INTEGRAL's X-ray Bursters

the Core Programme X-ray bursters team, led by
A. Bazzano (IASF Rome) includes investigators from
almost all the institutes/institutions involved in the ISWT

outline:

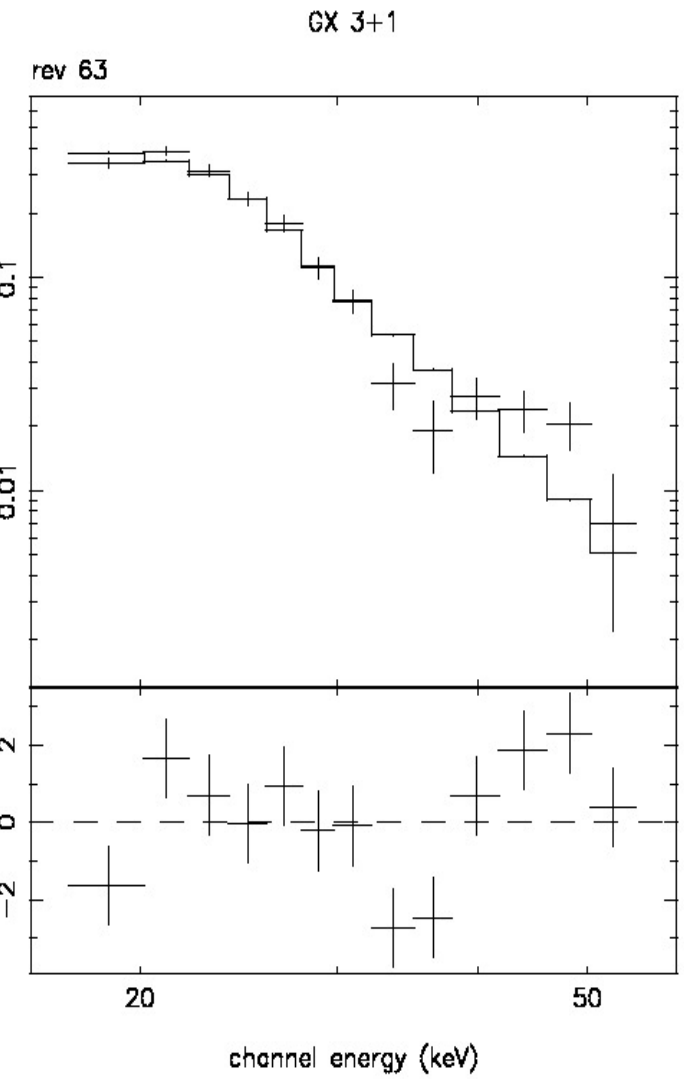
- Preliminary results of IBIS spectral analysis of **8** X-rB's
  (out of the so far >20 *INTEGRAL* detected bursting sources)
- [for news about 4U 1812-12 please refer to the talk by A. Tarana]
- summary of the analyzed data sets
- source spectra
- discussion / general properties of *INTEGRAL* bursters
- future work

the observations

- Public and/or ISWT data
- For each observed burster the exposure time (in ks) of the analysed data in each revolution is shown

source	rev 61	rev 63	rev 100	rev 232
GX 3+1		**144**		
4U 1820-303	**171**	**141**		36
GS 1826-238	**161**	**142**		**22**
SLX 1744-300	**176**	142		60
GX 354-0			**169**	**75**
H 1705-440			**212**	**73**
4U 1735-444			**193**	**71**
H 1702-429		79		

GX 3+1



(see talk by R. Farinelli for details)

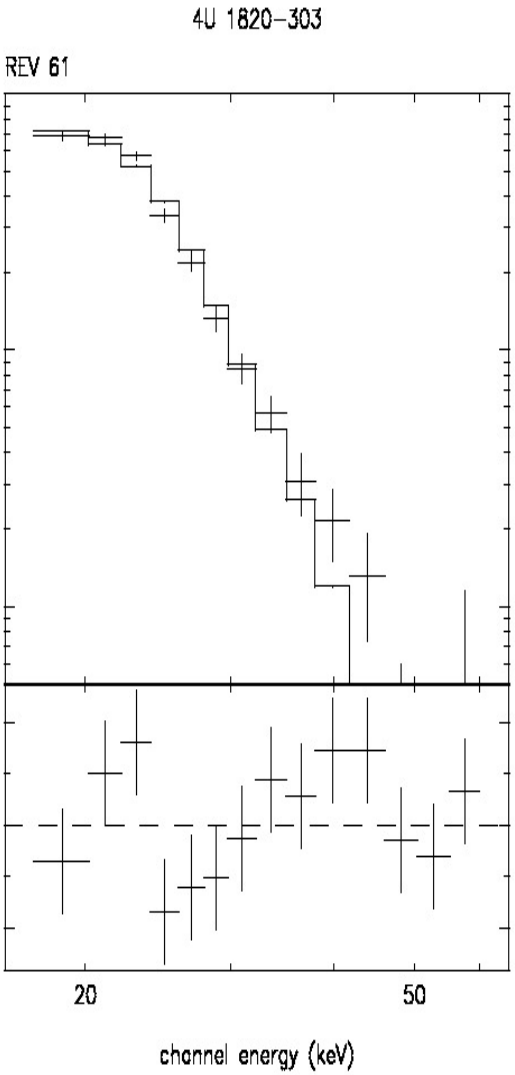
spectrum obtained in rev. 63, 144 ks

syst.err. 5%

compST, $kT = 8.6 \pm 3.4$ keV
$\tau = 2.9 \pm 1.2$
$\chi^2(\mathrm{dof}) = 3.0\ (10)$
$\phi = 1.63 \times 10^{-10}$ erg cm^{-2} s^{-1}

notes:
- excesses up to ~80 keV, likely SW artifacts (see e.g. GS1826-238 later)
- removing the first (below 20 keV) point doesn't affect the fit

