

# Cross-Calibration between Chandra and other X-ray Telescopes

Herman L. Marshall

Chandra X-ray Center, MIT Kavli Institute



# Overview

- Published analyses to web
- Continued effort to cross-cal formally
- Attended meetings for joint cal discussions
- Started cross-cal work with Suzaku
  
- Continuing XMM-Chandra cross-cal analysis
- Attending cross-cal meetings
- Completing first Chandra-Suzaku cross-cal
- Completing Chandra grating internal checks

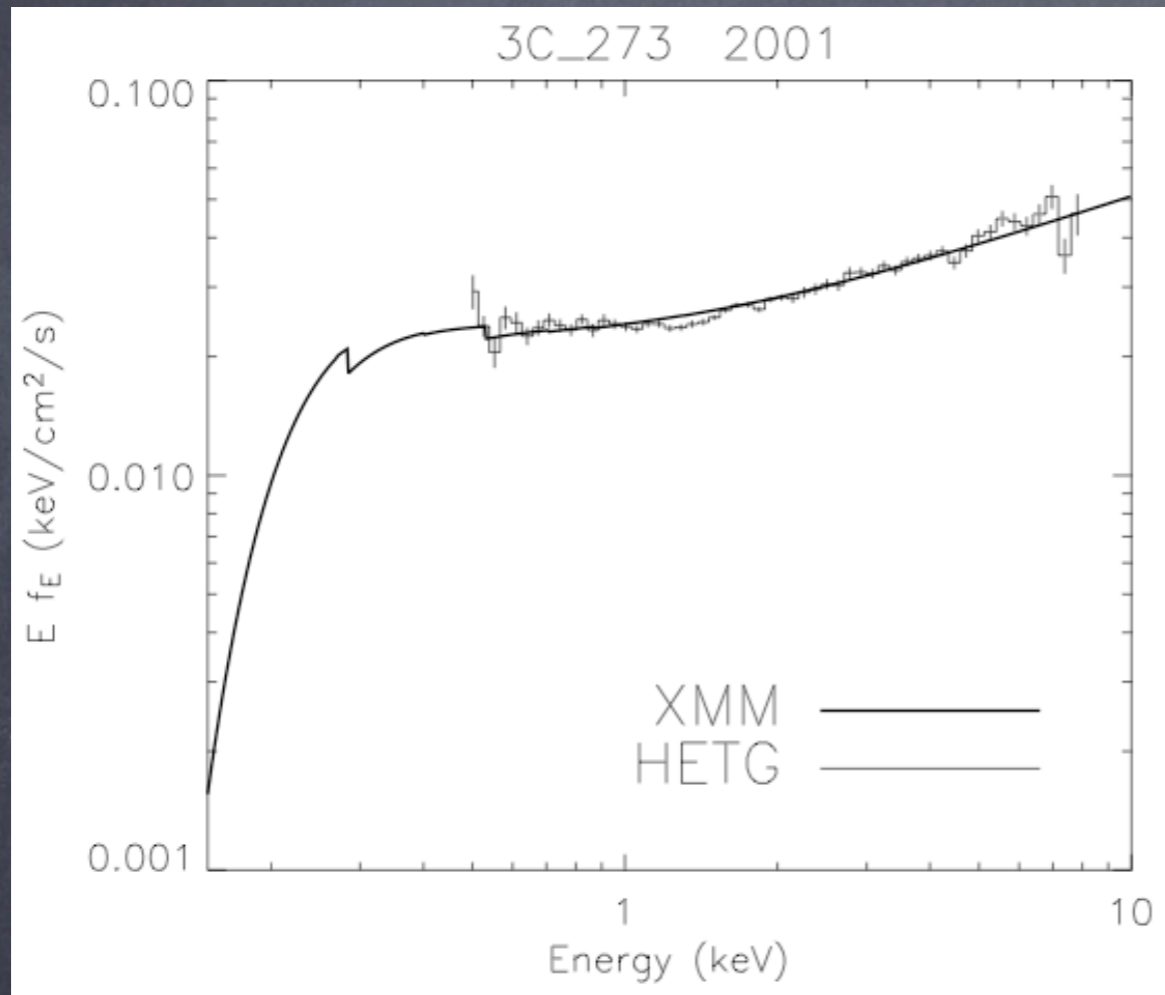


