The Modified Timing Mode - Observing Bright Sources With XMM-Newton

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Outline

Observing bright sources with *XMM-Newton*

Why bright sources?

Bright (>100 mCrab) sources are crucial for our detailed understanding of accretion as a physical process.

- test relativity (variable and broad Fe Kα lines)
- soft X-ray spectroscopy $\Longrightarrow$ stellar winds, absorption dips,...
- Accretion geometry: Comptonization versus jet emission, reflection,...
- strong short term variability out to >100 Hz (30% rms $\Longrightarrow$ produced close to compact object?)
- variability on all timescales ($\dot{M}$ variations? – cannot study with AGN at all!)

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Need High SNR, High Time Resolution Broadband Observations

Observing bright sources with *XMM-Newton*

What is available? – Look at *XMM* UHB:

	Time res.	Live time [%]	Max. cps	mCrab
MOS				
Full frame (600×600)	2.6 s	100.0	0.70	0.24
Large window (300×300)	900 ms	99.5	1.8	0.6
Small window (100×100)	300 ms	97.5	5	1.7
Timing uncompressed (100×600)	1.5 ms	100.0	100	35
pn				
Full frame (376×384)	73.4 ms	99.9	6	0.7
Ext. full frame (376×384)	200 ms	100.0	2	0.25
Large window (198×384)	48 ms	94.9	10	1.1
Small window (63×64)	6 ms	71.0	100	11
Timing (64×200)	0.03 ms	99.5	800	85
Burst (64×180)	7 μs	3.0	60000	6300

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The *XMM-Newton* Modified Timing Mode

Important to note

cps limit of EPIC-pn timing mode due to *telemetry*, NOT due to camera capabilities!

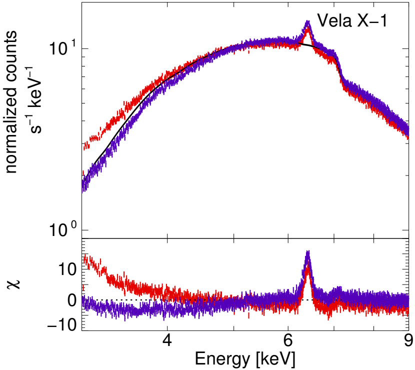
Therefore:

- Give EPIC-pn as much telemetry as possible
  $\Longrightarrow$ switch off EPIC-MOS
- Only transmit those events that are most interesting for spectral-temporal studies
  $\Longrightarrow$ disregard soft photons

Modified Timing Mode:

increase lower energy threshold in EPIC-pn from 200 eV to 2.8 keV

Modified Timing Mode - Calibration



Single/double fraction changes as low energy split partners disappear

→ energy redistribution changes

→ Timing mode requires recalibration!

Vela X-1:
Standard timing mode versus simulated modified timing mode, using *STANDARD MODE RESPONSE MATRIX*.

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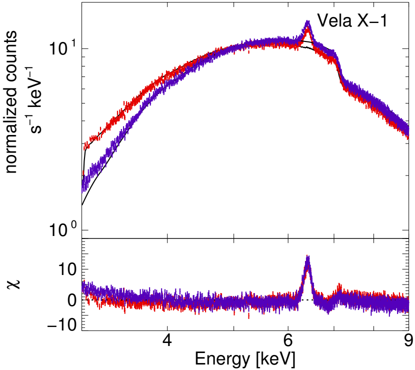

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Vela X-1:
Standard timing mode versus simulated modified timing mode, using *NEW RESPONSE MATRIX FOR MODIFIED TIMING MODE*.

Cygnus X-1 - an example of a bright source

Why Cygnus X-1?

- Never before observed with *XMM-Newton* (Earth avoidance zone)
- Broad Fe Kα line
- Strong, energy dependent variability

2 main parts of analysis:

Broadband Continuum

- constrain models for Comptonizing plasma (non-thermal Comptonization?)
- constrain amount of Compton reflection

Iron Line

- search for structure of the Fe Kα line (relativistic broadening)
- determine shape and strength of the Fe K edge

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INTEGRAL, *RXTE*

Iron Line

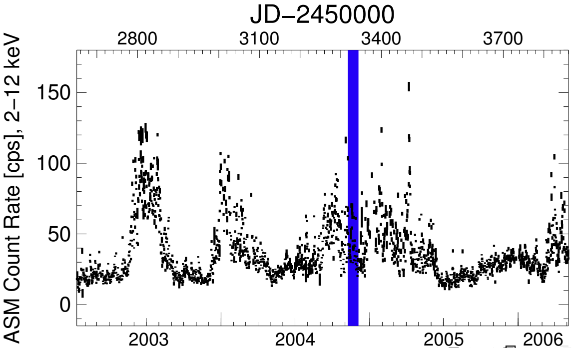
XMM-Newton

The Observations

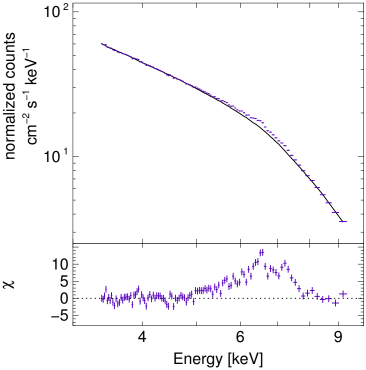
Cyg X-1 was observed simultaneously by

- *XMM-Newton* (total observation time: ∼40 ksec)
- *RXTE* (total observation time: ∼152 ksec)
- *INTEGRAL* (total observation time: ∼320 ksec)

