

Beam Scan (RHC mode) : May 1, 2024

Athula Wickremasinghe
TSD Topical Meeting
05/16/2024

Introduction

In this talk, we present a comparison of 2024-MAY (RHC) mode beam scan data with 2019-DEC (FHC) and 2022-NOV (FHC) beam scans.

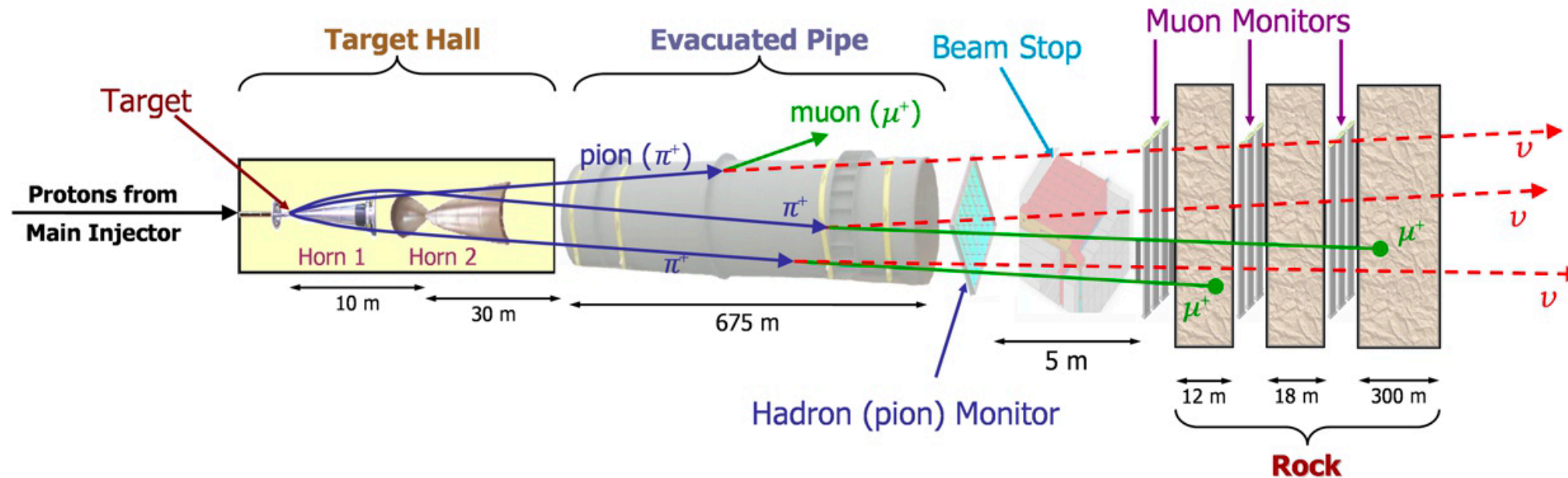
Muon monitor data is:

- » **a measurement of the muon flux from the hadron decay.**
- » **sensitive to the beam parameters and systematic changes in the NuMI beamline.**

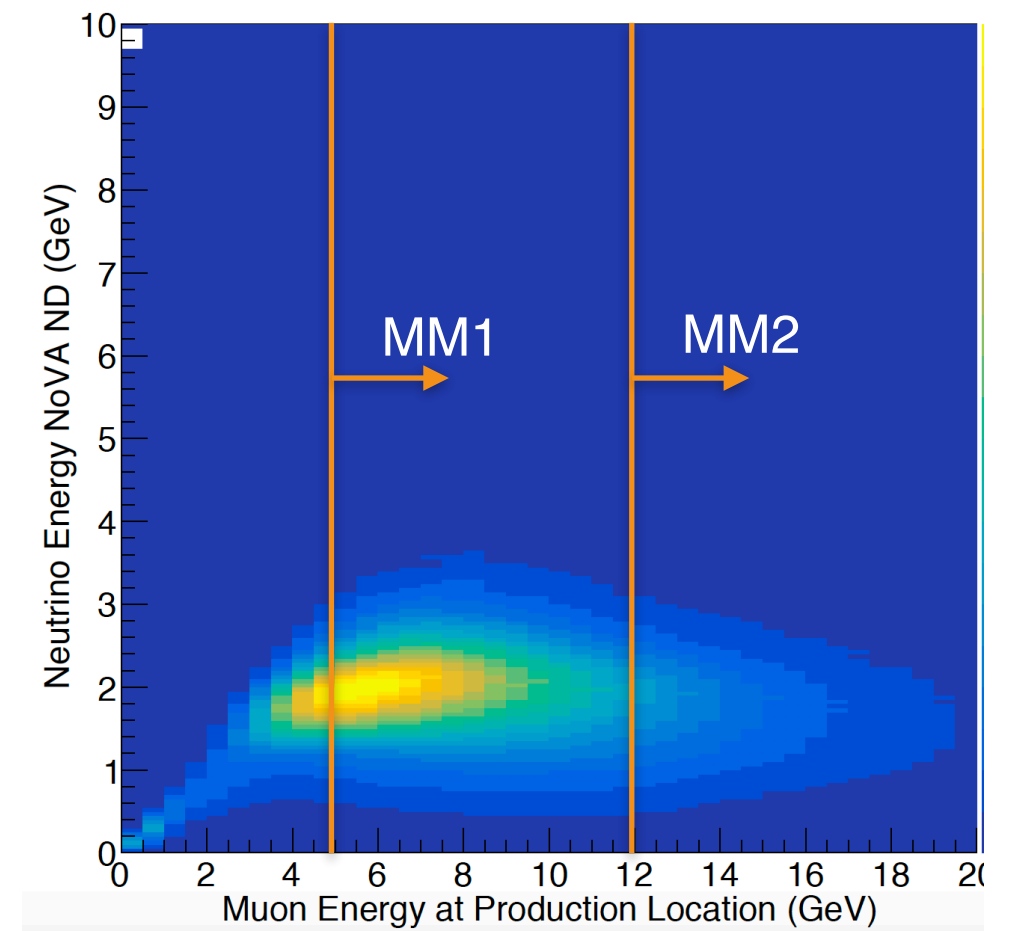
Importance of the beam scans:

- » **Useful to make comparisons with past scans.**
- » **Helping to study physics models in simulations.**
- » **Providing data to build ML models to understand the primary beam performance.**
- » **May useful to model the pion phase space with simulations.**

Introduction to Muon Monitors

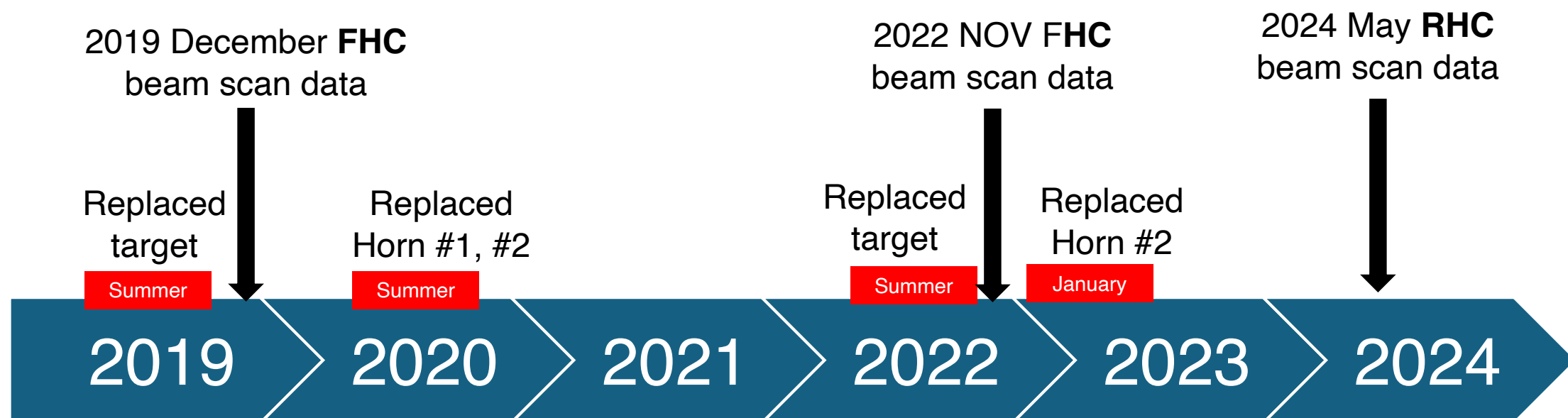


- Three muon monitors are located in the downstream of the hadron absorber
- Each muon monitor consist of 9x9 arrays of ionization chambers
- Each ionization chamber consists of two ceramic parallel plates with the separation of 3 mm gap
- The chambers are filled with He gas



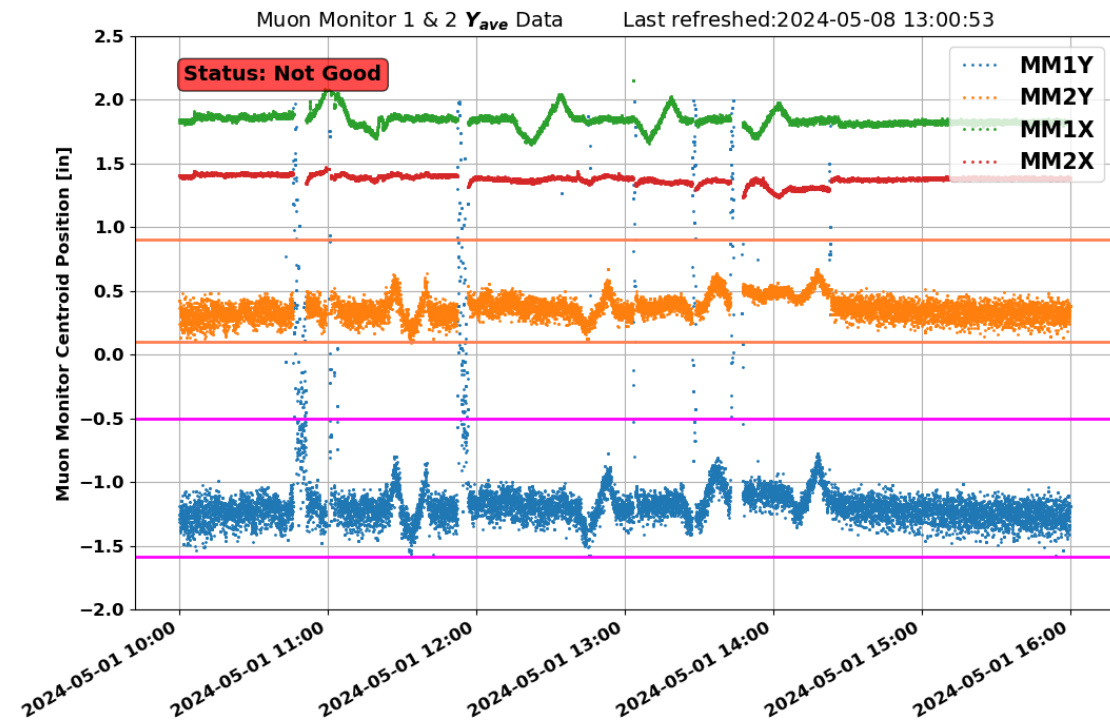
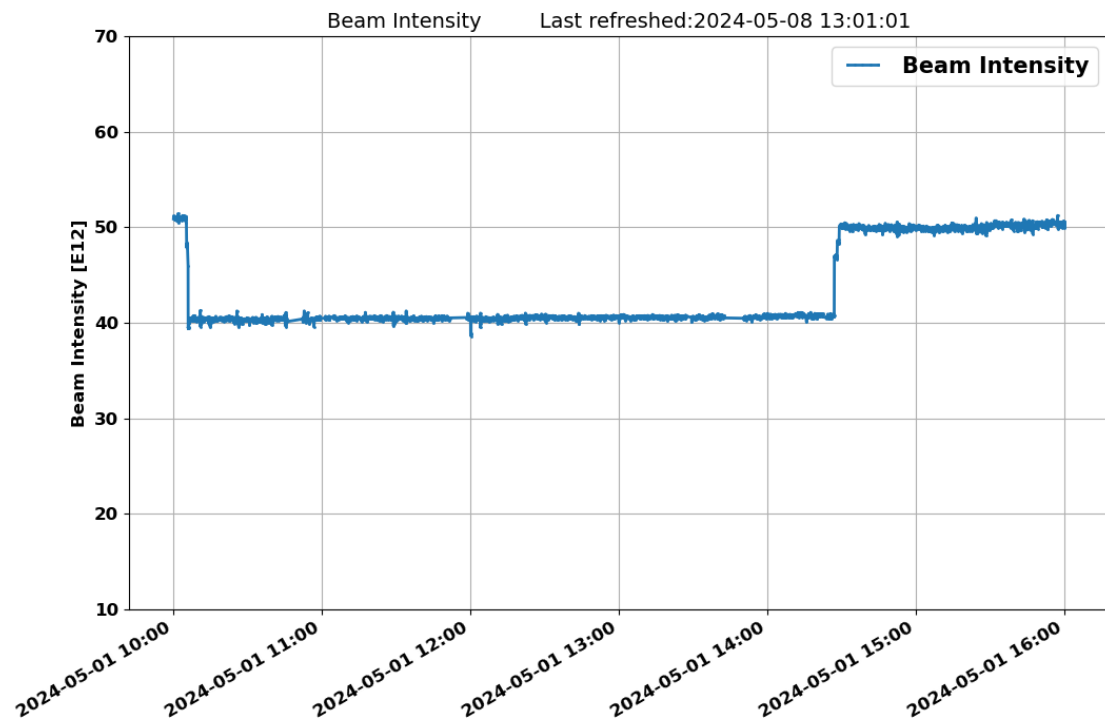
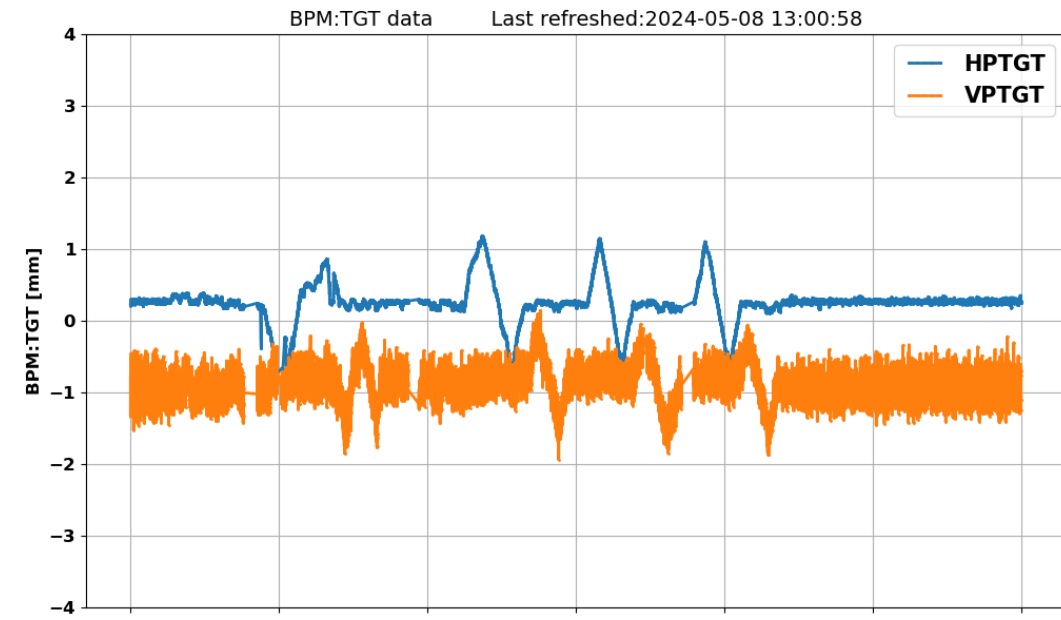
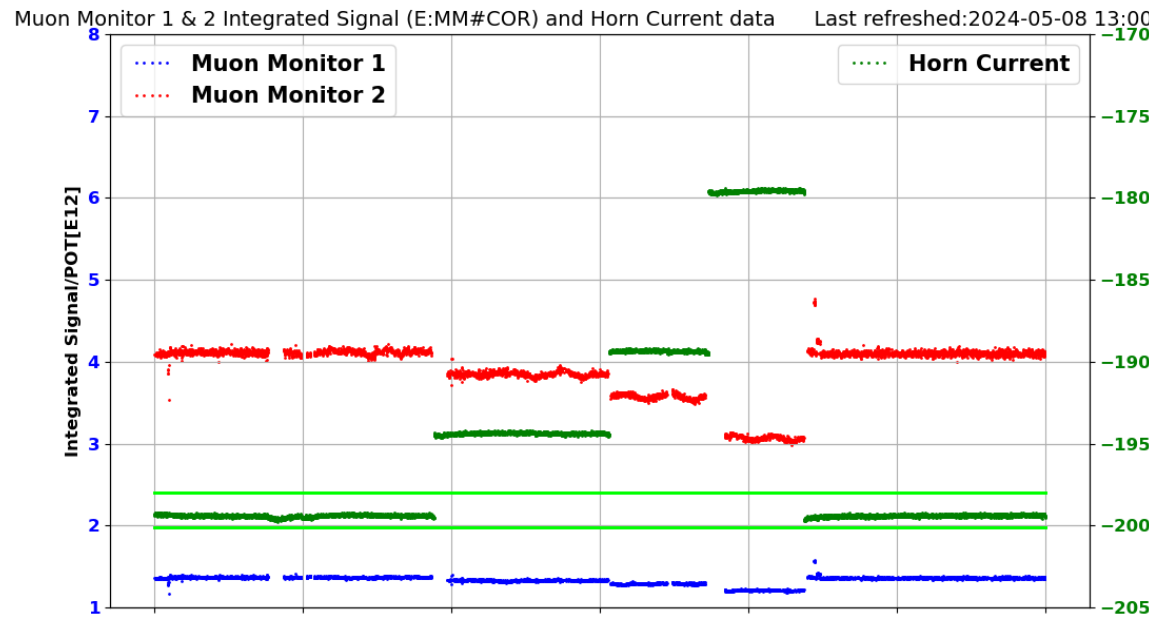
Beamline Component Changes

