Continuous UV-to-IR SED of distant quasars

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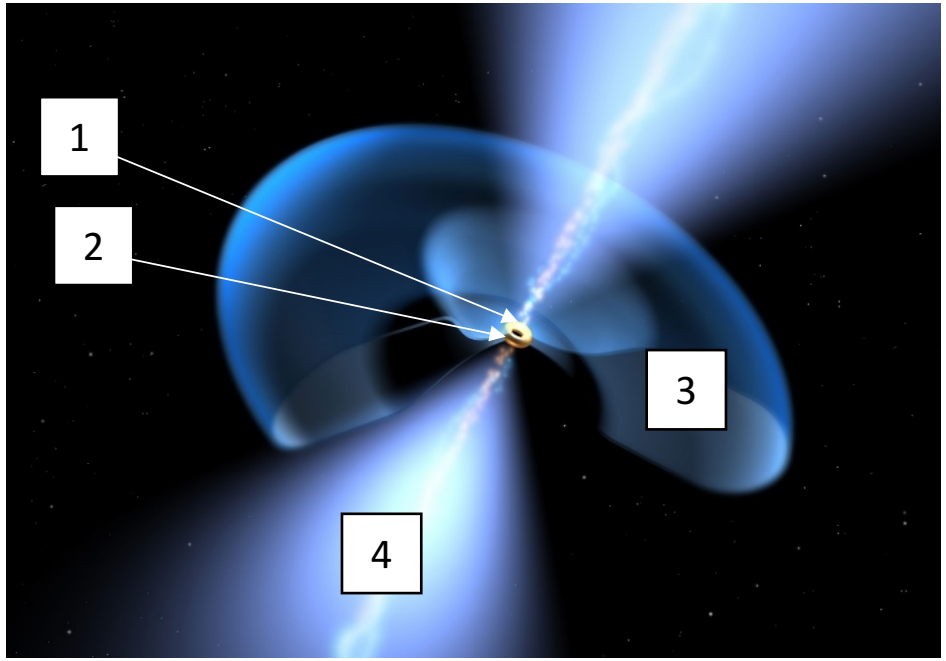
Multiwavelength AGN templates are needed in the UV-to- far-IR to interpret the present and future data of ALMA, Gaia, JWST and EUCLID
(work in progress)

Journées 2019, Observatoire de Paris, 7-9 October 2019

Plan

- **At high redshifts, AGN reference models require z=0 templates and corrections (k-correction, aperture)**
- **The far- IR AGN torus In distant radiogalaxies, after subtraction of young and old stellar components with Pegase.3**
- **The best UV and far-IR AGN and torus models**
- **Conclusions and future for ALMA, Gaia, WISE and JWST, EUCLID**

Quasars :



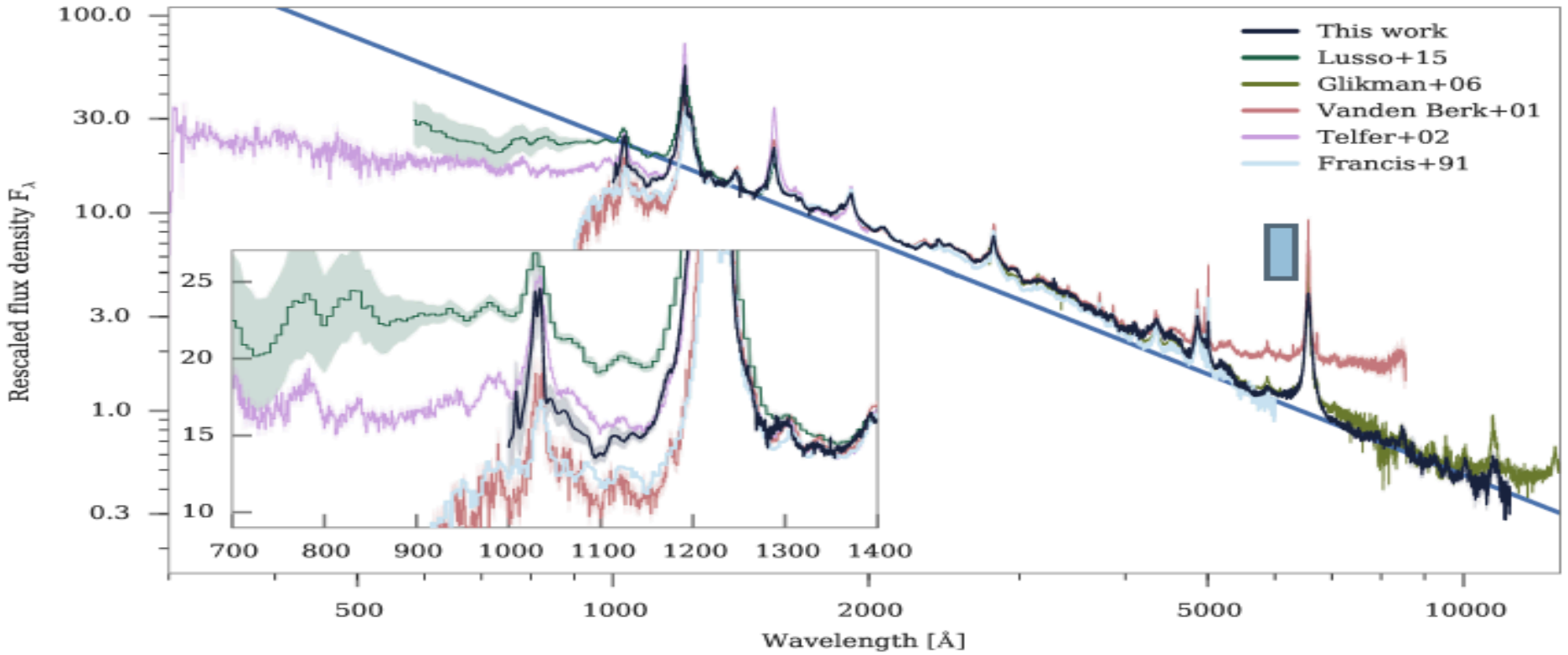
- 1 : Centra black hole
- 2 : Accretion disk
- 3 : Dust Torus
- 4 : Plasma jet

- The most luminous targets
- X ray ➔UV to farIR➔ radio
- Continua
- Very large emission lines and no stellar continuum (Vanden Berk & al, 2001 and many others)
- Dust Torus in the mid- and far- IR
- At high distances: Corrections for expansion of the Universe and apertures: the possible contribution of the torus and of the host galaxy

QSO templates z=0 UV-optical models

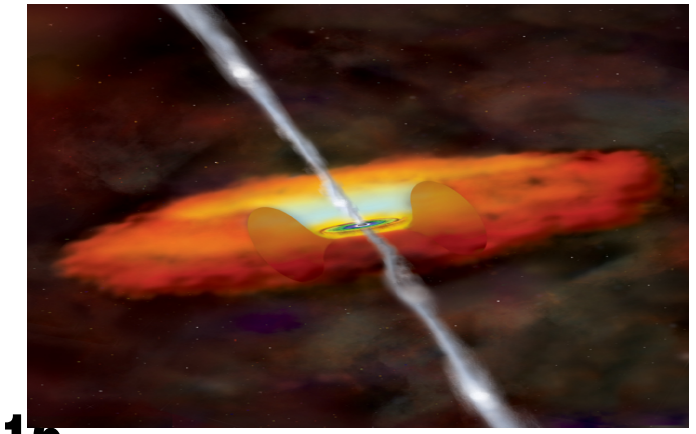
The continuum of a single quasar spectrum modeled as a power law, $f_\lambda \alpha \lambda^{\alpha(\lambda)}$ **with** $\alpha(\lambda) = -1.70$

