Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

WP2 Parallel Session Summary

Marc-André Pleier

DRD6 Collaboration Meeting, CERN, April 11, 2024

@BrookhavenLab

Overview of WP2 Sessions

Indico: [technical session]

09:00 → 11:20 **WP2 - Parallel Session 1: WP2 technical progress** 40/S2-D01 - Salle Dirac Join 40/S2-D01

09:00 **Round table** 25m
- Short oral reports
- Plans for studies in the next months

09:25 **Cryostat design** 15m
Speaker: Soledad Molina (CERN)
20240410_NovelMa...

09:40 **Report on absorbers studies** 20m
Speaker: Fernando Aretio Zárate (CERN)
FCC-ee_ECAL_MM_...

10:00 **Update on PCB measurements & plans for CERN PCB prototype v2** 20m
Speaker: Juska Pekkanen (CERN)
pcb_update_and_v2...

10:20 **Report on simulation studies at APC** 20m
Speaker: Giovanni Marchiori (APC, CNRS/IN2P3 and Université Paris Cité)
2024:04:10 - Progre...

10:40 **Ideas for ALLEGRO detector design** 20m
Speaker: Nicolas Morange (Université Paris-Saclay (FR))
2024-04-10_ALLEG...

[open IB session]

11:30 → 12:30 **WP2: Parallel Session 2: WP2 Open IB Meeting** 40/S2-D01 - Salle Dirac Join 40/S2-D01

Convener: Marc-Andre Pleier (Brookhaven National Laboratory (US))

11:30 **Expressions of interest to WP2** 20m
New institutes to WP2 can express their interest in potential contributions.

11:50 **WP2 organizational structure proposal** 20m
Presentation of proposed organizational structure, kick-off meeting, regular meetings.
Speaker: Nicolas Morange (Université Paris-Saclay (FR))
2024-04-10_WP2_IB...

12:10 **Discussion of organizational structure** 20m

Selection bias and any mistakes → me; praise for progress → authors!

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WP2 technical progress

Brief Recap

Nicolas Morange

Allegro Ecal Barrel Design

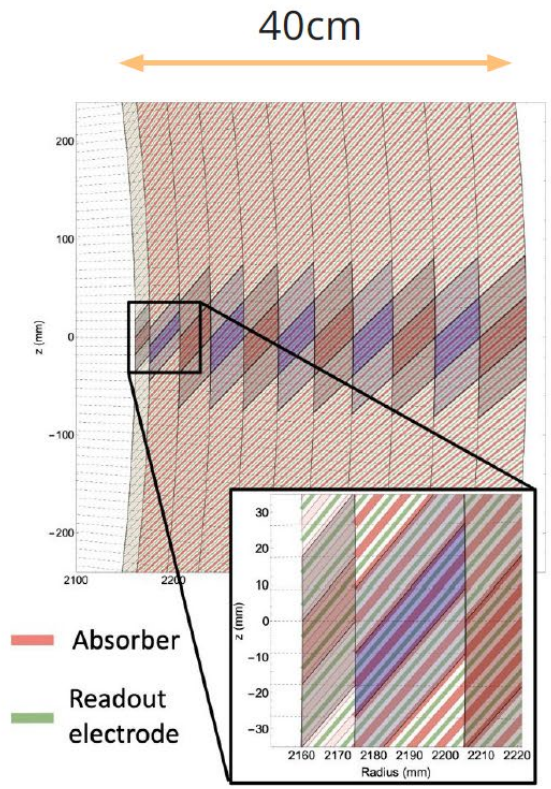
Design driven by the solution used for electrodes

- 1536 **straight inclined** (50°) 1.8mm **Pb** absorber plates
- Multi-layer PCBs as readout electrodes
- 1.2 – 2.4mm **LAr** gaps (**LKr** seriously considered)
- 40cm deep (22 X_0)
- $\Delta\theta$ = 10 (2.5) mrad for regular (strip) cells, $\Delta\phi$ = 8 mrad,
  12 longitudinal layers

Copper electrodes: lots of flexibility

- Number of layers and granularity of layers fully optimizable
- Projective cells

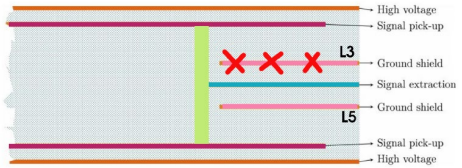
➢ Lots of room for optimisation !