- * *Replaced the target in 2019 (summer)*
- * *Replaced the Horn1 and the Horn2 for 1 MW operations in 2020 (summer)*
- * *Replaced the target in 2022 (summer)*
- * *Replaced the Horn2 in 2023 (Jan)*



Note: Data sets collected in 2020 and 2021 are not included in this talk.

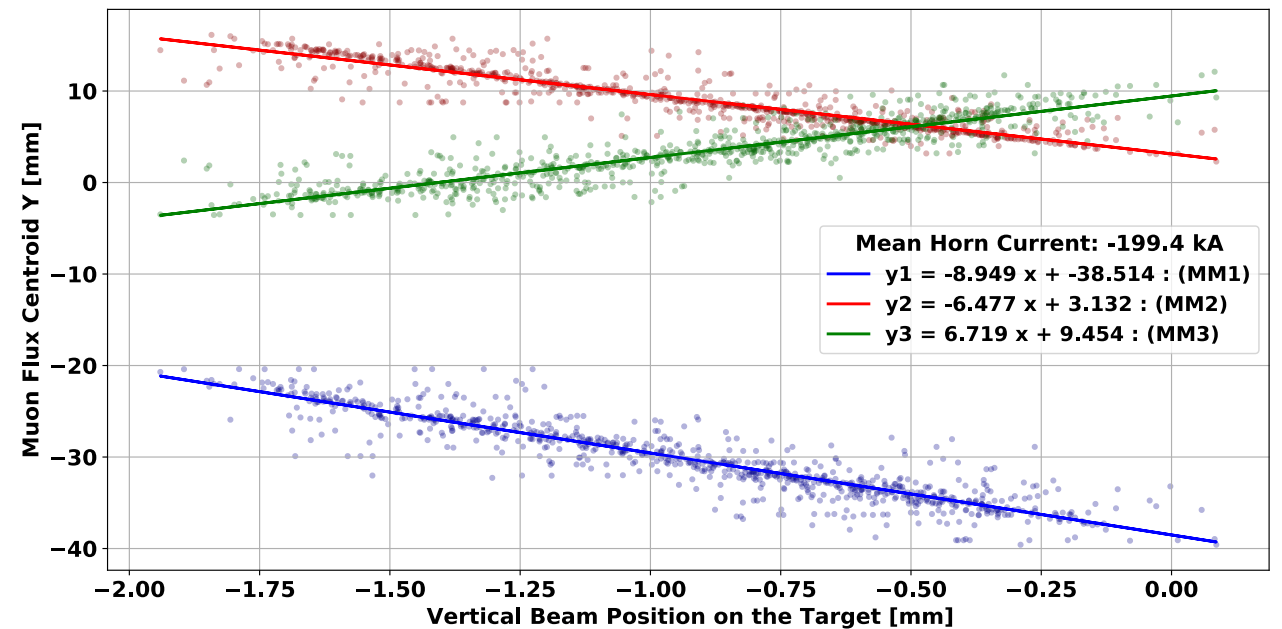
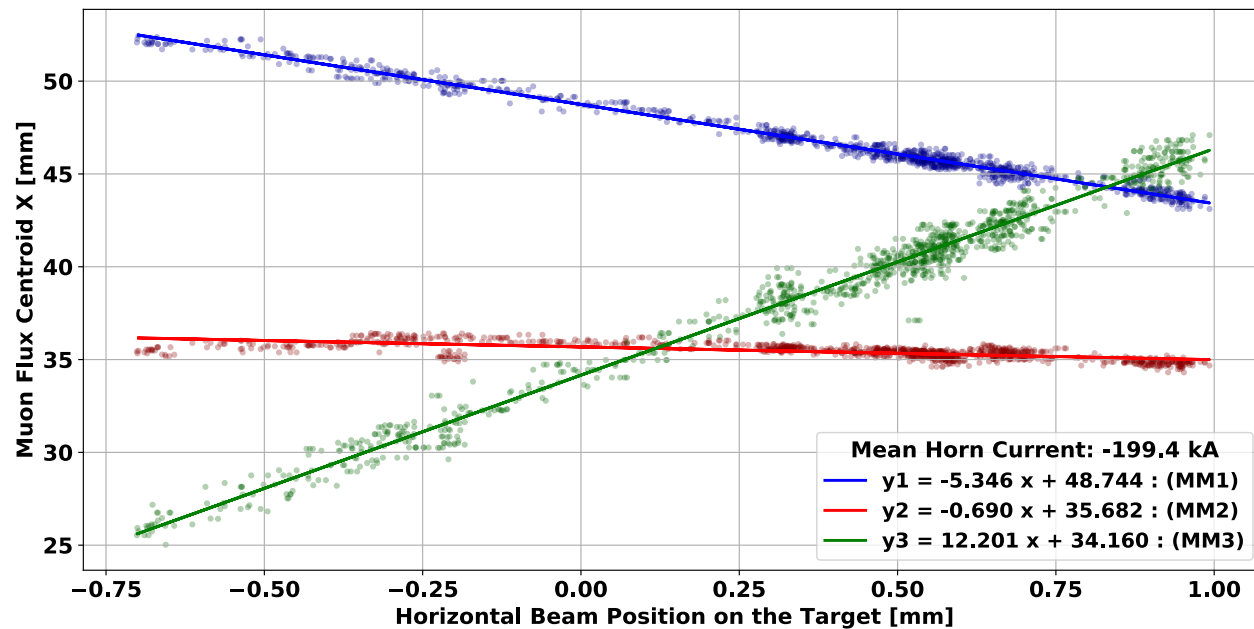
Beam Scan (RHC)



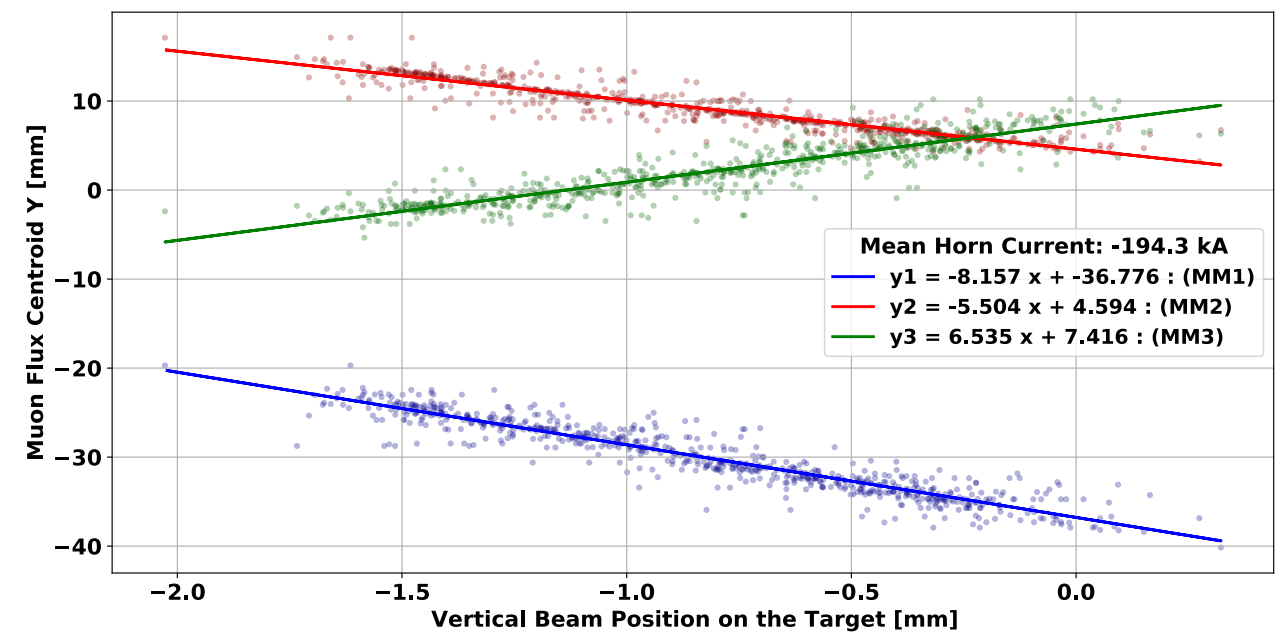
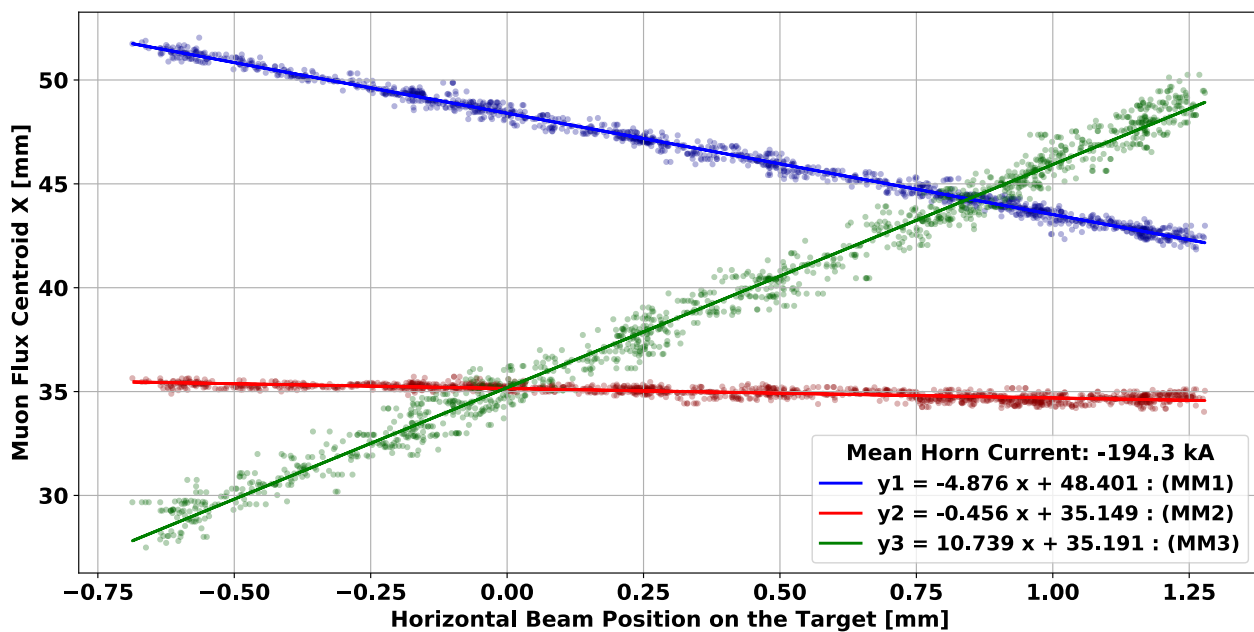
Note: The actual horn current is 1% higher than the ACNET recorded horn current.

