SuperMon
and
Black Hole Tracker

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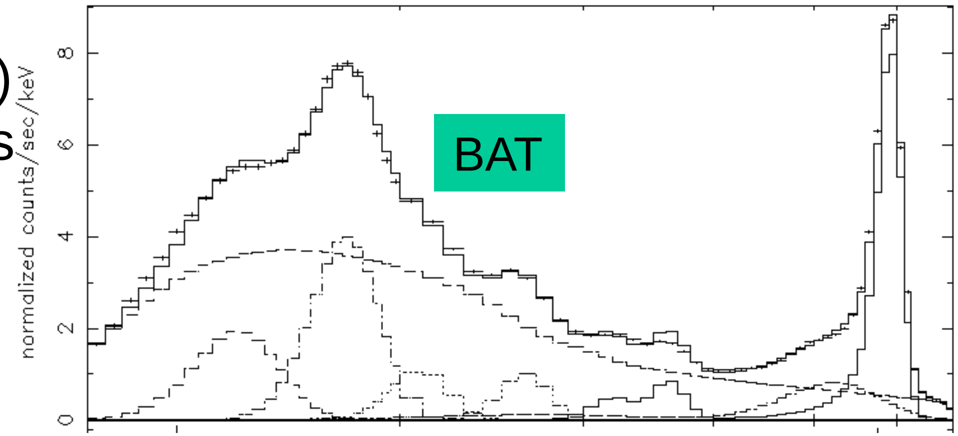
Plan

- Basic concepts
- Instrument concept - SuperMon
- Expected Science
- Scaling up – Black Hole Tracker
- TRL and Cost
- Conclusions

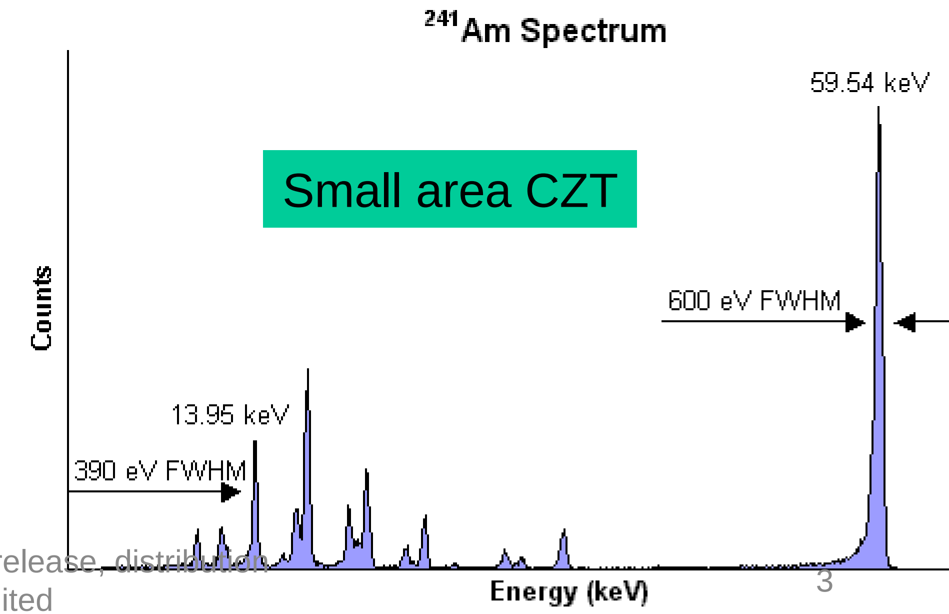
Concept 1: X-ray spectroscopy

Solid state detectors (Si/ CdZnTe/ CdTe) can be packaged into large area formats with excellent energy resolution.



A stack of these detectors will have:

- good background reduction
- modest position information for simultaneous background measurement (by coarse passive imaging) & polarimetry for low energy (above 12-15 keV) Compton scattering.
- individual pixel handling and hence well determined response.



Concept 2: Sky monitoring

- X-ray sky is highly variable. The requirements of the knowledge of variability varies from milli-seconds to days.
- Large Field of View (FOV) detectors have inherently low sensitivity.
- A combination of large FOV shallow all-sky monitoring and a narrow FOV deep monitoring of pre-decided sources meets a wide variety of purposes.

Concept 3: open detectors

- Low energy (2 – 10 keV) open detectors are more efficient in capturing the transient sky, ***including gamma-ray bursts***.
- The huge count rates can be handled by the present day fast electronics.
- This leads to huge weight saving.

Count rates for 100 cm^2

Energy range (keV)	2 - 10	10 - 50	50 - 200
CDXRB (1^o)	2.3	0.3	0.03
CDXRB (π)	7552	985	99
Crab	290	50	8
50 mCrab	15	3	0.4
5 mCrab	1.5	0.3	0.04
100 Crab (faint GRB, 1/3days)	2900	5000	800
10^4 Crab (bright GRB 1/month)	290000	500000	80000

