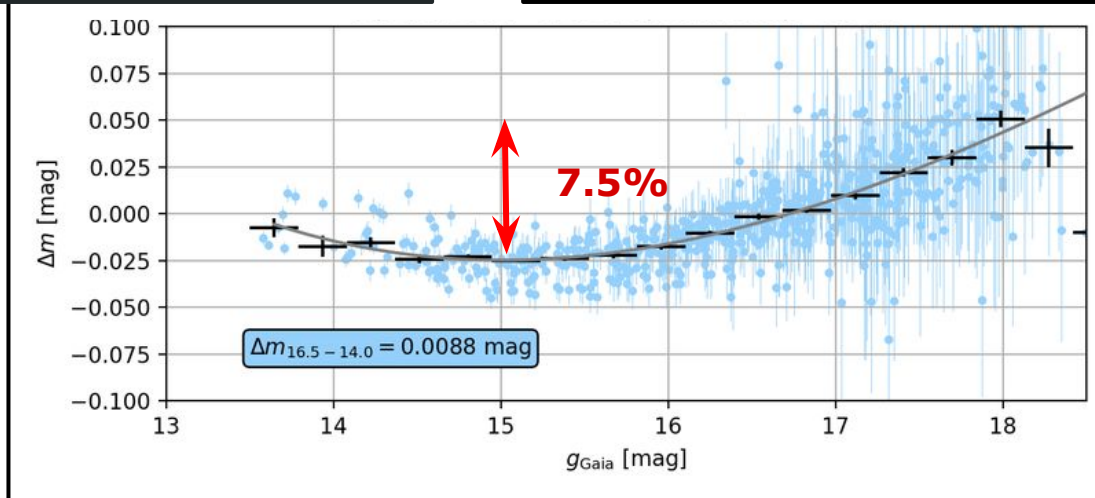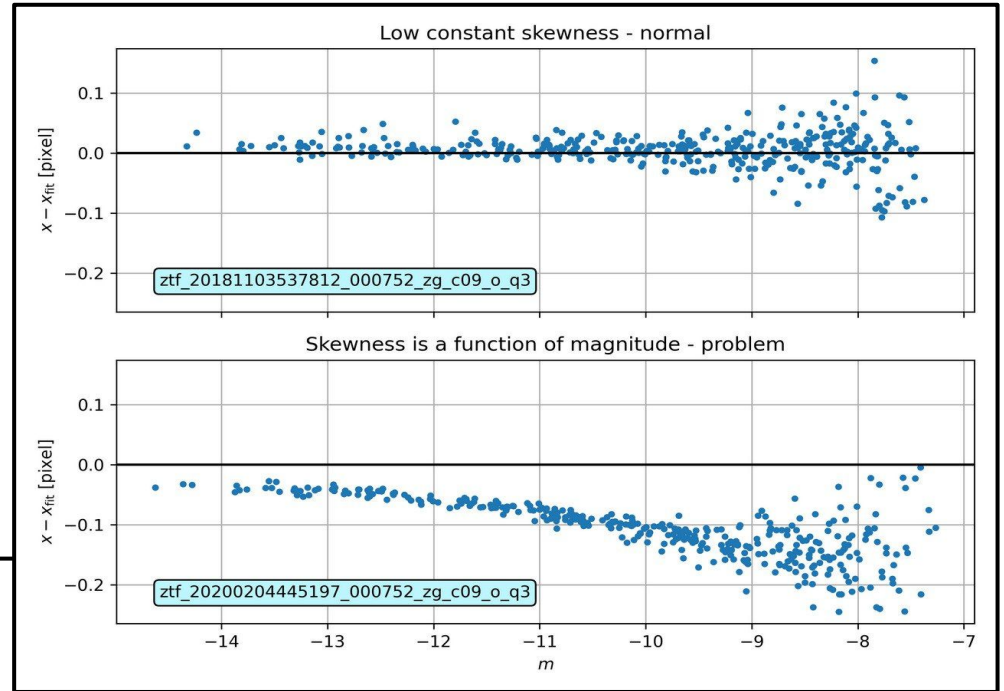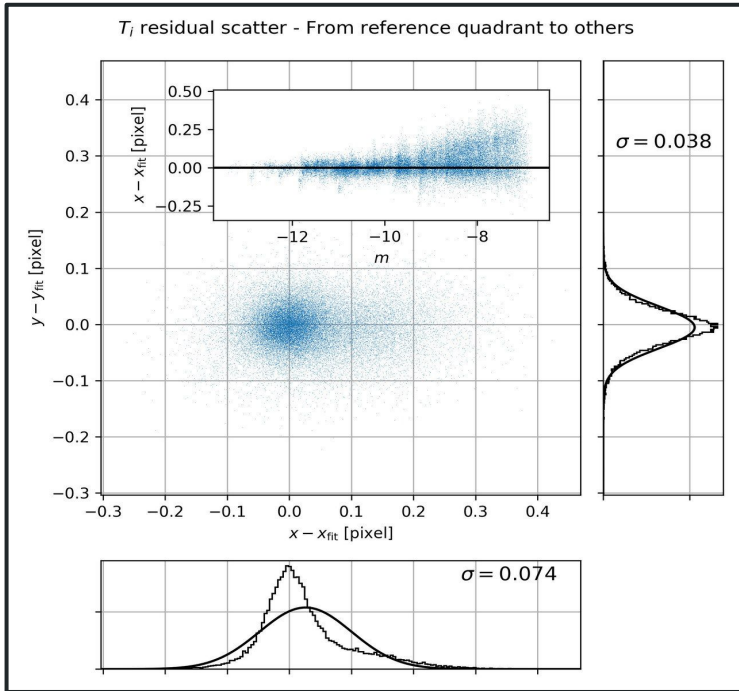# Cosmology with DR2.5

