Fe Kα Lines with *SIMBOL-X*

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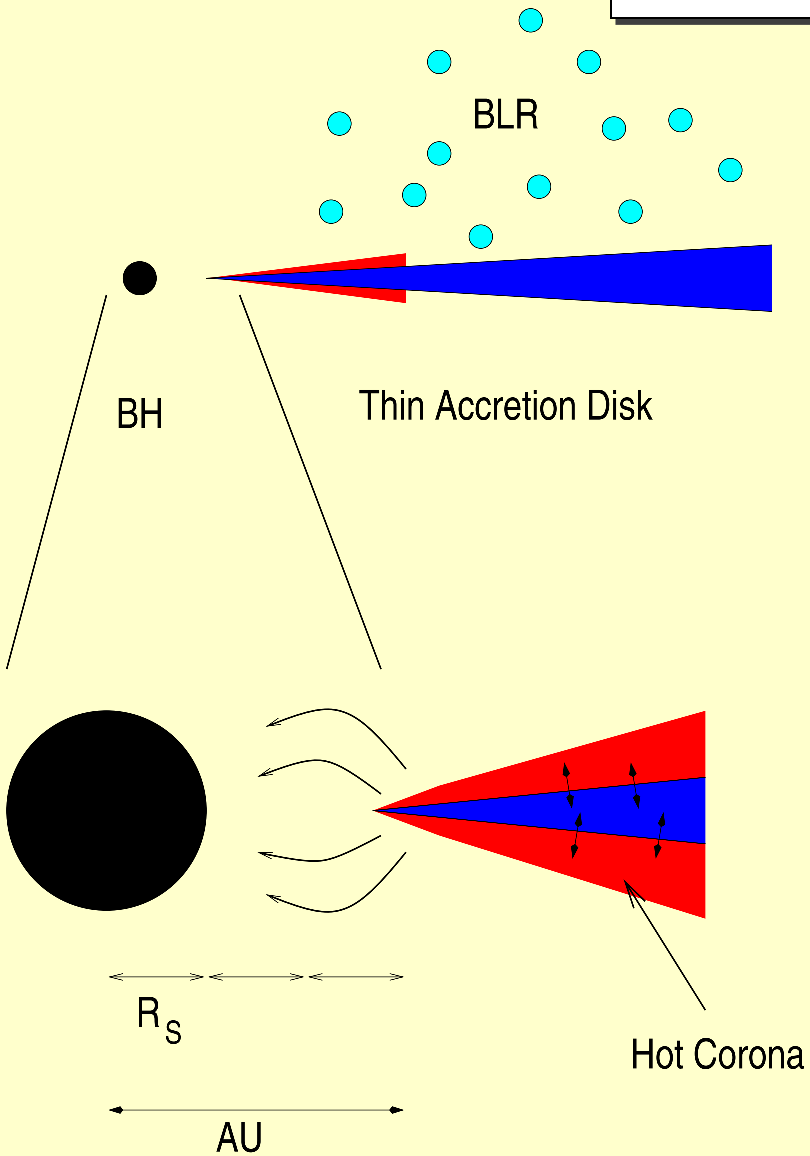
Structure

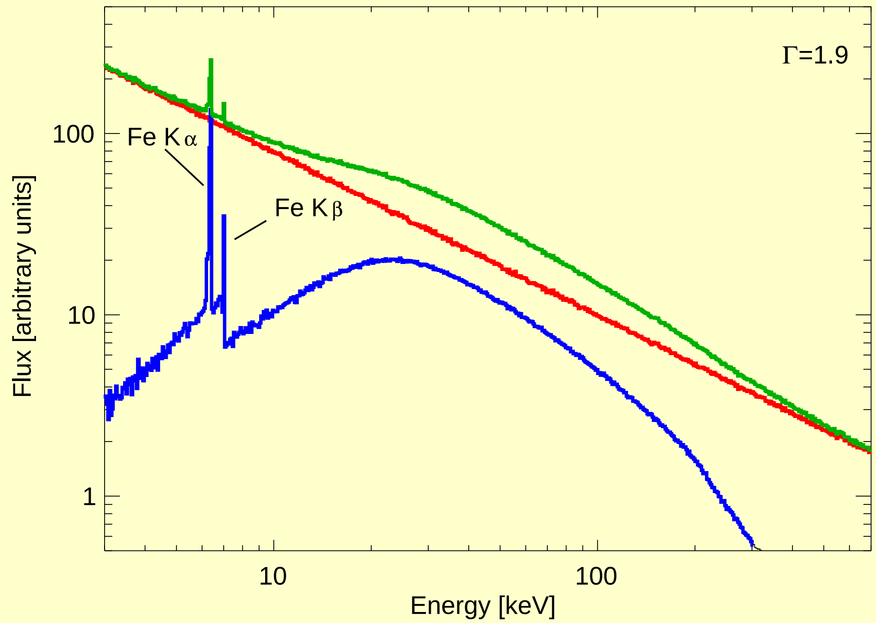
- Kα Line Diagnostics
  - Accretion geometry/Fe Kα generation
  - Potential Fe Kα diagnostics
- Simulations for *SIMBOL-X*:

  Narrow Lines:
  - Detectability
  - Line Parameters

  Broad Lines:
  - Emissivity Parameter
  - Ionisation State
  - Inclination
  - Line Parameter Variability Studies
  - (Kerr-Parameter: Schwarzschild vs. Kerr)
- Summary

Kα Line Diagnostics





AGN X-Ray Spectrum:

- Comptonisation of soft X-rays from accretion disk in hot corona ($kT \sim 100$ keV): power law continuum.
- Thomson scattering of power law photons in disk: Compton Reflection Hump
- Photoabsorption of power law photons in disk: fluorescent Fe Kα Line at $\sim$6.4 keV

