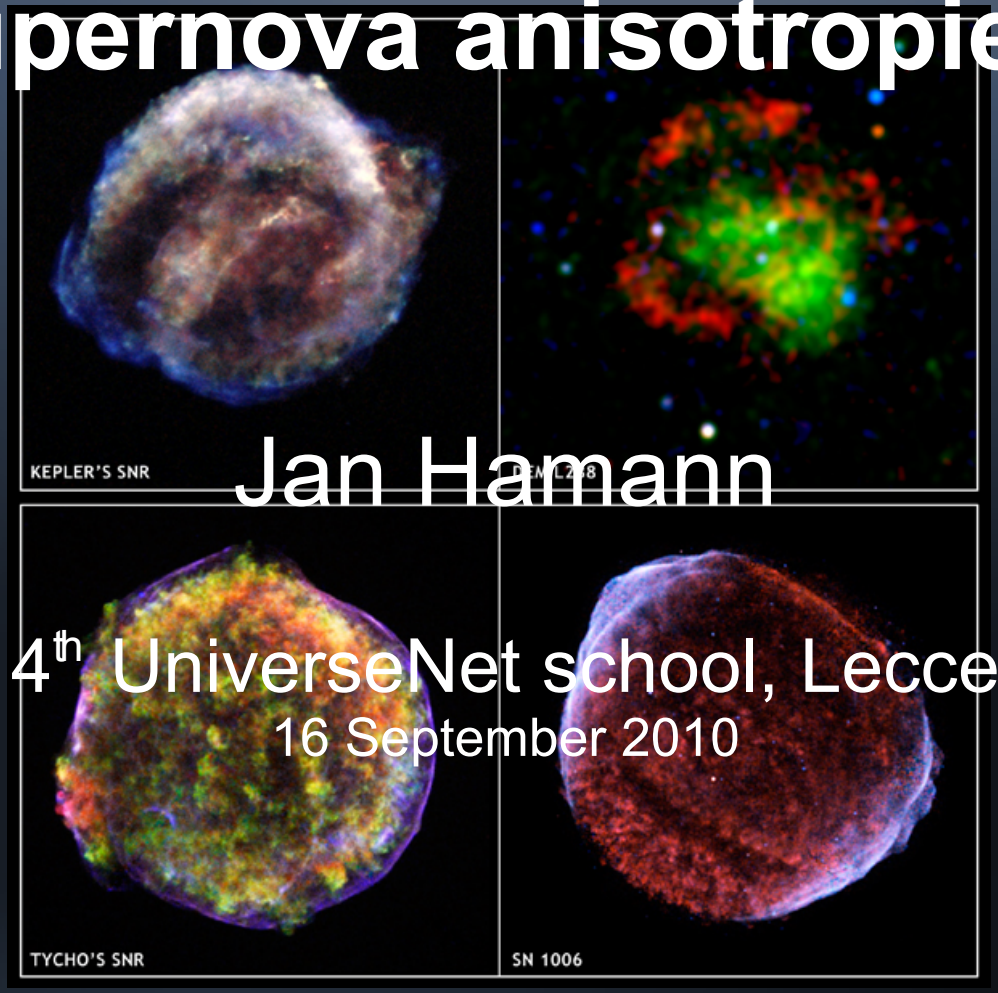
Supernova anisotropies



Jan Hamann

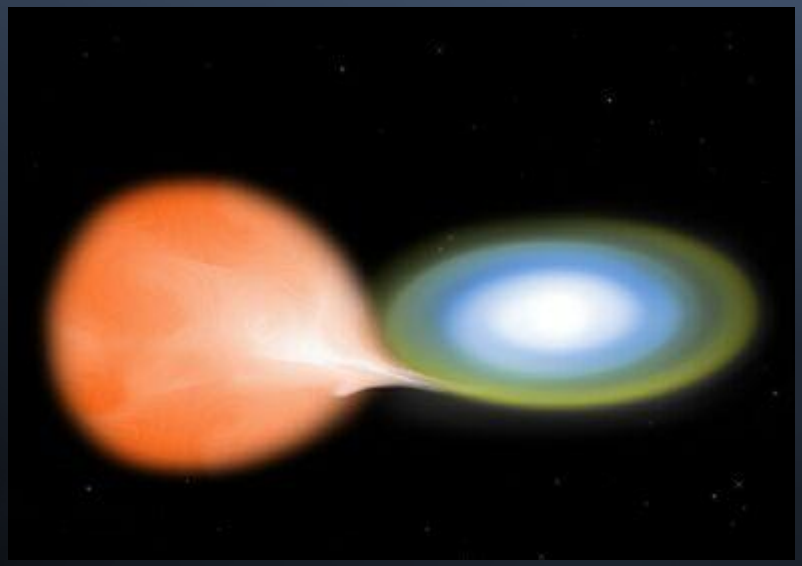
4th UniverseNet school, Lecce

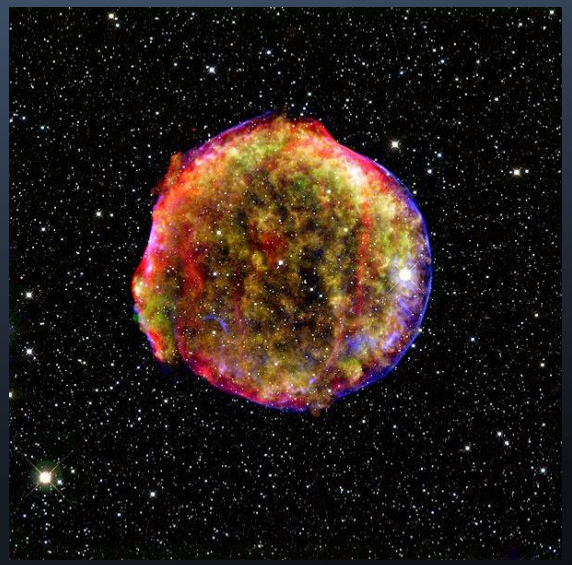
16 September 2010

AARHUS UNIVERSITET

Alexander von Humboldt
Stiftung/Foundation

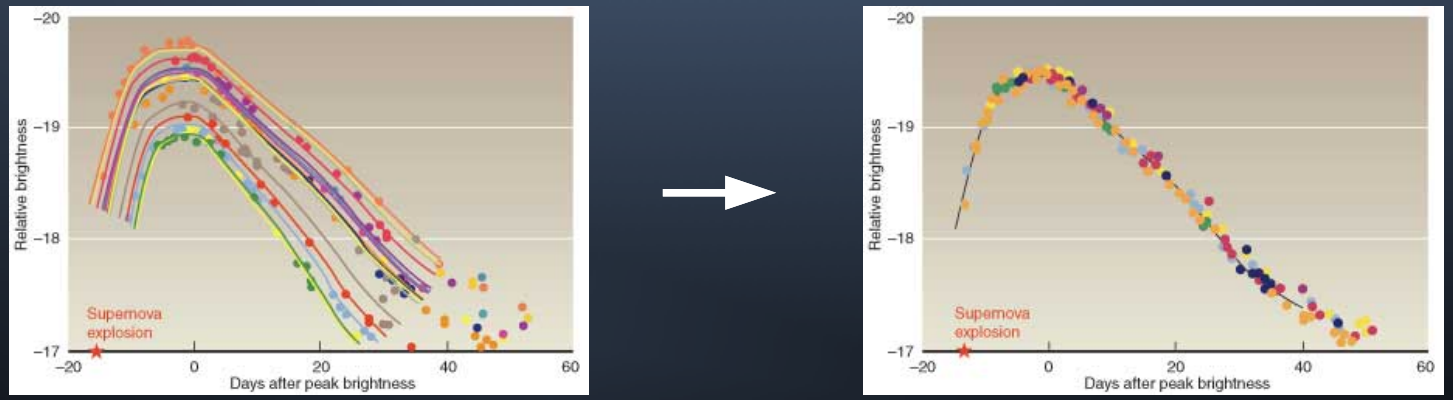
