Study of running bottom quark mass at 250GeV ILC

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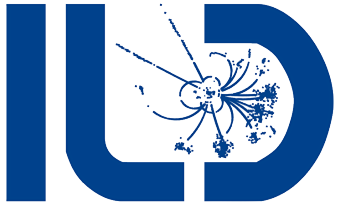

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Introduction

- ✓ LEP had measured b mass at Z-pole, and it was agree with the SM.

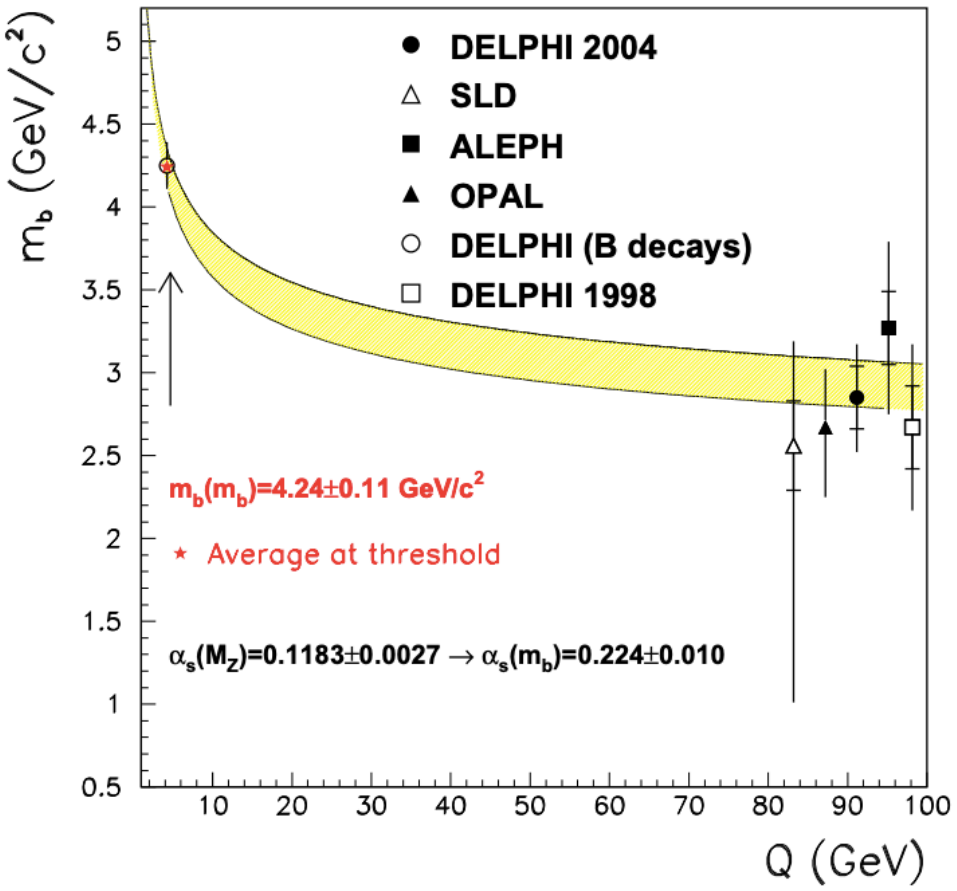
- ✓ Since any probes of BSM hadn't be seen at Z-pole, as the next challenge, we're focusing 250GeV.

- ✓ Looking energy dependence of b mass provides
1. Precise verification of QCD theory
2. Discussion of viability of BSM(e.g. SUSY GUTs)

- ✓ Using the 3 jet ratio R_3^{bl} is the method in order to measure b mass at 250GeV.

Observable : $R_3^{bl} = \dfrac{\text{3 b-jet event / all b-jet event}}{\text{3 uds-jet event / all uds-jet event}}$

b mass evolution from threshold scale to Z-pole



- ✓ Signal event : $e^+e^- \to q\bar{q}$
- ✓ Backgrounds : radiative return on $e^+e^- \to q\bar{q}$, Full hadronic mode of $e^+e^- \to WW/ZZ/Zh$

Pre-Selection

Radiative return Cut

- $\mathrm{K_{reco}} < 50\mathrm{GeV}$ & $\mathrm{m_{2jets}} > 130\mathrm{GeV}$

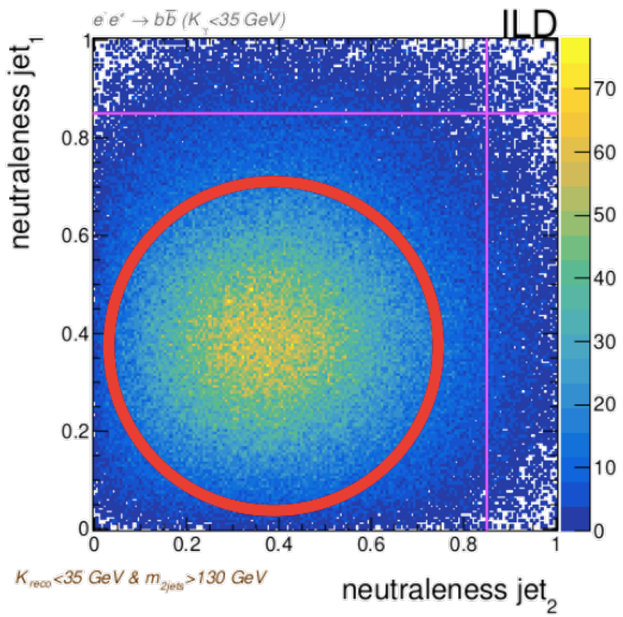
$$K_\gamma \equiv \frac{250\mathrm{GeV} \cdot \sin\psi_{acol}}{\sin\psi_{acol} + \sin\theta_1 + \sin\theta_2}$$

