Muon Monitor Data Analysis and Simulation

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New Perspectives 2019

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  - Correlation between muons and neutrinos
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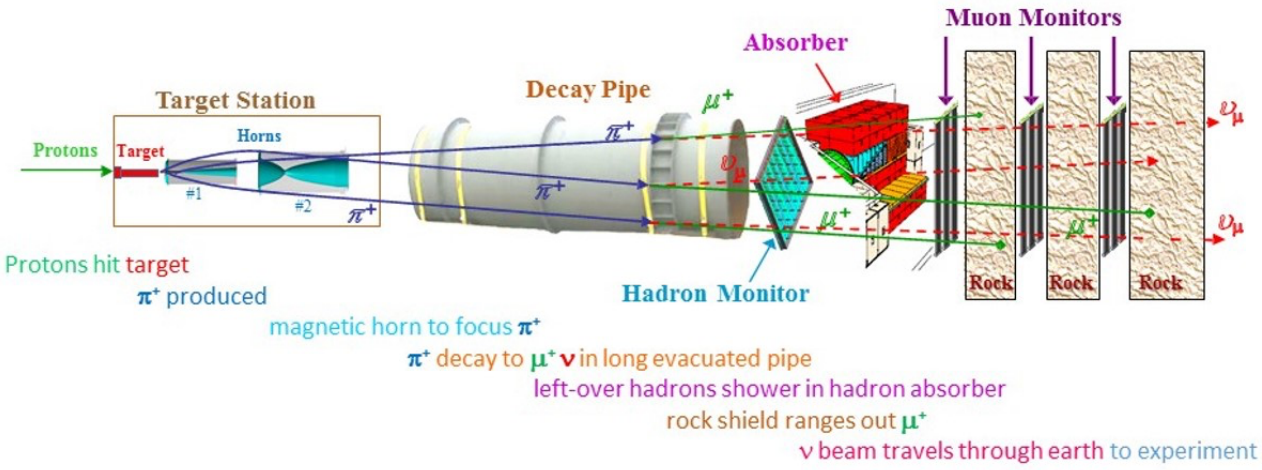
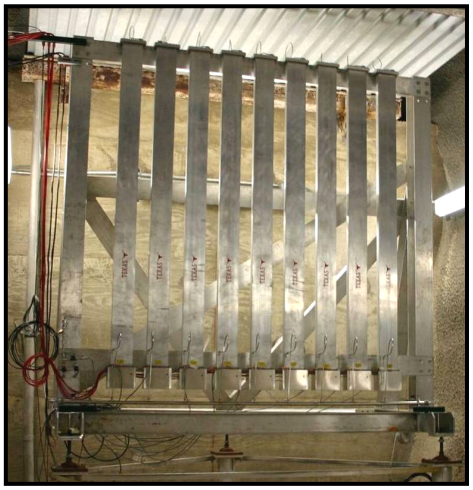
Introduction





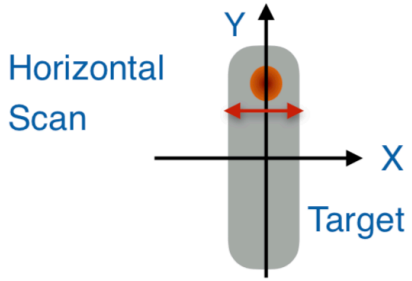
Muon Monitor Array

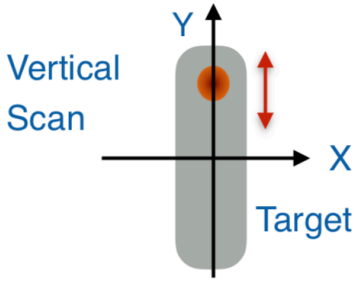
- Purposes
  - Find correlation between MM data and simulation
  - Use a combination of data and simulation to identify issues with beam
    - Incoming proton beam
    - Neutrino flux
- We simulate the effect of the variation in
    - Beam position
    - Spot size
    - Horn current
- Agreement between MM data and simulation suggests that the simulation is reliable.

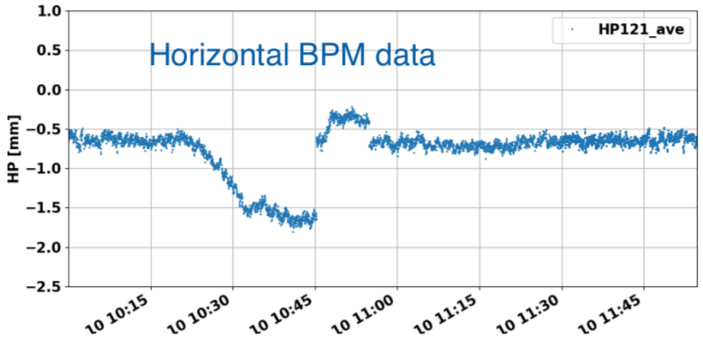
→ Why :
Without MINOS data, we rely on MM

