Energy calibration refinement of EPIC-pn eFF mode and verification of energy calibration of all EPIC modes

XMM-EPIC Operations and
Calibration Meeting

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Overview

- Analyze a special observation of the supernova remnant Cas-A in order to refine the energy cross-calibration of the EPIC-pn extended Full Frame mode (eFF) with respect to the Full Frame mode (FF)

- Analyze observations of Cas-A and N132D from different revolutions in order to verify the agreement in energy calibration between modes

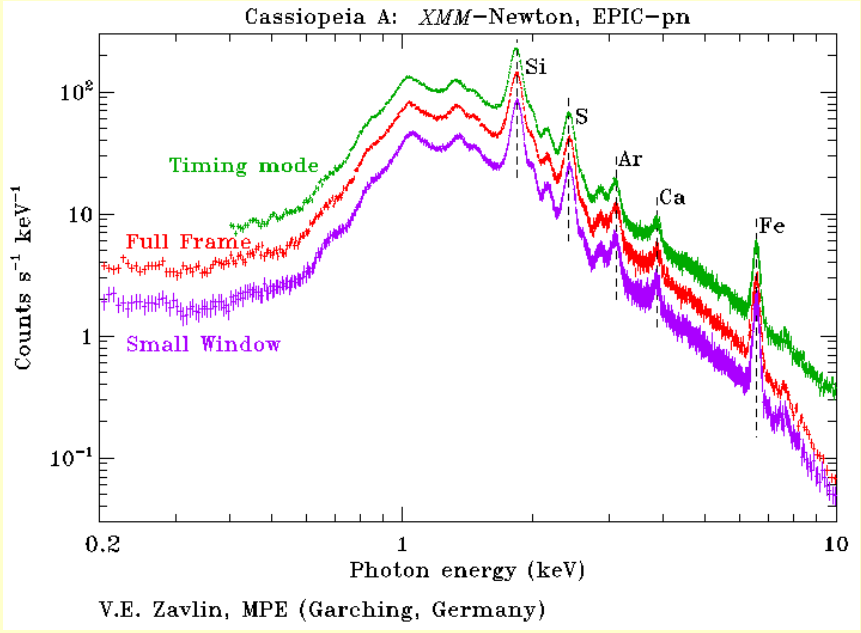
- Analyze CalClosed observations to check the energy line position for Al and Mn_{α} lines

General data analysis

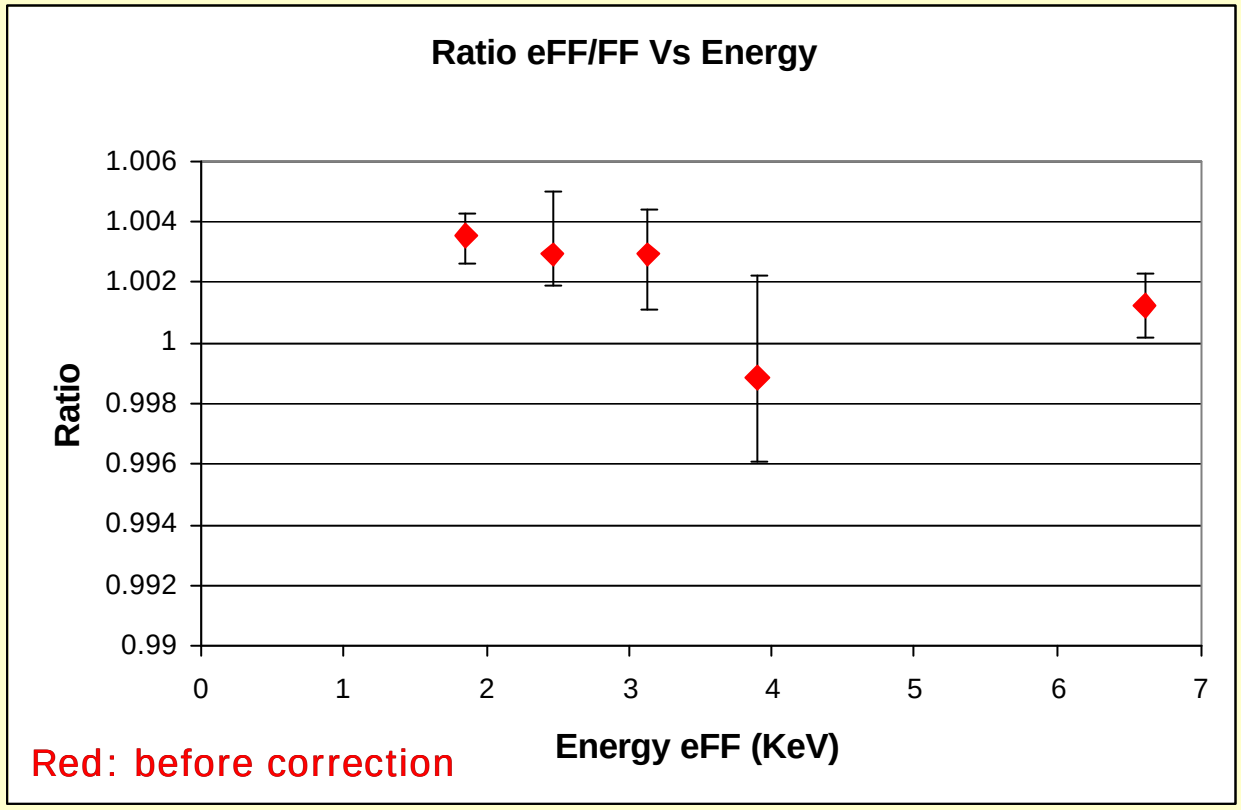
- Extract spectra of the targets for
  - Different mode
  - Different revolution
- Determine and compare line positions

