Road Map to Test Module and Test Beam

Current Situation

Next Steps

Discussion

Current Situation

- Currently effort started in various fields
  - Electrode design
  - Noise and cross-talk simulations for warm and cold electronics
  - Performance simulations (granularity, different active and passive material)
  - Feedthroughs
  - Thin solenoid
  - Thin cryostat
- First electrode prototypes have been produced

Next Steps Towards a Prototype

- Next step would be to build a small test module
  - Full depth $22X_0$ (~45cm) x 40cm x 40cm
  - Necessary features: inclined absorbers, inclined electrodes, increasing gap width(?)
  - Challenges:
    - Inclined plates
      - Lots of cut-out special absorbers and PCB ?
      - Else makes the prototype quite a bit bigger
    - Increasing gap width
      - Difficult spacers?
      - One could also think of “knobs” on the PCB with well-defined height?
      - 3D-printed spacers?
- → Needs considerable engineering effort, and of course electrodes, absorbers, electronics, cables,…

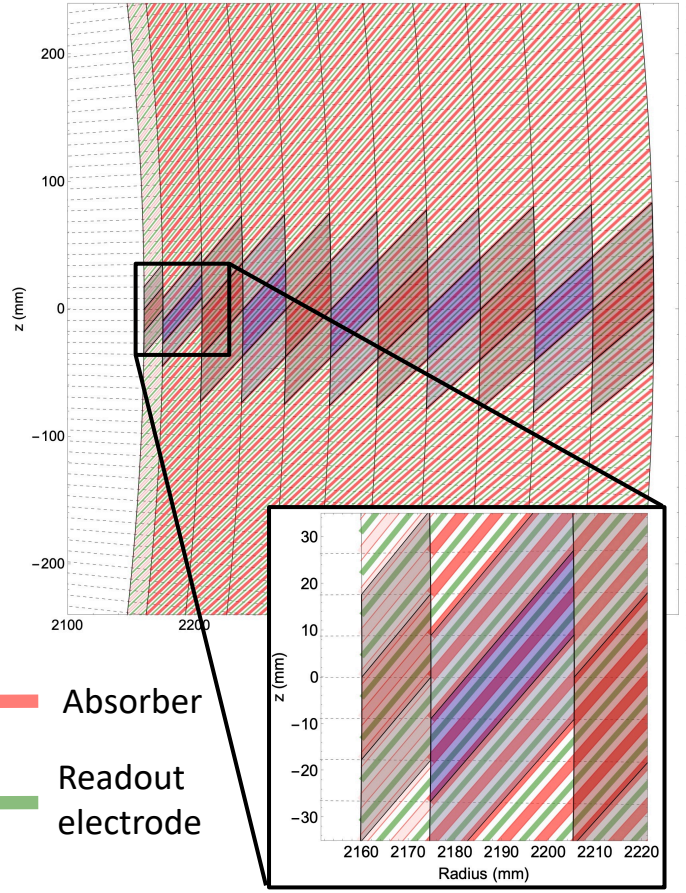
Work To Be Done – Very Preliminary

Item	Groups interested	Comment
Electrodes	IJCLab, CERN	First small prototype exists (IJCLab), larger prototype being produced (CERN)
Absorbers	CERN	New fellow at CERN
Module mechanical structure	CERN	New fellow at CERN
Electronics	IJCLab? BNL?	Cold and warm electronics? Could we use/adapt HKROC? Other candidates?
Cables	?	
Cryostat	CERN	Either existing cryostat or carbon-fibre 1m prototype
DAQ	?	
…		

