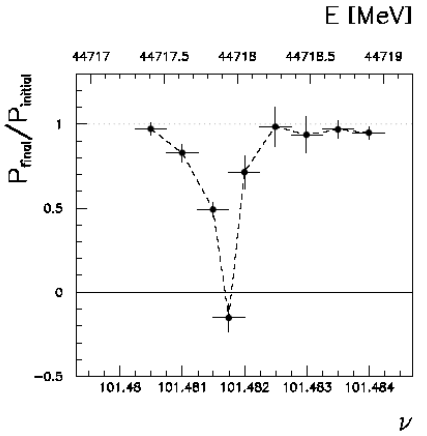
Beam polarization and E-calibration

Precise meast of E_{beam} by resonant depolarization

~100 keV each time the meast is made *LEP* →



At LEP transverse polarization was achieved routinely at Z peak.

instrumental in 10^{-3} measurement of the Z width in 1993

led to prediction of top quark mass (179+- 20 GeV) in March 94

Polarization in collisions was observed *(40% at BBTS = 0.04)*

At LEP a beam energy spread σ_E > 55 MeV destroyed polarization above 61 GeV

$\sigma_E \propto E^2/\sqrt{\rho}$ ➔ *At FCC-ee transverse polarization up to > 81 GeV (WW threshold)*

FCC-ee: use 'single' bunches to measure the beam energy continuously

no interpolation errors due to tides, ground motion or trains etc…

➔ *further work is needed to understand operability*

<< 100 keV beam energy calibration around Z peak and W pair threshold.

Δm_Z ~0.1 MeV, $\Delta\Gamma_Z$ ~0.1 MeV, Δm_W ~ 0.5 MeV

Constraints on energy spread

1. Experimental evidence of effect of energy spread on polarization from LEP Wigglers at fixed energy or hihest energy without wigglers
   -- compilation was done – limit between 52 to 58 MeV
   -- needs to cross-check J_x that was used.

2. Effect of energy spread on measurement of the Z width
   -- needs to be known to a fraction of MeV – measure!
   -- we cannot use the the bunch length measurement in crab waist
   -- avoid measurements outside of physics conditions
   -- synchrotron light monitors? Qs changes?

effect of energy spread on Polarization in a given machine was studied using the damping wigglers

