Acceptance and Resolution Studies for Forward Tracking Stations

26th June 2013

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Outline:

- Acceptance Studies
- Resolution Studies for FTS standalone
- Resolution Studies for MVD+GEM+FTS
- Conclusions

Aim:

Study the x-y intensity distribution for pions at the z-position of tracking stations.

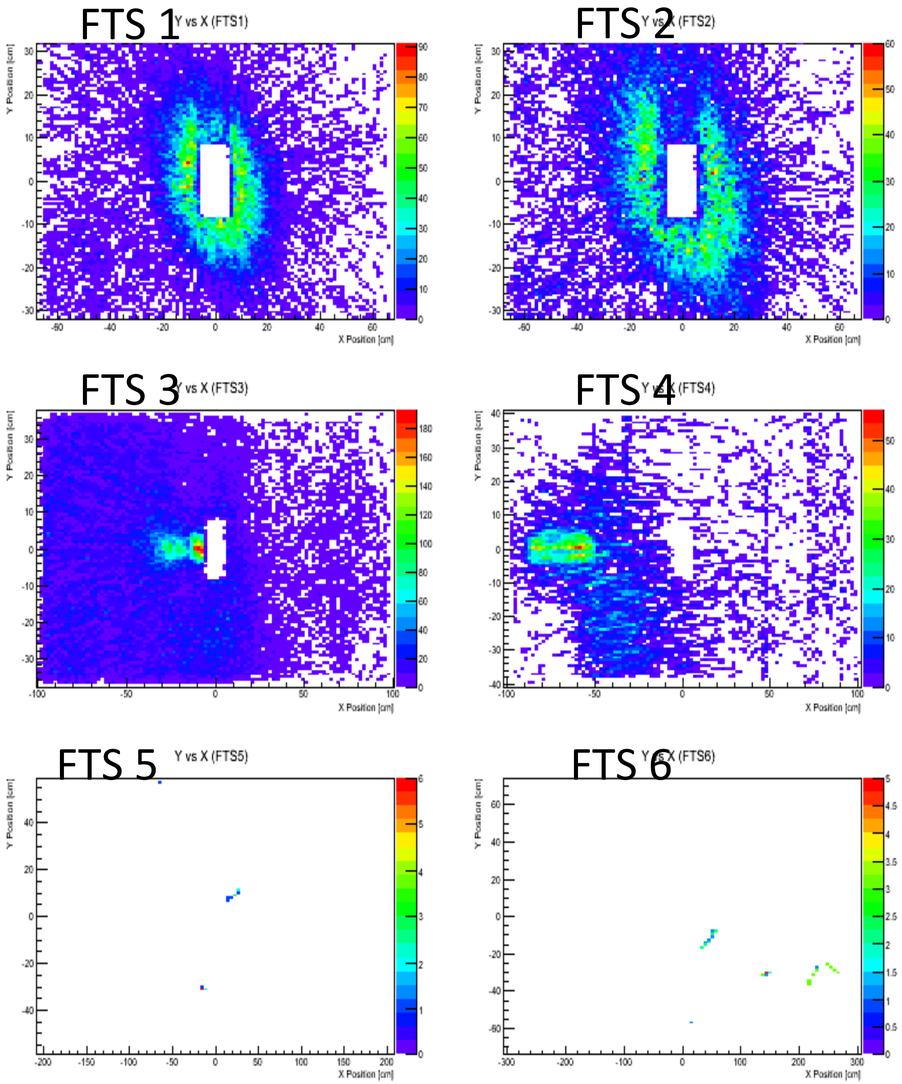
Strategy:

- BoxGenerator is used for the simulation
- **10.000 Pions** simulated with different momentum:
  200 MeV, 500 MeV, 1 GeV, 2 GeV, 3 GeV, 4 GeV, 5 GeV
- Uniformly in phi: [0,360°]
- **Uniformly in theta: [0,10°]**
- Multiple scattering and energy losses included
- Detectors included: MDV+GEM+FTS
- Beam Momentum = 15 GeV/c
- Pandaroot version: 19960
- **Not only primary tracks selected**

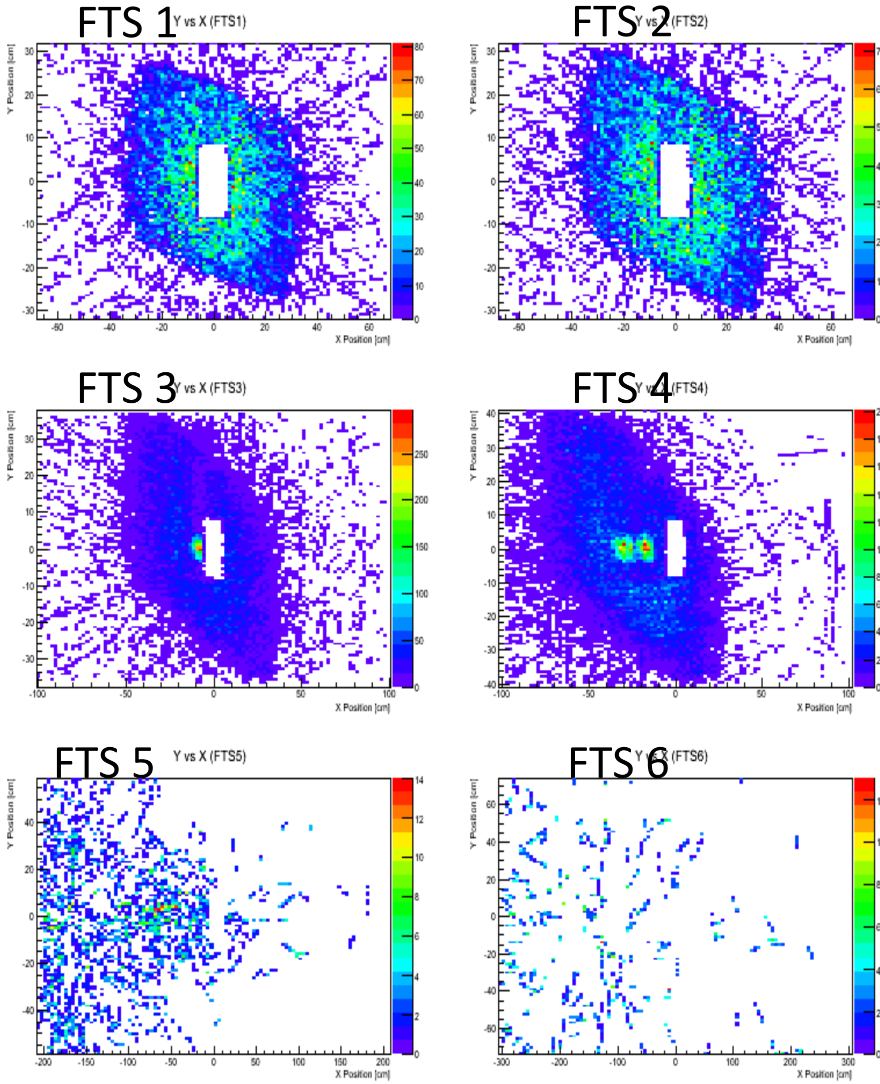
Geometry v1 (Rich between FTS 5 and FTS 6)

x: x stations dimensions
y: y stations dimensions

Pion momentum: 200 MeV



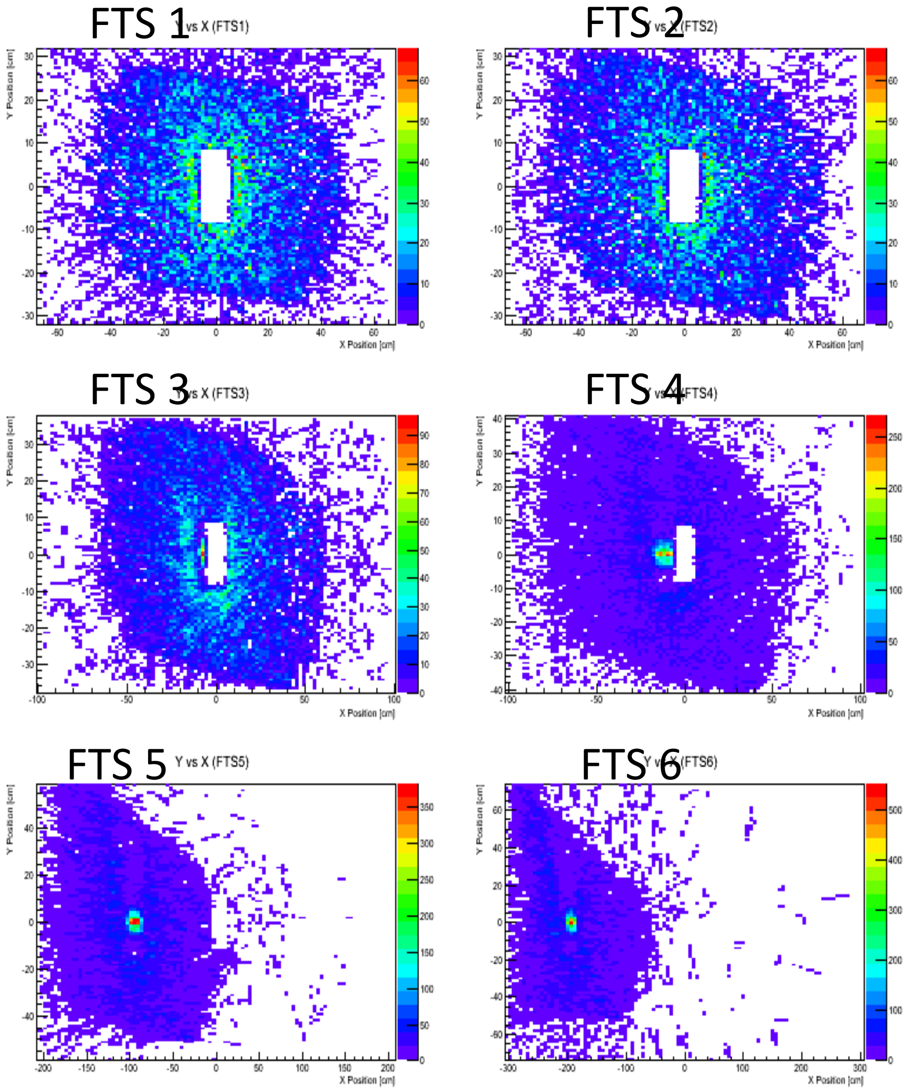
Pion momentum: 500 MeV



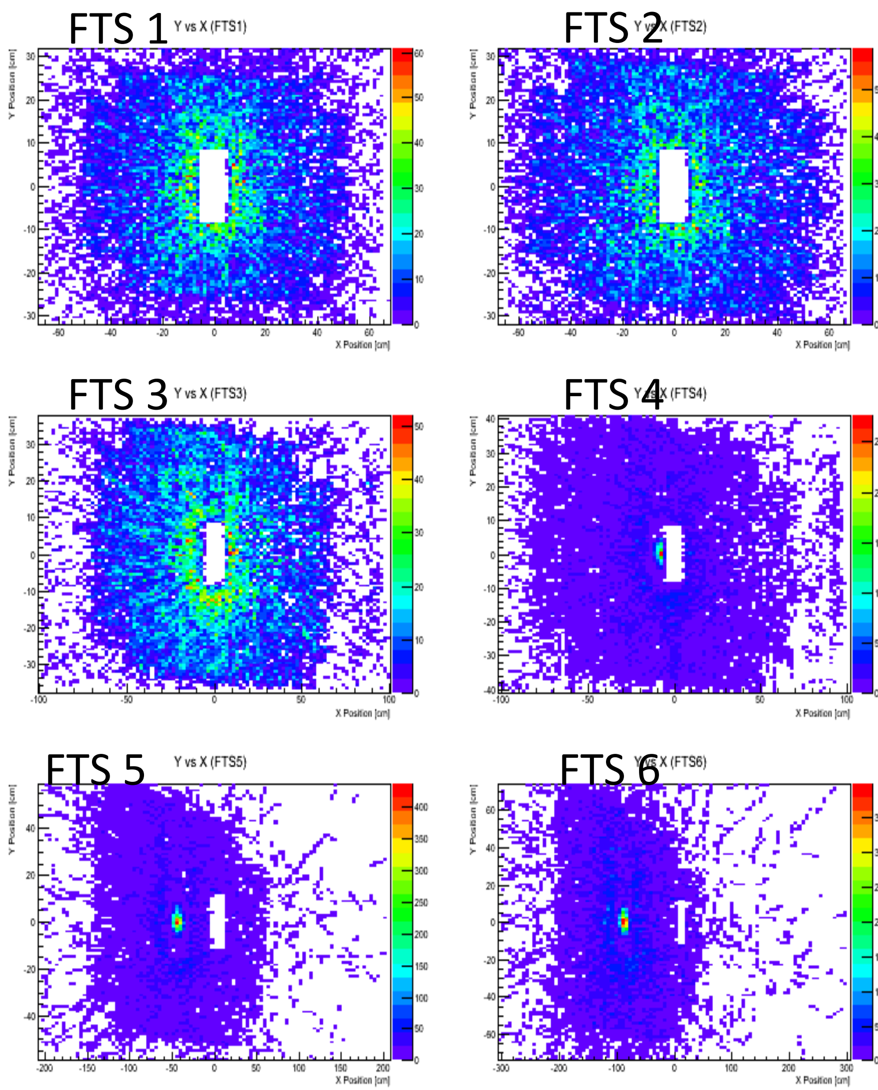
Geometry v1 (Rich between FTS 5 and FTS 6)

