

# Calán-Tololo, CSPI and CSPII optical spectra of Type Ia supernovae

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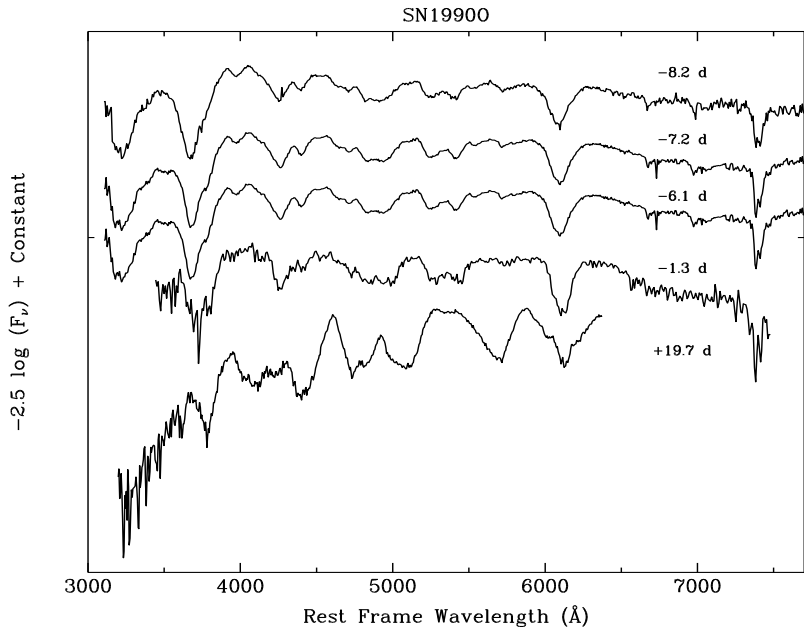
CSP Team Meeting

Pasadena, October 2017

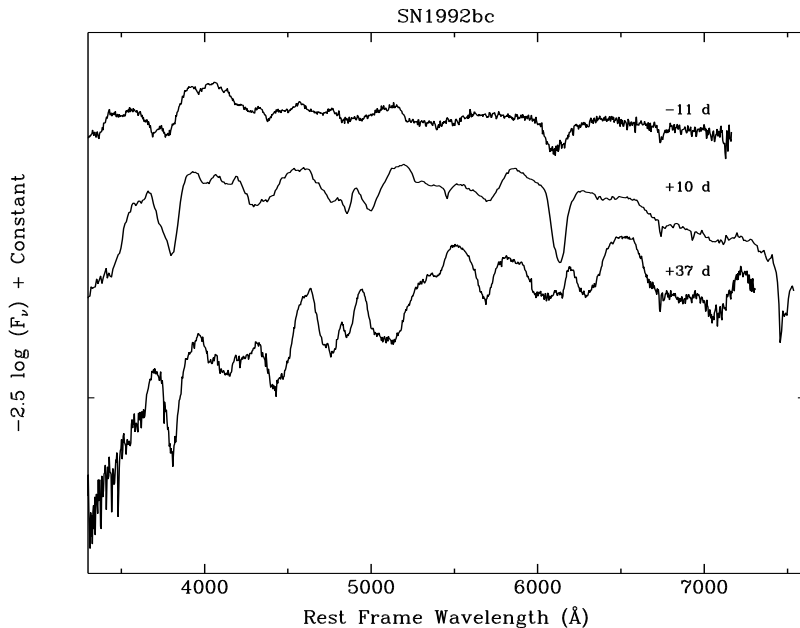
# The Calán-Tololo Survey

- ▶ Hamuy et al. 1996, AJ, 112, 240
- ▶ BVRI light curves for 29 type Ia supernovae.
- ▶ From the 29 supernovae in Hamuy et al. 1996, 26 have been observed spectroscopically at or near maximum ( $\pm 7$  days) by the Calán-Tololo team.
- ▶ There are 52 unpublished spectra from the Calán-Tololo sample.
- ▶ In addition we analysed spectra for 18 supernovae observed by the same team later.
- ▶ We considered 194 spectra from which  $\sim 60$  are unpublished.
- ▶ We have measured expansion velocities and equivalent widths for selected features in the near maximum available optical spectra.

