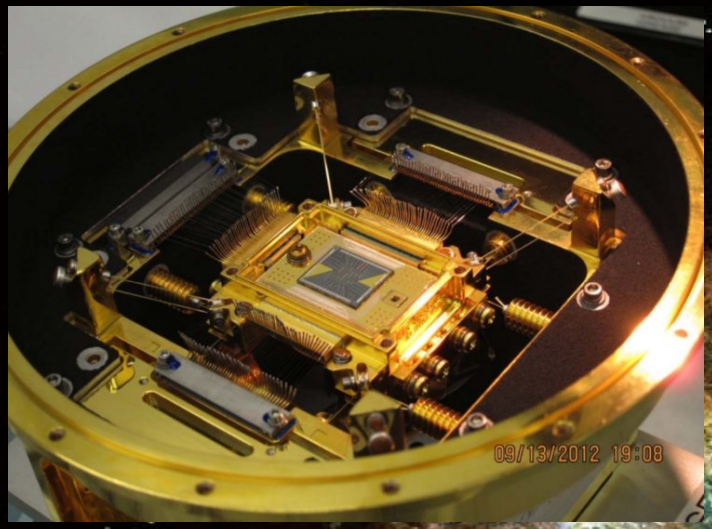
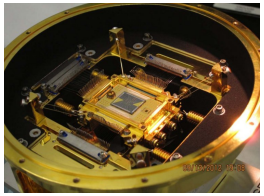


Hitomi SXS in-flight calibration with Crab

NASA, ESA and Allison Loll/Jeff Hester (Arizona State University). Acknowledgement: Davide De Martin (ESA/Hubble)

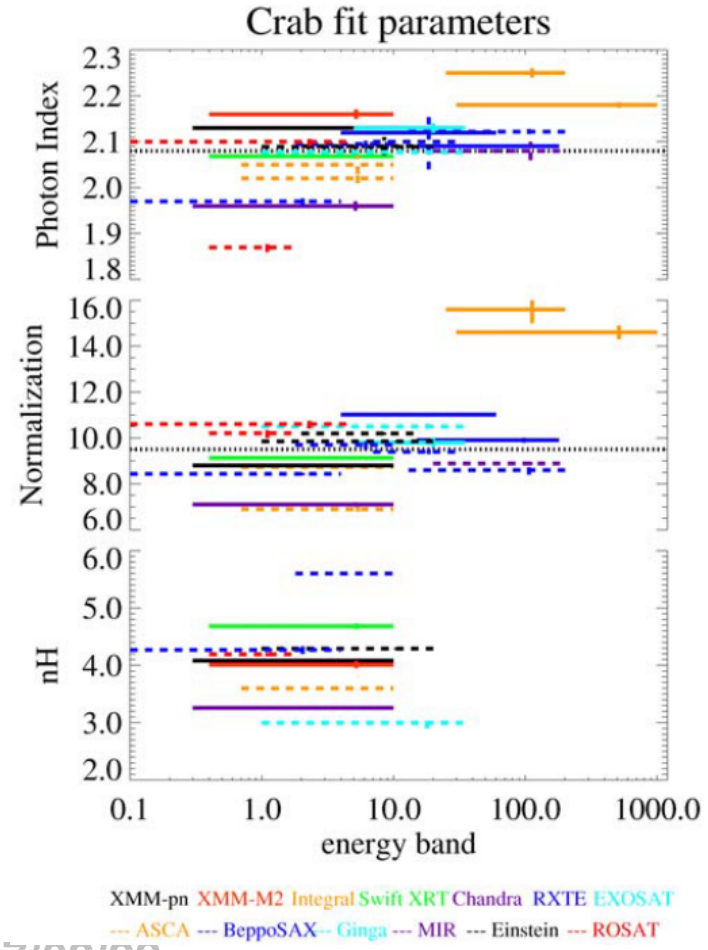
ASTRO-H
SOFT X-RAY SPECTROMETER
NASA/GSFC · ISAS/JAXA