x: x stations dimensions
y: y stations dimensions

Pion momentum: 1 GeV



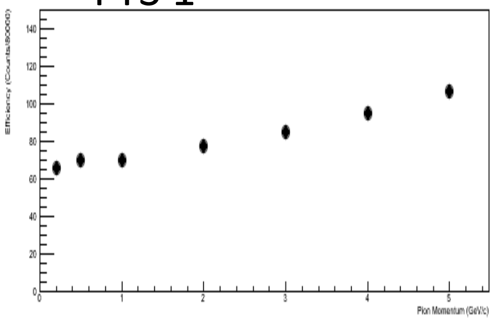
Pion momentum: 2 GeV



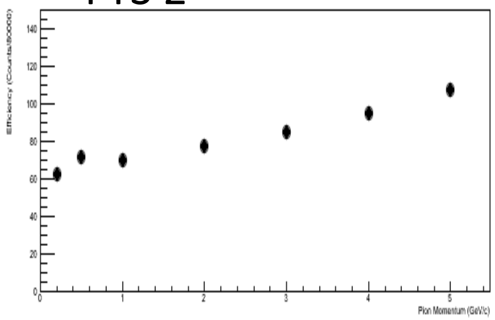
Geometry v1
(Rich between FTS 5 and FTS 6)

x axis: Pion Momentum
y axis: Efficiency [counts/(10000*8)]

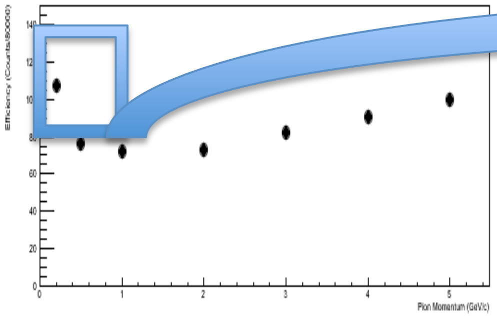
FTS 1



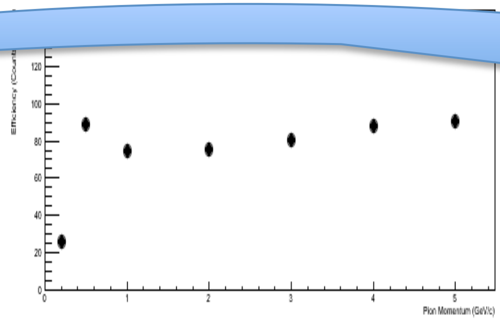
FTS 2



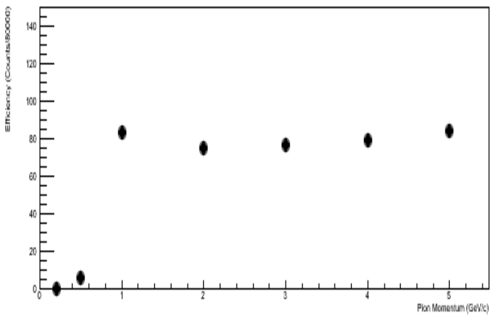
FTS 3



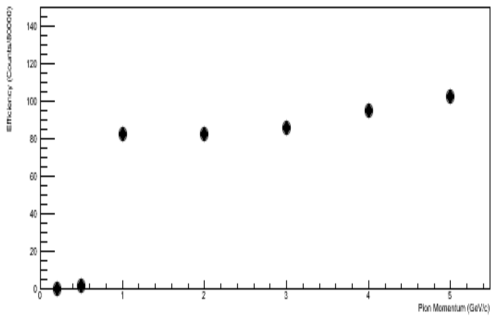
FTS 4



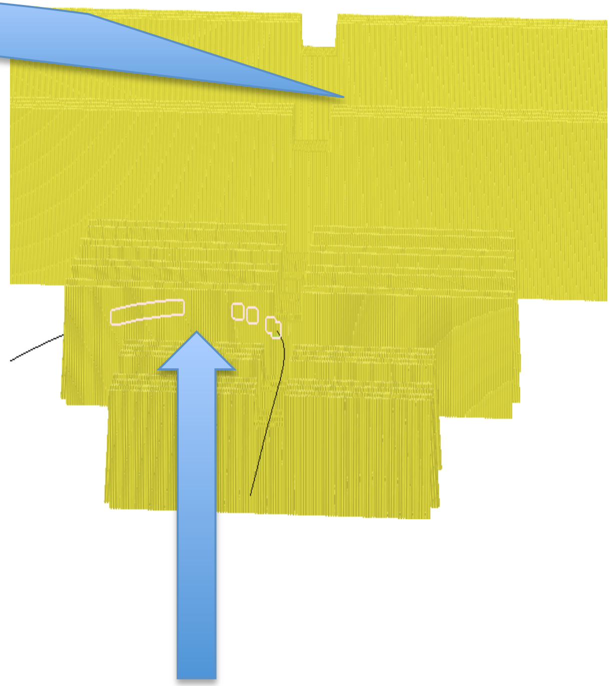
FTS 5



FTS 6



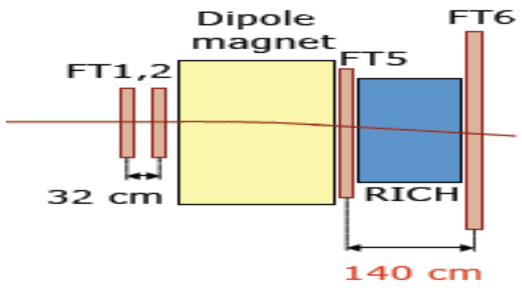
Why acceptance > 100% ?

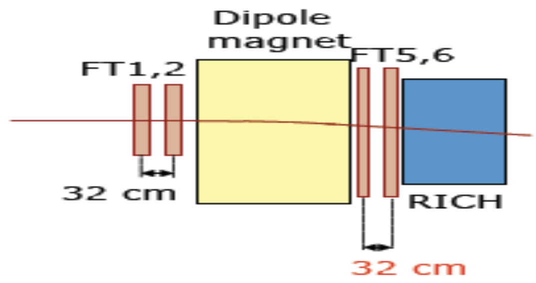


In the FTS 3 the trajectory
is bent by the magnetic field

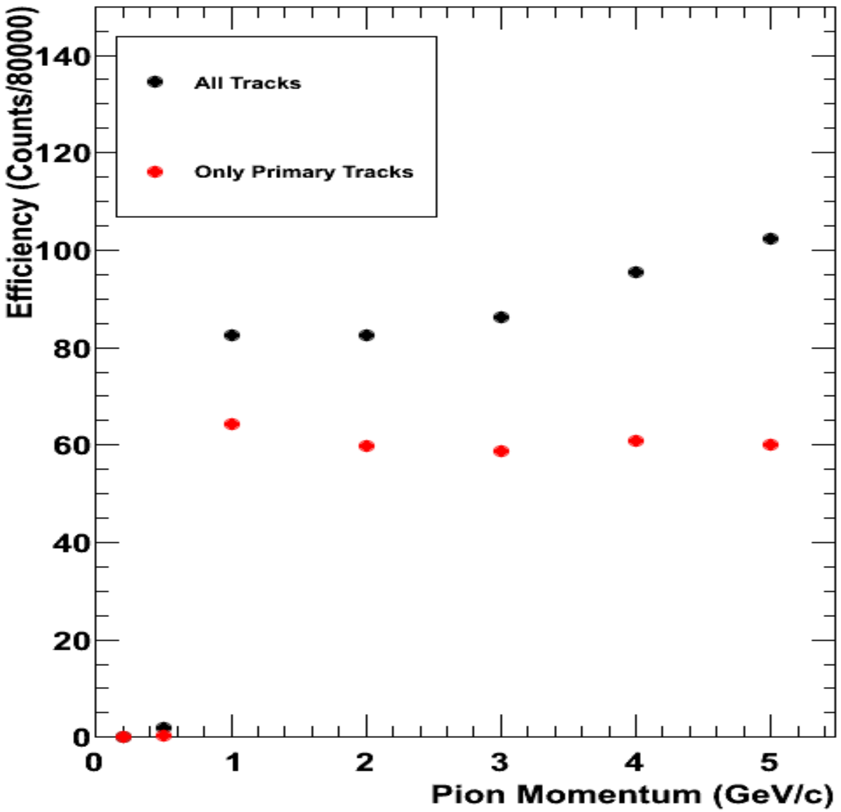
Geometry v1 (Rich between FTS 5 and FTS 6)

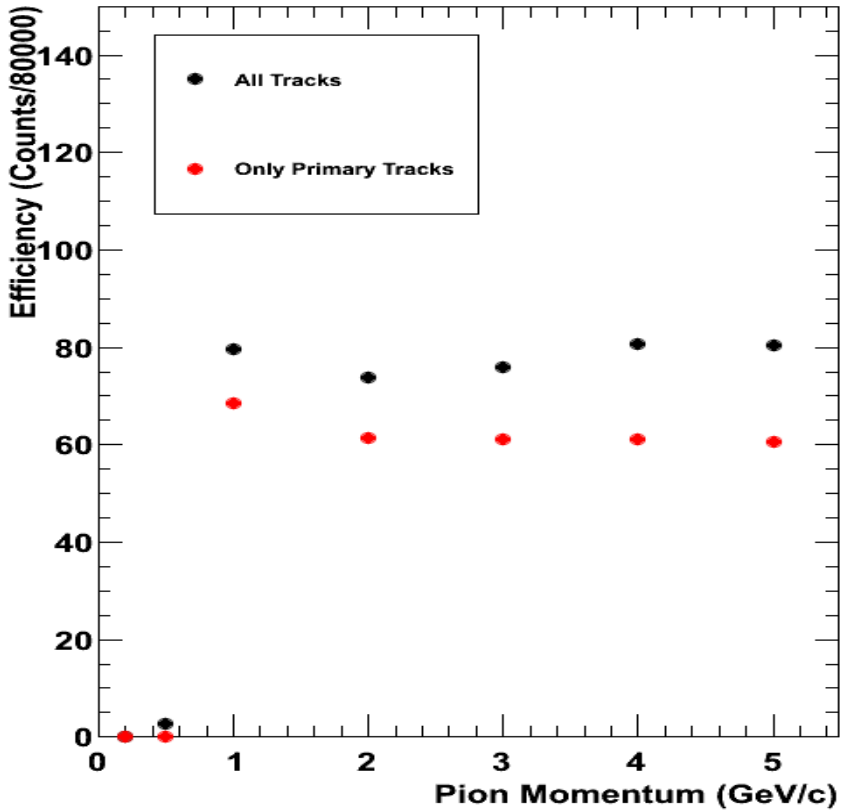
Geometry v2 (Rich after FTS 6)