4U 1820-303



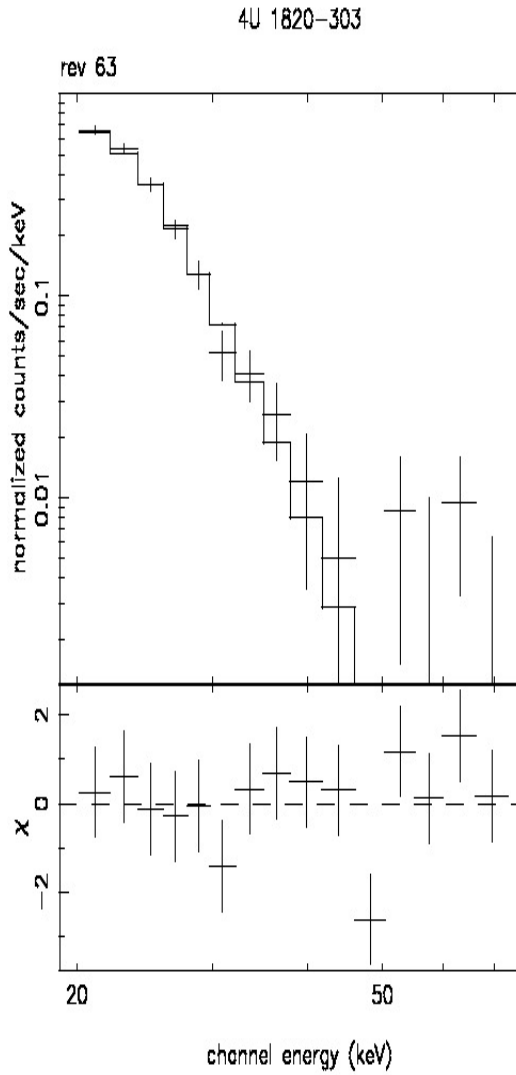
spectra in rev. 61 (171 ks) and 63 (141 ks)

compST, syst.err. 5%

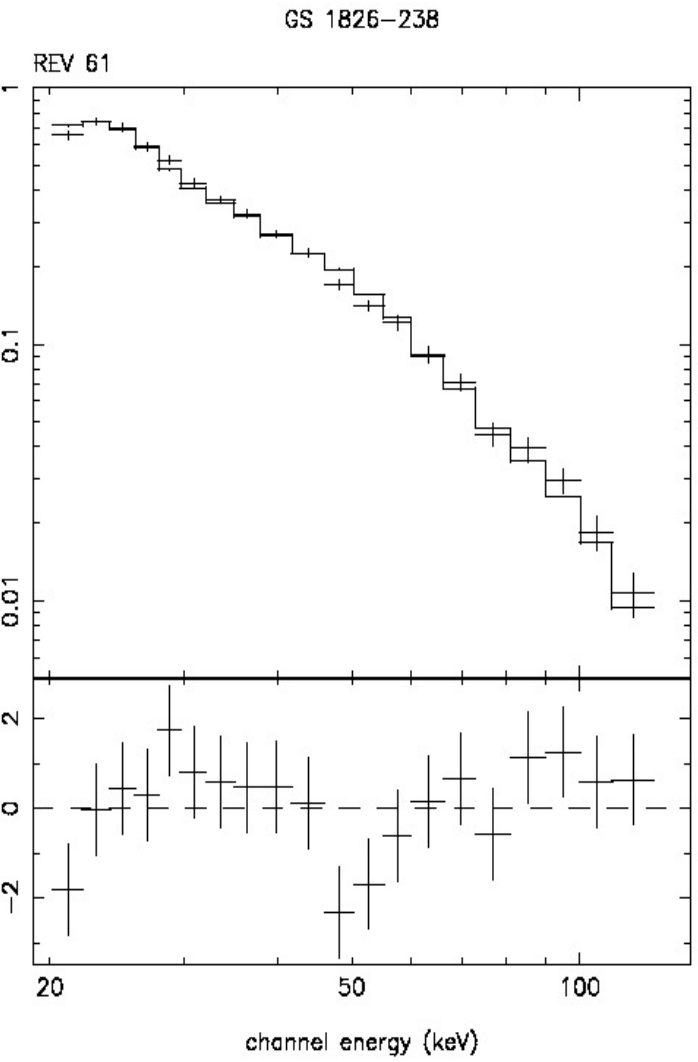
$kT = 3.7 \pm 0.4$ keV
$\tau = 7.8 \pm 2.9$
χ^2(dof) = 1.4 (11)
$\phi = 2.29 \times 10^{-10}$ erg cm^{-2} s^{-1}

