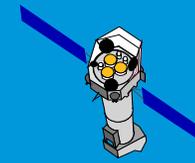


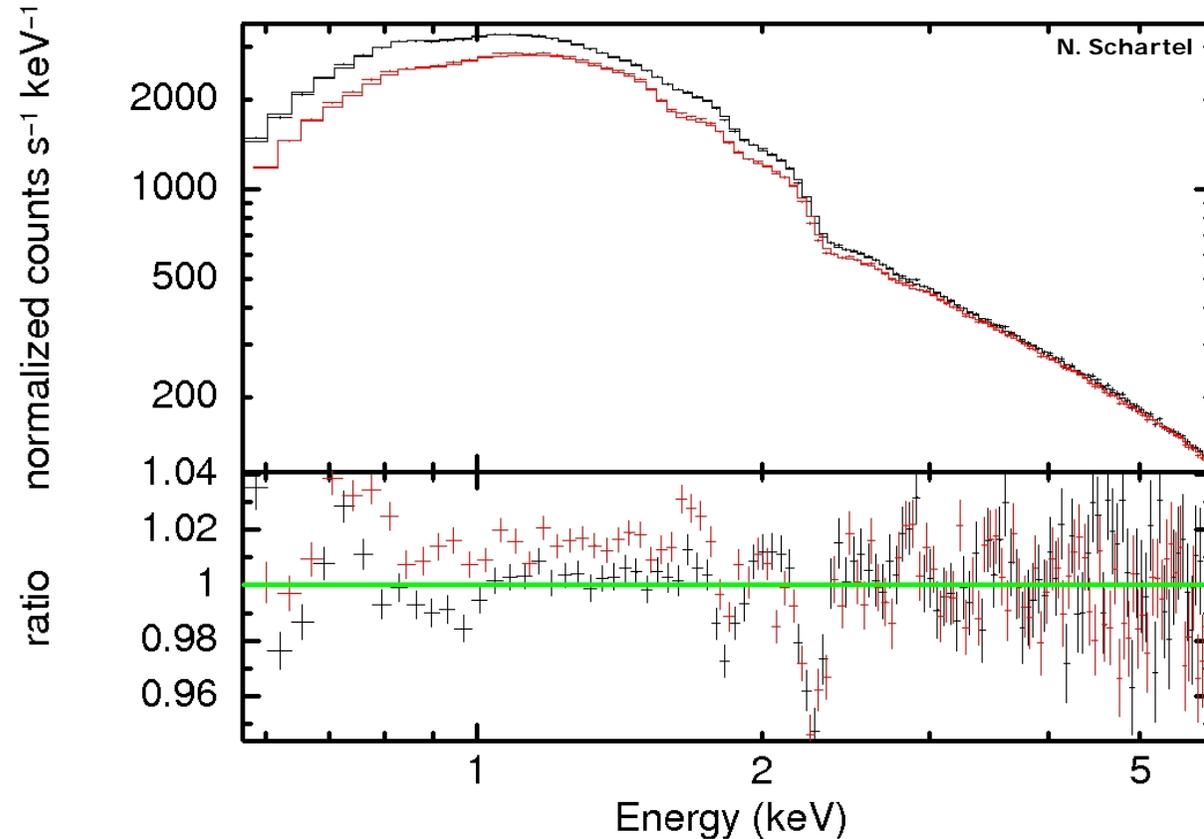
# EPIC FILTER TRANSMISSION INVESTIGATIONS

