Cross spectral calibration of Suzaku/ XMM/Chandra with PKS2155-304

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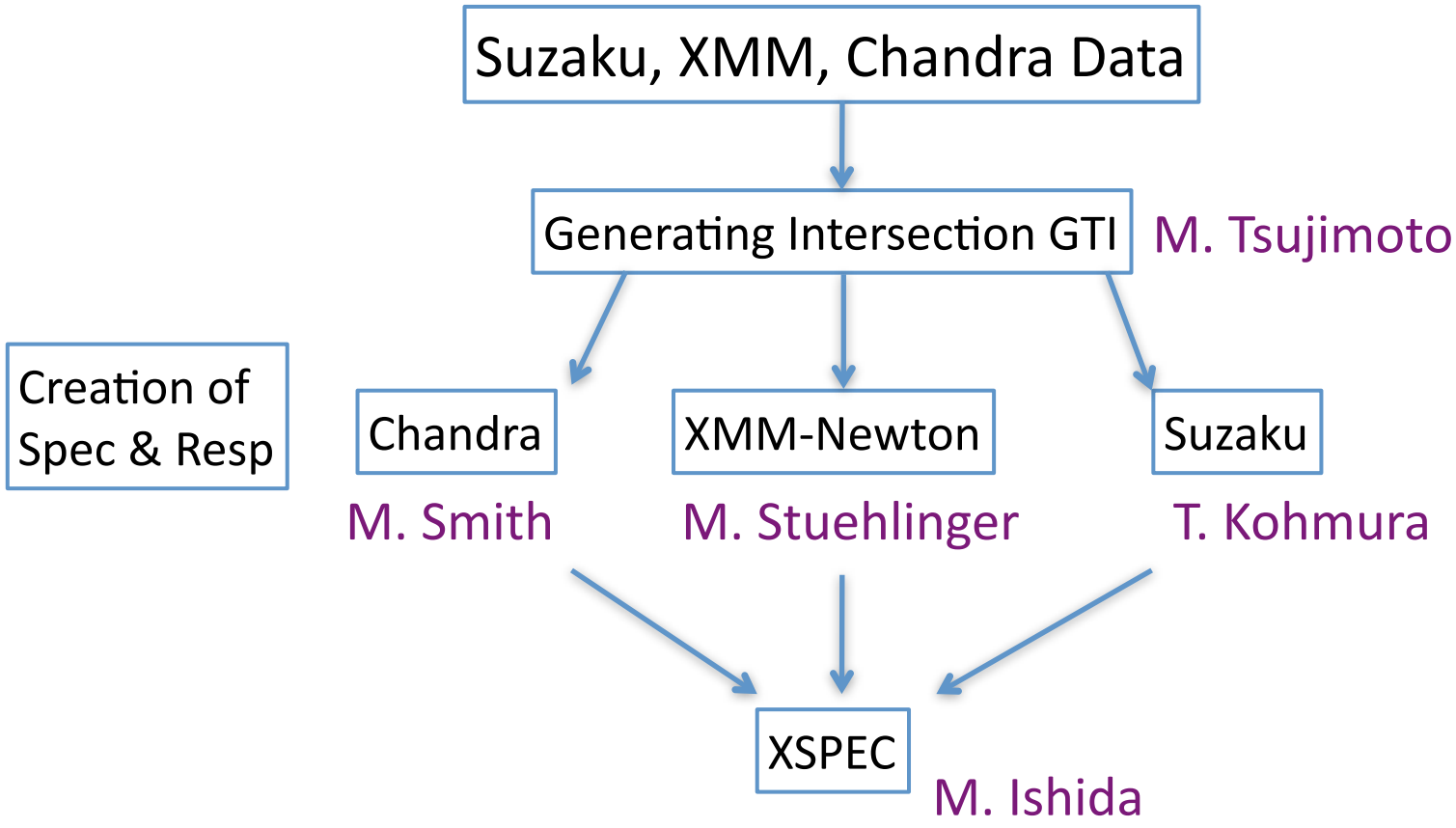
PKS2155-304

- We have carried out cross spectral calibration with PKS2155-304 among Suzaku, Chandra, and XMM-Newton since 2005.
- One of the brightest BL Lac objects.
  - Represented by a simple power-law (possibly broken power-law) spectrum at least up to 10 keV.
- Point source.
  - Needless to care about telescope vignetting associated with spatial extension of the source.
  - Free from contamination from a thermal component (unlike a rotation-powered pulsar in thermal SNRs).
- Variable: need simultaneous observation among alive missions.

⇛ We have carried out coordinated observation among Suzaku, XMM-Newton and Chandra for calibration purpose since 2005.

