X-CIGALE: Fitting AGN/galaxy SED from X-ray to infrared

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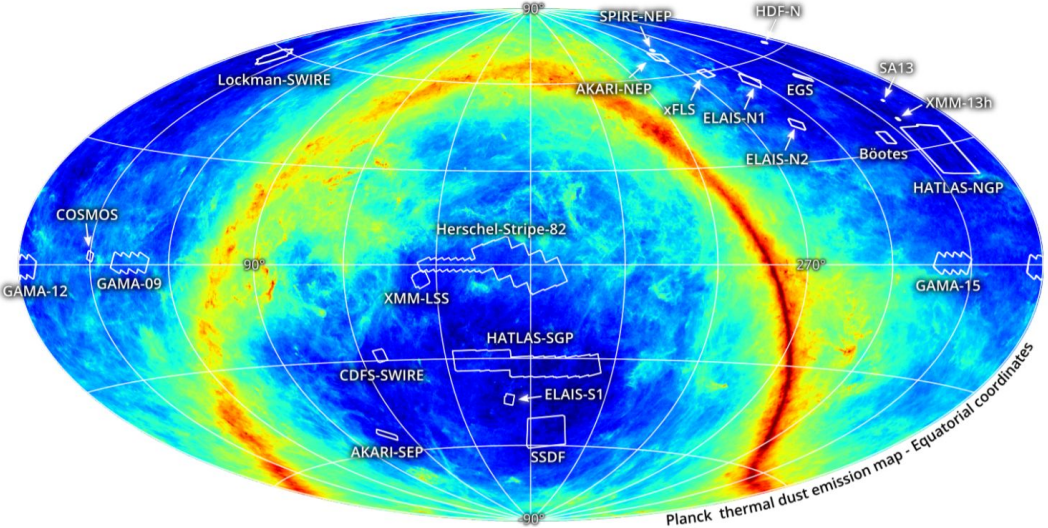
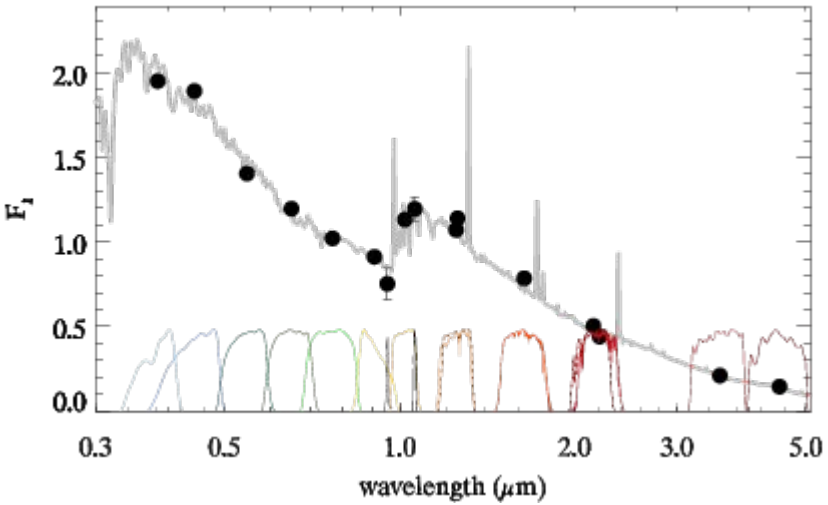
Extragalactic surveys are popular today



