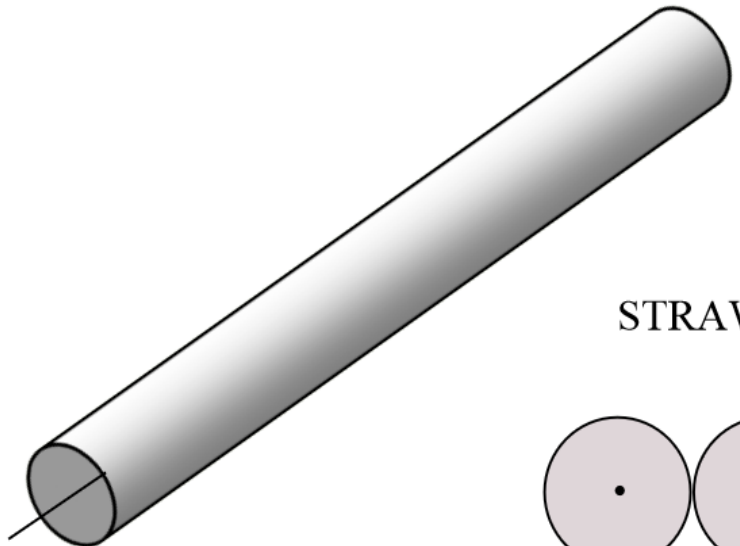
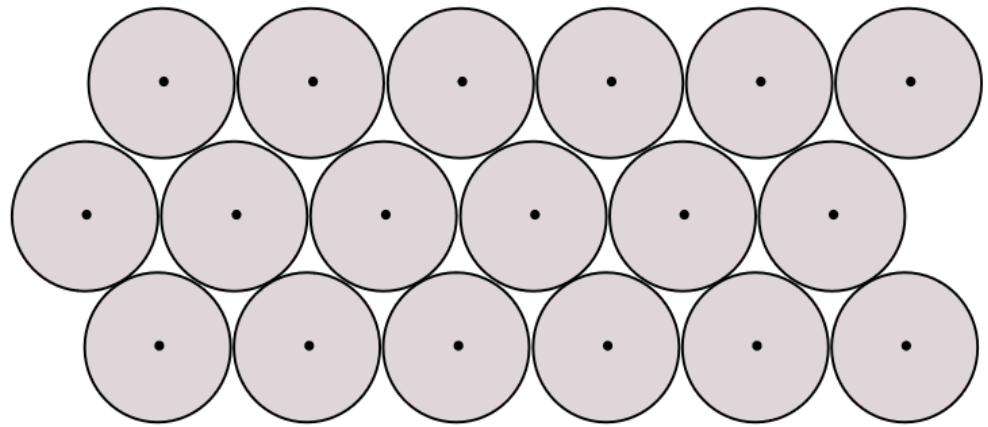
Straw tracker

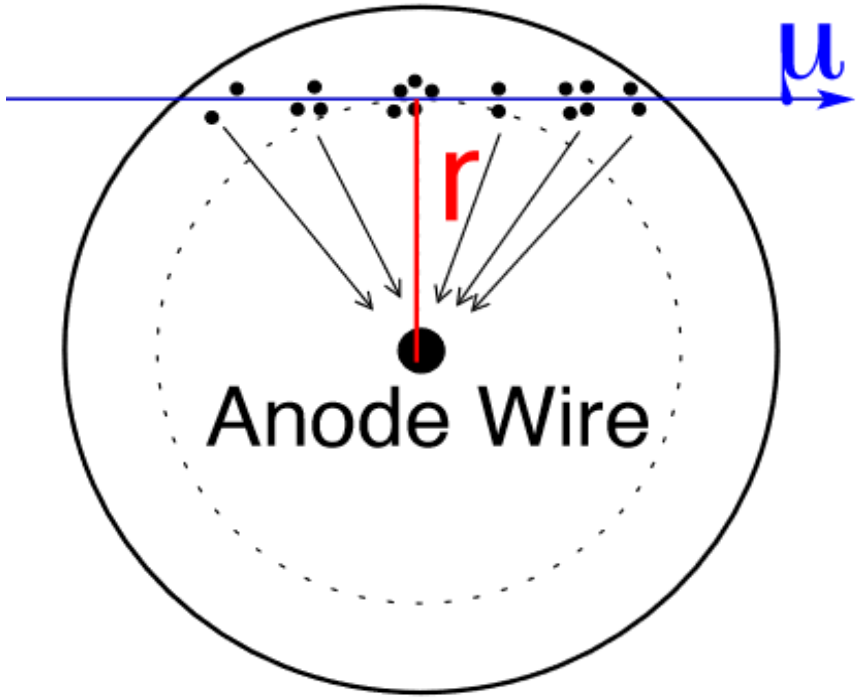
SINGLE WIRE PROPORTIONAL COUNTERS



STRAWS ARRAYS:

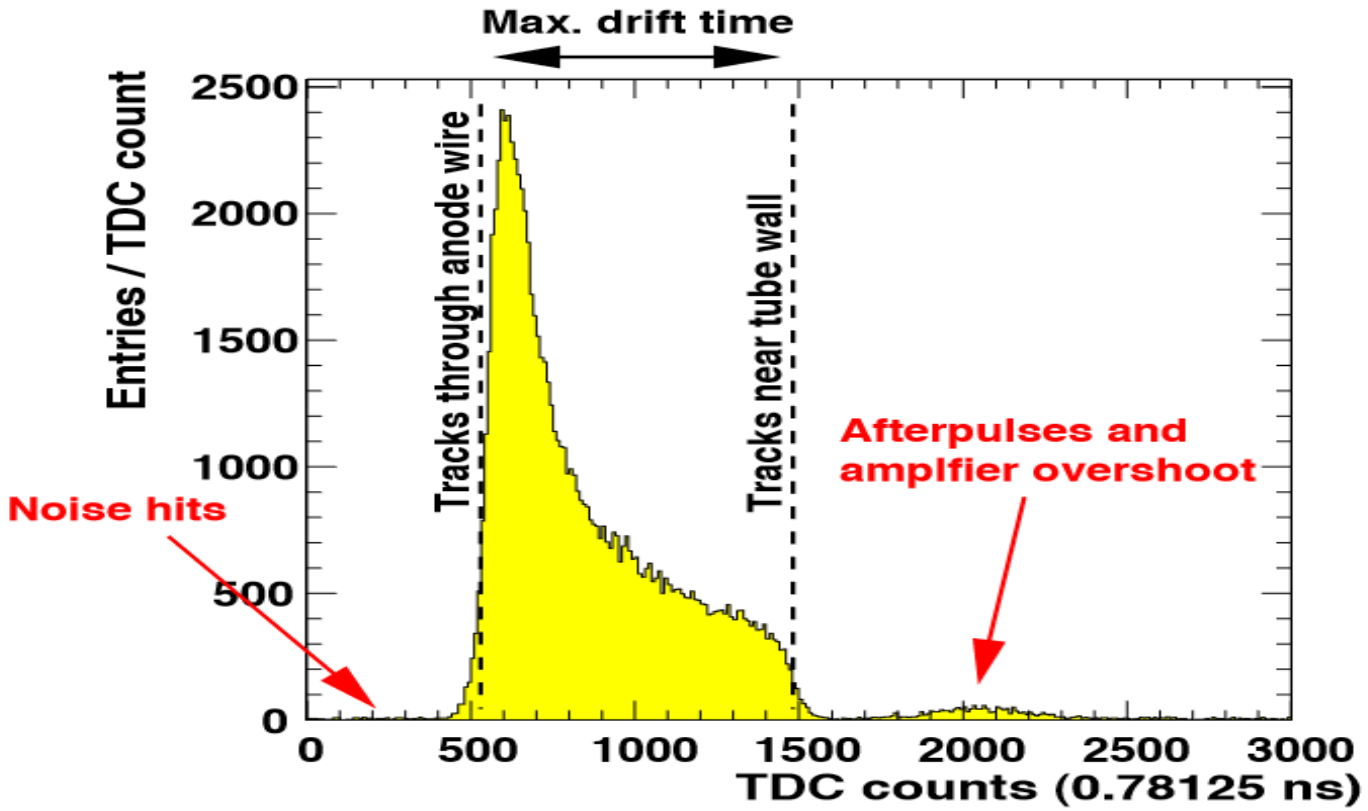


Detection process



Principle of a straw position measurement. A ionizing particle passes at the distance r from anode wire, creating ionization clusters along its path. The primary electrons will drift to the anode wire.

Drift time spectrum



Preliminary 1 mm ~20 nsec

RT-relation

The $r(t)$ relation ("V shape")

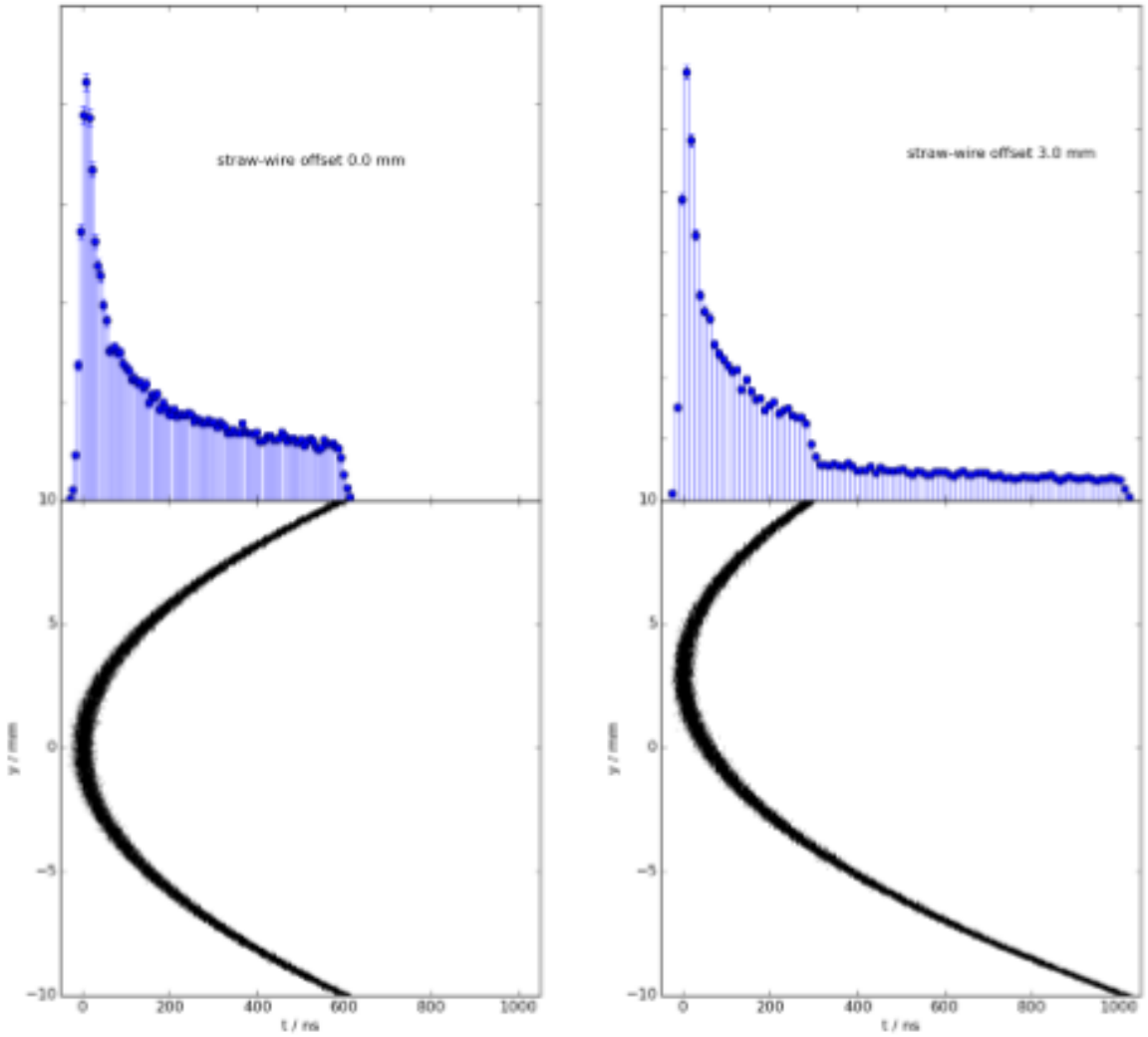
Left figure:

- no wire offset,
- symmetric V shape

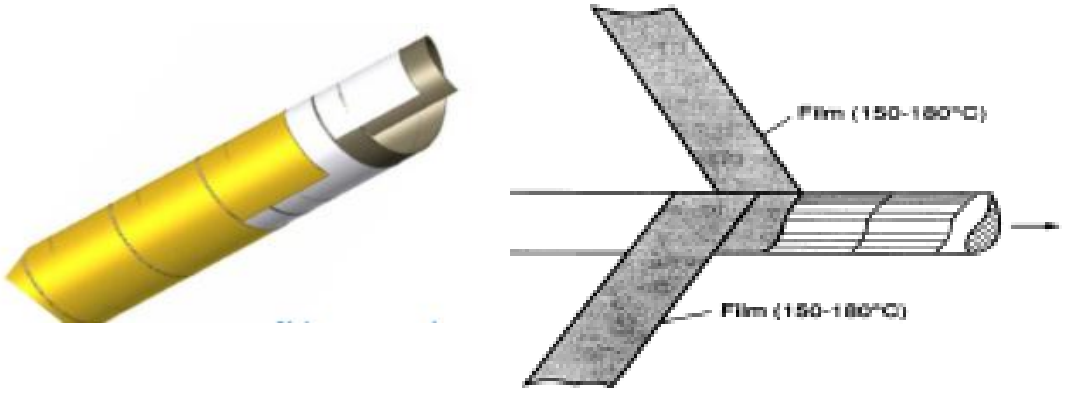
Right figure:

- 3mm wire offset,
- asymmetric V shape

Homogeneous flux of particles impinging onto the ordinate axis $\Rightarrow$



Two design of the straw-tube production



Straw winding. Two film strips are wound around the mandrel

Microscope pictures of a straw cross-section for quality control of the weld

Ultrasonic welding of straws

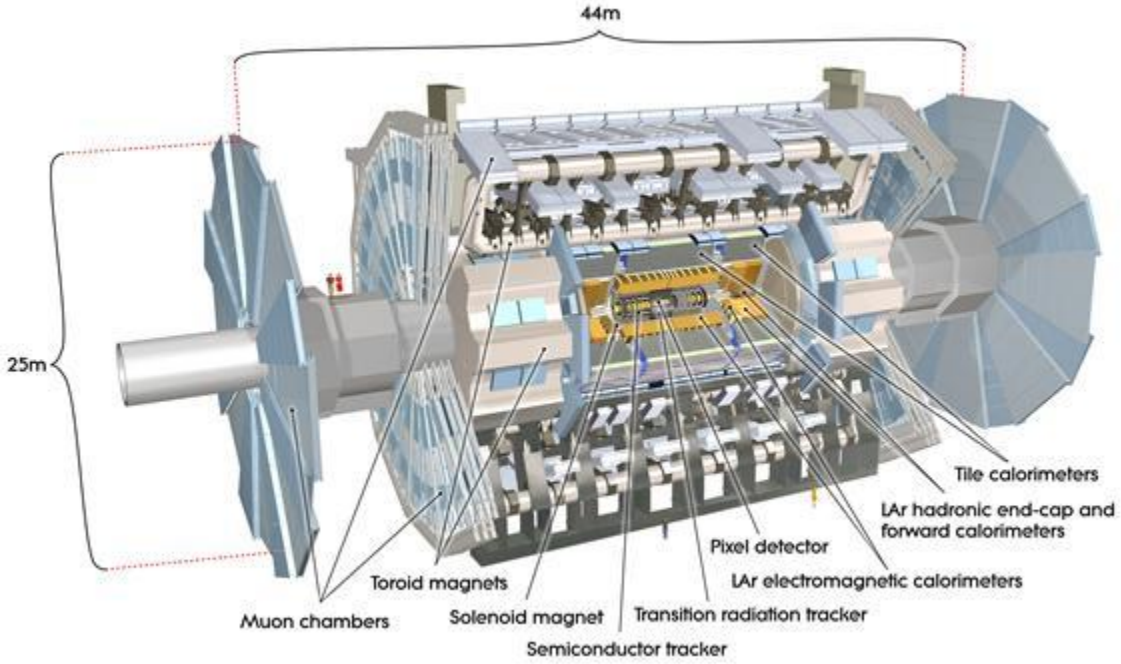
Straw winding

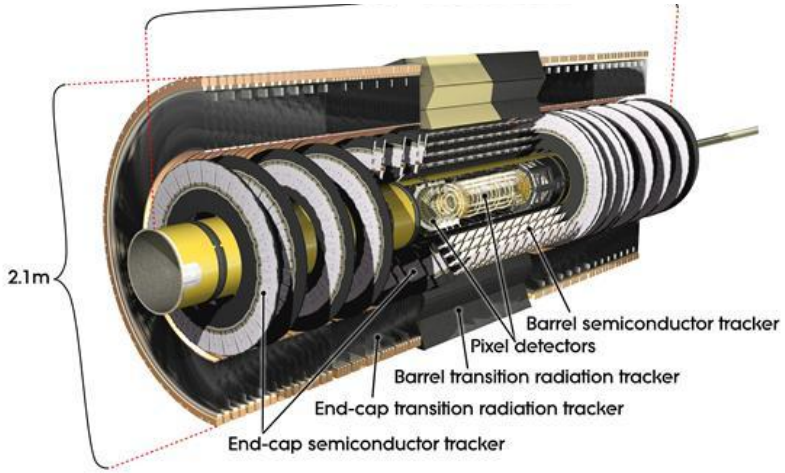
- ATLAS
- LHCb
- PANDA
- CBM
- COMPASS
- Mu2e
- NA64
- ..

Straw welding

- NA62
- COMET
- SHiP
- DUNE
- ..

ATLAS

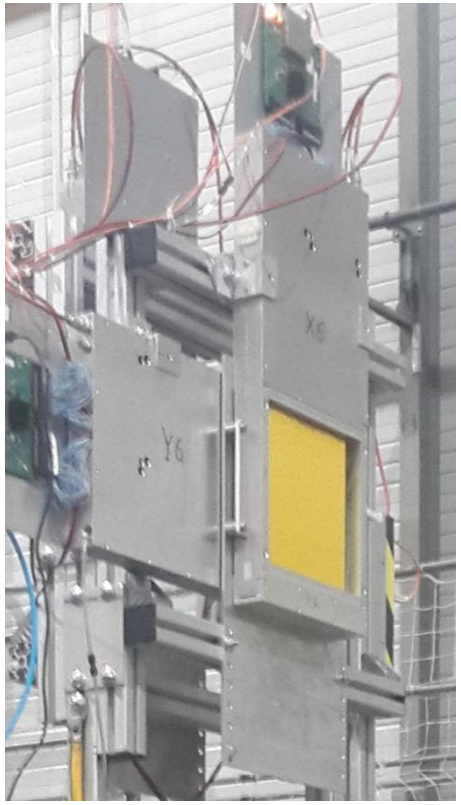




Transition Radiation Tracker
- 350,000 read-out channels
- Volume 12m^3
- Basic detector element: straw tube with 4mm diameter, in the centre a 0.03mm diameter gold-plated tungsten wire
- 50,000 straws in Barrel, each straw 144 cm long. The ends of a straw are read out separately
- 250,000 straws in both endcaps, each straw 39 cm long
- Precision measurement of 0.17 mm
- Provides additional information on the particle type that flew through the detector, i.e. if it is an electron or pion

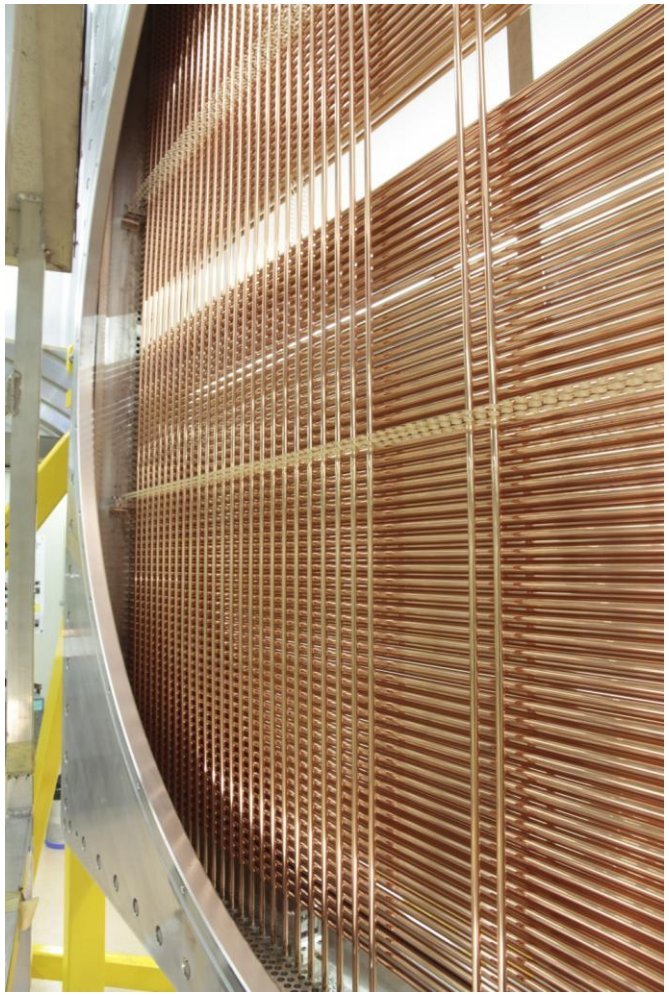
- Endcap modules:	**248760 straw**
Module of type A (PNPI)	**147456 straw**
Module of type B (LHEP)	**98304 straw**

NA64



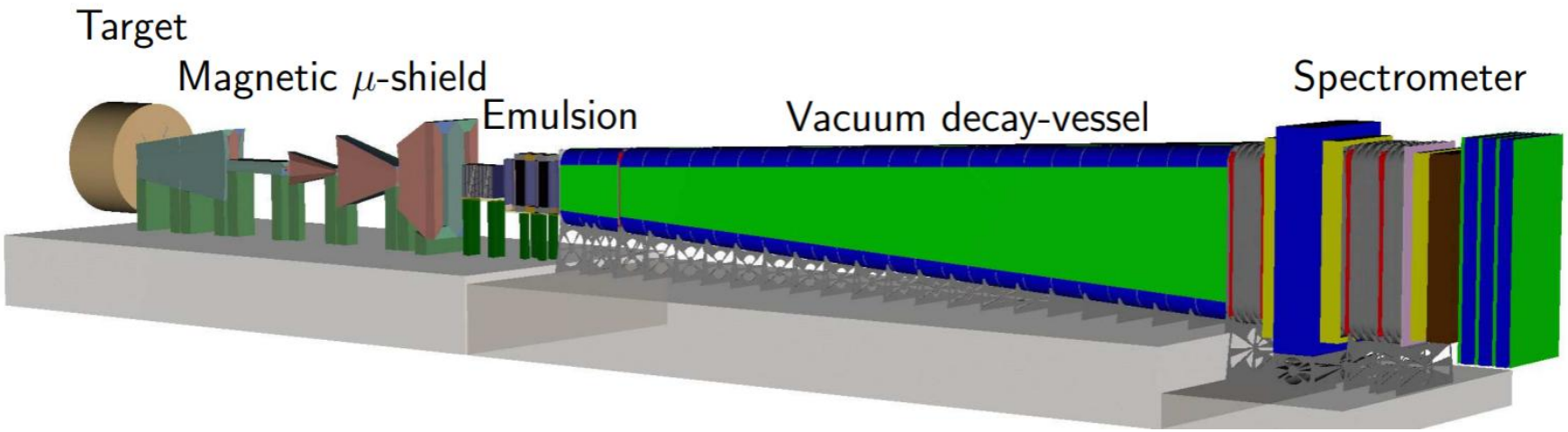
StrawTracker
•768 straws
•6 XY station
•straw tube with 6mm diameter, in the centre a 0.03mm diameter gold-plated tungsten wire
•Length straw 20 cm
•Precision measurement of 0.2 mm