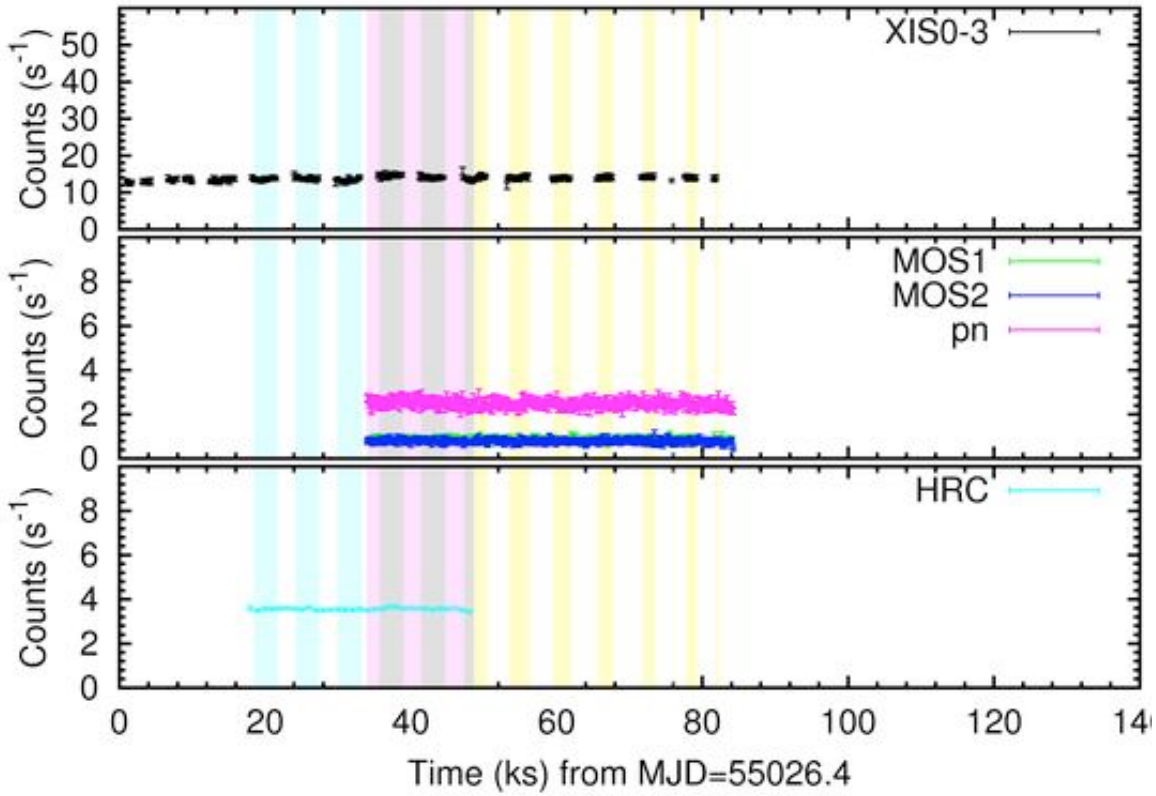
Data reduction procedure

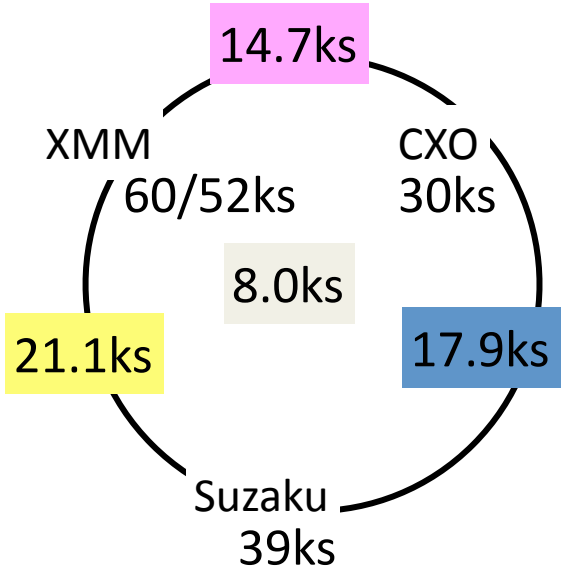


Rough observation log

- 2005 Nov 30-Dec 2
  - XIS-FI/BI, EPIC-MOS/pn
- 2006 May 1-2
  - XIS-FI/BI, EPIC-MOS/pn, HRC-LETG
- 2007 Apr 22
  - XIS-FI/BI, EPIC-MOS/pn, HRC-LETG
- 2008 May 12-13
  - XIS-FI/BI, EPIC-MOS/pn, ACIS-LETG
- 2009 May 27-29
  - Not yet analyzed

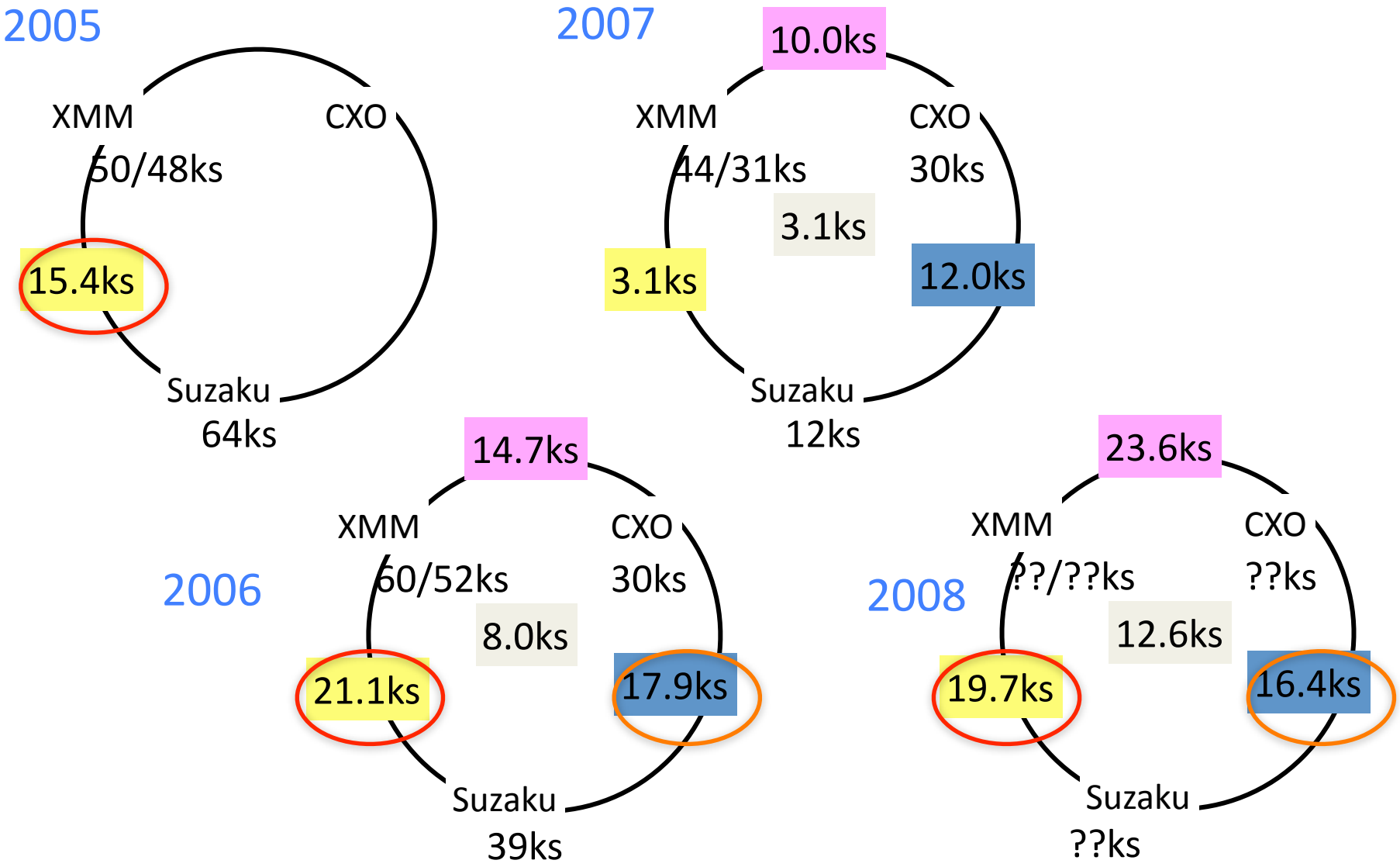
Intersection GTI (2006, as an example)





