Detector-related Warm/Cold Discussion

Luminosity, Energy and Polarization Measurements

Lumi spectrum determination
and effect on Physics Measurements

Crossing Angle impact on L,E,P measurements

L,E,P Measurement Goals

Luminosity, Luminosity Spectrum

- Total cross sections: absolute $\delta L/L$ to ~0.1%
- Z-pole calibration scan for Giga-Z: relative $\delta L/L$ to ~0.02%
- threshold scans (ex. top mass): relative $\delta L/L$ to 1%

  +L(E) spectrum: core width to <0.1% and
  tail population to <1%

Energy

- Top mass: 200 ppm (35 MeV)
- Higgs mass: 200 ppm (25 MeV for 120 GeV Higgs)
- W mass: 50 ppm (4 MeV) ??
- 'Giga'-Z A_{LR}: 200 ppm (20 MeV) (comparable to ~0.25% polarimetry)

  50 ppm (5 MeV) (for sub-0.1% polarimetry with e^+ pol) ??

Polarization

- Standard Model asymmetries: < 0.5%
- 'Giga'-Z A_{LR}: < 0.25% (<0.1% with e^+ pol)

Luminosity measurements from small angle Bhabhas
at polar angles of ~40-120 mrad.
⟶ **expect similar precision for warm/cold**

Energy measurements from upstream BPM spectrometer
or downstream Synchrotron-stripe spectrometer.
⟶ **expect similar precision for warm/cold**

Polarization measurements from an upstream Compton
polarimeter or a downstream Compton polarimeter.
⟶ **expect similar precision for warm/cold**

$$\langle E \rangle^{lum-wt} \neq \langle E \rangle$$

The beam energy spectrometers measure <E>, but for physics we need to know $\langle E \rangle^{lum-wt}$ and the luminosity spectrum, L(E).

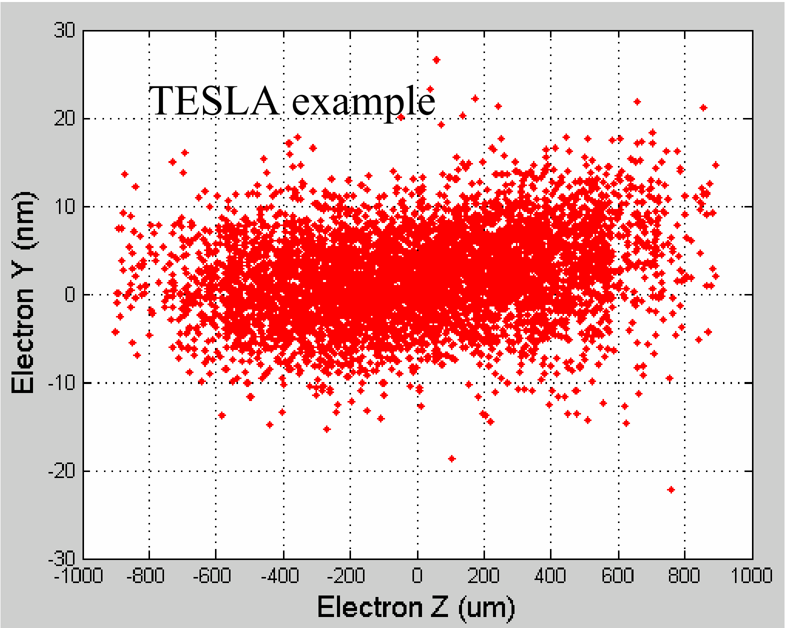
The largest source of bias are ISR and beamstrahlung. ISR can be calculated to high precision. Beamstrahlung is similar for warm/cold and its effects can largely be determined from a Bhabha acollinearity analysis.

