The Nearby Supernova Factory

A Unique Handle on SNIa Physics and Cosmology

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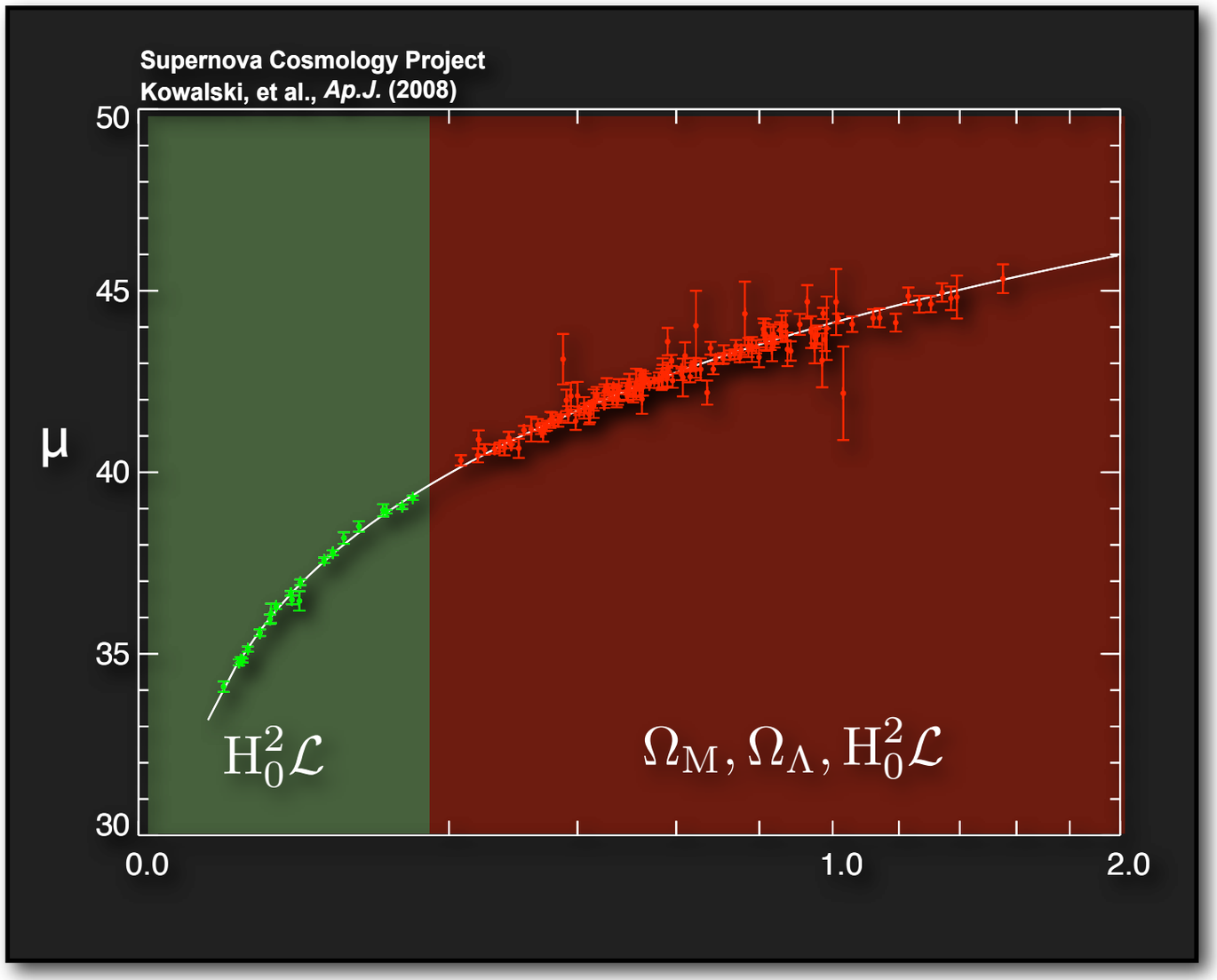
Overview:

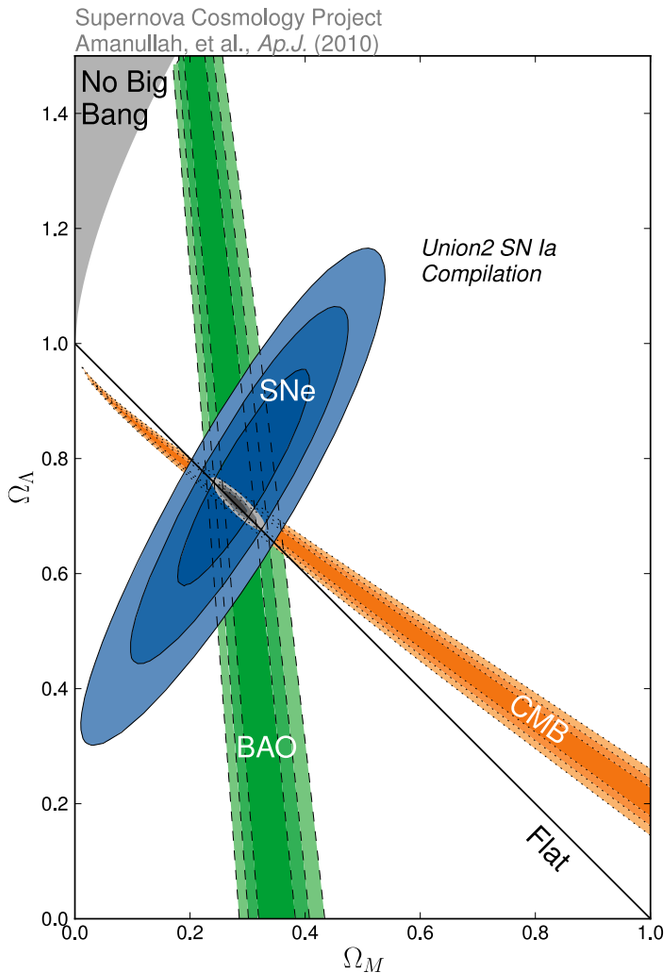
- Cosmology with Supernova Ia
- The Nearby Supernova Factory (SNfactory)
- Spectrophotometry
- Sharpening the Standard Candle

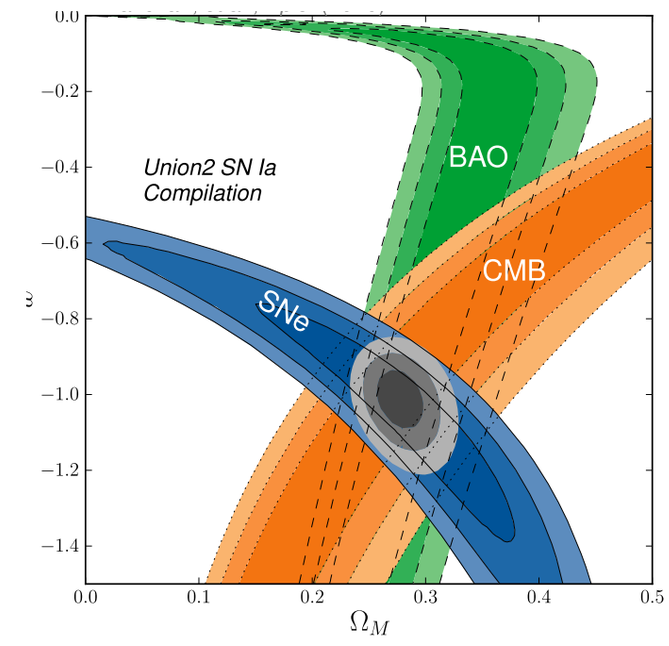
Cosmology and Supernovae Ia

Precision Cosmology:

- Baryon Acoustic Oscillations (BAO)
- Cosmic Microwave Background (CMB)
- Supernovae Ia (SNIa) as Standard Candles

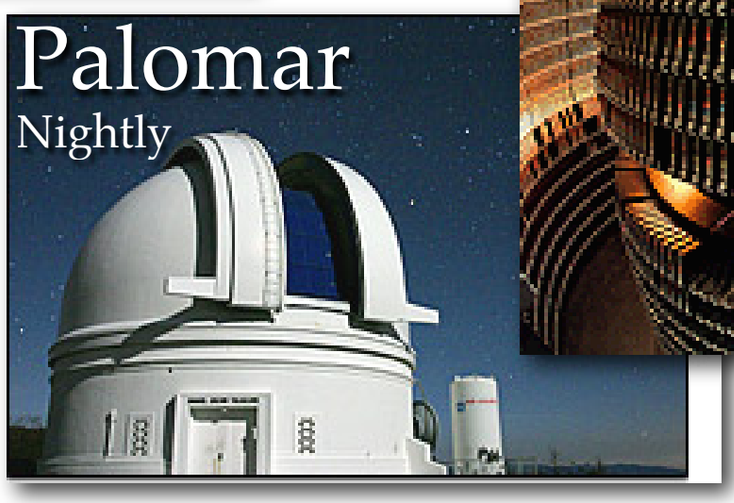






The Nearby Supernova Factory

Discover

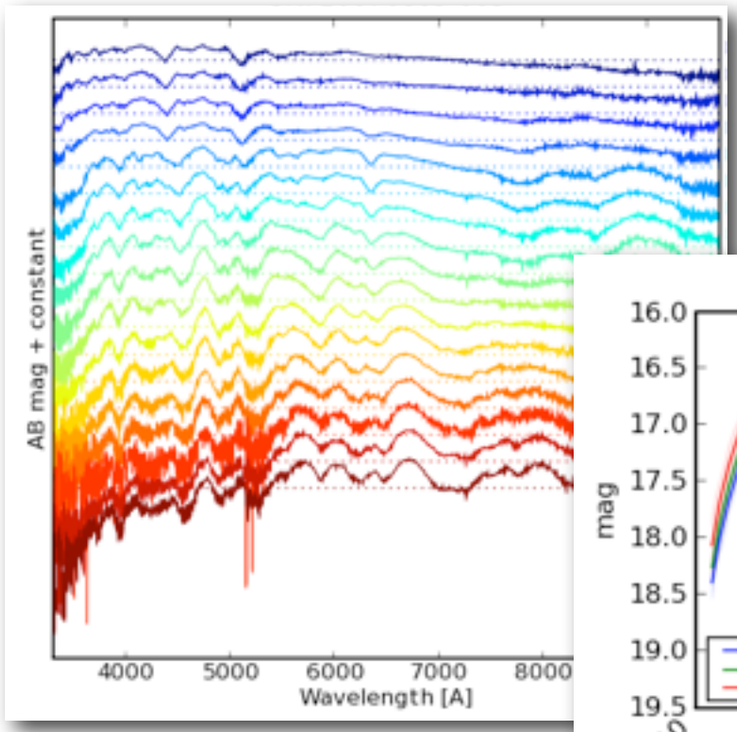


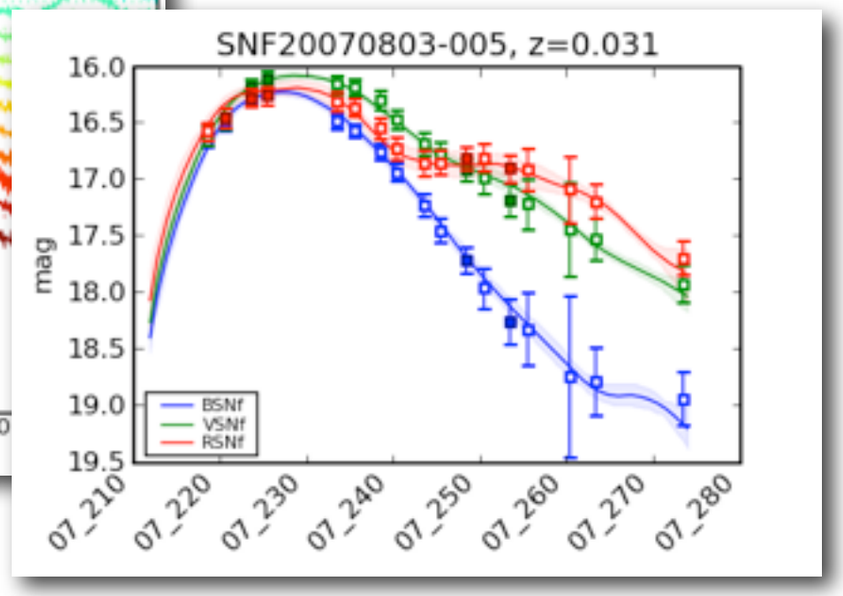
Search ended Sept 2008;
>1000 SNe discovered in 28 months of searching
185 followed in detail, 0.02 < z < 0.09

