Beam Matching Measurements

Ryan Bayes

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Questions Needed Before Block Simulation Resumption

- What are the properties of the beam transport through the full beam line?
- What is the current prediction of the emittance reduction through the absorbers?
  - What cuts/acceptance criteria should be assumed?
- Can we produce a better match between the conventional and solenoid channels?
  - Jaroslaw has proposed new beam settings (Match1) to improve the match.

Two stage analysis

- Extract good reconstruction events from batch analysis and place in a new tree file.
  - Required because batch analysis mainly produces events with no trigger.
  - Only keep events that produce slab hits in TOF2(1).
  - Reduces a 16 G set of root files to one file of 1.8 G
  - Extracted reconstructed TOFEvent, CkovEvent, KLEvent, SciEvent, and EMREvent objects and MCEvent objects.
- Extract ensembles of muons that pass acceptance criteria.
  - Calculate mean values of phase space parameters.
  - Calculate emittance and beta functions.
  - Plot beam spots.

Acceptance Criteria

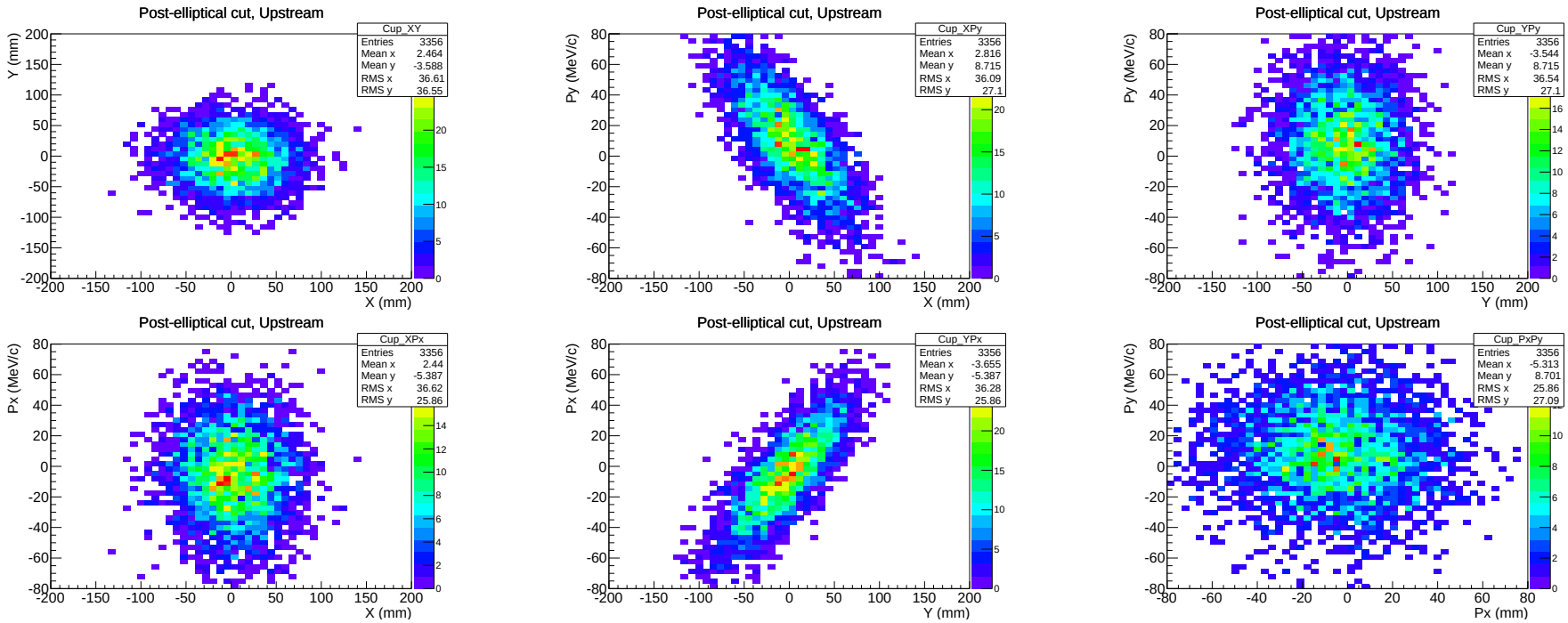
- (TOF space points not working) Event must produce one slab hit in each TOF plane.
- Time of flight between station 0 and 1 between 42 ns and 48 ns.

