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NARODOWE CENTRUM NAUKI

Absorption Measure Distribution in Active Galactic Nuclei

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AGN Winds on the Georgia Coast , 25-29 June 2017

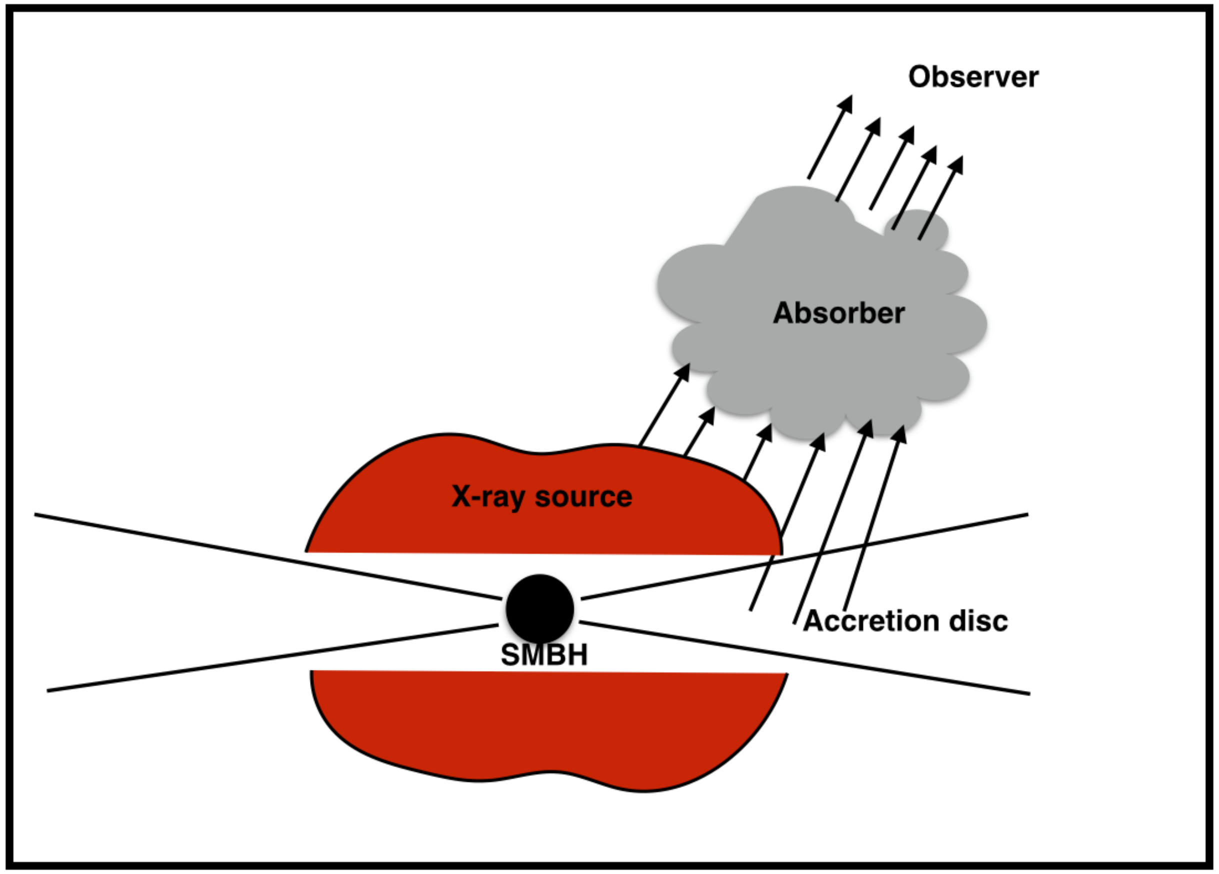
Outline

- Absorption Measure Distribution (AMD) in AGNs: definition and observational motivation

- Photoionisation modelling of AMD

- Results from our modelling using TITAN (Dumont+ 2000) photoionisation code

- Summary



Absorption measure distribution (AMD) in AGNs : from observations

Holczer+ 2007

- AMD requires ξ and N_H

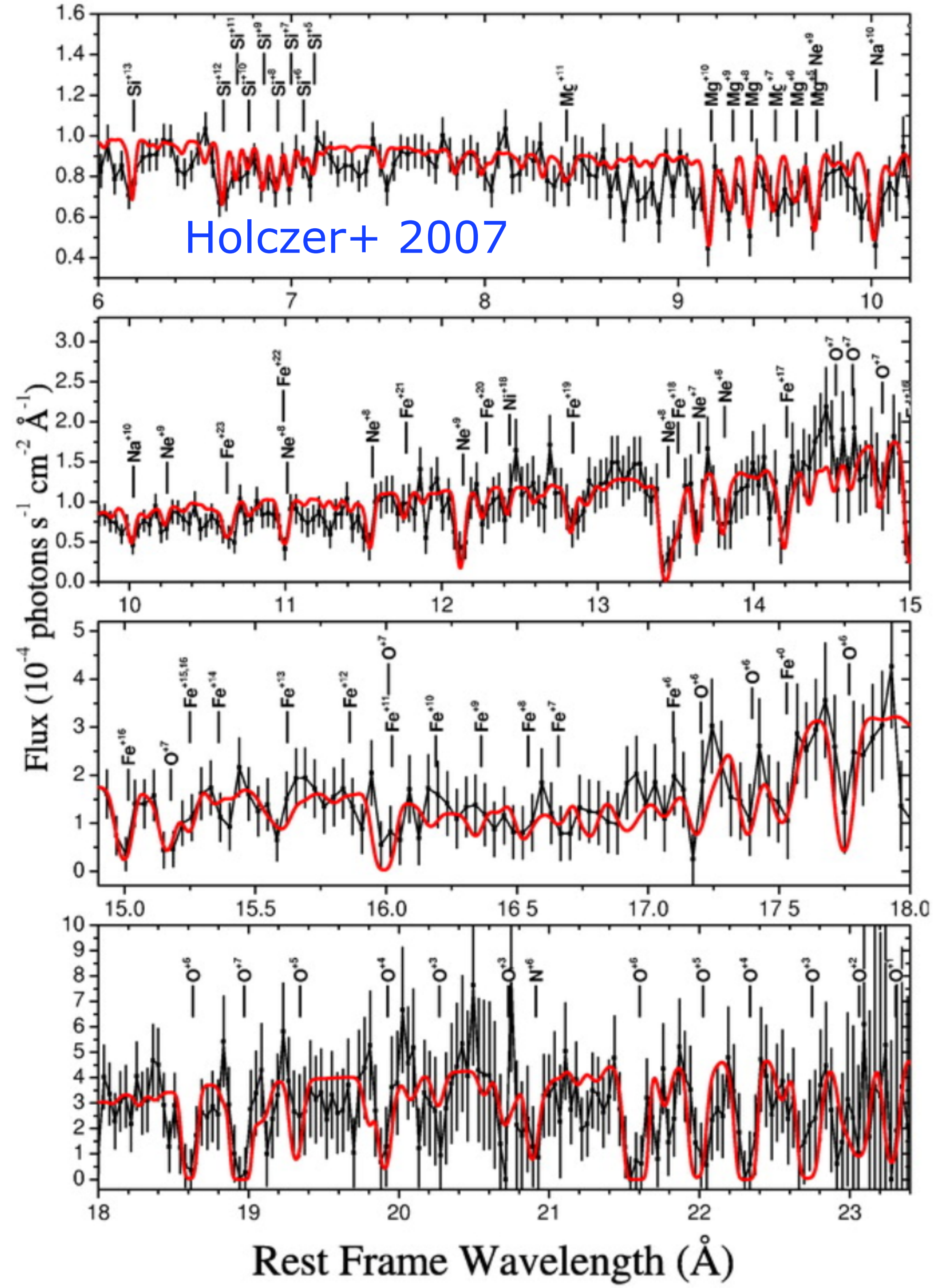
$$\mathrm{AMD} = dN_{\mathrm{H}}/d(\log \xi), \quad \xi = L/nR^2$$

$$N_{\mathrm{H}} = \int \mathrm{AMD}\, d(\log \xi).$$

- N_{ion} is derived by fitting Gaussian profiles to the X-ray absorption lines in the observed spectra

$$N_{\mathrm{ion}} = A_z \int \frac{dN_{\mathrm{H}}}{d(\log \xi)} f_{\mathrm{ion}}(\log \xi)\, d(\log \xi).$$

