2nd mini-workshop on FCC-ee detector requirements

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electroweak b (and c) physics at FCCee and detector requirements

Roberto Tenchini

INFN Pisa

Opportunity for an high precision measurement of b (and c) quark couplings

- beauty and charm selection tools
  - b tagging (secondary vertexes, semileptonic decays)
  - charm tagging (D*, semileptonic decays)

$$A_{FB}(b) = \frac{\sigma_F - \sigma_B}{\sigma_{tot}} = \frac{3}{4} A_e A_b$$

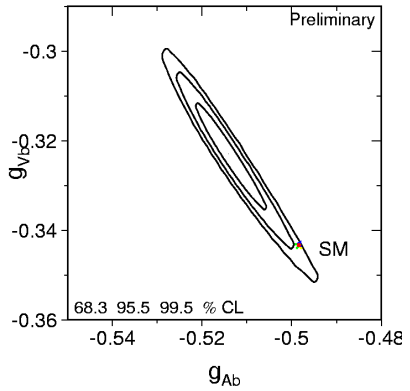
$$R_b = \frac{\Gamma(Z \to b\bar{b})}{\Gamma_{had}} \propto g_v^2 + g_a^2$$

$$A_{pol} = \frac{\sigma_{F,R} + \sigma_{B,R} - \sigma_{F,L} - \sigma_{B,L}}{\sigma_{tot}} = -A_b \propto \frac{g_v}{g_a}$$

$$A_{pol}^{FB} = \frac{\sigma_{F,R} - \sigma_{B,R} - \sigma_{F,L} + \sigma_{B,L}}{\sigma_{tot}} = -\frac{3}{4} A_e$$

Need to measure both R_b and A_b, experimentally very different situation:

- R_b dominated by systematic uncertainties
- A_b at present dominated by statistics



Measurement of R_b : double tagging

Divide event in two hemispheres according to thrust direction

- F_1 fraction of single tag
- F_2 fraction of double tag

$$F_1 = R_b(\varepsilon_b - \varepsilon_{uds}) + R_c(\varepsilon_c - \varepsilon_{uds}) + \varepsilon_{uds}$$

$$F_2 = R_b(C_b\varepsilon_b^2 - \varepsilon_{uds}^2) + R_c(\varepsilon_c{}^2 - \varepsilon_{uds}{}^2) + \varepsilon_{uds}{}^2$$

current uncertainty ≈0.3%

With a detector with high suppression of charm and uds:

- statistical uncertainty coming from double tag sample (already small at LEP)
- systematic uncertainty from hemisphere correlations becomes dominating

$$R_b \approx \frac{C_b F_1^2}{F_2}$$

$$\varepsilon_b \approx \frac{F_2}{C_b F_1}$$

- NOTE that
  - it is simplistic to say that "correlation becomes irrelevant in the limit of 100% b-tagging efficiency "
  - the method assumes that the two b-jets are in two different hemispheres, hard gluon radiation breaks it

Efficient and pure secondary vertex finding will be important to study gluon splitting and nasty sources of correlations (e.g. momentum correlations)

$A_{FB}(b)$ from two very different experimental techniques

- Use semileptonic b decays used for b tagging: b / anti-b distinguished by lepton charge.
- Use inclusive b tagging (impact parameter, secondary vertexes, K, etc.) . Separate b/anti-b with jet charge.

Example $\longrightarrow$ $Q_{jet} = \dfrac{\sum_i |p_i|^k q_i}{\sum_i |p_i|^k}$

The two measurements are essentially uncorrelated for systematic uncertainties. Low statistical correlation (25%-40% at LEP)

$A_{FB}(b)$: from LEP to TLEP (FCC-ee)

LEP final combination statistically dominated

	ΔAFB(b)
STATISTICS	0.00156
UNCORRELATED SYSTEMATIC	0.00061
QCD CORRECTION	0.00030
LIGHT QUARK FRAGMENTATION	0.00013
SEMILEPTONIC DECAYS MODELLING	0.00013
CHARM FRAGMENTATION	0.00006
BOTTOM FRAGMENTATION	0.00003
TOTAL SYSTEMATIC ERROR	0.00073

→ 0.00002

→ Most of this depends on stat.

→ Can be reduced with improved calculations and proper choices of analysis methods (e.g. measure the asymmetry as a function of jet parameters, etc.

Reduction of uncertainty by one order of magnitude possible

Detector requirements

- Highly efficient and pure b-tagging is mandatory to improve R_b
- Pay attention to (correlations)
  - flat performance as a function of b momentum
  - flat geometrical performance
  - primary vertex reconstruction with minimal contamination from secondary tracks
- Low angle b-tagging (both for vertexing and leptons) important for A_b