STAR Note

Proposal for the TPC Geometry in GEANT

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1 TPC Geometry

The TPC detector occupies the area shown in Fig 1. The TPC volume is named TPCV. All the other volumes are positioned inside it:

1. Outer Field Cage (TOFC).
2. Inner Field Cage (TIFC).
3. Central Membrane (TPCM).
4. Gas Volume (TPGV).
5. Endcap Areas (TPEA).
6. Wheel (TPCW). The wheel could not be combined easily with the endcap, because the endcap and the wire structure are inside the fieldcage and the wheel has the outer radius that matches the outer radius of the Outer Field Cage.

Positioning of these volumes and their dimensions are shown in Fig. 1. The TPC Outer

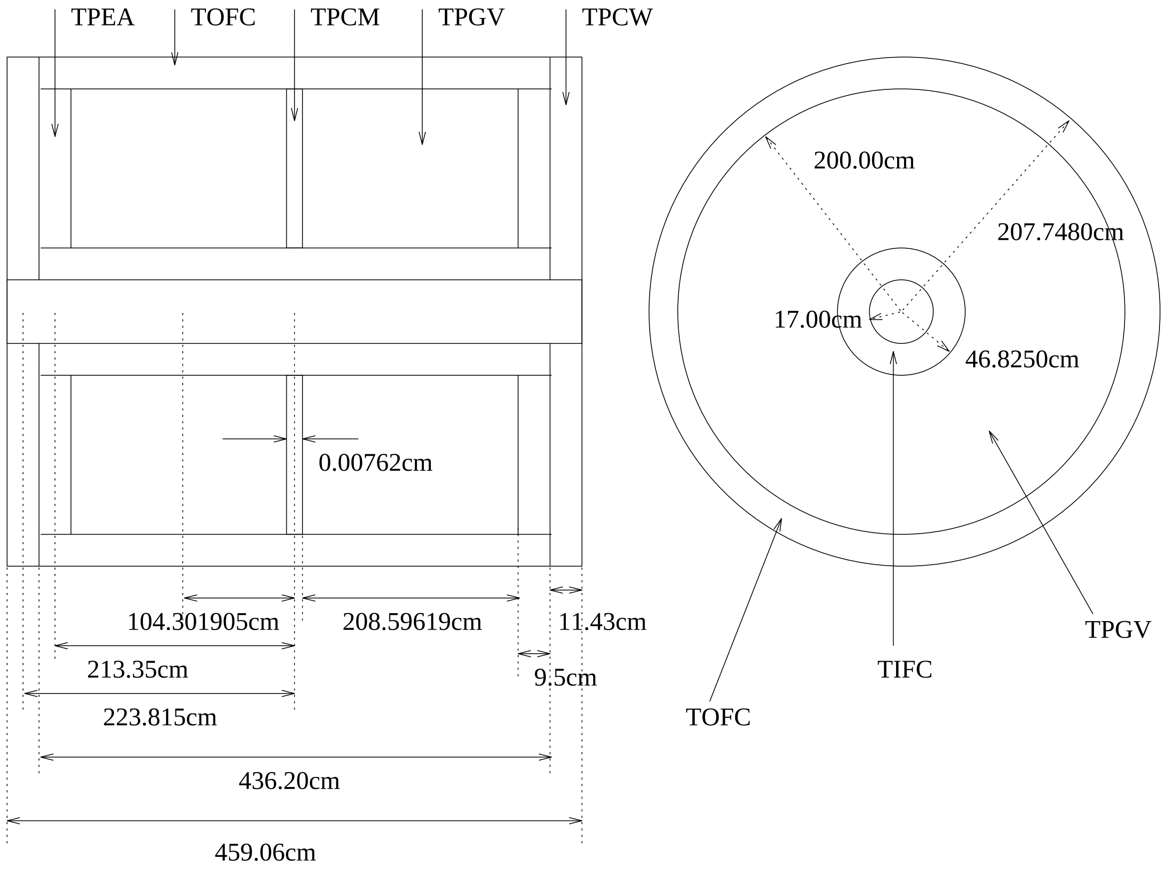

Figure 1: TPC voulme definitions.

Field Cage (TOFC) is shown in Fig. 2. It consists of several volumes itself. They are:

1. Insulating Gas (TOIG). The insulating gas will be either N_2 or C_2F_6.
2. Outer Field Cage Structure (TOFS). The Outer Field Cage Structure is rather complex and is built from the following layers:
   - Copper Strips (TOCS).
   - Kapton (TOKA).
   - Nomex (TONX).
   - Adhesive (TOAD).