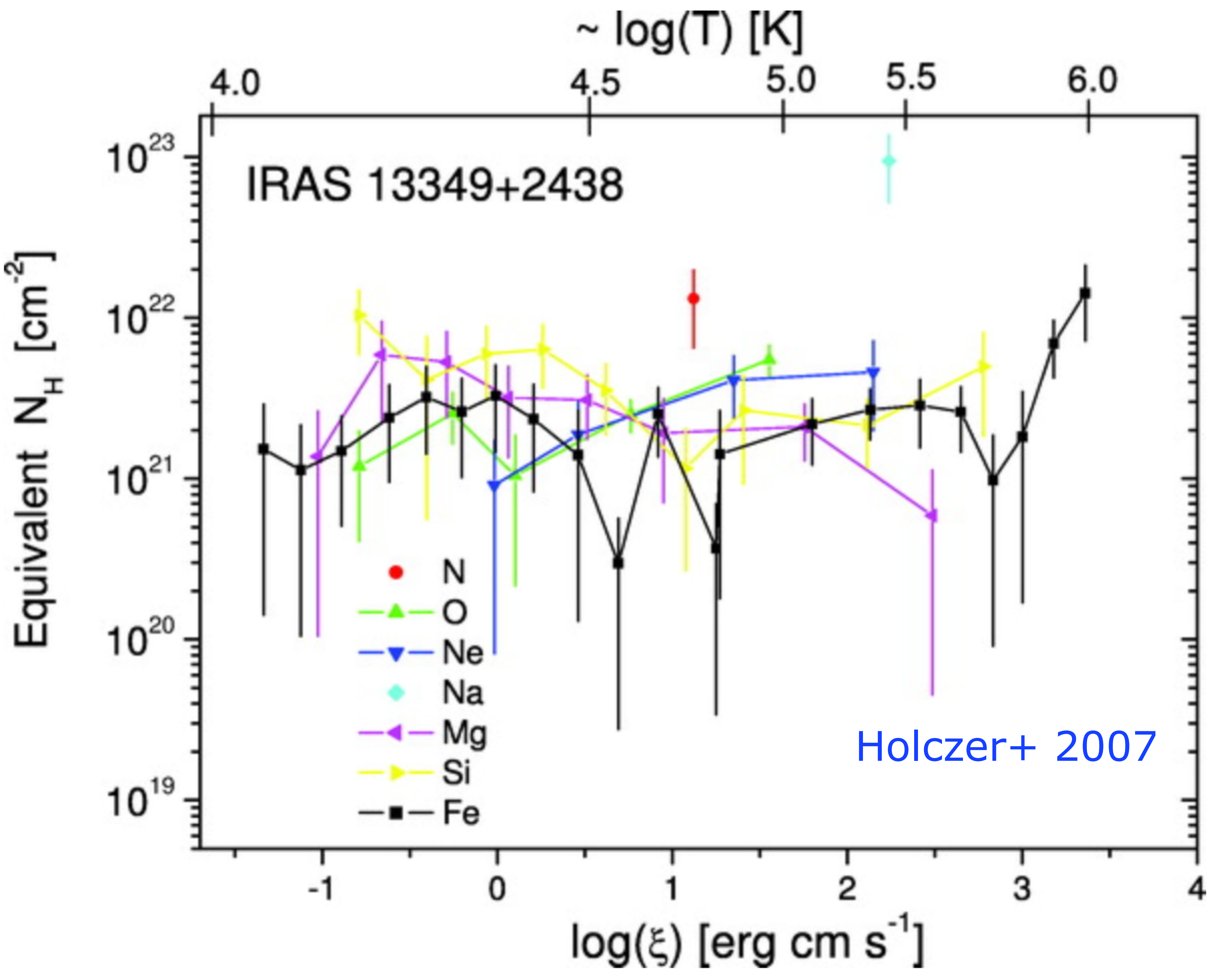
- ξ and f_{ion} are computed from photoionisation models



