Measurements of A_q (A_b, A_c, A_s) at SLD

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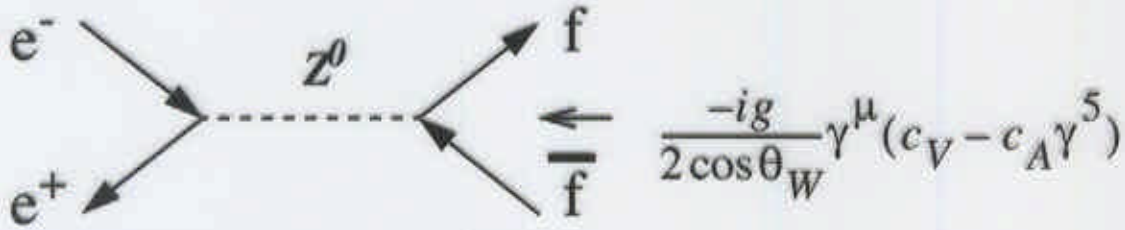
Representing the SLD collaboration

Contents:

1) Introduction

SLC : E_{CM} = 91.2GeV ... on Z^0 pole

--> SLD can probe the couplings of Z^0 to fermions



$$\frac{-ig}{2\cos\theta_W}\gamma^{\mu}(c_V - c_A\gamma^5)$$

Parity Violation parameter

$$A_f = \frac{2c_V^f c_A^f}{(c_V^f)^2 + (c_A^f)^2} = \frac{g_L^2 - g_R^2}{g_L^2 + g_R^2}$$

The measurement provides a sensitive test of SM

To measure A_f, using Forward-Backward Asymmetry

$$A_{FB}^f = \frac{\sigma^f(F) - \sigma^f(B)}{\sigma^f(F) + \sigma^f(B)} = A_e A_f \frac{2\cos\theta}{1 + \cos\theta^2}$$

SLD can toss A_e by Left-Right Forward-Backward Asymmetry

$$\tilde{A}_{FB}^f = \frac{[\sigma_L^f(F) - \sigma_L^f(B)] - [\sigma_R^f(F) - \sigma_R^f(B)]}{[\sigma_L^f(F) + \sigma_L^f(B)] + [\sigma_R^f(F) + \sigma_R^f(B)]} = |P_e| A_f \frac{2\cos\theta}{1 + \cos\theta^2}$$

SLD can measure A_f directly

SLD has statistical advantage of $(P_e / A_e)^2 \sim 25$

Unique Features of the SLD/SLC

Polarized electron beam

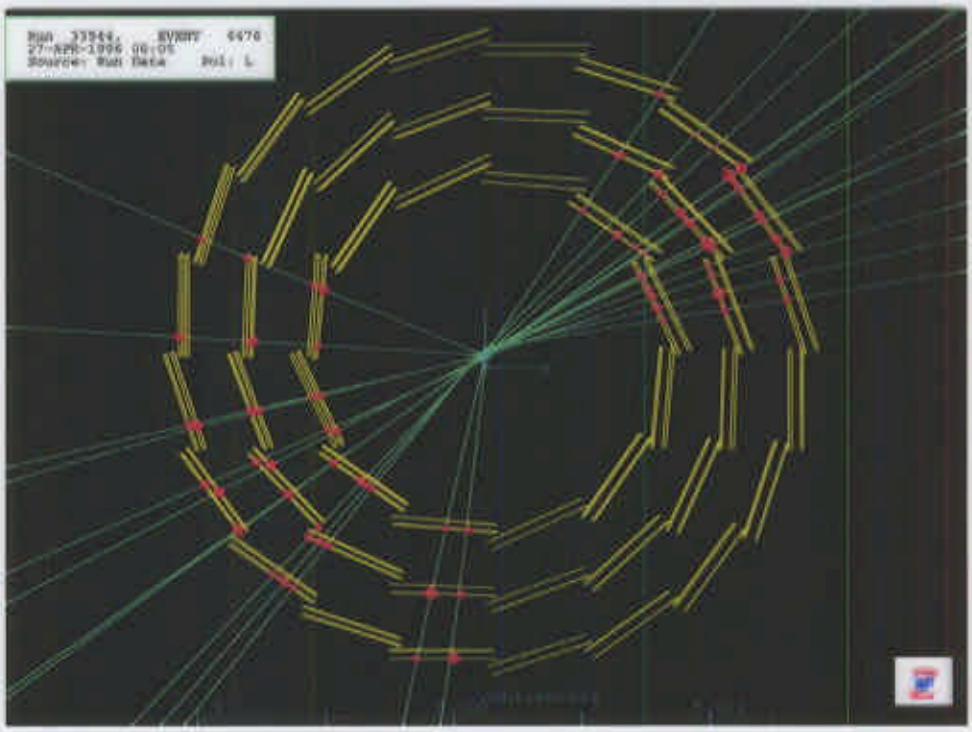
~63% in 1993, ~75% in 1994-98

Small and stable SLC beam spot

Primary vertex resolution $\sigma(r\phi) = 4\mu m$

High resolution CCD Vertex Detector (VXD3)

Impact parameter resolution of 7.8 μm ($r\phi$), 9.7 μm(rz)



Excellent particle ID with the CRID

Kaon ID 0.3 GeV - 35GeV

2) A_b measurements

2-1) A_b with Vertex charge

b-quark tag: Mass-tag **quark-sign:** Vertex charge

1. Improve b-tagging with Neural Nets

Use Neural Nets for BG rejection and track association

ε_b : 50% --> 57%, Π_b 98% (for hemisphere)