Outline of the eFF Vs FF calibration

- The extended Full Frame mode showed an overcorrection for the onboard calibration source at Al and Mn energies compared to the Full Frame mode
- A special observation of Cas A was performed in order to measure and correct these differences in a wider range of energy
- Ratio of line positions between eFF and FF modes were calculated and used to derive a correction function to be implemented into SAS and in a new Current Calibration File (EPN_CTI_0014.CCF)



Ratio of line positions: Cas-A



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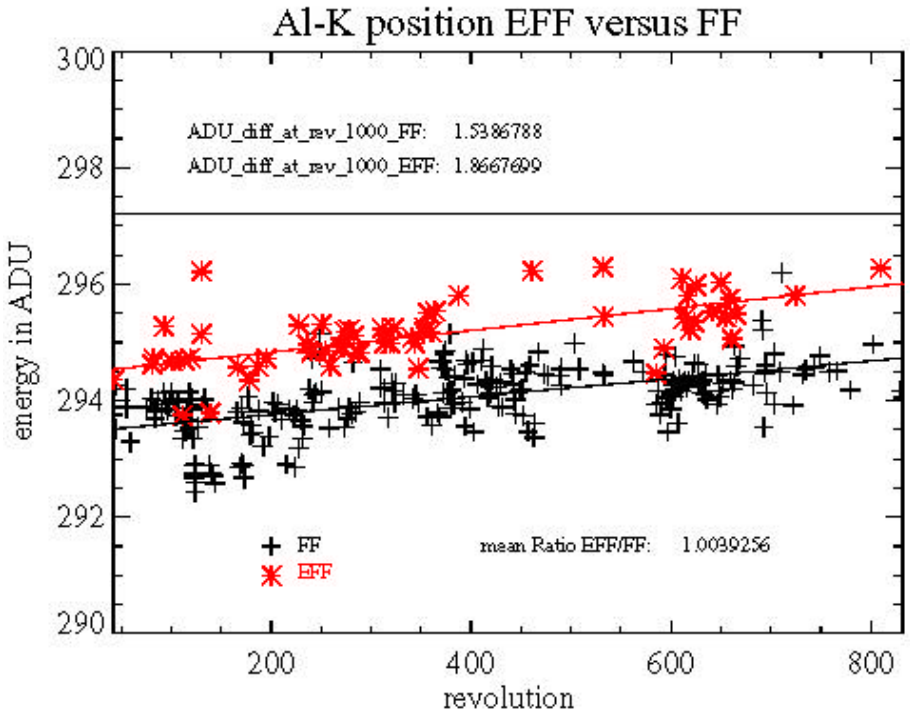
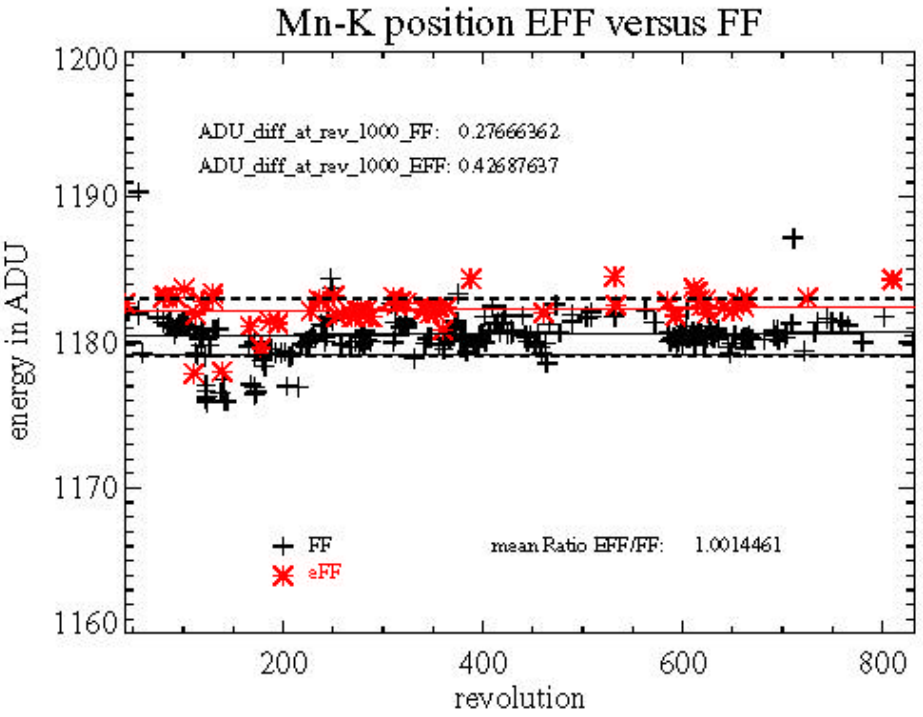
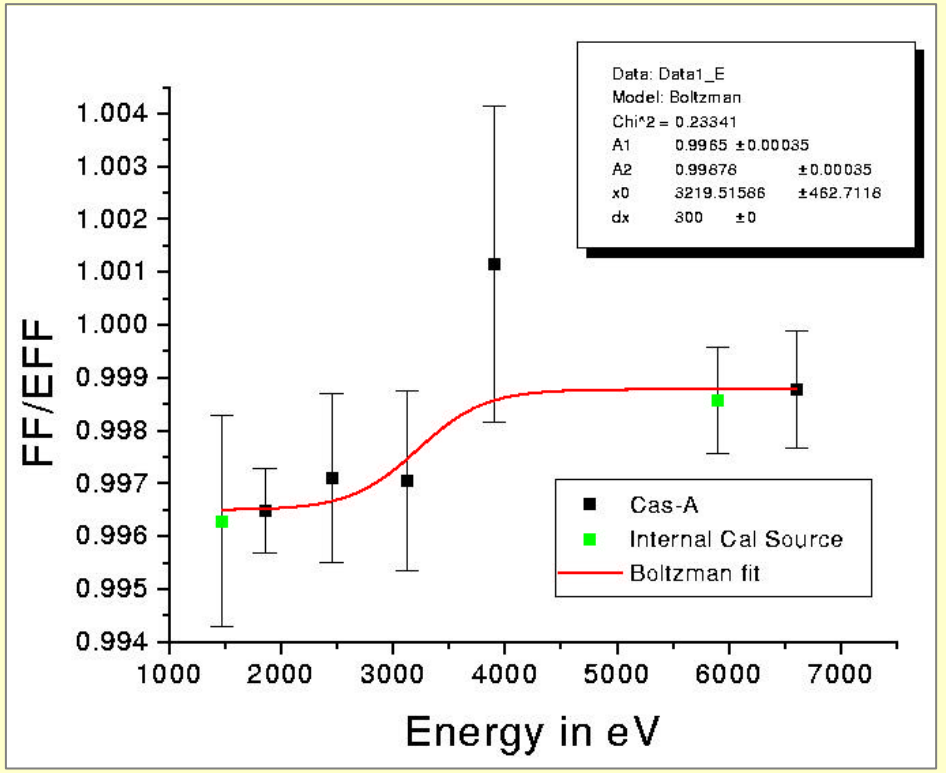
Information from cal source





