MC geometry studies

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A reminder

I have been trying to track down the source of the discrepancy between the data and MC

As part of this, have been trying to check the MC is as realistic as possible
In the MC protons are propagated from $S_3$ through the vessel and to $S_4$

- The direction and momenta of these particles are drawn from the measured $S_3$ distributions
- The vessel is represented as an argon-filled cylinder with a hollow ellipsoid at each end (the doors)
Previously, I thought I had checked the positions within the MC and found them all to be correct (to a reasonable precision)

On the next few slides I’ll show histograms of the true MC particle positions within various detectors as a function of off-axis angle.

The coordinate system is centred on $S_1$ and the nominal beam axis is at $\theta = \phi = 0$.

If you imagine these plots as being from a ‘beam’s eye view’ they are flipped in $\theta$ due to the coordinates used in the survey.
The lines are based upon the survey data.

We see that nearly all of the MC S3 hits fall within the surveyed data.

S. Jones (UCL)
As expected, once we require S2 trigger, MC hits mainly fall within shadow of S2
MC hits in $S4$

- Looking at the same distributions for $S4$, we see that the MC falls pretty much within the measured points.
MC hits in vessel doors

However, for the doors there appears to be an offset between the data and the MC.

The green points are the measured points on the doors on the flanges (labelled ‘Measured circle’ in picture).

There appears to be an offset between the MC positions of the doors and their measured positions.
Hit positions in global coordinates

- Measured points in green
- Offset appears to be mainly in X
- Vessel also needed to be rotated
Changes made to MC

- Vessel needed to be shifted by $(-0.1796, -0.04165, -0.0108) \text{ m}$ and rotated by $5.91^{\circ}$
- Also discovered that $S4$ had a rotation that was slightly off
- Thanks to Toby for implementing these changes
The interesting part of all this is the effect it has on the distributions in S4
■ We lose the sharp peaks we had on the beam side edge of S4, with our MC now resembling our data more
The data and MC distributions look to be offset by \(\sim 20\) cm but this could be a resolution effect.
### Effects on $S3/S4$ proton ratios

<table>
<thead>
<tr>
<th>N. blocks</th>
<th>$(S3/S4)_{Data}$</th>
<th>$(S3/S4)_{MC}$</th>
<th>Data/MC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0621</td>
<td>0.0281 ± 0.0008</td>
<td>2.21</td>
</tr>
<tr>
<td>1</td>
<td>0.1265</td>
<td>0.0680 ± 0.0011</td>
<td>1.86</td>
</tr>
<tr>
<td>2</td>
<td>0.1352</td>
<td>0.0861 ± 0.0013</td>
<td>1.57</td>
</tr>
<tr>
<td>3</td>
<td>0.0599</td>
<td>0.0582 ± 0.0019</td>
<td>1.03</td>
</tr>
<tr>
<td>4</td>
<td>0.1118</td>
<td>0.0149 ± 0.0004</td>
<td>7.5</td>
</tr>
</tbody>
</table>

- Errors on MC ratio are stats only
- Errors on data are likely of a similar magnitude. 3 block sample is the only one that is consistent between data & MC
- However, factor of $\sim 2$ agreement is quite good given simplicity of MC model
- 4 block: We are down at very low proton kinetic energies and susceptible to any slight changes to material in beam line
Conclusion

- An offset was found in the vessel position relative to other beamline object within the proton MC.
- Once corrected the $S4_{MC}$ proton spatial distributions look much more like the data.
- Ratios of protons in $S3$ and $S4$ range from factor of 2 out to consistent (excluding 4 block).