ZTF France Meeting
:
NaCl

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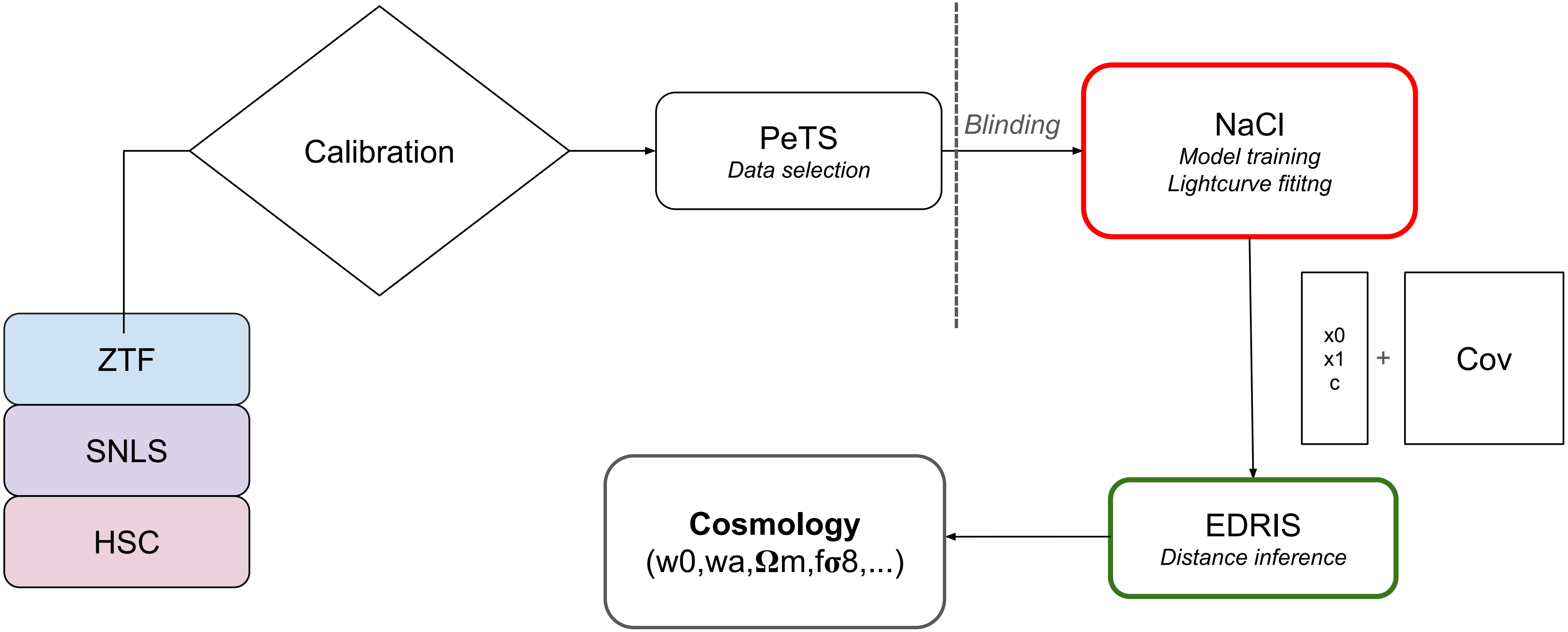
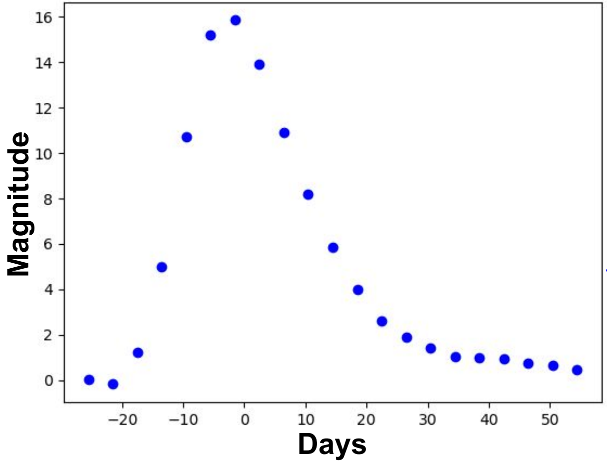
Supervised by Nicolas Regnault & Pauline Zarrouk

