

Studying supernovae with narrow band filters

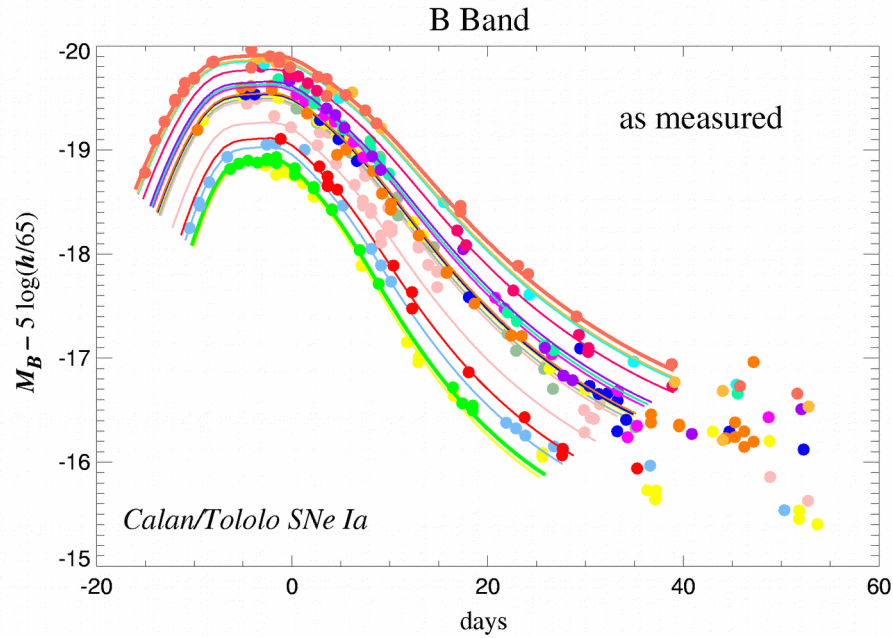
Ribamar R. R. Reis



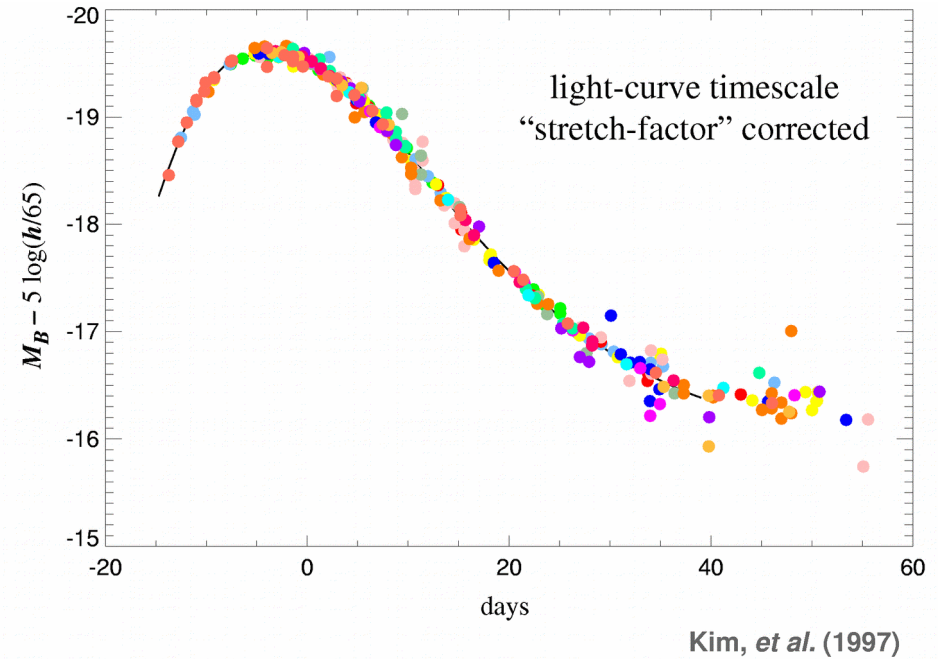
Work in collaboration with:

- Beatriz Siffert
- Alessandro Ederoclite
- Henrique Xavier
- Raul Abramo
- Miguel Quartin
- Karolina Garcia
- Héctor Vazquez Ramió

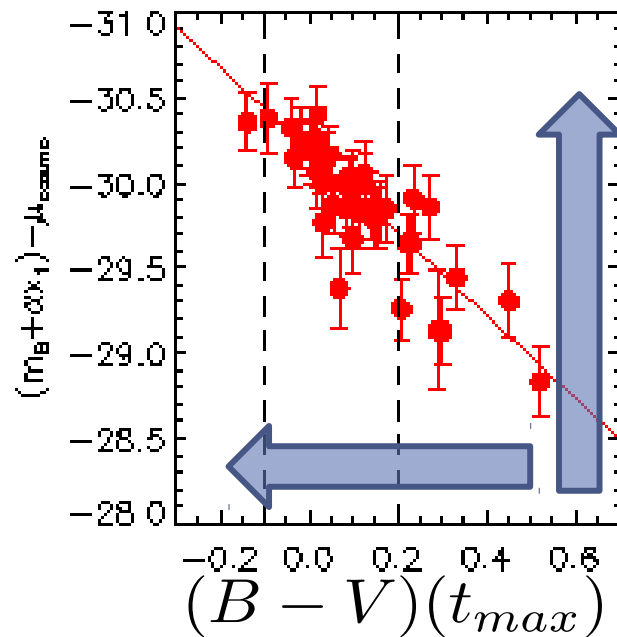
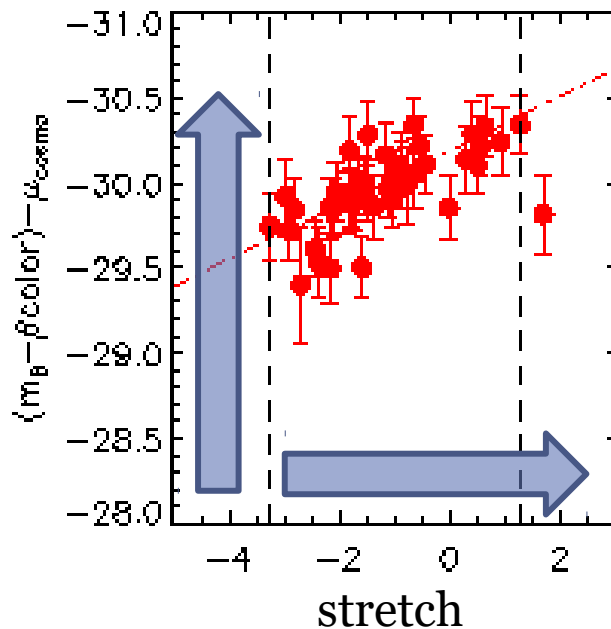
- Estimating distances as a function of redshift allow us to constrain cosmological models.
- In the case of luminosity distance, we need standard candles.
- Type Ia supernovae (SneIa) are thermonuclear explosions of CO white dwarfs in binary systems.
- Bright events ($\sim 10^{43}$ ergs/s).
- Fairly homogeneous class.
- Good candidates for standard candles.