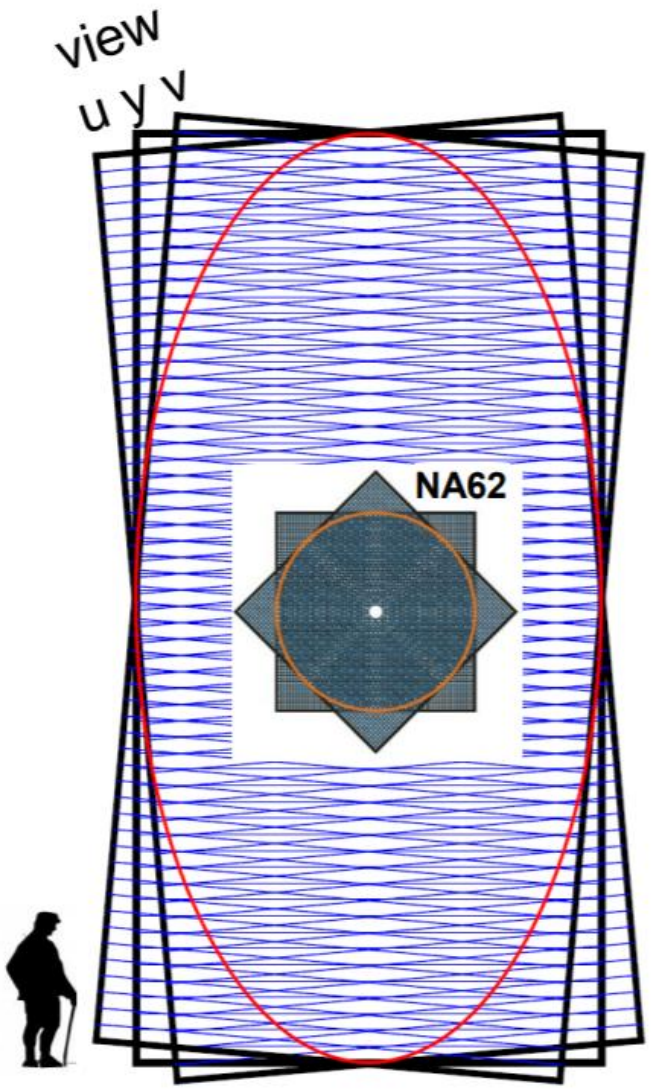
NA62



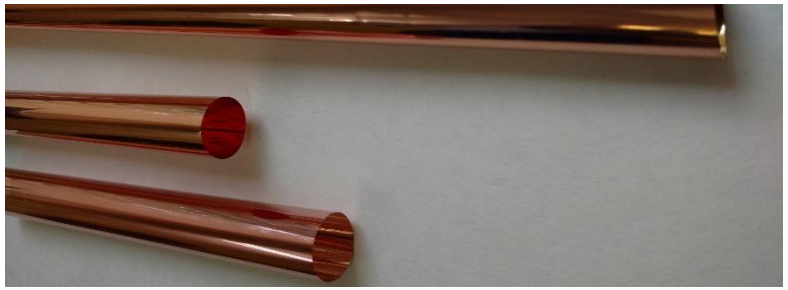
StrawTracker
•7200 straws
•4 XYUV station
•straw tube with 10mm diameter, in the centre a 0.03mm diameter gold-plated tungsten wire
•Length straw 225 cm
•Precision measurement of 0.16 mm

SHiP

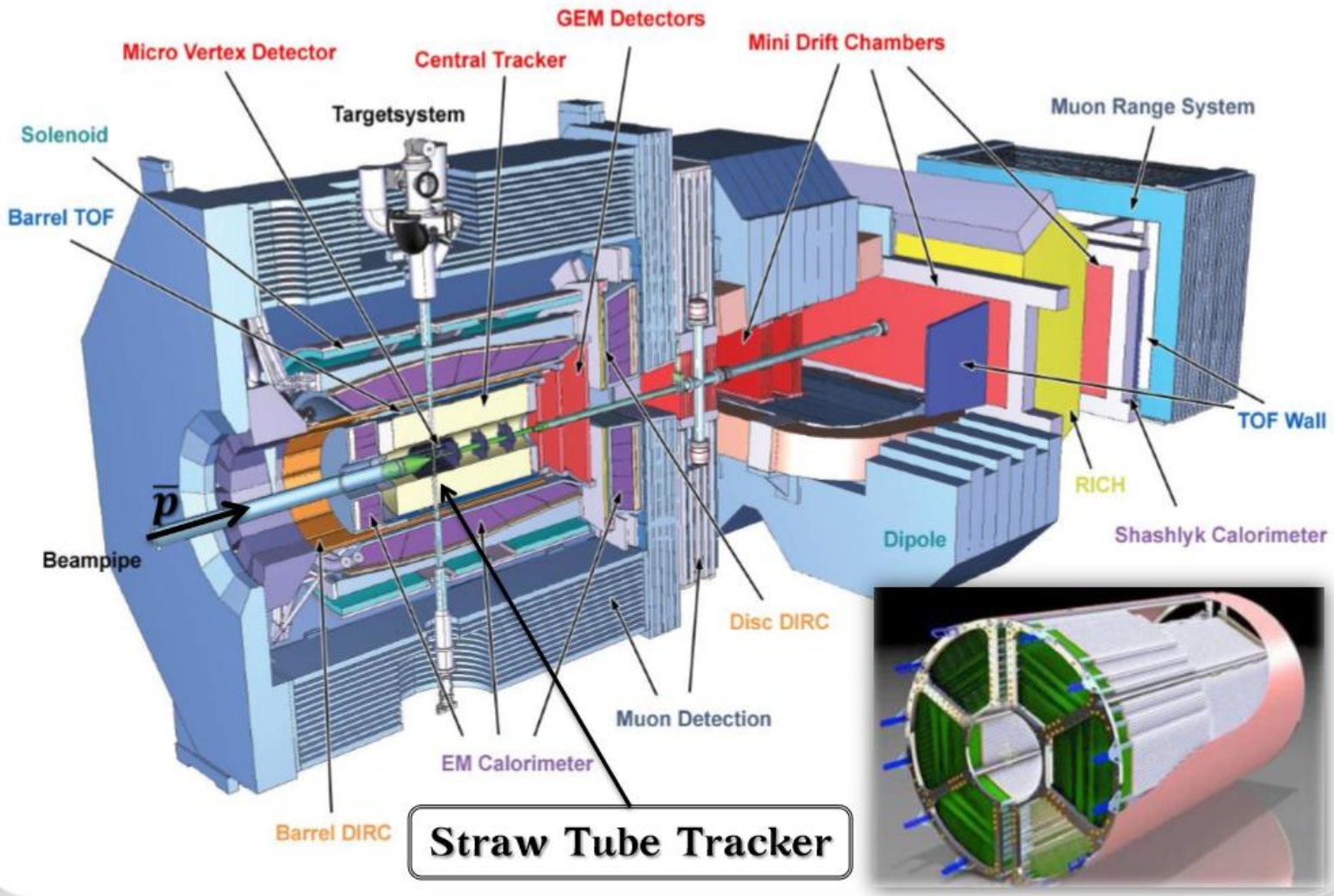




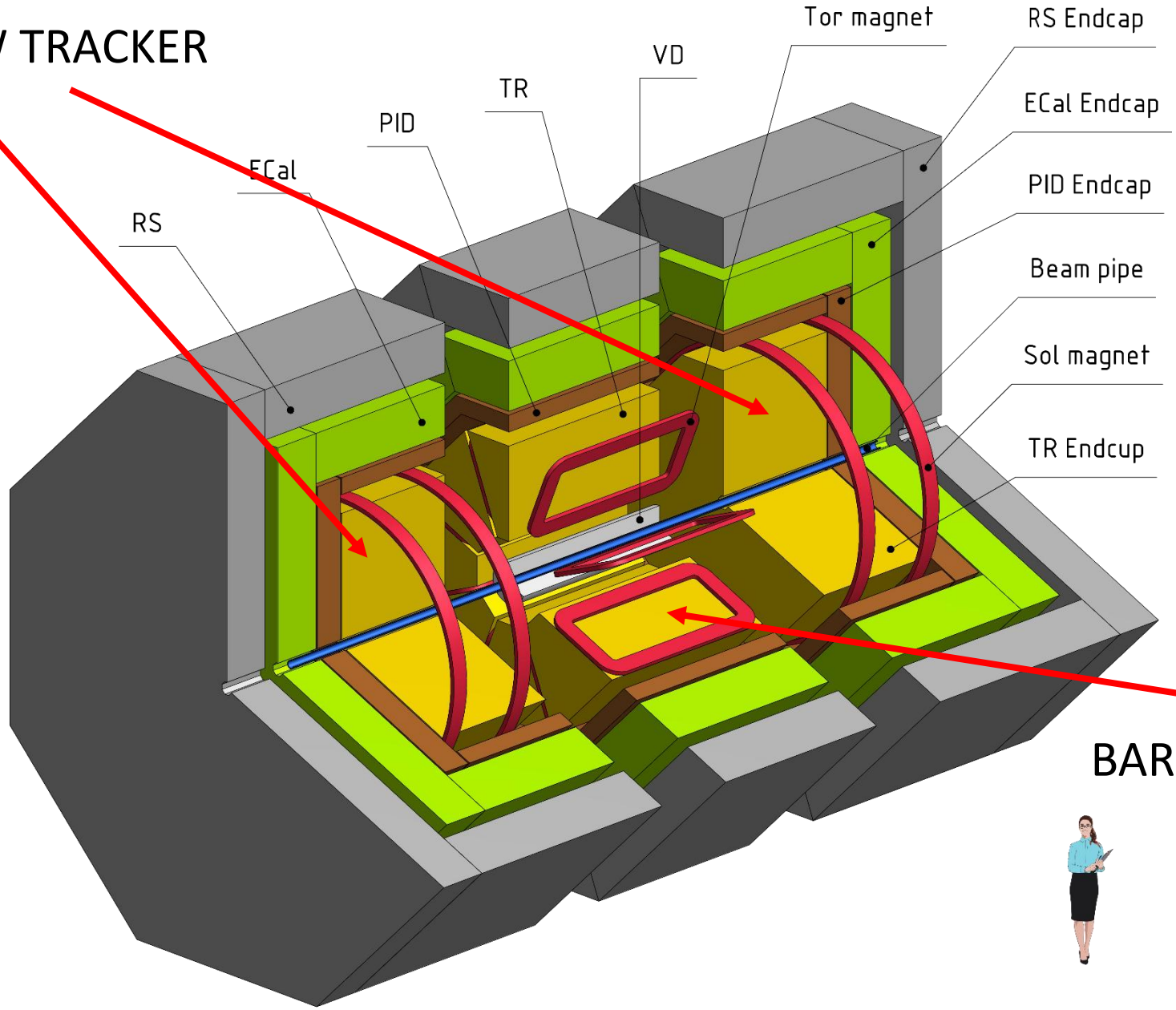
- Ultra light straw detectors, in vacuum, $R = 10$ mm, $L = 5$ m, ~ 1 bar
- 4 stations, each 4 views (Y-U-V-Y), 5 m$\times$10 m, in total $\sim$ 16k straws
- Aim: hit spatial resolution ~ 0.12 mm, efficiency $> 99\%$



PANDA Detector Overview

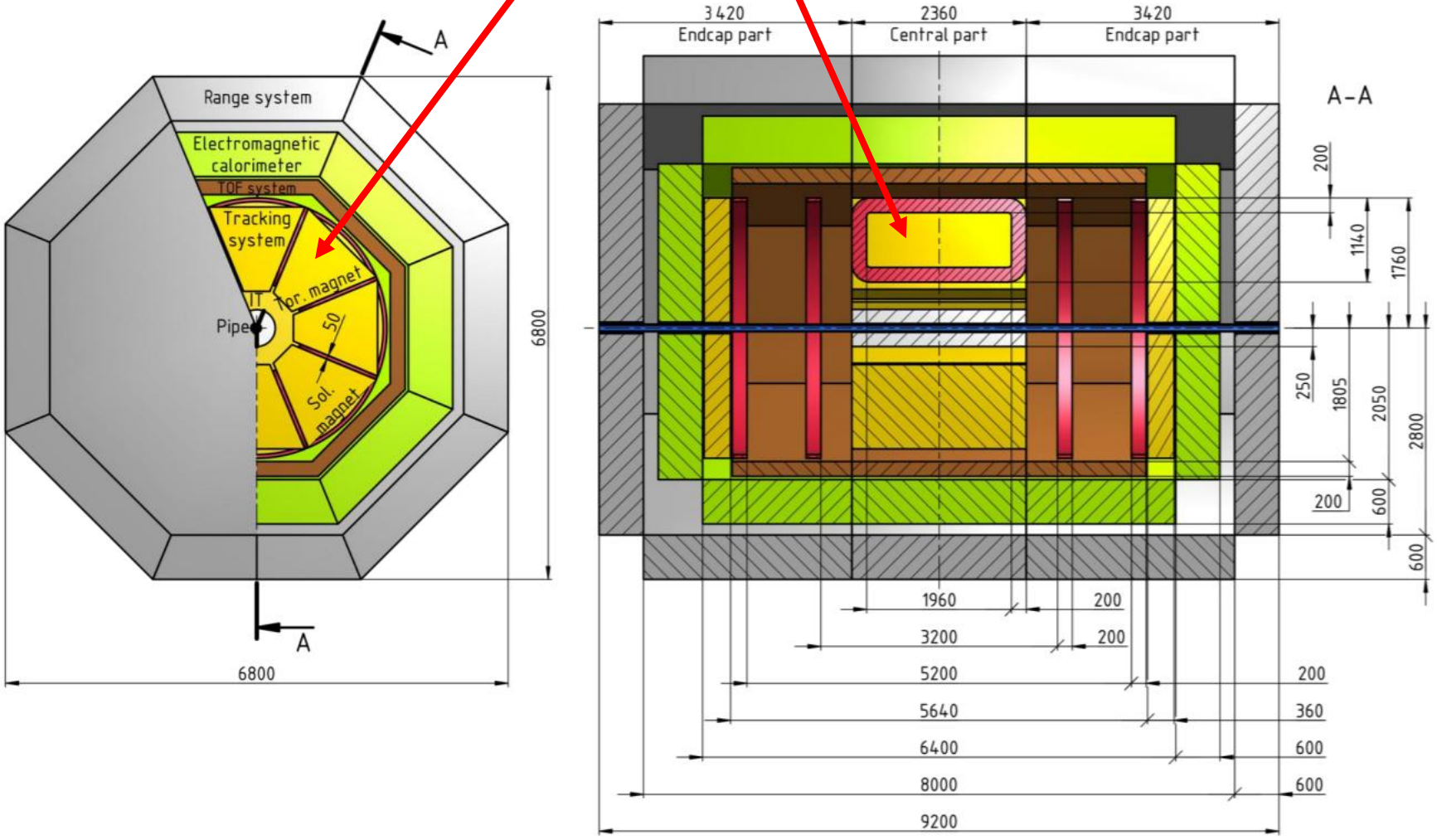


ENDCAP STRAW TRACKER

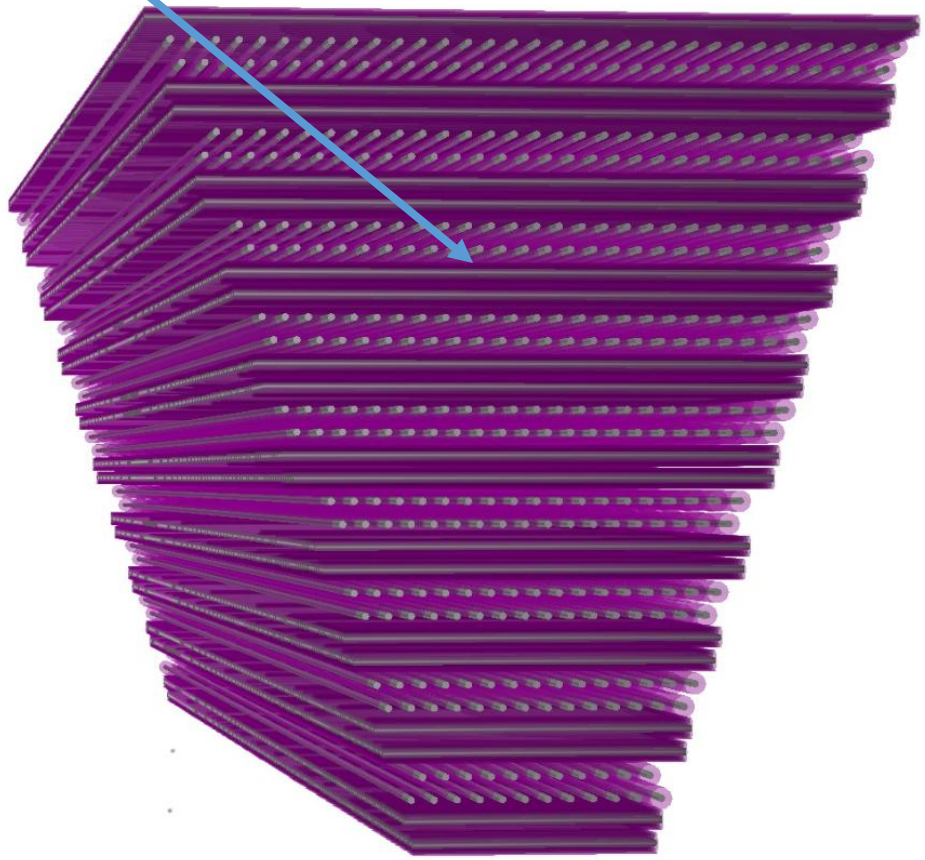


BARREL STRAW TRACKER

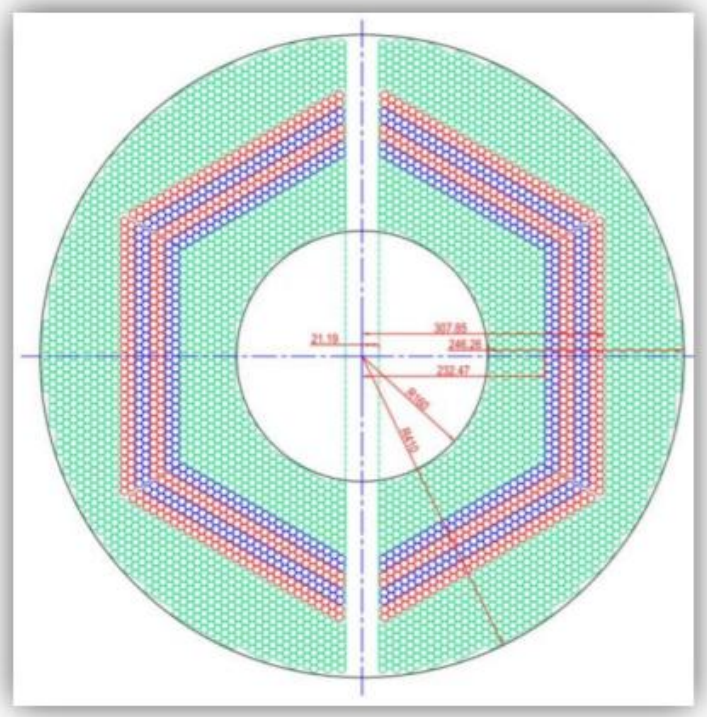
BARREL STRAW TRACKER



BARREL STRAW TRACKER



The PANDA Straw Tube Trackers

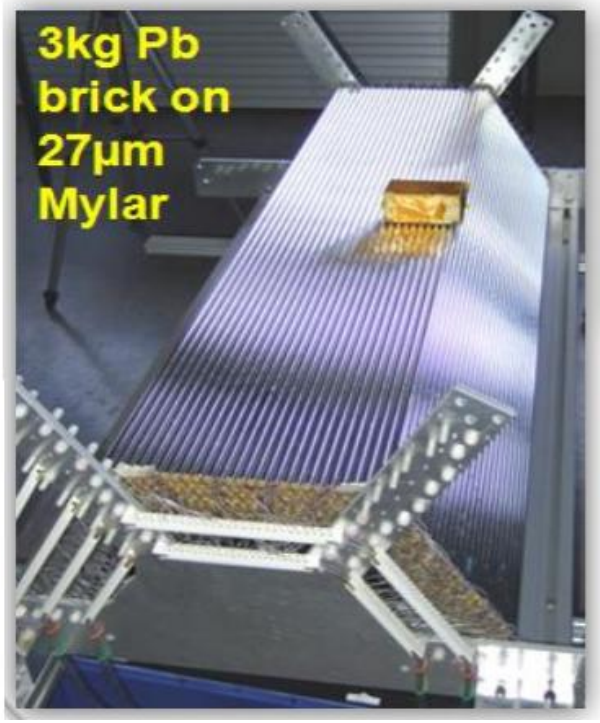


STT LAYOUT

- 4636 straw tubes in 2 semi-barrels around beam/target pipe
- 23-27 planar layers in 6 hexagonal sectors
  - 15–19 axial layers (green) parallel to the detector axis
  - 8 stereo layers ($\pm$ 2.89°) for 3D reconstruction (blue/red)
- Length: 1500mm + 150mm (RO upstream)
- R_{in}/R_{out}: 150 / 418 mm
- Angular acceptance: near 4π
- High momentum resolution: δ_p/p ~ 1-2% at B = 2 Tesla
- High spatial resolution: $\sigma_{r\varphi}$ ~ 150 (100) μm, σ_z ~ 3.0 (2.0) mm (single hit)

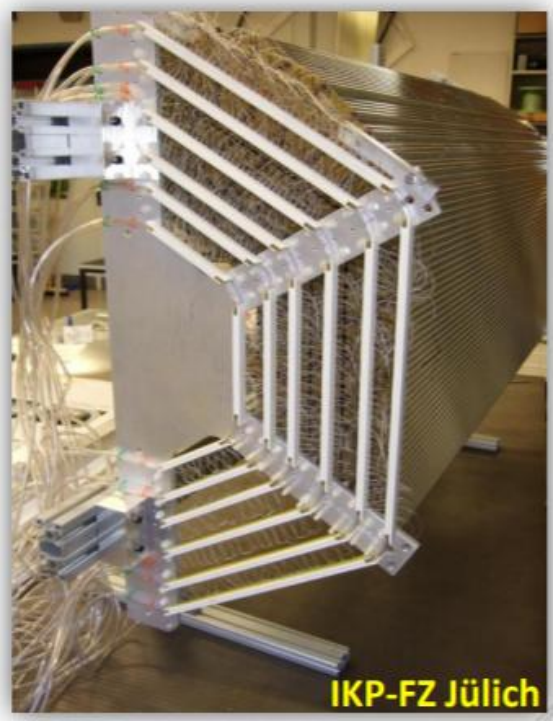
ADVANTAGES of self-supporting straws:
lowest weight, precise geometry, maximal straw density

- Strong rigidity: pressurised, close-packed multi-layer straw modules are self-supporting
- Perfect and cylindrical tube shape thanks to inner gas overpressure
- Strong wire/tube stretching corresponding to 230 kg/3.6 t equiv.
  - No stretching of straw ends from mechanical frame are needed
  - No reinforcements structure are needed along the tube length
- "Light" mechanical support frame needed (STT: 2x 8.2 kg)

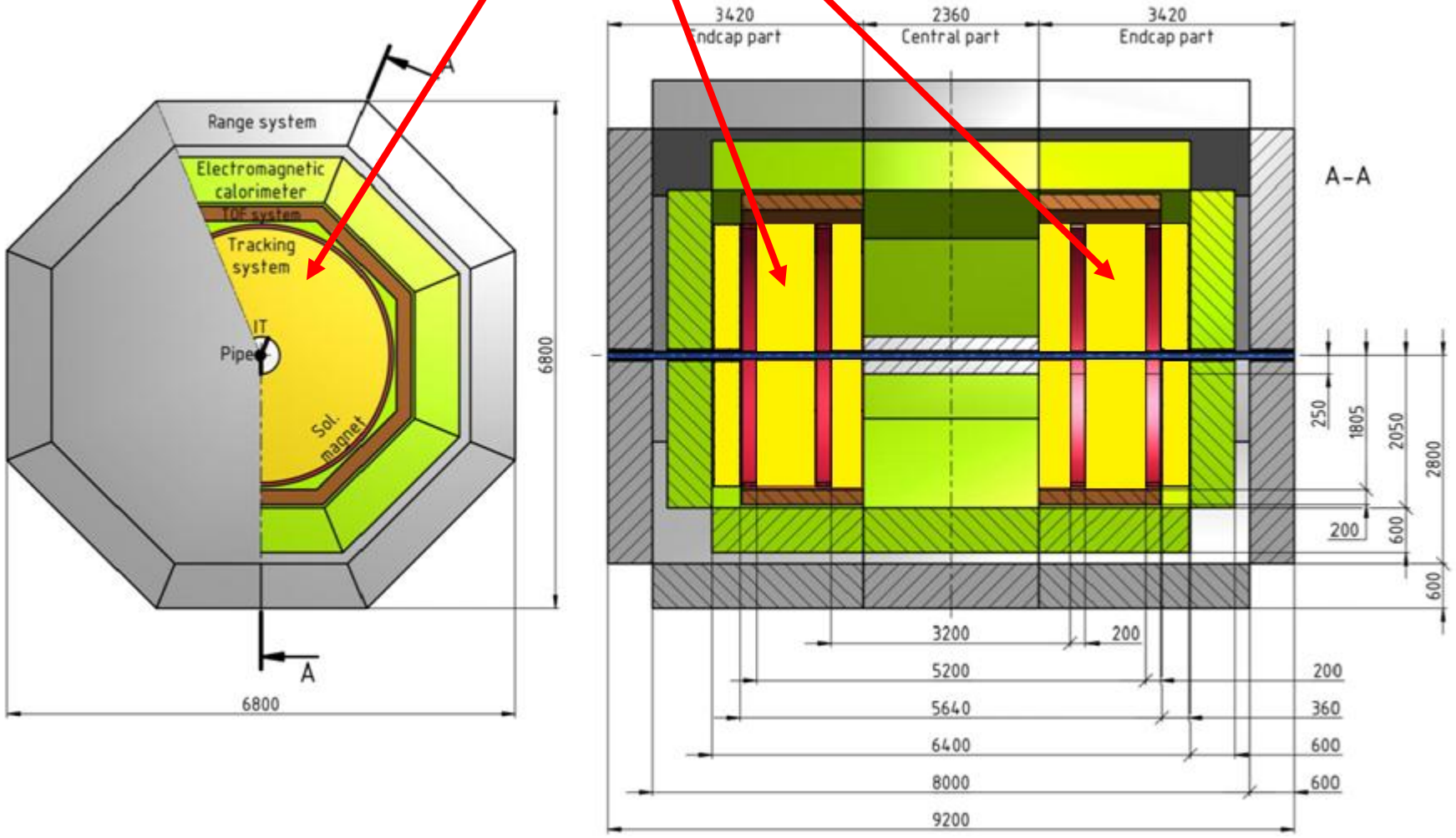


Material	Aluminum
Density	2.7 g/cm^3
Youngs modulus	70 GPa
Radiation length (X_0)	9 cm
Thermal expansion	24 ppm/°C