Fig. 8 Selsing et al. 2016, AA, 585, 57



FIR models AGN/QSO torus templates @z=0

see review by Antonucci, R. 1993, ARA&A, 31, 473



Dust near active galactic nuclei (AGNs) is distributed in a torus-like geometry

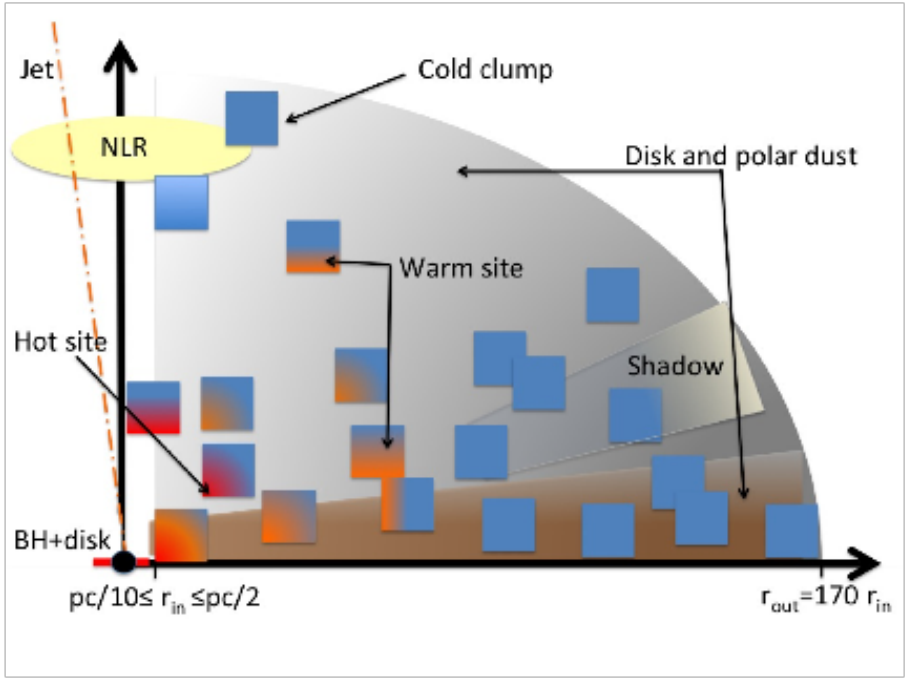
-- homogeneous disk, **Fritz et al, 2006 (adopted by Drouart et al, 2016**

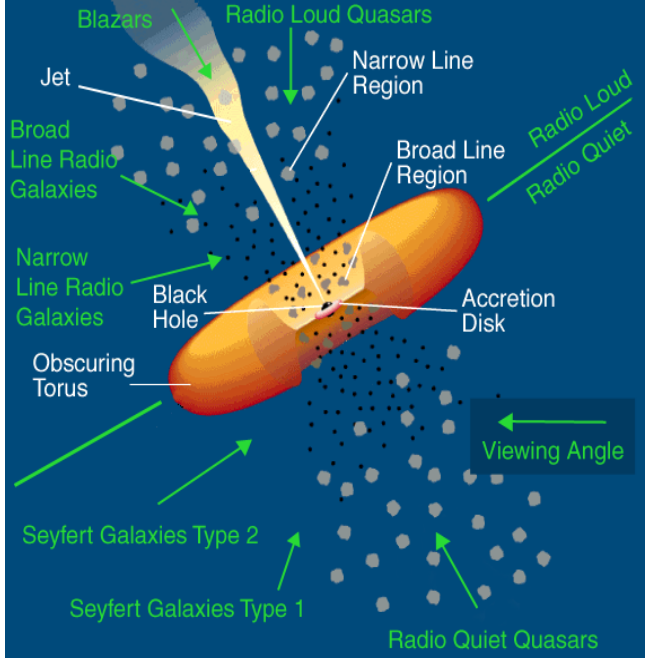
or

-- SA self-consistent two-phase medium **Siebenmorgen et al, 2015 (adopted by Podigachoski et al, 2016)**

- Dust particles: fluffy, higher submillimeter emissivities than grains in the diffuse interstellar medium. The dust-photon interaction is treated in a fully self-consistent three-dimensional radiative transfer code.

The main parameters are :
Inclination i, inner radius R,
covering factor Vc, opacity Ac

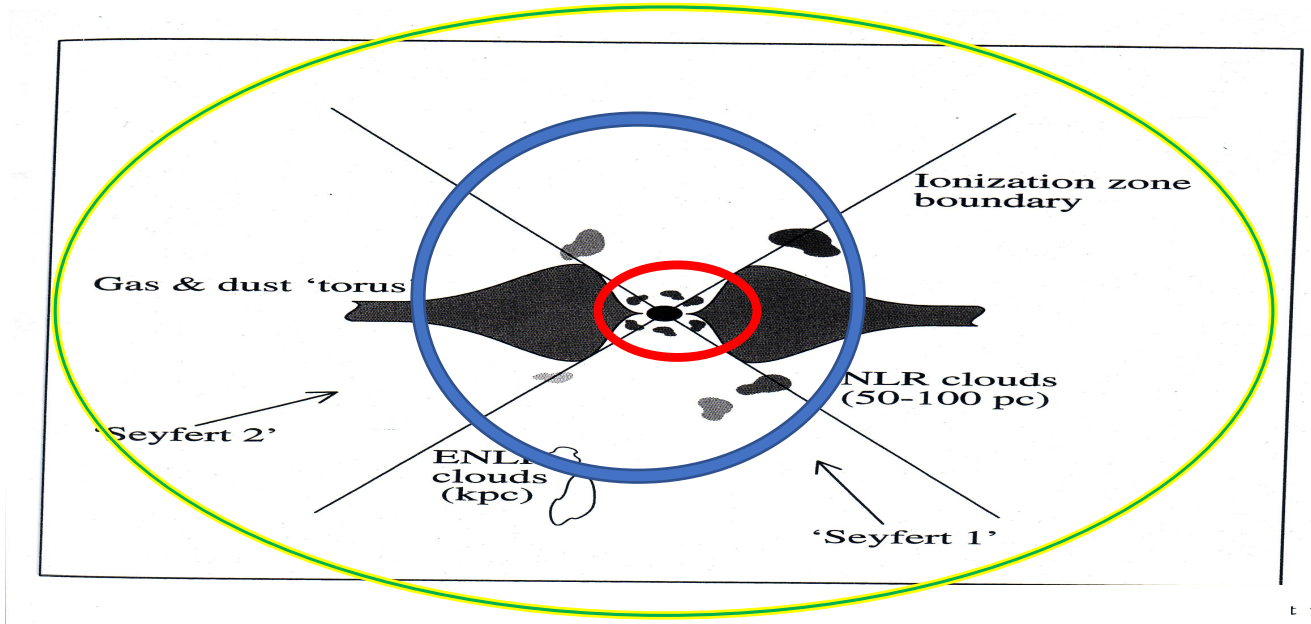




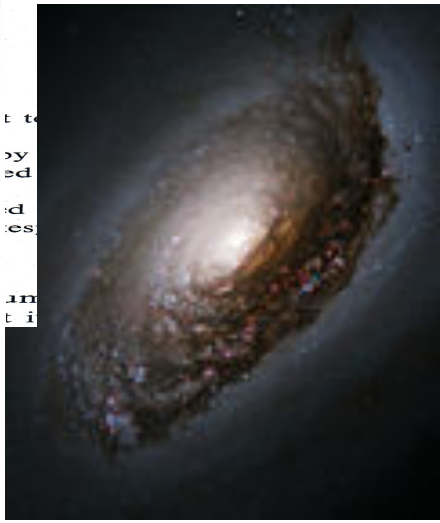
The distance corrections to local z=0 AGN/QSO models

I. The aperture correction

Gunn & Oke, 1975, Lilly et al, 1975, Dunlop et al, 1989



from the nucleus (red circle) to the torus (blue circle) and to the host galaxy (yellow circle)



