Robust and Complete* Demographics of Active Galactic Nuclei

Compon-thick AGN fraction over cosmic time $N_H > 10^{24}\mathrm{cm}^{-2}$: $\mathbf{38^{+8}_{-7}\%}$

Obscured AGN fraction over cosmic time $N_H > 10^{22}\mathrm{cm}^{-2}$: $\mathbf{77^{+4}_{-5}\%}$

Authors: **Johannes Buchner**, Antonis Georgakakis, Kirpal Nandra, et al. (Max Planck Institute for extraterrestrial Physics)

http://arxiv.org/abs/1501.02805

* $L_X > 10^{42}$erg/s

Context

Most AGN are obscured. The X-ray spectrum of most AGN is absorbed by a toroidal obscurer with significant line-of-sight column densities up to the Compton-thick regime. When investigating the growth phases of Supermassive Black Holes (SMBHs) over cosmic time, obscured AGN are thought to play a major role in the mass accretion. In fact, it has been suggested that most of the growth occurs in a completely enshrouded phase. Determining the fraction of obscured AGN and Compton-thick AGN is thus an important step.

The de-absorbed **luminosity function**

$$\Phi(L_{2-10\mathrm{keV}}, z, N_H)$$

including the **distribution in column density** N_H is reconstructed as a smooth field, without assuming a model.

The fraction of obscured and Compton-thick AGN is investigated, and shows dependence on both redshift and luminosity. We compare the fraction of obscured and Compton-thick AGN to hydrodynamic simulations of Wada12, and find that that model predicts similar Compton-thick fractions.

Data

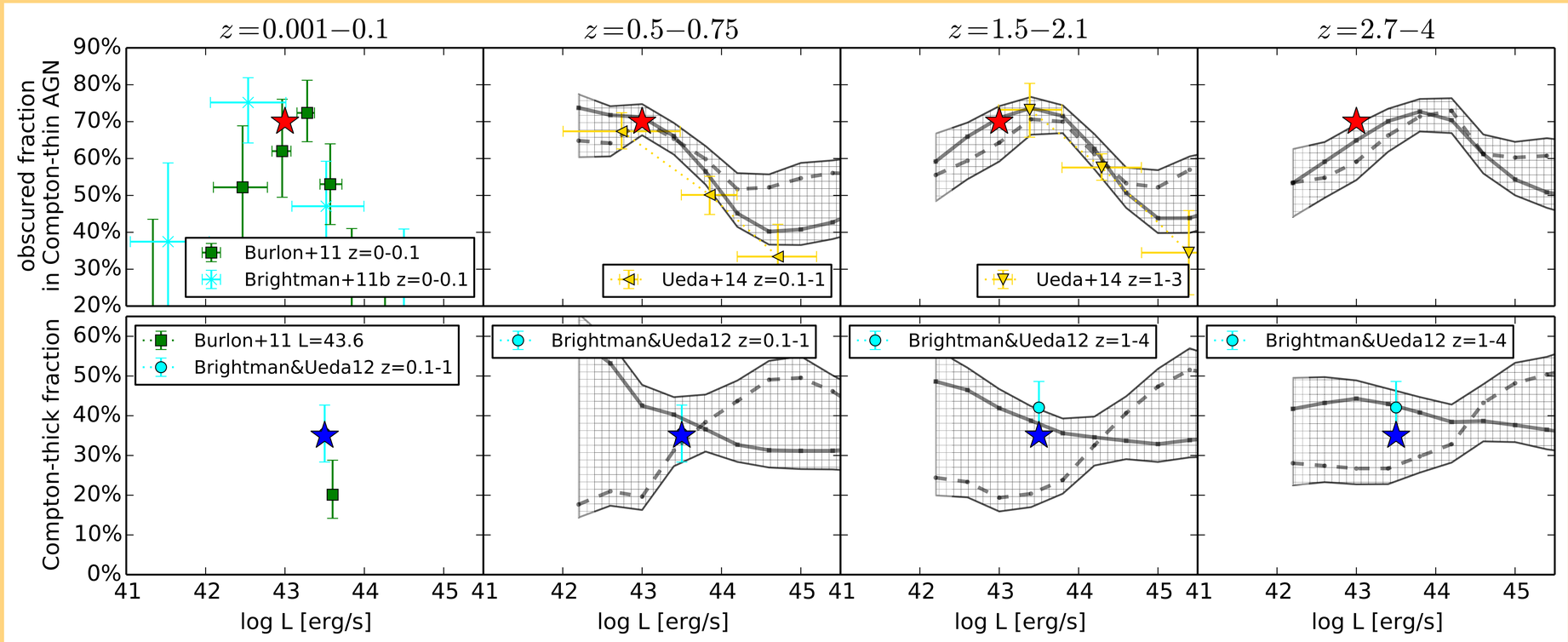
- 2-10 keV detection
  - ▷ CDFS4Ms (322 sources)
  - ▷ AEGIS-XD (564)
  - ▷ Chandra COSMOS (1010)
  - ▷ XMM-XXL (206, $20\mathrm{deg}^2$)
- Analysis of 2000 source spectra assuming a intrinsic powerlaw, a toroidal obscurer (Brightman & Nandra 2011) and a soft scattering component.
- Including sources without counterparts
- Accounting for redshift uncertainty
- Detailed X-ray spectral analysis for intrinsic luminosity $L_{2-10\mathrm{keV}}$, redshift and column density N_H.