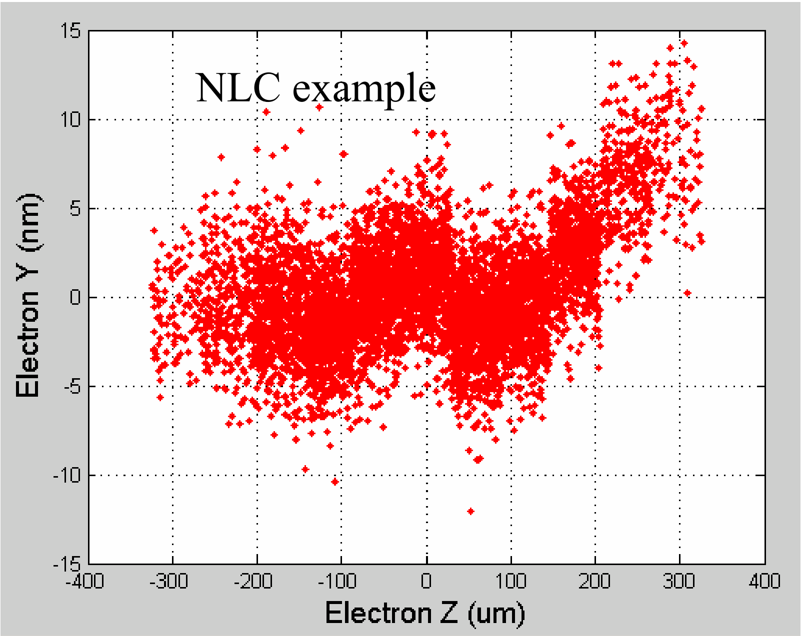
Another source is the beam energy spread before collision

At JLC/NLC, $\sigma(E) \sim 0.3\%$ rms, and at TESLA it is $\sim 0.1\%$ rms.
(3000 ppm) (1000 ppm)

Wakefields, Disruption and Kink instability

Linac wakefields generate "banana" beam distortions (larger for NLC than for TESLA)





Disruption parameter is ratio of bunch length to focal length:

$$D_y \equiv \frac{\sigma_z}{f_y} = \frac{2 r_e N \sigma_z}{\gamma \sigma_x (\sigma_x + \sigma_y)}$$

Disruption Parameter	NLC-500	TESLA-500
D_x	0.16	0.23
D_y	13.1	25.3

(larger for TESLA than for NLC)

Kink instability and E_{CM} Bias

(larger for NLC) **Wakefields** + (larger for TESLA) **Disruption** → (comparable at NLC, TESLA) **Kink instability**

(larger for NLC) **E-Spread** + (comparable at NLC, TESLA) **E-z correlation** + **Kink instability** → (larger for NLC) **E_{CM} Bias**

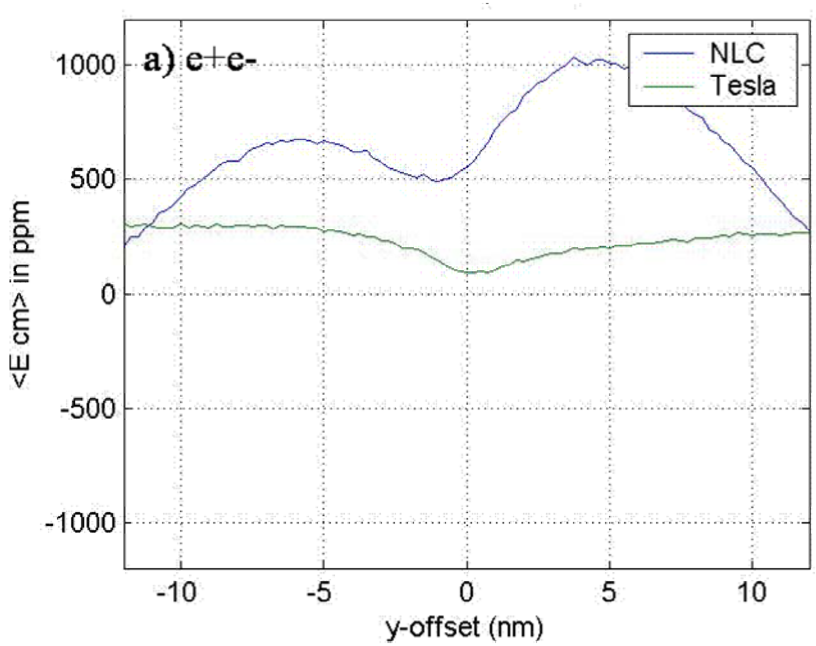
$$E_{CM}^{Bias} = \frac{\langle E_1 \rangle + \langle E_2 \rangle - \langle E_{CM}^{lum-wt} \rangle}{\langle E_1 \rangle + \langle E_2 \rangle},$$