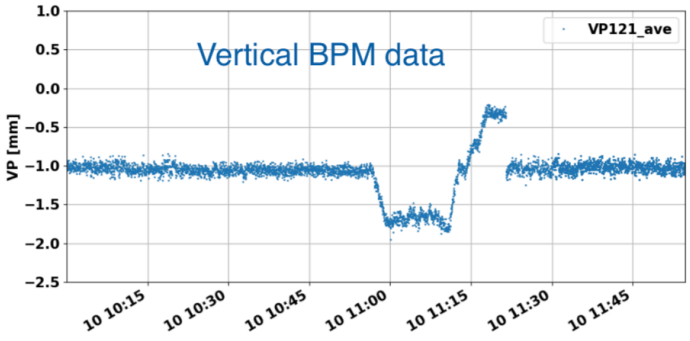
Data with Beam scan

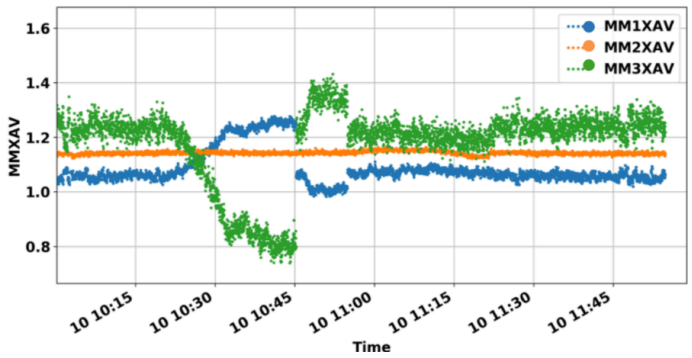
Athula

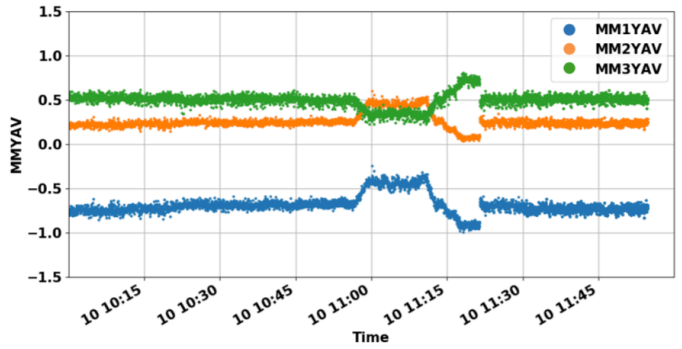












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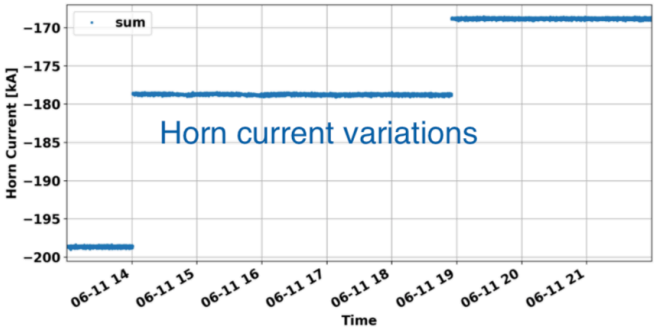
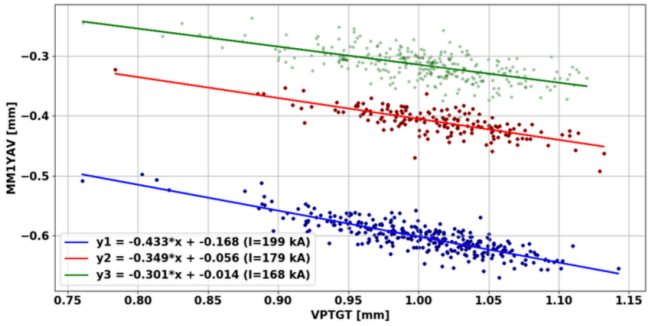
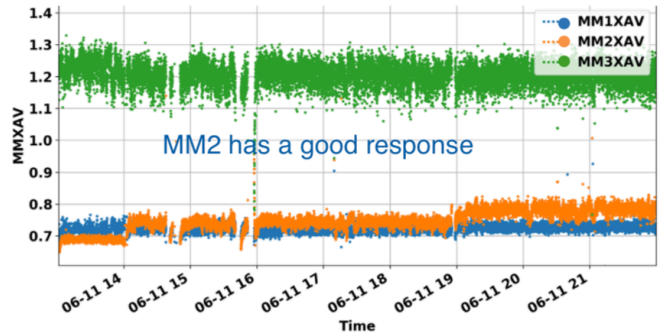
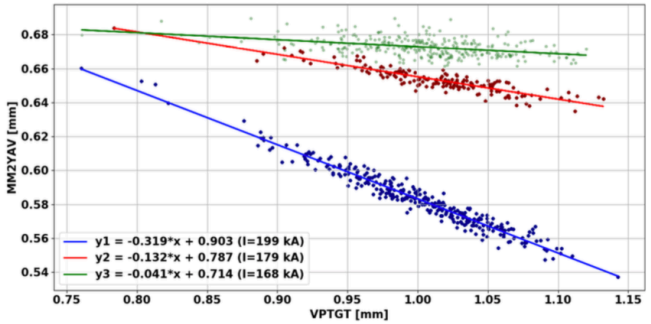
Data with Horn current scan

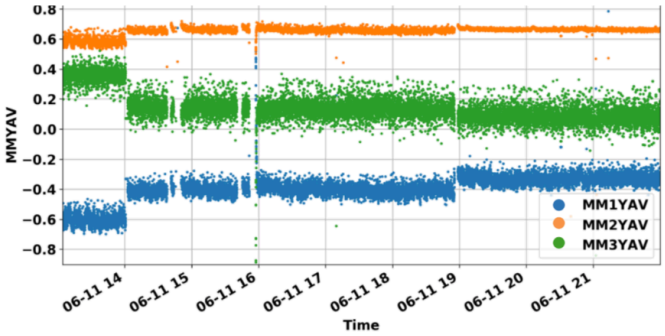
Athula

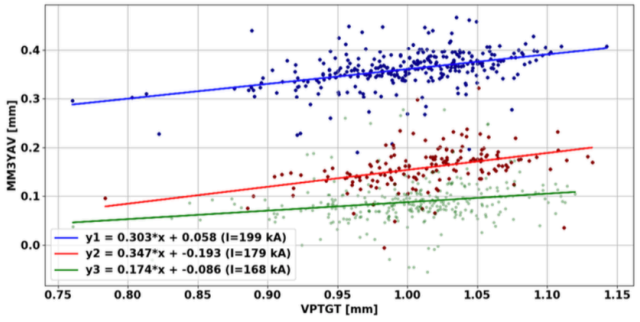












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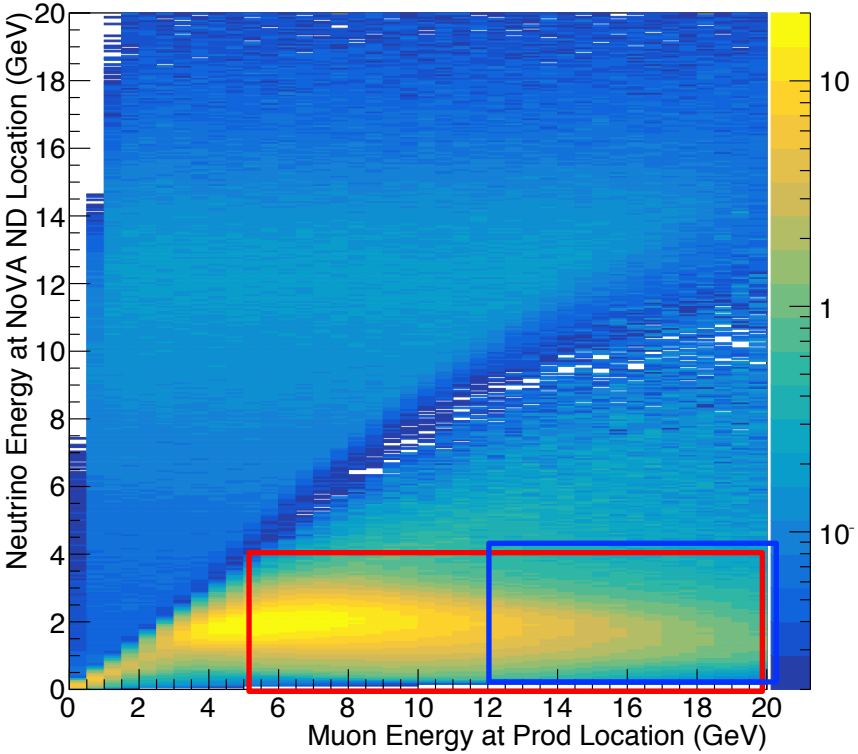
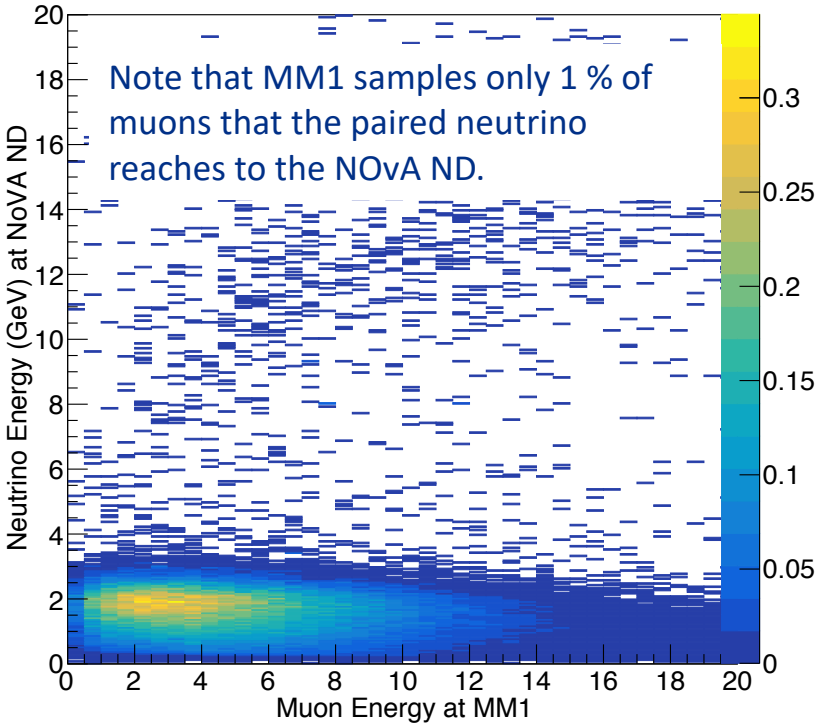
Correlation between muons and neutrinos

Amit

MM1 can see a core part of muons





Range of detectable muons in MM1 (MM2)

Note that muon energy at MM1 has 5 GeV less than energy at production due to energy loss in Hadron Absorber