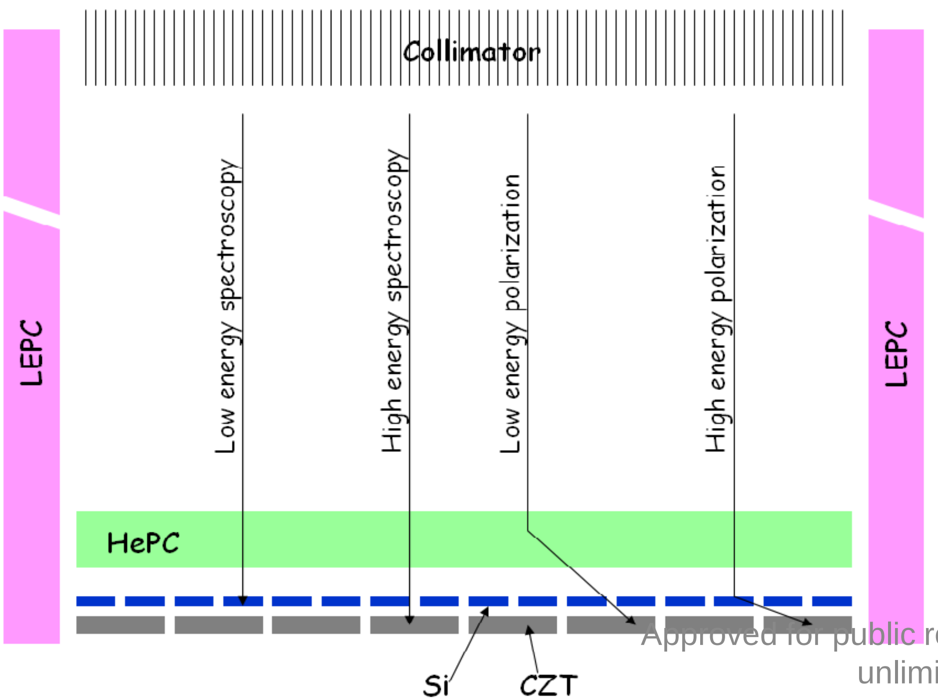
Payload Concept : SuperMon

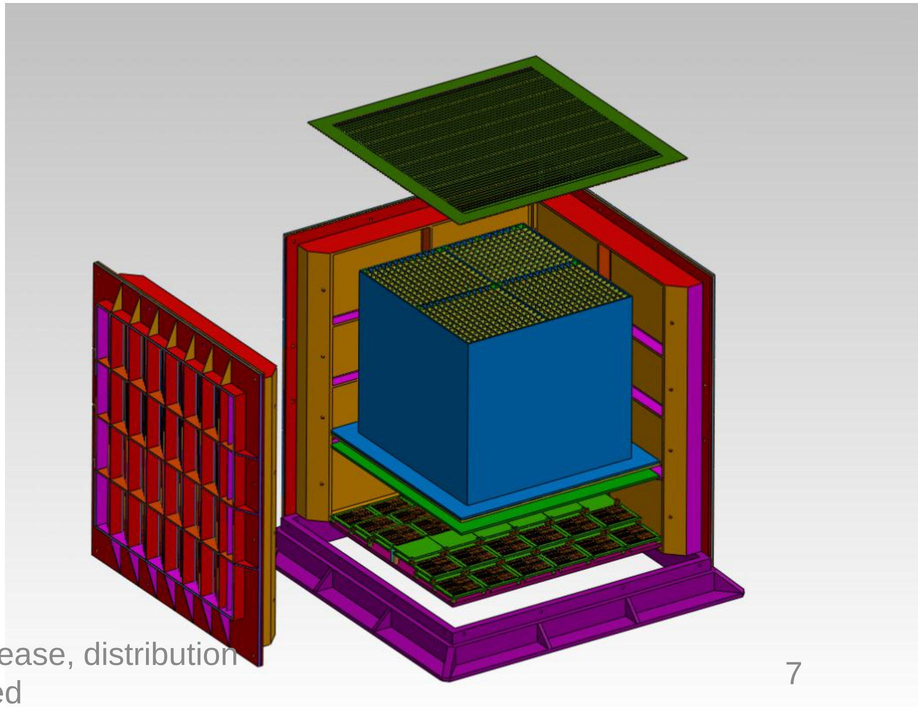
LEPC: 4 X 1000 cm^2; 2 – 30 keV

SiCZT: 400 cm^2; 2 – 60 keV; mm pos. res.

HePC: 200 cm^2; 0.5 – 20 keV; mm pos. res.

Fast slew rate: 5 degree/ second

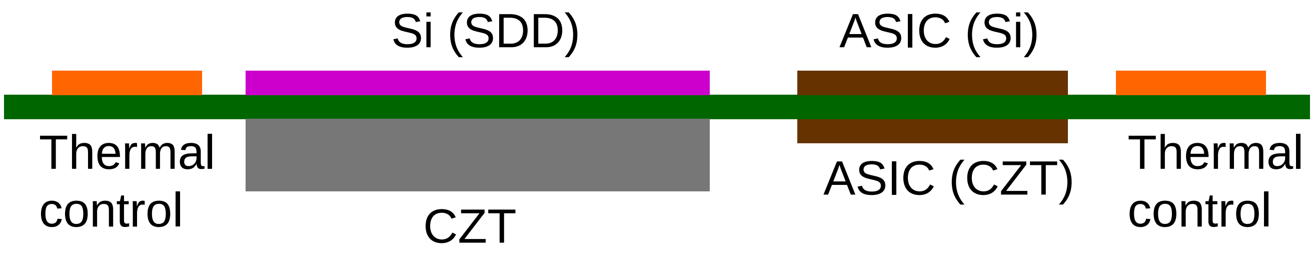




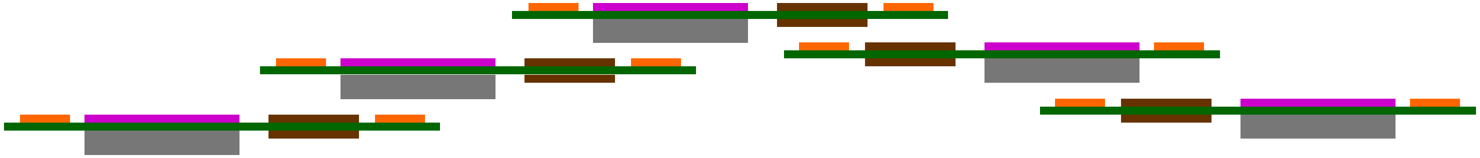
Payload Concept : SuperMon

Si / CZT “semiwich” detector

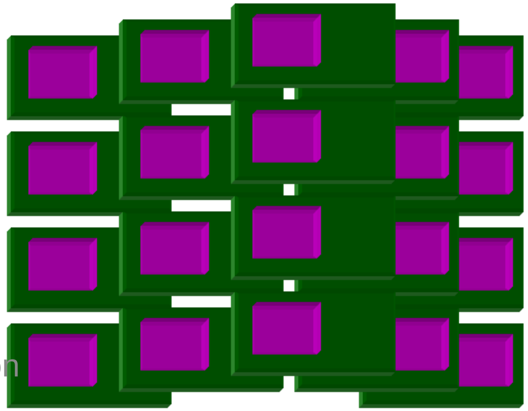
Stack of 4 x 4 cm^2 Si and 4 + 4 cm^2 CZT