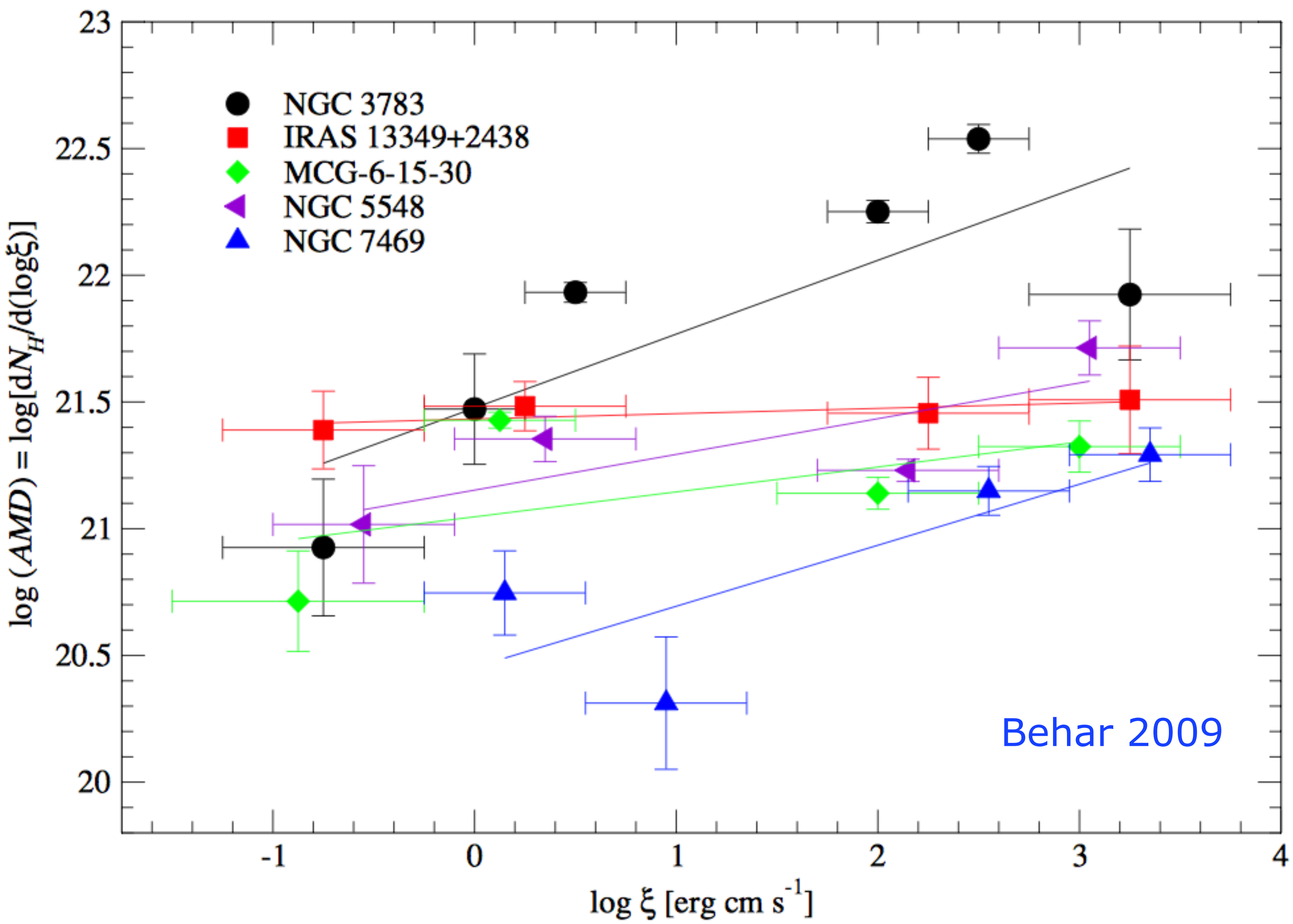
Equivalent H- column densities

Importance of different ions, Fe in particular

$$N_{\rm H} \simeq \frac{N_{\rm ion}}{f_{\rm ion}(\xi_{\rm max}) A_{Z_\odot}}$$

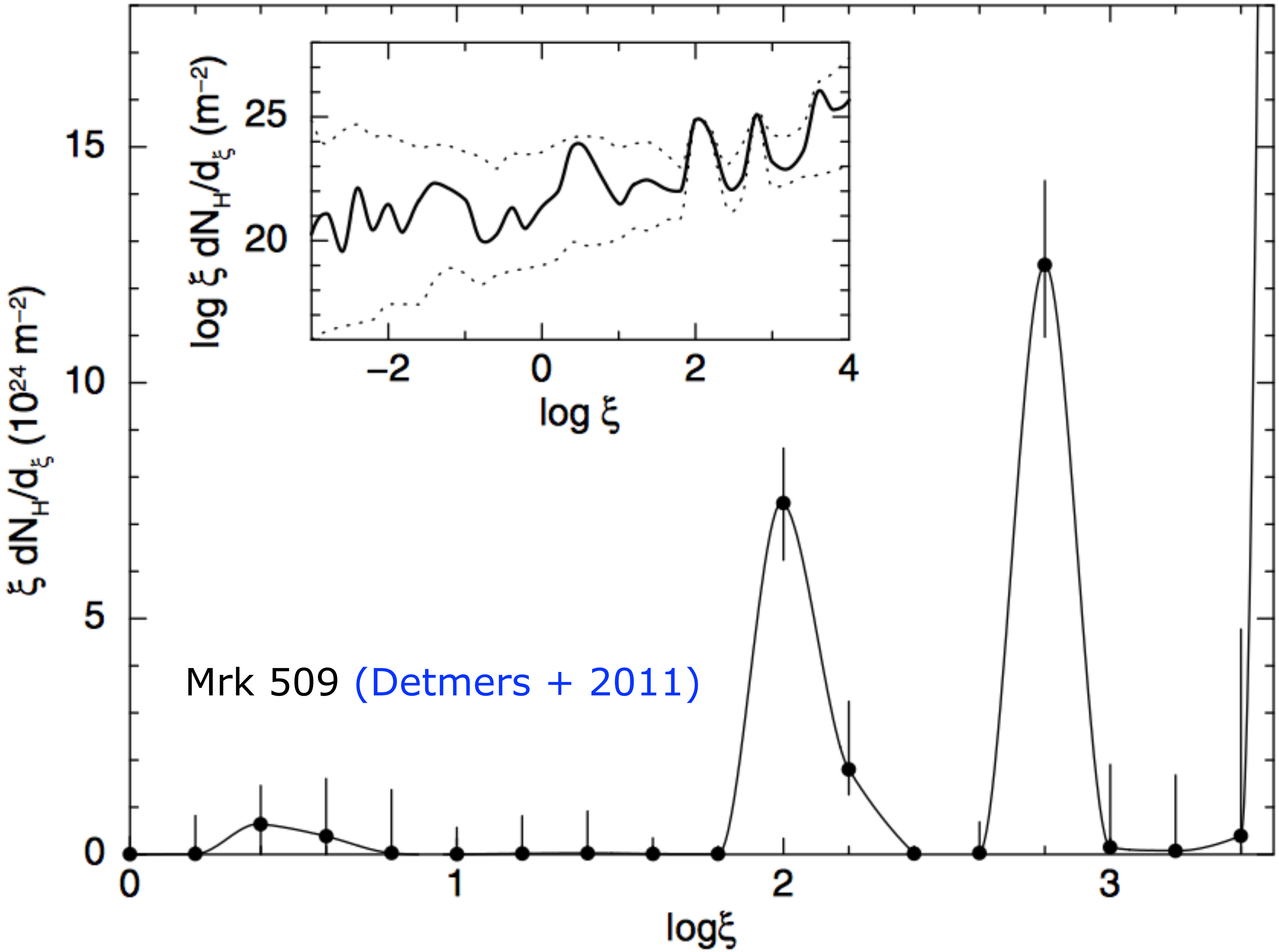


Absorption measure distribution (AMD): Observation



Discontinuity in the observed AMD → Observational evidence of Thermal instability (TI)? Holczer + 2007, Behar 2009

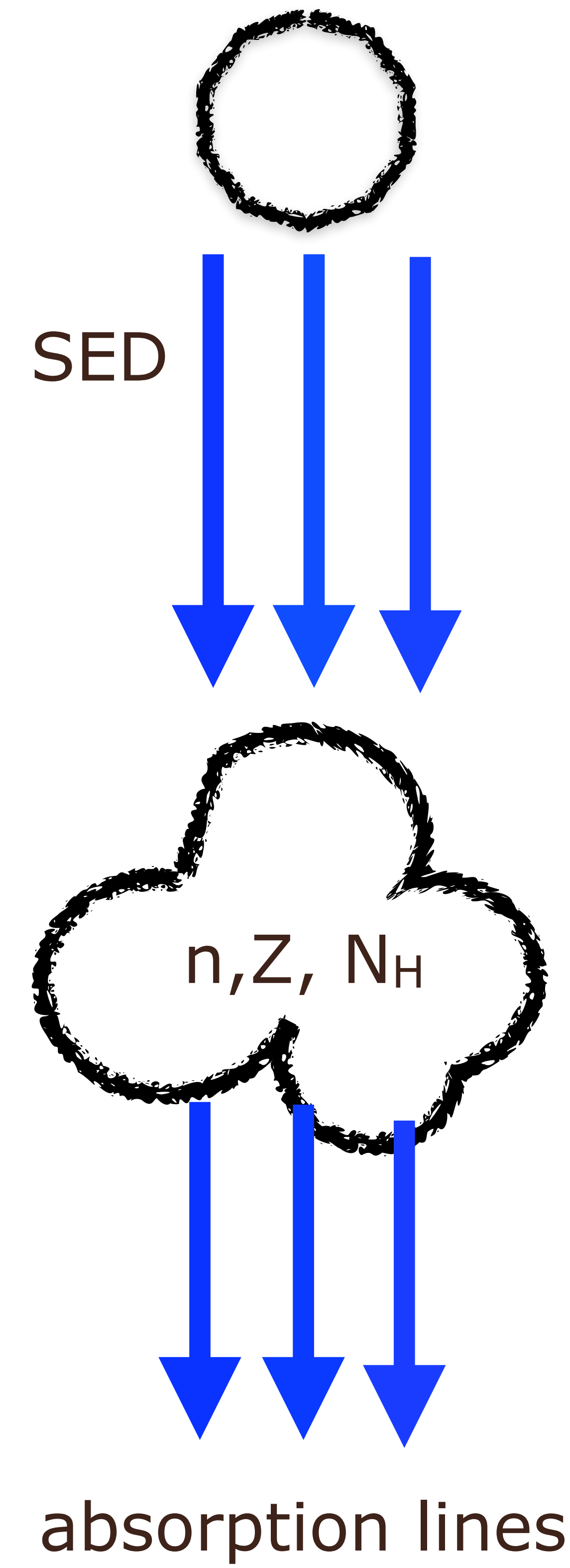
Absorption measure distribution (AMD): Observation



two AMD dips !

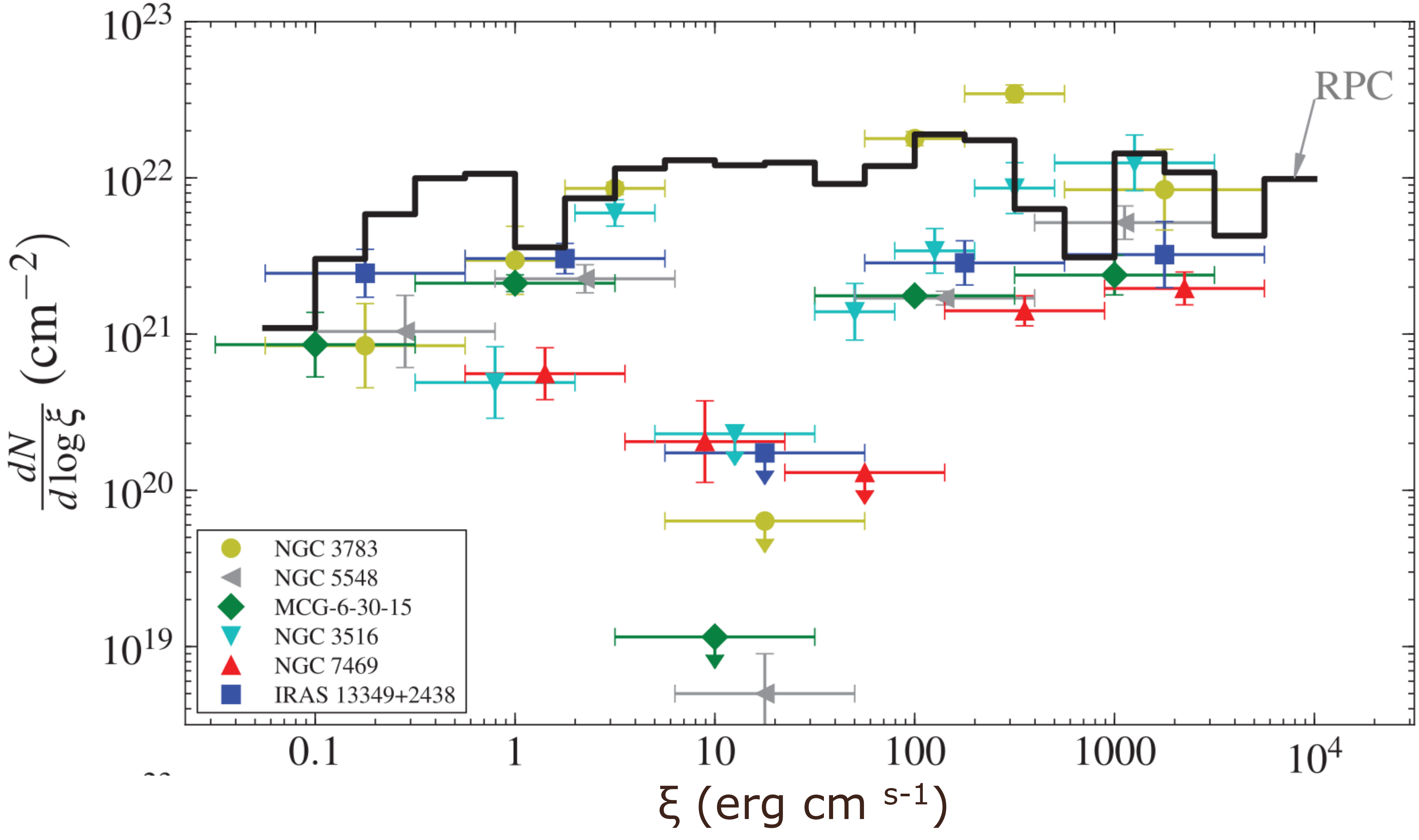
Absorption measure distribution (AMD): Modelling