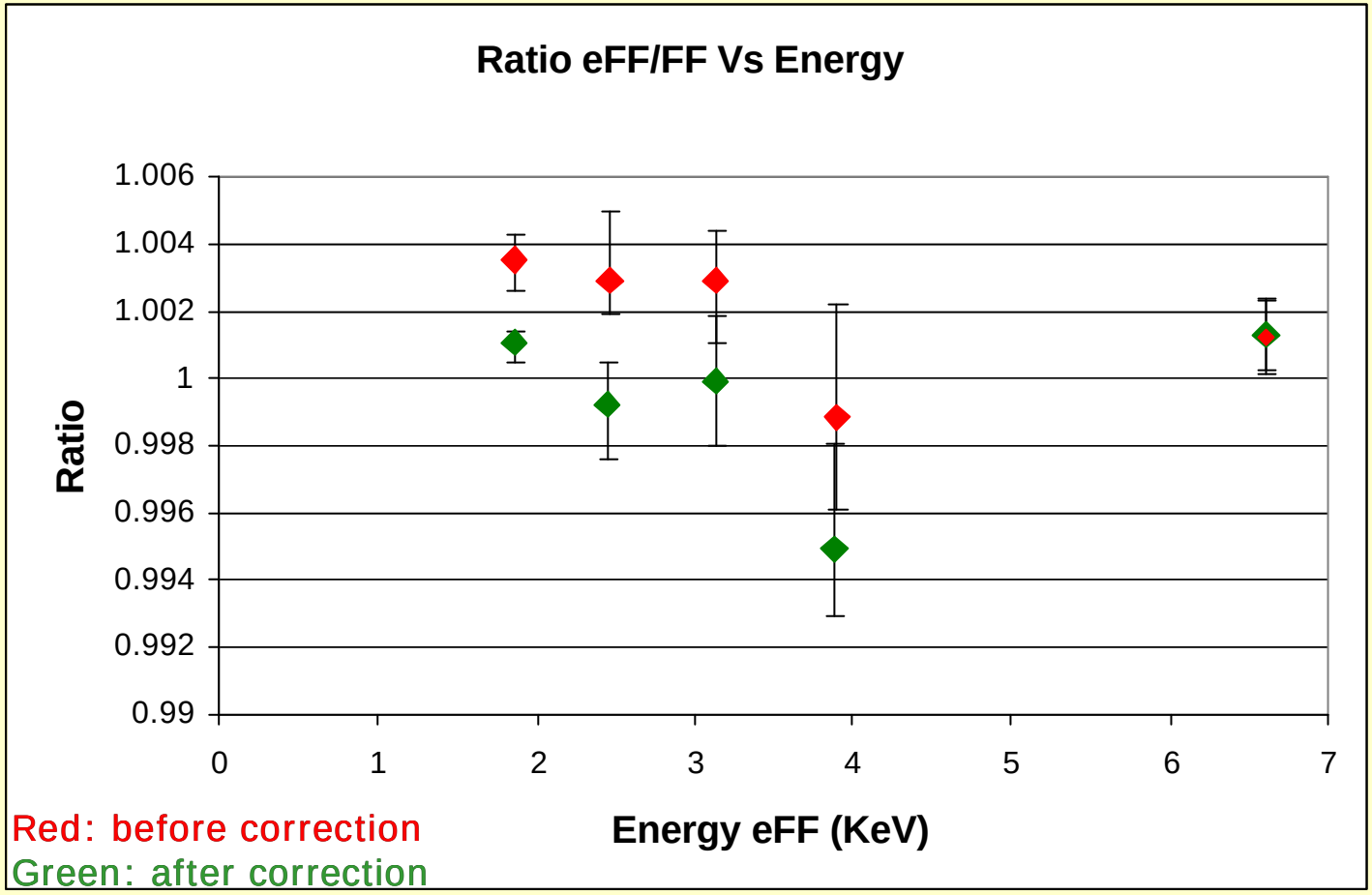
Calibration of eFF Vs FF mode: correction function