A work plan for DR2.5
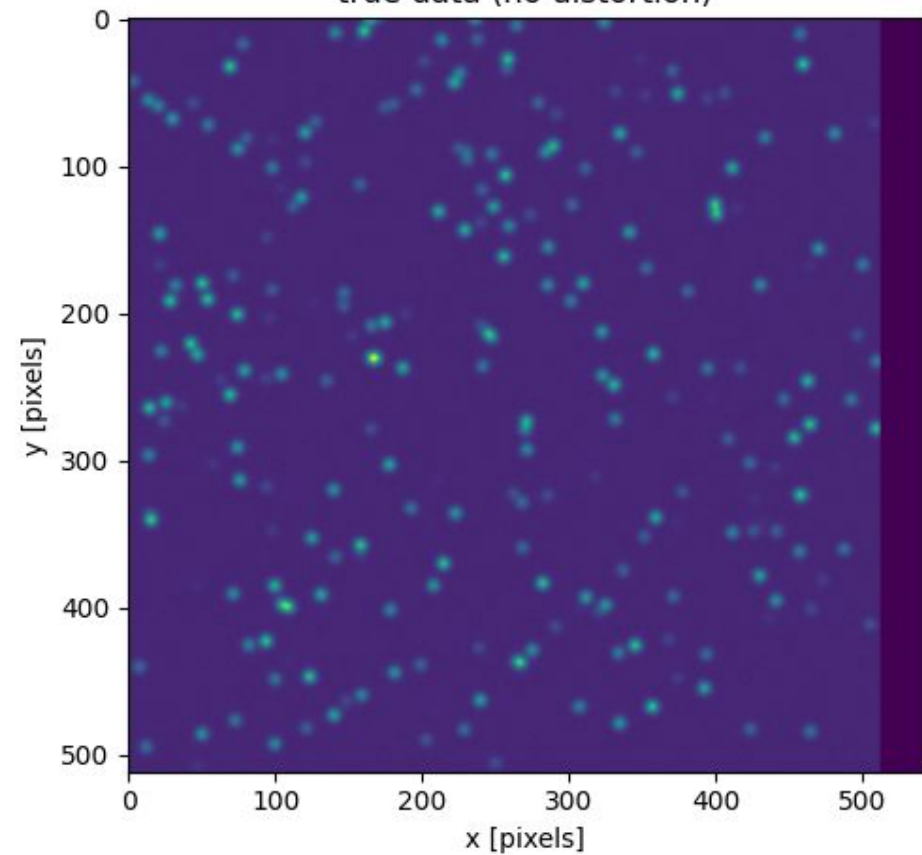
Why not "Cosmology with DR2" ?

Lacroix & Regnault

Why not "cosmology with DR2 ?"

- While working on scene modeling we found a strong, background and IQ-dependant non-linearity affecting:
  - Star positions (up to 200 mas, along serial direction)
  - PSF photometry (1% to 8% non-linearity on 13 - 18 mag range)
- Tracked down to flux-dependent variations of PSF profile
  - PSF skewness varies with flux
  - In the serial direction
  - Effect most present after nov-2019, on low-background images
- and finally, to an instrumental effect on the ZTF sensor
  - Some kind of "pocket" @ end of serial register

need to reprocess, starting from the raw exposures

How does it affect stars ?
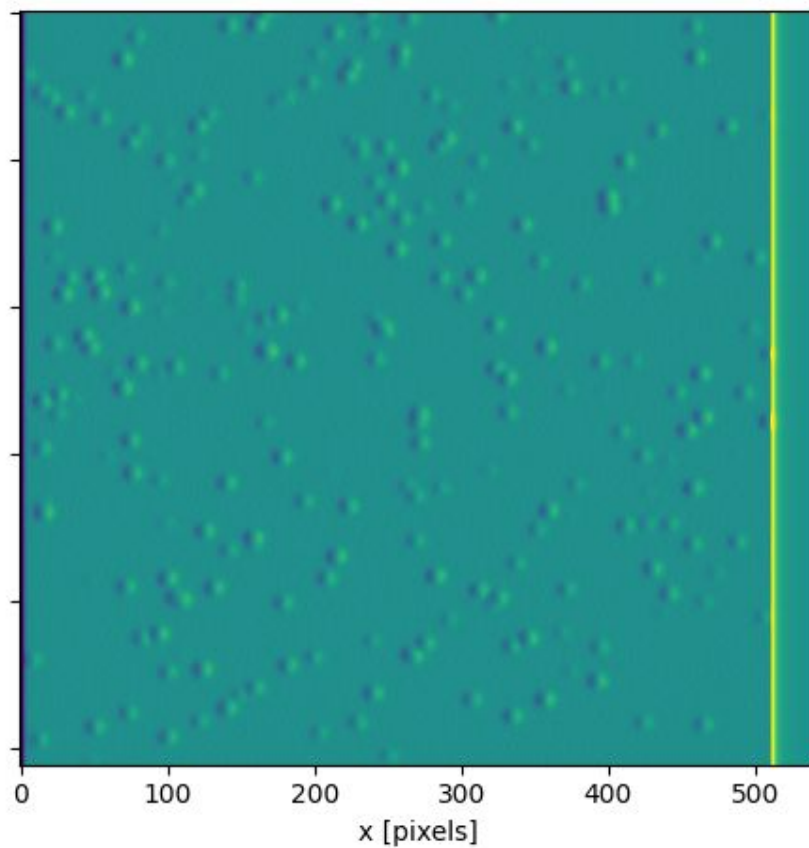
Can we correct for it ?
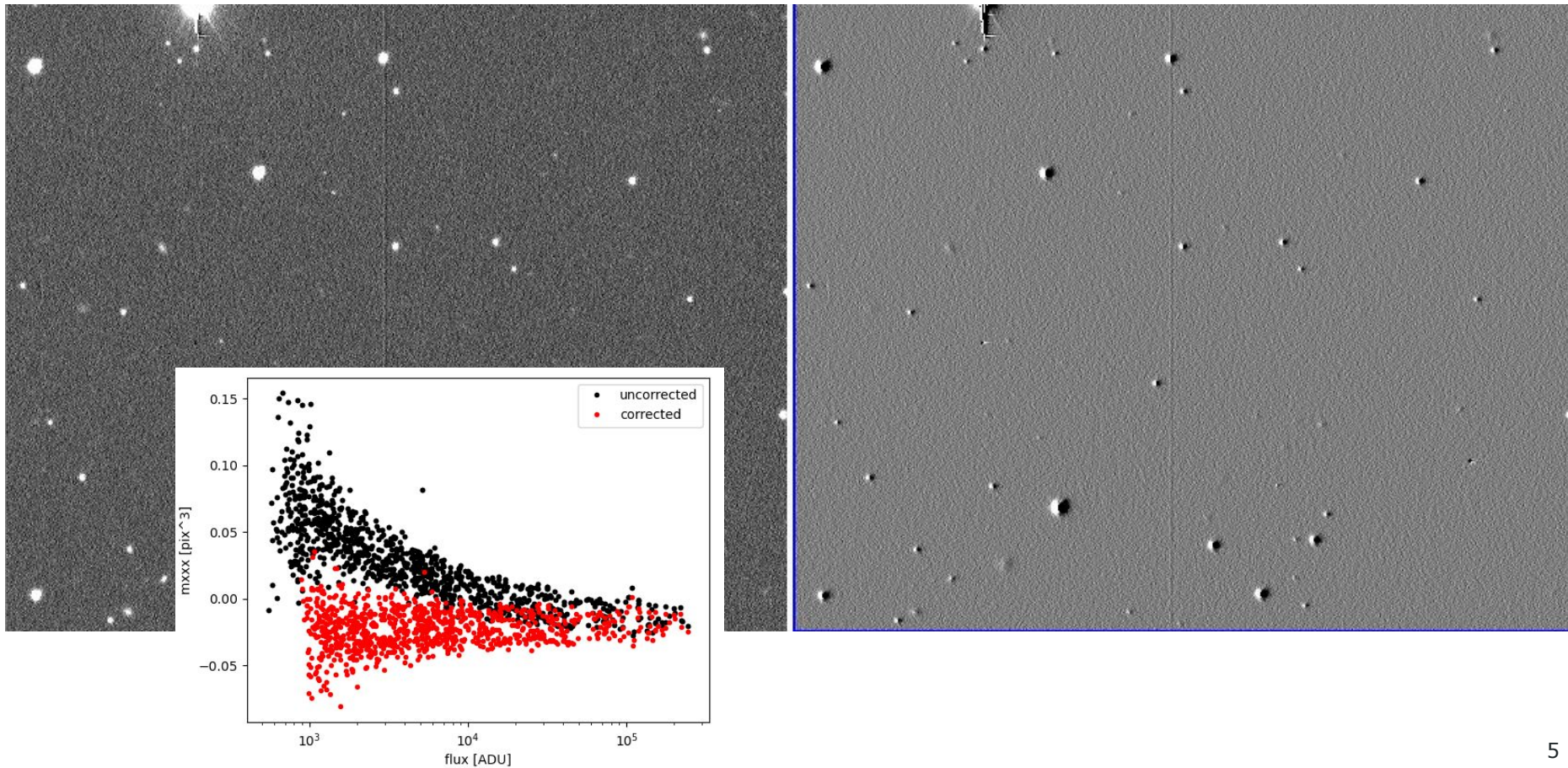
Last attempts are promising