   All these volumes are positioned in TOFS at (0,0,0). All the layers are rather thin and of comparable radiation length so in the future they all could be combined into one volume filled with a mixture of appropriate density.
3. Support Tube (TOST). The Support Tube has two components:
   - Aluminum Cylinder (TOAL).
   - Mixture of Aluminum Honeycomb and Adhesive (TOHA).

   These two volumes are positioned in TOST at (0,0,0) and could be also combined into one.

The TOIG, TOFS and TOST volumes are positioned in TOFC at (0,0,0). All the dimensions and materials describing the Outer Field Cage are listed in Tab. 1.

Table 1: Outer Field Cage structure and materials.

Component	Inner Radius [cm]	Outer radius [cm]	Thickness [cm]	Material	% L_r
Copper (TOCS)	200.000	200.013	0.013	Cu	0.91
Kapton (TOKA)	200.013	200.028	0.015	Mylar[1]	0.05
Nomex (TONX)	200.028	201.028	1.000	Nomex[1]	0.12
Adhesive (TOAD)	201.028	201.048	0.020	Mylar[1]	0.06
Gas (TOIG)	201.048	206.748	5.700	N_2	0.02
Support (TOAL)	206.748	207.148	0.400	Al	4.31
Structure(TOHA)	207.148	207.748	0.600	Al,N_2 mixt.[1]	0.56

The Inner Field Cage (TIFC) is shown in Fig. 3. Its geometry is very much the same as that of the Outer Field Cage. The set of volumes consists of:

1. Insulating Gas (TIIG).

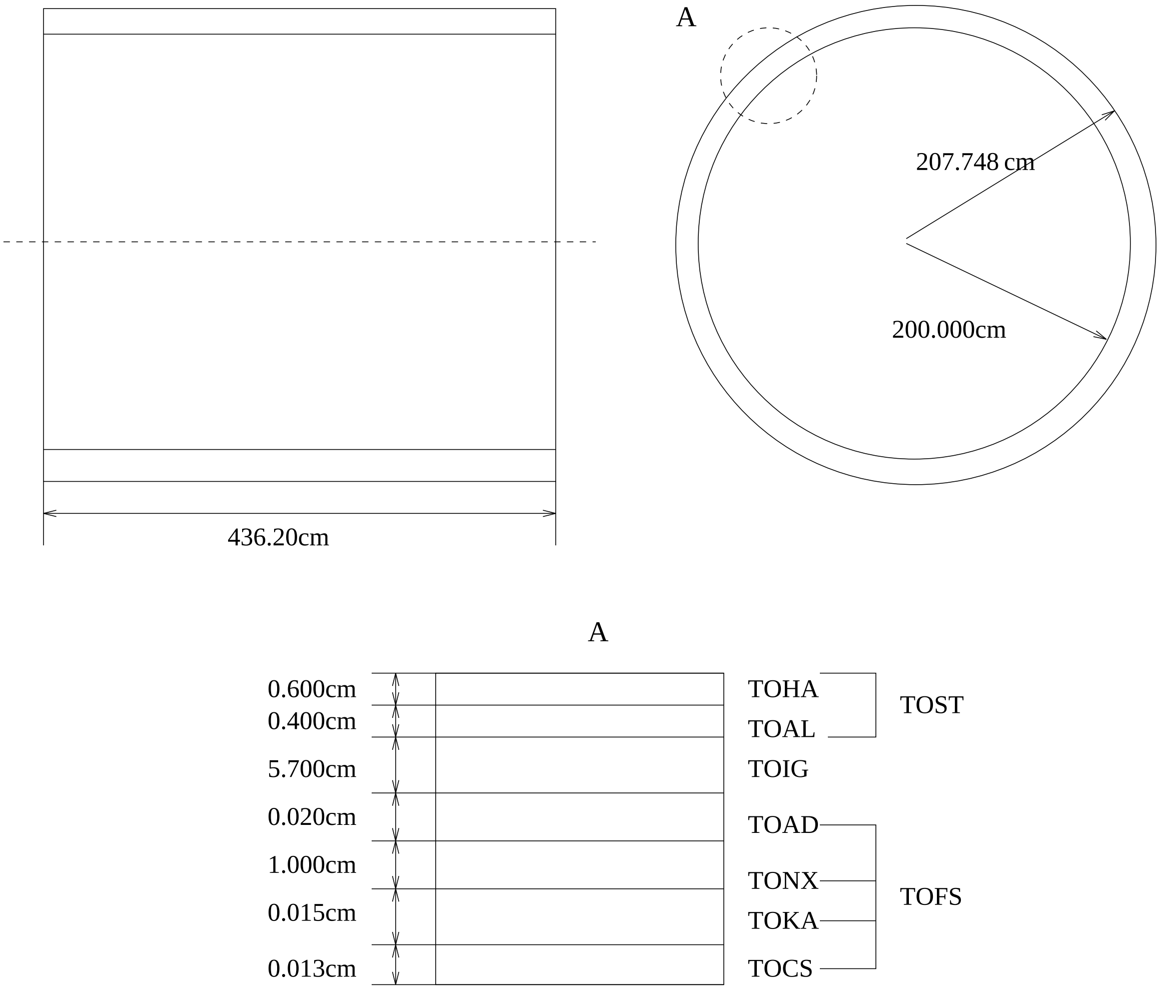

Figure 2: TPC Outer Field Cage.

2. Inner Field Cage Structure (TIFS). The Inner Field Cage structure is identical to that of the Outer Field Cage. Only the copper strips are replaced by the aluminum ones. So the Inner Field Cage structure consists of the following layers:

   - Aluminum Strips (TIAL).
   - Kapton (TIKA).
   - Nomex (TINX).
   - Adhesive (TIAD).

   And again as in the Outer Field Cage case all the layers are not active and rather thin and could be replaced by one volume of appropriate density.

All the dimensions and materials describing the Inner Field Cage are listed in Tab. 2 The Inner Field Cage structure is self-supporting, so there is no support in this case.

The central Membrane (TPCM) is a thin cylinder positioned inside the TPC. It is made of copper. Its dimensions and positioning are shown in Fig. 1.

Table 2: Inner Field Cage structure and materials.

Component	Inner Radius [cm]	Outer radius [cm]	Thickness [cm]	Material	% L_r
Aluminum (TIAL)	46.812	46.825	0.013	Al	0.15
Kapton (TIKA)	46.797	46.812	0.015	Mylar[2]	0.05
Nomex (TINX)	45.797	46.797	1.000	Nomex[1]	0.12
Adhesive (TIAD)	45.697	45.797	0.100	Mylar[1]	0.30
Gas (TIIG)	17.002	45.697	28.685	N_2	0.10