Observe

Custom, unique spectrometer designed for nearby SN obs

Analyze



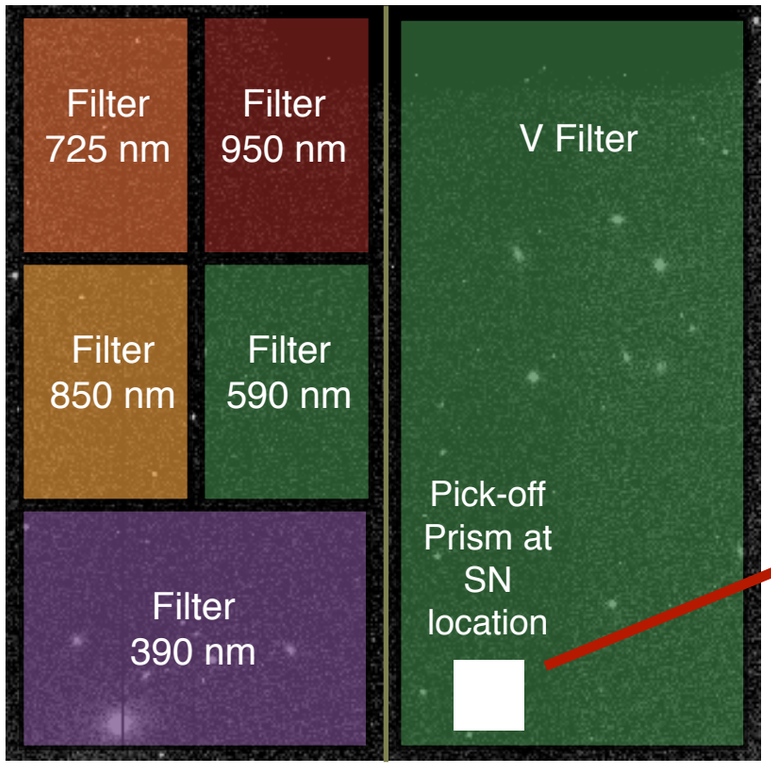


Spectroscopic Follow-up: SNIFS

- SNIFS: SuperNova Integral Field Spectrometer
- Custom designed and built by SNfactory for nearby SNe
- Remotely operated every 2-3 nights
  on UH 2.2m on Mauna Kea

SuperNova Integral Field Spectrometer (SNIFS)

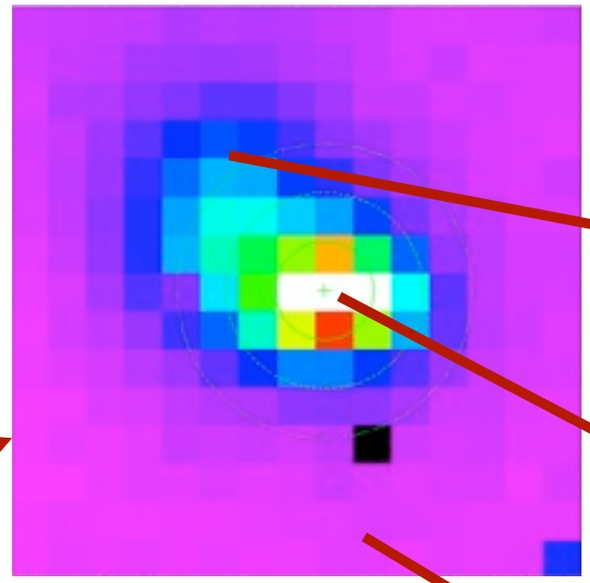
9.4’ x 9.4’ FOV; 0.14”/pix



Photometric Channel field of view

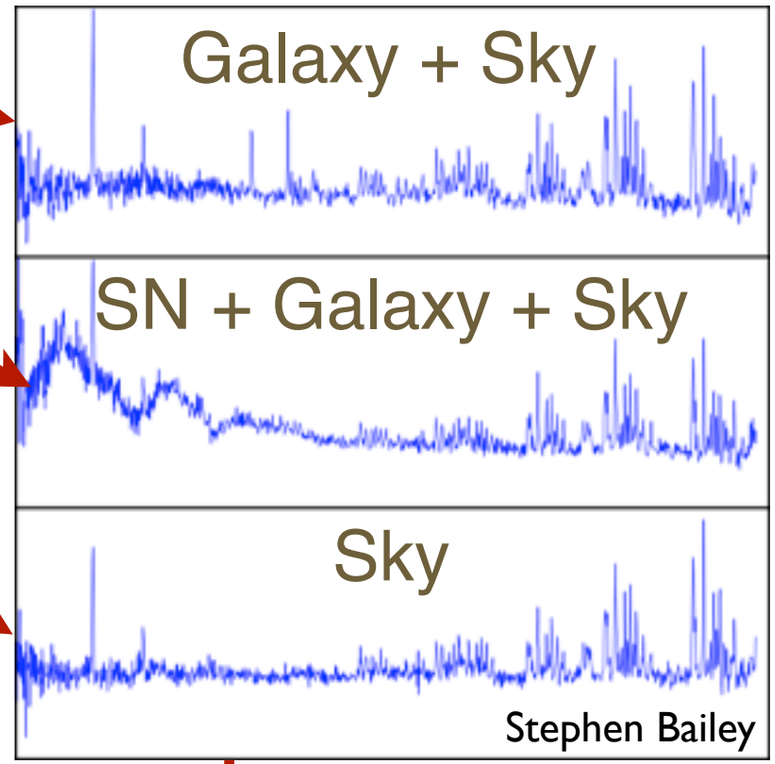
Guiding Channel field of view

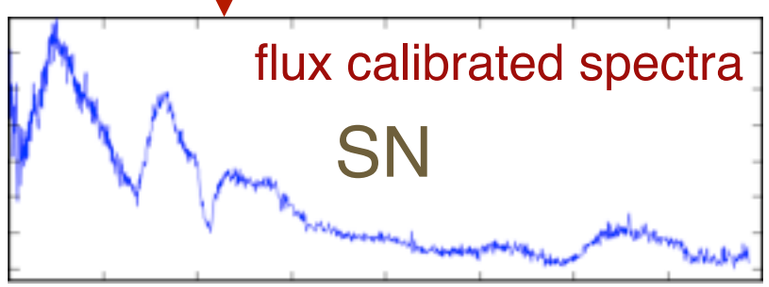
6” x 6” FOV; 0.4”/spaxel



Microlens array to two channel spectrograph (15x15=225 spectra)

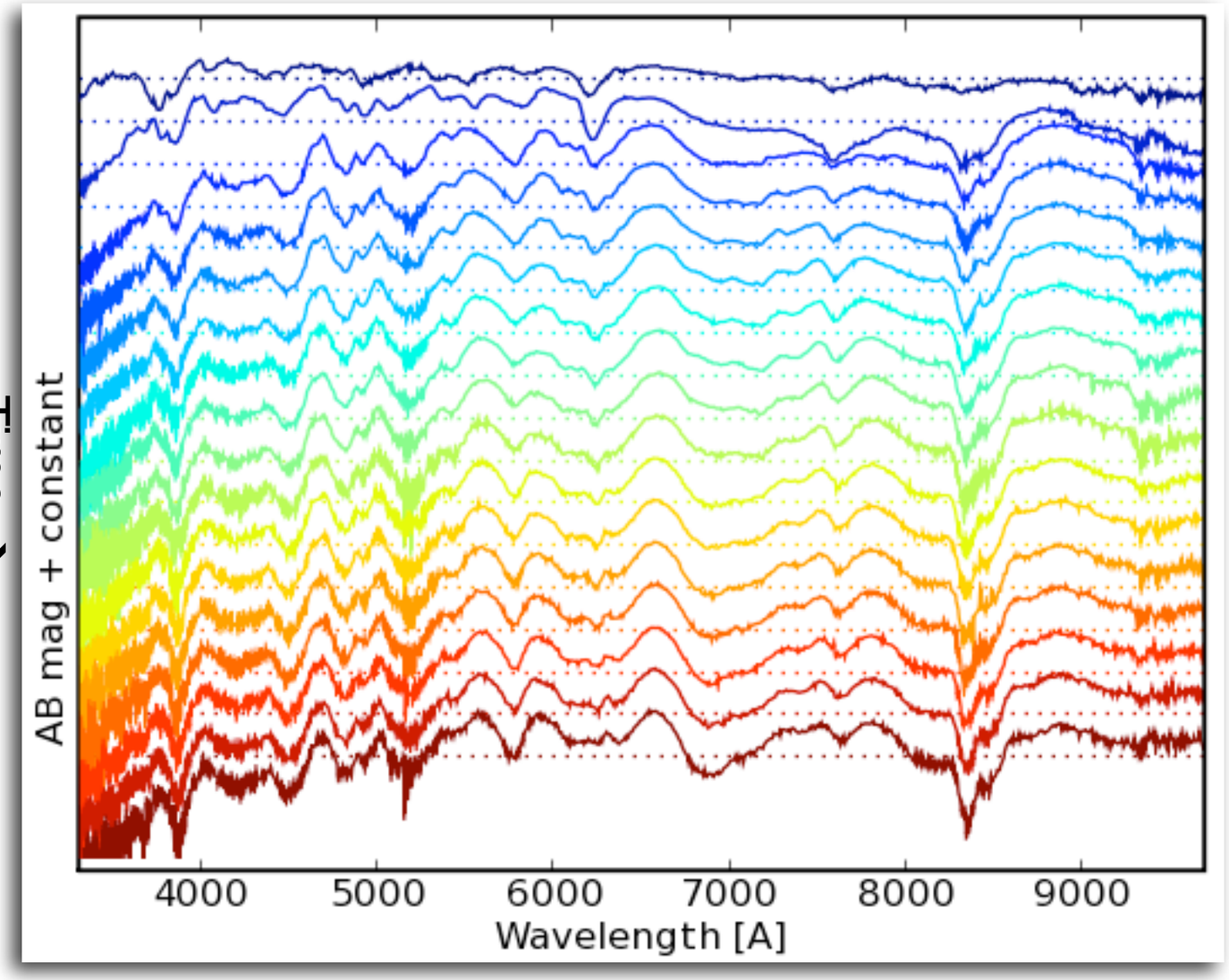
R channel:





320 – 520, 510 – 1000 nm coverage

Supernova Spectrophotometry

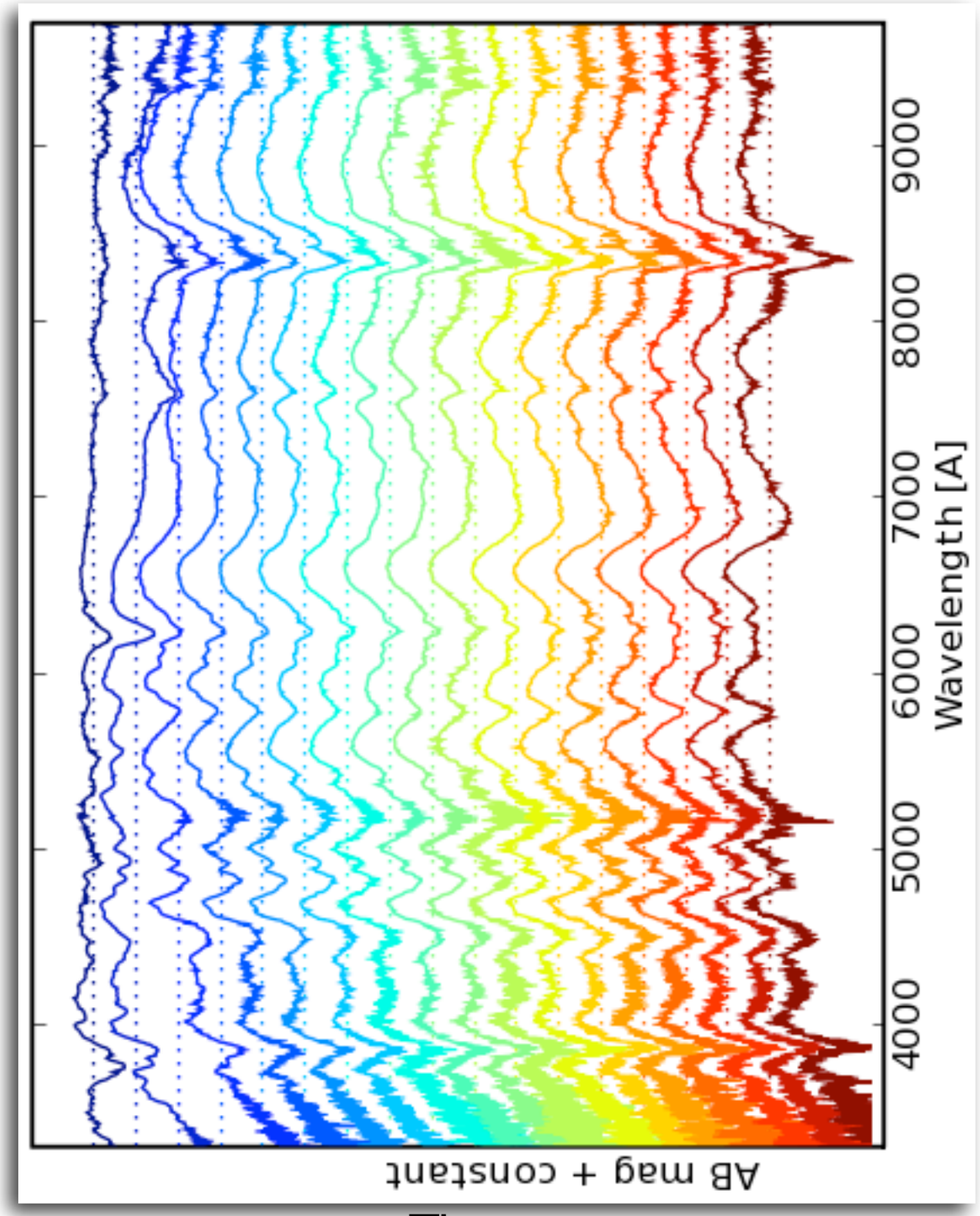


- Median: 15 Observations/SN
- first spectrum 4 days before maximum

➡Photometry can be synthesized in **any** filter

➡Dense sample of spectra

Supernova Spectrophotometry



Time ➔

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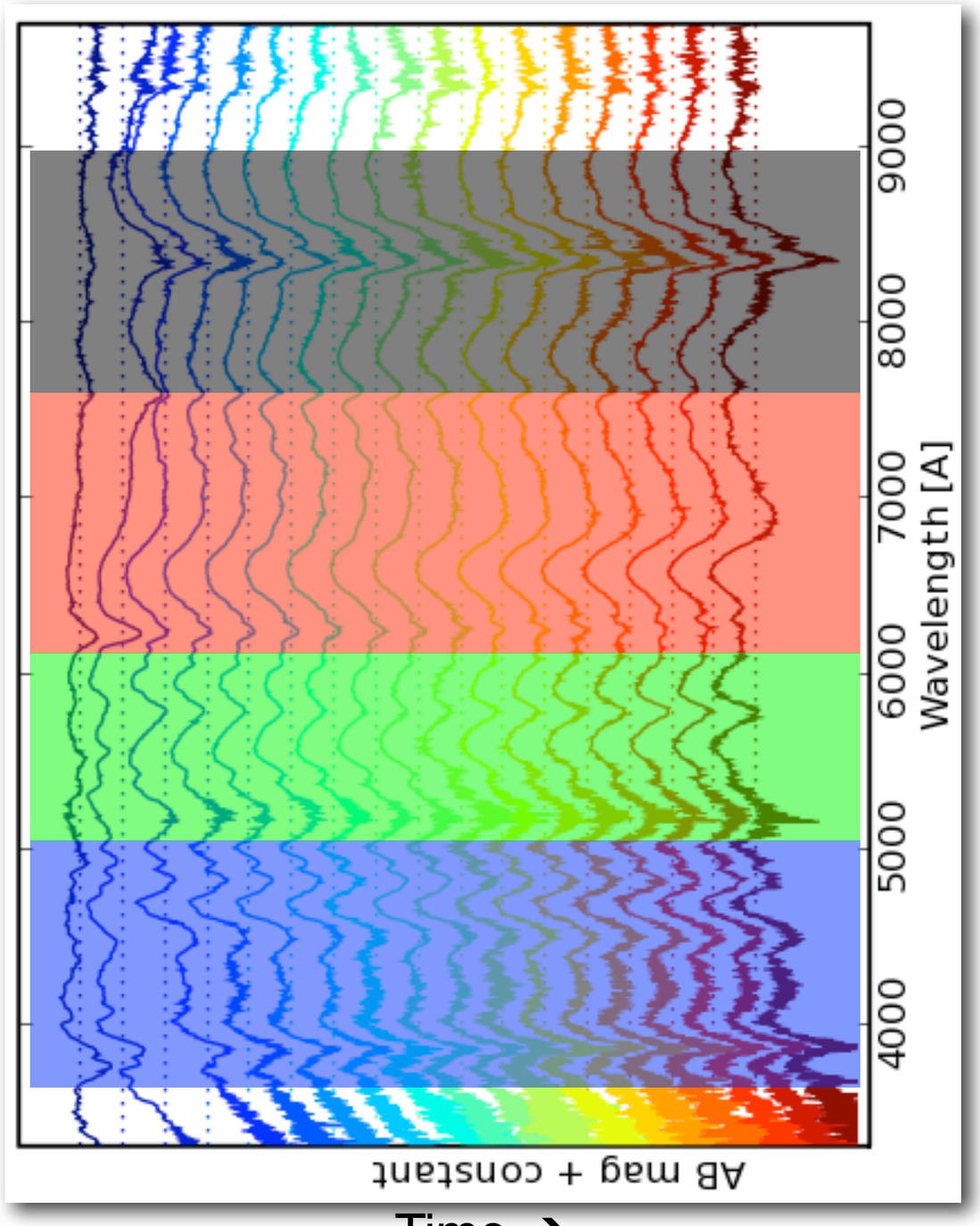
Supernova Spectrophotometry



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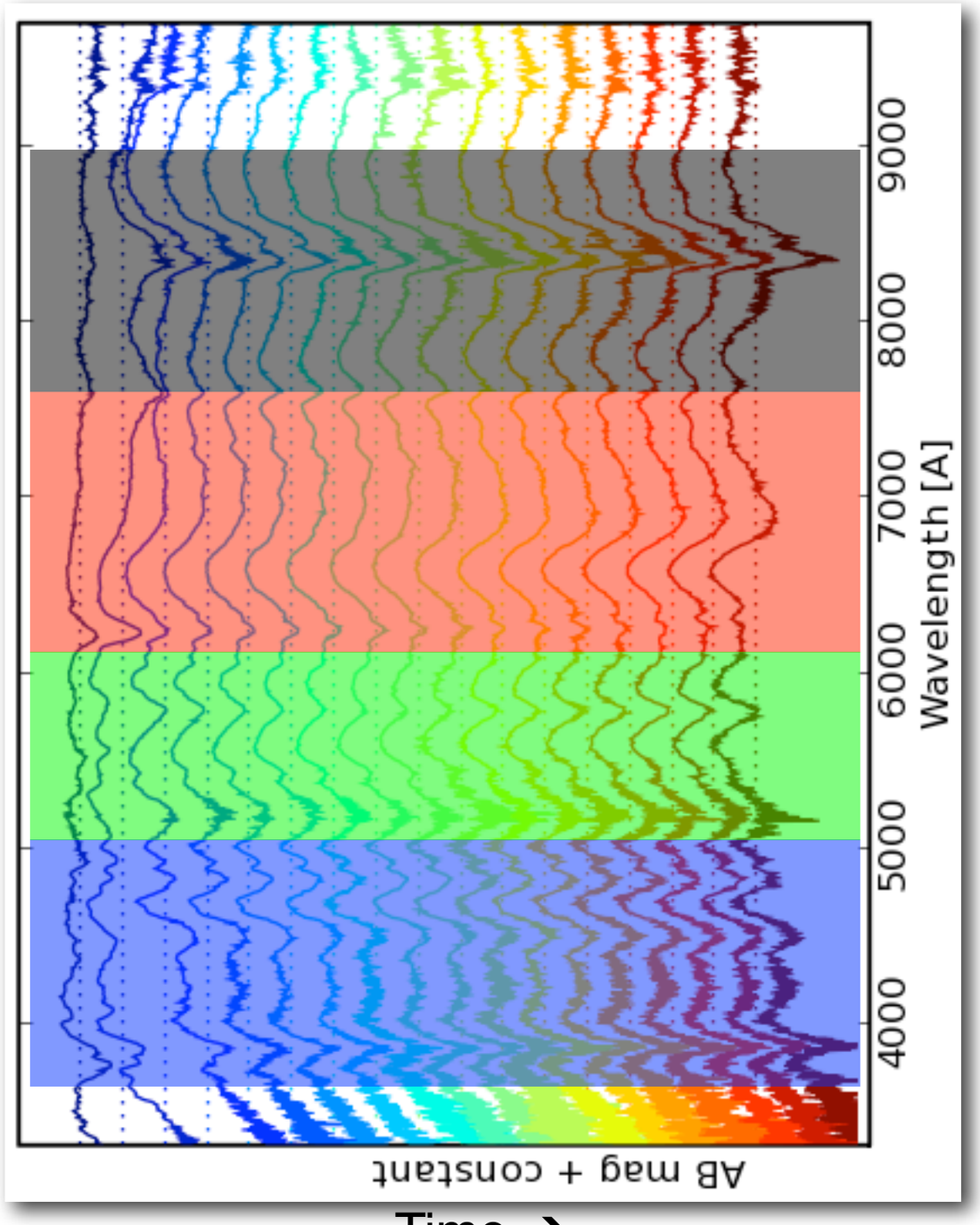
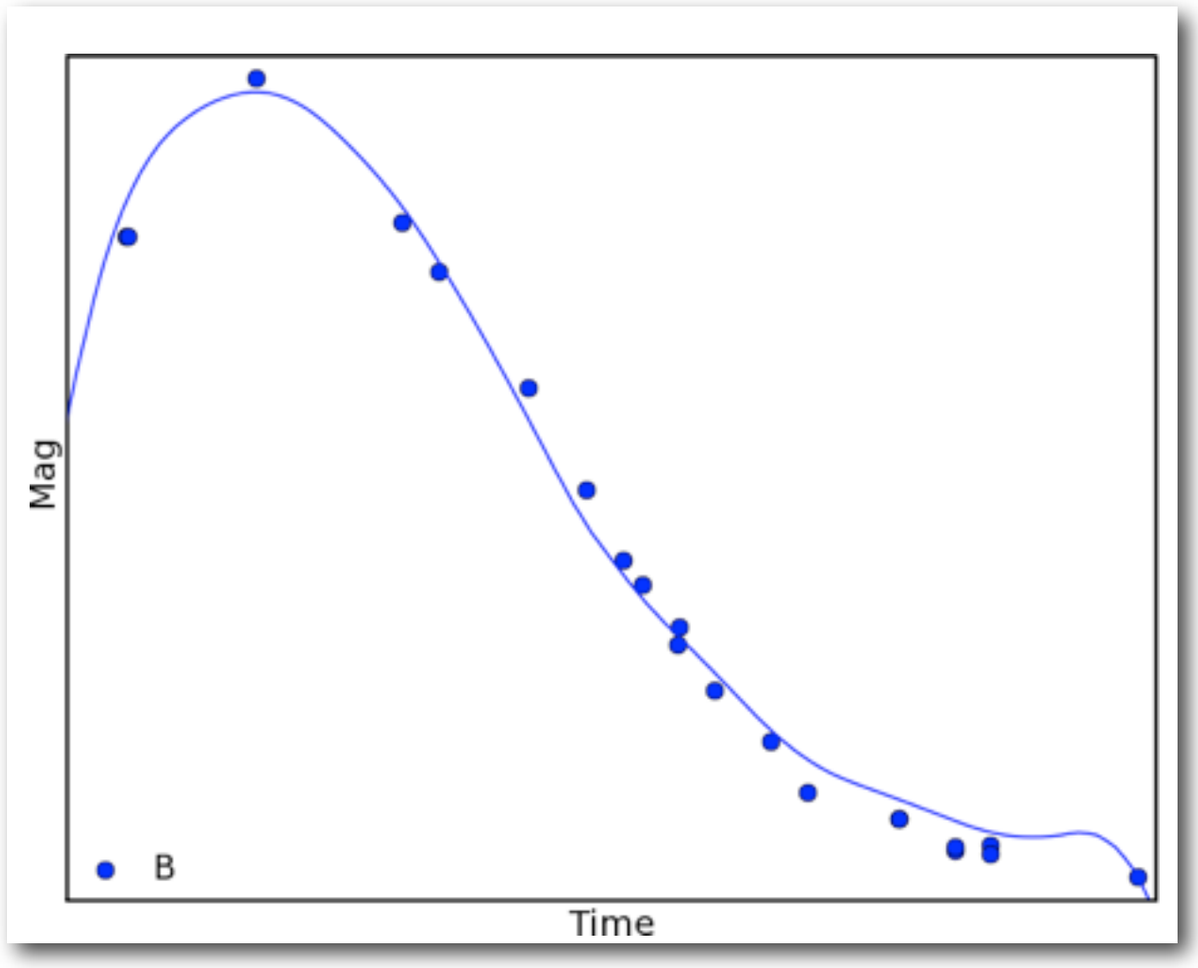


