Questions and answers - James Mott Lecture

The following questions were submitted through Google Form. Some / all may have been answered in the Q&A session already. Nevertheless, we request our lecturers to provide written answers here for the benefit of those who could not attend that session. Thank you!

Slide 25. This shows positive muons going in. Can you run with negative muons? Is there any benefit to running with negatives? And what are the difficulties in doing so?

Yes, we can run with negative muons and indeed we actually put in a proposal to do this during our final-year run (Run-6). Unfortunately it didn't work out with other constraints and we didn't do the negative run.

The BNL experiment took roughly equal statistics with μ^+ as with μ^- and they were able to confirm the same a_μ value with both with the precision they had available. They actually assume CPT invariance and combine the two to get their final result:

The two positive muon values for $\mathcal{R}$ can be combined and compared to the negative muon result:

$$\mathcal{R}_{\mu^+} = 0.003\,707\,204\,7(2\,6) \quad (55)$$

$$\mathcal{R}_{\mu^-} = 0.003\,707\,208\,3(2\,6), \quad (56)$$

giving $\Delta\mathcal{R} = \mathcal{R}_{\mu^-} - \mathcal{R}_{\mu^+} = (3.6 \pm 3.7) \times 10^{-9}$, which is in good agreement with the expectation from CPT invariance. Assuming CPT invariance, we obtain the average value

$$\mathcal{R}_\mu(\text{E821}) = 0.003\,707\,206\,4(2\,0), \quad (57)$$

giving the anomalous magnetic moment

$$a_\mu(\text{Expt}) = 11\,659\,208.0(6.3) \times 10^{-10} \quad (0.54\,\text{ppm}). \quad (58)$$

The total uncertainty includes a 0.46 ppm statistical uncertainty and a 0.28 ppm systematic uncertainty, combined in quadrature.

(from https://arxiv.org/abs/hep-ex/0602035)

We would've been able to improve on the BNL precision for μ^- by about a factor 2 with one year's running. There's not really any significant difference between the positive/negative muons from an experimental perspective, so we wouldn't have been

able to alter the effect of any significant systematics. But we would've been able to greatly expand our program of CPT and Lorentz-violation searches. See e.g. https://arxiv.org/abs/1907.00162 for more details on that.

As for the difficulties, there are only a few technical challenges. You have to flip the polarities of all the magnets in the beamline as well as the main storage ring field. You also need to flip the electrostatic quad and kicker polarities. Everything was designed to make this possible and would've been completed in ~3 months [a normal summer shutdown]. The main downside is the lower number of μ^- that we get from our incoming 8 GeV protons - it's approximately a factor of 2 lower muons per proton than for μ^+.