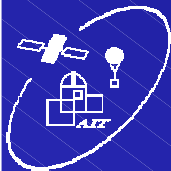# Calibration of the EPIC-pn Camera in the Fast Modes
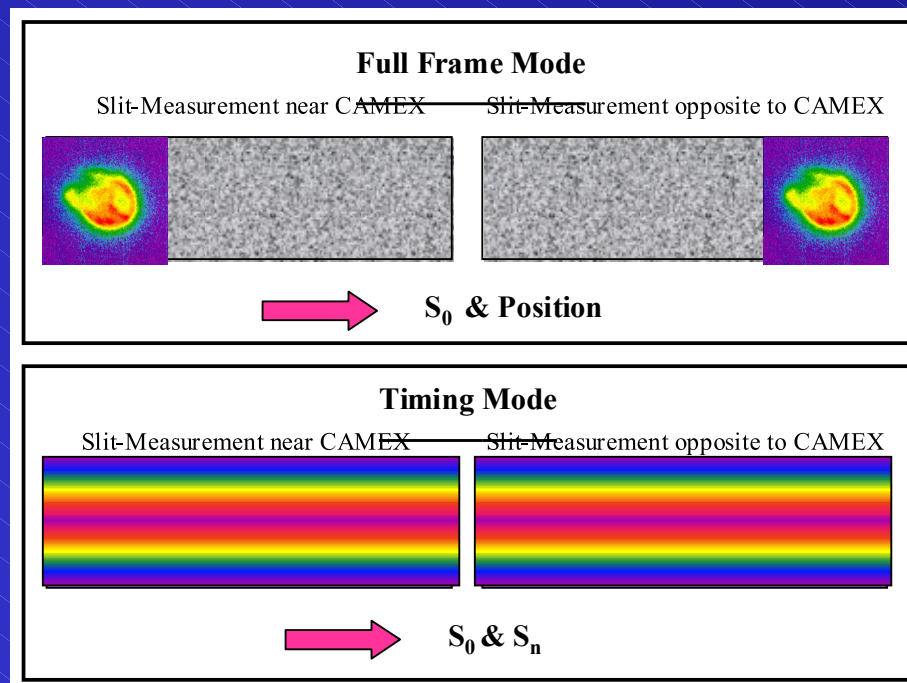
## Marcus Kirsch IAAT

- **update Timing Mode**
  - status of calibration based on N132D
  - CAS A observation
  - final CTE/gain tuning function
  - accuracy of calibration

- **update Burst Mode**
  - calibration campaign @ PANTER
  - in-orbit-cal with CRAB
  - fine-tuning and accuracy
  - necessity for new cal observation

# status of cal with N132D

**Full Frame Mode**

Slit-Measurement near CAMEX    Slit-Measurement opposite to CAMEX

$S_0$ & Position

**Timing Mode**

Slit-Measurement near CAMEX    Slit-Measurement opposite to CAMEX

$S_0$ & $S_n$

1. CTE
   – line positions after CTE correction for near and opposite to CAMEX compared
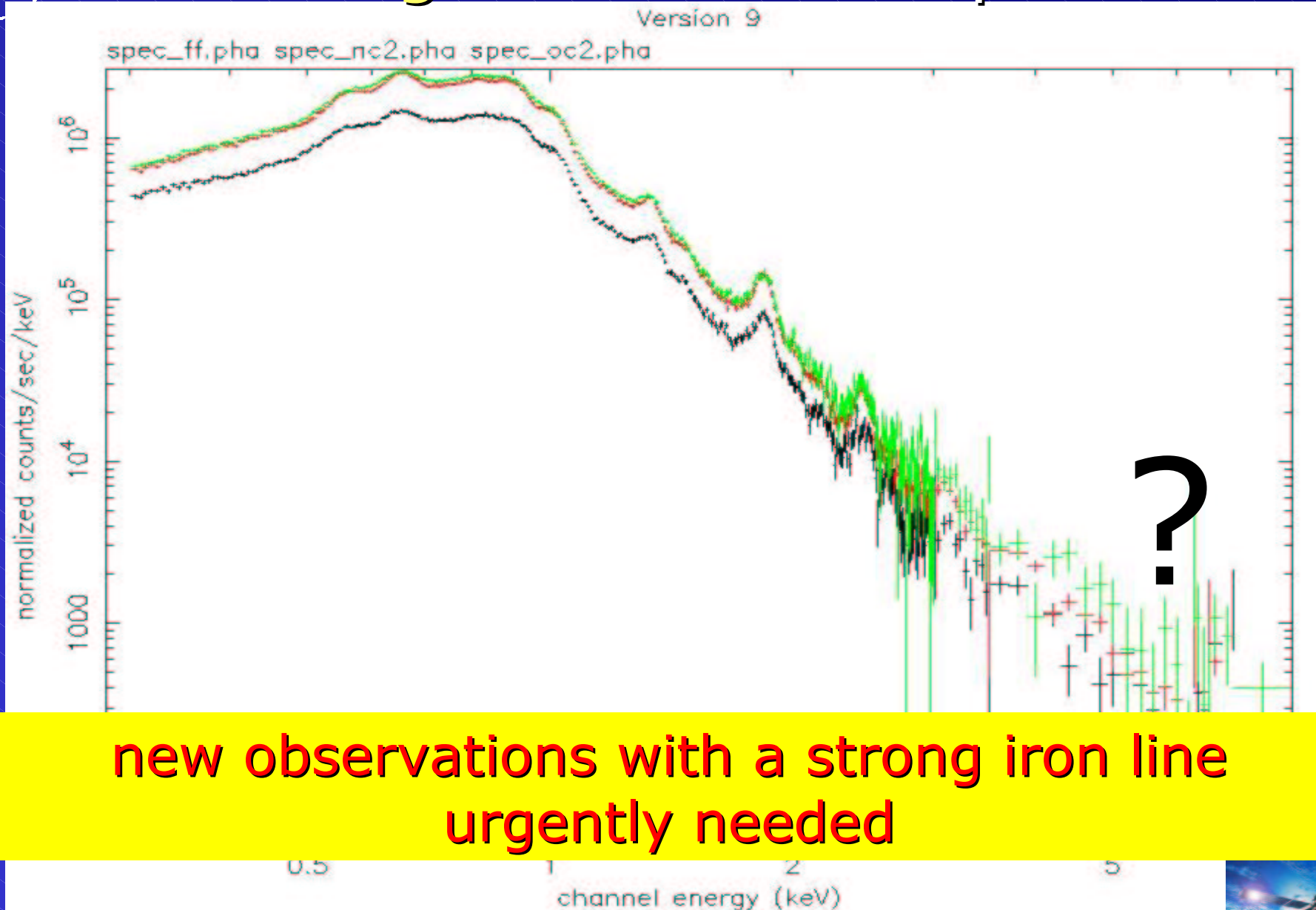   – CTE-model parameters tuned
   – CTE self consistent in Timing