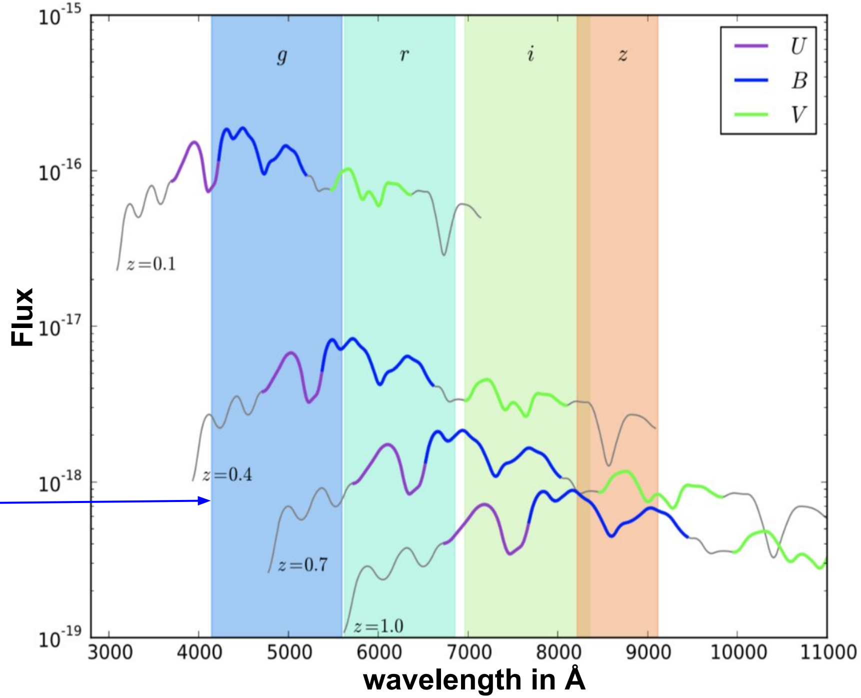
LEMAÎTRE pipeline



SN Ia spectrophotometric modelling

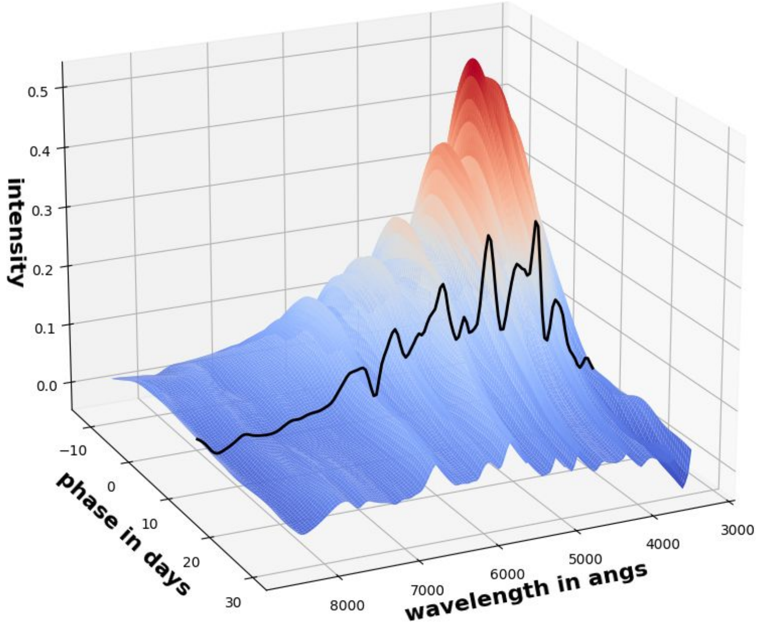
- In order to measure SN Ia distances we need to reconstruct its **restframe flux**





SN Ia spectrophotometric modelling

- For that we interpolate the SN Ia flux from a spectrophotometric model



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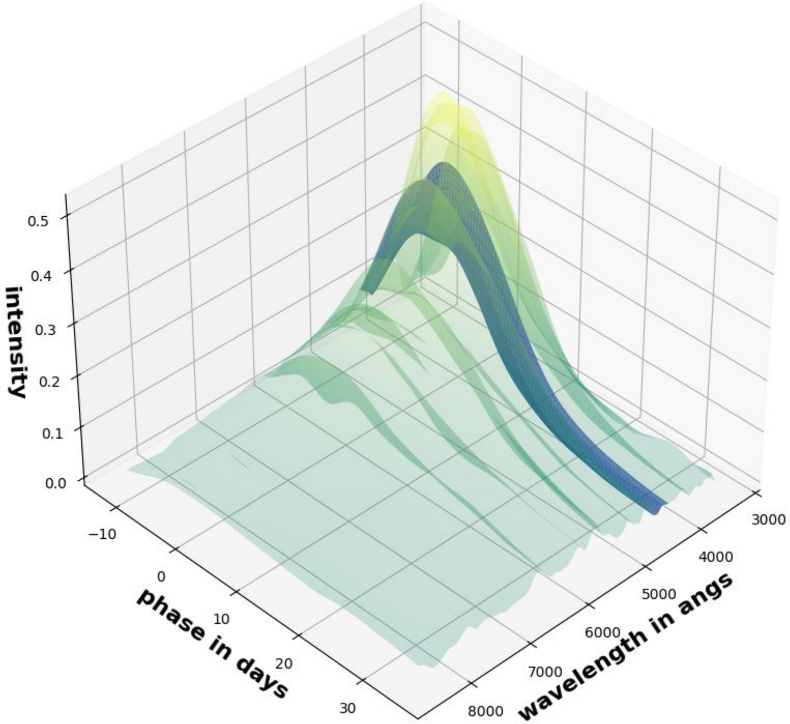


SN Ia spectrophotometric modelling

- Natural dispersion in SN Ia
- Standardizable with 2 parameters : **color** and **stretch**

Tripp (98) relation :

$$-2.5\log_{10}(f) = m_{meas} = m_{std} + \alpha X_1 + \beta c$$

Measured magnitude

Model magnitude

Stretch parameter

Color factor

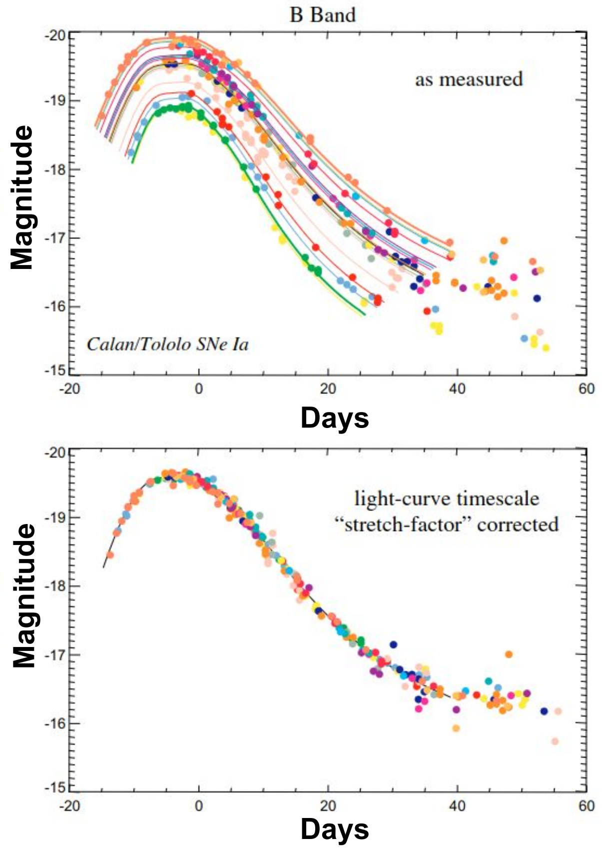


Illustration of light curves before and after stretch-factor corrections

Source : Huterer & Shafer (2017) based on A. G. Kim (1997)

