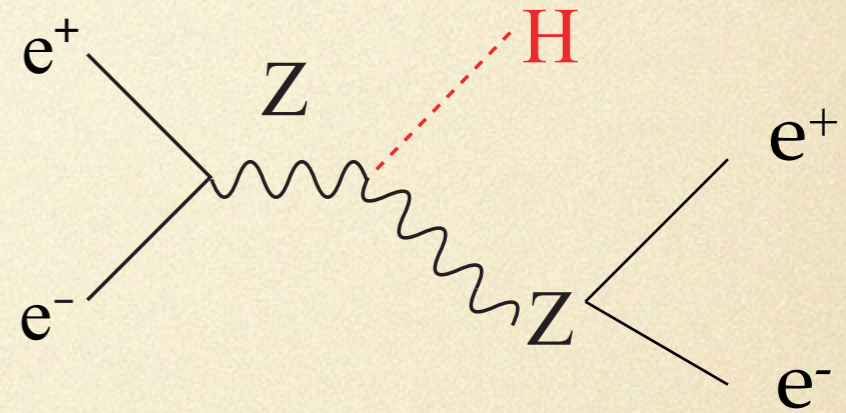
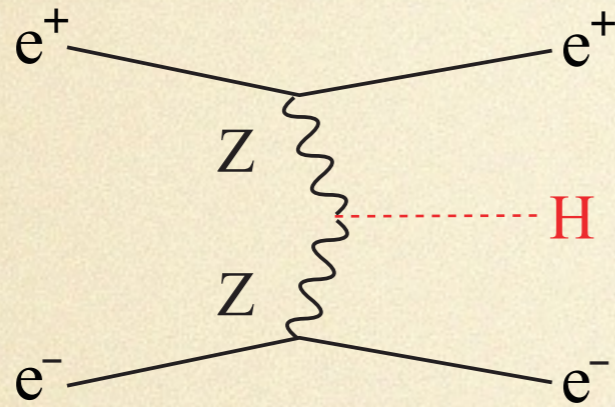


Matrix Element Method for ILC Physics Analysis

Junping Tian (KEK)

Mar. 14 @ Asian Physics and Software Meeting

status: ongoing analysis of $e^+e^- \rightarrow e^+e^-H$



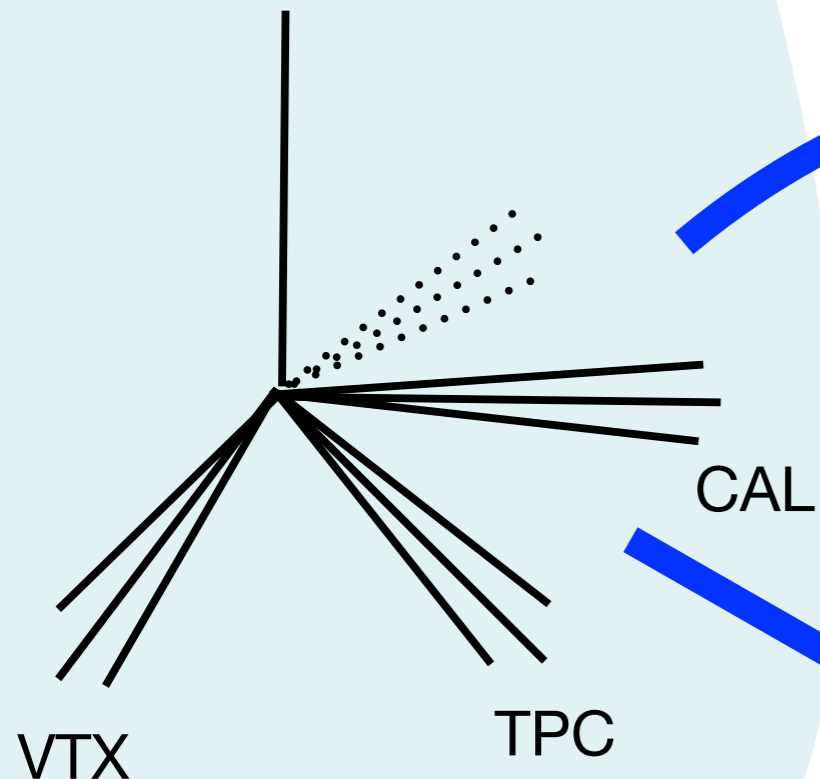
$$\sigma_S = 0.7 / 7.5 / 22.8 \text{ fb @ } 250 / 500 / 1000 \text{ GeV}$$

- analysis ongoing: optimizing forward electron selection and overlay removal for this fusion process.
- today: detector optimization & analytic calculation of recoil mass resolution.

