Estimating the coronal parameters in AGN with MoCA

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Finding Extreme Relativistic Objects

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ROMA TRE
UNIVERSITÀ DEGLI STUDI

Work flow

Very often AGN spectra are fitted with a phenomenological model
i.e. a power law with an exponential cut-off

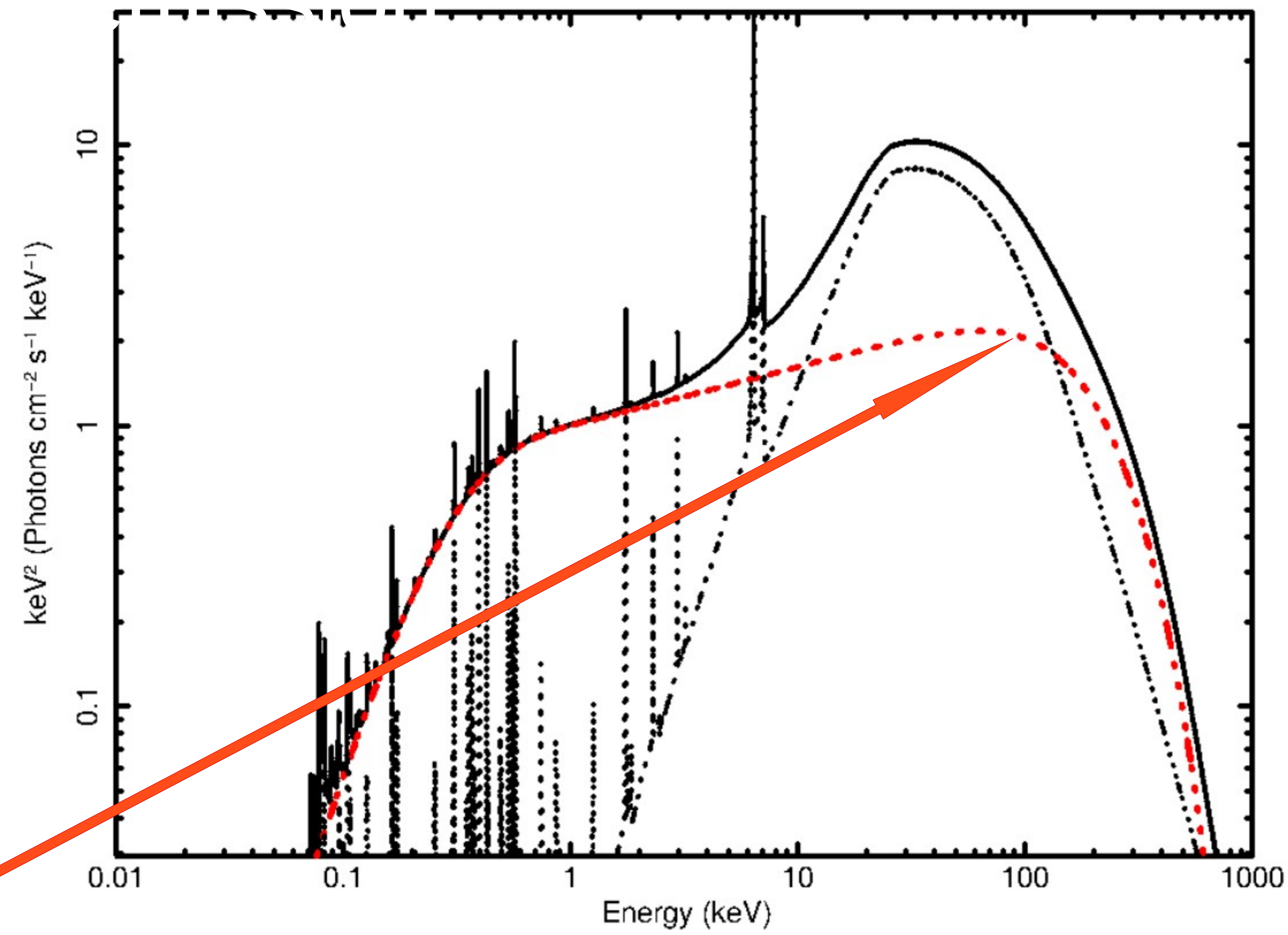
We used a Monte Carlo code
for simulating spectra for a large range of temperatures and optical depths

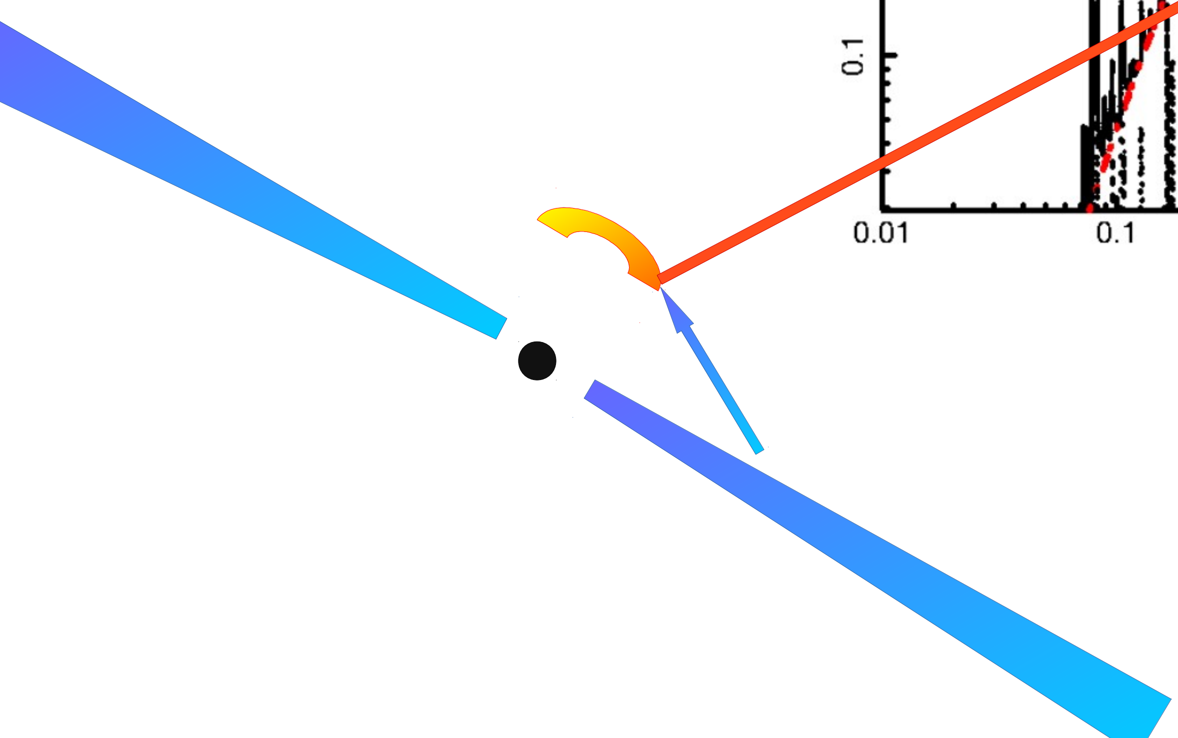
We fit the simulated spectra
with a cut-off power law

We derive a direct way to convert phenomenological parameters into physical ones

Inverse-Compton behind AGN continuum

AGN X-ray continuum
can be interpreted as the effect of inverse-Compton scattering





