The ASTRO-H view of the high-energy sky

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Plan

1. The Astro-H high-energy instruments : HXI and SGD
2. Astro-H view of the Milky-Way
3. Active Galactic Nuclei
4. Galaxy clusters

The HXT/HXI telescope

HXT : Pt/C multilayer hard X-ray mirror.

HXI : Si/CdTe DSSD stacked detectors, protected by a BGO anticoincidence.

Focal length : 12 m.

Energy range	5 – 80 keV
FOV	6,4’ x 6,4’ (30 keV)
HPD	1.7’
Energy res.	260 eV (6 keV)
Timing res.	~ 50 μs

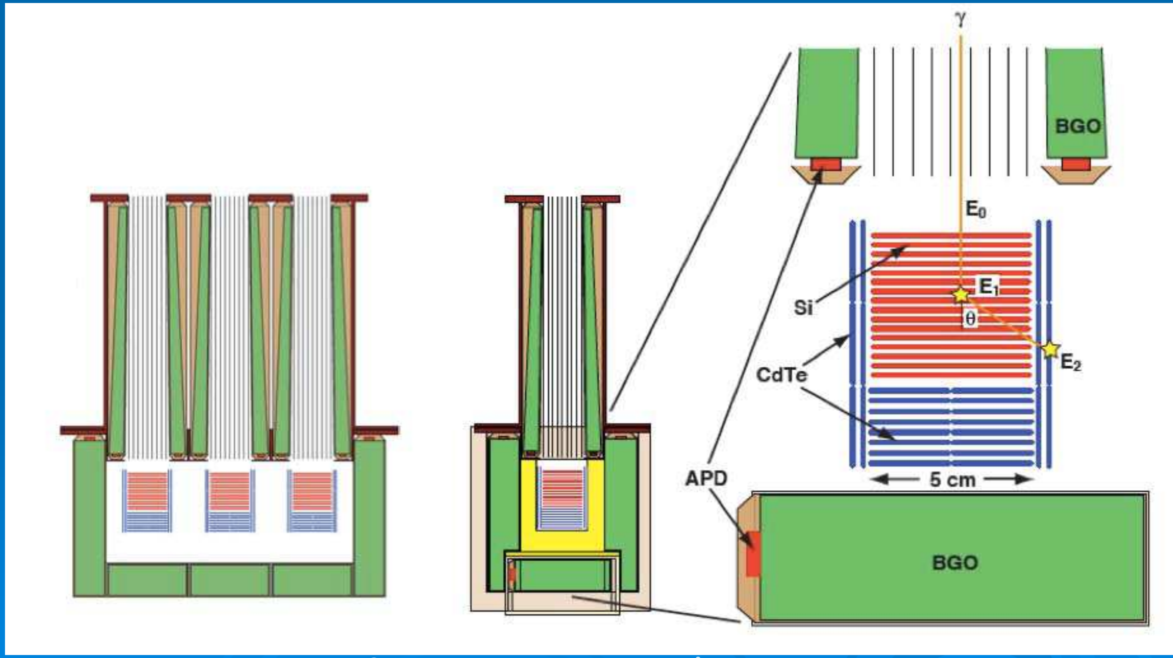
HXT mirror

HXI detectors

The SGD Compton telescope

SGD : Si/CdTe DSSD stacked detectors, protected by a BGO anticoincidence. FOV limited by passive and BGO collimators.

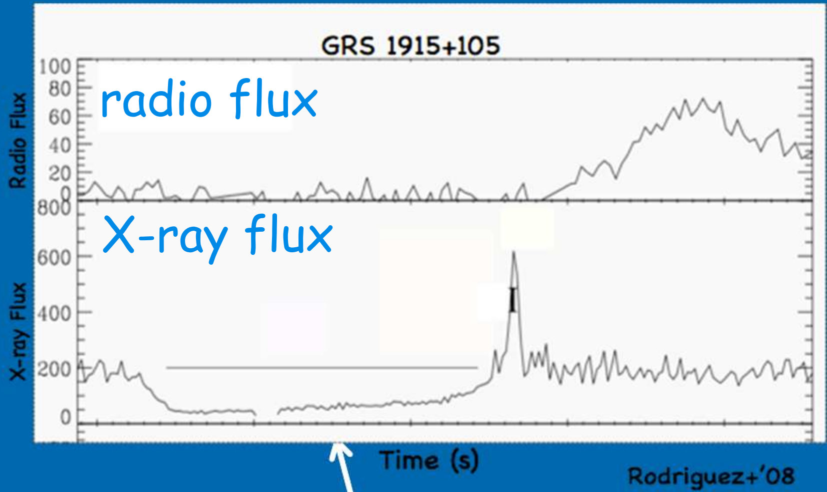
Energy range	10 – 600 keV
FOV	33' x 33' (<150 keV)
Energy res.	2 keV (40 keV)
Timing res.	~ 50 µs
MDP	??