# Web Page Publishing

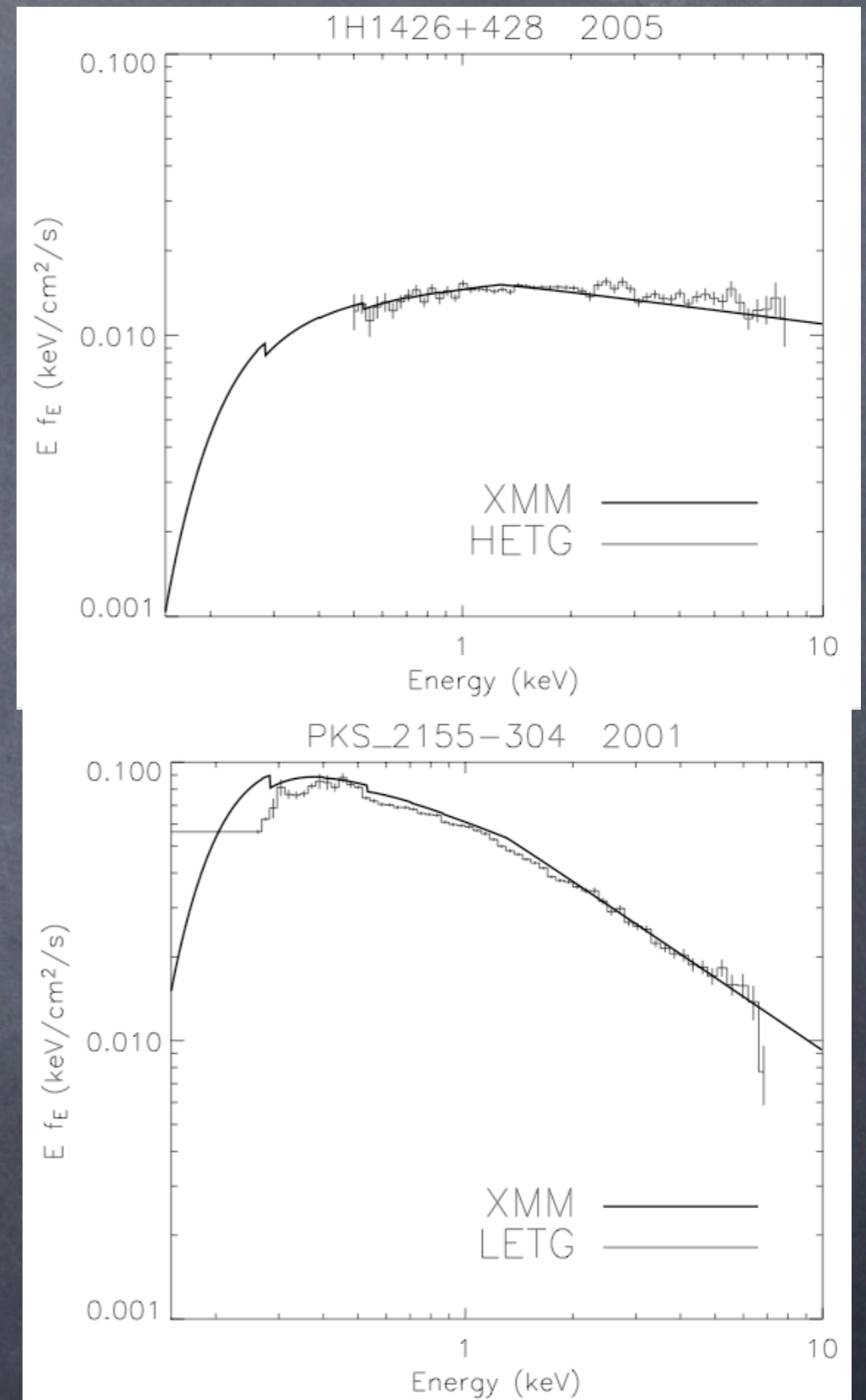
- CXC web page live: <http://space.mit.edu/ASC/calib/crosscal/>
- XMM web page is live: [http://xmm.esac.esa.int/external/xmm\\_sw\\_cal/calib/cross\\_cal/index.php](http://xmm.esac.esa.int/external/xmm_sw_cal/calib/cross_cal/index.php)
  - Cross-linked with CXC cross-cal page
  - Three cases shown, using public data
- International Astronomical Consortium for High Energy Calibration: <http://www.iachec.org/>



