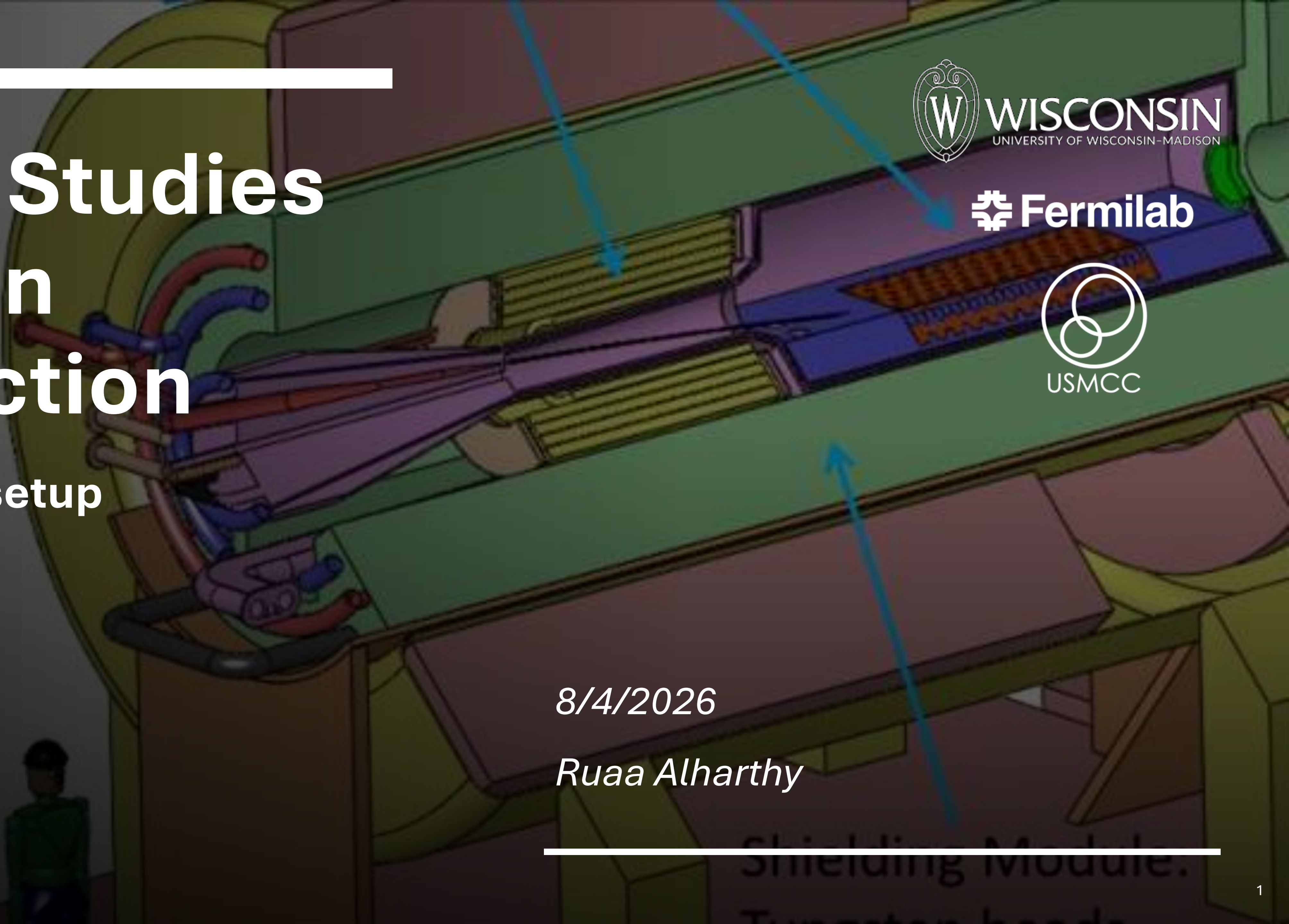
# Target Studies for Pion Production

## Simulation setup




8/4/2026

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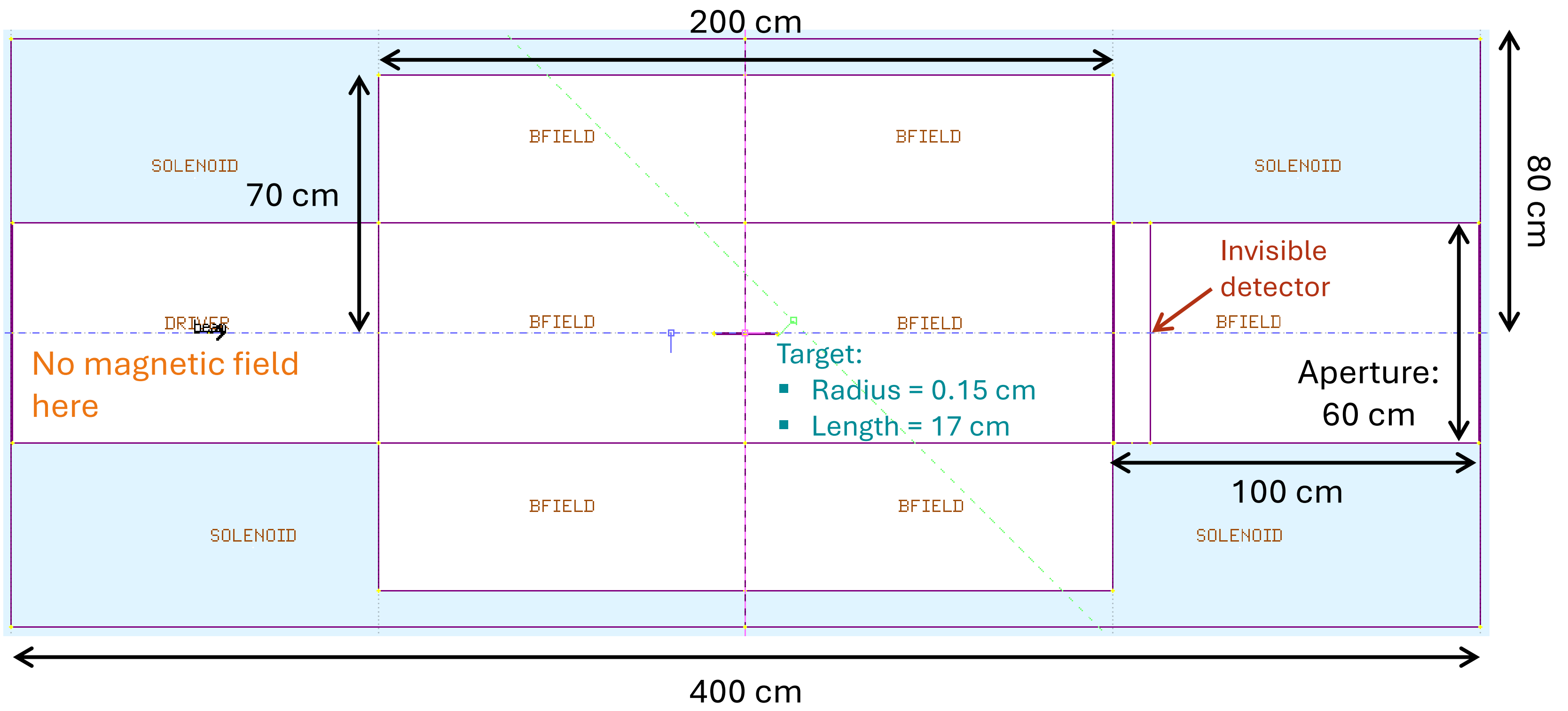
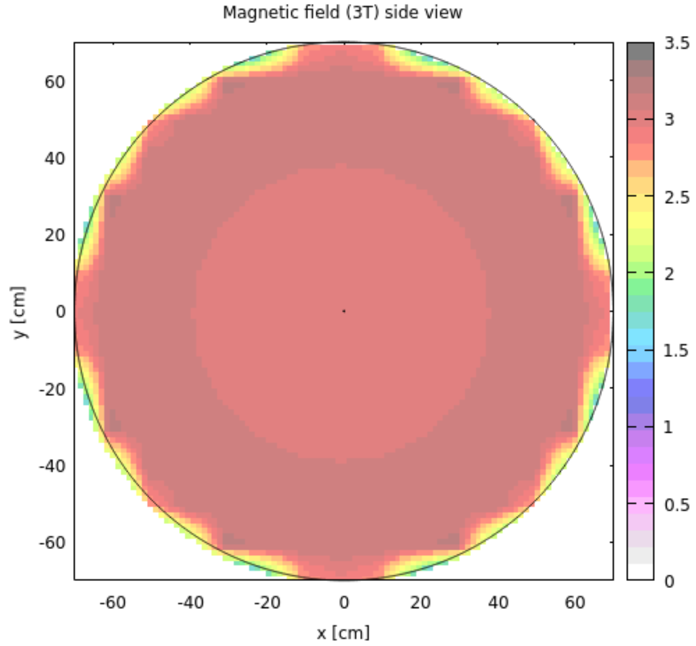
# Geometry Setup

