Cosmic X-ray Background and Earth albedo with Swift/BAT

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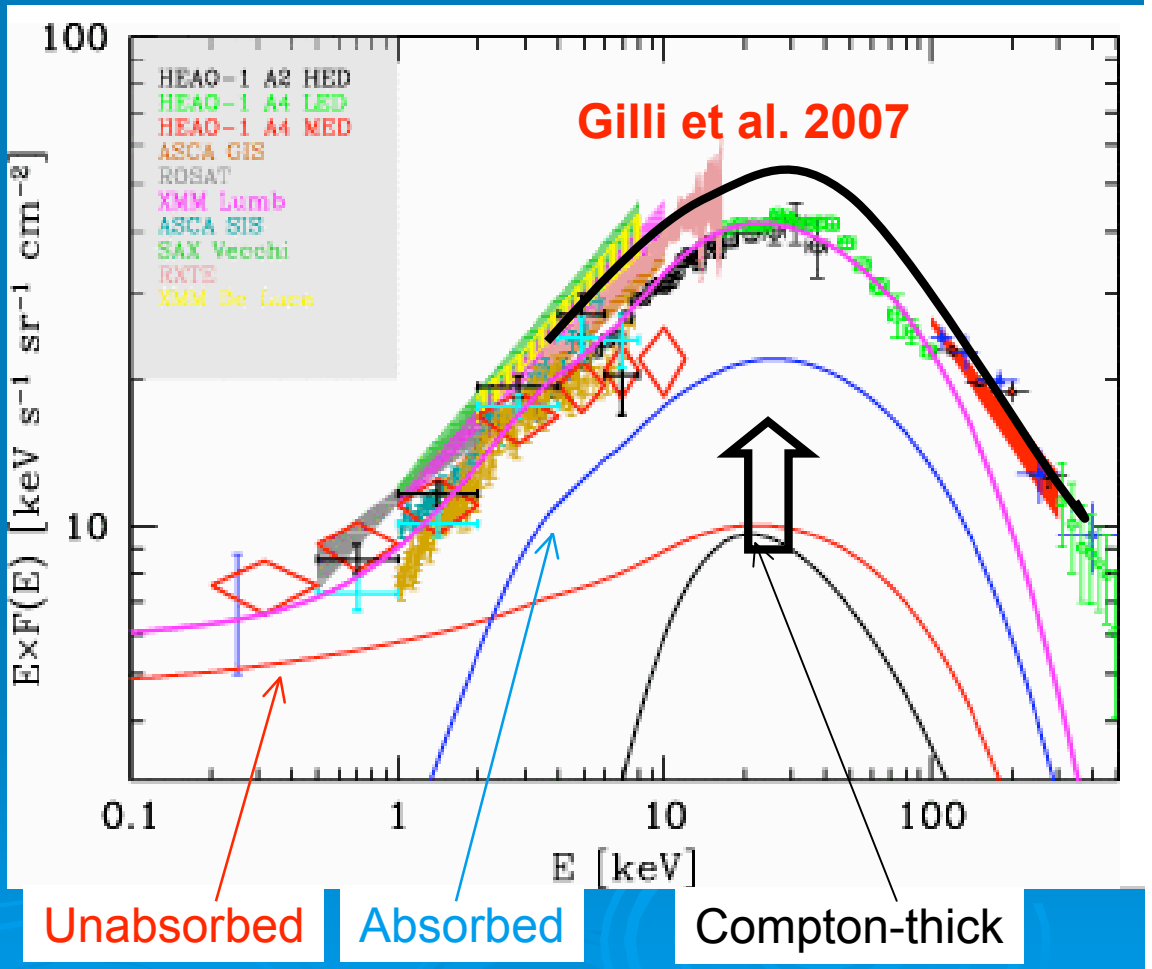
and on behalf of the **BAT-team**

Foreword: CXB issues

1. CXB constrains the density of Compton-thick objects:
   - Larger CXB intensity ---> larger density of Compton-thick AGN
2. A few Compton-thick AGN have been found; where are the rest ?



BAT

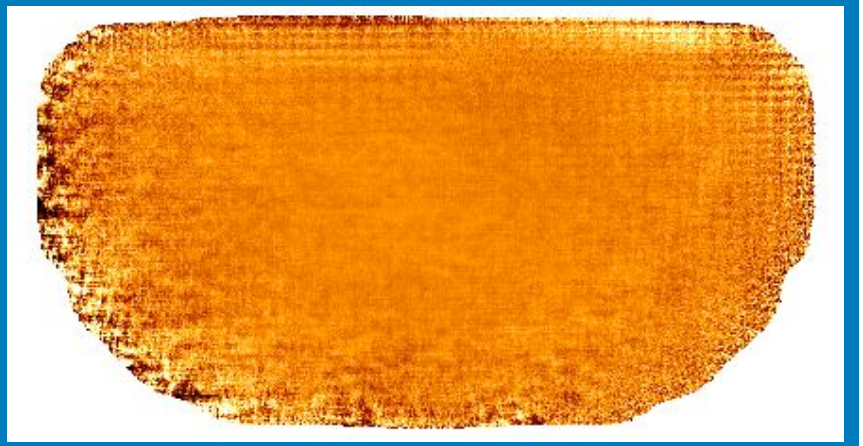
- Burst Alert Telescope:
  - Coded mask telescope [15-200 keV]
  - 32768 CdZnTe detectors
  - 5200 cm^2 detecting area
  - PSF 22 arcmin
  - Pos. accuracy 1-5 arcmin
  - Passive shielding
  - FOV of 2.5 sr (120° x 90°)
  - Flying at 600 km (LEO)