Type Ia supernovæ as standard(isable) candles





- Common underlying mechanism
  → common luminosity?

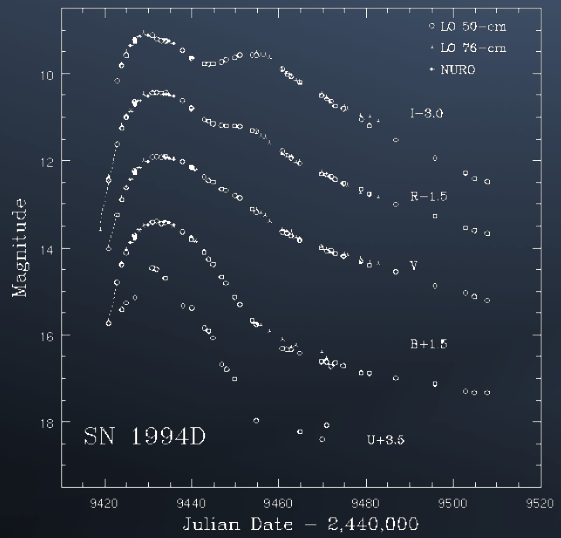
Type Ia supernovæ as standard(isable) candles



- Width of light curves correlated with peak brightness
- Empirical rescaling possible [Phillips (1993)]