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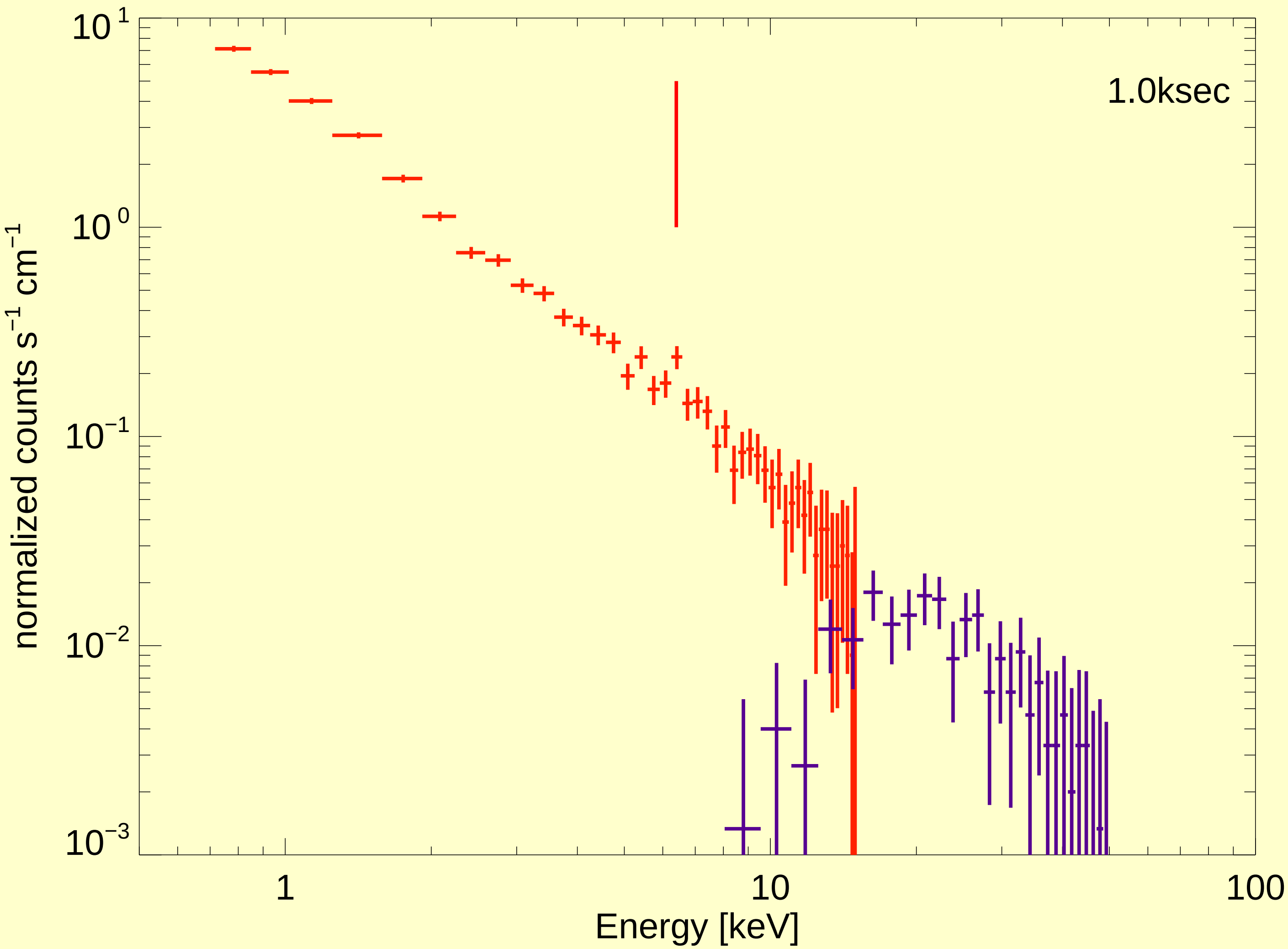
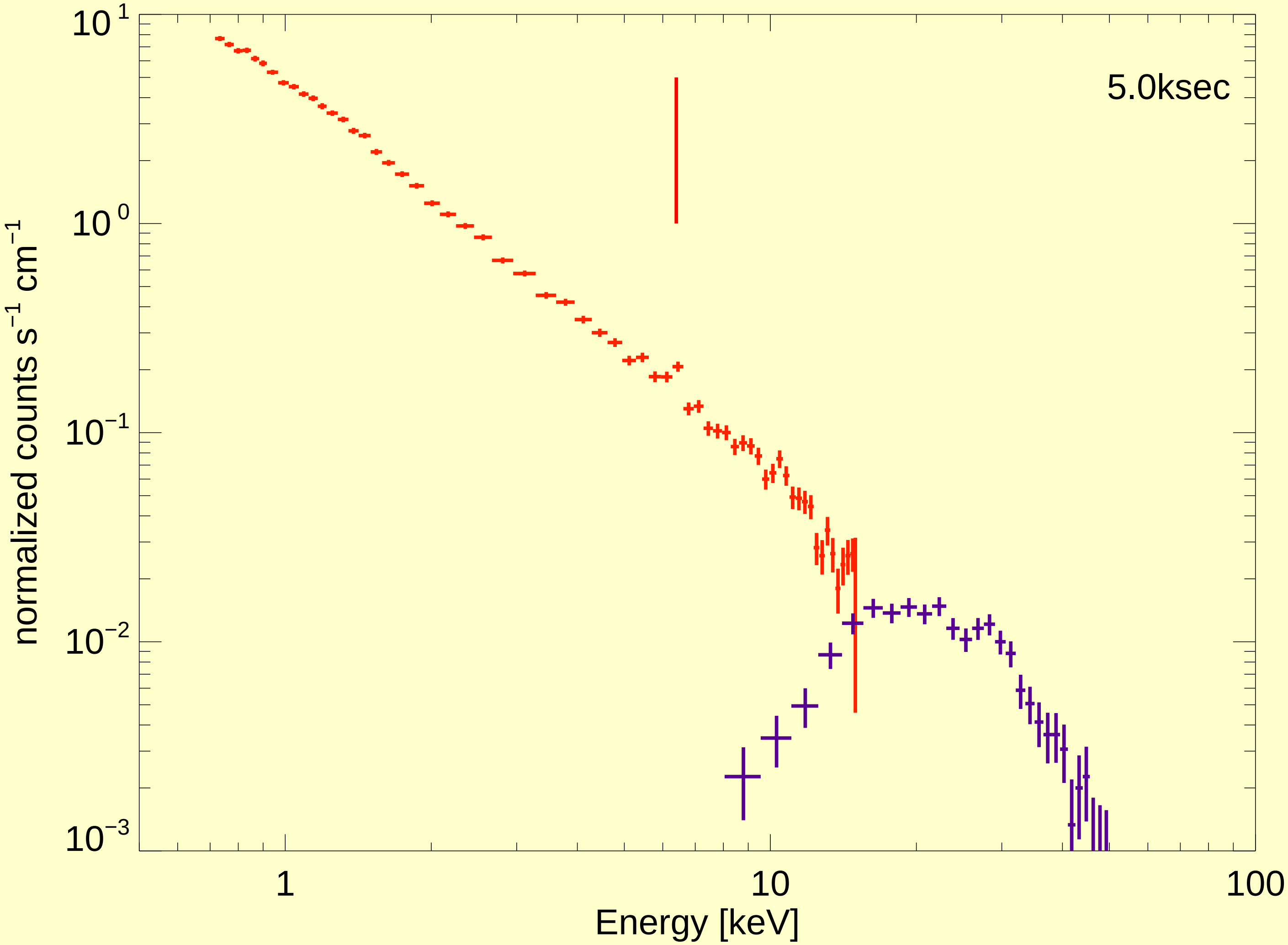
Narrow Lines, I