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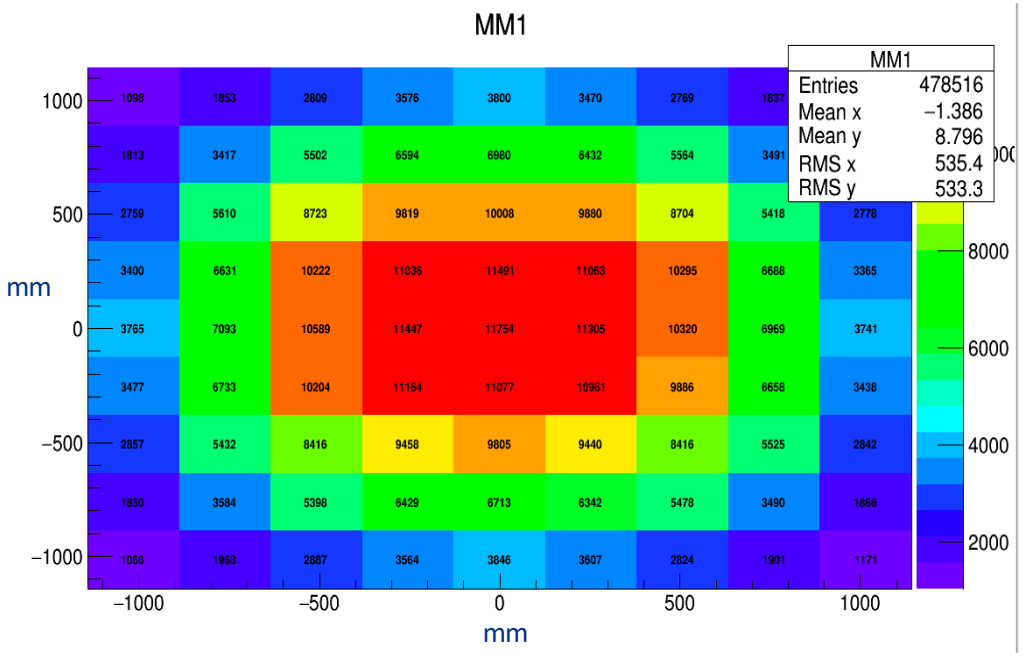
Horizonal Beam Scan Simulation

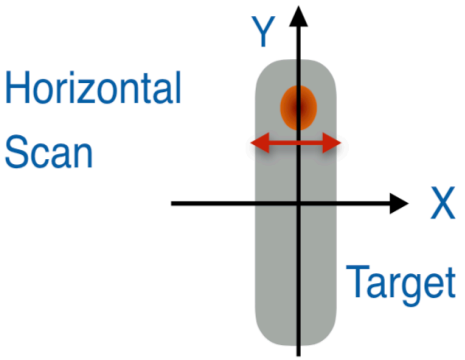


What we have for muons

- Horizonal position
- Vertical position
- Momentum at MMs in x, y and z directions
- Production Momentum in x, y and z directions

There are 81 pixels at each muon monitor.

The number on each pixel is the number of muons hitting that area.



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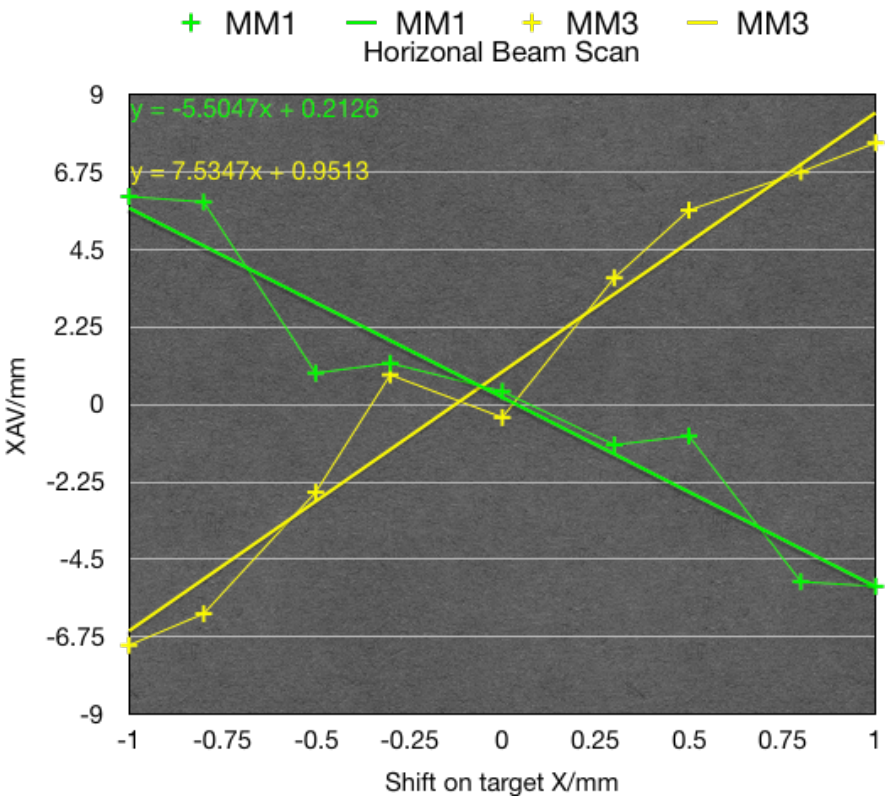
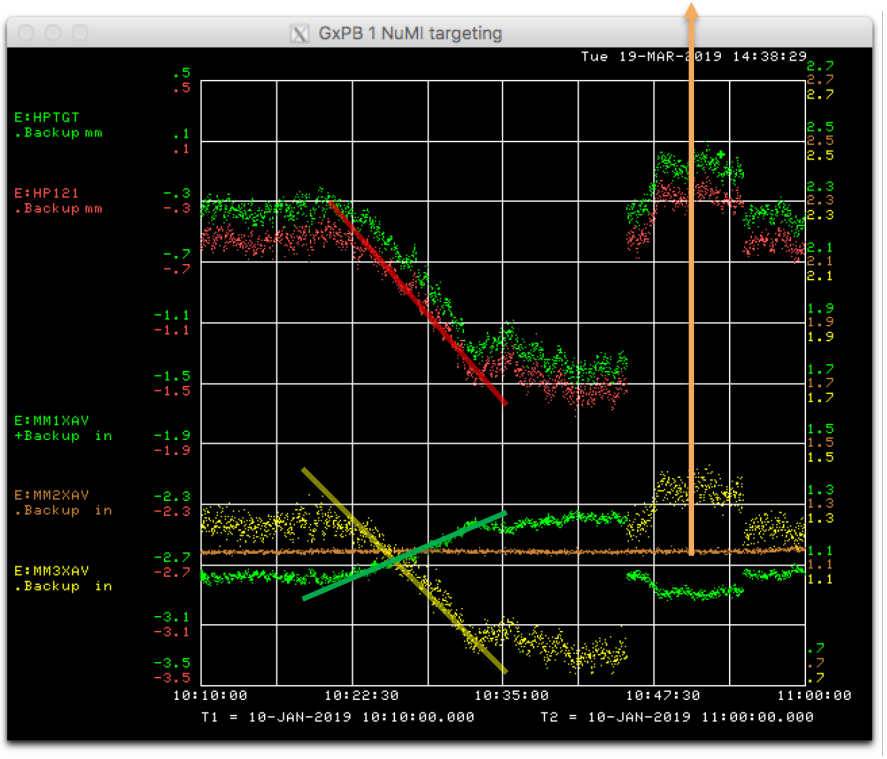
Horizonal Beam Scan Simulation vs data



There are some issues on MM2 data



MM1:The shift at MM1 is inverse to shift on target. The slope is -5.5 .

MM3:The shift at MM3 is proportional to shift on target. The slope is 7.5 .

MM1:The shift at MM1 is inverse to shift on target. The slope is -4.8 .

MM3:The shift at MM3 is proportional to shift on target. The slope is 10.6 .

