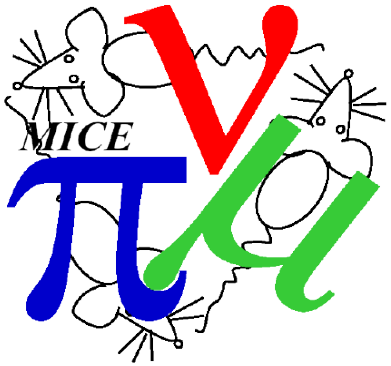
Tracking through Measured Misalignments



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Three Questions

- Can we observe measured misalignments using a beam based alignment technique, with only one module at a time powered?
- Can we observe measured misalignments using a beam-based alignment technique, with all modules powered?
- Can we tolerate measured misalignments and still observe cooling

- First study
- No material or detectors...
  - Probably given sufficient statistics, we can untangle these effects
- No thought given to proper magnet currents...
  - We can at least change FC, M1, M2 currents
  - We can probably change E1, CC, E2 currents
    - I do not intend to use momentum reconstruction in any analysis

Geometry as per 2015-04-22

	Z (local)	Z (global)	x0	y0	theta_x [rad]	theta_y [rad]
SSU						
Upstream Flange	-3256	-3956	0.09	-0.36		
Centre Centre coil	-1750	-2450	0.317856	-0.8974	0.0001512989	-0.000356837
Downstream Flange	247	-453	0.62	-1.61		
FC						
Upstream	-422	-422	0.588	-0.730		
Centre	0	0	0.431	-0.3385	-0.0003720379	0.0009277249
Downstream	422	422	0.274	0.053		
SSD						
Upstream Flange	853	453	0.8	-3.9		
Centre centre coil	2850	2450	0.609693	-8.64541	-9.529664896E-005	-0.0023762636
Downstream Flange	4106	3706	0.49	-11.63		

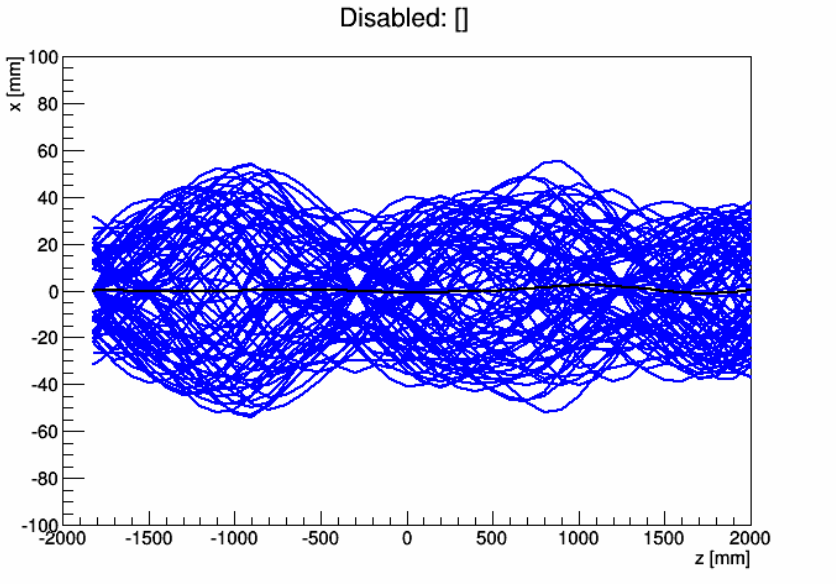
- Blue numbers are Rogers calculated position/alignment
- I insert test volumes, at the flange position, into my geometry and check that they return appropriate position rotation