**Martin Stuhlinger**  
**EPIC OPS/CAL meeting**  
**ESAC, 14.03.2019**

# Motivation



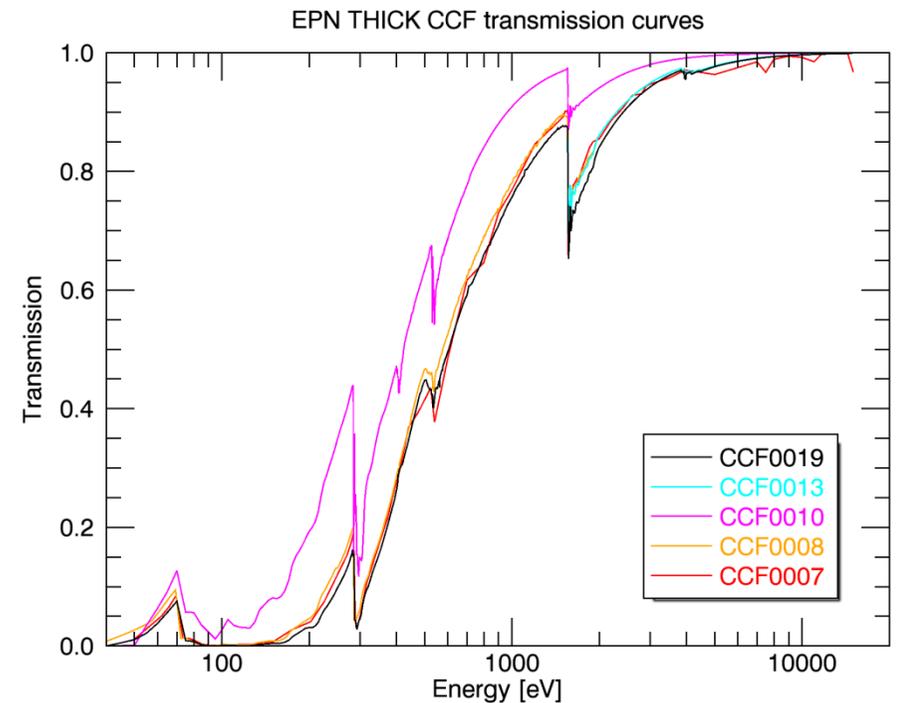
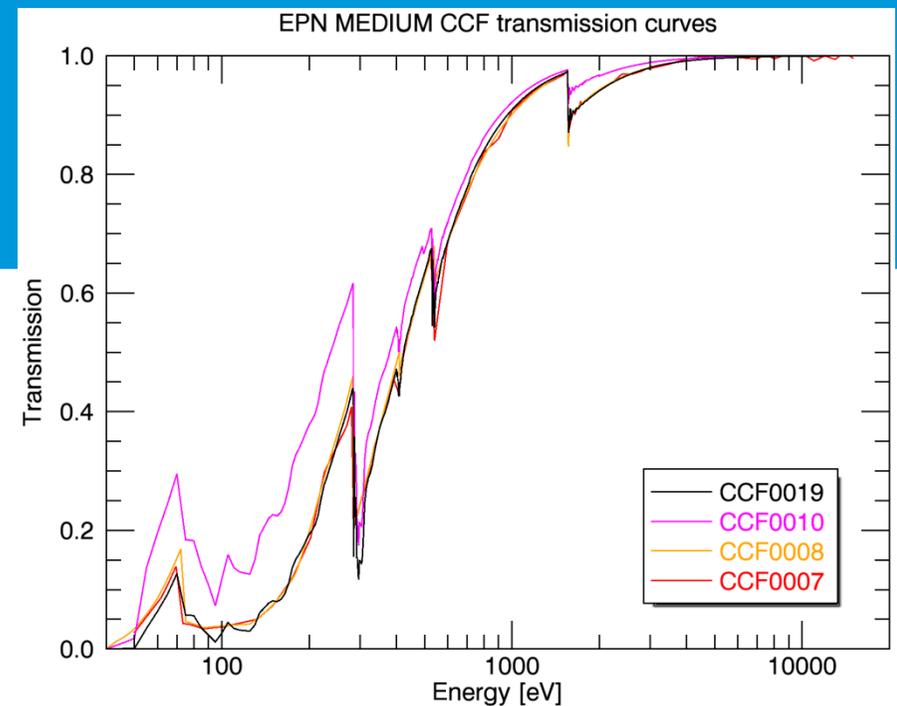
- Norbert Schartel reported systematic difference between thick and medium filter observations of Crab burst mode exposures.
- Thick filter data systematically above the medium filter data below Al-edge.
- Difference is the order of about <2%.
- Started of review of the filter transmissions as possible origin.

