M1 Off Analysis of Tracks

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Motivation

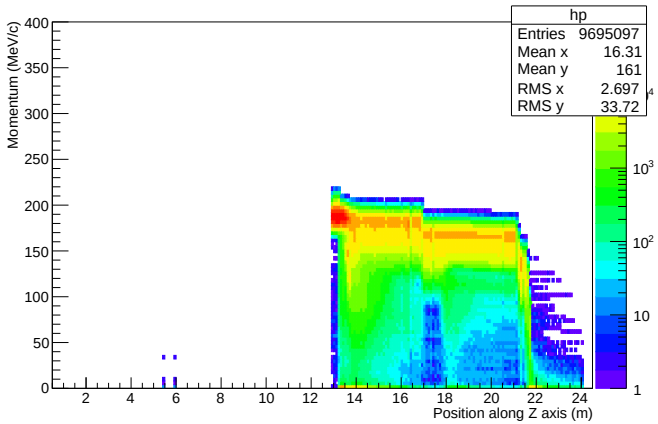
- Would like to verify tracking of particles through channel with matter.
- Previous analysis seemed specious.
- Re-consider analysis with previously developed analysis algorithms
  - Developed from code committed to `https://code.launchpad.net/~ryan-bayes/+junk/reduced-ensemble-analysis`

Simulation

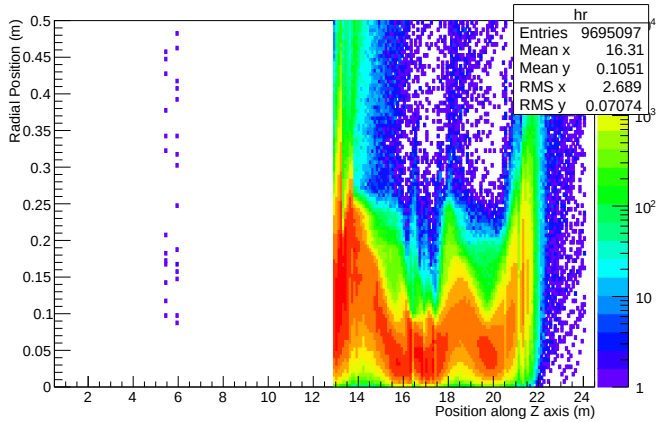
- The simulation consists of a solenoid beam generated upstream of TOF1.
  - Initial energy of 227 MeV assigned to muons.
  - Only μ^+ are simulated.
  - Initial position prior to TOF1 chosen to facilitate analysis.
- Used settings provided by Rogers on Sept. 24.
  - p=200.0 FC=225.0 M1-DS=0.0 M2-DS=-231.63 M1-US=250.91 M2-US=107.83
  - p=200.0 FC=96.0 M1-DS=-0.0 M2-DS=245.01 M1-US=257.22 M2-US=208.42
- Ran simulations with
  - diffuser (set by hand to appropriate initial emittance).
  - lithium hydride absorber.

