Type Ia Supernova Inference: Hierarchical Bayesian Statistical Models in the Optical and Near Infrared

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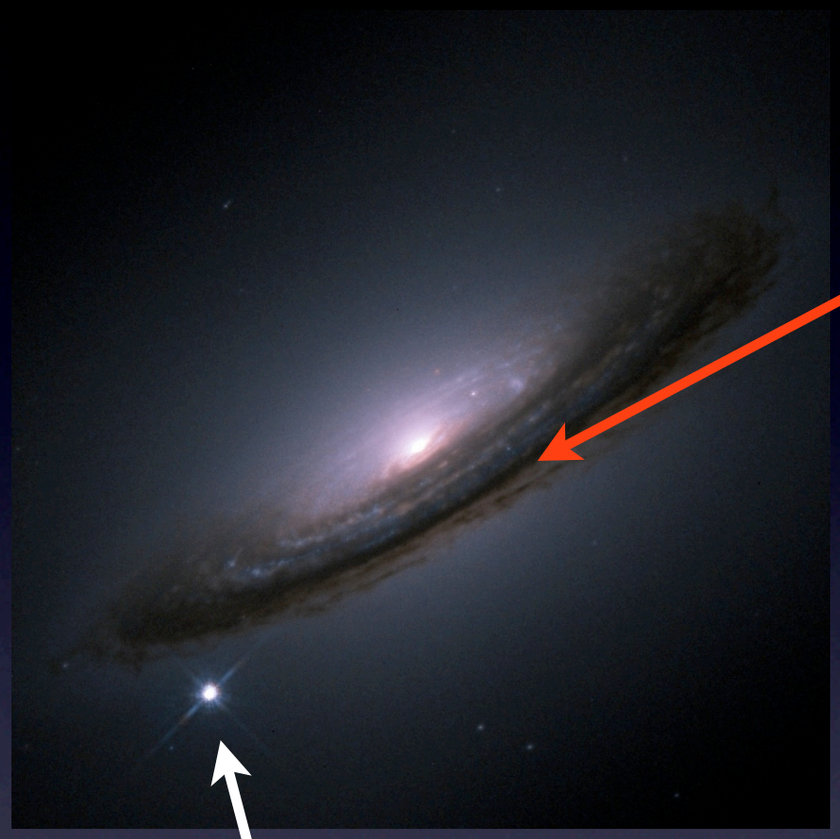
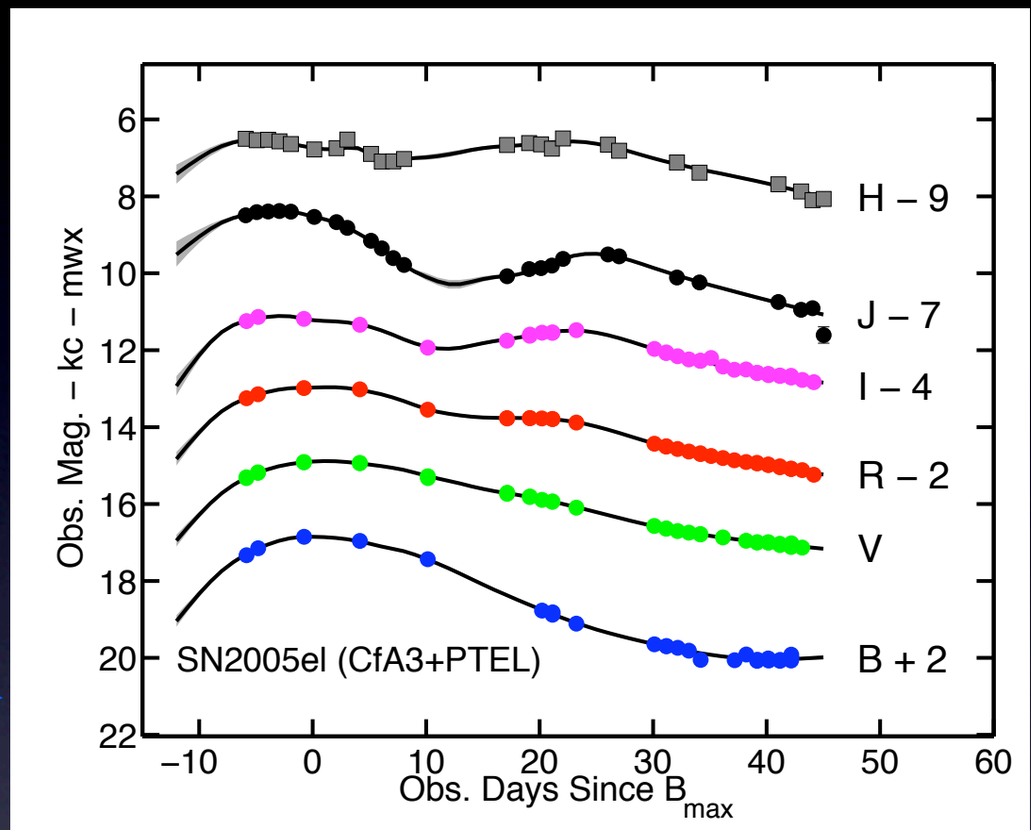


