The Nearby Supernova Factory

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For the Nearby Supernova Factory

Universität bonn

Experimental Astroparticle Physics and Cosmology

Physikalisches Institut
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AG Prof. Marek Kowalski

Contents

- Cosmology with SN Ia
- The Nearby Supernova Factory
- Spectro-photometry
- SNF Results

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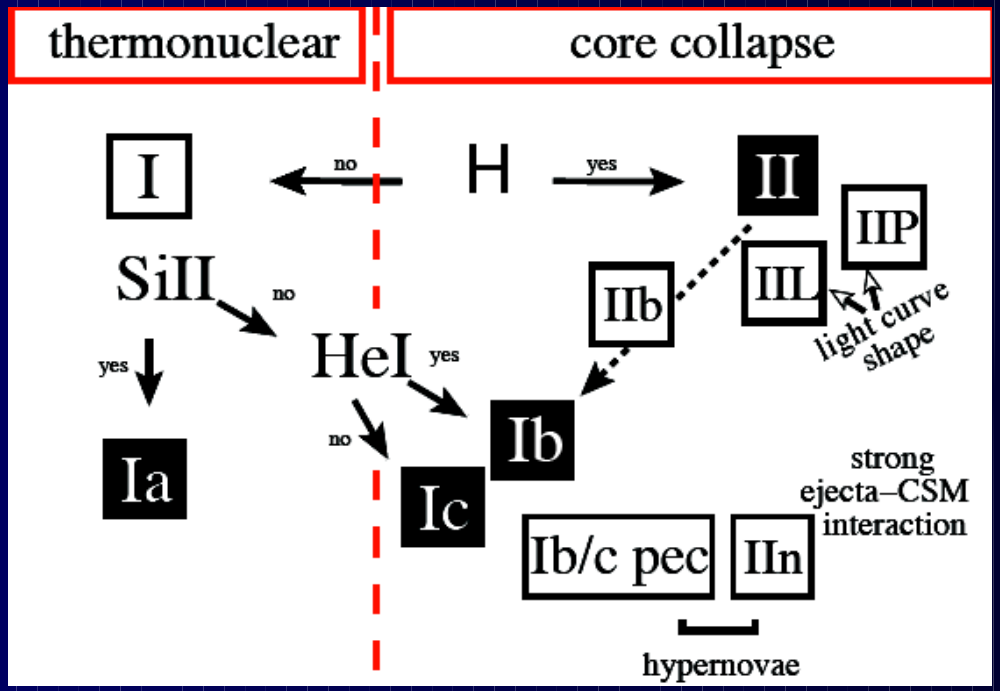
Supernova Classification



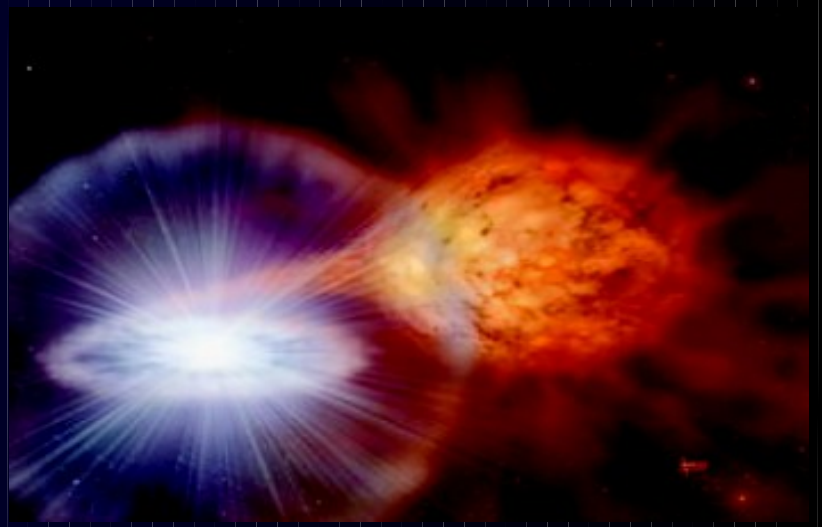
- Core collapse vs thermonuclear
- Spectroscopic classification
- Great diversity in core collapse SNe (mass)
- SN Ia – spectroscopic homogeneity

- Single Degenerate (SD) model:

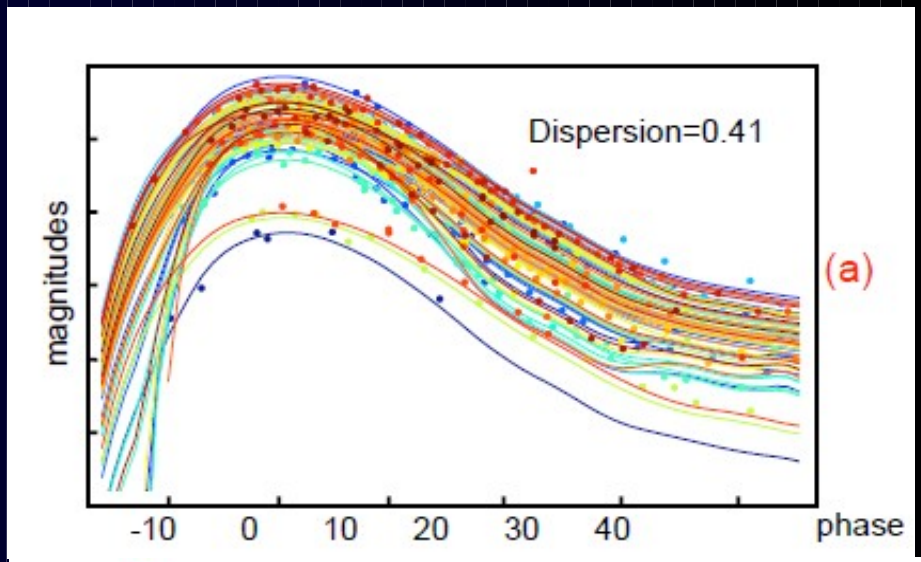
  * White dwarf accreting matter from companion

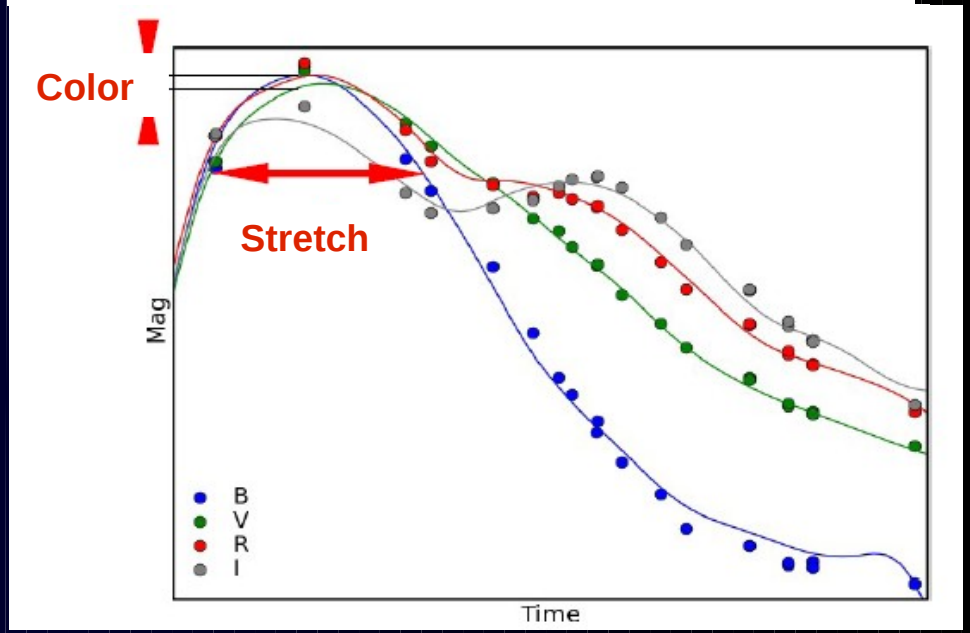
  * reaches Chandrasekhar mass (1.4 M_{sun})

→ thermonuclear explosion



SN Ia as Standard Candles





Established standard candles:

- Bright Mb ~ -19.5
- Standardizable empirically

broader - brighter (stretch)

bluer - brighter (color)

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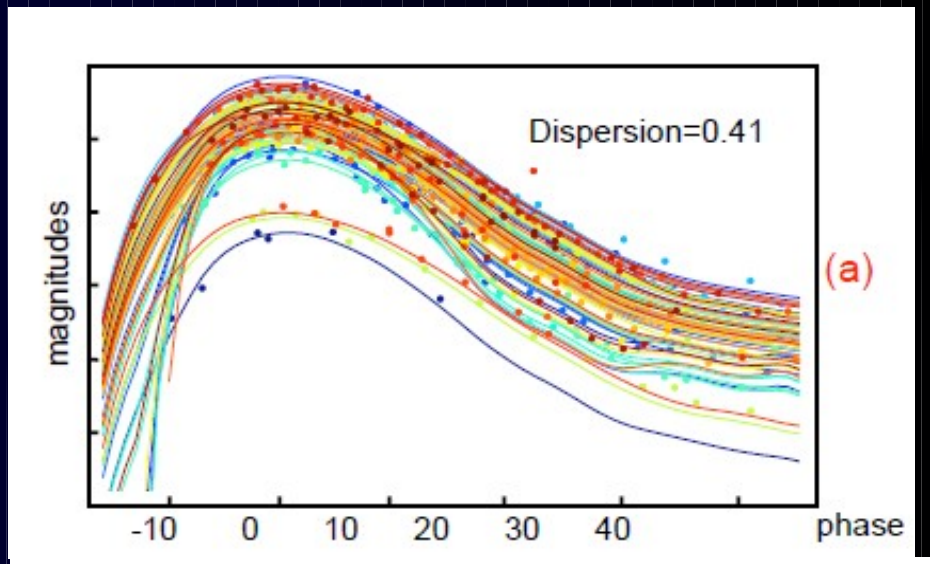