Evolution of beam from MC

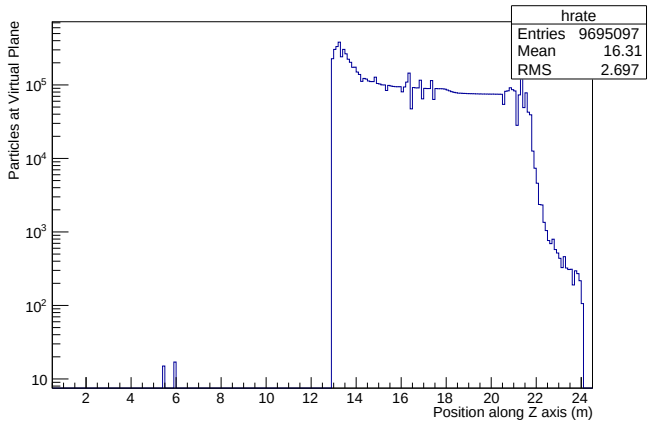
Momentum of Beam



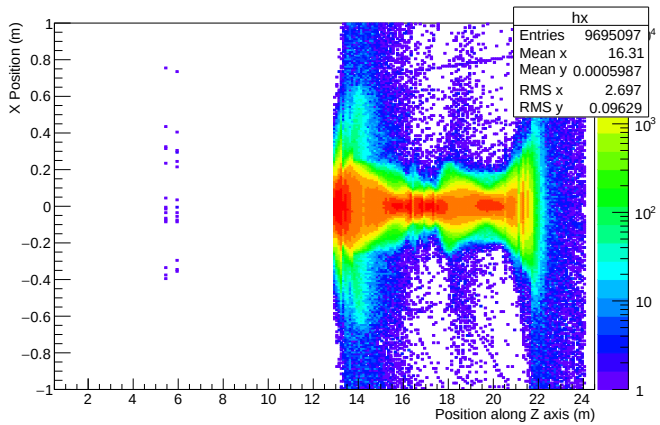
Radius of Beam



Particle rate, $\epsilon_0 = 10$ mm



Beam in x-z plane



Analysis Description

- Consider events that produce triggers in TOF2
  - Require that a muon is the event primary particle.
  - Require that $120 < p_{tot} < 280$ MeV.
- Compile ensembles of particles at tracker reference planes and virtual planes
  - use positions and momenta to calculate moments to define α, β, ϵ

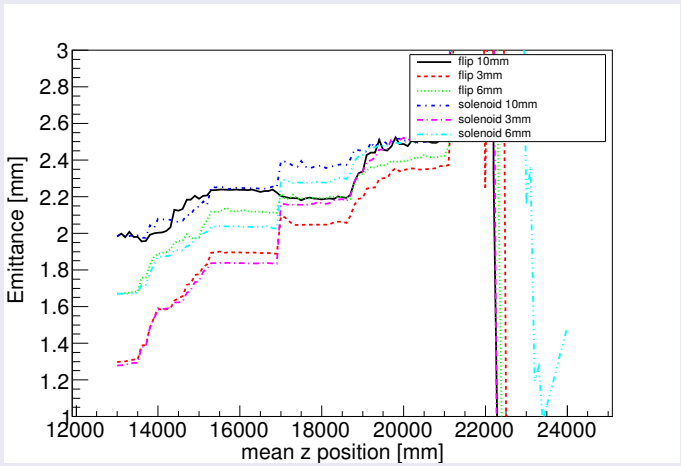
Beam Selection

- Further beam selection applied after initial calculations.
- Require that $190 < p_z < 210$
- Apply 2.5σ cut to reconstruction
- Require that virtual plane hits be within 20 cm of beam line axis

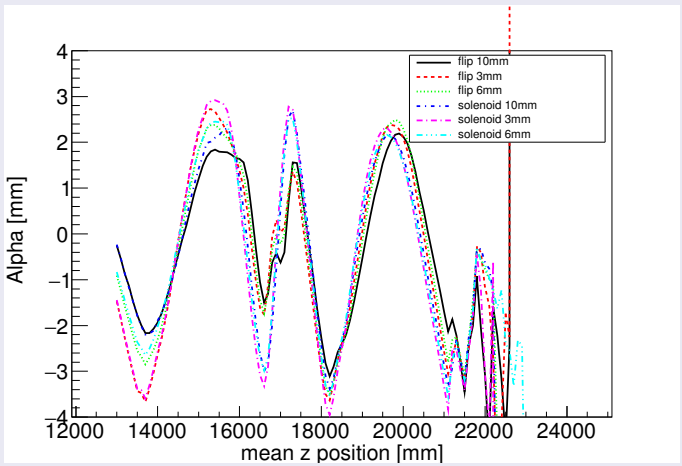
Evolution of Beam with p_z Cut

- Introducing a p_z cut improves the matching of the beam.
- Still see an emittance increase across the absorber.
- Have not included beam selection in evolution analysis.

