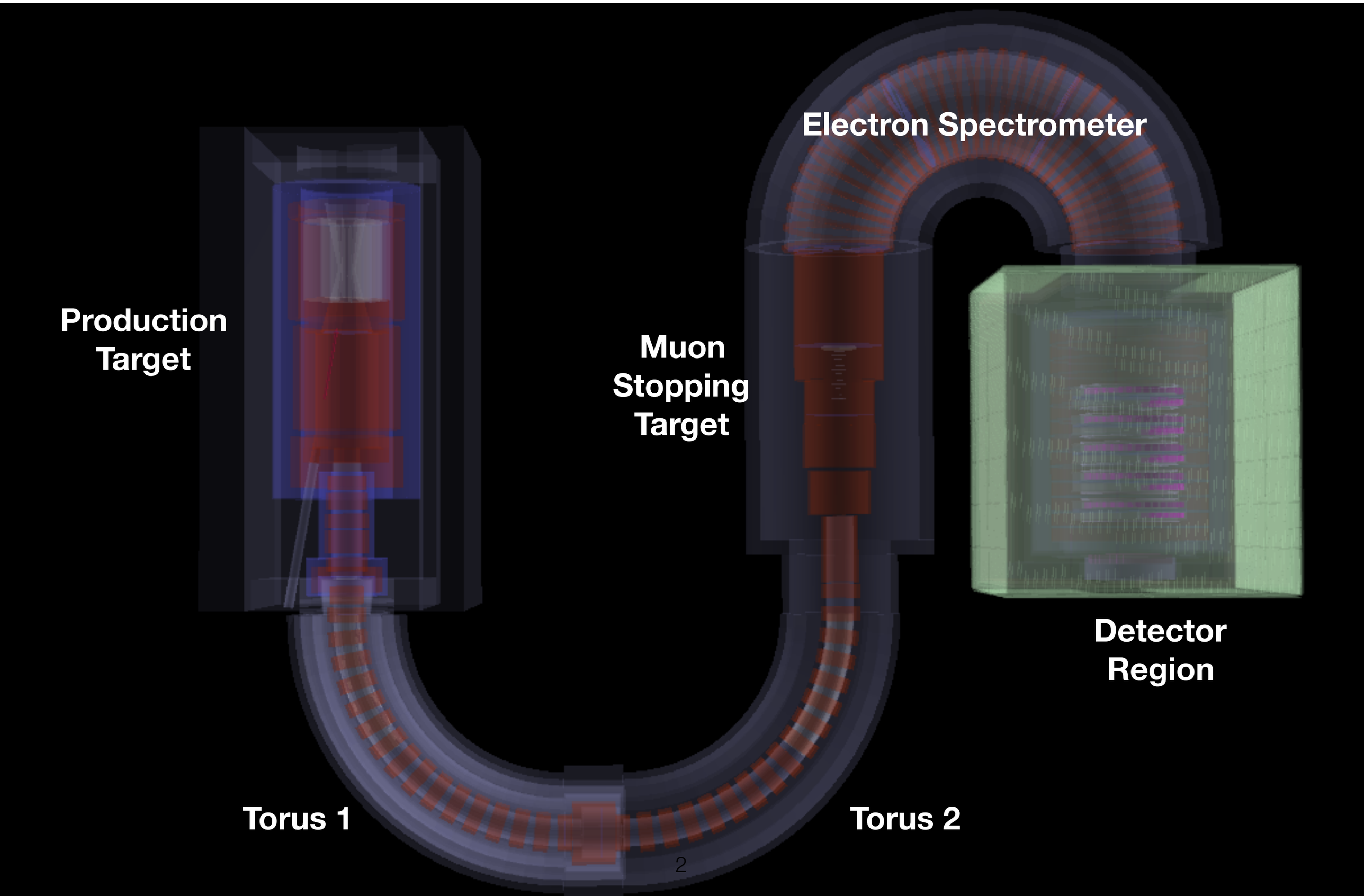
Stopping Target Optimization for COMET Phase II