- Broad band SED
- Gas density n
- Metallicity Z
- Column Density N_H
- Ionisation parameter, $\xi = L/nR^2$
- Solving the radiative transfer, ionisation equilibrium and thermal balance
- Main Codes: CLOUDY (Ferland +2013), **TITAN** (Dumont+ 2000), XSTAR (Kallman & Bautista 2001),..



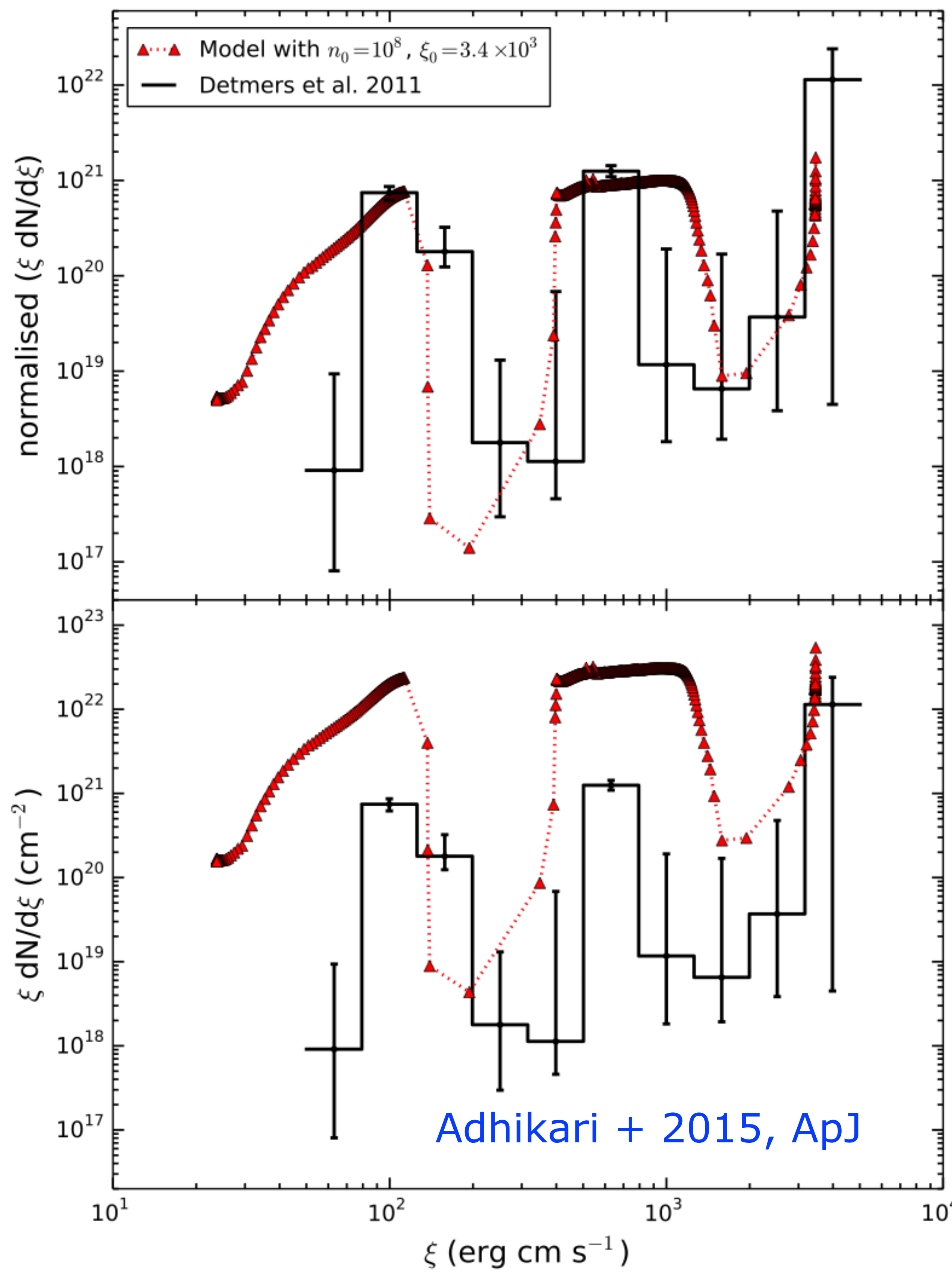
AMD: models

Radiation Pressure Confinement (RPC) model (Stern+ 2014) using CLOUDY



RPC model in CLOUDY did not reproduce TI

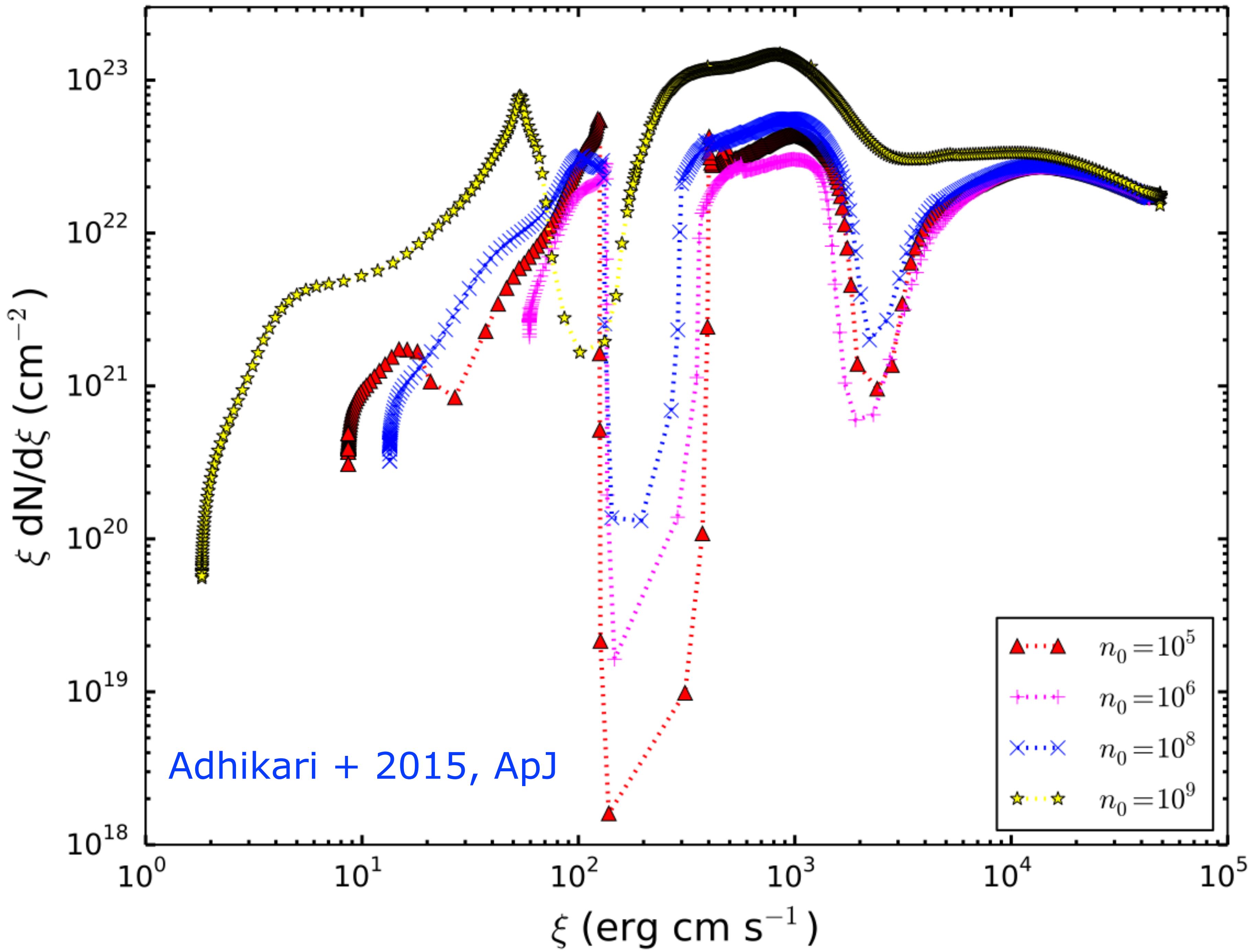
AMD in Mrk 509: constant total pressure ($P_{gas}+P_{rad}$) single model