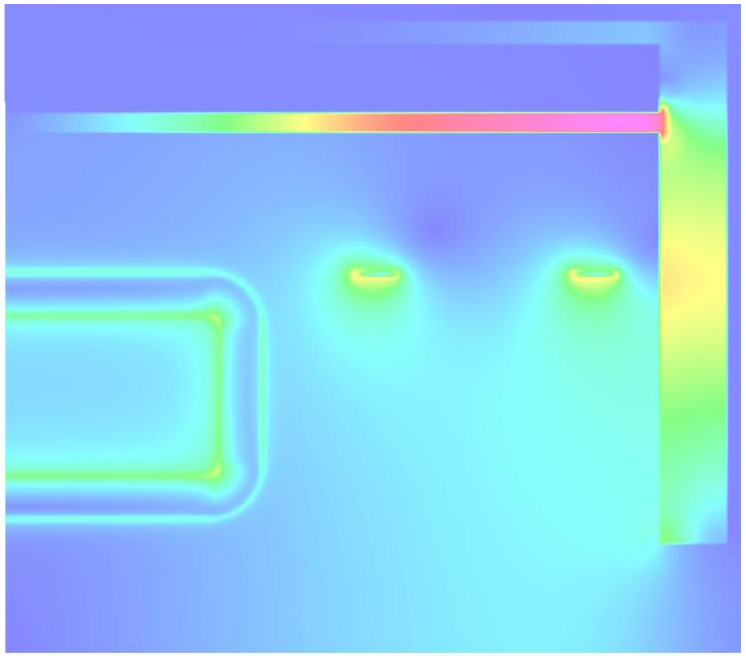
Full-scale prototype assembly
@ IKP-FZ Jülich



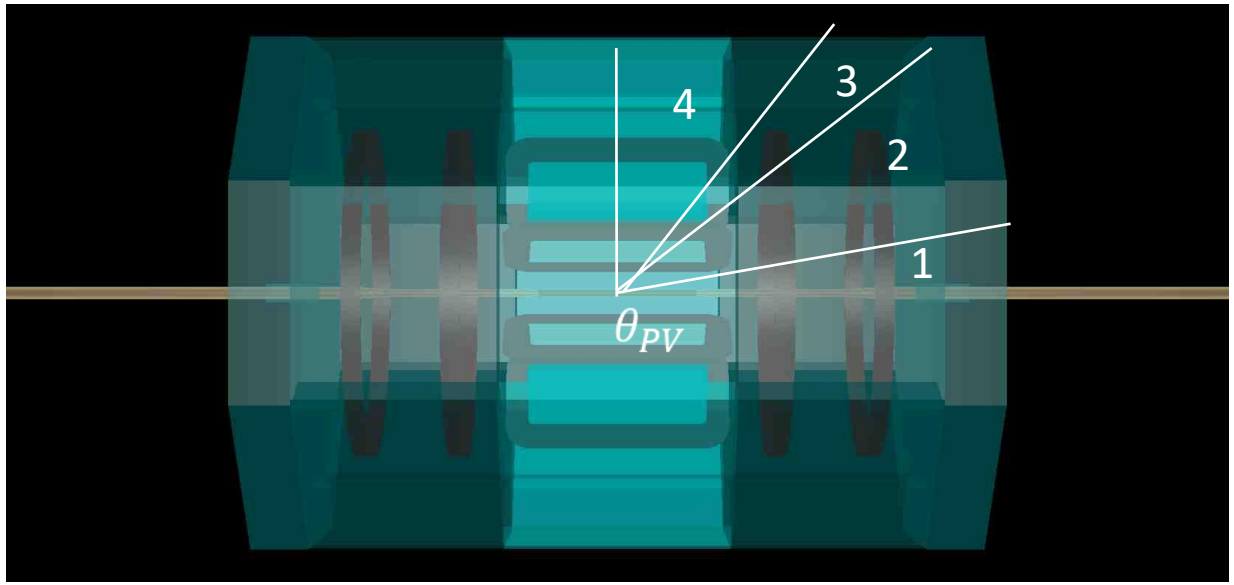
ENDCAP STRAW TRACKER



Magnetic Field

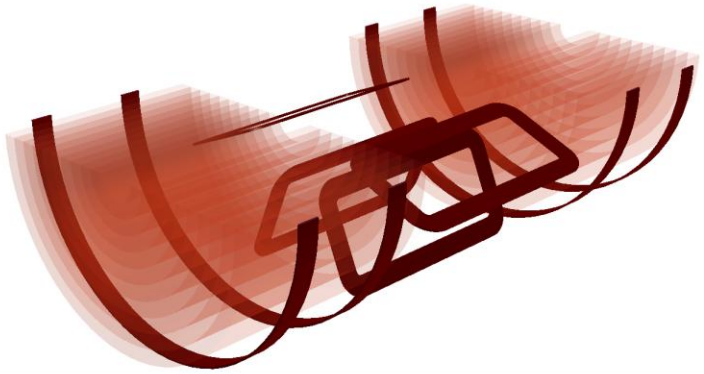


1 – Endcap = only solenoid
2 – Endcap = solenoid + toroid
3 – Barrel = solenoid + toroid
4 – Barrel = toroid

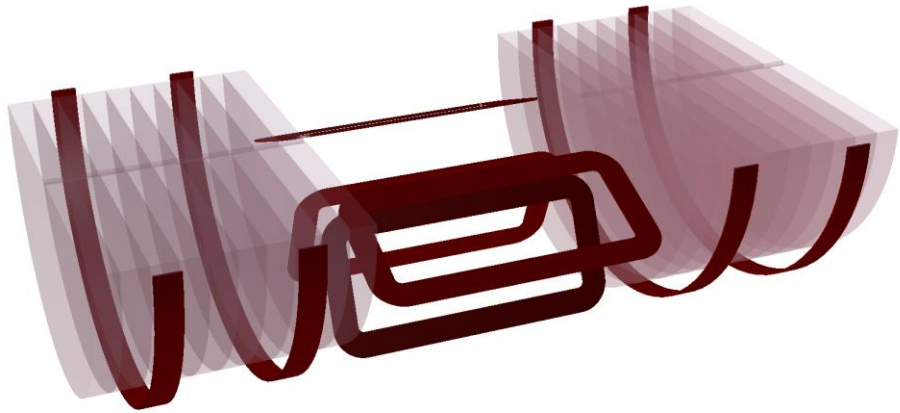


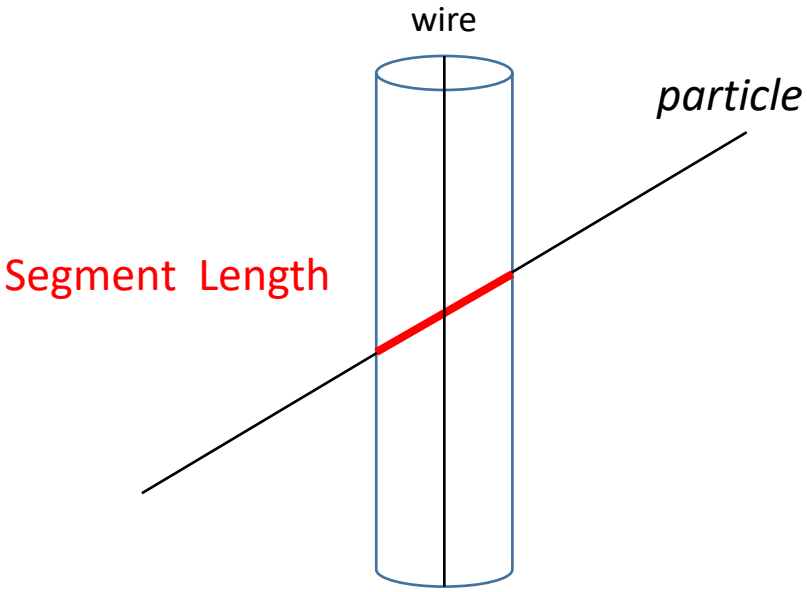
Two possible cases

tubes parallel to beam axis



tubes perpendicular to beam axis



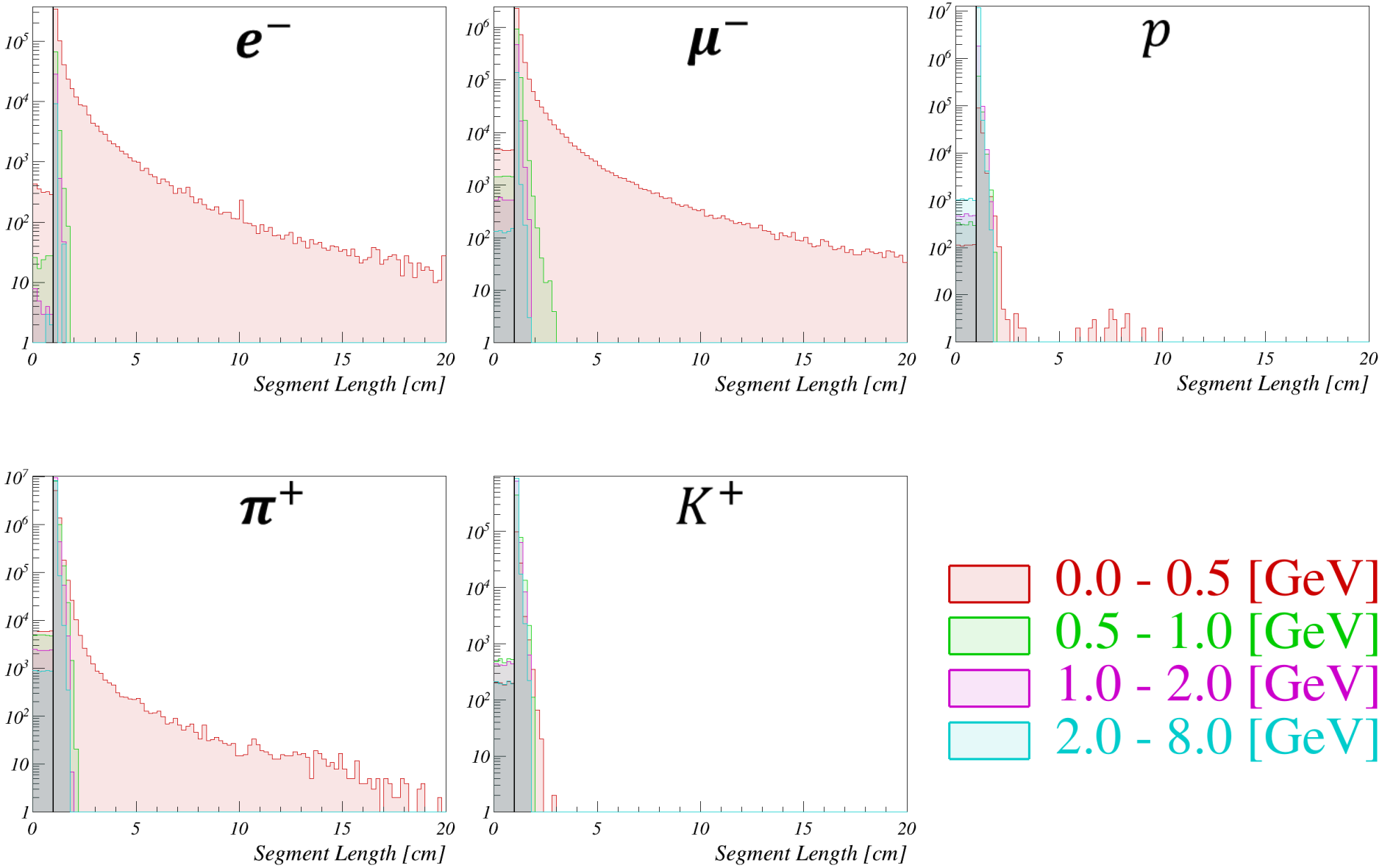


To study segment length

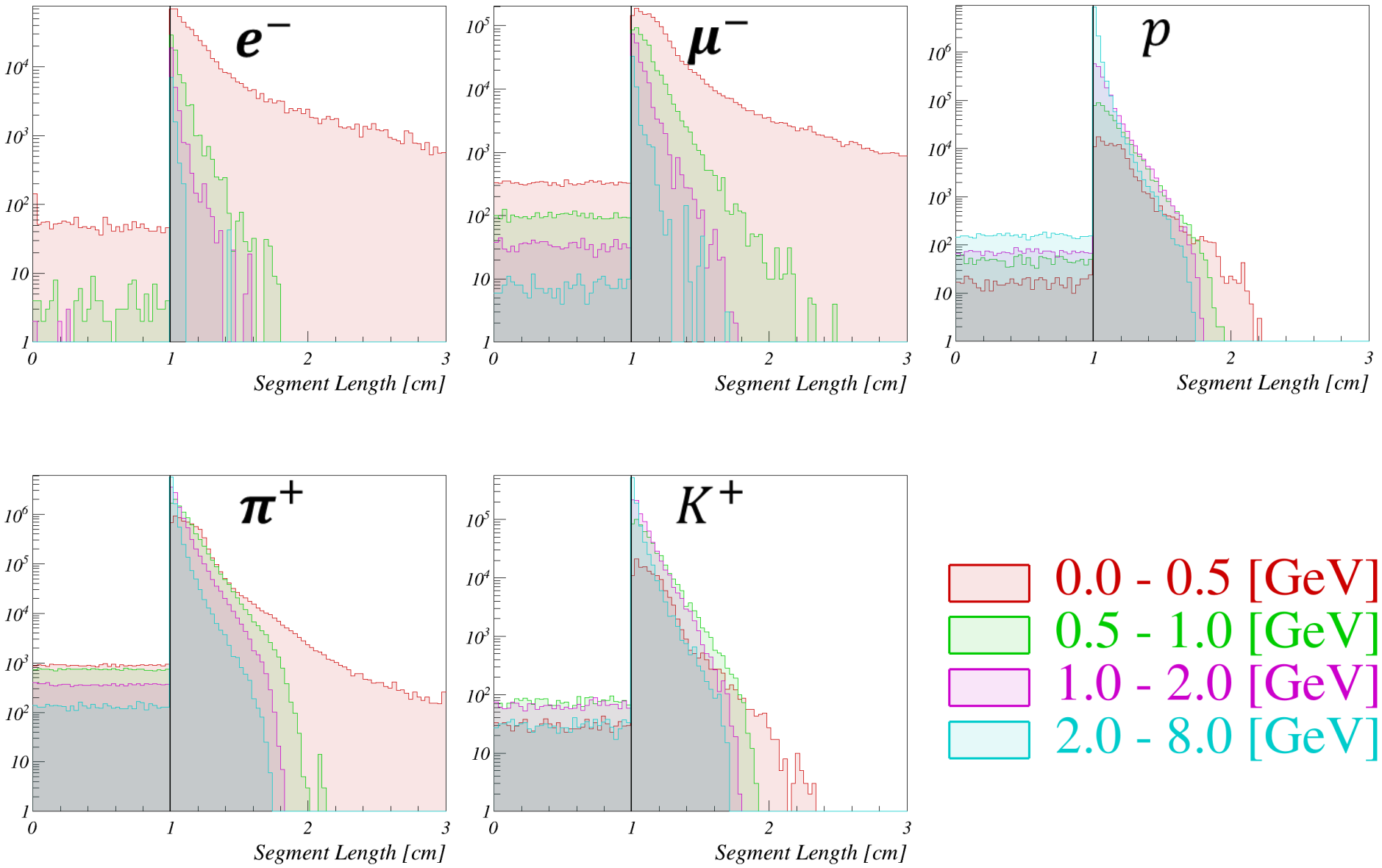
Space in solenoid part were divided into slices with size **= 1 cm**.

