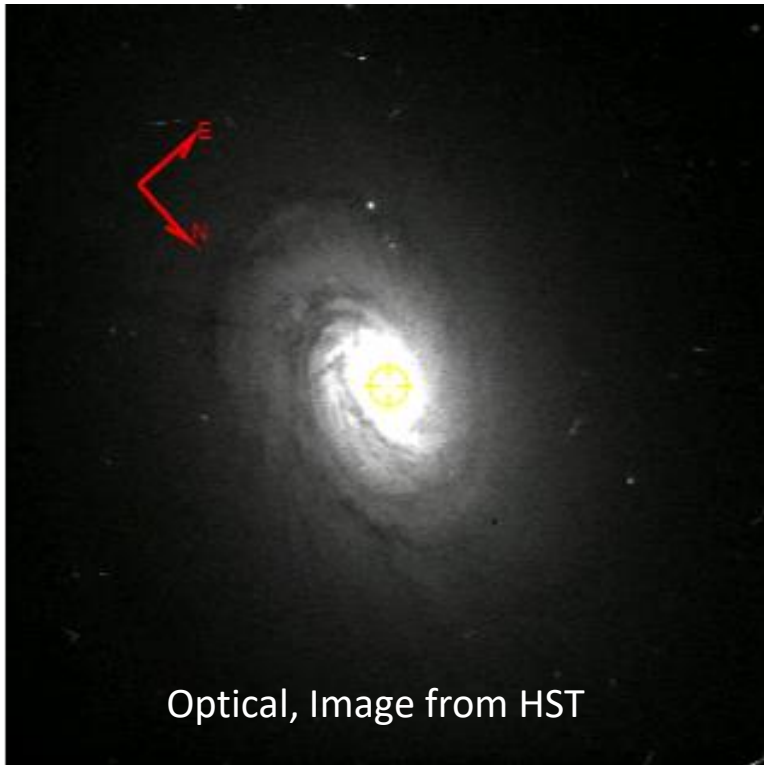




# ANALYSIS OF THE AGN OF NGC2110



Name: NGC 2110

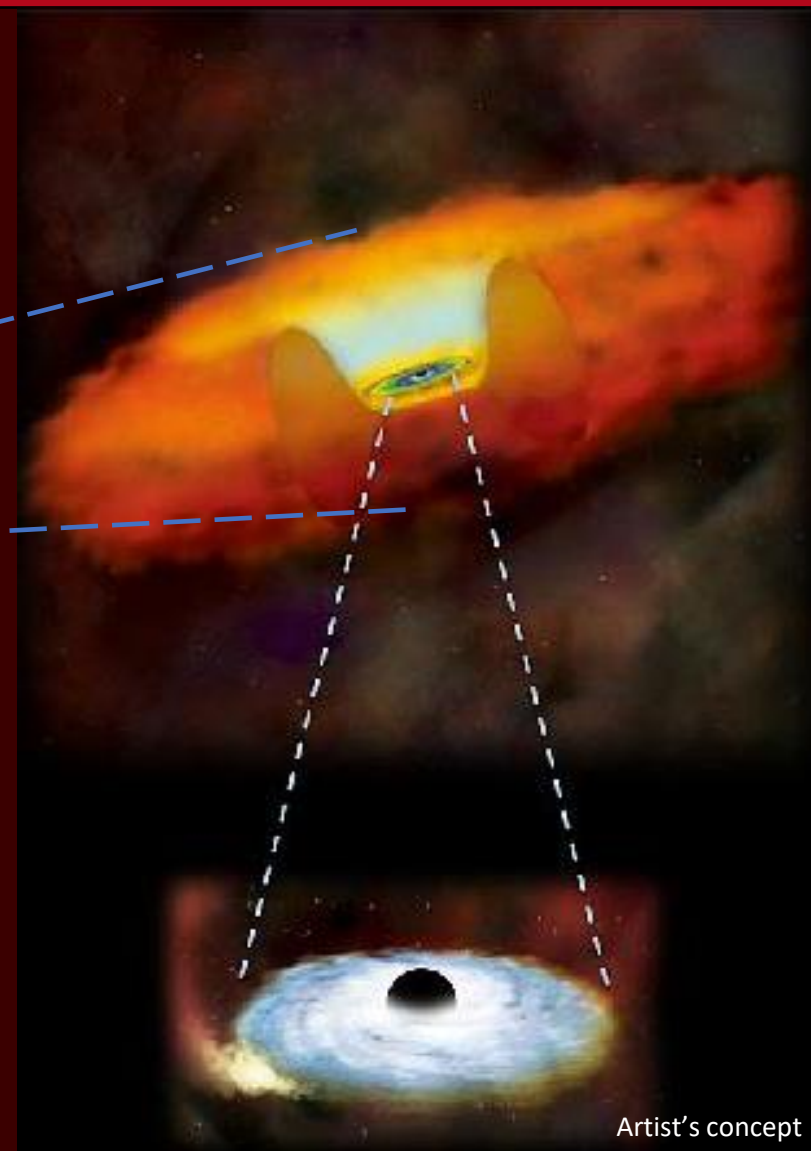
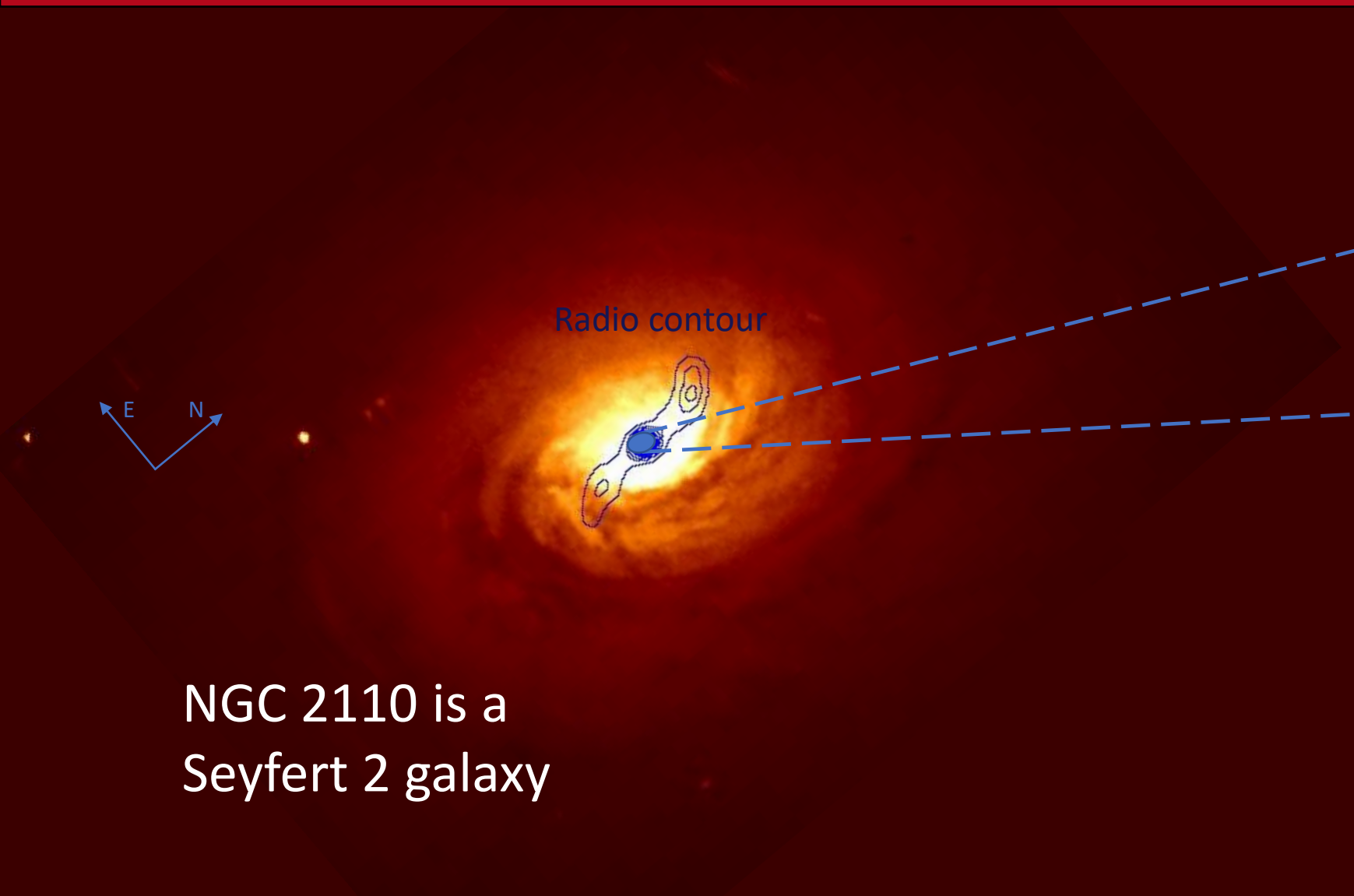
Equatorial coordinates (RA,dec): 88.047420, -7.456212

