Nuclear obscuration in AGN: an X-ray perspective

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1993

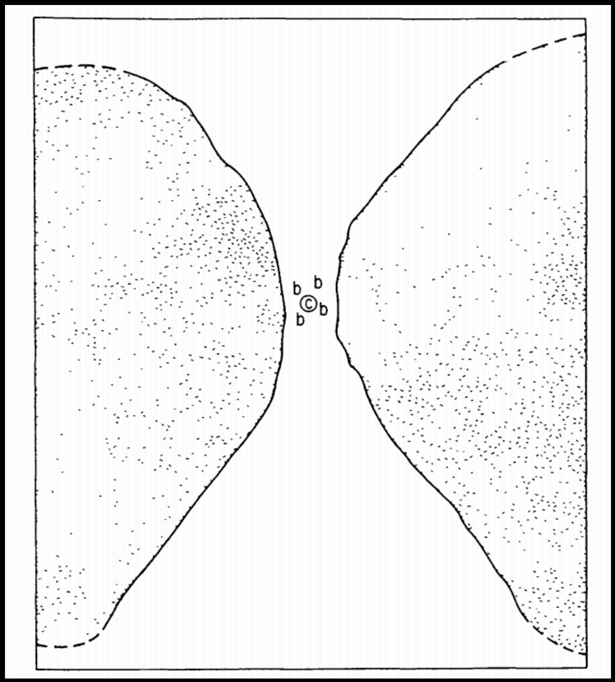
1993

2018

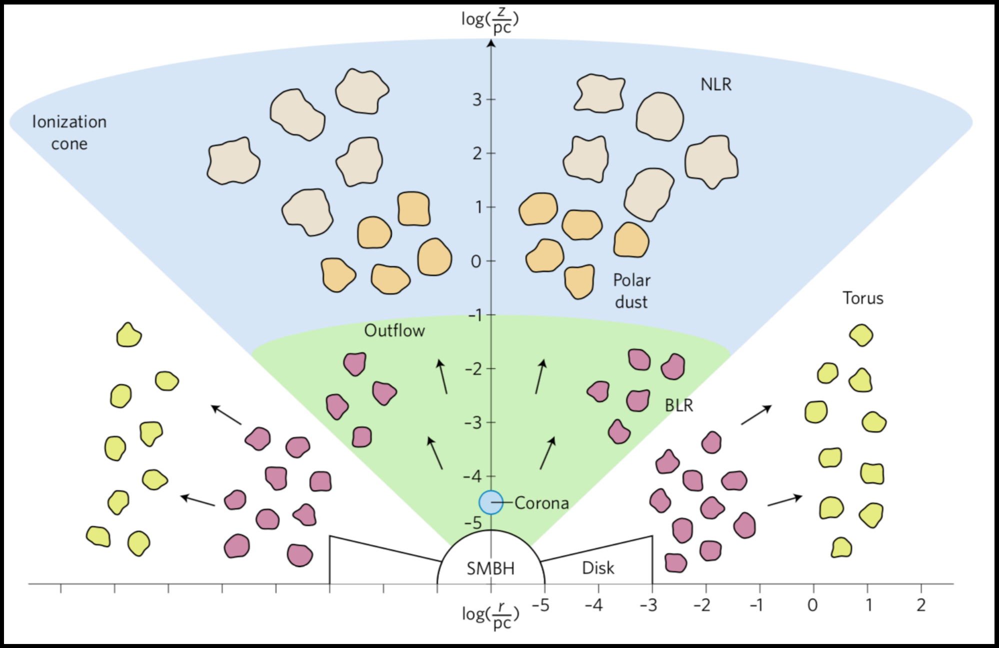
Cake by P. Boorman (see https://www.southampton.ac.uk/~pgb2g11/baking.html)

1993

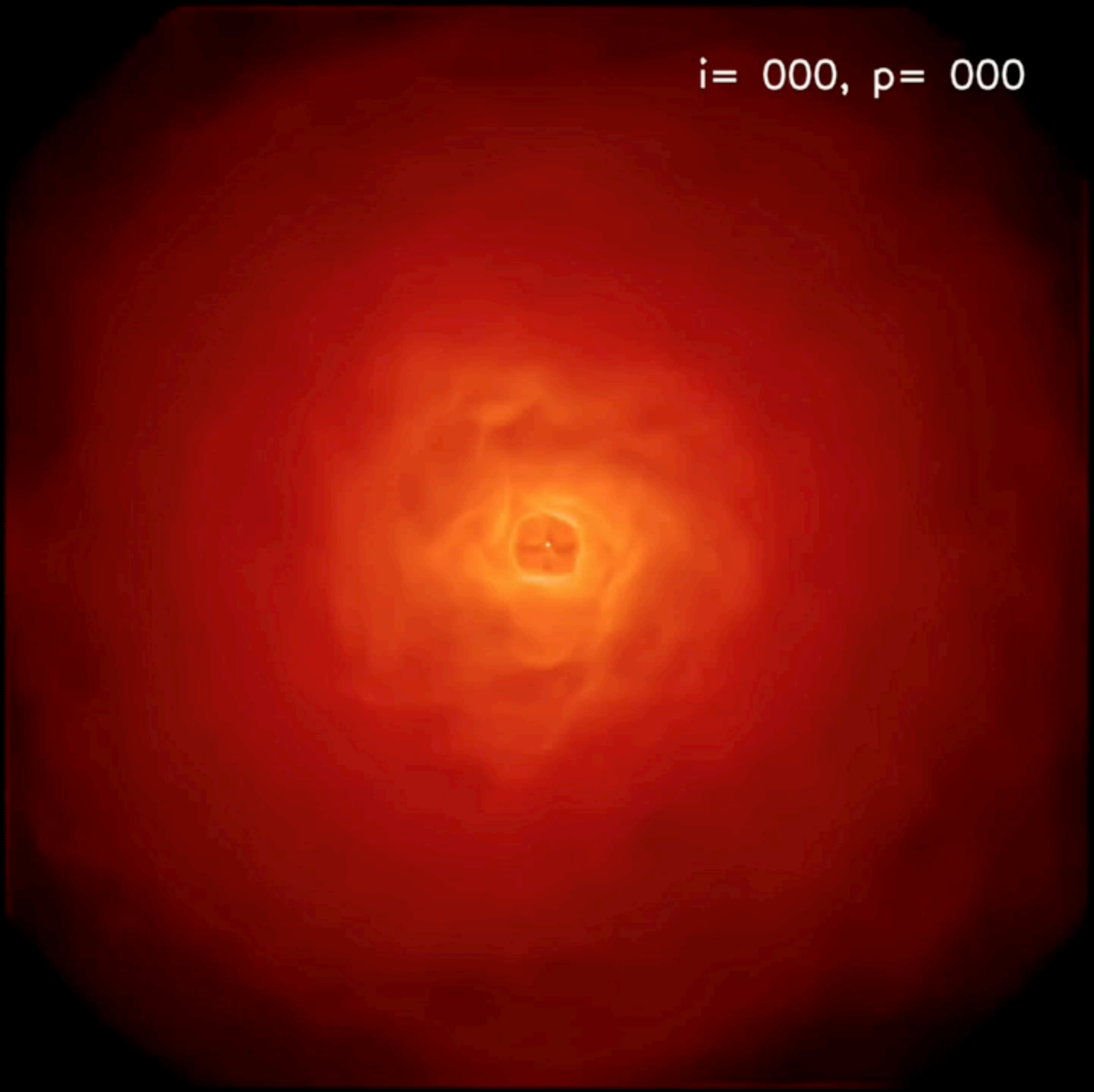
2018



Antonucci (1993)

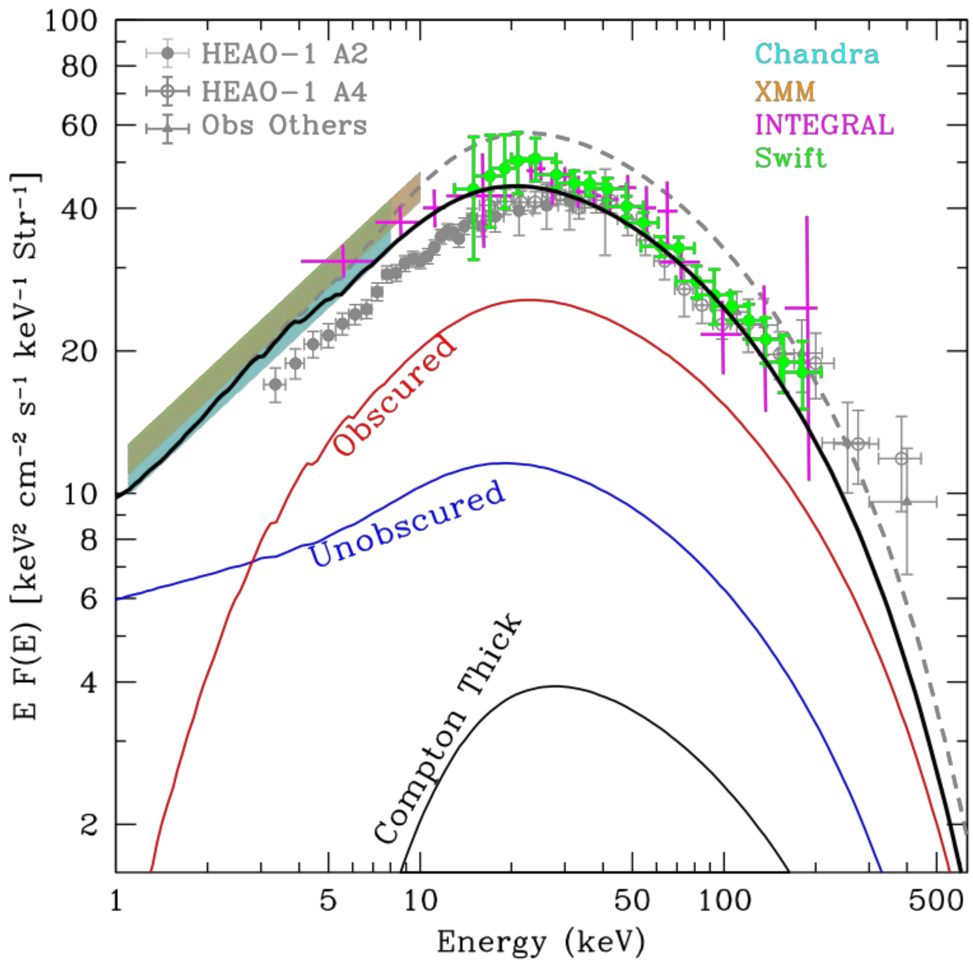


Ramos Almeida & Ricci (2017)



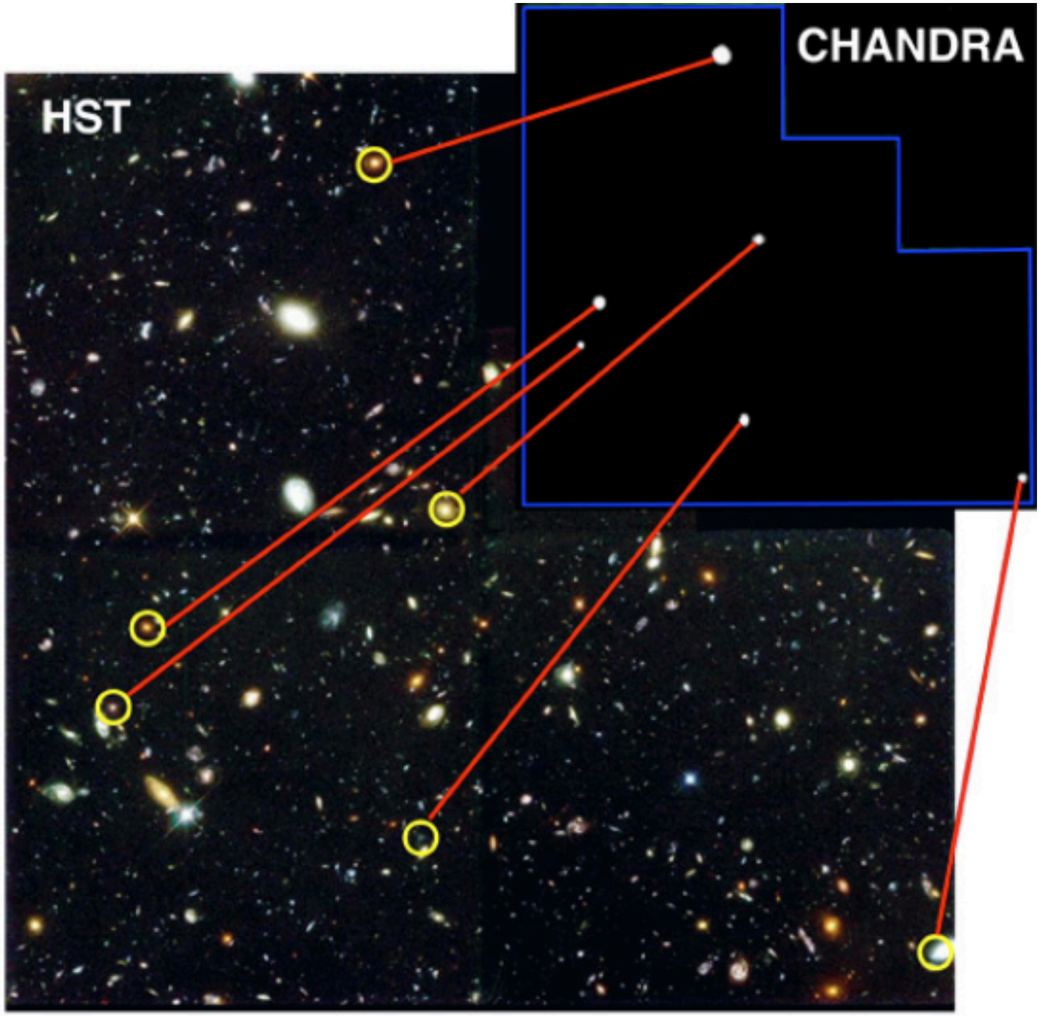
Wada et al. (2016); See talks by K. Wada, D. Williamson, C.-H. Chan, A. Dorodnitsyn, D. Angles-Alcazar

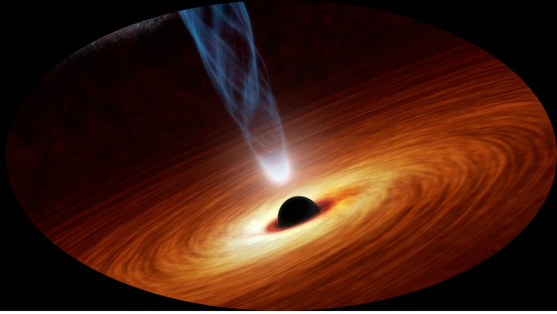
Obscured accretion



Treister et al. (2009); see also Tasnim Ananna et al. (2018), Ueda et al. (2014), Akylas et al. (2012), Draper & Ballantyne (2010), Gilli et al. (2007)

X-ray emission of AGN

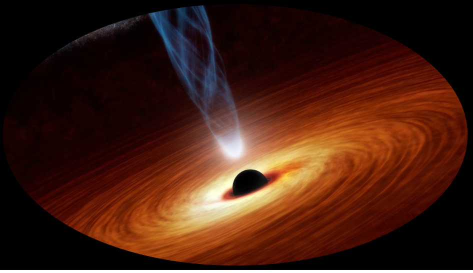


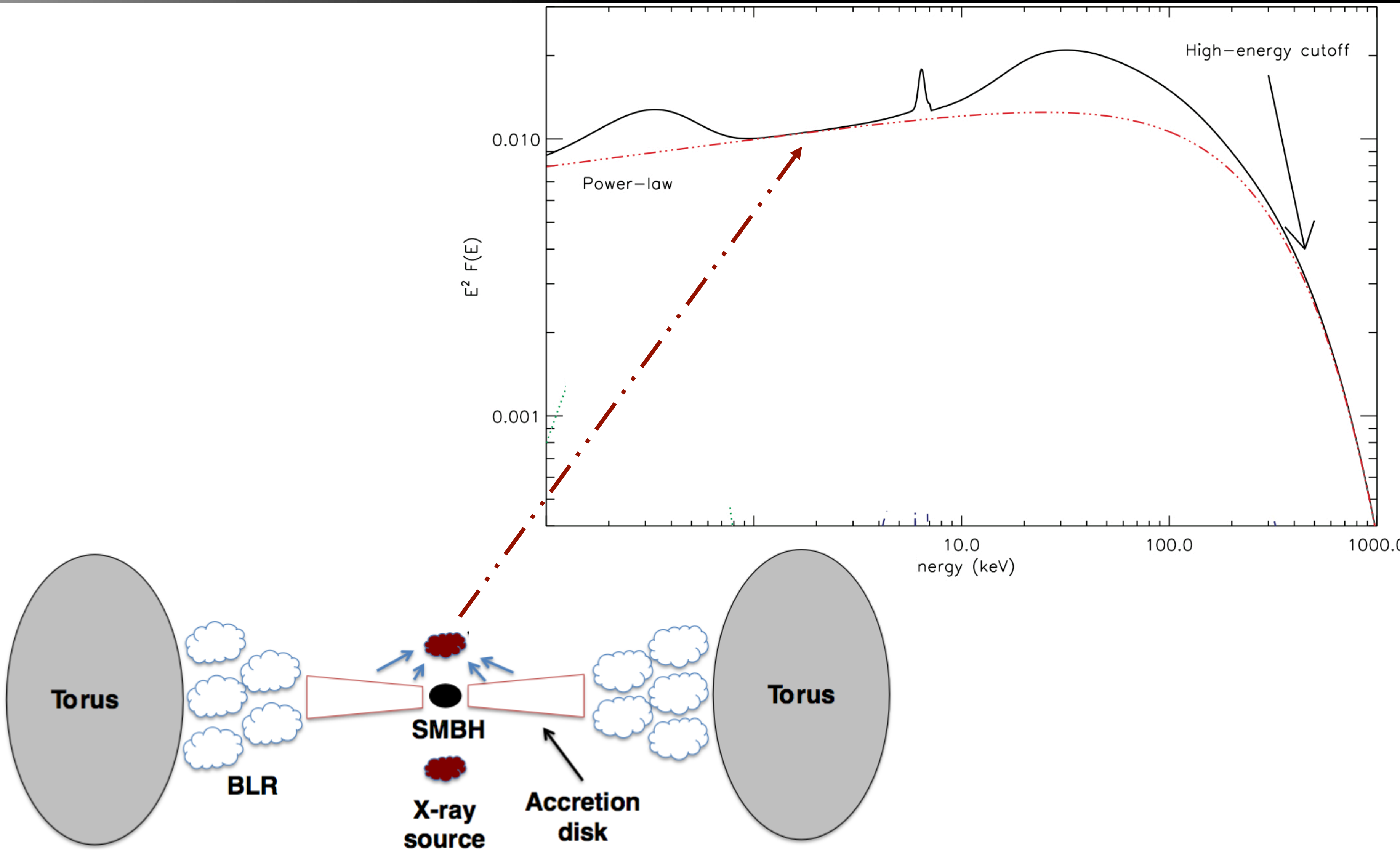


Hubble deep-field north

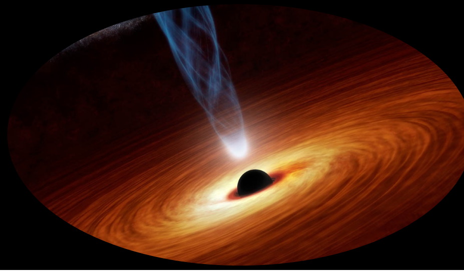
Credit: Optical: NASA/HST, X-ray: NASA/PSU