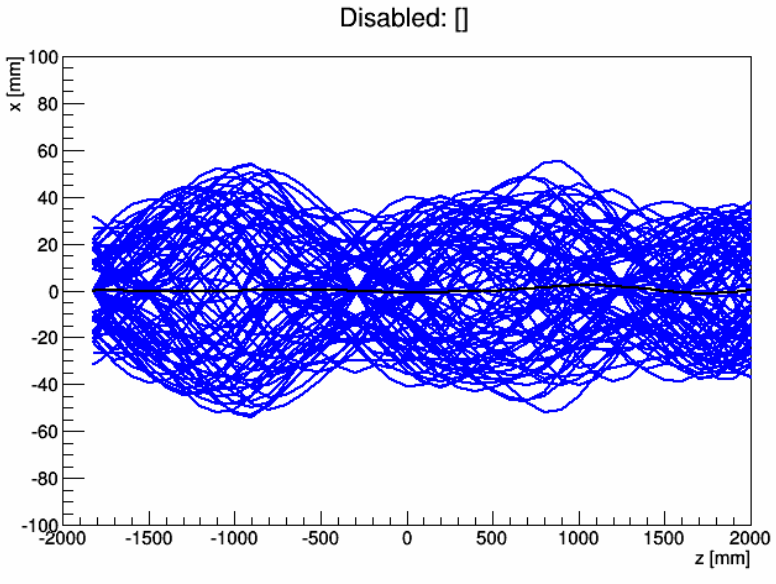
MAUS Coil Geometry

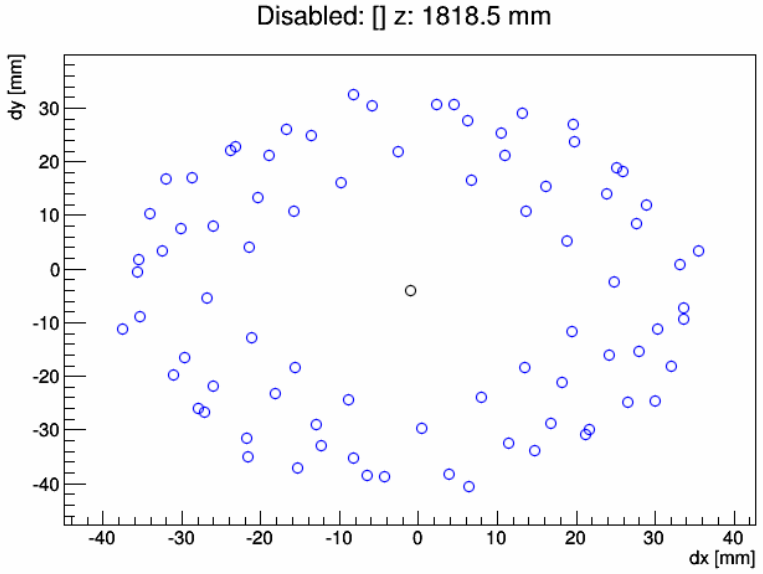
Name	Current Density	Position	Rotation Vector	Angle
FocusCoil_US	60	(0,0,-202.75)	(0,0,1)	0
FocusCoil_DS	60	(0,0,202.75)	(0,0,1)	0
MatchCoil1_DS	129	(0,0,861)	(0,0,1)	0
MatchCoil2_DS	120	(0,0,1300)	(0,0,1)	0
EndCoil1_DS	124.512	(0,0,1700)	(0,0,1)	0
CenterCoil_DS	144.896	(0,0,2450)	(0,0,1)	0
EndCoil2_DS	133.877	(0,0,3200)	(0,0,1)	0
MatchCoil1_US	129	(0,0,-861)	(0,0,1)	0
MatchCoil2_US	120	(0,0,-1300)	(0,0,1)	0
EndCoil1_US	124.512	(0,0,-1700)	(0,0,1)	0
CenterCoil_US	144.896	(0,0,-2450)	(0,0,1)	0
EndCoil2_US	133.877	(0,0,-3200)	(0,0,1)	0

Name	Current Density	Position	Rotation Vector	Angle
FocusCoil_US	60	(0.506431,-0.526596,-202.75)	(-0.928149,-0.372208,-0.000172653)	0.0572696
FocusCoil_DS	60	(0.355569,-0.150404,202.75)	(-0.928149,-0.372208,-0.000172653)	0.0572696
MatchCoil1_DS	129	(0.761119,-4.86953,861.004)	(0.999197,-0.0400713,4.76101e-05)	0.136259
MatchCoil2_DS	120	(0.719283,-5.91271,1300)	(0.999197,-0.0400713,4.76101e-05)	0.136259
EndCoil1_DS	124.512	(0.681165,-6.86321,1700)	(0.999197,-0.0400713,4.76101e-05)	0.136259
CenterCoil_DS	144.896	(0.609693,-8.64541,2450)	(0.999197,-0.0400713,4.76101e-05)	0.136259
EndCoil2_DS	133.877	(0.53822,-10.4276,3200)	(0.999197,-0.0400713,4.76101e-05)	0.136259
MatchCoil1_US	129	(0.55827,-1.46441,-861)	(0.920662,0.390361,-6.96476e-05)	0.0222071
MatchCoil2_US	120	(0.49185,-1.30776,-1300)	(0.920662,0.390361,-6.96476e-05)	0.0222071
EndCoil1_US	124.512	(0.43133,-1.16502,-1700)	(0.920662,0.390361,-6.96476e-05)	0.0222071
CenterCoil_US	144.896	(0.317856,-0.897397,-2450)	(0.920662,0.390361,-6.96476e-05)	0.0222071
EndCoil2_US	133.877	(0.204382,-0.629769,-3200)	(0.920662,0.390361,-6.96476e-05)	0.0222071