2. gain
   – line positions in Timing and FF compared
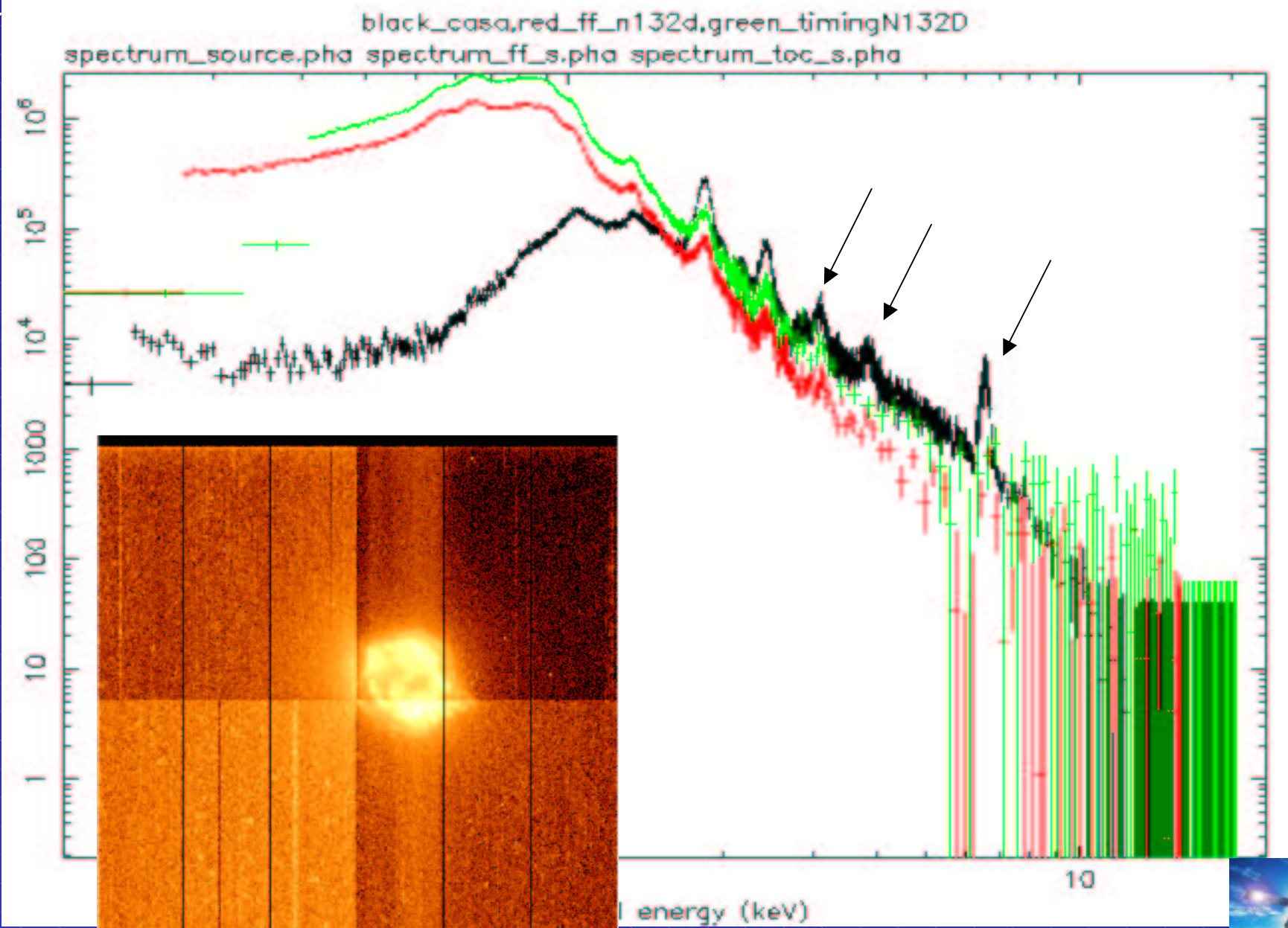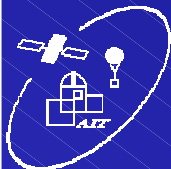   – adjusted to FF

# CTE & gain corrected spectra



new observations with a strong iron line urgently needed

M. Kirsch EPIC-pn

# CAS-A



black_casa,red_ff_n132d,green_timingN132D
spectrum_source.pha spectrum_ff_s.pha spectrum_toc_s.pha

energy (keV)

# NRCO CAS-A



Q0    Q1

Q3    Q2
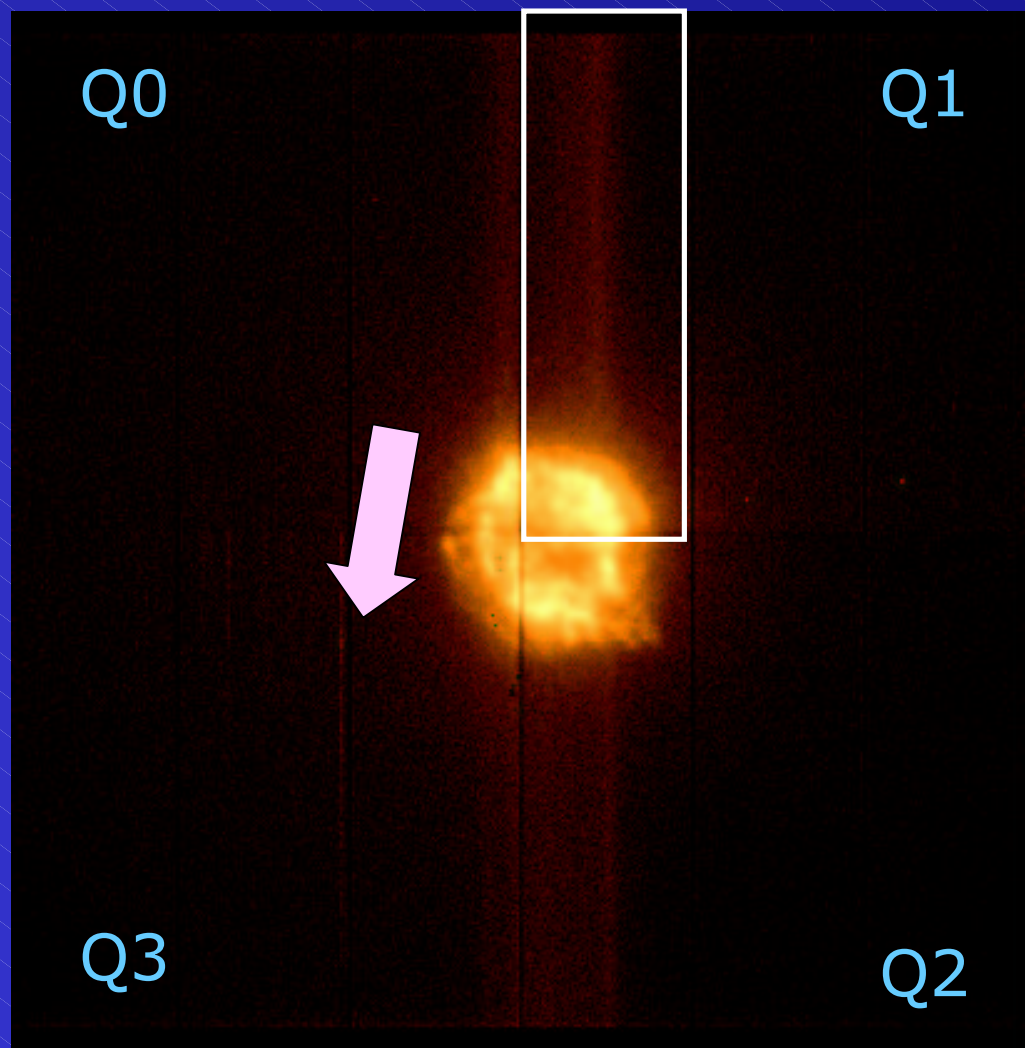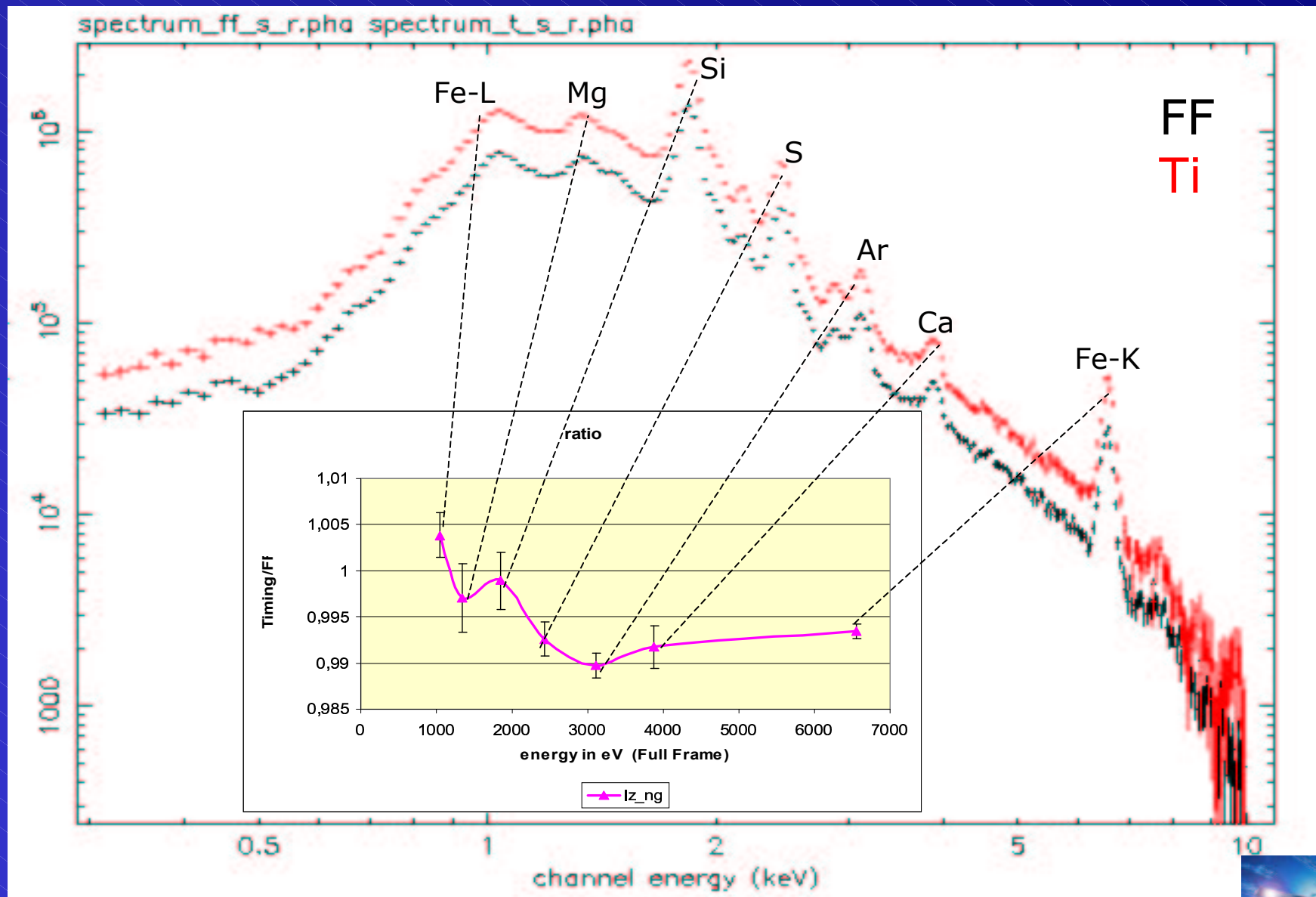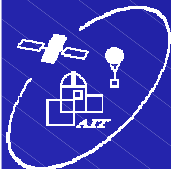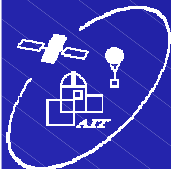
- special pointing in Q1 for Timing Cal with the least feasible extension of source