ZTF impact on *w*

~ 0.2%

~ 10^4 SNeIa (σ_{int} ~ 15%)
+
Control of systematics @ 0.1%

Betoule

ZTF

Planck ΛCDM
$w = -0.95$
$w = -0.99$

$\Delta\mu$

z
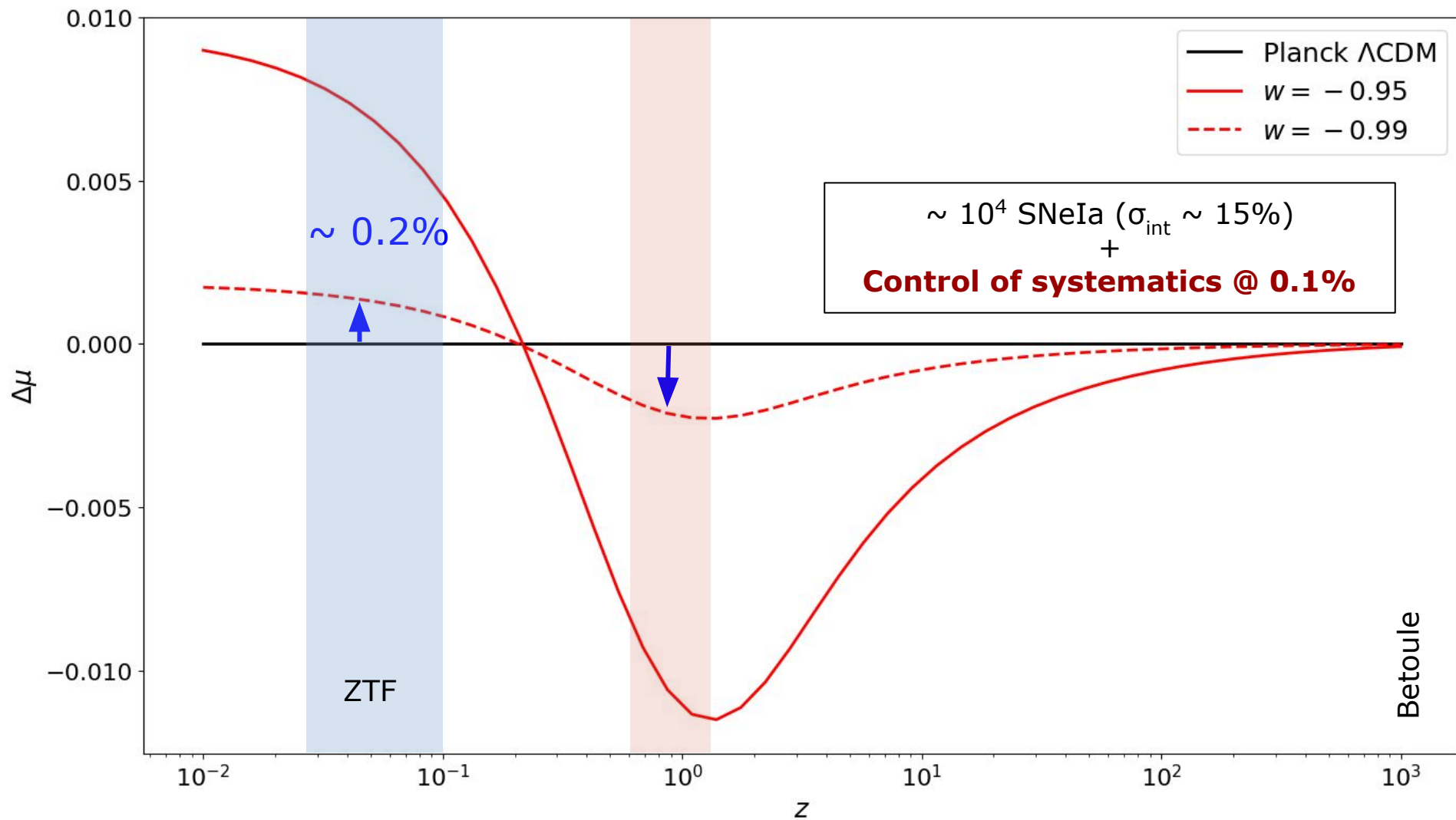
w-plans for DR2.5

- Recent w-measurements are
  - Systematics-limited
    - Photometric calibration, SN-model, malmquist bias, environment, evolution…
    - … and the interplay between all these
  - Quite complex
    - O(25) photometric systems (mostly for nearby samples)
    - 100+ bands to intercalibrate
    - Daunting task - Scolnic et al (supercal) / Rubin et al (Xcalibur) accomplished a real tour de force. I am not sure we have the workforce to duplicate this kind of effort.
    - BBC and Unity are extremely complex methodologies
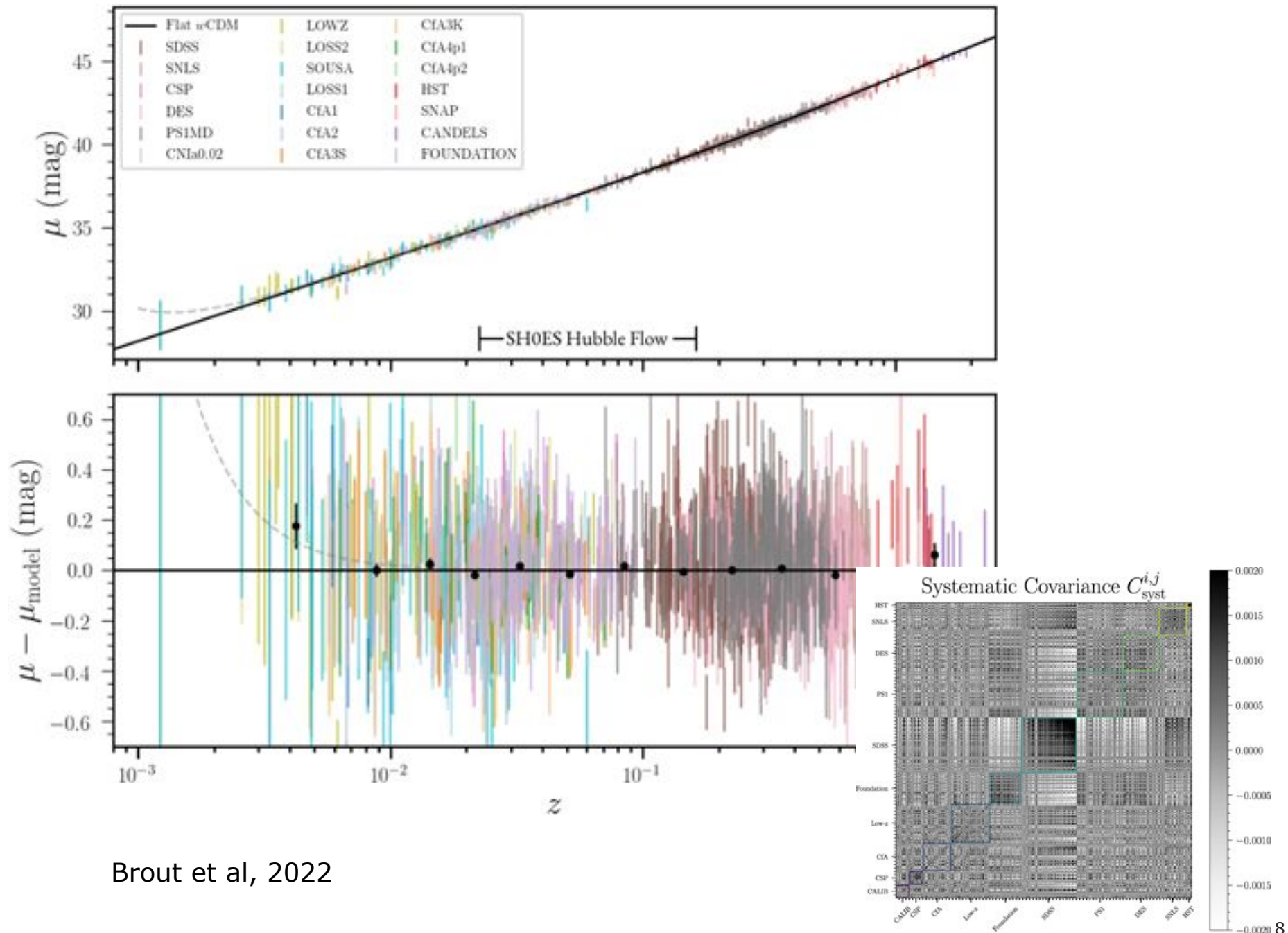
Brout et al, 2022

Our proposal

- **We have the opportunity to**
  a. Assemble a unique dataset, homogeneous and *distinct* from what has been used so far in cosmology analyses
  b. Build a shorter and more robust calibration chain
  c. Perform a thorough check of the accuracy of the primary flux standards