***Swift* satellite**

Measurement via Occultation

- BAT total signal is given by:
  - Source signal *variable*
  - background:
    - CXB, constant
    - CR flux, *variable*
    - albedo photons *variable*
    - electronic noise *small*
- How to discriminate the CXB ?
- Perform ON-OFF measurement:
  - ON : I_{on}
  - OFF: $I_{off} - \Omega \cdot CXB$
  - If you don't have a shutter, how do you "close" your experiment? Use the Earth disk!

ON



OFF

3 Step process

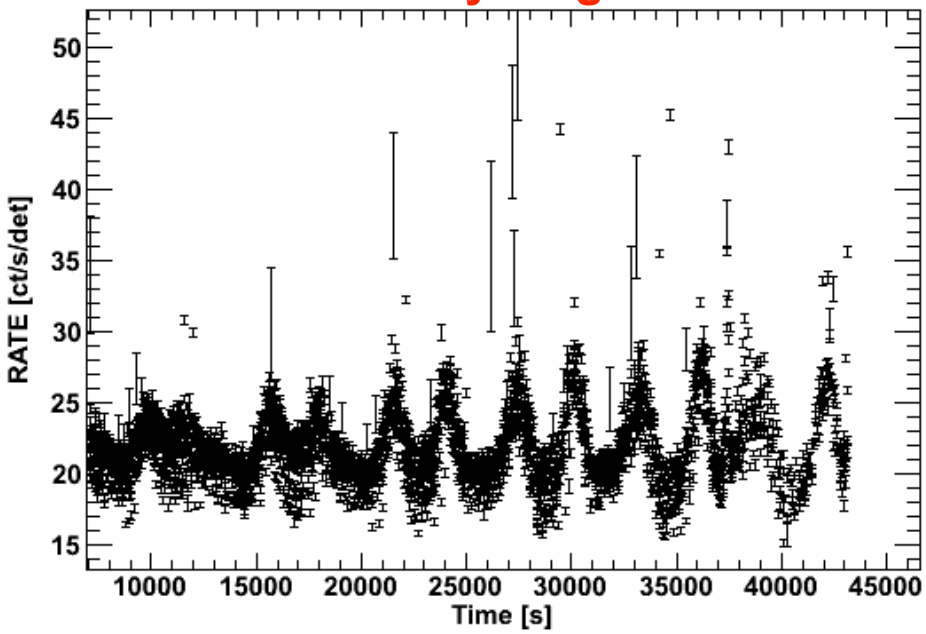
$$On - Off = I_{on} - I_{off} + \Omega\ (CXB - Earth)$$

1. Understanding the orbital background
    1. Goal: suppression of the rate variation due to CR flux so that : $I_{on} - I_{off} \approx 0$
2. Finding times when: $\Omega \neq 0$
3. Addressing Earth emission

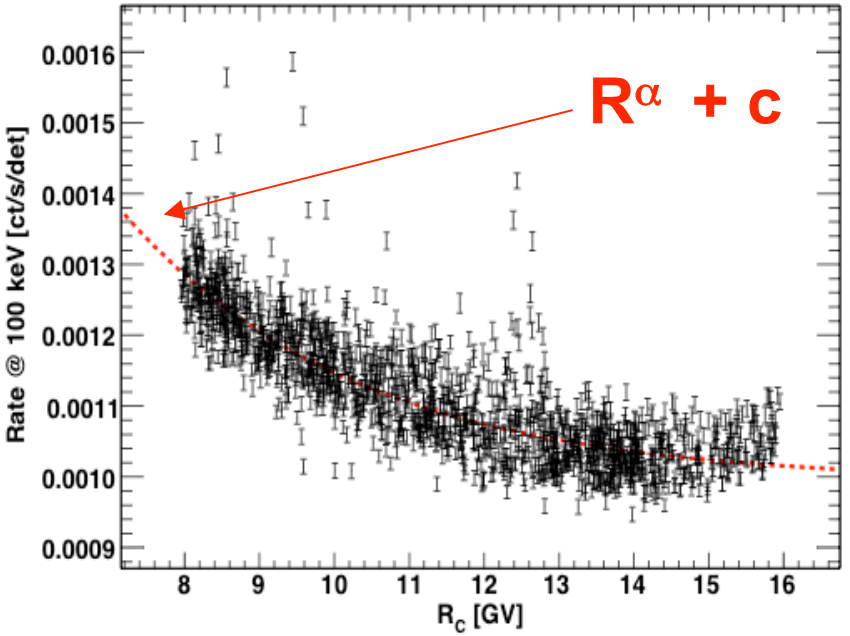
Step 1: Understanding the orbital background