Only FTS6

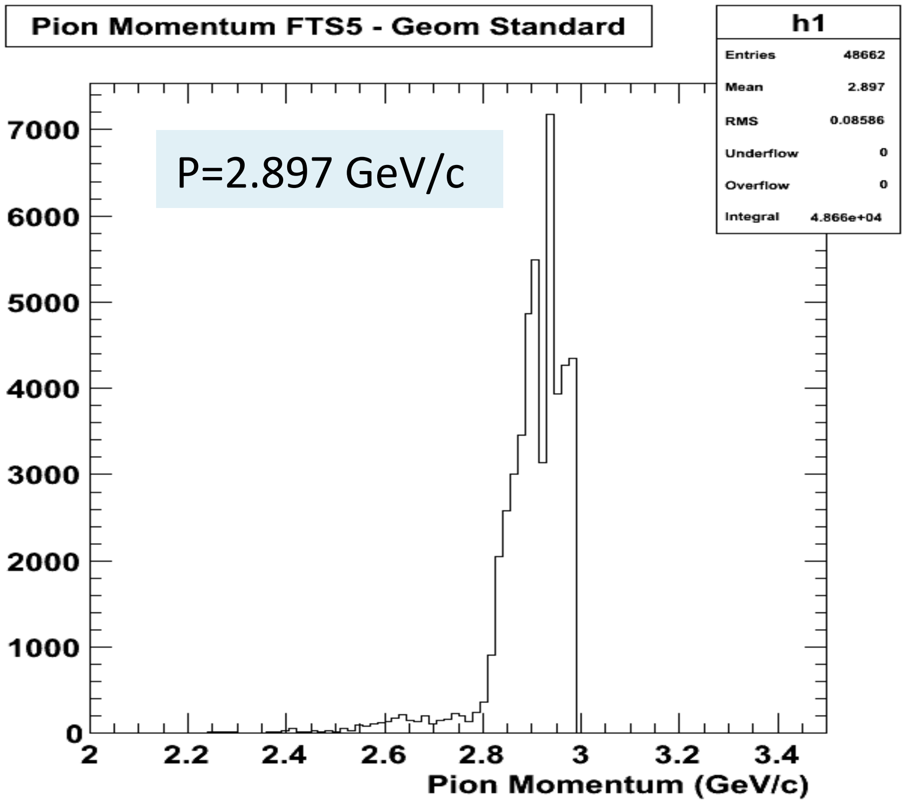


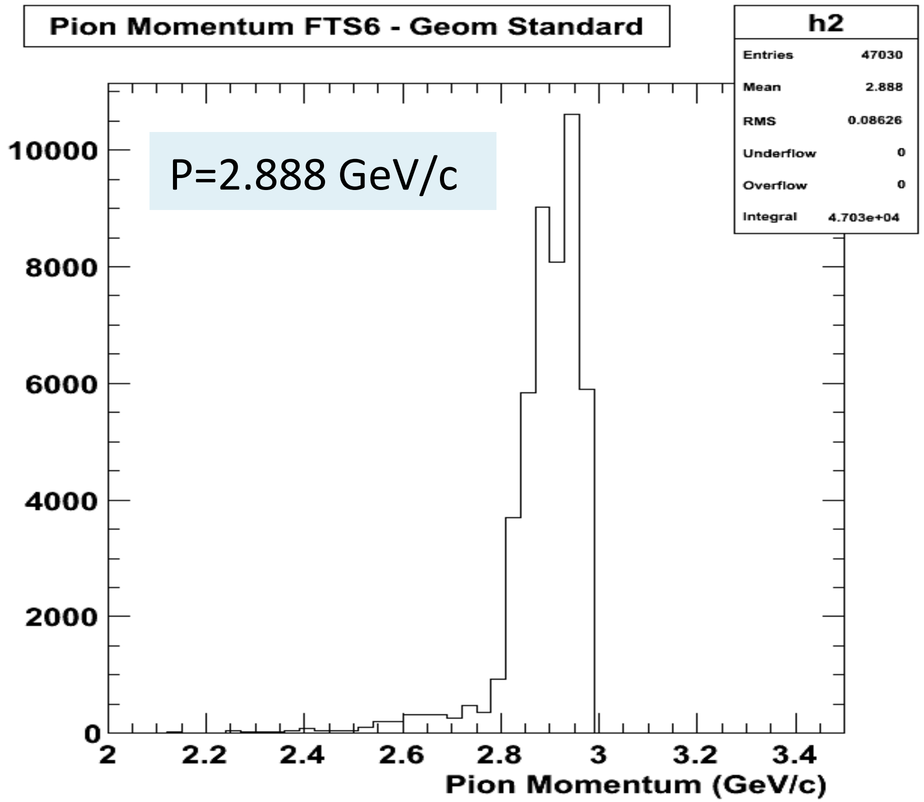


How much is the energy loss in the RICH detector?

We check the pion's momentum in the Forward Station number 5 and number 6, so just before the RICH detector and after the RICH detector in the standard geometry configuration.

Generated Pion's Momentum = 3 GeV/c
Only Primary Tracks selected





Difference in Momentum =9 MeV/c

Aim:

Study the **Momentum and Position Resolution** (x, y, z) of the **FTS Standalone** for muons at different momentum. The study is done also for **different skew angles**.
Fit with a double gaussian function

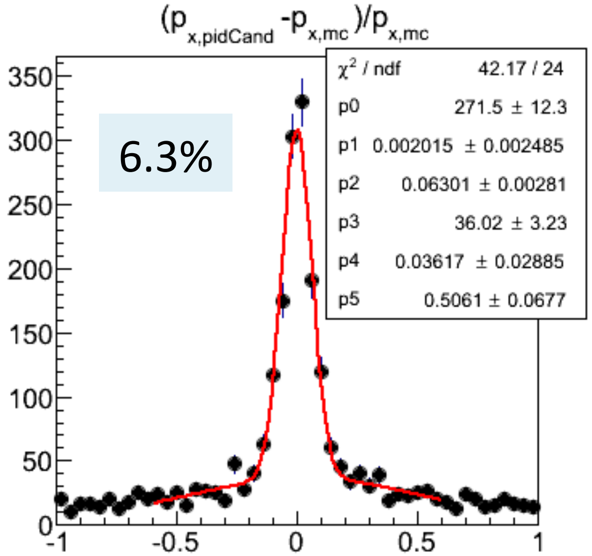
Strategy:

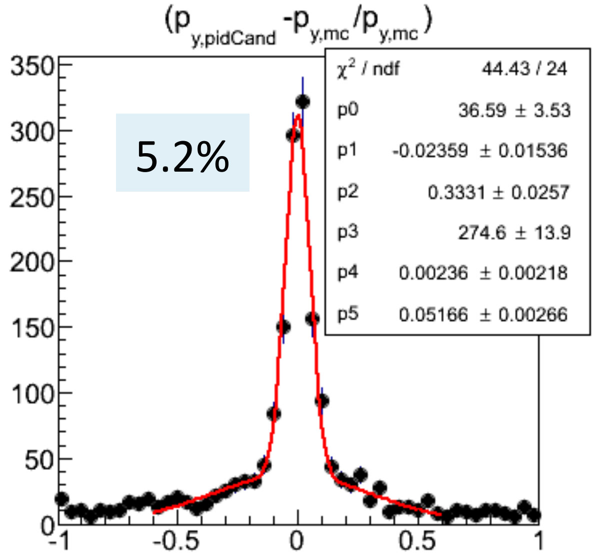
- BoxGenerator is used for the simulation
- **10.000 Muons** simulated with different momentum:
  500 MeV, 1 GeV, 3 GeV, 5 GeV
- **Straws inclinations**: 0, 1, 3, 5 (standard), 8, 10 degrees
- Uniformly in phi: [0,360°]
- **Uniformly in theta: [0,5°]**
- Detectors included: **FTS standalone**
- Beam Momentum = 15 GeV/c
- Pandaroot version: 19906
- **Only primary tracks selected**
- Ideal Forward Tracking
- **Vertex smearing: (0.1, 2, 0.1) cm**
- **Momentum smearing: 10%**
- **Numbers of Fts Hits>40 (>24 for p=500 MeV)**
- **We select only the reconstructed tracks by the Kalman fit**

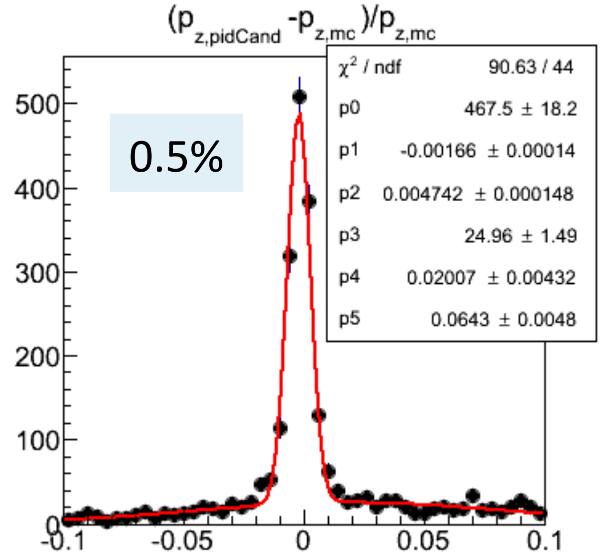
Momentum Resolution

Muon 3 GeV/c
Theta: [0,5]°
Skew Angle: 5°

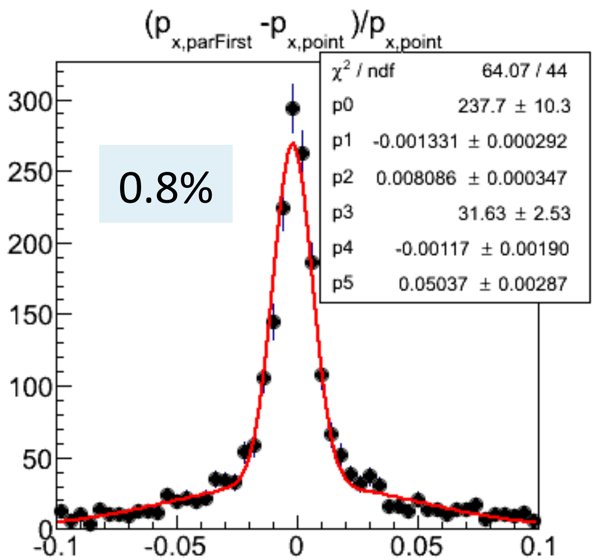
(Reconstructed Momentum – MC Momentum) / MC Momentum