$\Longrightarrow$ Fe Kα: $E = 6.39^{+0.03}_{-0.07}$ keV

Narrow Lines, II



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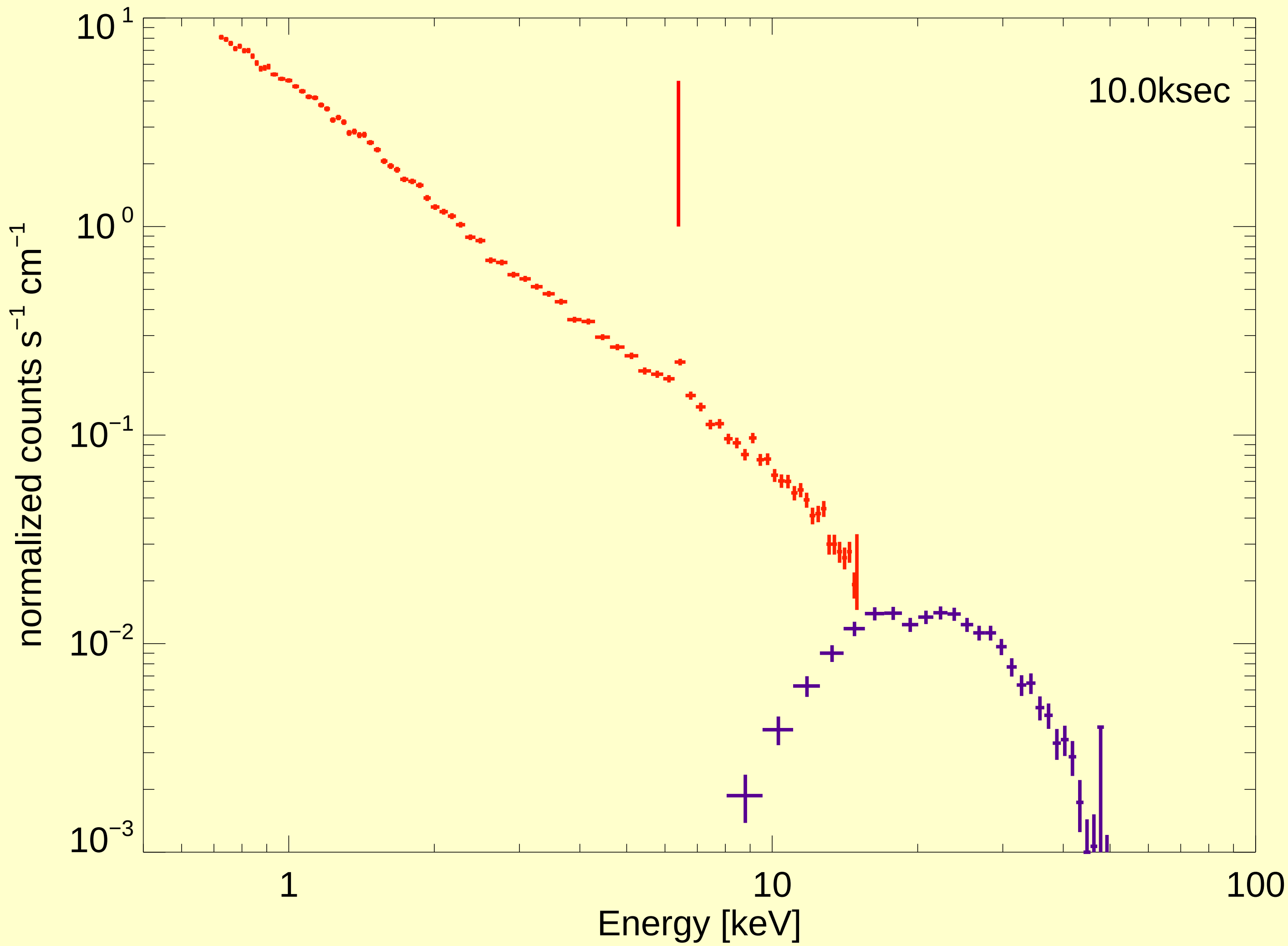
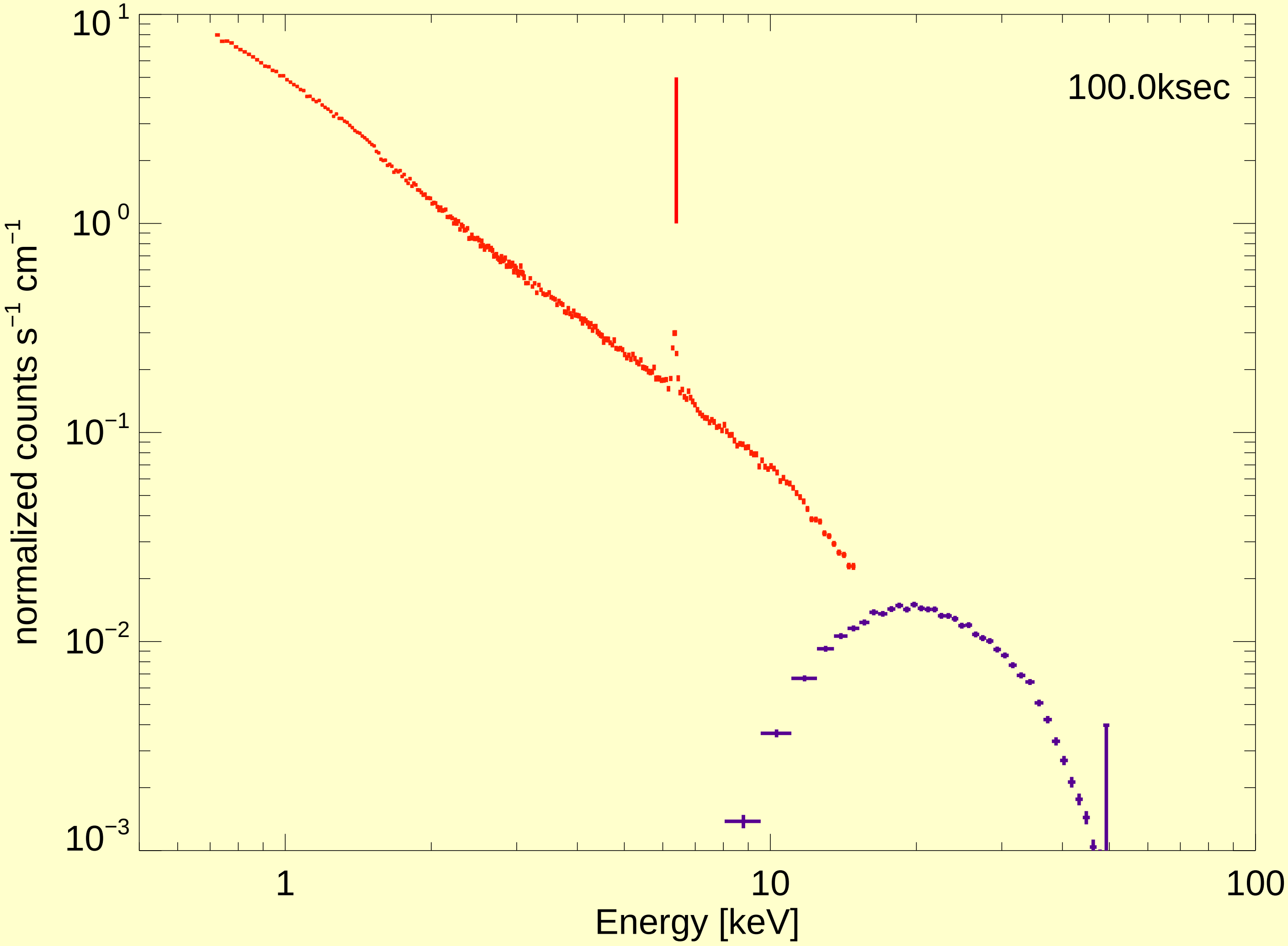
Narrow Lines, III

