Simulation of Super Charm-Tau Inner Tracker, choice of options

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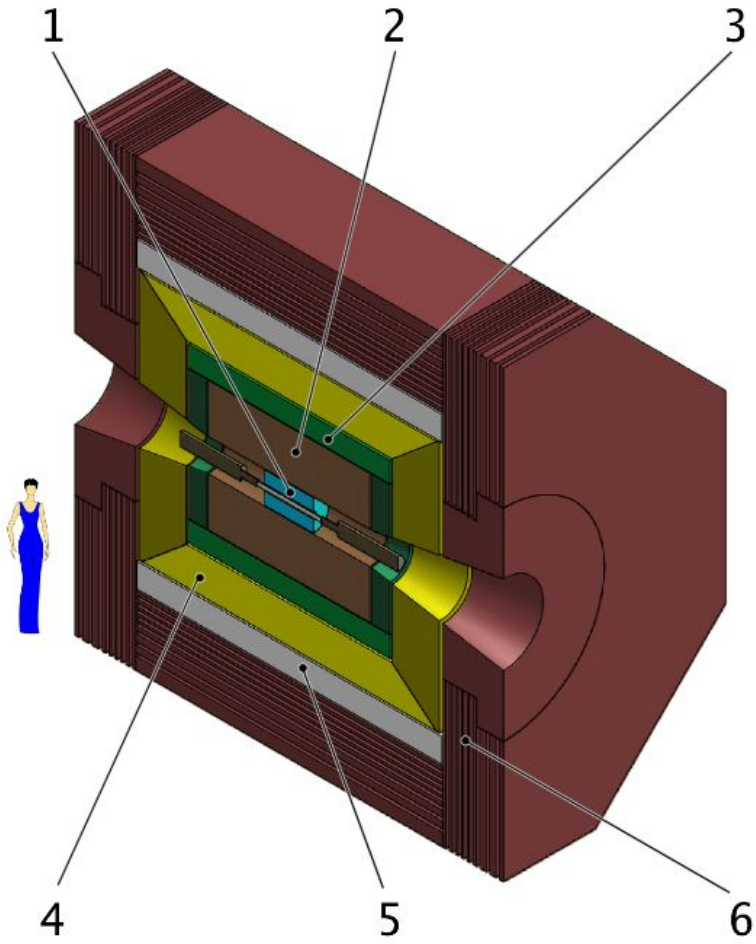
Detector for Super Charm-Tau Factory

Tasks

- Rare decays
  - τ lepton
  - D mesons
  - D^0 — anti-D^0 oscillations
- Search for τ→μγ

Collider parameters

- Luminosity 10^{35} cm^{-2} s^{-1}
- Energy range 2 — 7 GeV



1 Inner Tracker
2 Drift chamber
3 FARICH identification system
4 Calorimeter on pure CsI
5 Superconducting coil
6 Yoke with a muon system

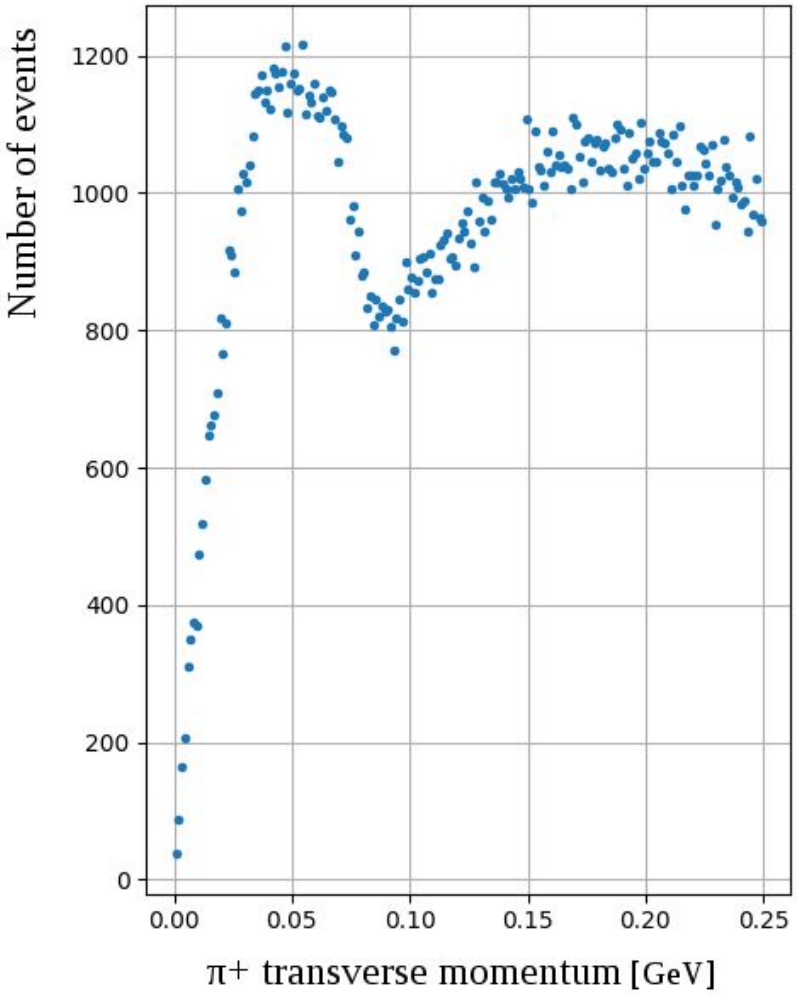
Inner Tracker (IT)

Tasks

- Detect secondary vertices from the decays of short-lived particles such as K^0_S or Λ
- Complement the drift chamber in measuring the momenta
- Soft $\pi^{\pm}$ mesons registration (with momenta < 100 MeV/c)

Requirements

- Handle with high particle flux - luminosity of 10^{35} cm^{-2} s^{-1}



Soft hadrons registration is required

Simulation of π^+ transverse momentum distribution in $e^+e^- \rightarrow DD^*$ (V. Vorobyev)

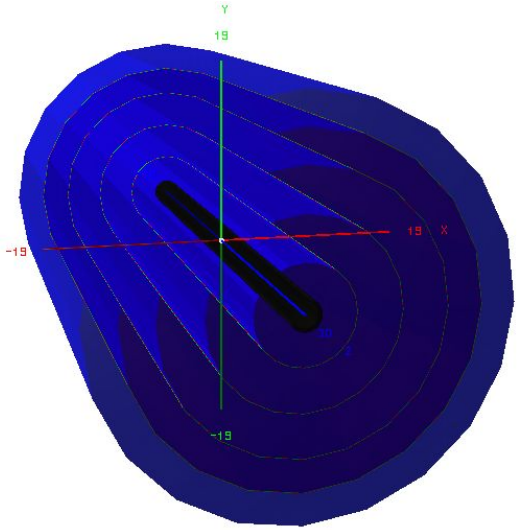
Inner Tracker

- Located between vacuum chamber and drift chamber
- Detection solid angle up to 98%
- Cylinder
  - Length 60 cm
  - Inner diameter 3 cm
  - Outer diameter 40 cm

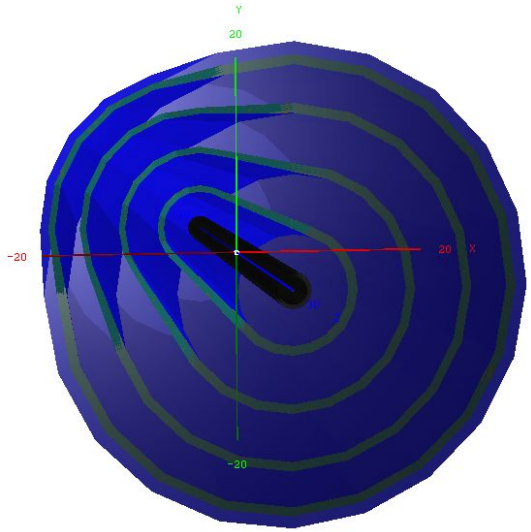
Simulation in DD4hep
dd4hep.web.cern.ch

Options

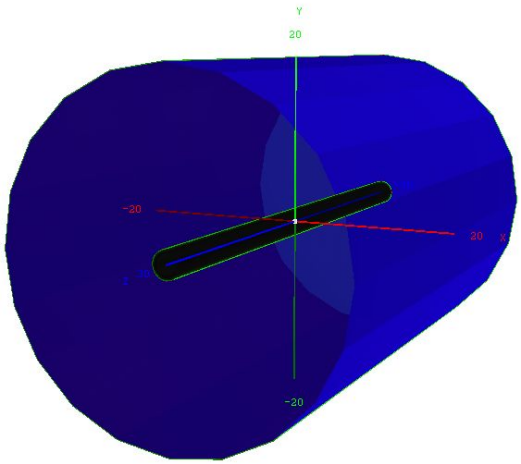
- Cylindrical silicon strip 4-layer detector (Si-strips)
- Cylindrical GEM (Gas Electron Multiplier) (CGEM) 4-layer detector
- Time Projection Chamber (TPC)



Si-strips



CGEM



TPC

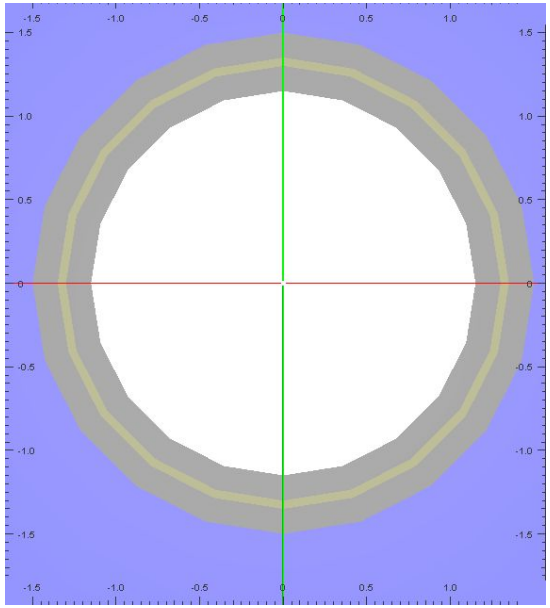
Inner Tracker

Options

- Cylindrical silicon strip 4-layer detector (Si-strips)
- Cylindrical GEM (Gas Electron Multiplier) (CGEM) 4-layer detector
- Time Projection Chamber (TPC)

option/subsystem	Materials	Thickness (X0)
Vacuum Pipe	3 mm Be + 0.5 mm paraffin	1%
TPC	2x(1mm glass fiber (G10) + 0.1 mm teflon +15 μm copper)	1%
CGEM	4x(0.25 mm kapton + 40 μm copper)	1.2%
Si-strips	4x(0.32 mm Si + 0.4 mm carbon fiber)	2.4%