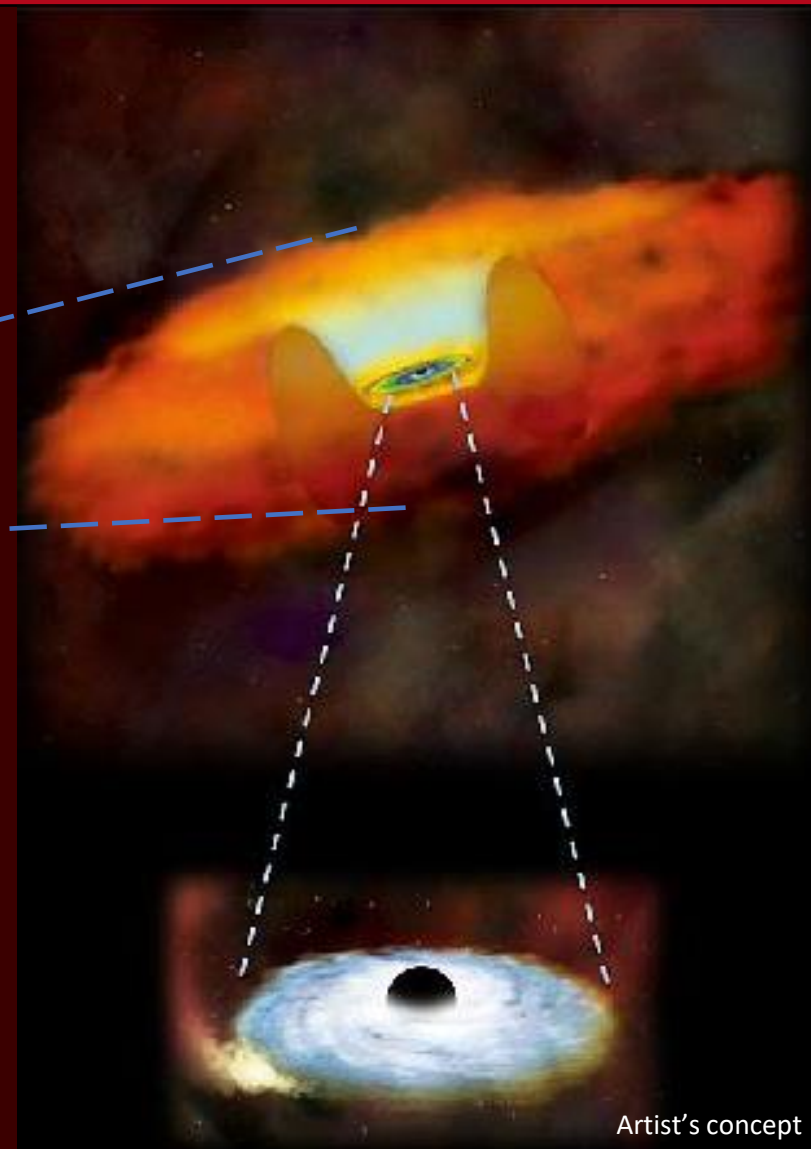
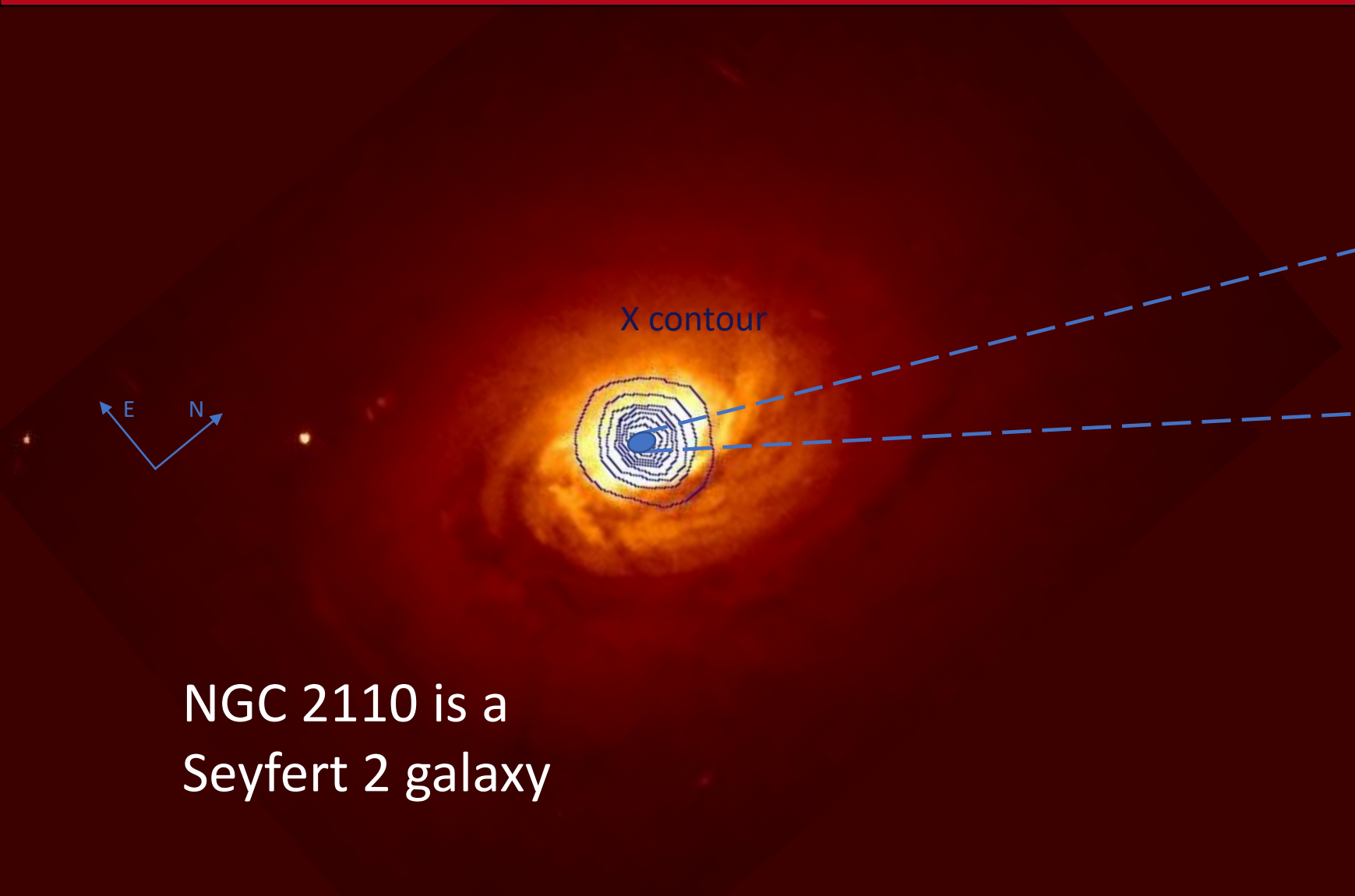
Redshift: 0.0078

Luminosity distance: 34.5 Mpc

Diameter: 26.61 kpc

Morphology: SAB0<sup>+</sup>-









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# CHANDRA



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di Fisica  
e Astronomia  
Galileo Galilei

