Top electroweak couplings at 500 GeV ILC

The 48th General Meeting

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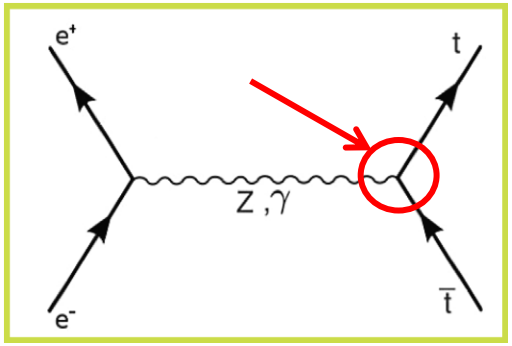
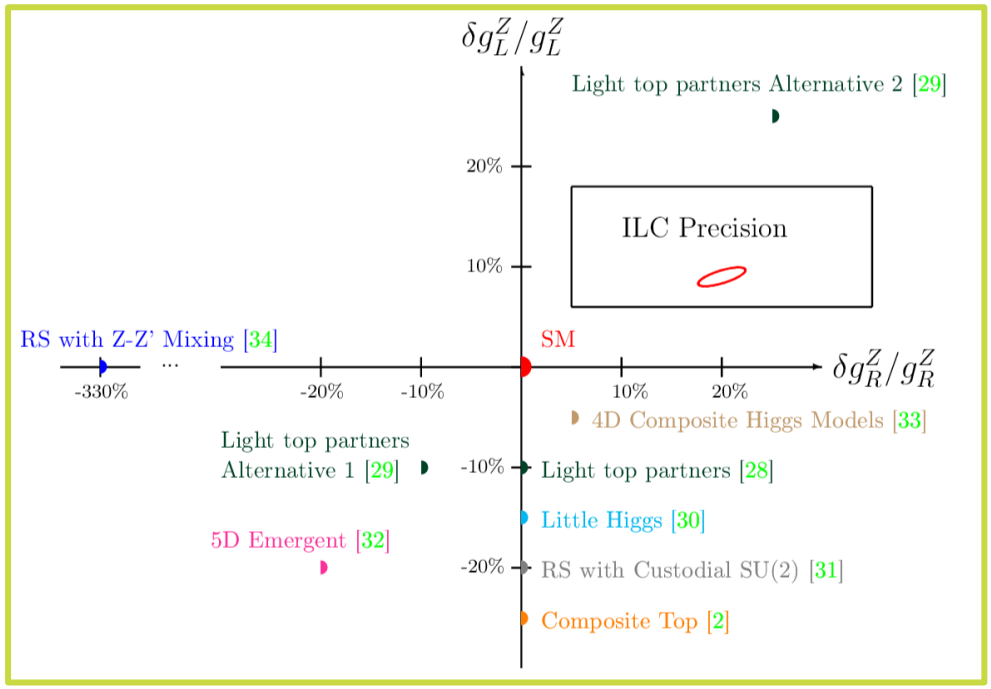
Motivation

The top quark mass is comparable with the electroweak symmetry breaking scale. Top quark may be related to new physics behind EWSB, such as composite models, so top quark electroweak coupling is a good probe of new physics.





Plots show the predicted deviations from the Standard model of Z^0 couplings to t_L and t_R in composite models

Precision expected at the ILC will allow to distinguish between models.

arXiv:1505.06020 [hep-ph]

Matrix element method

The most efficient method when all the kinematics can be reconstructed.

We obtained less than 1% precision for 10 form factors at parton level.

Sample

- ttbar di-leptonic channel ($t\bar{t} \rightarrow b\bar{b}\mu^+\mu^-\nu\bar{\nu}$) at $\sqrt{s}$ = 500 GeV without ISR and beamstrahlung

Flow of analysis

- Reconstruct isolated leptons and directions and energies of b quarks
- Reconstruct the directions of top quarks (and mass of top and W)
- Reconstruct missing neutrinos
- Fit the form-factors using above information

Today's topics

- Reconstruct directions of b quarks using thrust axis method
  - The hadronization effect
  - The detector reconstruction effect
  - Compare with jet clustering
- Reconstruct directions of top quarks from kinematical constraints and χ^2 algorithm
  - Two contours and measurement of b energy at parton level
  - χ^2 algorithm to locate optimal solution

Measurement of b direction

The precision of measurement of b direction gets worse from the hadronization effect and the detector effect.