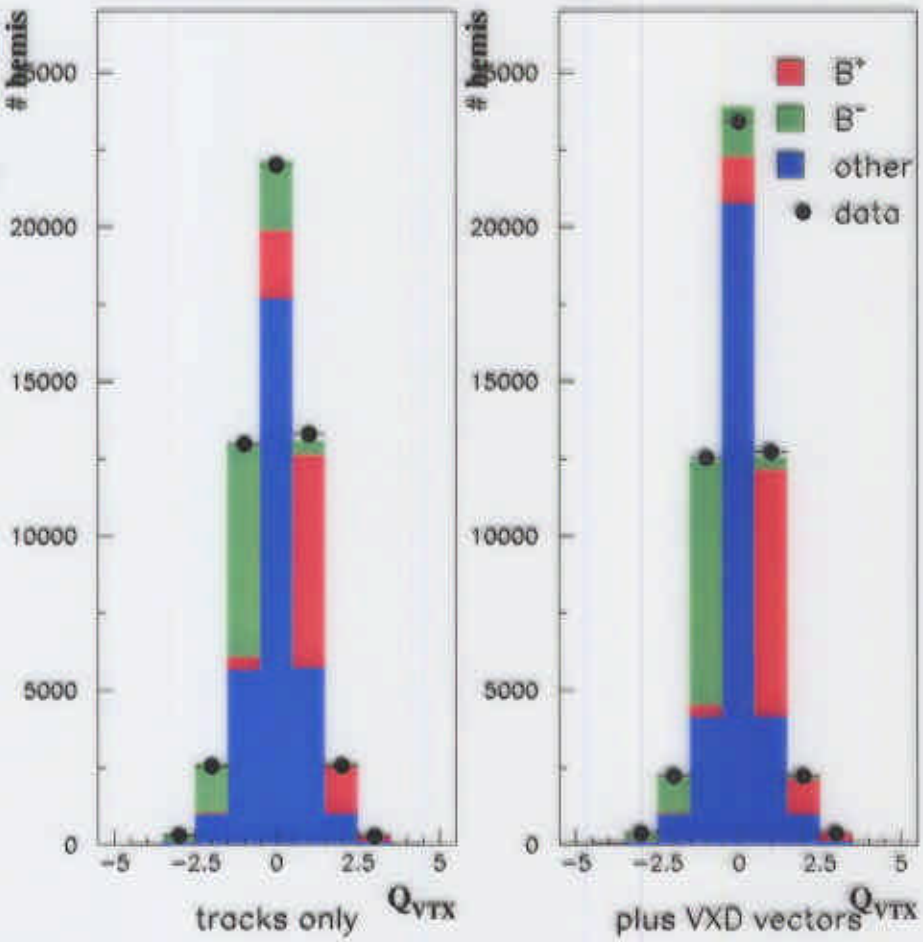
For $Q_{VTX} \neq 0$ **Analyzing Power (A.P.) = 0.50 --> 0.58**

2. Improve Q separation with VXD-only tracking

Q right probability
75% --> 83%

For $Q_{VTX} \neq 0$
A.P. = 0.58 --> 0.64

$$\left(AP \equiv \frac{N_{correct} - N_{wrong}}{N_{correct} + N_{wrong}} \right)$$



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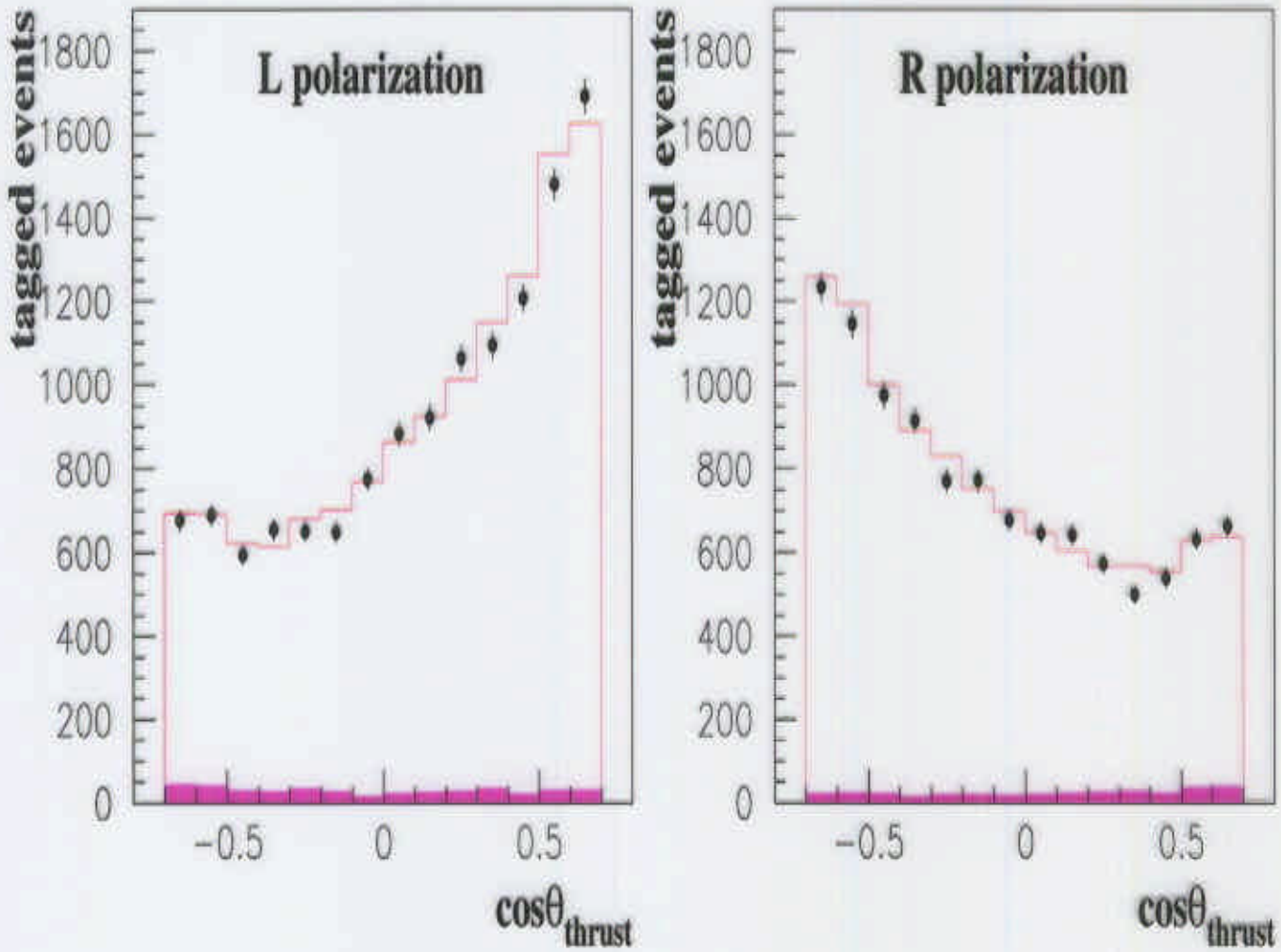
A_b with Vertex Charge