- CR flux is modulated by the Earth magnetic field
  - Count rates should correlate with rigidity

Modulation by magnetic field

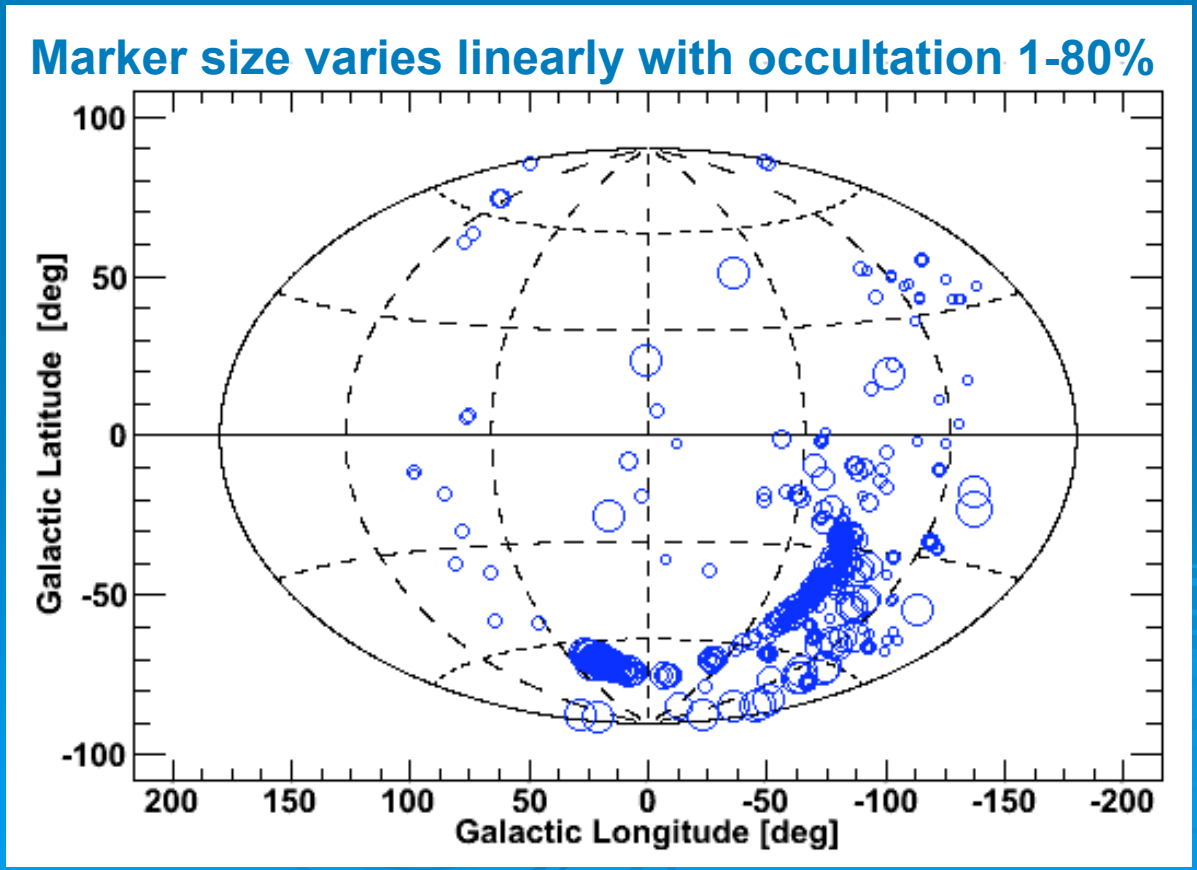


100 keV



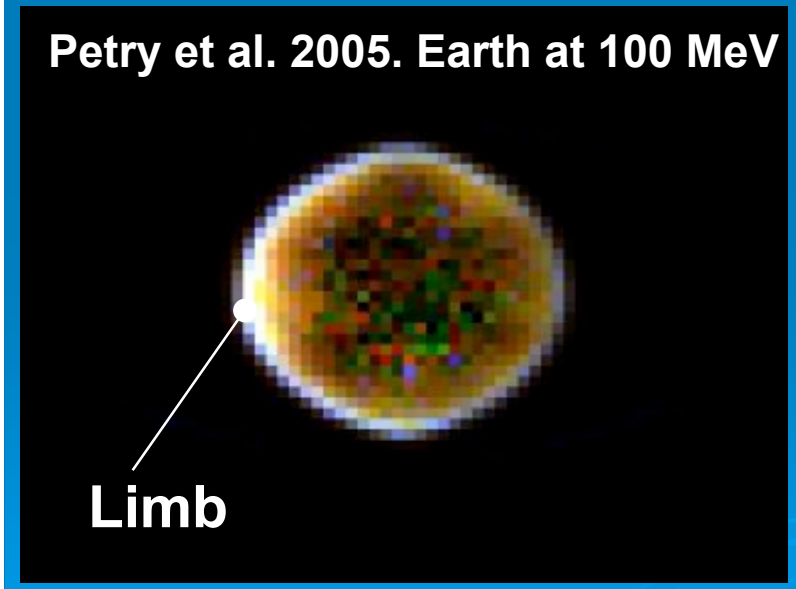
Step 2: Earth Occultations

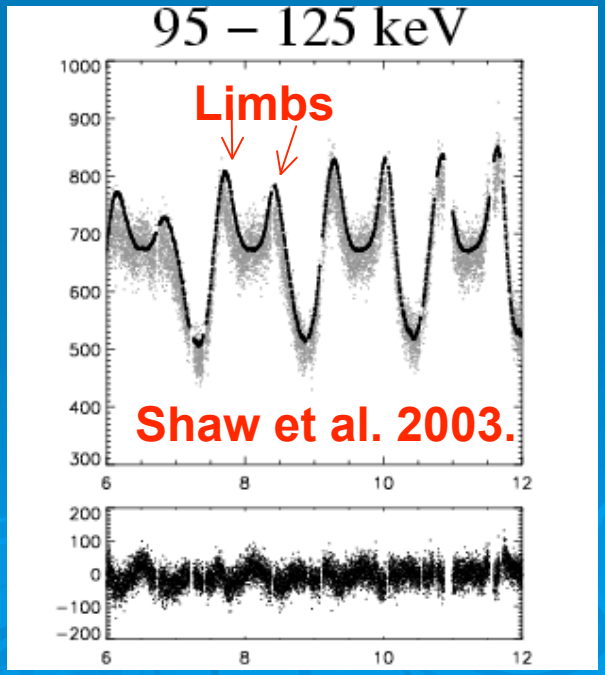
