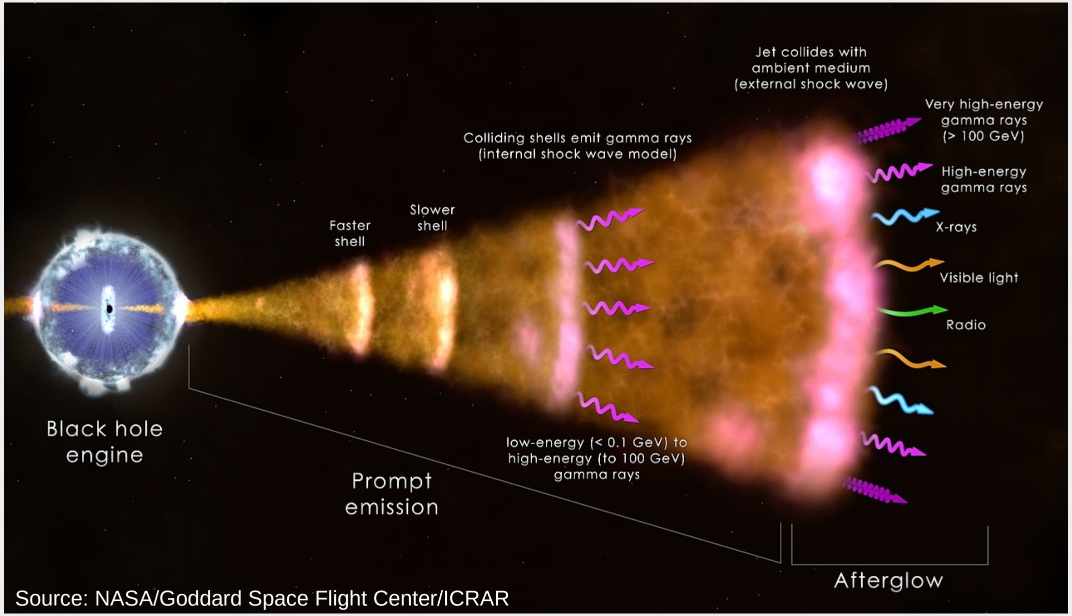
Dust extinction in GRB afterglow with GROND/Swift: Implication for COLIBRI/SVOM

Ny Avo Rakotondrainibe[1] - 1st year PhD student
Thesis advisor: Véronique Buat[1]
Co-advisors: Damien Dornic[2], Damien Turpin[3]

[1] Aix-Marseille Université, CNRS, CNES, LAM
[2] Aix-Marseille Université, CNRS, IN2P3, CPPM
[3] CEA Saclay, DRF/IRFU/Département d'astrophysique

Astrophysical context



Progenitors:

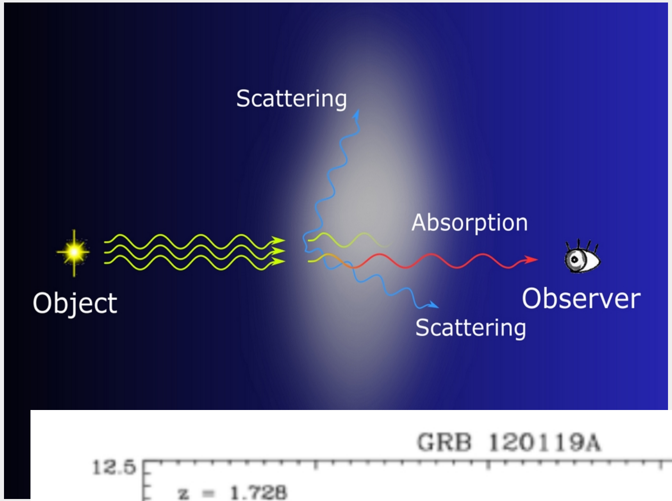
- **Collapsar: Long GRB (>2s)**
- NS/BH, NS/NS mergers: Short GRB (<2s)

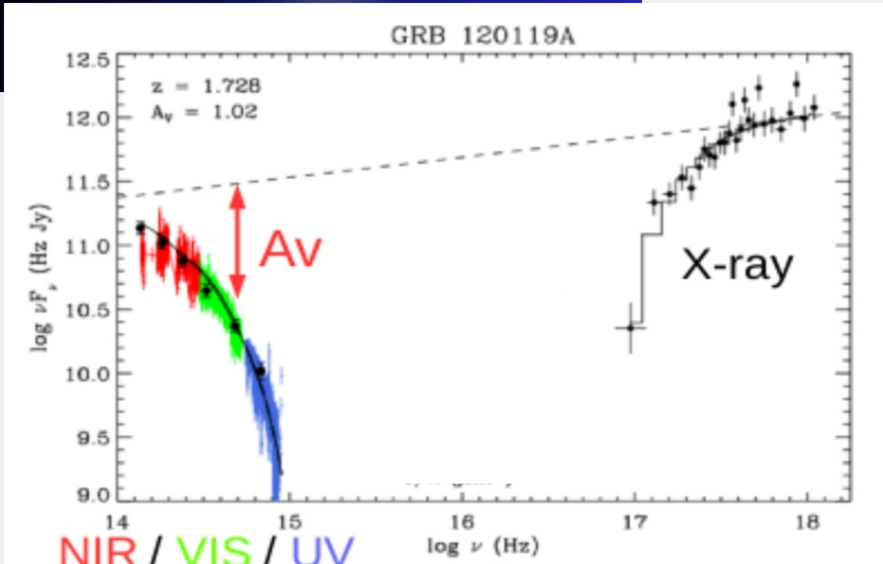
Fireball model:

- Prompt emission: Intense bursts of ɣ-ray produced by synchrotron
- **Afterglow emission**: X-ray, optical, radio synchrotron emission produced by the electron acceleration in the external shock region between the ejecta and the Interstellar Medium

Simple power law (SPL) model: $F(\nu, t) \propto \nu^{\beta}$ → Study the host galaxy properties

Study of the interstellar dust medium in galaxies





Zafar et al., 2018

- Deviation from the SPL due to dust
- Dust absorbs and scatters UV/NIR and re-emits in FIR

