# Beam paper update

Seb Jones

Department of Physics & Astronomy
University College London

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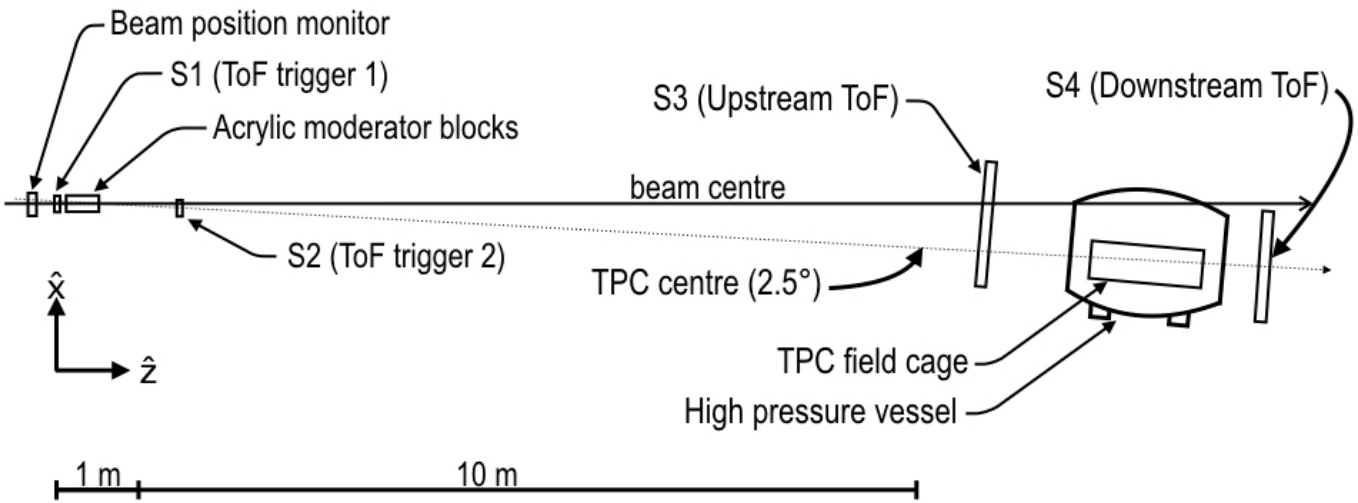
# Beam flux MC studies: Background

- In our MC simulations we propagate protons from *S3* through the TPC to *S4*
- The positions, direction and momenta are drawn from the information recorded in the *S3* data
- In the beam flux paper the number we compare in data and MC is the ratio of protons in *S3* to those detected in *S4*



