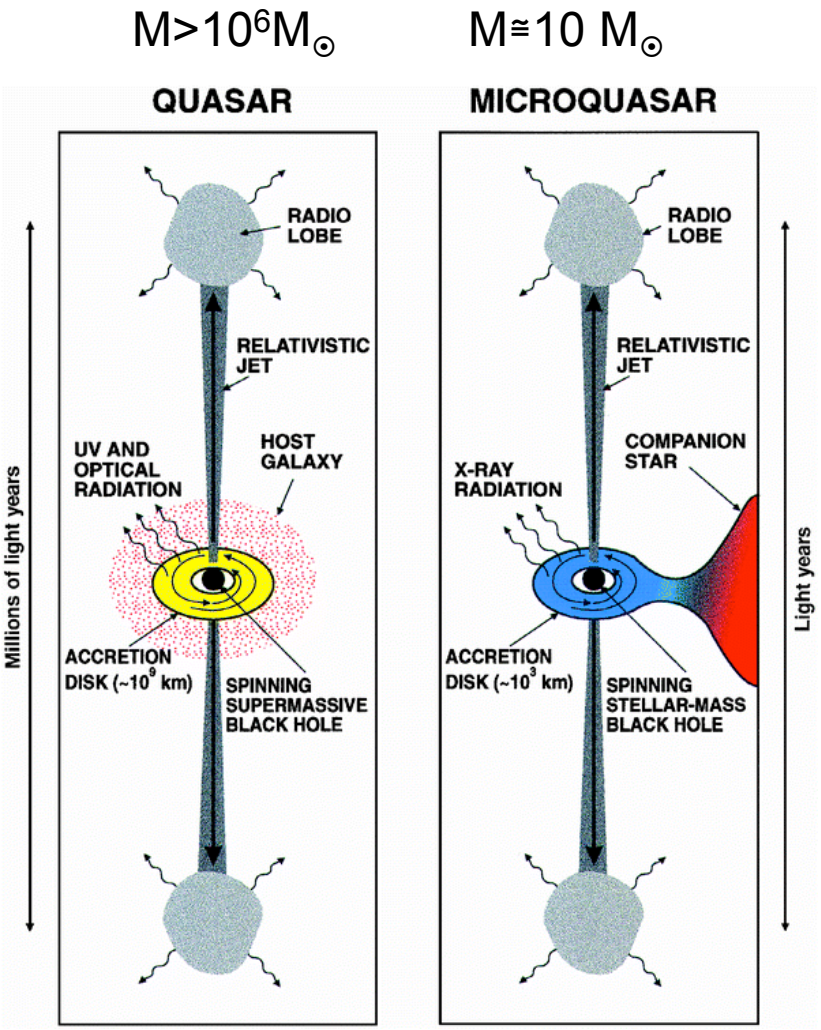
Black holes of all scales as seen by INTEGRAL

- *Introduction*
- *Cyg X-1*
- *NGC 4151*
- *3C 454.3*

From microquasars to AGN

Black holes of all scales as seen by INTEGRAL

- **249** (88 new) **AGN** and **several Galactic BH** detected by INTEGRAL
- **4 new BHC**: IGR J17091-3624, IGR J17098-3628, IGR J17464-3213 (H1743-322), IGR J18539+0727
- Many **heavily obscured** BH
- Important contribution in determining spectral (cutoff, reflection) and physical (temperature of the plasma, optical depth) characteristics
- Study of BH systems in different states