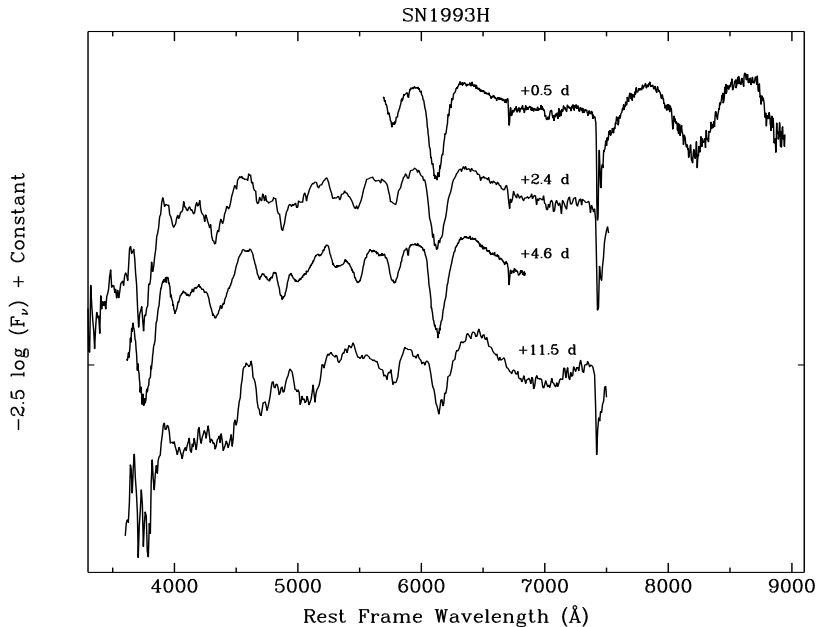
# Calán-Tololo examples: SN1990



# Calán-Tololo examples: SN1992bc



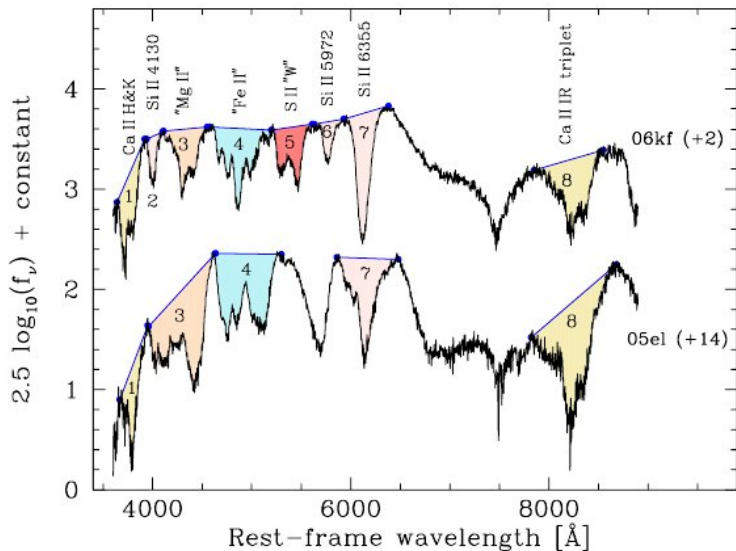
# Calán-Tololo examples: SN1993H



## CSP I Type Ia optical spectroscopy

- ▶ First release: Folatelli et al. 2013, ApJ, 773, 53 (F13).
- ▶ 604 previously unpublished spectra of 93 type Ia supernovae.
- ▶ Phases from -12 to +150 days from B-band maximum light.
- ▶ Expansion velocities from absorption minima.
- ▶ Pseudo-equivalent widths as in Garavini et al. 2007, A&A, 470, 411
- ▶ All the SNe considered have definitive photometry allowing comparison of photometric and spectroscopic properties.