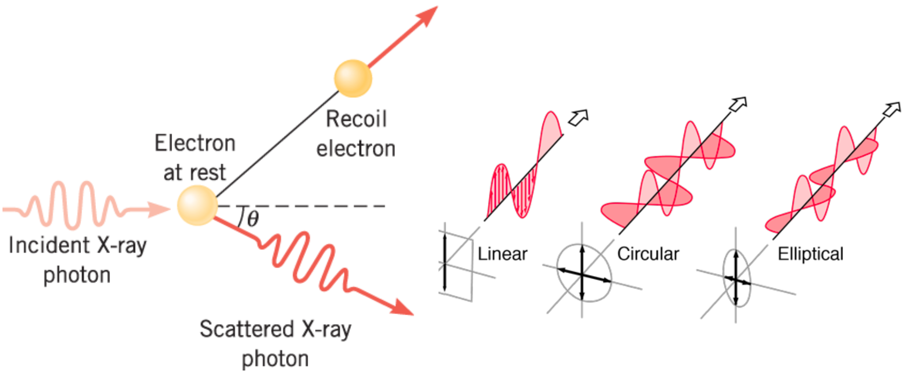
MoCA, a flexible code

MoCA:

a Monte Carlo code for accretion in Astrophysics

Assumptions:

1. Shakura-Sunyaev accretion disc
2. thermal coronae
3. Single photon approach
4. Full special relativity
5. Polarization signal



details in Tamborra et al. submitted

Can be used for studying several astrophysical sources e.g. Binary black hole sistems

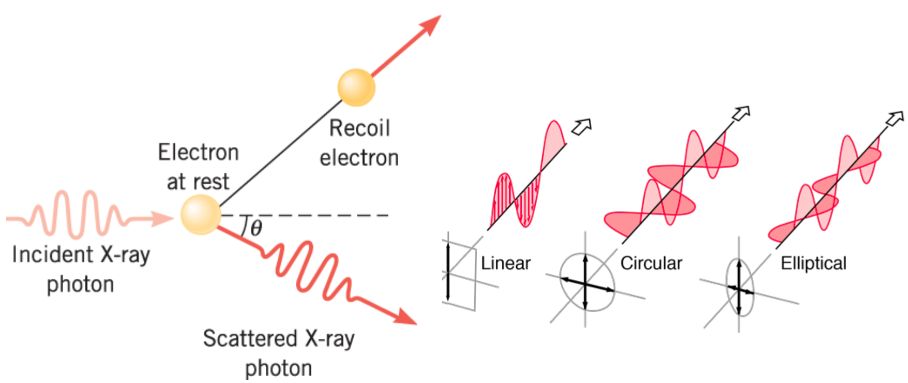
MoCA, a flexible code

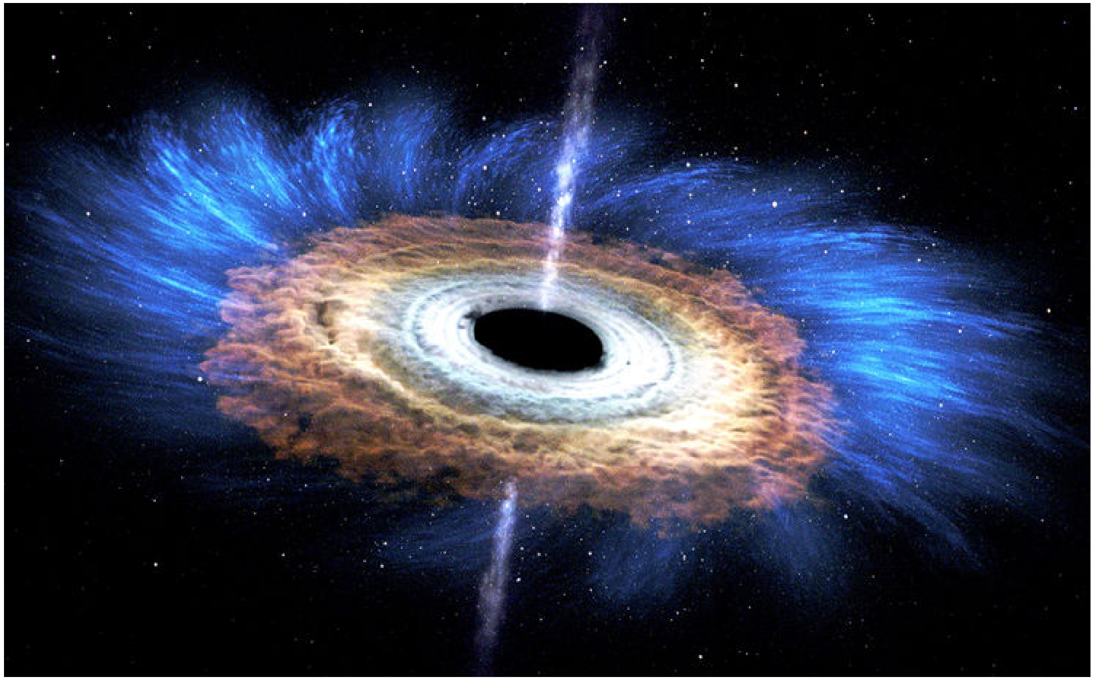
MoCA:

a Monte Carlo code for accretion in Astrophysics

Assumptions:
1. Shakura-Sunyaev neutral accretion disc
2. Extended coronae
3. Single photon approach
4. Full special relativity included
5. Polarization signal

In particular, for investigating the coronal region of Active Galactic Nuclei





details in Tamborra et al. submitted

MoCa, a tunable code

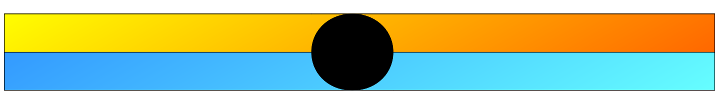
Different setup for the AGN are permitted

We used

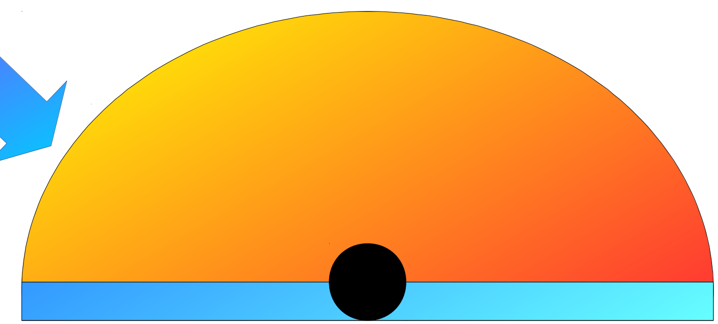
$M_{BH}=1.5\times10^{8}\,M_{O}$

$\dot{M}=0.01$ in units of L/L_{edd}

as for ARK120



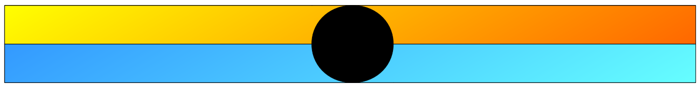
Slab geometry
$0.5<\tau<4.5$
$10<kT<120$ keV
$H=10\ R_{grav}$
$R_{in}=6\ R_{grav}$
$R_{out}=500\ R_{grav}$

