XMM-Newton — Chandra Blazar Flux Comparison

M.J.S. Smith (ESAC) & H. Marshall (MIT)

7th IACHEC, Napa, March 2012

Blazar Sample

- Objective: Comparison of XMM-Newton — Chandra fluxes in various bands.
- Using a sample of Blazars observed by XMM and Chandra:
  - **PKS 2155-304**, **3C 273**, **H 1426+428**

Blazar Sample

- Objective: Comparison of XMM-Newton — Chandra fluxes in various bands.
- Using a sample of Blazars observed by XMM and Chandra:
  - **PKS 2155-304**, **3C 273**, **H 1426+428**
- Smooth spectra over 0.1 – 10.0 keV

Blazar Sample

- Objective: Comparison of XMM-Newton — Chandra fluxes in various bands.
- Using a sample of Blazars observed by XMM and Chandra:
  - **PKS 2155-304**, **3C 273**, **H 1426+428**
- Smooth spectra over 0.1 – 10.0 keV
- Bright:
  - piled-up in EPIC -> PSF core excision introduces added uncertainty in flux determination

Blazar Sample

- Objective: Comparison of XMM-Newton — Chandra fluxes in various bands.
- Using a sample of Blazars observed by XMM and Chandra:
  - **PKS 2155-304**, **3C 273**, **H 1426+428**
- Smooth spectra over 0.1 – 10.0 keV
- Bright:
  - piled-up in EPIC -> PSF core excision introduces added uncertainty in flux determination
- Highly variable, even within observation timescale:
  - require XMM / Chandra / … coordinated observations
  - simultaneous GTIs across instruments
  - normalise fluxes to compare between observations

Blazar Sample

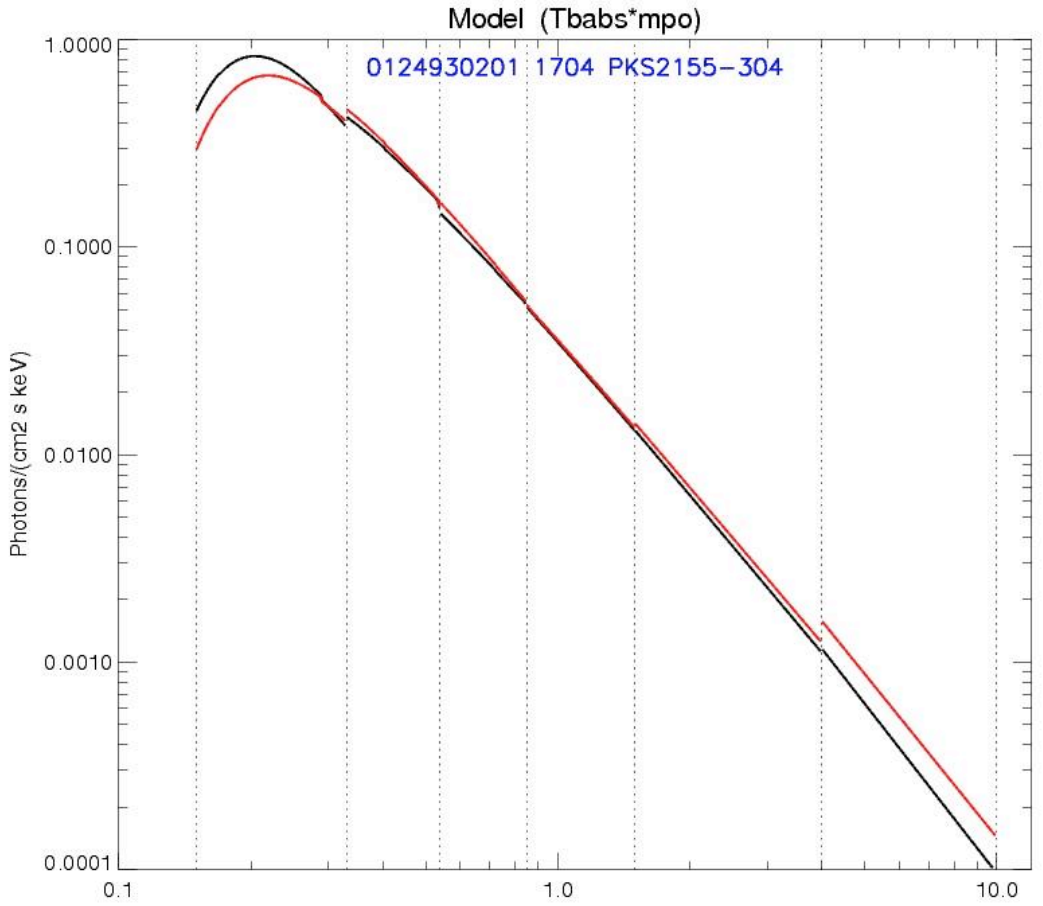
- Objective: Comparison of XMM-Newton — Chandra fluxes in various bands.
- Using a sample of Blazars observed by XMM and Chandra:
  - **PKS 2155-304**, **3C 273**, **H 1426+428**
- Smooth spectra over 0.1 – 10.0 keV
- Bright:
  - piled-up in EPIC -> PSF core excision introduces added uncertainty in flux determination
- Highly variable, even within observation timescale:
  - require XMM / Chandra / … coordinated observations
  - simultaneous GTIs across instruments
  - normalise fluxes to compare between observations
- 17 coordinated XMM-Newton — Chandra observations:
  - 32 strictly simultaneous GTIs for flux comparison
- Instruments being compared are:
  - **EPIC**, **RGS**, **ACISS-L/HETG**, **HRCS-LETG**

Data Analysis (I)

- Energy bands are those used originally in the XMM-Newton Cross Cal Archive:
  - 0.15 – 0.33 keV (Lower EPIC - Lower RGS bound)
  - 0.33 – 0.54 keV (Up to the O-edge)
  - 0.54 – 0.85 keV (O-VII, O-VIII)
  - 0.85 – 1.50 keV (Ne-IX, Ne-X)
  - 1.50 – 4.00 keV
  - 4.00 – 10.0 keV

Data Analysis (I)

- Energy bands are those used originally in the XMM-Newton Cross Cal Archive:
  - 0.15 – 0.33 keV (Lower EPIC - Lower RGS bound)
  - 0.33 – 0.54 keV (Up to the O-edge)
  - 0.54 – 0.85 keV (O-VII, O-VIII)
  - 0.85 – 1.50 keV (Ne-IX, Ne-X)
  - 1.50 – 4.00 keV
  - 4.00 – 10.0 keV
- Spectral fitting: model consists of:
  - multiple independent power laws
  - absorption with nH fixed
    - PKS 2155-304: 1.42 x 10^{20} cm^{-2}
    - 3C 273: 1.79 x 10^{20} cm^{-2}
    - H 1426+428: 1.36 x 10^{20} cm^{-2}
- Per simultaneous exposure:
  - fit each instrument independently
  - additional "Joint Fit" of all instruments in use
- Determine band fluxes from resulting best fits.



Data Analysis (II)

- Normalise fluxes within simultaneous exposures (GTIs) to compare instruments across observations:

- Preferably the same reference across all GTIs and bands.
  - PN & MOS: when in TI mode no useful data in the lowest energy band
  - RGS: no data in the lower or higher bands
  - Chandra instrument configurations vary from exposure to exposure

Data Analysis (II)

- Normalise fluxes within simultaneous exposures (GTIs) to compare instruments across observations:

- Preferably the same reference across all GTIs and bands.
  - PN & MOS: when in TI mode no useful data in the lowest energy band
  - RGS: no data in the lower or higher bands
  - Chandra instrument configurations vary from exposure to exposure

- Use as reference the **Joint Fit Flux** of all instruments in use in a particular exposure.

Data Analysis (II)

- Normalise fluxes within simultaneous exposures (GTIs) to compare instruments across observations:

- Preferably the same reference across all GTIs and bands.
  - PN & MOS: when in TI mode no useful data in the lowest energy band
  - RGS: no data in the lower or higher bands
  - Chandra instrument configurations vary from exposure to exposure

- Use as reference the **Joint Fit Flux** of all instruments in use in a particular exposure.

- For 32 GTIs and 6 energy bands: a total of ~ 200 spectra and ~ 1200 derived flux values.

Data Analysis (II)

- Normalise fluxes within simultaneous exposures (GTIs) to compare instruments across observations:

- Preferably the same reference across all GTIs and bands.
  - PN & MOS: when in TI mode no useful data in the lowest energy band
  - RGS: no data in the lower or higher bands
  - Chandra instrument configurations vary from exposure to exposure

- Use as reference the **Joint Fit Flux** of all instruments in use in a particular exposure.

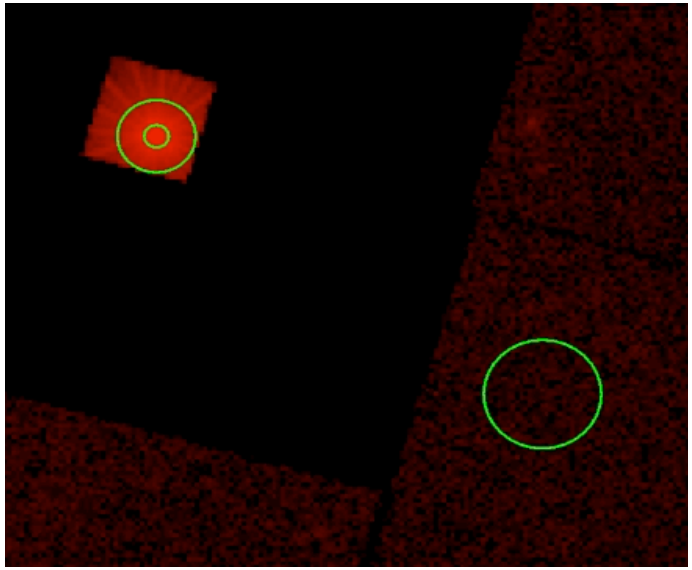
- For 32 GTIs and 6 energy bands: a total of ~ 200 spectra and ~ 1200 derived flux values.