- Apply elliptical cut at 6 σ

Future Considerations

- TOF space point reconstruction known to be result of using G4beamline.
  - Can be corrected with clever definition of particle time zero.
- Should use global PID
- Could use some weighting method to reduce impact of cuts(?)

Beam spots for 6π200 MeV/c Batch Simulation



- Beam spots derived from tracker reconstruction.
- Correlations suggest (counter-)clockwise beam orbits for up(down)stream tracker.
  - Channel is in flip mode.
- Taken from "pass2" batch simulation.

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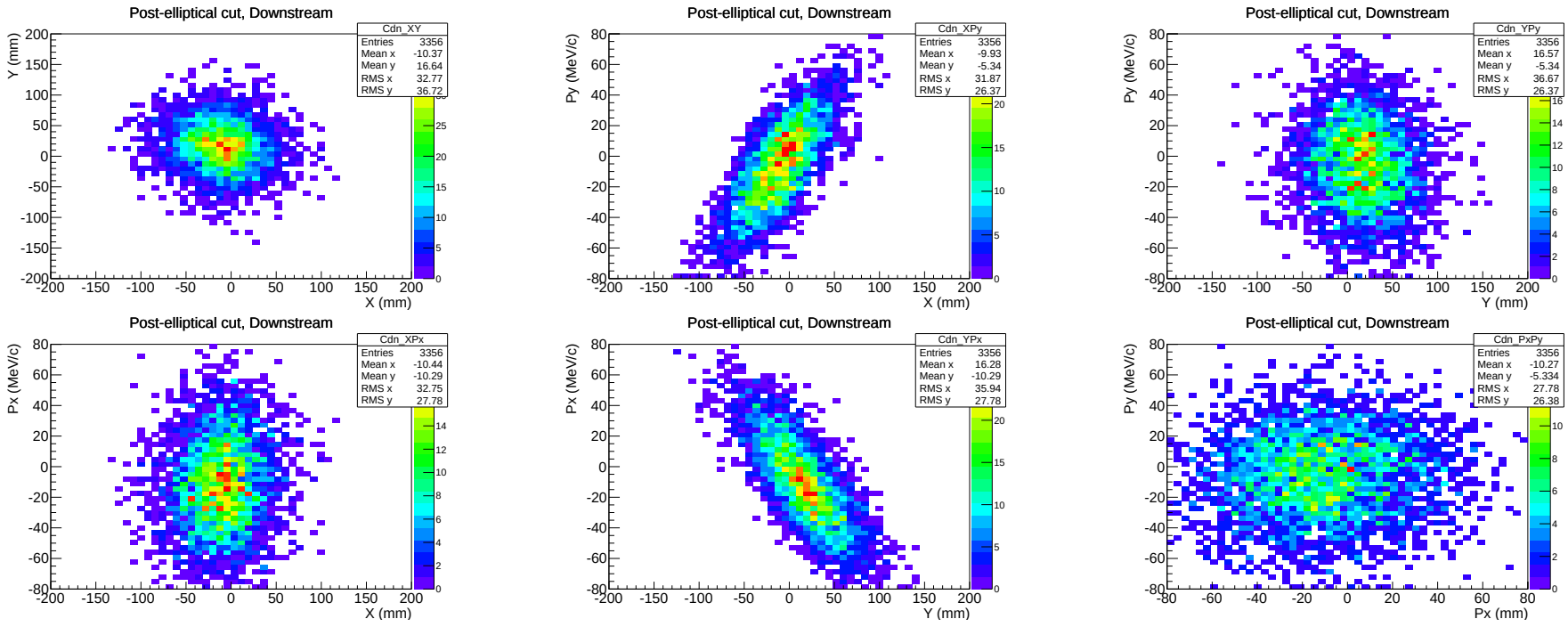