Optimization Space

Global parameters

R, L (CAL), θ_{\min}, \dots
 B-field
 Material budget



Confirmation to clear the threshold rather than optimization?

Full simulation

Global parameters

Granularity

$\Delta E_J/E_J$
 $\Delta E/E$

Δb

$\Delta p/p$

Single particle performance

resolutions on x^μ and p^μ , etc.

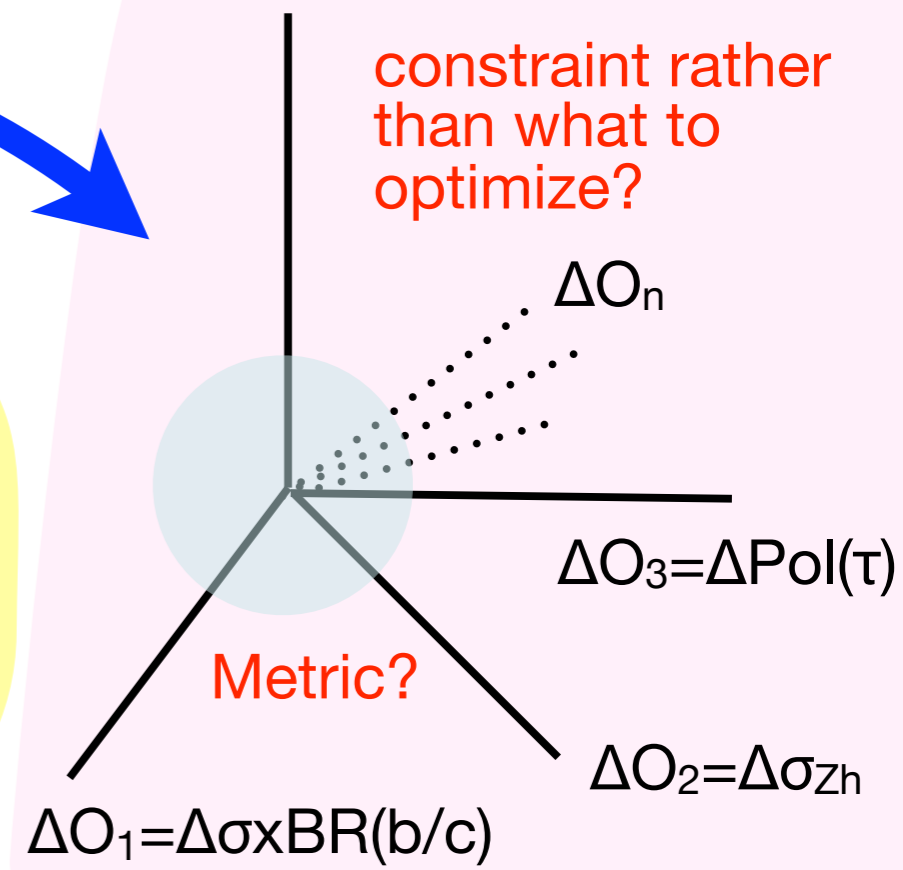
Local, detector component parameters

Internal & **scale-invariant**
 Technology choice
 detailed design

Make them as orthogonal or diagonal as possible!

Cost = $fn(R, L, \text{granularity}, \dots)$

constraint rather than what to optimize?



Physics performance

Benchmark observables for evaluation

New benchmark?