The distance corrections to local z=0 models

II. The cosmic k-correction due to the expansion of the universe ➔ redshift effect

$$\lambda_{Obs} = \lambda_{rest\text{-}frame}(1+z)$$

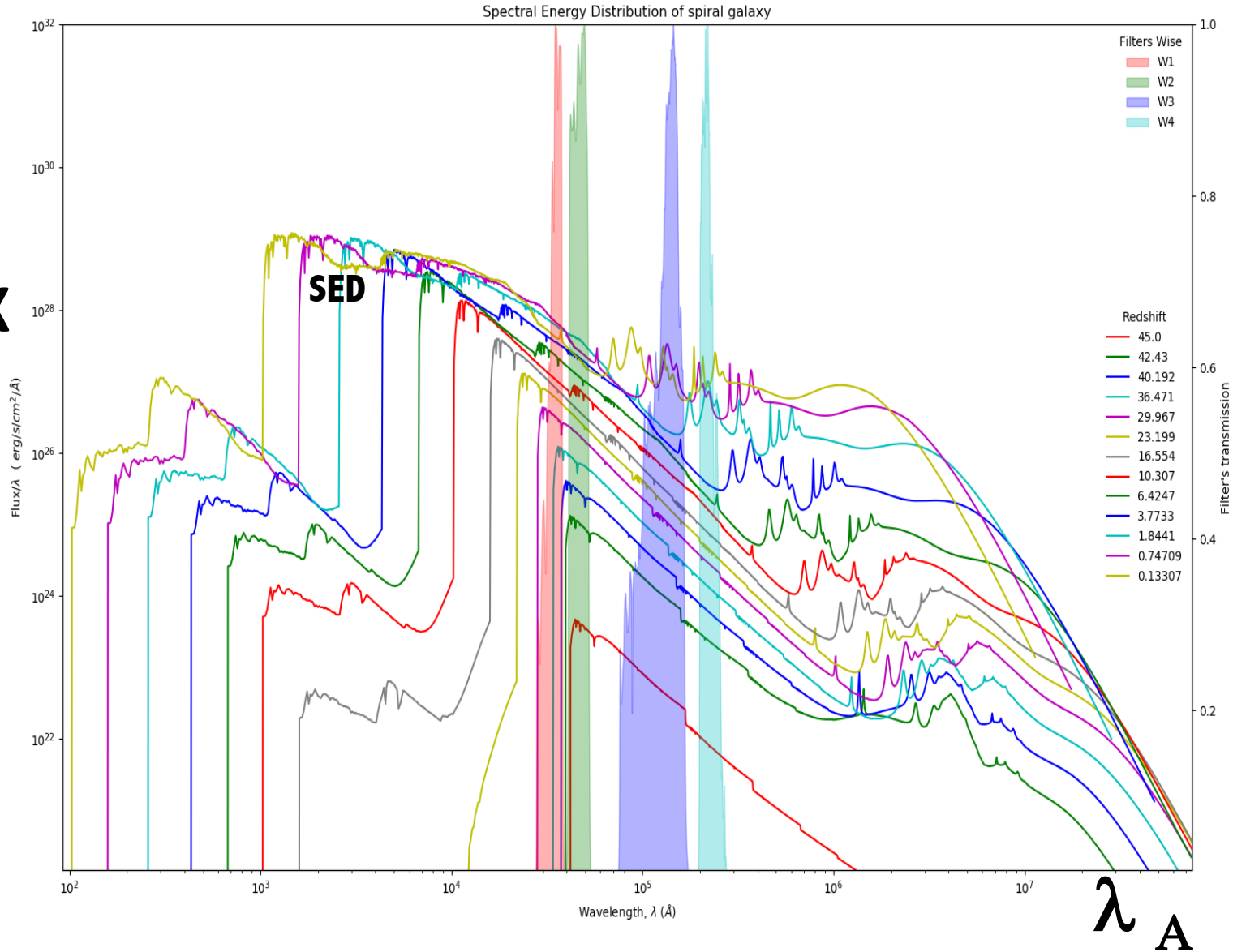
$$\lambda\ F(\lambda) = \nu\ F(\nu)$$

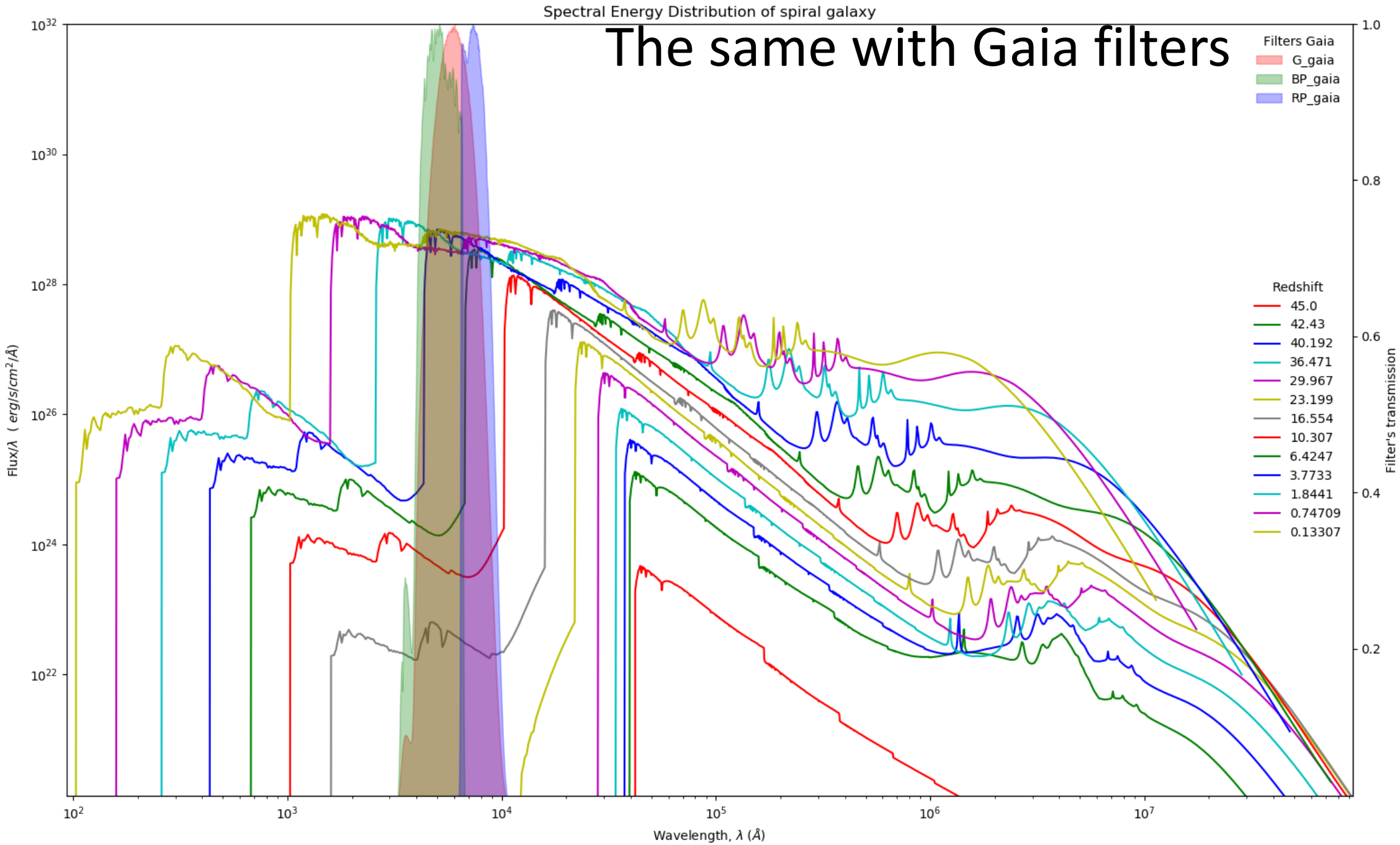
- An EXAMPLE on transmission by Filters **on distant Spiral galaxies** taking into account the k+e corrections:
- K-correction (expansion)
- E-correction (galaxy evolution) with Pegase3

For AGNs (QSOs), in most cases no evolution correction is considered

- **Pass-band filters** WISE1 (pink), WISE2 (green), WISE3 (blue) and WISE4 (turquoise)

FLUX




Spectral Energy Distribution of spiral galaxy
The same with Gaia filters
Filters Gaia
G_gaia
BP_gaia
RP_gaia
Redshift
45.0
42.43
40.192
36.471
29.967
23.199
16.554
10.307
6.4247
3.7733
1.8441
0.74709
0.13307
Flux/λ (erg/s/cm²/Å)
Filter's transmission
Wavelength, λ (Å)

