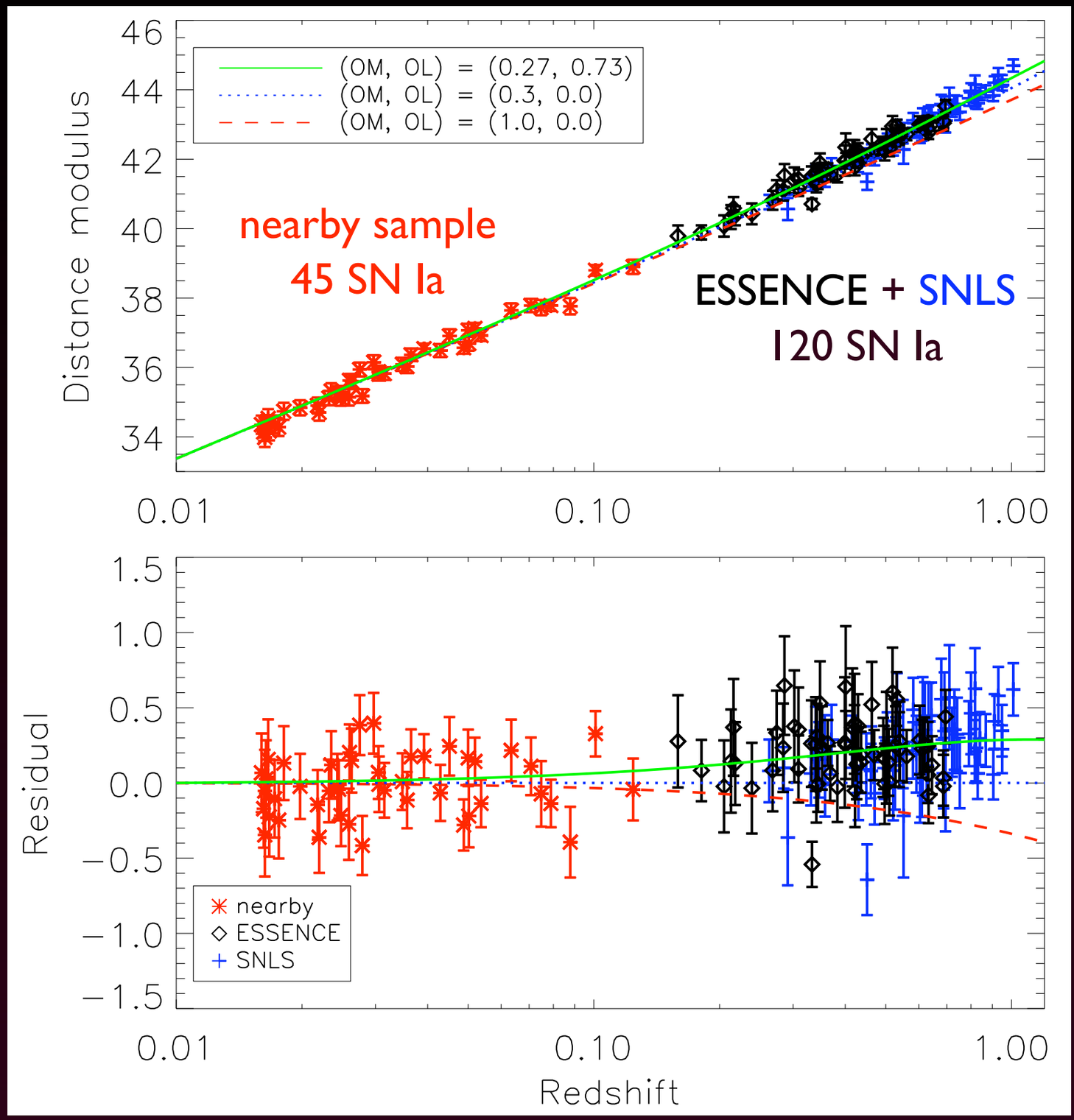
The Low-z SN Ia Sample: Critical to Cosmology

Saurabh Jha
Kavli Institute for Particle Astrophysics and Cosmology
Stanford Linear Accelerator Center

Paths to Exploding Stars: Accretion and Eruption KITP/UCSB March 23, 2007

Critical to Cosmology

- nearby sample: z < 0.15 (arbitrary, but practical defintion)
- anchor the Hubble diagram, essentially independent of Ω_M, Λ, w
- provide the empirical correlations that make Ia's precisely calibrated candles
- studied in greatest detail



Astier et al. (2006), Wood-Vasey et al. (2007)

The modern sample:
a detector-based classification

- Eyeballs: Tycho (1572), Kepler (1604)? *prehistoric*

- Photographic SN I(a?) *ancient history*

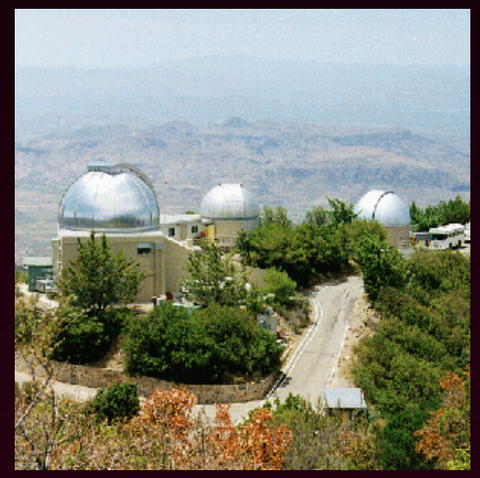
- Photoelectric photometry *dawn of the modern age*
  - SN 1972E, SN 1980N, SN 1981B, ...

- CCD photometry (mid 1980s - present)
  - secure spectroscopic identifications of SN Ia
  - high-precision, multicolor photometry
  - establishment of the Phillips (1993) relation
  - advent of large, homogeneous surveys

Nearby SN Ia photometry samples: today

- Calán/Tololo (1990-1993; Hamuy et al. 1996)
  - photographic search *and* CCD follow-up
  - 29 objects, BVI template-subtraction photometry
  - mean redshift *cz* = 13500 km/s

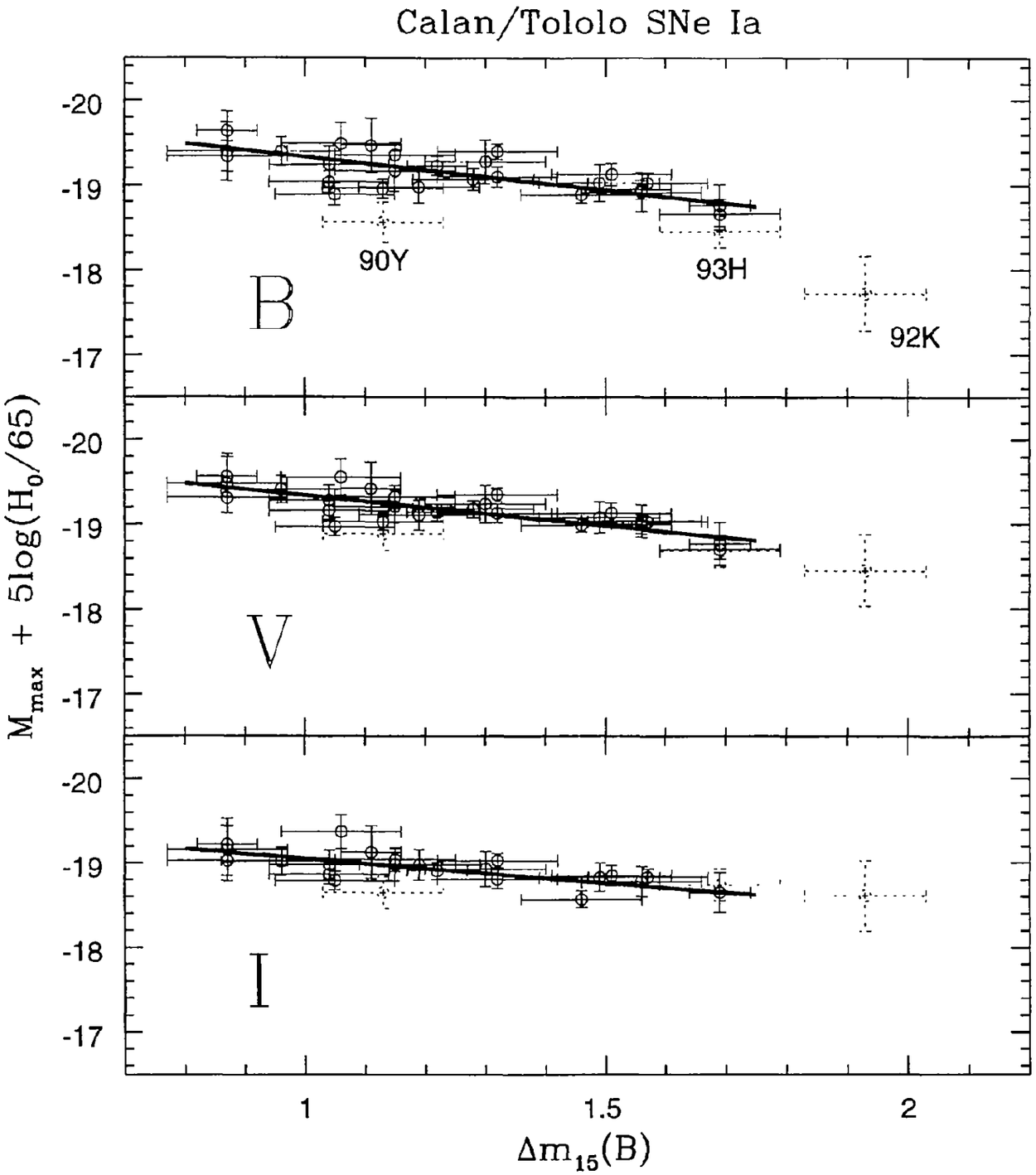
- CfA I (1993-1996; Riess et al. 1999)
  - follow-up only, 22 objects, BVRI photometry
  - mean redshift *cz* = 7500 km/s