SNeIa are not standard candles, but we can standardize them using empirical correlations.



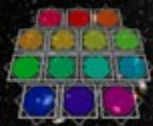
Brighter
Broader



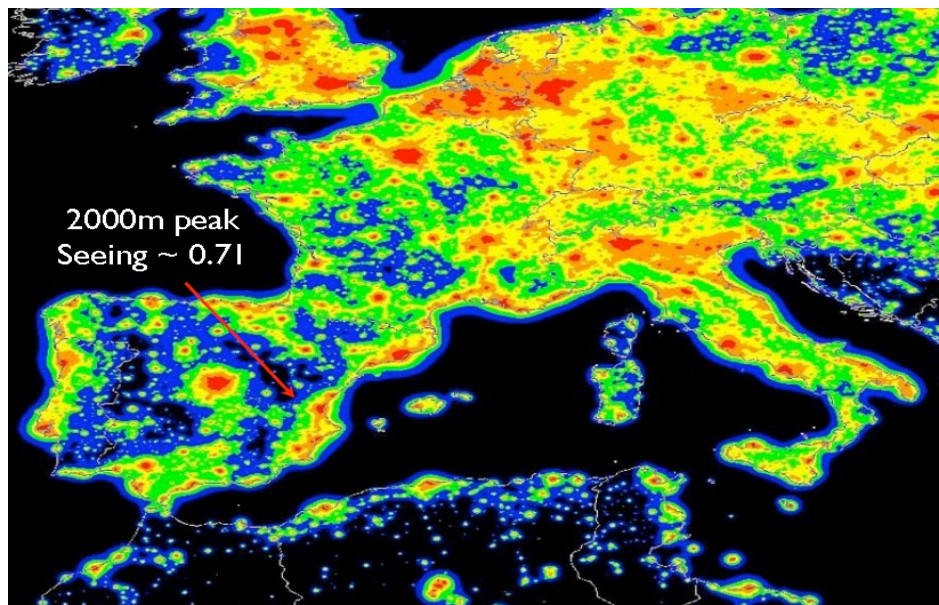
Brighter
Bluer

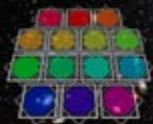


- J-PAS is a photometric survey which will cover 8000 squared degrees of the sky using a novel system with 56 narrow band filters (145 angstroms), besides 4 broad band ones (SDSS).
- The main goal is to observe Baryon Acoustic Oscillations (BAO), both radial and transversal, up to $z \sim 1$, using photometric redshifts.
- The survey will be carried out with a new 2.55 m telescope, mounted at a new observatory, Observatorio Astrofísico de Javalambre (OAJ).
- The camera will have a 14 9.2k by 9.2k CCD mosaic and 7 squared degree field of view.
- The telescope is now running with a provisional camera (Pathfinder), all filters available.

