HEAVY QUARK ASYMMETRIES with the SLD

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St Francis Yacht Club
SLD Swan Song Collaboration Meeting

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Parity Violation in the Standard Model

\[ \text{SU}(2)_L \otimes \text{U}(1) \]

\[ \text{maximal P.V.} \quad \text{mixed P.V.} \]

Neutral Sector

\begin{align*}
\text{(photon) } A_\mu &= W_\mu^3 \sin \theta_W + B_\mu \cos \theta_W \\
\text{(Z0) } Z_\mu &= W_\mu^3 \cos \theta_W - B_\mu \sin \theta_W
\end{align*}

\[ \Rightarrow \text{Parity violation in weak neutral sector is a telling test of S.M.} \]
Parity Violation $\iff$ L, R handed couplings differ

Define "parity violation parameters"

$$\Delta \gamma = \frac{(g_L)^2 - (g_R)^2}{(g_L)^2 + (g_R)^2}$$

where $g_L, g_R$ are couplings of fermion $f$ to the $Z^0$.

$\Rightarrow$ Quantitative measure of extent of PV in coupling of $Z^0$ to fermion $f$. 
But how to MEASURE!? \( (e^+e^- \rightarrow Z^0 \rightarrow f\bar{f}) \).

Use angular momentum arguments:

Polar angle distribution sensitive to \( A^f \)'s (participating).

\[ \frac{d\sigma}{d\cos\theta} = 1 + Z^2 + 2 A^f A^\bar{f} \cos\theta \]

\( \Rightarrow \) sensitive to combination \( A^f A^\bar{f} \)

With Electron Polarization \( P_e = \pm |P_e| \) (SLC)

\[ \frac{d\sigma}{d\cos\theta} = (1 - A_e P_e)(1 + Z^2) + 2 A^f A^\bar{f} A_e P_e \cos\theta \]

\( \Rightarrow \) sensitive to \( A^f \) in isolation.
Table 1. Standard Model Couplings and Parity Violation (assuming $\sin^2 \theta_W = 0.231$)

<table>
<thead>
<tr>
<th>Fermion</th>
<th>$t^f_3$</th>
<th>$Q^f$</th>
<th>$g^f_L$</th>
<th>$g^f_R$</th>
<th>$A_f$</th>
<th>$dA_f/d\sin^2 \theta_W$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$e, \mu, \tau$</td>
<td>$-1/2$</td>
<td>$-1$</td>
<td>$-0.269$</td>
<td>$0.231$</td>
<td>$0.151$</td>
<td>$-7.8$</td>
</tr>
<tr>
<td>$\nu$</td>
<td>$+1/2$</td>
<td>$0$</td>
<td>$0.500$</td>
<td>$0.000$</td>
<td>$1.000$</td>
<td>$-0.0$</td>
</tr>
<tr>
<td>$d, s, b$</td>
<td>$-1/2$</td>
<td>$-1/3$</td>
<td>$-0.423$</td>
<td>$0.077$</td>
<td>$0.935$</td>
<td>$-0.6$</td>
</tr>
<tr>
<td>$u, c, t$</td>
<td>$+1/2$</td>
<td>$+2/3$</td>
<td>$0.346$</td>
<td>$-0.154$</td>
<td>$0.669$</td>
<td>$-3.5$</td>
</tr>
</tbody>
</table>

For the couplings of the $Z^0$ to fermion $f$:

$$g^f_L = t^f_3 - Q^f \sin^2 \theta_W$$

$$g^f_R = -Q^f \sin^2 \theta_W$$

$= 3$ = 3rd component of weak isospin

$Q_f$ = electric charge

$\Rightarrow$ A lept. very sensitive to $\sin^2 \theta_W$ ($A_{LR}$, etc).

$\Rightarrow$ A $d, s, b$ very insensitive to $\sin^2 \theta_W$ (complementary)

$\Rightarrow$ A $c, t, u$ is somewhere in between.