Mirabel & Rodrigues 1998

Galactic black holes

Spectral and flux variability on different time-scales

3 major states

Hard state

Low flux

Power law model with exponential cut-off at few hundreds keV + radio emission

Thermal Comptonization of cool seed photons in a hot e- plasma

Thermal state

High flux

Strong thermal component, soft spectrum

Geometrically thin and optically thick accretion disk

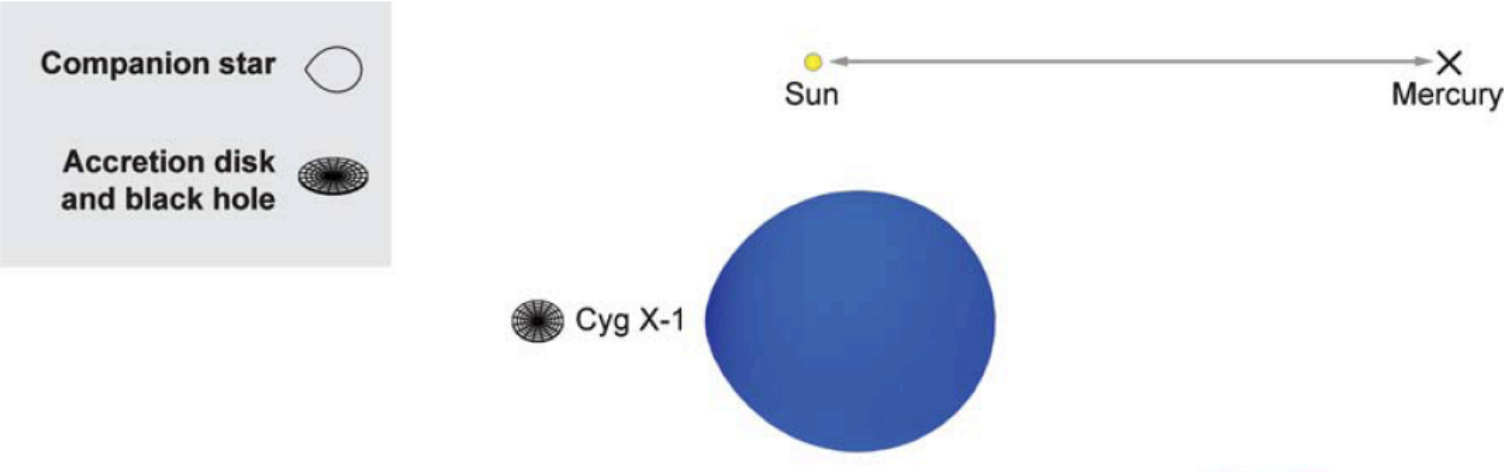