Dust

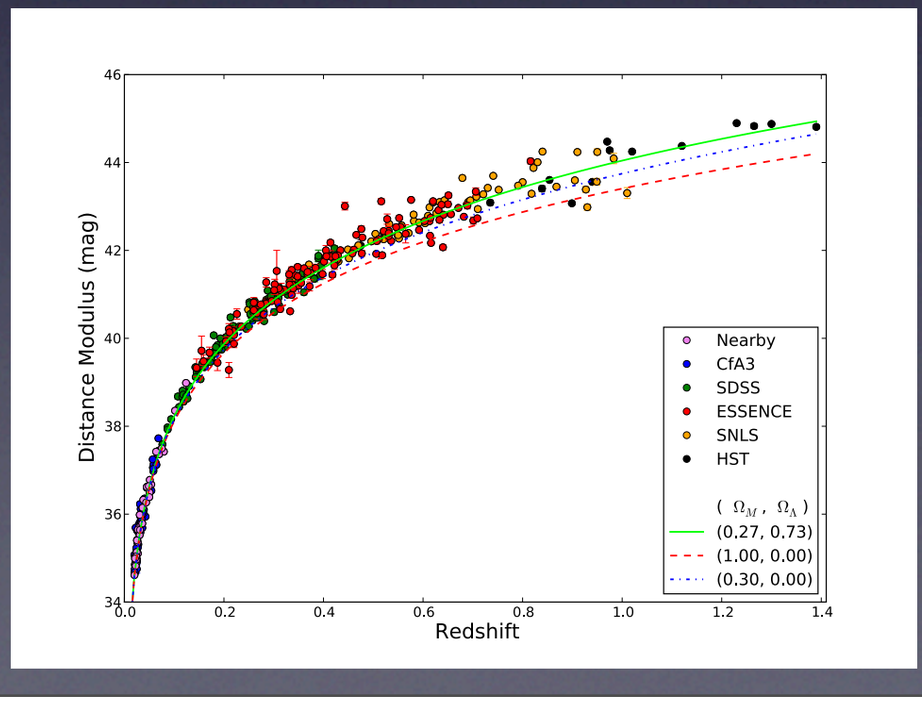
Type Ia Supernova
(Standard Candles?)

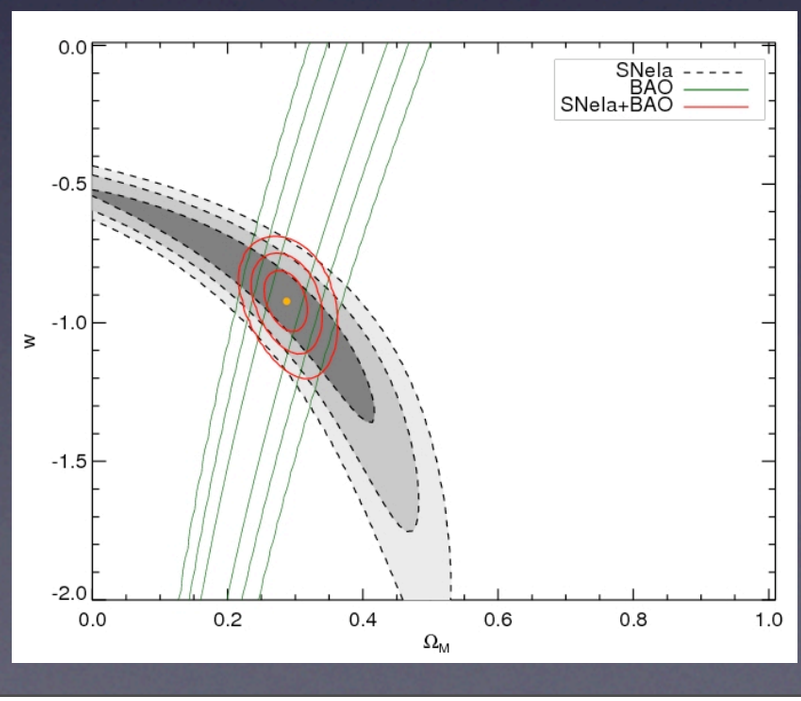
Light Curve
(Time Series)