TITAN code reproduces TI

problem with the normalisation!

Density dependence of AMD



for Mrk 509 SED, the position of AMD dip depends on density

RPC in Cloudy versus constant pressure in TITAN

TITAN (Constant total pressure)

- more accurate Accelerated Lambda Iteration (ALI) method

$$\mu \frac{dI_\nu}{d\tau_\nu} = I_\nu - \frac{j_\nu}{\kappa_\nu + \sigma_\nu} = I_\nu - S_\nu$$

- radiation pressure is computed from radiation field and goes into the gas structure directly

CLOUDY (RPC)

- Escape probability method of radiative transfer

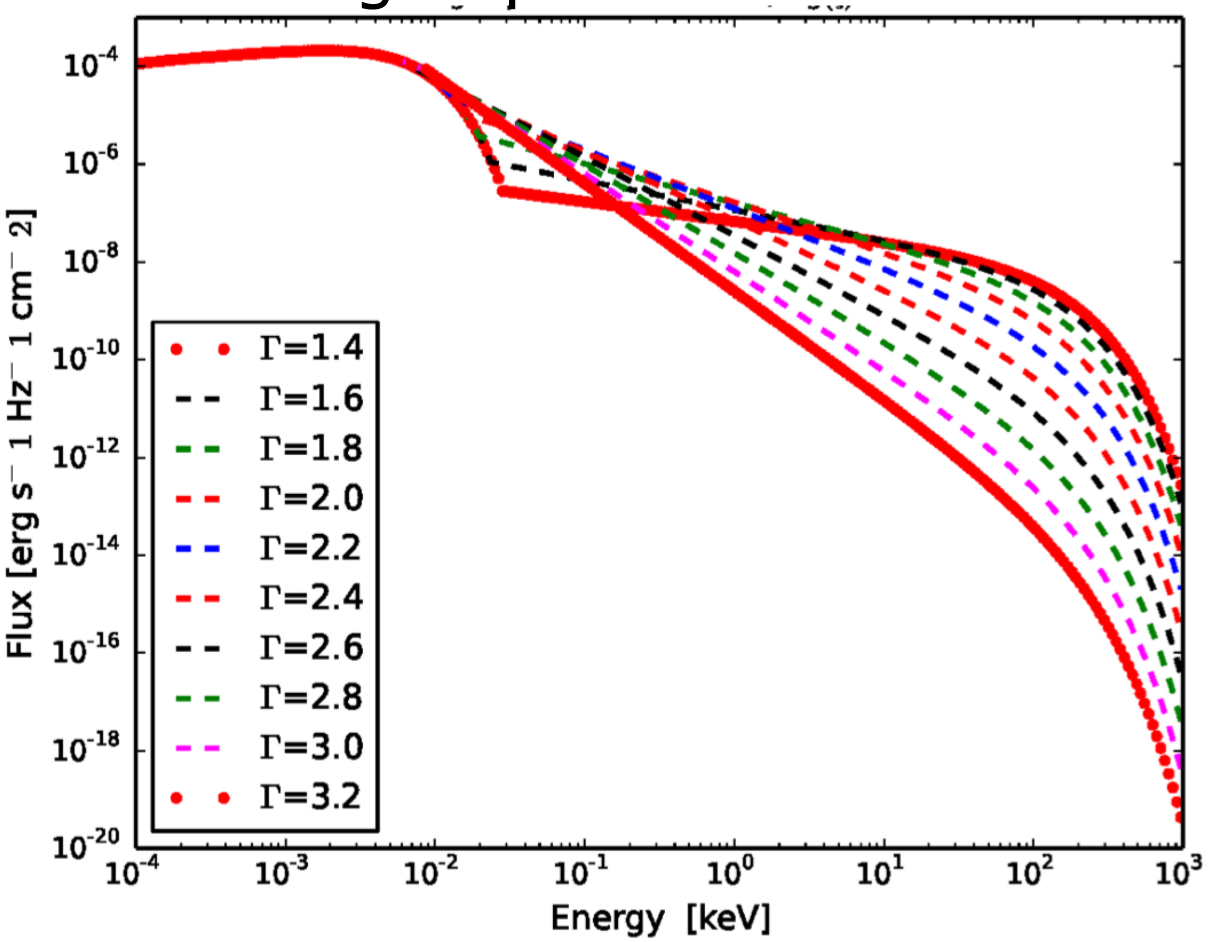
$$dP_{gas}(\tau) = P_{rad} e^{-\tau} d\tau$$

- pressure induced by the trapped emitted radiation is not considered

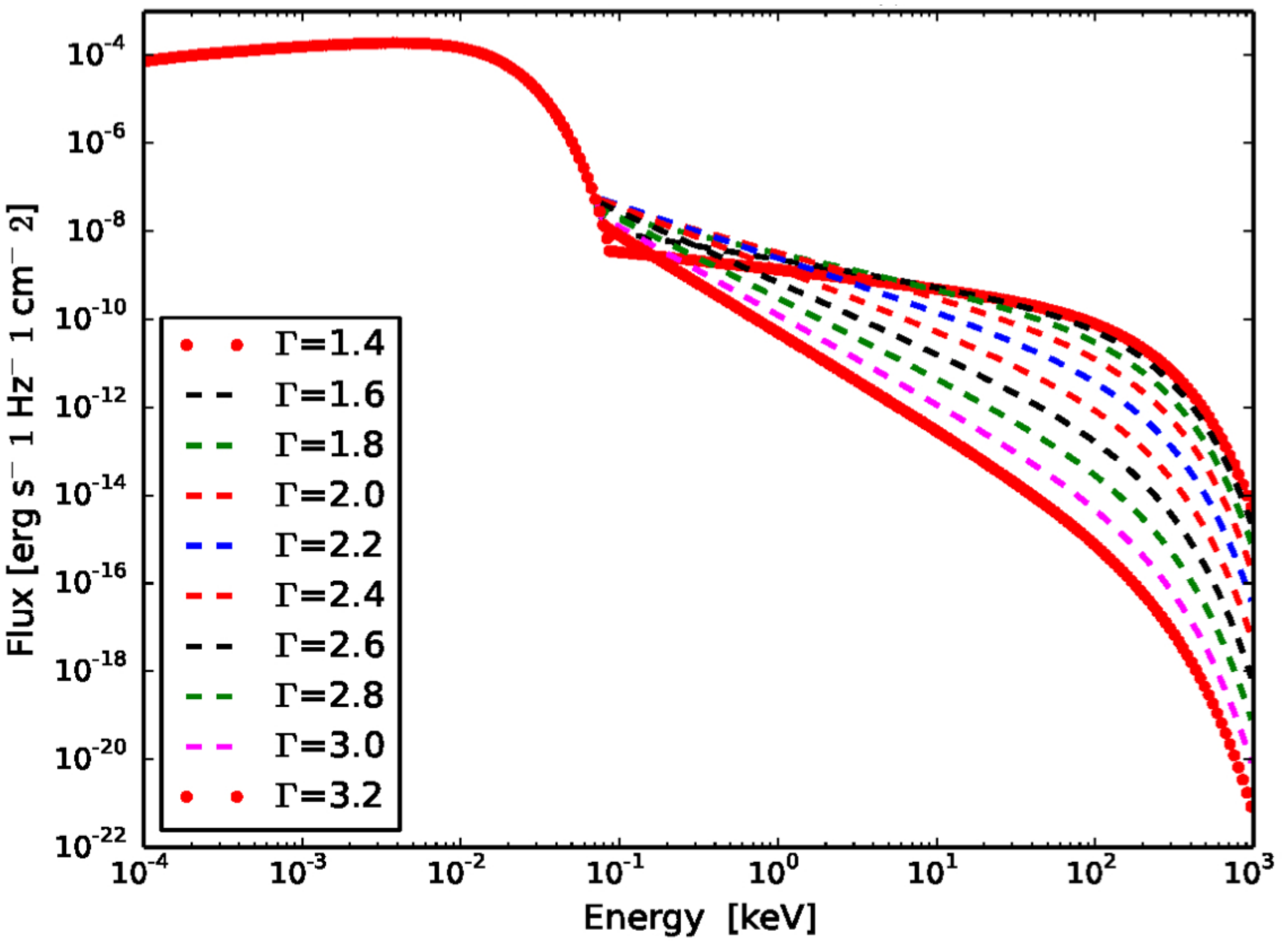
Escape probability method versus ALI method (Dumont+ 2003)