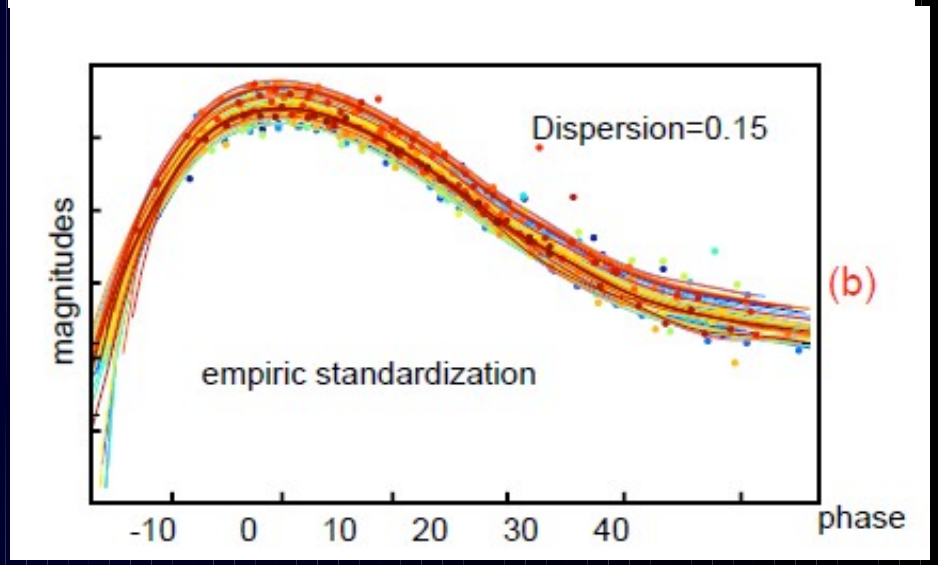

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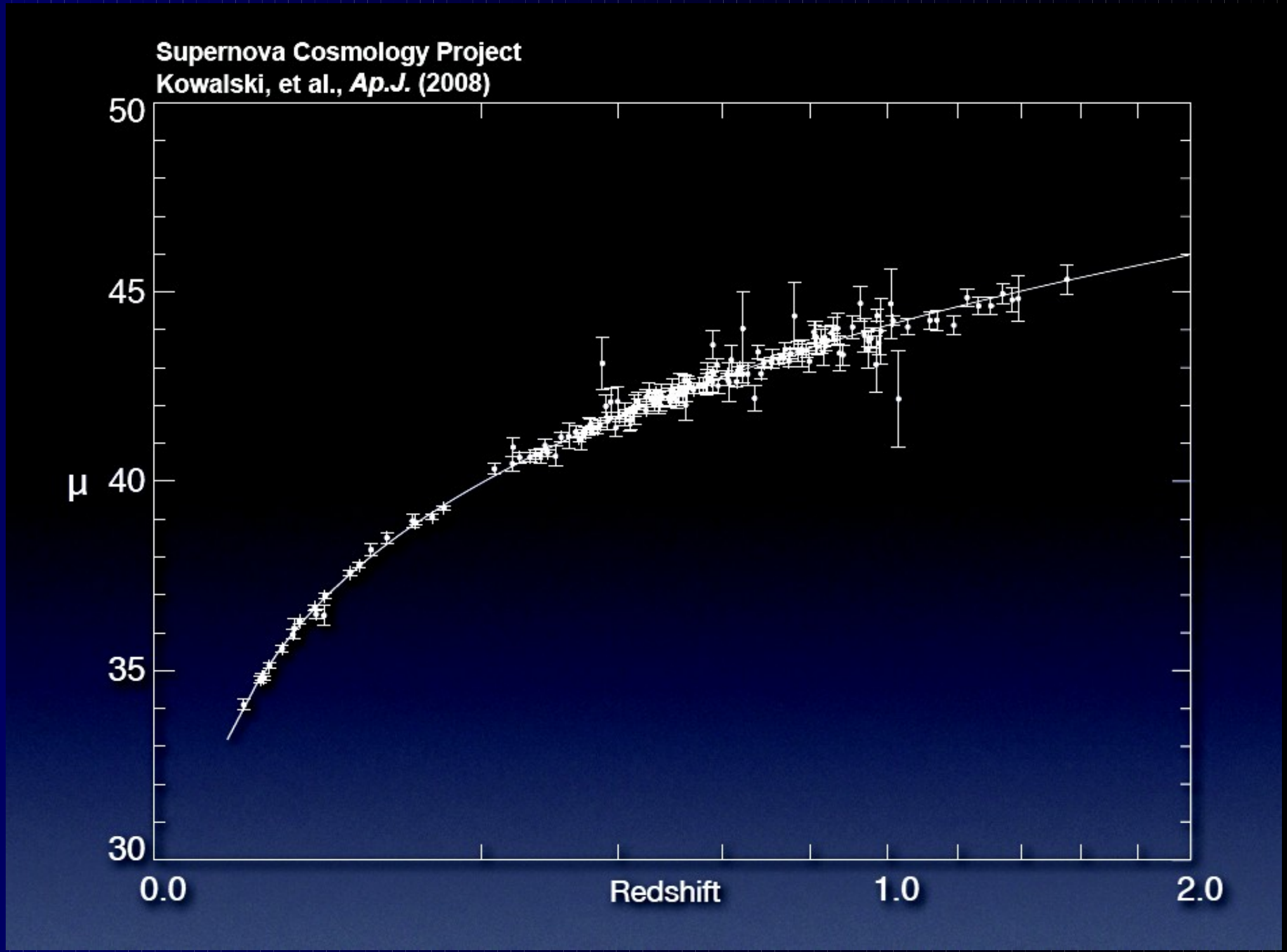
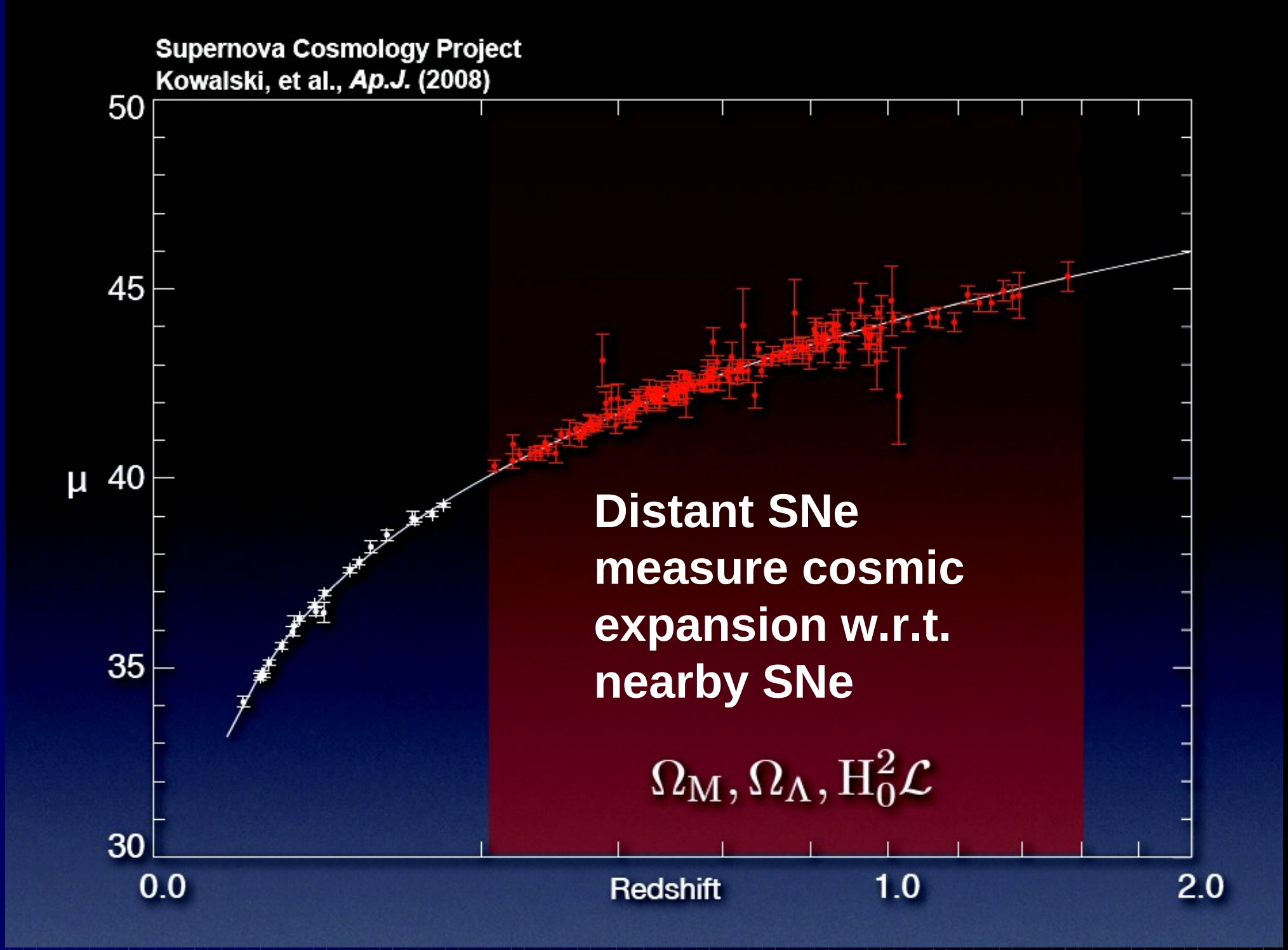


Courtesy R. Pereira



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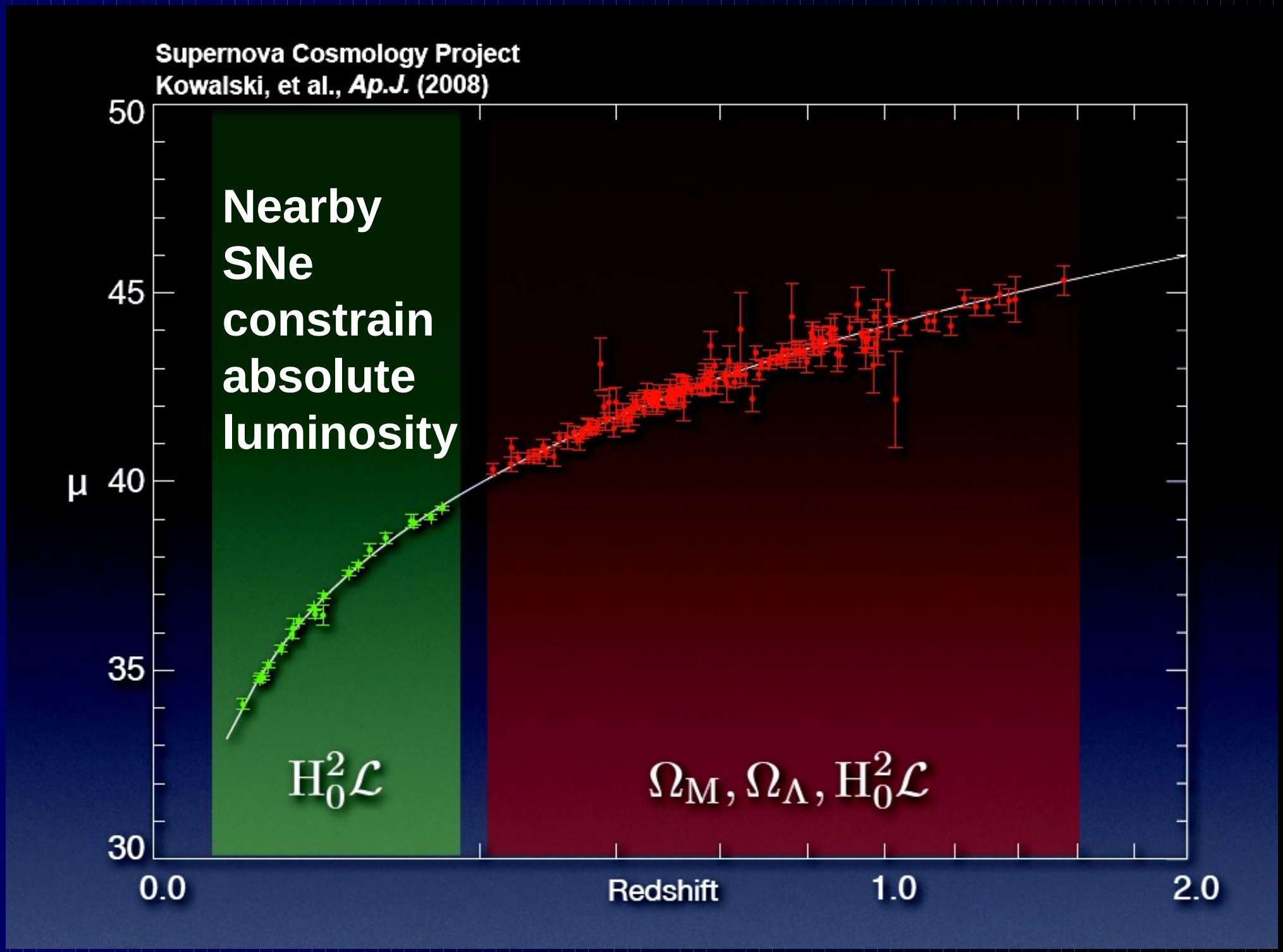