# Additions to web pages



From <http://space.mit.edu/ASC/calib/crosscal/>  
(H. Marshall, EPIC calibration meeting)

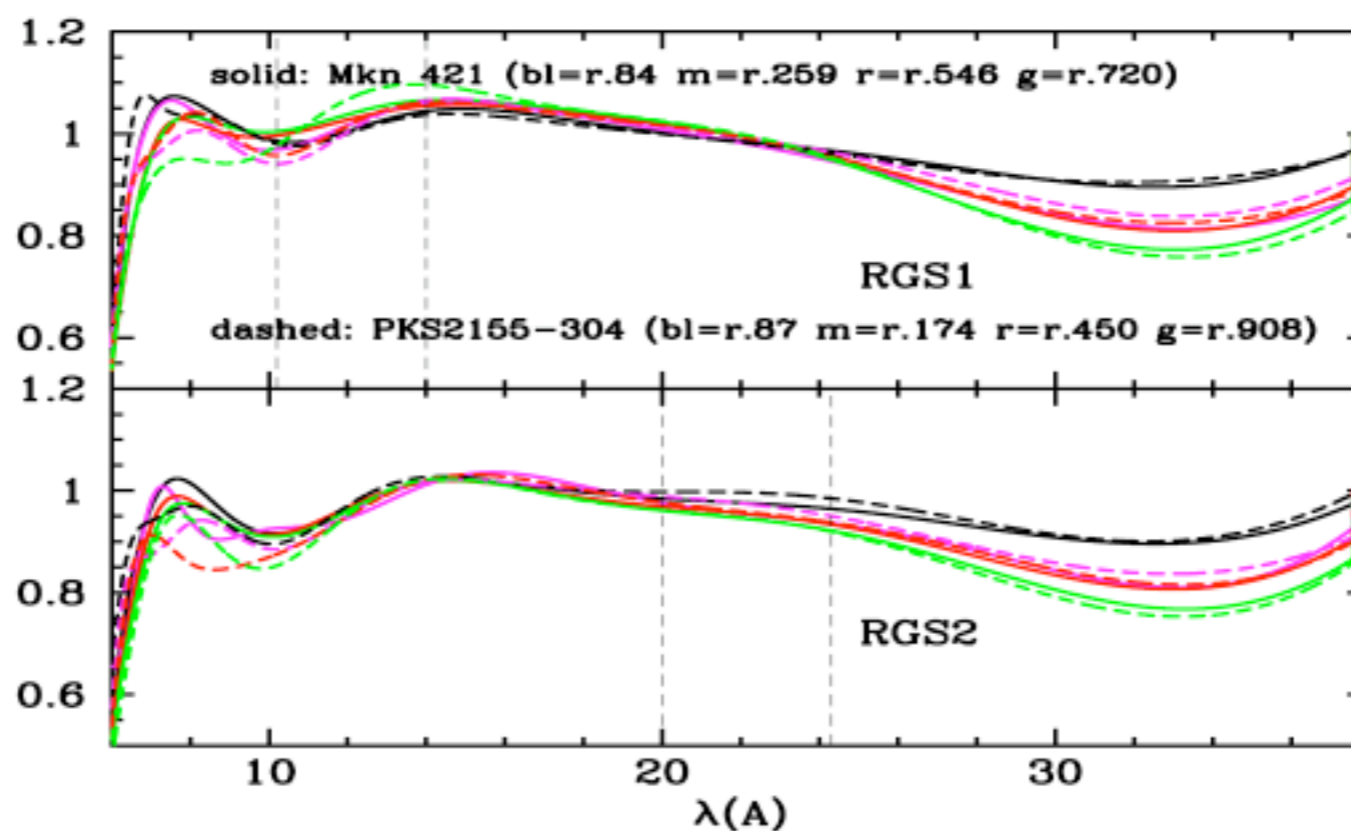




# RGS EA Adjustment

## RGS effective-area corrections

- fit blazar spectrum with ISM-absorbed powerlaw  $10 < \lambda(\text{\AA}) < 25$
- model residuals by sum of Chebyshev polynomials
- repeat throughout the mission  $\otimes$  Crab normalisation and slope adjustments
- correction calculated at 5 epochs  $\Rightarrow$  EFFAREACORR \* CCF
- 8 example epochs shown here (r == XMM rev)



