The Effect of Correlated Peculiar Velocities on Cosmology from Type Ia Supernovae

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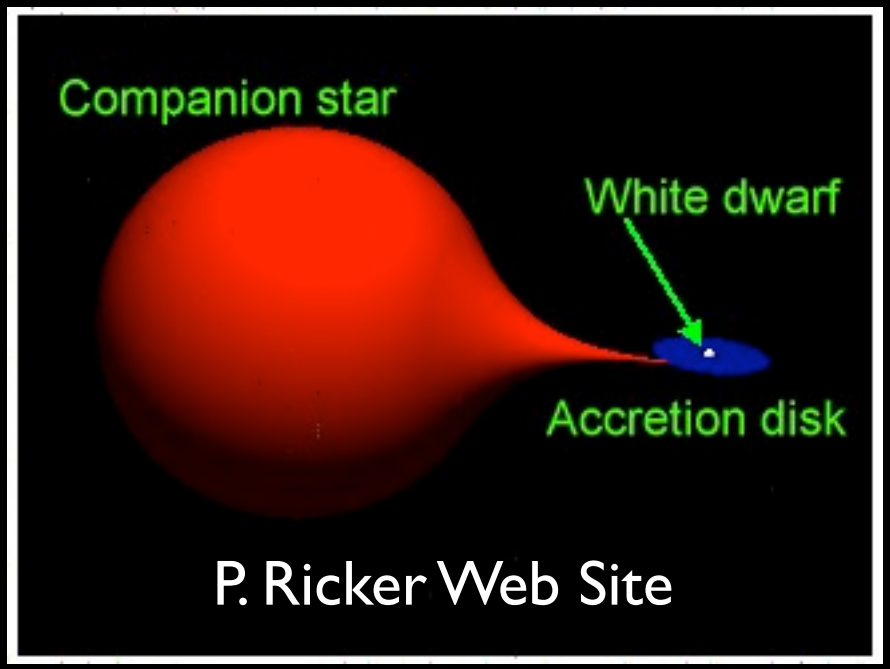
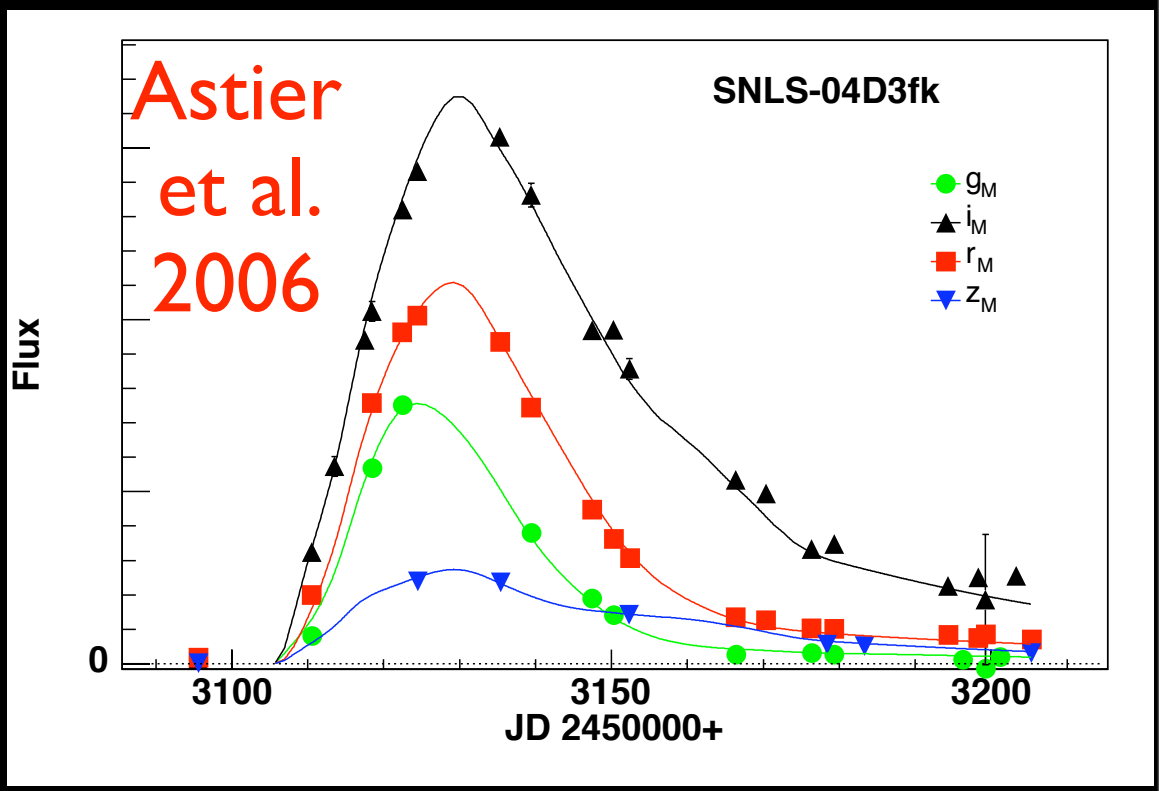
Based on work done with Kate Land and Anze Slosar