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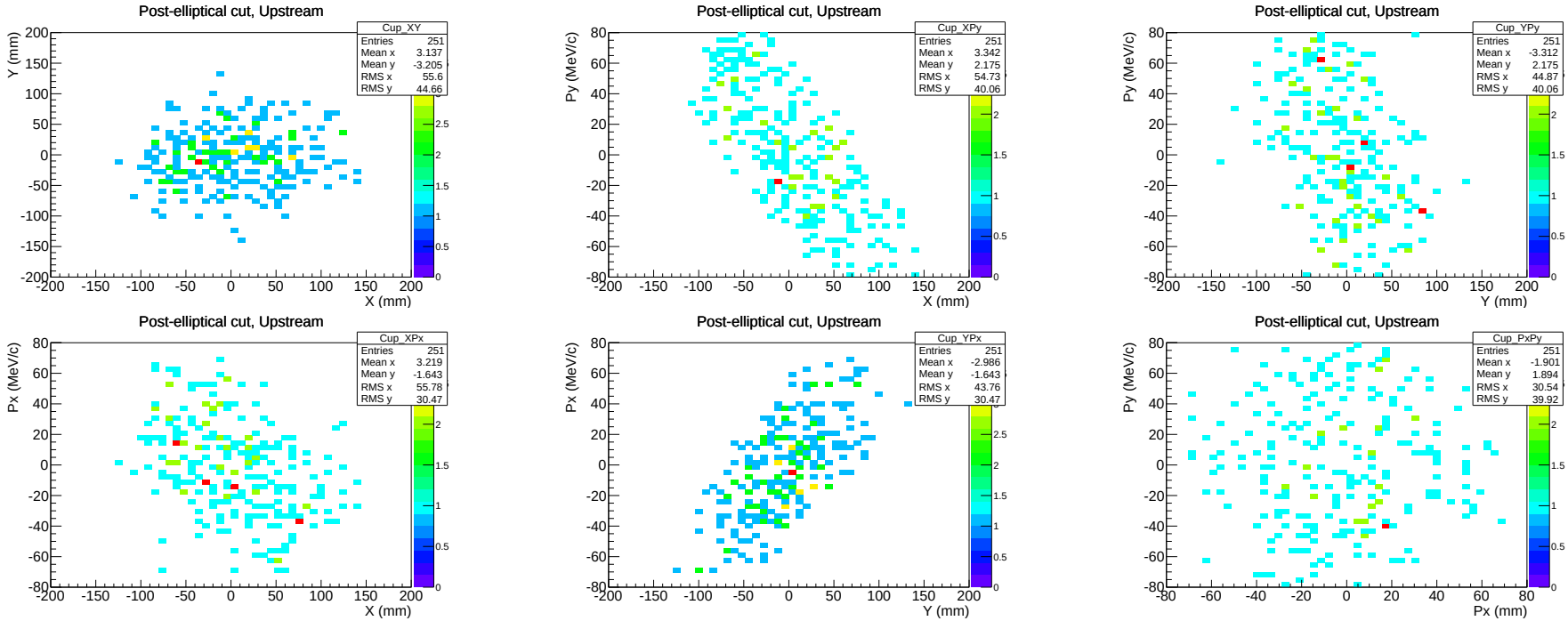
Summary of 6π200 MeV/c Batch Simulation

	Upstream	Downstream
N_{tracks}	3356	3356
$< X >$[mm]	2.5±0.6	-10.4±0.6
$< Y >$[mm]	-3.6±0.6	16.6±0.6
$< Z >$[mm]	15049.7±0.6	18868.2±0.8
$< P_x >$[MeV/c]	-5.3±0.5	-10.6±0.5
$< P_y >$[MeV/c]	9.0±0.5	-5.8±0.5
$< P_z >$[MeV/c]	204.0±0.1	187.9±0.1
ϵ_{xy} [mm]	6.05±0.10	5.91±0.10
β_{xy} [mm]	427.5±7.4	365.2±6.3