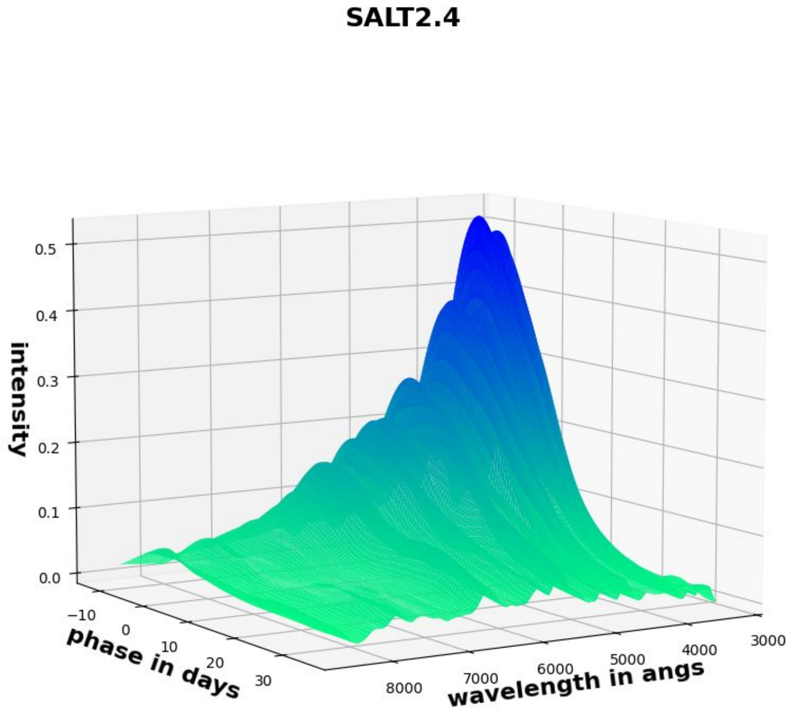
SN Ia spectrophotometric modelling

- To describe all of this we use spectrophotometric models like SALT2

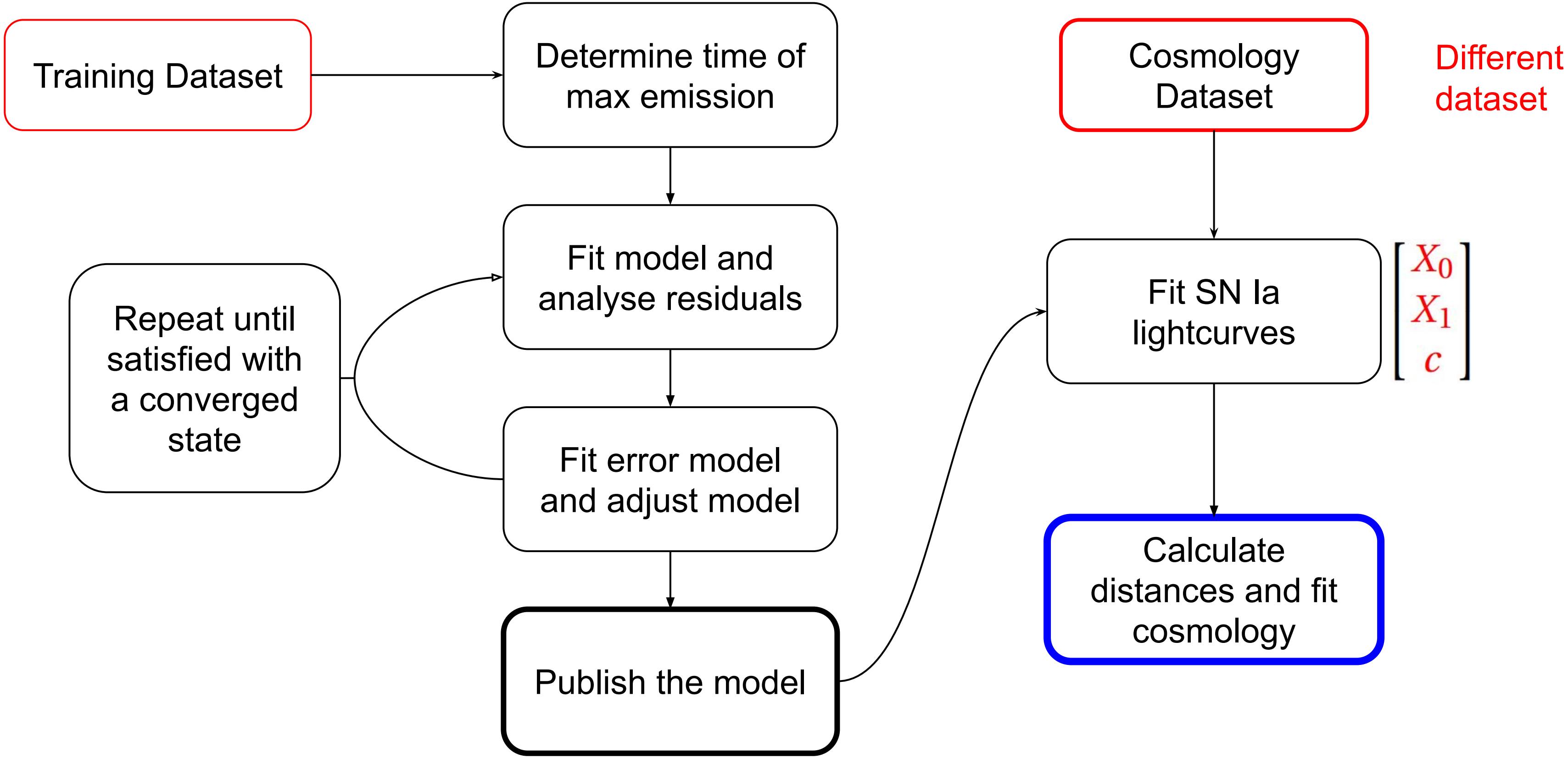
Model

$$S(\lambda, \mathrm{p}) = X_0 \times \left[M_0(\lambda, \mathrm{p}) + X_1 \times M_1(\lambda, \mathrm{p}) \right] \, 10^{0.4cCL(\lambda)}$$

