Reconciling X-ray and IR observations of the Circinus Galaxy

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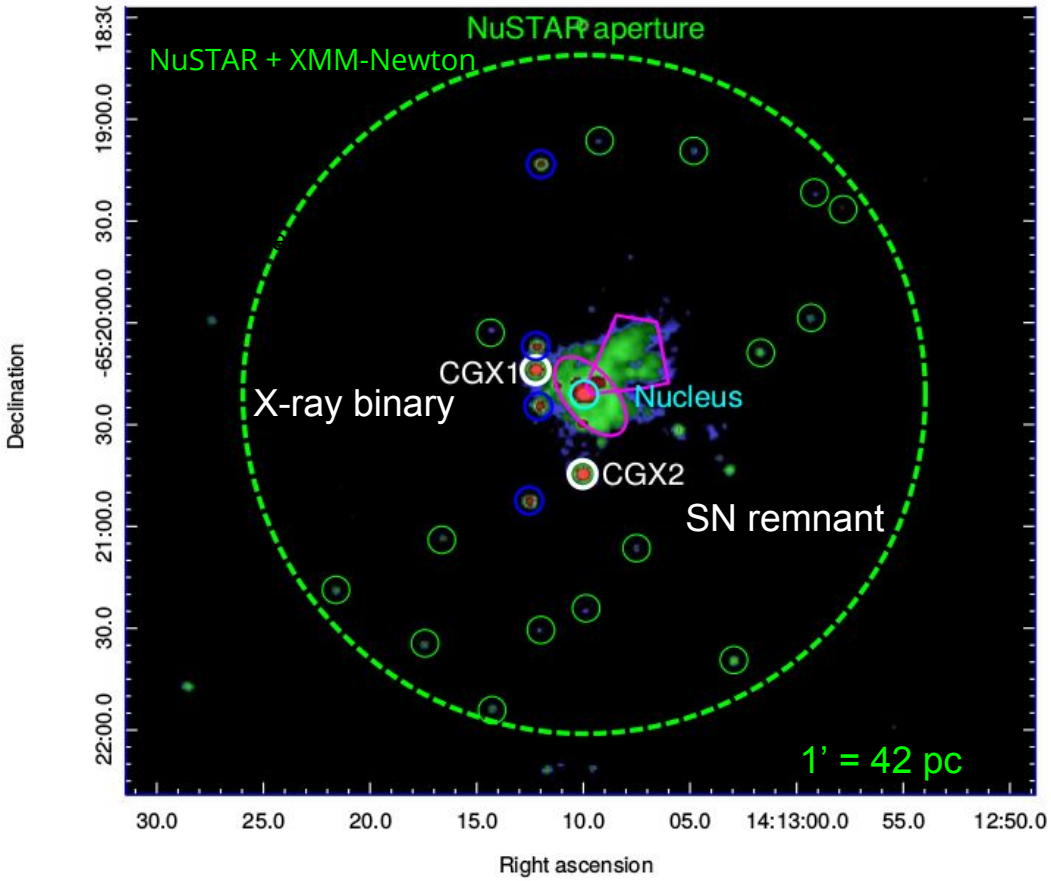
The Circinus Galaxy

- 2 components in the parsec scale:
  - Disk like component in the equatorial plane of the system
  - Large structure elongated in the polar direction
- Stalevski et al. (2017,subm) proposed for the dusty emitting regions:
  - A flared disk for the disk like component
  - A cone/hyperboloid shell for the elongated emission