ENERGY RANGE:  
0.1-10 KeV

HIGH RESOLUTION  
MIRROR ASSEMBLY

SPACECRAFT  
MODULE

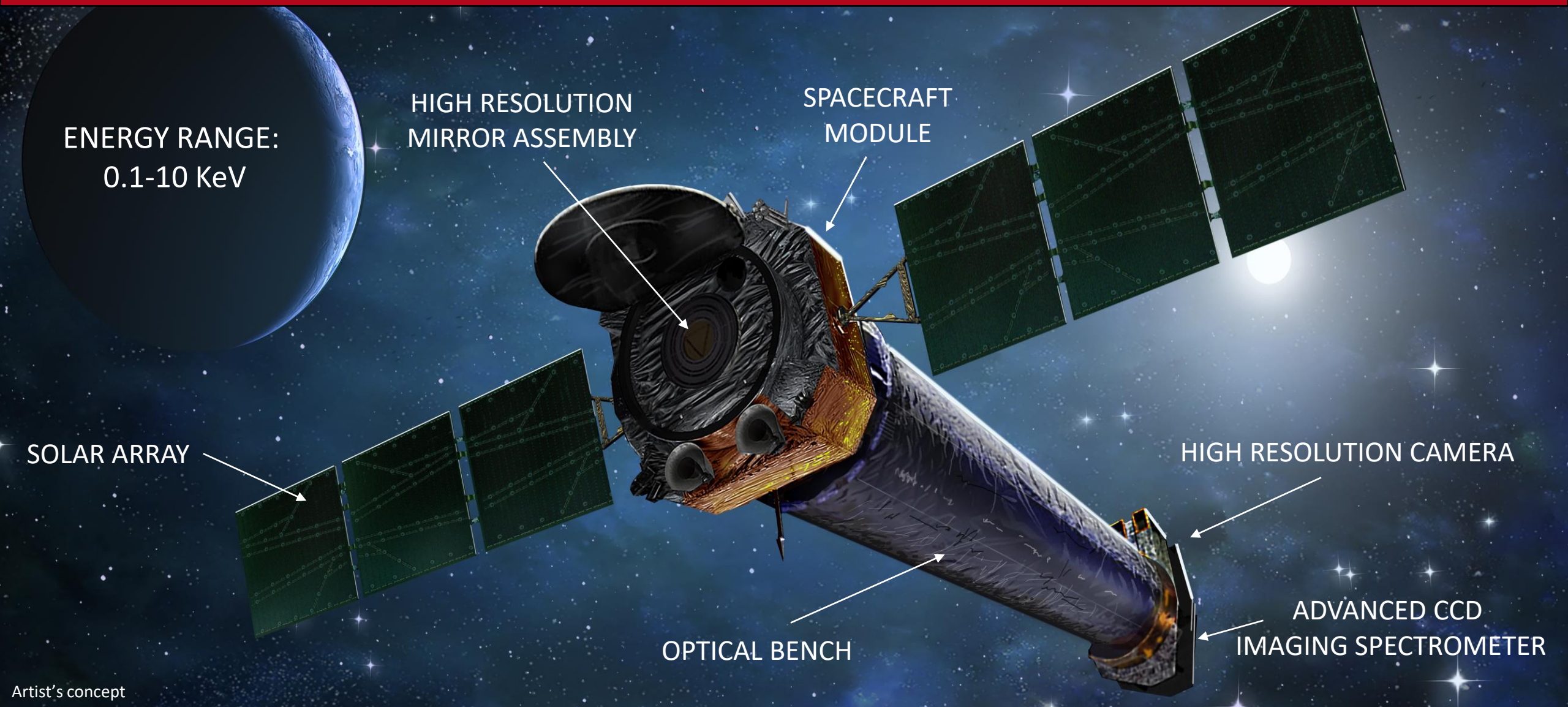
SOLAR ARRAY

HIGH RESOLUTION CAMERA

OPTICAL BENCH

ADVANCED CCD  
IMAGING SPECTROMETER

Artist's concept





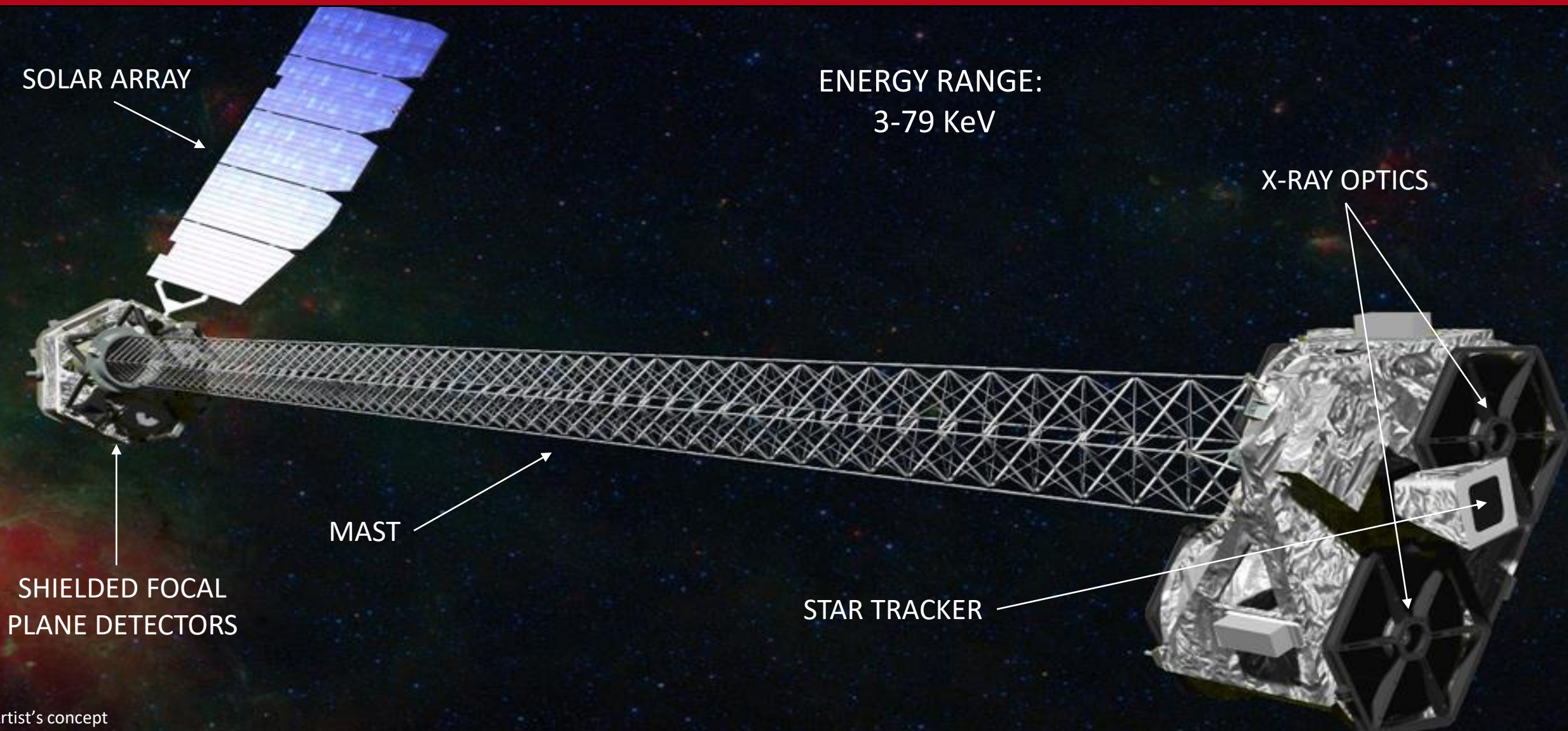


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# NuSTAR

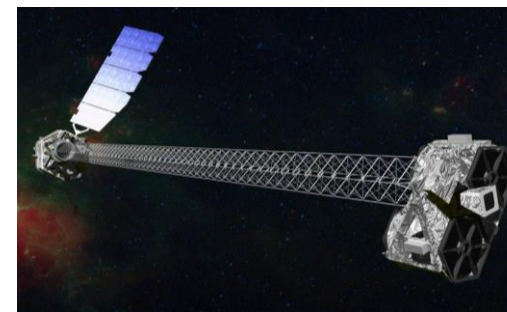
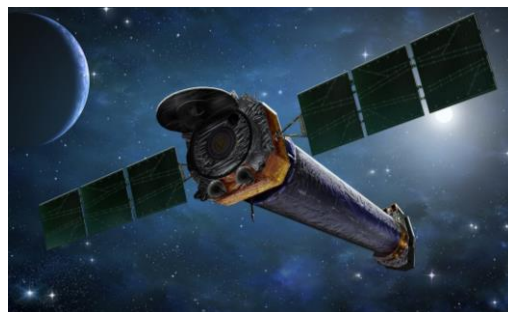


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e Astronomia  
Galileo Galilei



Artist's concept

# Chandra and NuSTAR specifications



## Telescope

## Launched on

## Energy range

## Angular resolution (FWHM)

## Spectral resolution (FWHM)

## Sensitivity

## Temporal resolution

## Chandra

July 23, 1999

0.1-10 keV

0.5"

120 eV (ACIS at 6 keV)

$4 \times 10^{-15}$  ergs cm<sup>-2</sup> s<sup>-1</sup> (0.4-6 keV)

3 ms

## NuSTAR

June 13, 2012

3-79 keV

18"

400 eV (at 10 keV)

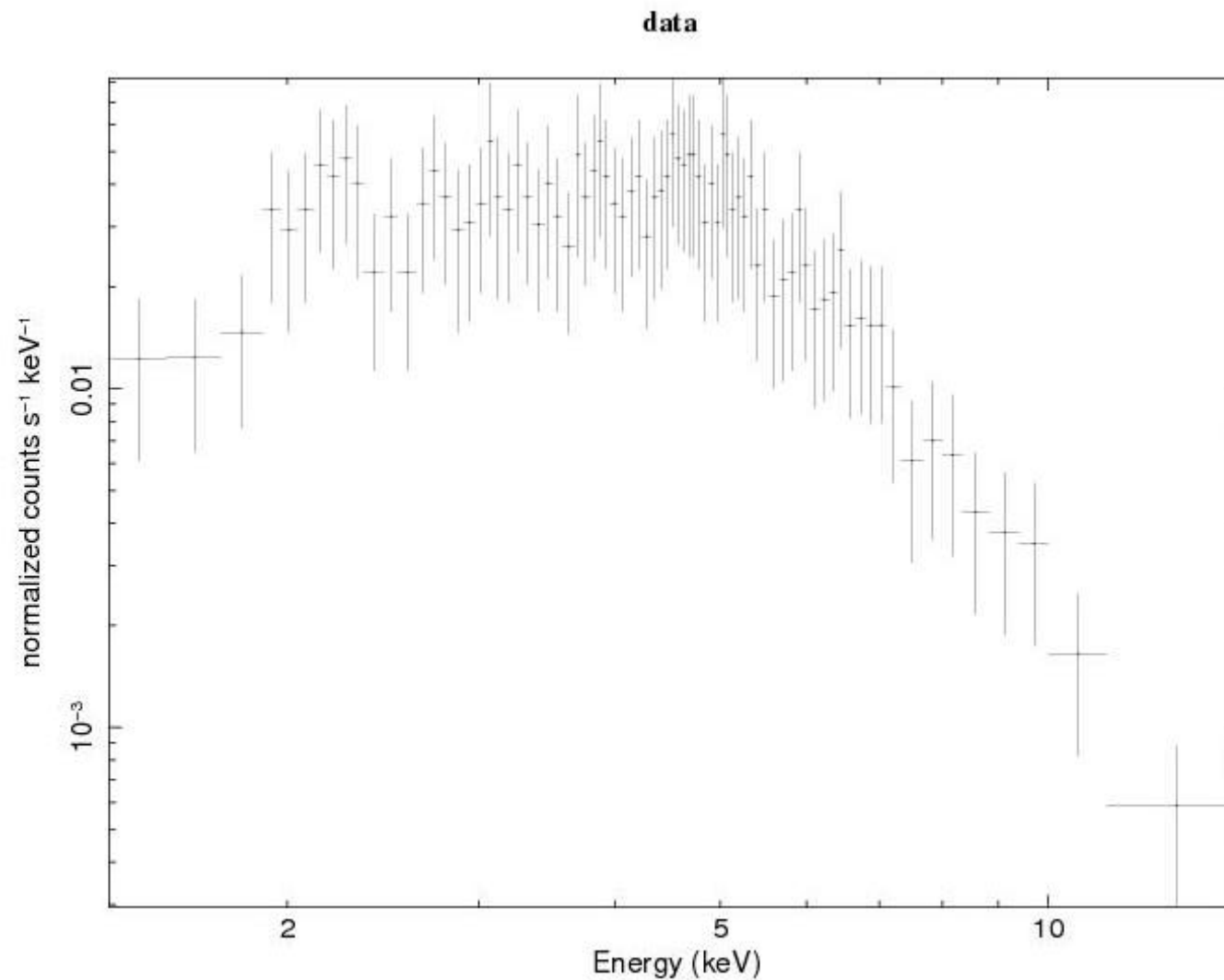
$2 \times 10^{-15}$  erg cm<sup>-2</sup> s<sup>-1</sup> (6-10 keV)

2 μs



Instrument: Chandra  
Exposure time: 80 ks  
Date: 20 December 2001

**Dearth of data!**







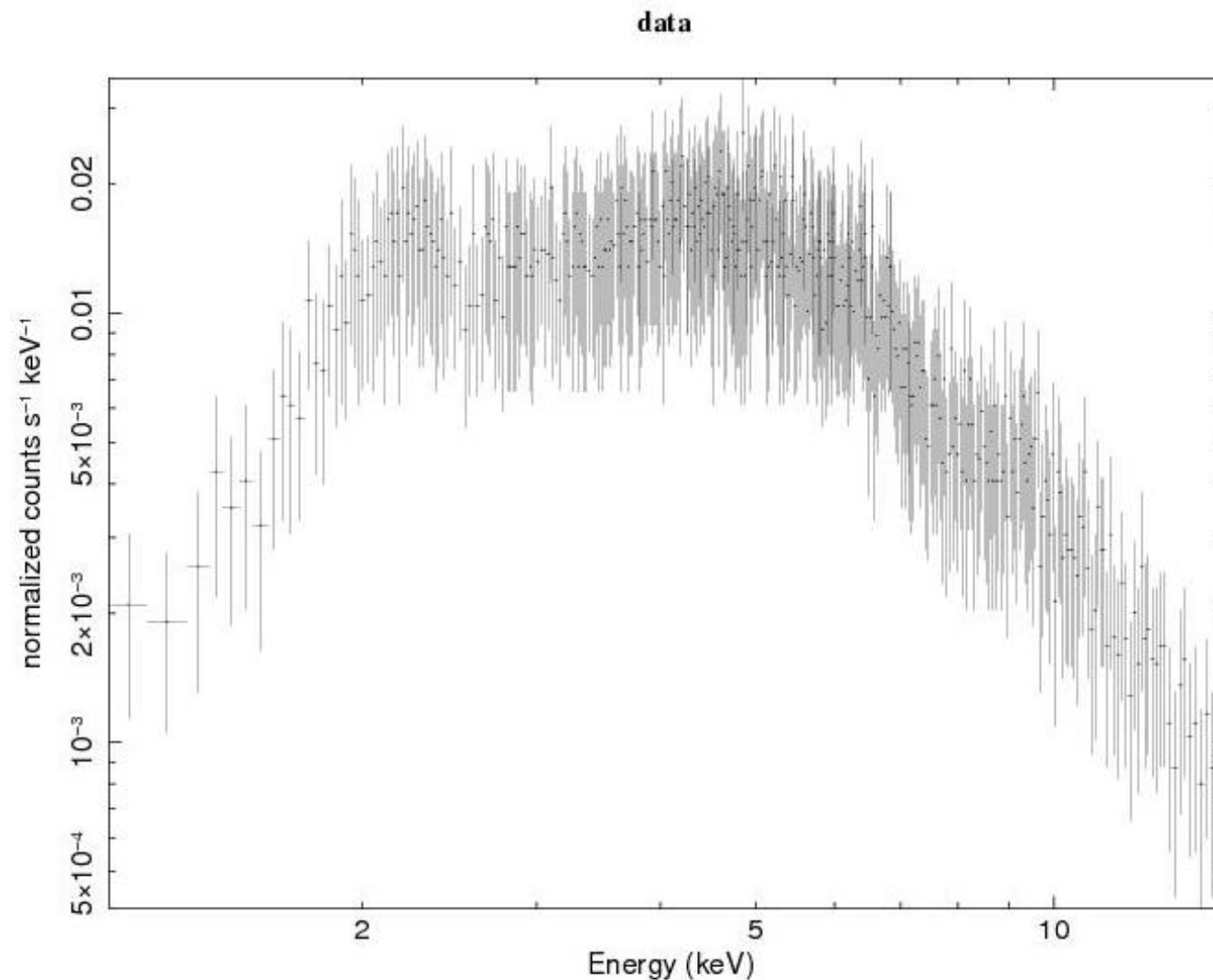
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# ObsID 3418 e2



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e Astronomia  
Galileo Galilei

Instrument: Chandra  
Exposure time: 80 ks  
Date: 20 December 2001



Range considered: 2-8 keV

Best fit model: WABS(powerlaw+gauss)

## Best fit parameters

Line:  $6.81 \pm 0.06$  keV

Element: Magnesium (Mg K $\alpha$ )