We calibrate

Purity from double-tag rate: 0.964 ± 0.006

A.P. from opposite-sign rate: 0.649 ± 0.010

The self-calibration reduces the systematic error

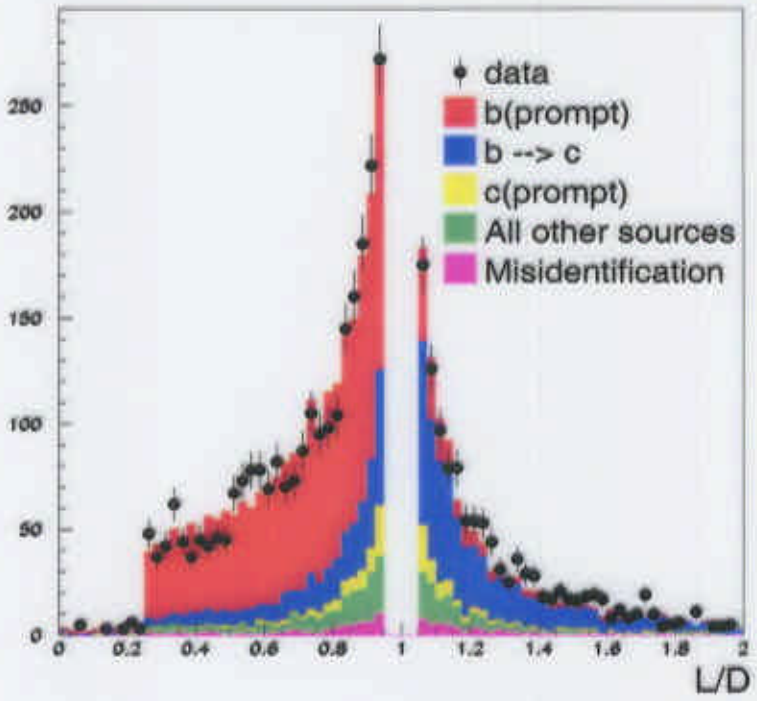


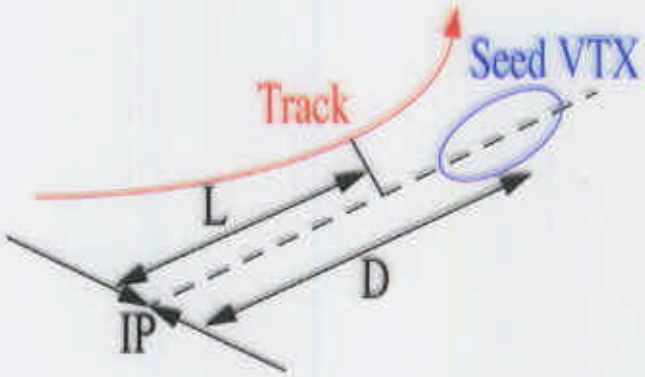
SLD 97-98 (350k Z^0) preliminary result

$$A_b = 0.926 \pm 0.019 \text{ (stat)} \pm 0.027 \text{ (sys)}$$

2-2) A_b with lepton tag

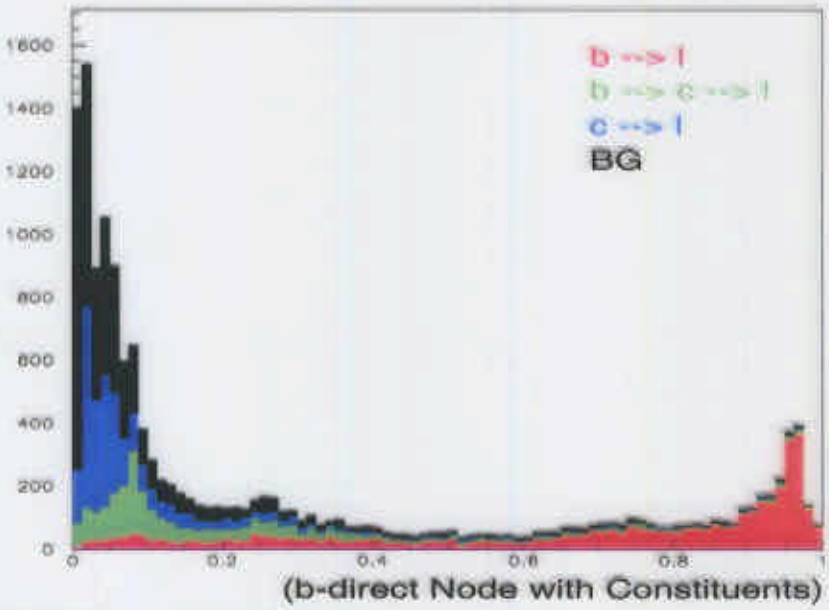
Lepton analysis use P, P_T and geometrical information to separate prompt and cascade





L/D < 1 : b --> l
L/D > 1 : b --> c --> l

Electron analysis uses neural net for source classification
--> reduce systematics



SLD 93-98 (550k Z^0) Preliminary result:

$$A_b = 0.922 \pm 0.029\ (stat) \pm 0.024\ (sys)$$

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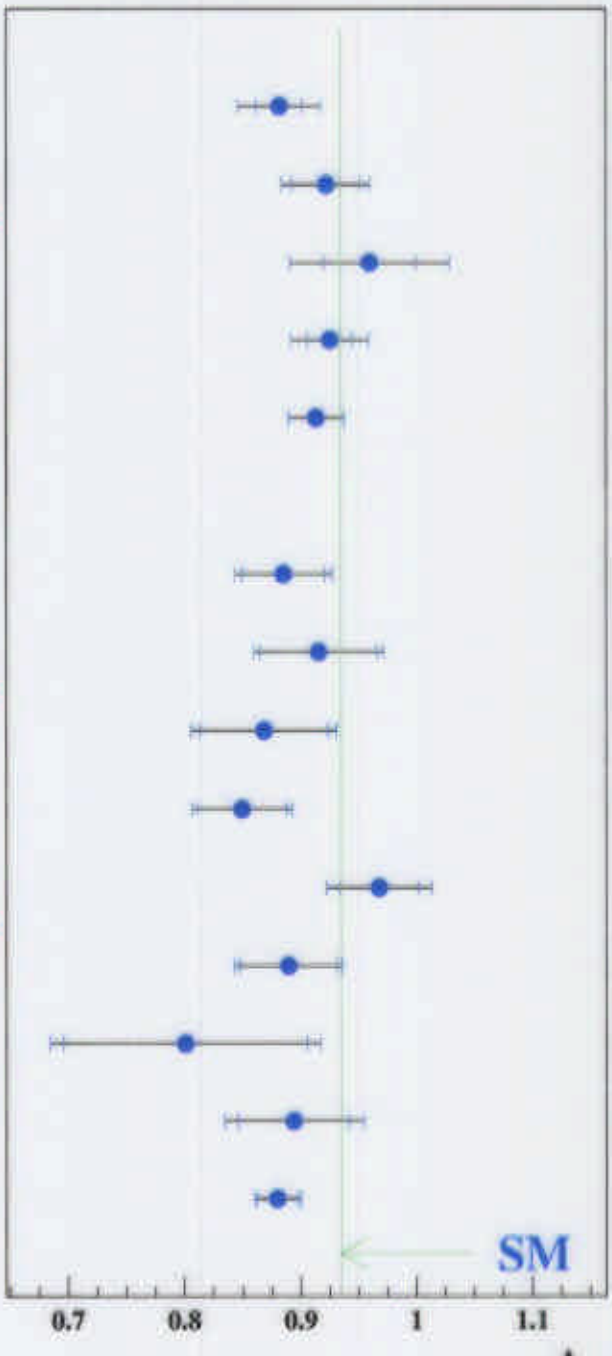
A_b Measurements (Summer-2000)

