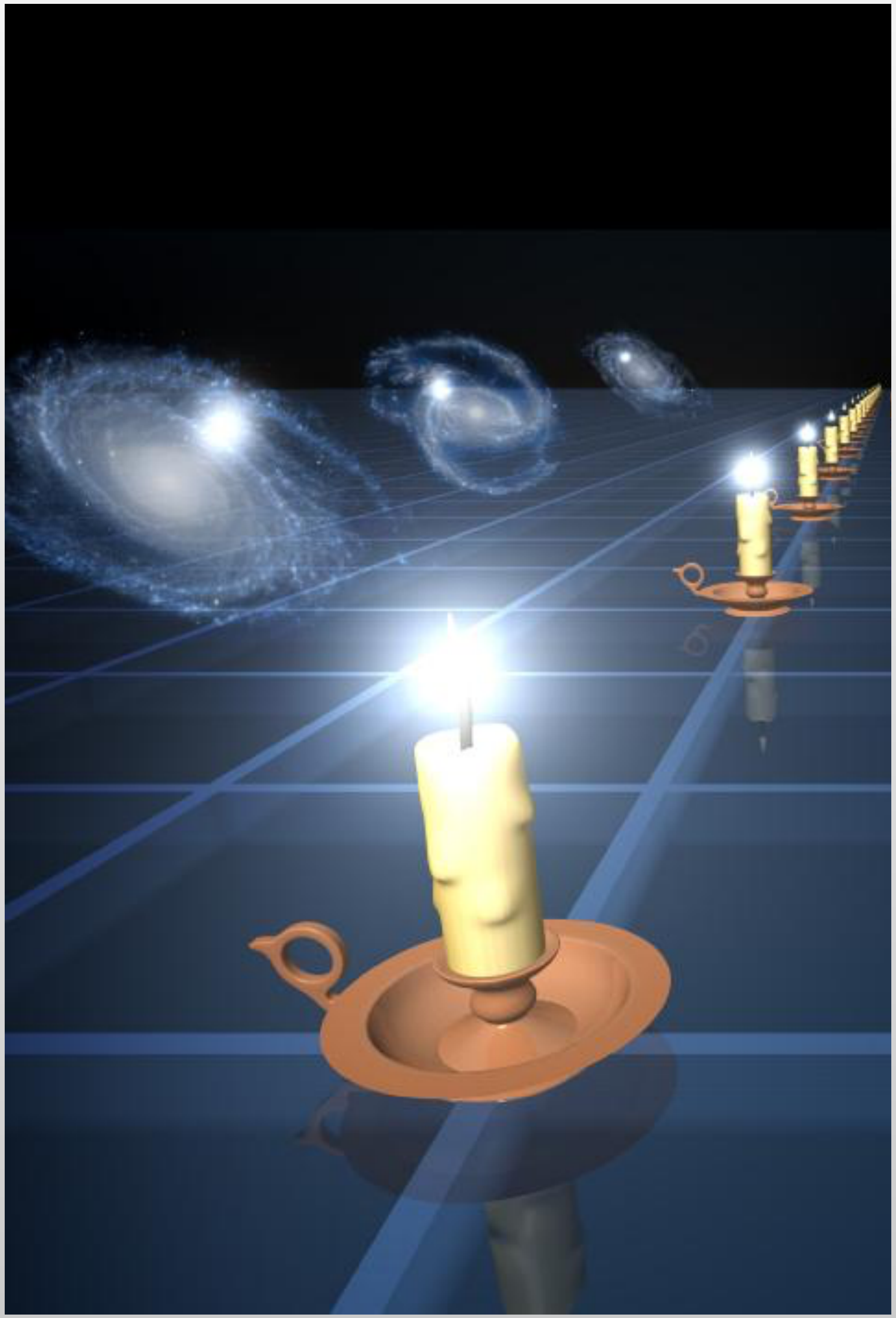
Supernovae spectra extraction through host galaxy HyperSpectral modeling.

Jérémy LEZMY

02/11/2021

Cosmology with Supernovae Ia



A priori known…
For SNIa

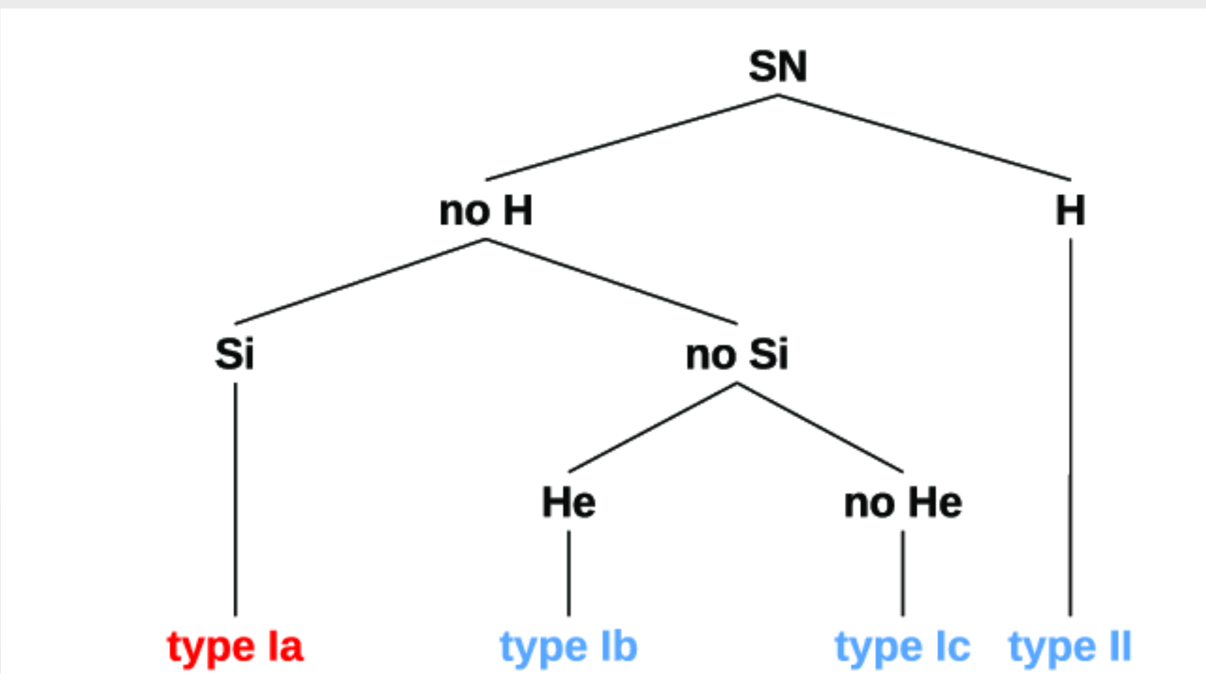
measured

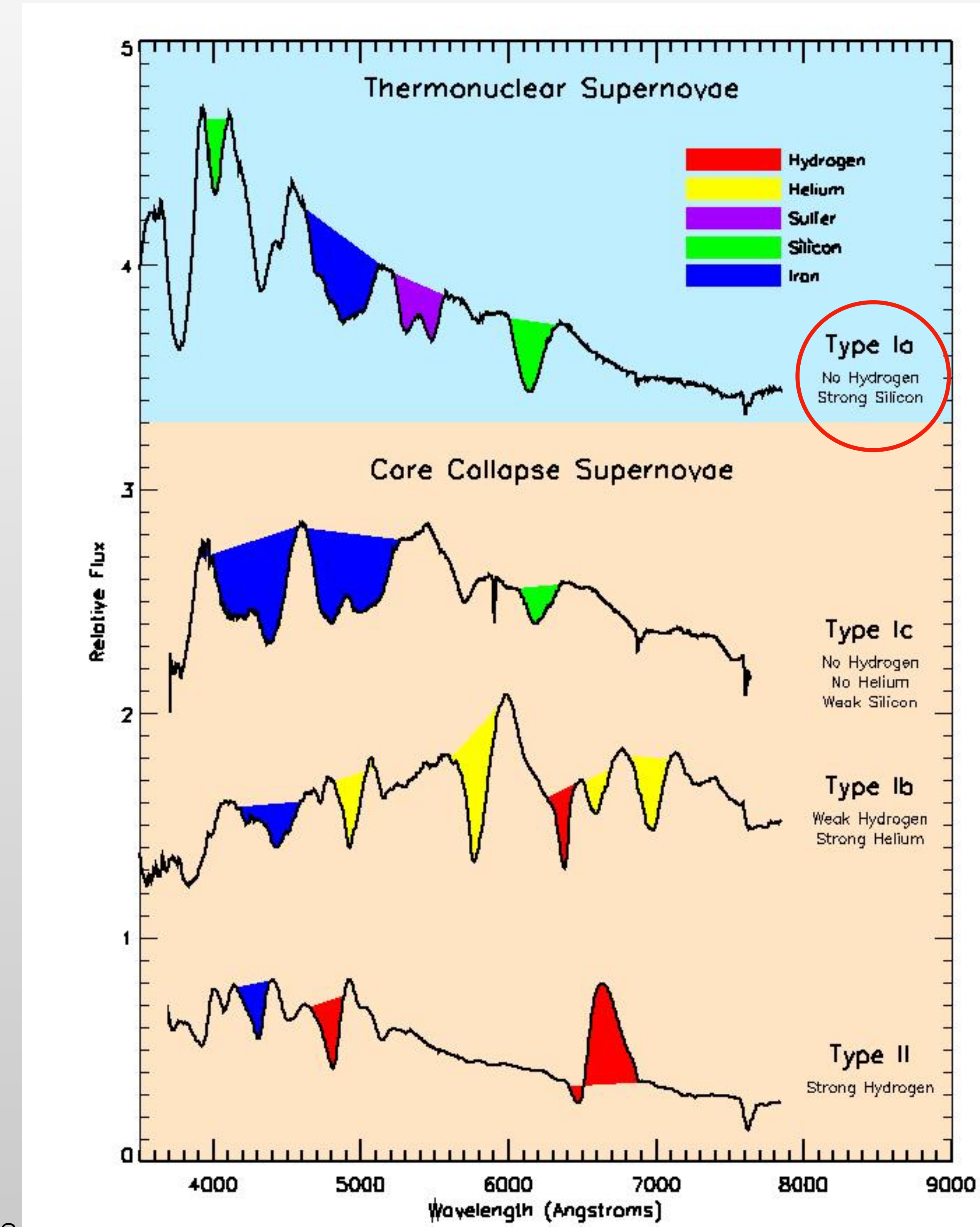
$$f = \frac{L}{4\pi d_L^2}$$

Cosmology

$$d_L = \frac{c}{H_0}(1+z) \times f(\Omega_r, \Omega_k, \Omega_m, \Omega_\Lambda)$$