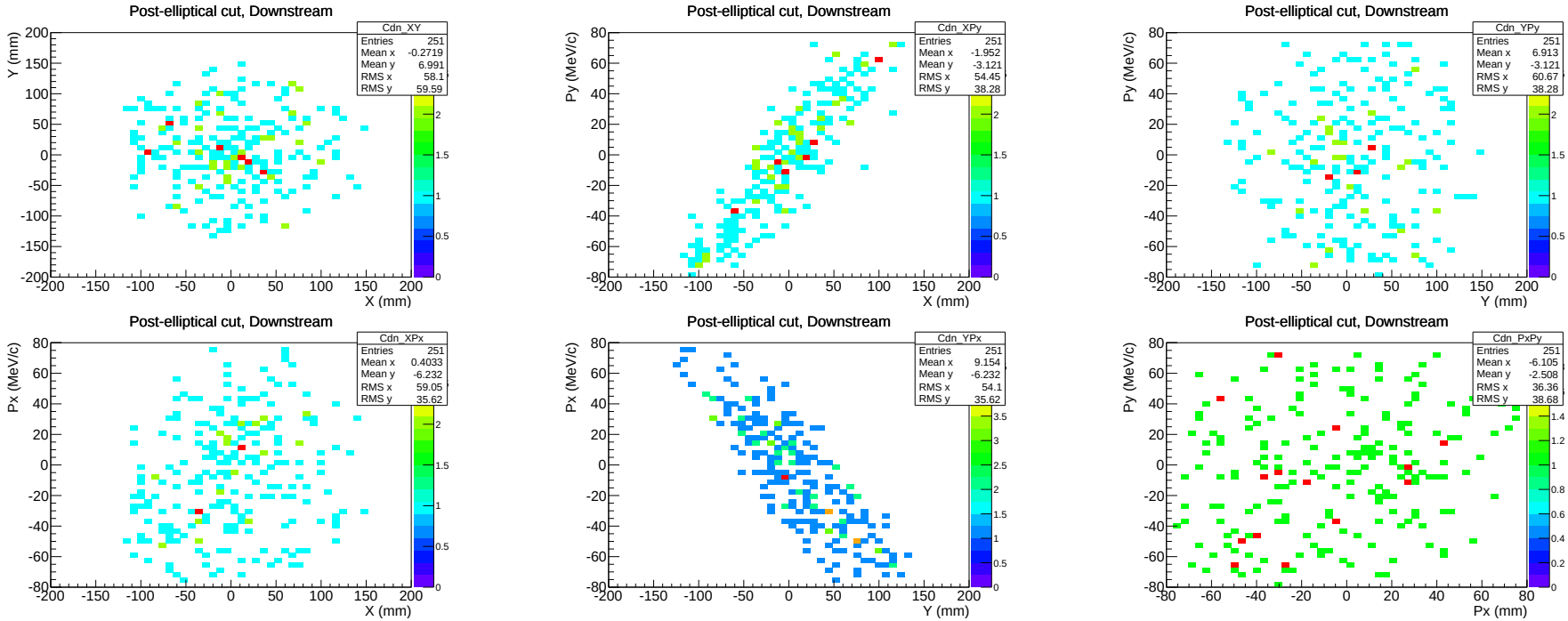
- A total of 42953 events accepted from TOF2 "trigger".
- Relaxing or displacing momentum cut increases emittance difference.

Beam spots for 6π200 MeV/c Match1 Batch Simulation



- Ran simulation with the same G4Beamline seed, Match 1 quad currents.
- Simulation generated less than half the number of successful simulations with 24 wall time in comparison to pass 2 simulation
  - 3.6% of TOF2 triggers produce selected events in Match1.
  - 7.8% of TOF2 triggers produce selected events in Match0.
  - Used maus v0.9.4 for simulation (rather than v0.9.2).