SPDRoot, Pythia6, Minimum bias, pp, $\sqrt{26}$, standard magnetic map

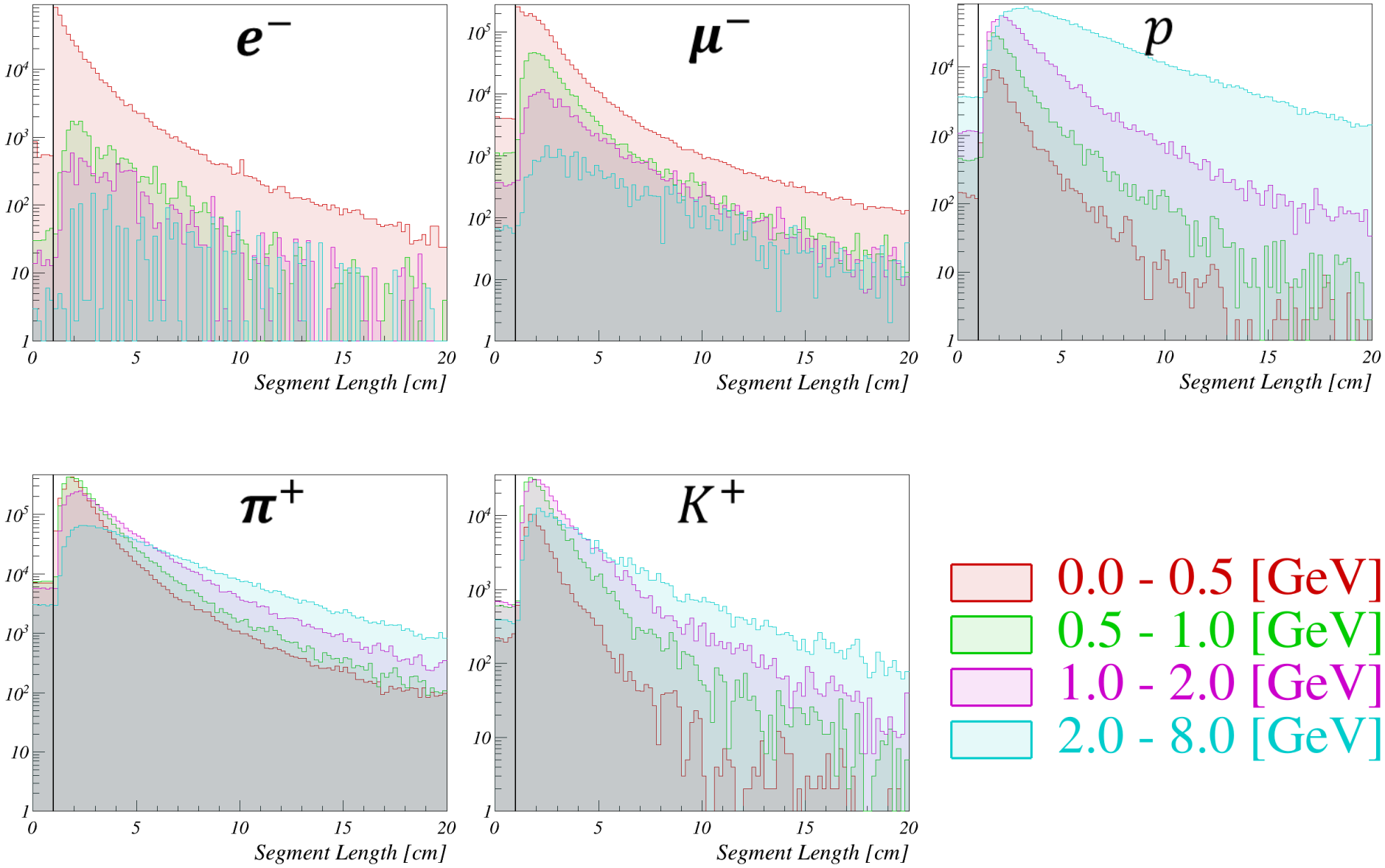
Tubes perpendicular to beam axis



Tubes perpendicular to beam axis: zoom



Tubes parallel to beam axis



100 events **25 events**

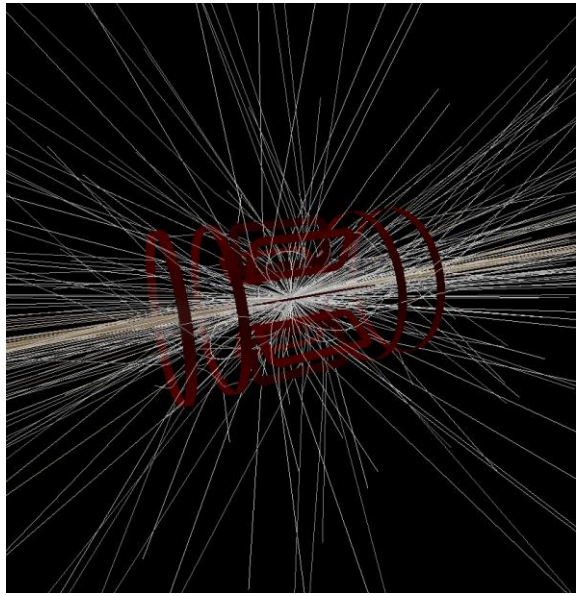
$e^{\pm}$

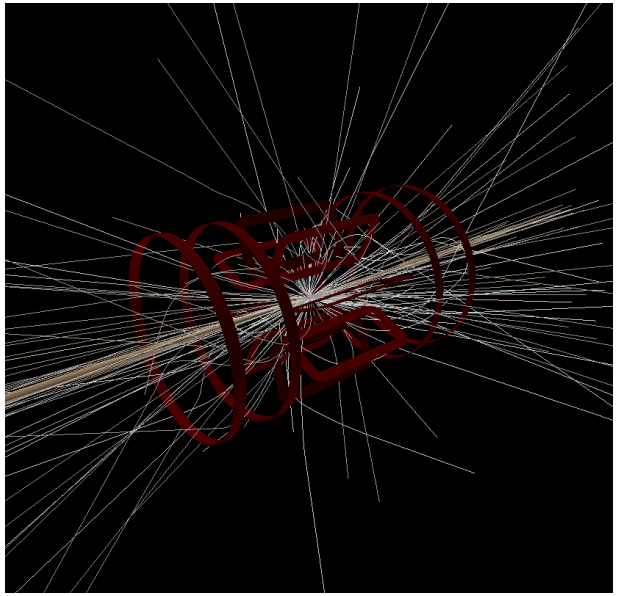
$\mu^{\pm}$

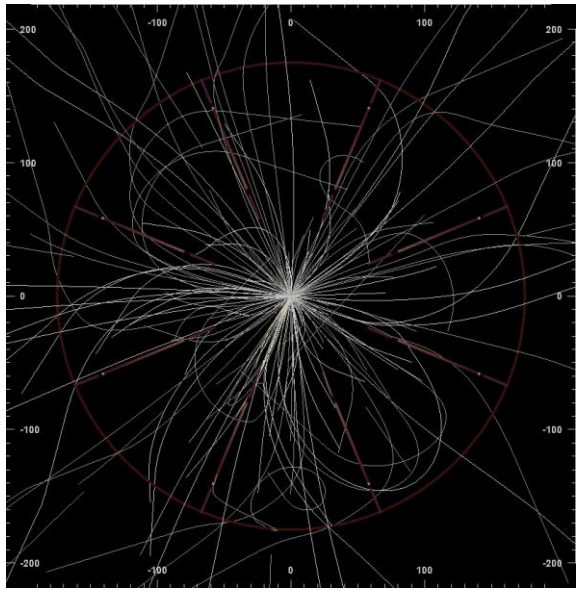
$p, \bar{p}$

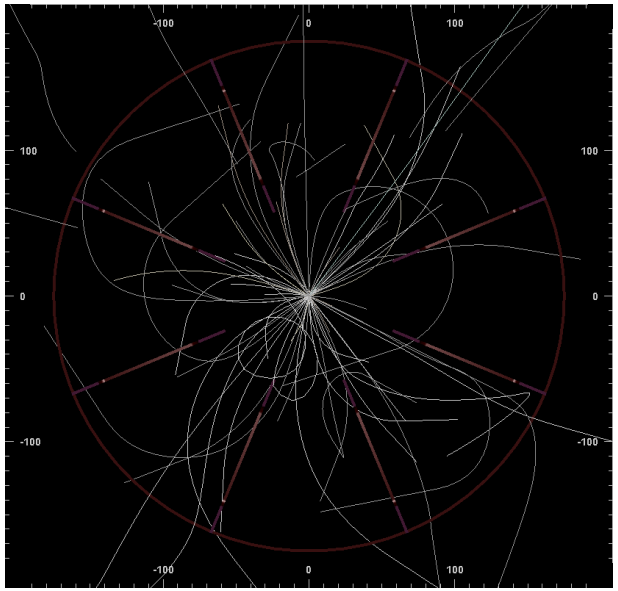
$\pi^{\pm}$

$K^{\pm}$

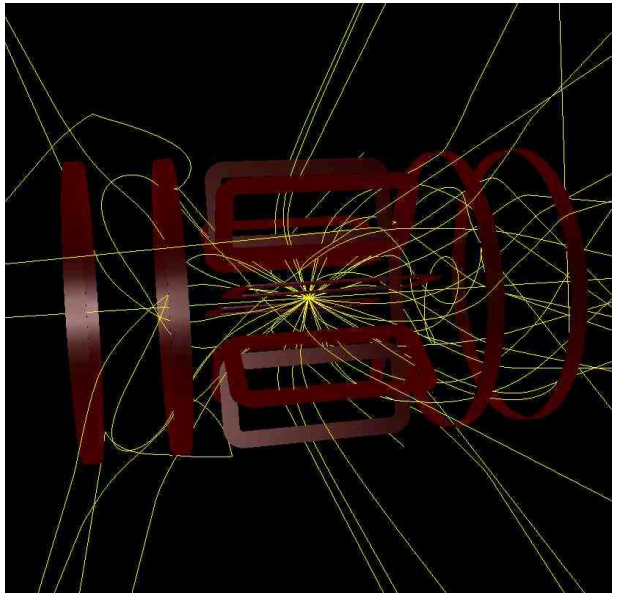


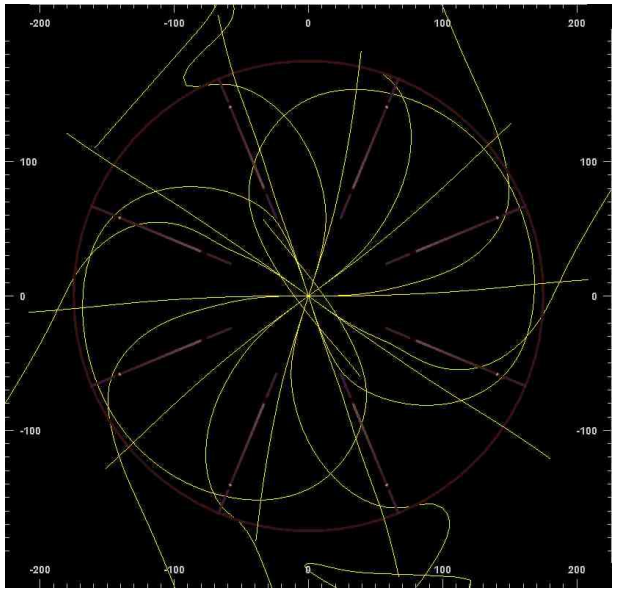




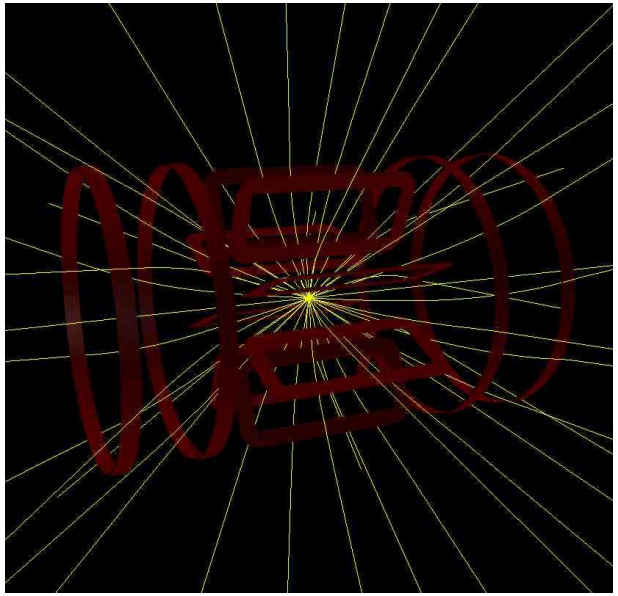


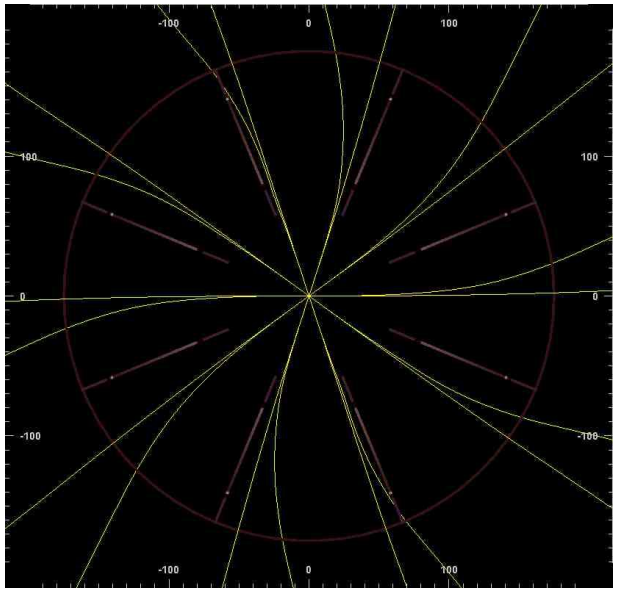
0.1 GeV



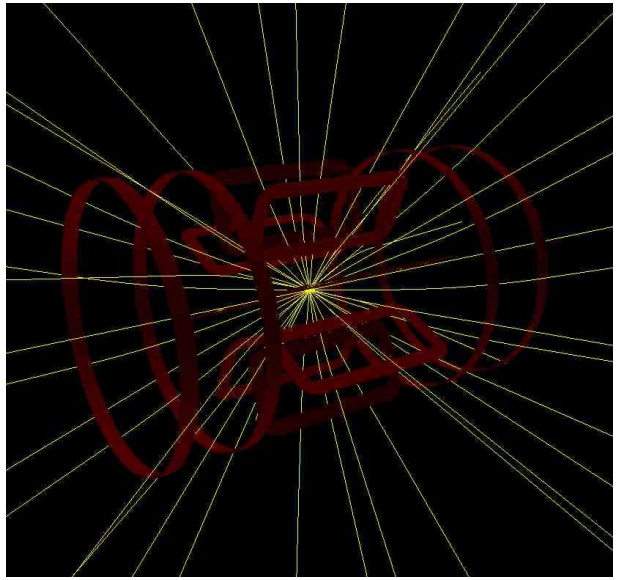


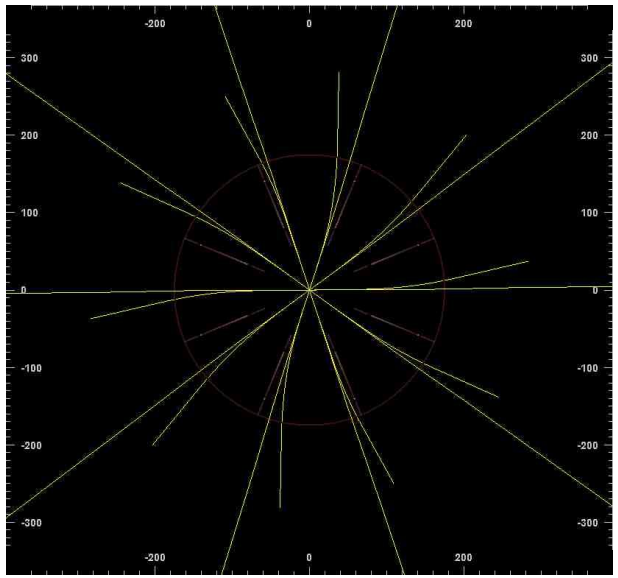
0.5 GeV





1.0 GeV





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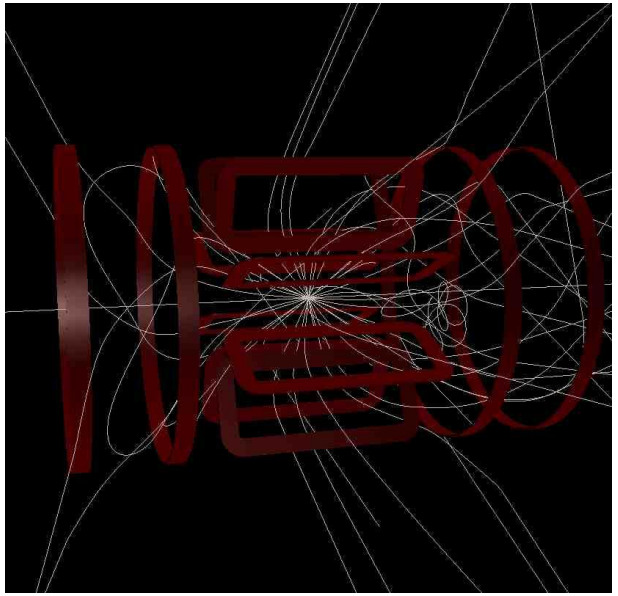
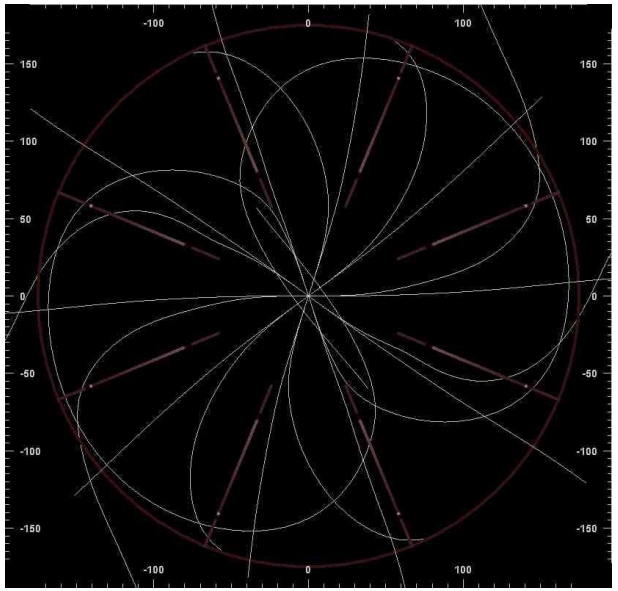
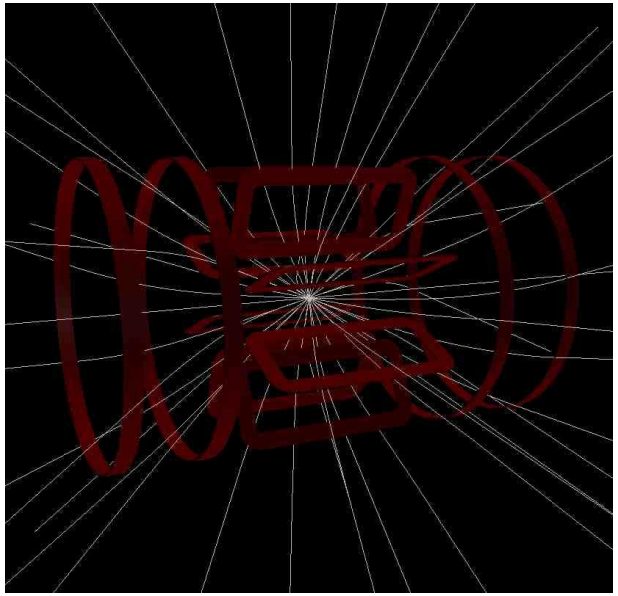
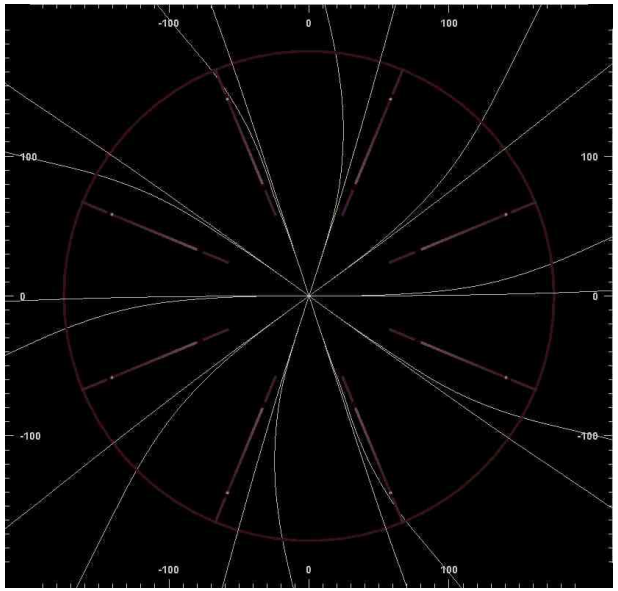




0.5 GeV





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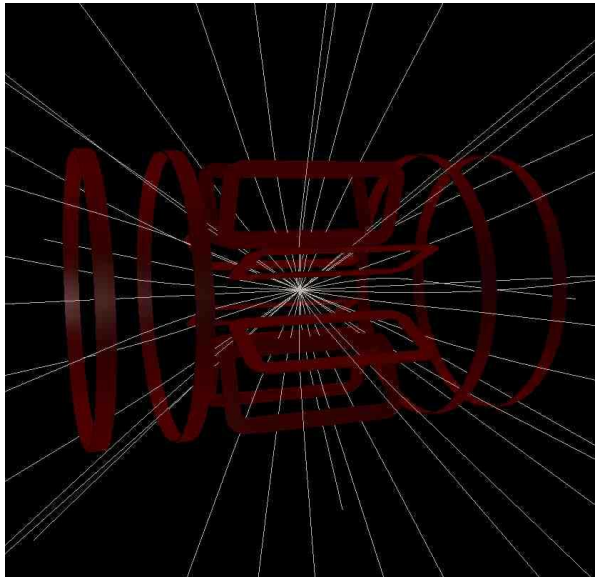

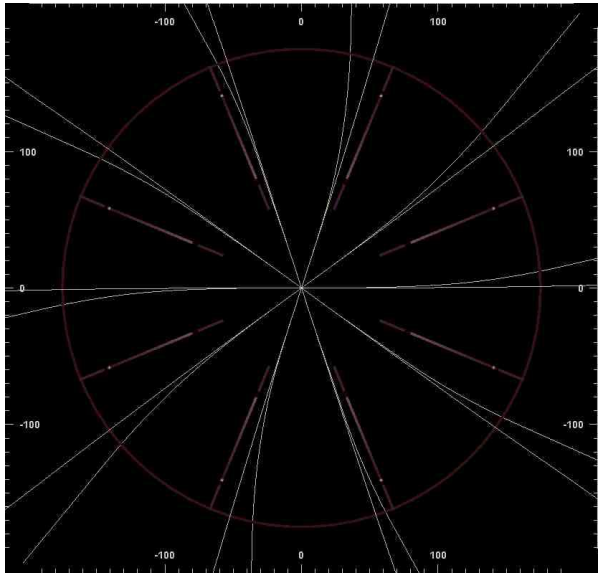

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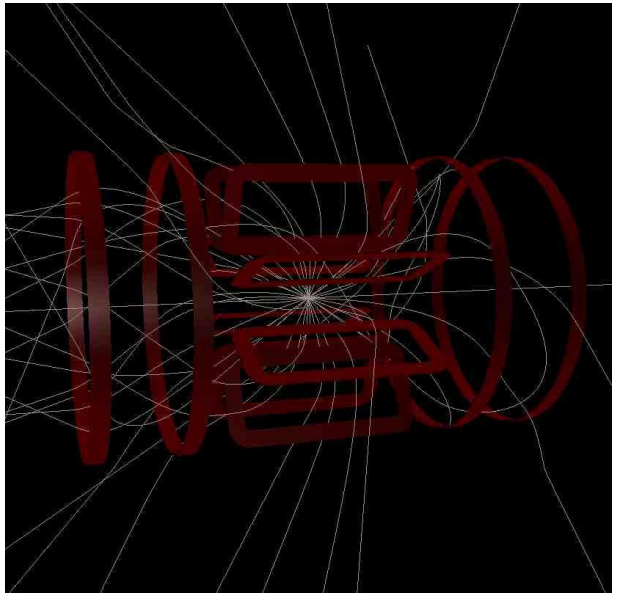

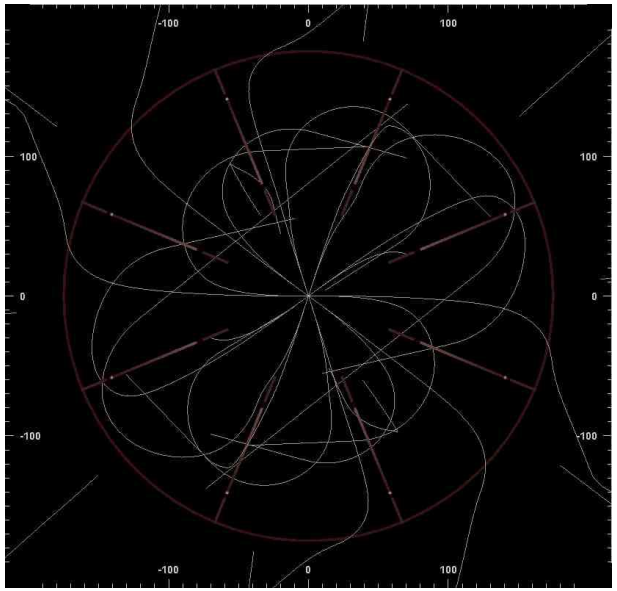

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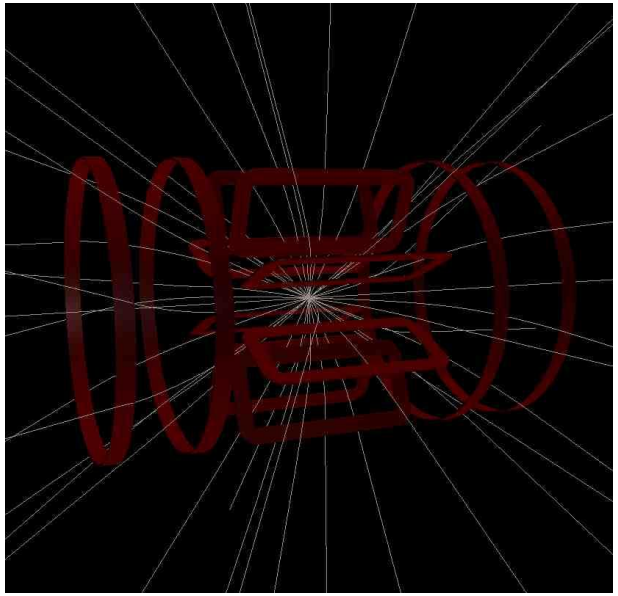
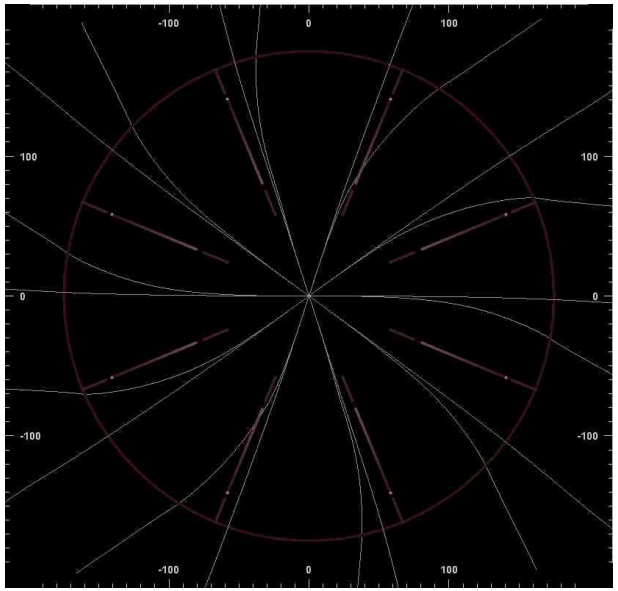
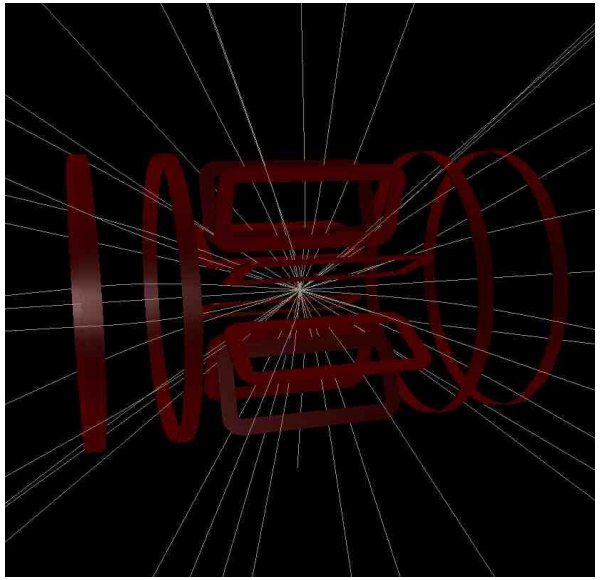
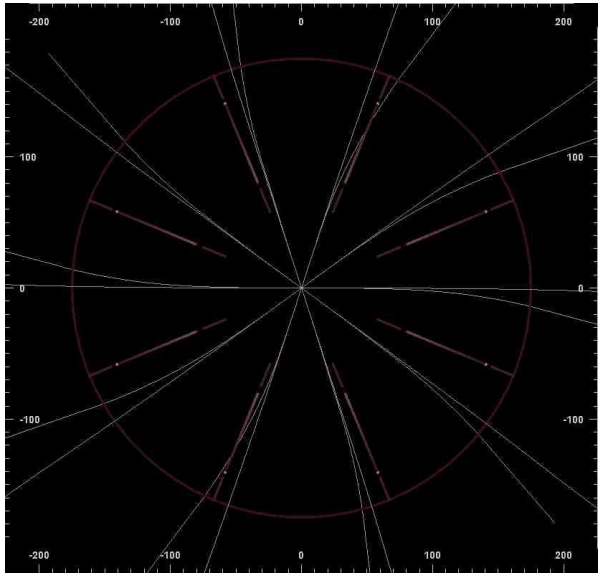