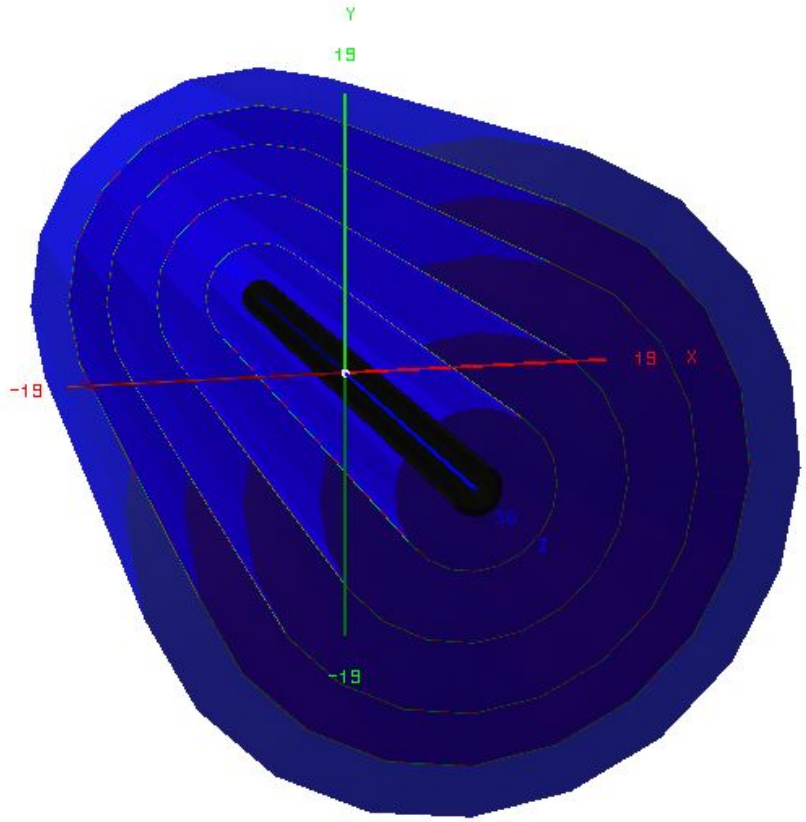
Vacuum pipe

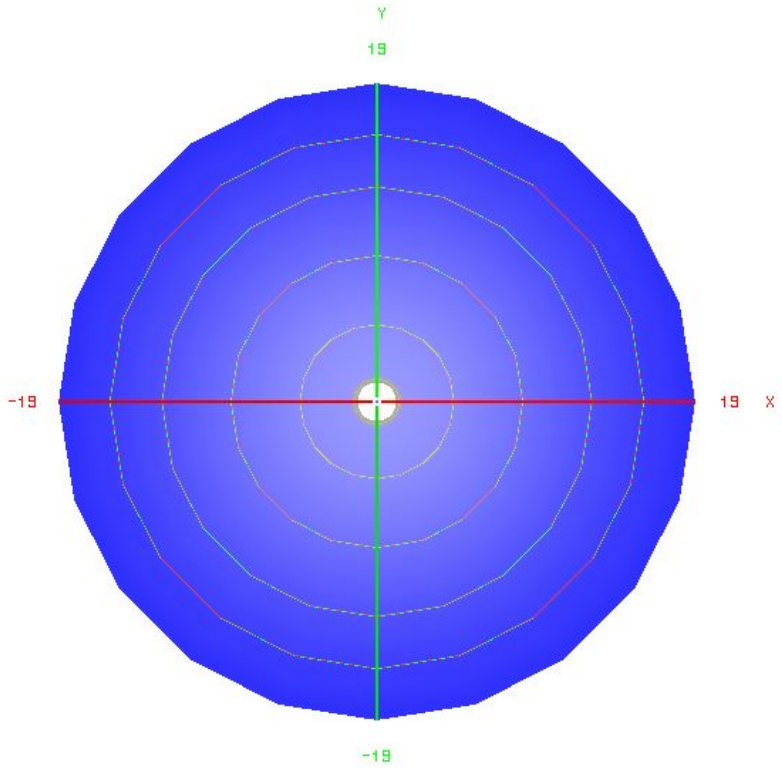


Inner Tracker

Si-strips

- 4 layers of 0.32 mm Si + 0.4 mm carbon fiber
- Gas - air
- Magnetic field 1.5 T
- Air is also outside the Inner Tracker (in all simulations)
- Pions with different momenta were gun perpendicular to beam axis

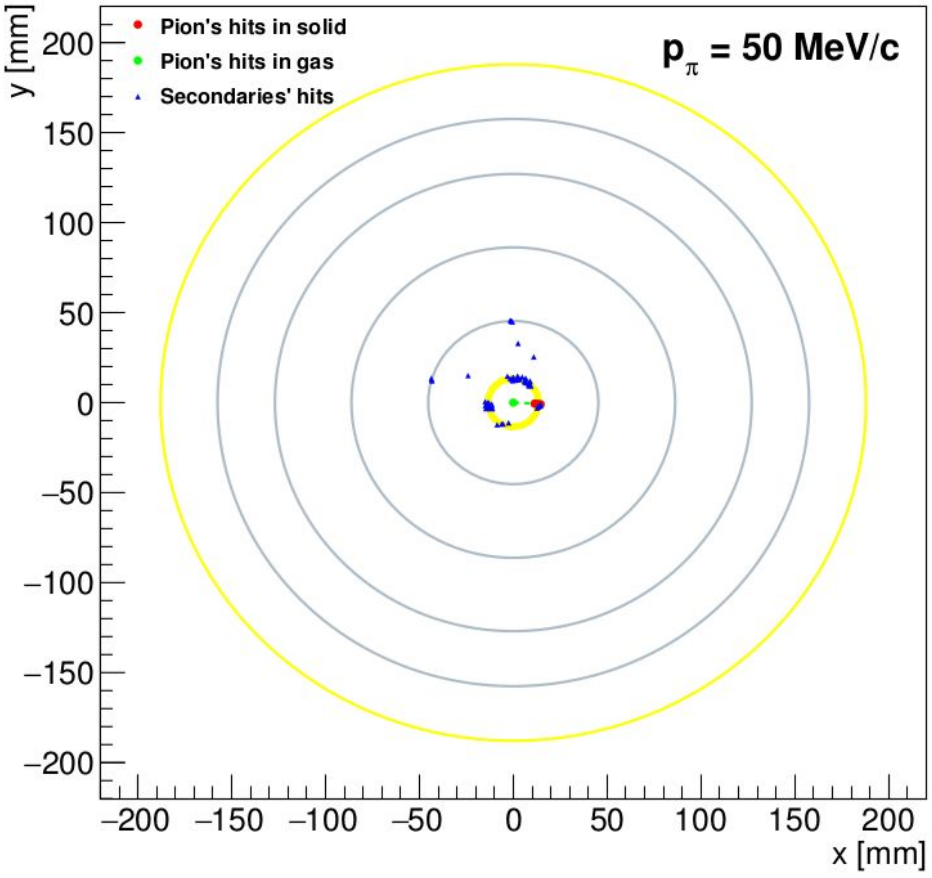


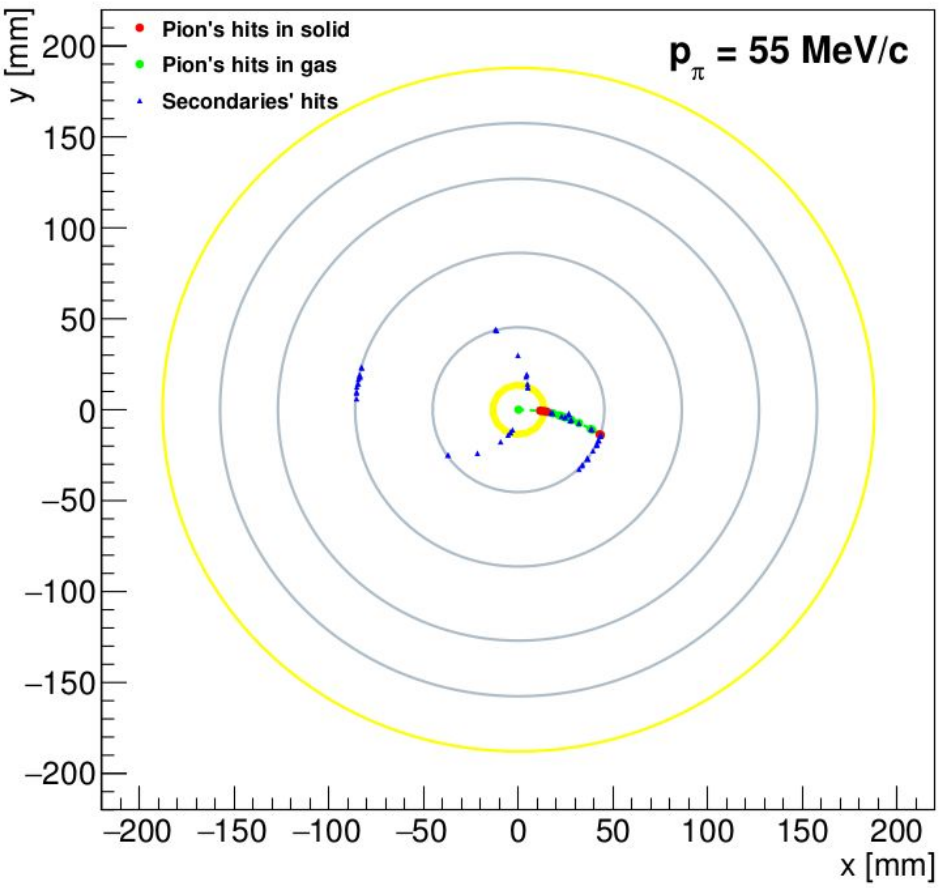


Inner Tracker

DD4hep simulation

Si-strips



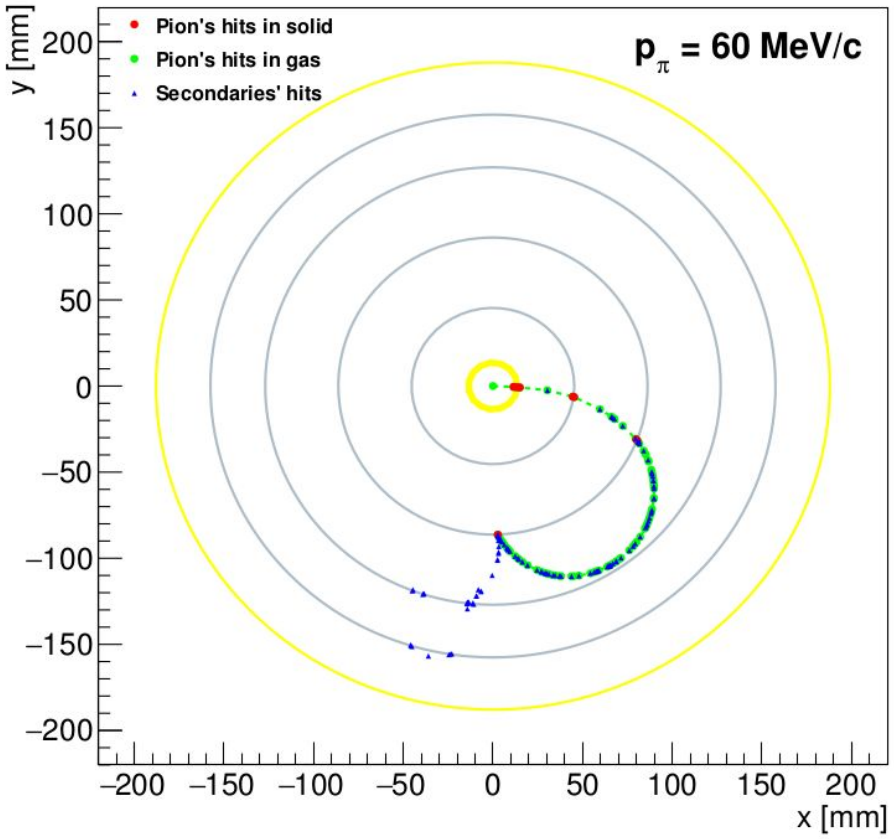


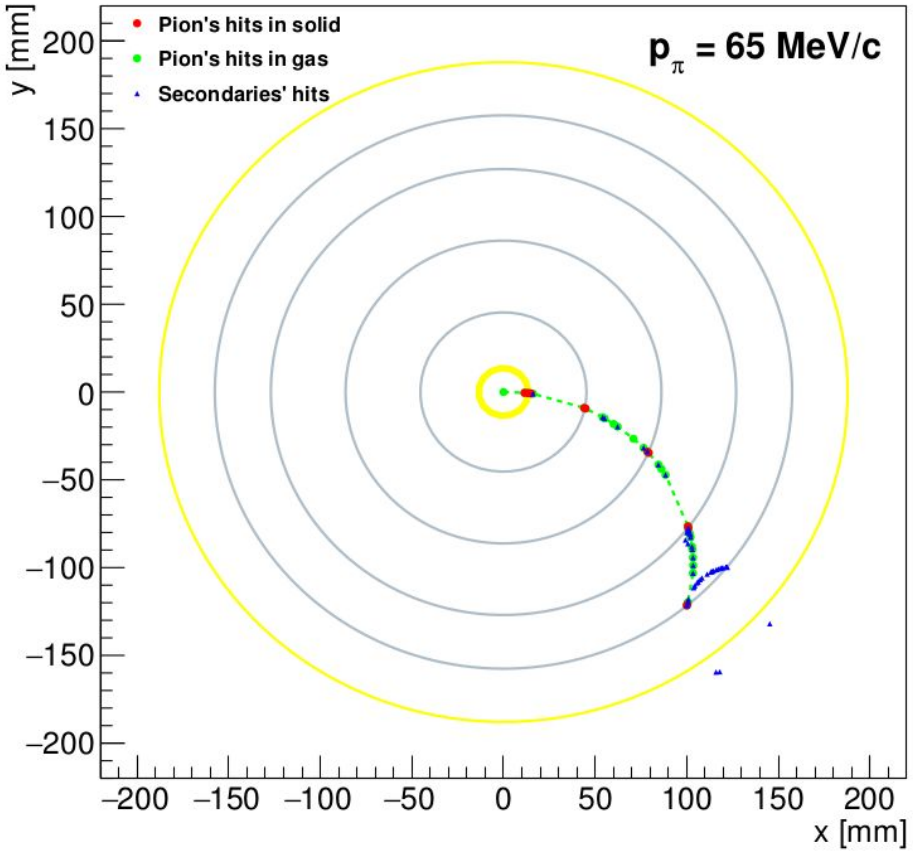
- Pions with momenta less than 50 MeV/c do not pass through the beampipe
- Starting from p_π = 55 MeV/c the first layer is reached by pions