Beam Scan Results (RHC)

Mean Horn Current : -199.4 kA

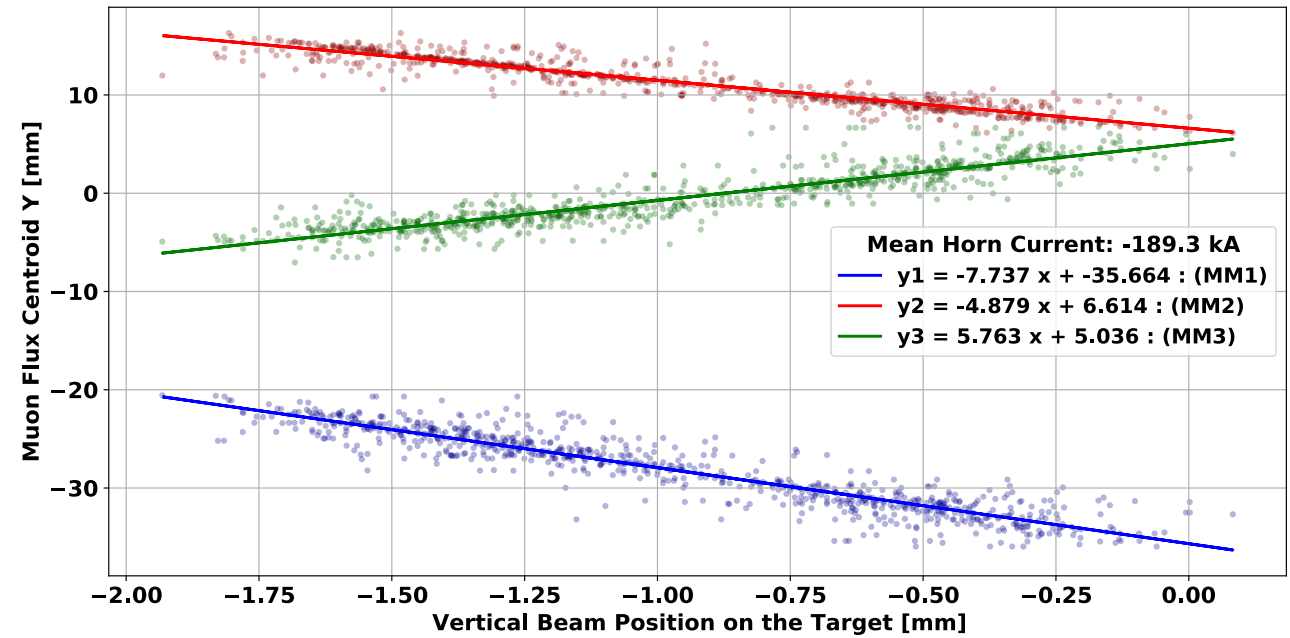
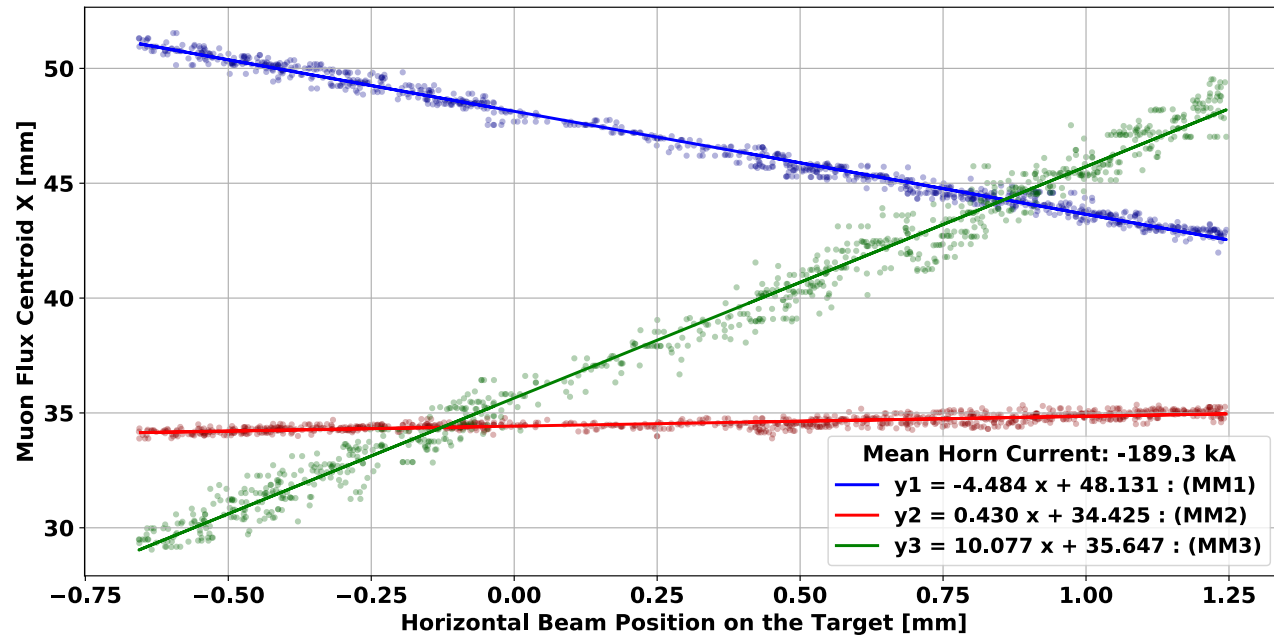


Mean Horn Current : -194.3 kA

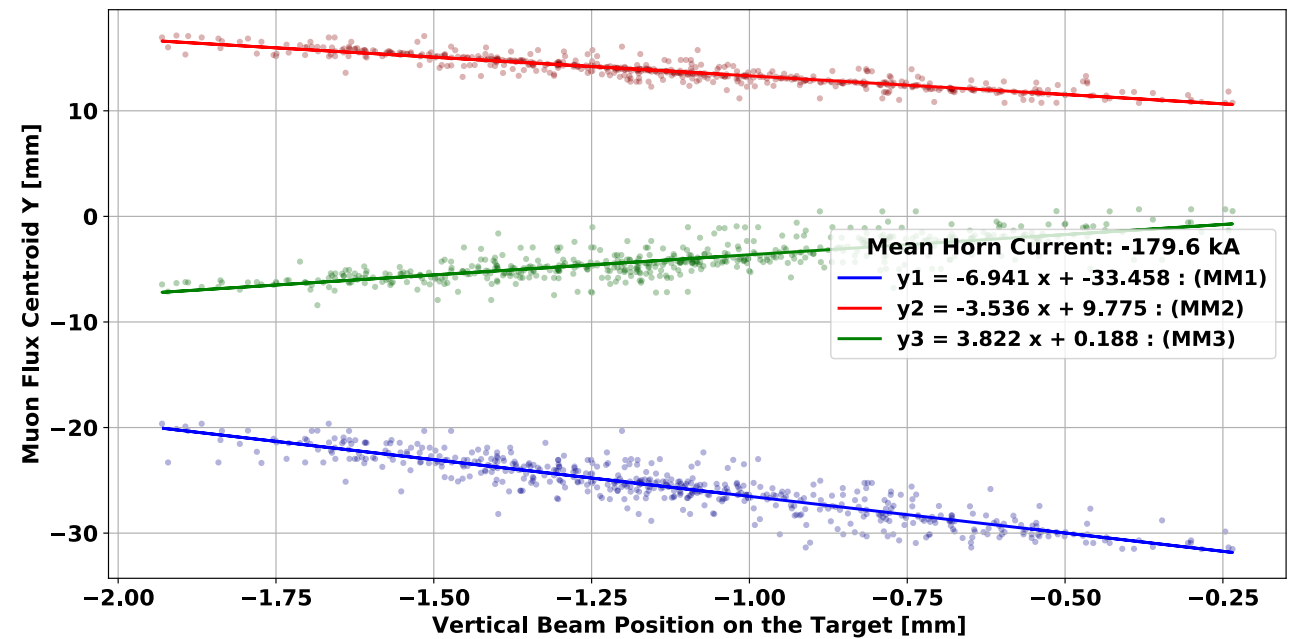
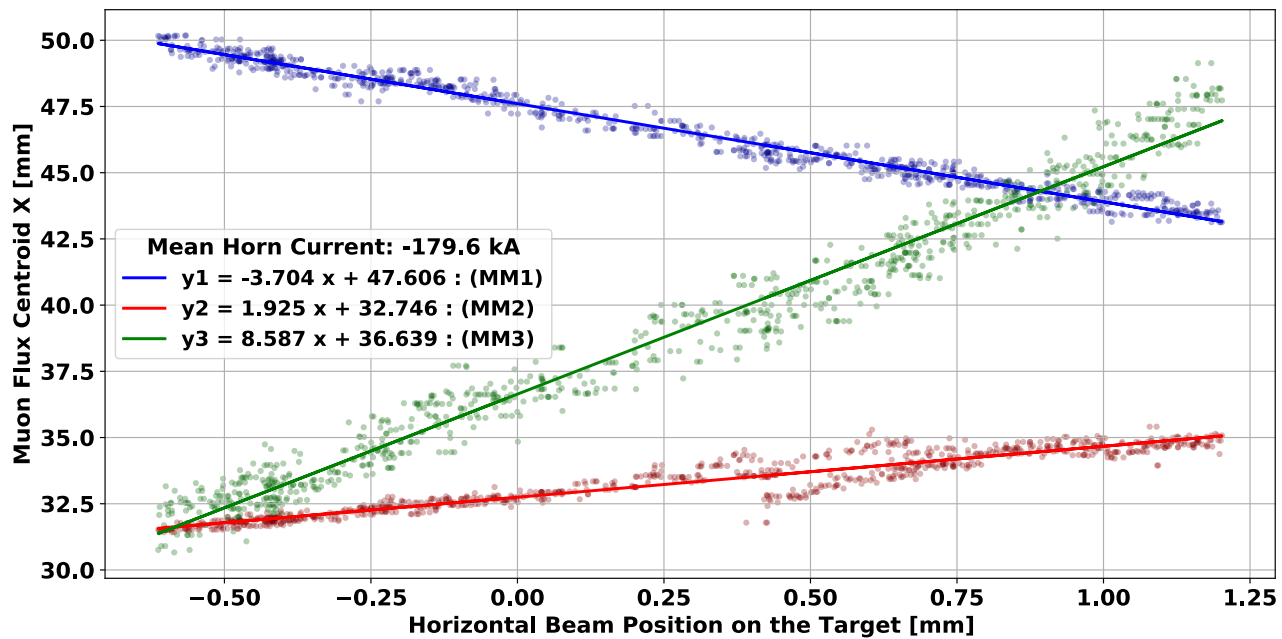


Beam Scan Results (RHC)

Mean Horn Current : -189.3 kA

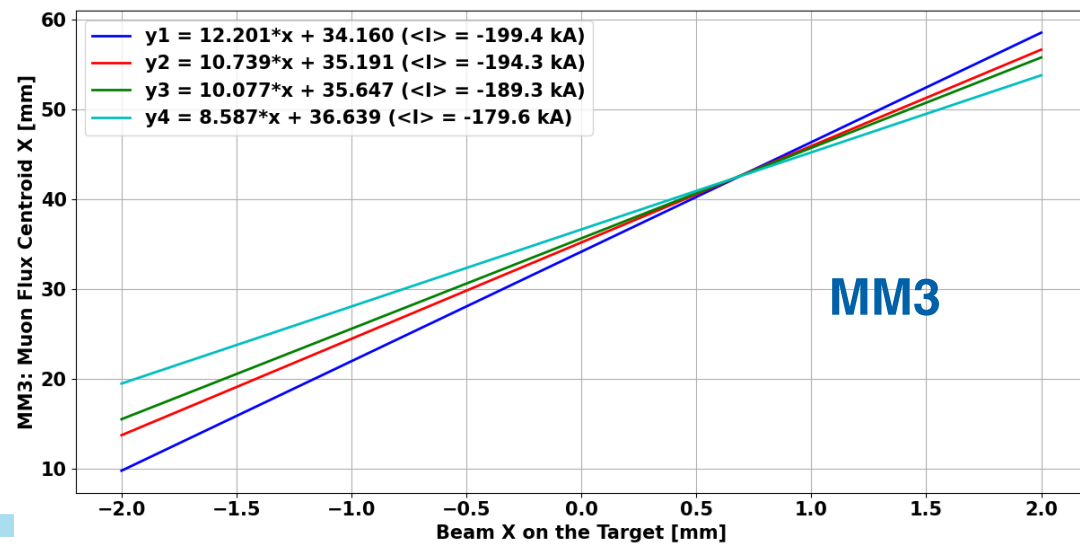
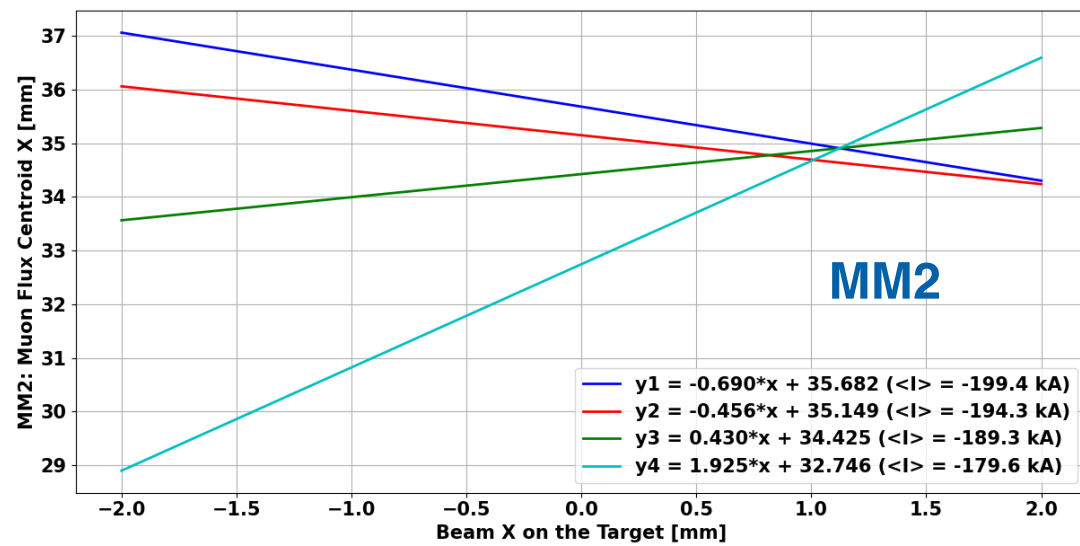
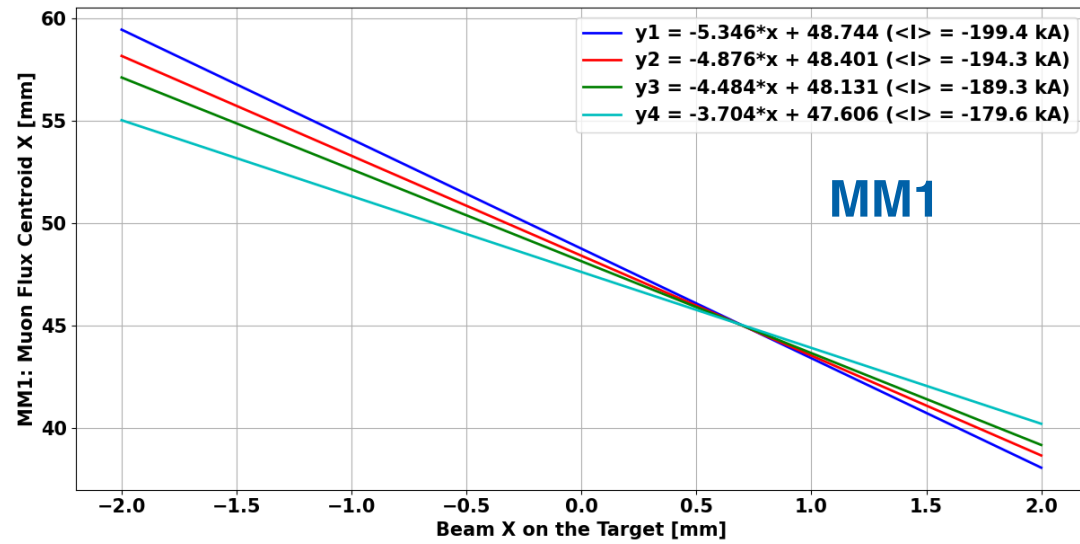


