Studies of $b\bar{b}$ gluon and $c\bar{c}$ vertices

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  gluon splitting into $b\bar{b}$ (SLD): 691

Motivation

- Complete study of 3 and 4 jets final state events (identify $q,\bar{q},g$ jets)
- Recent years:

  excitement in $Z^0 \rightarrow b\bar{b}$ sector; R_b and A_b

  (PA05a session talked by Su Dong and Masako Iwasaki)
- Important to make cross-check on STRONG interaction dynamics of b/c quark.

$b\bar{b}g$ OBSERVABLES

1. Gluon distributions:

energy ($x_g \equiv E_{gluon}/E_{beam}$) **and polar-angle** ($\theta_g$)

⇒ **Test for anomalous** $b\bar{b}g$ **couplings**

2. b-quark polar (θ) **and azimuthal** (χ) **angles:**

$$\frac{d\sigma}{d\cos\theta} \propto (1-P_e\cdot A_e)(1+\alpha\cos^2\theta) + 2A_P(P_e-A_e)\cos\theta$$

$$\frac{d\sigma}{d\cos\chi} \propto (1-P_e\cdot A_e)(1+\beta\cos 2\chi) - \frac{3\pi}{2\sqrt{2}}A'_P(P_e-A_e)\cos\chi$$

⇒ **Test for P violation** $b\bar{b}g$ **vertex**

3. polar-angle distn. of $\perp$ **to** $b\bar{b}g$ **plane** (ω)**:**

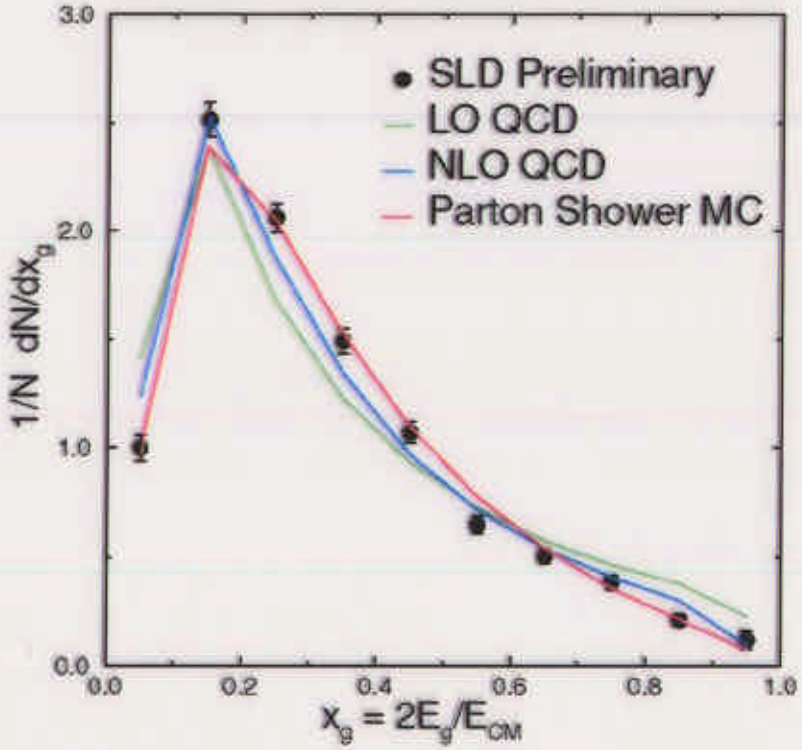
$$\frac{d\sigma}{d\cos\omega} \propto (1-P_e\cdot A_e)(1+\gamma\cos^2\omega) + 2A_T(P_e-A_e)\cos\omega$$

⇒ **Test for final-state interactions in** $b\bar{b}g$ **events**

$\perp$ **defined by** $\vec{b_1}\times\vec{b_2}$ ($|b_1| > |b_2|$)**: CP+ T−**

$\perp$ **defined by** $\vec{b}\times\vec{\bar{b}}$**: CP− T−**

Gluon energy spectrum in $b\bar{b}g$



- Select 3-jet events
- Tag (only) 2 jets as b/$\bar{b}$; the other is g
- Calculate gluon jet energy kinematically
- Well described by pQCD.