RGS calibration

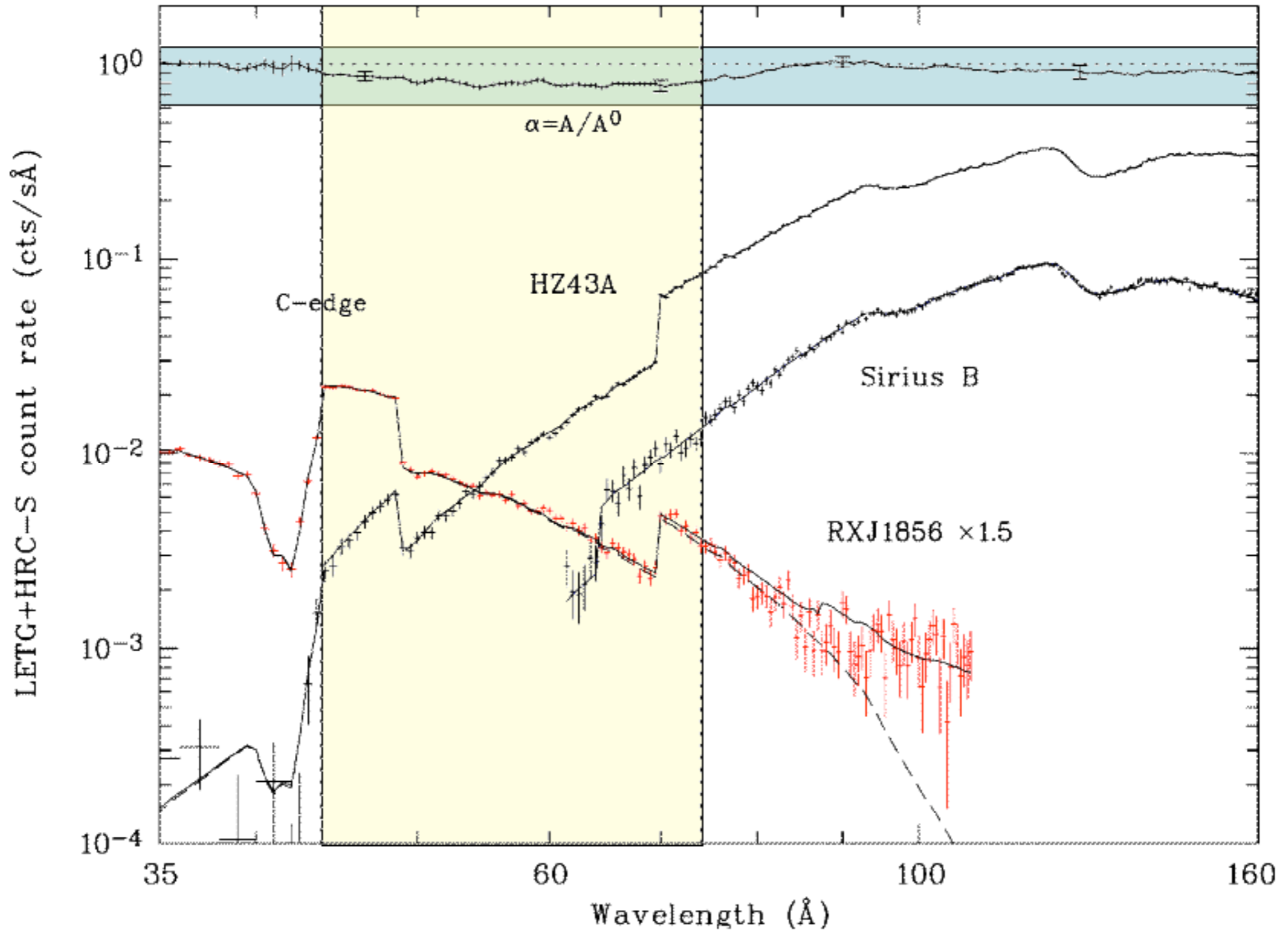
Andy Pollock  
XMM-Newton SOC

European Space Astronomy Centre  
Villafranca del Castillo, Madrid, Spain

(A. Pollock, EPIC calibration meeting)



# LETG/HRC EA Fix?



(V. Burwitz, EPIC calibration meeting)



# Flux Comparisons

- Analysis of 17 AGN over XMM mission
- Defined 4 bandpasses, fluxes from fits
- Suggests: MOS QE drop at low E & +5-7% global MOS QE change or global PN QE drop

Band (keV)	(MOS1-PN)/PN	(MOS2-PN)/PN
0.54-0.85	-5.4%	-1.6%
0.85-1.50	+2.4%	+4.1%
1.50-4.0	+6.8%	+7.3%
4.0-10.0	+11.4%	+7.4%