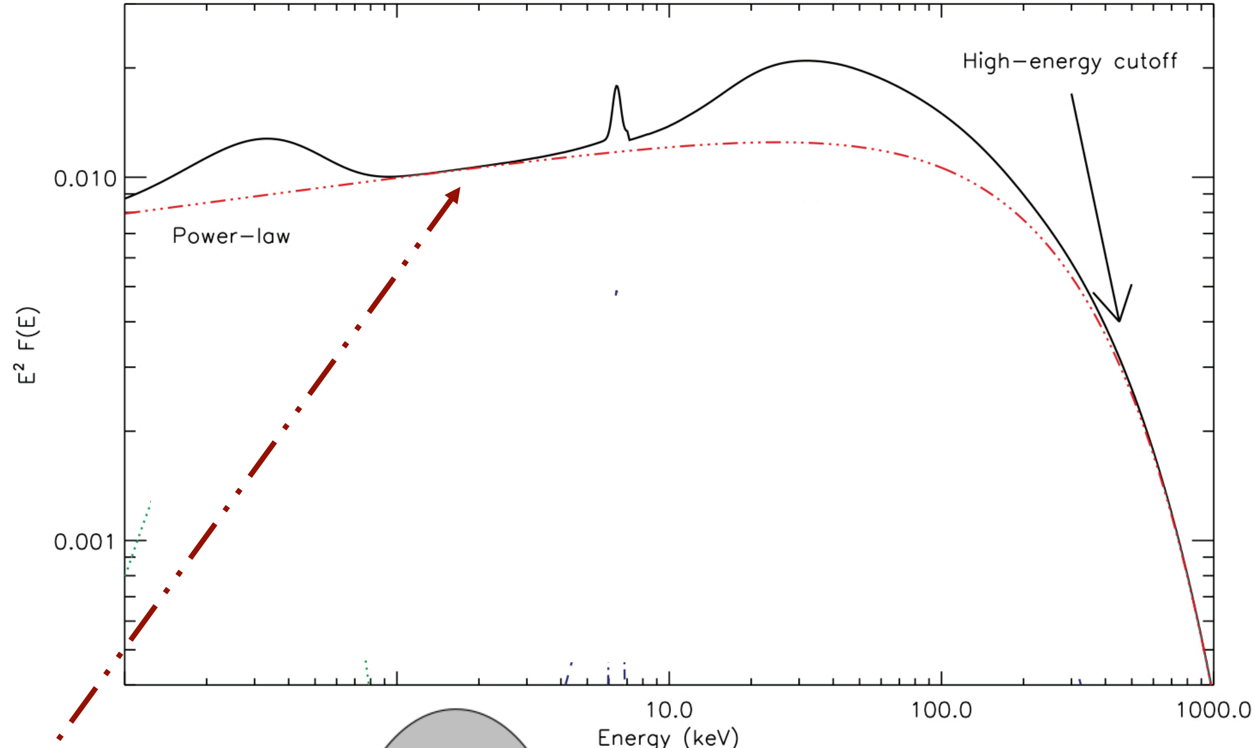
X-ray spectra of AGN

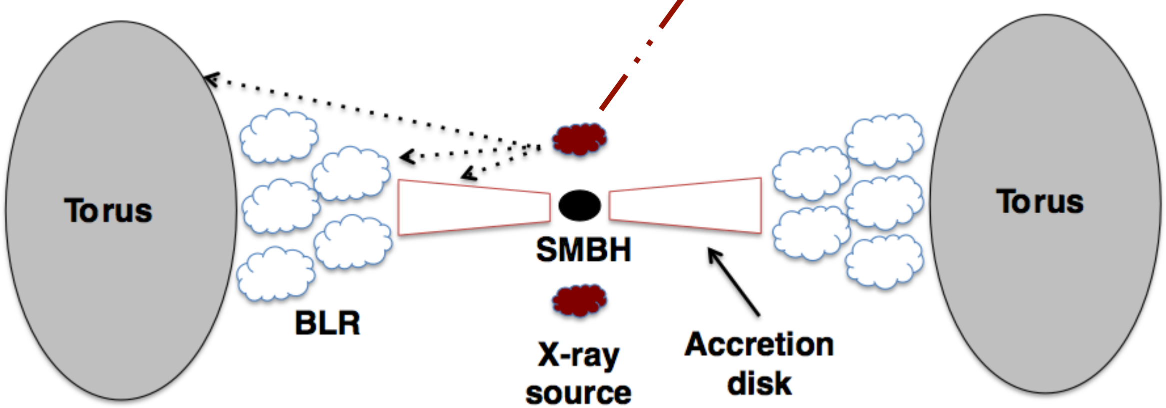




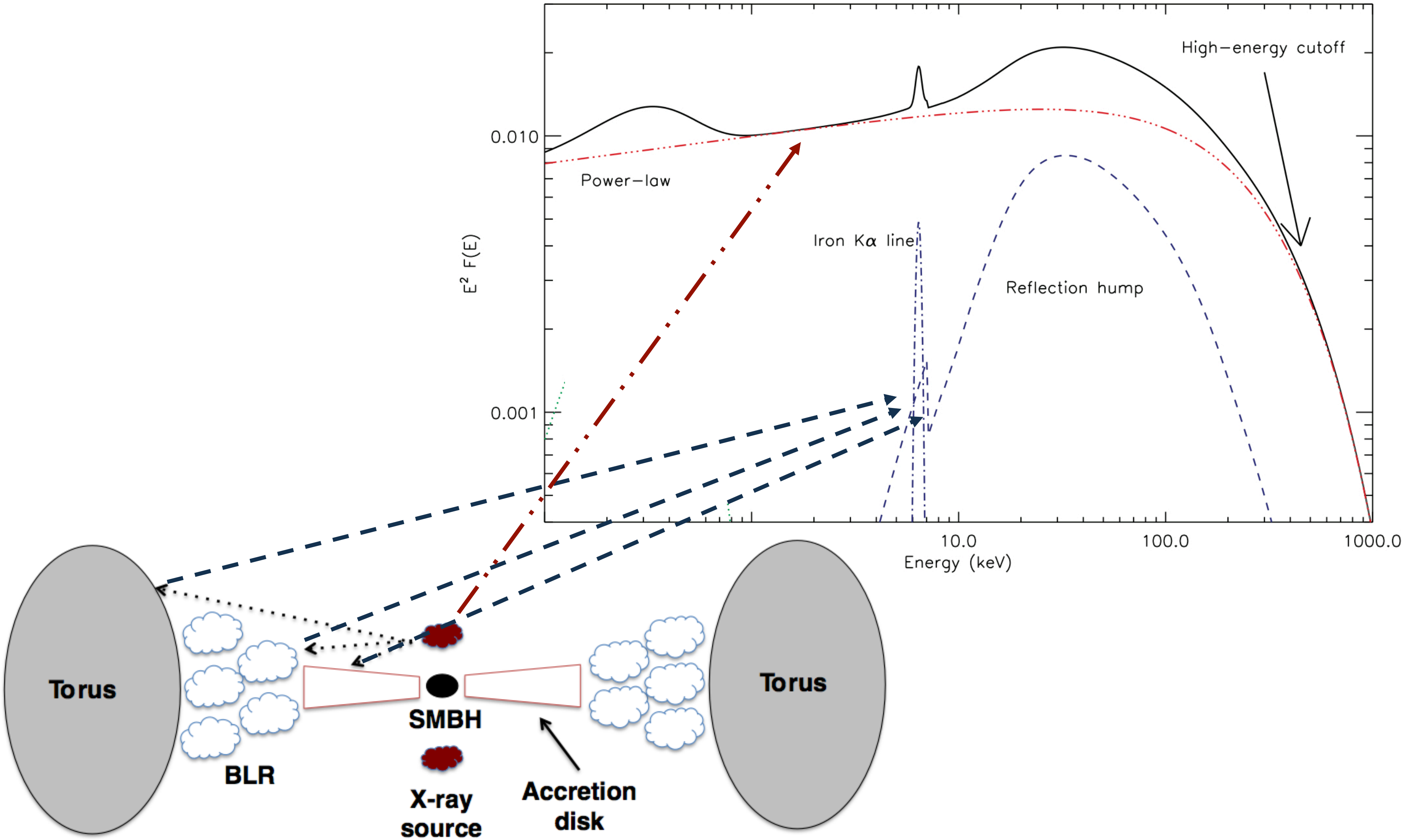
X-ray spectra of AGN



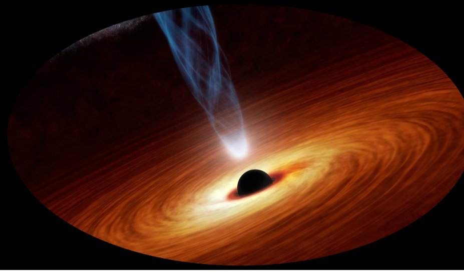


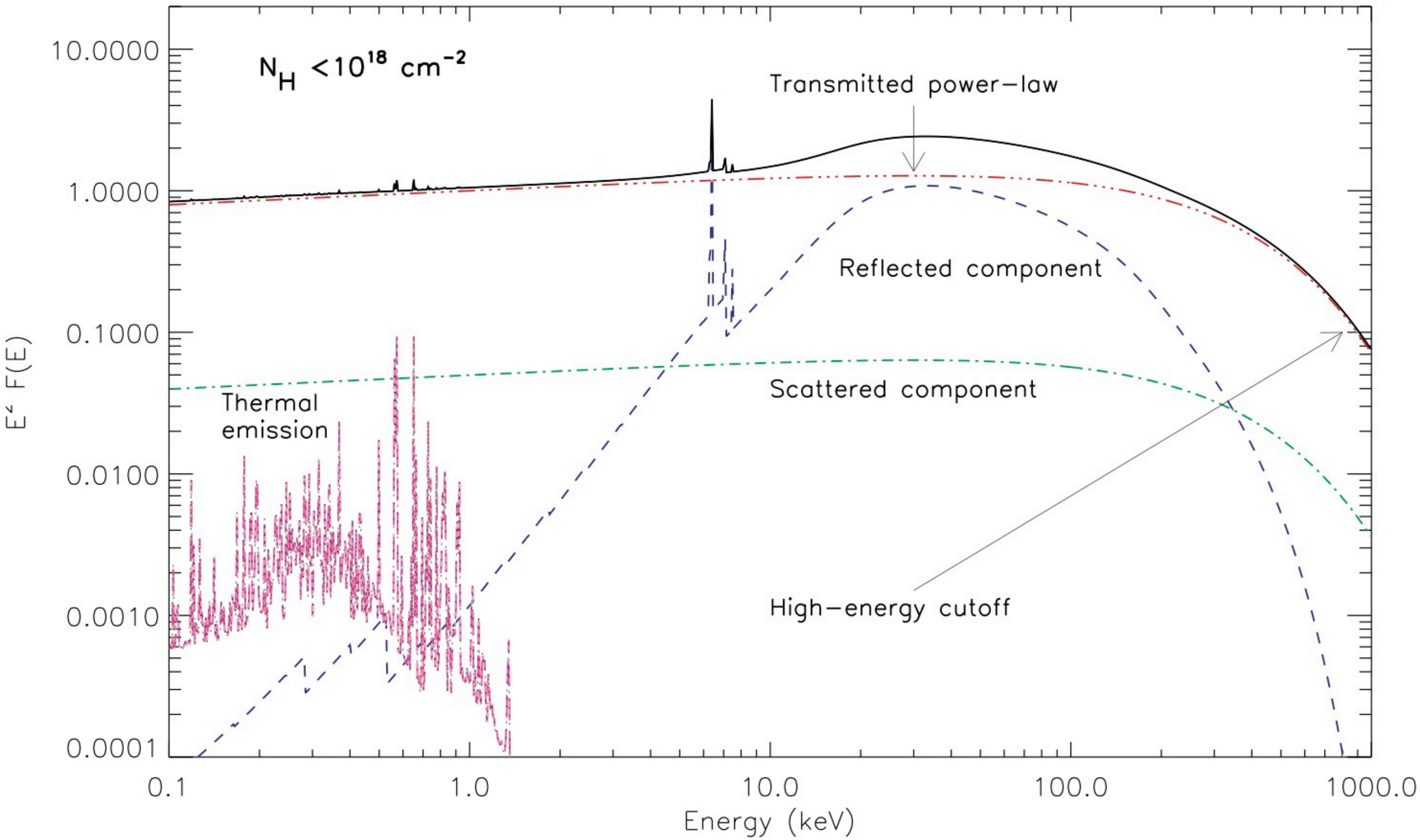


X-ray spectra of AGN

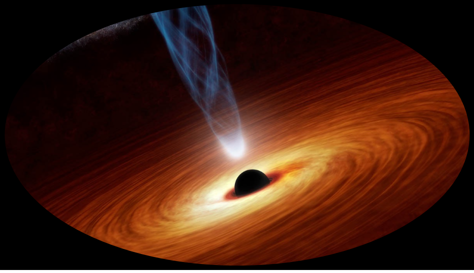


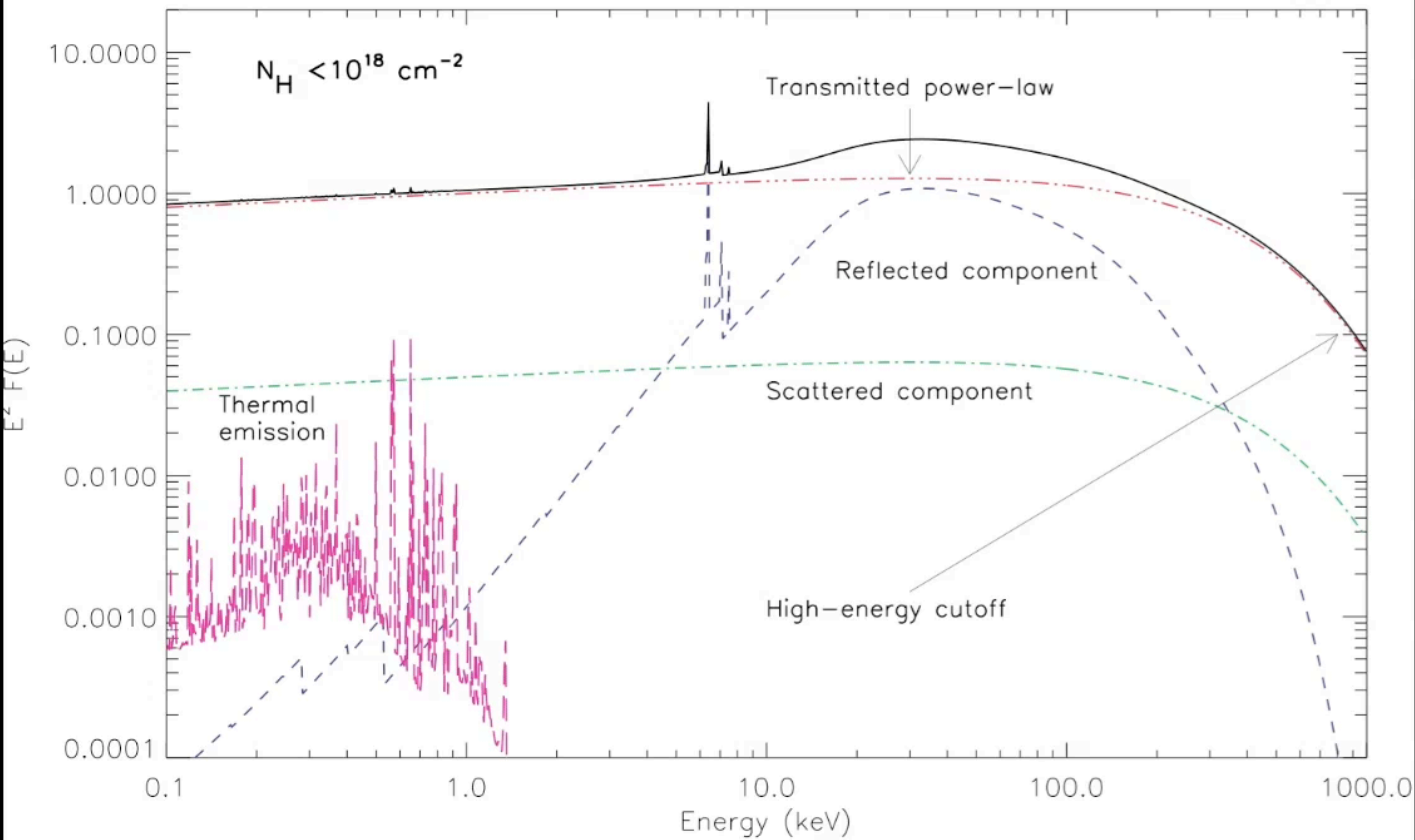
Absorption in the X-rays

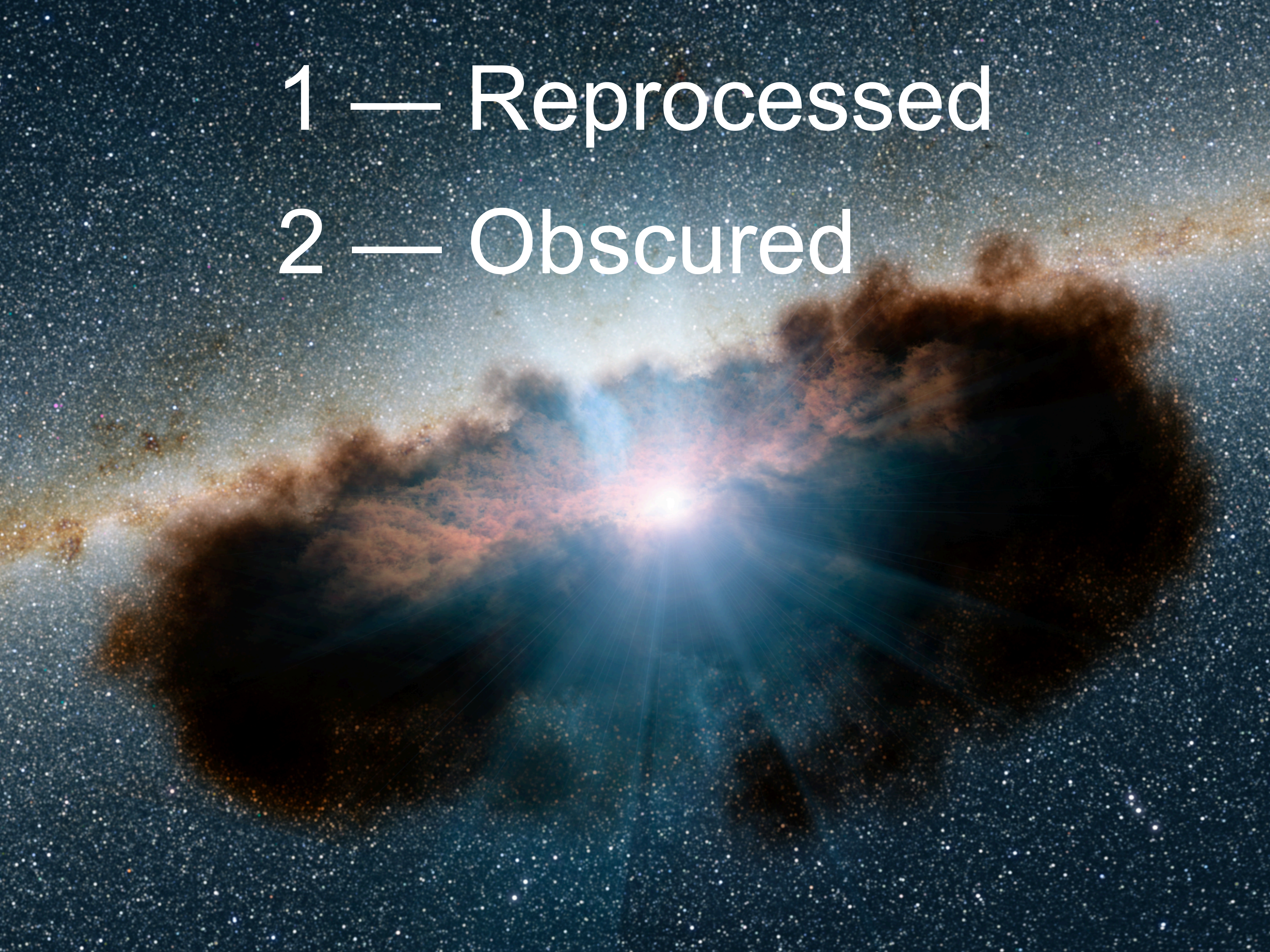




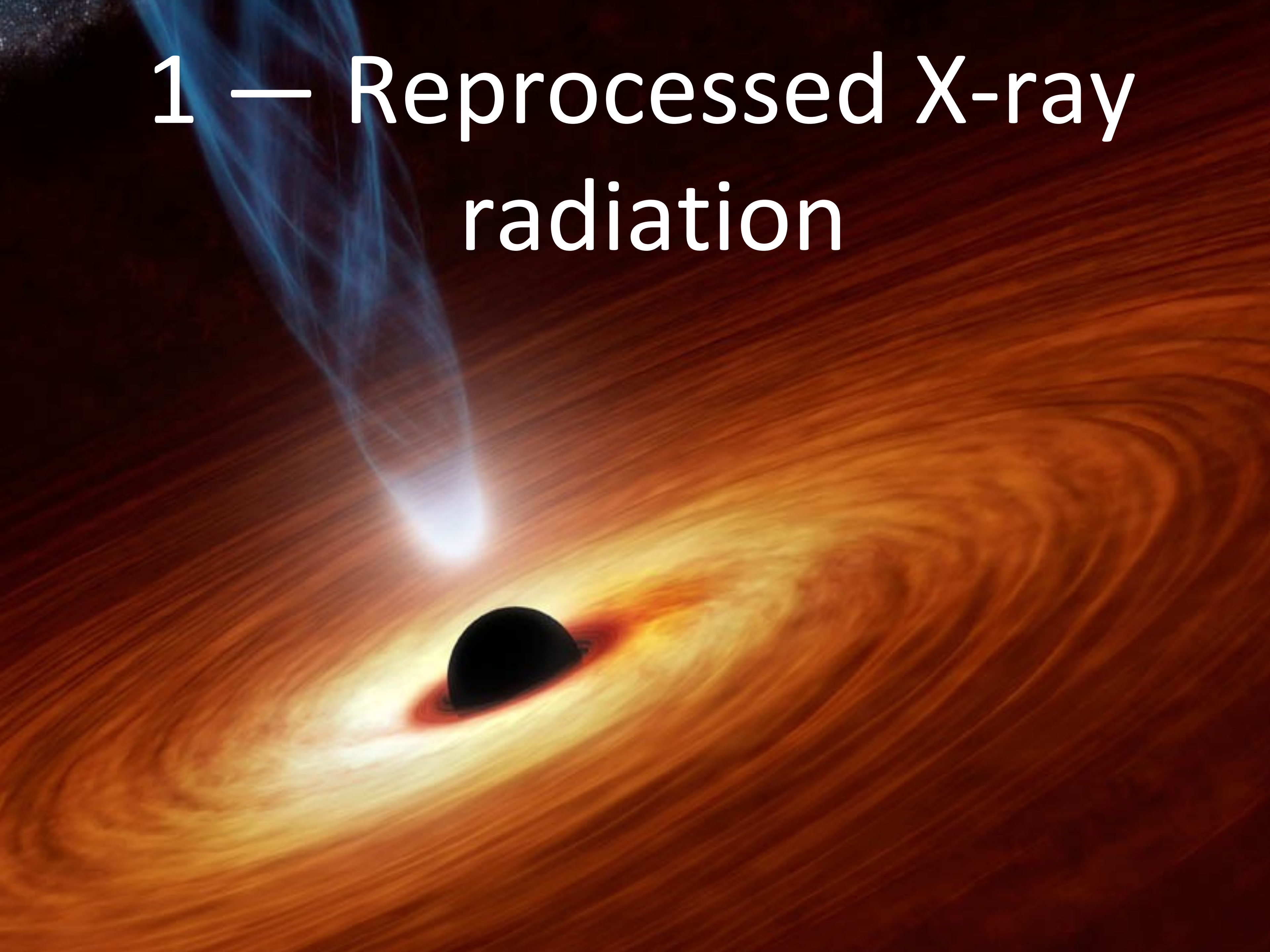
Absorption in the X-rays



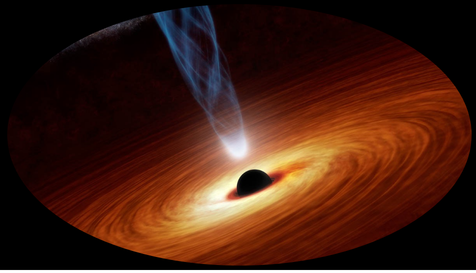


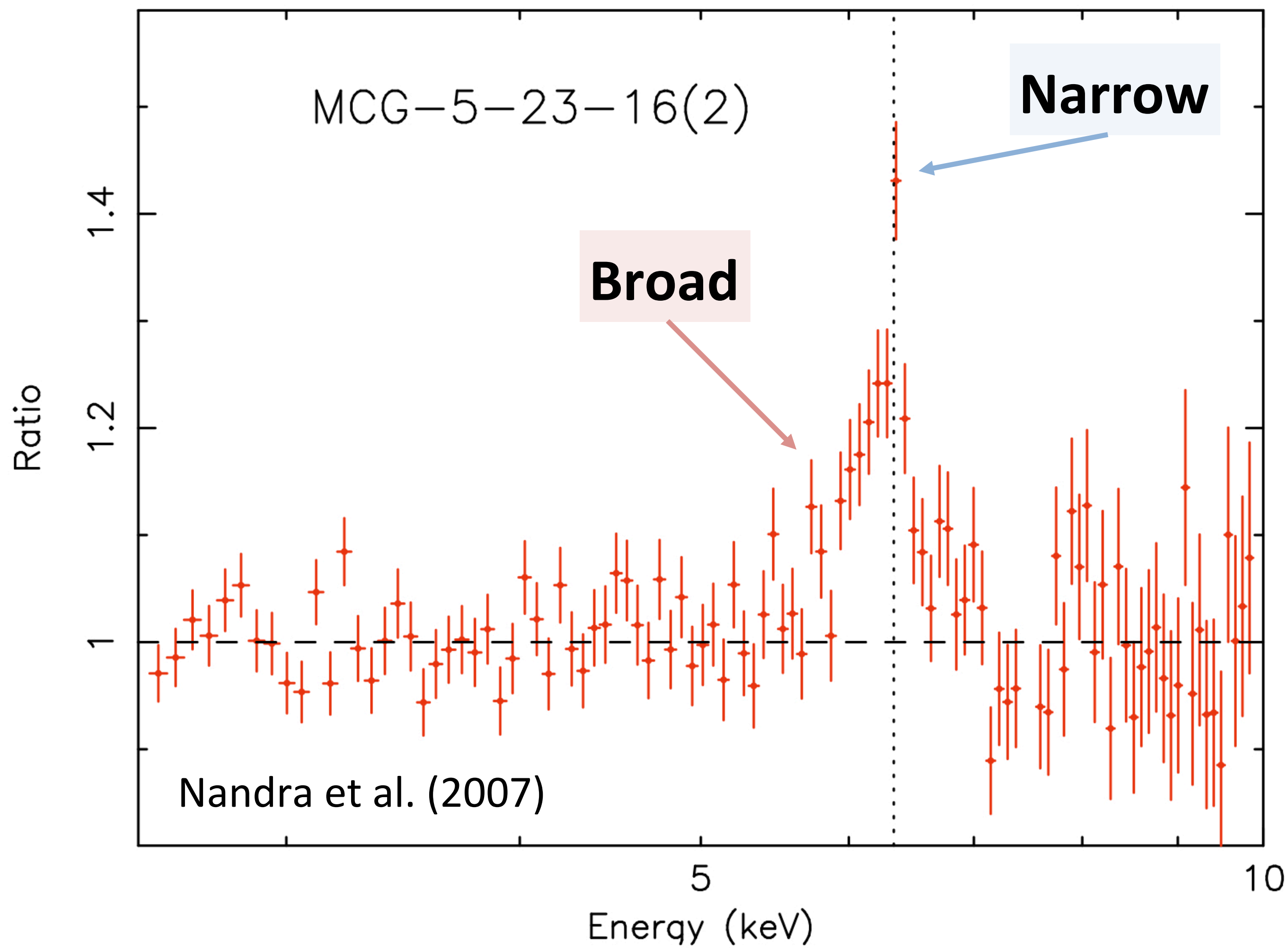

1 — Reprocessed
2 — Obscured

1 — Reprocessed X-ray radiation

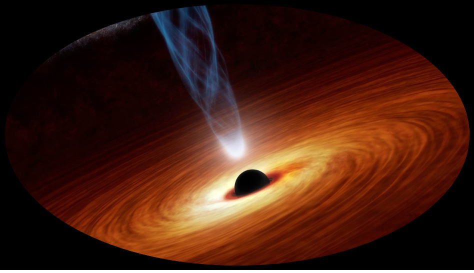


The Fe Kα line

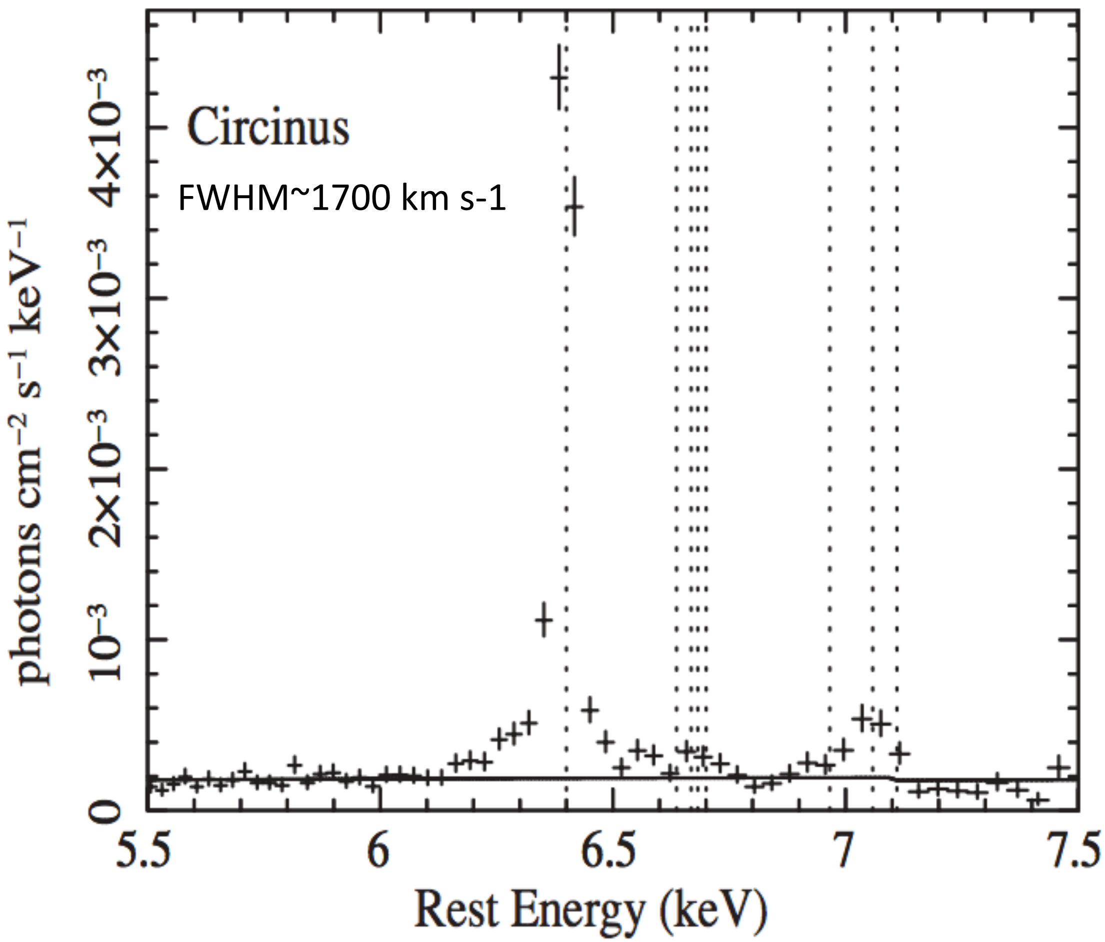




The Fe Kα line

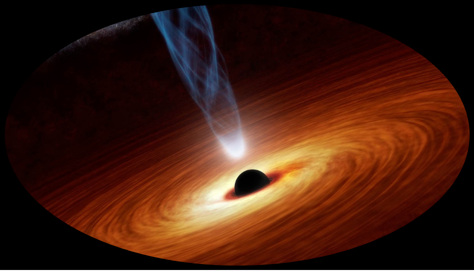


Chandra/HETG

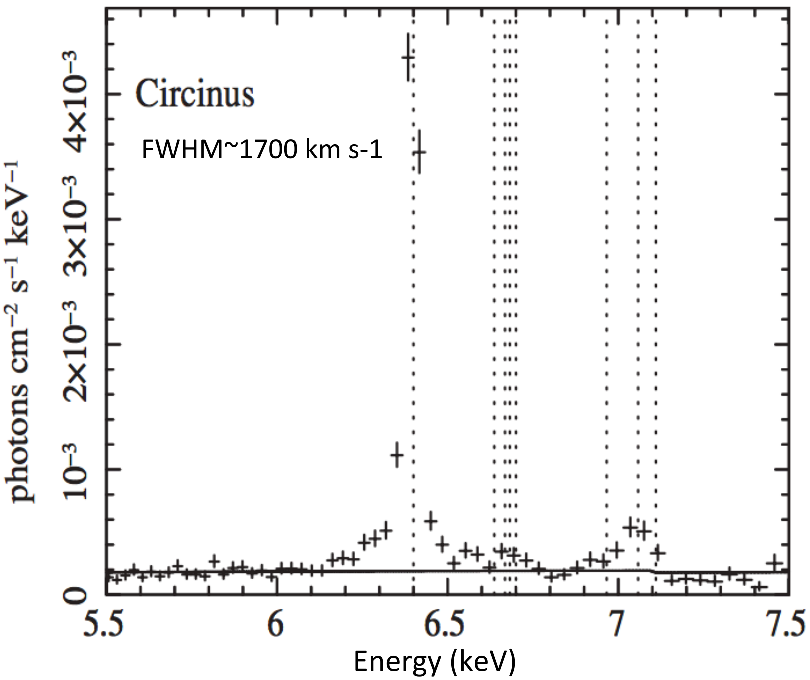


Shu et al. (2011), see also Shu et al. (2010)

The Fe Kα line

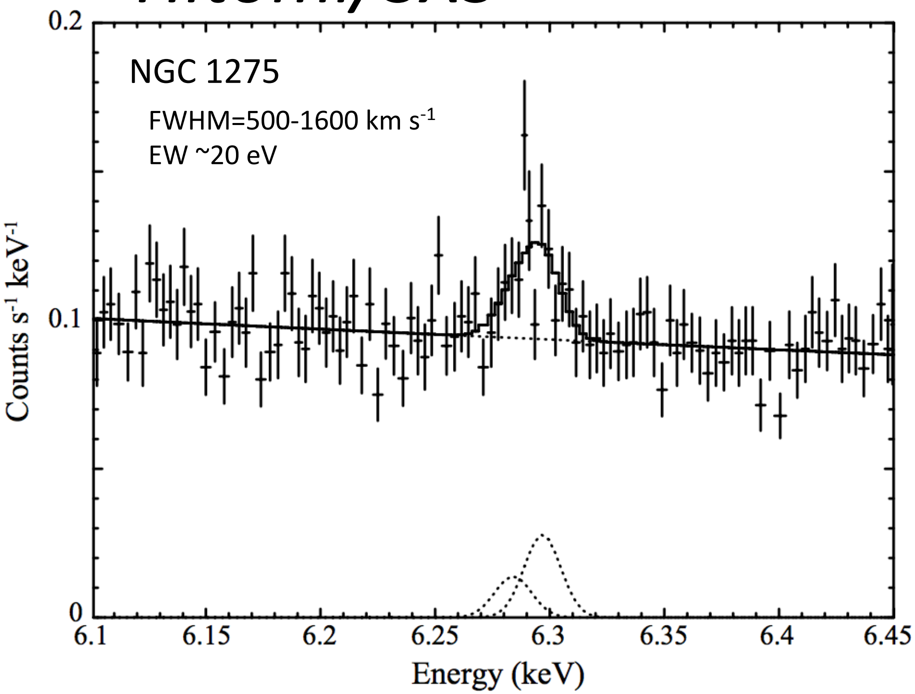


Chandra/HETG



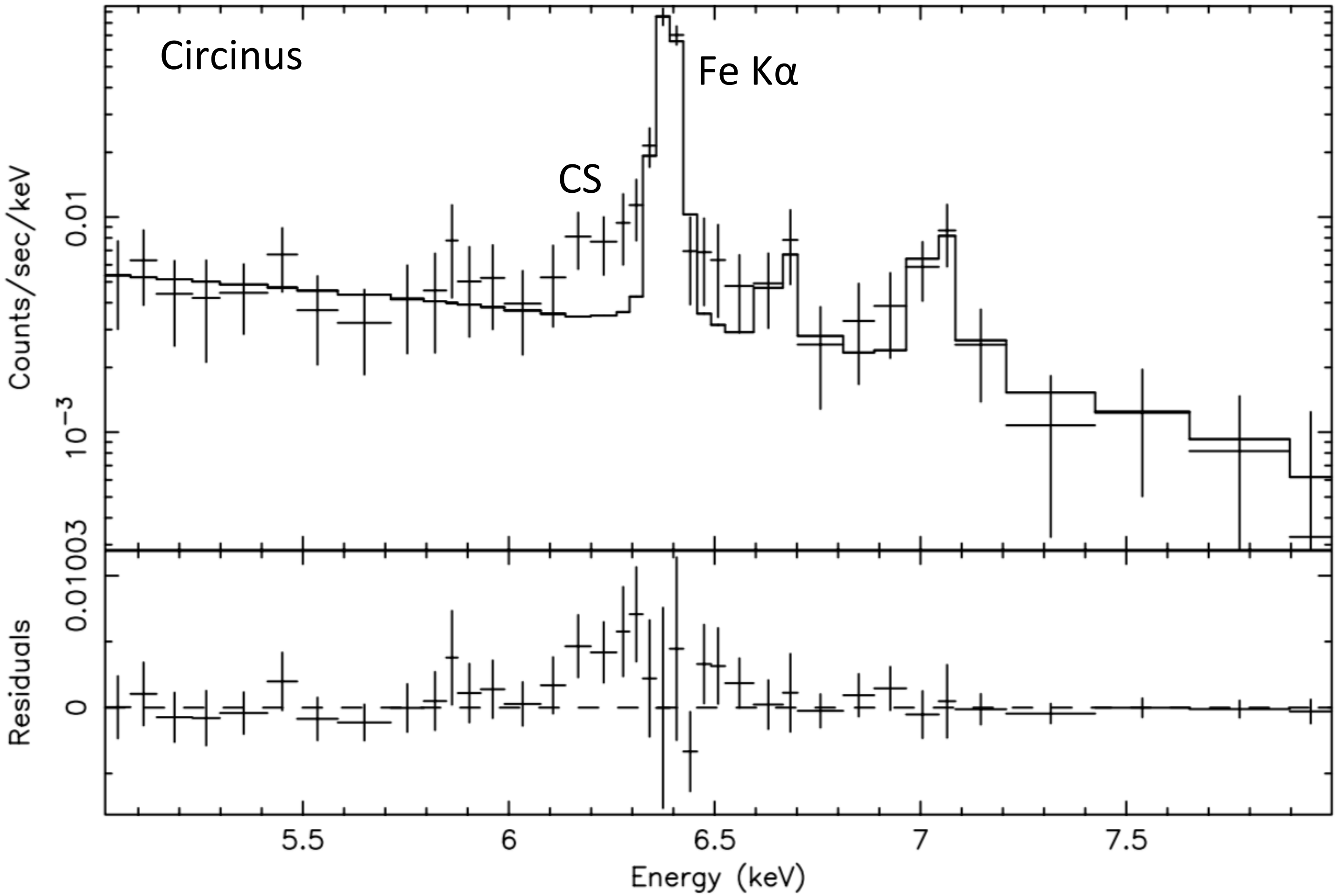
Shu et al. (2011), see also Shu et al. (2010)

Hitomi/SXS



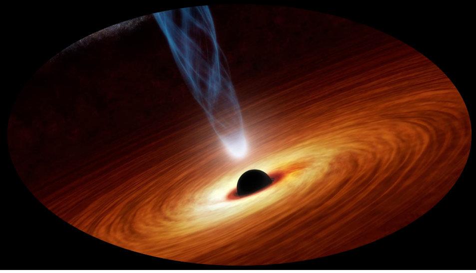
Hitomi collaboration (2018)