Simulation results are consistent with data

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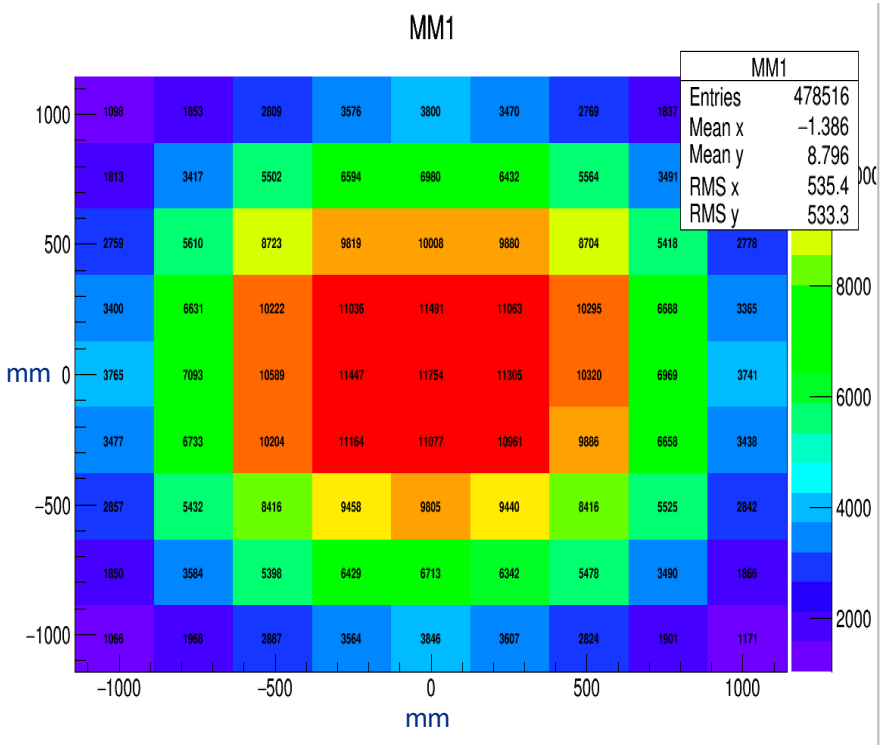
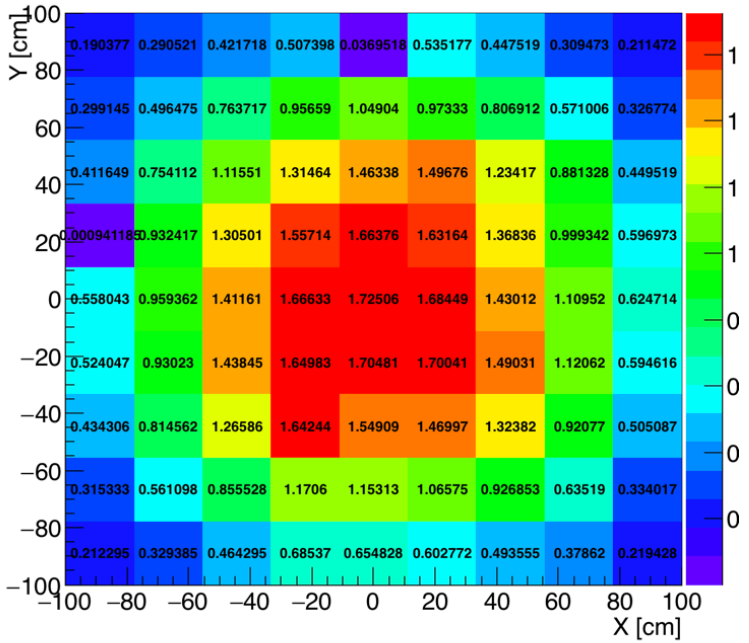
Different spot size(1.4 mm,1.3 mm,0.9 mm)

Number of muons at MM1



Signal voltage at MM1



From Athula

Simulation: spot size 1.4 mm

Data: spot size 1.4 mm

Both have a similar distribution. The 9 central pixels are very flat.

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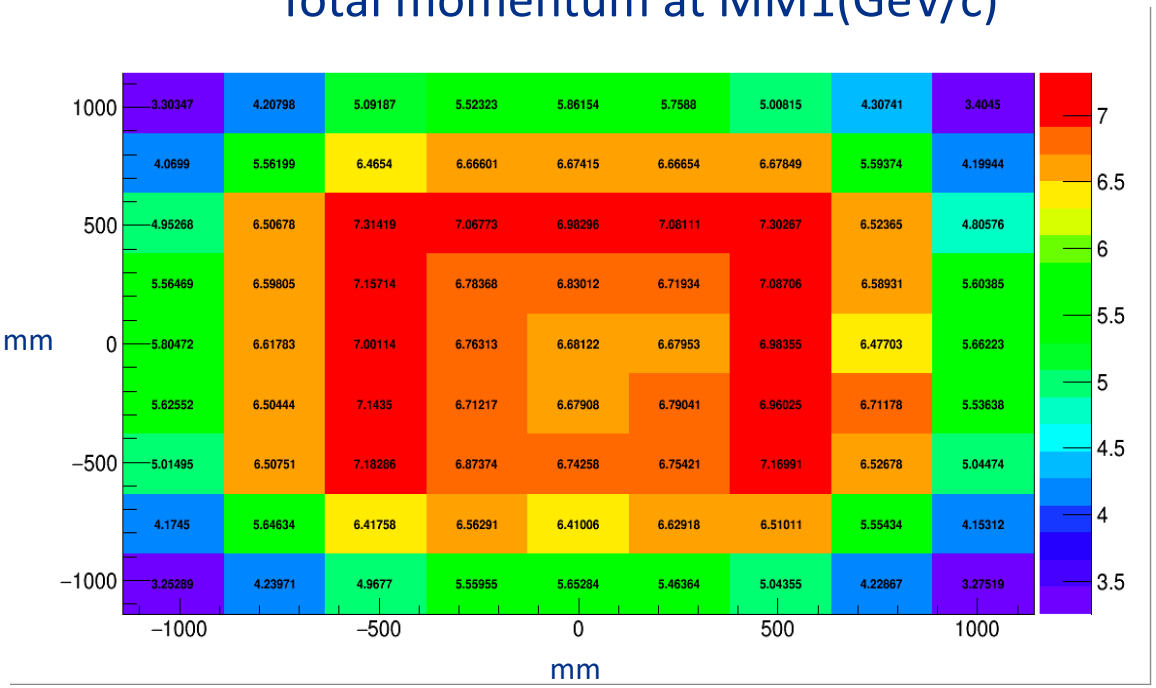
Different spot size(1.4 mm,1.3 mm, 0.9 mm)

Total momentum at MM1(GeV/c)



This 2-D histogram show how the muons with different momentum are distributed at muon monitor 1.

The number on each pixel is average total momentum of muons(GeV/c)