M. Tsujimoto, T. Okajima on behalf of SXS team

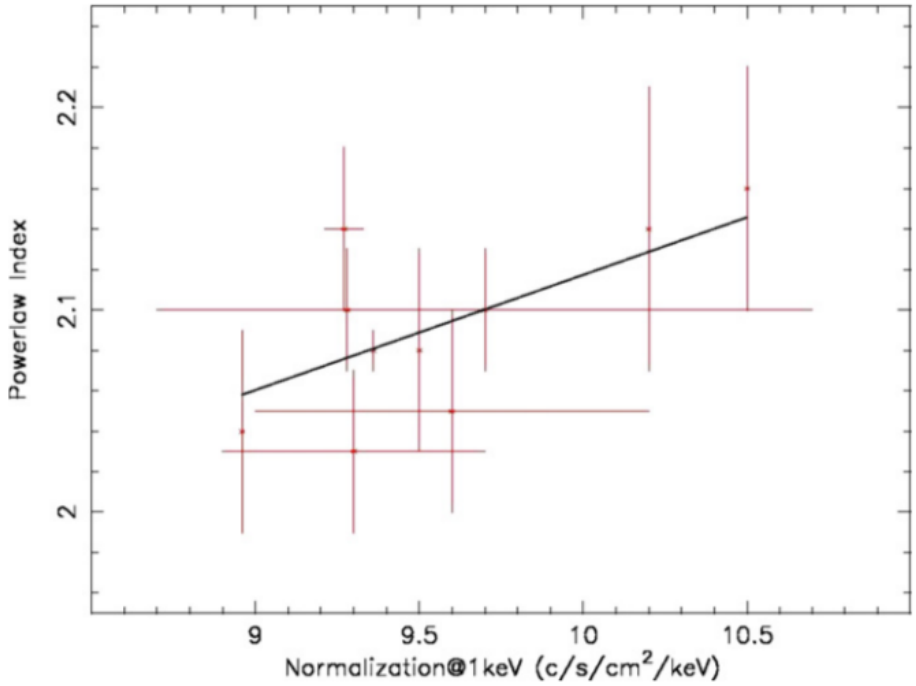


Goals

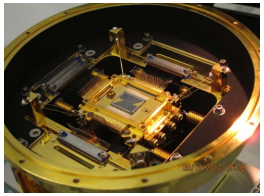
1. Validate SXS calibration with Crab.
2. Add SXS to IACHEC Crab cross-cal results.



Kirsch et al. (2005)

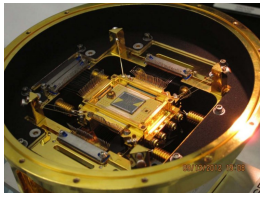


Weisskopf et al. (2010)



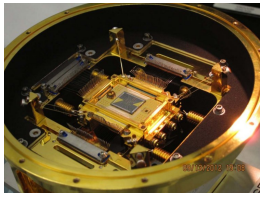
Crab as a standard candle

- Definition of X/γ-ray flux (in the unit of “Crab”).
- Merits:
  - Spectrum is nearly stable, simple, and flat.
  - Built-in clock.
  - Frequently observed. Wealth of data.
- Complexities:
  - Bright. Some flux variability.
  - Extended (pulsar + nebula).
  - Spectral dependence on phase & position.