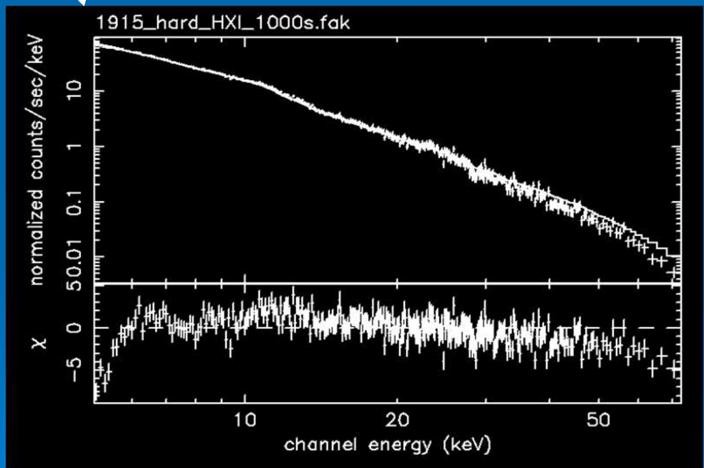


SGD Compton telescope

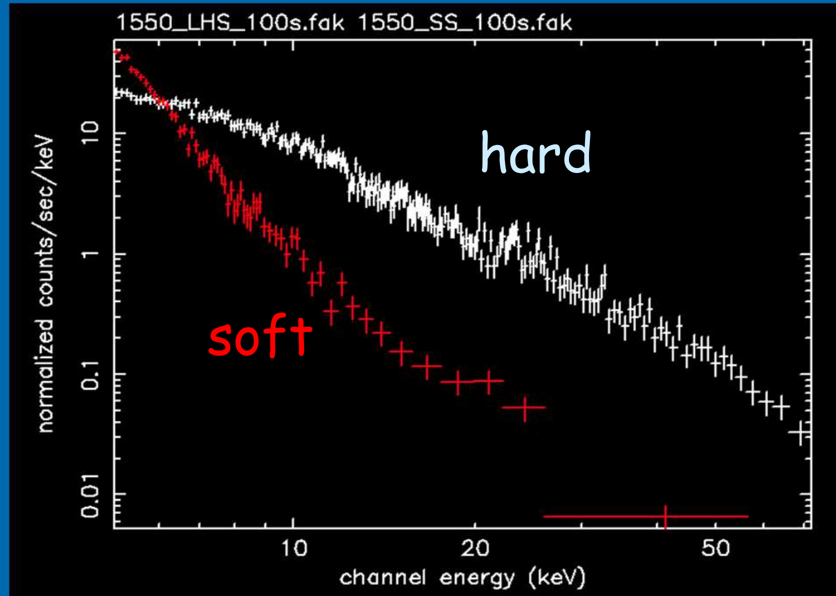
Astro-H view of the Milky Way

Black Hole Binaries spectroscopy





Hard spectra of soft X-ray dips
=> Physics of corona/jet



Simulations of XTE J1550-564 spectral states (100s).

Astro-H/HXI will characterise BHB spectral states in short time (100s) observations.

BHB : Timing studies (LFQPO)

$$A(\%) \approx 100 \times 2n_{\sigma} \times \left[\frac{W_{QPO}}{T}\right]^{1/4} \times F^{-1/2}$$

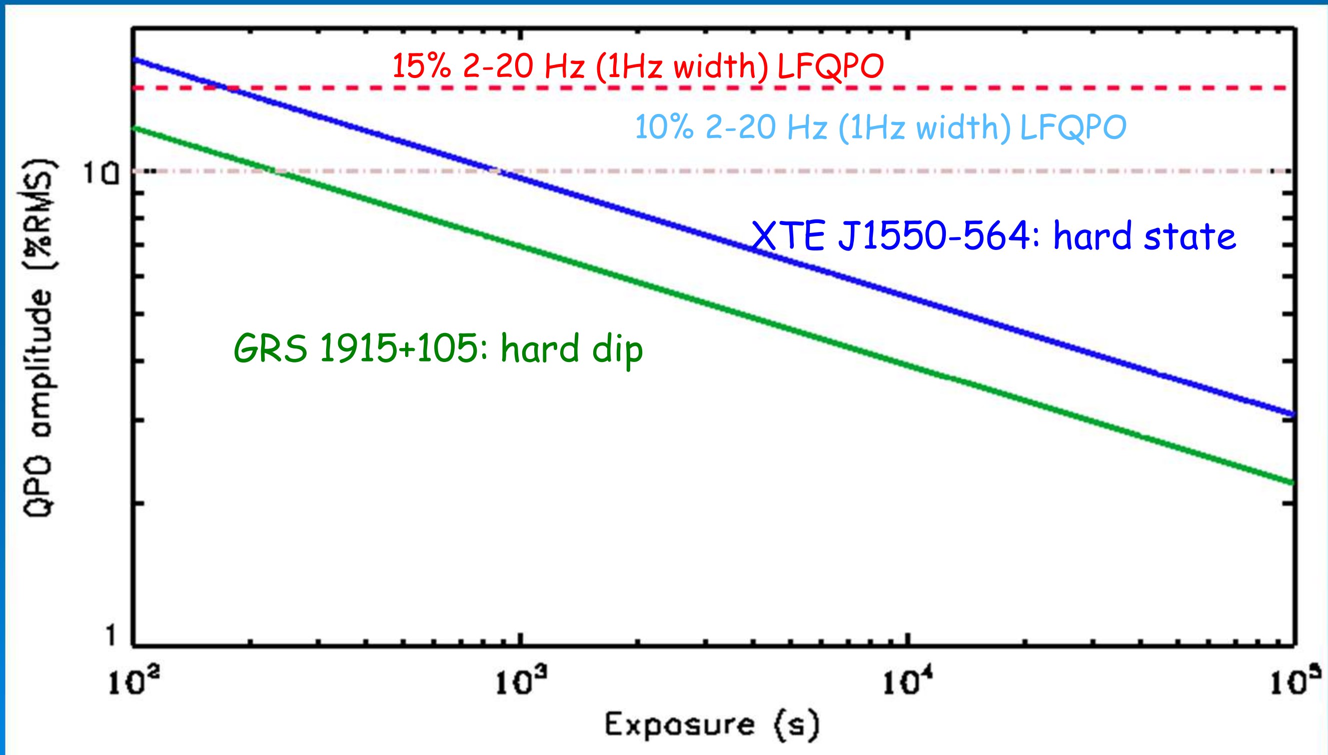
QPO width (Hz)

RSM amplitude

Significance

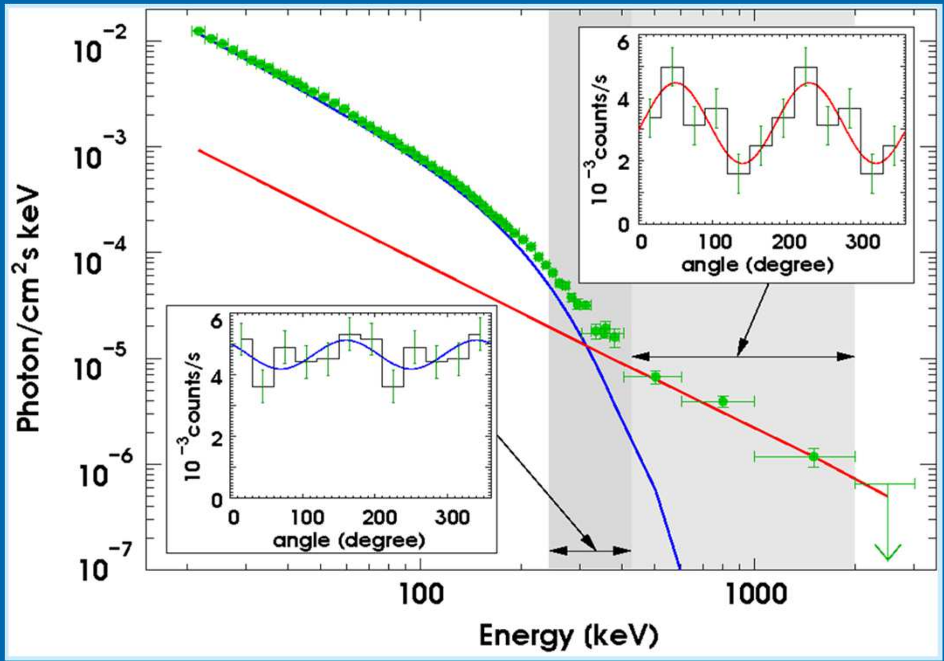
Exposure time

Count rate (bgd negligible)



Astro-H will enable the detection of LFQPO in short times (~100s) above 10 keV.

