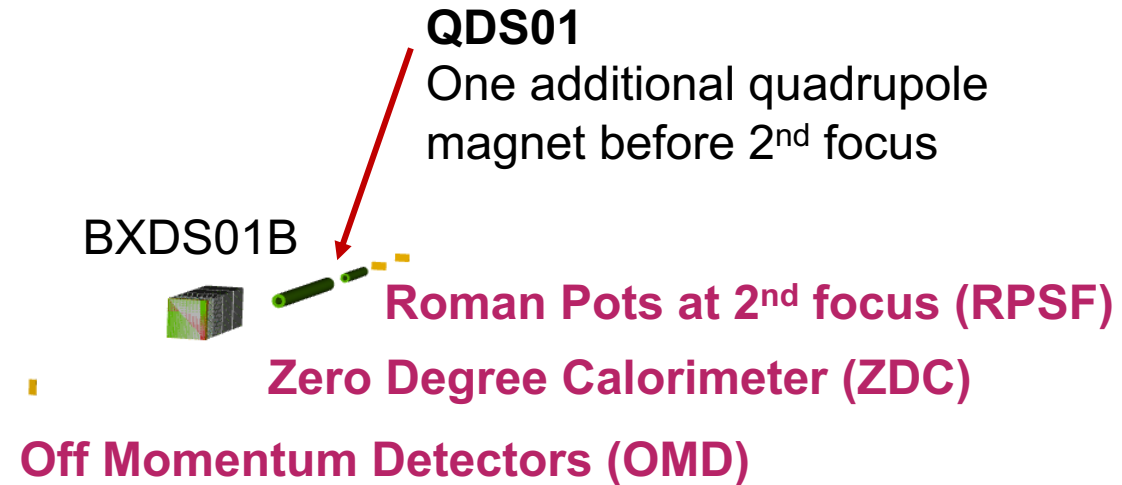
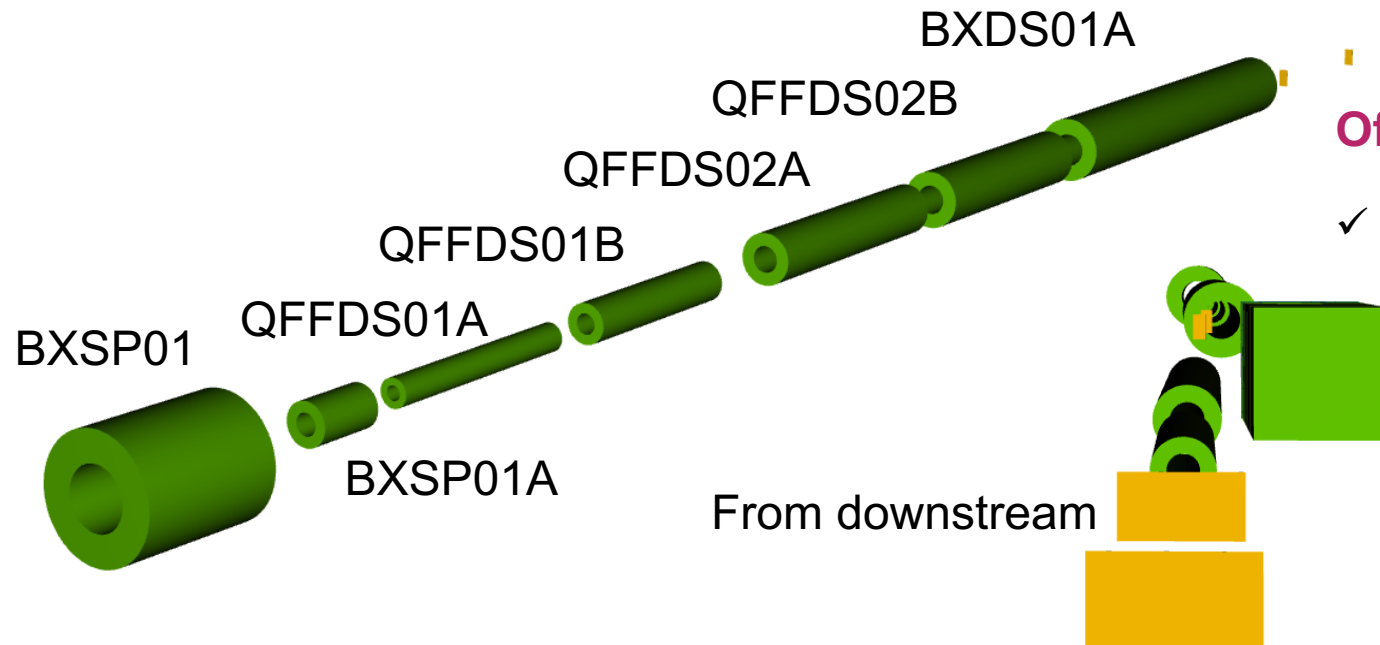


Study of IP8 Far-Forward acceptance

Jihee Kim (jkim11@bnl.gov)

IP8 Far-Forward Layout

- World Volume filled with Vacuum
- Origin (65 cm, 0 cm, 5.7673 cm)
- Crossing angles
 - Electron crossing angle = -0.011 rad
 - Ion crossing angle = 0.024 rad
- No beam pipe implemented yet



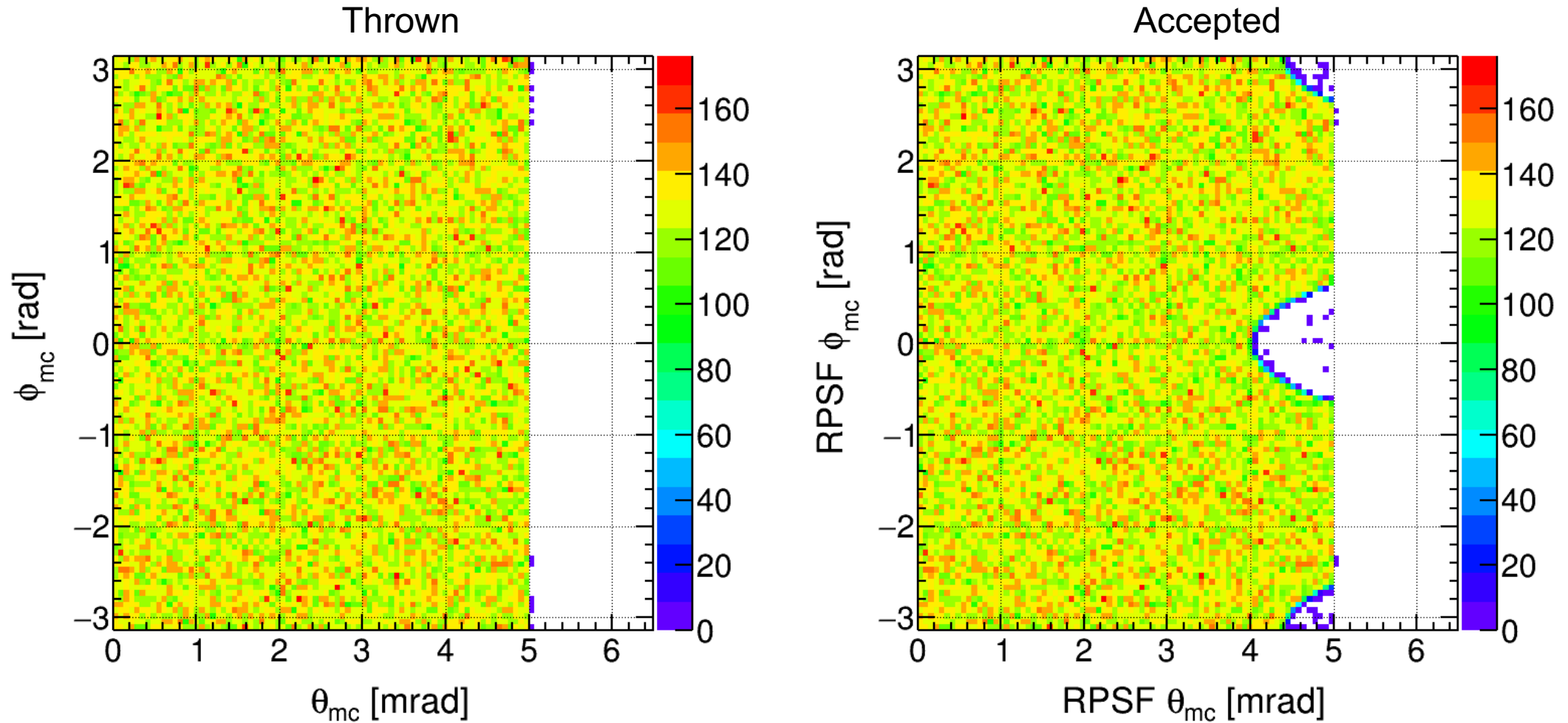
- ✓ Implemented far-forward detectors in IP6 configuration
 - OMD assumed 20 cm tall and 10 cm wide placed at $(x,z) = (1.0878\text{m}, 26\text{m})$ & $(1.0451\text{m}, 28\text{m})$
 - ZDC assumed 2 meter-long and $60 \times 60 \text{ cm}^2$ placed at $(x,z) = (1.64\text{m}, 35.5\text{m}(\text{front}))$
 - RPSF assumed 14 cm tall and 26 cm side placed at $(x,z) = (1.1727\text{m}, 44\text{m})$ & $(1.18806\text{m}, 45.5\text{m})$

Reference from https://wiki.bnl.gov/eic-detector-2/images/d/de/IP8_magnet_layout_12052022.xlsx

Reference from https://wiki.bnl.gov/eic-detector-2/images/8/86/IP8_HSR_lattice_performance_10_13_22_v3.pdf