TO isolate AGN/QSOs component in Multiwavelength (UV-IR) observations of distant radio galaxies by FITTING the UV-farIR observations of distant radiogalaxies

Building Hybrid models associating
Starburst (Pegase.3) and AGN (Fritz et al2006) by Drouart et al, 2016
Starburst (Pegase.3) and AGN torus (Siebenmorgen et al, 2015) by Podigachoski et al, 2016

Large libraries $F_{hybrid}(t) = F_{SB}(t) + F_{AGN} \times f_{AGN}^{20microns}$ **(f=10^{-3} to 10^{3})**

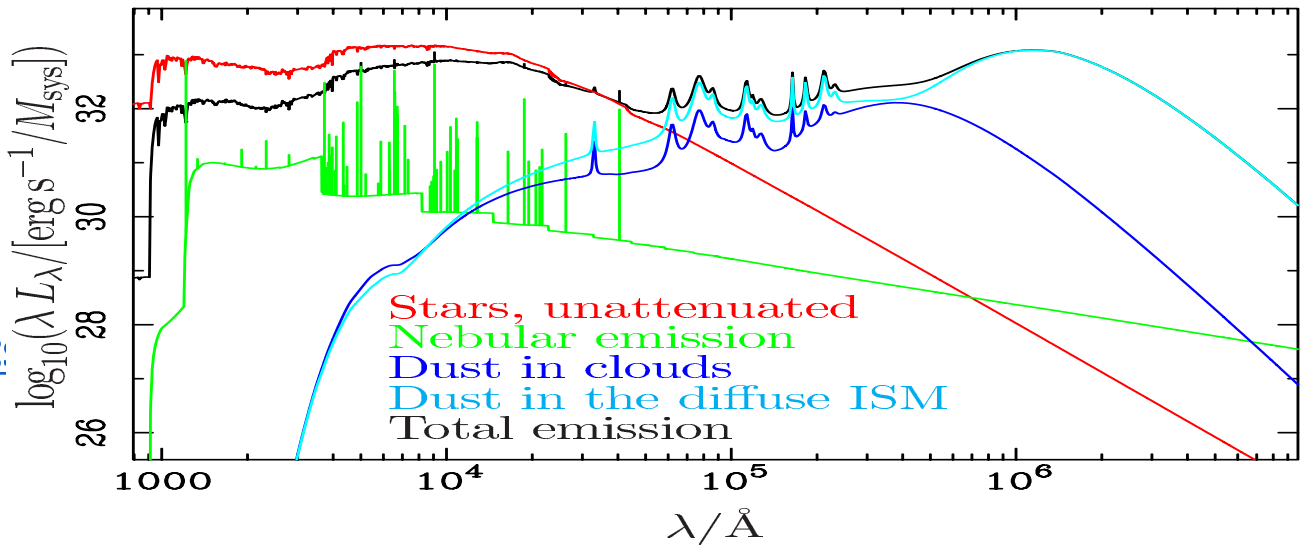
+ Galaxy host SEDs

The code Pegase.3

2019arXiv190202198F

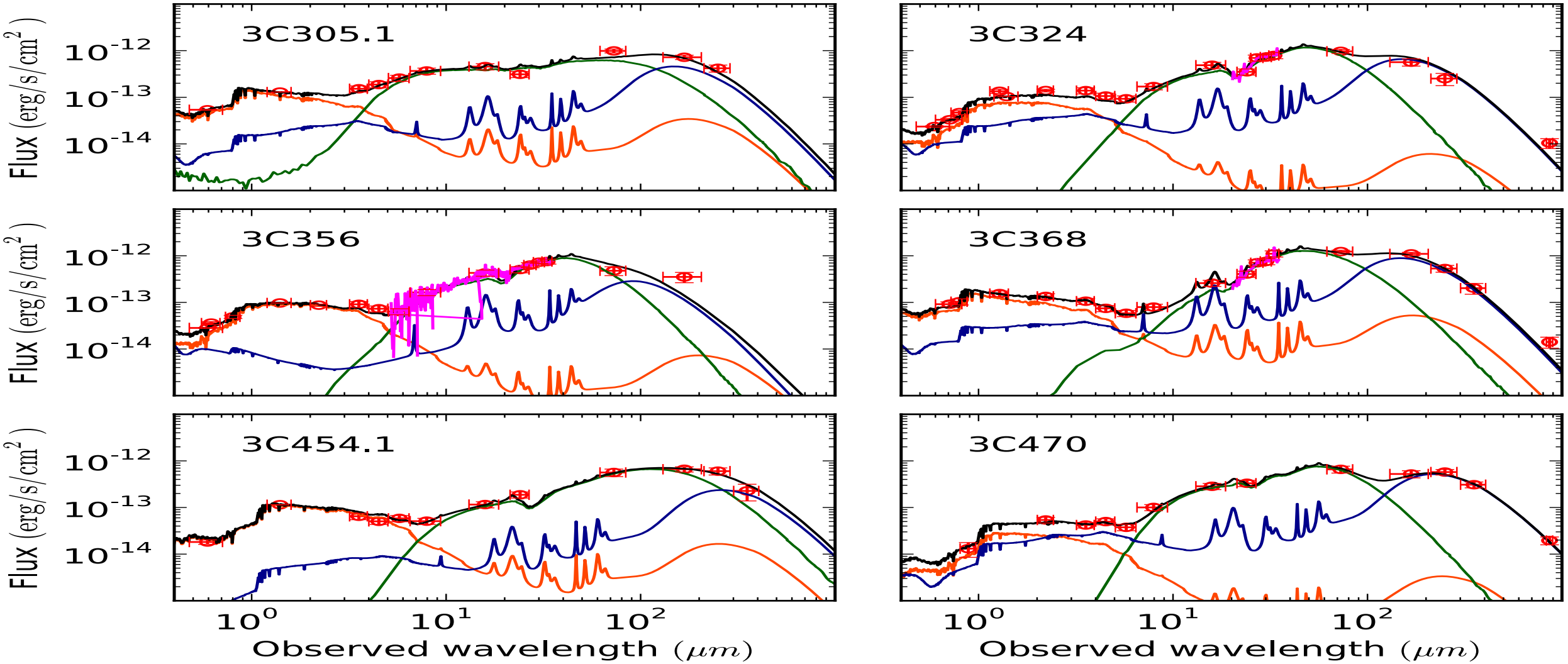
The Pégase.3 code of spectrochemical evolution of galaxies: documentation and complement

Fioc, Michel;
Rocca-Volmerange, Brigitte



The automatic best-fitting procedure is applied to the 3CRR catalog of radio galaxies with the hybrid librairies + an old component (Podigachoski et al, 2016):

Old galaxy:red ; starburst: blue; AGN torus (green) : Mass, ages and NHI for about 20 best-fits with A robust fit on IRS/SPITZER spectra



Confirmed from SPITZER/MIPS spectra : Identification of 3 components in distant 3CR radiogalaxies with the code PEGASE.3