⇒ Dust extinction represented by extinction curve (λ dependent, dust size and composition)

- X-ray: Photoelectric absorption from $N_{H,X}$

⇒ Attenuation of the spectrum:

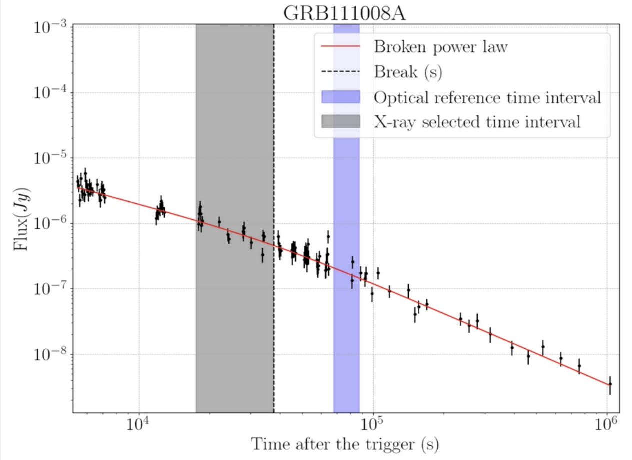
Soft X-ray = 124 eV < E < 5 keV

⇒ Negligible in hard X-ray = E > 5-10 keV

Goals:

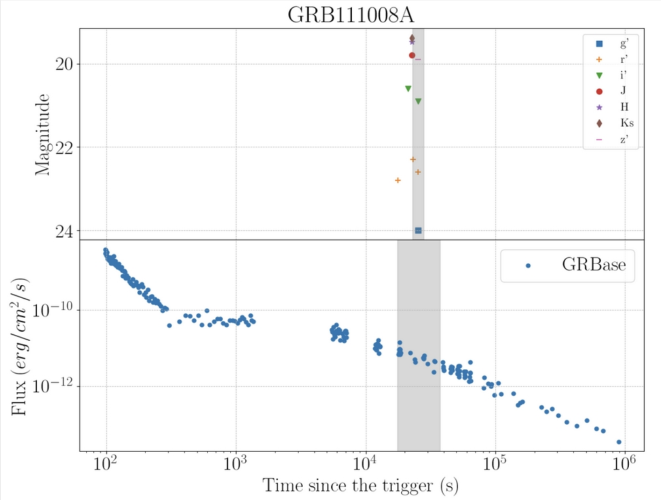
- Use GRBs to determine the dust extinction law parameters of high-*z* galaxies
- Construct the Spectral Energy Distribution from X to NIR of a large samples of GRBs
- Preparatory work for COLIBRI/SVOM using GROND/SWIFT

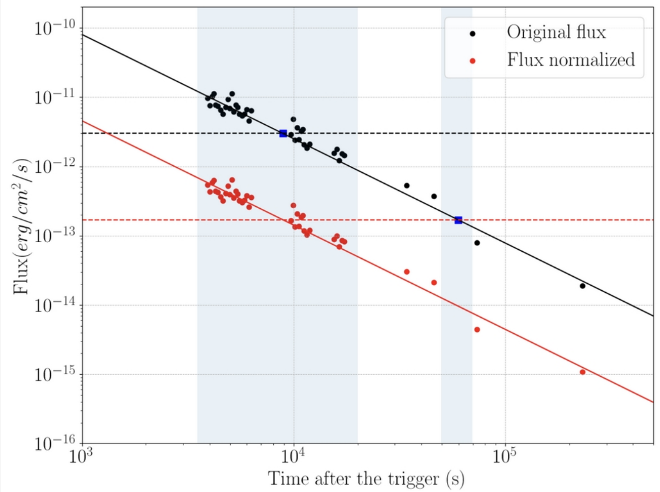
Problem of simultaneity: X-ray data and optical



normalisation = 0.000001, +-0.00000, alpha1 = 0.95100, +-0.09000, alpha2 = 1.55200, +-0.07400, tb = 37726.49500, +-17460.04400
chi-square = 8.248015192123641e-06

- Problem: X-ray and optical observations are not simultaneous
- Fit X-ray light curve to a reference time = Optical reference time

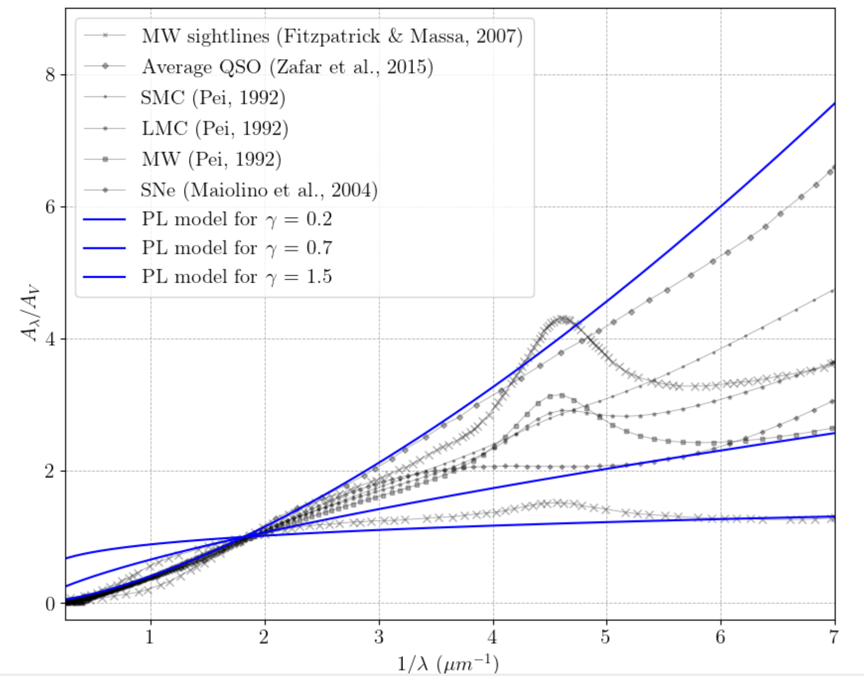




- From light curves to spectra
- Next: Fit extinction laws

Extinction laws: Optical part

- Different known models: MW, SMC, LMC, …
- **Goal**: Use a simple model to define the extinction law