Mean Horn Current : -179.6 kA

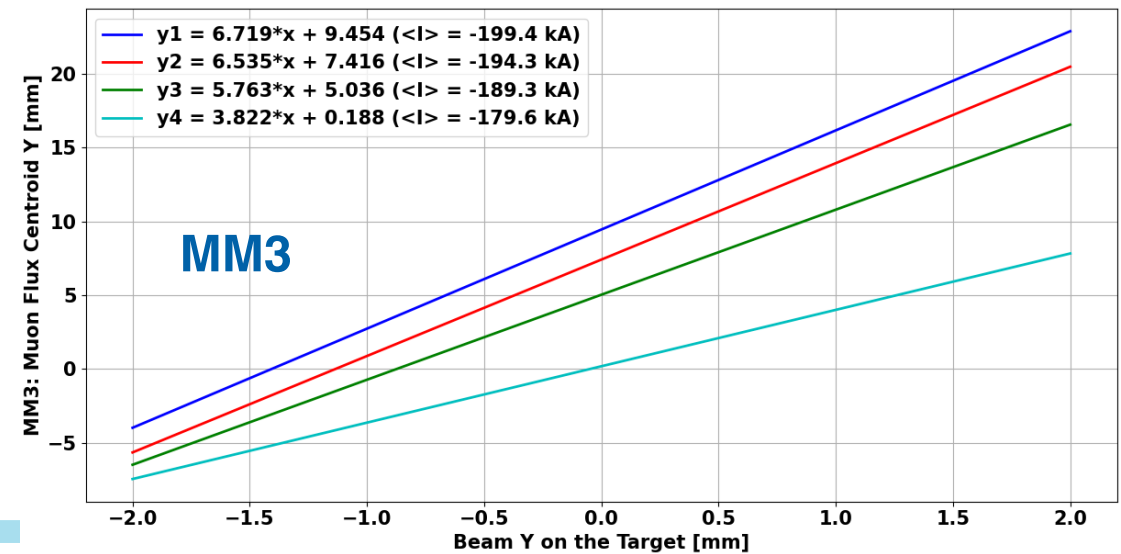
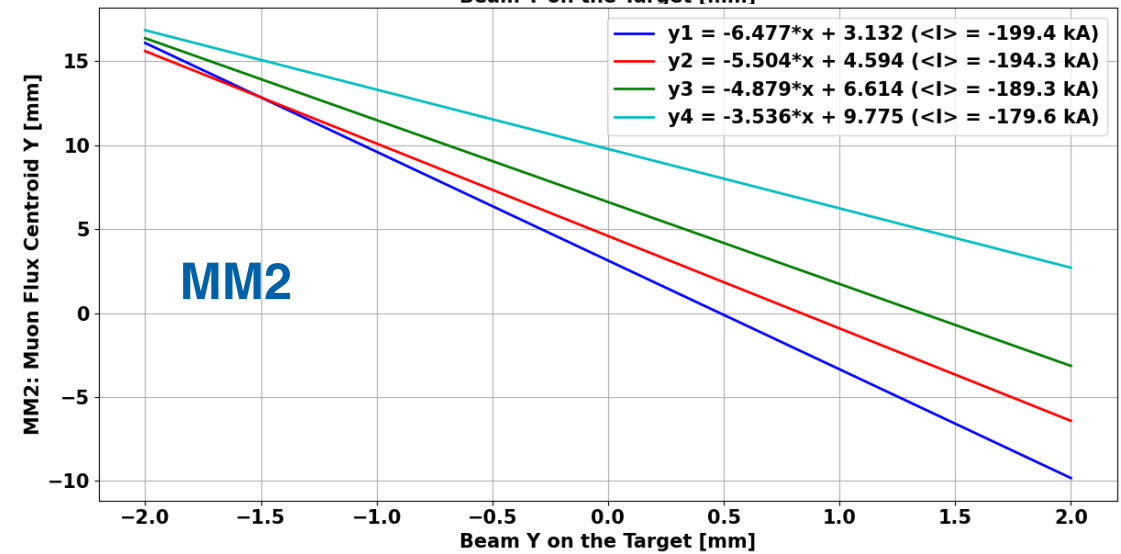
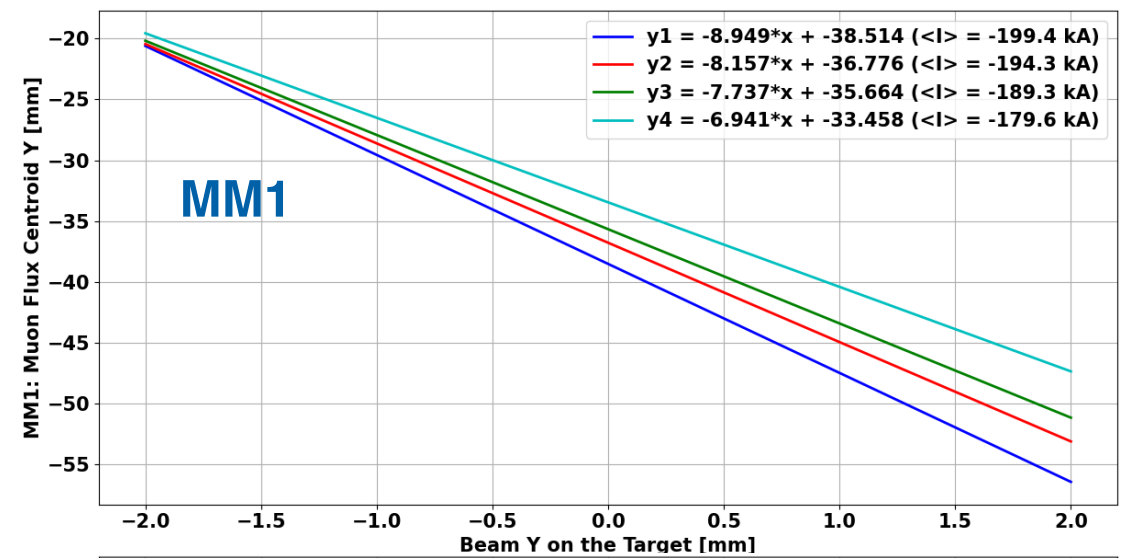


Beam Scan Results (RHC)

Horizontal Scan



Vertical Scan



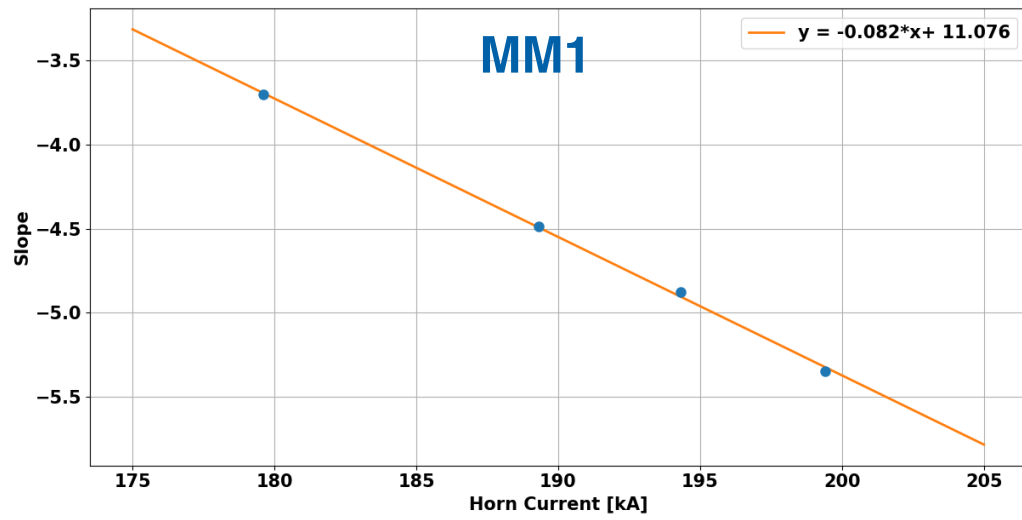
Beam Scan Results (RHC)

	Horn Current	2024-MAY-01 [RHC]		
		MM1	MM2	MM3
Horizontal Scan	199.4 kA	-5.346 ± 0.019	-0.690 ± 0.020	12.201 ± 0.051
	194.3 kA	-4.876 ± 0.012	-0.456 ± 0.009	10.739 ± 0.033
	189.3 kA	-4.484 ± 0.016	0.430 ± 0.010	10.077 ± 0.039
	179.6 kA	-3.704 ± 0.017	1.925 ± 0.021	8.587 ± 0.048
Vertical Scan	199.4 kA	-8.949 ± 0.136	-6.477 ± 0.094	6.719 ± 0.114
	194.3 kA	-8.157 ± 0.111	-5.504 ± 0.080	6.535 ± 0.118
	189.3 kA	-7.737 ± 0.108	-4.879 ± 0.062	5.763 ± 0.095
	179.6 kA	-6.941 ± 0.143	-3.536 ± 0.066	3.822 ± 0.129

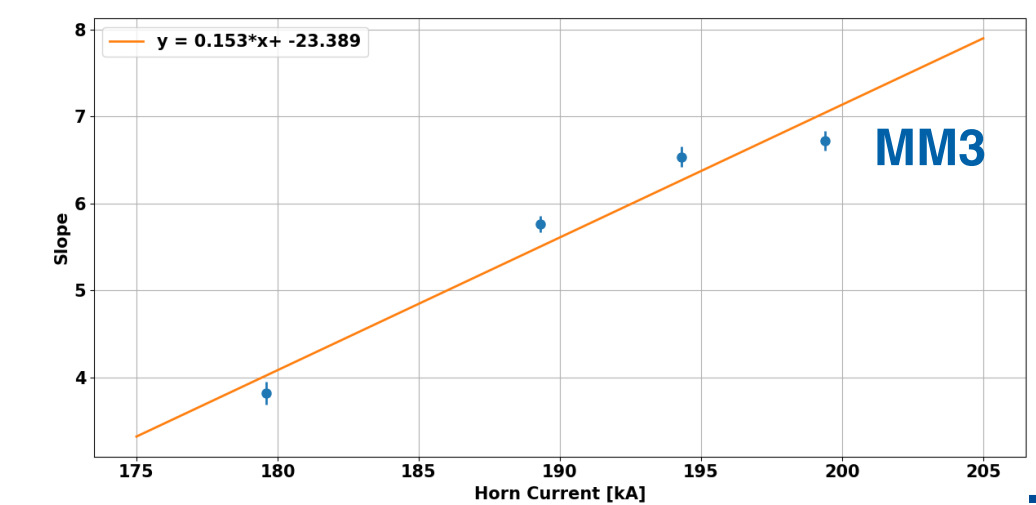
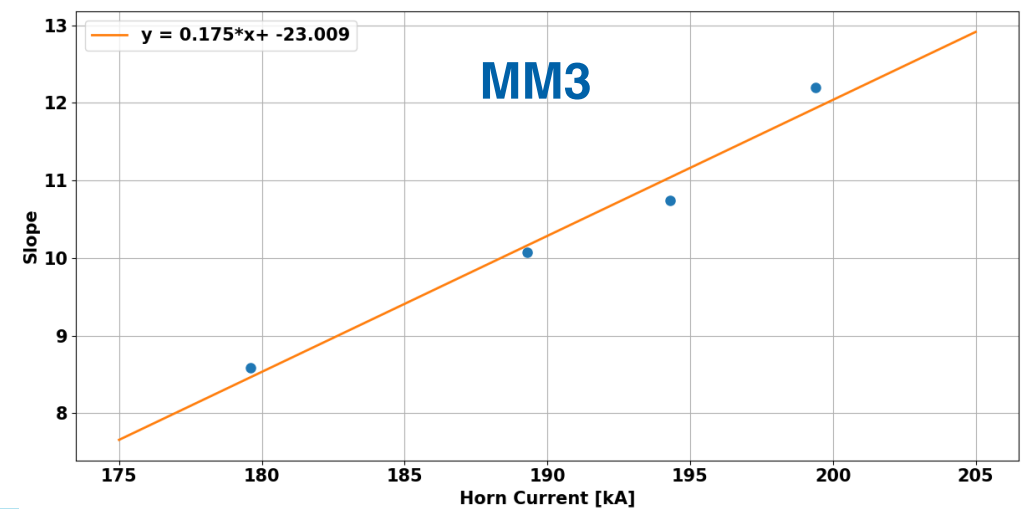
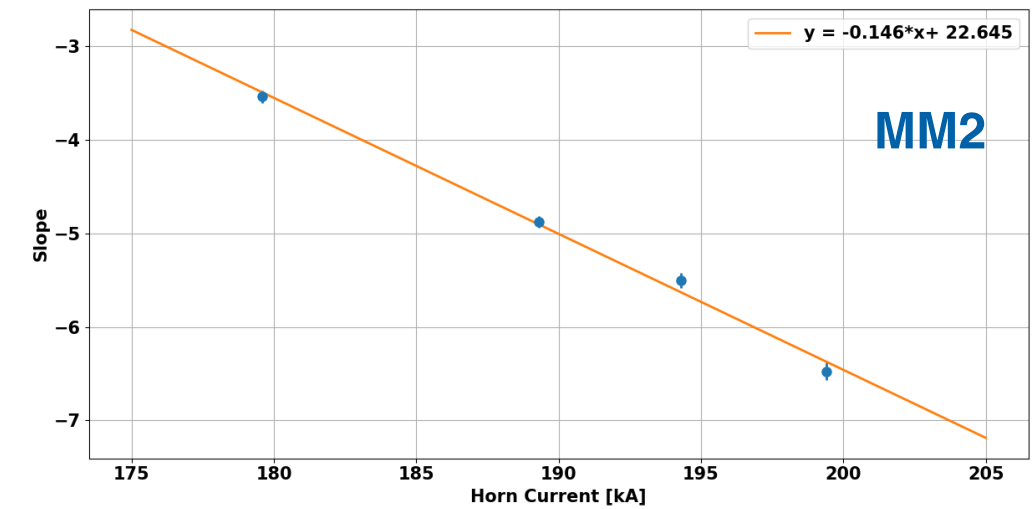
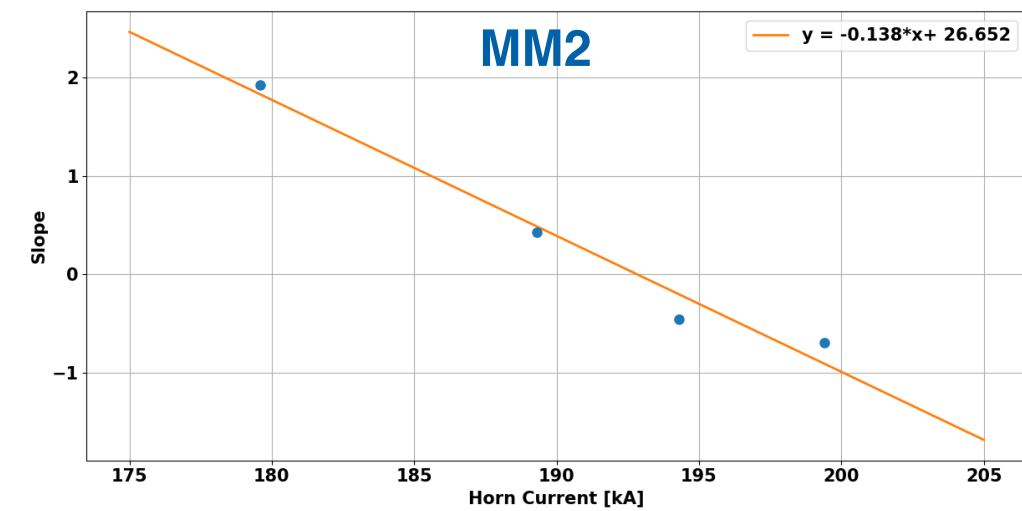
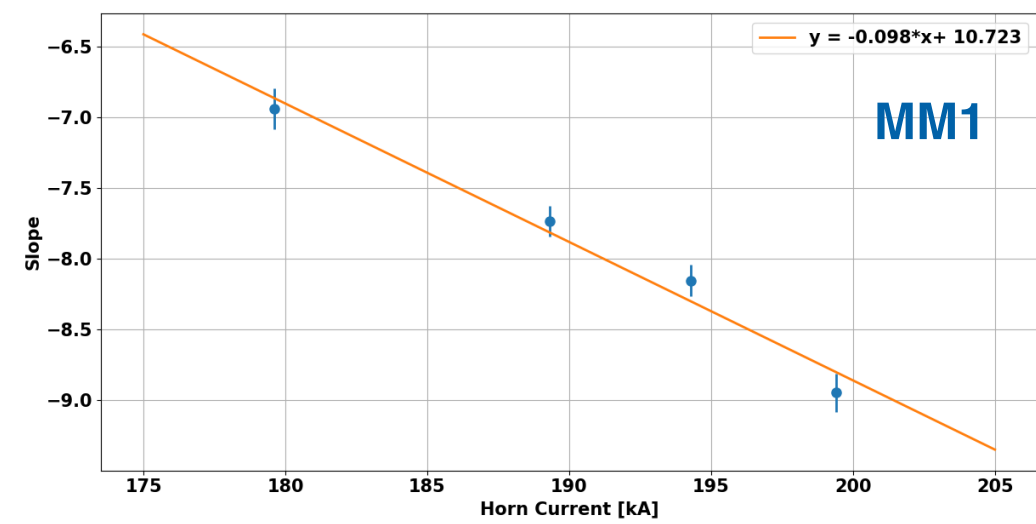
Note: Only the fitting errors are provided in the table.