$kT = 3.0 \pm 0.1$ keV
$\tau = 17 \pm 10$
χ^2 (dof) = 1.0 (18)
$\phi = 2.15 \times 10^{-10}$ erg cm^{-2} s^{-1}

note:
• similar spectra, can be combined



GS 1826-238



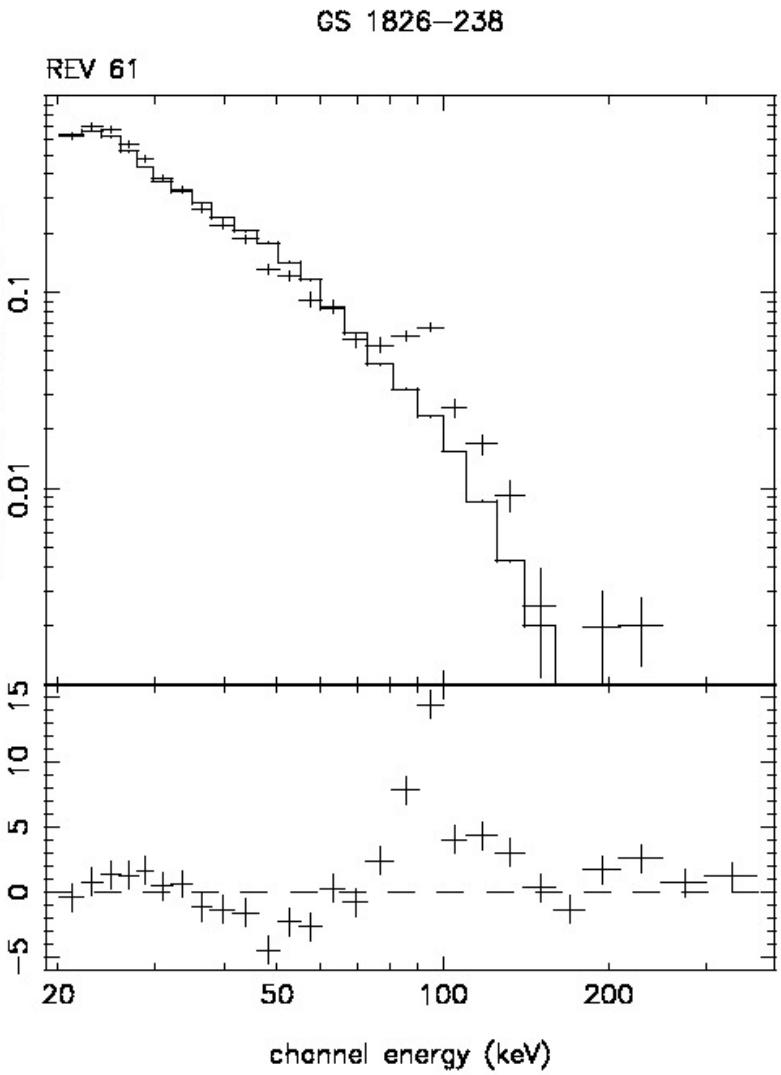
spectrum obtained in rev. 61 (161 ks)
(imaging SW, normalizing to Crab spectrum)
syst.err. 4%

cutoffPL, $\Gamma = 1.6 \pm 0.1$
$E_c = 52.7 \pm 0.8$ keV
$\chi^2(\mathrm{dof}) = 1.2$ (17)
$\phi = 11.3 \times 10^{-10}$ erg cm^{-2} s^{-1}

compST, $kT = 22 \pm 2$ keV
$\tau = 3.3 \pm 0.2$
$\chi^2(\mathrm{dof}) = 1.5$ (17)
$\phi = 11.2 \times 10^{-10}$ erg cm^{-2} s^{-1}

compTT, $kT = 28 \pm 5$ keV
$\tau = 1.1 \pm 0.2$
$\chi^2(\mathrm{dof}) = 1.3$ (17)
$\phi = 11.5 \times 10^{-10}$ erg cm^{-2} s^{-1}

GS 1826-238



- spectral extraction SW
- fit model is the 53 keV cutoffPL as above
- normalization allowed to vary

GS1826-238, *BeppoSAX* results:

- in ‘t Zand et al. 1999 (~40 ks, 1997 data) **?**

  bb+CompTT, kT_e = 20 keV, τ = 2-5 (depending on geometry)

  bb+cutoffPL, Γ = 1.38, E_c = 52 keV

- Cocchi et al. 2000 (1999 data)

  bb+CompTT, kT_e = 21 keV, τ = 1.9 (disk geometry)