Cosmology

CMML-NIPS, 16 Dec 2011





Statistical inference with SN Ia

- SN Ia cosmology inference based on empirical relations
- Statistical models for SN Ia learn from the data
- Several Sources of Randomness & Uncertainty

  1. Photometric Measurement errors
  2. "Intrinsic Variation" = Population Distribution of SN Ia
  3. Random Peculiar Velocities of Galaxies in Hubble Flow
  4. Host Galaxy Dust: extinction and reddening.

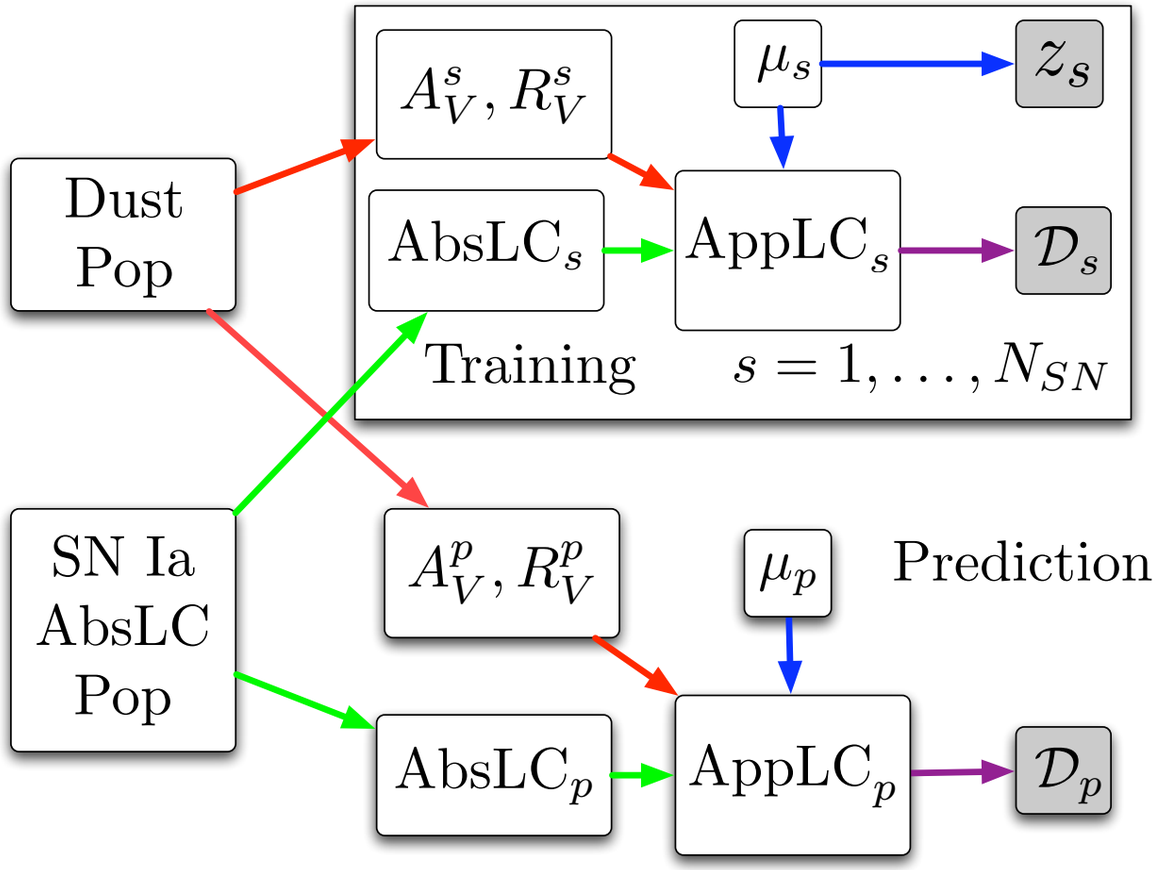
- Observed Data Distributions are convolutions of effects
- How to incorporate this all into a coherent statistical model? (How to de-convolve?)
- Optimal Extraction of Information to Predict Distances

