

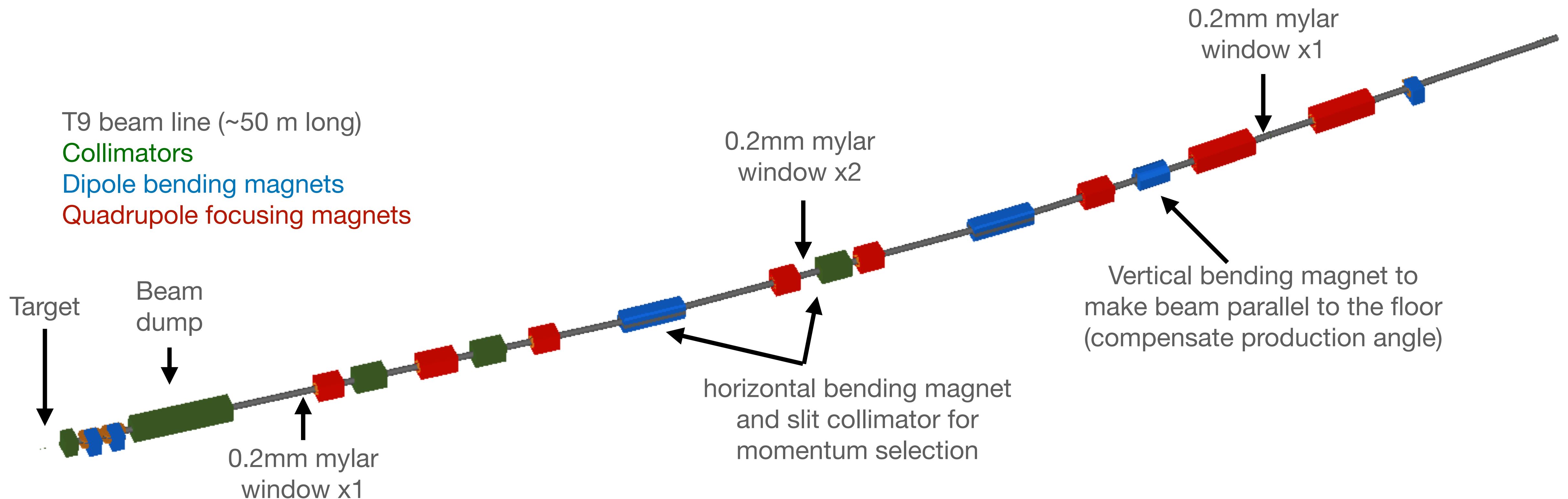
T9 beam line simulation update

Arturo Fiorentini

WCTE collaboration meeting - 21 July 2022

T9 secondary beam line simulation

- Simulation based on BDSIM framework (GEANT4 extension) used by CERN's beam experts that they kindly shared with us
- Full simulation from primary protons on target is slow (10^6 POT in ~ 48 h, need 10^{11}) so I separated it in two steps: 1) target and 2) T9 beam line

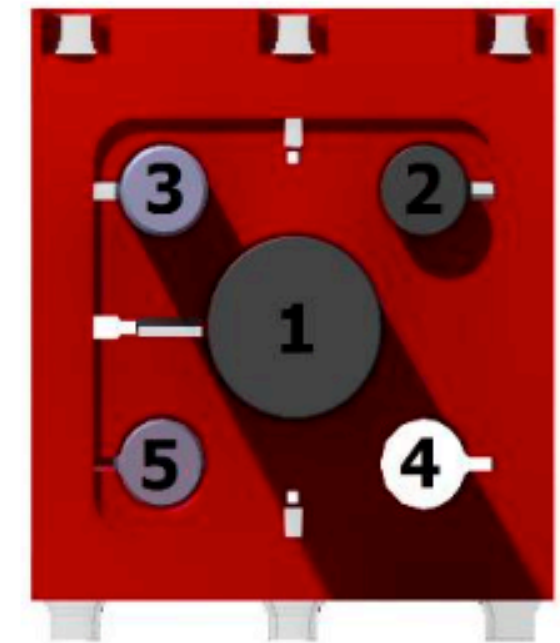


Primary beam and target

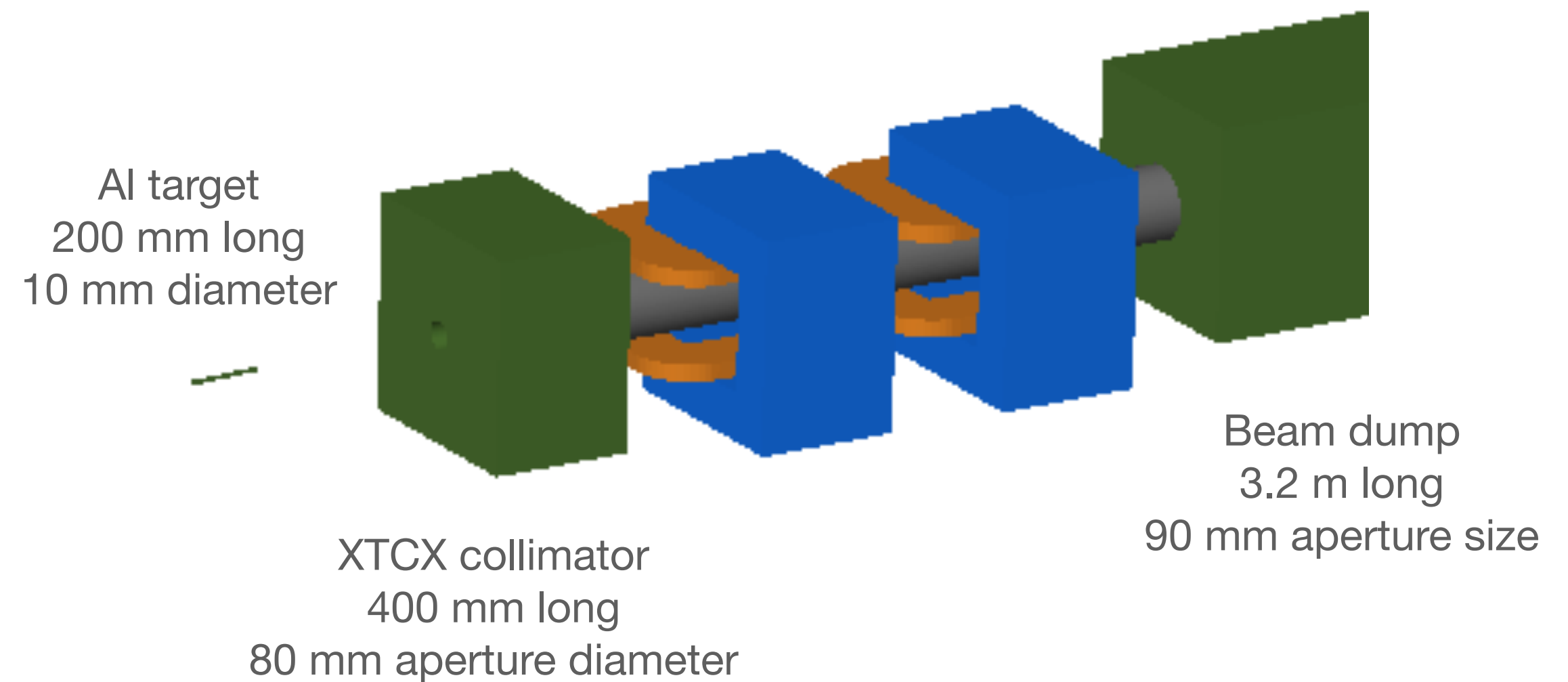
- Primary beam consist of 24 GeV/c protons
- Using “head 3” as proton target as in current actual T9 setup
- Proton beam profile is at the centre of the target with a width of 1.7mm in X and 0.7mm in Y (from T9 documentation)
- Particles at a production angle of -30mrad enter the T9 secondary beam line