	Energy eFF (KeV)	Energy FF (KeV)	Ratio FF/EFF
Al-K	1.47649	1.47072	0.99608975
Si XIII	1.86454	1.85800	0.99649243
S XV	2.46067	2.45355	0.99710648
Ar XVII	3.13805	3.12881	0.99705550
Ca XIX	3.89890	3.90339	1.00115161
Mn-K	5.91143	5.90290	0.99855595
Fe XXV	6.60701	6.59980	0.99877860

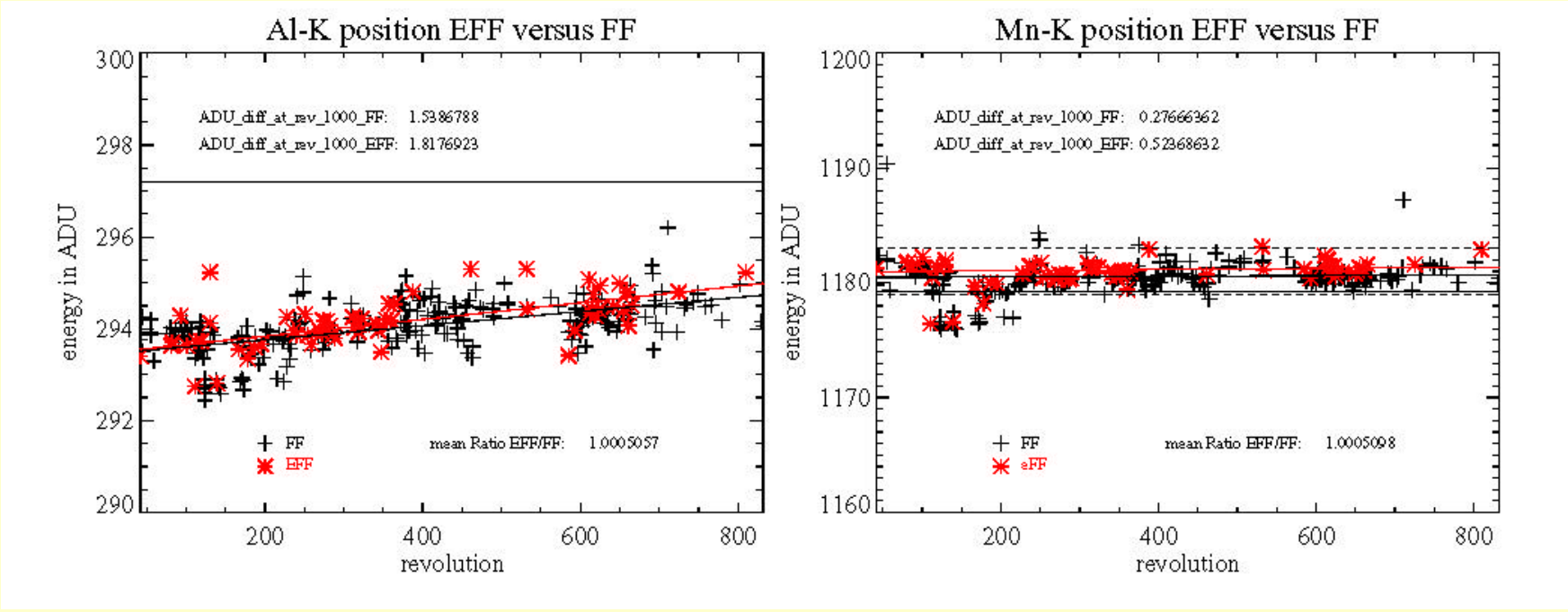


Energy eFF * f(E) = Energy eFF $_{corrected}$

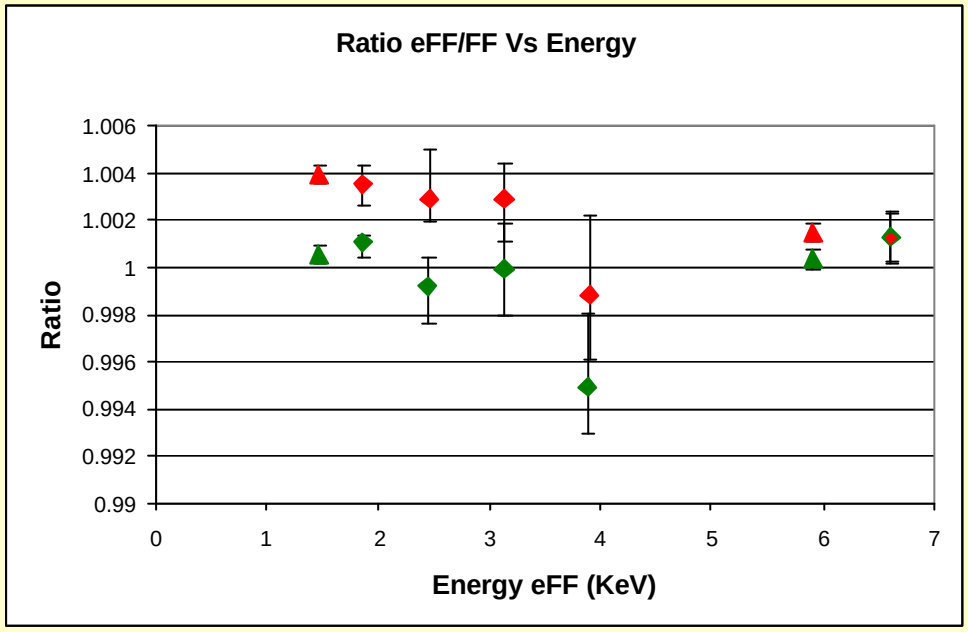
Verification of correction: Cas-A



Verification of correction: cal source



Calibration of eFF Vs FF mode



	| Difference %| Before correction	| Difference % | After correction
Al-K	0.39	0.06
Si XIII	0.35	0.10
S XV	0.29	0.08
Ar XVII	0.29	0.01
Ca XIX	0.12	0.51
Mn-K	0.14	0.04
Fe XXV	0.12	0.13