Roman Pots at Secondary Focus

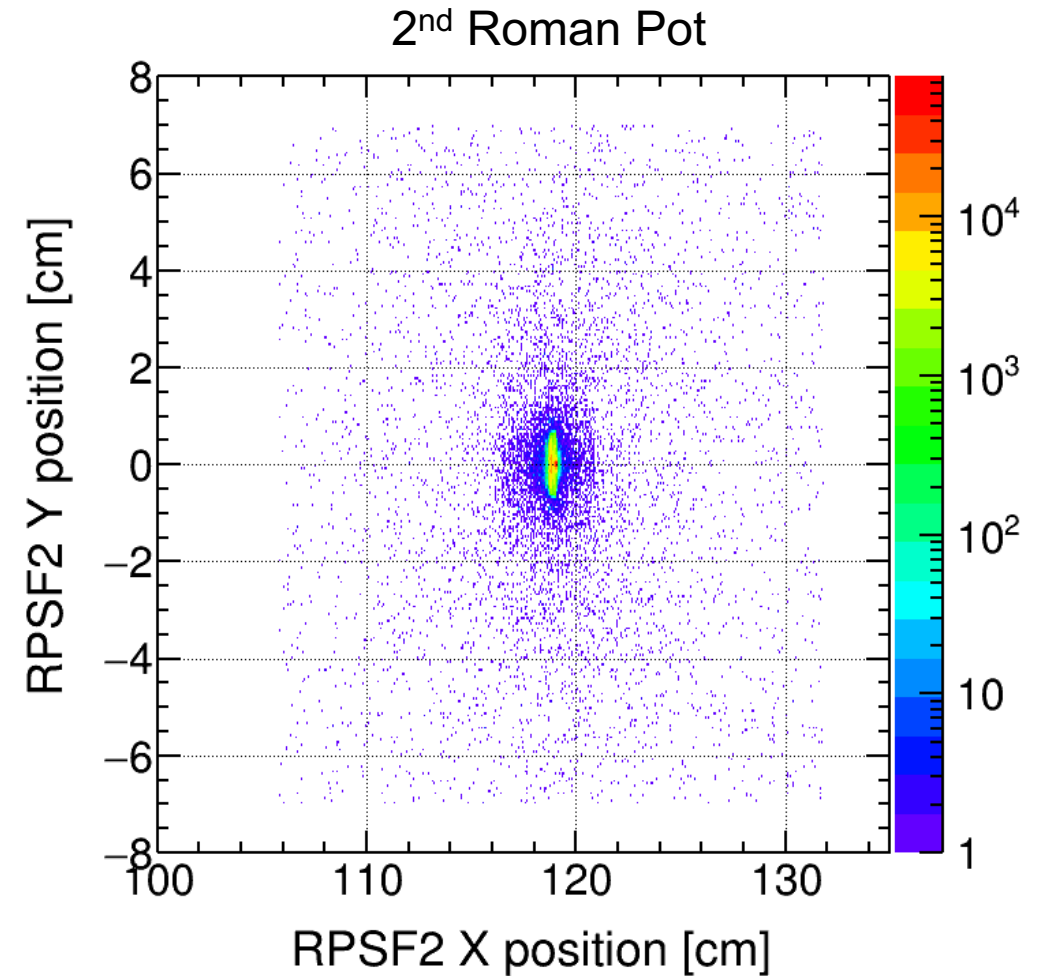
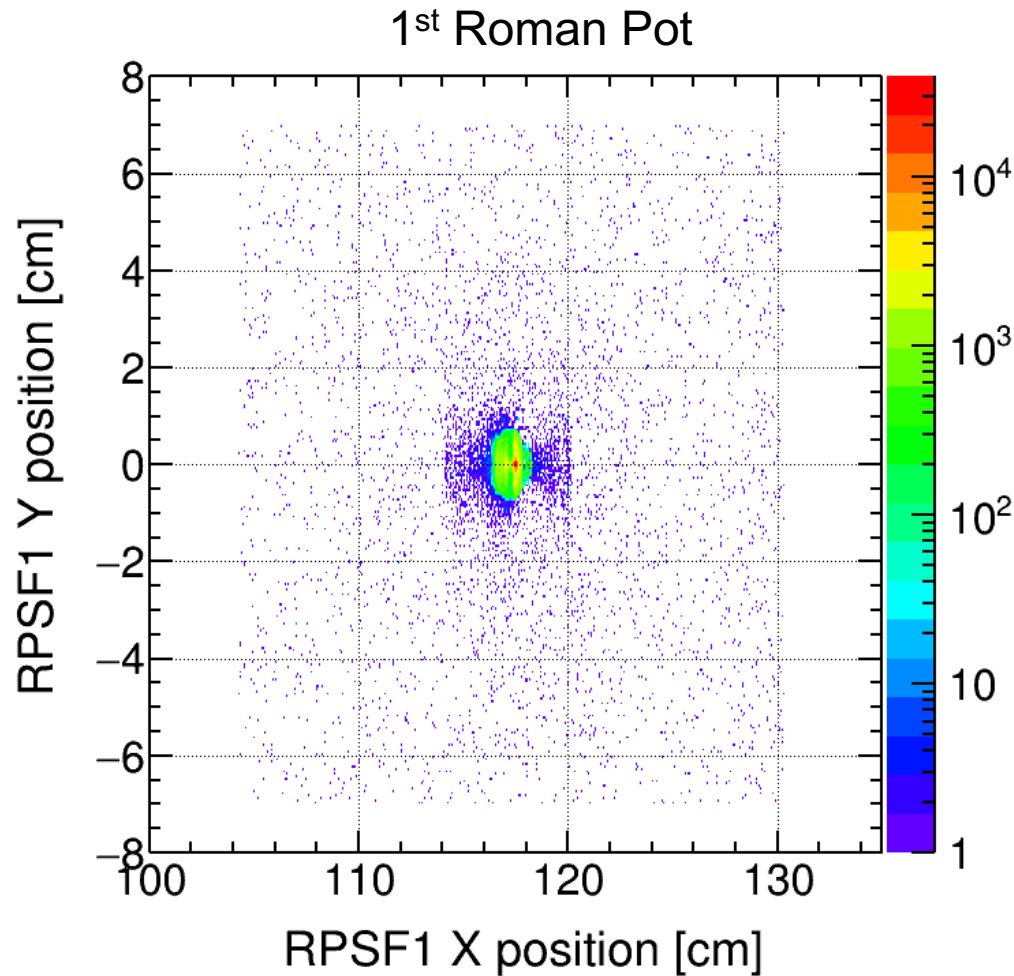
Single Proton
E = 275 GeV
 $0 < \theta_{MC} < 5$ mrad



From thrown upto 5 mrad, **95.4 % events were accepted** and observed losses at higher theta (polar angle)

Roman Pots at Secondary Focus

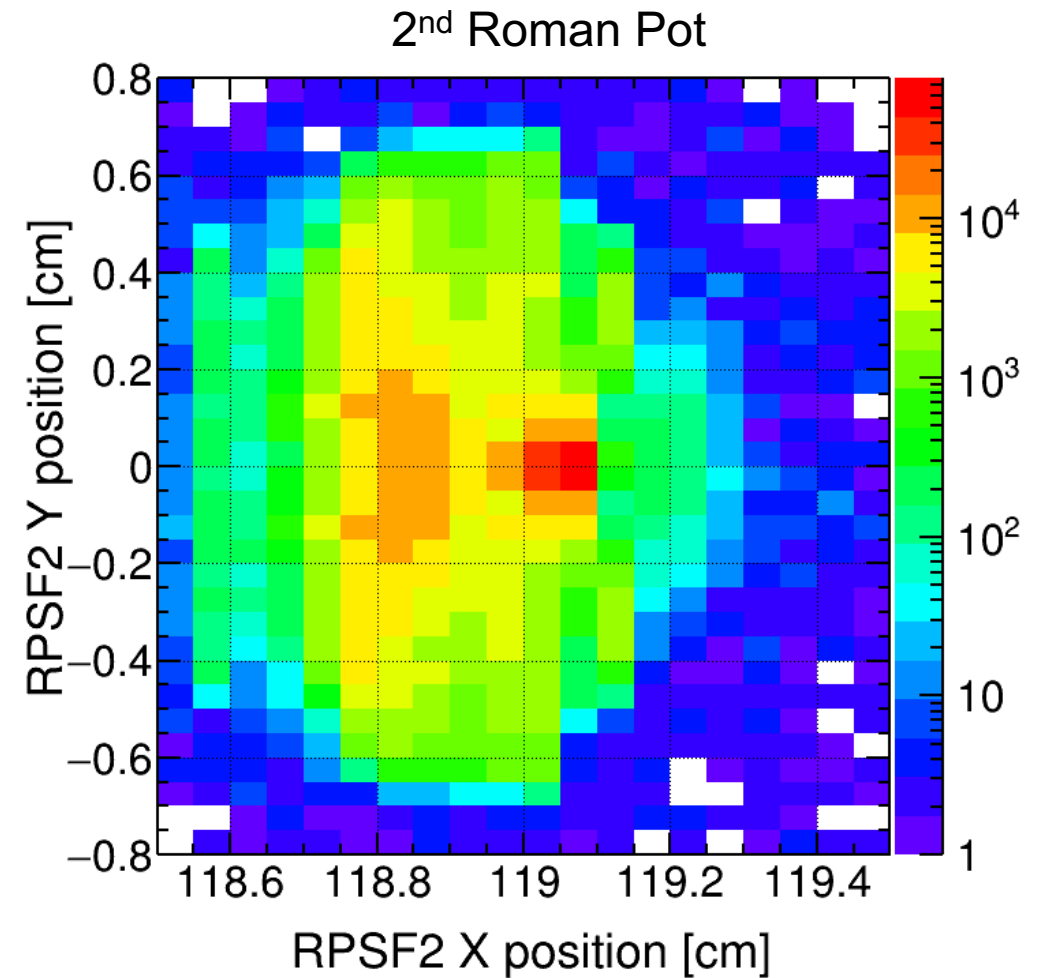
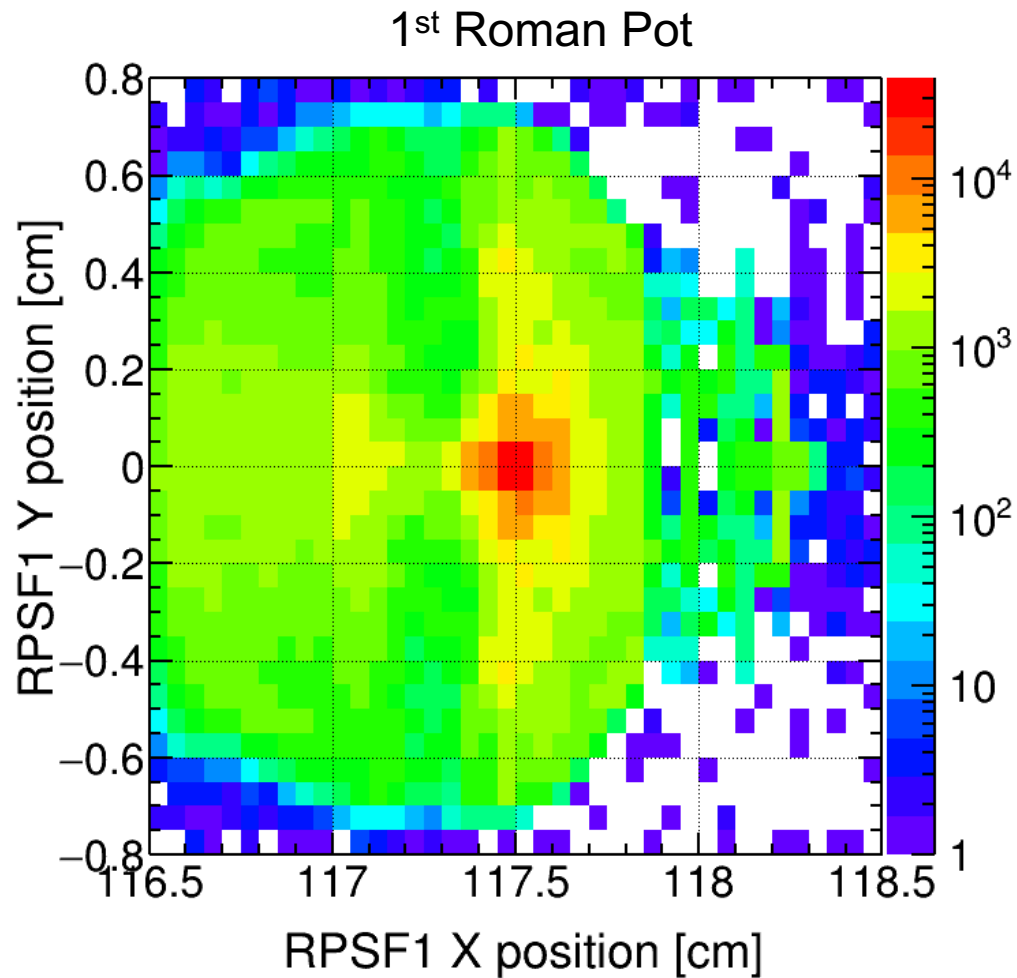
Single Proton
 $E = 275 \text{ GeV}$
 $0 < \theta_{MC} < 5 \text{ mrad}$