Systematic study of AMD using TITAN

high-spin-low-mdotr

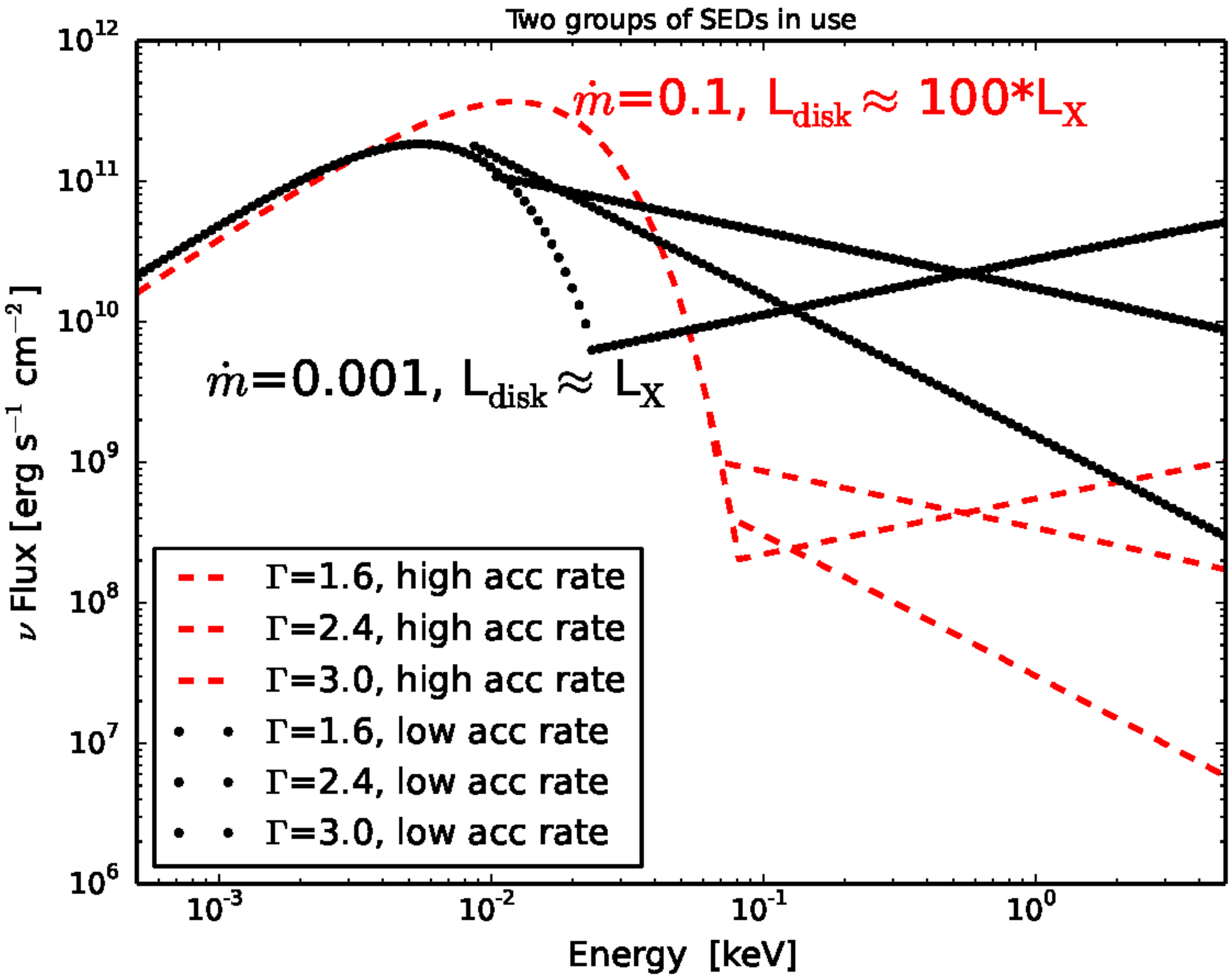


low-spin-high-mdotr



Adhikari+ 2017, in preparation

Systematic study of AMD using TITAN

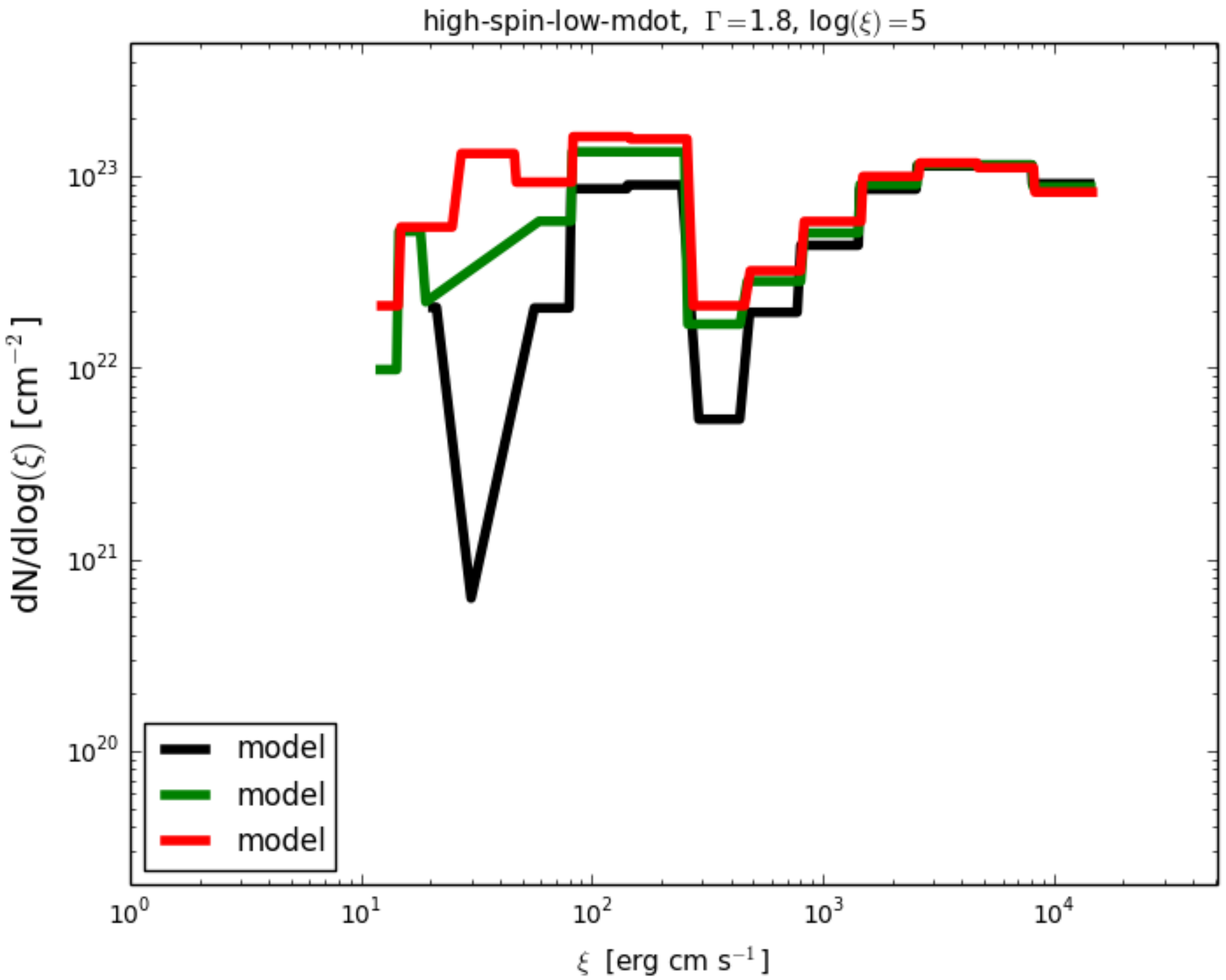


Adhikari+2017, in preparation

Systematic study of AMD using TITAN: normalisation and position of dip in AMD

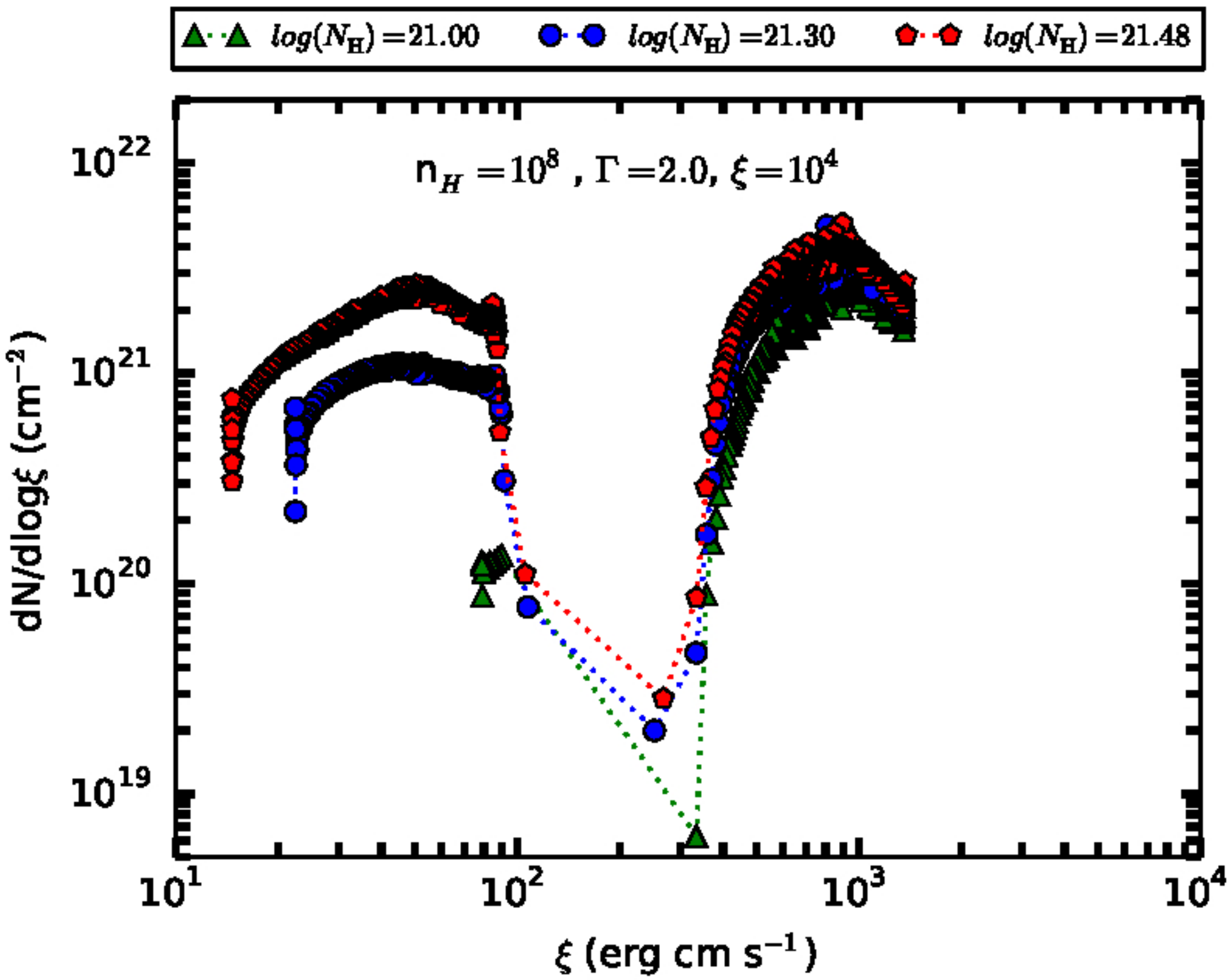
$N_H \geq 10^{23}$ cm^{-2}

SED - with strong X-ray illumination



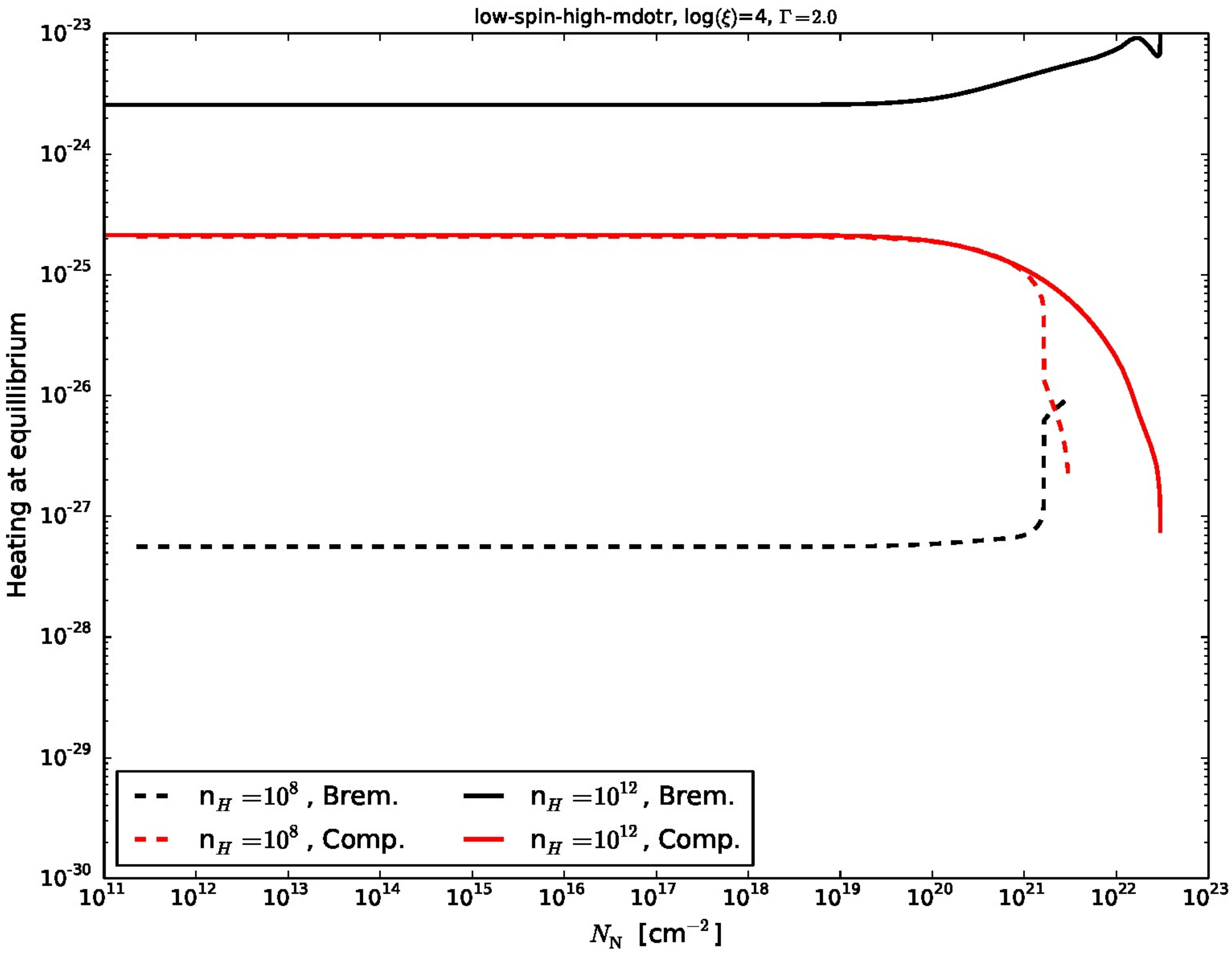
$N_H \sim 10^{21}$-10^{22}cm^{-2}