Back-Up

Introduction – Geometry Used Here

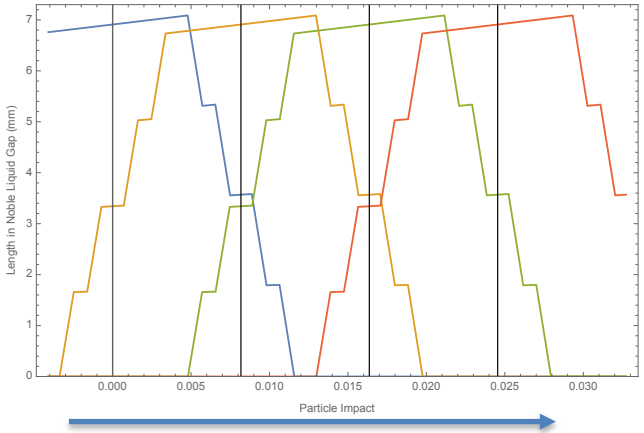
- No Pb/W in the first compartment = presampler (PS) → used to compensate for lost energy upstream
- 1536 absorbers in 2π, flat, no step-increase with r.
- 11 longitudinal compartments, particle traverses 2 absorbers in 1st comp., 4 in all others
- r_i=2160mm, r_o=2560mm, inclination of absorbers at r_i is α_i=50.381° (α_i depends on r_i and r_o)
- Cells line up in projective towers in θ and ϕ, add 2 double gaps in the PS and strips (1st and 2nd longitudinal compartment) and 4 double gaps in each other layer
  - Strips (2nd comp.): Δϕ x Δθ = 8.2mrad x 2.5mrad = 17.8mm x 5.4mm
  - Other compartments: Δϕ x Δθ = 16.4mrad x 10mrad = 36mm x 22mm$|_{r=2205mm\ (3rd\ comp.)}$
- Readout with 7-layer PCB (FR4), 1.2mm thick
- With LAr/Pb this leads to ~20.5 X_0, $f_{sampl} \approx 1/6$.
- Studies ongoing with other absorbers (Pb/W) and other noble liquid (LAr/LKr) → leading also to other detector dimensions

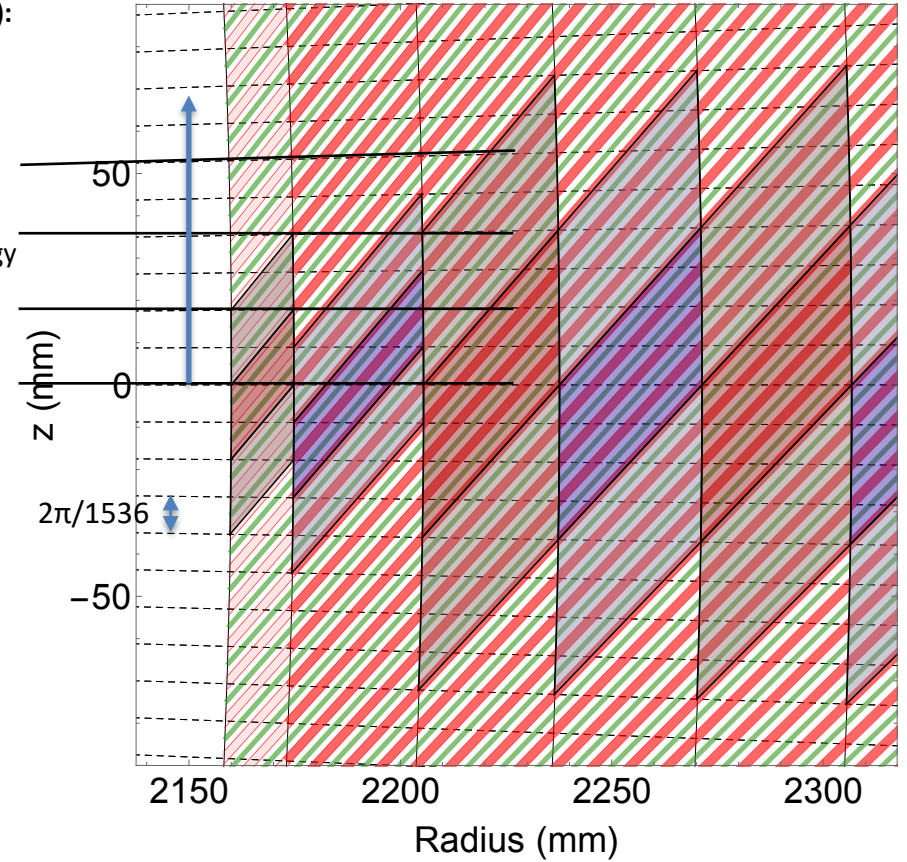


Track-Length of a MIP in Inclined Cell

Track-length of a projective MIP inside active material in one cell (2 double-gaps):

