Supermassive black hole spin under the microcalorimeter microscope

Astronomical Institute of the Czech Academy of Sciences

X-IFU
ATHENA X-ray Integral Field Unit

Peter Boorman

With Daniel Kynoch, Jiří Svoboda, Michal Dovčiak, Elias Kammoun, Giovanni Miniutti, Didier Barret, Emanuele Nardini & the X-IFU team

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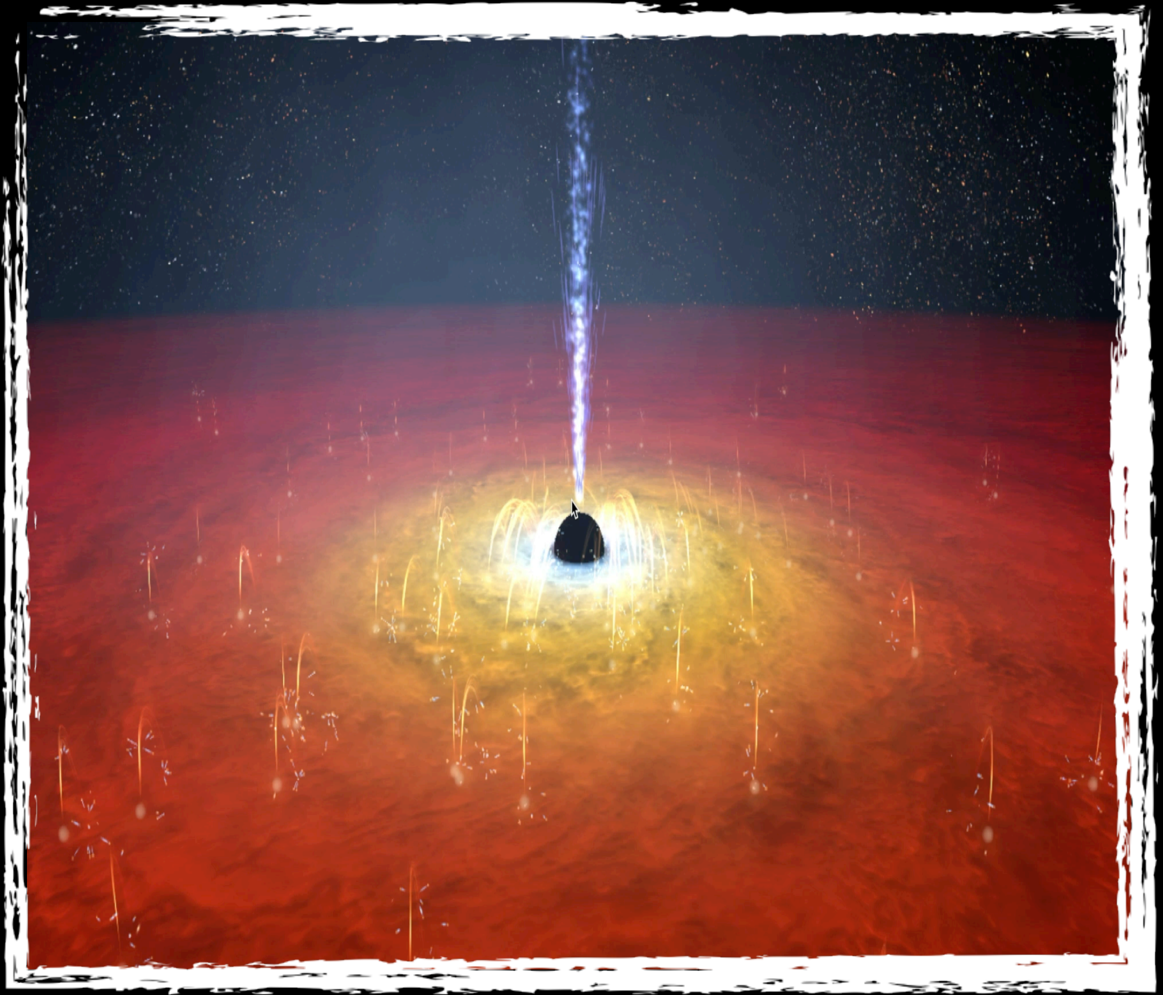
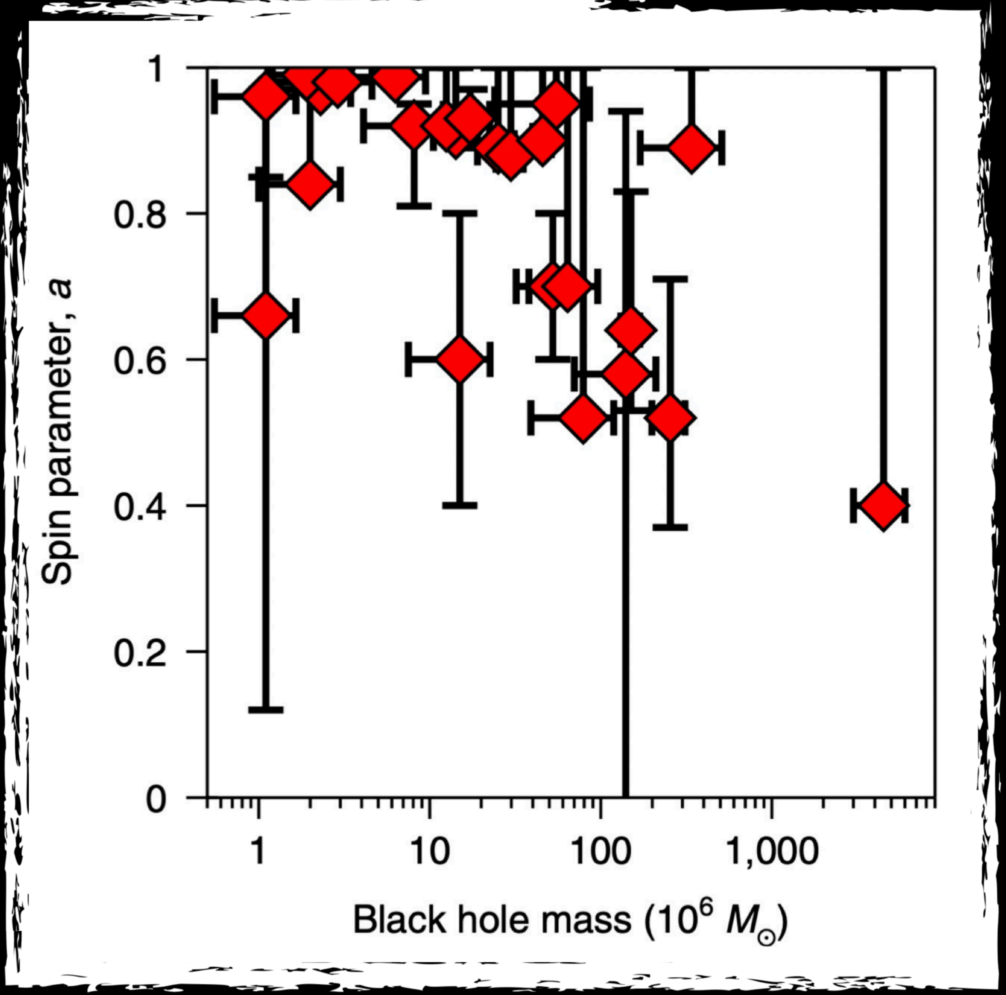
Supermassive black hole spin