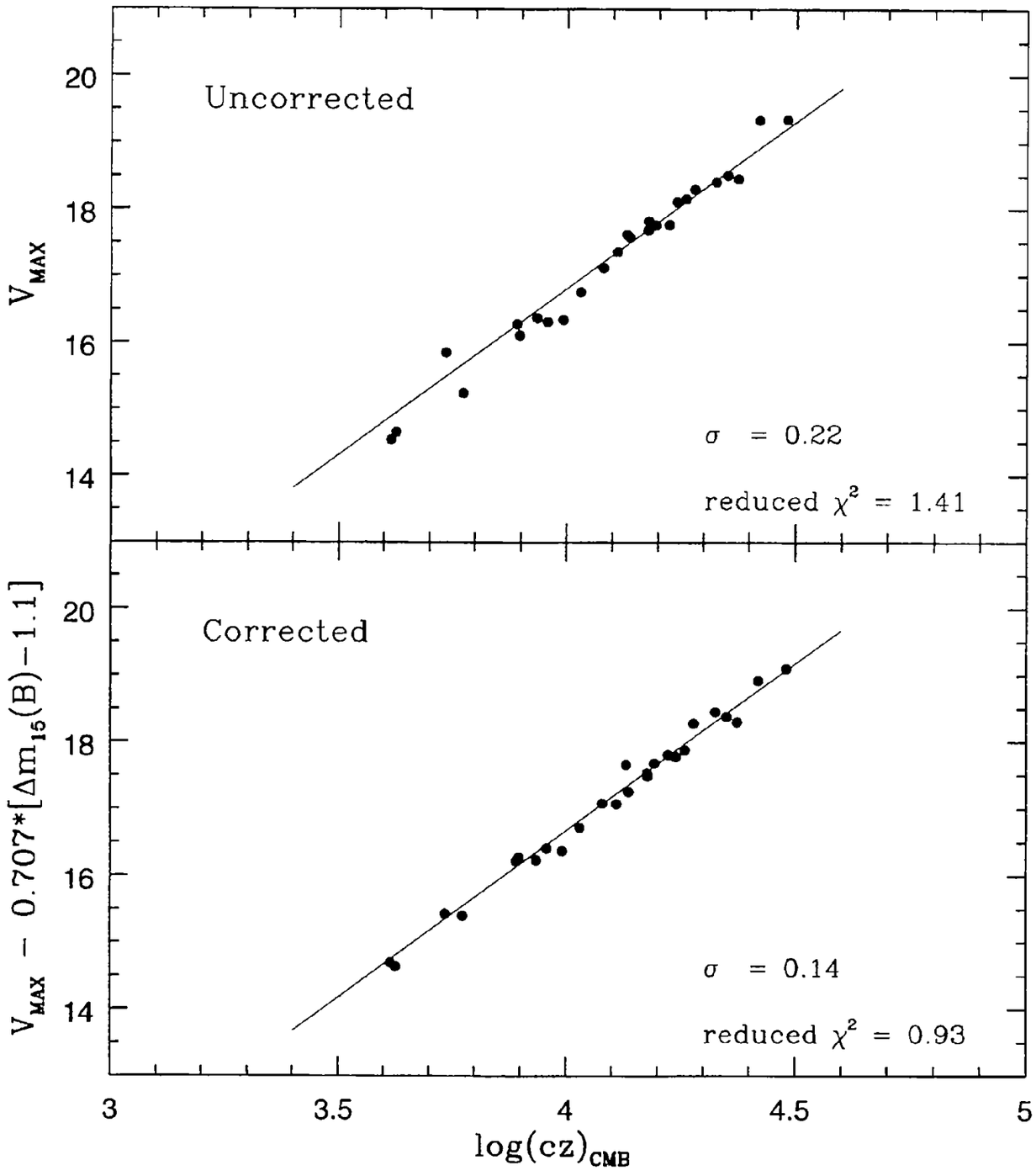


- CfA II (1997-2000; Jha et al. 2006)
  - 44 objects, UBVRI photometry
  - mean redshift *cz* = 5300 km/s

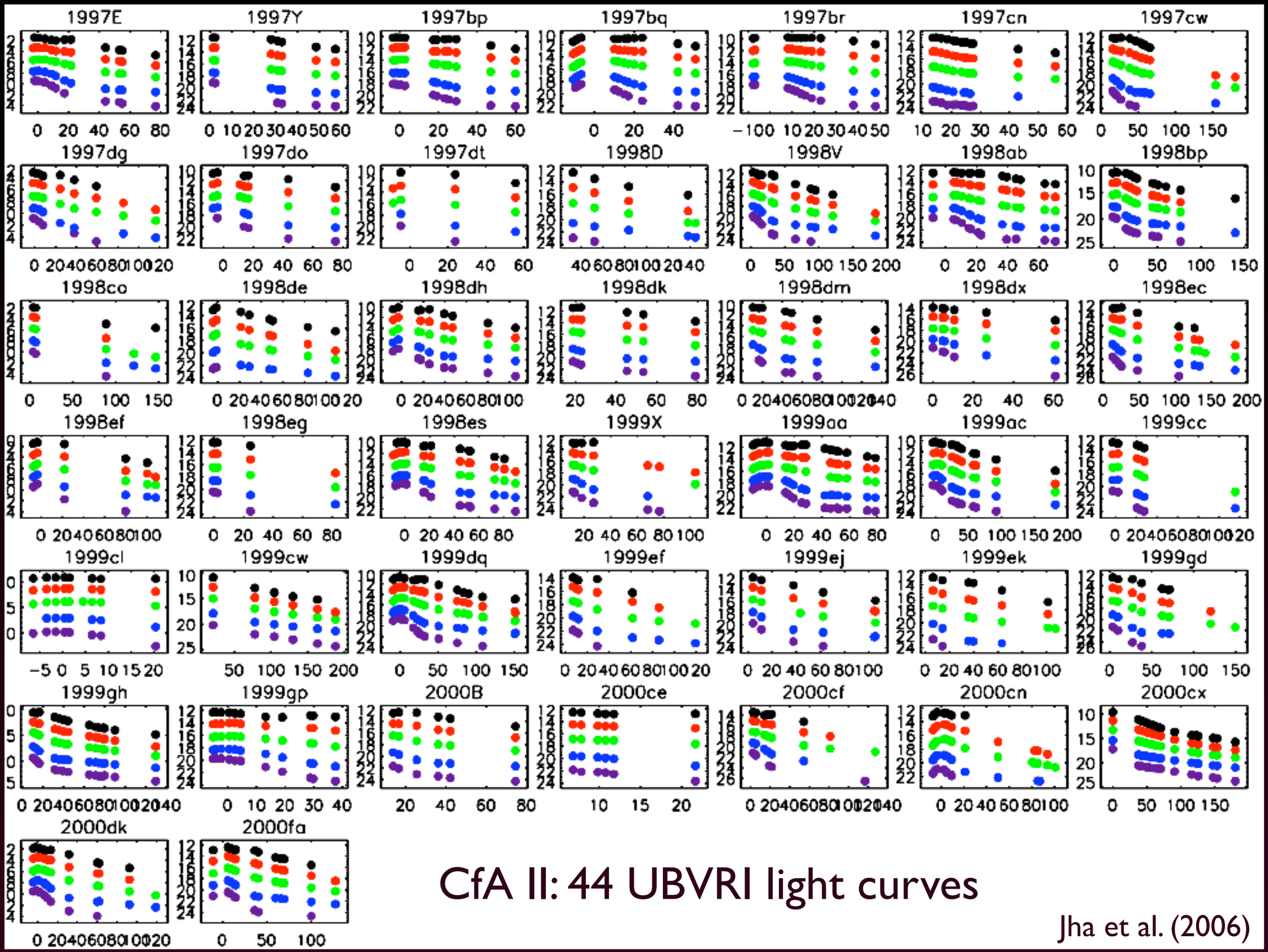
- APO/CTIO/LCO (Krisciunas et al. 2000,03,04,06,07; 19 SN Ia 1999-2004)
- ESO (Altavilla et al. 2004; 18 objects 1991-2000)
- many papers with individual or a few objects

The Groundbreaking Work: Calán/Tololo





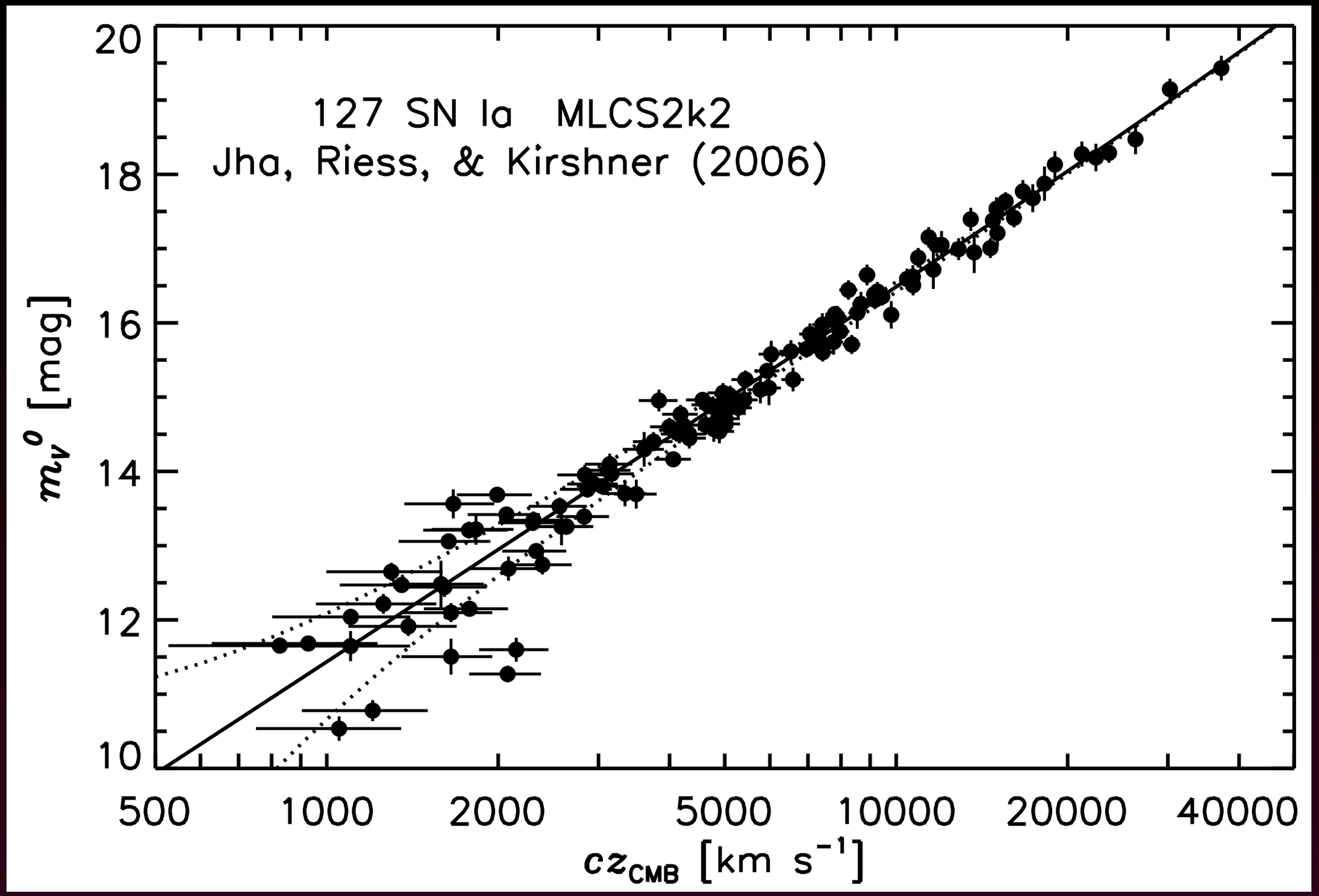
Hamuy et al. (1996a,b)