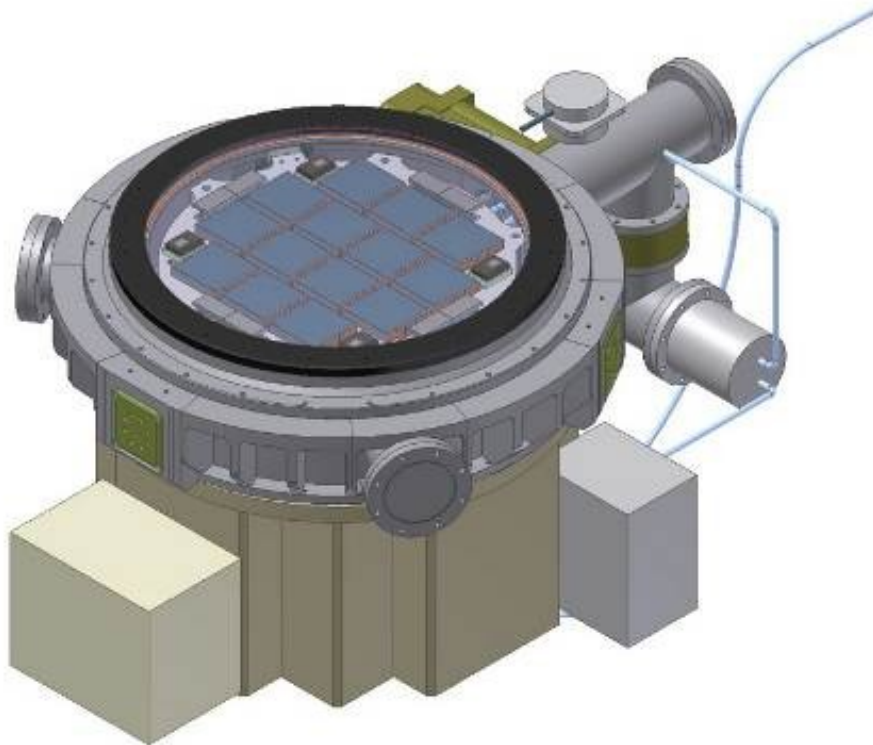


Javalambre
Physics of the Accelerating Universe
Astrophysical
Survey



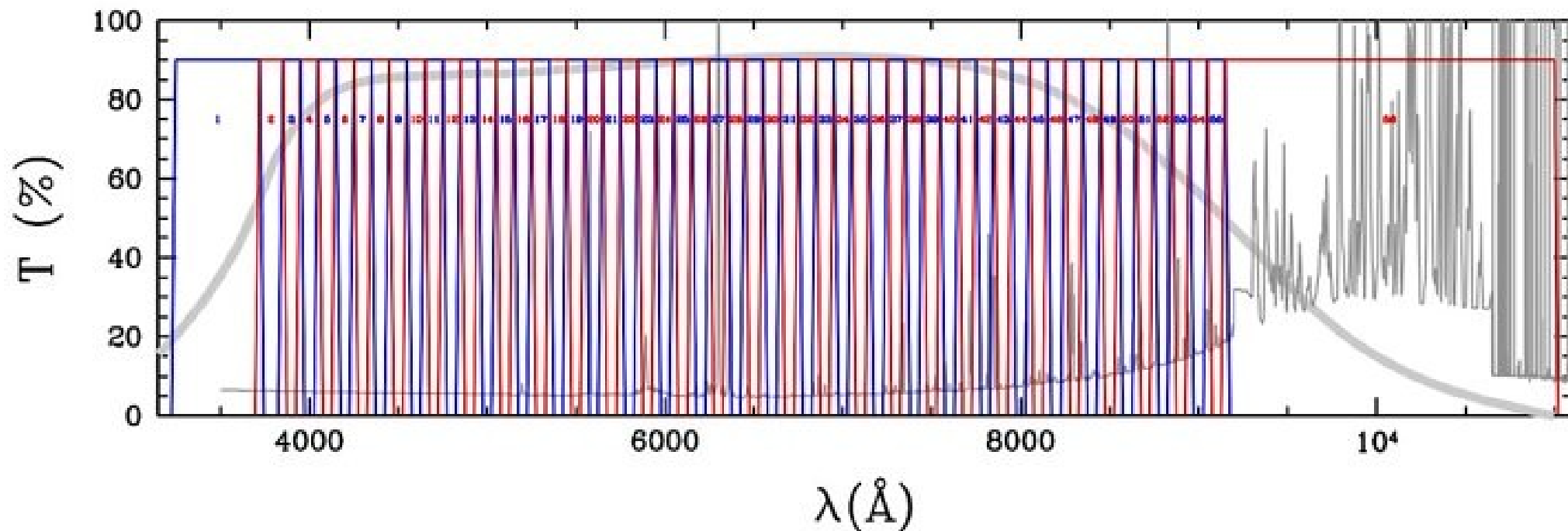


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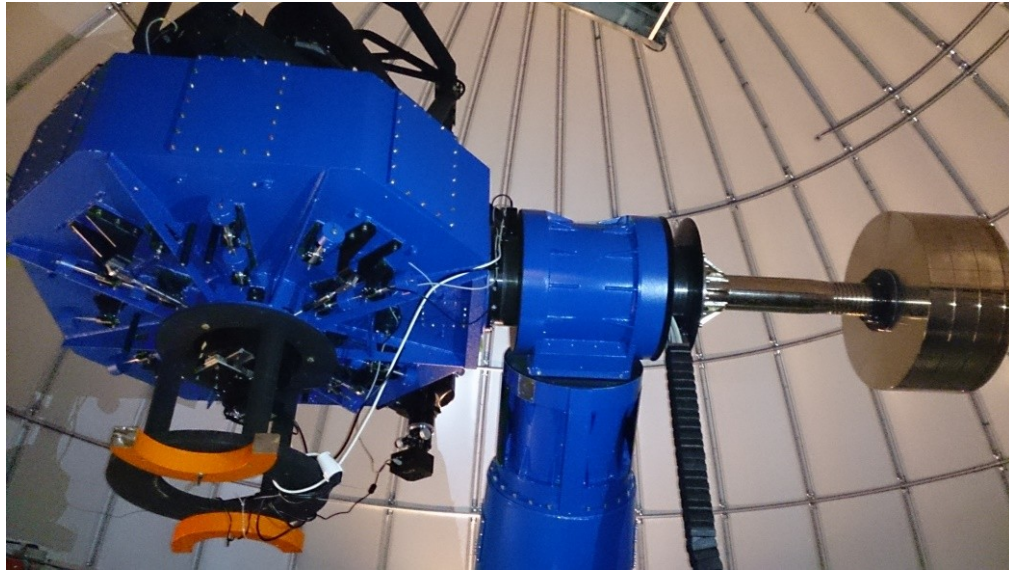
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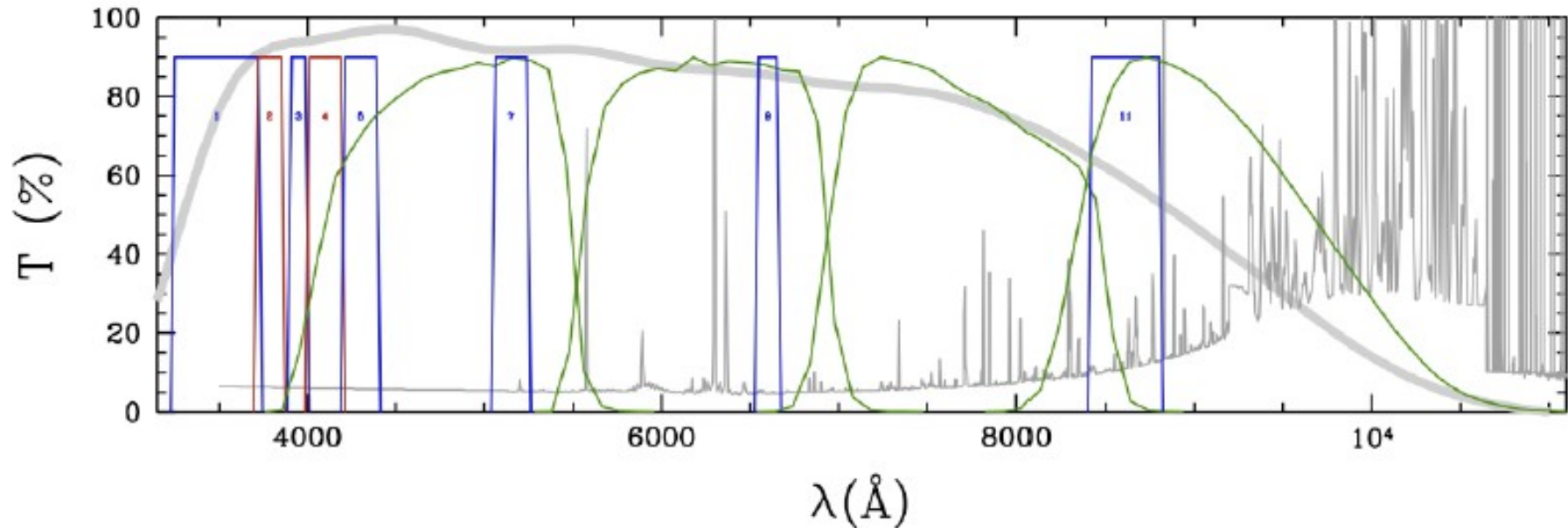


Javalambre Photometric Local Universe Survey

- The survey will cover the same area of J-PAS with a 80 cm telescope at OAJ;
- The main goal is to provide photometric calibration to J-PAS filter system;



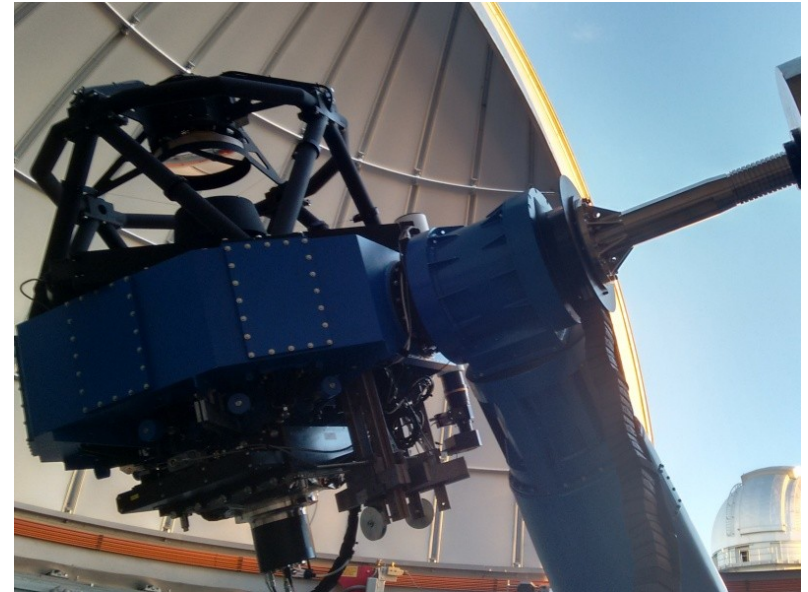
$$\begin{aligned} &\text{SDSS}(g, r, i, z) + u_J + J378(OII) + J395(H + K) \\ &+ J410(H\delta) + J430(\text{G-band}) + J515(Mgb - Fe) \\ &+ J660(H\alpha) + J861(CaT) \end{aligned}$$