From thrown upto 5 mrad, observed protons were focused into a shape of football with divergence in y axis

Roman Pots at Secondary Focus

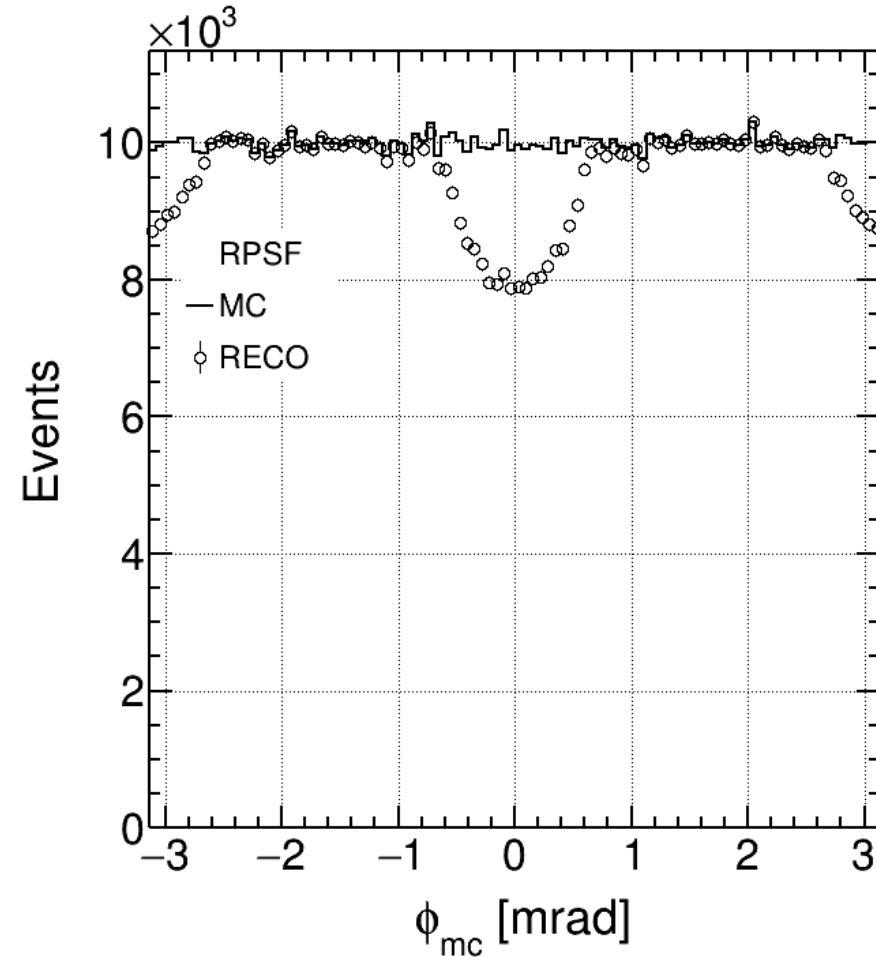
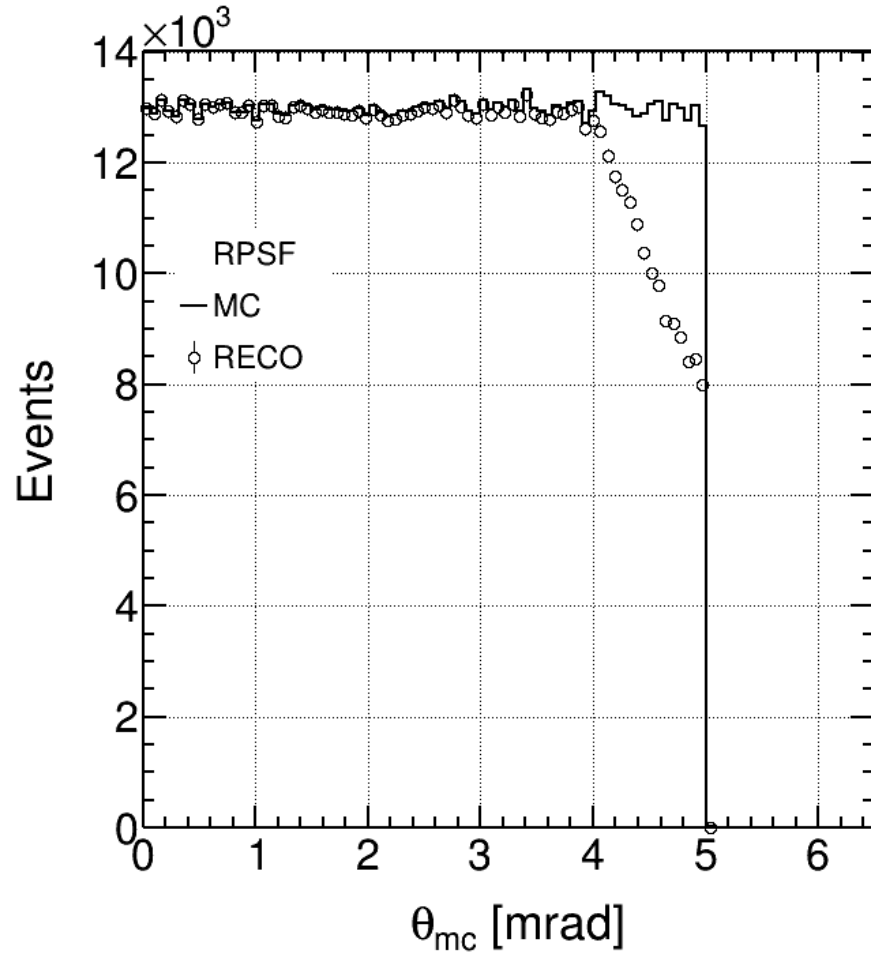
Single Proton
 $E = 275 \text{ GeV}$
 $0 < \theta_{MC} < 5 \text{ mrad}$



Hot spot size is $\sim 0.1 \text{ cm}$ in y (slit height) and $\sim 0.1 \text{ cm}$ in x (slit width)

Roman Pots at Secondary Focus

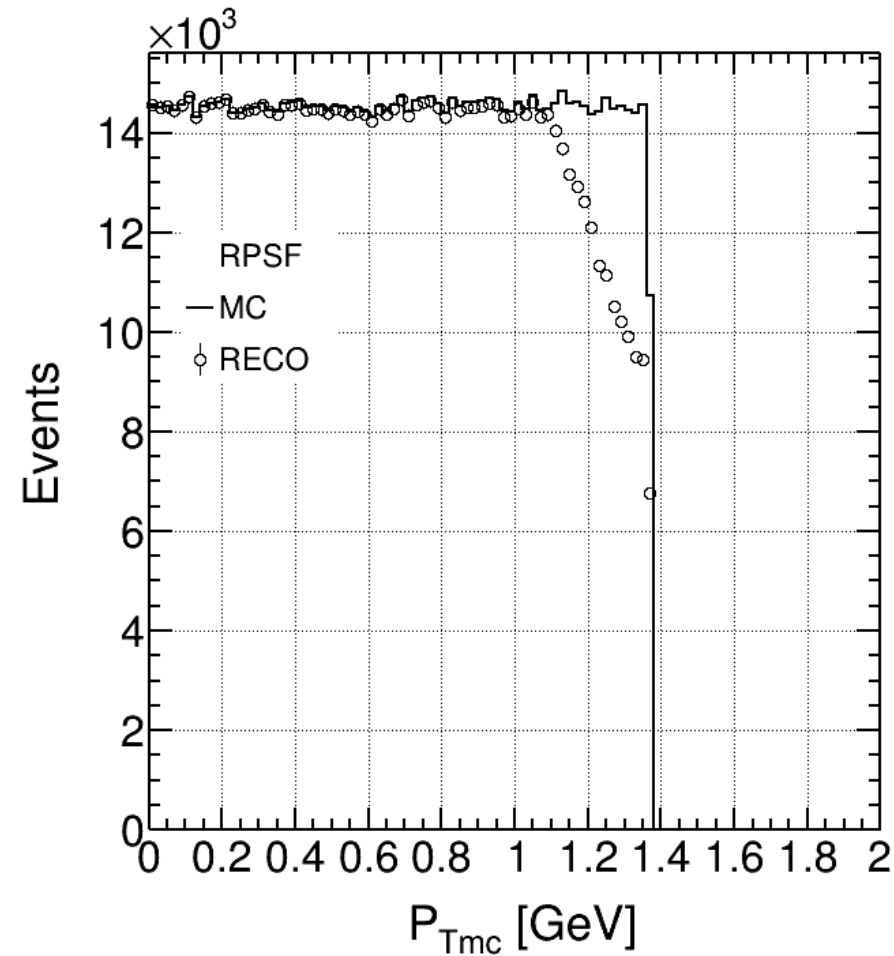
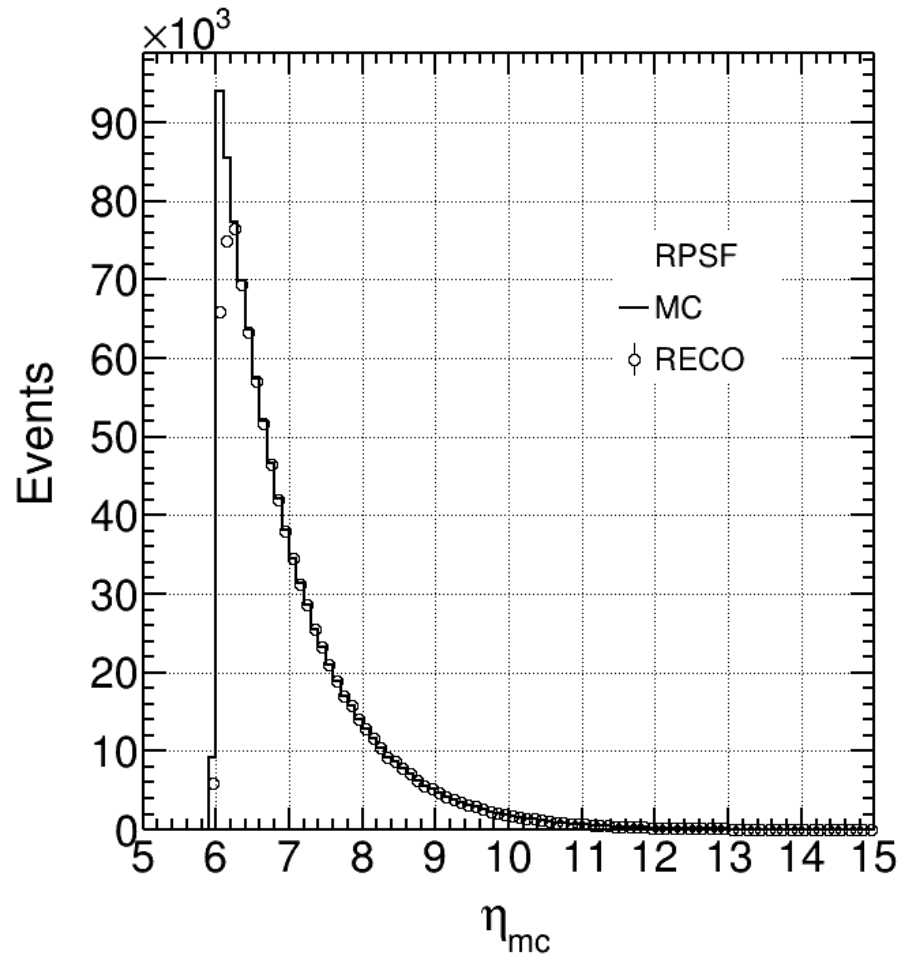
Single Proton
 $E = 275 \text{ GeV}$
 $0 < \theta_{MC} < 5 \text{ mrad}$