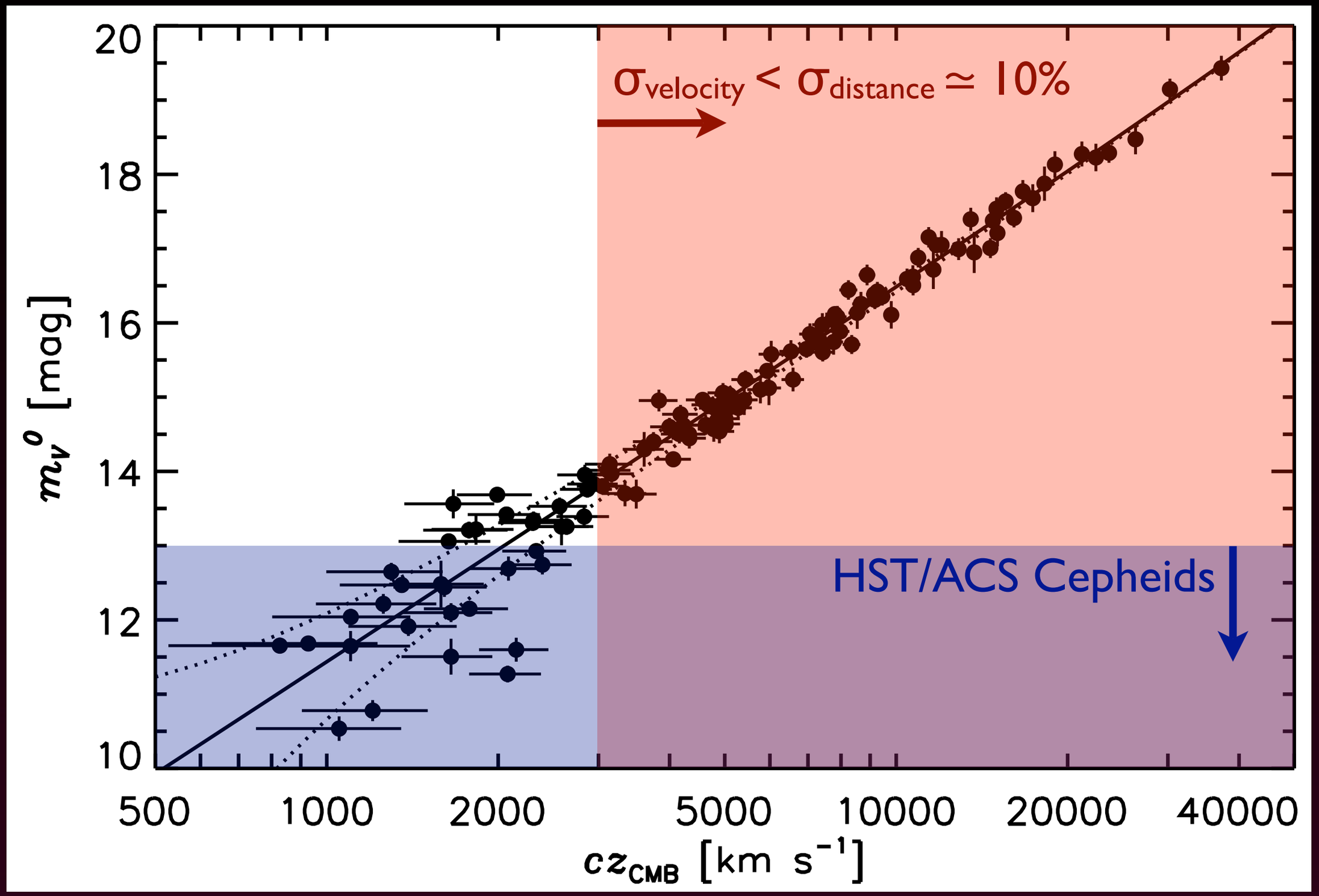
CfA II: 44 UBVRI light curves

Jha et al. (2006)

