

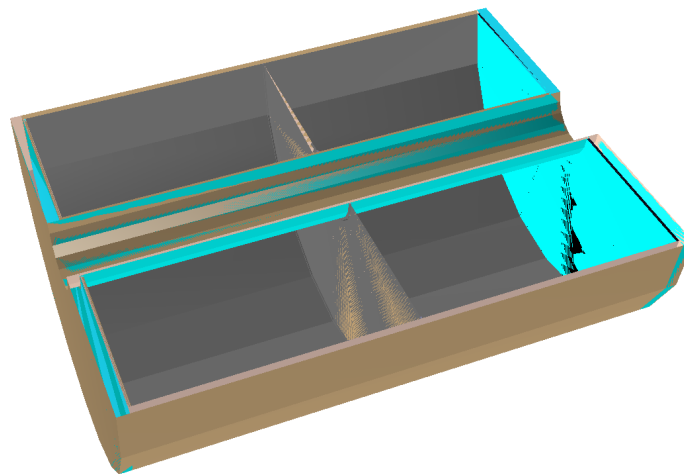
TPC DD4HEP Detector Model

Talk given at the ILD Software meeting in Lyon and feedback

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On behalf of the LCTPC collaboration
ILD Software and Technical Meeting
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Dimensions

- > We have started looking into the TPC DD4HEP detector model
- > Model exported from Mokka (ILD_o1_v5)
- > Dimensions in agreement with DBD
 - Inner radius: 329mm, Outer radius: 1808 mm, half length: 2350 mm
 - Inner wall thickness: 25mm, Outer wall thickness: 60mm
 - Inner and Outer radius of sensitive volume: 384-1718 mm (222 pad rows of 6mm height)
- > In agreement with model ILD_l1_v01
- > ILD_s1_v01 also checked → Difference in outer radius and subsequently in sensitive volume



Barrel Dimensions

ILD_I1_v01



+ Material scan between: x_0 = (0.00, 0.00, 50.00) [cm] and x_1 = (200.00, 0.00, 50.00) [cm] :

\ Material Num. \ Name Layer \	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)

Inner field cage										
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)

ILD_s1_v01

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)

Barrel Description

- > While checking the material budget for the ILD TPC, one mismatch from expectation was seen
- > Both the inner and outer field cage walls had the same material budget $0.9\% X_0$
- > DBD: $1\% X_0$ inner wall, $1\% X_0$ gas, $3\% X_0$ outer wall
- > Fix: Increase all materials by x3 for outer wall to reach desired material budget
- > Fix2: Change the order of Cu and Al. Now Cu is on the outside of the TPC → provides better shielding

Before

```
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.
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Now

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TPC10: Add Material to Outer Wall: dr = 0.03 mm. Material = G4_Al X0 = 8.8789 0.00033788% X0
TPC10: Add Material to Outer Wall: dr = 0.15 mm. Material = G4_KAPTON X0 = 28.5903 0.000524653% X0
TPC10: Add Material to Outer Wall: dr = 0.9 mm. Material = g10 X0 = 16.1529 0.00557174% X0
TPC10: Add Material to Outer Wall: dr = 57.66 mm. Material = G4_AIR X0 = 30280.2 0.000190422% X0
TPC10: Add Material to Outer Wall: dr = 0.9 mm. Material = g10 X0 = 16.1529 0.00557174% X0
TPC10: Add Material to Outer Wall: dr = 0.15 mm. Material = G4_KAPTON X0 = 28.5903 0.000524653% X0
TPC10: Add Material to Outer Wall: dr = 0.21 mm. Material = G4_Cu X0 = 1.43516 0.0146325% X0
TPC10: Outer wall material corresponds to 2.7% of a radiation length.
```

Air thickness slightly decreased to keep total dimensions unchanged



Endcap Dimensions

+ Material scan between: x_0 = (50.00, 0.00, 0.00) [cm] and x_1 = (50.00, 0.00, 300.00) [cm] :

Material 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	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