SN Ia Inference with Hierarchical Bayes Models

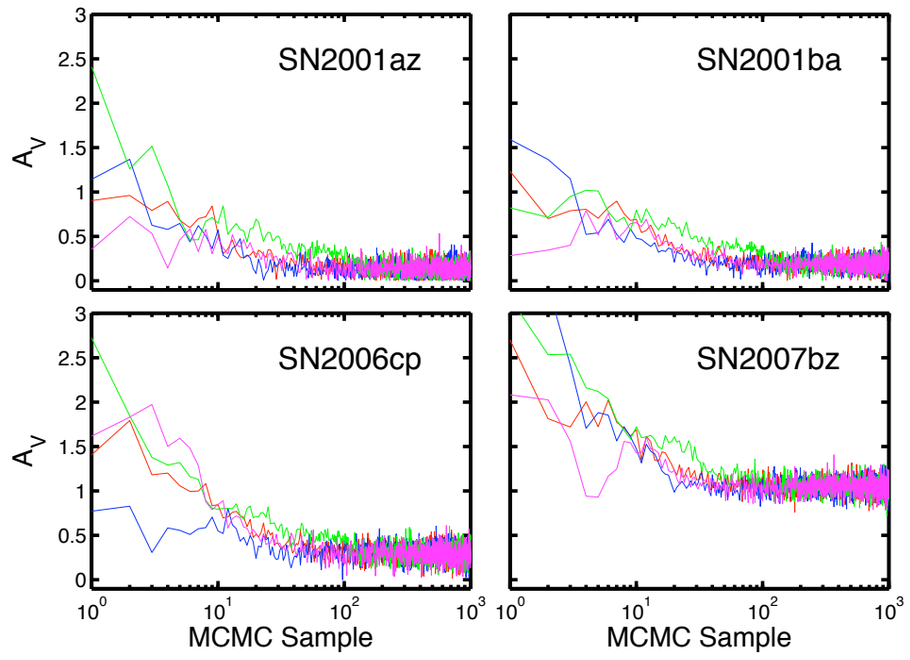
Strategy: Build Structured Generative Probabilistic Model

- Intrinsic SN Ia Variation (Covariance[t,λ])
- Host Galaxy Dust Extinction & Reddening
- Galaxy Peculiar Velocities & Distance
- Measurement Error

"Training" - Learn about Populations



- Global Posterior Probability Density conditional on all SN data
- Compute using MCMC with Gibbs Sampling structure (BayeSN)