Time ➔



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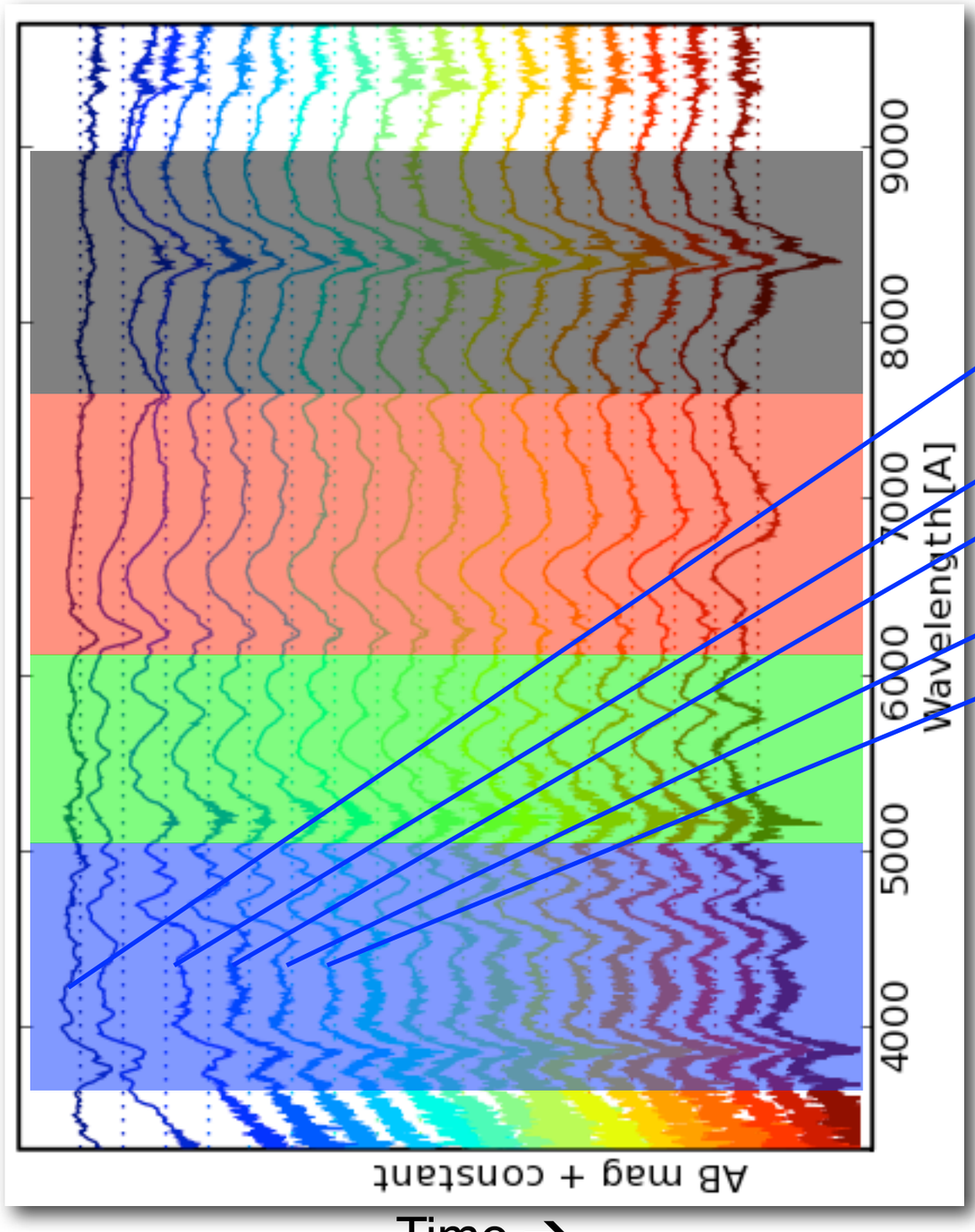

