Towards a precision measurement of the muon pair asymmetry in e^+e^- annihilation at $\sqrt{s}$ = 10.58 GeV

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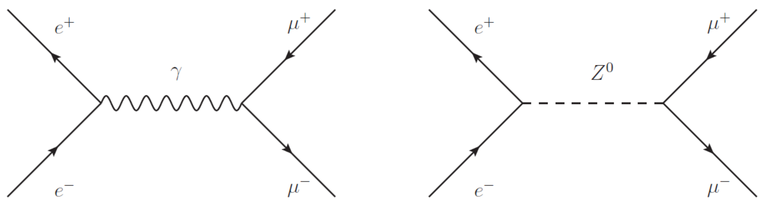
Muon pair asymmetry A_{FB} at Belle



The Standard Model predicts a forward-backward asymmetry A_{FB} of muons produced in the electroweak process $e^+e^-\to\mu^+\mu^-$. This asymmetry is caused by the interference between γ and Z^0 exchange at Born level.

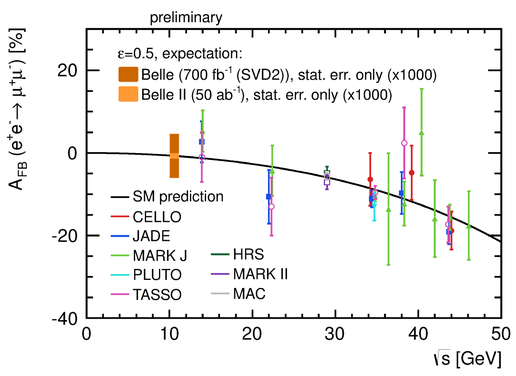


Fig. 1: SM prediction and measurements of A_{FB}. Belle and Belle II symbols are shown at the SM value and only indicate the expected statistical uncertainty (x1000).

$$A_{FB} = \frac{N(\cos(\theta) \geq 0) - N(\cos(\theta) < 0)}{N(\cos(\theta) \geq 0) + N(\cos(\theta) < 0)}$$

$A_{FB}(\sqrt{s}=10.58\text{GeV})\approx -0.75\%$

Belle: (stat. unc. only) with 7×10^8 muon pairs:
$\Delta A_{FB}(\text{stat.})/A_{FB} \approx 1\%$

Event selection

Muon pairs from the process $e^+e^-\to\mu^+\mu^-$ have a clear signature of two back-to-back tracks in the center of mass system. Background processes are:

- radiative muon pairs
- $e^+e^-\to e^+e^-\mu^+\mu$
- (radiative) tau pairs
- (radiative) Bhabha
- cosmics

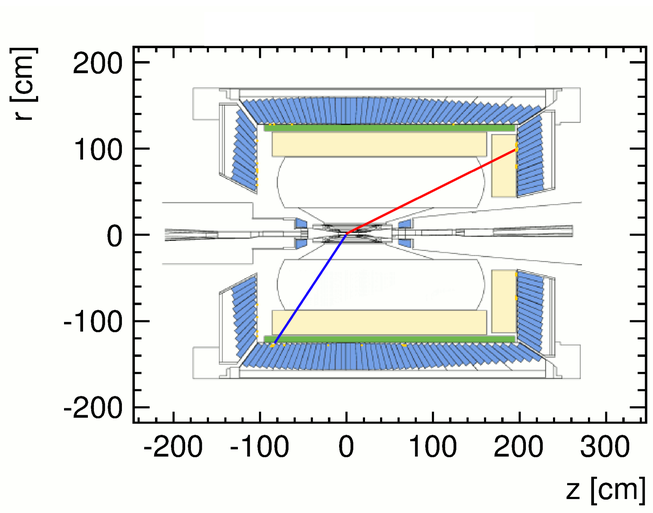


Fig. 3: Muon pair (MC) without ISR or FSR photons. The muon tracks are not back-to-back in the lab system.

Efficiency

Incl. acceptance and trigger, kinematic cuts and particle identification: $\varepsilon \approx 50\%$

Rad. Corrections

The raw asymmetry is modified mainly by $\gamma\gamma$ box-diagrams. QED effects are corrected using Monte Carlo calculations. Weak corrections are absorbed into effective couplings.

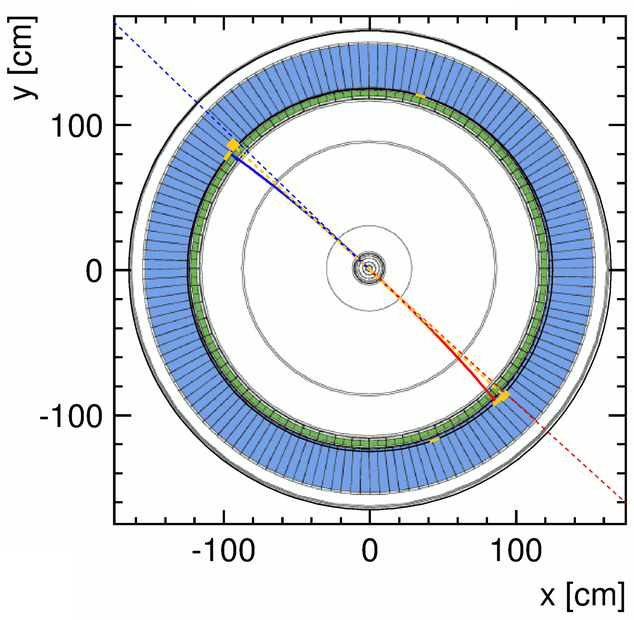


Fig. 4: Radiative muon pair (MC) with double final state radiation (FSR) and beam background photons in the Belle detector.