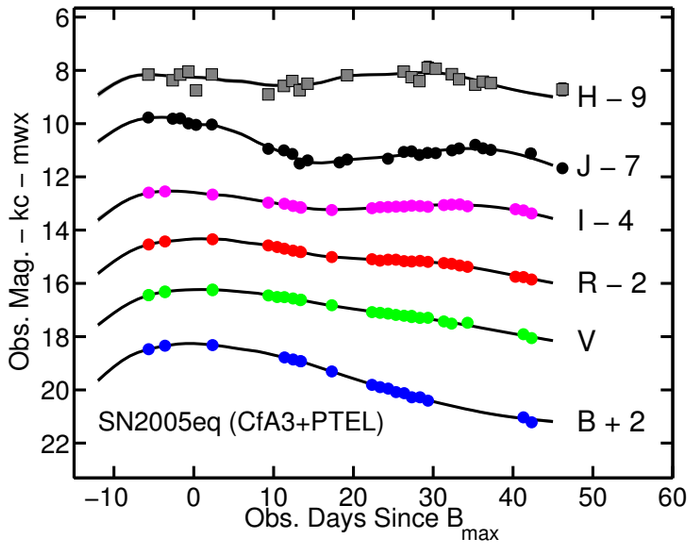


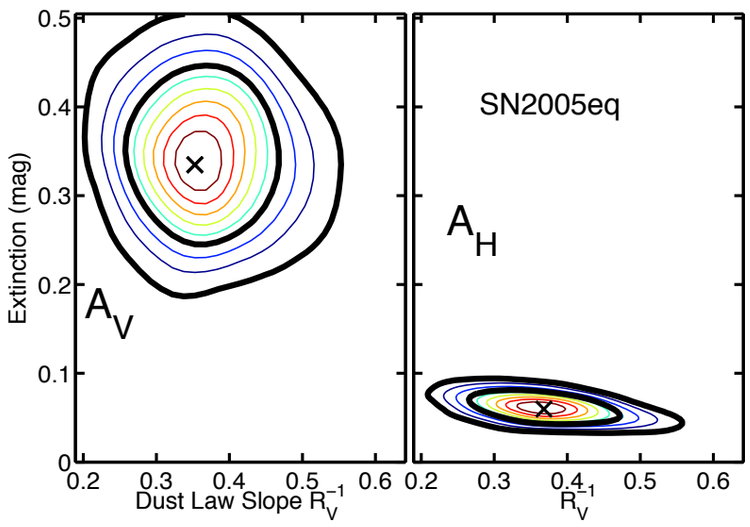
Directed Acyclic Graph / Bayesian Network

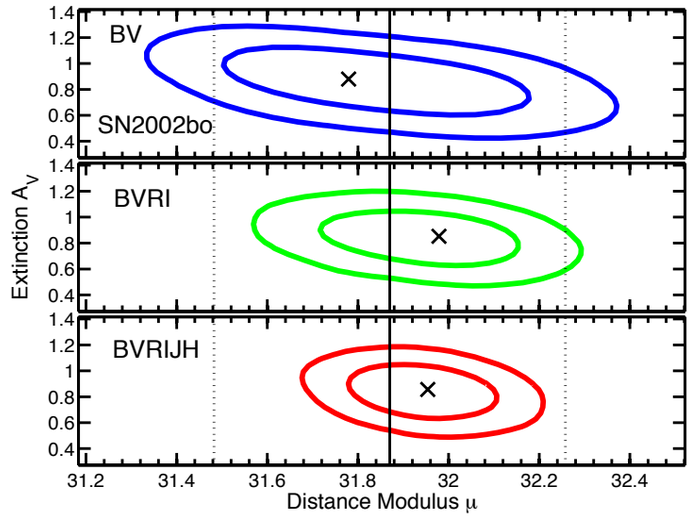
Application to Optical+NIR SN Ia Data & Results

(Mandel, Narayan & Kirshner 2011. ApJ, 731, 120)