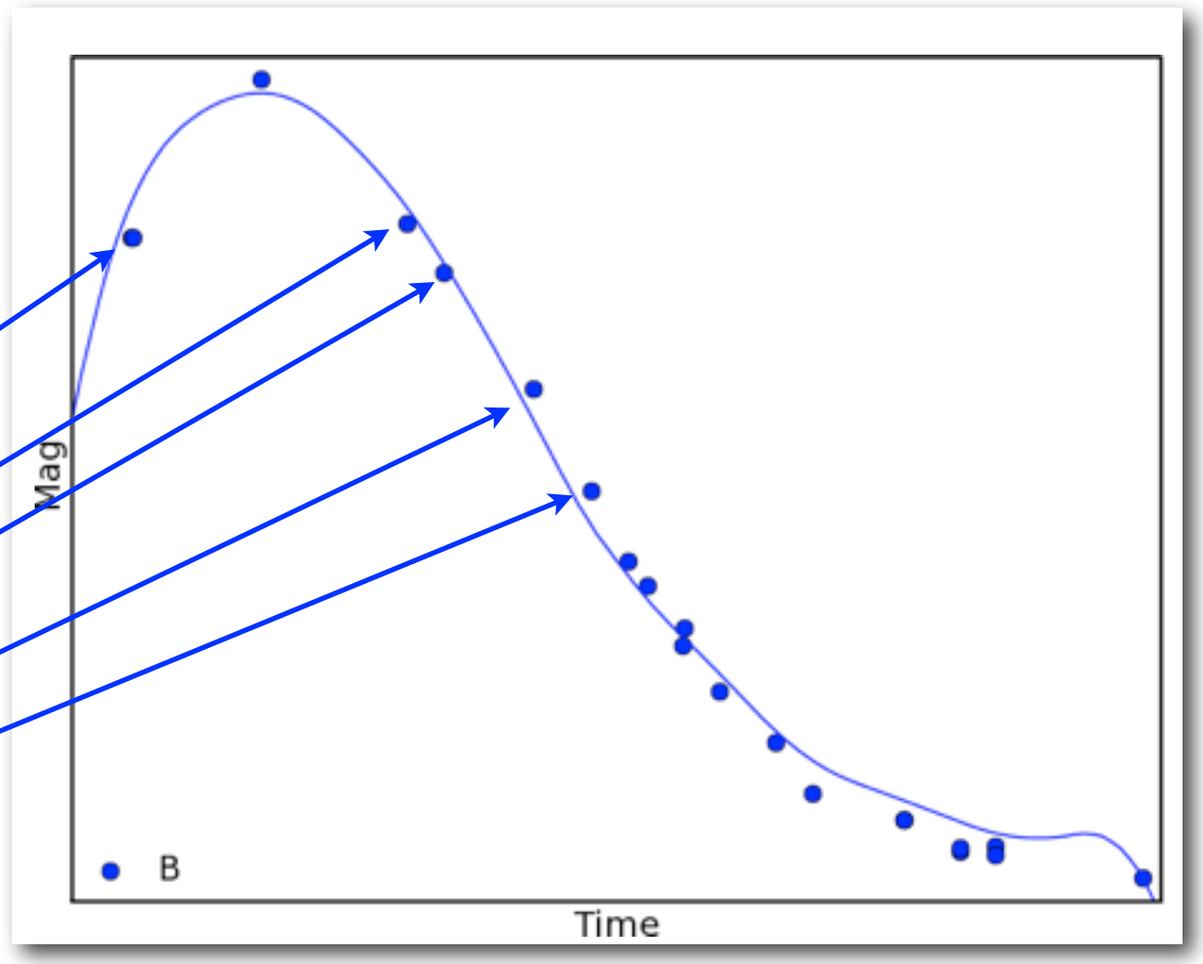

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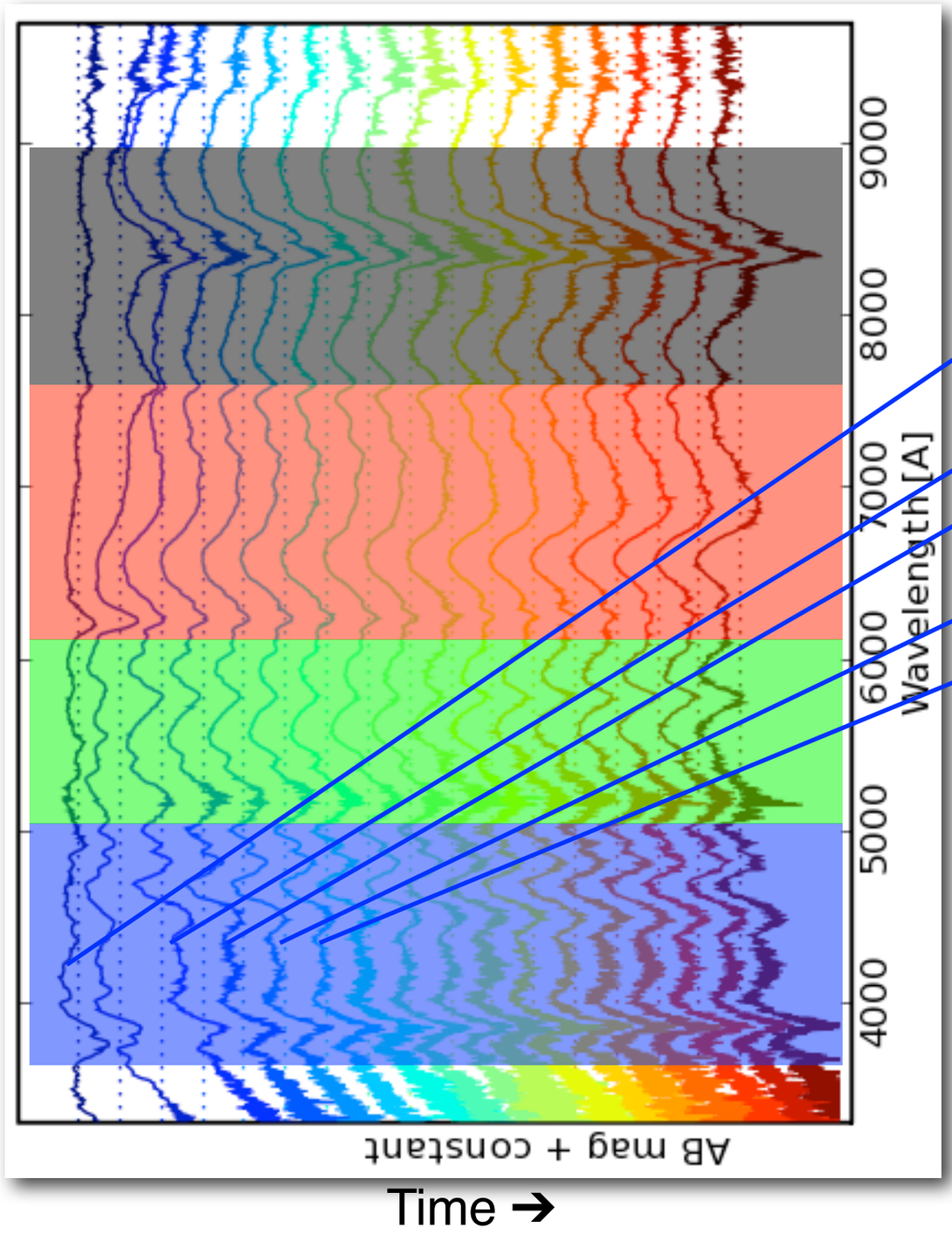

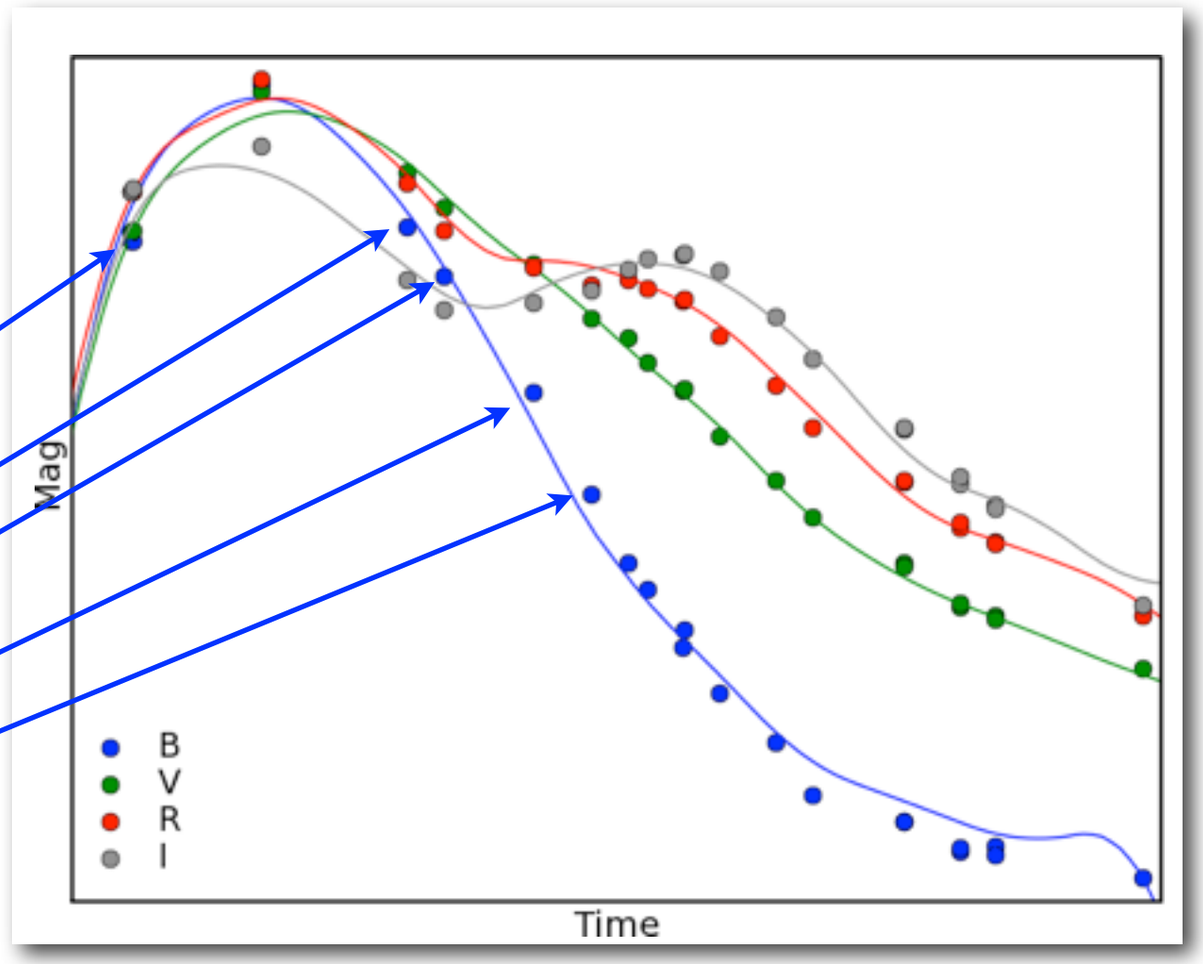

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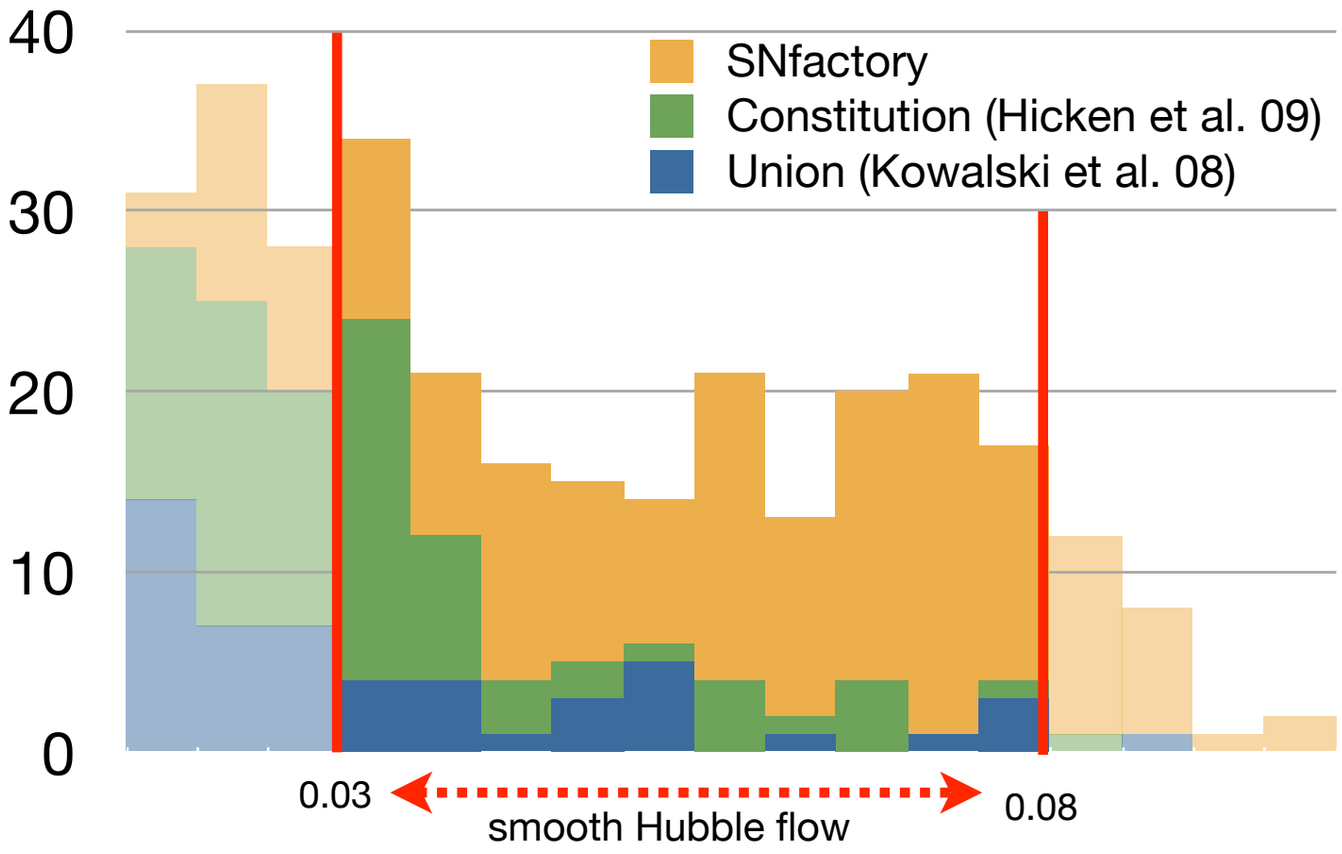
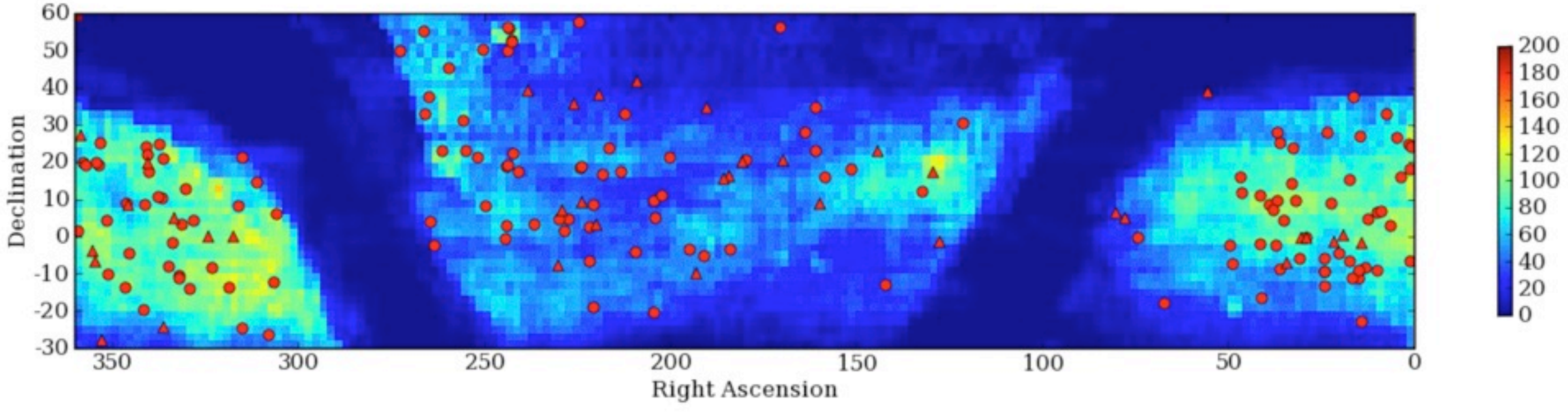
SNfactory - Data set