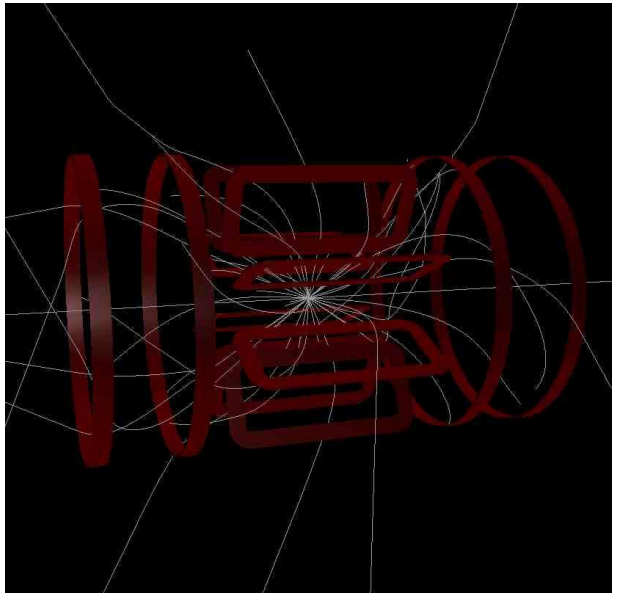


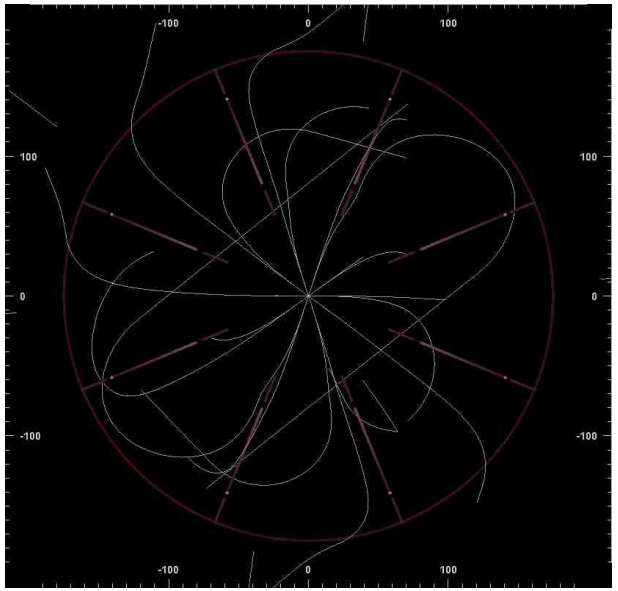
1.0 GeV



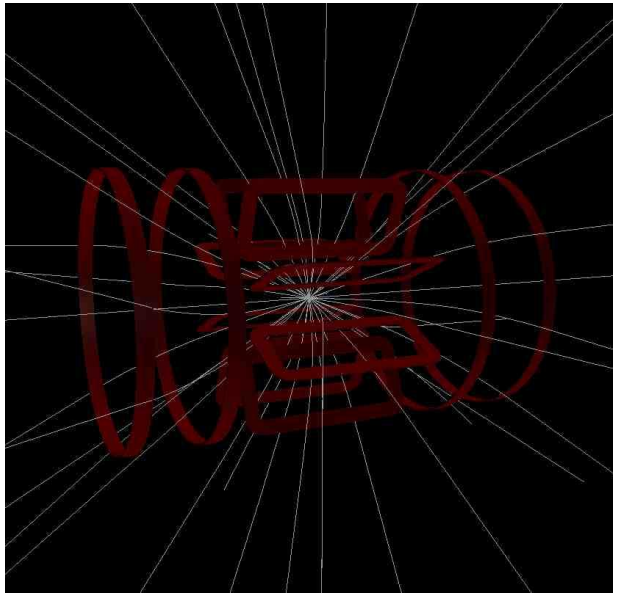


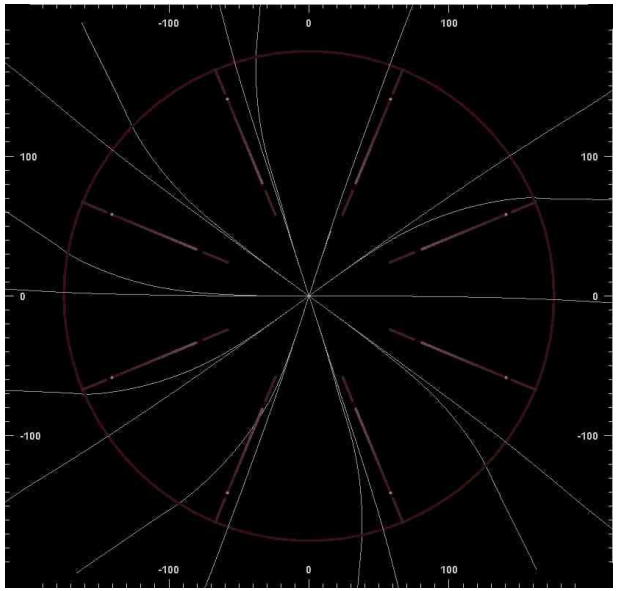
0.1 GeV



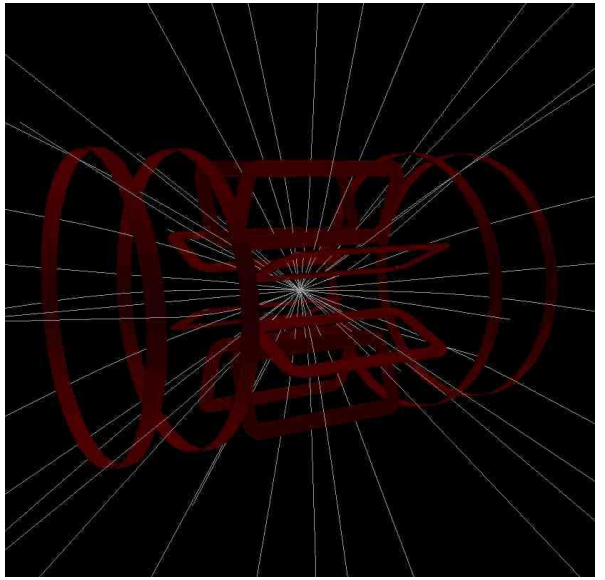


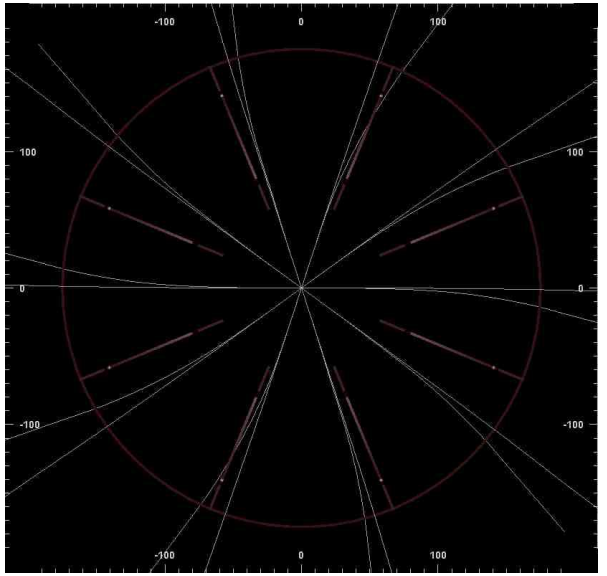
0.5 GeV



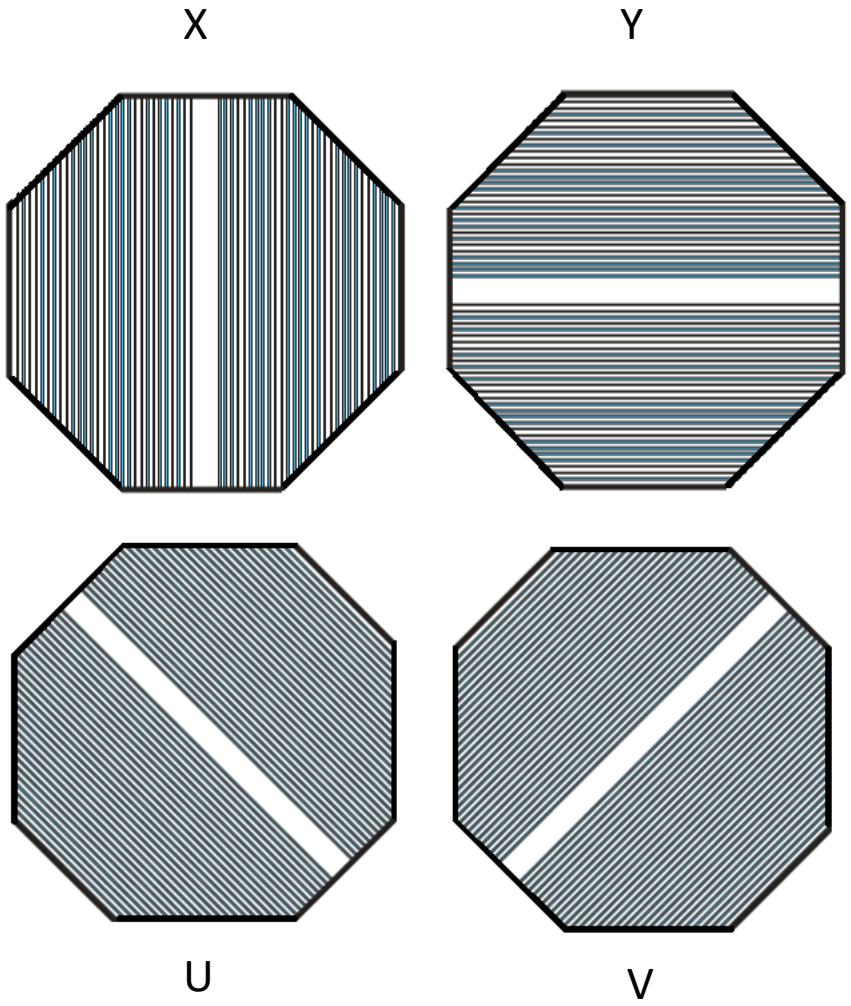


1.0 GeV

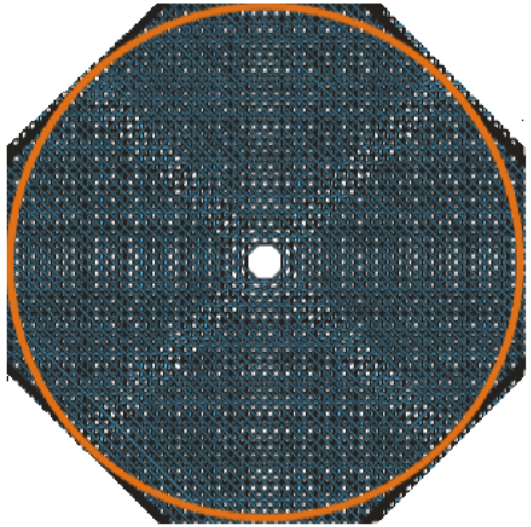




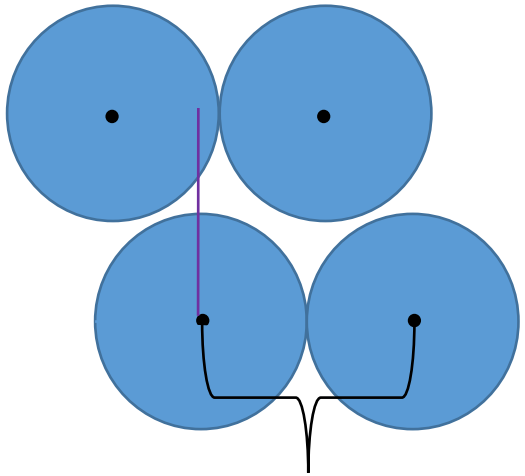
ENDCAP STRAW TRACKER

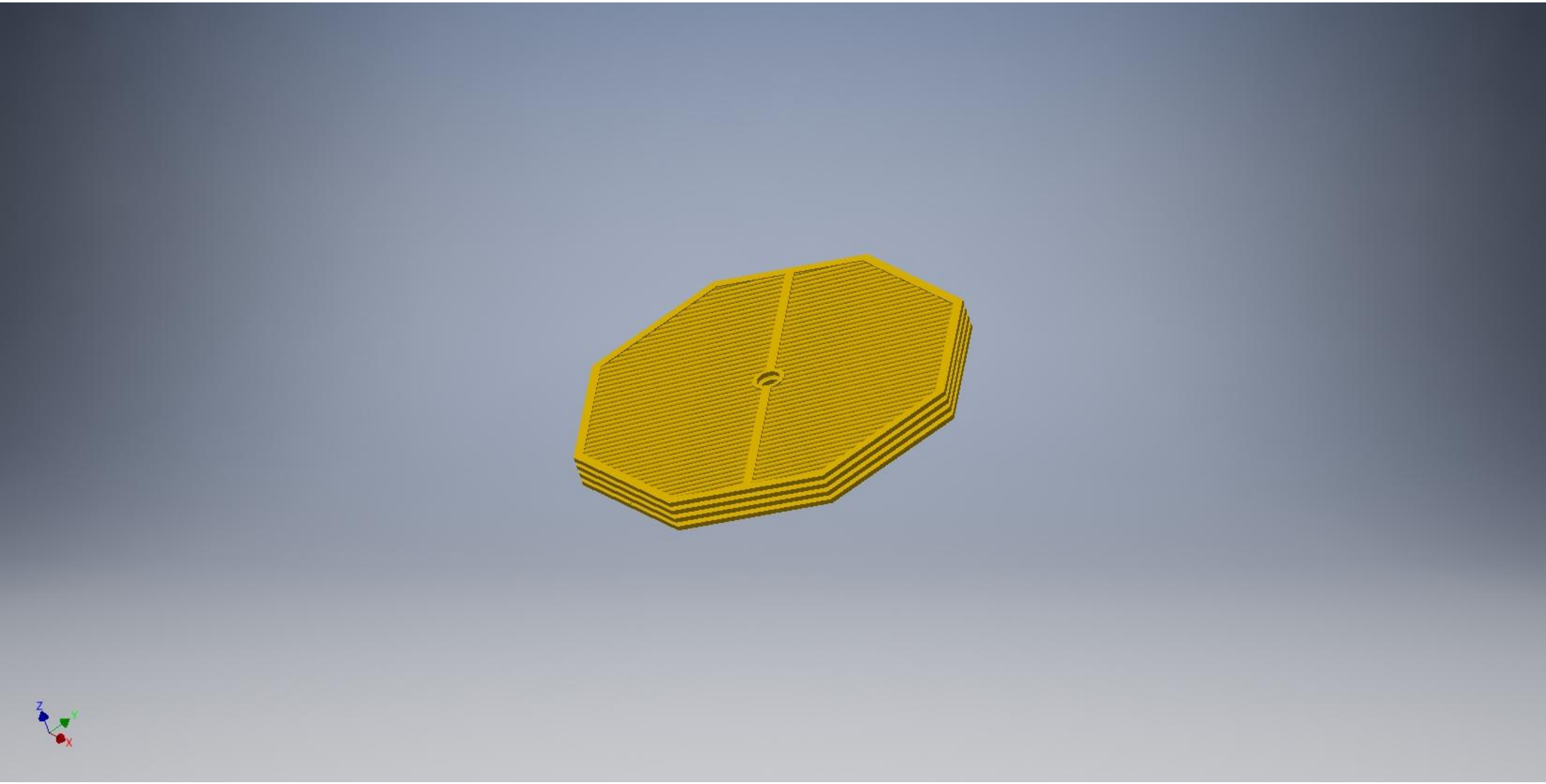


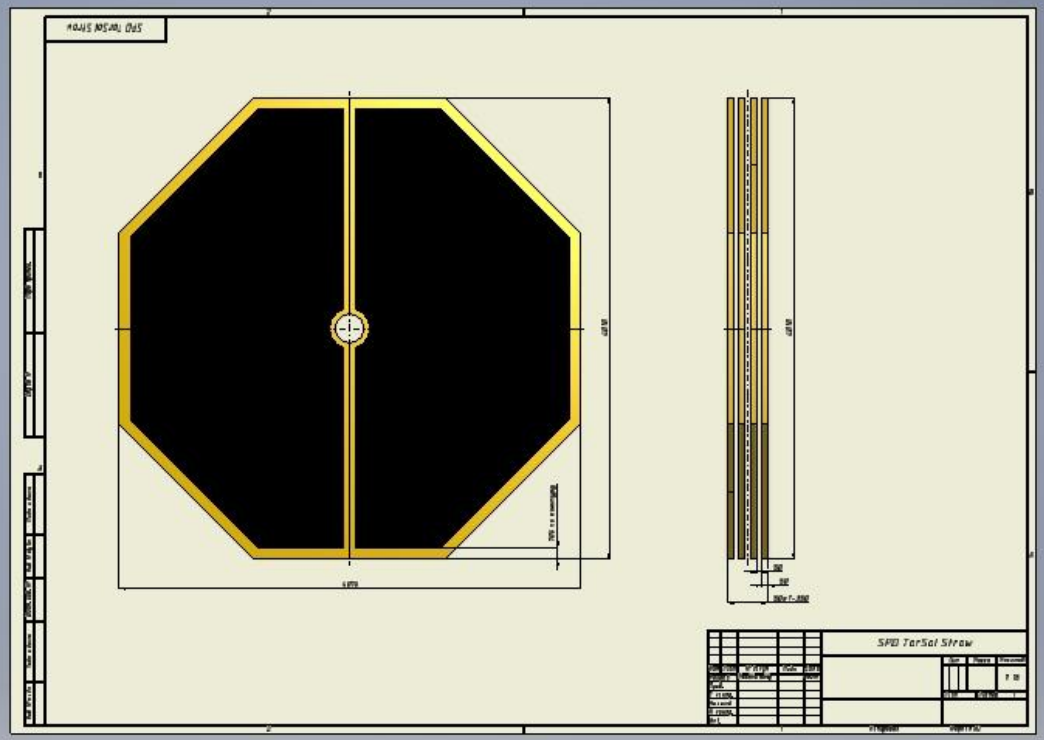
The overall structure of the straw tracker is schematically shown in Fig.

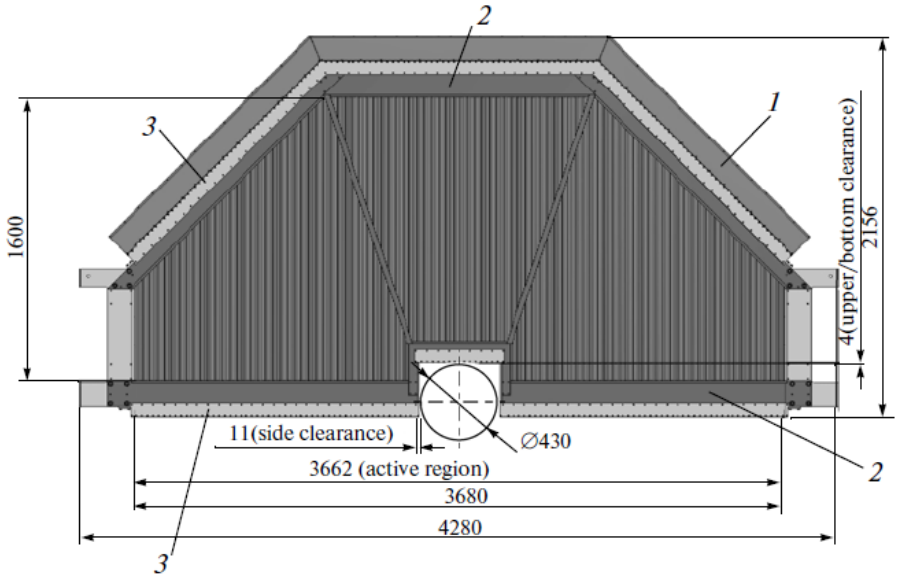


ENDCAP TRACKER состоит из 2 станций. Каждая станция состоит из 4 модулей-X,Y,U,V. Каждый модуль состоит из двух слоев straw.

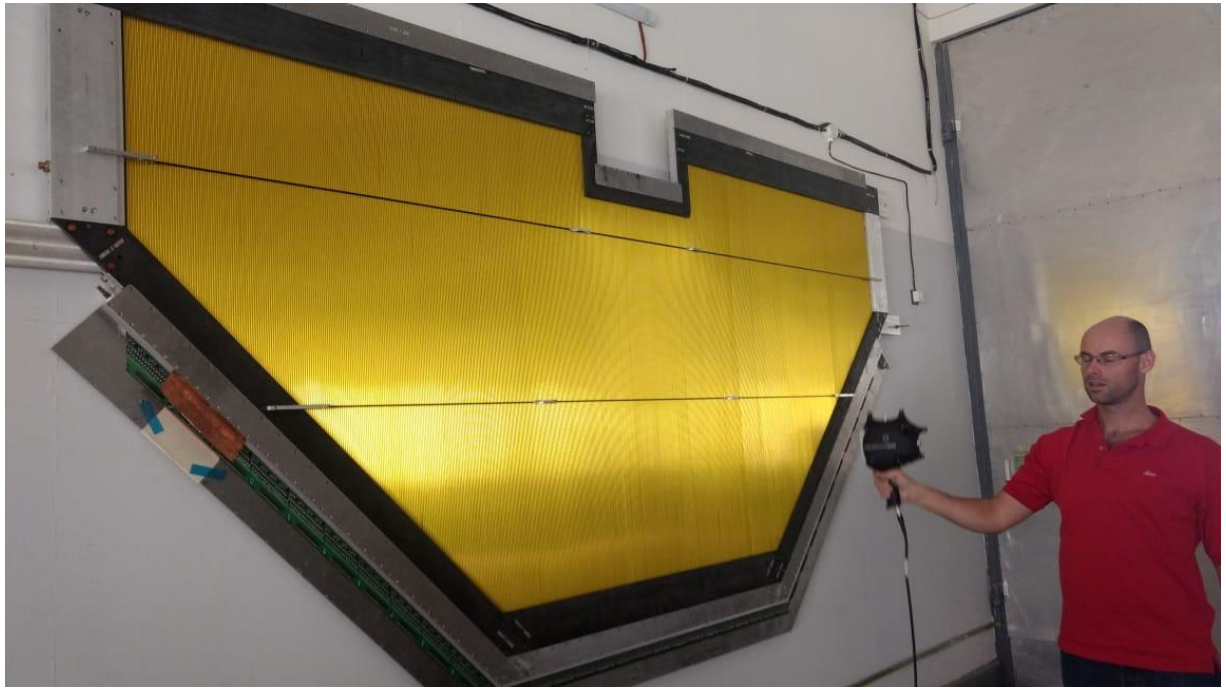



Z
Y
X

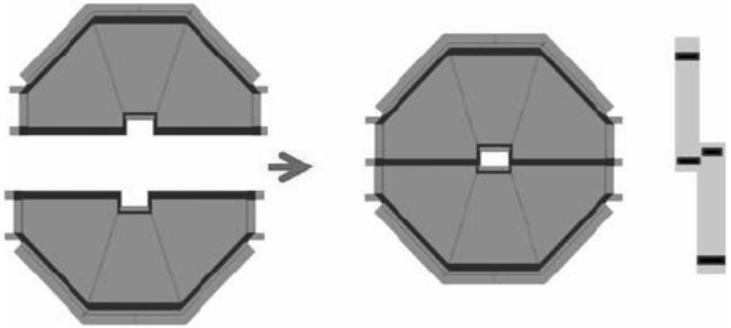

SPD TorSol Straw



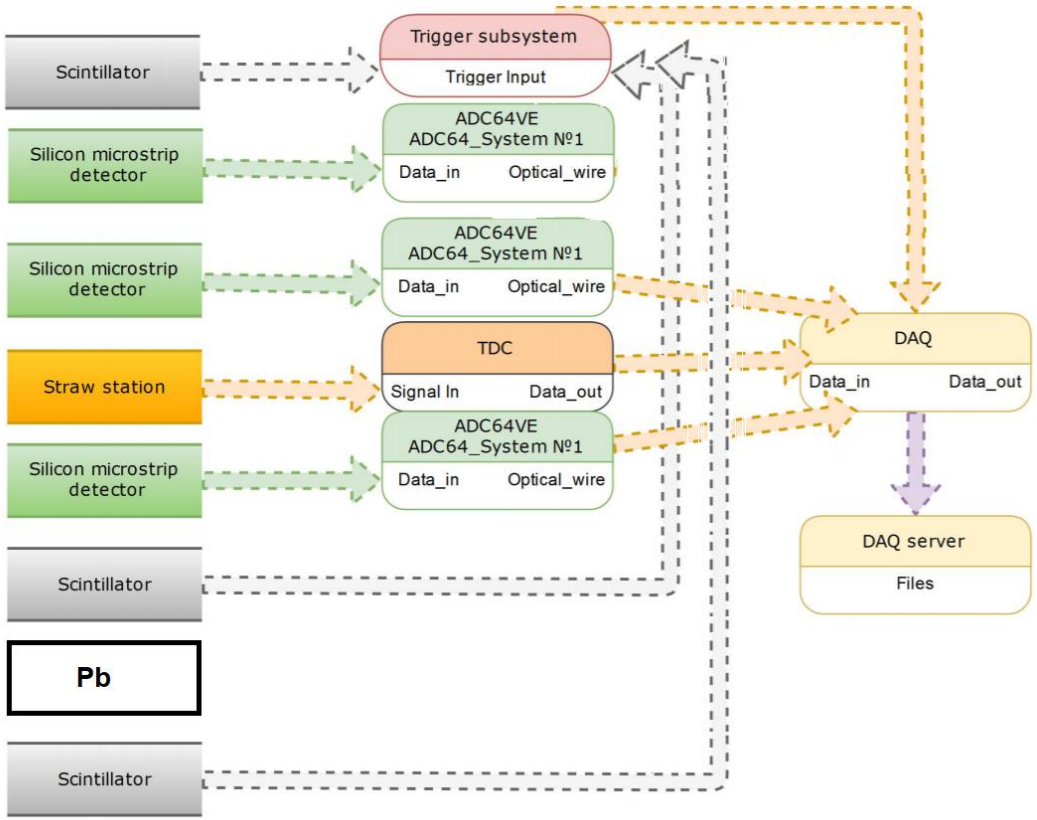
Schematic view of the MUCH straw module. 1— mother boards for the readout and high voltage supply of the straw anodes; 2— carbon plastic elements, and 3— Al elements of the frame.