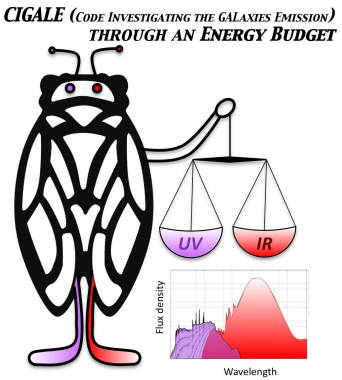


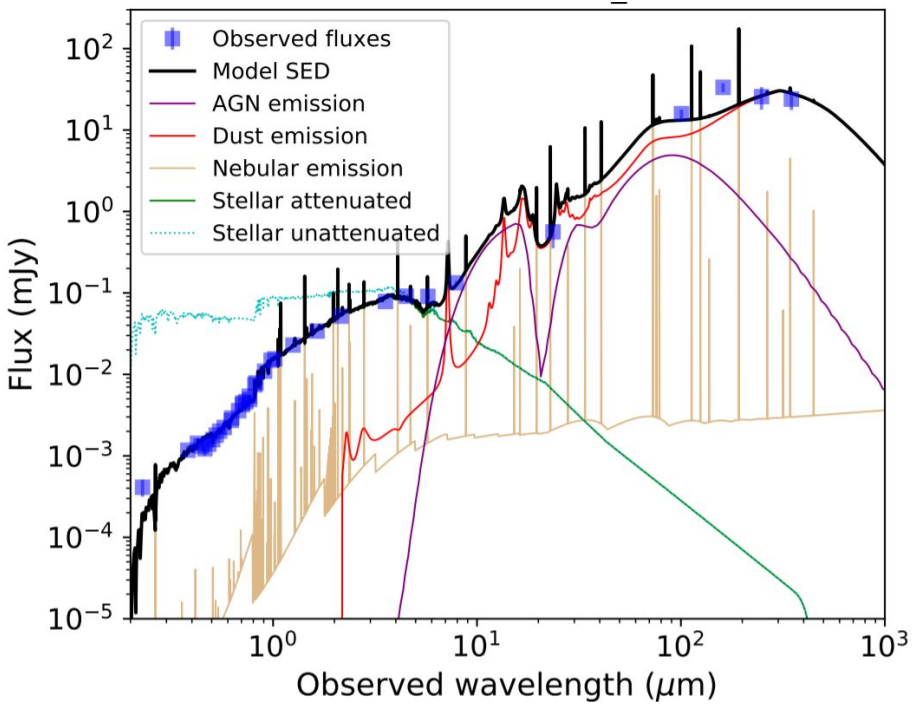
CIGALE: a powerful SED fitting code

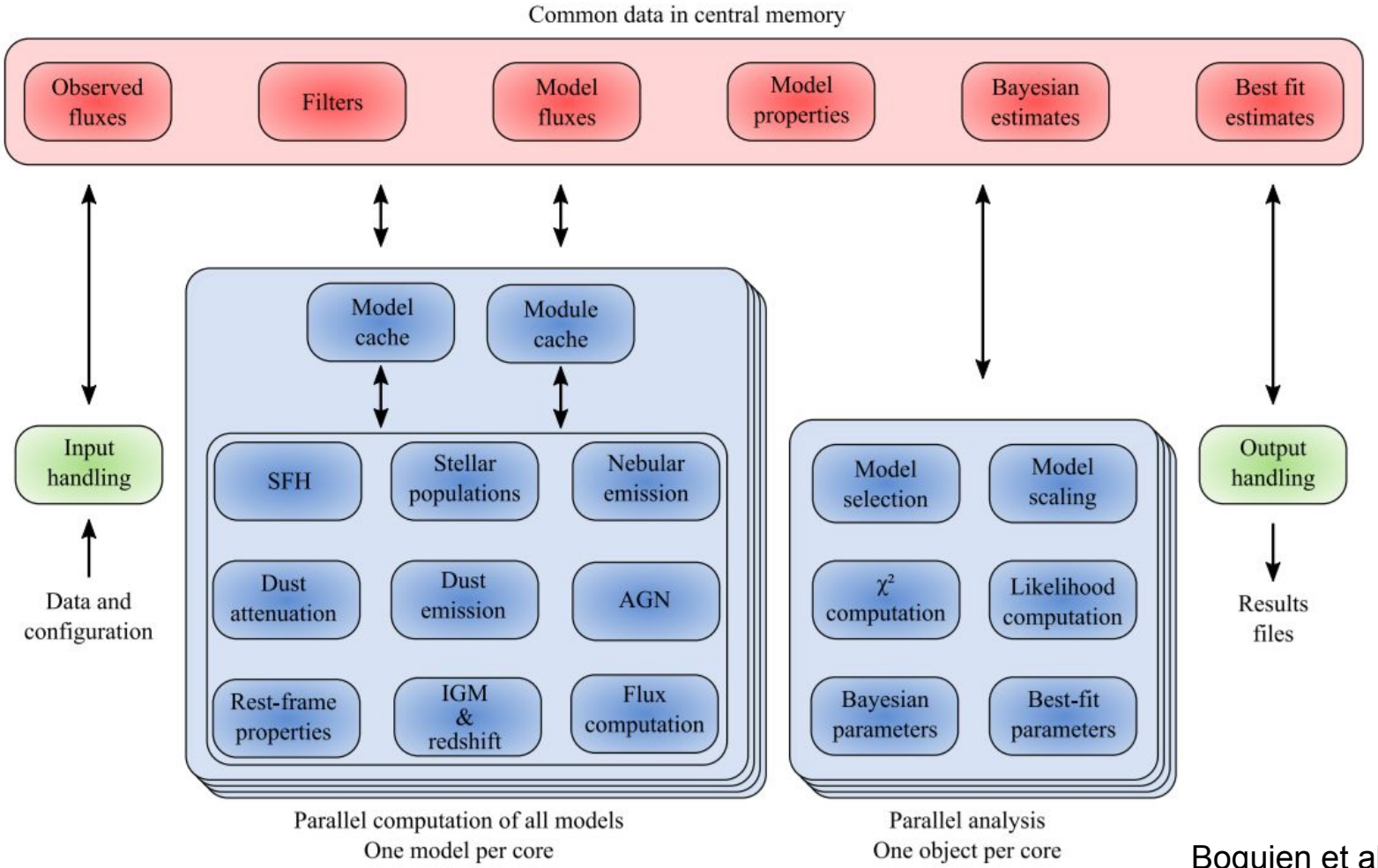
1. Physical: multicomponent models obeying energy conservation

2. Efficient: ~ 100 million models only take <~ 1 day on laptop

3. Modern: Python







Boquien et al. (2019)

But the AGN part needs improvement

1. Cannot deal with X-ray data
2. AGN torus model is outdated
3. Do not have models of obscured type 1 AGNs

New version: X-CIGALE

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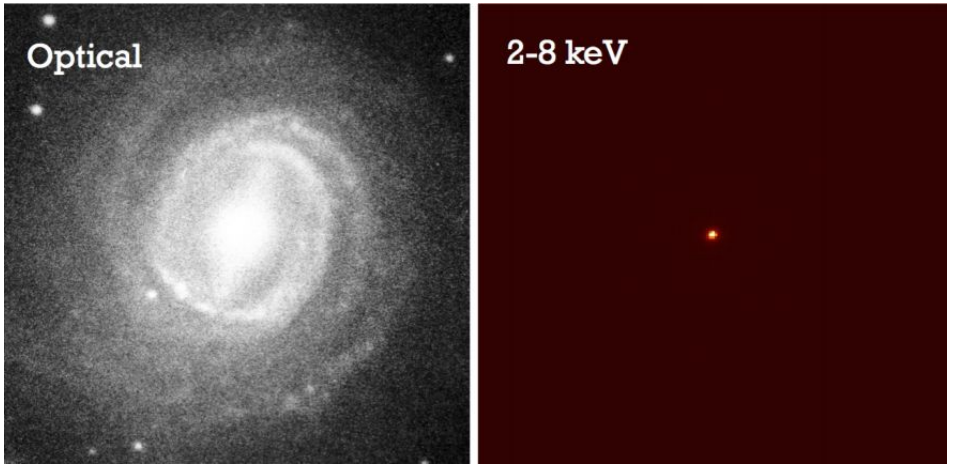
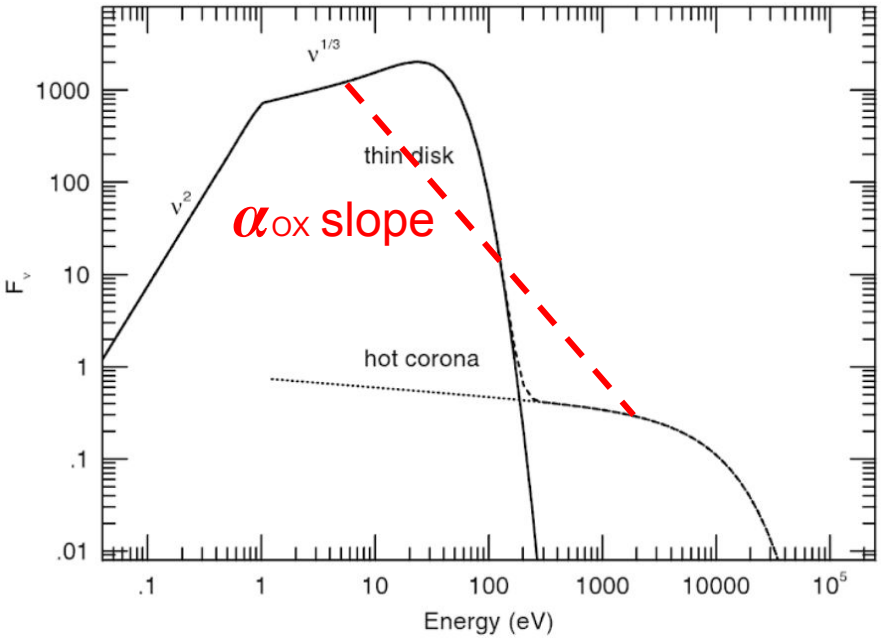
X-ray emission is a unique feature of AGNs