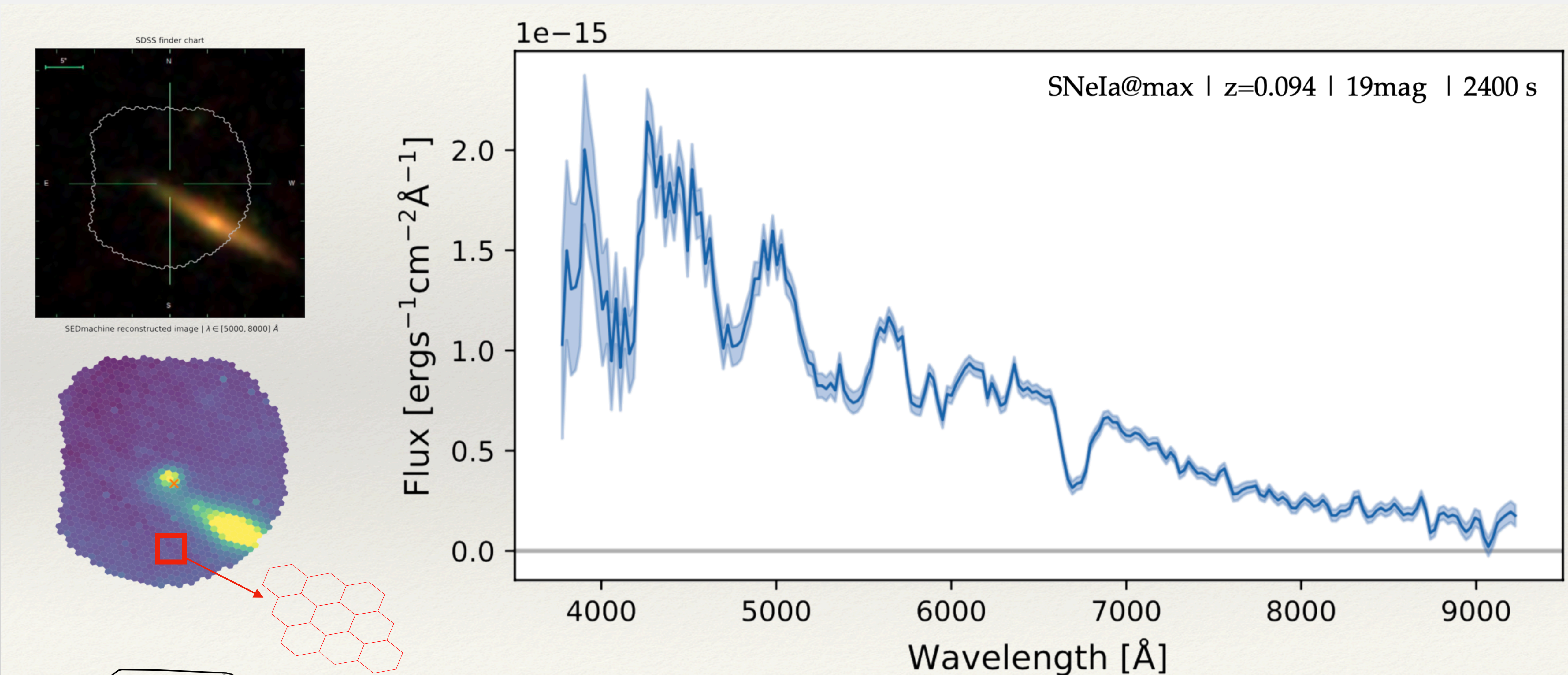
Typing of Supernovae Ia

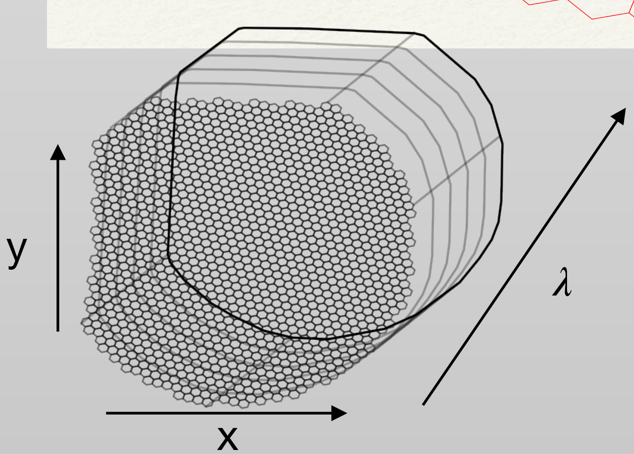




Zwicky Transient Facility

Spectral Energy Distribution machine (SEDm)

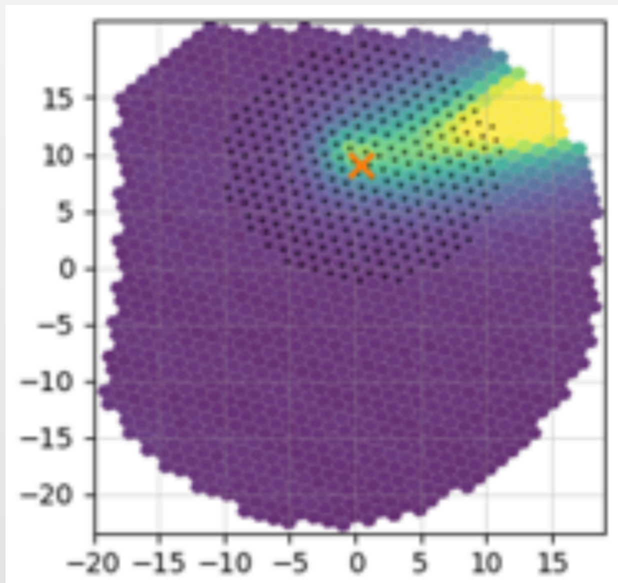


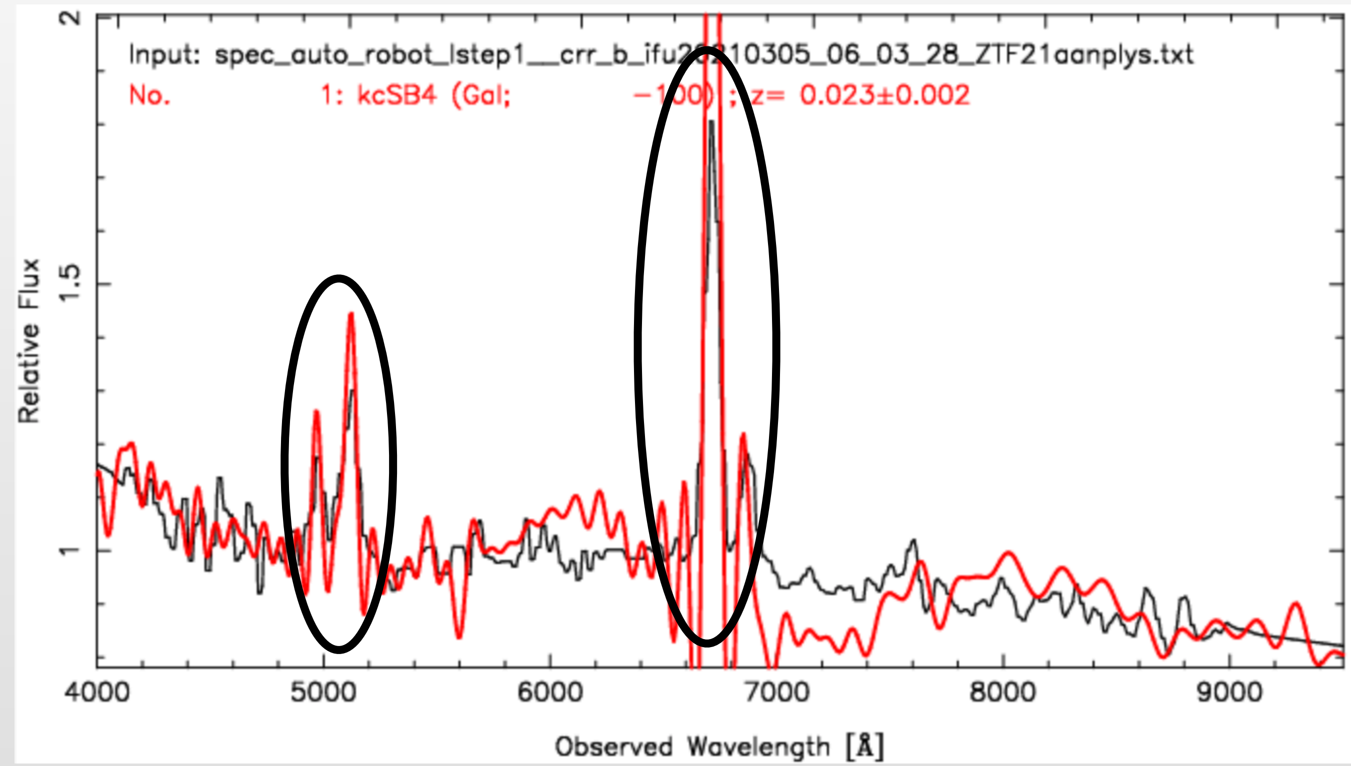


~10-15 spectra/night

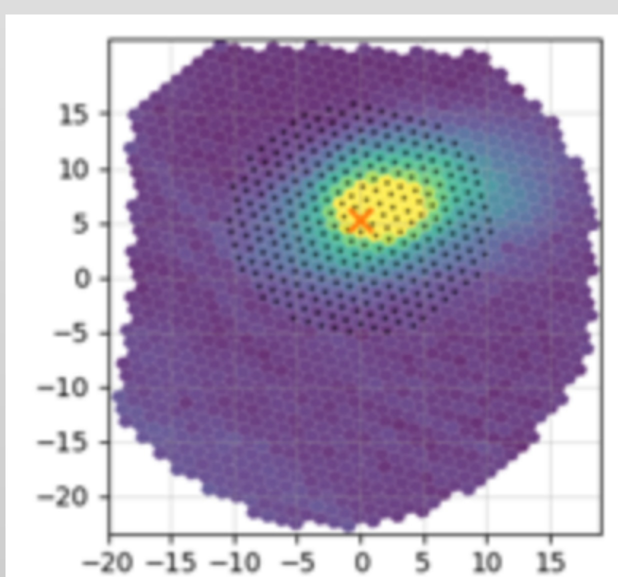
Host contamination

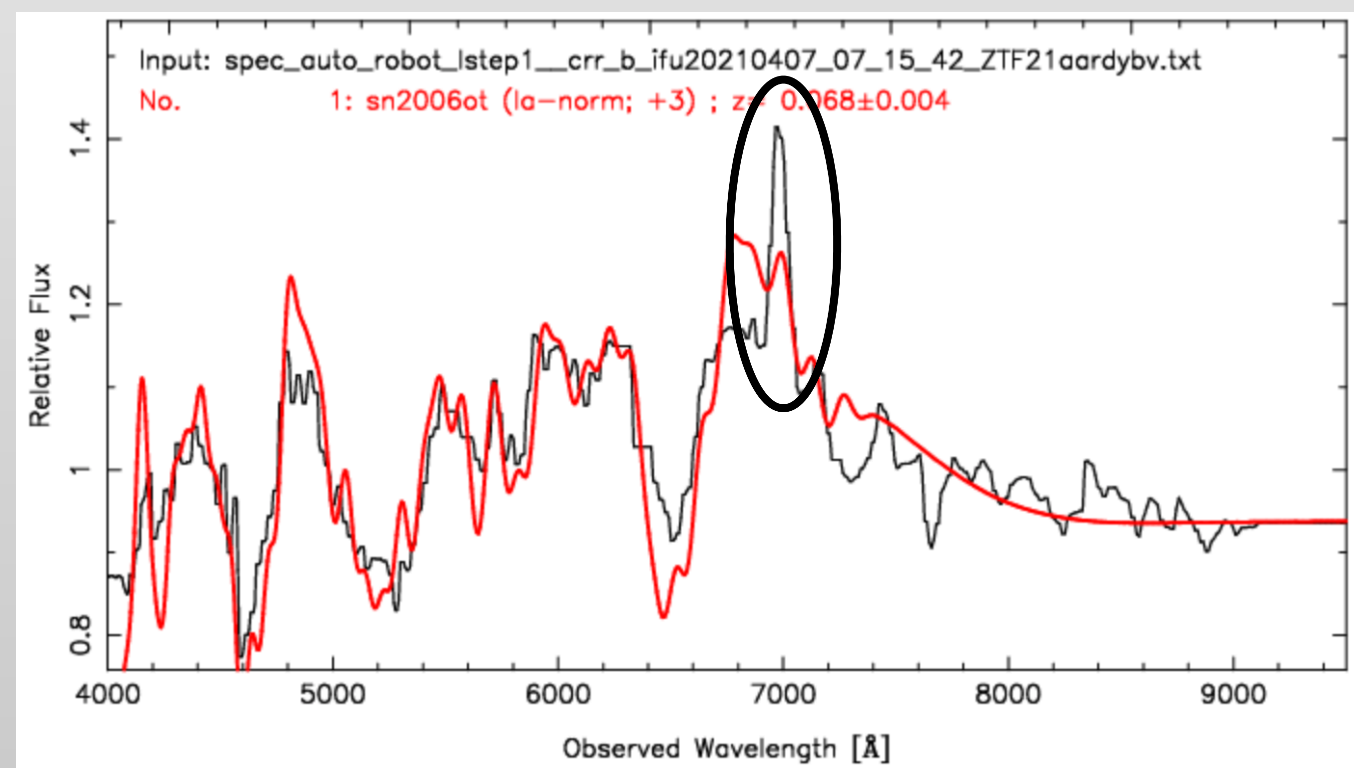
ZTF21aanplys





ZTF21aardybv





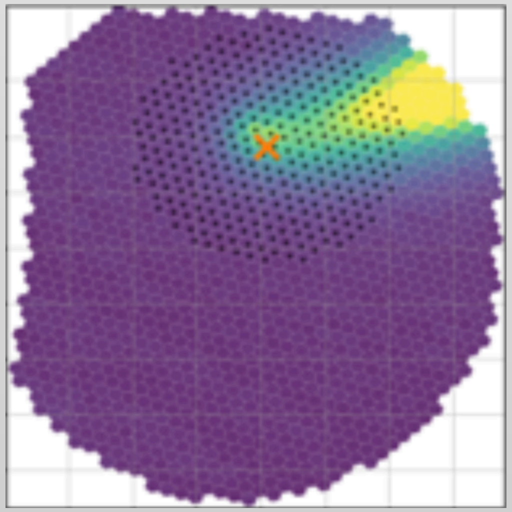
Hypergal Pipeline: Why?

- 30% of the observed SN are partially host contaminated, 5-10% are unusable. → **Selection Bias**
- 100% of the host spectra are currently … thrown in the trash!

