G4BL Models of Step I

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Table of Contents

Aims

- Studies have shown that in Step I there were some small discrepancies between data and Monte Carlo (MC) [Emittance, 2012].

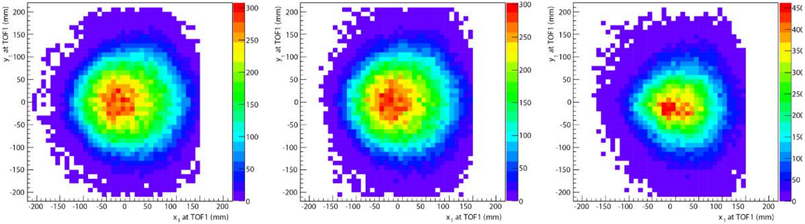


Figure: *xy*-distributions at TOF1 for simulation (left), reconstructed simulation (centre) and data (right) for a (6, 200)μ^- beam

- Highlighted at CM 37 [Durga, 2013] that as a minimum for Step IV we require end-to-end MC simulation of MICE beam line
- Part of that involves G4beamline - G4BL deck must be validated

G4BL Deck

- 2009 Apollonio deck left on Launchpad
- MICE Note 216 documents surveys done in 2009 of MICE beam line including details of the elevation of beam line elements. Not included in previous G4BL decks
- 2012 MICE beam line paper contains a table (table 3, [Emittance, 2012]) with most up-to-date geometry information of Step I
- All magnet currents were taken from Marco's Magic Spreadsheet
- Simulations which have been performed so far are of 6π 140, 200 & 240 MeV/c positive beams

Simulating MICE

Table: A typical G4BL simulation

No. of protons on target	$1\text{x}10^{15}$
No. of particles off target	$1\text{x}10^{14}$
No. of muons at TOF1	$1\text{x}10^{5}$
No. of CPUs	$\sim$100
Total jobs time	$\sim$48 hrs

- Generating high statistics sample at downstream detectors requires non-trivial amounts of computing power

Beam Profile

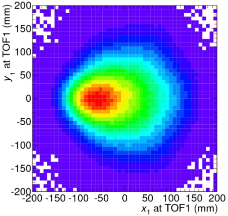


Figure: G4BL *xy*-distribution TOF1 (6, 200)μ^+ beam, (proj.)

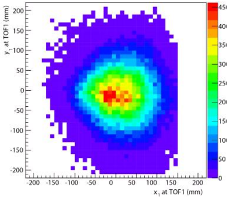
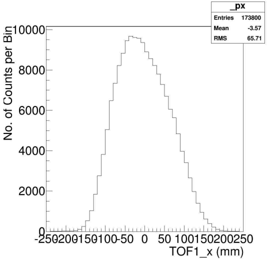
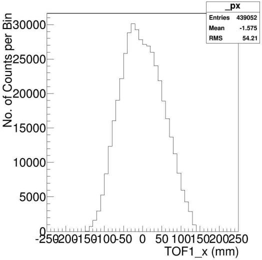


Figure: Data *xy*-distribution TOF1 (6, 200)μ^- beam, (proj.)





G4BL Beam Envelope

- Place VirtualDetector planes every 10 cm from centre of DS to TOF1
- Calculate the measured beam size at every plane and plot as a function of Z (where Z is oriented along the dirction of the MICE beam line)

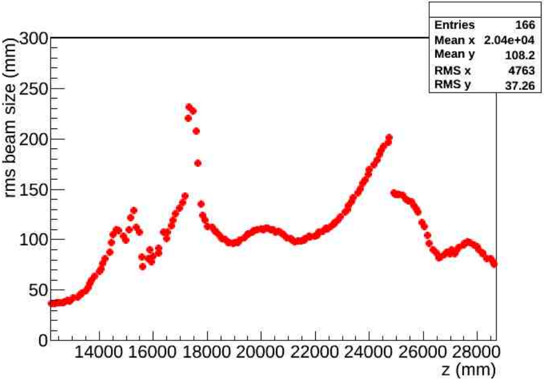


Figure: G4BL beam envelope as a function of position along the MICE beam line (6, 140)μ^+ beam

π Contamination

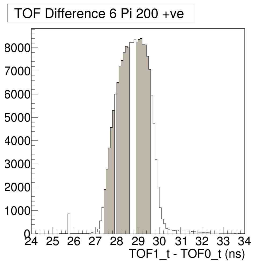


Figure: G4BL TOF (6, 200)μ^+ beam
Table: % π contamination at TOF points

	% π in Point 1	**% π in Point 2**	**% π in Point 3**
elevation	1.270 ± 0.009	0.0900 ± 0.0004	0.0400 ± 0.0002
flat	2.00 ± 0.002	0.200 ± 0.006	0.100 ± 0.004

- Contamination for the entire profile is 0.220000 ± 0.000005 %, compare with 0.33 ± 0.03 [MICE Note 416, 2013]

Step I Emittance Measurement

MC Analysis

- G4BL deck with updated geometry information shows closer agreement with data
- Further qualify agreement - compare MC with data across a range of parameters, including the Step I emittance measurement.
- Take MC output at TOF0 and passing it through the Step I analysis code.