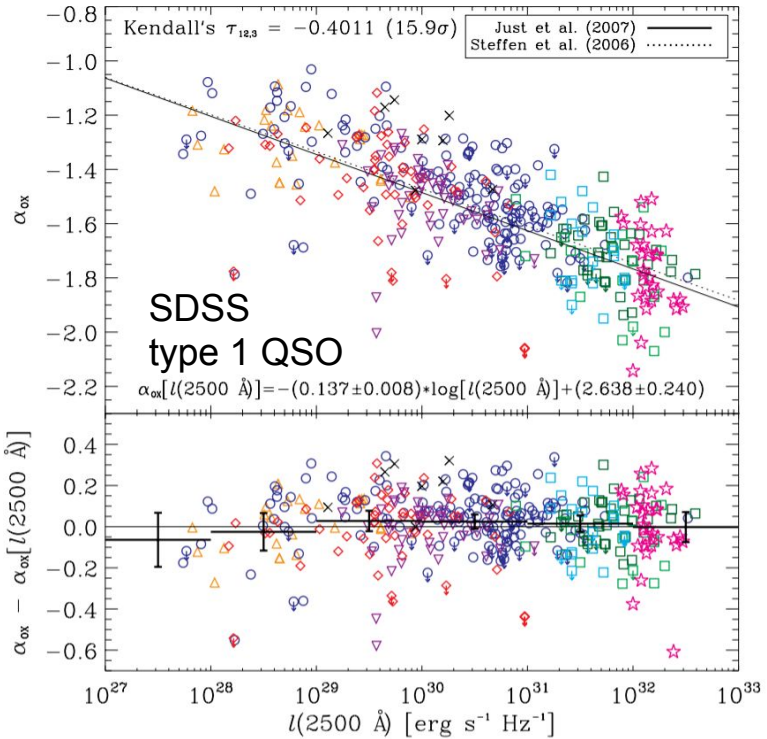
Brandt & Alexander (2015)

AGN X-ray is well correlated with UV

$$\alpha_{ox} = -0.3838 \log(L_{2500\text{Å}} / L_{2\text{keV}}).$$



Netzer (2013)

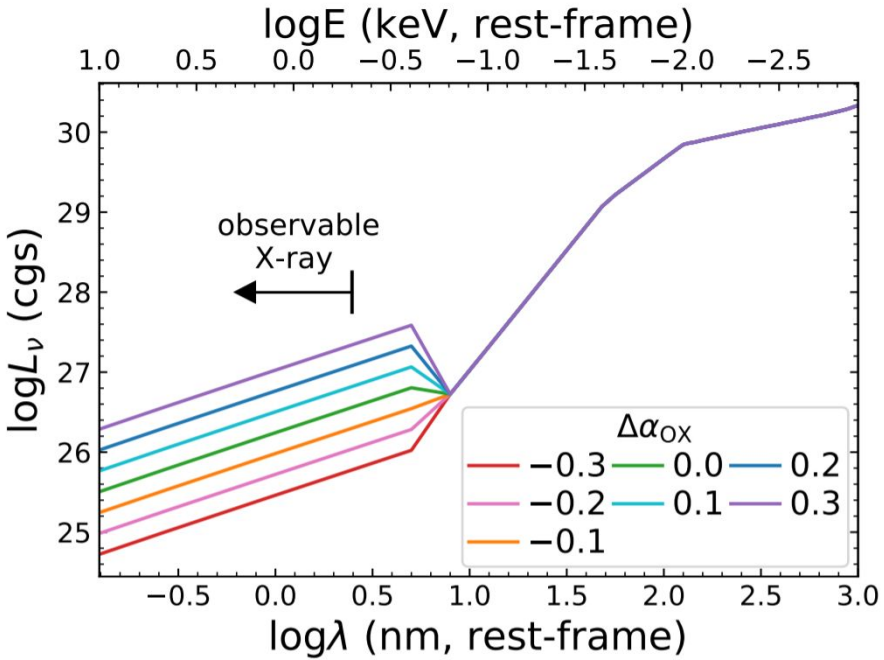


Brandt & Alexnader (2015)