All Modules Powered

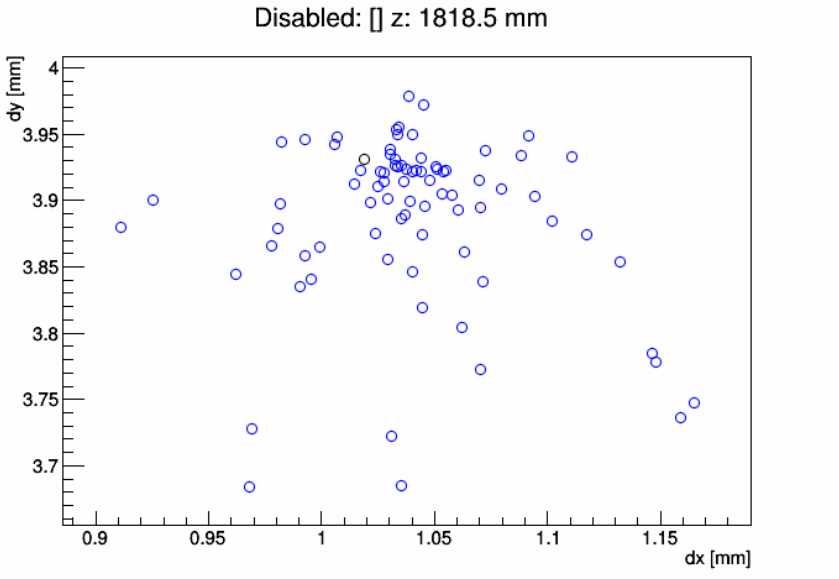


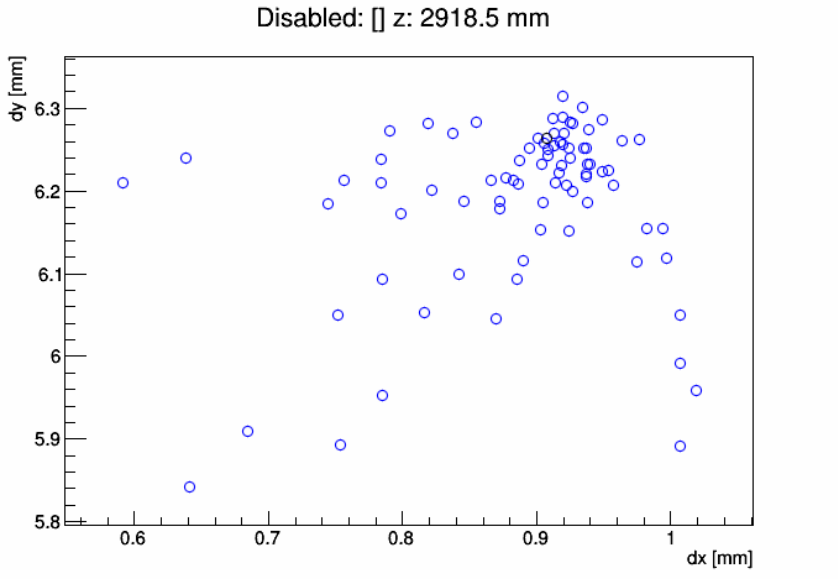




- Tracking, shell of particles
  - 8 mm amplitude
  - Typical of low emittance beamline
- Beam is basically well behaved

