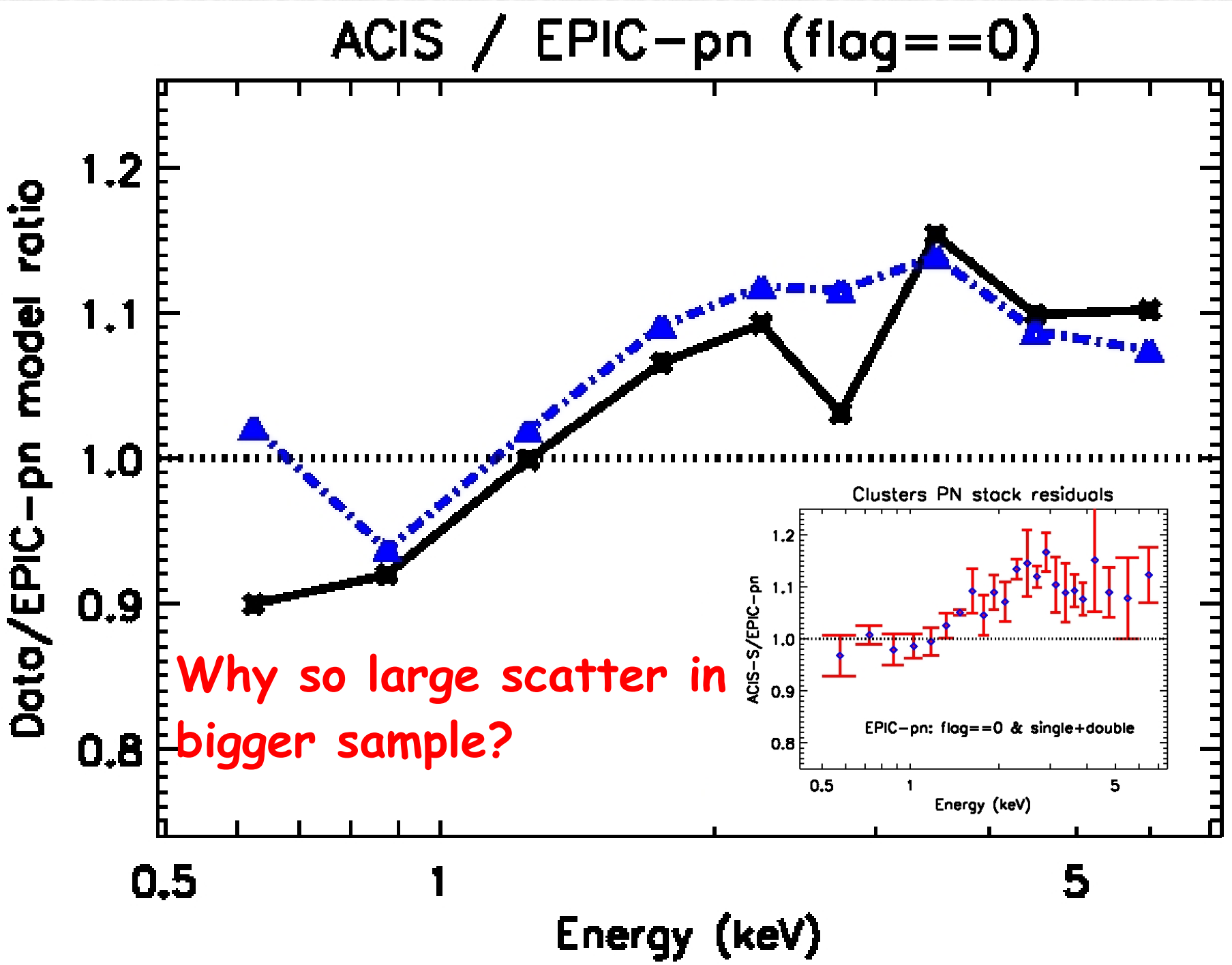
# Sample info

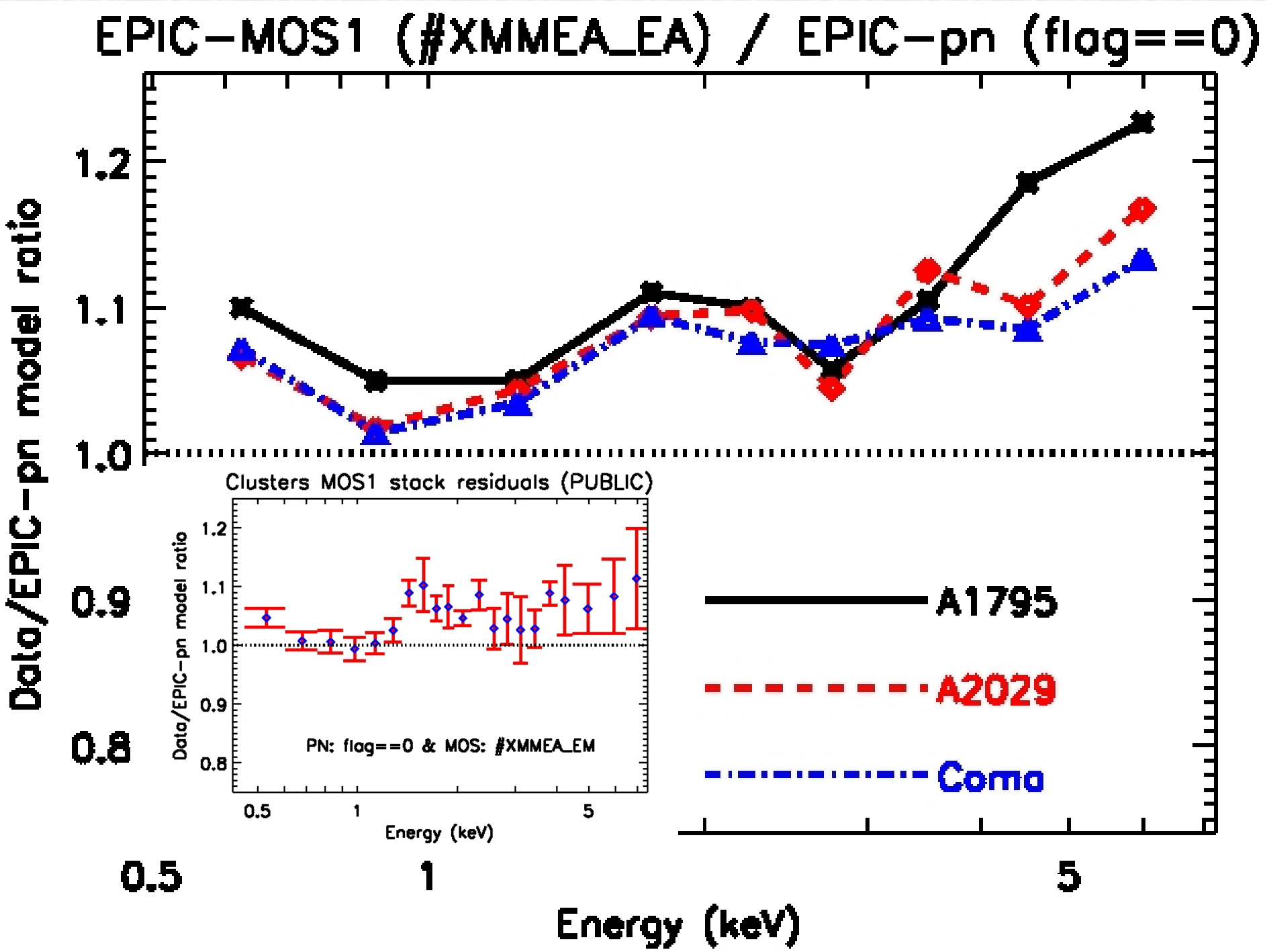
| | A1795 | | | A2029 | | | Coma | | |
|---|---|---|---|---|---|---|---|---|---|
| Center | 207.22083, 26.5902 | | | 227.7342, 5.7446 | | | 194.9447, 27.9326 | | |
| | obsid | off-axis (arcmin) | exp (ks) | obsid | off-axis (arcmin) | exp (ks) | obsid | off-axis (arcmin) | exp (ks) |
| XIS | 800012010 | 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 | | | | | | |