- Simple power law model of extinction (Savaglio & Fall, 2004):
  - Intrinsic emission: $F_\nu = F_0\,\nu^{-\beta}$
  - Observed spectra: $F_\nu^{obs} = F_\nu 10^{-0.4\,A_\lambda}$

PL dust extinction law: $A_\lambda = A_V\left(\dfrac{5500}{\lambda}\right)^{\gamma}$

Some expected values of γ:

Law	QSO	MW	SNe
γ	1.4	0.7	0.6

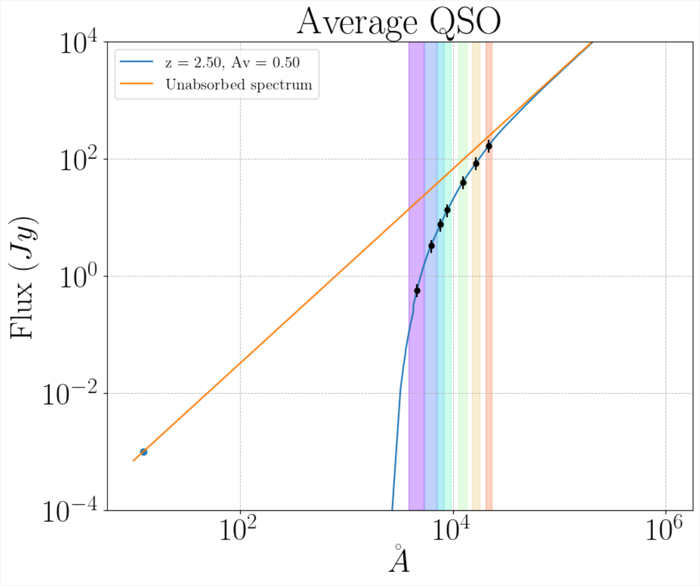
- Problem of the bump:
  - Addition of a Drude profile to the PL model

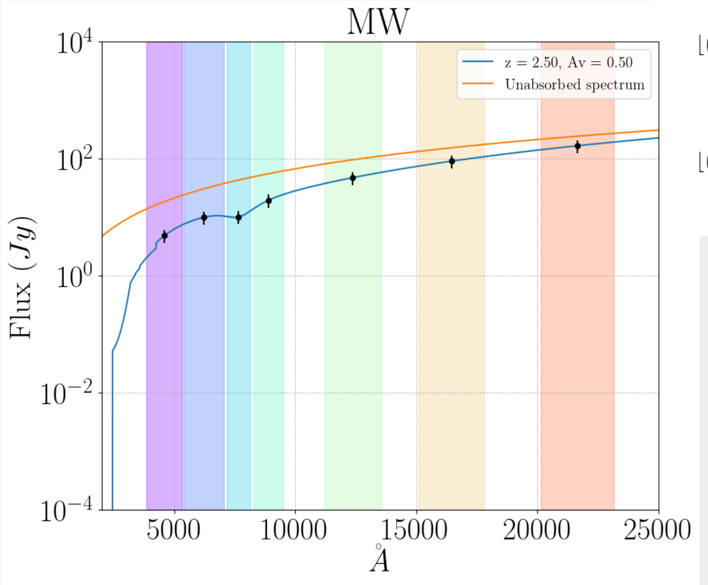
$$D(E_b,\lambda) = \frac{E_b(\lambda\,\Delta\lambda)^2}{(\lambda^2-\lambda_0^2)^2+(\lambda\,\Delta\lambda)^2}$$

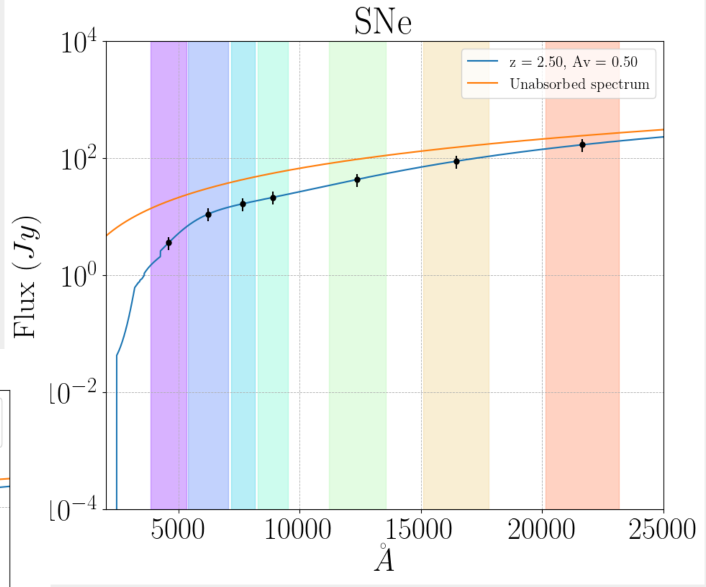
with $\lambda_0 = 2175.8\,\mathring{A},\ \Delta\lambda = 300\,\mathring{A}$

First tests on “perfect” mock populations: Methodology

- Mock populations from z = 0.5 – 6 and A_V = 0.1 – 2.4 mag for the 7 laws
- Fixed the X-ray part: F_0, β
- Using MCMC code for the parameters estimation: A_V, γ, E_b