Method

- Simplistic description: a finely binned, three-dimensional histogram is fitted as a luminosity function model.
- A Bayesian analysis takes into account selection biases
- Non-parametric method: no empirical evolution model is assumed.
- Result: Volume densities with realistic uncertainties at every intrinsic luminosity, redshift and column density.

arxiv.org/abs/1501.02805

Luminosity-dependence of the obscured fraction evolves



Shaded gray: Our non-parametric reconstruction of the Compton-thick AGN fraction (*bottom panels*) and the remaining obscured fraction (*top panels*) across various redshift intervals (*left to right*). Star symbols are at fixed points for reference.

- The obscured fraction shows redshift evolution.
- At high-z, the turnover is at higher luminosities.
- There is no evidence for a luminosity dependence or evolution of the Compton-thick fraction

Comparison to Hydrodynamic Simulations of Wada12

Background:

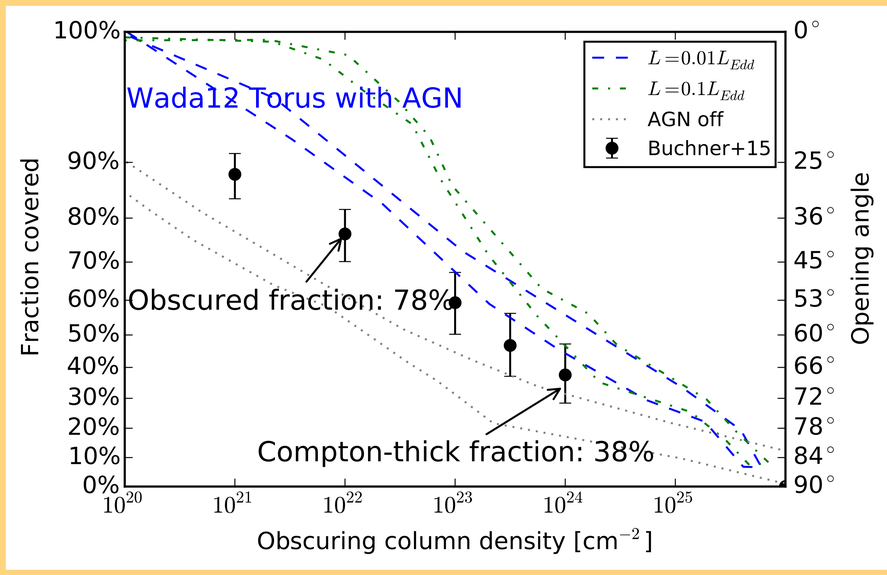
- Hydrodynamical simulation of a "fountain torus"
- radiative feedback from the AGN creates a spatially extended torus