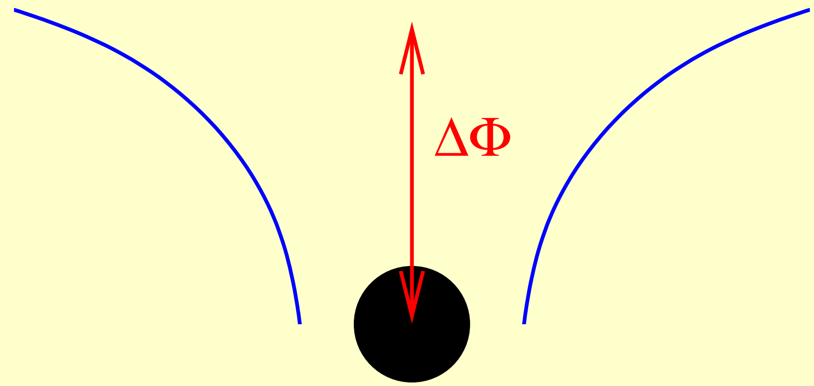


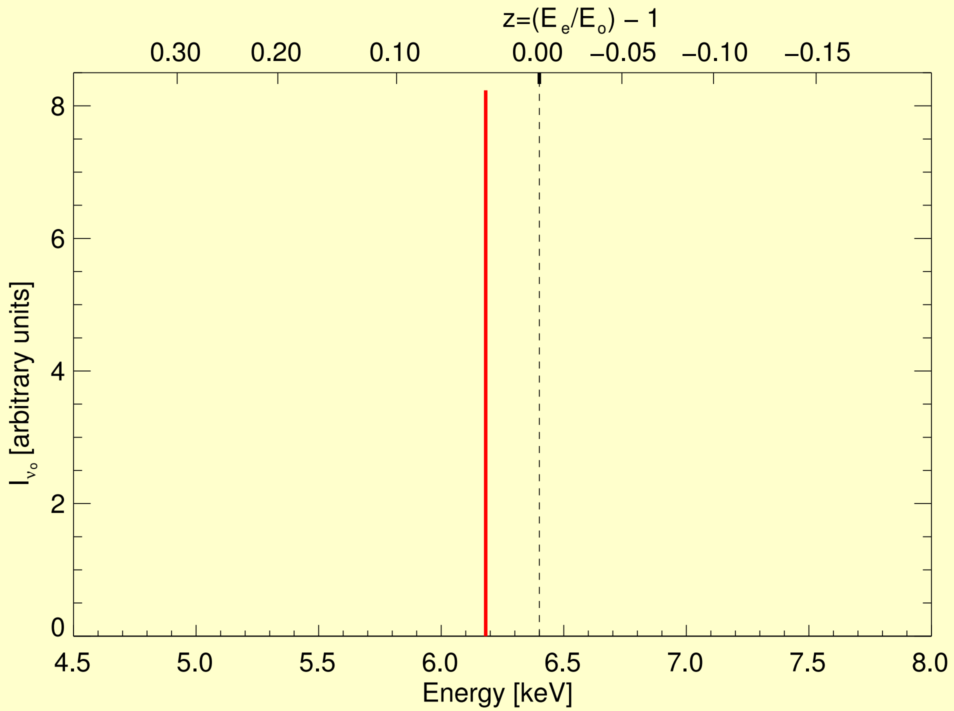
$\Longrightarrow$ Fe Kα: $E = 6.39^{+0.02}_{-0.01}$ keV

Narrow Lines, IV



Broad Lines

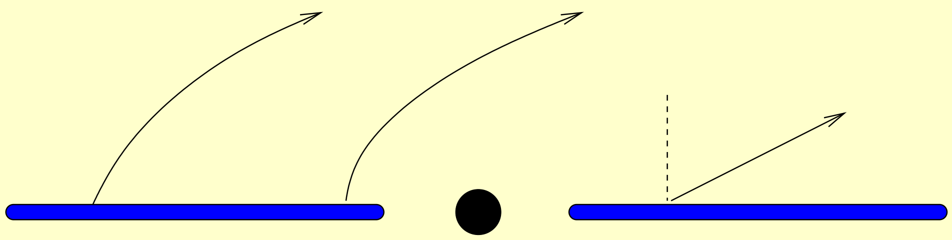


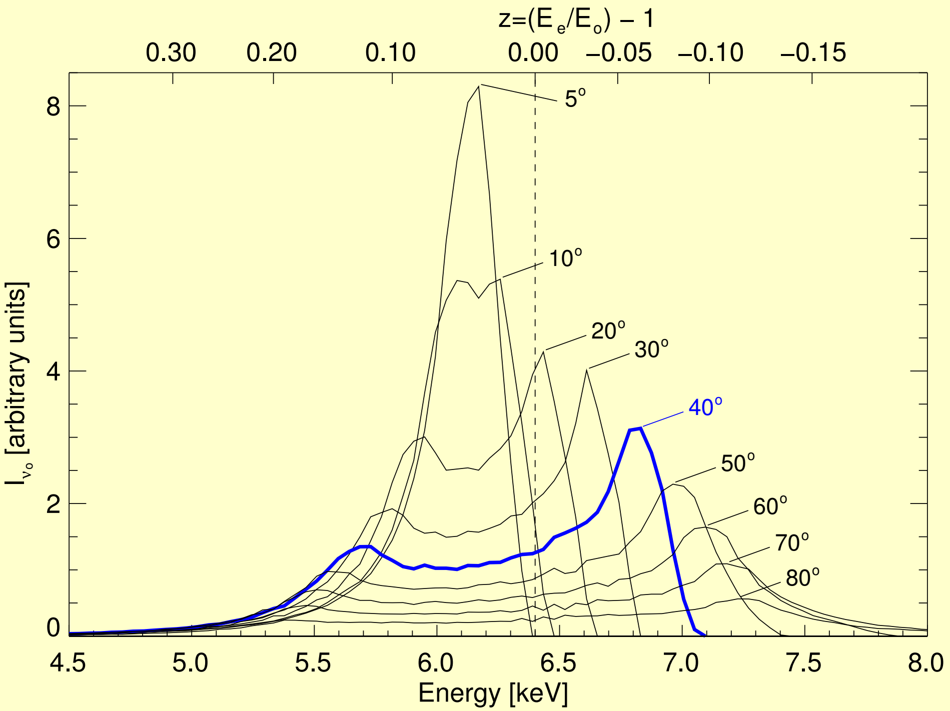


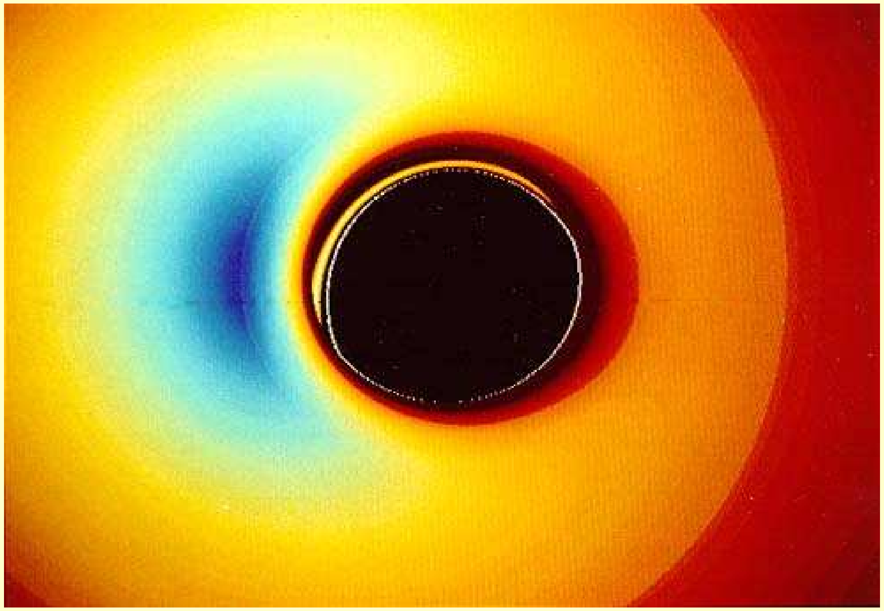
Total observed line profile affected by

- grav. Redshift

Broad Lines







Total observed line profile affected by

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- Light bending
- rel. Doppler shift