$\sigma$  :  $2.08 \times 10^{-6} \pm 3$

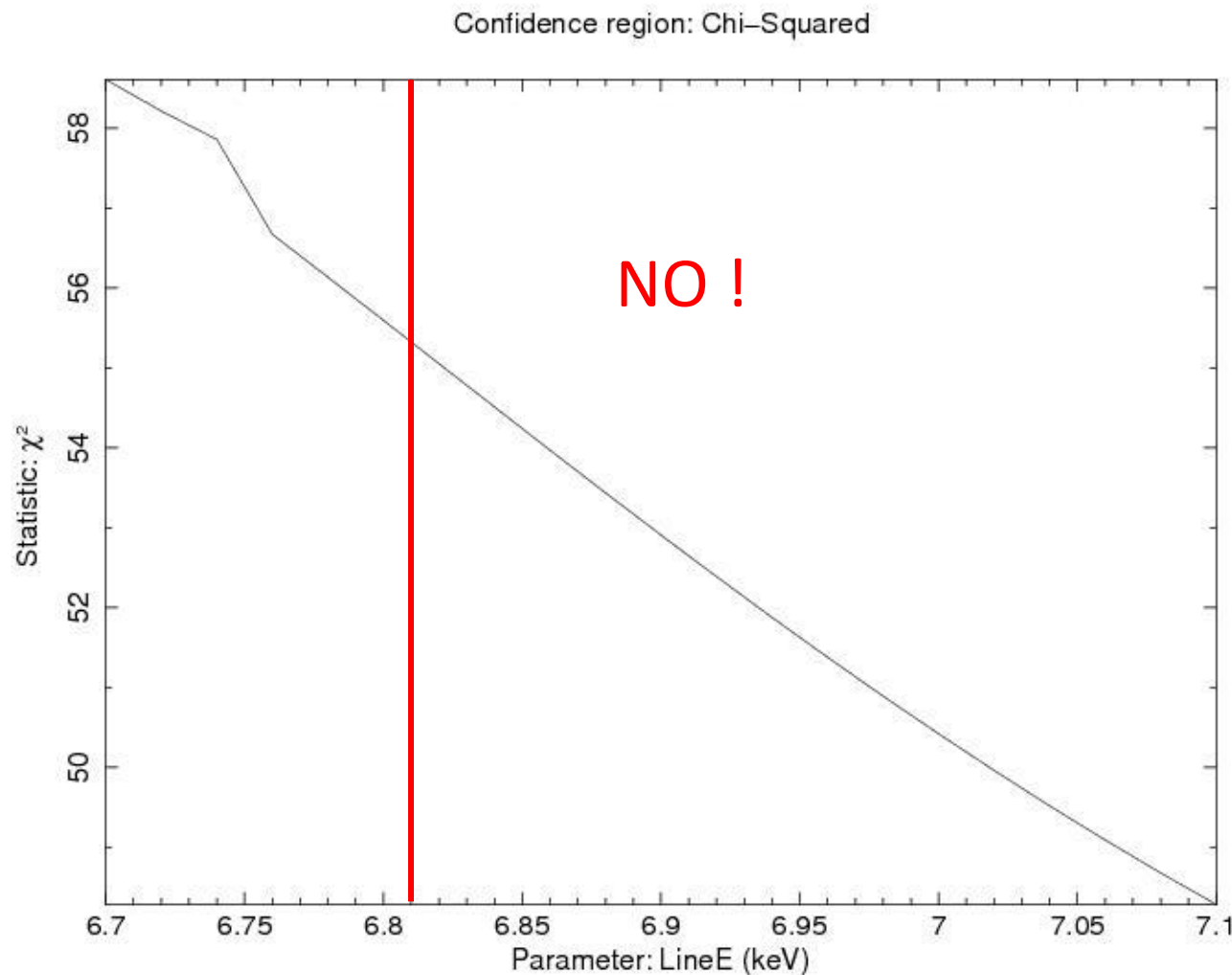
$\chi^2$  : 0.2347

$N_H$  :  $(2.71 \pm 0.81) \times 10^{22}$  atoms cm $^{-2}$

$\Gamma$  :  $0.30 \pm 0.08$

$\Gamma_{\text{NORM}}$  :  $(1.81 \pm 0.27) \times 10^{-4}$

## Is it a real line?





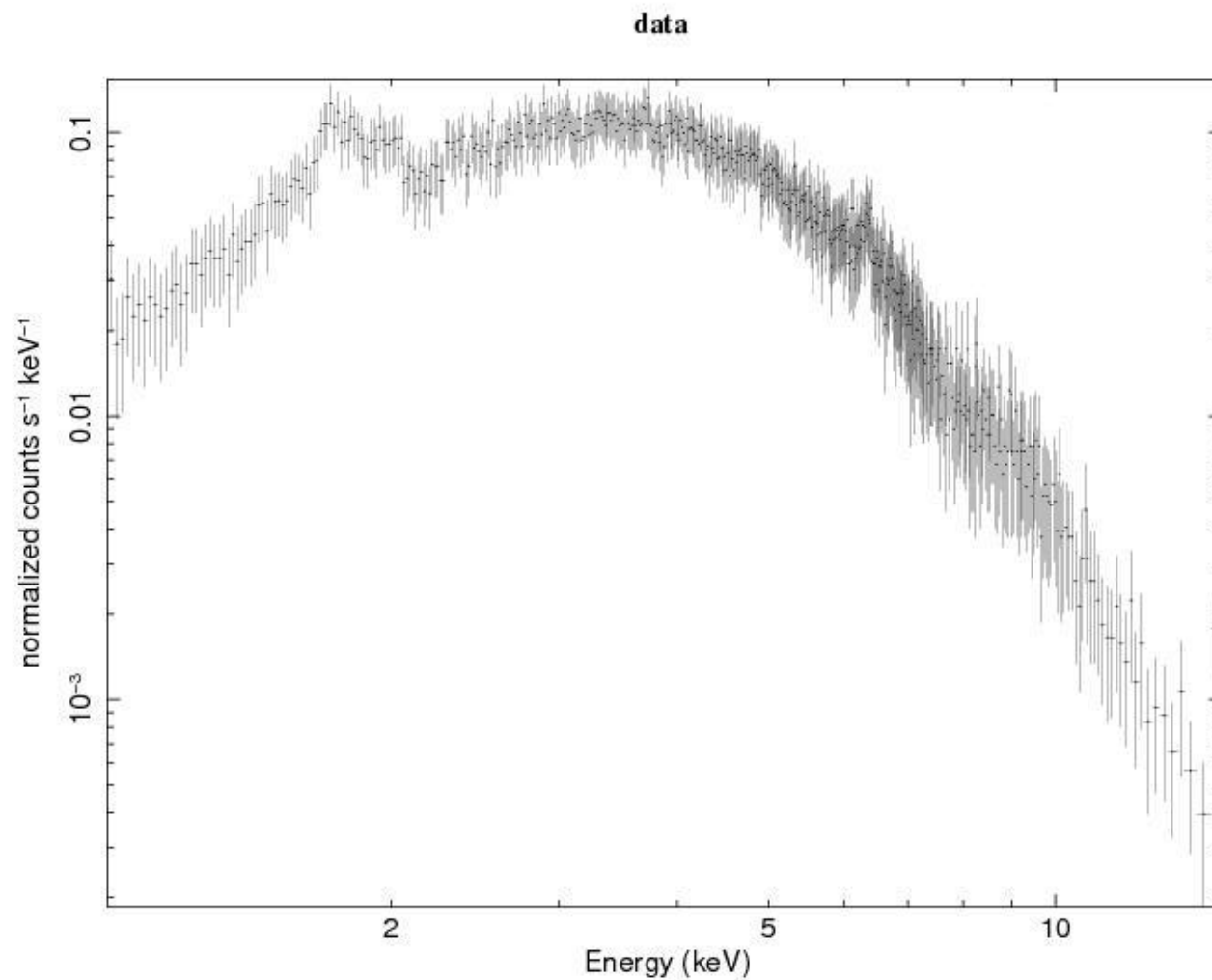
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# ObsID 883



Dipartimento  
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e Astronomia  
Galileo Galilei

Instrument: Chandra  
Exposure time: 50 ks  
Date: 22 April 2000



27-Nov-2019 09:47



Range considered: 1.5-8 keV

Best fit model: WABS(powerlaw+gauss)

## Best fit parameters

Line:  $6.34 \pm 0.03$  keV

Element: Iron (Fe  $K\alpha$ )

$\sigma$ :  $(3.16 \pm 0.80) \times 10^{-2}$

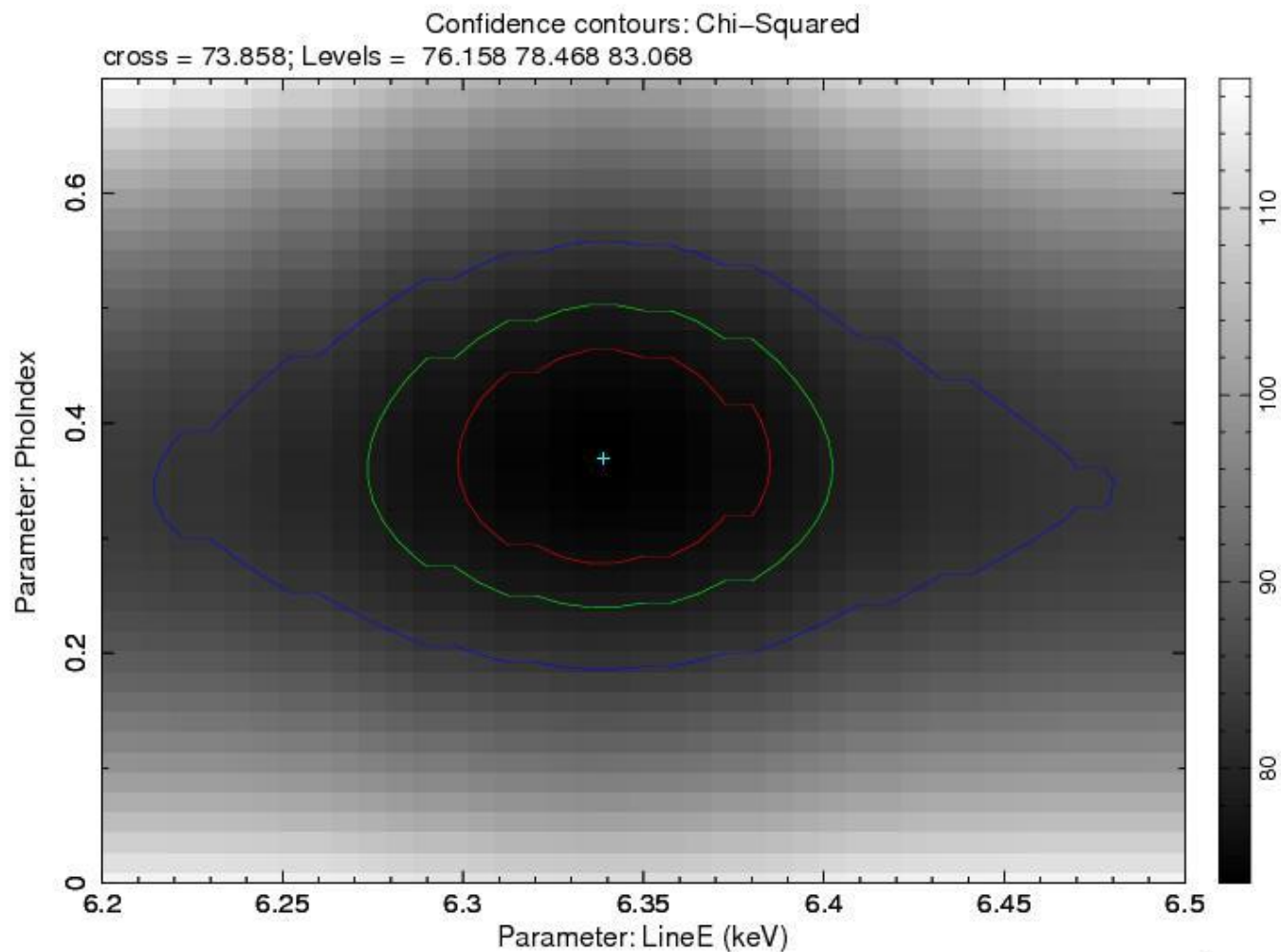
$\chi^2$ : 0.2752

$N_H$ :  $(2.34 \pm 0.15) \times 10^{22}$  atoms  $\text{cm}^{-2}$

$\Gamma$ :  $0.71 \pm 0.07$

$\Gamma_{\text{NORM}}$ :  $(7.74 \pm 0.86) \times 10^{-4}$

Flux:  $5.59 \times 10^{-13}$  erg  $\text{cm}^{-2} \text{s}^{-1}$



Range considered: 1.5-8 keV

Best fit model: WABS(powerlaw+gauss)