- Check GTIs individually.
- Calculate intersection GTIs between all pairs out of three, as well as among all three satellites.

Intersection GTI Summary



Data screening: Suzaku

- CALDB XIS20090402, XRT20080709
- Heasoft 6.6.2
- grade ....0+2+3+4+6
- BAD column ....excluded
- SAA .... SAA_HXD=0 && T_SAA_HXD＞436
- ELV .... > 5° / DYE_ELV .... >20°
- ANG_DIST ...<1.5’
- Source ....r<4.33’ / BGD .... r=4.33’−6’

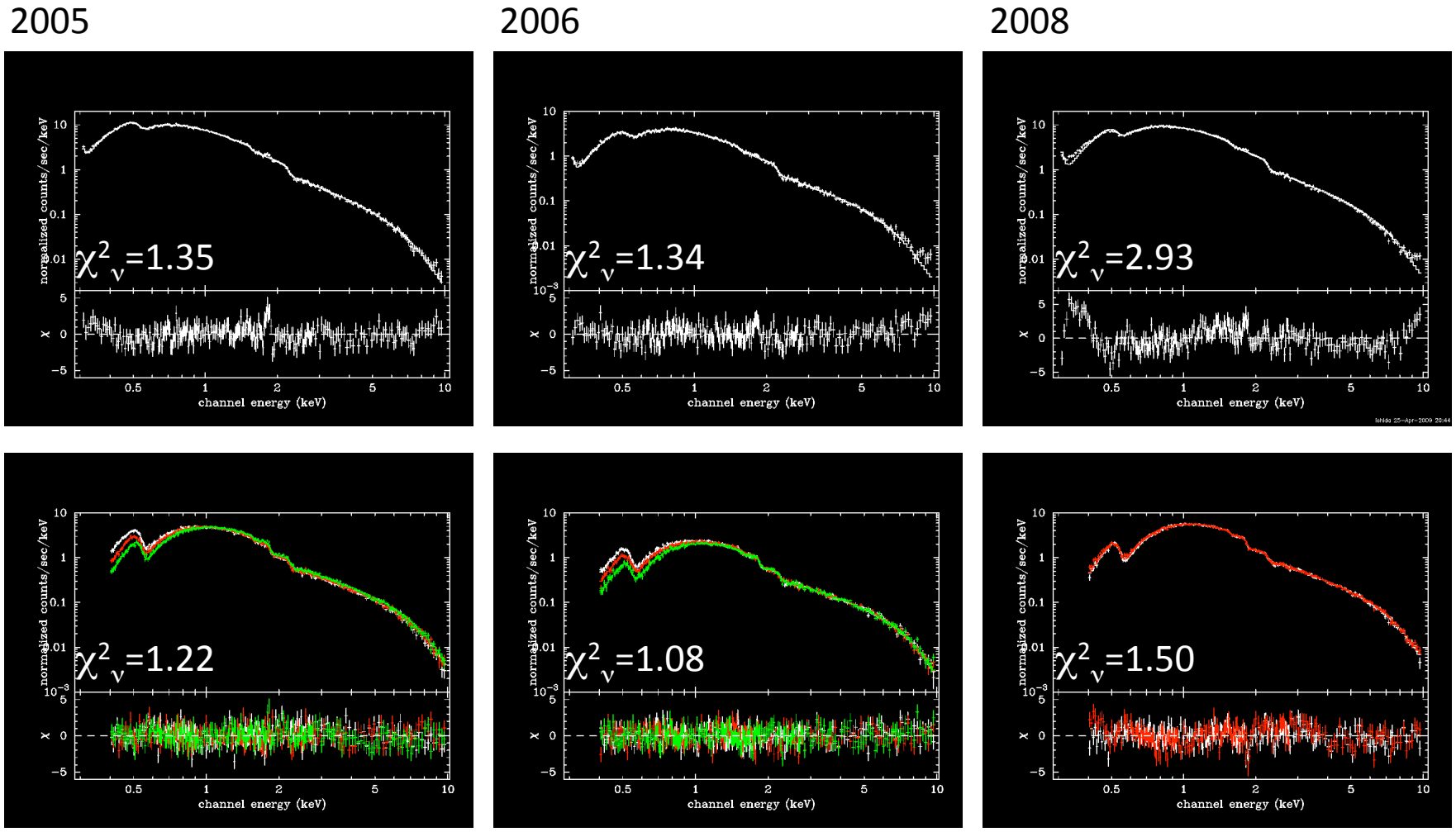
Data screening: Chandra

- Data reduced with CIAO 4.1 + CALDB 4.1.1.
- The 2006 observation was performed with the HRC + LETG
  - Spectra with orders ±1 to ±10 have been generated (only ±1 have been used for spectral analysis), together with corresponding response and background files.
- The 2008 observation was performed with ACIS-S + LETG
  - Spectra with orders ±1 have been generated, together with corresponding response and background files.