Courtesy R. Pereira

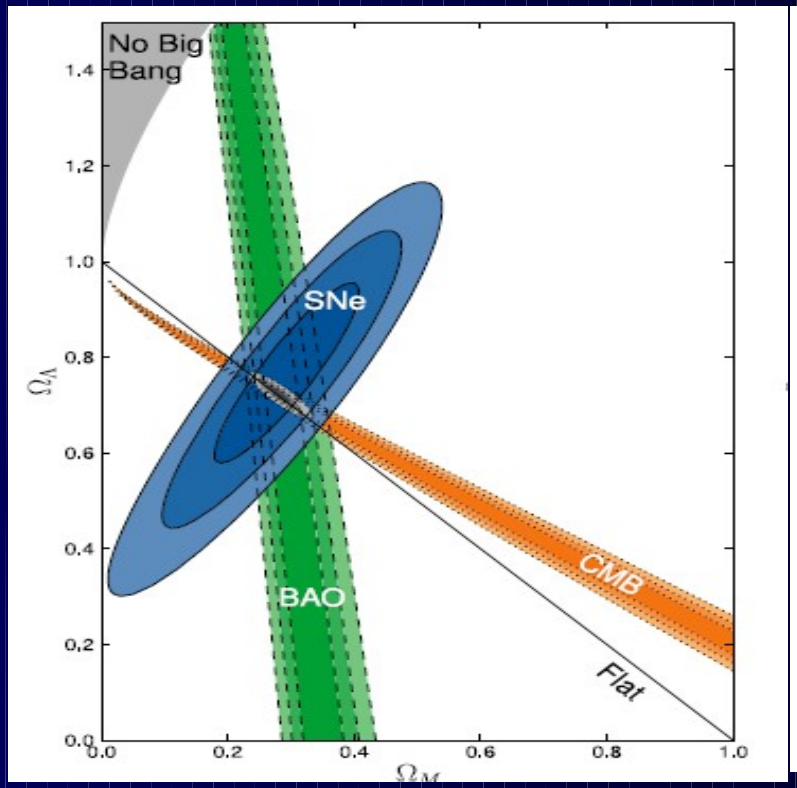
Precision Cosmology with SN Ia

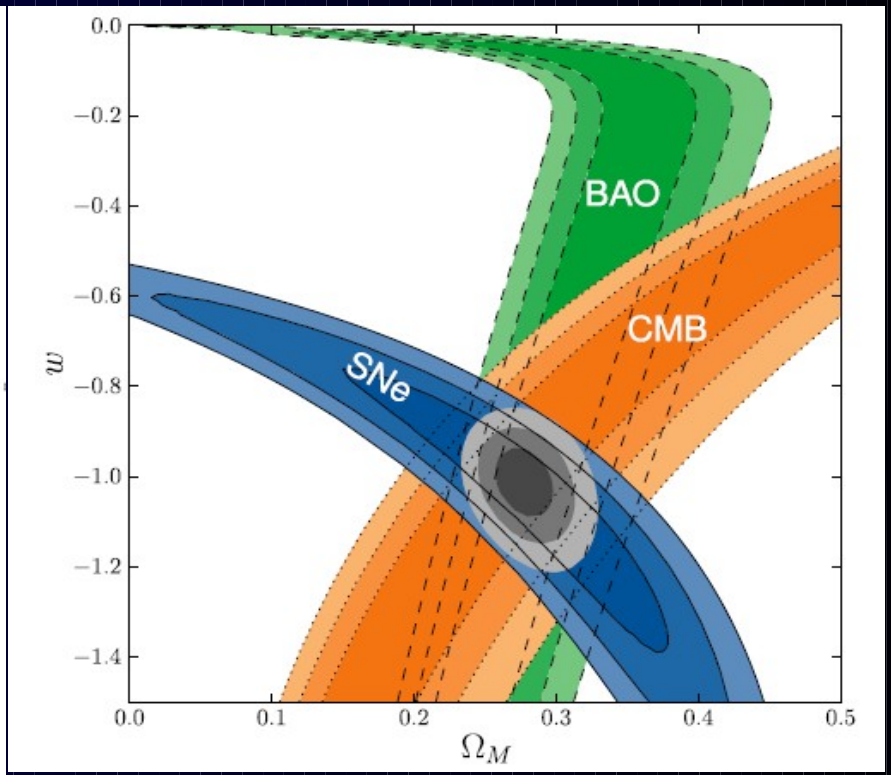
Many sources of cosmological information, e.g.

- Baryon Acoustic Oscillations BAO
- Cosmic Microwave Background CMB
- SN Ia standard candles

BAO+CMB+SN Ia → $\Omega_M = 0.279^{+0.017}_{-0.016}$, $\omega = -0.997^{+0.077}_{-0.082}$

(Amanullah et al. 2010)





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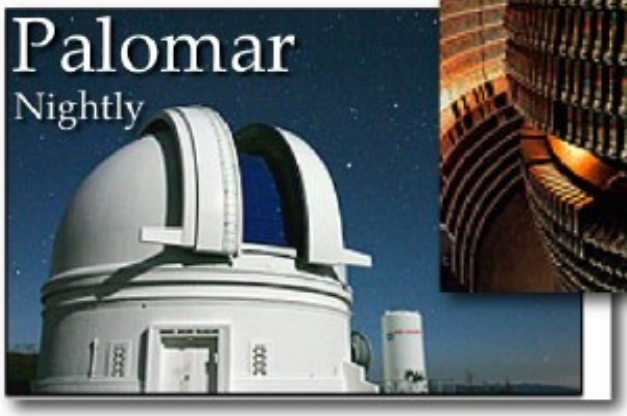
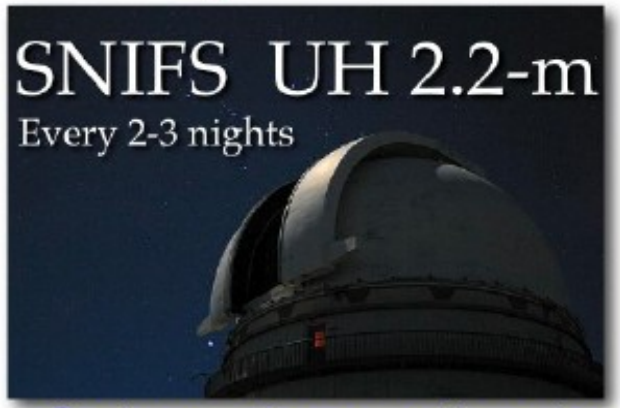
The Nearby SNfactory