Fast Simulation

parametric study

How exactly to do?
example: Higgs total width

$$Y_1 = \sigma_{ZH}$$

$$Y_2 = \sigma_{\nu\bar{\nu}H} \cdot \text{Br}(H \rightarrow b\bar{b})$$

$$Y_3 = \sigma_{ZH} \cdot \text{Br}(H \rightarrow b\bar{b})$$

$$Y_4 = \sigma_{\nu\bar{\nu}H} \cdot \text{Br}(H \rightarrow WW^*)$$

$$\Delta\Gamma_H \sim 2\Delta Y_1 \oplus 2\Delta Y_2 \oplus 2\Delta Y_3 \oplus \Delta Y_4$$

$$\Gamma_H \propto \frac{g_{HWW}^4}{Y_4} \propto \frac{Y_1^2 Y_2^2}{Y_3^2 Y_4}$$

Global Fit

physics analysis (signal and background)

$$\Delta Y_1 \sim c_{11} \frac{\Delta P}{P} \oplus c_{12} \frac{\Delta E_B}{E_B} \oplus c_{13} \frac{1}{\Omega}$$

$$\Delta Y_2 \sim c_{21} \frac{\Delta E_j}{E_j} \oplus c_{22} \Delta Btag$$

$$\Delta Y_3 \sim c_{31} \frac{\Delta P}{P} \oplus c_{32} \frac{\Delta E_j}{E_j} \oplus c_{33} \Delta Btag \oplus c_{34} \Delta Jconfusion$$

interesting in many aspects to see those coefficients!

$$\frac{\Delta P}{P} \quad \frac{\Delta E_j}{E_j} \quad \Delta Btag \quad \Omega$$

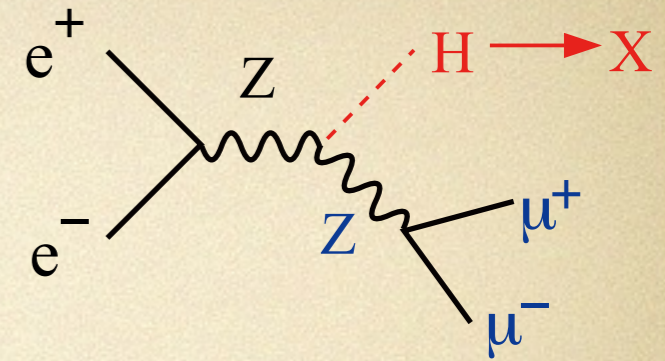
tracking, PFA, flavor tagging...

Detector Optimization

$\Delta\Gamma_H/\Gamma_H$	250 GeV	+ 500
Baseline	11%	5%
LumiUP	5.4%	2.5%

$$\frac{\Delta M_H}{M_H}$$

resolution of recoil mass



$$M_H^2 = (E_{cm} - E_1 - E_2)^2 - |\vec{p}_1 + \vec{p}_2|^2$$

$$= E_{cm}^2 - 2E_{cm}(E_1 + E_2) - M_Z^2$$

i) pure beam effect: $\Delta P = 0$

$$\frac{\Delta M_H}{M_H} = F_B \frac{\Delta E_{cm}}{E_{cm}} \quad F_B = \frac{E_{cm}^2}{2M_H^2} \left(1 + \frac{M_H^2 - M_Z^2}{E_{cm}^2} \right)$$

$$E_1 = P_1$$

$$E_2 = P_2$$

$$\Delta\theta_{12} = 0$$

$$\frac{\Delta M_Z}{M_Z} = \frac{\Delta P_1}{2P_1} \oplus \frac{\Delta P_2}{2P_2}$$

ii) pure detector effect: $\Delta E_{cm} = 0 \quad \sim \Delta\theta_{12} = 0$

$$\frac{\Delta M_H}{M_H} = F_D(P_1) \frac{\Delta P_1}{P_1} \oplus F_D(P_2) \frac{\Delta P_2}{P_2} \quad F_D(P) = \frac{E_{cm}P + M_Z^2/2}{M_H^2}$$

iii) overall:

$$\frac{\Delta M_H}{M_H} = F_B \frac{\Delta E_{cm}}{E_{cm}} \oplus F_D(P_1) \frac{\Delta P_1}{P_1} \oplus F_D(P_2) \frac{\Delta P_2}{P_2}$$

Ecm / GeV	F	F	F	$\Delta E_{cm}/E_{cm}$	$\Delta M/M$ (B)	$\Delta M/M$ (D)	$\Delta M/M$
250	2.2	1.4	0.9	0.17%	0.38%	0.21%	0.43%
350	4.2	2.7	1.4	0.13%	0.54%	0.62%	0.82%
500	8.2	5.4	2.8	0.10%	0.80%	1.8%	2.0%