## Best fit parameters

Line:  $1.71 \pm 0.03$  keV

Element: Silicon (Si K $\alpha$ )

$\sigma$ :  $1.45 \times 10^{-3} \pm 0.56$

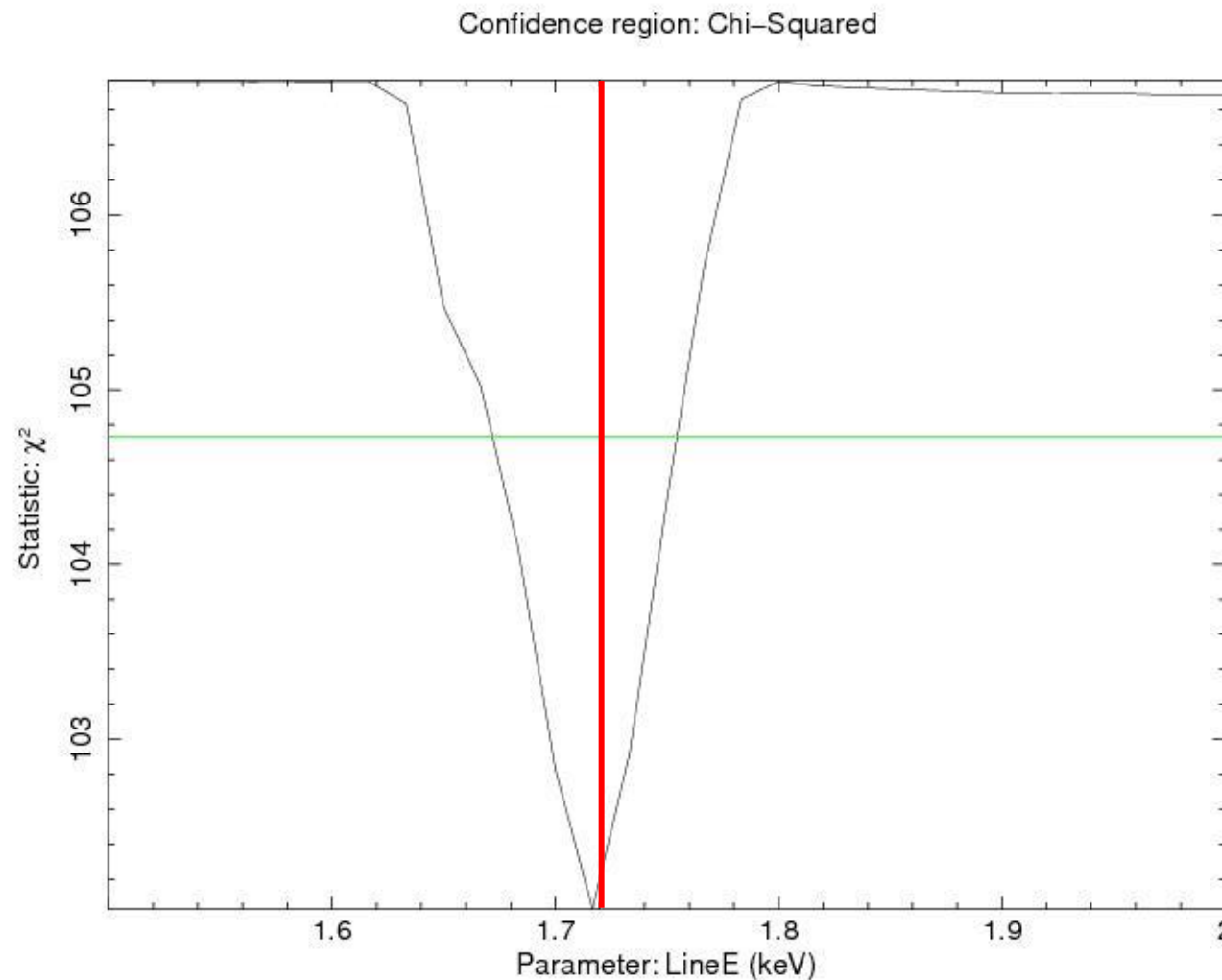
$\chi^2$ : 0.2671

$N_H$ :  $(2.48 \pm 0.17) \times 10^{22}$  atoms cm $^{-2}$

$\Gamma$ :  $0.74 \pm 0.07$

$\Gamma_{\text{NORM}}$ :  $(8.17 \pm 0.95) \times 10^{-4}$

Flux:  $5.29 \times 10^{-14}$  erg cm $^{-2}$  s $^{-1}$



Range considered: 1.5-8 keV

Best fit model: WABS(powerlaw+gauss)

## Best fit parameters

Line:  $2.32 \pm 0.09$  keV

Element: Sulfur (S K $\alpha$ )