Inner Tracker

DD4hep simulation

Si-strips



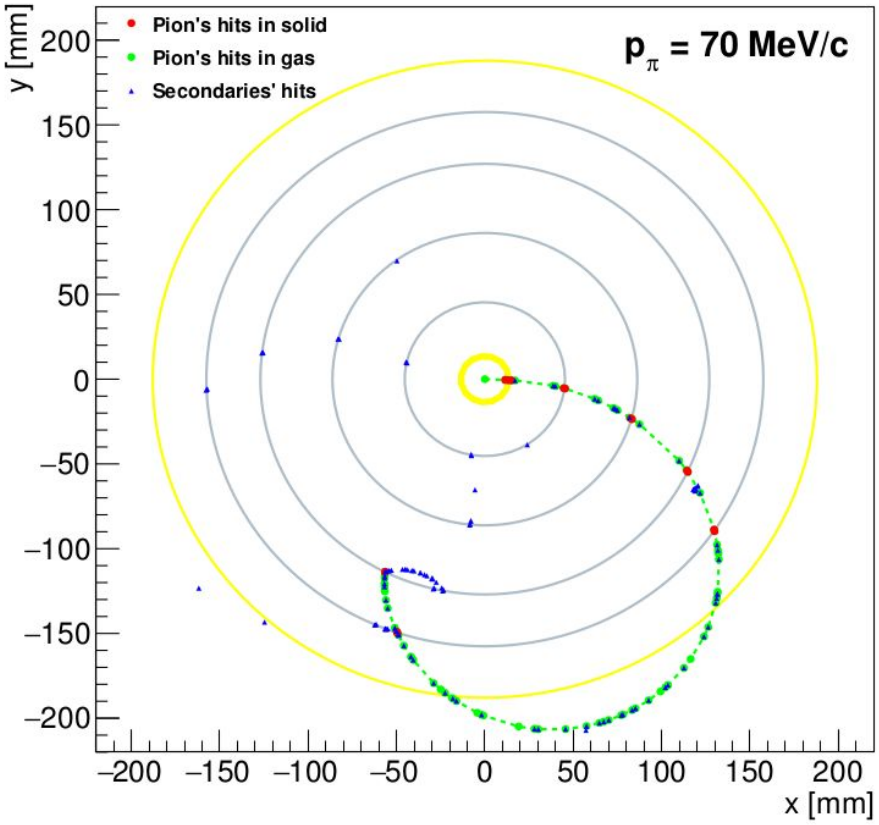


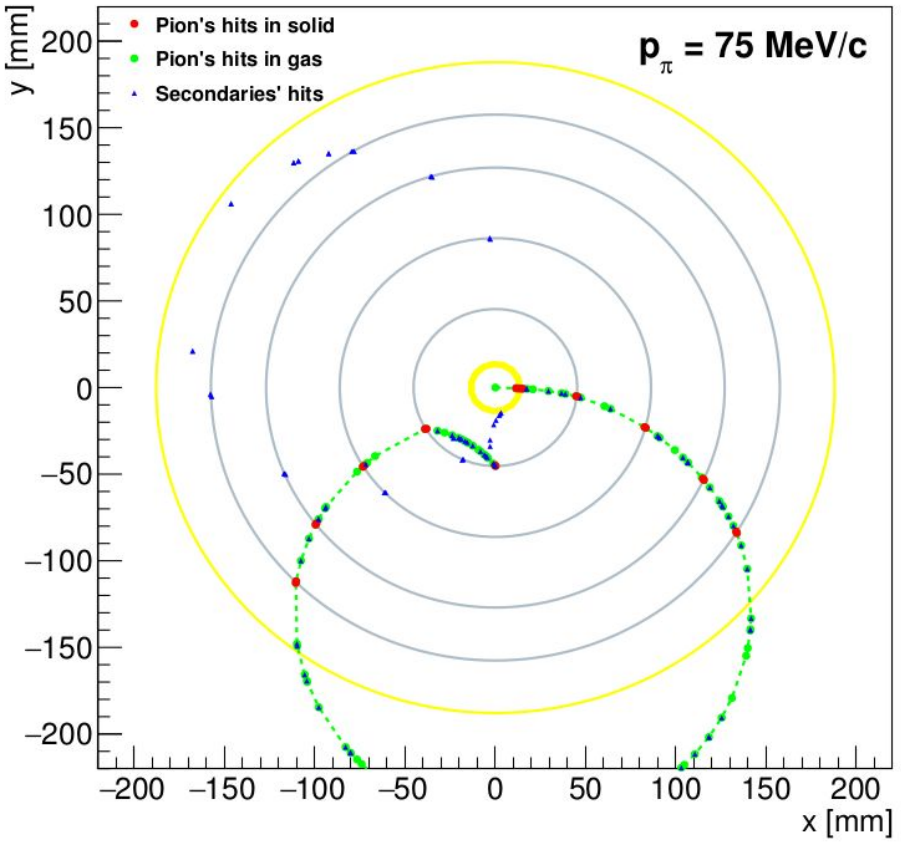
- Pions with momenta 60 MeV/c pass through two layers
- Starting from p_π = 65 MeV/c the all 4 layers are reached by pions

Inner Tracker

DD4hep simulation

Si-strips



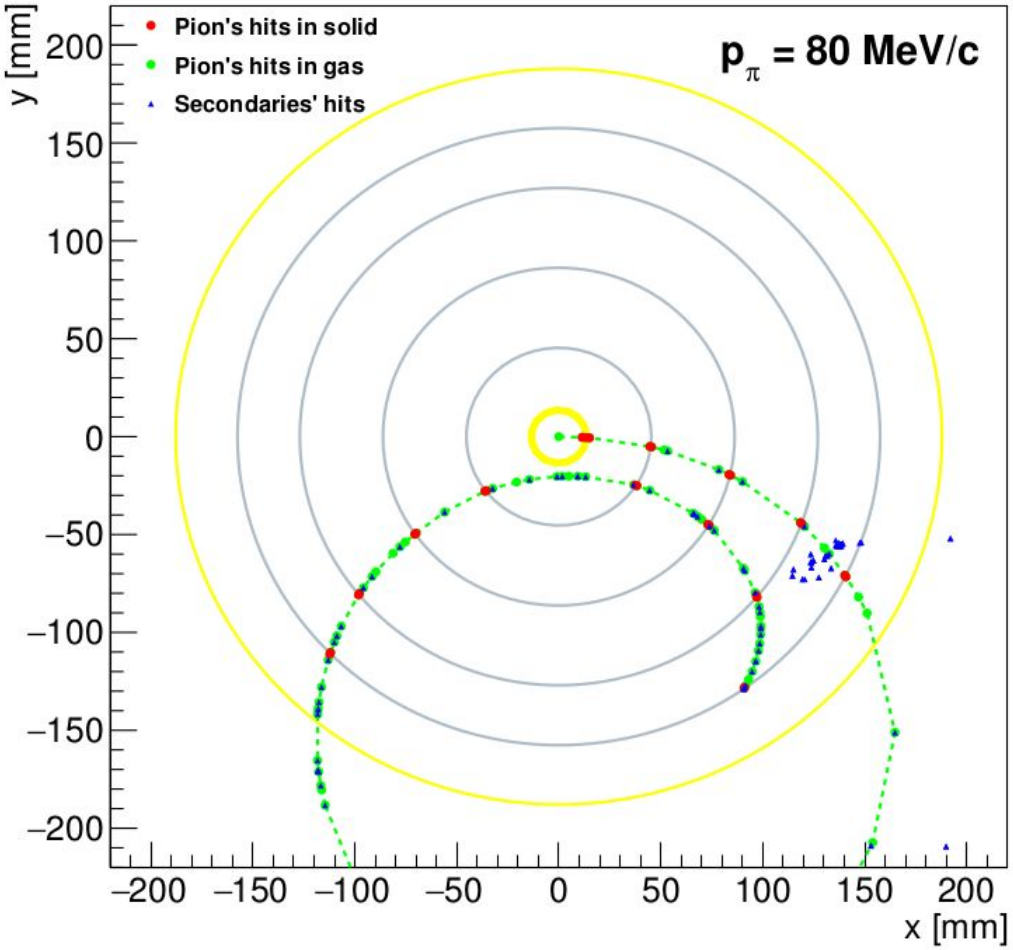


- If air is placed outside IT, pions return back with momentum around 70 MeV/c
- Pions with p_π = 75 MeV/c cross layers twice

Inner Tracker

DD4hep simulation

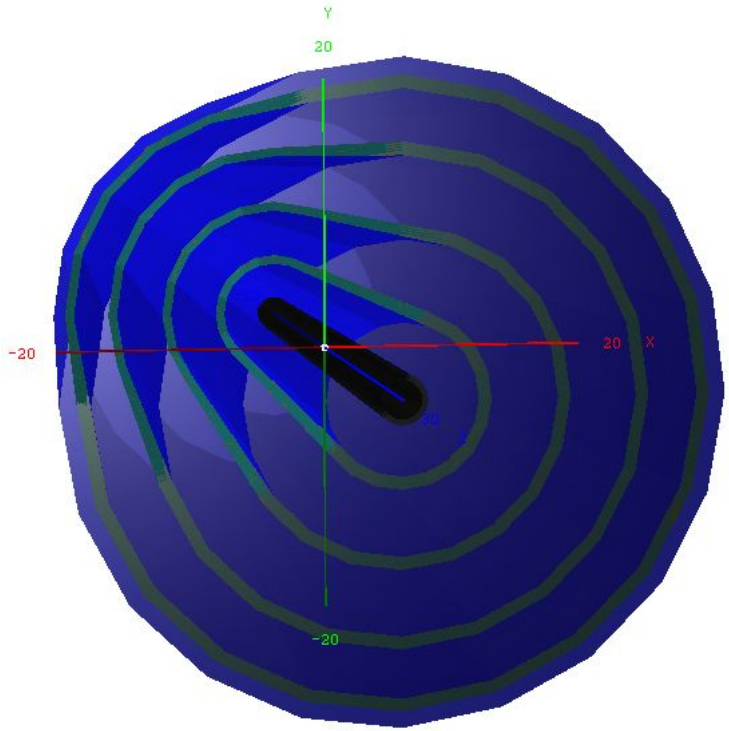
Si-strips

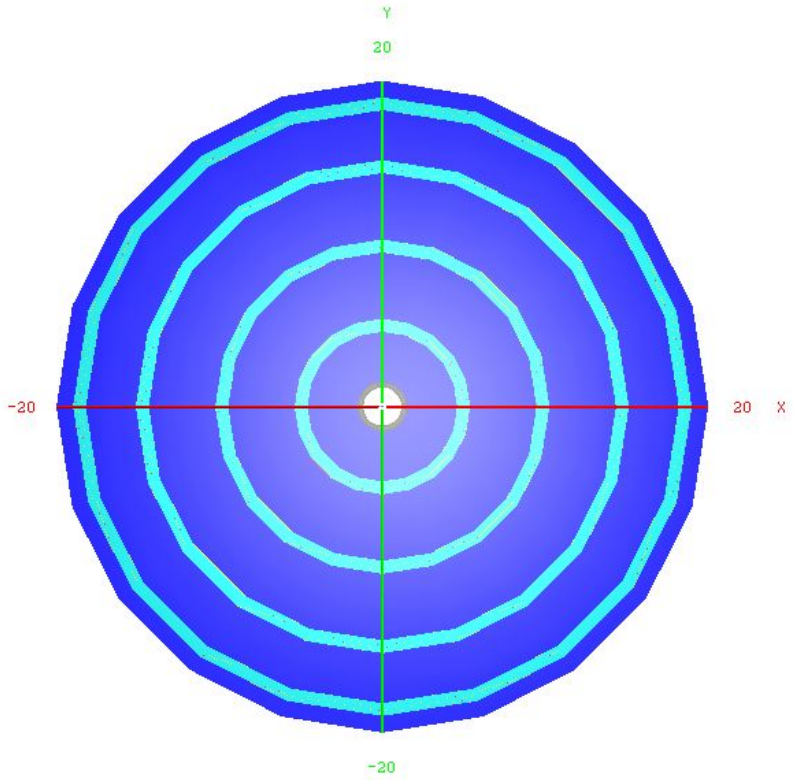


The reconstruction of pions with hits in 4 layers for Si-strips option of Inner Tracker is possible for pions with momentum, greater than 65 MeV/c