Multi-target heads

Head	Material	Length (mm)	Diameter (mm)	Comments
1	Be W	200 3	10 + Al case	Electron enriched
2	Al W	100 3	10	Electron enriched
3	Al	200	10	Hadron
4	Air	-	-	Empty
5	Al	20	10	Hadron

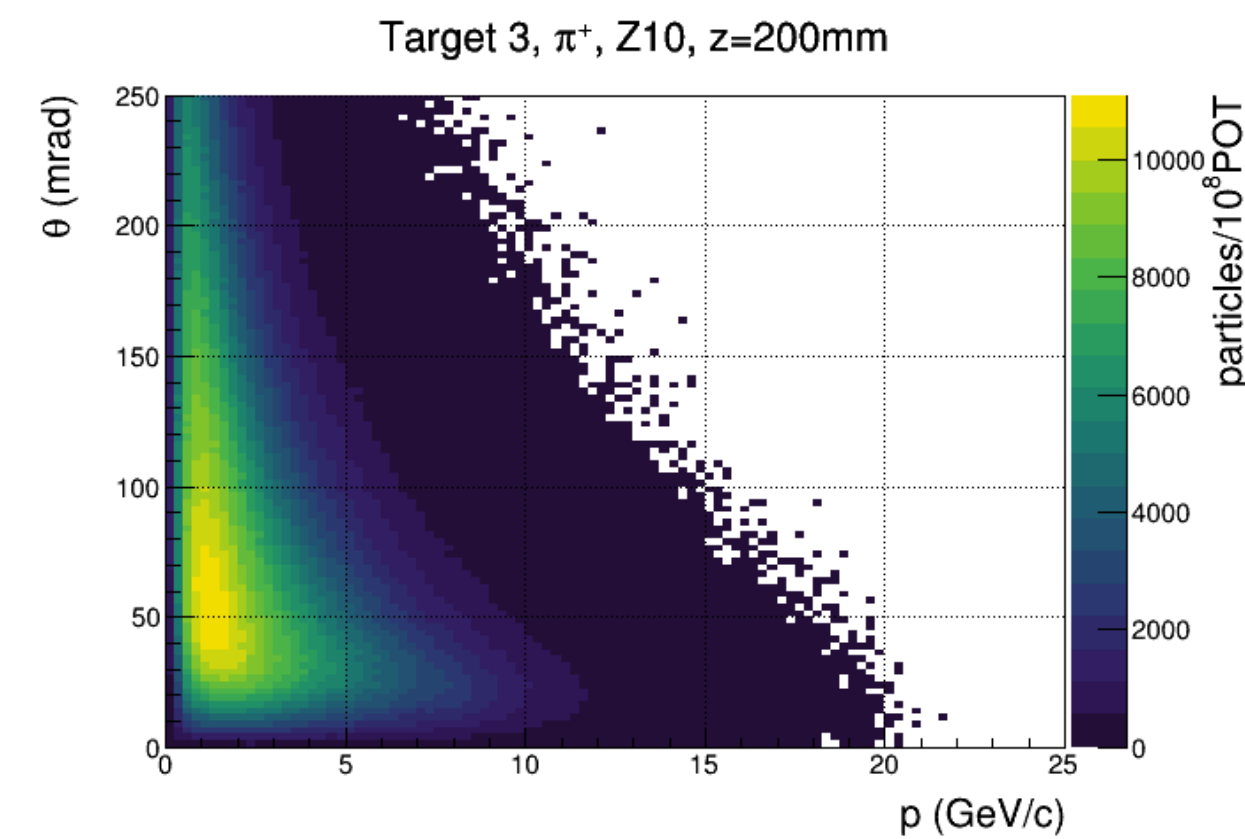
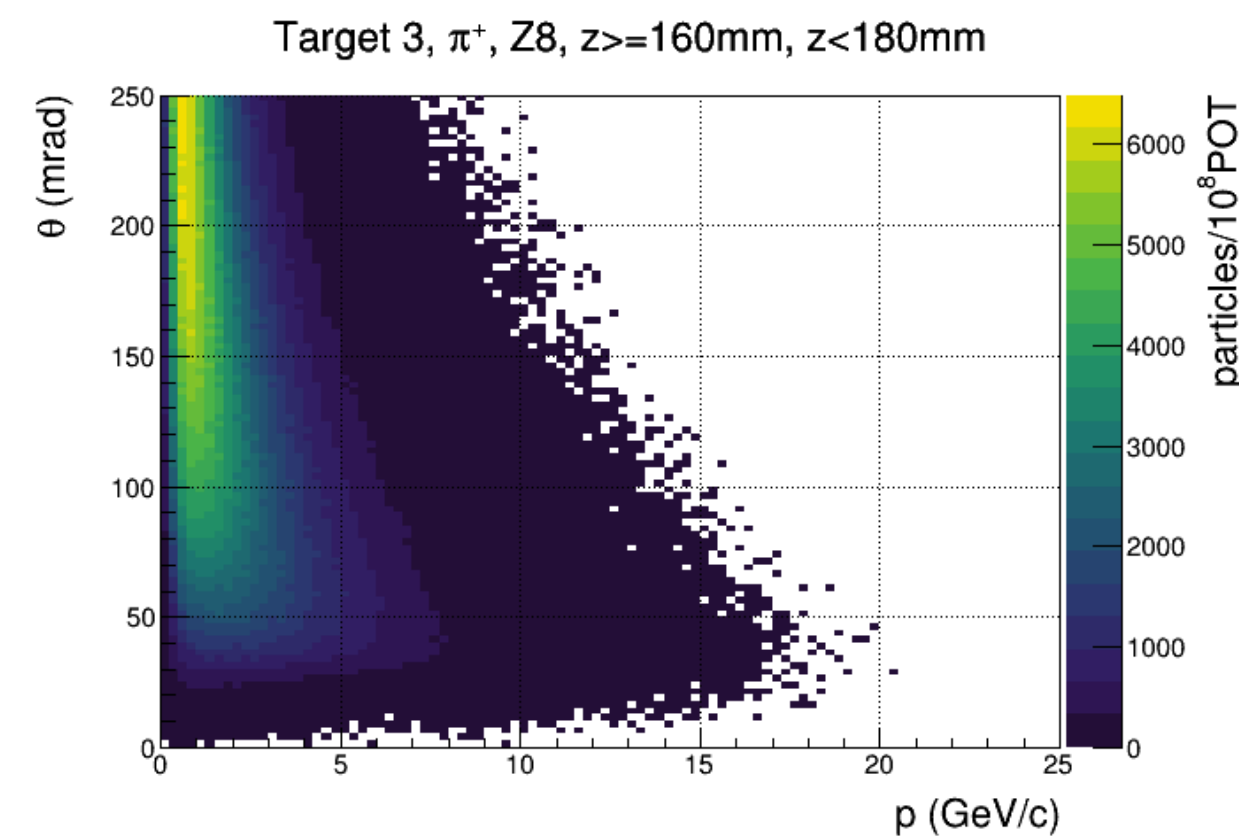
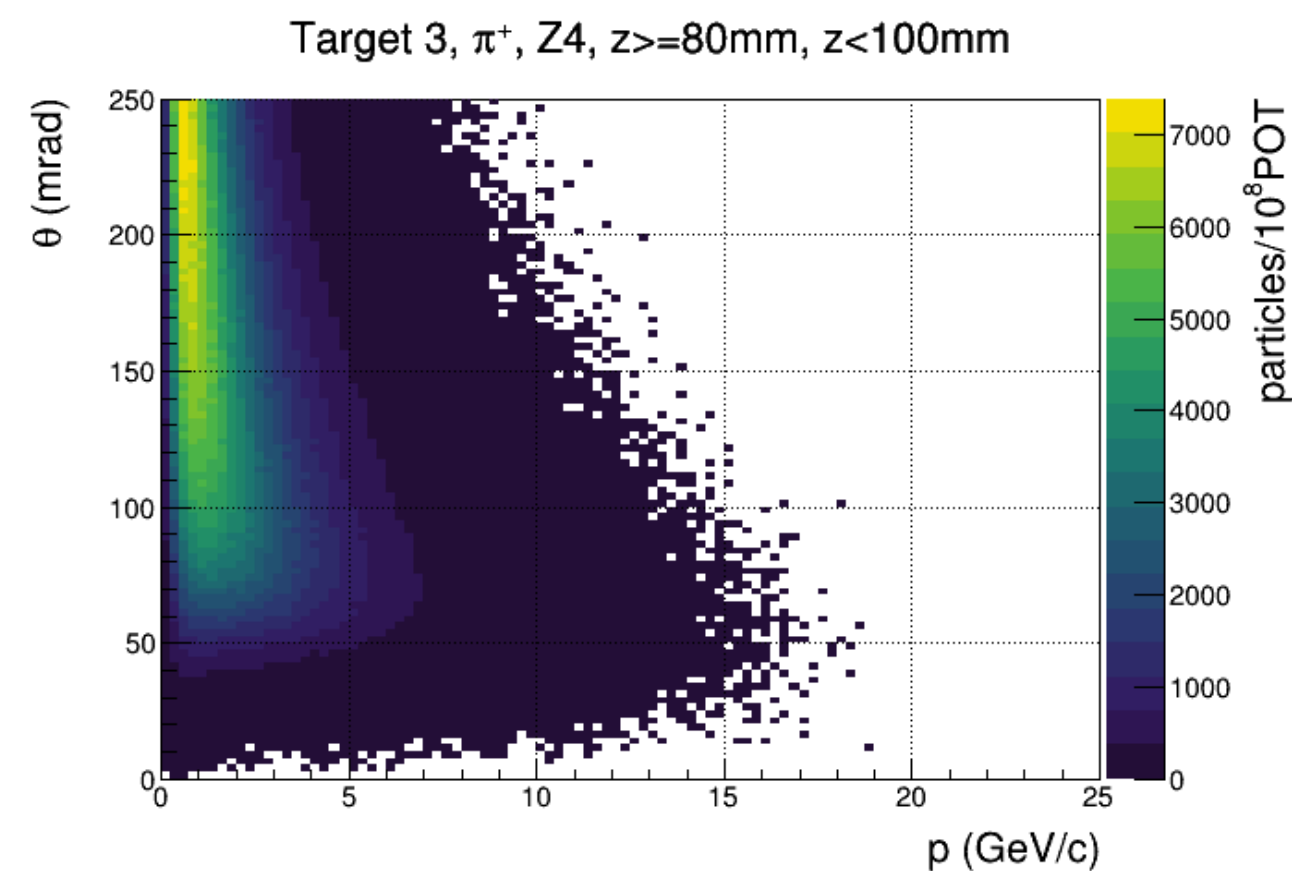
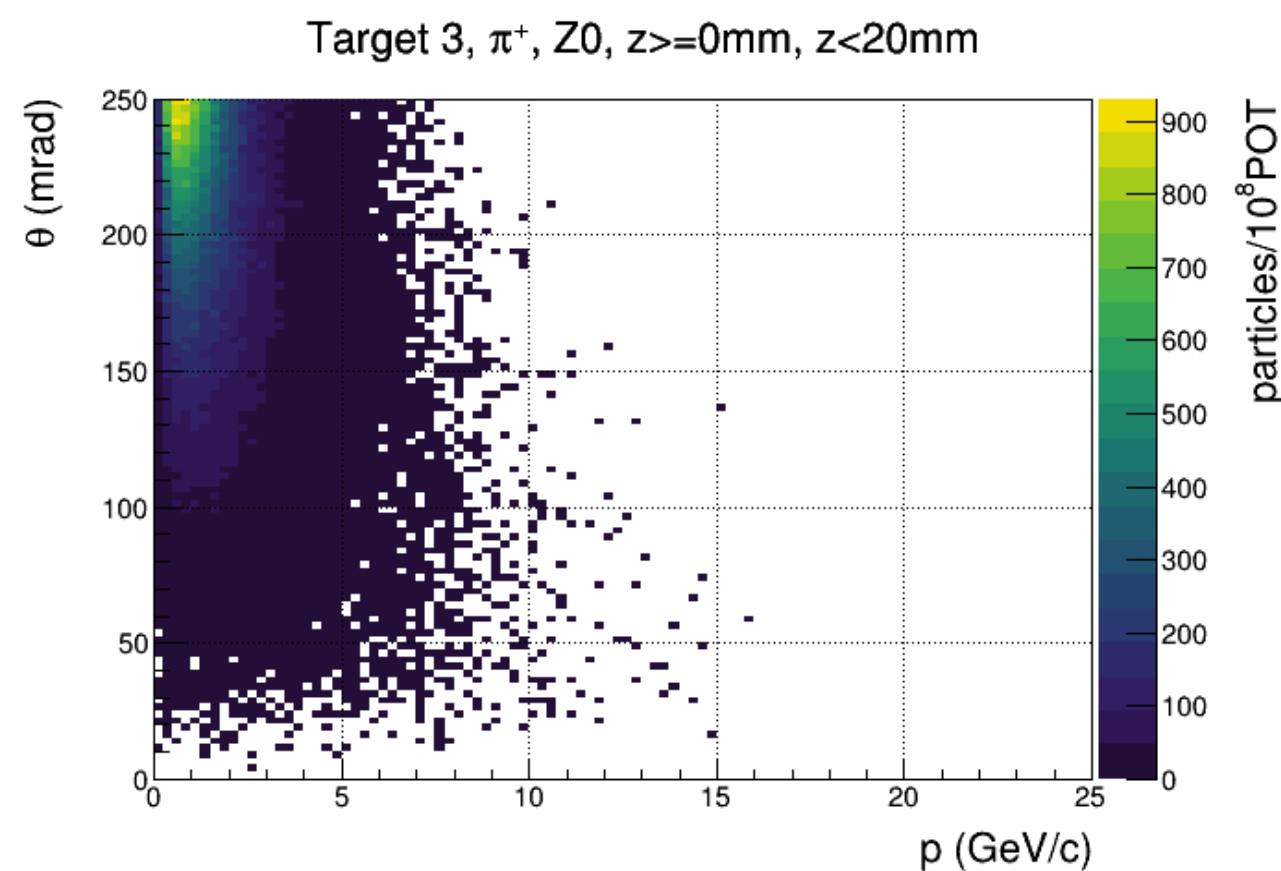
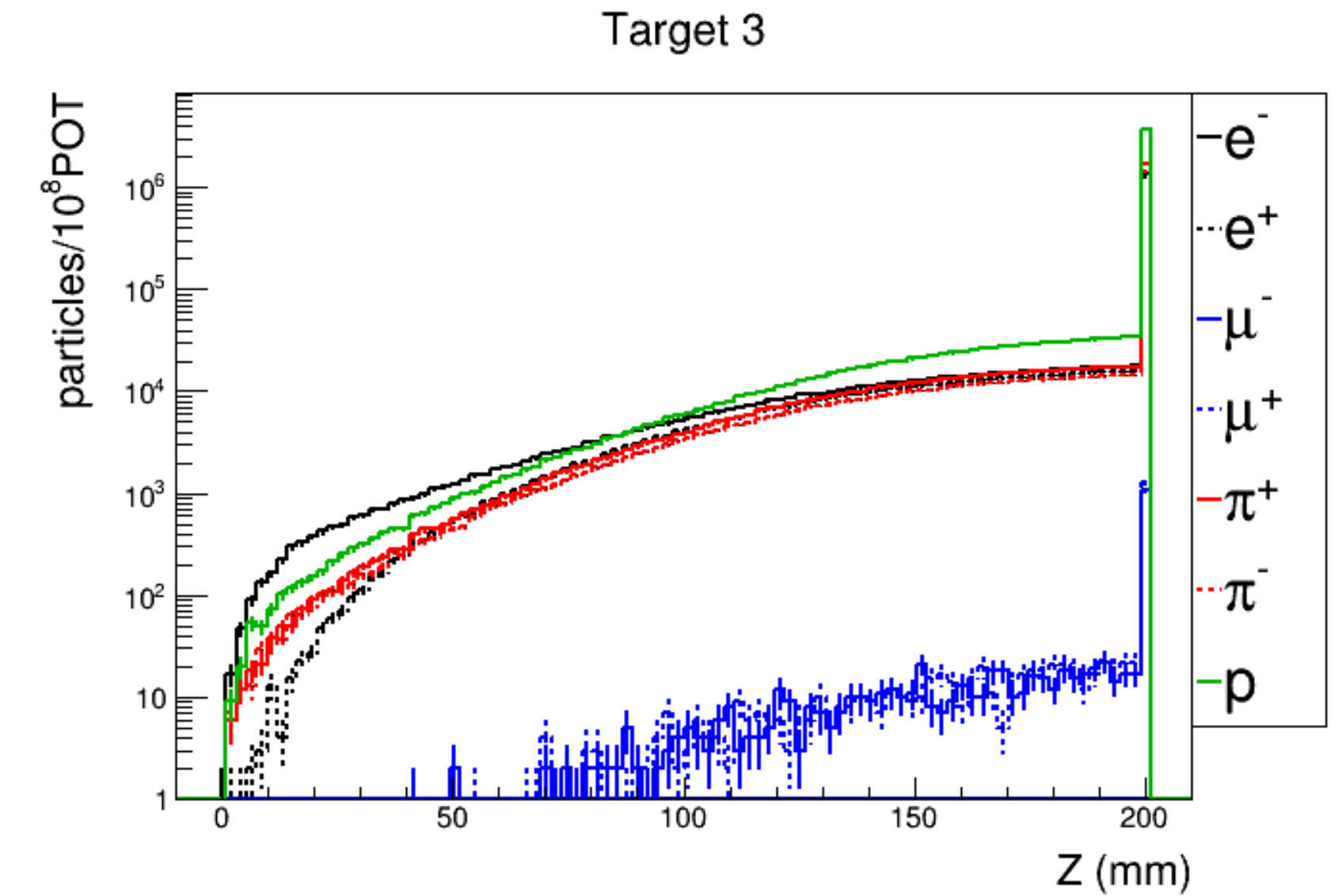