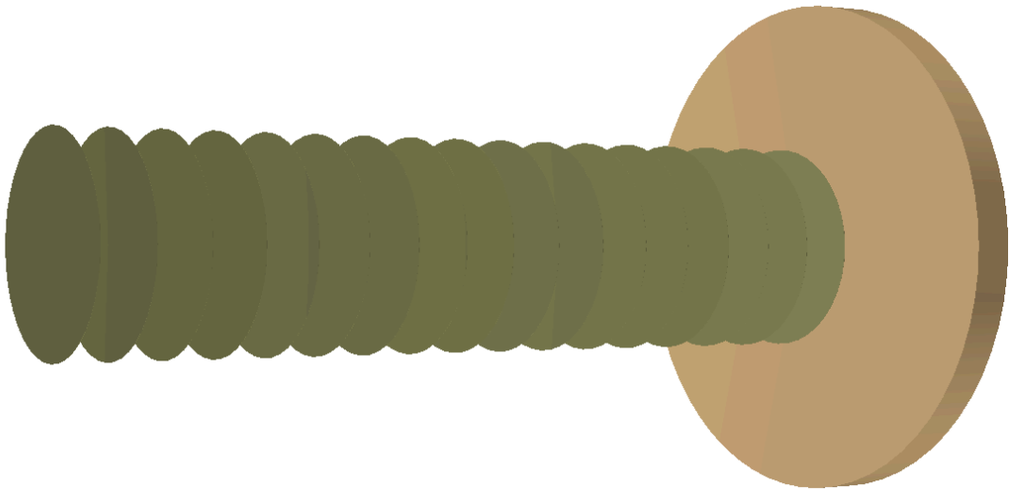
Giorgi Kumsiashvili M2

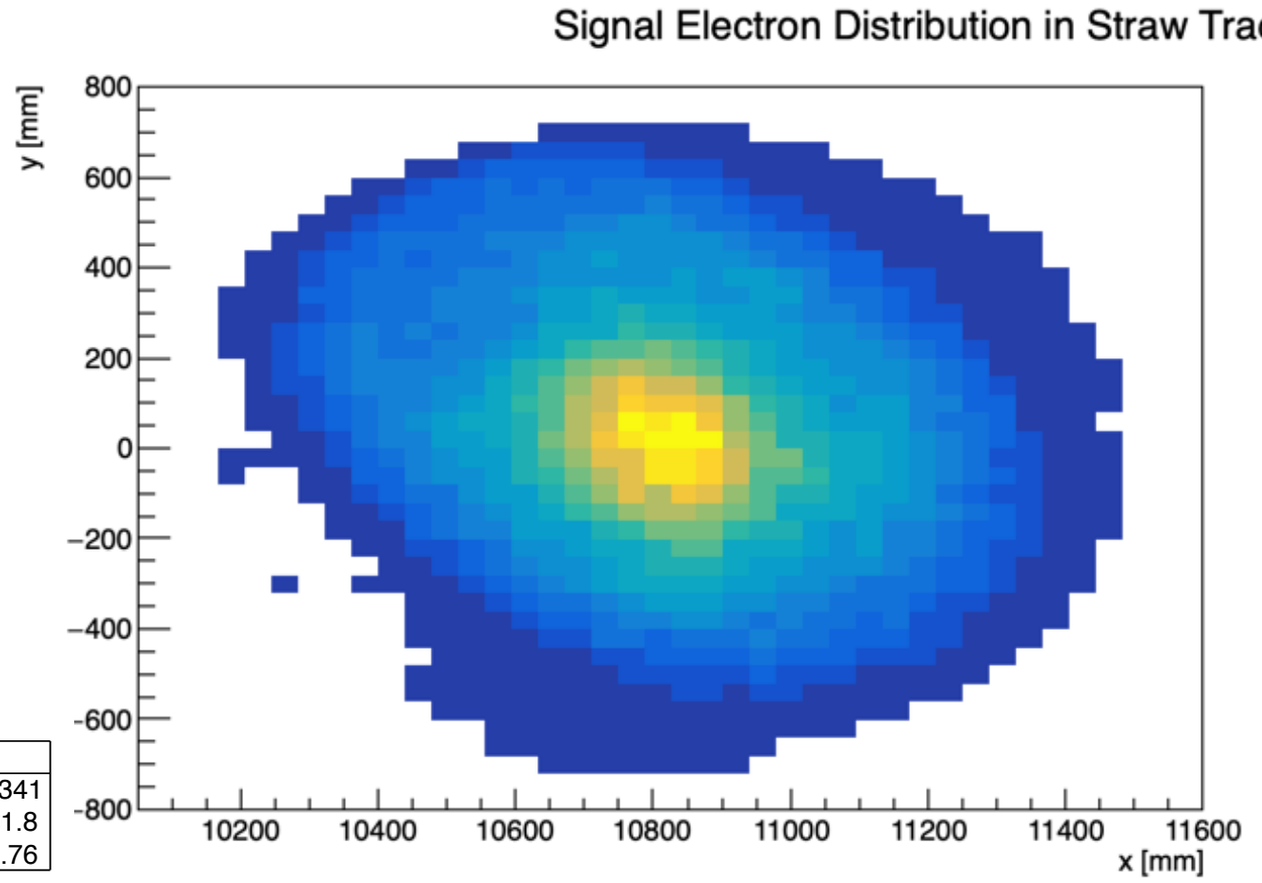
Year-end Presentation 2019

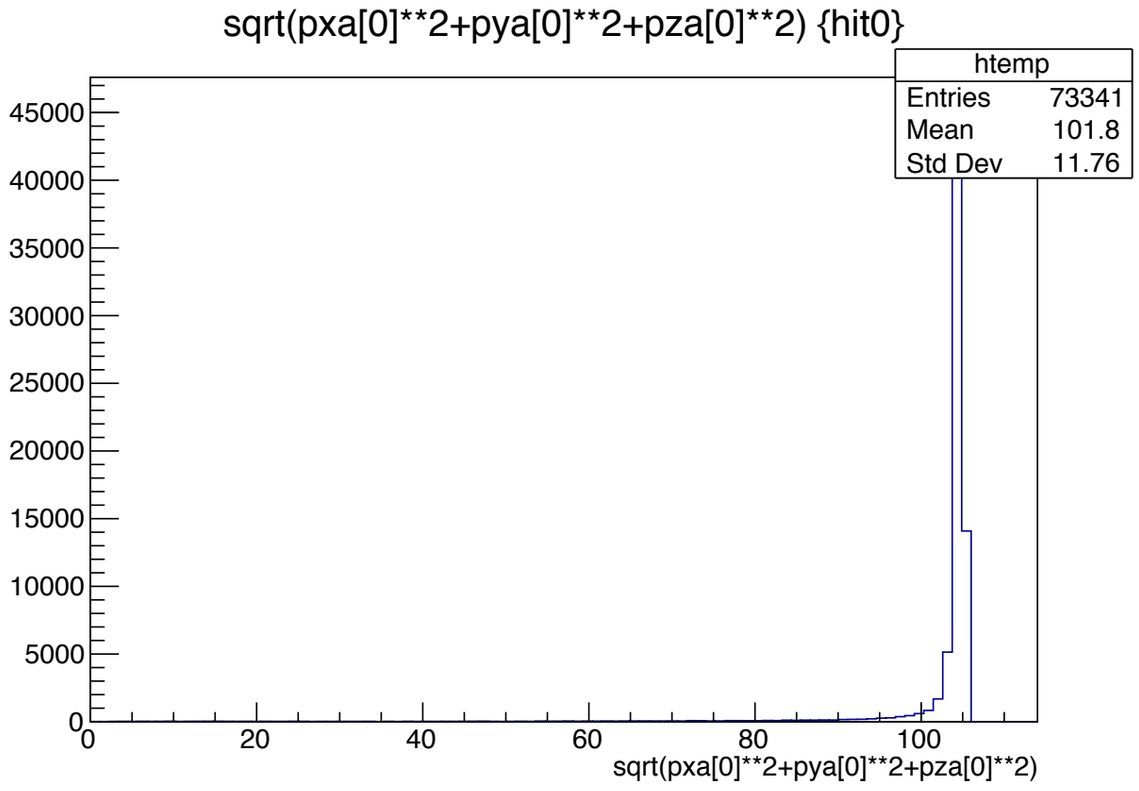
COMET Phase II Beamline



Original Target Design

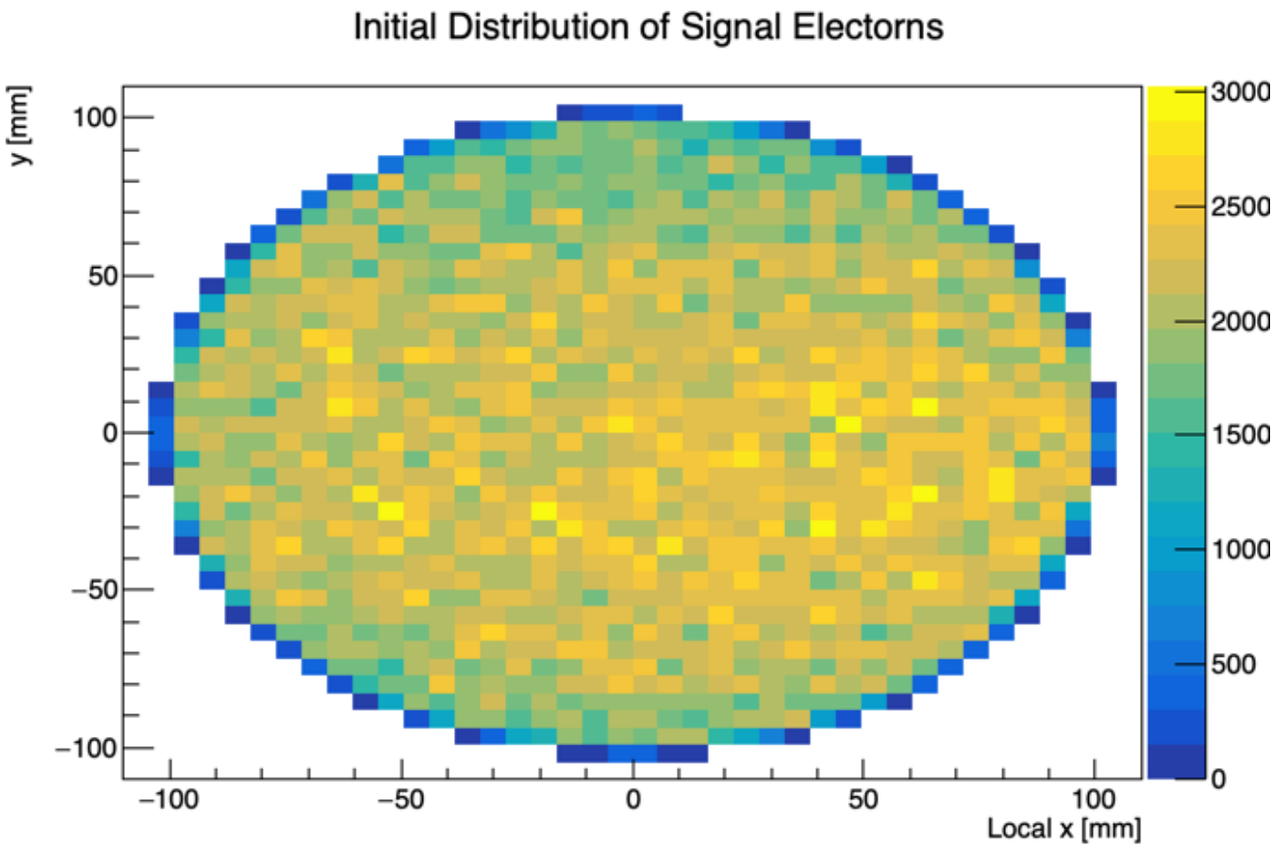




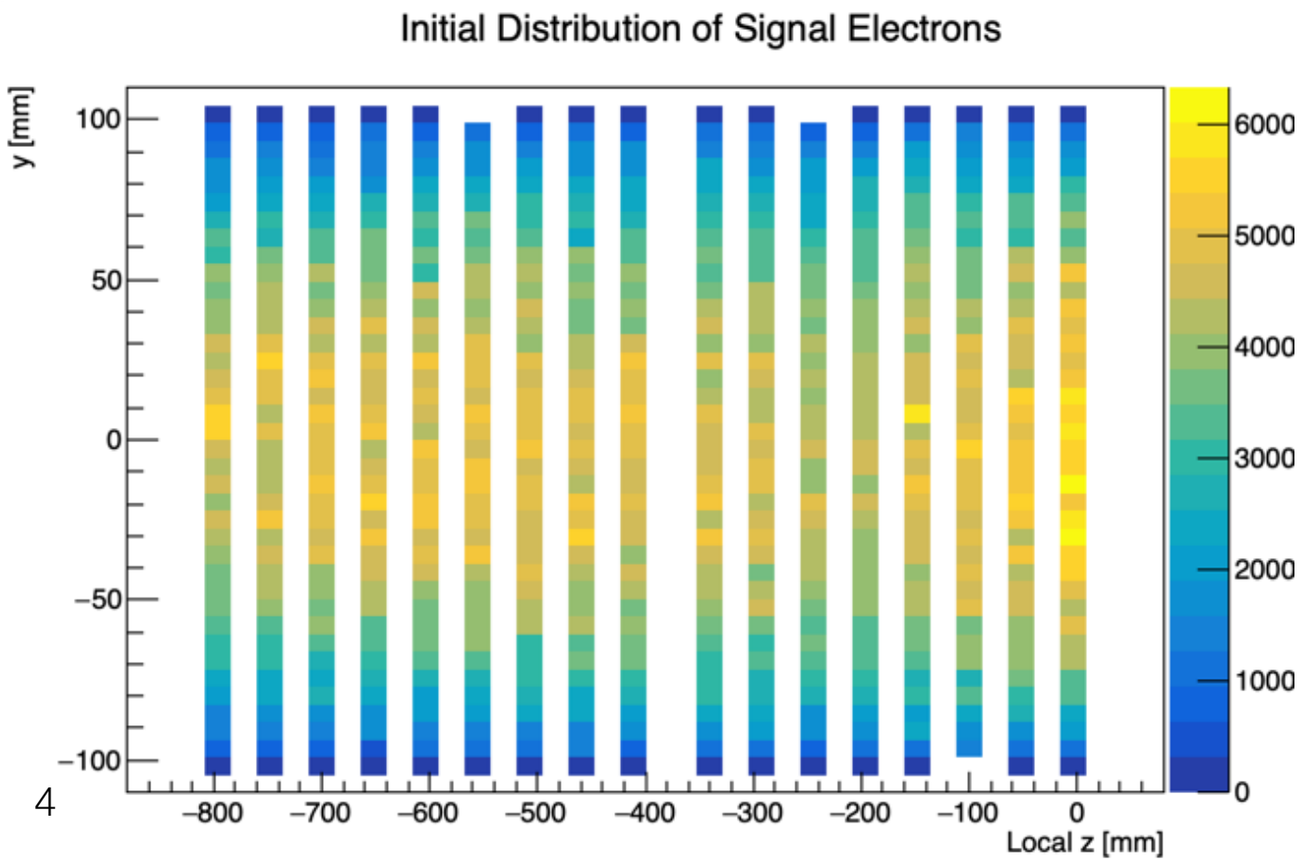


Target Radius 100mm
Beam Blocker - Vacuum
DIO Blocker - Vacuum
Default Gradient Mag. Field

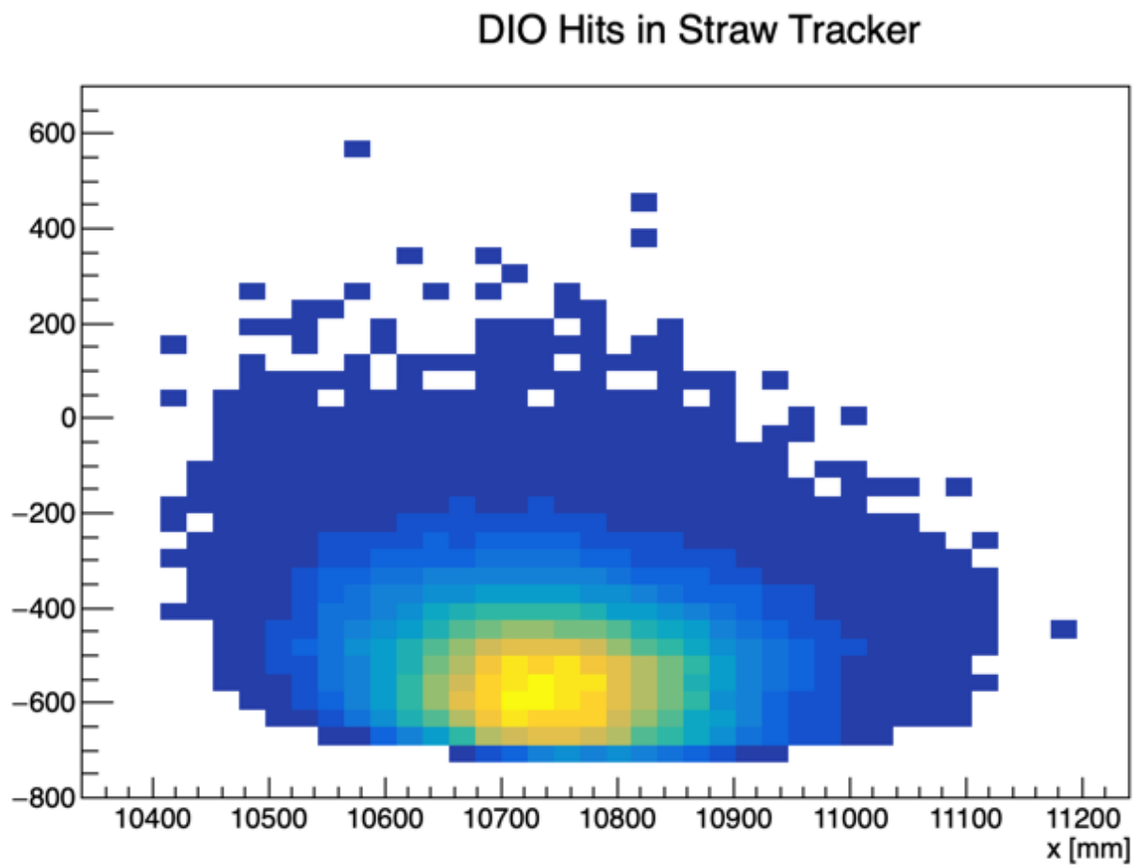
Signal Electrons

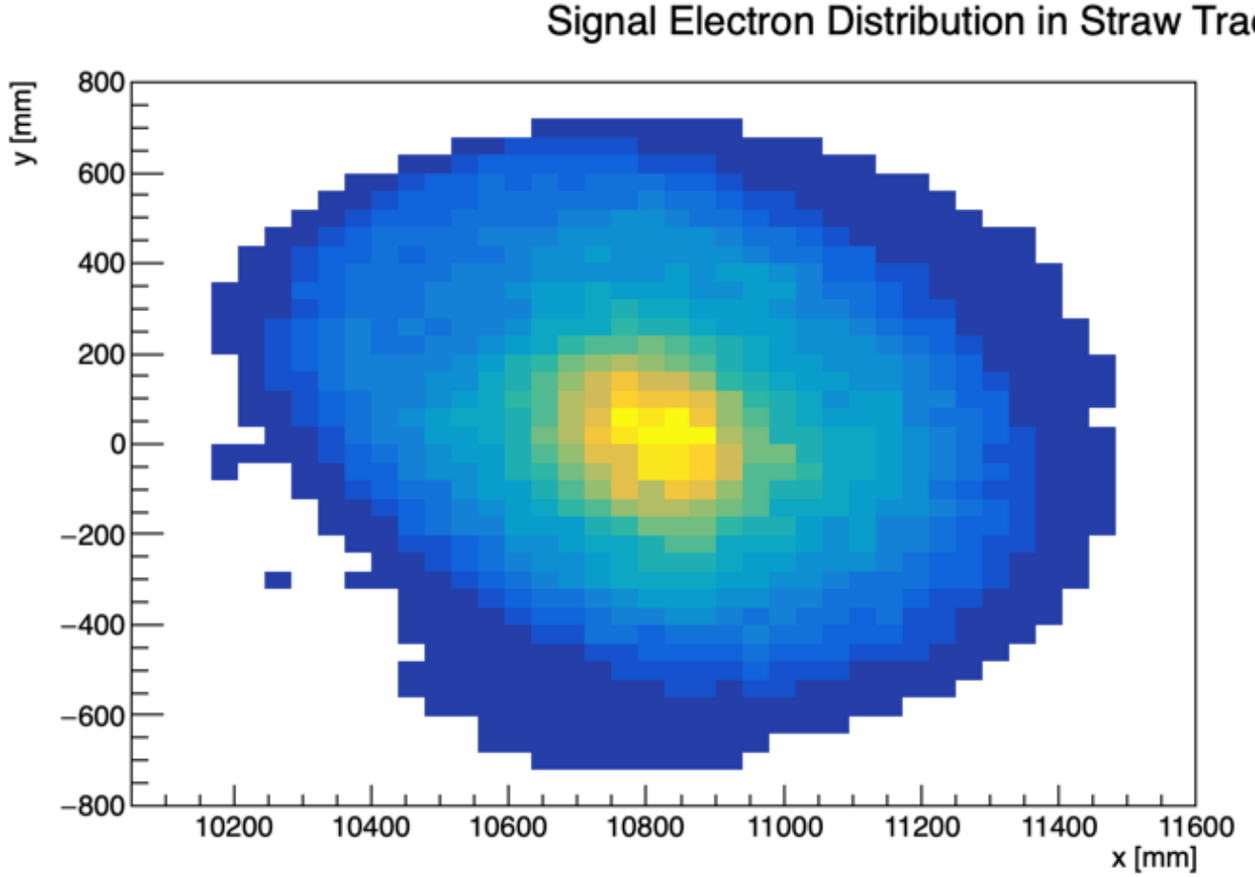


Signal Electrons that are later accepted by the detector



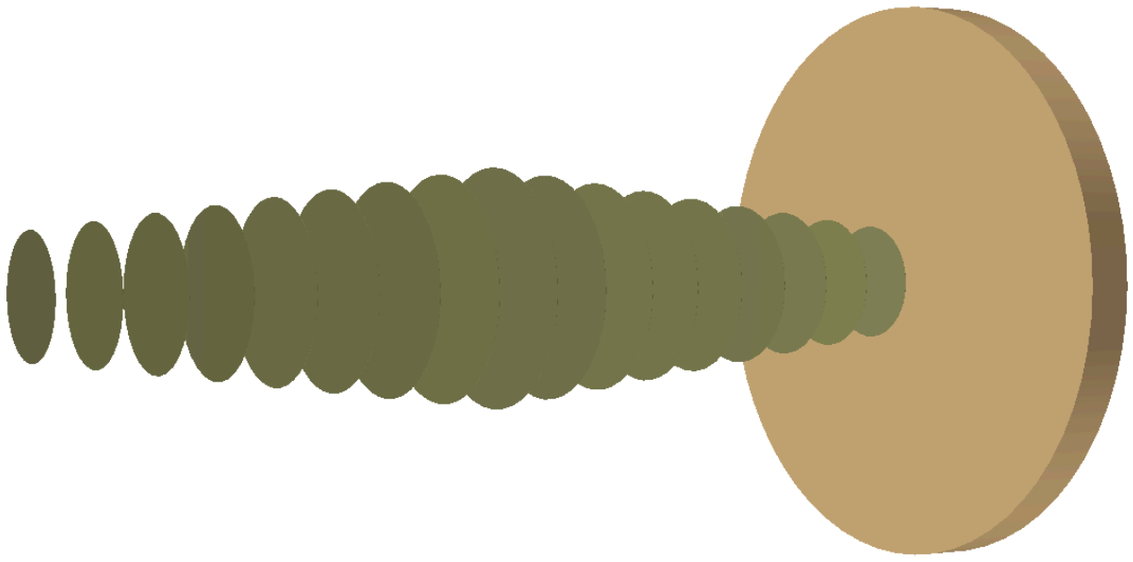
Distribution in Straw Tracker



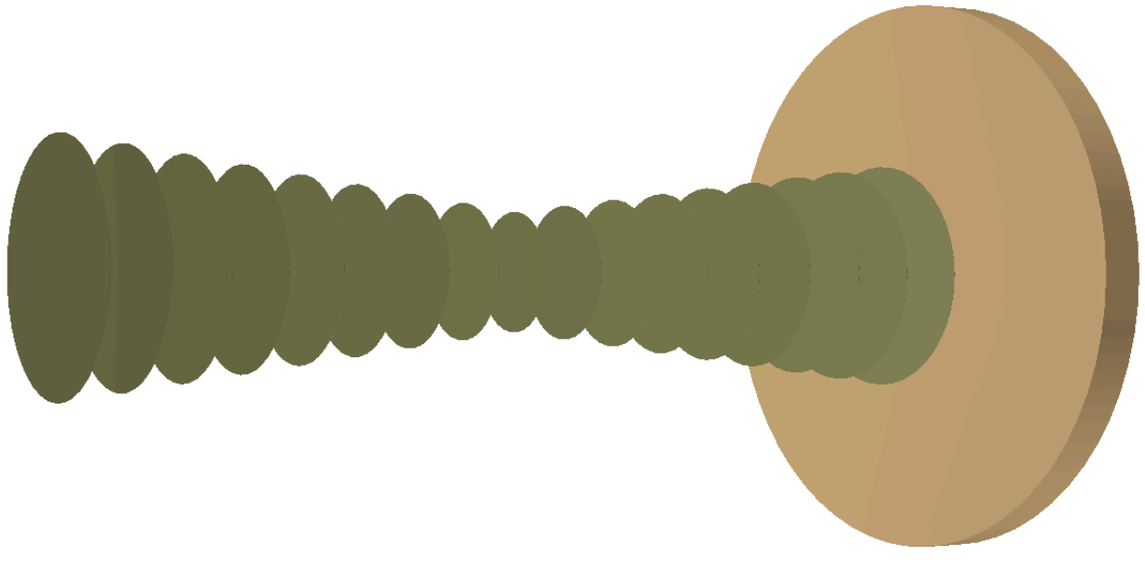


Test Designs

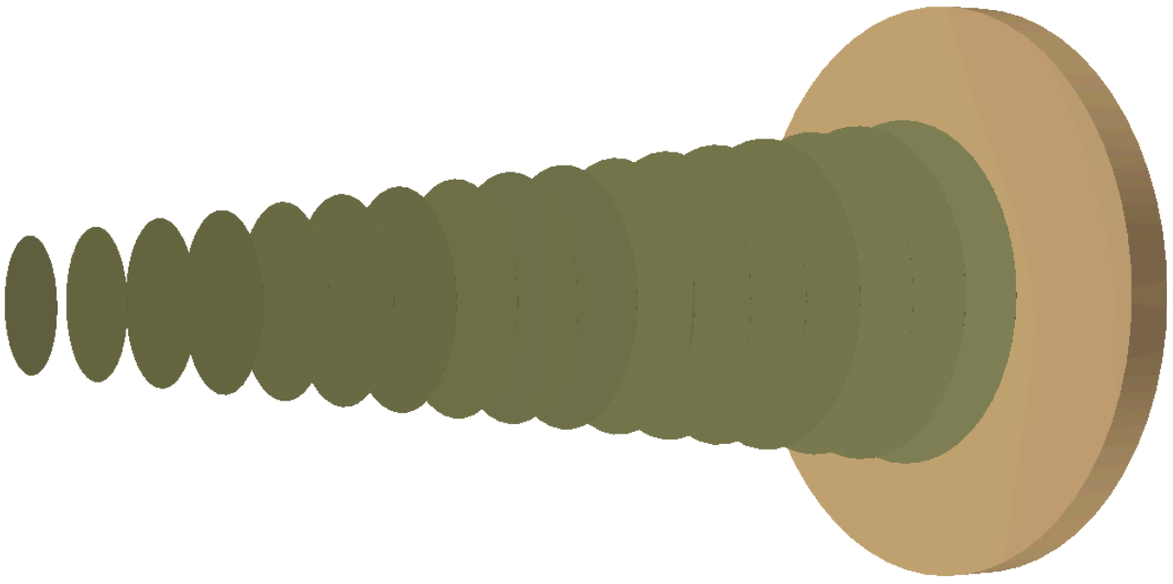
1st Disk - 50mm, 9th - 100mm, 17th - 50mm