  d. Set up a simpler cosmology inference chain
- **And derive a measurement of *w* which would be *independent* of the** Pantheon and Union measurements:
  a. Not the same data
  b. Different methodology

a) SN sample

- We have the opportunity to build a cosmology SN sample
  - Homogeneous: 3-4 surveys instead of 25+
  - With a good coverage of the $z<0.05$ and $z>0.8$ critical regions
  - *totally independent on the published statistics*
- The recipe is:
  - ZTF DR2.5   +   SNLS-5 years *minus* JLA   +   HSC

    (3500)   (250)   (500)

- 3 surveys only
  - Sharing the same footprint
  - Well characterized instruments
  - With photometric systems potentially well understood

b) Metrology chain

- Opportunity to build a shorter flux calibration chain
  - ZTF footprint covers the SNLS and Subaru/SSP fields
  - Many stars in common, over ~ 4 magnitudes (16 - 20)
  - -> it is easier to intercalibrate these surveys
- Only limitation is ZTF has no z-band
 - Good idea to introduce PS1 / GAIA for redundancy
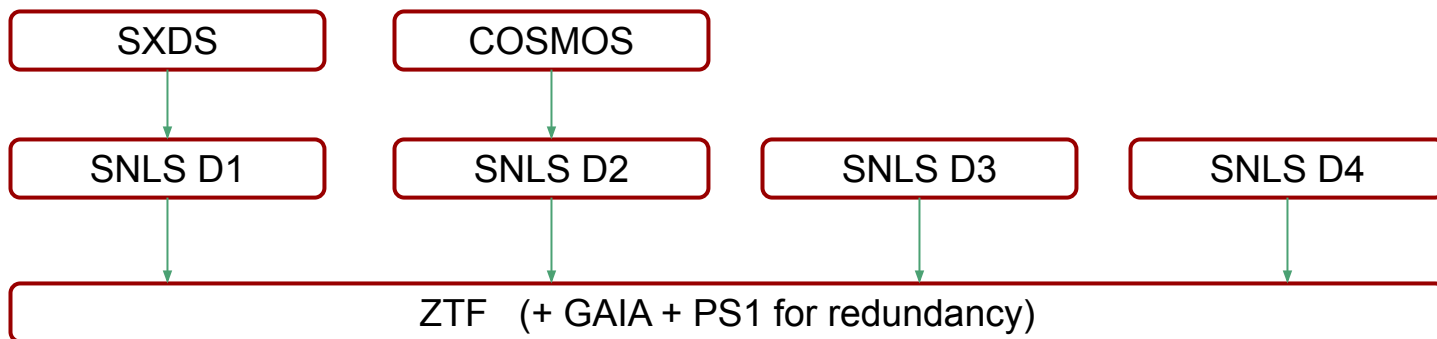
SXDS	COSMOS		
SNLS D1	SNLS D2	SNLS D3	SNLS D4