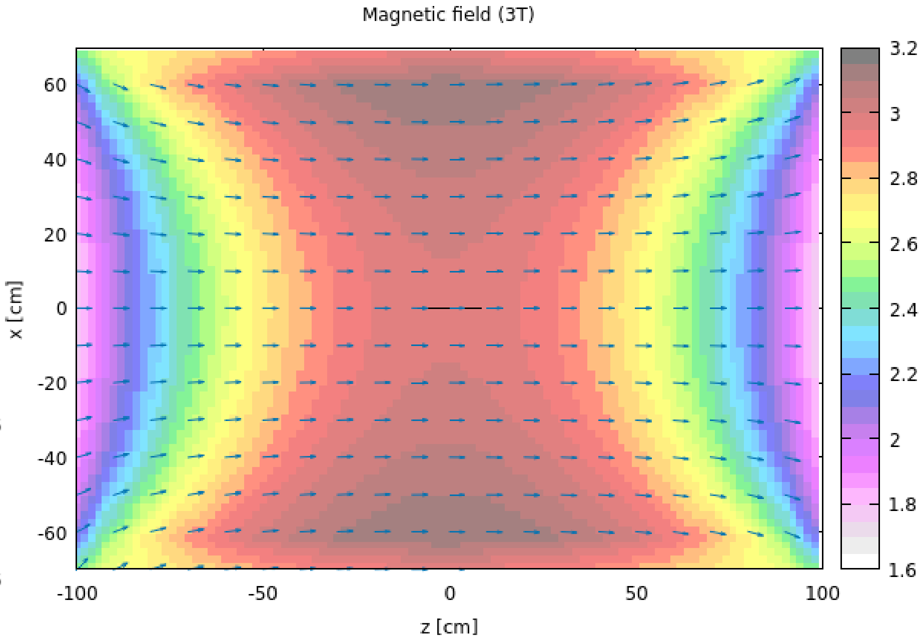
- The solenoid is 2m wide and has a radius of 70cm.
- The target is located at the center of the solenoid.
- For now, I chose the transport system to have an aperture that is 60cm wide.
- The driver section does not have magnetic field (to ensure the protons move in a straight line)
- Used 100,000 8GeV protons.

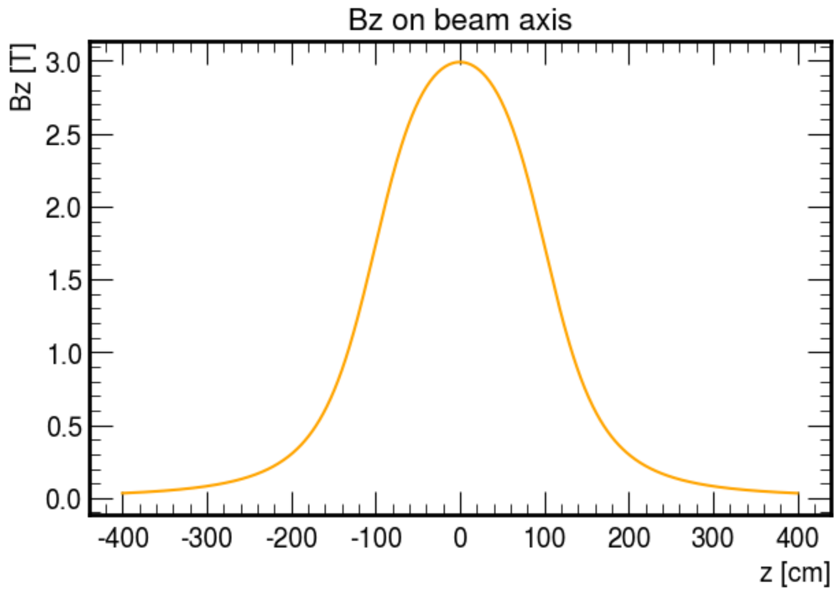


# Magnetic field topology

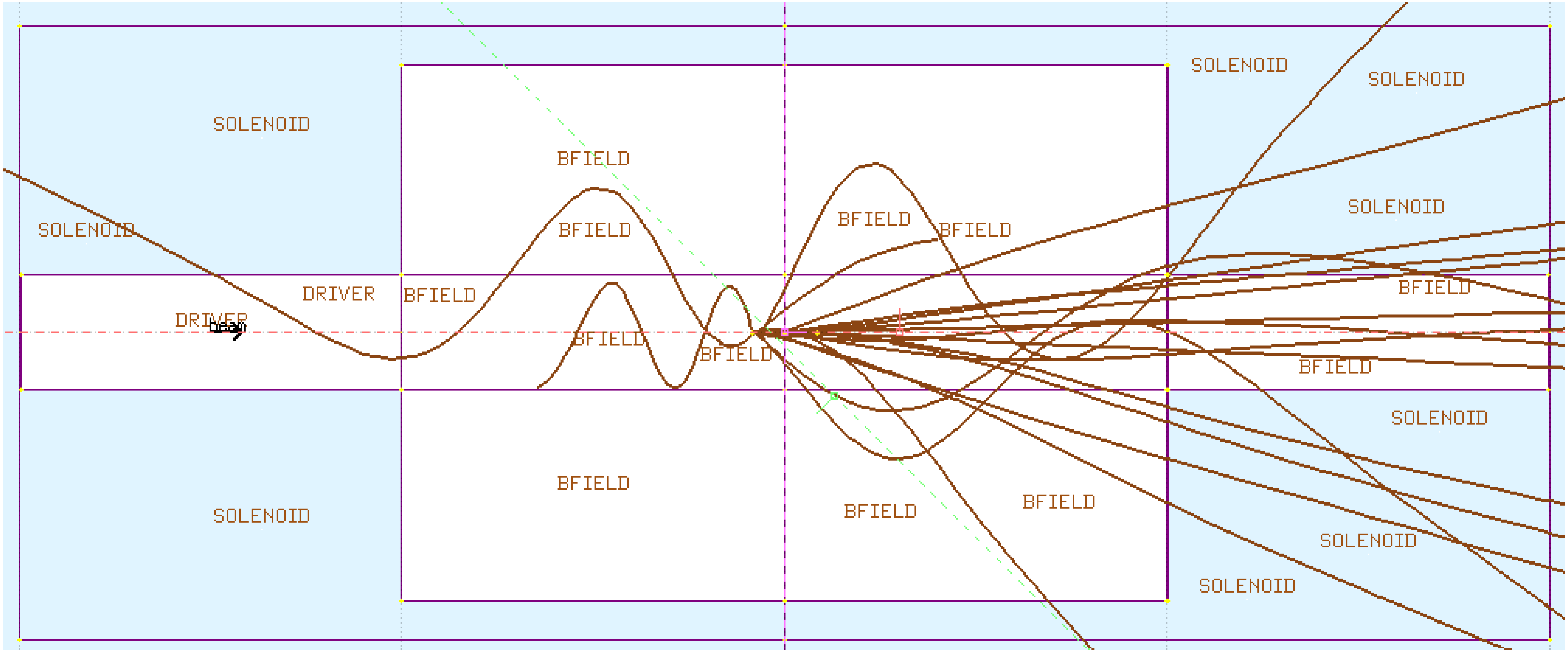
- I created magnetic fieldmaps for 3T – 10T.
- Initially, I am planning to make a simple comparison of the performance of the different magnetic field strengths.
- I also made sure to include fringe fields that span more than 100cm outwards.