Beam Scan Results

Horizontal Scan



Vertical Scan

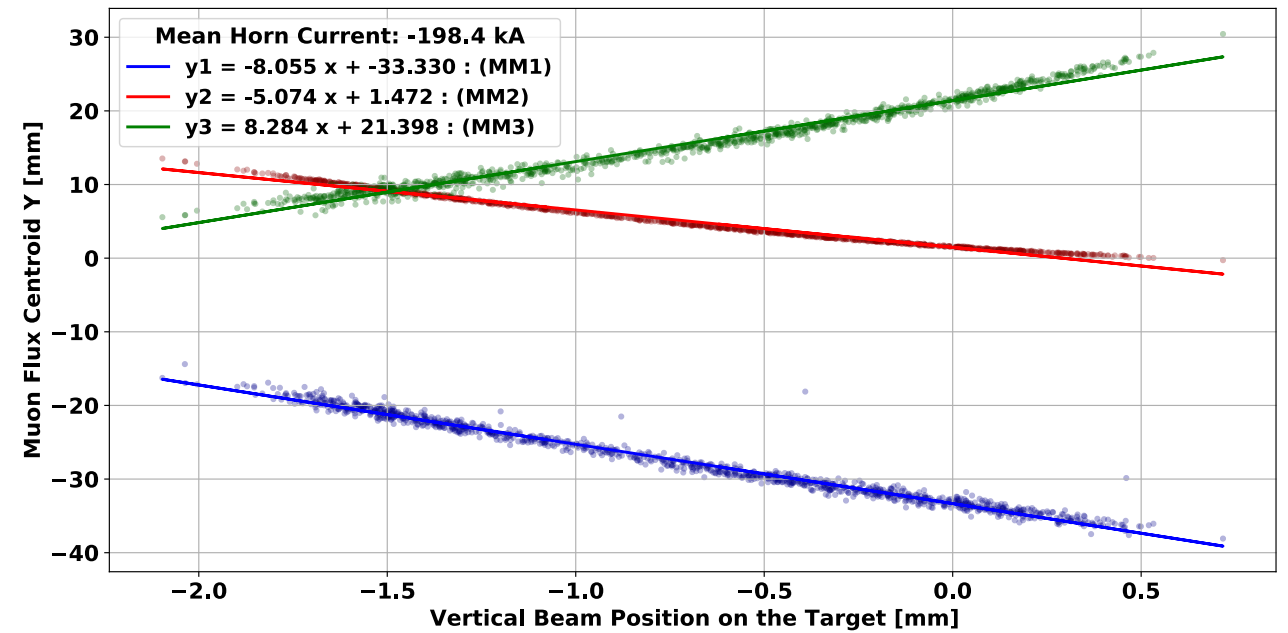
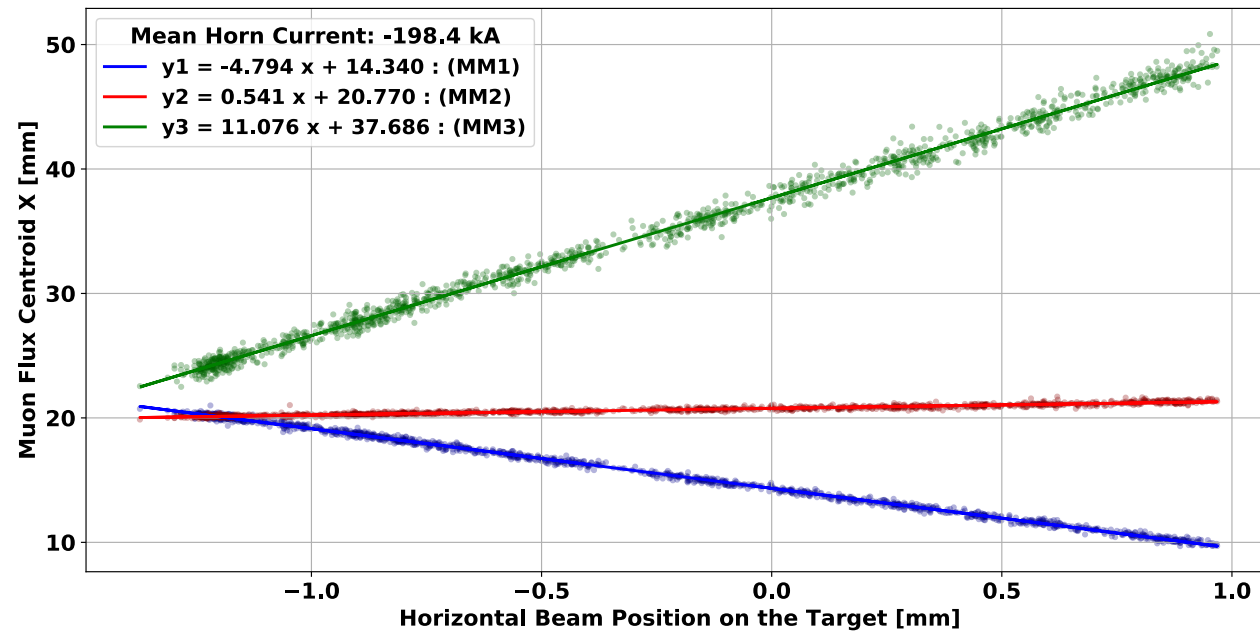


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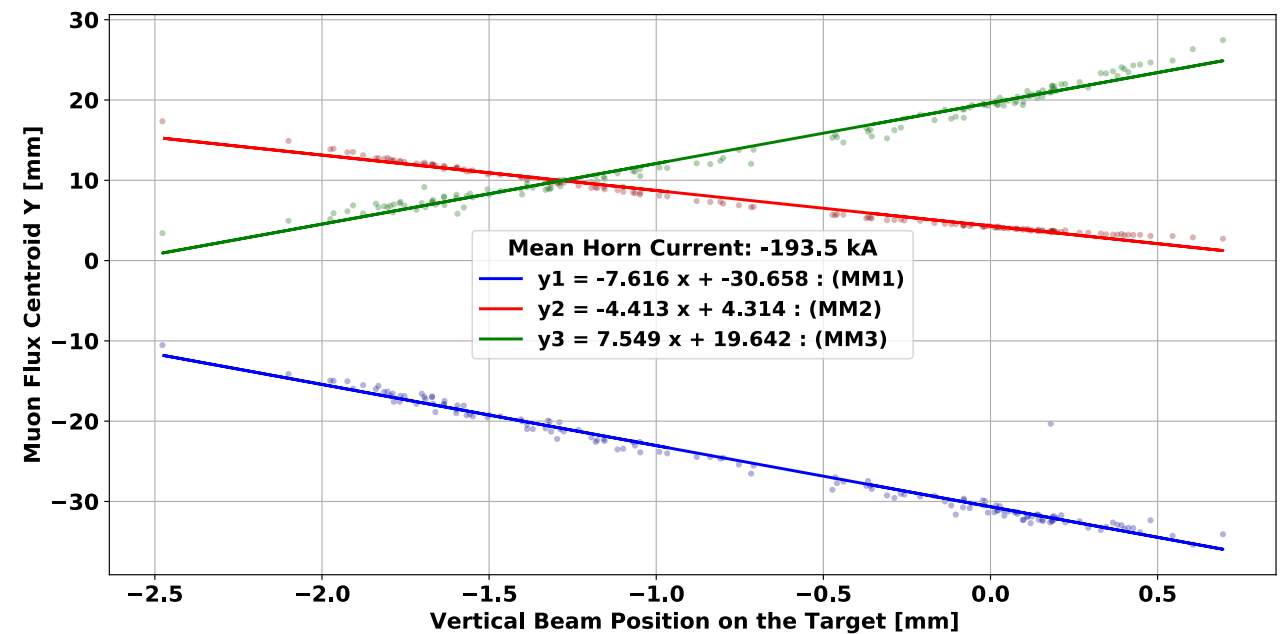
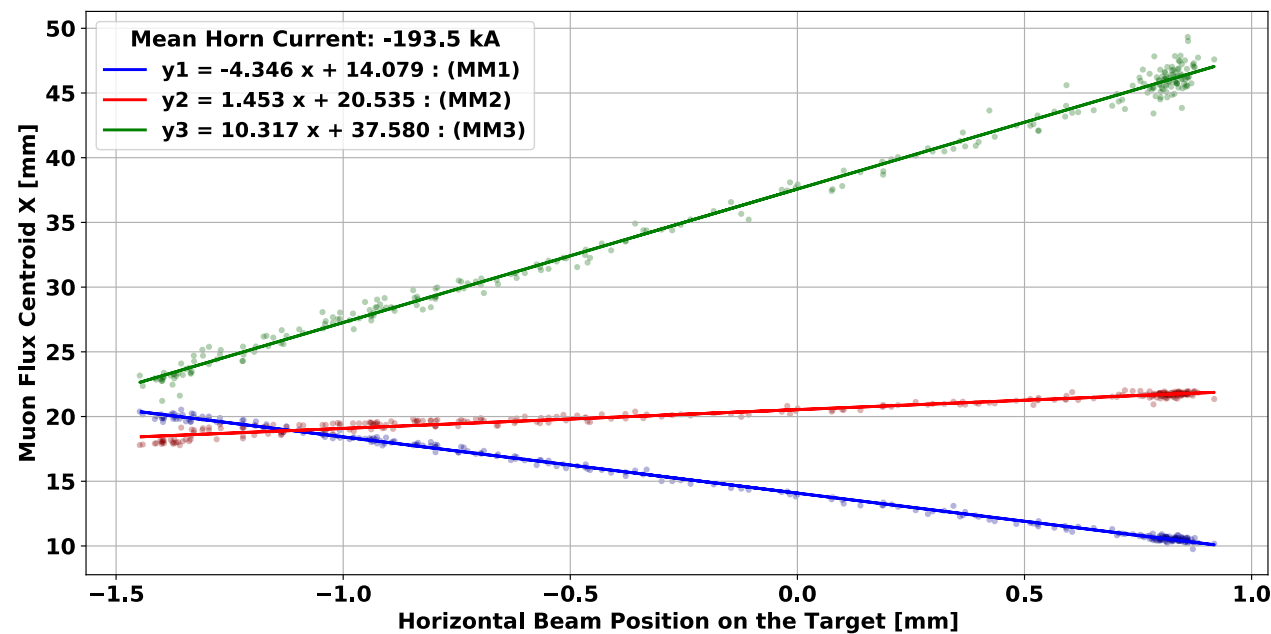
**Beam Scan Results: Dec 12,
2019 (FHC)**

Beam Scan: Dec 12, 2019 (FHC)

Mean Horn Current : -198.4 kA

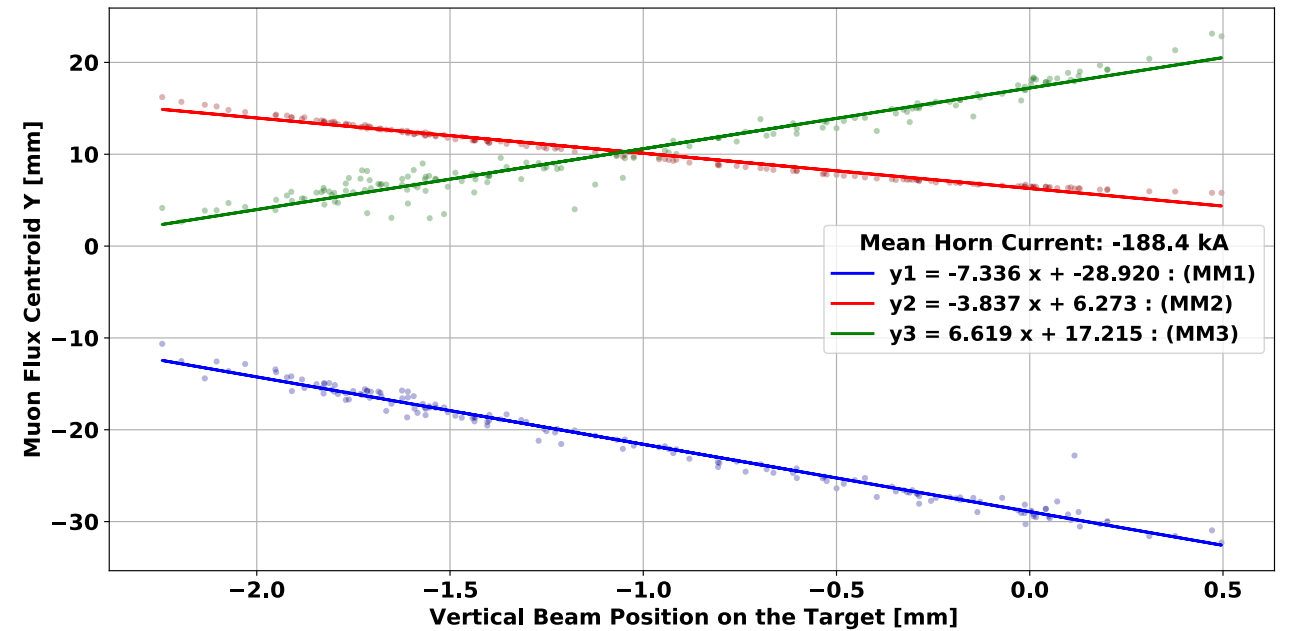
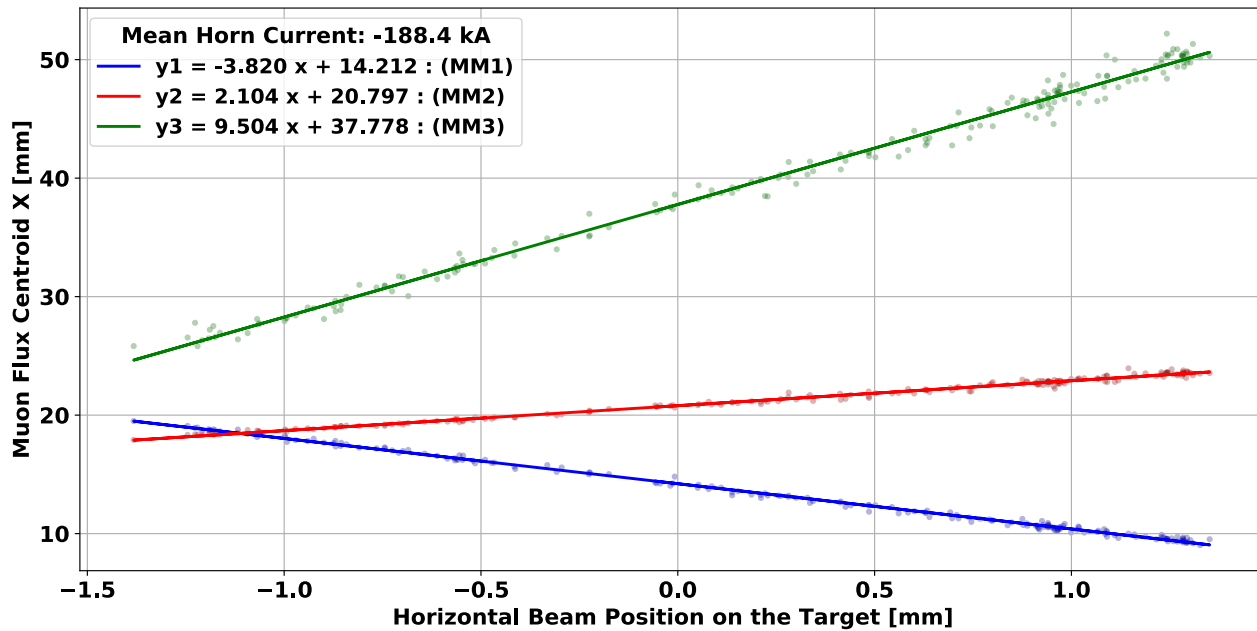