The weak mixing angle $\sin^2(\theta_w)$

The muon pair asymmetry A_{FB} is related to the weak mixing angle $\sin^2(\theta_w)$. For $\sqrt{s}$=10.58 GeV:

$$A_{FB}(s) \approx \frac{3\rho G_F}{4\sqrt{2}\pi\alpha}\frac{sM_Z^2}{s-M_z^2}g_A^e g_a^\mu$$

The weak mixing angle is energy dependent in the SM (see Fig. 2): Extract A_{FB}, $\sin^2(\theta_w)$ and ρ from a fit to the differential cross section $d\sigma/d\cos(\theta^{CM})$. Deviations from the predicted behavior hint to New Physics.

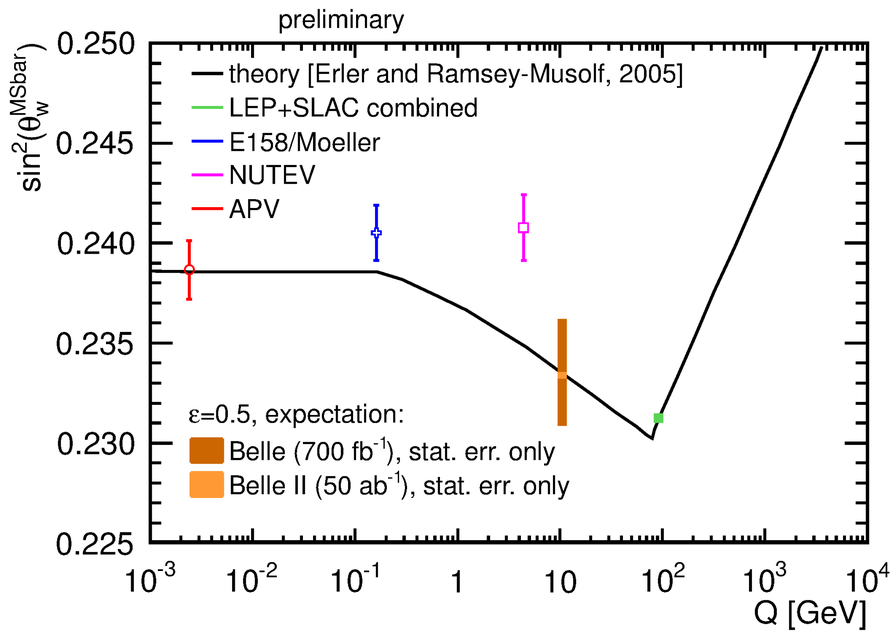


Fig. 2: SM prediction of the energy dependency and measurements of $\sin^2(\theta_w)$. Belle and Belle II symbols are shown at the SM value and only indicate the expected statistical uncertainty.

Unique Belle data set at DESY

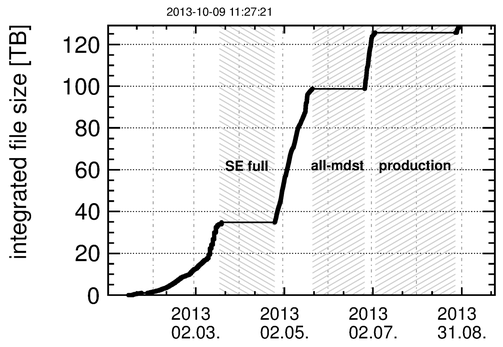


Fig.5: Transfer of Belle data from KEK to DESY.

- ~700fb^{-1} "mDST" Belle data duplicated at DESY (data preservation)
- MC for A_{FB} and skimmed data for further analysis

→ 300TB on dCache SE

Belle II and SuperKEKB

SuperKEKB is an upgrade project at KEK to increase the instantaneous luminosity to 8×10^{35} cm^{-2}s^{-1}, the final goal is to acquire 50ab^{-1} by the end of 2023.

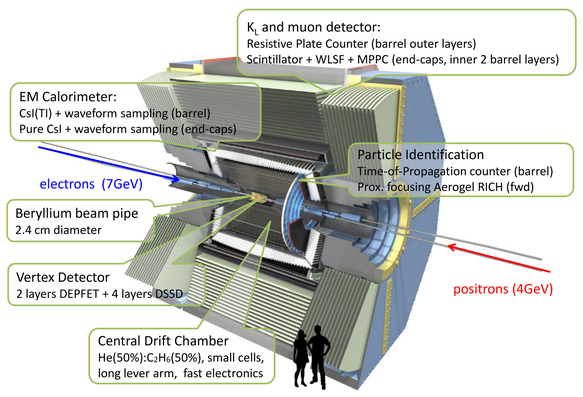


Fig.6: Drawing of the Belle II detector.

Belle II: (stat. unc. only) with 50×10^9 muon pairs:

$\sigma_{stat}(A_{FB})/A_{FB} \approx 0.1\%$

$\sigma_{stat}(\sin^2\theta_w) \approx 3\times10^{-4}$

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