- Revolution 312
    - 12.3 ks Full Frame
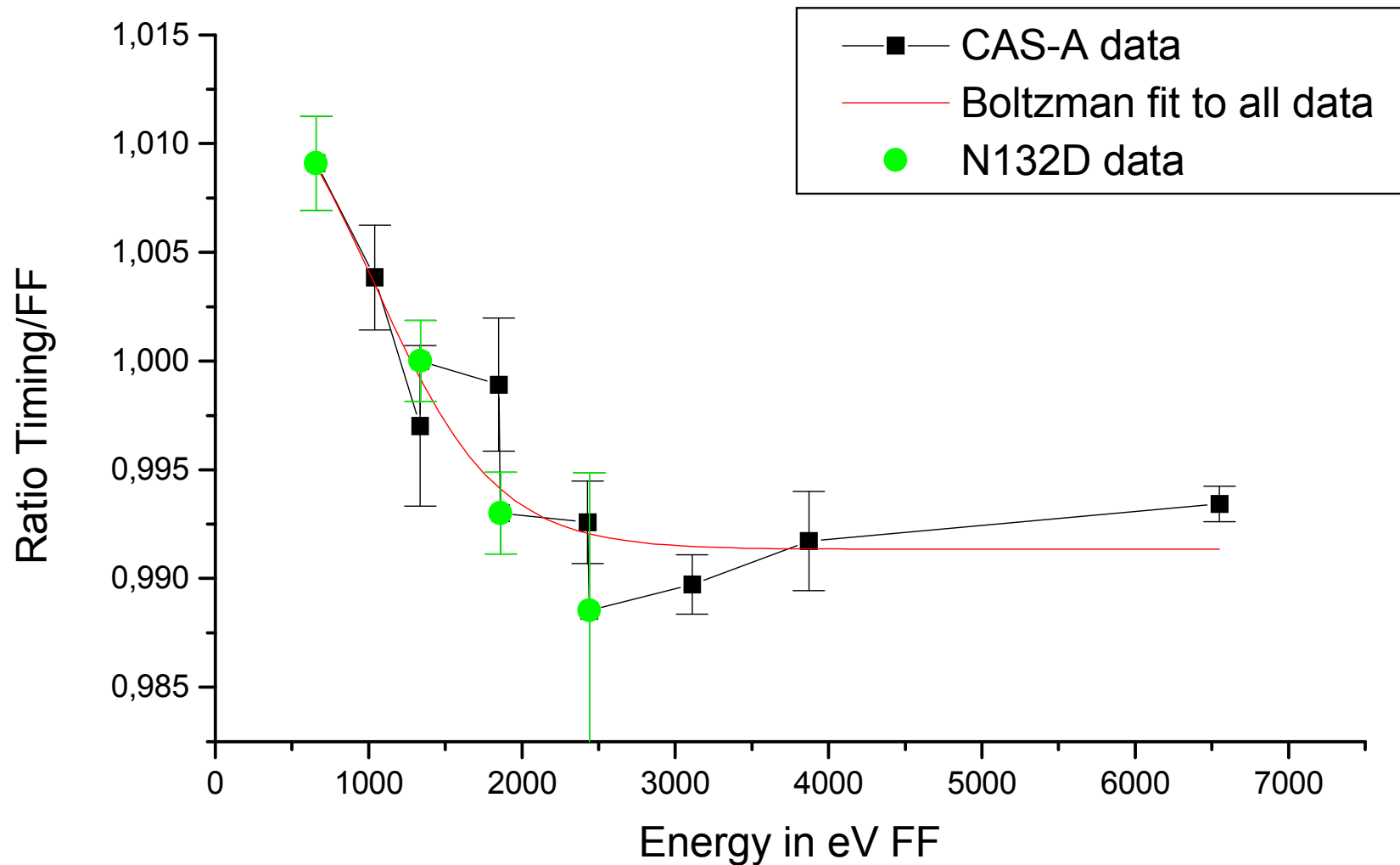    - 12.4 ks Timing
    - 14.1 ks Small Window