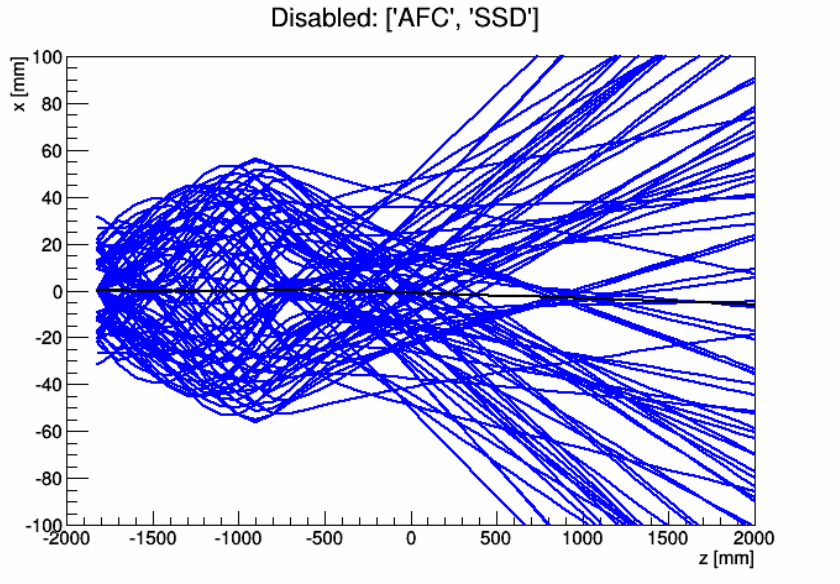
All Modules Powered

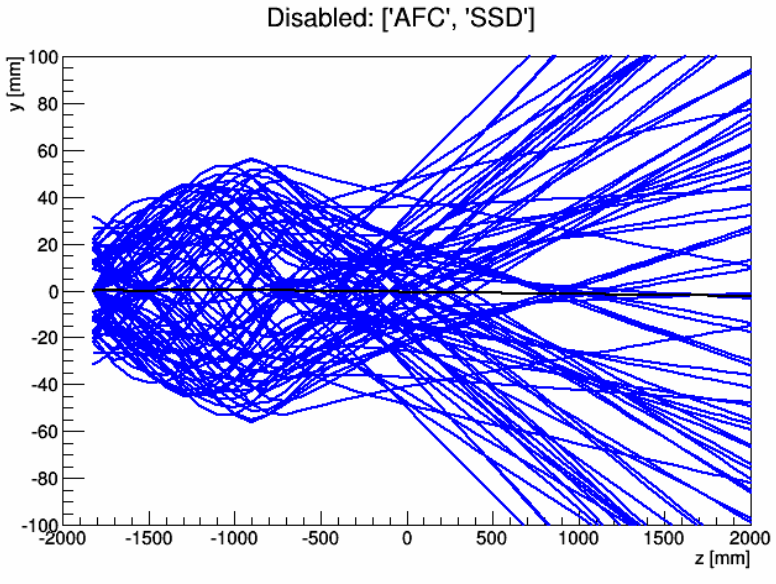


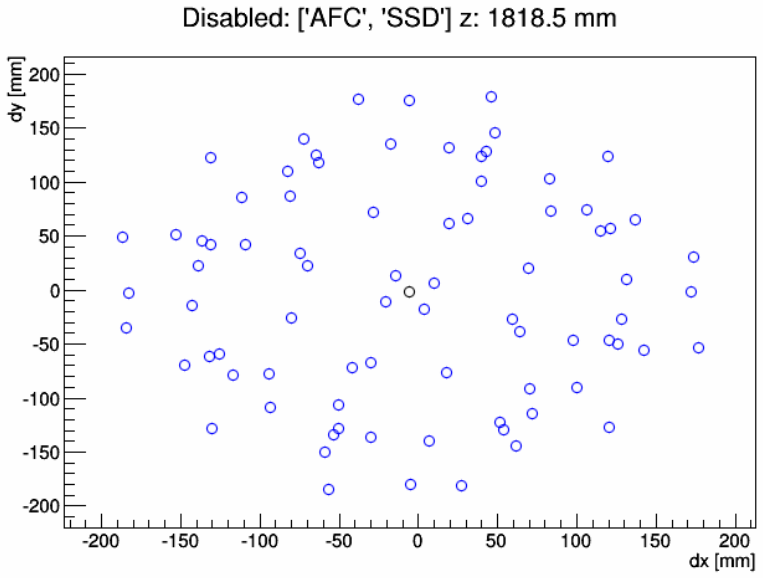


- Transverse displacement of the particles (dx, dy), following misaligment, at downstream tracker planes is readily observable
  - No guarantee that we can untangle the different magnet misalignments from each other

SSU Powered, reference currents

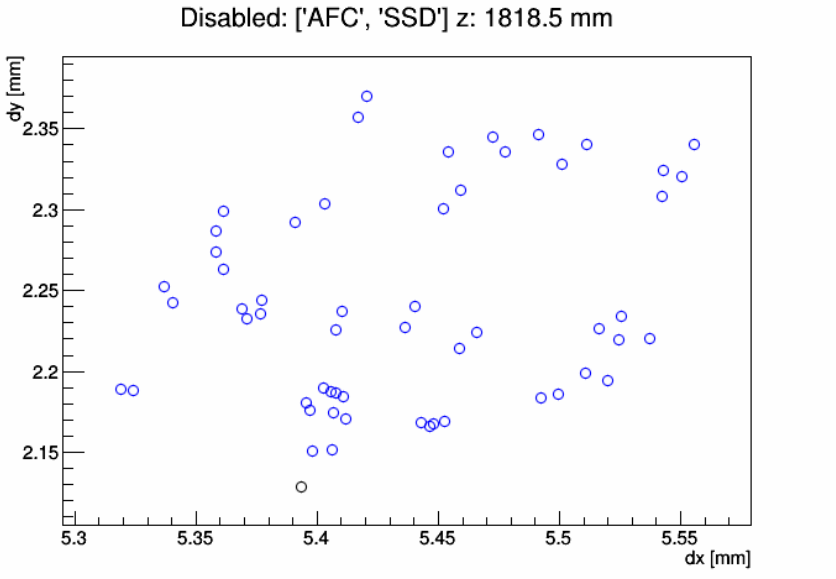


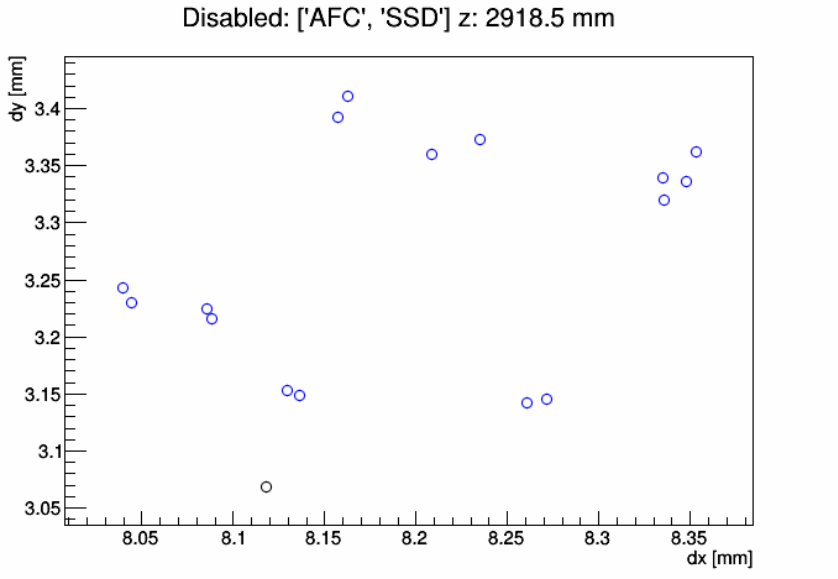




- Tracking, shell of particles
  - 8 mm amplitude
  - Typical of low emittance beamline
- Straight tracks downstream