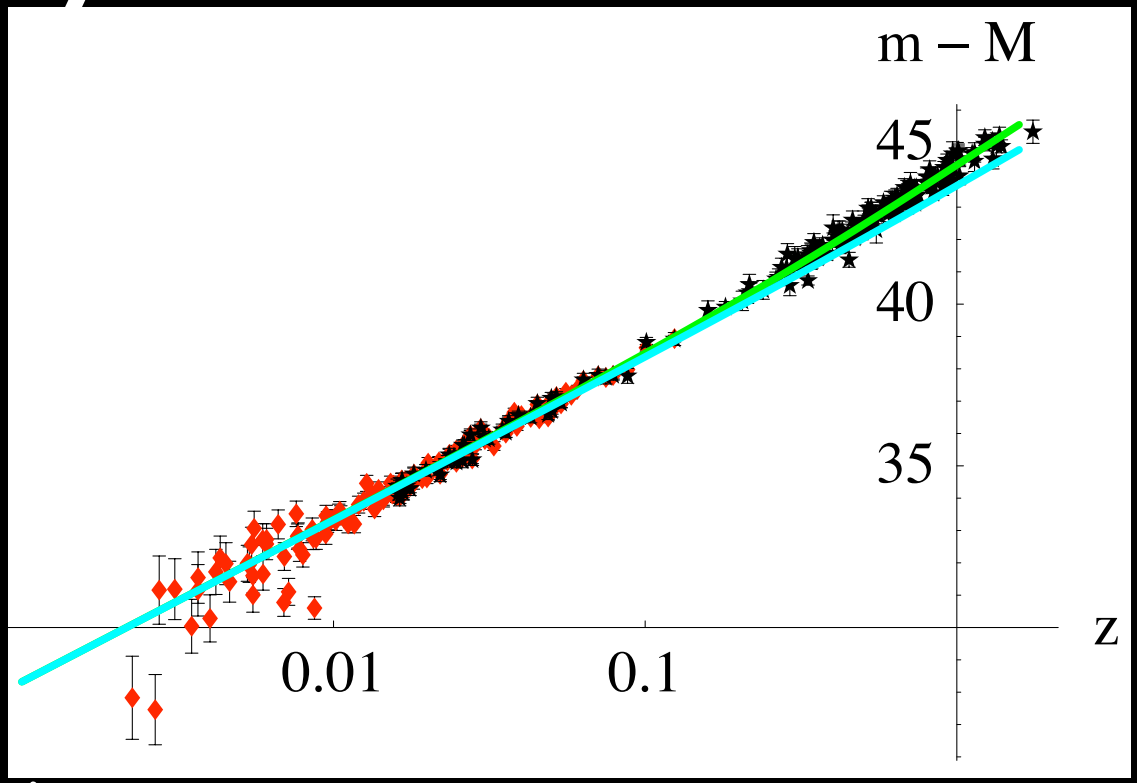


- White dwarf explodes when Chandrasekhar limit of 1.44 solar masses is reached.
- Scatter reduced by taking into account correlations between rate of decline, colour, and intrinsic luminosity, e.g. MLCS2K2, SALT.