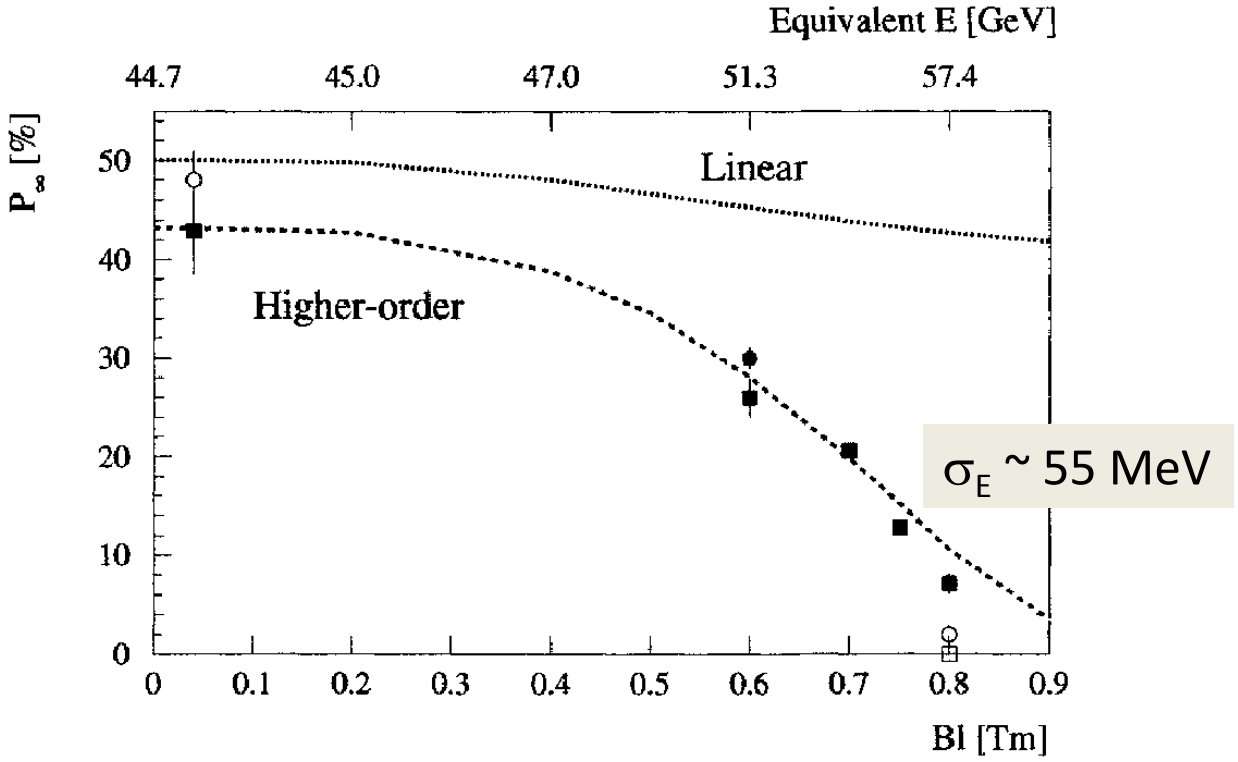
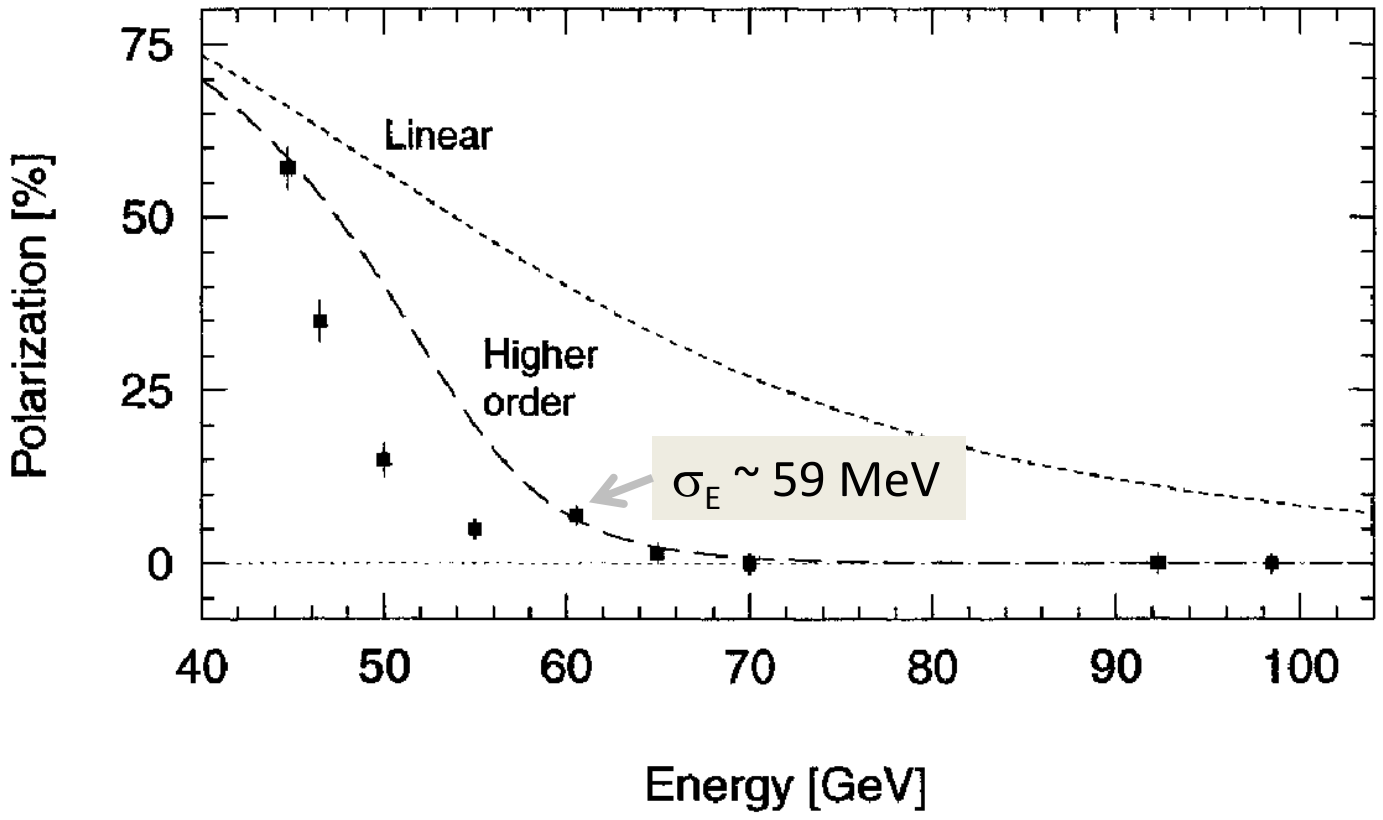