- Data reduction:
  - SAS 11.0 + CCFs as of February 2012
    - with 2D-PSF for EPIC
  - CIAO 4.3 + CALDB 4.4.6.1 (including HETG Grating Efficiency v. N0007)

Data Analysis (III)

Systematic uncertainties:

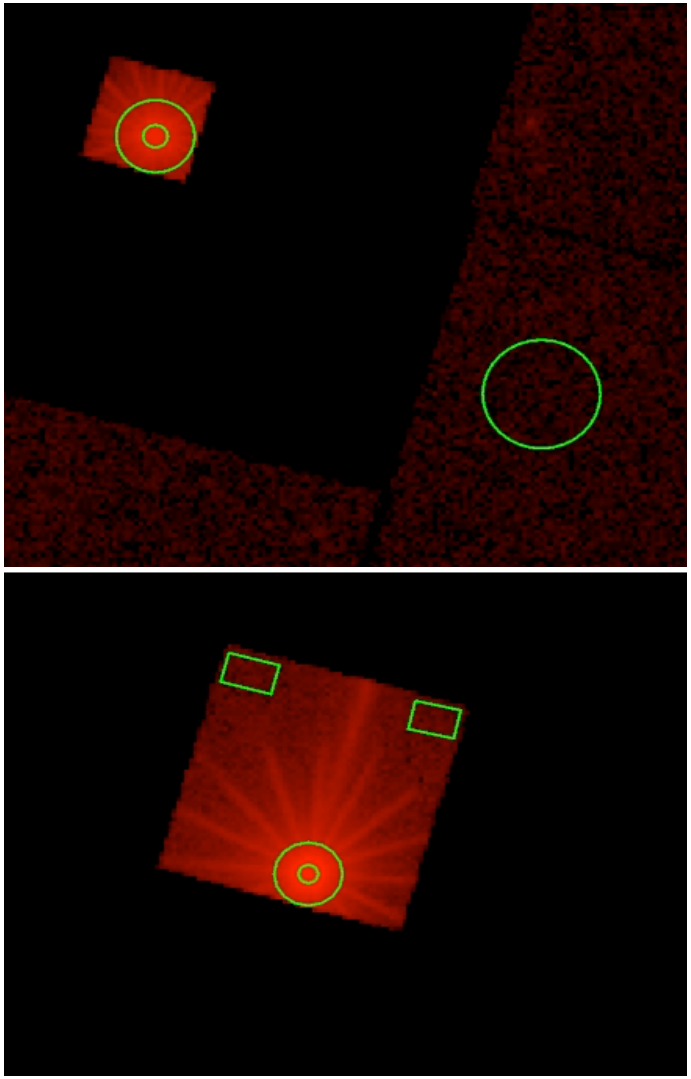
- Pile-up:
  - EPIC requires excision of PSF core: use source extraction annuli.
  - Per observation: for both MOSs use the largest common outer radius within window, and a common inner radius.
  - However, radii vary from observation to observation, and are generally different from the PN radii.
  - Differing annuli may introduce systematic uncertainties due to imperfect EE correction and RMF weighting.



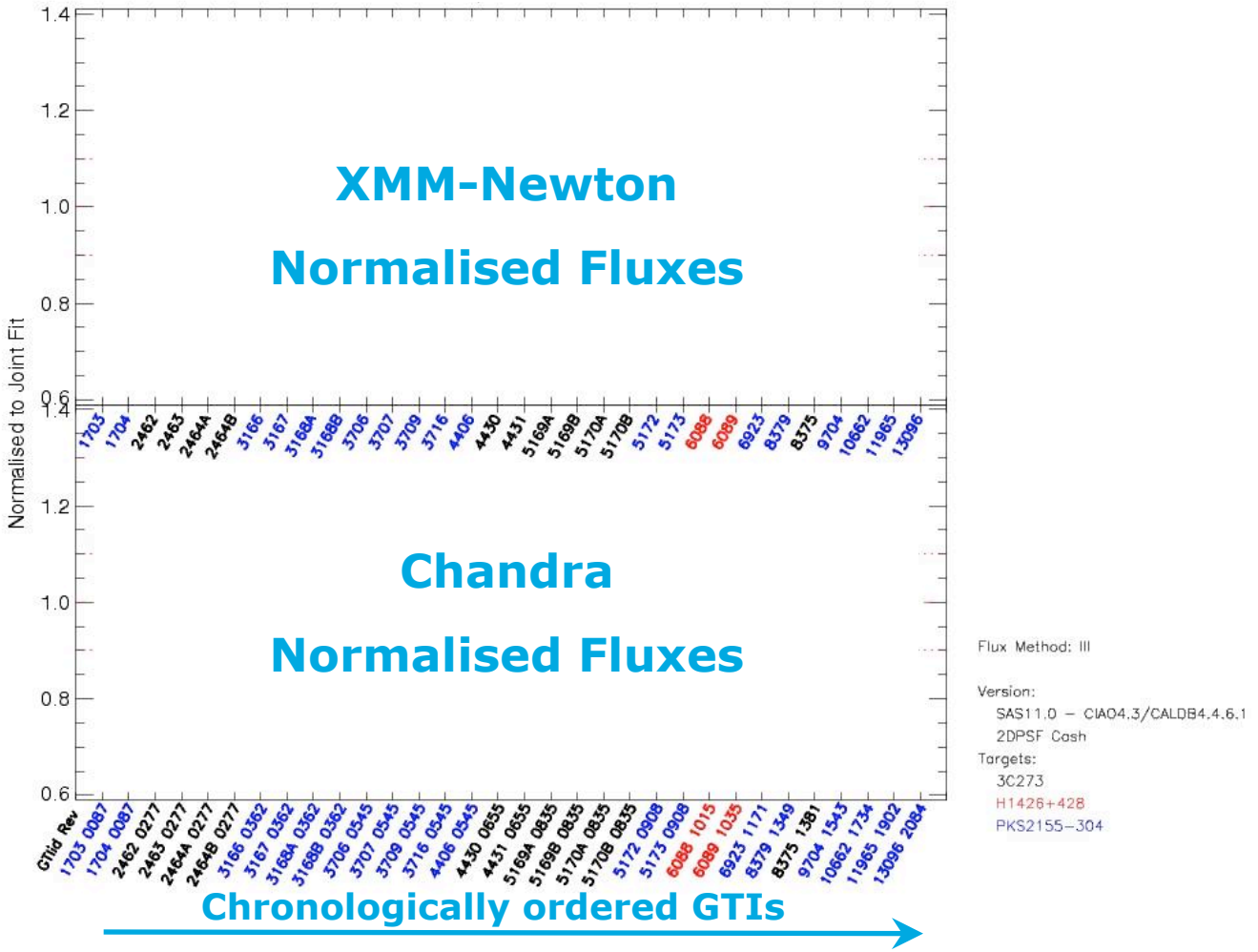
Data Analysis (III)

Systematic uncertainties:

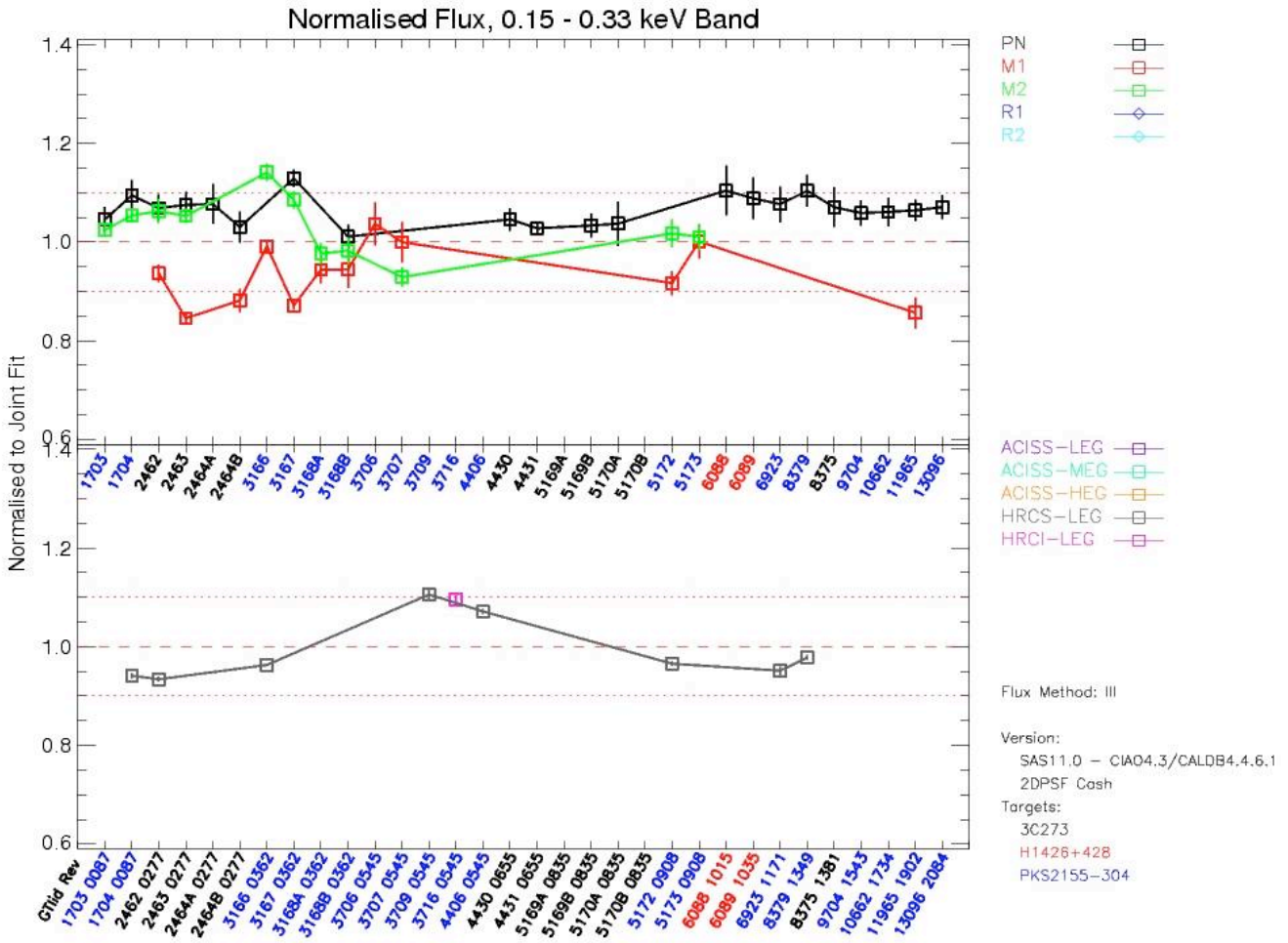
- Pile-up:
  - EPIC requires excision of PSF core: use source extraction annuli.
  - Per observation: for both MOSs use the largest common outer radius within window, and a common inner radius.
  - However, radii vary from observation to observation, and are generally different from the PN radii.
  - Differing annuli may introduce systematic uncertainties due to imperfect EE correction and RMF weighting.
- PN background:
  - Extracted from regions within the small window: some degree of source contamination.