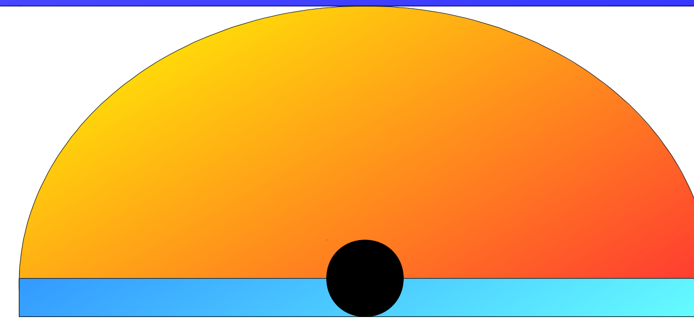


Sphere geometry
$0.5<\tau<7$
$10<kT<120$ keV
$R_{in}=6\ R_{grav}$
$R_{out}=500\ R_{grav}$

Hundreds of simulated AGN spectra

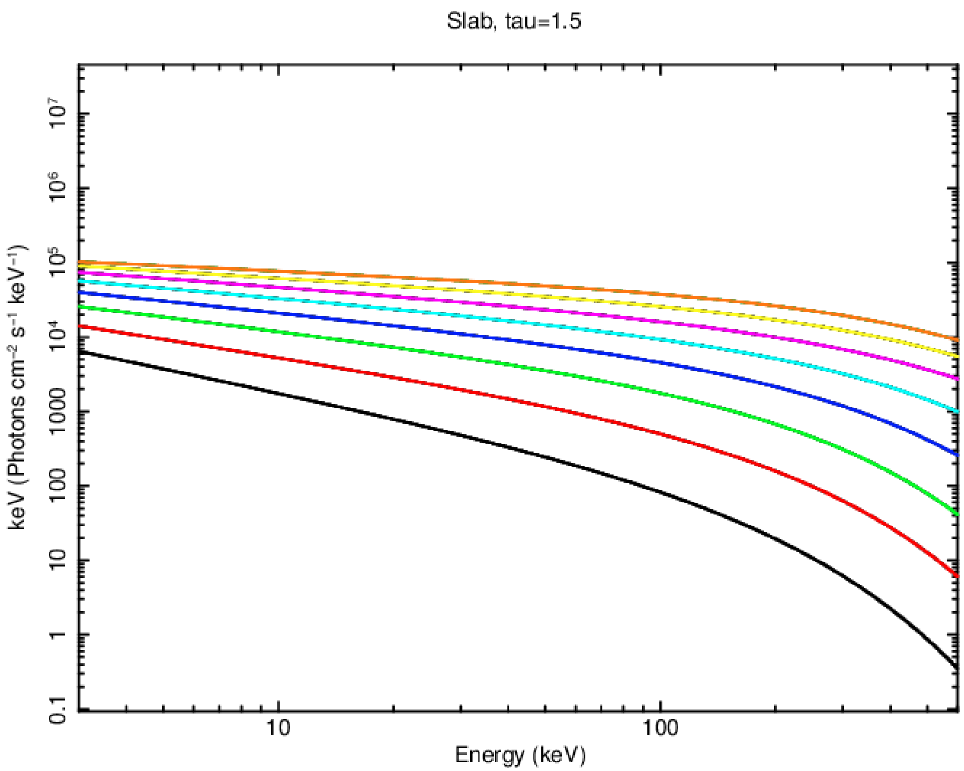
MoCa, a tunable code

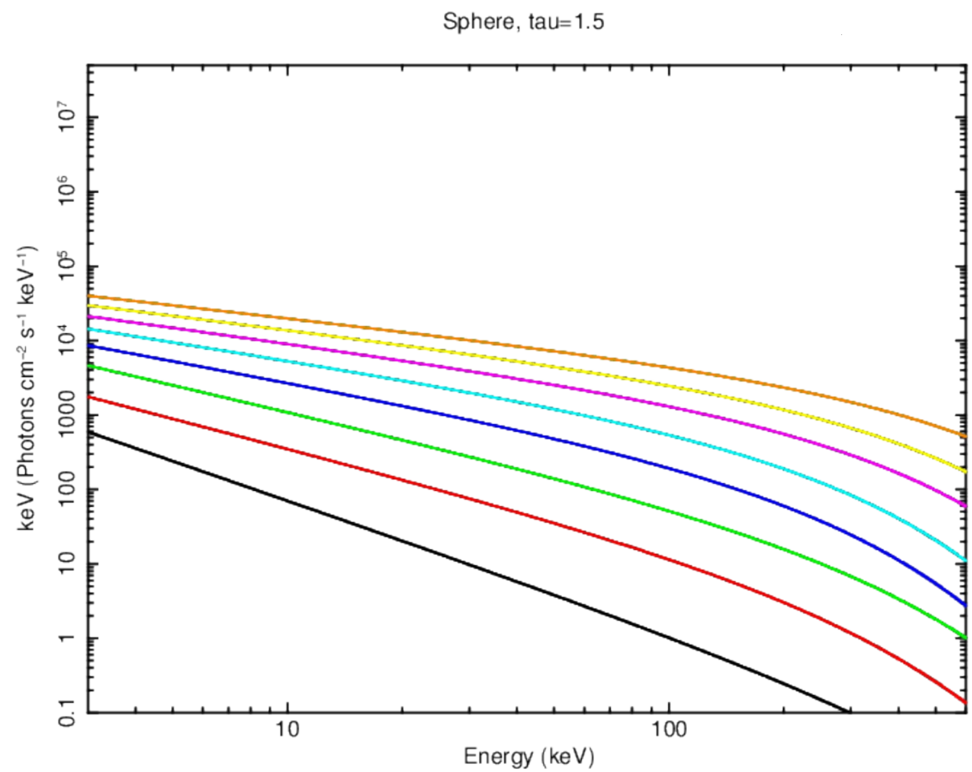




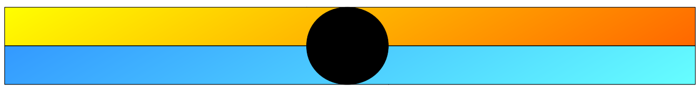
Parameters range:
$0.5<\tau<4.5$
$10<kT<120$ keV

Parameters range:
$0.5<\tau<7.0$
$10<kT<120$ keV





Fitting procedure, SLAB geometry



For the Slab geometry all the spectra are analyzed using XSPEC

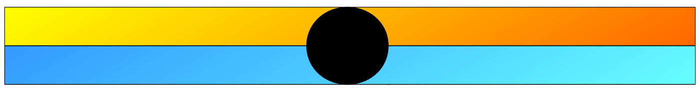
Statistic: cstat
Model: cut-off power law
Energy range: 2-700 keV