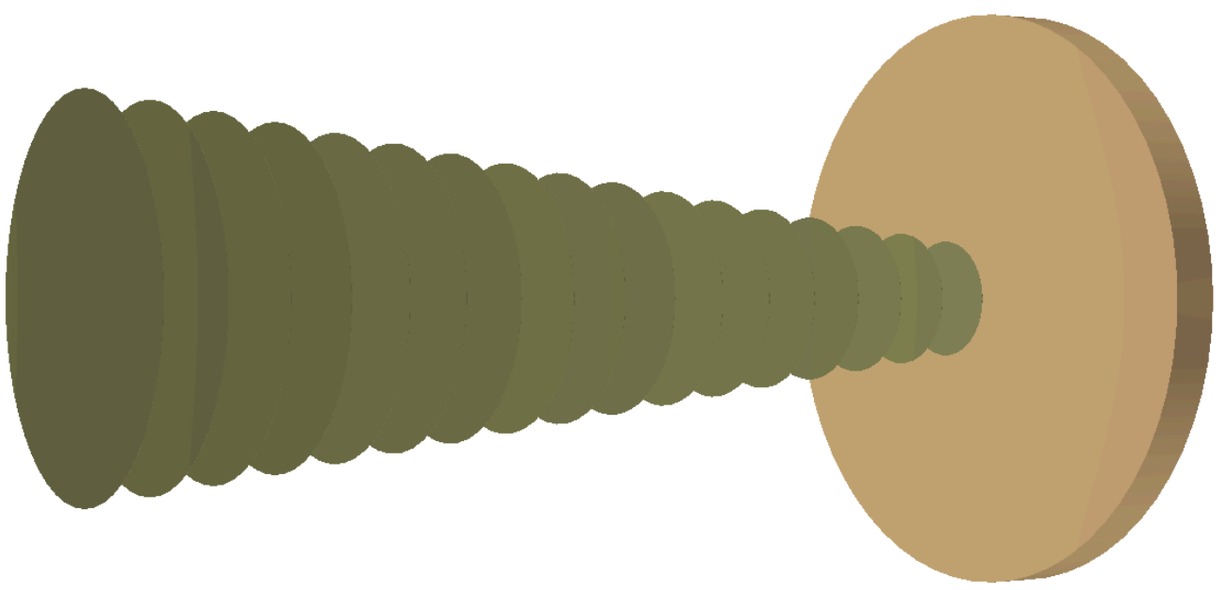
1st Disk - 100mm, 9th - 50mm, 17th - 100mm