Intermediate

Switching from Compton to Thermal dominated and the other way round

Galactic black holes

An important cases of Galactic BH: **Cyg X-1**

The 2nd brightest object in the hard X-ray sky



Remillard & McClintock 2006

Galactic black holes

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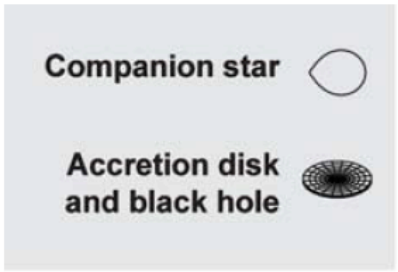
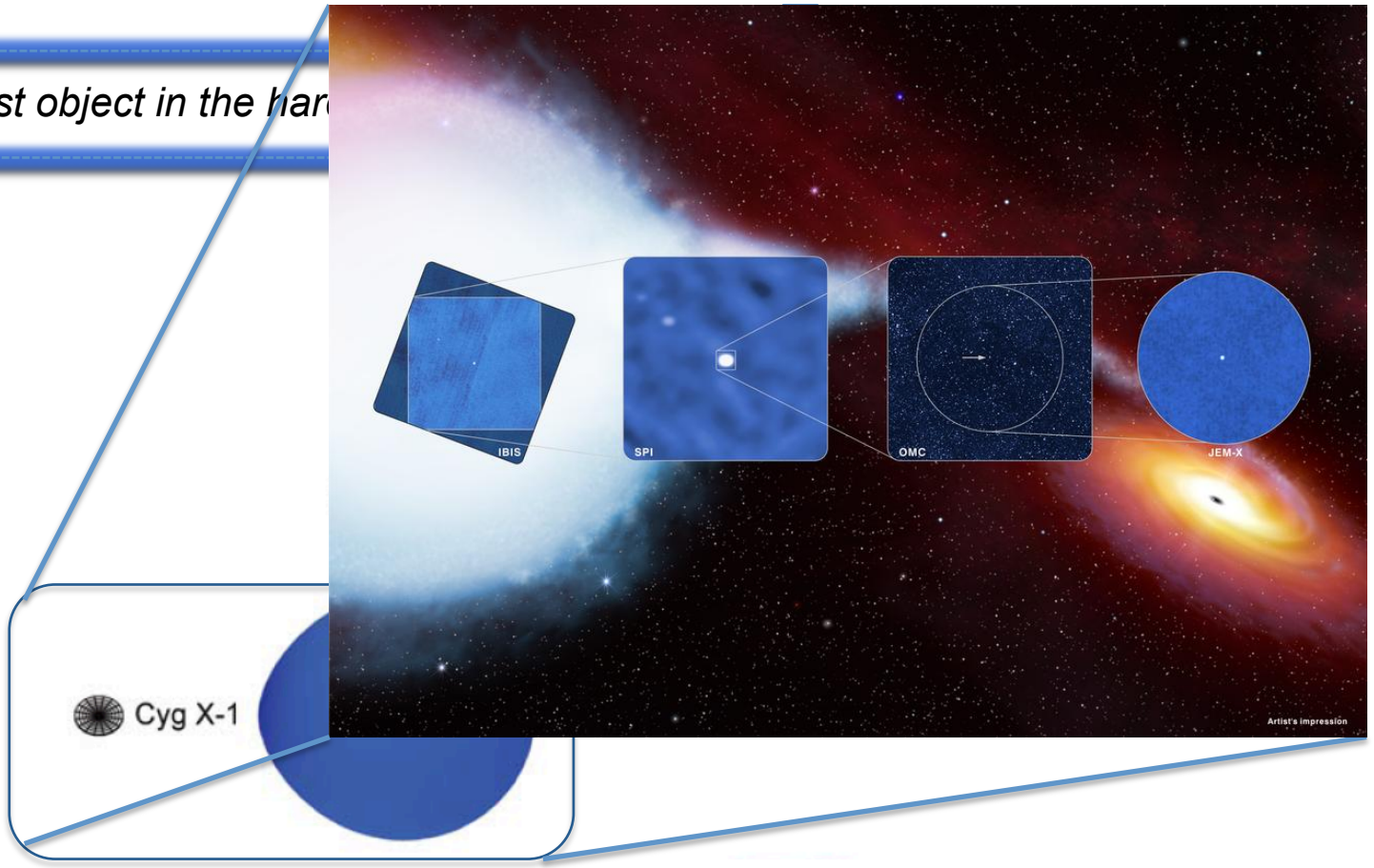
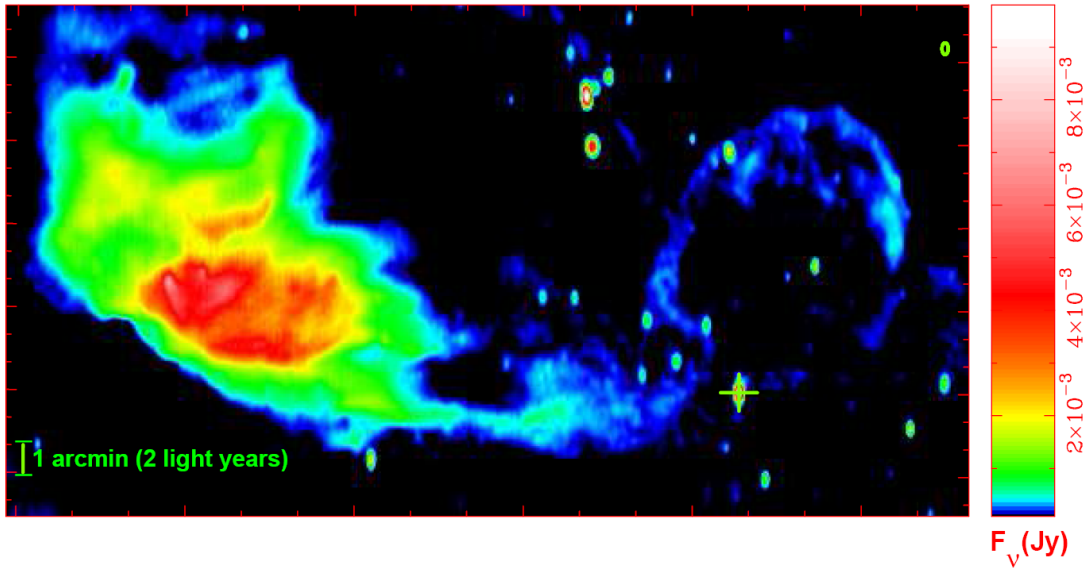