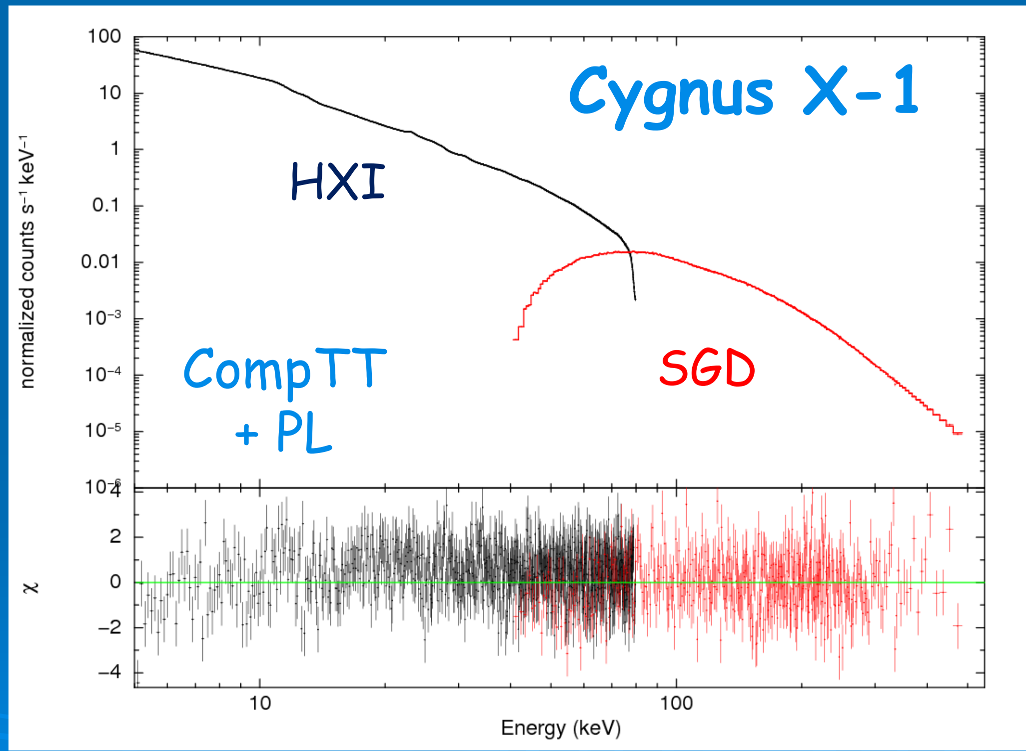
BHB : polarimetric studies



Integral/IBIS observations

Model (according to IBIS obs.)

compTT : kT = 55.3 +/- 0.12 keV
τ = 0.89 +/- 0,002
powerlaw : α = 1.47 +/- 0,05



Astro-H/HXI and SGD simulations

Astro-H will measure the bright BHB polarisation from 40 to 500 keV.

Astro-H observations of pulsars

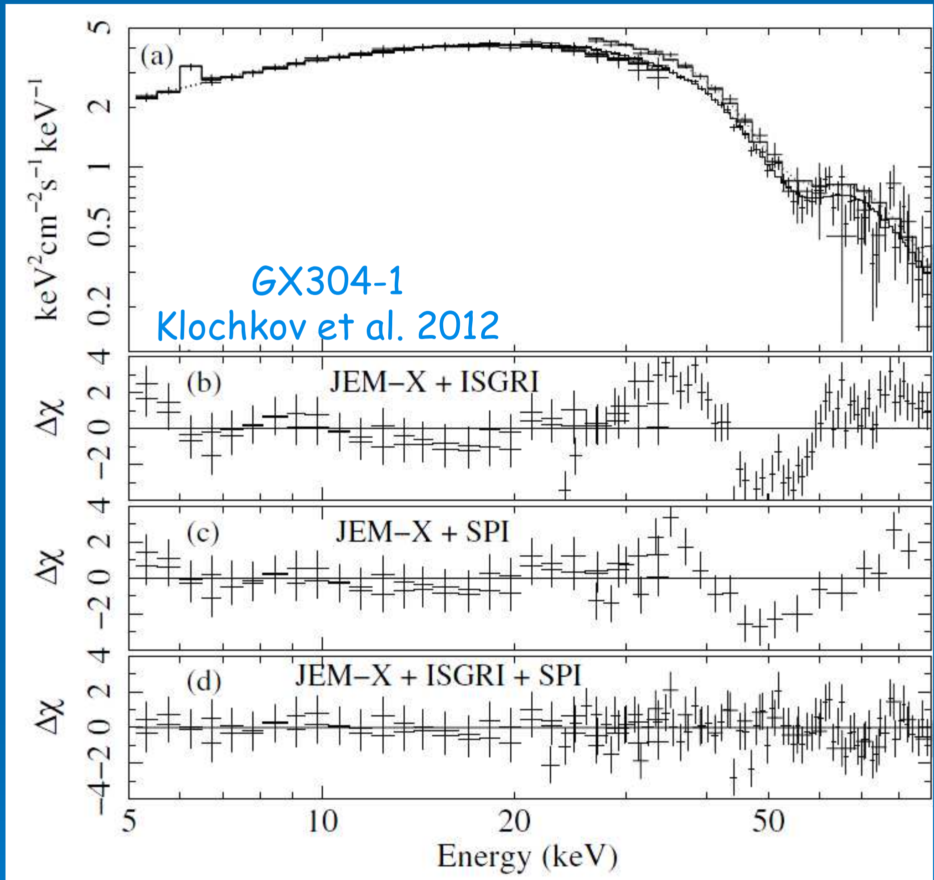
- The origin of the pulsars emission is far from understood:
  soft X-ray ⇒ neutron star surface
  hard X-ray ⇒ magnetosphere and pulsar's environment.