From ~ 4 mrad in polar angle, observed it losses acceptance

Roman Pots at Secondary Focus

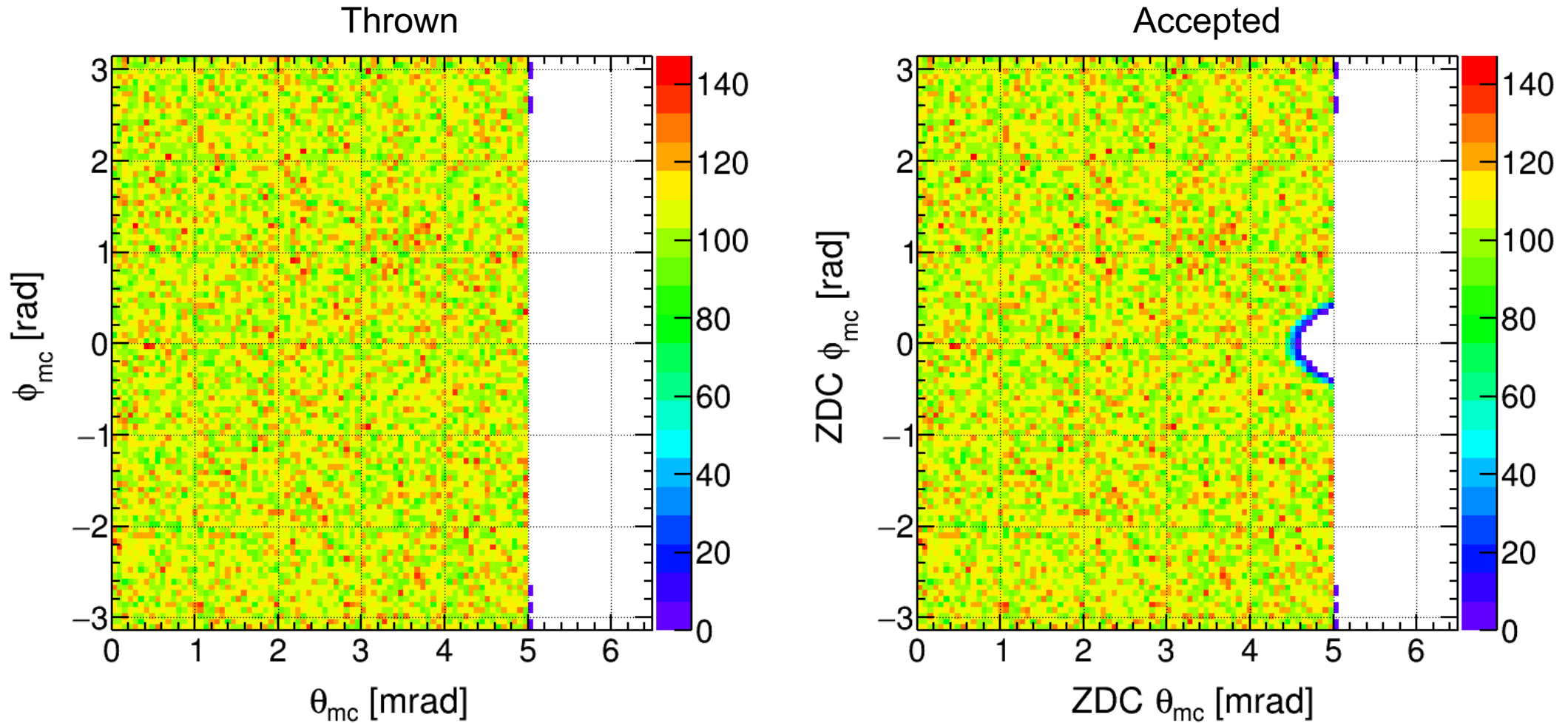
Single Proton
 $E = 275 \text{ GeV}$
 $0 < \theta_{MC} < 5 \text{ mrad}$



From $\sim 1.1 \text{ GeV}$ in P_T , observed it losses acceptance

Zero Degree Calorimeter

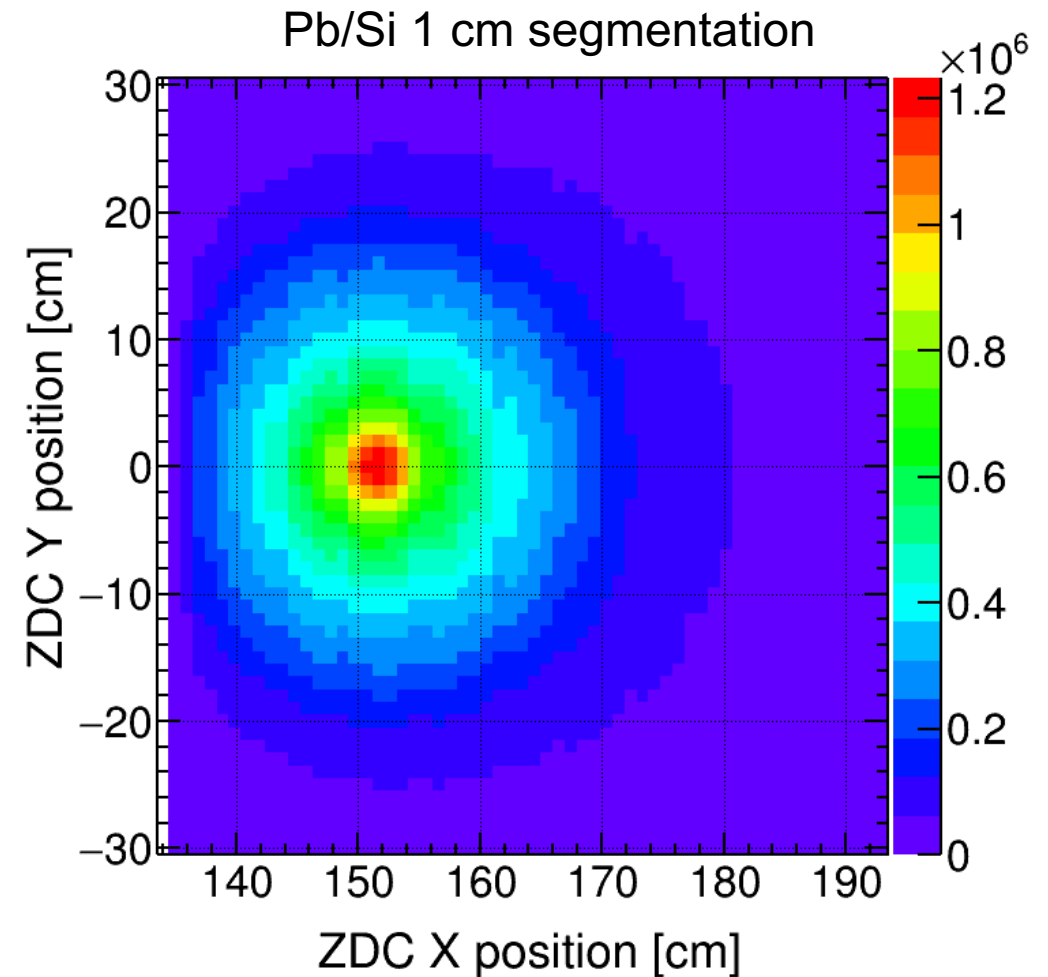
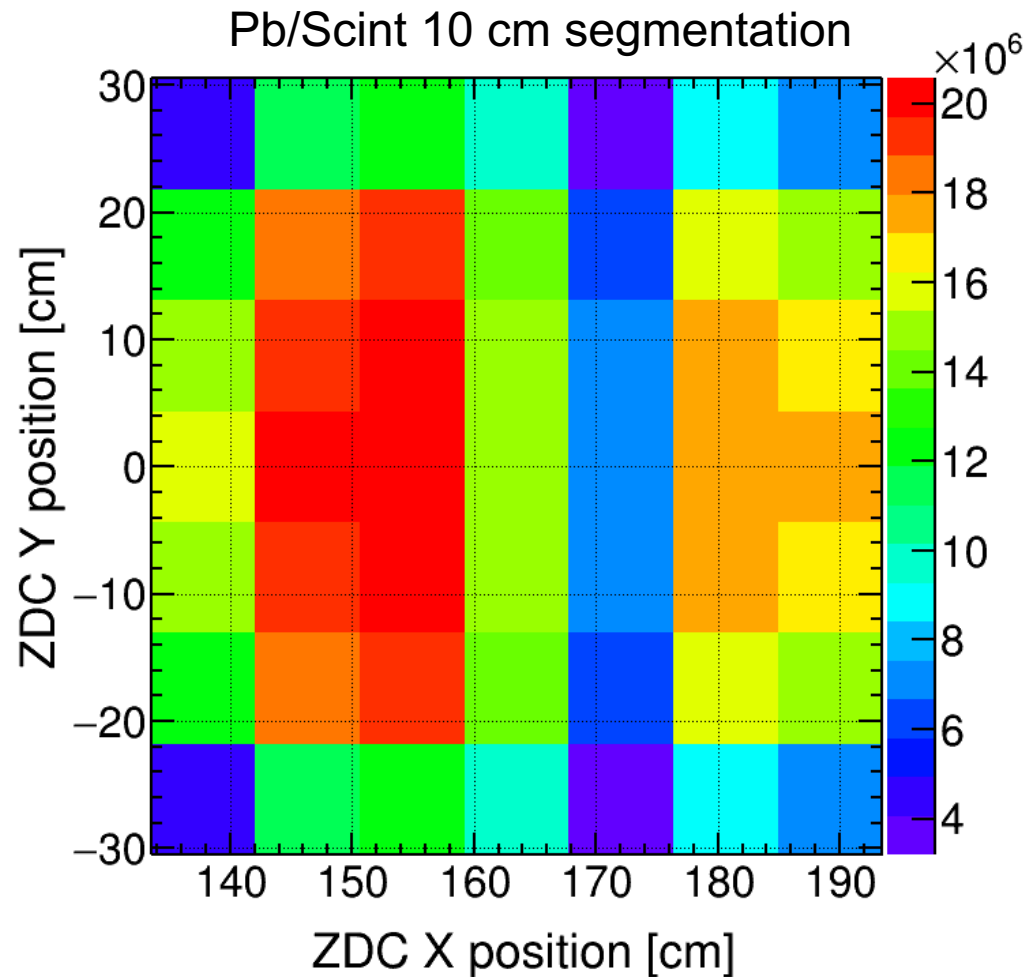
Single Neutron
 $E = 275 \text{ GeV}$
 $0 < \theta_{MC} < 5 \text{ mrad}$