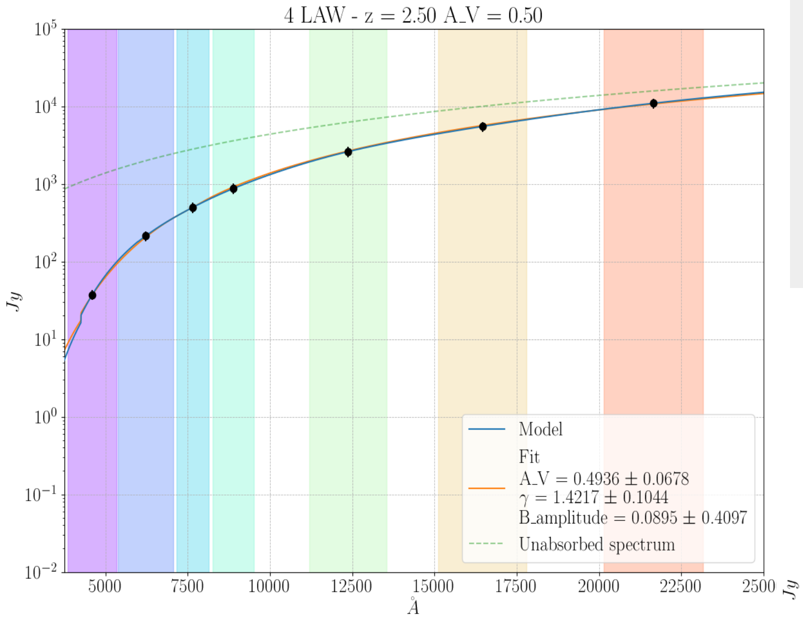


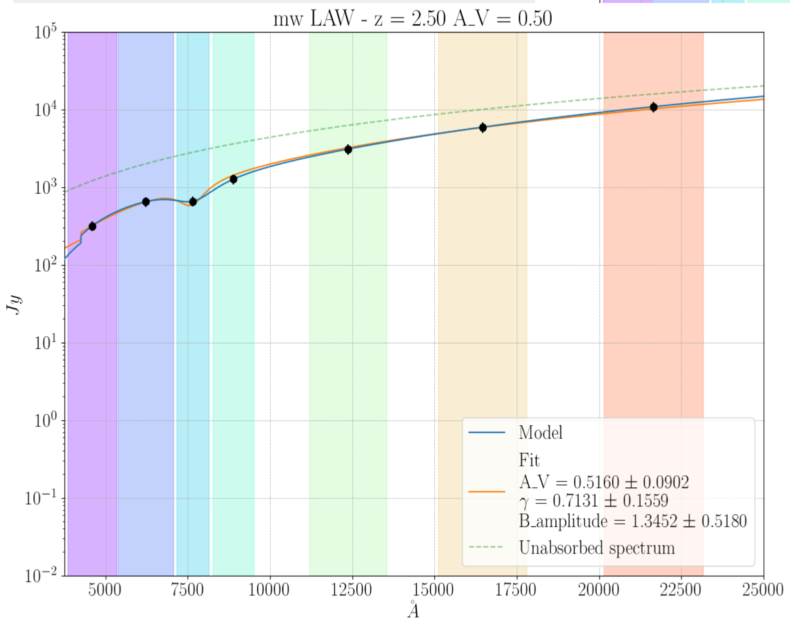


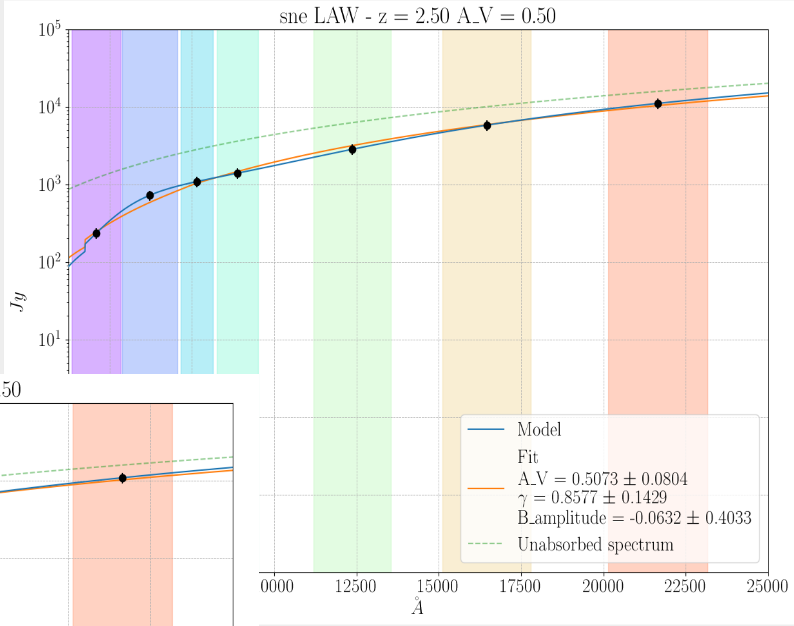
Using GROND filter bands

First tests on “perfect” mock populations: Methodology

- Example of fit with the PL model



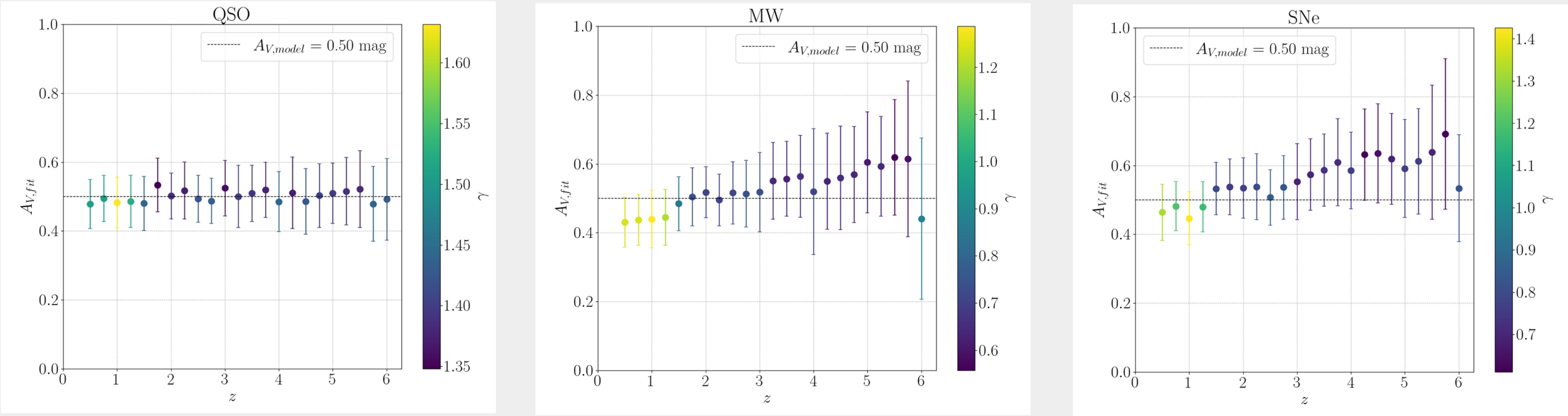




Using GROND filter bands

First tests on "perfect" mock populations: Results

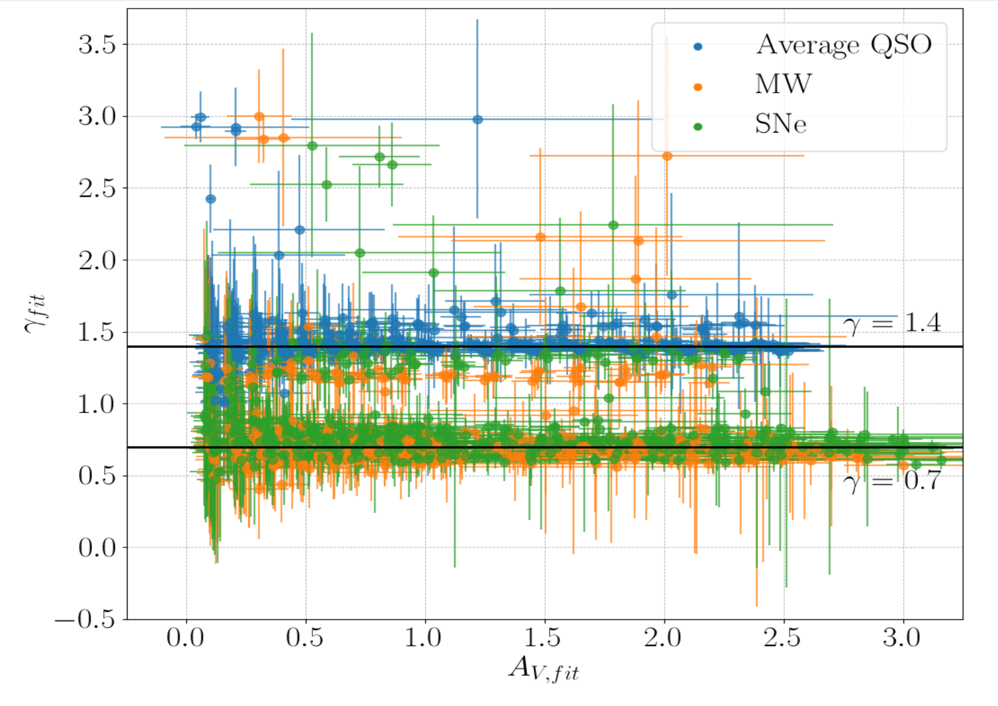
Estimation of A_V using the PL extinction law model