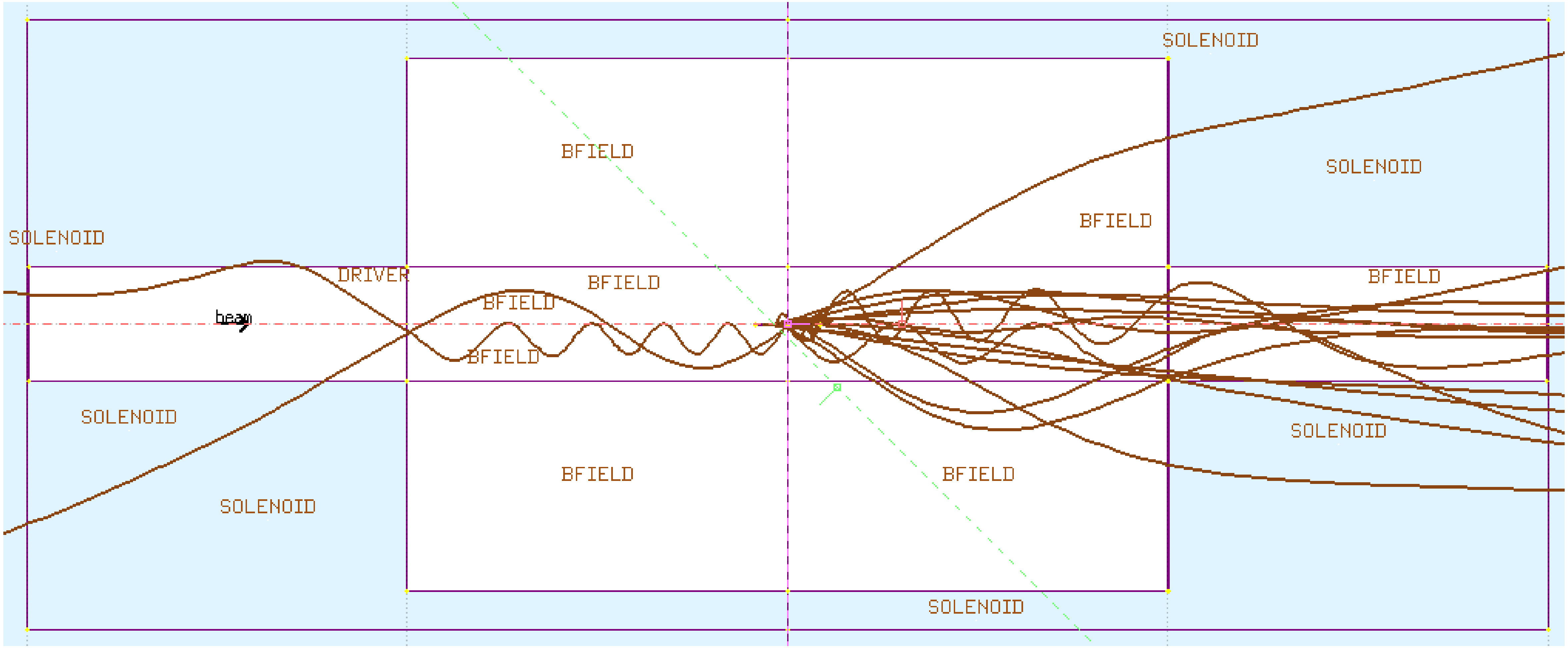



# Here are some tracks – 3T

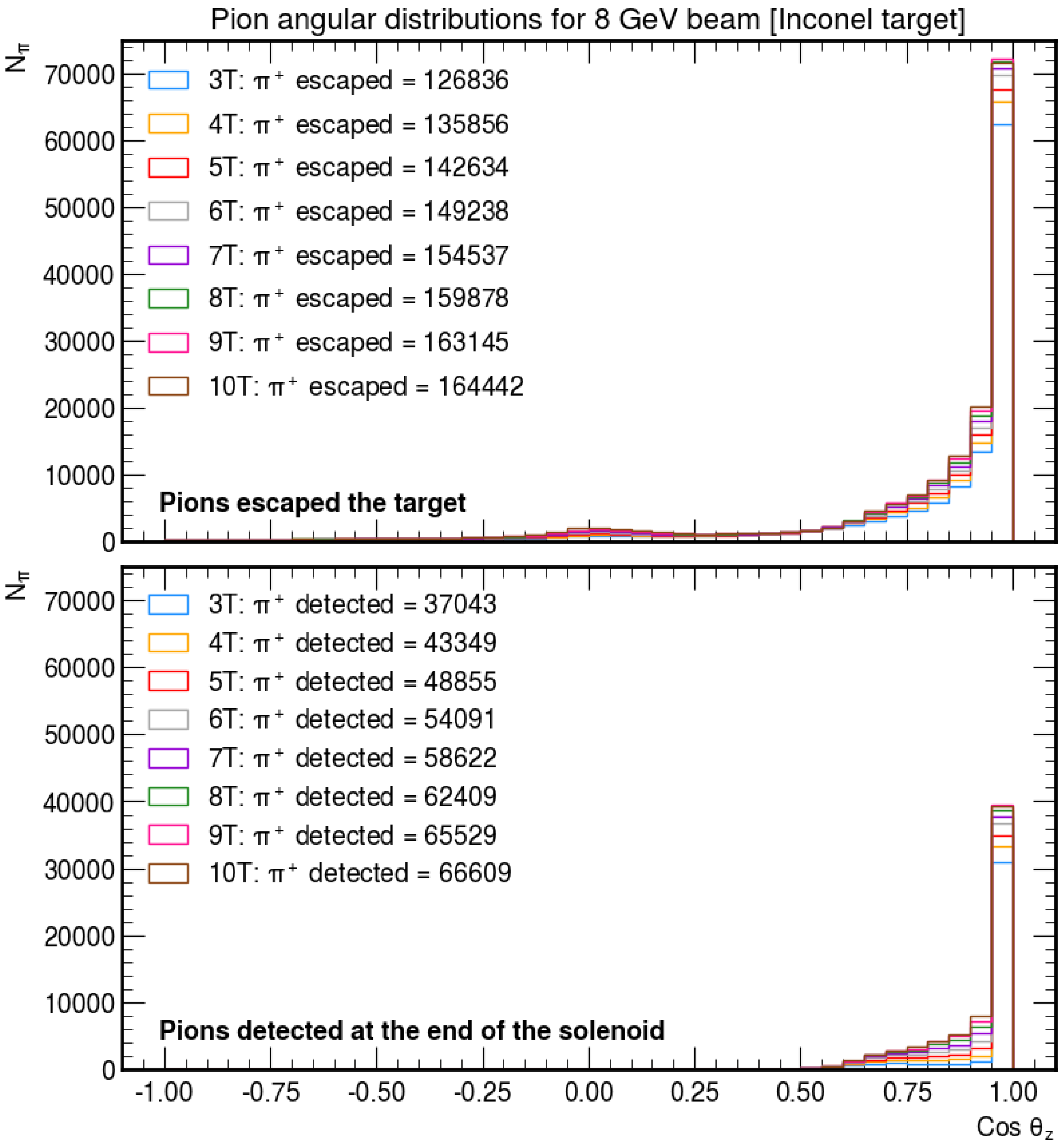


# Here are some tracks – 8T



# Angular distribution

- The following are angular distributions of pions that have escaped the target and those that have been detected by the detector at the end of the solenoid.
- Θz is the angle of the momentum of the particle w.r.t the beam axis.
- Cos Θz = 1 means that the pion's momentum is completely along the beam axis.
- Cos Θz = 0 means that the pion's momentum is perpendicular to the beam axis.
- So, for an aperture of 60cm, we can capture pions that have Cos Θz > 0.5 .