1st Disk - 50mm, 17th - 150mm

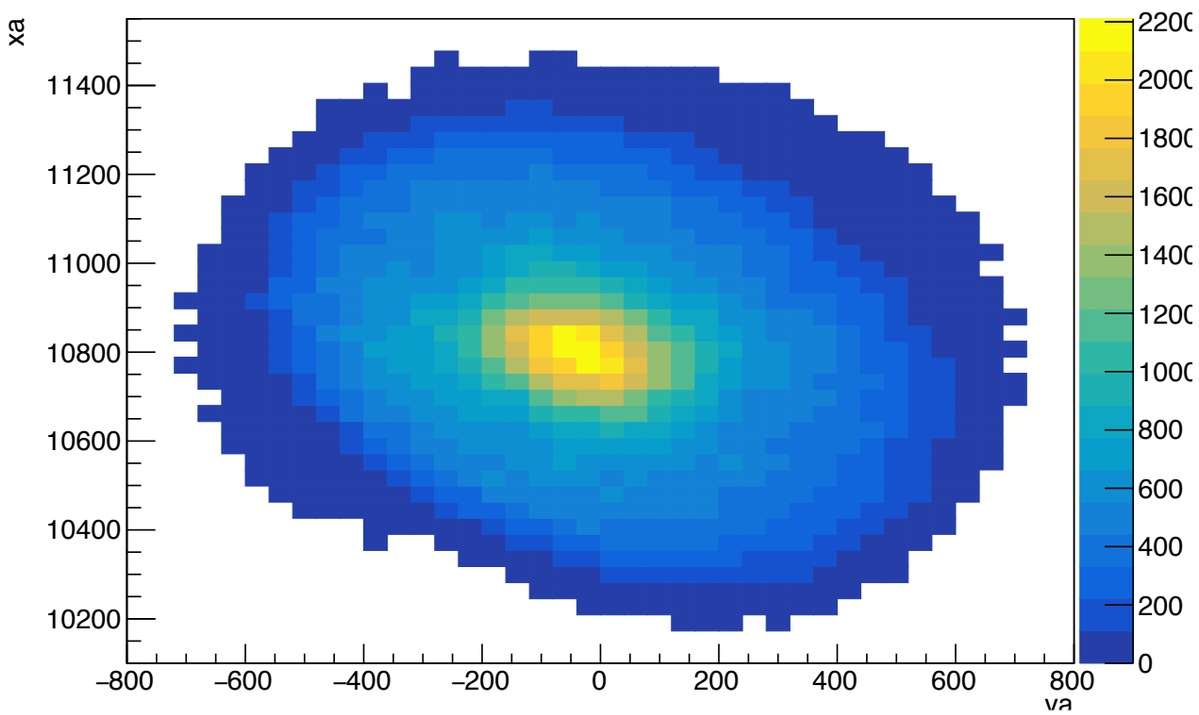


1st Disk - 150mm,17th - 50mm

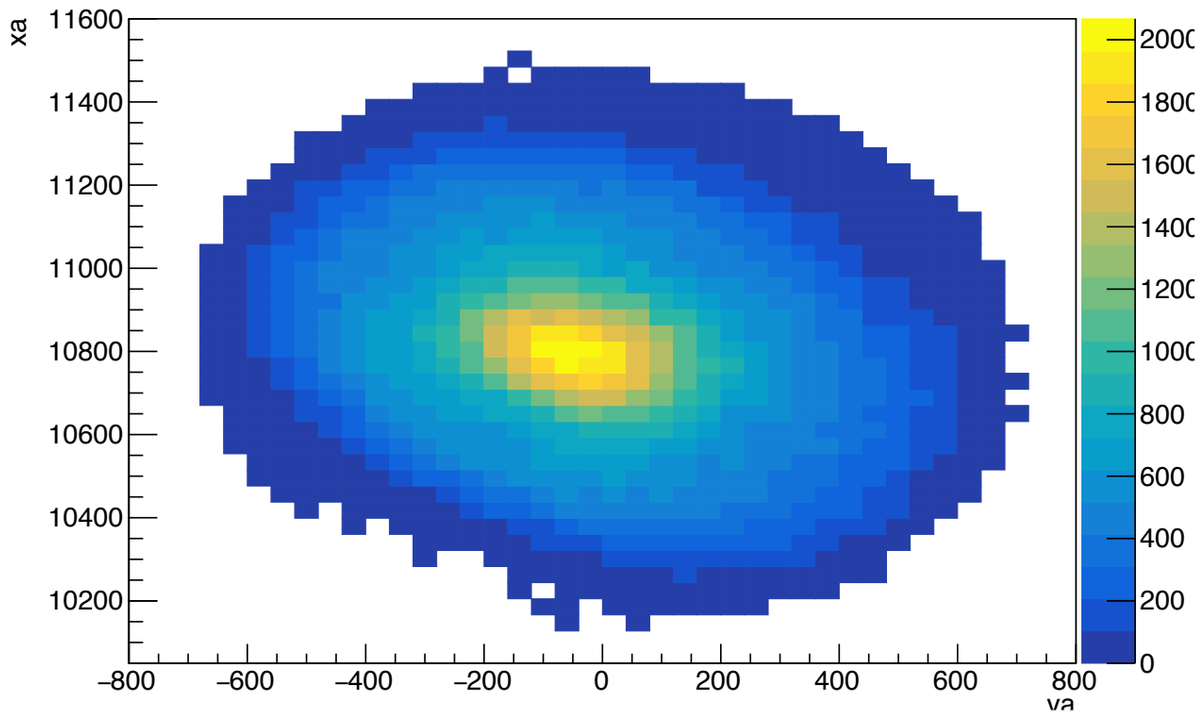


Distributions In Straw Tracker

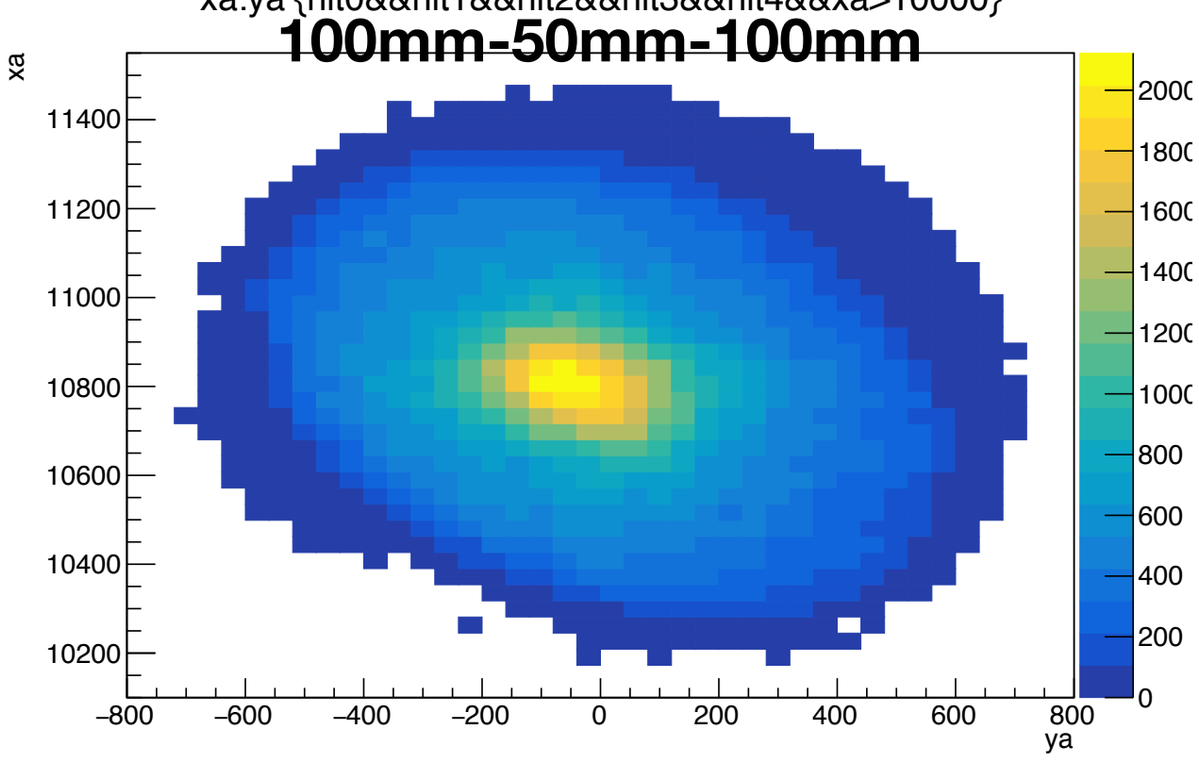
50mm-100mm-50mm



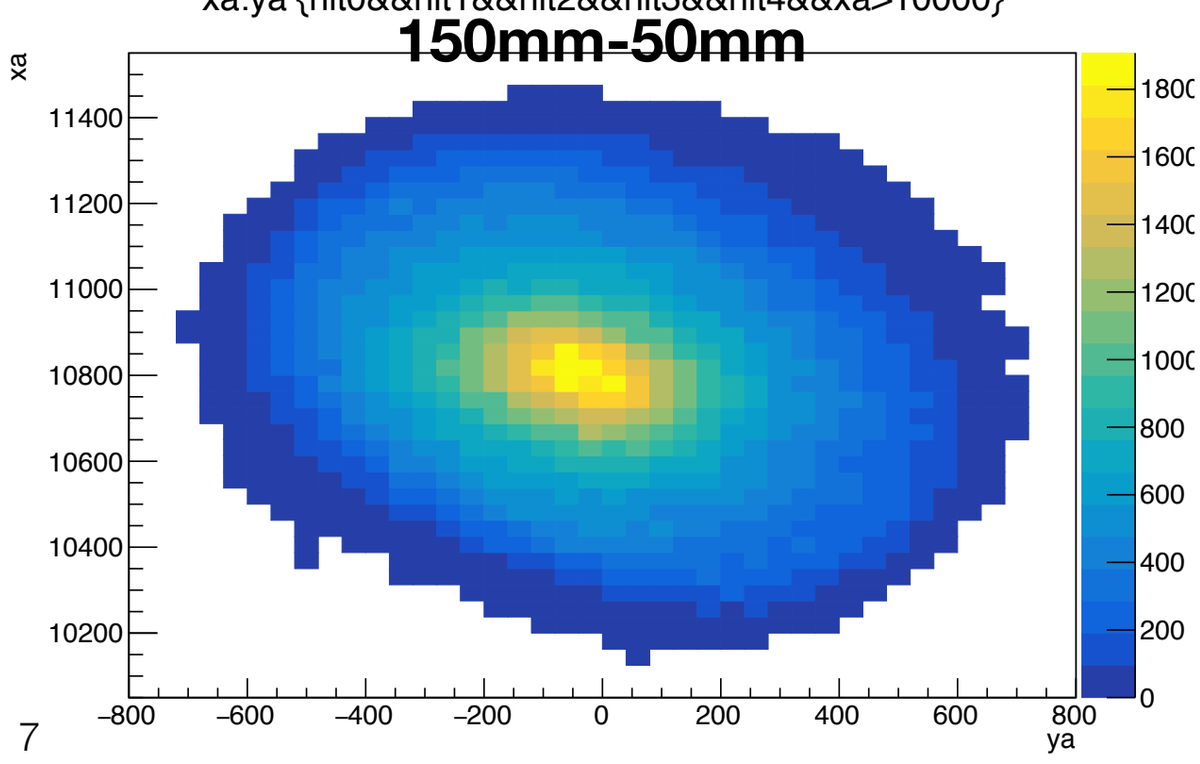
50mm-150mm



100mm-50mm-100mm

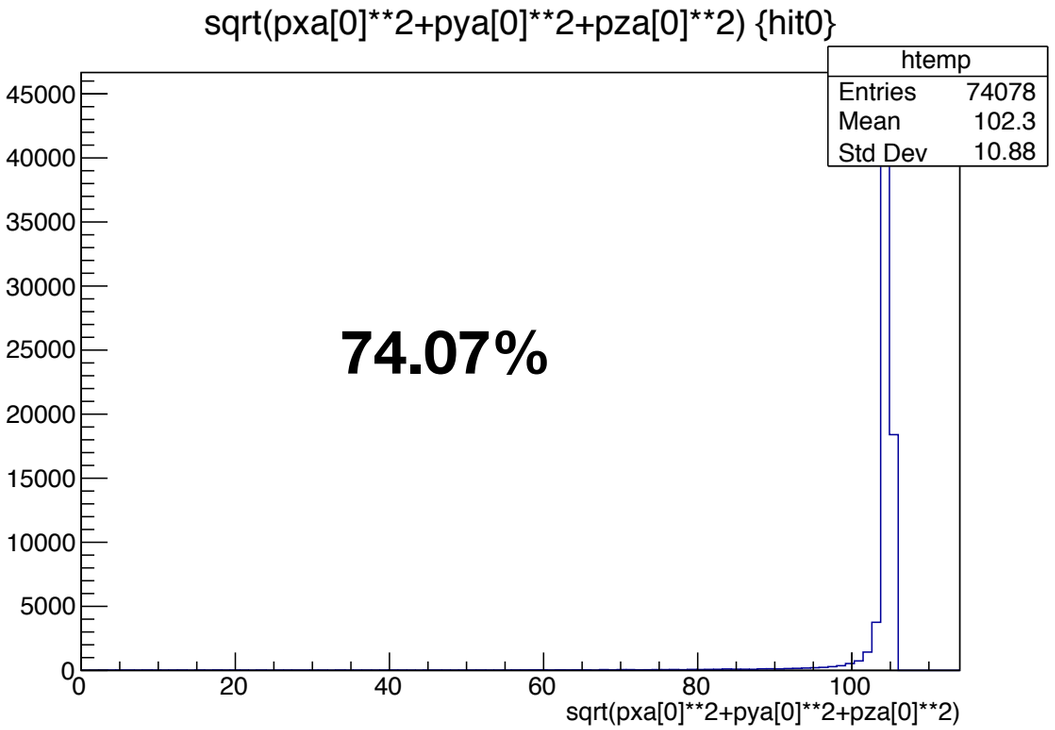


150mm-50mm

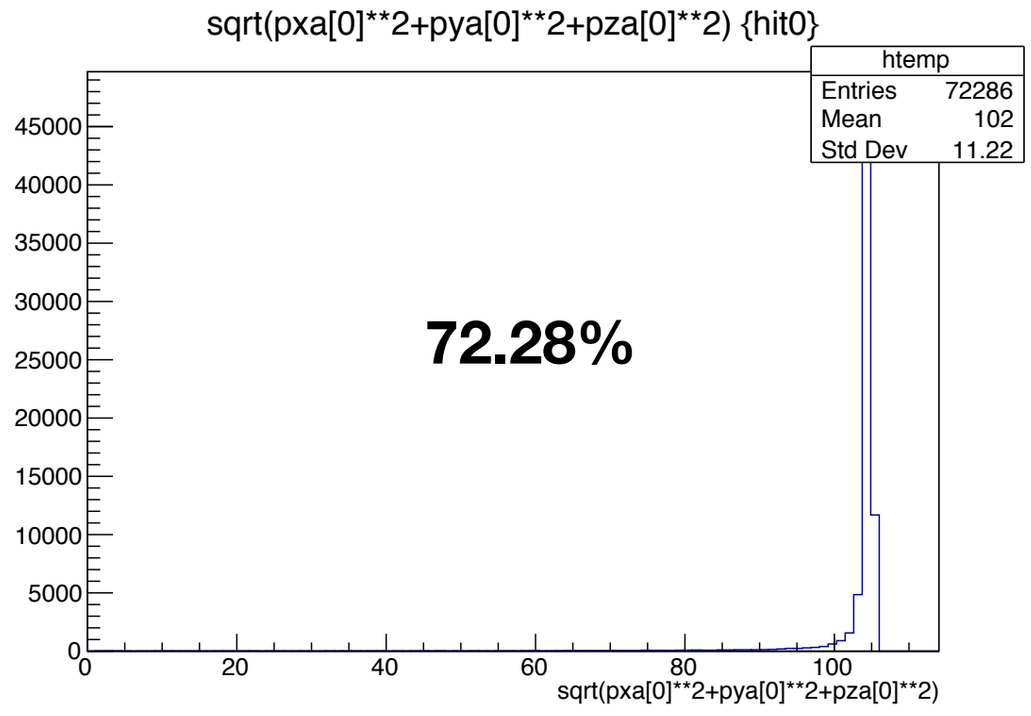


Momentum

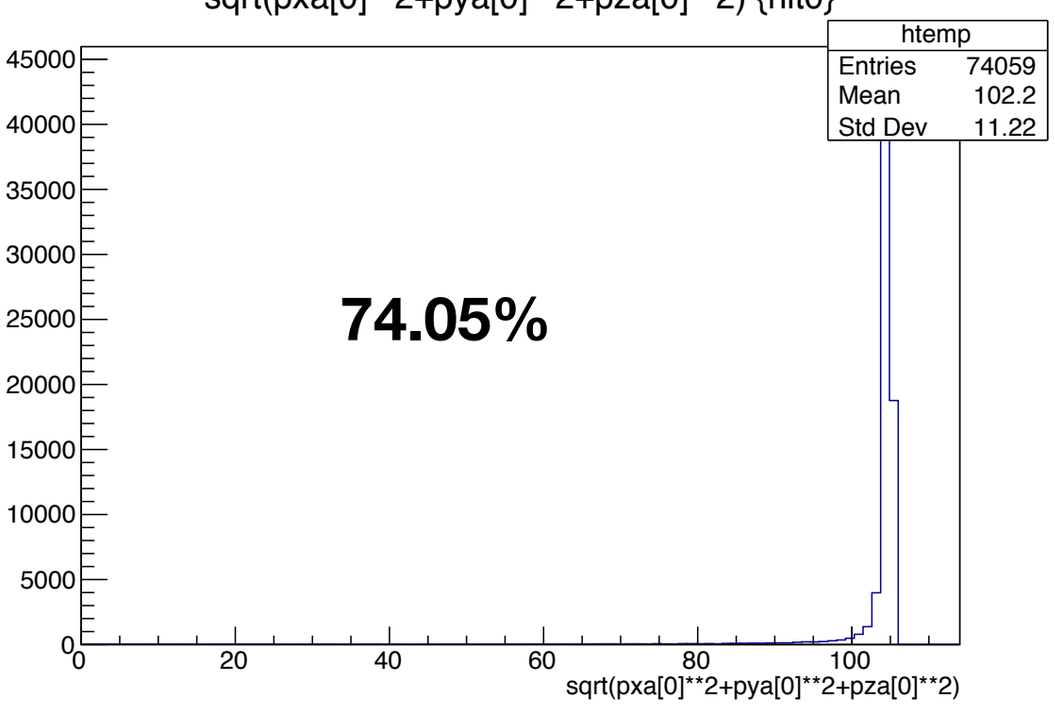
50mm-100mm-50mm



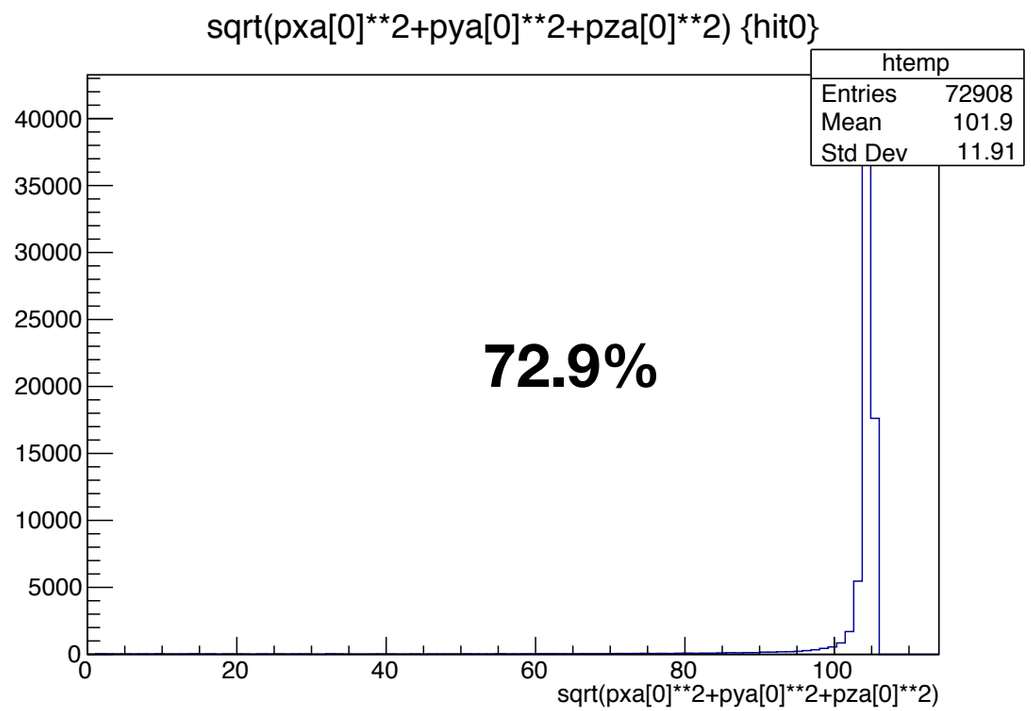
50mm-150mm



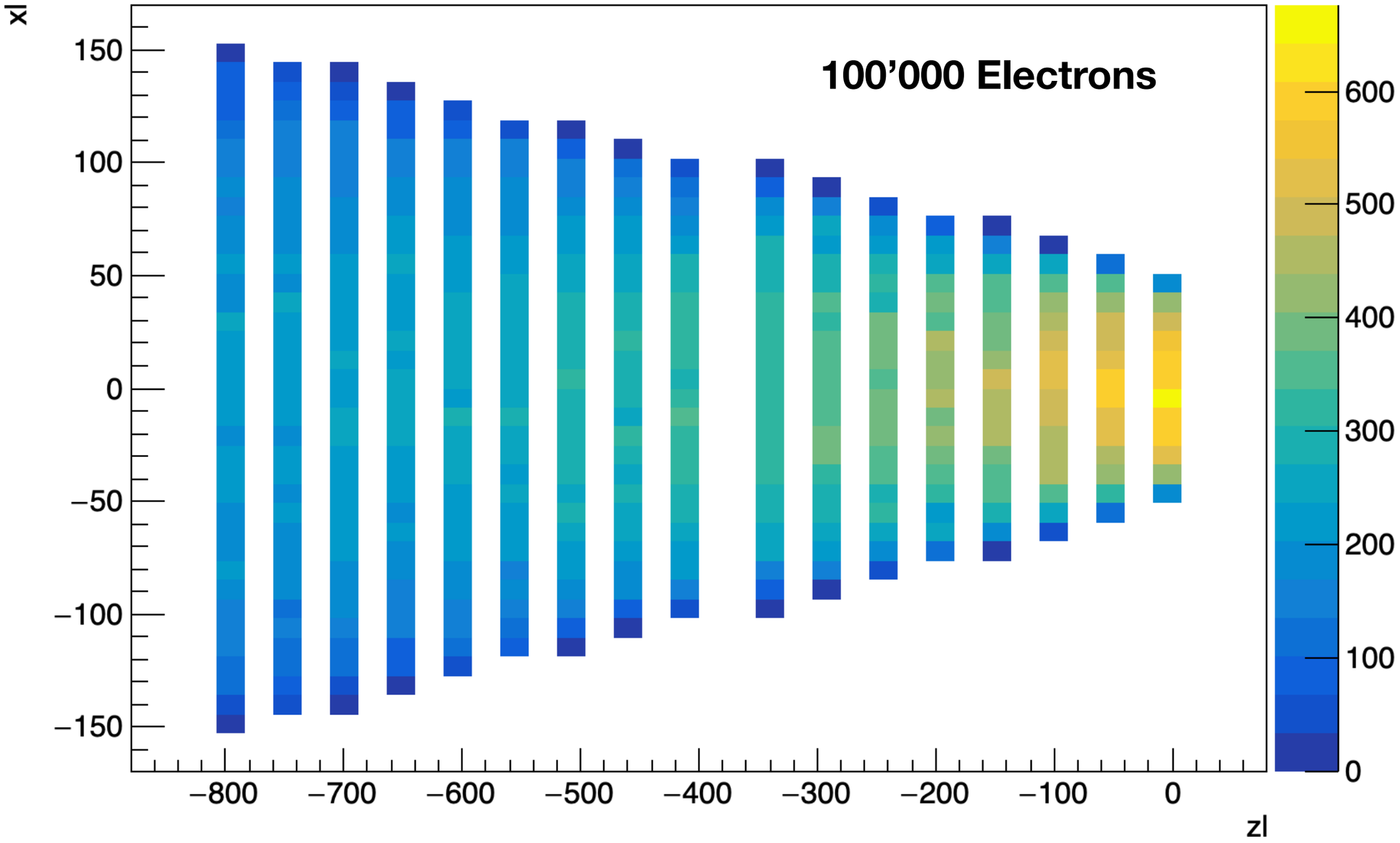
100mm-50mm-100mm



150mm-50mm

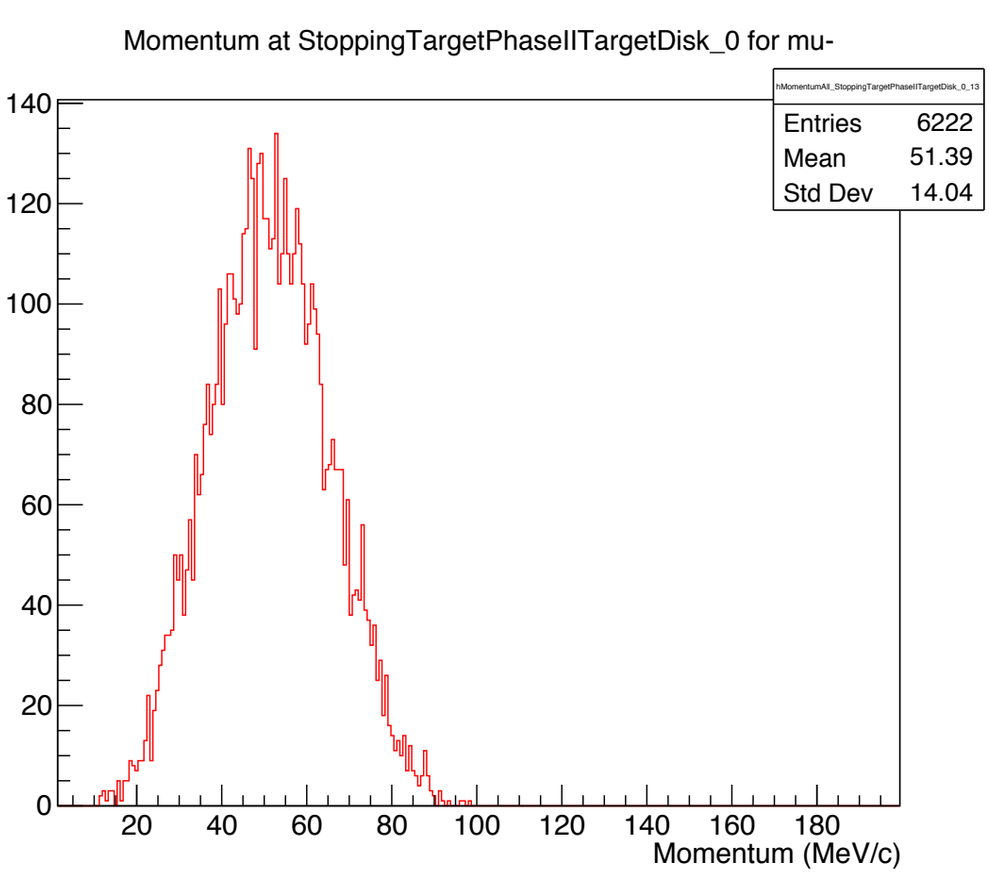


Initial Distribution