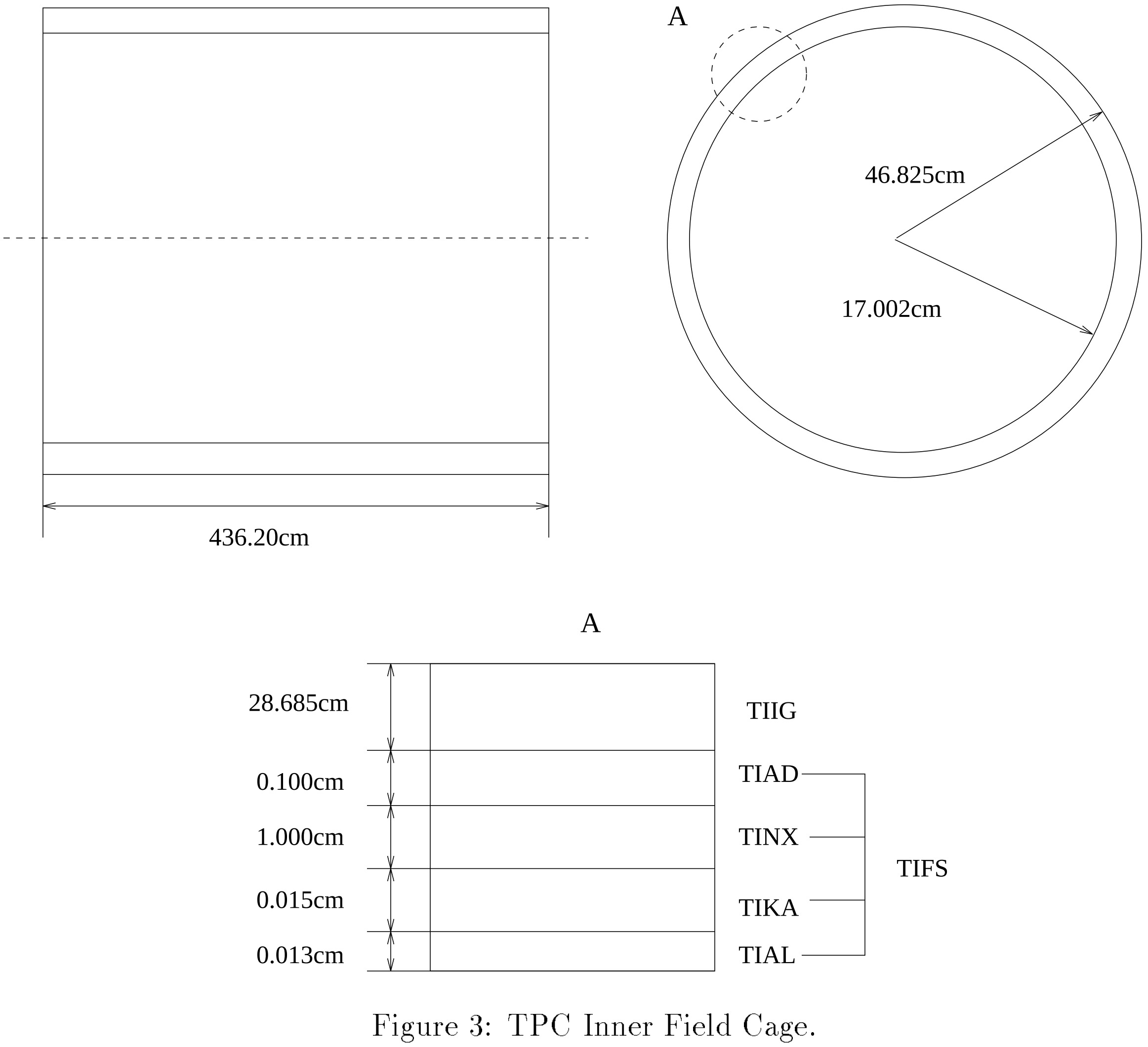

Figure 3: TPC Inner Field Cage.

The TPC Gas Volume is a cylinder. It is positioned twice (to the left and to the right) from the Central Membrane. Its dimensions and positioning are shown in Fig 1. It is divided into 12 sectors. It is filled with either P10 or He-Ethane mixture that is not a tracking medium. The TPC padrows are positioned inside the sectors. They are represented by boxes that are as long as the gas volume is. In the outer sector they are

row number	position	number of pads
1	60.0cm	88
2	64.8cm	96
3	69.6cm	104
4	74.4cm	112
5	79.2cm	118
6	84.0cm	126
7	88.8cm	134
8	93.6cm	142
9	98.8cm	150
10	104.0cm	156
11	109.2cm	166
12	114.4cm	174
13	119.6cm	184

Table 3: Positioning and number of pads for the inner TPC rows.

1.95cm and in the inner sector 1.15cm tall. The padrow width is given by the following formula:

$$w^i = n^i \times p^a$$

where
i - row number
w - padrow width
n - number of pads in this row
p^a - pad pitch for the inner or the outer sector
The pad pitch for the outer sector is 0.67cm and for the inner sector 0.335cm. The radial coordinates for positioning the padrows and number of pads per padrow are given in Tables 3 and 4.

row number	position	number of pads
14	127.195cm	98
15	129.195cm	100
16	131.195cm	102
17	133.195cm	104
18	135.195cm	106
19	137.195cm	106
20	139.195cm	108
21	141.195cm	110
22	143.195cm	112
23	145.195cm	112
24	147.195cm	114
25	149.195cm	116
26	151.195cm	118
27	153.195cm	120
28	155.195cm	122
29	157.195cm	122
30	159.195cm	124
31	161.195cm	126
32	163.195cm	128
33	165.195cm	128
34	167.195cm	130
35	169.195cm	132
36	171.195cm	134
37	173.195cm	136
38	175.195cm	136
39	177.195cm	138
40	179.195cm	140
41	181.195cm	142
42	183.195cm	144
43	185.195cm	144
44	187.195cm	144
45	189.195cm	144

Table 4: Positioning and number of pads for the TPC rows.