Luminosity Distance

$$\mathcal{F} = \frac{\mathcal{L}}{4\pi d_L^2}$$

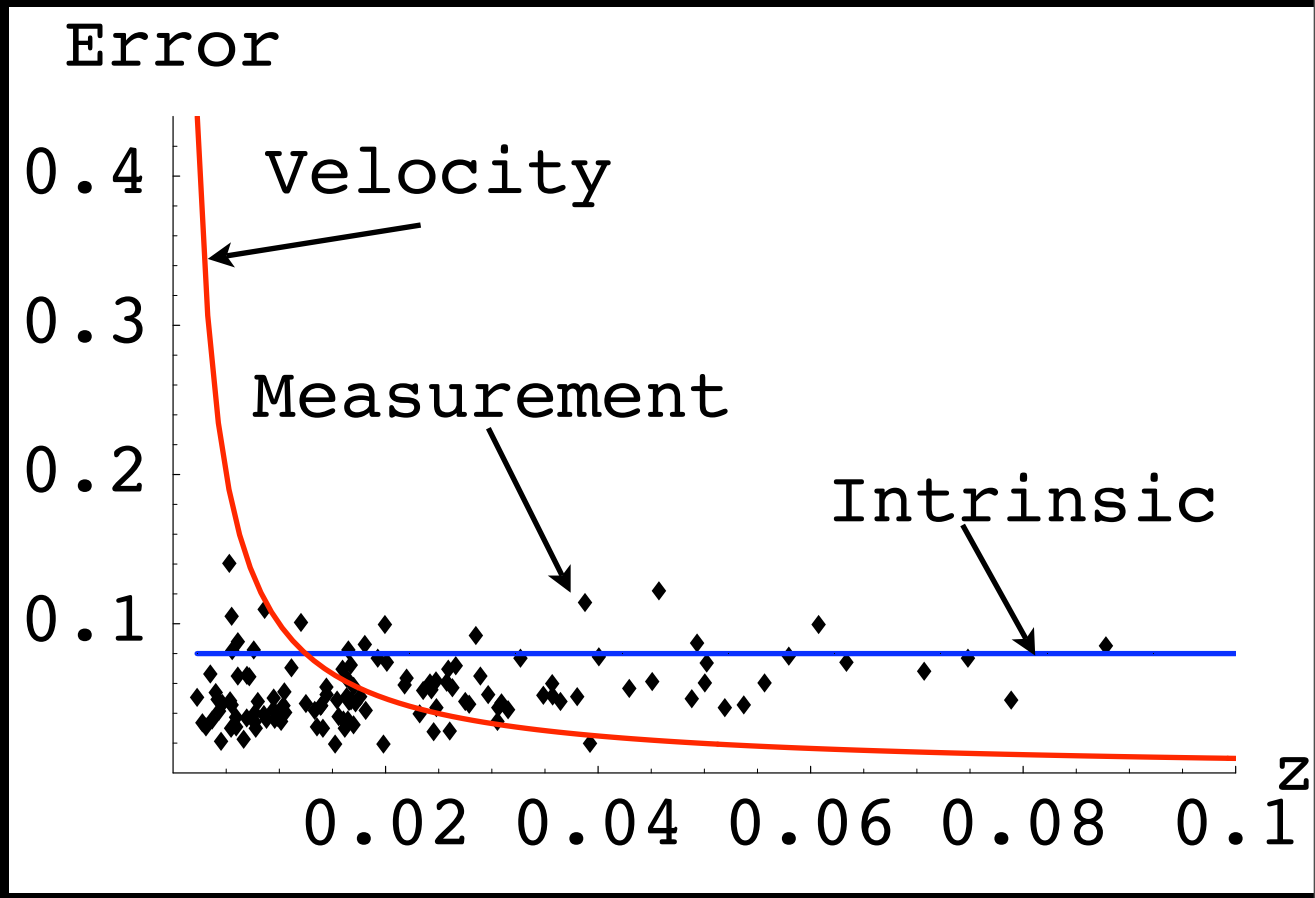
$$m = 5 \log d_L + 25 + M$$

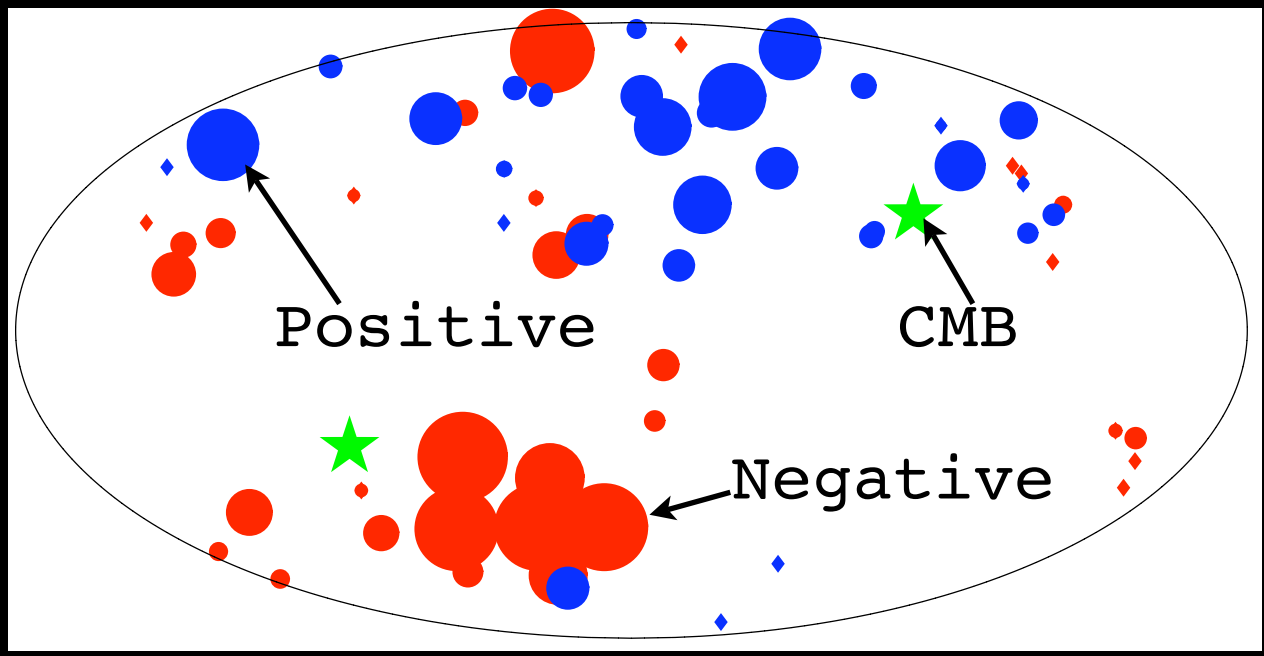


$$d_L(z) = (1+z) \int_0^z \frac{\mathrm{d}z'}{H(z')}$$

$$H^2 = \frac{8\pi G}{3} \rho_0 \left(\Omega_m (1+z)^3 + \Omega_d (1+z)^{3(1+w)} \right)$$

$$\frac{\delta d_L}{d_L} \approx \frac{\hat{r}.(v_{\rm obs} - v)}{z} + \delta m + \delta n$$