Remillard & McClintock 2006

Galactic black holes: Cyg X-1

- Bright X-ray emission
- First black hole observed (1972)
- X-ray binary (P=5.6d) at 2.4 kpc
- Black hole of $M \cong 8.7 M_{\odot}$ and blu super-giant companion (type O9.7 I) of $33 M_{\odot}$



Detection of a relativistic jet in Cyg X-1
Gallo et al. 2005, Nature, 436, 819

INTEGRAL: broad band capability and long monitoring

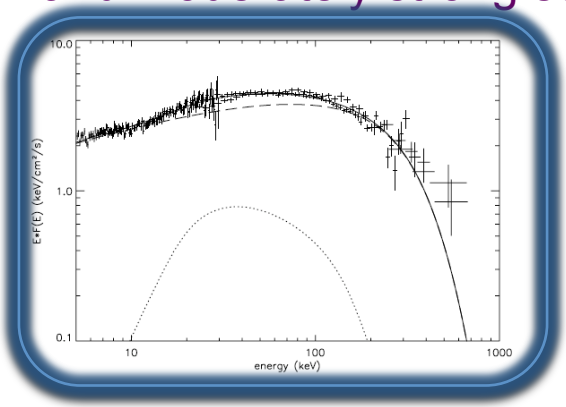
Galactic black holes: Cyg X-1

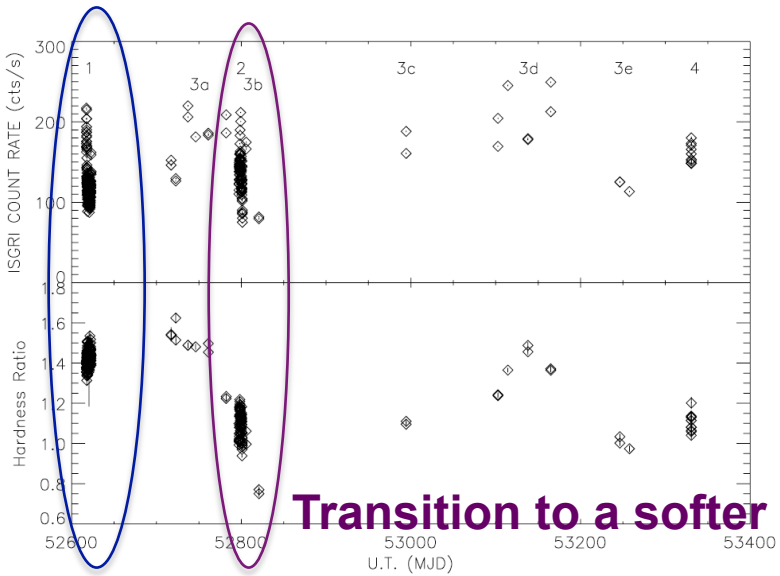
- **Hard State** 90% of its time

- **Thermal Dominated State**

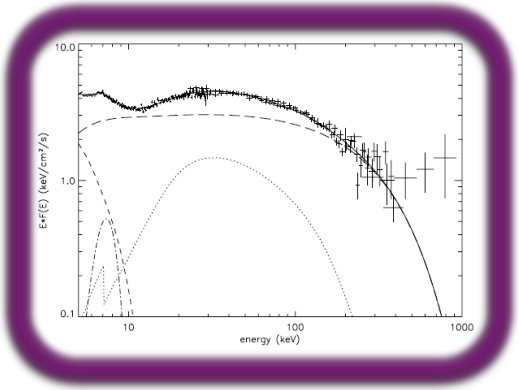
- **Intermediate State**, soft hard X-ray spectrum and moderately strong soft thermal component