→We estimate δ_{θ_b} (the angle between b-quark and b-jet) at two levels.

1. Hadronized particles level (include photons from isolated leptons)
2. Detector reconstructed particles level.

Thrust axis method

We use the thrust axis method for b direction measurement.

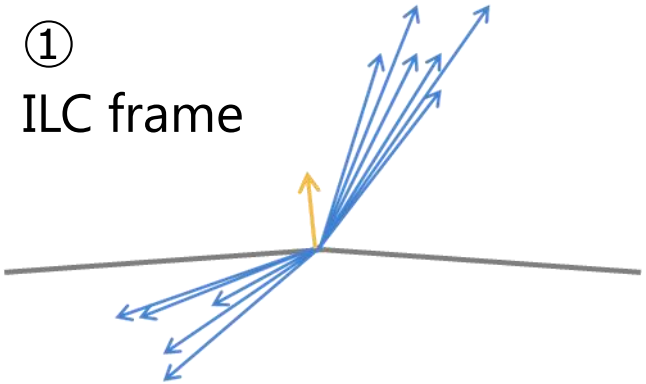
① Collect all hadronized particle and photons in the ILC frame

② Boost them to their rest frame and calculate thrust axis in this frame (defined as the BB frame in this slide)

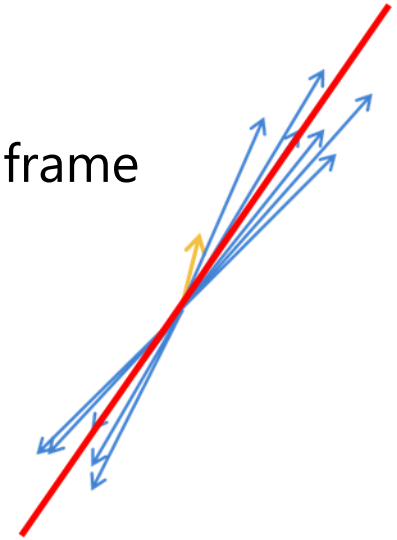
③ Boost the vectors along thrust axis to the ILC' frame

(ILC' frame : the frame in which head-on-collision occurs)