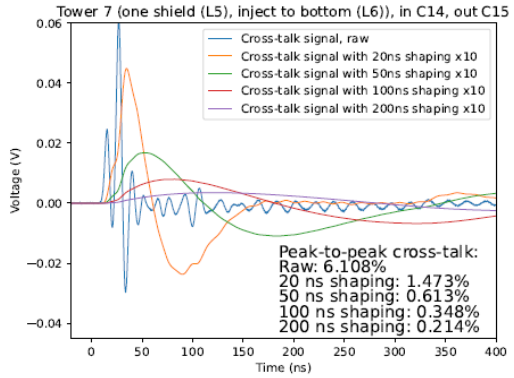
PCB Measurements & Plans

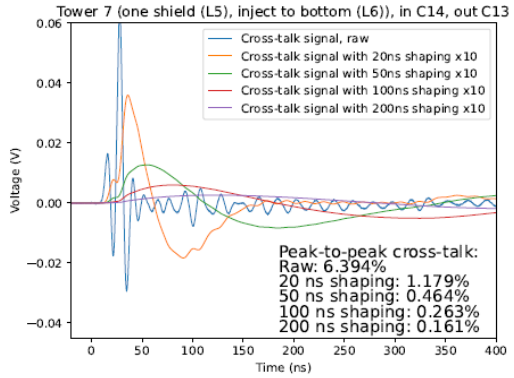
Juska Pekkanen

- Study of cross-talk between cells:
  - Bottom-side to top-side
  - Within the strip layer
  - Across neighbors
- Understand cross-talk impact of having only one vs. two ground shields for signal lines
  - Roughly x2 worse top-bottom than with 2 shields
  - 6-layer PCB easier to manufacture vs. 7-layer
- Cross-talk specifications to be determined from physics performance
- Next prototype PCB under development with updated geometry



X-talk from bottom - the "new case"



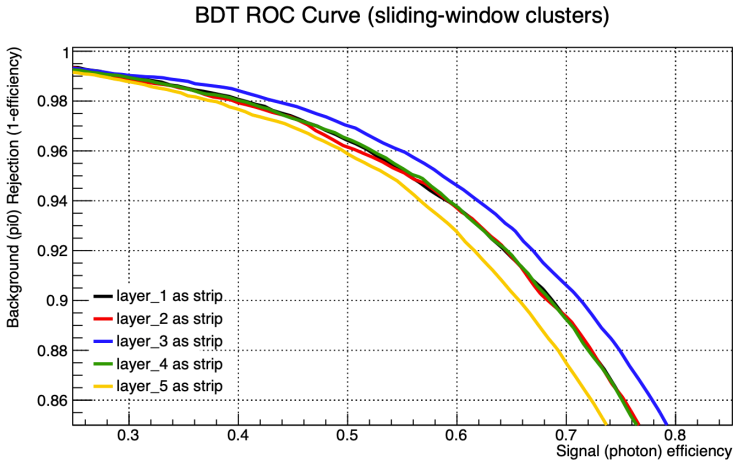


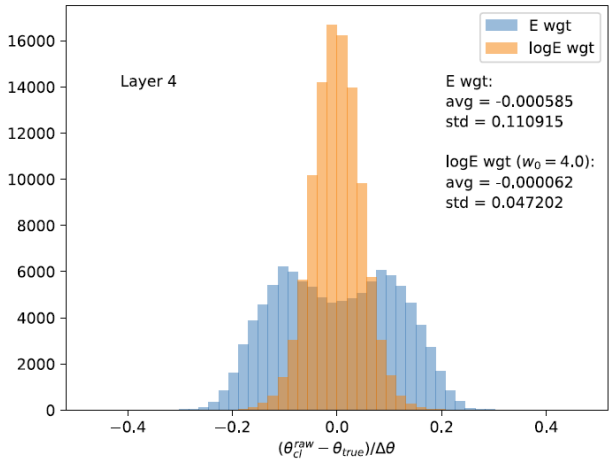
- Injecting to "bottom" side of tower 7 through a hole in the absorber
- Readout from the back - inject to cell 14
- Readout from C15 (top) and C13 (bottom)
- Cross-talk down to 0.16-0.21% with 200 ns shaping
- Raw cross-talk higher, but after shaping lower
- **Injecting to side closer to shield yields slightly lower x-talk**
  - As ~expected..?