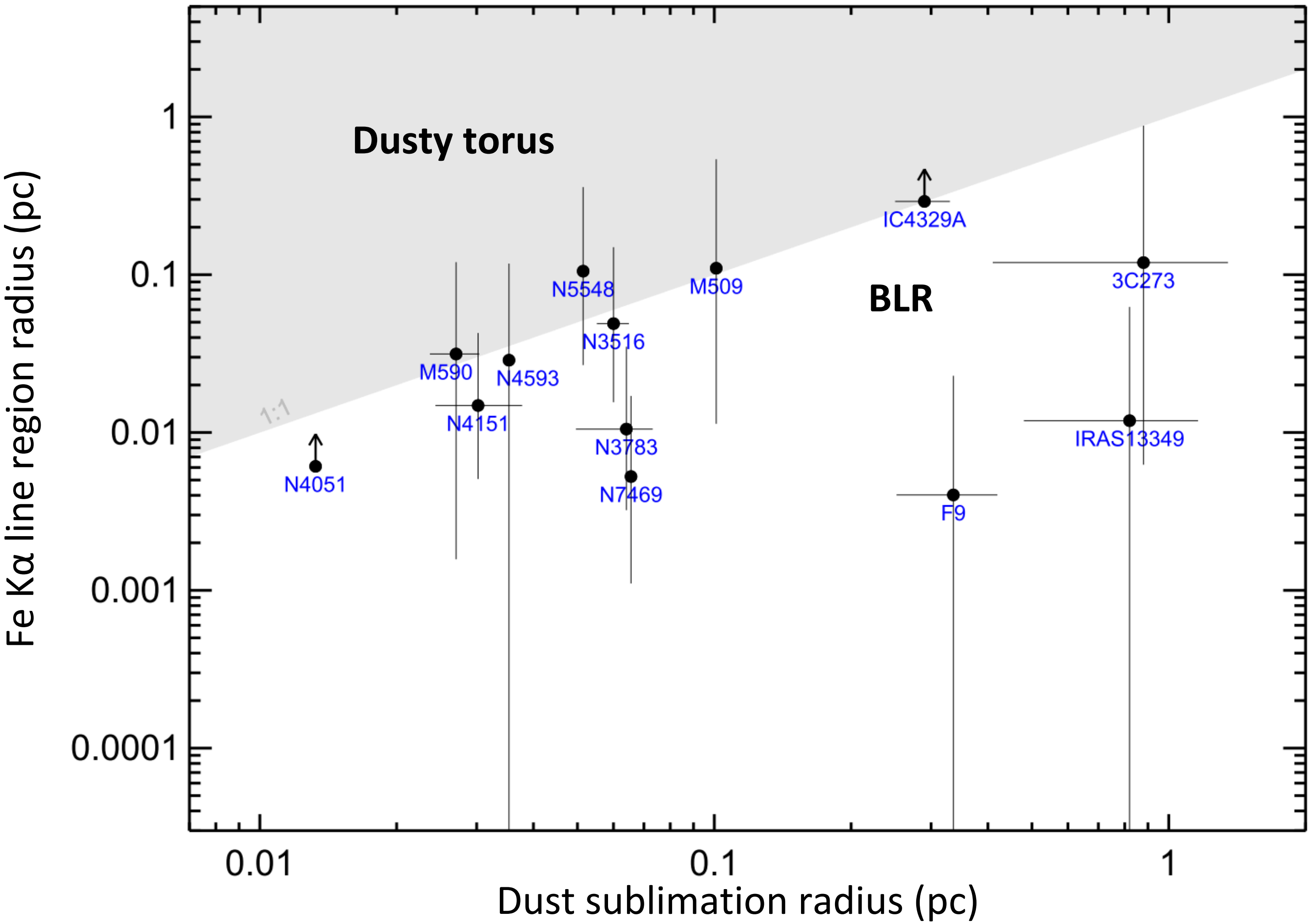
The Compton shoulder



Bianchi et al. (2002); See C. Andonie's talk

The Fe Kα line

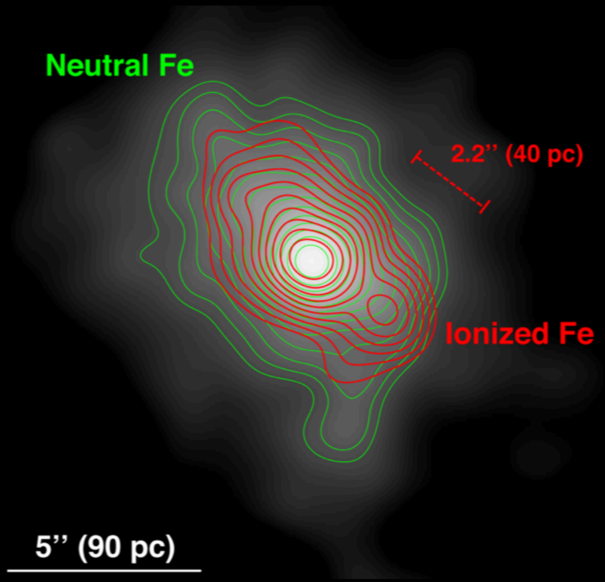




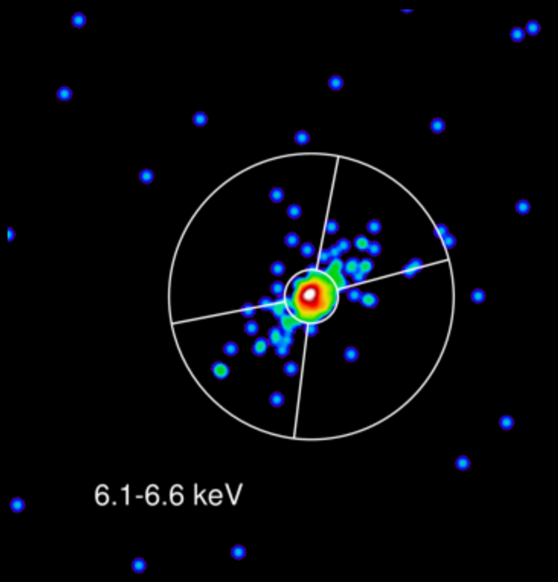
Gandhi et al. (2015)

Extended Fe Kα lines

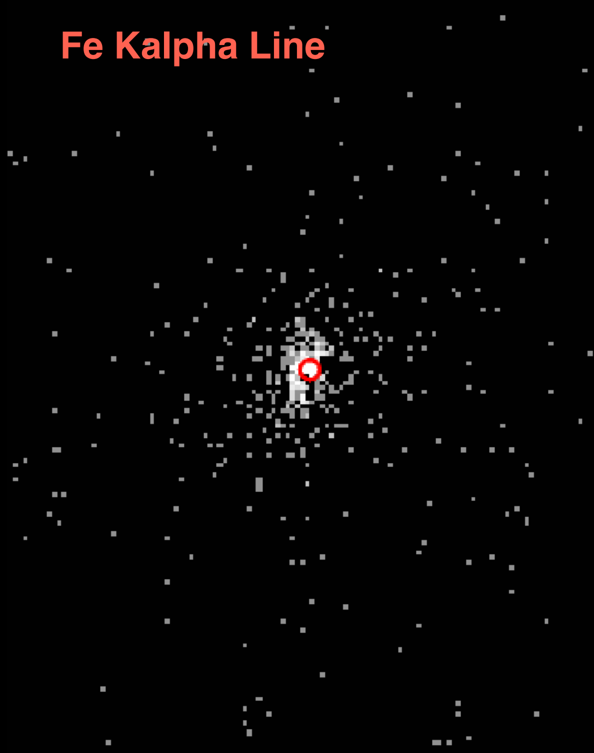
NGC 4945: Marinucci et al. (2017)



ESO428–G014: Fabbiano et al. (2017)

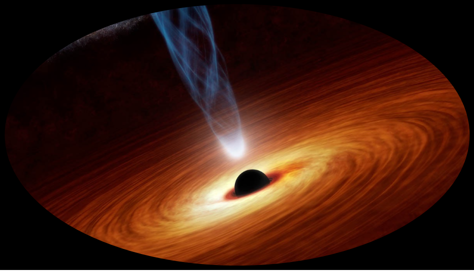


NGC 2110: Bauer et al. (in prep.)

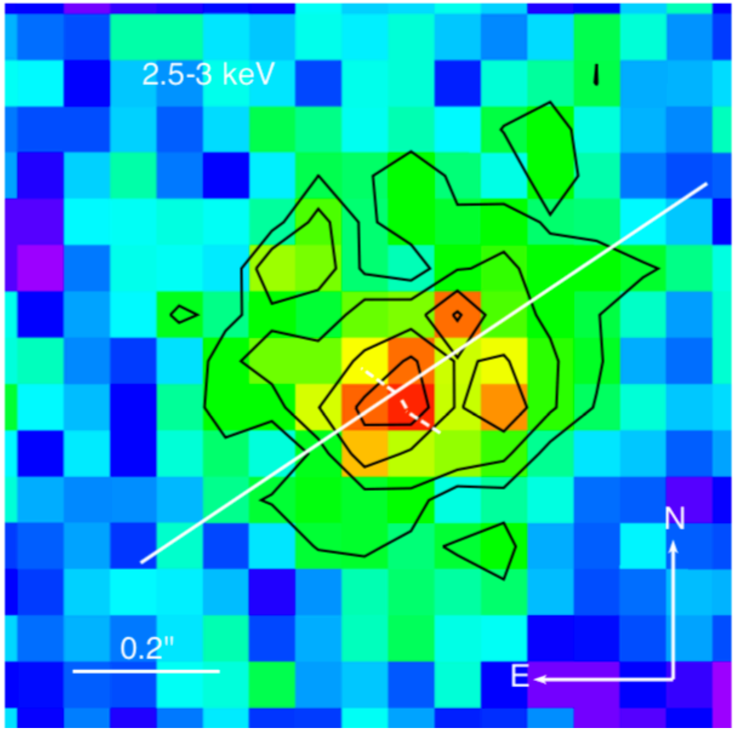


See talks by G. Fabbiano, M. Elvis, F. Bauer

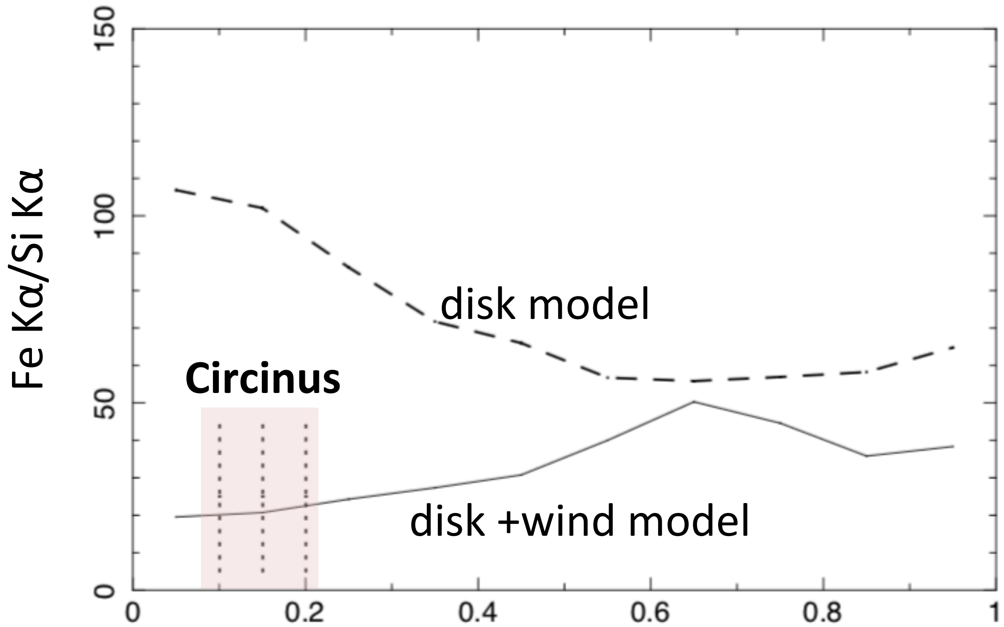
Extended Si Kα lines



Chandra 2.5-3 keV image of Circinus

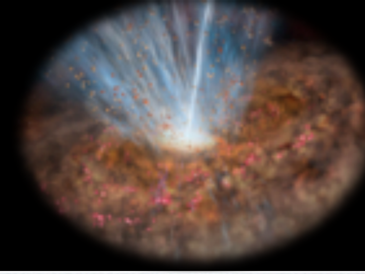


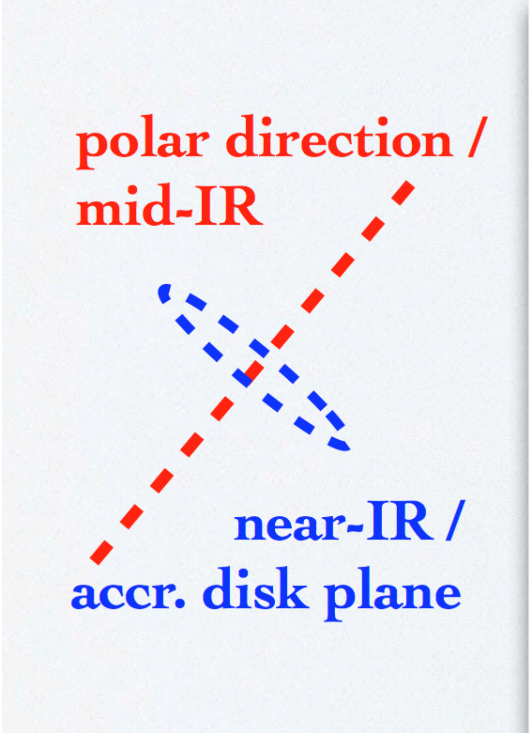
Simulations with two different models

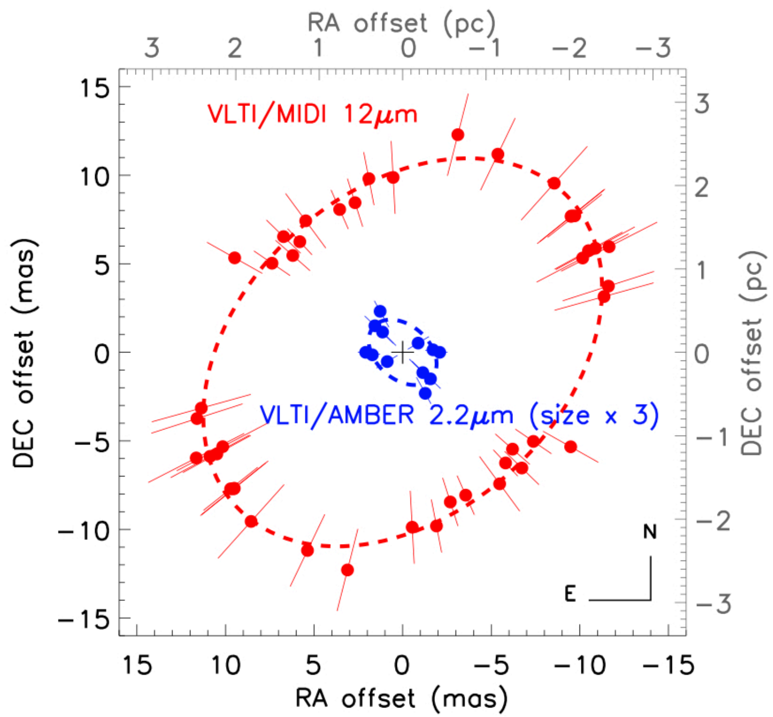


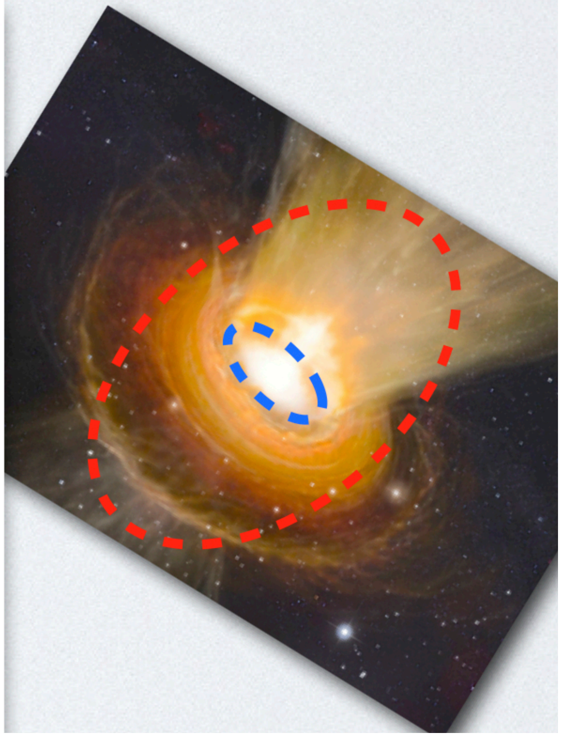
Liu, Hoenig, Ricci & Paltani (in prep.)

Polar emission in the IR









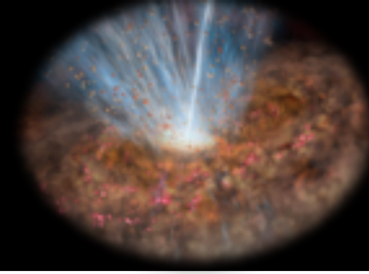
Hoenig et al. (2013)

VLTI: significant mid-IR emission from **polar region**

(Raban+09, Hoenig+12,13, Burtscher+13, Tristram+14, Lopez-Gonzaga+16, Leftley+18)

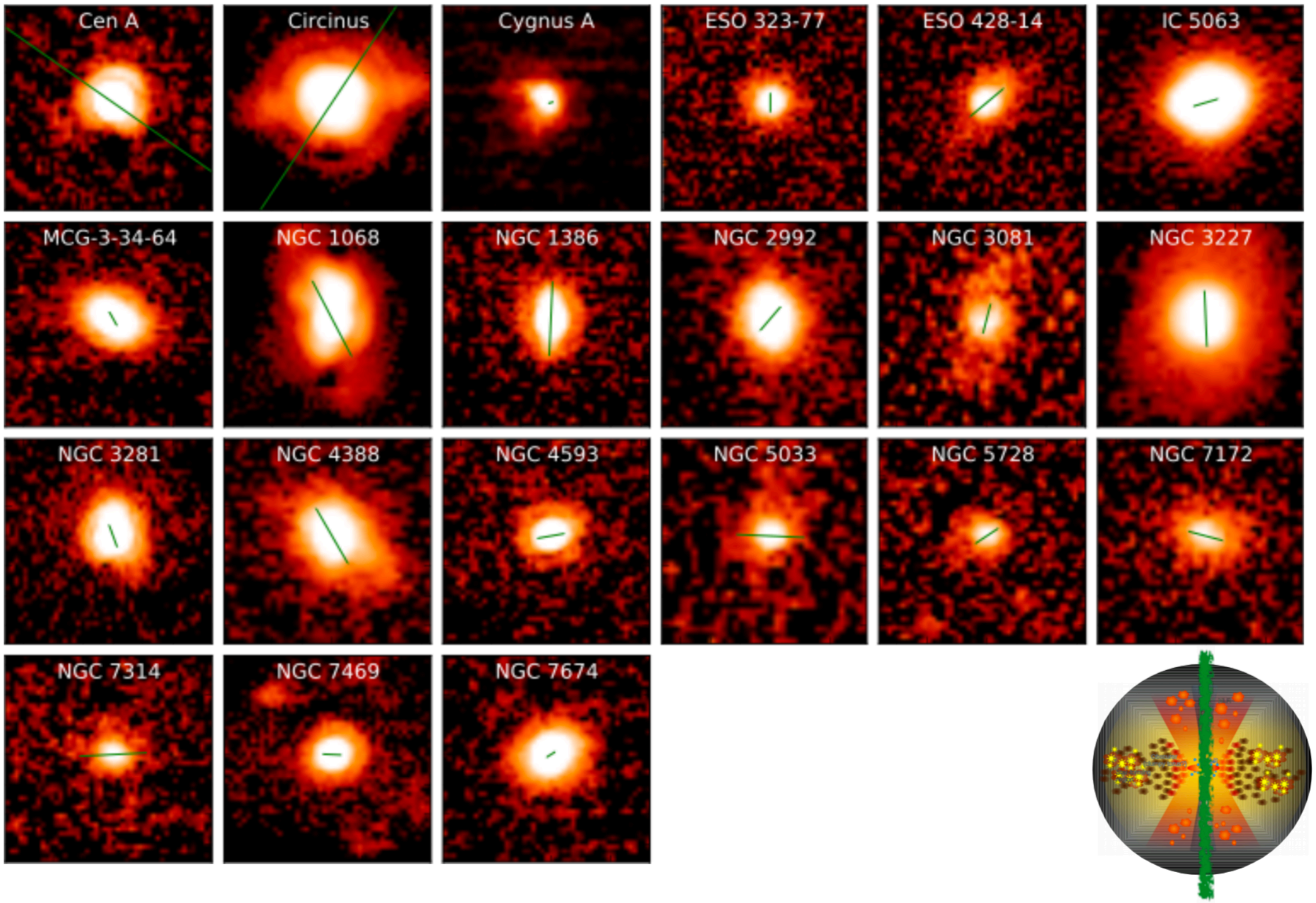
See also talks by D. Asmus, M. Stalevski; Poster by J. Leftley

Polar emission in the IR

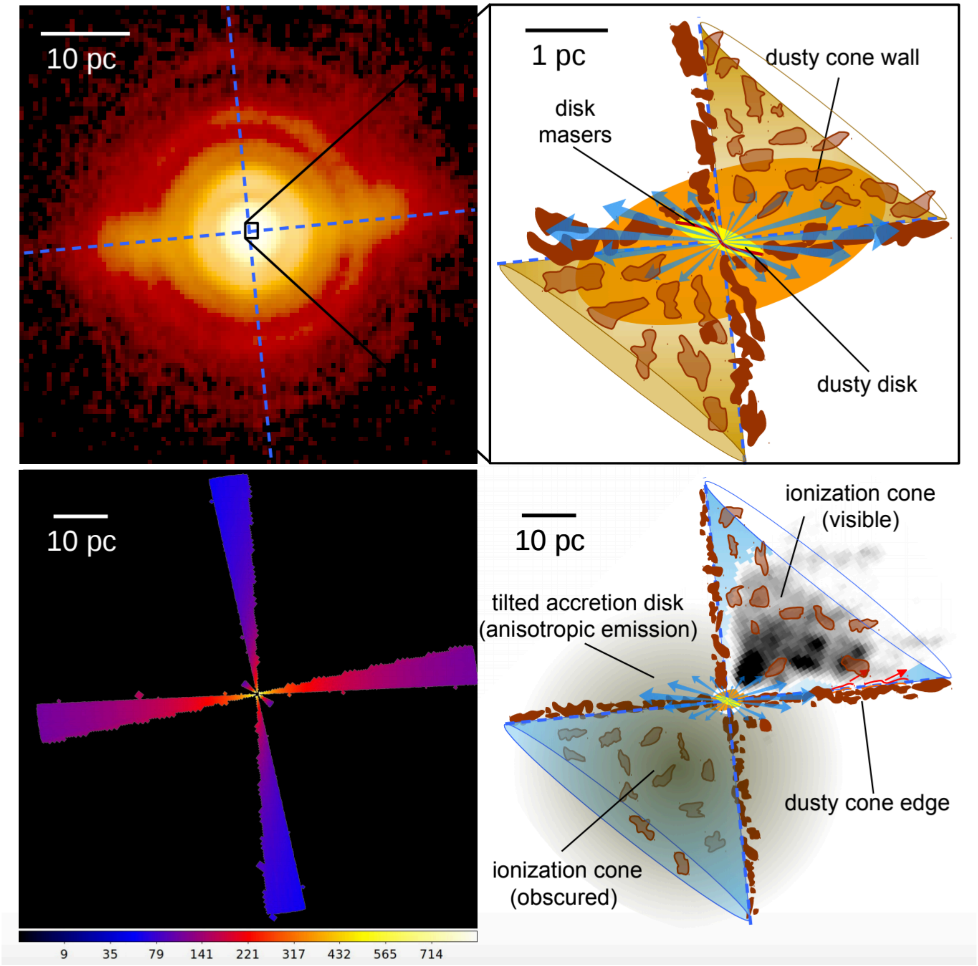


VISIR images of local AGN

Asmus, Honig, Gandhi (2016)

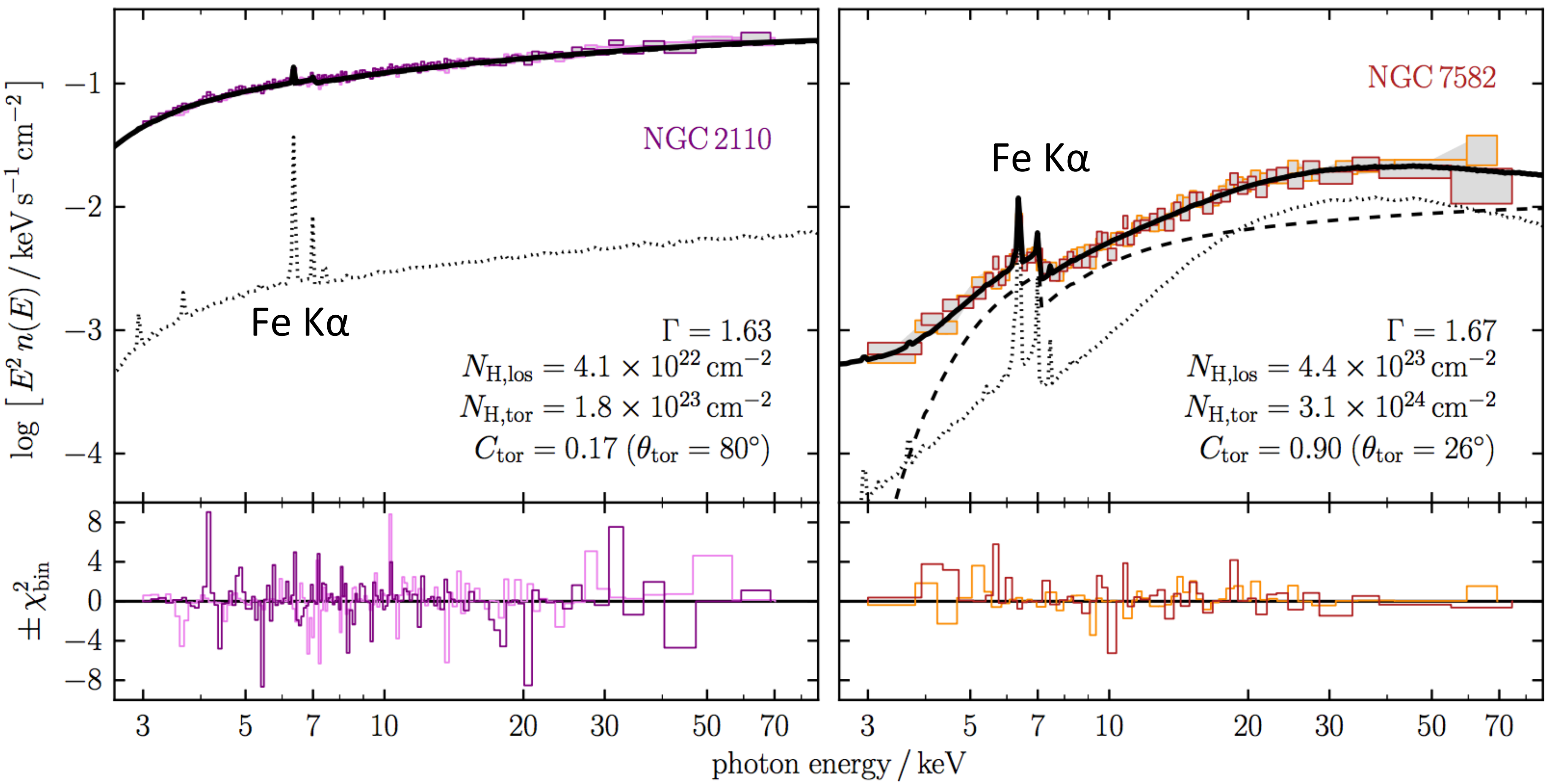


Polar emission in the IR



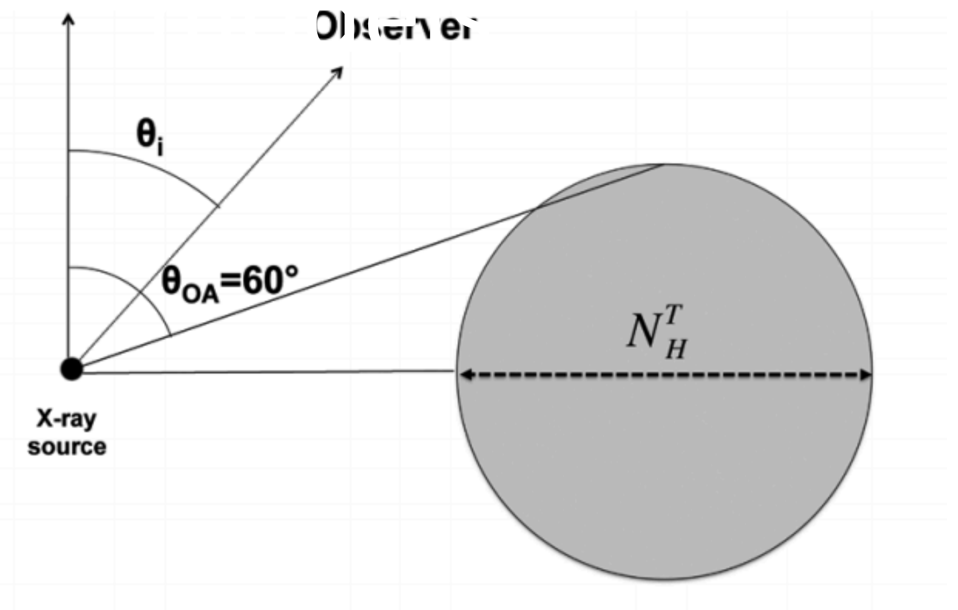
Stalevski, Asmus & Tristram (2017, 2019); see talks by D. Asmus, M. Stalevski; Poster by J. Lyu.