M. Kirsch EPIC-pn

spectrum_ff_s_r.pha spectrum_t_s_r.pha

FF
Ti

Si
Fe-L
Mg
S
Ar
Ca
Fe-K

ratio

Timing/Ff

1,01
1,005
1
0,995
0,99
0,985

0    1000   2000   3000   4000   5000   6000   7000

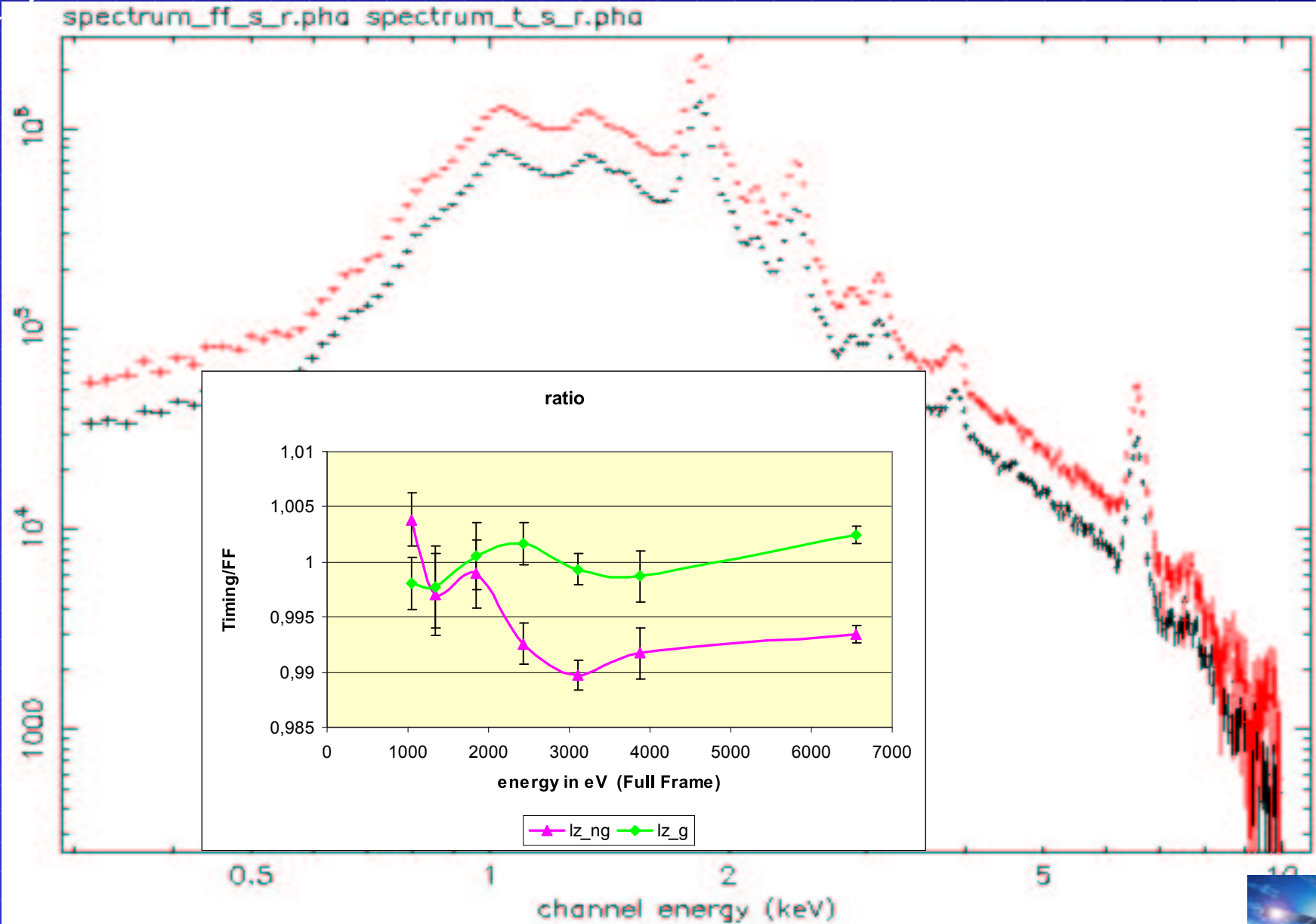energy in eV  (Full Frame)

Iz_ng

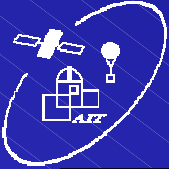channel energy (keV)

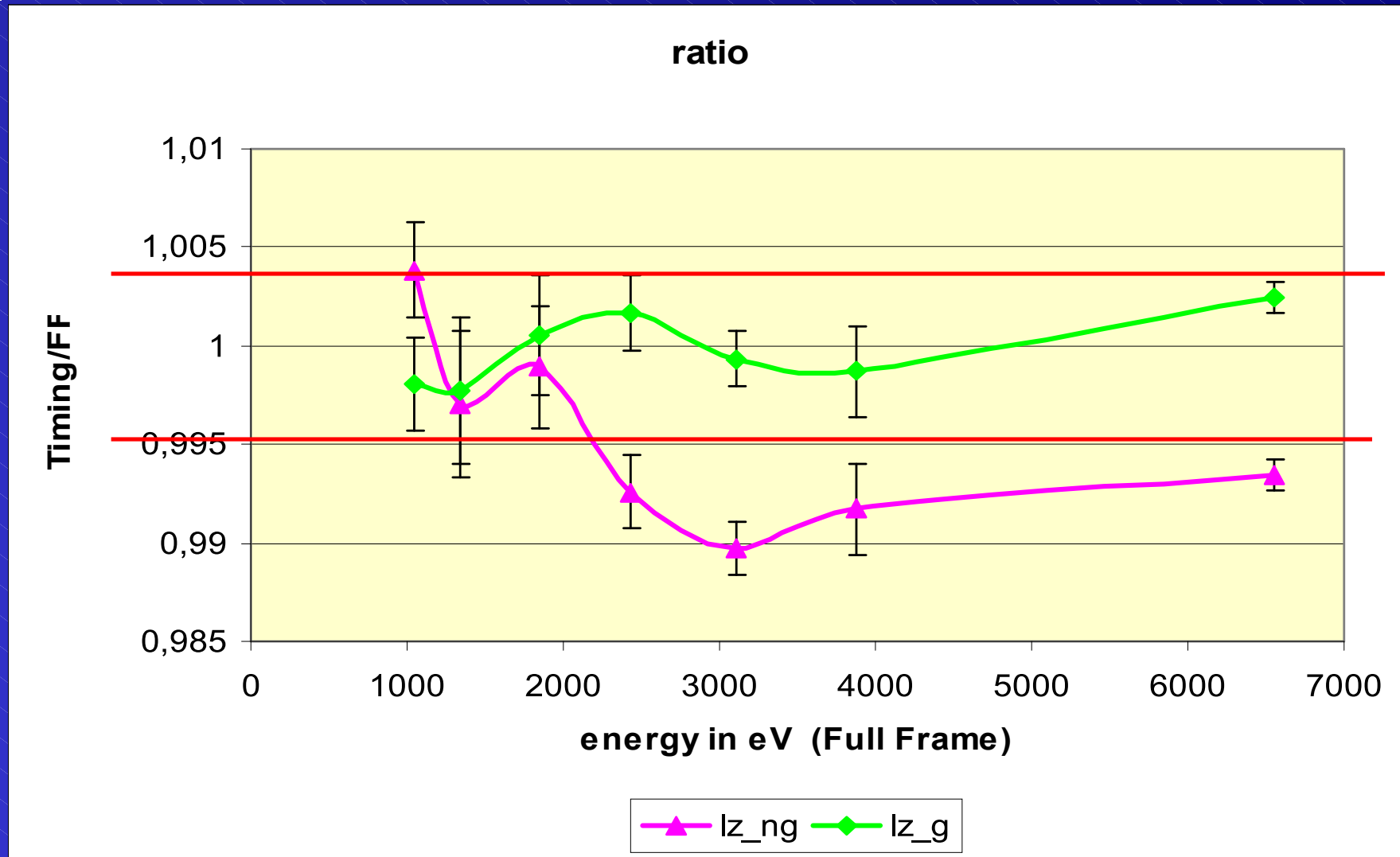# new gain tuning function

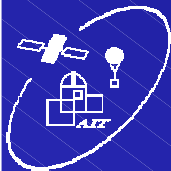# ratio after gain tuning

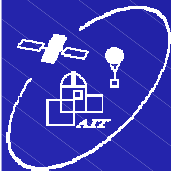# accuracy of calibration

ratio



better than ± 0.3 %

# mainstream of corrections in Timing Mode

1. gain correction Full Frame

2. CTE correction Timing

3. additional gain correction for Timing

4. $2^{nd}$ order corrections Full Frame
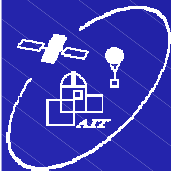   (long term CTE & temperature)