From thrown upto 5 mrad, **98.9 % events were accepted** and observed small losses at very large scattering angle

Zero Degree Calorimeter

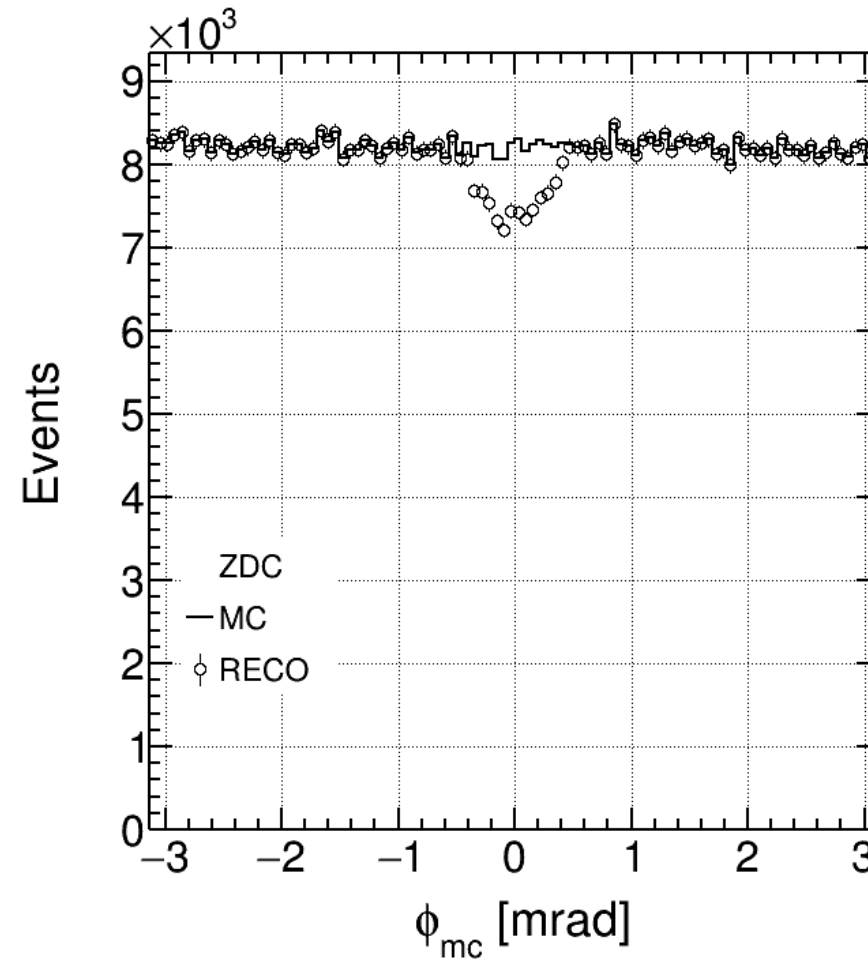
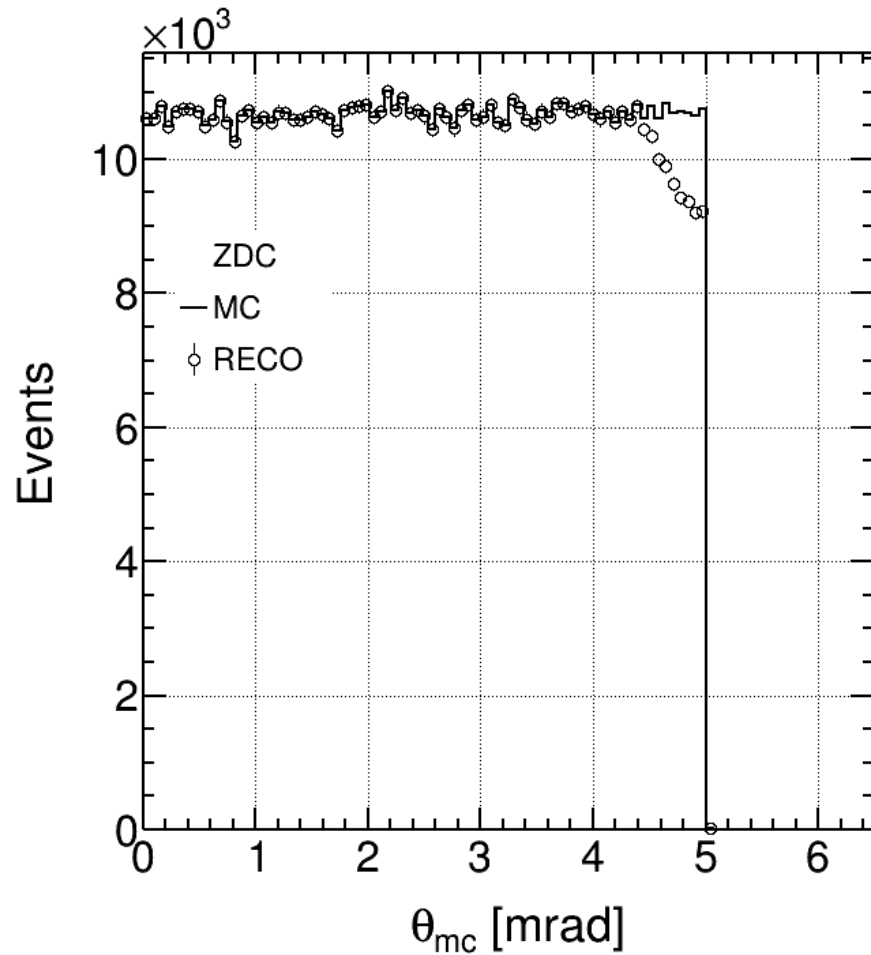
Single Neutron
 $E = 275 \text{ GeV}$
 $0 < \theta_{MC} < 5 \text{ mrad}$



From thrown upto 5 mrad, based on observed actual hits, hot spot is located little in left side from the center, but it should be centered when clustering/particle shower reconstruction folds into.