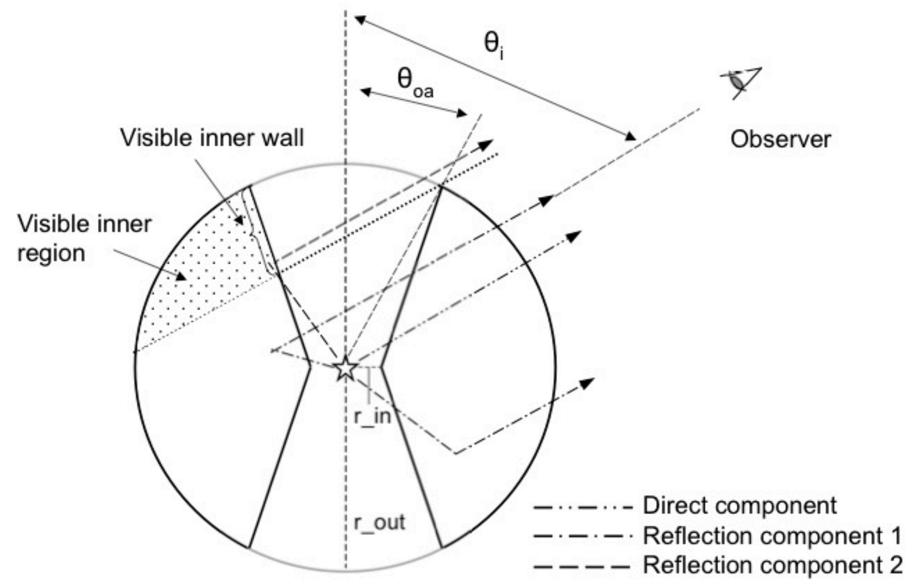
Broad-band spectroscopy



Balokovic et al. (2018); See talks by M. Balokovic, J. Buchner, N. Osorio-Clavijo; Poster by T. Kawamuro

Reprocessed radiation: spectral models





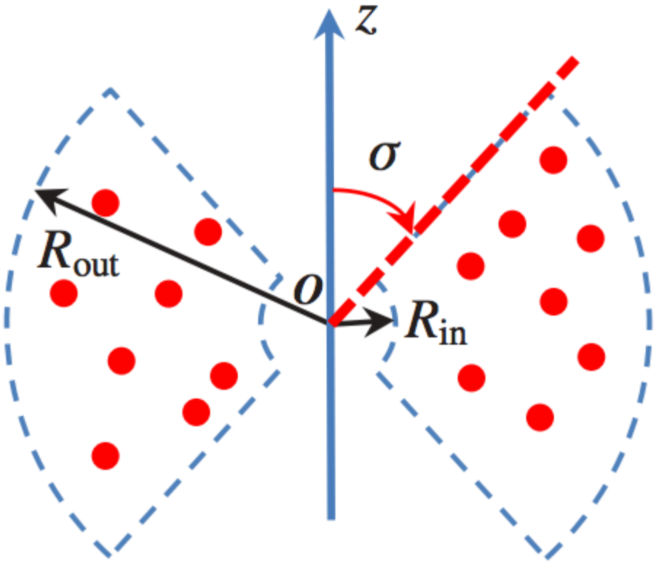
Ikeda et al. (2009)

MyTORUS (Murphy & Yaqoob 2009)

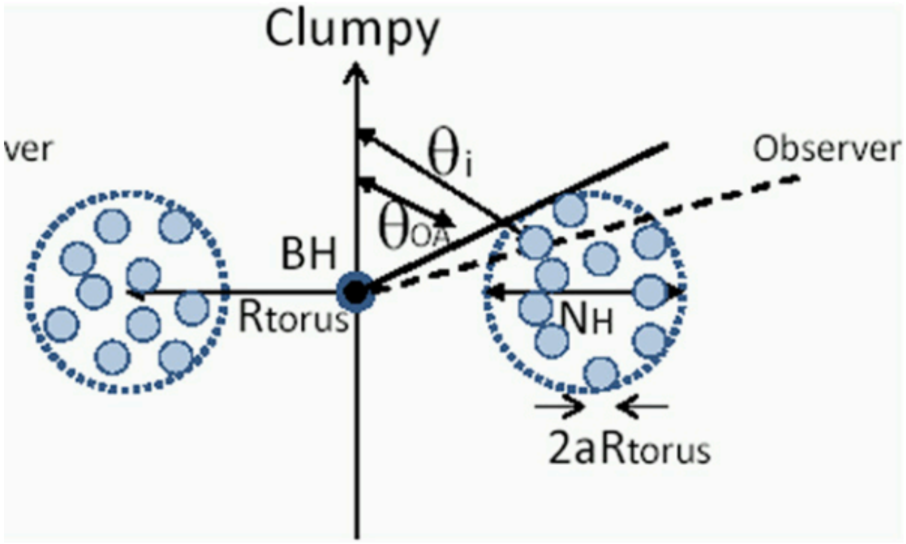
BNTorus (Brightman et al. 2011), *Borus* (Balokovic et al. 2017); Ikeda et al. (2009)

See talks by M. Balokovic, M. Elvis; Posters by A. Tanimoto, D. Esparza Arredondo

Reprocessed radiation: spectral models



Liu & Li (2014)



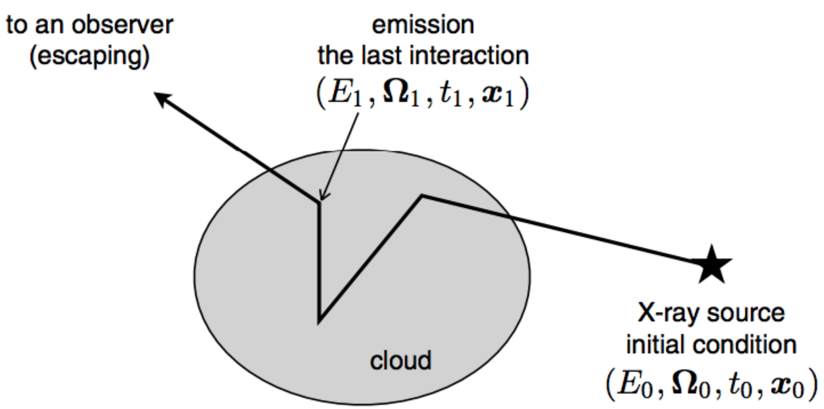
Furui et al. (2016)

See talks by M. Balokovic, M. Elvis; Posters by A. Tanimoto, D. Esparza Arredondo

Reprocessed radiation: simulation platforms

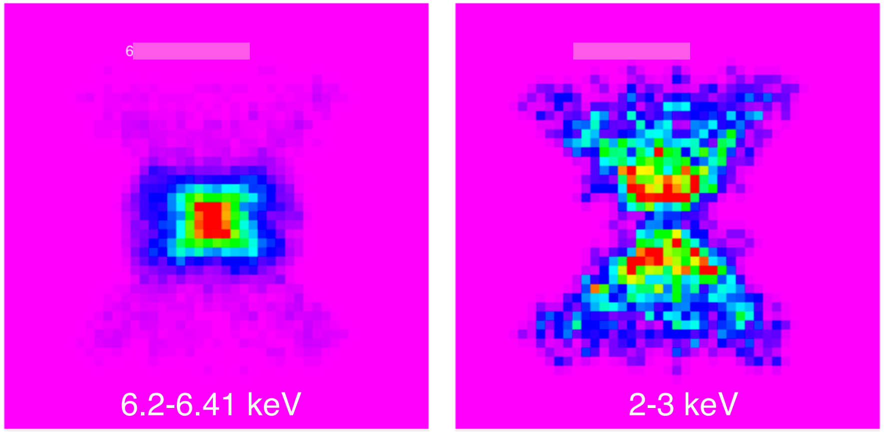
MONACO (Geant4)

Odaka et al. (2011)



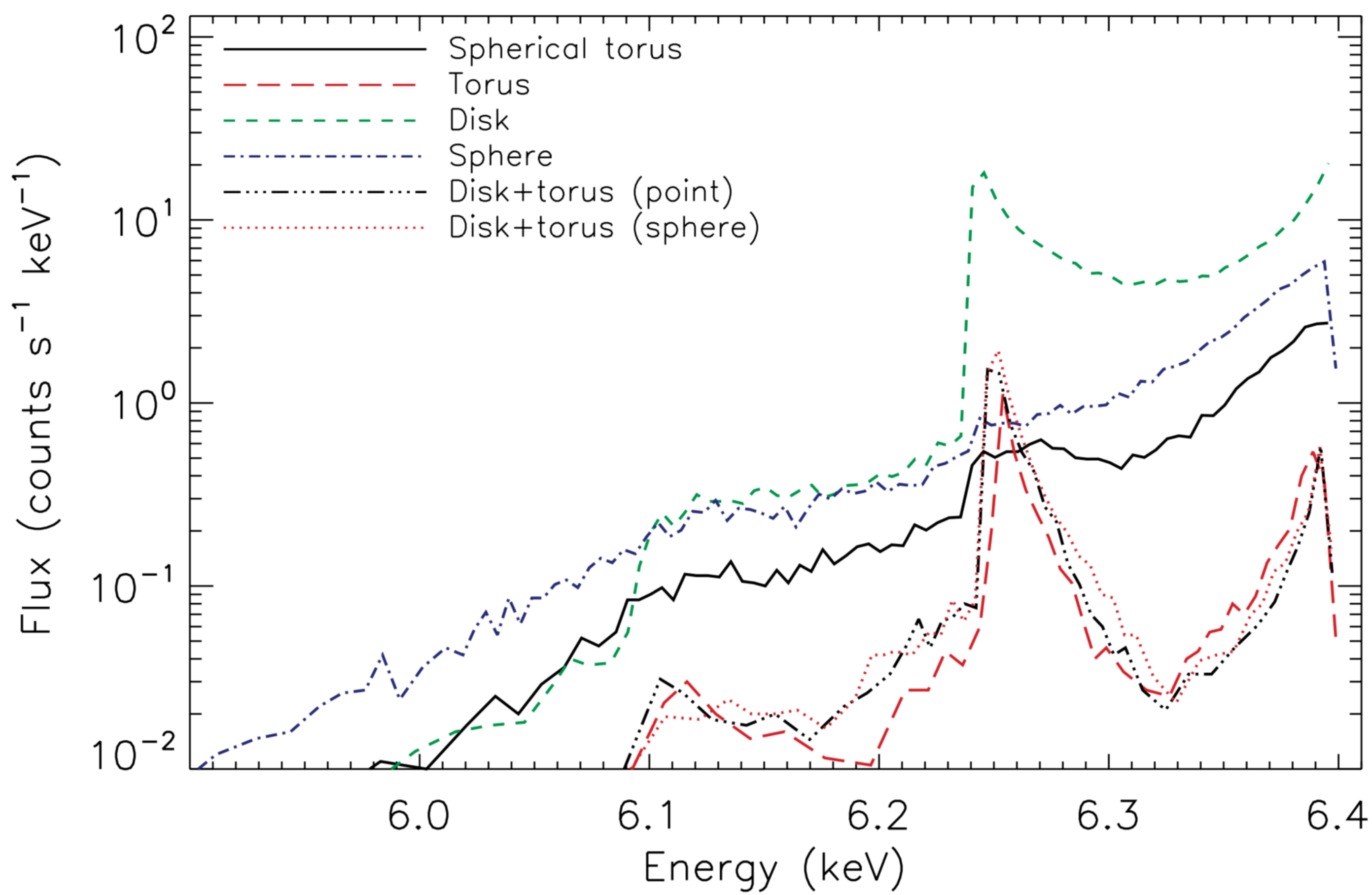
RefleX

Paltani & Ricci (2017)

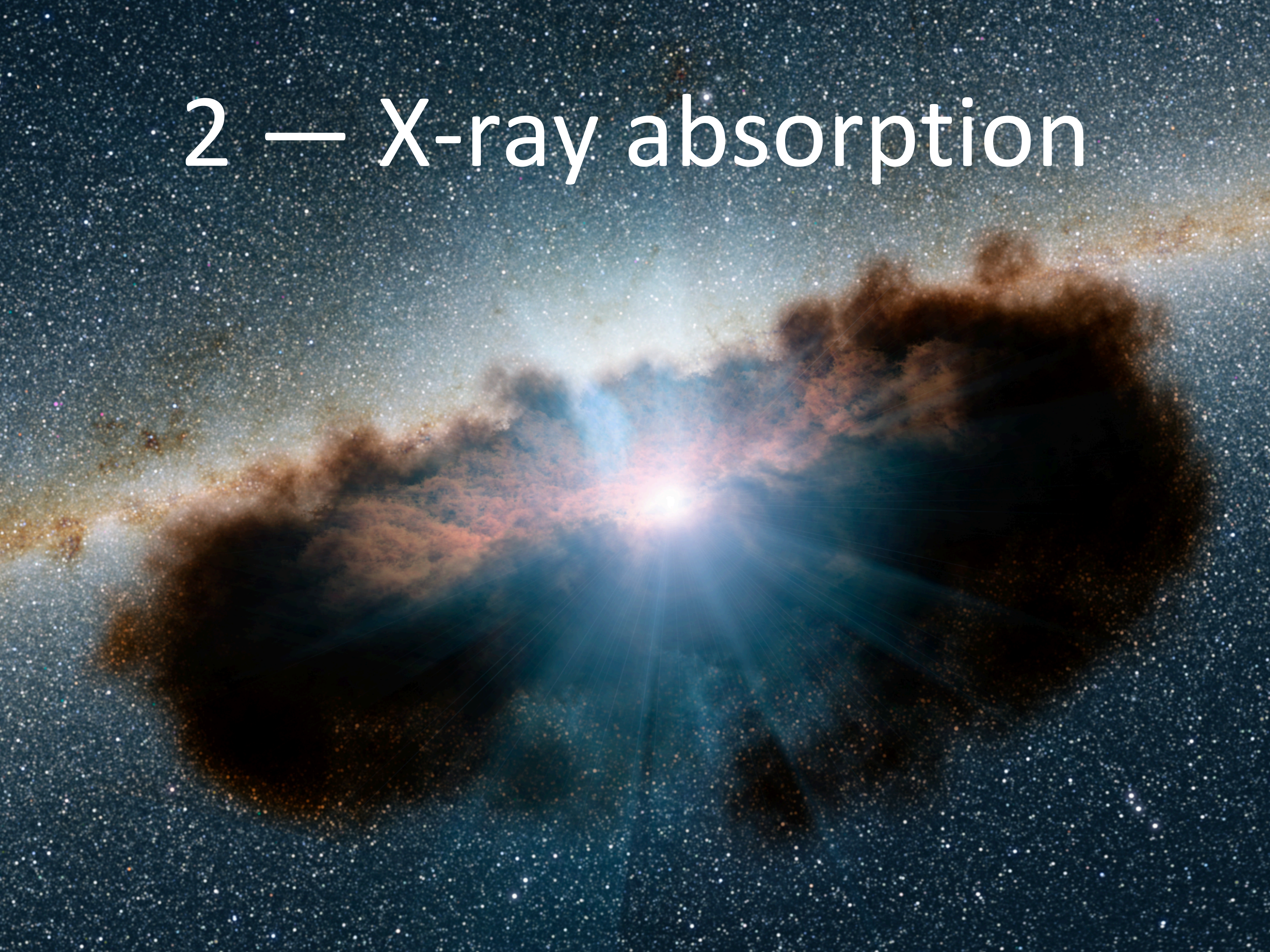


Liu et al. (in prep.)

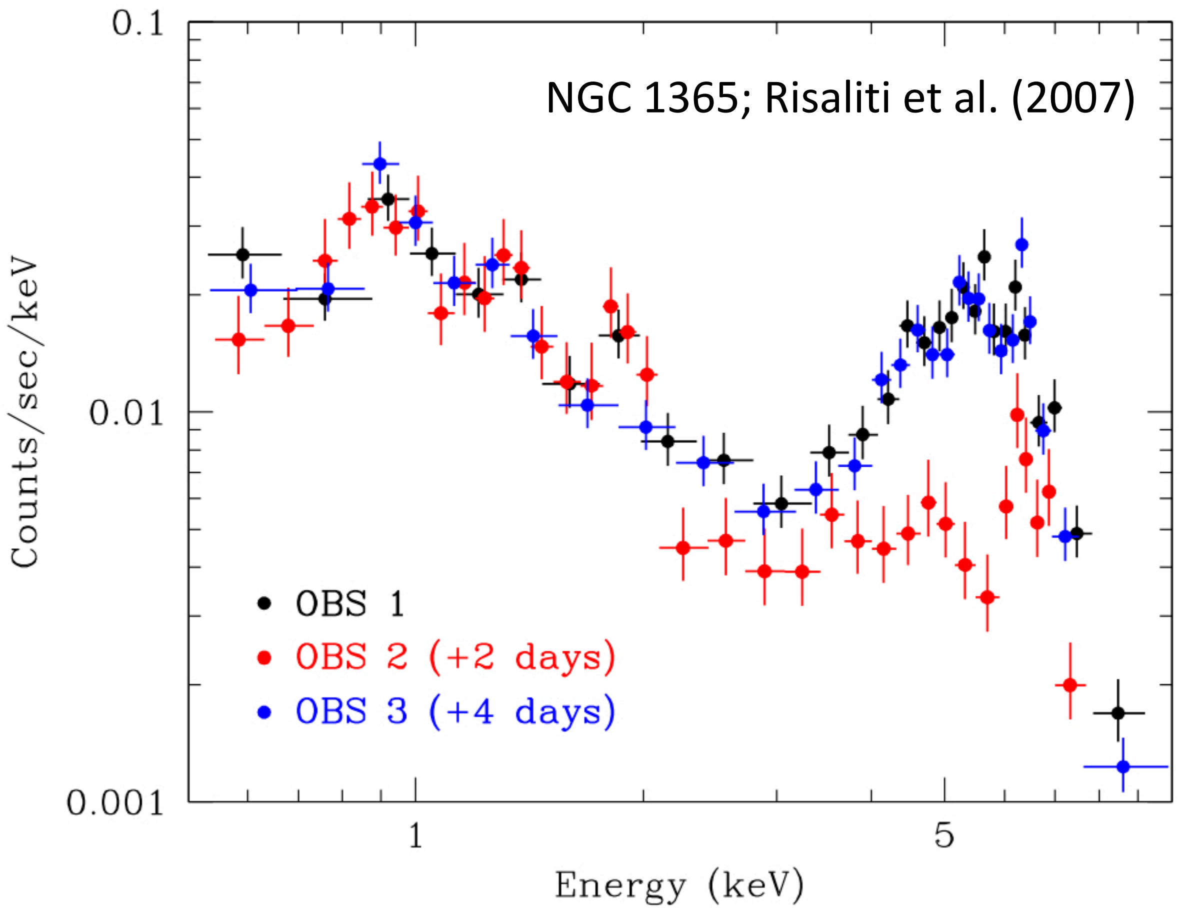
Reprocessed radiation: simulation platforms



Ricci et al. (in prep.); see also Odaka et al. (2016)
See talk by C. Andonie


2 — X-ray absorption

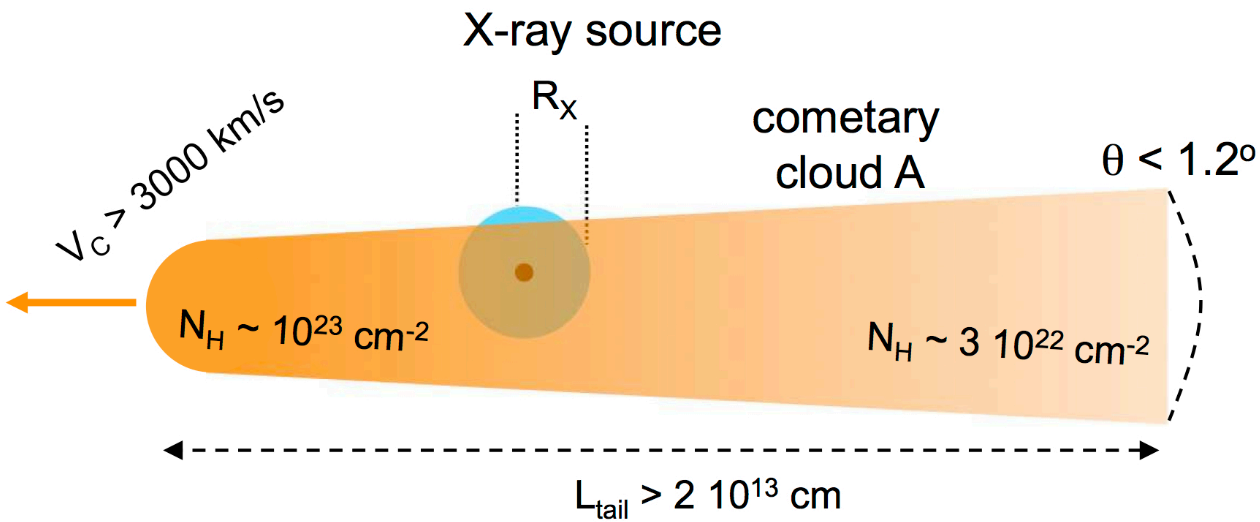
Obscuration variability



More than 20 AGN *(e.g., Risaliti+05, Bianchi+09, Marinucci+13, Miniutti+14, Rivers+15, Burtscher+15, Ricci+16b); See talk by S. Lamassa*

Obscuration variability

Broad-line regions clouds?

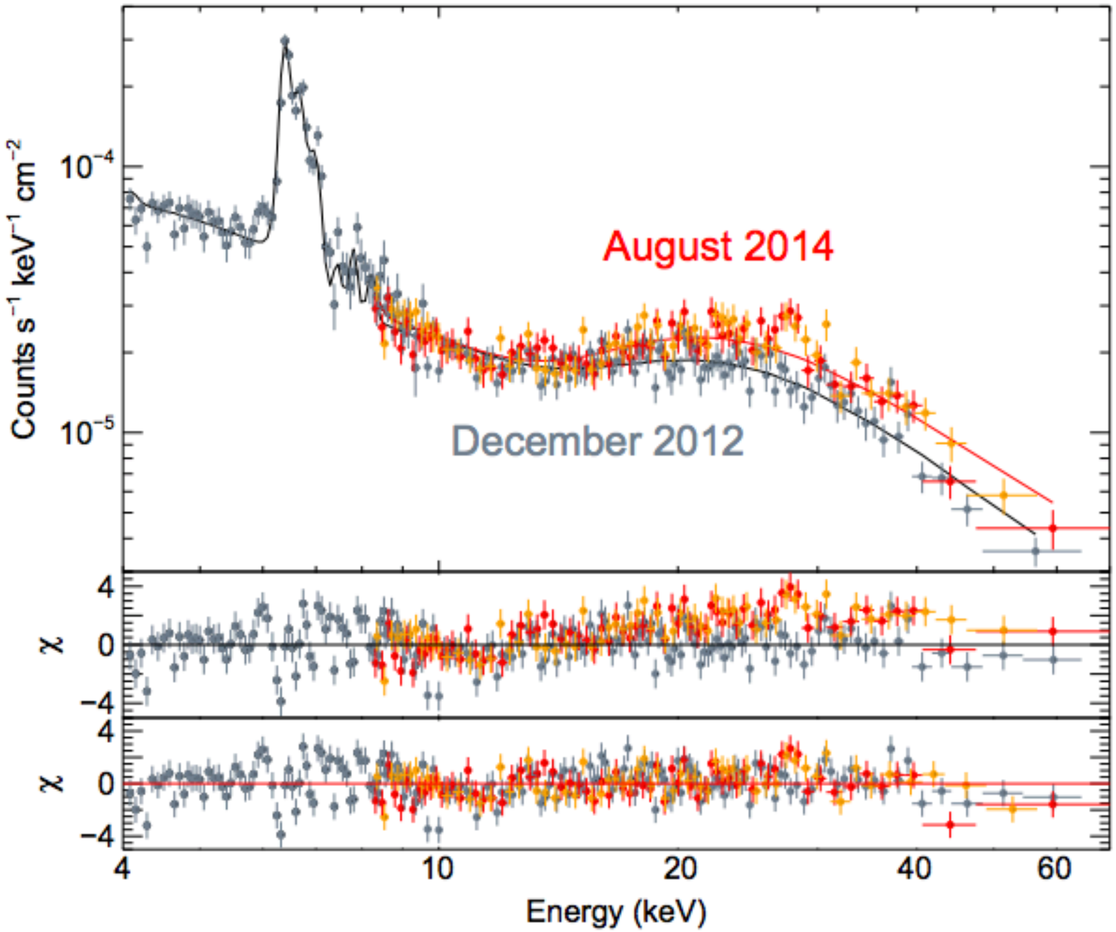


Maiolino et al. (2010)

See talk by S. Lamassa, E. Sturm, M. R. Stock, A. Laor, T. Waters

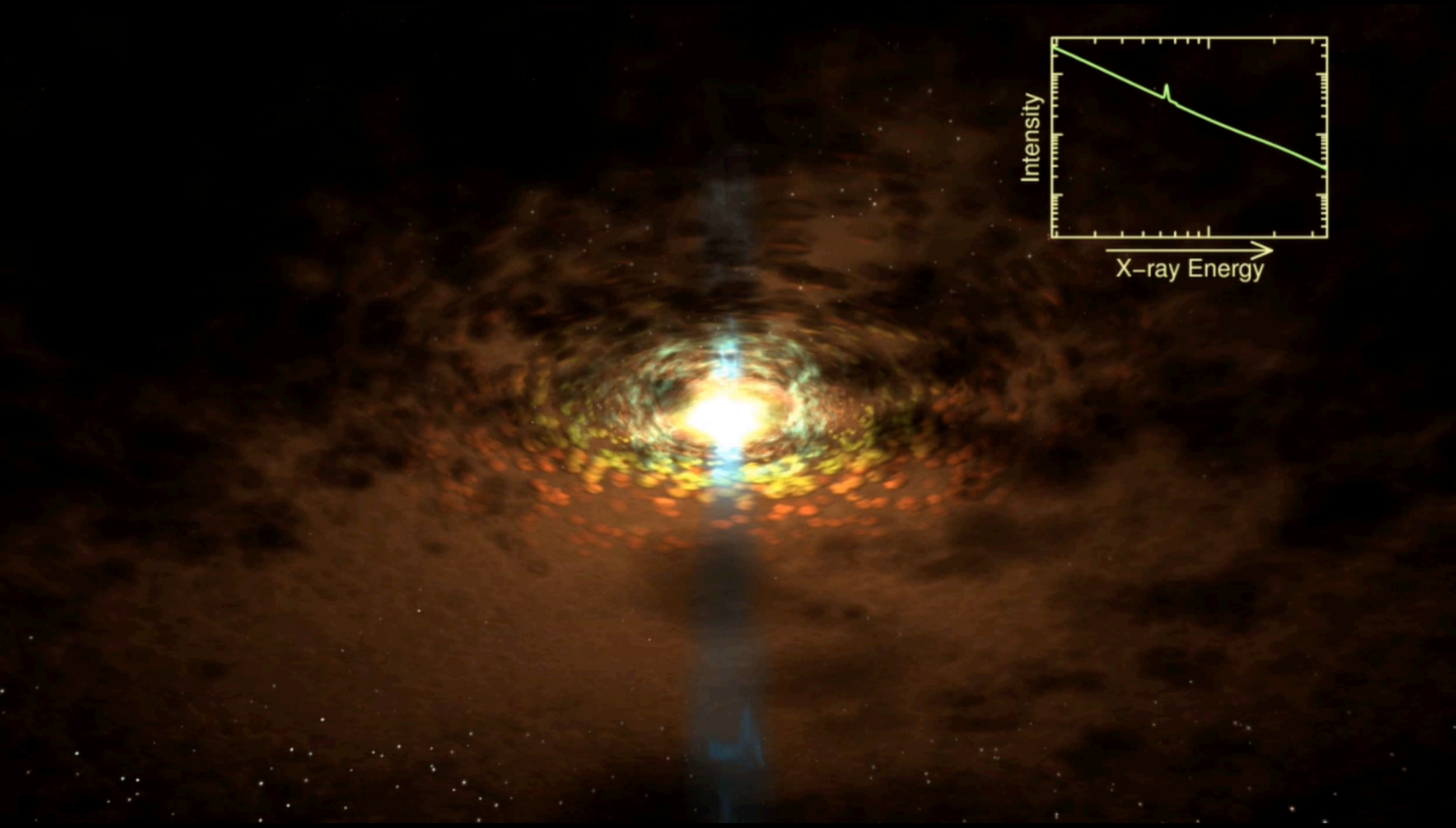
Obscuration variability

NGC 1068



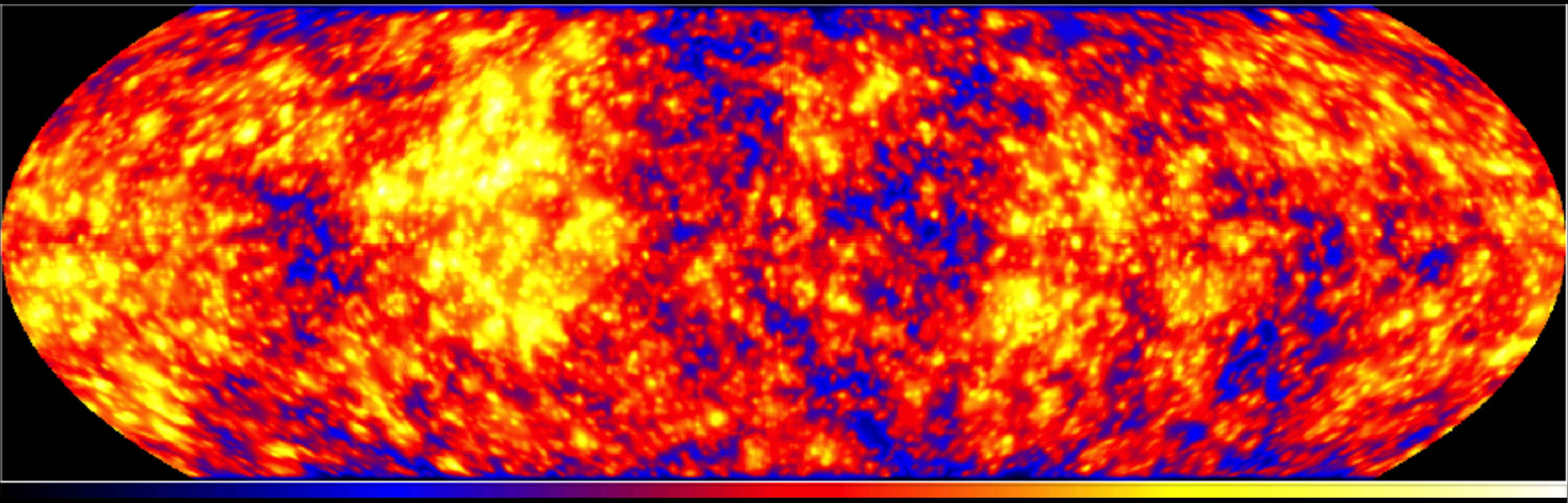
Marinucci et al. (2016); See talk by A. Zaino