## Pseudo-equivalent widths prescription

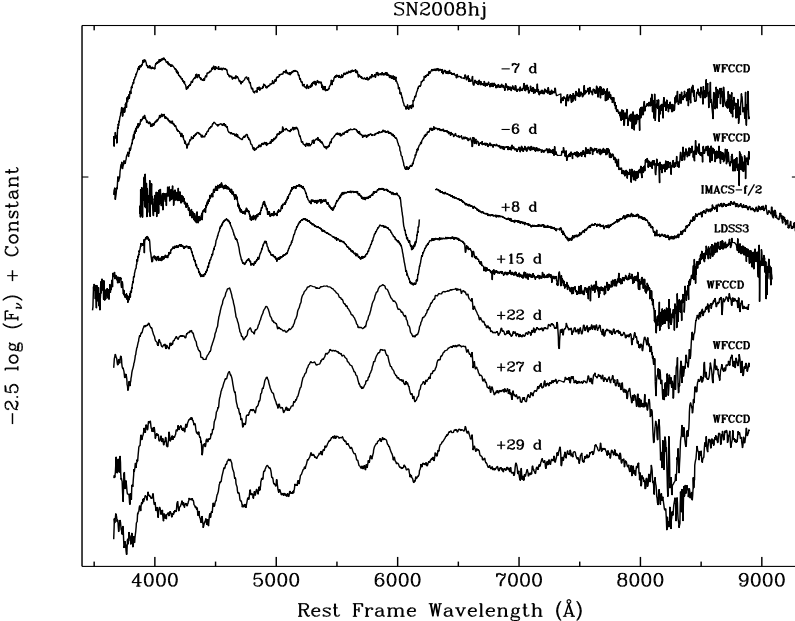


## CSPI unpublished Type Ia spectra

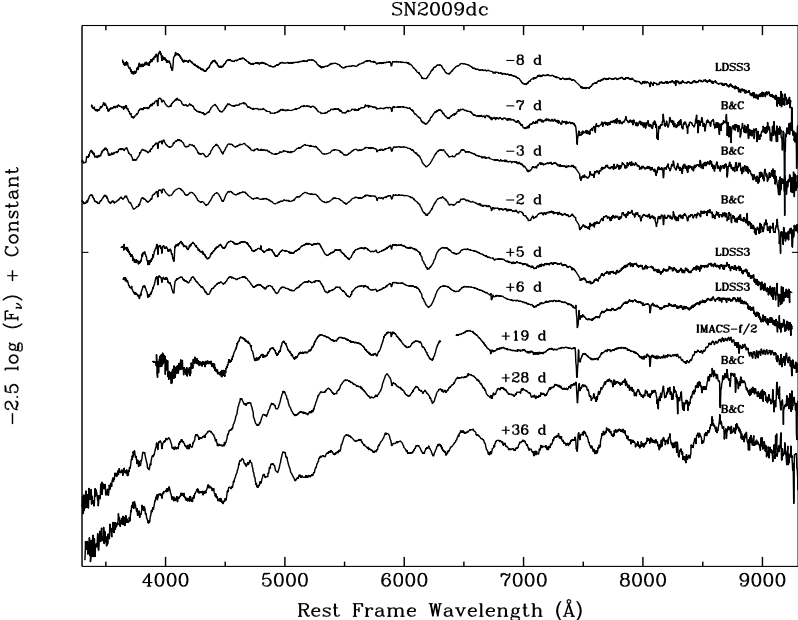
- ▶ There is now final photometry for 26 SNe Ia not included in Folatelli et al. 2013
- ▶ For 18 among those SNe we have CSP spectra obtained at or near maximum.
- ▶ The total number of new CSPI type Ia spectra to be released is 108.



