Top Quark Electroweak Couplings at the ILC - Open Questions

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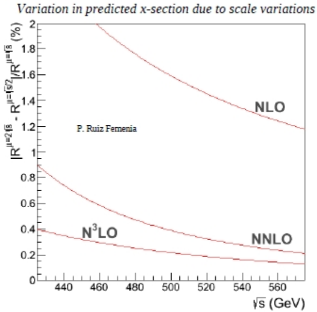
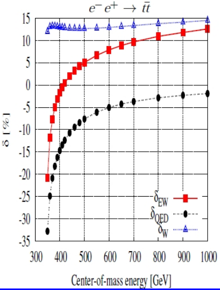
Outline

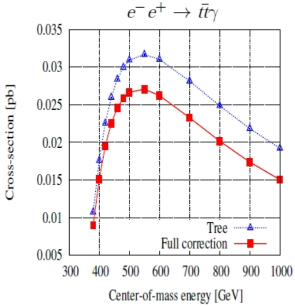
Theoretical Uncertainties

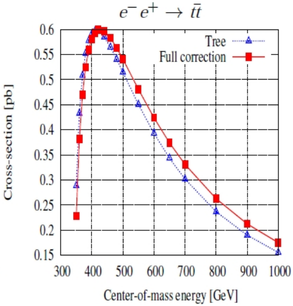




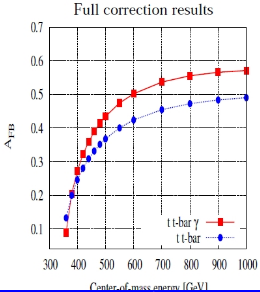
- Study from P. Ruiz Femenia: QCD correction at N^3LO is now at the per-mil level.
- Study from P. H. Khiem *et al.*: Electroweak correction at one loop level is $\approx 5\,\%$ for cross section, and $\approx 10\,\%$ for A_{FB}.
- Estimation of the size of two-loop corrections is ongoing.

Other Theoretical Aspects



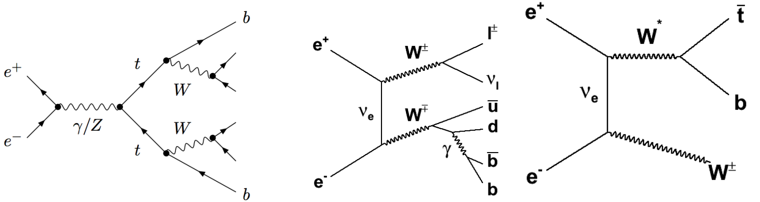


$E_\gamma \geq 10GeV, 0^0 \leq \theta_\gamma \leq 170^0.$



- $e^+e^- \longrightarrow t\bar{t}\gamma$ production gives different prediction.
- Show the importance to have the more possible physics effects in the generator (ISR, FSR, gluon radiation, ...).

Generator and Physics

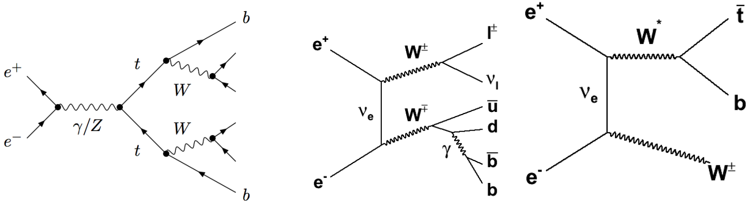


All these process are 6 fermions final state

They are irreducible background, even in the generator, but we are only interested in $t\bar{t}$ cross section.

- Is it meaningful to talk of $t\bar{t}$ cross section or should we consider 6 fermions cross section ?
- The last two diagrams have an opposite asymmetry with respect to the $t\bar{t}$ one.

Generator and Physics



Strategy

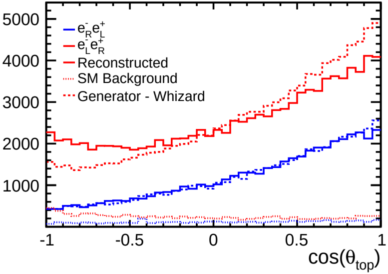
We should have the best generator possible, and try to match simulated data and nature data.