J-Var

- Due to its calibration goal, J-PLUS is subjected to specific quality requirements for the images. Non-photometric nights will not be used, for instance.
- What can we do on these nights? Look for variables and transients!
- The plan is looking for variables and transients during the nights that do not fulfil J-PLUS requirements.
- The initial plan is to cover 12 squared degrees, taking eleven images in each filter;
- We can also use J-PLUS images;

- It is a J-PLUS “twin” which will observe 6000 squared degrees of the south celestial hemisphere;
- The telescope is at Cerro Tololo, Chile;
- It will use the filter system of J-PLUS.
- The observation strategy is different, allowing more revisits;



Supernova detection in J-PAS

We will use difference imaging to look for transients and variables:

1. Choose two images of the same field in different epochs (template and search);
2. Subtract the template from the search image;
3. Generate a catalog of objects detected at the resulting image;
4. Reduce the candidates list, excluding artifacts, cosmic rays, asteroids and known variables;
5. Measure magnitudes and build the light curves;
6. Identify the host galaxy and estimate its properties;
7. Classify the supernova.

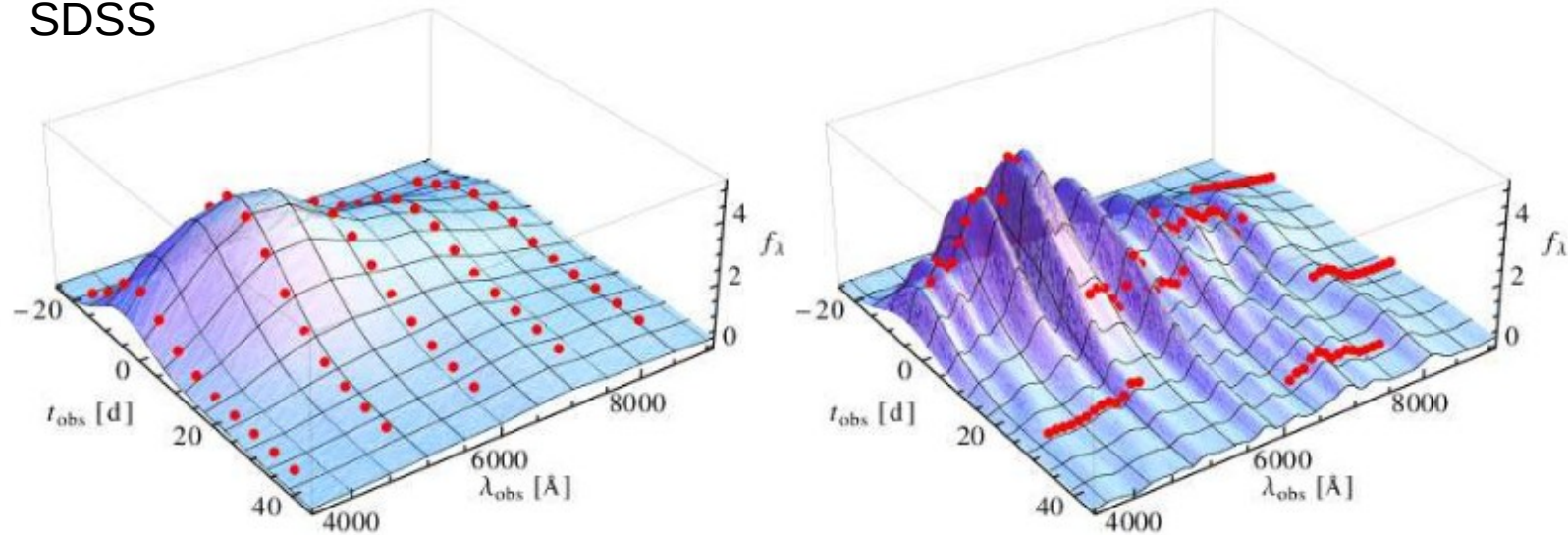
J-PAS strategy:

2 images (same night) + 1 image (two weeks after) + 1 image (two weeks after)

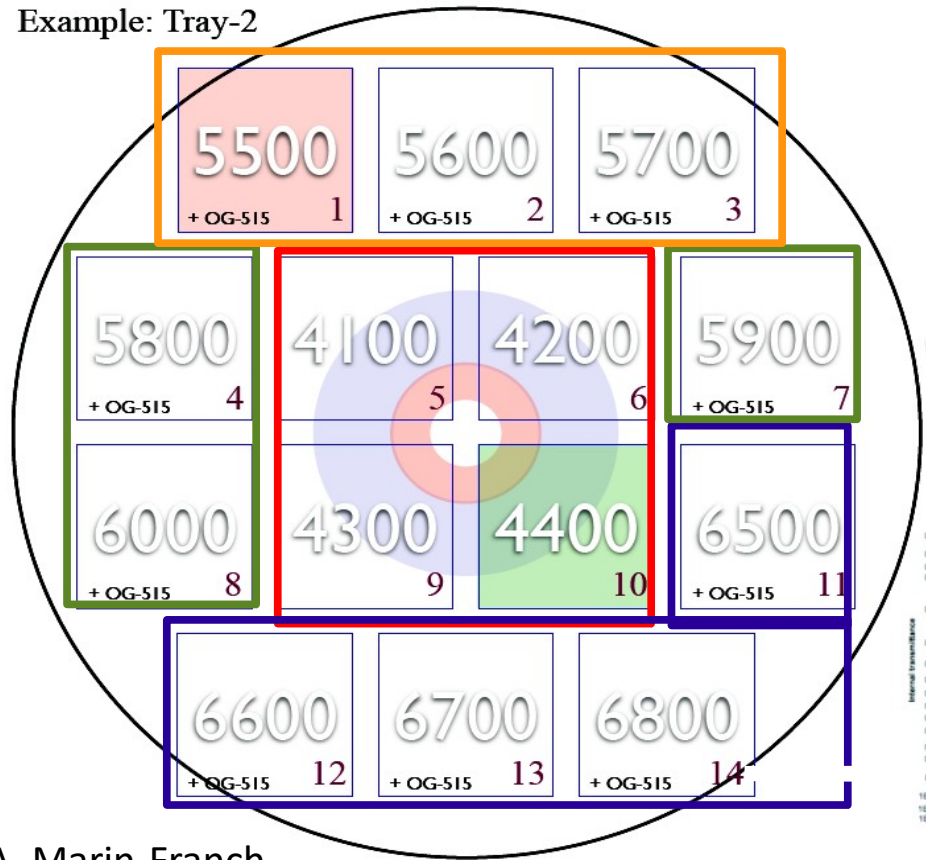
For each field and each filter

What is the difference from a “typical” supernova survey?
The sampling of the spectral surface (specific flux)