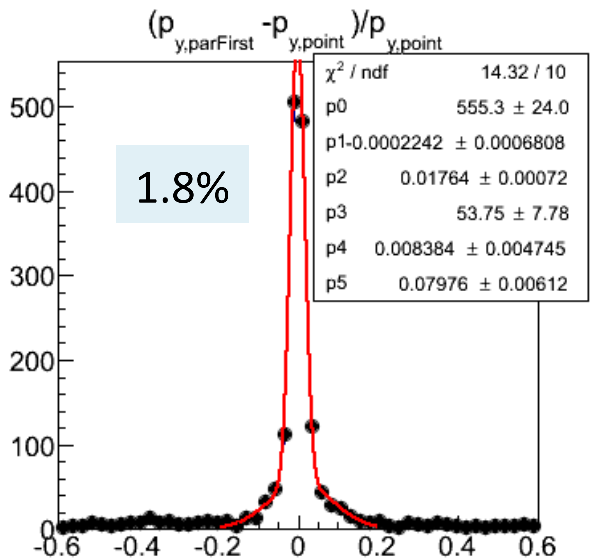


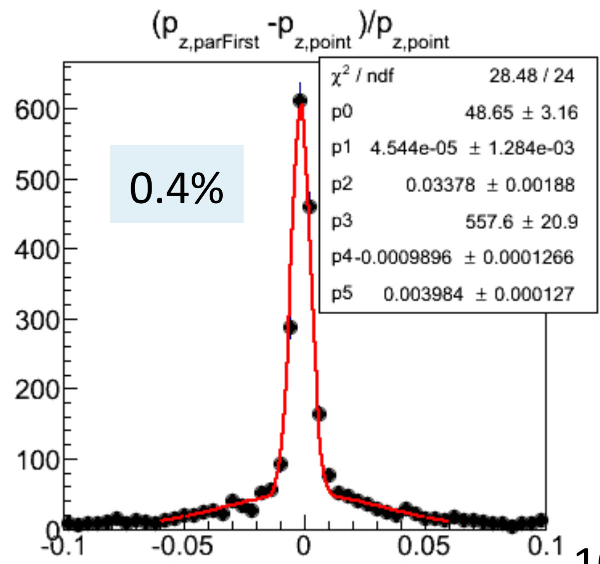




Residual distribution of the first parameter of the track



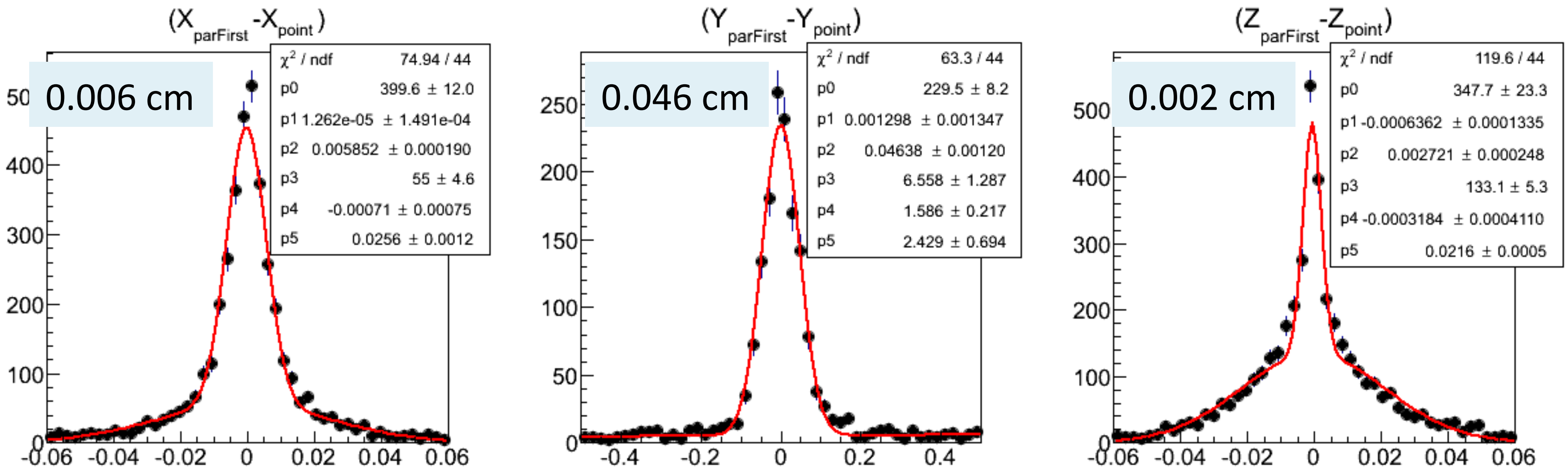




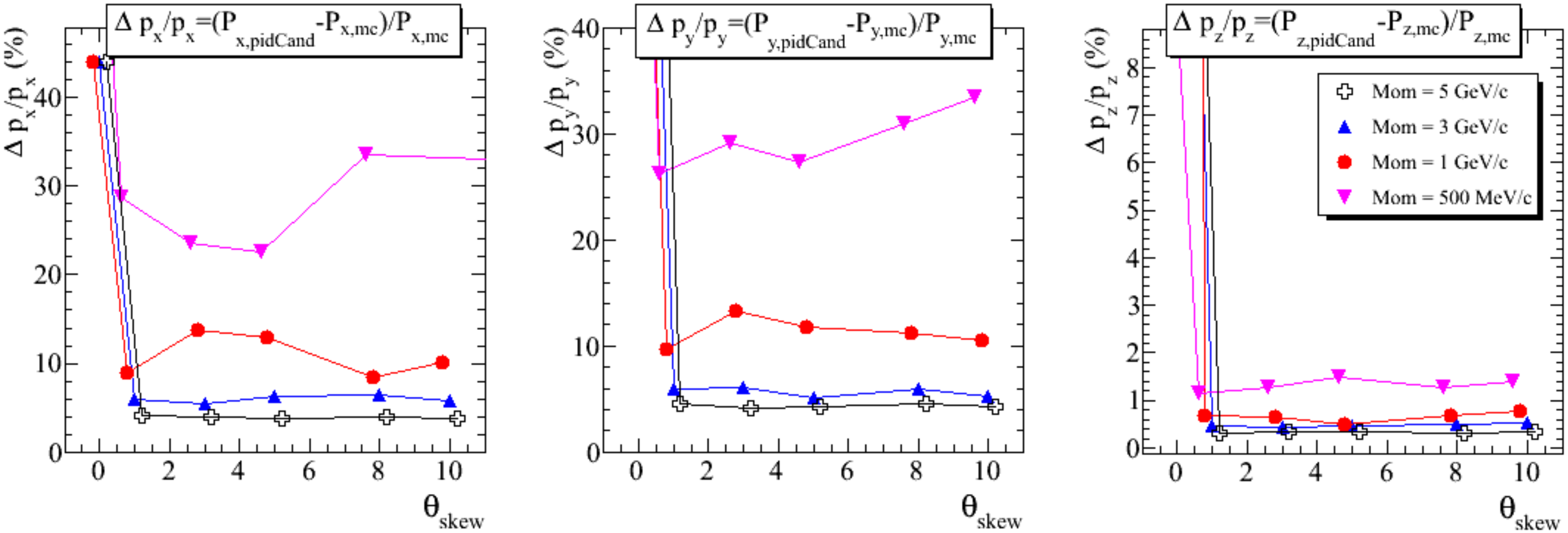
Position Resolution

Muon 3 GeV/c
Theta: [0,5]°
Skew Angle: 5°

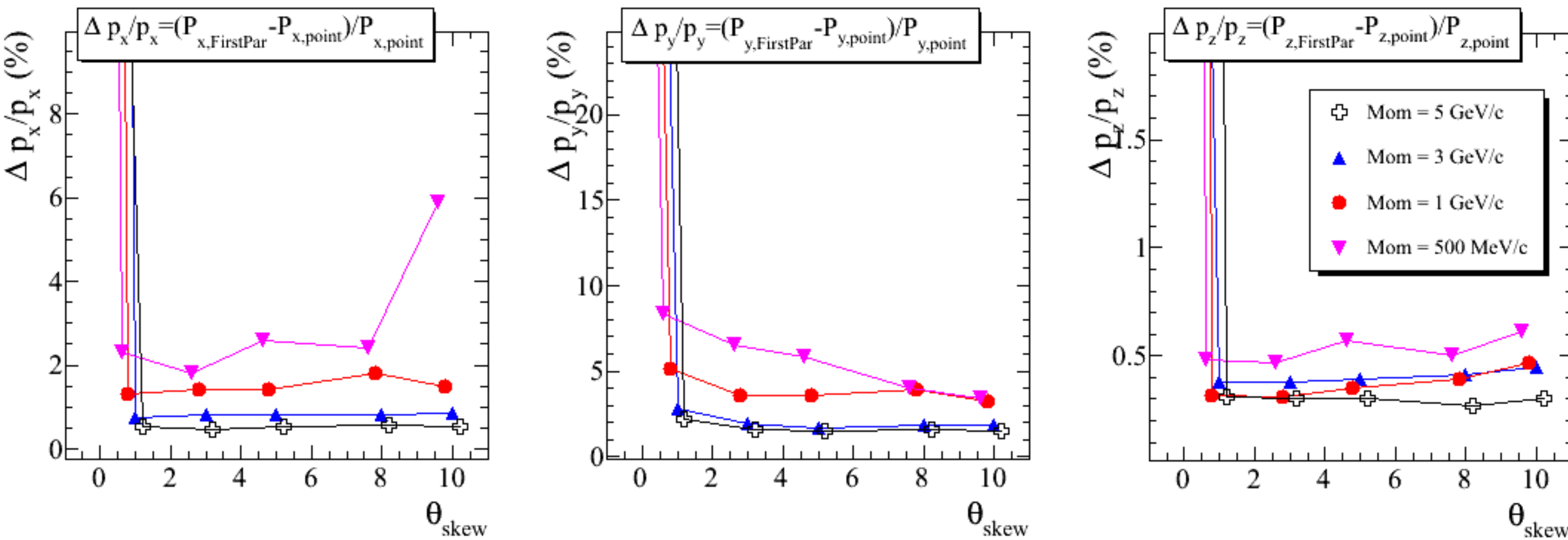
Residual distribution of the first parameter of the track



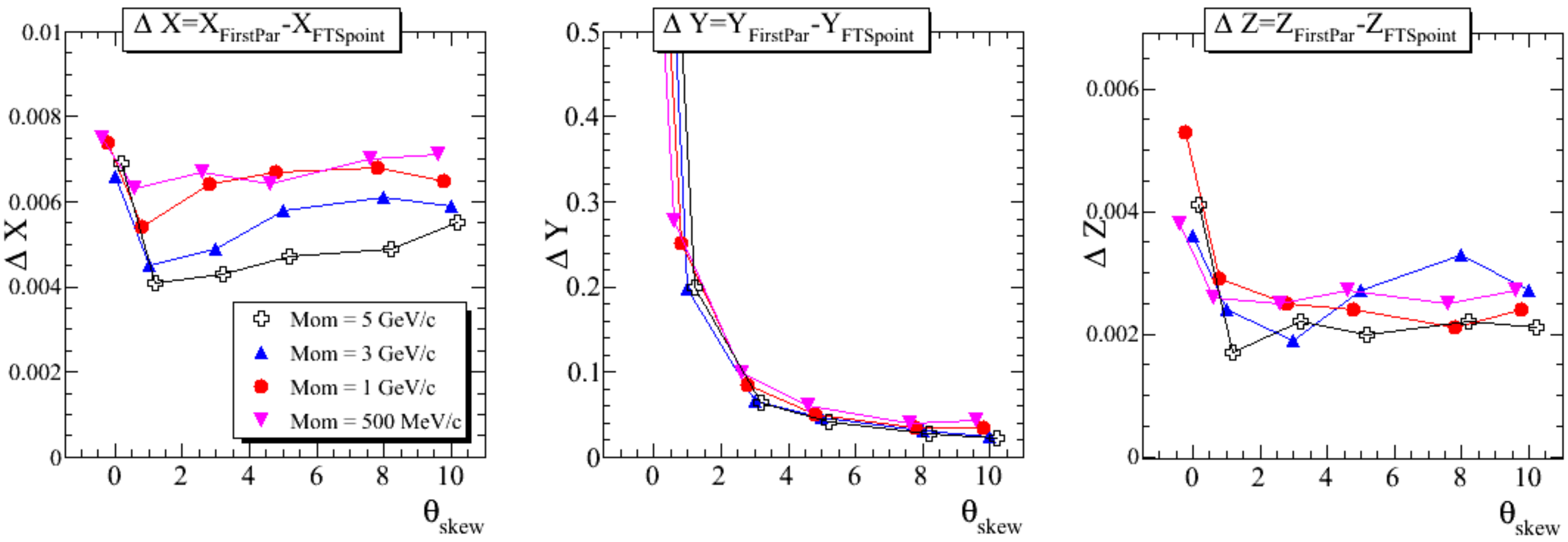
x axis: Straw skew angle Y axis: x,y,z Momentum Resolution (%) calculated as (RECO-MC)/MC



x axis: Straw skew angle; Y axis: x,y,z Momentum Resolution (%) calculated for the first parameter of the track



x axis: Straw skew angle Y axis: x,y,z Position Resolution (cm) calculated the first parameter of the track



Aim:

Study the momentum resolution in **x, y and z** for the MVD+GEM+FTS pions simulation at different momentum.

(Reconstructed Momentum – MC Momentum) / MC Momentum

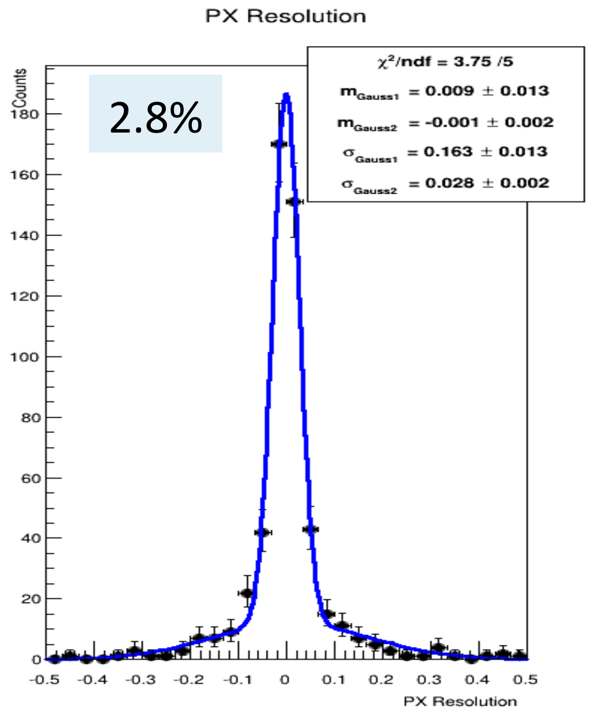
Fit with a double gaussian function

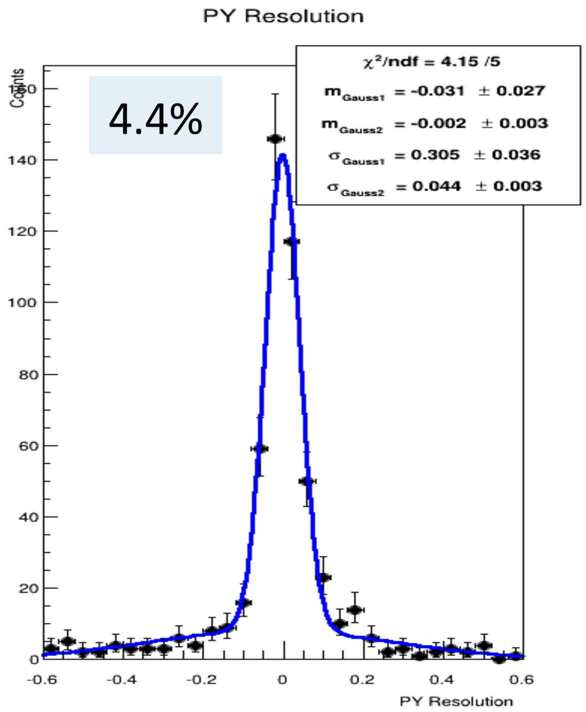
Strategy:

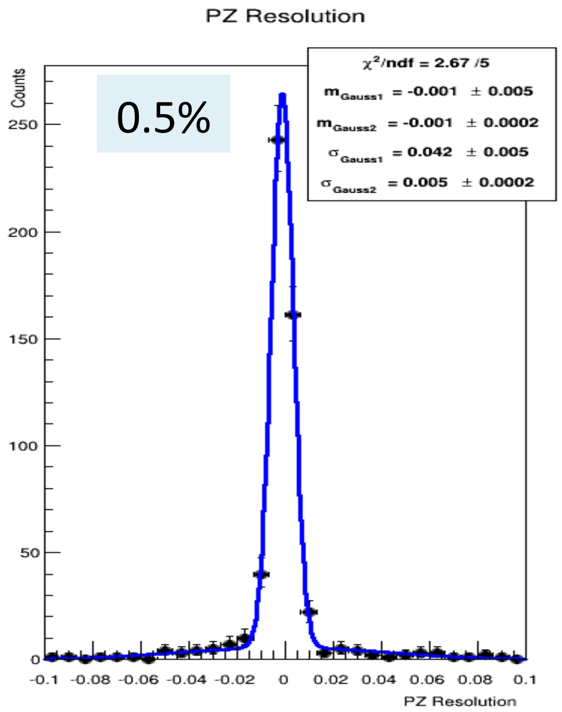
- BoxGenerator is used for the simulation
- **1000 Pions** simulated with different momentum:
  1 GeV, 2 GeV, 3 GeV, 4 GeV, 5 GeV
- Uniformly in phi: [0,360°]
- **Uniformly in theta: [0,10°]**
- Detectors included: **MDV+GEM+FTS**
- Beam Momentum = 15 GeV/c
- Pandaroot version: 19960
- Ideal Forward Tracking
- **Vertex smearing: (0.05, 0.05, 0.05) cm**
- **Momentum smearing: 0.05 %**
- **Not only primary tracks selected**
- **We select only the reconstructed tracks by the Kalman fit**

3 GeV
Geov1: standard

(Reconstructed Momentum – MC Momentum) / MC Momentum

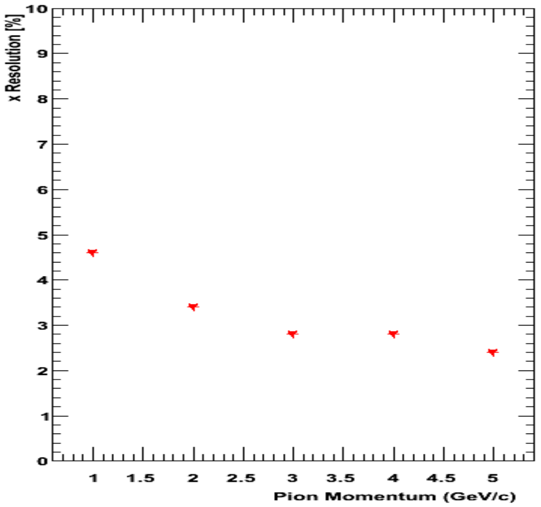


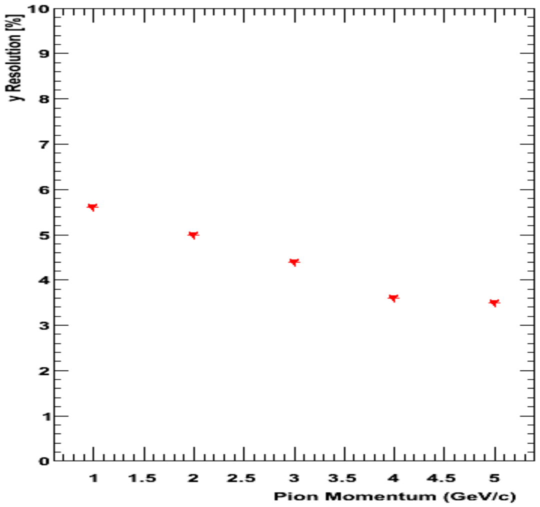


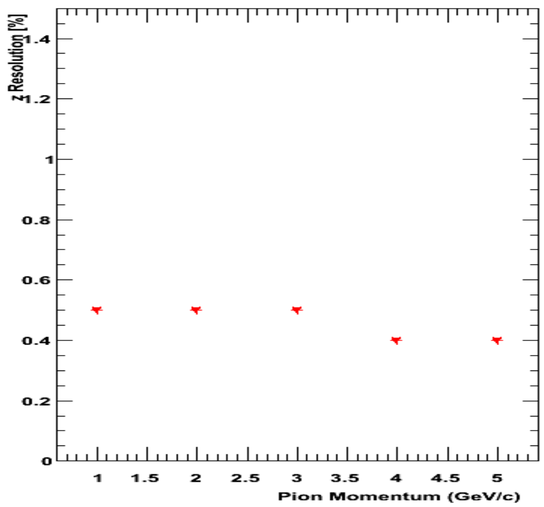


Standard Geometry (geov1)

x axis: Pion Momentum Y axis: x,y,z Momentum Resolution (%)

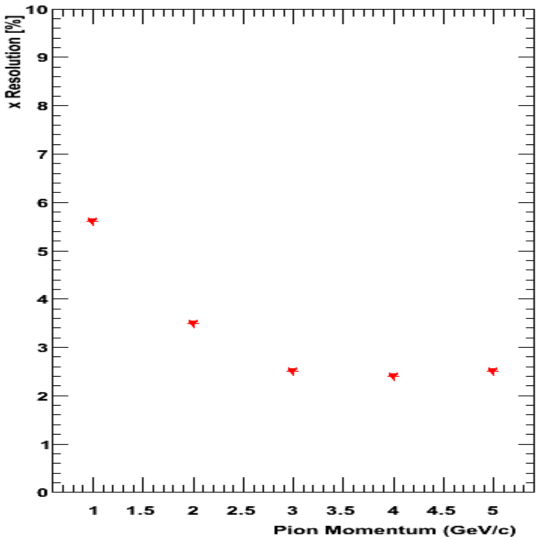


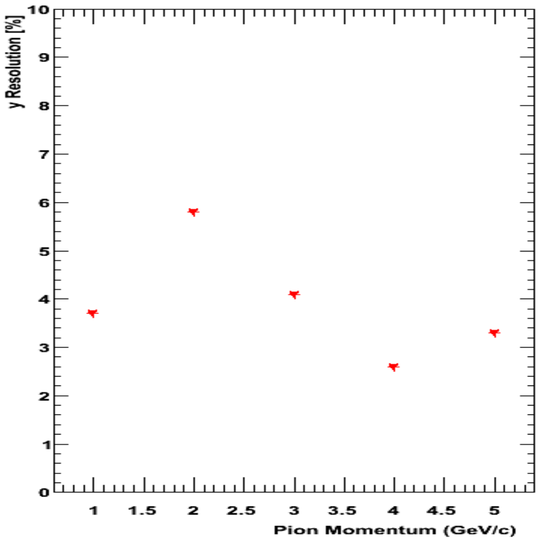


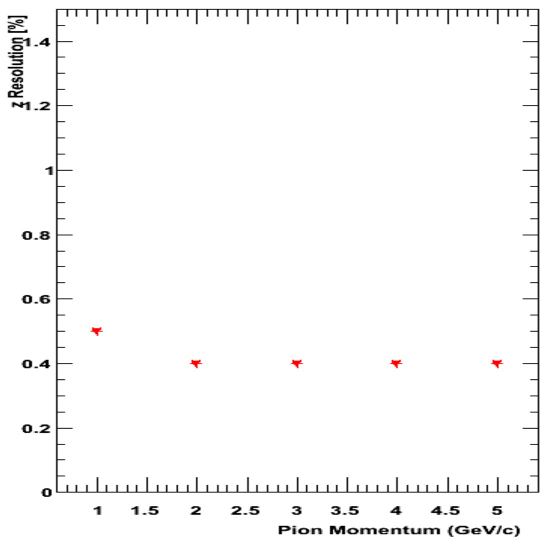


Compact Geometry (geov2)

x axis: Pion Momentum Y axis: x,y,z Momentum Resolution (%)

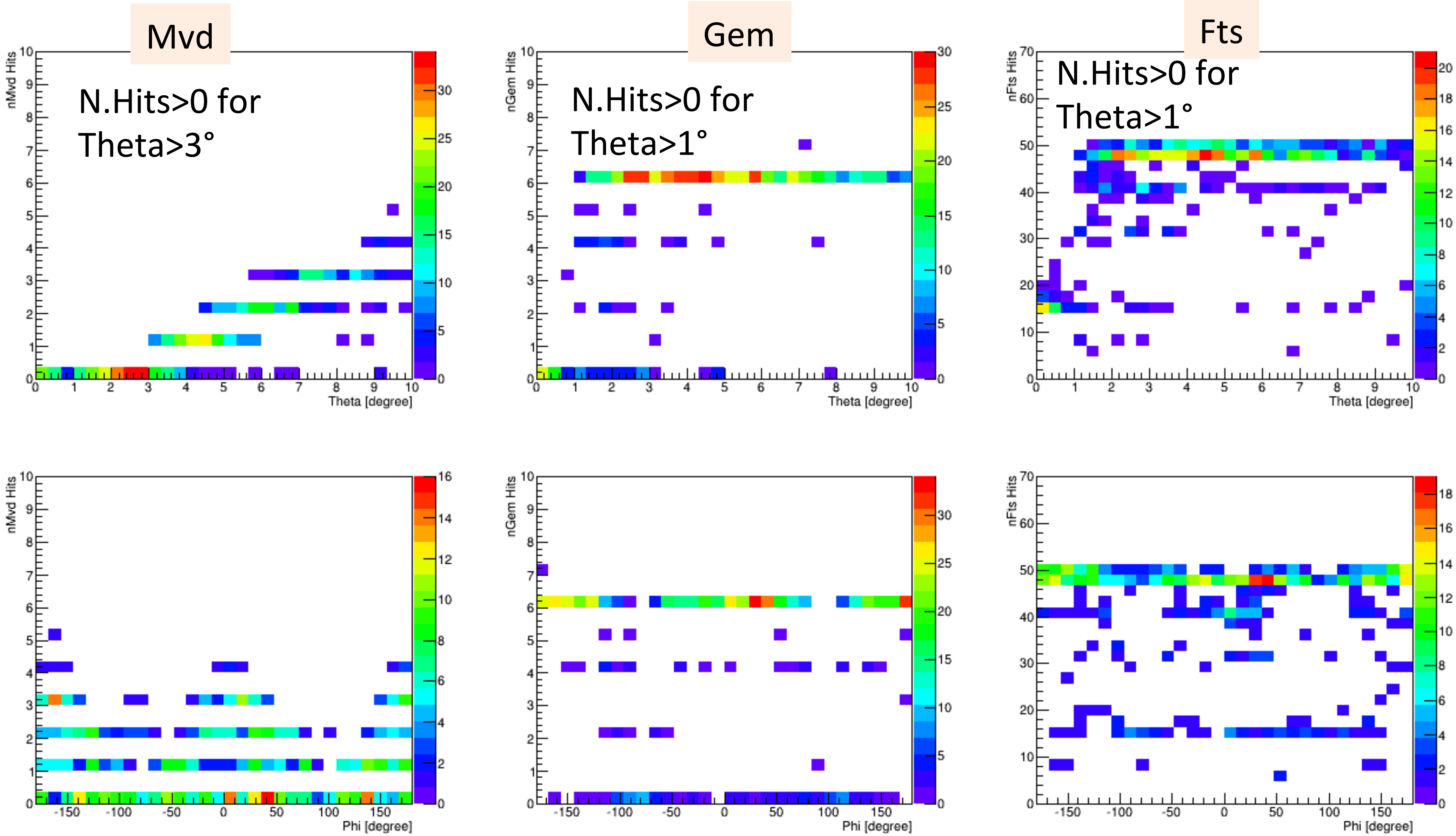






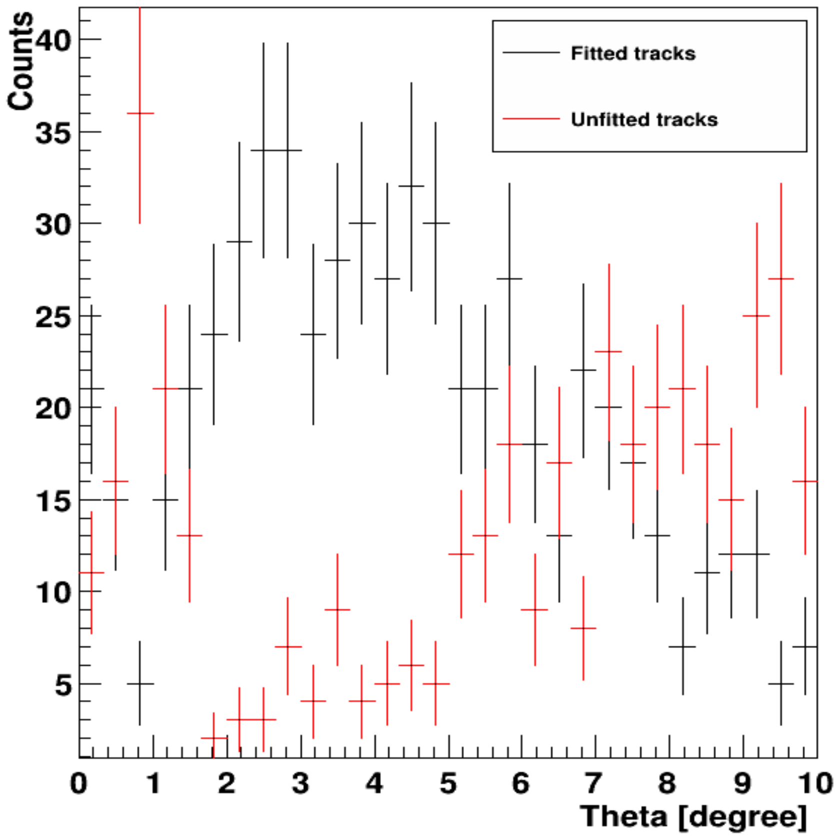
Which is the number of: Mvd, Gem and Fts Hits in function of theta and phi angles?