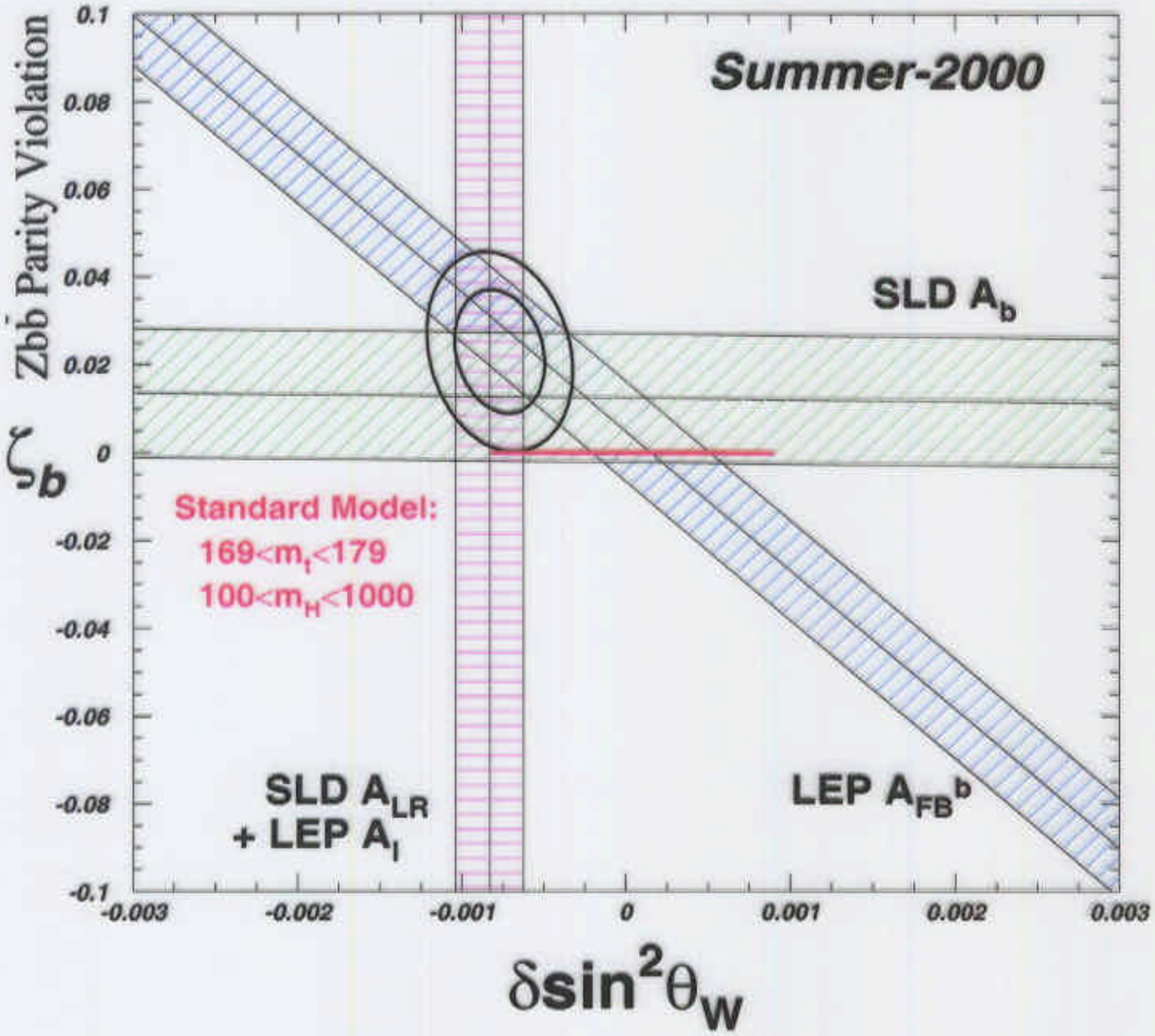


SLD JetC	0.882 ± 0.020 ± 0.029
SLD Lepton Update	0.922 ± 0.029 ± 0.024
SLD $K^{\pm}$ tag	0.960 ± 0.040 ± 0.069
SLD Vtx-Q Update	0.926 ± 0.019 ± 0.027
SLD Average	0.914 ± 0.024
ALEPH Lept	0.886 ± 0.036 ± 0.023
DELPHI Lept Update	0.916 ± 0.051 ± 0.023
L3 Lept	0.868 ± 0.055 ± 0.030
OPAL Lept	0.850 ± 0.038 ± 0.021
ALEPH JetC Update	0.968 ± 0.034 ± 0.030
DELPHI JetC	0.890 ± 0.042 ± 0.020
L3 JetC	0.801 ± 0.105 ± 0.051
OPAL JetC	0.894 ± 0.048 ± 0.036
LEP Average	0.880 ± 0.020

LEP Measurements: $A_b = 4\, A^{0,b}_{FB} / 3\, A_e$

Using A_e=0.1500±0.0016 (Combine SLD A_{LR} and LEP A_l)

After Takeuchi, Grant, and Rosner:



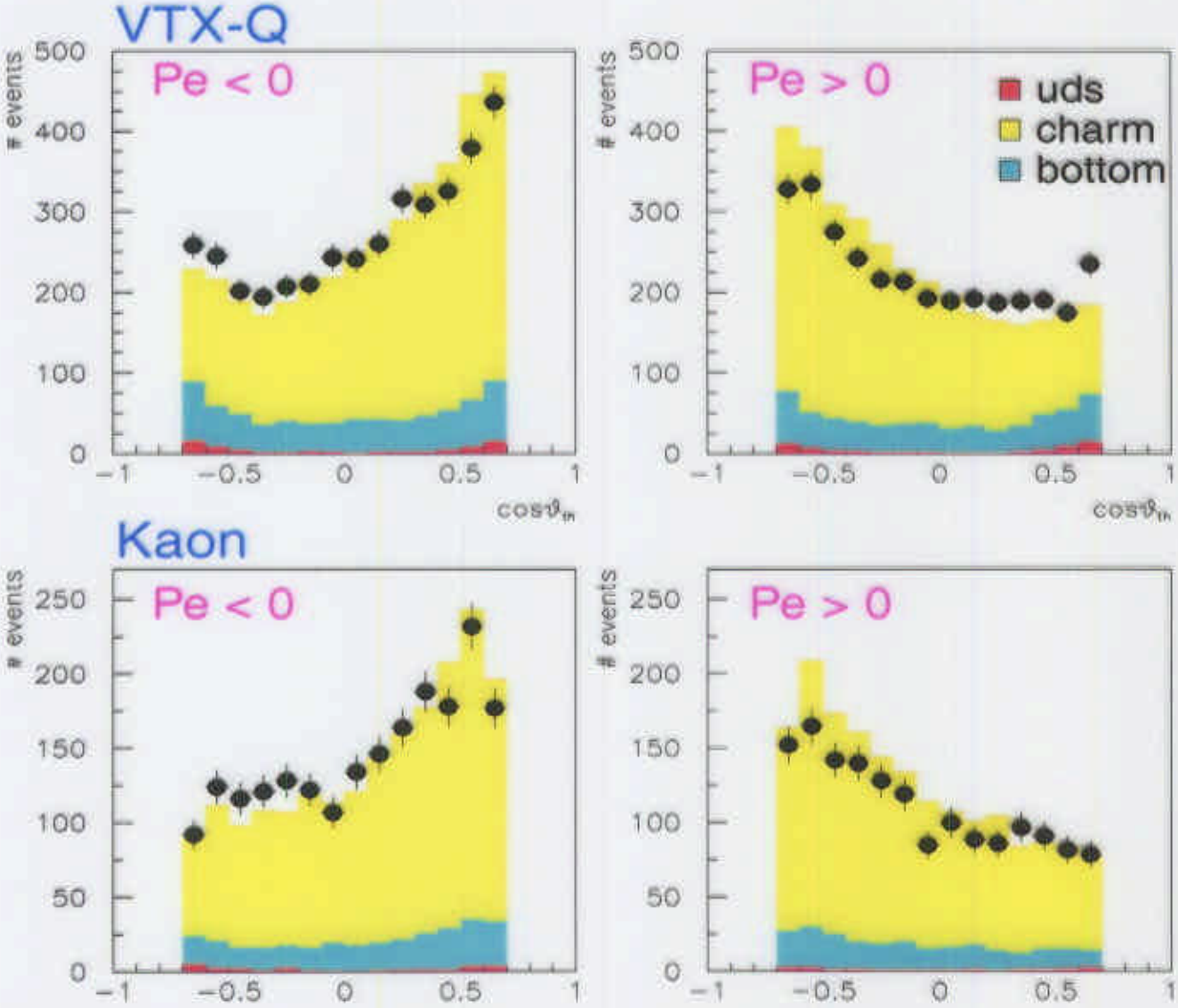
(0,0) determined by m_t=174, m_H=300,
α_s=0.119 α_{EM}=1/128.905

3) A_c measurements

3-1) A_c with Kaon + Vertex charge

c-quark tag:: Mass-tag ε_c : 29%, Π_c 82% (for event)

quark-sign :: Kaon + VTX charge Q right ... 94%



Self-Calibration technique reduces the systematics

SLD 93-98(550k Z^0) preliminary result:

$$A_c = 0.603 \pm 0.028\ (\text{stat}) \pm 0.023\ (\text{sys})$$

3-2) A_c with Exclusive D*/D reconstruction

We use 6 decay modes:

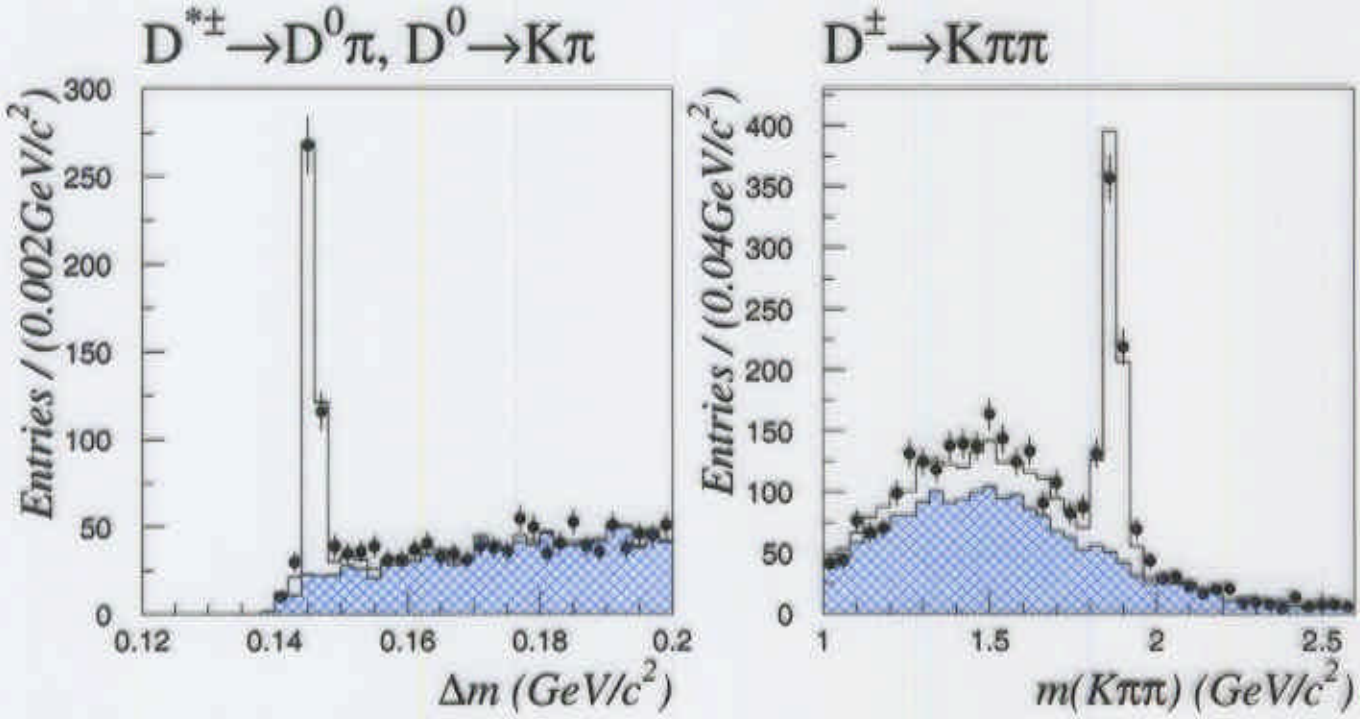
1. $D^{*+} \to D^0 \pi^+$ $(D^0 \to K^- \pi^+)$
2. $D^{*+} \to D^0 \pi^+$ $(D^0 \to K^- \pi^+ \pi^0)$
3. $D^{*+} \to D^0 \pi^+$ $(D^0 \to K^- \pi^+ \pi^+ \pi^-)$
4. $D^{*+} \to D^0 \pi^+$ $(D0 \to K^- l^+ \nu)$
5. $D^+ \to K^- \pi^+ \pi^-$
6. $D^0 \to K^- \pi^+$