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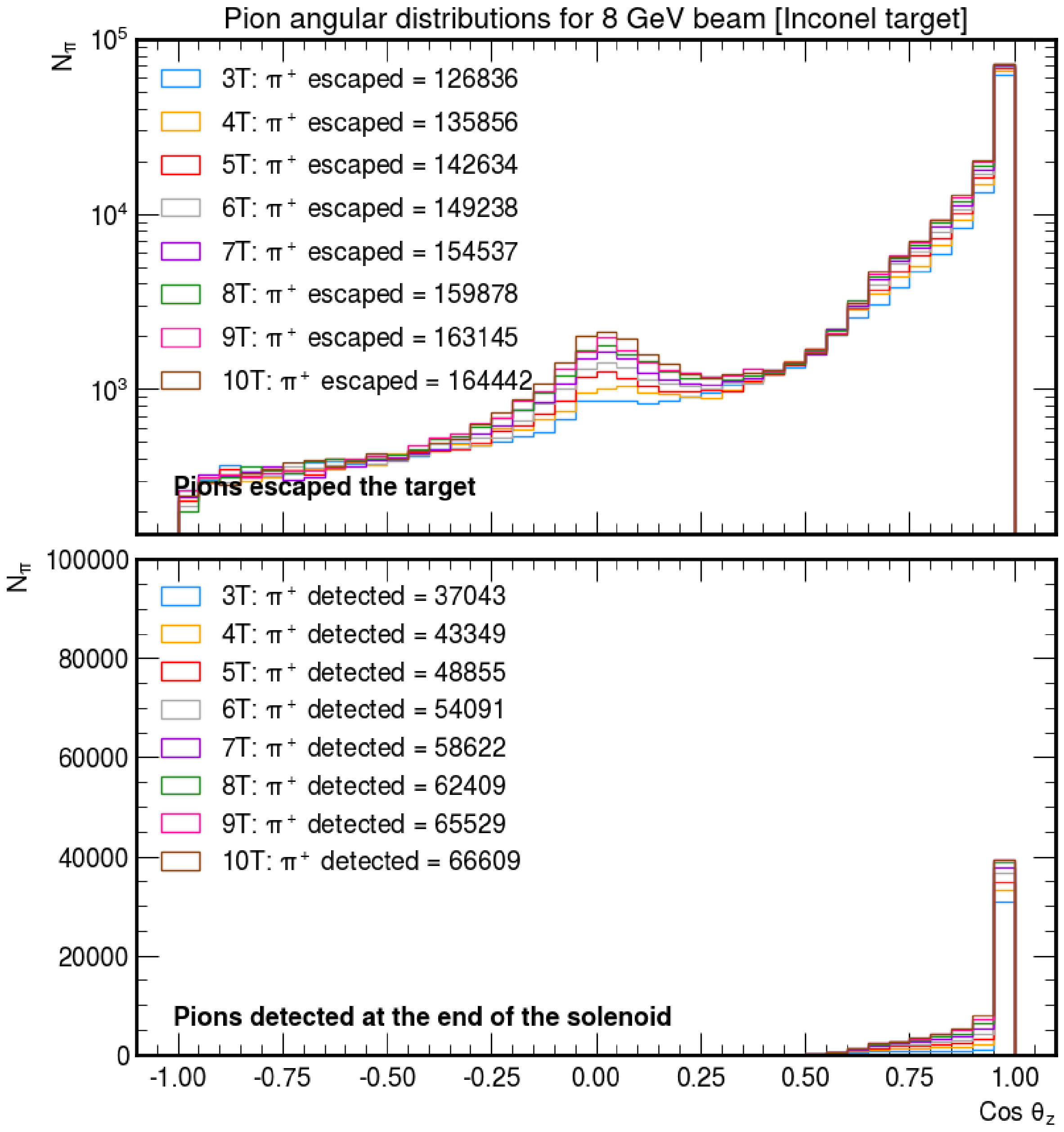
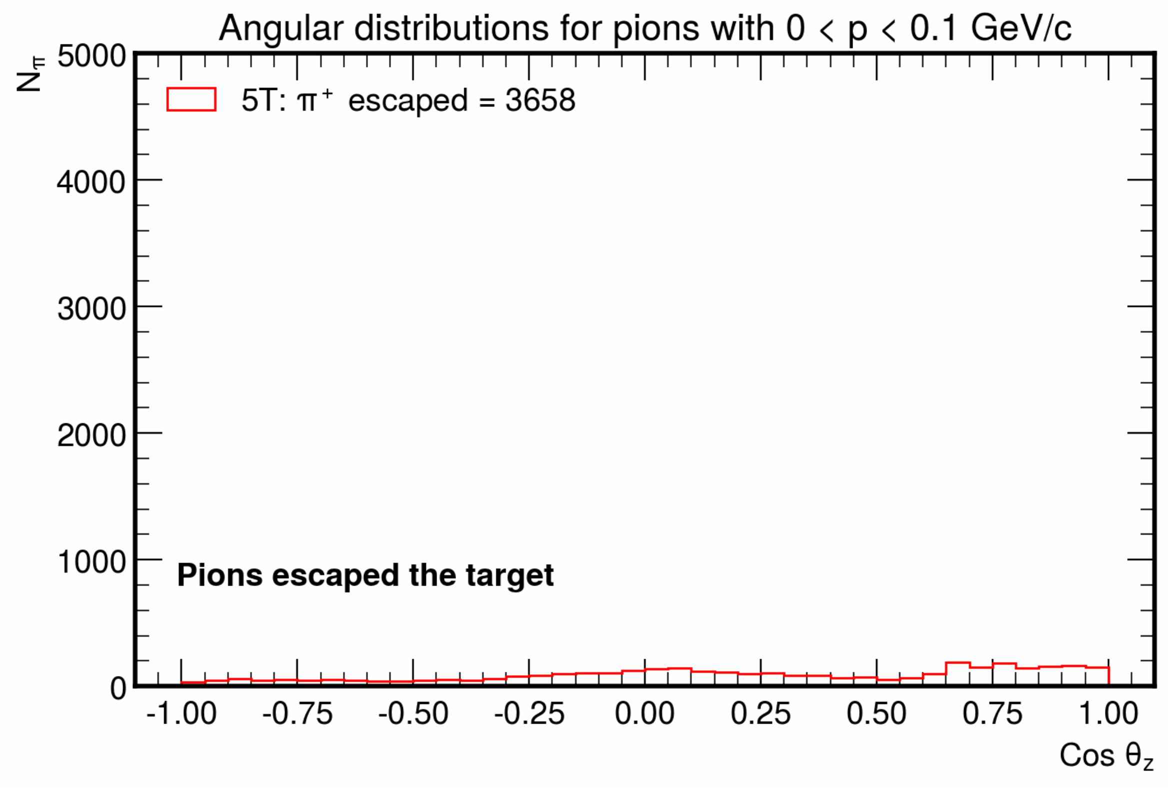
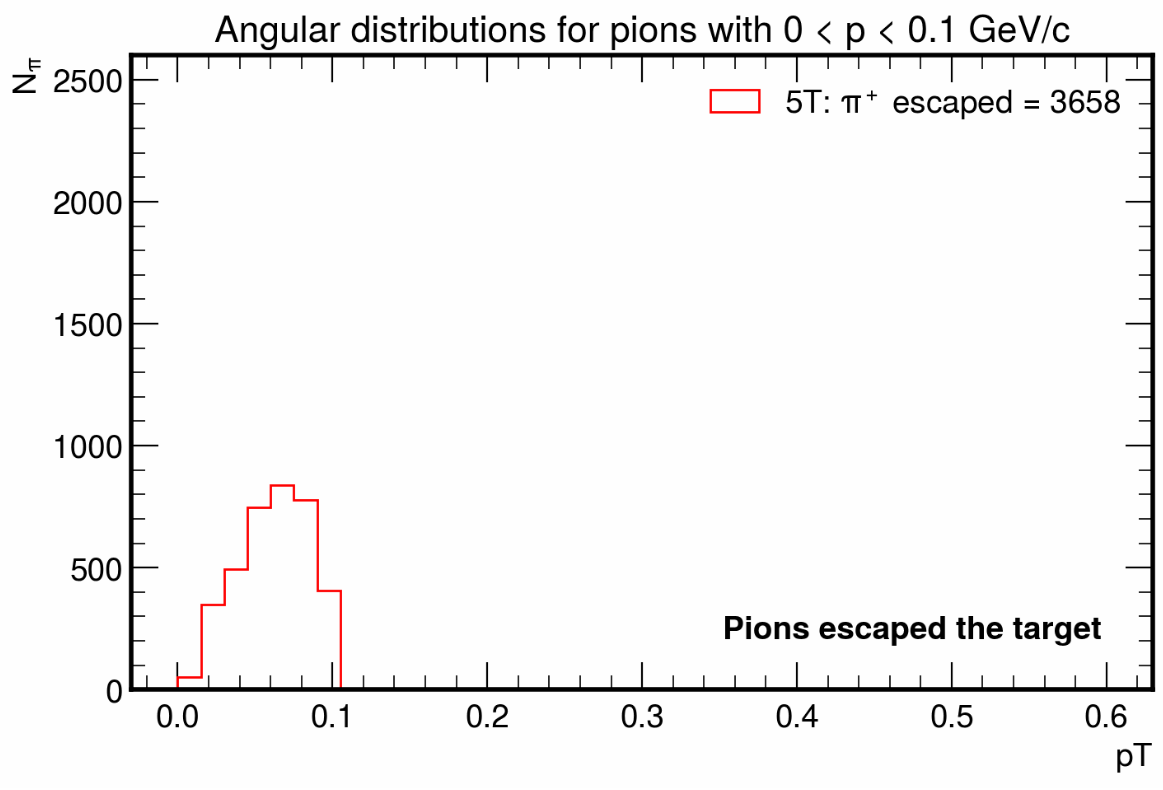
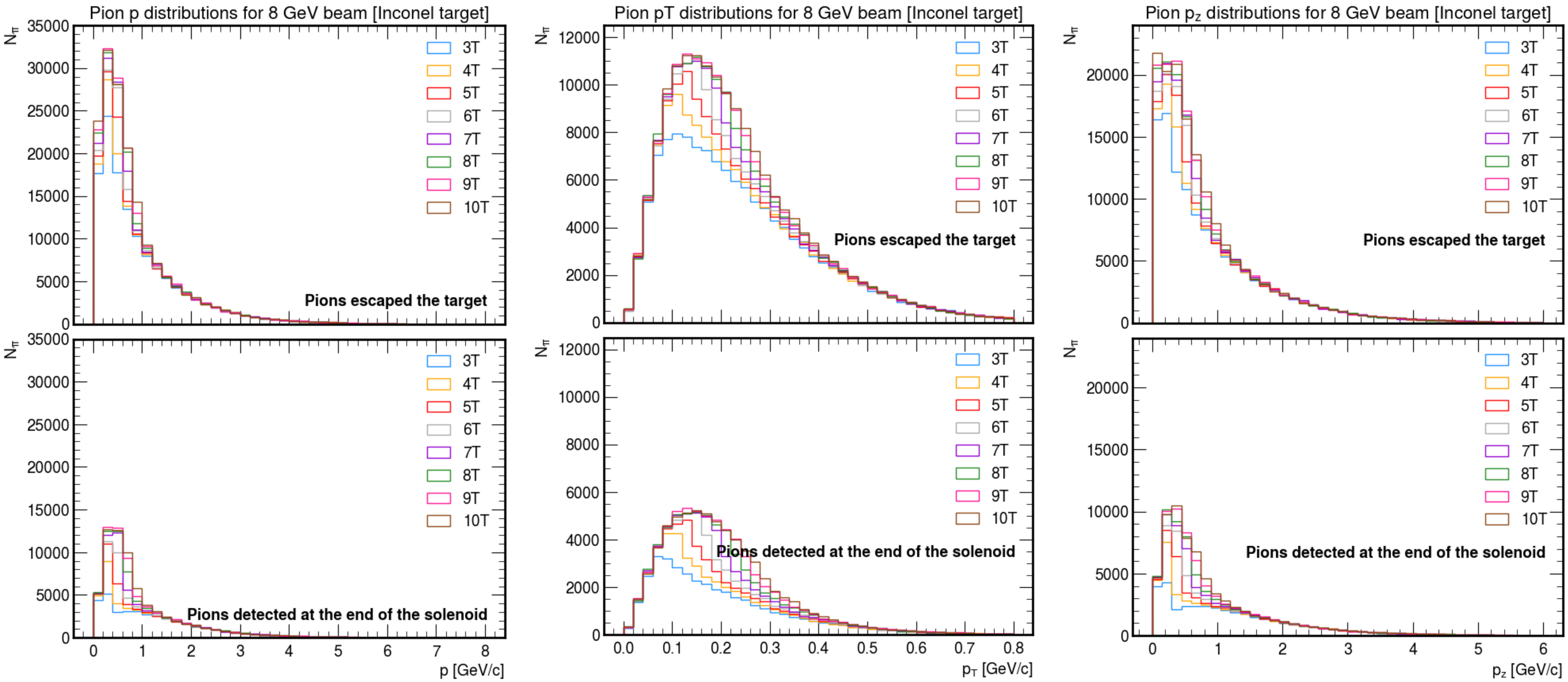