ZTF   (+ GAIA + PS1 for redundancy)
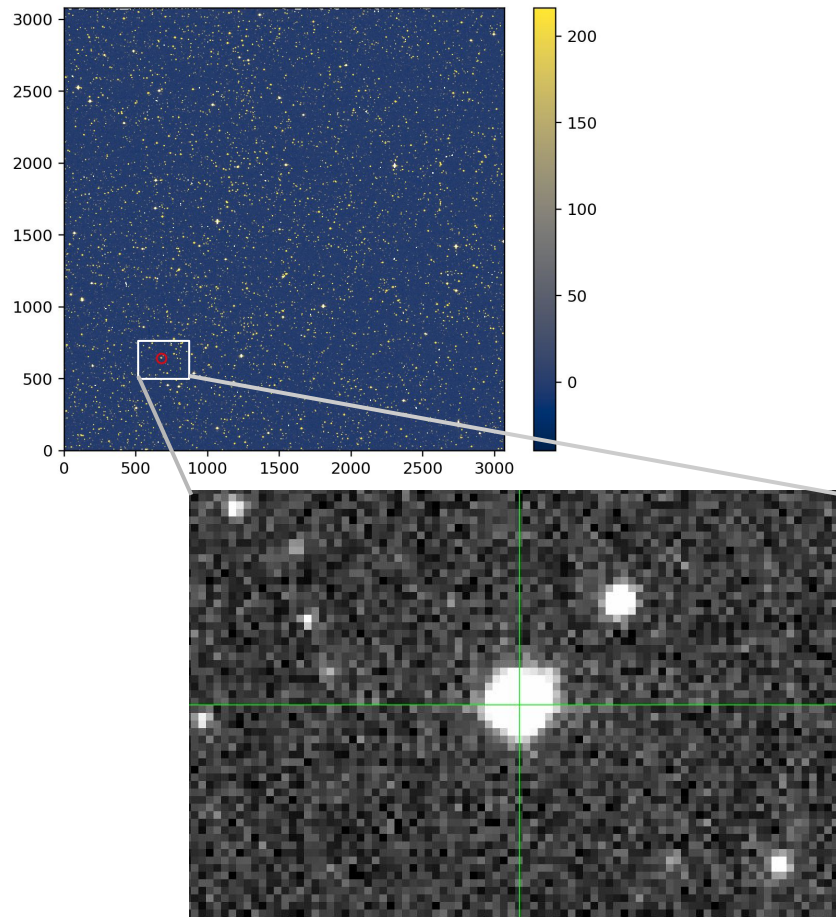
c) Primary flux standards

The Pantheon+ Analysis: SuperCal-Fragilistic Cross Calibration, Retrained SALT2 Light Curve Model, and Calibration Systematic Uncertainty

Dillon Brout,[1,2] Georgie Taylor,[3] Dan Scolnic,[4] Charlotte M. Wood,[5] Benjamin M. Rose,[4] Maria Vincenzi,[4] Arianna Dwomoh,[6] Christopher Lidman,[7,8] Adam Riess,[9] Noor Ali,[10] Helen Qu,[11] Mi Dai,[9] and Christopher Stubbs[12]
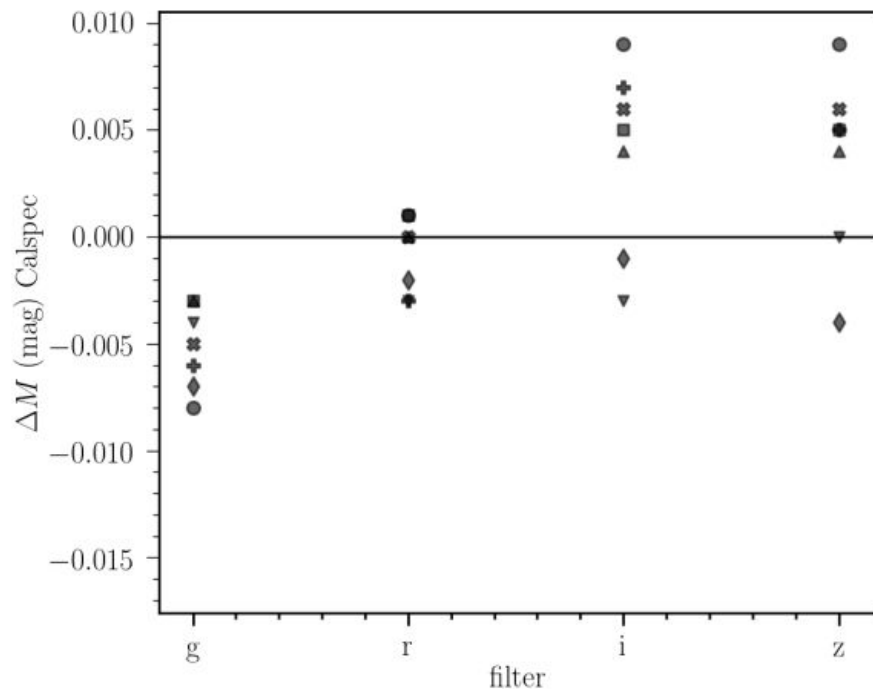
ences arising from updates to the CALSPECs. The most recent and improved stisnic 007/008 and stiswfcnic 002 versions of the CALSPECs results in a 1.5-2% change from g/B to I/z, $\sim 3\times$ larger than the expected systematic uncertainty of the CALSPEC calibration of $\sim 0.5\%$ over 7000 A. These changes in the absolute calibration due to the update of the CALSPEC standards have the largest impact in our analysis when comparing to the previous Betoule et al. (2014) and SuperCal calibrations. Since this is a change in the reference, this affects the inferred zeropoint offsets of all SN samples.

c) Primary flux standards

CALSPEC primary standards (WD with models) *are just normal ZTF stars*:

- GD71   V ~ 13.032
- GD153   V ~ 13.34
- ~~G191B2B   V ~ 11.78~~

Saturated in most exposures

Plus O(30) CALSPEC secondary standards (HST STIS/NICMOS spectra) with 12 < V < 16

c) Primary flux standards

- Opportunity to check primary flux standard accuracy, comparing
  - CALSPEC
  - Narayan
  - Perfect BB (Suzuki et al)
  - DESI calibrated white dwarfs