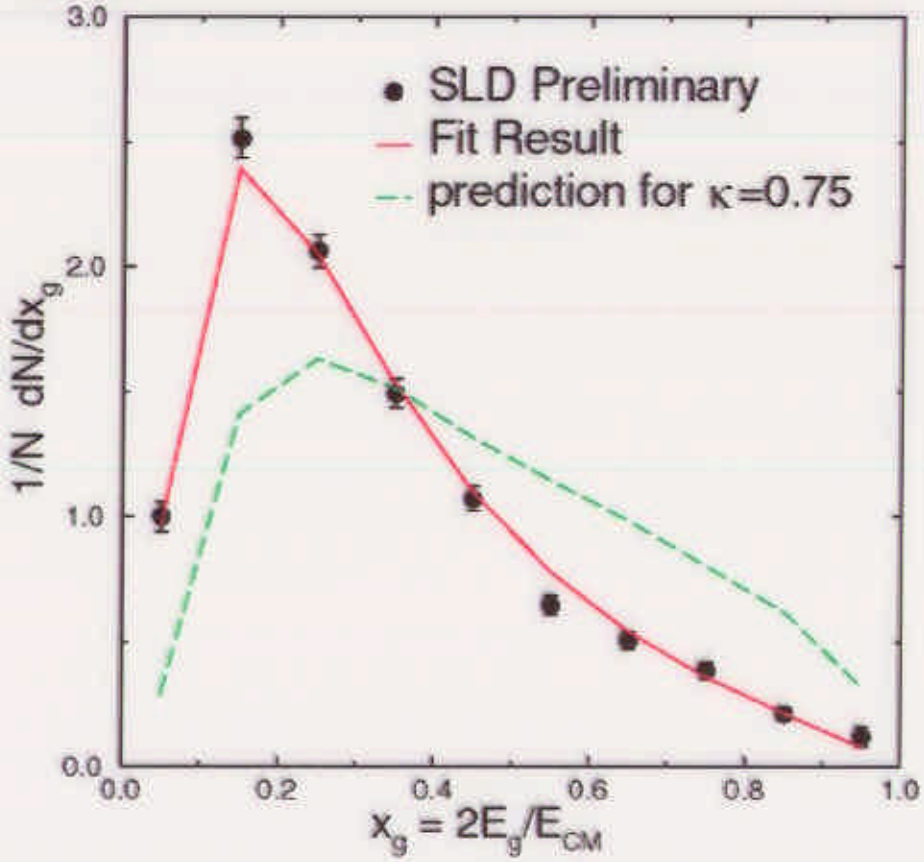
Search for anomalous chromomagnetic coupling at $b\bar{b}g$

$$L^{b\bar{b}g} = g_s \bar{b} T_a \left[\gamma_\mu + i\sigma_{\mu\nu} k^\nu (\kappa - i\tilde{\kappa}\gamma_5)/2m \right] b G_a^\mu$$

QCD

Electric(~~CP~~)

Magnetic



95% C.L. limits:

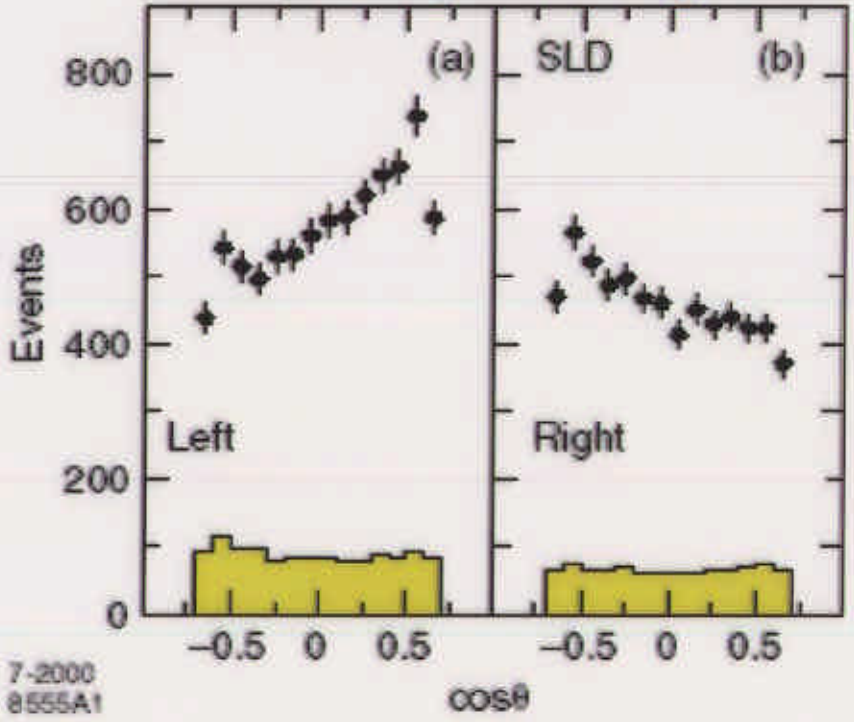
$-0.11 < \kappa < 0.08$

with $\tilde{\kappa}=0$

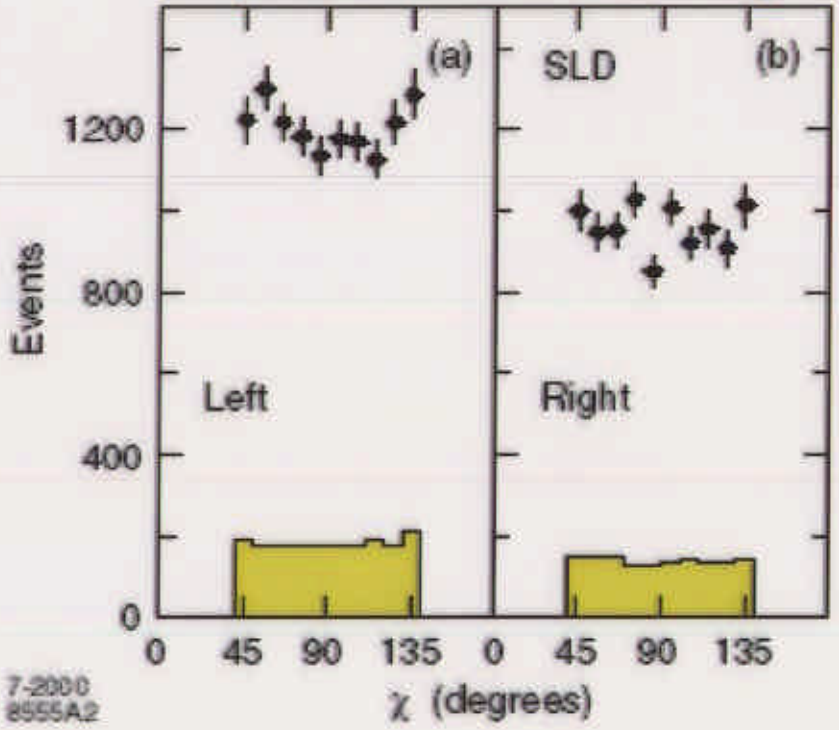
Preliminary

Parity Violation in $b\bar{b}g$

b-quark polar angle



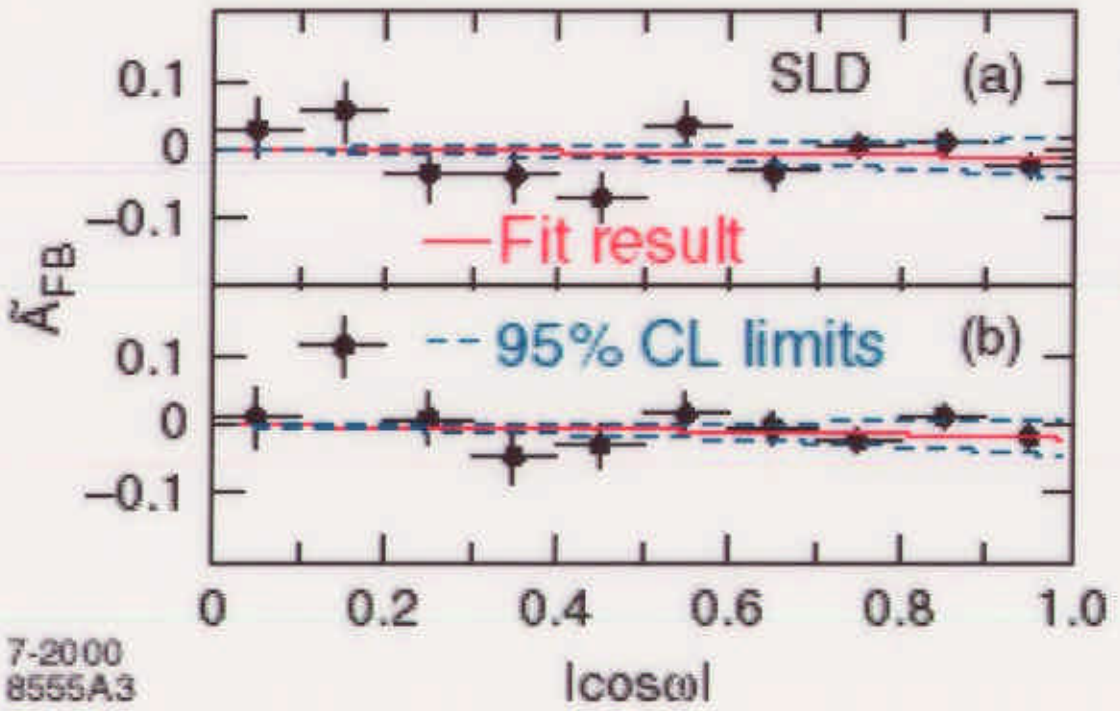
b-quark azimuthal angle