Out of plane tiling ➔ for better thermal management



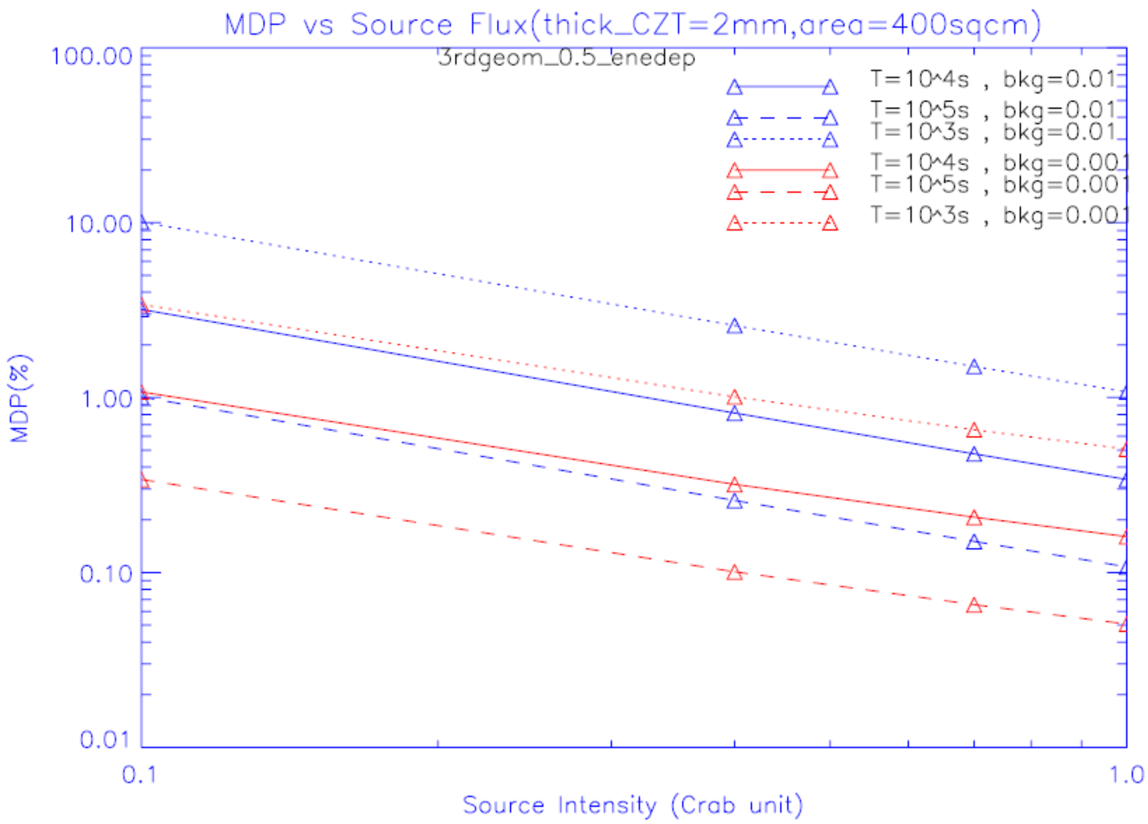
Detector plane ➔ 4 x 5 array of Si/CZT detector



Expected count rates

	LEPC (2-30 keV)	Si-CZT (2-60 keV)	CZT-open (50-300 keV)
Area	1000 cm^2	200 cm^2	400 cm^2
Background	60,000	10	100
Crab	3000	700	30
50 mCrab	150	35	1.5
5 mCrab	15	3.5	0.15
Faint GRB (1 per day)	5000	---	200
Bright GRB (1 per month)	150000	---	6000
Sensitivity	~ 30 mCrab (a few hrs)	Spectra: 1.5 mCrab – 10000s	

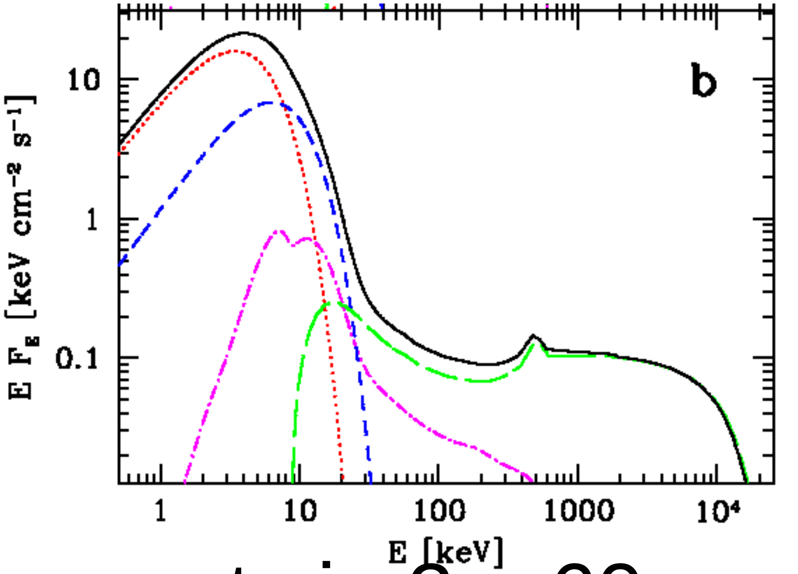
Poalarization



- Stack of Si(SDD) + CZT provides feasibility of Compton polarimetry by measuring azimuthal distribution of scattered photons
- Low energy threshold ~0.5 keV of SDD enables polarization measurement from ~15 keV
- Sensitivity of ~1 – 2 % MDP for 100 mCrab source in ~10^4 seconds

IXO Science:

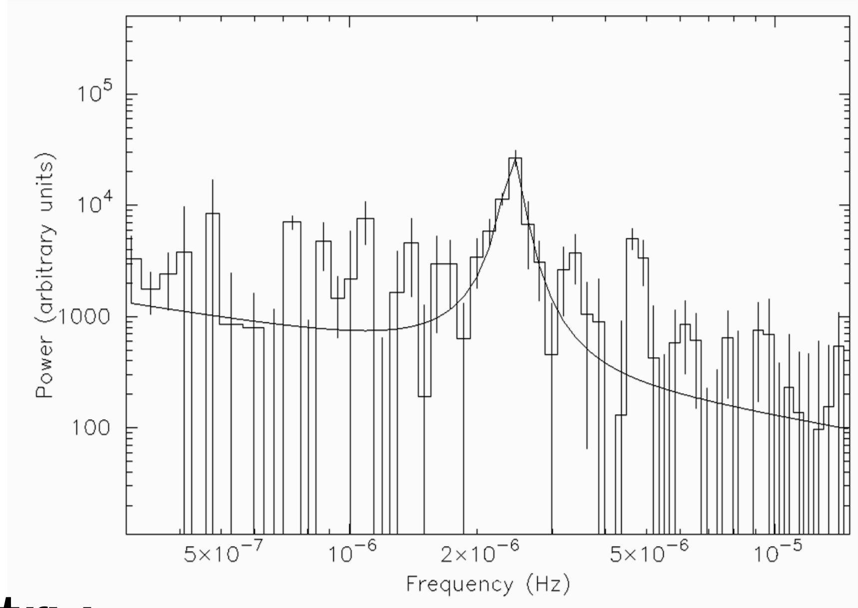
What happens close to a black hole ?



