Status of 1997 Rb Measurement

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Status of 1997

R\textsubscript{b} Measurement

R\textsubscript{b} Group:

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CAVEAT

Work in Progress

NOT

a

Preliminary Measurement
Theoretically:

\[ R_b = \frac{\Gamma(Z \rightarrow b\bar{b})}{\Gamma(Z \rightarrow qq)} \]

Experimentally:

- just a counting experiment

-&gt; count the number of bottom events in hadronic decays of the \(Z^0\)

\[ \frac{\# \text{ b events}}{\# \text{ quark events}} \]

Measure:

we "count" the number of hemispheres passing an invariant mass cut...

Double Tag Technique

\( \rightarrow \text{reduces systematic error due to B modeling} \)
Double Tag Method

Split event in two by thrust axis and try and tag each half separately

\[ F_s = R_b \varepsilon_b + R_c \varepsilon_c + (1 - R_b - R_c) \varepsilon_{uds} \]

\[ F_d = R_b \varepsilon^{double}_b + R_c \varepsilon^{double}_c + (1 - R_b - R_c) \varepsilon^{double}_{uds} \]

Can solve for \( R_b \) and \( \varepsilon_b \) from tagging rates

\( \varepsilon_i = \) Efficiency for tagging a hemisphere

\( \varepsilon_i^{double} = \) Efficiency for tagging both hemispheres in event

\( F_s = \) single tag rate

\( F_d = \) double tag rate

\( R_c = \) Standard model value (0.171 \( \pm \) 0.006)

\[ \varepsilon^{double}_b = \varepsilon_b^2 + \lambda_b (\varepsilon_b - \varepsilon_b^2) \]
Basic Procedure of Analysis

1 - Identify hadronic decays of the $Z^0$

2 - Split each event into two halves using the thrust axis

3 - Look for displaced vertices in each hemisphere using topological vertexing

4 - Add tracks to displaced vertex which are consistent with coming from a B decay

5 - Calculate the invariant mass of the candidate vertex in each hemisphere

6 - Correct the invariant mass for possible missing $P_t$

7 - Tag hemisphere as bottom if the invariant mass is $> 2$ GeV

8 - Calculate $R_b$ and $\varepsilon_b$ from tagging rates
Hadronic Event Selection

≥7 good tracks in CDC

>18 GeV in charged tracks

\[|\cos \theta_{\text{thr}}| < 0.71\]

≥3 tracks w/ Linked VXD hits

≥1 tracks starting at \( r_{r\phi} < 50 \text{ cm} \)

use 2 and 3 jet events only

~63K data events passing event selection

Hadronic event selection bias = 0.5%
b-mass Effect

the mass of the b quark affects the 4-jet rate in \( bb \) events

Arnd Brandenburg:

\[
m_b(m_{Z0}) = 3 \text{ GeV} \quad f^b_4 = 4.033\% \\
m_b(m_b) = 5 \text{ GeV} \quad f^b_4 = 3.653\% \\
\]

\( f^b_4 \) is the 4-jet rate in \( bb \) events.

we expect a decrease in the number of events passing hadronic event selection

For 1993-95 analysis:

\[
\delta(4\text{-jet rate}) \sim 0.31\% \\
\delta R_b/R_b \sim 0.31\% 
\]
Quality Track Selection

(Cuts on CDC Track)

\[ |\delta_Z| < 1.5\text{cm}, \ |\delta_{r\phi}| < 1.0\text{cm} \]

\[ \chi^2_{/\text{d.o.f.}} < 8, \ p_t > 0.25 \text{ GeV/c} \]

\[ r_0 < 50\text{cm}, \geq 23 \text{ CDC hits} \]

\[ |\cos\theta| < 0.87 \]

(Cuts on CDC+VXD Track)

\[ \sigma_{r\phi} < 250\mu\text{m}, \ \chi^2_{/\text{d.o.f.}} < 8 \]

\[ |\delta_{xy}| < 3\text{mm} \]
Secondary Vertex

After finding vertices with topological vertexing, we require that these vertices to satisfy a significance cut:

$$\frac{D}{\sqrt{\sigma_{IP}^2 + \sigma_{SV}^2}} \geq 5$$

D = distance between IP and secondary vertex
\(\sigma\) = error on the vertices along secondary vertex direction

We find secondary vertices in \(~65%\) of b hemispheres

- \(B \rightarrow D\) cascade \(\Rightarrow\) not all tracks originate from one space point

Attach tracks to vertex:

- \(T < 1\text{mm}\)
- \(L > 0.5\text{mm}\)
- \(L/D > 0.25\)
- Compute $M_{raw}$ mass of tracks in secondary vtx (assign $m_\pi$)

- Exploit additional mass information from kinematics:

\[ M = \sqrt{M_{raw}^2 + P_T^2 + |P_T|} \]

Impose:

\[ M \leq 2M_{raw} \]

Use smallest $P_T$ allowed by IP and vtx position uncertainties
$P_T$ Corrected Vertex Mass

Number of Hemispheres

- mc
- Data

above 2 GeV: charm and uds suppressed
R_{b} Mass Tag Dependence

SLD Preliminary 1997 Data

R_{b} = 0.2207 \pm 0.0023 \text{(stat)}

SM R_{b} = 0.2158

Mass Cut vs GeV

John Coler - Boston University
$R_b$ Mass Tag Performance

Graph showing the performance of $R_b$ mass tagging with respect to mass cut. The graph indicates:

- **b purity**: 97.9%
- **b efficiency**: 51.4%
- **c efficiency**
- **uds efficiency**

The graph plots the efficiency of mass cuts ranging from 0.1 to 3 GeV.
Cos(θ) Distribution of Thrust Axis

after event selection

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John Coller - Boston University
Concluding Remarks

Attemded measurement of $R_b$ using 1997 data

\[ R_b = 0.2152 \pm 0.0034 \pm 0.0016 \]

\[ R_b = 0.2101 \pm 0.0034 \pm 0.0021 \]

Need to investigate MC - Data distributions:

Correct for possible discrepancies

then:

Rerun analysis