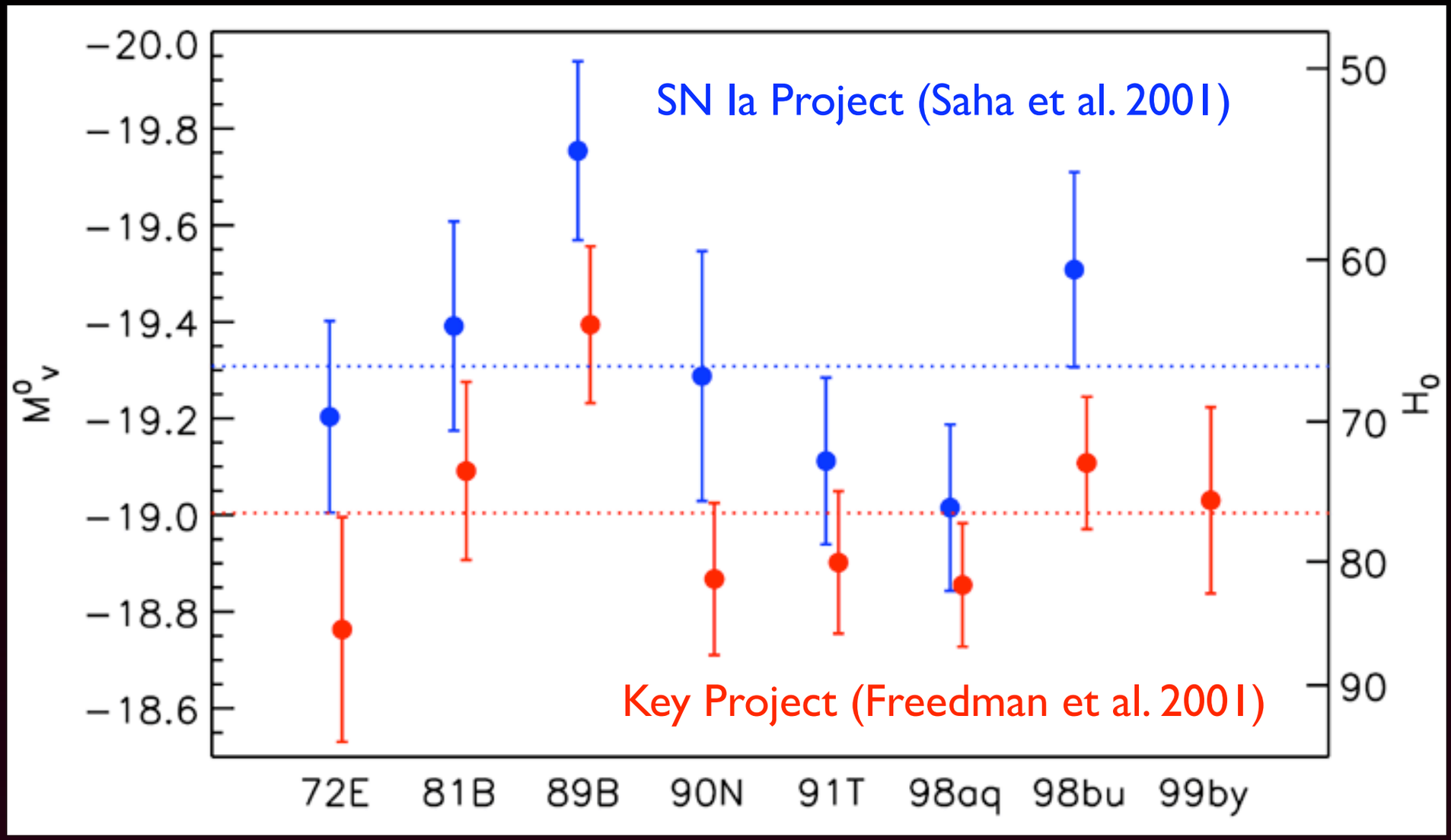
Nearby Hubble Diagram



Low-z cosmology: the Hubble constant



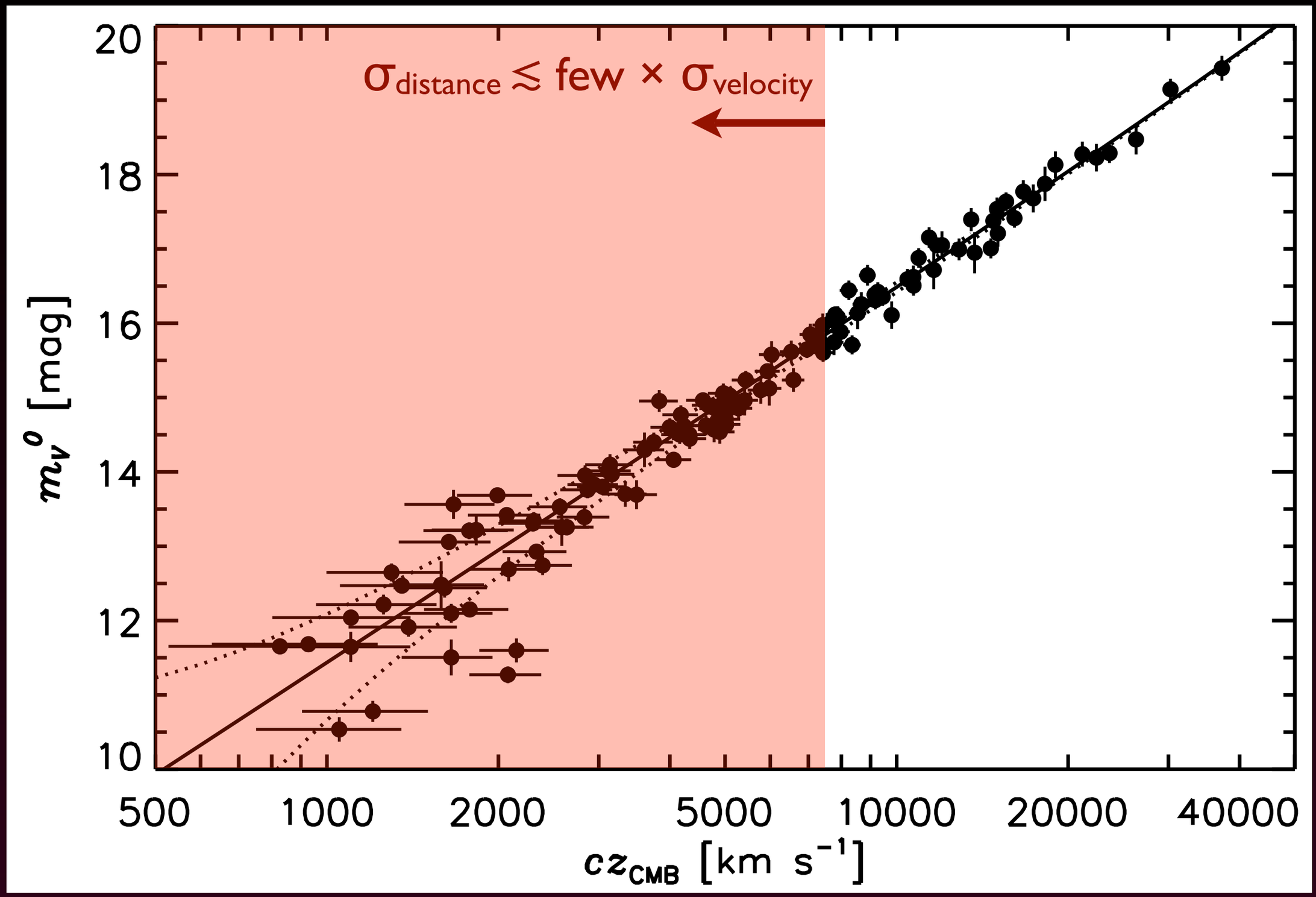
Hubble Trouble: measuring H_0



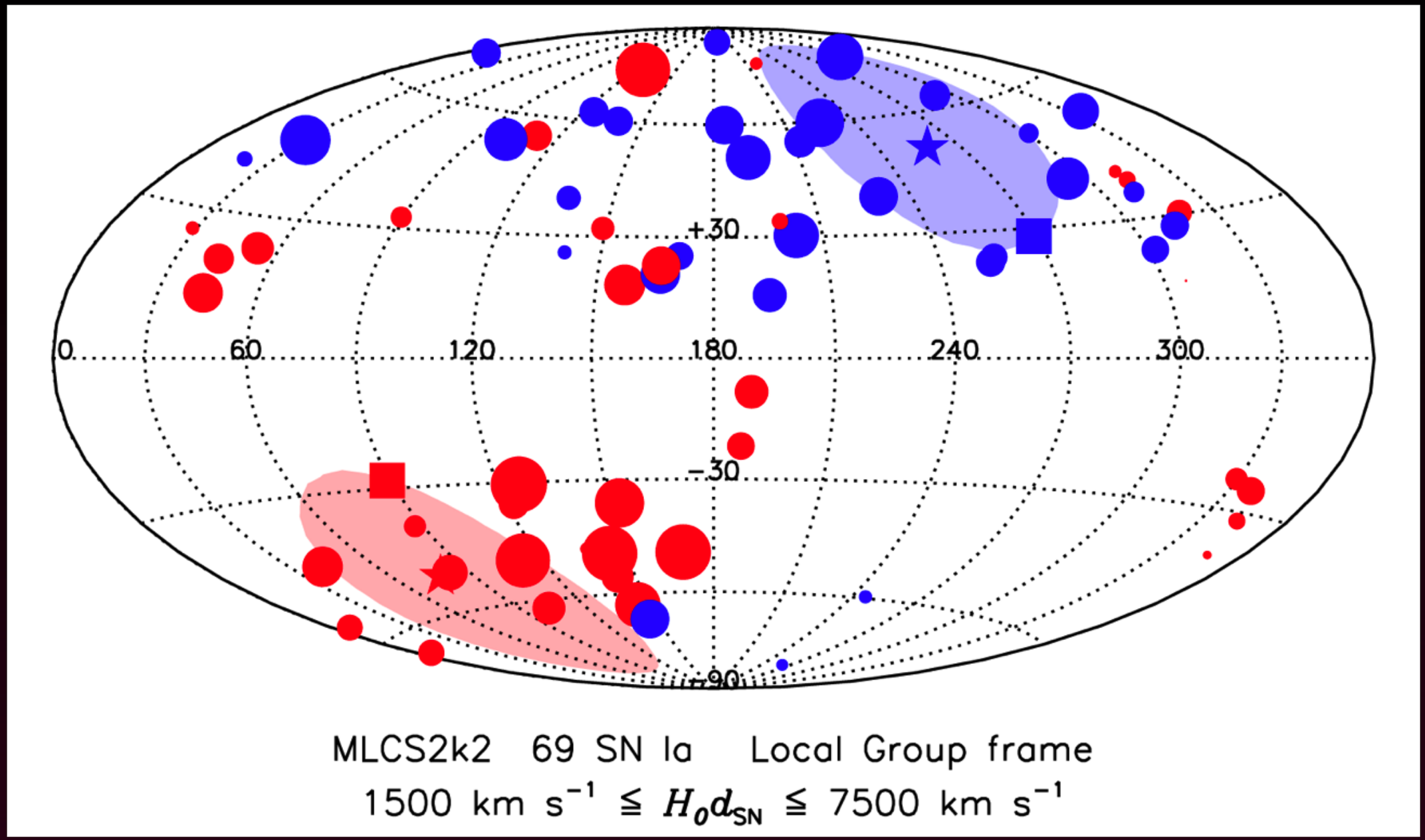
same HST Cepheid data! same SN distances!

from 4 "ideal" calibrators: $H_0 = 73 \pm 6$ km s^{-1} Mpc^{-1} (Riess et al. 2005)
5% precision in the near(-IR) future, bypassing the LMC...

Going with the flows



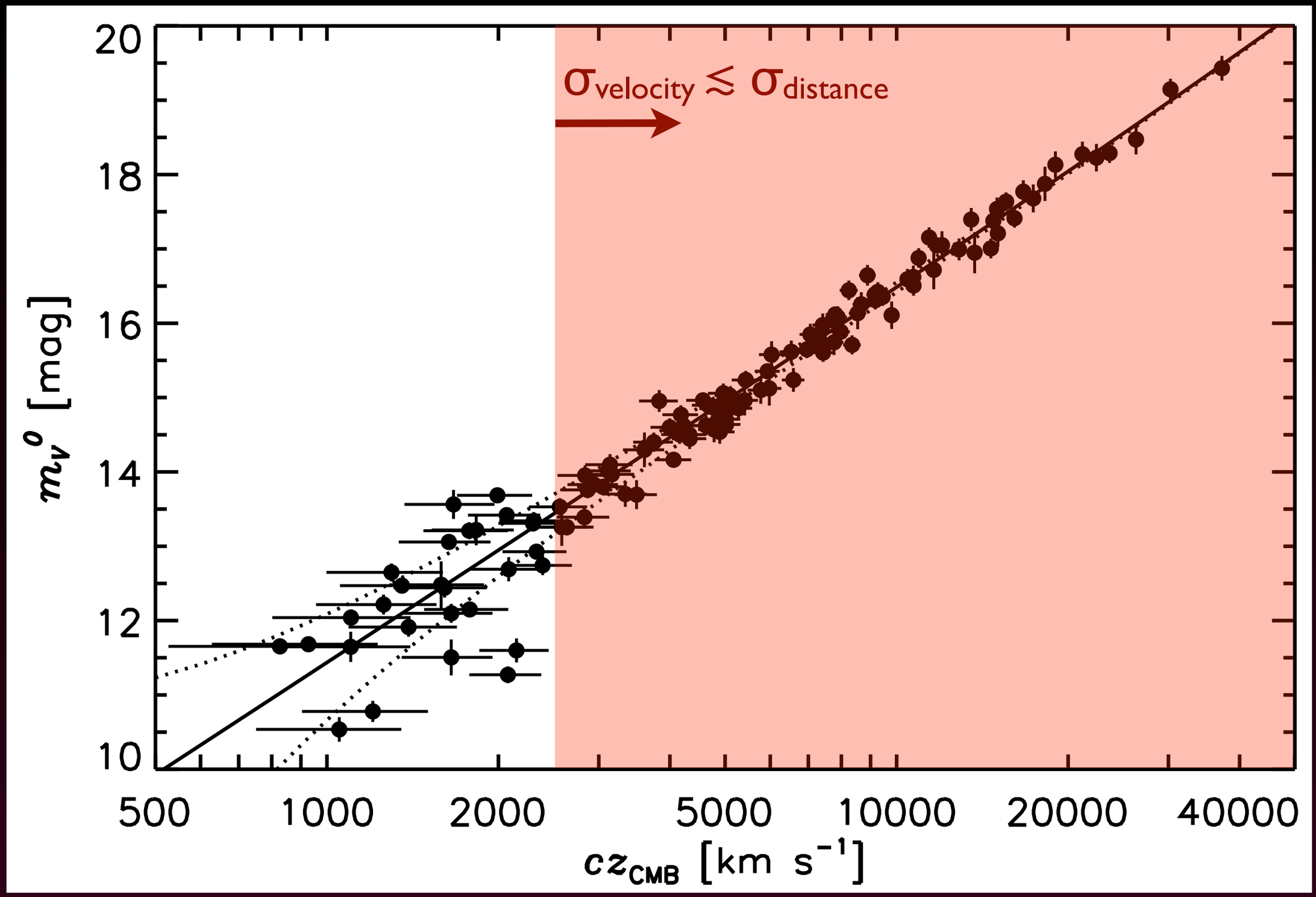
Going with the flows



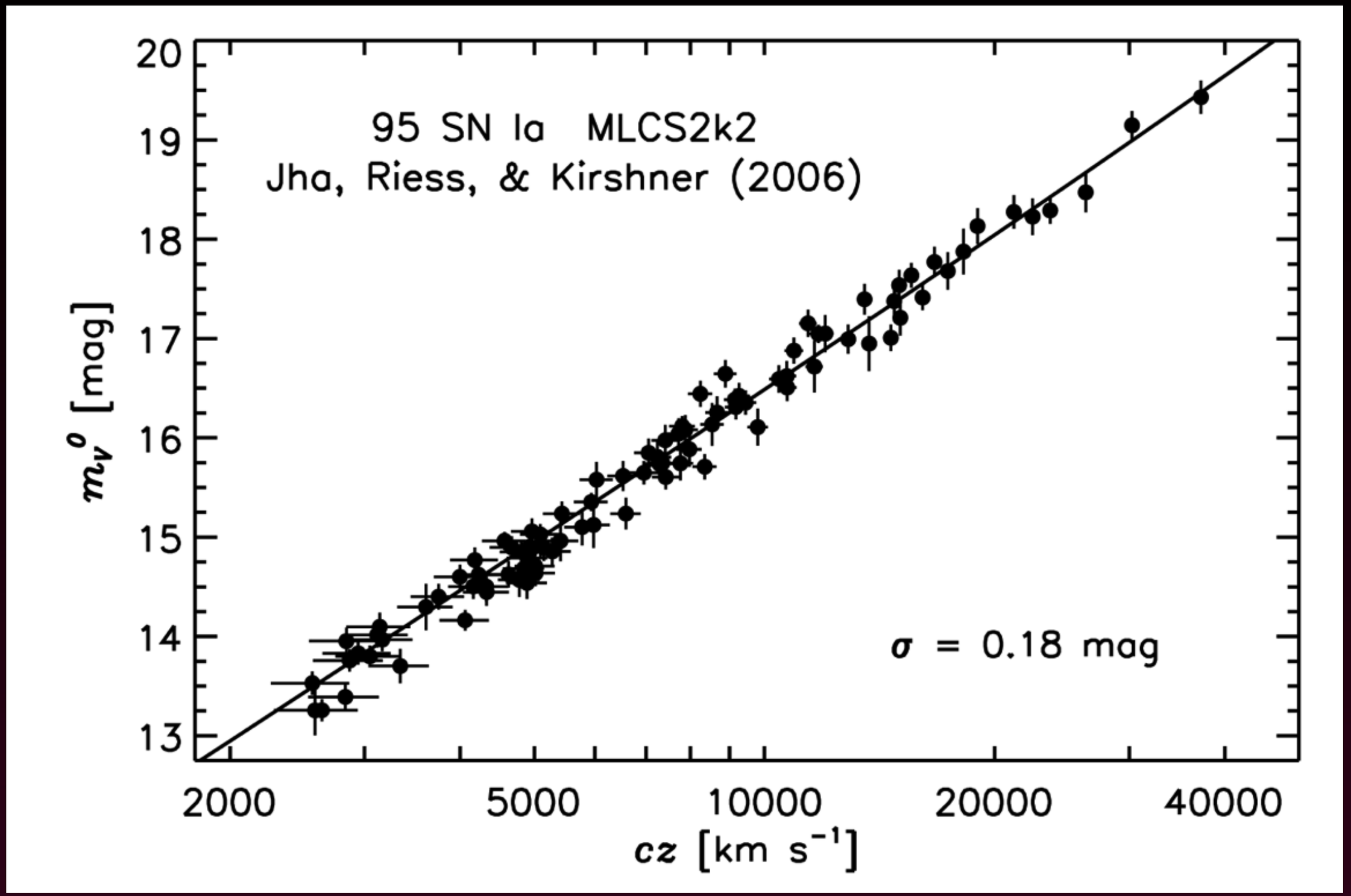
Jha, Riess, & Kirshner (2006)

data also amenable to more sophisticated analysis (e.g., Haugbølle et al. 2006)