$A_p / A_b = 0.914 \pm 0.053 \pm 0.063$ $A_A / A_b = -0.014 \pm 0.035 \pm 0.002$

0.93 (expected) -0.06 (expected)

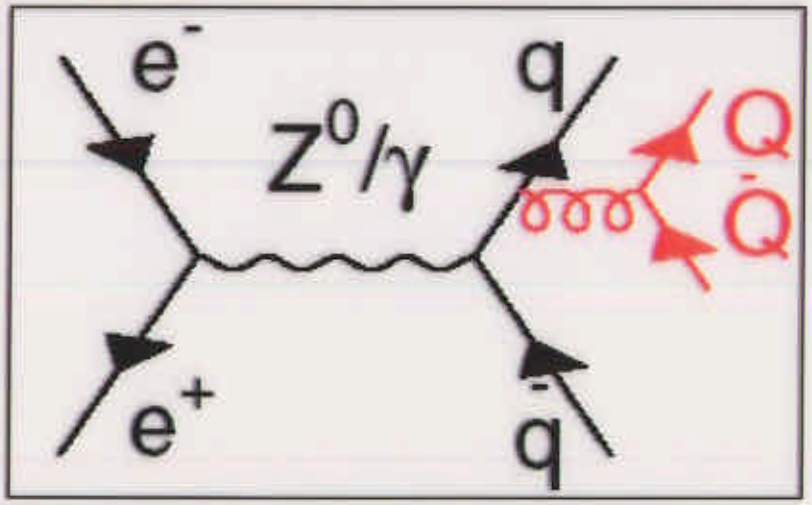
T_N-odd and CP



- $-0.045<A_T^{+}<0.016$ @95% CL limit
- $-0.082<A_T^{-}<0.012$ @95% CL limit

$|A_T|<10^{-5}$ (expected)