# Background

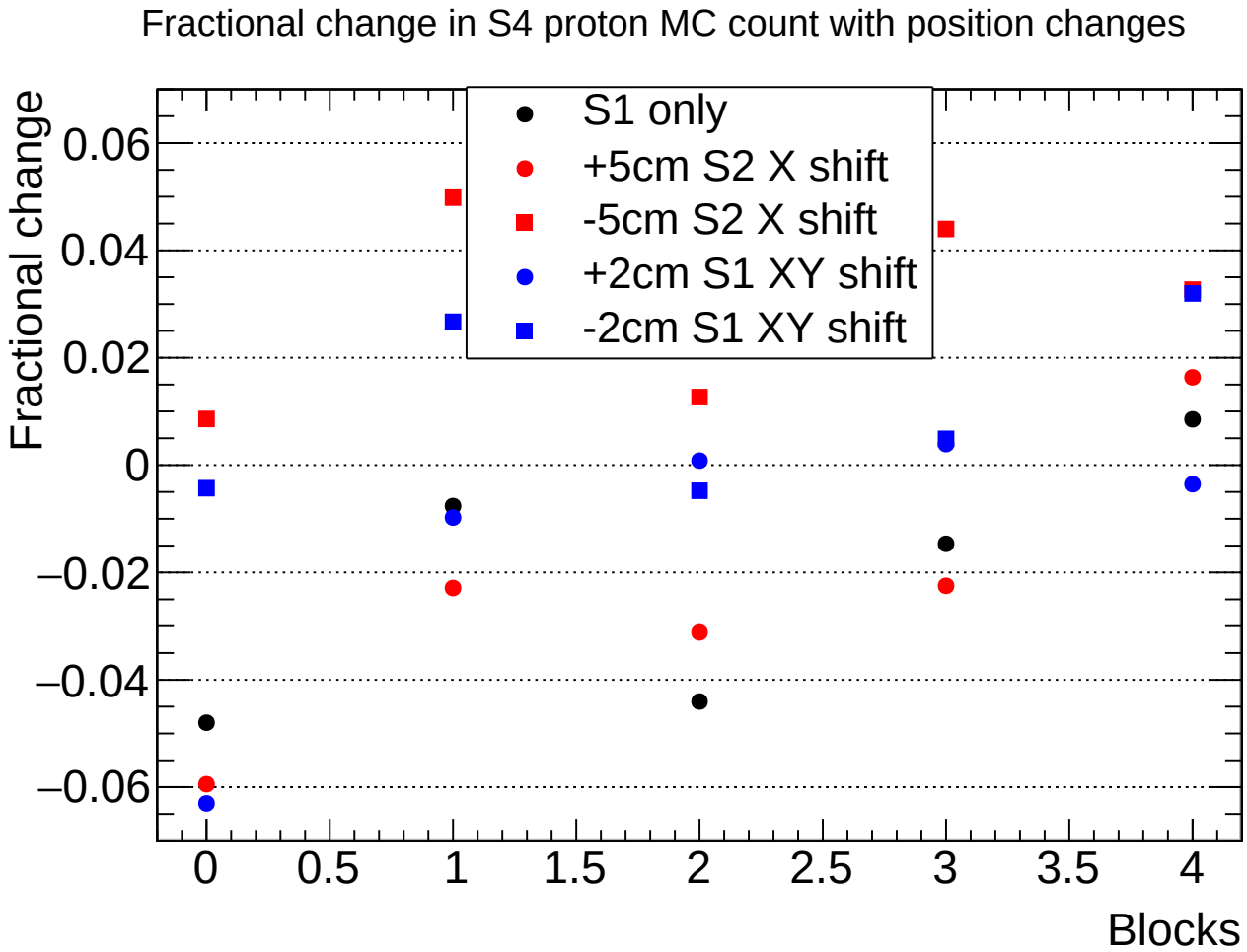
| N.blocks | Monte Carlo | Data | Data/MC |
|---|---|---|---|
| 0 | $0.0281 \pm 0.0008$ | $0.0617 \pm 0.0011$ | 2.20 |
| 1 | $0.0680 \pm 0.0011$ | $0.1098 \pm 0.0030$ | 1.61 |
| 2 | $0.0861 \pm 0.0013$ | $0.1218 \pm 0.0015$ | 1.41 |
| 3 | $0.0582 \pm 0.0019$ | $0.0513 \pm 0.0012$ | 0.88 |
| 4 | $0.0149 \pm 0.0004$ | $0.0389 \pm 0.0013$ | 2.61 |

- These numbers, with the current errors (which are statistical in the MC case), are obviously not consistent
- **Data errors**: Statistical + a small contribution from cosmic efficiency – otherwise systematics not considered
- However, the systematics on the MC haven't really been accounted for