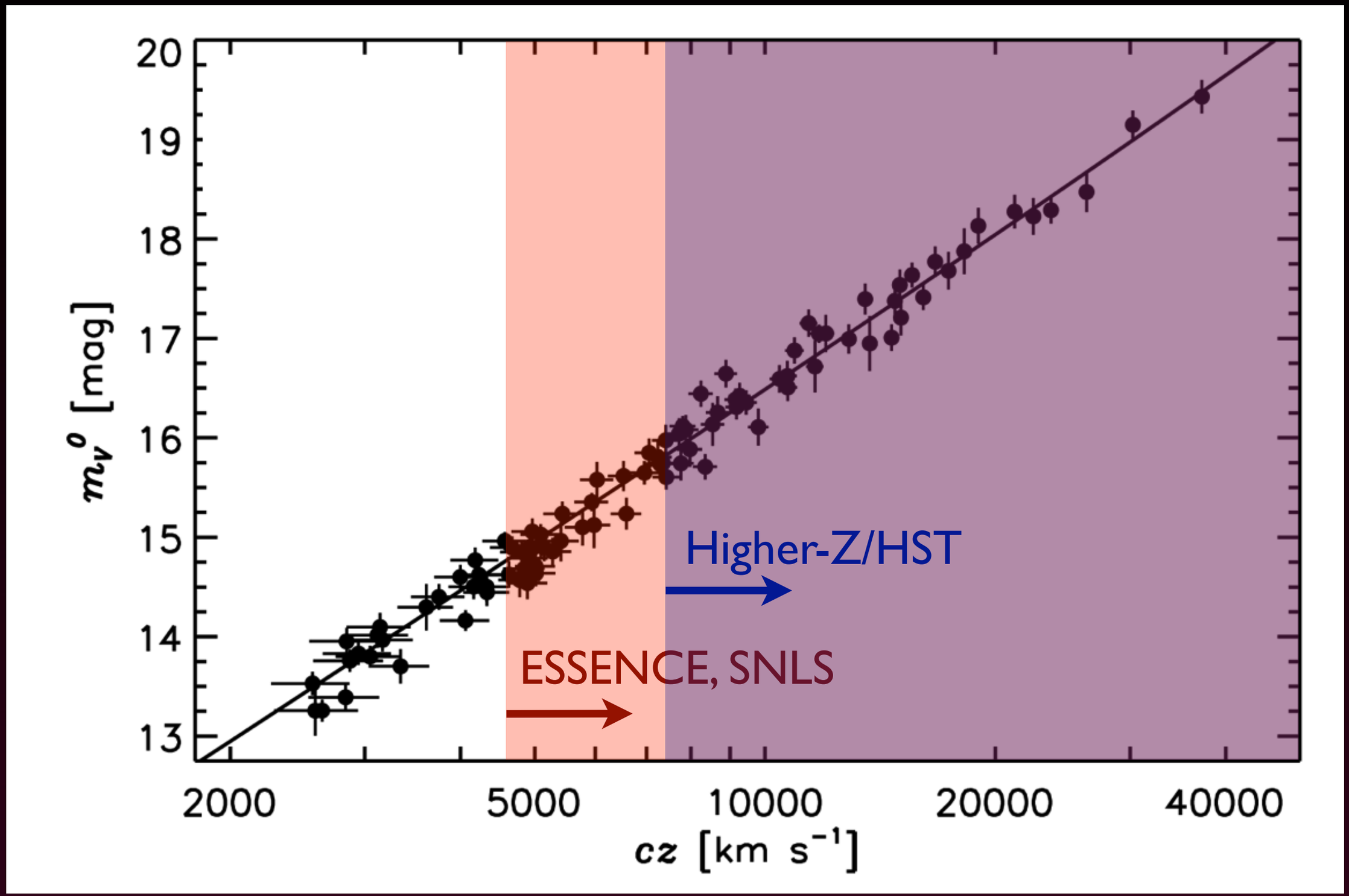
The smooth Hubble flow



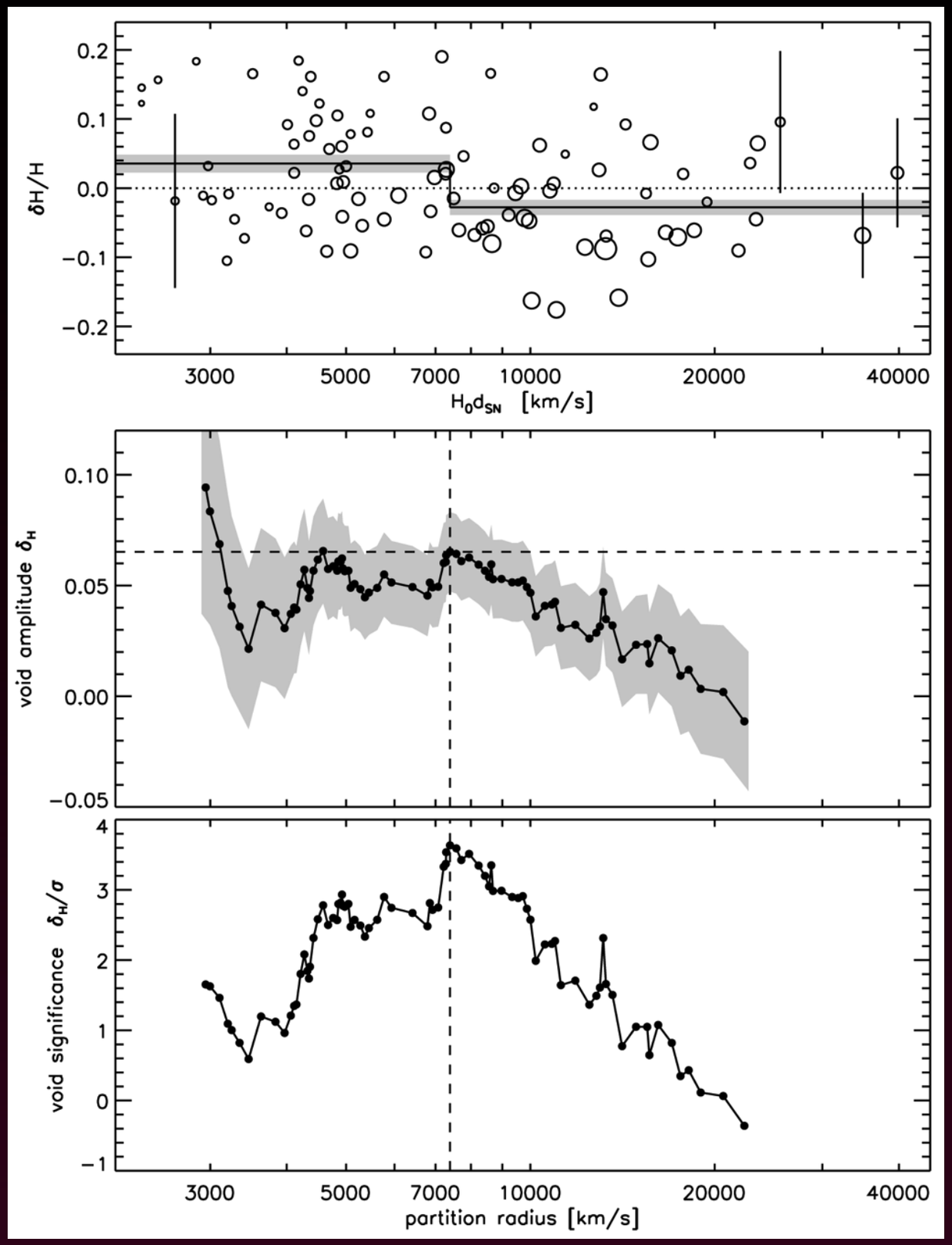
Hubble flow Hubble diagram



Hubble flow Hubble diagram



A Hubble Bubble?

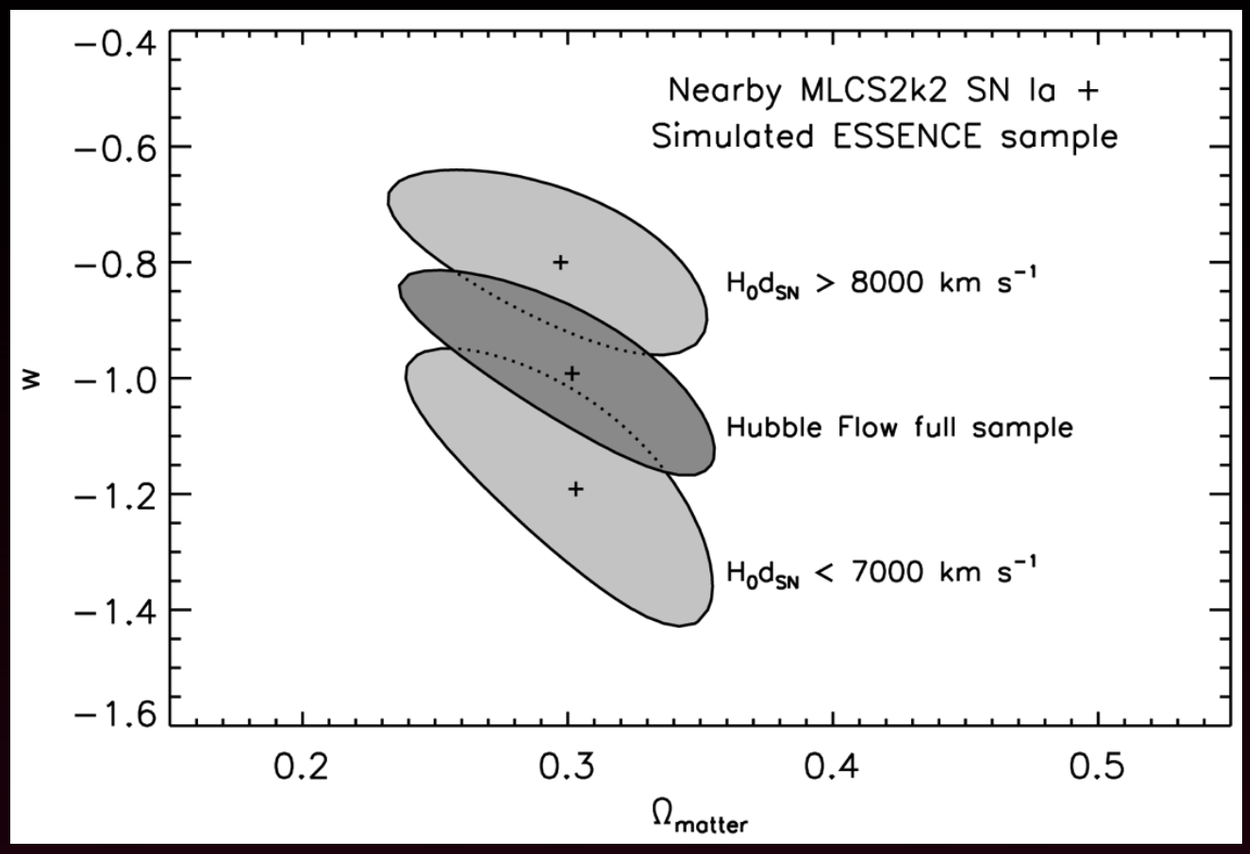


Jha, Riess, & Kirshner (2006)

↕ a 6% difference in the expansion rate at a radius of 100 Mpc, roughly isotropic

statistical signifcance is 2.5σ, but robust with subsamples, other distance techniques

A Hubble Bubble?