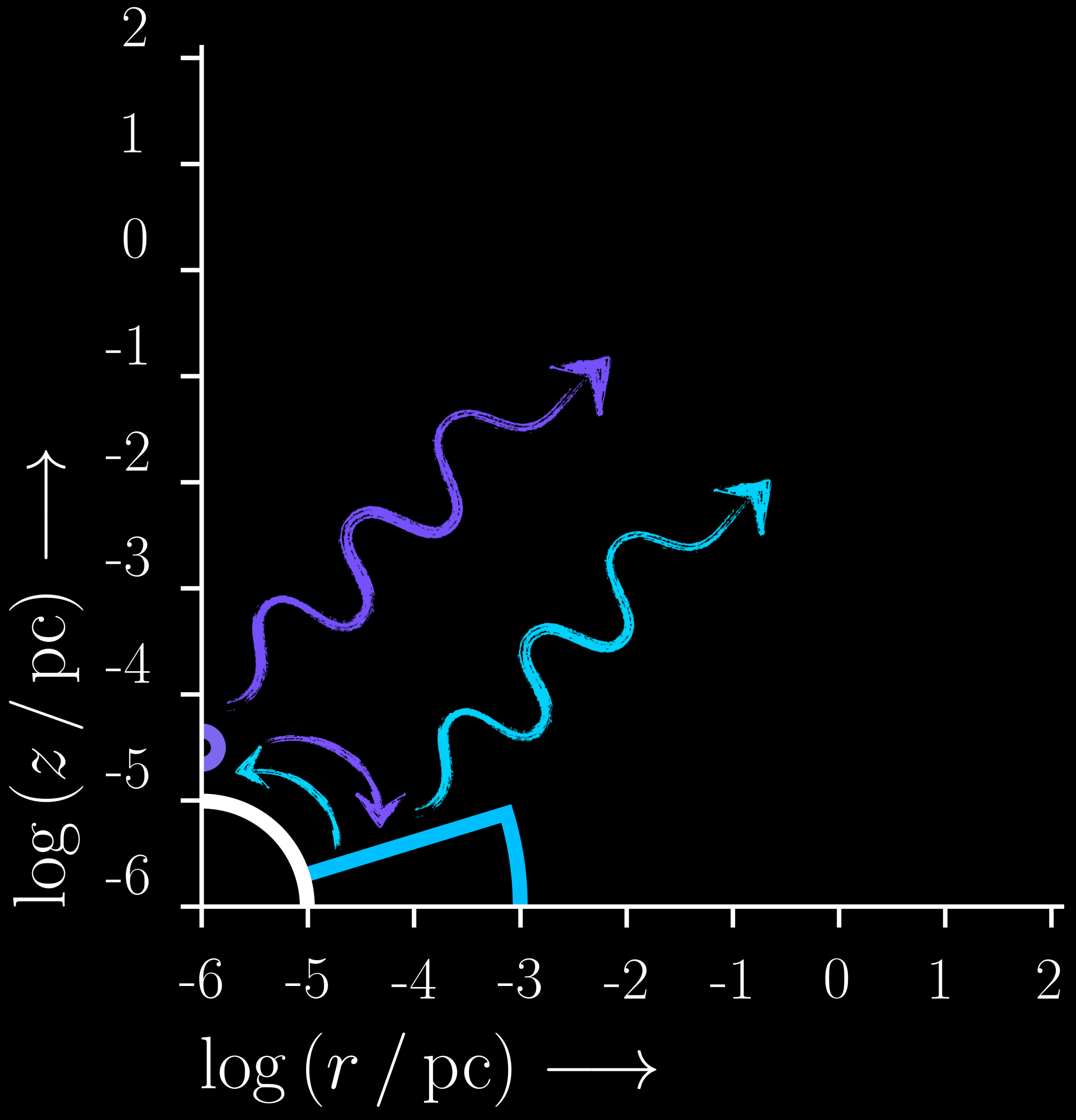


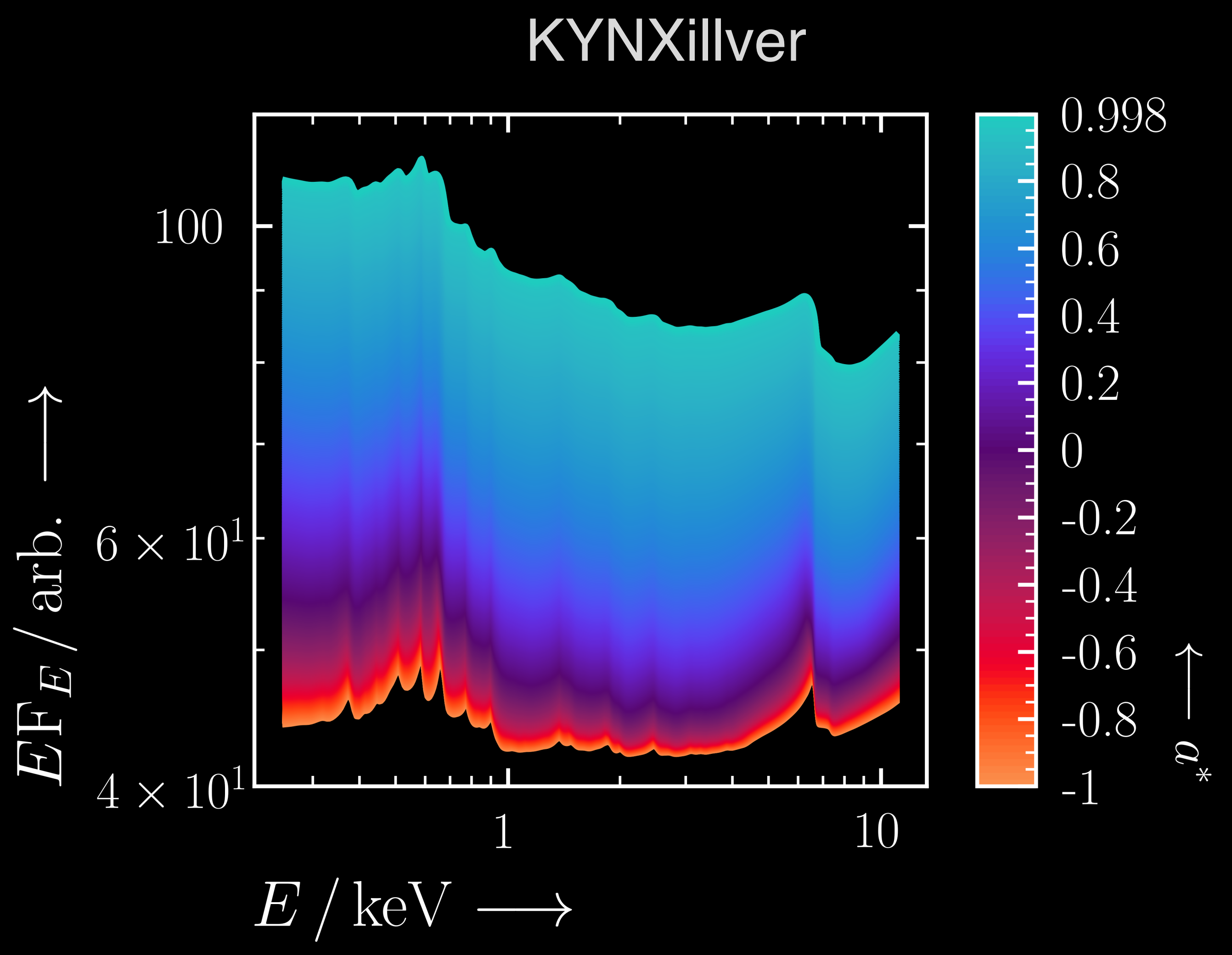
N. Tr'Ehnl, N. Brandt



Reynolds19

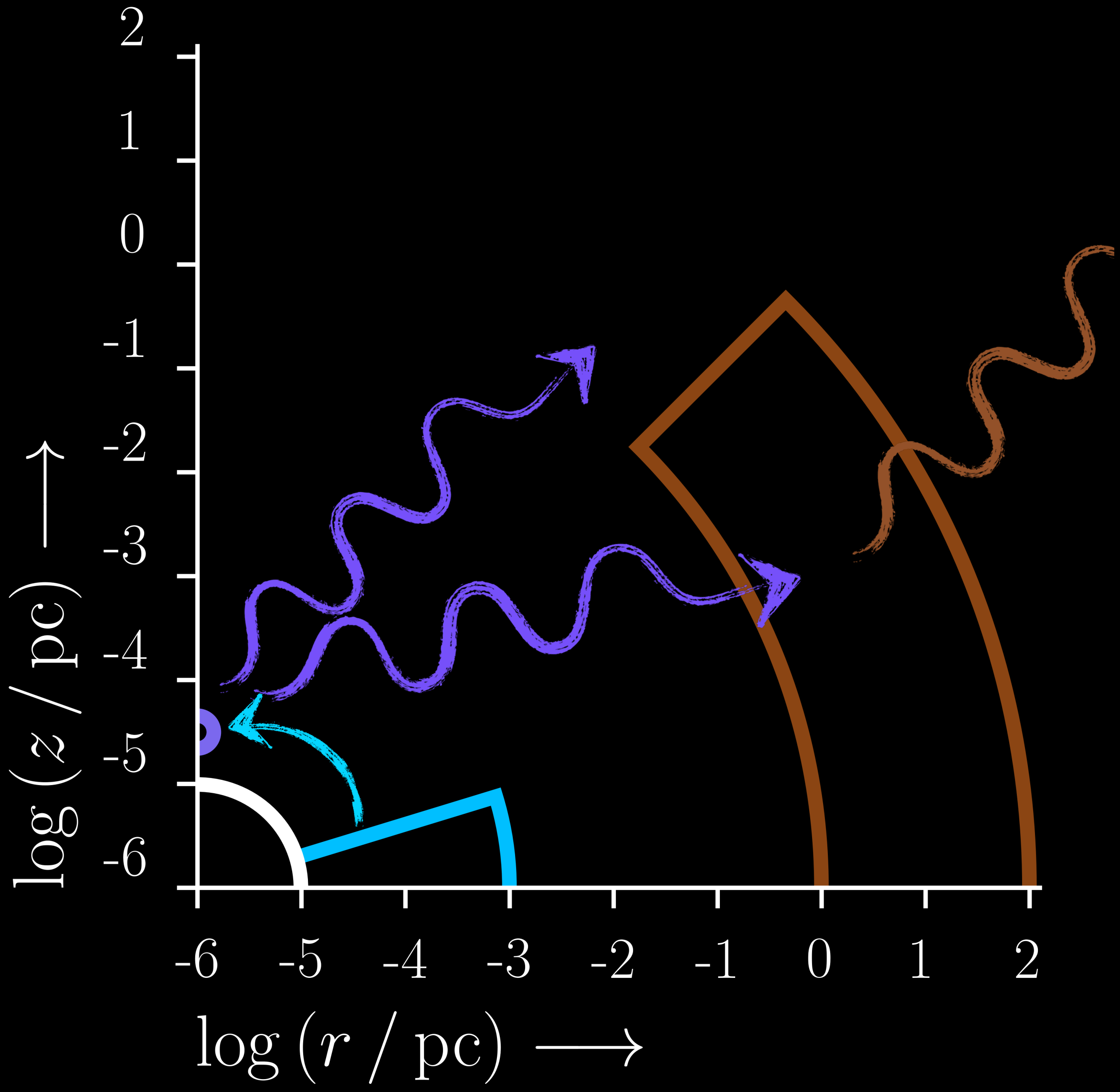
Relativistic reflection

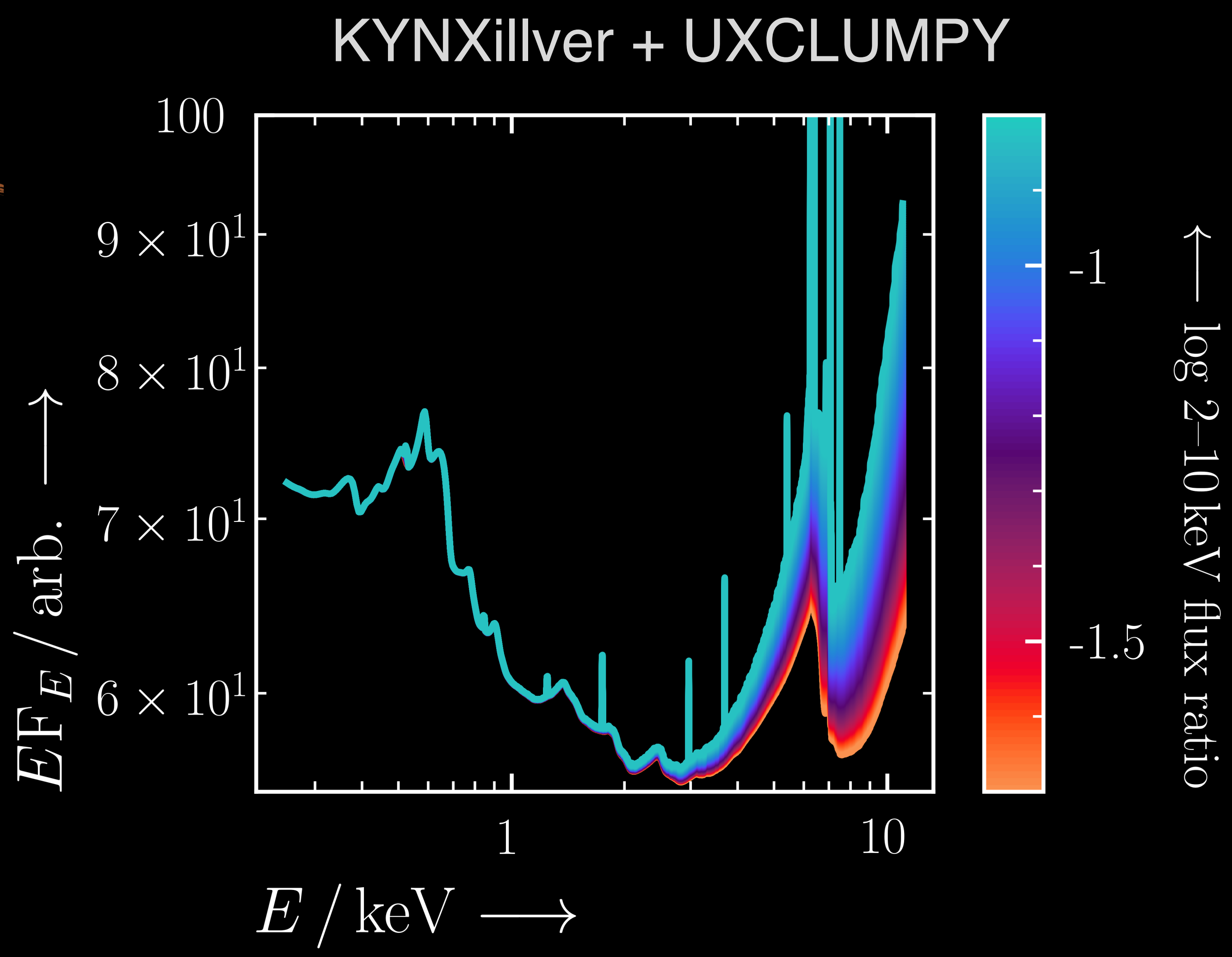




E.g., Fabian+00, Dovčiak+04, García & Kallman10

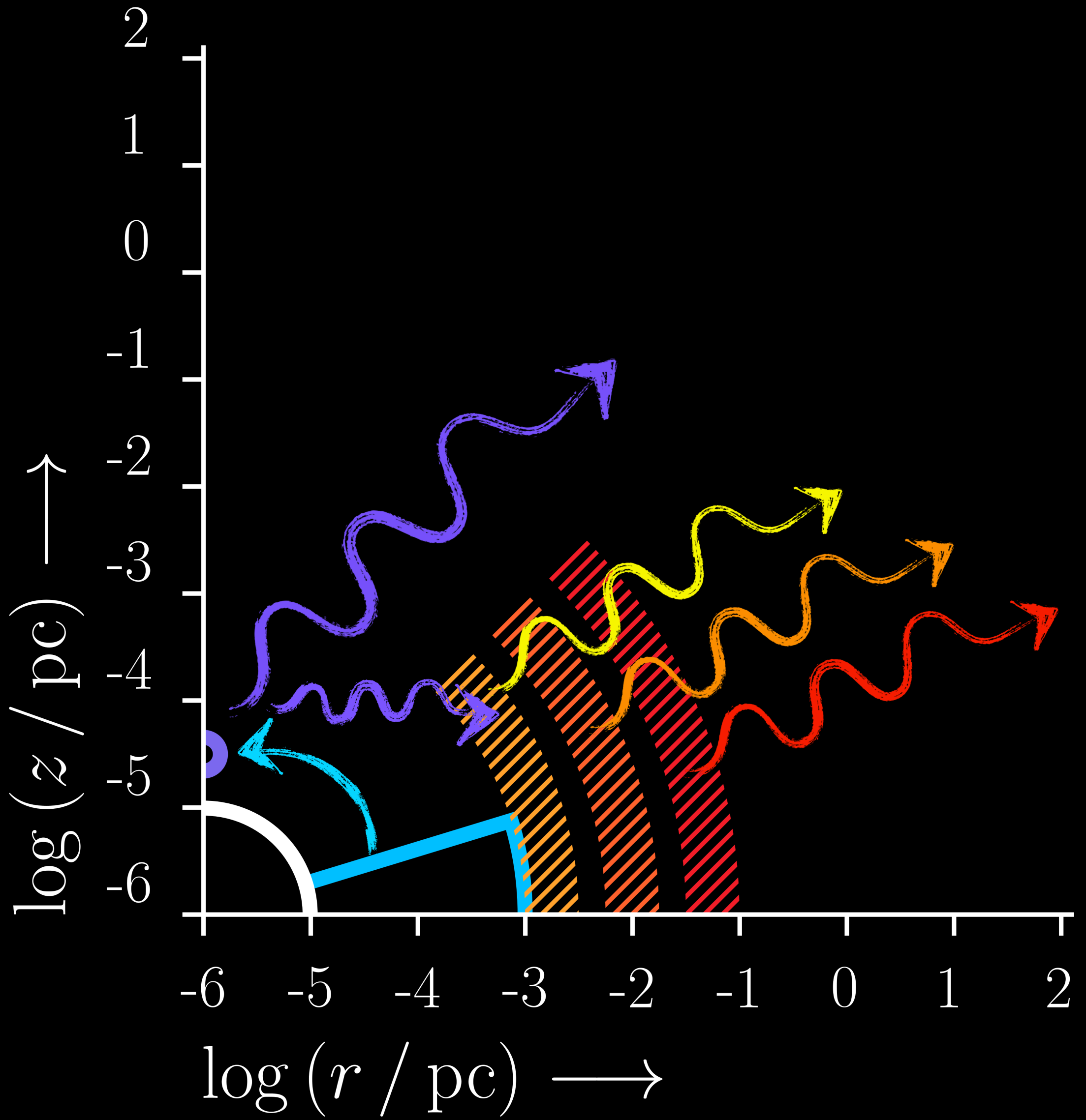
Distant reflection



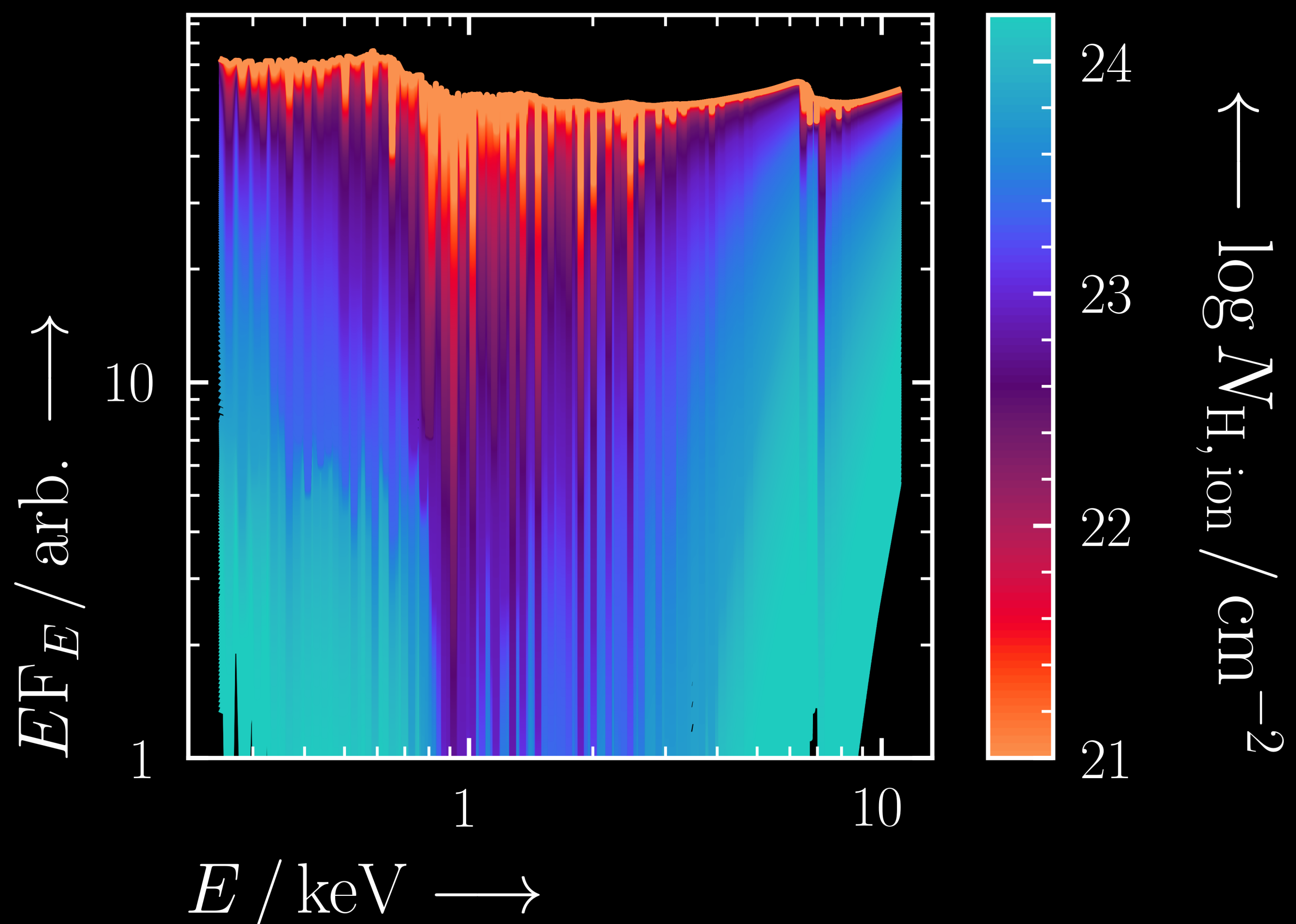


E.g., Risaliti+13, Walton+14, Tzanavaris+21

Warm absorber(s)