→ infer luminosity distance: $d_L \equiv \sqrt{\frac{L}{4\pi F}}$

Type Ia supernovæ as standard(isable) candles



host galaxy spectroscopy

$d_L(z)$

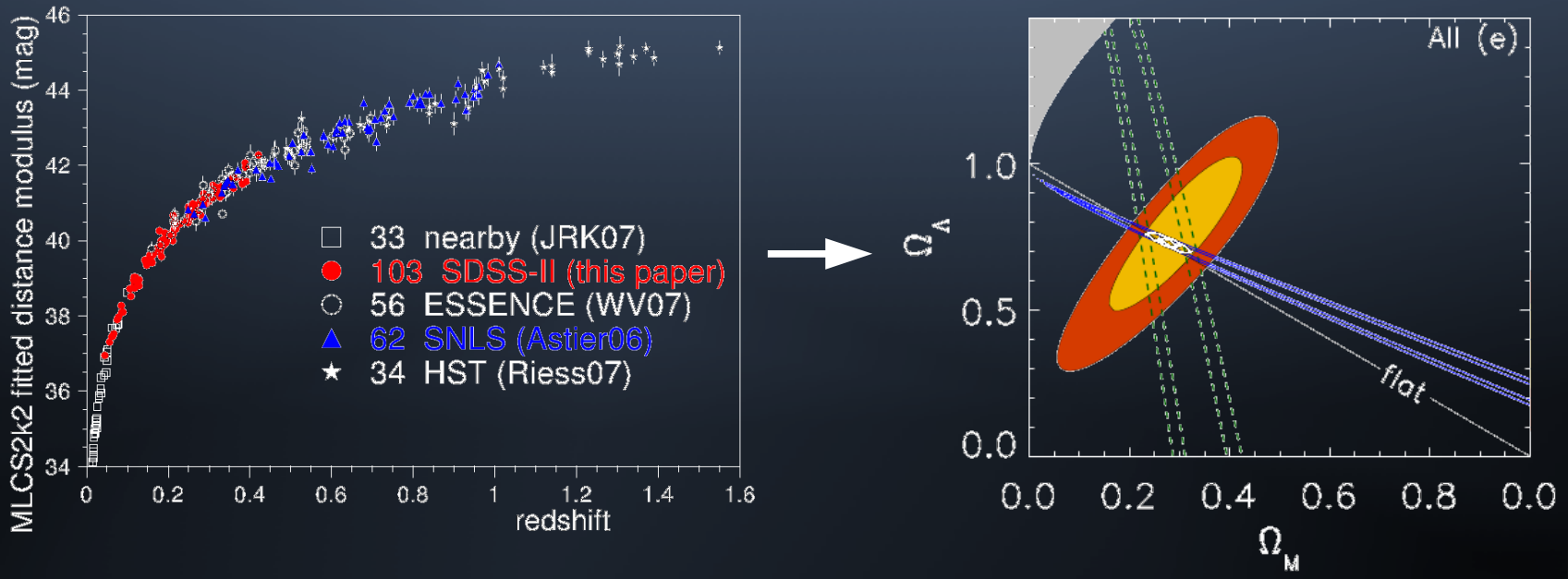
Light curve fitter, e.g., MLCS2k2, SALT-II

[Jha, Riess, Kirshner (2007); Guy et al. (2007)]

- Compare to prediction, e.g., flat FLRW-cosmology:

$$d_L(z) = c(1+z)\int_0^z \mathrm{d}z' \, \frac{1}{H(z')}$$

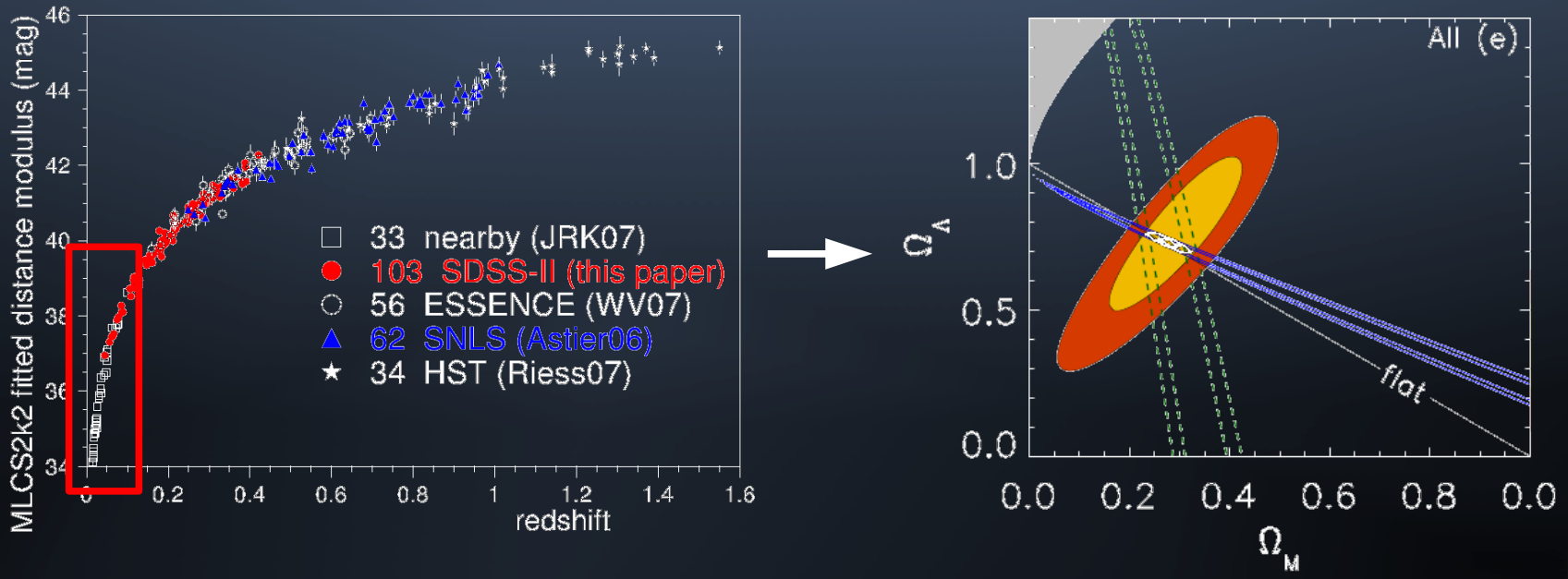
Type Ia supernovæ as standard(isable) candles



[Kessler et al. (2009)]

- Does not require calibration, absolute magnitudes are marginalised over

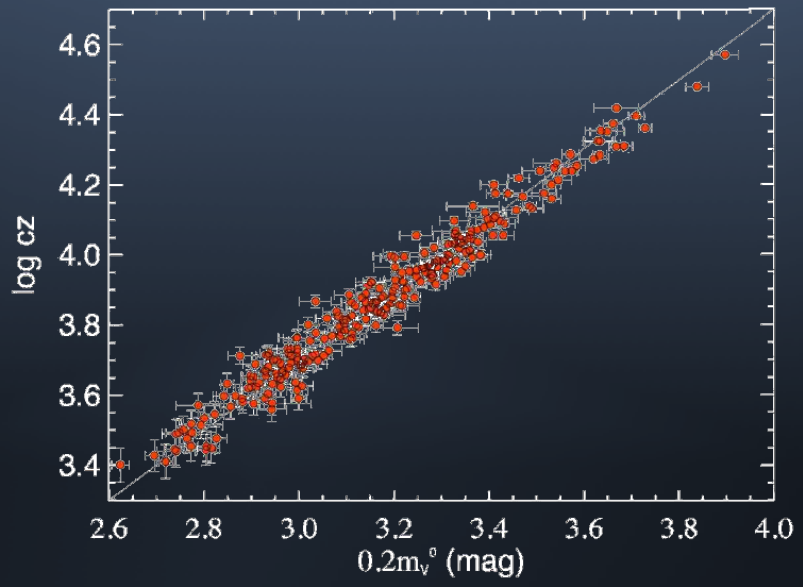
Type Ia supernovæ as standard(isable) candles



[Kessler et al. (2009)]

- Does not require calibration, absolute magnitudes are marginalised over

Probing the Hubble parameter with nearby supernovæ

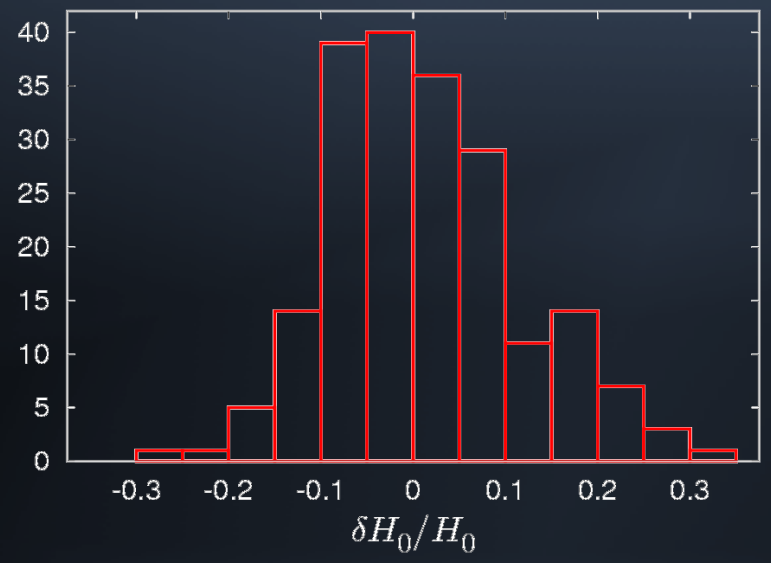


Calibration of distance scale (Cepheids)