Zero Degree Calorimeter

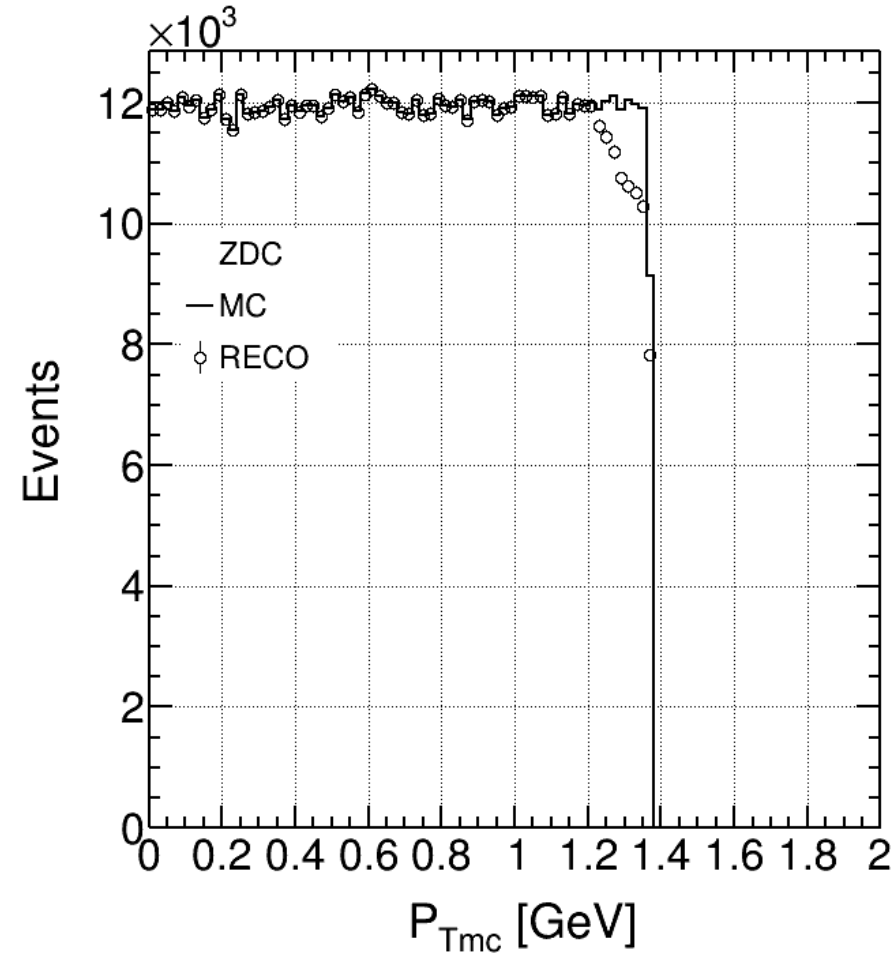
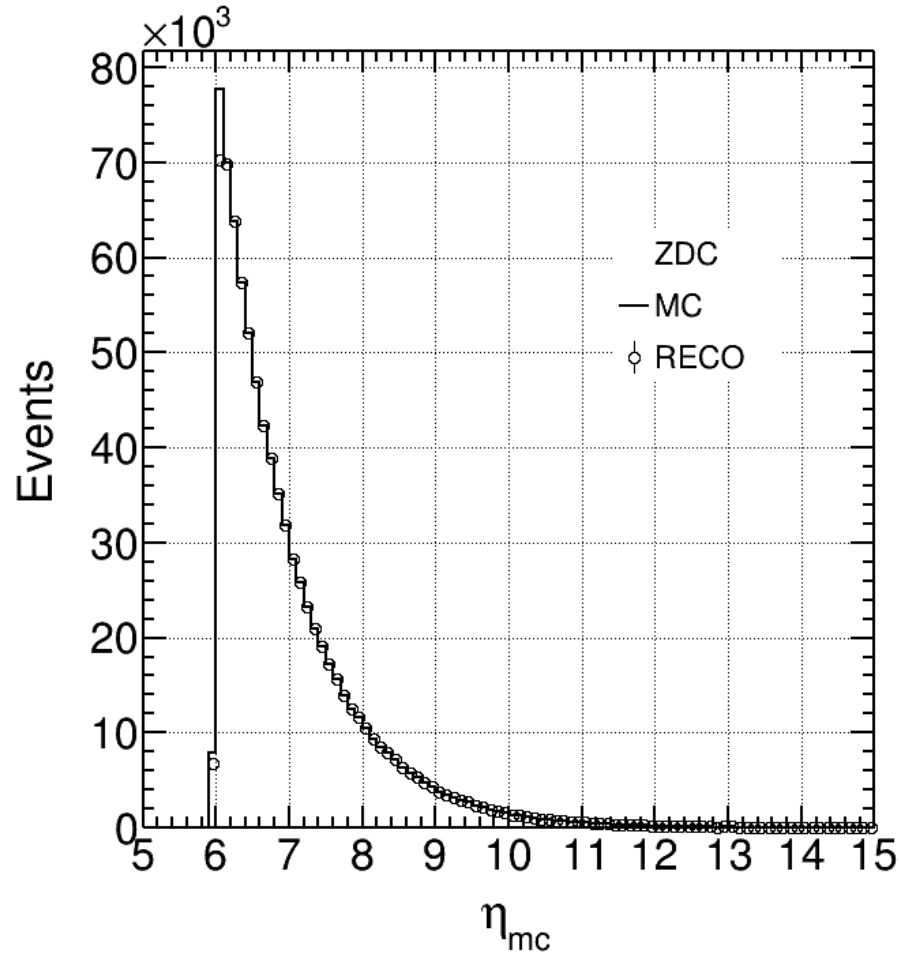
Single Neutron
 $E = 275 \text{ GeV}$
 $0 < \theta_{MC} < 5 \text{ mrad}$



From ~ 4.5 mrad in polar angle, observed it losses acceptance

Zero Degree Calorimeter

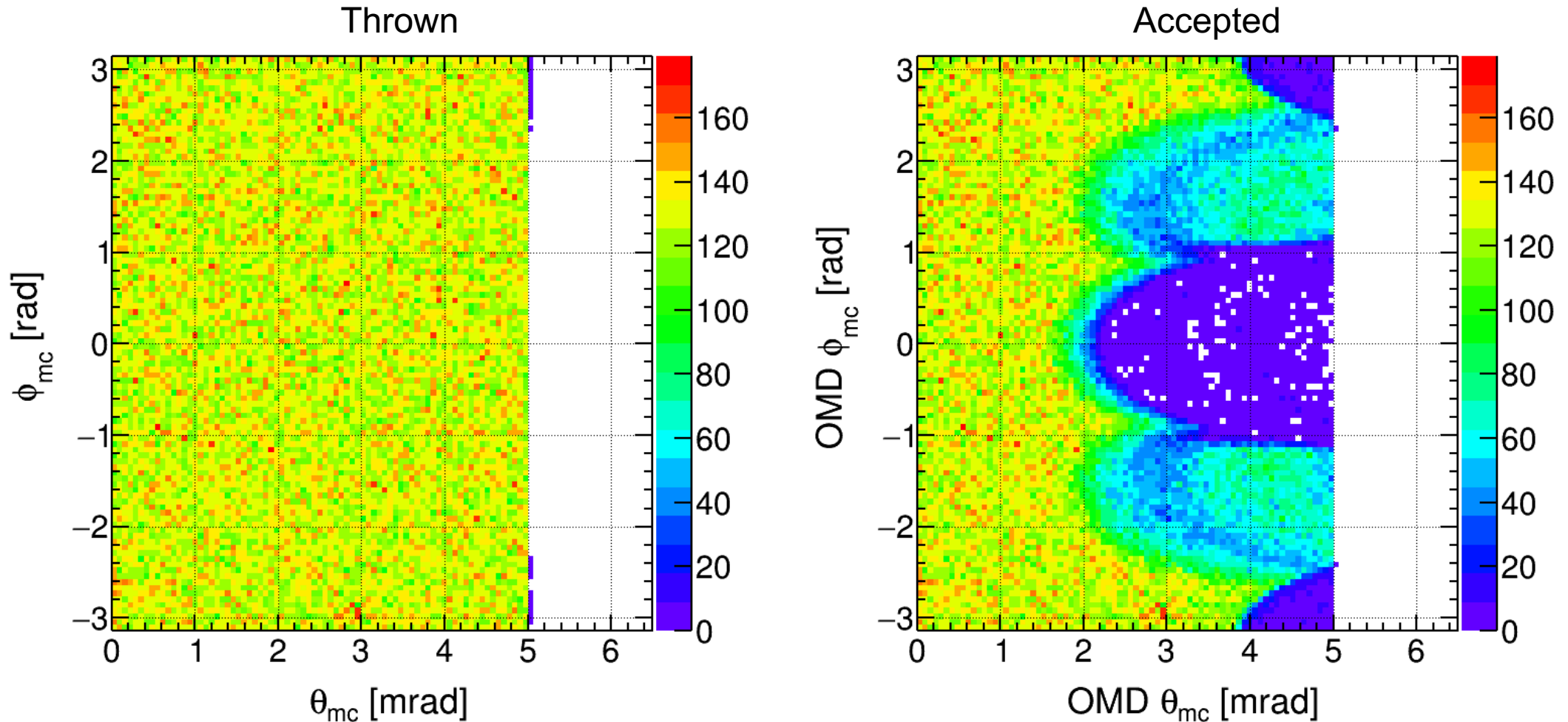
Single Neutron
 $E = 275 \text{ GeV}$
 $0 < \theta_{MC} < 5 \text{ mrad}$



From $\sim 1.2 \text{ GeV}$ in P_T , observed it losses acceptance

Off Momentum Detectors

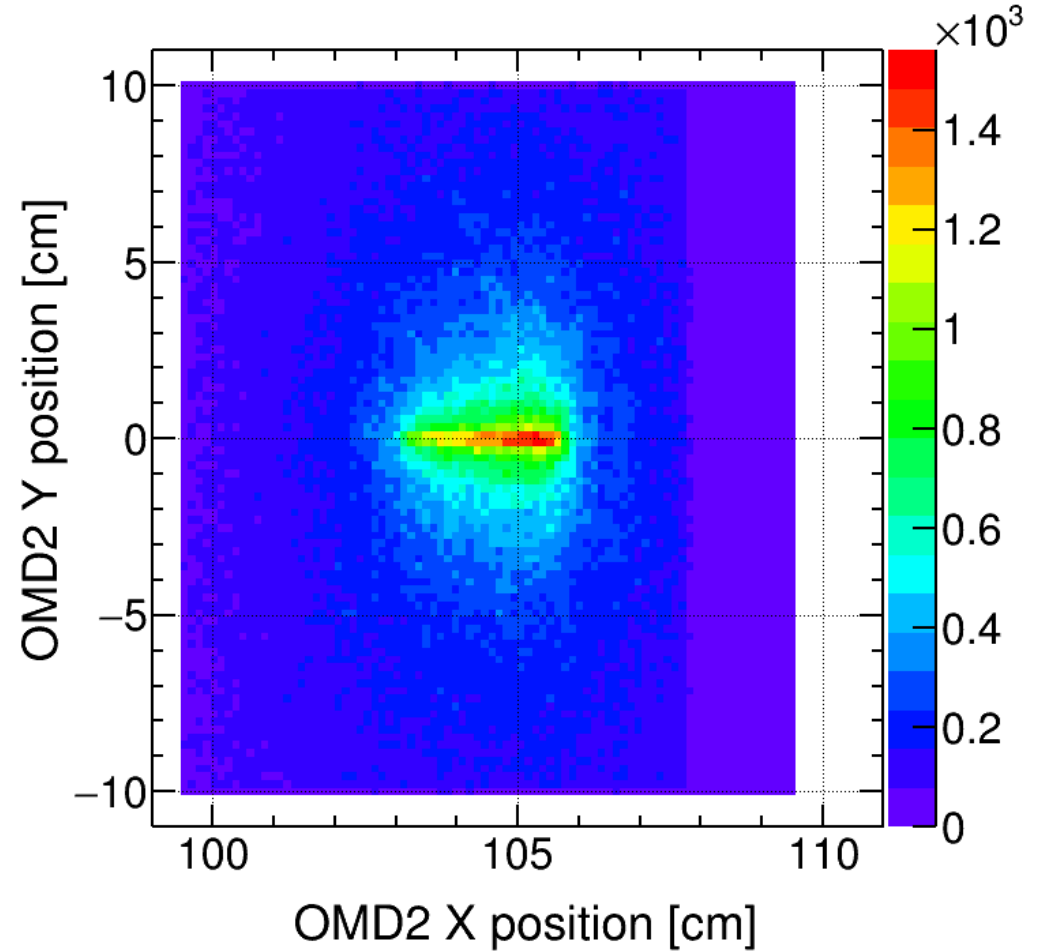
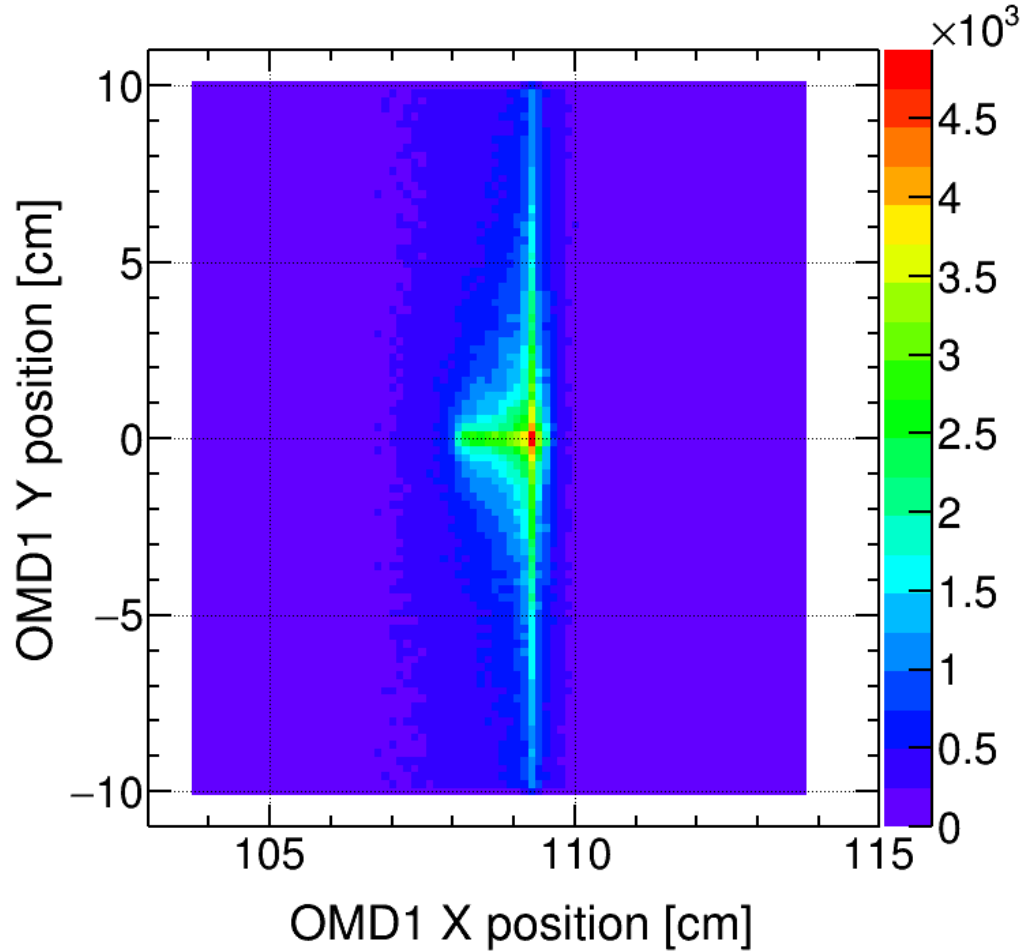
Single Proton
 $123.75 \text{ GeV (45\%)} < E < 151.25 \text{ GeV (55\%)}$
 $0 < \theta_{MC} < 5 \text{ mrad}$