Beam spots for 6π200 MeV/c Match1 Batch Simulation



- Ran simulation with the same G4Beamline seed, Match 1 quad currents.
- Simulation generated less than half the number of successful simulations with 24 wall time in comparison to pass 2 simulation
  - 3.6% of TOF2 triggers produce selected events in Match1.
  - 7.8% of TOF2 triggers produce selected events in Match0.
  - Used maus v0.9.4 for simulation (rather than v0.9.2).

Summary of Match 1 correction to 6π200 MeV/c

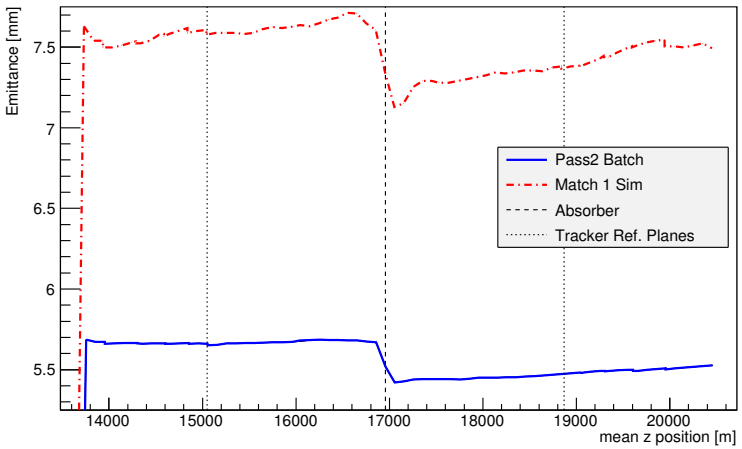
	Upstream	Downstream
N_{tracks}	544	544
$< X >$ [mm]	5.3±2.3	-2.3±2.4
$< Y >$ [mm]	-0.0±2.0	0.1±2.6
$< Z >$ [mm]	15049±1.5	18864.7±1.7
$< P_x >$ [MeV/c]	-1.6±1.4	-1.1±1.8
$< P_y >$ [MeV/c]	-1.0±1.7	-2.9±1.9
$< P_z >$ [MeV/c]	202.6±0.4	181.3±0.6
$\epsilon_{x,y}$ [mm]	10.0±0.4	11.0±0.5
$\beta_{x,y}$ [mm]	482±21	546±23

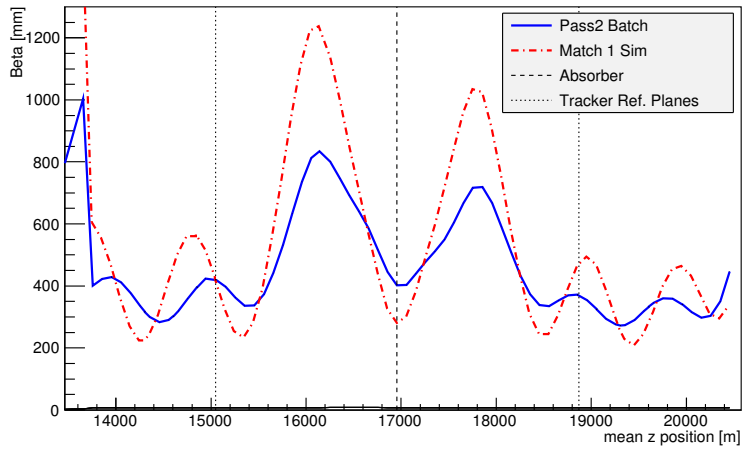
- 14996 events accepted from TOF2 trigger.
- Cannot select a beam with a reduction in emittance.

- Less than half the fraction of reconstructed tracks over TOF2 triggers when compared with the M0 setting
  - The Match 1 setting does not out-perform the M0 setting.