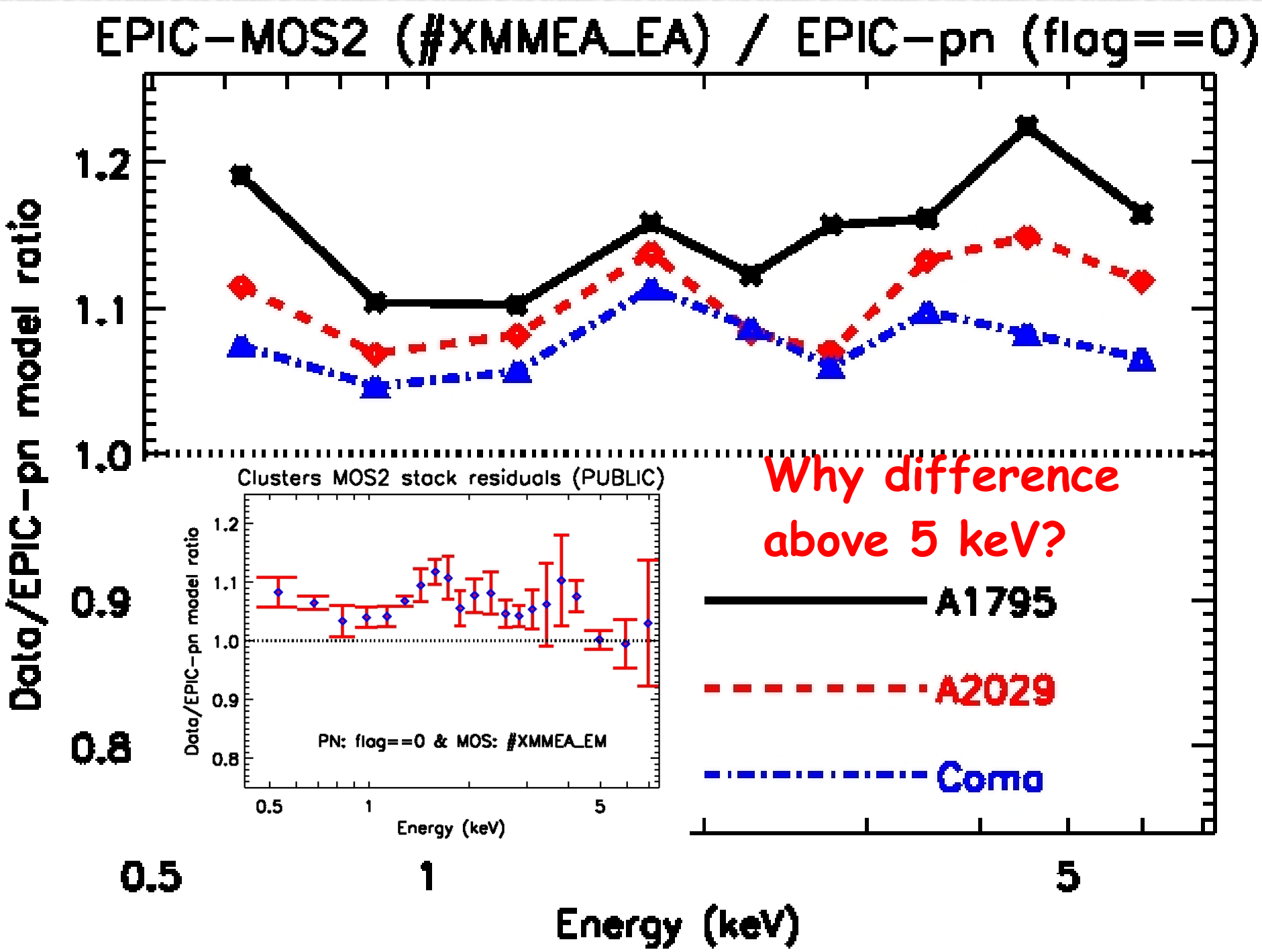
- PKS0745-19 also observed by all, but XMM obs badly flared and needs extra care