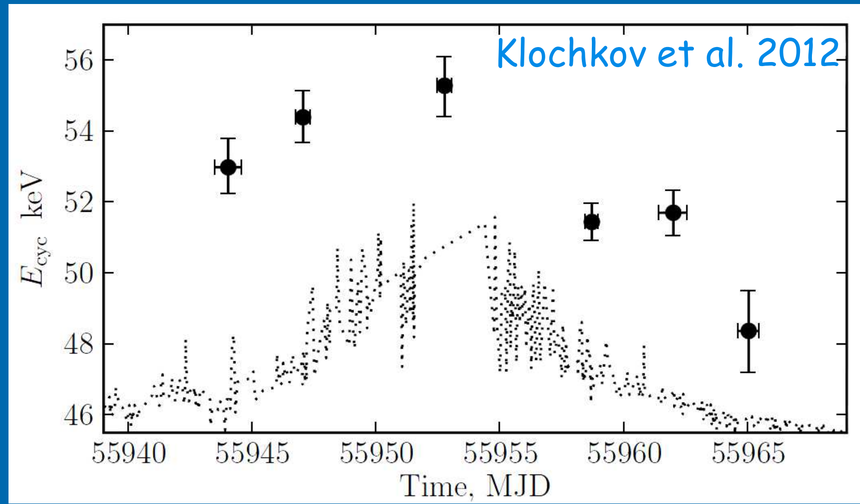
Astro-H : studies of phase-resolved spectroscopy and polarimetry of isolated neutron stars.

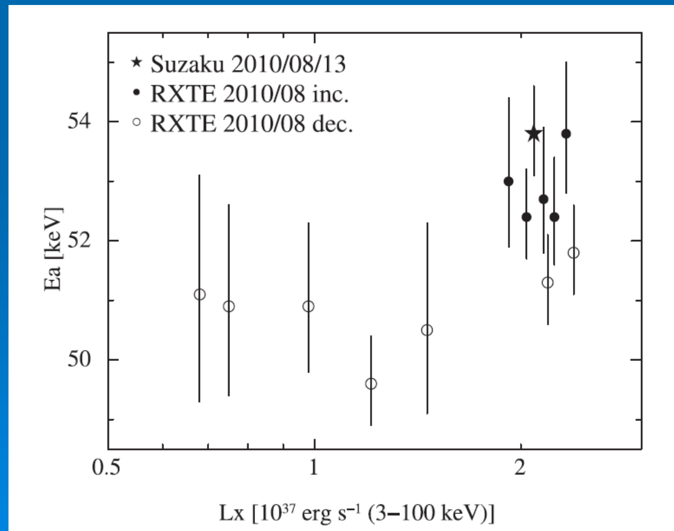
	Period (ms)	Pulse size (ms)	5-15 keV (cts/s)	15-80 keV (cts/s)	Estimated Observation time (s)* 5-15 keV	Estimated Observation time (s)* 15-80 keV
Crab pulsar	33	~21	80	13	120	600
PSR 1509-58	150	~90	1,2	0,4	6 800	21 000
PSR 0540-69 in LMC	50	~42	0,13	0,02	31 000	220 000
Crab polar.	33	~21	1,3 (40-300 keV)		30 000 (S/N=8)	
Background			0,01/0,03	0,0035		

*This time is the estimated time to get a mean signal to noise ratio equal to 3 in each bin of the pulse in the light curve for a 100 microseconds temporal resolution.

Astro-H observations of accreting pulsars



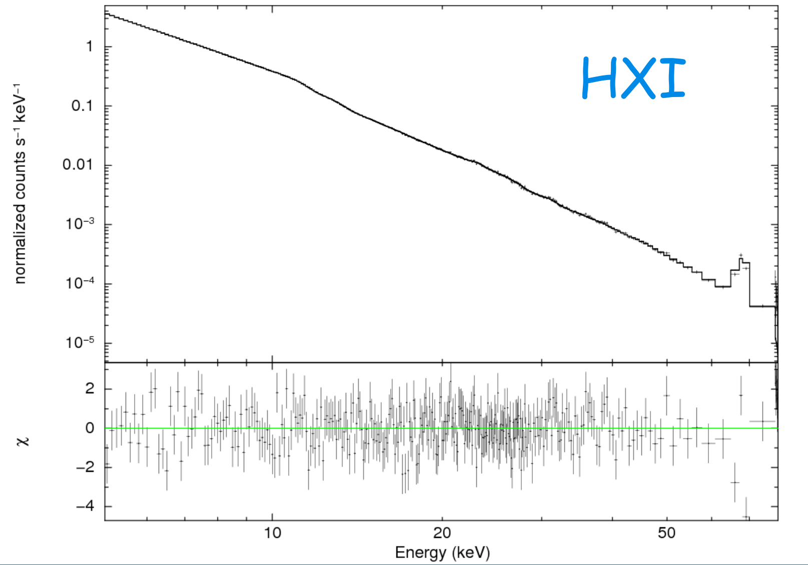




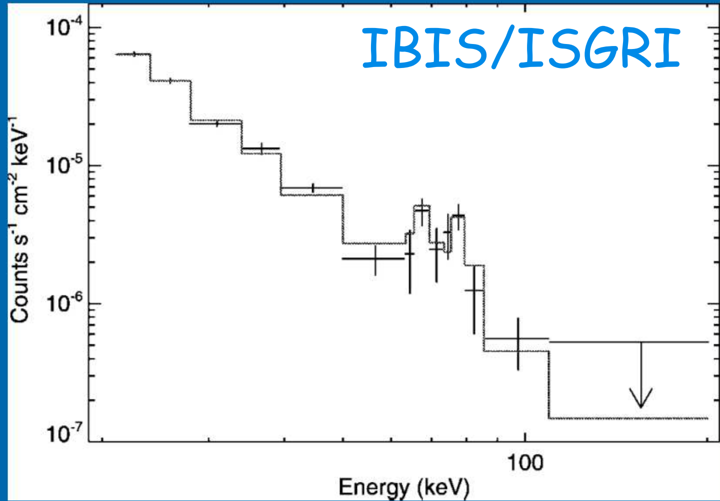
Yamamoto et al. 2012

Astro-H : studies of phase-resolved spectroscopy (cyclotron lines).