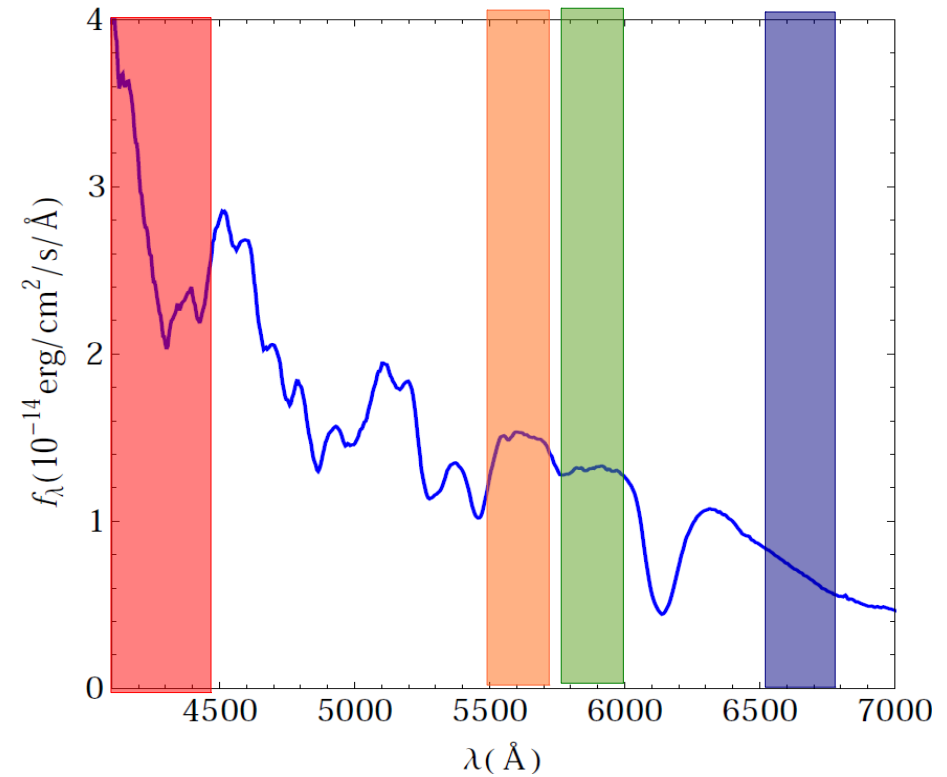
SDSS



Example: Tray-2

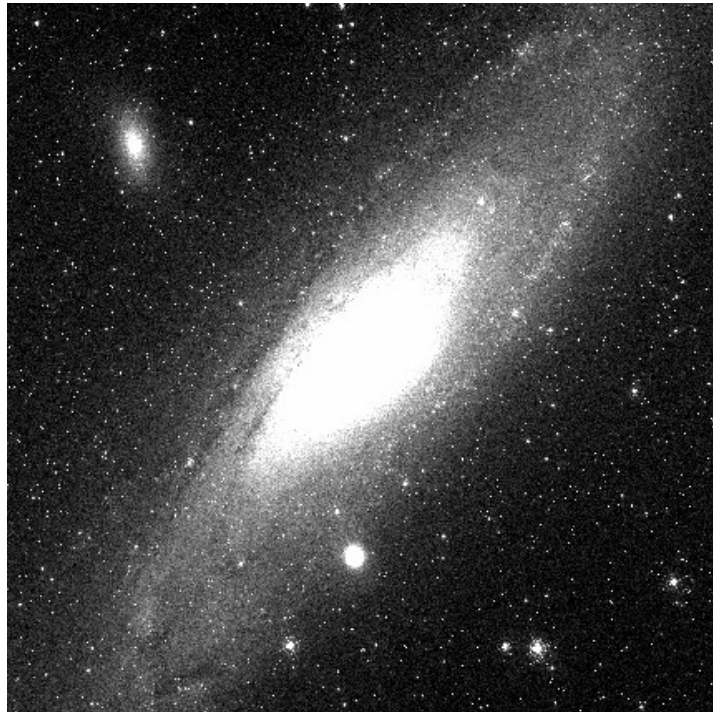


A. Marin-Franch



Performance tests

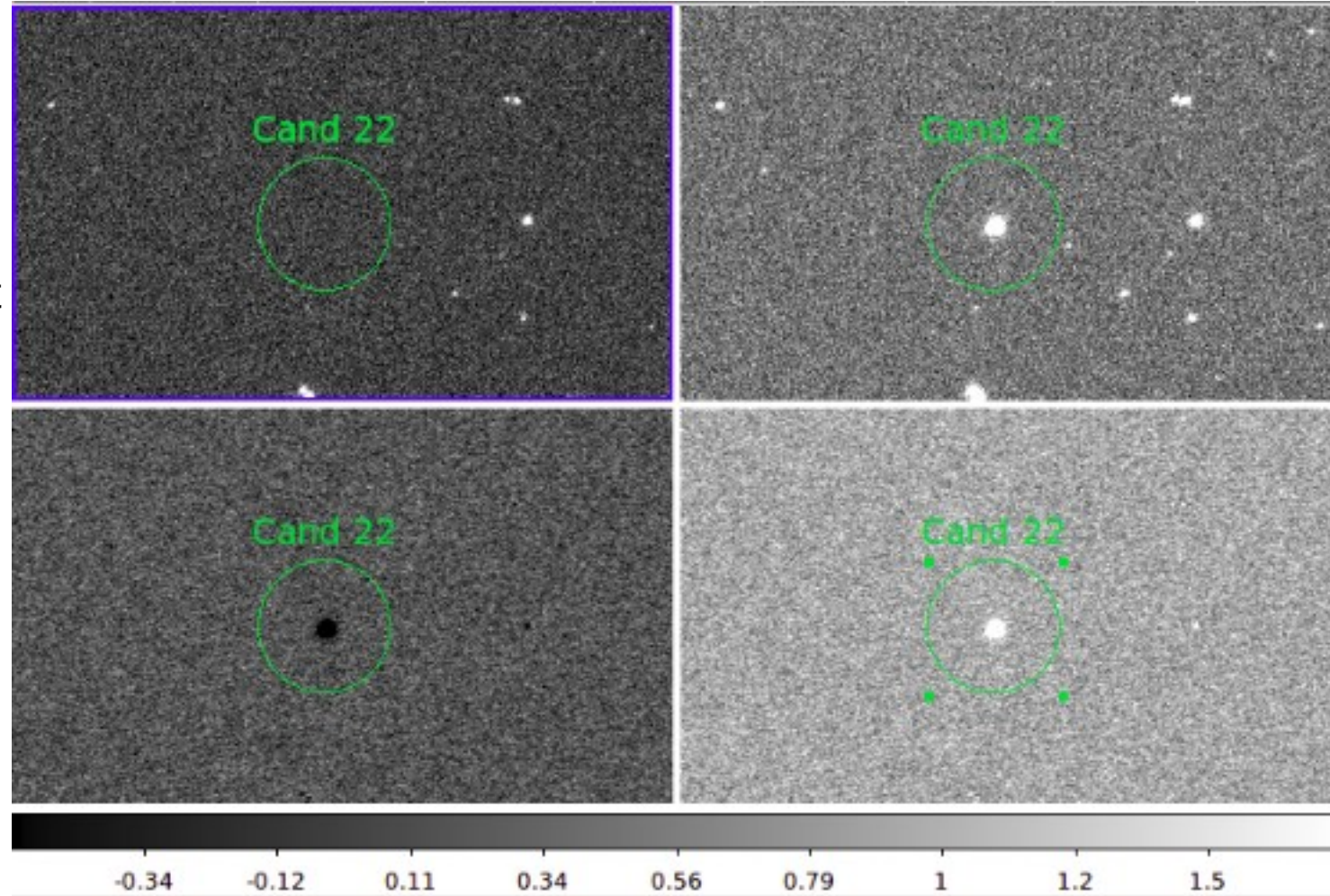
- Variable stars in M31 and M33 proposal with T-80 telescope;
- Images in 4 filters, in 10 different epochs;