- Seyfert 2 AGN
- 4.2 Mpc

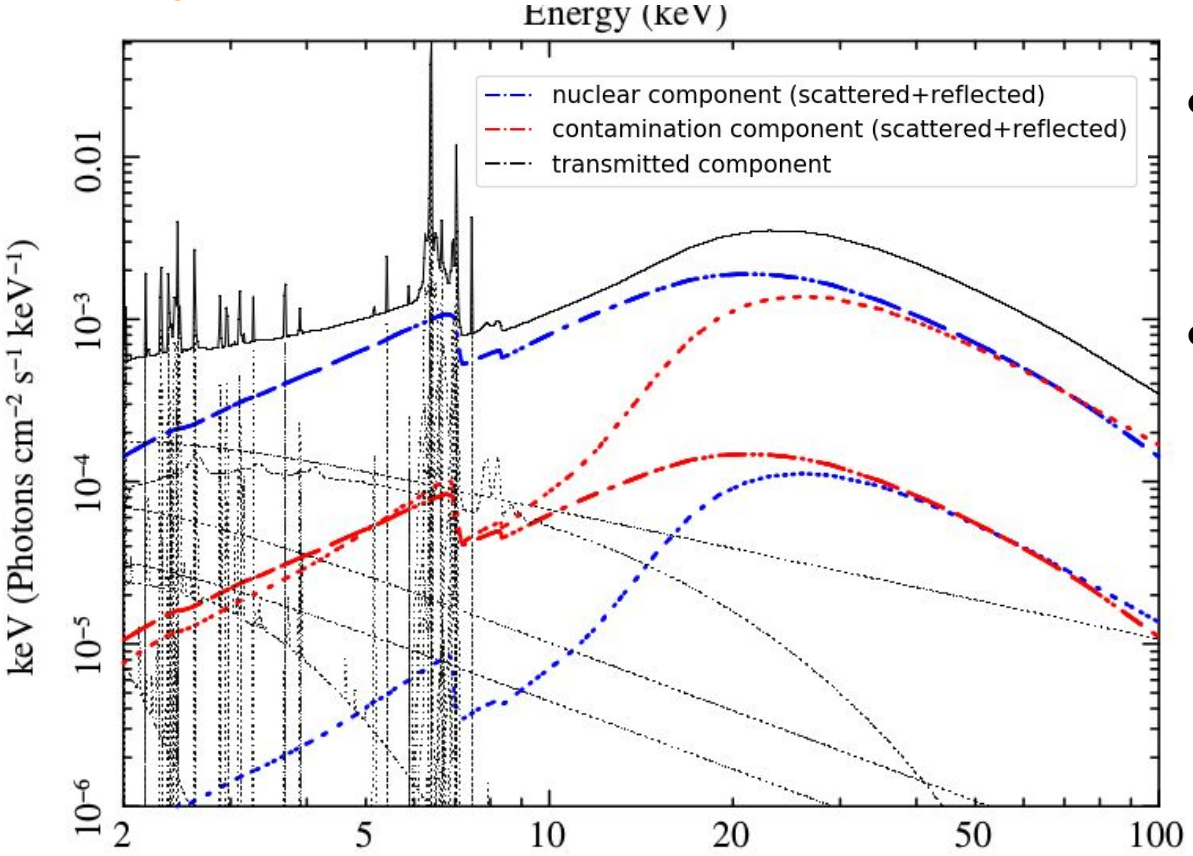
Chandra ACIS image of Circinus



The NuSTAR and XMM-Newton aperture is contaminated by point sources

Arévalo et. al (2014)

X-ray spectrum of Circinus

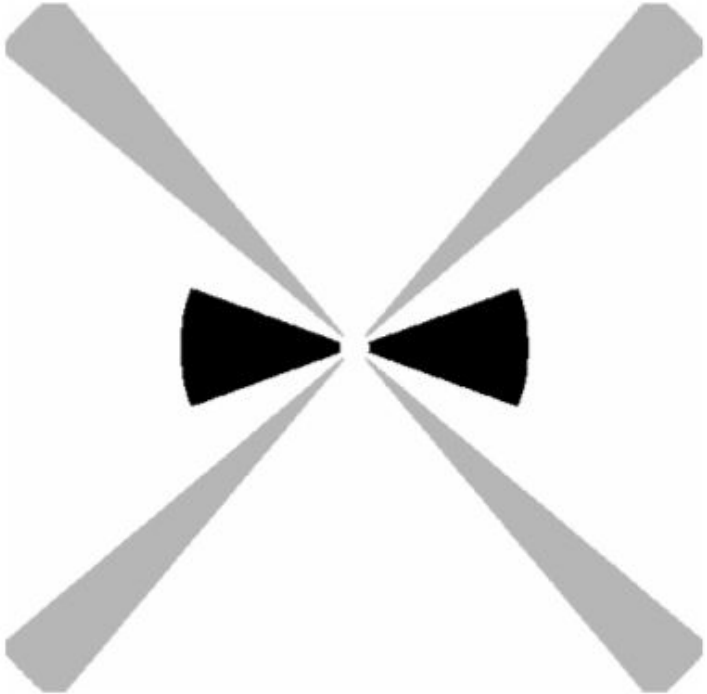


- The Circinus spectrum is dominated by scattered and reflected component
- The transmitted componer is almost negligible

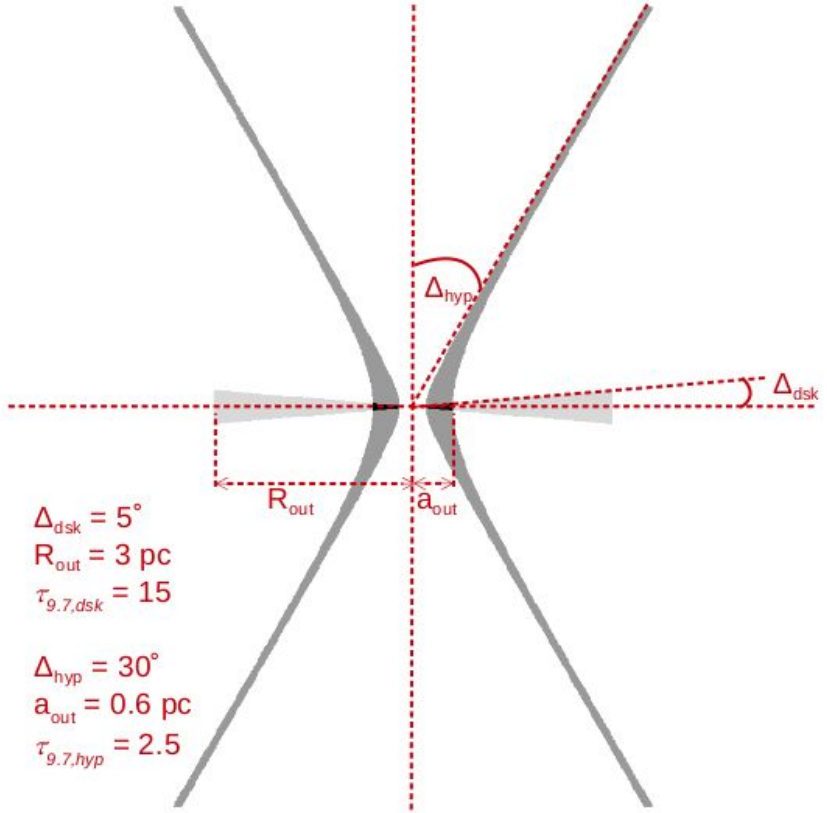
Arévalo et. al (2014)

Infrared Model

Cone shell model



Hyperboloid shell model



Stalevski et. al (2017, subm)