$$H_0 = 74.2 \pm 3.6 \text{ km s}^{-1}\text{Mpc}^{-1}$$

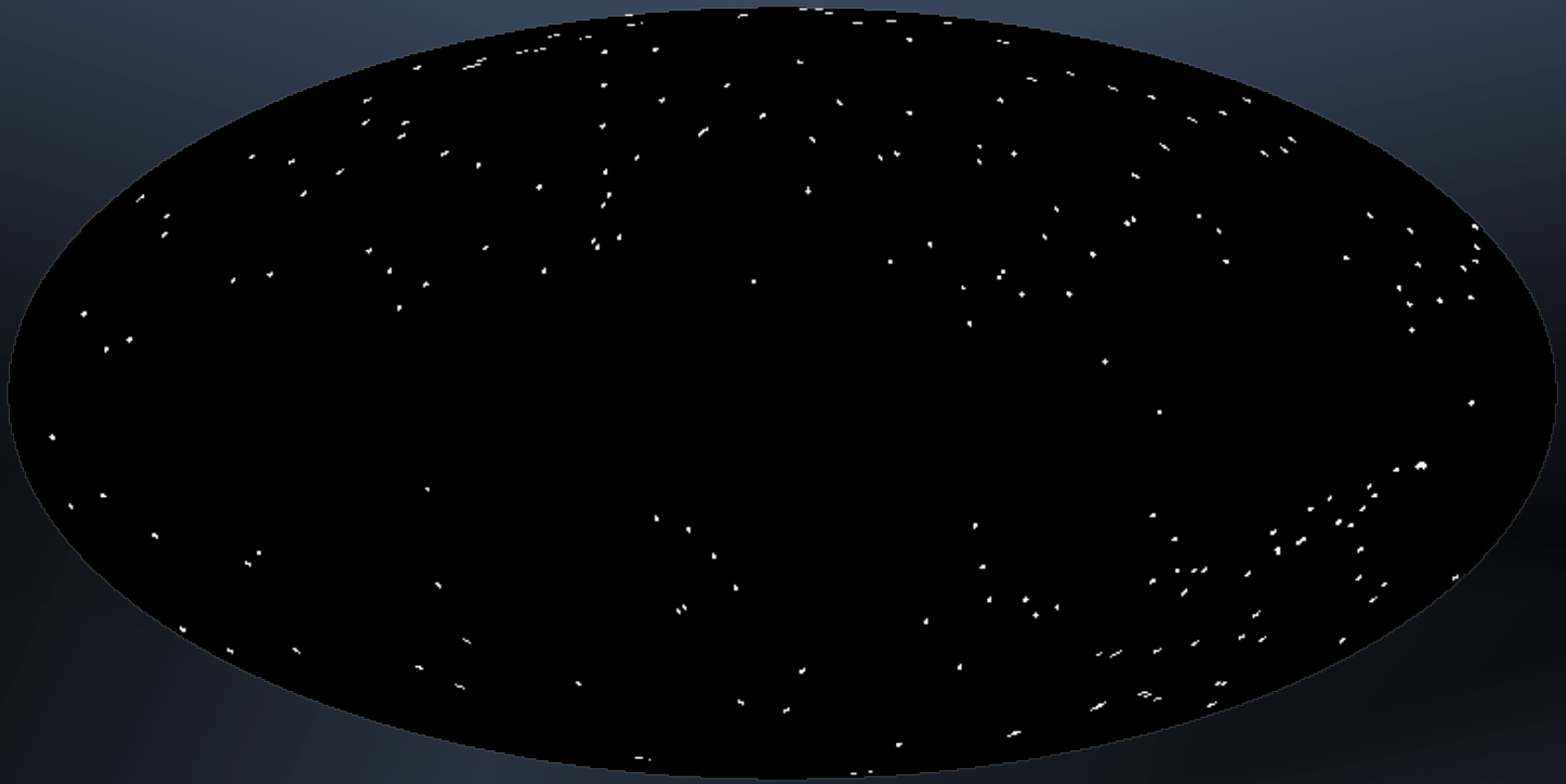
[Riess et al. (2009)]