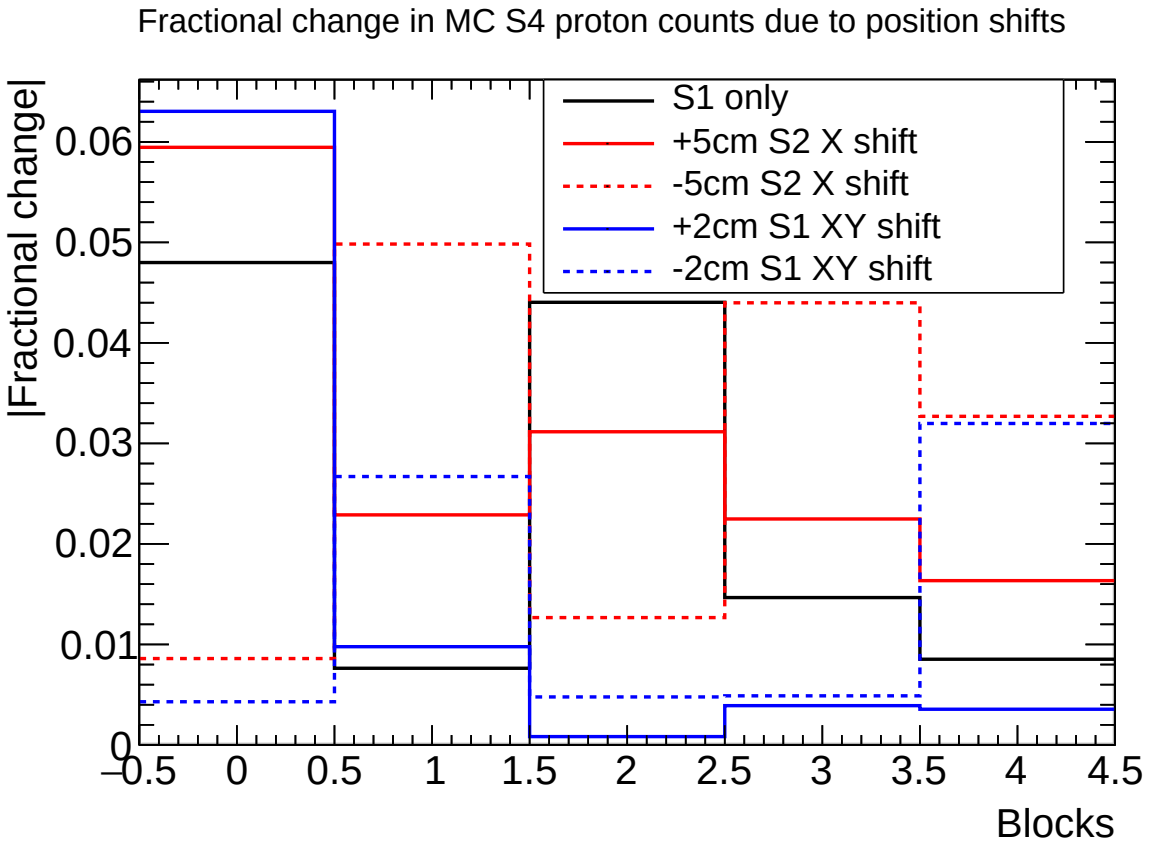
# Potential sources of error

- In the MC, our starting proton position and momentum are calculated using measurements from the beamline system
- I.e. the direction of a particle is calculated by drawing a line from the upstream detected position of a particle to its downstream detected position
- **S1 shift**: Looked at the effect of shifting *S1* by $\pm 2$ cm up and horizontally – particles coming through extremity of *S1*
- **S2 shift**: Shift *S2* by $\pm 5$ cm in a horizontal direction – what if *S2* was put down in different position
- **S1 only**: MC also rerun calculating all particle directions from *S1* only
- The measure I've used to evaluate the effects of these systematics is the fractional change in the number of *S4* protons