Obscuration variability



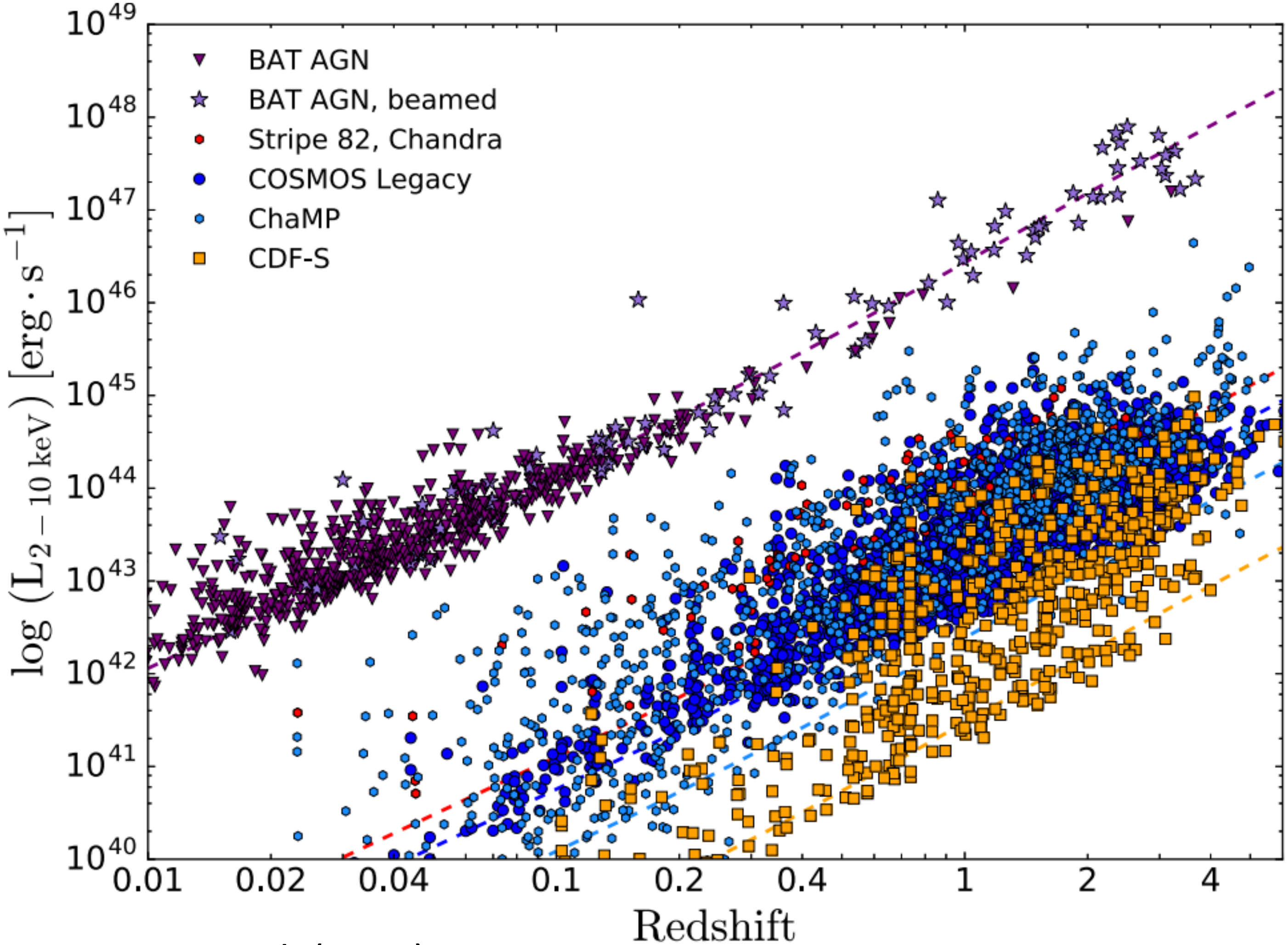
Markowitz et al. (2014)

The sky seen from the SMBH



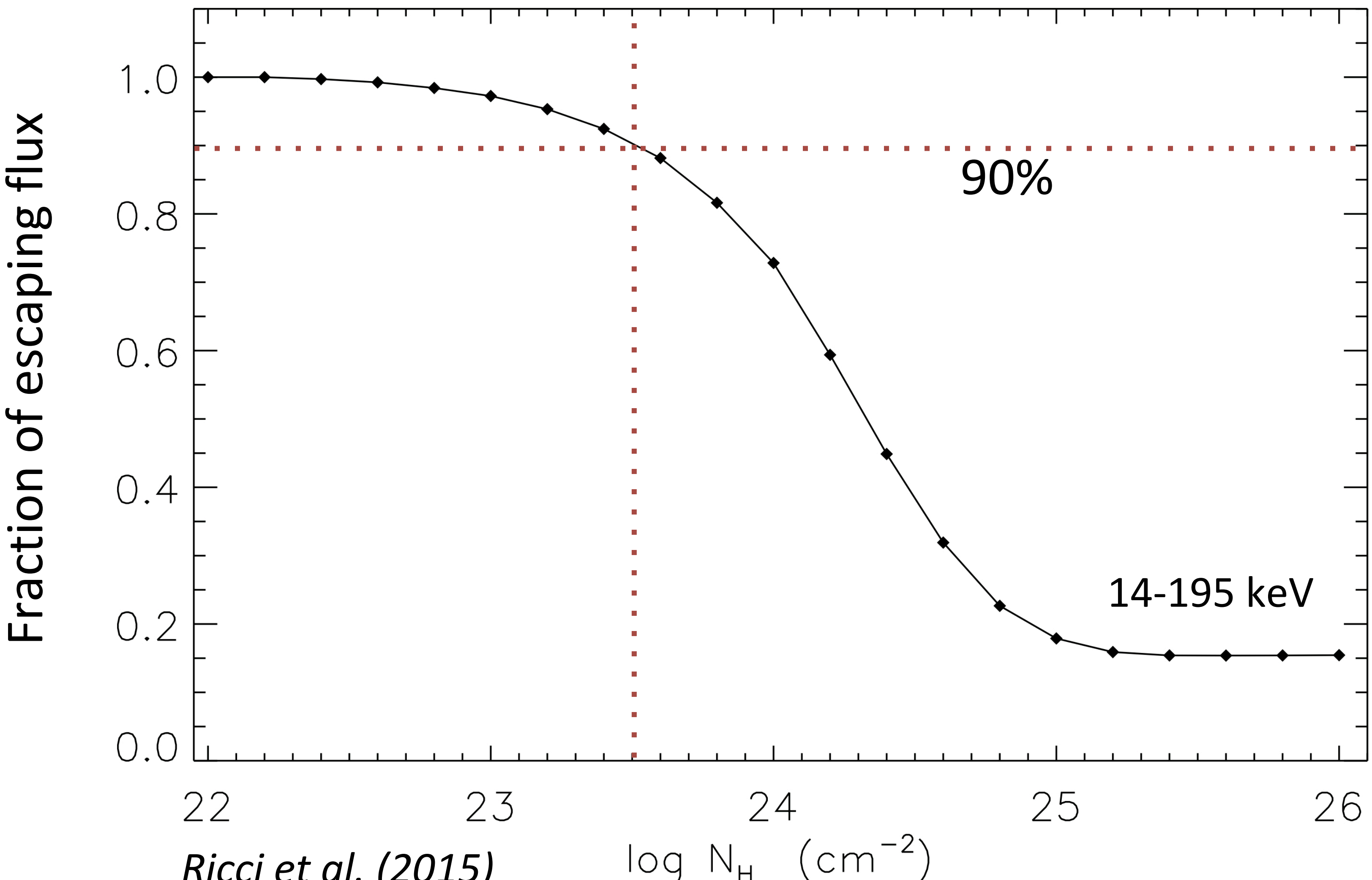
Stalevski et al. (2012); See talk by R. Nikutta, ; Poster by E. Lopez-Rodriguez

X-ray Surveys



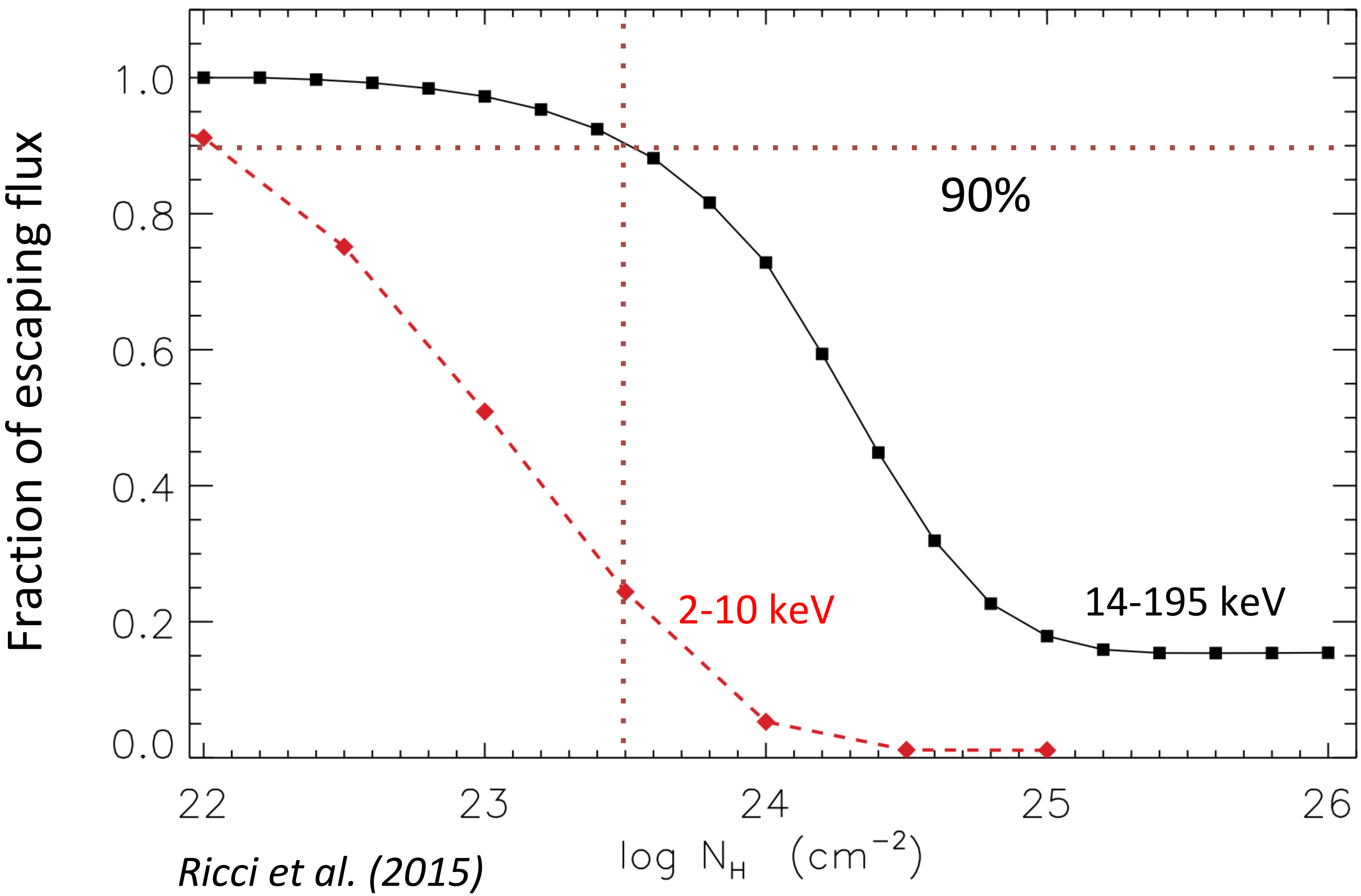
Koss et al. (2017)

Obscured AGN in the hard X-ray band



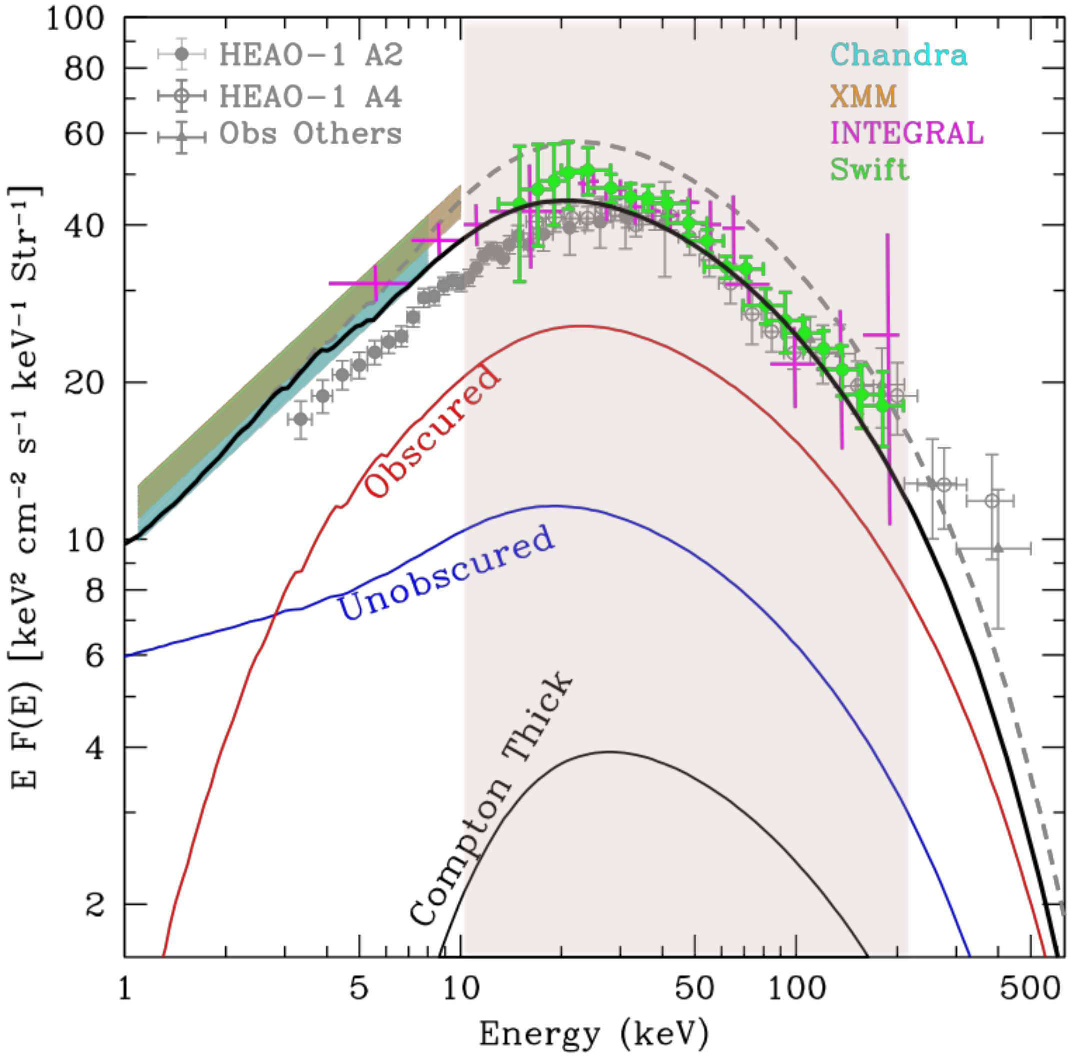
Ricci et al. (2015)

Obscured AGN in the hard X-ray band



Ricci et al. (2015)

Obscured AGN in the hard X-ray band

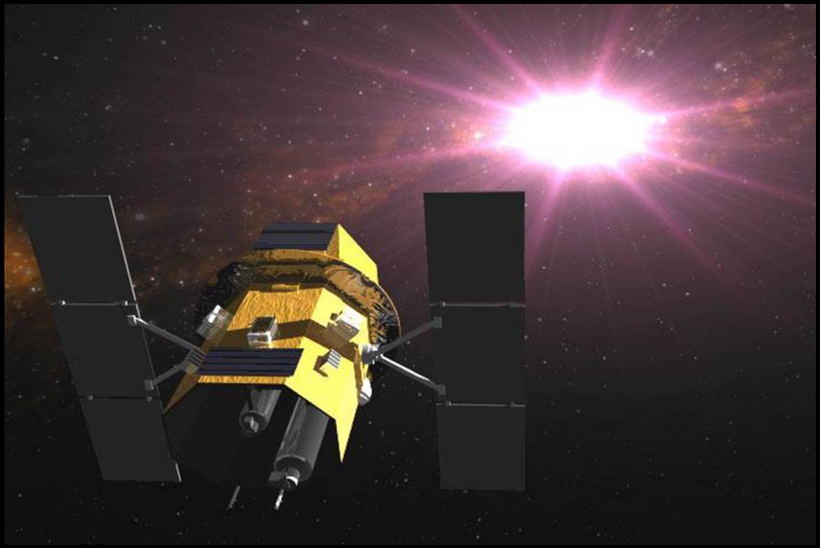


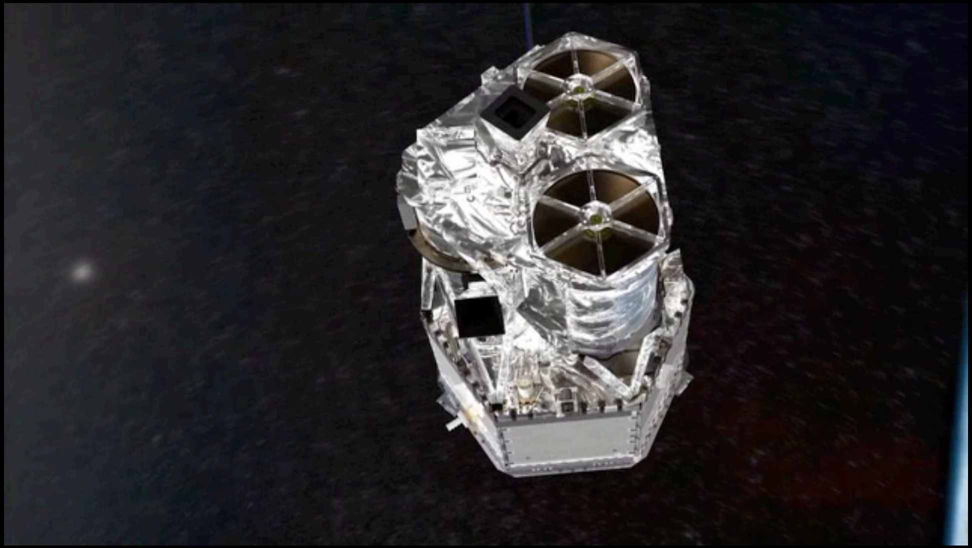
Treister et al. (2009)

Obscured AGN in the hard X-ray band

Swift/BAT
(14-195 keV)

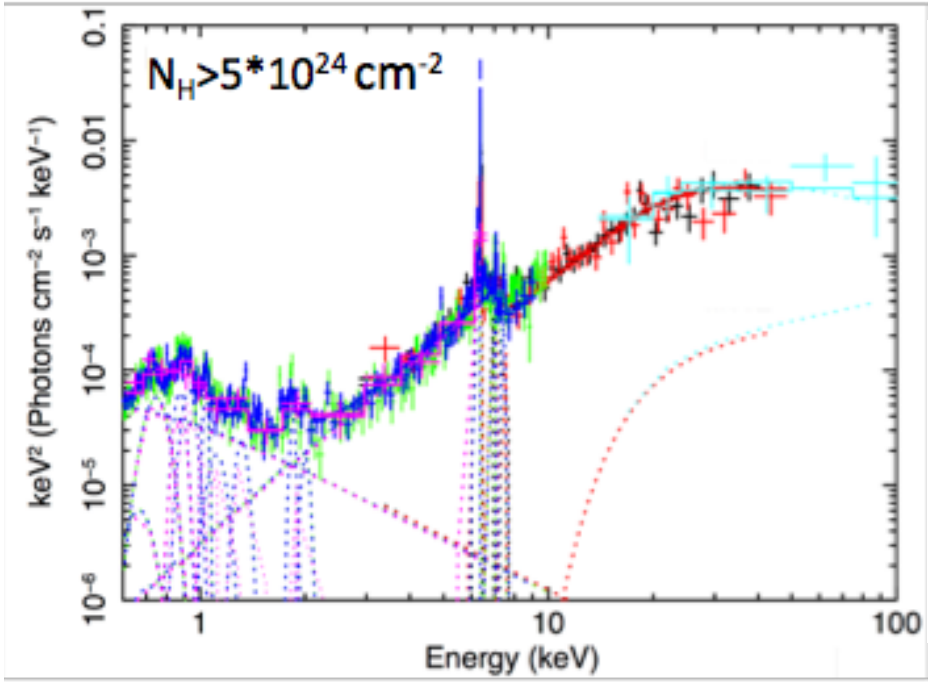
NuSTAR
(3-80 keV)





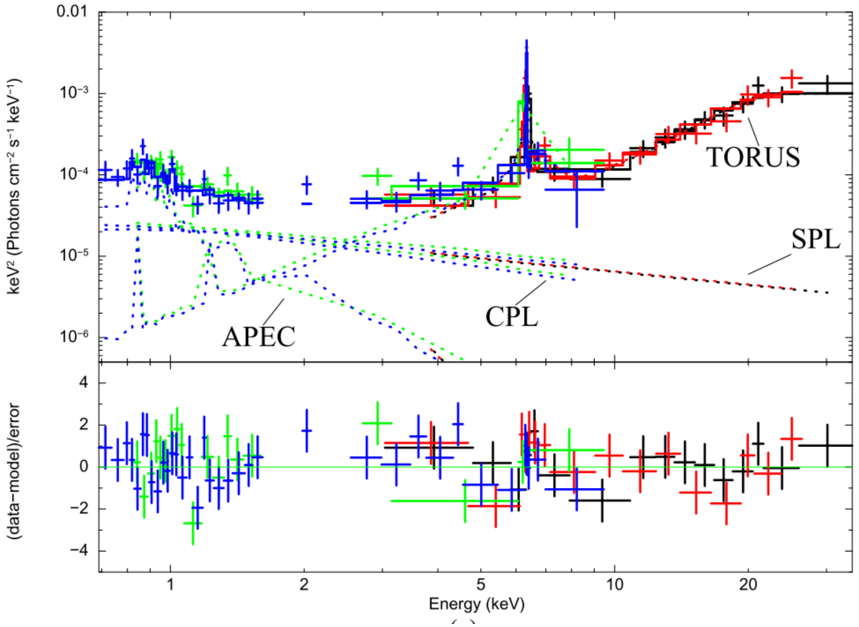
Obscured AGN in the hard X-ray band

NGC 5643



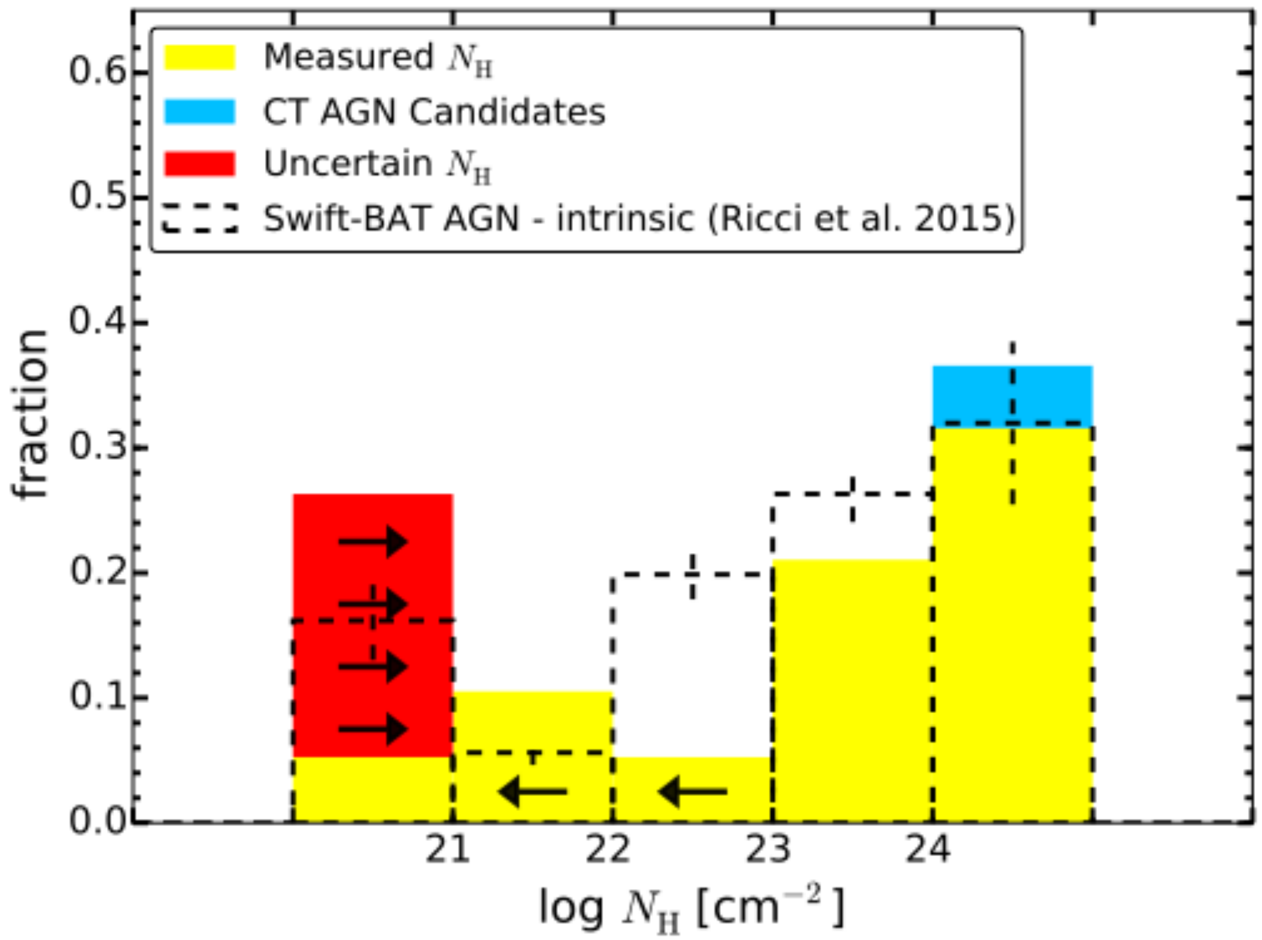
Annuar et al. (2015)

IC 3639



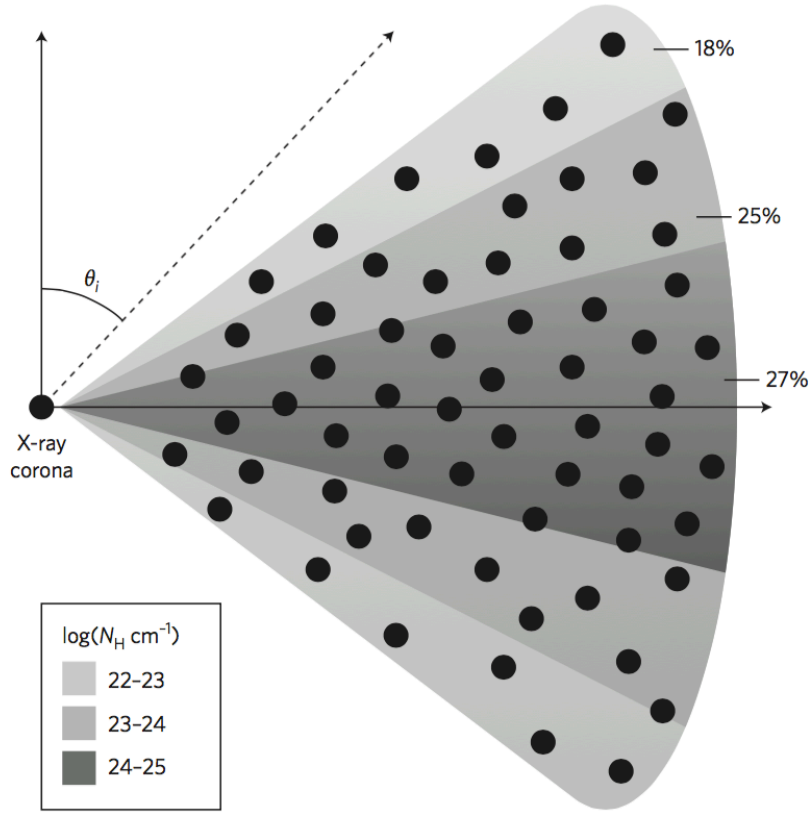
Boorman et al. (2016)

The Covering factor of gas and dust



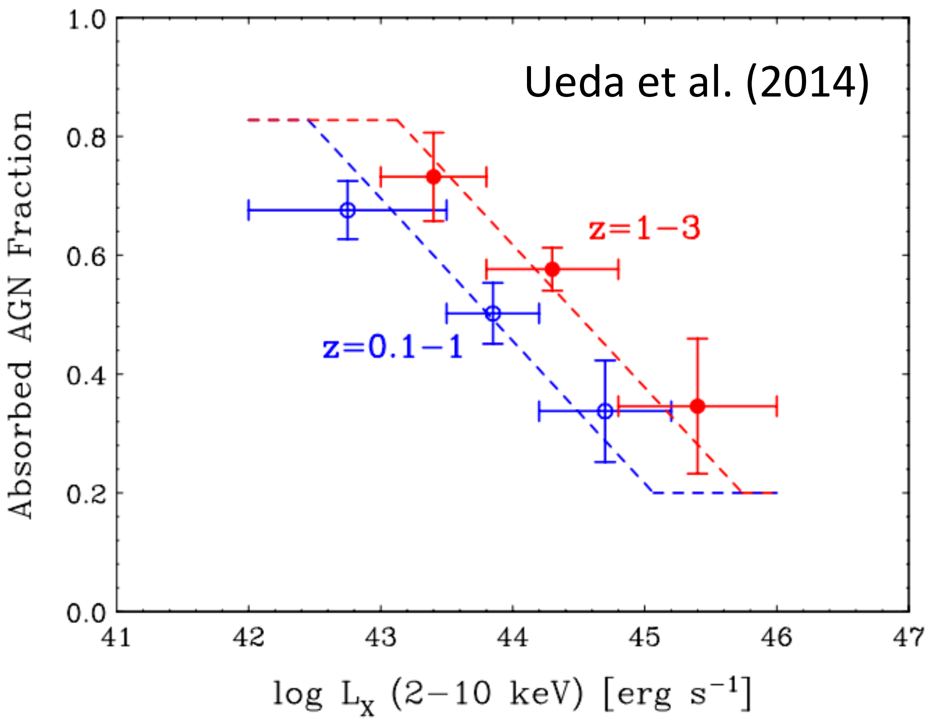
Annuar et al. (in prep.),

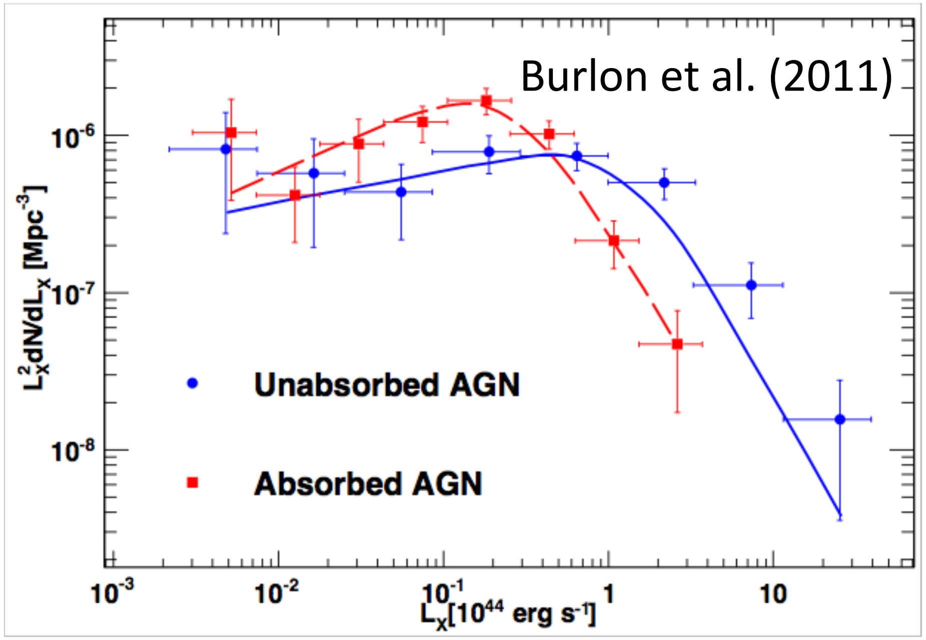
The Covering factor of gas and dust



Ramos Almeida & Ricci, Nature Astronomy 2017, see also Ricci et al. (2015); talks by P. Boorman, K. Ichikawa, S. Mateos, L. Lanz