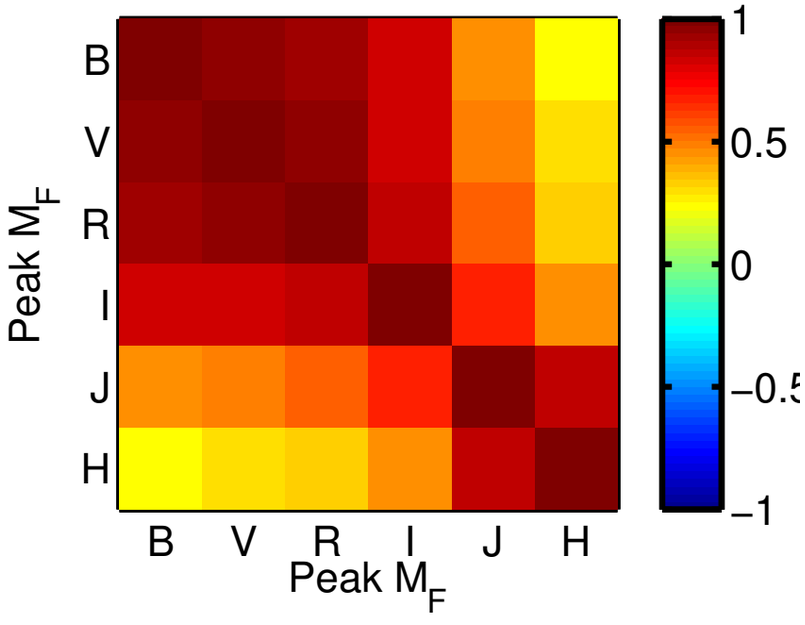
Inferences for Individual SN Ia



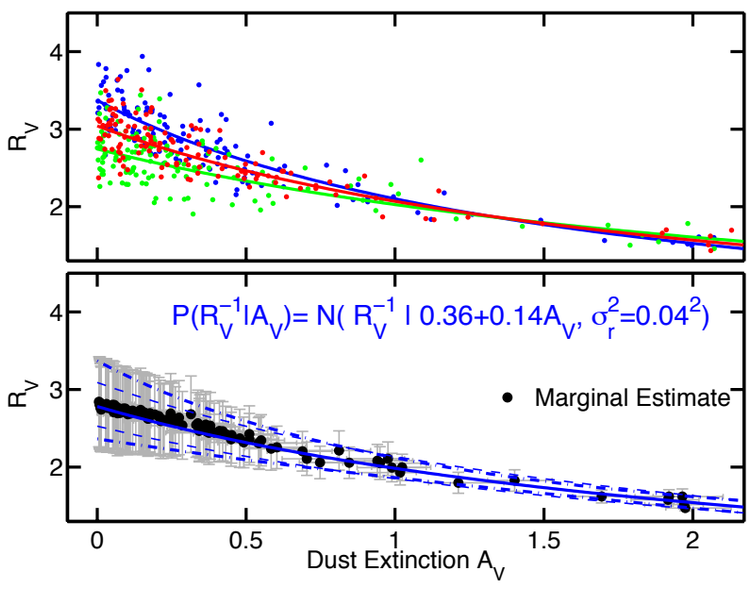




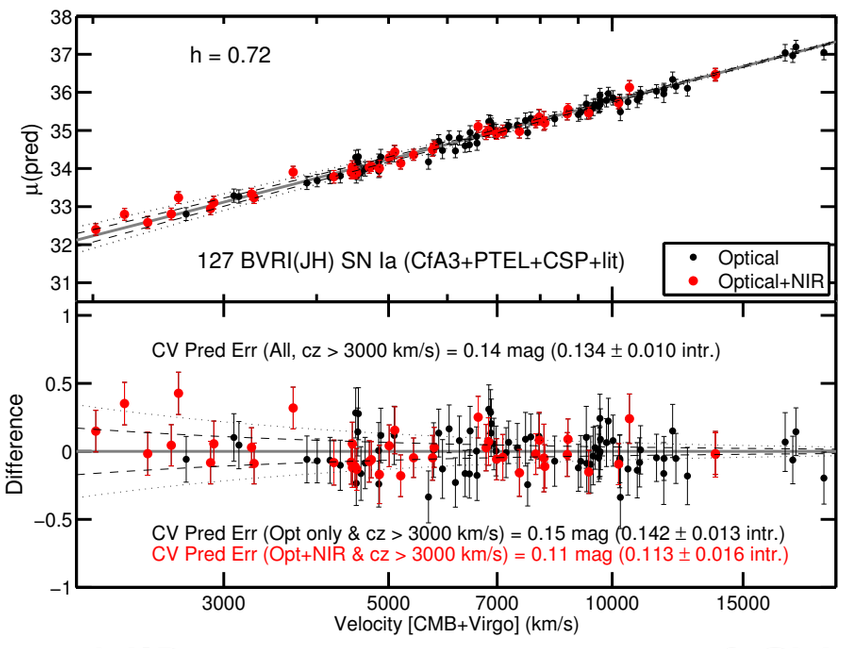
Opt+NIR SN Ia LC Fit



Opt+NIR Dust Estimates



NIR narrows constraints on dust and distance



Insights into Dust Properties

Low Correlation btw Opt and NIR Luminosities

Inferences for Population

NIR increases precision of CV distance predictions by ~2x