RefleX (S. Paltani & C. Ricci, 2017)

- RefleX is a ray-tracing code, which simulates the physical processes of X-ray photons through quasi-arbitraries geometries, using Montecarlo simulations

- 4 engines of RefleX:
  - X-ray generator
  - Objects
  - Propagator
  - Physical processes

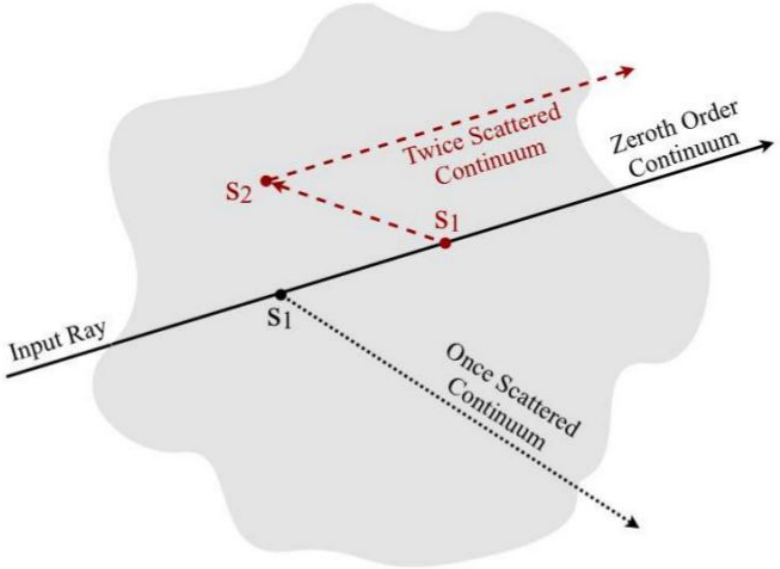
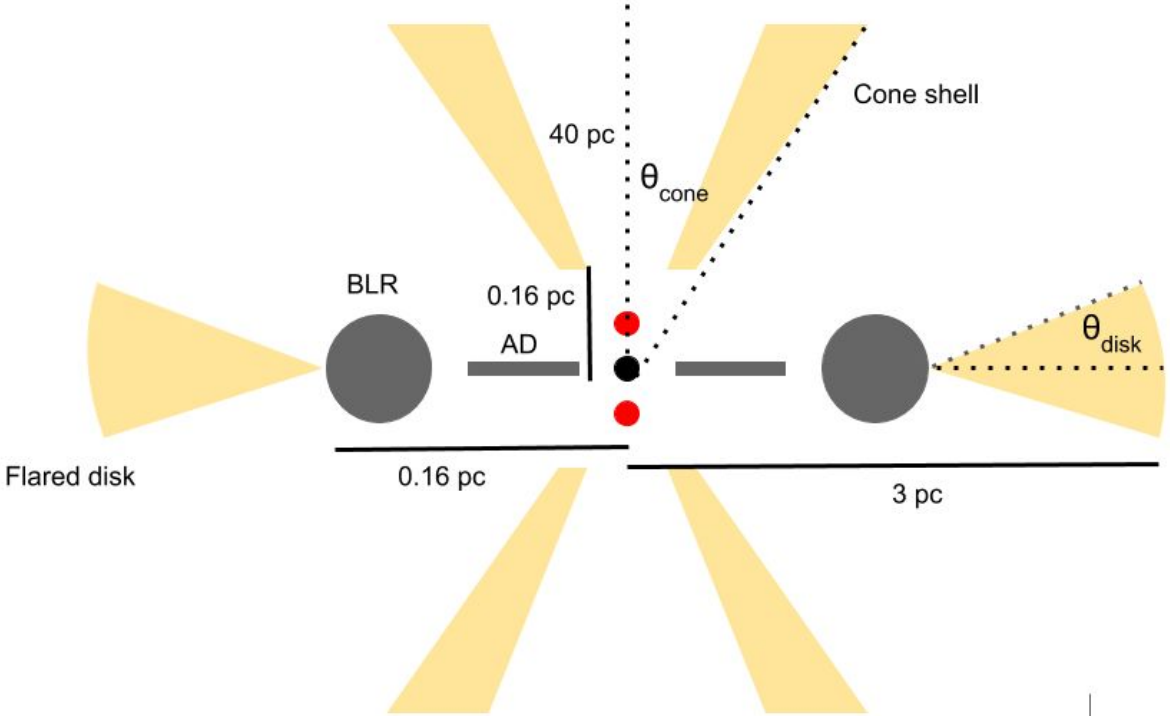