Gluon splitting to heavy quarks



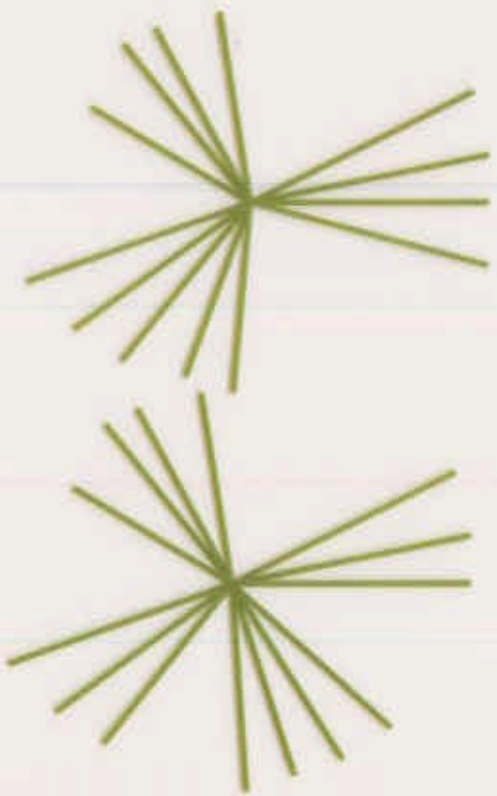
Q=b or c

- Production rate:

$$g_{Q\bar{Q}} = \frac{N(Z^0 \to q\bar{q}g; g \to Q\bar{Q})}{N(Z^0 \to q\bar{q})}$$

$g_{Q\bar{Q}}$ is small (~2%/0.2%) and sensitive to α_S and m_Q.
→ measurement of $g_{Q\bar{Q}}$ is important test of QCD
→ Main systematic source of R_b and R_c

Experimental signature for $g \rightarrow Q\bar{Q}$

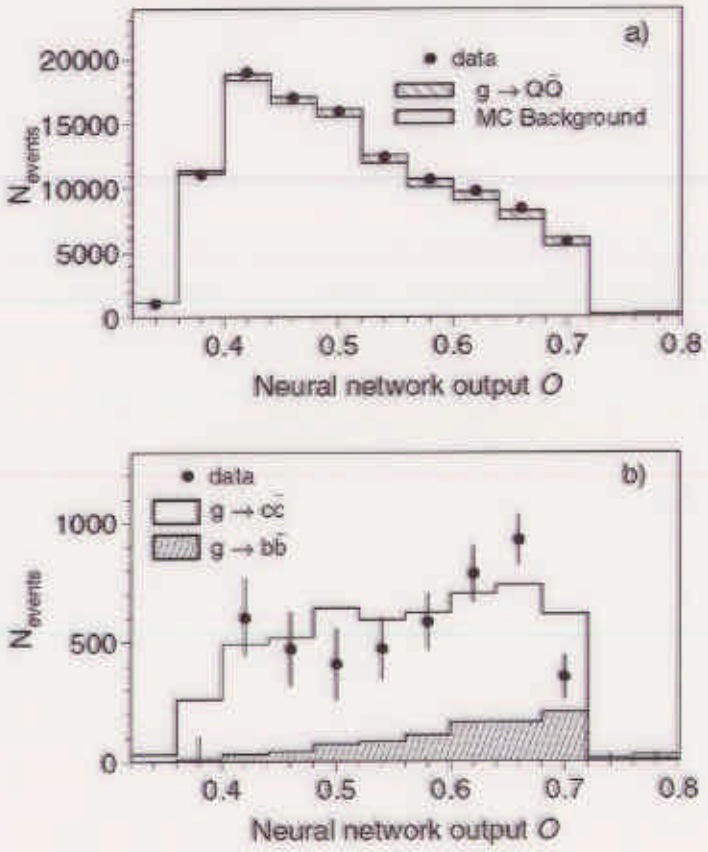


$g \rightarrow c\bar{c}$ • 3 jets, one of the jets (low energy, broad) with charm decay products

$g \rightarrow b\bar{b}$ • 4 jets, two of the jets (low energy, close in phase space) with bottom decay products

Neural Network plays an important role to separate signal from backgrounds.