$\text{Note: masses in SM not yet understood; } b \text{ couples strongly}$

$\text{to generation mechanism } \Rightarrow A_b \text{ interesting!}$
Measuring $A_1$: Practical Note

One needs to:

- Isolate sample of $Z \rightarrow f\bar{f}$ decay for $Y'$ of interest
- Discriminate $f$ from $\bar{f}$
- Estimate $Z=\cos\Theta$ of parton
- Monitor polarization appropriately

Exploits full capabilities of detector

- Tracking (Vtx, mass reconstruction)
- Cal (electron ID)
- CRID ($K,e,\mu$ 3D)
- Muon system ($\mu$ 3D, tracking)
- Polarimetry
1) Xenji Abe  
   $A_b$ kaons  
   JAPAN

2) Giulia Bellodi  
   $A_b, A_c$ muons  
   ITALY

3) Jorge Fernandez  
   $A_b$ electrons  
   USA

4) Mike Hildreth  
   $A_c$ $D^0$'s  
   USA

5) Tom Junk  
   $A_b$ jet charge  
   USA

6) Giampiero Mancinelli  
   $A_b, A_c$ muons  
   ITALY

7) Shinya Narita  
   $A_s$  
   JAPAN

8) Hermann Stoegle  
   $A_s$  
   GERMANY

9) David Williams  
   $A_b$ muons  
   USA

10) Tom Wright  
    $A_b, A_c$ jet charge  
    IOWA
Structure of $e^+e^- \rightarrow s\bar{s}$ Events

- An s-jet often includes a high-momentum particle with strangeness -1, such as
  
  $K^-$, ‘stable’
  $K^0_S$, $\sim 50$ cm flight dist. 68% $\rightarrow$ 2 tracks
  $K^0_L$, ‘stable’
  $\Lambda^0$, $\sim 80$ cm flight dist. 64% $\rightarrow$ 2 tracks

- However: exact rate unknown
  - large bkg. from B, D decays
  - bkg. from leading K,L in u,d jets
  - bkg. from fragmentation
  - analyzing power unknown

$\rightarrow$ A measurement of $R_s$ or $A_s$ using strange particle tags could be highly model-dependent

Dave Muller
• We know that:
  ♦ there is a signal in s jets
  ♦ the a.p. is high
  ♦ $0.4 < (u+d):s < 0.8$

  ♦ a leading $K^+$ in a u or d jet
    is accompanied by a fast $K^-, K^0, \Lambda^0, ...$

  ♦ a fast $K^+$ in an s jet is
    accompanied by two fast $K^-, K^0, \Lambda^0, ...$

  ♦ the heavy flavor background can
    be suppressed independently
    using vertexing

• Strategy: take advantage of these features
  use data to constrain rates

  Dave Muller
Dave Muller
• Difficult to measure any of the unknowns cleanly from the data...

• ...but there are several checks/constraints available, given that the simulation contains the above qualitative features of the data. For example:

1) Compare the number of jets with 3 ID'd $K^\pm$, $K^0$ with the prediction of the simulation
   → 33% ‘measurement’ of the wrong-sign fraction

2) Compare the number of jets with an ID'd $K^+K^-$ or $K^\pm K^0$ pair with the prediction
   → 13% ‘measurement’ of (u+d):s

3) Compare the number of events with an ID'd $K^+$ (or $K^-$) in both jets with the prediction
   → 57% ‘measurement’ of the a.p. for u,d

Result: $A_s = 0.85 \pm 0.17$ (stat.) $\pm 0.10$ (syst.)

Expect: $A_s = 0.67 \pm 0.08$ (stat.) $\pm 0.07$ (syst.)

OLD, BUT...
$A_s$ SLD
(0.55 M events)

$A_s$ DELPHI
(3.2 M events)

$A_{d,s}$ DELPHI
(0.7 M events)

$A_{d,s}$ OPAL
(4.3 M events)

Coupling parameter

SM

0.895 ± 0.090

0.903 ± 0.107

1.00 ± 0.56

0.61 ± 0.33
Measuring $A_c$

1) Exclusive Reconstruction

$D^{**+} \rightarrow D^0 \pi^+_2$ ; $D^0 \rightarrow K^- \pi^+$

$D^+ \rightarrow K^- \pi^+ \pi^0$

$D^0 \rightarrow K^- \pi^+ \pi^+ \pi^-$

$D^+ \rightarrow K^- \pi^+ \pi^+ \pi^-$

Charge determined by slow pion $\pi^-_2 \text{ or } \pi^+$

Precise, but not so efficient!