Image from MyTorus Manual, Tahir Yaqoob & Kendrah D. Murphy, 2010

Cone shell model



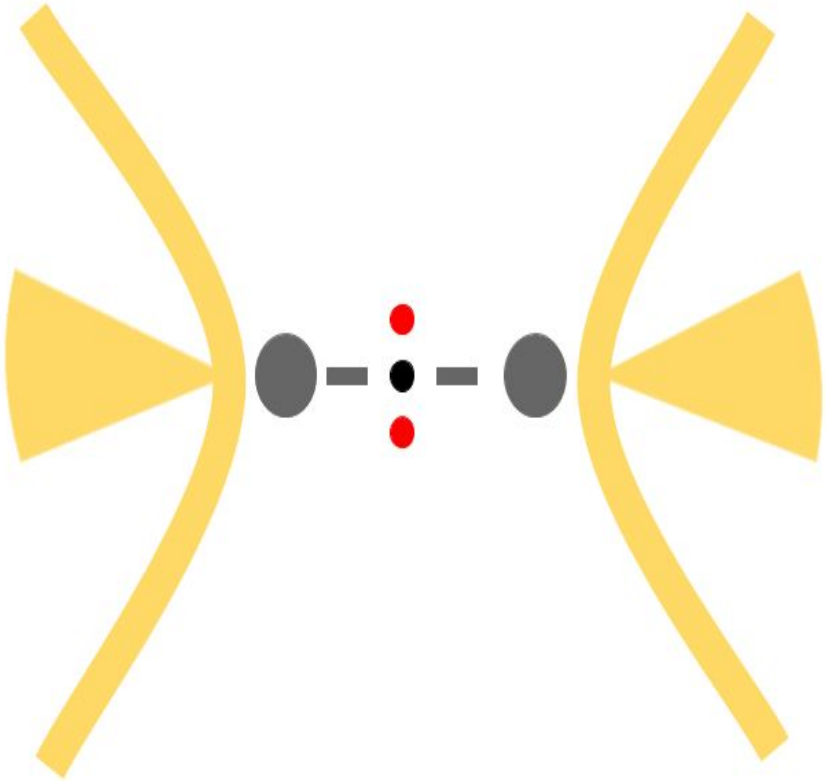
$N_{H,cone} = 10^{22}$ cm^{-2}

$N_{H,disk} = 3x10^{24}$ cm^{-2}

$\theta_{disk} = 5°$

$\theta_{cone} = 40°$

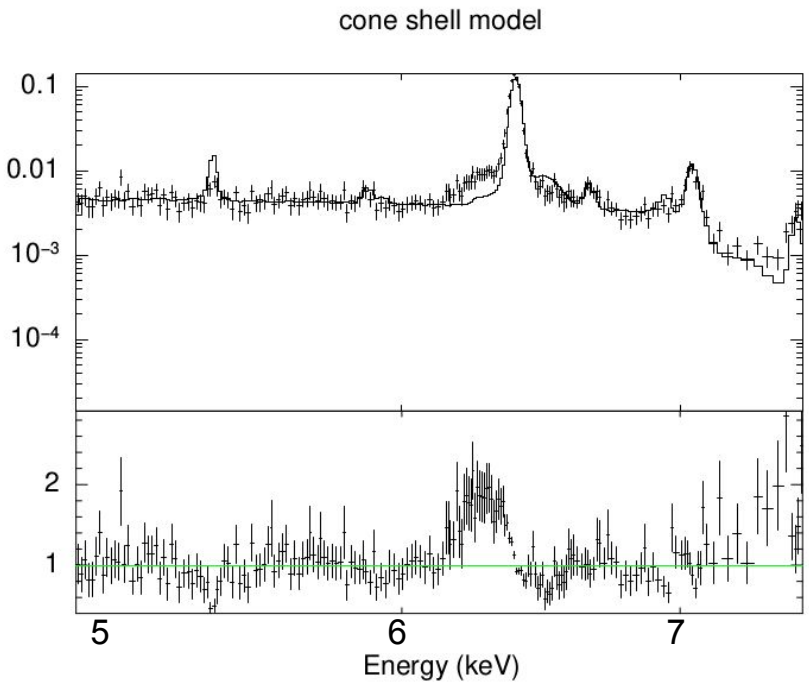
Hyperboloid shell model

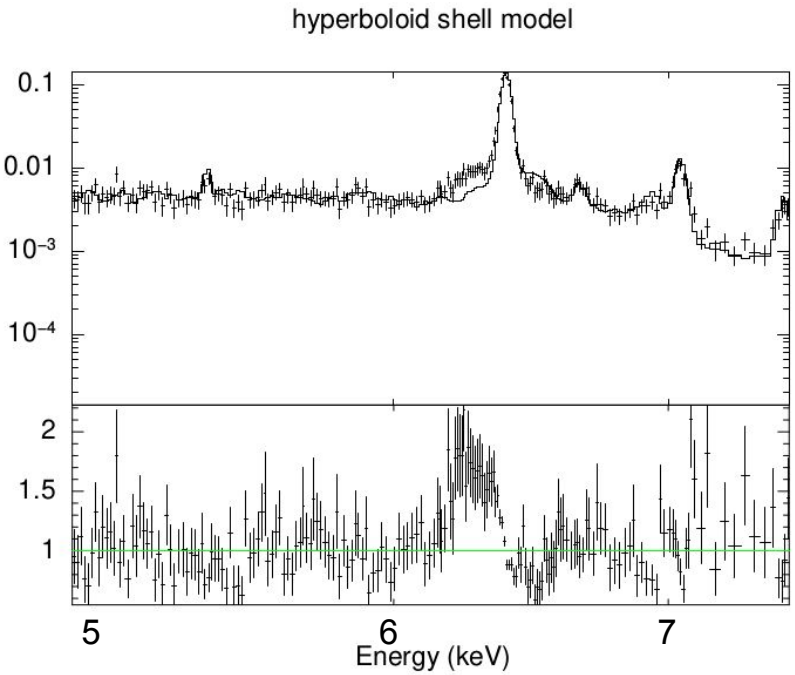


Differences with the cone model:

- $N_{H,hyperboloid} = 6x10^{23}\ cm^{-2}$
- $\theta_{cone} = 30°$
- Walls of the hyperboloid in the plane of the disk