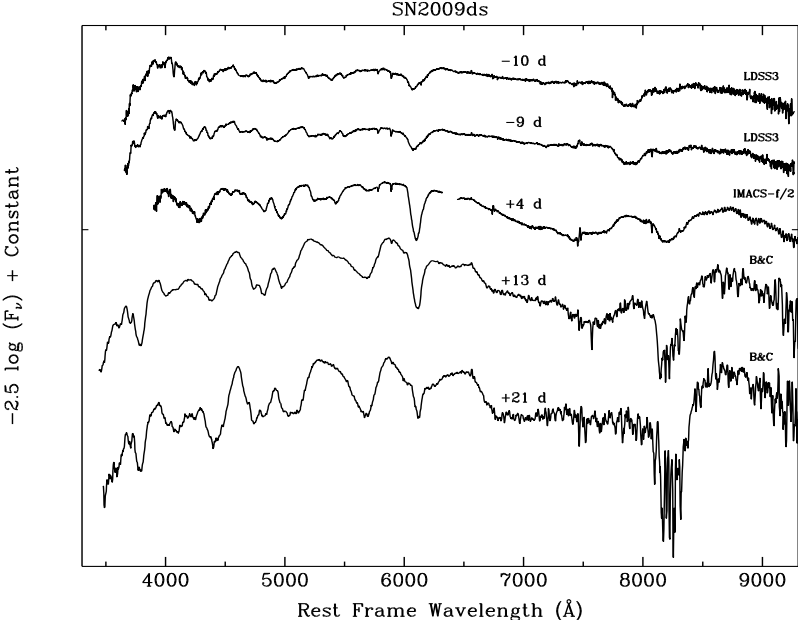
# CSPI: SN2008hj



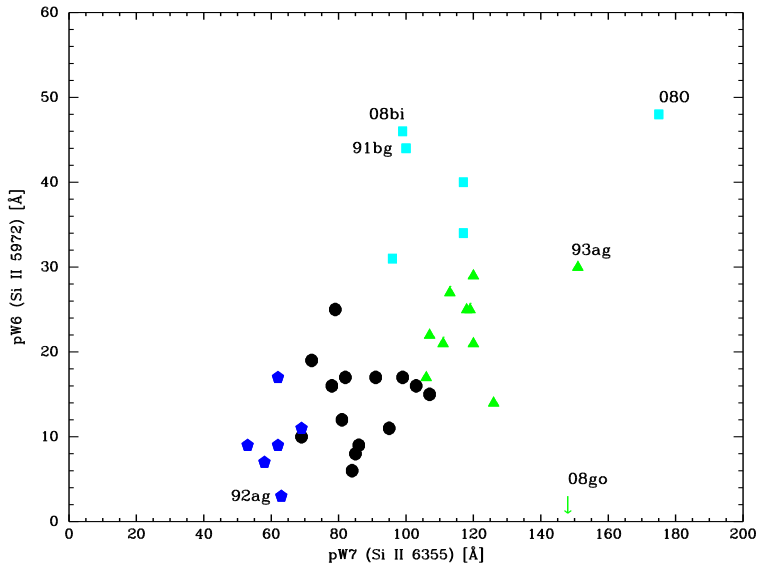
# CSPI: SN2009dc



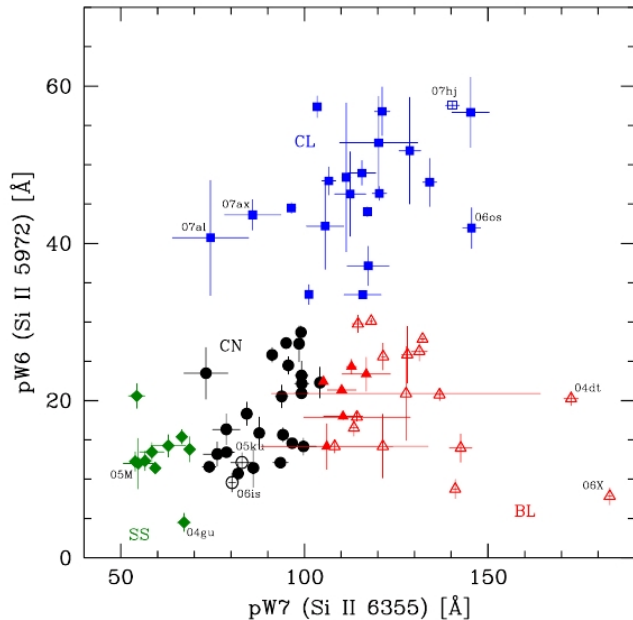
# CSPI: SN2009ds



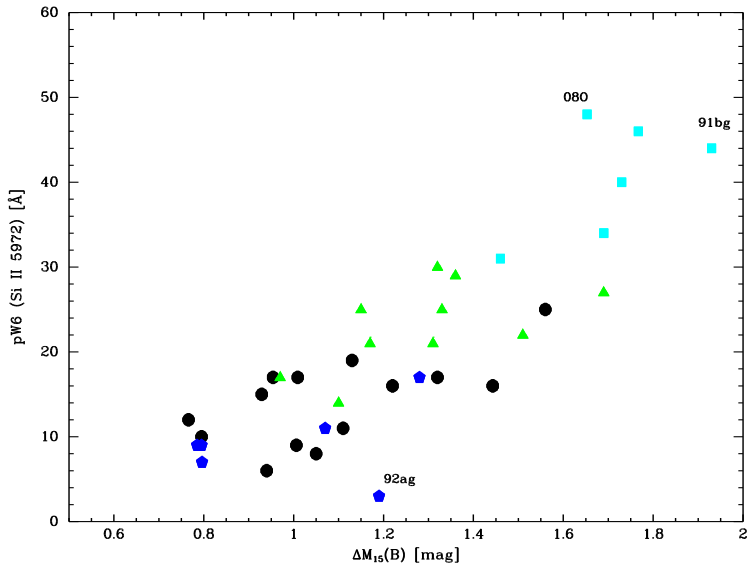
# Branch subtypes for CSP I new plus CT spectra