# update Burst Mode

- Calibration campaign @ PANTER
  - energy resolution
  - energy redistribution
  - Burst Mode versus SW Mode
  - tuning function
- In orbit calibration with the CRAB
  - applying ground tuning function
  - final tuning with gold-edge
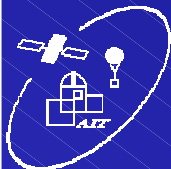  - photon index
  - new in orbit cal measurement
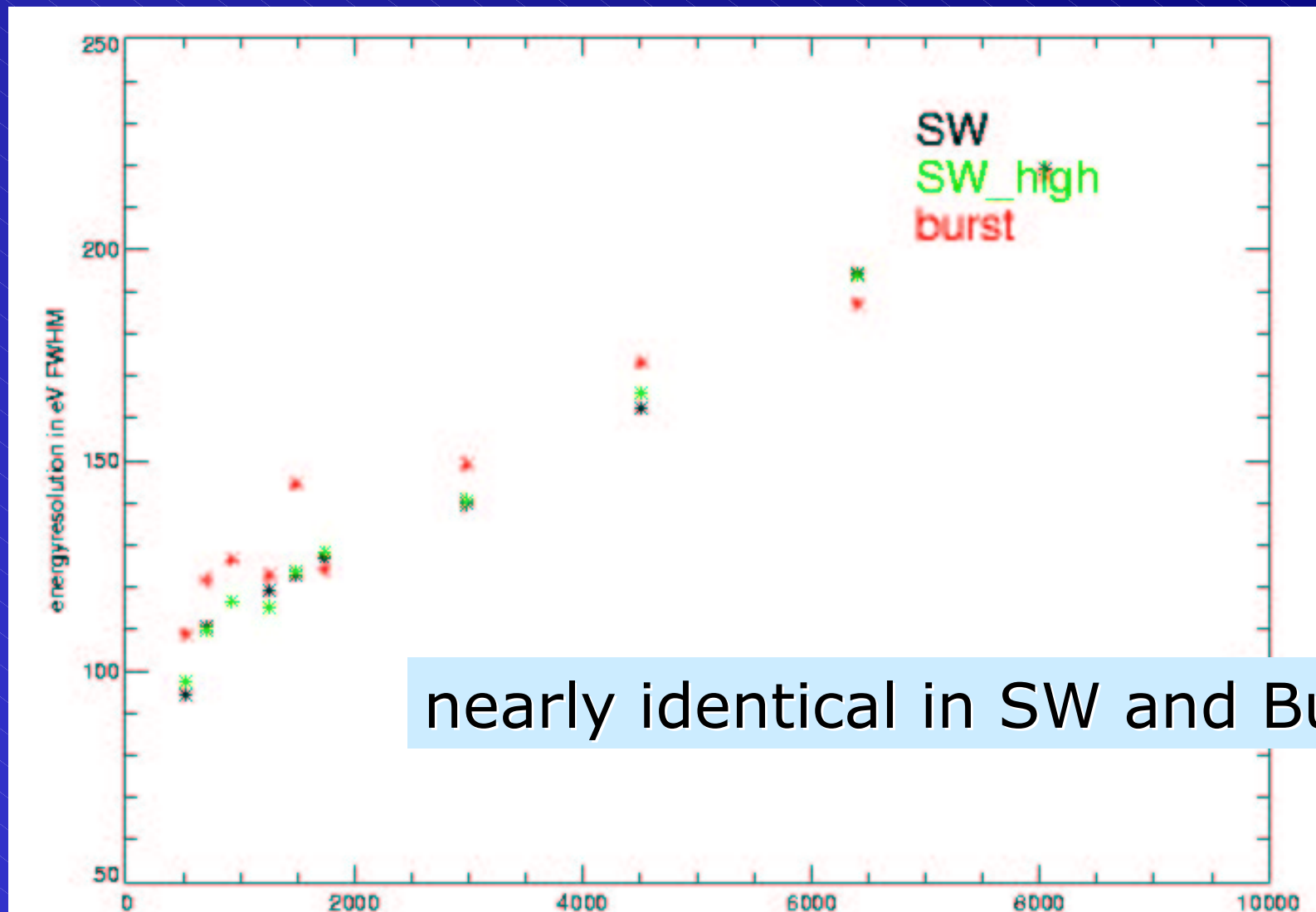
# Burst Mode boot strapping

1. slit near CAMEX in FF

2. slit POS 1 in SW

3. slit POS 2 in SW

4. slit POS 2 in SW max. rate

5. slit POS 2 Burst max. rate

| Target | Energy in eV |
|--------|--------------|
| O      | 525          |
| Fe-L   | 705          |
| Cu-L   | 930          |
| Mg-K   | 1254         |
| Al-K   | 1487         |
| Si-K   | 1740         |
| Mo-L   | 2293         |
| Ag-L   | 2984         |
| Ti-K   | 4511         |
| Fe-K   | 6404         |
| Cu-K   | 8048         |

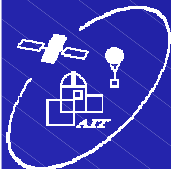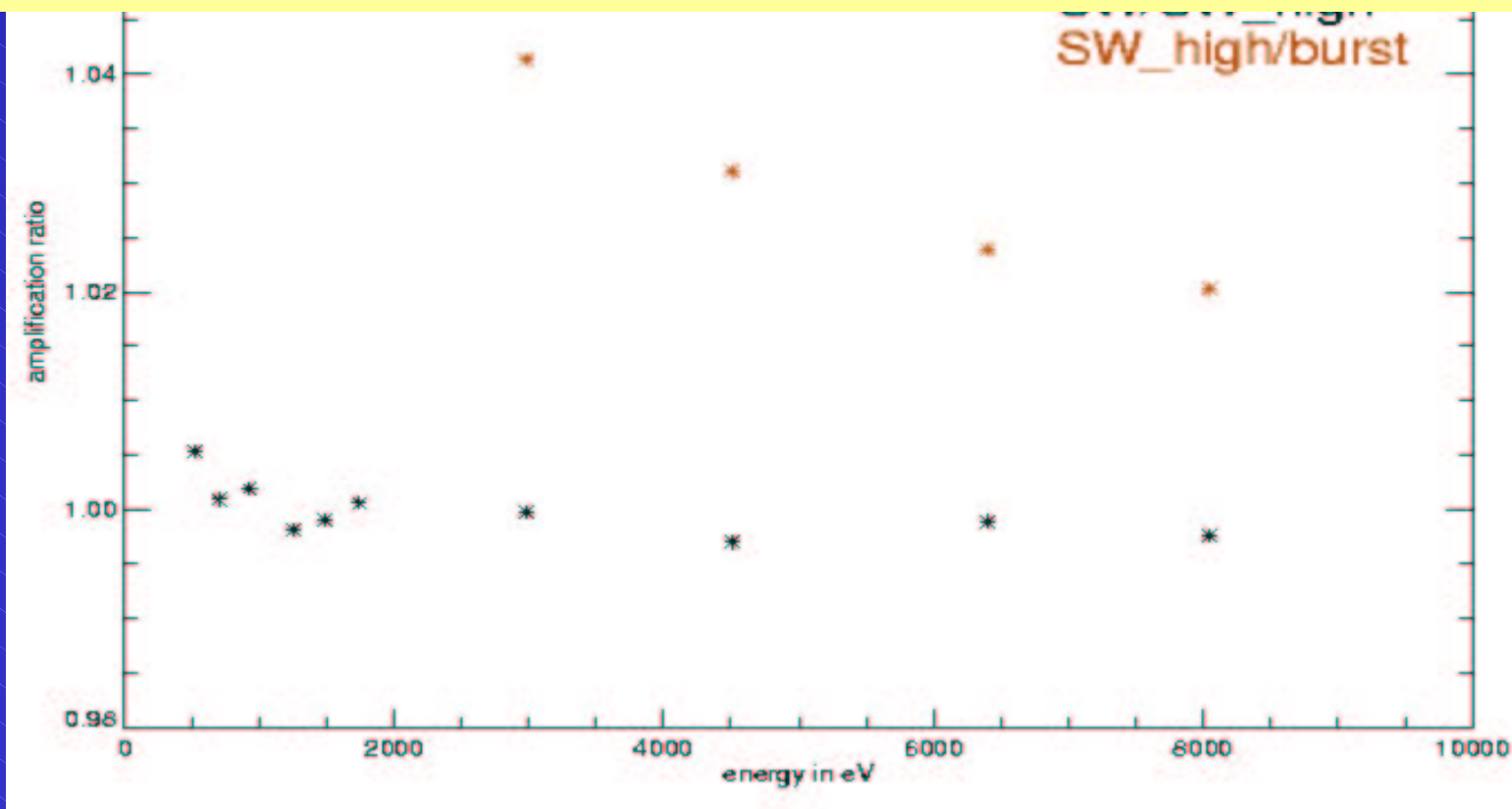# energy resolution