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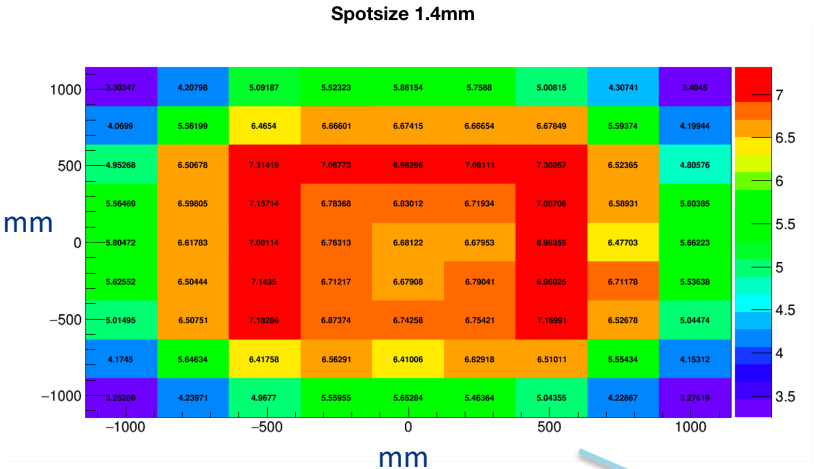
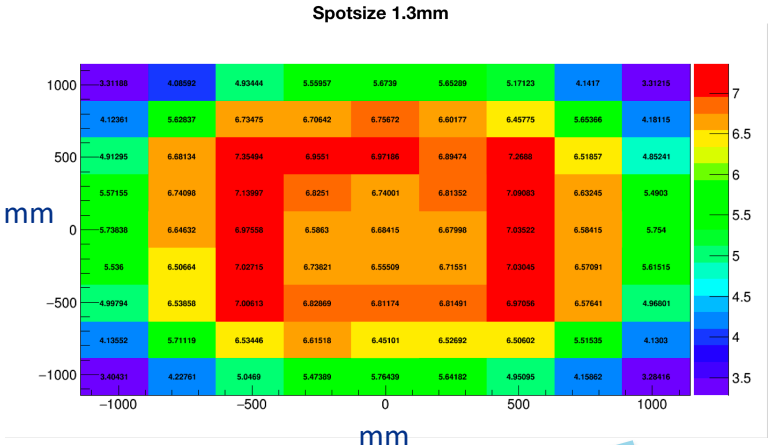
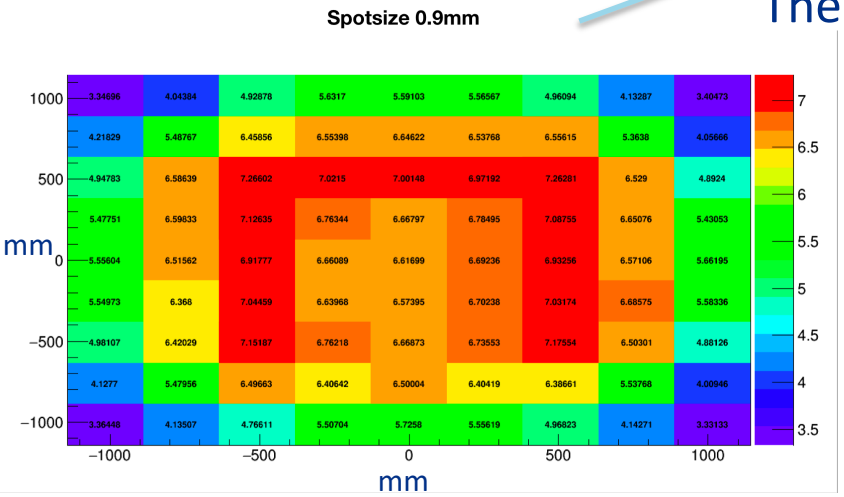
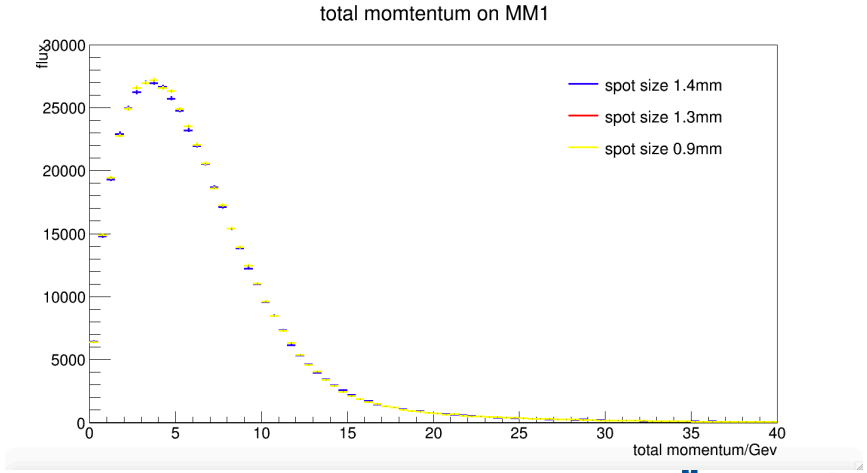
Total momentum histograms at MM1





All have the “ring structure”.
The difference is small.





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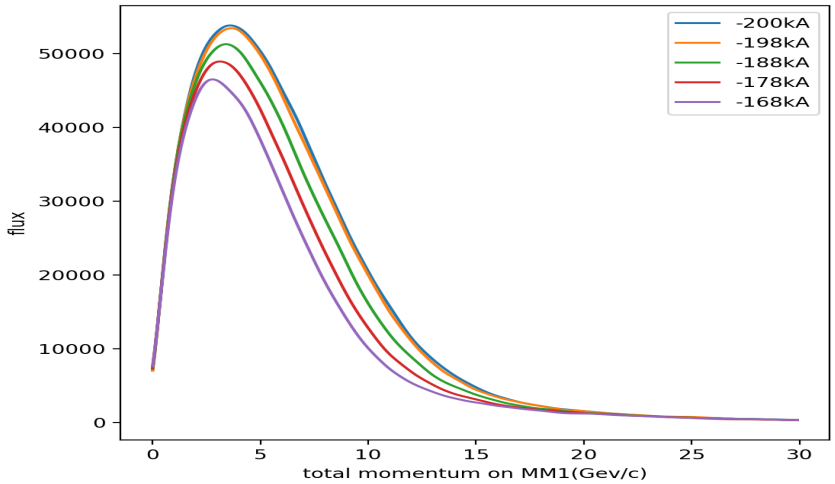
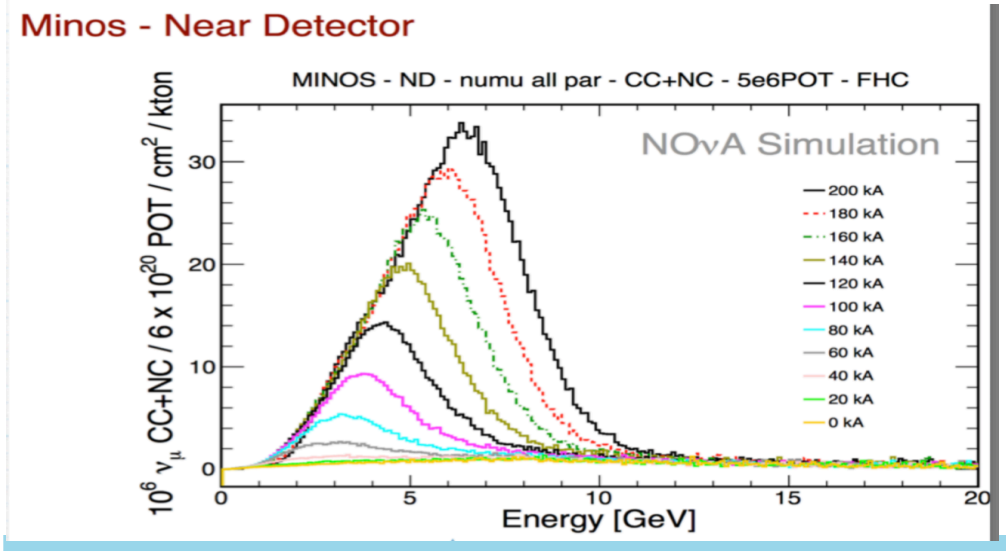
Different spectra for different horn current

Total momentum at MM1





There should be a correlation between spectra for neutrinos and muons.

This plot is from Anna Holins's numiX talk (numix Docdb, 210v1)