  Not been done before

- *All have ZTF magnitudes*, (no z, unfortunately)
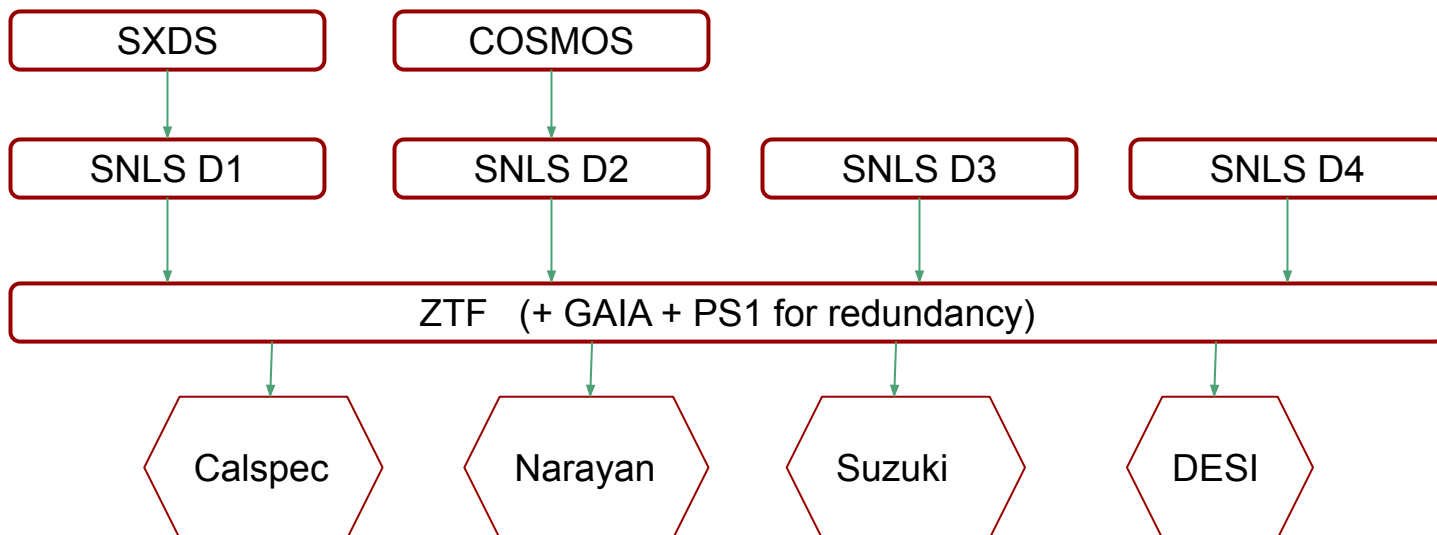
c) starDICE first analysis : spring 2024

T. Souverin

Thierry Souverin
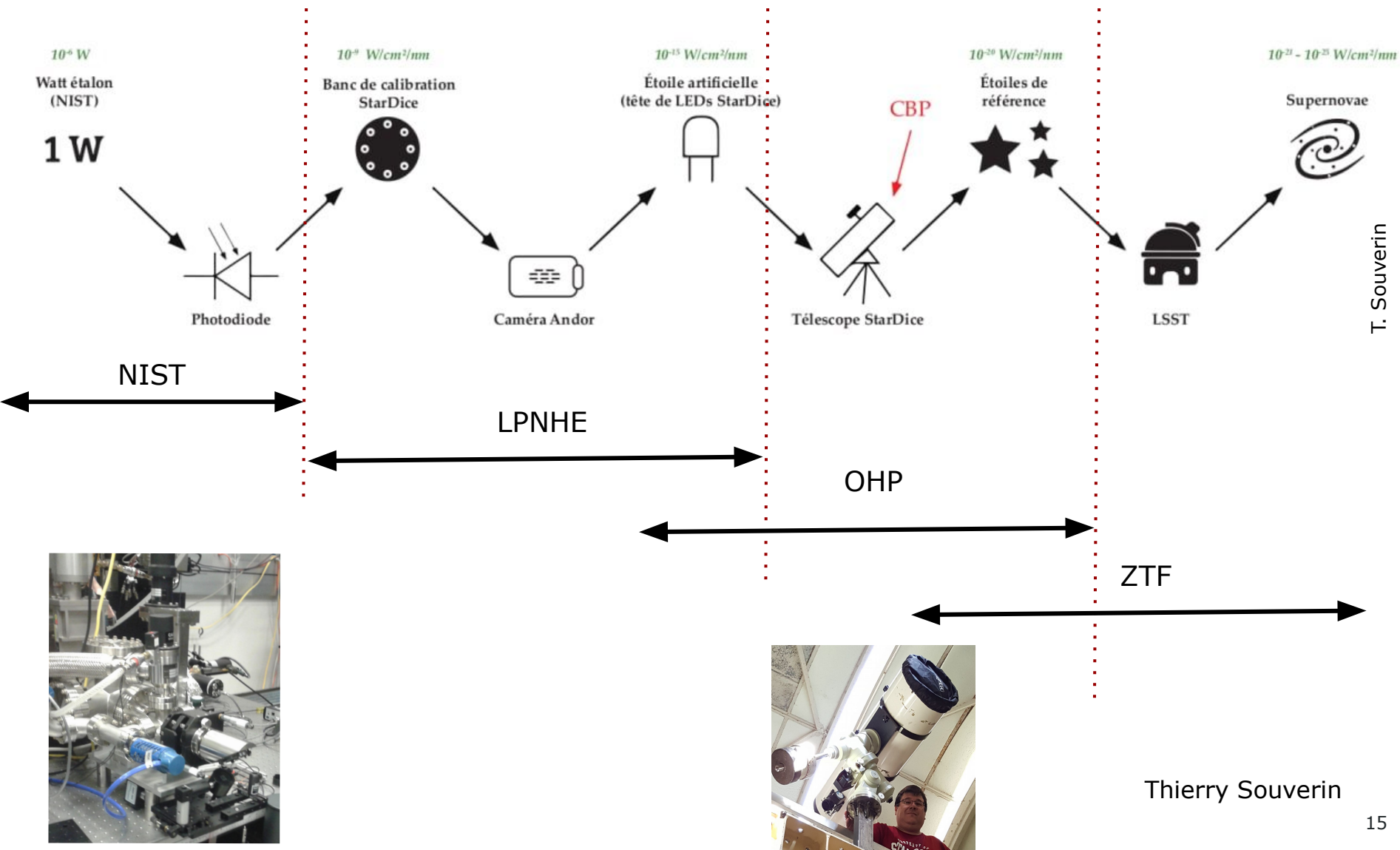
d) cosmology inference

- Opportunity to assemble a cosmology inference framework
  - *Independent* of what has been used in recent analyses
  - In which the two keys points of distance inference
    - model training
    - distance standardization and binning
  - are *encapsulated in likelihoods*
  - are fast, and easy to characterize