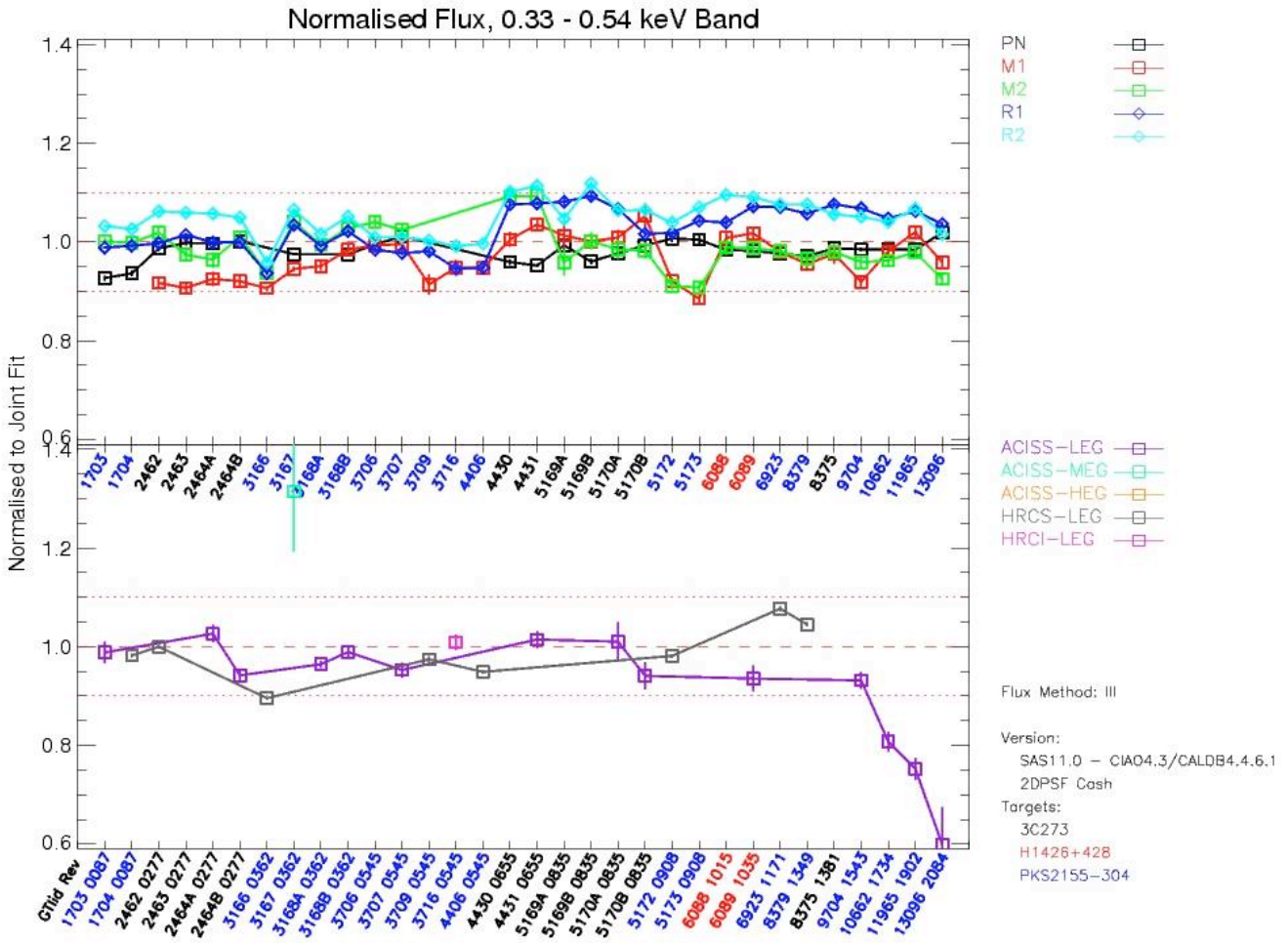
Results


XMM-Newton
Normalised Fluxes
Chandra
Normalised Fluxes
Normalised to Joint Fit
1.4
1.2
1.0
0.8
0.6
GTid Rev
1703 0087
1704 0087
2462 0277
2463 0277
2464A 0277
2464B 0277
3166 0362
3167 0362
3168A 0362
3168B 0362
3706 0545
3707 0545
3709 0545
3716 0545
4406 0545
4430 0655
4431 0655
5169A 0835
5169B 0835
5170A 0835
5170B 0835
5172 0908
5173 0908
6088 1015
6089 1035
6923 1171
8379 1349
8375 1381
9704 1543
10662 1734
11965 1902
13096 2084
Chronologically ordered GTIs
Flux Method: III
Version:
SAS11.0 – CIAO4.3/CALDB4.4.6.1
2DPSF Cash
Targets:
3C273
H1426+428
PKS2155–304