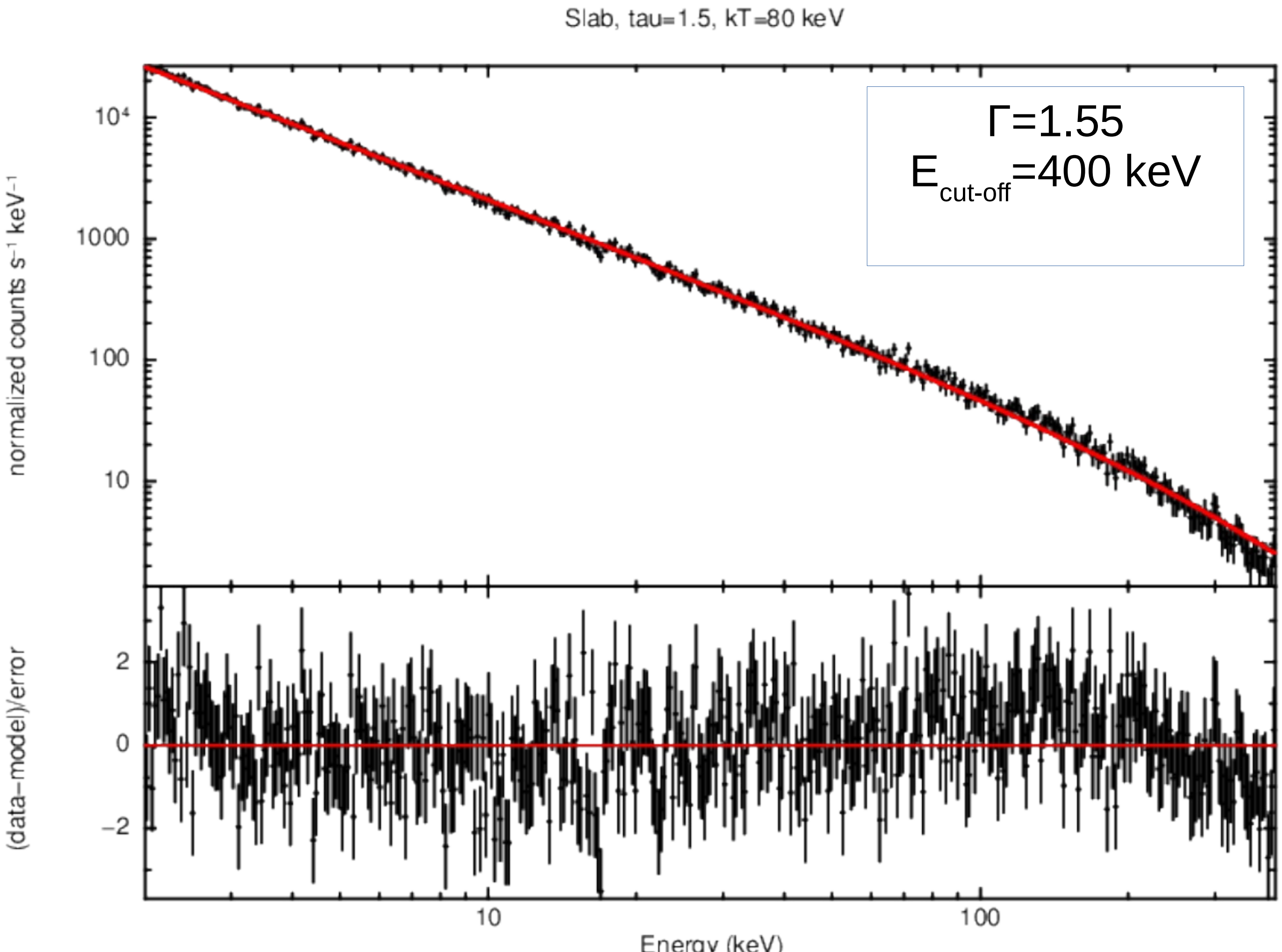
All the best-fit parameters with the corresponding uncertainties are stored into a matrix

τ	KT	E_{cut}	Γ	c/dof
...	...	...	...	...
...	...	...	...	...

Fitting procedure, examples and results

In XSPEC
Statistics:cstat
Model: cut-off power law
Energy range: 2-700 keV

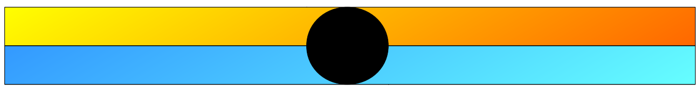


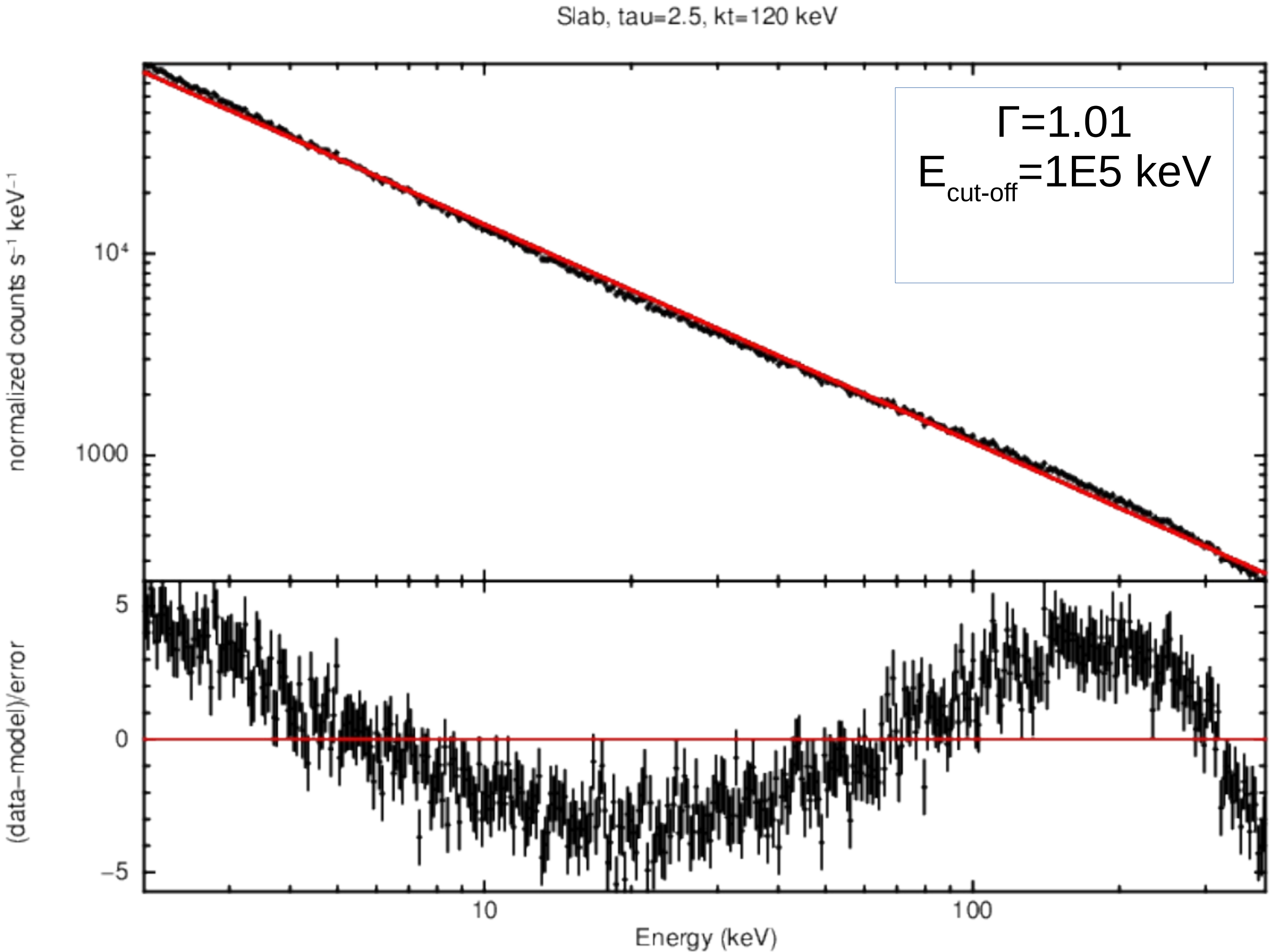


Parameters are accepted and stored

Fitting procedure, examples and results

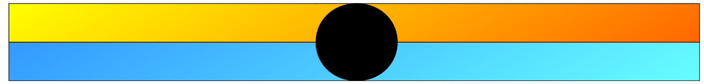
In XSPEC
Statistics: cstat
Model: cut-off power law
Energy range: 2-700 keV