- $z < 1.5$: Under-estimation of A_V correlated to the over-estimation of γ
- Intensity of the feature: bump, plateau increases the error and difficulty to constrain A_V
- Position of the feature (redshift and filters) is another factor for the goodness of the estimation

First tests on “perfect” mock populations: Results

- Estimation of γ using the PL extinction law model



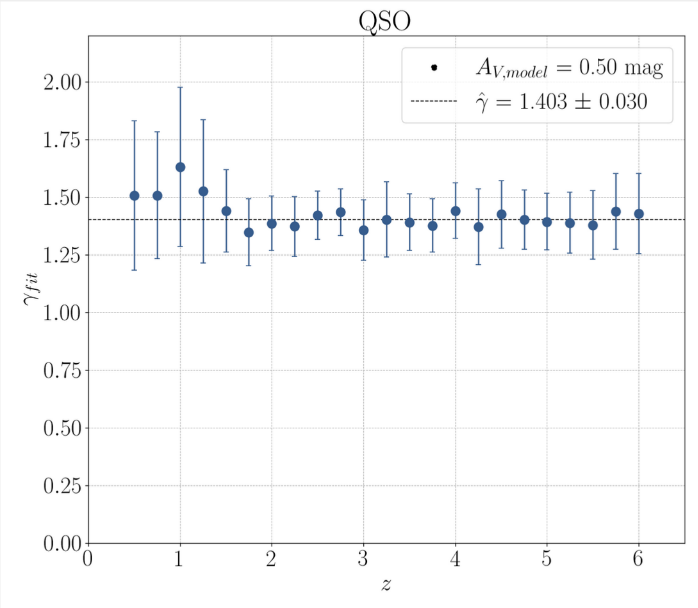
Expected values:

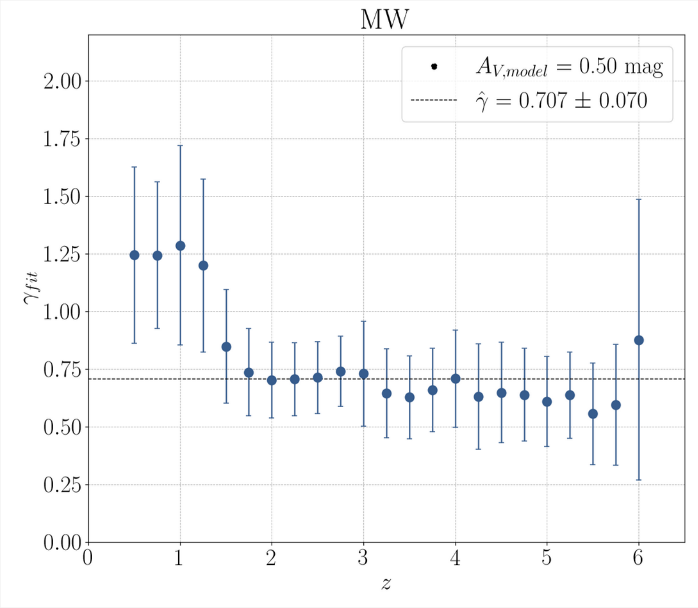
Law	QSO	MW	SNe
γ	1.4	0.7	0.6

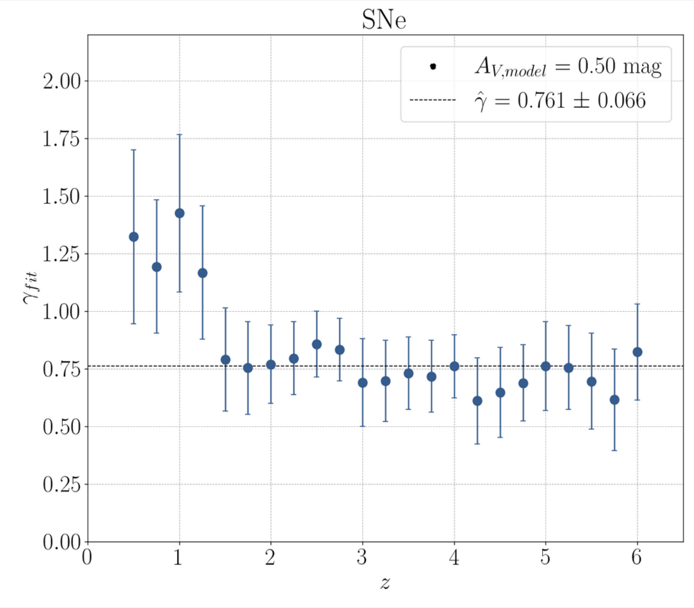
- Intensity and position of the feature also impact the estimation of the expected γ
- z < 1.5: Over-estimation of γ correlated to the under-estimation of A_V

First tests on “perfect” mock populations: Results

- Estimation of γ using the PL extinction law model

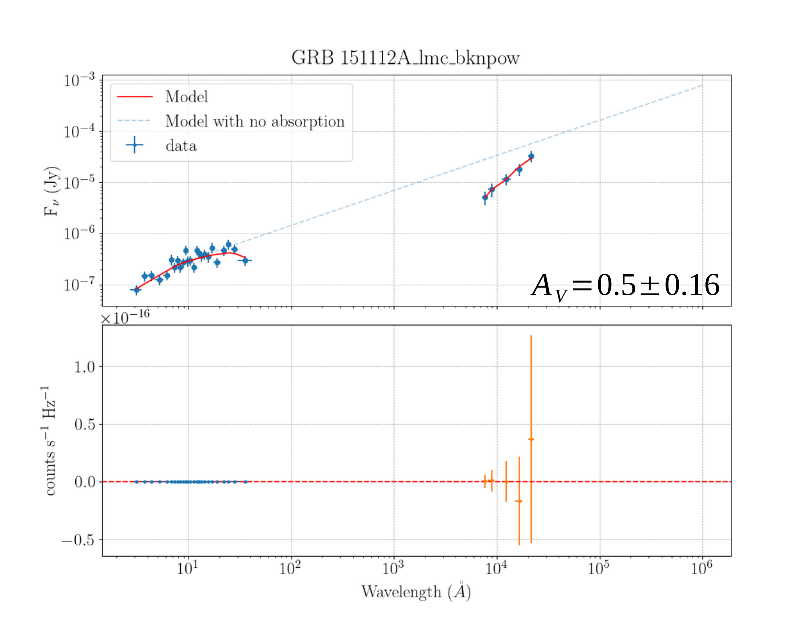


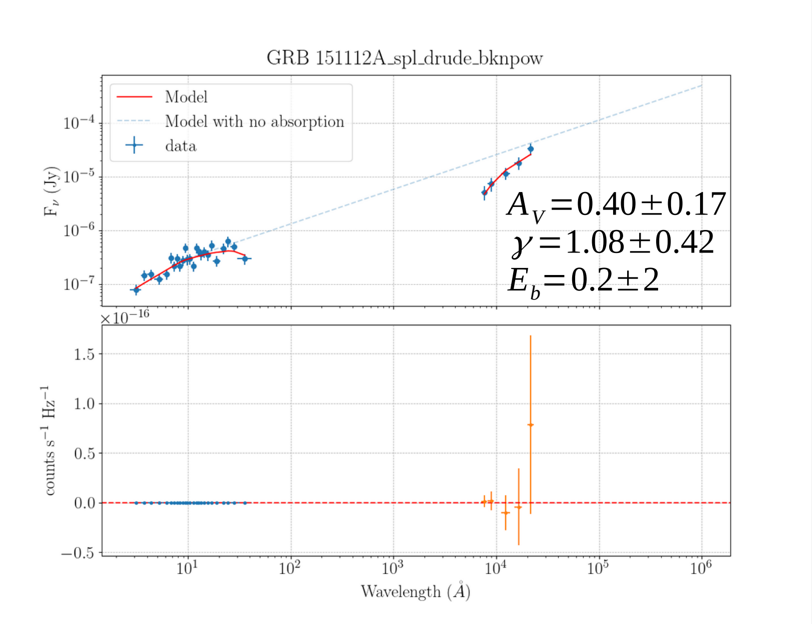




Test on real data: GRB151112A (Bolmer et al., 2018)

- Fit is done with *xspec*
- PL-Drude extinction law model + X-ray photoelectric absorption + Galactic extinction correction + IGM
- LMC vs SPL+Drude law