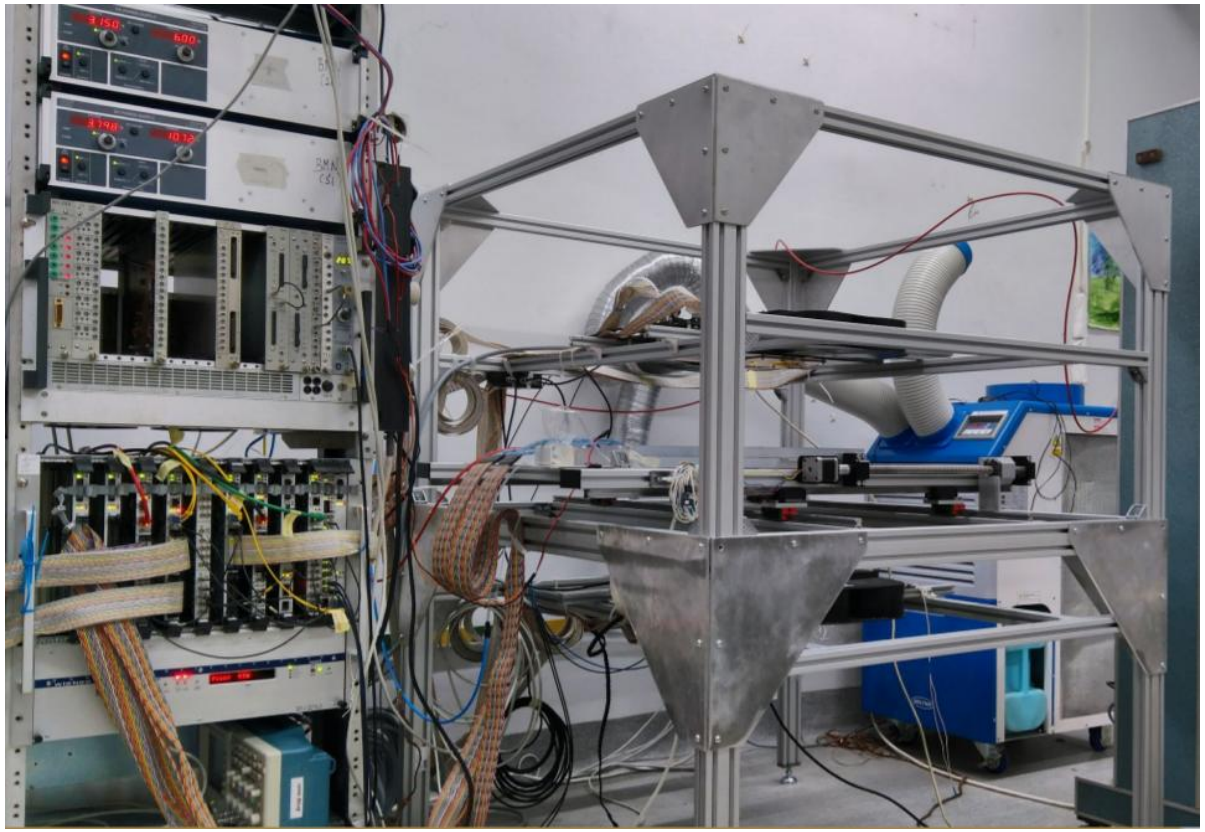


The full size prototype of the straw detector for CBM MUCH

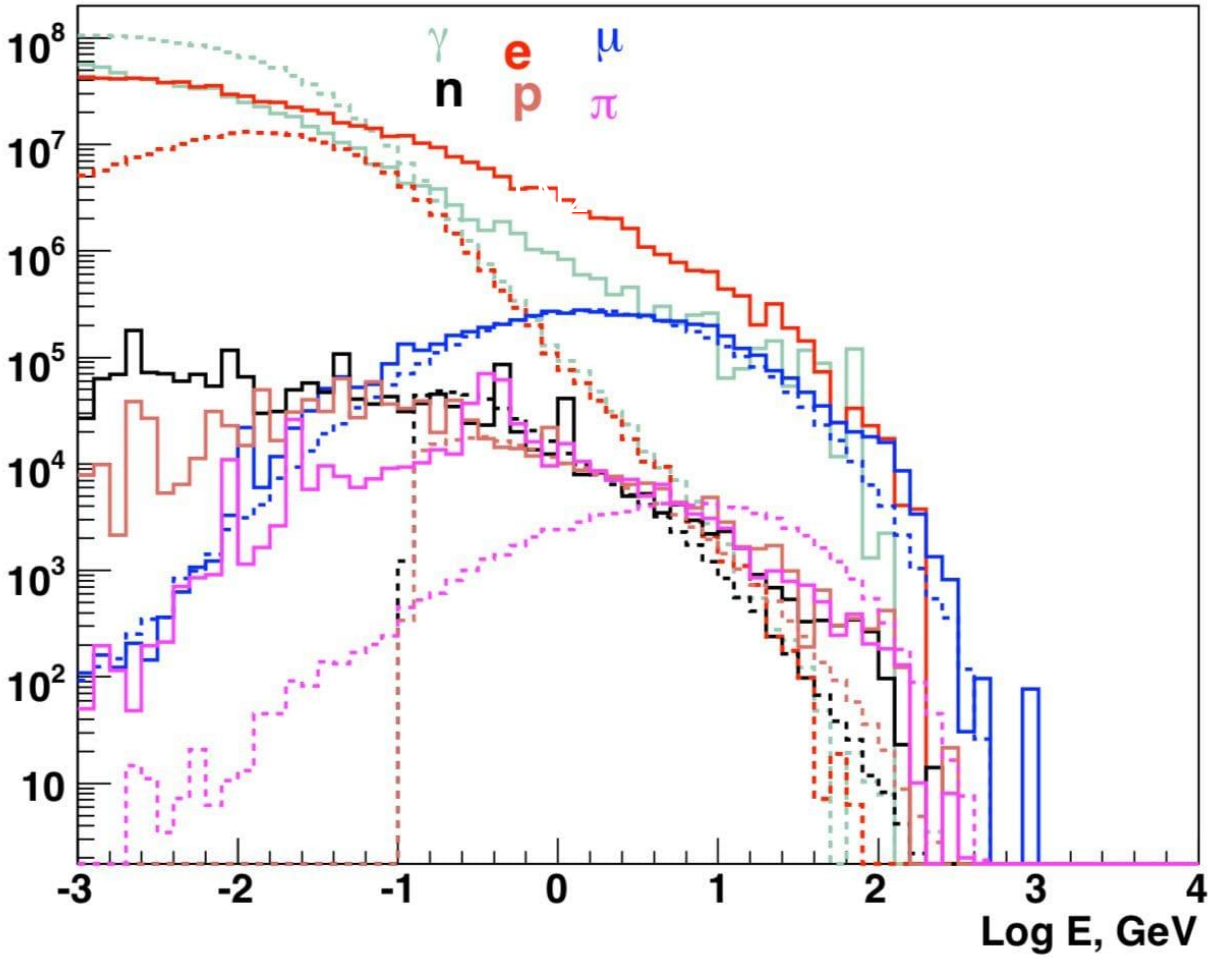


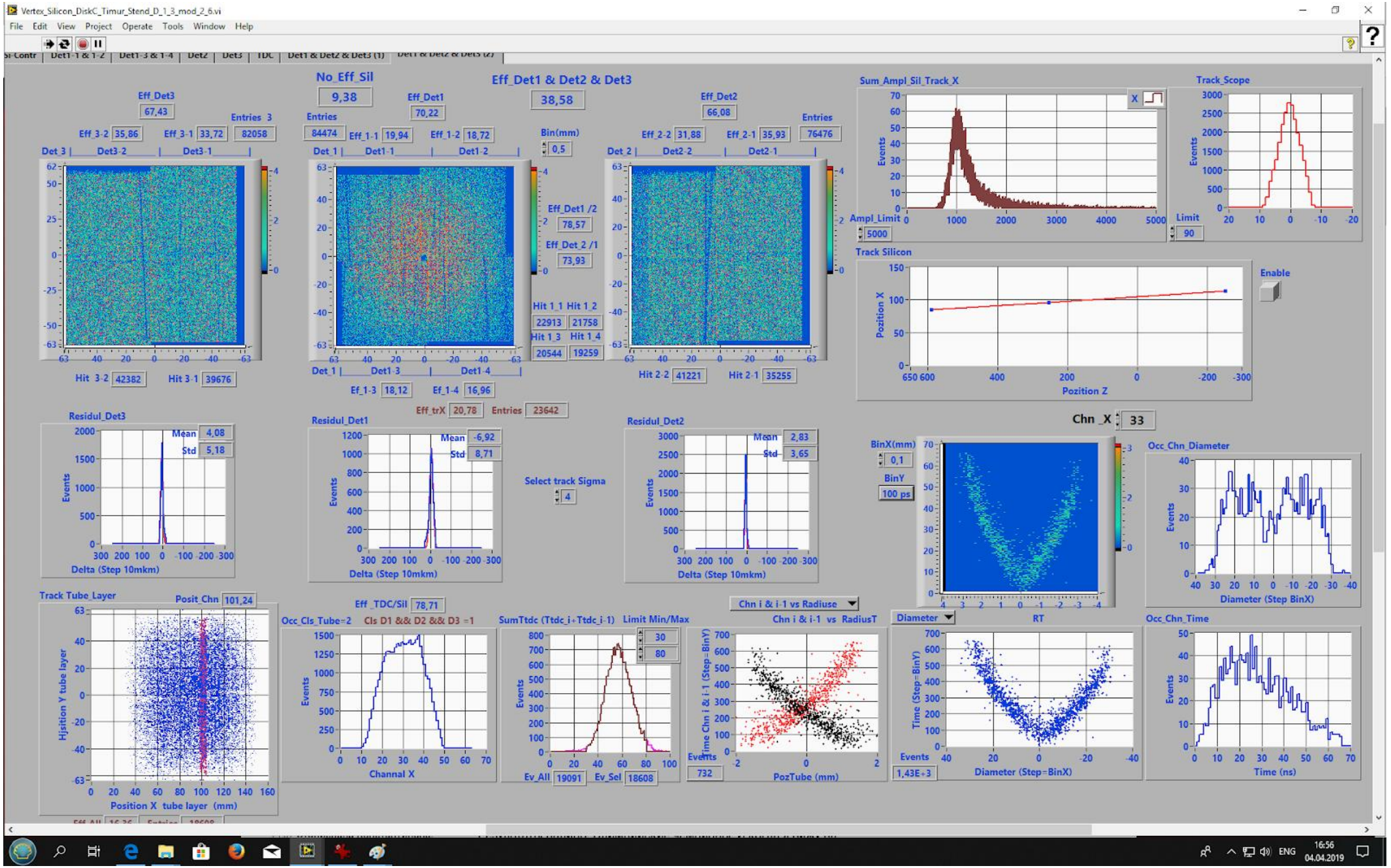
Schematic view of the MUCH straw chamber.


Scintillator
Silicon microstrip detector
Silicon microstrip detector
Straw station
Silicon microstrip detector
Scintillator
Pb
Scintillator
Trigger subsystem
Trigger Input
ADC64VE
ADC64_System №1
Data_in
Optical_wire
ADC64VE
ADC64_System №1
Data_in
Optical_wire
TDC
Signal In
Data_out
ADC64VE
ADC64_System №1
Data_in
Optical_wire
DAQ
Data_in
Data_out
DAQ server
Files



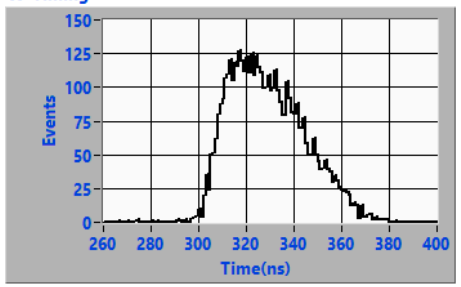
Distribution of cosmic ray particle energies



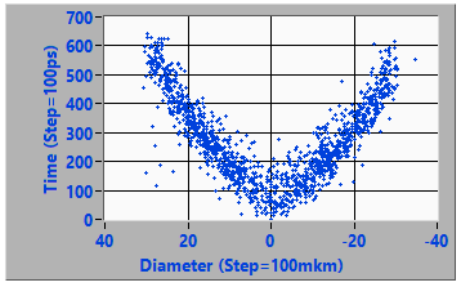

Vertex_Silicon_DiskC_Timur_Stend_D_1_3_mod_2_6.vi
File Edit View Project Operate Tools Window Help
No_Eff_Sil
9,38
Eff_Det1 & Det2 & Det3
38,58
Eff_Det3
67,43
Entries 3
Eff 3-2 35,86
Eff 3-1 33,72
82058
Det 3 | Det3-2 | Det3-1
Hit 3-2 42382
Hit 3-1 39676
Entries
84474
Eff_Det1
70,22
Eff 1-1 19,94
Eff 1-2 18,72
Det 1 | Det1-1 | Det1-2
Det 1 | Det1-3 | Det1-4
Ef 1-3 18,12
Ef 1-4 16,96
Bin(mm)
0,5
Eff_Det1 /2
78,57
Eff_Det 2 /1
73,93
Hit 1_1 Hit 1_2
22913 21758
Hit 1_3 Hit 1_4
20544 19259
Eff_trX 20,78
Entries 23642
Eff_Det2
66,08
Entries
76476
Eff 2-2 31,88
Eff 2-1 35,93
Det 2 | Det2-2 | Det2-1
Hit 2-2 41221
Hit 2-1 35255
Sum_Ampl_Sil_Track X
Ampl_Limit 5000
Track_Scope
Limit 90
Track Silicon
Pozition X
Pozition Z
Enable
Residul_Det3
Mean 4,08
Std 5,18
Delta (Step 10mkm)
Residul_Det1
Mean -6,92
Std 8,71
Delta (Step 10mkm)
Select track Sigma
4
Residul_Det2
Mean 2,83
Std 3,65
Delta (Step 10mkm)
Chn _X 33
BinX(mm) 0,1
BinY 100 ps
Occ_Chn_Diameter
Diameter (Step BinX)
Track Tube_Layer
Posit_Chn 101,24
Hjsition Y tube layer
Position X tube layer (mm)
Eff _TDC/Sil 78,71
Occ_Cls_Tube=2
Cls D1 && D2 && D3 =1
Channal X
SumTtdc (Ttdc_i+Ttdc_i-1)
Limit Min/Max
30
80
Ev_All 19091
Ev_Sel 18608
Chn i & i-1 vs Radiuse
Chn i & i-1 vs RadiusT
Time Chn i & i-1 (Step=BinY)
PozTube (mm)
732
Diameter
RT
Time (Step=BinY)
Diameter (Step=BinX)
1,43E+3
Occ_Chn_Time
Time (ns)
ENG
16:56
04.04.2019