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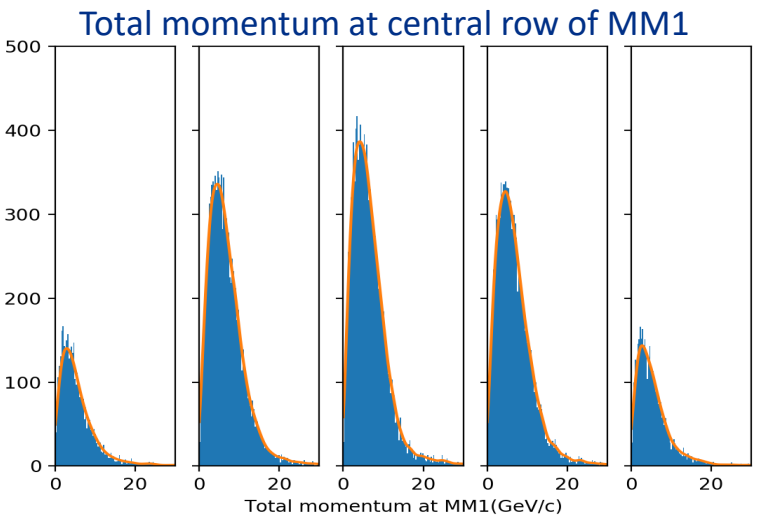
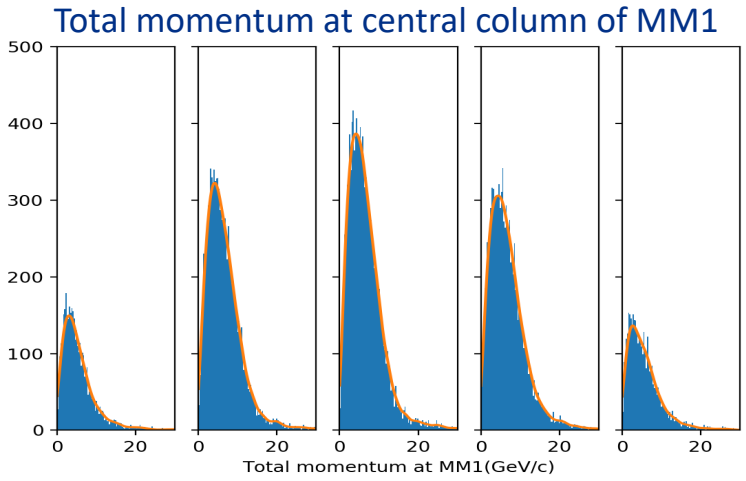
Different spectra for different pixels

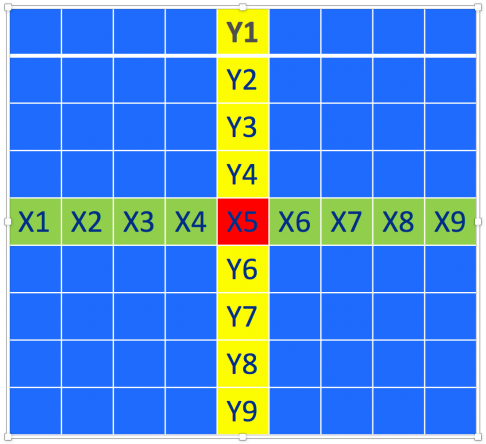


X1 X3 X5 X7 X9

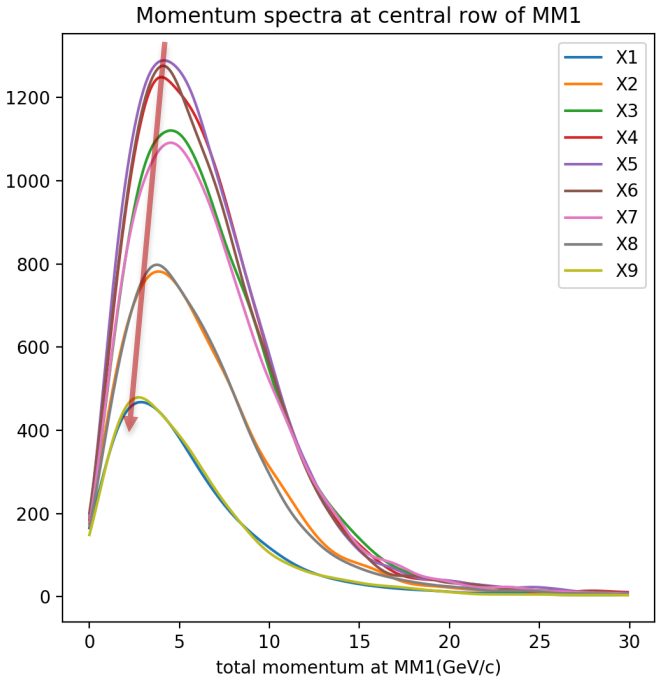


Y1 Y3 Y5 Y7 Y9

MM1



Horizonal



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Summary

- Data study with different parameters(beam position, horn current)
- Simulation
  - For different beam position on target
    - Simulation results are consistent with true data
  - For different spot size
    - 2D histograms of total momentum at MM1 all have a ring structure
  - For different horn current
    - Different pixels have different spectra
- Our ultimate goal is to use pattern recognition on MM1 & MM2 to be able to tell what the proton beam status is and how it affects the neutrino beam quality

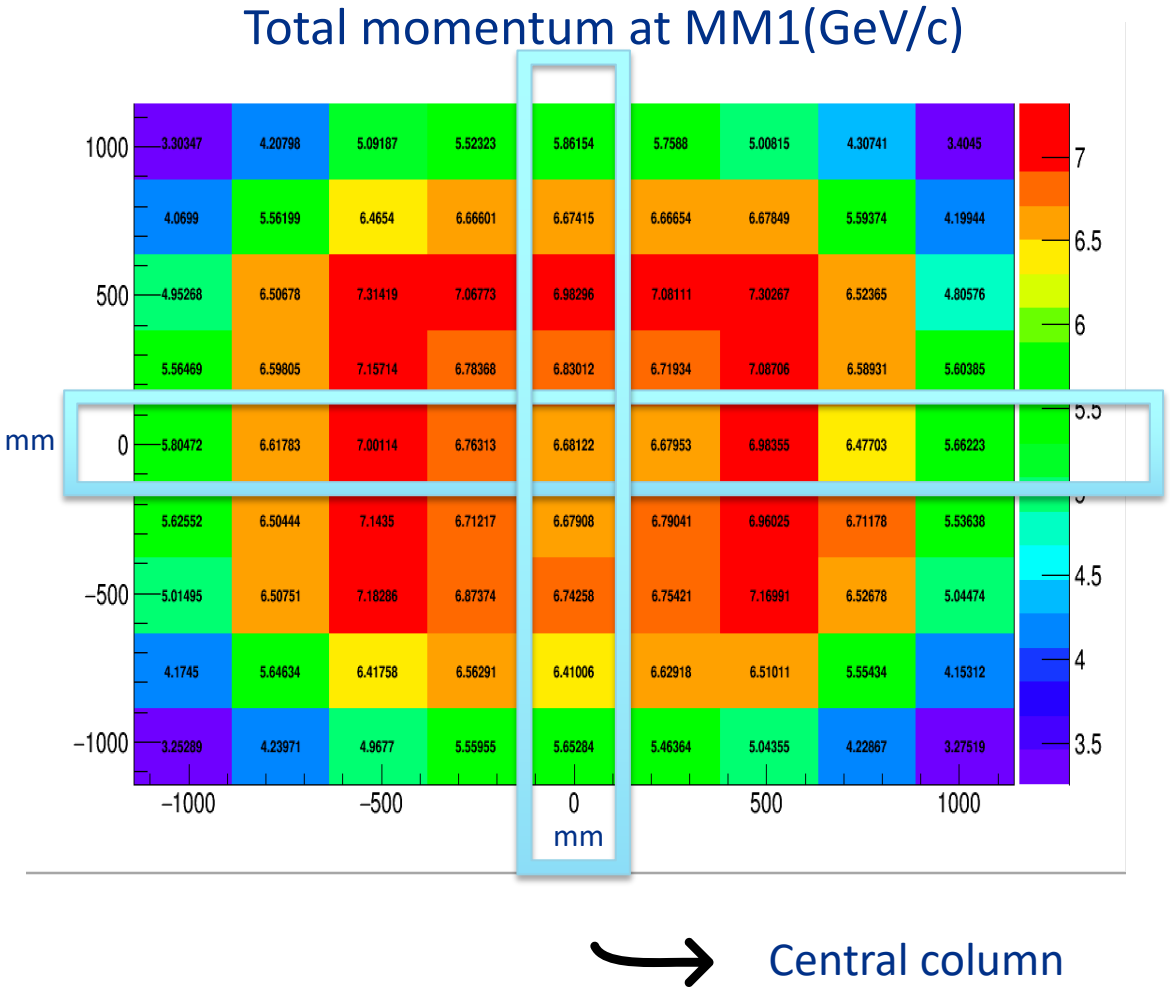
Questions

- Please contact yyu79@hawk.iit.edu for any questions regarding MM simulation

THANK YOU

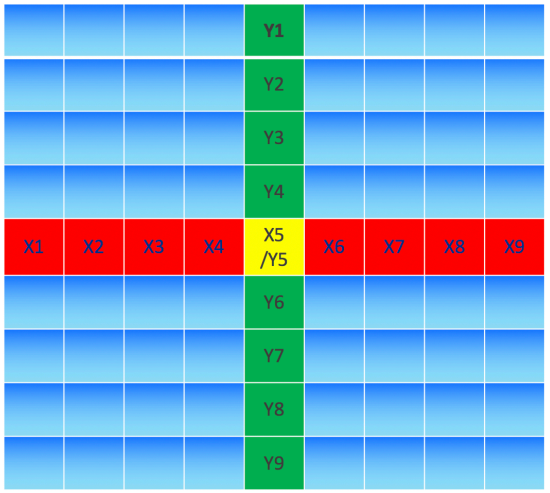
BACK UP

Different spectra for different pixels



We look into the spectra for pixels in central row and central column.