$A_c = 0.590 \pm 0.042 \pm 0.021$

(Cut on $D$ momentum ' $k_D$ ' selected against $B \rightarrow D$)

Dominant systematic:

Backgrounds = .018

Mixing = .009
FIG. 2. The mass-difference distributions for the decay of (a) $D^{*+} \to D^0 \pi^+$, $D^0 \to K^- \pi^+$, (b) $D^0 \to K^- \pi^+ \pi^0$, (c) $D^0 \to K^- \pi^+ \pi^+ \pi^-$, and (d) $D^0 \to K^- l^+ \nu_l$ ($l = e$ or $\mu$). The solid circles indicate the experimental data, and histograms are MC of signal (open) and RCBG (double hatched).
FIG. 4. The distributions of $q \cdot \cos \theta_D$ for the selected $D$ meson sample for (a) left- and (b) right-handed electron beams. The solid circles are experimental data, and double hatched histograms are RCBG estimated from side-band regions.
2) Inclusive Soft $T_s^+$

- Look for $p_T$ relative to nearest jet.
- Jets must have vertex, significant impact parameters, but not be $b$-tagged.
- Sign with $T_s$ charge.

$\Rightarrow$ Efficient, somewhat sloppy

$A_c = 0.685 \pm 0.052 \pm 0.038$

Dominant systematic:

- Backgrounds $\pm 0.036$
- Mixing $\pm 0.012$. 
FIG. 6. The $P_T^2$ distributions for soft-pion candidate tracks. (a) The solid circles indicate the experimental data. The curves are the result of the a fit $S(P_T^2) + F_1(P_T^2)$ performed for $P_T^2 < 0.1$ GeV/c (solid line), and the extrapolations of $F_1(P_T^2)$ (dashed line) and $F_2(P_T^2)$ (dotted line). The definition of the functions are described in the text. (b) The solid circles are the experimental data, and histograms are MC predictions for $D$ mesons from $c$-decay (open), $D$ mesons from $b$-decay (single hatched), and background (double hatched). The extrapolation of $F_1(P_T^2)$ is also shown as a dashed line.
FIG. 7. The distributions of $q \cdot \cos \theta_D$ for the selected $D^{*+}$ meson sample for (a) left- and (b) right- handed electron beams. The solid circles are experimental data, and hatched histograms are RCBG estimated from side-band regions.
(3) Inclusive leptons from SL decays (μ only!)

To be described later

\[ A_c = 0.583 \pm 0.055 \pm 0.055 \]

Dominant systematic:

Sample purity \[ \pm 0.053 \]

(4) VTX and Kaon Charge

To be described later

\[ A_c = 0.673 \pm 0.029 \pm 0.023 \]

Dominant systematic:

Self-calibration statistics \[ \pm 0.020 \]

Combined

\[
A_c = 0.671 \pm 0.027
\]
$A_c$ Summary

$A_c$ Measurements (Winter-01)

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLD K &amp; vtx-Q Update</td>
<td>0.674 ± 0.029 ± 0.025</td>
</tr>
<tr>
<td>SLD Lepton</td>
<td>0.591 ± 0.055 ± 0.053</td>
</tr>
<tr>
<td>SLD D^+,D^-</td>
<td>0.690 ± 0.042 ± 0.021</td>
</tr>
<tr>
<td>SLD soft π^-</td>
<td>0.685 ± 0.052 ± 0.038</td>
</tr>
<tr>
<td>SLD Average</td>
<td>0.671 ± 0.027</td>
</tr>
<tr>
<td>ALEPH Lepton</td>
<td>0.580 ± 0.047 ± 0.040</td>
</tr>
<tr>
<td>DELPHI Lepton</td>
<td>0.634 ± 0.083 ± 0.056</td>
</tr>
<tr>
<td>L3 Lepton</td>
<td>0.739 ± 0.269 ± 0.161</td>
</tr>
<tr>
<td>OPAL Lepton</td>
<td>0.575 ± 0.054 ± 0.039</td>
</tr>
<tr>
<td>ALEPH D^+</td>
<td>0.627 ± 0.080 ± 0.024</td>
</tr>
<tr>
<td>DELPHI D^+</td>
<td>0.635 ± 0.083 ± 0.025</td>
</tr>
<tr>
<td>OPAL D^+</td>
<td>0.637 ± 0.104 ± 0.050</td>
</tr>
<tr>
<td>LEP Average</td>
<td>0.612 ± 0.032</td>
</tr>
</tbody>
</table>

LEP Measurements: $A_c = 4 A^0_{t \tau \bar{\nu}} / 3 A_\tau$

Using $A_\tau = 0.1500 ± 0.0016$ (Combine SLD $A_{tLR}$ and LEP $A_t$)
Semileptonic Decays