Mean Horn Current : -193.5 kA

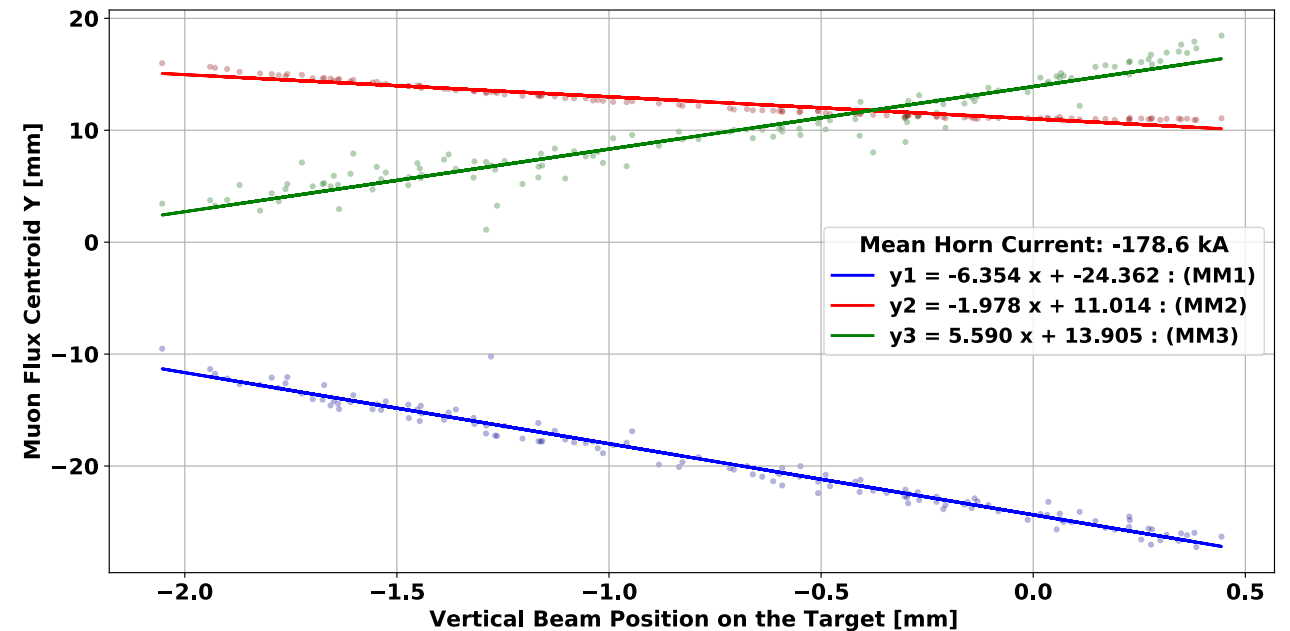
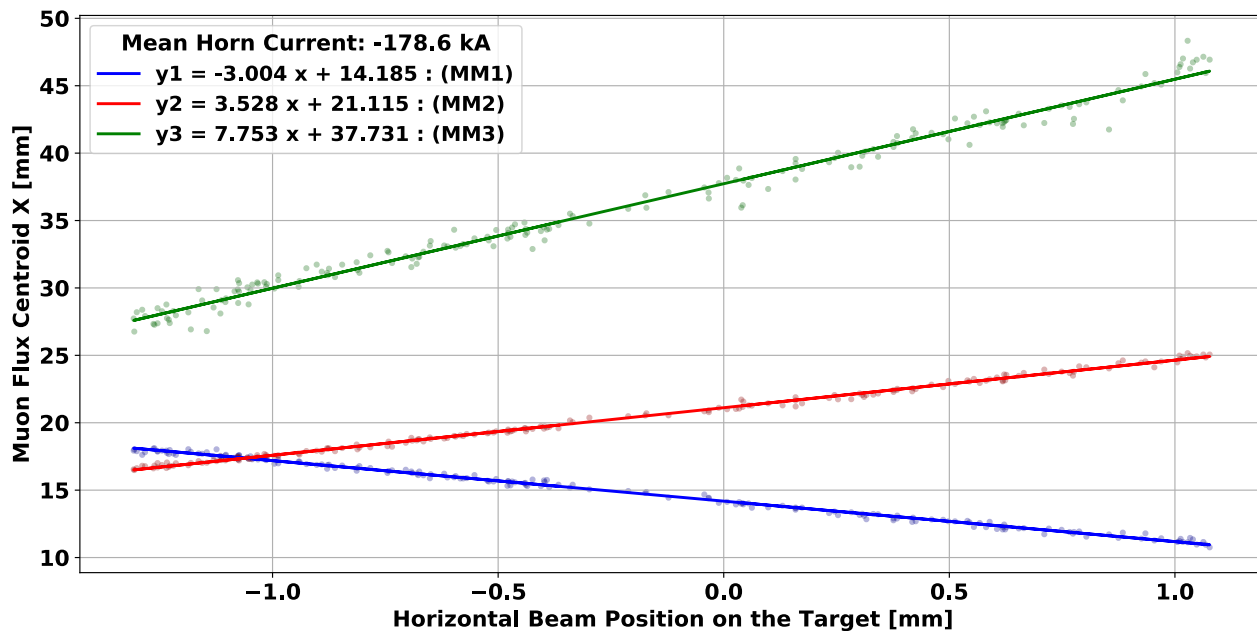


Beam Scan: Dec 12, 2019 (FHC)

Mean Horn Current : -188.4 kA



Mean Horn Current : -178.6 kA



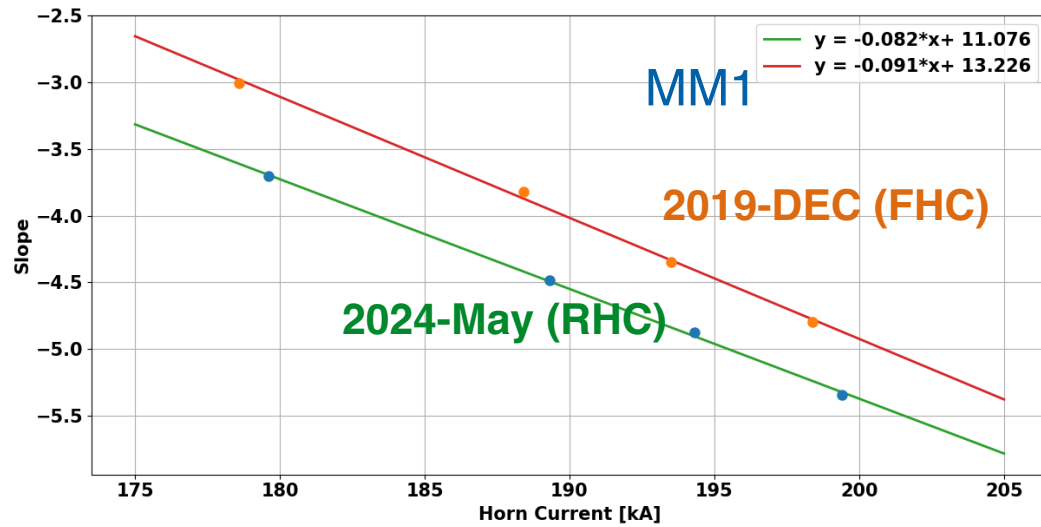
Beam Scan: Dec 12, 2019 (FHC)

	Horn Current	2019-DEC-12 [FHC]		
		MM1	MM2	MM3
Horizontal Scan	198.4 kA	-4.794 ± 0.006	0.541 ± 0.004	11.08 ± 0.022
	193.5 kA	-4.346 ± 0.014	1.453 ± 0.019	10.317 ± 0.049
	188.4 kA	-3.820 ± 0.016	2.104 ± 0.015	9.504 ± 0.064
	178.6 kA	-3.004 ± 0.016	3.528 ± 0.016	7.753 ± 0.069
Vertical Scan	198.4 kA	-8.055 ± 0.033	-5.074 ± 0.018	8.284 ± 0.035
	193.5 kA	-7.616 ± 0.119	-4.413 ± 0.050	7.549 ± 0.088
	188.4 kA	-7.336 ± 0.091	-3.837 ± 0.045	6.619 ± 0.126
	178.6 kA	-6.354 ± 0.103	-1.978 ± 0.048	5.590 ± 0.156

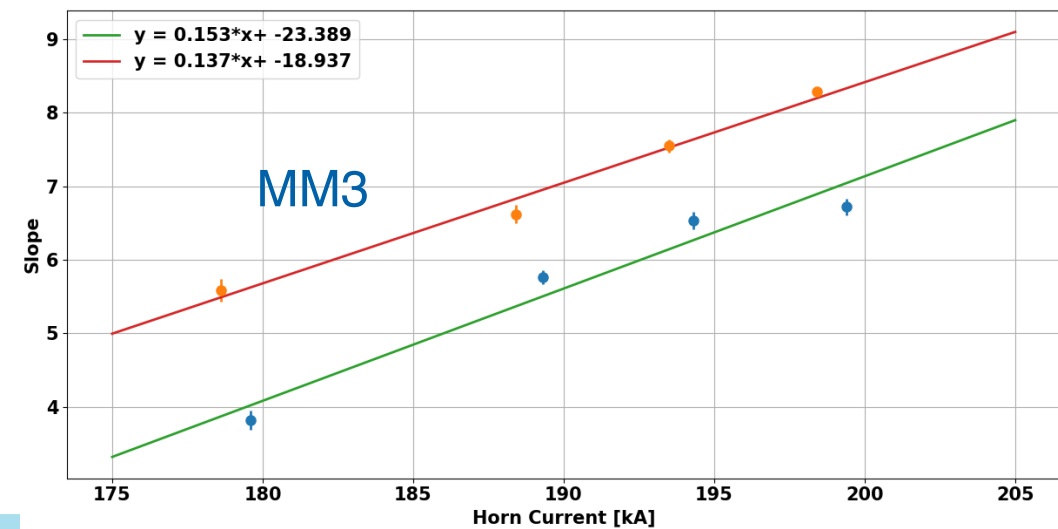
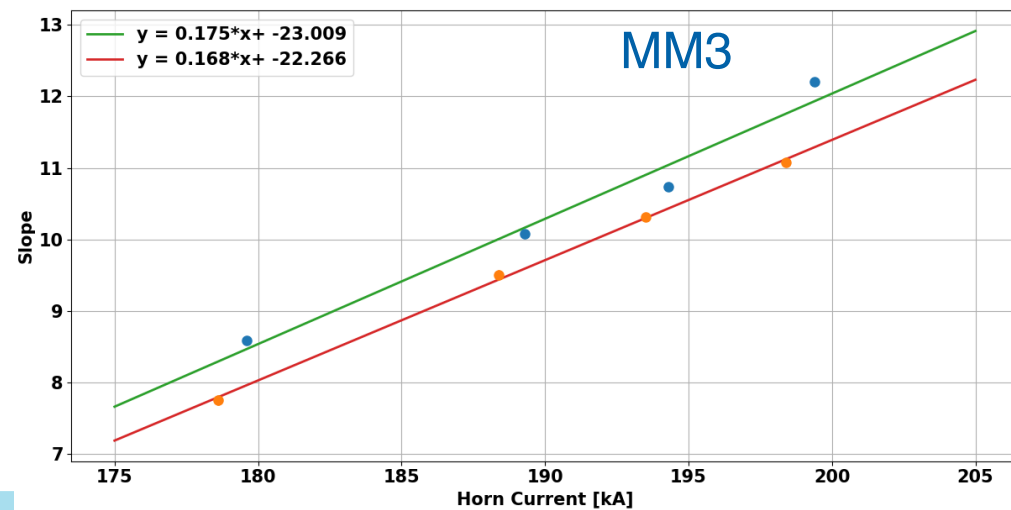
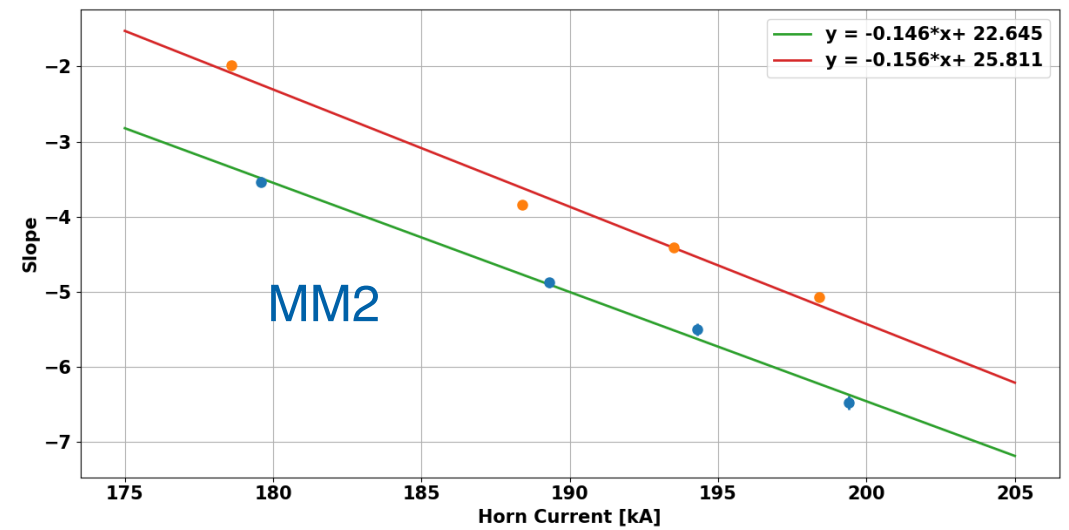
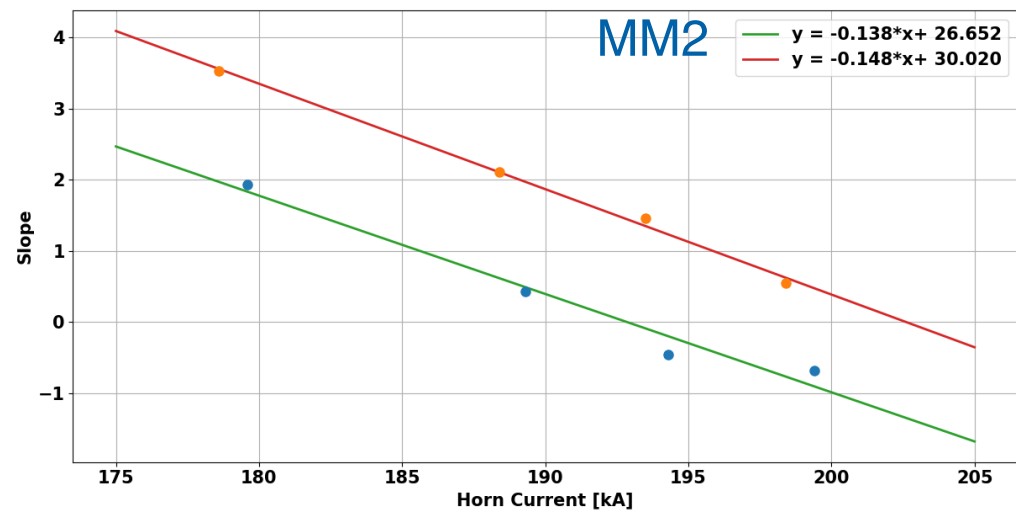
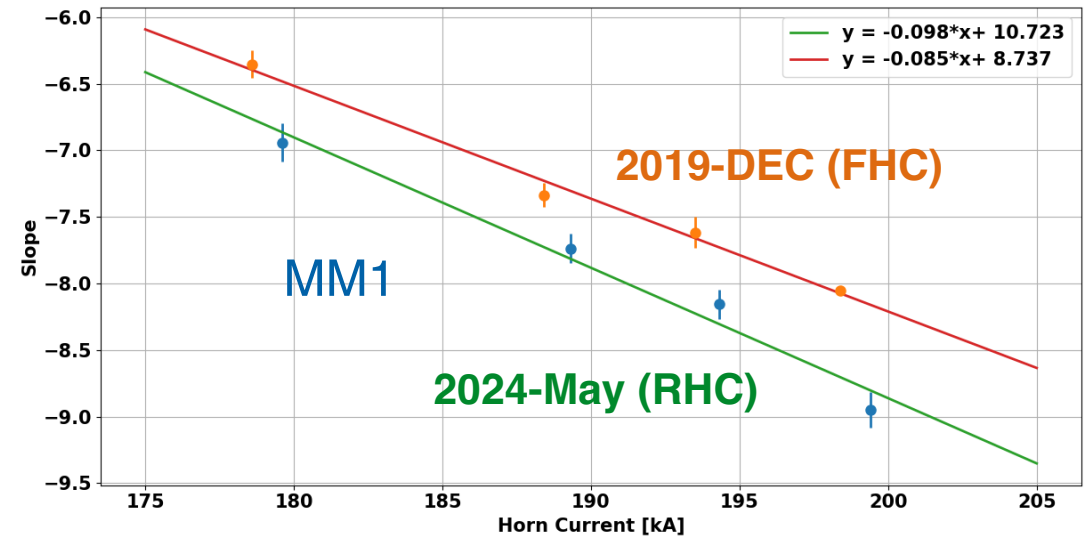
Note: Only the fitting errors are provided in the table.