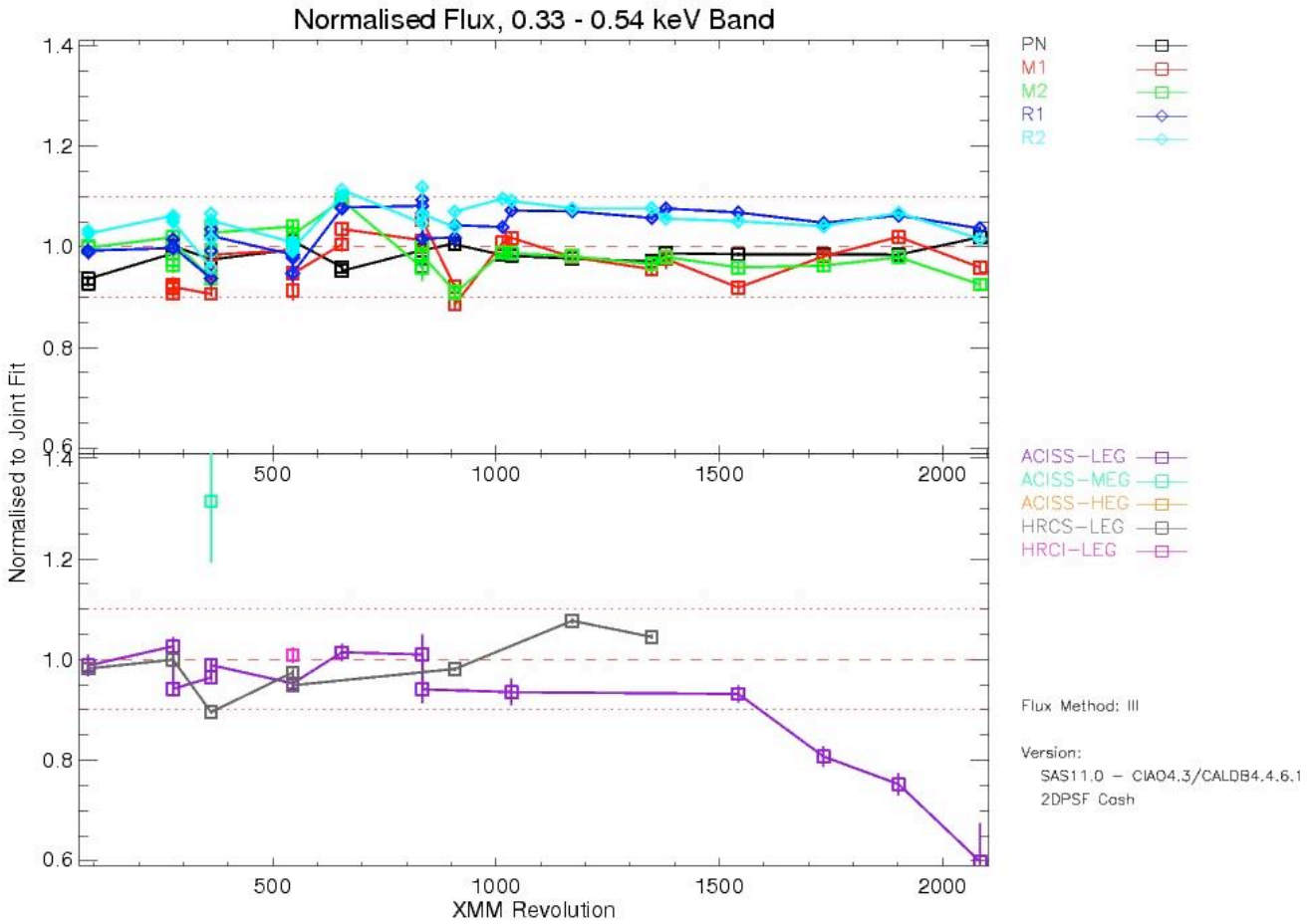
Band 1: 0.15 – 0.33 keV



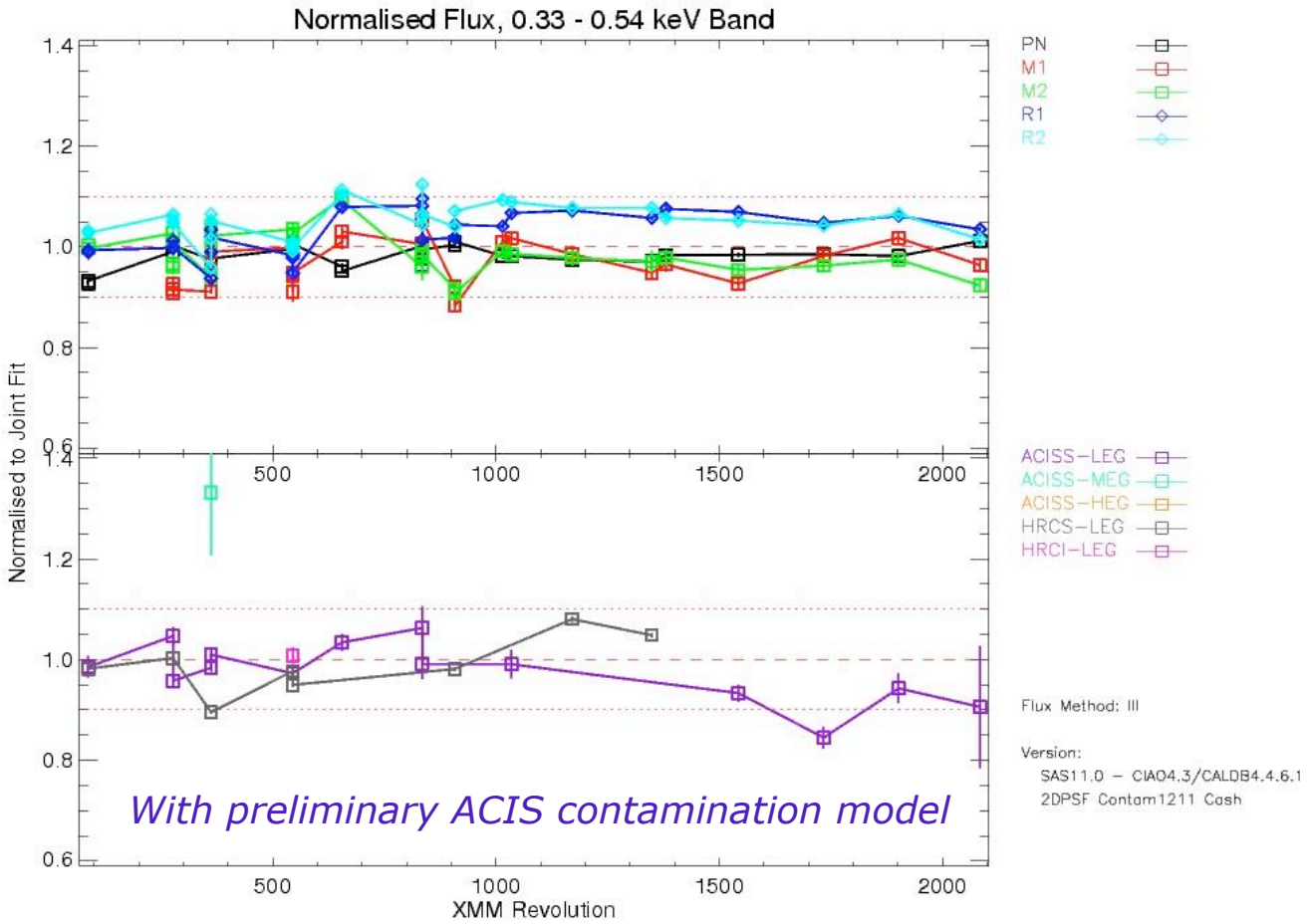
Band 2: 0.33 – 0.54 keV



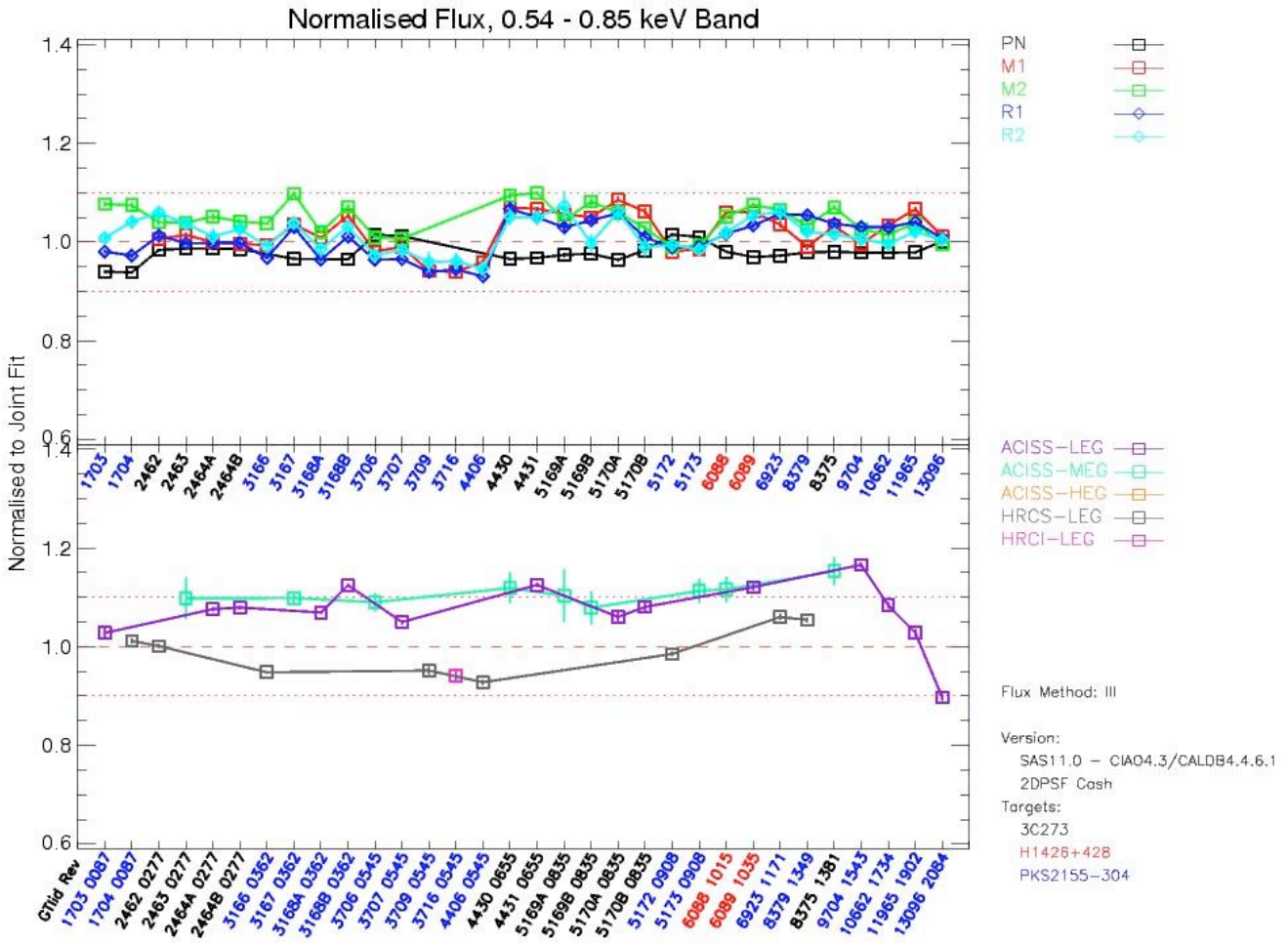
Band 2: 0.33 – 0.54 keV



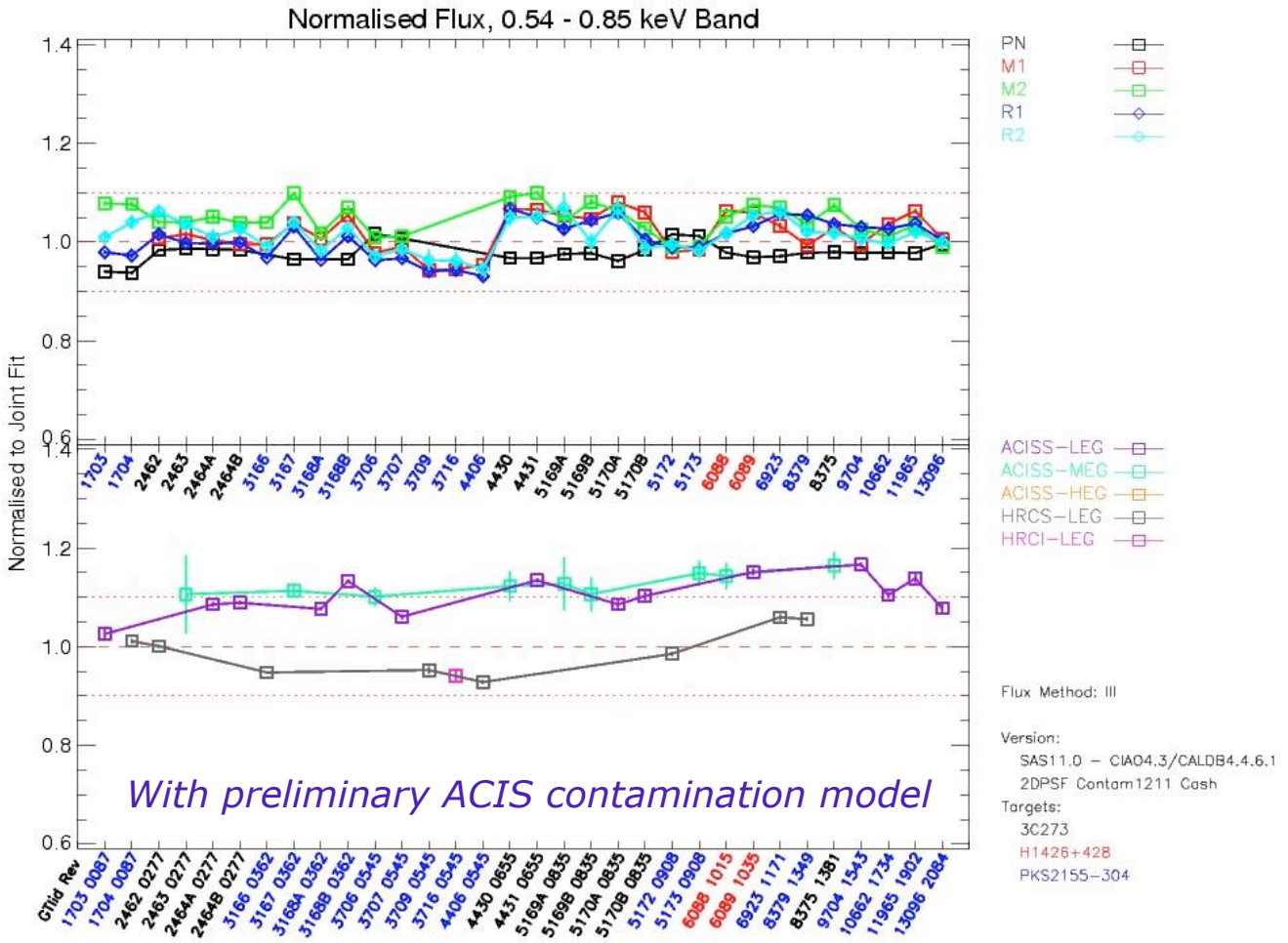