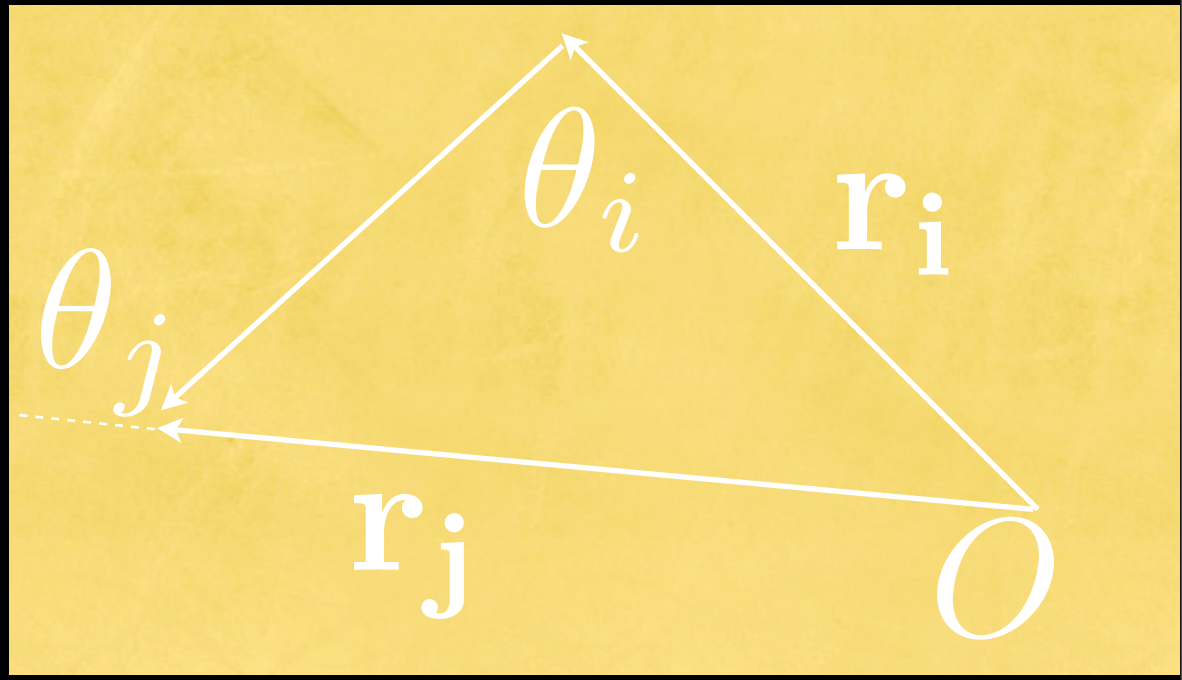




Peculiar Velocities

$$\delta_{\mathbf{k}}(z) = D(z)\tilde{\delta}_{\mathbf{k}}$$

$$\mathbf{v}_{\mathbf{k}} = -iD'\frac{\tilde{\delta}_{\mathbf{k}}}{k^2}\mathbf{k}$$



$$\xi = \sin\theta_i \sin\theta_j \xi_\perp + \cos\theta_i \cos\theta_j \xi_\parallel$$

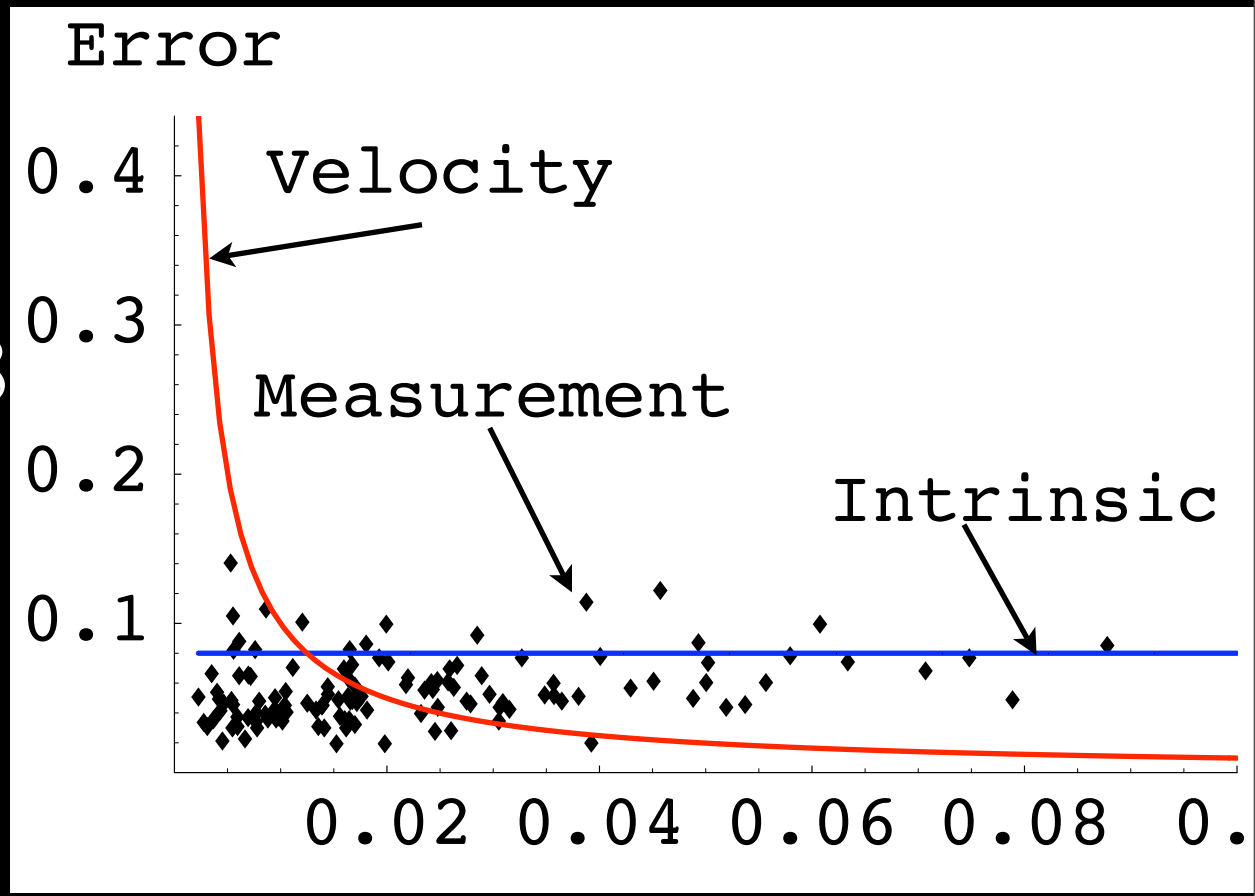
$$\xi_{\parallel,\perp} = D'(z_i)\, D'(z_j) \int_0^\infty \frac{\mathrm{dk}}{2\pi^2} P(k) K_{\parallel,\perp}(kr)$$