Data screening: XMM-Newton

- Calibration Files
  - CCF status as of 01.01.2009
- Photon extraction
  - emproc / epproc referencepointing=object
- pixel patterns and flags used
  - pn: PATTERN 0-4 with FLAG=0
  - MOS: PATTERN 0-12 with FLAG=#XMMEA_EM
- Integration regions
  - Rout = 1200pixels / Rin = 100-200pixels to avoid photon pile up.

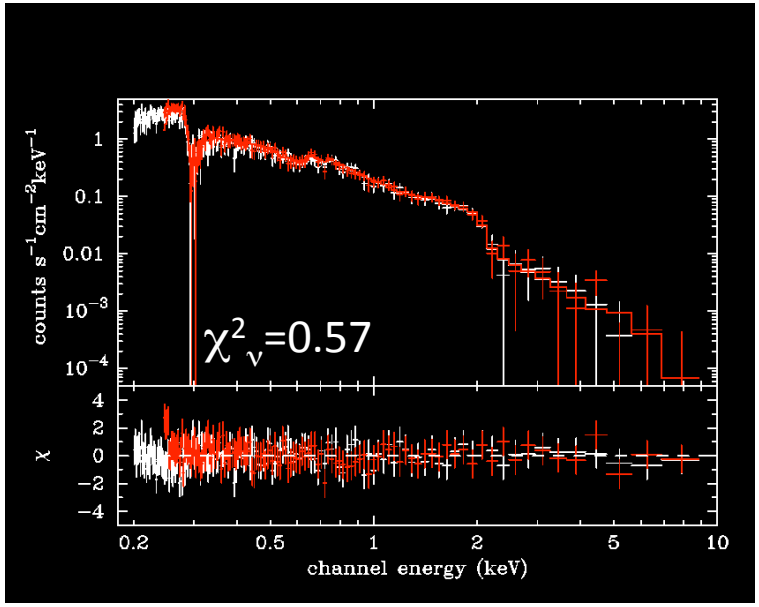
Suzaku XIS: 2005, 2006, 2008



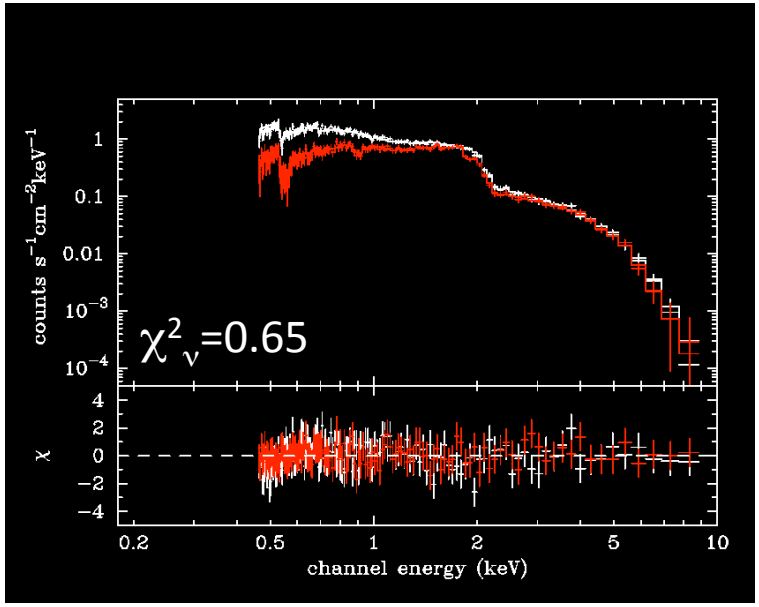
Common GTI with XMM-Newton