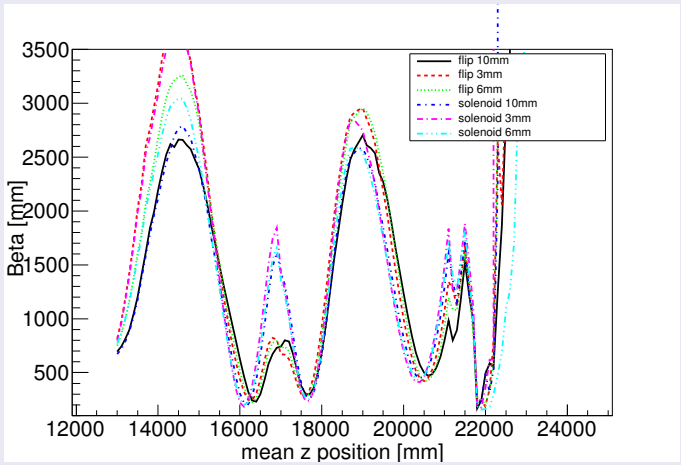
ϵ_{4D}



$\alpha(x, y)$



$\beta(x, y)$



Evolution of Beam with p_z Cut

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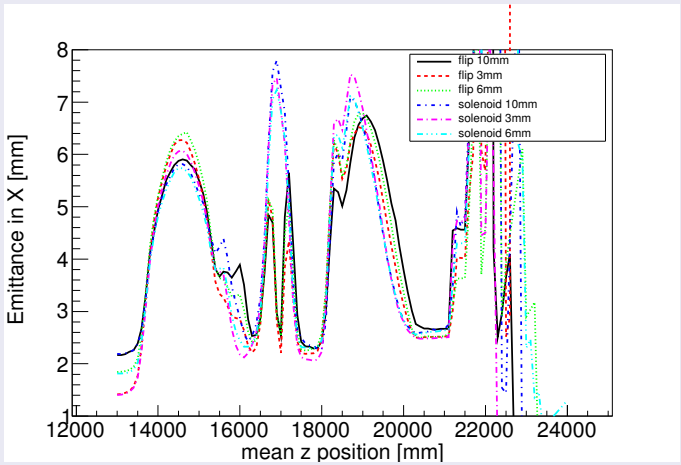
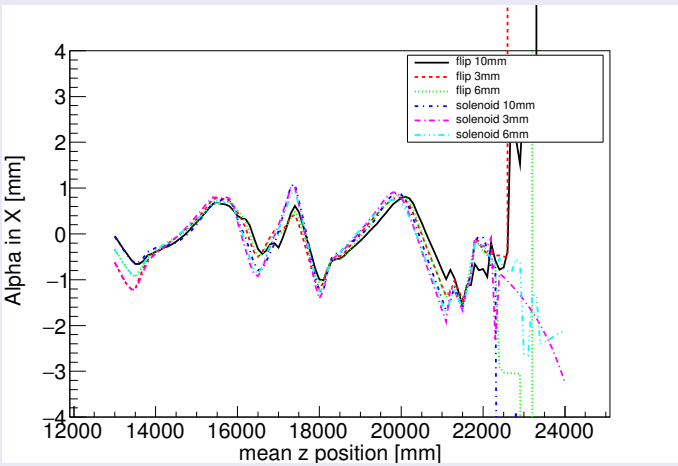
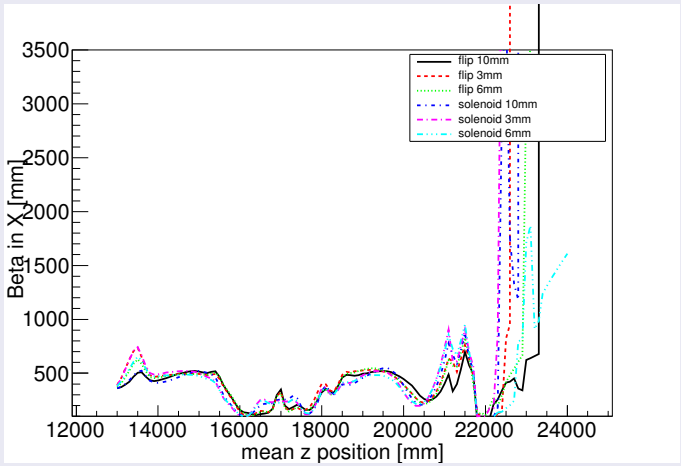
ϵ_X