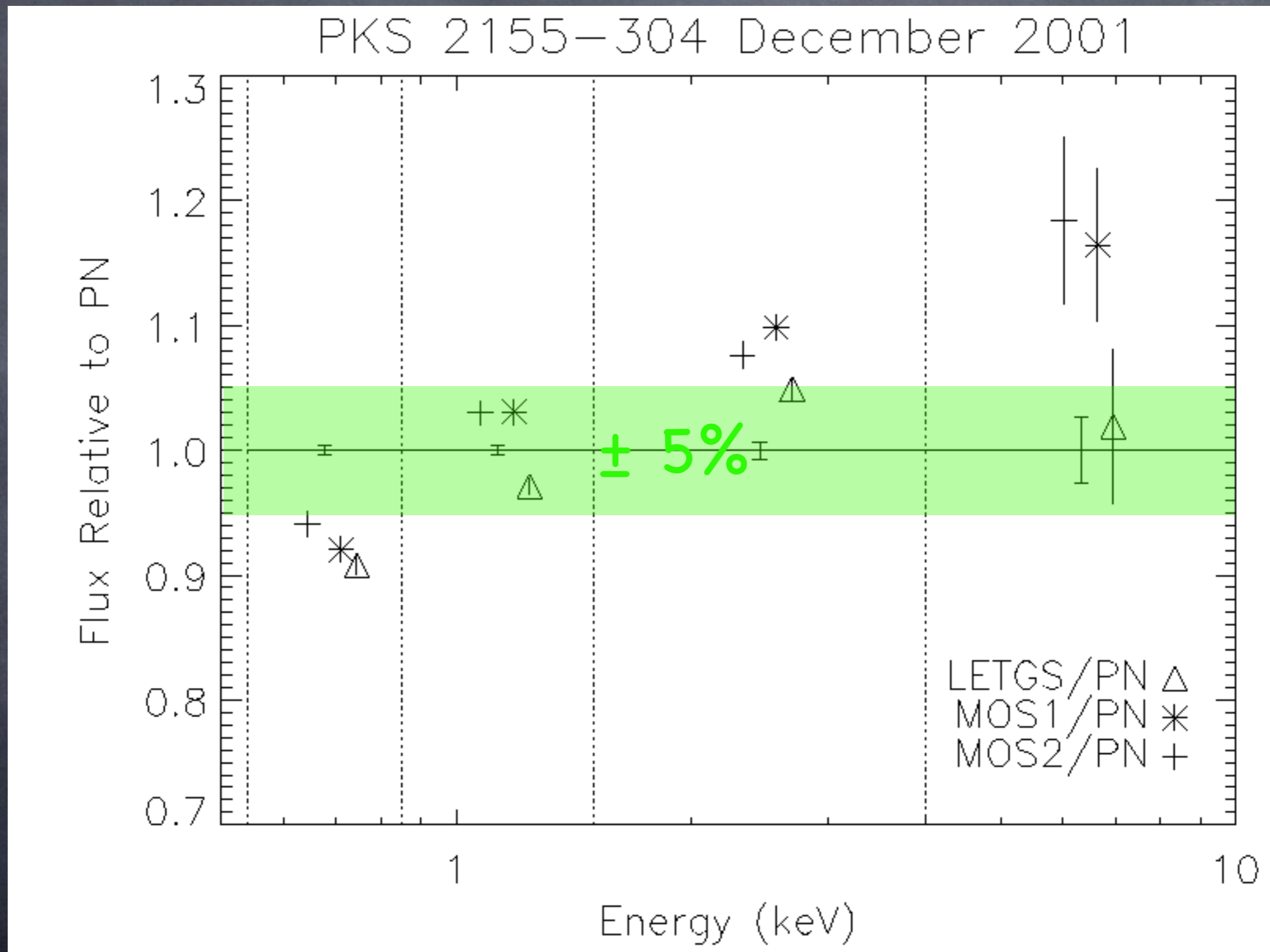
Steve Sembay (sfs5@star.le.ac.uk)  
MPE 04/05/06