Luminosity-dependent obscuration

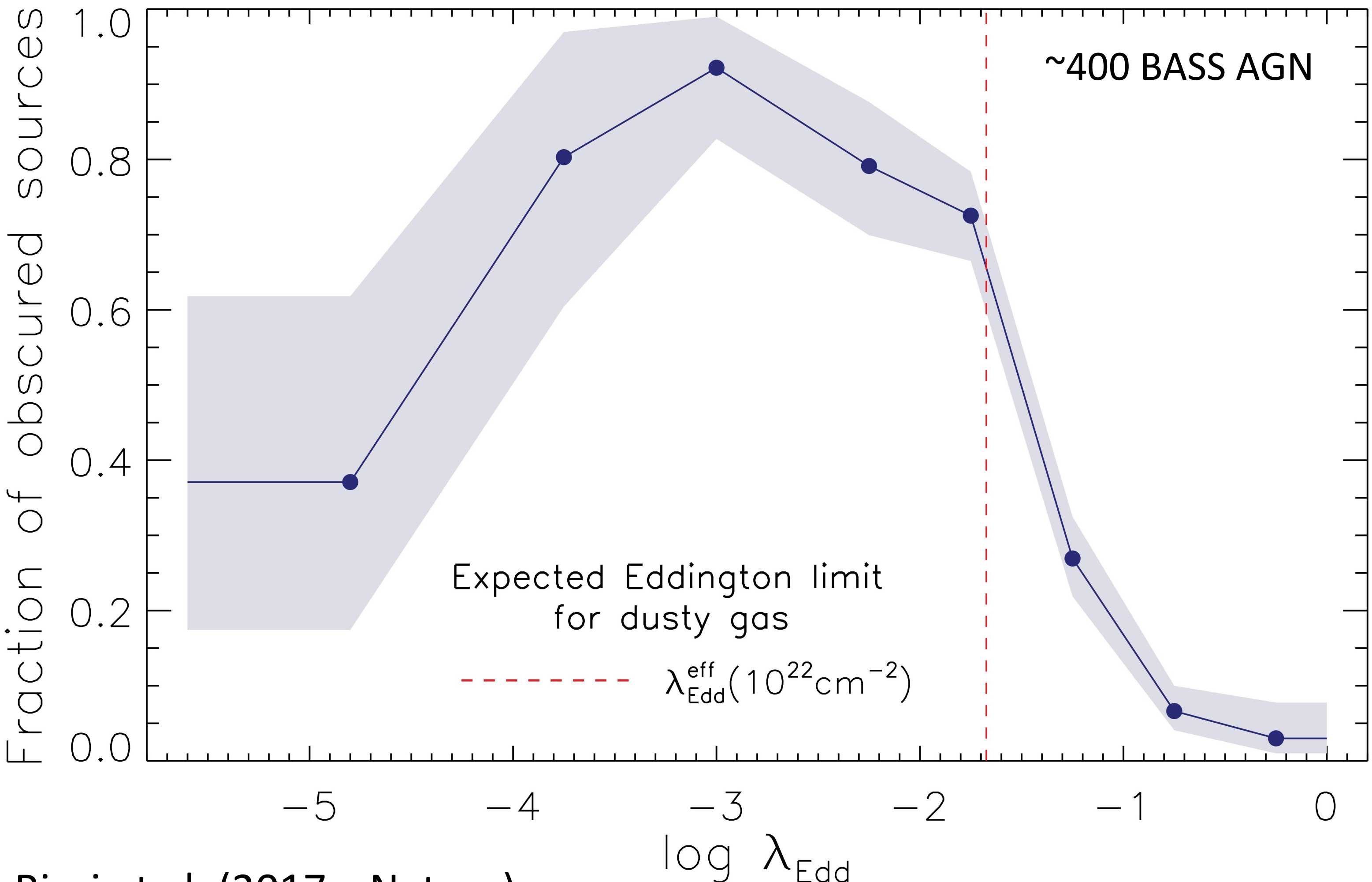




see also Ueda et al. (2003, 2011), LaFranca+05, Sazonov+07, Hasinger 08, DellaCeca+08, Beckmann+09, Brightman+11, Merloni+14, Buchner+15, Aird+15, Sazonov+16, Georgakakis+17, Mateos+17, Ricci+17

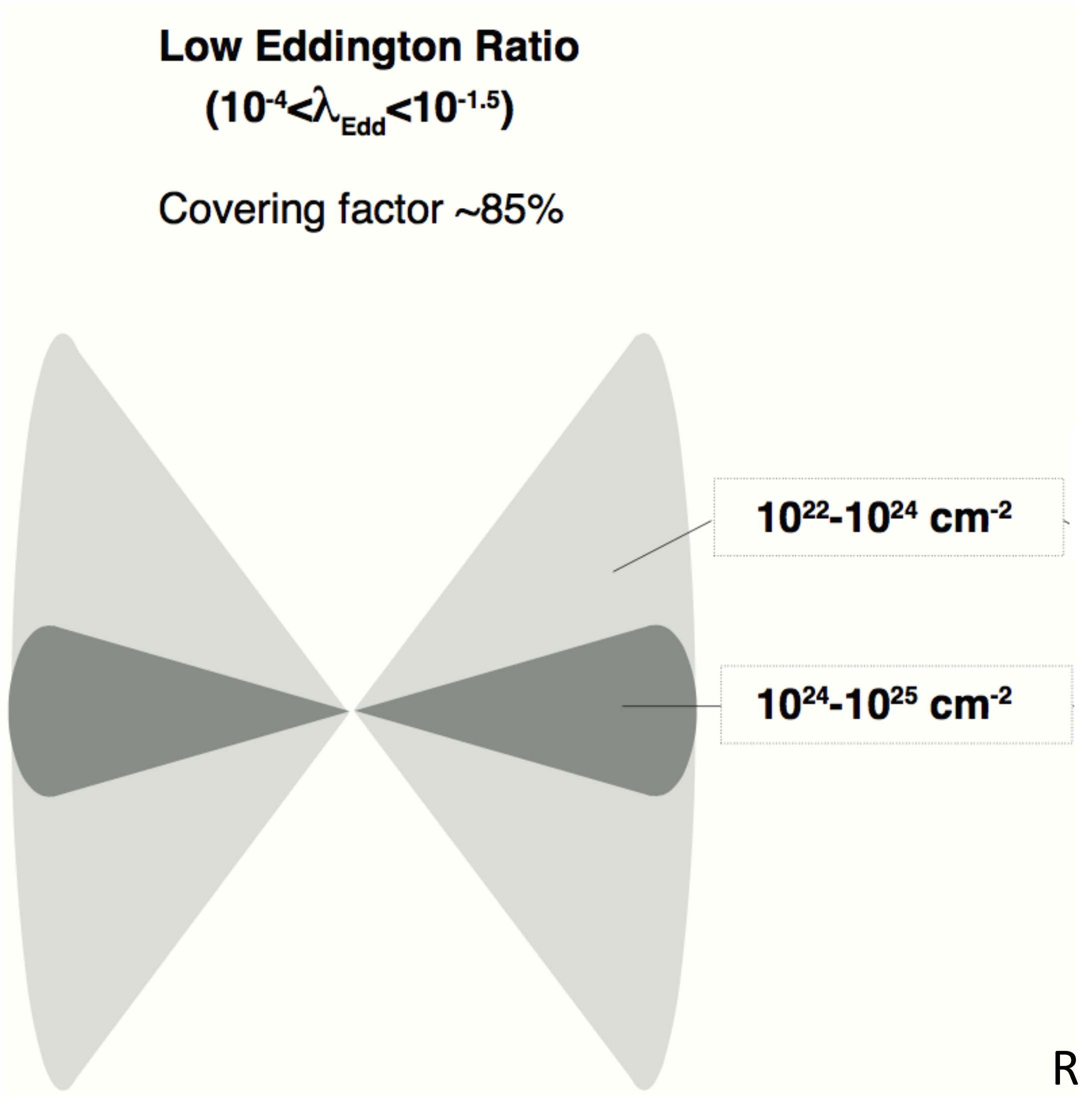
See talks by C. Ramos Almeida, K. Ichikawa, S. Mateos, L. Lanz

Obscuration vs Eddington ratio



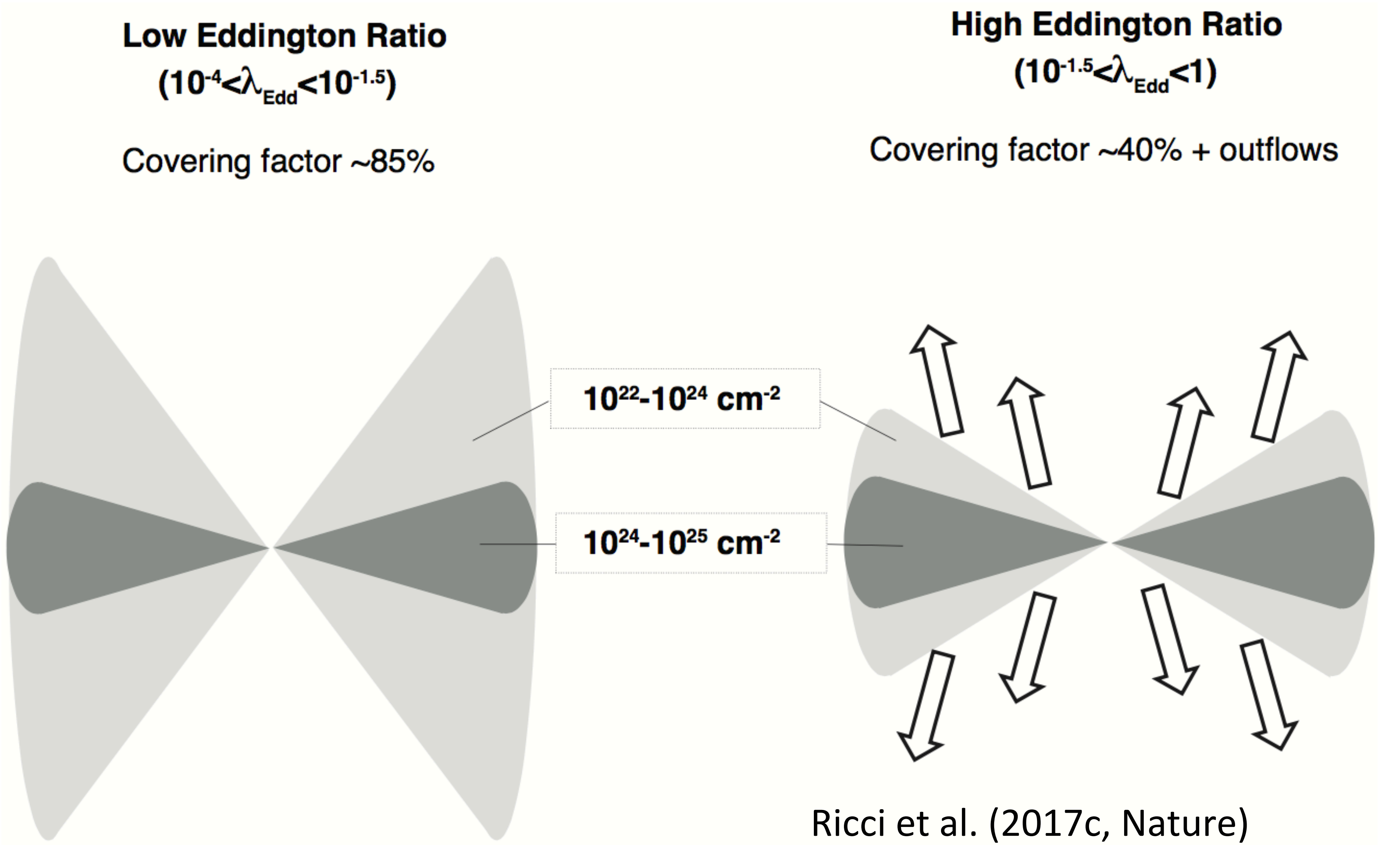
Ricci et al. (2017c, Nature)

Radiation-regulated unification



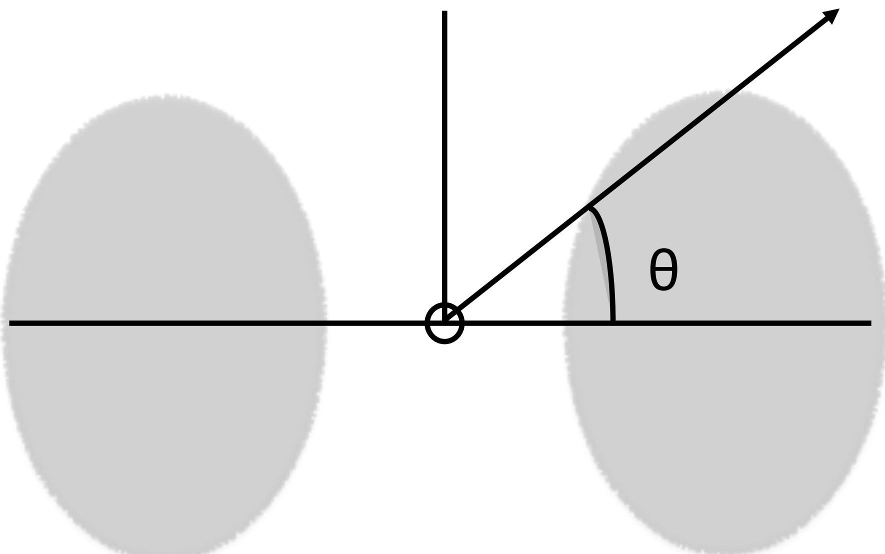
Ricci et al. (2017c, Nature)

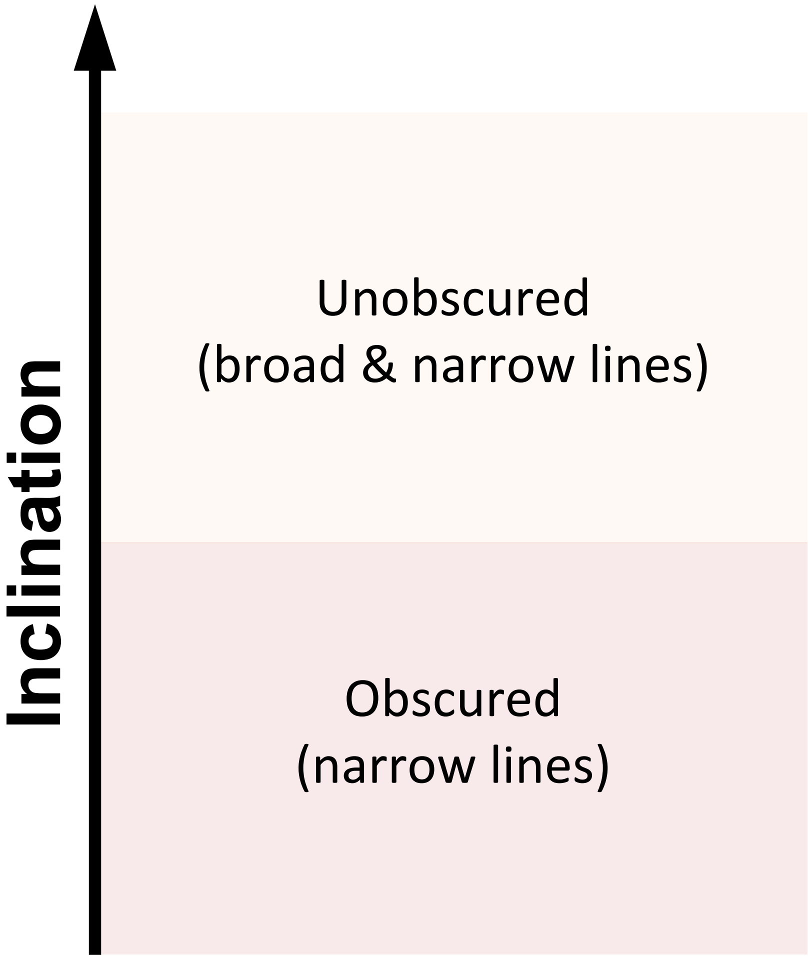
Radiation-regulated unification



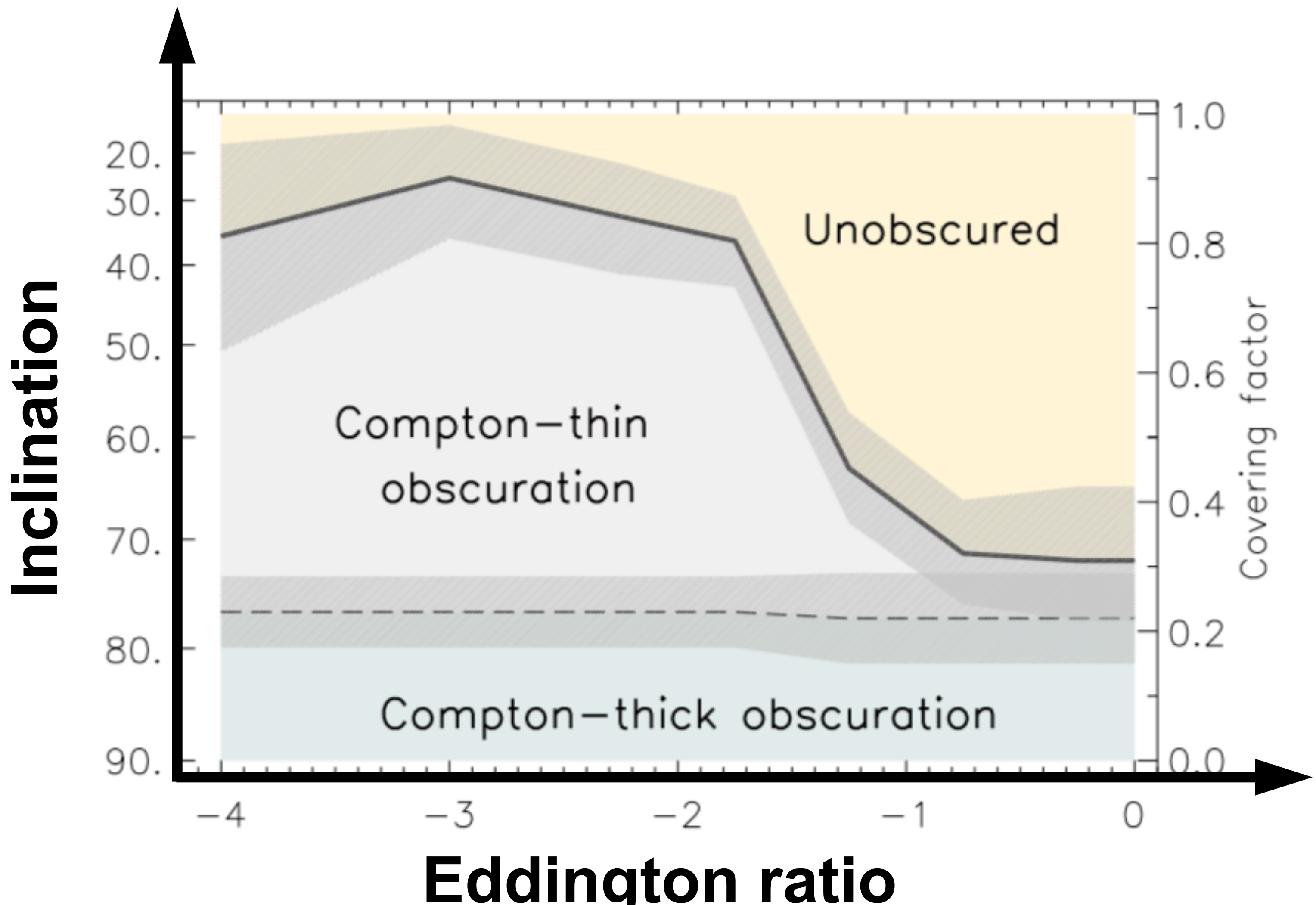
Ricci et al. (2017c, Nature)

AGN unification

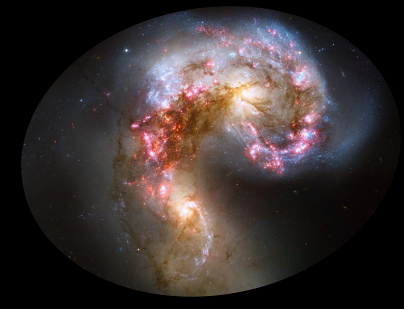


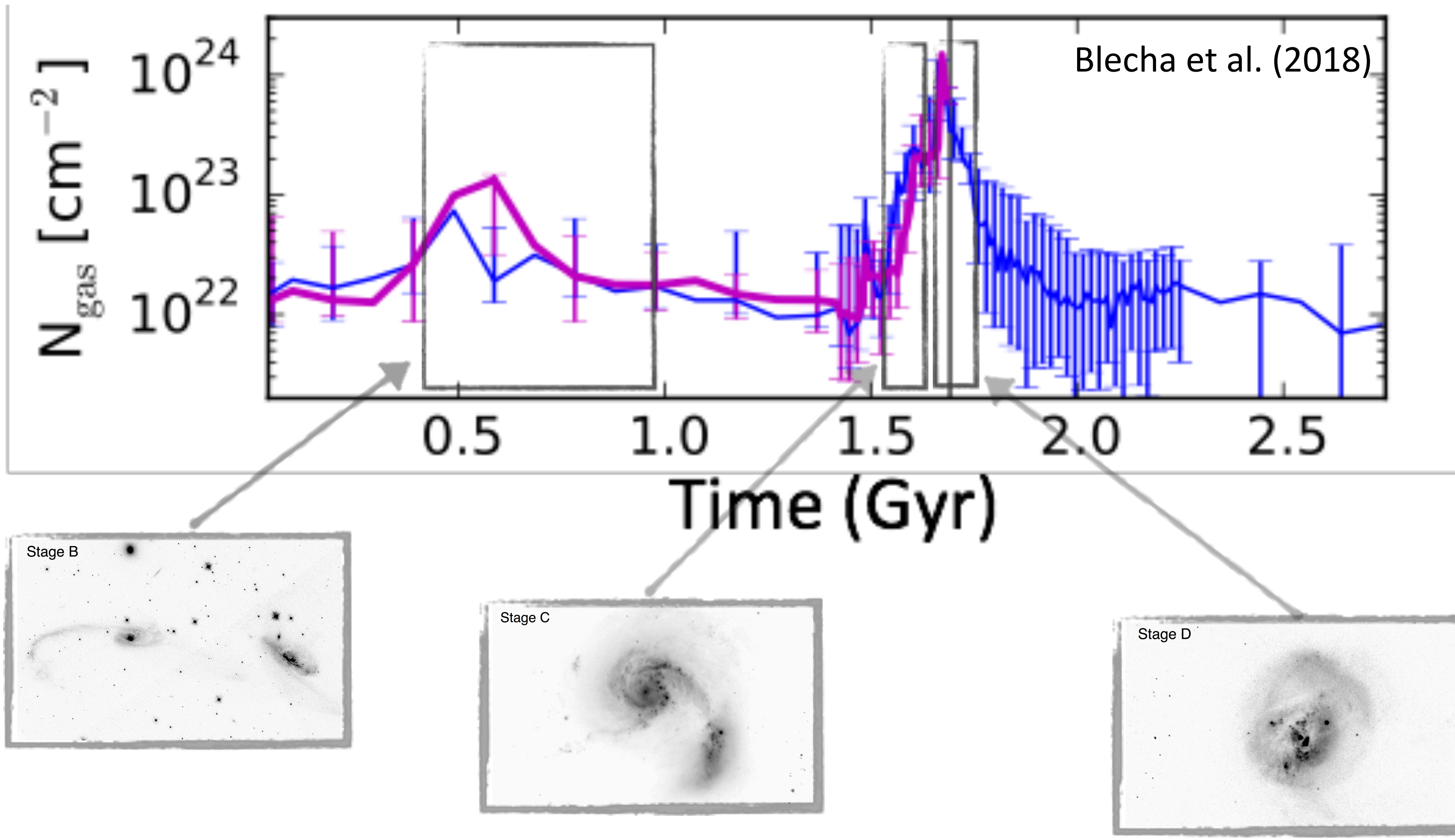


Radiation-regulated unification

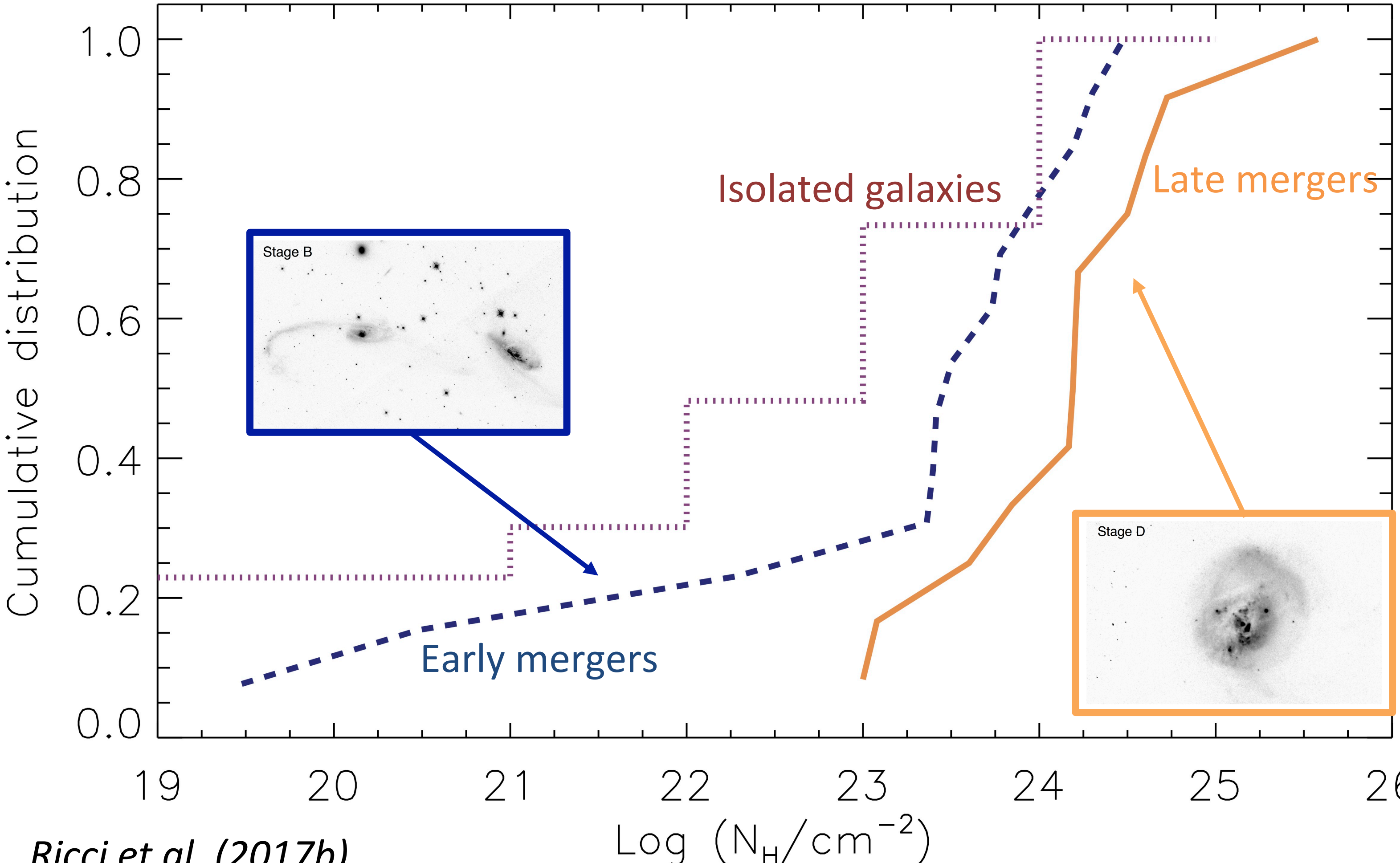


Galaxy mergers and obscuration





Galaxy mergers and obscuration

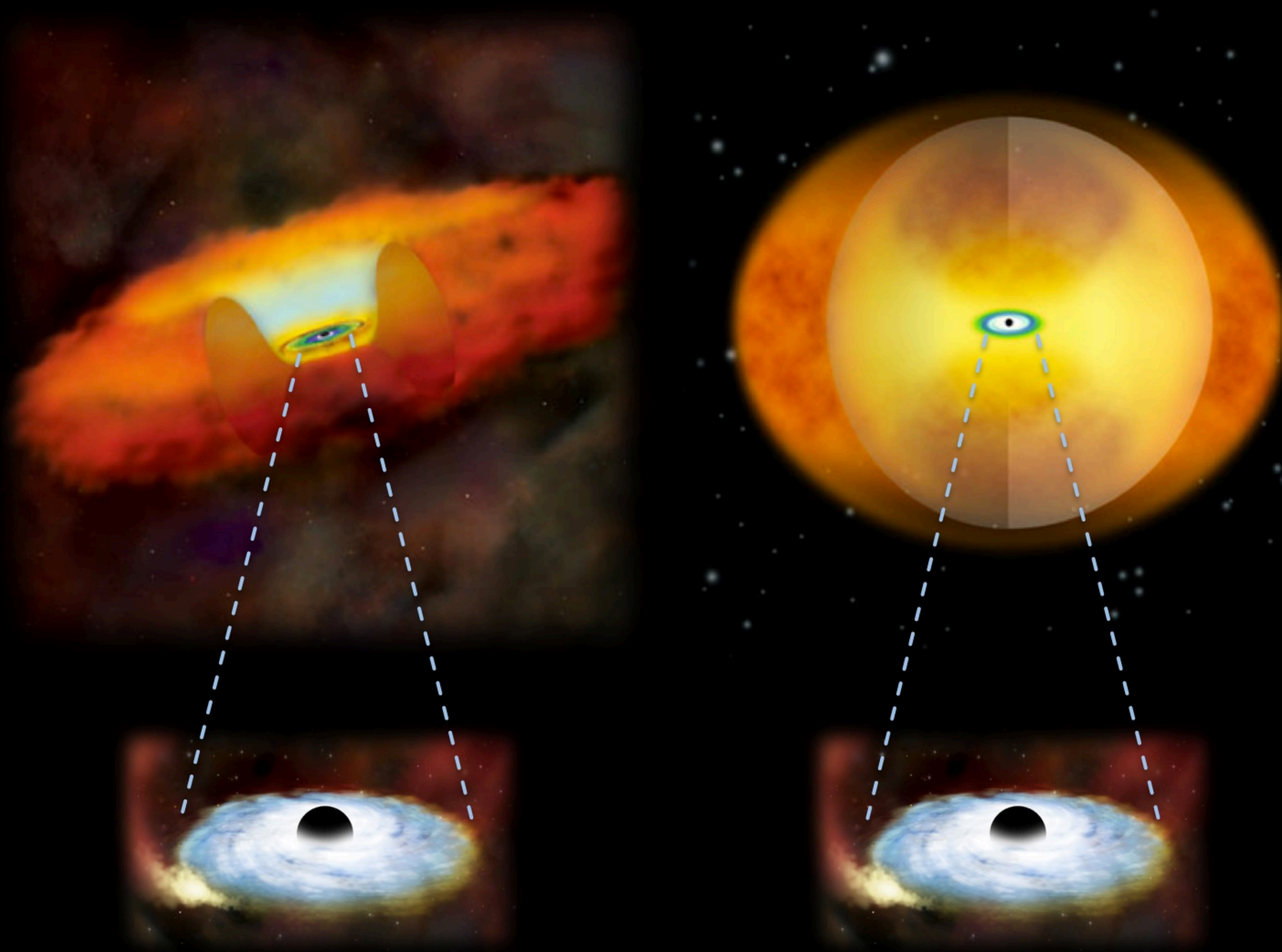


Ricci et al. (2017b)