$\sigma$ :  $1.91 \times 10^{-3} \pm 0.58$

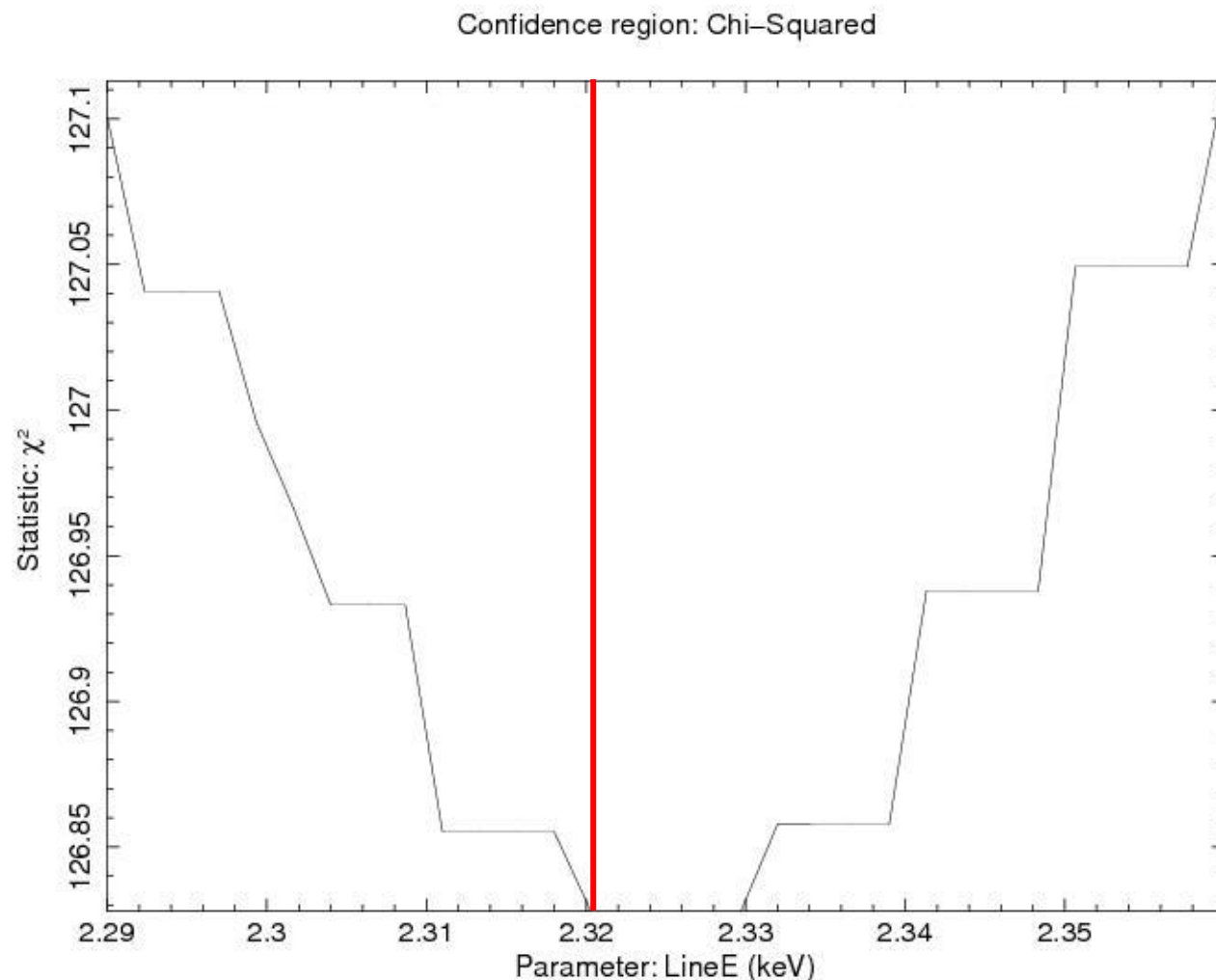
$\chi^2$ : 0.3027

$N_H$ :  $(2.24 \pm 0.15) \times 10^{22}$  atoms cm $^{-3}$

$\Gamma$ :  $0.65 \pm 0.06$

$\Gamma_{\text{NORM}}$ :  $(7.03 \pm 0.77) \times 10^{-4}$

Flux:  $1.92 \times 10^{-14}$  erg cm $^{-2}$  s $^{-1}$







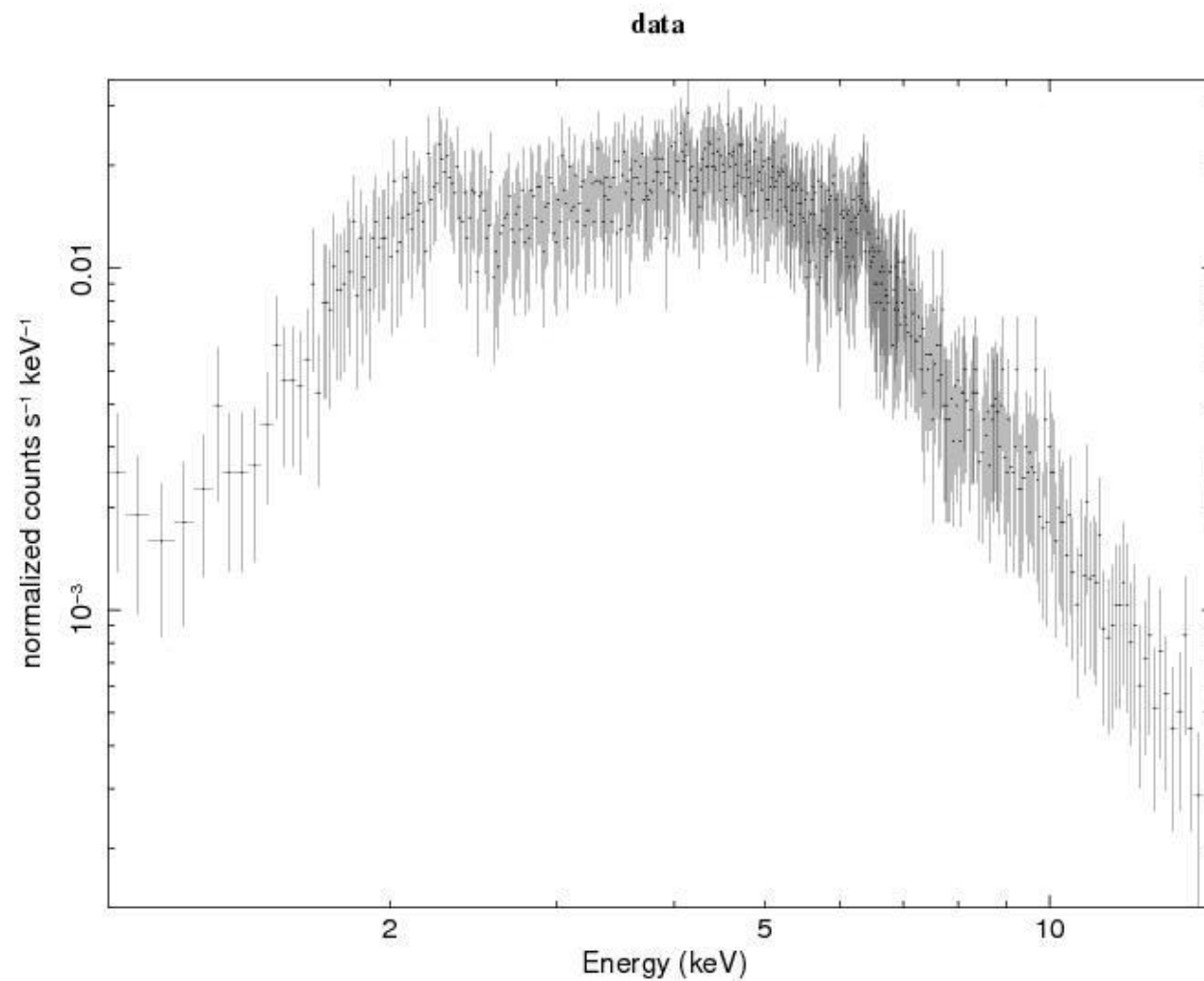
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# ObsID 4377



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Galileo Galilei

Instrument: Chandra  
Exposure time: 100 ks  
Date: 5 March 2003



4-Feb-2020 11:18

Range considered: 1.5-8 keV

Best fit model: WABS(powerlaw+gauss)

## Best fit parameters

Line:  $6.34 \pm 0.04$  keV

Element: Iron (Fe  $K\alpha$ )

$\sigma$ :  $(3.65 \pm 1.12) \times 10^{-2}$

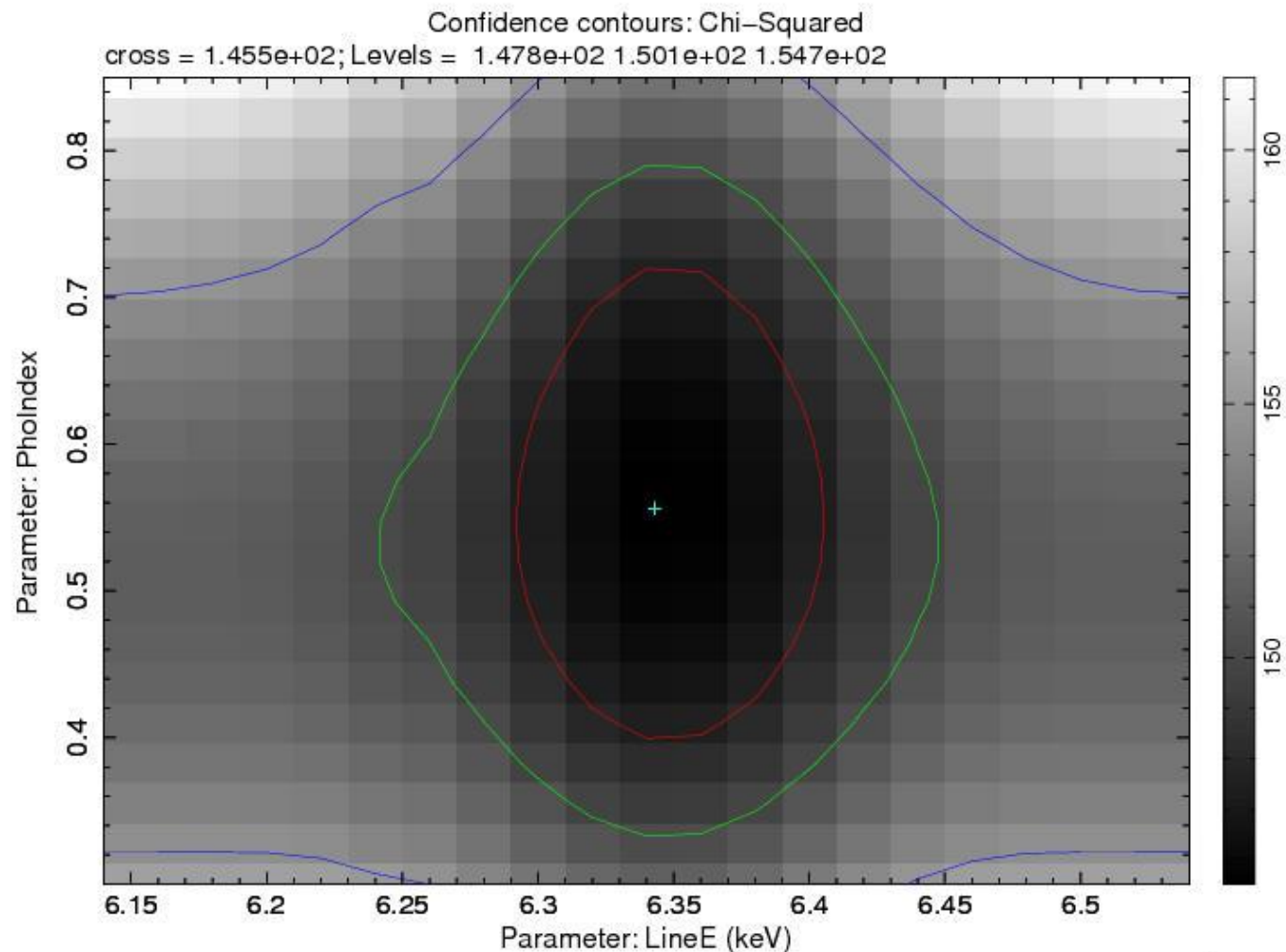
$\chi^2$ : 0.2709

$N_H$ :  $(1.61 \pm 0.29) \times 10^{22}$  atoms  $\text{cm}^{-2}$

$\Gamma$ :  $1.07 \pm 0.13$

$\Gamma_{\text{NORM}}$ :  $(4.55 \pm 0.84) \times 10^{-4}$

Flux:  $3.38 \times 10^{-13}$  erg  $\text{cm}^{-2} \text{s}^{-1}$



Range considered: 1.5-6 keV

Best fit model: WABS(powerlaw+gauss)

## Best fit parameters

Line:  $2.30 \pm 0.04$  keV

Element: Sulfur (S K $\alpha$ )