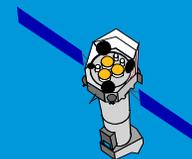


# Review of CCF history

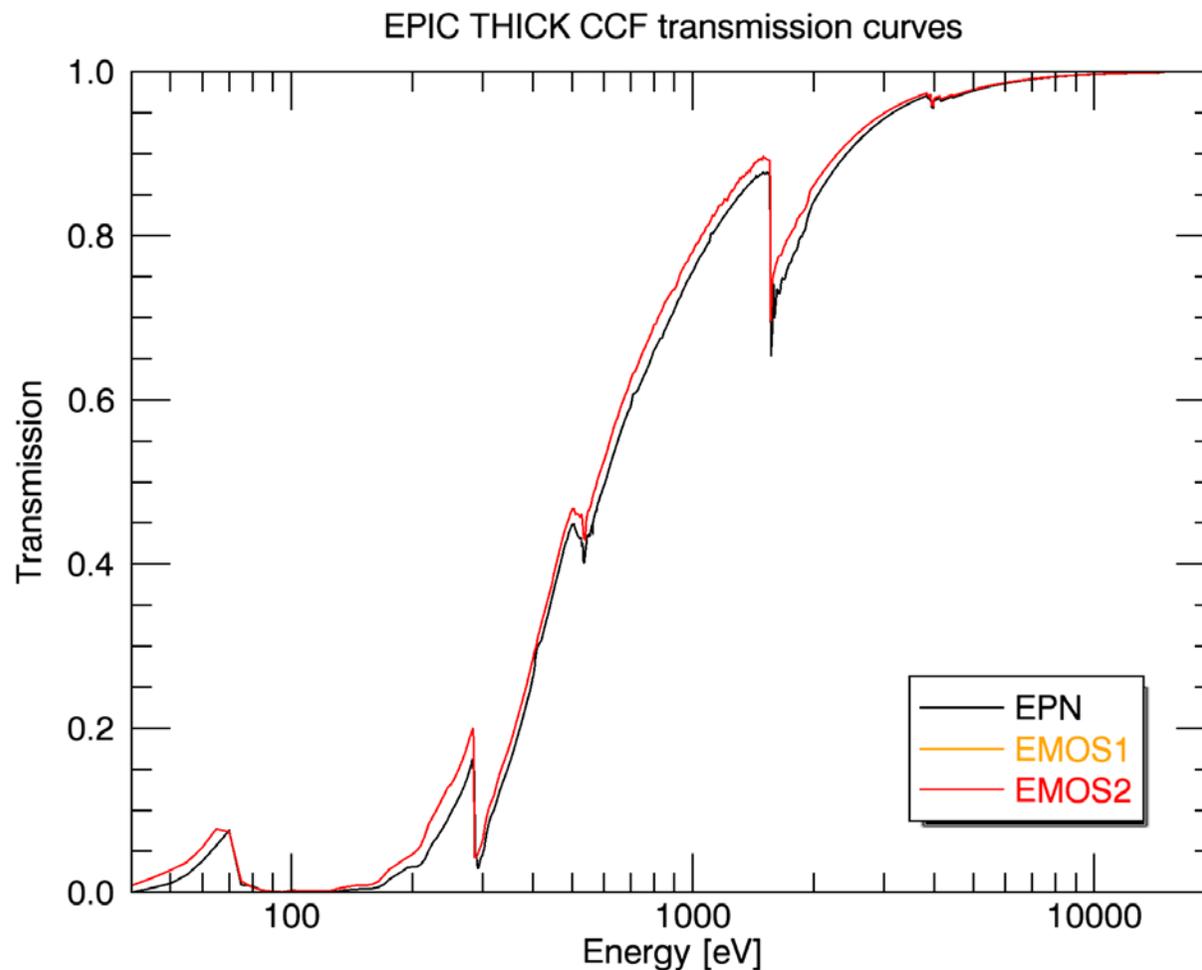
Table 5: Changes to the EPIC filter transmission CCF according to the release note.

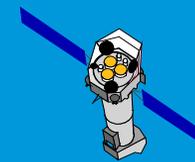
Year	SRN	CCF	EPIC	Tables	Change
2000	27	MOS-0006 PN-0008	all	THICK	Data changed to match measurements made by MPE team at BESY.
2000	47	MOS-0007 PN-0010	all	all	Thick: Flight model data sets measured at HASY lab. identified and used for CCF, mixed with scaled BESY data. MOS thick filter piece numbers unknown. Medium, thin: Match Orsay synchrotron measurements for a limited set of energies.
2000	48	MOS-0008 PN-0011	all	all	Removed duplicated energy values.
2000	53	MOS-0009 PN-0011 PN-0012	all	THICK MEDIUM	Rectified error of incorrect data (THIN2 data in extension MEDIUM and MEDIUM data in THICK extension).
2002	115	MOS-00010 PN-0013	all	all	Spatial region selection expression has been expanded from 1000 arcsec to 1100 arcsec, plus editorial change to anchor the low energy point at 0 eV instead of 40 eV.
2003	146	MOS-0011	MOS	all	MOS thick filter data changed to match BESY measurements. Energy binning changed for all filters (modified re-release of issue 0006).
2004	170	MOS-0012	MOS	all	Combine thin and medium filter transmissions of issue 0010 with thick filter transmission of issue 0011. MOS thin and medium filter transmission values are brought back into line with the identical pn thin and medium filter transmissions of PN-0013 by using the issue 0010 values. MOS thick filter transmission values of issue 0011 maintained.
2005	186	PN-0014	pn	THICK	With respect to issue 0013, the issue 0014 pn thick filter transmission values have been lowered by up to 5% at and above the Al-K edge (1.559 keV). Transmission data provided by Frank Haberl (MPE).
2012	287	MOS-00014 PN-0018	all	all	Added six new blocks which contain transmission data of filter plus calibration source, identical to those of the respective science filter.
2016	335	MOS-00015 PN-0019	all	CLOSED CAL- CLOSED	A new block containing transmission data for the Closed filter wheel position has been added. Already existing unity Calclosed transmission values changed to be identical with Closed filter values.