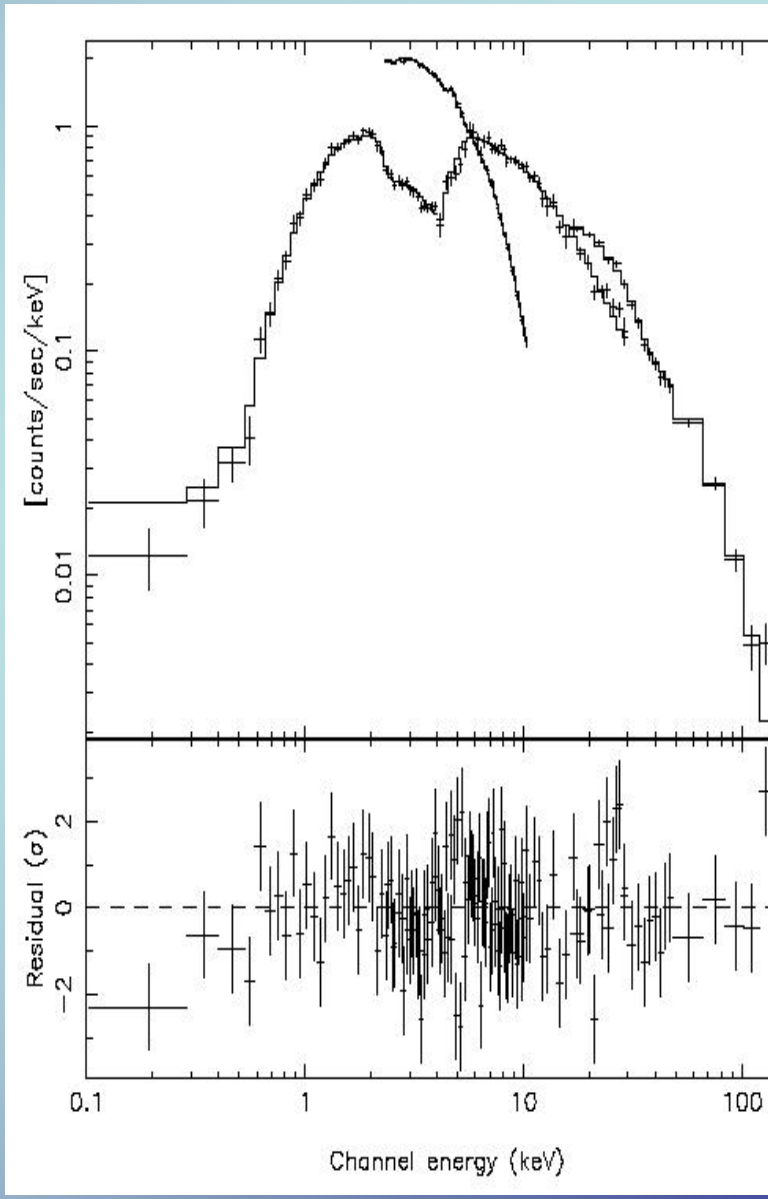
  bb+cutoffPL, Γ = 1.38, E_c = 46 keV

- this data (rev 61, spring 2003)

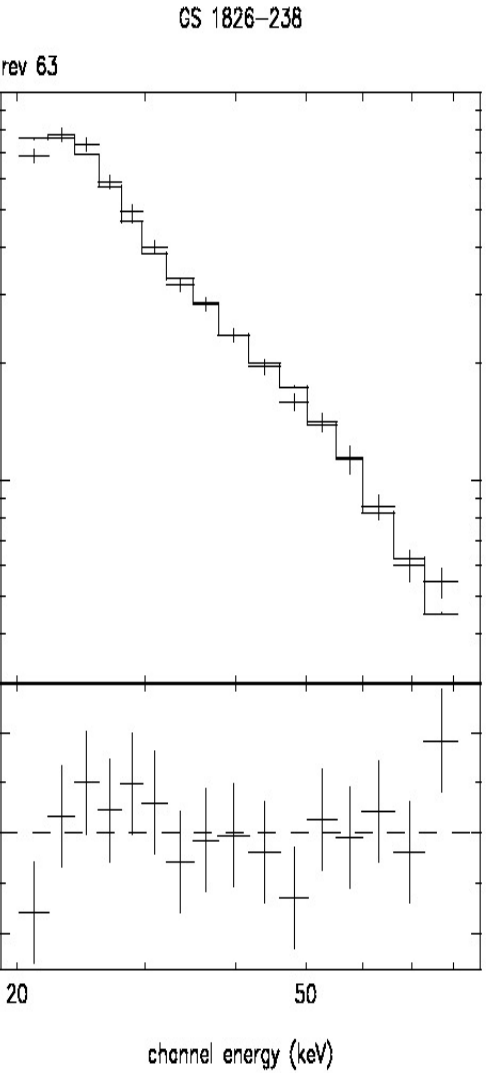
  CompTT, kT_e = 28 ± 5 keV, τ = 1.1 (disk geometry)