nearly identical in SW and Burst

Singles & Splits in Small Window & Burst Mode
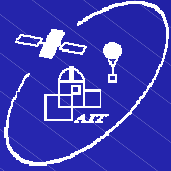
more singles in Burst
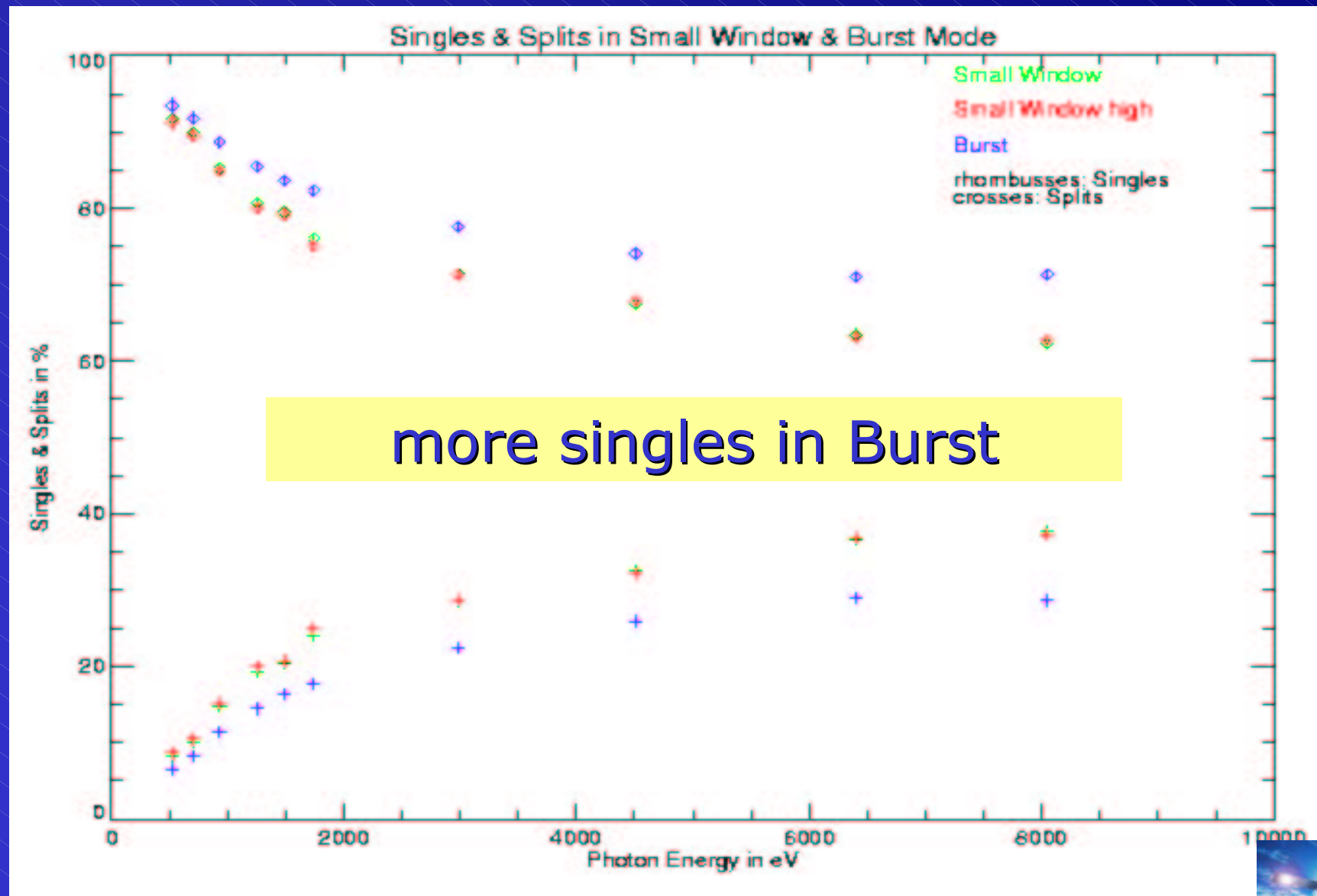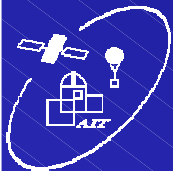
# peak position in SW and Burst
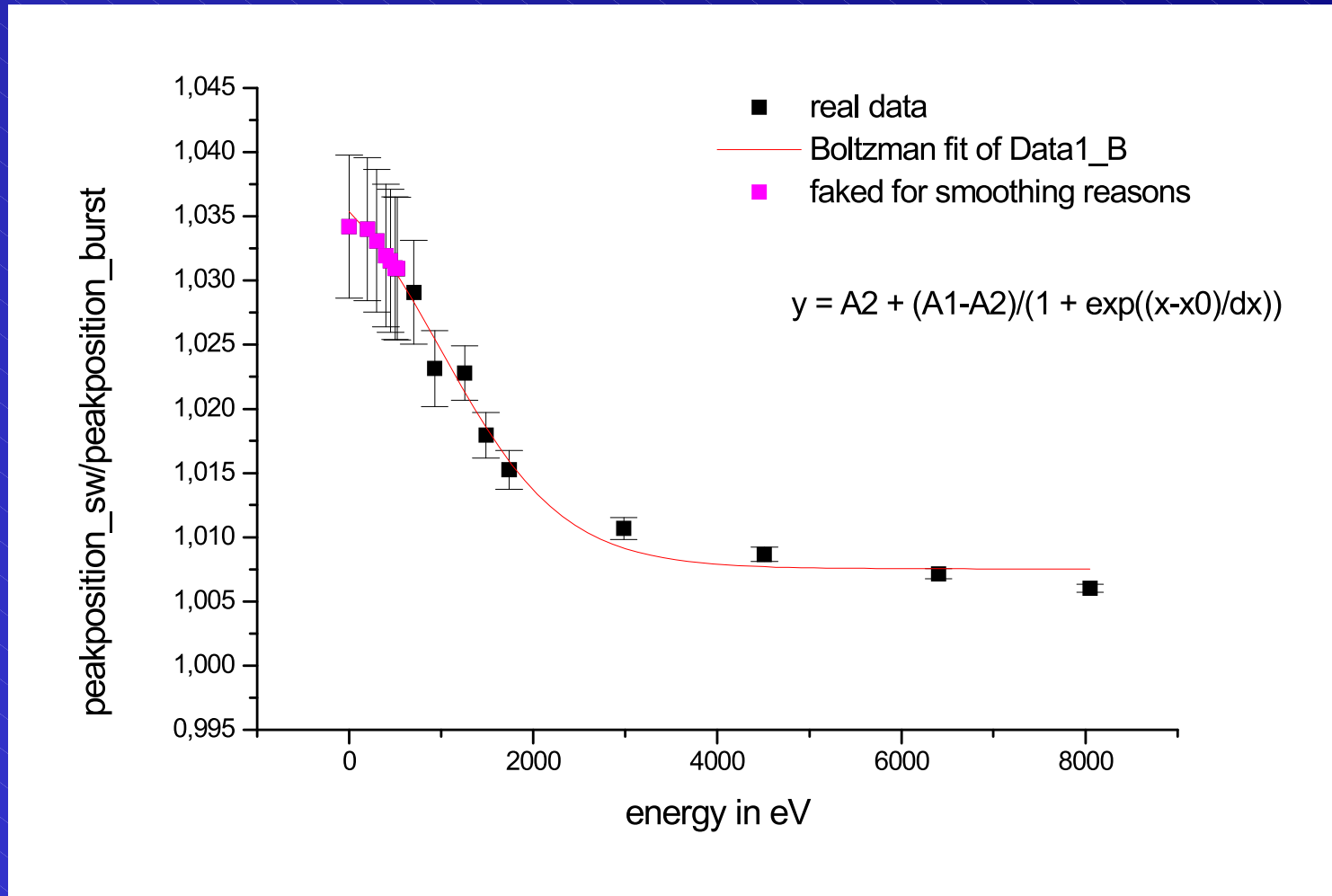## no CTE correction applied