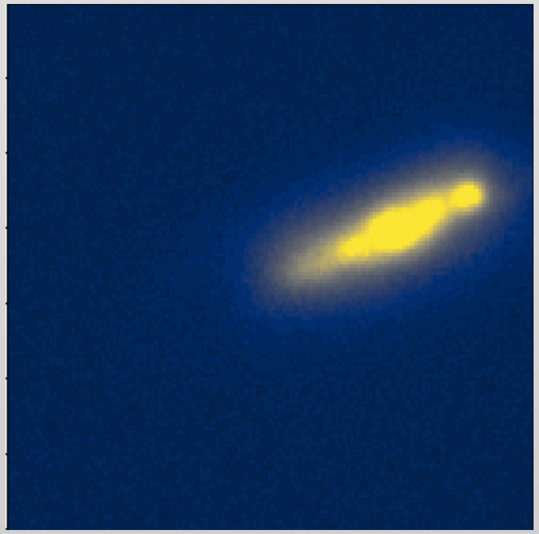
Hypergal Pipeline: What?

- Full scene modeler of the SEDm observation.

- New method of host spectral modeling from **<u>photometric images</u>** : no need to come back months later!

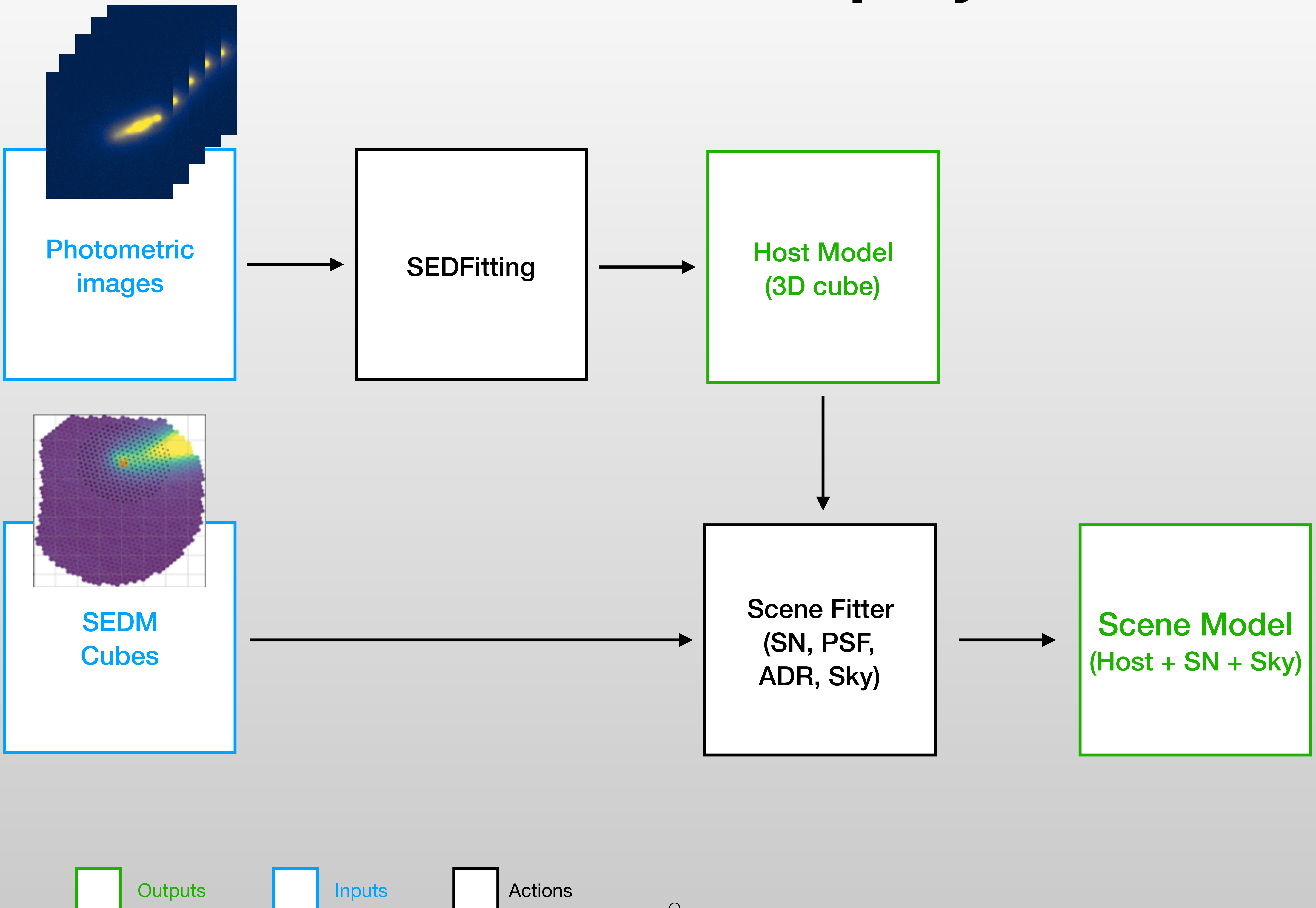


SEDm (spectroscopic)



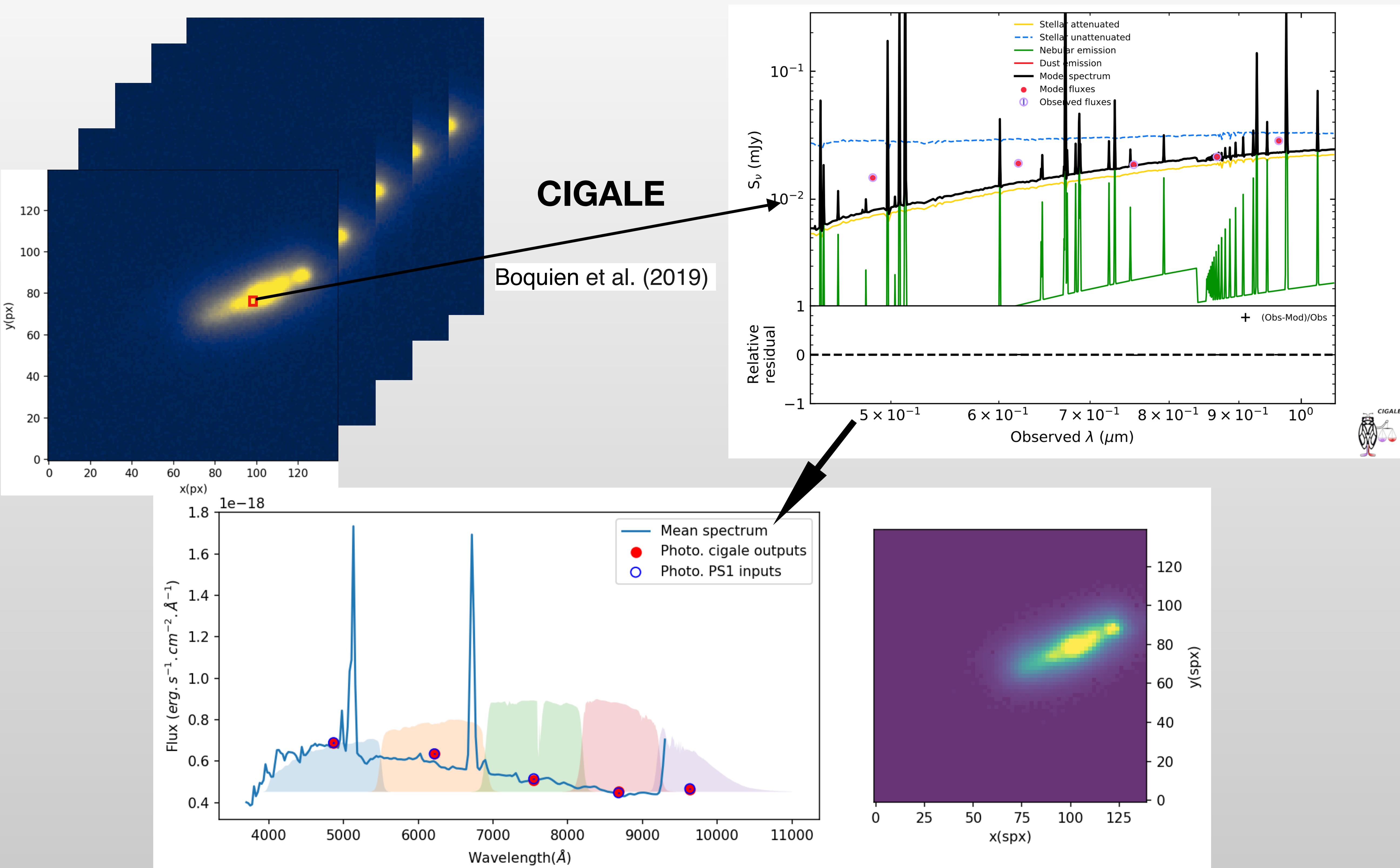
Panstarrs (photometric)

The Scene Model project



Pixel SEDFitting

Panstarrs broadbands



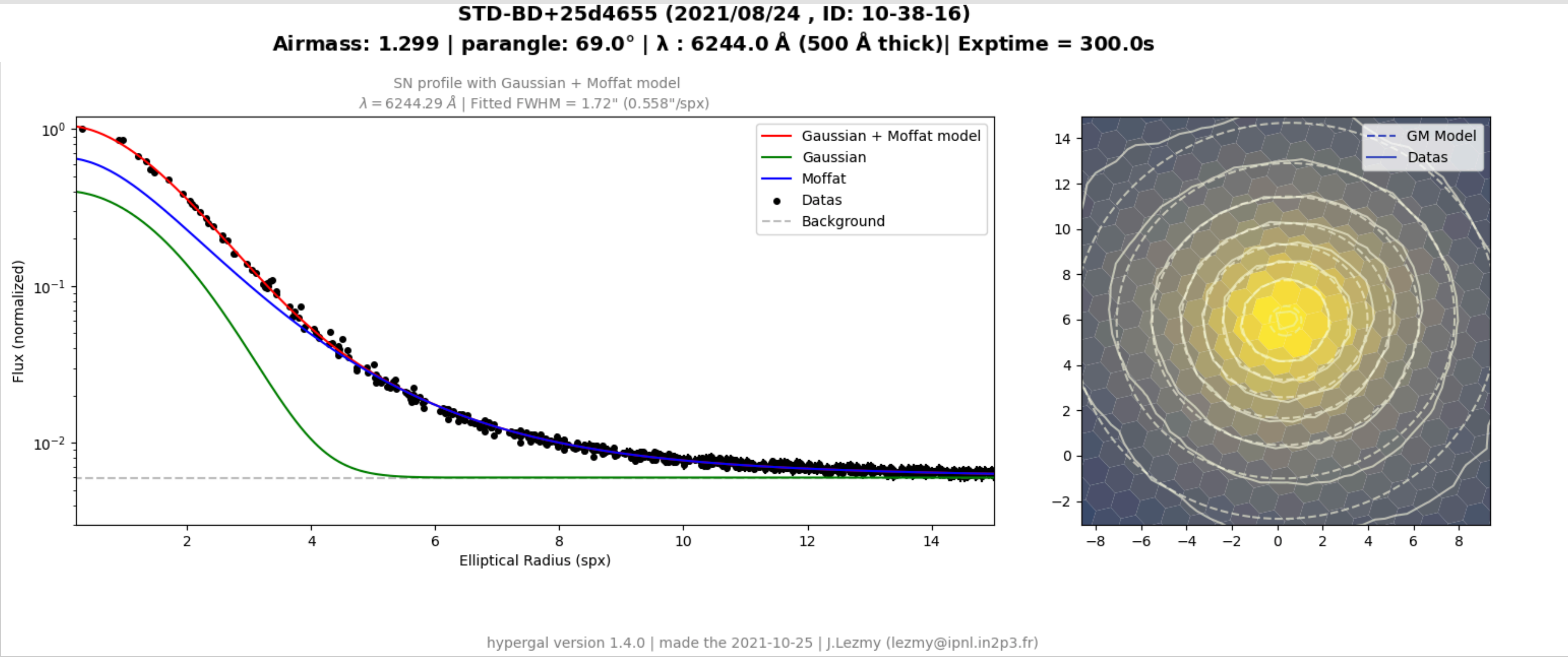
SEDm PSF characterization

We assume a Gaussian (core) + Moffat (wings) profile, describes as follow:

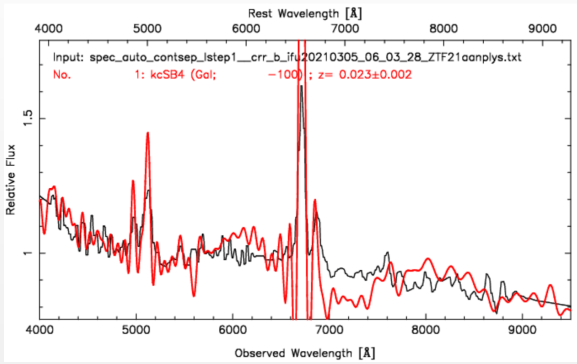
$$\mathcal{P}(r;\alpha,\beta,\sigma,\eta) = \eta\mathcal{N}(r;\sigma) + \mathcal{M}(r;\alpha,\beta)$$

$$r_{ell}^2 = (x-x_0)^2 + a(y-y_0)^2 + 2b(x-x_0)(y-y_0)$$

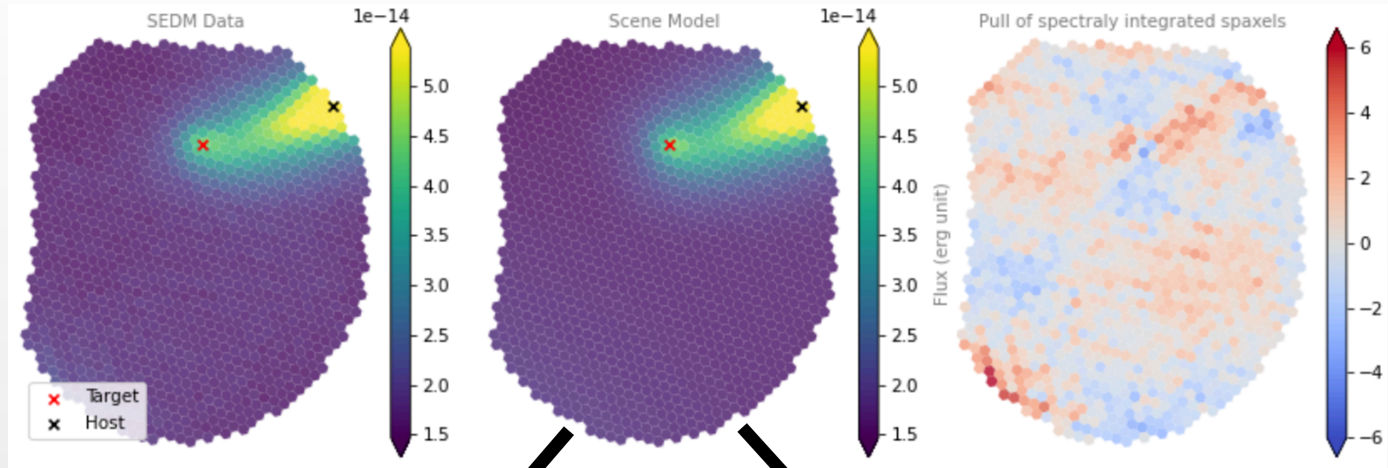
Describe orientation + ratio of the 2 axis



ZTF21aanplys (2021-03-05)

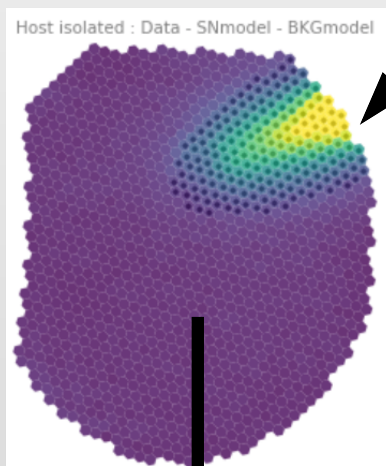


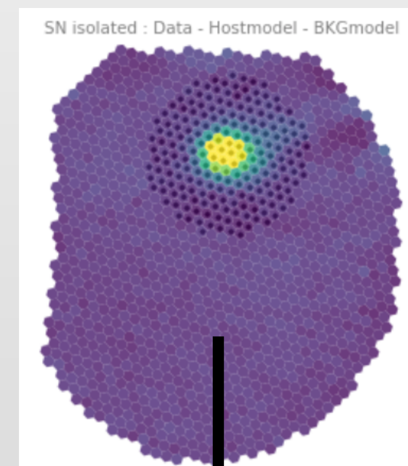
Before

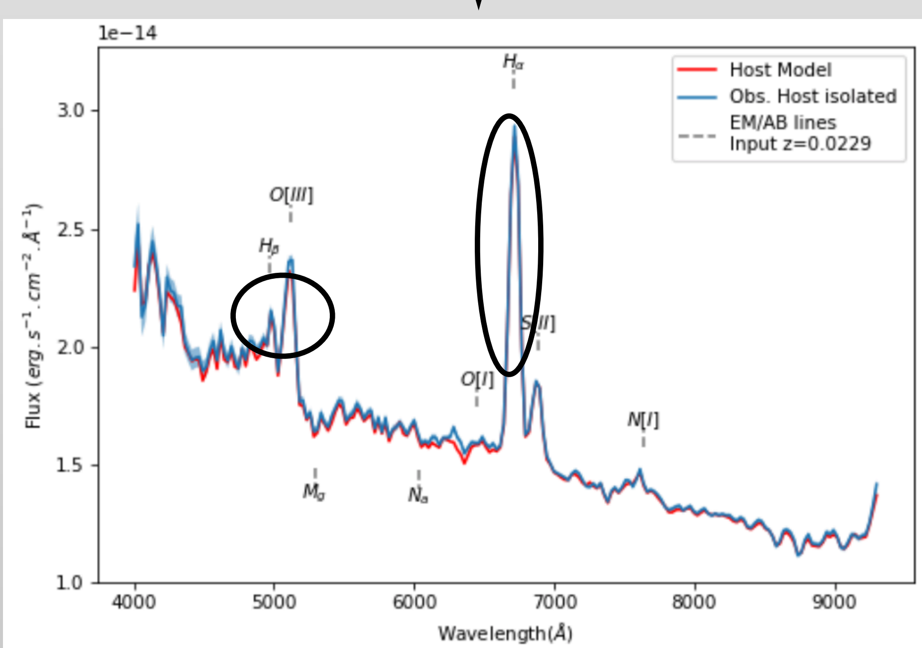


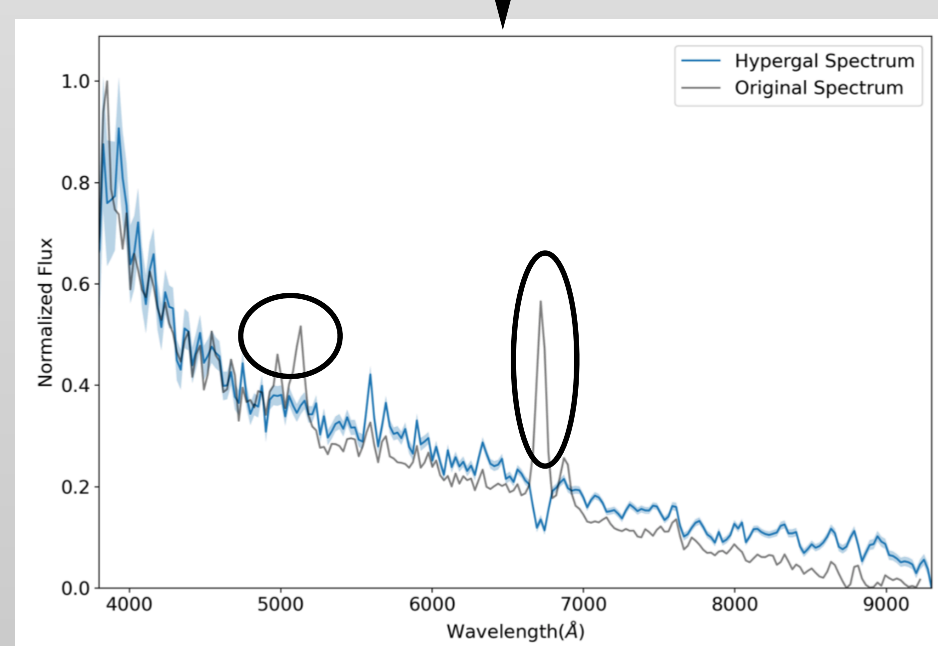
Obs. Host :
Data - (SN mod + Bkgd mod)

Obs. SN :
Data - (Host mod + Bkgd mod)









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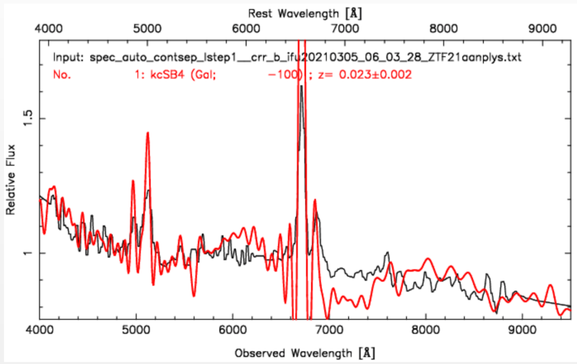

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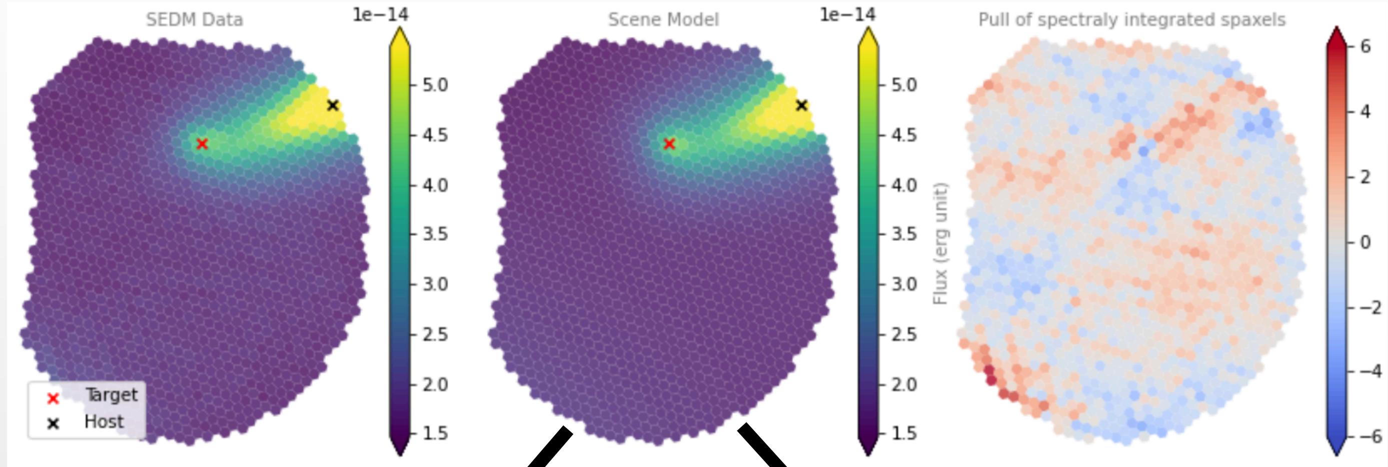