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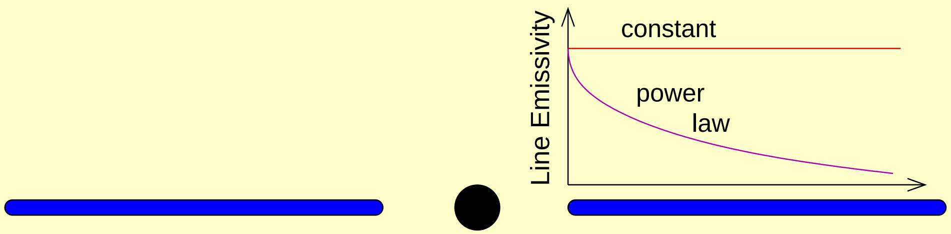
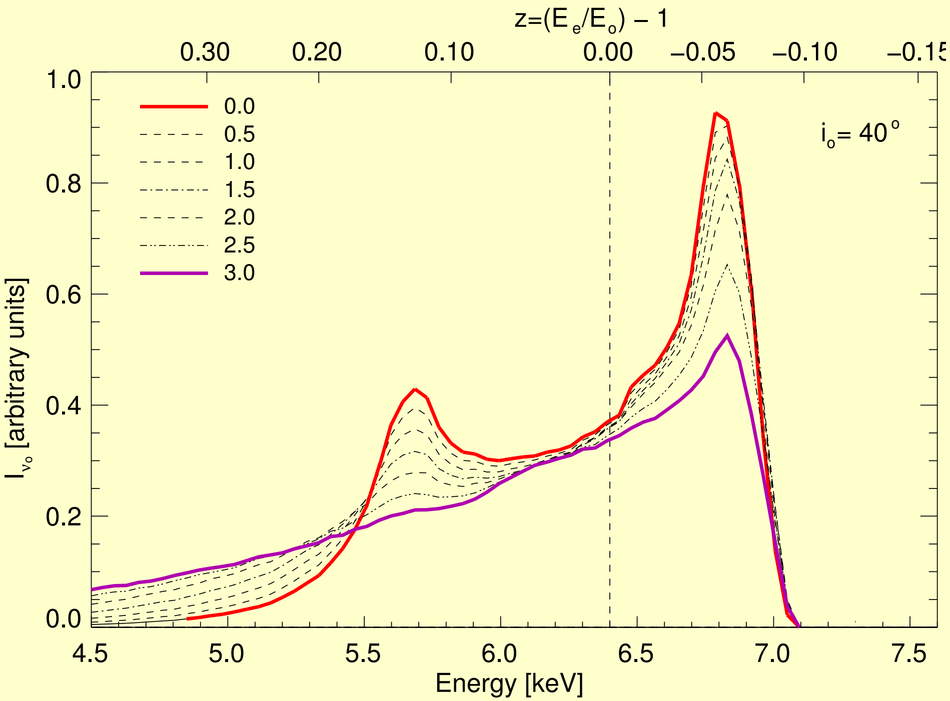
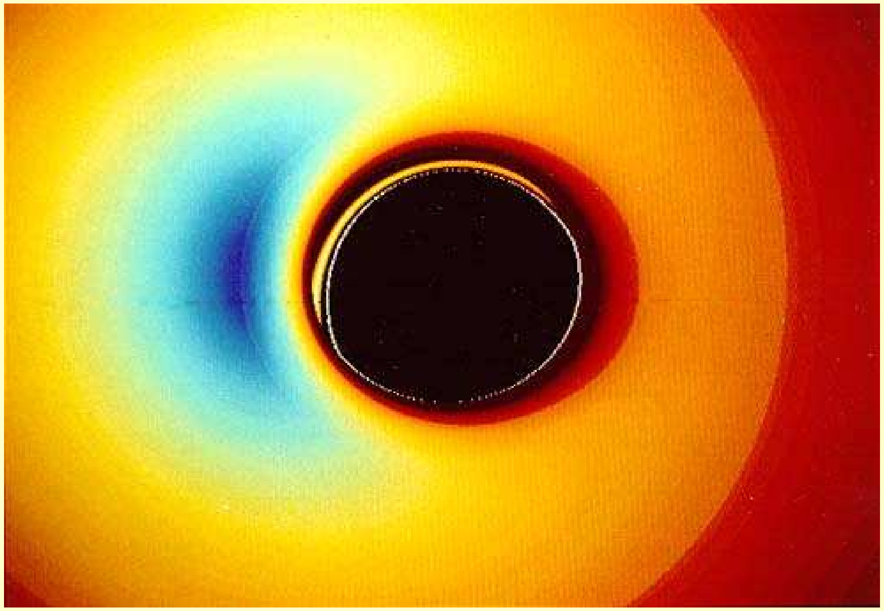
Broad Lines







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- emissivity profile

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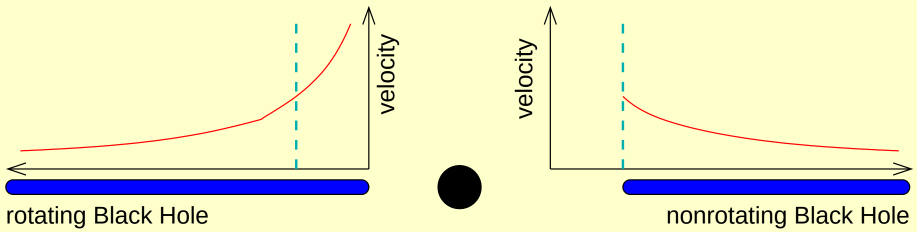
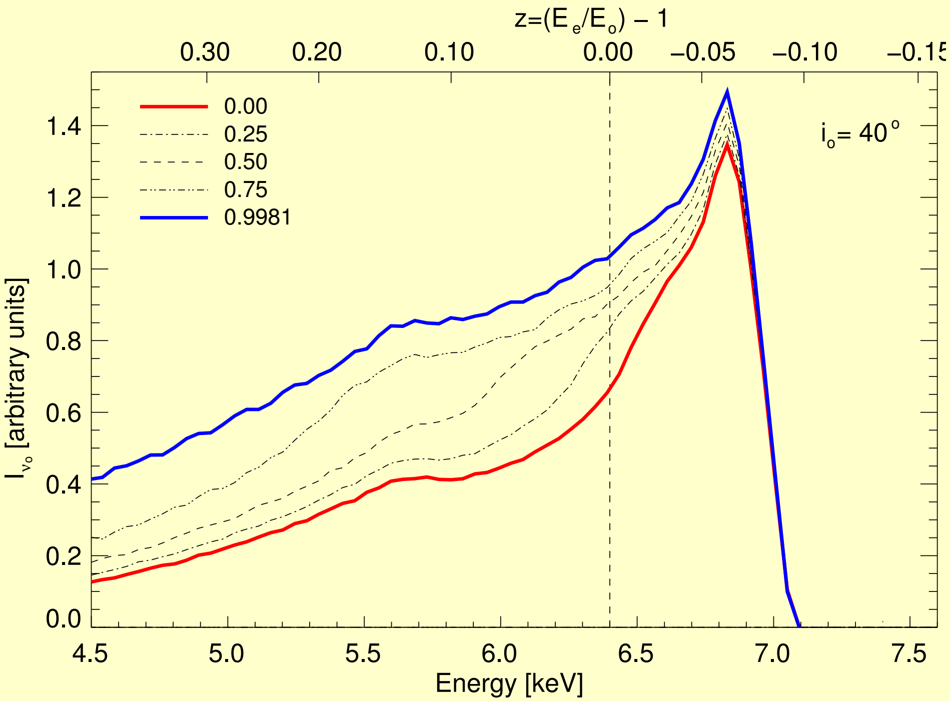
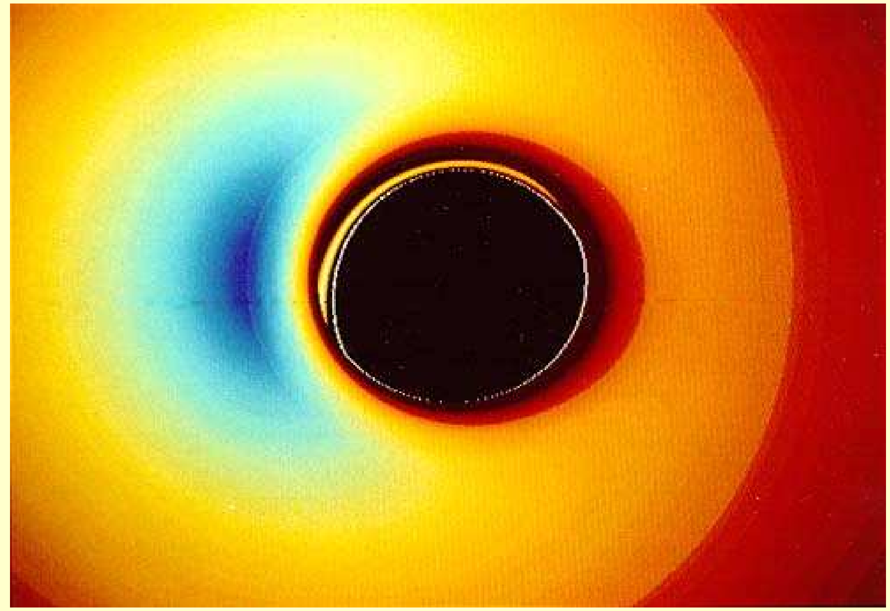
Broad Lines