# Effects of these changes

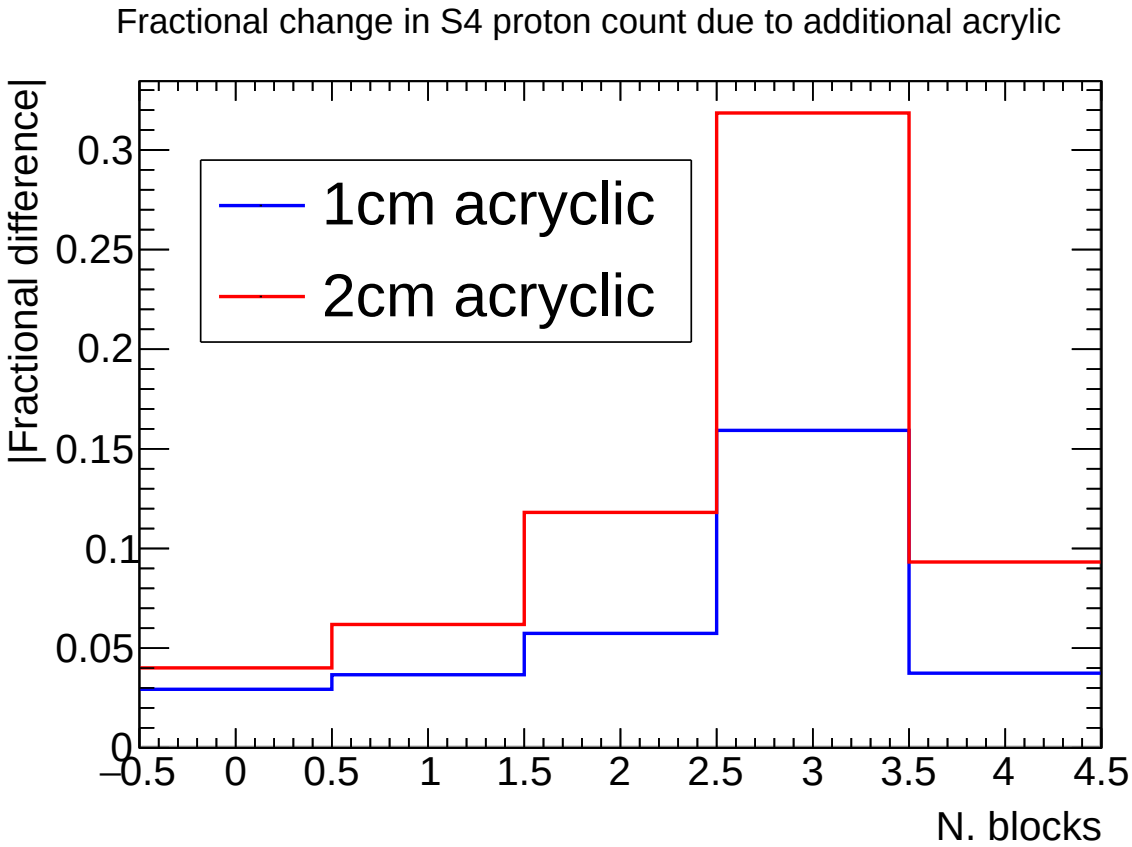


# Effects of these changes



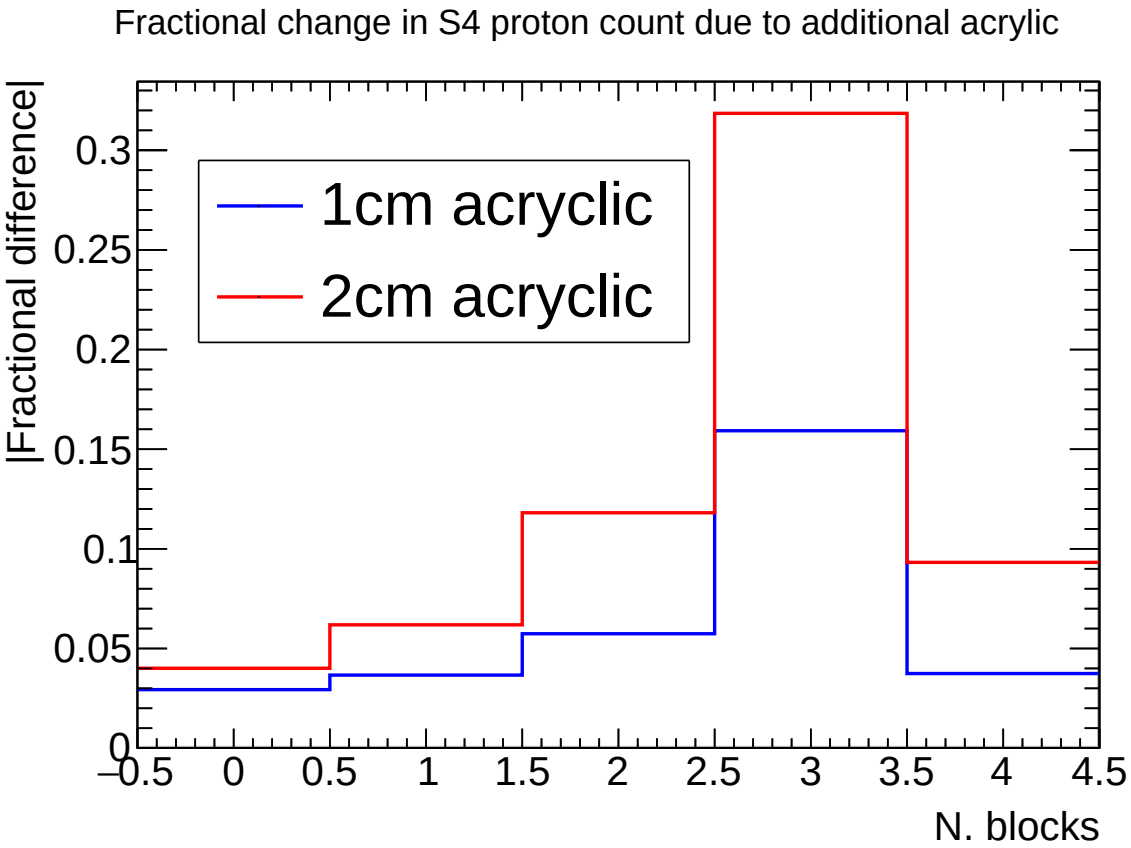

- Effects of all of these changes are of order a few %

# Additional acrylic




- Also reran MC with a 1cm and 2cm acrylic sheet immediately after *S3*
- Shown here is the change in *S4* proton count for each sample