- **~7mm track length in one cell**, but track in 2-3 consecutive cells (13.7mm in one layer)
- **Energy deposit of a MIP**
  - LAr: 2.105 MeV/cm
  - LKr: 3.281 MeV/cm
- **EM energy scale:** Needs to be divided by sampling fraction f_{sampl} to get energy in the EM scale
  - → 0.7 cm x 2.105 MeV/cm / 0.17 = 8.7 MeV (MIP signal in strips)
  - Simulation obtains similar value (see studies by B. Francois)





LAr with Pb Absorbers

- LAr as active aterial
- Absorber (t = 2mm): 1.8mm Pb, 0.1mm glue, 0.1mm stainless steel

Absorbers	Length (mm)	Radius (mm)	LAr gap (mm)	$\langle X_0 \rangle$ (mm)	ΔL (mm)	Δr (mm)	Δr (X_0)	Accum. X_0	f_{sampl}
0	0	2160.	1.21718	-	-	-	-	-	0.317843
2	23.0979	2174.8	1.26442	140.735	23.0979	14.8018	0.105175	0.105175	0.158756
6	70.2646	2205.47	1.36089	16.51	47.1667	30.6687	1.85758	1.96276	0.168823
10	118.794	2237.62	1.46015	16.9973	48.5292	32.1537	1.89169	3.85445	0.178933
14	168.773	2271.35	1.56237	17.495	49.9787	33.7222	1.92753	5.78198	0.189091
18	220.295	2306.73	1.66775	18.0036	51.5222	35.3812	1.96523	7.74721	0.199303
22	273.462	2343.87	1.7765	18.5237	53.1672	37.1383	2.00491	9.75212	0.209575
26	328.384	2382.87	1.88883	19.0561	54.9221	39.0021	2.0467	11.7988	0.219913
30	385.18	2423.85	2.00499	19.6015	56.7963	40.982	2.09075	13.8896	0.230322
34	443.981	2466.94	2.12526	20.1607	58.8002	43.0884	2.13724	16.0268	0.240811
38	504.926	2512.27	2.24991	20.7345	60.9452	45.3328	2.18634	18.2132	0.251384
42	568.17	2560.	2.37926	21.3239	63.2442	47.7283	2.23826	20.4514	0.26205

→ **20.5 X_0**

LKr with Pb Absorbers

- LKr as active aterial
- Absorber (t = 2mm): 1.8mm Pb, 0.1mm glue, 0.1mm stainless steel

Absorbers	Length (mm)	Radius (mm)	LKr gap (mm)	$\langle X_0 \rangle$ (mm)	ΔL (mm)	Δr (mm)	Δr (X_0)	Accum. X_0	f_{sampl}
0	0	2160.	1.21718	-	-	-	-	-	0.420707
2	23.0979	2174.8	1.26442	75.3403	23.0979	14.8018	0.196467	0.196467	0.227289
6	70.2646	2205.47	1.36089	14.9402	47.1667	30.6687	2.05277	2.24923	0.24046
10	118.794	2237.62	1.46015	15.2791	48.5292	32.1537	2.10443	4.35366	0.253552
14	168.773	2271.35	1.56237	15.6205	49.9787	33.7222	2.15884	6.5125	0.26657
18	220.295	2306.73	1.66775	15.9647	51.5222	35.3812	2.21621	8.72872	0.279524
22	273.462	2343.87	1.7765	16.3119	53.1672	37.1383	2.27676	11.0055	0.292421
26	328.384	2382.87	1.88883	16.6623	54.9221	39.0021	2.34074	13.3462	0.305267
30	385.18	2423.85	2.00499	17.0162	56.7963	40.982	2.40841	15.7546	0.318069
34	443.981	2466.94	2.12526	17.3738	58.8002	43.0884	2.48007	18.2347	0.330836
38	504.926	2512.27	2.24991	17.7354	60.9452	45.3328	2.55606	20.7908	0.343574
42	568.17	2560.	2.37926	18.1012	63.2442	47.7283	2.63675	23.4275	0.356289