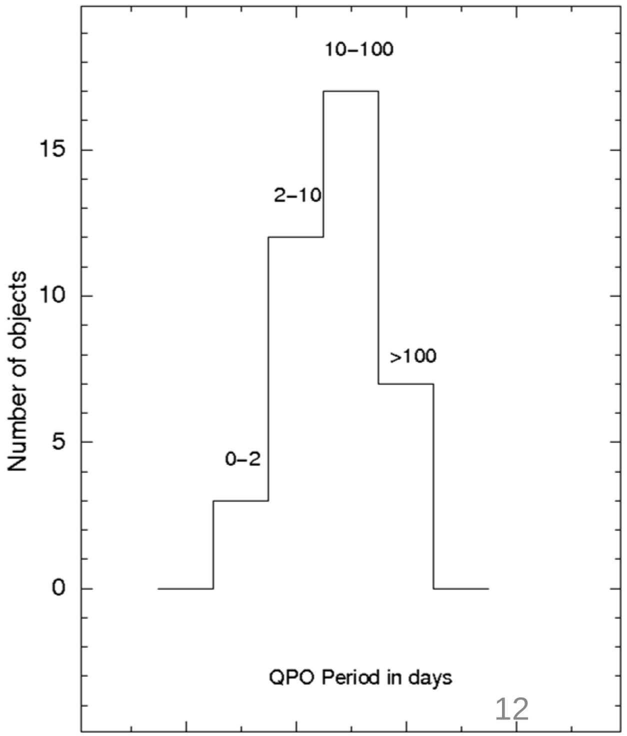
- Multiple continuum components in 2 – 60 keV range.
- Measurement of these at a variety of accretion events – episodic jet emission; state transitions; elusive HF QPOs.
- Variation of spectral parameters with timing parameters.

IXO Science:

What happens close to a black hole ?



- Make spectro-photometry of elusive QPOs in AGNs.
- A simulation of QPO observations (top)
- Expected number of AGNs with QPO periods.



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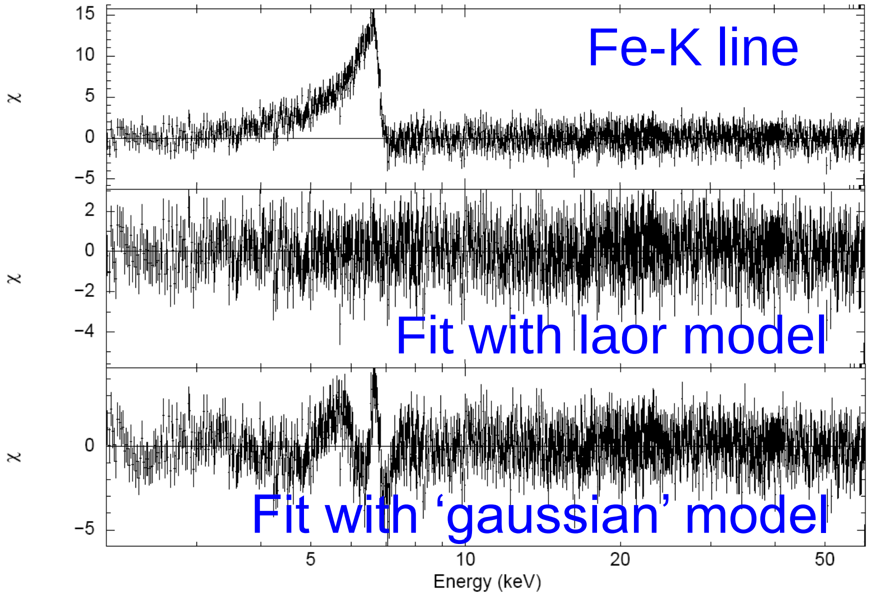
IXO Science:

What happens close to a black hole ?

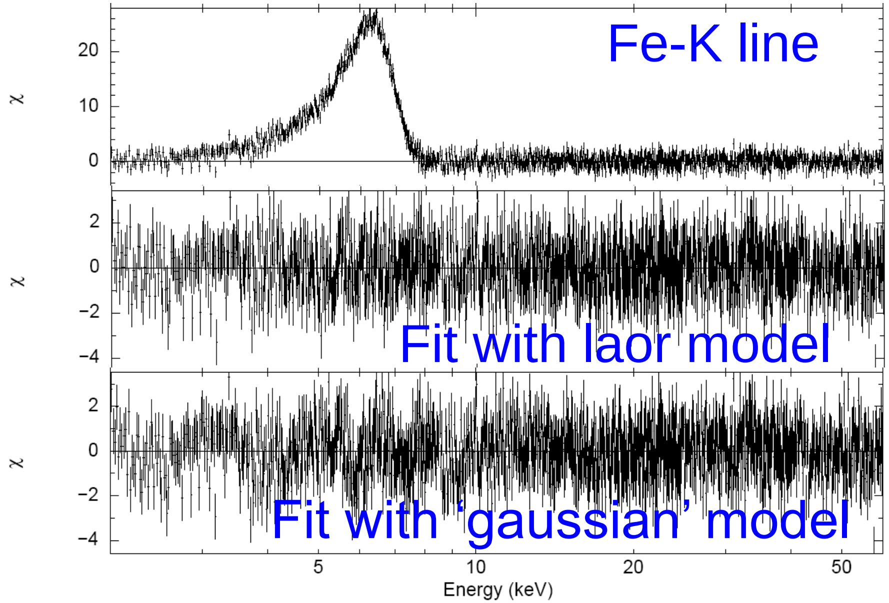
Measure Black hole spin with accurate spectroscopy

Broad Fe-K line in Cygnus X-1 (Gau et al. 2011 – Model 4)



Proposed detector

FWHM ~200 eV @ 5.9 keV

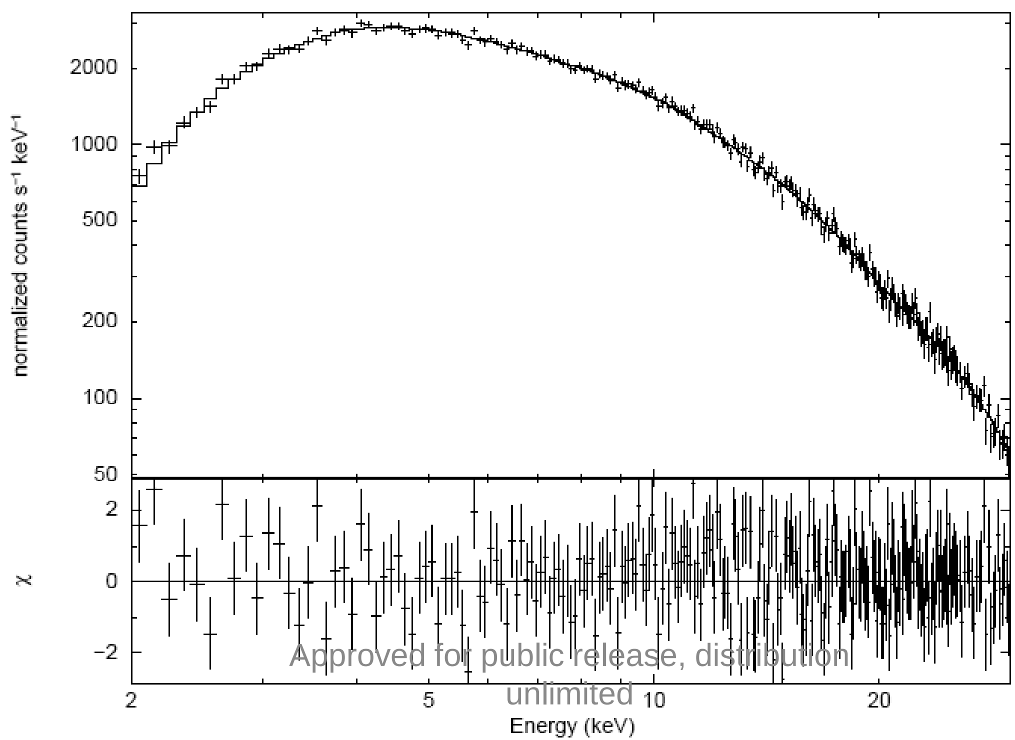


Present day detector

FWHM ~1000 eV @ 5.9 keV

IXO Science: GRBs

- Use GRBs as a probe of High-z universe.
- A typical GRB (10^{-6} erg/cm^2) as observed by LEPC