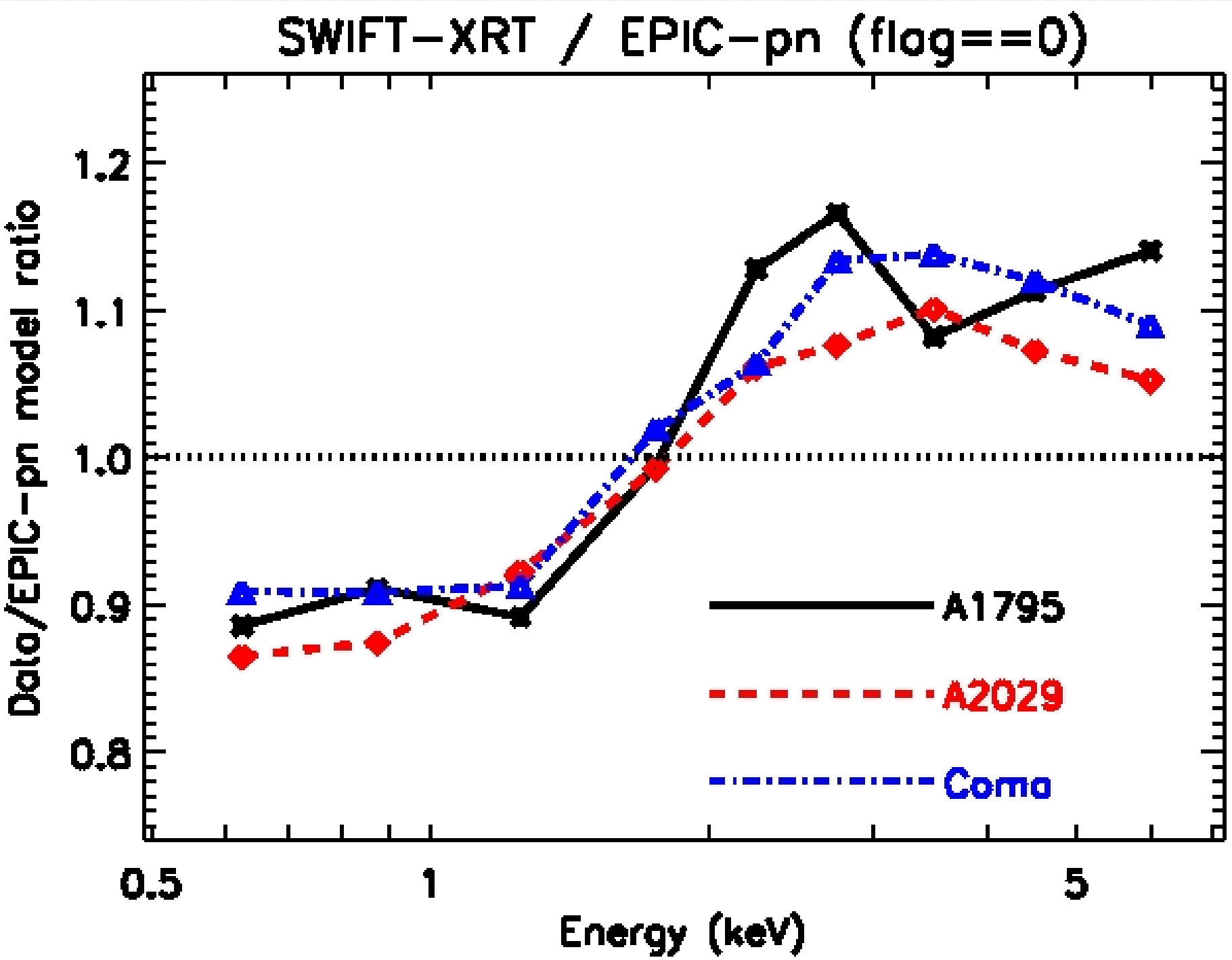
# Preliminary results

(ROSAT and Suzaku TBD)