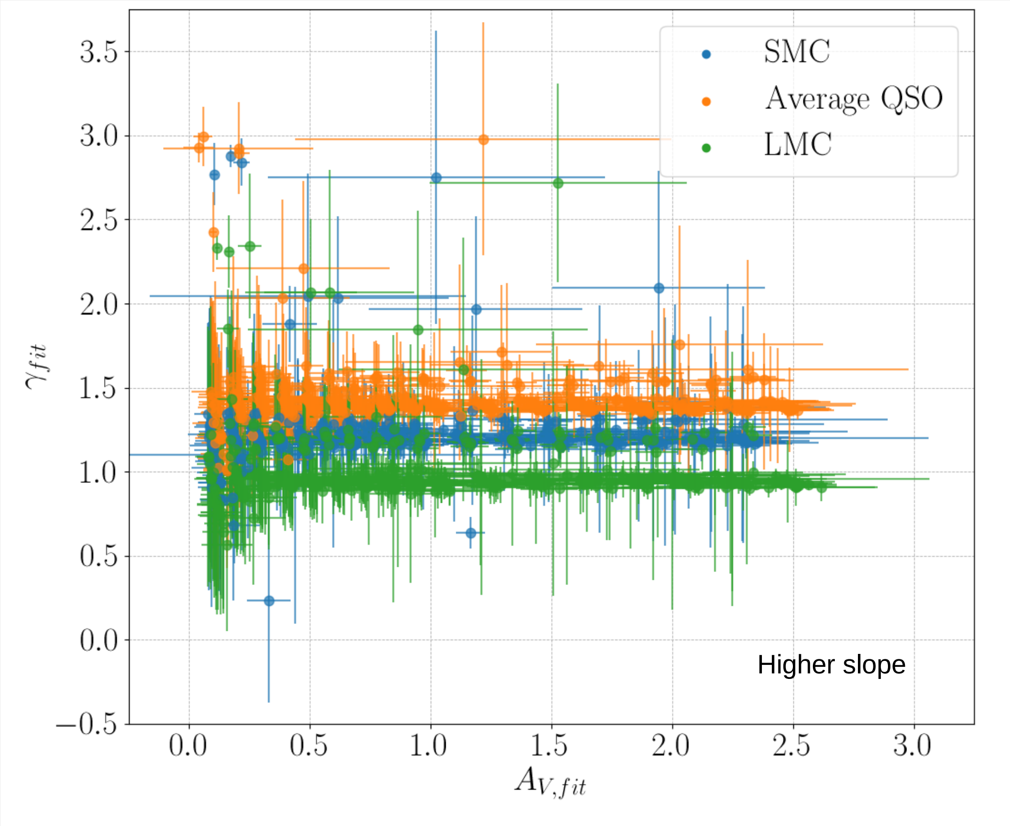


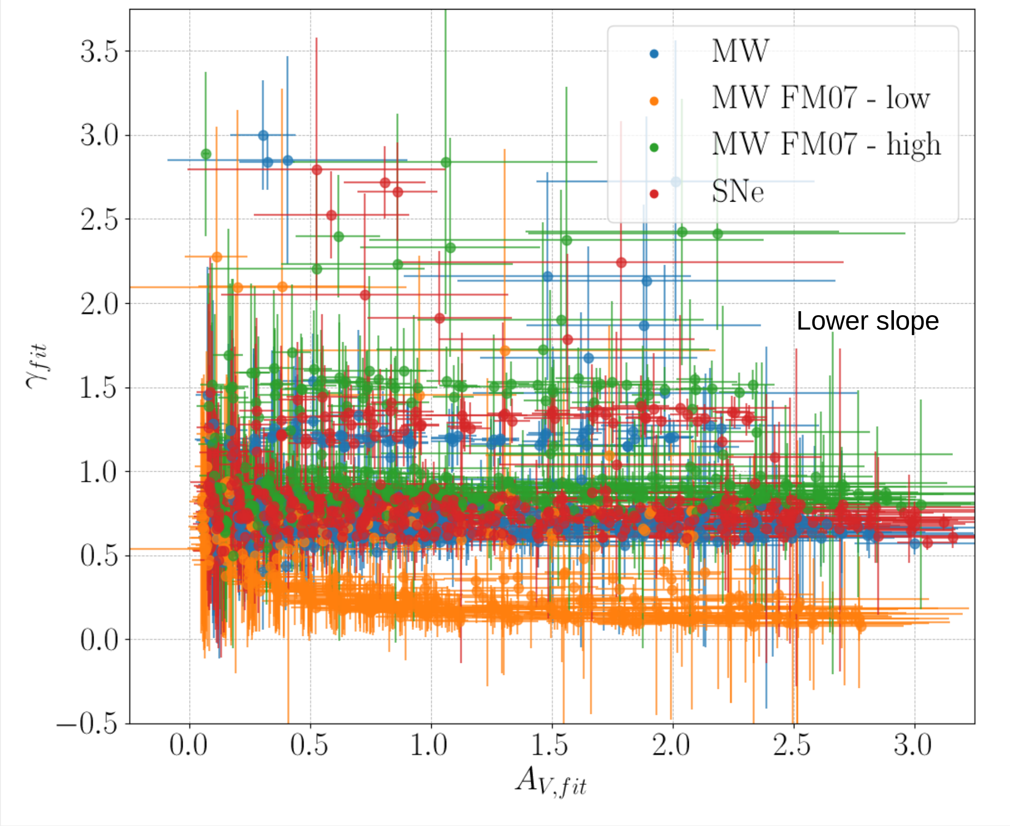


BACK UP SLIDES

First tests on “perfect” mock populations: Results

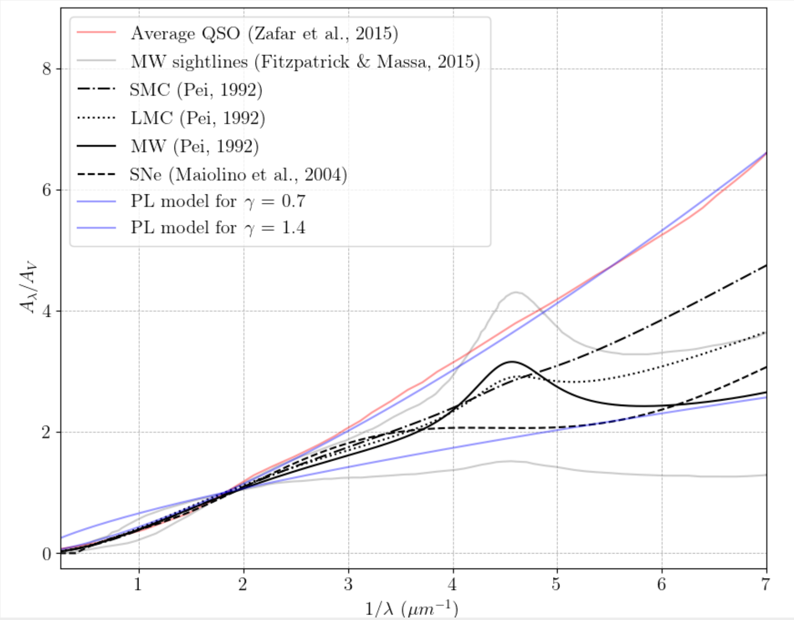
Estimation of γ for all the simulated extinction laws