Chandra Spectra: 2006, 2008

2006, HRC+LETG



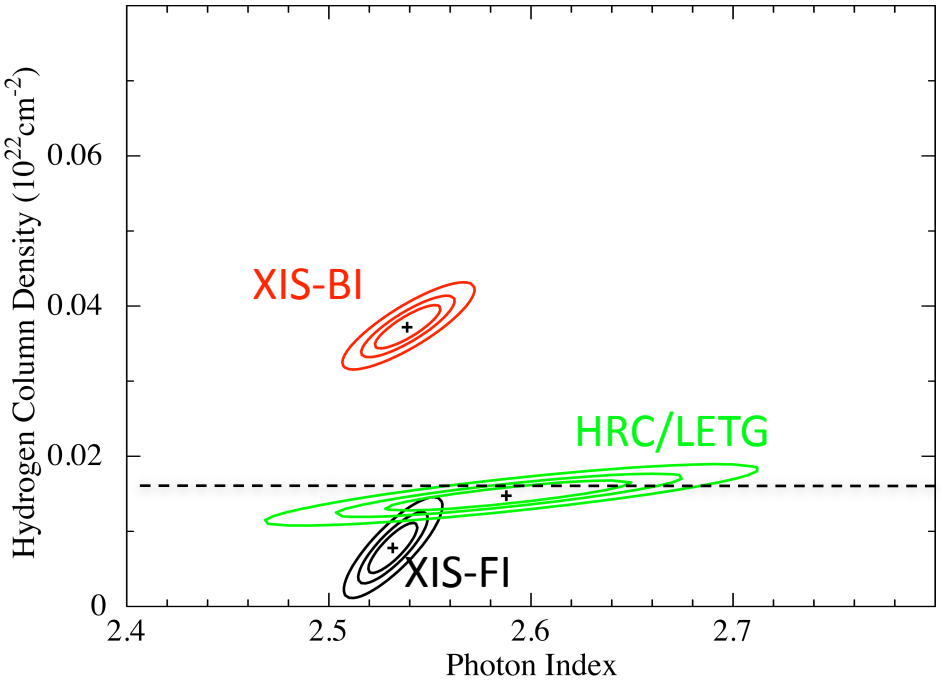
2008, ACIS-S+LETG

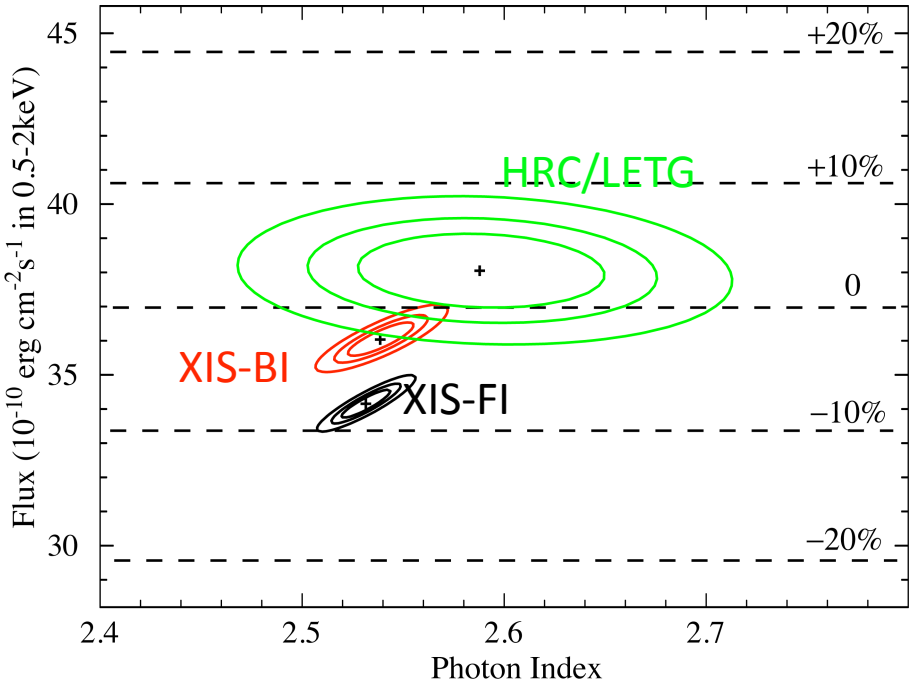


Common GTI with Suzaku

XIS/HRC-LETG parameters (2006)

XIS-FI: 0.4-10.0 keV, HRC/LETG: 0.2-10 keV (+1)
XIS-BI: 0.3-10.0 keV, : 0.245-10 keV (-1)



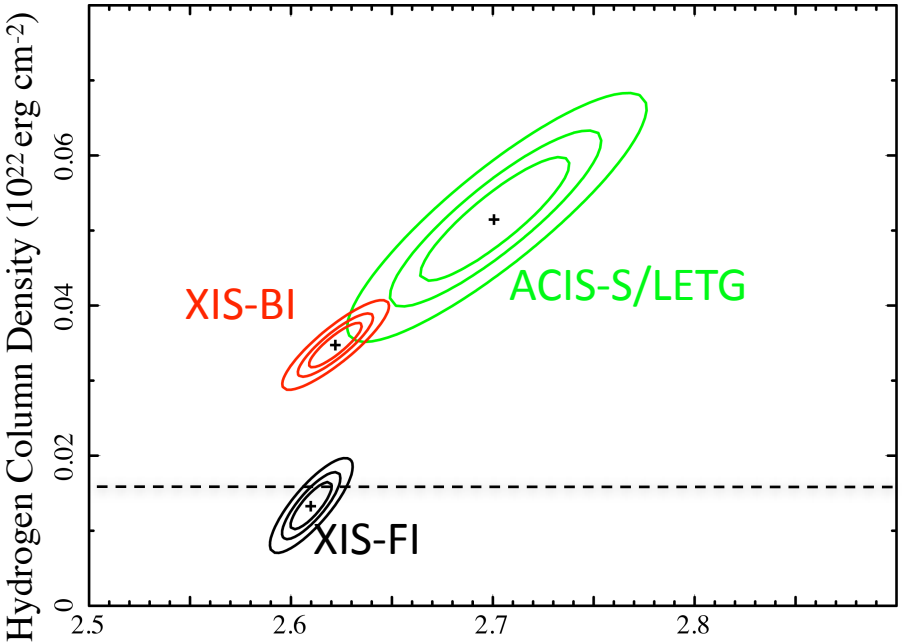


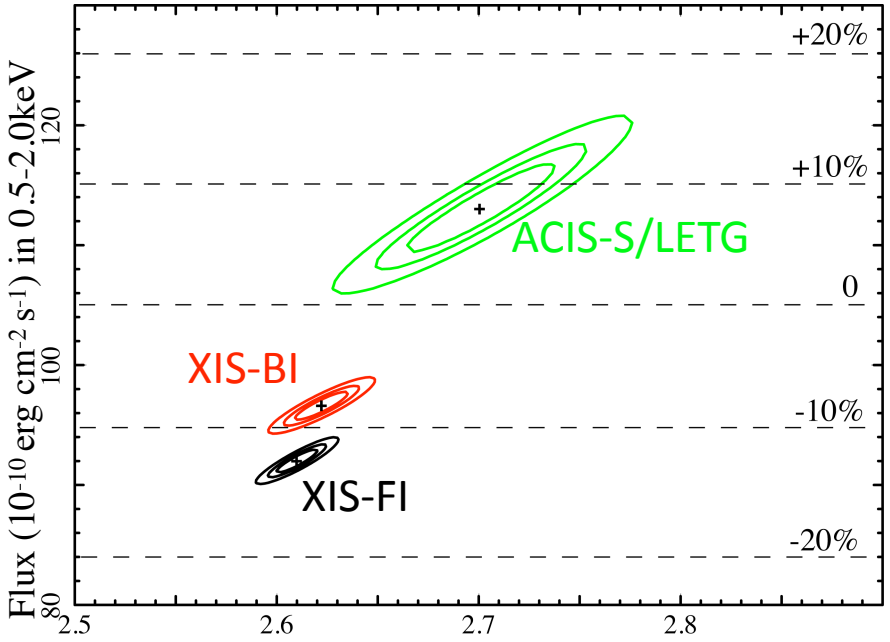
Photon index: 2.53-2.59

HRC/LETG flux in 2006 is larger than those of XIS by 5-10%

XIS/ACIS-S+LETG parameters (2008)