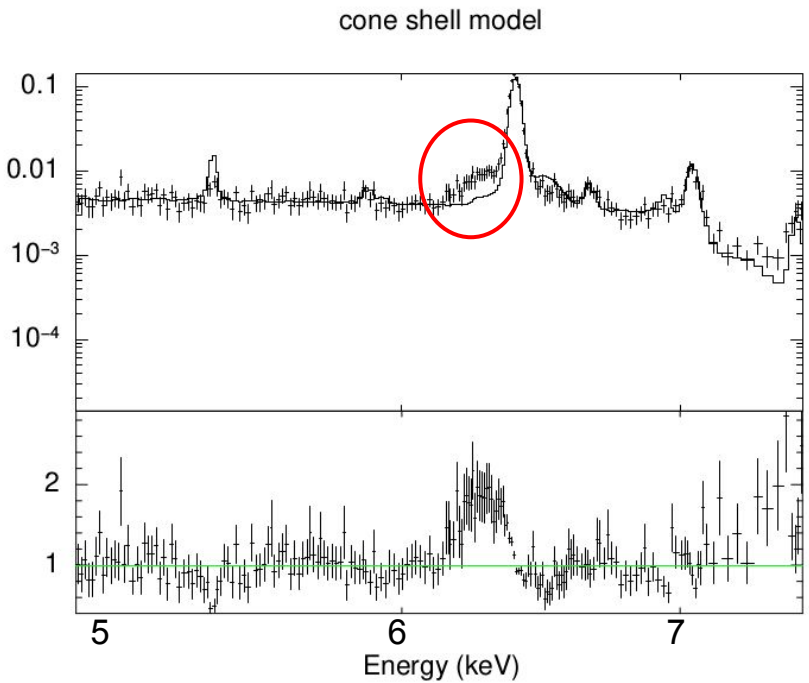
Chandra - HEG

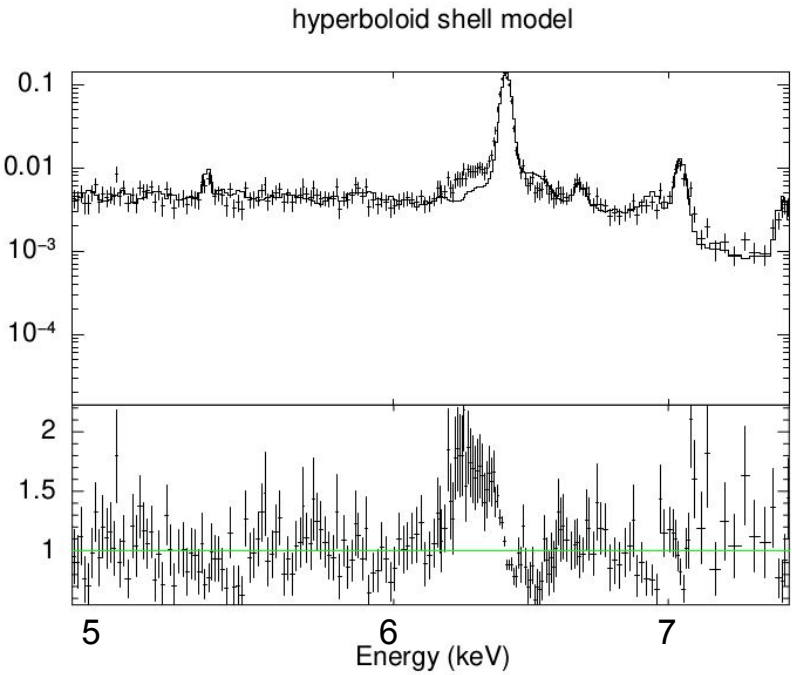




The Compton Shoulder of the Iron Kα line is not reproduced by any model

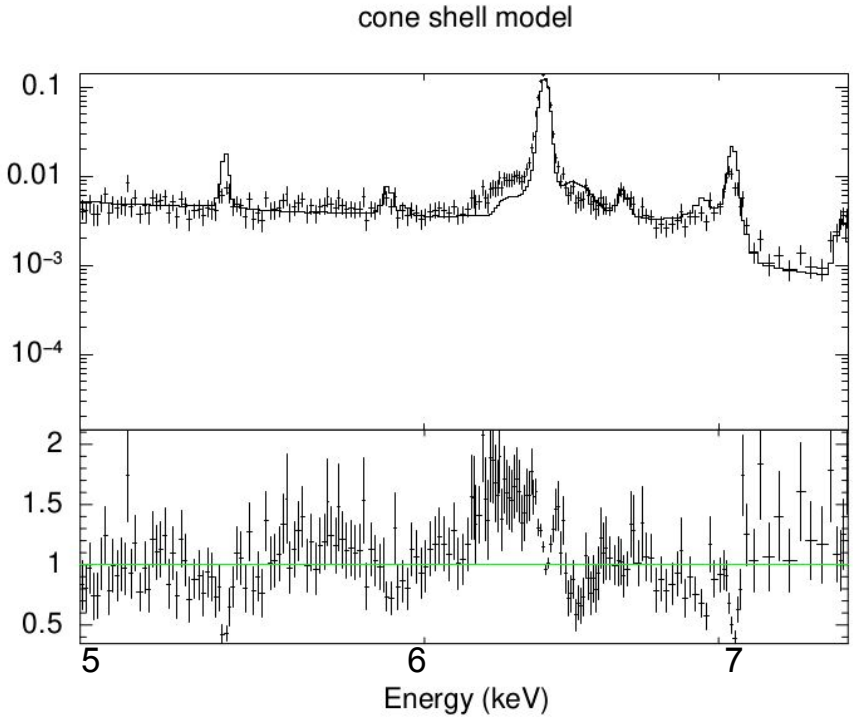
Chandra - HEG





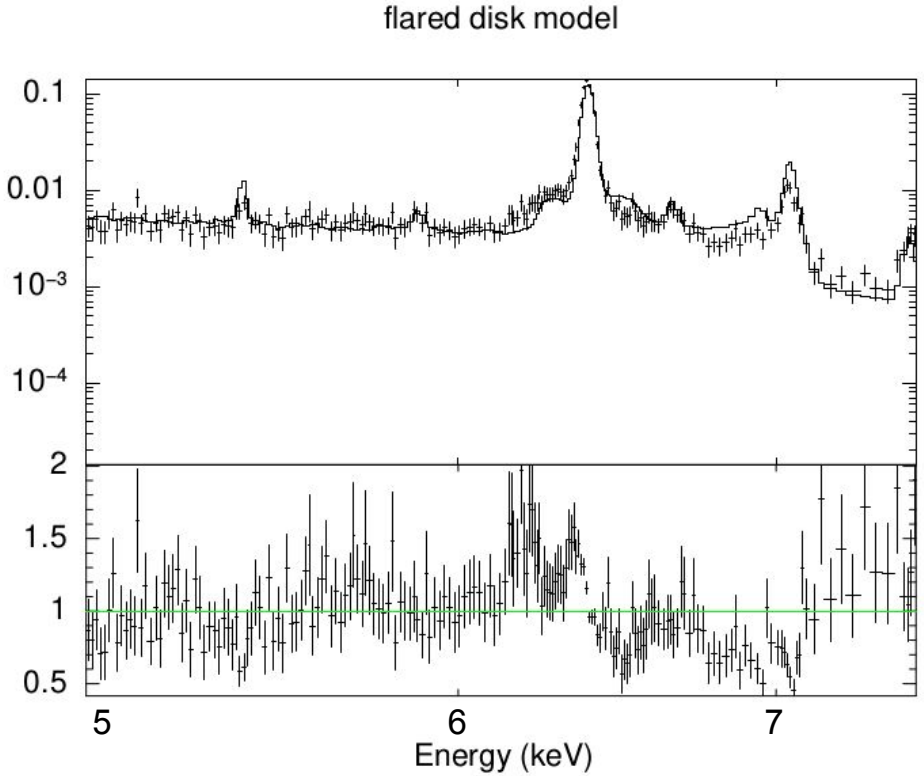