Amplitude Stretch Color



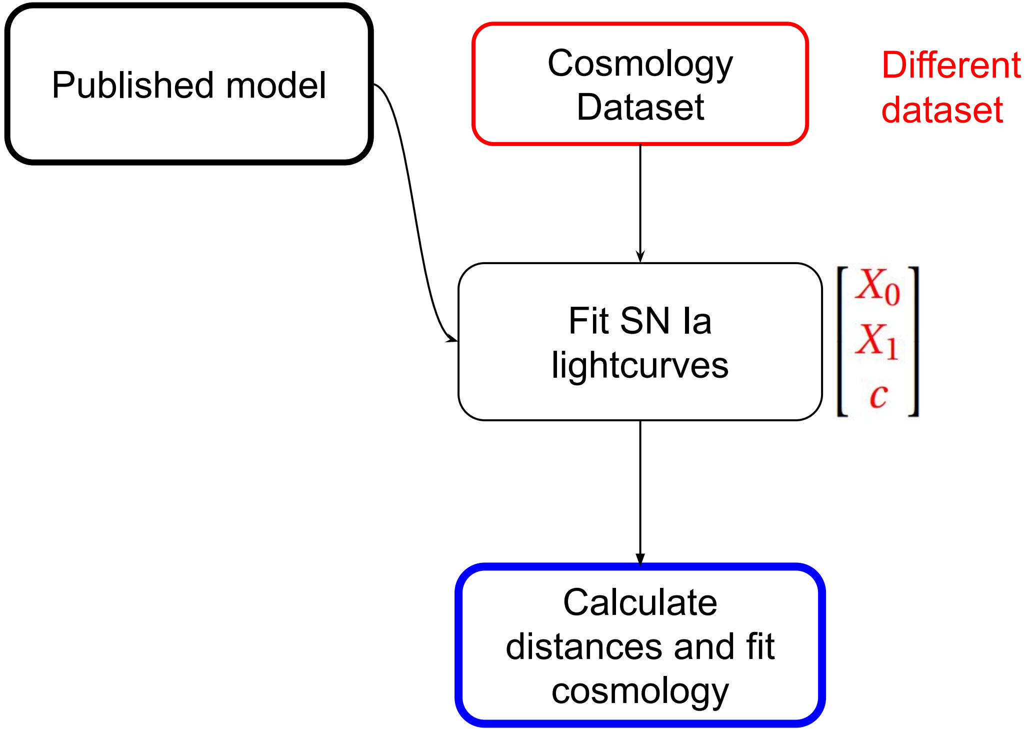
SN Ia spectrophotometric modelling : why not use one of the SALT models?



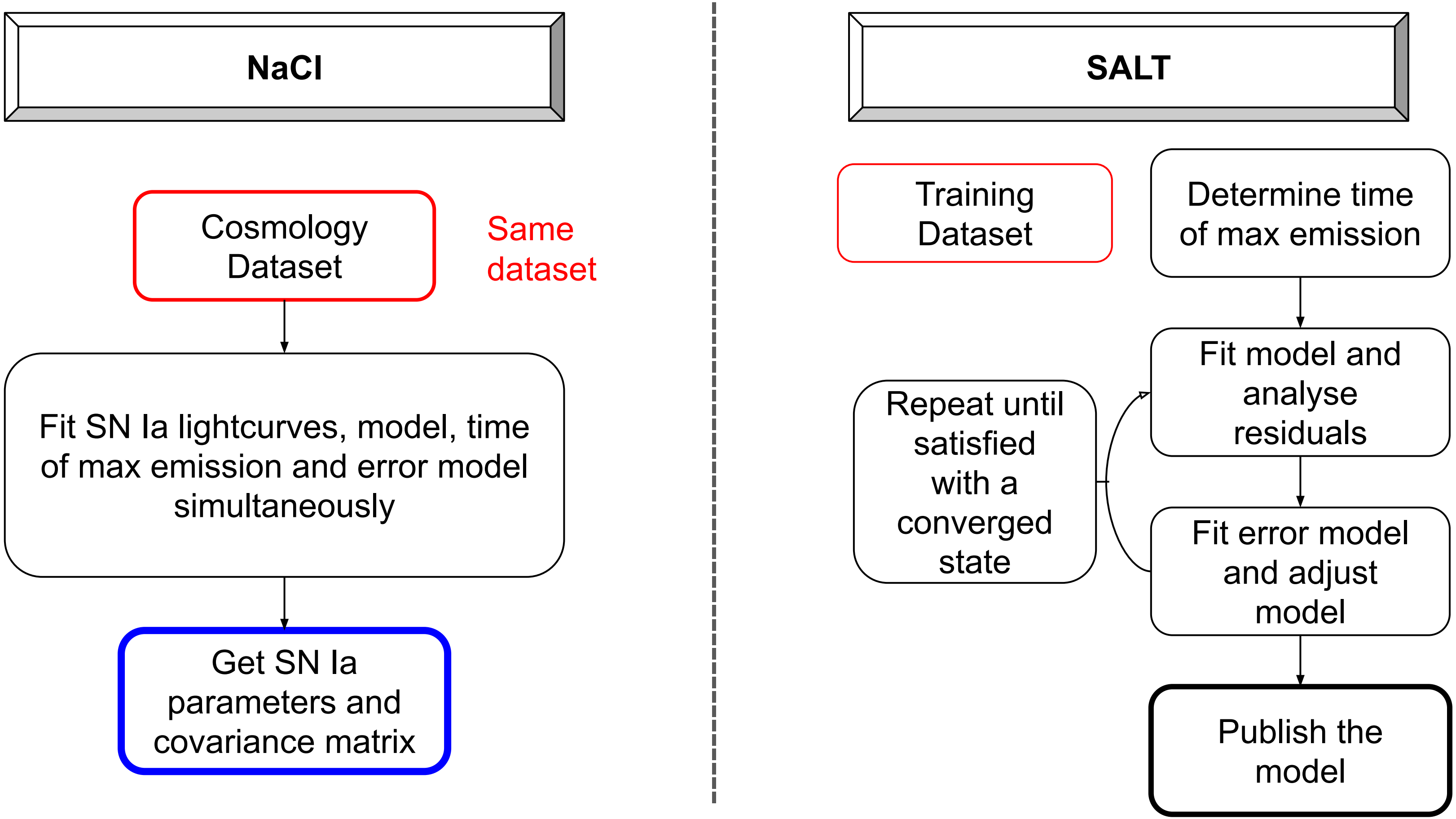
SN Ia spectrophotometric modelling : why not use one of the SALT models?