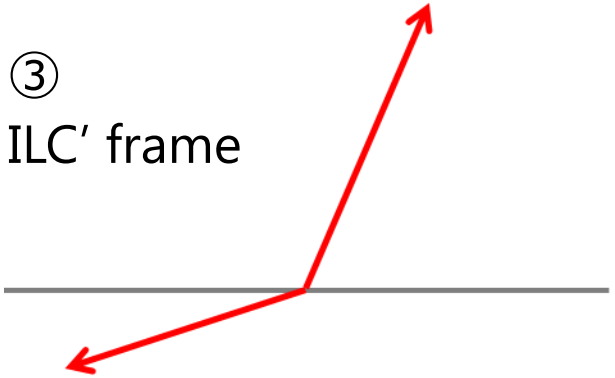
①
ILC frame



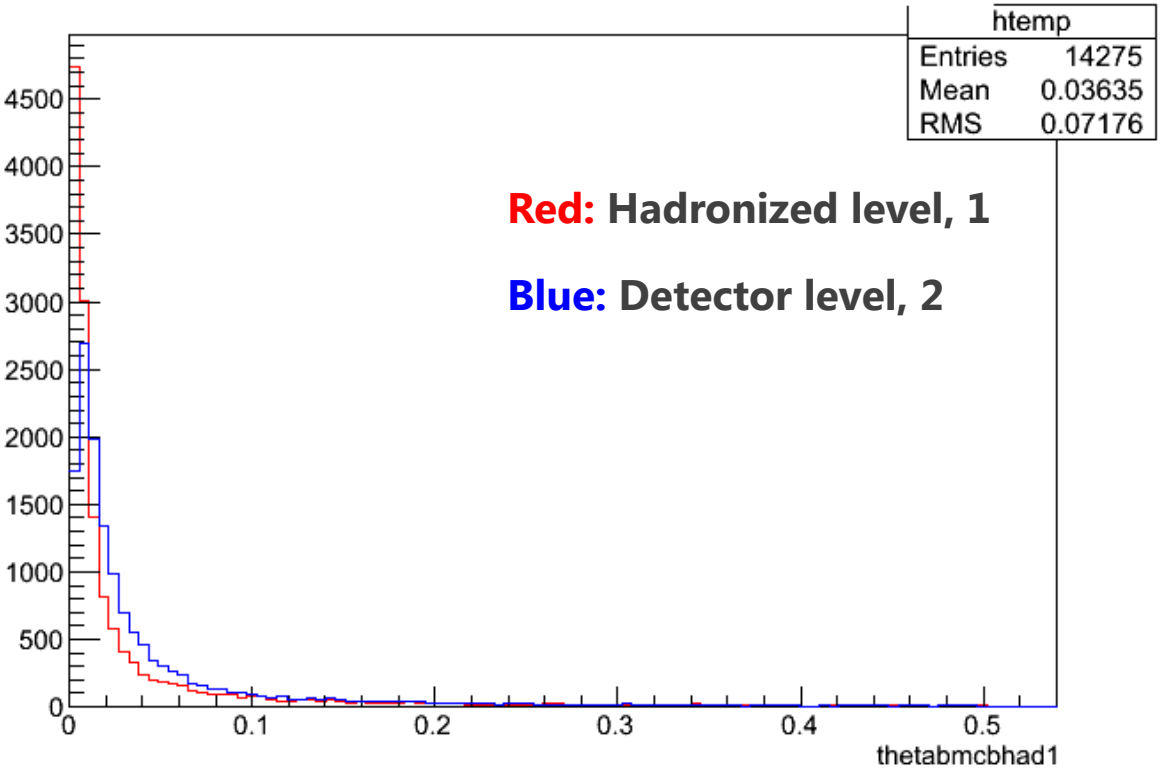
②
BB frame



③
ILC' frame



Hadronization effect v.s. Detector effect, δ_{θ_b}

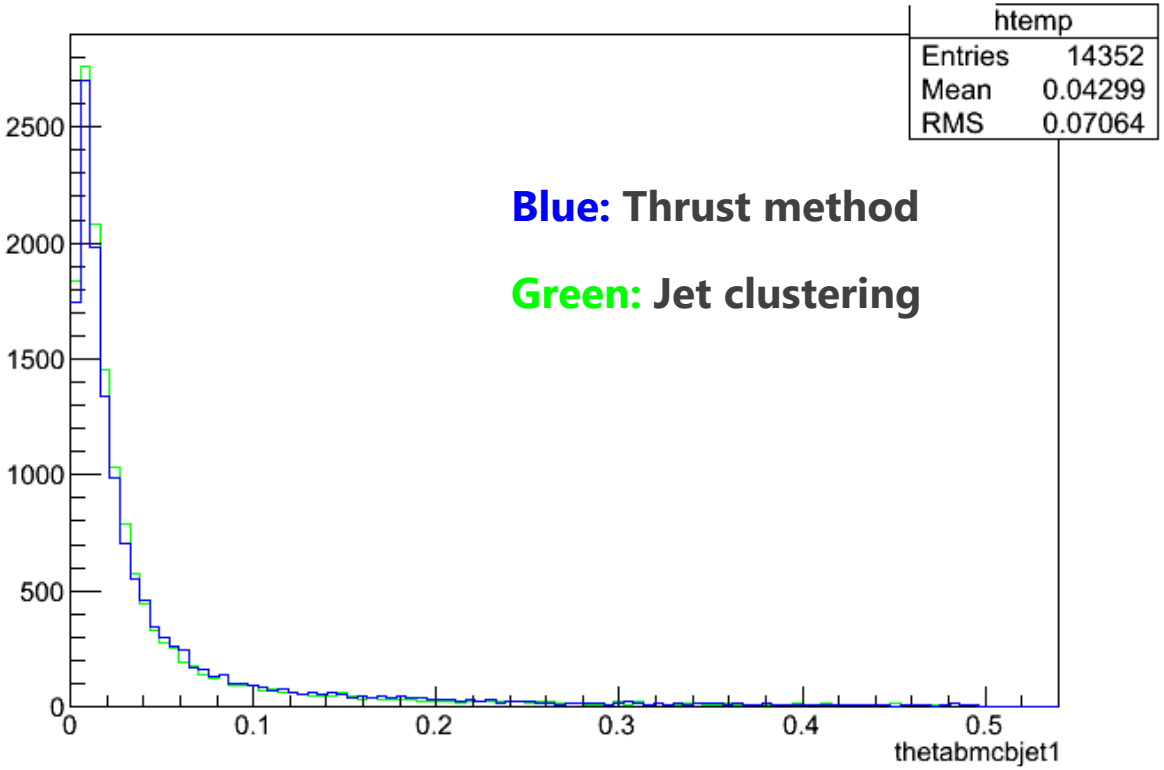


* Each effect is not so large (~0.05 rad.)

* Blue histogram is wider than red one