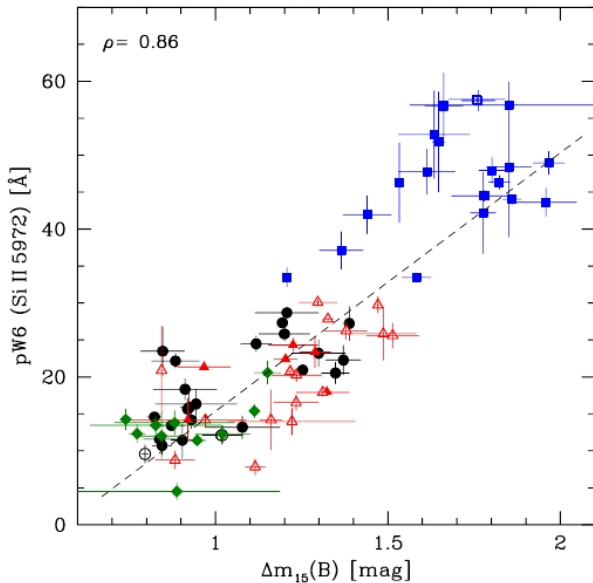
# Branch subtypes for the F13 sample



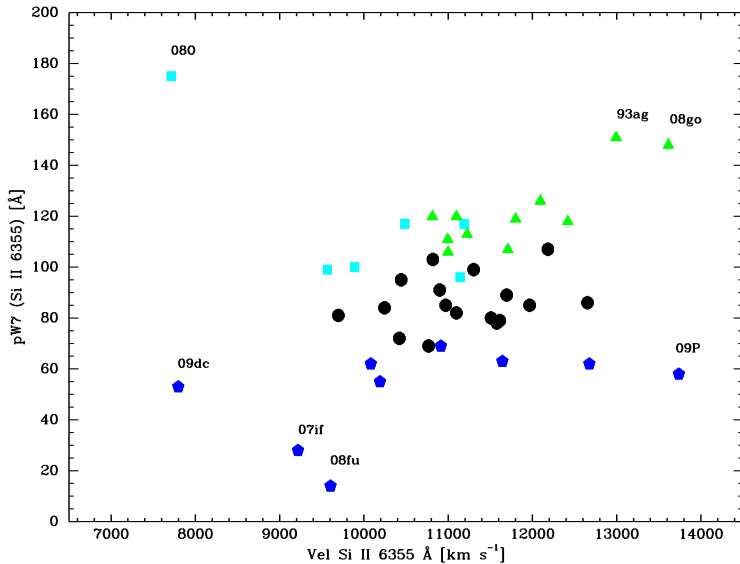
# Pseudo-equivalent width of Si II 5972 vs. decline rate