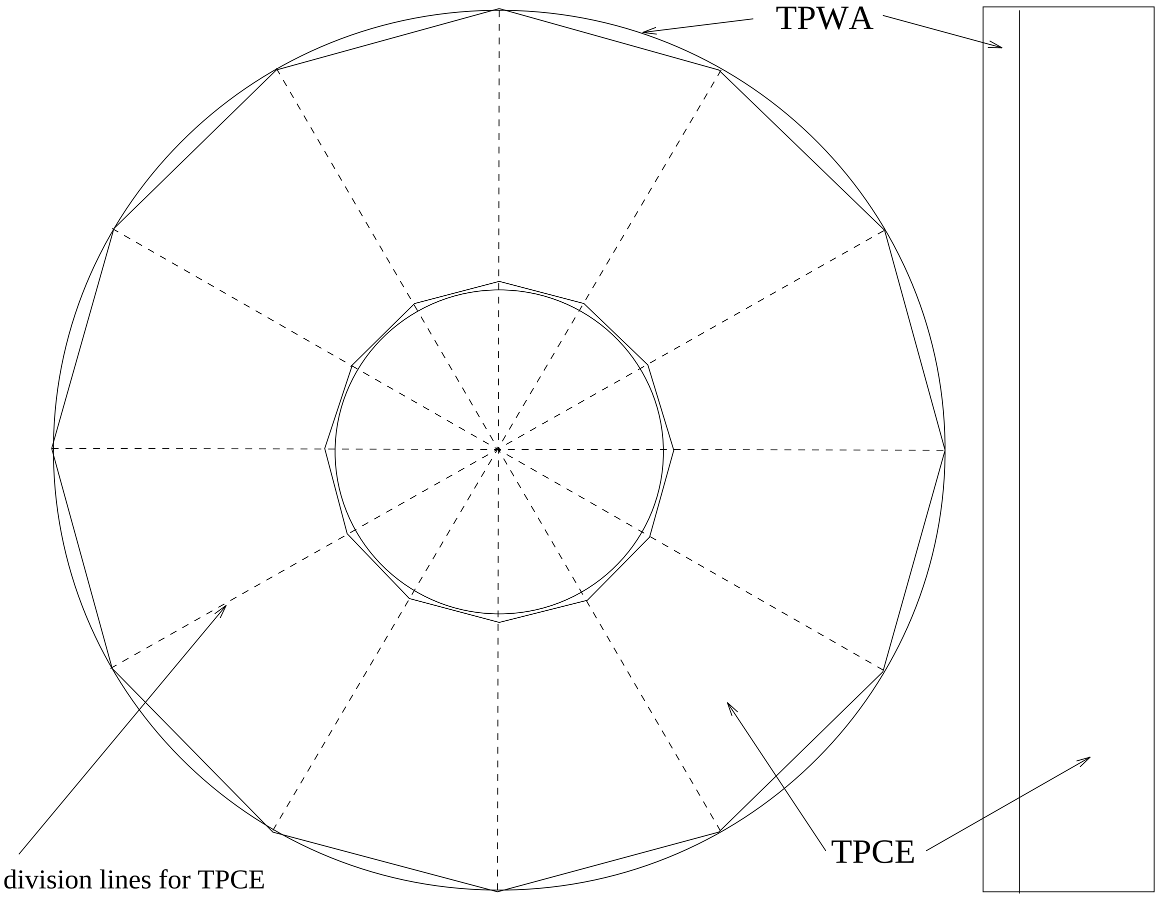

Figure 4: Endcap structure.

The TPC Endcap Area (TPEA)shown in Fig. 4 consists of the following volumes:

1. Endcap Wire Areas (TPWA). This is a cylinder 1.4cm long, filled (for the time being) with the same medium as the gas volume. A proper mixture of gas and wires should be calculated for this area.

2. Endcaps (TPCE).Each of the TPC endcaps consists of 12 outer and 12 inner sectors. The front face of every sector is covered with pads. The back side is a rather complex aluminium structure shown in Fig. 6 (the outer sector) and Fig. 5 (the inner sector). The endcap will be approximated by a polygon type aluminium structure divided into 12 sections (Fig. 4). In every section two trapezoids that correspond to the inner and the outer sector will be placed. Since spacing between the wireplanes and the padplane is different in both sectors, a 4mm volume of gas will be positioned in the outer sector (Fig. 6, side view). Then in both the inner and the outer sector a trapezoid will be positioned at the side that faces the drift region (a volume shadowed on the Fig 6 and Fig. 5). It will be filled with a mixture of copper, kapton aluminium and air to properly represent all the material that is in the pad/connector area. The rib structure at the back will be modeled by positioning trapezoids filled