Band 2: 0.33 – 0.54 keV



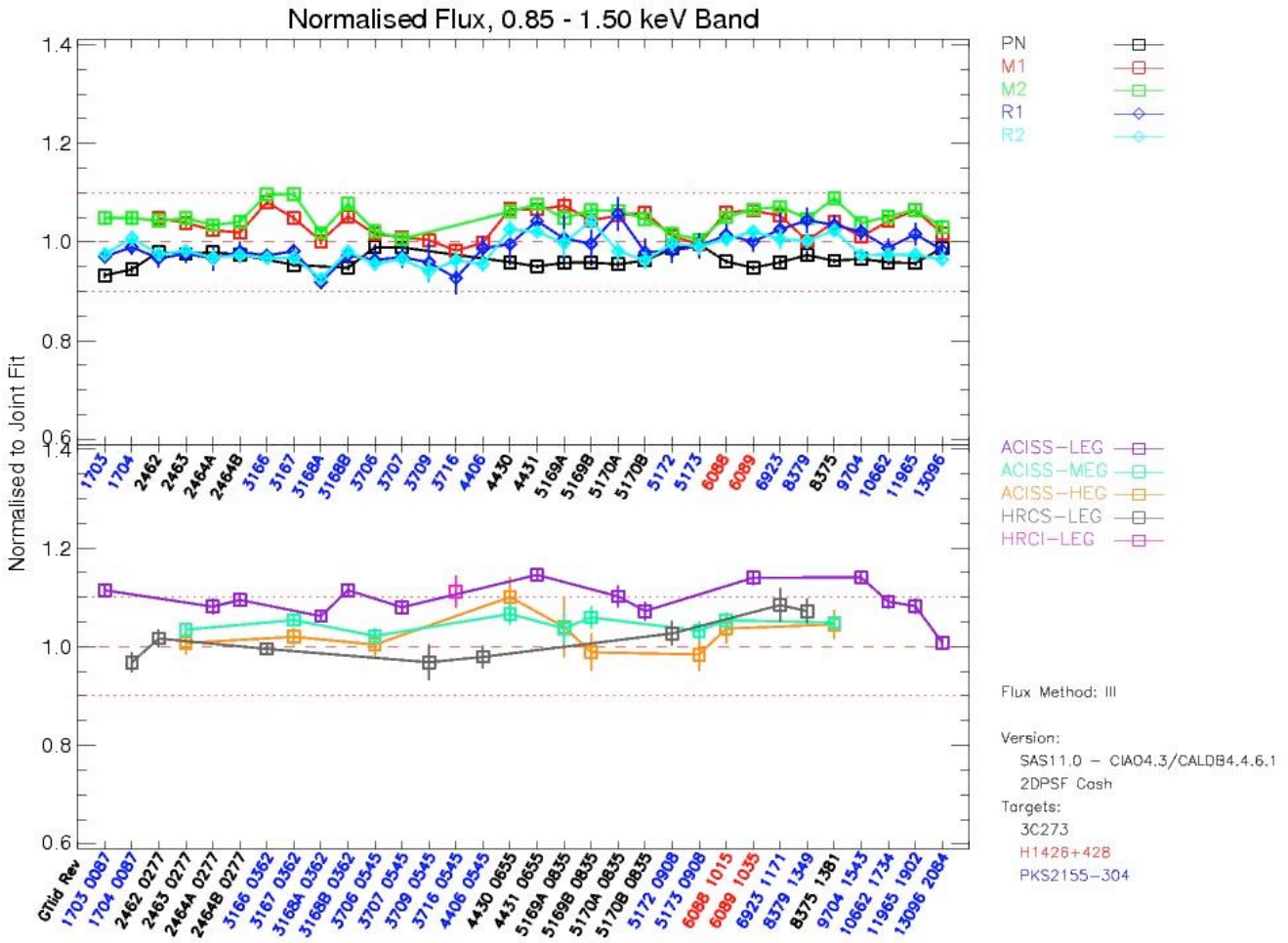
Band 3: 0.54 – 0.85 keV



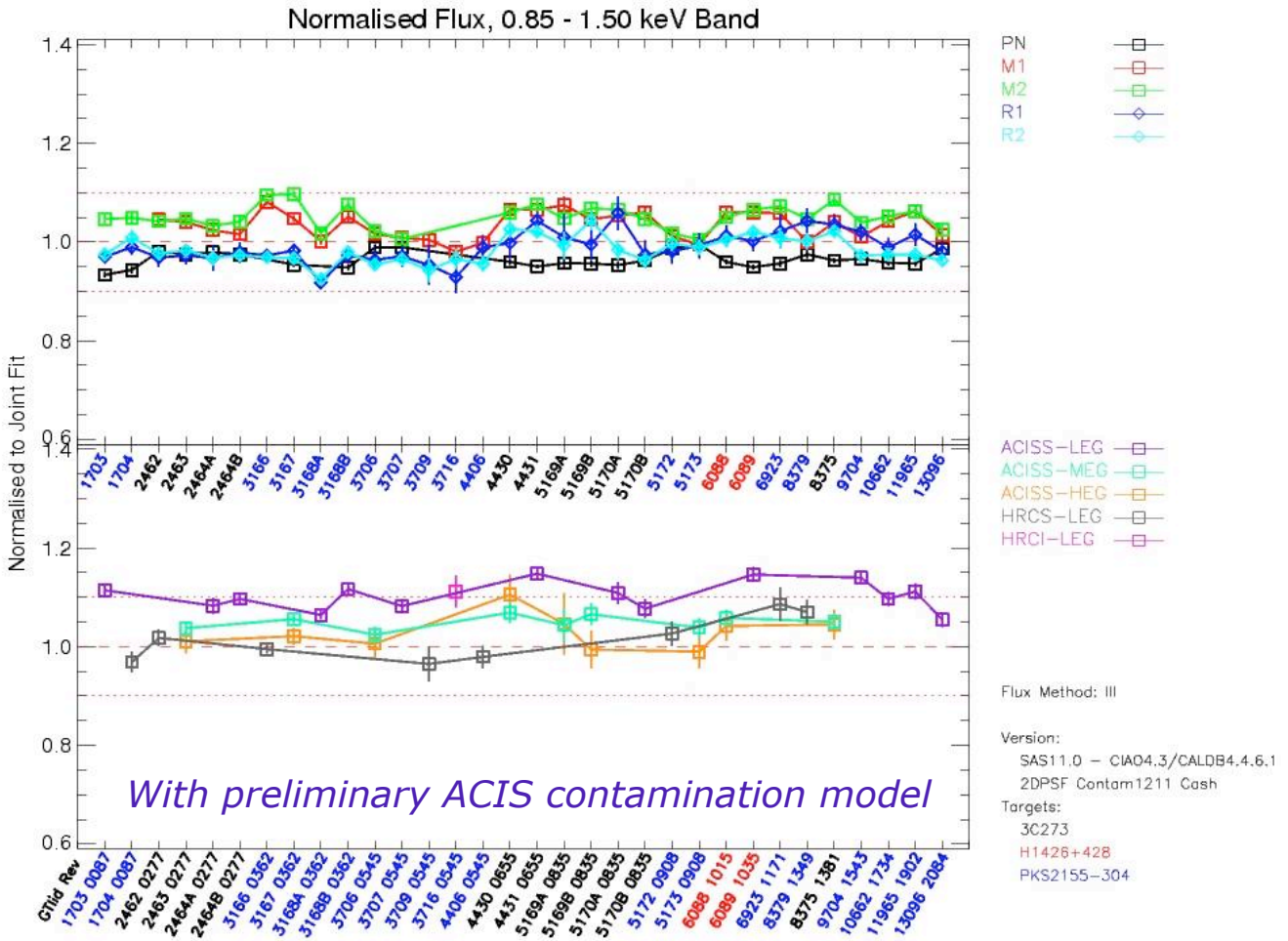
Band 3: 0.54 – 0.85 keV



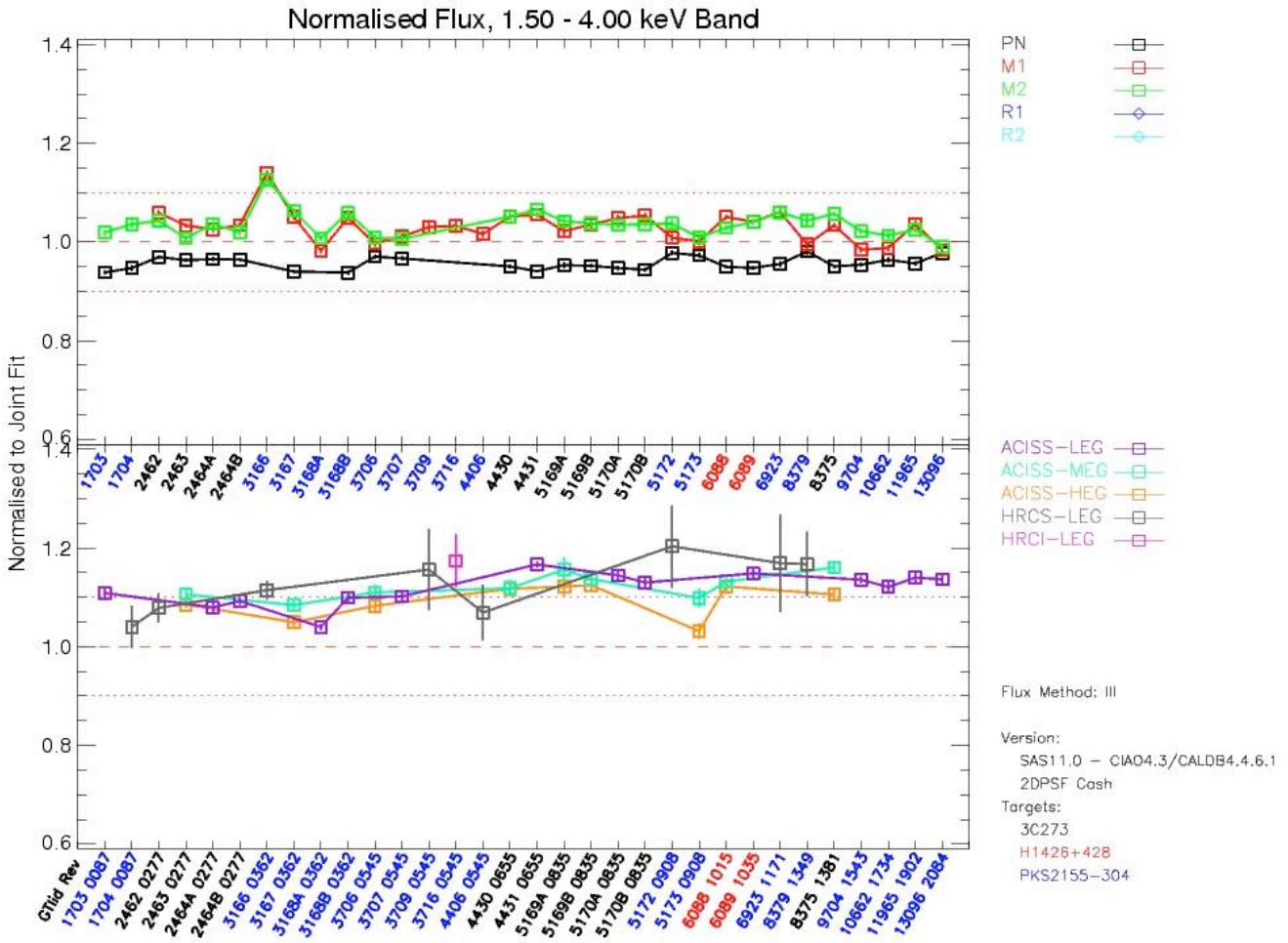