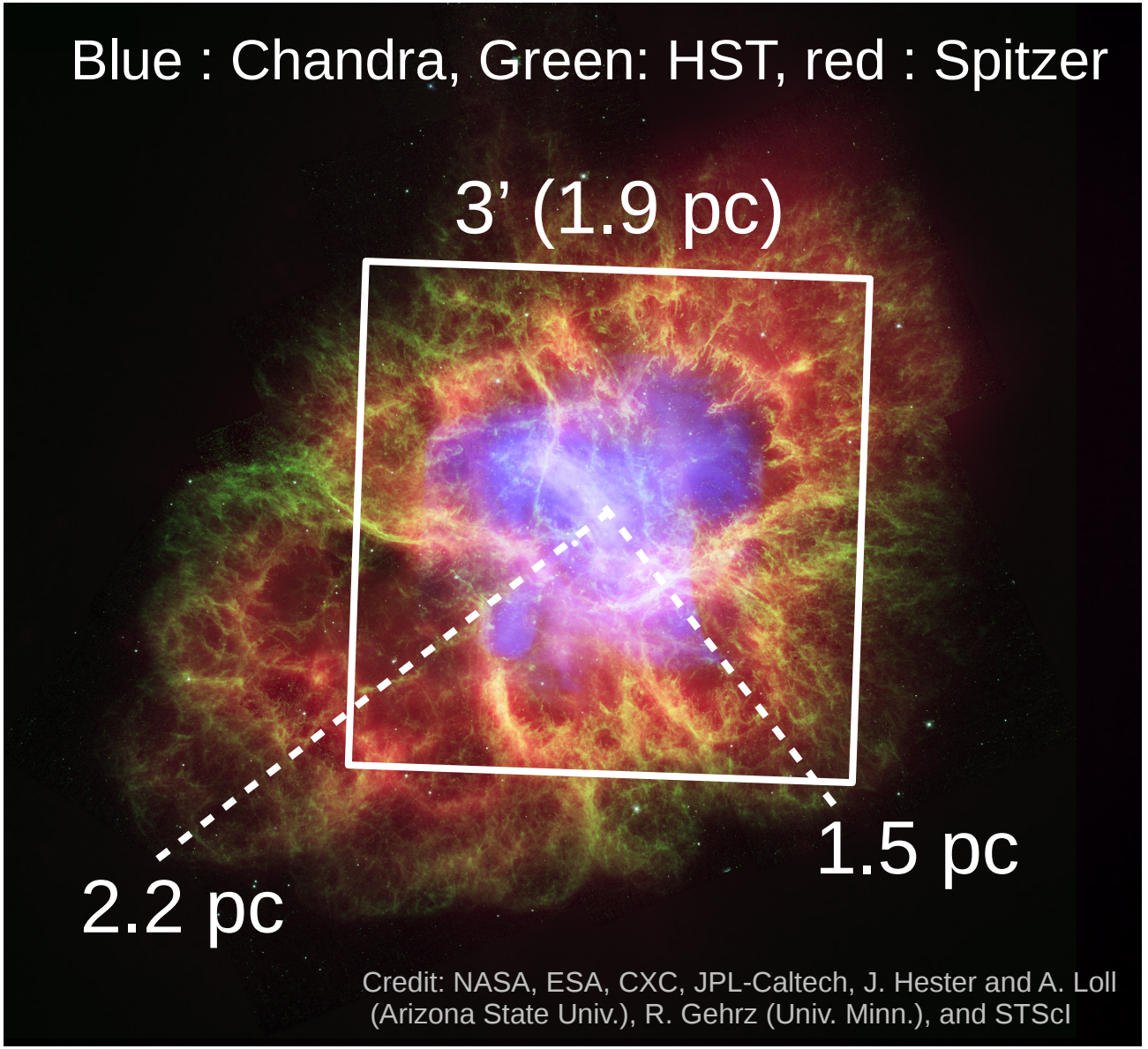
What SXS can & cannot offer

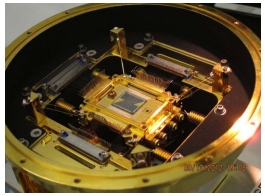
- Merits:
  - Non-dispersive.
  - Sharp LSF. Very low NXB (< 1 /5eV/100ks).
  - Only one observation mode.
  - <80μs timing resolution to resolve phase.
  - Wide bandpass: 0.1-20 keV.
  - Comparison with SXI: CCD w. same telescope.
- Demerits:
  - Coarse spatial resolution. $\Delta\theta \sim 1.2$ arcmin.
  - Data w. gate valve. Sensitivity < 2 keV lost.



Observation

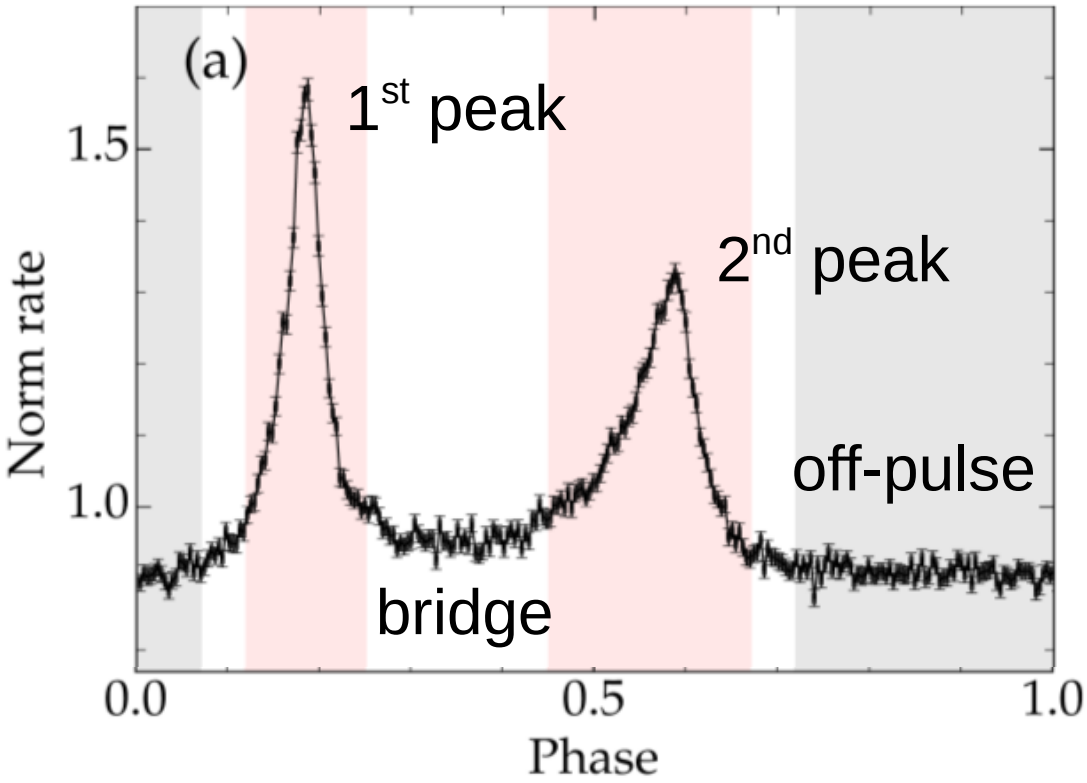
- 2016/3/25
- t_{exp} = 9.7 ks
- *E* > 2 keV & *Fx*~0.13 “Crab” w. GV.
- 1.8M events.