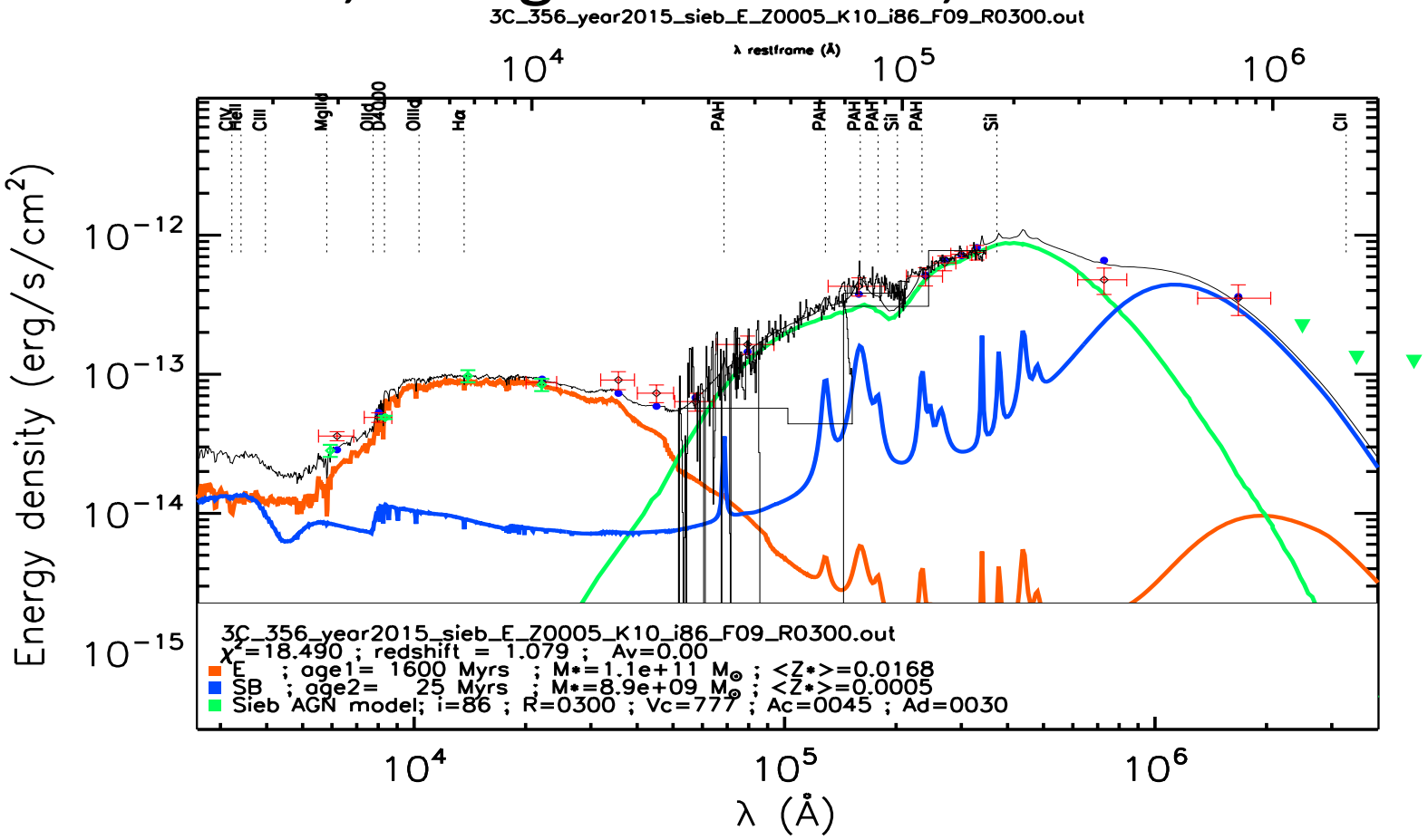
Drouart et al. 1996, Podigachoski et al, 1996

Observations :

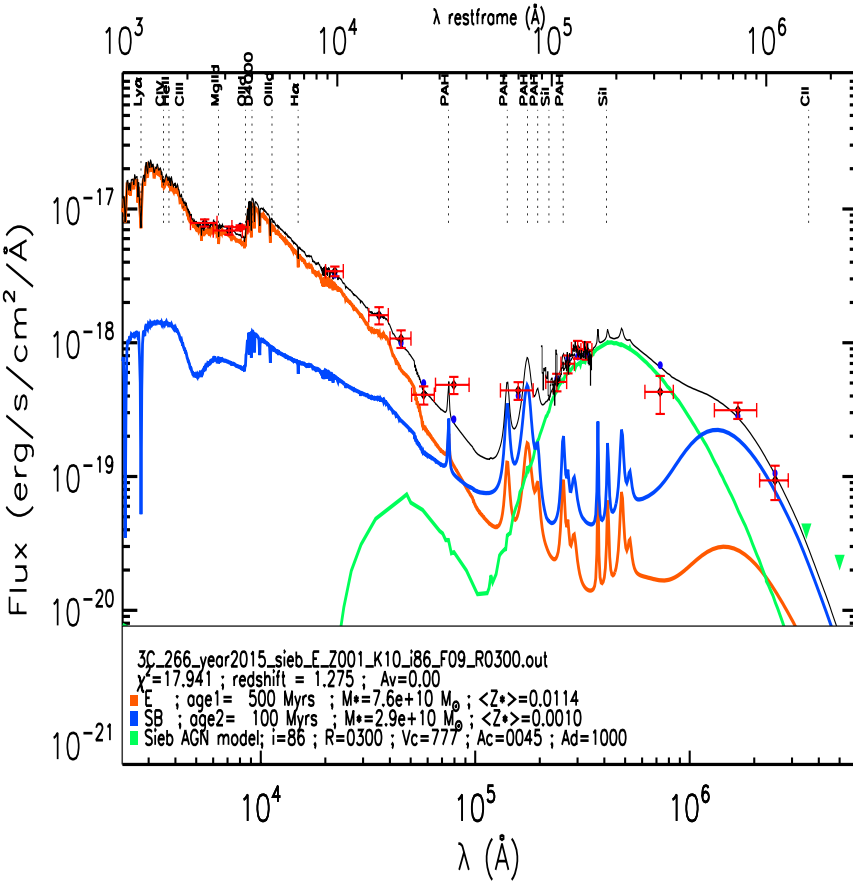
HST, SPITZER and Herschel(red crosses)+ Spectrum (Spitzer)