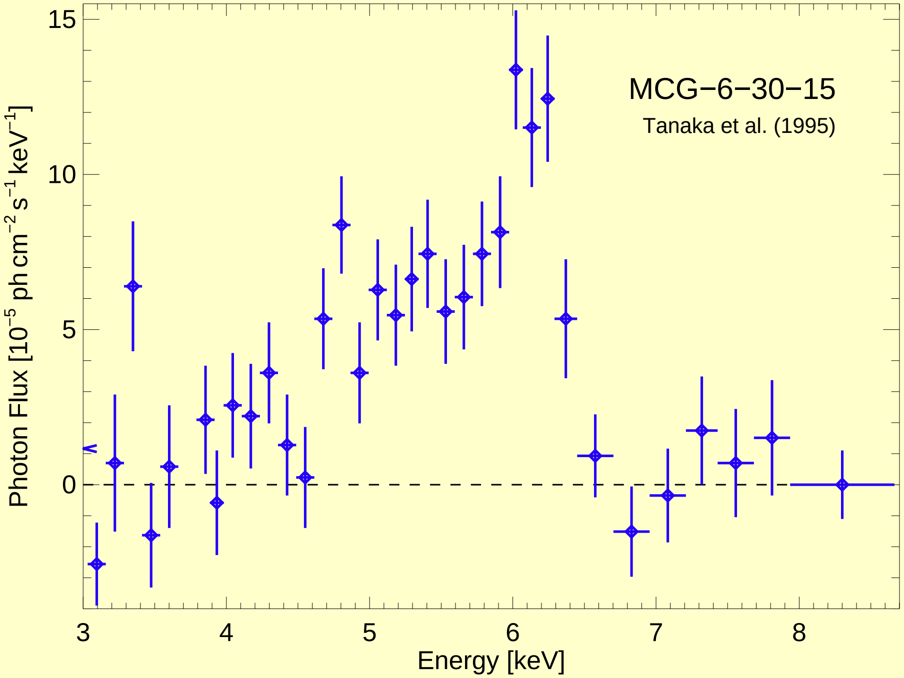




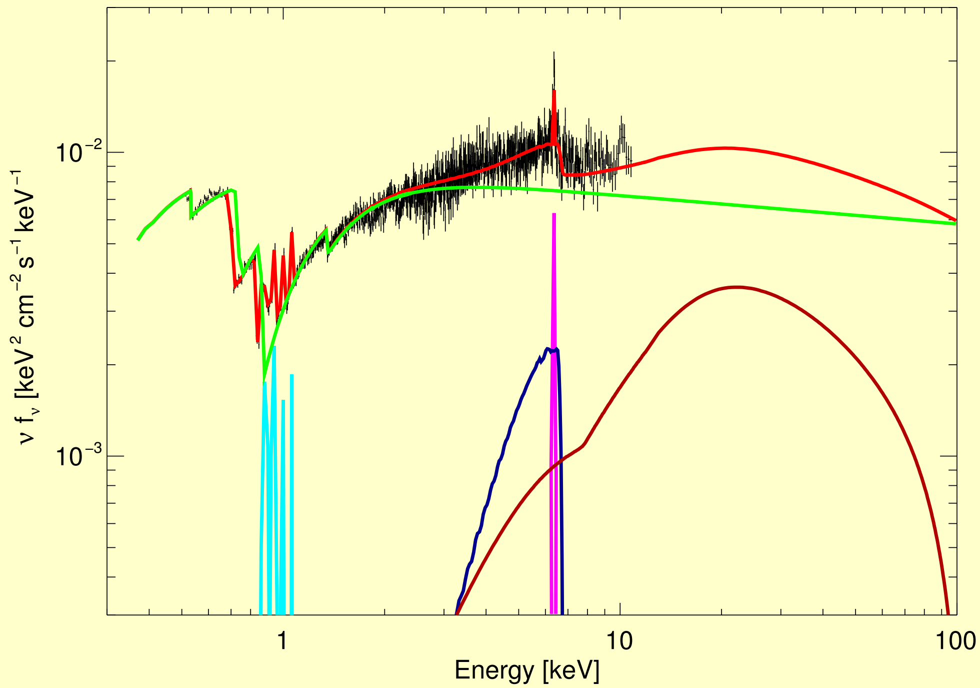
Total observed line profile affected by

- grav. Redshift
- Light bending
- rel. Doppler shift
- emissivity profile
- spin of black hole

Current State of the Art



Tanaka et al., 1995



Wilms et al., 2001, 2003

MCG−6-30-15: Line-Width: Kerr Black Hole is required

Many other sources with similar lines (AGN and GBHC), often shape is more complicated, evidence also for outflows etc.

The emissivity index, β, is large $\Longrightarrow$ Line from centralmost regions!

Needed Capabilities, I

In order to use diagnostic capabilities of broad Fe Kα line need:

- good energy resolution (obvious)
- broad energy range (0.5 keV to $\gtrsim$30 keV; beware of cross calibration!)
- large collecting area (problem for *SIMBOL-X*?)

