

# TPC for ILD

## DD4HEP

Dimitra Tsionou  
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# Detailed detector dimensions - Barrel

Material scan between: x\_0 = ( 0.00, 0.00, 50.00) [cm] and x\_1 = ( 200.00, 0.00, 50.00) [cm] :

Num. Layer \	Material Name	Atomic		Density [g/cm3]	Radiation	Interaction	Thickness [cm]	Path	Integrated	Integrated	Material		
		Number/Z	Mass/A		Length [cm]	Length [cm]		Length [cm]	X0 [cm]	Lambda [cm]	Endpoint ( cm, cm, cm)		
1	Air	7	14.801	0.0012	30280.1689	66568.7074	32.900	32.90	0.001087	0.000494	( 32.90,	0.00,	0.00)
2	G4_Al	13	26.982	2.6990	8.8789	38.8766	0.001	32.90	0.001199	0.000520	( 32.90,	0.00,	0.00)
3	G4_KAPTON	6	12.701	1.4200	28.5903	24.8436	0.005	32.91	0.001374	0.000721	( 32.91,	0.00,	0.00)
4	g10	11	21.318	1.7000	16.1529	68.2164	0.030	32.94	0.003231	0.001161	( 32.94,	0.00,	0.00)
5	G4_AIR	7	14.801	0.0012	30280.1689	66568.7074	2.422	35.36	0.003311	0.001197	( 35.36,	0.00,	0.00)
6	g10	11	21.318	1.7000	16.1529	68.2164	0.030	35.39	0.005169	0.001637	( 35.39,	0.00,	0.00)
7	G4_KAPTON	6	12.701	1.4200	28.5903	24.8436	0.005	35.39	0.005343	0.001838	( 35.39,	0.00,	0.00)
8	G4_Cu	29	63.546	8.9600	1.4352	15.5141	0.007	35.40	0.010221	0.002290	( 35.40,	0.00,	0.00)
9	TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	3.000	38.40	0.010481	0.002333	( 38.40,	0.00,	0.00)
10	TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	0.300	38.70	0.010507	0.002337	( 38.70,	0.00,	0.00)
454	TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	0.200	171.80	0.022041	0.004265	( 171.80,	0.00,	0.00)
455	TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	3.000	174.80	0.022301	0.004308	( 174.80,	0.00,	0.00)
456	G4_Cu	29	63.546	8.9600	1.4352	15.5141	0.007	174.81	0.027178	0.004759	( 174.81,	0.00,	0.00)
457	G4_KAPTON	6	12.701	1.4200	28.5903	24.8436	0.005	174.81	0.027353	0.004961	( 174.81,	0.00,	0.00)
458	g10	11	21.318	1.7000	16.1529	68.2164	0.030	174.84	0.029211	0.005400	( 174.84,	0.00,	0.00)
459	G4_AIR	7	14.801	0.0012	30280.1689	66568.7074	5.922	180.76	0.029406	0.005489	( 180.76,	0.00,	0.00)
460	g10	11	21.318	1.7000	16.1529	68.2164	0.030	180.79	0.031263	0.005929	( 180.79,	0.00,	0.00)
461	G4_KAPTON	6	12.701	1.4200	28.5903	24.8436	0.005	180.80	0.031438	0.006130	( 180.80,	0.00,	0.00)
462	G4_Al	13	26.982	2.6990	8.8789	38.8766	0.001	180.80	0.031551	0.006156	( 180.80,	0.00,	0.00)
463	Air	7	14.801	0.0012	30280.1689	66568.7074	19.200	200.00	0.032185	0.006445	( 200.00,	0.00,	0.00)
0	Average Material	13	26.957	0.0034	6214.0706	31034.0836	200.000	200.00	0.032185	0.006445	( 200.00,	0.00,	0.00)

Inner field cage

Outer field cage



# Detailed detector dimensions – Endcap

+ Material scan between: x\_0 = ( 50.00, 0.00, 0.00) [cm] and x\_1 = ( 50.00, 0.00, 300.00) [cm] :