XIS-FI: 0.4-10.0 keV, ACIS-S/LETG: 0.4-10 keV
XIS-BI: 0.3-10.0 keV





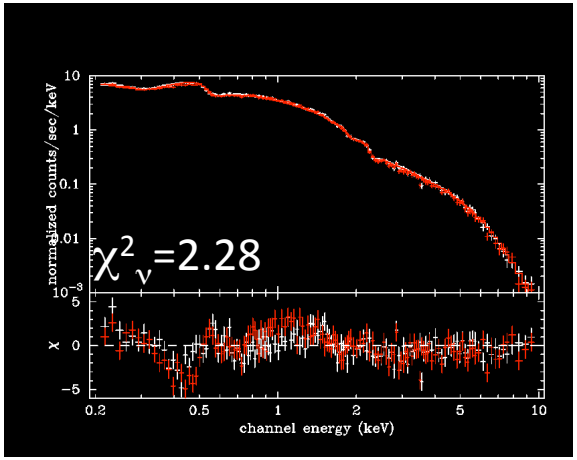
Photon index: 2.61-2.70

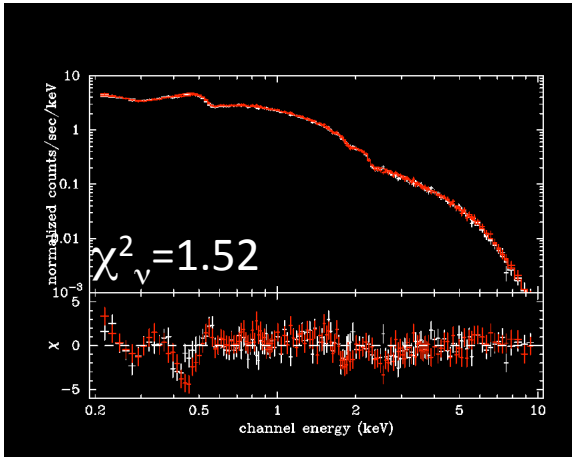
ACIS-S/LETG flux in 2008 is larger than that of XIS by ~20%.