→ Central row



→ Central column

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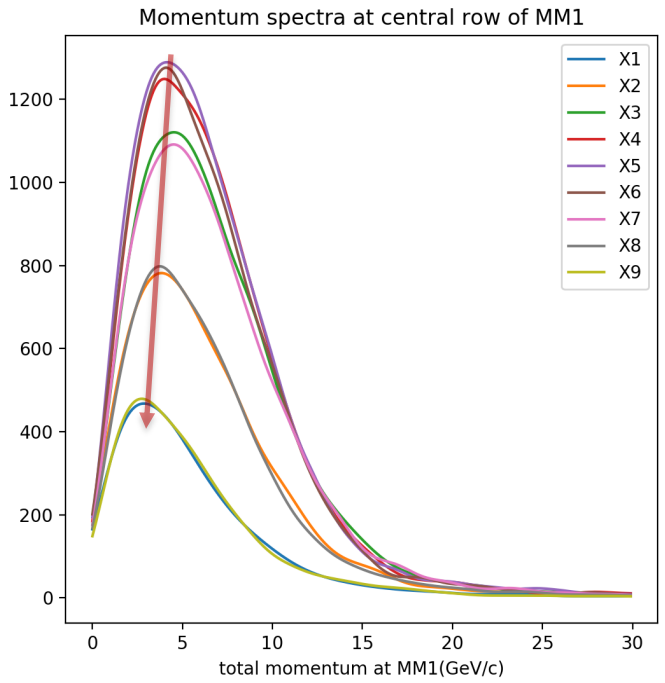
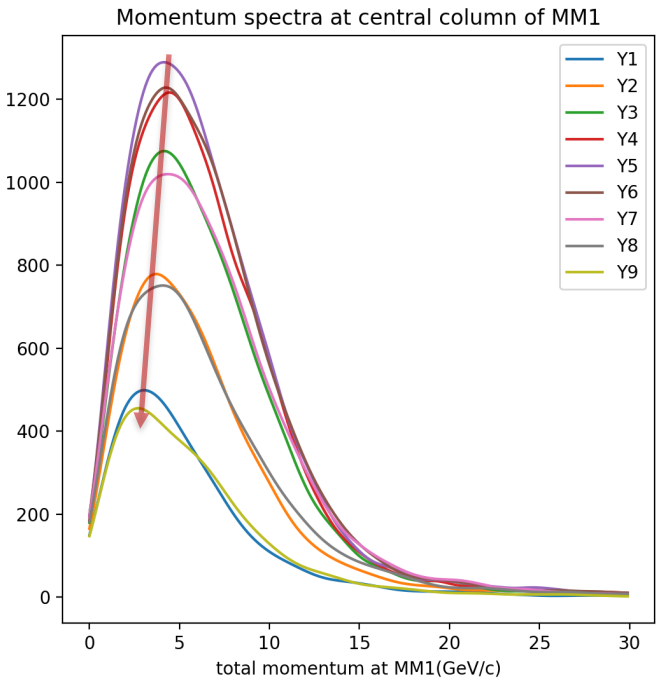
Different spectra for different pixels





The peaks of the spectra move to low momentum from center to edge of MM1.

The peaks of the spectra move to low momentum too.

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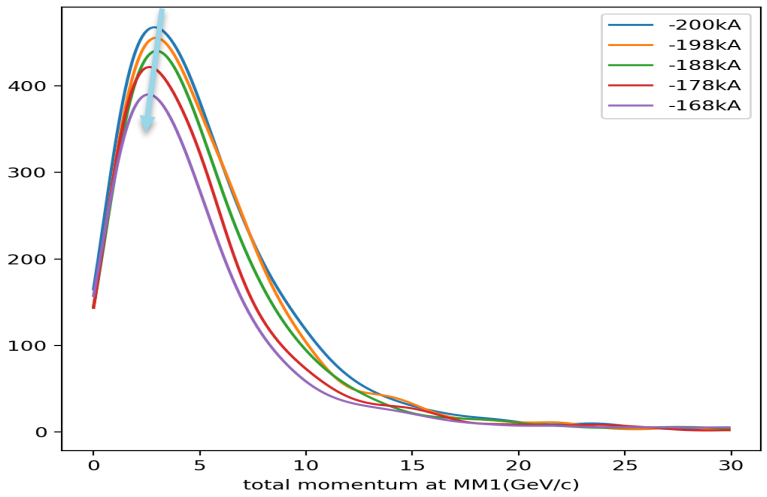
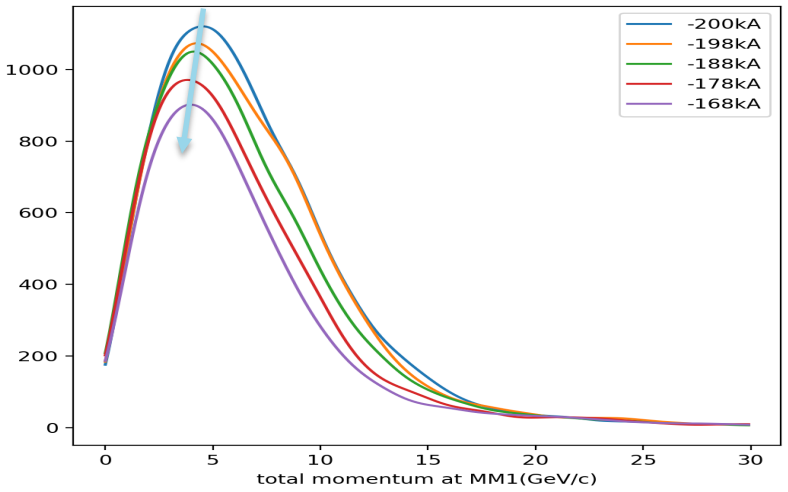
Different spectra for different horn current

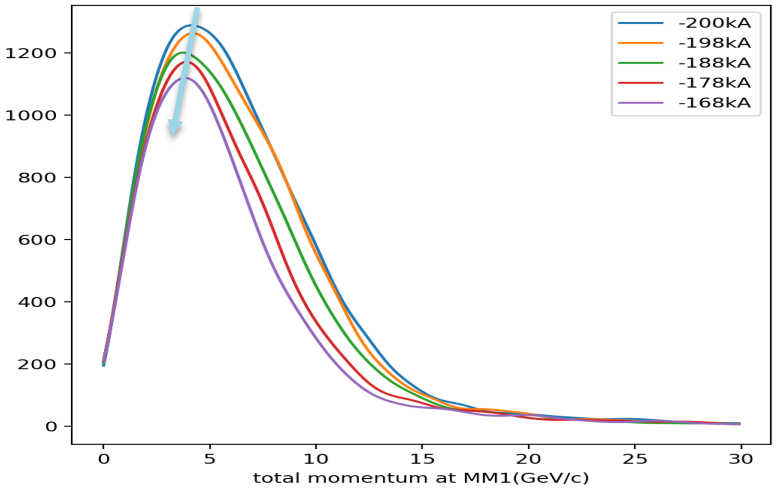
Total momentum at X1 of MM1



Total momentum at X3 of MM1



Total momentum at X5 of MM1



The peaks move to low momentum with lower horn current.
The intensity decrease with lower horn current