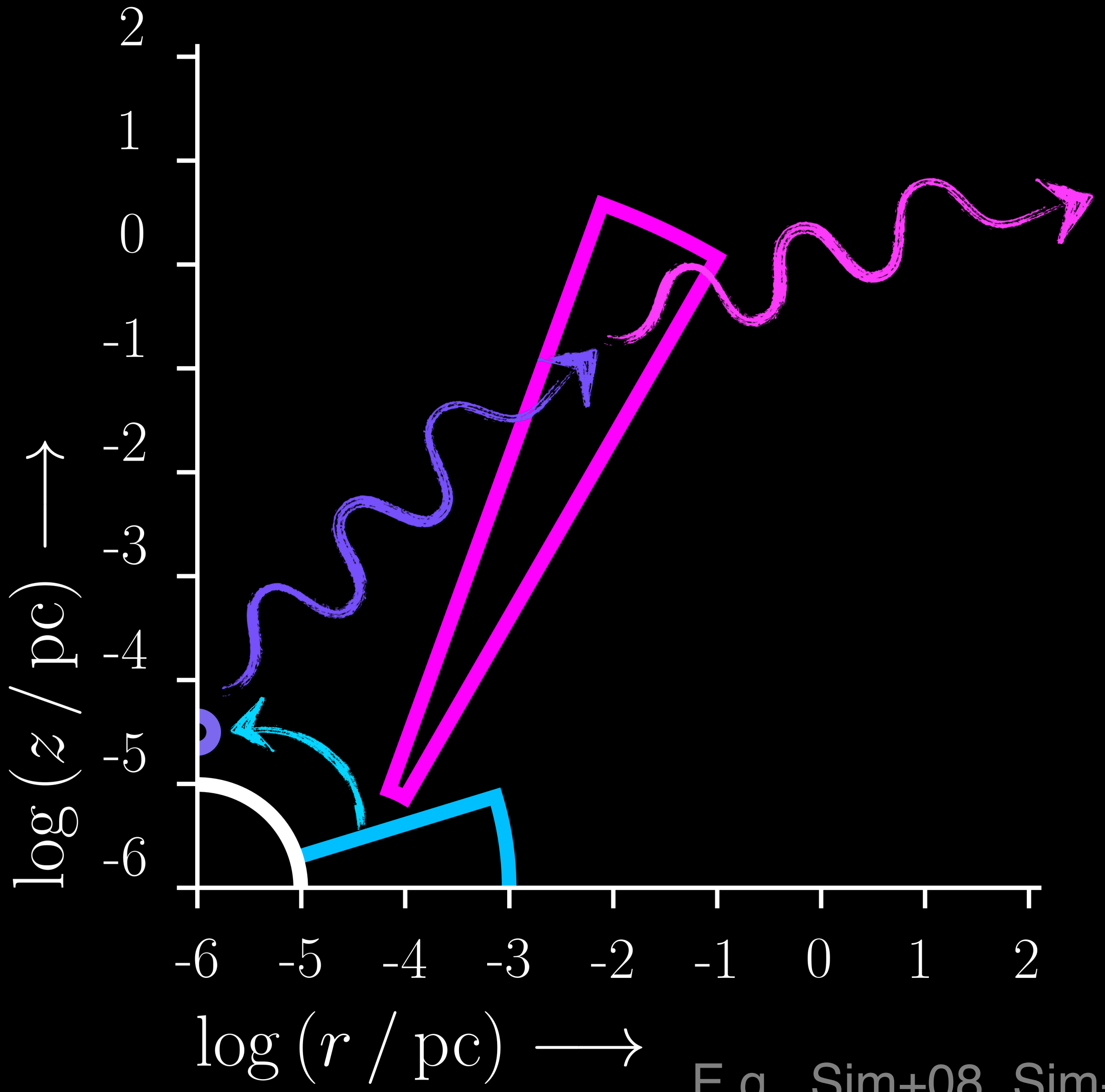


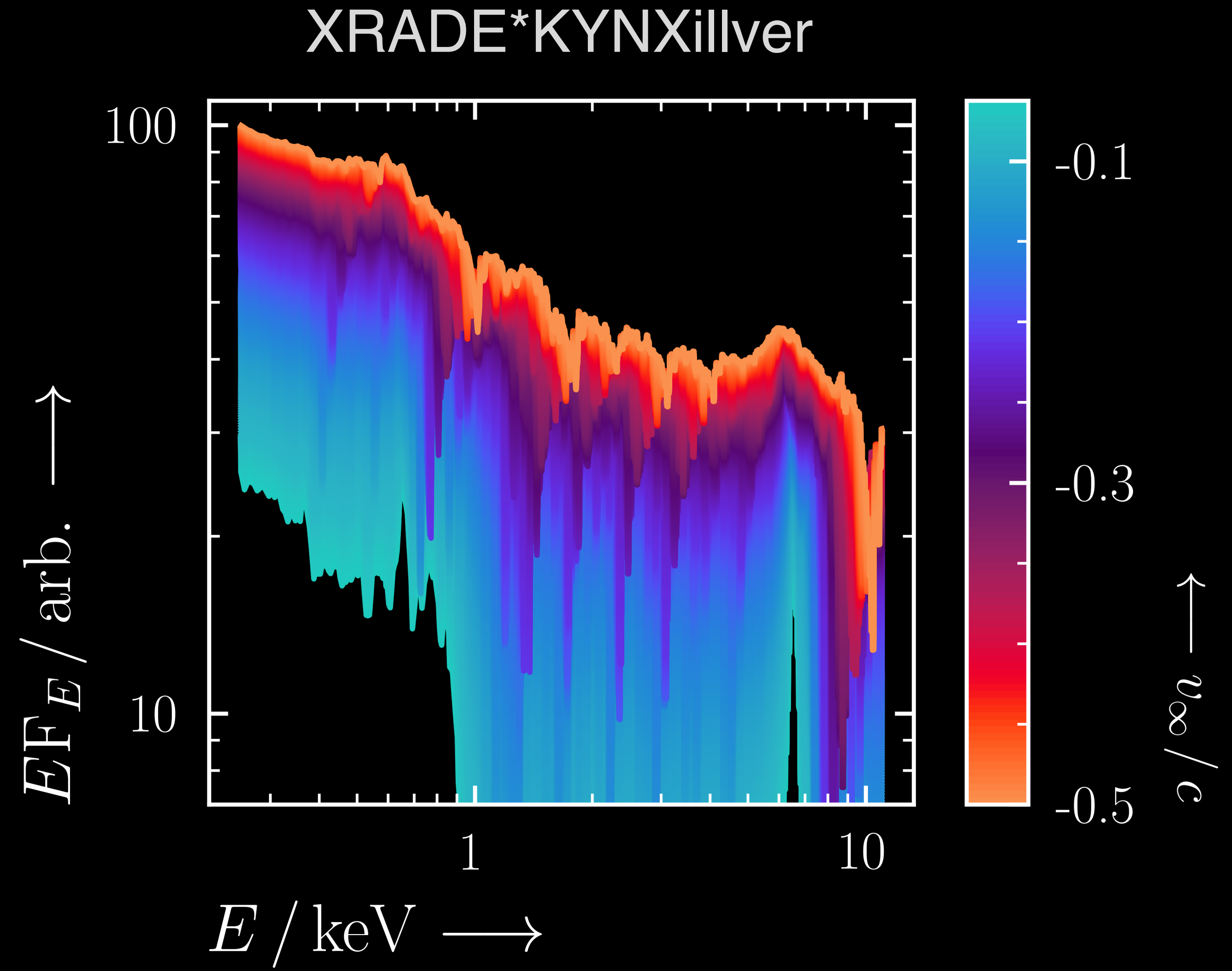
zxipcf1*zxipcf2*zxipcf3*KYNXillver



E.g., Turner & Miller09, Barret & Cappi19

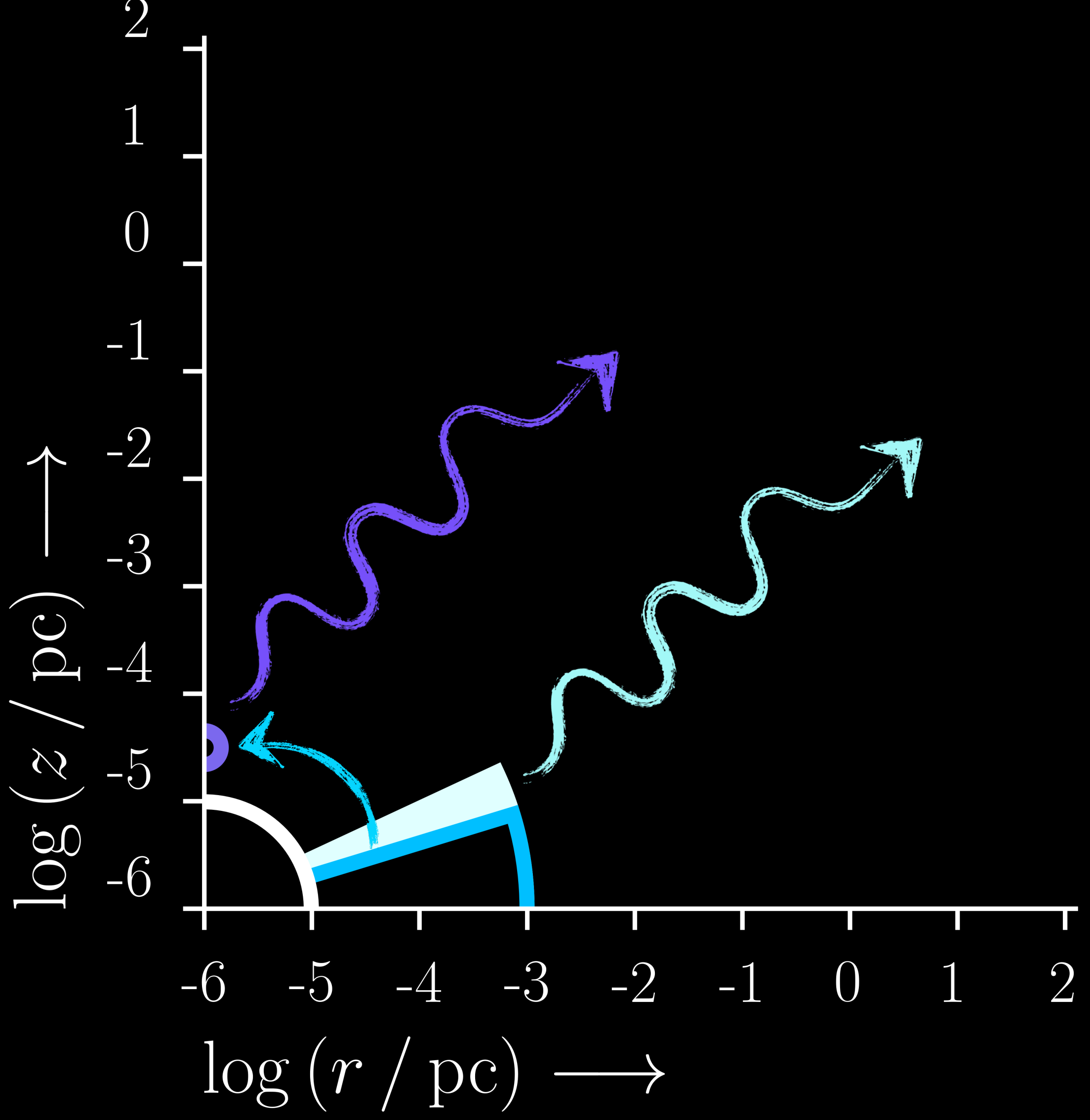
Ultra-Fast Outflows



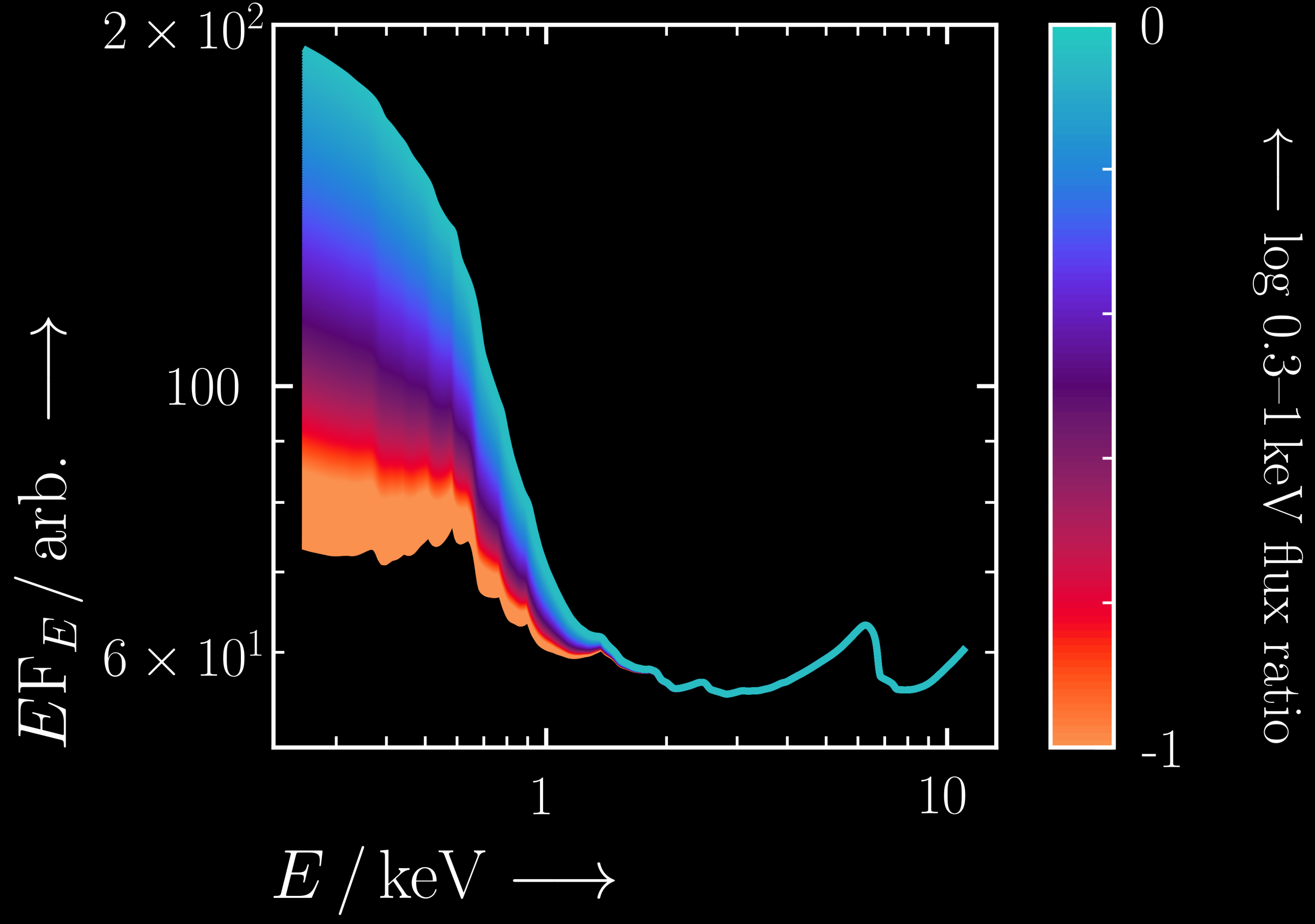


E.g., Sim+08, Sim+10, Braito+22, Parker+22, XRADE; Matzeu+, in prep.

Soft excess

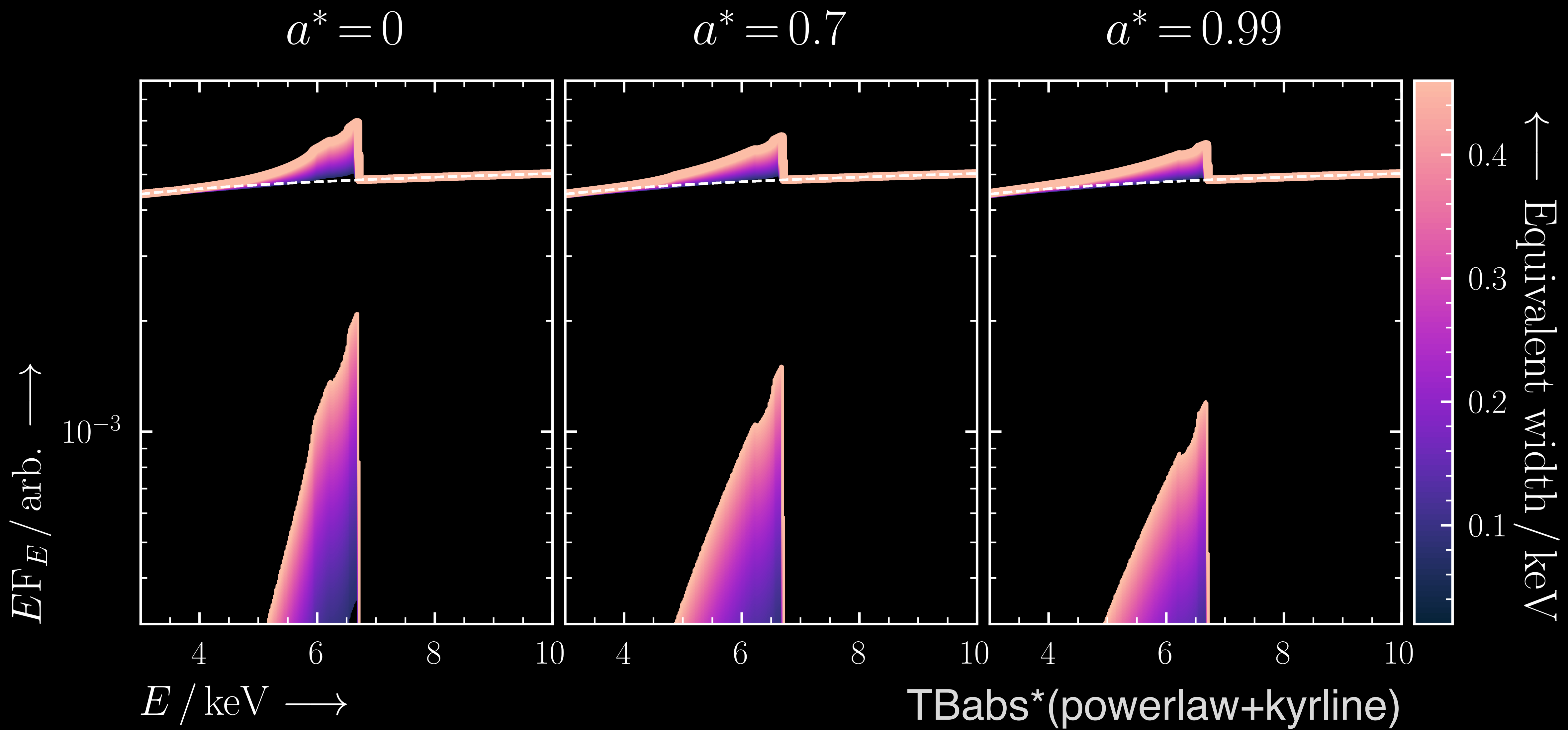