In recent years, analyses have benefitted from:

- Neural-net particle identification, including CRID information (e/π and μ/κ separation)

- Multivariate separation of sources:
  \[ b \to \ell \, b \to c \to \ell \, c \to \ell \, \text{background} \]

  - Lepton \( \ell_1 \)
  - Associated VTX mass
  - Opposite VTX mass
  - \( \ell_1 \) momentum

* electrons only

**NOTE:** VTX requirement for e sample \( \Rightarrow \) no \( A_\ell \) from electrons.
Figure 5.17: Reduced space for event classifications in the 1995 Monte Carlo. This distribution is used to calculate the weights as a function of NN outputs for each data candidate. In this space, the axes are defined as: $z = \text{NN}_{bc} + \text{NN}_b$ and $y = \text{NN}_c + \text{NN}_b$, where $\text{NN}_b = b$-direct, $\text{NN}_{bc} = b$-cascade and $\text{NN}_c = c$-direct output nodes from the NN. By explicit omission, the miss-ID's fall to the origin.
With source determined, lepton provides charge and direction of underlying quark.

\[ A_b = 0.919 \pm 0.030 \pm 0.024 \]

Dominant systematic:

- Sample purity = 0.13
- B mixing = 0.010
- \( B(B \to D\bar{D} \to \ell) \) = 0.009
Inclusive Jet Charge (b-tagged events)

- In each hemisphere, form weighted sum
  \[ Q_{\text{hem}} = \sum_{\text{tracks}} q_i \sqrt{p_i^2 + 1} \]

- \( Q_{\text{hem}} < 0 \Rightarrow b \) quark

- Self-calibration: compare
  \[ |Q_{\text{di}}| = |Q_{(1)} - Q_{(2)}| \]
  to
  \[ Q_{\text{sum}} = Q_{(1)} + Q_{(2)} \]

- Dominant systematic:
  Hemisphere correlations (fragmentation)

- \( A_b = 0.907 \pm 0.020 \pm 0.02 \)
$Q_0 + Q_6$ wider than $Q_{\text{diff}}$; comparison gives analyzing power of $Q_{\text{sum}} = Q_0 + Q_6$

Soft for 0 events ($|Q_{\text{diff}}|$ is observable)

$\sqrt{2} \cdot Q_{\text{hem}}$ width
Vertex/ Koon Charge

- Net charge of secondary VTX signs heavy quark (also incorporate high-b K for Z+cc)

- NJ charm/bottom separation

- Exhaustive & exacting study of correlations

- Multi-faceted calibration

\[ A_b = 0.919 \pm 0.018 \leq 0.017 \]

Dominate systematic:
- Calibration stats \( \pm 0.014 \)
- Charm background \( \pm 0.005 \)
- Polarization \( \pm 0.005 \)
- QCD correction \( \leq 0.004 \)
Charmed/Bottom Separation

Uses (4:5:1) neural network

- $M_{VTX}$ (GeV/c$^2$)
- $P_{VTX}$ (GeV/c)
- $(P_{VTX} - 10)/M_{VTX}$
- $D_{VTX}$ (cm)
- $N_{trk}$
- $NN_{sel}$

Require
- $NN_{sel} < 0.4, P_{VTX} > 5$ for charm tag
- $NN_{sel} > 0.9, M_{VTX} < 7$ for bottom tag
Efficiency Definitions

Only interested in charged tags
→ if $Q_{VTX} = Q_K = 0$, consider hemisphere untagged
→ if $Q_{VTX}$ and $Q_K$ disagree, untag hemisphere

Each tag has an associated efficiency $\omega^q_f$, with:
$\omega = (X, \eta, \epsilon)$ for (untagged, $c$-tagged, $b$-tagged)
$q = (r, w, 0)$ for (right-sign, wrong-sign, unsigned)
→ only $0$ possible for untagged hemispheres
→ only $r, w$ possible for HF-tagged hemispheres
→ right-sign means signed $\bar{T}$ points along primary quark
$f = (uds, c, b)$ for (light-flavor, charm, bottom) event flavor

There are $(1 \times 2 \eta + 2 \epsilon) \times (3 \text{ flavors}) = 15$ total efficiencies