Band 4: 0.85 – 1.50 keV



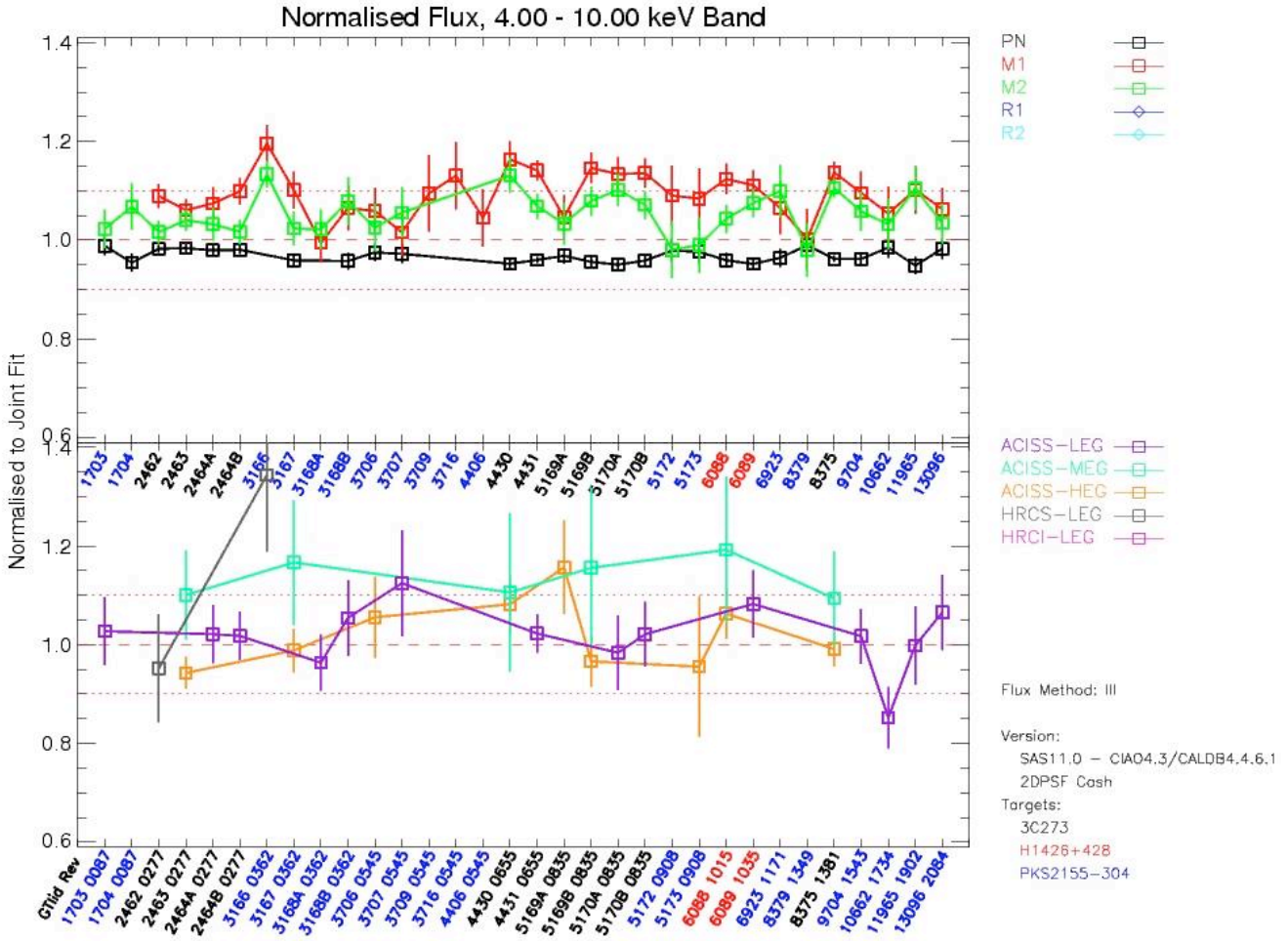
Band 4: 0.85 – 1.50 keV



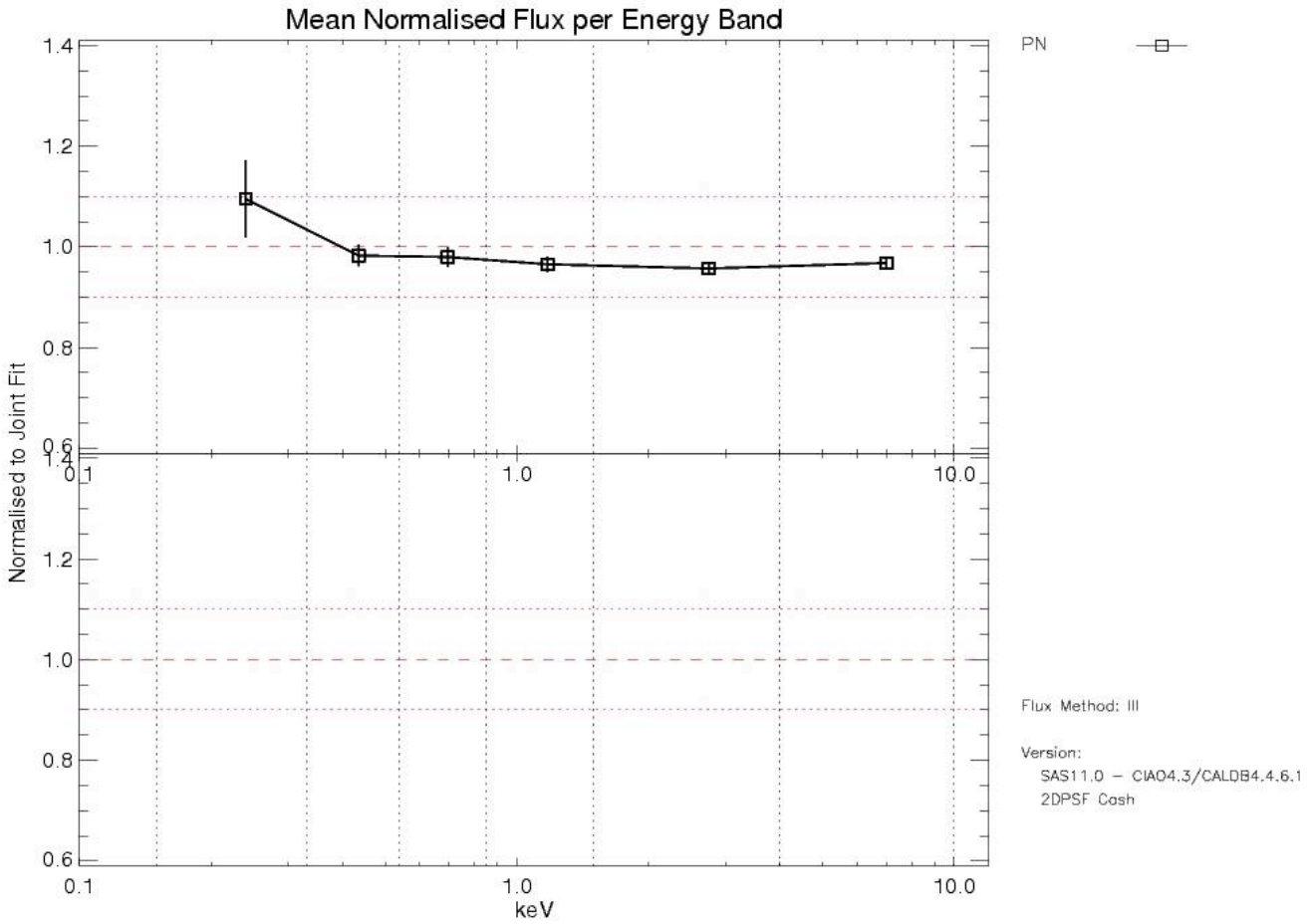
Band 5: 1.50 – 4.00 keV



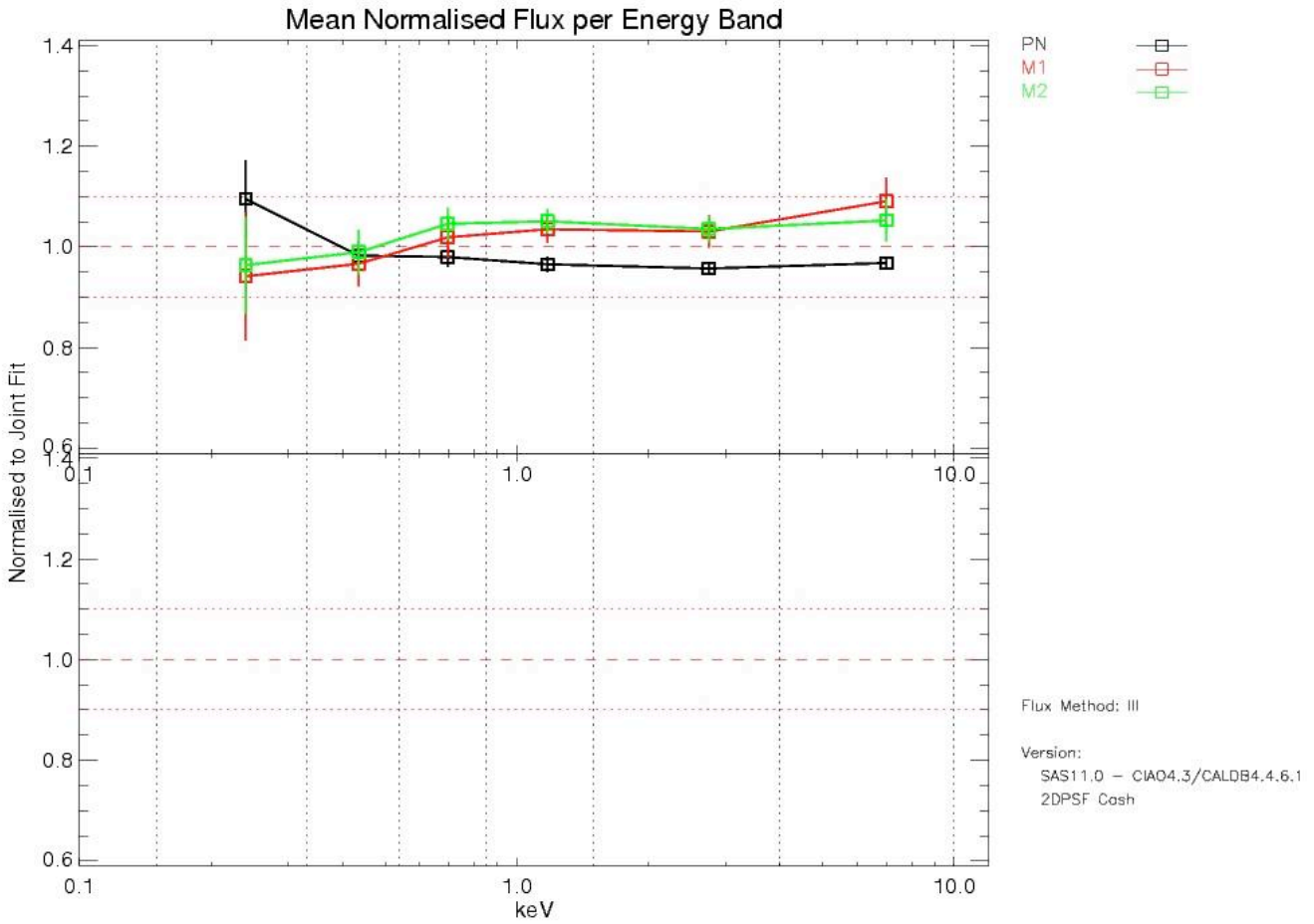
Band 6: 4.00 – 10.0 keV