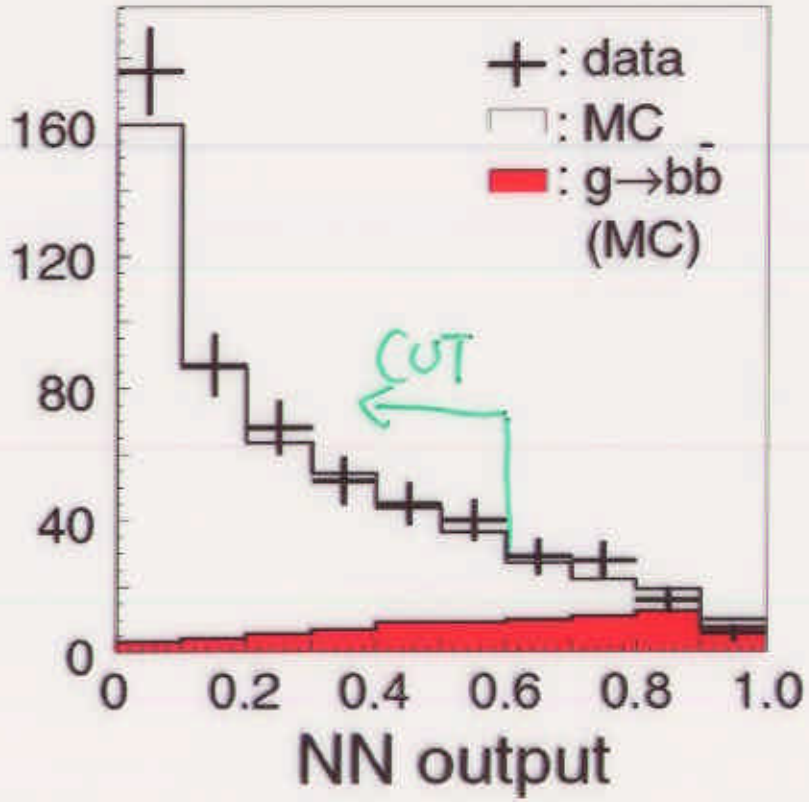
$g \to c\bar{c}$ measurement at L3



- 5 event shape variables as input
- NN output>0.59
- 1700±300 signal events after background subtraction.