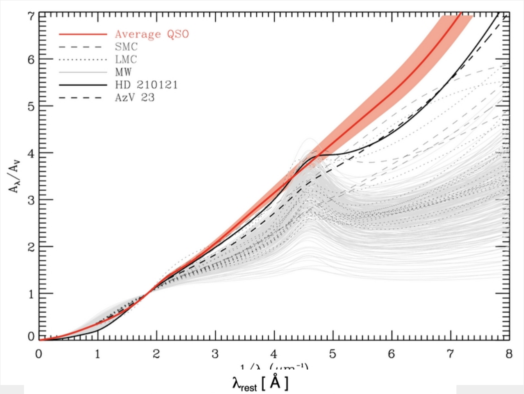


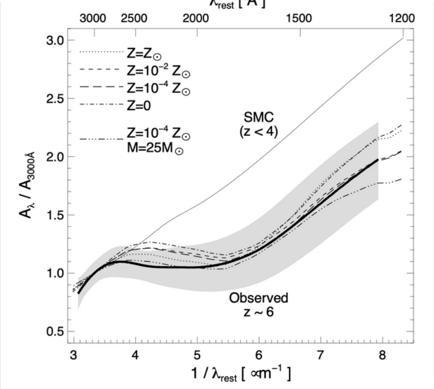


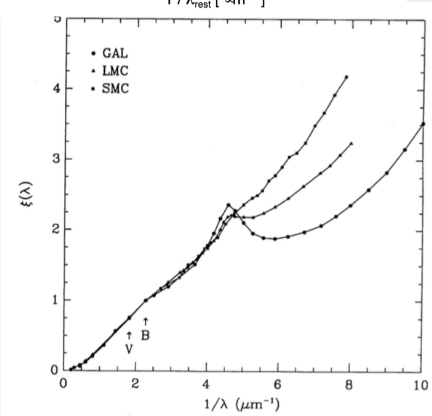
Different extinction laws model

- Empirical model: SMC, LMC, MW
- Fitted models: MW sightlines, SNe, QSO



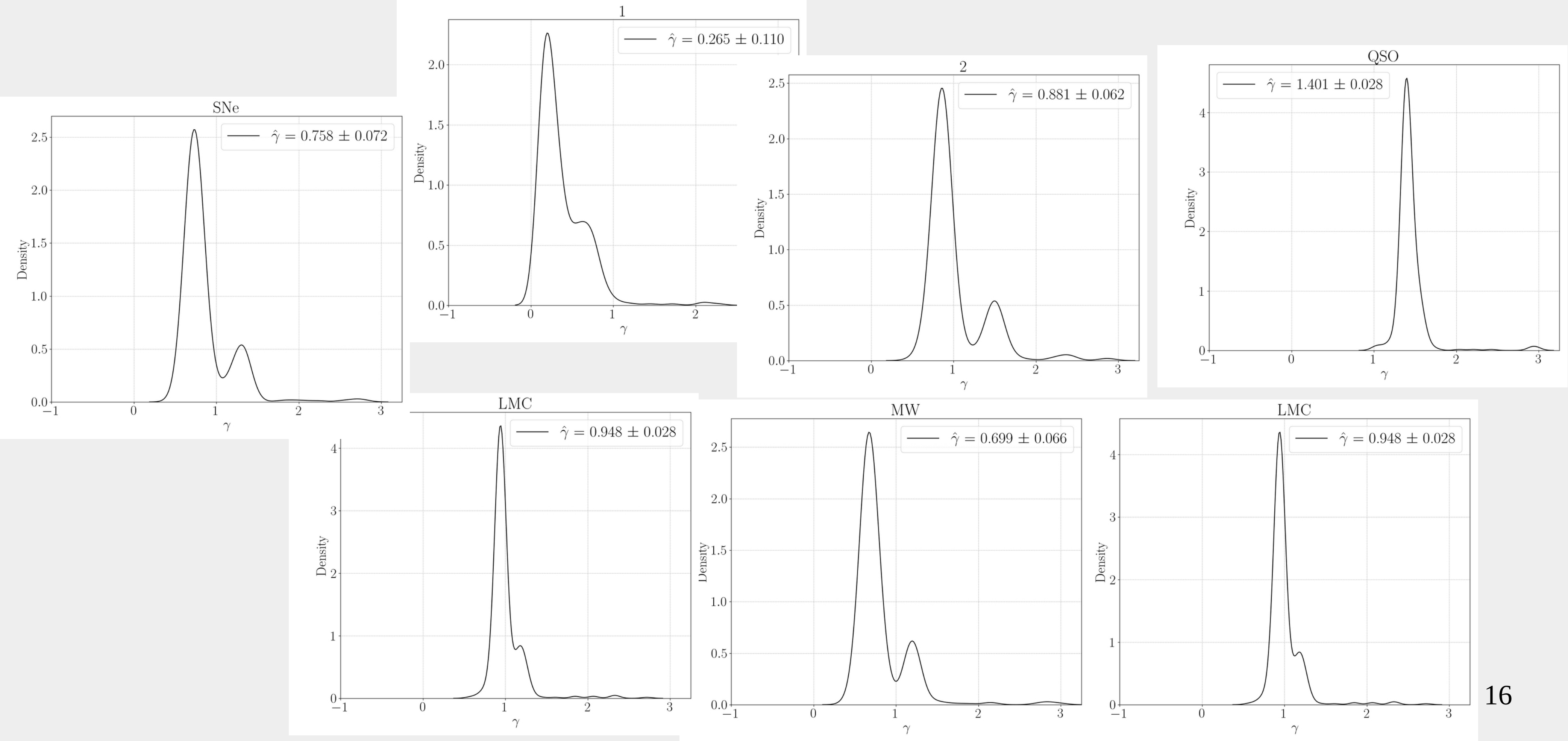






First tests on “perfect” mock populations: Results

Distribution of γ for all the different fitted laws



Implication on SVOM/COLIBRI

- Preparatory work for COLIBRI/SVOM using GROND:SWIFT
- Create a routine to make a “simultaneous” observation
- Suggestion on the observation strategy for this science ?
- Cycle through *g/r/i/z/y/J/H* to cover a larger LC