- 9 months of data used for this analysis
  - No point like sources allowed
- ~1000 occulted observations found
- Selected only those at |b|>20 deg

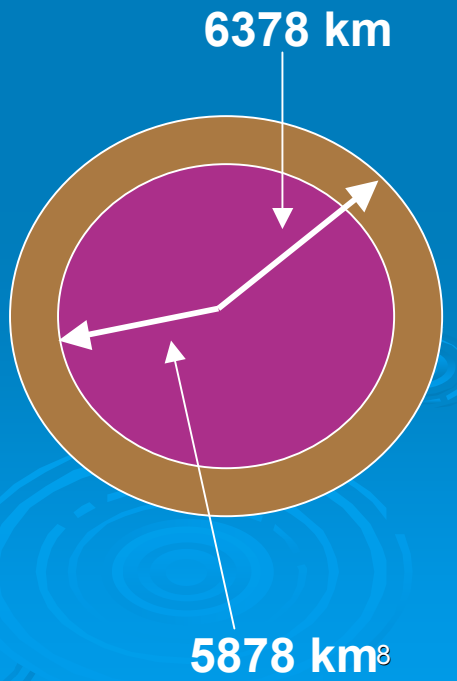


Step 3: Earth model

- Limb-brightening, rigidity-dependent model
- Based on: COMPTEL, EGRET, BATSE measurements and on detailed MC for BAT