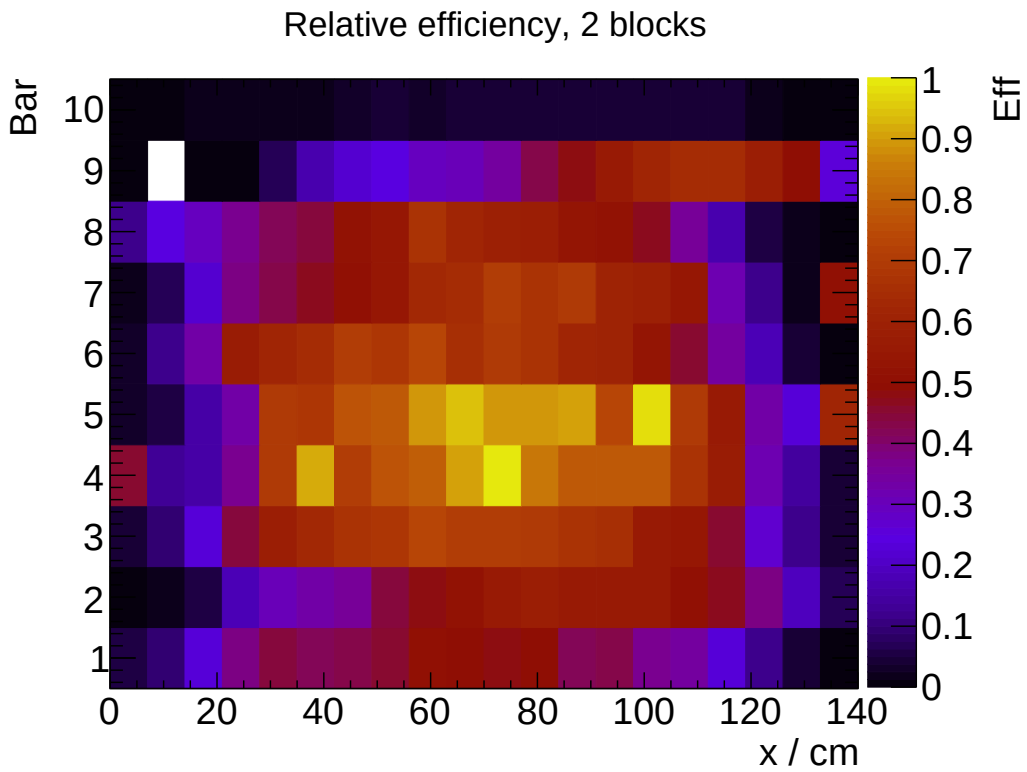
# Additional acrylic




- Effects here are in general larger than those caused by position shifts (especially 3 block which we don't fully understand)

# Recap: *S4* efficiency correction

- For each sample, we count all out of spill hits as cosmic rays
- Build 2D histogram of these hits
- Scale all bins such that maximum bin has an efficiency of 0.8 (ideal bar) – assume we always miss some fraction of events
- Weight *S4* beam events based upon position

