In contrast to the partial widths, which we define using the full complex couplings in order to ensure that their sum exactly equals the total width, the pole asymmetries are defined purely in terms of the real parts of the effective Z couplings,

$$A_{\mathrm{FB}}^{0,\mathrm{f}} \equiv \frac{3}{4}\mathcal{A}_{\mathrm{e}}\mathcal{A}_{\mathrm{f}} \quad \text{with} \tag{1}$$

$$\mathcal{A}_{\mathrm{f}} = \frac{2g_{\mathrm{Vf}}g_{\mathrm{Af}}}{g_{\mathrm{Vf}}^2 + g_{\mathrm{Af}}^2}. \tag{2}$$

When the couplings conform to the structure imposed by the Standard Model

$$\mathcal{A}_{\mathrm{f}} = \frac{1-x}{1-x+\frac{x^2}{2}}, \quad \text{where} \tag{3}$$

$$x = \frac{2Q}{T_3}\sin^2\theta_{\mathrm{eff}}^{\mathrm{f}}. \tag{4}$$

Figure 1 shows this expected variation of $\mathcal{A}_{\mathrm{f}}$ with $\sin^2\theta_{\mathrm{eff}}^{\mathrm{f}}$.

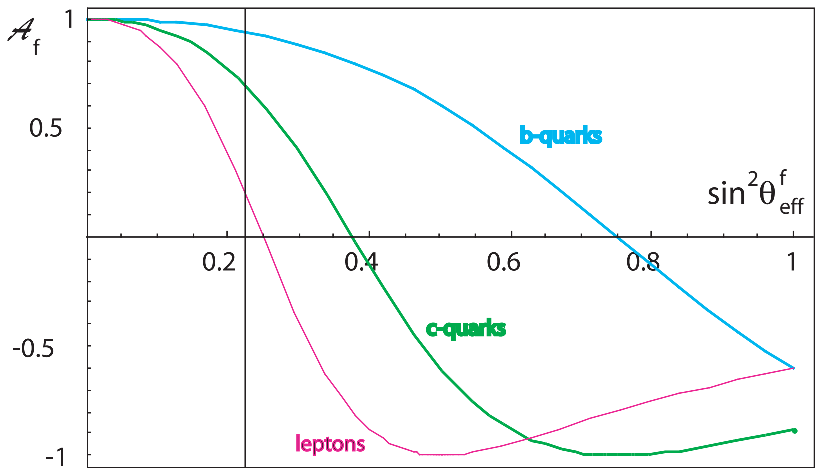

Figure 1: In the Standard Model the variation of $\mathcal{A}_{\mathrm{f}}$ with $\sin^2\theta_{\mathrm{eff}}^{\mathrm{f}}$ is controlled by the charge and weak isospin assignment of the fermion species concerned. For values of $\sin^2\theta_{\mathrm{eff}}^{\mathrm{f}}$ near nature's choice (shown by the vertical line), $\mathcal{A}_{\ell}$ depends strongly on $\sin^2\theta_{\mathrm{eff}}^{\mathrm{lept}}$, while $\mathcal{A}_{\mathrm{b}}$ depends much more weakly on $\sin^2\theta_{\mathrm{eff}}^{\mathrm{b}}$

Due to the proximity of $\sin^2\theta_{\mathrm{eff}}^{\mathrm{f}}$ to 1/4, $\mathcal{A}_{\ell}$ and the leptonic forward-backward asymmetry at $\sqrt{s} = m_{\mathrm{Z}}$ are small, but very sensitive to $\sin^2\theta_{\mathrm{eff}}^{\mathrm{f}}$. QED corrections are in fact as large as $A_{\mathrm{FB}}^{0,\ell}$ itself, and therefore must be understood precisely. Off-peak the contributions from γ–Z interference to the asymmetries become even larger. But since the slope of the asymmetry as a function of energy is proportional to the axial-vector couplings of the Z, which are well-determined by the measured cross-sections, only the small imaginary parts of the couplings remain to give asymmetry contributions which must be calculated rather than experimentally determined. The measured coupling parameters are therefore determined in a largely model-independent manner. Here it must be noted that although only the real parts of the couplings are used in the definition of the pole asymmetries, the complete complex couplings are used in the extraction of the pole asymmetries from the measured asymmetries.

The forward-backward asymmetries for hadronic states with identified quarks can also be measured. Following the purely leptonic case, these results are interpreted in terms of the quark pole asymmetries, $A_{\mathrm{FB}}^{0,\,\mathrm{q}}$, after corrections for QCD effects, QED radiation, γ exchange and γ–Z interference are applied.

The coupling parameters for heavy quarks can be measured by two independent routes with comparable accuracy. The first is the direct measurement of $\mathcal{A}_{\mathrm{c}}$ and $\mathcal{A}_{\mathrm{b}}$ via the left-right-forward-backward asymmetry with polarised beams at SLD, described in Chapter **??**. The second is through the ratio of the quark and lepton forward-backward asymmetries, utilizing Equation 1.

Compared with leptons, the coupling parameters of the quarks in the Standard Model are determined more by the quark's fundamental charge and weak isospin assignments than by $\sin^2\theta_{\mathrm{eff}}^{\mathrm{f}}$. For down-type quarks in particular, as can be seen from Equations 3,4 and Figure 1, the relative sensitivity of $\mathcal{A}_{\mathrm{q}}$ to changes in $\sin^2\theta_{\mathrm{eff}}^{\mathrm{q}}$ is a factor of almost 100 less than it is for $\mathcal{A}_{\ell}$. This fact makes the Standard Model a particularly rigid target for comparison with measurements of $\mathcal{A}_{\mathrm{q}}$. On the other hand, when the validity of the Standard Model prediction for $\mathcal{A}_{\mathrm{q}}$ is assumed, Equation 1 can be exploited to measure $\sin^2\theta_{\mathrm{eff}}^{\mathrm{lept}}$ through the forward-backward asymmetry observed for quarks, particularly $A_{\mathrm{FB}}^{0,\,\mathrm{b}}$, since the variation of $\mathcal{A}_{\mathrm{b}}$ can essentially be ignored.