Nthcomp+KYNXillver



E.g., Mehdipour+11, Done+12, Boissay+14, 16

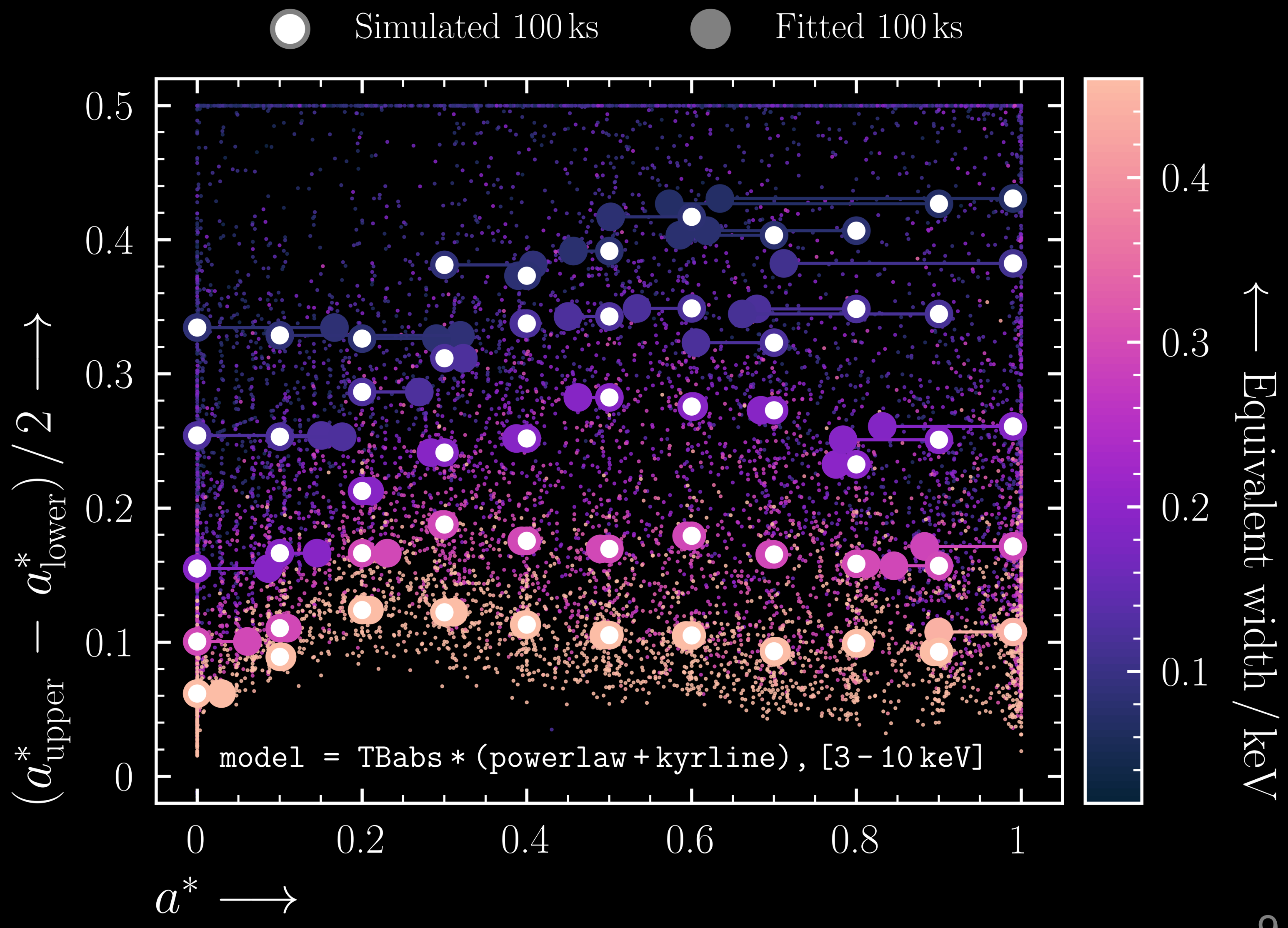
Phenomenological modelling



TBabs*(powerlaw+kyrline)

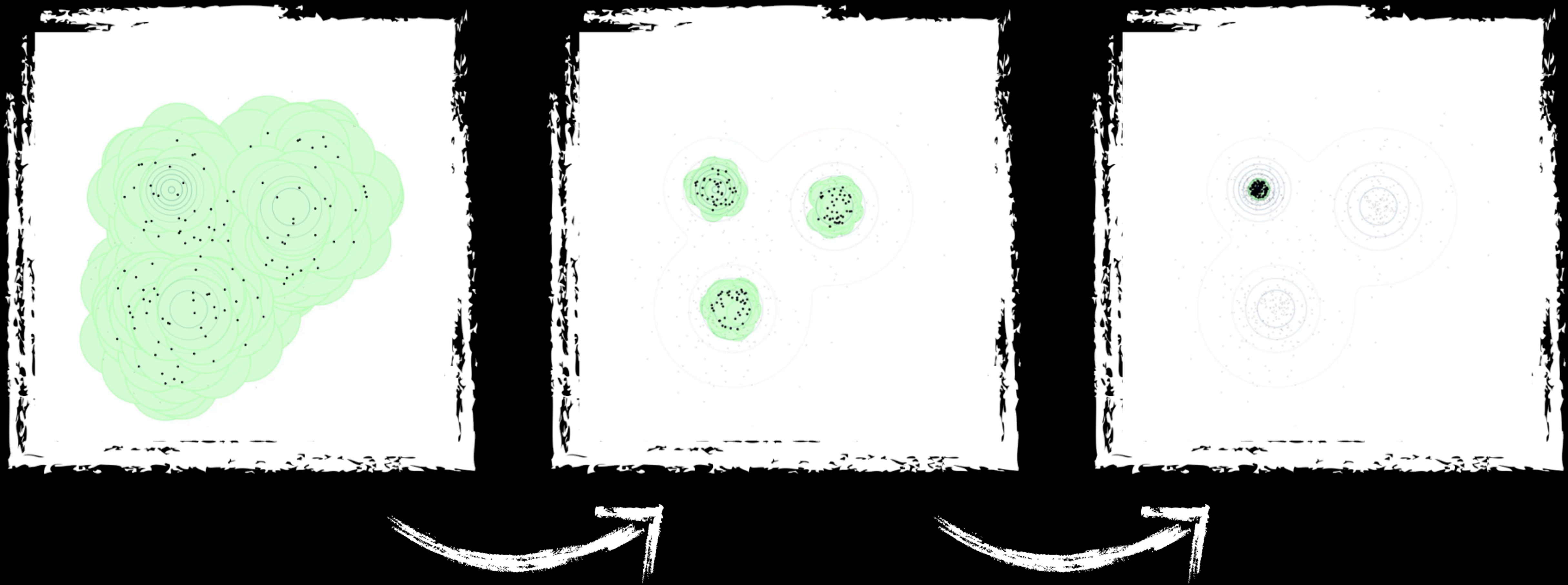
Phenomenological modelling

- Spin difficult to constrain with EW < 100 eV
- Number of spin limits increases with decreasing EW
- Parabolic shape possibly due to parameter boundary effects