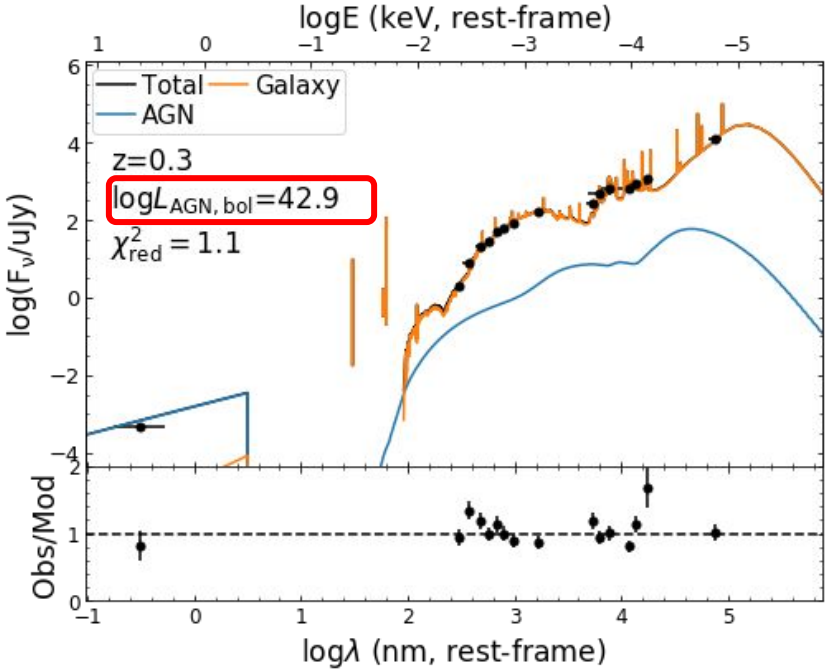
Implementation in X-CIGALE

$$\alpha_{\rm ox} = -0.137 \log(L_{2500\text{Å}}) + 2.638$$

$$\Delta\alpha_{\rm ox} = \alpha_{\rm ox} - \alpha_{\rm ox}(L_{2500\text{Å}}).$$

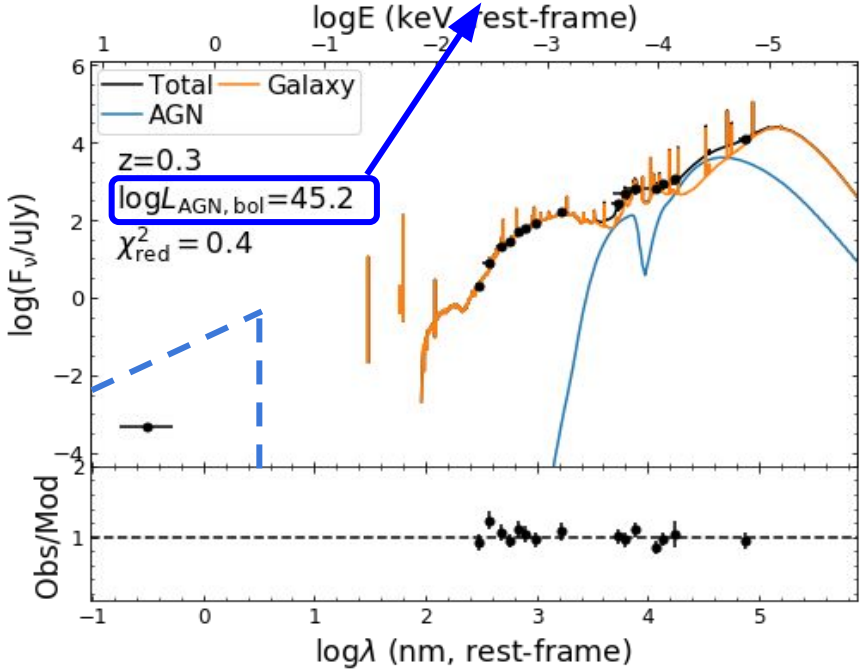


An example AGN SED



Fitting with X-ray

AGN overestimated!



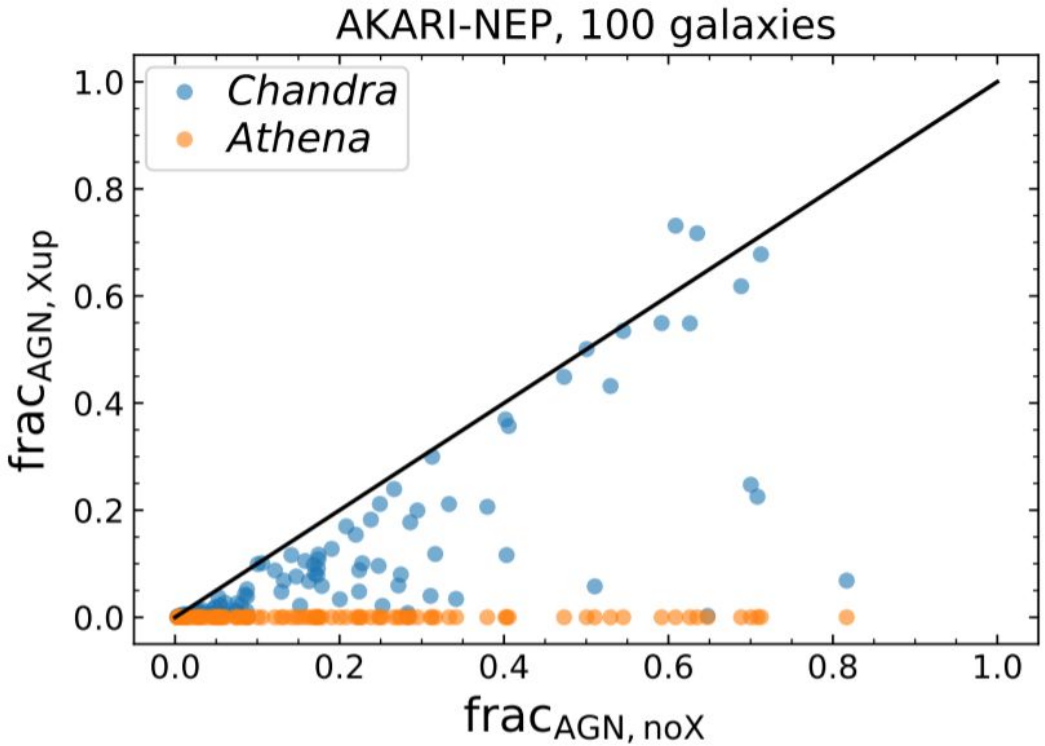
Fitting without X-ray

Also good for X-ray undetected galaxies

Most optical/IR sources are X-ray undetected

IR AGN fraction can be constrained even with X-ray upper limit

Deeper X-ray → tighter constraint



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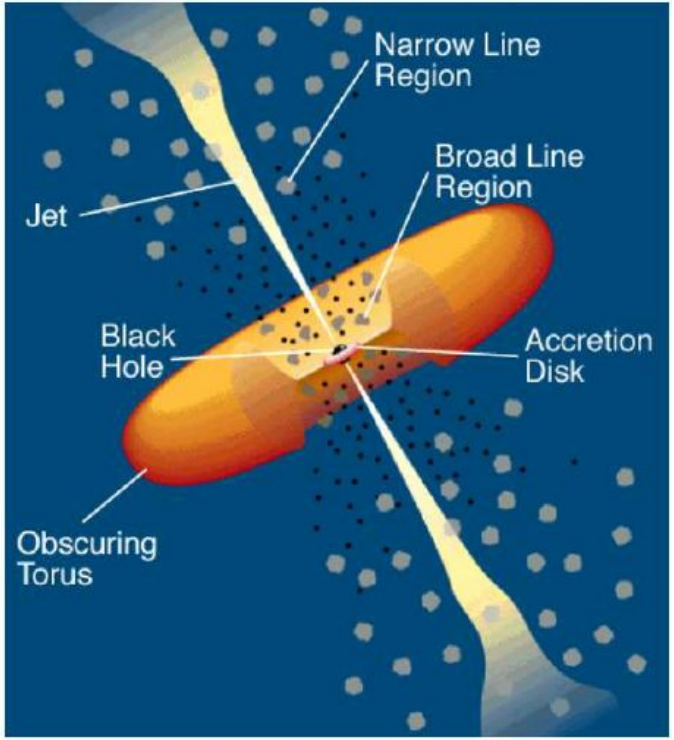
New version: X-CIGALE