- MOS1 and MOS2 use identical filter transmission values for all filters (thin, medium, thick).
- MOS and pn use identical filter transmission values for thin and medium filters.
- MOS and pn use different filter transmission values for thick filter.
- Real filters are similar, but detailed layer thicknesses can differ for the individual units.



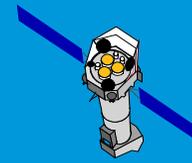


- Documentation of detailed layer thicknesses of the filters in orbit not easy to find.
- Details of thin and medium filters documented in an email by Steve Sembay within an communication between Leicester, MPE and ESAC in 2006.

No.	Detector	Polymide	Al	Position
1	m1	1818	406	Thin 2
8	pn spare	1778	413	Thin 1 FS model in orbit!
11	pn spare	1723	406	Thin 2 FS model in orbit!
12	pn	1818	406	Thin 2 FM model at PANTER
14	m1	1778	404	Thin 1
18	m2	1723	406	Thin 2
21	mos spare	1778	404	
24	mos spare	1779	398	
33	m2	1800	388	Thin 1
40	pn	1723	406	Thin 1 FM model at PANTER
65	m1	1647	859	
66	pn	1707	834	Medium FM model at PANTER
67	m2	1707	834	
68	pn spare	1707	834	Medium FS model in orbit!

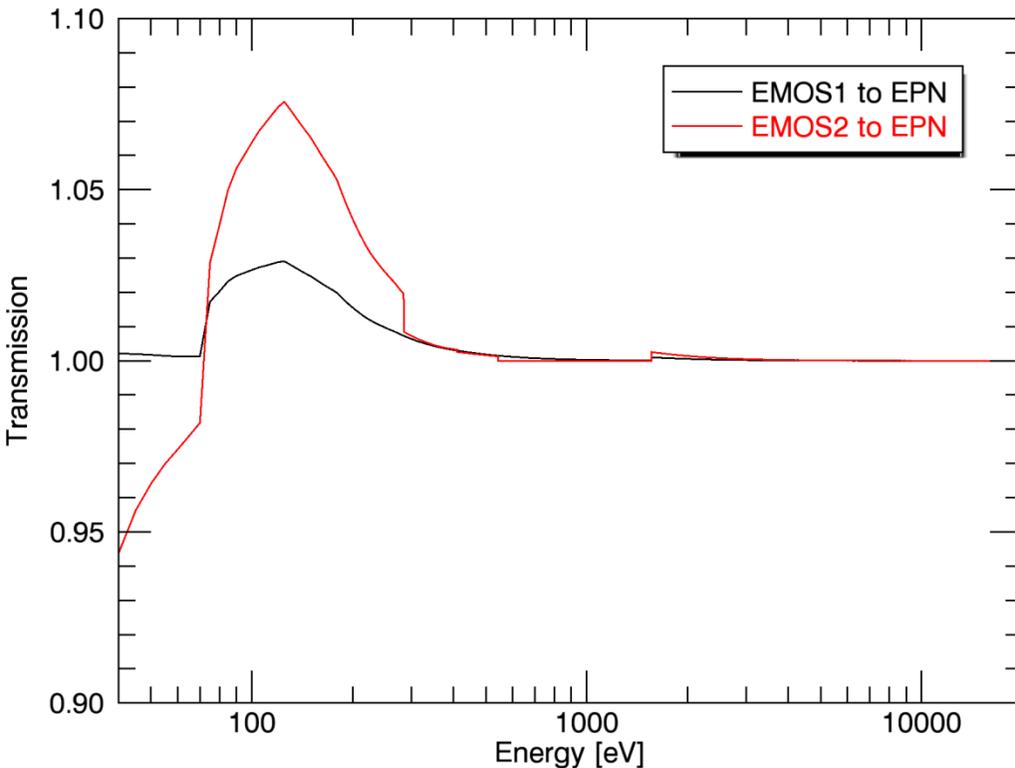
- But: I couldn't find any detailed layer thicknesses of the thick filters so far.