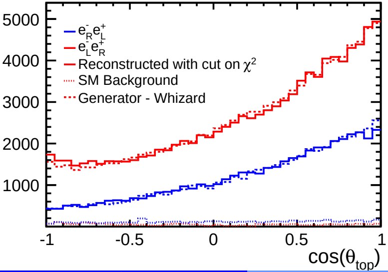
- Then it is to theorists to go from 6 fermions data to the Born $t\bar{t}$ level which is relevant for the couplings.
- But so far we only have simulated data. So we can only compare fully reconstructed simulated data and parton level.

Generator and Physics

- Currently, for the DBD samples, the generation is done with Whizard and the hadronization with Pythia.
- But there are some problems:
  1. The hadronization is not done properly by Pythia for tops off-mass shell and other 6 fermions topologies.
  2. The gluon radiation is done in Pythia and not in Whizard, and we are missing the hard gluon radiation.
  3. The semi leptonic cross section is higher than the fully hadronic one while it should be the opposite.
- The DBD samples were simulated with an old version of Whizard and the new version 2.x have a better treatment of the color object which solve these problems.
- New simulation of the 6 fermions with Whizard 2.x is planned.

How to cure migration ? The "raison d'être" of the χ^2 (see talk by R. Poeschl)





- A cut on χ^2 reduce the number of bad combination.
- After the χ^2 cut the fully reconstructed simulated data match the parton level.
- Also a way to reduce the non $t\bar{t}$ events from the 6 fermions.

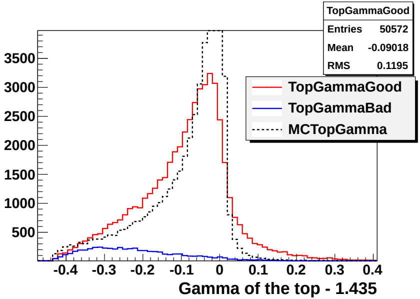
Principle

Why using the b charge in the semi-leptonic decay

- With the charge of the lepton we can disentangle between t and $\bar{t}$.
- But missing the charge of the b leads to migrations for the left polarization.
- Measuring the b vertex charge should help to cure the migrations.

1. Same method than for the fully hadronic mode: Event charge: charge b1 - charge b2 (see talk by R. Poeschl)
2. For each reconstructed top we can compare the lepton charge and the event charge to see if there is agreement.
3. Number of event for each case:
   - Good charge: 29181 (51.9%)
   - Bad charge: 12900 (23%)
   - Zero event charge: 14092 (25.1%)

Using this new information



γ_{top} is lower for flipped top (γ_{top} is the one from relativity).

1. % of good combination for the reconstructed top in each type of events:
   - Good charge: 86.3%
   - Bad charge: 49.9%
   - Zero charge: 72.9%
2. Better rate for event with good charge or zero event charge.

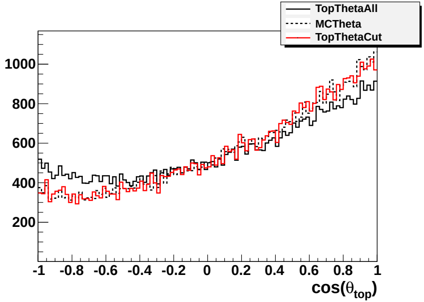
Simple selection

Classification of the type of event depending on the charges (lepton+b) measurement and just one cut on one variable.

Results

Cut using the B charge

$\gamma_{top} - 1.435 > -0.2$ for top with the good event charge.
$\gamma_{top} - 1.435 > -0.1$ for top with a null event charge.



$A_{FB} = 31.56$; $Eff. = 30.8\%$; $\delta_{A_{FB}}/A_{FB} = 1.7$

Reminder with χ^2 cut:
$A_{FB} = 32.63$; $Eff. = 28.5\%$; $\delta_{A_{FB}}/A_{FB} = 1.7$

Advantages

1. New method to cure the migrations: having two methods is useful to estimate the systematic errors.
2. Tacking advantage of the vertex charge measurement capability of the vertex detector.
3. Become immediately more efficient with an optimized vertex charge measurement.
4. Start to check why the vertex charge is wrong: b decay length, number of tracks in the vertex ...

Conclusion and Outlook

1. Good collaboration with theorists to works on errors.
2. The identified problems of the generator will be solved in the next months.
3. On a longer term generator should be ameliorate (NNLO, hard gluon, ...) and the theoretical errors should reach, at least, the level of the statistical ones: workshop at LAL in March.
4. Using the b vertex charge to select the good events give the same results than the χ^2 method: always good to have different methods.
5. Now works with the LCFIPlus team on the vertex charge optimisation.
6. Things to check: effect on standard model background, using the vertex charge in the reconstruction ...