Red: Cas-A data before correction
Green: Cas-A data after correction
Triangle: internal calibration source

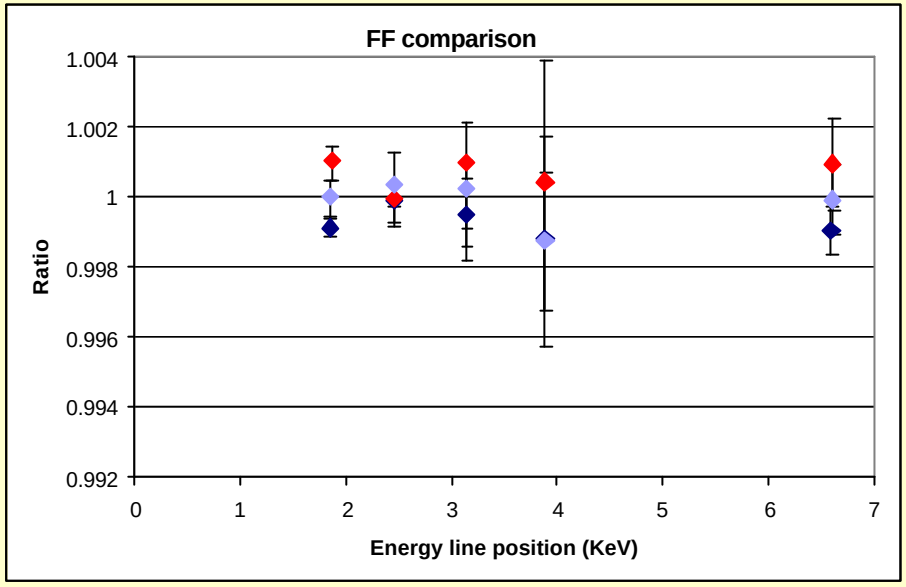
eFF energy calibration agrees with FF within ~0.1% (before 0.4%)

General verification of energy calibration

- PN camera
  - FF mode stability: Cas-A
  - Different PN modes:
    - eFF/FF: Cas-A
    - LW/FF: Cas-A & N132D
    - SW/FF: Cas-A & N132D
    - Timing/FF: Cas-A
- MOS cameras
  - LW mode stability: N132D
  - Different MOS modes:
    - LW/FF: N132D
- MOS & PN cameras
    - FF mode: N132D

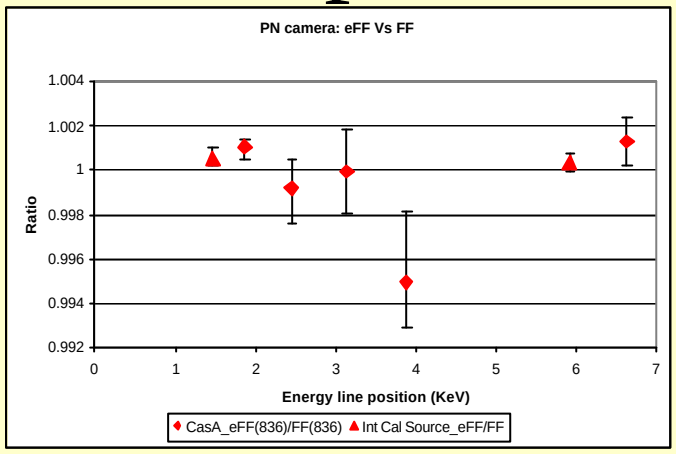
PN camera: FF mode stability.