$\sigma$ :  $3.88 \times 10^{-3} \pm 0.17$

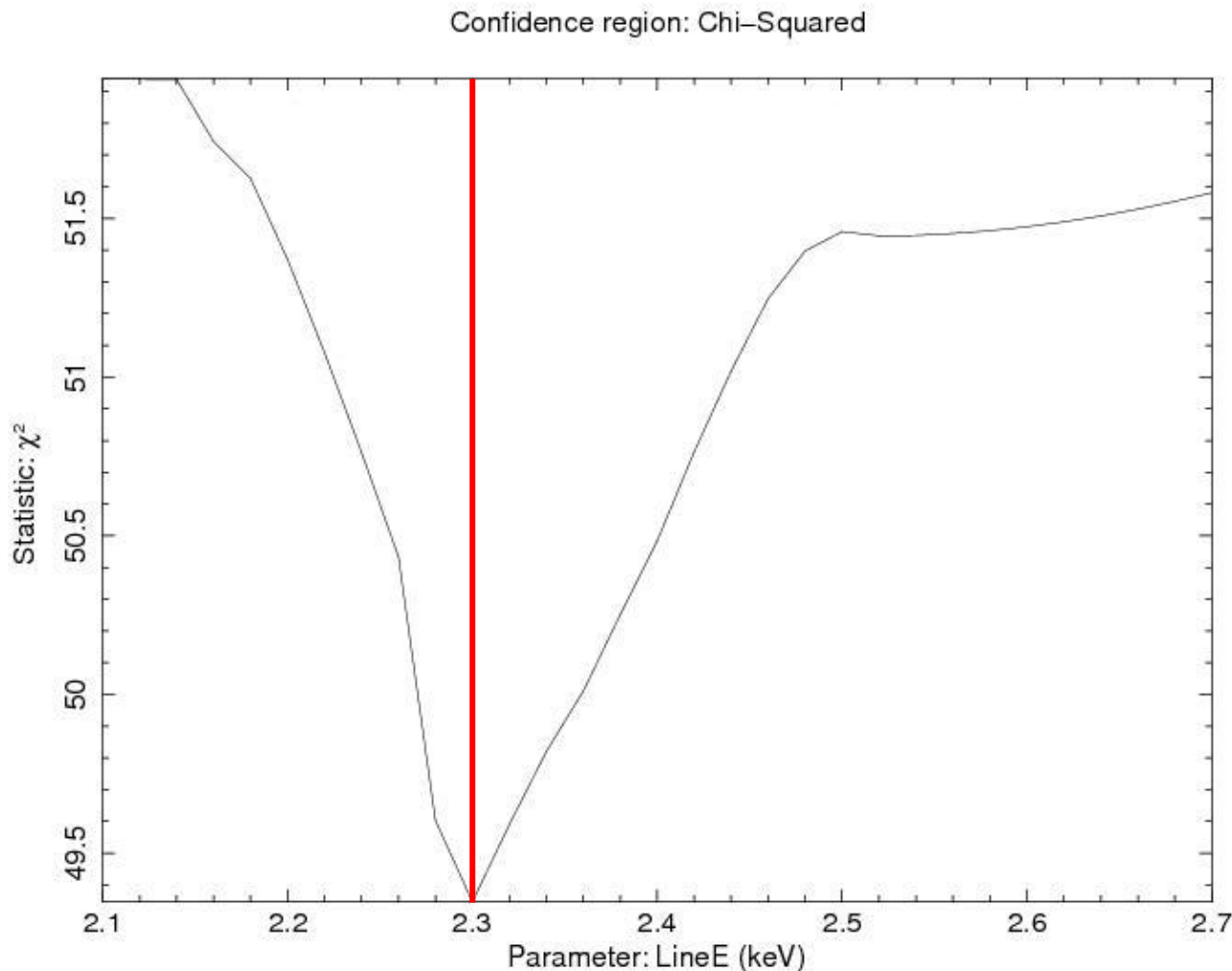
$\chi^2$ : 0.2282

$N_H$ :  $(2.47 \pm 0.38) \times 10^{22}$  atoms cm $^{-2}$

$\Gamma$ :  $1.02 \pm 0.14$

$\Gamma_{\text{NORM}}$ :  $(6.69 \pm 1.53) \times 10^{-4}$

Flux:  $7.10 \times 10^{-14}$  erg cm $^{-2}$  s $^{-1}$







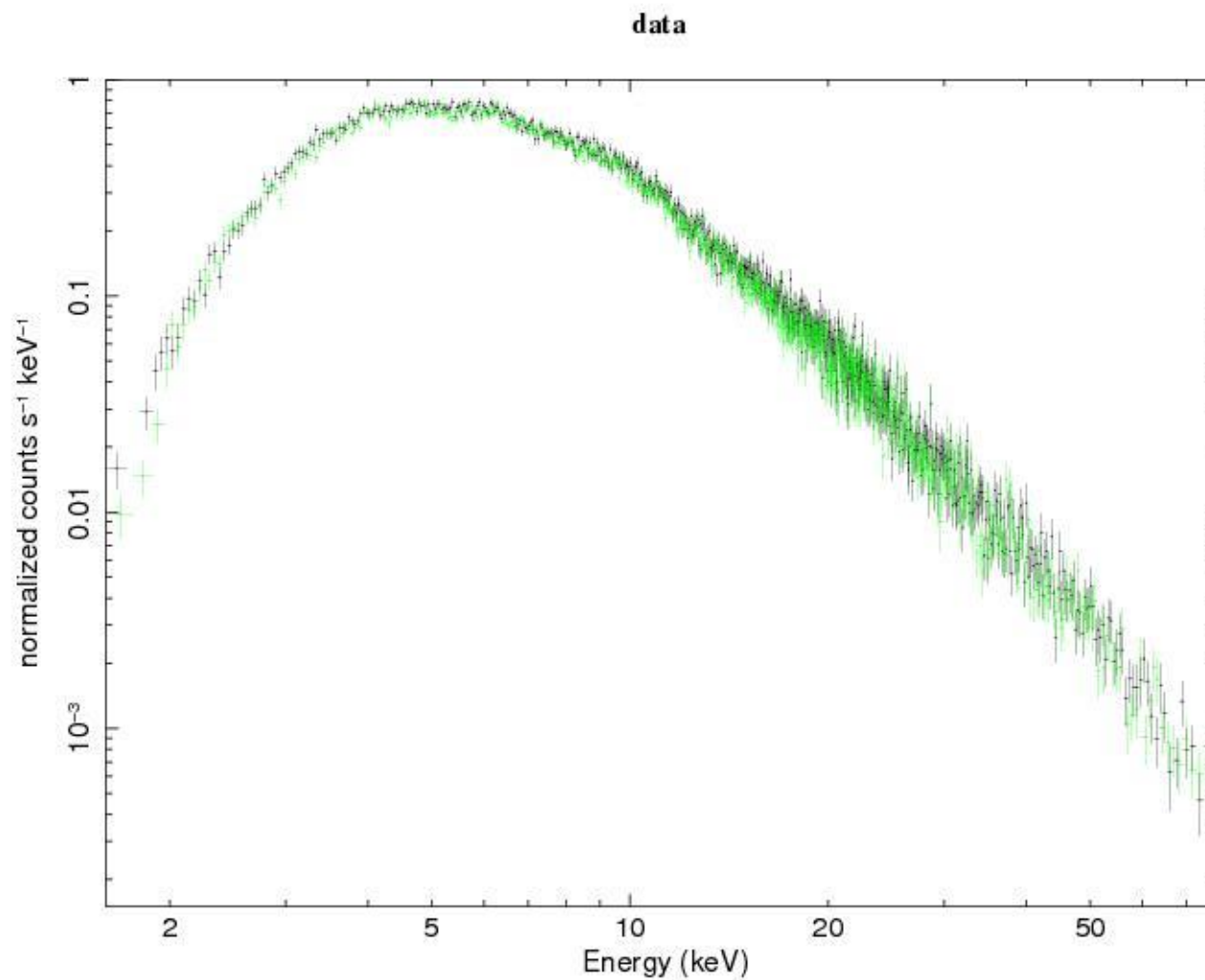
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ObsID 60061061002



Dipartimento  
di Fisica  
e Astronomia  
Galileo Galilei

Instrument: NuStar  
Exposure time: 15.5 ks  
Date: 5 October 2012



4-Feb-2020 12:26

Range considered: 3-13 keV

Best fit model: WABS(powerlaw+gauss)

## Best fit parameters

Line:  $6.22 \pm 0.04$  keV

Element: Iron (Fe K $\alpha$ )

$\sigma$ :  $3.78 \times 10^{-2} \pm 0.13$

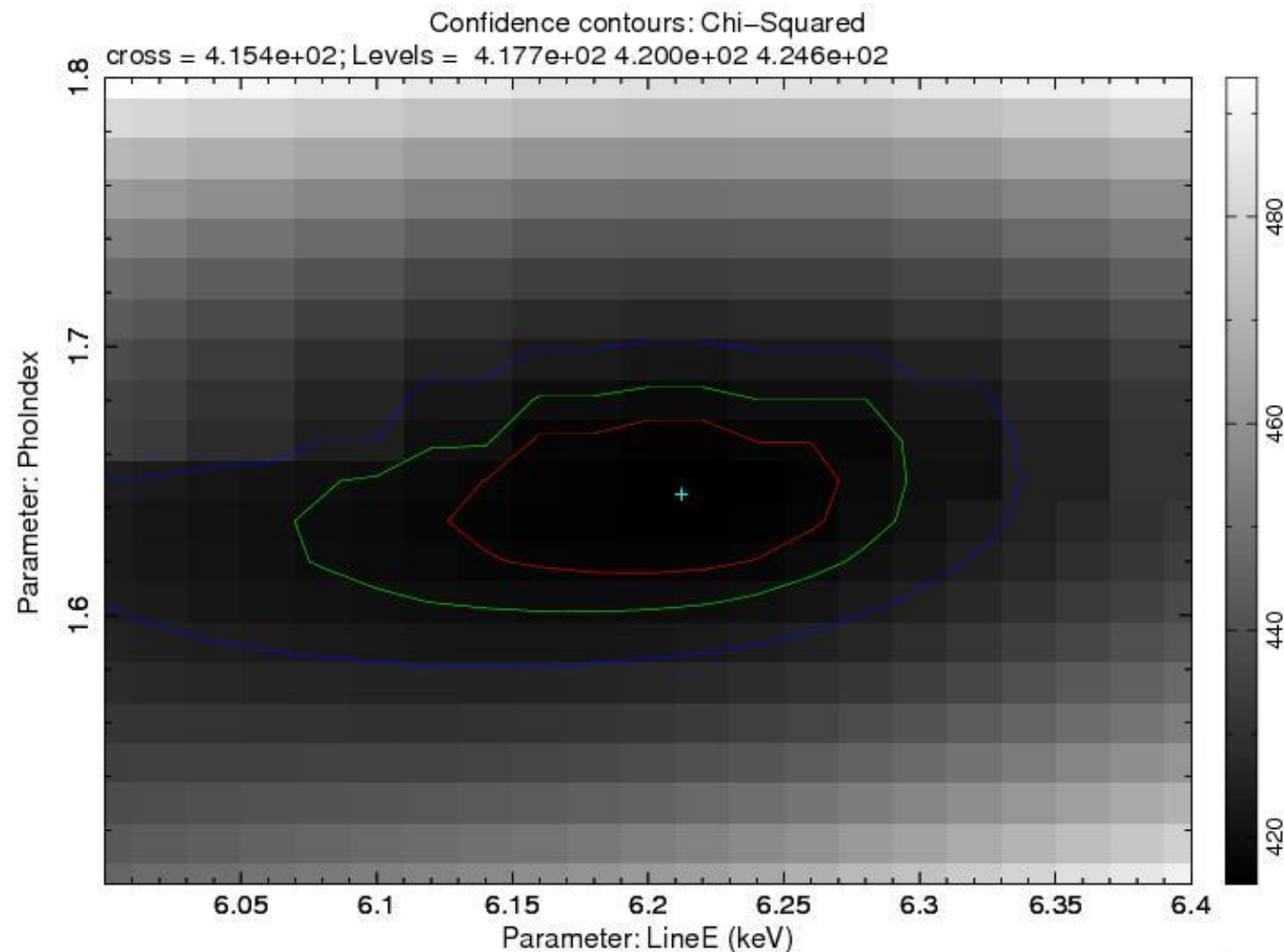
$\chi^2$ : 1.0596

$N_H$ :  $(3.07 \pm 0.24) \times 10^{22}$  atoms cm $^{-2}$

$\Gamma$ :  $1.59 \pm 0.02$

$\Gamma_{\text{NORM}}$ :  $(5.09 \pm 0.18) \times 10^{-2}$

Flux:  $9.78 \times 10^{-12}$  erg cm $^{-2}$  s $^{-1}$





# Data comparison



	$N_H$ ( $\times 10^{22}$ atoms $\text{cm}^{-2}$ )	$\Gamma$	FeK $\alpha$ (KeV)	SiK $\alpha$ (KeV)	SK $\alpha$ (KeV)	$F_{\text{FeK}\alpha}$ ( $10^{-5}$ ph $\text{cm}^{-2}$ $\text{s}^{-1}$ )
Chandra 3418	$2.71 \pm 0.81$	$0.30 \pm 0.08$	–	–	–	–
Chandra 883	$2.34 \pm 0.15$	$0.71 \pm 0.07$	$6.34 \pm 0.03$	$1.71 \pm 0.03$	$2.32 \pm 0.09$	5.50
Chandra 4377	$1.61 \pm 0.29$	$1.07 \pm 0.14$	$6.34 \pm 0.04$	–	$2.30 \pm 0.04$	3.33
Chandra (Evans et al., 2006)	$2.89 \pm 0.16$	$1.40 \pm 0.04$	$6.379 \pm 0.007$	$1.741 \pm 0.002$	$2.303 \pm 0.008$	–
Chandra (Marinucci et al., 2015)	$< 4.5$	$1.25^{+0.48}_{-0.33}$	$6.391 \pm 0.016$	–	–	$5.5^{+2.5}_{-2.0}$
NuStar 60061061002	$3.07 \pm 0.24$	$1.59 \pm 0.02$	$6.22 \pm 0.04$	–	–	95.5
NuStar (Marinucci et al., 2015)	$4.0 \pm 0.4$	$1.64 \pm 0.03$	$6.33 \pm 0.07$	–	–	$9.5 \pm 3.0$