Assign charges so that $Q_{hemi} > 0$ means right-sign
→ for $\eta$ tags, $Q_{hemi} = +Q_{VTX}$ or $-Q_K$
→ for $\epsilon$ tags, $Q_{hemi} = -Q_{VTX}$ or $-Q_K$

Calibrate these tags by counting event rates in data
straightforward extension of $R_b$ technique
Efficiency Calibration

Can express expected number of tagged events as:

\[ N_{\text{tags}} = N_{\text{tot}} \sum_f \left( \sum \omega_{f,1}^{q_1} \omega_{f,2}^{q_2} \right) R_f \]

→ sum over \( \omega^q \) combs. which can produce an event type
→ \( R_f \) is hadronic partial width to flavor \( f \)

<table>
<thead>
<tr>
<th>tags</th>
<th>( Q_1 )</th>
<th>( Q_2 )</th>
<th>( N_{\text{tags}} )</th>
<th>( \sum \omega_{1}^{q_1} \omega_{2}^{q_2} )</th>
<th>gives</th>
</tr>
</thead>
<tbody>
<tr>
<td>( X - X )</td>
<td>00</td>
<td></td>
<td>189575</td>
<td>( X_f^0 X_f^0 )</td>
<td>( X_f^0 )</td>
</tr>
<tr>
<td>( X - \eta )</td>
<td>0±</td>
<td></td>
<td>9440</td>
<td>( X_f^0 (\eta_f^r + \eta_f^w) )</td>
<td>( \eta_c )</td>
</tr>
<tr>
<td>( X - \epsilon )</td>
<td>0±</td>
<td></td>
<td>22070</td>
<td>( X_f^0 (\epsilon_f^r + \epsilon_f^w) )</td>
<td>( \epsilon_c )</td>
</tr>
<tr>
<td>( \eta - \eta )</td>
<td>±±</td>
<td></td>
<td>465</td>
<td>( \eta_f^r \eta_f^r + \eta_f^w \eta_f^w )</td>
<td>( \eta_c, \eta_c^w )</td>
</tr>
<tr>
<td>( \eta - \eta )</td>
<td>±±</td>
<td></td>
<td>92</td>
<td>( \eta_f^r \eta_f^w )</td>
<td>( \eta_c, \eta_c^w )</td>
</tr>
<tr>
<td>( \eta - \epsilon )</td>
<td>±±</td>
<td></td>
<td>421</td>
<td>( \eta_f^r \epsilon_f^r + \eta_f^w \epsilon_f^w )</td>
<td>( \eta_b, \eta_b^w )</td>
</tr>
<tr>
<td>( \eta - \epsilon )</td>
<td>±±</td>
<td></td>
<td>389</td>
<td>( \eta_f^r \epsilon_f^w + \eta_f^w \epsilon_f^r )</td>
<td>( \eta_b, \eta_b^w )</td>
</tr>
<tr>
<td>( \epsilon - \epsilon )</td>
<td>±±</td>
<td></td>
<td>4231</td>
<td>( \epsilon_f^r \epsilon_f^r + \epsilon_f^w \epsilon_f^w )</td>
<td>( \epsilon_b, \epsilon_b^w )</td>
</tr>
<tr>
<td>( \epsilon - \epsilon )</td>
<td>±±</td>
<td></td>
<td>2029</td>
<td>( \epsilon_f^r \epsilon_f^w )</td>
<td>( \epsilon_b, \epsilon_b^w )</td>
</tr>
</tbody>
</table>

Nine independent Poisson-distributed variables - measure these \( N_{\text{tags}} \) and fit for the efficiencies?
→ life is not quite so easy...
Correlations

Two hemispheres are not independent
→ if \( x_1 = x_1(x_2) \) and \( \omega = \omega(x) \), then \( \omega_{12} \neq \omega_1 \omega_2 \)

Example: \( B \)-hadron energies

Define correlation parameter \( \gamma \) as:

\[
\gamma_{12}^{q_1 q_2} = \frac{\omega_{12}^{q_1 q_2}}{\omega_1^{q_1} \omega_2^{q_2}}
\]

where \( \omega_{12}^{q_1 q_2} \) is the efficiency to tag an event of that type.

For each flavor and tag combination, get a \( \gamma \) from MC
→ enumerate sources, do they saturate total correlation?