# A look at the pT of pions

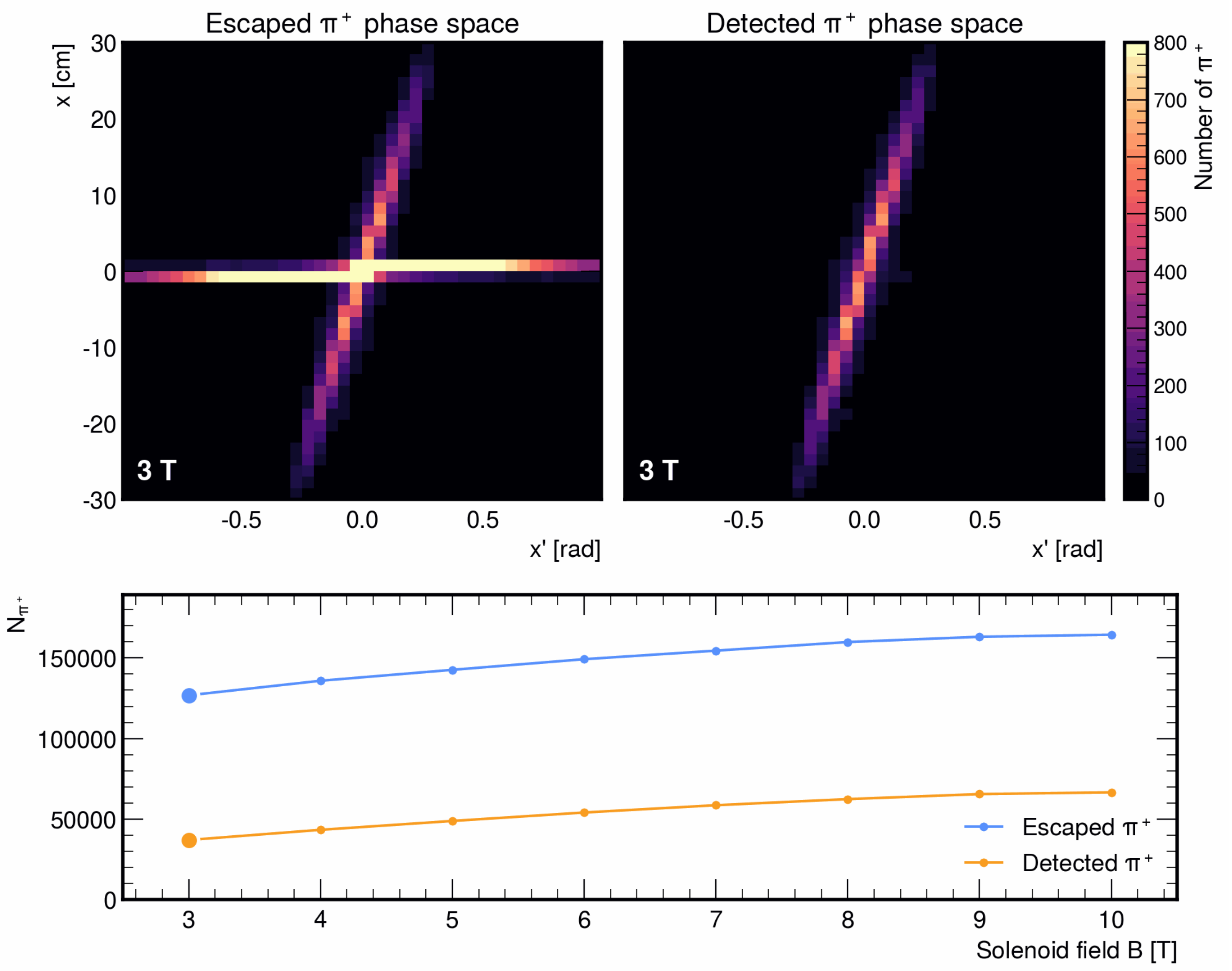


# Momentum distribution

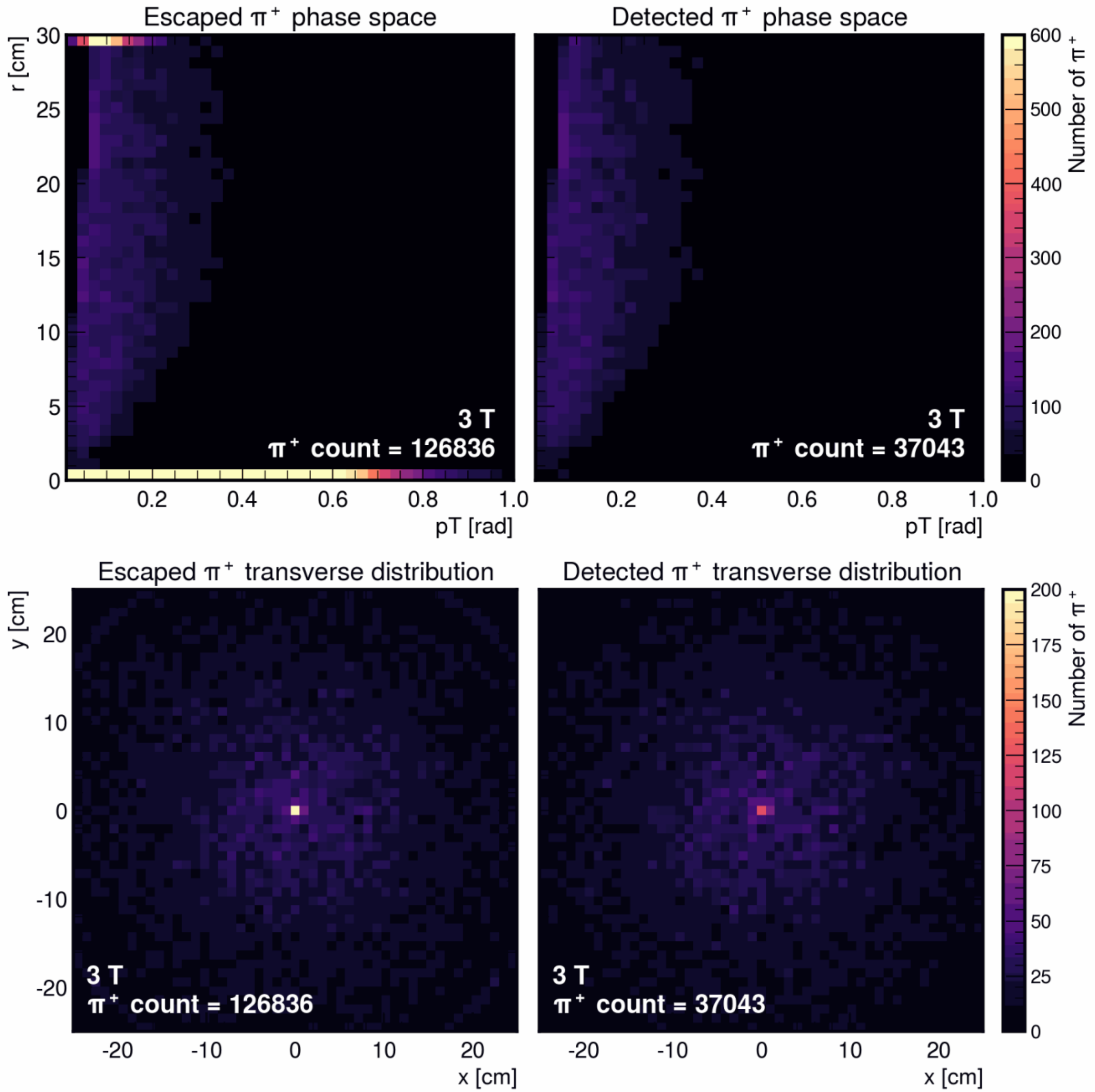


# $\pi^+$ phase space

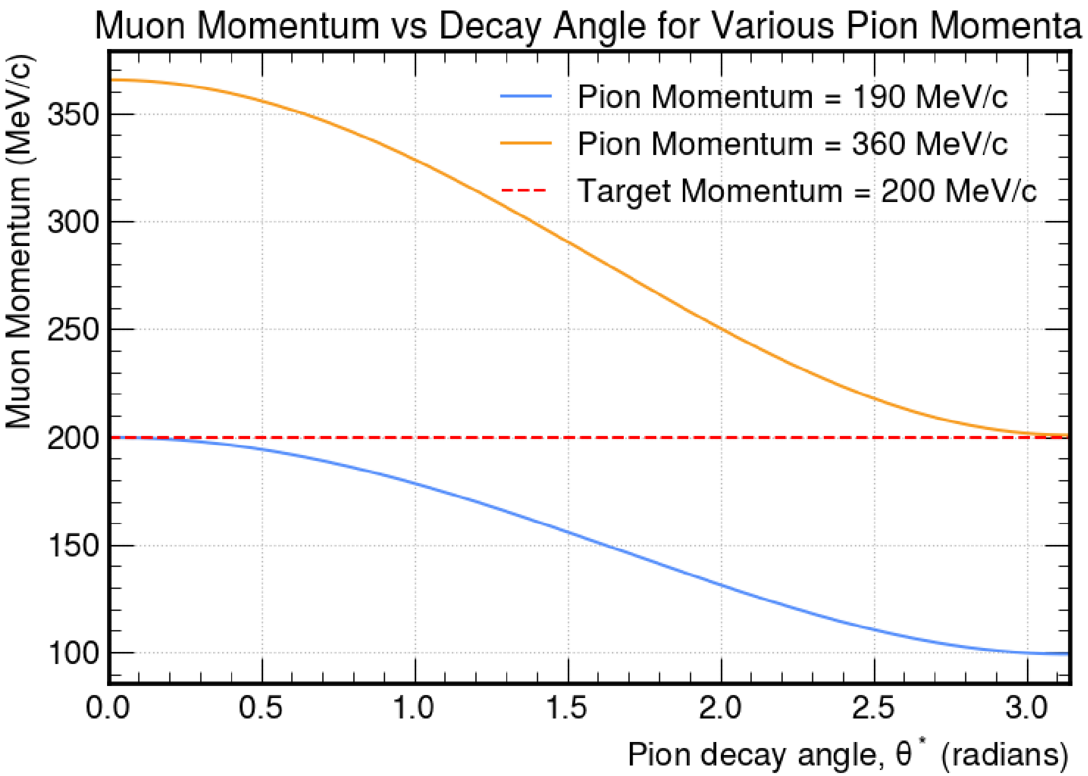


# $\pi^+$ phase space

- The top row shows r vs pT plots for escaped and detected pi+.
- The r vs pT plot suggests that higher pT leads to larger escape radius.
- This result is expected as the pions are in a region of significant magnetic field.
- As the slope of the r vs pT plot increases the the beam tends to occupy a larger transverse area for the same momentum spread.