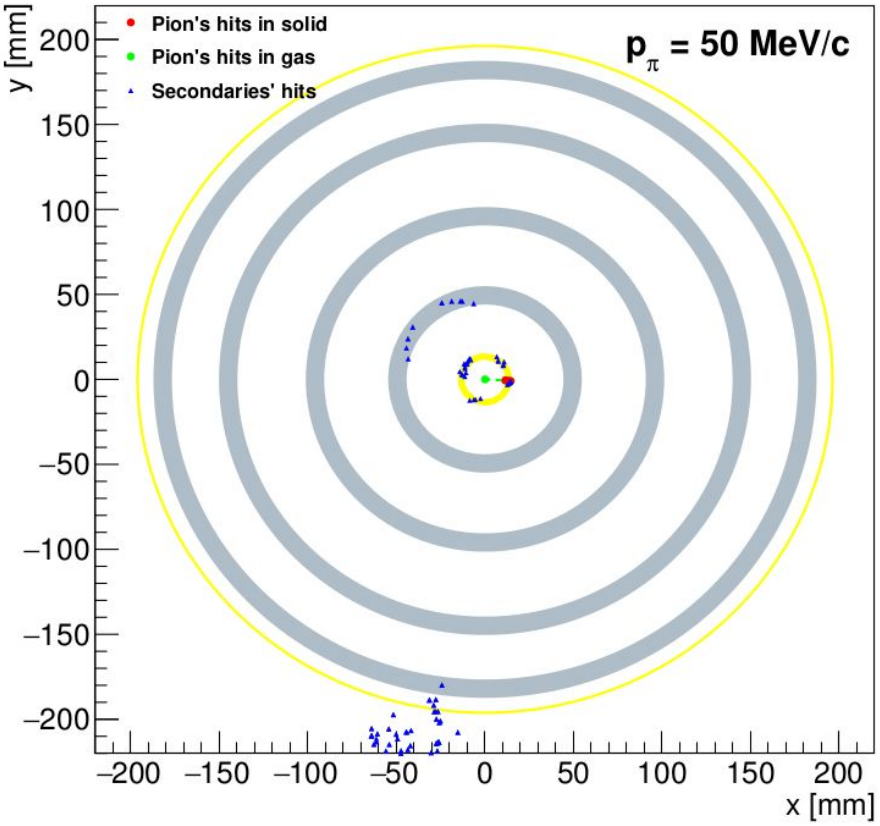
Inner Tracker DD4hep simulation CGEM

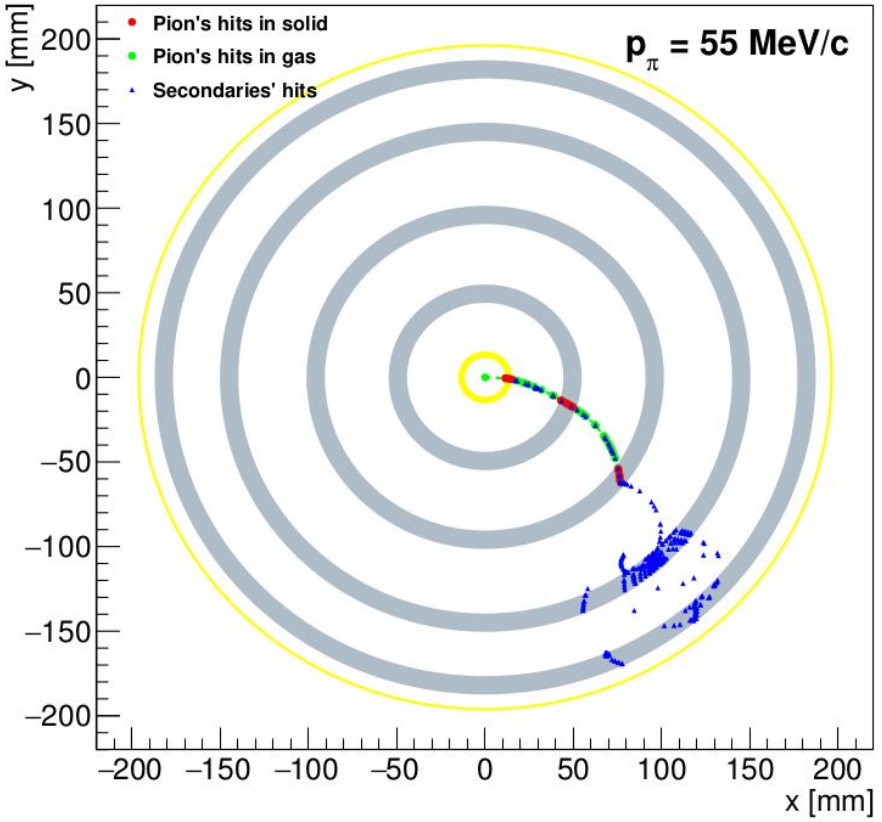
- 4 layers of GEMs
  - GEM gas Ar(75%)-CO_2(25%)
  - GEM gaps 3+1.5+1.5+1.5 [mm]
  - GEM holes are accounted by decreasing density in copper and kapton (factor 0.8)
- Gas outside GEMs is air
- Magnetic field 1.5 T
- Pions with different momenta were gun perpendicular to beam axis





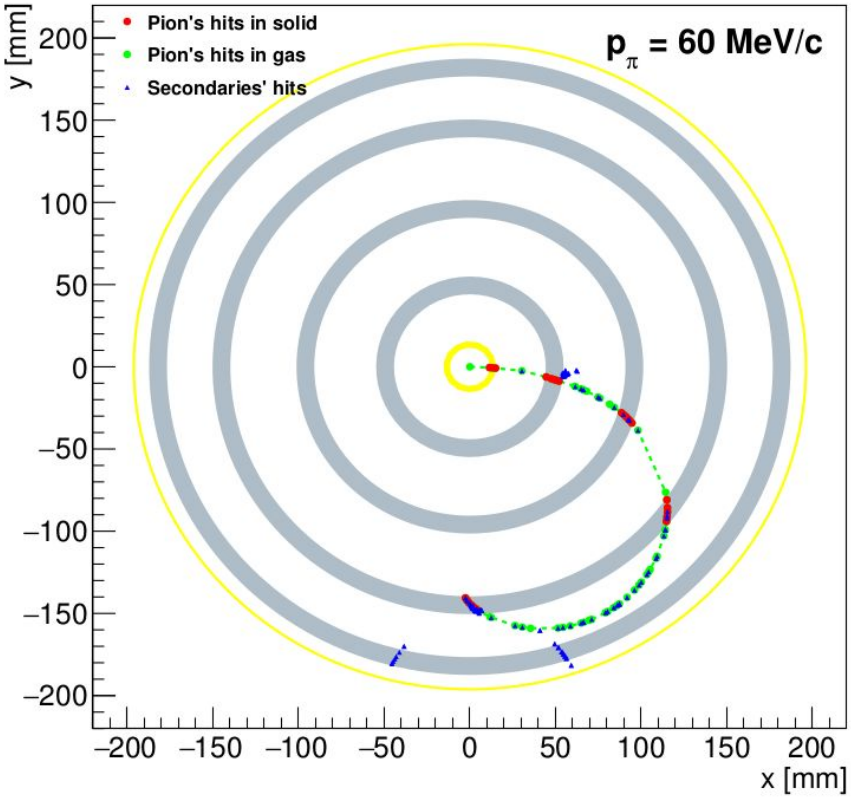
Inner Tracker DD4hep simulation CGEM

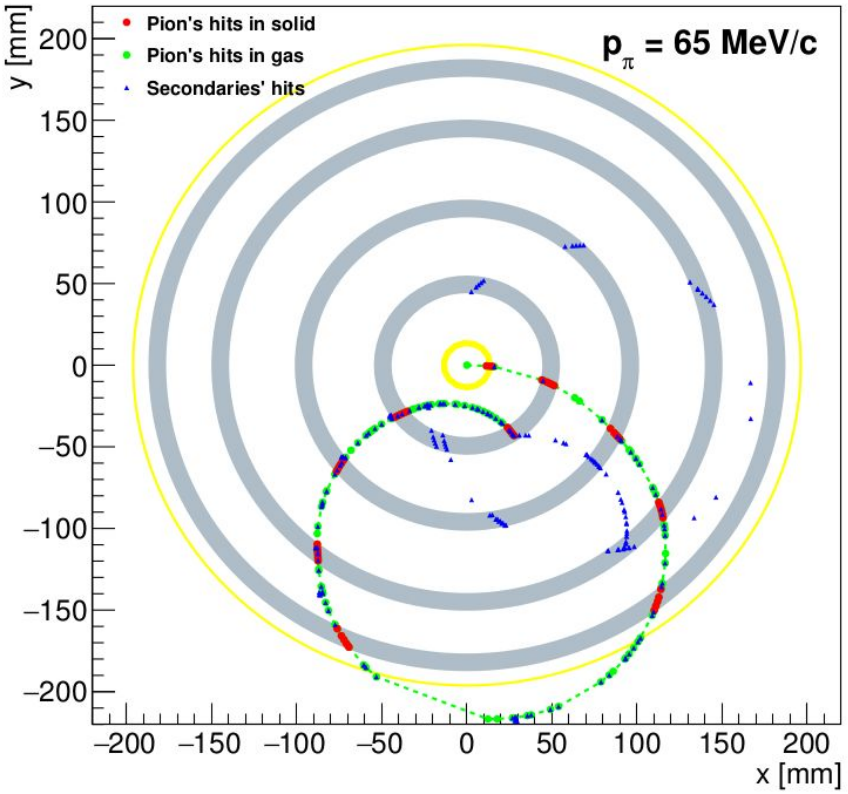




- Pions with momenta less than 50 MeV/c do not pass through the beampipe
- Starting from p_π = 55 MeV/c two layers can be reached by pions