# pW6 vs. $\Delta m_{15}(B)$ , F13 sample



# pW7 vs expansion velocity (Wang 2009)





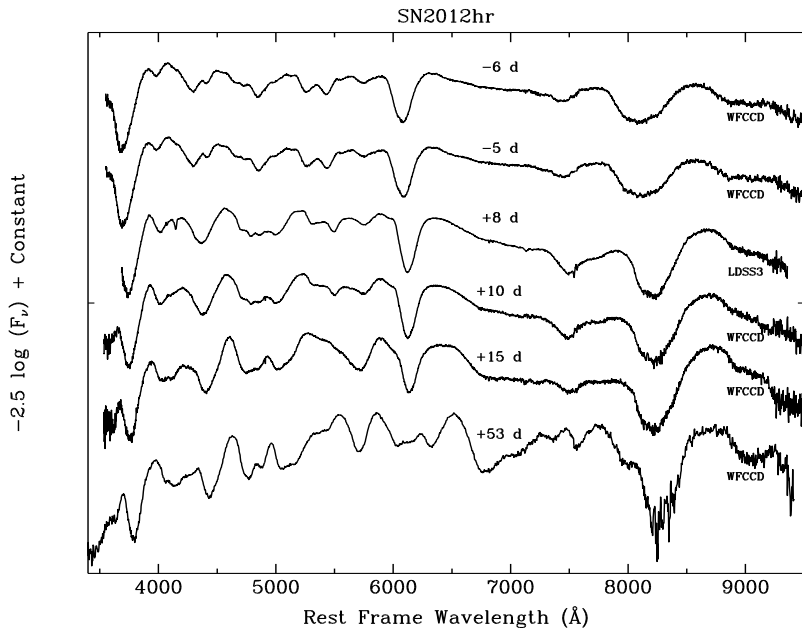
## CSP II optical spectroscopy of Type Ia SNe

- ▶ Optical spectroscopy was not our priority.
- ▶ Nevertheless we've gathered some NOT, du Pont, and Magellan optical spectra, produced a number of spectral classifications, etc.
- ▶ First campaign: 34 SNe Ia, 18 with spectra at or near maximum; 90 sp. in total (71 from CSP); 11 SNe without spectra.
- ▶ Second campaign: 60 SNe Ia, 32 with spectra at or near maximum; 112 sp. (94 from CSP); 21 SNe without spectra.
- ▶ Third campaign: 72 SNe, 50 with spectra at/near max.; 80 sp. (42 from CSP); 19 SNe without spectra.
- ▶ Fourth campaign: 72 SNe, 58 with spectra at/near max; 154 sp. (129 from CSP); 4 SNe without spectra.

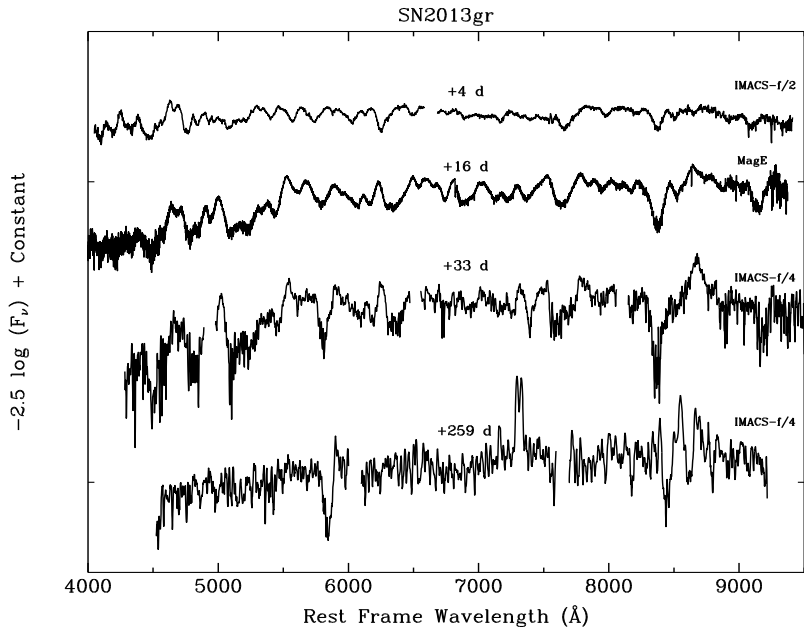
## CSP II Type Ia optical spectroscopy summary

- ▶ 183 SNe Ia observed spectroscopically
- ▶ 158 with spectra near maximum light
- ▶ 436 spectra in total (336 from CSP)
- ▶ Phases run from -12 days (LSQ15alq, NOT) to +500 days (SN2012fr, IMACS) related to B-band maximum light.
- ▶ Number of spectra per object goes from 1 (103 objects) to 27 (1 object).
- ▶ Resources:
  - LCO: du Pont (WFCCD, B&C, echelle), Baade (IMACS), Clay (LDSS3, MagE, MIKE)
  - NOT-ALFOSC
  - ESO-NTT via PESSTO (EFOSC)
  - Also: HET, SALT, Yunnan, Lick, Faulkes, APO, WHT, P200, HCT, Keck