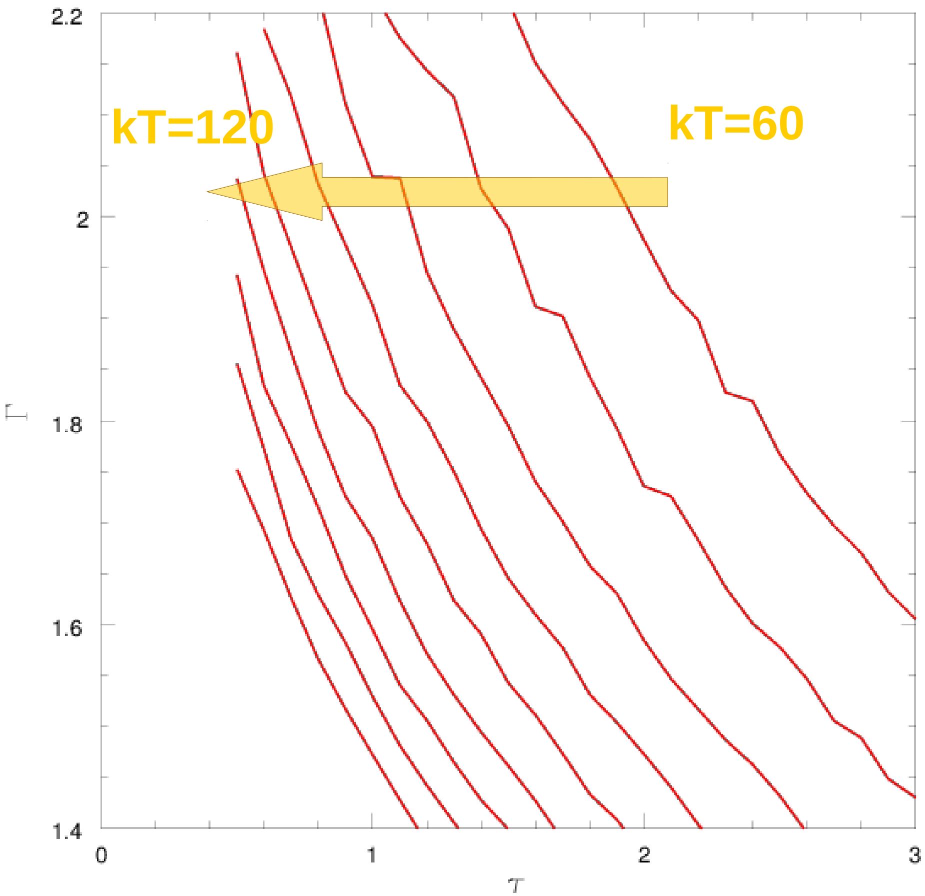
Parameters are not acceptable and a cut-off power law is not a good description of the Comptonized spectrum