Beam Scan Results

Horizontal Scan



Vertical Scan

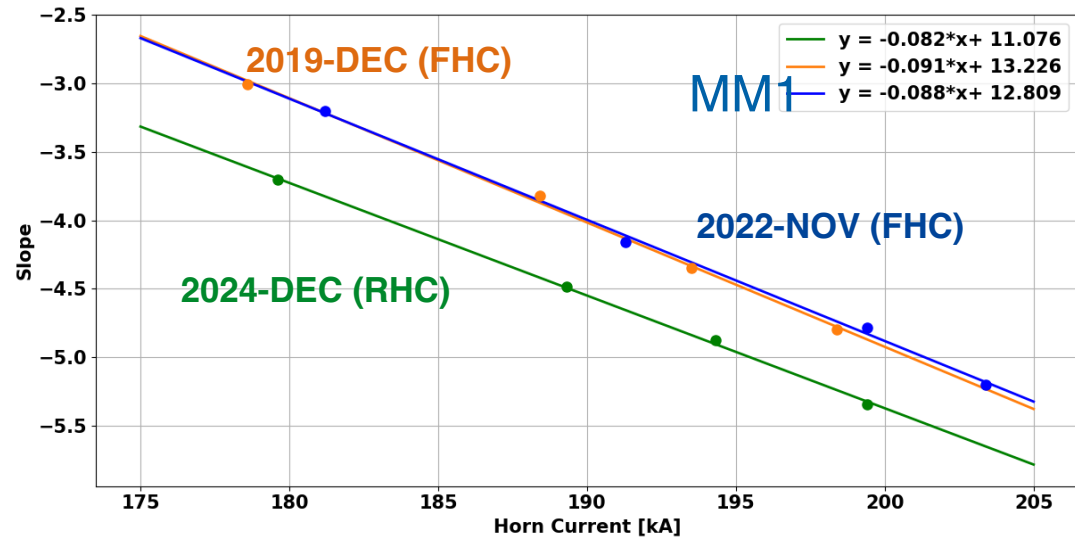


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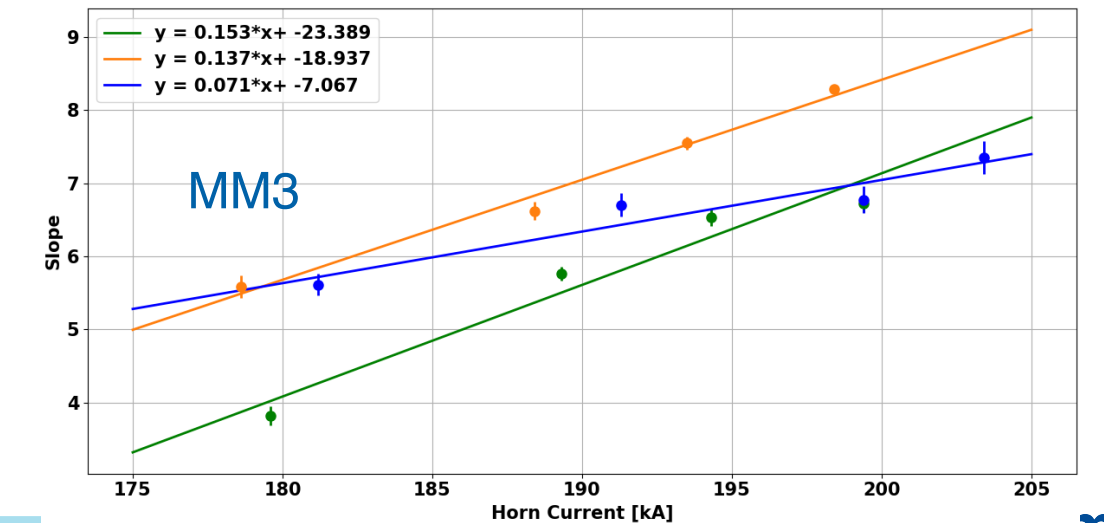
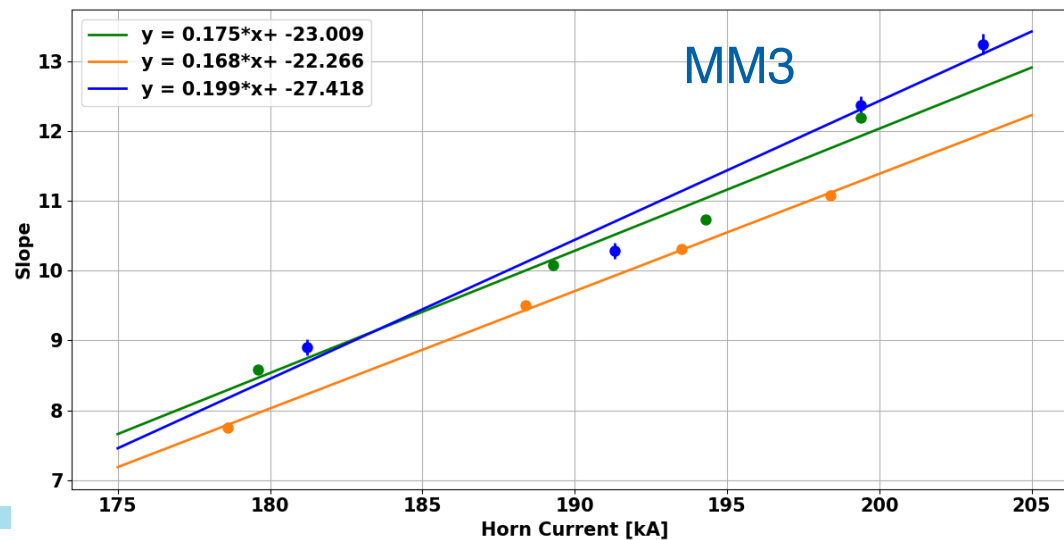
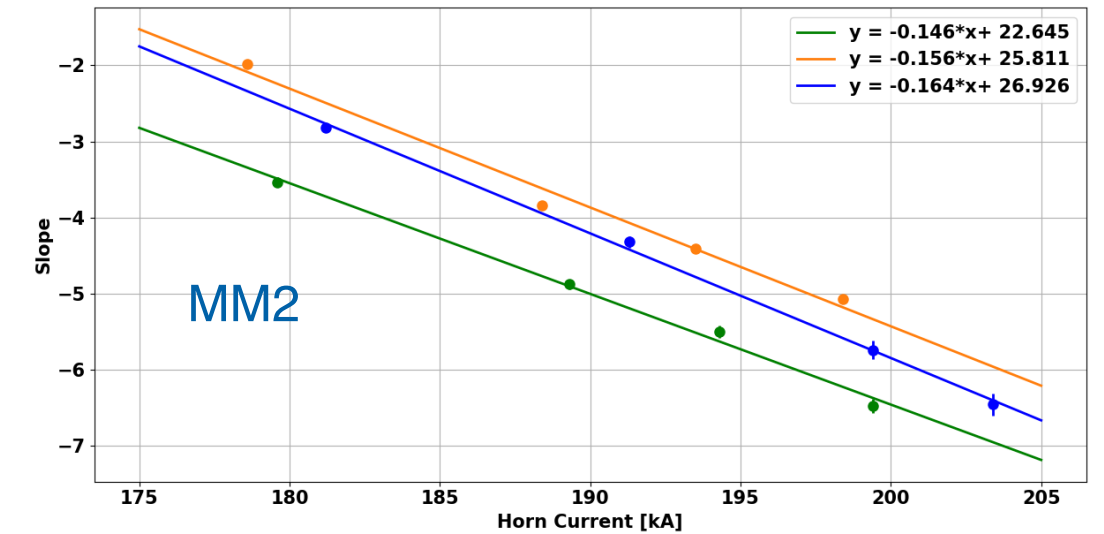
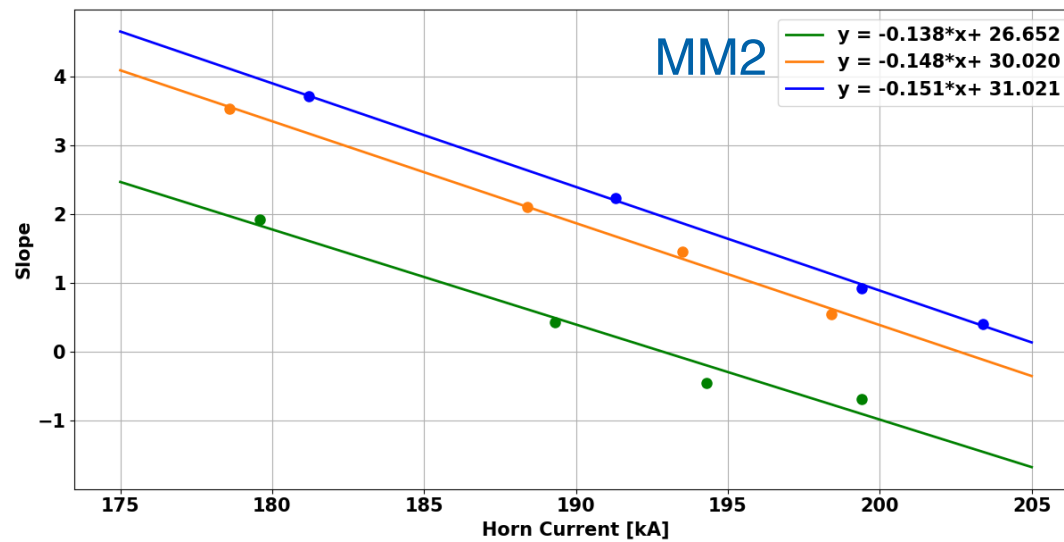
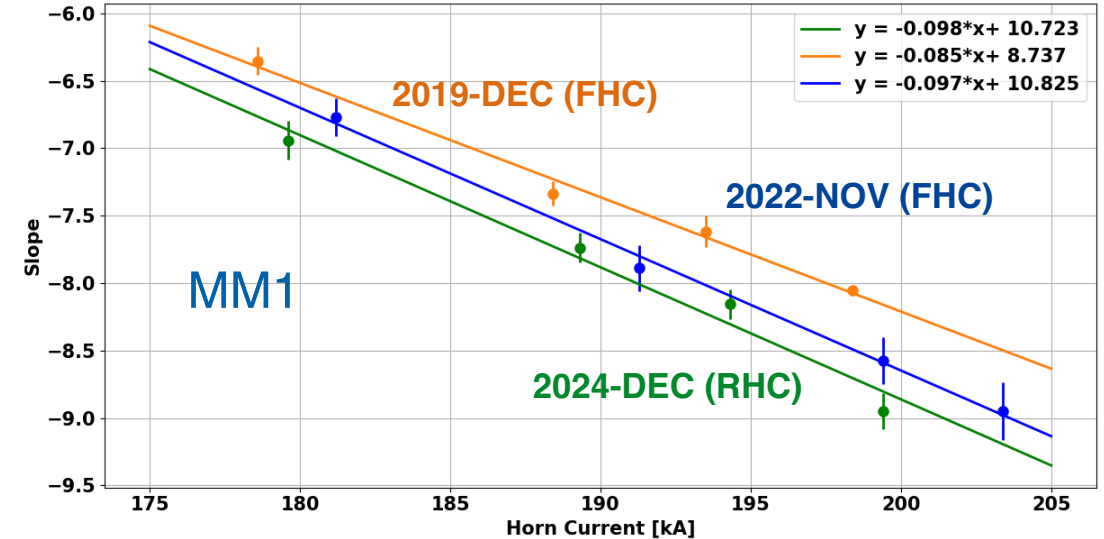
**Beam Scan Results: Nov, 2022
(FHC)**

