SuperB EW Physics Update: Is there a strong EW case for polarisaton at the charm threshold?

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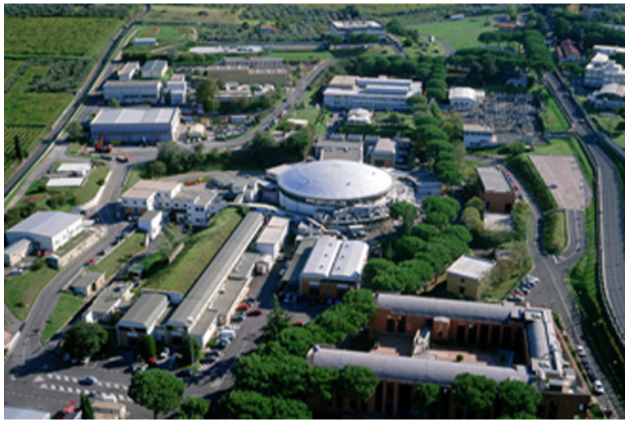
LNF



Outline

- Very Quick reminder of the EW programme

- Address question:

  What do we learn in the EW program if we have polarized beams at charm threshold?

EW programme reminders…

Polarised e- beam yields product of the neutral axial-vector coupling of the electron and vector coupling of the final-state fermion via Z-γ interference:

$$A_{LR} = \frac{4}{\sqrt{2}}\left(\frac{G_F s}{4\pi\alpha Q_f}\right) g_A^e g_V^f \langle Pol \rangle$$

$$\langle Pol \rangle = 0.5\left\{\left(\frac{N_R^{e-} - N_L^{e-}}{N_R^{e-} + N_L^{e-}}\right)_R - \left(\frac{N_R^{e-} - N_L^{e-}}{N_R^{e-} + N_L^{e-}}\right)_L\right\}$$

$$g_A^e = T_3^e = 1/2 \qquad\qquad g_V^f = T_3^f - 2Q_f \sin^2\theta_W$$

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EW programme …

- A_{LR} programme -> rich precision probe of the vector coupling of e, μ, τ, c, b all within the same experiment

- Absolute vector coupling gives measure of $\sin^2\theta_W$ requires absolute polarisation and electron axial-vector coupling (g_A^e)

- Relative vector couplings are given by ratios of A_{LR} and can be expected to be statistics limited as polarisation and g_A^e cancel in the ratios

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e.g. $e^+e^- \rightarrow \mu^+\mu^-$ @ $\sqrt{s}$=10.58GeV

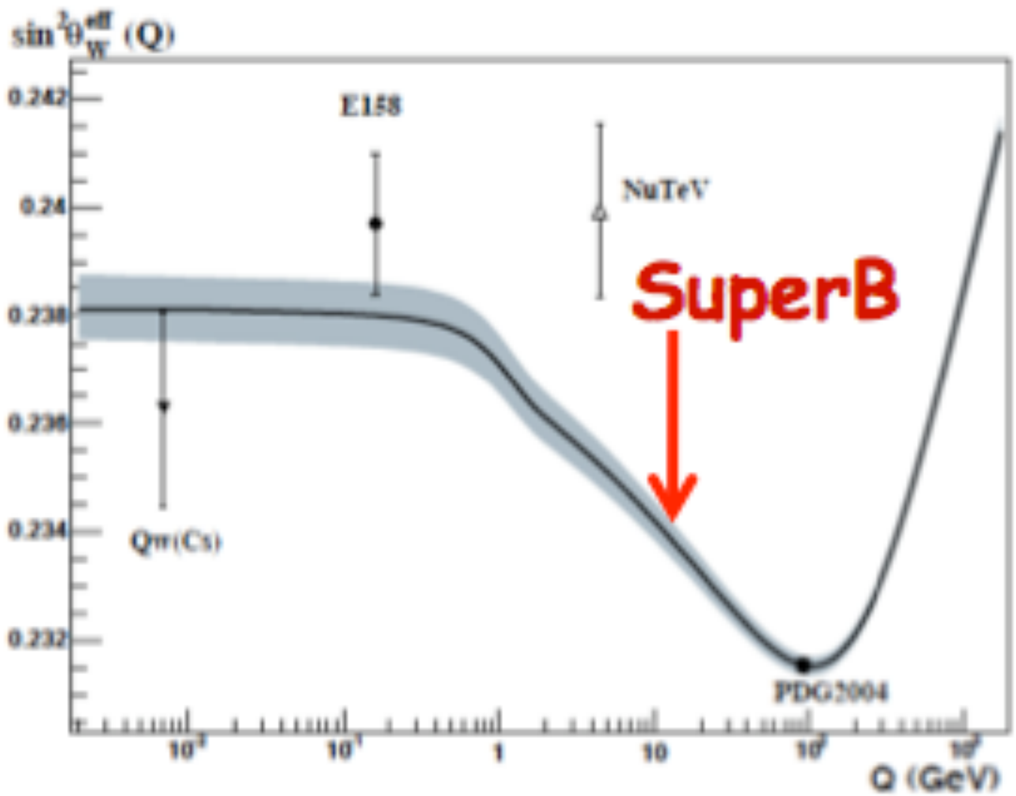
Diagrams	Cross Section (nb)	A_{FB}	A_{LR} (Pol = 100%)
$\lvert Z+\gamma \rvert^2$	1.01	0.0028	-0.00051

σ_{ALR} =6x10^{-6} → $\sigma_{(sin2\theta eff)}$ =0.0002

cf SLC A_{LR} $\sigma_{(sin2\theta eff)}$ =0.00026

relative stat. error of 1% (pol=80%) require <~0.5% systematic error on beam polarisation