Upstream part of T9 beam line



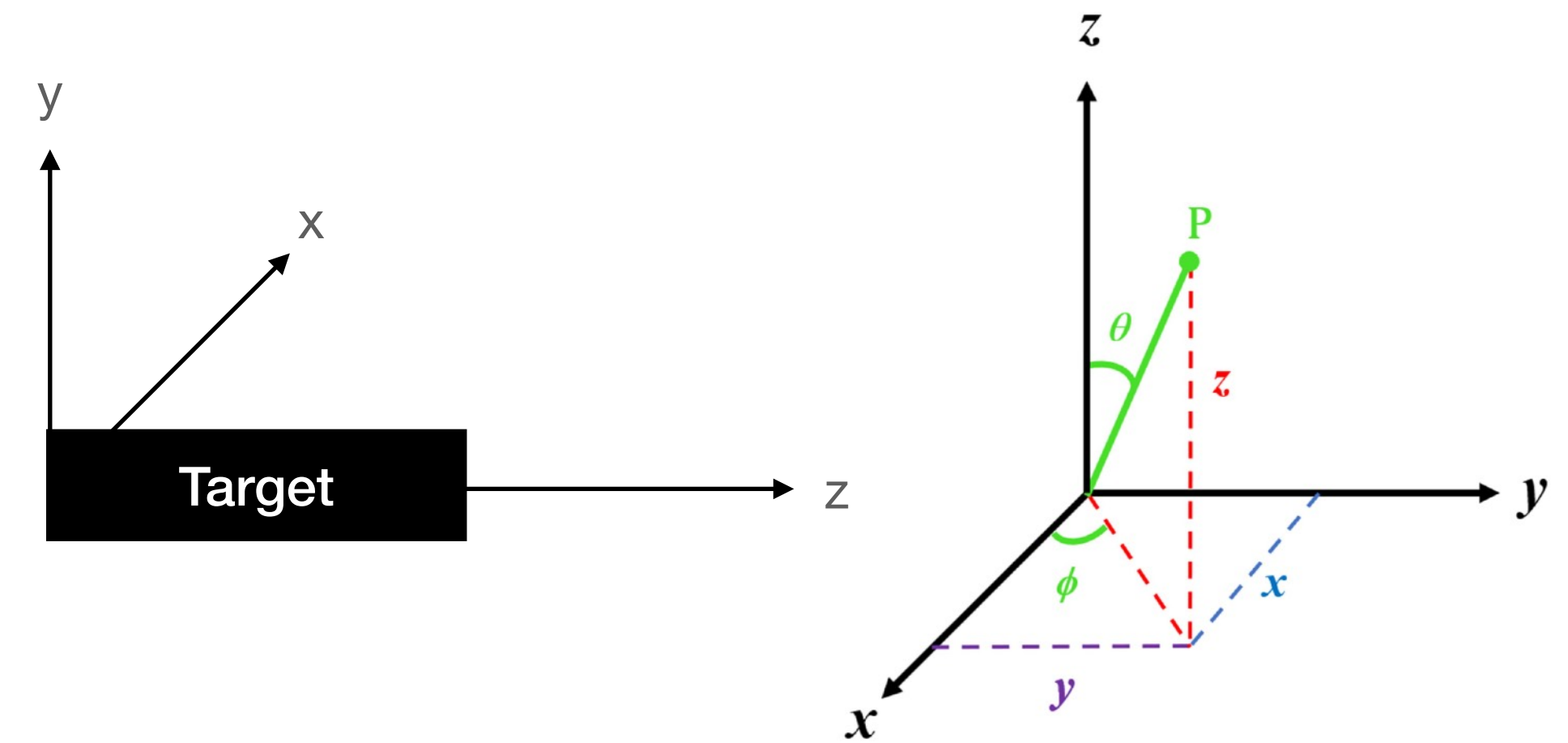
Target simulation

- Generated 10^8 POT at 24 GeV/c
- Geant4-10.7.3 FTFP_BERT physics list
- Filled histograms with e, μ , π and protons exiting the target
- 200mm long target was divided in 10 z bins
- P vs θ distributions for each z bin