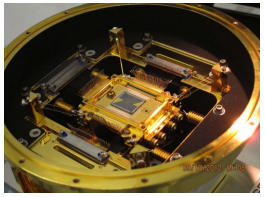
Data sets (1) Image & Pulse

(a)	P23 2.03	P24 3.69	P26 4.52	P34 3.23	P32 2.25	P30 1.29
	P21 3.87	P22 10.70	P25 16.01	P33 16.44	P31 8.00	P29 2.83
acB 0.17	P19 5.78	P20 18.73	P18 37.35	P35 34.39	P28 13.69	P27 35.60
acA 0.20	P9 4.75	P10 21.32	P17 35.60	P0 27.49	P2 11.47	P1 4.20
	P11 3.90	P13 11.98	P15 15.62	P7 10.73	P4 5.97	P3 2.32
		P14 3.57	P16 3.98	P8 3.60	P6 2.22	P5 1.02
P12 5.98						

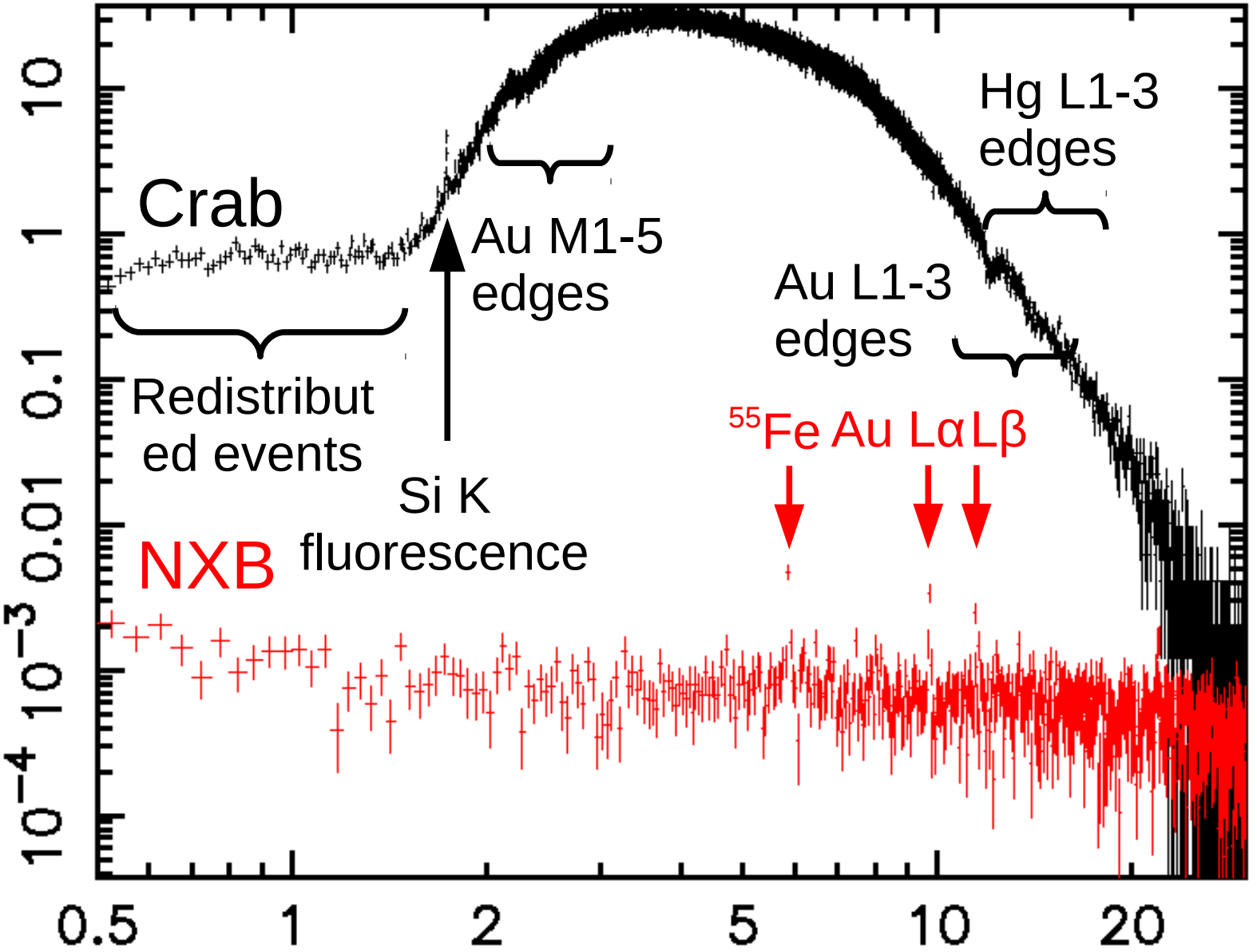


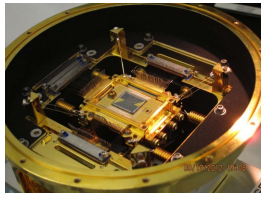
Event candidate rate by FPGA.
36 independent spectrometers.
Contrast by x40.

“Raw” folded light curve.
(No correction needed.)