- no difference          ratio          (10 singles/sec) and high rate (20-200 singles/sec) in SW
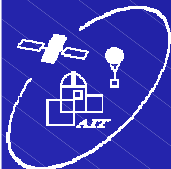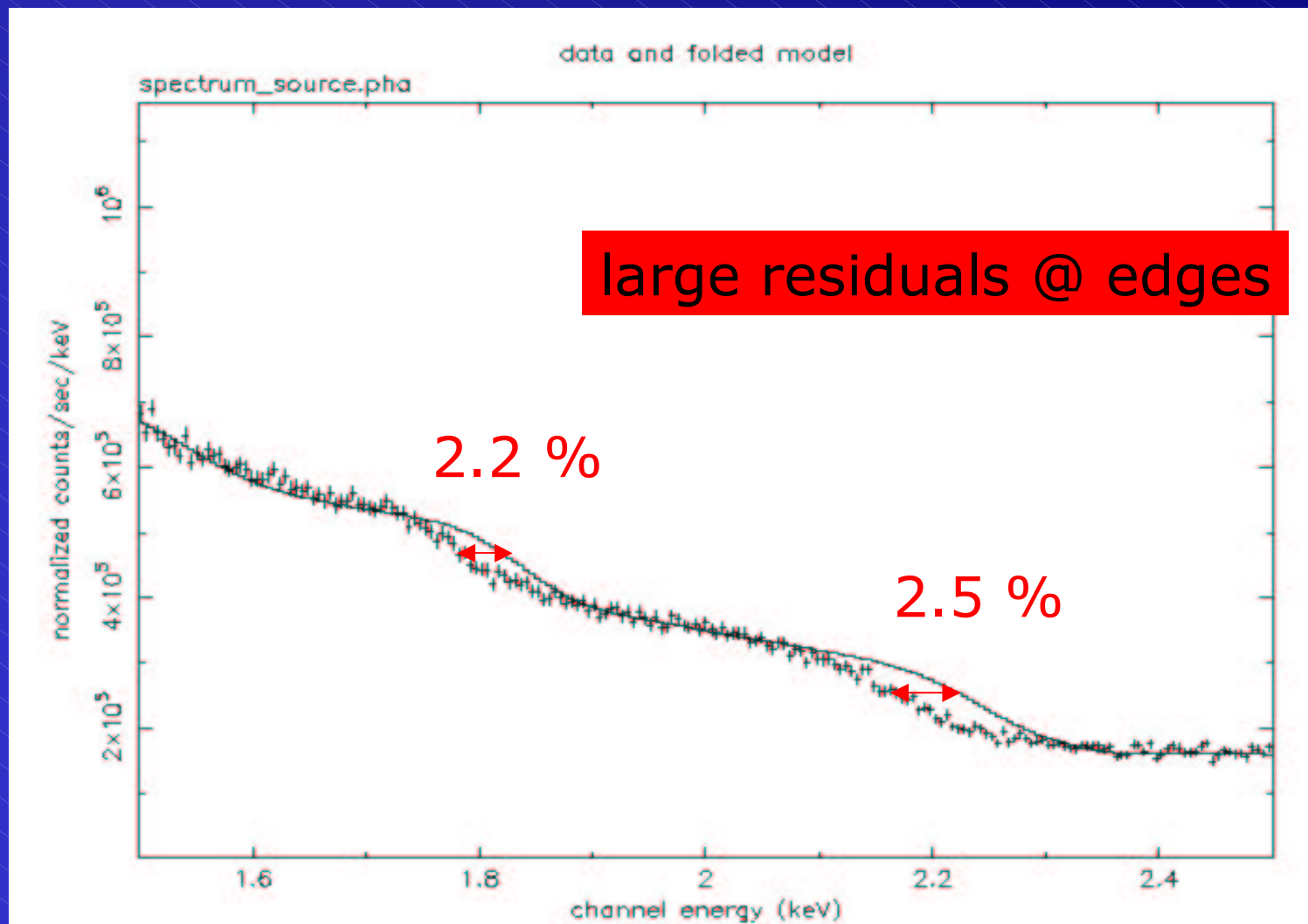
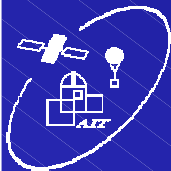- difference between SW and Burst Mode

# first tuning function
## ratio between peak position in SW and Burst as a function of energy
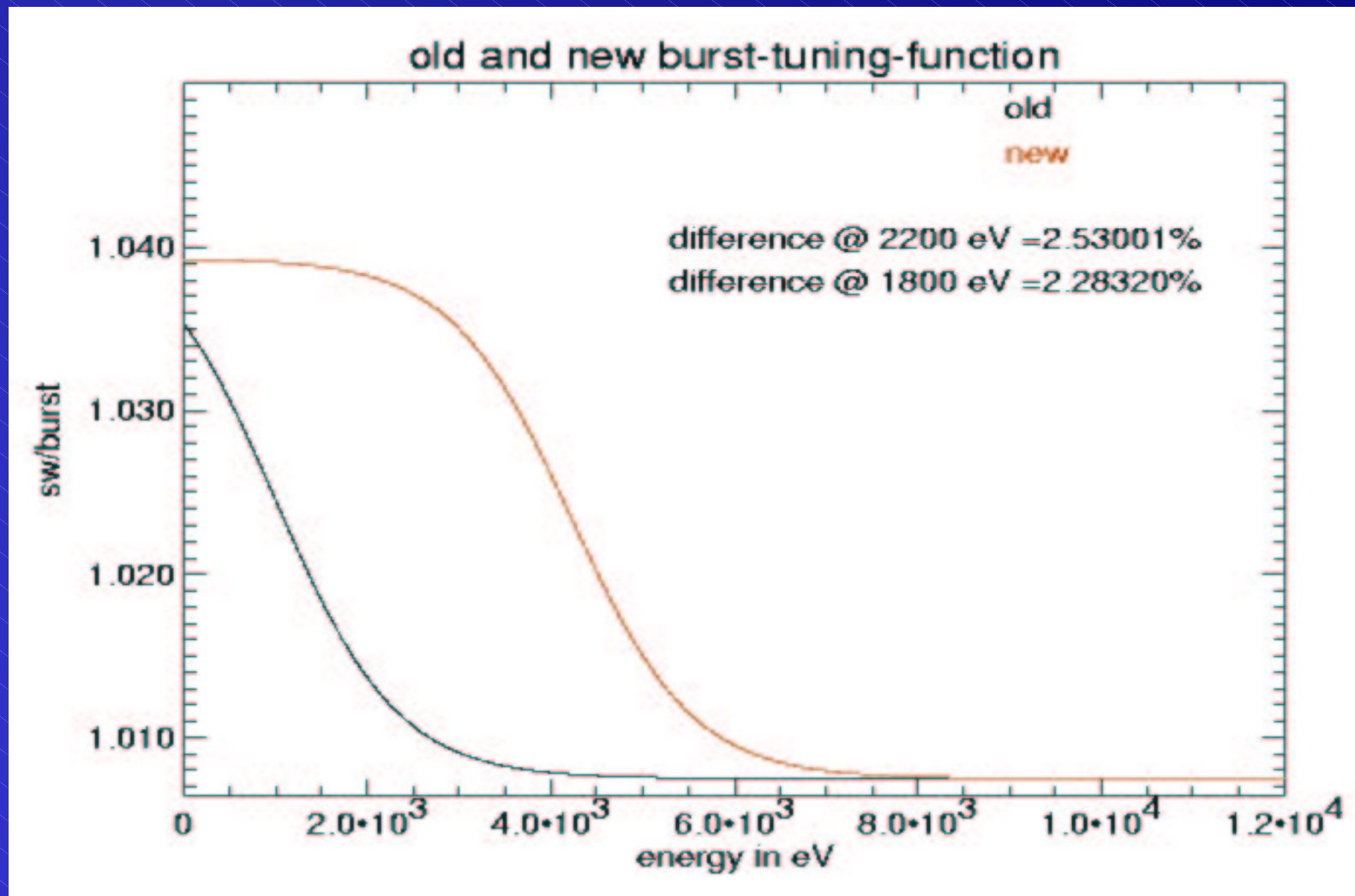


y = A2 + (A1-A2)/(1 + exp((x-x0)/dx))

# results with ground tuning function for CRAB observation



data and folded model

spectrum_source.pha

large residuals @ edges

2.2 %

2.5 %

# retuning with the edges



old and new burst-tuning-function
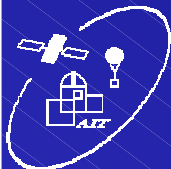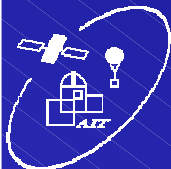
# results with new tuning function for CRAB observation