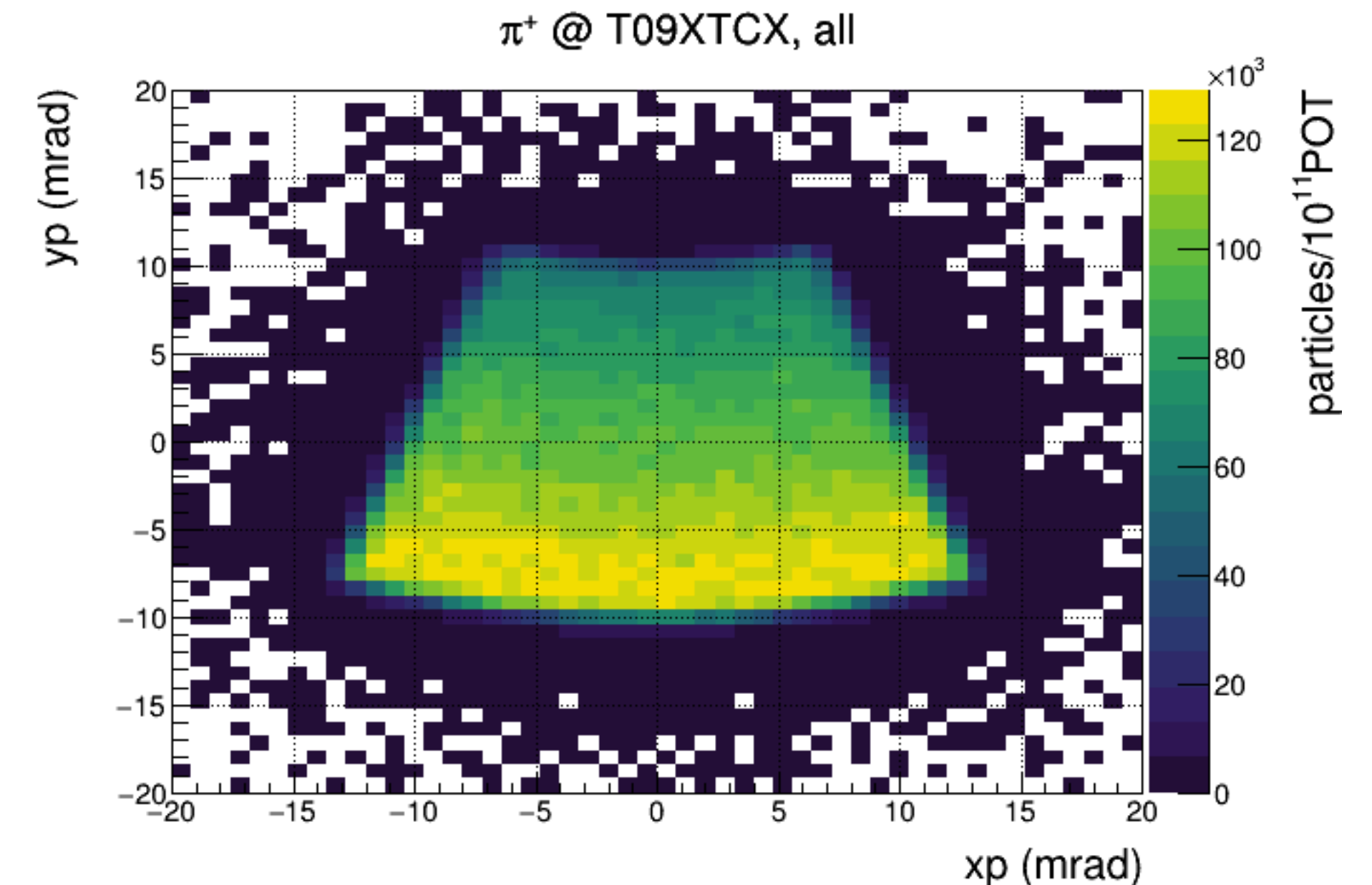


Input for T9 beam line simulation

- Used histograms from target simulation to generate particles in the acceptance region of the T9 beam line
 - $20 < \theta \text{ (mrad)} < 40$
 - $-0.333 < \phi - 2\pi/3 \text{ (rad)} < 0.333$
 - $p < 2\text{GeV}/c$
- According to T9 documentation, angular acceptance is $\sim 4\text{mrad}$ in X and Y which is covered by generated particles
- Still need to increase statistics (goal is $> 10^{11}$ POT per particle)

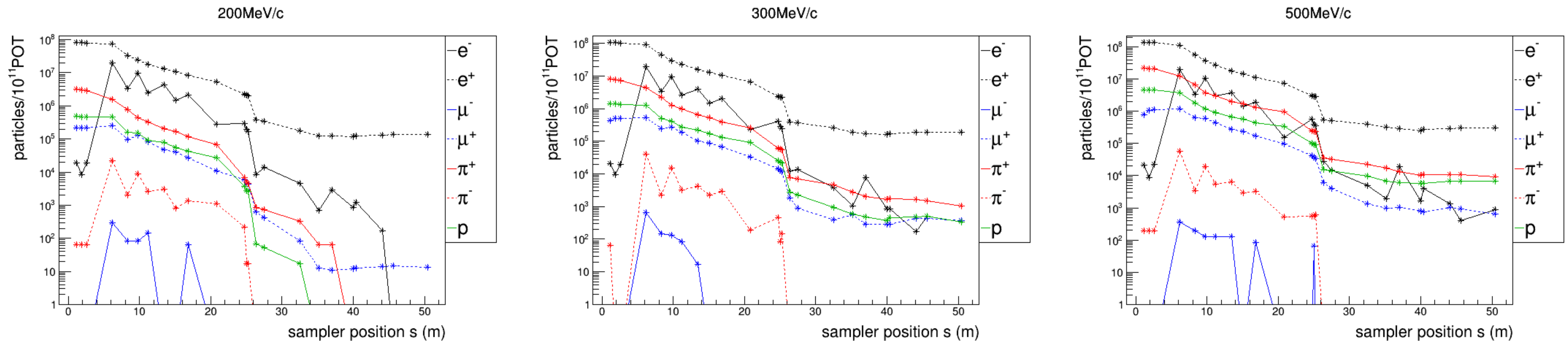


	Generated # of particles	POT equivalent
e^+	10^6	5.8×10^8
μ^+	10^6	7.9×10^{11}
π^+	10^6	1.5×10^9
protons	10^6	5.8×10^9



T9 beam line simulation

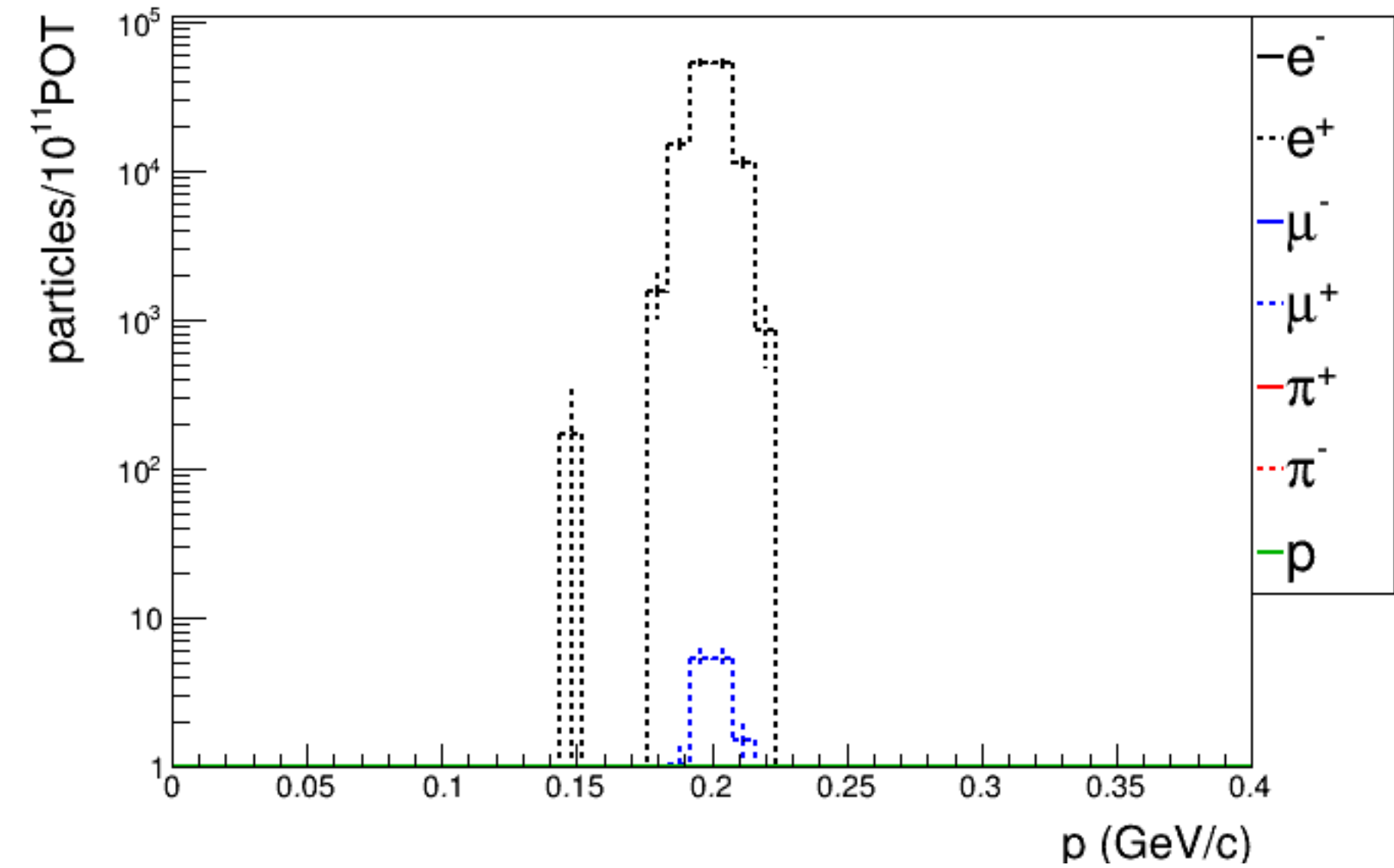
- Generated particles are transported through T9 beam line in 3 momentum configurations: 200, 300, 500 MeV/c
- No scintillators planes in the beam line are included (only 0.2mm mylar windows x4)
- Counted number of particles at 24 different 10x10cm² area planes (samplers)
- Number of particles are normalized to 10¹¹ POT
- Most particles with wrong momentum are rejected due to momentum slit collimator (s= \sim 27m)