The Compton Shoulder of the Iron Kα line is not reproduced by any model

Chandra: cone shell model with θ_{disk}=30°



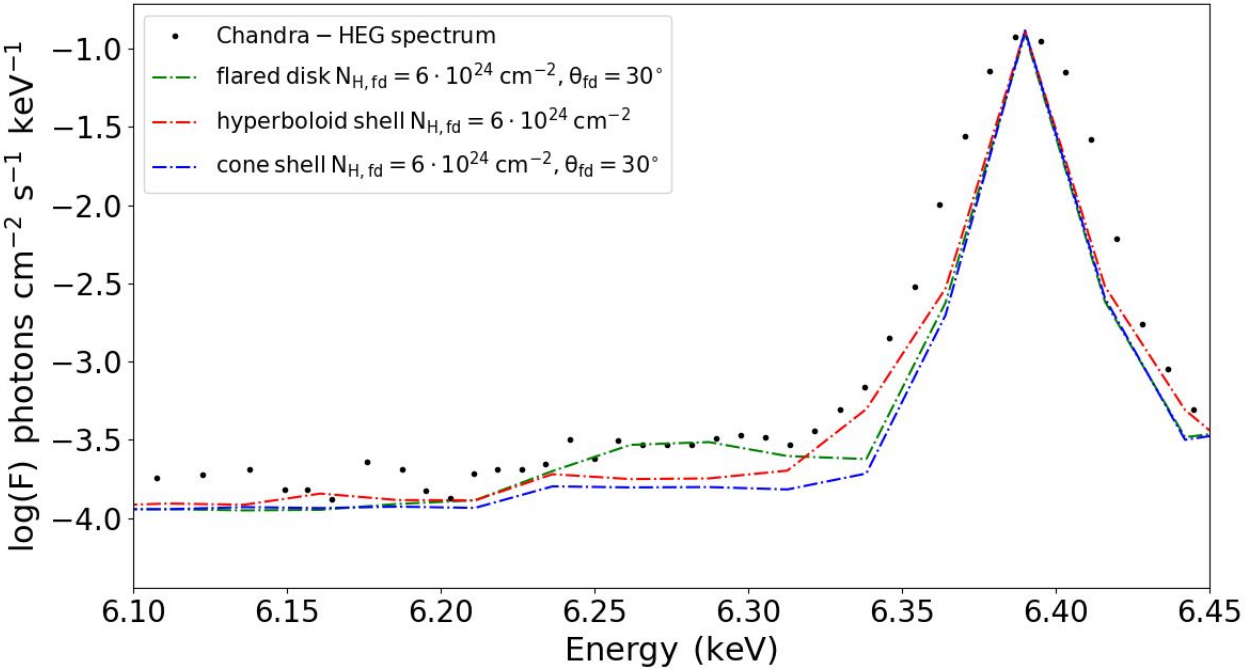
A higher covering factor of the flared disk does not improve the results