$g_{cc}=(2.27\pm0.30\pm0.54)\%$

$g \to b\bar{b}$ measurement at SLD

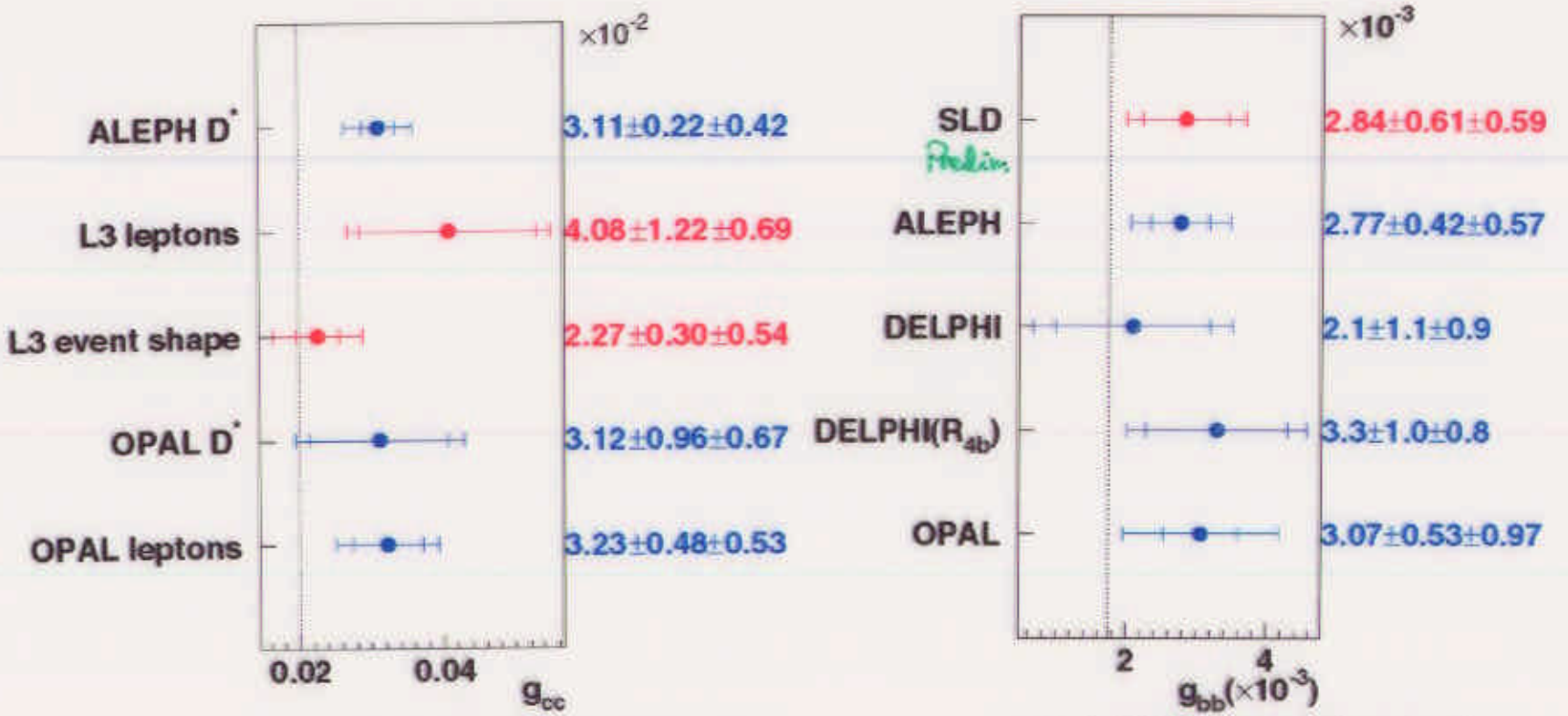


- Vertices in both jets with smallest opening angle
- 9 topological variables as input
- NN output>0.6

$g_{b\bar{b}} = (2.84 \pm 0.61 \pm 0.59) \times 10^{-3}$

Preliminary

The world $g_{c\bar{c}}$ and $g_{b\bar{b}}$ measurements



g_{cc}=2.007% (Miller and Seymour)

g_{bb}=1.75 (Miller and Seymour)

α_S=0.118 m_b=5.0GeV

α_S=0.120 m_c=1.2GeV m_b=4.5GeV g_{cc}=2.3% g_{bb}=0.27%

Summary

- Tests of P-, T_N-, CP-violation in $Z^0 \to b\bar{b}g$

  $A_p / A_b = 0.914 \pm 0.053 \pm 0.063$

  $A_A / A_b = -0.014 \pm 0.035 \pm 0.002$

  $-0.045 < A_T^+ < 0.016$

  $-0.082 < A_T^- < 0.012$

- Structure of $Z^0 \to b\bar{b}g$ events

  Limits on new physics, e.g. $-0.11 < \kappa < 0.08$ 95%C.L.

- Gluon splitting to heavy quarks

  $g_{cc} = (2.45 \pm 0.29 \pm 0.53)\%$ (L3)

  $g_{bb} = (2.84 \pm 0.61 \pm 0.59) \times 10^{-3}$ (SLD)