  cutoffPL, Γ = 1.6, E_c = 53 keV

So, no evidence for spectral variability in 1997-2003, but…



GS 1826-238



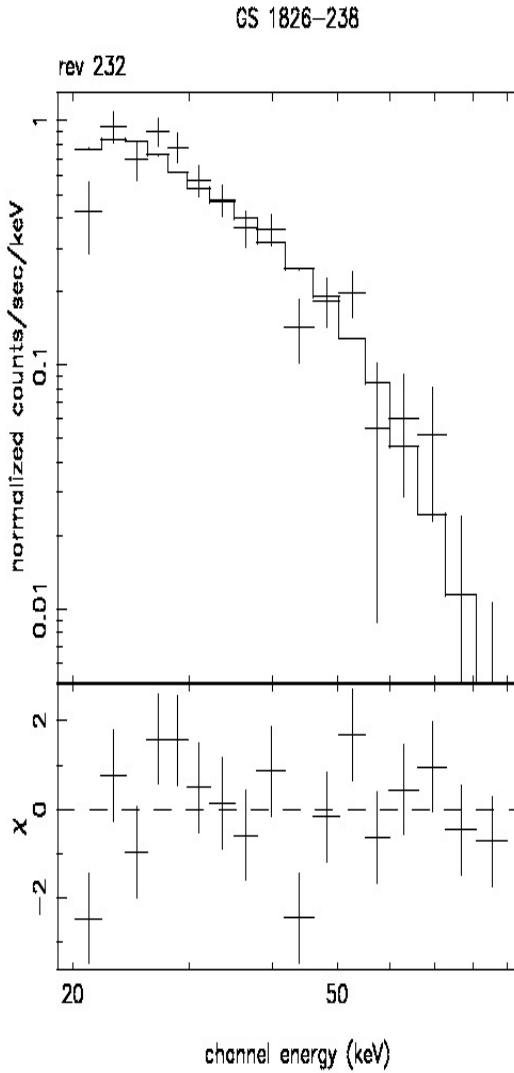
spectra in rev. 63 (142 ks) and 232 (22 ks)

compST, syst.err. 5%

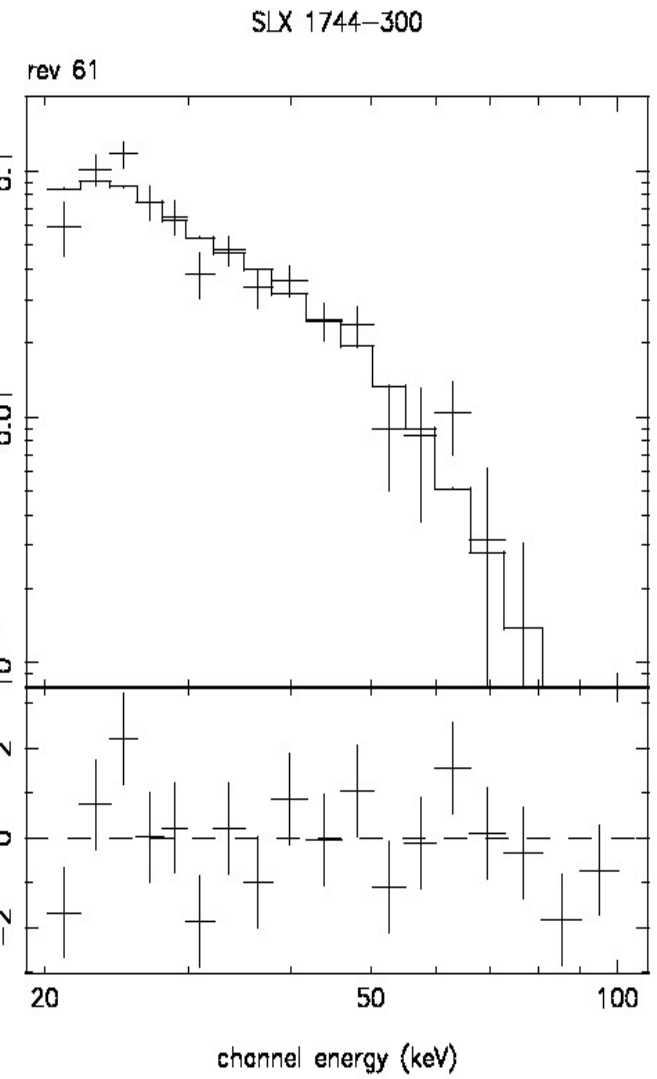
$kT = 38 \pm 19$ keV
$\tau = 2.0 \pm 0.8$
χ^2(dof) = 0.9 (13)
$\phi = 11.2 \times 10^{-10}$ erg cm^{-2} s^{-1}

$kT = 8.1 \pm 0.8$ keV
τ = n.c.
χ^2 (dof) = 1.8 (14)
$\phi = 9.6 \times 10^{-10}$ erg cm^{-2} s^{-1}

notes:
- likely artifacts at ~100 keV in rev 232
- ? evidence for spectral variability from 61-63 to 232 (fall 2004)