- **Complicates propagation** of model and calibration uncertainties which turn into **systematics**

- SALT calibration systematics are one of the leading sources of uncertainties



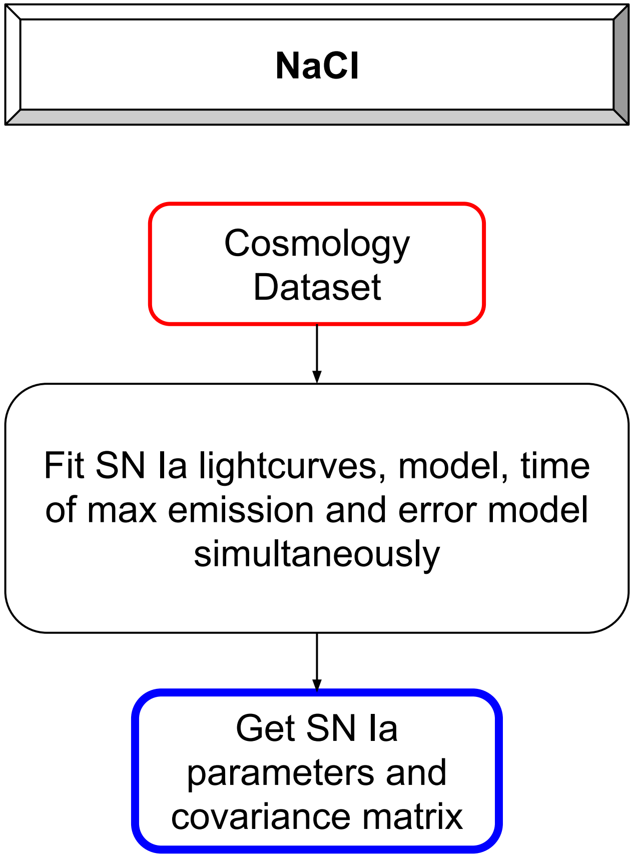
NaCl : a new framework for training spectrophotometric models



NaCl : a new framework for training spectrophotometric models

- The training procedure is **simplified into one log likelihood minimisation** which encapsulates the **propagation of measurement, model and calibration uncertainties**

- NaCl is **easy** to use, **fast** for training models and can be easily **reparameterized** to train more sophisticated models



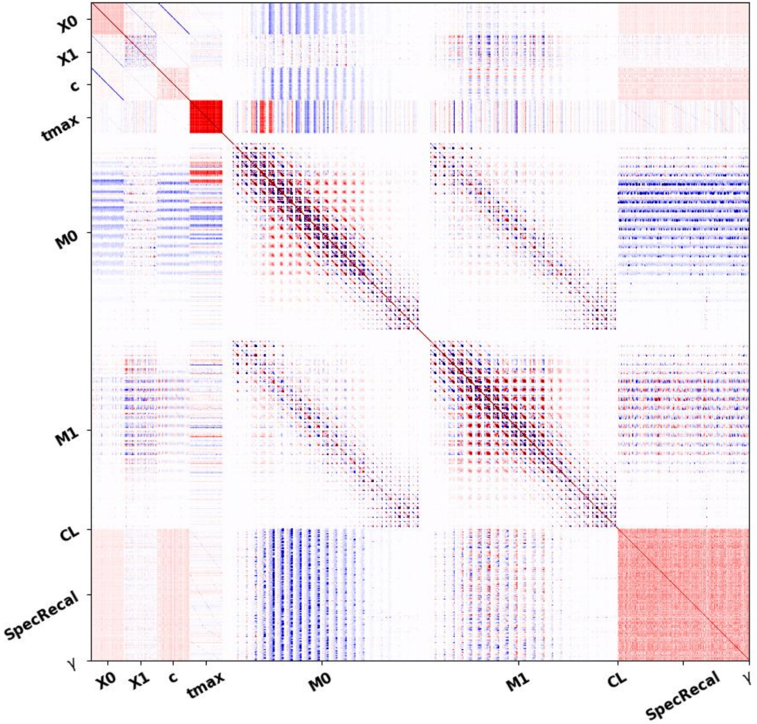
NaCl : a new framework for training spectrophotometric models