SED- with strong opt/UV component

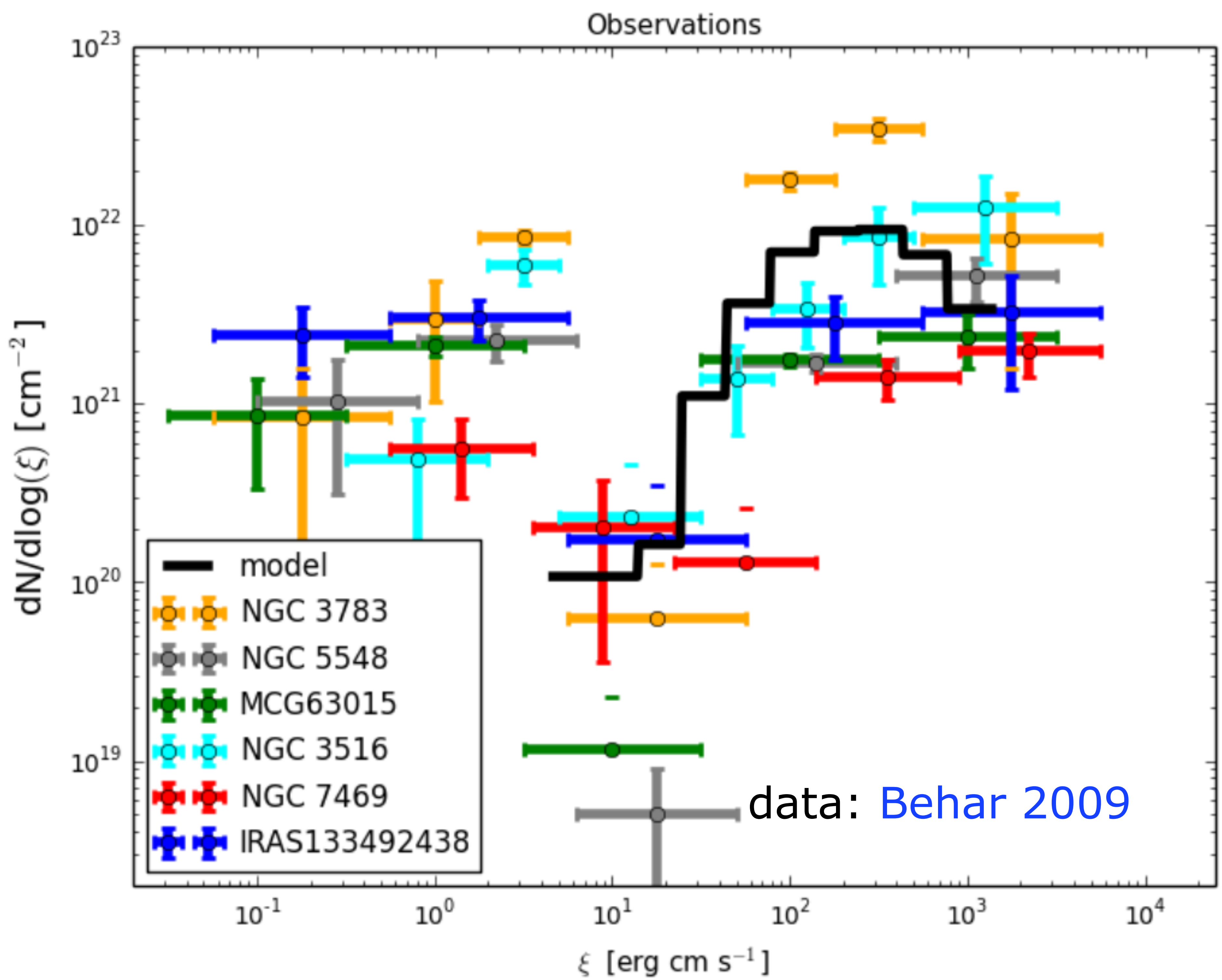


Adhikari+ 2017, in preparation

normalisation is higher for SED with strong X-ray illumination



In case of SED with strong optical/UV component and for high density, free free heating dominates over the Compton heating



TITAN model: SED with with strong optical/
UV component, log N_H =22.48, log n_H =12

Summary

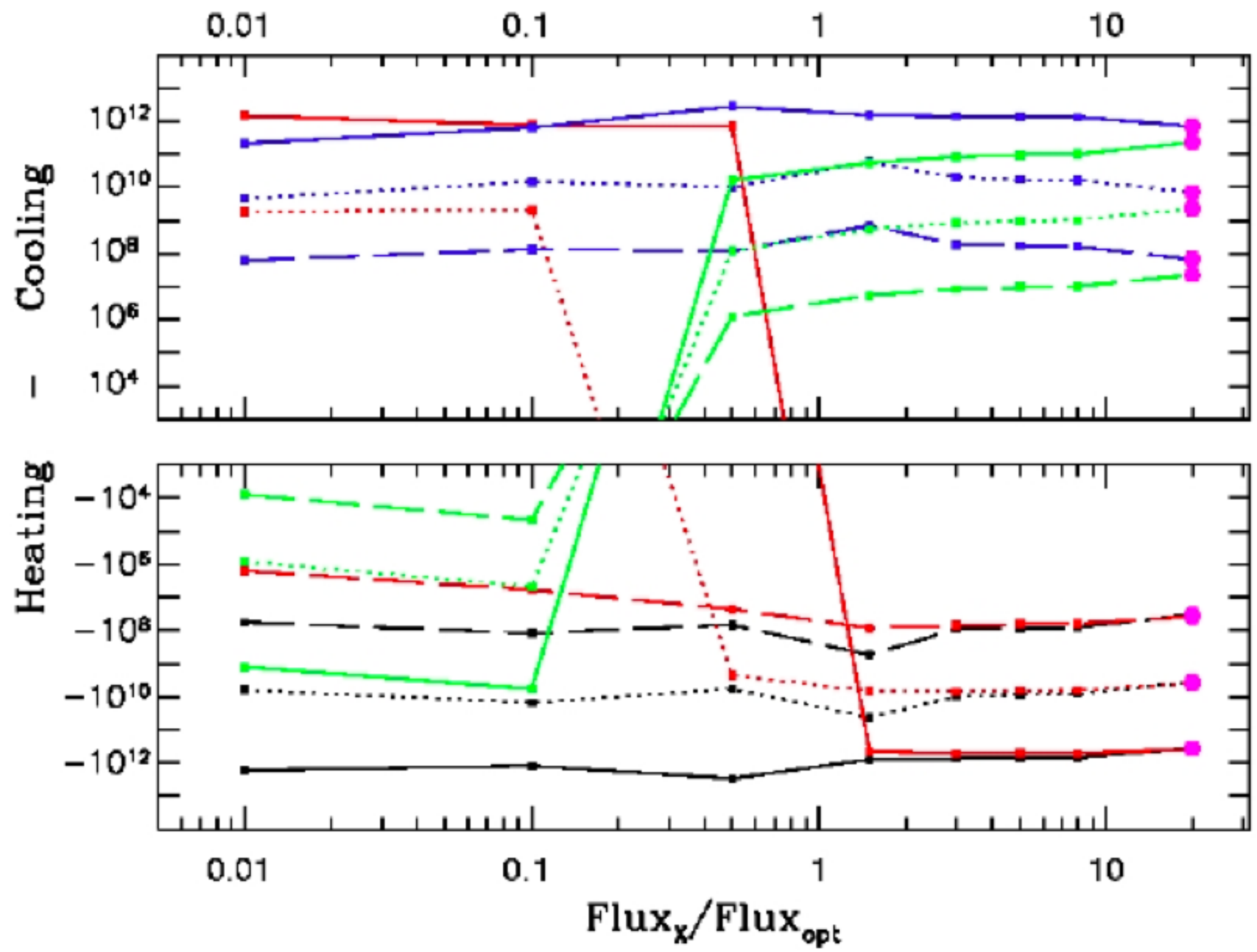
- Constant total pressure single component WA model explains the observed AMD in Mrk 509.

- Computations of AMDs with the constant pressure assumption for different SED components shows that the normalisation is higher for SED with strong X-ray illumination and weak optical/UV component.

- For the given SED, the position of AMD dip depends on the density of the absorber.

Back up slides…

Różańska +08, **Processes**



Net bound–free (Ion. – Rec.)
Net free–free (H – C)
Net Compton (H – C)
Net bound–bound (H – C) LINES

Solid line – n = 10^{10} cm^{-3}
Dotted line – n = 10^{8} cm^{-3}
Dashed line – n = 10^{6} cm^{-3}