Comparison of Beam Settings in Virtual Planes

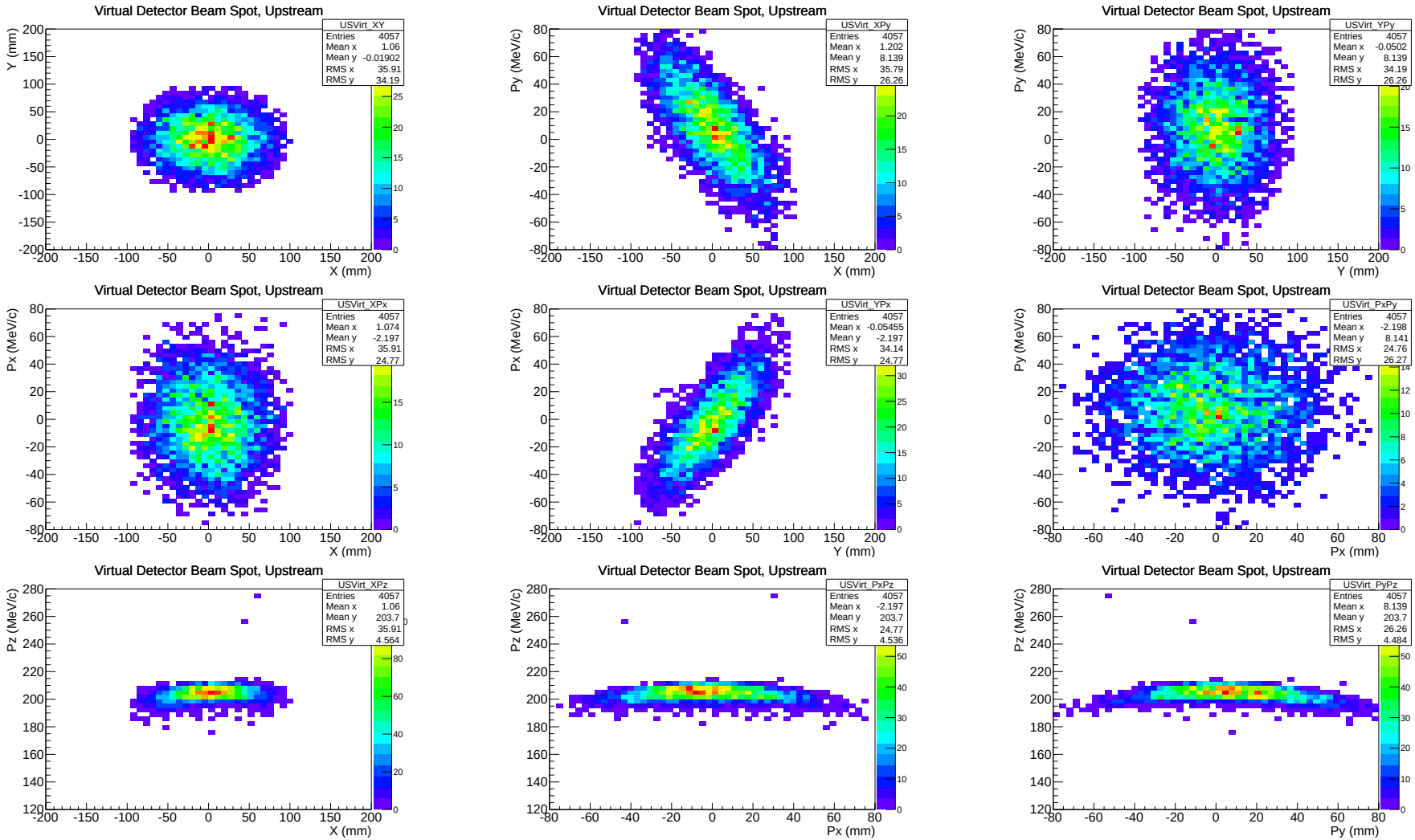
- Why does the Match 1 setting underperform?
- Used virtual plane analysis to evaluate behaviour away from the reference planes.





- Emittance reduction in MC of a similar magnitude for the two settings.
- Beta function is larger in the solenoid channel for M1 than M0 setting.
- MC selection is independent of selection from reconstruction.
  - Does not remove events that might leave the solenoid bore.
  - May alter the emittance inconsistency, and reduce the beta function.

Beam spots from the virtual plane analysis.



- Seeds for a "Fast" $6\pi 200$ MeV/c Batch Simulation.
- Could simulate particles using the pregenerated beamspots as the source distributions (i.e. interface at $z_{hall} = 1$ m).