E_1 and E_2 are beam energies measured by the energy spectrometers. (ISR and beamstrahlung are turned off for this study.)

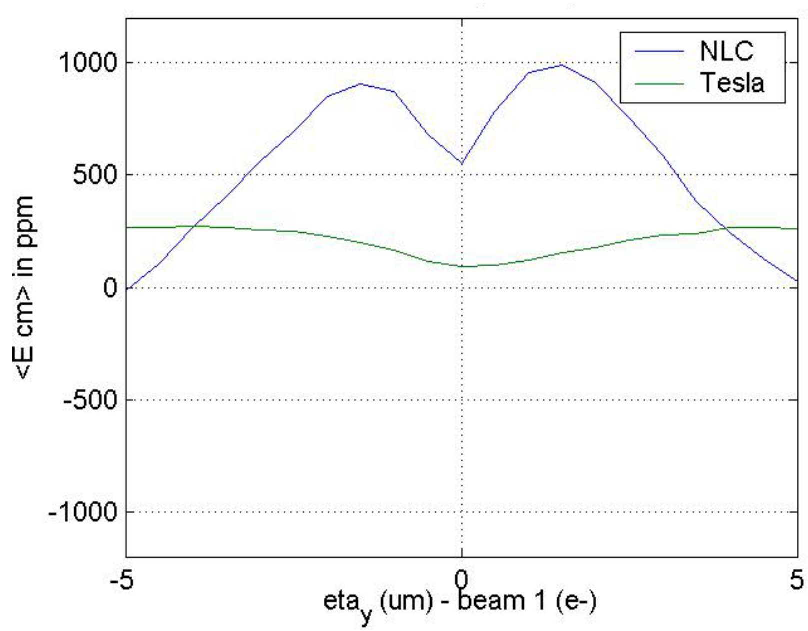
Summary of E_{CM}^{bias} from energy spread effects

LC Machine Design	Collider Mode	$<E_{CM}^{bias}>$ ($\Delta y = 0$)	$\sigma(E_{CM}^{bias})$ ($\Delta y = 0$)	$Max(E_{CM}^{bias})$ vary Δy, η_y
NLC-500	e^+e^-	+520 ppm	170 ppm	+1000 ppm
TESLA-500	e^+e^-	+50 ppm	30 ppm	+250 ppm