Obs. Host :
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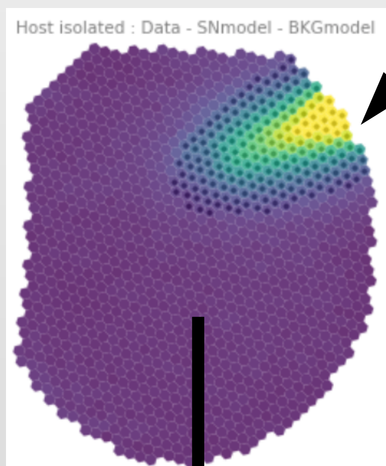
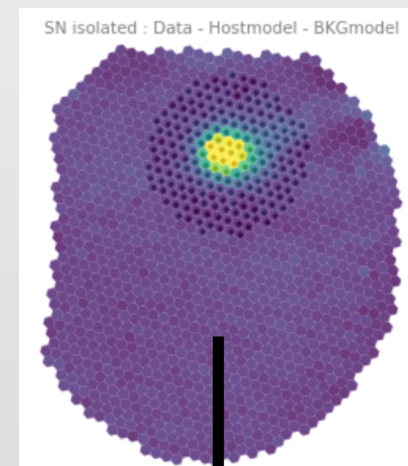
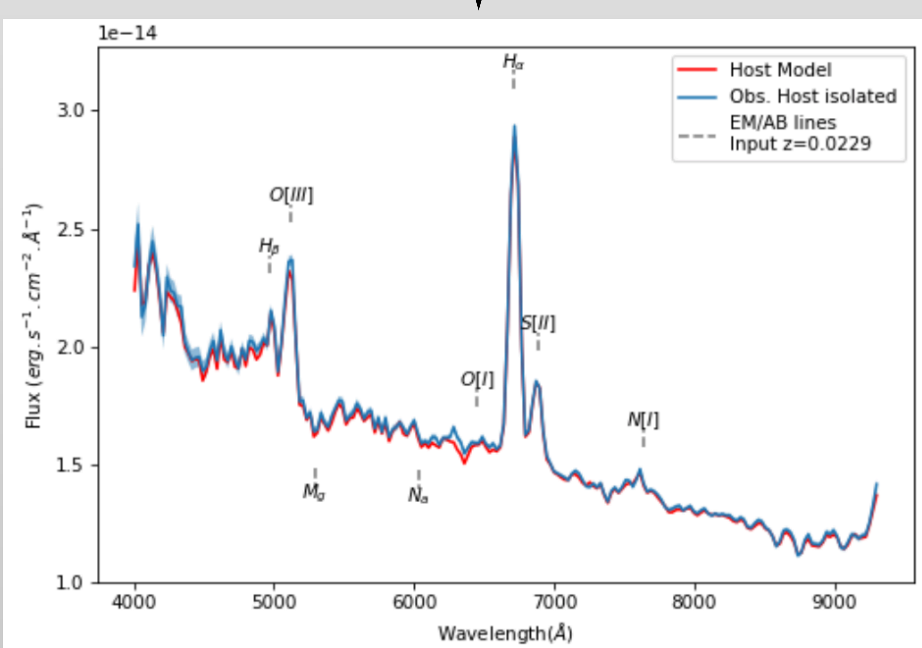
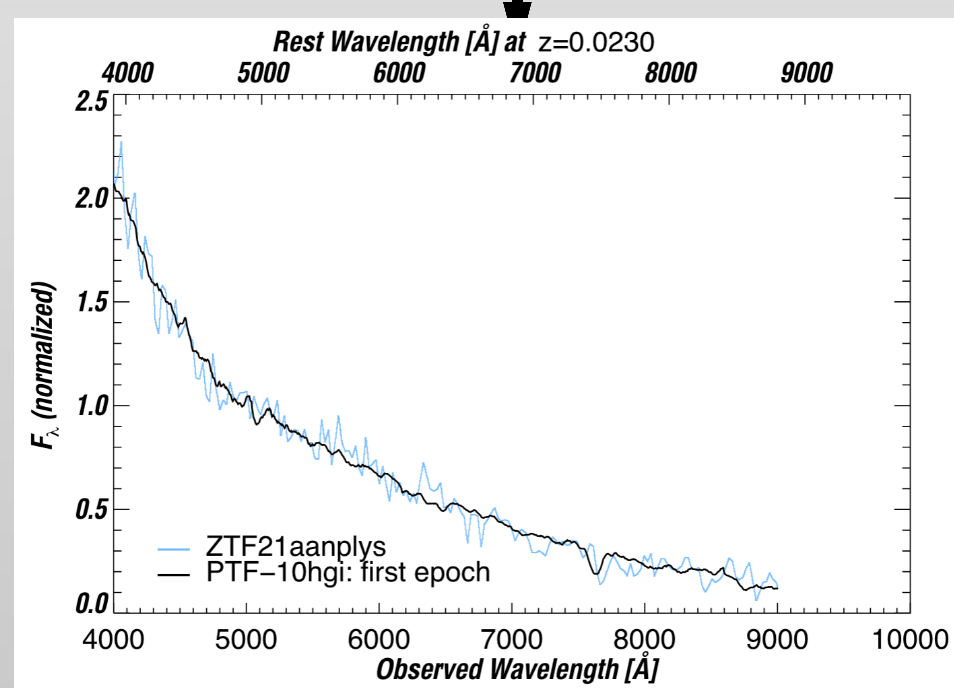
Data - (Host mod + Bkgd mod)

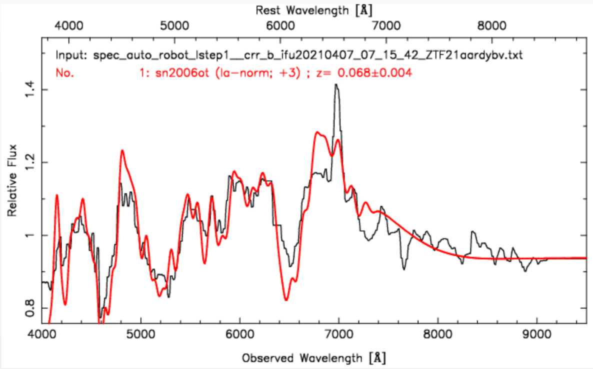




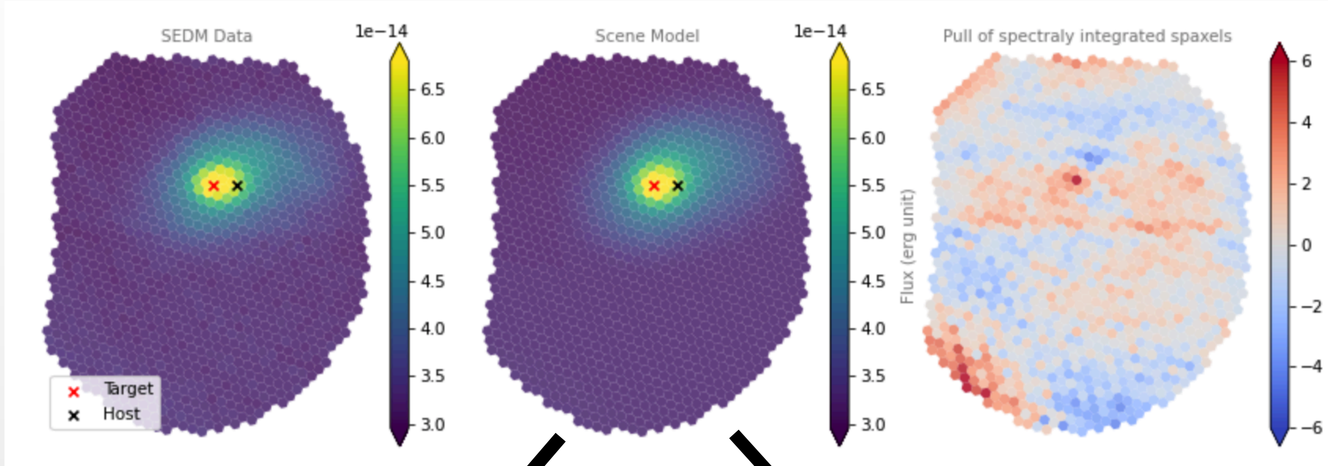




ZTF21aardybv (2021-04-07)



Before



Obs. Host :
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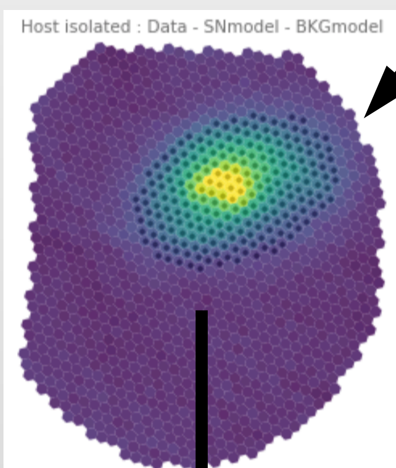

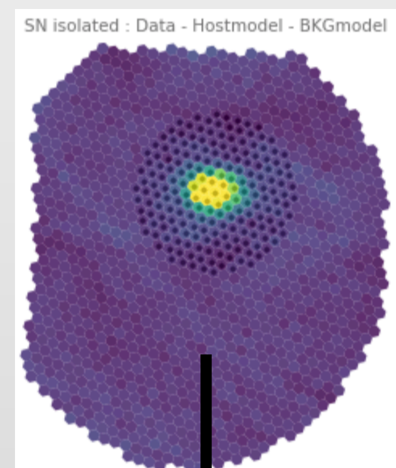

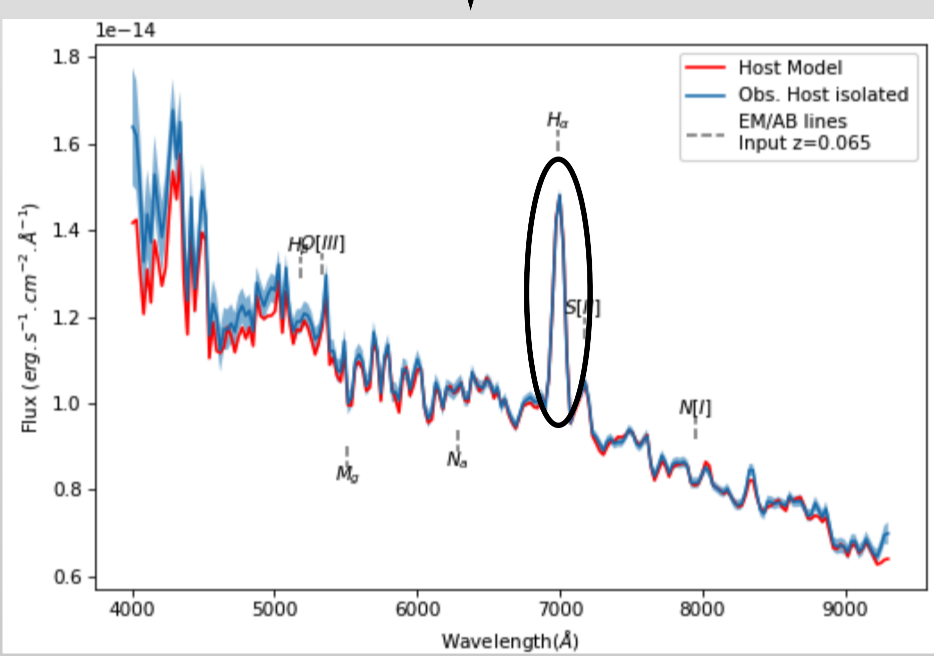

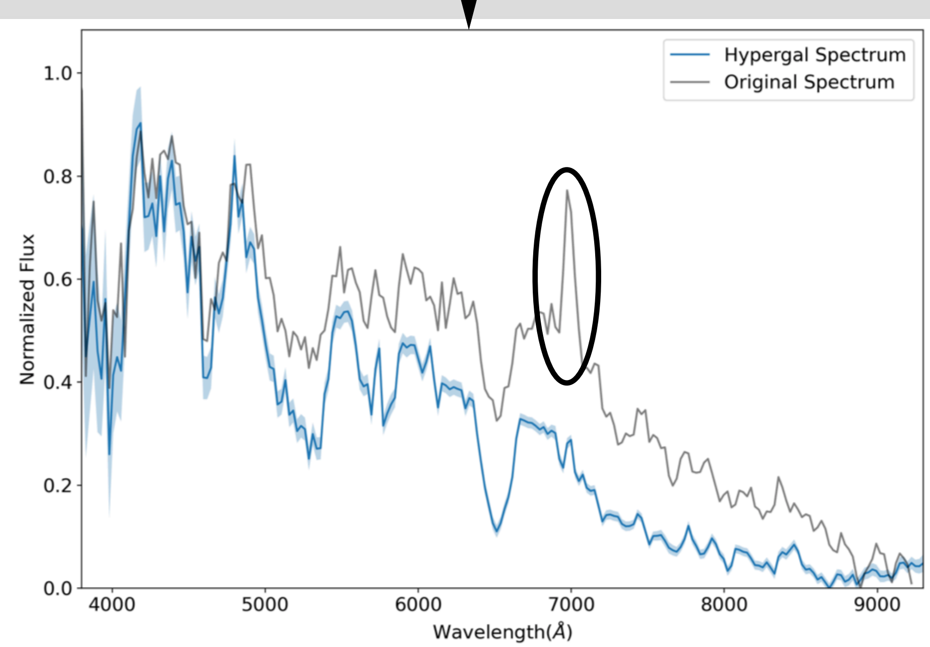

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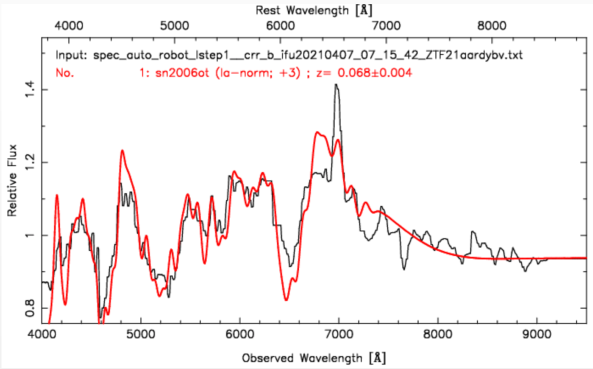