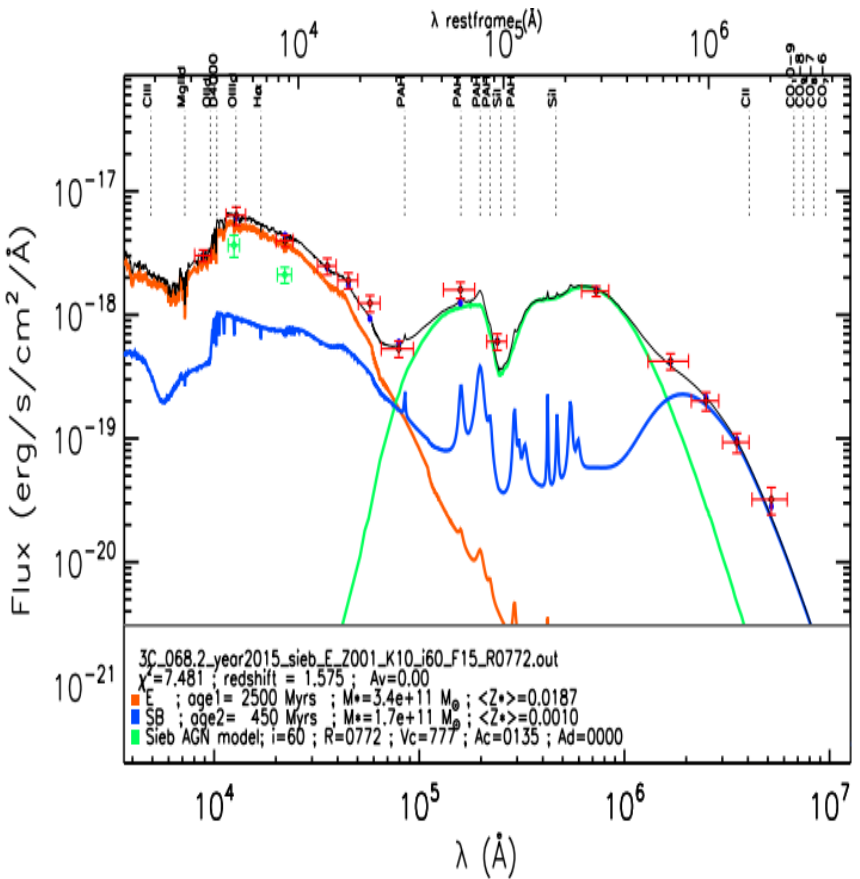
3 components

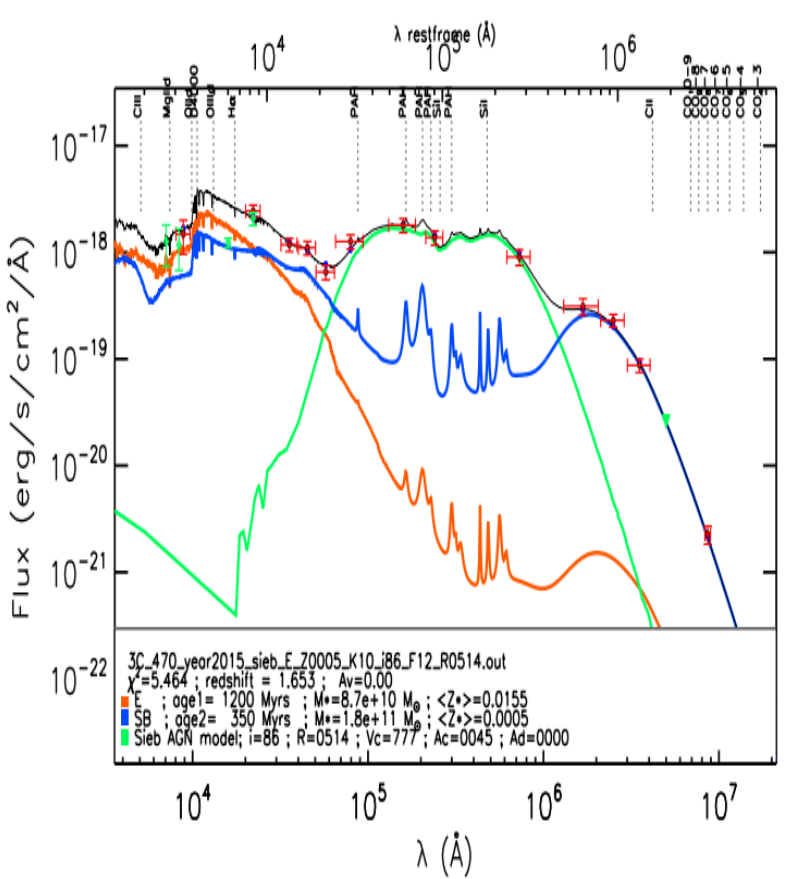
- **AGN torus (green)**
- **Young burst (blue)**
- **Old galaxy (red)**



The same for 3C266, and many others ….
a faint AGN (green) and young Starburst (blue)







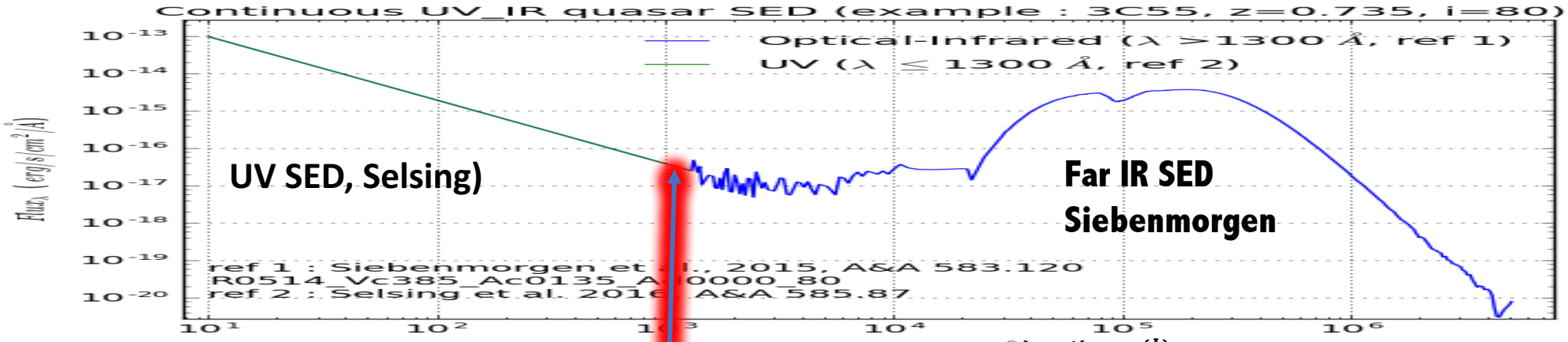
BUILDING THE UV-far IR SEDs of distant AGN/QSO

1. THE far-IR AGN torus fitted from SPITZER observations
with Siebenmorgen, 2015
In coherence with UV-optical and far IR data

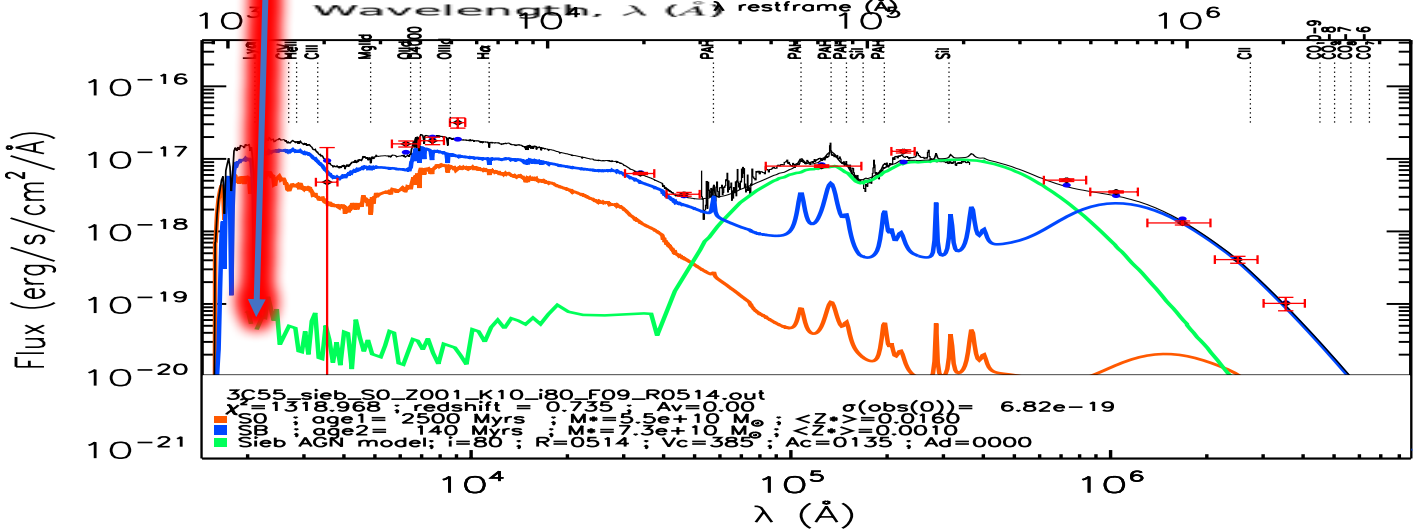
2. A tentative to connect the far-IR model with the UV-optical QSO model
f_l a $l^{a(l)}$ with a(l) = -1.70

3. The link is proposed for several radio galaxies, in particular when MIPS spectraum is fitted

The combined UV + FarIR QSO SED : 3C 55 (z=0.735. i=80°)