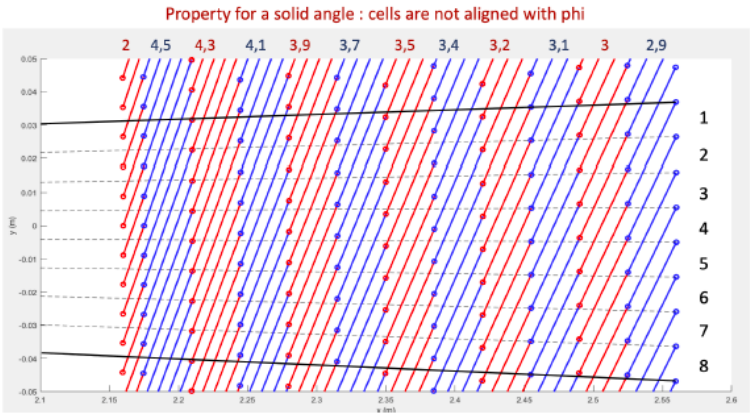
Simulation Studies

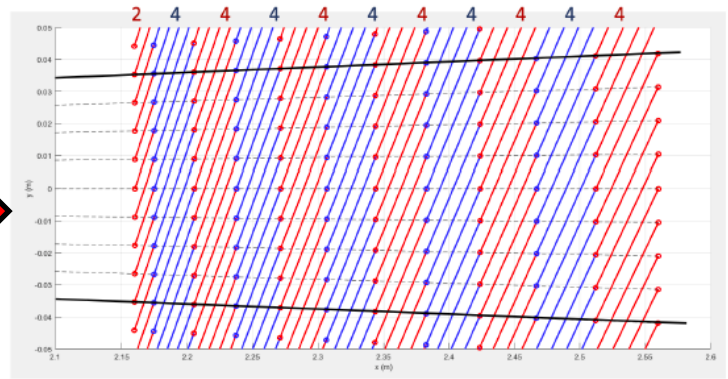
Giovanni Marchiori

- ALLEGRO ECAL barrel full simulation
- π/γ discrimination BDT based on shower shape
  - Test performance of different detector designs
- ECAL cluster layer barycentre calculation with log(E) weights
  - Improved θ position resolution
- Updated geometry with cell corners projective in φ
- Event display
- MVA-based e/γ energy calibration