$$K_\parallel(x) = j_0(x) - \frac{2j_1(x)}{x}, \quad K_\perp(x) = j_1(x)/x$$

- z>0.016 (192 SNe), Davis et al. 2007.

- SN+WMAP:

$$w = -0.94 \pm 0.08$$



- SN+WMAP, no correlated PV:

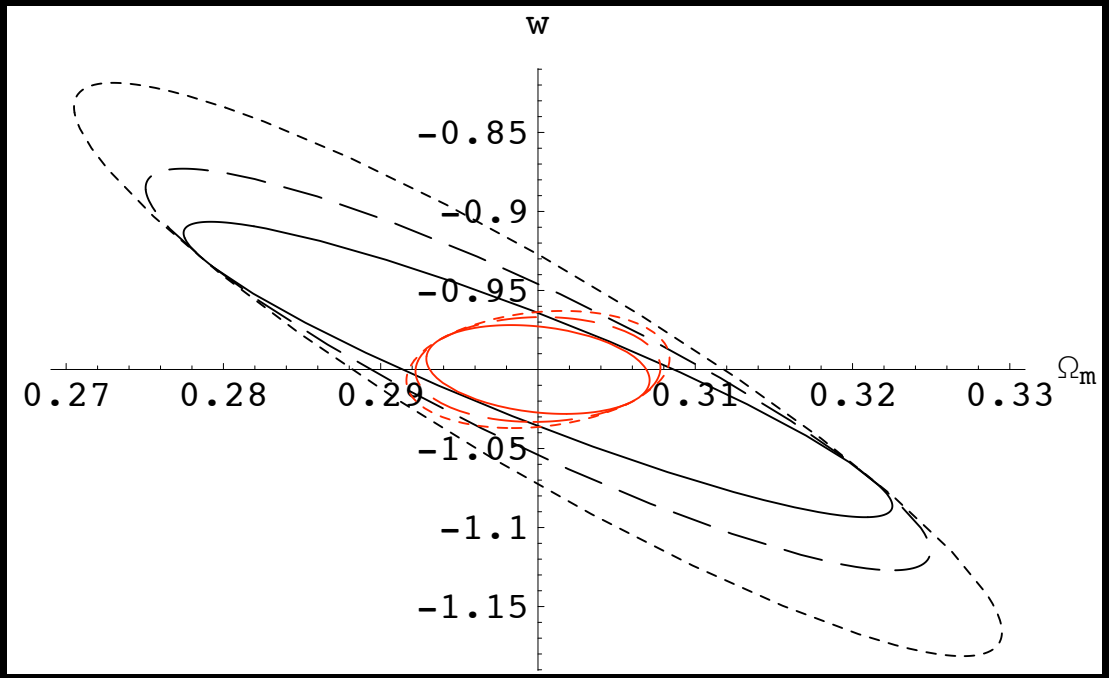
$$w = -0.96 \pm 0.09$$

Forecasts

- Fisher Matrix: $$\mathrm{F}_{\alpha\beta} \equiv -\left\langle \frac{\partial^2 \mathcal{L}}{\partial p_\alpha \partial p_\beta} \right\rangle$$

$$\mathrm{F}_{\alpha\beta} = \mathbf{d}_{,\alpha}\, \mathrm{C}^{-1} \mathbf{d}^{\mathrm{T}}{}_{,\beta} + \frac{1}{2}\, \mathrm{Tr}\left(\mathrm{C}^{-1}\mathrm{C}_{,\alpha}\, \mathrm{C}^{-1}\mathrm{C}_{,\beta}\right)$$

- SNe factory:300 SNe, $0.03 < z < 0.08$
- SNAP:2000 SNe, $0.2 < z < 1.7$



Conclusions

- Current observations can ignore correlated peculiar velocities if $z>0.016$.
- SN factory will need to account for correlated peculiar velocities even if $z>0.03$.