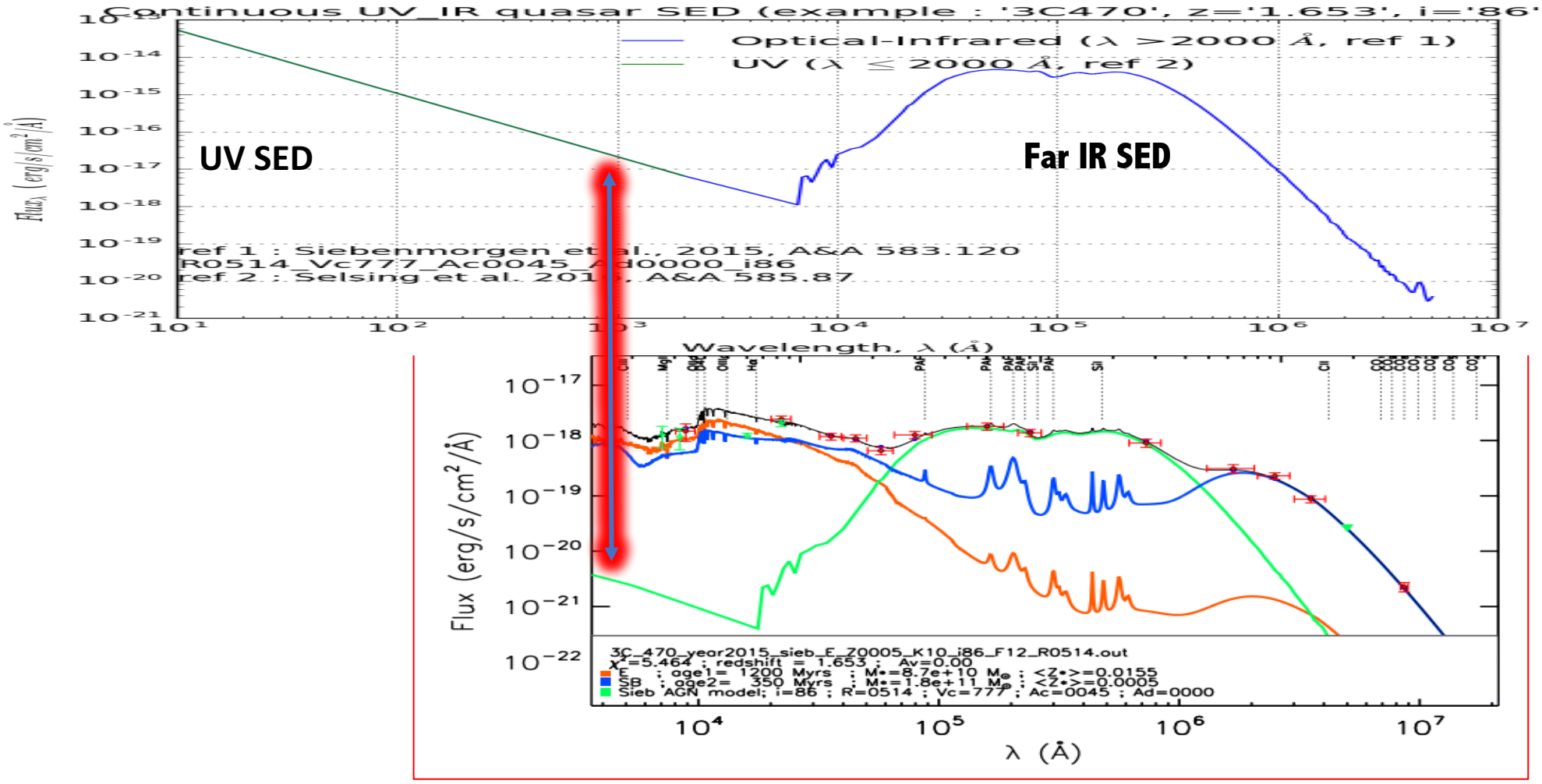


UV-farIR QSO (AGN + torus) SED



AGN TORUS Green line

The combined UV + FarIR QSO SED : 3C470 (z=1.053, i=86°)