	CGRO/SAX	Swift	SuperMon
Prompt (10 s)	3º (gamma - open)	<1º (gamma - CAM)	3º (X-ray - open)
Next	0º.2 (X-ray – CAM) Min	0º.05 (X-ray – focus) Min - hr	0º.2 (X-ray – CAM) Min
Follow-up	Arc-min (X-ray – focus) hours	Arc-sec (Ground based) hours	Arc-sec (Ground based) minutes
Final (days)	Arc-sec (Ground based)	Sub-arcsec (ground/space)	Sub-arcsec (ground/space)

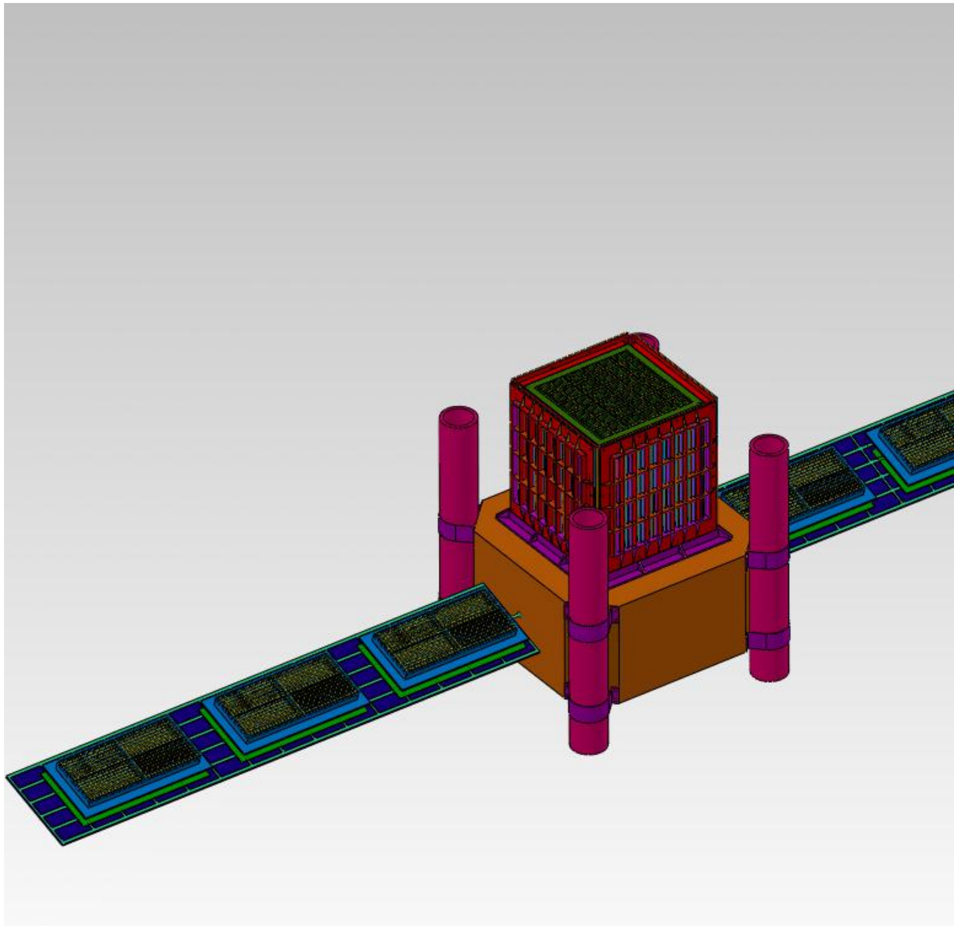
Black Hole Tracker

Requirements:

- X-ray continuum spectroscopy of a select 100 black hole sources to measure mass, spin and accretion rate across redshift/ mass range.
- A very large area low energy detector to find peculiar and `interesting’ sources.

Black Hole Tracker

- Scaling to 10 times area;
- 5 m^2 LEPCs for transient monitoring;
- Modest area focusing detectors to enhance low energy coverage.



IXO Science:

- Black Hole Growth: Use continuum spectroscopy to measure mass, spin, accretion rate of AGNs.
- Matter at high density: use spectroscopy to measure radius.
- Large scale structure: Use GRBs as illuminating sources ?
- Others: if GRB emission mechanism can be understood, they can be used to measure the distance modulus of high z objects.

TRL & Cost

- Currently at TRL 2 – 5
- No new technology; all existing known technologies.
- Each of the concepts can be pushed to TRL – 5 in about a year.
- TRL 5 – 8 can be done in 2 years for SuperMon and 4 – 5 years for BHT.
- Cost (BHT): Launch ~$50-60M; S/C ~ $100M; Instruments ~ $40-50.

TRL & Cost

	SuperMon		BHT	
	Present TRL	Time for TRL=7	Present TRL	Time for TRL=7
LEPC	4-5	2 year	3-4	3 year
Si/CZT	2-3	3 year	2-3	3 + 1 year
HePC	4	2 year	4	1 year
Collimator (conventional)	5	1 year	5	2 year
Collimator (FZP)	3	1 year	3	3 + 1 year
Data handling / telemetry	5	2 year	3	4 year
S/C Structure	5	2 year	3	4 year
S/C Thermal	4	2 year	3	4 year

Cost

	Instruments	S/C	Launch	Total
SuperMon	$ 25 M	$15 M X 3	$10 M X 3	$100 M
BHT	$40-50 M	$40-50 M	$50-60 M	$200 M

Conclusions

- Fine imaging, high resolution spectroscopy, fast timing etc. in low energies are established and essential sciences.
- Wide band X-ray spectroscopy with timing and polarimetry is an unexplored region and breakthrough science awaits being exploited.