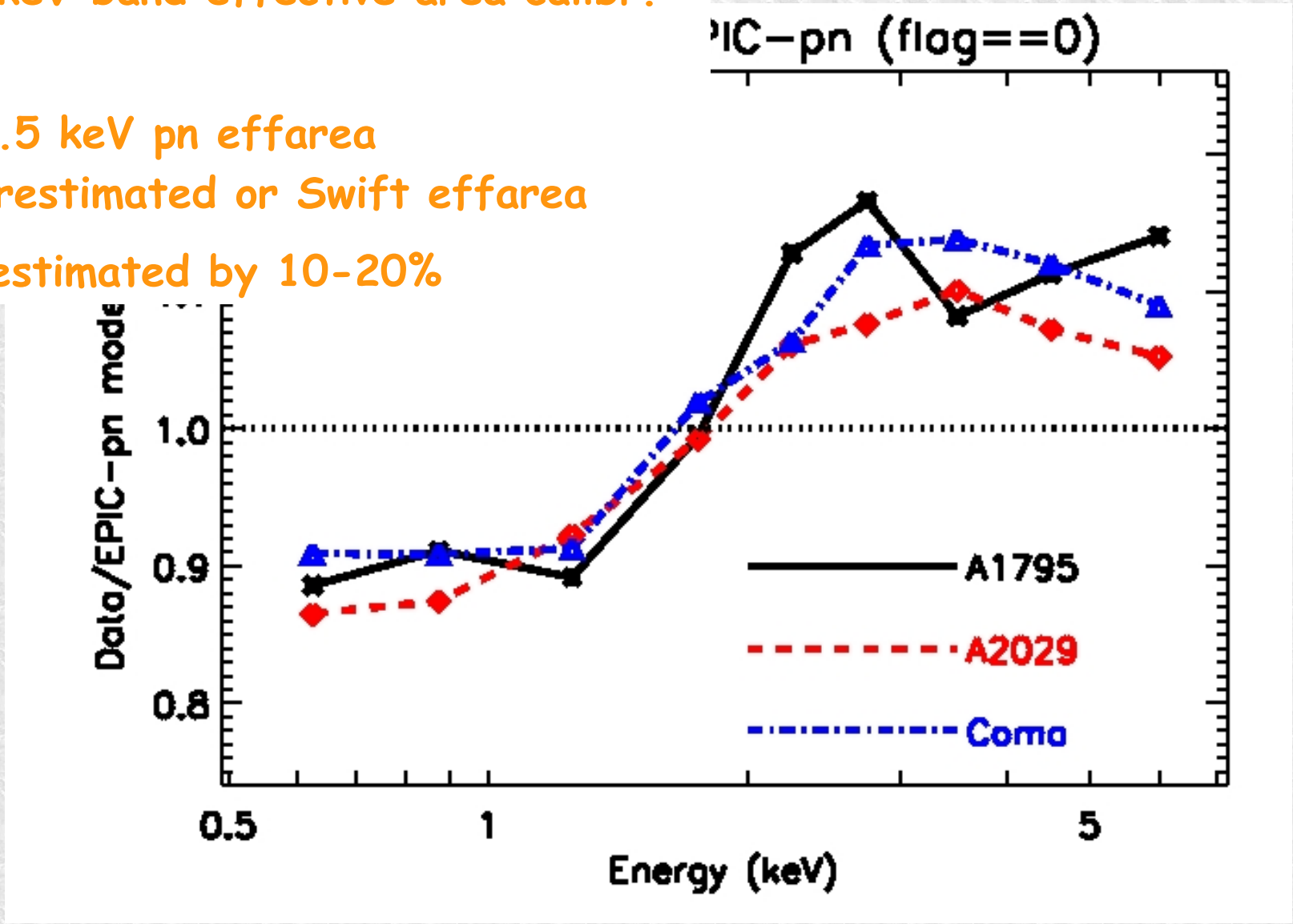

ACIS / EPIC-pn (flag==0)
Data/EPIC-pn model ratio
1.2
1.1
1.0
0.9
0.8
0.5
1
5
Energy (keV)
Why so large scatter in bigger sample?
Clusters PN stack residuals
ACIS-S/EPIC-pn
EPIC-pn: flag==0 & single+double
Energy (keV)


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)