- old Burst
- new Burst
- SW
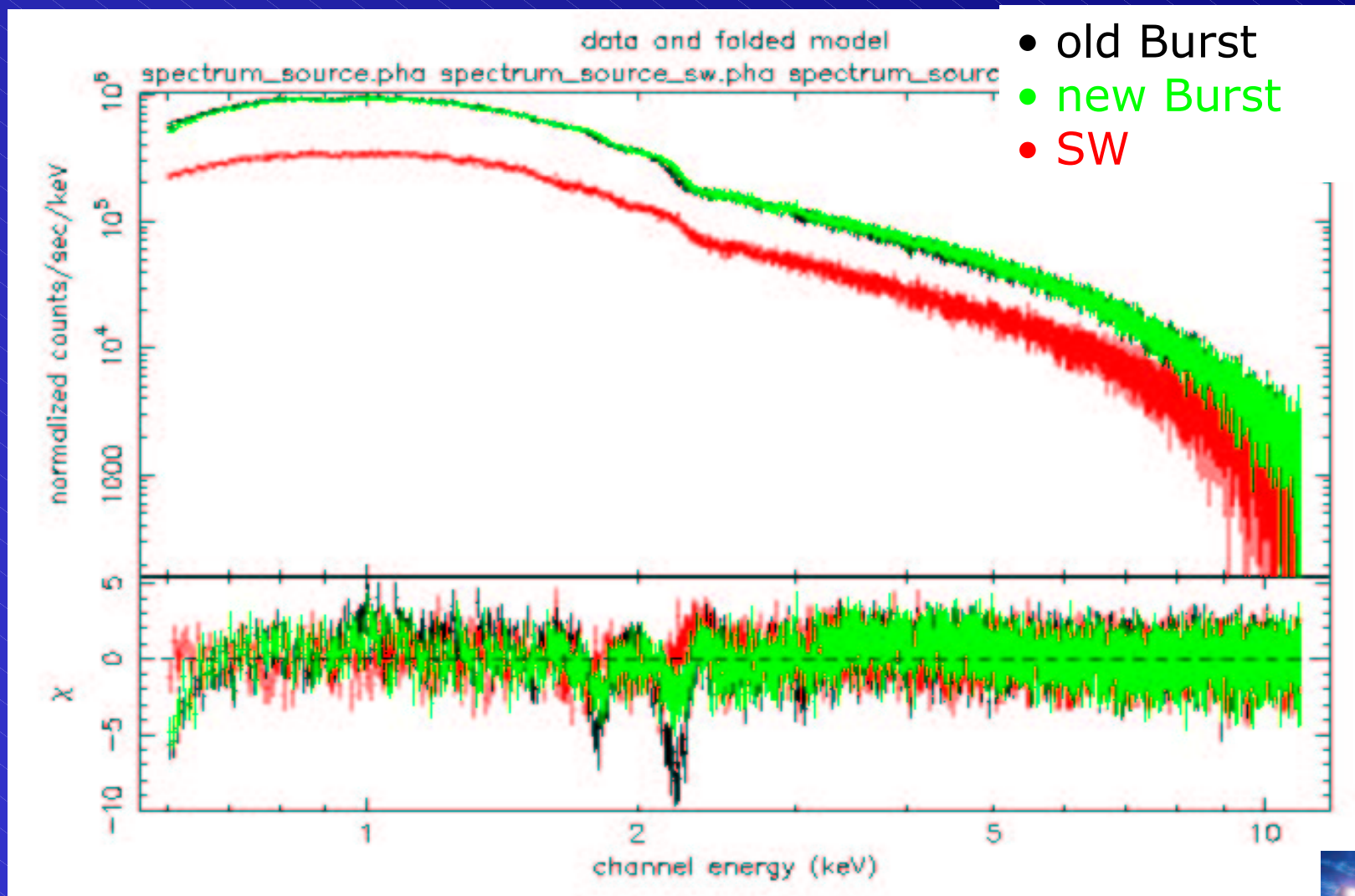
# last check with observation in rev 234



- SW
- Burst rev 234 **thick** filter
- Burst rev 40 medium filter
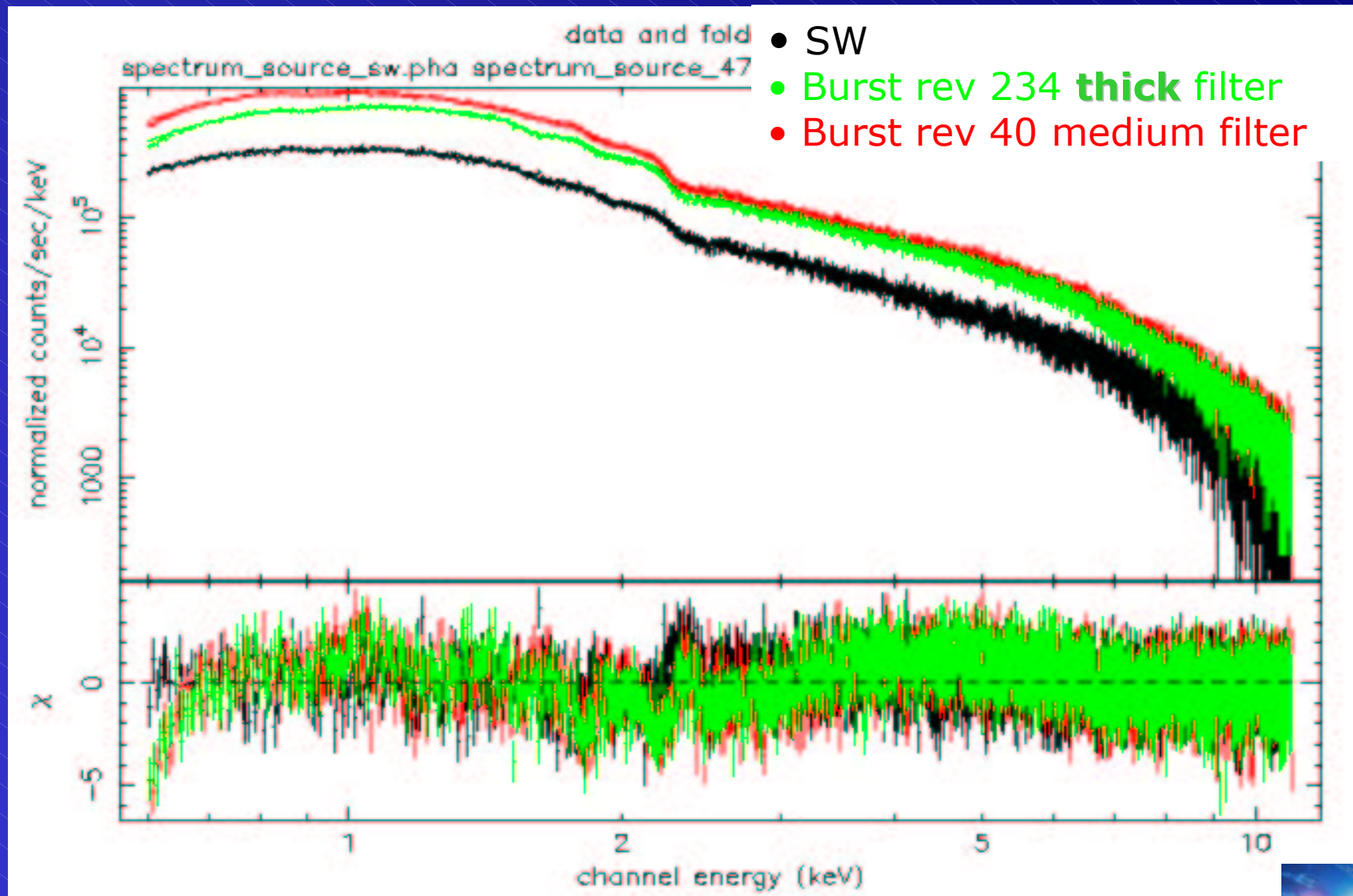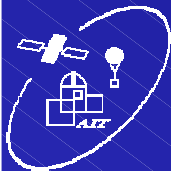
# open questions:

- photon index
  - can't be fixed to photon index in SW because SW measurement is highly piled-up
  - is not identical with canonical photon index
    - SW: 1.998 ± 0.007
    - Burst: 2.024 ± 0.005
    - canonical: 2.08
- energy calibration
  - only source with prominent lines will bring progress
  - estimated cal-time would be very long due to only 3% lifetime (f.ex. CAS-A 4 rev)