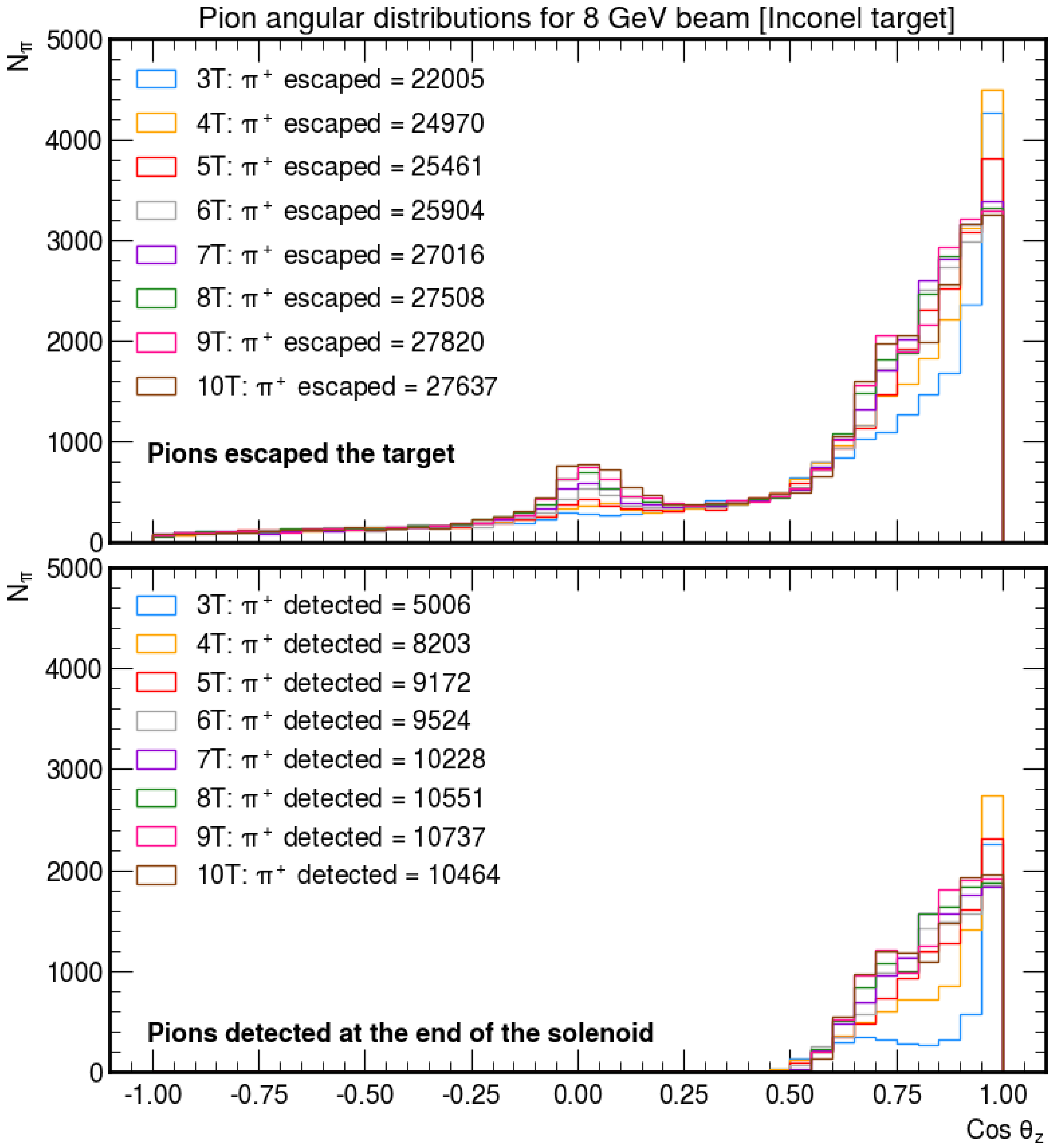
# Pion momentum range (from Katsuya)




- This plot shows the pion momentum range that would produce 200 MeV muons.
- The 190-360 MeV/c momentum interval is used as a first estimate of the pion phase space most relevant for capture.
- In practice, the capture channel has a finite momentum acceptance. Muons with momenta near the design value can also be transported efficiently. Consequently, the relevant pion momentum range is broader than the strict 190–360 MeV/c interval.