Without Kaon ID (except for 6.)

Exclusive reconstruction yields quark sign+direction with High accuracy

--> High analyzing power, Small Systematic error

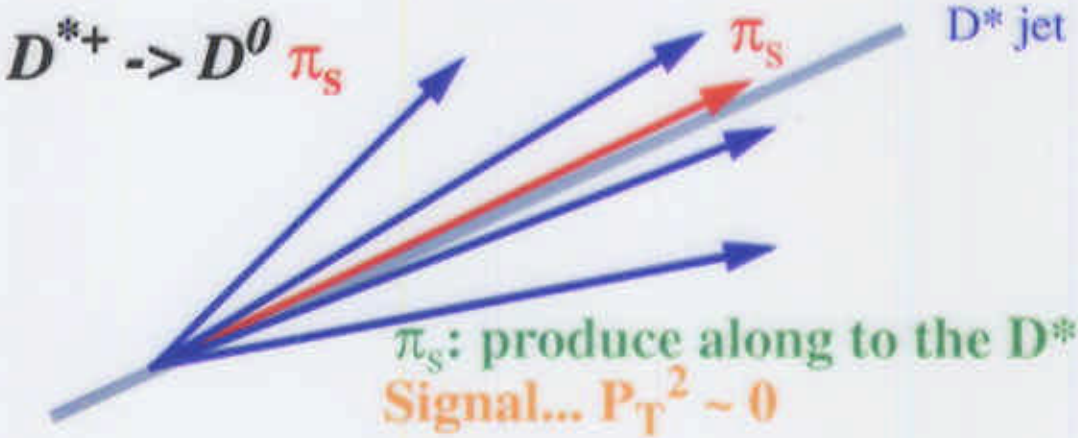
Using VXD information, we reduce b->D BG



SLD 93-98 (550k Z^0)