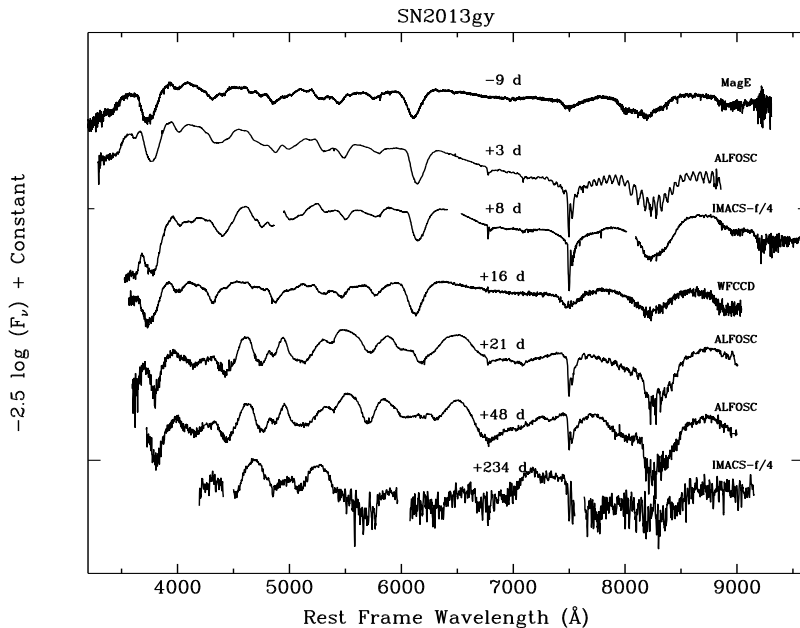
# CSP II examples: SN2012hr



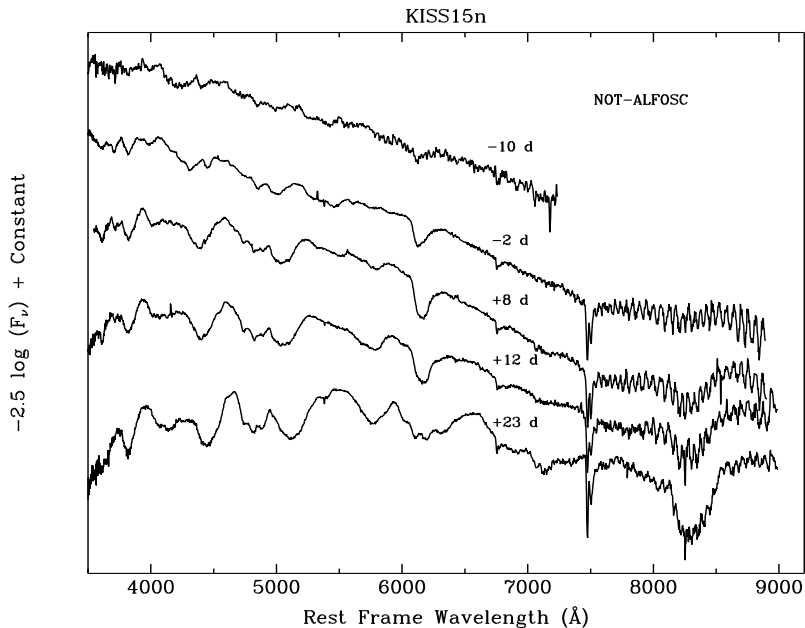
# CSP II examples: SN2013gr



# CSP II examples: SN2013gy



# CSP II examples: KISS15n



## Where we are now

Calan-Tololo + CSPI (unpublished): analysis complete.

Measurements are complete for CSP II first 3 campaigns and most of the 4th campaign.

We searched WiseRep for other available data near maximum light and are adding those to our analysis.

When available, we also measure Si II 6355 velocities around 20 days past maximum to compare with the relation with decline rate found in F13.

Several interesting objects to discuss, for example: flat velocity evolution in 2012bl, 2013ao (peculiar?) and others, LSQ14age: only one sp. by PESSTO, high velocities ( $\sim 15000 \text{ km s}^{-1}$ ), redshift checked ok; ASASSN-15cb classified as a normal Ia but perhaps a 91T-like SN, etc.

Hoping to show full results soon (whatever it means).