from EPIC calibration meeting

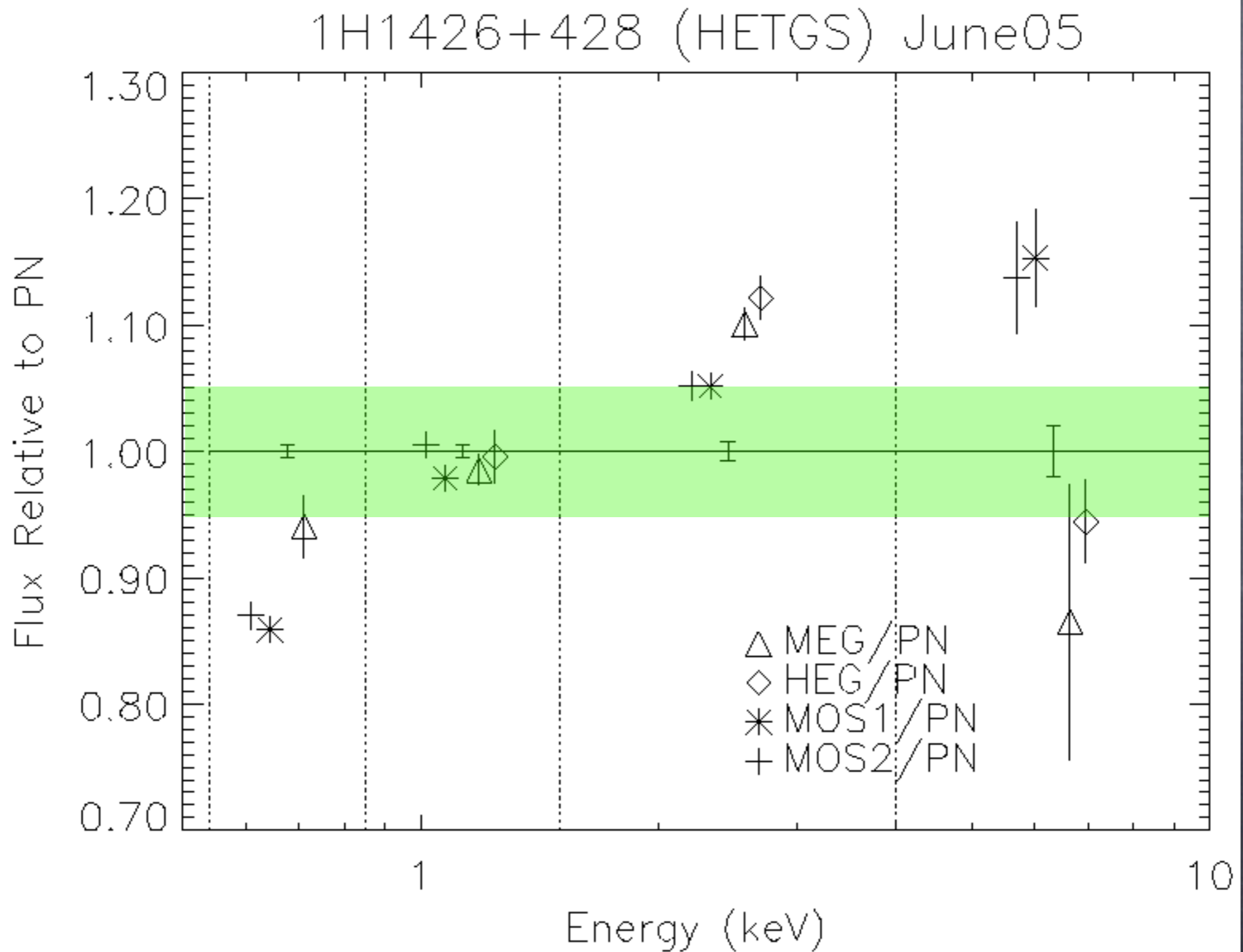


# Flux Comparisons





# Flux Comparisons





# XMM/Chandra Blazar Observations to Date

XMM-Chandra Cross-Calibration Observations of AGN												
Target	XMM						Chandra					
	Rev	Seq #	Start Date	exp (ks)	A	$\Gamma$	Config	ObsID	Start Date	exp (ks)	A	$\Gamma$
PKS 2155-304	87	124930101	2000-05-30:0530	61			HETGS	1705	2000-05-31:1740	30	4e-2	2.507
		124930201	2000-05-31:0030	72			LETG/ACIS	1703	2000-05-31:0220	30	0.051 1e-1	2.66 1.72
							LETG/HRC	1704	2000-05-31:0950	30		
3C 273	94	126700301	2000-06-13:2340	73			ACIS-S	1711	2000-06-14:0550	30		
	96	126700801	2000-06-17:2320	73	0.0024 0.0176	3.17 1.63	ACIS-S	1712	2000-06-14:1420	30		
	277	136550101	2001-06-13:0710	90	6.48e-3 0.0187	3 1.57	HETG	2463	2001-06-13:0700	30	2e-2	1.74
							LETG/ACIS	2464	2001-06-13:1610	30	7e-3 1e-2	2.577 1.47
PKS 2155-304	362	89210101	2001-12-01:0600	15	0.063 0.068 Eb=1.22	2.5 2.86	HETGS	3167	2001-11-30:2010	30	6e-2	2.738
							LETG/ACIS	3168	2001-11-30:1120	30	9e-2 0.171	2.995 1.71
							LETG/HRC	3166	2001-11-30:0230	30		
	545	124930601	2002-11-29:2330	115	0.0272 0.0269 Eb = 0.98	2.28 2.81	HETGS	3706	2002-11-29:2230	30	0.02	2.72
							LETG/ACIS	3707	2002-11-30:0700	30	2e-2 0.052	2.91 1.67
							HETGS	3708	2002-11-29:1430	30	3e-2	2.759
3C 273	655	159960101	2003-07-07:1740	58	2.15e-3 0.0278	3.14 1.81	HETGS	4430	2003-07-07:1230	30	3e-2	1.837
							LETG/ACIS	4431	2003-07-07:2050	30	7e-3 0.021	2.16 1.675