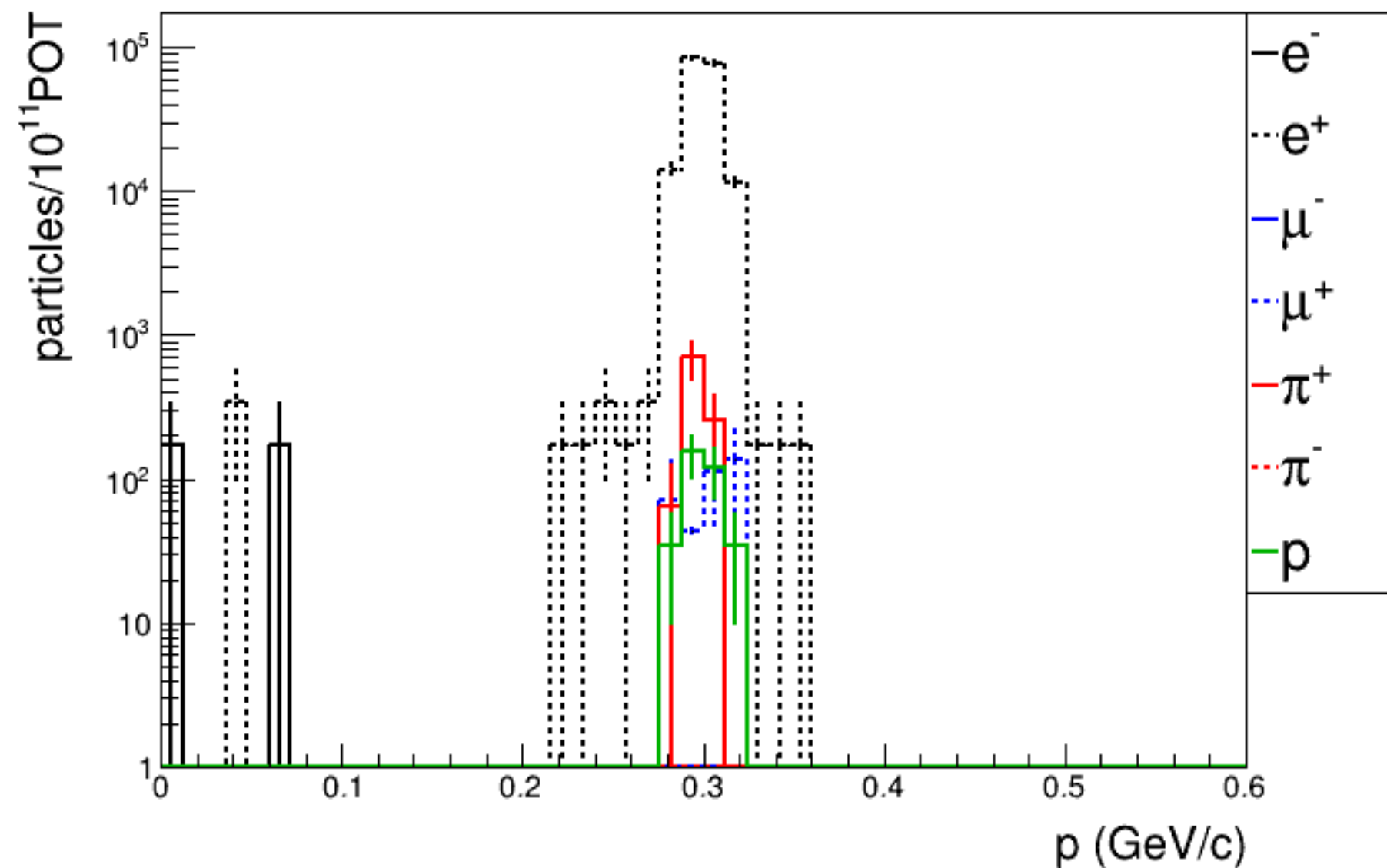
At the end of the T9 beam line ($s \sim 50\text{m}$)

T09XBPF050, 200MeV/c, $|X| < 5\text{cm}$ && $|Y| < 5\text{cm}$

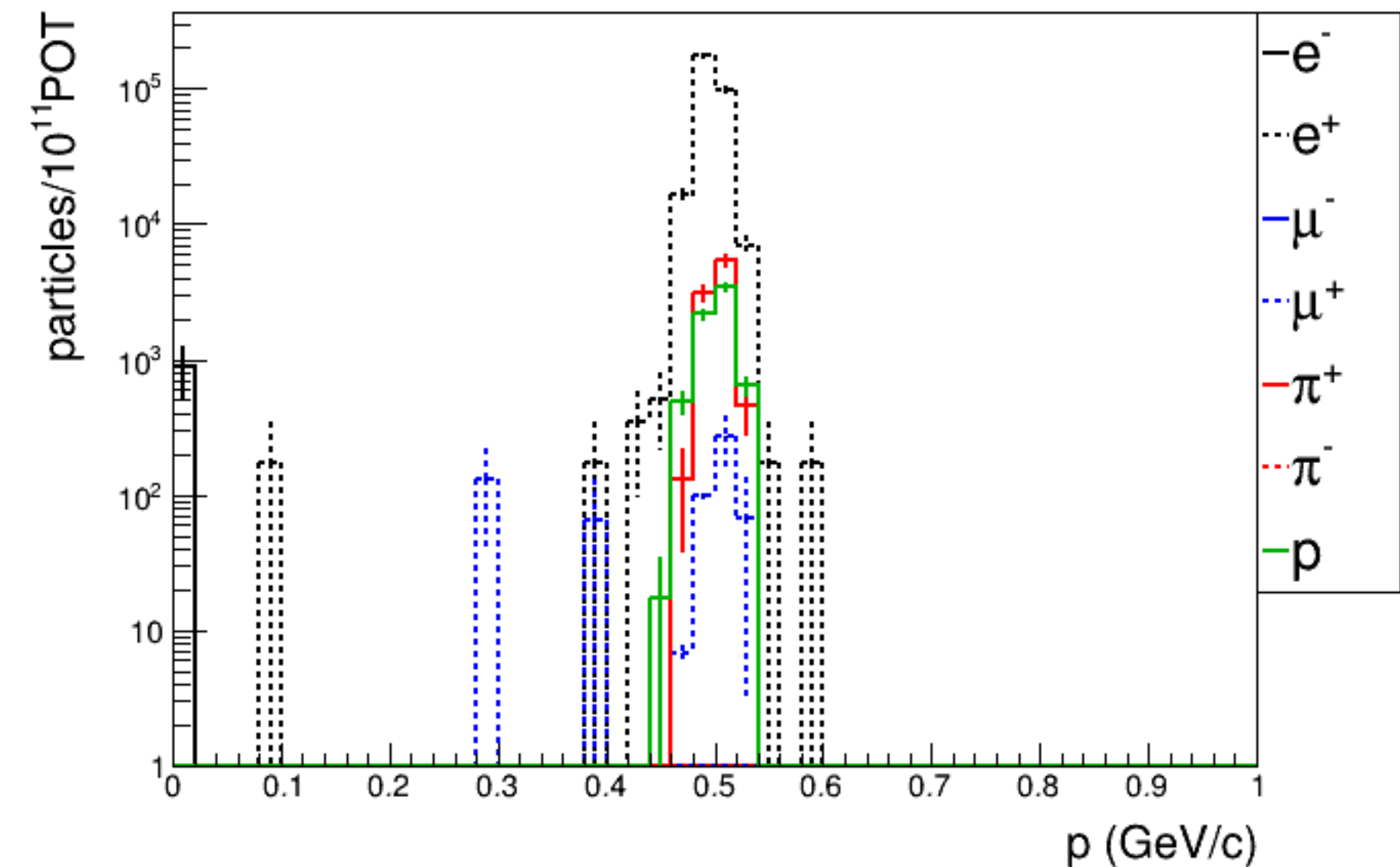
Number of particles / 10^{11} POT (stat. error)			
	200 MeV/c	300 MeV/c	500 MeV/c
e^+	134041 (4%)	191732 (3%)	298896 (2%)
μ^+	13 (10%)	363 (3%)	642 (3%)
π^+	-	1039 (25%)	9162 (8%)
protons	-	342 (22%)	6837 (5%)