Inference framework
(from light curves to distances)
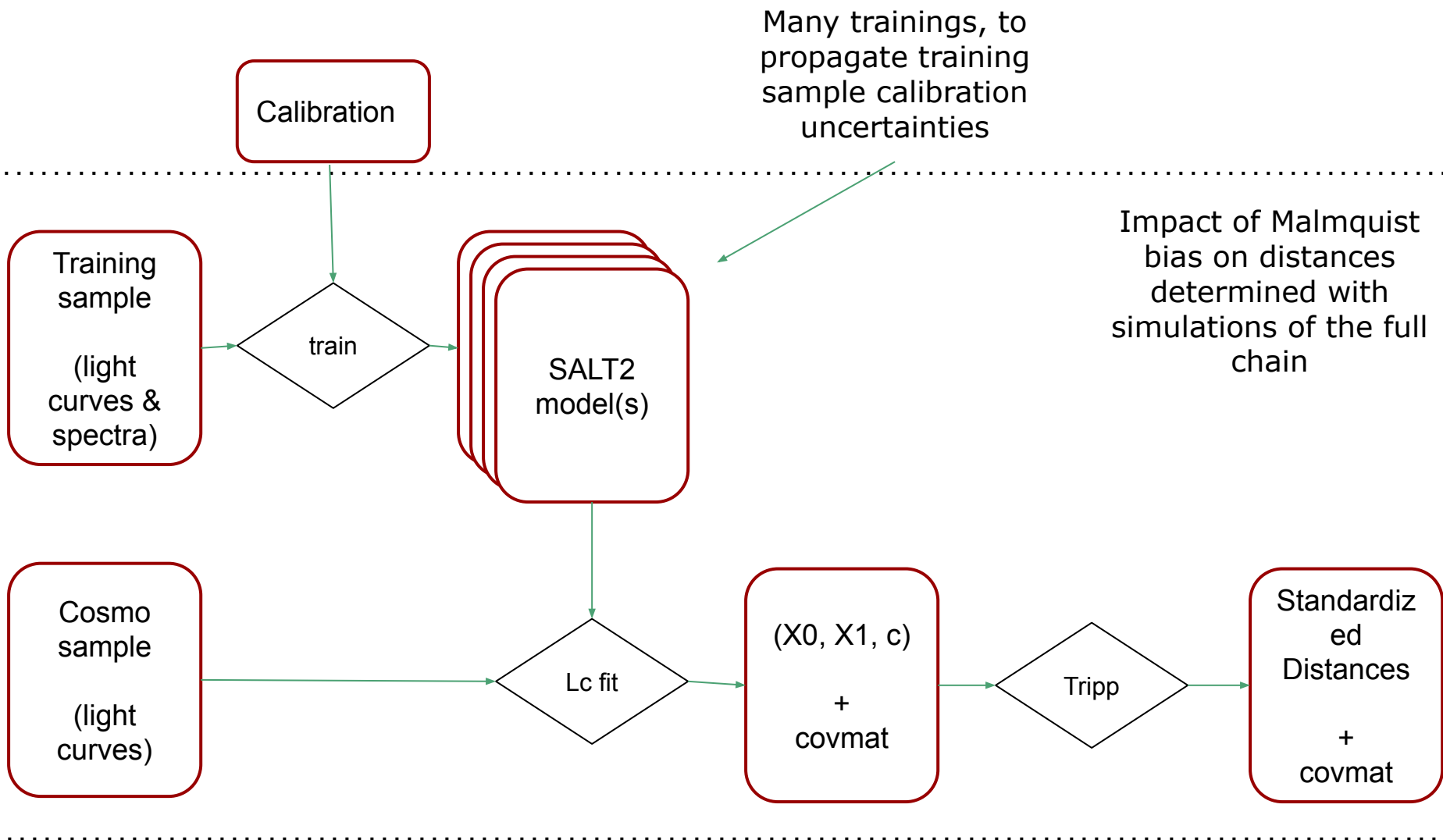
Proposed inference framework
(from light curves to distances)
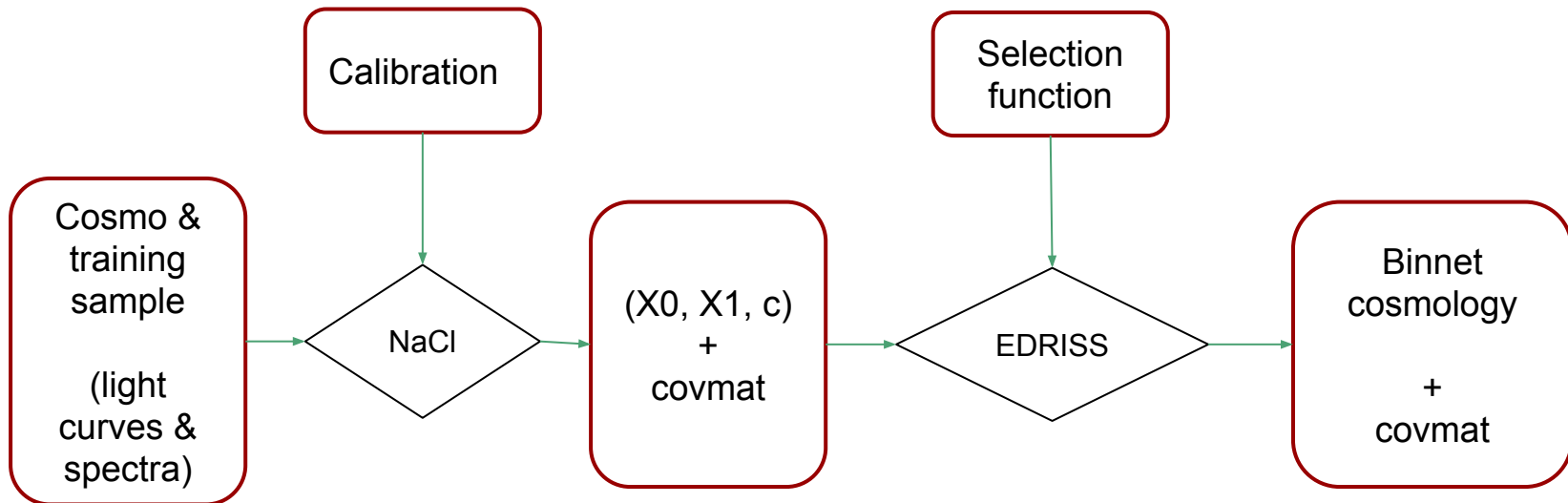
- One single training + LC fit (marginalize over the model)
- Distance estimator immune to Malmquist bias

The road to *w*

- **Work on sensors (3 months) NR/MA/MR/?**
  - Pocket effect model
  - Brighter-fatter
  - Integrate this into detrend pipeline
  - Validate at least on field #600

  1 paper on ZTF sensors
  1 paper on detrend pipeline

- **Work on filter model (2 months ?)   PR/**
  - Build position dependent filters
  - Filter validation (missing)

  1 paper on instrument model(s)

- **Lightcurve Reprocessing (3 months) LL/**
  - Reprocess all DR2 lightcurves, starting from raw exposures
  - Detrend on the fly, so low-disk space requirements
  - but : /sps/ztf is 92% full

The road to *w* (cont'd)

- Work on ubercal catalog (3 months) BR/FF/
    - Relies on aperture photometry => not limited by pocket effect
    - We probably can rely on photometry as it exists
    - For DR2.5 we can rely on PS1 for uniformity. So, just stick to that
- Work on primary flux standards (3 months) ?
    - Unique opportunity to discuss primary flux standards
        - Integrate primary flux standards in ubercal catalog
        - Investigate tensions between calibration sources
        - Merge ?