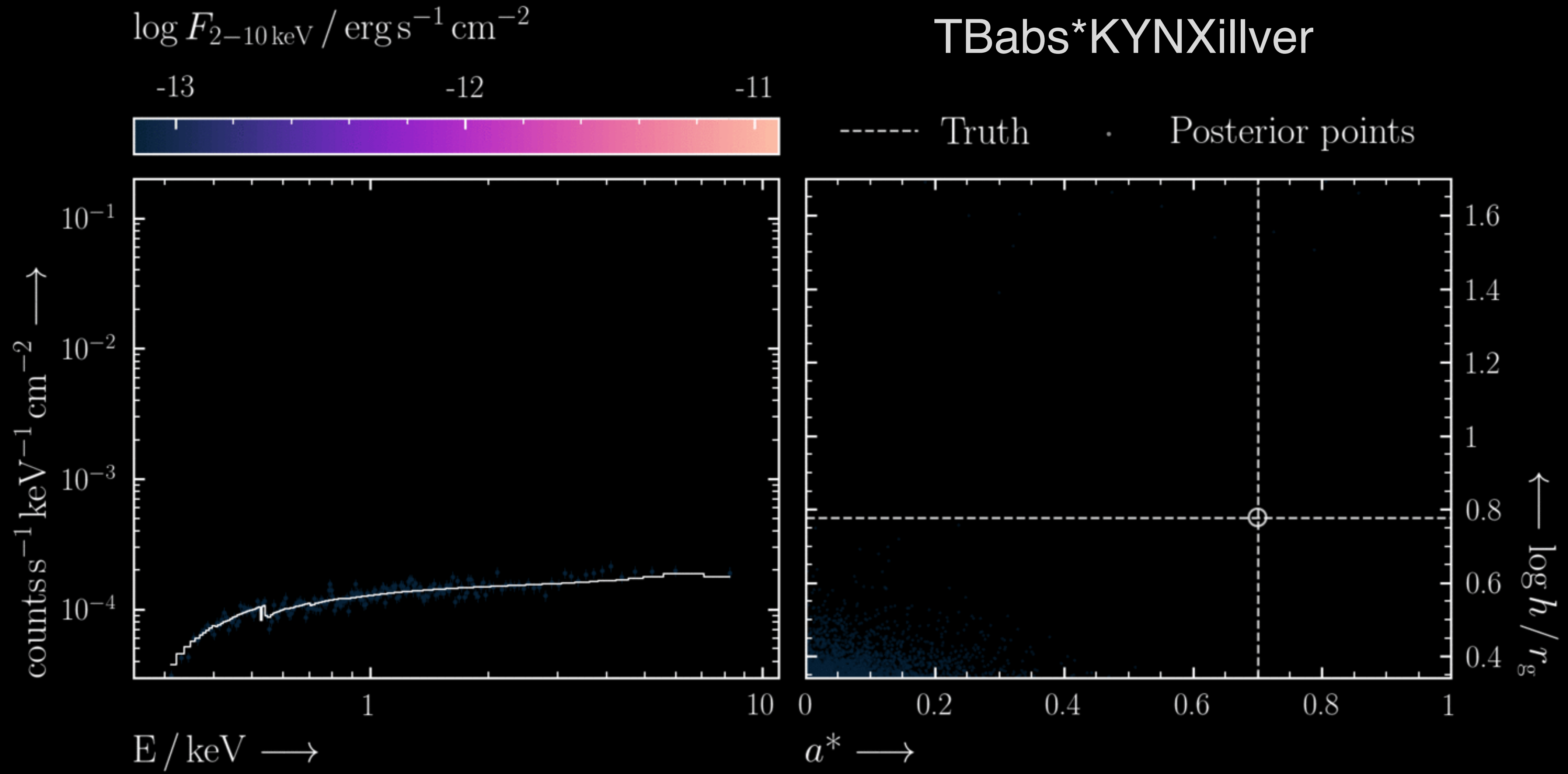
Bayesian X-ray Analysis

Skilling 04, Feroz 07, Buchner+14, Buchner 21

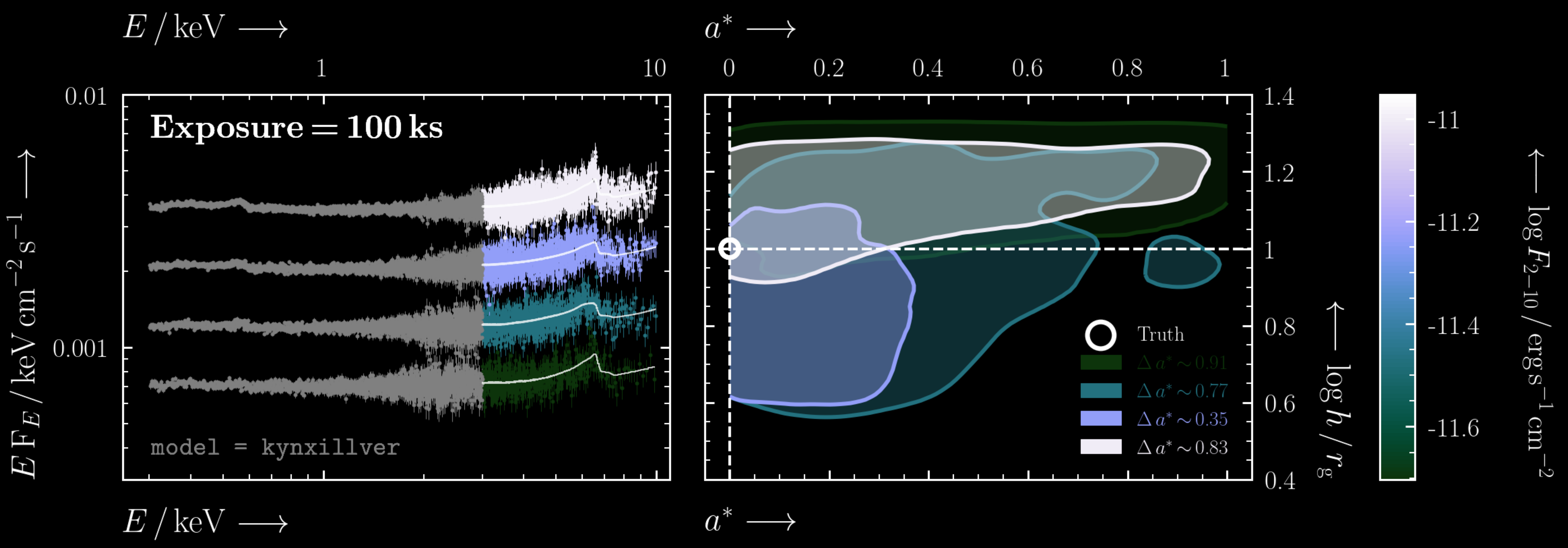


Simulations from: github.com/chi-feng/mcmc-demo (see also peterboorman.com/tutorial_bxa)

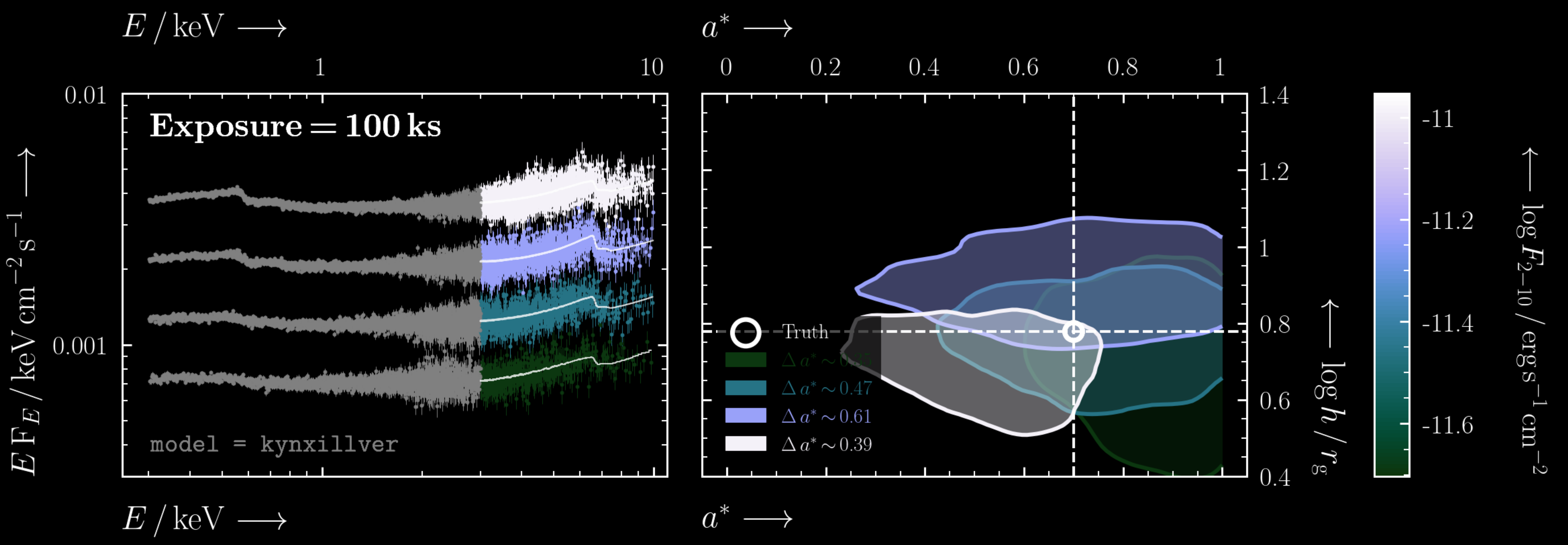
KYNXillver modelling with BXA, a* = 0.7



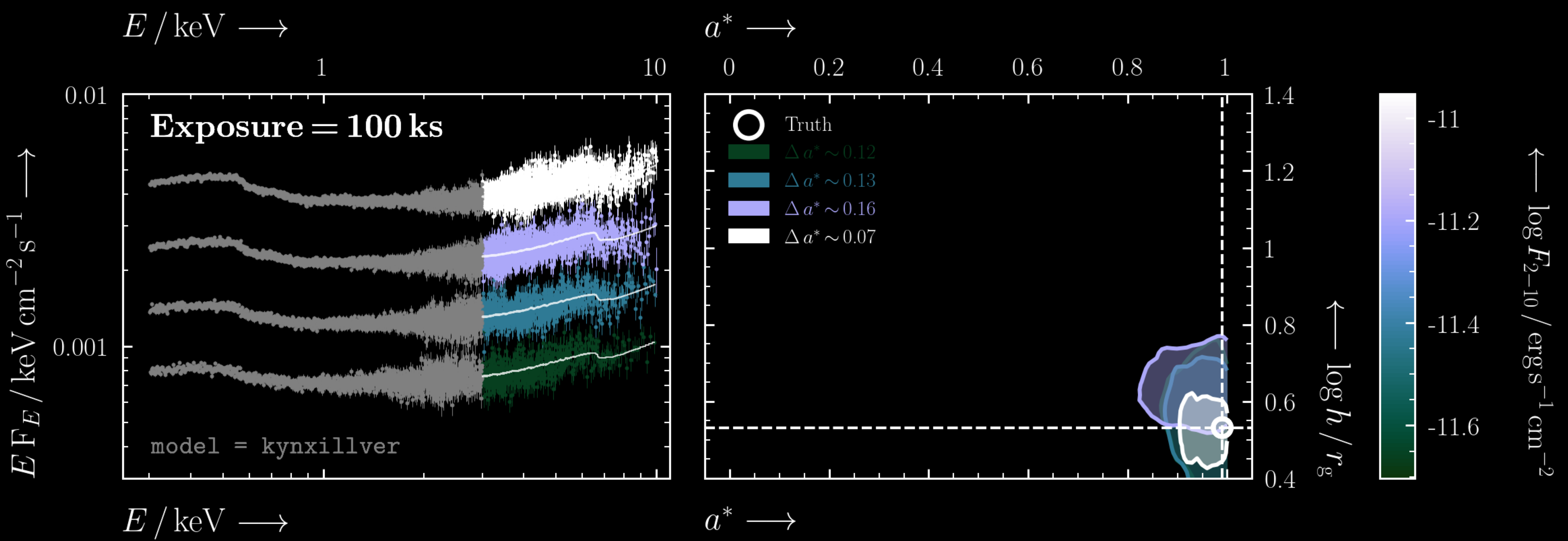
Physically-motivated modelling, $h = 10\ r_g$