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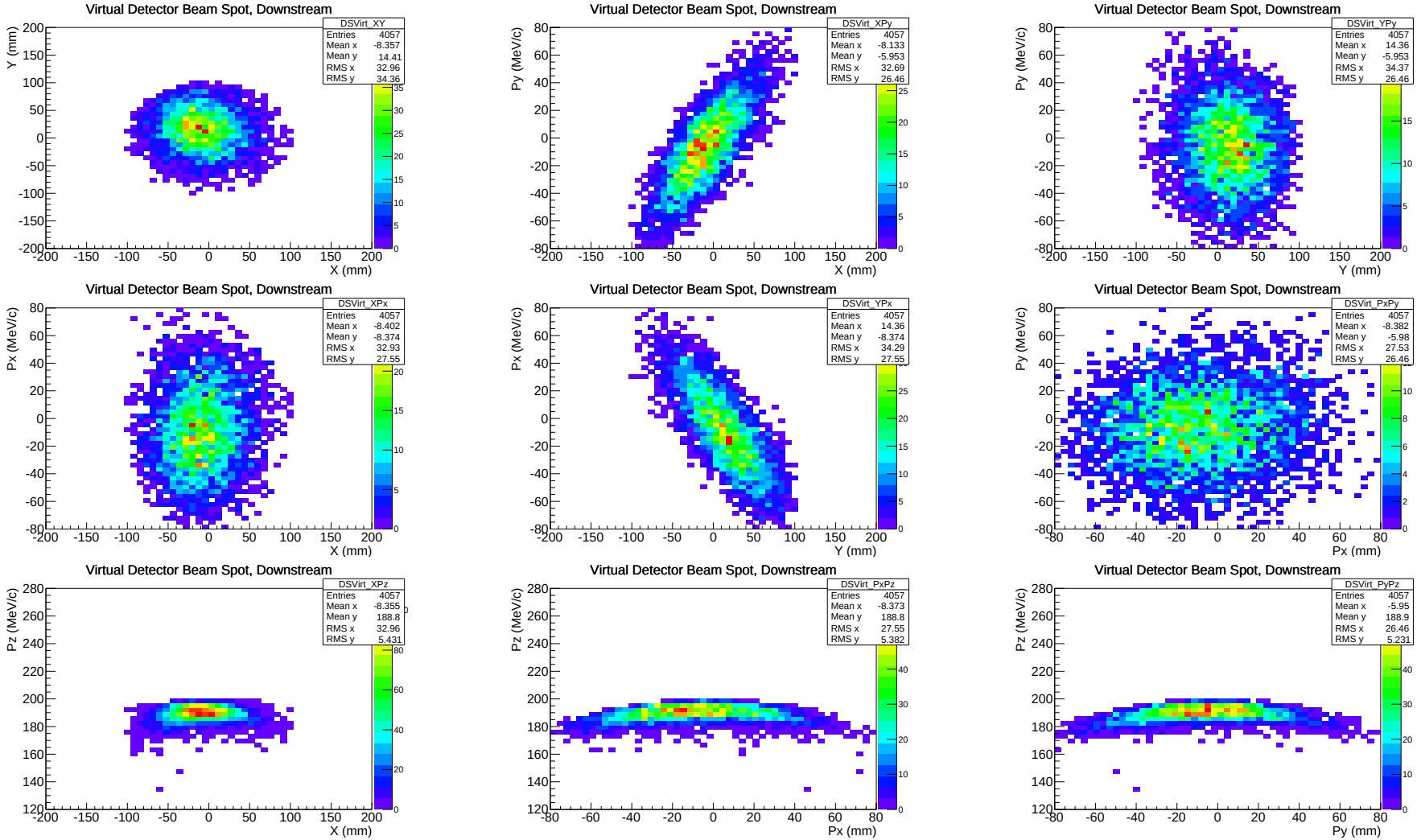