$\alpha(x)$



$\beta(x)$



Evolution of Beam with p_z Cut

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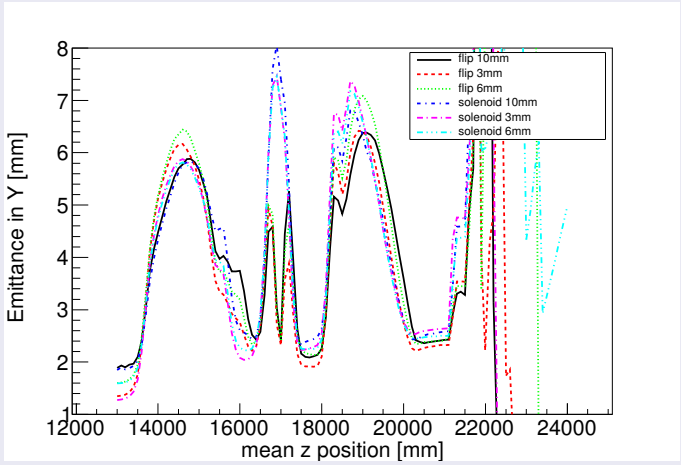
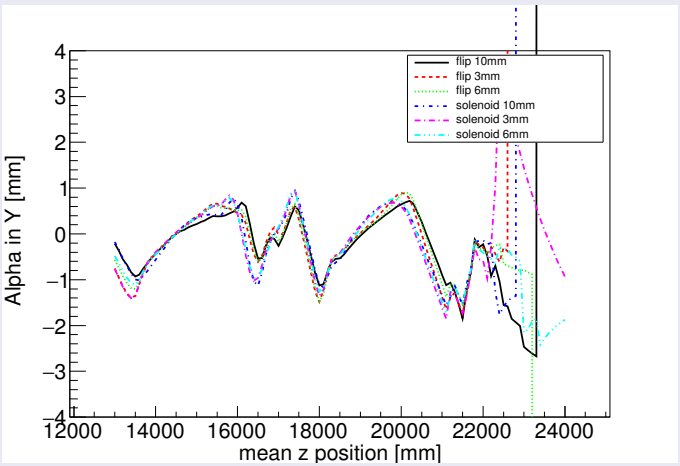
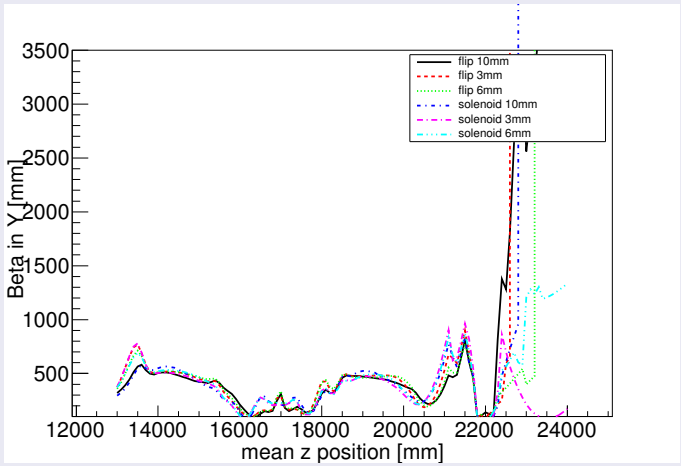
ϵ_y