Chandra: flared-disk with $N_H=6x10^{24}$ cm^{-2} and $\theta_{disk}=30°$



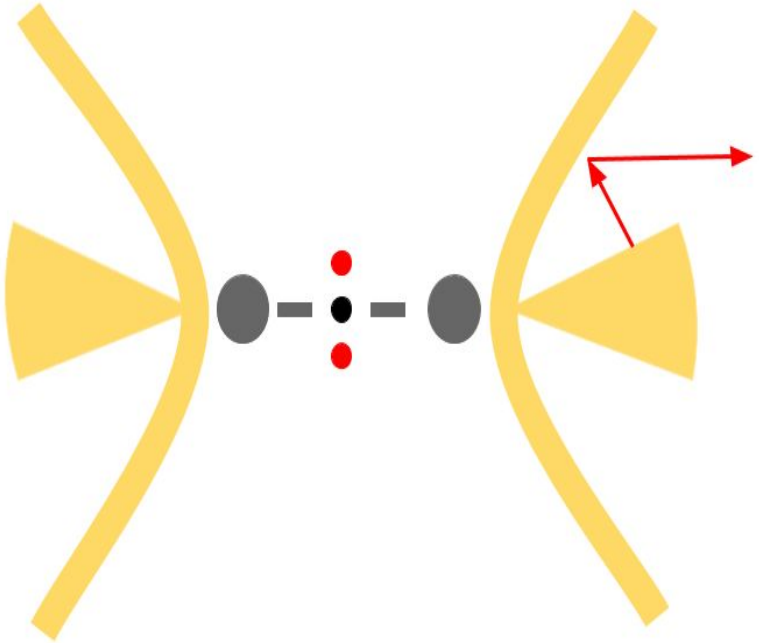
Without a cone/hyperboloid shell the Compton shoulder is better reproduced

Compton Shoulder of the Iron Kα line: comparison between the models



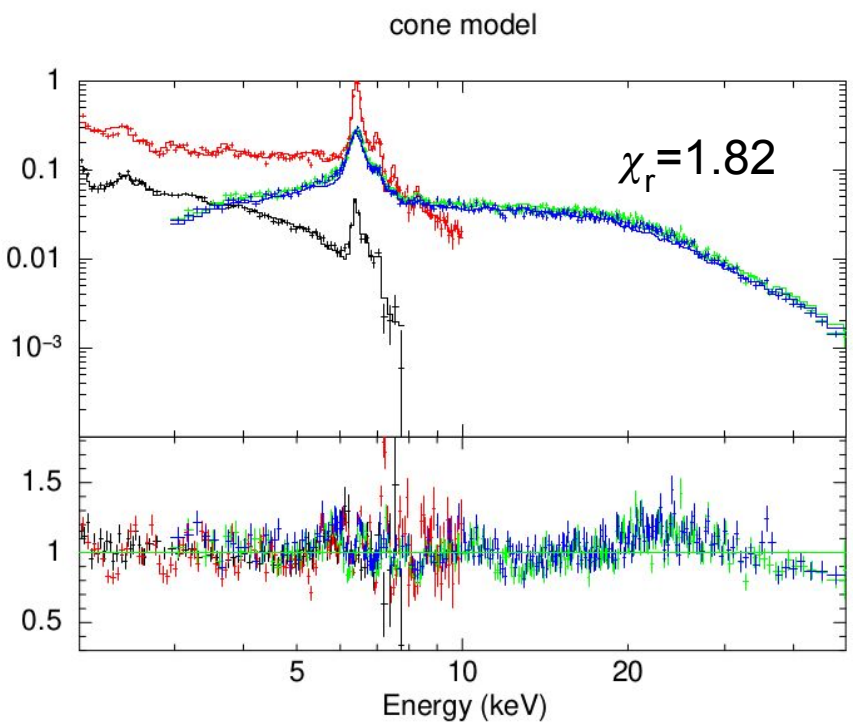
The flared disk model produces more flux in the Compton shoulder than the hyperboloid/cone shell model

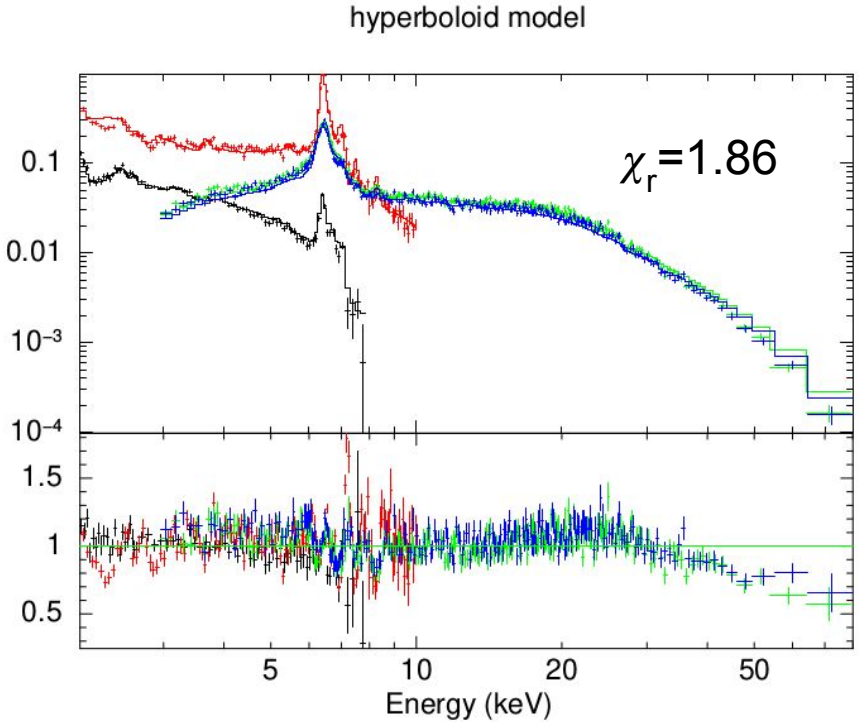
Why the hyperboloid/cone models produce less photons in the Compton shoulder?