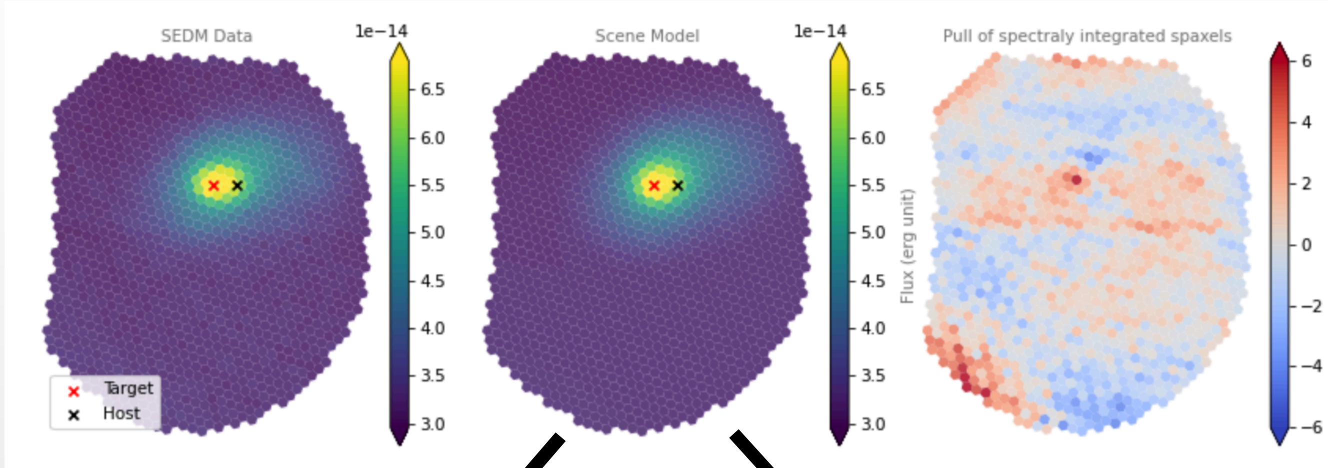

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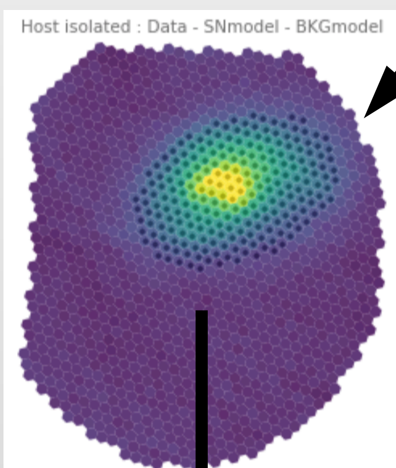
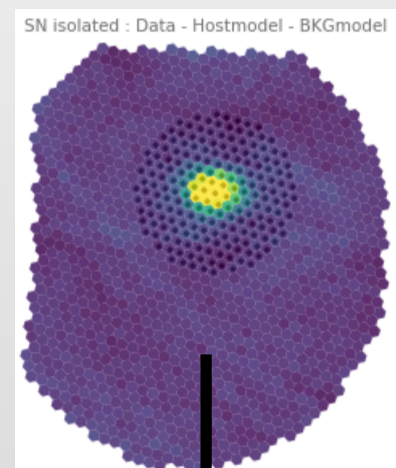
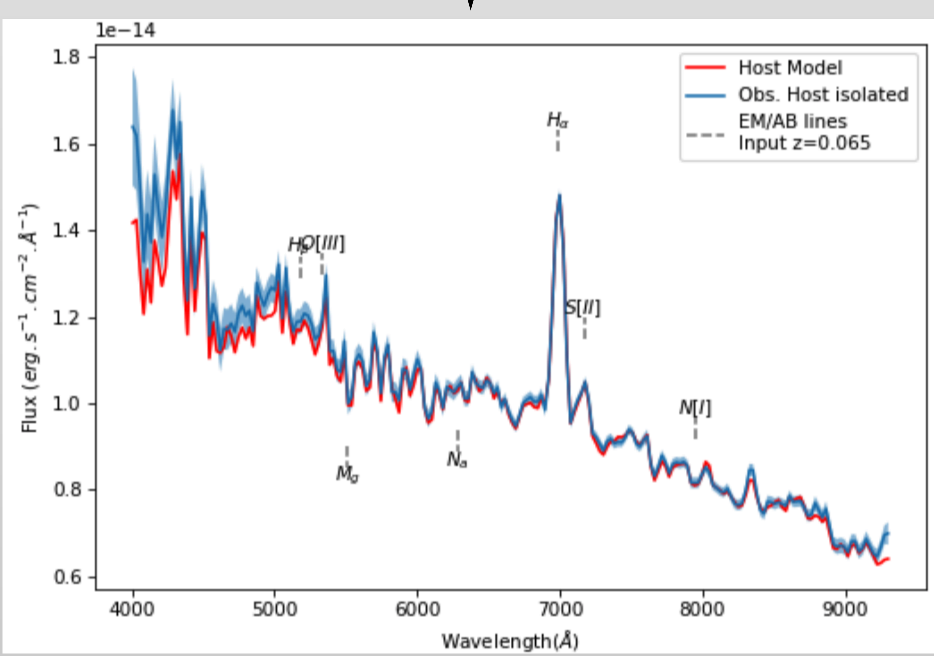
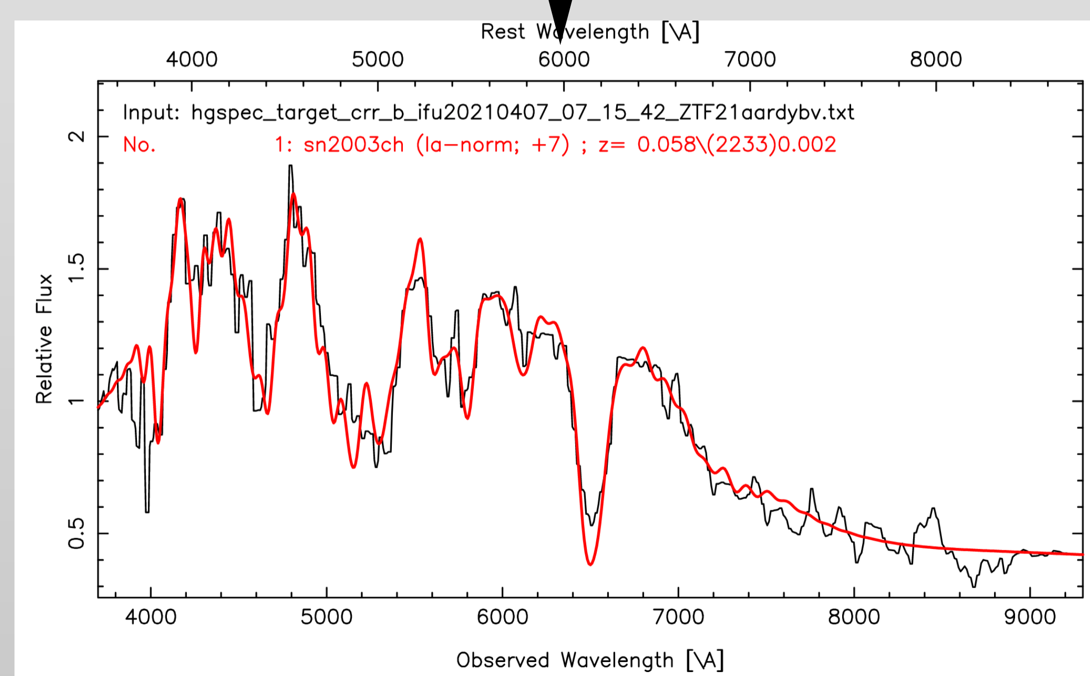








It works! And now?

- Pipeline in progress for the production step at the CNRS-IN2P3 Computing Center.
- Full ZTF sample will be processed, currently ~4000 targets.
- SN typing improvement analysis.
- Main paper currently in preparation.

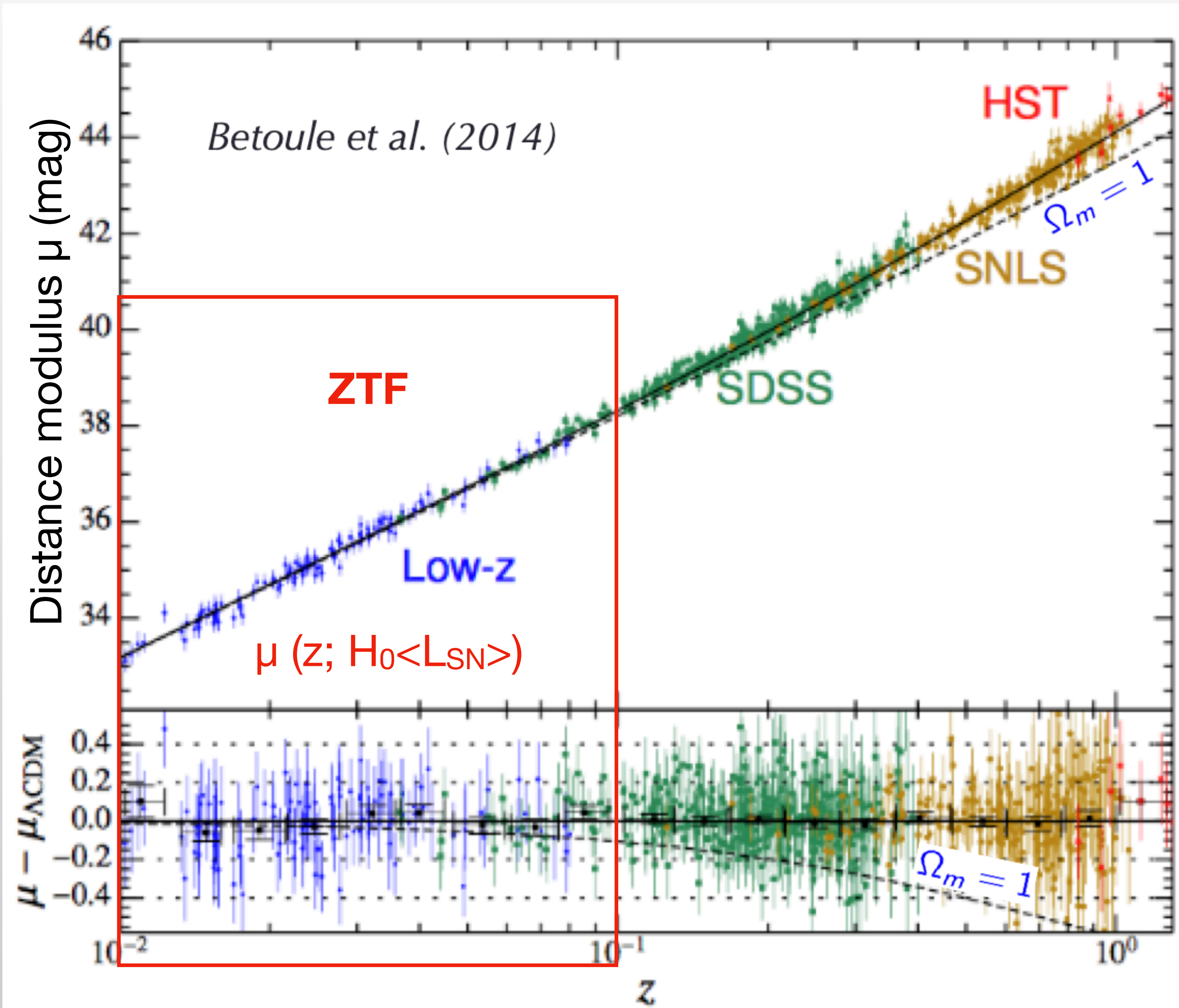
Conclusion

- We’ve built an entire SN extraction pipeline, fully automated, which might be mainstream in the ZTF collaboration.
- Pipeline built on python, and optimized with Dask integration (parallelization software).
- Hypergal can model all the spectra components of the SEDm observations, which are the Sky, the Host and the Supernova.
- Potential to save 10% of unusable SN spectra in the ZTF sample, and improve or correct the typing trust level of 30% of the SN.
- Provide the host spectra, unused whatever the observation until then.

