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

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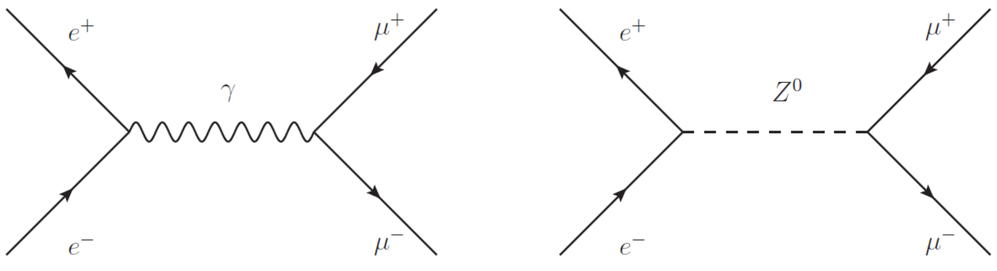
Muon pair asymmetry A_{FB} at Belle



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.

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

- $A_{FB}(\sqrt{s}=10.58\text{GeV}) \approx -0.75\%$
- Belle: (stat. uncertainty only) with 7×10^8 muon pairs: **$\sigma_{stat}(A_{FB})/A_{FB} \approx 1\%$**

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

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.

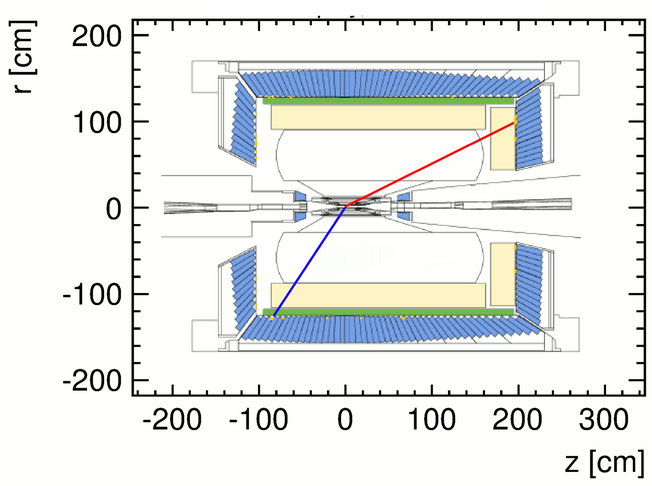


Fig. 2: Muon pair (MC) without ISR or FSR photons. The muon tracks are not back-to-back in the lab system.

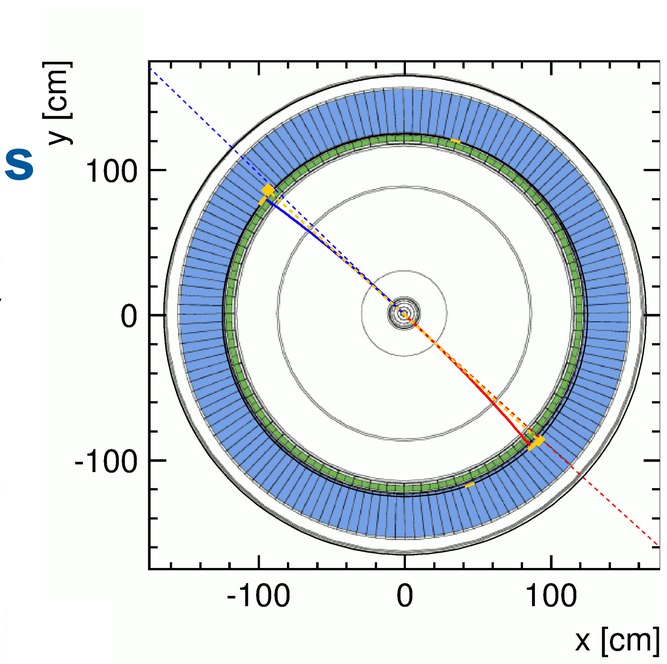


Fig. 3: Radiative muon pair (MC) with double final state radiation (FSR) and beam background photons in the Belle detector.

Precision test of the Standard Model

The muon pair asymmetry A_{FB} is precisely predicted by the Standard Model (SM) → For $\sqrt{s}$=10.58 GeV:

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

Compare the differential cross section $d\sigma/d\cos(\theta^{CM})$ to the SM prediction, extract ρ → Deviations from the predicted behavior hint to New Physics.