# Angular distribution
## (select 0.19 < p < 0.36 GeV/c)

- Here I applied the momentum selection of 190-360 MeV/c for pions.
- Now we see an interesting shift in the pion angular distribution.
- Pions produced in 3T, 4T, and 5T solenoid tend to have higher Cos Θz values than those produced in stronger magnetic fields.



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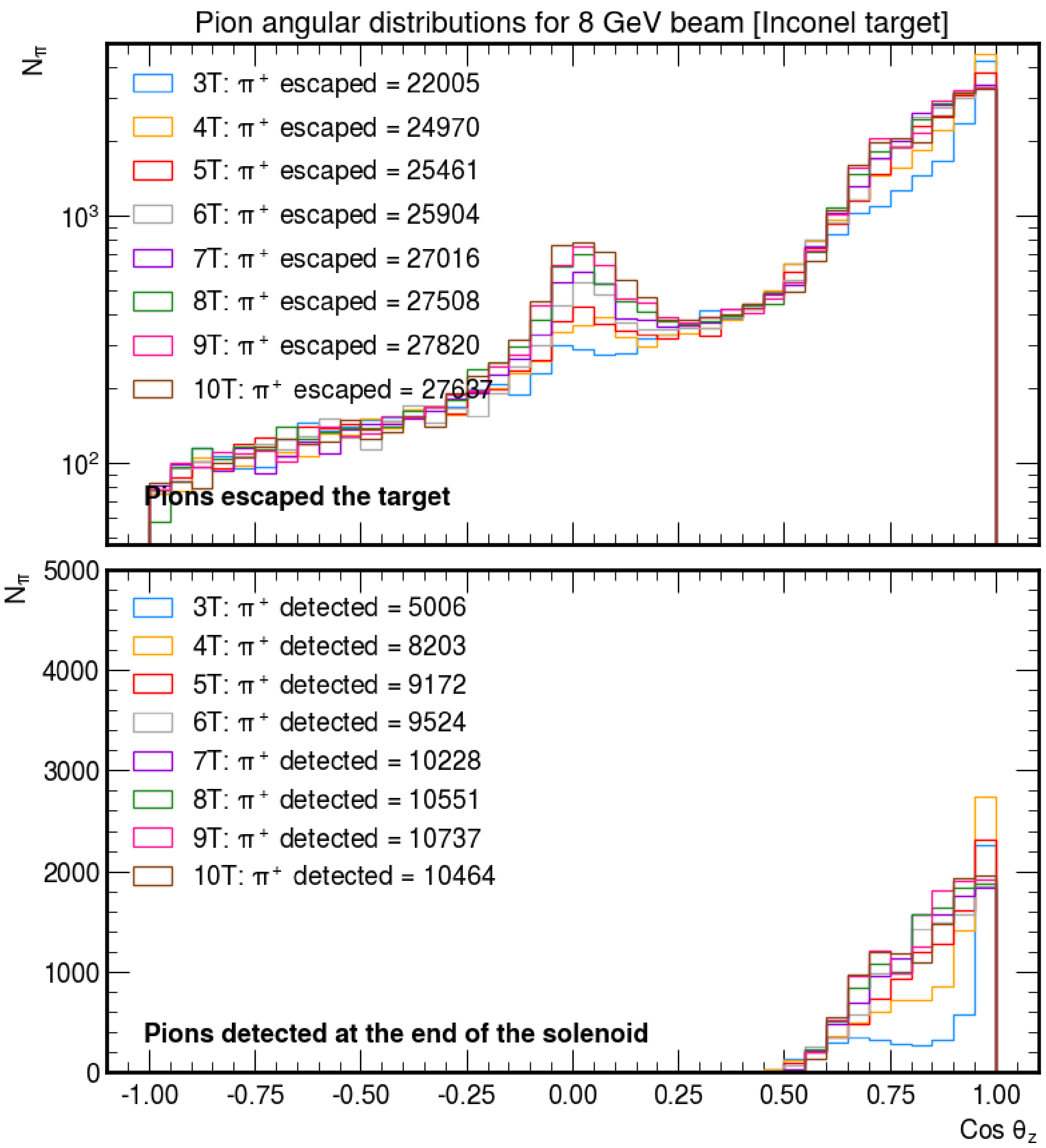

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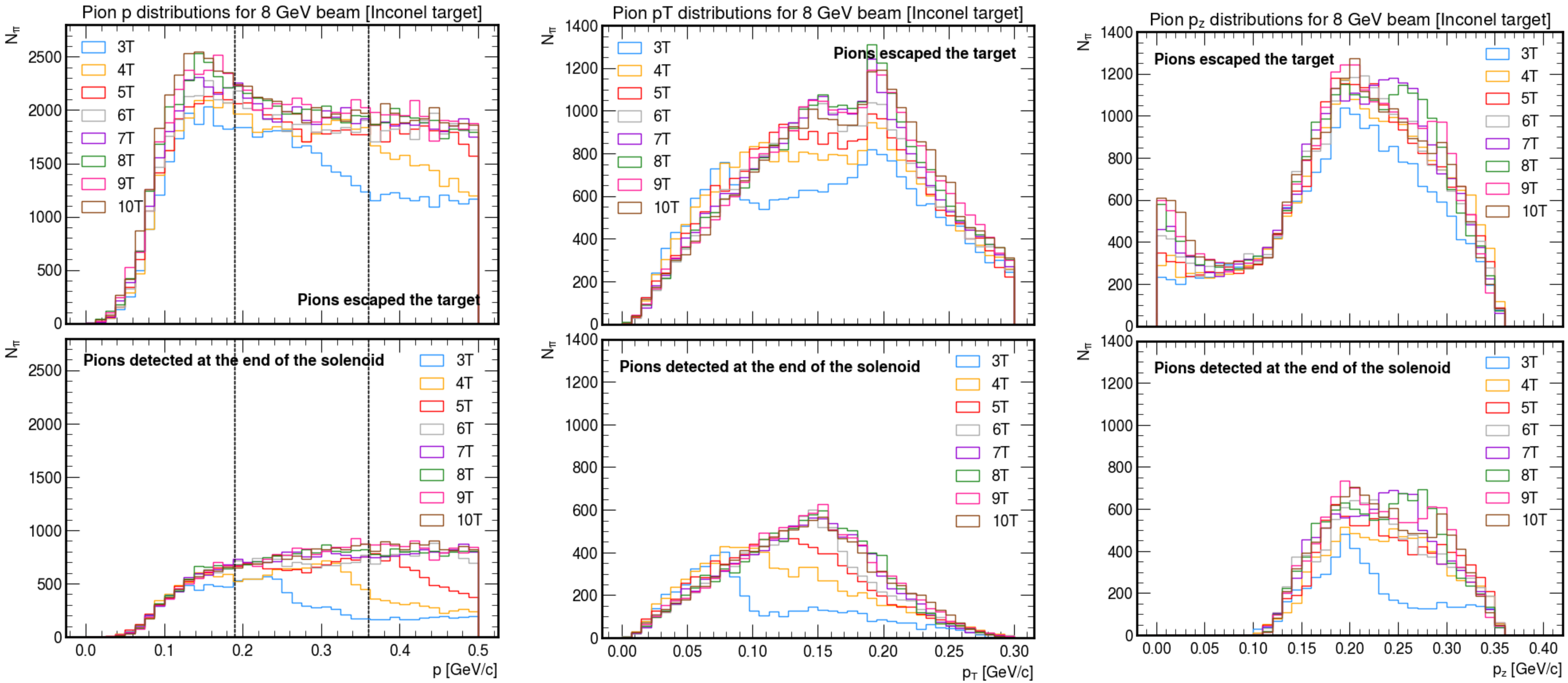