1. Discover

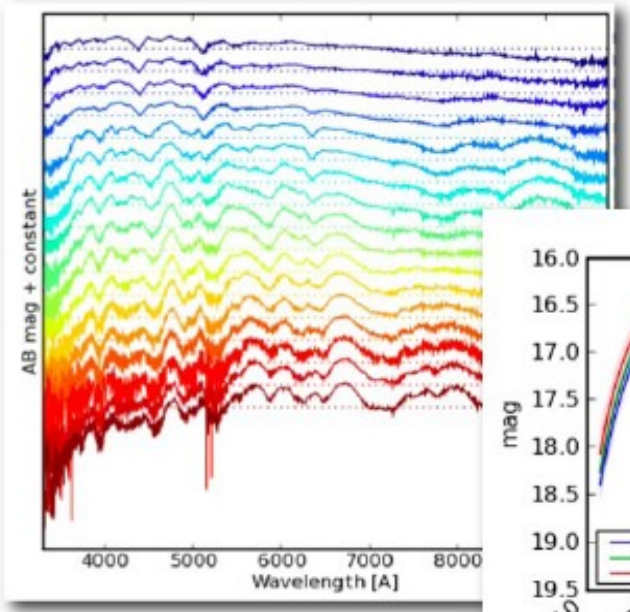


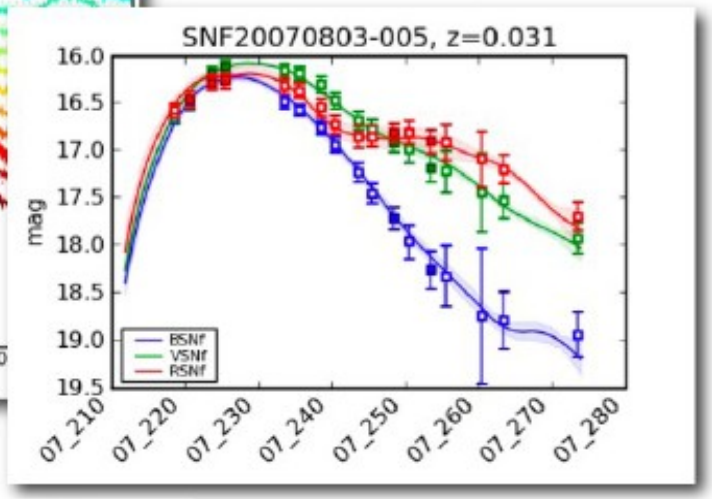
2. Observe



Custom, unique spectrometer designed for nearby SN obs

3. Analyze



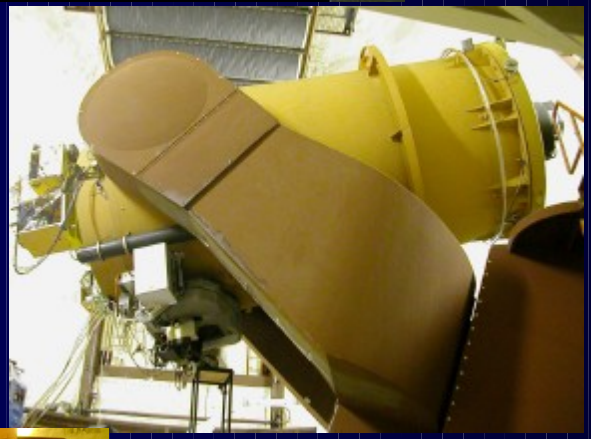


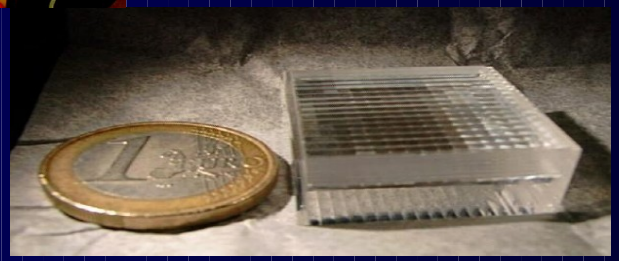
Stephen Bailey

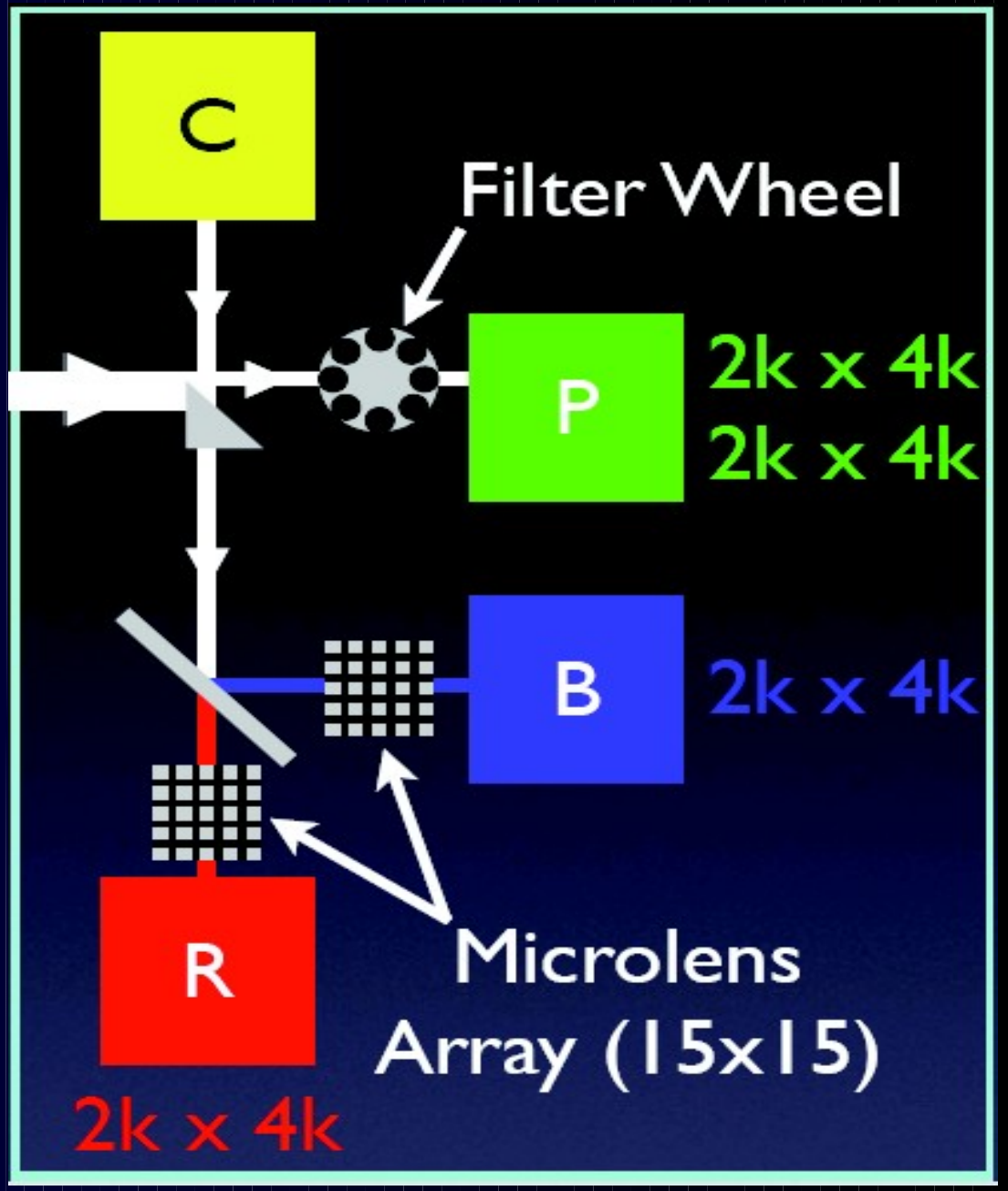
SNF Science Objectives

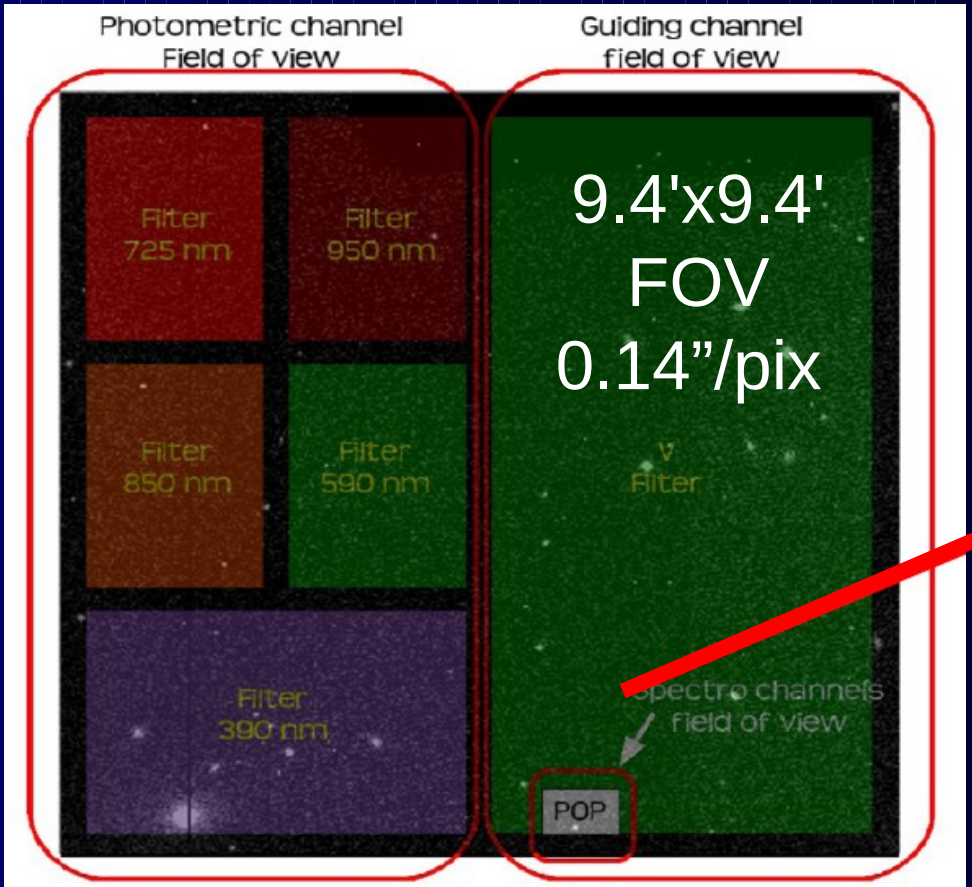
- Make SN Ia standard candles even better
- Determine zero point of HD with unprecedented accuracy
- Investigate SN Ia physics such as progenitors, environments, explosion models, dust etc.

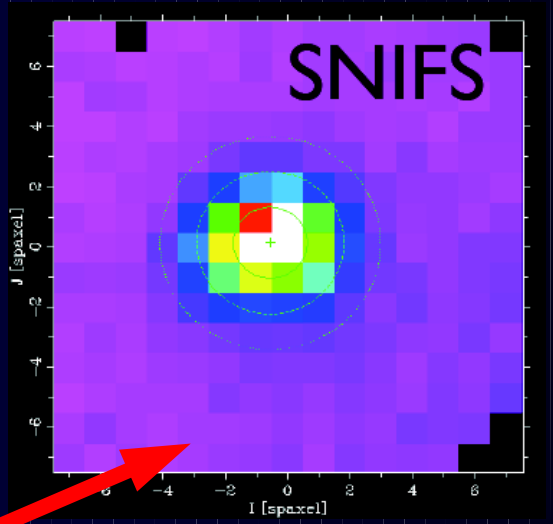
Supernova Integral Field Spectrograph (SNIFS)





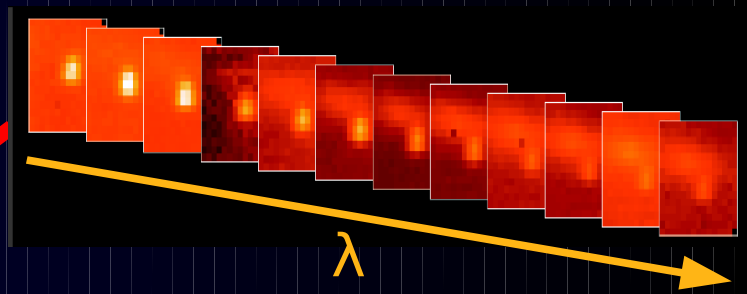




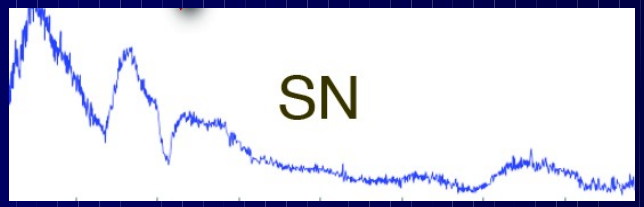


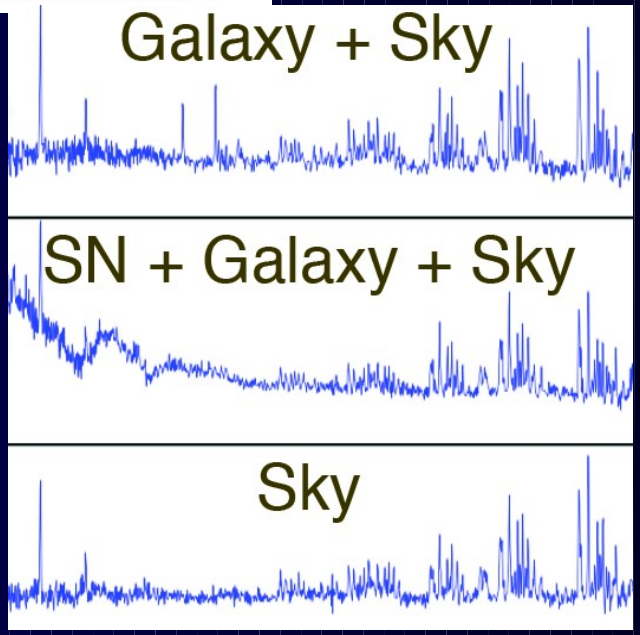
15x15 spaxels
=
225 spectra

6"x6" FOV
0.4"/spaxel



3D Datacube





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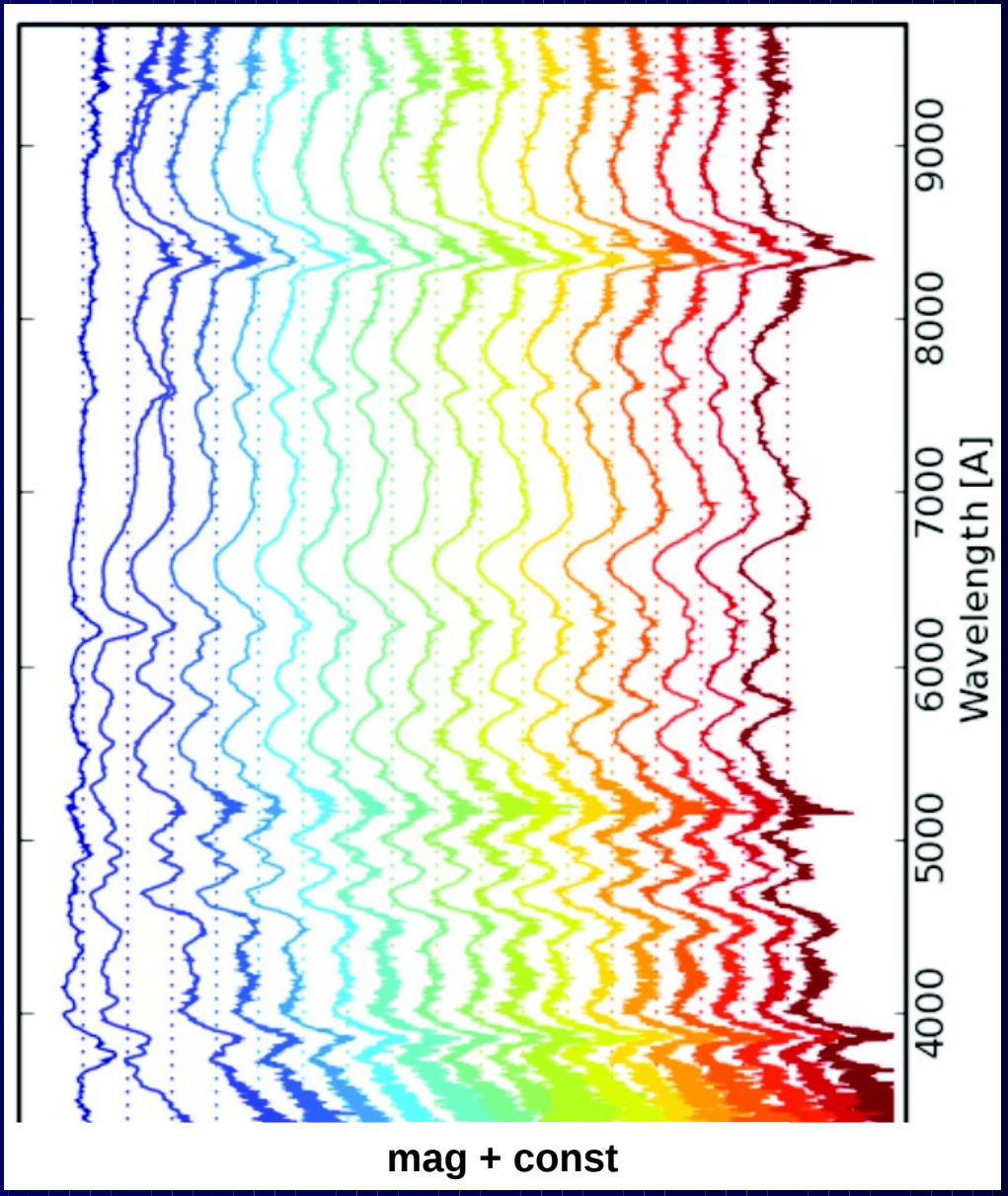


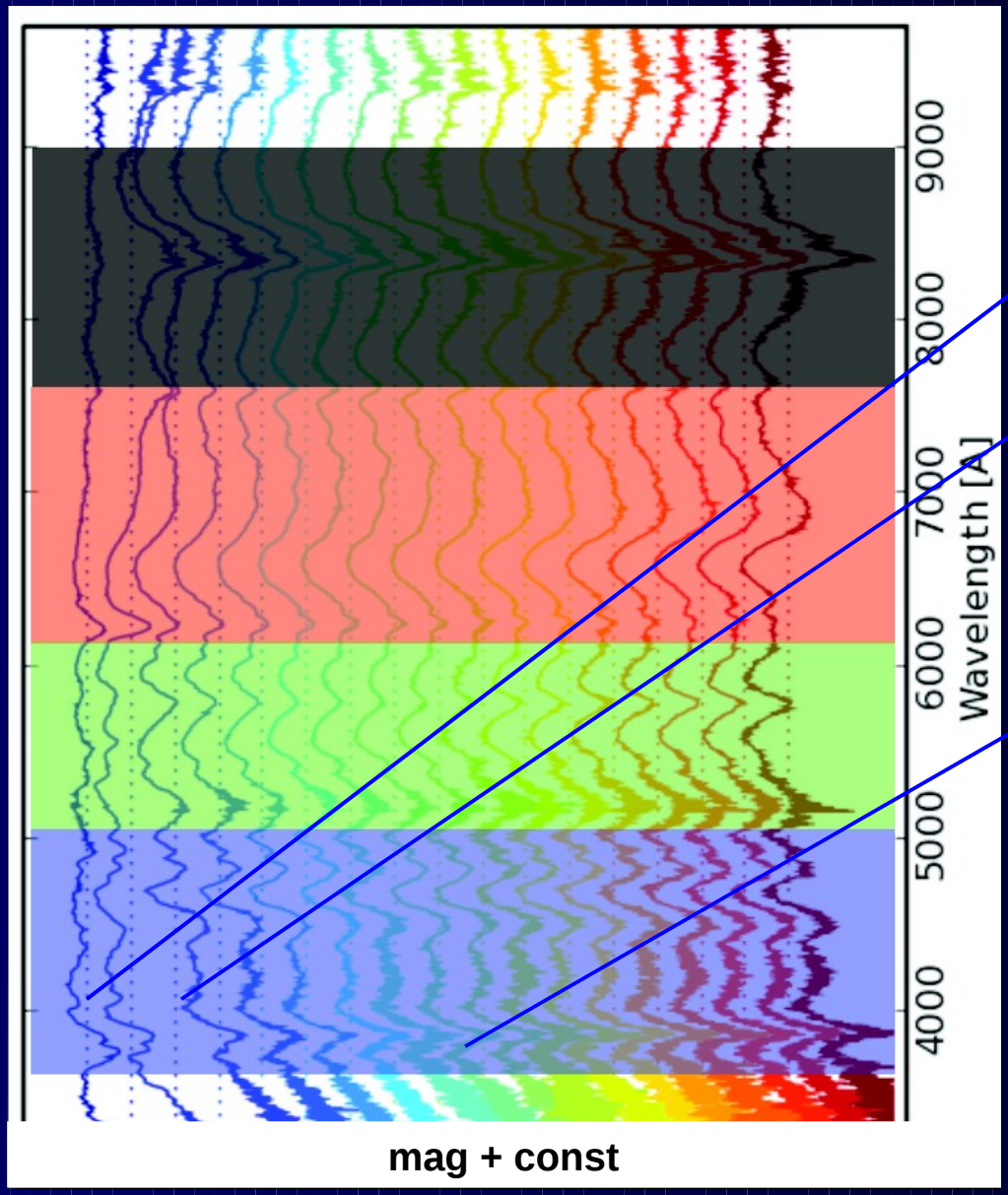
Spectral time series:

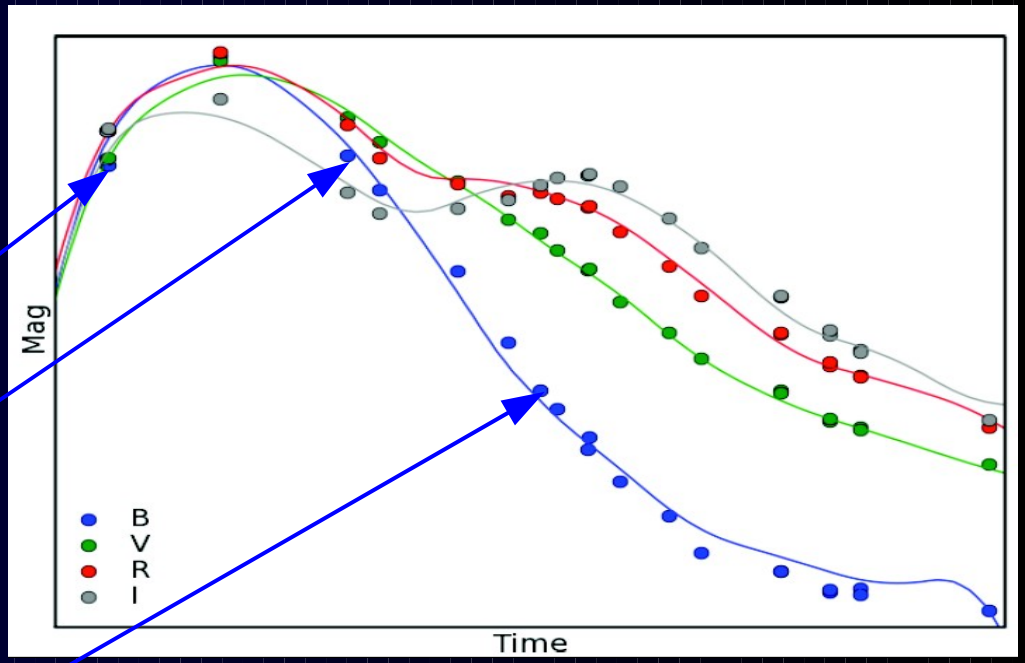
- ~15 observations per target
- First spectrum typically at τ = -4 d

Spectral and Flux features:

- Full 4D (t,x,y,λ) spectral information
- Integration over any filter bandpass → Lightcurve

Spectro-photometry





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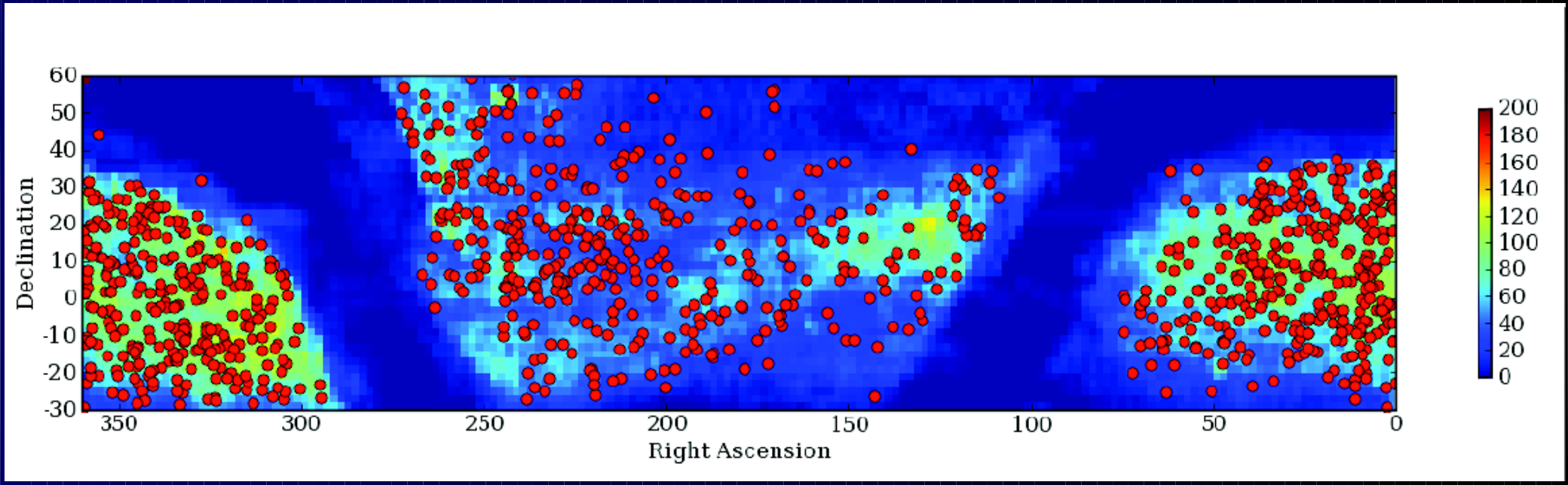
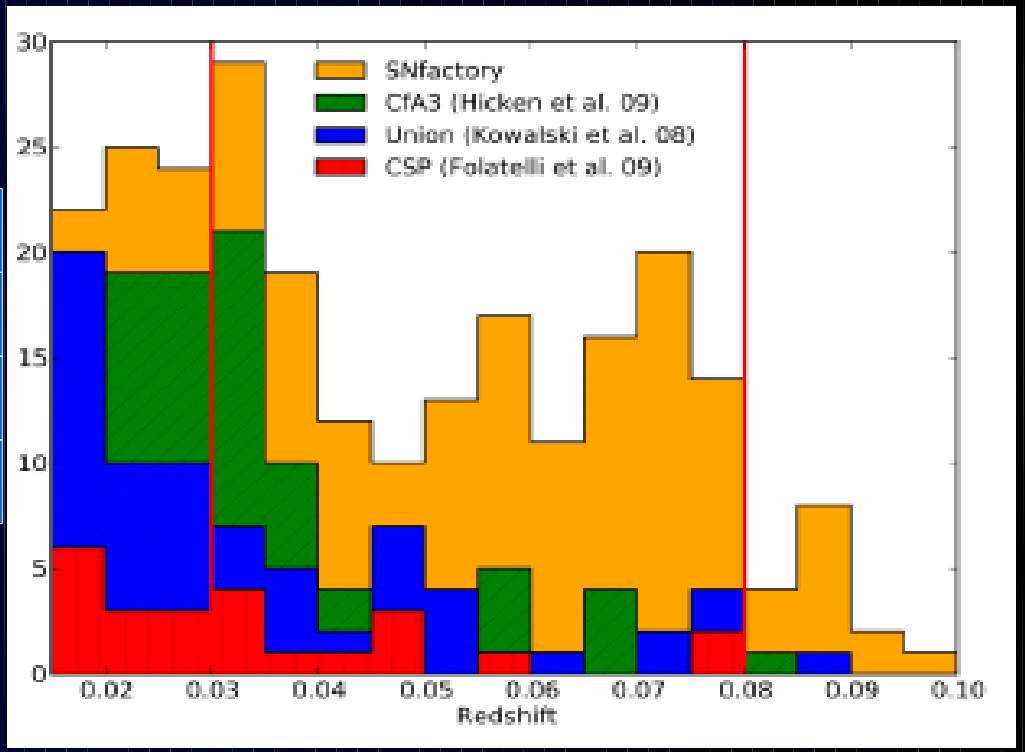


	SNfactory	Others	Total
SN	~620	~70	~690
SN Ia	~400	~50	~450
Follow-up	~150	~40	~190



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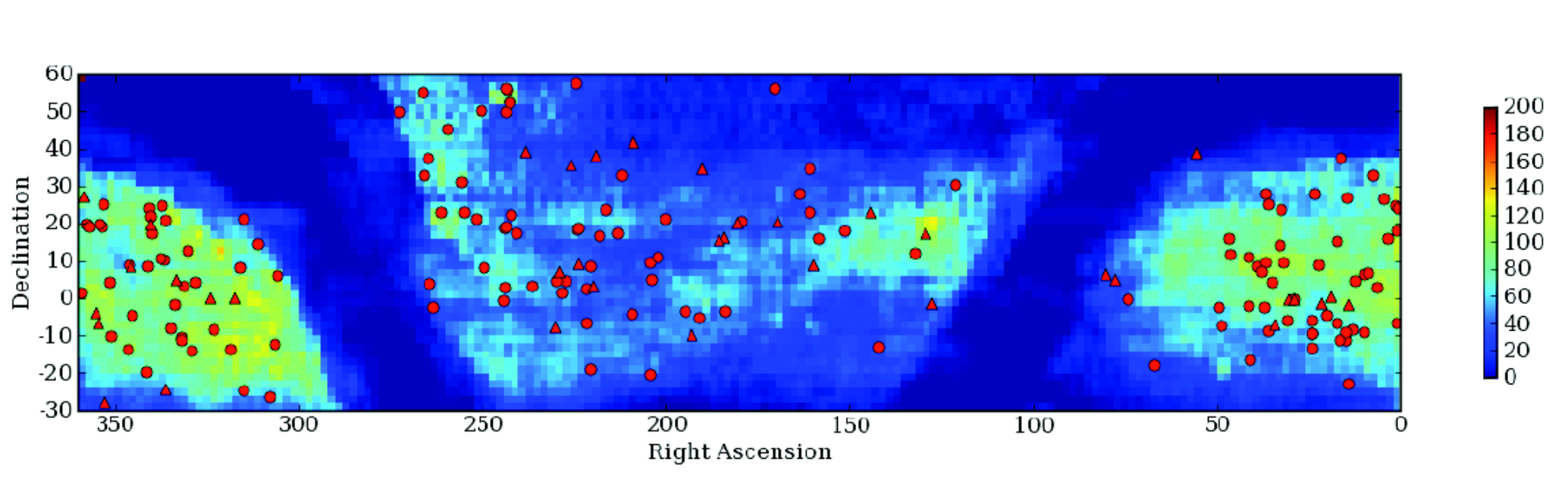