See also Kocevski et al. (2015), Lanzuisi et al. (2015), Lansbury et al. (2017b), Del Moro et al. (2016), Koss et al. (2016), De Rosa et al. (2018), Koss et al. (2018); Talks by R. Pfeifle, E. Treister, C. Carroll

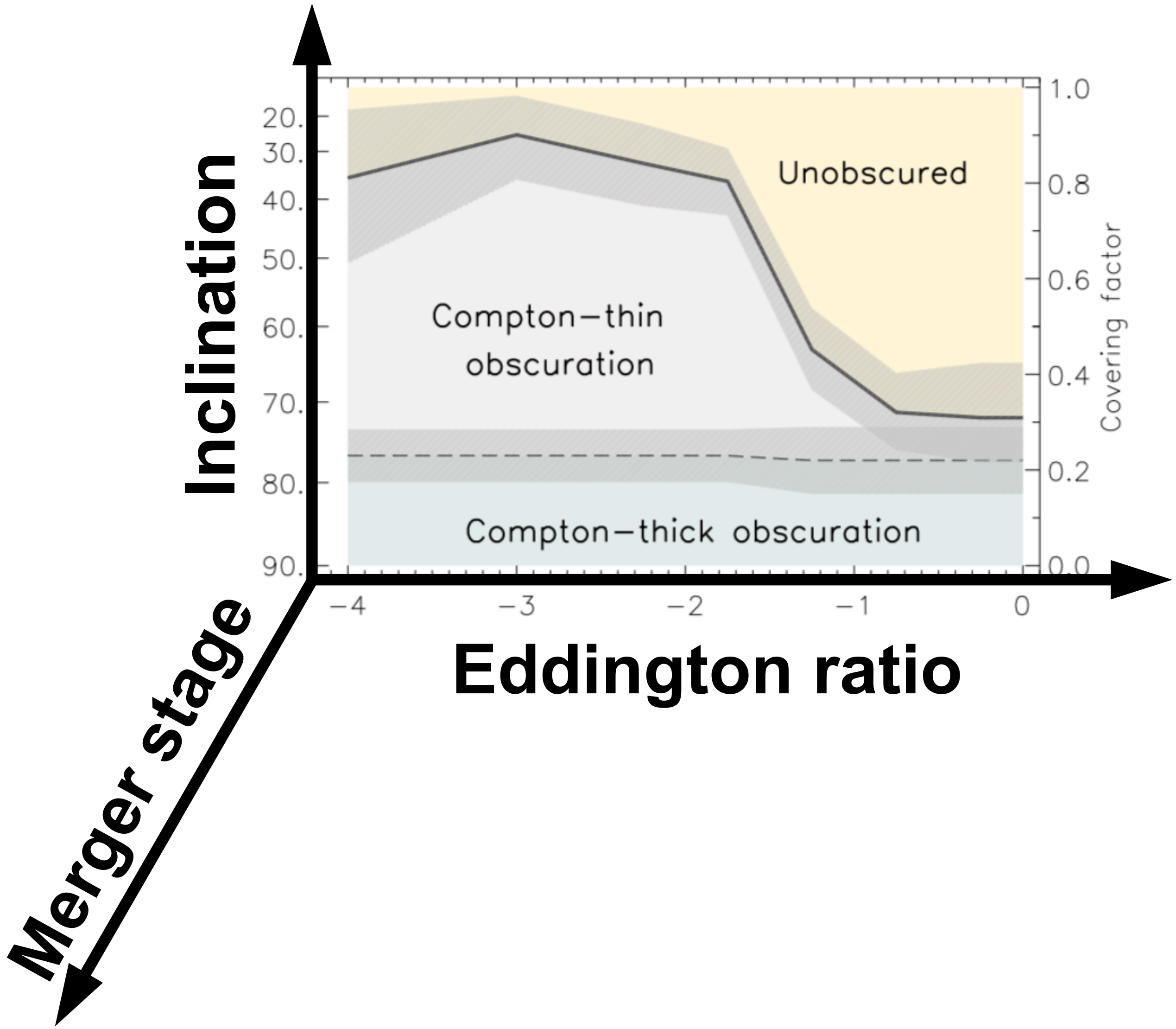
Isolated galaxies

Late stages of merger



From the NASA press release; Credits: NAOJ/NASA/CXC/M. Weiss (Imanishi et al. 2006)

The drivers of obscuration



Summary

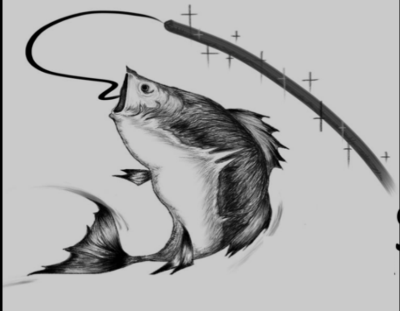
- X-rays are a great probe of the circumnuclear environment of AGN
- Studies of reprocessed X-ray radiation have shown elongated emission
- More and more complex X-ray spectral models are being developed
- Absorption variability show a dynamic environment
- Hard X-ray surveys have allowed to infer the typical covering factor of local AGN
- Covering factor depends on the Eddington ratio
- Probability of observing obscured AGN is very high in close mergers

AGN in Santiago

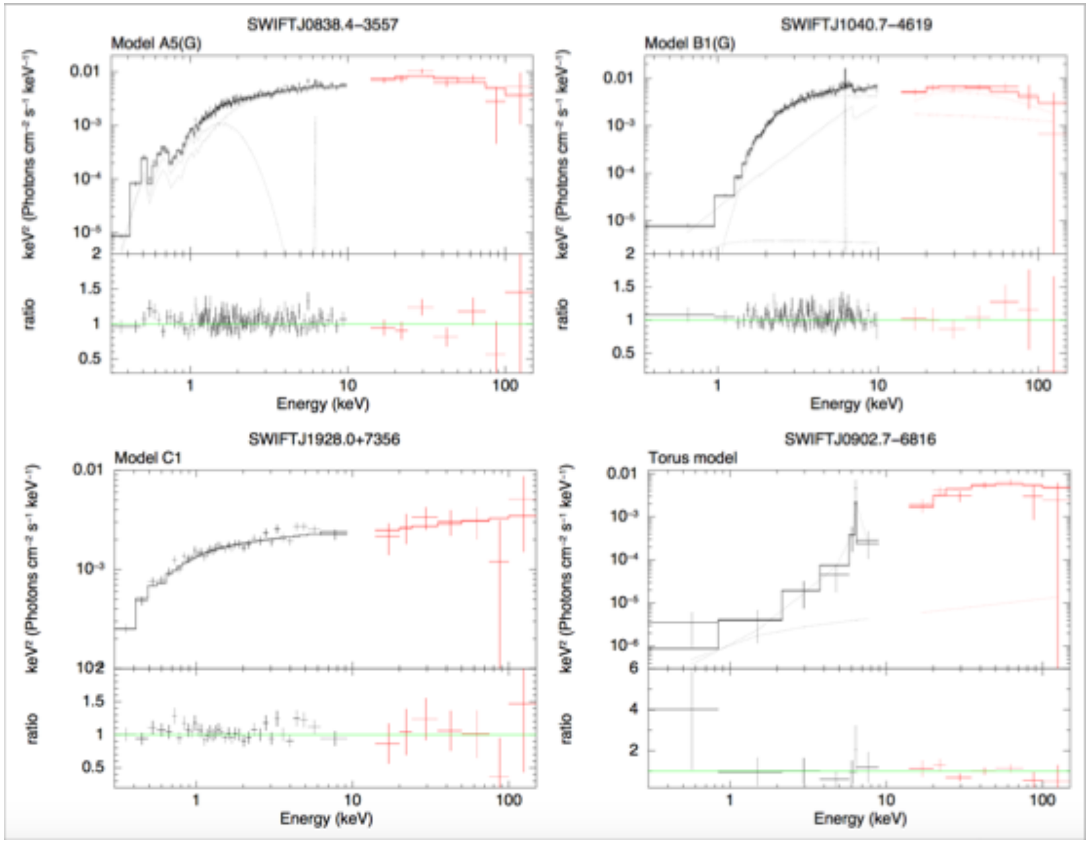
www.agnsantiago.cl

BACK UP SLIDES

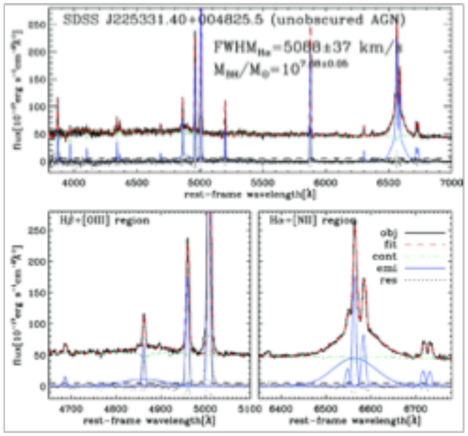
The BAT AGN Spectroscopic Survey (BASS)

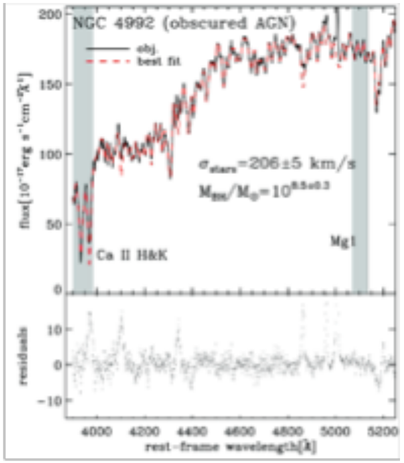


X-ray spectroscopy (Ricci et al. 2017d)



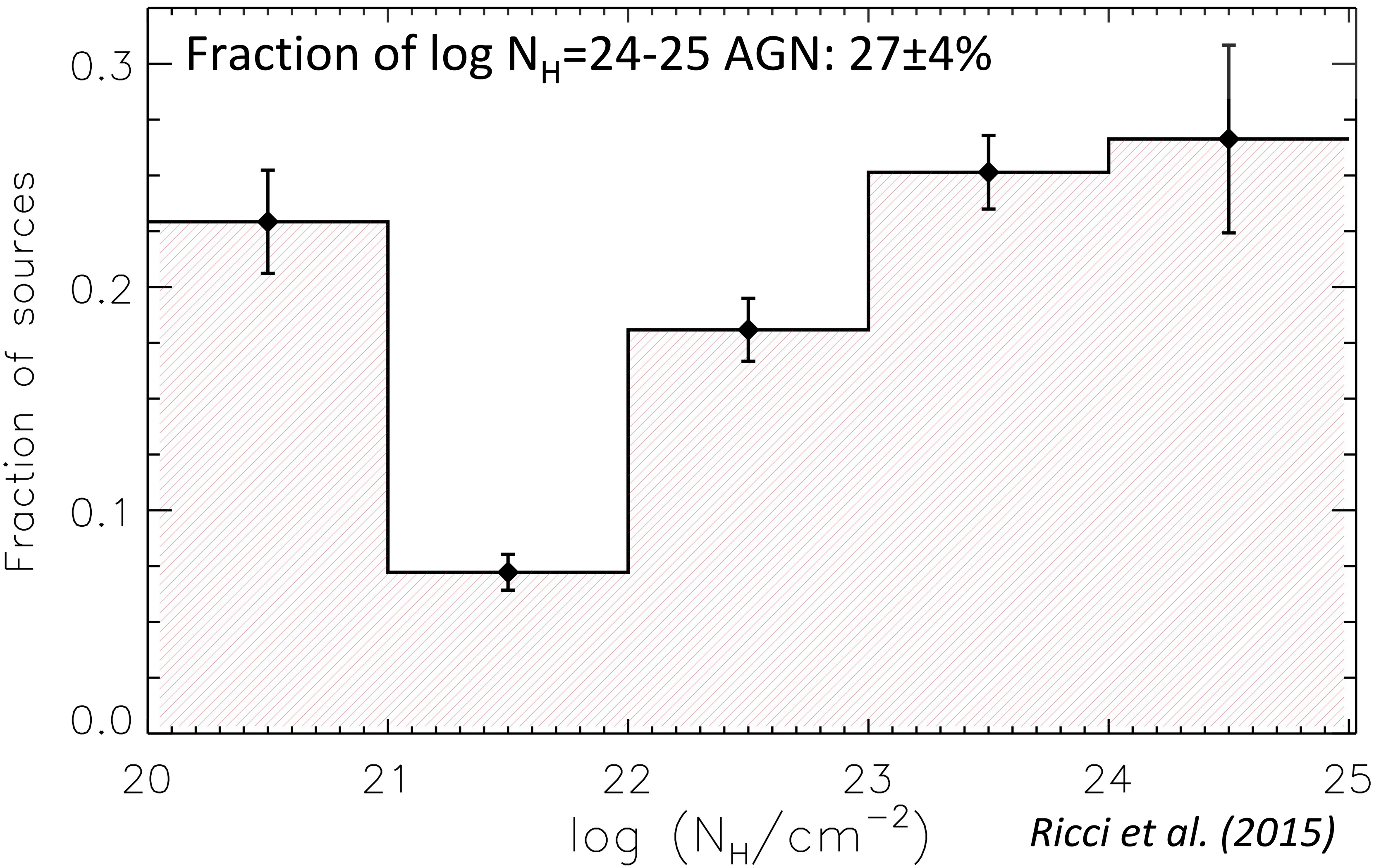
Optical spectroscopy (Koss et al. 2017)





Talk by M. Koss

Intrinsic column density distribution



Ricci et al. (2015)

Covering factor of gas and dust

X-rays

1) Fraction of obscured AGN
   (e.g., Ueda+03,11, Brightman+11,
   Merloni+14, Buchner+15, Aird+15)

2) Spectroscopy with torus models
   (e.g., Brightman+15, Balokovic+ prep.)

Covering factor of gas and dust

X-rays

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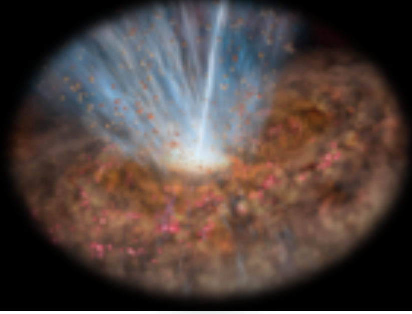
Infrared

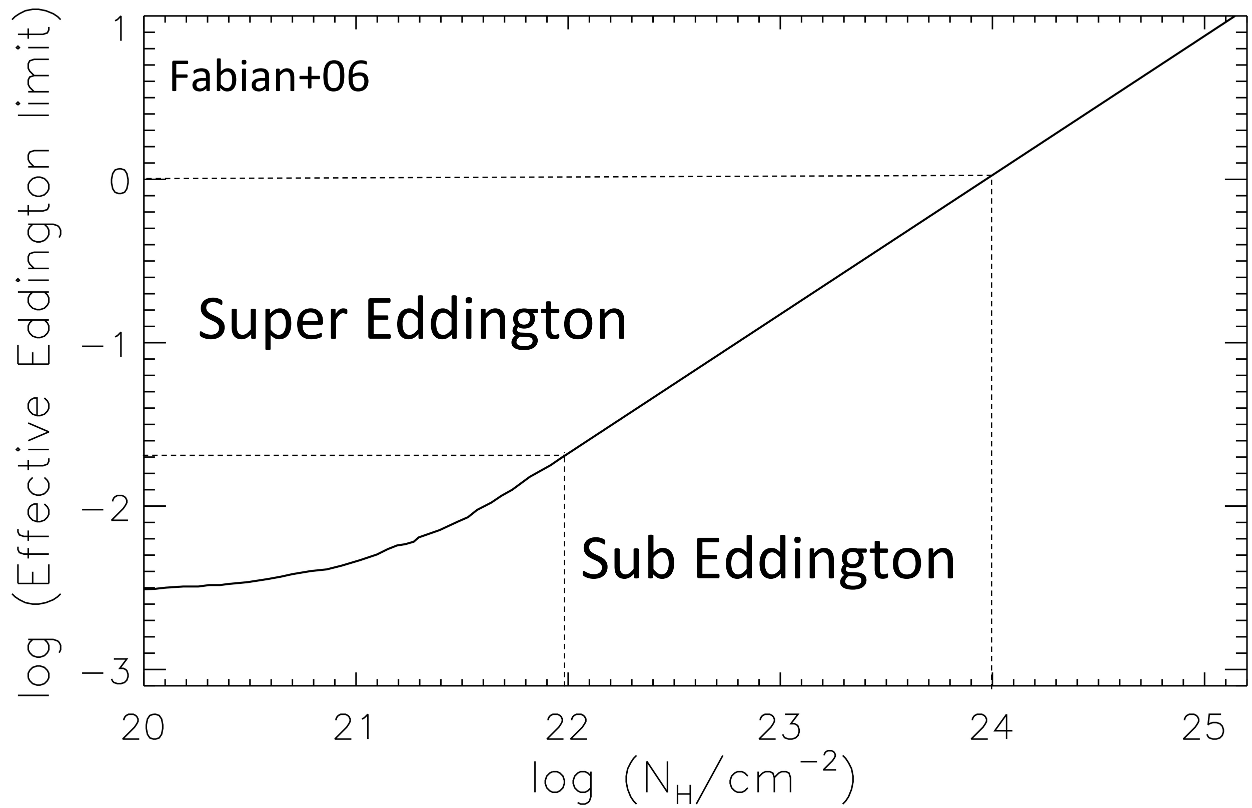
1) L_{IR}/L_{Bol}
   (e.g., Maiolino+07, Treister+08, Assef+13, Mateos+16, Ichikawa+17)

2) Spectroscopy with torus models
   (e.g., Alonso Herrero+11, Ramos Almeida+11)

Radiation pressure on dusty gas



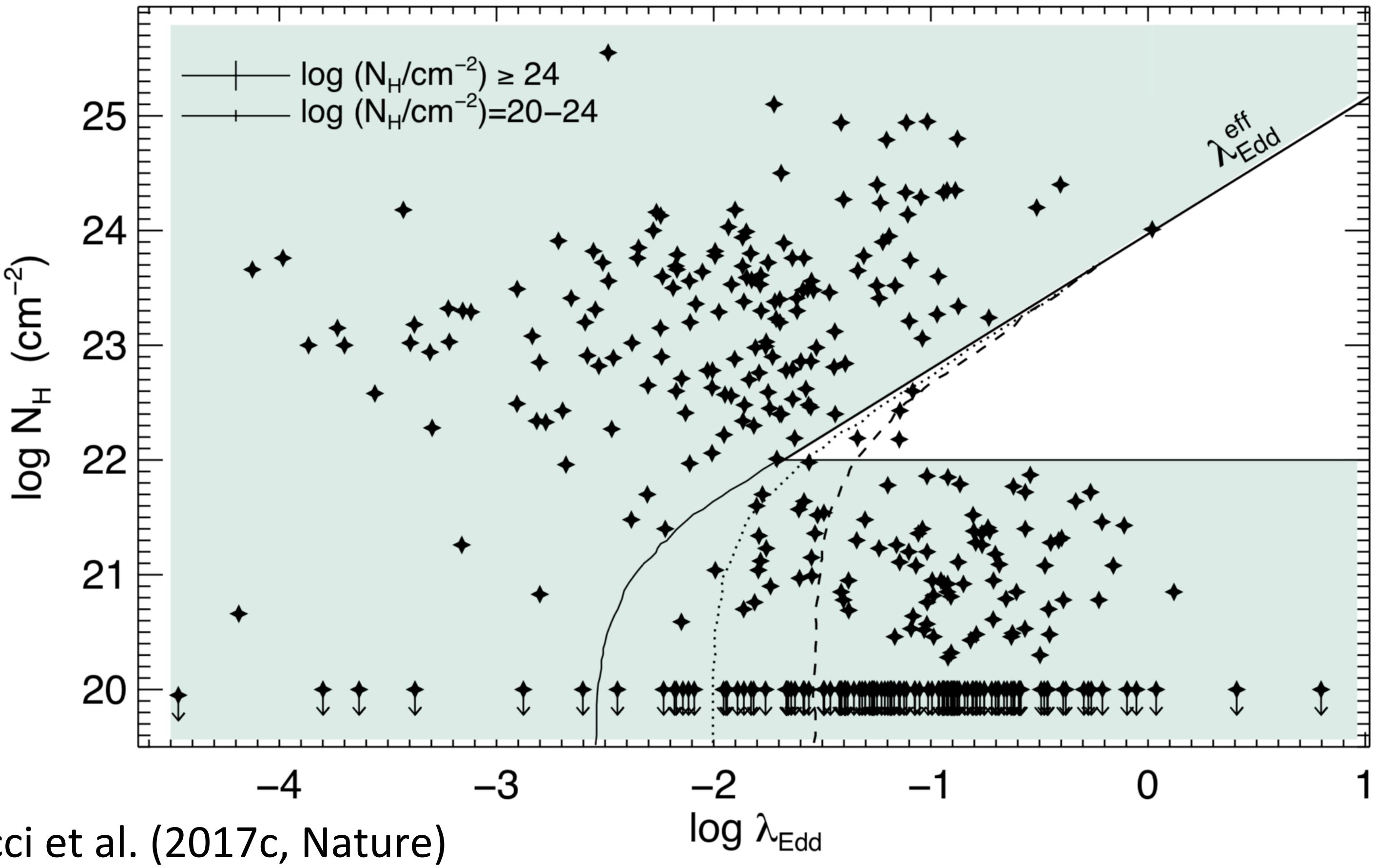
Effective Eddington limit $\lambda_{Edd}^{eff} = \sigma_T / \sigma_i(N_H; \xi)$



see also Fabian+08; Fabian+09; Raimundo+10; Vasudevan+13, Ishibashi+18

Radiation pressure on dusty gas

Effective Eddington limit $\lambda_{Edd}^{eff} = \sigma_T / \sigma_i(N_H;\xi)$



Ricci et al. (2017c, Nature)

Radiation pressure on dusty gas

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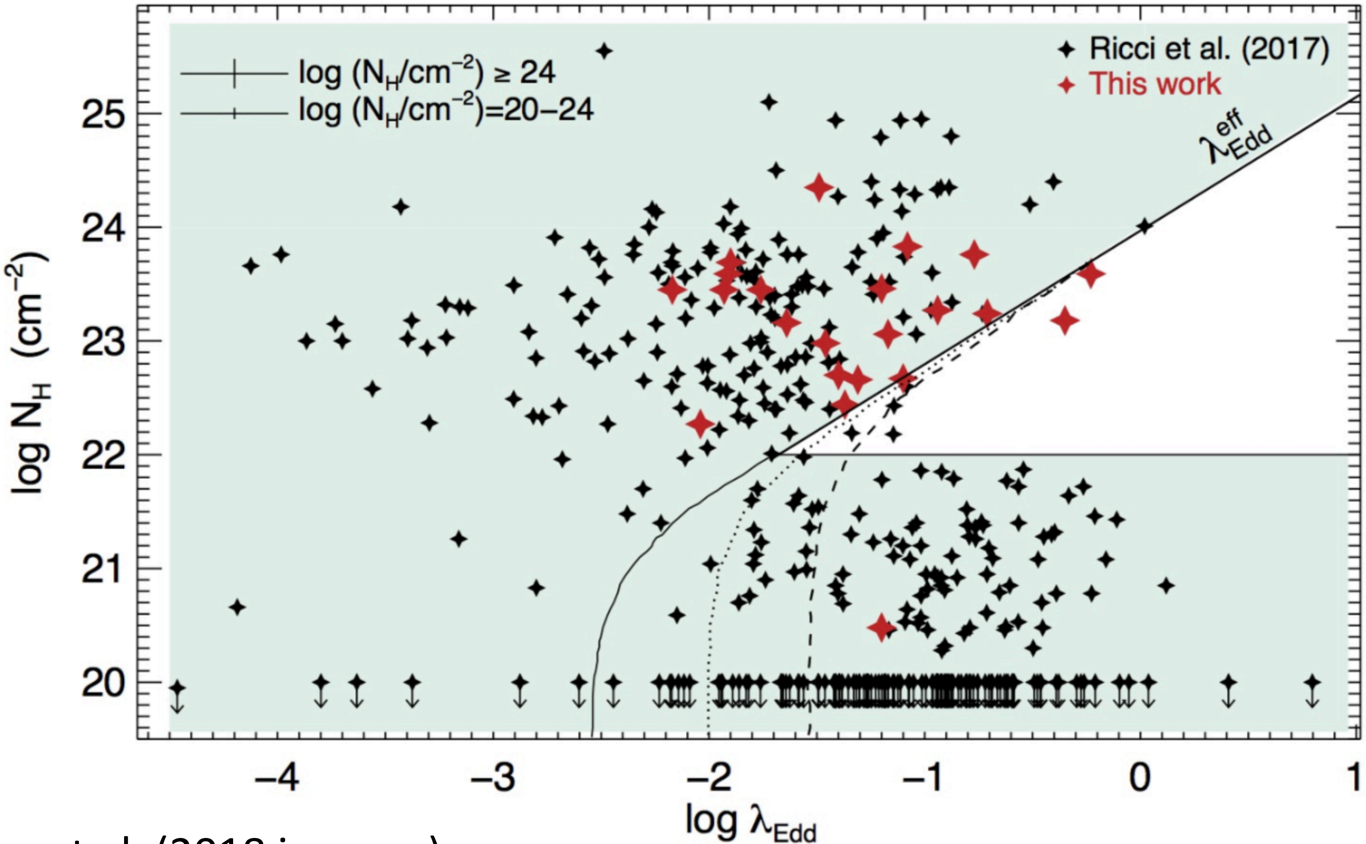
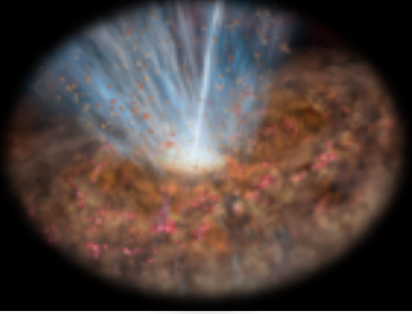
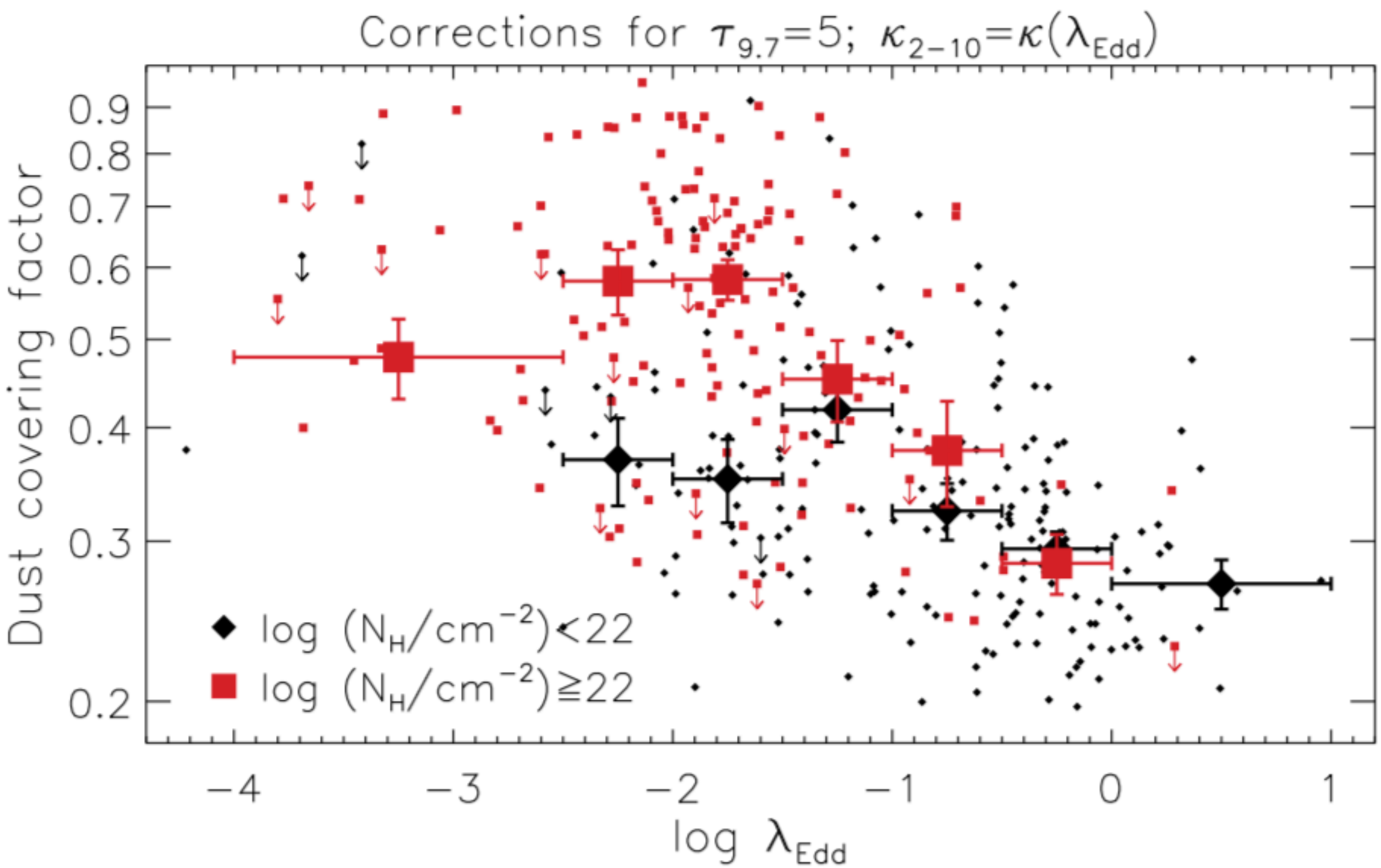


Baer et al. (2018 in prep.)