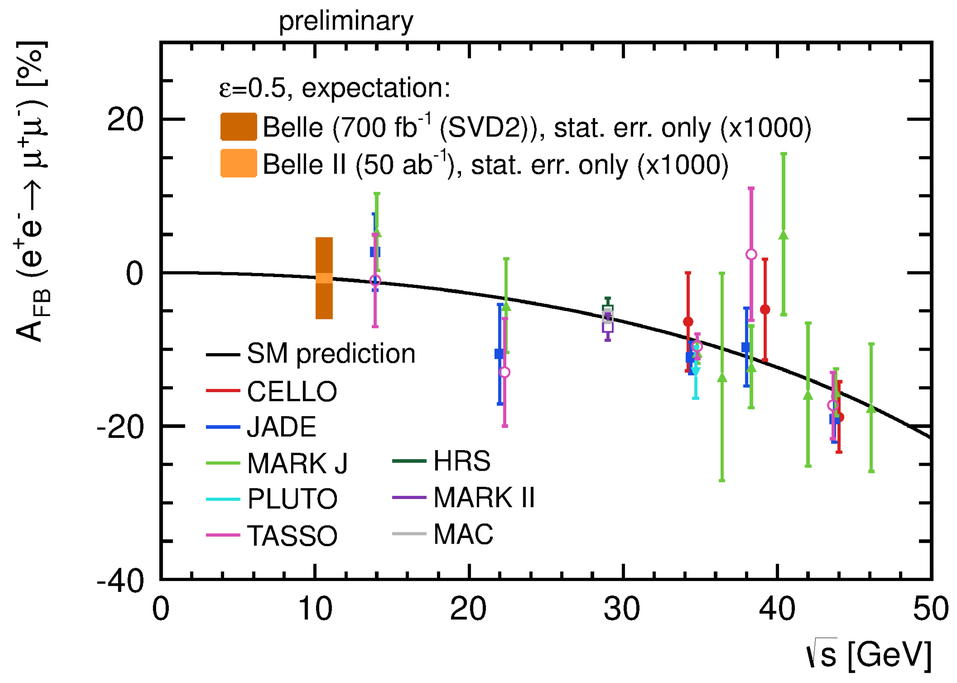


Fig. 1: SM prediction and measurements of A_{FB}. Belle and Belle II symbols are shown at the SM value and only indicate the expected statistical uncertainty (x1000).

Unique Belle data set at DESY

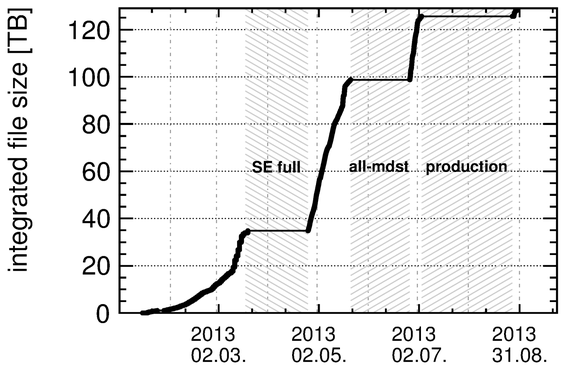


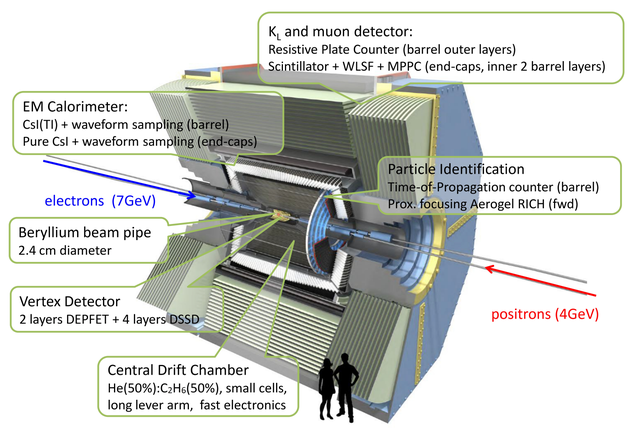
Fig.4: Transfer of Belle data from KEK to DESY.

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

→ 300TB on dCache to be analyzed at the NAF

Belle II and SuperKEKB

SuperKEKB is an upgrade project at KEK (Japan) to increase the instantaneous luminosity to $8\times10^{35}\text{cm}^{-2}\text{s}^{-1}$ → 50ab^{-1} by the end of 2023.



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

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

DESY

HELMHOLTZ ASSOCIATION