The AGN unification scheme

Different AGNs are essentially the same type of object

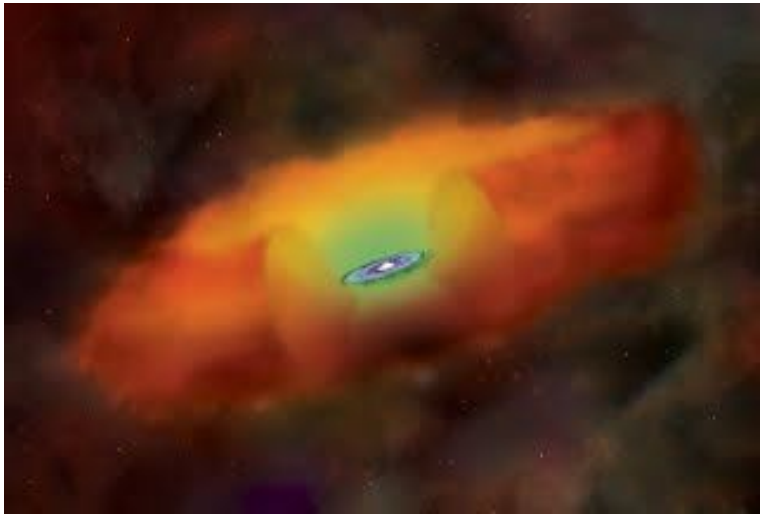
The central engine is obscured by the dusty torus

Type 1 AGN: face on
Type 2 AGN: edge on

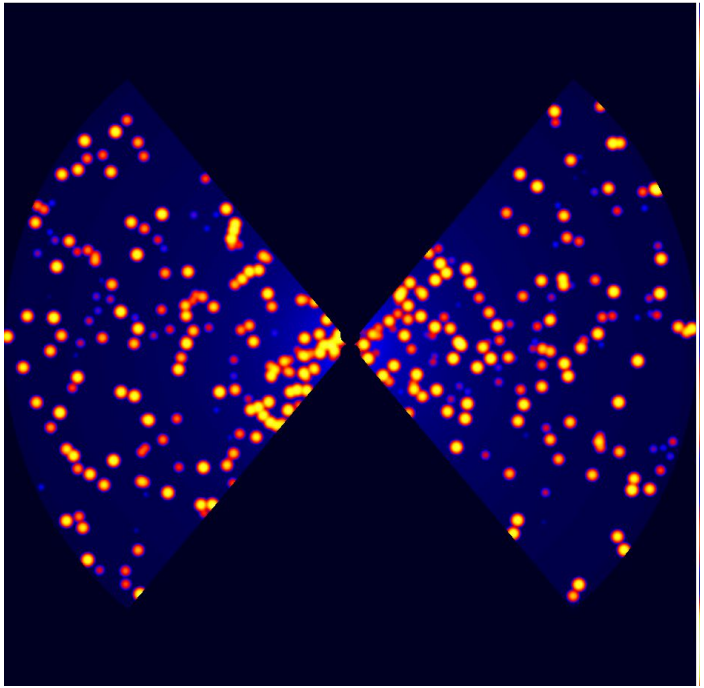


AGN torus model in CIGALE

Unphysical: temperature too high (~ million K)

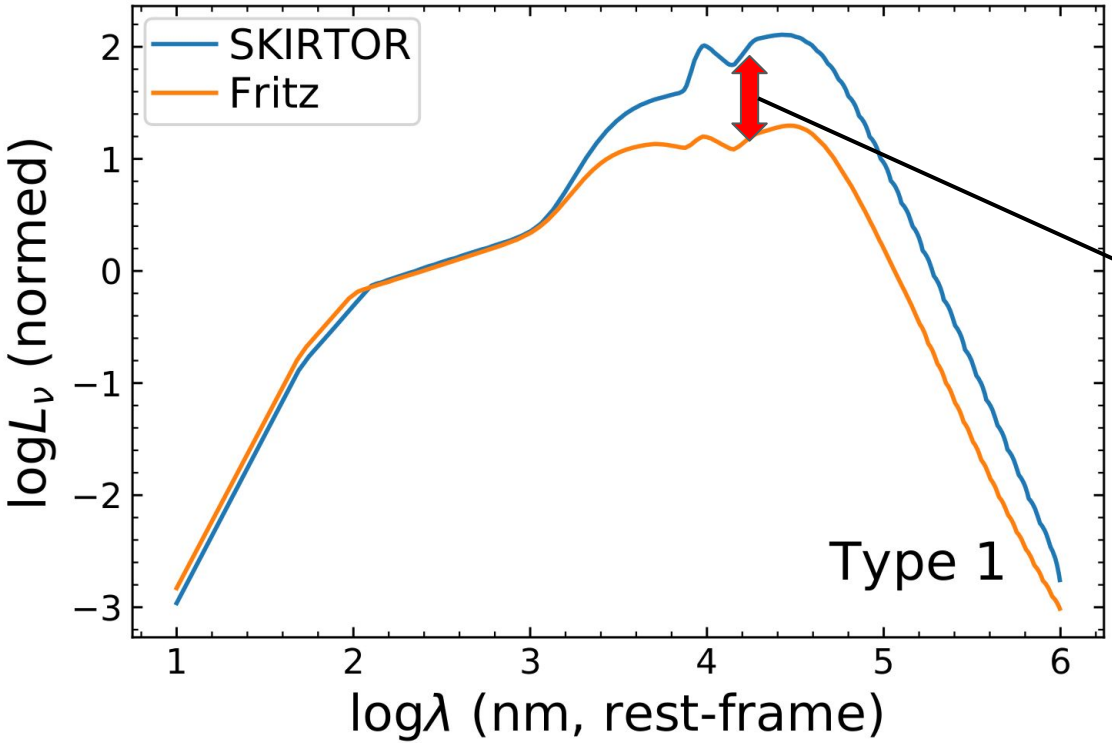


Old: smooth, Fritz et al. (2006)



New: clumpy, Stalevski et al. (2012, 2016)

The old model does not follow energy conservation!



The old model underestimates the dust IR reemission!