Dispersion in apparent expansion rate

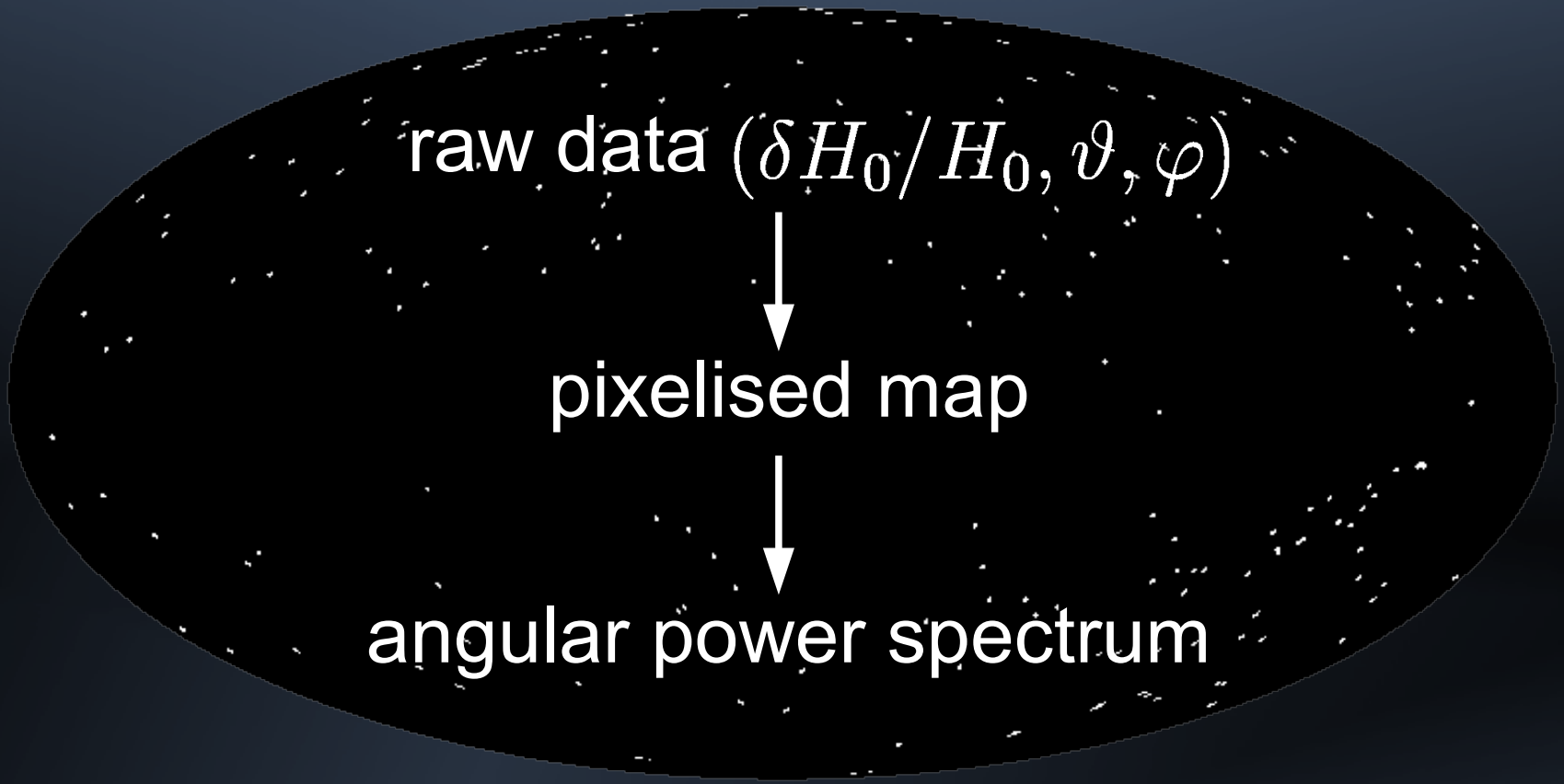


- Uncertainty budget
  - redshift
  - peculiar velocity
  - lightcurve fitter
  - 'intrinsic'
- and perhaps an underlying anisotropy in the Hubble rate?