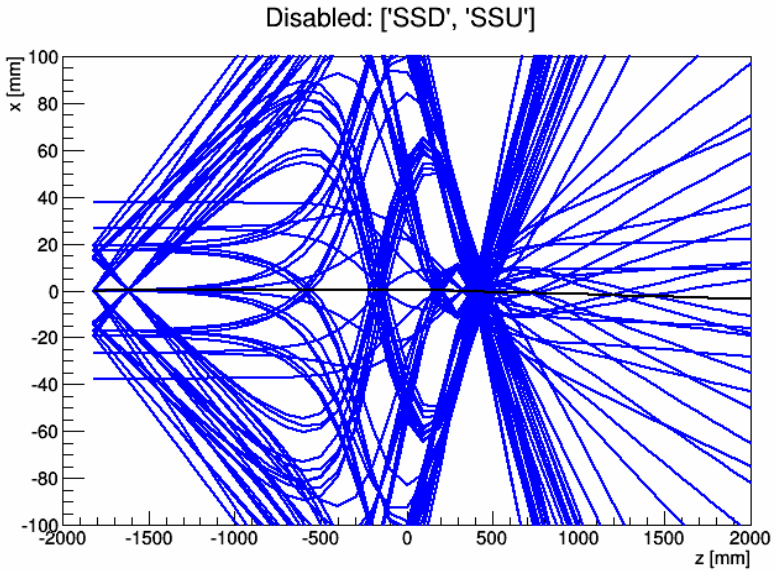
SSU Powered

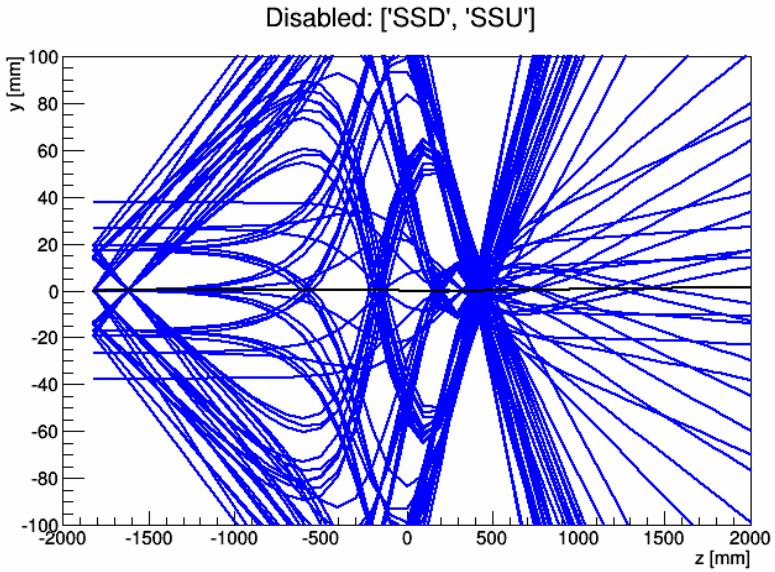


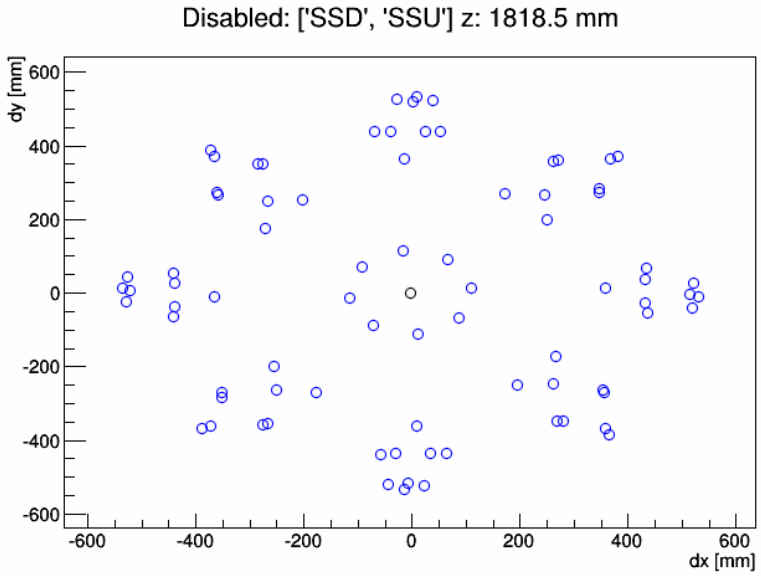


- Transverse offset at downstream tracker planes is readily observable

AFC Powered, reference currents

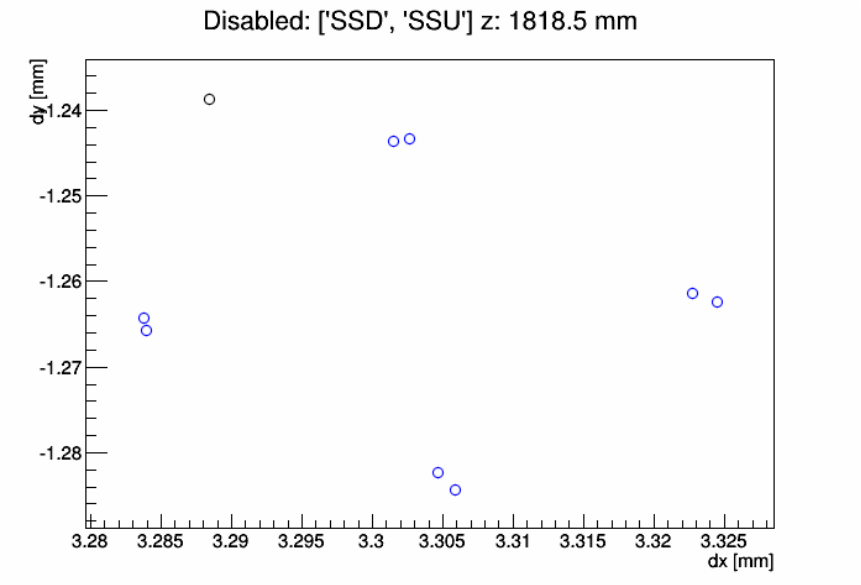






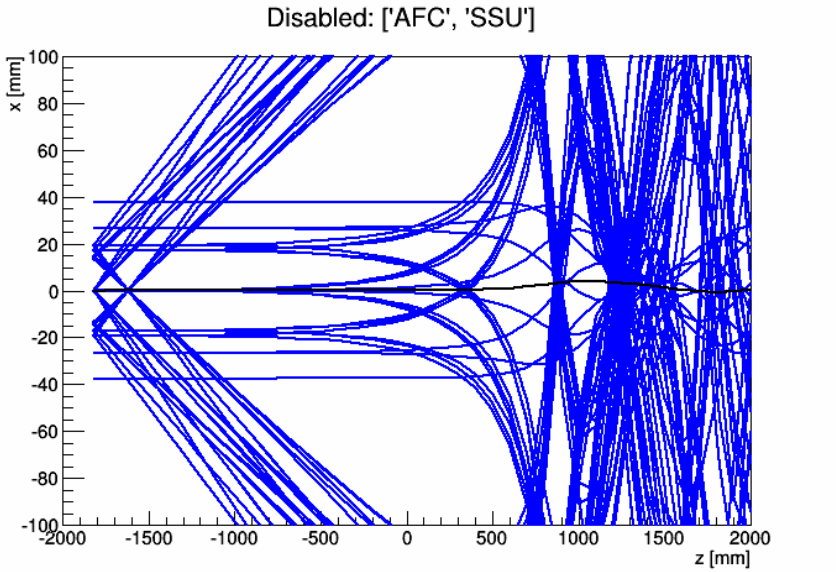
- Tracking, shell of particles
  - 8 mm amplitude