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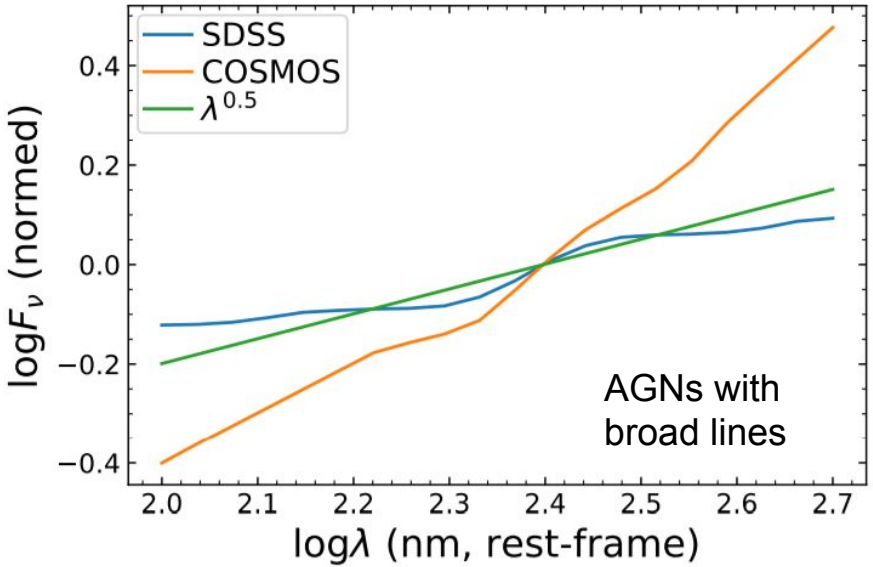
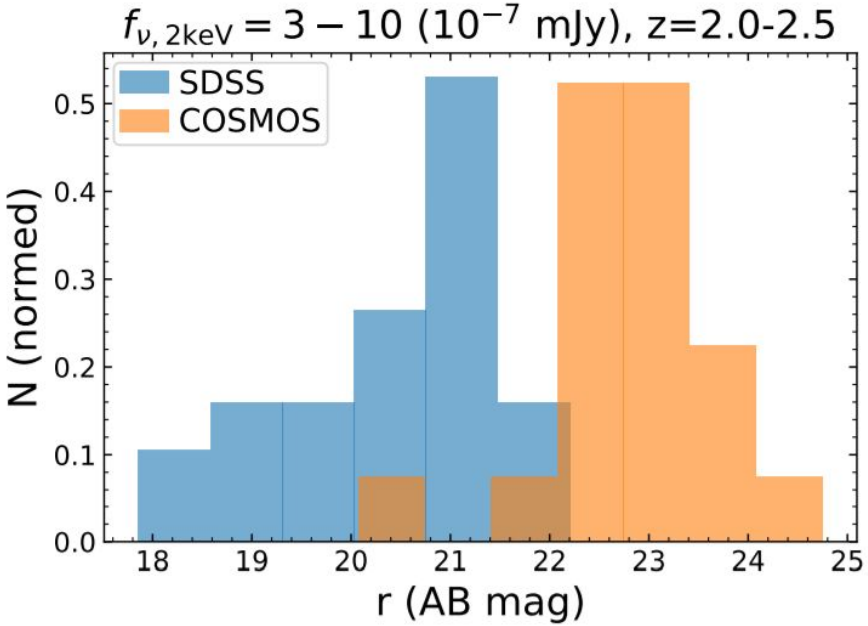
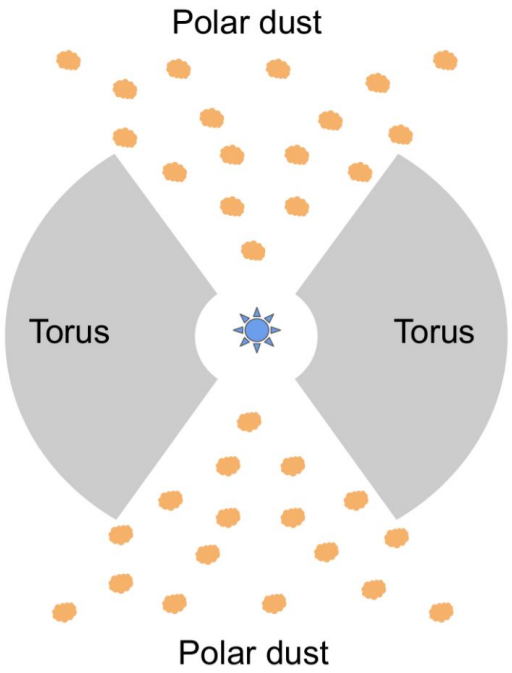
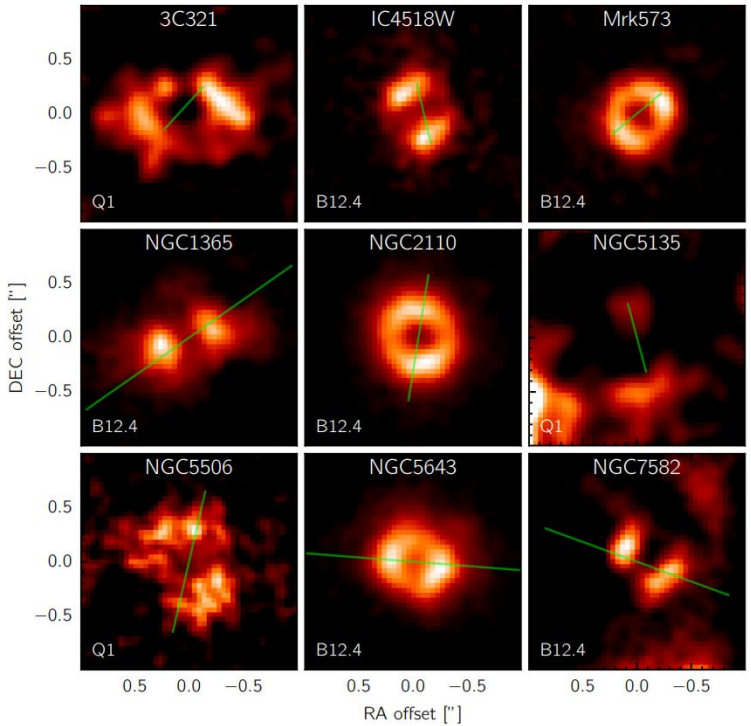
Obscured type 1 AGNs are common in X-ray selected sample