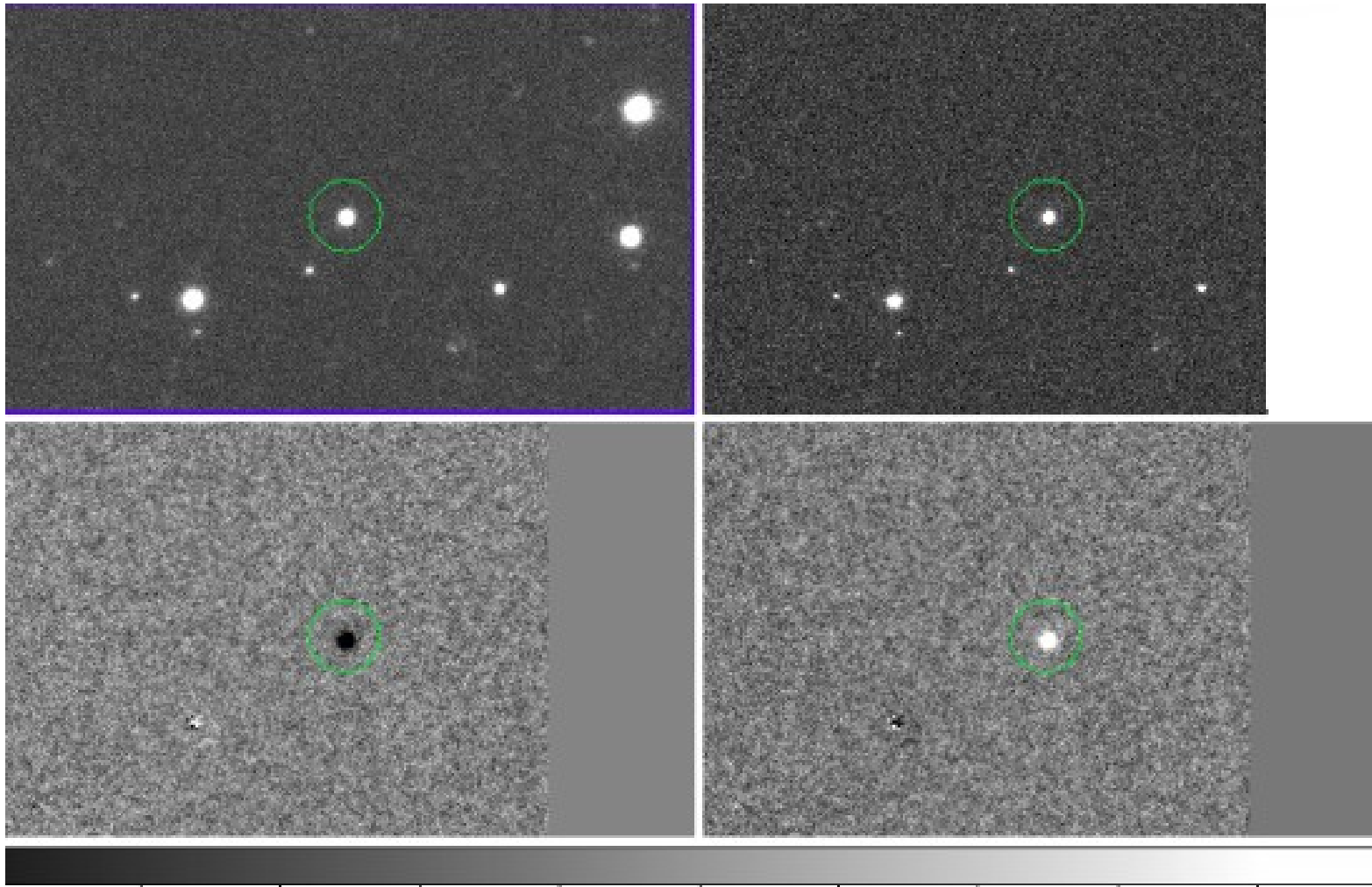
Performance tests

- Variable stars in M31 and M33 proposal with T-80 telescope;
- Images in 4 filters, in 10 different epochs;
- Crowded fields: thousands of candidates;
- More than 95% removed by shape and coincidence between filters requirements;
- Result for M33: pipeline identified several variable stars, a nova candidate and one asteroid.