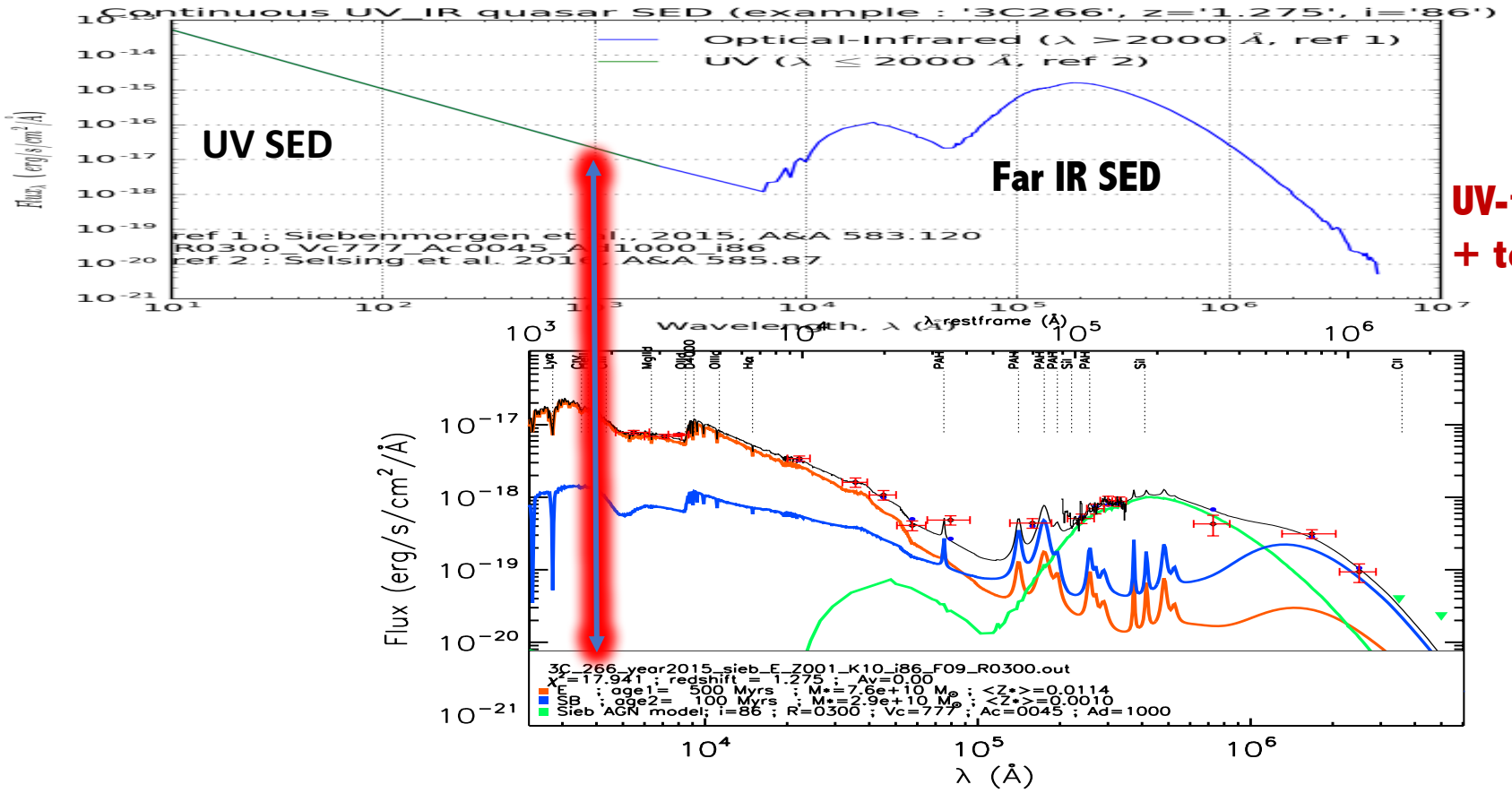


UV-farIR QSO (AGN + torus) SED

AGN Torus Green line

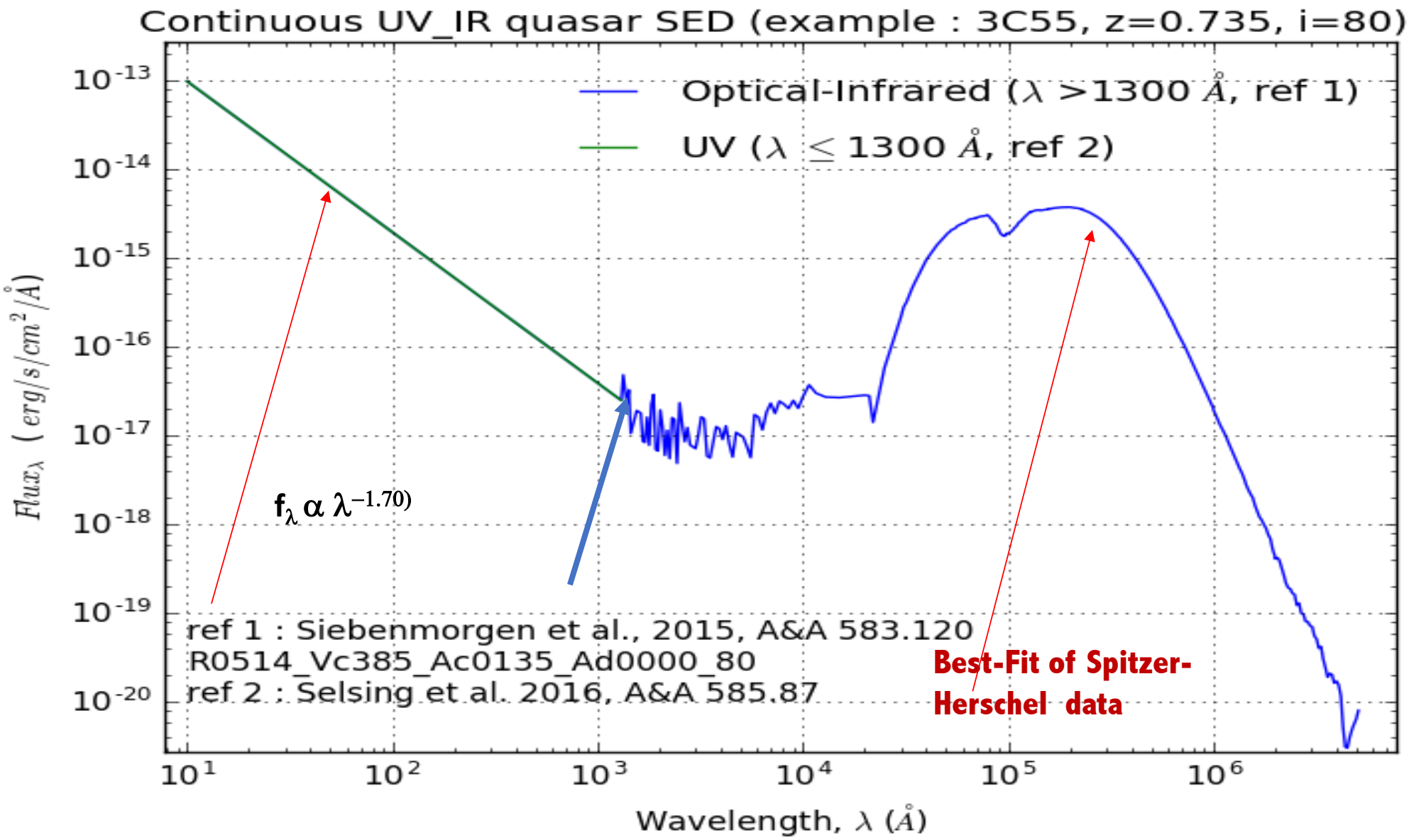
The combined UV + FarIR QSO SED : 3C266 (z=1.275, i=86°)

UV-farIR QSO (AGN + torus) SED

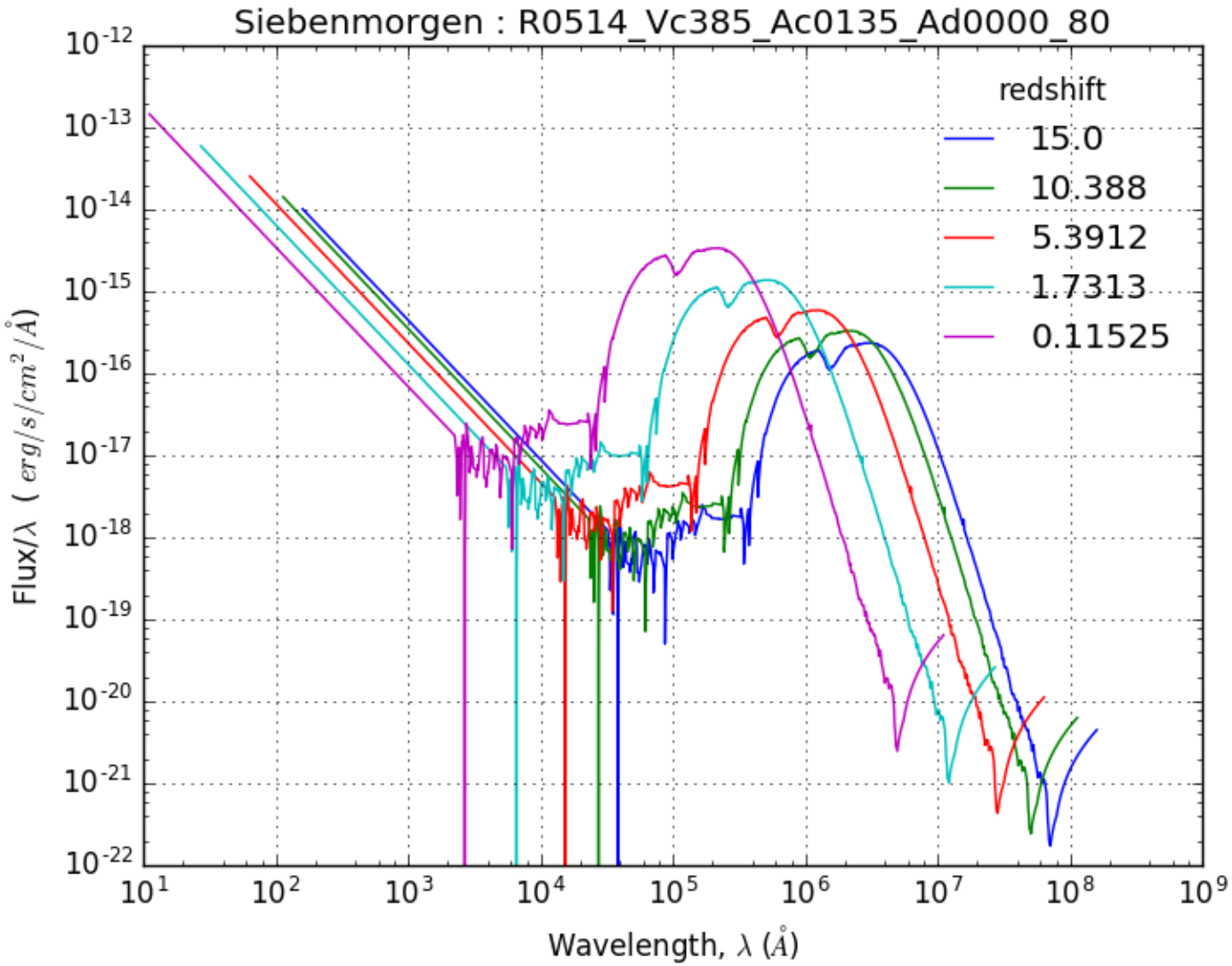


UV-farIR QSO (AGN + torus) SED

AGN Torus Green line


Continuous UV_IR quasar SED (example : 3C55, z=0.735, i=80)
Optical-Infrared (λ >1300 Å, ref 1)
UV (λ ≤ 1300 Å, ref 2)
$f_\lambda \alpha \lambda^{-1.70)}$
ref 1 : Siebenmorgen et al., 2015, A&A 583.120
R0514_Vc385_Ac0135_Ad0000_80
ref 2 : Selsing et al. 2016, A&A 585.87
Best-Fit of Spitzer-Herschel data
$Flux_\lambda$ ($erg/s/cm^2/Å$)
Wavelength, λ (Å)
10^{-13}
10^{-14}
10^{-15}
10^{-16}
10^{-17}
10^{-18}
10^{-19}
10^{-20}
10^1
10^2
10^3
10^4
10^5
10^6

At high redshifts (z=0 to 15) , with k-correction



CONCLUSION and future

Work in progress

- **Distant AGN/ QSOs SED in the Far-IR : torus dust emission from a clumpy model (Siebenmorgen, 2015)**
- **Distant AGN/ QSOs SED in the UV-optical is in agreement with $f_\lambda \alpha \lambda^{\alpha(\lambda)}$ with $\alpha(\lambda) = -1.70$**

- **A continuous UV – farIR AGN/QSO SEDs are significant by linking the two models**

- **But Depends on inclination**

- **More Dependence on redshift z, through the filter passbands**

- **Future : Magnitudes and colors of distant AGN/QSOS through filter passbands and calibration parameters of the Gaia, WISE, JWST and EUCLID telescopes**

ALMA and JWST (see below)