Thanks

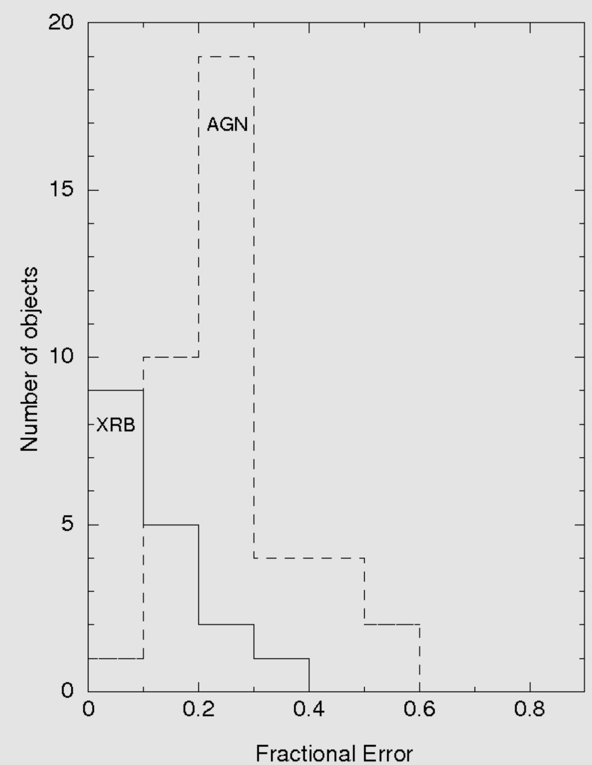
Additional Slides

IXO Science:
What happens close to a black hole ?

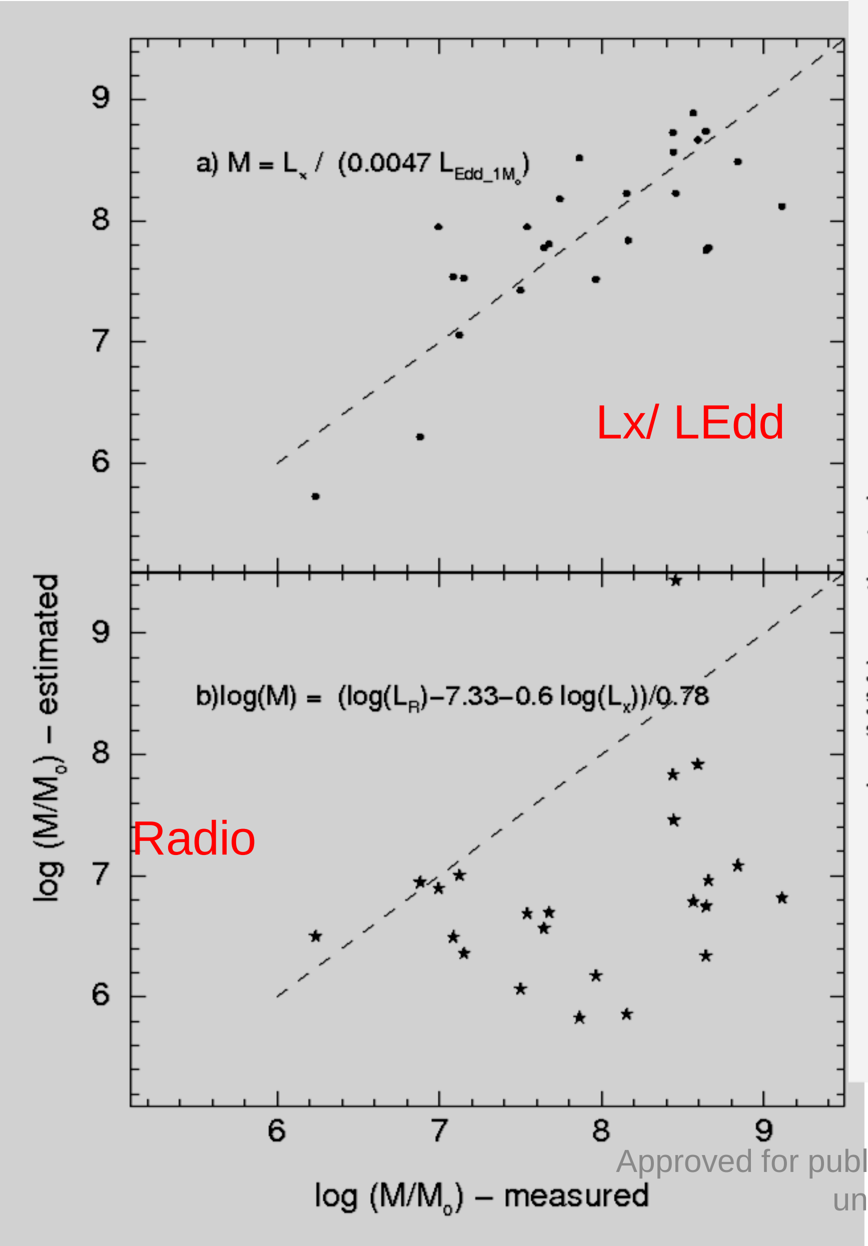
- Mass measurements available for 39 AGNs and 17 XRBs.
- Typical accuracy