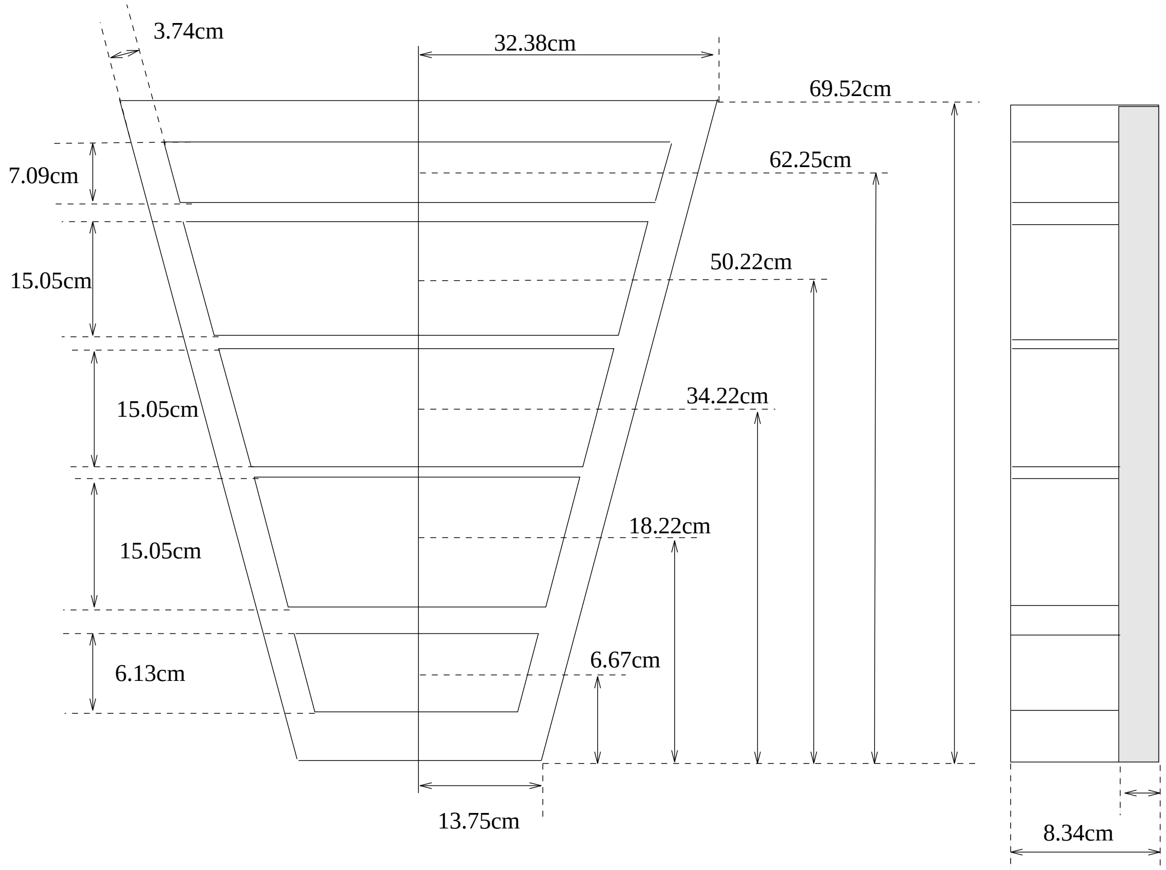

Figure 5: Inner Sector.

with a mixture that represents the density of the electronics and the cooling system. Aluminium boxes shadowed in Fig. 6 will be positioned in some of the trapezoids of the outer sector so the cross-rib structure could be preserved.