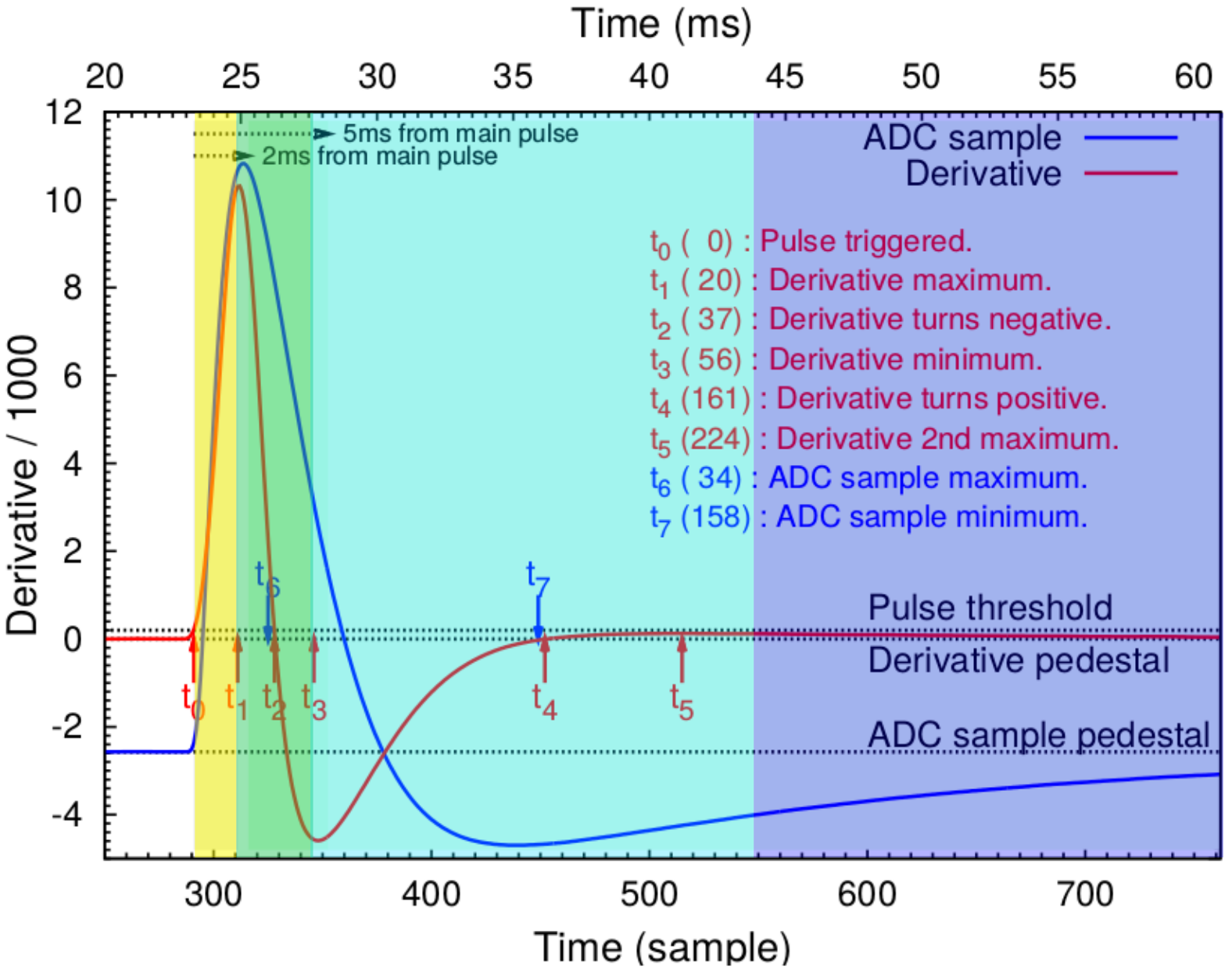


Data sets (2) Spectrum



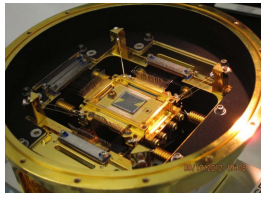


(1) Pile-up



Pile-up pulses are:

- De-blended, graded medium.
- De-blended, graded low.
- Flagged, not de-blended, discarded (~0.1%)
- Unrecognized (~0.1%)



(2) CPU dead time

Event candidate rate by FPGA

Live time fraction

Event processed Rate by CPU

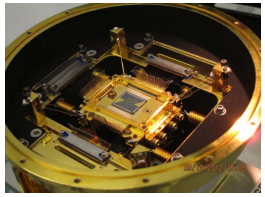
P23 2.03	P24 3.69	P26 4.52	P34 3.23	P32 2.25	P30 1.29
P21 3.87	P22 10.70	P25 16.01	P33 16.44	P31 8.00	P29 2.83
P19 5.78	P20 18.73	P18 37.35	P35 34.39	P28 13.69	P27 35.60
P9 4.75	P10 21.32	P17 35.60	P0 27.49	P2 11.47	P1 4.20
P11 3.90	P13 11.98	P15 15.62	P7 10.73	P4 5.97	P3 2.32
	P14 3.57	P16 3.98	P8 3.60	P6 2.22	P5 1.02