Thank you for your attention

Backups

Cosmology with Supernovae Ia

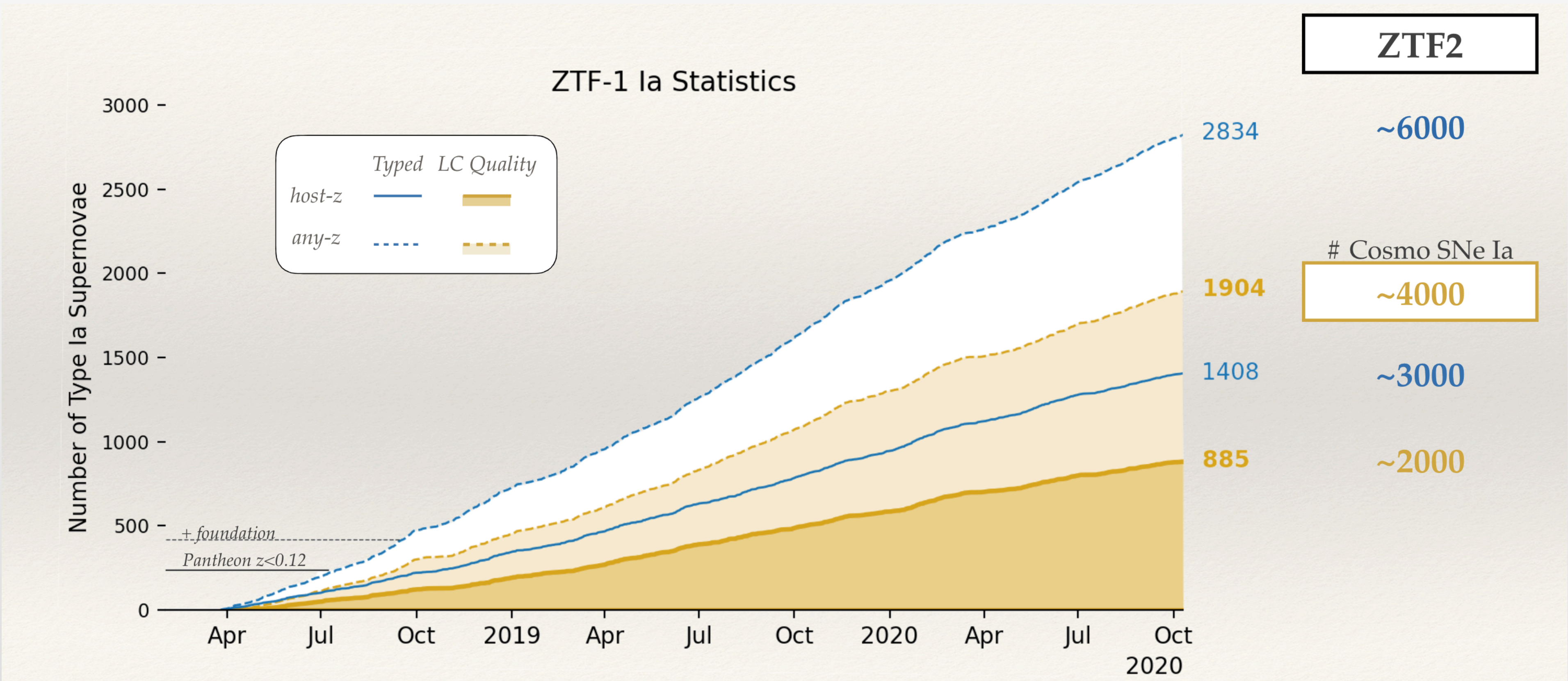


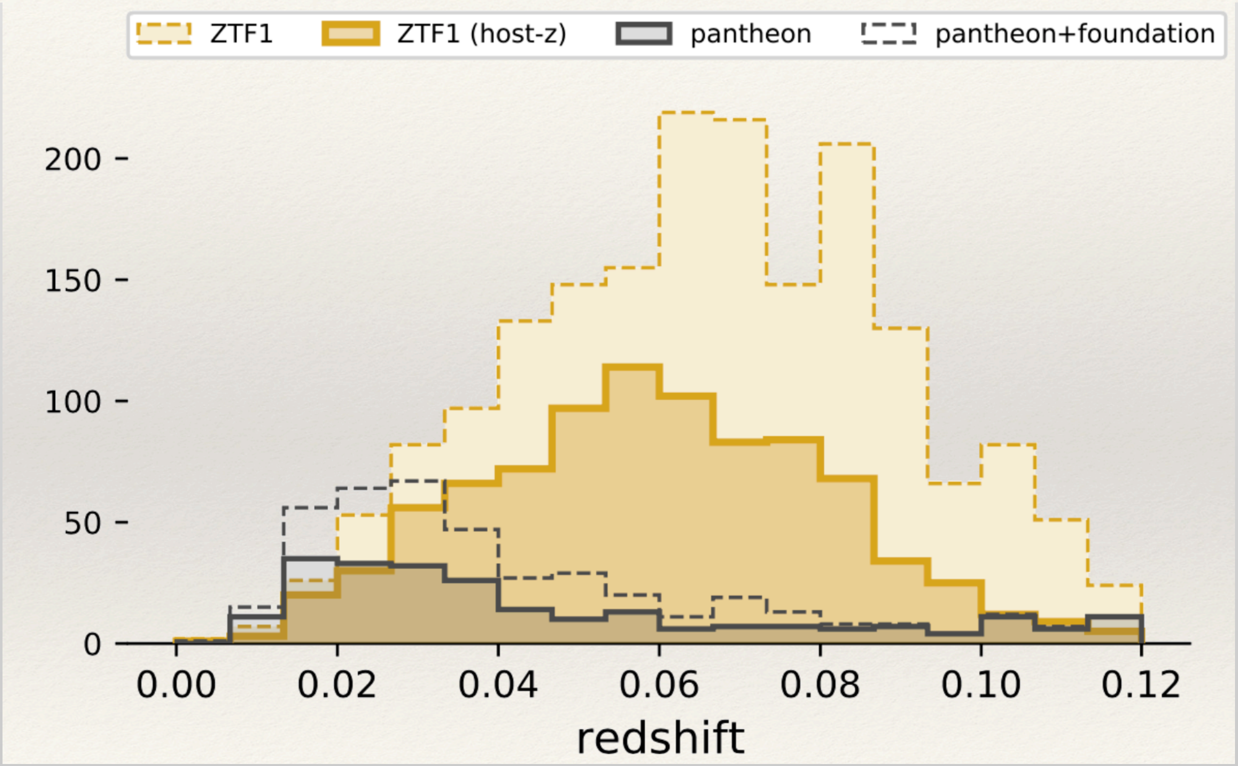
Accelerated expansion

Source	Number
Cálan/Tololo	17
CfAI	7
CfAII	15
CfAIII[a]	55
CSP[a]	13
Other low-z	11
SDSS[a]	374
SNLS	239
HST	9
Total	740

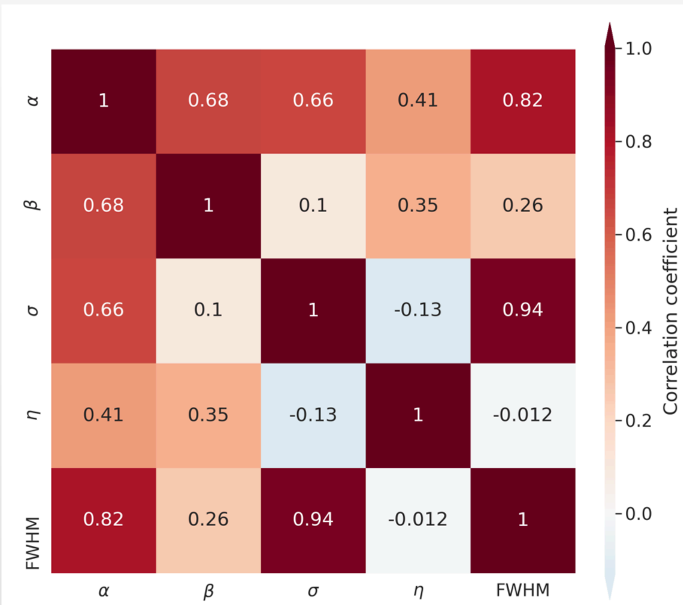
Betoule et al. (2014)

ZTF Type Ia Supernovae



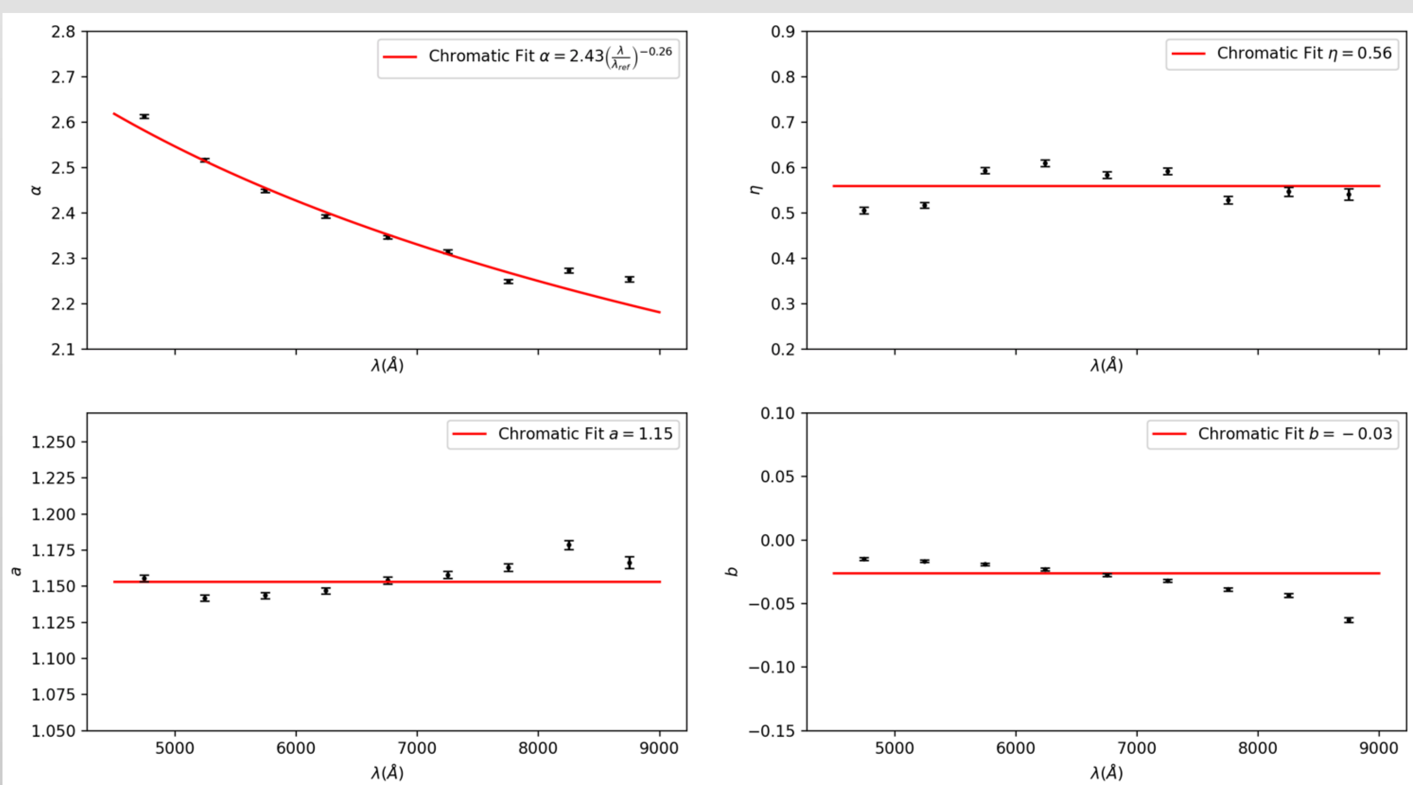


We then use this model over more than 500 standards stars to fit the parameters (each cube split into metaslices), and fix the strongest correlations between them successively. The chromaticity of the correlations turned out to be negligible.



$$\Rightarrow \mathcal{P}(r;\alpha,\eta) = \eta\mathcal{N}(r;\sigma(\alpha)) + \mathcal{M}(r;\alpha,\beta(\alpha))$$

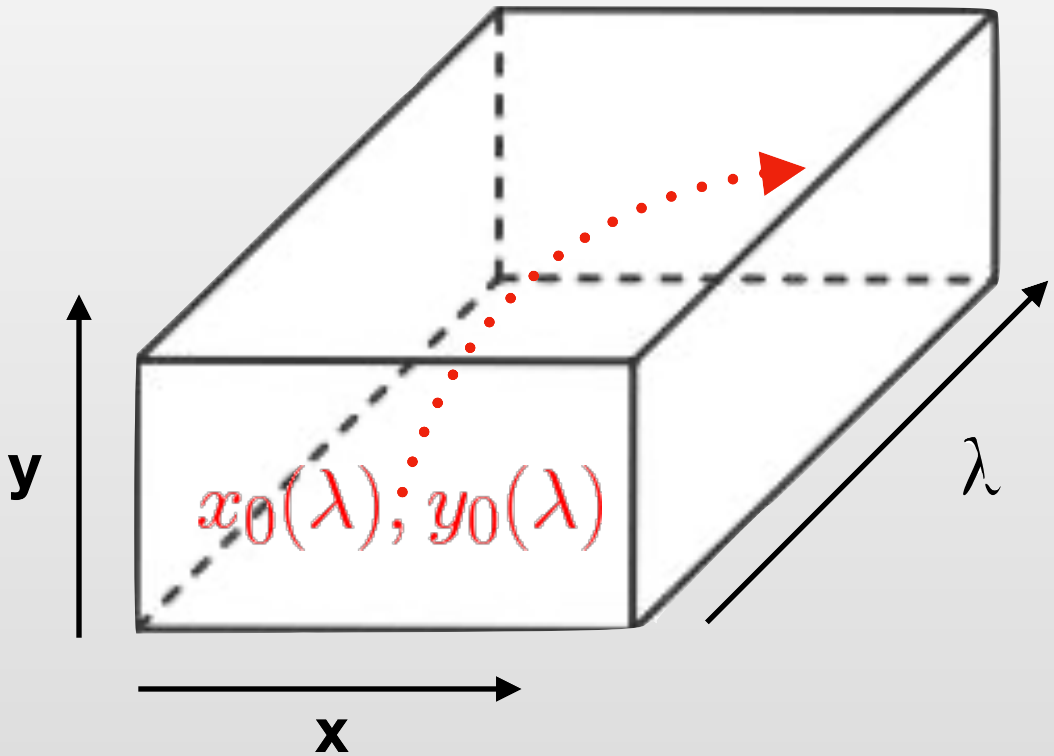
3D PSF model: Chromaticity



The chromaticity of the PSF profile is carried by α , that we modeled as a power law such as :