# Investigate differences according to layer thicknesses

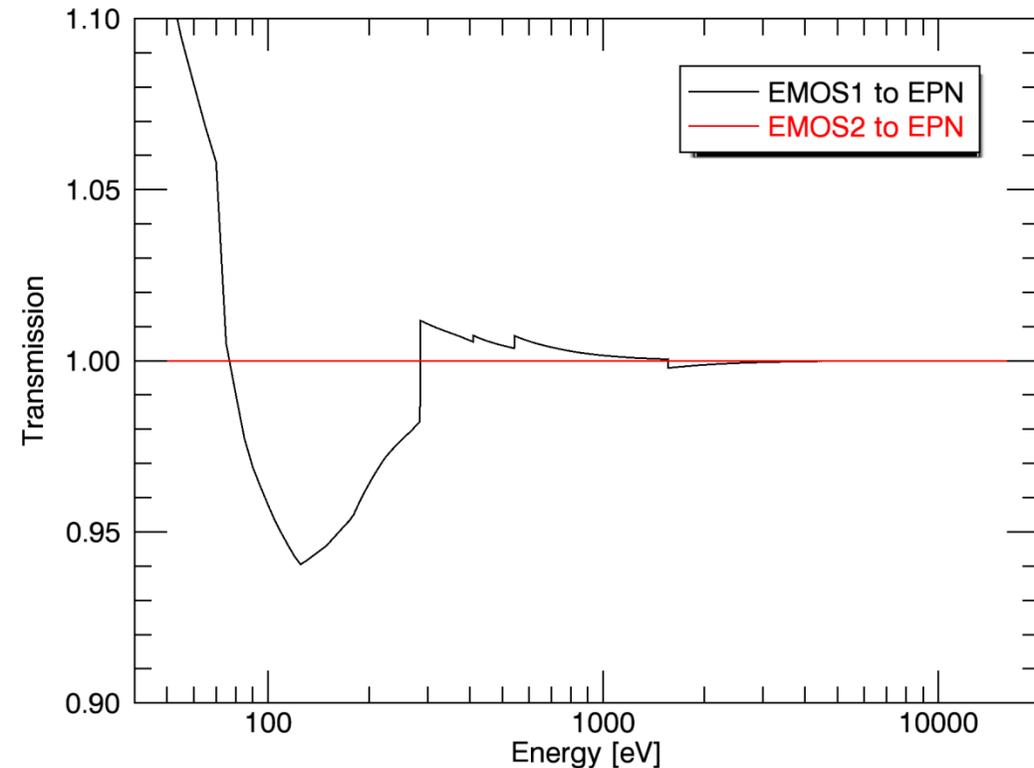


- Check if layer thicknesses are significant for transmission values.
- Get theoretical transmission values for different materials and thicknesses from [http://henke.lbl.gov/optical\\_constants/filter2.html](http://henke.lbl.gov/optical_constants/filter2.html)