Material Layer \ Num. \ Name	Atomic Number/Z	Mass/A [g/mole]	Density [g/cm3]	Radiation Length [cm]	Interaction Length [cm]	Thickness [cm]	Path Length [cm]	Integrated X0 [cm]	Integrated Lambda [cm]	Material Endpoint (cm, cm, cm)
1 G4_AIR	7	14.801	0.0012	30280.1689	66568.7074	0.003	0.00	0.000000	0.000000	( 0.00, 0.00, 0.00)
2 TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	222.497	222.50	0.019281	0.003222	( 0.00, 0.00, 222.50)
3 G4_Cu	29	63.546	8.9600	1.4352	15.5141	0.000	222.50	0.019490	0.003241	( 0.00, 0.00, 222.50)
4 G4_KAPTON	6	12.701	1.4200	28.5903	24.8436	0.003	222.50	0.019595	0.003362	( 0.00, 0.00, 222.50)
5 G4_Cu	29	63.546	8.9600	1.4352	15.5141	0.000	222.50	0.019804	0.003381	( 0.00, 0.00, 222.50)
6 TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	0.445	222.95	0.019843	0.003388	( 0.00, 0.00, 222.95)
7 G4_Cu	29	63.546	8.9600	1.4352	15.5141	0.000	222.95	0.020052	0.003407	( 0.00, 0.00, 222.95)
8 G4_KAPTON	6	12.701	1.4200	28.5903	24.8436	0.003	222.95	0.020157	0.003528	( 0.00, 0.00, 222.95)
9 G4_Cu	29	63.546	8.9600	1.4352	15.5141	0.000	222.95	0.020366	0.003547	( 0.00, 0.00, 222.95)
10 TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	0.445	223.40	0.020404	0.003554	( 0.00, 0.00, 223.40)
11 G4_Cu	29	63.546	8.9600	1.4352	15.5141	0.000	223.40	0.020613	0.003573	( 0.00, 0.00, 223.40)
12 G4_KAPTON	6	12.701	1.4200	28.5903	24.8436	0.003	223.40	0.020718	0.003694	( 0.00, 0.00, 223.40)
13 G4_Cu	29	63.546	8.9600	1.4352	15.5141	0.000	223.40	0.020927	0.003713	( 0.00, 0.00, 223.40)
14 TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	0.445	223.84	0.020966	0.003719	( 0.00, 0.00, 223.84)
15 G4_Cu	29	63.546	8.9600	1.4352	15.5141	0.005	223.85	0.024450	0.004042	( 0.00, 0.00, 223.85)
16 g10	11	21.318	1.7000	16.1529	68.2164	0.200	224.05	0.036831	0.006974	( 0.00, 0.00, 224.05)
17 G4_Si	14	28.085	2.3300	9.3496	45.7532	0.050	224.10	0.042179	0.008066	( 0.00, 0.00, 224.10)
18 epoxy	6	11.888	1.3000	32.2936	27.1368	0.200	224.30	0.048372	0.015436	( 0.00, 0.00, 224.30)
19 G4_KAPTON	6	12.701	1.4200	28.5903	24.8436	0.100	224.40	0.051870	0.019462	( 0.00, 0.00, 224.40)
20 G4_Al	13	26.982	2.6990	8.8789	38.8766	0.200	224.60	0.074395	0.024606	( 0.00, 0.00, 224.60)
21 G4_KAPTON	6	12.701	1.4200	28.5903	24.8436	0.100	224.70	0.077893	0.028631	( 0.00, 0.00, 224.70)
22 CarbonFiber	6	11.956	1.4667	28.8192	54.6827	0.300	225.00	0.088303	0.034118	( 0.00, 0.00, 225.00)
23 TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	0.000	225.00	0.088303	0.034118	( 0.00, 0.00, 225.00)
24 TPC_endplate_mix	9	17.288	0.5828	56.2236	137.6252	10.000	235.00	0.266164	0.106779	( 0.00, 0.00, 235.00)
25 Air	7	14.801	0.0012	30280.1689	66568.7074	65.000	300.00	0.268311	0.107755	( 0.00, 0.00, 300.00)
0 Average Material	9	17.556	0.0278	1118.1072	2784.0921	300.000	300.00	0.268311	0.107755	( 0.00, 0.00, 300.00)