Chn _X 30

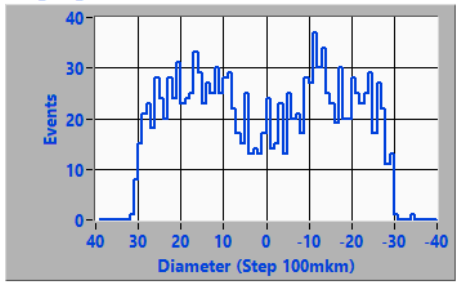
X Timing



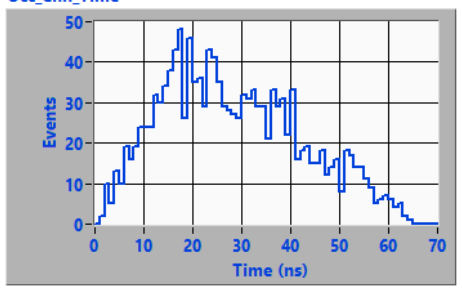
RT



Occ_Chn_Diameter

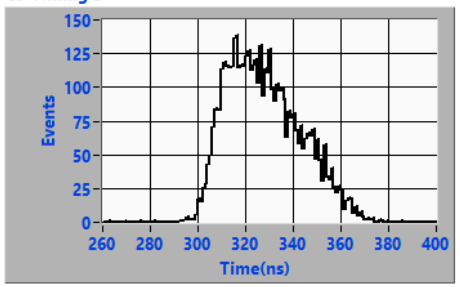


Occ_Chn_Time

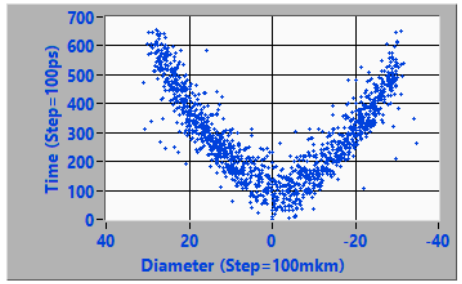


Chn _X 3 32

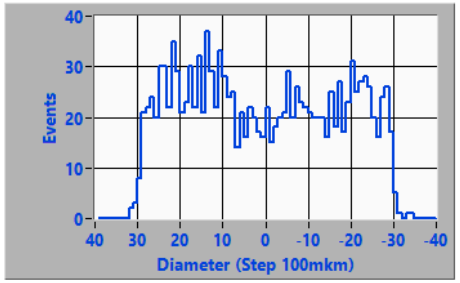
X Timing 3



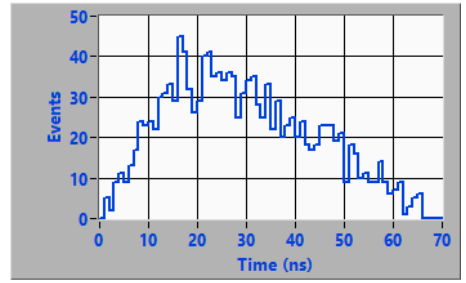
RT 3



Occ_Chn_Diameter 3

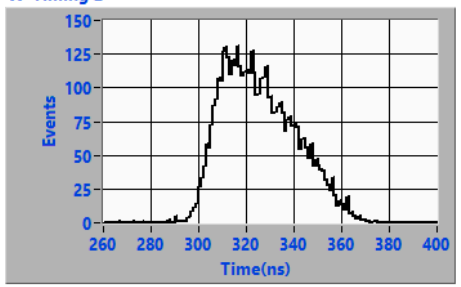


Occ_Chn_Time 3

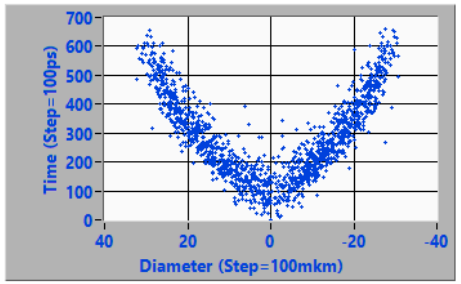


Chn _X 2 31

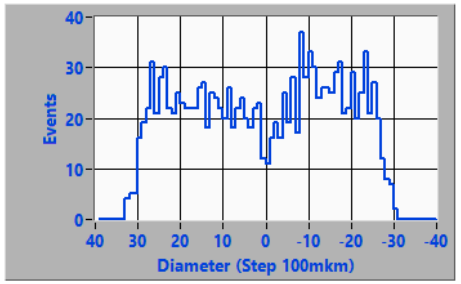
X Timing 2



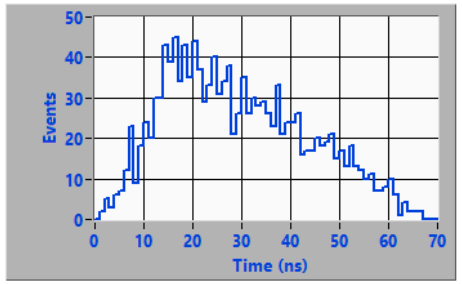
RT 2



Occ_Chn_Diameter 2

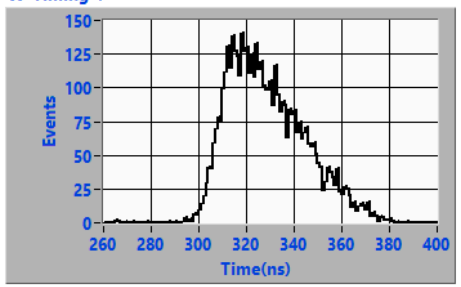


Occ_Chn_Time 2

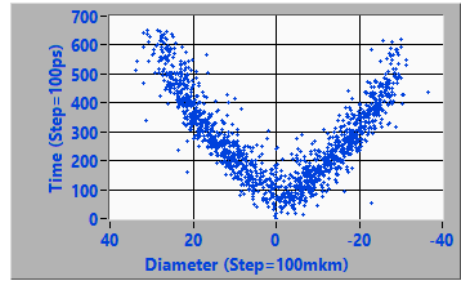


Chn _X 4 33

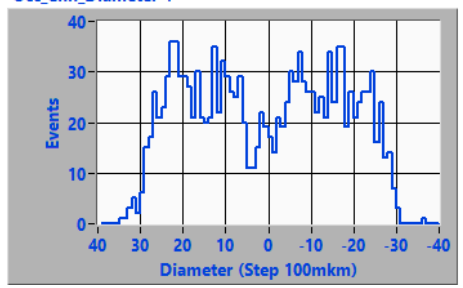
X Timing 4



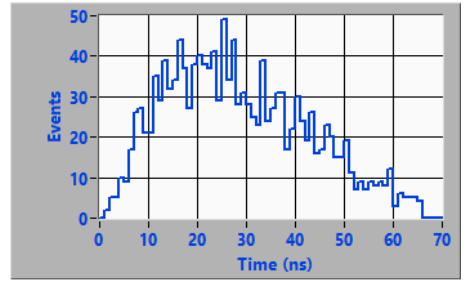
RT 3



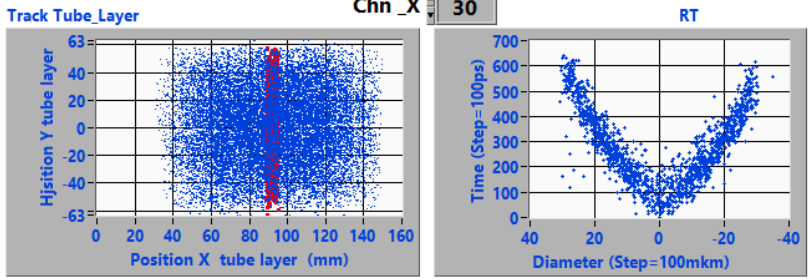
Occ_Chn_Diameter 4



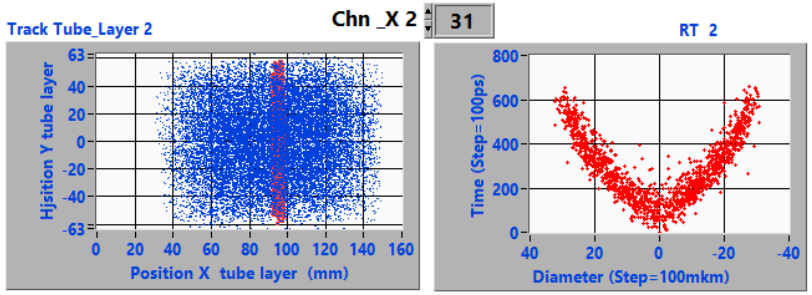
Occ_Chn_Time 4



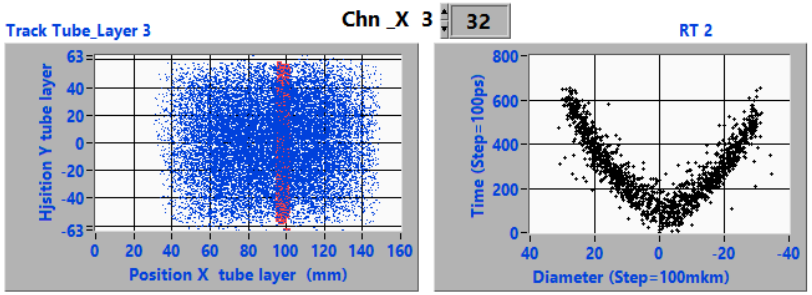
Chn _X 30



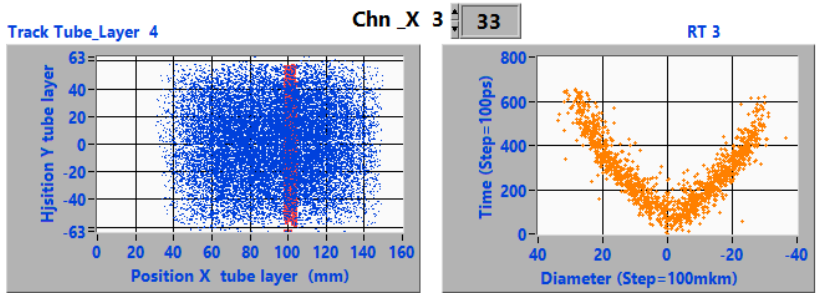
Chn _X 2 31

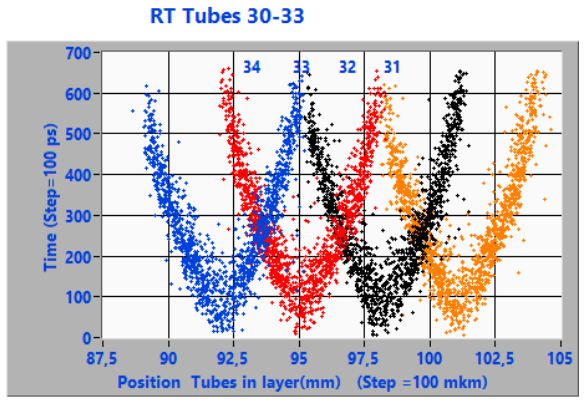


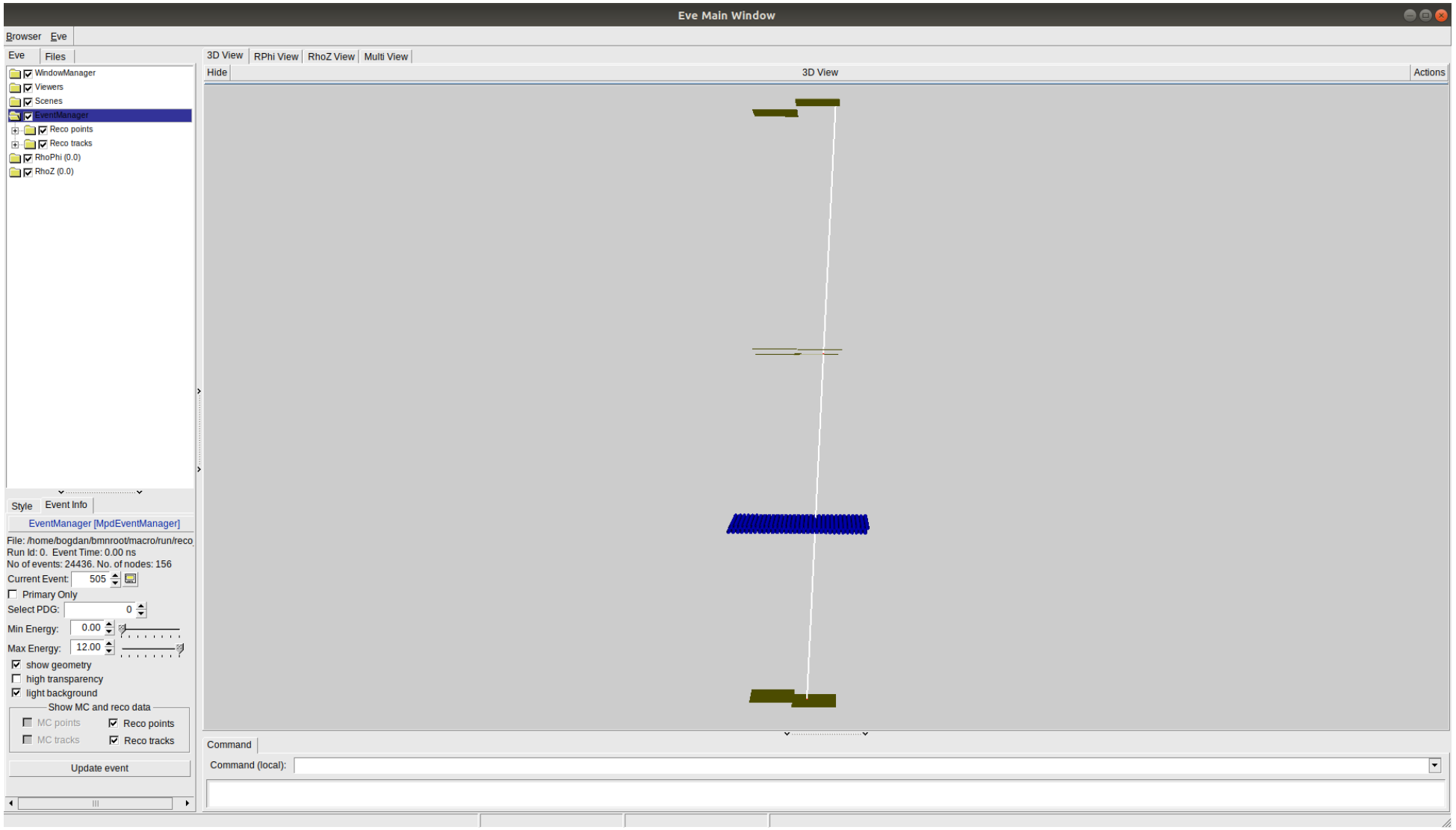
Chn _X 3 32

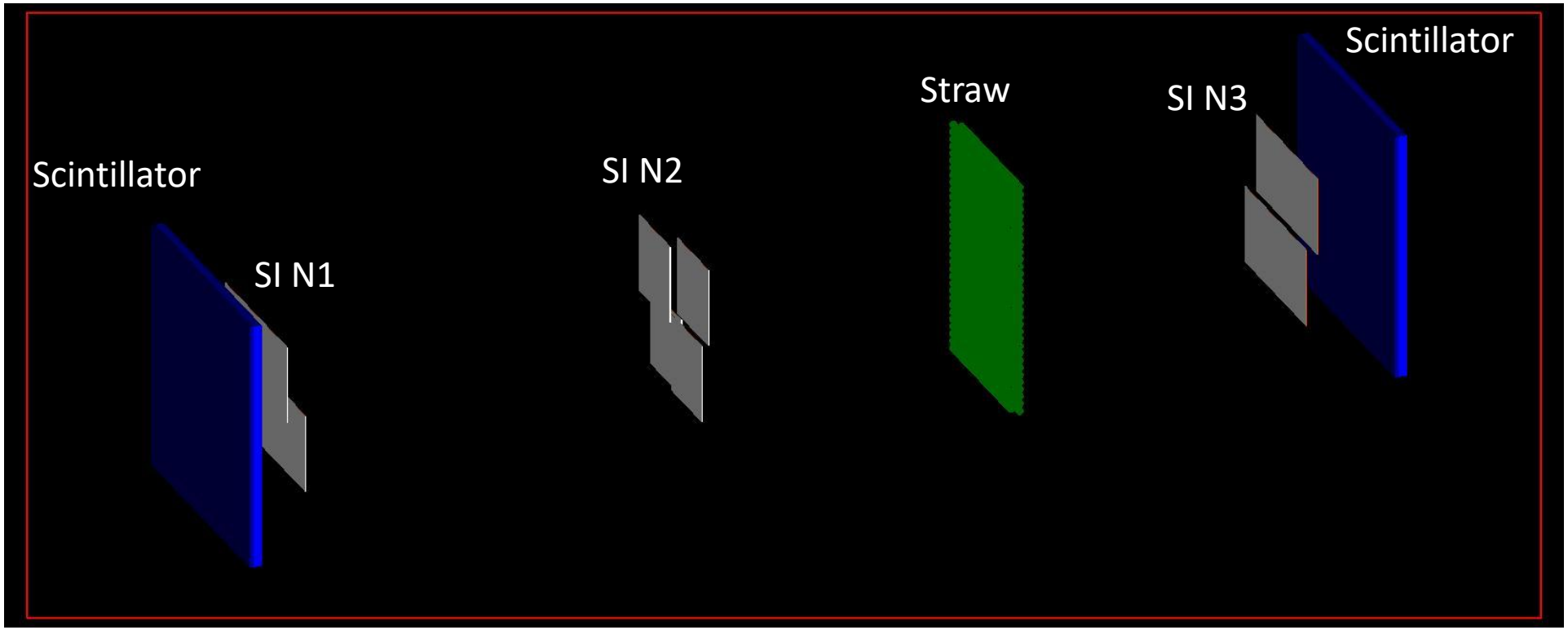


Chn _X 3 33





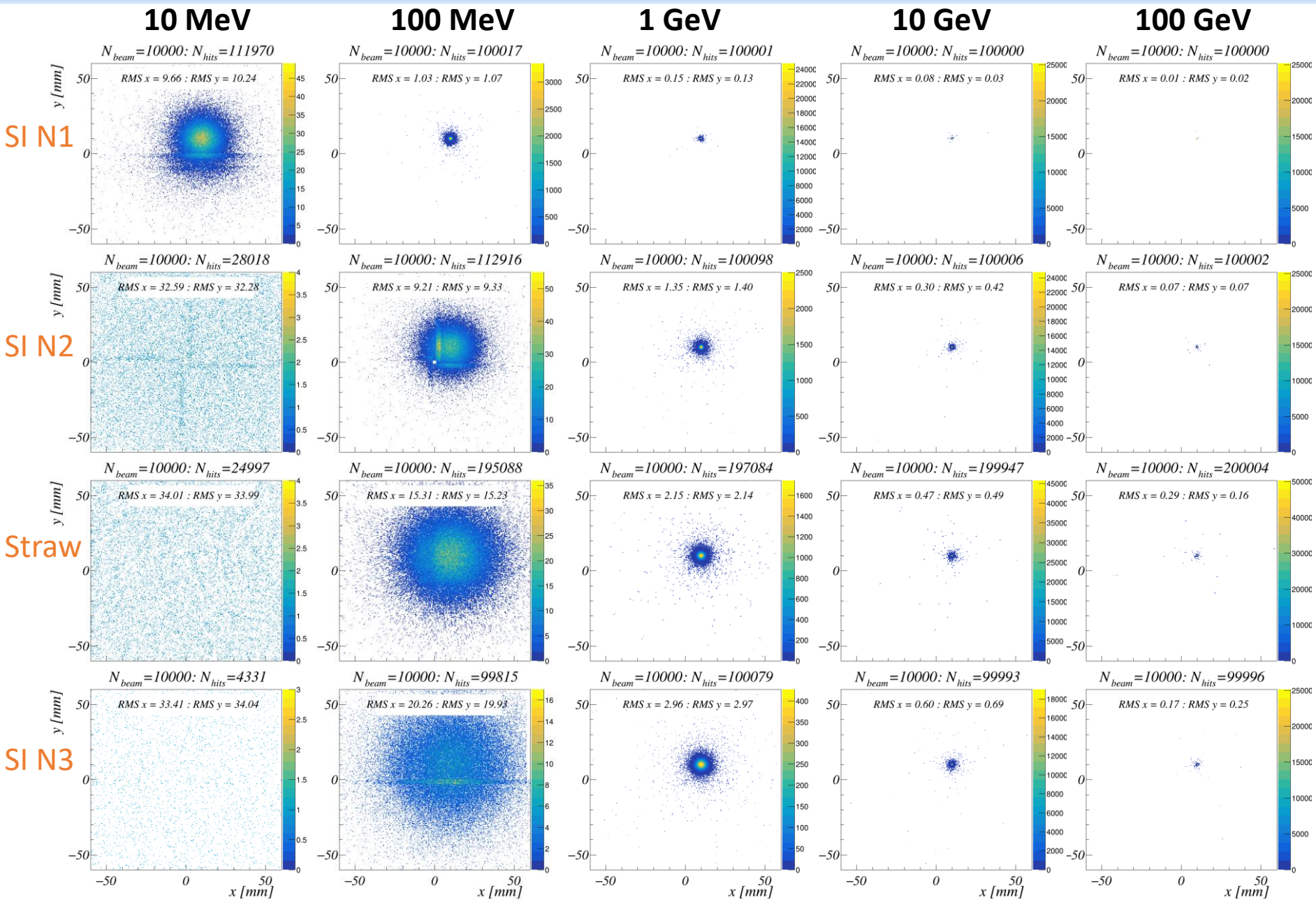

Eve Main Window
Browser
Eve
Eve
Files
WindowManager
Viewers
Scenes
EventManager
Reco points
Reco tracks
RhoPhi (0.0)
RhoZ (0.0)
Style
Event Info
EventManager [MpdEventManager]
File: /home/bogdan/bmnroot/macro/run/reco
Run Id: 0. Event Time: 0.00 ns
No of events: 24436. No. of nodes: 156
Current Event: 505
Primary Only
Select PDG: 0
Min Energy: 0.00
Max Energy: 12.00
show geometry
high transparency
light background
Show MC and reco data
MC points
Reco points
MC tracks
Reco tracks
Update event
3D View
RPhi View
RhoZ View
Multi View
Hide
3D View
Actions
Command
Command (local):



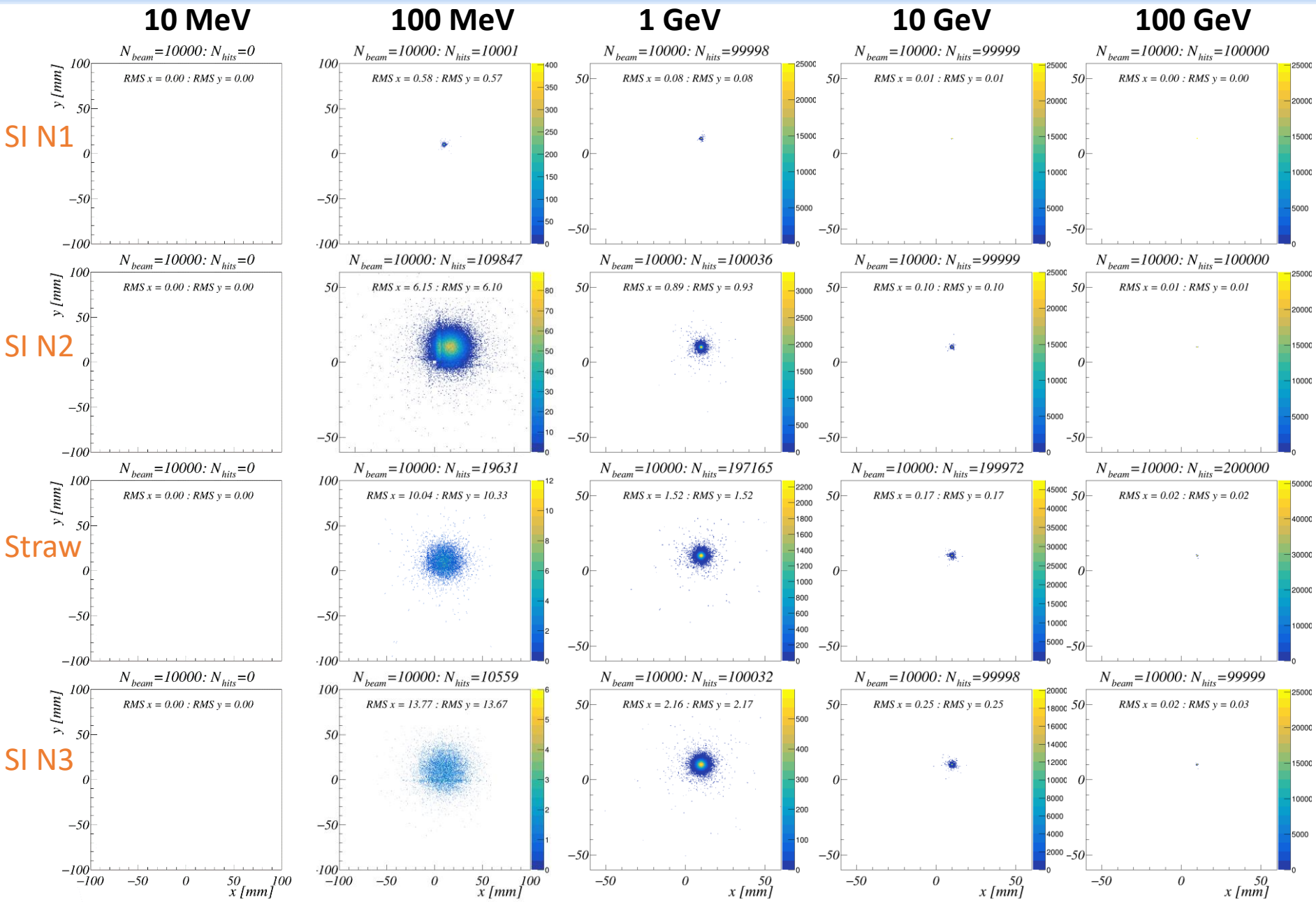
Generation condition:

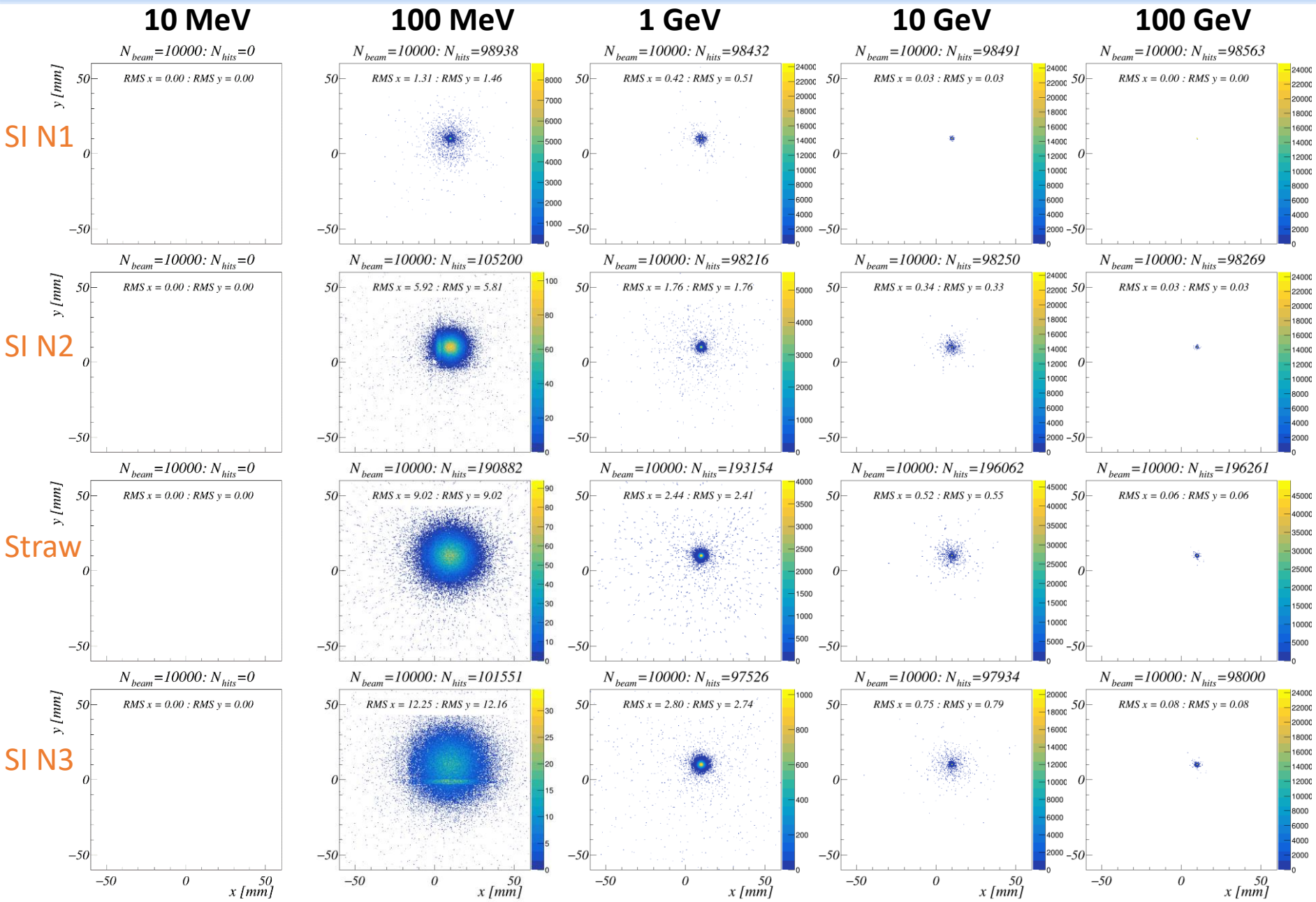
- 100 000 events
- PV (10, 10, -80) mm

e^- - only beam

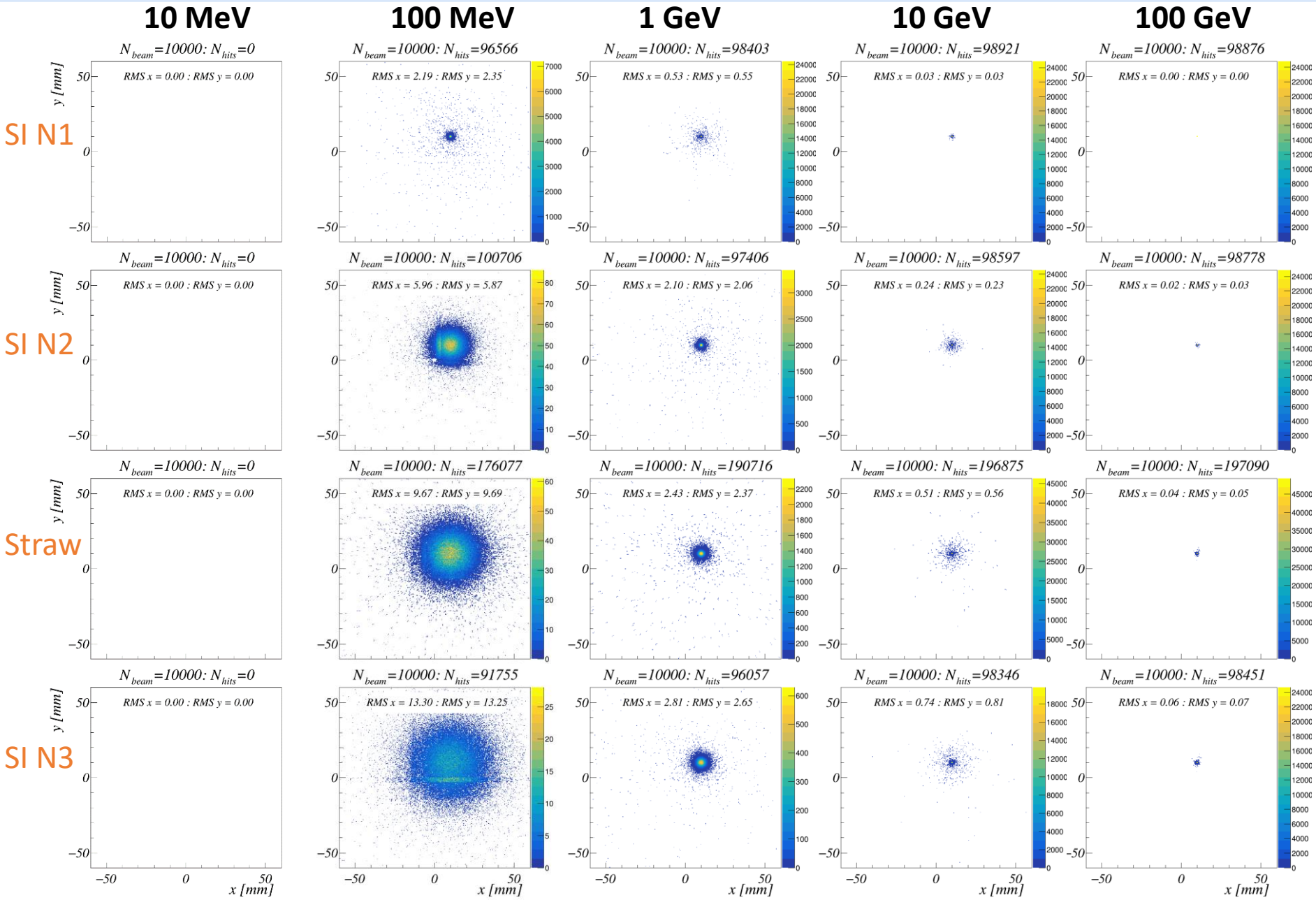

10 MeV
100 MeV
1 GeV
10 GeV
100 GeV
SI N1
SI N2
Straw
SI N3
N_beam=10000: N_hits=111970
RMS x = 9.66 : RMS y = 10.24
N_beam=10000: N_hits=100017
RMS x = 1.03 : RMS y = 1.07
N_beam=10000: N_hits=100001
RMS x = 0.15 : RMS y = 0.13
N_beam=10000: N_hits=100000
RMS x = 0.08 : RMS y = 0.03
N_beam=10000: N_hits=100000
RMS x = 0.01 : RMS y = 0.02
N_beam=10000: N_hits=28018
RMS x = 32.59 : RMS y = 32.28
N_beam=10000: N_hits=112916
RMS x = 9.21 : RMS y = 9.33
N_beam=10000: N_hits=100098
RMS x = 1.35 : RMS y = 1.40
N_beam=10000: N_hits=100006
RMS x = 0.30 : RMS y = 0.42
N_beam=10000: N_hits=100002
RMS x = 0.07 : RMS y = 0.07
N_beam=10000: N_hits=24997
RMS x = 34.01 : RMS y = 33.99
N_beam=10000: N_hits=195088
RMS x = 15.31 : RMS y = 15.23
N_beam=10000: N_hits=197084
RMS x = 2.15 : RMS y = 2.14
N_beam=10000: N_hits=199947
RMS x = 0.47 : RMS y = 0.49
N_beam=10000: N_hits=200004
RMS x = 0.29 : RMS y = 0.16
N_beam=10000: N_hits=4331
RMS x = 33.41 : RMS y = 34.04
N_beam=10000: N_hits=99815
RMS x = 20.26 : RMS y = 19.93
N_beam=10000: N_hits=100079
RMS x = 2.96 : RMS y = 2.97
N_beam=10000: N_hits=99993
RMS x = 0.60 : RMS y = 0.69
N_beam=10000: N_hits=99996
RMS x = 0.17 : RMS y = 0.25
y [mm]
x [mm]