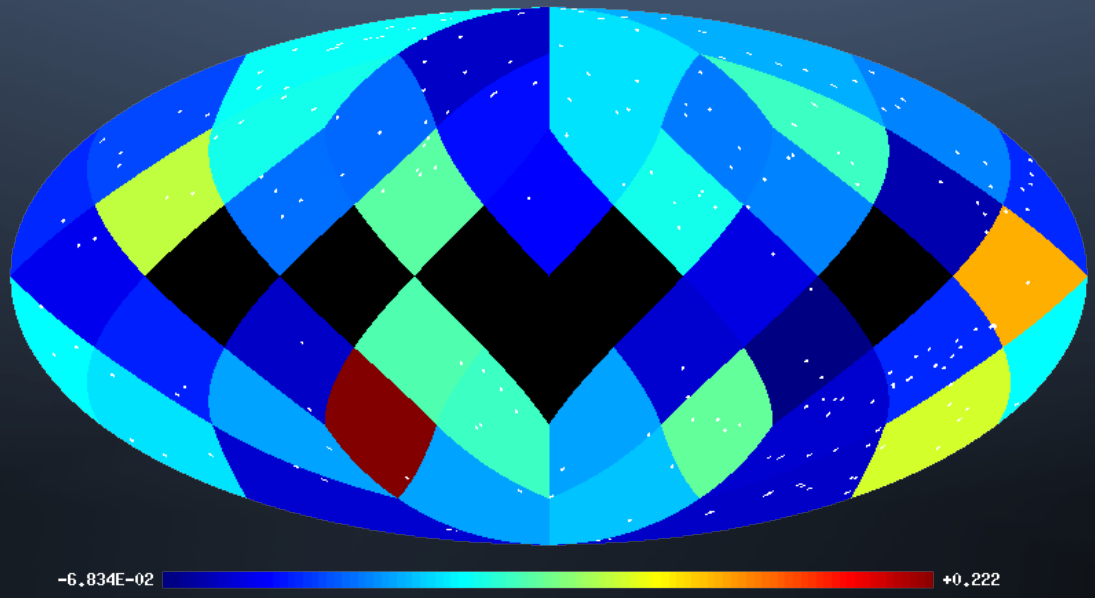
Extracting directional information



Extracting directional information



Healpix map



$\delta H_0 / H_0$

- Apply quadratic maximum likelihood estimator

  $\longrightarrow \hat{C}_\ell^{\rm pix}$ + covariance matrix [Tegmark (1996)]

Estimating the noise

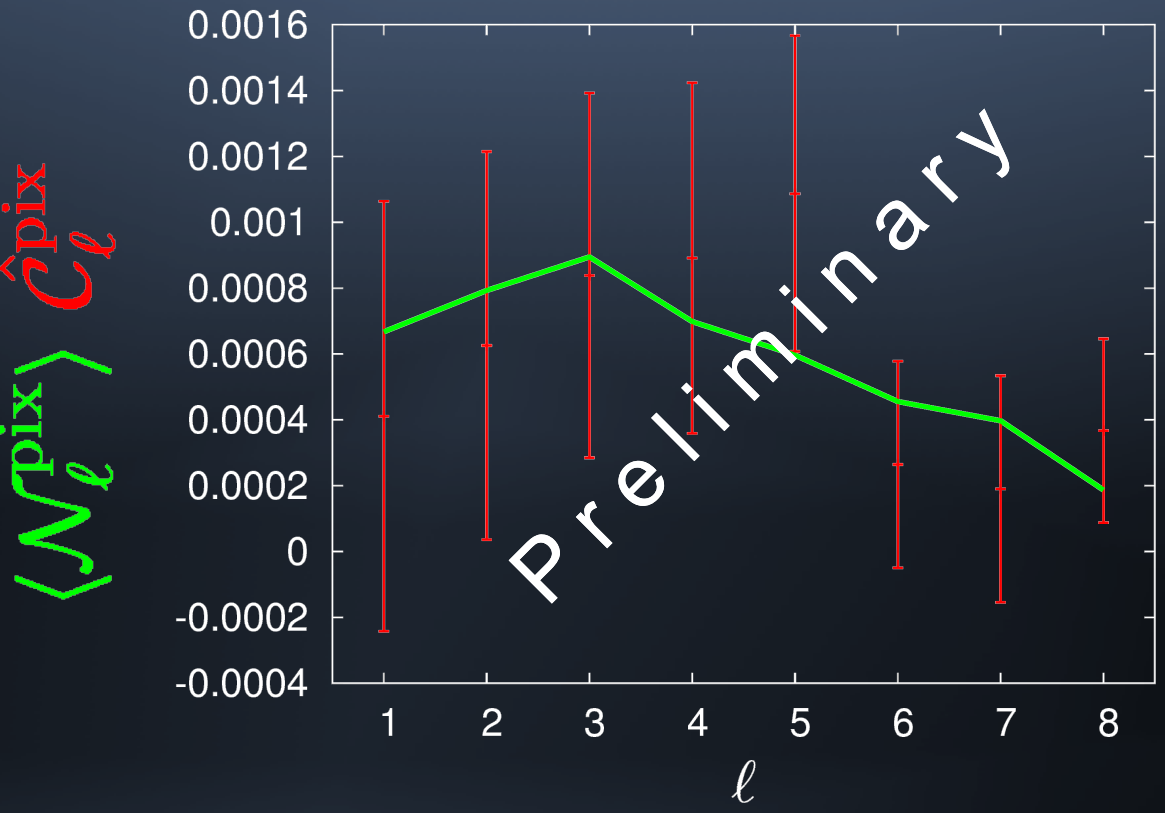
$$\mathcal{C}_\ell = \mathcal{H}_\ell + \mathcal{N}_\ell$$

signal | underlying anisotropy | uncorrelated noise

- Noise = sum of statistically isotropic uncertainties
- Simulate large number of isotropic data sets
- Estimate power spectra and average over them