~ 400 SN Ia discovered
~ 185 SN Ia followed-up



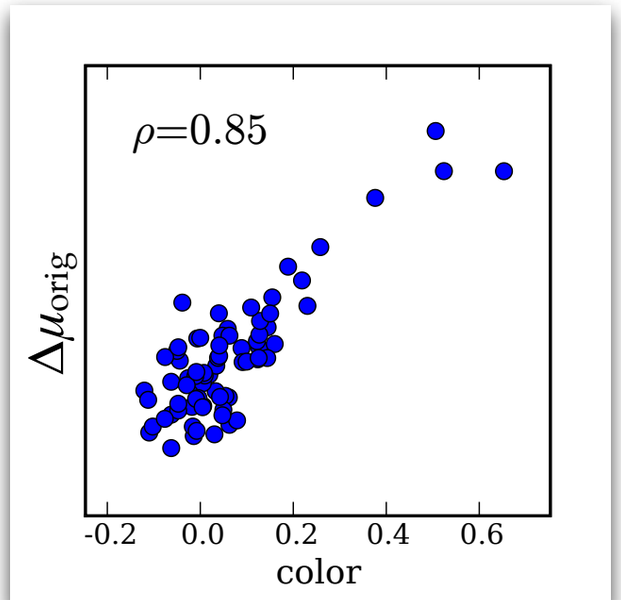


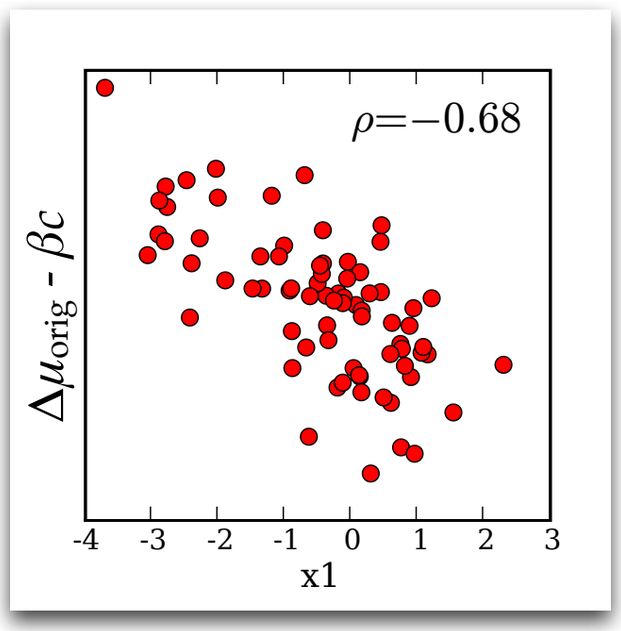
SNfactory - Science Goals

- Refine zero-point of Hubble diagram
- Physics of SNIa (intrinsic properties, host environment, progenitors, explosion models, ...)
- K-correctionless Hubble diagram
- Sharpen SNIa as standard candles

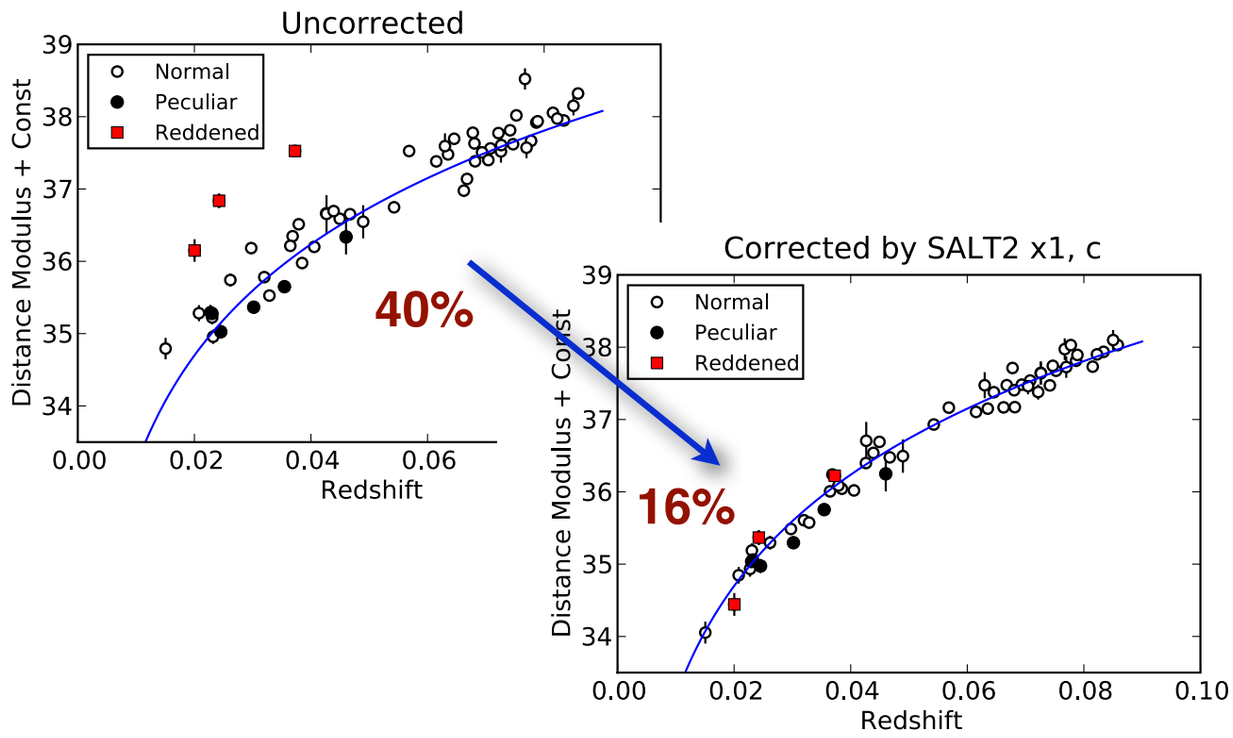
Sharpening the Standard Candle - Lightcurve Level

Two Classic Corrections





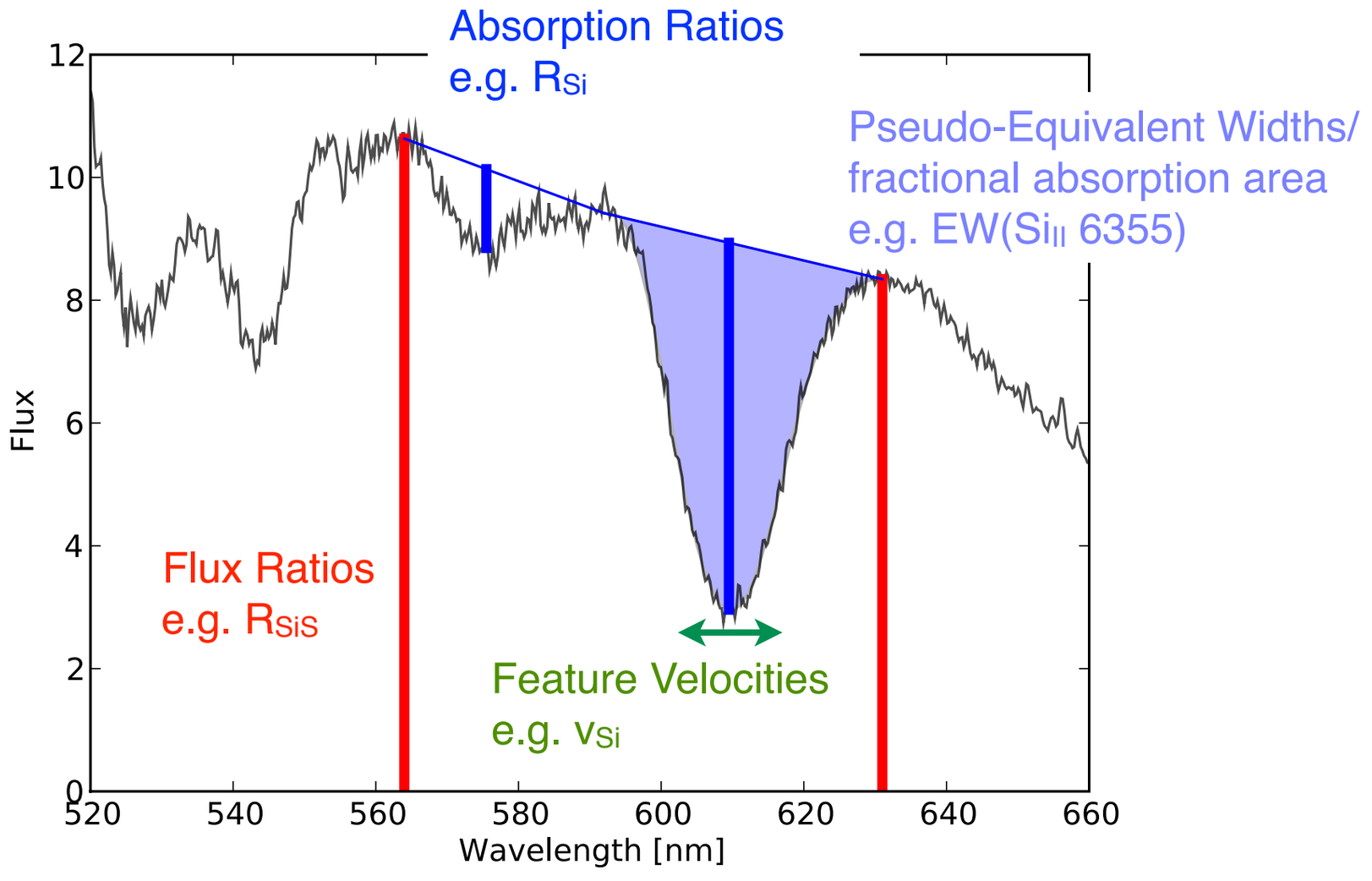
- Classic corrections
  - Color: Bluer = Brighter
  - Lightcurve shape: Broader = Brighter
- ~40% → ~16 – 20% scatter
- Can we do better with spectral info?
  - Search correlations of features with residuals



Supernovae Ia as Standard Candles

Spectral features approach:

try to correlate specific spectral features
with absolute brightness



Use a more general approach:

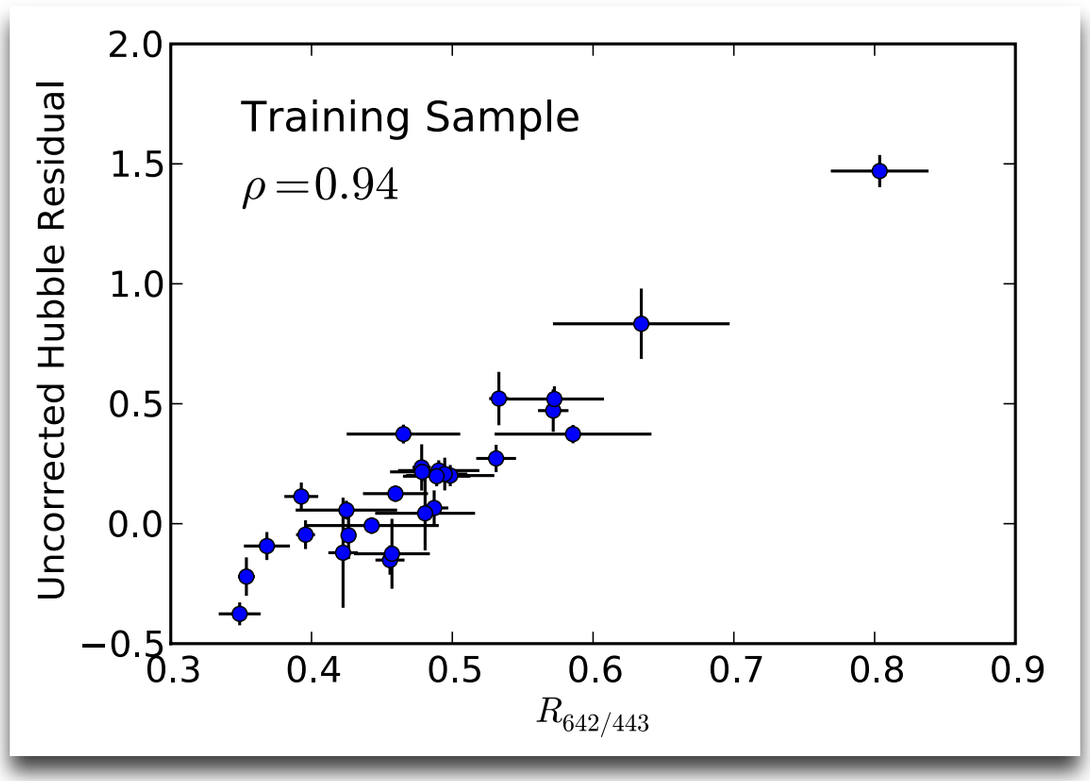
➡ look at all flux ratio combos - not just specific peaks

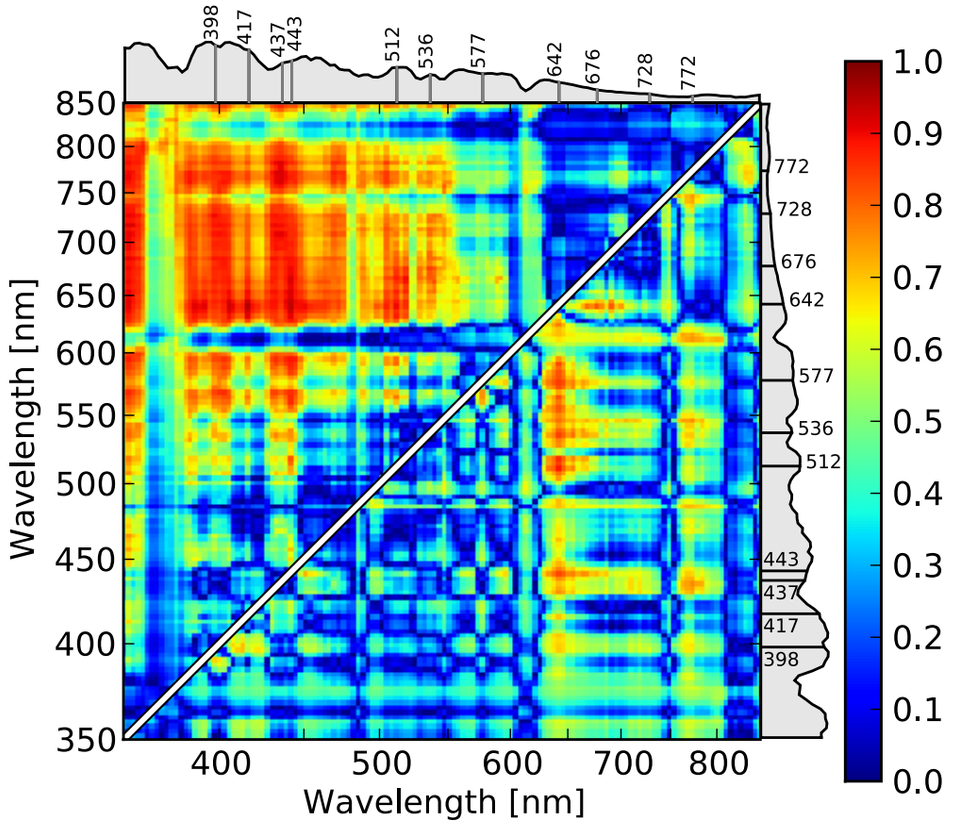
Generalized Flux Ratios

More General approach

(Bailey et al. A&A 500, L17-L20, 2009)

- Consider **all flux ratio $R_{x/y} = F_x/F_y$ combos**
- Search for correlations with uncorrected Hubble residuals
- Find the ratio that minimizes the scatter in the Hubble diagram
- SNfactory spectra (flux calibrated, within ± 2.5 days peak brightness)
- Search with training set (28 SNe), cross check with validation set (30 SNe)





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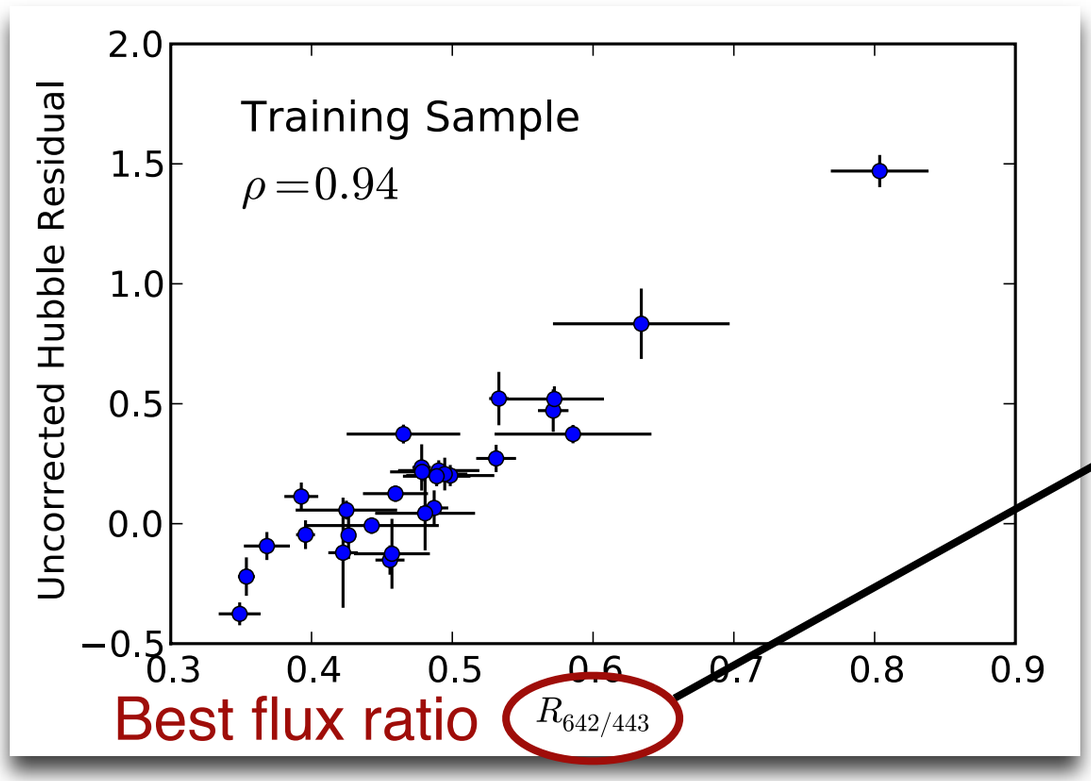
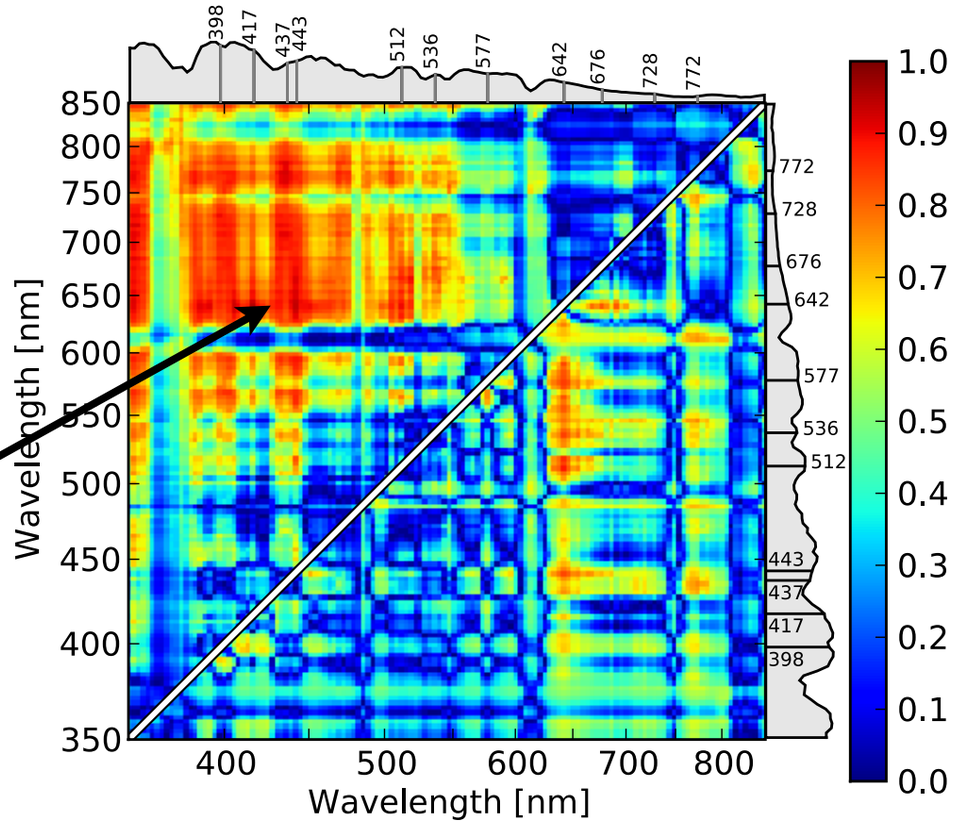
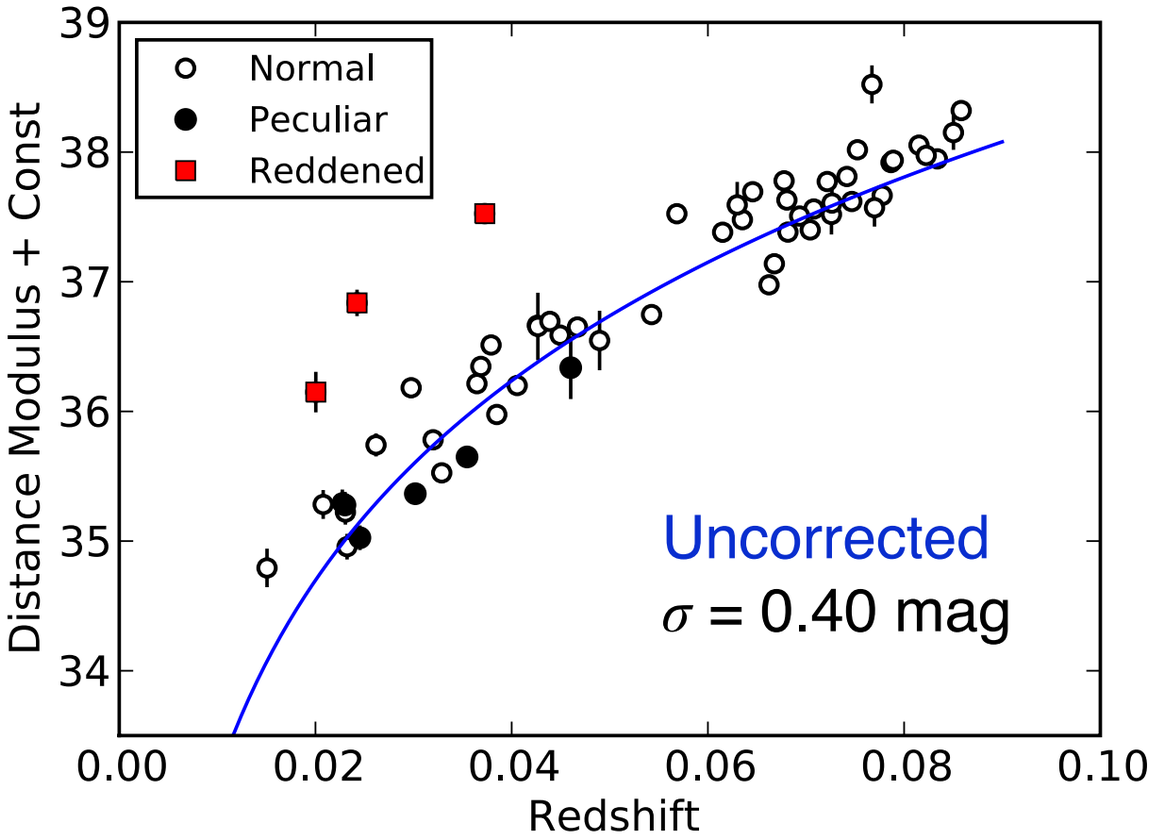