For a source characterized by \( x \), find \( \omega(x) \) and calculate:

\[
\gamma_x = \frac{\langle \omega_1^{q_1}(x) \omega_2^{q_2}(x) \rangle}{\langle \omega_1^{q_1}(x) \rangle \langle \omega_2^{q_2}(x) \rangle}
\]

then compare \( \prod \gamma_x \) to the total \( \gamma \)
Results

C-tagged: 9727 events
\[ \langle F_c \rangle = 0.845 \quad \langle \alpha_c \rangle = 0.838 \]

B-tagged: 26595 events
\[ \langle F_b \rangle = 0.984 \quad \langle \alpha_b \rangle = 0.635 \]

SLD preliminary results

\[ A_c = 0.674 \pm 0.029 \quad A_b = 0.913 \pm 0.019 \]

Errors are statistical only

Thomas Wright

University of Wisconsin
$A_6 = 0.916 \pm 0.021$

SLD Final Overall Average

$\Delta m = 125$
**$A_b$ Summary**

**$A_b$ Measurements (Winter-2001)**

- SLD JetC: $0.907 \pm 0.020 \pm 0.024$
- SLD Lepton: $0.926 \pm 0.030 \pm 0.024$
- SLD $K^2$ tag: $0.855 \pm 0.088 \pm 0.102$
- SLD VtxQ+$K$: $0.913 \pm 0.019 \pm 0.018$
- SLD Average: $0.913 \pm 0.021$
- ALEPH Lept: $0.886 \pm 0.035 \pm 0.020$
- DELPHI Lept: $0.926 \pm 0.051 \pm 0.024$
- L3 Lept: $0.874 \pm 0.058 \pm 0.026$
- OPAL Lept: $0.852 \pm 0.038 \pm 0.021$
- ALEPH JetC: $0.900 \pm 0.024 \pm 0.015$
- DELPHI JetC: $0.893 \pm 0.042 \pm 0.015$
- L3 JetC: $0.844 \pm 0.090 \pm 0.050$
- OPAL JetC: $0.895 \pm 0.049 \pm 0.036$
- DELPHI NN: $0.849 \pm 0.030 \pm 0.016$
- LEP Average: $0.873 \pm 0.018$

**LEP Measurements:**

$A_b = 4 A^{0 \text{FB}} / 3 A_t$

Using $A_t = 0.1500 \pm 0.0016$ (Combine SLD $A_L R$ and LEP $A_t$)
"TGR" Fits

\[ \sin^2 \theta_W \text{ relative to SM} \]

\[ \begin{align*}
    \text{SM} & \Rightarrow M_H = 114 \\
    & \quad M_H = 300 \\
\end{align*} \]

- \[ \sin^2 \theta_W \text{ lepton} \]
- \[ A_{FB} \]
- \[ A_{b \tau} \]
- \[ M_H = 100 \]
- \[ M_H = 1000 \]

VX contribution to \[ A_{b \tau} \]
**TGR Results**

Some numbers from simultaneous fit for $\delta \sin^2 \Theta_W$, $\delta R_b$, $\delta A_b$ : ($M_H = 300$)

$$\delta \sin^2 \Theta_W : \quad -0.00085 \pm 0.00017$$

$$\delta R_b : \quad -0.00060 \pm 0.00072$$

$$\delta A_b : \quad 0.0245 \pm 0.0087 \quad (2.8\sigma)$$

**Without SLD $A_b$**

$$\delta \sin^2 \Theta_W : \quad -0.00095 \pm 0.00020$$

$$\delta R_b : \quad -0.00058 \pm 0.00072$$

$$\delta A_b : \quad 0.0353 \pm 0.0116 \quad (3.0\sigma)$$
Publication Status (Final Results)

- $A_s$ (Muller)
  

- $A_c$ from $D^0$ (Iwasaki)
  

- $A_b, A_c$ from leptons (Schumm)
  
  Final comments in, ready for submission to PRL

- $A_j$ from jet charge (Schumm)
  
  Draft exists, awaiting final plots, numbers from Victor

- $A_b, A_c$ from VTX, Kaon Charge (Wright)
  
  As soon as Tom's thesis is done
WRAP-UP

- Very successful component of SLD program
  $SA_b = \text{all LEP}$
  $SA_c, SA_s \text{ dominate WA}$
  Unique direct measurement

- SLD mass of $A_b$ has saved a lot of theorists from needless speculation

- Future? Giga-Z proposal: speculate
  $SA_b \approx 0.003$

  (now, $A_b = 0.915 \pm 0.021$)