E_{CM} Bias vs Δy, η_y



Y-offset scan



Y-dispersion scan

Improved analysis techniques for determining the luminosity-weighted E_{CM}

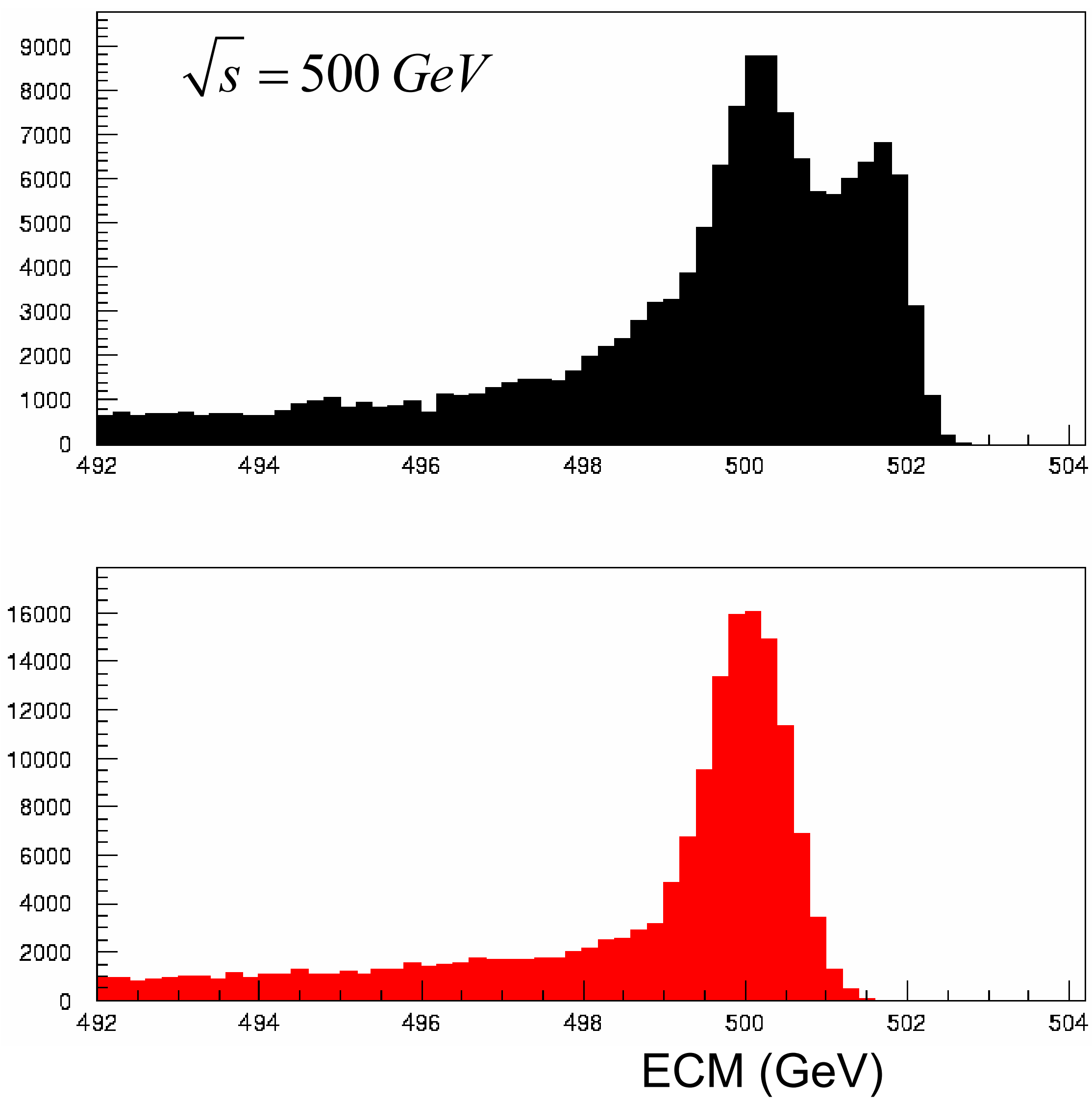
1. Continue to use energy spectrometers and Bhabha acollinearity, but correct for energy bias by modelling the beam-beam interaction.
2. Possibilities for additional input:
   i) γZ, ZZ and WW events; use existing Z and W mass measurements
   ii) utilize Bhabha energies in addition to Bhabha acolinearity
   iii) μ-pair events; use momentum measurements for the muons

The improved analysis techniques should work well to achieve 200 ppm precision on $E_{CM}^{lum\text{-}wt}$ for both NLC-500 and TESLA-500.

Achieving 50 ppm precision on $E_{CM}^{lum\text{-}wt}$ will be difficult for both NLC-500 and TESLA-500. Detailed studies are required. May be easier to achieve sub-200ppm precision with cold machine.