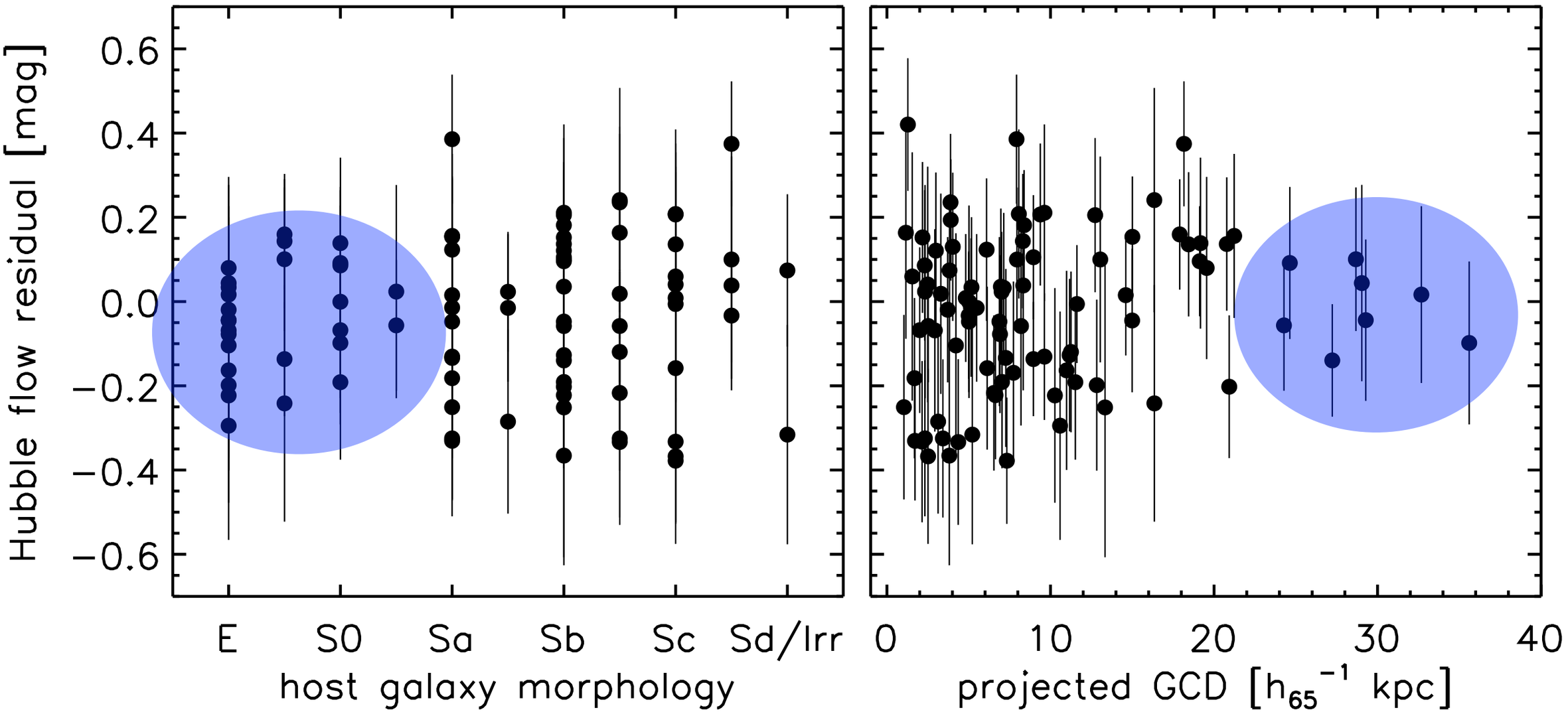
- a real local void?
- K-corrections?
- photometric offset?
  - new data vs. Calán/Tololo?
  - morphology/extinction?

a potentially huge systematic

→ *test with more nearby objects!*

Sharpening our precision tools

Jha, Riess, & Kirshner (2006)



Are we battling the fog of dust?

Intrinsic dispersion of subsamples could be much lower: 3% distances?

→ *we need more nearby objects!*

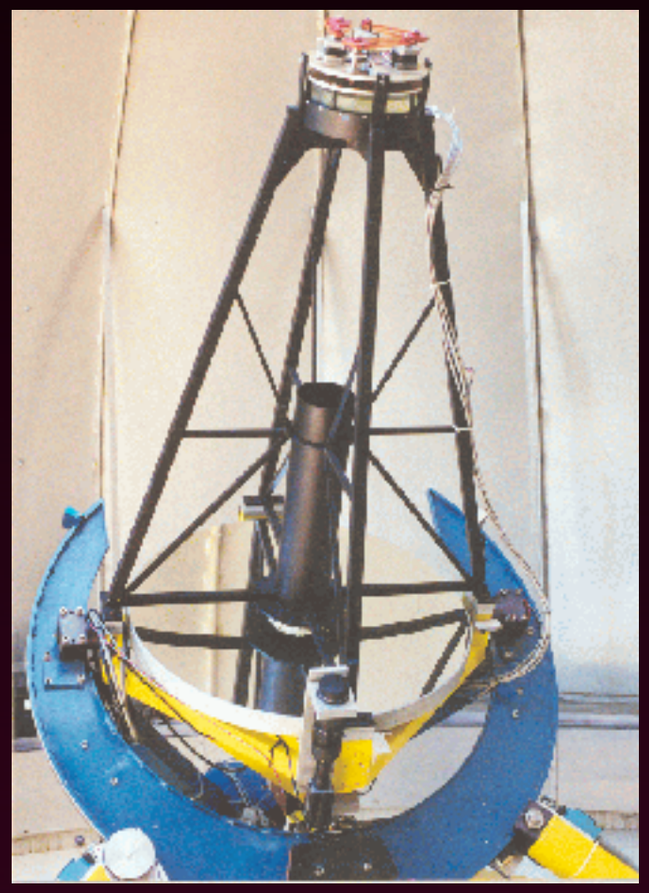
Nearby SN Ia photometry samples: tomorrow

- Lick Observatory SN Search (and follow-up!)
  - 96 SN Ia from 1998-2004, BVRI light curves
  - mean redshift *cz* = 6000 km/s (Ganeshalingam et al. 2007, in prep)
- CfA III (Hicken et al. 2007, in prep)
  - ~80 SN Ia from 2000-2004 (and >70 more from 2005-2007)
  - mean redshift *cz* = 6800 km/s
- Carnegie Supernova Program (Hamuy et al. 2007)
  - ~35 SN Ia from 2004-2006 (~100 over 5 years)
  - wide wavelength coverage: uBVgrizYJH (optical + near-infrared)
- SDSS-II: ~40 SN Ia/yr with z < 0.15 from 2005-2007 (Garnavich talk)
- Nearby SNFactory: IFU spectrophotometry (Thomas talk)
- Skymapper, Pan-STARRS, etc.

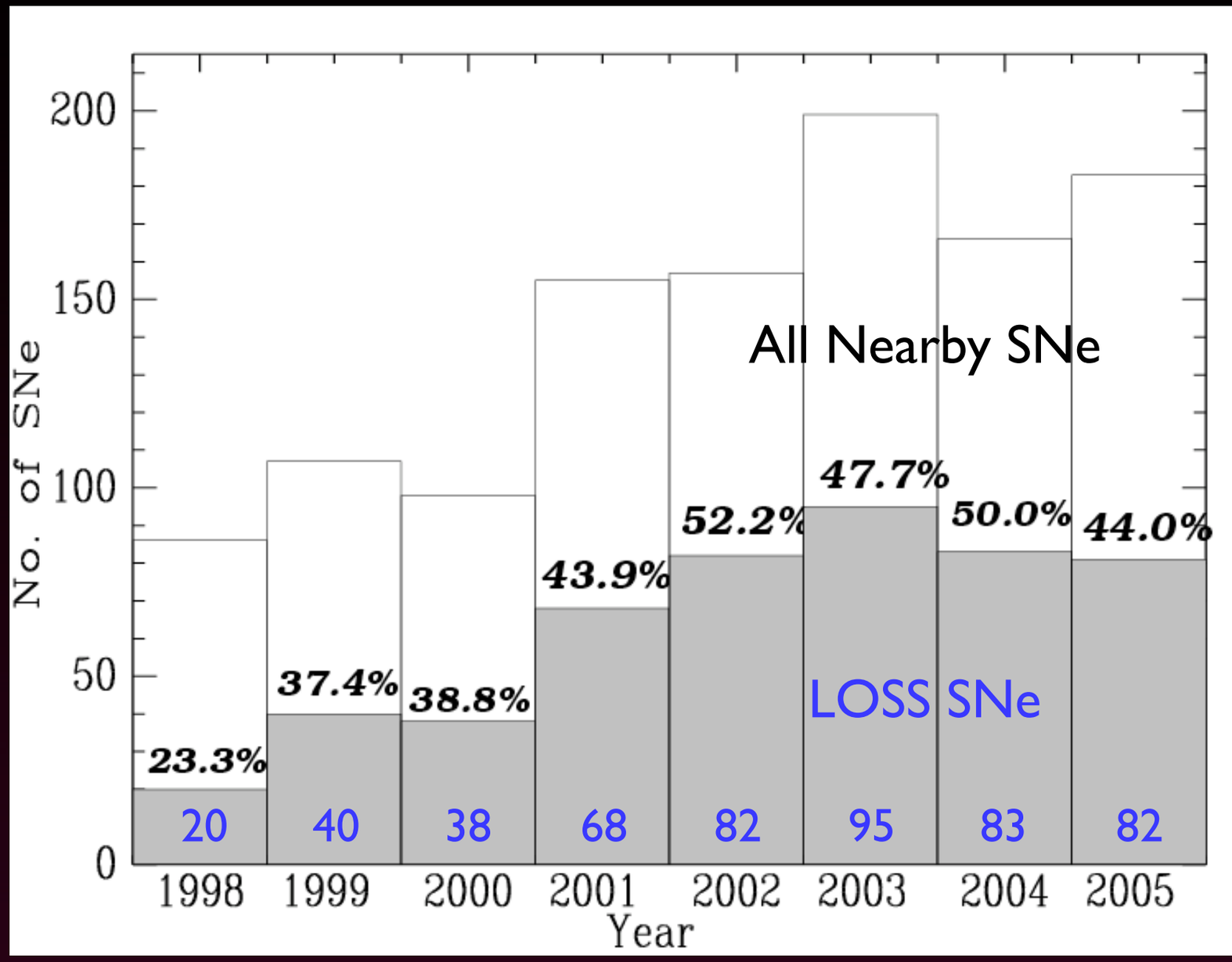
DETF report requires >500 nearby SN Ia to reach precision envisioned

we're on our way there...