Plotted: Column density of the stirred gas

- vs. angle from then zenith (*right axis*)
- vs. corresponding population fraction (*left axis*)
- Blue: AGN on, $L = 1\% L_{\mathrm{edd}}$.
- Green: AGN on, $L = 10\% L_{\mathrm{edd}}$.
- Black data points: Our constraints

Takeaway:

- The measured column density distributions are approximately those predicted by the Wada12 model with $L \lesssim 0.01 L_{\mathrm{Edd}}$ accretion rate.



also see Wada15

Summary of Results

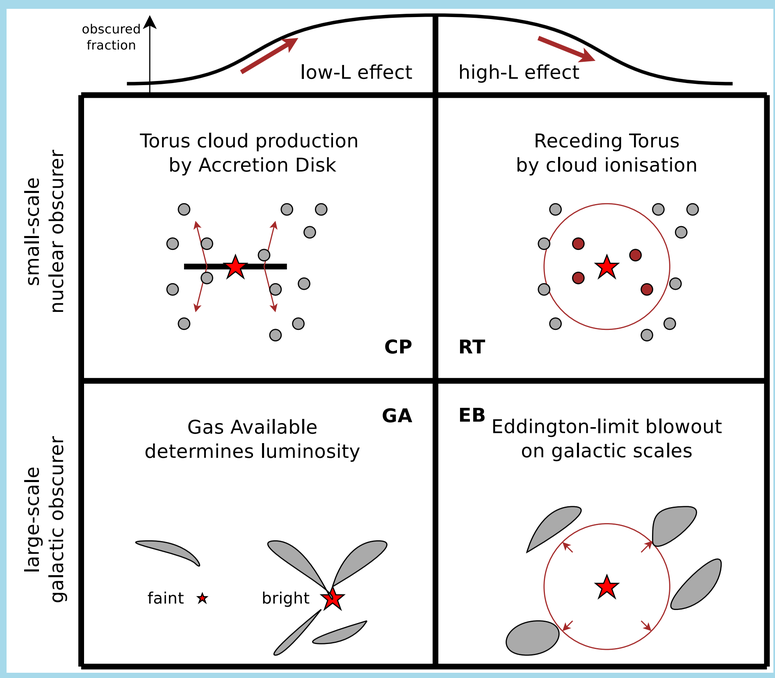
- Averaged over cosmic time:
  - ▷ Fraction of obscured AGN is $77^{+4}_{-5}\%$
  - ▷ Fraction of Compton-thick AGN is $38^{+8}_{-7}\%$.
- Evidence for both evolution and luminosity-dependence of the obscured fraction: at high-z, the turnover is at higher luminosities $\rightarrow$ increase of the obscured fraction with z.
- What causes this evolution? Most torus maintainance or destruction models depend linear on mass (see right box) $\rightarrow$ mass downsizing?

Overall accretion luminosity:

- The luminosity output of the AGN population is dominated by obscured AGN ($74^{+4}_{-5}\%$), with Compton-thick AGN contributing $\sim 40 \pm 6\%$.
- The local black hole mass density can be explained by the constrained luminosity function; higher values by a factor of a few are also permitted.

Discussion of Results

Models for luminosity-dependent obscurers



- Top left / bottom right are mass-dependent – mass downsizing may explain the evolution.

You may also like: http://arxiv.org/abs/1402.0004
Introduces a new, general Bayesian method for deciding between two physical models by X-ray spectra. Applicable also in the low count regime. Derives probability distributions on physical parameters. Application: Is the geometry of AGN a torus or does it cover the source completely? What spectral components can be detected?

Name: Johannes Buchner
Association: MPE, PUC
Contact: **johannes.buchner.acad@gmx.com**
Web: http://www.mpe.mpg.de/~jbuchner

Full co-author list: Antonis Georgakakis, Kirpal Nandra, Murray Brightman, Marie-Luise Menzel, Zhu Liu, Li-Ting Hsu, Mara Salvato, Cyprian Rangel, James Aird, Andrea Merloni, Nicholas Ross

It is great working with you all!