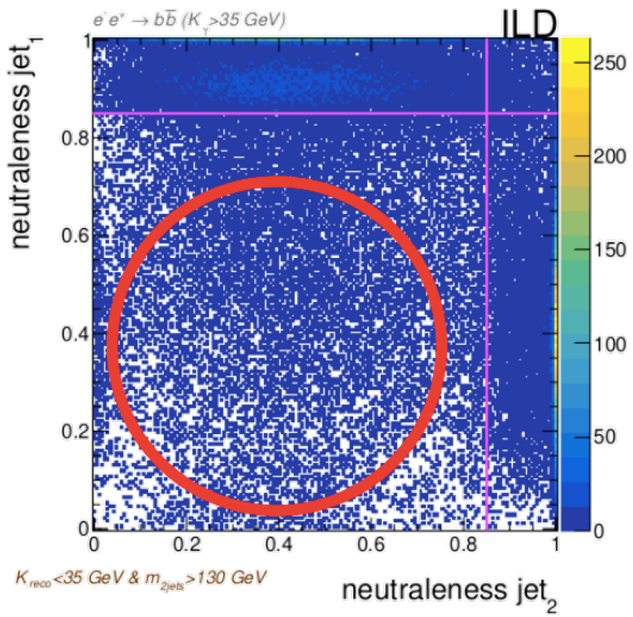
- Photon veto cuts by neutral PFO :
  1. The neutraleness of both jets has to be smaller than 0.85
  2. Both jets should contain more than 5 neutral PFOs
  3. None of the jets should contain a neutral PFO with $\mathrm{E} > 50\mathrm{GeV}$ in the very forward region ($|\cos\theta| > 0.98$)

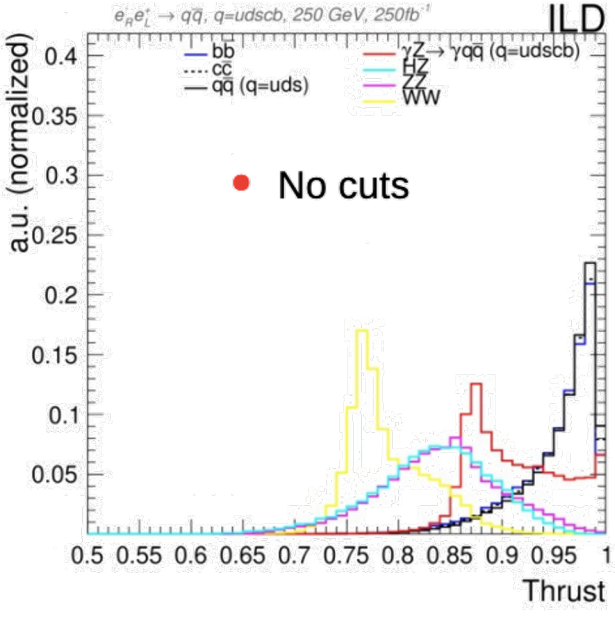
- Radius on neutraleness plane < 0.35 (inside of red circle) $\mathrm{Neutraleness} \equiv (\mathrm{Neutral\ PFO}\ E)/(\mathrm{All\ PFO}\ E)$

Background events Cut

- Thrust > 0.85







Obtained accuracy of R_3^{bl}

Statistic error	100% left polarization (MC 250fb^{-1})	100% right polarization (MC 250fb^{-1})	(-80%,+30%) polarization (H20 900fb^{-1})	(+80%,-30%) polarization (H20 900fb^{-1})
Statistics	9960354	3273497	21209680	8090066
R_3^{bl} $(@y_c = 0.01)$	1.0604 ± 0.0115278	1.08258 ± 0.0230363	1.06073 ± 0.00791657	1.07821 ± 0.0142826

Systematic	Uncertainty (for b-quark)	Uncertainty (for light-quark)	Uncertainty on R_3^{bl} (100% Left)	Uncertainty on R_3^{bl} (100% Right)
Flavor-Tagging	0.1-0.3%	0.1-0.3%	0.0053-0.016%	0.015-0.044%
Pre-Selection	0.5-1.0%		0.021-0.043%	0.043-0.085%
Flavor-Tagging (Rad.ret.)	0.5-1.0%		0.07-0.15%	0.056-0.11%
Pre-Selection (Rad.ret.)	1.0-2.0%		0.04-0.08%	0.07-0.14%
Other BKGs rejection	0.1-1.0%		0.01-0.15%	0.034-0.34%
Total	—		**0.08-0.23%**	**0.09-0.38%**

←Dominant in systematic sources

Errors on Observable： $\Delta R_3^{bl}(stat.) = 0.65\%$, $\Delta R_3^{bl}(had.) = 0.1\%$, $\Delta R_3^{bl}(exp.) = 0.23\%$

NOTE) Systematic error which comes from hadronization model is extrapolated from LEP here.

Updated News

- ✓ Since using MC sample simulates gluon radiation up to LO with massless quarks, obtained R_3^{bl} is not reliable completely.
- ✓ However, we can estimate the precision of b mass measurement at 250GeV ILC itself.
- ✓ Our MC 3 jet ratio may be unreliable and it'll affect to statistical error. We're waiting for theoretical calculation as reference.
- ✓ WHIZARD authors have worked update the current version to the new one; NLO with massive quarks.

For the moment, b mass accuracy will be

$$\left|\frac{\Delta m_b}{m_b}\right| \sim 100\frac{\Delta R_3^{bl}}{R_3^{bl}} = 65(stat.) + 10(had.) + 23(exp.) = 98\%$$

If the central value is 2.5GeV, the error is about 2.45GeV(quite large!).