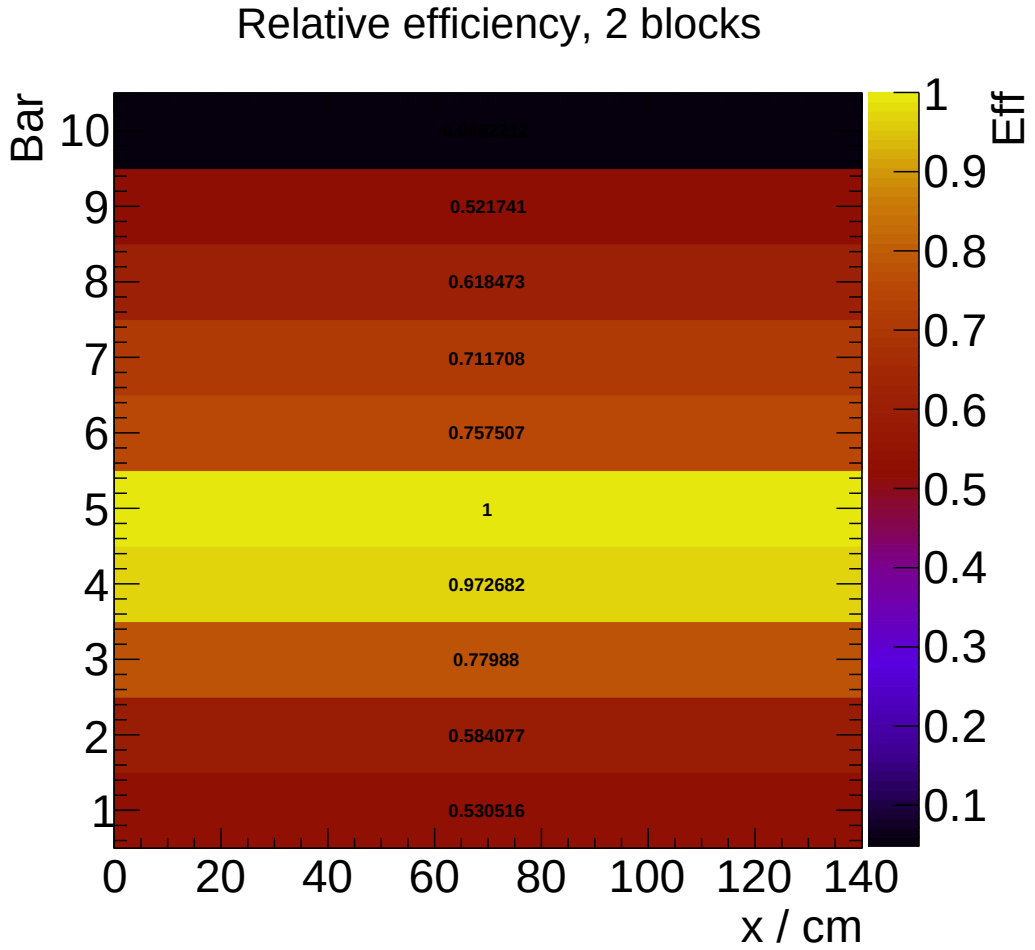


# Sources of error

- **Overall efficiency**: The 0.8 number has some basis in tests done at UCL but should probably have some uncertainty attached (say 10%)
- **Angular correction**: what if our angular correction is radically wrong?

# Angular correction

- What if we use one number to correct for the efficiency of each bar? How large a change does this induce?
- Some of our bins with few cosmics have a large fractional uncertainty



# No angular correction

| N.blocks | Monte Carlo | Data | Data/MC |
|---|---|---|---|
| 0 | $0.0281 \pm 0.0008$ | 0.0318 | 1.13 |
| 1 | $0.0680 \pm 0.0011$ | 0.0623 | 0.92 |
| 2 | $0.0861 \pm 0.0013$ | 0.0795 | 0.92 |
| 3 | $0.0582 \pm 0.0019$ | 0.0337 | 0.58 |
| 4 | $0.0149 \pm 0.0004$ | 0.0189 | 1.27 |

- Without an angular correction our data and MC agree far better than before which is interesting
- Is there some number of horizontal bins between 1 and 20 that gives this agreement while still giving some angular information?

# 2 horizontal bins

| N.blocks | Monte Carlo | Data | Data/MC |
|---|---|---|---|
| 0 | $0.0281 \pm 0.0008$ | 0.0398 | 1.42 |
| 1 | $0.0680 \pm 0.0011$ | 0.0751 | 1.10 |
| 2 | $0.0861 \pm 0.0013$ | 0.1020 | 1.18 |
| 3 | $0.0582 \pm 0.0019$ | 0.0416 | 0.72 |
| 4 | $0.0149 \pm 0.0004$ | 0.0238 | 1.60 |

- With 2 bins, our agreement is no longer as good but it is still better than with the full 20 bins

# 3 horizontal bins

| N.blocks | Monte Carlo | Data | Data/MC |
|---|---|---|---|
| 0 | $0.0281 \pm 0.0008$ | 0.0649 | 2.31 |
| 1 | $0.0680 \pm 0.0011$ | 0.1311 | 1.93 |
| 2 | $0.0861 \pm 0.0013$ | 0.1376 | 1.60 |
| 3 | $0.0582 \pm 0.0019$ | 0.0510 | 0.88 |
| 4 | $0.0149 \pm 0.0004$ | 0.0298 | 2.00 |

- With 3 bins, our numbers start to look similar to the numbers with the full 20 cosmic bins
- This pattern continues as you increase the number of bins

# Conclusions

- **MC systematics**
  - The position shifts give two effects of say 4% each
  - The acrylic gives an effect of about 6%
- **Data systematics**
  - There should probably be something like a 5-10% systematic attached to our data numbers due to the unknown overall bar efficiency
  - Our data numbers appear to be highly dependent on the binning used for our cosmic data, to the point that if it is removed, our data and MC appear much more consistent