Q^2 dependence of $\sin^2\theta_W$: SuperB will provide precisions at least as high as at Z-pole - but at much lower Q^2



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Absolute vector couplings: $\sin^2\theta_W$

- Absolute vector coupling gives measure of $\sin^2\theta_W$: requires absolute polarisation and electron axial-vector coupling (g_A^e)
- Beam polarisation with Compton Polarimeter and tau-polarisation FB asymmetry to ~0.5% (see Sept 2011 presentation)
- g_A^e : can either assume SM ½; use LEP measurement and assume it is the same at 10.58GeV; or can check it with $A_{FB}^{\mu} \sim g_A^e g_A^{\mu}$ assuming Lept. Univ. (In principle $A_{FB}^e \sim g_A^e g_A^e$ gives this w/o assuming Lept. Univ. but A_{FB}^e dominated by QED)

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ZFitter vs simple tree A_{LR}

With mass measurements of Z and top, Higgs we have SM values for the vector couplings and rigorous predictions of the vector couplings:

at 10.58GeV	Zfitter	Zfitter (Weak Rad Corr off)	Simple Analytic no Rad Cor
muon	-0.00050	-0.00086	-0.00077
charm	-0.00478	-0.0052	-0.00547
beauty	-0.01936	-0.0200	-0.0194

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Relative vector couplings

take ratios of μ,τ,c,b A_{LR} so that of the electron cancels polarisation systematic errors and the electron axial-vector coupling: stat. error dominated

	SM (Mh=125GeV)	LEP/SLD	SuperB error
g_V^{μ} / g_V^{τ}	1	0.997 +/- 0.068	~2% from tau stats
g_V^{c} / g_V^{lepton}	5.223 +/-	-4.991 +/- 0.074	~1% muon stats +/-0.05
g_V^{b} / g_V^{lepton}	9.357 +/-	8.58+/- 0.16	~1% from mu stats +/- 0.08

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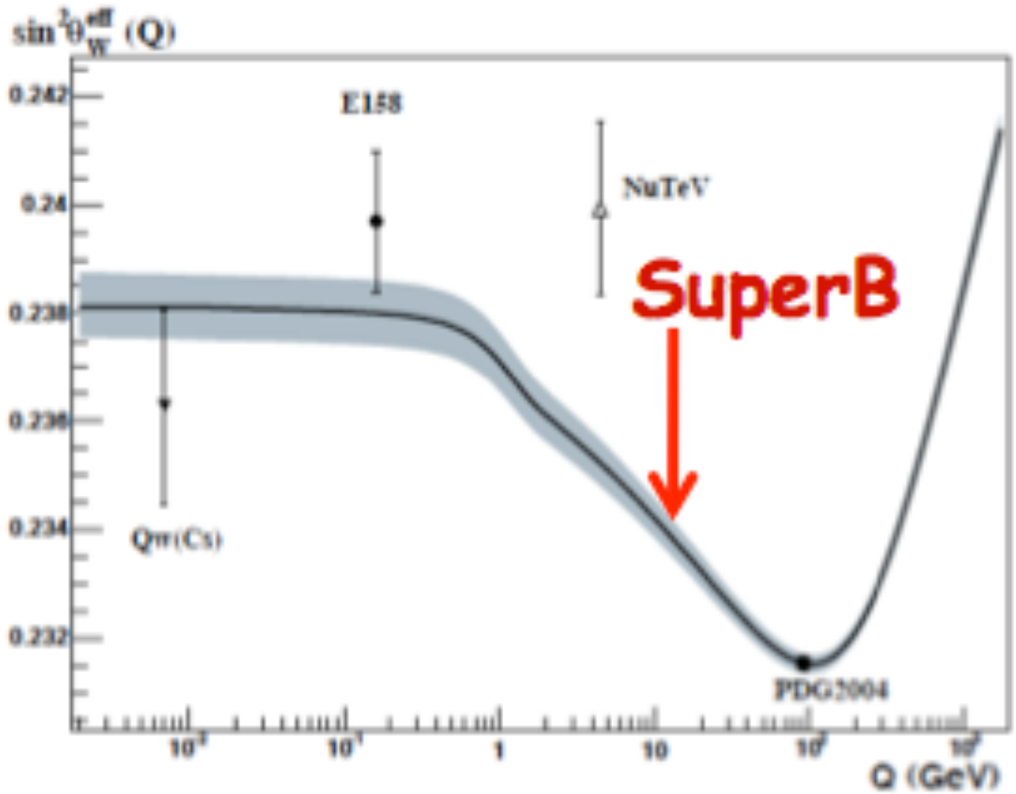
How do we get high precision?

- High statistics
  - the 75/ab is needed to give precision with mu-pairs
- Polarization: A_{LR} insensitive to detector systematic errors
  - Systematic errors dominated by polarization error
  - Using tau polarization FB asymmetry to get polarization error: 3.6 ab^{-1} is need to get to 0.005 relative error on beam polarization if only pion decays used – beyond that systematic errors come in

Running at charm threshold would give information near NuTeV Q^2



Relative vector couplings

But running at lower energies is possible, but suffers from loss in statistics: if 1/ab of data is collected there, errors will be many times larger and not at all competitive with measurements at the 4S or Z

Question: how much value is there in a low precision measurement at slightly lower Q^2 cf that at 4S or Z?

Does it justify additional cost and complications of having polarisation there?

Summary

- We have a very rich EW programme at 4S that gives unprecedented precision measurements of the vector coupling via A_{LR} –for mu, tau, charm and b fermions – the best place for b's
- EW case for running with polarization at charm threshold comes down to:
  - how much value is there in a low precision measurement at slightly lower Q^2 cf that at 4S or Z?

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