→ **23.4 X_0**

LAr with W Absorbers

- LAr as active aterial
- Absorber (t = 2mm): 1.8mm W, 0.1mm glue, 0.1mm stainless steel

Absorbers	Length (mm)	Radius (mm)	LAr gap (mm)	$\langle X_0 \rangle$ (mm)	ΔL (mm)	Δr (mm)	Δr (X_0)	Accum. X_0	f_{sampl}
0	0	2160.	1.21718	–	–	–	–	–	0.317843
2	23.0979	2174.8	1.26442	140.735	23.0979	14.8018	0.105175	0.105175	0.105664
6	70.2646	2205.47	1.36089	10.6734	47.1667	30.6687	2.87337	2.97855	0.112816
10	118.794	2237.62	1.46015	11.0038	48.5292	32.1537	2.92205	5.90059	0.120056
14	168.773	2271.35	1.56237	11.3422	49.9787	33.7222	2.97317	8.87376	0.127391
18	220.295	2306.73	1.66775	11.689	51.5222	35.3812	3.02689	11.9006	0.134824
22	273.462	2343.87	1.7765	12.0447	53.1672	37.1383	3.08338	14.984	0.142364
26	328.384	2382.87	1.88883	12.4099	54.9221	39.0021	3.14282	18.1268	0.150015
30	385.18	2423.85	2.00499	12.7852	56.7963	40.982	3.20542	21.3323	0.157786
34	443.981	2466.94	2.12526	13.1712	58.8002	43.0884	3.2714	24.6037	0.165682
38	504.926	2512.27	2.24991	13.5686	60.9452	45.3328	3.34101	27.9447	0.173712
42	568.17	2560.	2.37926	13.9781	63.2442	47.7283	3.4145	31.3592	0.181882

→ **31.4 X_0**

LKr with W Absorbers

- LKr as active aterial
- Absorber (t = 2mm): 1.8mm W, 0.1mm glue, 0.1mm stainless steel

Absorbers	Length (mm)	Radius (mm)	LKr gap (mm)	$\langle X_0 \rangle$ (mm)	ΔL (mm)	Δr (mm)	Δr (X_0)	Accum. X_0	f_{sampl}
0	0	2160.	1.21718	-	-	-	-	-	0.420707
2	23.0979	2174.8	1.26442	75.3403	23.0979	14.8018	0.196467	0.196467	0.155515
6	70.2646	2205.47	1.36089	9.99452	47.1667	30.6687	3.06855	3.26502	0.165417
10	118.794	2237.62	1.46015	10.2571	48.5292	32.1537	3.13478	6.3998	0.175366
14	168.773	2271.35	1.56237	10.5235	49.9787	33.7222	3.20447	9.60428	0.185367
18	220.295	2306.73	1.66775	10.794	51.5222	35.3812	3.27787	12.8821	0.195427
22	273.462	2343.87	1.7765	11.0688	53.1672	37.1383	3.35523	16.2374	0.20555
26	328.384	2382.87	1.88883	11.3482	54.9221	39.0021	3.43686	19.6742	0.215743
30	385.18	2423.85	2.00499	11.6324	56.7963	40.982	3.52308	23.1973	0.226013
34	443.981	2466.94	2.12526	11.9219	58.8002	43.0884	3.61423	26.8116	0.236365
38	504.926	2512.27	2.24991	12.2167	60.9452	45.3328	3.71073	30.5223	0.246807
42	568.17	2560.	2.37926	12.5173	63.2442	47.7283	3.81299	34.3353	0.257345

→ **34.3 X_0**