EMOS to EPN THIN1 transmission curve layer ratios

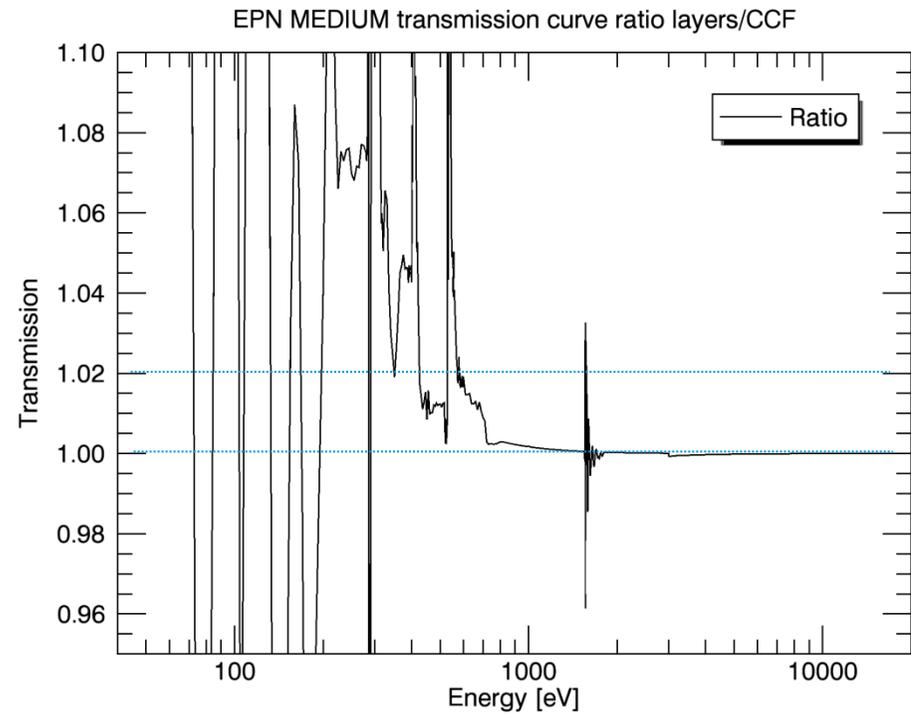
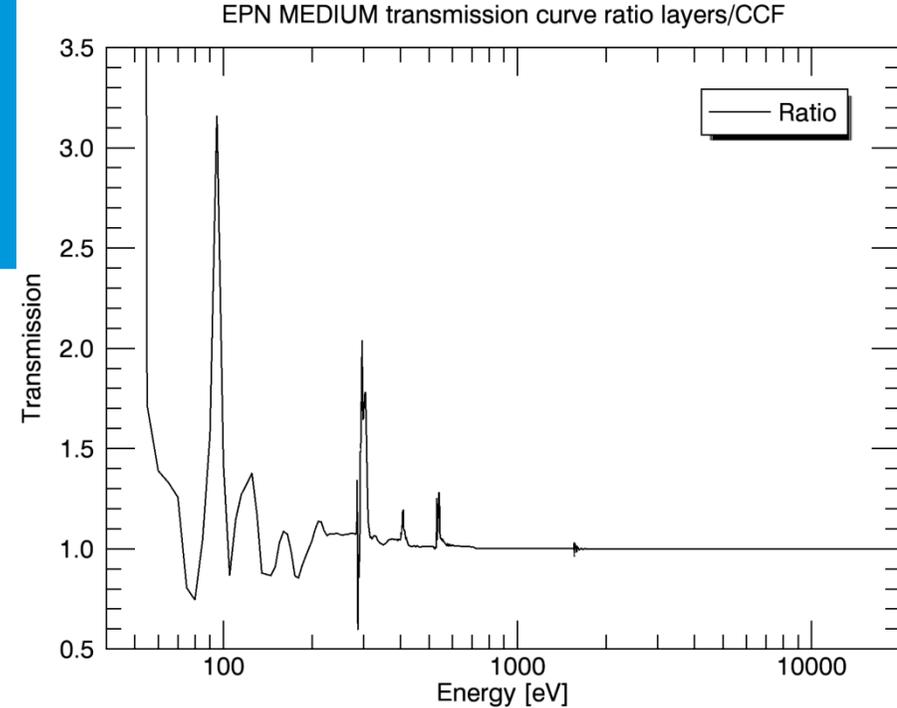
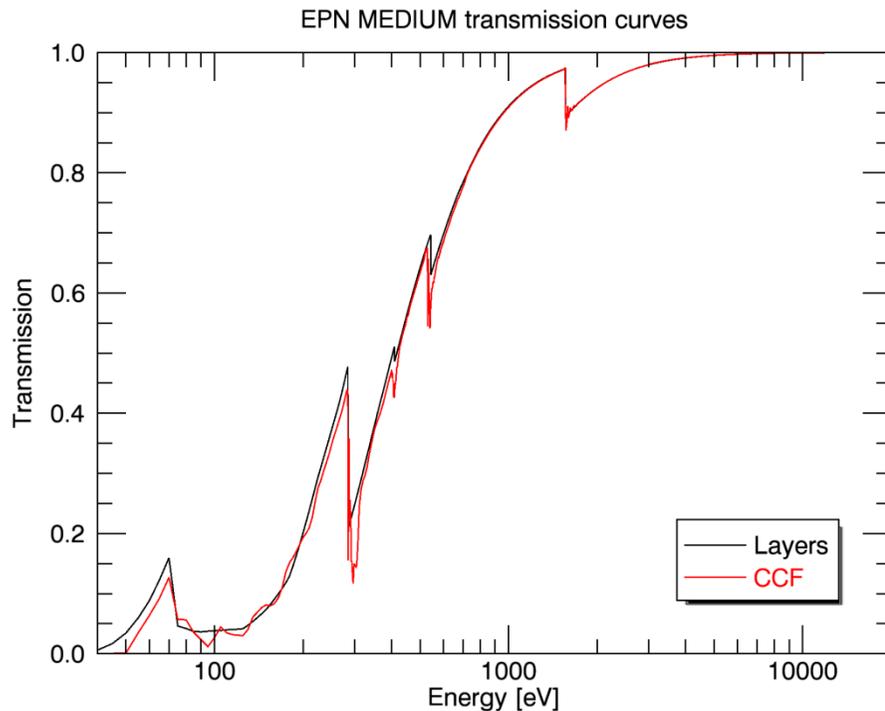