(Because the collinear photons are not eliminated, red one will improve)

Thrust method v.s. Jet clustering (LCFIPlus), δ_{θ_b}

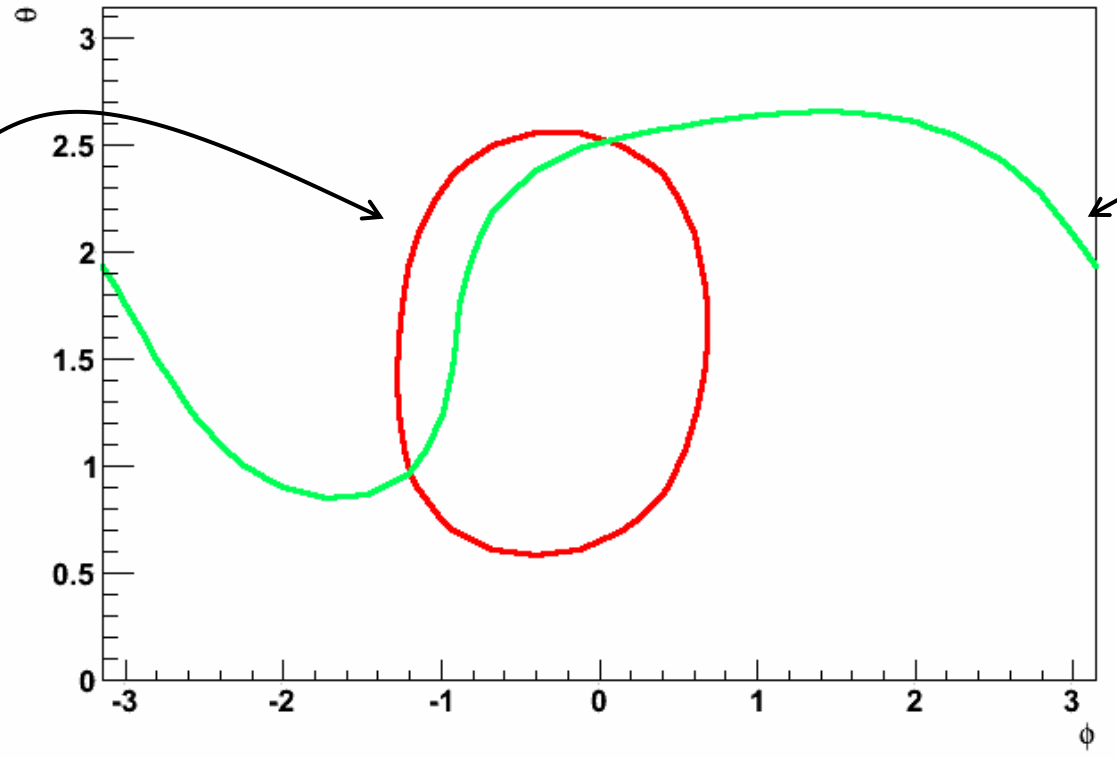


* Jet clustering (green histogram) produces almost same or slightly better result than thrust method (blue one).