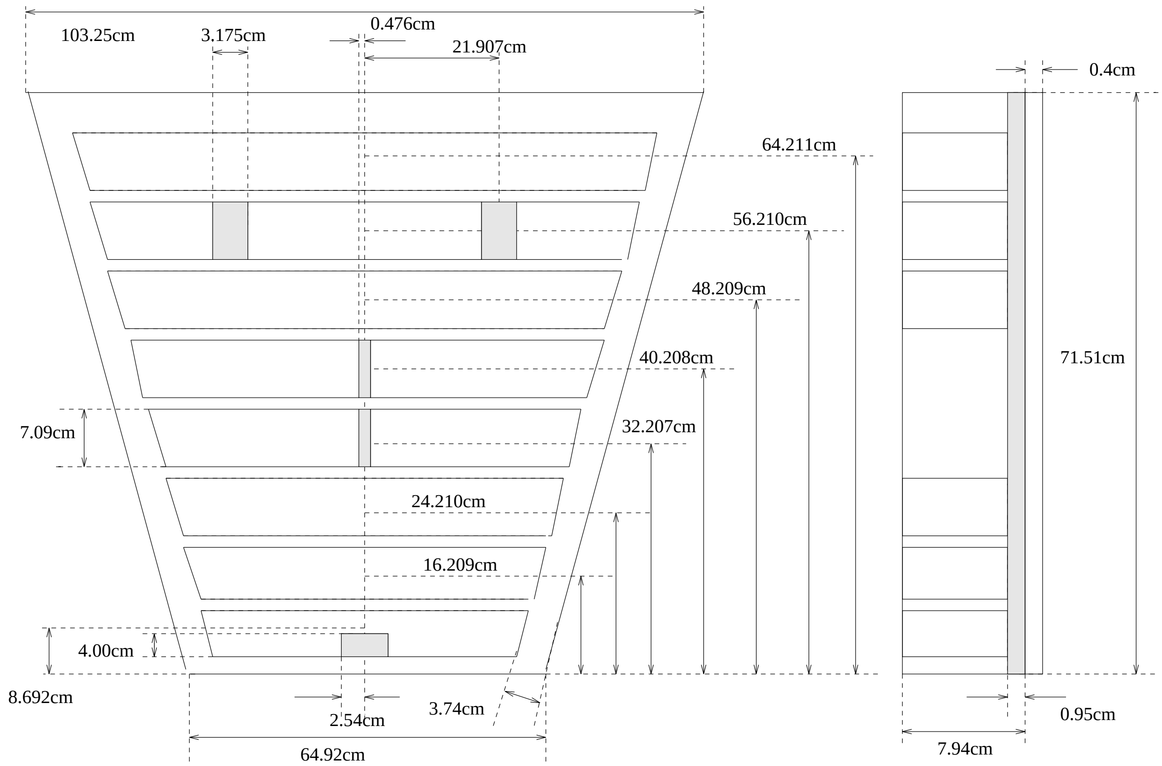

Figure 6: Outer Sector.

The Support structure for the sectors (so called wheel) is defined as a separate volume. Details of it's design are shown in Fig. 7. It is defined as a cylinder made of aluminum. It is divided into 12 sectors. Two volumes filled with air are positioned in every sector. This way its structure is reproduced rather accurately. The wheel is positioned in a way shown in Fig. 1.