The covering factor of dust

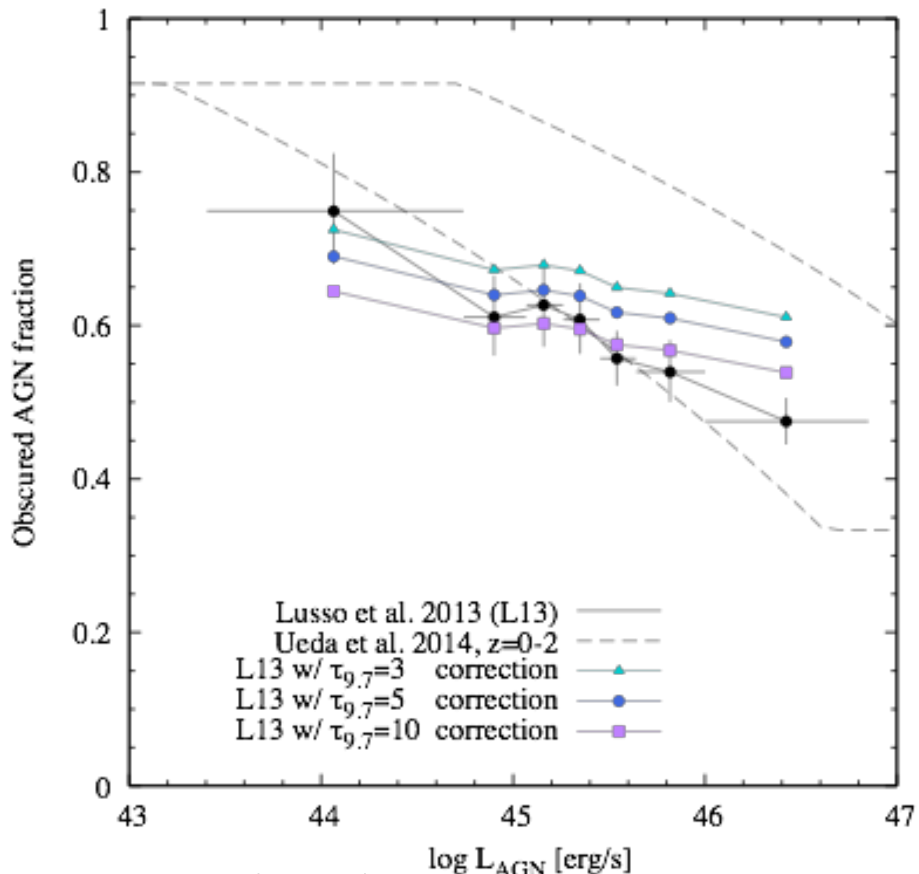


Covering factor from L_{IR}/L_{Bol}; ~360 BASS AGN



Ricci et al. (2018, in prep.); see also Ezhikode et al. (2017), Zhuang et al. (2018)

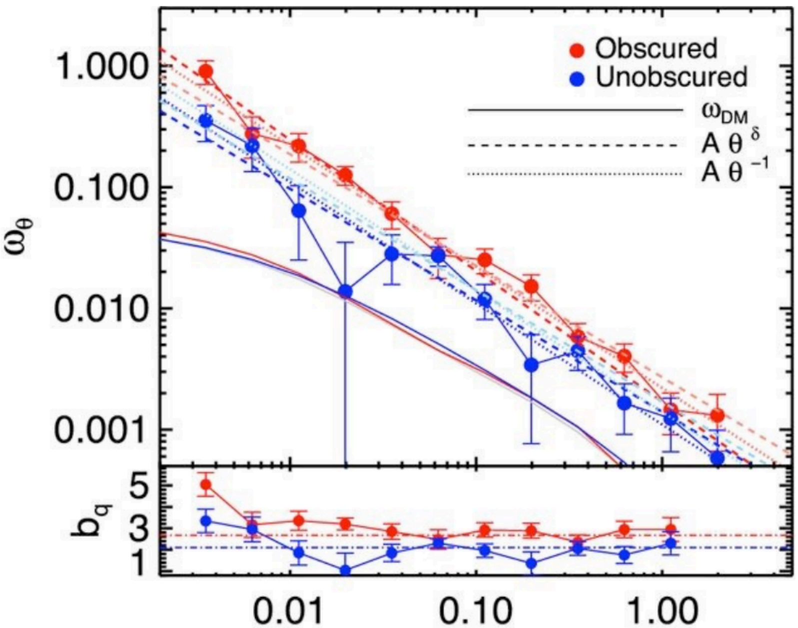
Luminosity dependence of obscuration - IR



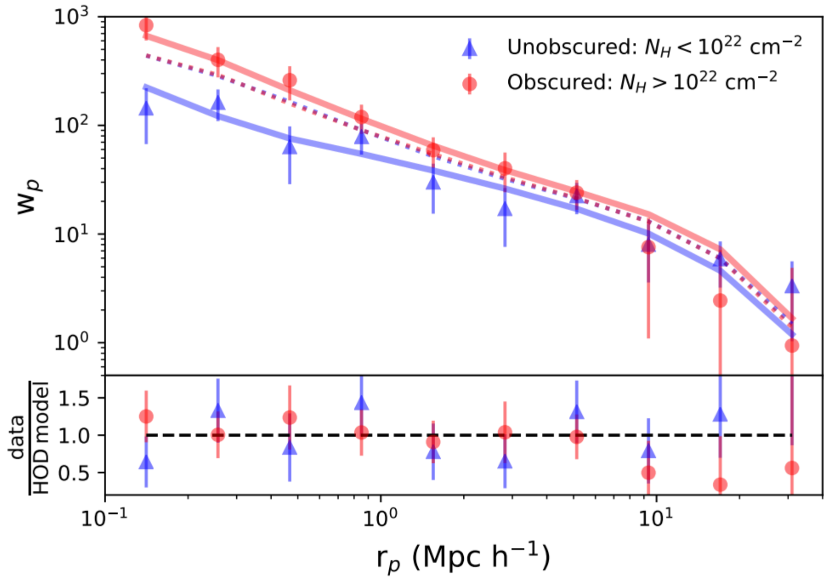
Stalevski et al. (2016)

see also Maiolino et al. (2007), Treister et al. (2008), Assef et al. (2013), Ichikawa et al. (2017), talk by S. Mateos

Clustering and obscuration



DiPompeo et al. (2014)

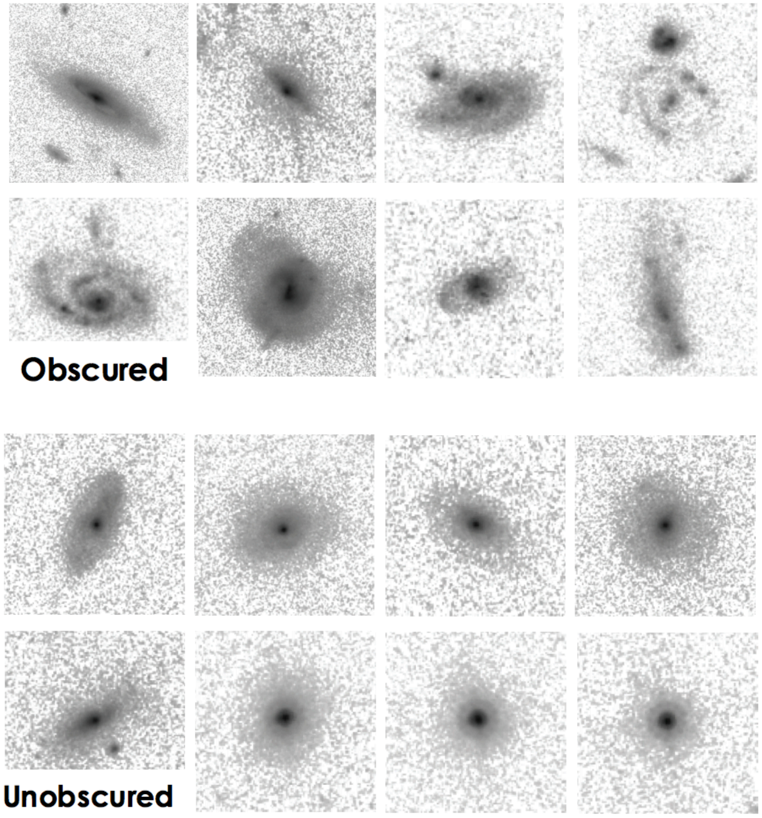


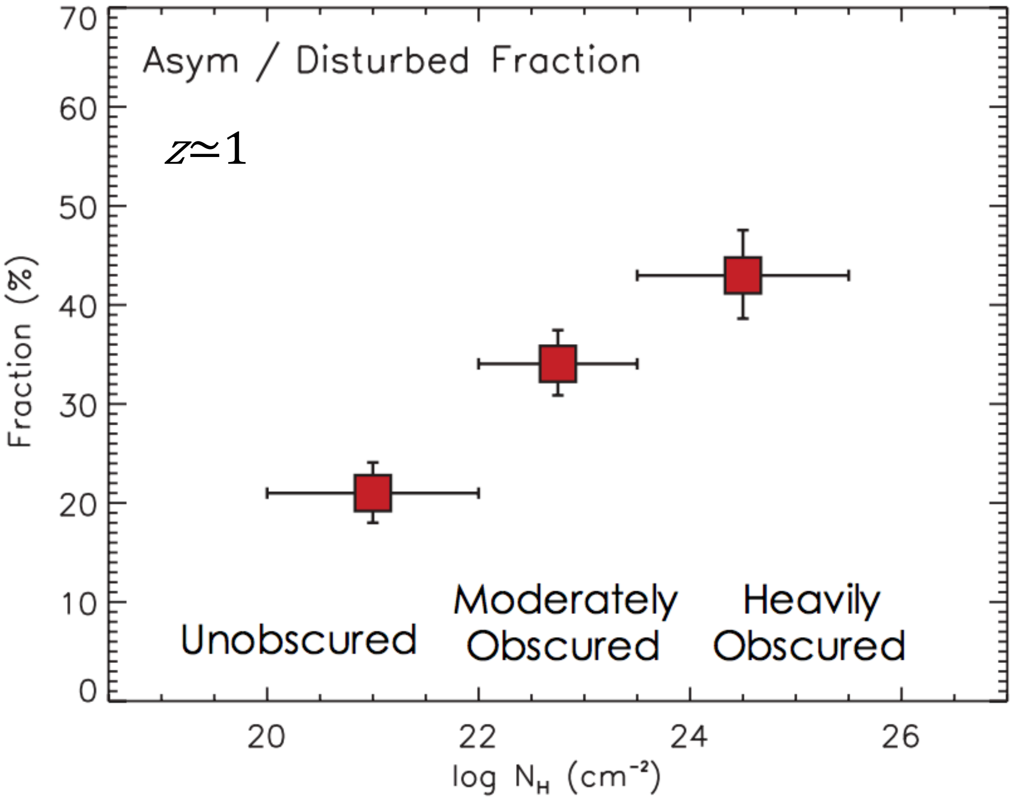
Powell et al. (2018)

See also Hickox et al. (2009), Allevato et al. (2011, 2014), Donoso et al. (2014), Di Pompeo et al. (2014, 2017a,b). See talk by V. Allevato, A. Masini

Obscured AGN tend to reside in denser environments than unobscured AGN

Galaxy mergers and obscuration

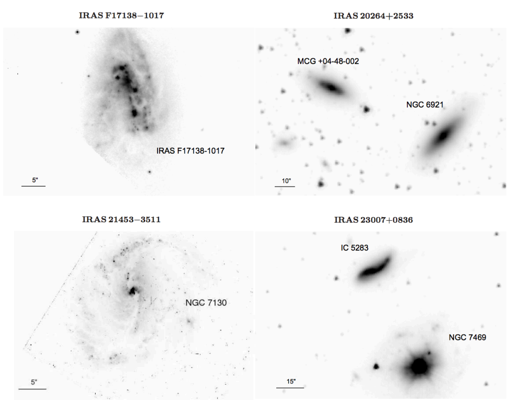


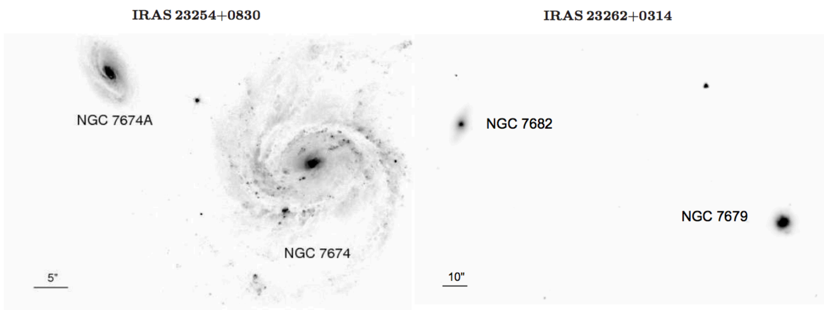


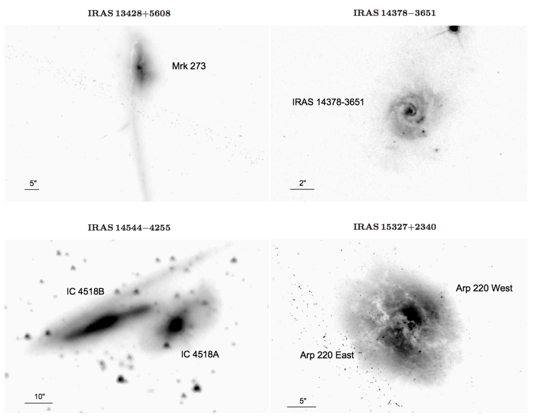
Kocevski et al. (2015)

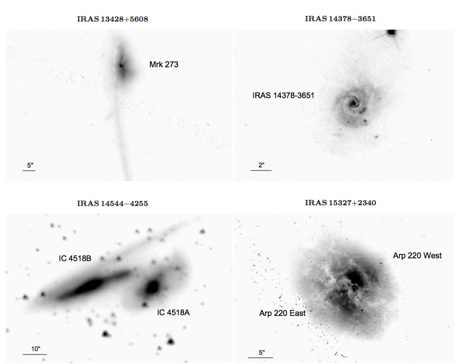
See also Lanzuisi et al. (2015), Lansbury et al. (2017b), Del Moro et al. (2016), Koss et al. (2016), De Rosa et al. (2018), Koss et al. (2018, submitted)

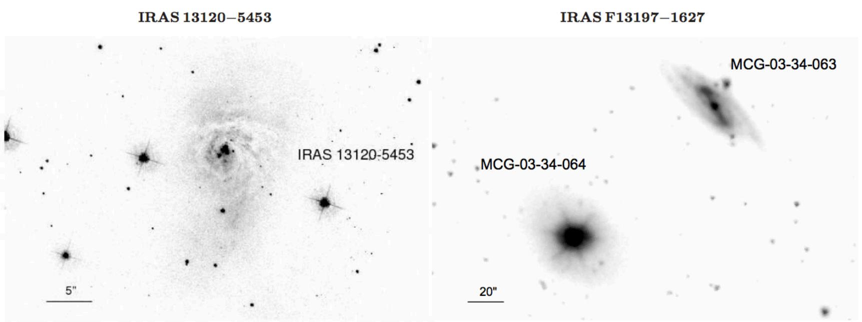
Obscuration properties of mergers

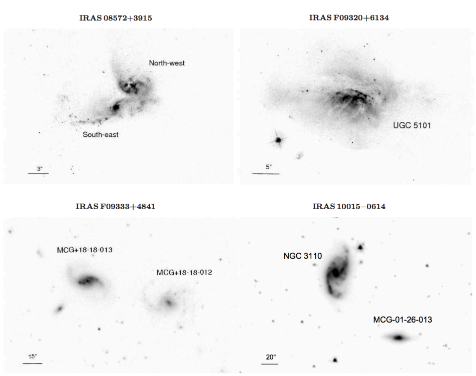


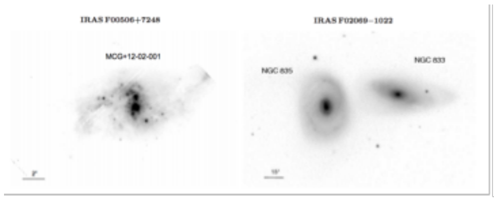


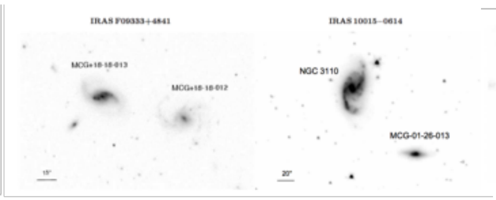


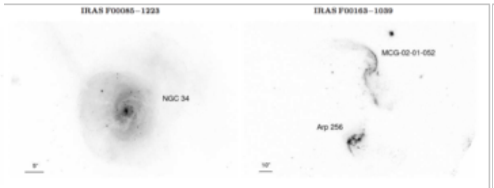


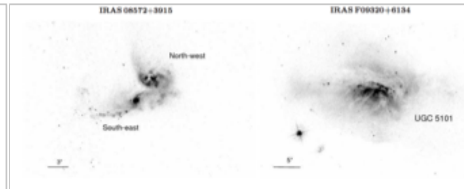




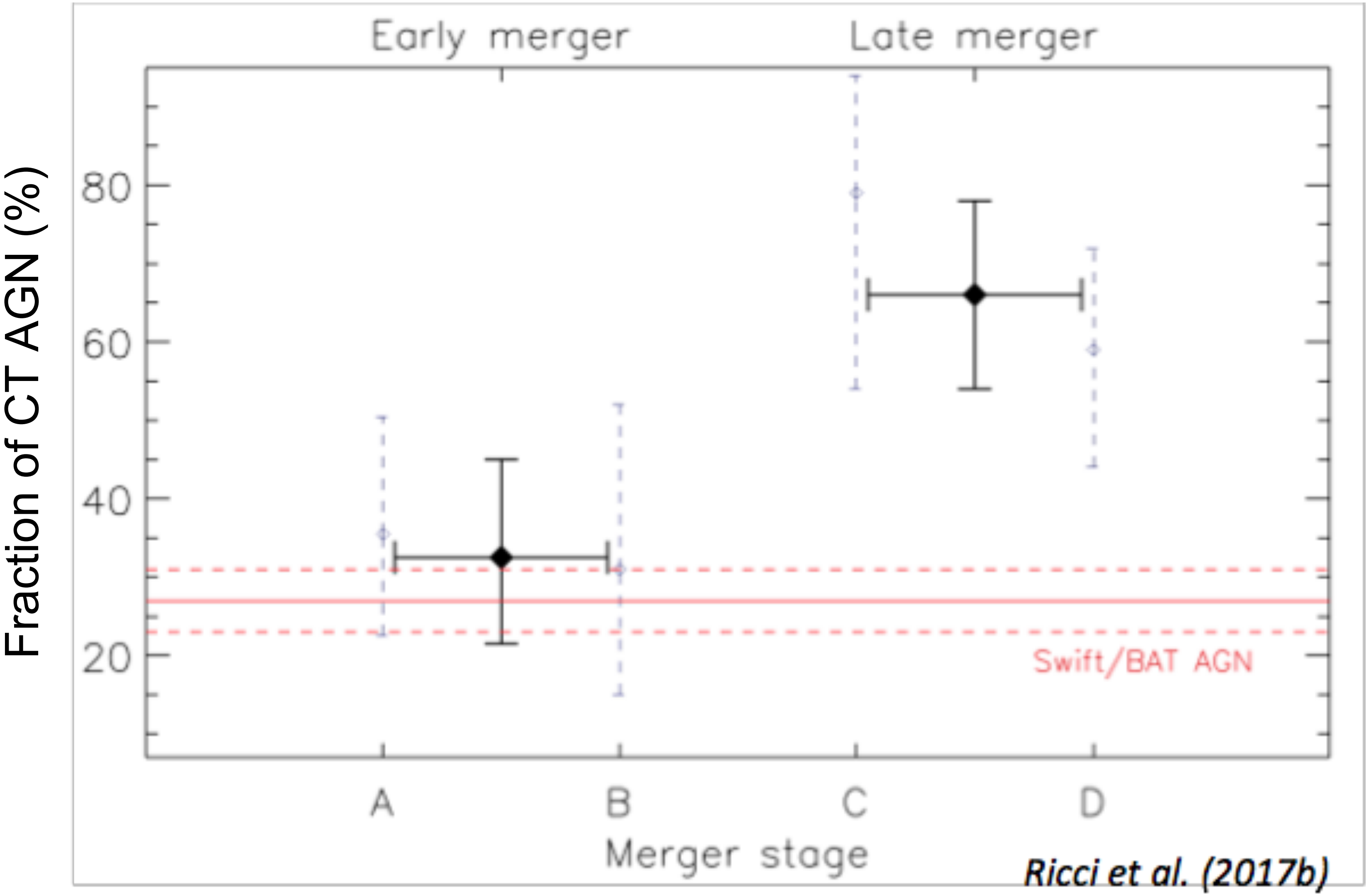






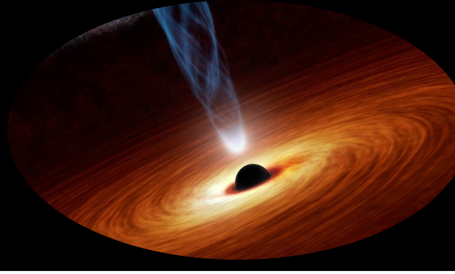


Obscuration properties of mergers

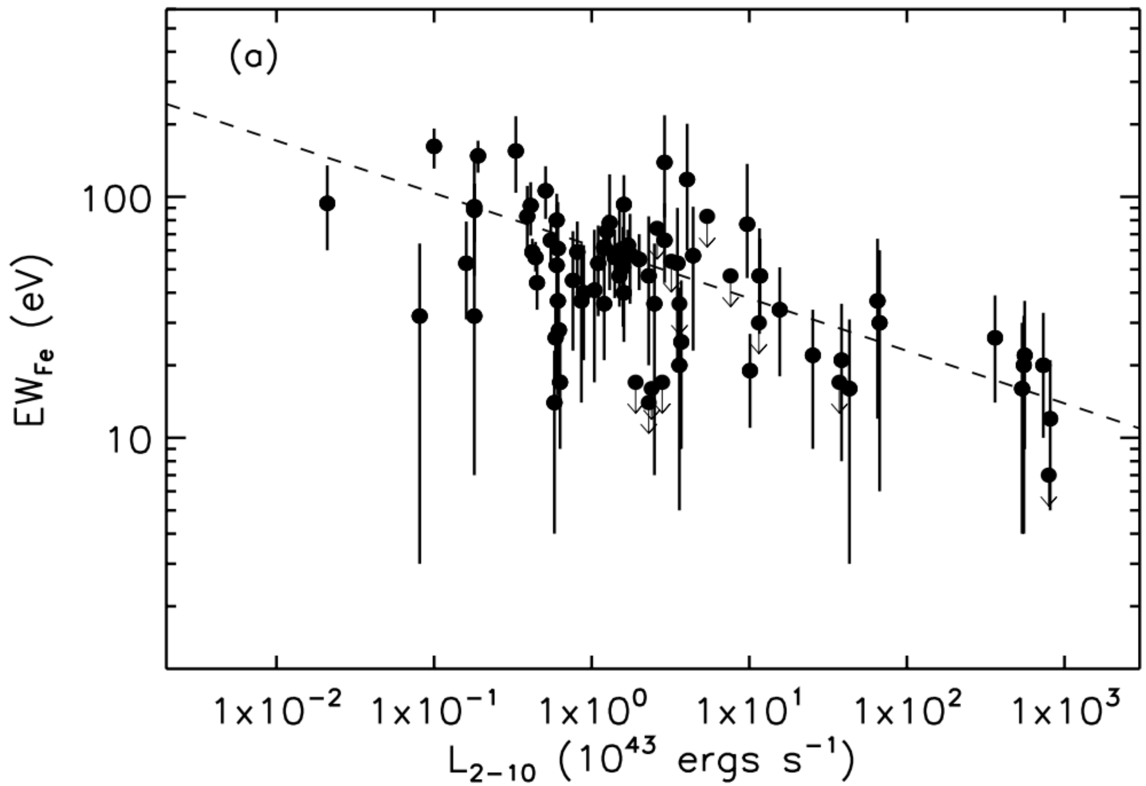


Ricci et al. (2017b)

The Iwasawa-Taniguchi effect

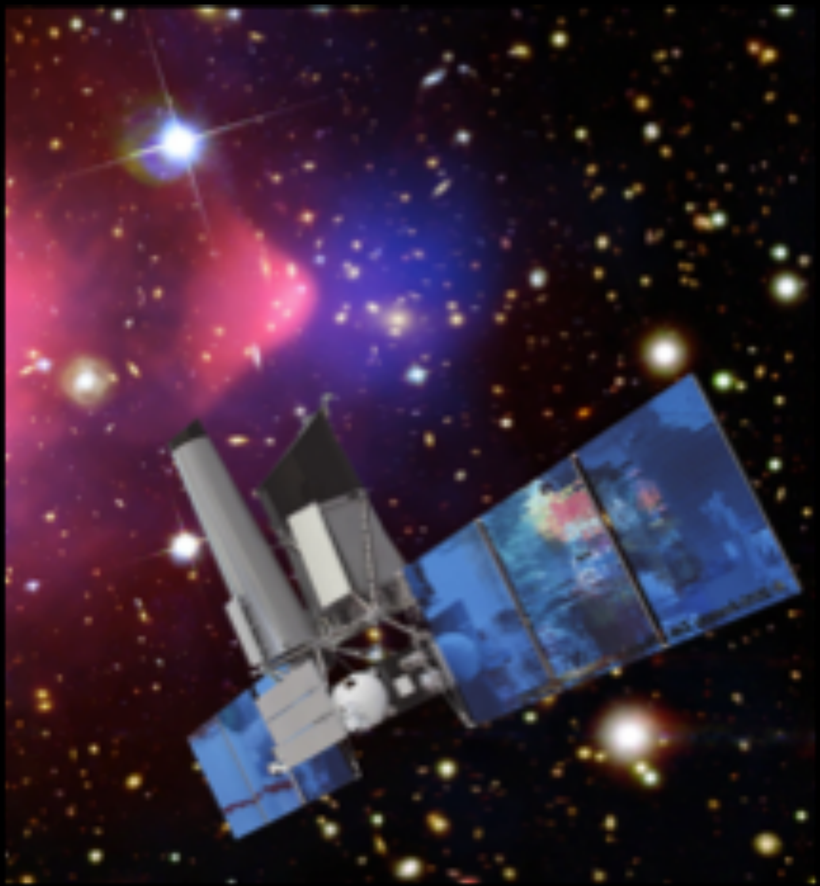


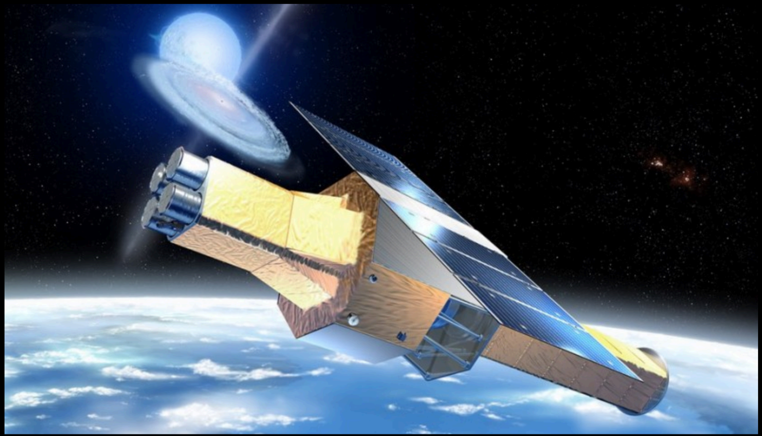
Iwasawa & Taniguchi (1993), Bianchi et al. (2007), Shu et al. (2010, 2011), Ricci et al. (2013,2014), Boorman et al. (2018)



Shu et al. (2010), see P. Boorman's talk

X-ray studies of obscured AGN: the future





Talk by M. Salvato

X-ray studies of obscured AGN: the future