Needed Capabilities, II

In order to use diagnostic capabilities of broad Fe Kα line need:

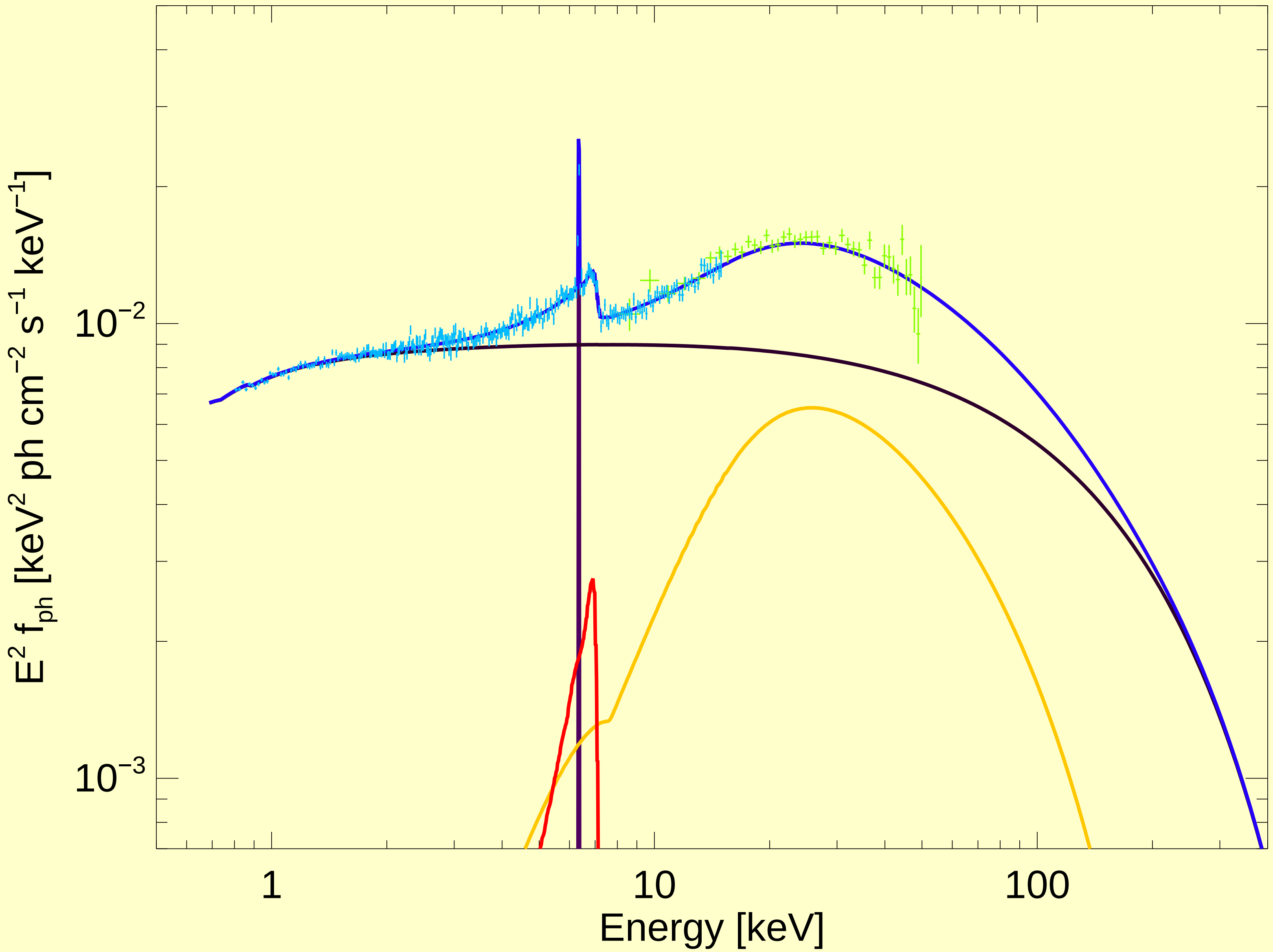
- good energy resolution (obvious)
- broad energy range (0.5 keV to $\gtrsim$30 keV; beware of cross calibration!)
- large collecting area (problem for *SIMBOL-X*?)

Will study what can be acheived using baseline model derived from MCG$-$6-30-15 and assuming 100 ksec exposure:

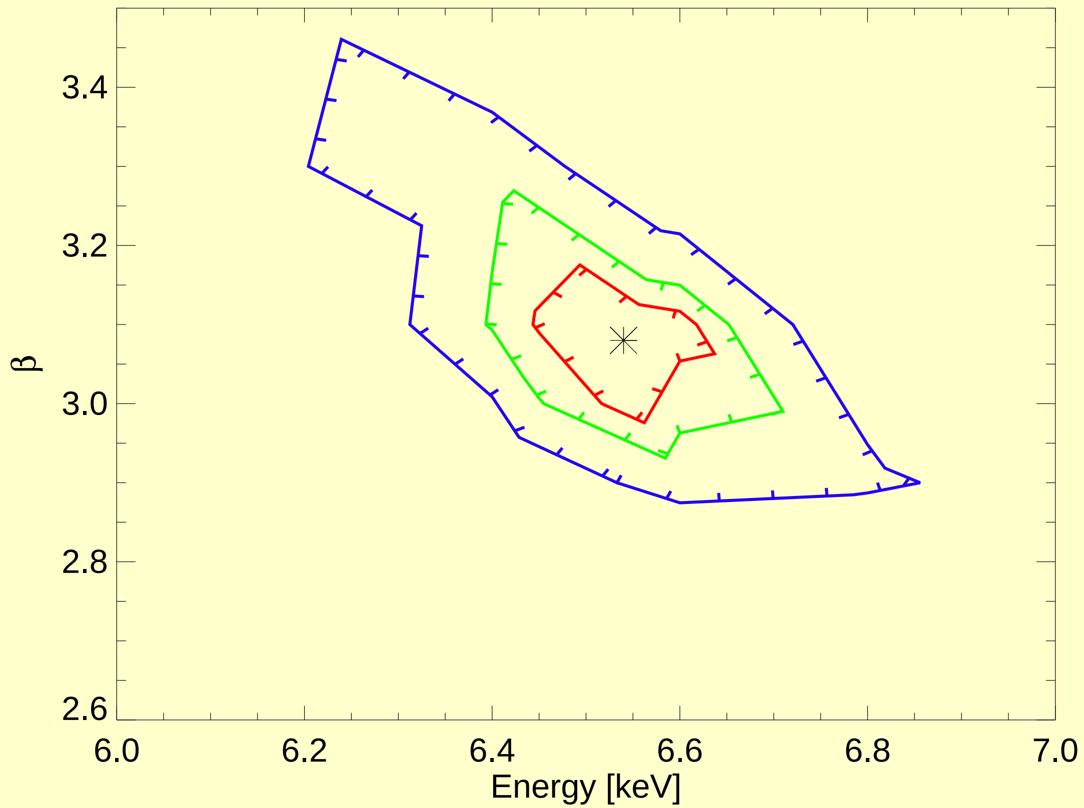
- Comptonisation continuum: $kT = 71$ keV, $\tau_e = 0.37$, $F_{2\text{–}10\,\text{keV}} = 2.6 \times 10^{-11}$ cgs
- narrow Fe Kα line from torus: $E = 6.4$ keV, $\sigma = 0.01$ keV, EW $= 52$ eV
- broad Fe Kα line: $E = 6.97$ keV, $i = 40^\circ$, EW $= 500$ eV; emissivity ($I \propto r^{-\beta}$): $\beta = 3$, $R_{\text{in}} = 1.2GM/c^2$, $R_{\text{out}} = 400GM/c^2$, Kerr
- Reflection ($\Omega/2\pi = 1.5$; relativistically smeared)

N.B. This is a *simplified* model, ignoring warm absorber, forcing β to canonical value, etc.