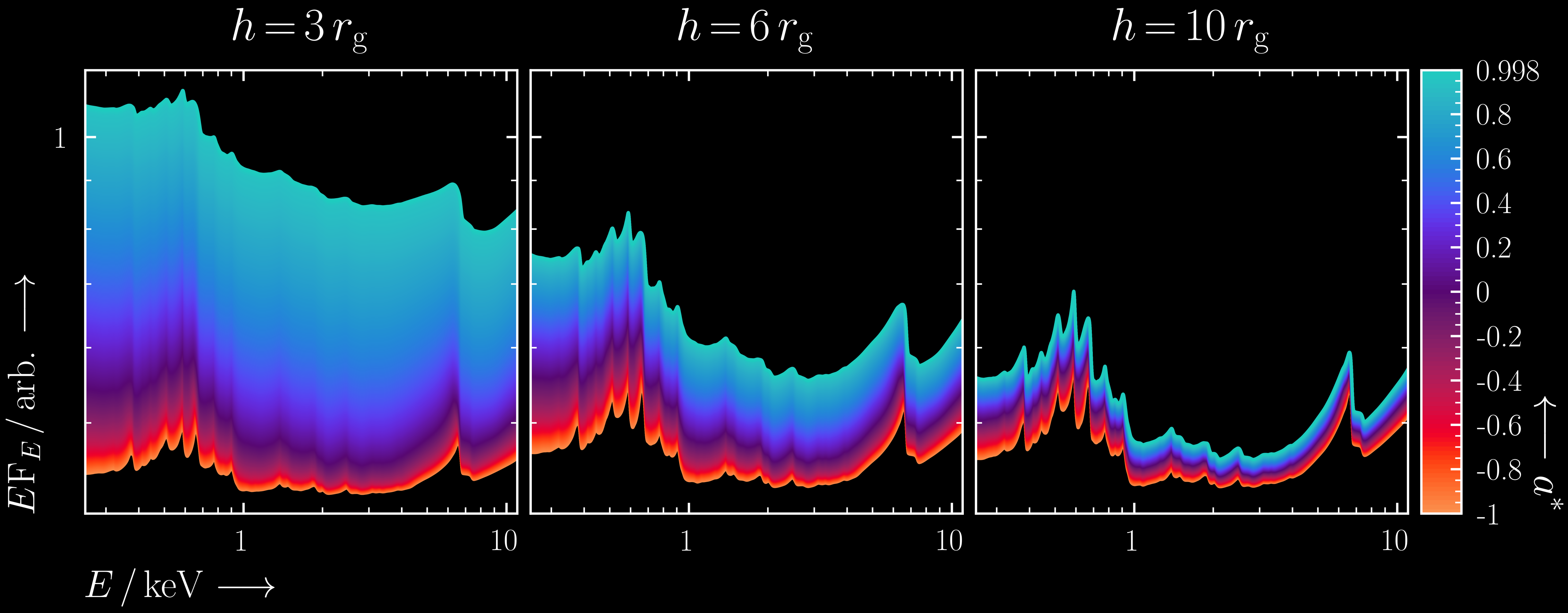
Physically-motivated modelling, h = 6 r_g