Beam Size

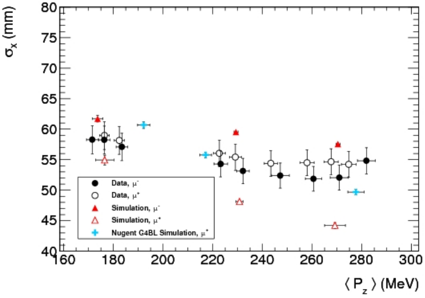


Figure: Horizontal beam size

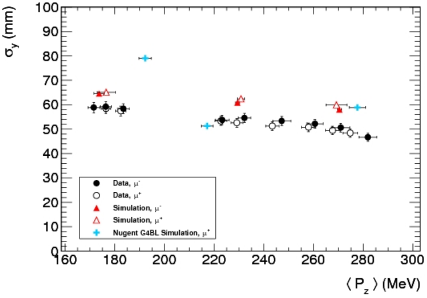


Figure: Vertical beam size

- 6π 200 MeV/c beam shows good agreements with data. 6π 140 & and 240 MeV/c comparible to old simulations

Dispersion

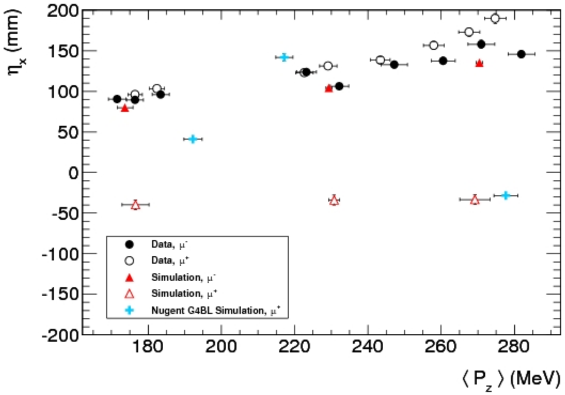


Figure: Horizontal beam dispersion

- 6π 200 MeV/c beam shows good agreements with data. 6π 140 & and 240 MeV/c weaker comparible to old simulations

Emittance

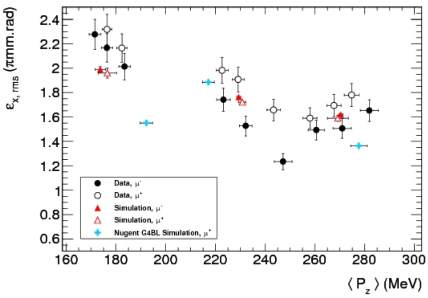


Figure: Horizontal Emittance

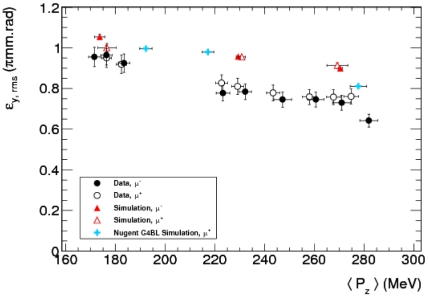


Figure: Vertical Emittance size

- 6π 200 MeV/c beam shows good agreements with data. 6π 140 & and 240 MeV/c comparible to old simulations

Impact of new G4BL geometry

- What are the diferences between the 200 MeV/c and 140, 240 MeV/c jobs?
- Marco Apollonio designed the G4BL target to be highly efficient, πs with a momenta too high or too low are discarded at the target.
- As a consequence we are seeing only a subsection of the beam at the downstream detectors
- These momenta cuts must be tailored for each beam or switched off.

A MAUS Step IV Requirement

- End-to-end simulation of MICE
- This will involve simulating pions being transported from the Target to D2
- D2 and downstream are under the remit of MAUS
- G4BL will be used for the upstream simulation. The output of G4BL will provide a realistic beam desciption to seed MAUS
- Part of a successful Step IV will be accurately predicting the measured parameters. Which will involve MICE being modelled accurately in both G4BL and MAUS
- The effort to validate G4BL with Step I data will ensure that for Step IV we have a throughly tried and tested simulation

G4BL-MAUS Integration

G4beamline as a MAUS third-party application

MAUS-v0.8.2 contains G4BL as a third-party app.

MAUS Mapper MapPyBeamlineSimulation

- User defines beam in the MAUS configuraton file
- Class simulates MICE from the MICE Target to the Geneva 1 counter in G4beamline.
- It populates a python dictionary with primaries for MAUS and writes the dictionary as a JSON document.
- No knowledge of G4BL is assumed
- If specified the mapper can retrieve the magnet currents and proton absorber thickness for a particular run from the CDB and write them to the G4BL configuration file.

G4BL-MAUS Integration

Caveat!

- Running high statistics G4BL simulations takes significant computing resources.
- Beams can take up to 48 hours to be completed (Glasgow cluster $\sim$100 CPUs).
- In future there will be a repository of pre-generated G4BL JSON documents which users can download and use via an Inputter.

Conclusions

- Validation of G4BL deck for MAUS on-going - getting closer agreement with data
- G4BL is now a third-party app in MAUS
- With access to MAUS Grid resources can run large scale jobs
- Aim to create beam library by next CM

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