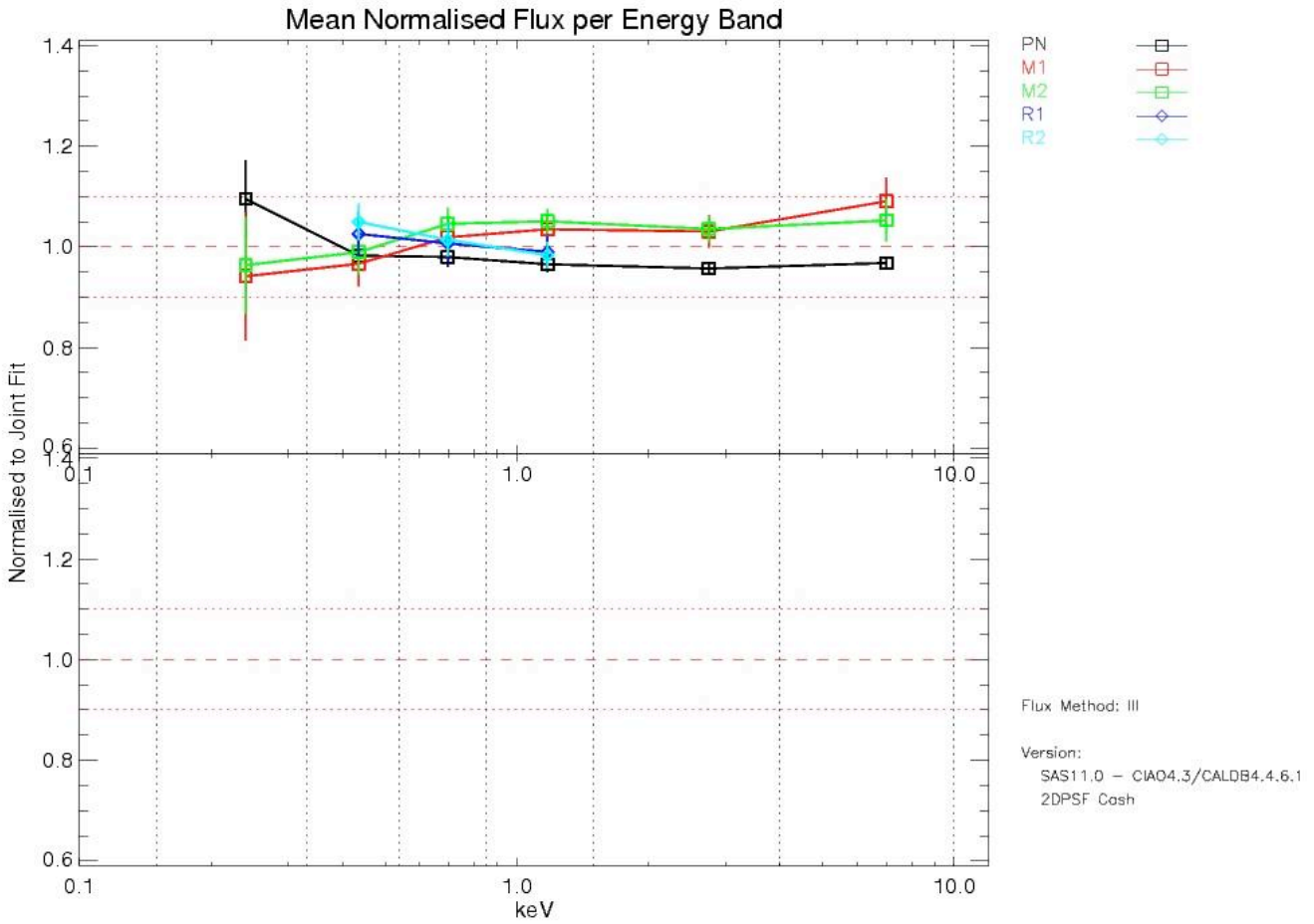
Mean Normalised Fluxes



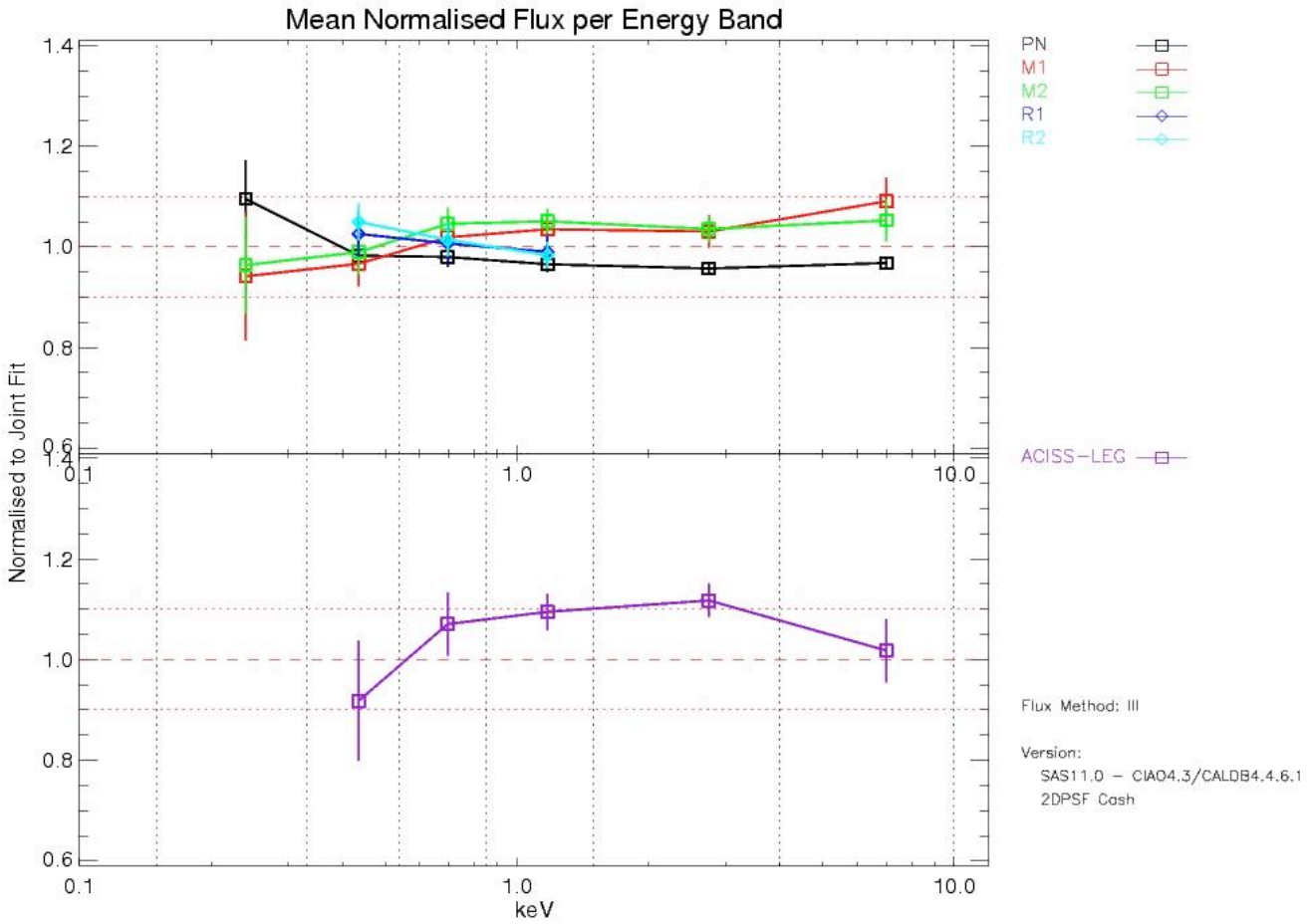
Mean Normalised Fluxes



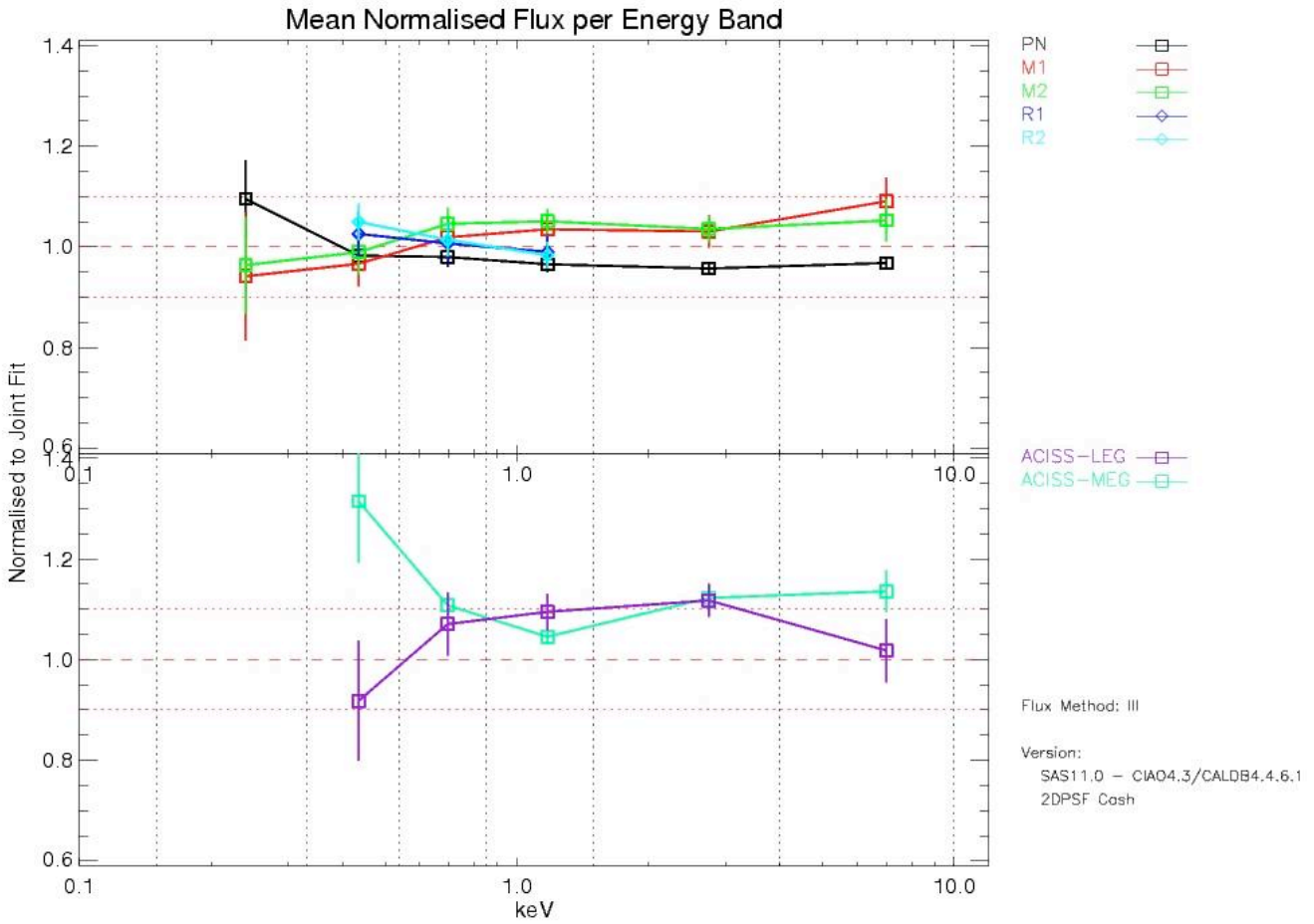
Mean Normalised Fluxes



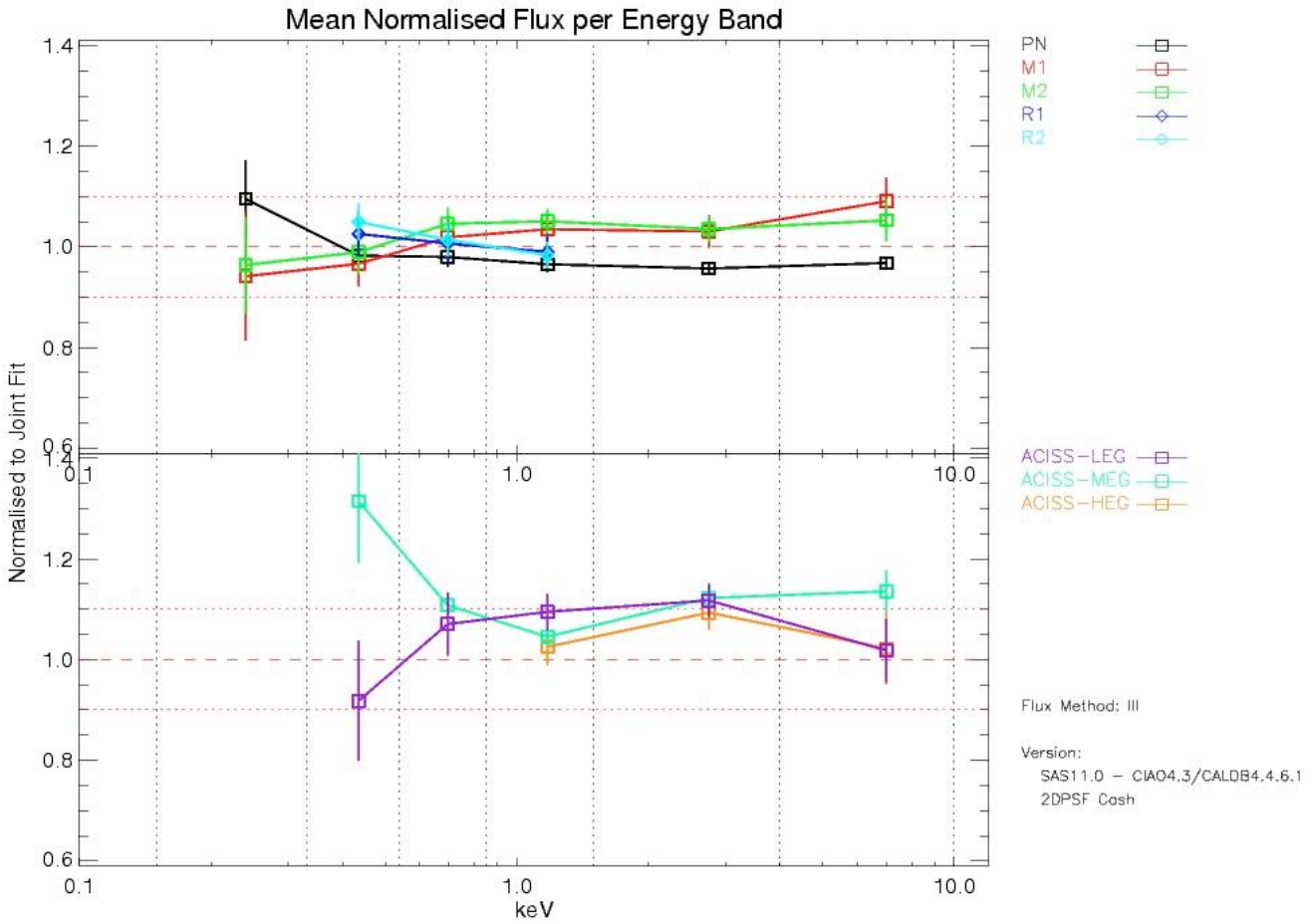