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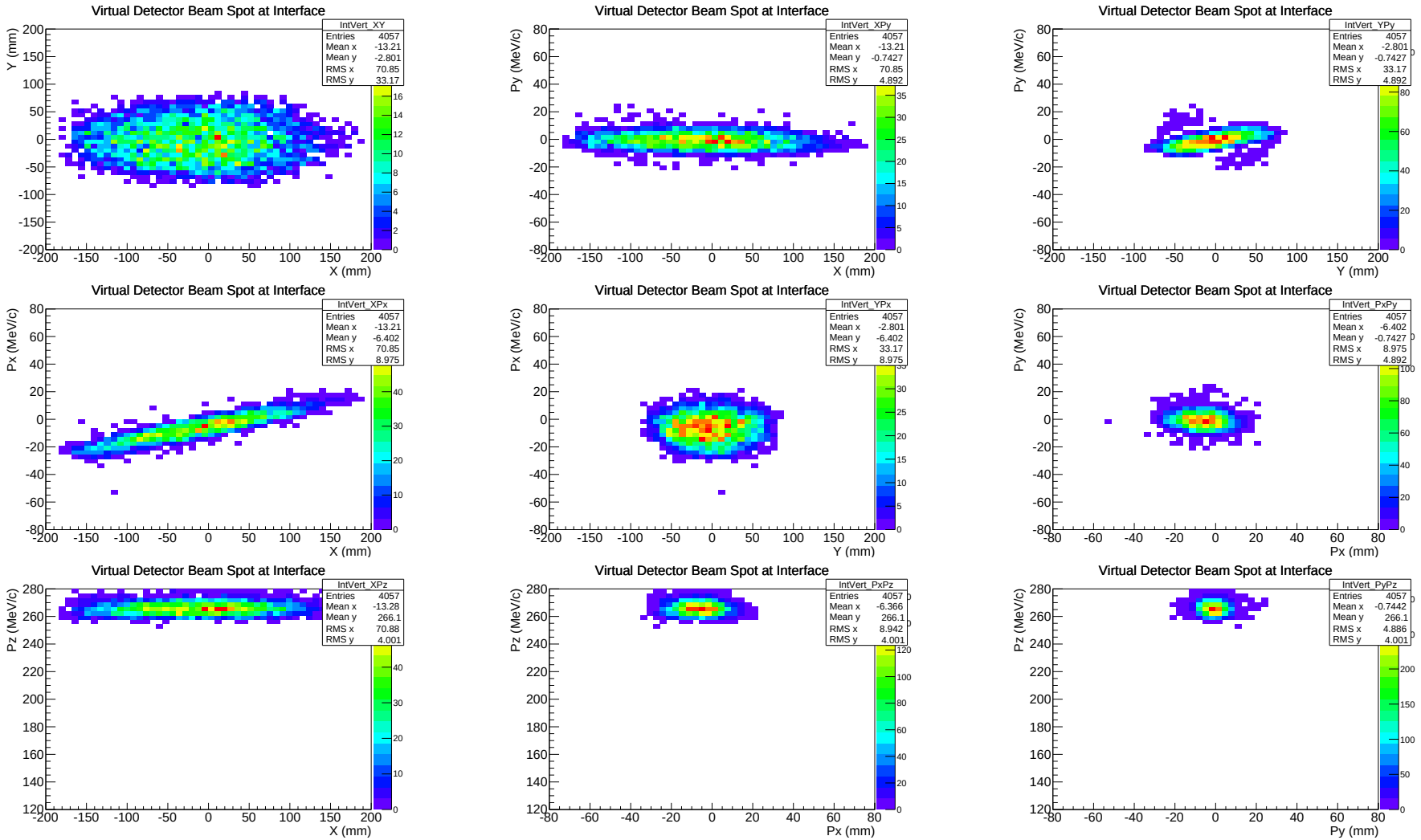

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Conclusions

- Simulation suggests that the 6π200 MeV/c Match1 simulation does not improve on M0 beam tune.
- Statistics for simulations is still low.
  - Consequence of the available G4 Beam line events and the simulation time.
  - Can use the beam behaviour from the existing simulation to model the behaviour of further simulations.