SLX 1744-300



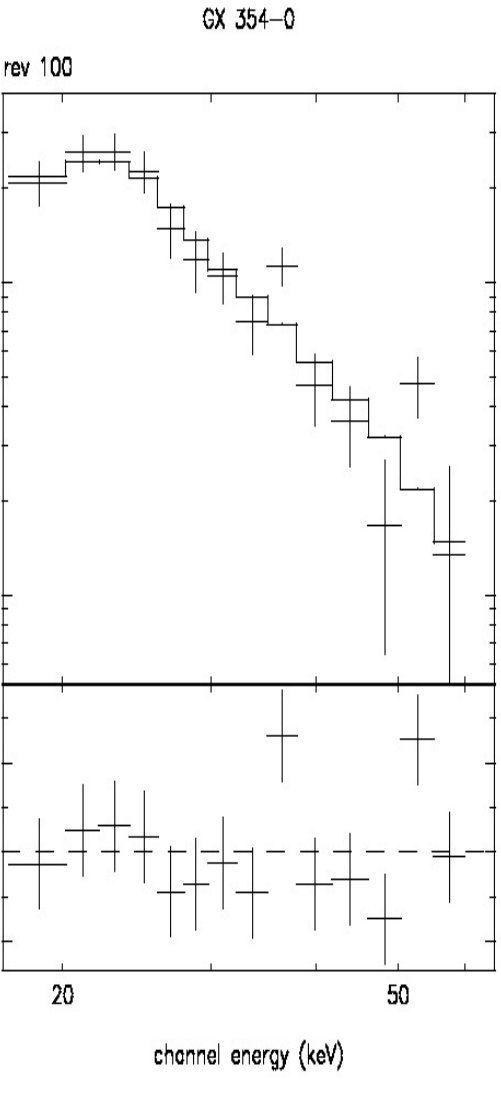
spectrum obtained in rev. 61, 176 ks

syst.err. 5%

compST, $kT = 8.7 \pm 1.5$ keV
$\tau = 11 \pm 7$
$\chi^2(\mathrm{dof}) = 1.5$ (15)
$\phi = 1.00 \times 10^{-10}$ erg cm^{-2} s^{-1}

notes:
• spectra in rev. 063 and 232 also computed, no evidence for spectral variability (see later)

GX 354-0



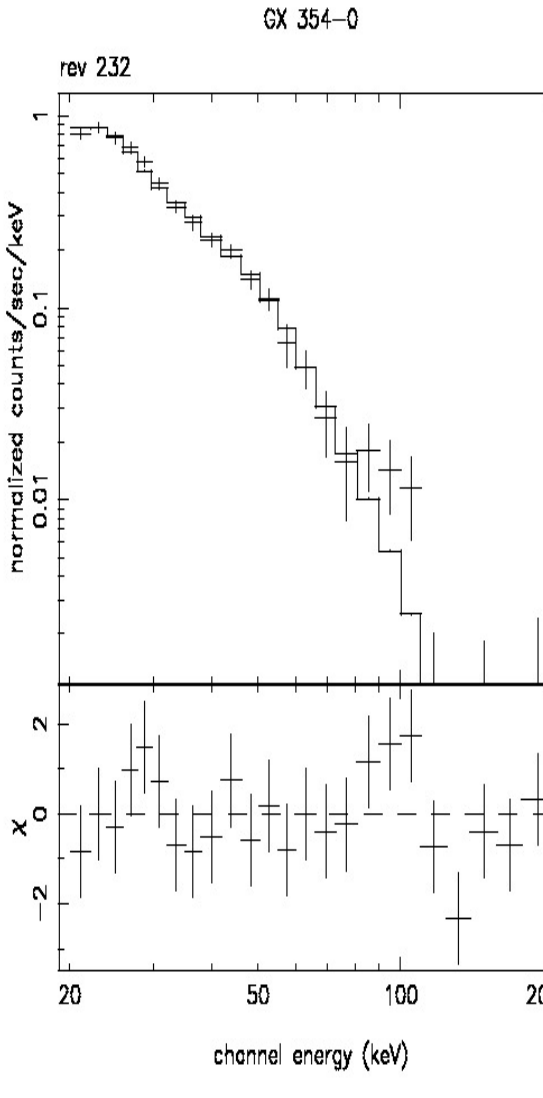
spectra in rev. 100 (169 ks) and 232 (75 ks)

compST, syst.err. 5%

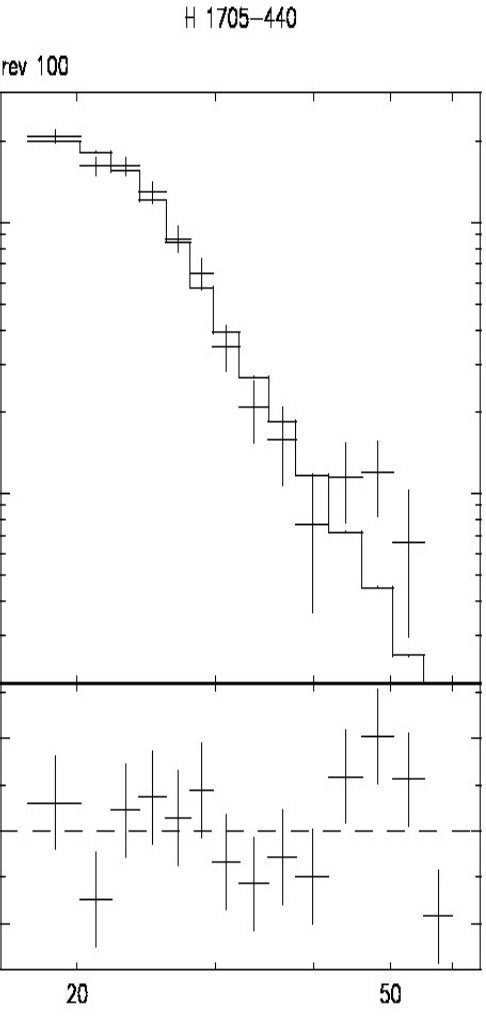
$kT = 10.0 \pm 3.8$ keV
$\tau = 5.0 \pm 2.5$
χ^2(dof) = 1.7 (11)
$\phi = 2.10 \times 10^{-10}$ erg cm^{-2} s^{-1}

$kT = 12.1 \pm 1.4$ keV
$\tau = 4.6 \pm 0.6$
χ^2 (dof) = 1.0 (21)
$\phi = 8.7 \times 10^{-10}$ erg cm^{-2} s^{-1}

notes:
- likely artifacts at ~80 keV in rev 100
- despite a factor of ~4 increase in intensity, the spectra are similar