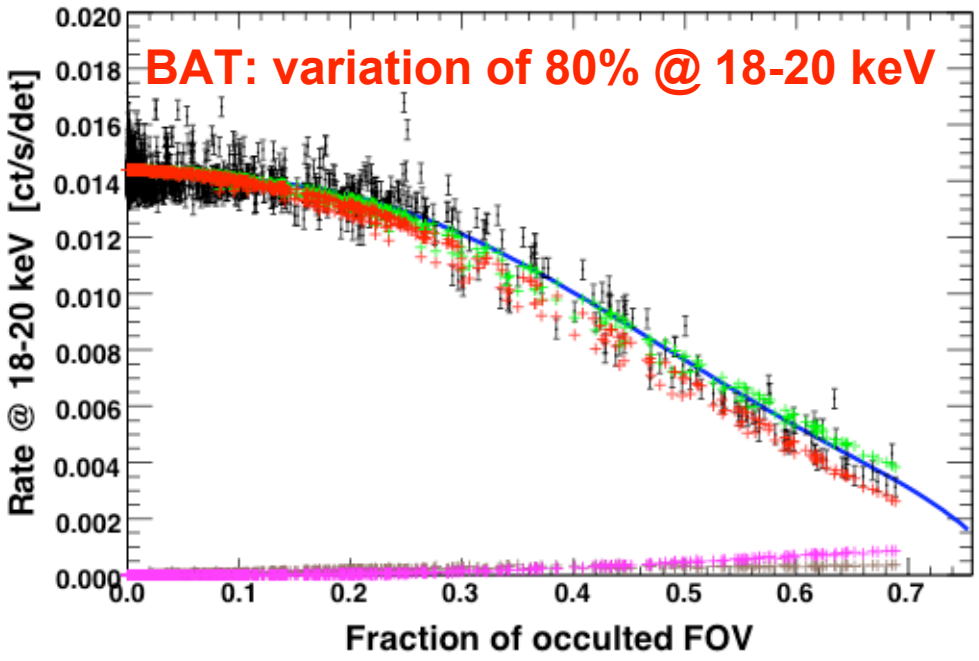


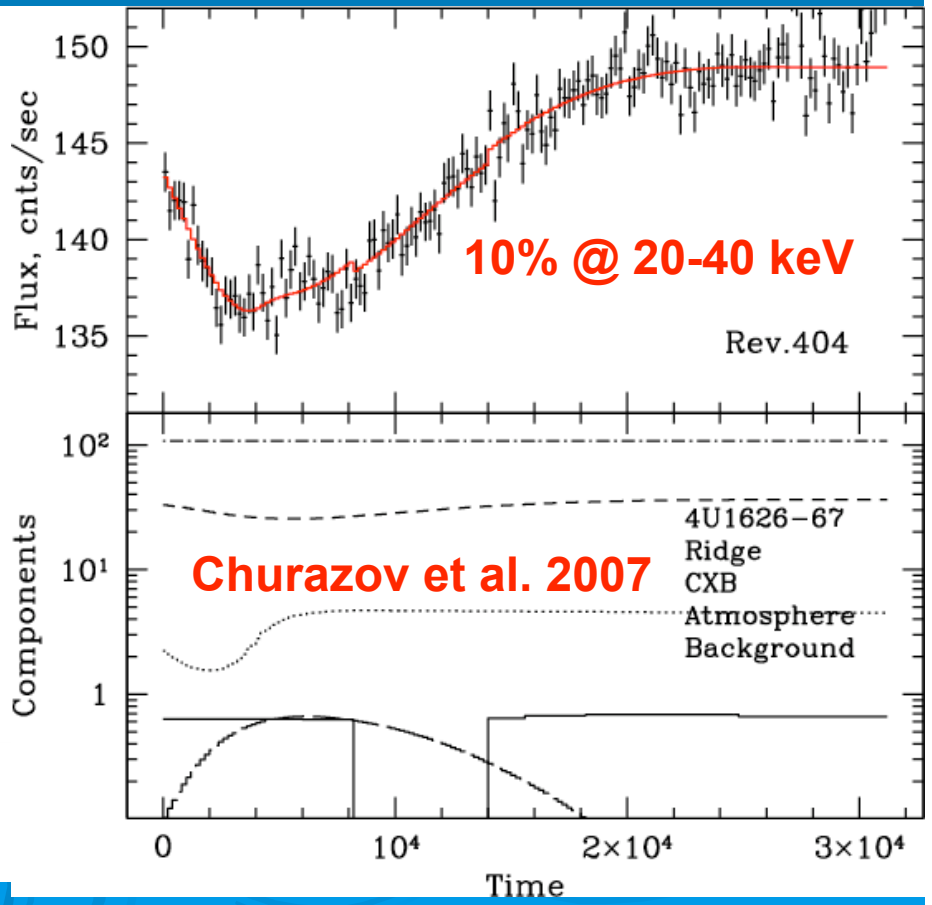




Where is BAT in the business?