$\alpha(y)$



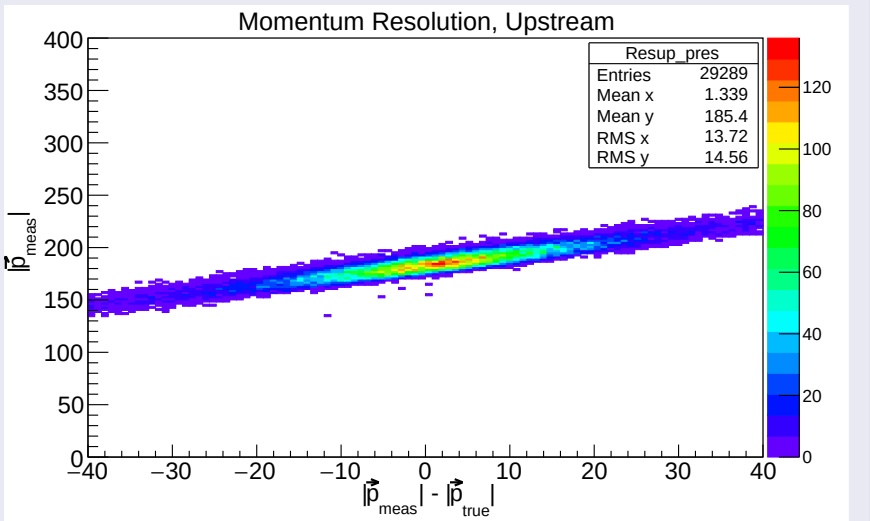
$\beta(y)$



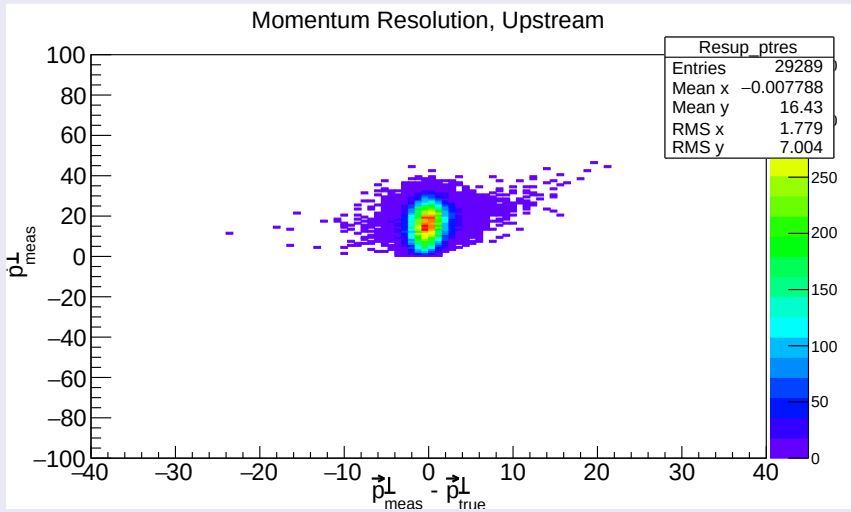
Momentum Response

- Generated the momentum response at the upstream reference plane.
- Confirms that transverse reconstruction is accurate with a resolution of $\approx 1 MeV/c$.
- Clear relationship between longitudinal momentum and momentum response.

Total momentum response



Transverse momentum response



Emittance from Tracker Reconstruction

4D Emittance with momentum cut $120 < p_{tot} < 280$ MeV

Mode	Flip		Solenoid	
	US	DS	US	DS
3 mm	2.12±0.01	2.29±0.01	1.84±0.01	2.27±0.01
6 mm	2.39±0.01	2.51±0.01	2.33±0.01	2.45±0.01
10 mm	2.72±0.01	2.70±0.01	2.35±0.01	2.60±0.01

4D Emittance with $190 < p_z < 210$ MeV, $\sigma < 2.5$

Mode	Flip		Solenoid	
	US	DS	US	DS
3 mm	1.57±0.01	1.37±0.03	1.44±0.01	1.21±0.03
6 mm	1.83±0.01	1.55±0.03	1.74±0.01	1.38±0.03
10 mm	2.11±0.01	1.67±0.04	1.91±0.01	1.45±0.04

Beta from Tracker Reconstruction

β with momentum cut $120 < p_{tot} < 280$ MeV

Mode	Flip		Solenoid	
	US	DS	US	DS
3 mm	2030±7	2232±7	1837±7	2311±9
6 mm	1863±6	2131±6	1500±5	2183±8
10 mm	1674±6	2052±8	1476±6	2066±9

β with $190 < p_z < 210$ MeV, $\beta < 2500mm$

Mode	Flip		Solenoid	
	US	DS	US	DS
3 mm	2869±20	2217±41	2536±20	1945±48
6 mm	2505±16	2087±35	2106±15	1830±42
10 mm	2182±17	1955±41	1877±16	1682±47

Alpha from Tracker Reconstruction

α with momentum cut $120 < p_{tot} < 280$ MeV

Mode	Flip		Solenoid	
	US	DS	US	DS
3 mm	2.45±0.01	-1.202±0.004	-1.60±0.01	-1.76±0.01
6 mm	-2.17±0.01	-1.058±0.003	-1.72±0.01	-1.94±0.01
10 mm	-1.84±0.01	-0.897±0.003	-2.21±0.01	-2.10±0.01

α with $190 < p_z < 210$ MeV, $\beta < 2500mm$

Mode	Flip		Solenoid	
	US	DS	US	DS
3 mm	-3.09±0.02	-0.93±0.02	-2.93±0.02	-1.26±0.03
6 mm	-2.61±0.02	-0.76±0.01	-2.35±0.02	-1.13±0.03
10 mm	-2.15±0.02	-0.64±0.01	-2.02±0.02	-0.94±0.03

Conclusions

- Initial emittances smaller than advertised (Why)
- Dynamics from virtual planes show a great deal of emittance growth
  - Using cuts on p_z and p_{tot}.
  - Did not successfully introduce a beam selection cut
- Did produce significant emittance reduction from tracker reconstruction.
  - Similar cuts on p_z and p_{tot}.
  - Applied a 2.5σ beam selection criterion.