	835	136550801	2004-06-30:1300	63	7.6e-4 0.0178	3.91 1.77	HETGS	5169	2004-06-30:1300	30	2e-2	1.737
PKS 2155-304							LETG/ACIS	5170	2004-06-30:2150	30	7e-3 9e-3	2.18 1.47
	908	158960901	2004-11-22:2130	29			LETG/HRC	5172	2004-11-22:2330	30		
		158961001	2004-11-23:1950	40			HETGS	5173	2004-11-23:2330	30	2e-2	2.8
1H1426+428	1015	310190201	2005-06-25:0603	45	0.015 0.0153	1.9 2.16	HETGS	6088	2005-06-25:0555	45	2e-2	2.03
	1035	310190501	2005-08-04:0452	47			LETG/ACIS	6089	2005-08-04:0436	45	2e-2 0.112	2.266 0.427

From <http://space.mit.edu/ASC/calib/crosscal/>



# International Astronomical Consortium for High Energy Calibration (IACHEK)

- Met near Reykjavik in June, 2006
- Topics
  - Calibration standards and models
  - Calibration analysis and results
  - Calibration management
  - Systematic error treatment, cross-cal
- Next meeting in May, 2007



# IACHEK Tasks and Goals

## • Mission statements:

- The ultimate goal of calibration is for scientific analysis to be limited only by Poisson statistics within the data.
- We aim to provide standards for high energy calibration and supervise cross calibration between different missions.

## • Evaluate calibration sources and models

## • Review calibrations and resolve discrepancies

## • Systematic error team suggestions:

- disseminate info on methods
- avoid xspec syserr usage
- provide analysis caveats pages, etc.



# Other Cross-cal Work

- Started Suzaku-Chandra joint analysis