# $\pi^+$ phase space

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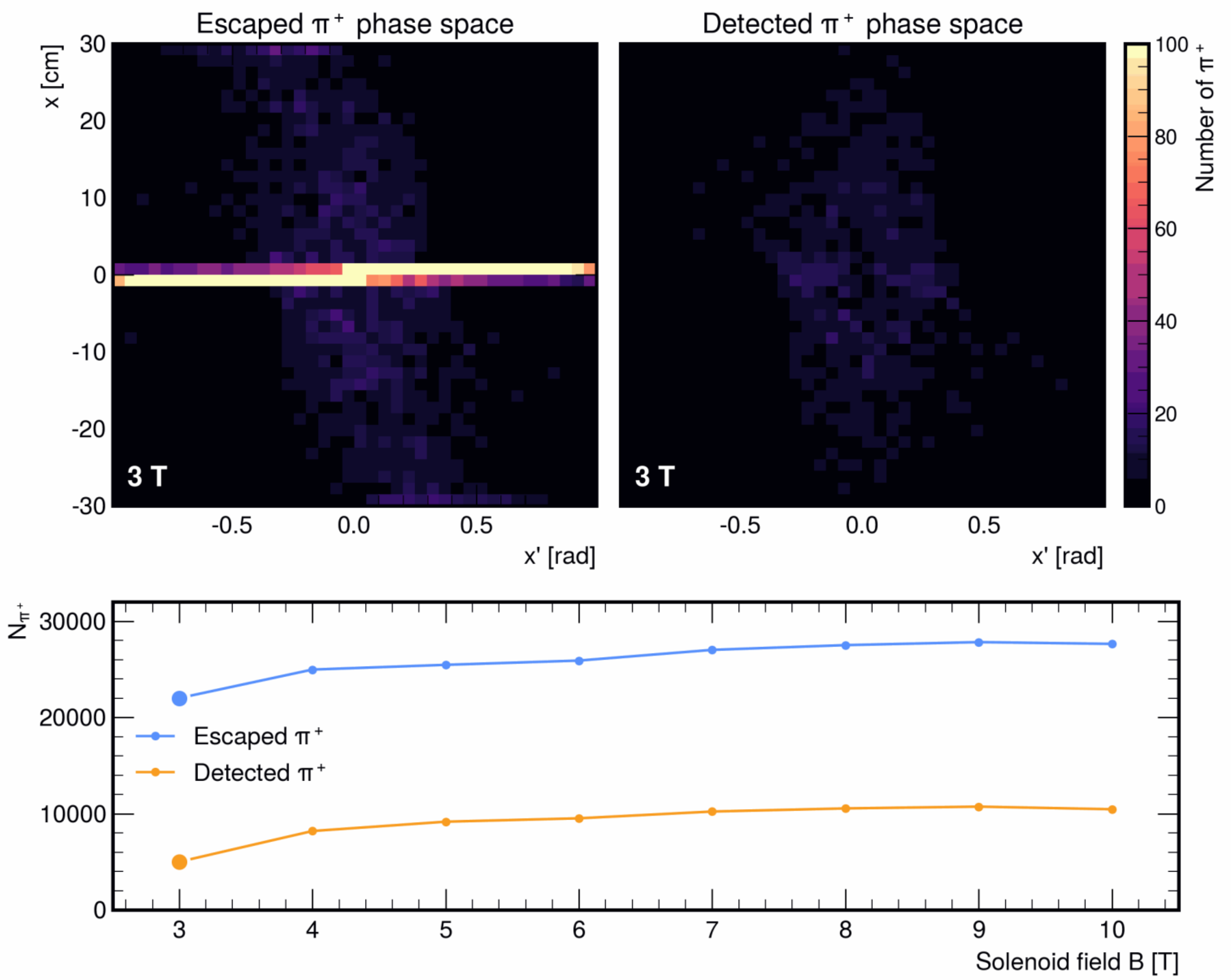
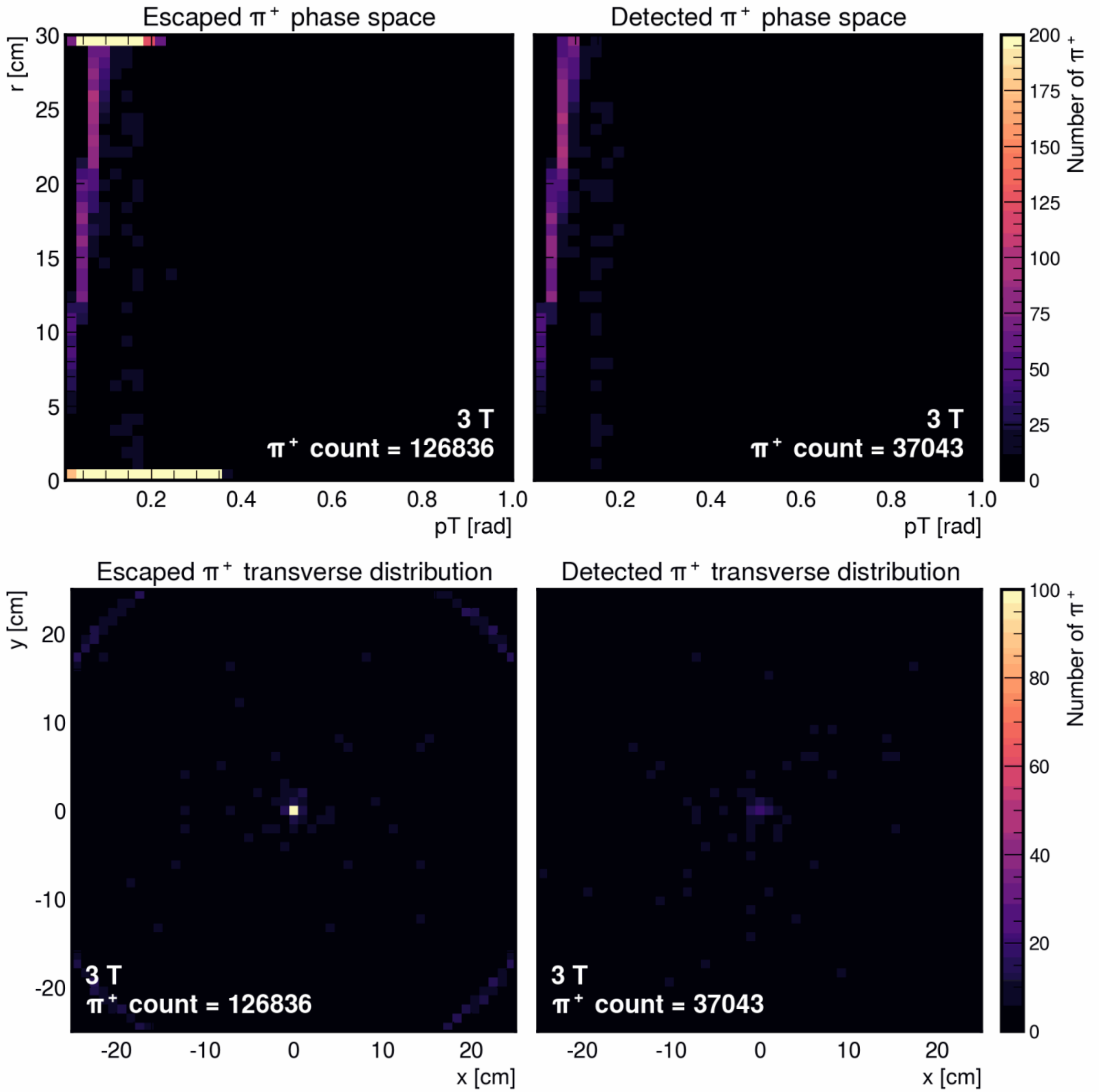


# $\pi^+$ phase space

- The cloudiness that we start to see with correlation in the r vs pT plot is due to the the transport mixing the phase space.
    - From ChatGPT



# Next steps

→Simulate pion production for 0T ~ no B-field

→Simulate 0.8 GeV pions to study pion pT in low energy regime.

→Maybe try to find a way to track particles (won’t spend so much time on this)

→I am also working on a way to create a source pion beam file to be used for G4bl simulations → working towards a full pion/muon tracking in G4bl.