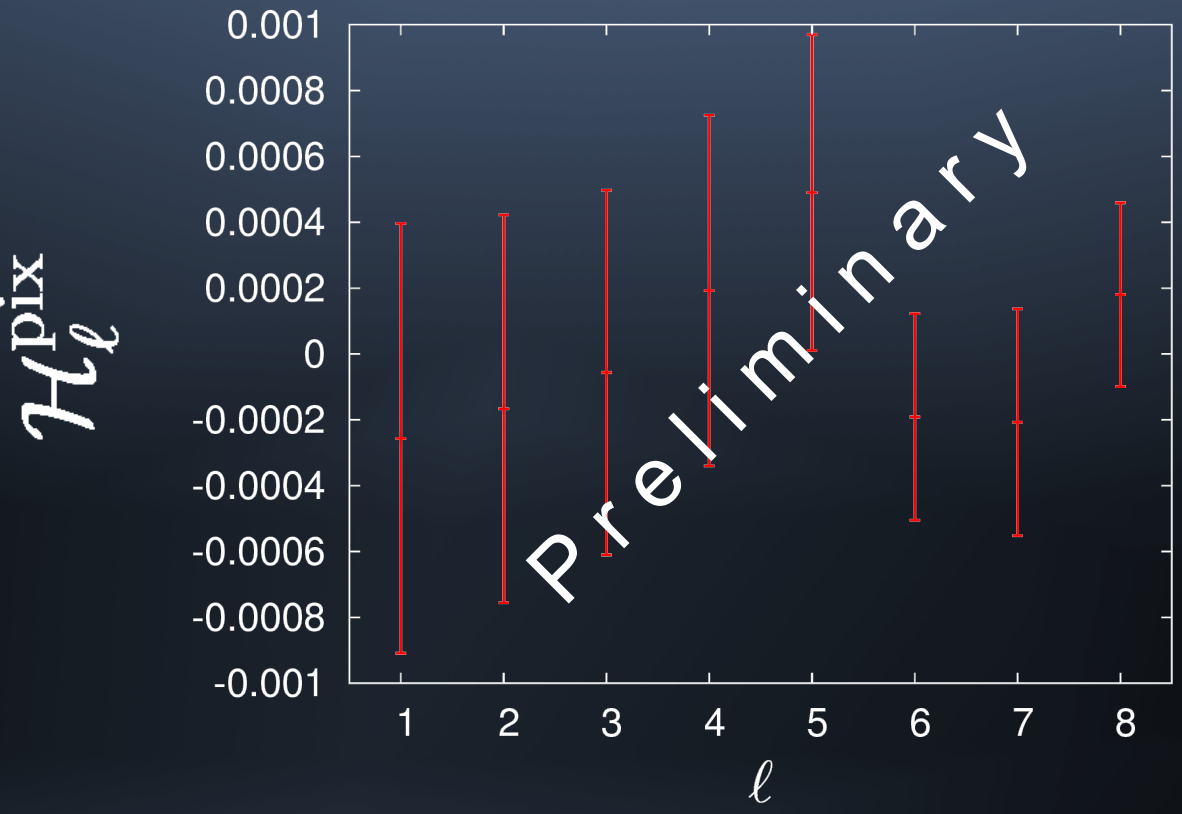
$$\longrightarrow \langle \mathcal{N}_\ell^{\mathrm{pix}} \rangle$$

Spectrum from 201 SNe



- Note: $\hat{C}_\ell^{\rm pix}$ is not an unbiased estimator of C_ℓ

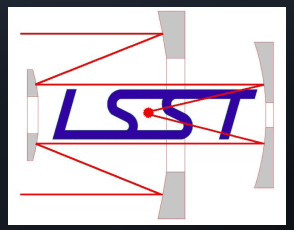
Spectrum from 201 SNe



- Present data compatible with isotropic Hubble expansion

Outlook

- Extract radial velocity field [Hui, Greene (2006)]
- Upcoming wide-field surveys will detect large numbers of type Ia SNe



- Binning in z ⟶ tomography
- Probe DE fluctuations with higher redshift SNe [Bhattacharya et al. (2010)]