B0 B1 A1 A0

P23 1.00	P24 1.00	P26 1.00	P34 1.00	P32 1.00	P30 1.00
P21 1.00	P22 0.94	P25 0.72	P33 0.98	P31 1.00	P29 1.00
P19 0.99	P20 0.61	P18 0.27	P35 0.66	P28 1.00	P27 0.37
P9 0.98	P10 0.62	P17 0.37	P0 0.89	P2 1.00	P1 1.00
P11 0.99	P13 0.99	P15 0.92	P7 1.00	P4 1.00	P3 1.00
	P14 1.00	P16 1.00	P8 1.00	P6 1.00	P5 1.00

P23 1.41	P24 2.60	P26 2.79	P34 2.21	P32 1.56	P30 0.96
P21 2.74	P22 7.80	P25 9.22	P33 11.30	P31 5.58	P29 1.93
P19 3.85	P20 9.21	P18 8.67	P35 17.45	P28 9.80	P27 9.61
P9 3.32	P10 9.87	P17 9.61	P0 17.02	P2 8.13	P1 2.83
P11 2.71	P13 8.35	P15 9.95	P7 7.75	P4 4.14	P3 1.59
	P14 2.43	P16 2.71	P8 2.41	P6 1.51	P5 0.71

- Duration of dead time ~ buffer size ~ 2-20 sec.
- Correction made for ARF.

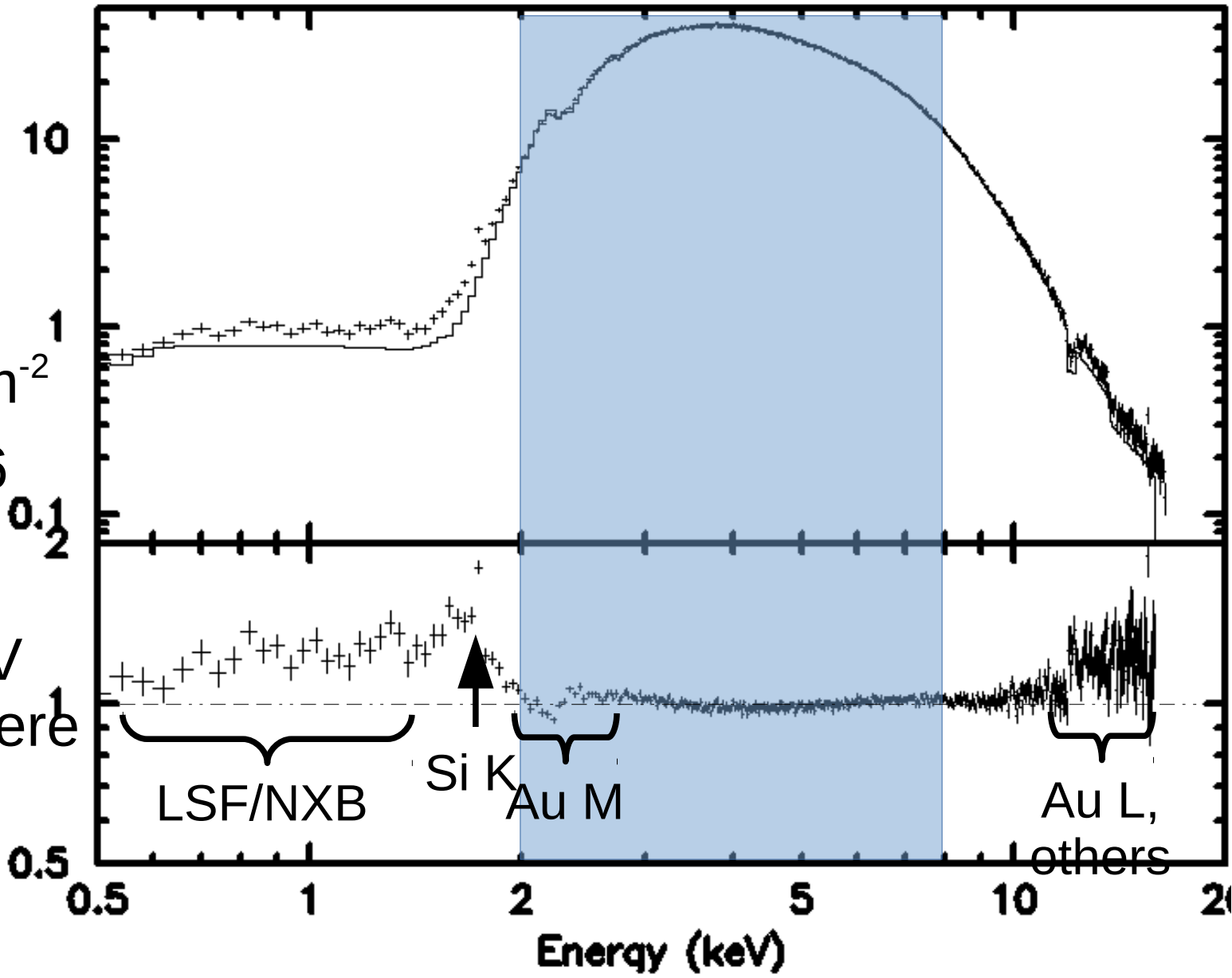


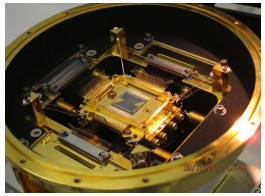
(1) Overall fitting

Data:
2-8 keV used.