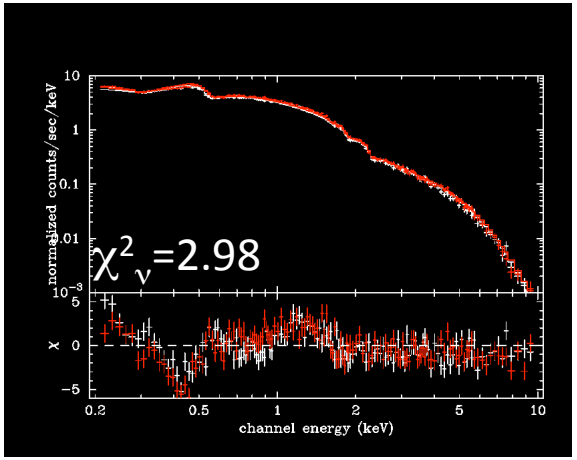
EPIC Spectra: 2005, 2006, 2008

2005 2006 2008

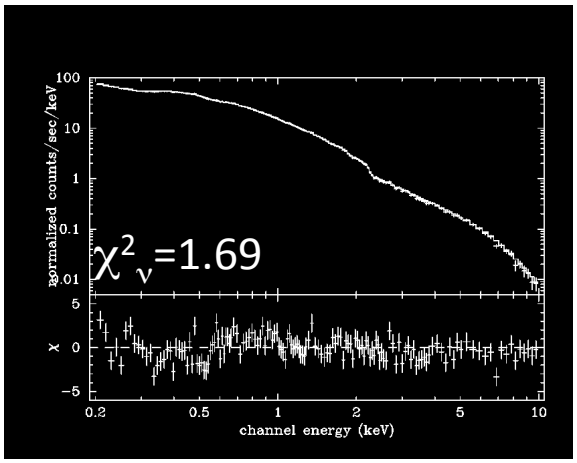
EPIC-MOS

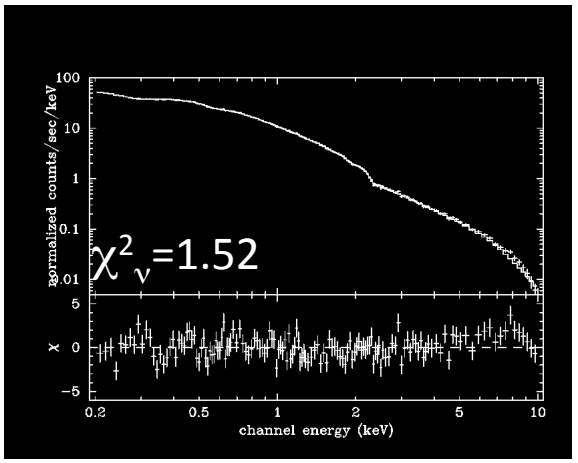


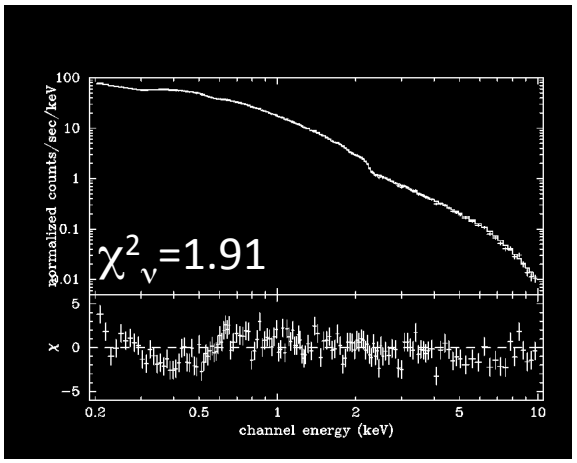




EPIC-pn



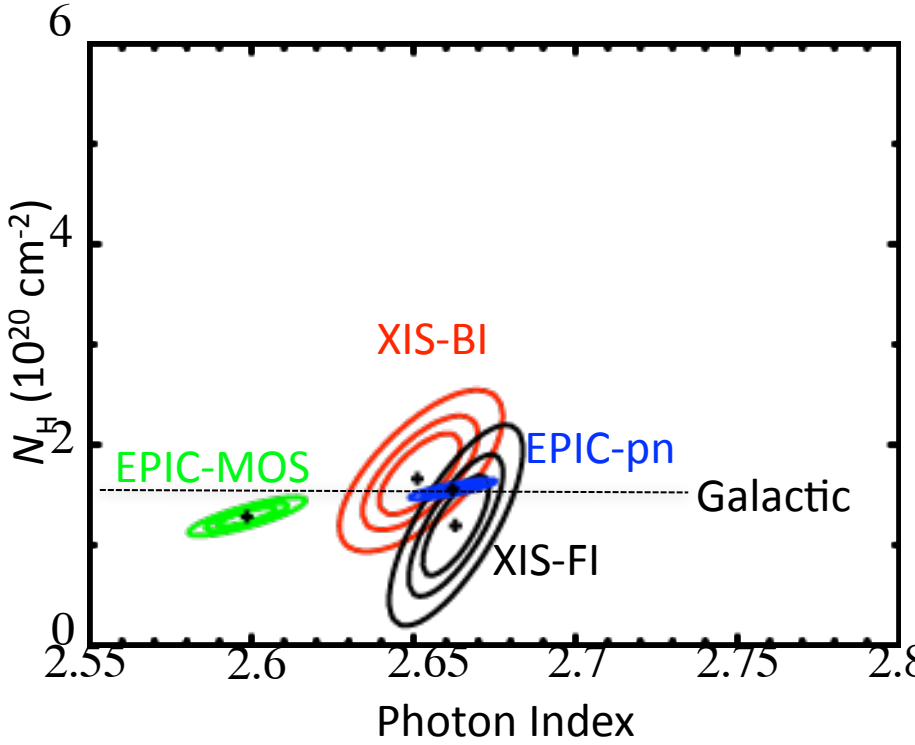


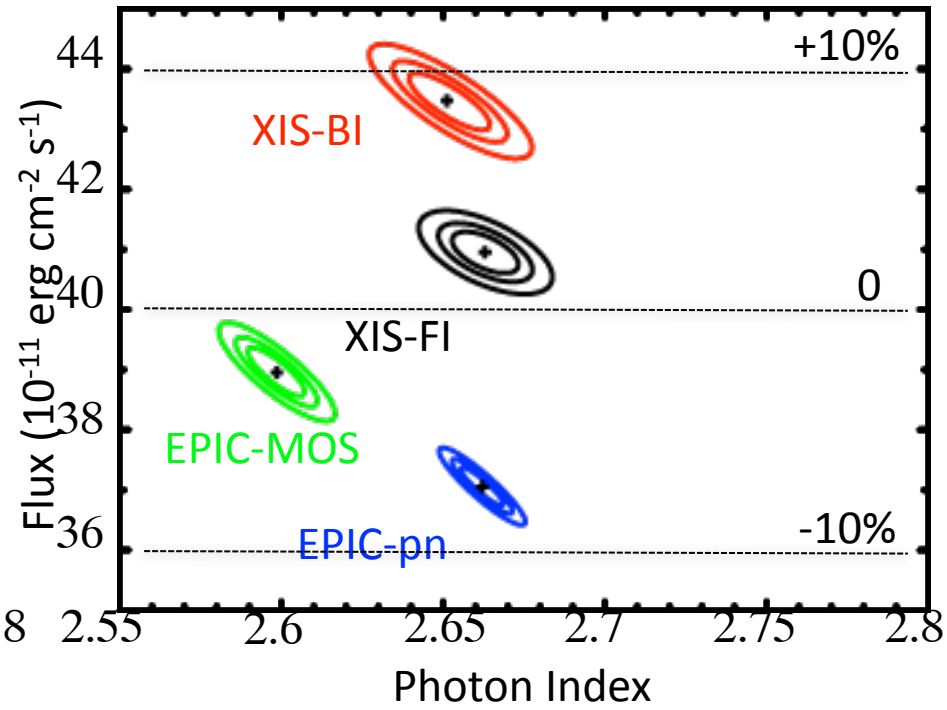


Common GTI with Suzaku

2005 XIS/EPIC parameters

XIS-FI: 0.4-10.0 keV, EPIC-MOS: 0.2-10.0 keV
XIS-BI: 0.3-10.0 keV, EPIC-pn: 0.2-10 keV