Physically-motivated modelling, h = 3 r_g

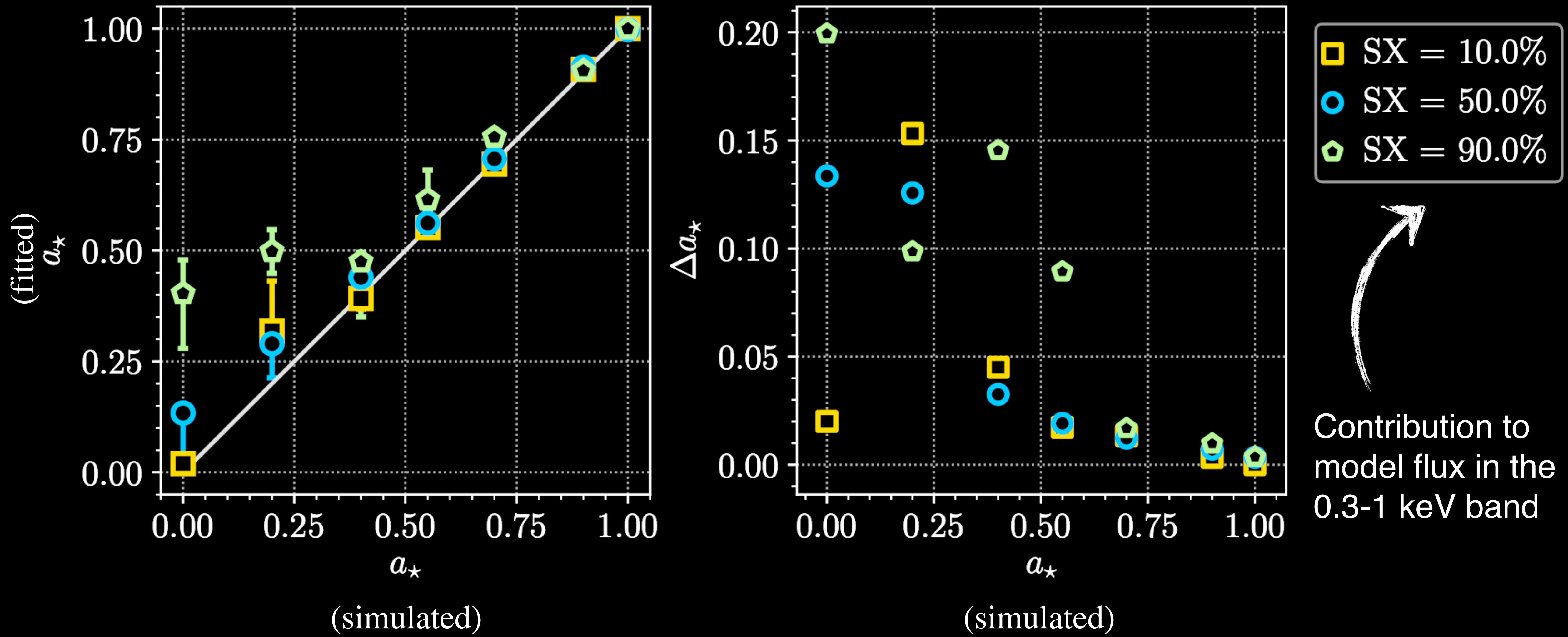


A compact corona



Soft excess contamination

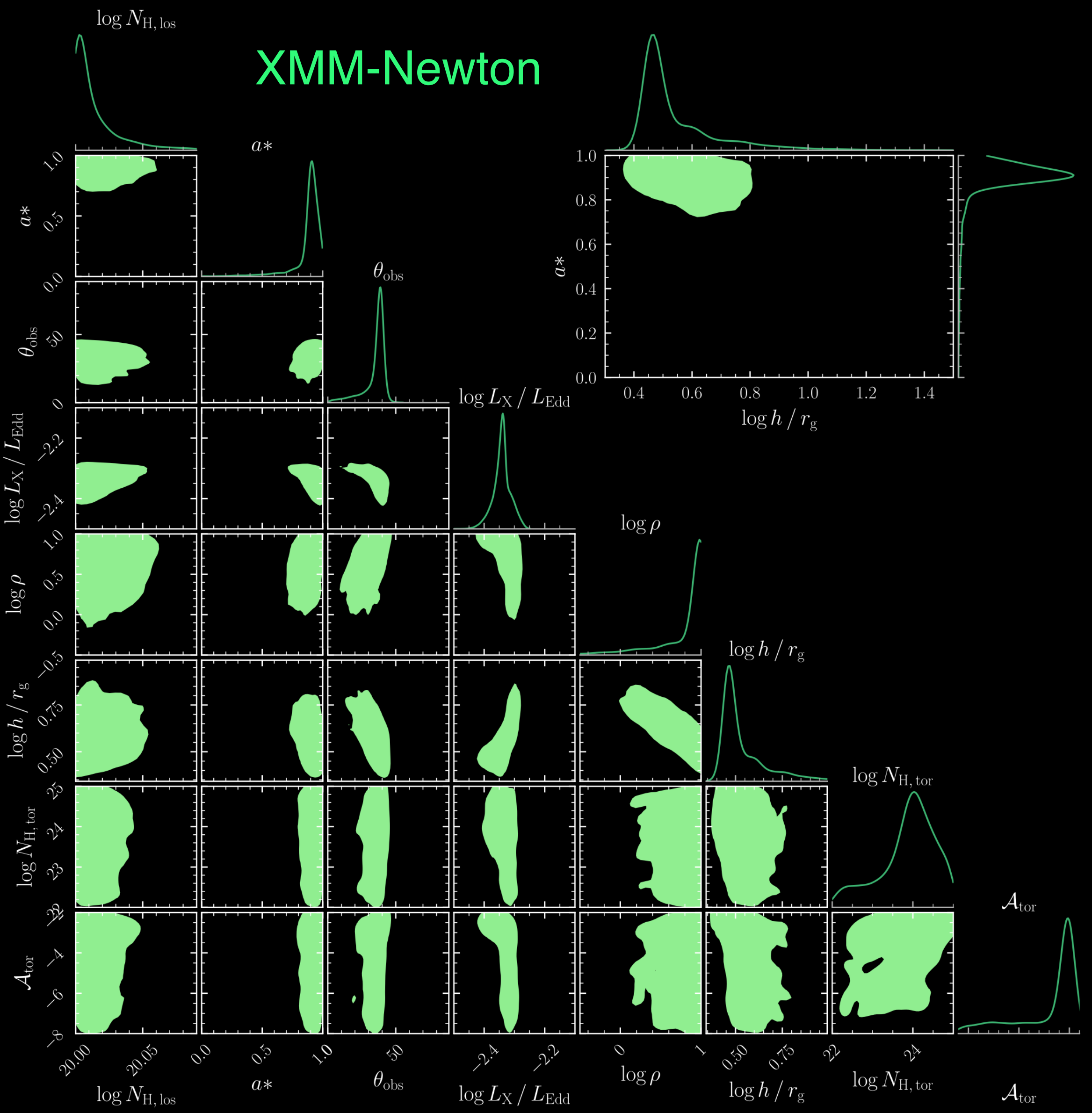
Work by Daniel Kynoch

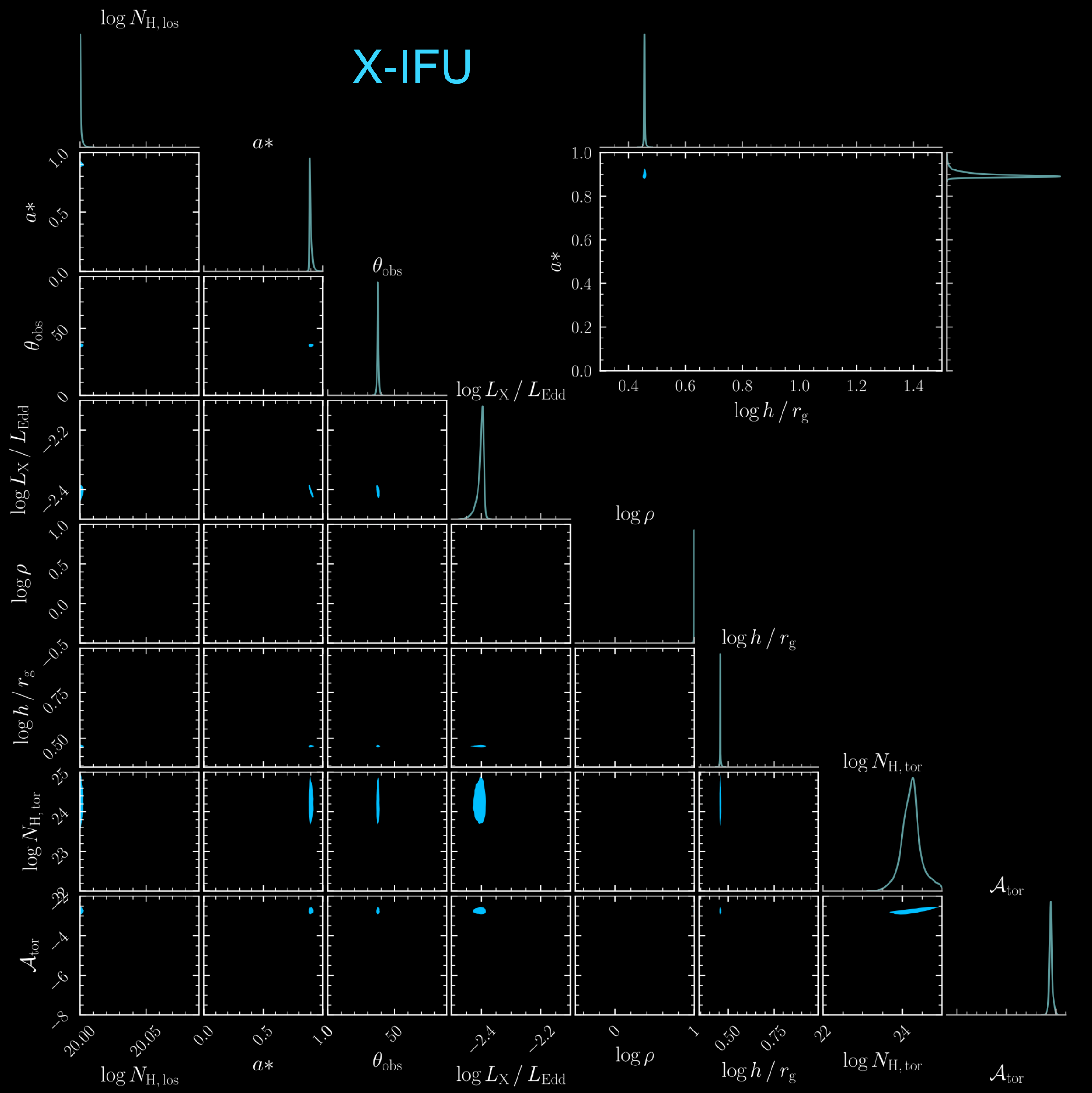


Contribution to model flux in the 0.3-1 keV band

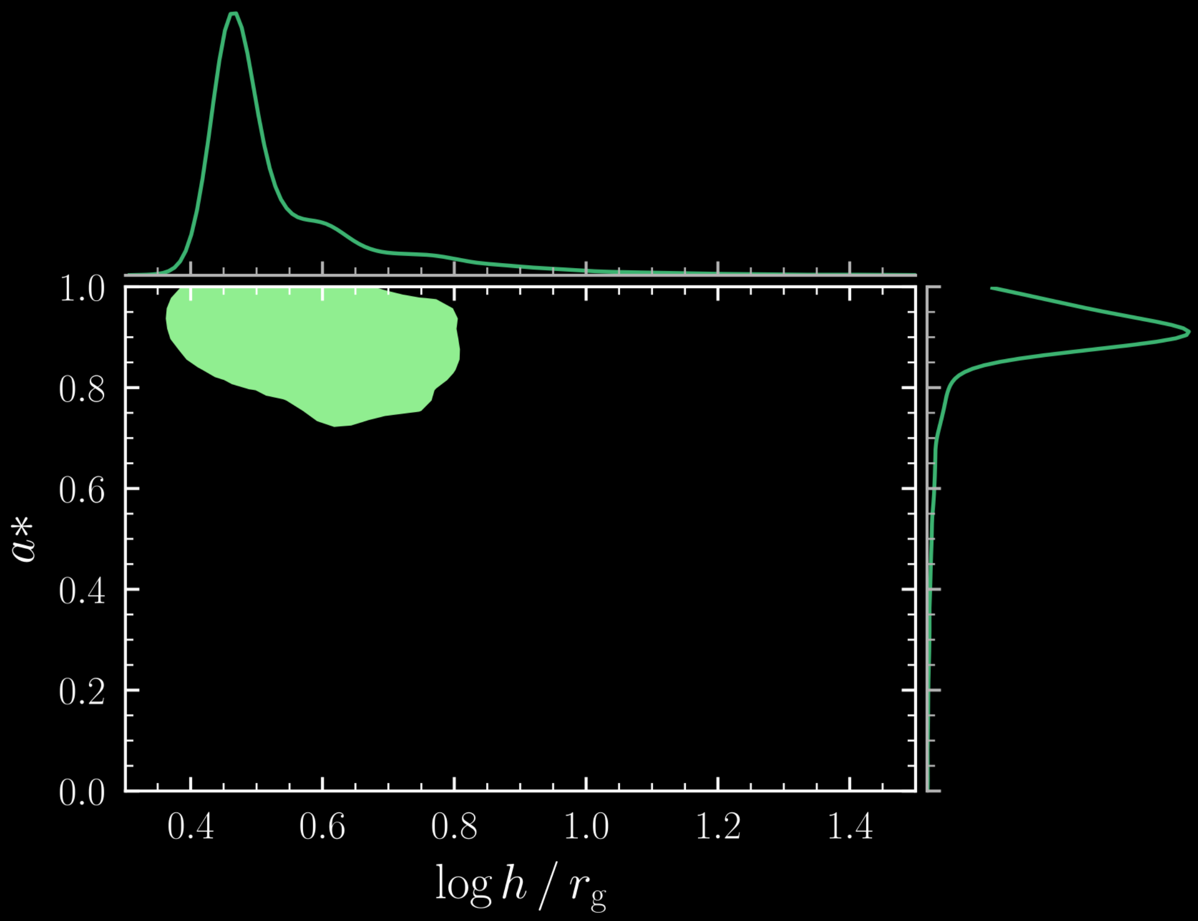
Distant reflection

zTBabs*cabs*KYNXillver+MYtorus

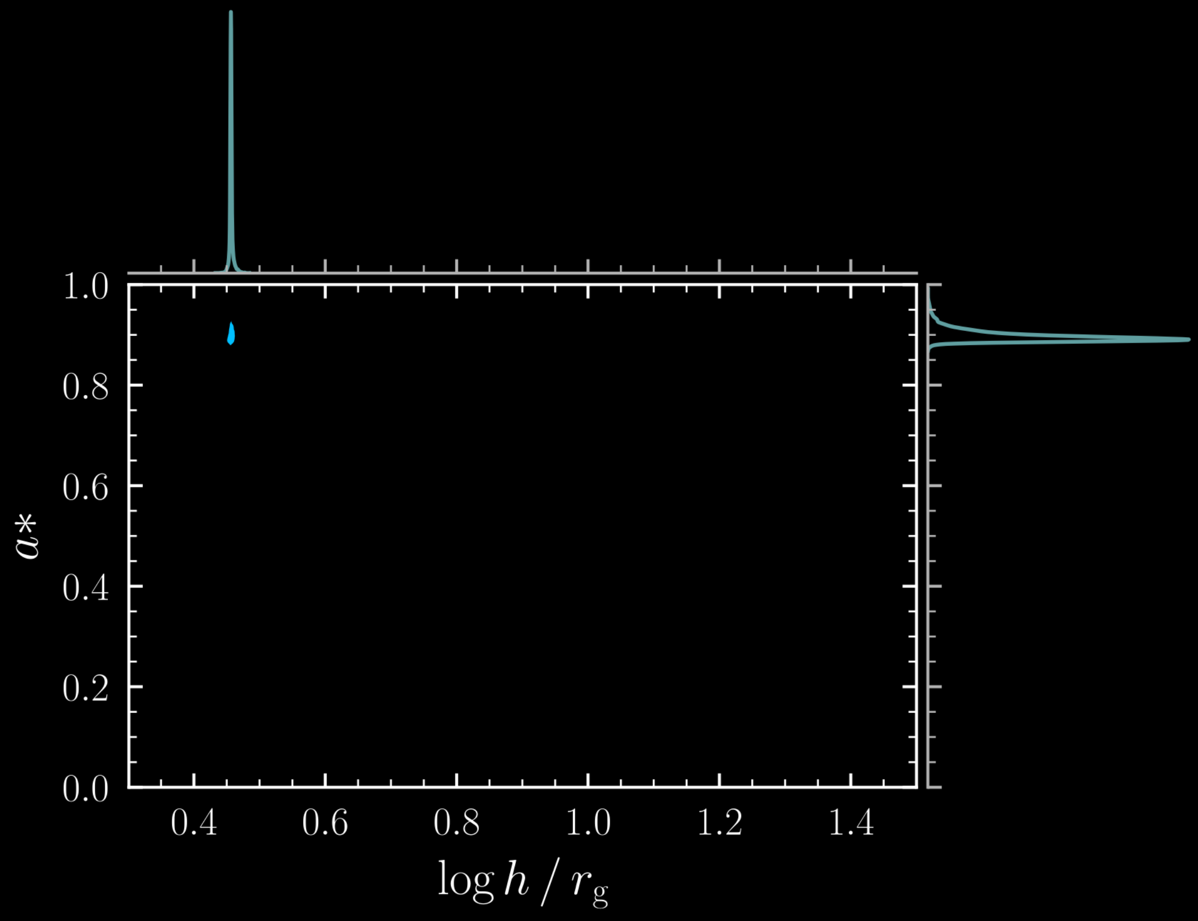




Marginalizing over distant reflection

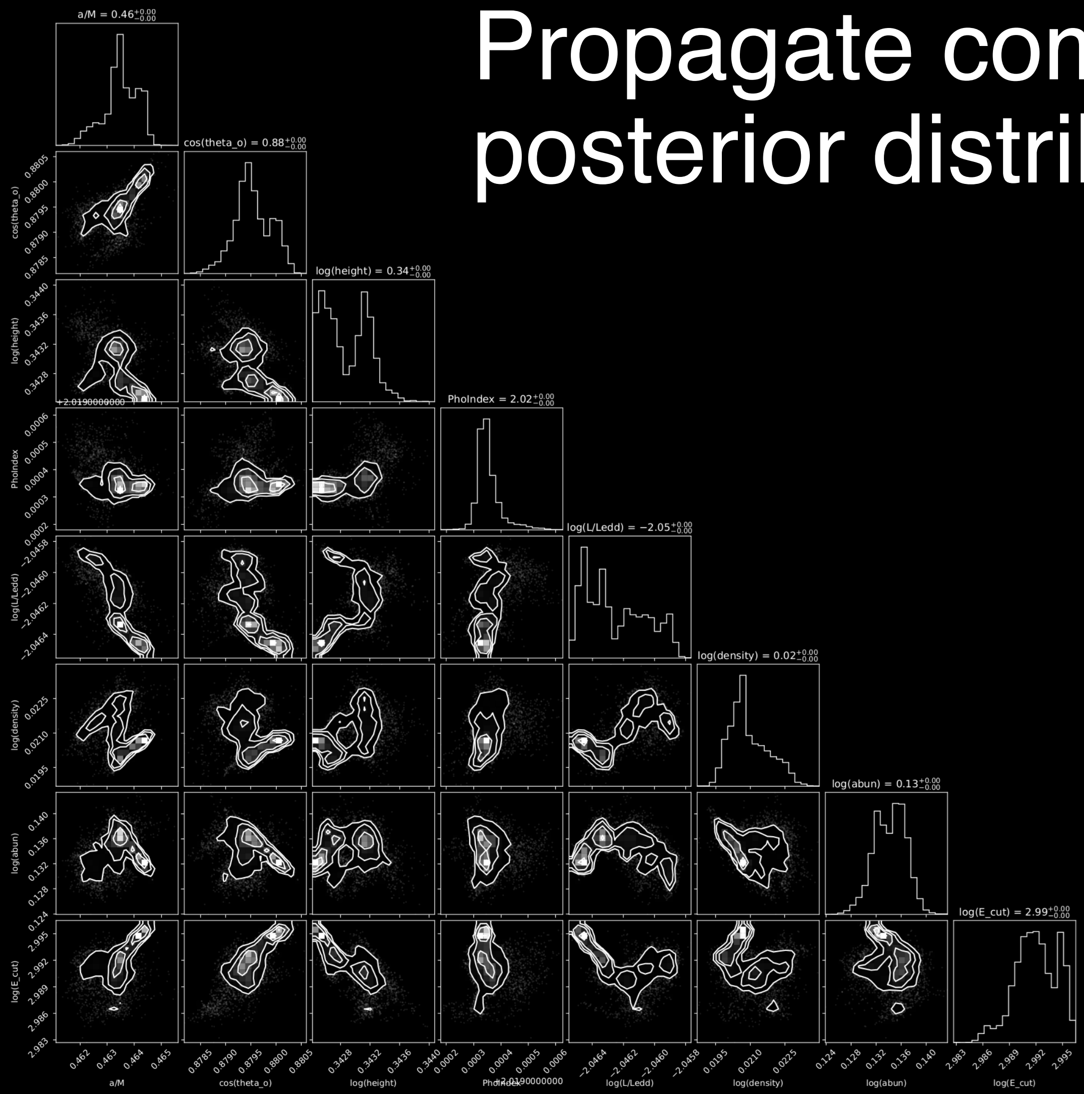


XMM-Newton

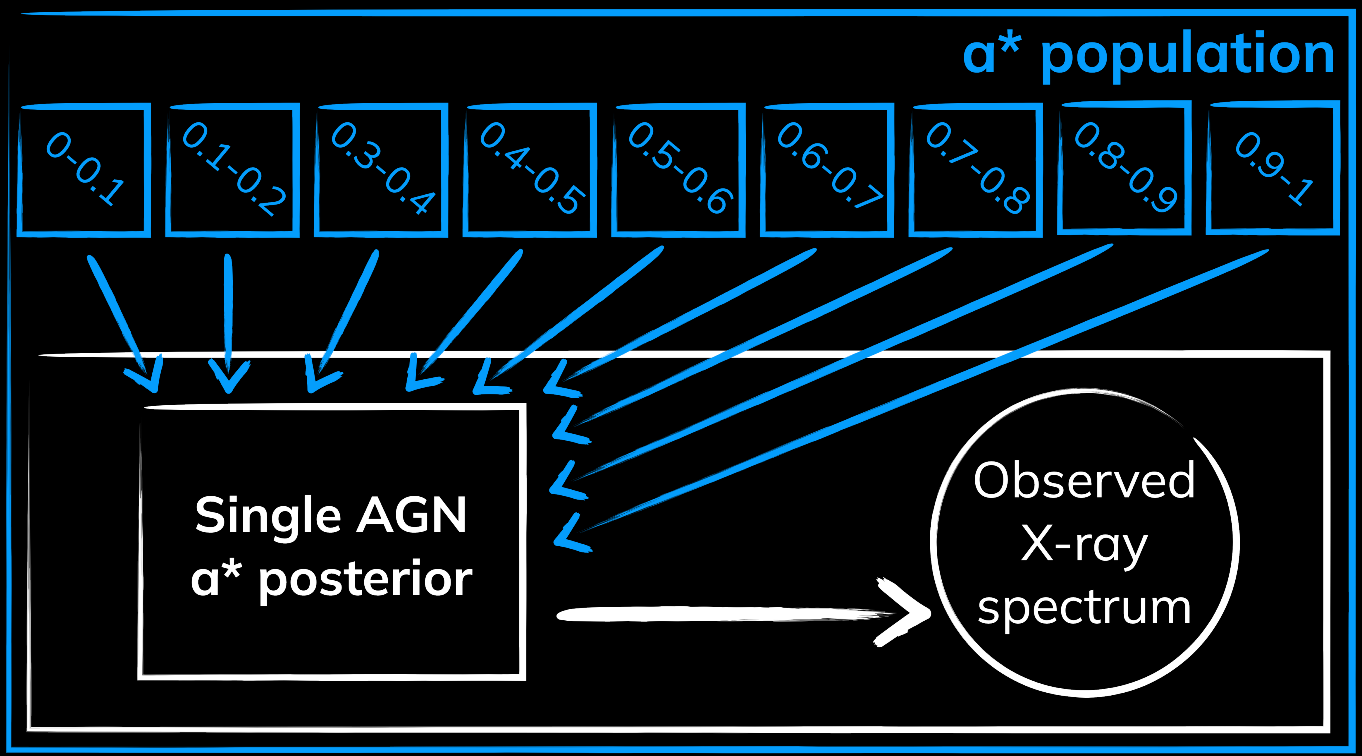


X-IFU

Hierarchical modelling



Propagate complex posterior shapes into the posterior distribution of the population