Study Statistical Effect of Energy Spread on Top, Higgs, and SUSY Mass Meas

Lumi Weight Ecm Distribution



NLC

FWHM ≈ 0.6% (peak region)

TESLA

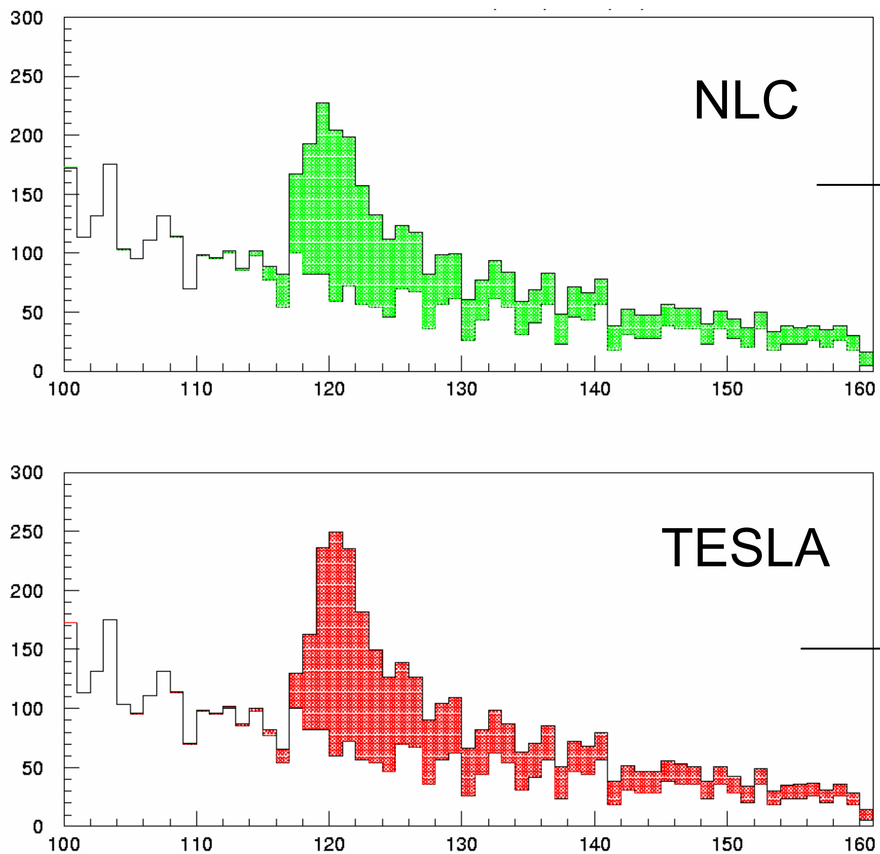
FWHM ≈ 0.2% (peak region)

Simdet Detector Simulation of e+e- → Zh

$\sqrt{s} = 350\ GeV\ \ L = 500\ fb^{-1}$

$Z \to e^+e^-, \mu^+\mu^-$

with background



Recoil Mass (GeV)