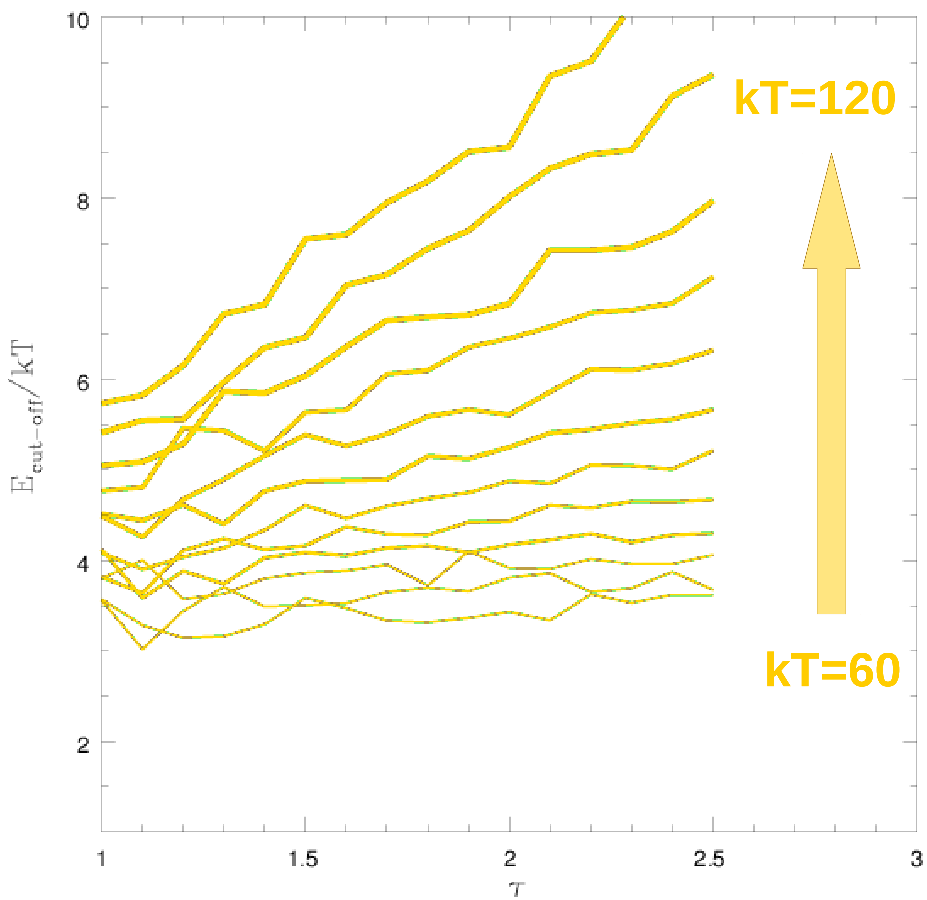
MoCA, trends



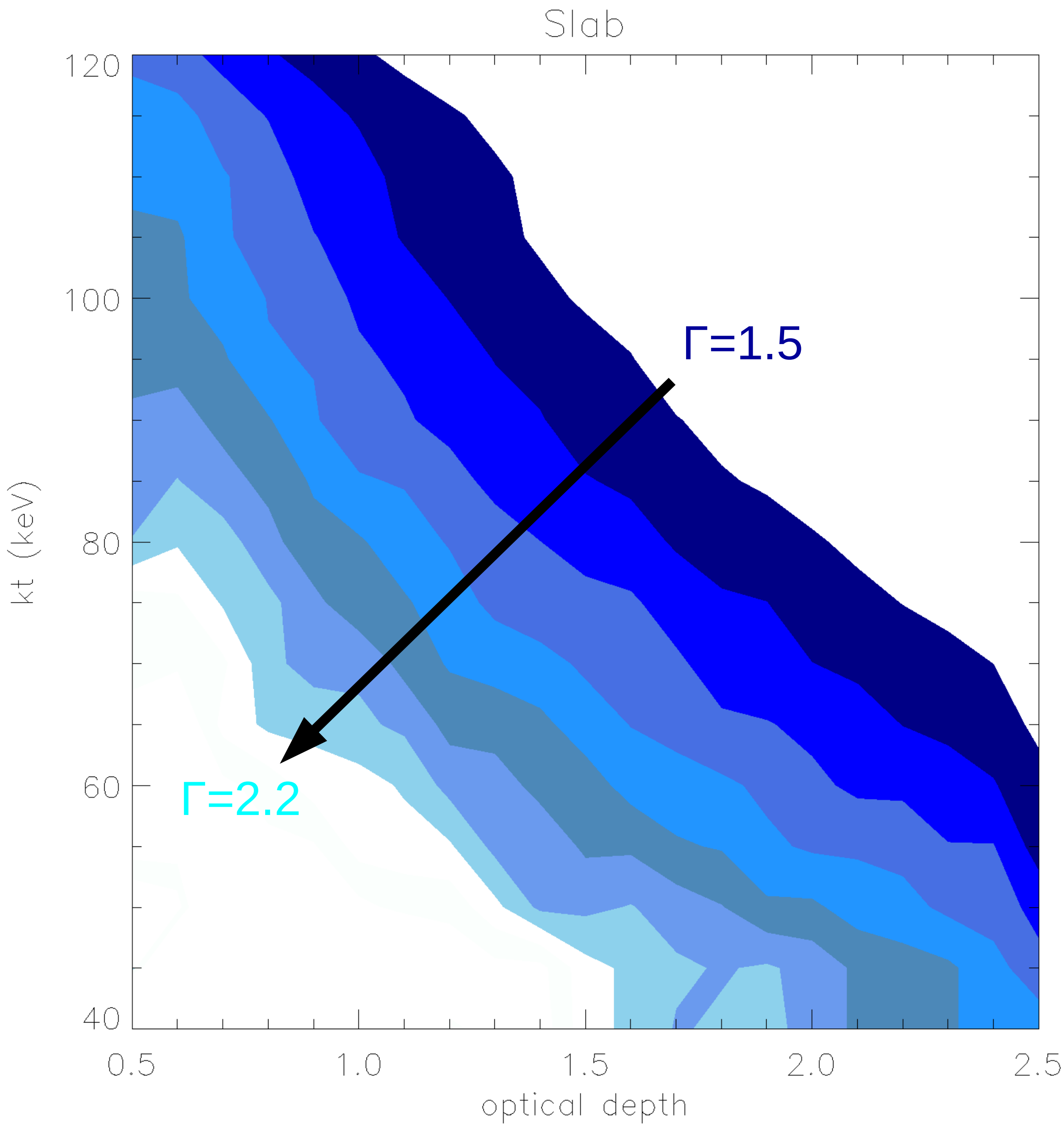
Γ is
a function of
both τ and the κT

The relation between the
observed E_{cut} and kT is
a function of both τ and the κT