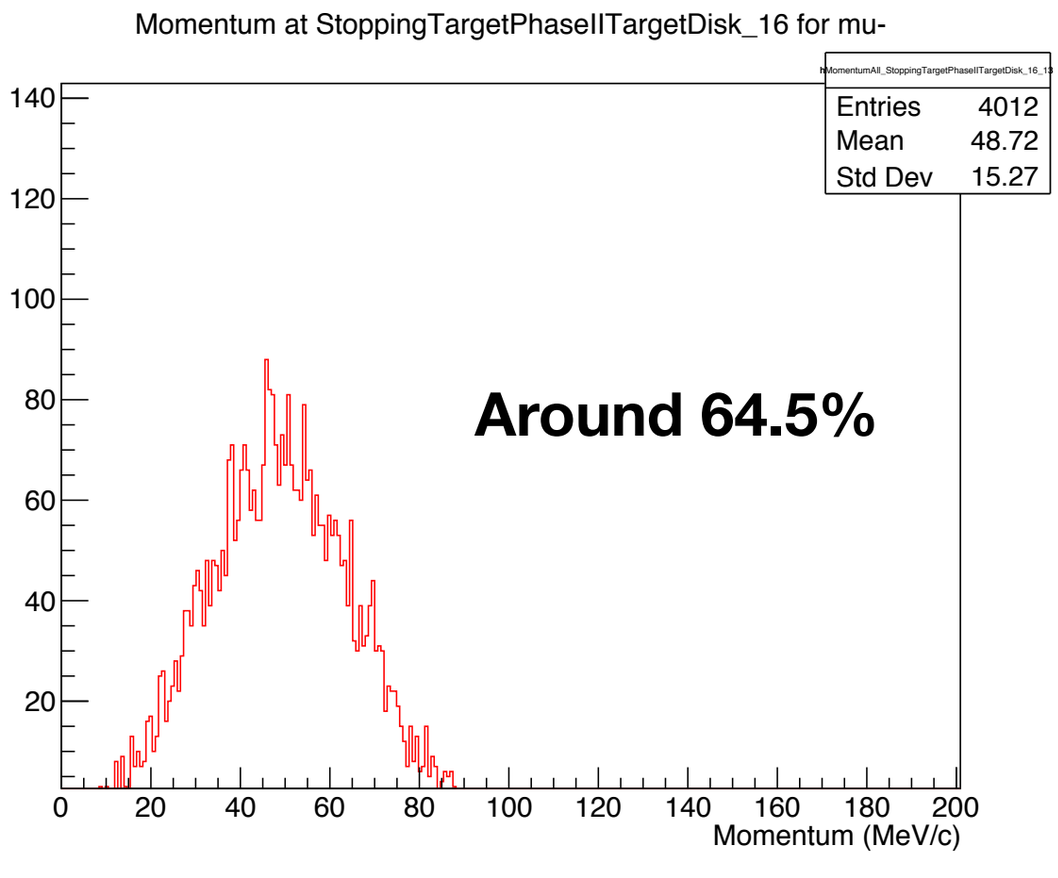


Mu- Momentum in Disks

In this example:
Number of disks - 17
Disk radius - 100mm



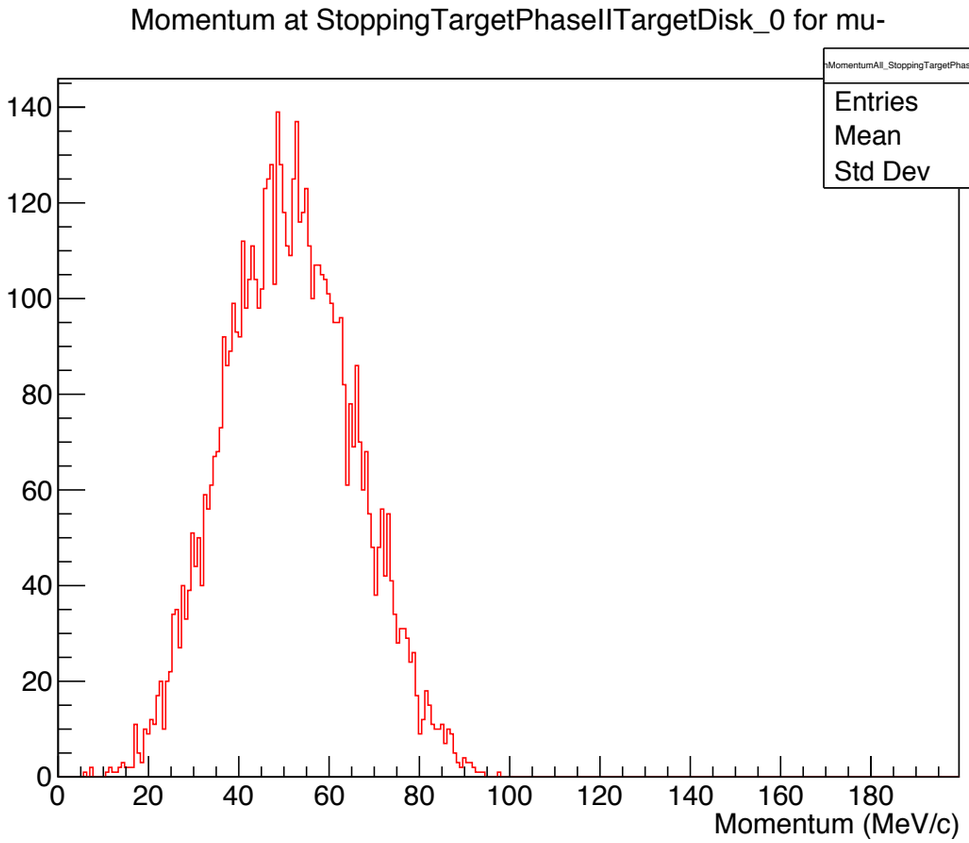
Disk 1



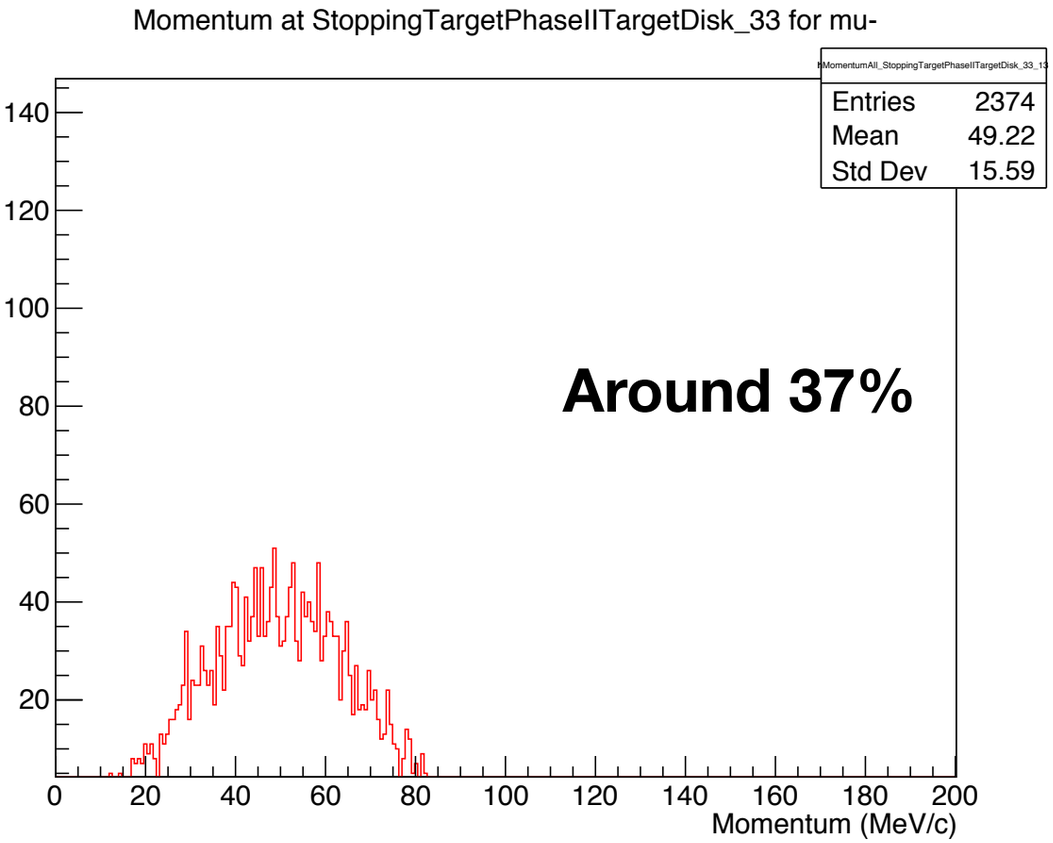
Disk 17

Mu- Momentum in Disks

In this example:
Number of disks - 34
Disk radius - 100mm



Disk 1



Disk 34

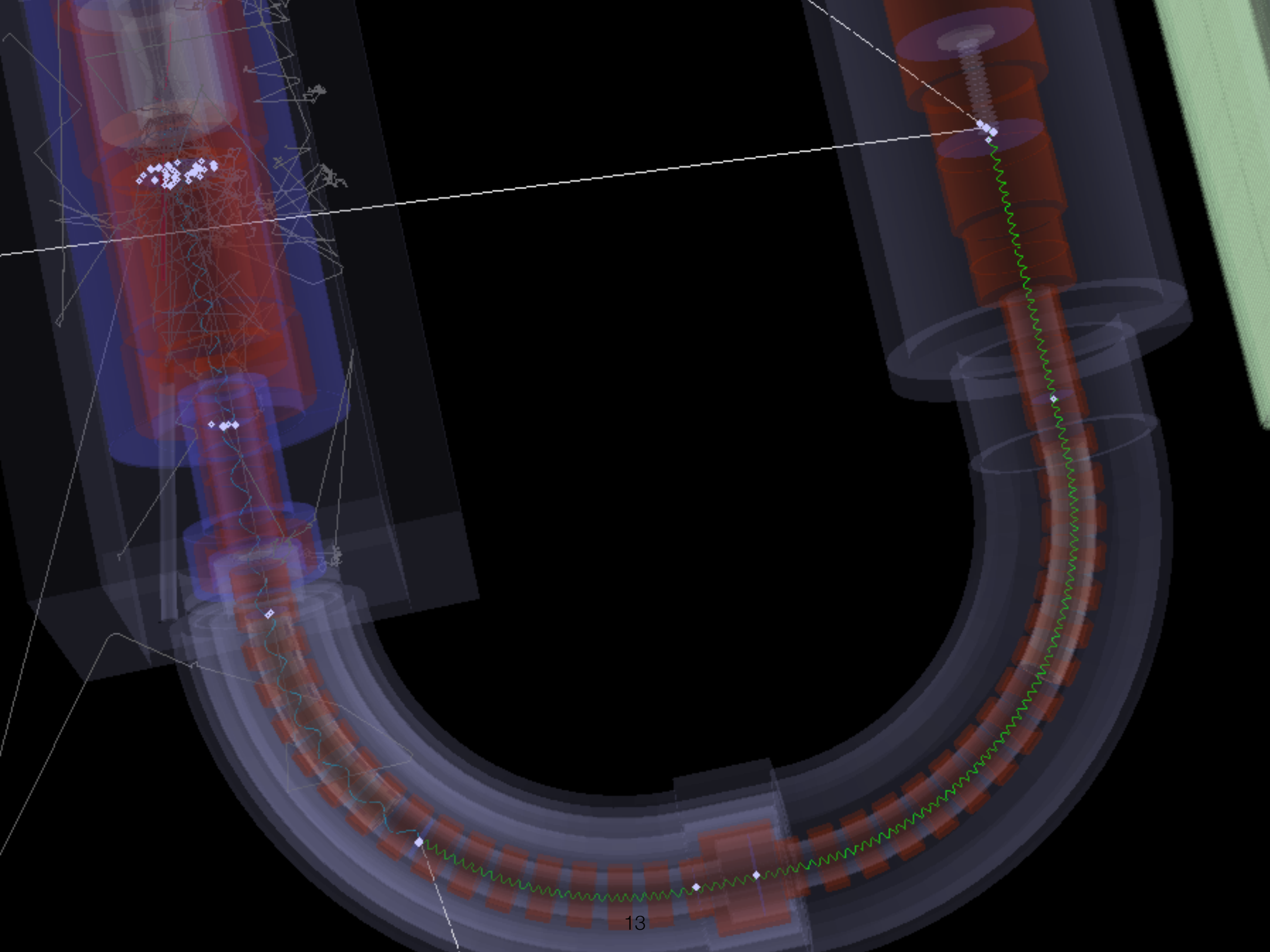
Summary and future work

- **The original muon stopping target design is not optimal.**
- **Test target designs yielded marginal improvements. There is a need to obtain realistic muon stopping distribution in target disks. (in progress)**
- **Significant number of Muons go through the target disks and downstream.**

What's next..