Hard state





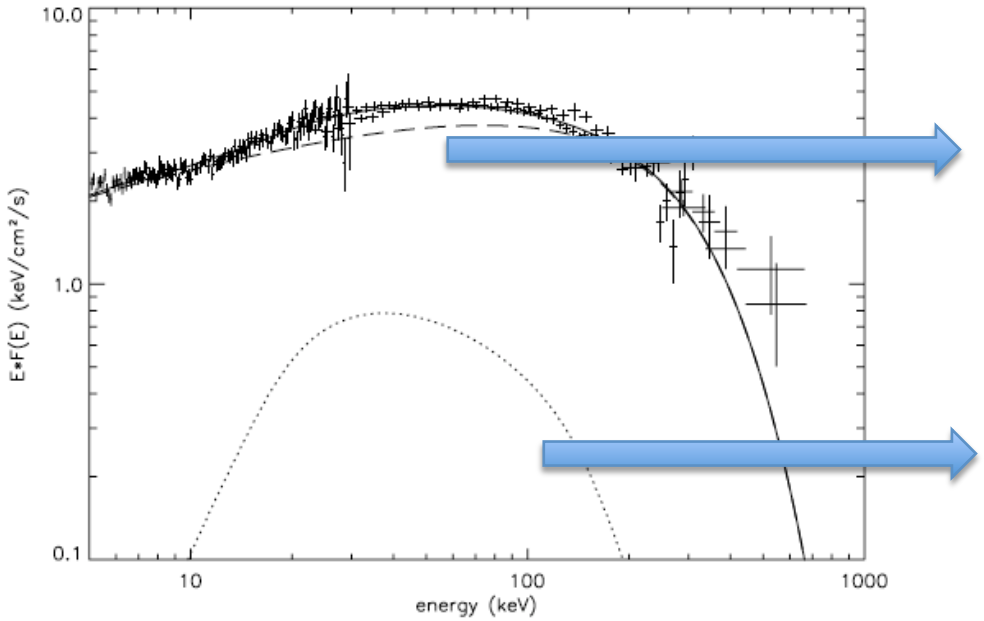
Transition to a softer state



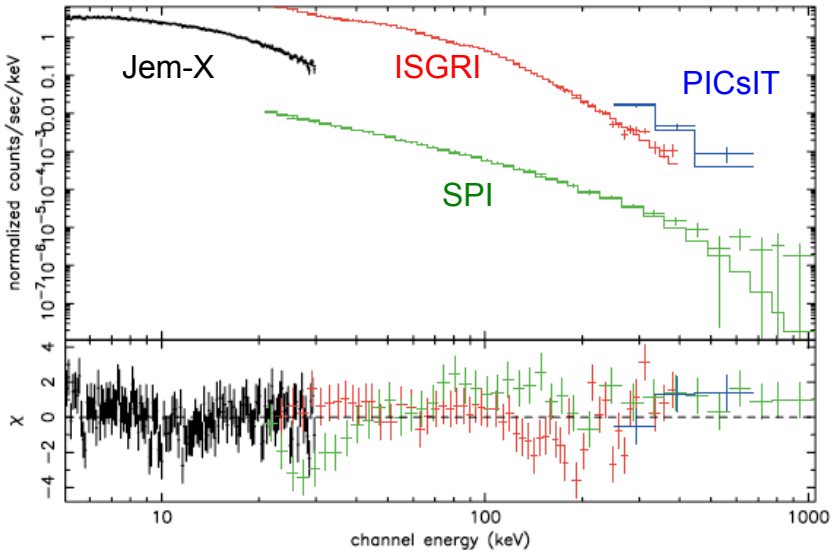
Cadolle Bell et al. 2006

Galactic black holes: Cyg X-1

Hard state



Cadolle Bell et al. 2006



Comptonization *Cadolle Bell et al. 2006*

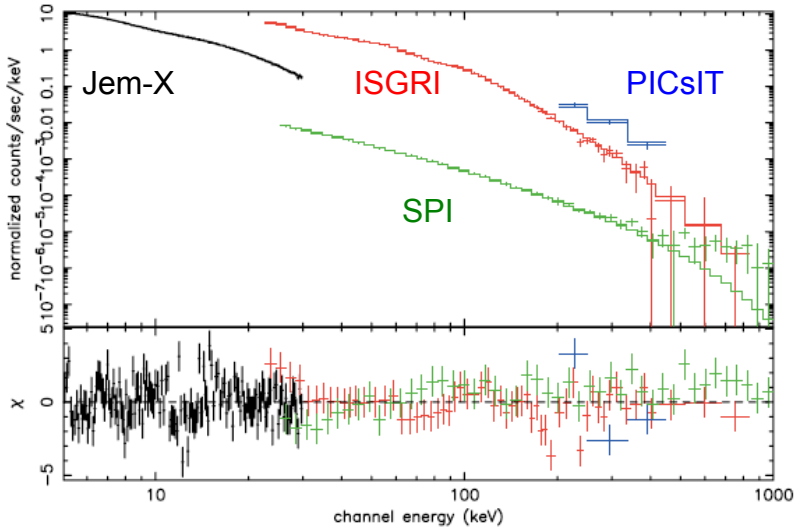
Reflection

$T_e \approx 60$ keV