Beatriz Siffert



Beatriz Sifert

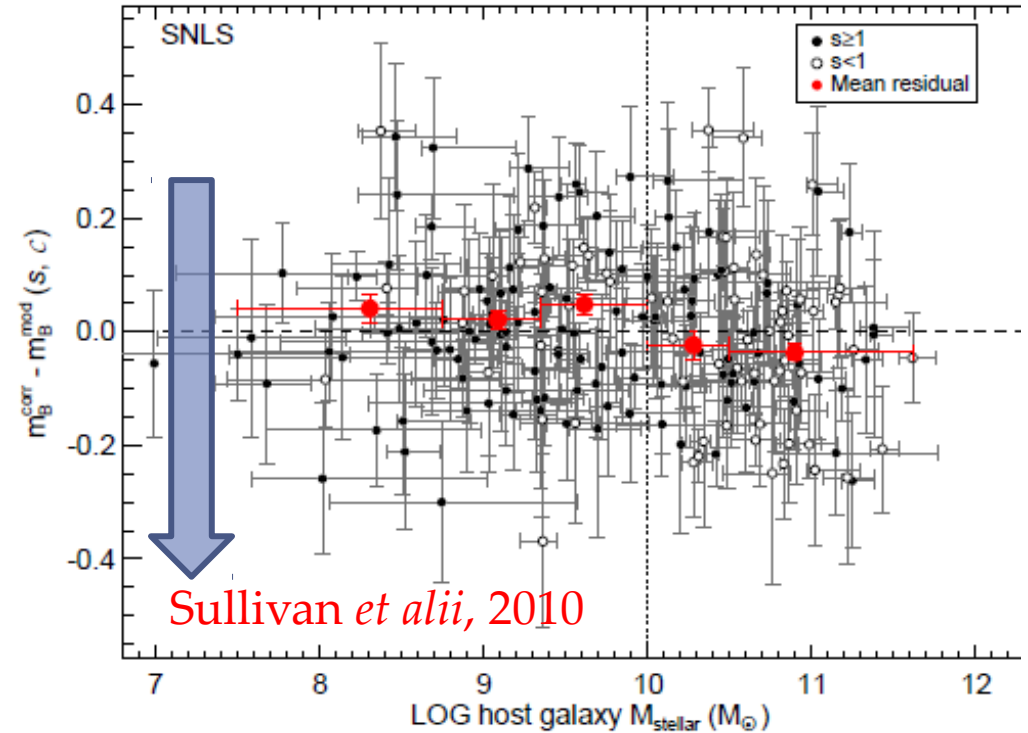
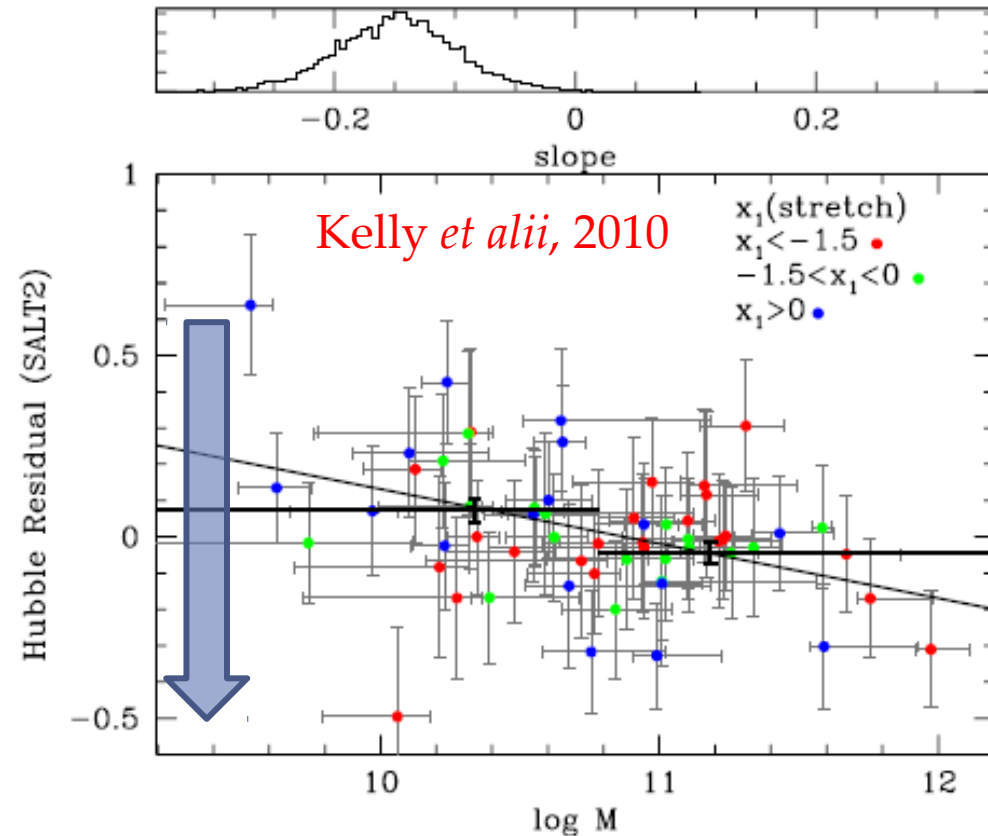


What can we do with these data?

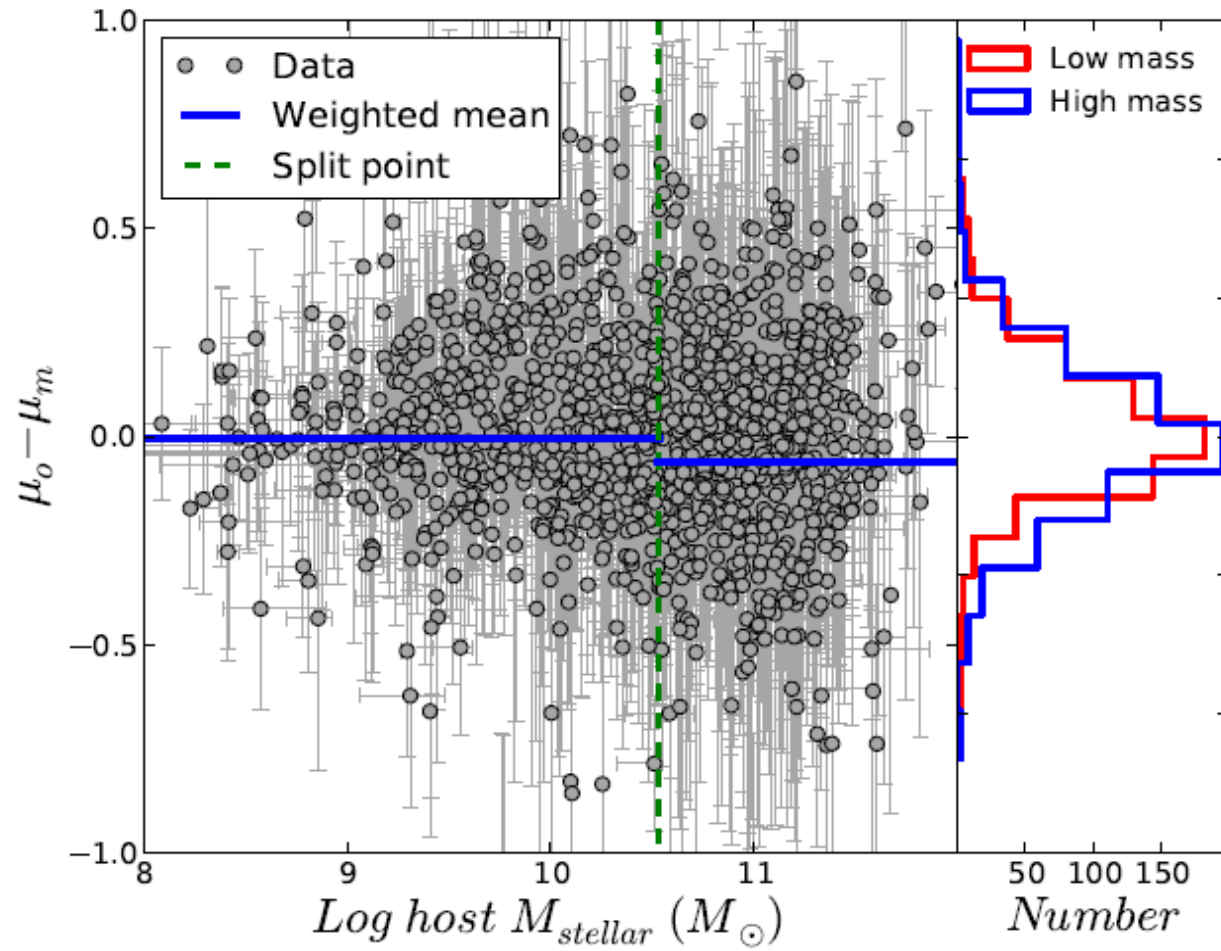
Correlations between host galaxy properties and SNeIa light curve

$0.015 < z < 0.08$

$0.01 < z \lesssim 1$



Uddin et al. 2017



Supernova photometric classification

Comparing the observed fluxes in multiple filters and epochs with the expected according models and templates, we estimate the probability of the event be a type Ia supernova.