for 4 times in November / December 2004

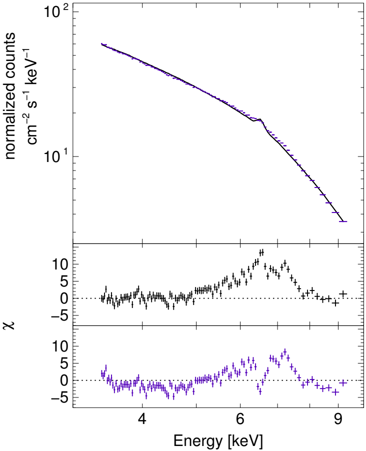


XMM-Newton Spectrum



- Power-law fit ($\Gamma = 1.97$): strong residuals in Fe Kα region

XMM-Newton Spectrum



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- adding narrow line ($E = 6.51$ keV, $\sigma = 50$ eV): still strong residuals in Fe Kα region

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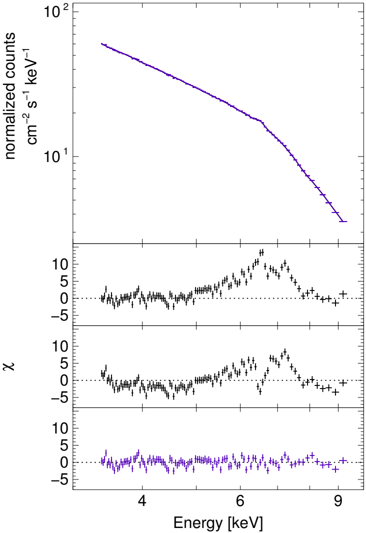
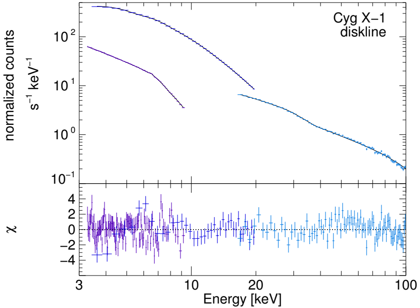


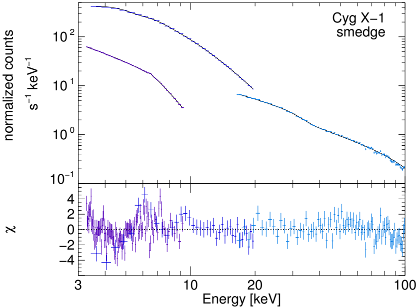
- Power-law fit ($\Gamma = 1.97$): strong residuals in Fe Kα region
- adding narrow line ($E = 6.51$ keV, $\sigma = 50$ eV): still strong residuals in Fe Kα region
- adding relativistic line ($E = 6.18$ keV, emissivity $\propto r^{-2.6}$): fit improves significantly ($\chi^2_{\text{red}} = 1.5$)

DISKLINE VS. SMEDGE

BUT: residuals might also be explained by ionized Fe K-shell absorption edge



$\chi^2_{\mathrm{red}} = 1.6$ (241 dof)



$\chi^2_{\mathrm{red}} = 2.2$ (242 dof)

$\rightarrow$ in *XMM-Newton* data already indications that relativistic line is needed

$\Longrightarrow$ confirmation using *RXTE*

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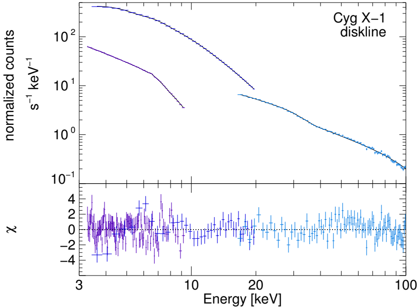

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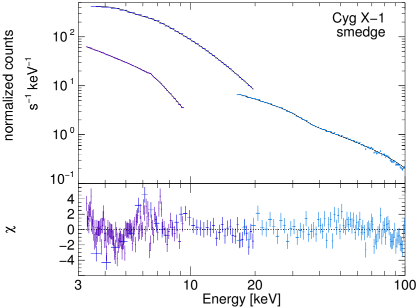

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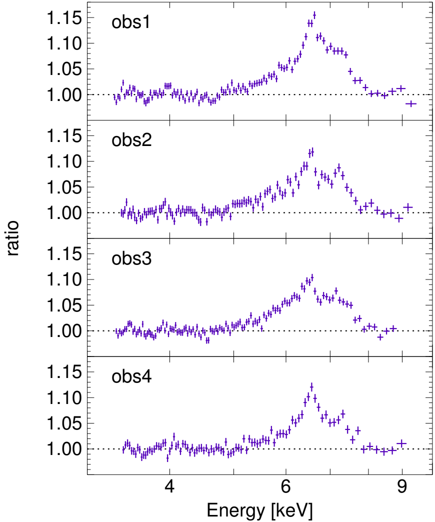
$\Longrightarrow$ spectrum best described by a narrow line and a relativistic line!

Variability of the Iron Line



Fe Kα line shows strong variability during the observations

$\Longrightarrow$ further analysis is ongoing!

Summary and Outlook

Modified Timing Mode

- EPIC-mos cameras switched off
- lower EPIC-pn threshold increased to 2.8 keV
- recalibration was needed

Cygnus X-1

- Cyg X-1 was in the Intermediate State
- confirmation of relativistically broadened Iron Line
- Fe Kα line shows strong variability during the observations

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Outlook

with the Modified Timing Mode bright sources can be observed with *RXTE* time resolution AND *XMM-Newton* energy resolution
$\Longrightarrow$ new opportunities for future observations