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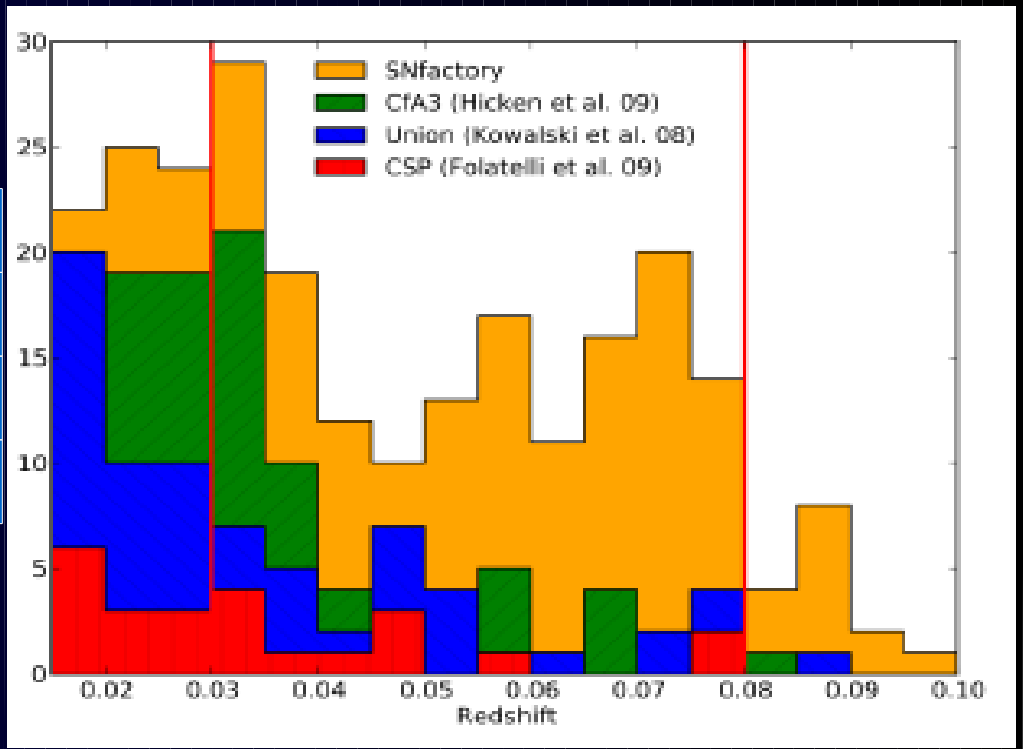
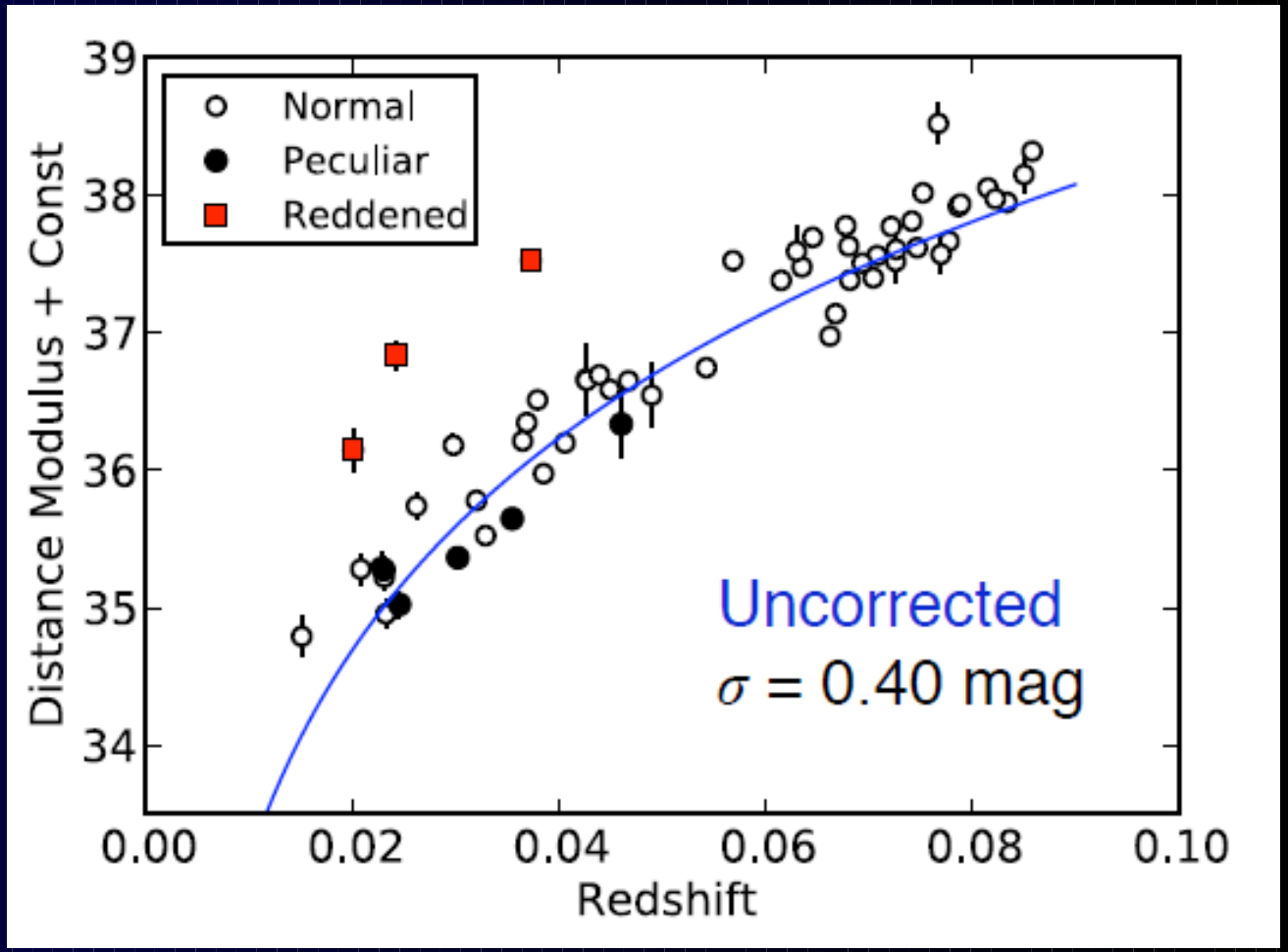



Making the best standard candles
even better

Classical Correction

Classic Corrections

- Color:
  bluer → brighter
- Shape:
  broader → brighter
- Result:
  0.4 mag → 0.16 mag



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

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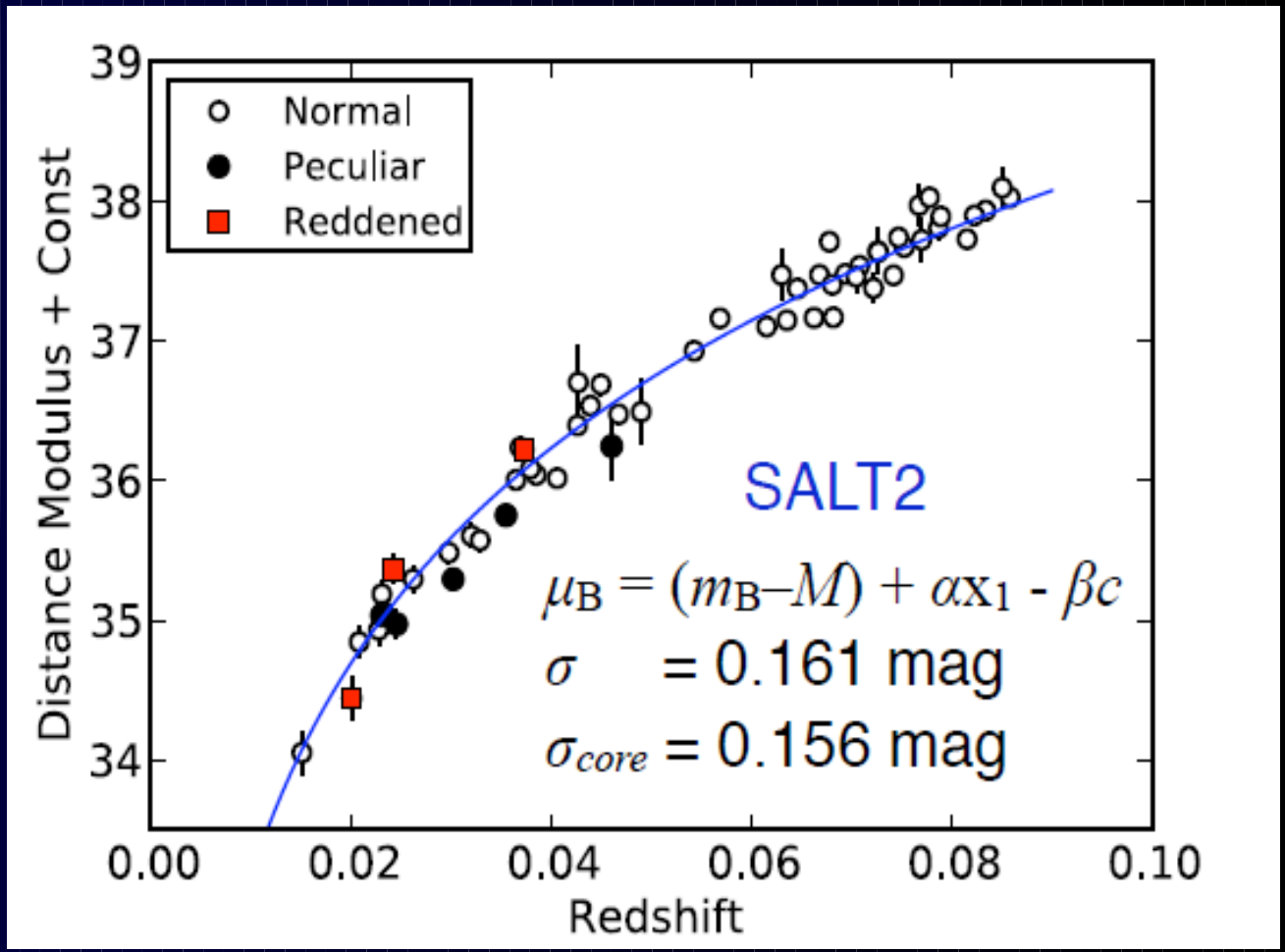

Bailey et al.
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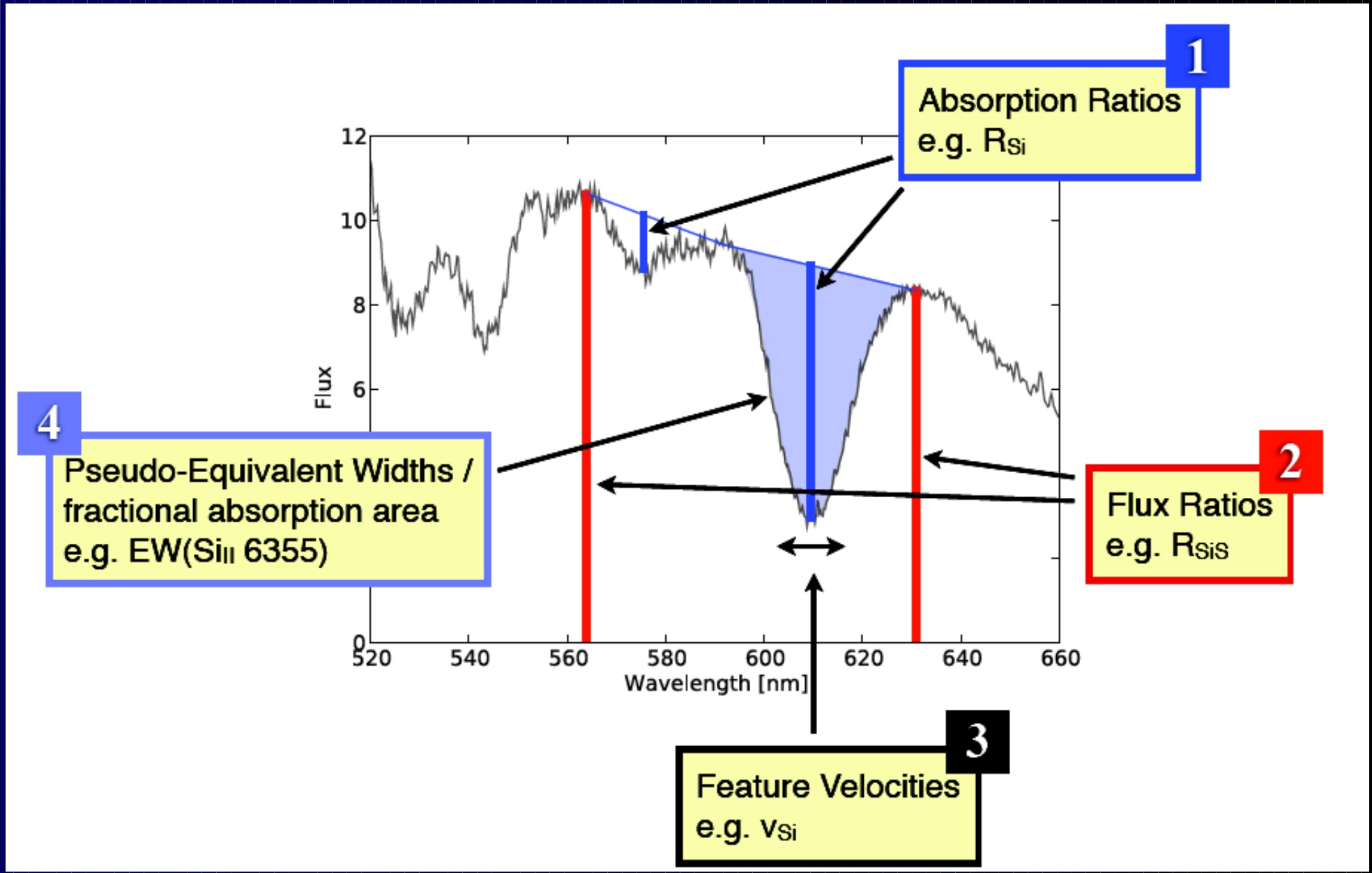
Using Spectral Metrics