Cas-A

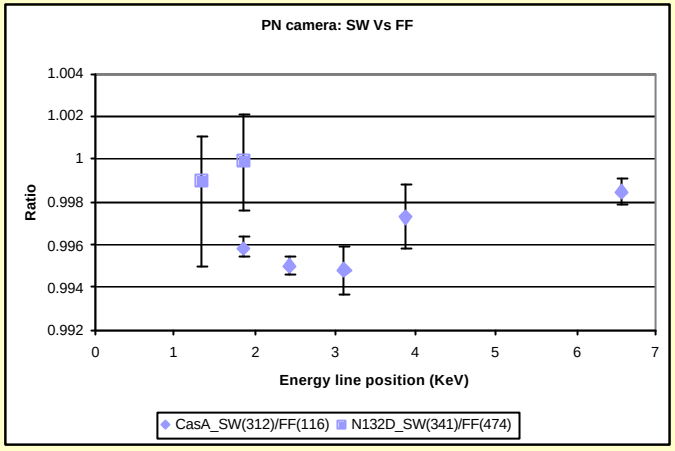


Rel. Accuracy in line energy determination ~0.1%

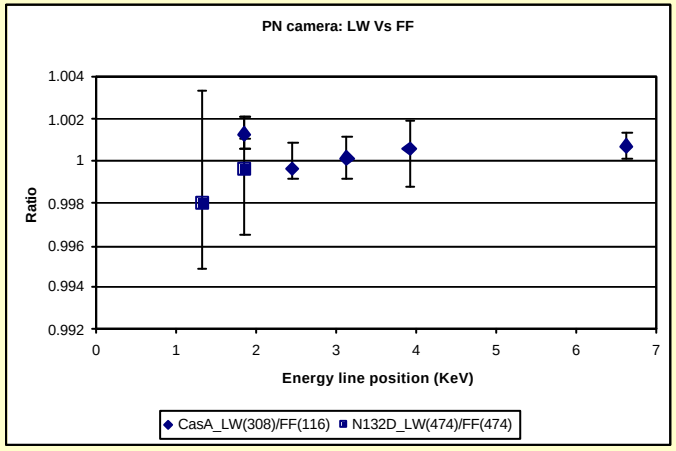
Different pn modes. Cas-A & N132D



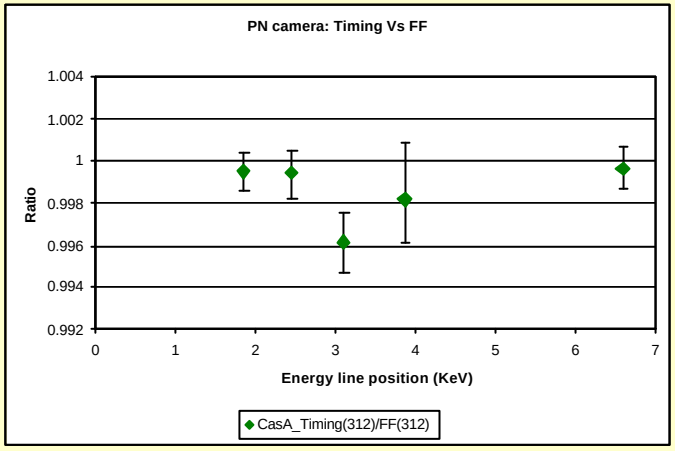
eFF Vs FF: ~0.1%



SW Vs FF: ~0.4%