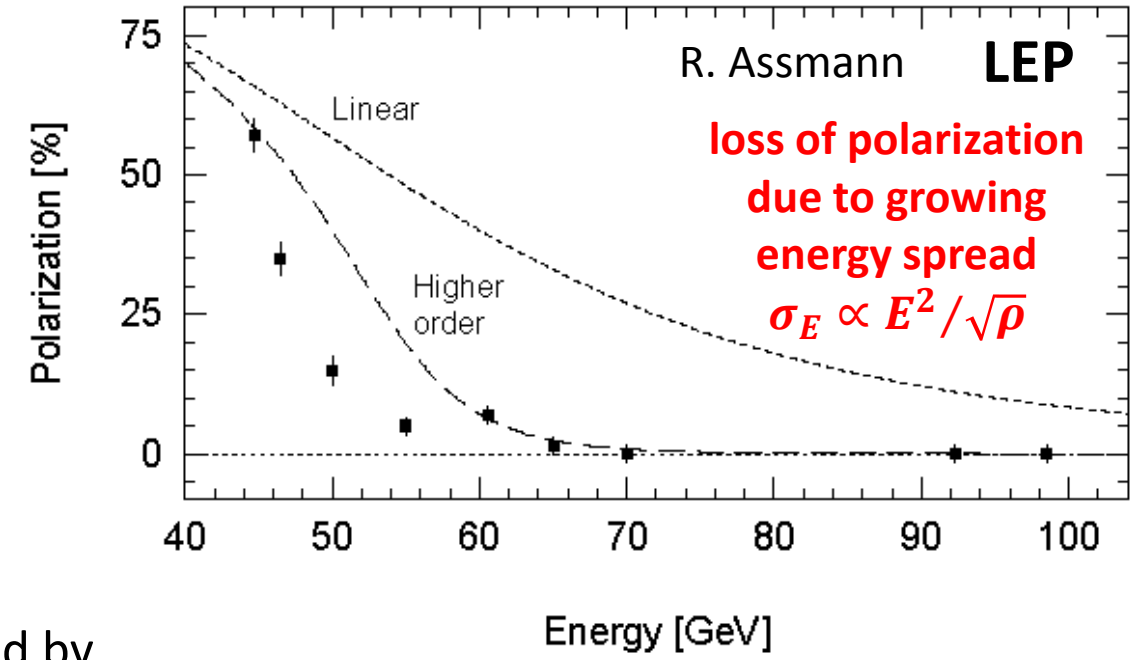
FIGURE 8. Observed polarization level at 44.7 GeV for different excitations Bl of the LEP damping wigglers. The upper scale indicates the beam energy that would produce the same spin tune spread. The polarization measurements are compared to the expectations from linear and higher-order theory.