Courtesy S.Bailey

Correlated flux ratios

Flux Ratio Correlation

- $R_{x/y} = F_x / F_y$
- Identify ratio with max correlation to HD residuals
- Search in training sample → check with validation sample
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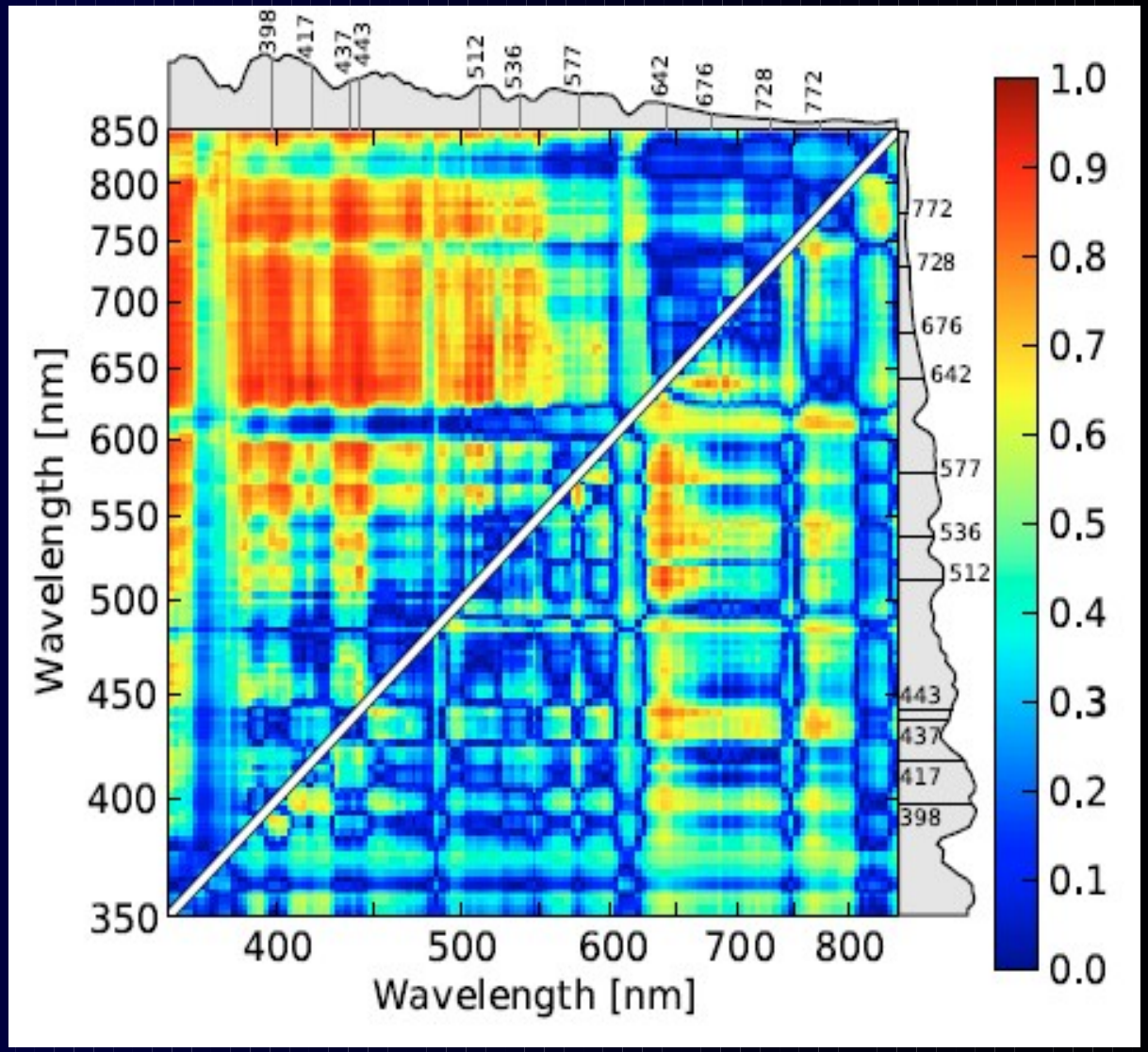

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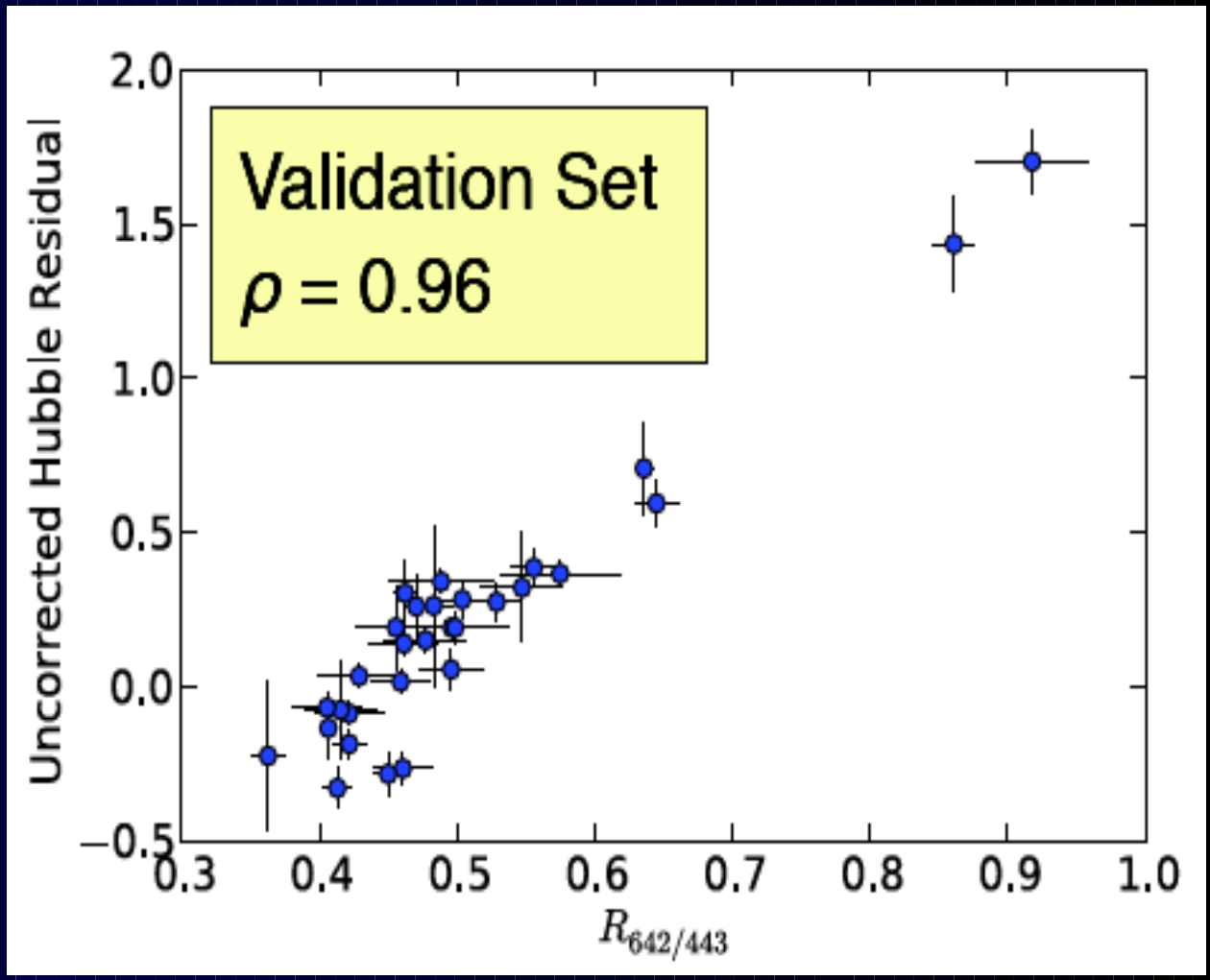

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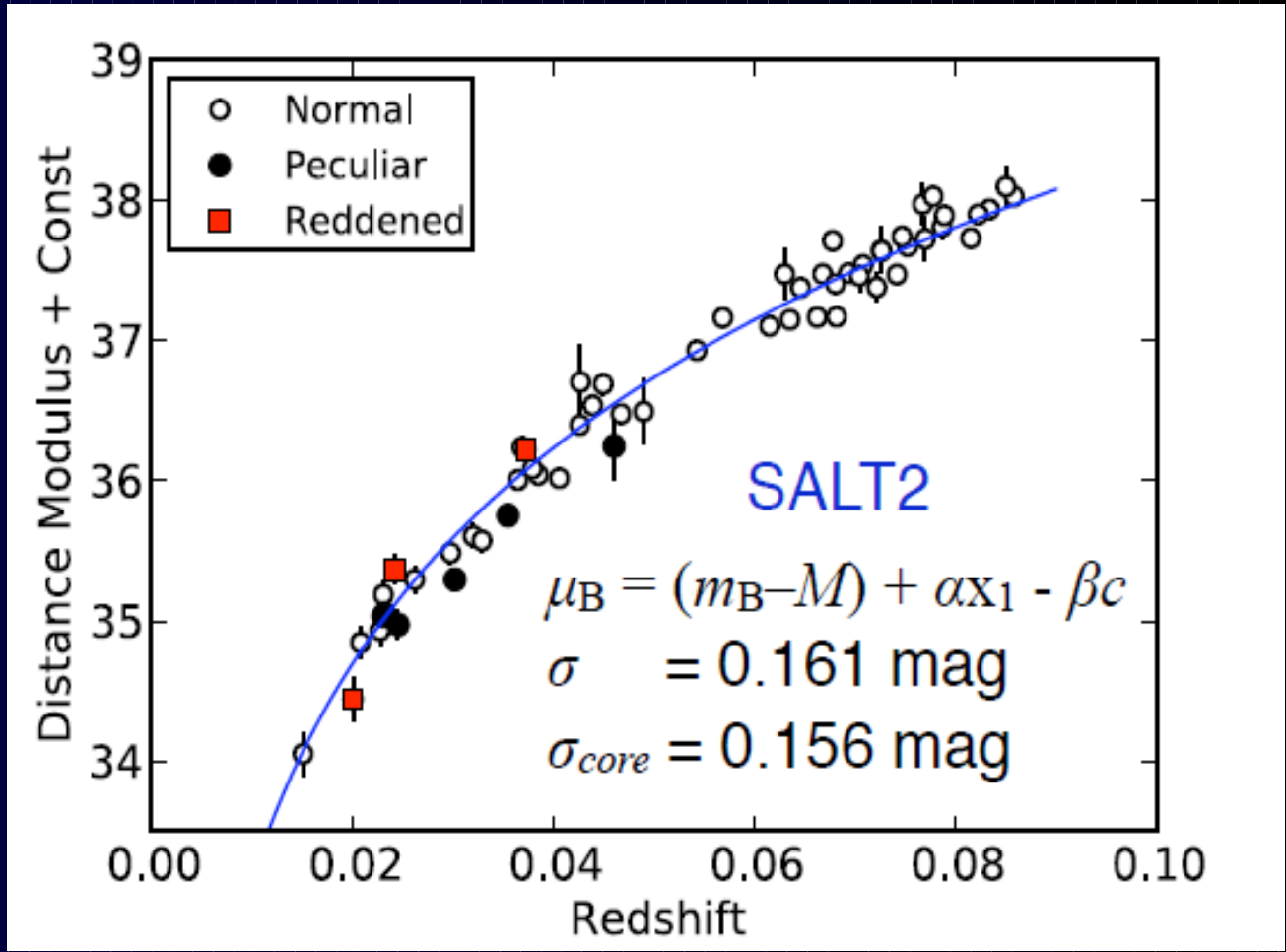