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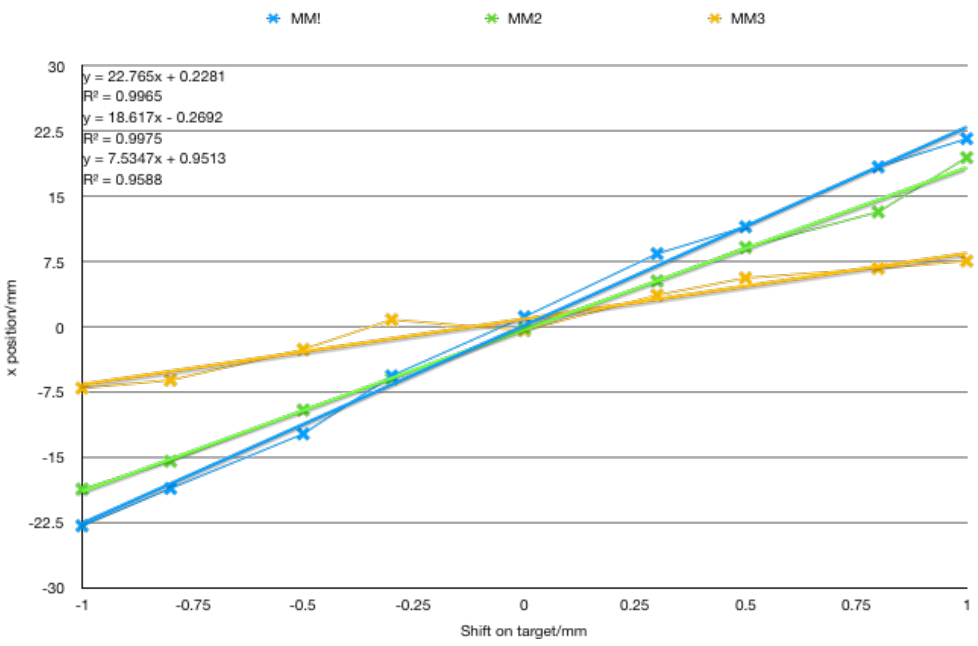
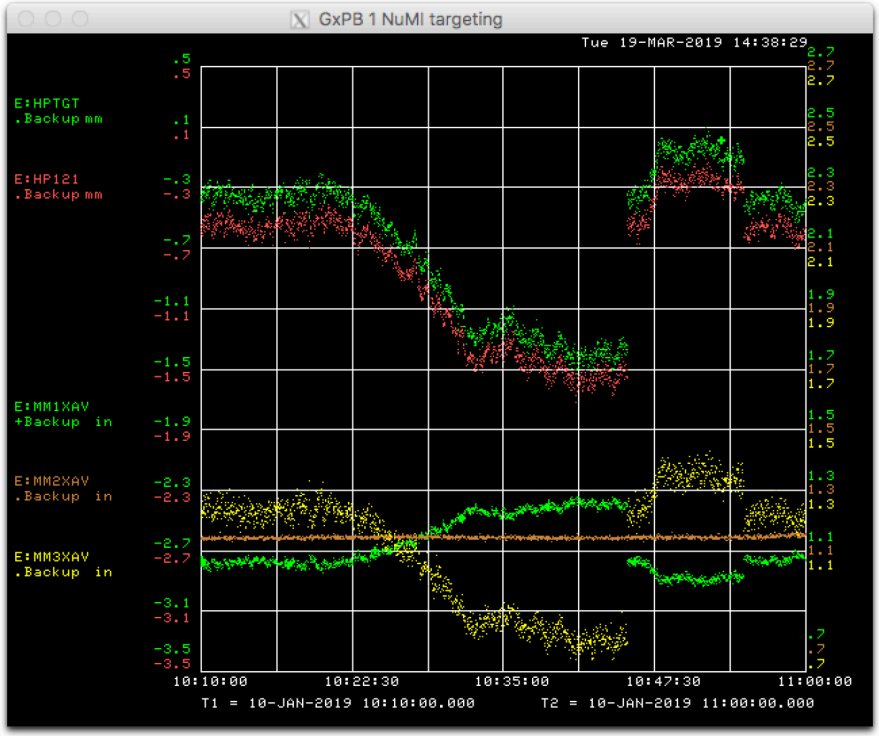
Horizonal simulation with a production energy cut





Simulation for horizonal beam scan

Slope of MM3 :7.5347

Horizonal beam scan

Slope of MM3 :10.683

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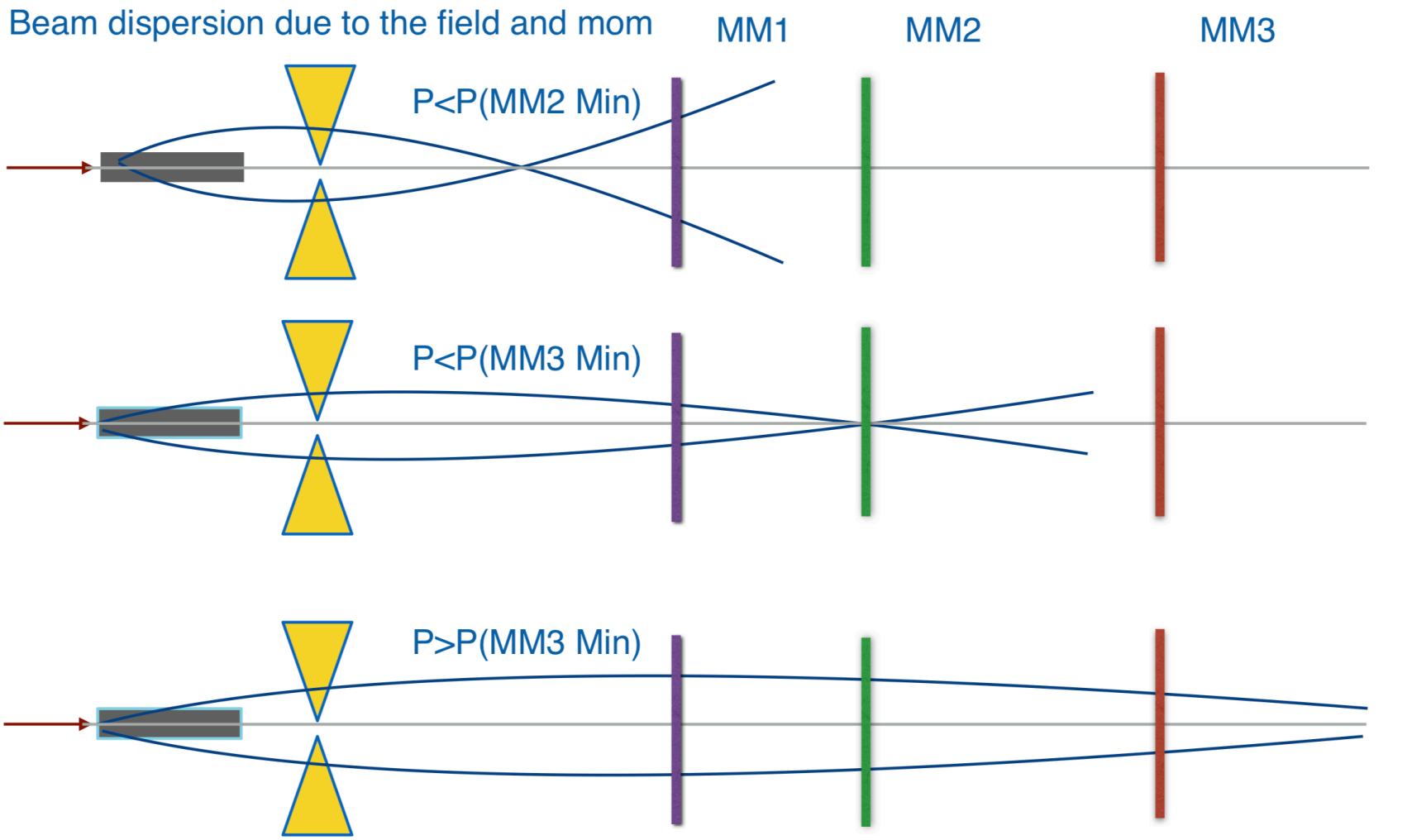
Beam shift on target scan

From Athula



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