$\sigma_E \propto E_b^2 / \sqrt{\rho}$

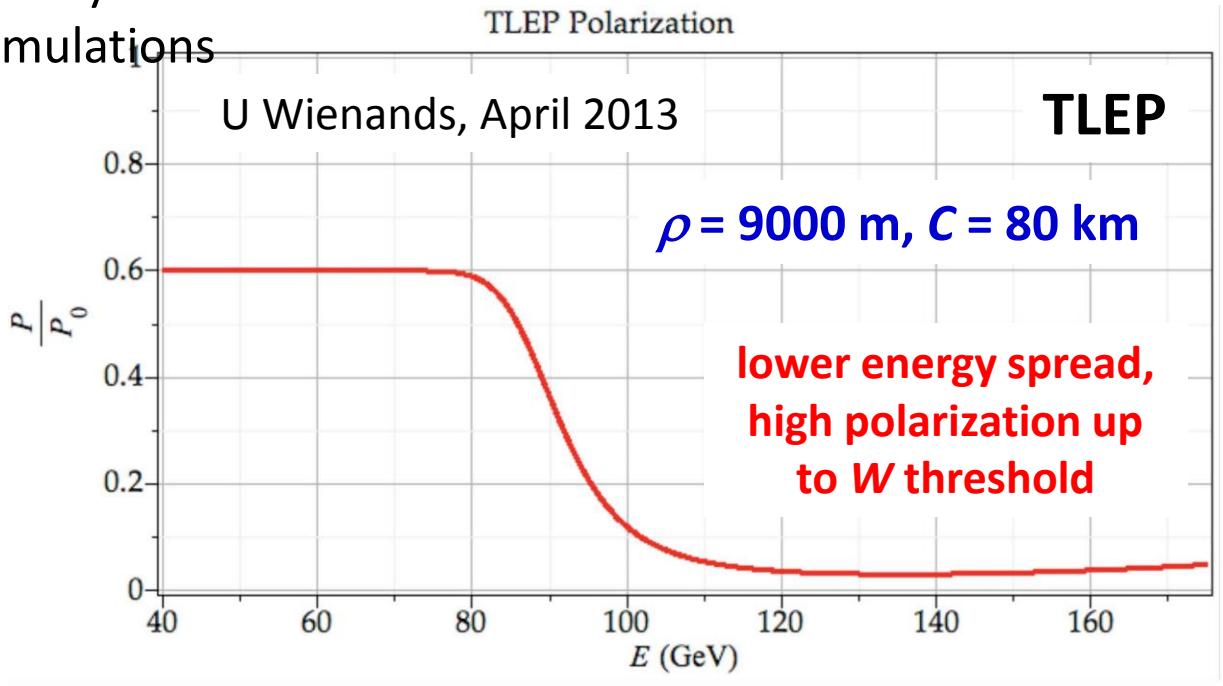


The good news is that polarization in LEP at 61 GeV corresponds to polarization in TLEP at 81 GeV

➔ Good news for M_W measurement



this is confirmed by higher order simulations



Effect of Energy spread on Physics

- For the Z width measurement, the energy spread needs to be known accurately.
- The energy spread is related to the bunch length which can be measured accurately by the experiments by

$$\sigma_{E_\mathrm{b}} = \frac{\sqrt{2}E_\mathrm{b}}{\alpha R_{LEP}} Q_s^{\mathrm{inc.}} \sigma_z$$

- Q(incoherent) can be estimated from

$$\frac{Q_s^{\mathrm{coh.}}}{Q_s^{\mathrm{inc.}}} = 1 - \kappa \frac{I}{I_0}\,,\ (I_0 = 300\,\mu A)$$

- κ was measured to be 0.045±0.022. This introduced the dominant error (700keV)
- Mom. Compaction factor α error of 1% translated to an energy spread error of 400keV
- Total error was **1000keV translating to 200keV for the Z width**

We need to improve this by at least a factor of 10 for FCC-ee

al this needs to be checked