- After a training NaCl marginalises over the model parameters and **only keeps the SN parameters used in the cosmological analysis** and their **covariance matrix**

One parameter per SN

A few thousand parameter

$$\begin{bmatrix} X_0 \\ X_1 \\ c \\ t_0 \\ M_0 \\ M_1 \\ CL \end{bmatrix} \\ \ldots$$



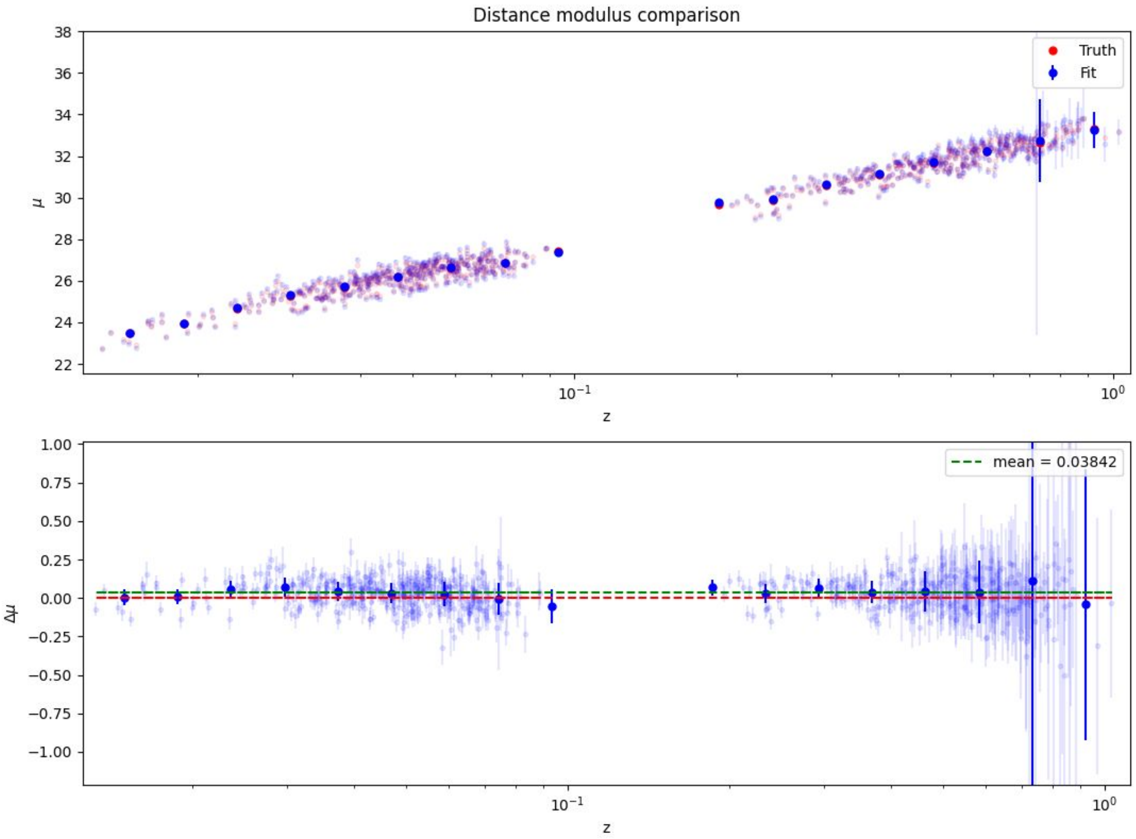
Details of our pre-DC1 simulations

- 800 supernovae simulated with mocksurvey

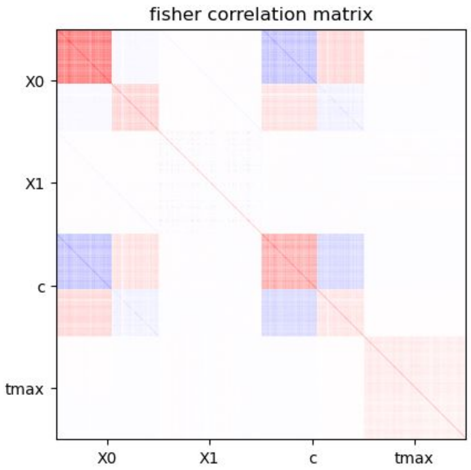
Adding noise to our simulations in steps:

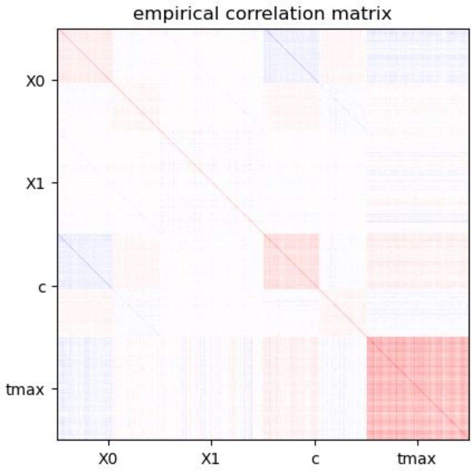
- Step 1 :
  - Only calibration errors (about 1%) per band added to the data
  - The calibration errors are multiplicative
  - There are no correlated errors between bands
- Step 2 :
  - + variance noise (error snake of 5% added to the data)
- Step 3:
  - + measurement errors
- Step X :
  - + color scatter

