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Evidence for an anomalous like-sign dimuon charge asymmetry

Frequently Asked Questions

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Interpretation of result

Q: "Can we be sure that this is the CP violation in mixing?"

A:

- We interpret the observed charge asymmetry as the CP violation in mixing
- B-meson oscillation is the only known physics source of like-sign dimuons;
- Upper cut on transverse momentum, small impact parameters prefer the muons coming from B mesons
- A test measurement with a stronger IP cut (0.5 mm instead of 3mm) shows that the asymmetry still remains:

$$A_{sl}^{b} = (-1.107 \pm 0.402\,(\text{stat}))\% \quad (\text{IP} < 0.5\,\text{mm})$$

- Dependence of asymmetry on dimuon mass is in favour of the oscillation source of this asymmetry
- However, since this is an inclusive measurement, other interpretations with the exotic models are possible

Mass dependence

Q: "Our mass dependence shows that the discrepancy in asymmetry for $A^b_{sl} = 0$ is only at low masses."

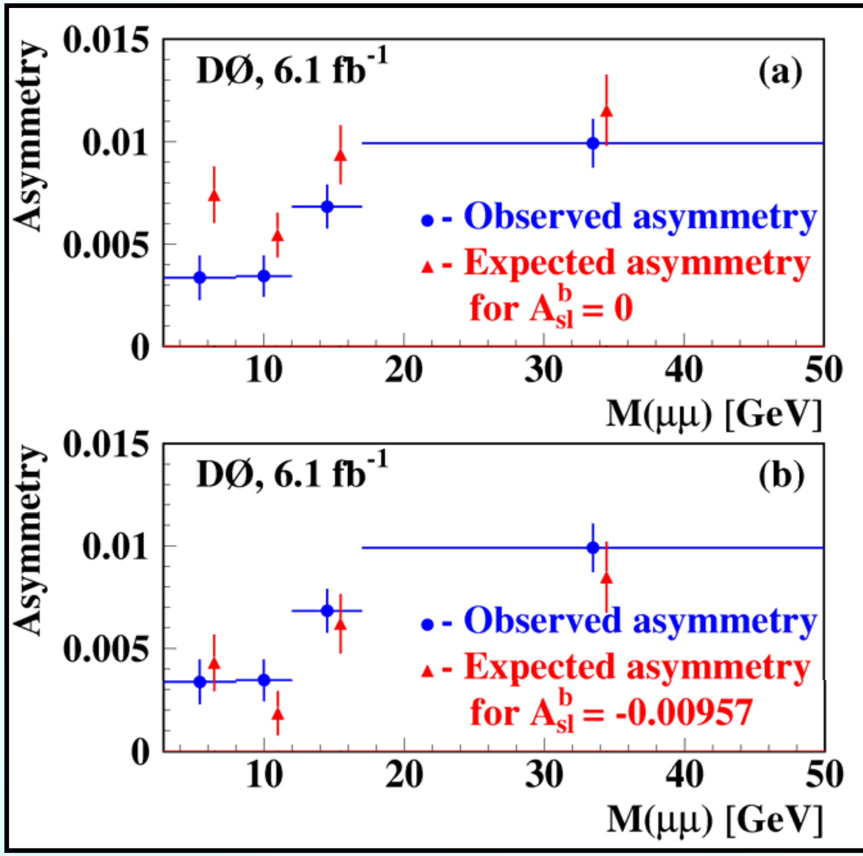
A:

- We observe a discrepancy for all masses;
- The measurement with M(μμ)>12 GeV gives:

$$A^b_{sl} = (-0.873 \pm 0.388\,(\text{stat}))\% \quad (M(\mu\mu) > 12\,\text{GeV})$$

- This result is statistically consistent with our main measurement:

$$A^b_{sl} = (-0.957 \pm 0.251\,(\text{stat}))\%$$



- Statistical significance of the difference between these two measurements is 0.281 (taking into account the correlation between the samples);

Background subtraction

Q: "How it can be that the combination of a positive value and a negative value gives the mean value which is even more negative?"

A:

- Our final number is not a weighted average of two measurements
- The asymmetry obtained in the inclusive muon sample (a) contains mainly the background contribution
- The asymmetry in the dimuon sample (A) is background + possible signal
- The background in both samples comes from the same sources and is highly correlated
- We subtract the background contribution ($A - \alpha a$, with $\alpha \approx 1$), reducing the related systematic uncertainties:

$$\left.\begin{aligned} a &= k\, A_{sl}^{b} + a_{bkg} \\ A &= K\, A_{sl}^{b} + A_{bkg} \end{aligned}\right\} \Rightarrow (A - \alpha a) = (K - \alpha k) A_{sl}^{b} + (A_{bkg} - \alpha a_{bkg})$$

$$A_{sl}^{b} = \frac{(A - \alpha a) - (A_{bkg} - \alpha a_{bkg})}{K - \alpha k}; \quad \alpha \approx 1$$

Detector Asymmetries

Q: "Why is the reversal of magnetic field so important? Can the measurement be done without this reversal?"

A:

- Detector asymmetries are reduced to <0.1% with the reversal of magnet polarities;
- Relative uncertainty of the residual detector asymmetry ≈35 %
- Without the reversal of magnet polarities, the detector asymmetry is ~1% (at least for DØ experiment);
- We would need to control it with the relative uncertainty ~2-3% to get the same accuracy of A^b_{sl} ;
- It would require even more advanced measurement methods and even more detailed knowledge of the detector;
- It is difficult, but not impossible;