From thrown upto 5 mrad with $45\% < x_L < 55\%$, 64.8 % events were accepted where scattering angle stretched upto 2 mrad.

Off Momentum Detectors

Single Proton
 $123.75 \text{ GeV (45\%)} < E < 151.25 \text{ GeV (55\%)}$
 $0 < \theta_{MC} < 5 \text{ mrad}$

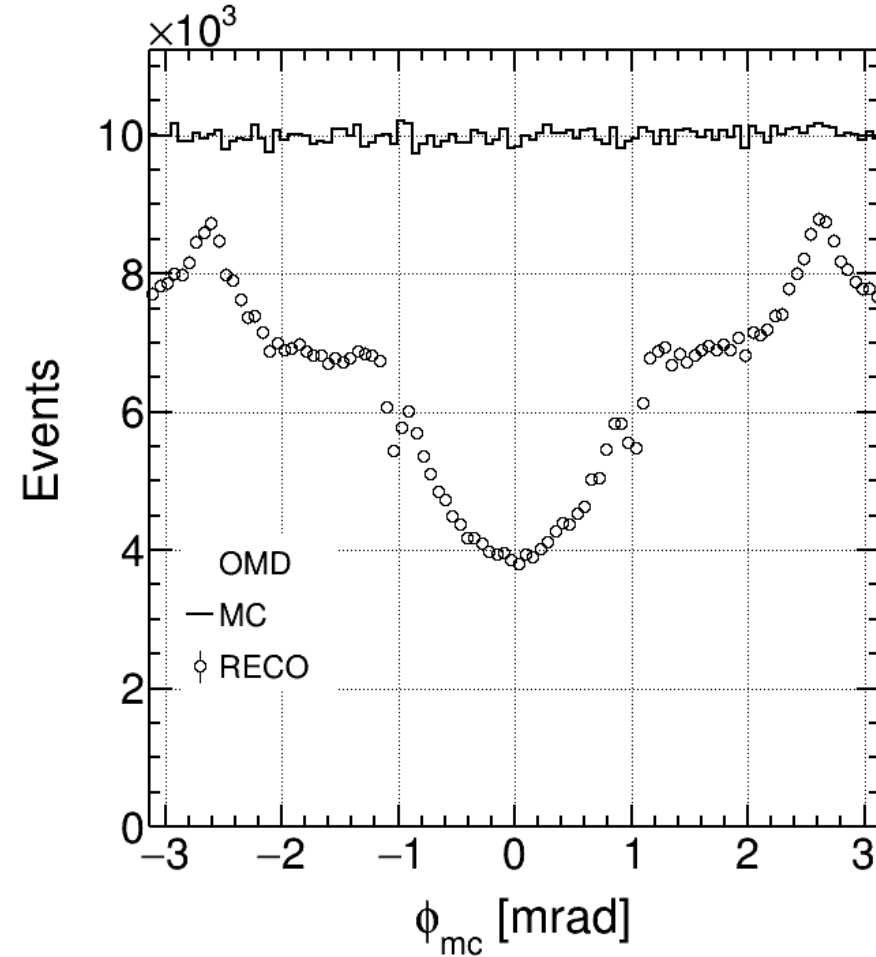
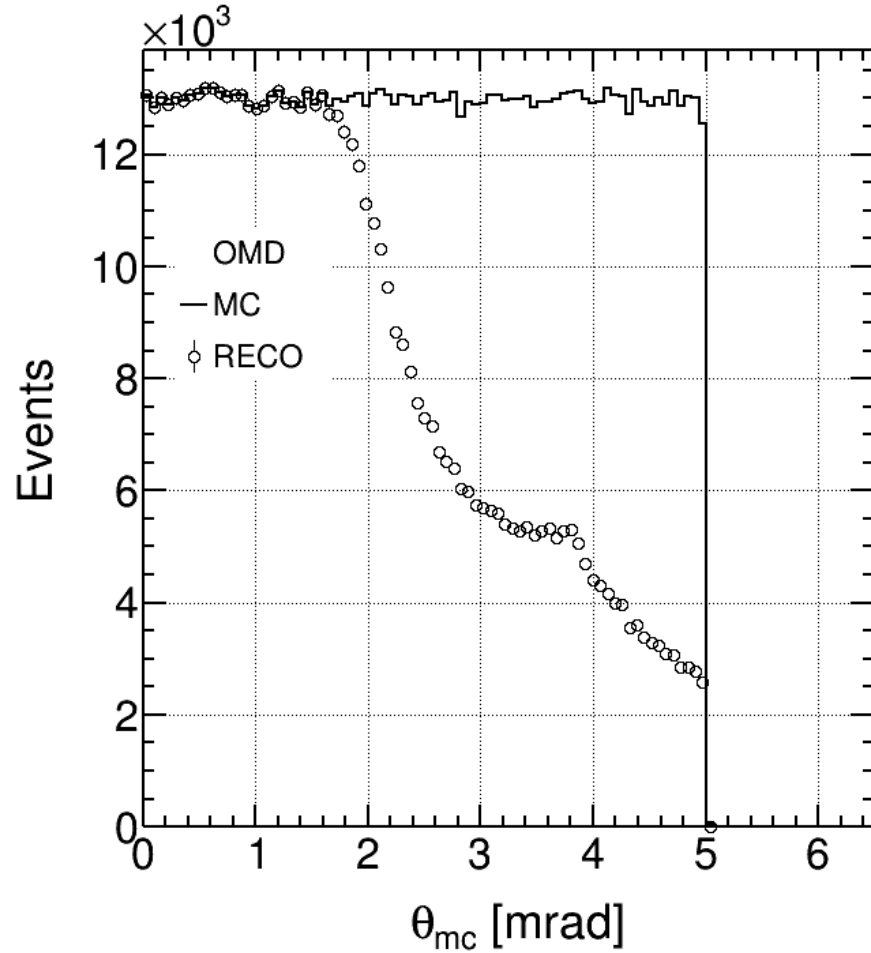