μ^- - only beam

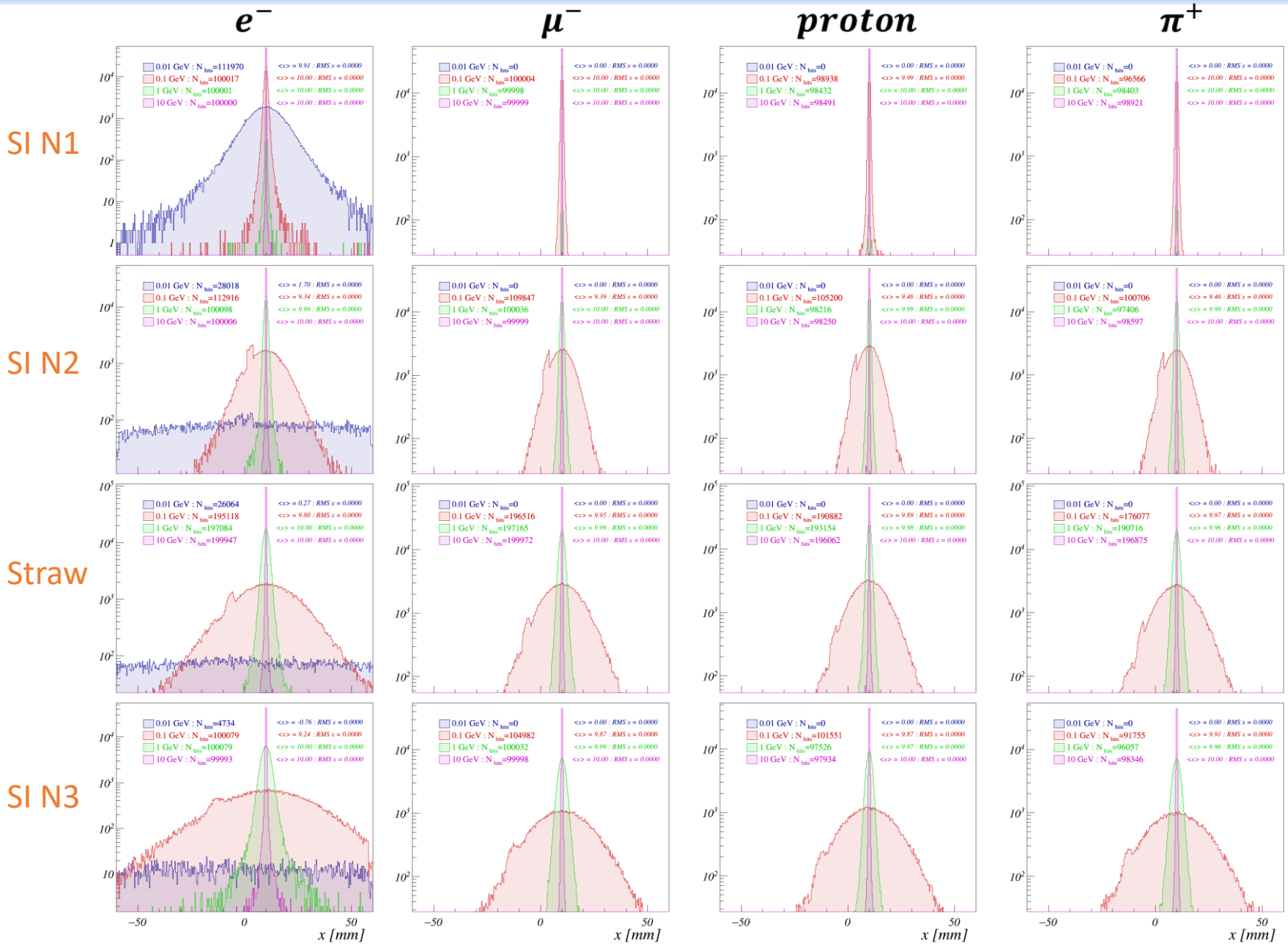

10 MeV
100 MeV
1 GeV
10 GeV
100 GeV
SI N1
SI N2
Straw
SI N3
N_{beam}=10000: N_{hits}=0
RMS x = 0.00 : RMS y = 0.00
N_{beam}=10000: N_{hits}=10001
RMS x = 0.58 : RMS y = 0.57
N_{beam}=10000: N_{hits}=99998
RMS x = 0.08 : RMS y = 0.08
N_{beam}=10000: N_{hits}=99999
RMS x = 0.01 : RMS y = 0.01
N_{beam}=10000: N_{hits}=100000
RMS x = 0.00 : RMS y = 0.00
N_{beam}=10000: N_{hits}=0
RMS x = 0.00 : RMS y = 0.00
N_{beam}=10000: N_{hits}=109847
RMS x = 6.15 : RMS y = 6.10
N_{beam}=10000: N_{hits}=100036
RMS x = 0.89 : RMS y = 0.93
N_{beam}=10000: N_{hits}=99999
RMS x = 0.10 : RMS y = 0.10
N_{beam}=10000: N_{hits}=100000
RMS x = 0.01 : RMS y = 0.01
N_{beam}=10000: N_{hits}=0
RMS x = 0.00 : RMS y = 0.00
N_{beam}=10000: N_{hits}=19631
RMS x = 10.04 : RMS y = 10.33
N_{beam}=10000: N_{hits}=197165
RMS x = 1.52 : RMS y = 1.52
N_{beam}=10000: N_{hits}=199972
RMS x = 0.17 : RMS y = 0.17
N_{beam}=10000: N_{hits}=200000
RMS x = 0.02 : RMS y = 0.02
N_{beam}=10000: N_{hits}=0
RMS x = 0.00 : RMS y = 0.00
N_{beam}=10000: N_{hits}=10559
RMS x = 13.77 : RMS y = 13.67
N_{beam}=10000: N_{hits}=100032
RMS x = 2.16 : RMS y = 2.17
N_{beam}=10000: N_{hits}=99998
RMS x = 0.25 : RMS y = 0.25
N_{beam}=10000: N_{hits}=99999
RMS x = 0.02 : RMS y = 0.03
y [mm]
x [mm]


10 MeV
100 MeV
1 GeV
10 GeV
100 GeV
SI N1
SI N2
Straw
SI N3
N_{beam}=10000: N_{hits}=0
RMS x = 0.00 : RMS y = 0.00
N_{beam}=10000: N_{hits}=98938
RMS x = 1.31 : RMS y = 1.46
N_{beam}=10000: N_{hits}=98432
RMS x = 0.42 : RMS y = 0.51
N_{beam}=10000: N_{hits}=98491
RMS x = 0.03 : RMS y = 0.03
N_{beam}=10000: N_{hits}=98563
RMS x = 0.00 : RMS y = 0.00
N_{beam}=10000: N_{hits}=0
RMS x = 0.00 : RMS y = 0.00
N_{beam}=10000: N_{hits}=105200
RMS x = 5.92 : RMS y = 5.81
N_{beam}=10000: N_{hits}=98216
RMS x = 1.76 : RMS y = 1.76
N_{beam}=10000: N_{hits}=98250
RMS x = 0.34 : RMS y = 0.33
N_{beam}=10000: N_{hits}=98269
RMS x = 0.03 : RMS y = 0.03
N_{beam}=10000: N_{hits}=0
RMS x = 0.00 : RMS y = 0.00
N_{beam}=10000: N_{hits}=190882
RMS x = 9.02 : RMS y = 9.02
N_{beam}=10000: N_{hits}=193154
RMS x = 2.44 : RMS y = 2.41
N_{beam}=10000: N_{hits}=196062
RMS x = 0.52 : RMS y = 0.55
N_{beam}=10000: N_{hits}=196261
RMS x = 0.06 : RMS y = 0.06
N_{beam}=10000: N_{hits}=0
RMS x = 0.00 : RMS y = 0.00
N_{beam}=10000: N_{hits}=101551
RMS x = 12.25 : RMS y = 12.16
N_{beam}=10000: N_{hits}=97526
RMS x = 2.80 : RMS y = 2.74
N_{beam}=10000: N_{hits}=97934
RMS x = 0.75 : RMS y = 0.79
N_{beam}=10000: N_{hits}=98000
RMS x = 0.08 : RMS y = 0.08
y [mm]
x [mm]

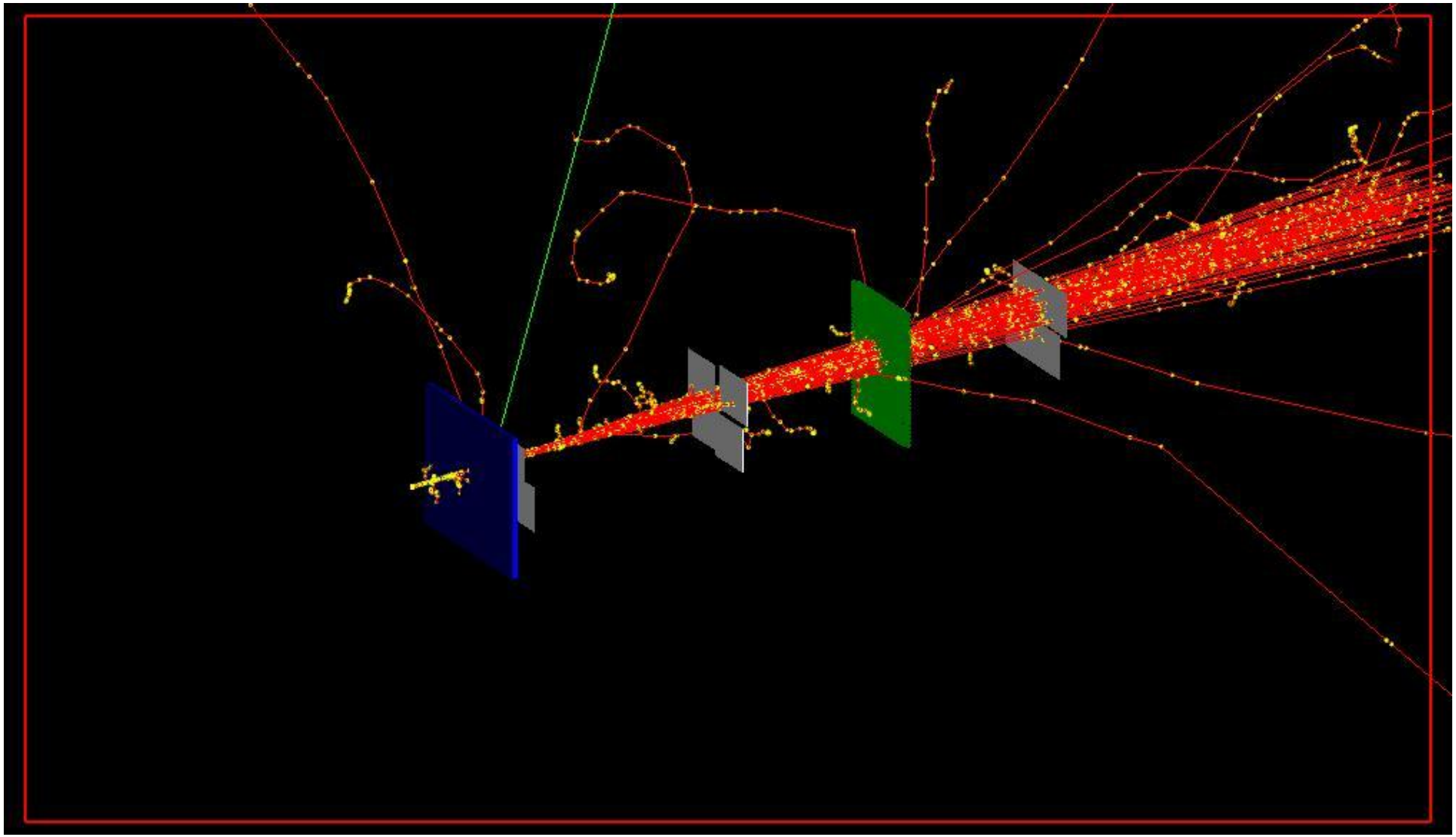
π^+ - only beam


10 MeV
100 MeV
1 GeV
10 GeV
100 GeV
SI N1
SI N2
Straw
SI N3
N_{beam}=10000: N_{hits}=0
N_{beam}=10000: N_{hits}=96566
N_{beam}=10000: N_{hits}=98403
N_{beam}=10000: N_{hits}=98921
N_{beam}=10000: N_{hits}=98876
N_{beam}=10000: N_{hits}=0
N_{beam}=10000: N_{hits}=100706
N_{beam}=10000: N_{hits}=97406
N_{beam}=10000: N_{hits}=98597
N_{beam}=10000: N_{hits}=98778
N_{beam}=10000: N_{hits}=0
N_{beam}=10000: N_{hits}=176077
N_{beam}=10000: N_{hits}=190716
N_{beam}=10000: N_{hits}=196875
N_{beam}=10000: N_{hits}=197090
N_{beam}=10000: N_{hits}=0
N_{beam}=10000: N_{hits}=91755
N_{beam}=10000: N_{hits}=96057
N_{beam}=10000: N_{hits}=98346
N_{beam}=10000: N_{hits}=98451
RMS x = 0.00 : RMS y = 0.00
RMS x = 2.19 : RMS y = 2.35
RMS x = 0.53 : RMS y = 0.55
RMS x = 0.03 : RMS y = 0.03
RMS x = 0.00 : RMS y = 0.00
RMS x = 0.00 : RMS y = 0.00
RMS x = 5.96 : RMS y = 5.87
RMS x = 2.10 : RMS y = 2.06
RMS x = 0.24 : RMS y = 0.23
RMS x = 0.02 : RMS y = 0.03
RMS x = 0.00 : RMS y = 0.00
RMS x = 9.67 : RMS y = 9.69
RMS x = 2.43 : RMS y = 2.37
RMS x = 0.51 : RMS y = 0.56
RMS x = 0.04 : RMS y = 0.05
RMS x = 0.00 : RMS y = 0.00
RMS x = 13.30 : RMS y = 13.25
RMS x = 2.81 : RMS y = 2.65
RMS x = 0.74 : RMS y = 0.81
RMS x = 0.06 : RMS y = 0.07
y [mm]
x [mm]

vX - only beam



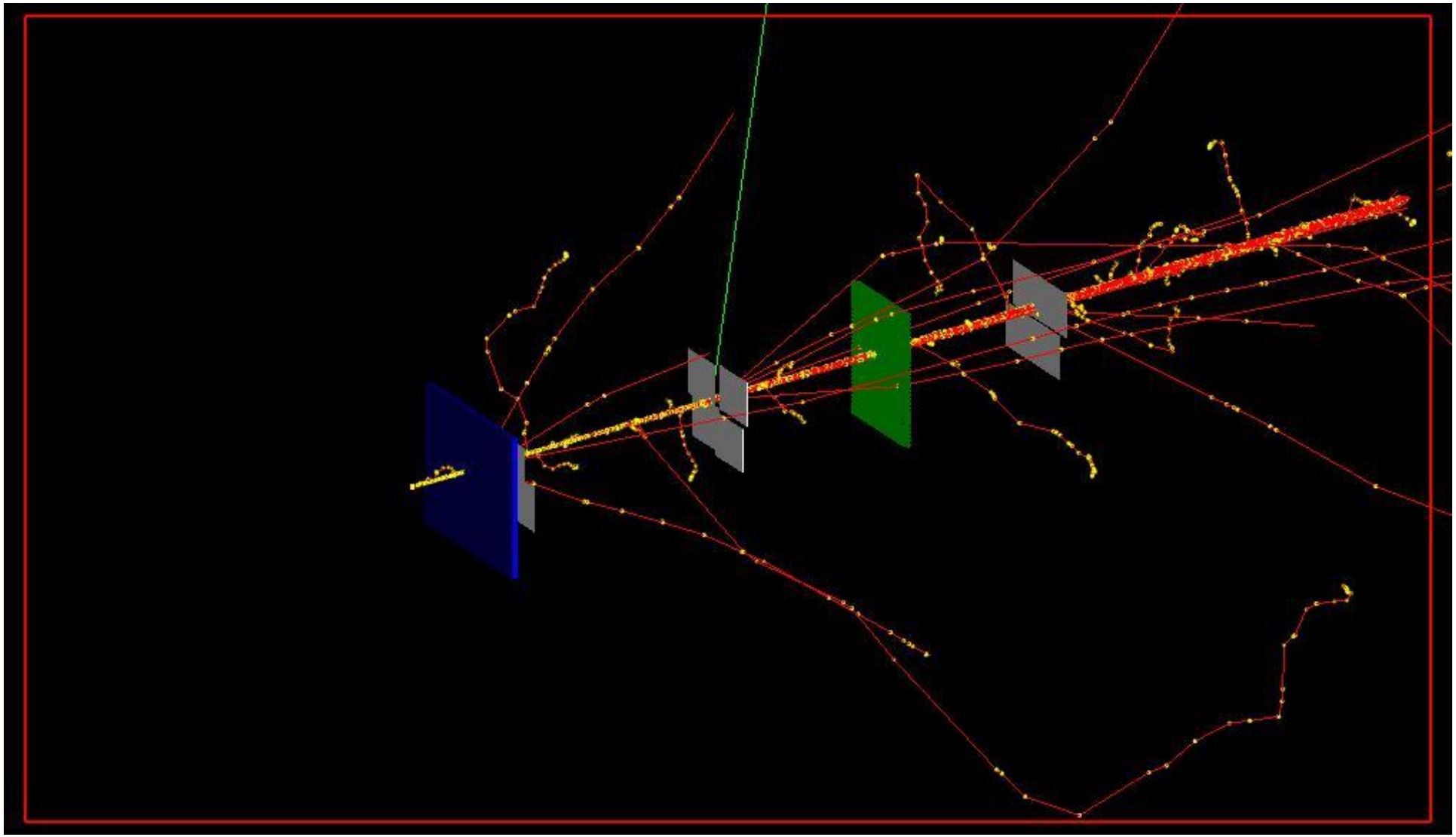
MiniSPD: μ^- - 100 MeV



Primary vertex position X=10 mm, Y=10 mm and Z=-80 mm

100 events

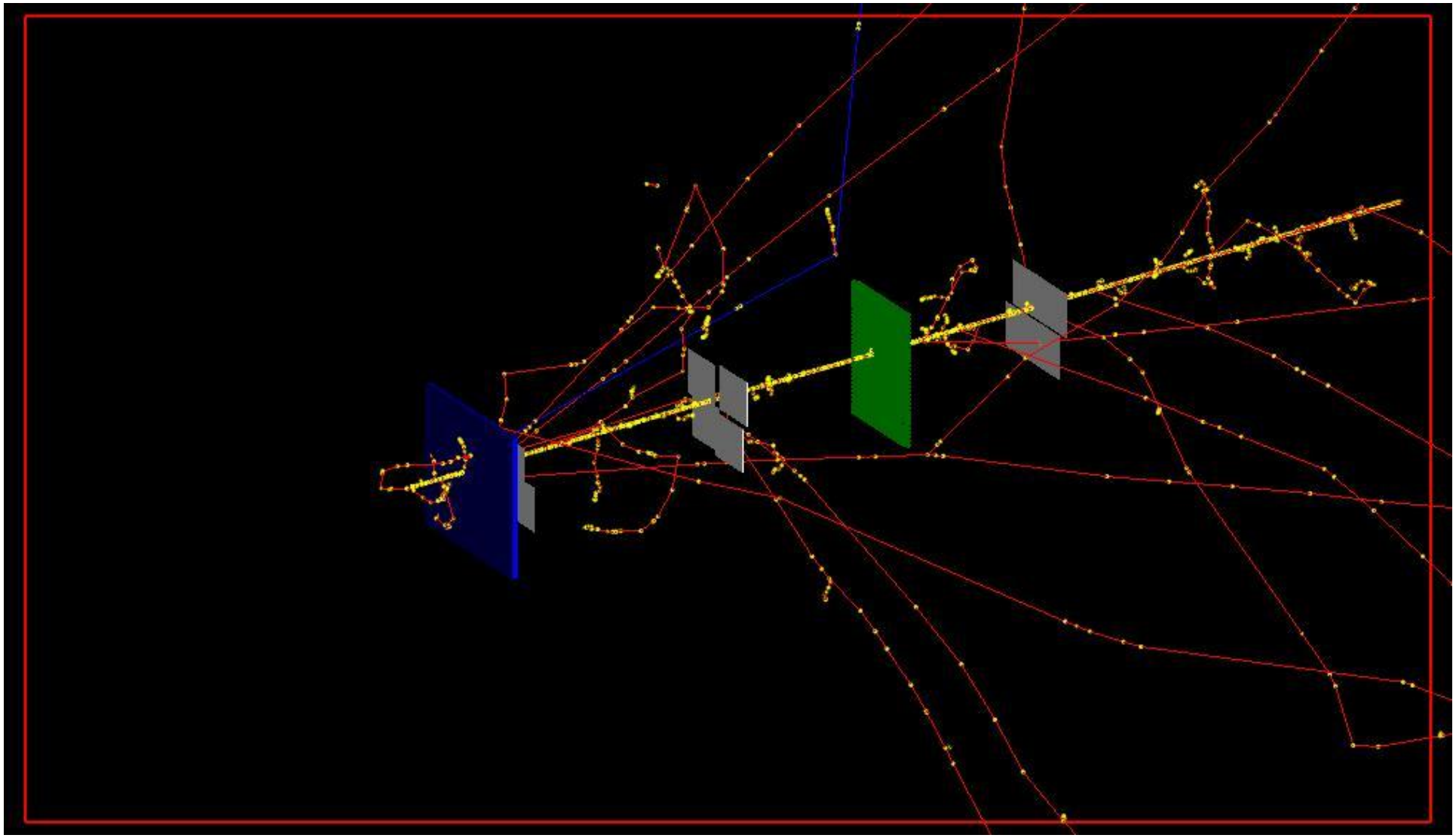
MiniSPD: μ^- - 1 GeV



Primary vertex position X=10 mm, Y=10 mm and Z=-80 mm

100 events

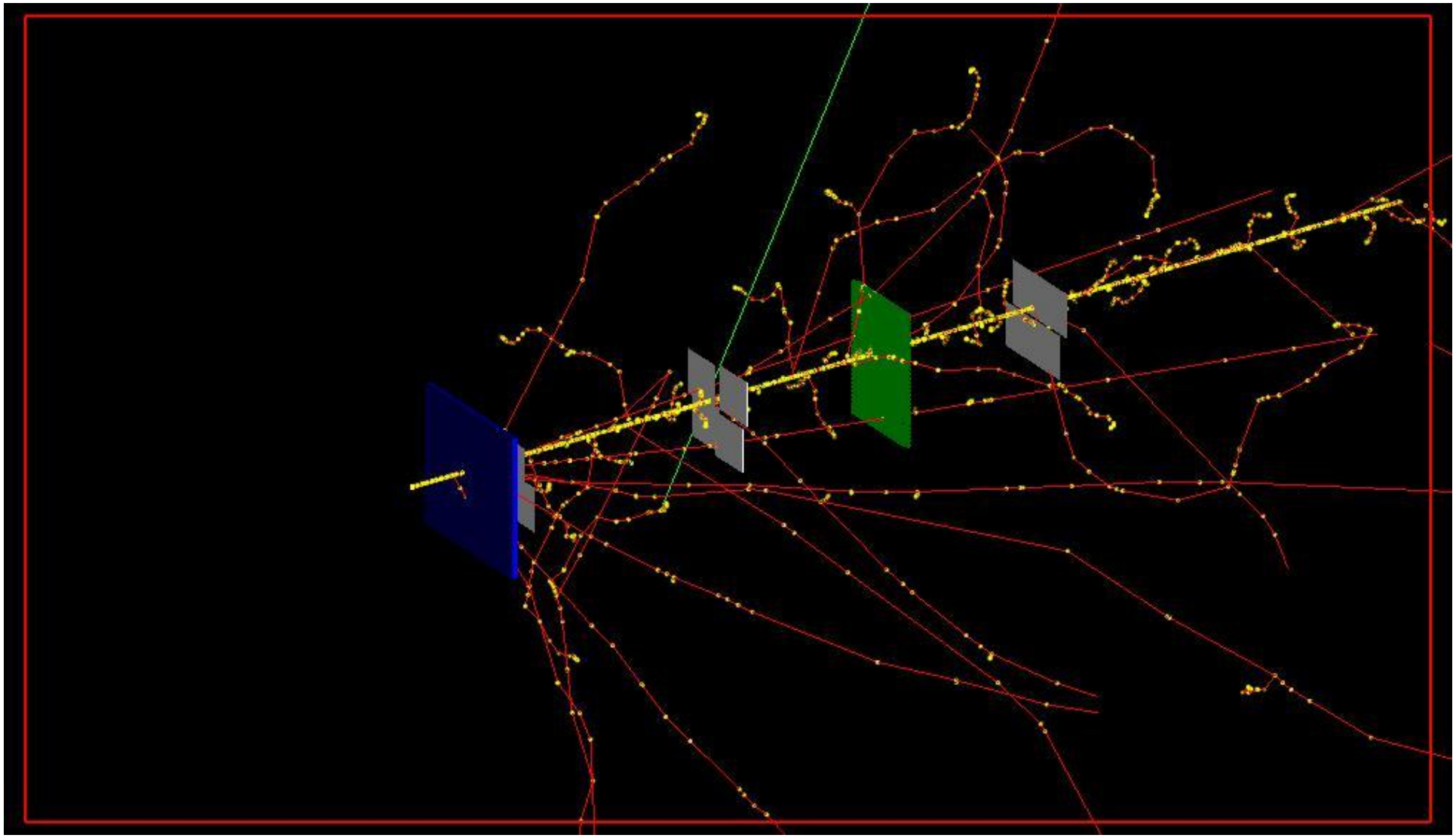
MiniSPD: μ^- - 10 GeV



Primary vertex position X=10 mm, Y=10 mm and Z=-80 mm

100 events

MiniSPD: μ^- - 100 GeV



Primary vertex position X=10 mm, Y=10 mm and Z=-80 mm

100 events