- As the cone/hyperboloid is Compton-thin, this only produces Iron Kα line photons, but it does not produce Compton shoulder photons
- Maybe the hyperboloid/cone shell scatters the Compton shoulder photons that come from the flared disk

NuSTAR + XMM-Newton fit (N_H=3x10^{24})

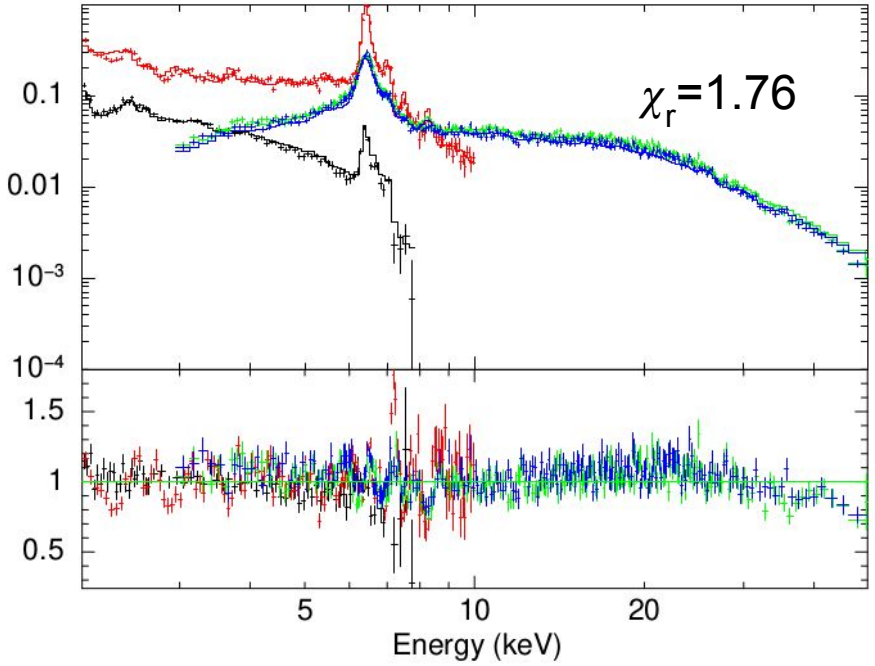




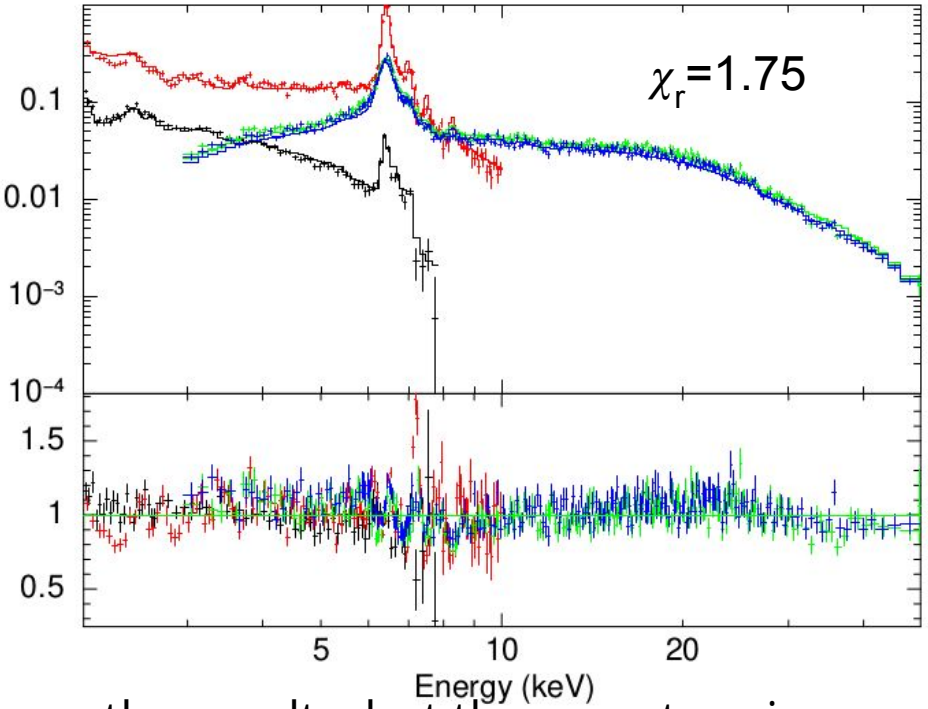
The results are quite similar, but the cone shell model produces more residuals in the curvature of the spectrum

NuSTAR + XMM-Newton fit (N_H=6x10^{24})

cone model



hyperboloid model



The increase in the column density improve the results, but the curvature is still not well reproduced

Next steps

- A clumpy distribution?
- Warped masers disk
- A higher column density
  - $N_{H,disk} > 10^{25}$ cm^{-2}
  - $N_{H,cone/hyperboloid} > 10^{24}$ cm^{-2}
- A table model with free parameters

Summary

- The infrared model by itself cannot reproduce the X-ray spectrum of Circinus
- Neither the hyperboloid nor the cone shell models can reproduce the Compton Shoulder of the Iron Kα line. Two options:
  - The cone/hyperboloid scatter the photons of the Compton Shoulder
  - The thin column density of the cone/hyperboloid shell produce more photons in the Iron Kα line, but it does not produce Compton Shoulder's photon
- About the curvature of the spectrum:
  - There is not a significant change between the cone and hyperboloid shell models
  - The increment in the column density improves the results, but still we cannot reproduce the whole spectrum
- **Next step**: a table model with free parameters