EMOS to EPN MEDIUM transmission curve layer ratios

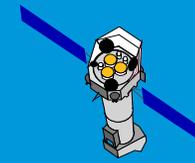


# Differences between Henke and CCF filter transmission values

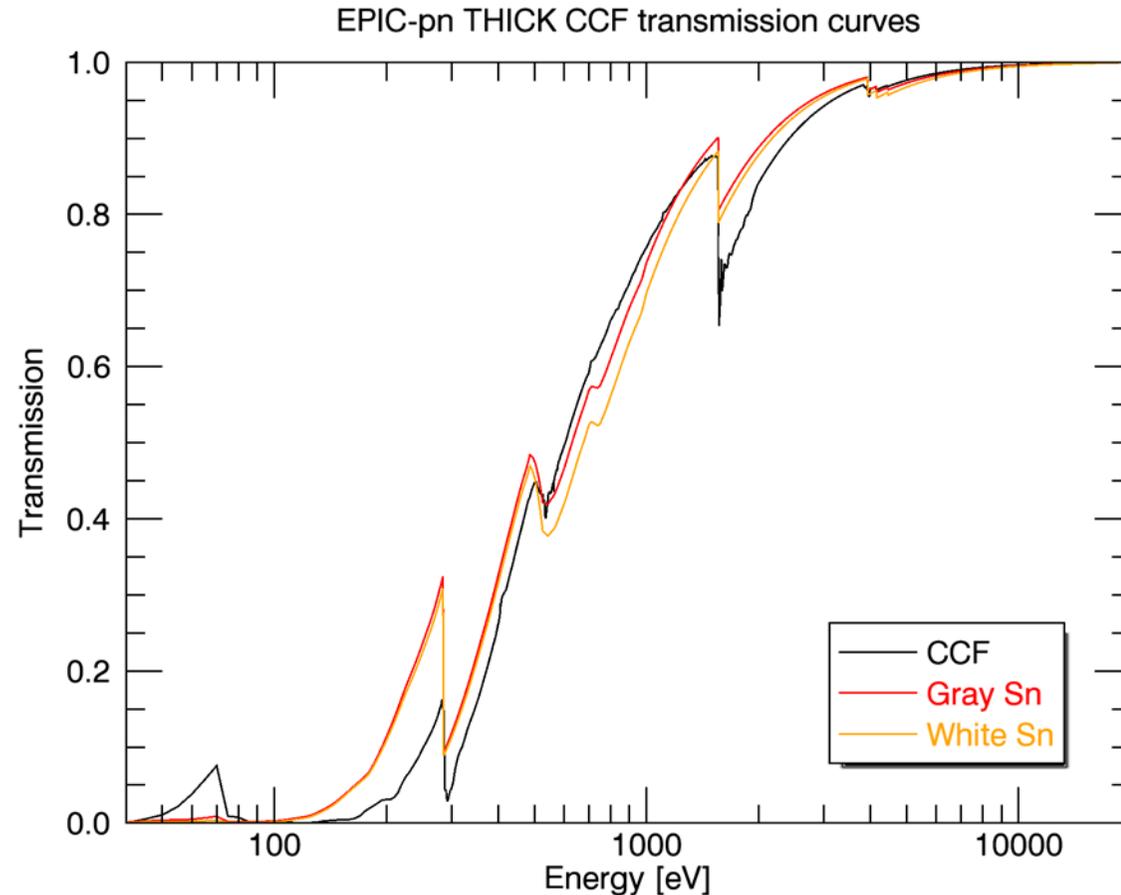
- How well can we reproduce the CCF filter transmission values using the Henke data?
- Significant differences at edges.
- CCF values more explicit around edges.