Needed Capabilities, III



Emissivity, I

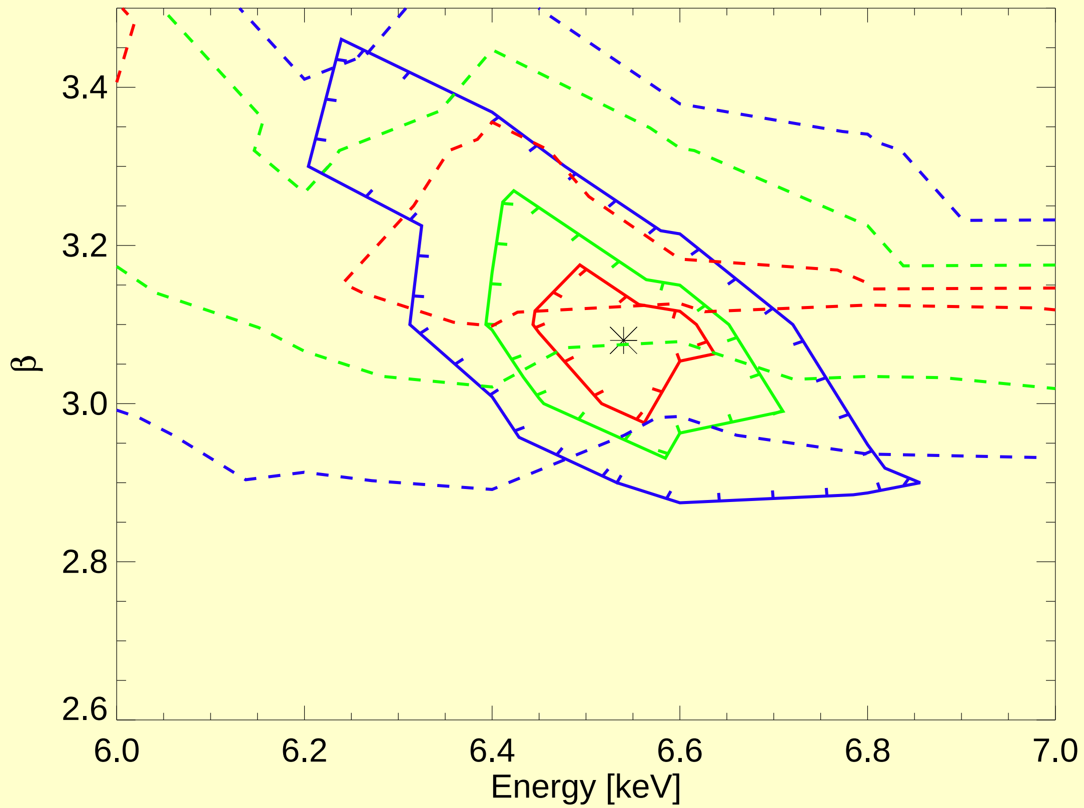


100 ksec simulation: Emissivity parameter

SIMBOL-X: $\beta = 3.08^{+0.15}_{-0.11}$ *XMM-Newton*: $\beta = 3.2^{+0.4}_{-0.2}$

$\Longrightarrow$ Emissivity index well determinable

Emissivity, II



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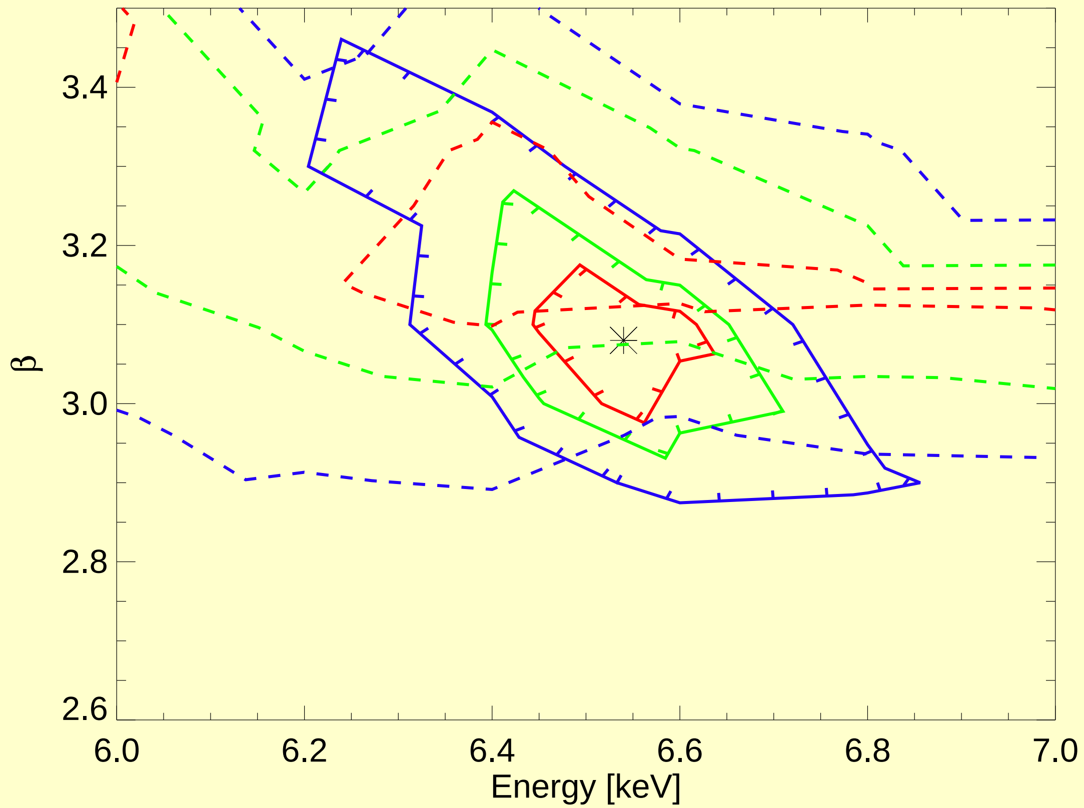
Ionisation State



100 ksec simulation: Ionisation state (Fe line energy)

SIMBOL-X: $E = 6.54^{+0.19}_{-0.10}$ keV   *XMM-Newton*: $E = 6.40^{+0.59}_{-0.16}$ keV

$\Longrightarrow$ Determination of ionisation state possible

Variability

Capability for line measurement in 10 ksec:

	SIMBOL-X	*XMM-Newton*
β:	$3.45^{+1.0}_{-0.6}$	$3.93^{+2.2}_{-0.7}$
E:	$6.3^{+0.3}_{-0.7}$ keV	$6.5^{+1.1}_{-0.9}$ keV
i:	47^{+18}_{-14}	41 ± 40

Uncertainty in *XMM-Newton* mainly due to inability to constrain reflection continuum.

$\Longrightarrow$ Improved with respect to *XMM-Newton*, but *SIMBOL-X* will not be able to start doing reverberation mapping (timescales $\lesssim$ 1 ksec)

Summary

To summarize:

Narrow line:

- 5 ksec for bright AGN (à la MCG−6-30-15) required
- can study time variability as seen, e.g., in NGC 5548

Broad line:

- Average line shape: *SIMBOL-X* about a factor 2 better than *XMM-Newton*
- Advantage mainly caused by better constraining reflection continuum
- Time resolved spectroscopy: not able to do reverberation mapping ($\Longrightarrow$ wait for PER-XEUS [or Con-X])

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To be done:

- Study Kerr vs. Schwarzschild
- Sensitivity limits for broad lines