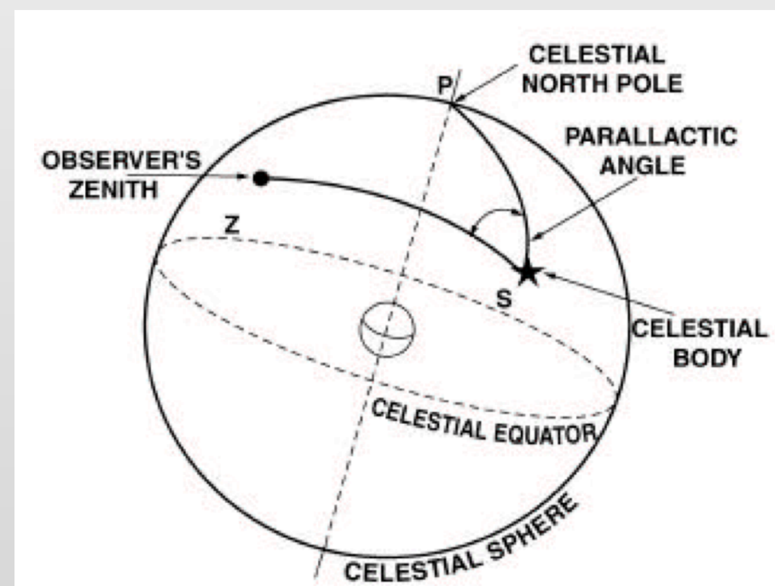
$$\alpha(\lambda) = \alpha_0 \left(\frac{\lambda}{\lambda_{\mathrm{ref}}}\right)^{\alpha_1}$$

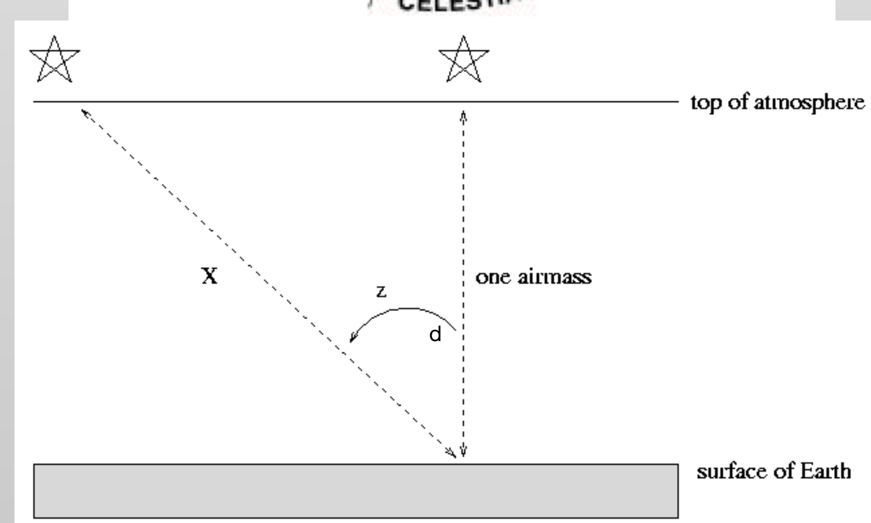
Atmospheric Differential Refraction (ADR)



$$\begin{cases} x(\lambda) = x(\lambda_{ref}) - \frac{1}{2}\left(\frac{1}{n^2(\lambda)} - \frac{1}{n^2(\lambda_{ref})}\right) \times tan(d_z)sin(\theta) \\ y(\lambda) = y(\lambda_{ref}) - \frac{1}{2}\left(\frac{1}{n^2(\lambda)} - \frac{1}{n^2(\lambda_{ref})}\right) \times tan(d_z)cos(\theta) \end{cases}$$

$$\begin{cases} \theta &= \text{parallactic angle} \\ d_z &= \text{zenith distance} \end{cases}$$

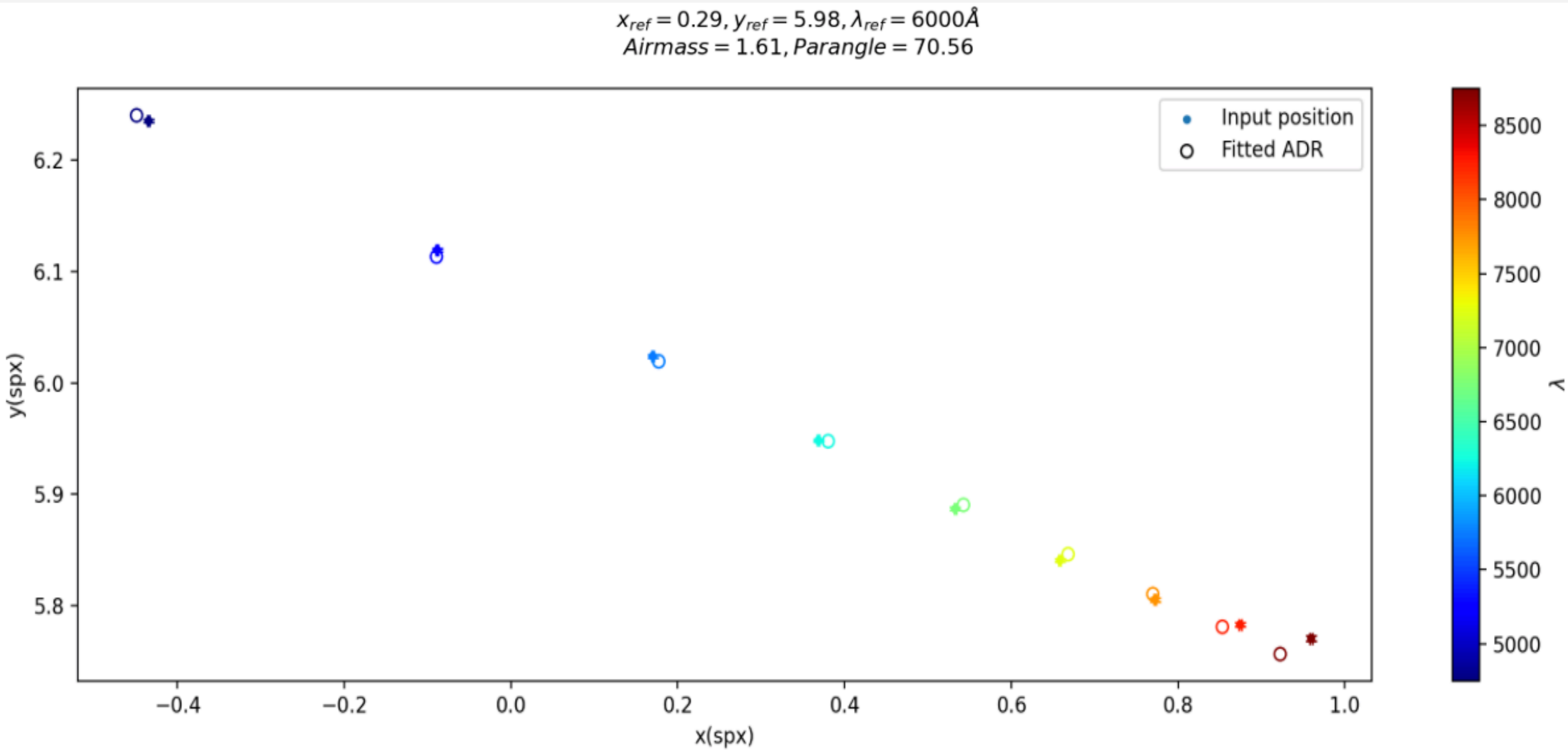




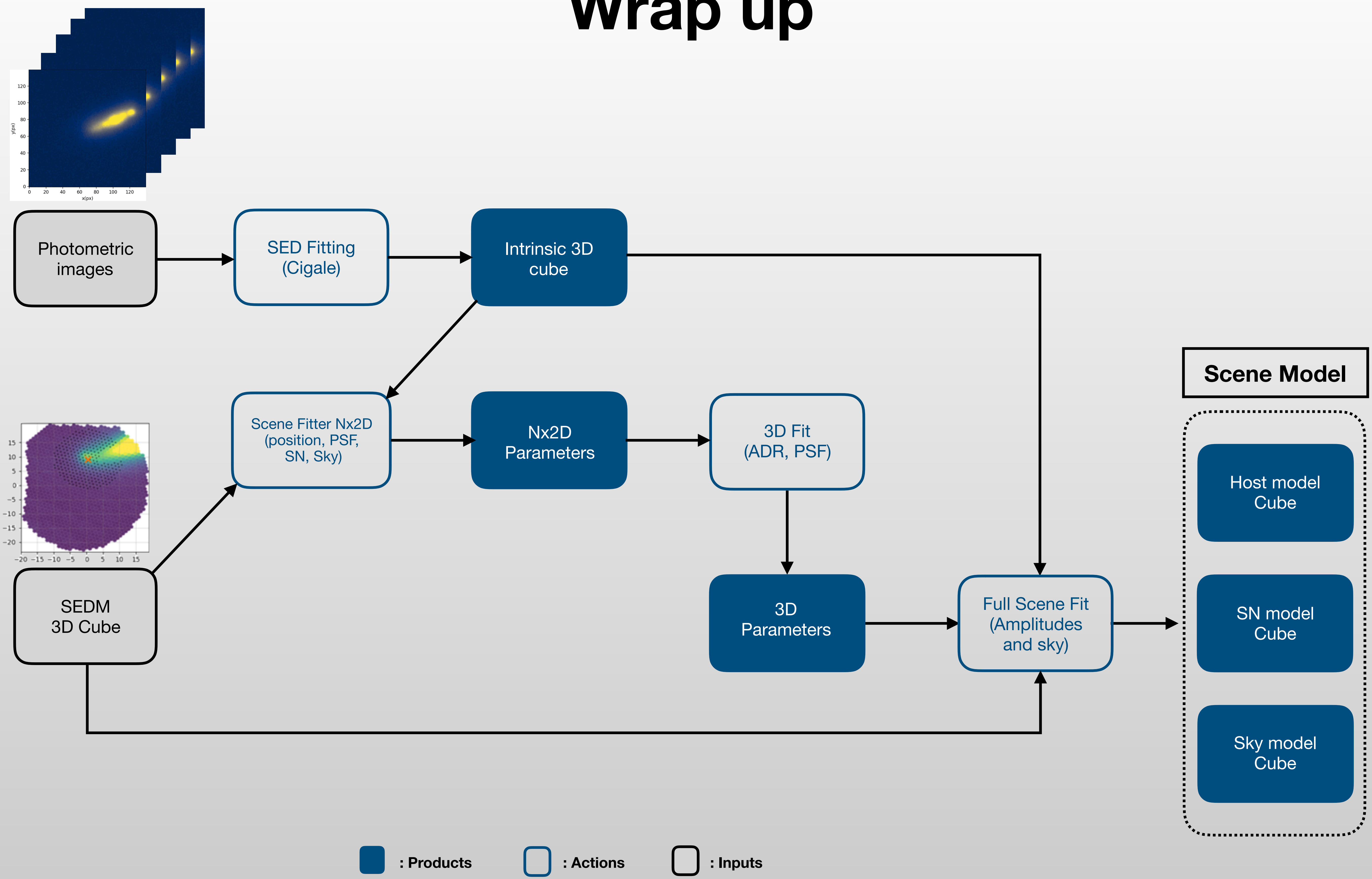
Plane-parallele atmosphere :

$$\chi = \frac{1}{cos(d_z)}$$

Consistency of ADR model



Wrap up


Photometric images
SED Fitting (Cigale)
Intrinsic 3D cube
Scene Fitter Nx2D (position, PSF, SN, Sky)
Nx2D Parameters
3D Fit (ADR, PSF)
3D Parameters
Full Scene Fit (Amplitudes and sky)
SEDM 3D Cube
Scene Model
Host model Cube
SN model Cube
Sky model Cube
: Products
: Actions
: Inputs