(Both two are at detector reconstructed level)

Kinematical constraints

In the W rest frame, the energy of isolated lepton is equal to $m_W/2$ (without considering ISR and bremsstrahlung)



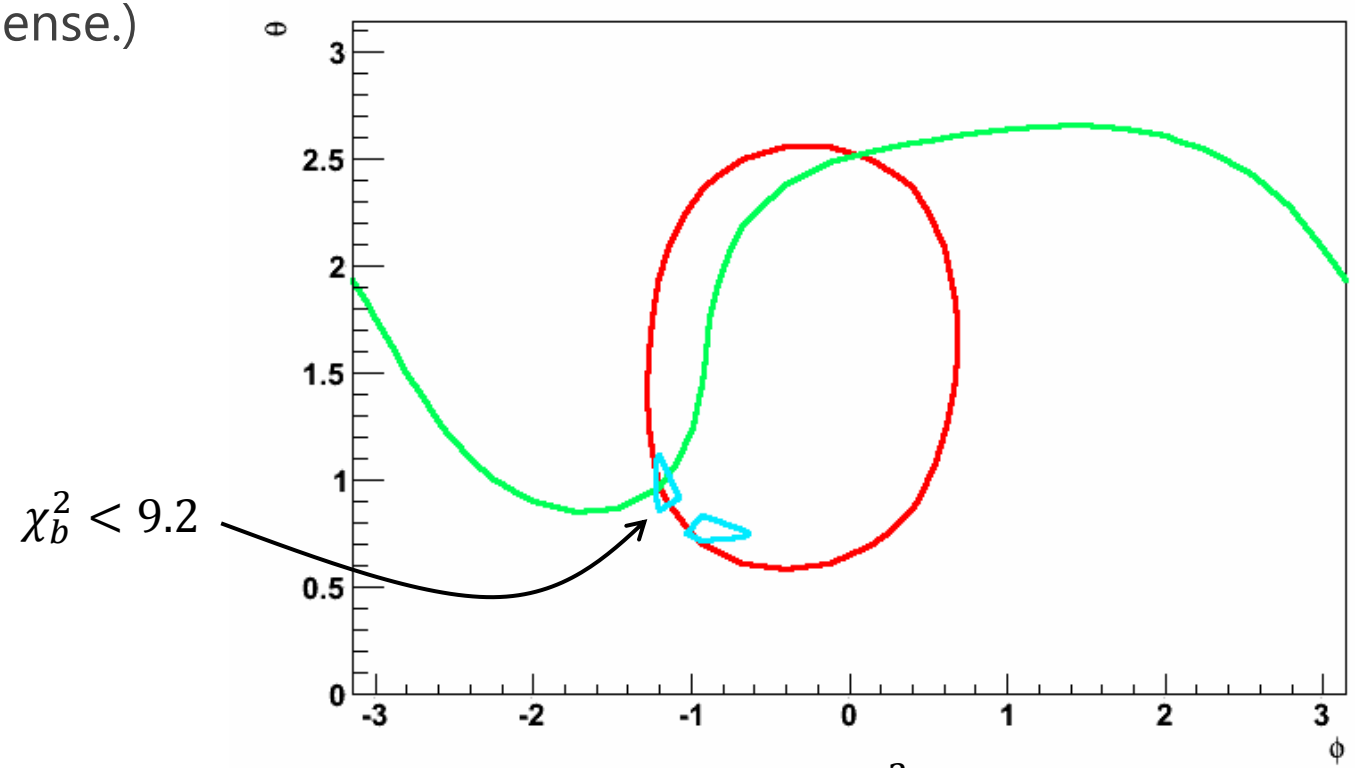
$\frac{m_{W^+}}{2} = E_{l^+}^{**}$

$\frac{m_{W^-}}{2} = E_{l^-}^{**}$

E^{**}: energy at W's rest frame

Measurements of b-quark energies

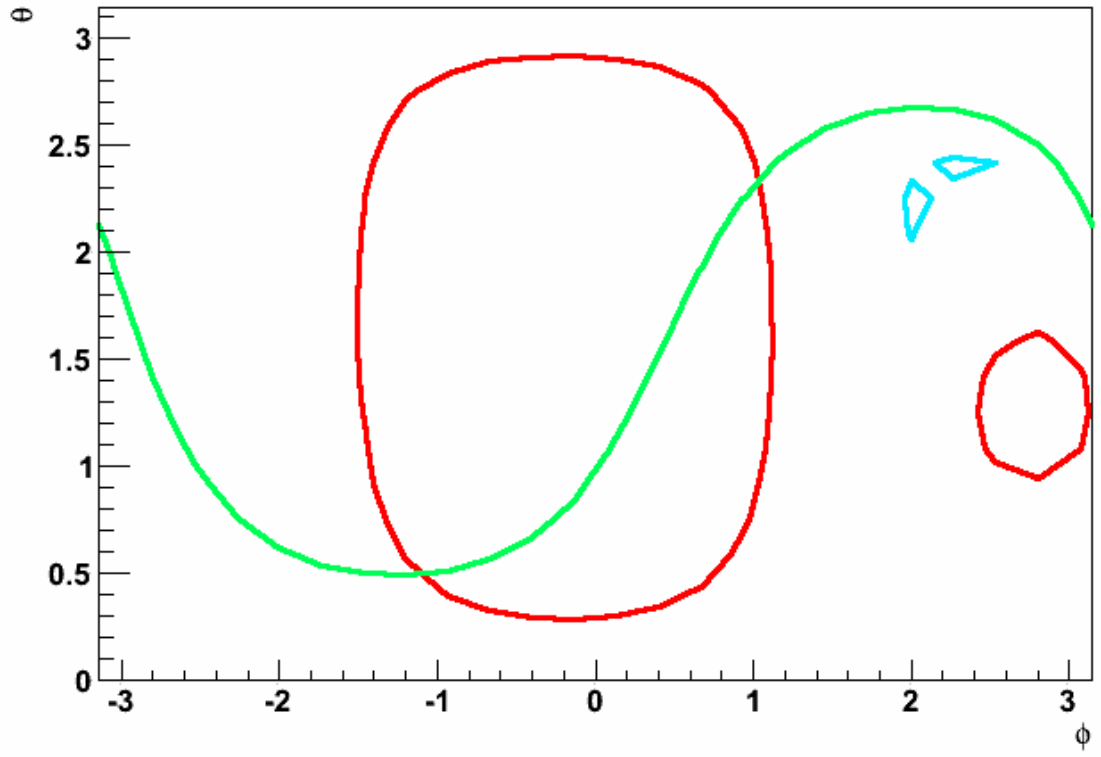
To select the right solution, we can use the measurements of b-quarks energies. (Because this figure is at parton level, this χ_b^2 doesn't make sense.)



$$\chi_b^2(\phi_t, \theta_t) = \left(\frac{E_{b,mes} - E_{b,reco}(\phi_t, \theta_t)}{\sigma_j \sqrt{E_{b,mes}}}\right)^2 + \left(\frac{E_{\bar{b},mes} - E_{\bar{b},reco}(\phi_t, \theta_t)}{\sigma_j \sqrt{E_{\bar{b},mes}}}\right)^2$$

Miss combination of b-quarks

When we use the anti-b direction for the top reconstruction, the measurements of b-quarks excludes this combination.



χ^2 Algorithm

We use the χ^2 algorithm to locate optimal solution and definition of χ^2 as following;

$$\chi^2(\theta_t, \phi_t) = \chi^2_\mu + \chi^2_b, \qquad \chi^2_\mu = \chi^2_{\mu^+} + \chi^2_{\mu^-}, \qquad \chi^2_{\mu^\pm} = \left(\frac{E^{**}_{\mu^\pm} - \frac{m_{w^\pm}}{2}}{\sigma\left[E^{**}_{\mu^\pm}\right]} \right)^2$$

To consider the width of mass of top and W, we can use 6 parameters $(\theta_t, \phi_t, m_t, m_{\bar{t}}, m_{W^+}, m_{W^-})$ instead of 2 parameters.