  - Typical of low emittance beamline
- Where SSU is not powered, I insert beam with unrealistic 333 mm beta but not angular momentum

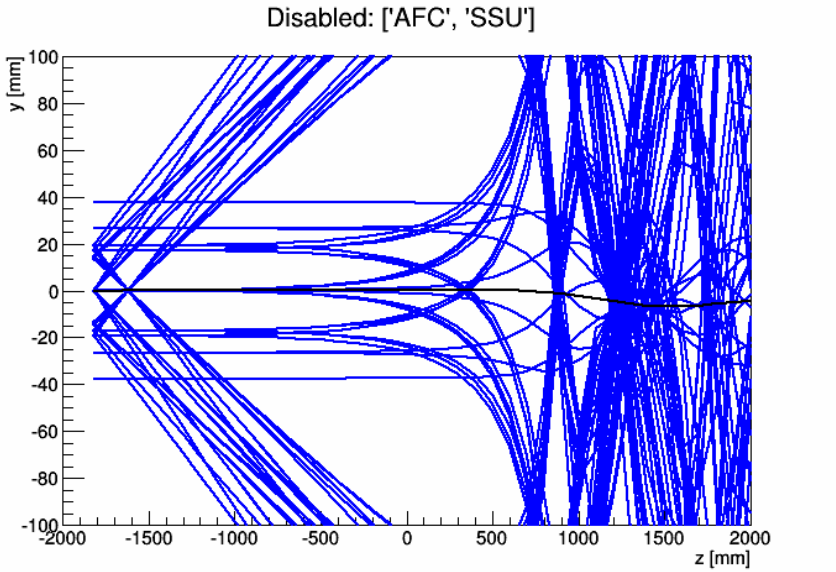
AFC Powered

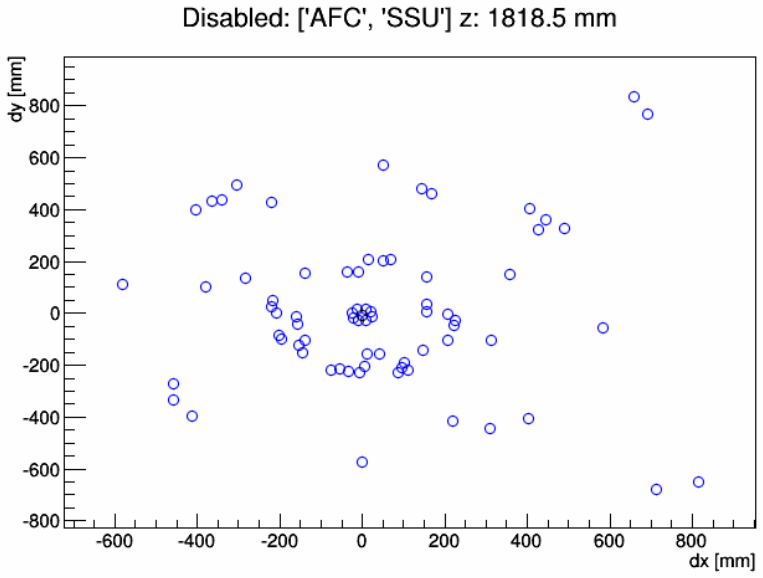


- Transverse offset at downstream tracker planes is readily observable
  - Note, no tracks at z = 2918.5
  - Transmission can be improved by tuning down the AFC current