See e.g., Kuraszkiewicz+21

ATHENA X-IFU
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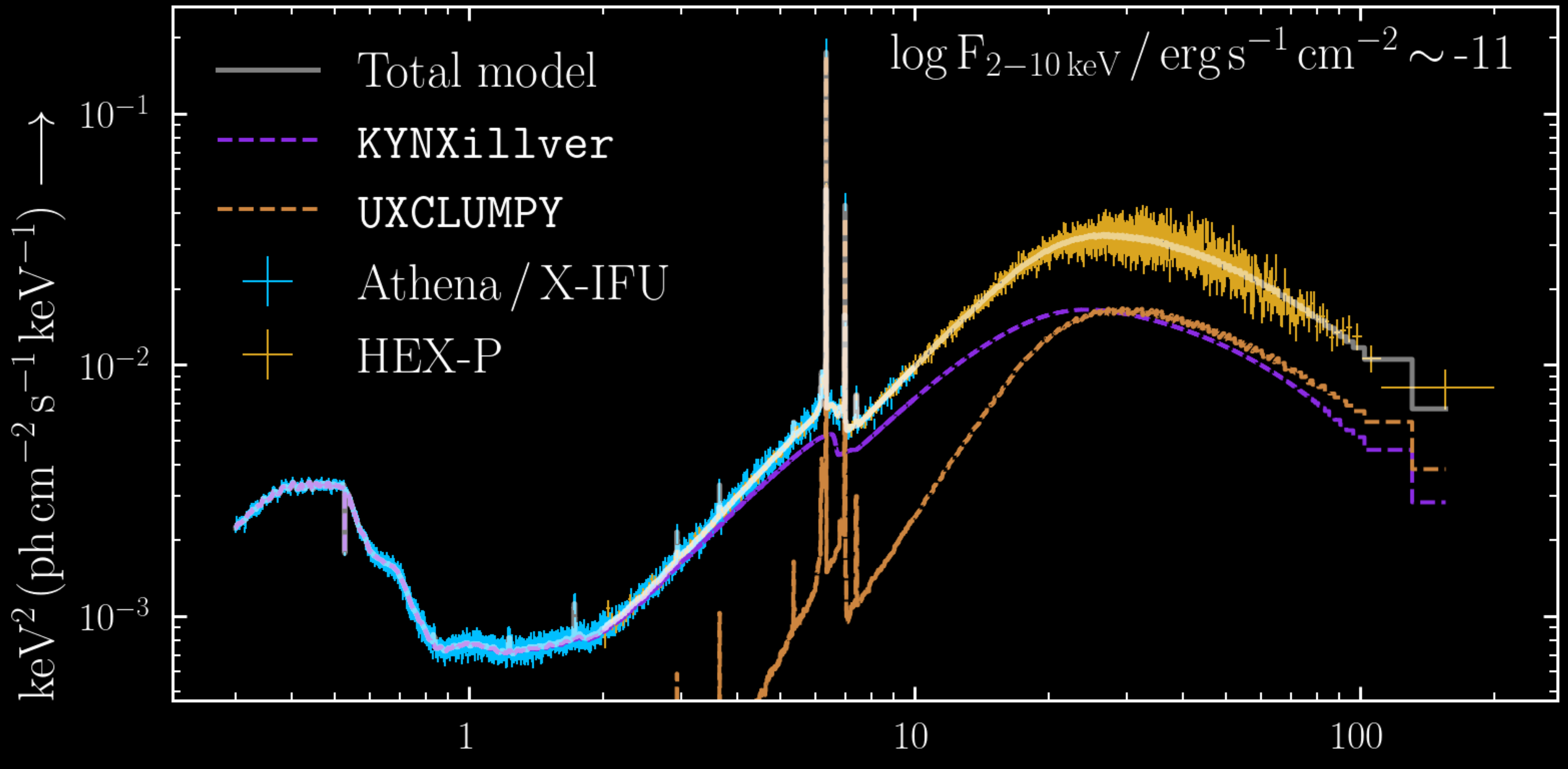
+

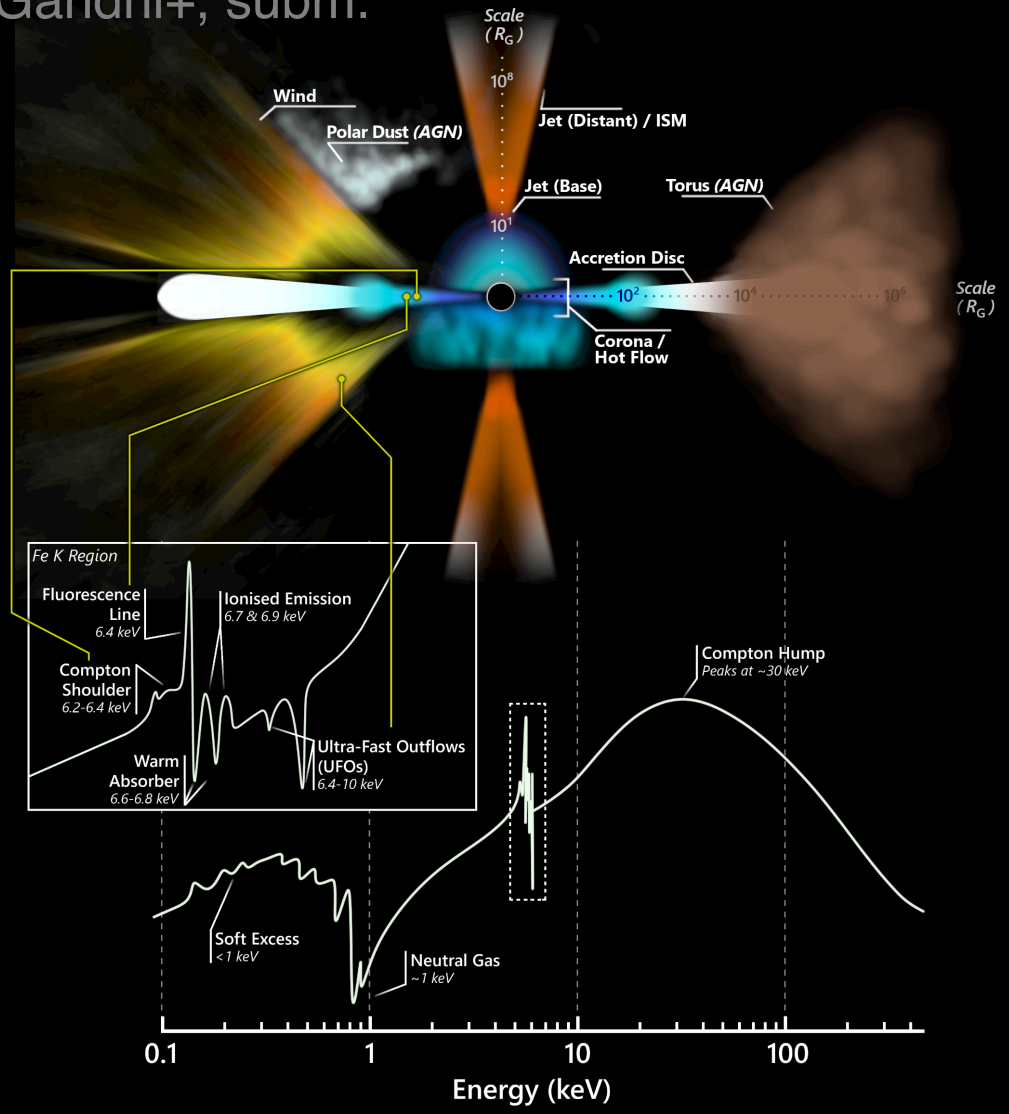
HEX-P
HIGH ENERGY X-RAY PROBE



For more info on HEX-P, see Madsen+19, hexp.org

Summary

Gandhi+, subm.

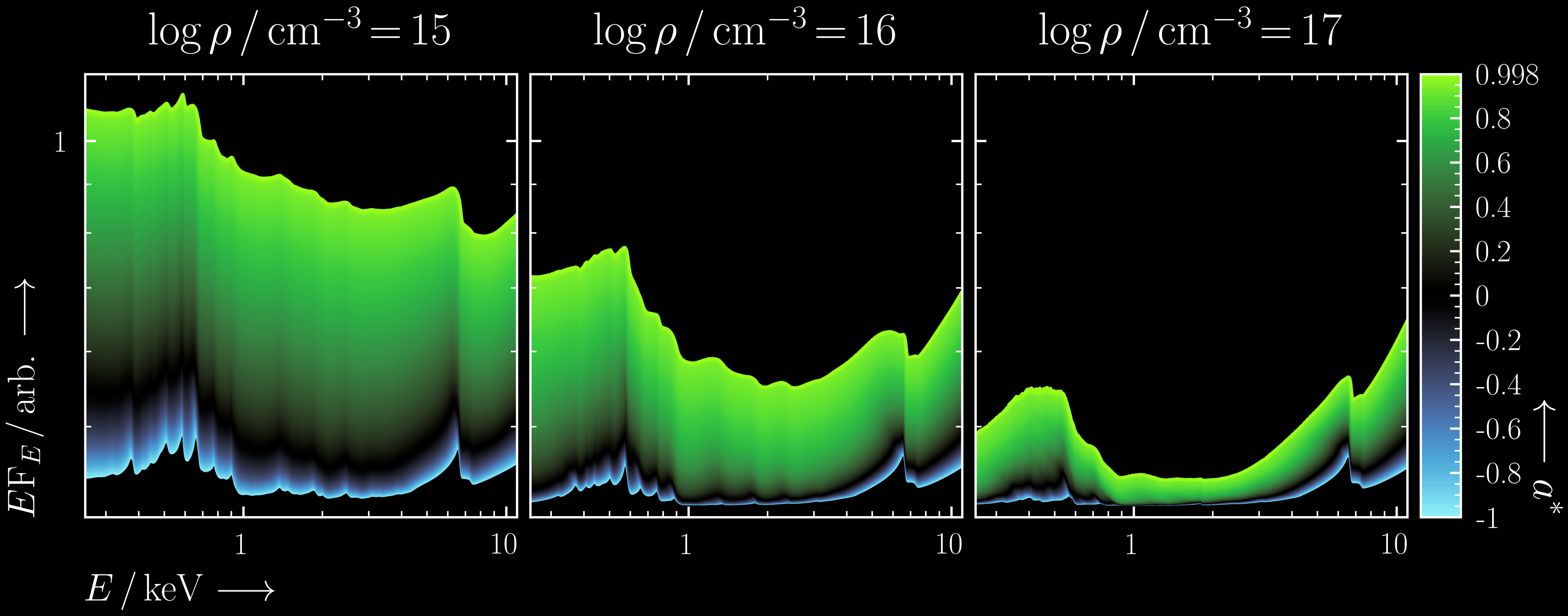


- Current strongest constraints for compact coronae & dense accretion discs
- Microcalorimeters (e.g., XRISM, Athena/X-IFU) can help explore large regions of parameter space that were not possible with CCDs
- Global parameter exploration and hierarchical modelling can propagate complex posteriors into a parent spin distribution

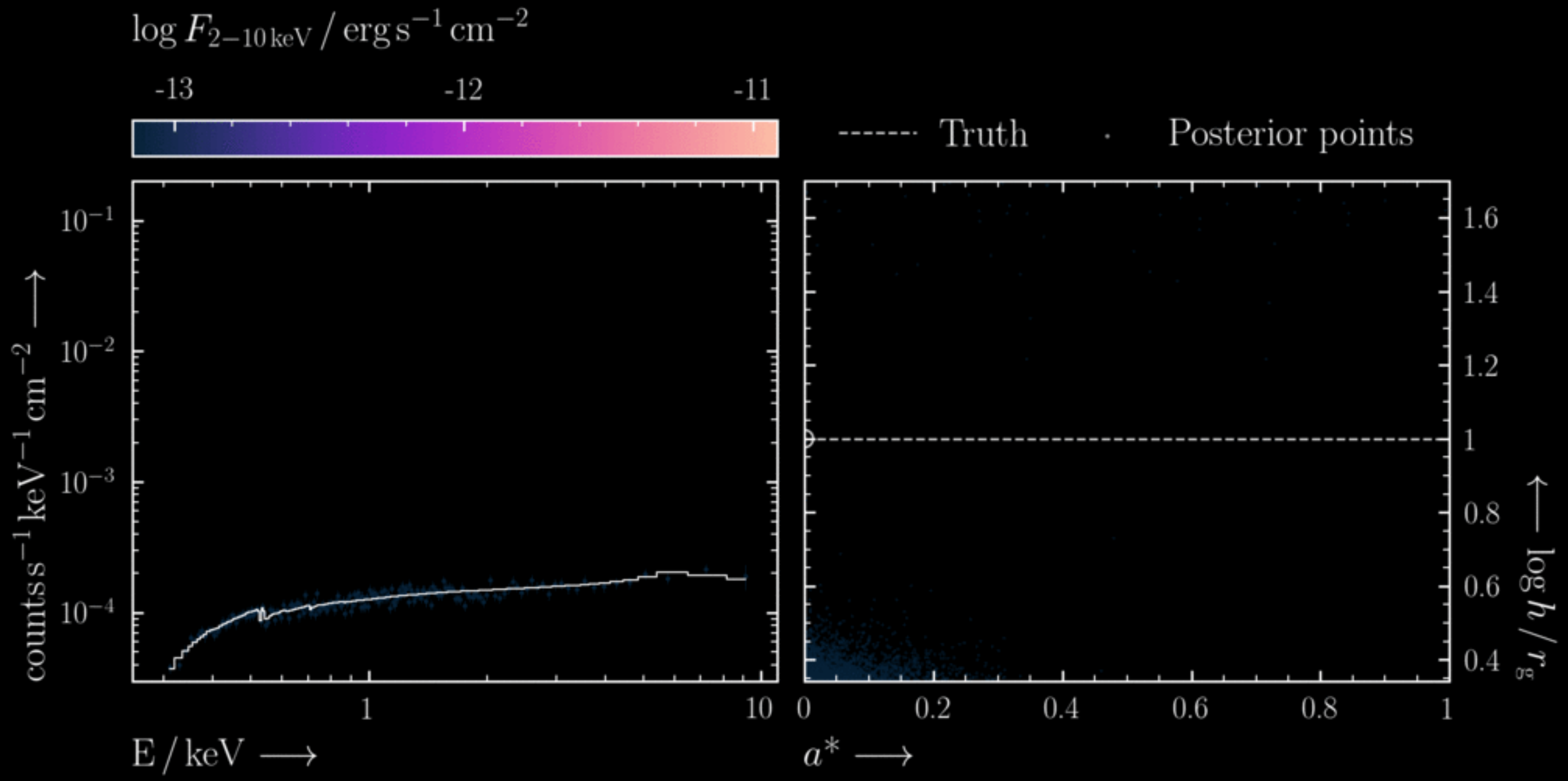
Thank you for listening!

Any questions?

Accretion disc density



Physically-motivated modelling, a* = 0



Physically-motivated modelling, a* = 0.99