- BAT has 8x more signal in a 2keV bin than INTEGRAL in a 20 keV bin

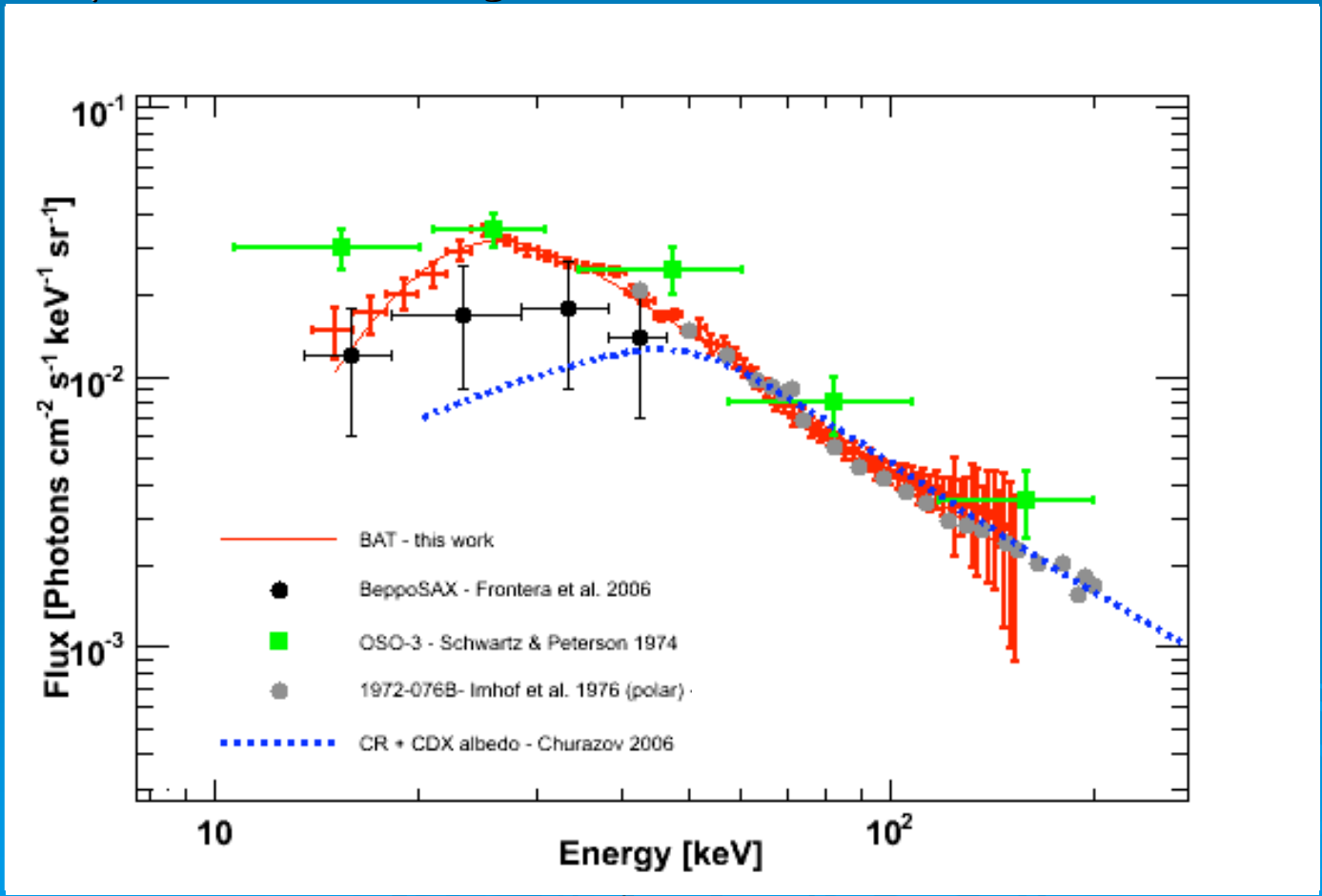




To each of the 80 energy channels: fit with 3 component model: const., CDX, Earth

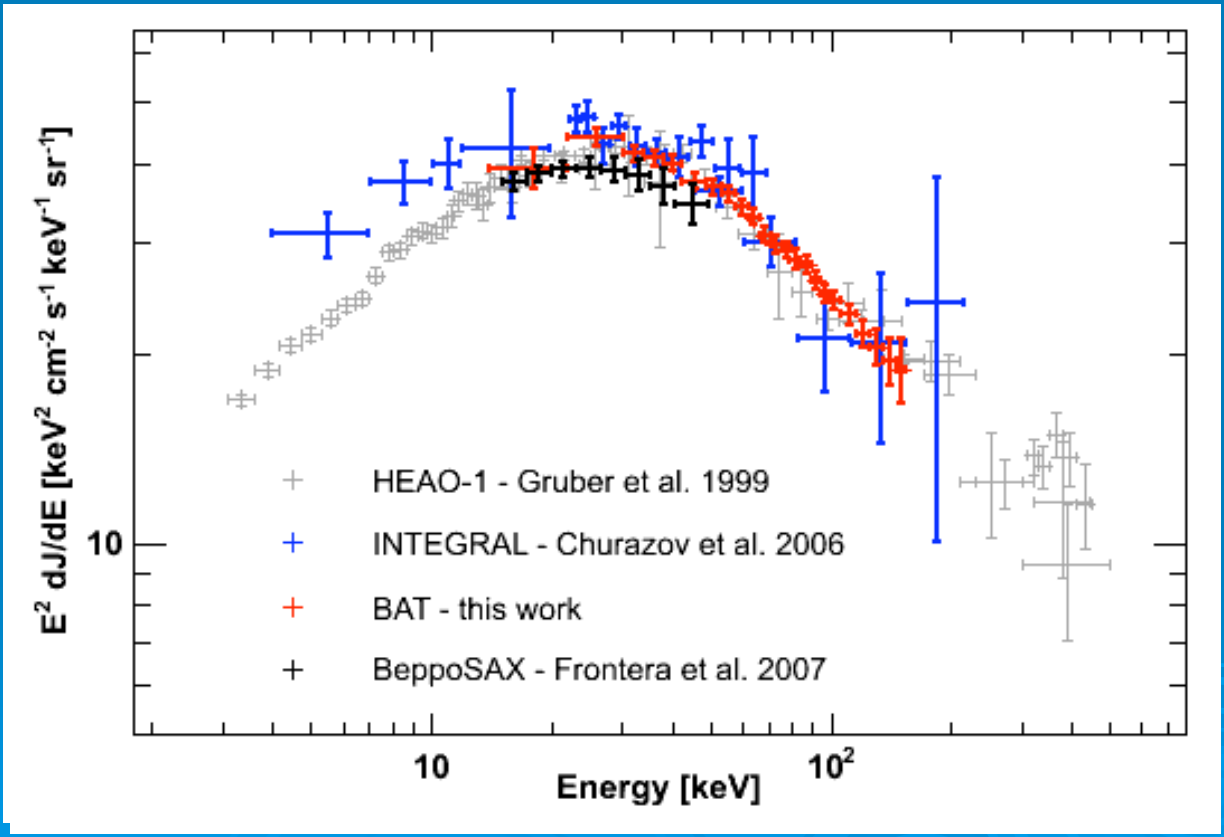
Results: Earth Spectrum

- Most accurate Earth spectrum to date
- Useful to predict the background level for future missions