T09XBPF050, 300MeV/c, $|X| < 5\text{cm}$ && $|Y| < 5\text{cm}$



T09XBPF050, 500MeV/c, $|X| < 5\text{cm}$ && $|Y| < 5\text{cm}$



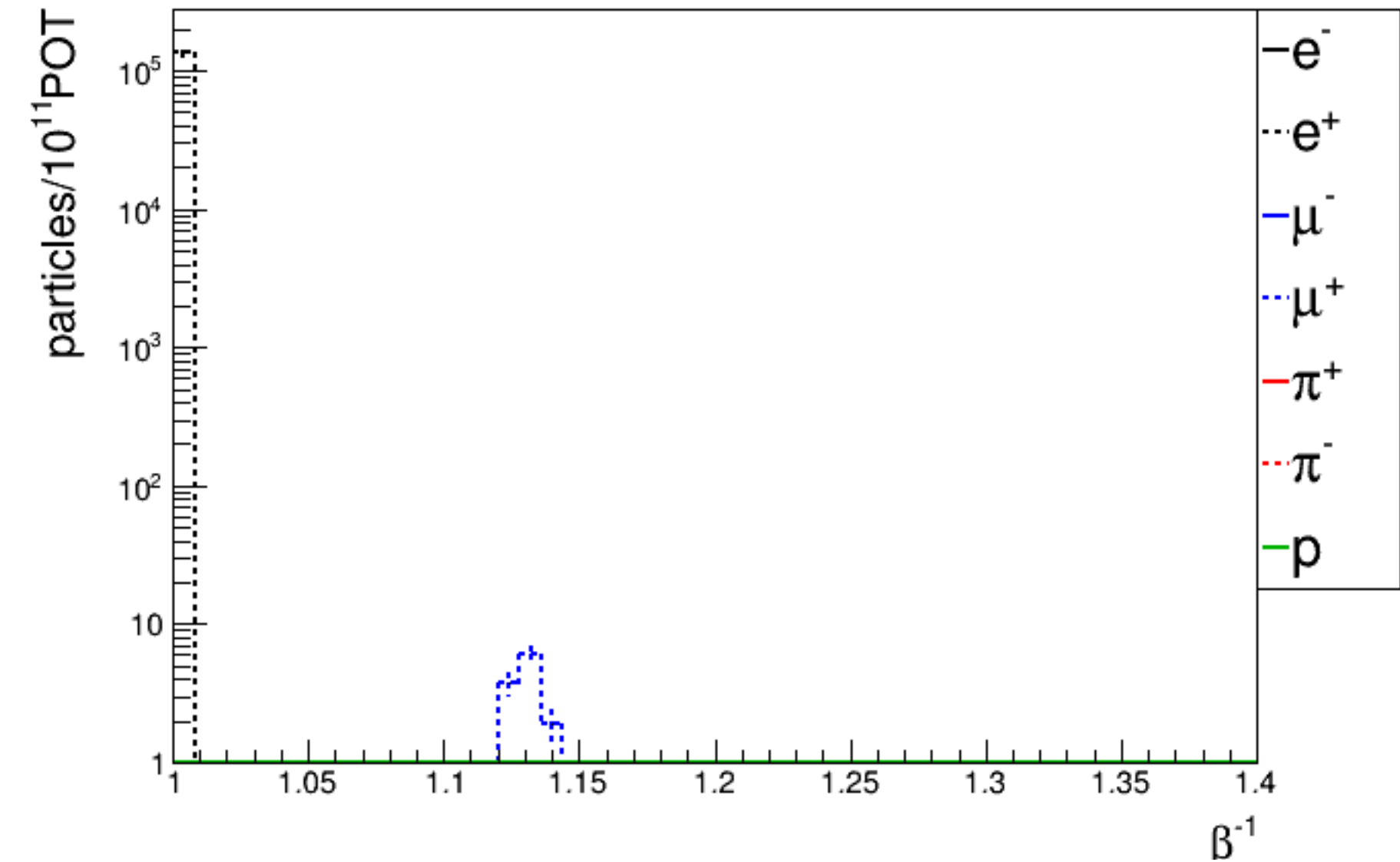
At the end of the T9 beam line (s= \sim 50m)