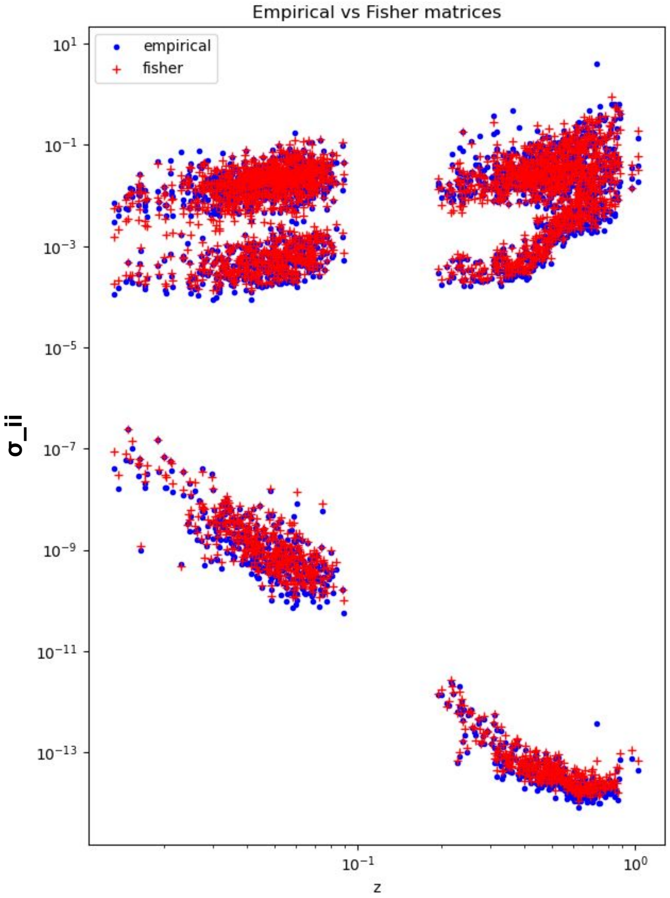
Distance modulus reconstruction



Fisher vs empirical



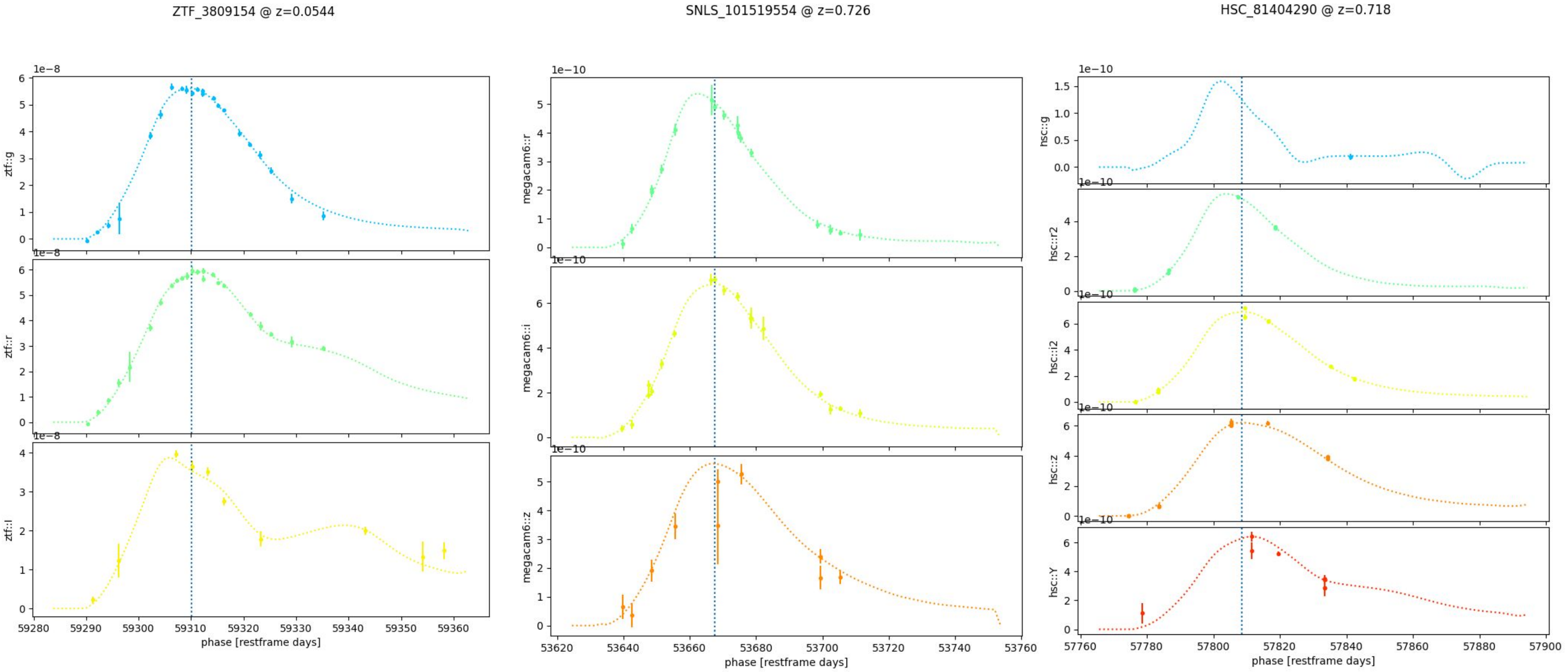


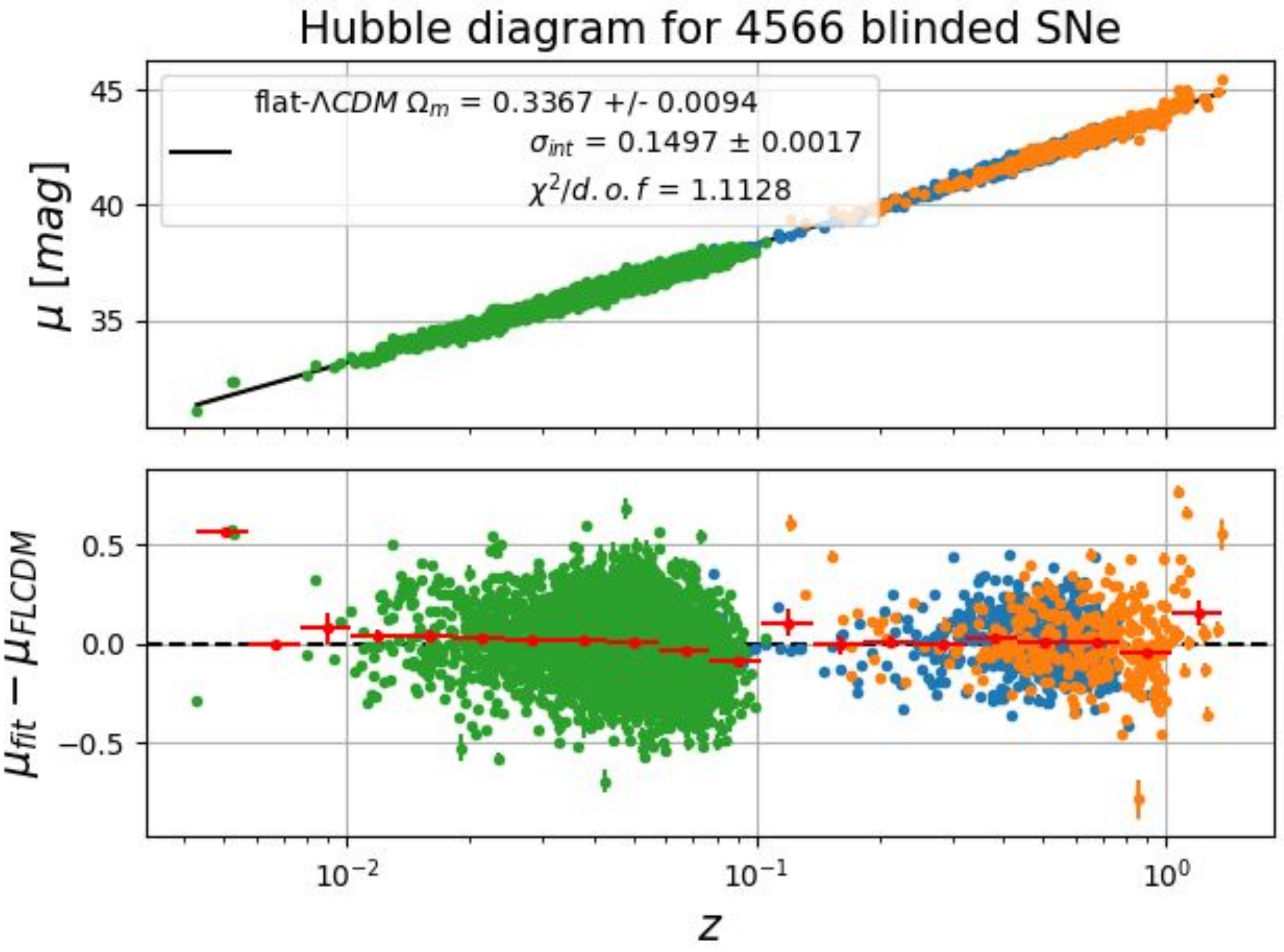


On DC1 we have preliminary results

- Implemented NaCl in LEMAÎTRE chaine
- Encountered issues with spectra generation (should be solved now)
- Fit hasn’t converged and takes too much time

On DC1 we have preliminary results




Hubble diagram for 4566 blinded SNe
flat-ΛCDM Ω_m = 0.3367 +/- 0.0094
σ_{int} = 0.1497 ± 0.0017
$\chi^2/d.o.f$ = 1.1128
μ [mag]
45
40
35
0.5
0.0
−0.5
$\mu_{fit} - \mu_{FLCDM}$
10^{-2}
10^{-1}
10^{0}
z

What's left : 1) Proper training recipe/logic/procedure

The idea is to find an initial state on NaCl that is already relatively close to reality **before training the model**

Currently this is done in 2 steps :

- fitting **X0, X1, c, tmax** and the **recalibration polynomial** (for the spectra) with SALT2.4
- fitting an **error model**

We then train the model while refitting all of the previously mentioned parameters at once

<u>**What's left**</u> : 1) Proper training recipe/logic/procedure

An idea is to also add an extra where we fit the M0 and M1 surfaces on the spectra to capture some model differences

– We are still testing different methods to find the optimal training recipe but what we currently have is not bad

<u>What's left</u> : 2) New model constraints

Constraints on SALT models are dataset dependent (e.g. average color and stretch defined as <X> = 0 in the dataset)