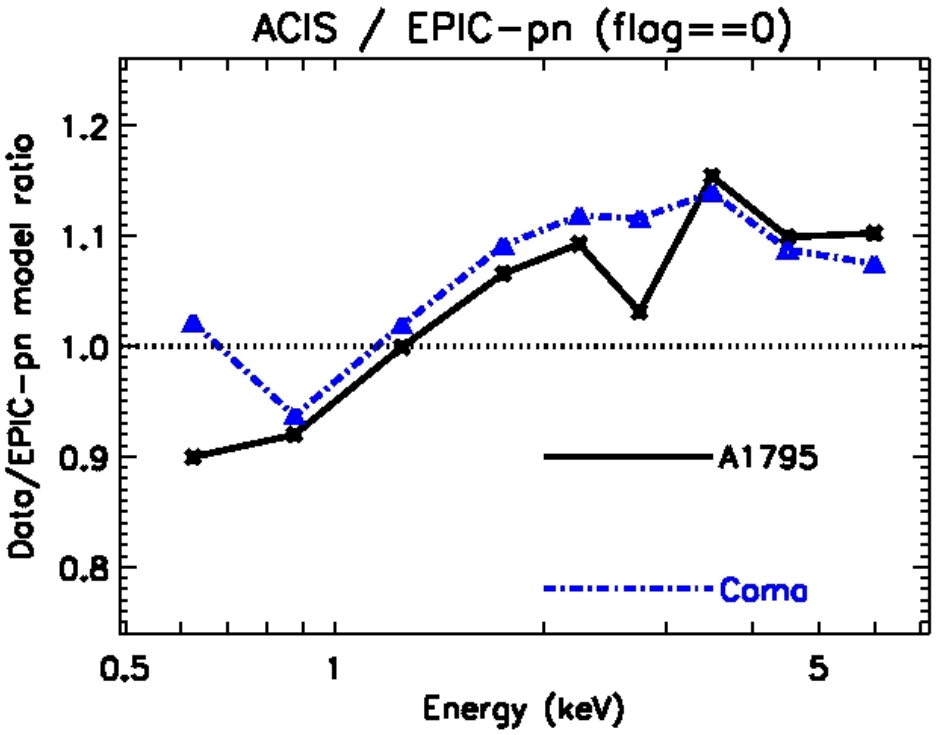

EPIC−MOS2 (#XMMEA_EA) / EPIC−pn (flag==0)
Data/EPIC−pn model ratio
1.2
1.1
1.0
0.9
0.8
0.5
1
5
Energy (keV)
Clusters MOS2 stack residuals (PUBLIC)
Data/EPIC−pn model ratio
PN: flag==0 & MOS: #XMMEA_EM
Why difference above 5 keV?
A1795
A2029
Coma

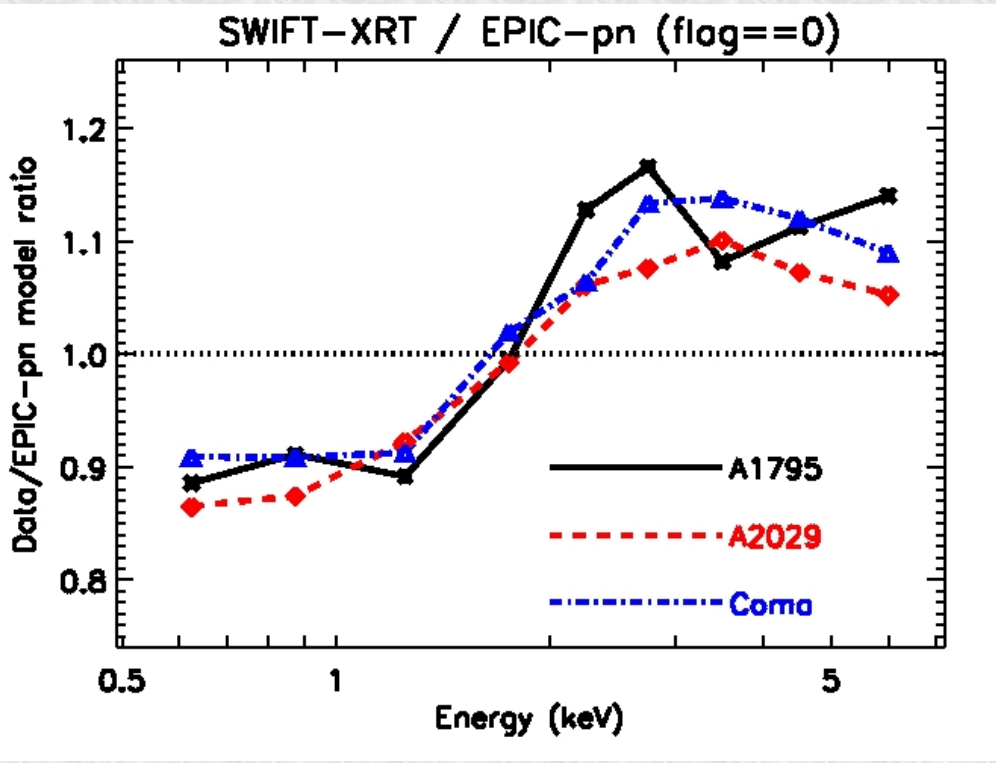

SWIFT−XRT / EPIC−pn (flag==0)
Data/EPIC−pn model ratio
1.2
1.1
1.0
0.9
0.8
0.5
1
5
Energy (keV)
A1795
A2029
Coma