H 1705-440



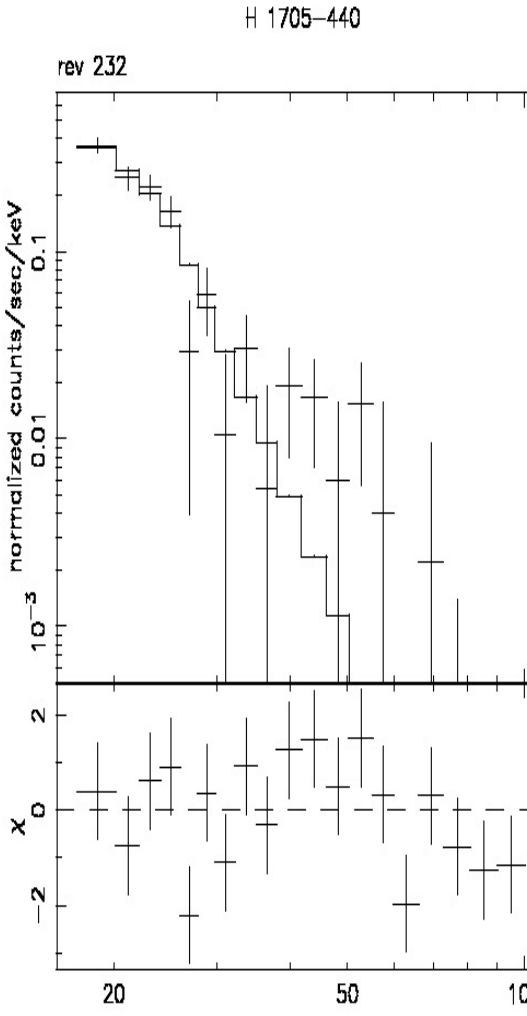
spectra in rev. 100 (212 ks) and 232 (73 ks)

compST, syst.err. 5%

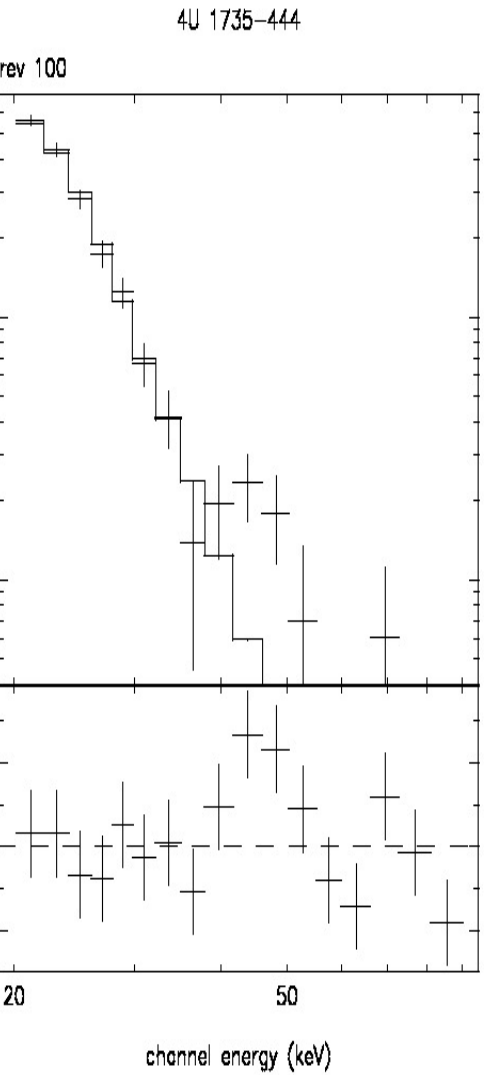
$kT = 5.0 \pm 1.2$ keV
$\tau = 5.7 \pm 3.0$
χ^2(dof) = 1.9 (11)
$\phi = 0.83 \times 10^{-10}$ erg cm^{-2} s^{-1}

$kT = 6.1 \pm 2.9$ keV
$\tau = 2.5 \pm 1.2$
χ^2 (dof) = 1.4 (16)
$\phi = 0.84 \times 10^{-10}$ erg cm^{-2} s^{-1}

notes:
• likely fake excesses above ~60 keV in rev 100
• no evidence for spectral variability