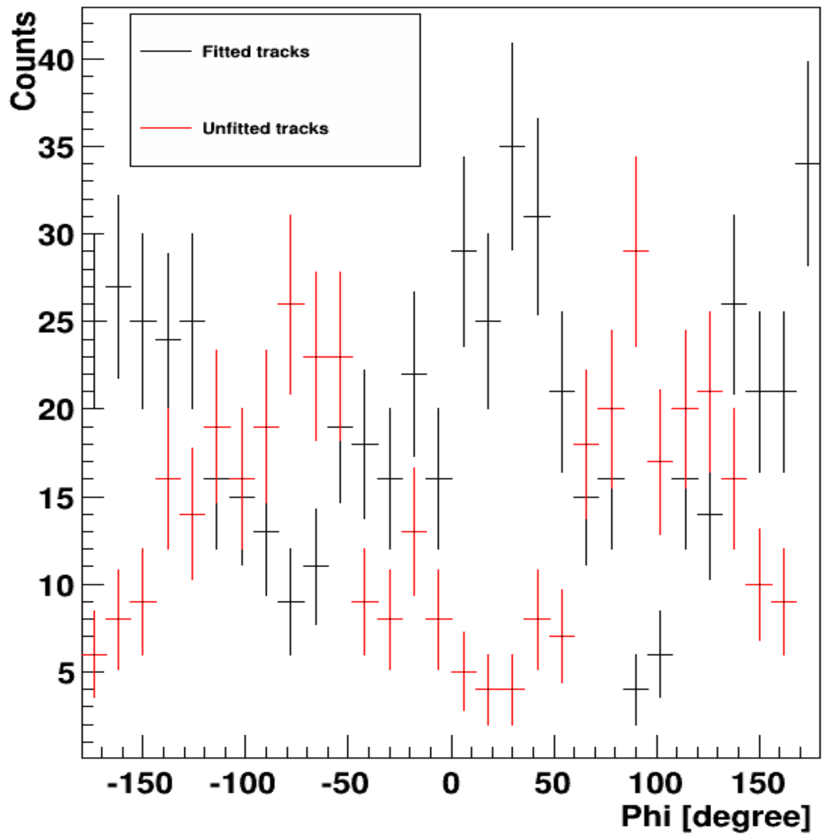
Standard Geometry geov1
Pion 3 GeV/c
Theta: [0,10]°



Which is the theta and phi distributions for fitted and unfitted tracks?

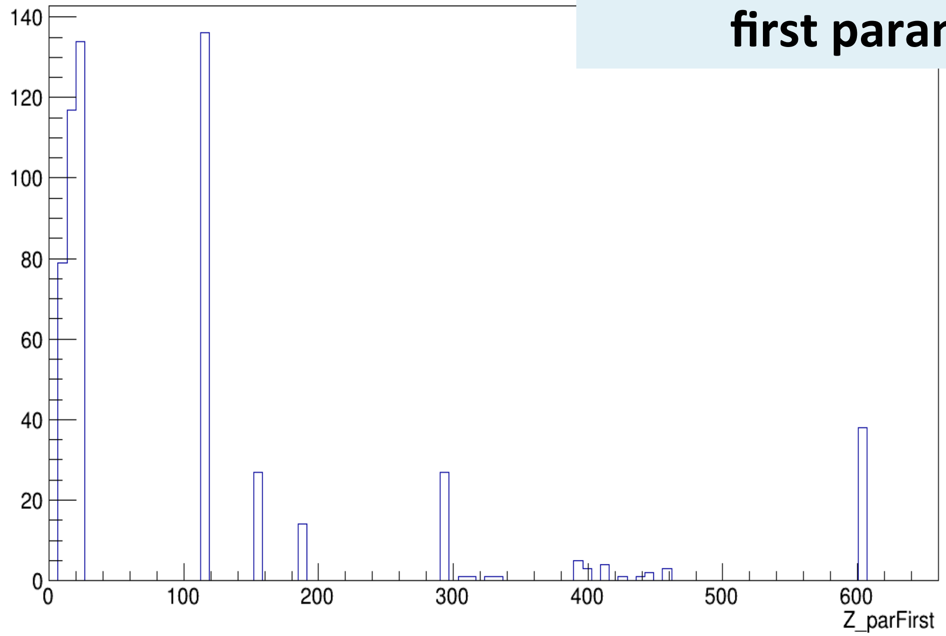
Standard Geometry geov1
Pion 3 GeV/c
Theta: [0,10]°





Unfitted tracks: for small (< 1°) and big theta (>5°)
for phi: ± 90°

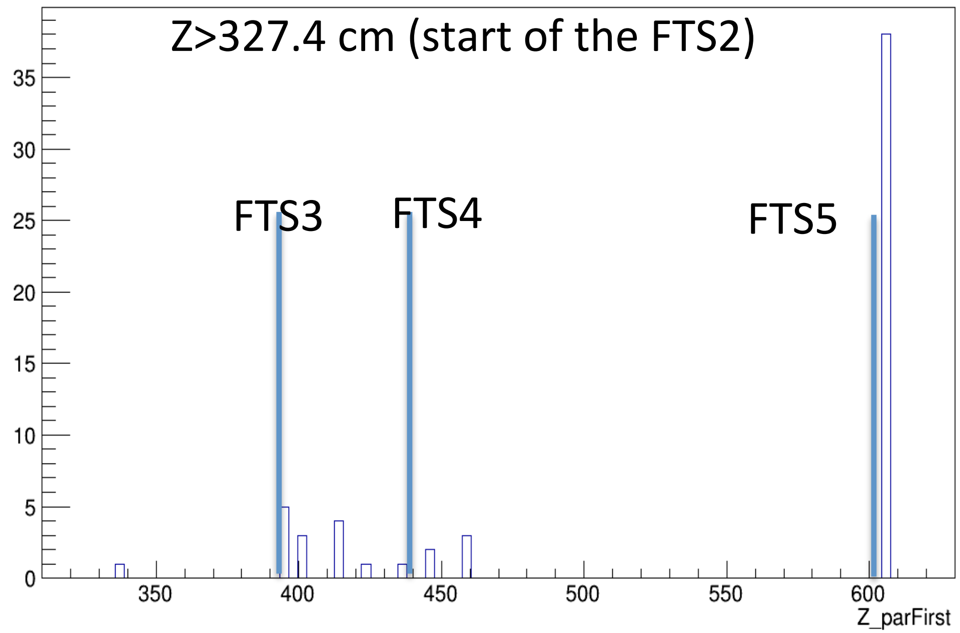
Which is the distribution of the z coordinate of the first parameters of the reconstructed track?



Standard Geometry geov1
Pion 3 GeV/c
Theta: [0,10]°

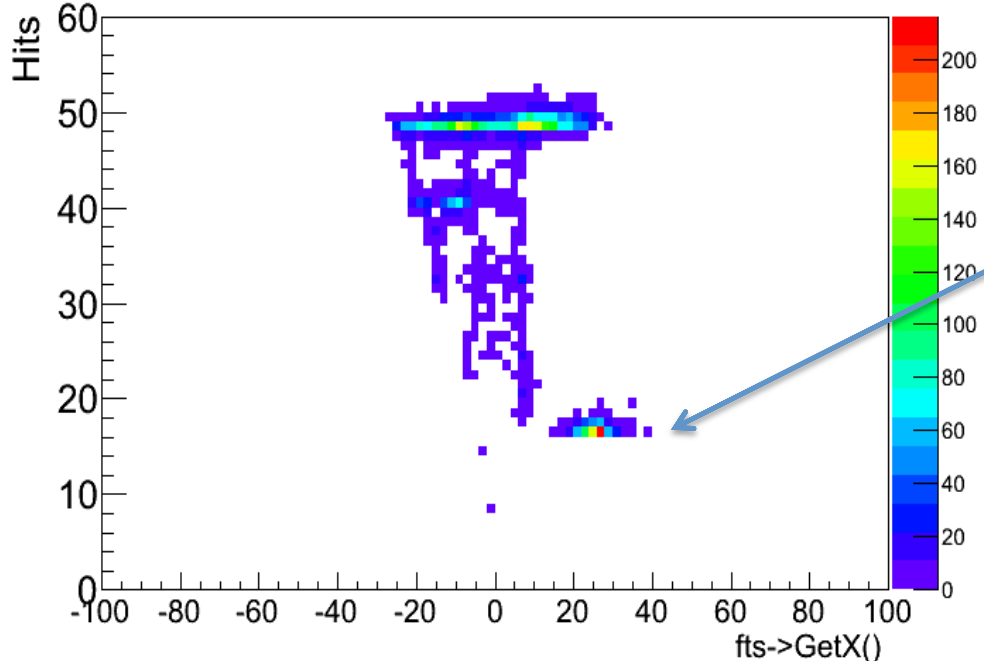
Some first parameters belong to the FTS2/3/4/5/6 !!

Start of the FTS1 z=2954 mm
FTS2 z=3274 mm
FTS3 z=3945 mm
FTS4 z=4385 mm
FTS5 z=6075 mm
FTS6 z=7475 mm



Standard Geometry geov1
Muon 3 GeV/c
Theta: [0,5]°
FTS Standalone

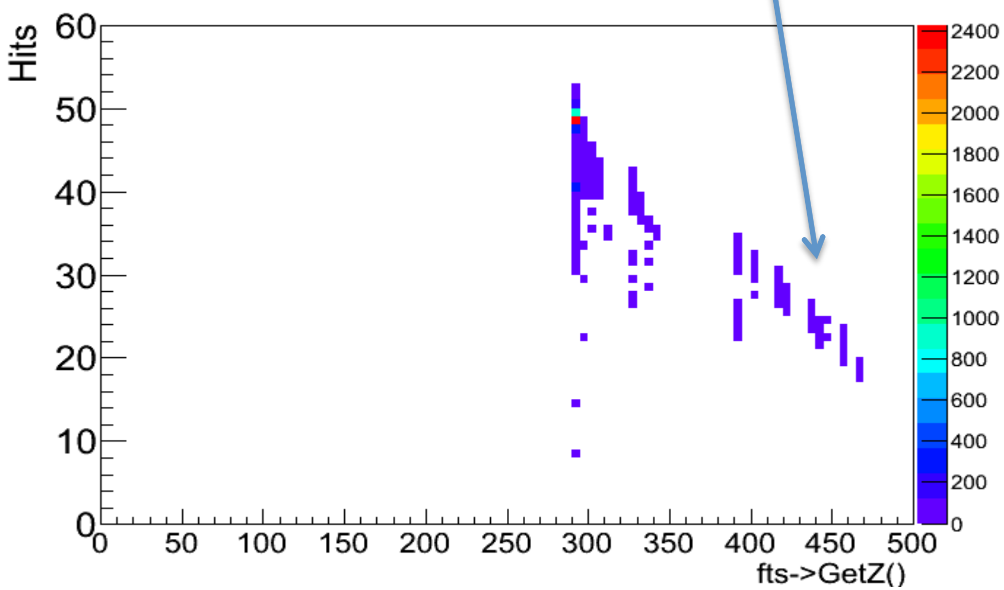
FTS Hits vs X coordinate



Muons that are inside the beam pipe and hit the 5-6 FTS stations:

- The hole of the beam pipe for the last two stations are shifted in order to introduce the bending of the beam pipe
- The trajectories are bent by the magnetic field

FTS Hits vs Z coordinate



Conclusions

Ferrara group is doing different studies about:

- **Resolution studies** on momentum (x,y,z) and position (x,y,z) for pions and muons (for different **geometry configurations** and for different **skew angles**) for FTS standalone and for MVD+GEM+FTS.