SSD Powered, reference currents

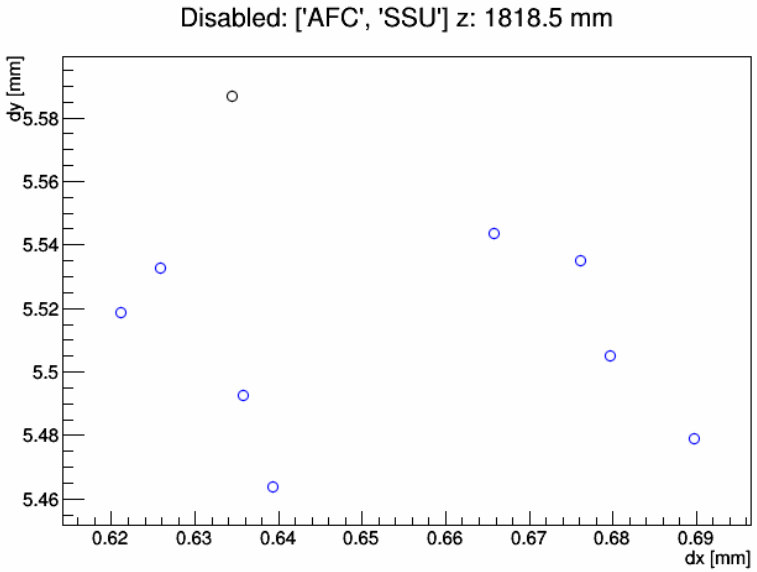


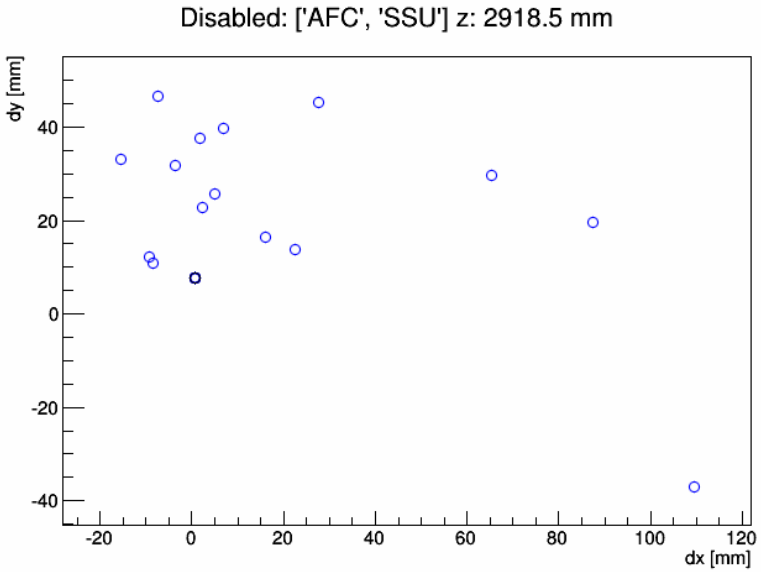




- Tracking, shell of particles
  - 8 mm amplitude
  - Typical of low emittance beamline
- Where SSU is not powered, I insert beam with unrealistic 333 mm beta but not angular momentum

SSD Powered

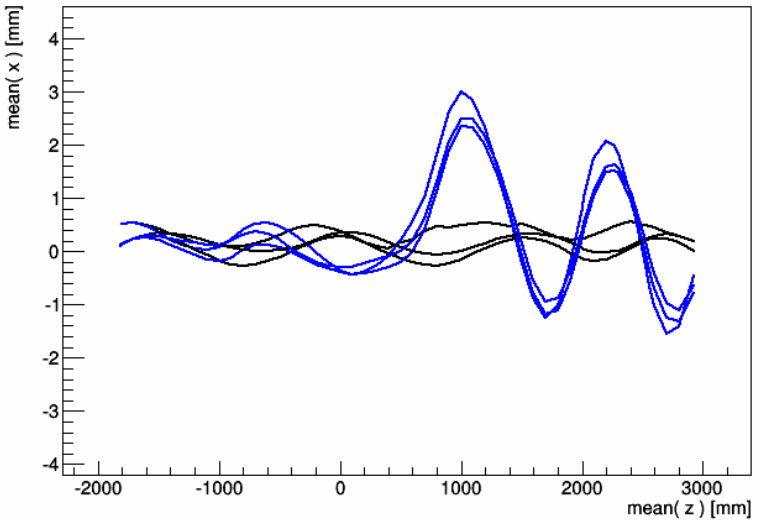




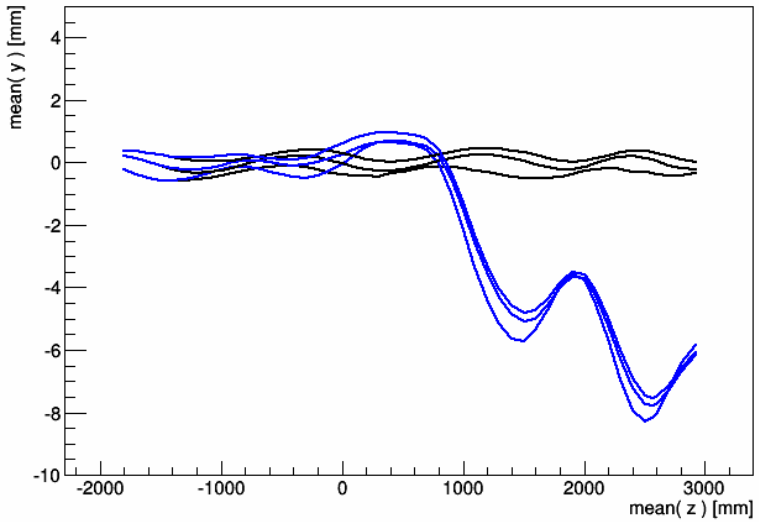
- Transverse offset at downstream tracker planes is readily observable
  - Note displacements ~ 100 mm