Astro-H observations of ^{44}Ti lines in young SNR (67,9 and 78,4 keV)

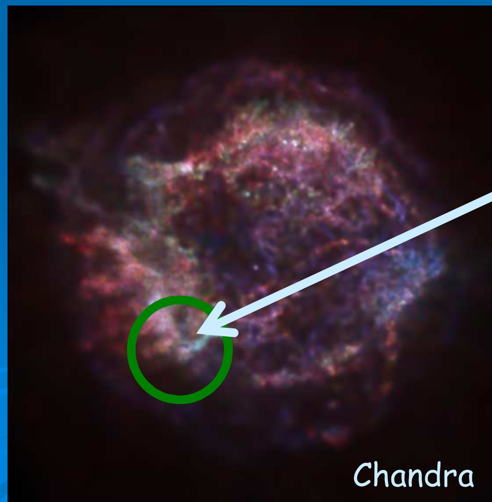


Simulations of Cas-A (1 Ms)



Integral observation of ^{44}Ti in Cas-A
(Renaud et al., 2006, 3.2 Ms)

powerlaw : $\alpha = 3{,}29 \pm 0{,}01$
Gauss : $E_{line} = 68{,}2 \pm 0{,}2$ keV
$\sigma = 1{,}53 \pm 0{,}16$ keV
$F = 3{,}1 \pm 0{,}2 \ cm^{-2} \ s^{-1}$



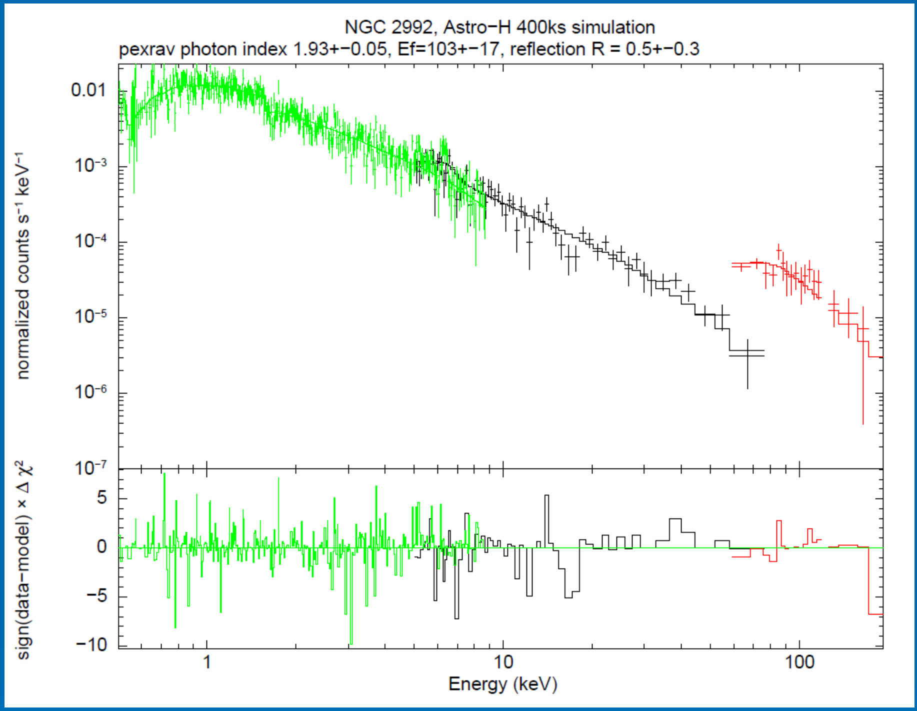
HXT FOV

Astro-H will localize the places where ^{44}Ti production occurs.

Active Galactic Nuclei

Astro-H observations of Seyfert

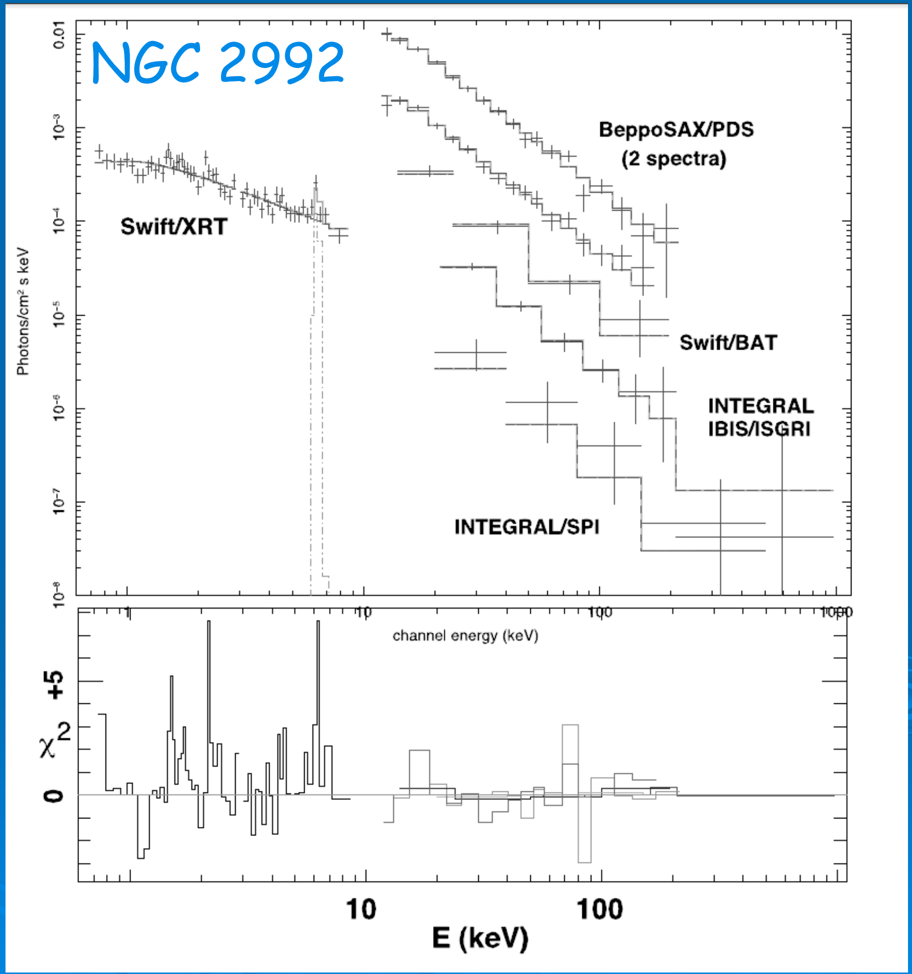
Comparison with Swift/Integral observations (Beckmann et al., 2007, 400 ks)