- **Acceptance studies**

http://panda-wiki.gsi.de/cgi-bin/view/Tracking/FwdEvoMeetings

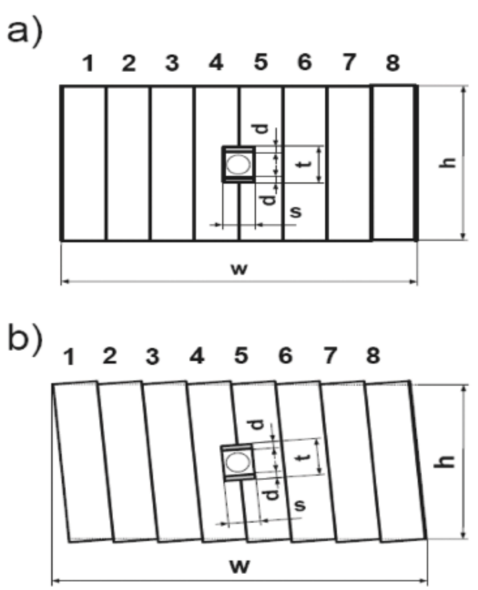
THANKS FOR YOUR ATTENTION

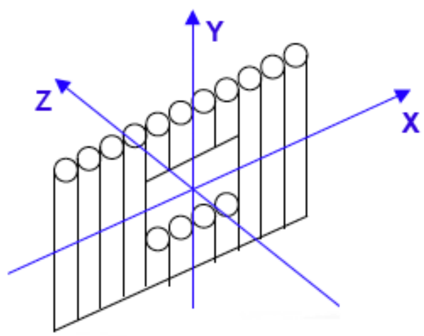
Backup slides

Tracking station	Double layer	Straw inclination	Number of modules (straws)	*z*-coordinate [mm]	Active area	
					w [mm]	*h* [mm]
FT1	1	0°	8 (2x128)	2954	1297.9	640
	2	+5°	8 (2x128)	3004	1358.8	640
	3	-5°	8 (2x128)	3054	1358.8	640
	4	0°	8 (2x128)	3104	1297.9	640
FT2	1	0°	8 (2x128)	3274	1297.9	640
	2	+5°	8 (2x128)	3324	1358.8	640
	3	-5°	8 (2x128)	3374	1358.8	640
	4	0°	8 (2x128)	3424	1297.9	640
FT3	1	0°	12 (2x192)	3945	1944.3	690.3
	2	+5°	12 (2x192)	4019.75	2013.2	703.4
	3	-5°	12 (2x192)	4165	2015.4	728.8
	4	0°	12 (2x192)	4239.75	1944.3	741.9
FT4	1	0°	12 (2x192)	4385	1944.3	767.3
	2	+5°	12 (2x192)	4459.75	2020.0	780.4
	3	-5°	12 (2x192)	4605	2022.2	805.8
	4	0°	12 (2x192)	4679.75	1944.3	818.9
FT5	1	0°	25 (2x400)	6075	4045.1	1180.0
	2	+5°	25 (2x400)	6125	4163.7	1180.0
	3	-5°	25 (2x400)	6175	4163.7	1180.0
	4	0°	25 (2x400)	6225	4045.1	1180.0
FT6	1	0°	37 (2x592)	7475	5984.3	1480.0
	2	+5°	37 (2x592)	7525	6136.6	1480.0
	3	-5°	37 (2x592)	7575	6136.6	1480.0
	4	0°	37 (2x592)	7625	5984.3	1480.0

Tracking station	Double layer	Straw affected by opening (split straws) 1st layer/2nd layer	*s* [mm]	*t* [mm]
FT1	1	59-70 / 59-70	116	172
	2	59-70 / 59-70	116	172
	3	59-70 / 59-70	116	172
	4	59-70 / 59-70	116	172
FT2	1	59-70 / 59-70	116	172
	2	59-70 / 59-70	116	172
	3	59-70 / 59-70	116	172
	4	59-70 / 59-70	116	172
FT3	1	91-102 / 91-102	116	166
	2	91-102 / 91-102	116	166
	3	91-102 / 91-102	116	166
	4	91-102 / 91-102	116	166
FT4	1	91-102 / 92-103	116	166
	2	91-102 / 92-103	116	166
	3	91-102 / 92-103	116	166
	4	91-102 / 92-103	116	166
FT5	1	197-215/ 197-215	187	238
	2	197-215 / 197-215	187	238
	3	197-215 / 197-215	187	238
	4	197-215 / 197-215	187	238
FT6	1	298-316 / 299-317	187	238
	2	298-316 / 299-317	187	238
	3	298-316 / 299-317	187	238
	4	298-316 / 299-317	187	238

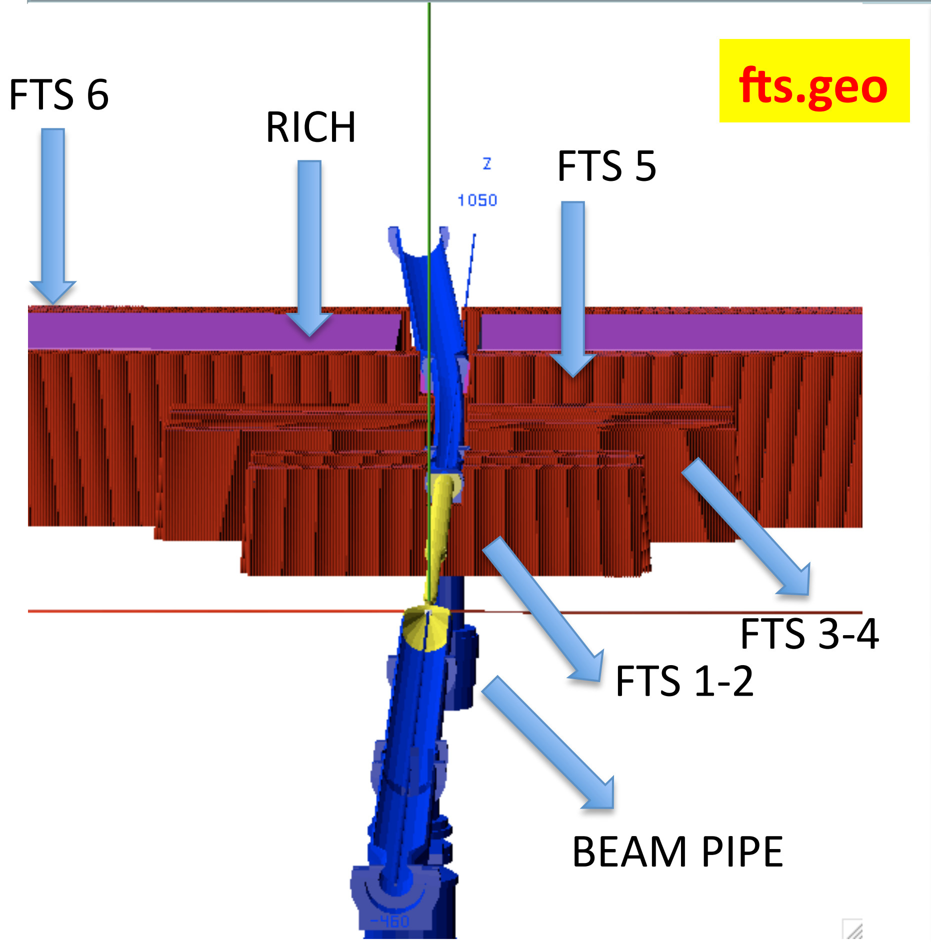
- All the dimensions and distances were decided on December 2009.
- Simulation of all the tubes: 13056

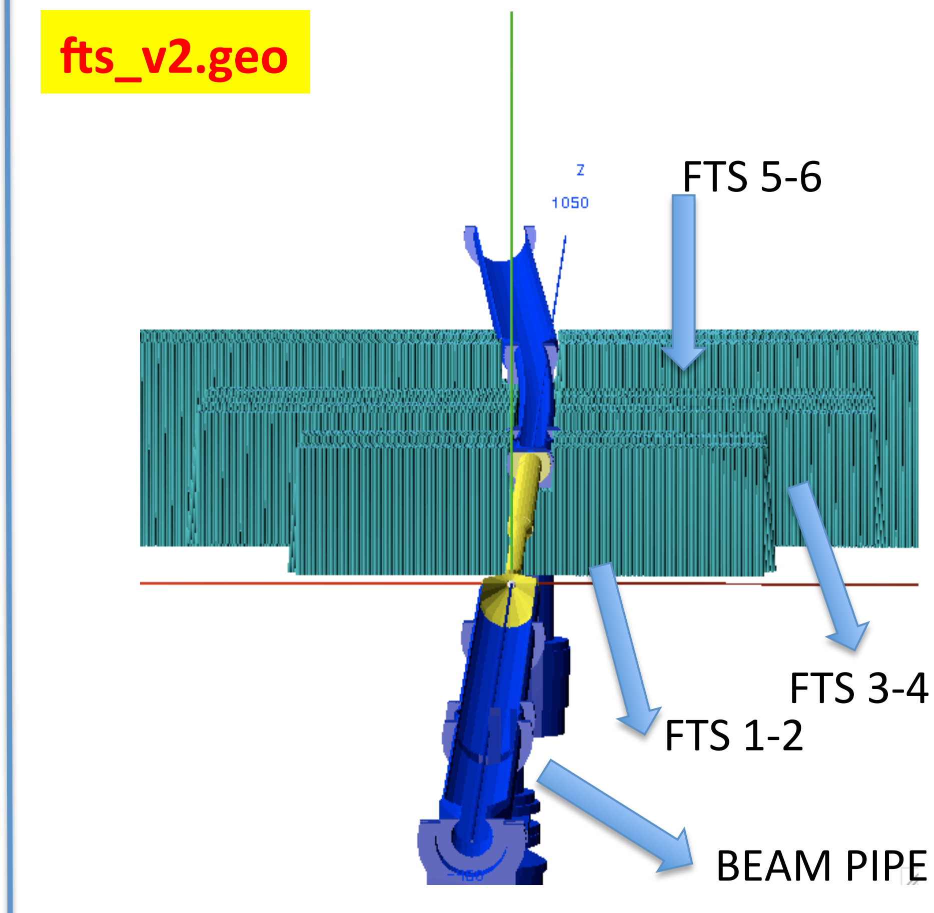


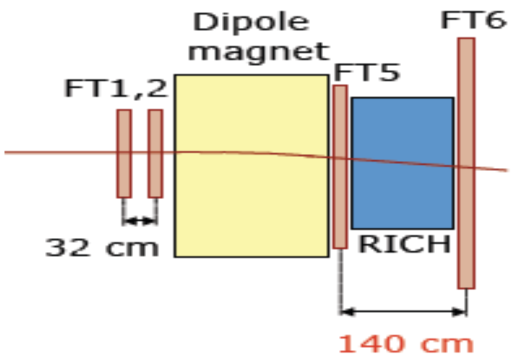


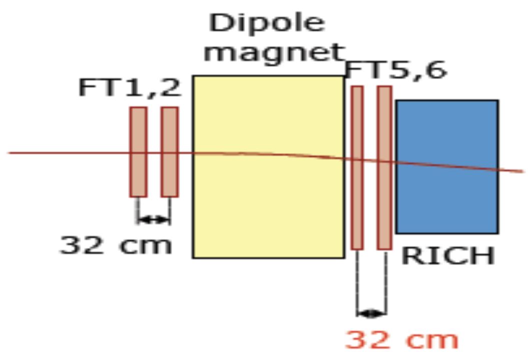
- 6 stations: two before, two inside, two after the dipole magnet.
- 4 double layers for each station: 24 double layers.
- For each double layers there are two planes. The double layers have different dimensions and distances.
- The second and the third double layers are inclined of ±5° (the central planes of each stations).
- The hole for the beam pipe is squared, inclined and different for each double layers