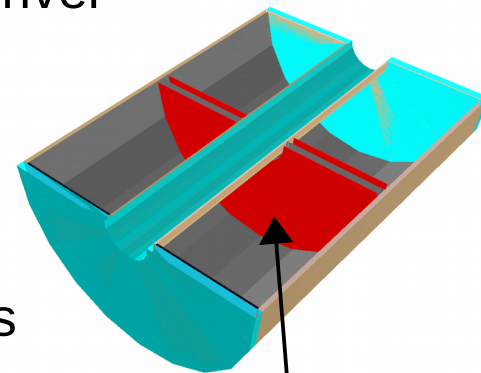
Module + Endplate 12.5 cm

Expected material budget



Cathode

- > TPC cathode is positioned at $z=0$. MaterialScan command showed cathode as “air”
- > However, the cathode was implemented in the TPC driver
- > Cathode volume was not part of the TPC mother volume. Because of that, the cathode didn't appear with the materialScan command (it only appeared if the end limits were cutting through the cathode volume). Overlap command didn't show any problems
- > However, the cathode could be seen with the visualisation (geoDisplay)
- > Fix: Frank placed cathode volume as a part of the TPC mother volume
- > Fix2: Cathode made slightly thicker from $60\mu\text{m}$ to $100\mu\text{m}$
 - $92\mu\text{m}$ thick Kapton and on each side $4\mu\text{m}$ Cu .



+ Material scan between: $x_0 = (100.00, 100.00, -10.00) [\text{cm}]$ and $x_1 = (100.00, 100.00, 10.00) [\text{cm}]$:

Num. Layer	Material Name	Atomic Number/Z	Mass/A [g/mole]	Density [g/cm ³]	Radiation Length [cm]	Interaction Length [cm]	Thickness [cm]	Path Length [cm]	Integrated X0 [cm]	Integrated Lambda [cm]	Material Endpoint (cm, cm, cm)
1	TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	9.995	10.00	0.000866	0.000145	(0.00, 0.00, 10.00)
2	G4_Cu	29	63.546	8.9600	1.4352	15.5141	0.000	10.00	0.001145	0.000171	(0.00, 0.00, 10.00)
3	G4_KAPTON	6	12.701	1.4200	28.5903	24.8436	0.005	10.00	0.001306	0.000356	(0.00, 0.00, 10.00)
4	G4_KAPTON	6	12.701	1.4200	28.5903	24.8436	0.005	10.00	0.001467	0.000541	(0.00, 0.00, 10.00)
5	G4_Cu	29	63.546	8.9600	1.4352	15.5141	0.000	10.00	0.001745	0.000567	(0.00, 0.00, 10.00)
6	TDR_gas	17	38.746	0.0017	11539.6342	69059.7950	9.995	20.00	0.002612	0.000711	(0.00, 0.00, 20.00)
0	Average Material	12	26.954	0.0027	7658.4155	28115.8466	20.000	20.00	0.002612	0.000711	(0.00, 0.00, 20.00)

Point resolution parametrisation

- > Looking into digitisation code for point resolution parametrisation
- > Comparing simulated/measured values for T2K gas with DD4HEP input (simulation for TDR gas)
- > Slight differences observed
- > Overall: Similar description in $r\phi$. We can do better in z wrt current model ($\sim 20\%$ for $z=0$)

- > Discussed within the TPC collaboration.
- > Preference to keep current values for
 - ongoing analyses and compatibility
 - are a bit more conservative .
- > Possibility to have two configurations for point resolution and the user can choose which one to use?
- > Comment: TPC gas has not yet been decided



Summary

- > TPC DD4HEP model under investigation
- > Overall, the detector model depicts the anticipated ILD TPC
- > Few mismatches have been found and have been corrected
 - Field cage outer wall material budget
 - Cathode volume (implemented) and dimensions

- > Point resolution checked. Action to be decided
- > Remaining aspects to be investigated:
 - double hit resolution
 - available space wrt other sub-detectors
 - ?