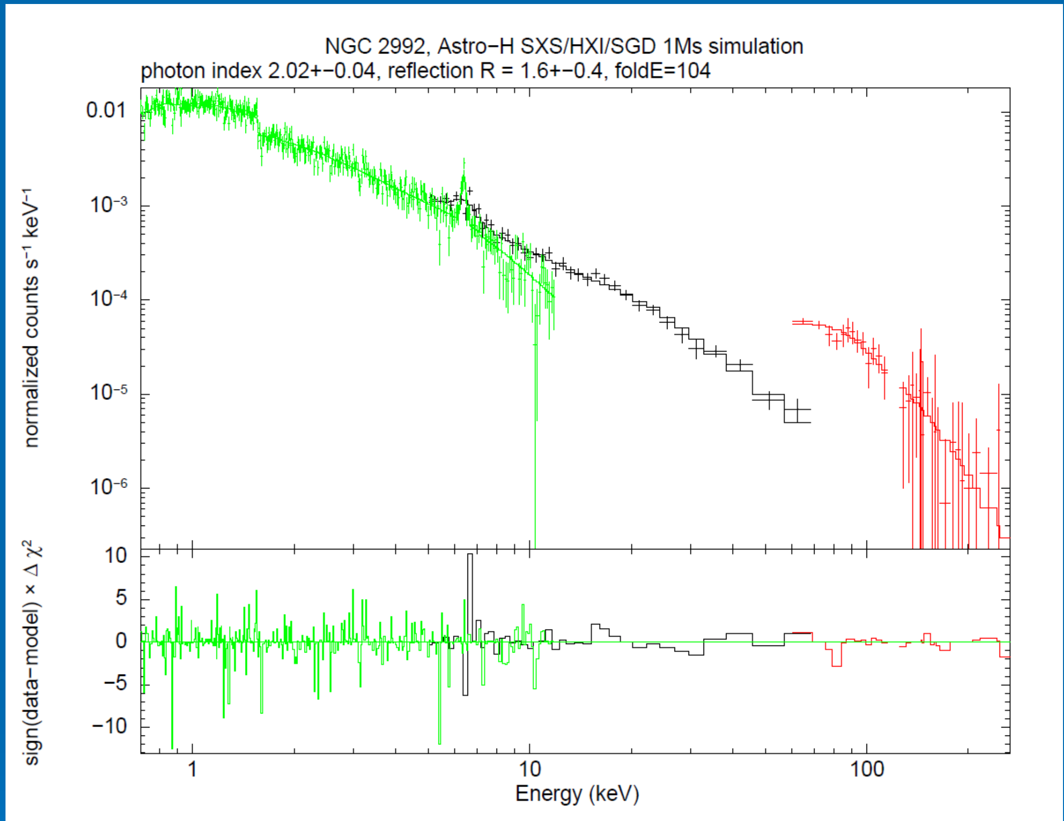
NGC 2992 : bright Seyfert 2 galaxy.

$F_{2\text{-}10} = 9\ 10^{-11}$ erg/cm^2/s

$F_{20\text{-}100} = 7\ 10^{-11}$ erg/cm^2/s



Astro-H observations of Seyfert



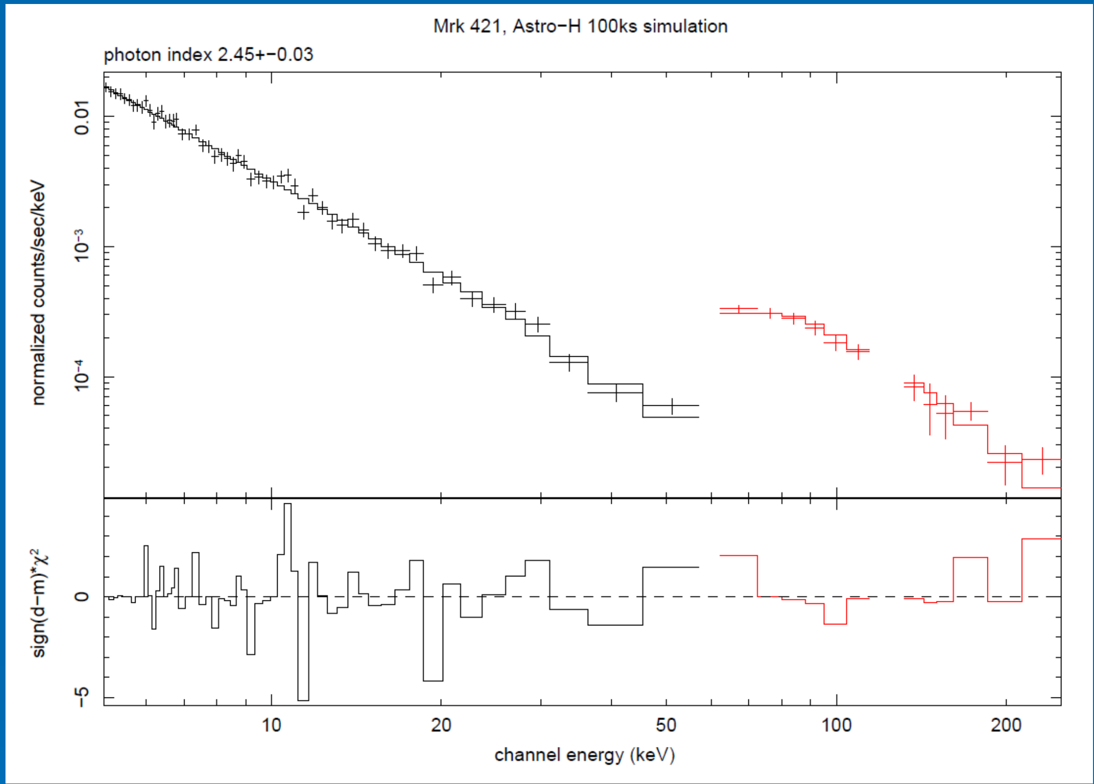
NGC 2992 : bright Seyfert 2 galaxy.

SXS/HXI/SGD simulated spectrum of NGC 2992 (1000 ks) : $\alpha = 2{,}02 \pm 0{,}04$

With 1 Ms :

- Broad band spectra of bright AGN clearly detected.
- Reflection well constrained.
- Hard X-ray polarization ?