→I confirmed this algorithm works at parton level, then I will move on other level study.

Summary

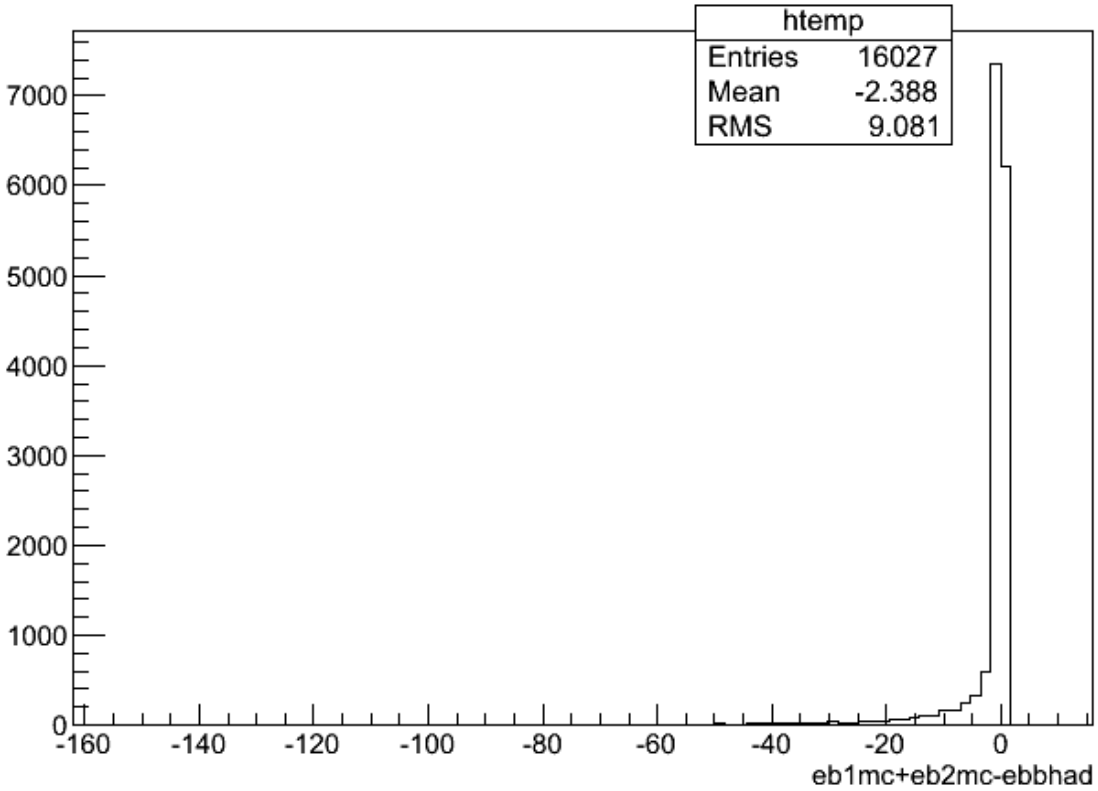
- Reconstruct directions of b quarks
  - Both of hadronization effect and detector effect are not so large (→ we have to check that is enough small or not)
  - Jet clustering and thrust axis method produce almost same result
- Reconstruct direction of top quarks
  - Two kinematical constraints make solutions and measurement of energies of b quarks can select right one. (if mass of top and W are near the on-shell mass)
  - χ^2 algorithm gives optimal solution (now undergoing)

Plan

- Eliminate collinear photons from hadronized particles list at hadronized particles level study.
- Finalize the χ^2 for each level study
- Reconstruct the 4-momentum of every particle (including the neutrinos)
- Analyze the quality of the kinematical reconstruction
- Analyze the reconstructed events with the 10 form factors fitting

Back up

Difference of $b\bar{b}$ energy



We haven't eliminated collinear photons from hadronized particles list.

→ In some events, sum of energy of hadronized particles are ~10GeV smaller than $b\bar{b}$ energy.