Discussion and outcome from Lyon Software meeting

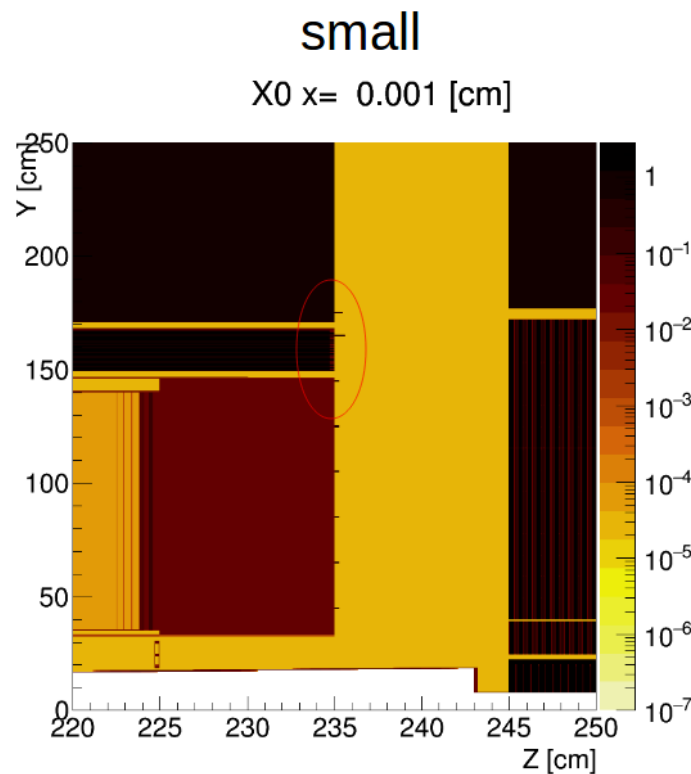
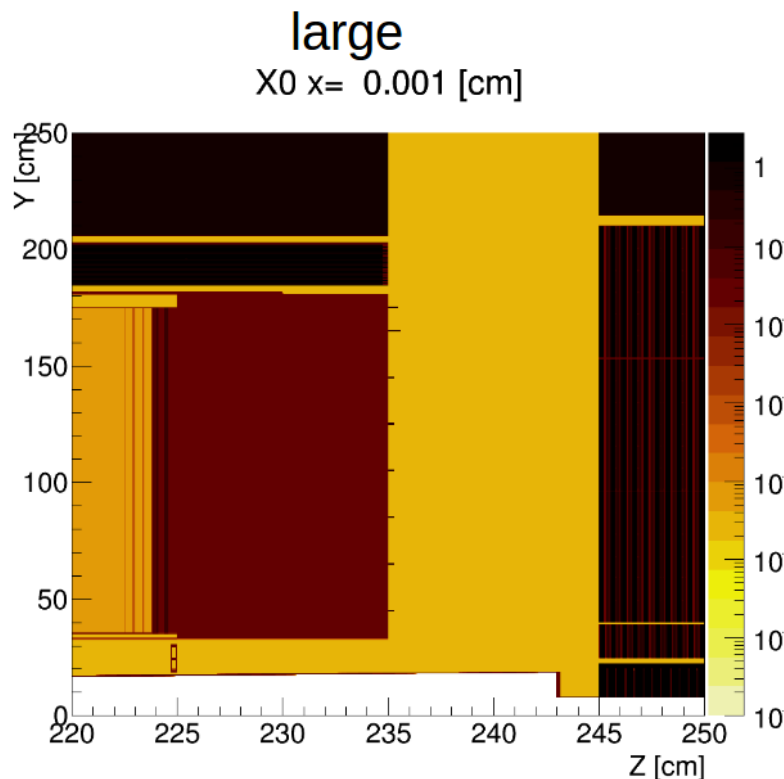
- > Things to check / to be discussed
- > Double hit resolution
- > Dead space between MPGD modules → Now full TPC is sensitive volume (222 pads of 6 mm height)
- > Available space between detectors (Ecal is currently too small and will have to expand → smaller TPC?)
- > Cables,... material → eg voltage box for cathode?
- > Cooling pipes → are they included in the endcap material budget of 25% X0?



Discussion and outcome from Lyon Software meeting

TPC services

From D. Jeans



cooling pipes not scaled in small models



Back-Up