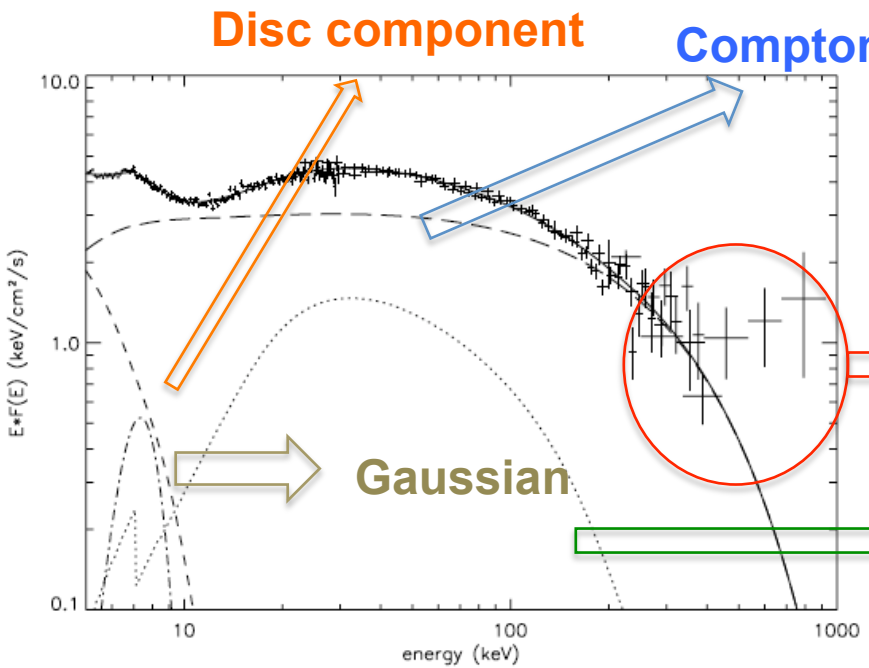
$\tau \approx 2$

Galactic black holes: Cyg X-1

Transition to a softer state



Cadolle Bell et al. 2006



Cadolle Bell et al. 2006

Non thermal emission

$T_e \approx$ 50-100 keV

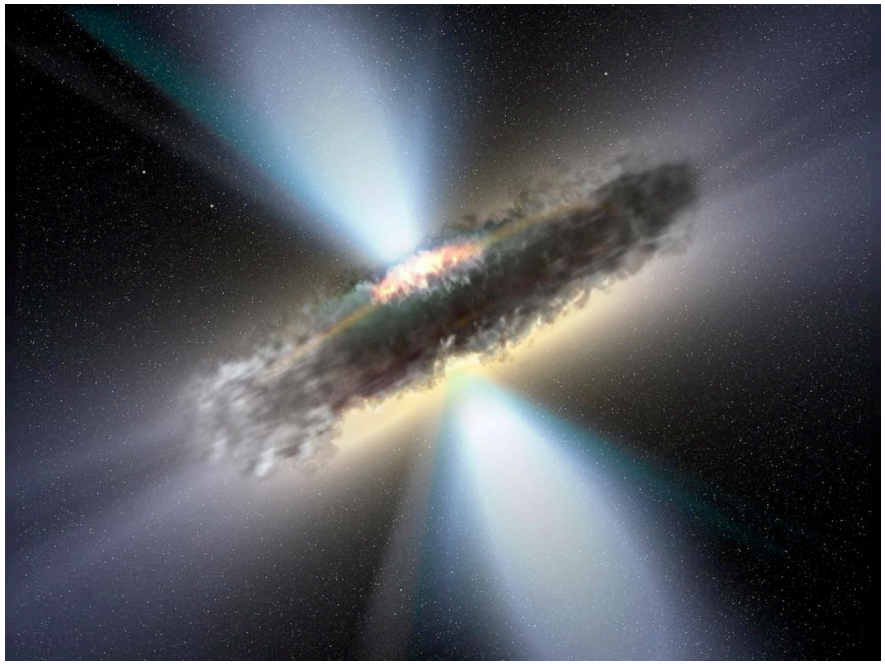
$\tau \approx 1$

$T_D \approx 1.16$ keV

AGN

Importance of INTEGRAL for:

- Study of reflection component
- Constraining physical parameters of the Comptonization
- Heavily absorbed and Compton thick AGN
- High energy population studies (INTEGRAL AGN catalogues, Beckmann et al. 09)
- Long monitoring of many AGN
- Deep fields (3C 273/Coma, Paltani et al. 2008)



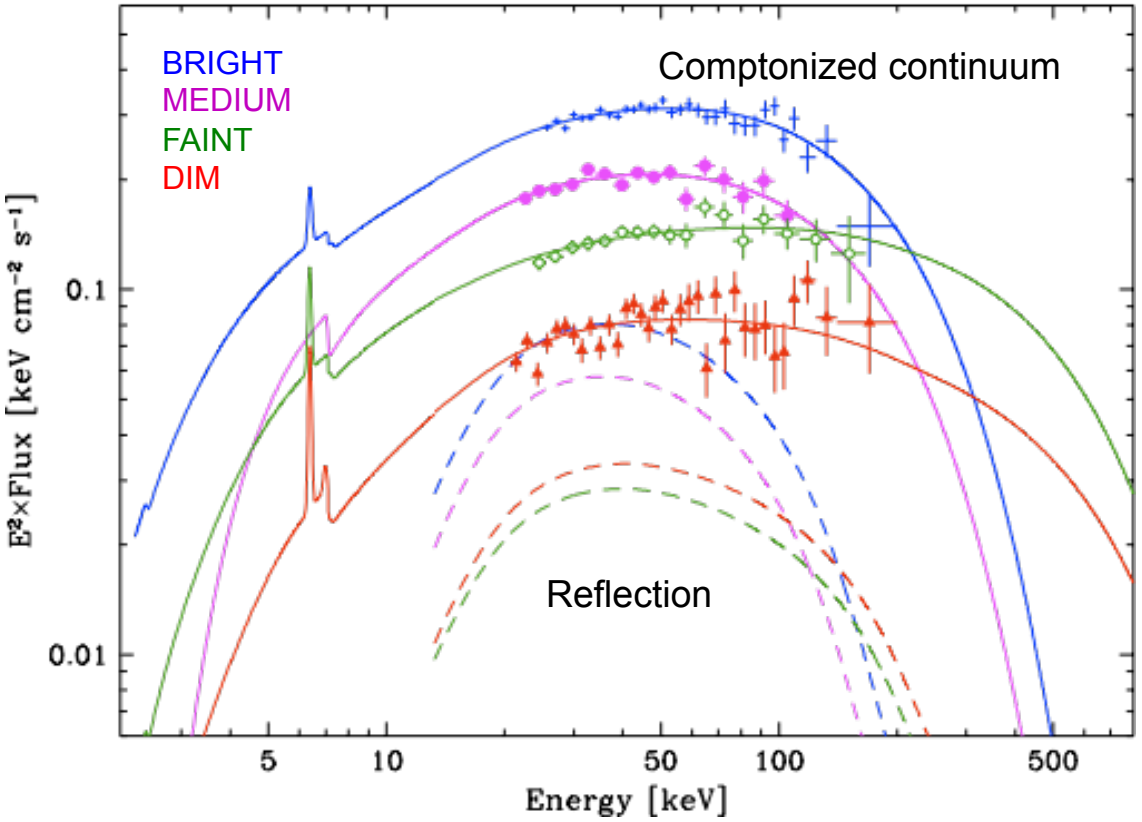
Credits: ESA / V. Beckmann

AGN: NGC 4151

→ Source variable: several states!