Cathode Sensitive volume

Module + Endplate 12.5 cm



# Small TPC

- Previous results on ILD\_I1\_v01
- Comparison with ILD\_s1\_v01
- Only difference in z outer r and subsequently on the sensitive volume

338	TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	0.200	137.00	0.019025	0.003761	( 137.00,	0.00,	0.00)
339	TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	3.000	140.00	0.019285	0.003804	( 140.00,	0.00,	0.00)
340	G4_Cu	29	63.546	8.9600	1.4352	15.5141	0.007	140.01	0.024163	0.004255	( 140.01,	0.00,	0.00)
341	G4_KAPTON	6	12.701	1.4200	28.5903	24.8436	0.005	140.01	0.024338	0.004457	( 140.01,	0.00,	0.00)
342	g10	11	21.318	1.7000	16.1529	68.2164	0.030	140.04	0.026195	0.004896	( 140.04,	0.00,	0.00)
343	G4_AIR	7	14.801	0.0012	30280.1689	66568.7074	5.922	145.96	0.026390	0.004985	( 145.96,	0.00,	0.00)
344	g10	11	21.318	1.7000	16.1529	68.2164	0.030	145.99	0.028248	0.005425	( 145.99,	0.00,	0.00)
345	G4_KAPTON	6	12.701	1.4200	28.5903	24.8436	0.005	146.00	0.028423	0.005626	( 146.00,	0.00,	0.00)
346	G4_Al	13	26.982	2.6990	8.8789	38.8766	0.001	146.00	0.028535	0.005652	( 146.00,	0.00,	0.00)
347	Air	7	14.801	0.0012	30280.1689	66568.7074	54.000	200.00	0.030319	0.006463	( 200.00,	0.00,	0.00)
0	Average Material	12	24.959	0.0033	6596.6117	30943.5413	200.000	200.00	0.030319	0.006463	( 200.00,	0.00,	0.00)



# Changes

- Cathode grip rings → 1.5x2x2 cm<sup>3</sup> (dzxdyxdx) SiC\_foam (30% C, 70%Si)
- Cathode → Currently 60μm air. Switch to 100 um Kapton?
- Field cage → Currently 0.9% X0 for inner and 0.9% X0 for outer wall
- Different or similar material budget for inner and outer wall?
  - honeycomb has low X0
- Make Cu layer thicker to account for material?
- More sophisticated model? Additional layers for field adjustment? (if 100kV option)
- 1.3%X0 for inner wall and 1.7%X0 for outer?
  
- Feedback/fixes expected from us during LCWS



# Summary

- Proposal
- Keep grip rings as they are
- Update cathode from 60 $\mu\text{m}$  air to 100  $\mu\text{m}$  kapton
  
- Discussion and recommendation/decision
- Inner and outer field cage material
- X0?
- How to model this?



# Back-Up



TPC10: Total Gas material corresponds to 0.120801% of a radiation length.  
 TPC10: Add Material to Inner Wall: dr = 0.01 mm. Material = G4\_Al X0 = 8.8789 0.000112627% X0  
 TPC10: Add Material to Inner Wall: dr = 0.05 mm. Material = G4\_KAPTON X0 = 28.5903 0.000174884% X0  
 TPC10: Add Material to Inner Wall: dr = 0.3 mm. Material = g10 X0 = 16.1529 0.00185725% X0  
 TPC10: Add Material to Inner Wall: dr = 24.22 mm. Material = G4\_AIR X0 = 30280.2 7.99863e-05% X0  
 TPC10: Add Material to Inner Wall: dr = 0.3 mm. Material = g10 X0 = 16.1529 0.00185725% X0  
 TPC10: Add Material to Inner Wall: dr = 0.05 mm. Material = G4\_KAPTON X0 = 28.5903 0.000174884% X0  
 TPC10: Add Material to Inner Wall: dr = 0.07 mm. Material = G4\_Cu X0 = 1.43516 0.00487749% X0  
 TPC10: Inner wall material corresponds to 0.9% of a radiation length.  
 TPC10: Inner wall effective X0 = 273.692  
 TPC10: Add Material to Outer Wall: dr = 0.07 mm. Material = G4\_Cu X0 = 1.43516 0.00487749% X0  
 TPC10: Add Material to Outer Wall: dr = 0.05 mm. Material = G4\_KAPTON X0 = 28.5903 0.000174884% X0  
 TPC10: Add Material to Outer Wall: dr = 0.3 mm. Material = g10 X0 = 16.1529 0.00185725% X0  
 TPC10: Add Material to Outer Wall: dr = 59.22 mm. Material = G4\_AIR X0 = 30280.2 0.000195574% X0  
 TPC10: Add Material to Outer Wall: dr = 0.3 mm. Material = g10 X0 = 16.1529 0.00185725% X0  
 TPC10: Add Material to Outer Wall: dr = 0.05 mm. Material = G4\_KAPTON X0 = 28.5903 0.000174884% X0  
 TPC10: Add Material to Outer Wall: dr = 0.01 mm. Material = G4\_Al X0 = 8.8789 0.000112627% X0  
 TPC10: Outer wall material corresponds to 0.9% of a radiation length.  
 TPC10: Outer wall effective X0 = 648.652