4U 1735-444



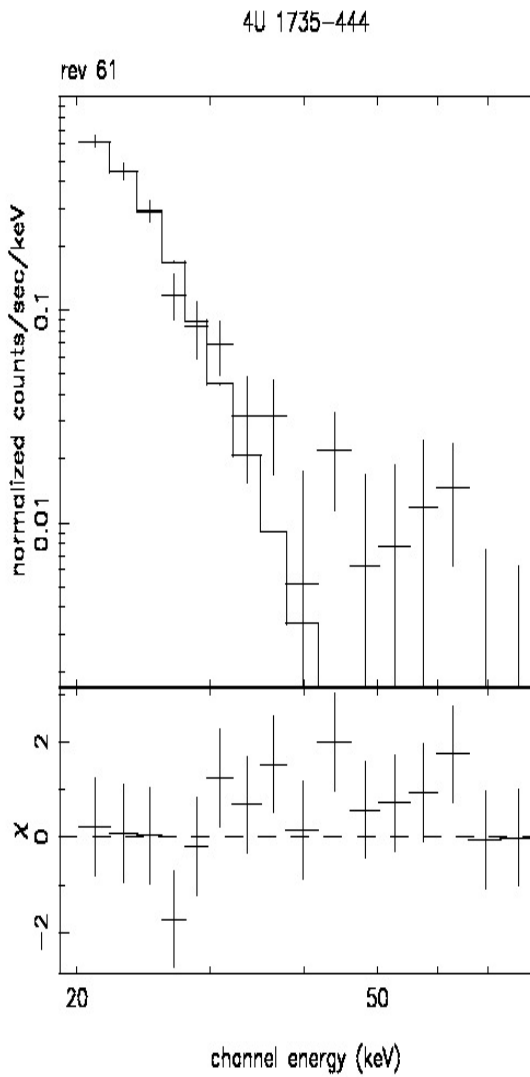
observed in rev. 100 (193 ks) and 232 (71 ks)

compST, syst.err. 5%

$kT = 3.1 \pm 0.7$ keV
τ = n.c.
χ^2(dof) = 1.2 (13)
$\phi = 1.88 \times 10^{-10}$ erg cm^{-2} s^{-1}

$kT = 2.8 \pm 1.3$ keV
τ = n.c.
χ^2 (dof) = 1.2 (13)
$\phi = 1.77 \times 10^{-10}$ erg cm^{-2} s^{-1}

note:
- marginal excess at ~50 keV, in rev. 100 (possibly a SW artifact)
- the lowest kT in our sample



Summary of the spectral fits

source	kT (*keV*)	intensity (E^{-10})	t	$?^2$ (dof)	ks (rev#)
GX 3+1	**8.6 ± 3.4**	**1.63**	**2.9 ± 1.2**	**3.0** (10)	**144** (063)
4U 1820-303	**3.7 ± 0.4**	**2.29**	**7.8 ± 2.9**	**1.4** (11)	**171** (061)
	3.0 ± 0.1	**2.15**	**17 ± 10**	**1.0** (18)	**141** (063)
	6.0 ± 2.5		**nc**	**2.3** (18)	**36** (232)
GS 1826-238	**22 ± 2**	**11.2**	**3.3 ± 0.2**	**1.5** (17)	**161** (061)
	38 ± 19	**11.2**	**2.0 ± 0.8**	**0.9** (13)	**142** (063)
	8.1 ± 0.8	**9.6**	**nc**	**1.8** (14)	**22** (232)
SLX 1744-300	**8.7 ± 1.5**	**1.00**	**11 ± 7**	**1.5** (15)	**176** (061)
	10.6 ± 4.2		**nc**	**1.1** (15)	**142** (063)
	~8.8 nc		**nc**	**1.3** (15)	**60** (232)
GX 354-0	**10.0 ± 3.8**	**2.10**	**5.0 ± 2.5**	**1.7** (11)	**169** (100)
	12.1 ± 1.4	**8.7**	**4.6 ± 0.6**	**1.0** (21)	**75** (232)
H 1705-440	**5.0 ± 1.2**	**0.83**	**5.7 ± 3.0**	**1.9** (11)	**212** (100)
	6.1 ± 2.9	**0.84**	**2.5 ± 1.2**	**1.4** (16)	**73** (232)
4U 1735-444	**3.1 ± 0.7**	**1.88**	**nc**	**1.2** (13)	**193** (100)
	2.8 ± 1.3	**1.77**	**nc**	**1.2** (13)	**71** (232)
H 1702-429 (*)	**3.5 ± 0.4**		**-**	**3.9** (10)	**79** (100)

(*) thermal bremsstrahlung fit for H 1702-429

summary & future work

- Simple Comptonized emission fits quite well the 20-200 keV spectra of *INTEGRAL* bursters
- Fitted electron kT's range from ~3 to ~20 keV, possibly clustered in 2-3 ranges of values, likely related to the source state:
  - **kT_e ~ 3 keV**, bursters in ***soft state***, no evidence for hard tail, emission drops at < 50 keV (4U 1735-444, 4U 1820-303, possibly H 1702-429)
  - **kT_e ~ 6-10 keV**, bursters in a sort of ***intermediate state***, emergence of a hard Compton tail at 50-100 keV (GX 3+1, SLX 1744-300, GX 354-0, H 1705-440, possibly GS 1826-238 in fall 2004)
  - **kT_e > 15 keV**, bursters in very ***hard state***, Compton hard tail extended well above 100 keV, up to 200 keV (GS 1826-238 before 2004, 4U 1812-12 – see A. Tarana's talk)
- Possible evidence for spectral variability (state transition?) in the (once!) very stable ("*clocked*" bursts!) source GS 1826-238
- Spectral stability of GX 354-0 regardless a ~ 4´ intensity variation

- The complete set of available IBIS data is still under analysis (a big amount of work!)
- SPI and Jem-X (when available) data has to be included
- Possibility to average, for each source, similar/consistent spectra to improve the statistics
- Analysis of bursts (Jem-X, IBIS/ISGRI)
- When possible, more refined Compton models (CompTT, CompPS) should be applied
- Next releases of spectral extraction SW should remove unwanted artifacts (? better fits!)

- Bursters papers to come!