Lick Observatory SN Search



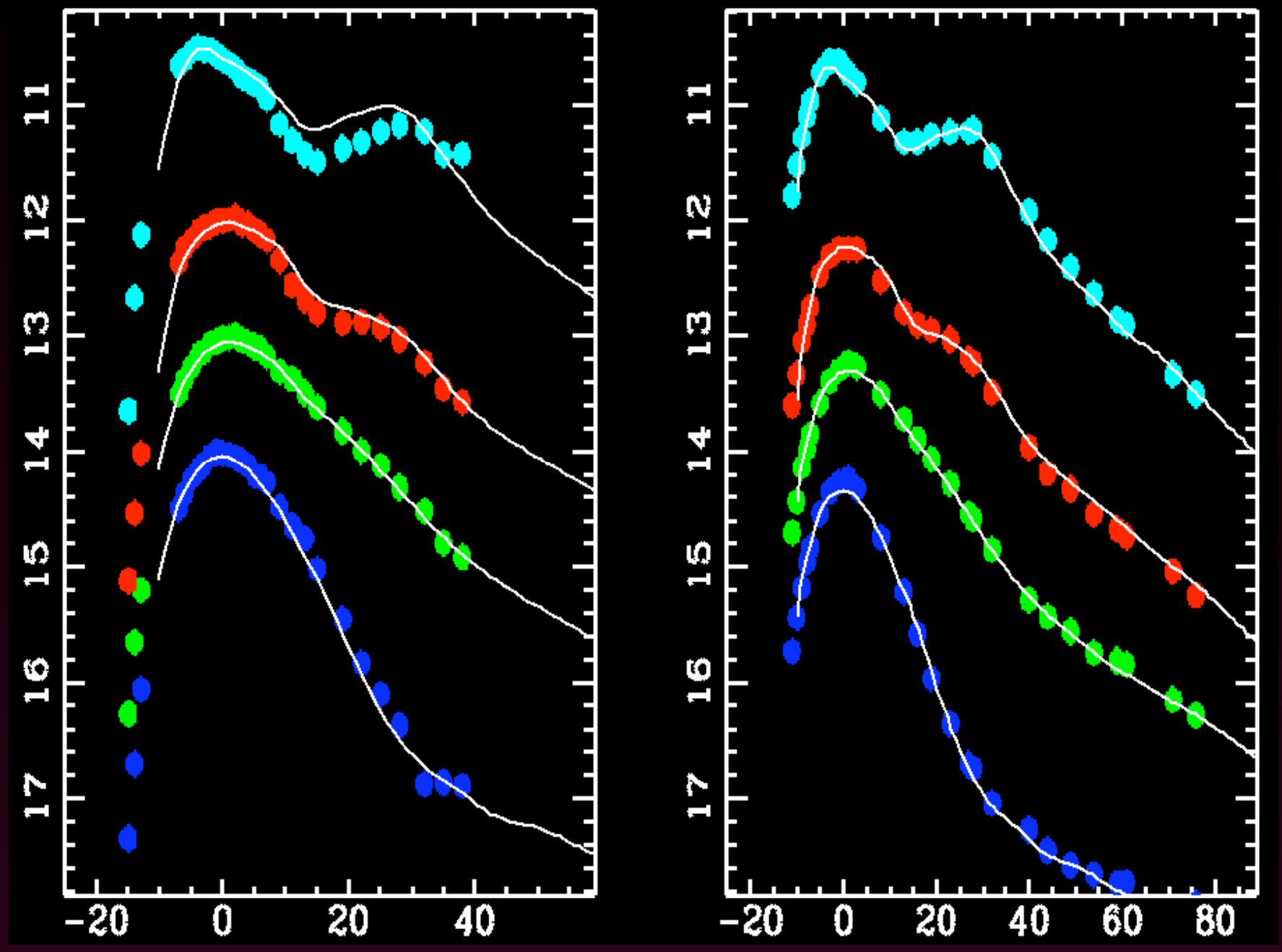
KAIT



world's most successful nearby SN search!

MLCS2k2 light curve fits

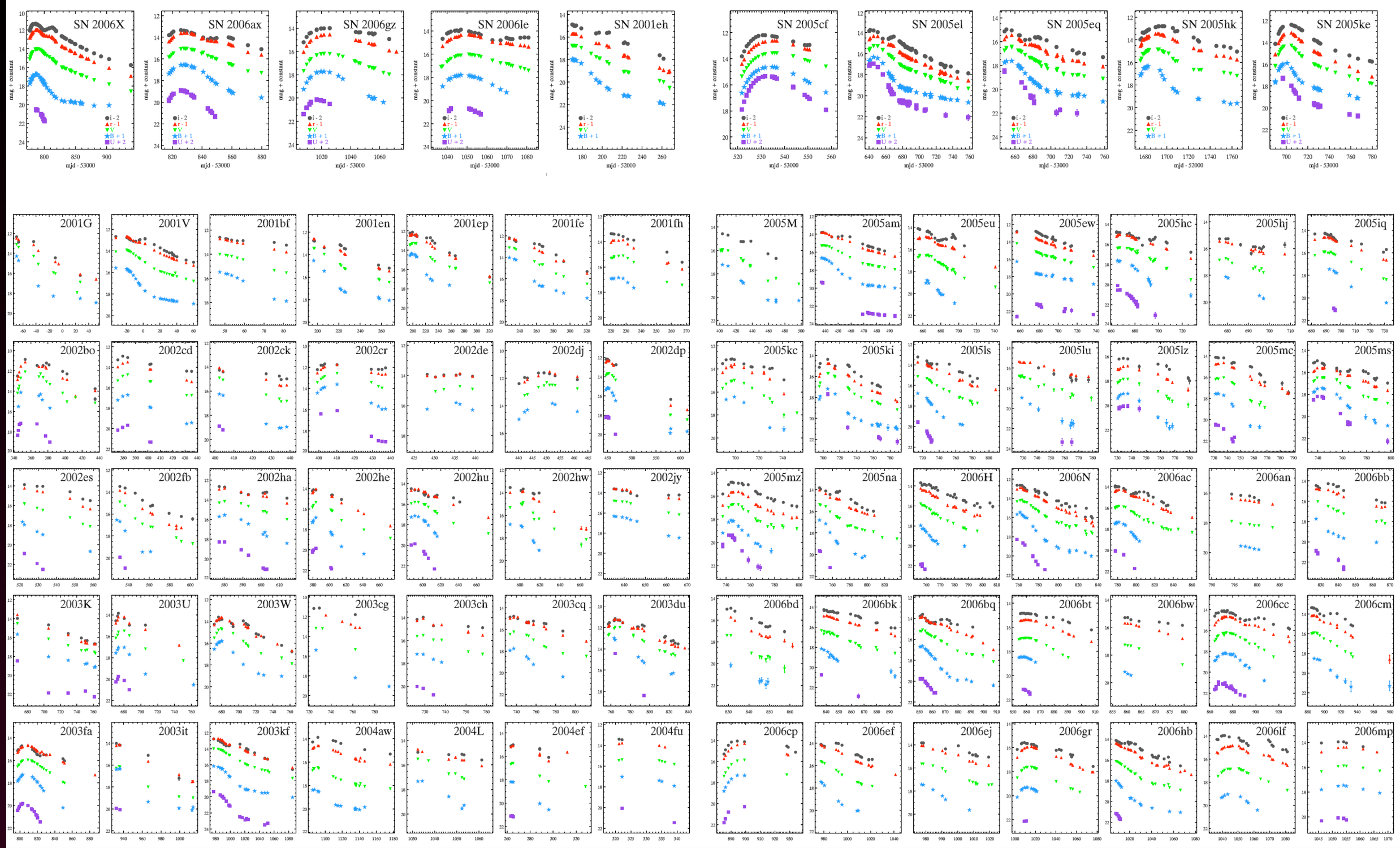
SN 1999cp KAIT BVRI photometry SN 2002cr



μ = 33.46 ± 0.07 mag μ = 33.49 ± 0.10 mag

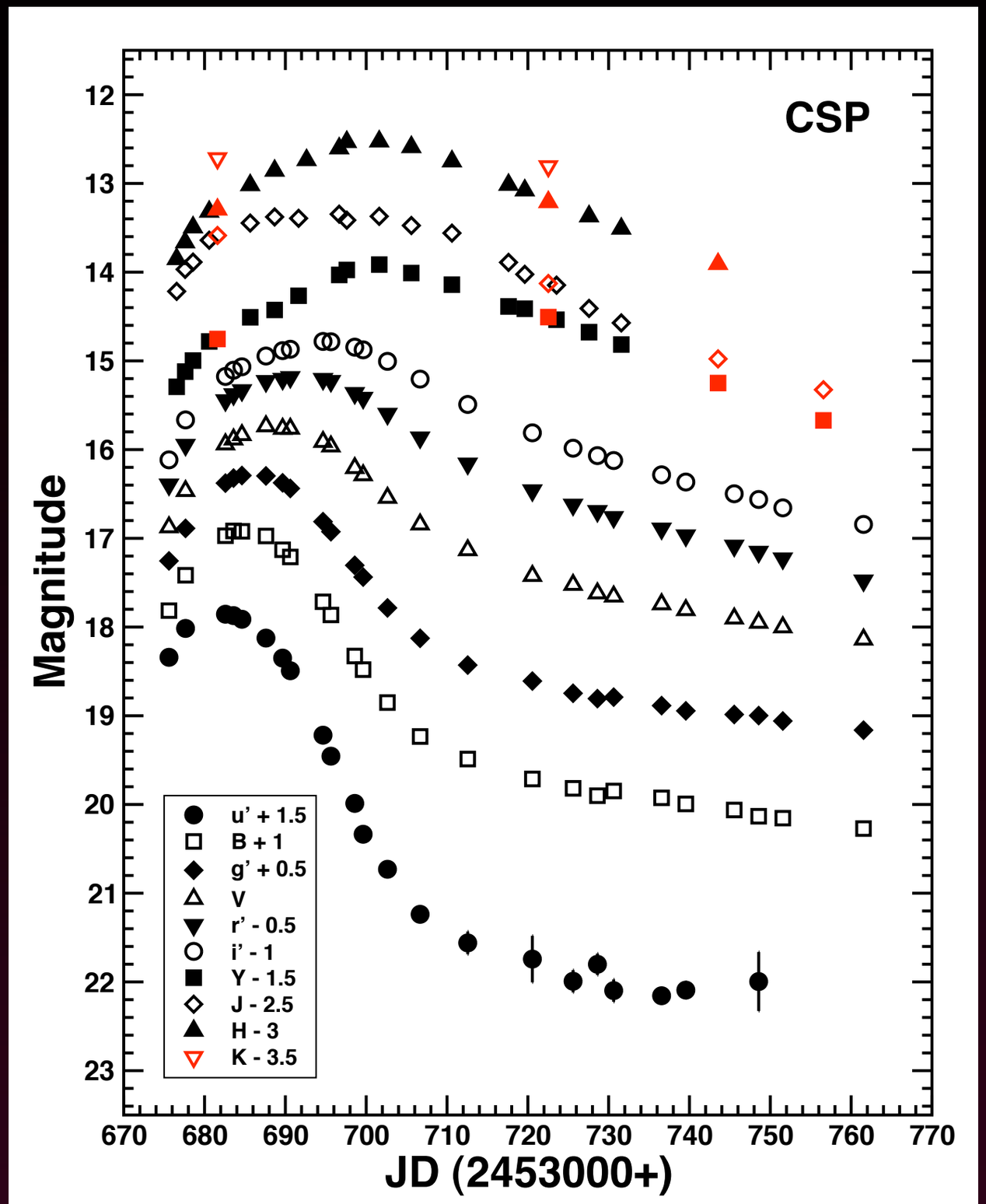
SN 1999cp and SN 2002cr are both in NGC 5468