- π and μ can be separated by Cherenkov threshold detector

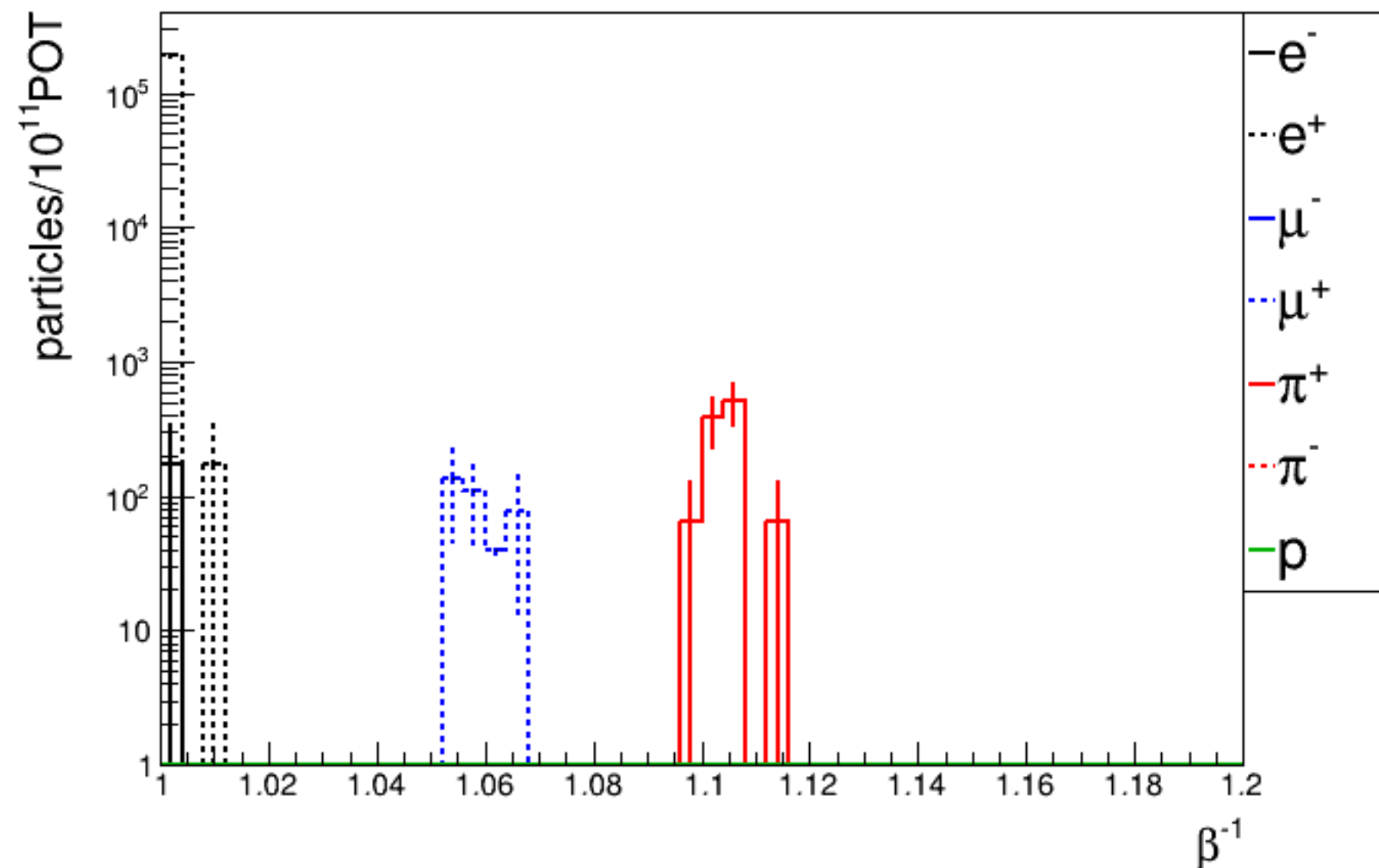
$$\cos \theta_C = \frac{1}{n\beta} \Rightarrow \beta^{-1} < n$$

- μ threshold: \sim 1.19 (200MeV/c), \sim 1.08 (300MeV/c), \sim 1.03 (500MeV/c)

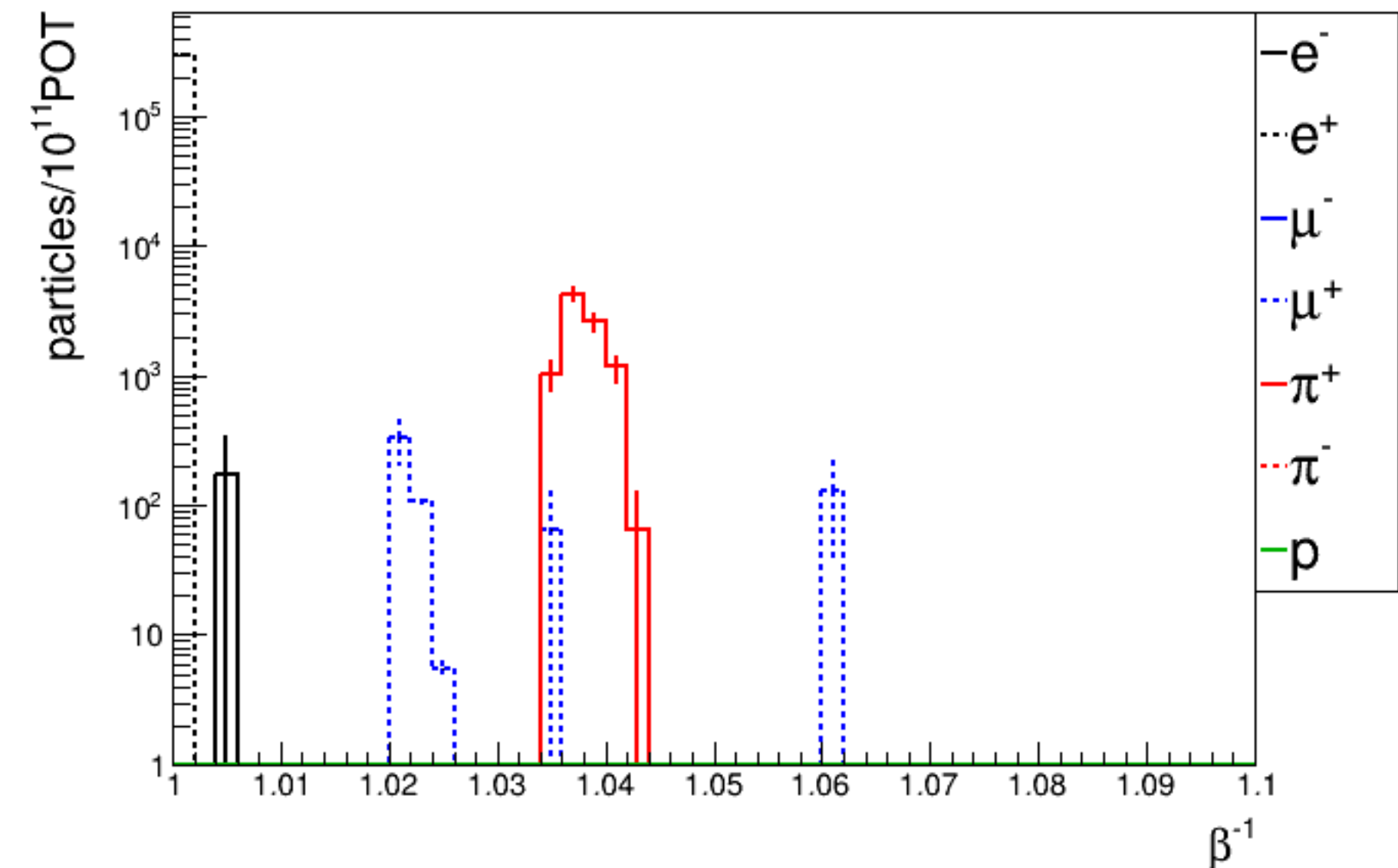
T09XBPF050, 200MeV/c, $|X|<5\text{cm}$ && $|Y|<5\text{cm}$



T09XBPF050, 300MeV/c, $|X|<5\text{cm}$ && $|Y|<5\text{cm}$



T09XBPF050, 500MeV/c, $|X|<5\text{cm}$ && $|Y|<5\text{cm}$



Summary & next steps

- Simulation was separated in two steps: 1) target and 2) T9 beam line
- Allows to increase statistics without re-running the target simulation
- Need to increase statistics to have at least 10^{11} POT as in the actual T9 primary beam spill
- Update T9 beam line geometry with detailed drawings I recently received from CERN's experts
- Main update will be that production angle is +30mrad instead of -30mrad among other minor changes in component dimensions (expect small impact on results)
- Update simulation to actual T9 low momentum mode (currently using T9 high momentum mode without scintillators and Aluminium windows in gas Cherenkov detectors)

Backup

At the end of the T9 beam line ($s \sim 50\text{m}$)

Number of particles			
	200 MeV/c	300 MeV/c	500 MeV/c
e^+	783	1120	1746
μ^+	105	821	1484
π^+	-	16	141
protons	-	20	399

Momentum mean/std (%)			
	200 MeV/c	300 MeV/c	500 MeV/c
e^+	3.4	5.6	3.2
μ^+	3.0	4.6	18
π^+	-	1.7	2.2
protons	-	3.2	2.8