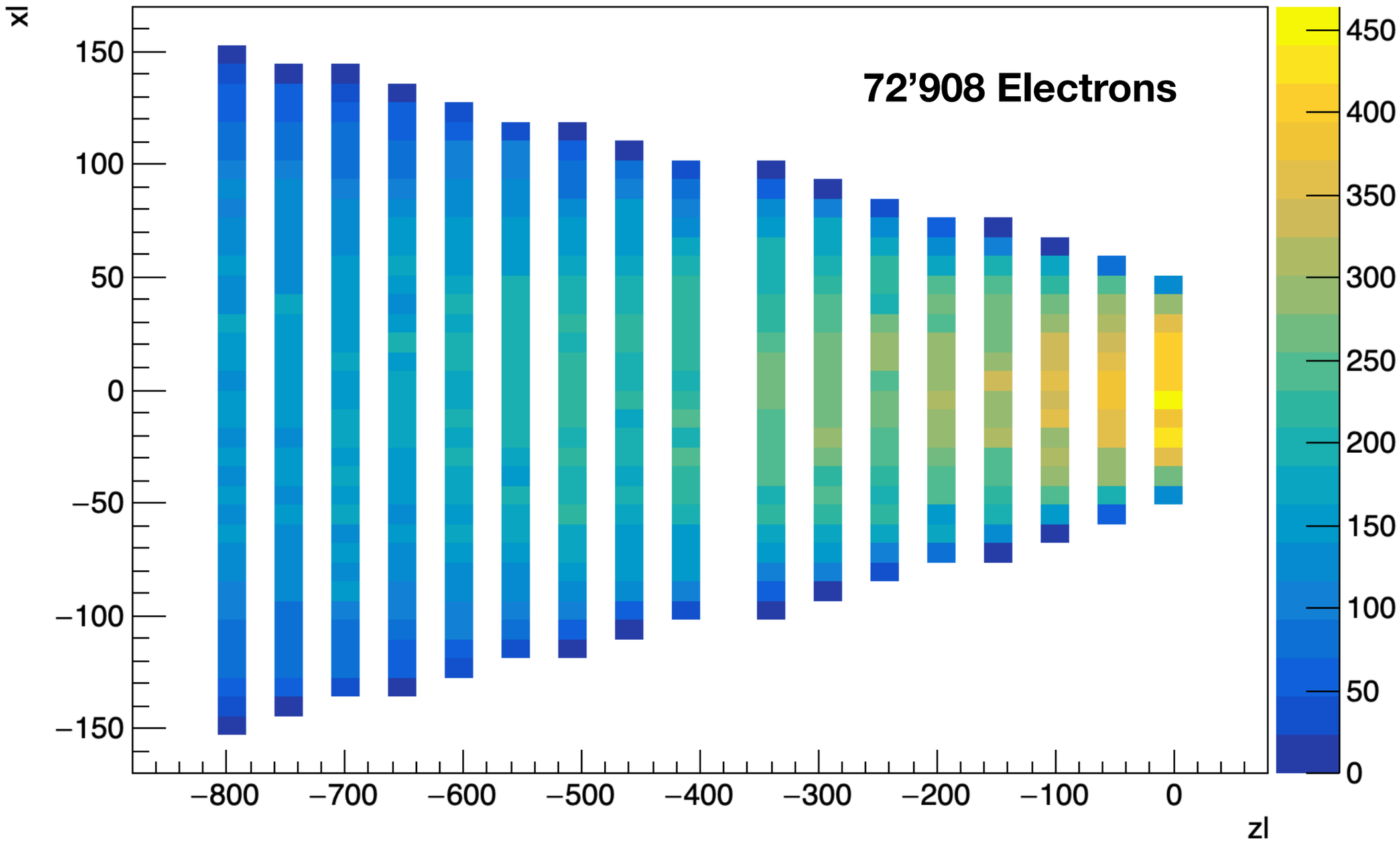
- **Run larger scale simulations for usage in signal acceptance tests.**
- **See if using 34 target disks hurt signal acceptance or not. (Smaller disks?.)**

Thank you for your attention!



BACKUP

Initial Distribution (That hit all 5 stations)



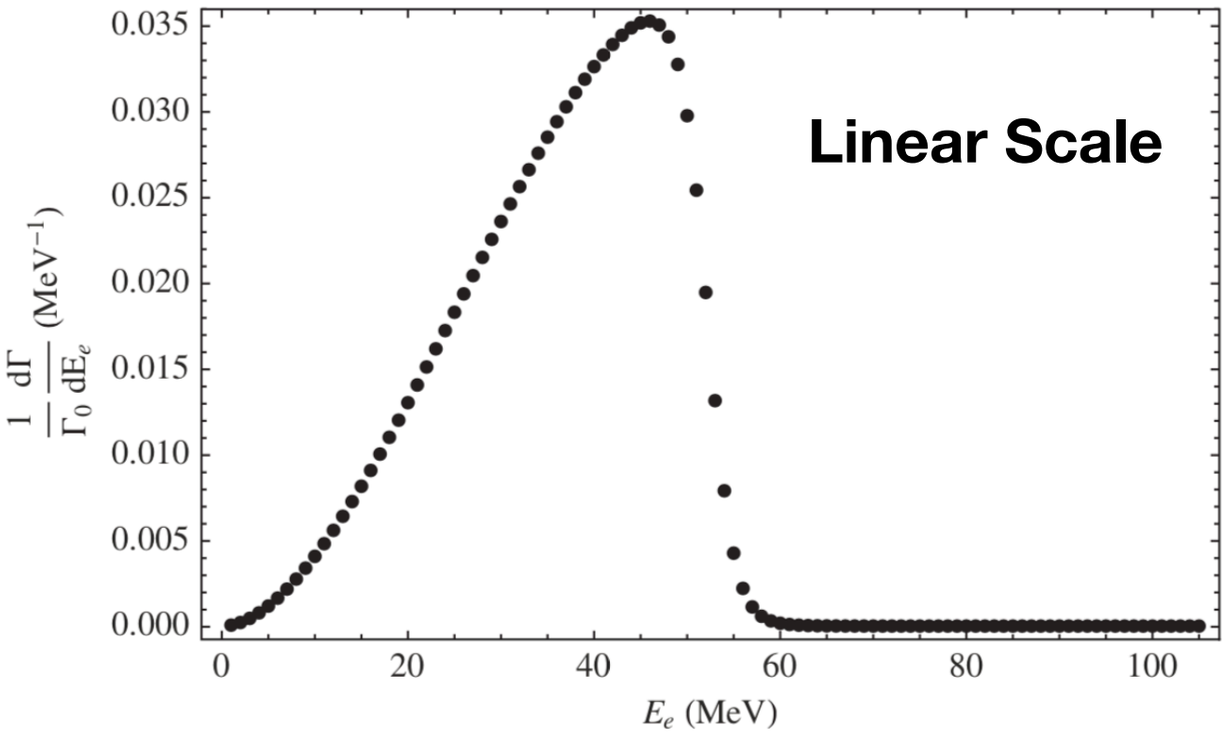
COMET Phase II Background Estimations

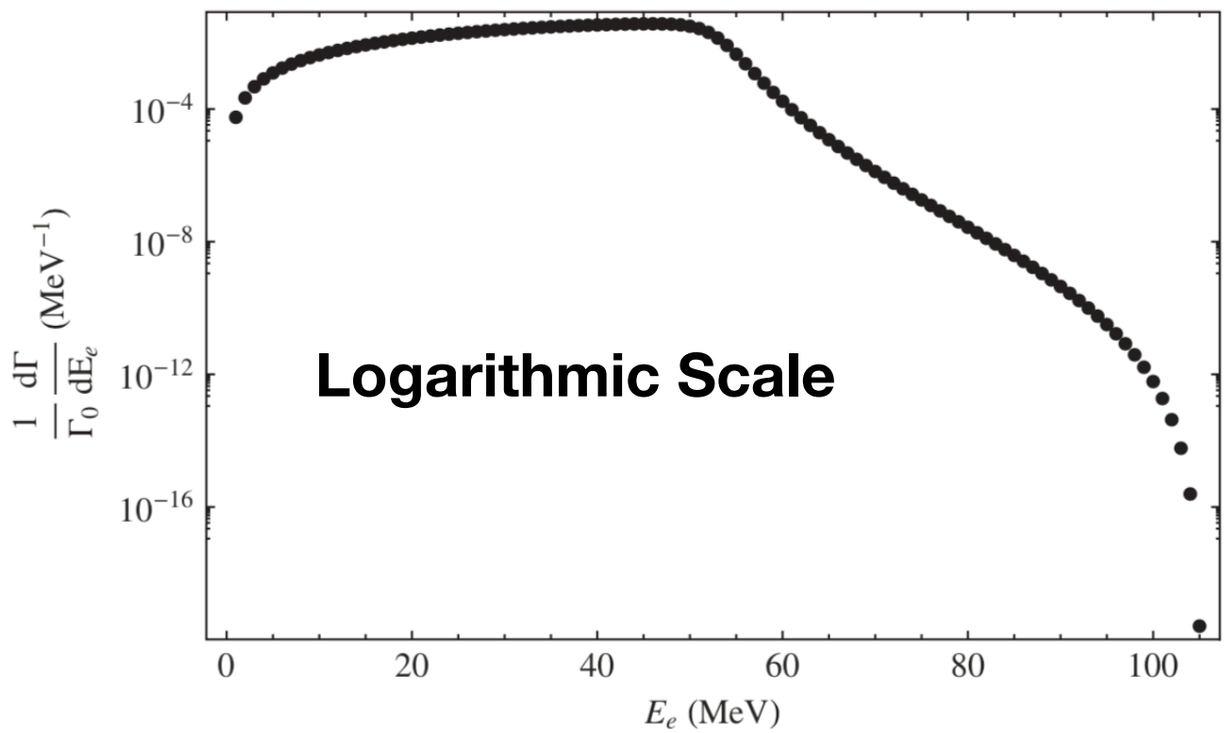
Type	Source	Ben's results	this study
Intrinsic	DIO	0.068	0.75
intrinsic	RMC	4.10×10^{-13}	2.46×10^{-12}
Delayed	RPC	1.18×10^{-6}	
Delayed	Beam	1.00×10^{-3}	
Delayed	Stopped $\overline{p}$	0.296	0.569
Delayed	π^- from $\overline{p}$	1.33×10^{-9}	
Prompt	RPC	1.23×10^{-3}	
Prompt	Beam	$1.91 \times 1o^{-3}$	
Prompt	π^- from $\overline{p}$	2.24×10^{-8}	
Cosmic rays		0.294	0.562
Total		0.662	1.9

