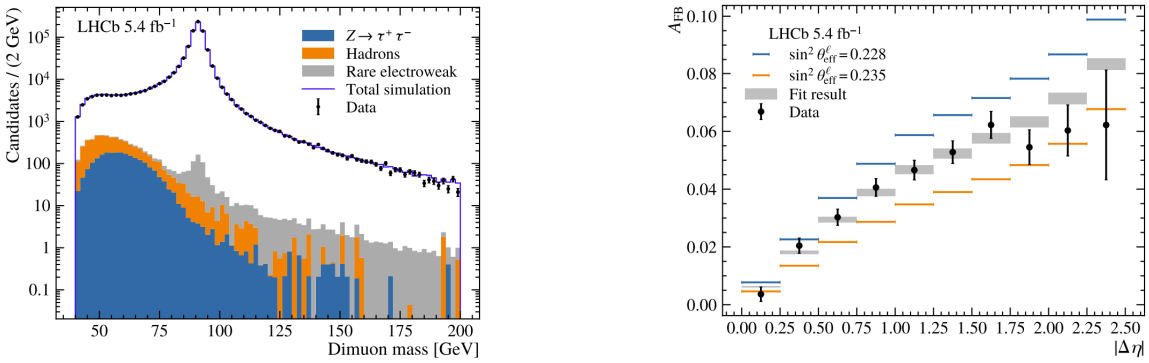


Figure 1 – Signal and background contributions of the large window mass selection of the dimuon pair (left), and the results of the $A_{\rm fb}$ measurement differentially in bins of $|\Delta\eta|$ (right). The sensitivity to different $\sin\theta^{\ell}_{\rm eff}$ values is overlaid, highlighting the strength of differential selection.

free parameters in blue, and the higher-order, BSM sensitive, contributions in purple.

$$m_W^2\left(1-\frac{m_W^2}{m_Z^2}\right)=\frac{\pi\alpha}{\sqrt{2}G_\mu}\left(1+\Delta r\right) \tag{1}$$

In recent years, LHCb has produced significant EW precision measurements, offering complimentary results to those produced by other LHC-based experiments due to the unique phase-space coverage, which gives differing sensitivities to PDF uncertainties than central measurements. This section will briefly share the two most recent measurements: the measurement of $\sin\theta^{\ell}_{\rm eff}$ and the measurement of the $Z$ boson mass.

### *3.1 Measurement of $sin\theta^{\ell}_{eff}$ with the LHCb Detector*

The weak mixing angle, $\theta_W$, is directly linked to the parameters of EW theory via Equation 2 and provides a relation between U(1) and SU(2) gauge couplings.

$$sin\theta_W=\left(1-\frac{m_W^2}{m_Z^2}\right) \tag{2}$$

The recently published LHCb measurement [9] leverages the connection of $\sin\theta^{\ell}_{\rm eff}$ (which is directly correlated to $\sin\theta_W$) to the forward-backward asymmetry ($A_{\rm fb}$ ) of leptons produced in the decay of $Z$ bosons. The muon pair final state provides an extremely clean sample of $Z$ boson decays, allowing the measurement of $A_{\rm fb}$ in bins of $|\Delta\eta|$ of the muon pair. Visualization of the signal and background processes in the dimuon mass spectra, and the subsequent $\sin\theta^{\ell}_{\rm eff}$ sensitivity of $A_{\rm fb}$ measured in bins of $|\Delta\eta|$ are provided in Figure 1.

The observed results of the effective weak mixing angle are $\sin\theta^{\ell}_{\rm eff} = 0.23152 \pm 0.00044$ (stat.) $\pm$ 0.00005 (syst.) $\pm$ 0.00022 (theory). The uncertainties from proton PDFs are significantly smaller than in central experiments, offering exciting prospects for future high-luminosity LHC runs.

### *3.2 Measurement of the Z Boson Mass*

Building on the measurement of $\sin\theta^{\ell}_{\rm eff}$ , LHCb has made the first measurement of the Z boson mass ($m_Z$) at a $pp$ collider. Similar to the $\sin\theta^{\ell}_{\rm eff}$ measurement, the very clean signal environment of the dimuon mass spectrum allows for a precis measurement of $m_Z$.

The analysis selection is allowed to remain simple, necessitating precision gains to arise from accurate understanding of the LHCb detector and the produced dataset. Numerous energy