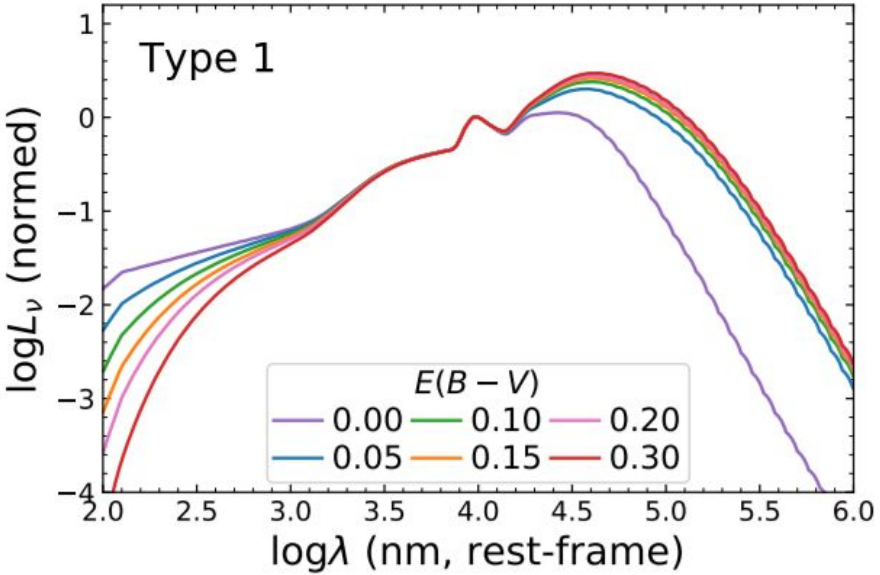
Can be explained by dust in polar directions