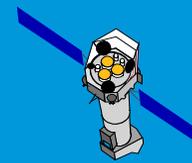


# Thick filter composition

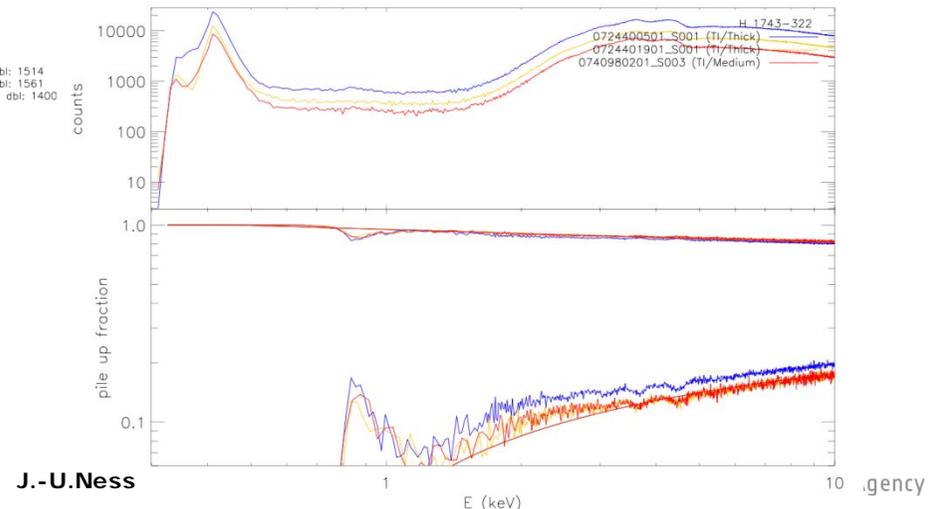
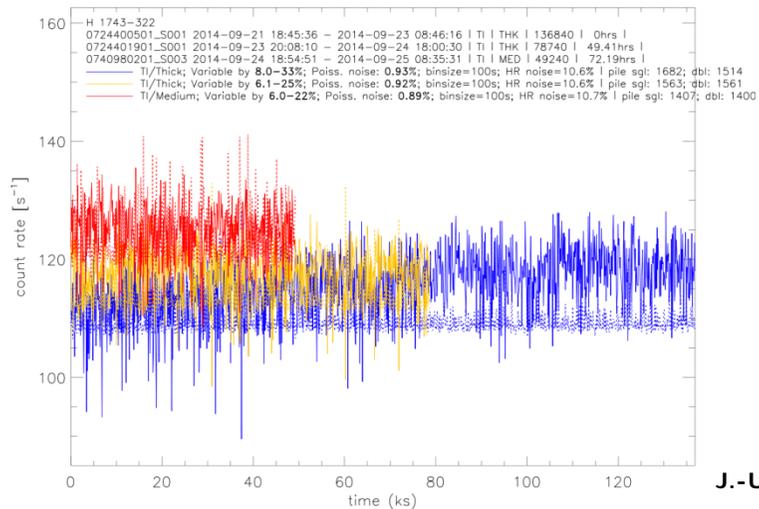


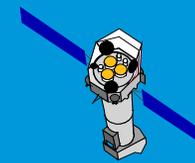
- Documentation on detailed thick filter layer thicknesses not yet found.
- EPIC technical details: 3300Å Polypropylene, 1100Å Aluminium, 450Å tin (Sn)
- Henke data using “XMM-Newton EPIC technical details” values differ significantly from CCF values.
- Which crystal structure for Sn (7.3 g/cm<sup>3</sup> tetragonal vs. 5.8 g/cm<sup>3</sup> diamond cubic)?





- Created XSPEC table model with 2 parameters which (should) allow to modify the effective areas below (flat) and/or above (thick filter) Al-edge by up to +/-5%.
- Archive search for more medium/thick filter exposures of same targets to confirm Crab result (Jan-Uwe Ness).
  - Same coordinates, less than 3 days apart, same mode but different filters.
  - Found 96 candidate observations of 24 targets fulfilling these criteria.
  - Further selection according to count rates, variability of light curves and hardness ratios, pile-up ongoing.





- Systematic difference found between medium/thick filter burst mode observations of the Crab in the order of 2% below the Al-edge.
- Currently we try to confirm this difference using similar observations of different targets. Archive search/selection ongoing.
- All EPICs use identical thin/medium filter transmission values in CCFs. Differences from Henke values for real thin/medium filter layer thicknesses less than 1% above  $\sim 300$  eV.
- Henke data more or less consistent with CCF values, but where is the origin of the detailed structures around the edges in the CCFs? Theoretical or measured edges?
- Anybody knows the detailed layer thicknesses of the EPIC on-board thick filters or where to find the corresponding documentation?