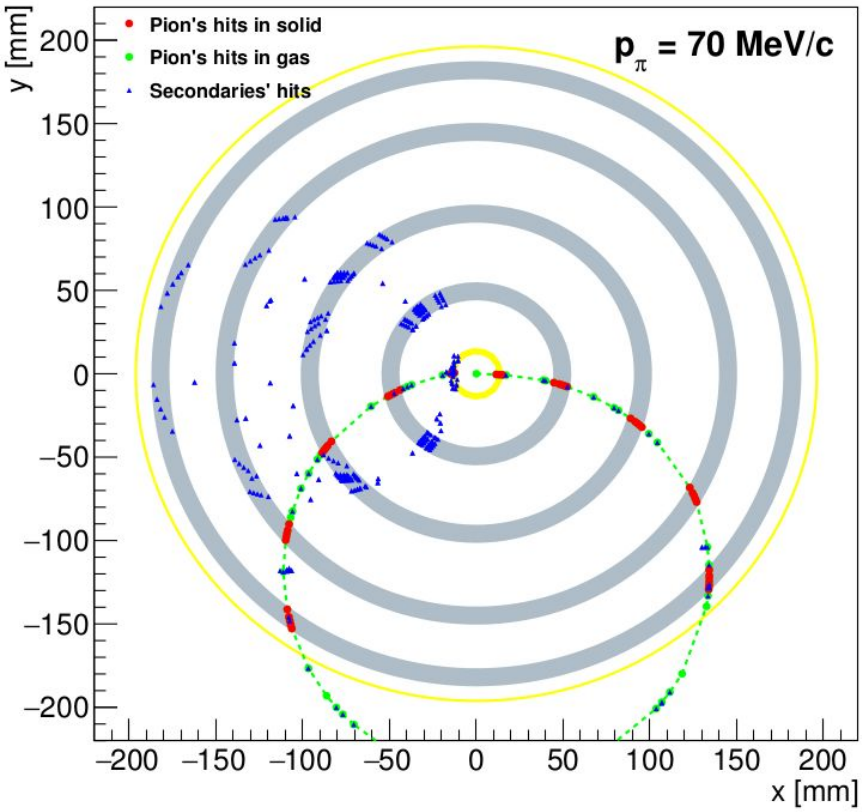
Inner Tracker DD4hep simulation CGEM

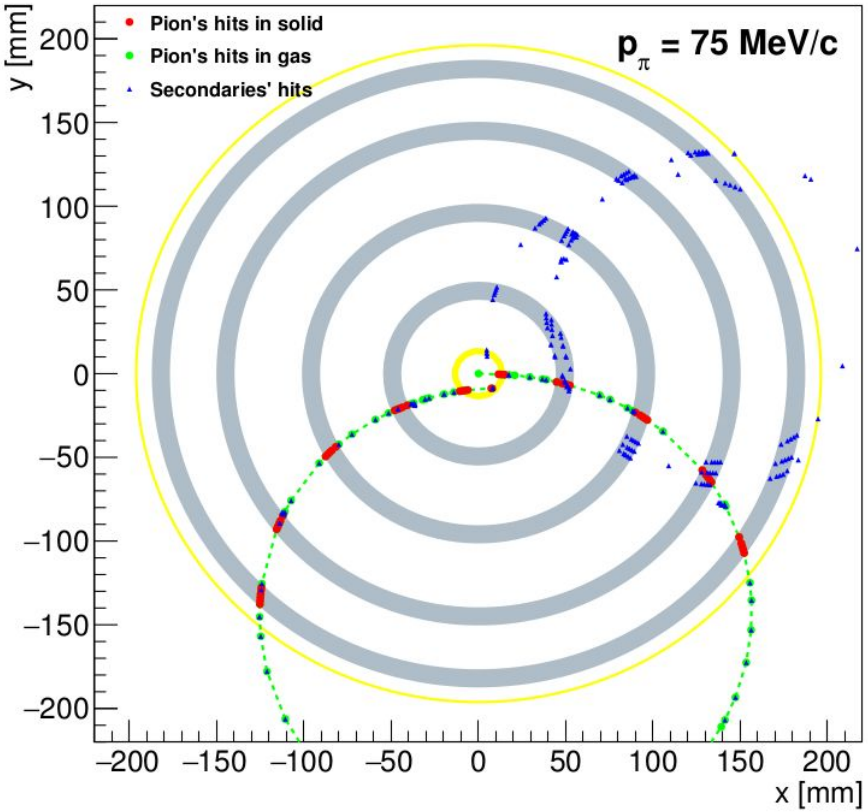




- Pions with momenta 60 MeV/c pass through three layers and curve back
- Starting from p_π = 65 MeV/c the all 4 layers are crossed by pions minimum twice

Inner Tracker DD4hep simulation CGEM



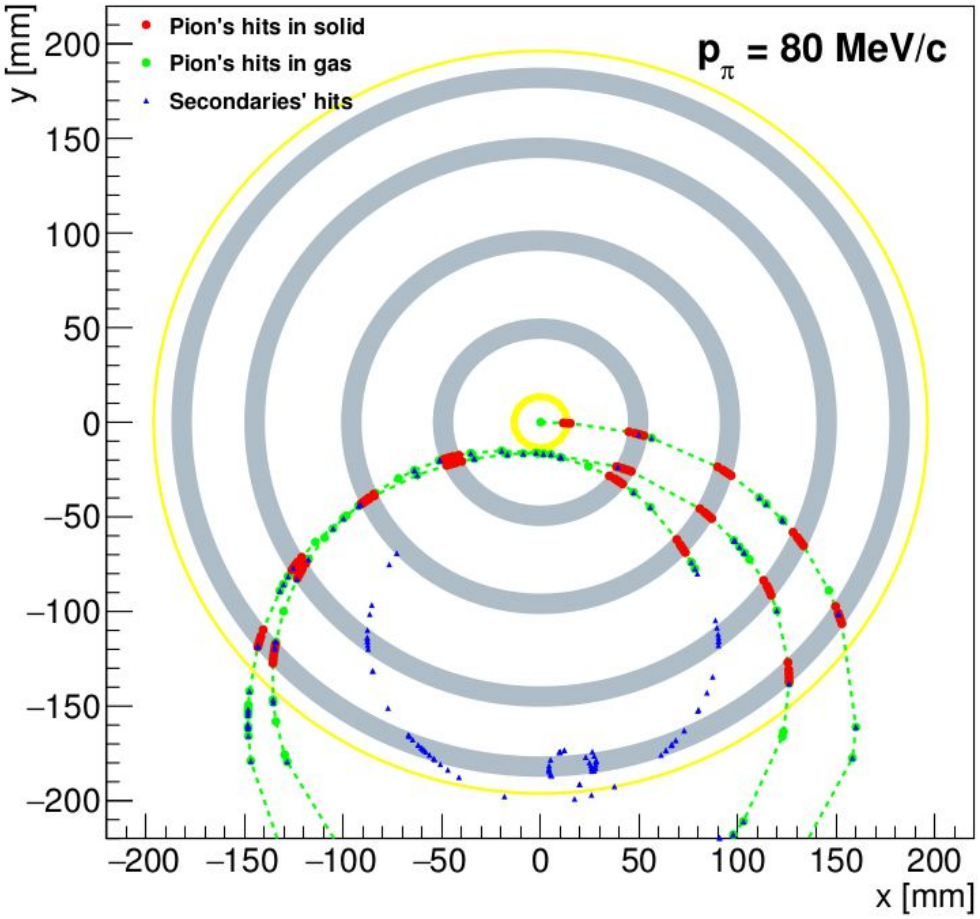


- Pions can be registered precisely for momentum, greater than 70 MeV/c in case of their transverse motion

Inner Tracker

DD4hep simulation

CGEM

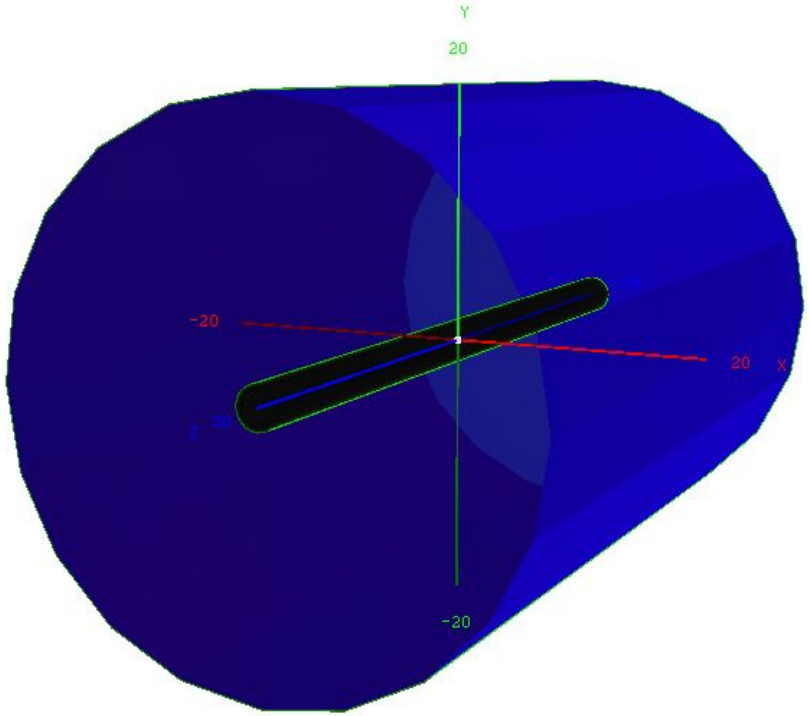


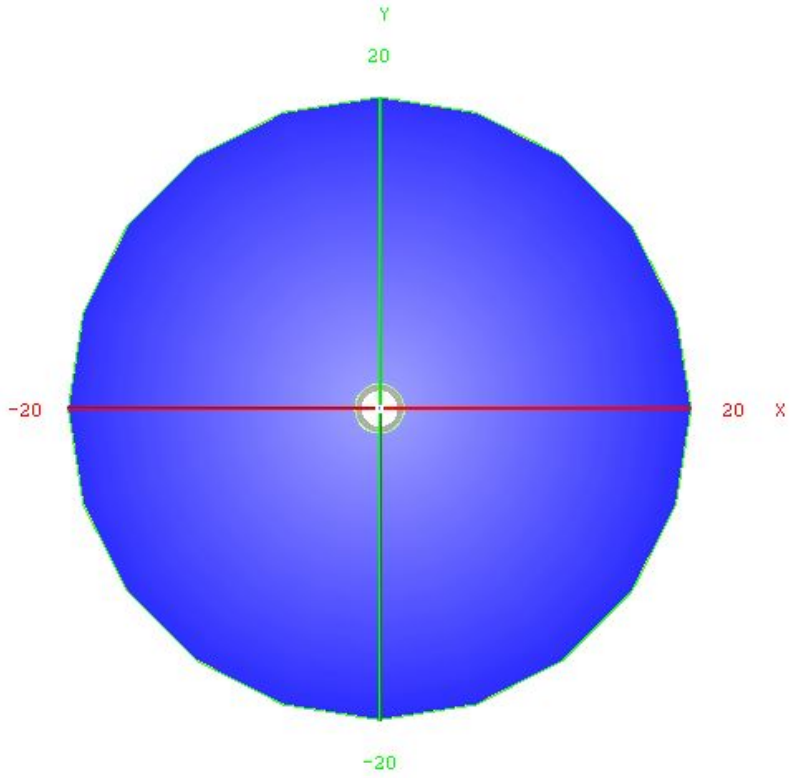
The reconstruction of pions with hits in 4 layers for CGEM option of Inner Tracker is possible for pions with momentum, greater than 60 MeV/c