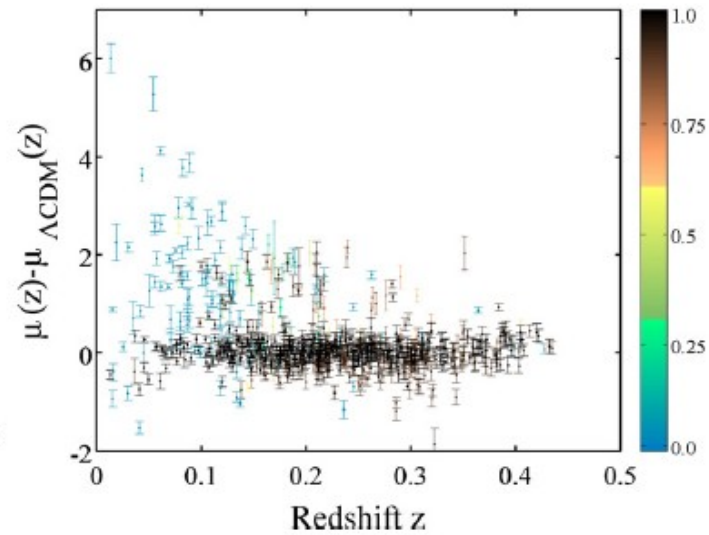
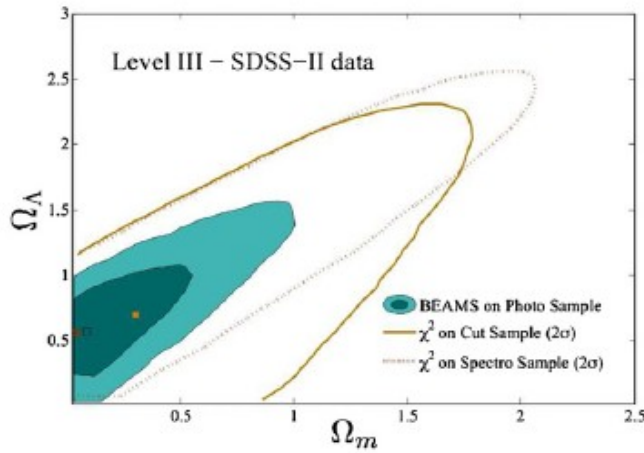
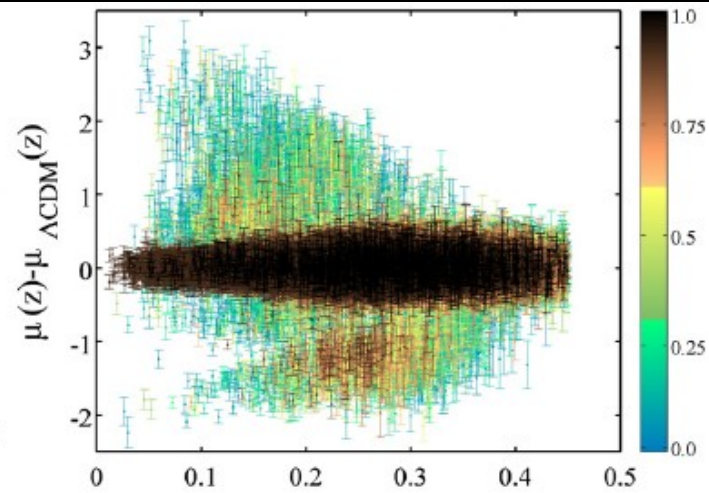
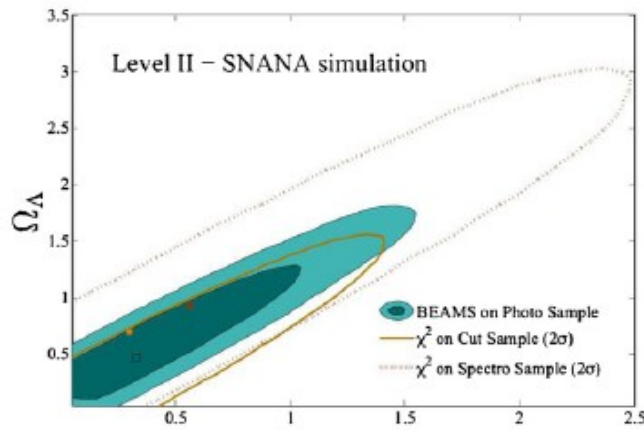
Table 2
The SDSS-II Spectroscopic Sample

Type	Total	Flat Redshift Prior			Spectroscopic Redshift Prior		
		Good ^a	$P_{\text{Ia}} \geq 0.9$	$P_{\text{Ia}} \leq 0.1$	Good ^a	$P_{\text{Ia}} \geq 0.9$	$P_{\text{Ia}} \leq 0.1$
Confirmed SN Ia	508	367	357	2	371	366	1
Confirmed CC SN	80	45	14	30	45	11	32
Confirmed AGN	202	83	32	44	135	86	46
SN with z_{SDSS}	2369	448	248	159	499	317	150
Total	3159	732	539	201	788	599	163

Note.

^a This sample includes SNe that satisfy the following photometric quality criteria: (1) there is at least one epoch of photometry at $-5 < t < +5$ days from peak and another epoch at $+5 < t < +15$ days from peak for the best-fit SN Ia model, (2) there is at least two filter measurements with $S/N > 5$, and (3) the candidate was detected in only a single search season.

Sako et al., *Astrophys.J.* 738 (2011) 162



Hlozek et al., Astrophys.J. 752 (2012) 79

- New observatory in Spain;
- T-80 telescopes fully operational;
- T-250 taking data with pathfinder;
- J-PLUS ongoing;
- S-PLUS ongoing;
- J-Var ongoing;
- J-PAS survey probably starting next year;
- Difference imaging pipeline working;
- So far tests show good performance;
- Hope to find out more about the nature of SNe.

Wait! What about Ioav?! What does he have to do with this?

- During my master and PhD (Ioav was my advisor), my work was essentially theoretical;
- Ioav introduced me to Joshua Frieman and Albert Stebbins and encouraged me to apply for a postdoc at Fermilab;
- Once in Fermilab, I started to work more directly with data analysis and simulation for SDSS and DES;
- Back at UFRJ, Ioav and Maurício negotiated our participation in the J-PAS collaboration which gave me access to all the resources mentioned here;
- In conclusion, in the last twenty years Ioav has been giving me lots of things to work and to think;
- THANKS, IOAV!!