From COMET Phase II note Background estimations

Decay-in-orbit

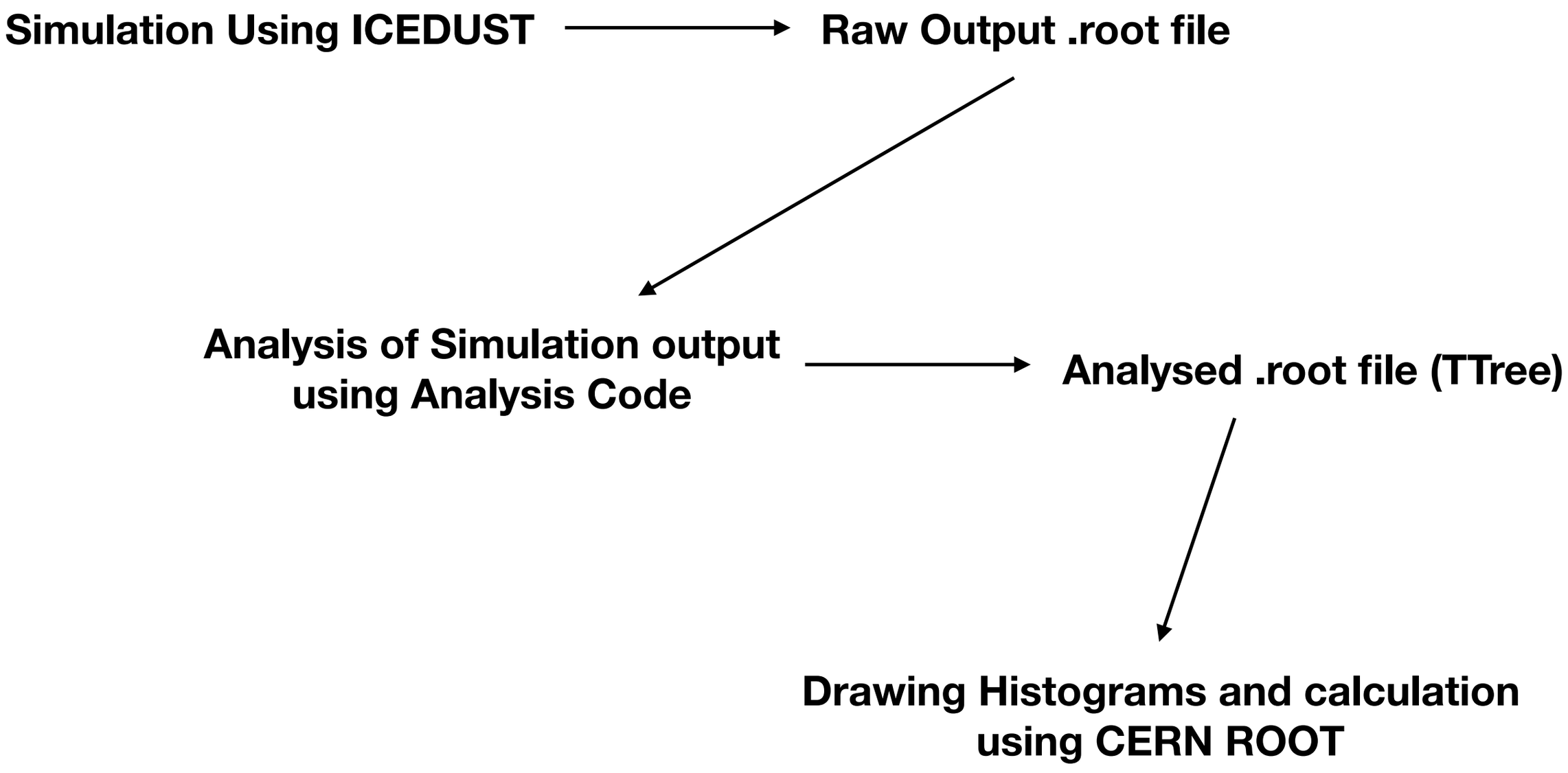
- DIO Spectrum





From Czernicki's Calculations

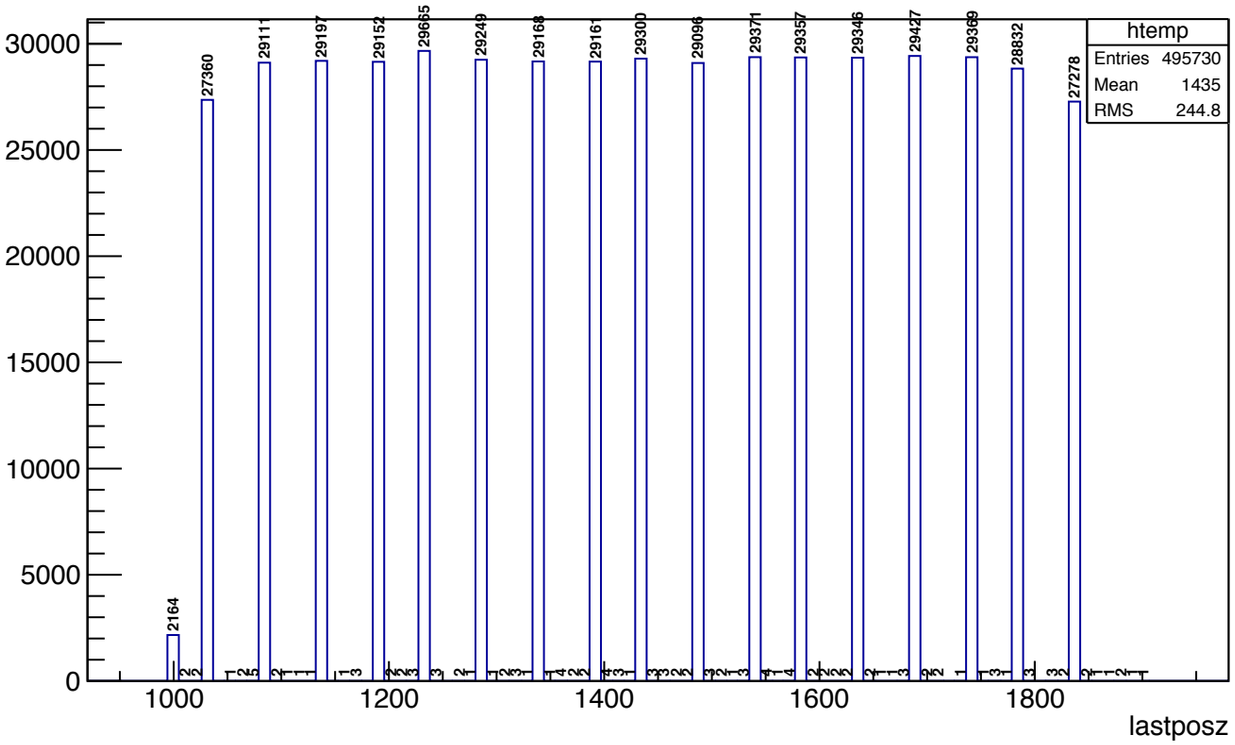
Analysis Workflow



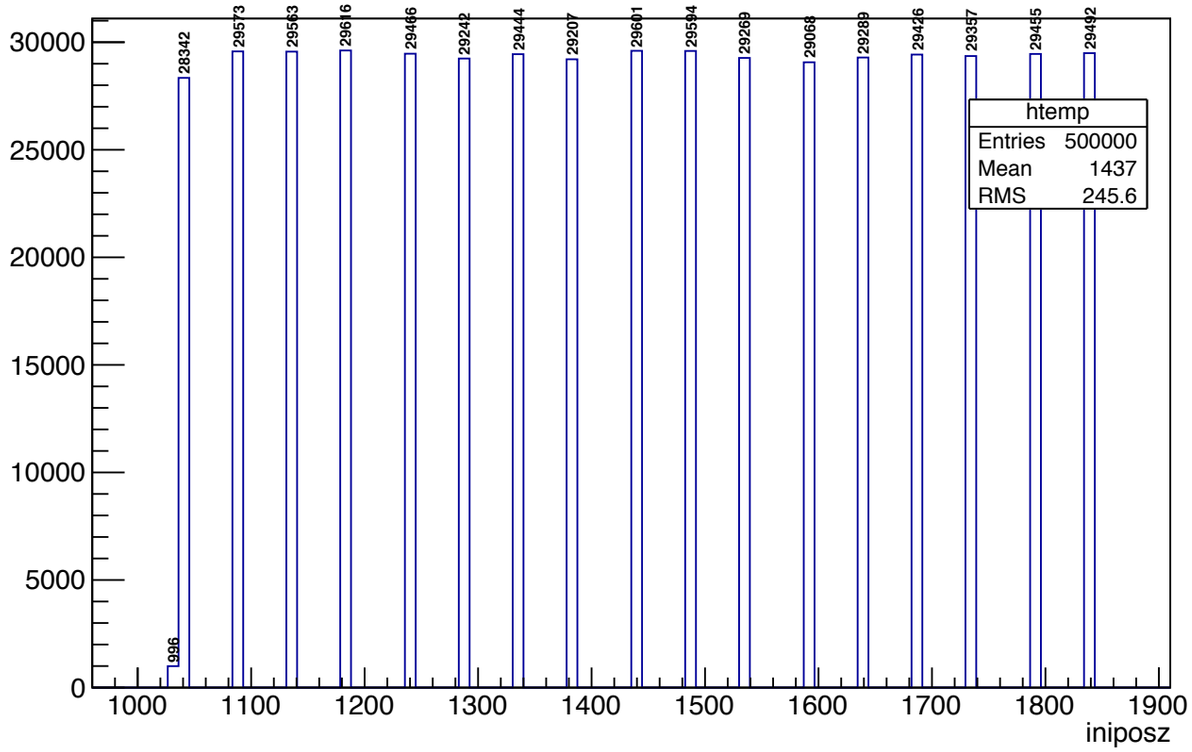
Signal and DIO Simulation

- **500000 Muons uniformly distributed in 17 disks**
- **Beam Blocker removed**
- **DIO Blocker removed**

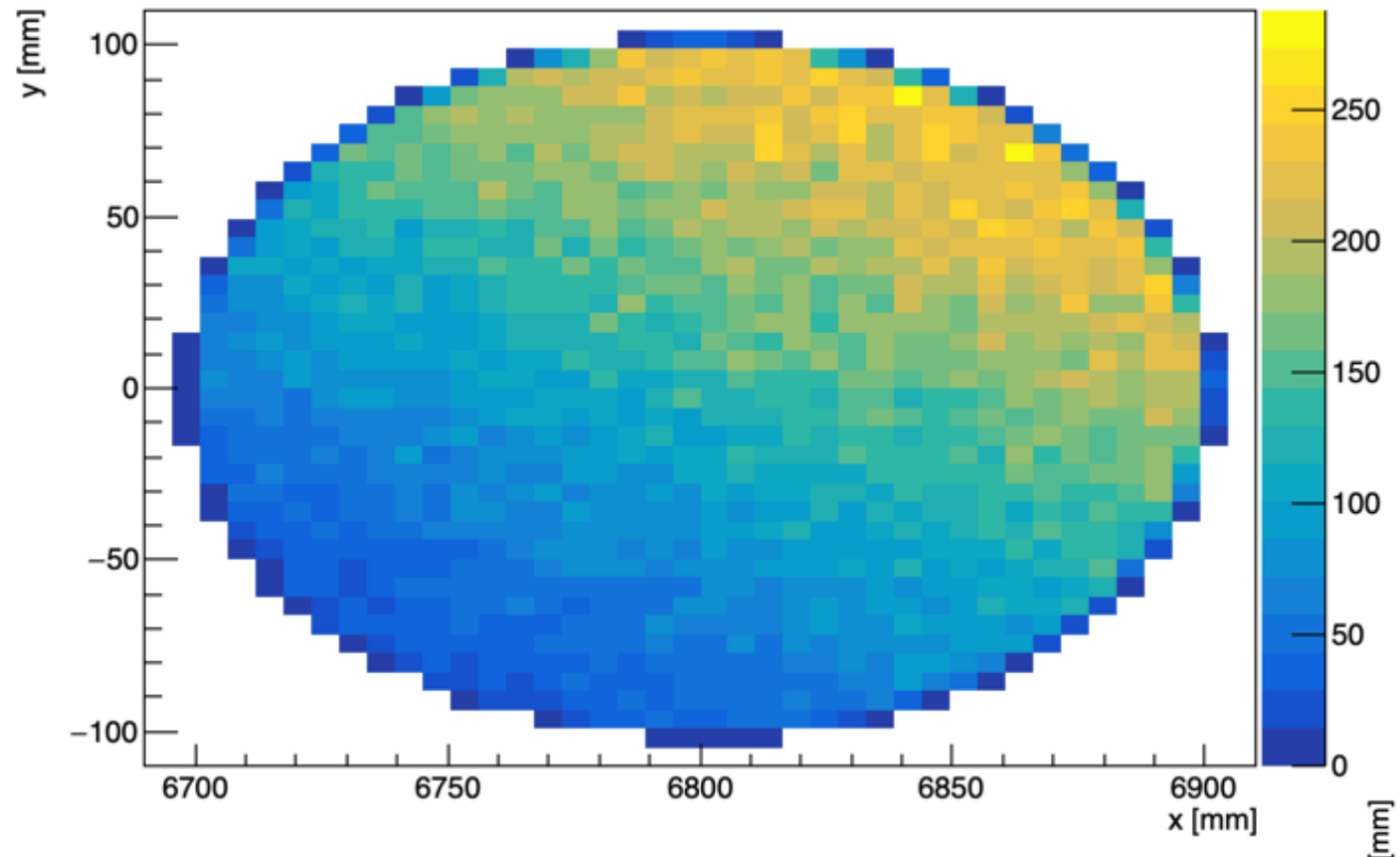
The number of stopped muons in each disks