Inner Tracker

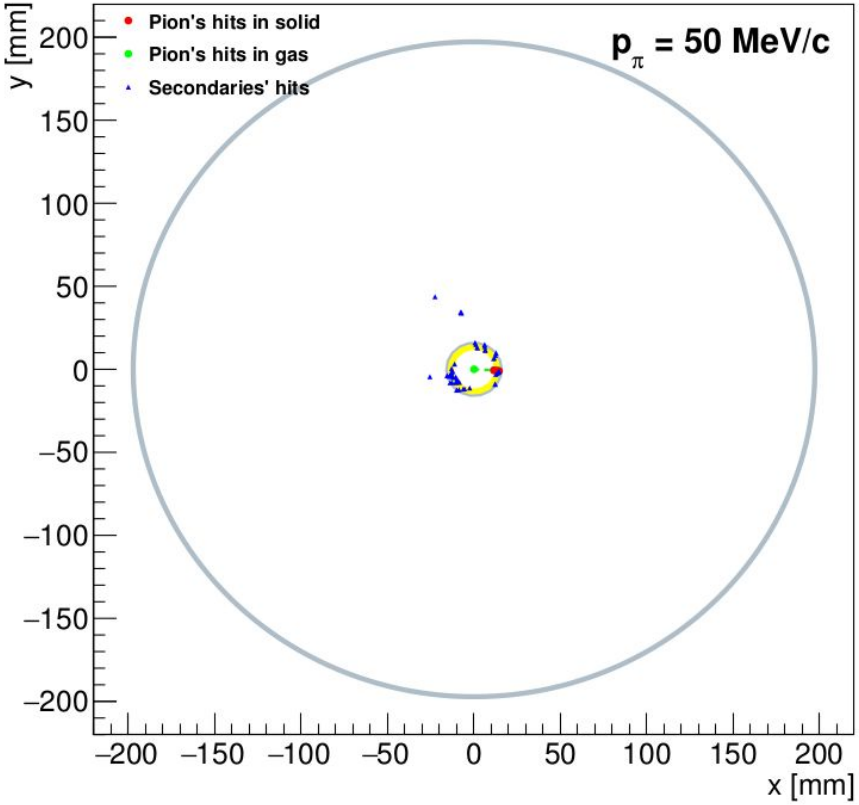
TPC

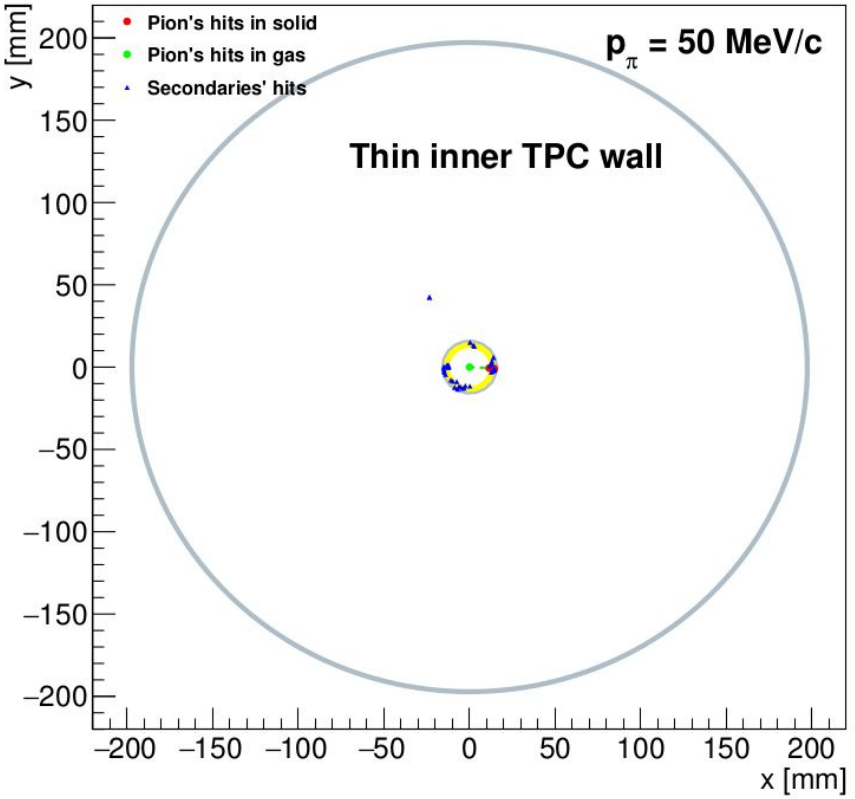
- Two walls - inner and outer
  - Two suboptions of TPC
    - Standard: 2 ✕(1 mm G10 + 0.1 mm Teflon + 15 μm Copper)
    - Standard outer + thin inner wall (50 μm Kapton + 0.1 mm Teflon + 5 μm Copper)
- Gas Ar(80%)-CO_2(20%)
- Magnetic field 1.5 T
- Pions with different momenta were gun perpendicular to beam axis





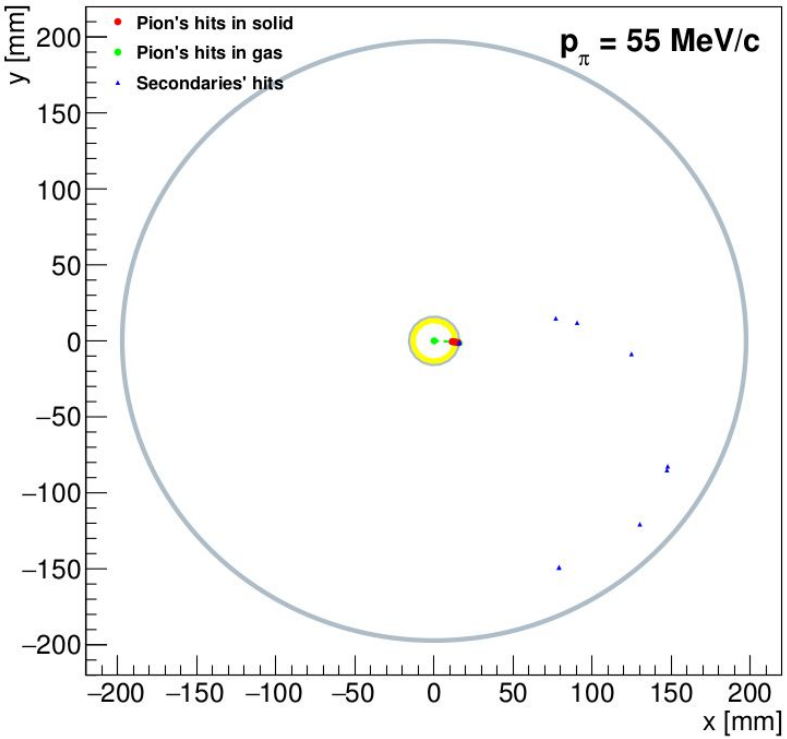
Inner Tracker DD4hep simulation TPC

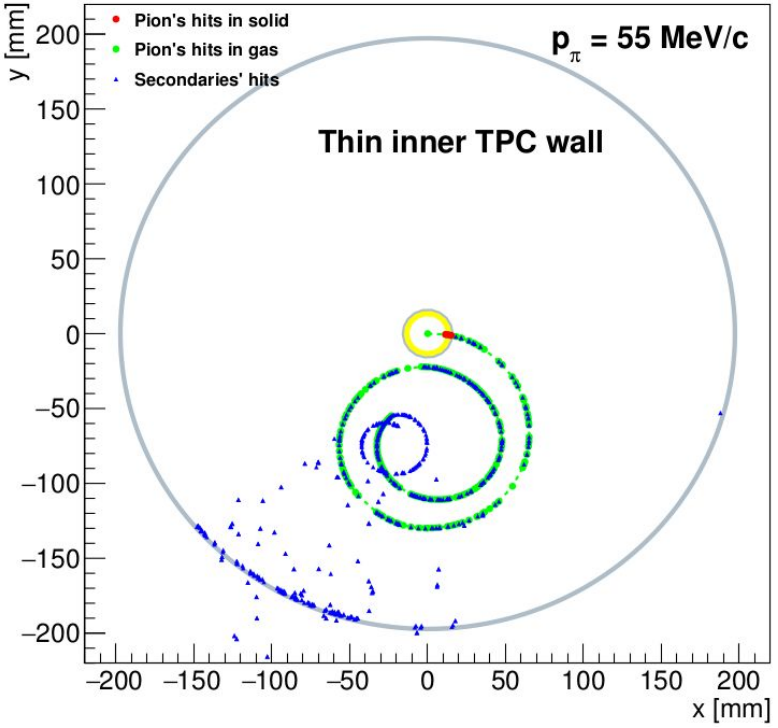




- Pions with momenta less than 50 MeV/c do not pass through the beampipe and, apparently, through the inner wall of TPC

Inner Tracker DD4hep simulation TPC



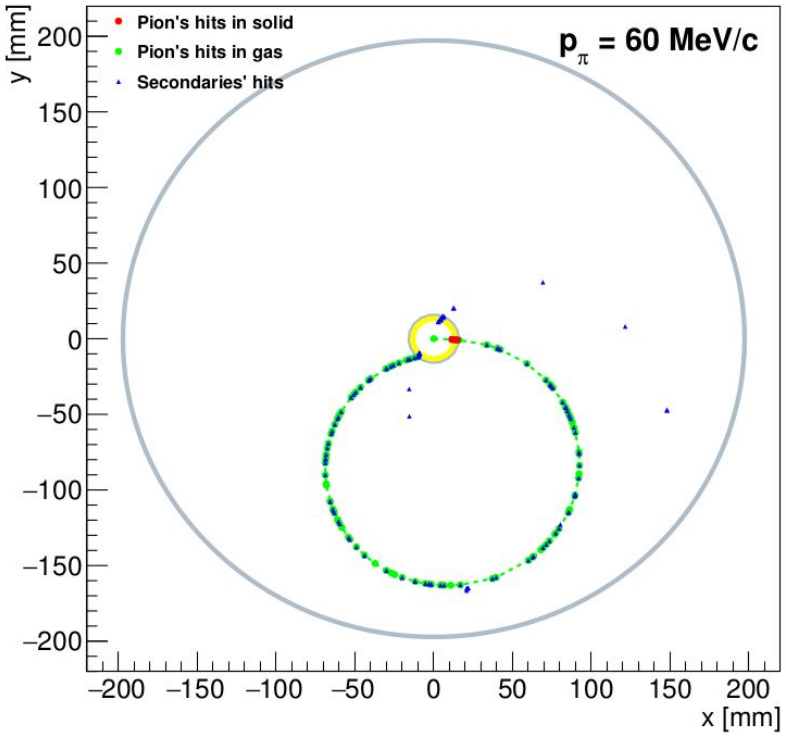


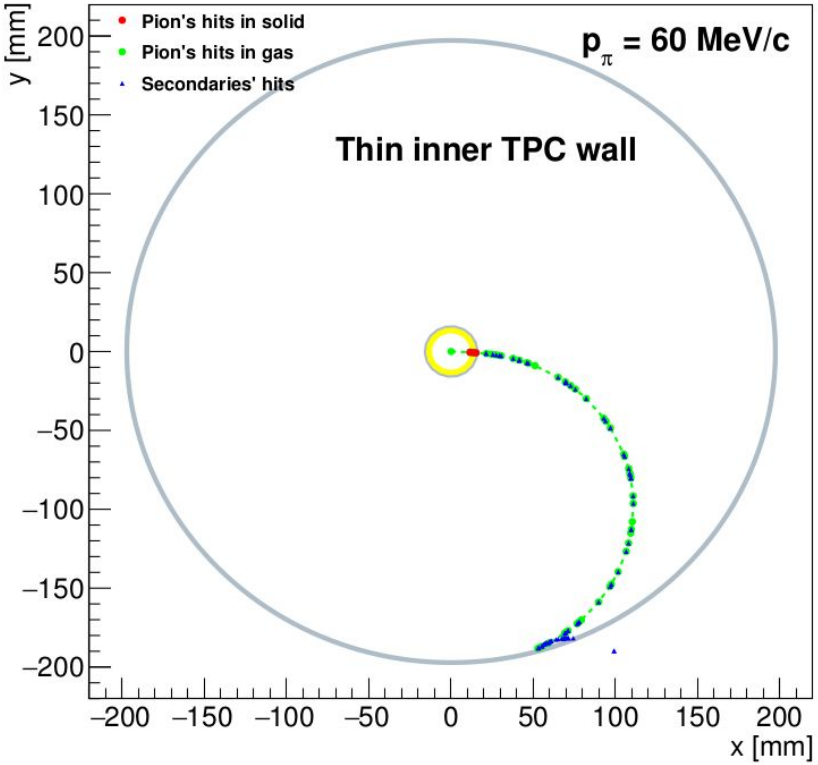
- Pions with momenta greater than 55 MeV/c pass through thin inner wall but they do not pass through standard inner wall