Mean Normalised Fluxes



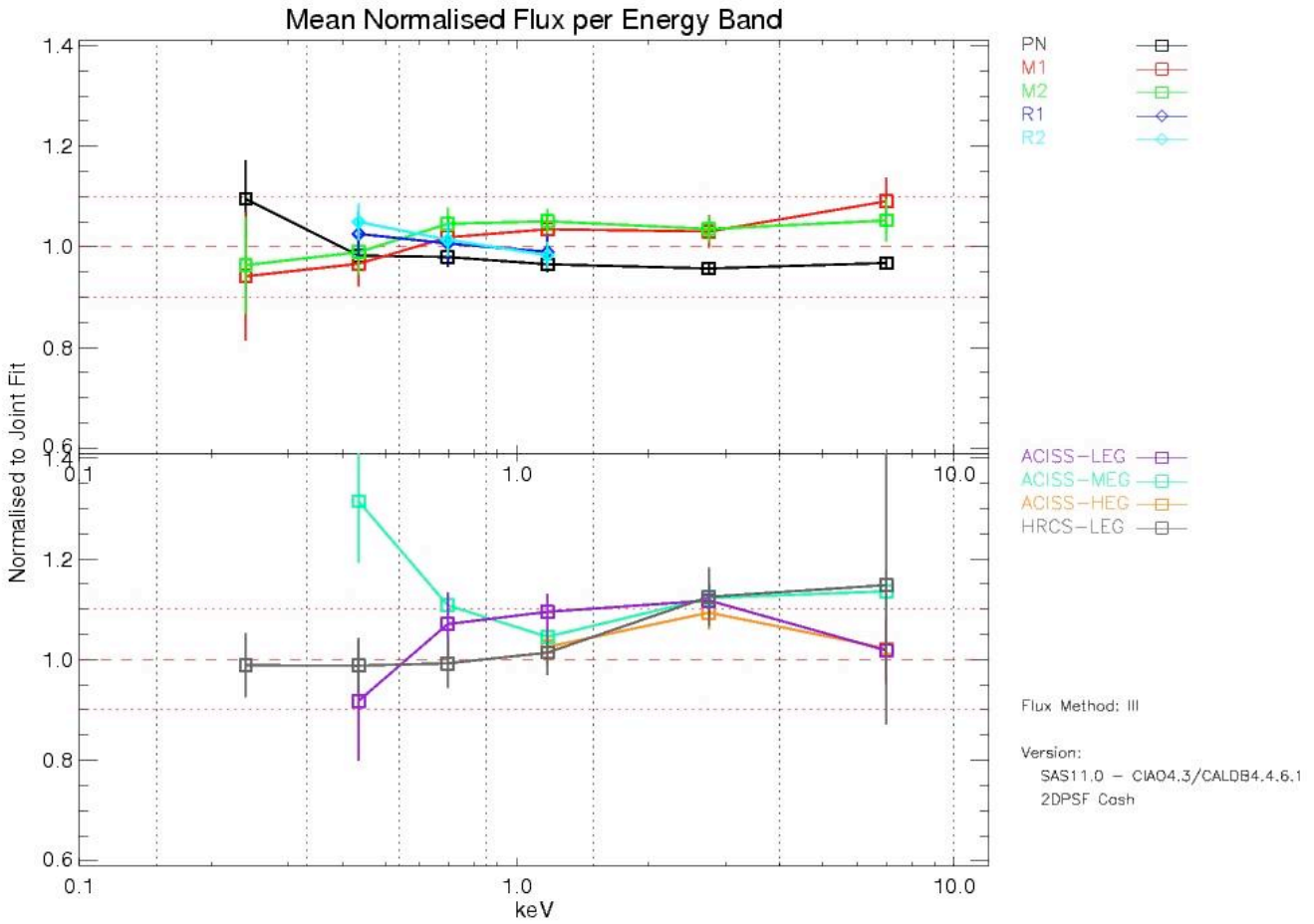
Mean Normalised Fluxes



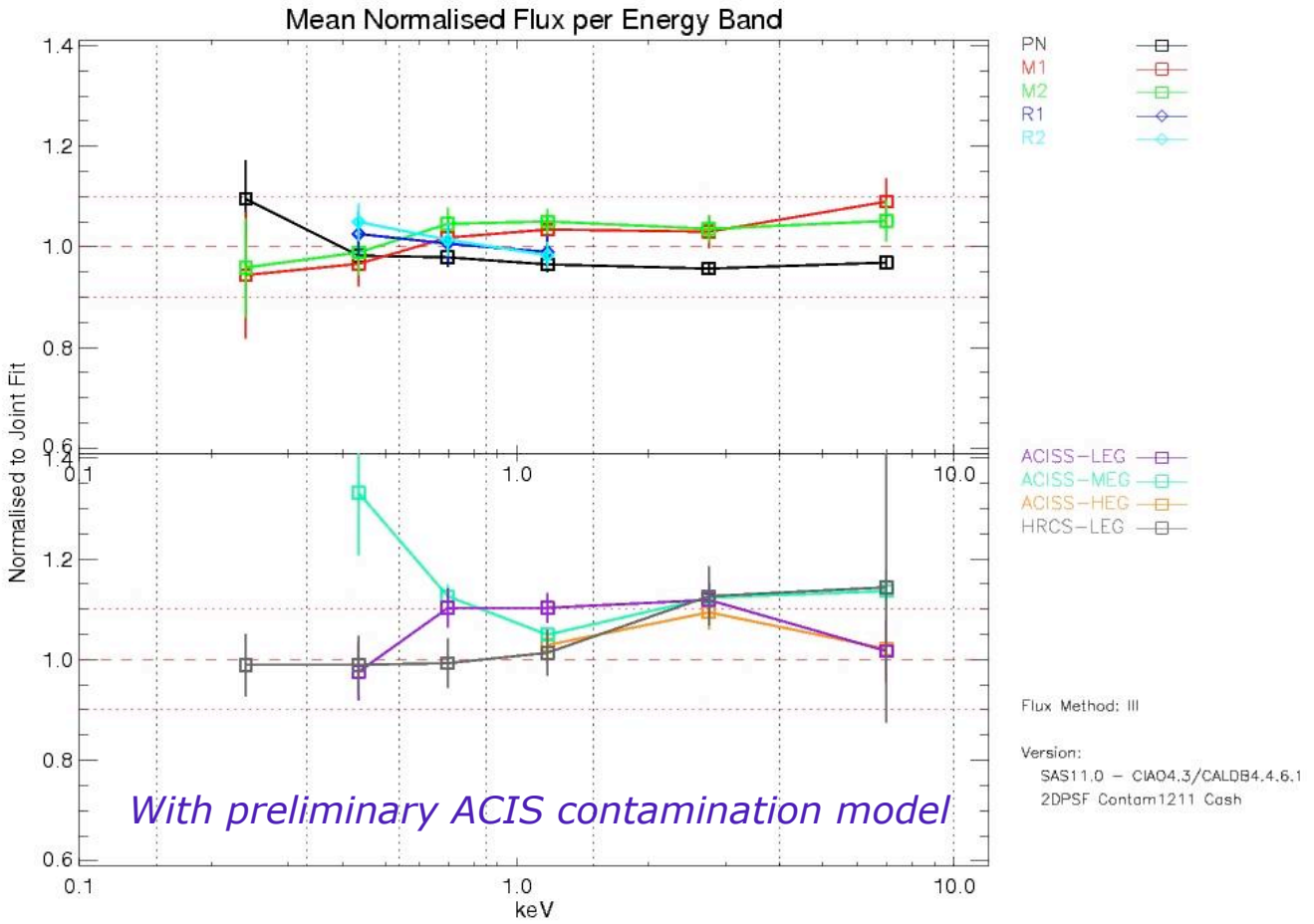
Mean Normalised Fluxes



Mean Normalised Fluxes



Mean Normalised Fluxes



Extra Material