- 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%



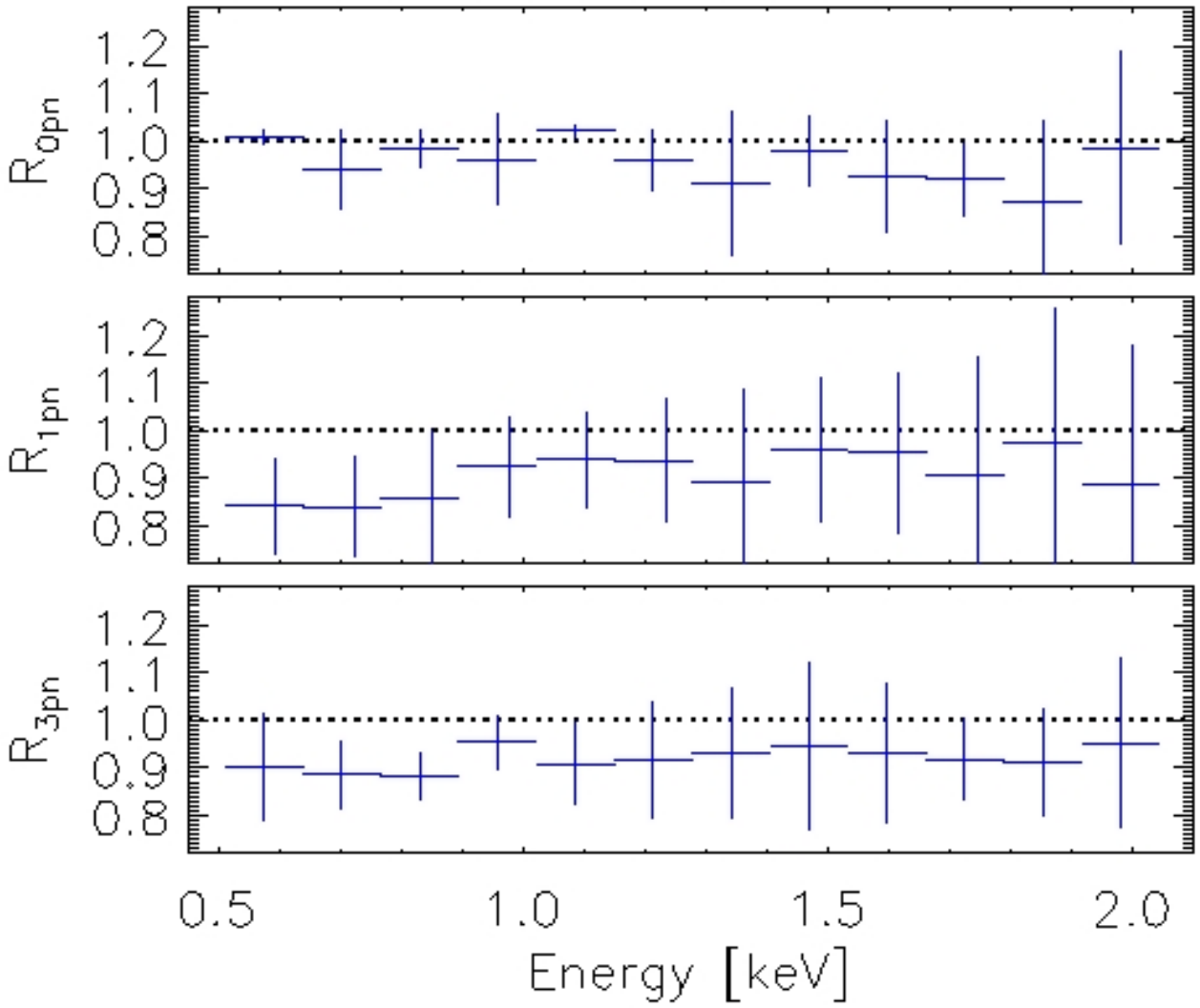
# Is pn a freak?


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)
A1795
Coma


SWIFT−XRT / 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

# 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)