Inner Tracker

DD4hep simulation

TPC



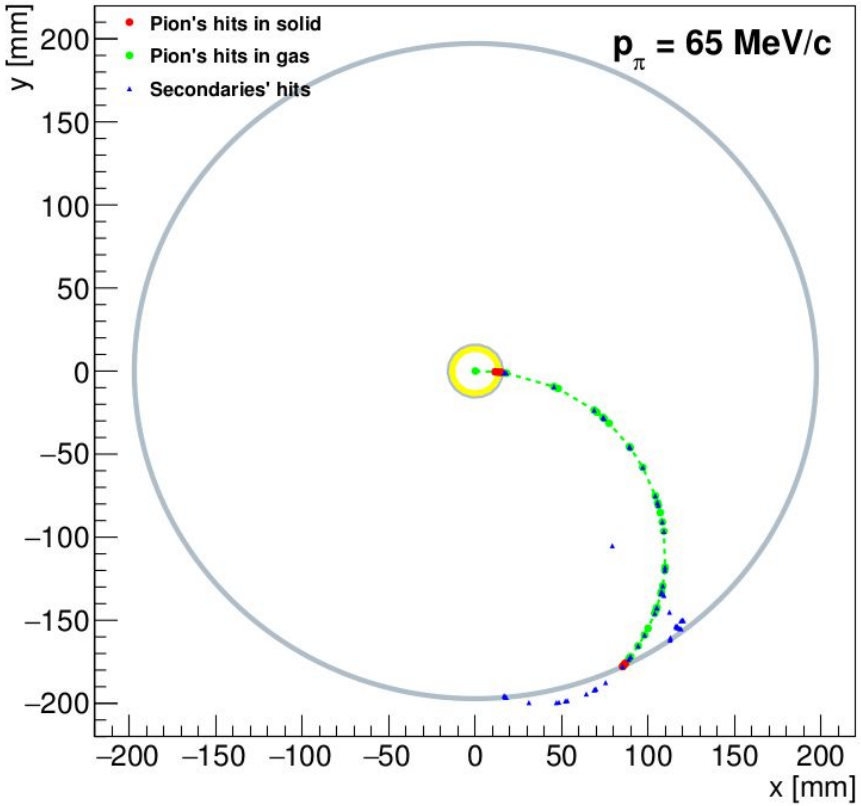


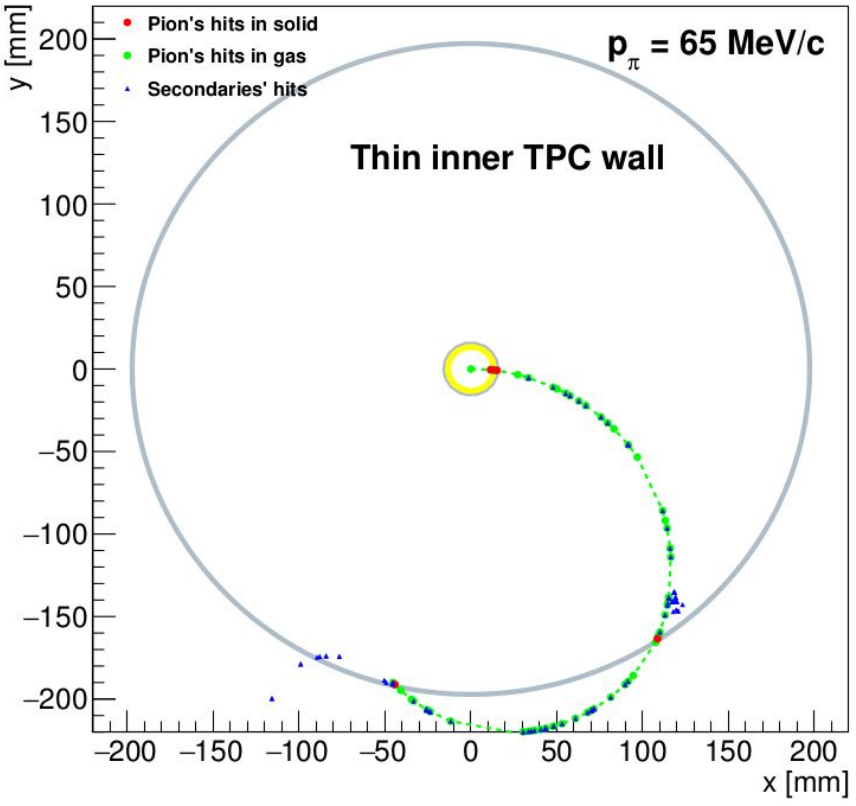
- Pions with momenta greater than 60 MeV/c can be reconstructed for both TPC suboptions

Inner Tracker

DD4hep simulation

TPC



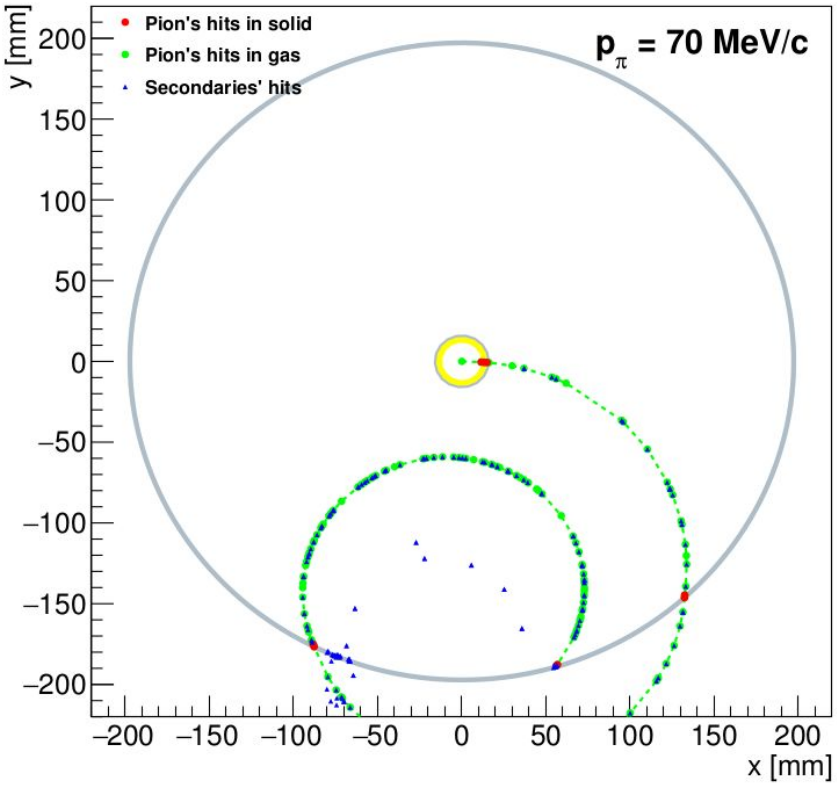


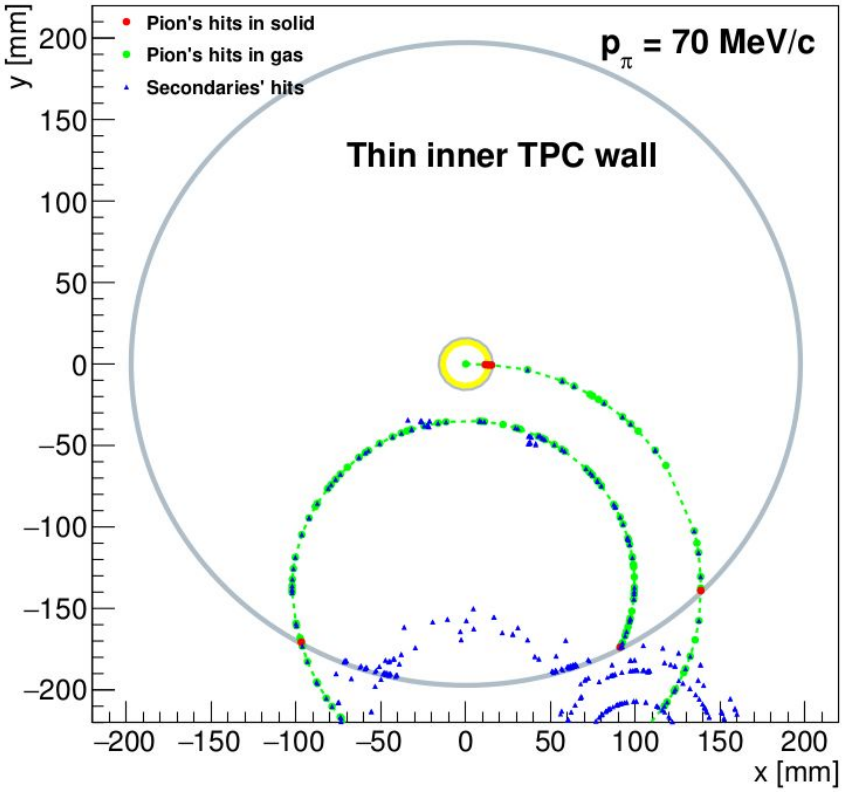
- Outer wall also influence the pions path in their further motion