Astro-H observations of Blazars

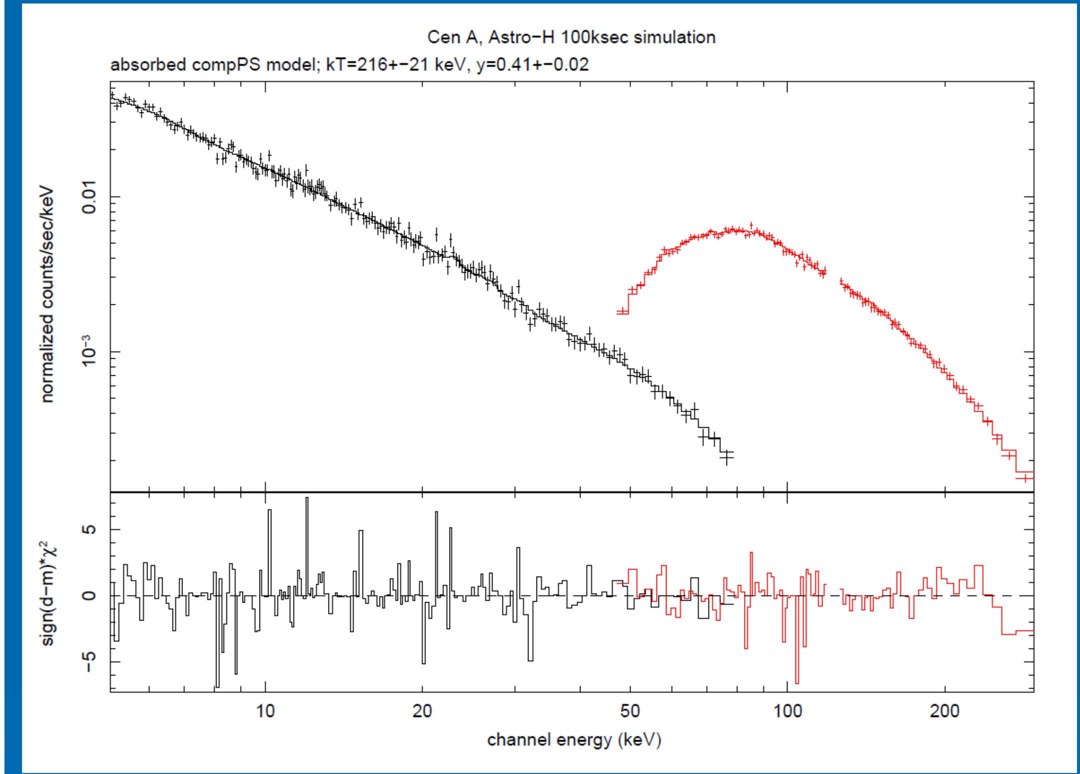


Mrk 421 : bright blazar.
$F_{2\text{-}10} \sim 7\ 10^{-10}$ erg/cm²/s
$F_{20\text{-}40} \sim 3\ 10^{-10}$ erg/cm²/s

Simulated spectrum of Mrk 421 (100 ks) :
$\alpha = 2{,}45 \pm 0{,}03$

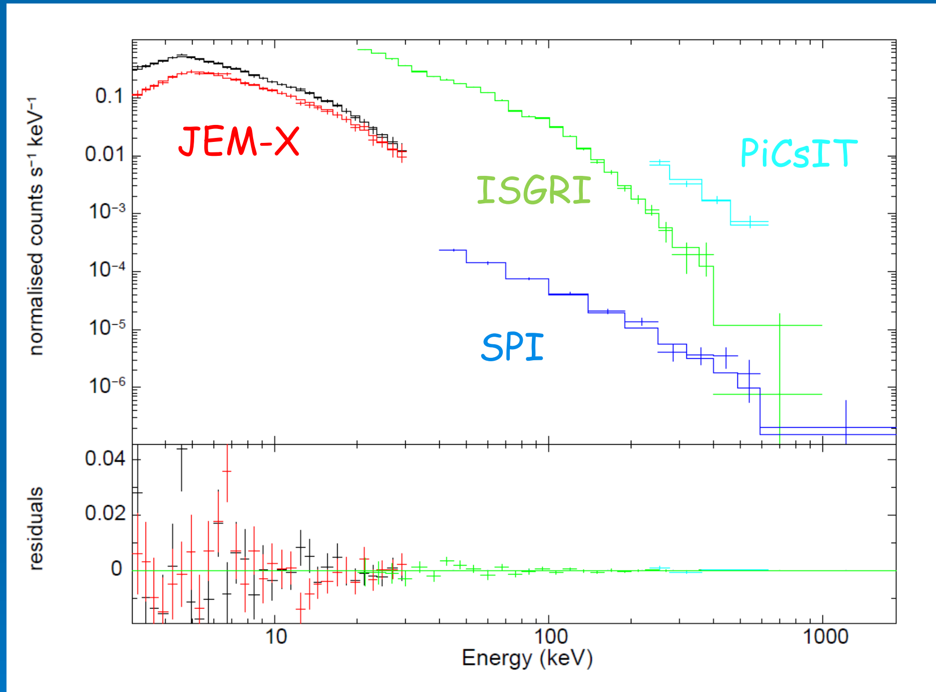
- Hard X-ray/soft γ-ray spectra of Mrk 421 clearly detected by the HXI and SGD in 100 ks.
- Connection with TeV observations (time variability).
- Hard X-ray polarization ?

Astro-H observations of Cen-A



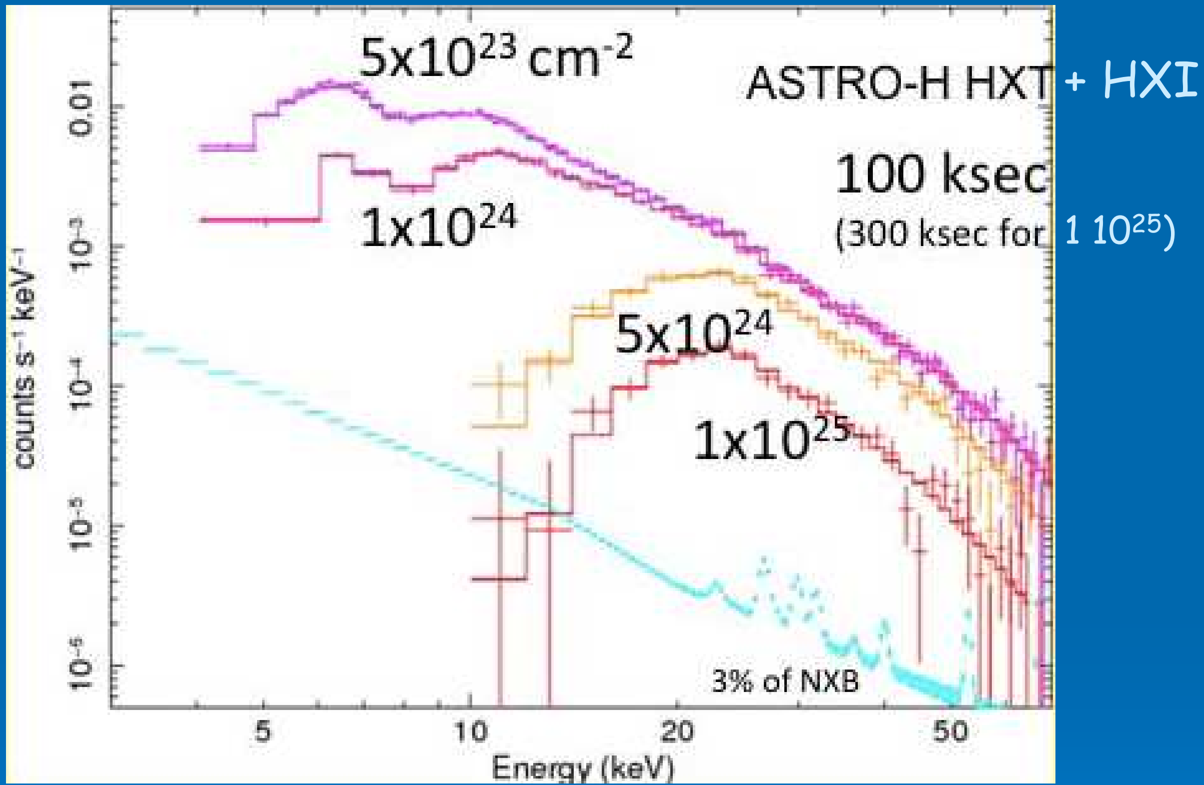
HXI/SGD simulated spectrum (100 ks)