Cathode dz = 0.00275

Place cathode +z at 0.001375

Place cathode -z at -0.001375

TPC10: Readout material corresponds to 6.9% of a radiation length.

TPC10: Total Endplate material corresponds to 8.68077% of a radiation length.

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 + Material scan between: x\_0 = ( 30.00, 0.00, 50.00) [cm] and x\_1 = ( 40.00, 0.00, 50.00) [cm] :  
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Num. \ Layer	Material \ Name	Atomic Number/Z	Mass/A [g/mole]	Density [g/cm3]	Radiation Length [cm]	Interaction Length [cm]	Thickness [cm]	Path Length [cm]	Integrated X0 [cm]	Integrated Lambda [cm]	Material Endpoint (cm, cm, cm)
1	Air	7	14.801	0.0012	30280.1689	66568.7074	2.900	2.90	0.000096	0.000044	( 2.90, 0.00, 0.00)
2	G4_Al	13	26.982	2.6990	8.8789	38.8766	0.001	2.90	0.000208	0.000069	( 2.90, 0.00, 0.00)
3	G4_KAPTON	6	12.701	1.4200	28.5903	24.8436	0.005	2.91	0.000383	0.000271	( 2.91, 0.00, 0.00)
4	g10	11	21.318	1.7000	16.1529	68.2164	0.030	2.94	0.002241	0.000710	( 2.94, 0.00, 0.00)
5	G4_AIR	7	14.801	0.0012	30280.1689	66568.7074	2.422	5.36	0.002321	0.000747	( 5.36, 0.00, 0.00)
6	g10	11	21.318	1.7000	16.1529	68.2164	0.030	5.39	0.004178	0.001186	( 5.39, 0.00, 0.00)
7	G4_KAPTON	6	12.701	1.4200	28.5903	24.8436	0.005	5.39	0.004353	0.001388	( 5.39, 0.00, 0.00)
8	G4_Cu	29	63.546	8.9600	1.4352	15.5141	0.007	5.40	0.009230	0.001839	( 5.40, 0.00, 0.00)
9	TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	3.000	8.40	0.009490	0.001882	( 8.40, 0.00, 0.00)
10	TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	0.300	8.70	0.009516	0.001887	( 8.70, 0.00, 0.00)
11	TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	0.300	9.00	0.009542	0.001891	( 9.00, 0.00, 0.00)
12	TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	0.300	9.30	0.009568	0.001895	( 9.30, 0.00, 0.00)
13	TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	0.300	9.60	0.009594	0.001900	( 9.60, 0.00, 0.00)
14	TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	0.300	9.90	0.009620	0.001904	( 9.90, 0.00, 0.00)
15	TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	0.100	10.00	0.009629	0.001906	( 10.00, 0.00, 0.00)
0	Average Material	12	25.693	0.0196	1038.5549	5247.8213	10.000	10.00	0.009629	0.001906	( 10.00, 0.00, 0.00)