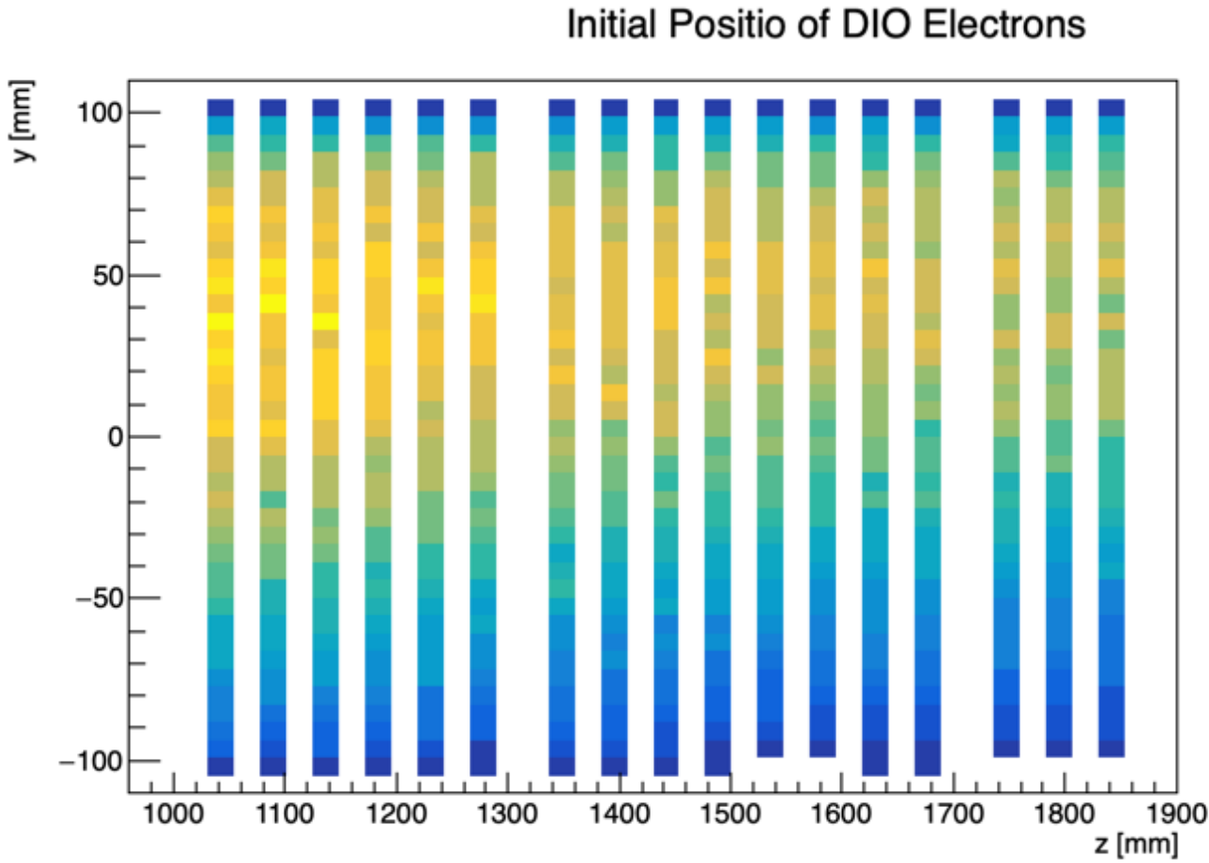


Initial electron with 105MeV

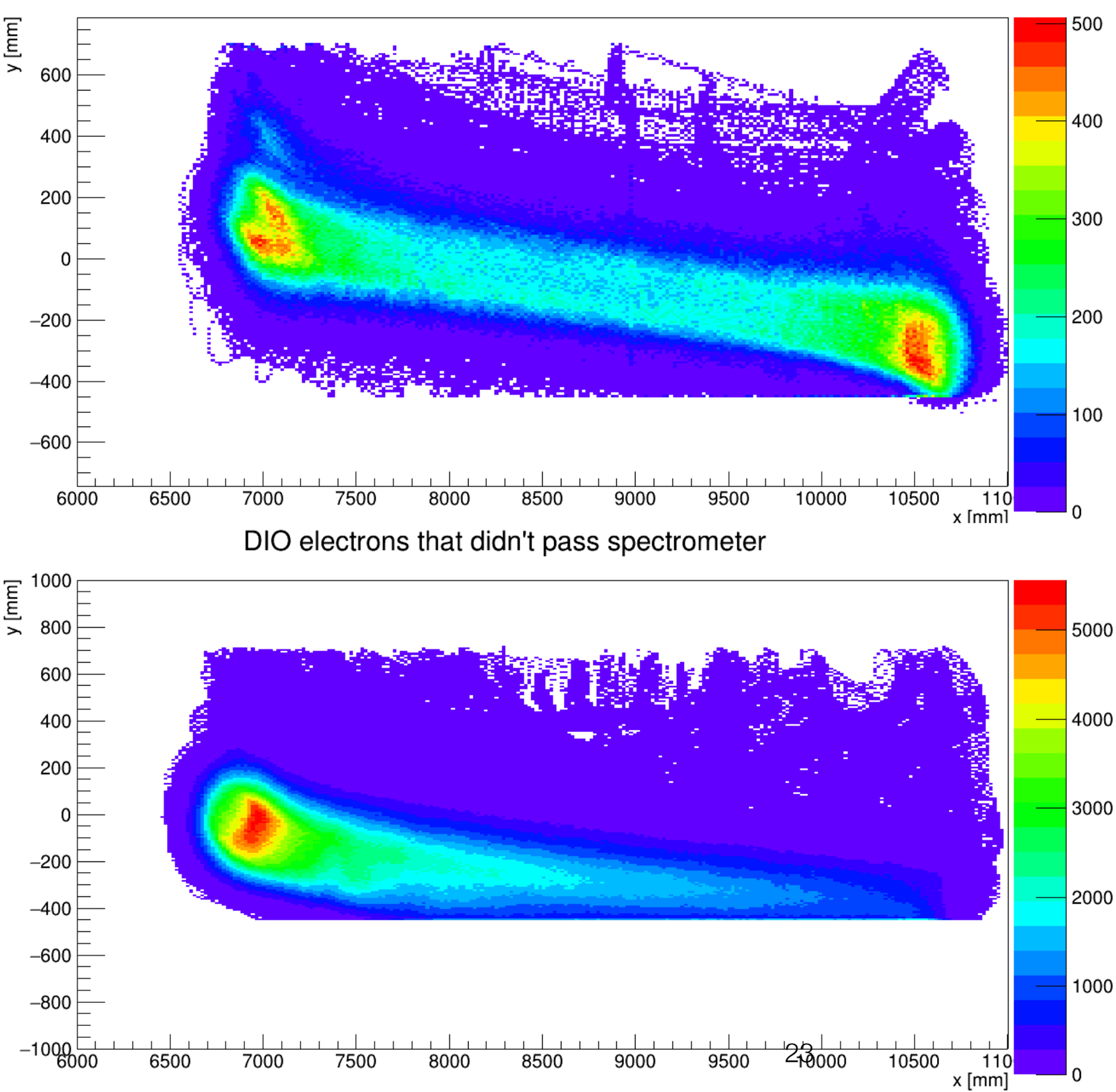


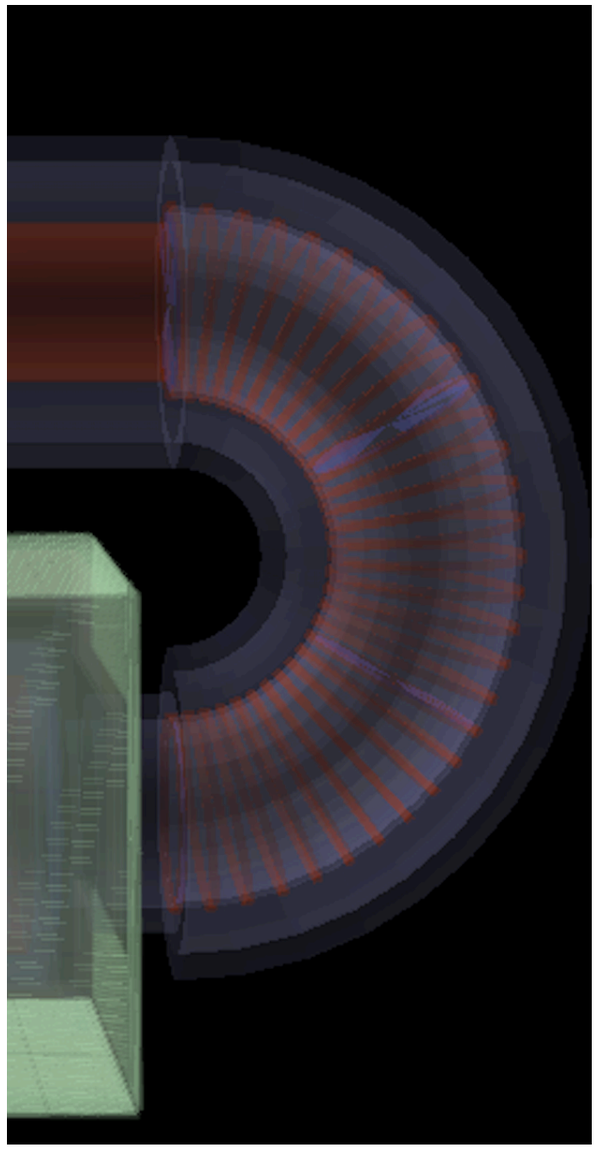
DIO Electrons





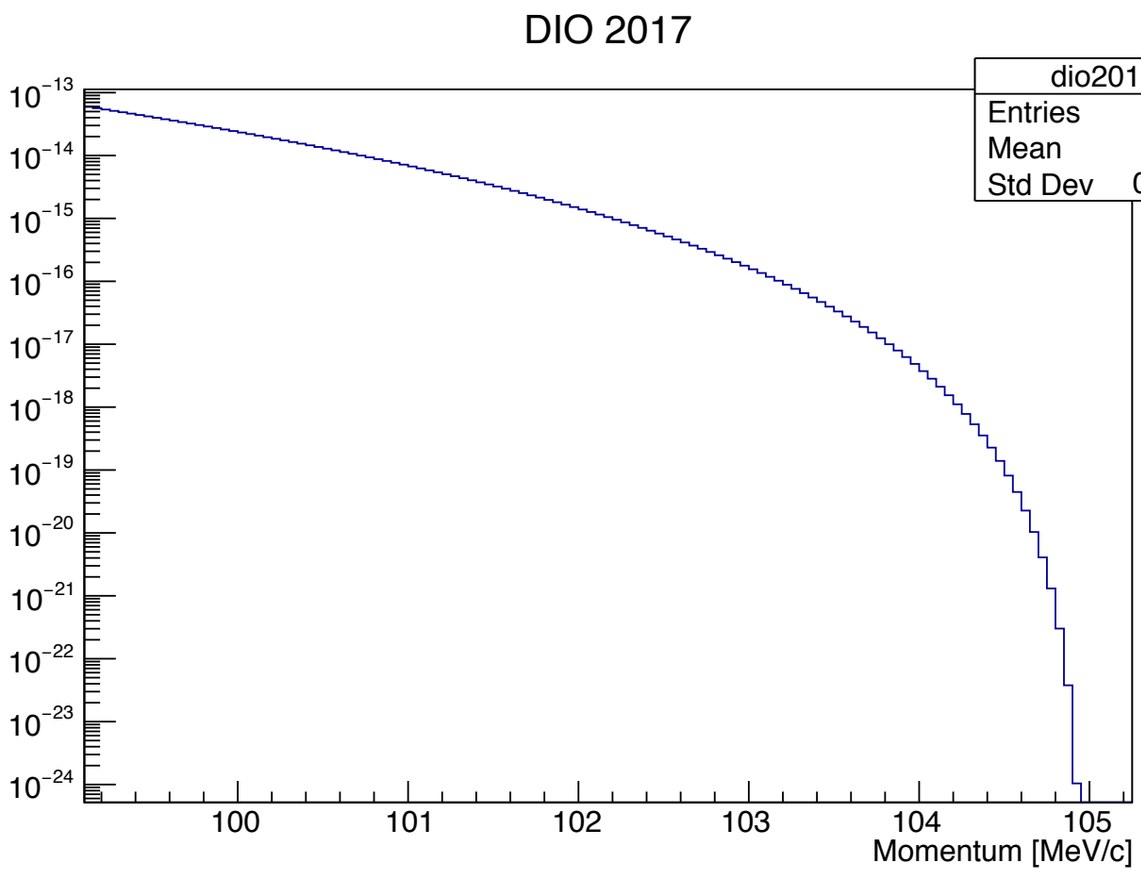
DIO Distribution in Spectrometer

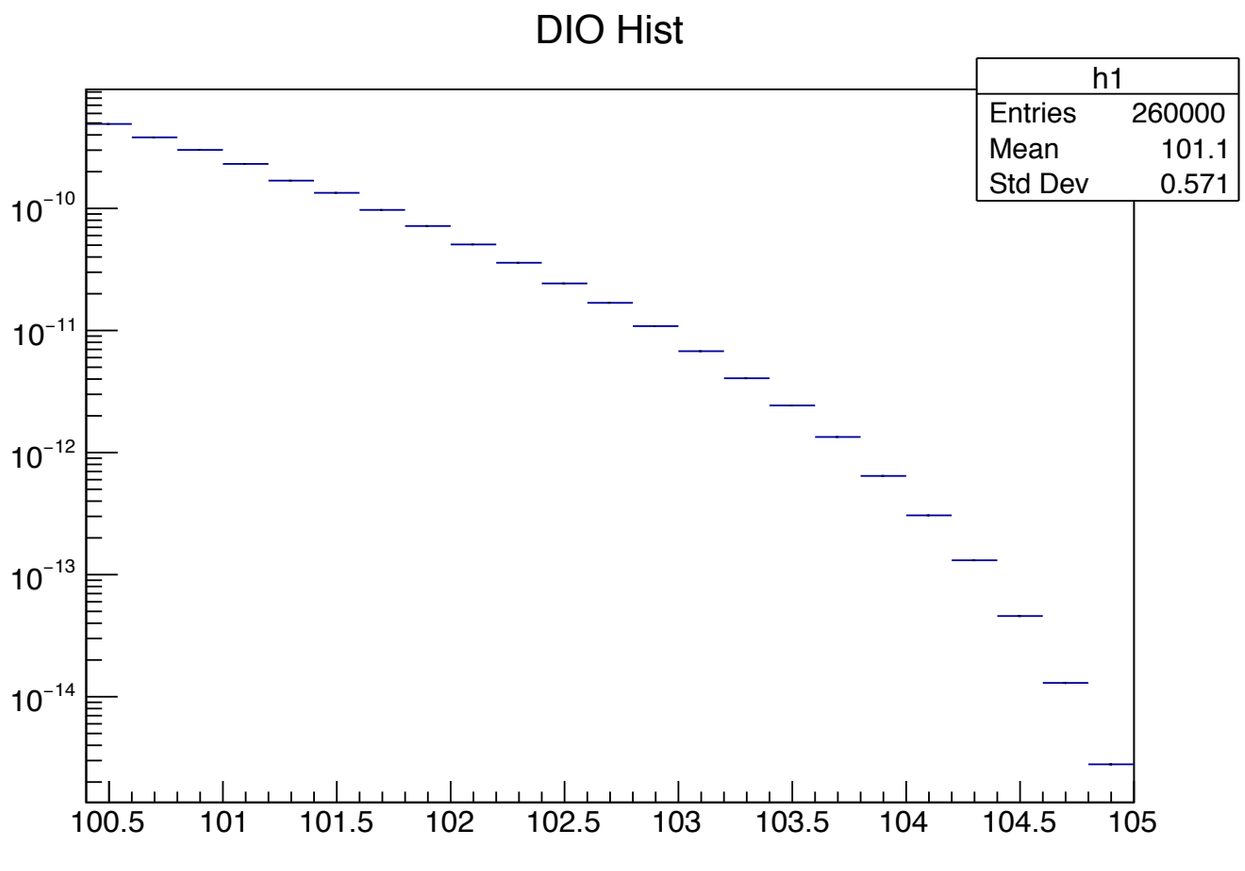




Plots by Wu Chen

DIO Spectrum Analysis





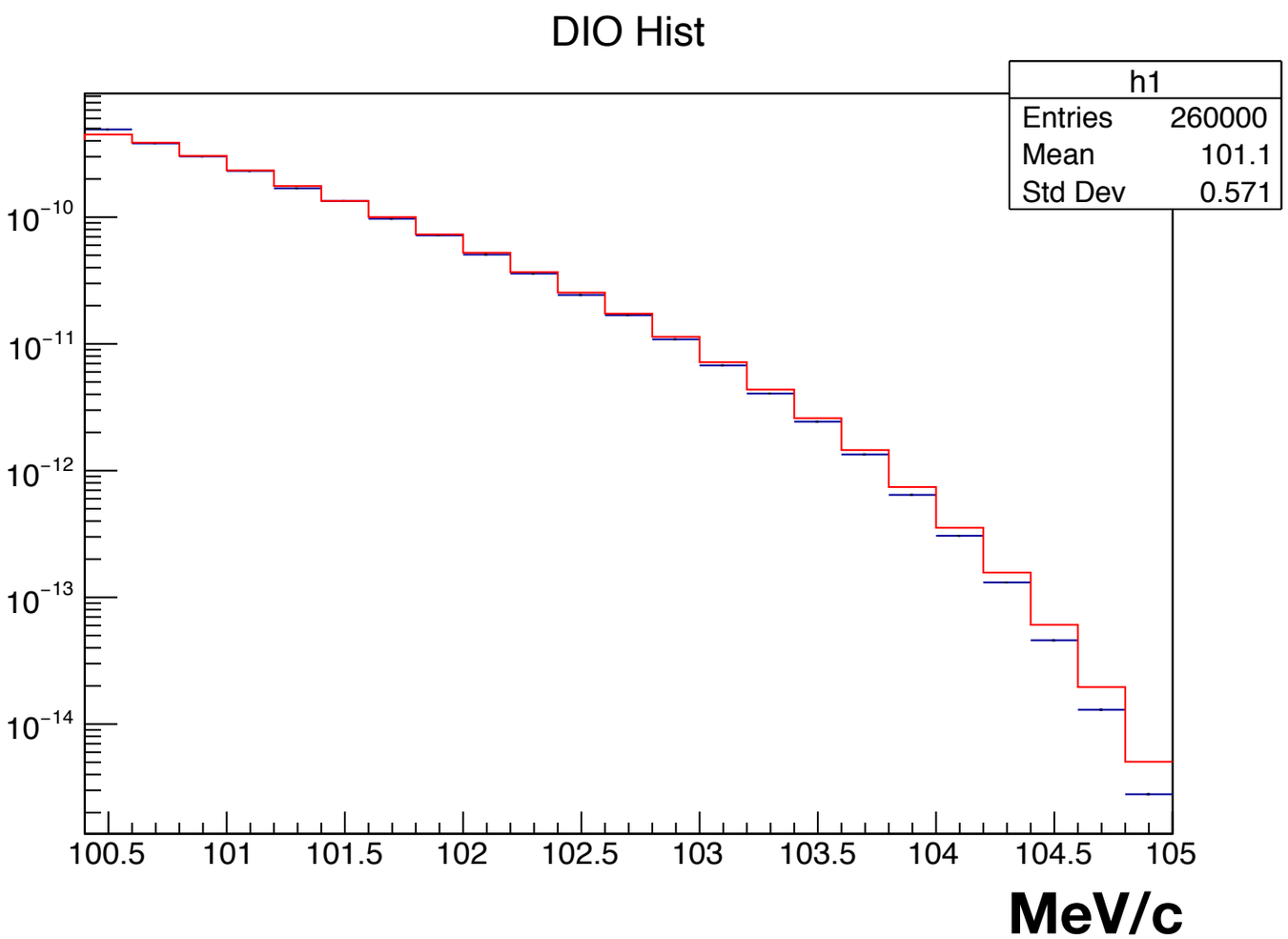
From Czarnecki's Calculations

DIO Spectrum recorded in the Straw Tracker

DIO Spectrum with logarithmic scale

Smeared DIO

DIO Spectrum smeared with a Gaussian with sigma of 150 KeV



Big thanks to Chen Wu for helping with the code!

Acceptance and Improvement factors

	this study	Ben's study [4]	CDR (2009) [3]
geometrical acceptance	0.52	0.22	0.22
$A_{\mu\to e}$ (net signal acceptance)	0.114	0.057	
DIO rejection	6×10^{-4}	4×10^{-5}	

	this study	Ben's study [4]	Improvement factor
N_{p}	4.3×10^{13}	4.3×10^{13}	
$R_{\mu/p}$	4.8×10^{-3}	1.61×10^{-3}	3
B_{cap}	0.61	0.61	
$A_{\mu\to e}$	0.114	0.057	2
t_{run}	3×10^{7}	1.57×10^{7}	1.9
S.E.S	2.3×10^{-18}	2.6×10^{-17}	11

Sensitivity

	Single event sensitivilty	total POT ($\times 10^{19}$)	Beam time (s)
COMET Phase-II (Ben Krikler 2016)	2.6×10^{-17}	68.3	1.57×10^{7}
COMET Phase-II CDR2009)	2.6×10^{-17}	85	2×10^{7}
Mu2e	2.4×10^{-17}	36	6×10^{7}
COMET Phase-I	3.0×10^{-15}	3.2	1.26×10^{7}

$$\mathrm{SES} = \frac{1}{N_p \cdot R_{\mu/p} \cdot B_{\mathrm{cap}} \cdot A_{\mu \to e} \cdot t_{\mathrm{run}}}$$

Stopping Rates

	this study	Ben's study	CDR ((2009)
target radius	4 mm	10 mm	4 mm
target length	400 mm	320 mm	
target location	2 mm downstream	8 mm downstream	
proton beam	$1.3\,\mathrm{mm(H)} \times 1.4\,\mathrm{mm(V)}$	$5.8\,\mathrm{mm(H)} \times 2.9\,\mathrm{mm(V)}$	
muon stop rate	2.63×10^{-3}	1.6×10^{-3}	2.2×10^{-3}

DIO Momentum Distribution on each straw station