Cen-A : bright FR-1 galaxy.
$F_{20-100} = 10^{-9}$ erg/cm^2/s



Count spectrum of Cen A using *INTEGRAL*
(Beckmann et al., 2011, ~ 2000 ks)

Astro-H observations of Compton-thick AGNs

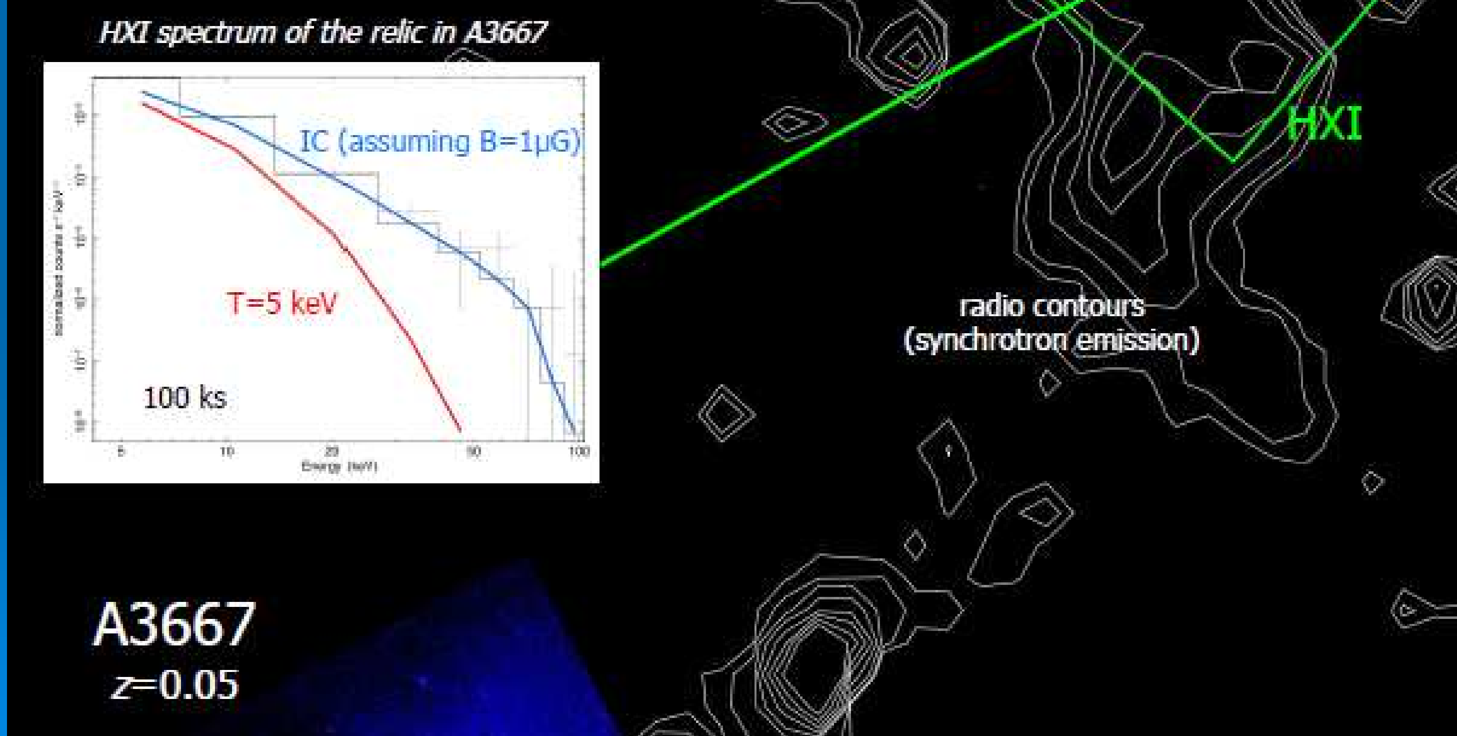


- Due to its high energy coverage and its focusing, HXI/HXT should detect many highly obscured AGNs.
- Sensitivity to resolve 40-50 % of the Cosmic X-ray Background @ 30 keV.
(Takahashi et al. 2011, "The X-ray Universe 2011", Berlin)

Galaxy clusters

Astro-H observations of Galaxy Clusters

Simulated spectra below give a sample of measurements that will push ASTRO-H capabilities to the limit. In a low surface brightness region of a nearby merging cluster A3667, the SXS will be able to detect turbulence with a Mach number (the speed of the flow compared to the speed of sound) as low as M=0.2. For the bright radio relic in A3667, believed to trace an outlying shock front, the HXI will disentangle thermal emission from the intra-cluster gas (observed by XMM) and Inverse Compton emission from ultra-relativistic electrons, producing the first unbiased estimate of the energy in cosmic rays and the cluster magnetic field.



Conclusions

Our Galaxy :

- Spectral-Timing-Polarization observations of Black Hole Binaries.
- Study of the Phase resolved spectroscopy and polarization of isolated and accreting neutron stars.
- Study of 44Ti nuclear line.

Active Galactic Nuclei :

- Study of broad-band spectra.
- Study of variability of 10-100 ks timescale.
- Polarization.
- Cosmic X-ray Background.

Galaxy clusters :

- Disentangle Thermal/non thermal emission in clusters.

Thank you !!