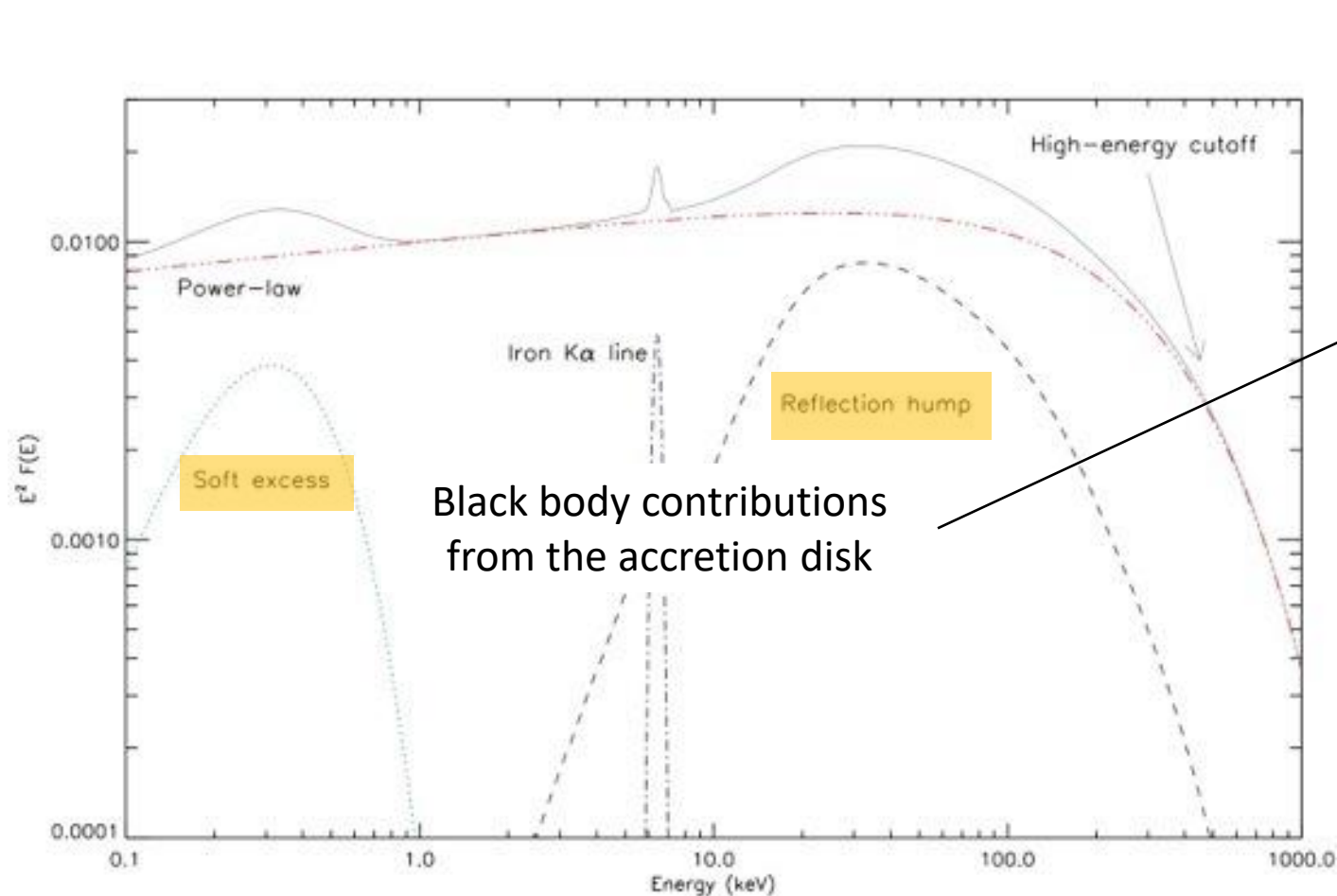
	$N_H$ ( $\times 10^{22}$ atoms $\text{cm}^{-2}$ )	$\Gamma$	FeK $\alpha$ (KeV)	SiK $\alpha$ (KeV)	SK $\alpha$ (KeV)	$F_{\text{FeK}\alpha}$ ( $10^{-5}$ ph $\text{cm}^{-2}$ $\text{s}^{-1}$ )
Chandra 3418	$2.71 \pm 0.81$	$0.30 \pm 0.08$	—	—	—	—
Chandra 883	$2.34 \pm 0.15$	$0.71 \pm 0.07$	$6.34 \pm 0.03$	$1.71 \pm 0.03$	$2.32 \pm 0.09$	5.50
Chandra 4377	$1.61 \pm 0.29$	$1.07 \pm 0.14$	$6.34 \pm 0.04$	—	$2.30 \pm 0.04$	3.33
Chandra (Evans et al., 2006)	$2.89 \pm 0.16$	$1.40 \pm 0.04$	$6.379 \pm 0.007$	$1.741 \pm 0.002$	$2.303 \pm 0.008$	—
Chandra (Marinucci et al., 2015)	$< 4.5$	$1.25^{+0.48}_{-0.33}$	$6.391 \pm 0.016$	—	—	$5.5^{+2.5}_{-2.0}$
NuStar 60061061002	$3.07 \pm 0.24$	$1.59 \pm 0.02$	$6.22 \pm 0.04$	—	—	95.5
NuStar (Marinucci et al., 2015)	$4.0 \pm 0.4$	$1.64 \pm 0.03$	$6.33 \pm 0.07$	—	—	$9.5 \pm 3.0$

Inside  $\pm 3$  times the errors, data obtained are considered consistent with those found in literature

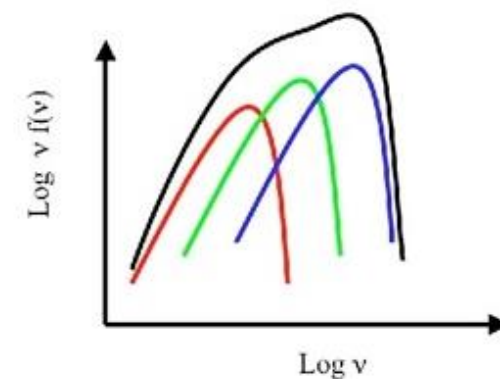


- V. Beckmann et al., The elusive radio loud Seyfert 2 galaxy NGC 2110, 2011
- D. J. Rosario et al., An accreting supermassive black hole irradiating molecular gas in NGC 2110, 2019
- A. Marinucci et al., The Seyfert 2 galaxy NGC 2110: hard X-ray emission observed by NuSTAR and variability of the iron K $\alpha$  line, 2015
- E. Rivers et al., Tracking the complex absorption in NGC 2110 with two Suzaku observations, 2018
- D. A. Evans et al., The Chandra, Hubble Space Telescope, and VLA View of the Circumnuclear Extended Emission in the Narrow Emission Line Galaxy NGC 2110, 2006
- D. A. Evans et al., Probing unification with Chandra HETGs and XMM-Newton epic and RGS spectroscopy of the narrow emission line galaxy NGC 2110, 2007
- P. Padovani et al., Active Galactic Nuclei: what's in a name?, 2017
- C. G. Mundell et al., Radio-Quiet AGN and the Transient Radio Sky, 2011

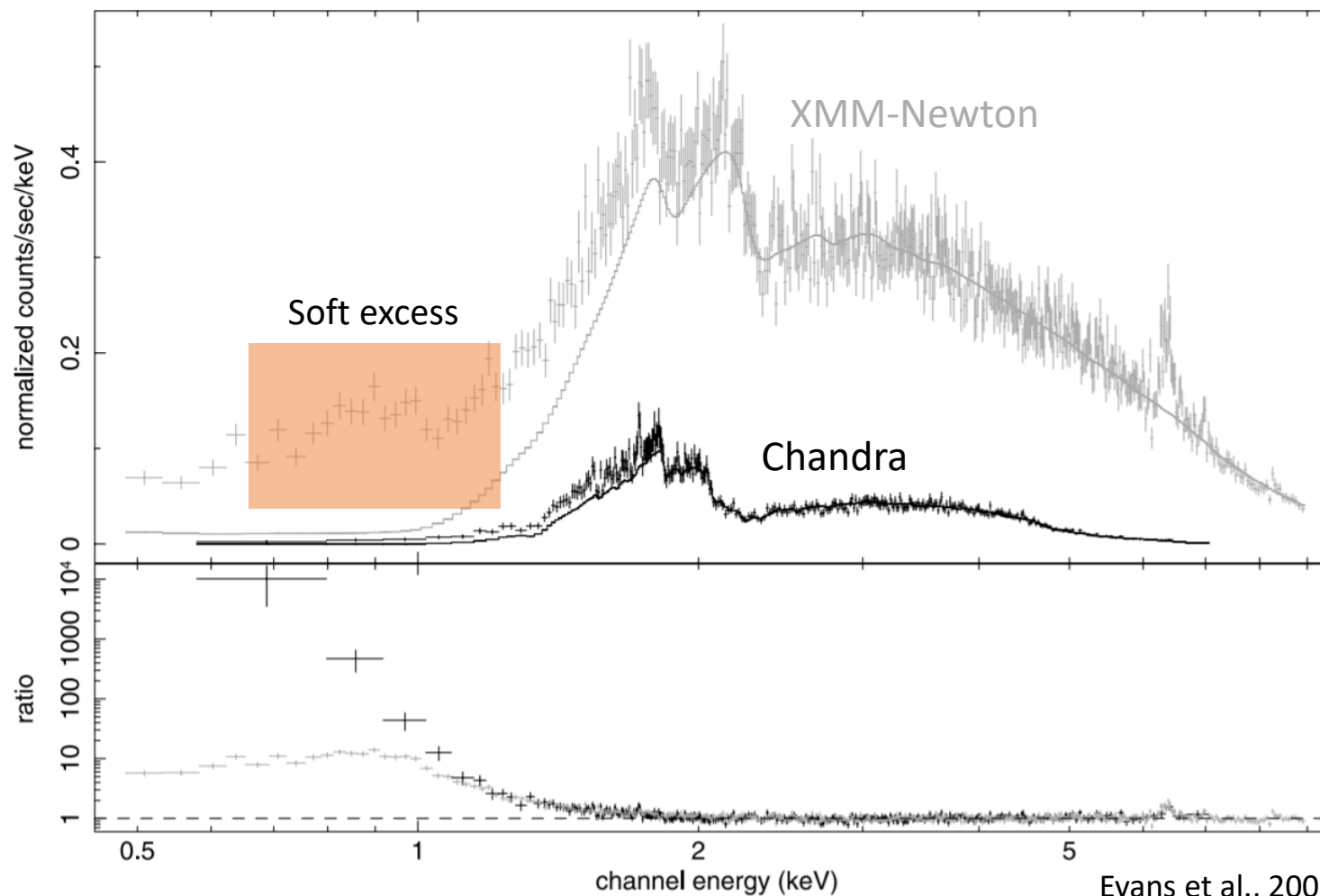
# Black body emission from the accretion disk?



Black body contributions  
from the accretion disk



# Black body emission from the accretion disk?



- Small soft excess in Chandra
- No reflection hump

↓  
NEGLIGIBLE DISK  
CONTRIBUTION

(Evans et al., 2007, Rivers et al., 2018)