→ISGRI provides the highest S/N high-energy spectra available

→ Plasma temperature constrained only by the ISGRI spectra, different in different states



Lubinski et al. 2010

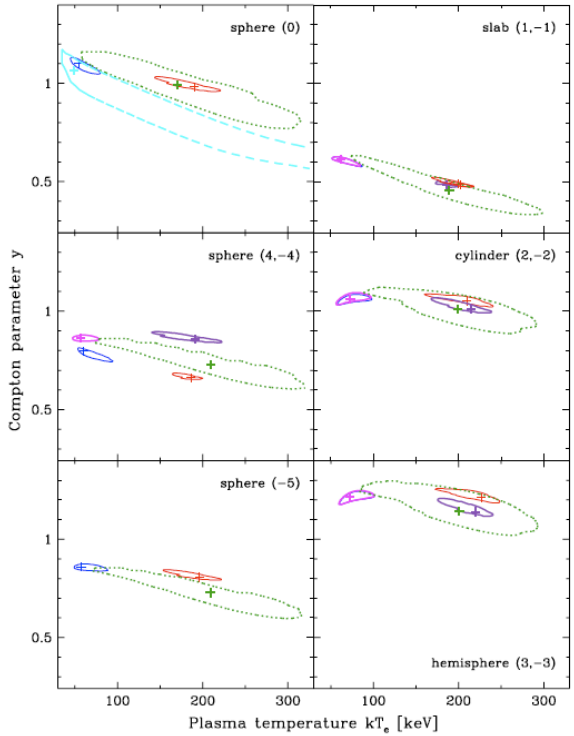
AGN: NGC 4151

State	kT_e	y	τ	R	A	Geometry	Test	$\chi^2/d.o.f.$
Bright	58^{+10}_{-7}	$1.06^{+0.02}_{-0.02}$	$2.3^{+0.3}_{-0.4}$	$0.39^{+0.05}_{-0.05}$	$6.4^{+1.5}_{-0.7}$	sphere (0)	all	3256.9/3472
Dim	163^{+13}_{-11}	$1.00^{+0.01}_{-0.01}$	$0.79^{+0.05}_{-0.06}$	$0.72^{+0.03}_{-0.03}$	$1.55^{+0.01}_{-0.01}$	sphere (0)	all	3385.0/3437

Two reflection components

Distant reflector → Torus

Nearby reflector → Disc



Lubinski et al. 2010

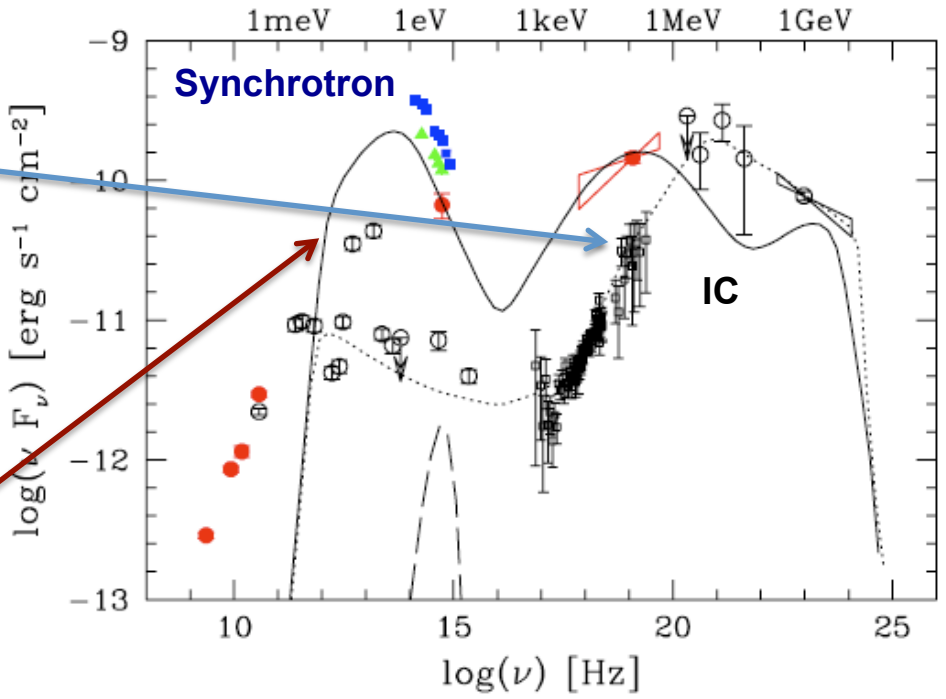
First determination of the source geometry based on reverberation mapping of the Compton reflection hump.

AGN: 3C 454.3

Strong outburst in spring 2005 (from mm to X-rays) detected INTEGRAL

Historical: Synchrotron + inverse Compton from *external* and *synchrotron photons*

Outburst: Synchrotron source brighter + Self Compton



Pian et al. 2006

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AGN

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