LW Vs FF: ~0.1%



Timing Vs FF: ~0.2%

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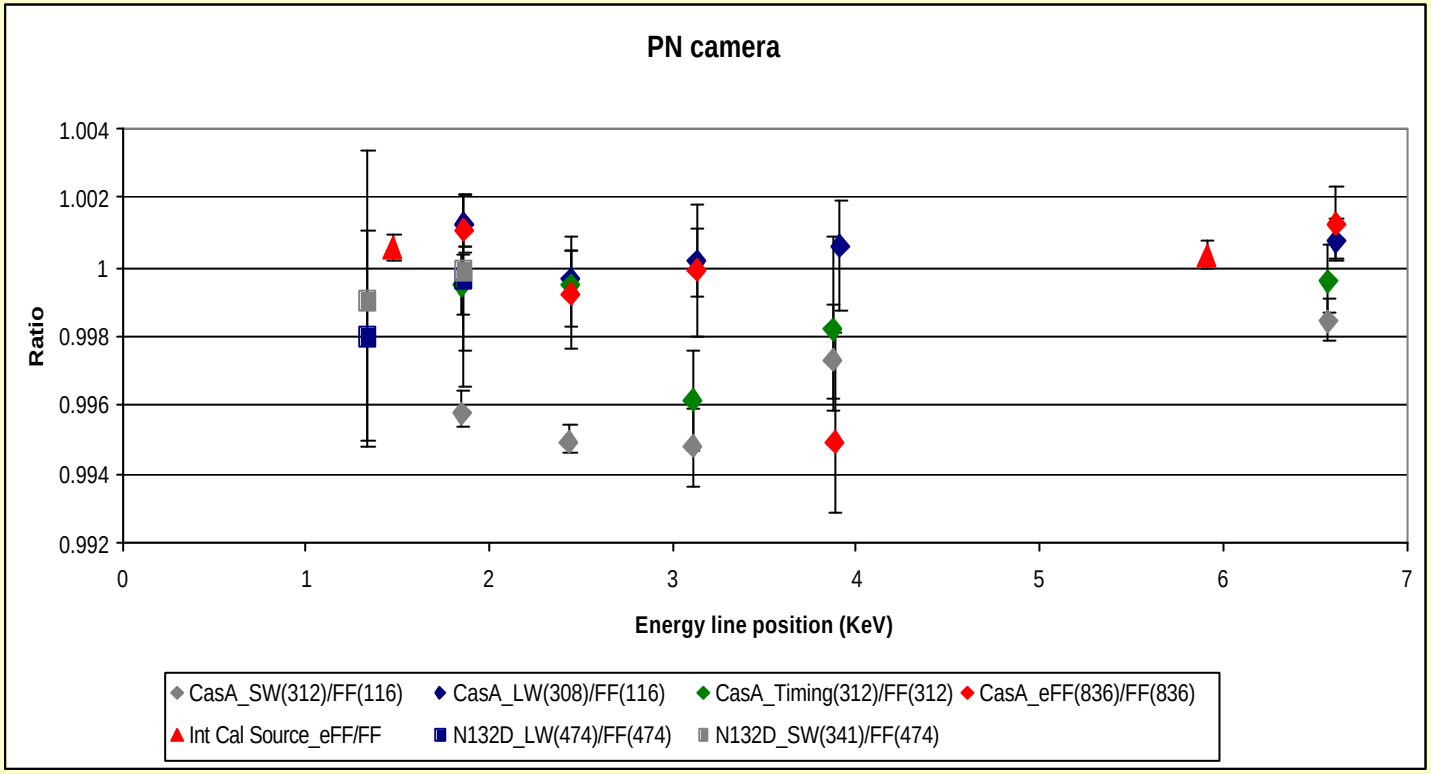
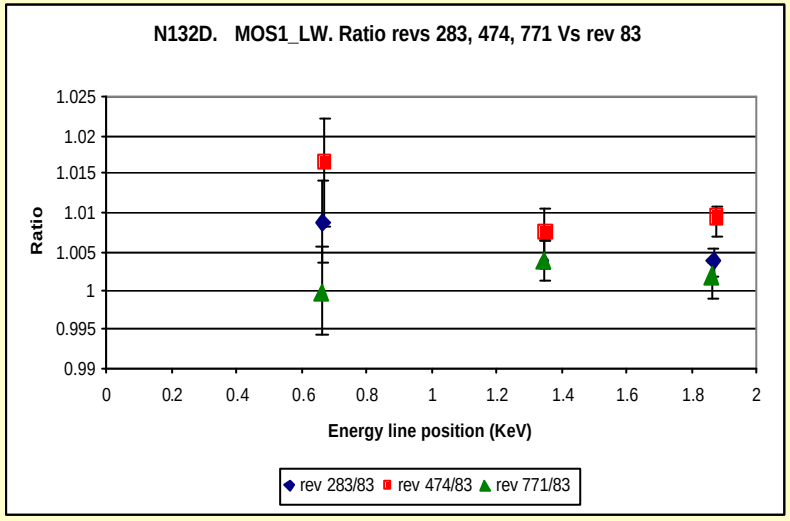
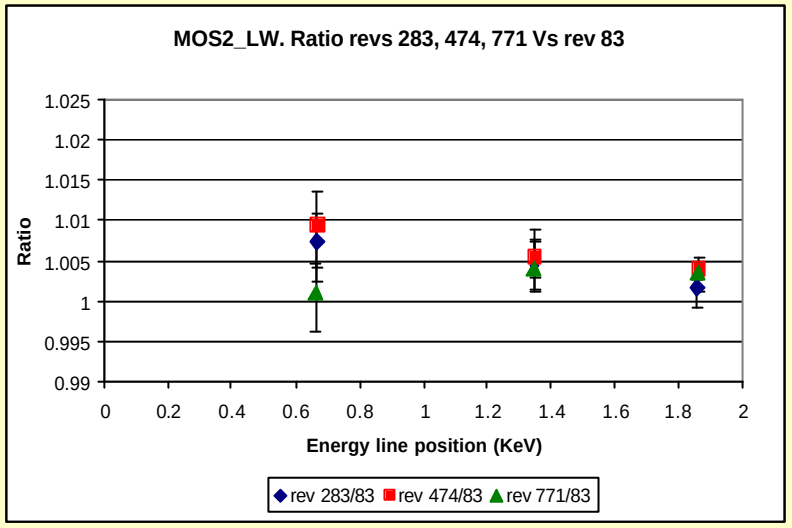
Summary of agreement between different pn modes