Beam Scan Results

Horizontal Scan



Vertical Scan



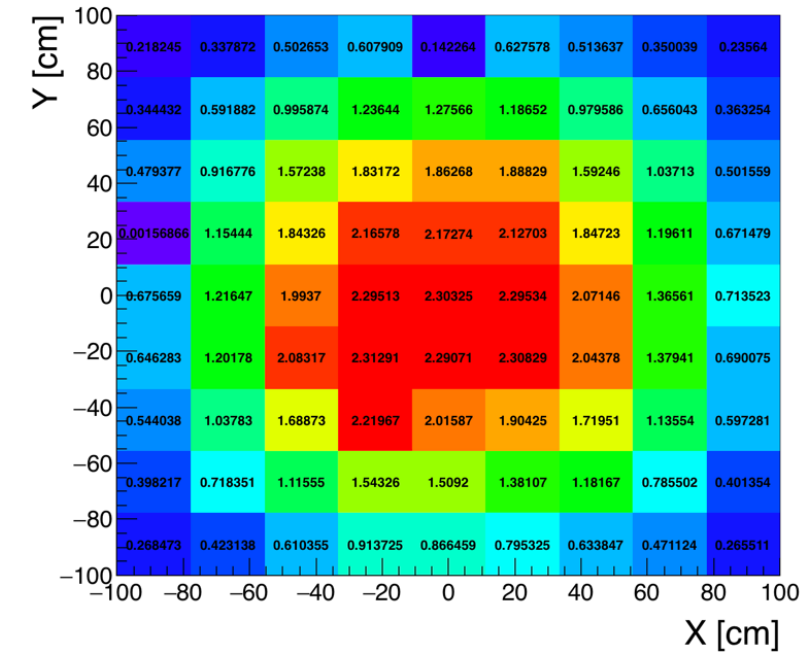
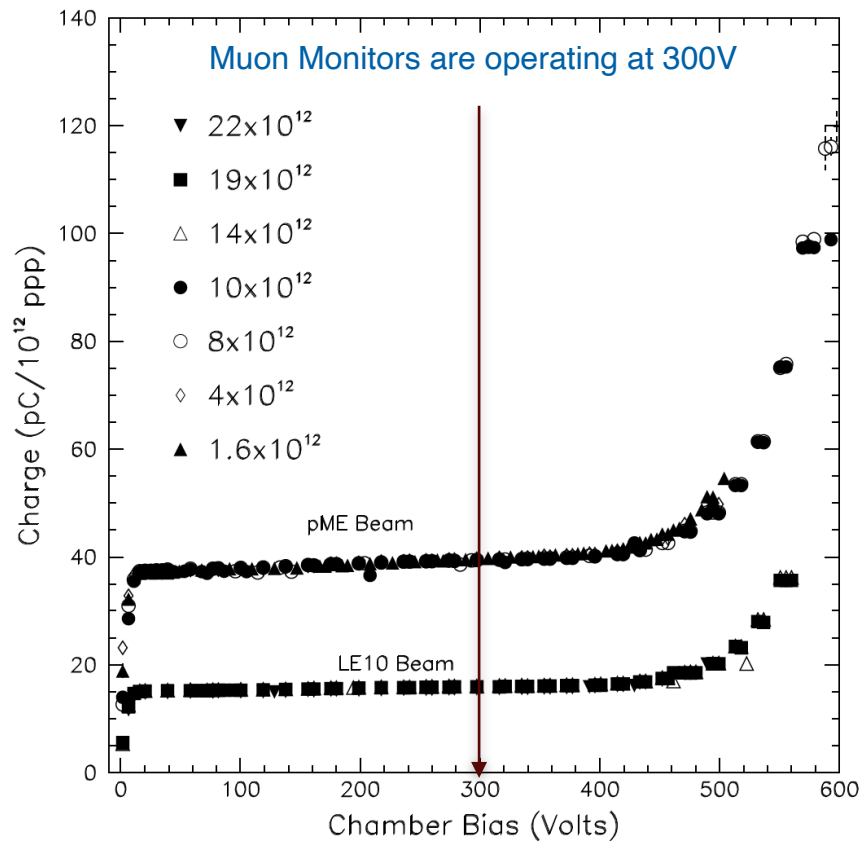
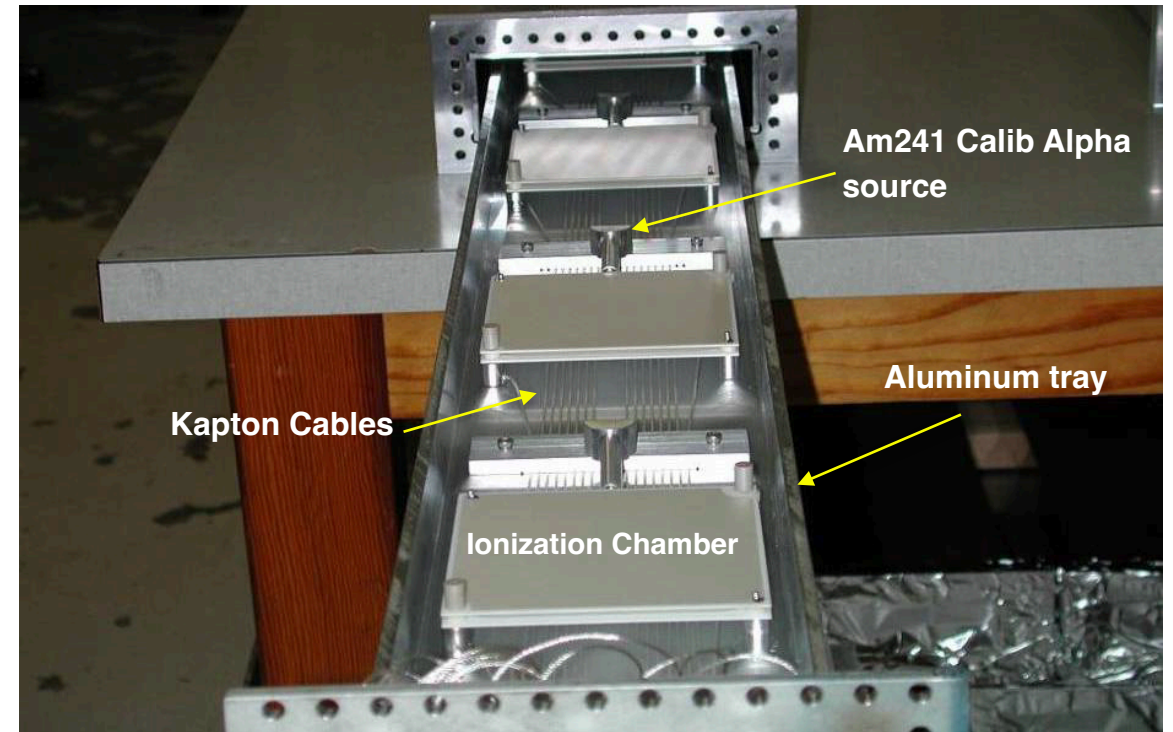
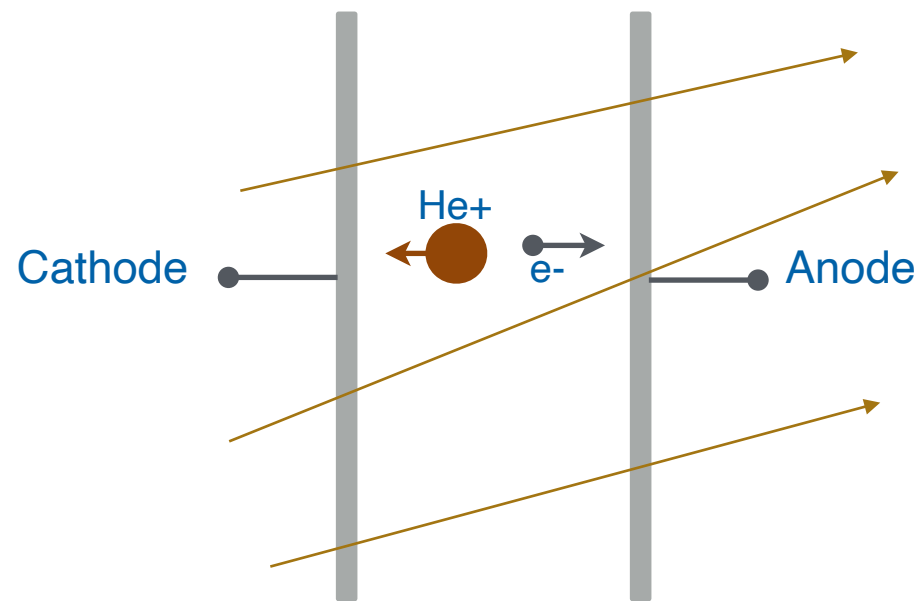
Remarks

- **Comparison studies show the slope differences.**
- **These differences are mainly coming from the systematic changes in the beamline components.**
- **Study is in its preliminary stage and findings are not yet conclusive.**
- **We are doing further studies with other available beam scan data.**
- **Beam scan results are encouraging dedicated simulation studies to understand the pion phase space behaviors.**

Thank you!

Backup Slides

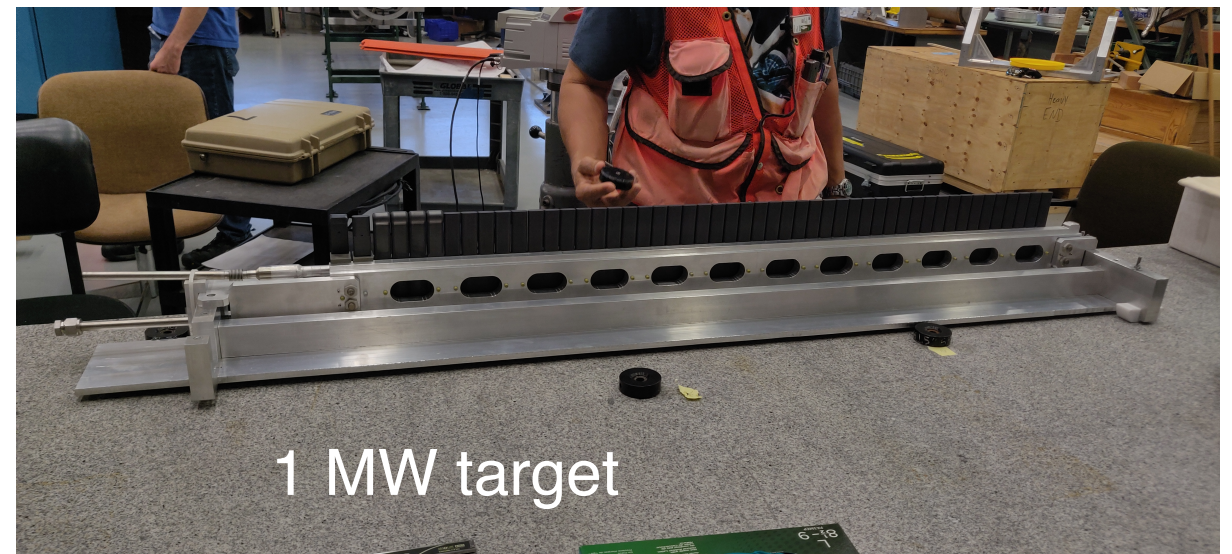
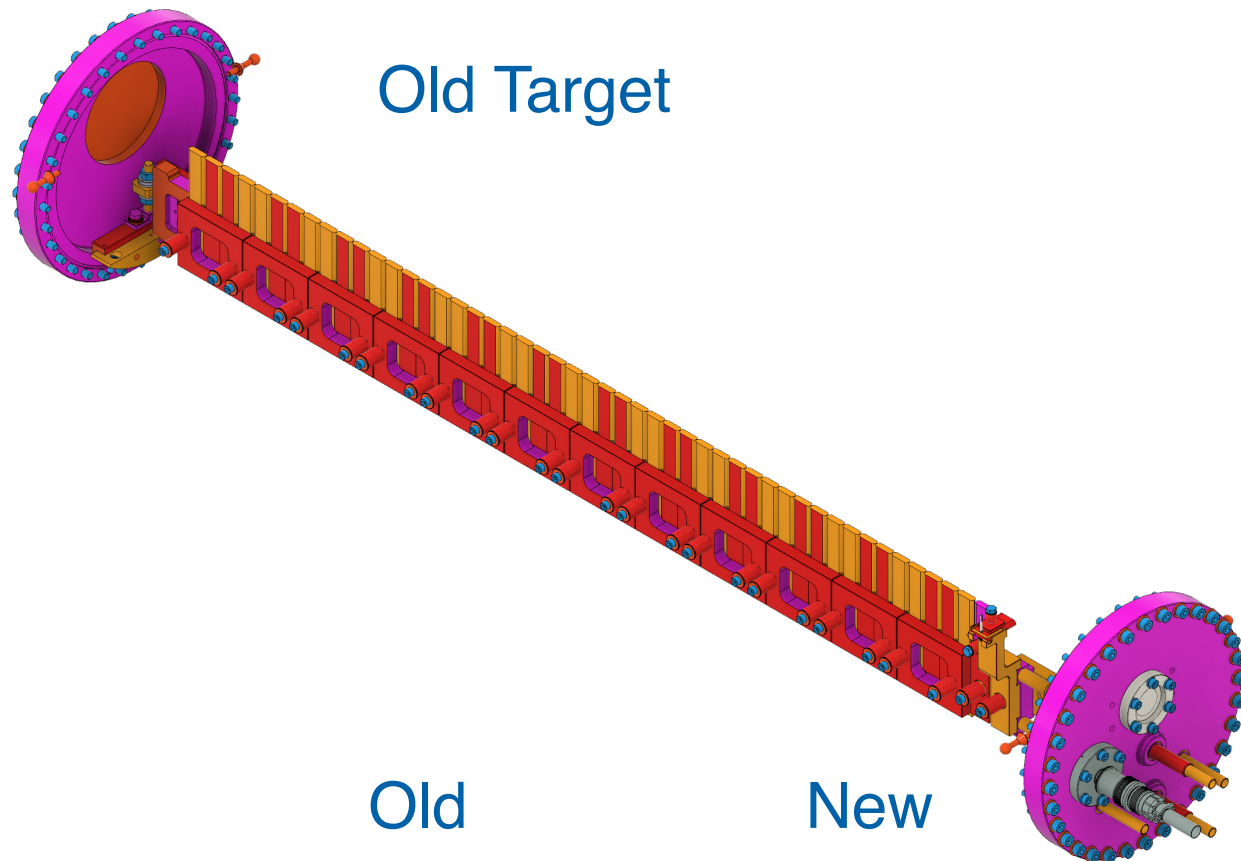
Introduction to Muon Monitors



- Operational voltage has been selected to minimize the recombination effects and to avoid the signal issues with the proportional region

New vs Old Targets

1-MW NuMI target has been installed during the summer shutdown in 2019



	Old	New
Width :	7.4 mm	9.0 mm
Height:	14.30 cm	15.53 cm
Segment length:	2.5 cm	2.5 cm



- Four target segments have cylindrical shapes tops in the new target system
- Densities are same

Beam Scans