$$A_c = 0.690 \pm 0.042 \text{ (stat)} \pm 0.021 \text{ (sys)}$$

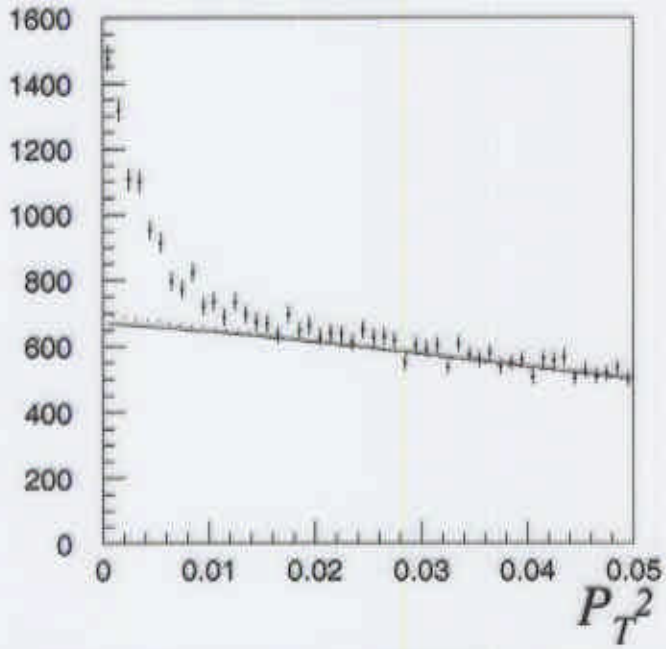
3-3) Inclusive Soft-pion

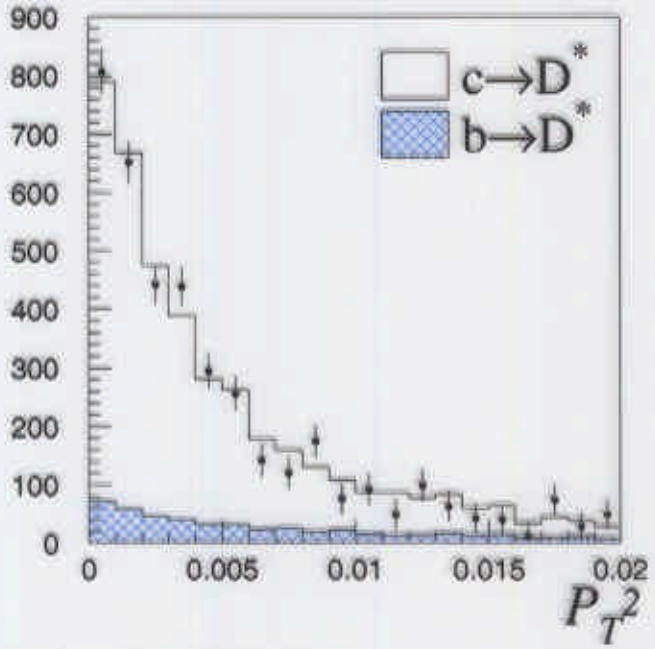


π_s: produce along to the D* jet direction

Signal... $P_T^2 \sim 0$

--> BG subtract





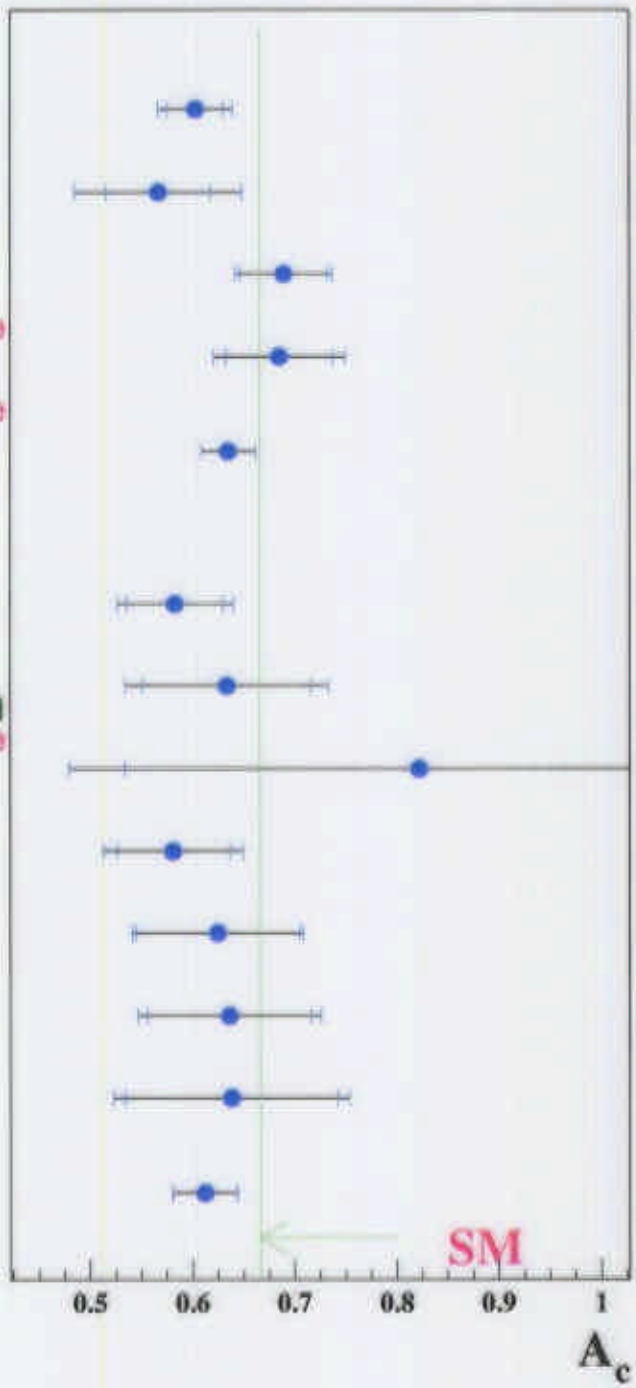
Obtain good S/N ratio of S:N ~ 1:2

Using the VXD information, we can reject both uds and b BG

SLD 93-98 (550k Z^0)

$$A_c = 0.685 \pm 0.052 \text{ (stat)} \pm 0.038 \text{ (sys)}$$

A_c Measurements (Summer-00)



SLD K & vtx-Q	0.603 ± 0.028 ± 0.023
SLD Lepton	0.567 ± 0.051 ± 0.064
SLD D^*, D^+ Update	0.690 ± 0.042 ± 0.021
SLD soft π^* Update	0.685 ± 0.052 ± 0.038
SLD Average	0.635 ± 0.027
ALEPH Lepton	0.58 ± 0.05 ± 0.03
DELPHI Lepton Update	0.68 ± 0.08 ± 0.06
L3 Lepton	0.82 ± 0.29 ± 0.19
OPAL Lepton	0.58 ± 0.06 ± 0.04
ALEPH D^*	0.63 ± 0.08 ± 0.02
DELPHI D^*	0.64 ± 0.08 ± 0.04
OPAL D^*	0.64 ± 0.10 ± 0.05
LEP Average	0.612 ± 0.032

LEP Measurements: $A_c = 4\, A^{0,c}_{FB} / 3\, A_e$
Using A_e=0.1500±0.0016 (Combine SLD A_{LR} and LEP A_l)

4) A_s measurement

s-quark tag::

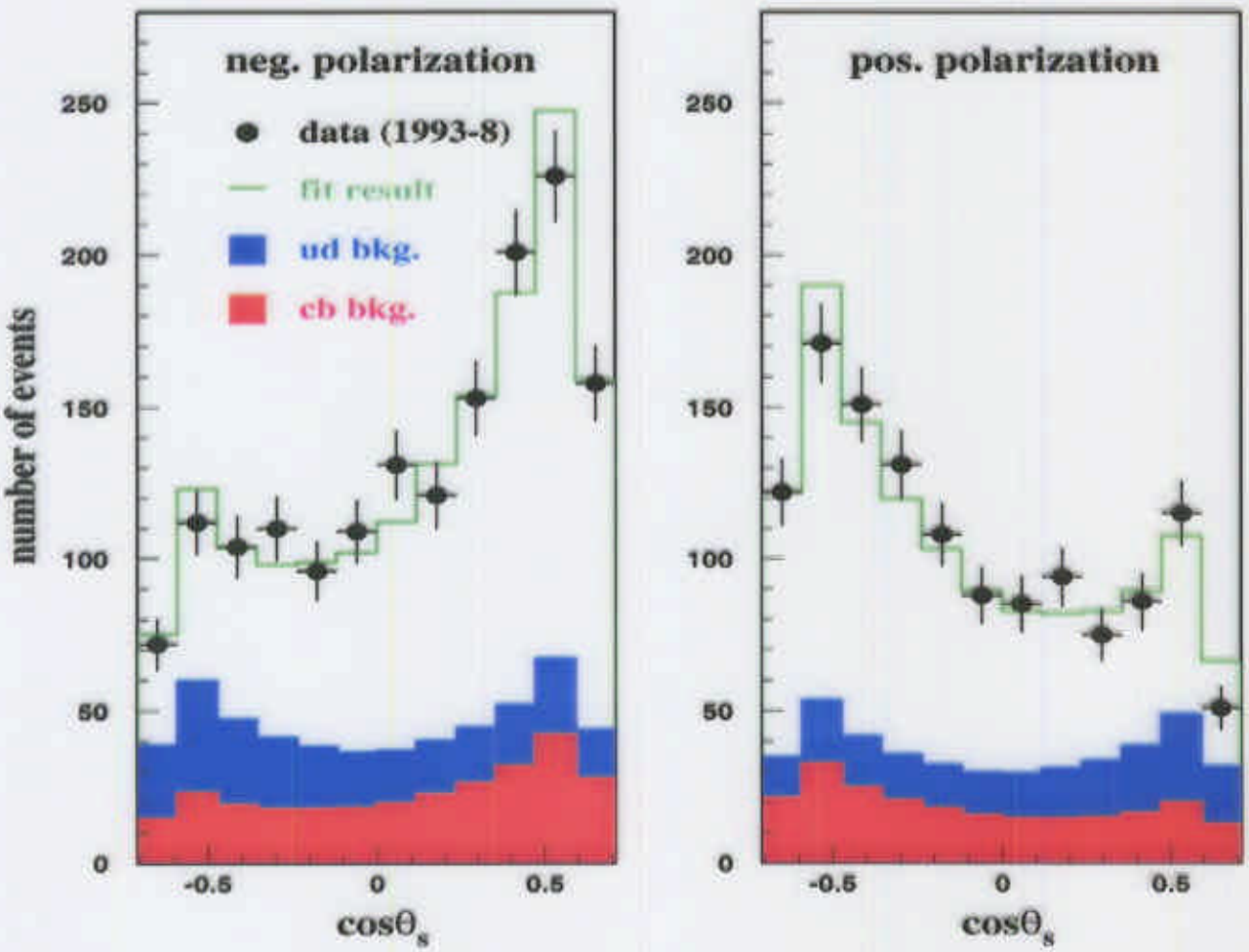
1) Select events with no detached vertices