MOS cameras: LW mode stability.N132D

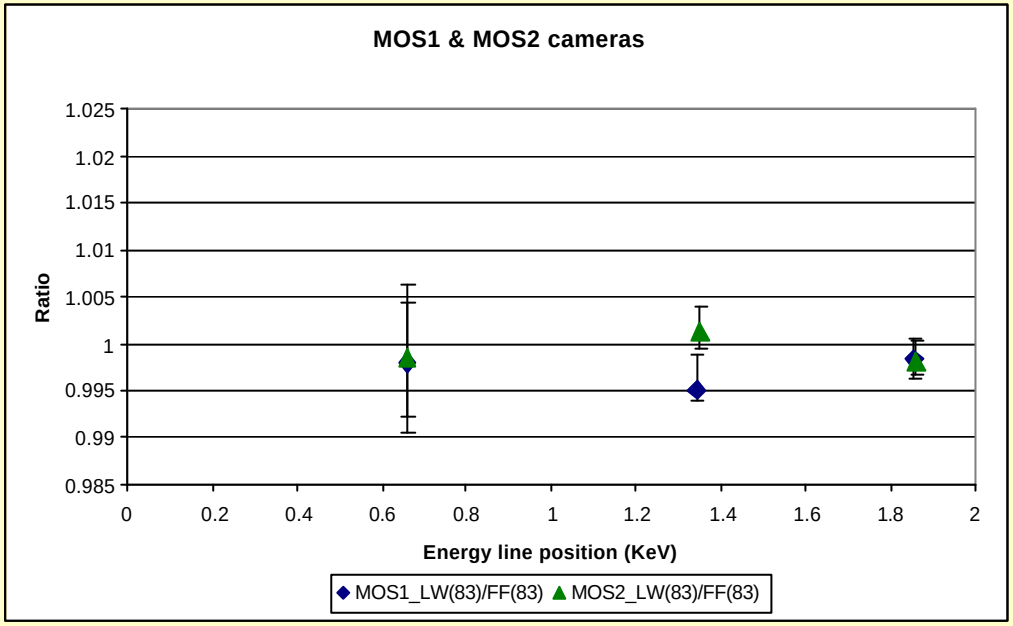




Rel. accuracy in line energy determination ~0.5%

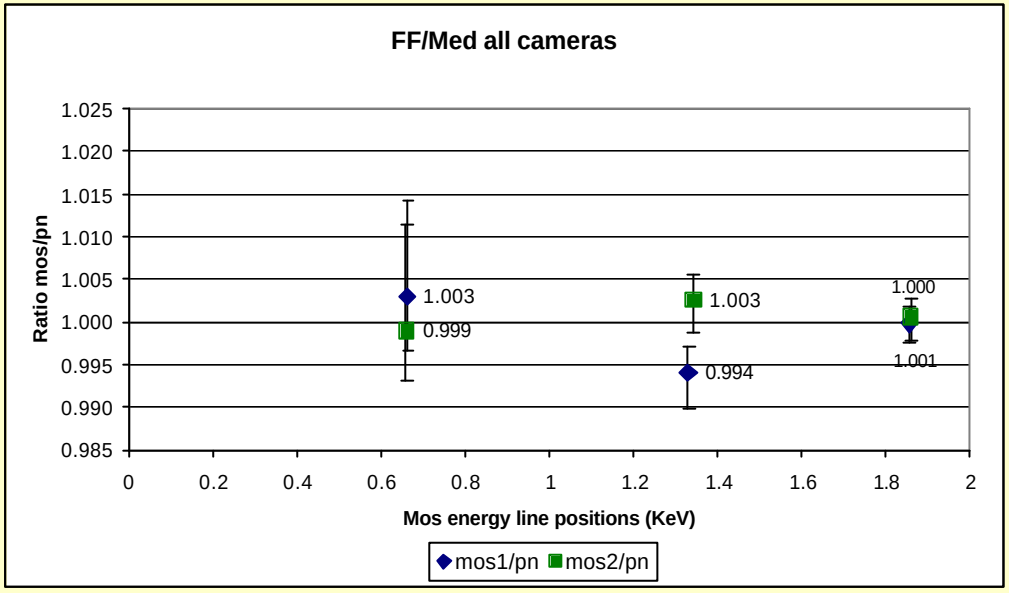
MOS cameras: LW Vs FF.

N132D



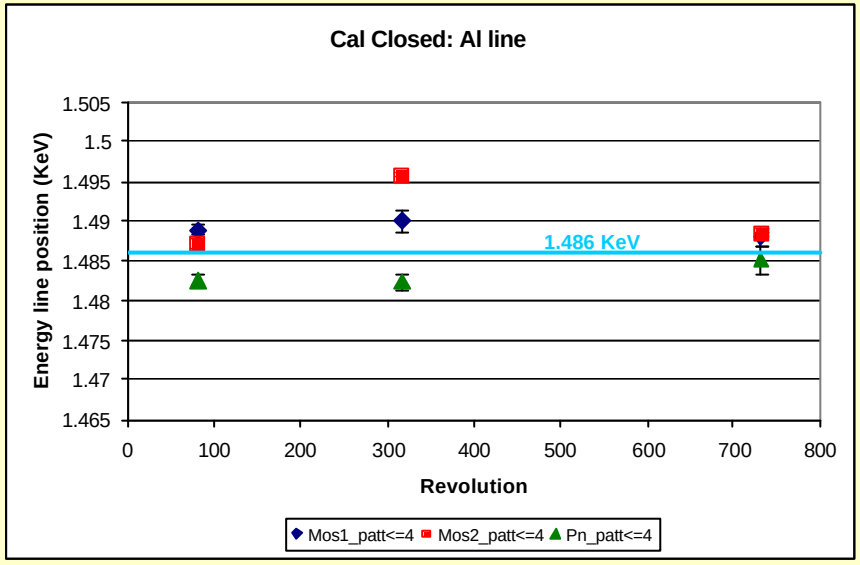
Rel. accuracy in line energy determination ~0.5%

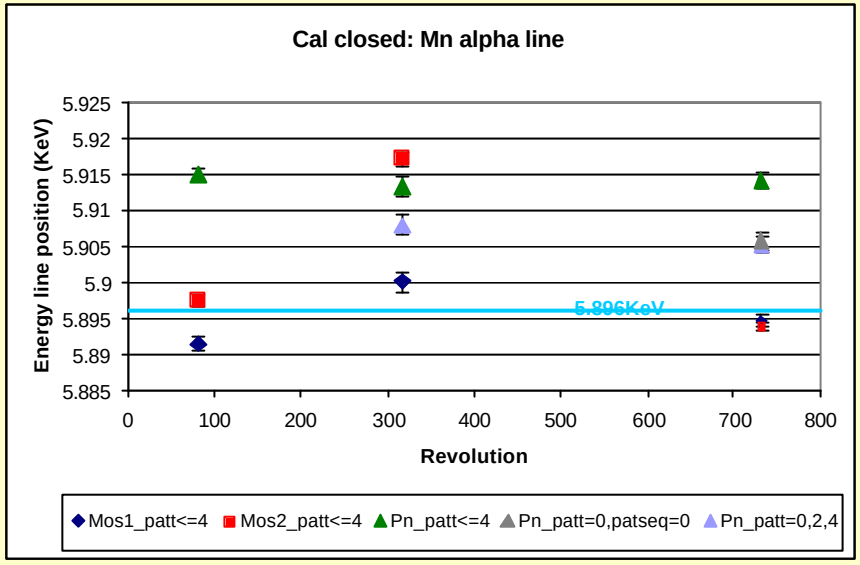
MOS Vs PN. N132D



Agreement between cameras: ~0.4%

CalClosed observations: absolute energy calibration





- Al line: all cameras agree in line energy
- Mn_{α} line: MOS cameras agree in line energy but for pn doubles (1,3) slight overcorrection

Results

- **Energy determination in eFF** mode will change by up to ~0.4% using the newest SAS (6.1.0) getting an accuracy of ~0.1% with respect to the FF mode
- **Relative** energy calibration pn (1-6 keV)
  - pn: 0.1% (0.4% SW)
- **Relative** energy calibration MOS (0.5-2 keV)
  - MOS: 0.5 %
- **Absolute** energy calibration
  - MOS: 0.3 % (Al), 0.1 % (Mn_{α})
  - pn: 0.3 % (Al), 0.2 % (Mn_{α})