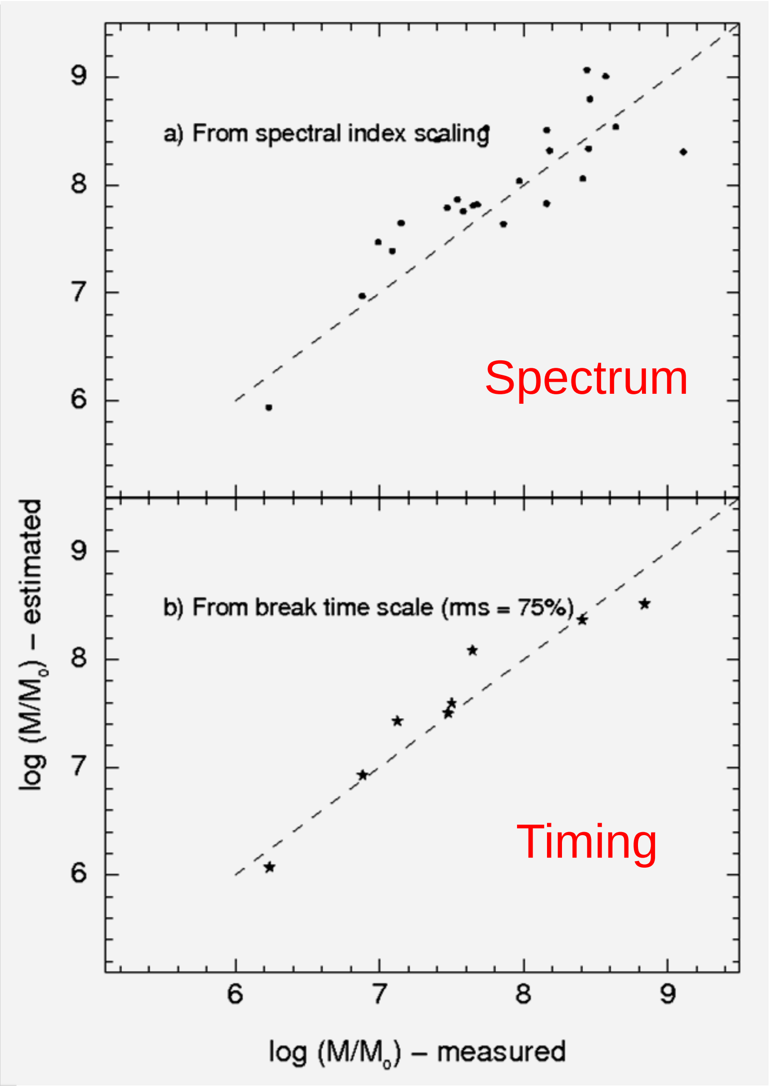
  ~ 30% for AGNs

  ~ 10% for XRBs

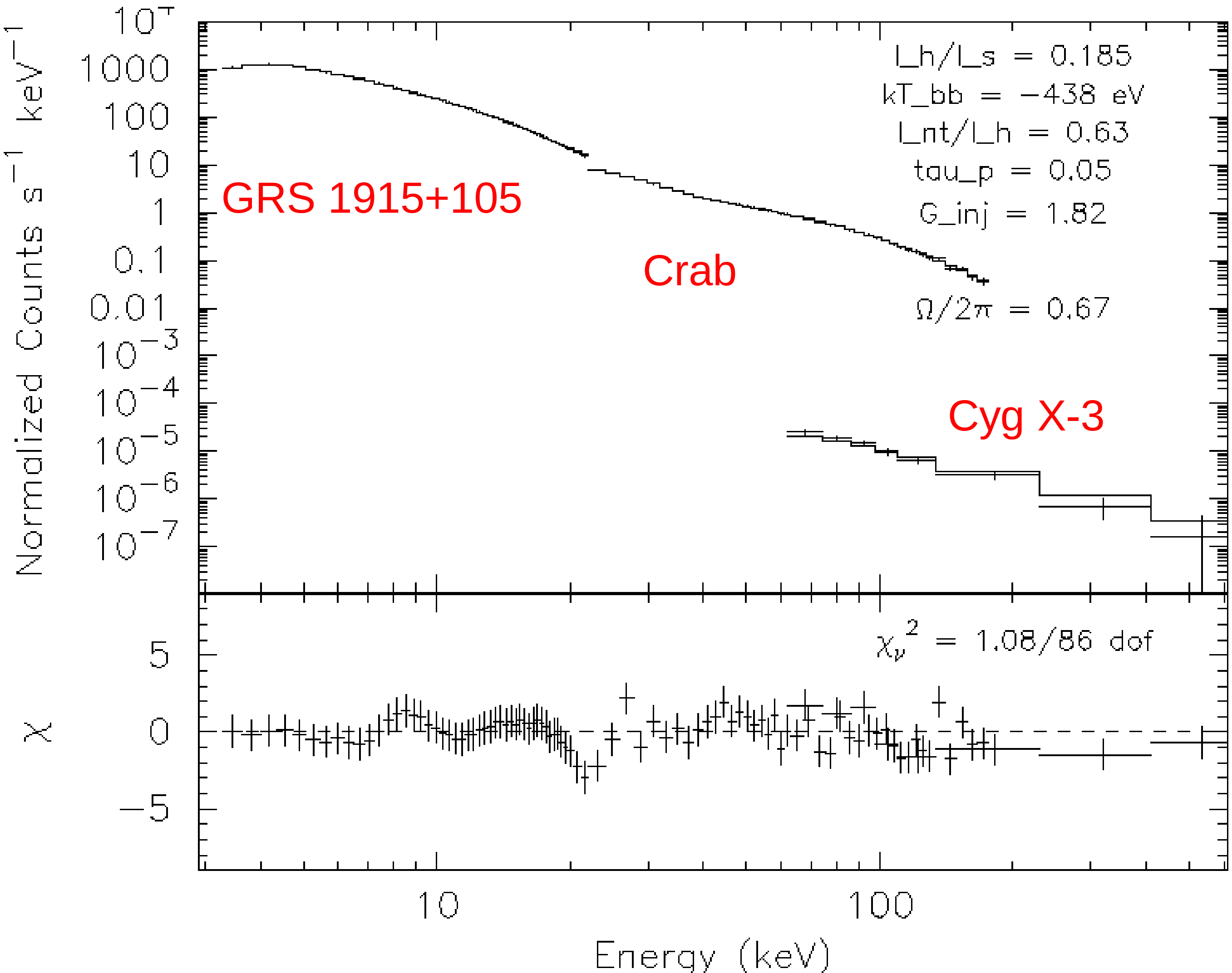


Black hole mass measurements

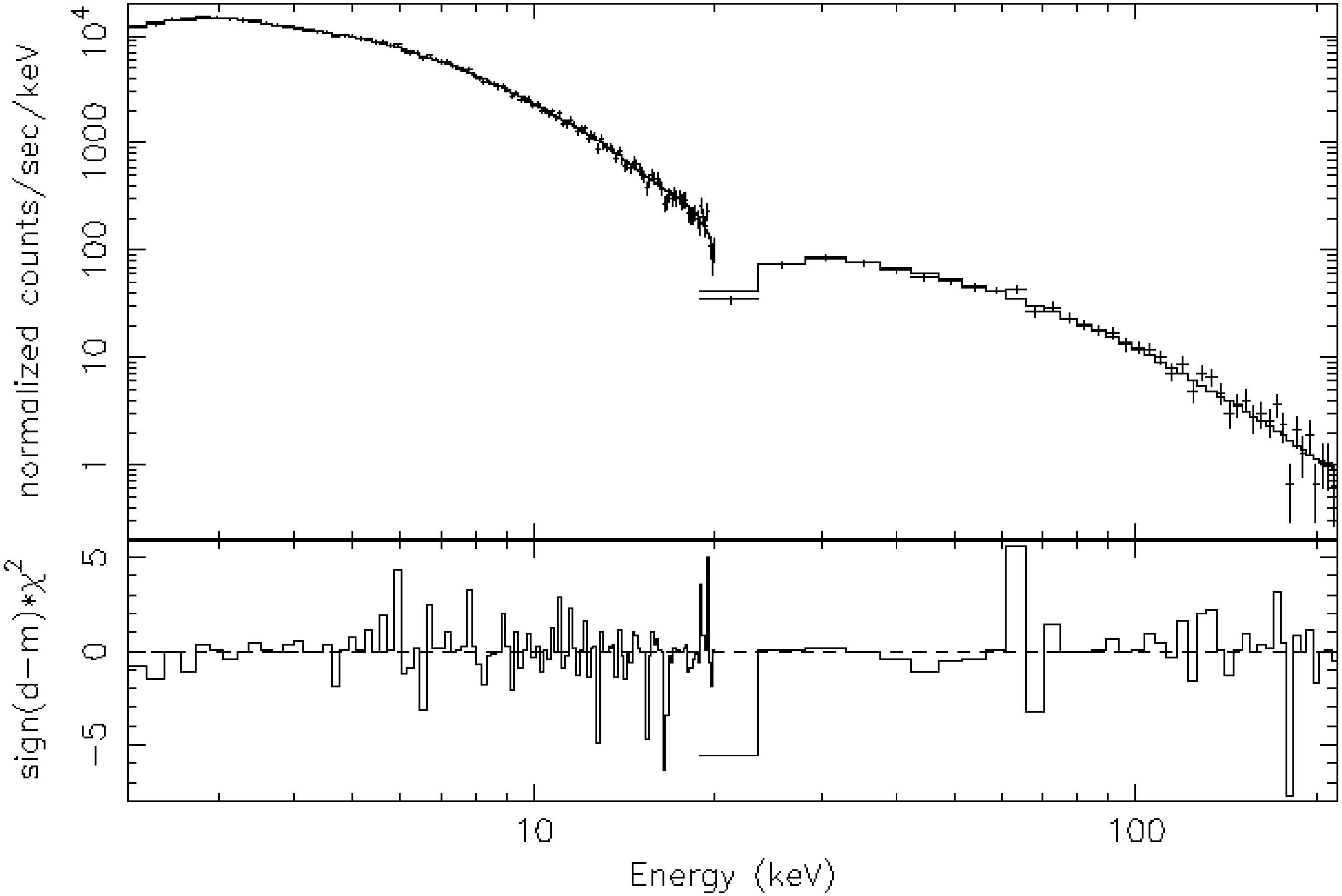




Eqpair for multiple sources



GRB spectrum in SuperMon



ASM sources (first 4 years)

Soft X-ray transients:

- 50 transients (11 new)
- About 80% > 100 mCrab; 90% |b| < 5 degree
- Daily photometry ($\pm$10 mCrab). Spectroscopy: PCA/ HEXTE

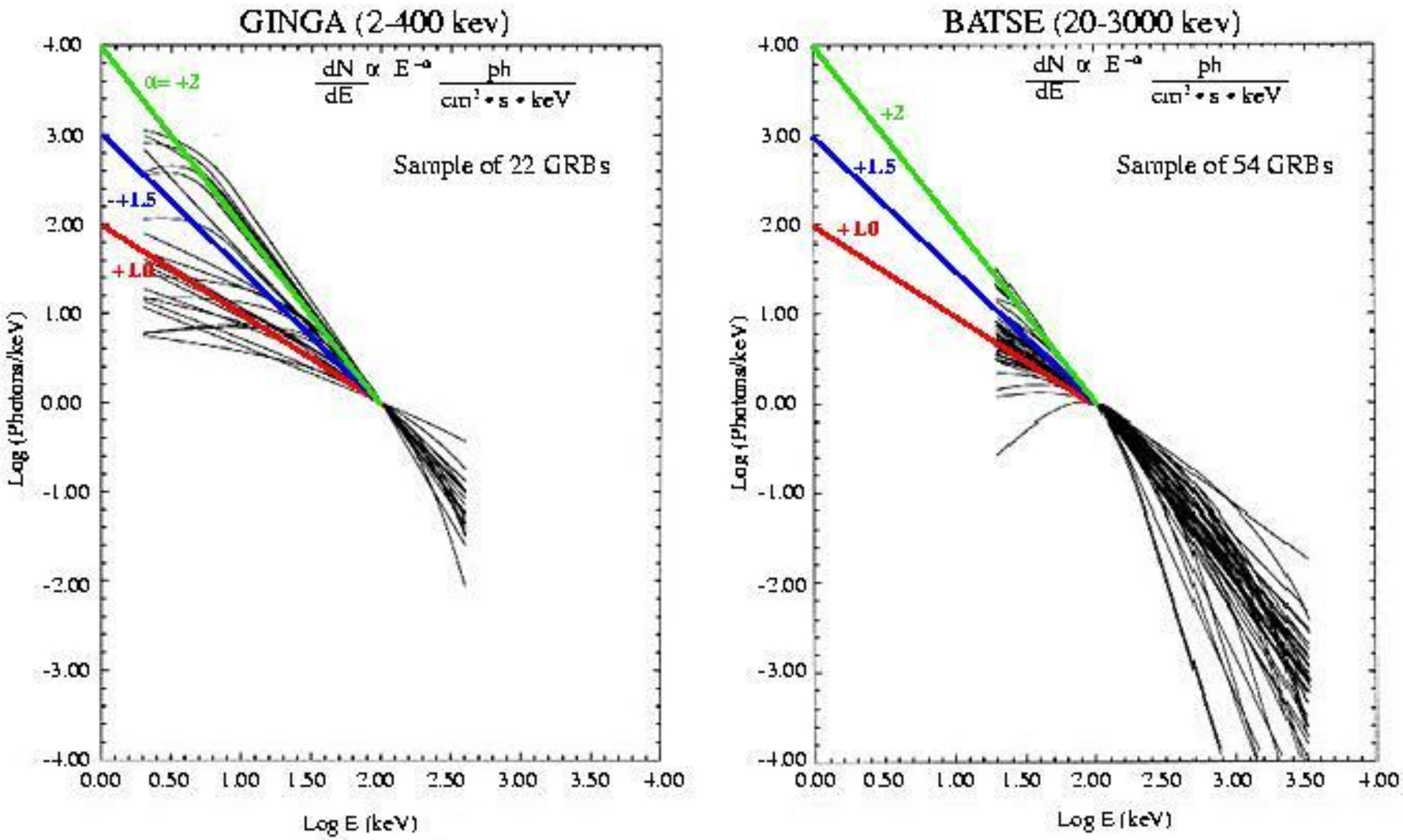
Periodicity measurement:

- 40 objects: 837 s spin period (X Per) to 164 d precession period (SS 433).

Extragalactic sources:

- 23 extragalactic objects (14 Sey1 and QSOs, 4 BL Lacs, and 5 clusters). Flux 2 – 15 mCrab.

Remaining assorted sources, mostly X-ray binaries



Relative # of Photons in Spectral Band			
Photon Index α	Energy Ranges (keV) 1-10	10-50	50-300
1	1.28	0.90	1
1.5	8.17	2.09	1
2	54	4.8	1

GRB Low energy spectrum

(Strohmayer, et al. 1998)