We are working on constraints that would be completely independent of the dataset and directly on the model

This should make the training procedure faster and we are working on having an initial model used that respects these constraints (a modified SALT2.4)

<u>**What's left**</u> : 3) Calibration uncertainties

Currently the way we only account for zp calibration uncertainties in NaCl

We are working on the calibration uncertainties related to the filters' spatial variances

<u>What's left</u> : 4) Color scatter (CS) (open question)

- **<u>Color scatter</u>** : intrinsic color variation that exists in SN Ia. This presents itself as a deviation of the model's color law specific to each SN

The issue we have is mainly with the ZTF data since many SNe are measured in only 2 bands

<u>What's left</u> : 4) Color scatter (open question)

<u>Methods suggested:</u>

Fit one parameter per lightcurve with a prior associated to to the CS parameters that is fitted during the training

1) The parameter could be directly multiplicative of the model flux. This biases the variance (what was done is Guy Augarde's PhD). This will be set to 0 if we are fitting it for SN measured in only 2 bands

2) The parameter could be evaluated within the color law (CL) if the CL is evaluated outside of the B-V range. This might work with SNe in 2 bands (Never been tested I think?)

3) Fit 2 colors held with a prior U-B and B-V

4) Don't add CS to NaCl and account for it in EDRIS (No clue how this works)