Beam centroid

10k muons



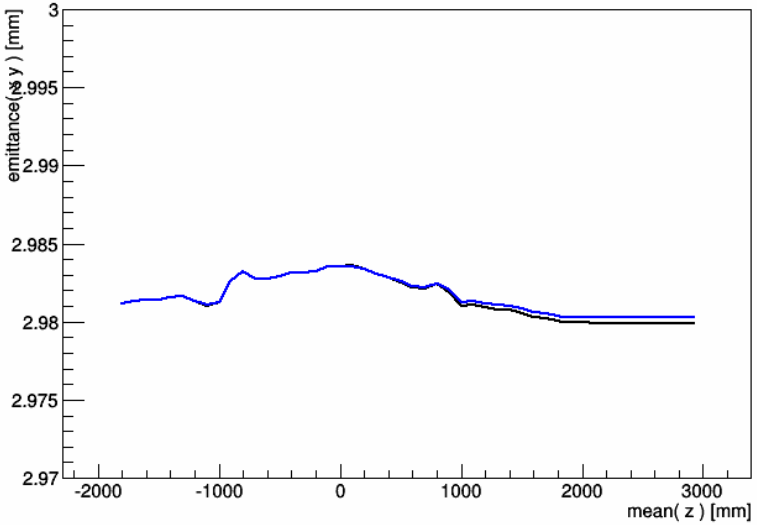
10k muons



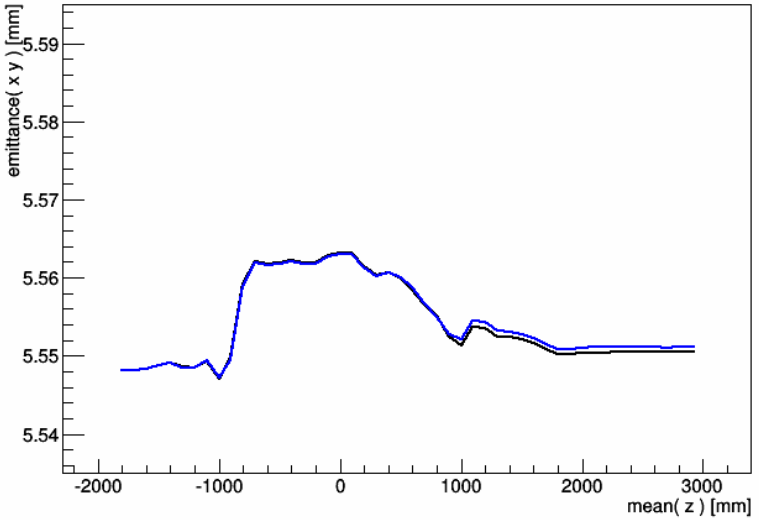
- Now track sample of particles through the cooling channel
  - All magnets powered
  - Random seed = initial emittance
- BLACK: magnets with perfect alignment (3, 6, 12 mm emittance)
- BLUE: magnets with measured alignment (3, 6, 12 mm emittance)
- X-z: no observation outside of statistics – sample too small?
- Y-z: observe systematic displacement of beam mean

Beam emittance

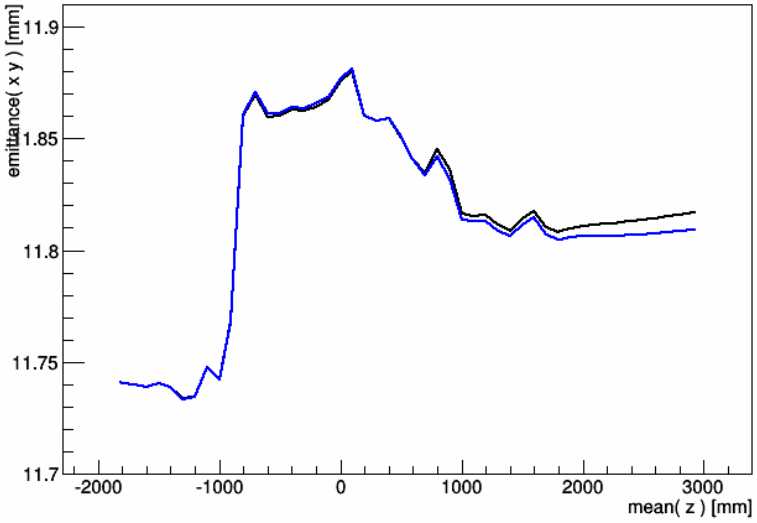
1k muons



1k muons



1k muons



- How does the emittance respond?
  - BLACK: magnets with perfect alignment
  - BLUE: magnets with measured alignment
  - Small increase in emittance

From the Beam's Perspective

- The measured misalignments are expected to induce a transverse kick to individual particles >> tracker resolution i.e. can be observed
  - Both for individual modules and the fully powered assembly
- The measured misalignments are expected to induce a transverse kick to the beam >> tracker resolution i.e. can be observed
- The number of particles and analysis required to make these observations are not determined
  - Number of particles => how much noise in the system?
  - Analysis => fit to position data through misaligned fields...
- The beam emittance does not appear to be perturbed by the misalignment
  - Something of a surprise, could do with a cross-check here
- Should choose magnet currents to catch more particles
- Show that it is within the possibility of the detectors
  - Now need to develop an analysis to show it works