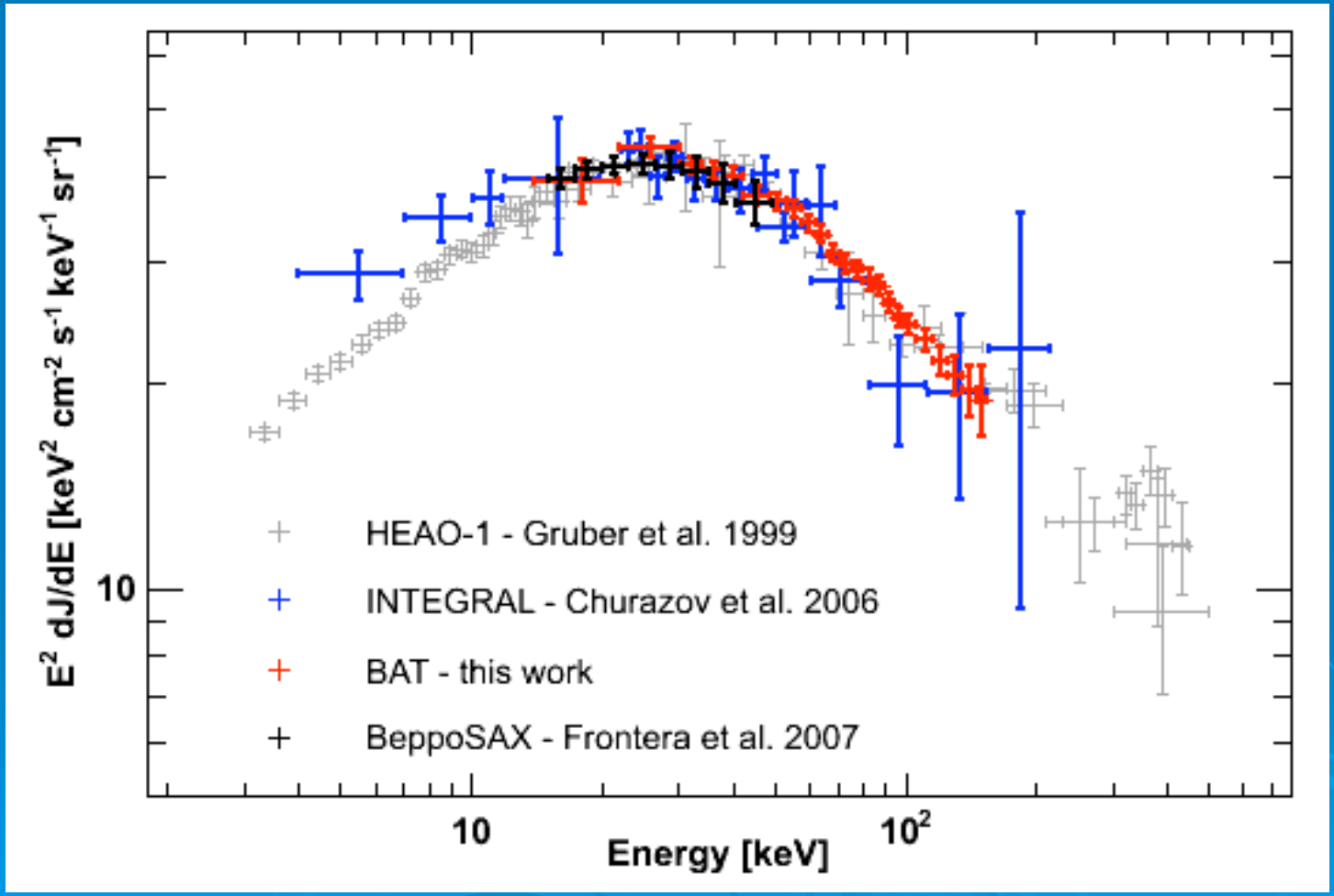


Results: CXB
(preliminary)

- BAT confirms HEAO-1 results with best accuracy so far



Re-normalising to a common Crab spectrum



How many Compton-thick AGN ?

- Risaliti+99 says: 30 %
- Known Compton-thick are 18 ! (Della Ceca +07)
- INTEGRAL:
  - Bassani+05 : 14%
  - Beckmann+06: 6-8 %
  - Sazonov+07: 10 %
- BAT:
  - Markwardt+05: 10 %
- Theory:
  - Gilli+07: 15 %

Consistent picture !