  - reduced LETG/HRC data
  - need GTIs from Suzaku for detailed work
- Started internal Chandra cross-cal
  - observations of PKS 2155 from July 2006
  - minor failure shouldn't affect results
  - reconciling HETGS in-house analyses
- Began supporting cal work on 1E0102
  - started with extant HETGS measurements
  - may require (nontrivial) HETGS reanalysis
- Continued tests of formal cross-cal method
  - adjusted method
- Continued ACIS contamination analysis



# Cross-cal Plans

- Complete flux measurements for 8 more cases of exact temporal overlap
  - similar to MOS-PN differences so far
  - need more GTI sets and XMM fluxes
- Start supporting comparisons using 1E0102
  - effort led by Paul Plucinsky as part of RMF tests
  - use some existing and new HETGS data
  - help Andy Pollock refine model using RGS
- Fit joint observations
  - complete and use formal methods
  - update ACIS contamination model
  - evaluate possible PN and MOS changes with XMM team



# Upcoming

- Joint web page population
  - add more flux measurements
  - reprocess all Chandra cal data
  - add analysis of 1E 0102-72
- Developing joint analysis methodology
  - continue prototyping
  - test with other instrument data
- Continue cross-cal work with Suzaku
- Analyze new internal cross-grating cal data
- Update ACIS contamination model
- Attend cross-cal meetings
  - EPIC meeting – Mallorca, Oct 26-7, 2006
  - IACHEC meeting – Calif., May 8-11, 2007