Using One Single Flux Ratio $R_{642/443}$



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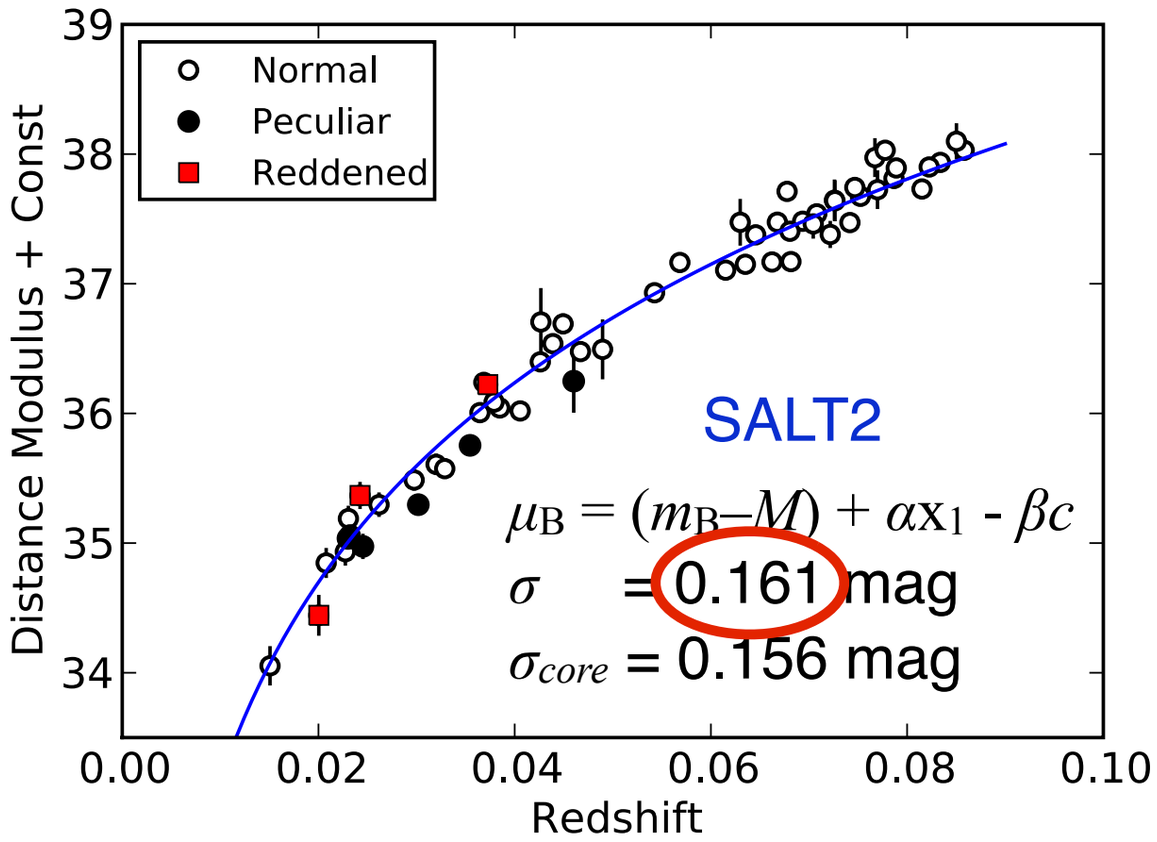
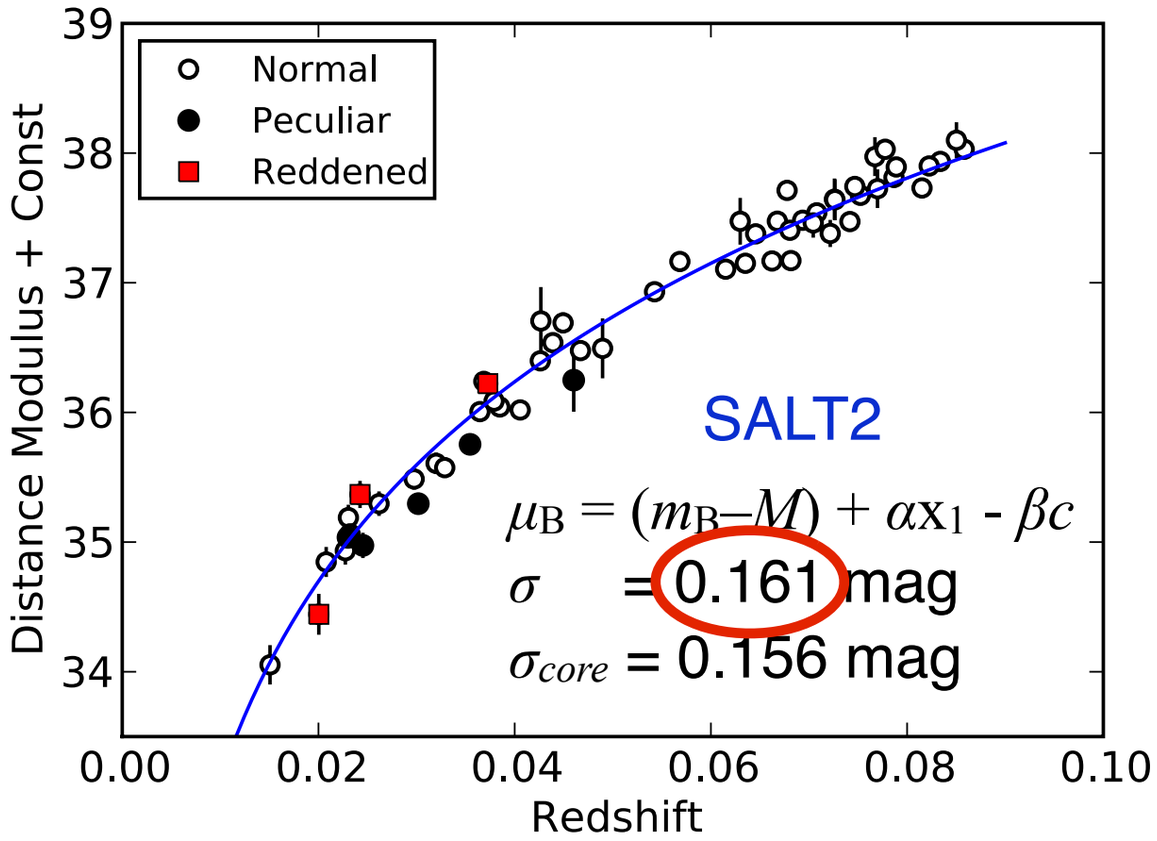
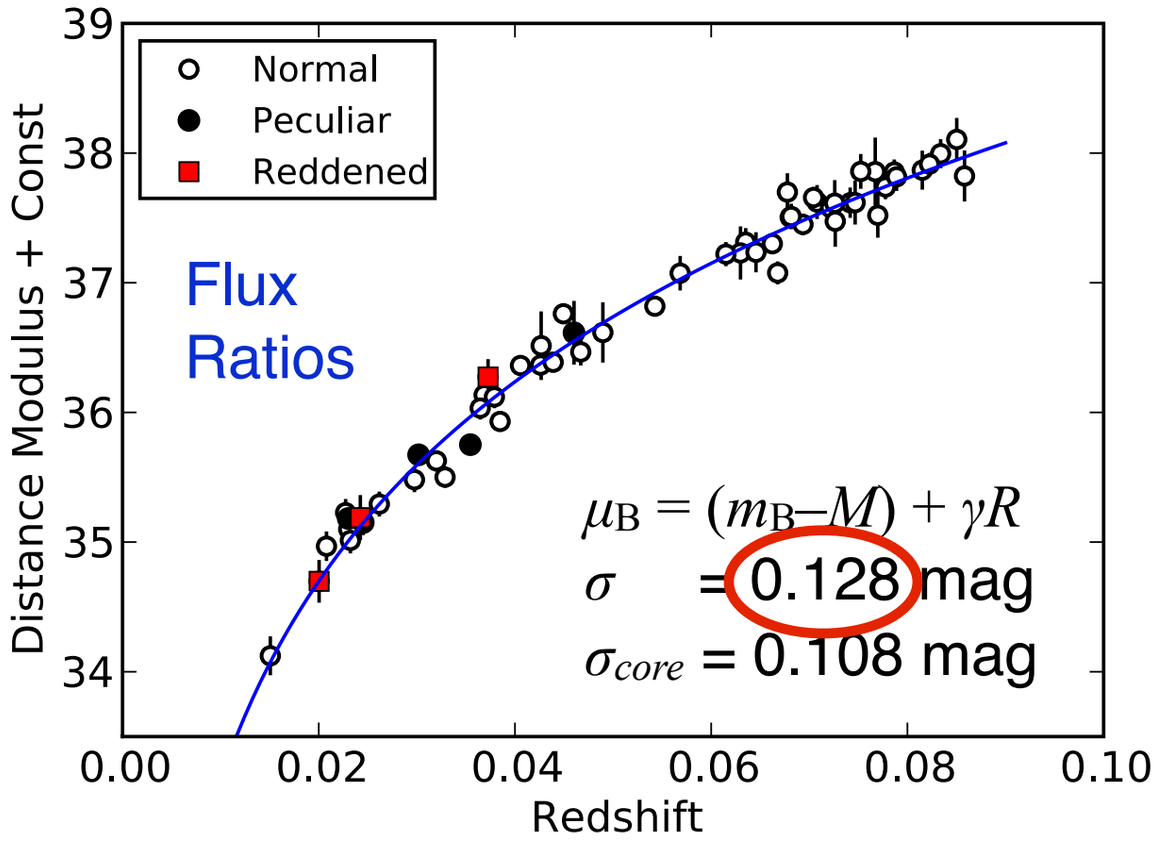


SALT2 corrects 0.40 → 0.16 mag

What if we fit with $R_{643/442}$ instead?

Using One Single Flux Ratio $R_{642/443}$





Flux Ratios standardize SNe Ia
better than the two classic corrections

Bailey et al 2009
A&A Letters 500, L17 - L20, 2009
(arXiv: 0905.0340)

Hubble Residuals		
Sample	**$R_{642/443}$**	**classic**
Training	0.130	0.154
Validation	0.134	0.171
All	0.128	0.161

Conclusions & Outlook

Unique dataset of SNIa:

~ 185 nearby SNIa, spectrophotometric timeseries

What can be done?

- Improved Standardization of SNIa
  - one Flux Ratio is doing better than classical corrections
  - do even better with more sophisticated approach
- K-correctionless Hubble diagram
- Allow for unprecedented accuracy for anchoring the Hubble diagram
- New SN Ia spectral timeseries template
- Input for SN Modeling
- Studies of individual SNe

Preparations under way for SNfactory Phase II