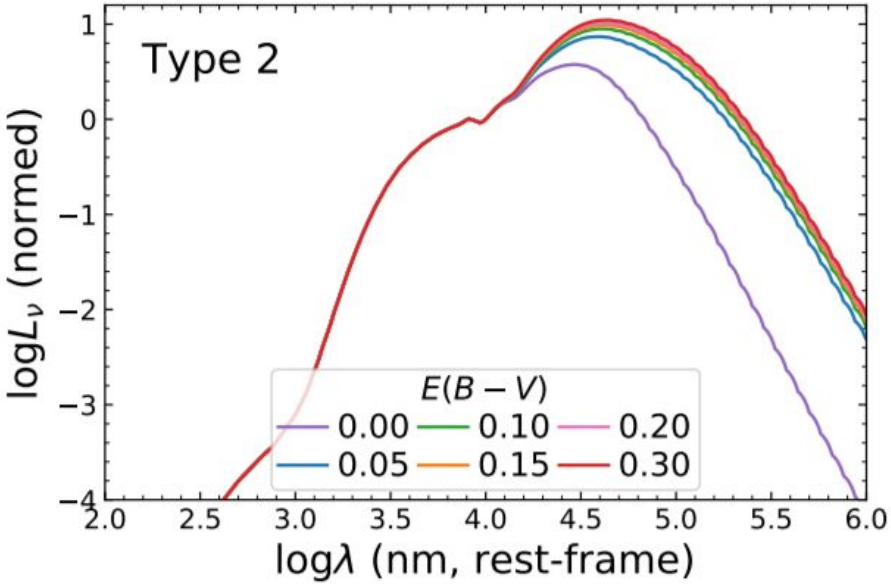




Asmus 2019

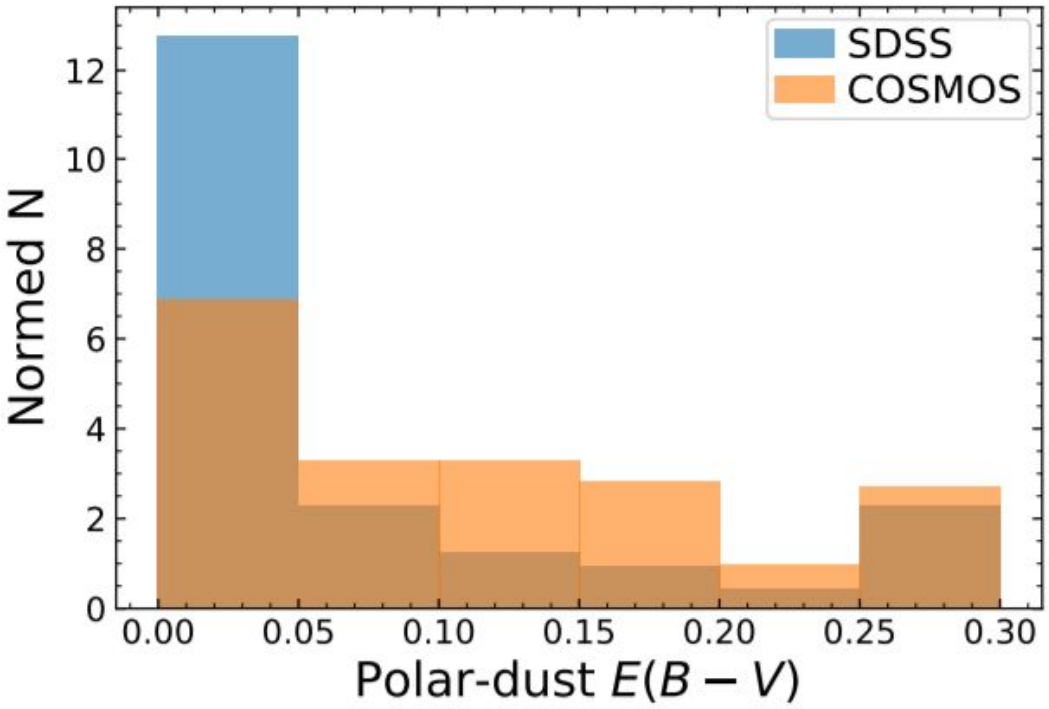
Polar-dust models in X-CIGALE



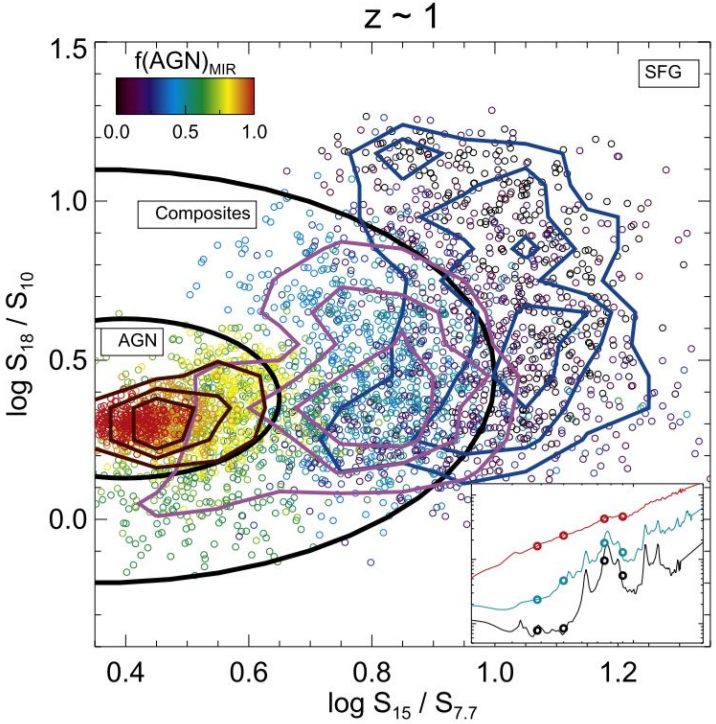


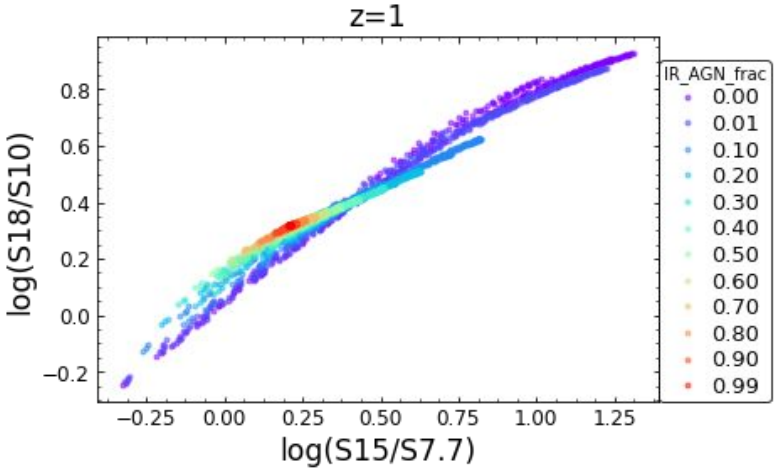
Application to real data

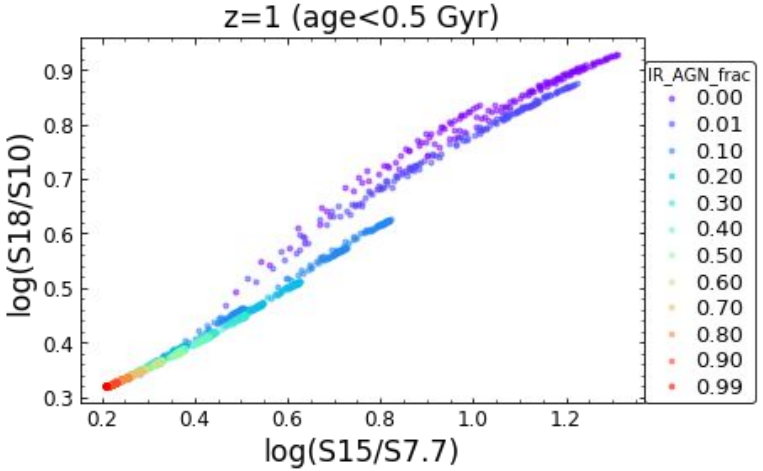
Indeed, SDSS AGNs have lower obscuration than COSMOS

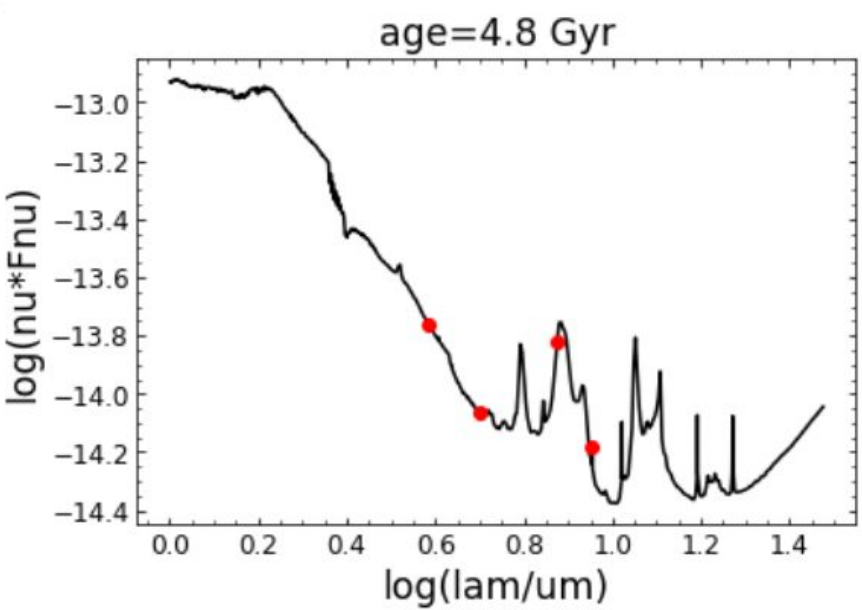


Future work: JWST





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log(nu*Fnu)
log(lam/um)
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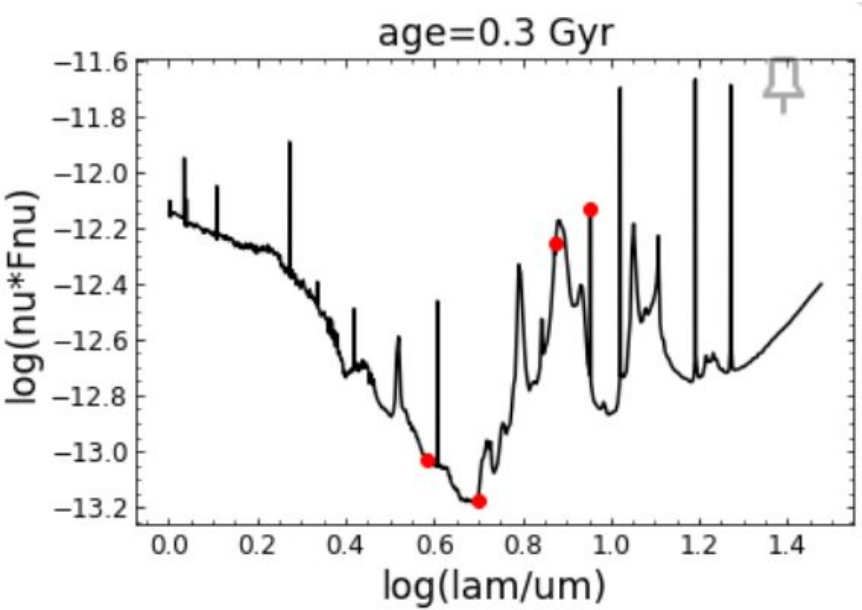
−13.2
−13.4
−13.6
−13.8
−14.0
−14.2
−14.4
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4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log(lam/um)
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−12.2
−12.4
−12.6
−12.8
−13.0
−13.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4