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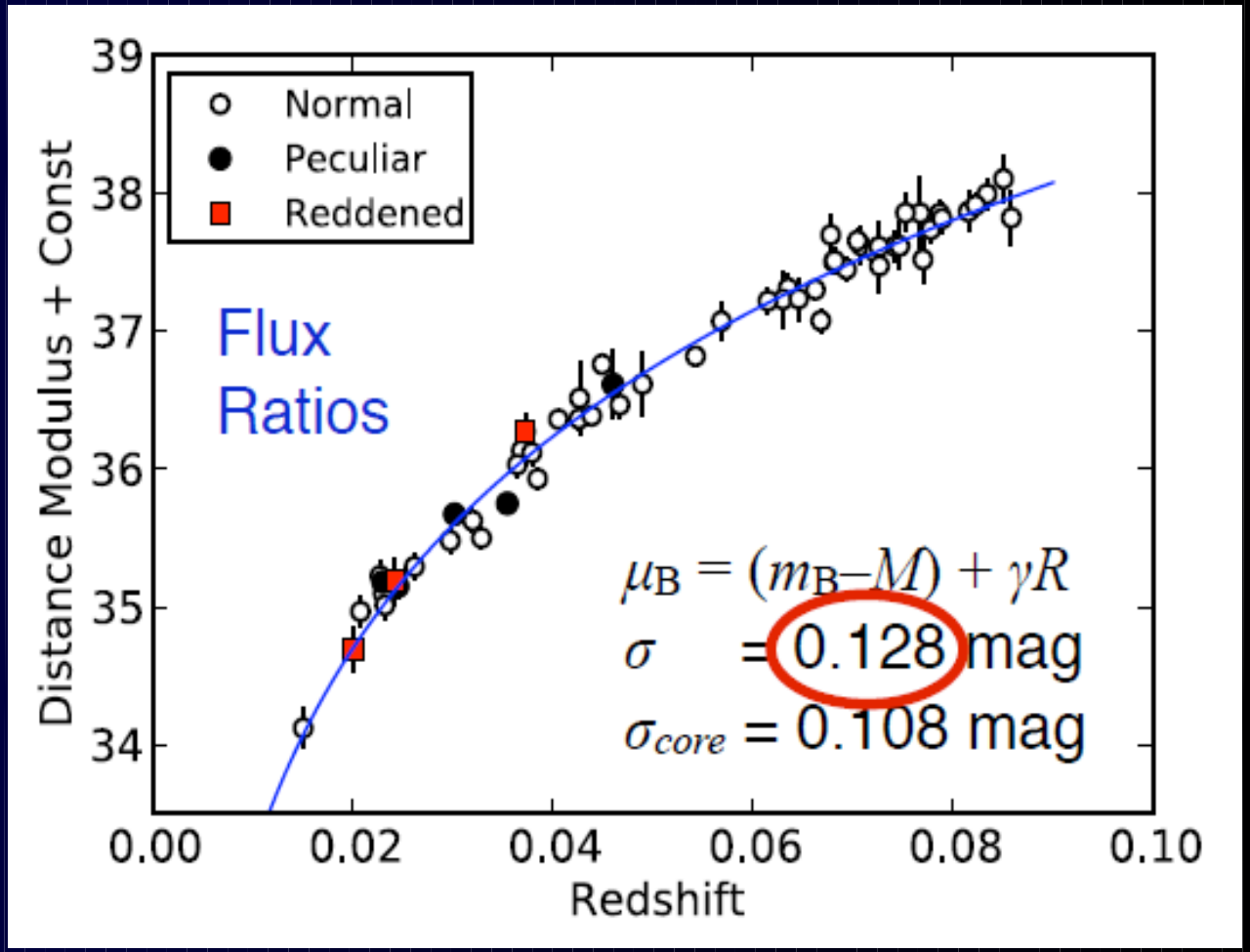
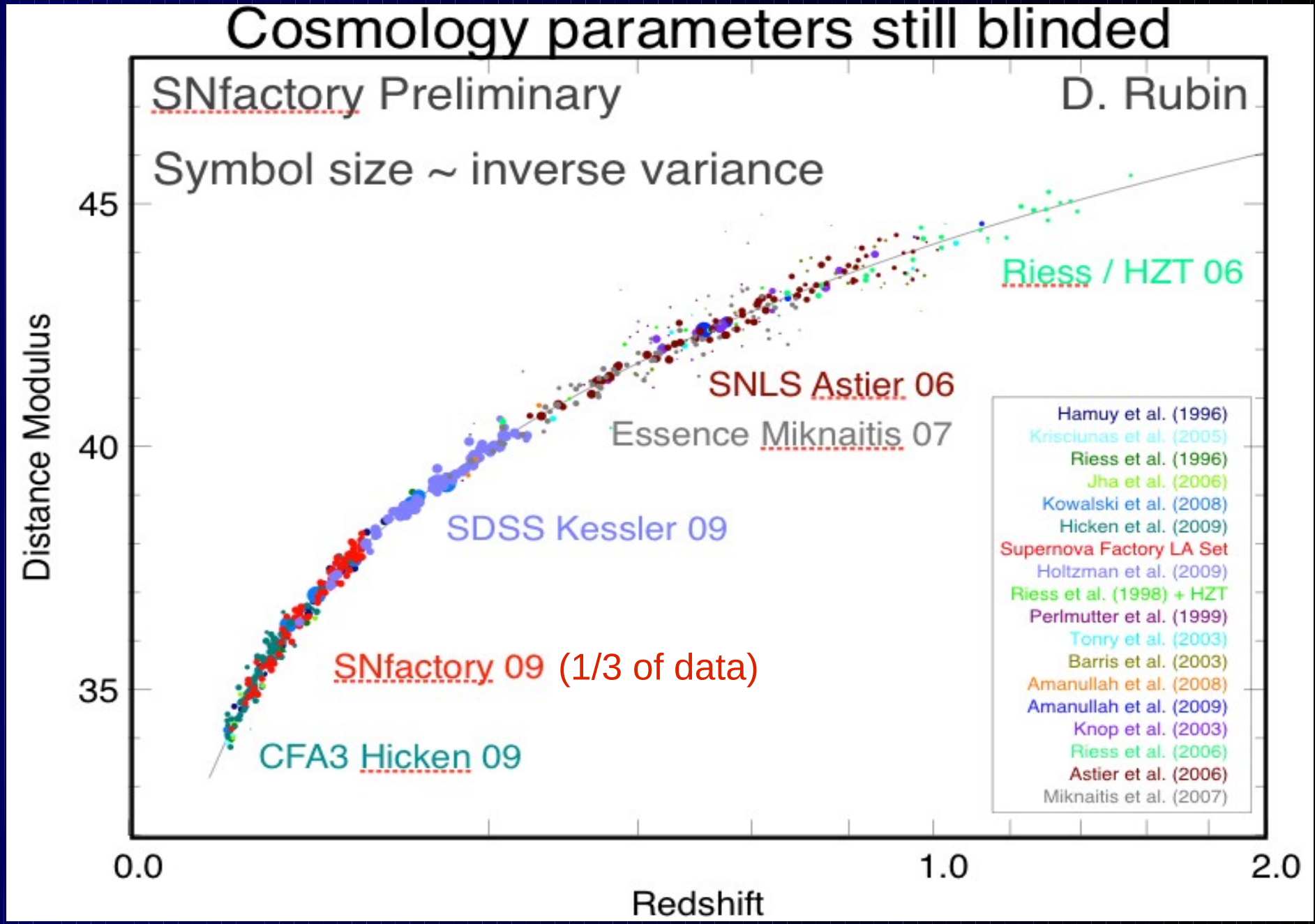


Bailey et al.
A&A 500, L17-L20 (2009)

Hubble Diagram

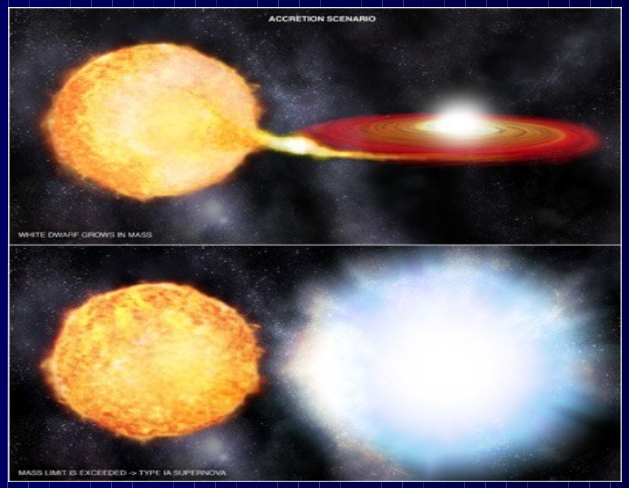


SN Ia physics
Super Chandrasekhar SN2007if

Super Chandrasekhar SN SN2007if:

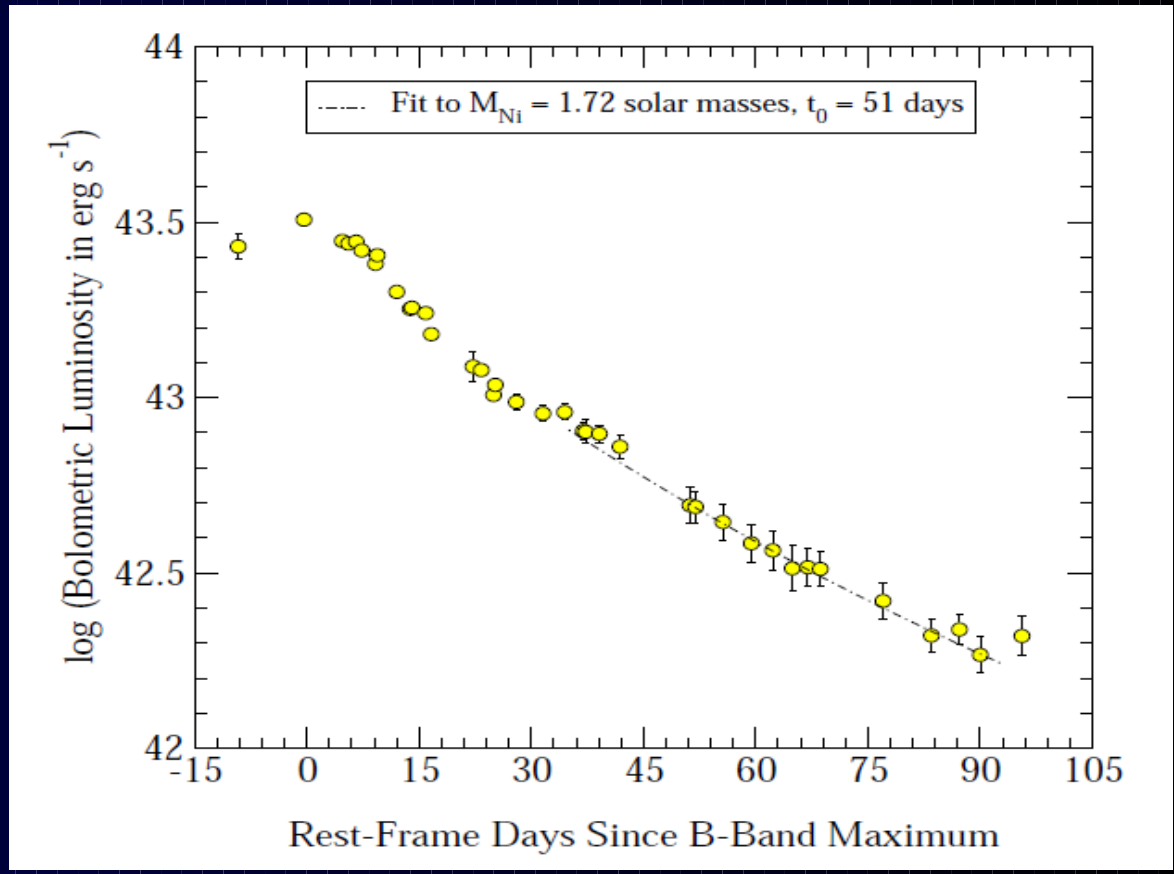
- Single degenerate (SD)

→ SD $M=M_{Ch}$



- double degenerate (DD) model

→ DD $M>M_{Ch}$



- Exploit spectral information for progenitor mass models
- SN2007if: M = 2.4 +- 0.2 M_{Sun}

R. A. Scalzo et al. 2010, ApJ

Conclusions

- ~190 nearby spectro-photometric SN Ia:
  * Invaluable spectral dataset
  * Improved statistical power and systematics control
  * Allowing for unprecedented accuracy for HD zero point
- New and robuster standardization methods:
  * Flux correlation ratios
- New insights into SN Ia physics:
  * e.g. Super Chandrasekhar
    SN 2007if
- Preparations for SNF phase II