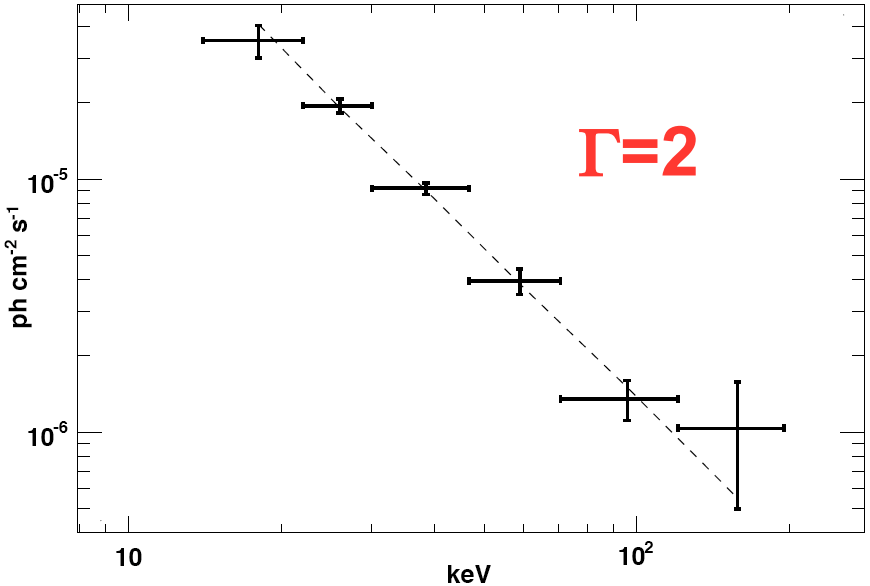
New Results from BAT

- Complete sample of 24 extragalactic objects
- 0 Compton-thick AGN detected; based on:
  - Nh value
  - EW of Fe Line (EW ~1 keV; e.g. Guainazzi+05)
  - Thickness parameter ($L_{2\text{-}10keV}/L_{OIII}$ <1 ; Bassani+99)
- Compton-thick are less than 15% (>2σ)
- Even though they are rare, that's not much of a problem (BAT and IBIS are biased anyway)
- Larger complete samples are needed to constrain lower fractions

Properties of AGN

- Sy1s softer than Sy2s:
  in agreement with OSSE, BeppoSAX, INTEGRAL
- Sy1s have stronger reflection component
- Sy1s show "weak" evidences for cut-off in ~100 keV range

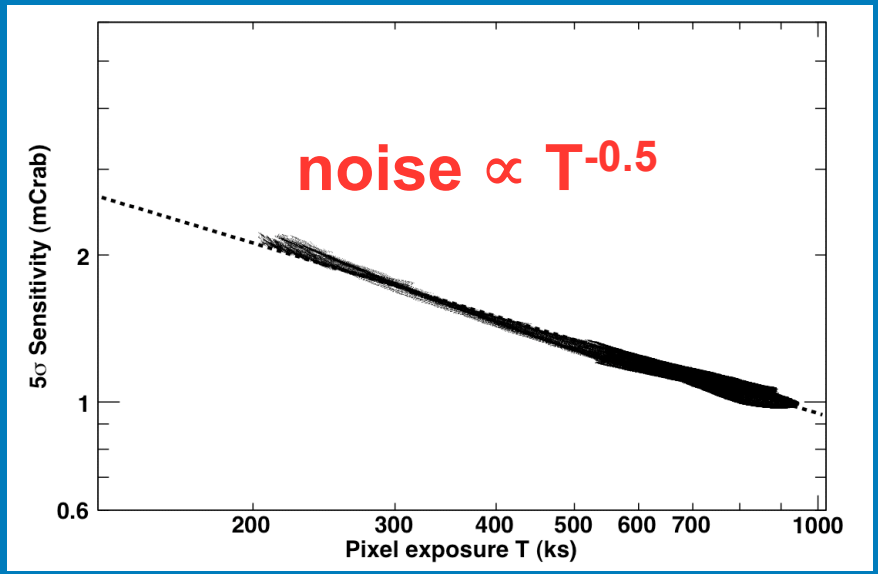
CLASS	Photon index	χ^2 /NDF
Seyfert 1	2.23±0.11	5.4/4
Seyfert 2	1.86±0.10	1.2/4
Seyfert 1.2-1.5	1.95±0.11	4.9/4
Seyfert All	2.00±0.07	2.1/4



At odds with the Unified Model

BAT sensitivity

- 3.0mCrab(T/100ks)$^{-0.5}$
  - ~1 mCrab @ 1 Ms
  - ~0.5 mCrab @ 3 Ms
- IBIS: 0.6-0.8 mCrab @ 1 Ms (Bassani+06)
- BAT already surveyed the whole sky to ~1 mCrab !!



Deep pointings are the strenght of INTEGRAL: key programme: NEP 6Ms observation !

Conclusions

- CXB and albedo with BAT:
  - BAT high-S/N CXB spectrum confirms HEAO-1
  - BAT, BeppoSAX, INTEGRAL, HEAO-1 consistent within cross-calibration errors
- BAT X-ray survey:
  - BAT is sensitive
  - Whole sky already surveyed to ~1 mCrab
  - Upcoming results in: Ajello 2007a, 2007b, Tueller 2007