MoCA, Γ as a function of τ and κT

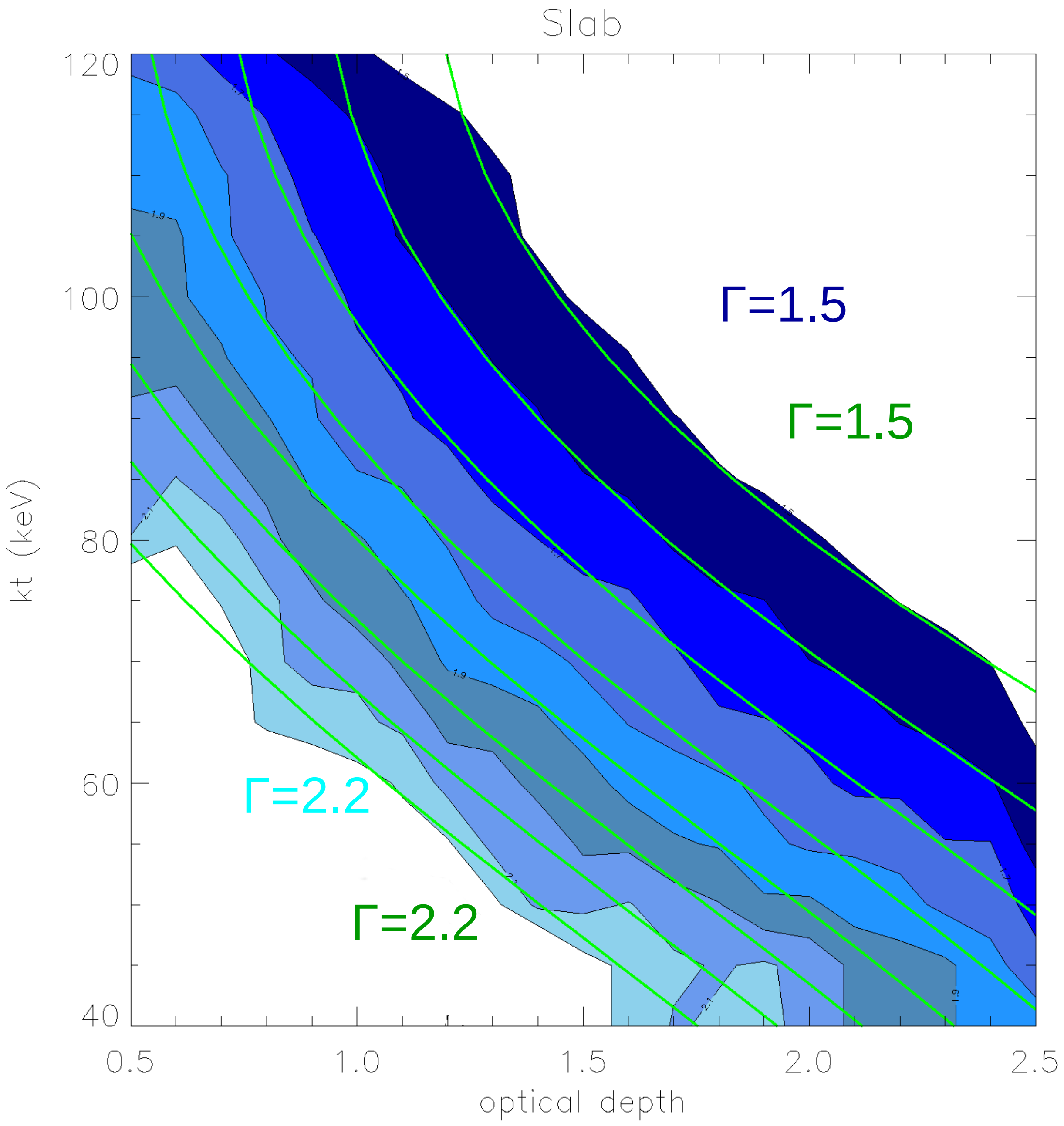


Distribution of the photon index for the simulated Spectra

40<kT<120 keV
0.5<τ<2.5

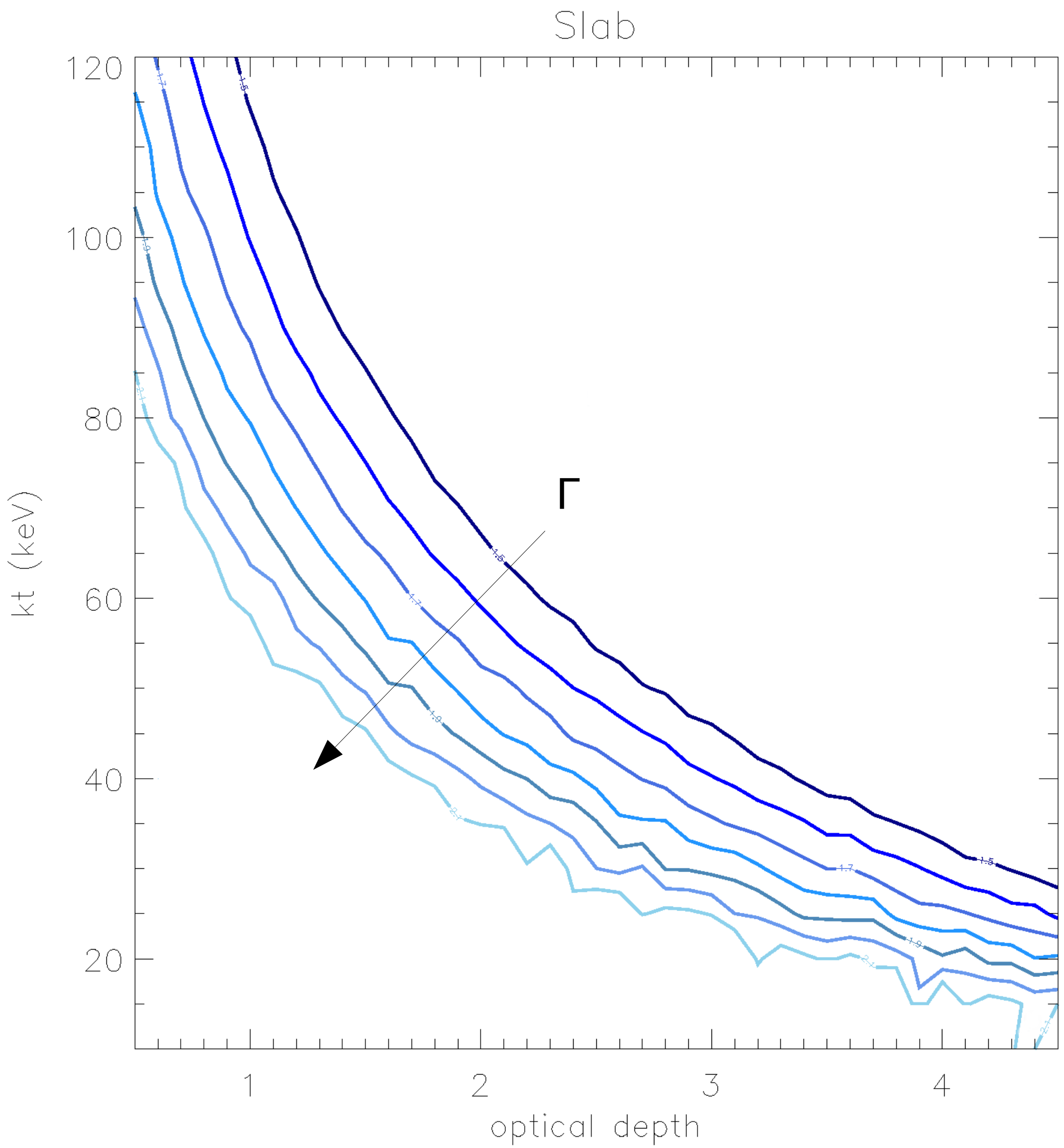
MoCA, Γ as a function of τ and κT

$$\Gamma \sim \; 4.8 \; + 0.1 \; \tau^2 + 0.006 \; \tau \times kT - 1.13 \; \tau + 0.00016 \; (kT)^2 - 0.0426 \; kT$$



$\Gamma_{moCA}(\tau,kT)$ reproduces the photon index distribution within $\Delta\Gamma < 0.1$