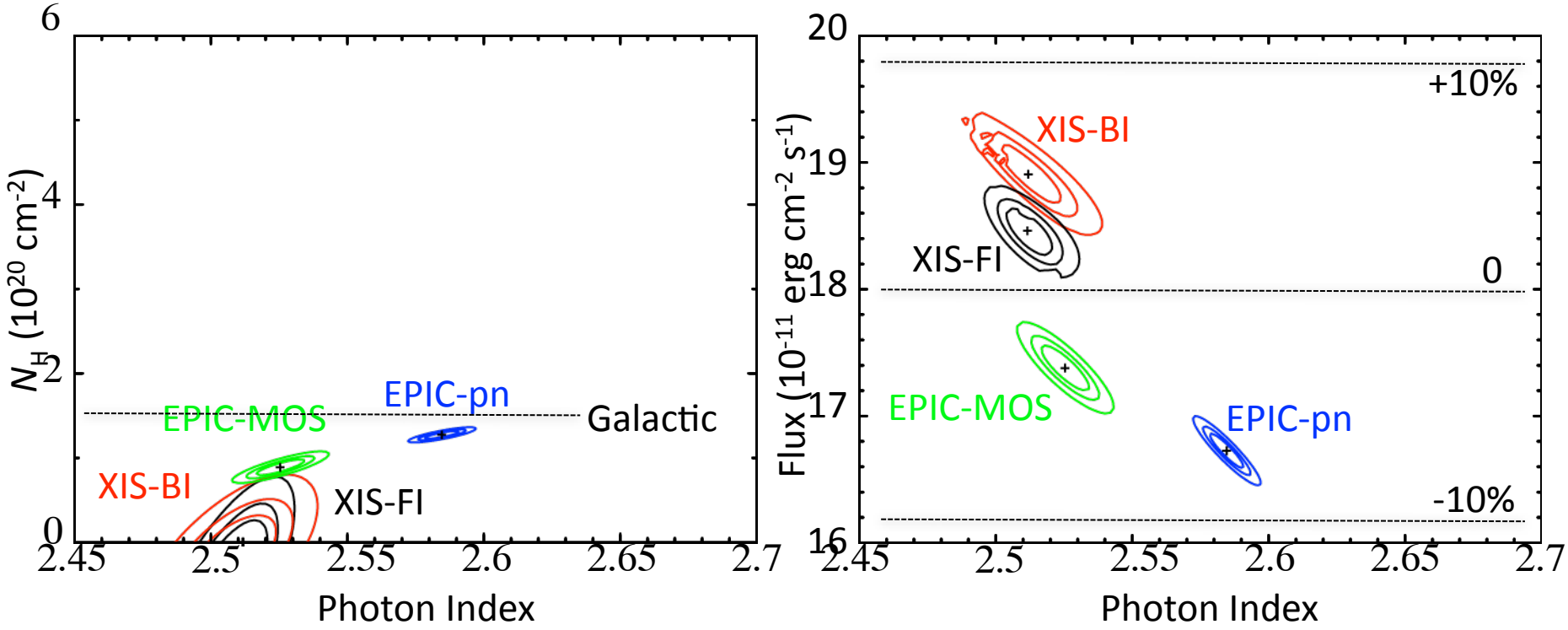


Photon index: 2.60-2.66
NH: consistent with the Galactic value

EPIC flux is smaller than that of XIS by ~10%.

2006 XIS/EPIC parameters

XIS-FI: 0.4-10.0 keV, EPIC-MOS: 0.2-10.0 keV
XIS-BI: 0.3-10.0 keV, EPIC-pn: 0.2-10 keV

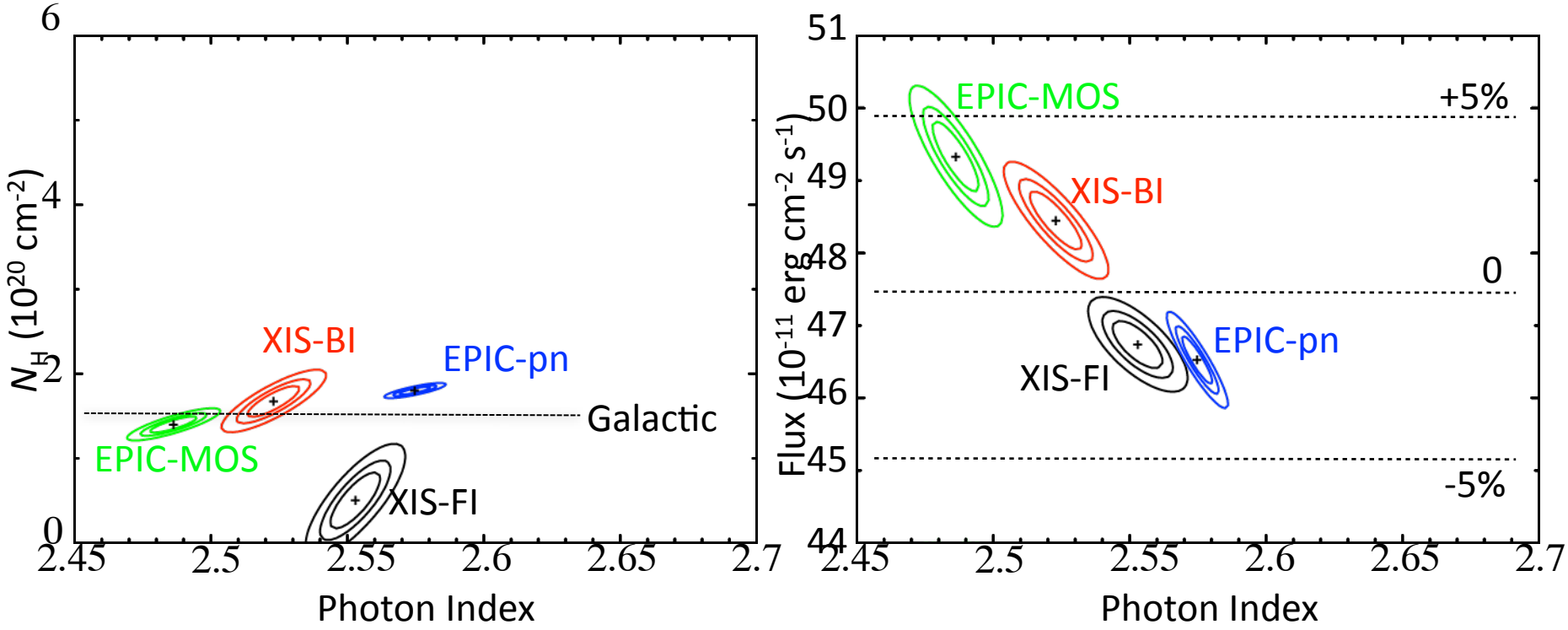


Photon index: 2.51-2.59

EPIC flux is smaller than that of XIS by ~10%.

2008 XIS/EPIC parameters

XIS-FI: 0.4-10.0 keV, EPIC-MOS: 0.2-10.0 keV
XIS-BI: 0.3-10.0 keV, EPIC-pn: 0.2-10 keV



Photon index: 2.48-2.57

XIS flux ~ EPIC flux (within 6%)

Summary

- Photon Index is consistent among all within ~0.1.
- Flux
  - HRC/LETG flux is larger than that of XIS by ~10% in 0.5-2keV in 2006.
  - ACIS-S/LETG flux is larger than that of XIS by ~20% in 0.5-2keV in 2008.
  - EPIC flux is smaller than that of XIS by ~10% in 2005 and 2006.
  - EPIC flux is similar to that of XIS within 6% in 2008.
  - XIS is between EPIC and LETG
- Need more calibration for years later than 2008 at least.