Inner Tracker

DD4hep simulation

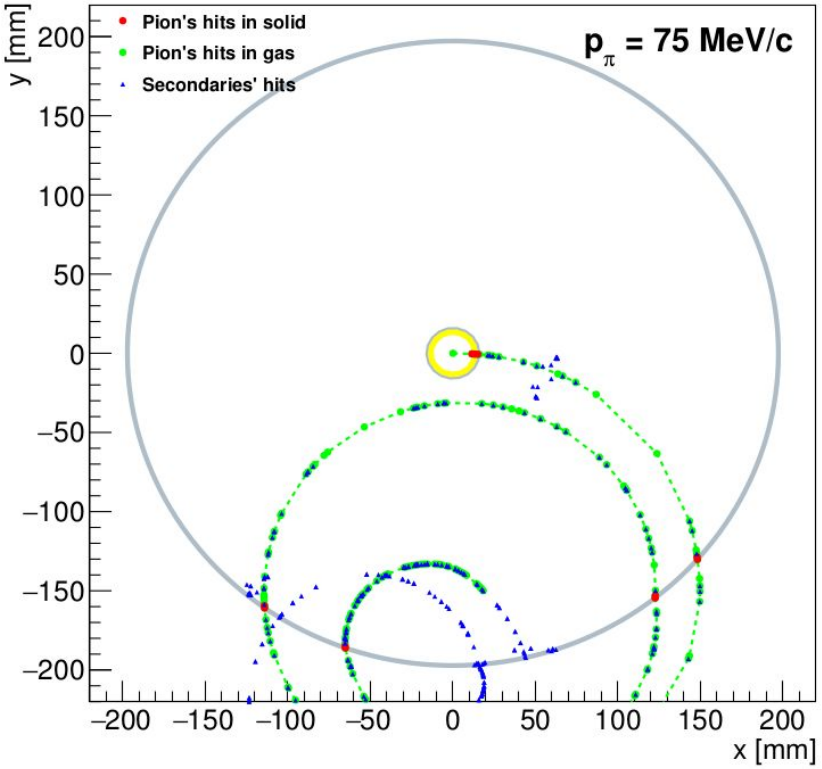
TPC

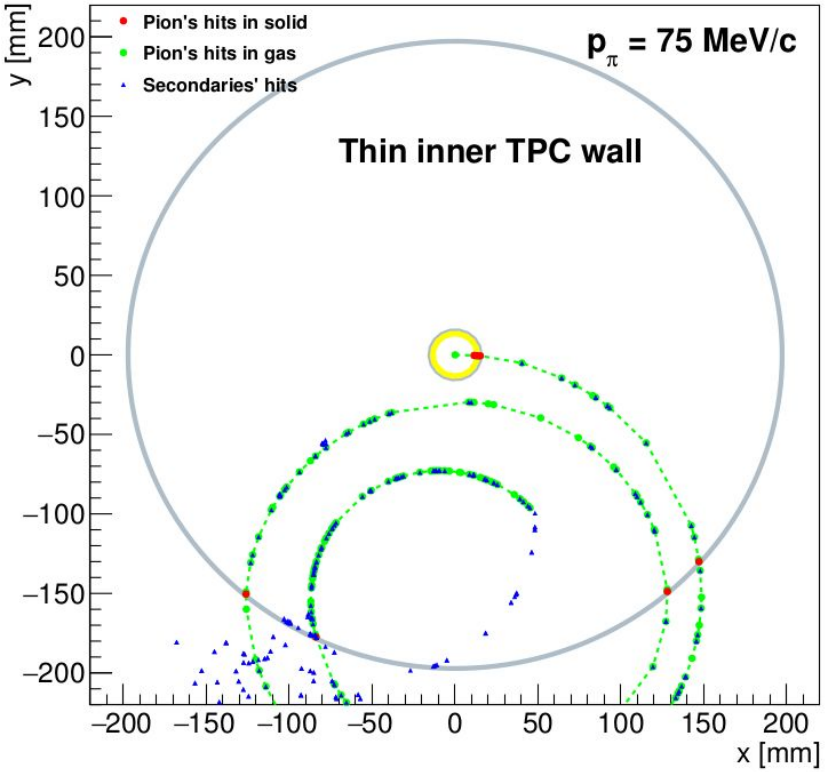




- Pions with momenta, higher than 70 MeV/c reach the outer wall minimum thrice

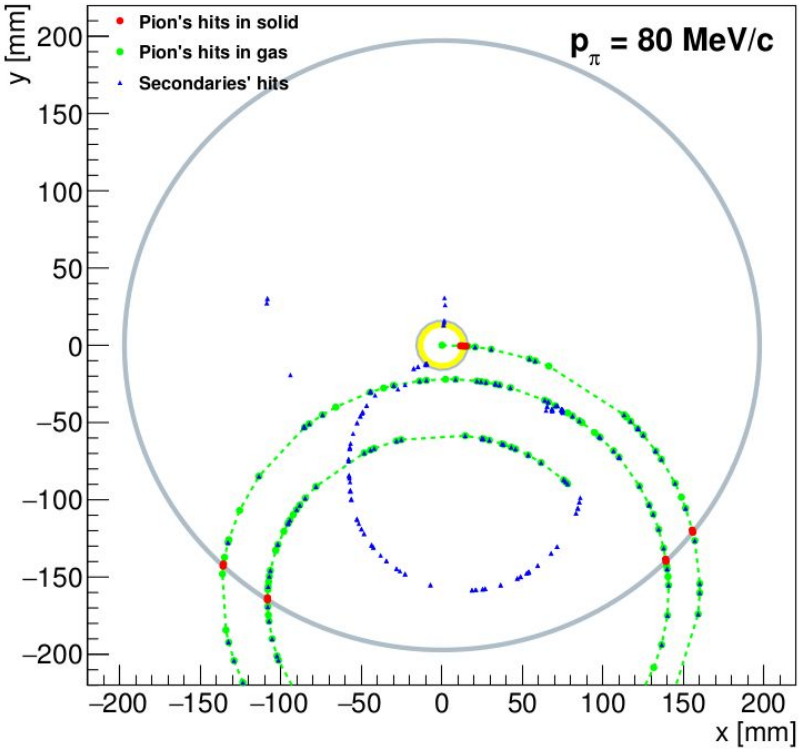
Inner Tracker DD4hep simulation TPC

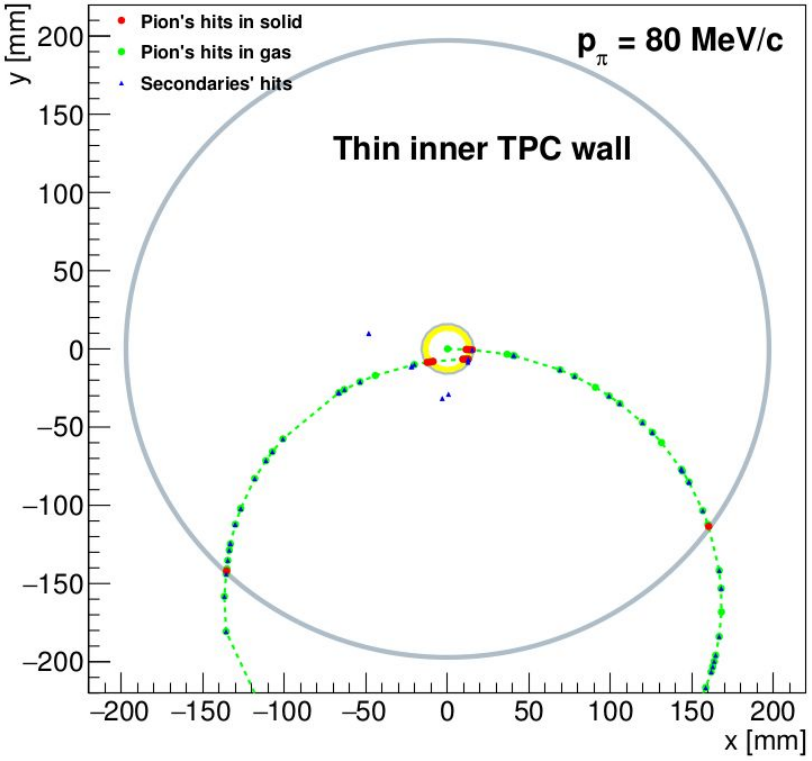




- Soft electrons leave a lot of ionization in the volume

Inner Tracker DD4hep simulation TPC



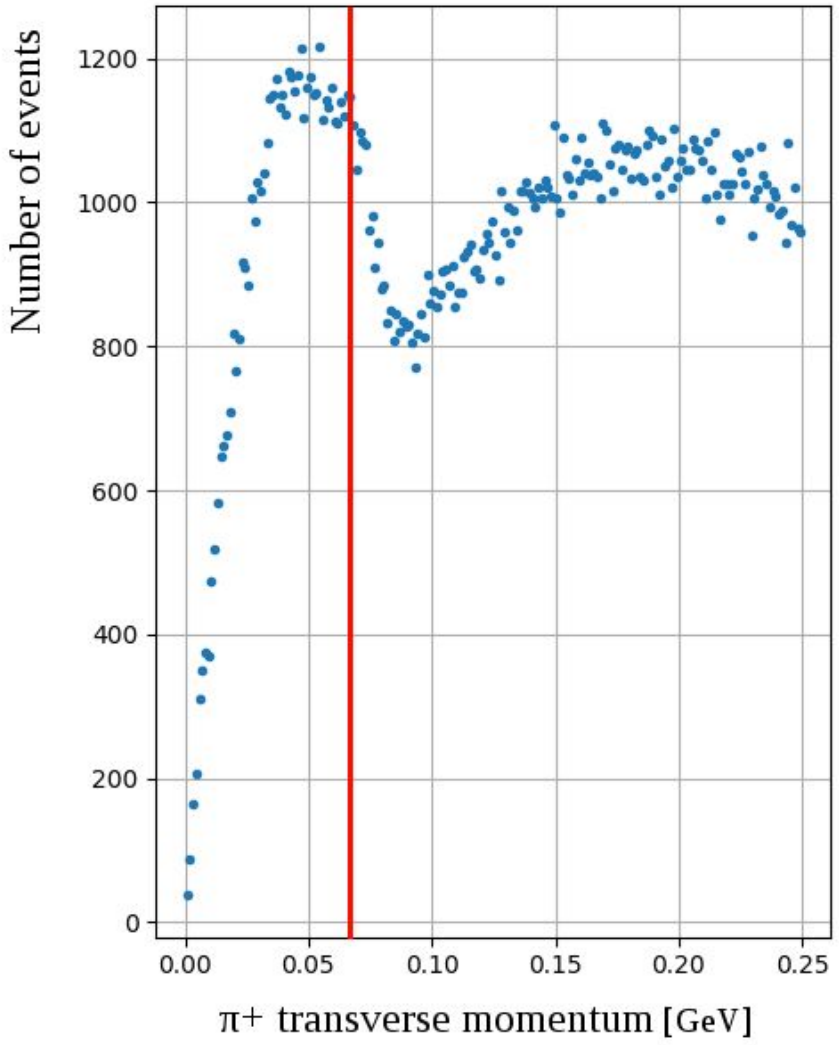


The reconstruction of pions for TPC option of Inner Tracker is possible:

- For standard wall suboption — $p_\pi > 60$ MeV/c
- For thin wall suboption — $p_\pi > 55$ MeV/c

Inner Tracker and pions spectra

Approximate momentum border demonstrating the pions, which can be reconstructed with the present tracking techniques



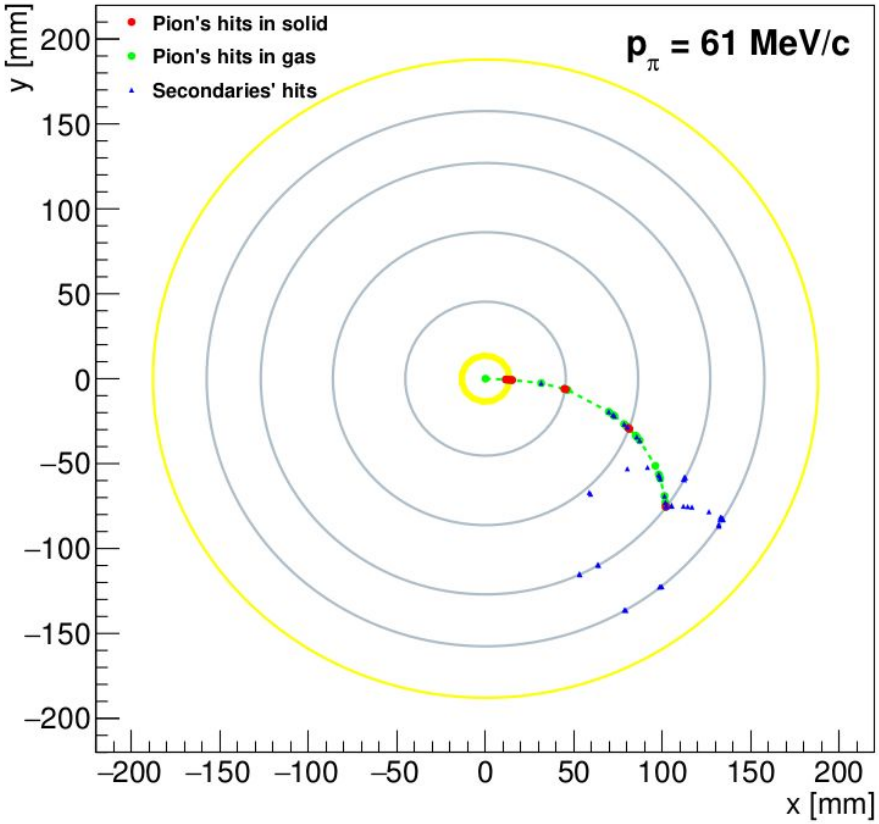
Simulation of π^+ transverse momentum distribution in $e^+e^- \rightarrow DD^*$ (V. Vorobyev)

Conclusions

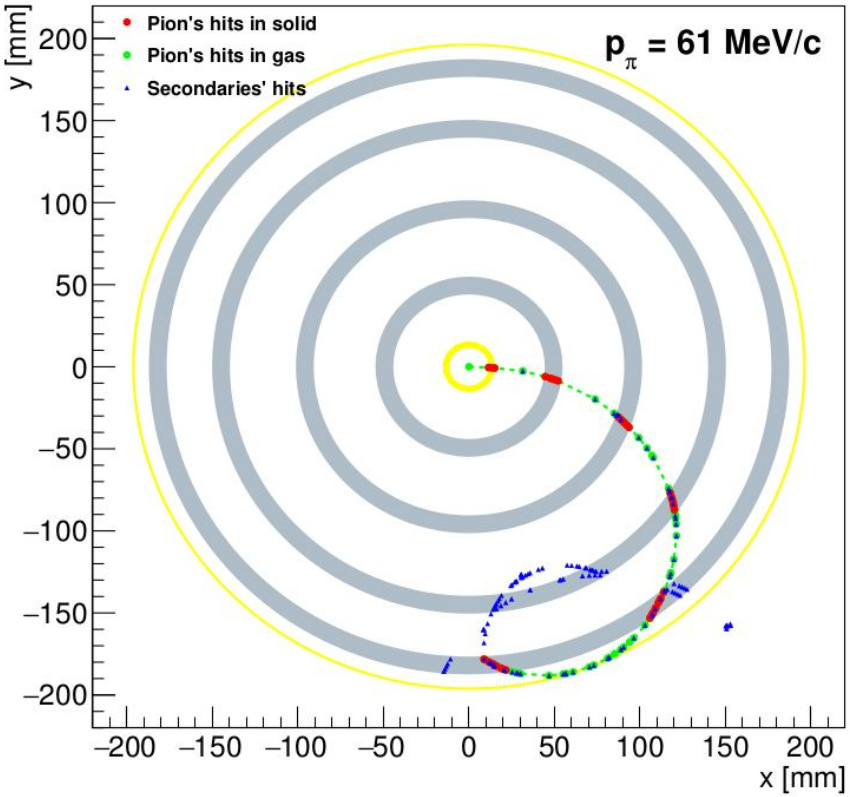
- Full simulation of Super Charm-Tau Inner Tracker with DD4hep is accomplished
- Pions with momenta less than 50 MeV/c do not pass through the beampipe
- Three options of Inner Tracker are considered
  - Si-strips — reconstruction for $p_{\pi} > 65$ MeV/c
  - CGEM — reconstruction for $p_{\pi} > 60$ MeV/c
  - TPC
    - Standard wall — reconstruction for $p_{\pi} > 60$ MeV/c
    - Thin wall — reconstruction for $p_{\pi} > 55$ MeV/c
- Next stage in simulation is study of reconstruction efficiency in presence of background according to the presentation of Lev Shekhtman

Merci pour votre attention!

Back-up



Si-strips



CGEM