Off Momentum Detectors

Single Proton

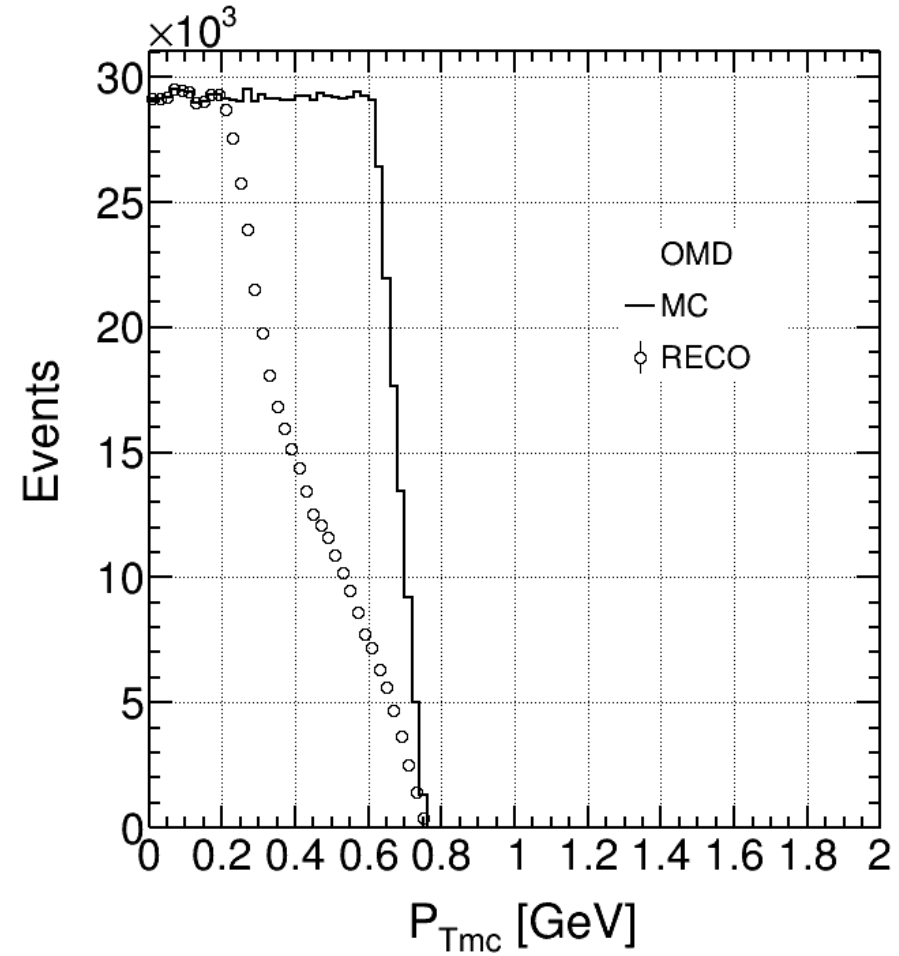
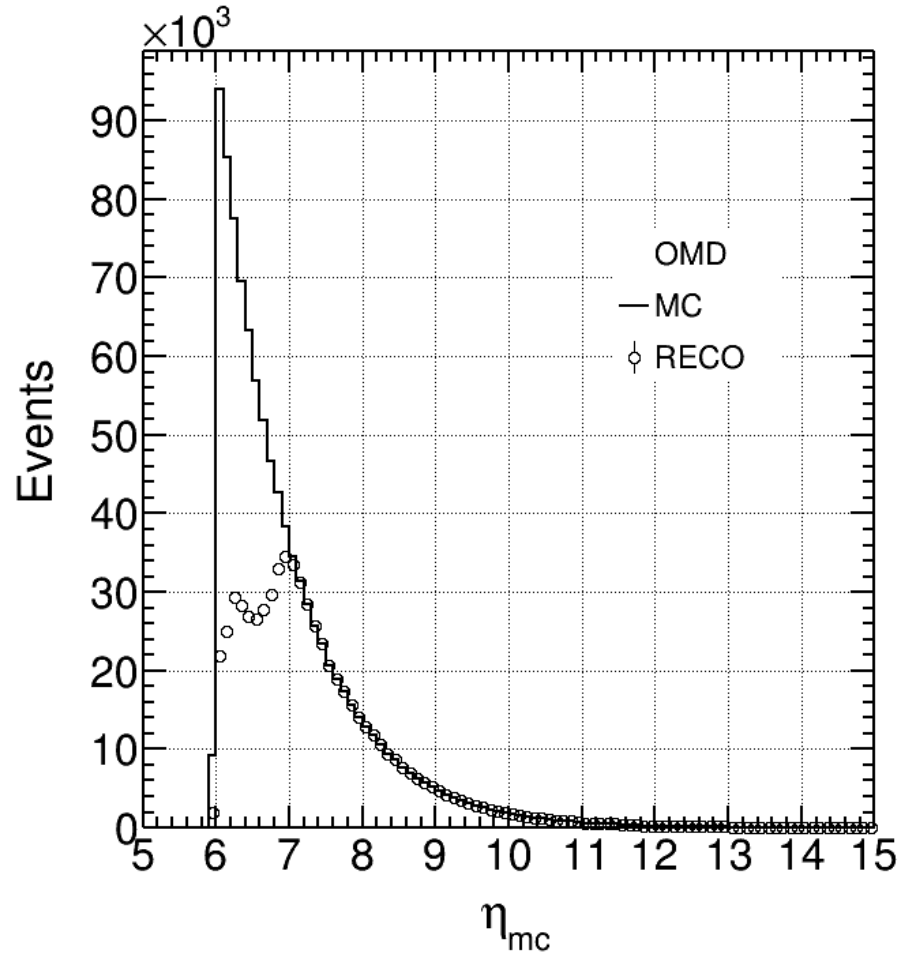
$123.75 \text{ GeV (45\%)} < E < 151.25 \text{ GeV (55\%)}$

$0 < \theta_{MC} < 5 \text{ mrad}$



Off Momentum Detectors

Single Proton
 $123.75 \text{ GeV (45\%)} < E < 151.25 \text{ GeV (55\%)}$
 $0 < \theta_{MC} < 5 \text{ mrad}$



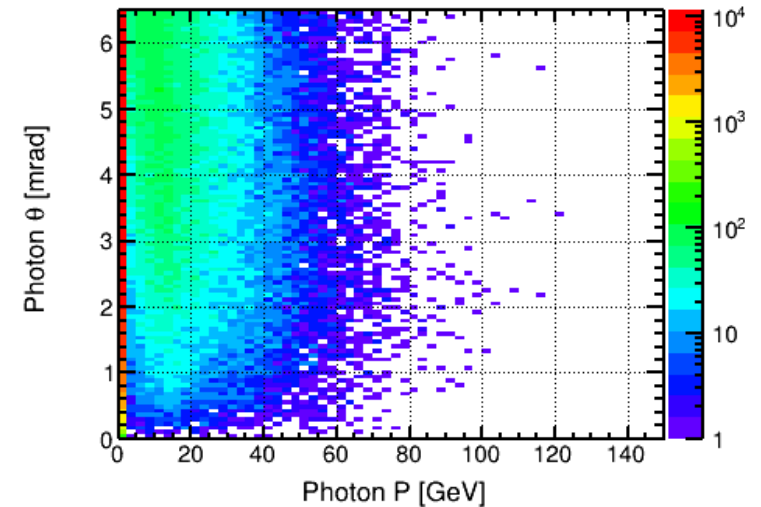
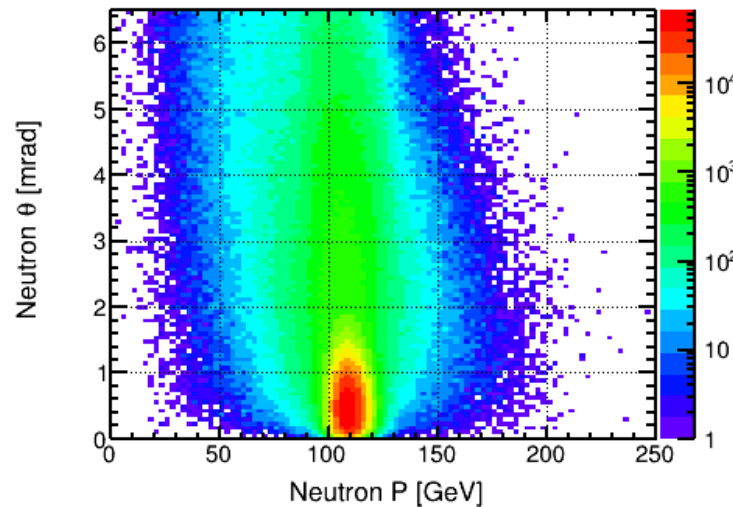
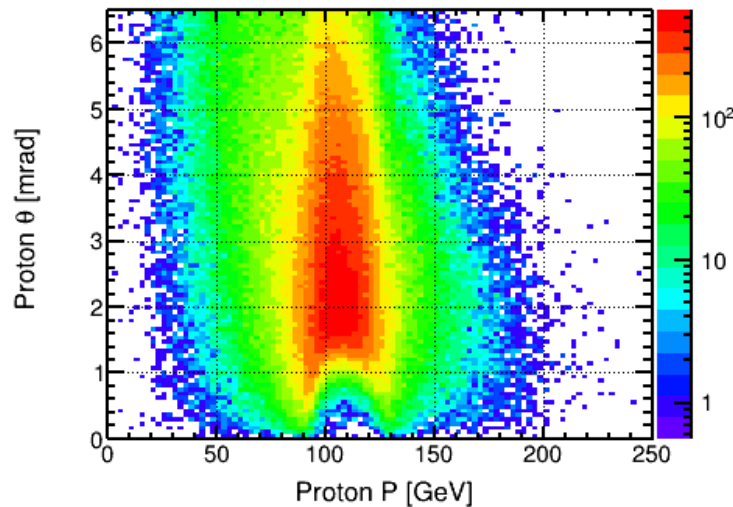
Summary

- Implemented IP8 far-forward magnets and detectors in DD4Hep
 - There is no IP8 detector design yet, so used IP6 configuration
 - Regarding Roman Pot at secondary focus, used silicon plane
- With basic components are in-place, looked at acceptance on each detector
- From roman pot at 2nd focus, protons are focused around 0.1 cm in height and 0.1 cm in width
- In general, compared to EicRoot standalone simulation and showed a good agreement in terms of acceptance
- Need more work on beampipe, slit size of roman pots ...

Next Steps

- Need more work on optimization in detector layout
 - Start with BeAGLE ePb 18×110 GeV incoherent diffractive J/ψ events
 - Below shows particles' (nuclear breakups – protons, neutrons, and photons) momentum vs polar angle with afterburner IP8
 - Examine veto efficiency and follow-up/compare with Physical Review D 104, 114030 (2021) Wan Chang's results
- EicRoot

BeAGLE ePb 18×110 GeV afterburner with IP8

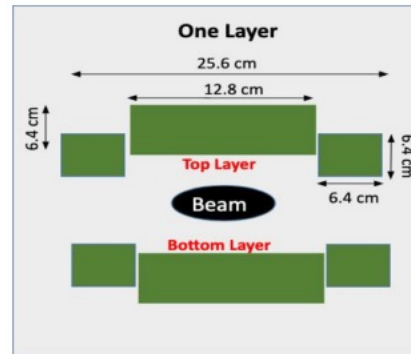
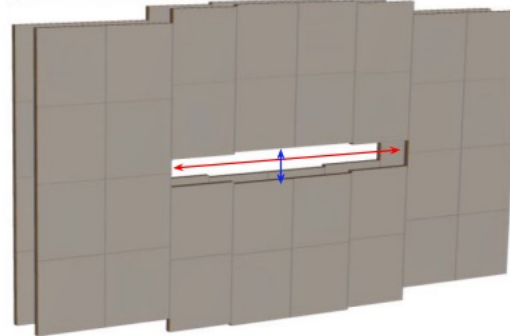


Next Steps

- From actual hits of roman pots at secondary focus, it has stretched to y axis direction.
- Learn **IP8 actual beam parameters** to estimate proper slit size at secondary focus

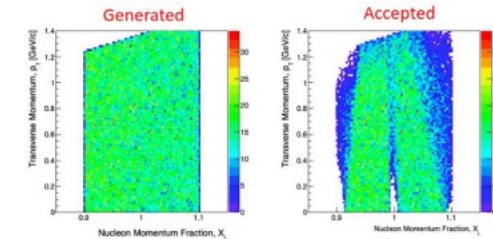
Roman Pots

Image by A. Jentsch, BNL



- **Primary consideration:**
 - Slit opening 10σ wider than the beam width.

	Slit width	Slit height
IP6 RP 1&2	8.8 cm	1.2 cm
IP8 1&2	6.2 cm	0.8 cm
IP8 3&4 (2nd focus)	0.7 cm	0.2 cm



Acceptance study by Alex Jentsch, see full study:
https://wiki.bnl.gov/eic-detector-2/images/8/86/IP8_HSR_lattice_performance_10_13_22_v3.pdf