$\delta m_H = 143\ \text{MeV}$

$\delta m_H = 117\ \text{MeV}$

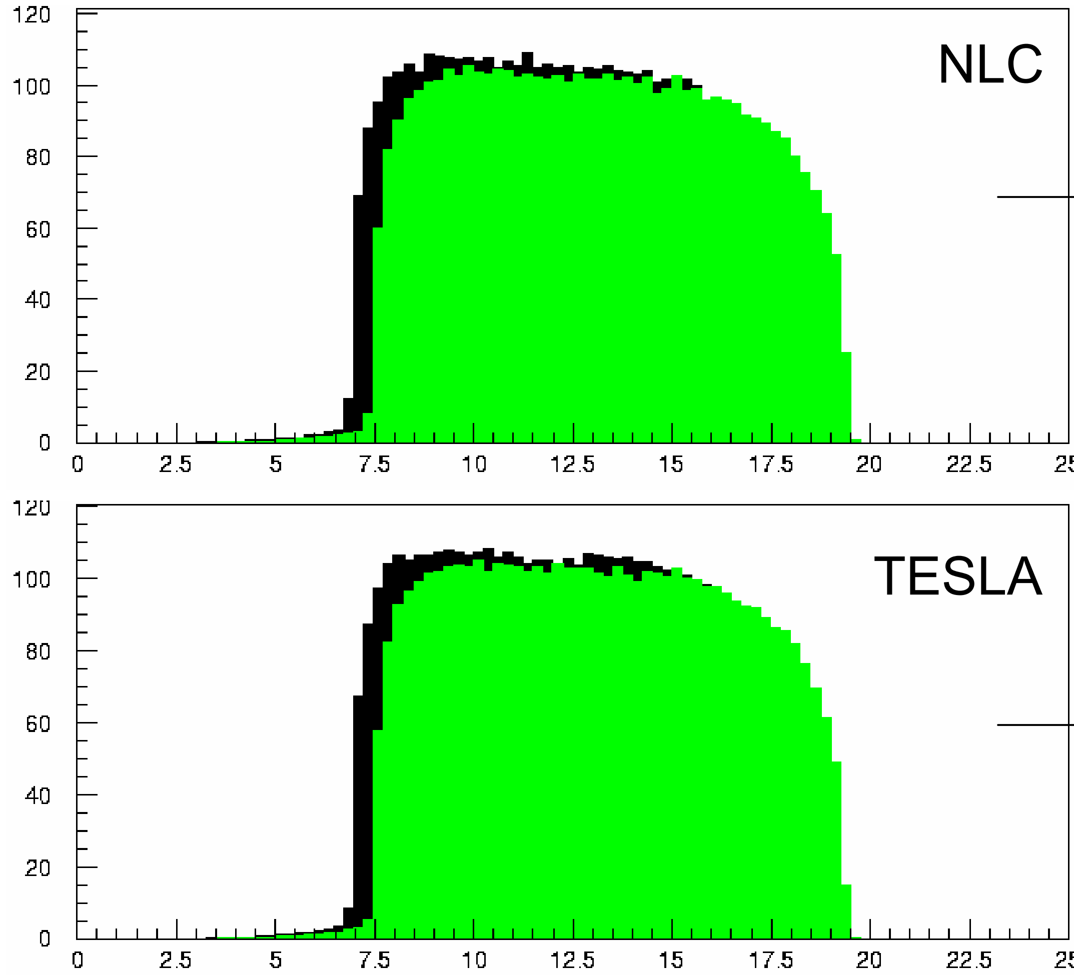
$$\frac{\delta E_b}{E_b} = 0.235\ \frac{\delta m_H}{m_H}$$

from T. Barklow

Simdet detector simulation of $e^+e^- \rightarrow \tilde{\mu}_R^+\tilde{\mu}_R^-$

$\sqrt{s} = 500\ GeV\ L = 500\ fb^{-1}$

$M_{\tilde{\mu}_R} = 223.6\text{GeV}$ vs $M_{\tilde{\mu}_R} = 224.4\text{GeV}$



Smuon Energy (GeV)

→ $\delta m_{\tilde{\mu}_R} = 35\ \text{MeV}$

→ $\delta m_{\tilde{\mu}_R} = 34\ \text{MeV}$

$$\frac{\delta E_b}{E_b} = 9.0\,\frac{\delta m_{\tilde{\mu}_R}}{m_{\tilde{\mu}_R}}$$

from T. Barklow

Crossing Angle impact on L,E,P measurements

Cold machine has option of head-on collisions for one of the 2 IRs.

For head-on collisions, as in the TESLA design, it is very difficult to have beam diagnostics, such as energy spectrometers or polarimeters, in the extraction line to the beam dump.

For physics requiring precise energy and polarization measurements, It is very desirable to have independent measurements with different Systematics. Extraction line diagnostics are important for achieving this. Also, there can be more flexibility for beam diagnostics after the IP, due to constraints on preserving beam emittance and avoiding to cause problems for MPS or detector backgrounds.