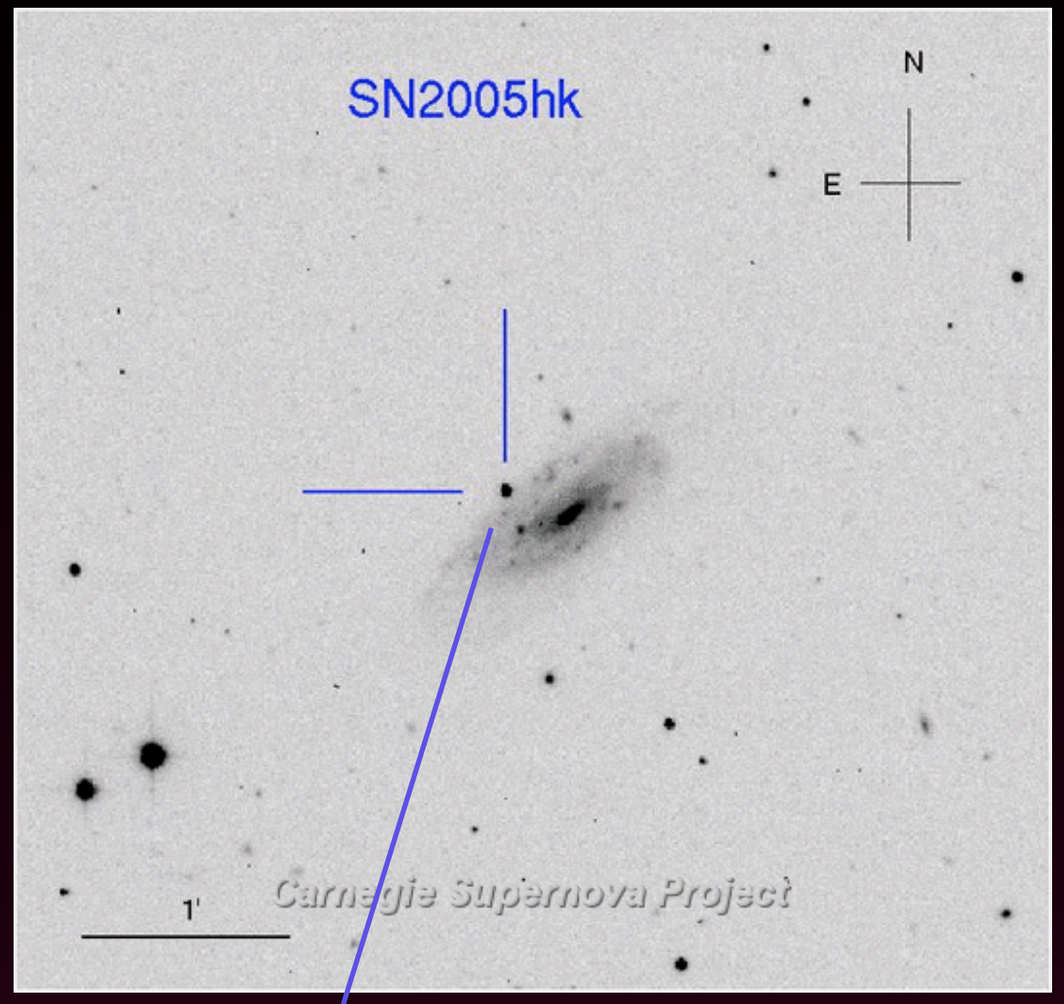
Follow-up at FLWO: CfA III



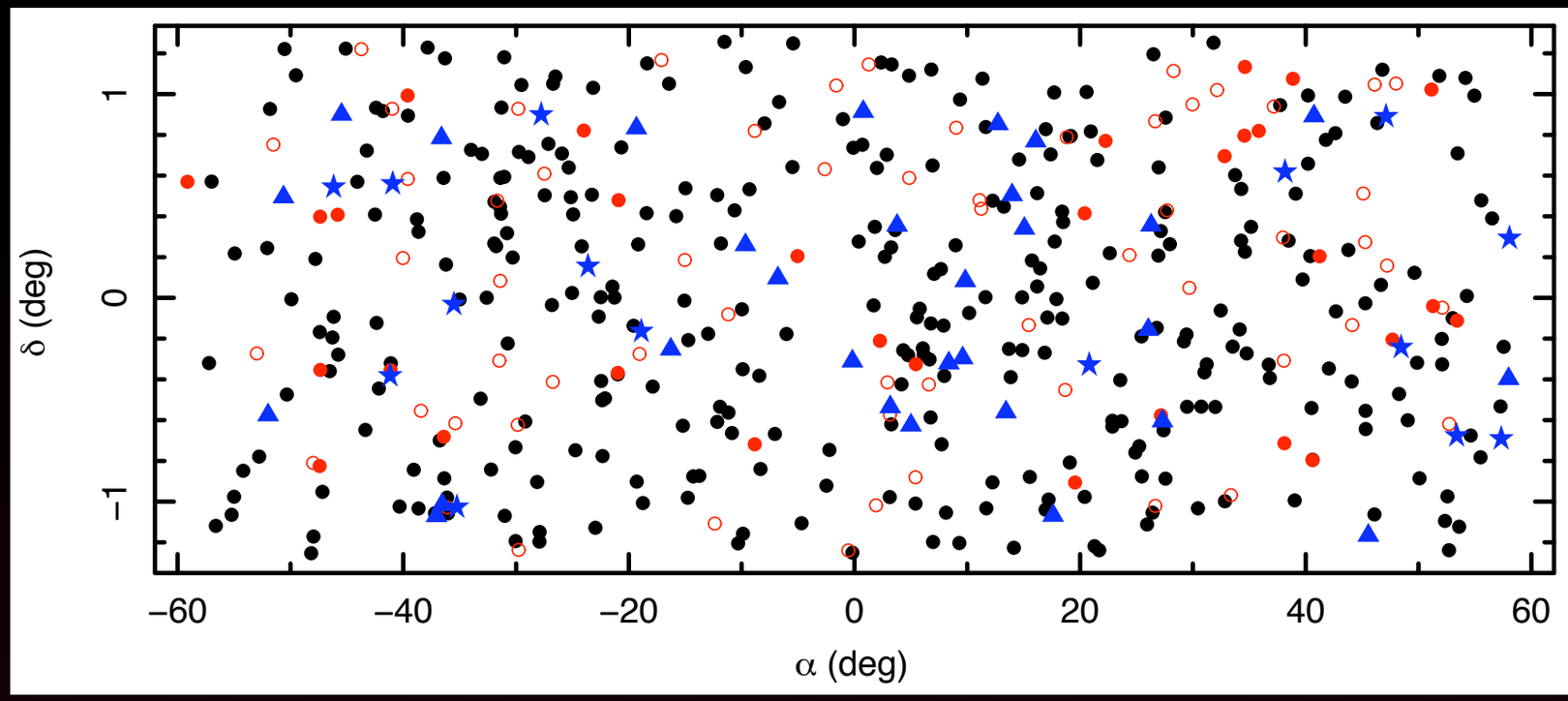
Hicken et al. (2007)

Carnegie SN Program: SN 2005hk





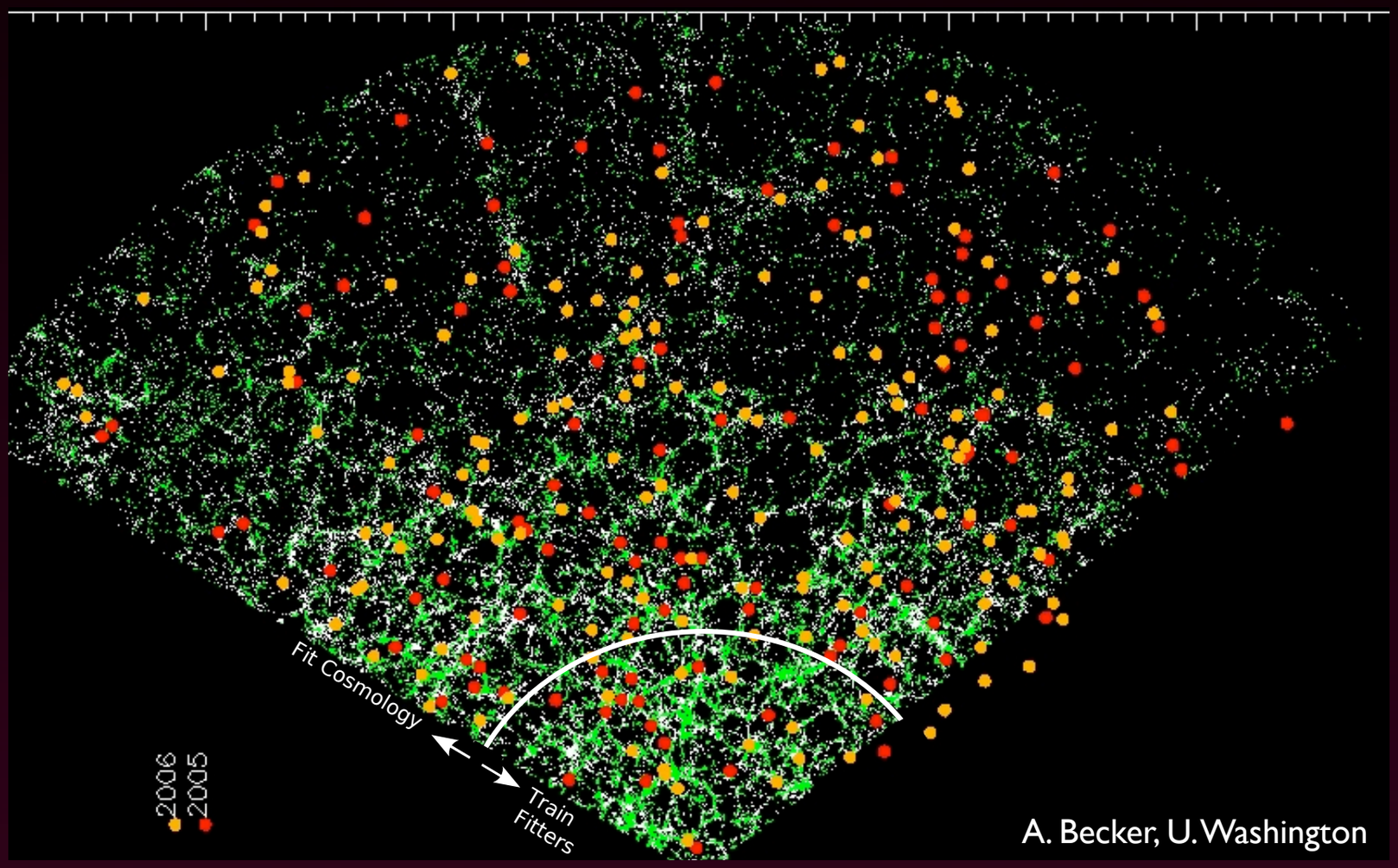
Phillips et al. (2006)



452 supernovae

spectroscopic SN Ia (313)
probable SN Ia
core-collapse SN

M. Sako, U. Pennsylvania



A. Becker, U. Washington