Three geometry configurations available

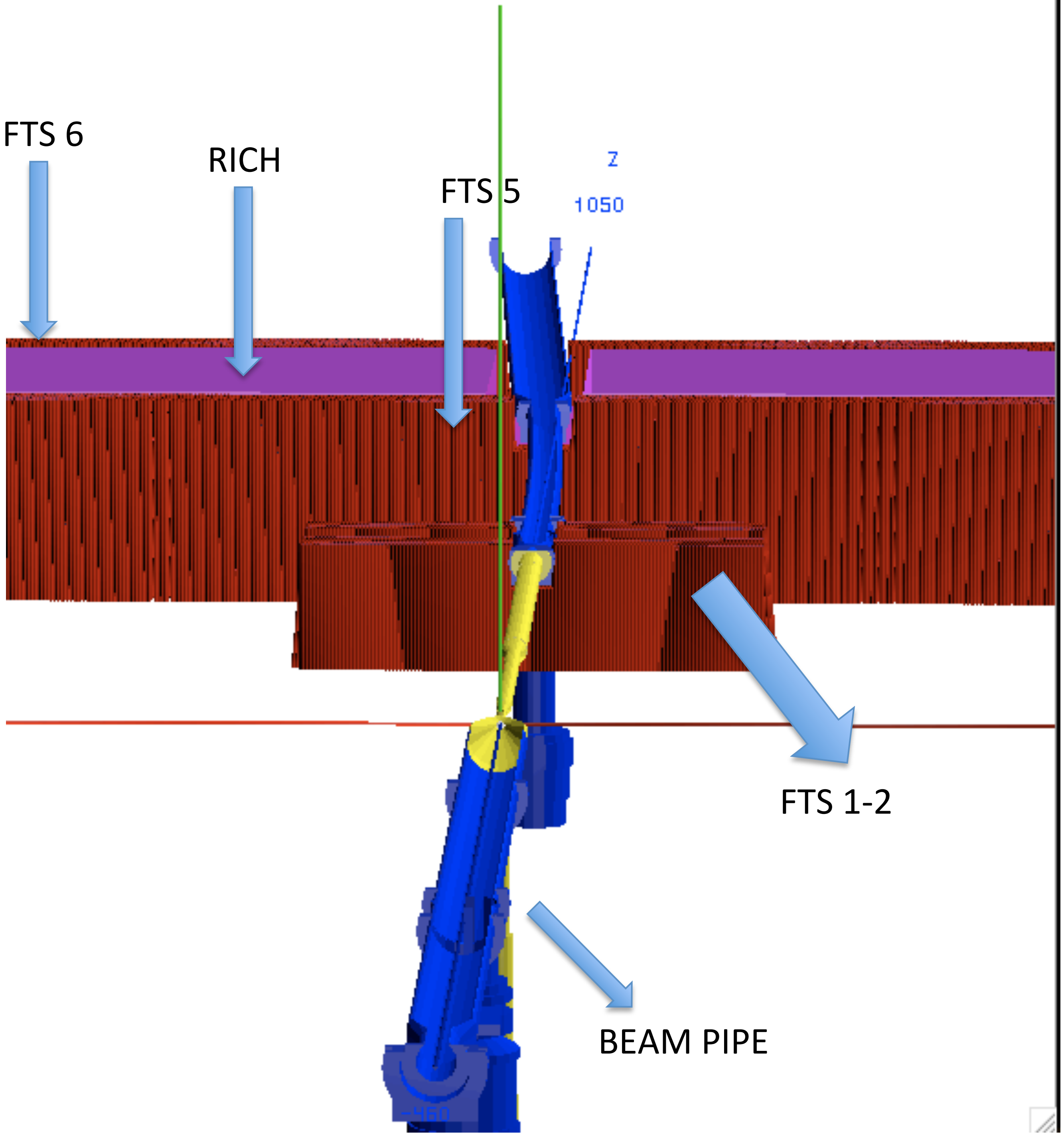








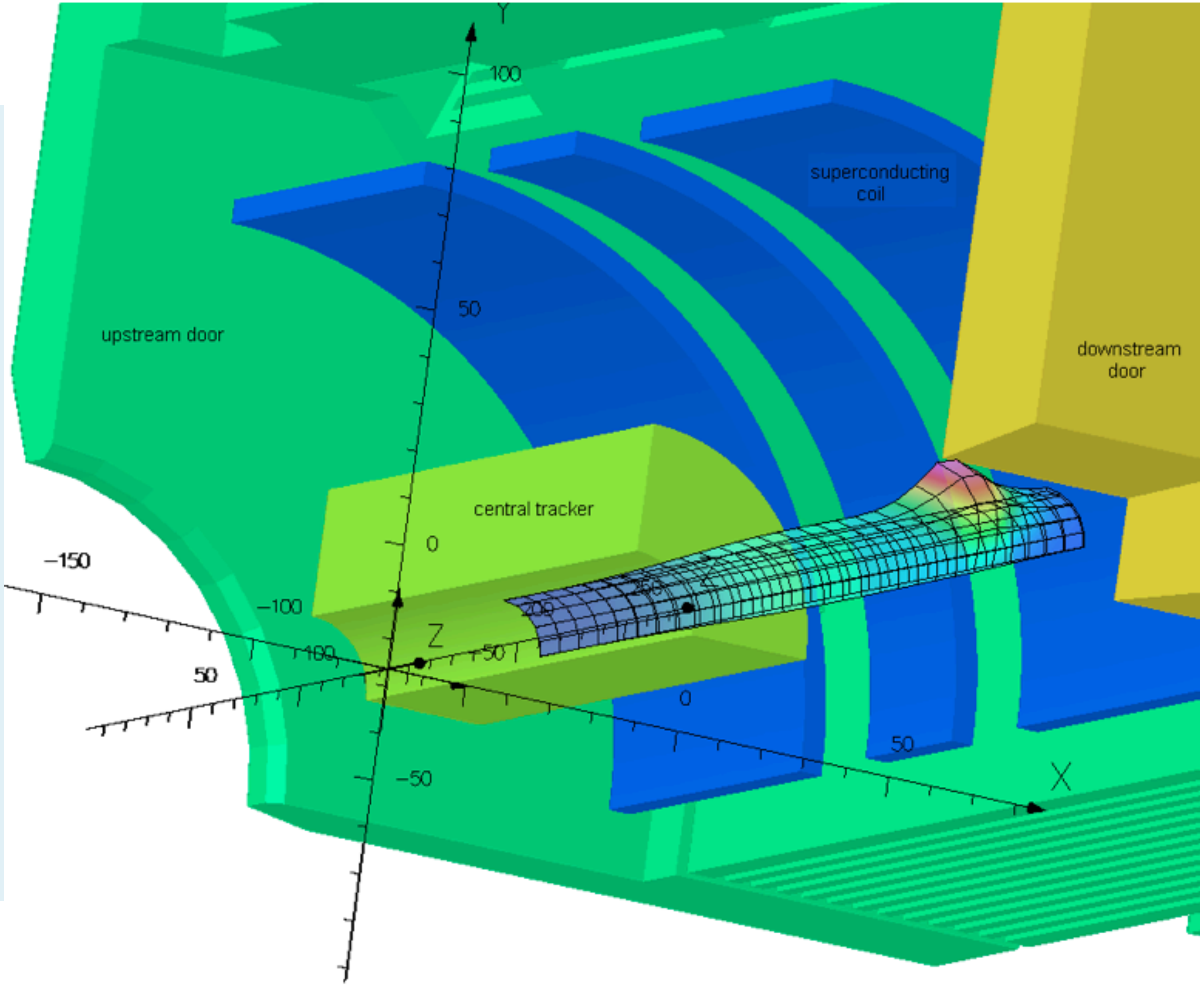
Fts_1256.geo



No FTS 3 and FTS 4:
No stations inside
The dipole

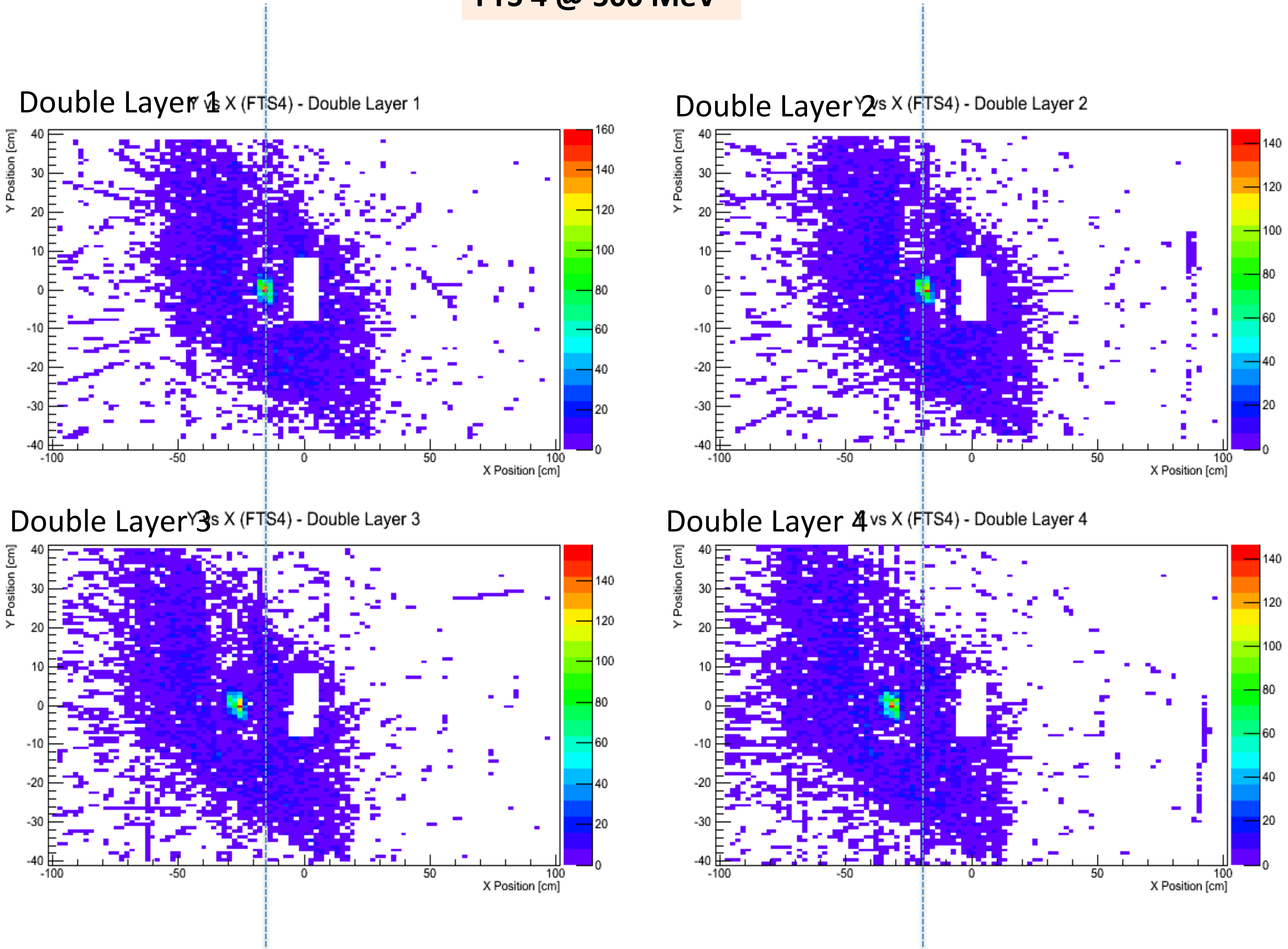
We asked help to Jost Luehning who told us that:

The distortion of the shape is due to the rectangular shape of the aperture which we need in the downstream door of the solenoid. In the aperture the field component in y-direction is much bigger than in x-direction



Radial field on the surface of a cylinder with a radius of 10 cm.
Maximum field towards the top edge of the aperture of the downstream door (red/pink): 2080 Gauss

FTS 4 @ 500 MeV


Double Layer 1
Y vs X (FTS4) - Double Layer 1
Double Layer 2
Y vs X (FTS4) - Double Layer 2
Double Layer 3
Y vs X (FTS4) - Double Layer 3
Double Layer 4
Y vs X (FTS4) - Double Layer 4
Y Position [cm]
X Position [cm]

Tracking station	Double layer	Straw inclination	Number of modules (straws)	z-coordinate [mm]	Active area	
					w [mm]	h [mm]
FT1	1	0°	8 (2x128)	2954	1297.9	640
	2	+5°	8 (2x128)	3004	1358.8	640
	3	-5°	8 (2x128)	3054	1358.8	640
	4	0°	8 (2x128)	3104	1297.9	640
FT2	1	0°	8 (2x128)	3274	1297.9	640
	2	+5°	8 (2x128)	3324	1358.8	640
	3	-5°	8 (2x128)	3374	1358.8	640
	4	0°	8 (2x128)	3424	1297.9	640
FT3	1	0°	12 (2x192)	3945	1944.3	690.3
	2	+5°	12 (2x192)	4019.75	2013.2	703.4
	3	-5°	12 (2x192)	4165	2015.4	728.8
	4	0°	12 (2x192)	4239.75	1944.3	741.9
FT4	1	0°	12 (2x192)	4385	1944.3	767.3
	2	+5°	12 (2x192)	4459.75	2020.0	780.4
	3	-5°	12 (2x192)	4605	2022.2	805.8
	4	0°	12 (2x192)	4679.75	1944.3	818.9
FT5	1	0°	25 (2x400)	6075	4045.1	1180.0
	2	+5°	25 (2x400)	6125	4163.7	1180.0
	3	-5°	25 (2x400)	6175	4163.7	1180.0
	4	0°	25 (2x400)	6225	4045.1	1180.0
FT6	1	0°	37 (2x592)	7475	5984.3	1480.0
	2	+5°	37 (2x592)	7525	6136.6	1480.0
	3	-5°	37 (2x592)	7575	6136.6	1480.0
	4	0°	37 (2x592)	7625	5984.3	1480.0

In addition:

For FTS1,FTS2,FTS5 and FTS6 (before and after the dipole magnet):

The distance (in z) between second and third double layer is 50 mm

Instead for FTS3 and FTS4 (inside the dipole magnet):

The distance (in z) between second and third double layer is 145.25 mm.

This effect is visible only at low momentum (below 1 GeV)