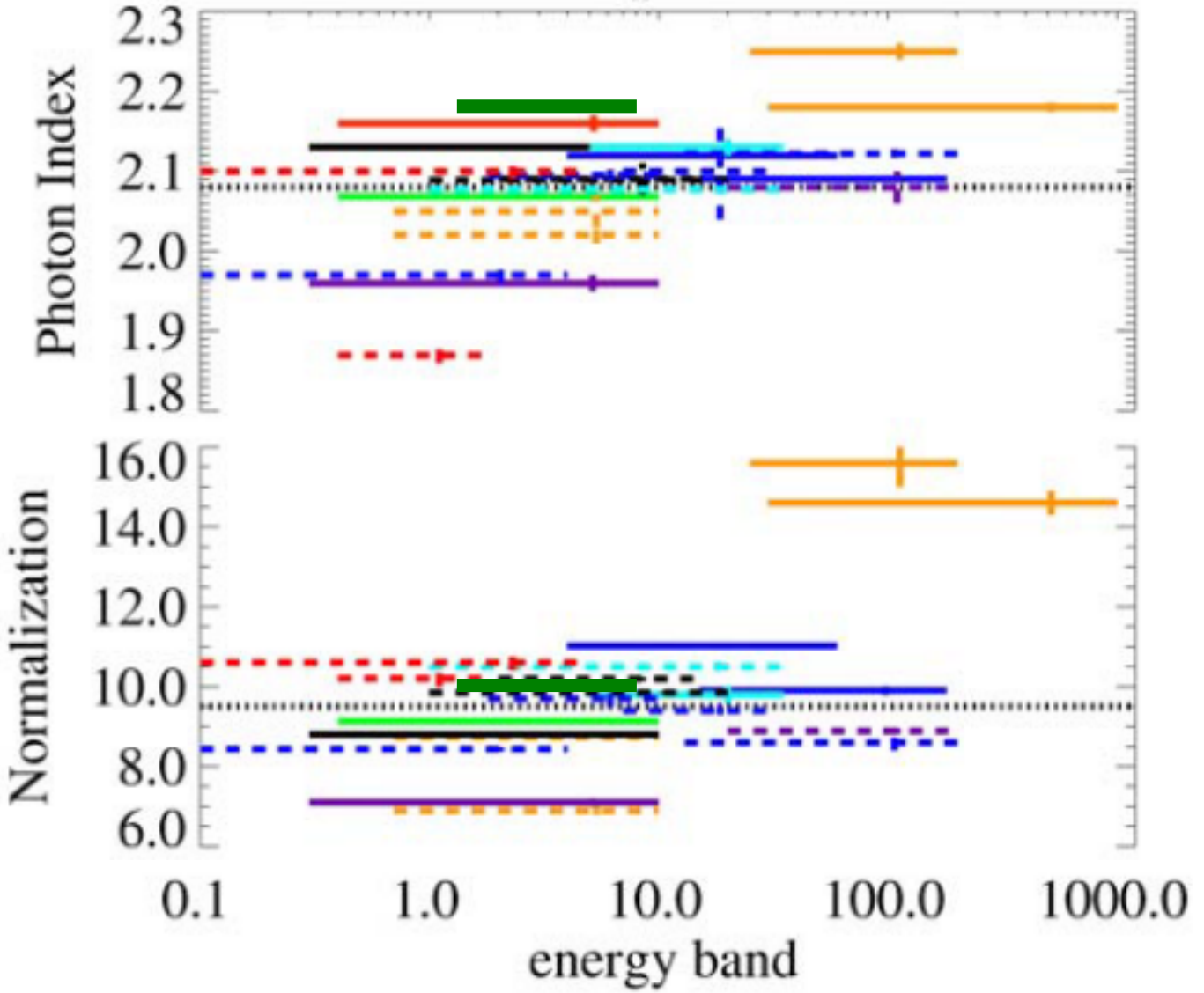
Model:
- Tbnew*pow.
- N_H=4.2x10^{21}cm^{-2}
- [O]/[H] = 0.676

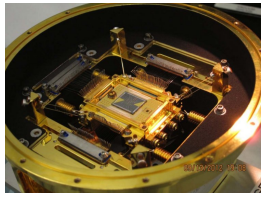
Residuals:
- < 3%@2-8 keV
- Larger elsewhere