The road to *w* (cont'd)

- Simulating the cosmo sample   3 months ?/DK/MB/NR
  - Skysurvey to simulate
    - cosmo sample
    - With selection bias and astrophysical biases (pop, env, …)
  - Plug in NaCl and EDRISS -> full analysis chain
- Use this framework to test against systematics 4-5 months /
  - Selection, calibration, dust, …

The road to w-publications (cont'd)

- Integrate the cosmology simulation chain

```
Cadence +        →  < sky      >  →  ZTF + hiz       →  < NaCl >  →  X0,X1,c +
instrument           survey         LCs and                          covmat
description                         spectra
```

```
Population
Environment
Selection
calibration
…
```

```
Cosmo          ←  < EDRISS >  ←  (Binned)
inference                        Distances
                                 + covmat
```

```
< EDRISS >
```
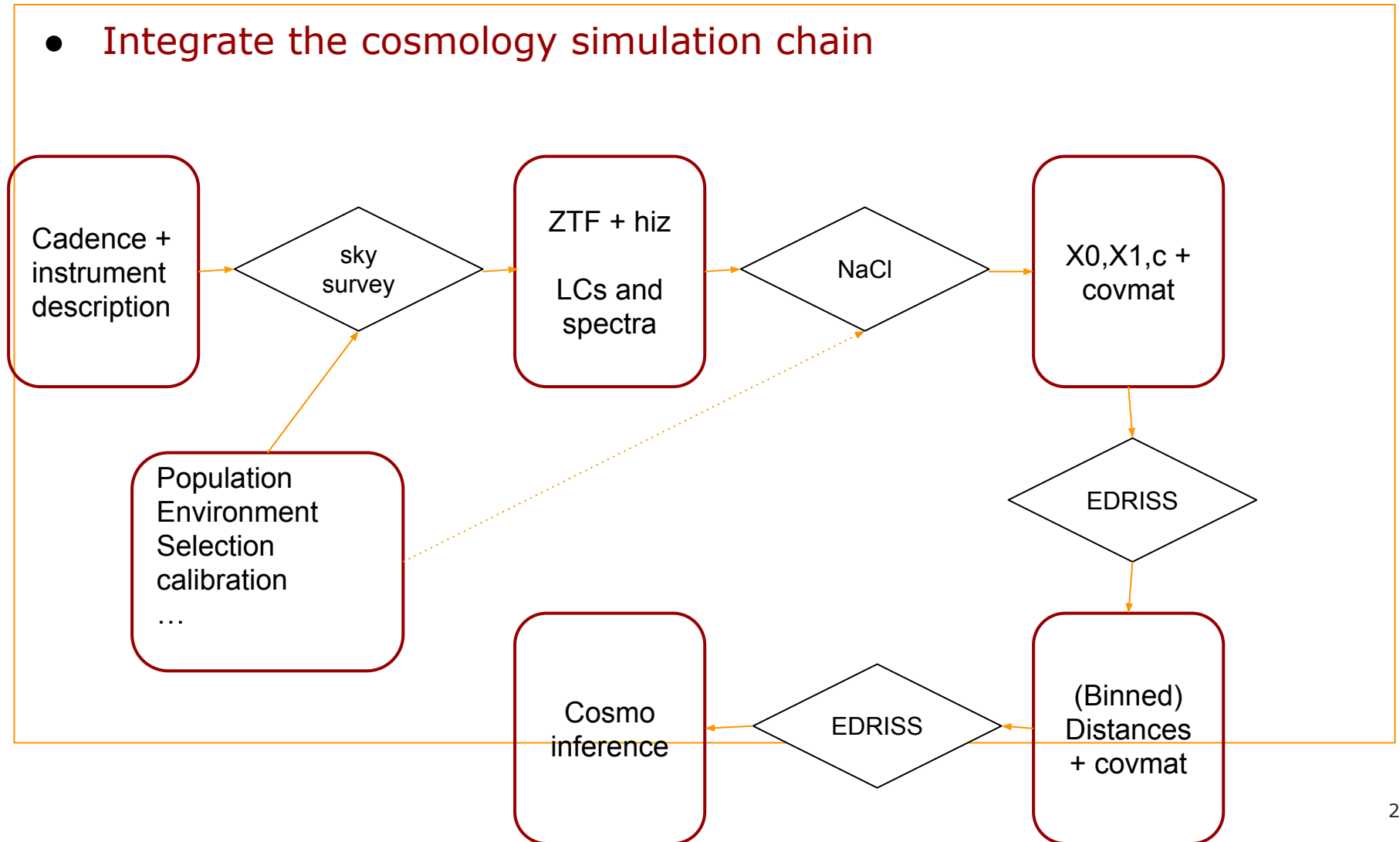
The road to *w* (cont'd)

- Build the training / cosmology sample   6 months TdJ
  - Curation work:
    - Revisit light curve and spectra selection criteria
    - Flag obvious outliers
    - Check survey intercalibration (tertiaries & passband model)
  - Collect redshifts and host data
  - Selection functions
- Output:
  - Training & cosmology sample
- Cosmo analysis 6 months   /NR/MB/
  - Once we have a cosmo sample and a

Ongoing tasks - schendule

	9/2023	10/2023	11/2023	12/2023	1/2024	2/2024	3/2024	4/2024	5/2024	6/2024		
Pocket correction validation	NR	NR										
BF measurements		NR	NR									
Integration into detrend pipeline		MA?/MR?/NR	MA?/MR?/NR	MA?/MR?/NR								
Validation on field #600		?	?/NR	?/NR								
ZTF filter model	PR	PR										
LC reprocessing (from RAWS)				LL	LL	LL						
Ubercal catalog (PS1)	BR/FF	BR/FF	BR/FF									
Primary flux standards comp		?	?	?								
NaCl	NR	NR										
EDRISS	DK/MB	DK/MB	DK/MB	DK/MB								
Simulation chain	DK/?	DK/?	DK/?	DK/?								
Astrophysical biases	?	?	?	?								
HSC dataset	NR/NS	NR/NS	NR/NS	NR/NS								
SNLS4-5 dataset	MB	MB	MB	MB								
Cosmology sample	TdJ	TdJ	TdJ	TdJ	TdJ	TdJ						
Training NaCl on cosmo sample		TdJ	TdJ	TdJ	TdJ	TdJ	TdJ					
Cosmological analysis												