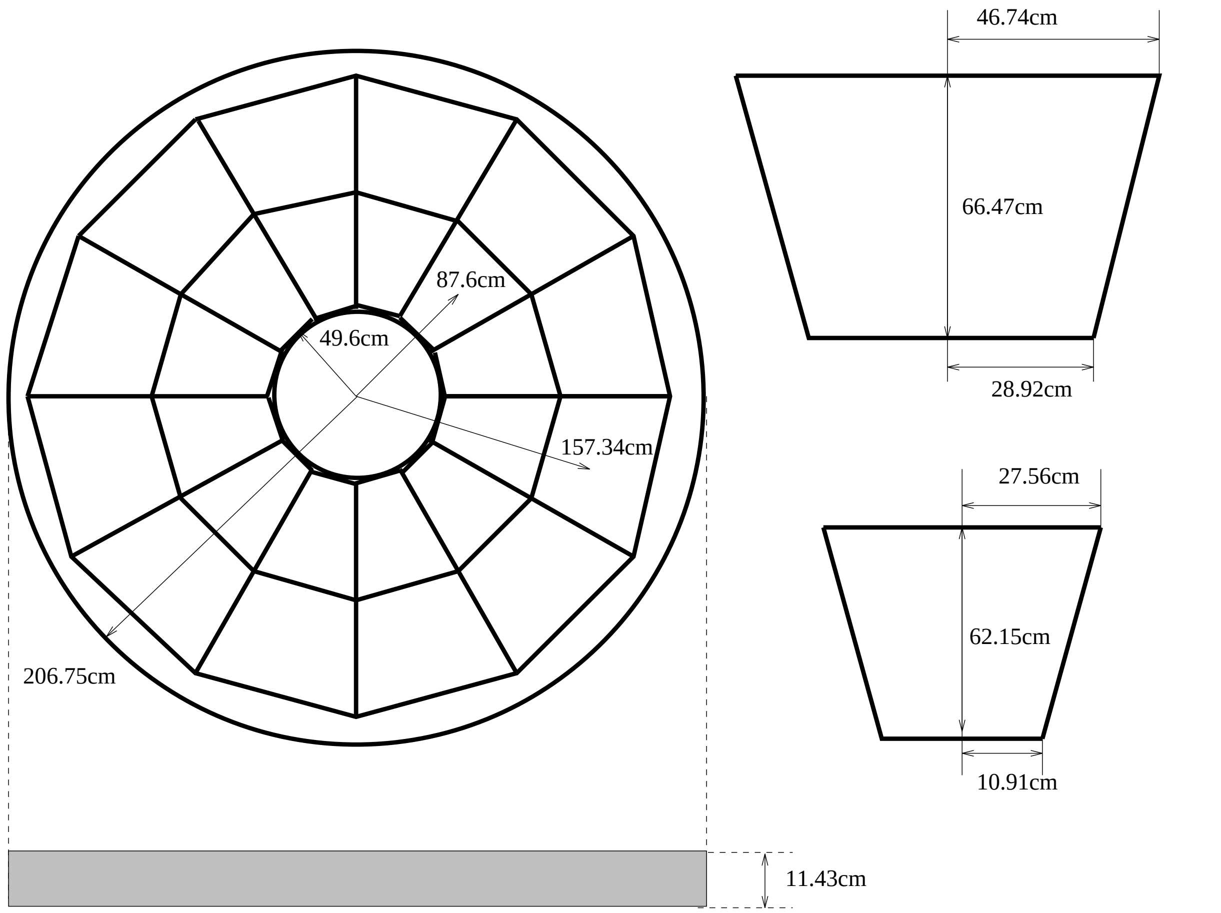

Figure 7: Sector support structure.

2 TPC Materials

There is no Kapton or Epoxy (adhesive) material defined so far in GEANT. But their properties listed in the Particle Data Book are close to those of Mylar. So Mylar will be used as a substitute. Mylar and Kapton have both density of 1.4 g/cm^3. Density of Epoxy is 1.2g/cm^3. Mylar and Kapton have identical dE/dx for minimum ionizing particles (1.8MeV/(g/cm^3)). This similarities justify usage of Mylar in place of Kapton or Epoxy.

In order to handle the Nomex, a new material is defined in the namelist file. Derek Shuman quotes the density as 0.048g/cm^3 and the radiation length as 833cm. Nomex is made of aramid fiber soaked in fenolic compounds, so a chemical composition of a lucite ($C_5H_8O_2$) used to calculate <A> and <Z> seems to be appropriate. it gives <A>=6.7 and <Z>=3.6.

So the definition of Nomex in the namelist file looks as follows:

Name	'NOMEX'
A	6.7
Z	3.6
density (g/cm^3)	0.048
radiation length (cm)	833.00

The Outer Field Cage support structure is built of an Aluminum Honeycomb. An estimate given by the TPC engineer Derek Shuman quots 75%Al and 25%Adhesive in this structure. It is adjacent to the Insulating Gas volume, so the Honeycomb is saturated with the nitrogen. Proportion between the aluminum and Nitrogen in the Honeycomb was calculated from the density given for the honeycomb (0.037 g/cm^3):

ρ_{Al}	=	2.7g/cm^3	density of Aluminum
ρ_{N_2}	=	0.00125g/cm^3	density of N_2
ρ_M	=	0.037g/cm^3	density of the Aluminum honeycomb

So if we denote by A and B ratios in which Al and N_2 are mixed in the honeycomb we get:

$$\frac{A \times \rho_{Al} + B \times \rho_{N_2}}{A + B} = \rho_M$$

This formula yields the ratio of A/B = 0.014. And of course Al and N_2 have to add up to 100%. From all that information we extract a final definition of the mixture used to fill this volume :

Name	'Al_Honeycomb'		
Atomic Weights	9	14	27
Atomic Numbers	4.5	7	13
Density (g/cm^3)	0.282		
Proportions by weights	.25	.7395	.0105