2) Tag fast strange particles

K^{+-} with p > 9 GeV, K^0_s with p > 5 GeV

in both hemispheres

s-quark purity .. 66% Analyzing Power 0.82

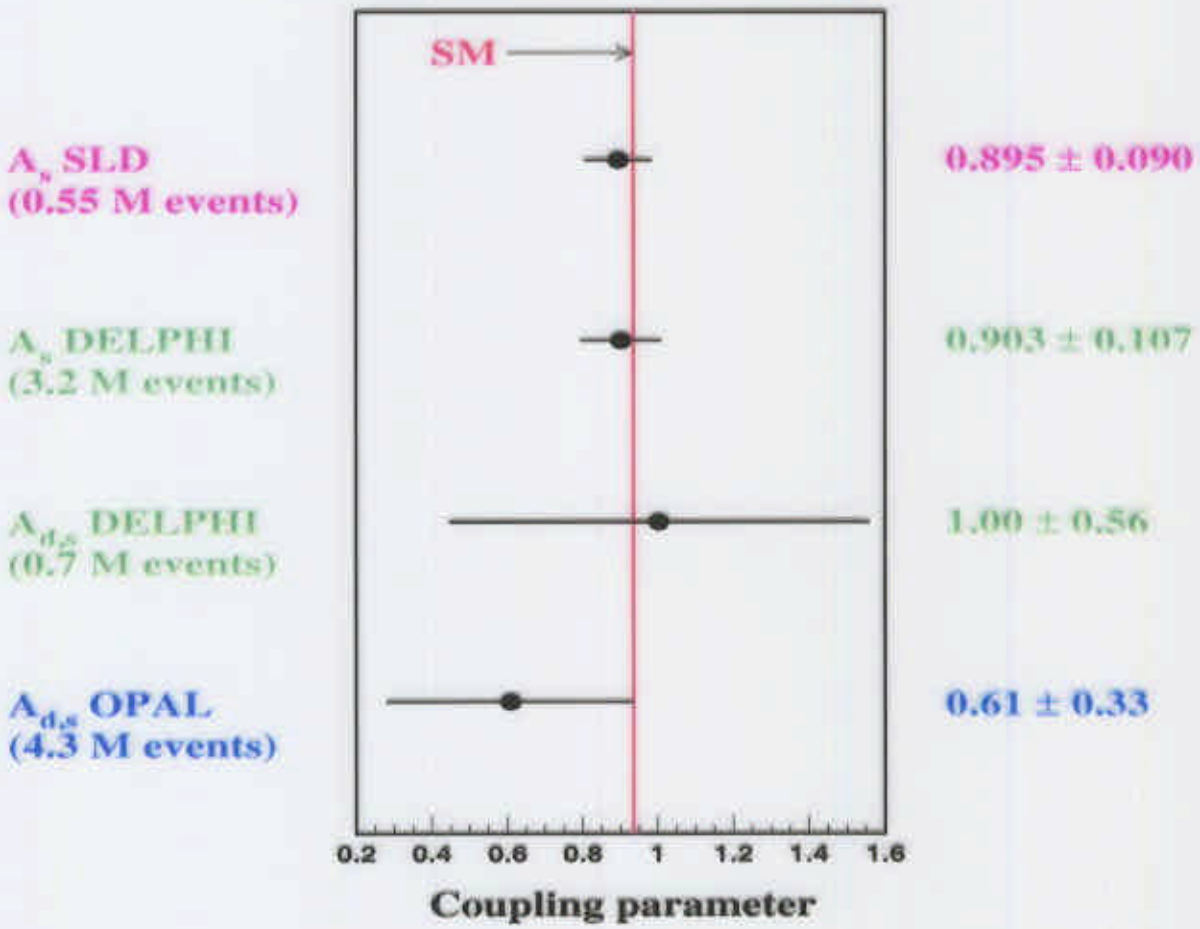


SLD 93-98 (550k Z^0)

$$A_s = 0.895 \pm 0.066\,(\text{stat}) \pm 0.062(\text{sys})$$

Test of d-type quark Universality

$A_b/A_s = 1.02 \pm 0.10$ (A_b: SLD combined)



5) Summary

Using the unique SLD/SLC features of:

Polarized beam
Small beam spot
Excellent CCD vertex detector, CRID particle ID

We measure the quark-coupling asymmetries.

$A_b = 0.914 \pm 0.024$ **(SLD combined)** **<3% precision**

$A_c = 0.635 \pm 0.027$ **(SLD combined)** **4% precision**

The best measurement!

$A_s = 0.895 \pm 0.090$ **10% precision**

All measurements are in agreement with SM
A_b discrepancy has become less significant
D-type quark universality test: $A_b/A_s = 1.02 \pm 0.10$

Many analyses are close to final,
but some are still being improved with new technique:
Heavy-flavor tag with NN, VXD only tracking, ...