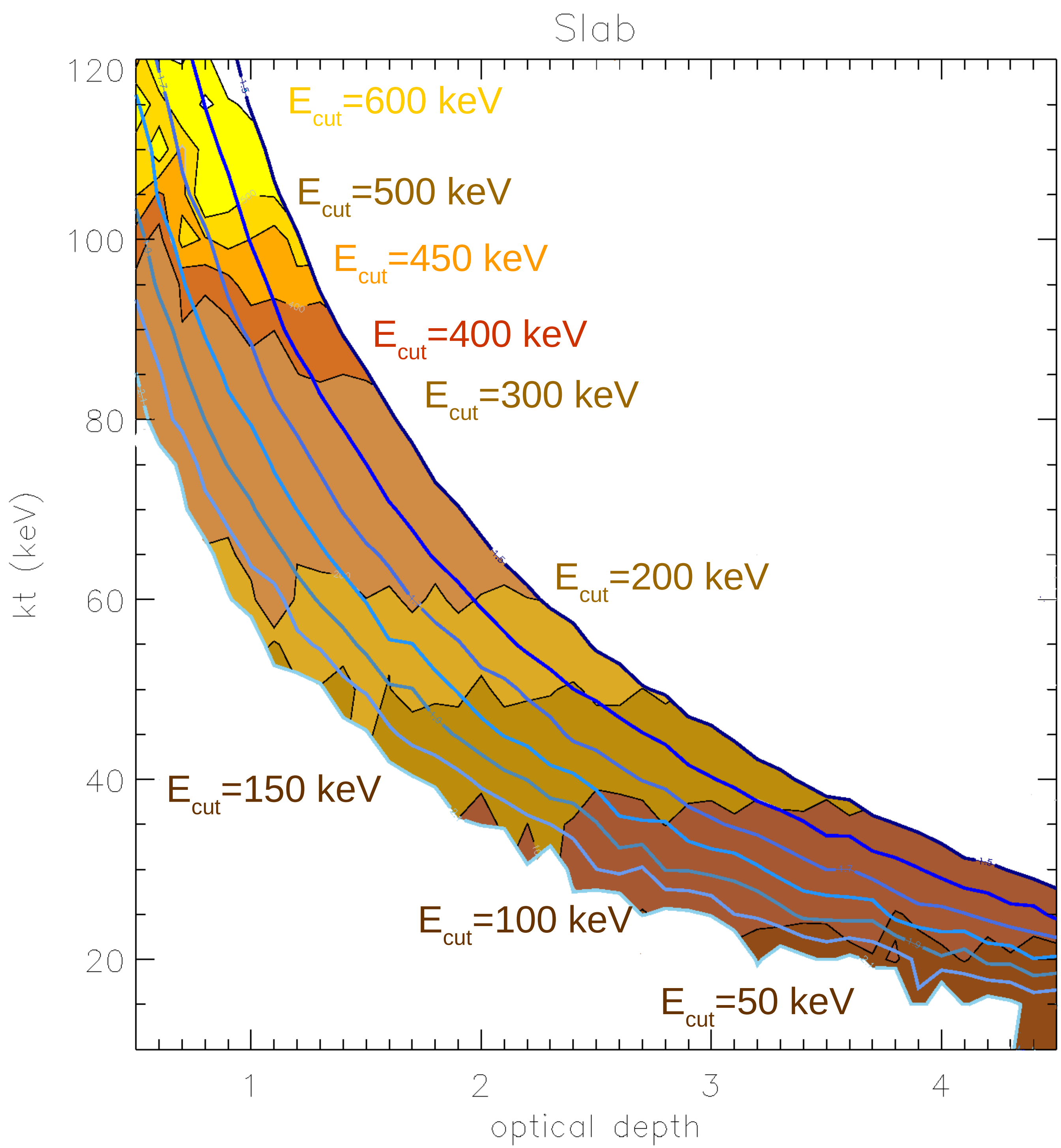
MoCA, enlarging the parameters space

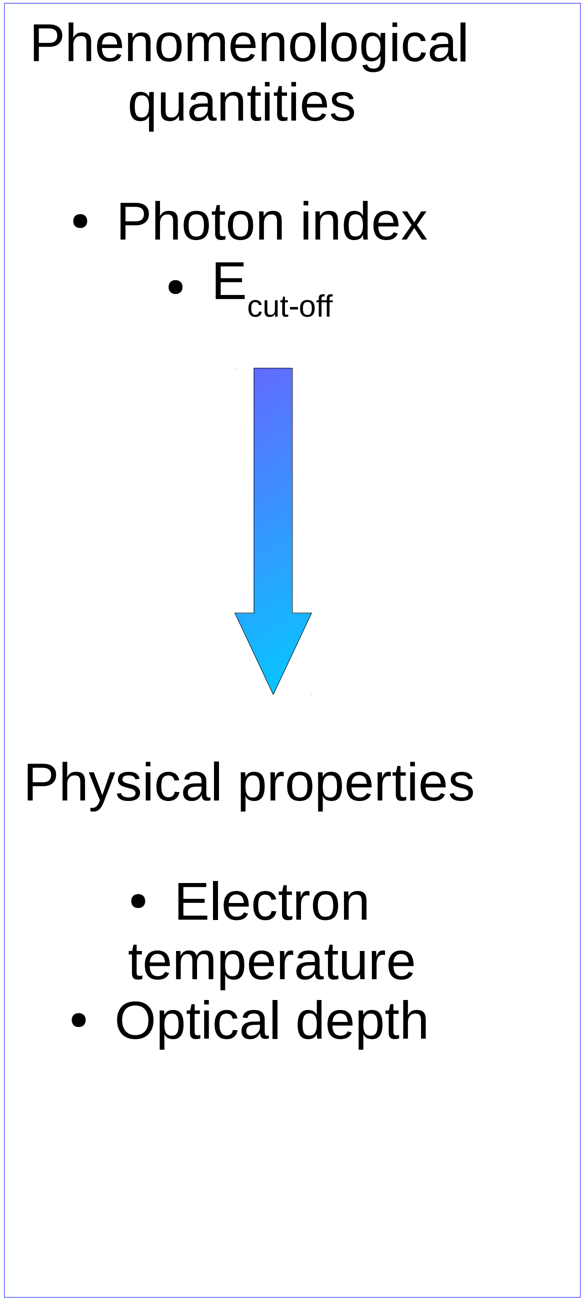


Here Γ(τ,κT) for the wider range of kT and τ used to simulate the spectra.

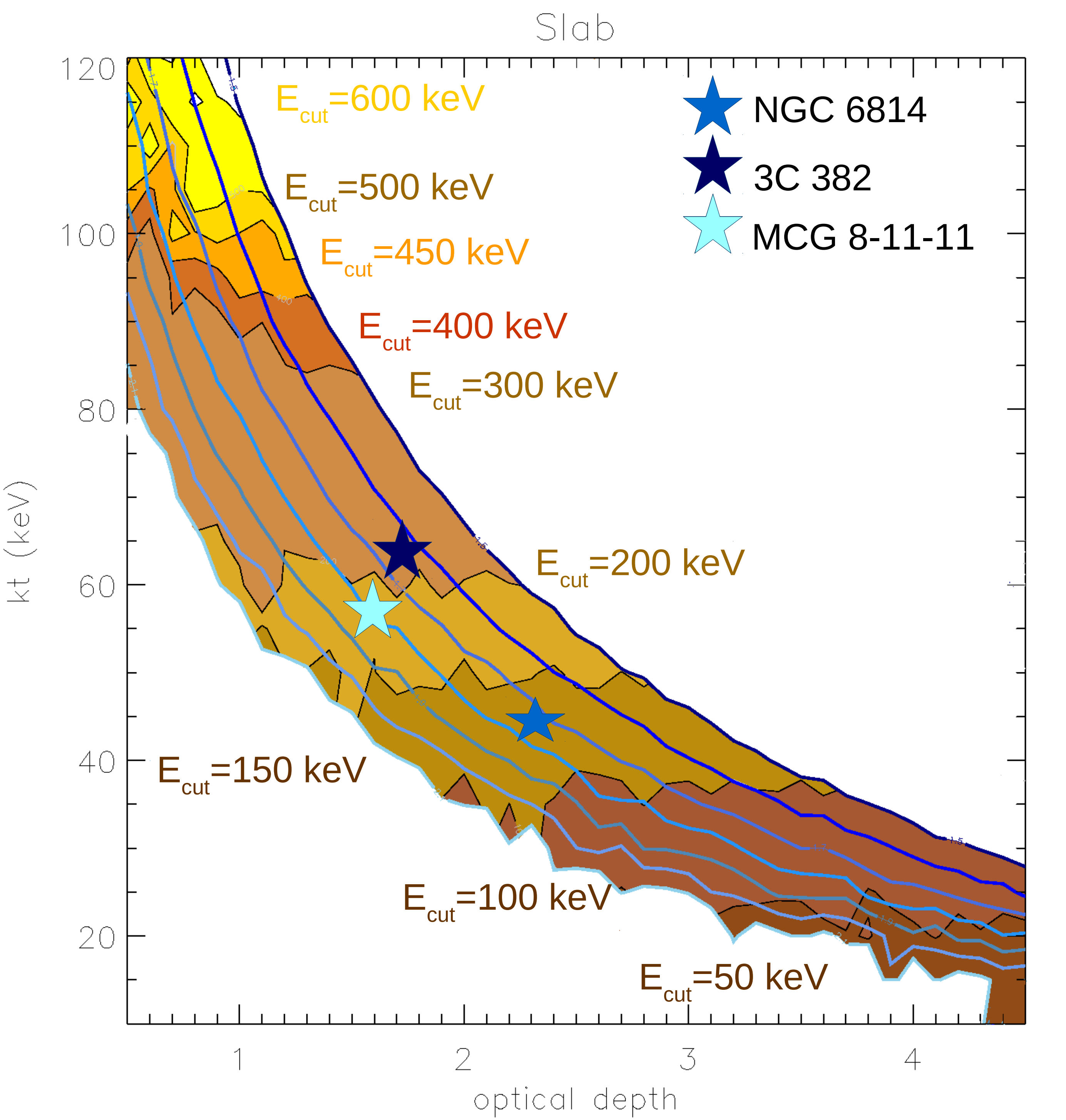
10<kT<120 keV
0.5<τ<4.5

MoCA, overlapping the regions





MoCA, overlapping the regions



from Tortosa+18

NGC 6814
E_{cut}=135 keV
Γ=1.71
κT~45 keV
τ~2.4

3C 382
E_{cut}=215 keV
Γ=1.68
κT~65 keV
τ~1.8

MCG 8-11-11
E_{cut}=175 keV
Γ=1.77
κT~55 keV
τ~1.6

Summary

- MoCA can be exploited for studying the X-ray AGN emission
- It is possible to exclude regions in the τ and kT parameters space for which we do not expect AGN emission in the X-rays
- We find that both E_{cut} and Γ are functions of kT and τ
- We infer a relation connecting the MoCA photon index with the hot electron temperature for the slab geometry:

$$\Gamma \sim 4.8 + 0.1\,\tau^2 + 0.006\,\tau \times kT - 1.13\,\tau + 0.00016\,(kT)^2 - 0.0426\,kT$$

- Phenomenological quantities ($E_{cut,}$ Γ) can be directly converted into the kT and τ

...more details in Middei et al. in preparation...

Thanks for your attention