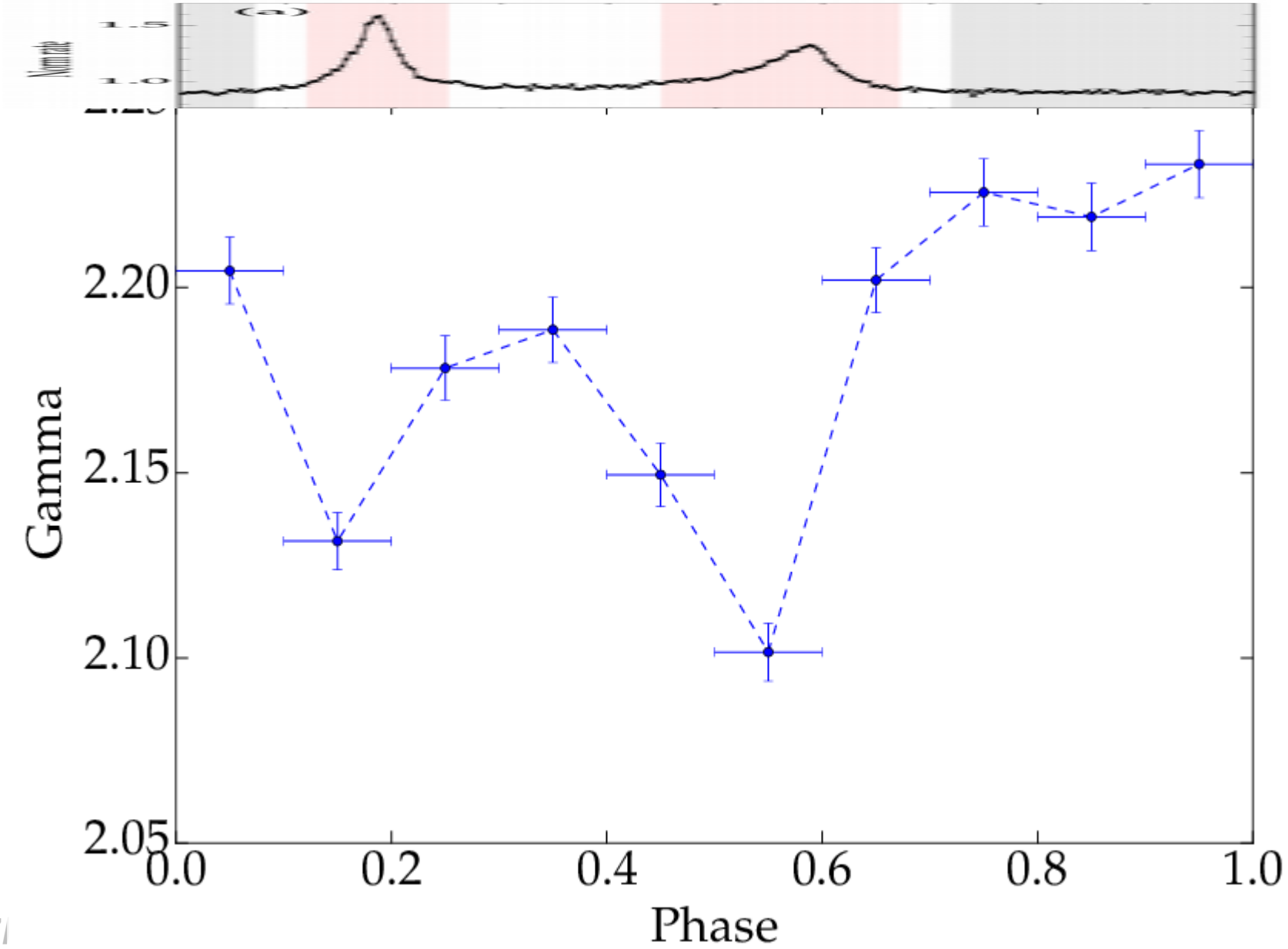


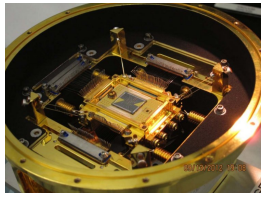
(2) Comparison w. IACHEC





(3) Phase dependence

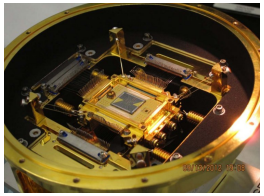




(4) Systematic uncertainties

(Preliminary) uncertainties in Norm.

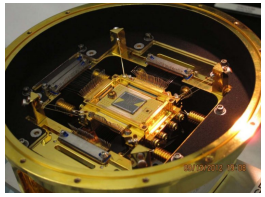
Range (keV)	2-4	4-8	8-16	2-20
Mirrors	2%	7%	2%	7%
GV	<1.4%	<0.4%	<0.4%	<1.4%
Filters	~1%	~1%	~1%	~1%
De QE	<0.1%	<0.4%	<0.8%	<1%
Dead time	<0.2%	<0.2%	<0.2%	<0.2%
NXB	<0.003%	<0.004%	<0.03%	<0.007%
Crab	?	?	?	?



Conclusion

- Goals:
  - (a) To validate SXS calibration.
  - (b) To compare with the IACHEC result.
- Results:
  - Norm, Gamma within IACHEC ranges.
  - Gamma softer than others.
  - Residuals outside of 2-8 keV range.
- See also
  - All the other SXS results (Session V)
  - S. Koyama for timing (Session VII)
  - T. Sato for SXT (Sessoin VIII)

BACKUP



(1) S/C pointing

Average position of events

Event candidate rate by FPGA

Anti-co evnet rate