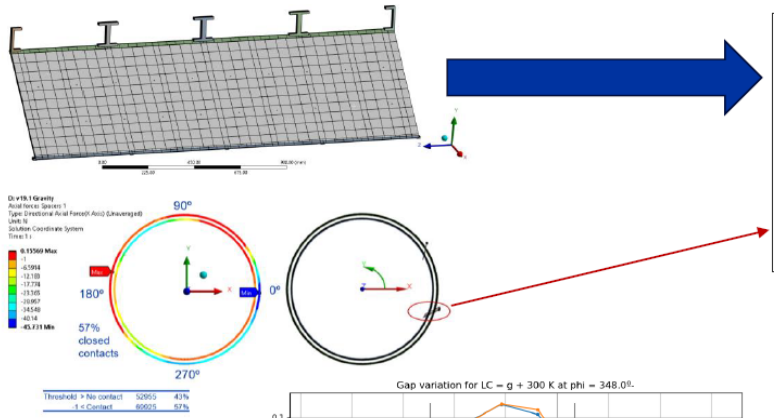
LAr Gap Analysis

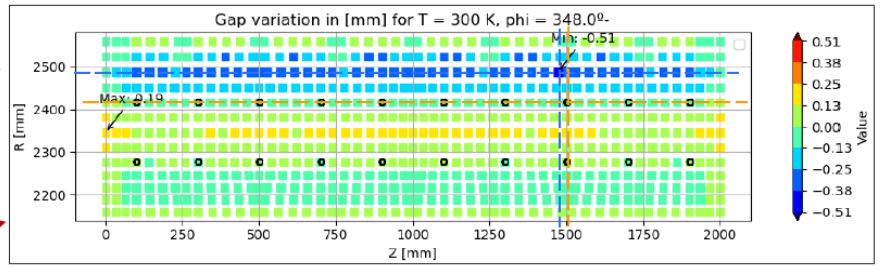
Fernando Aretio Zárate

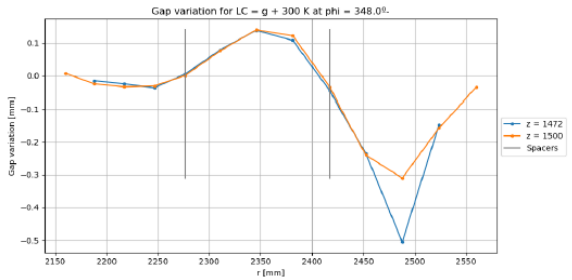
- LAr gap calculated in FE model between PCB and absorber
- Understand impact of thermal and gravitational load on LAr gap (deformations)
- FE model precision needs to be better understood
- Results will help e.g. optimization of spacer placement

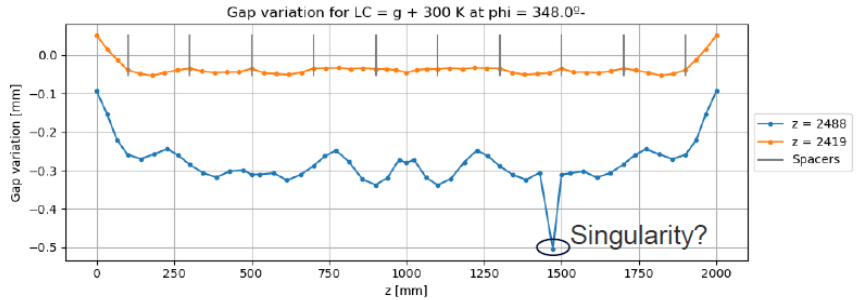
Gap variation in the simulation of a third barrel

- When gravity is applied, the maximum gap reduction is 0.51mm.
- These results are under study, as can appear some singularities due to several reasons (see *Conclusions*).









Cryostat design

Soledad Molina

- Minimise dead material in front calorimeter
  - Four nested cylinders:
    - Outer Warm Cylinder (OWC)
    - Outer Cold Cylinder (OCC)
    - Inner Cold cylinder (ICC)
    - Inner Warm Cylinder (IWC)
  - Use sandwich of CF and honeycomb: Carbon Composite Cryostat
  - Compare with Aluminum
- First large-scale prototype under test
  - l=1m, ⌀ = 30cm, 5mm wall
  - Long term leak-tightness
  - Production without autoclave

Profits of Carbon Composite compared to metal

8

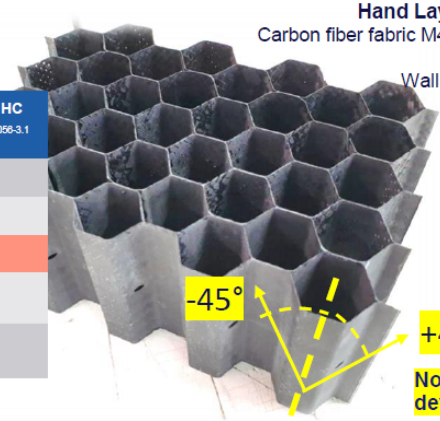
✓ Full carbon composite design offers: 64% savings in Mat Budget, 30% savings in Optimal Thickness, and one order of magnitude lower CTE.

Full carbon honeycomb for walls with structural, mass and thermal constraints:

*Tested by CERN-MME-MM

Results:

-293 K-	Carbon HC (Preliminary)	Aluminium HC Hexcel CRIII-3/16-5056-3.1 of Plane 1NS
Density [Kg/m3]	36	49.7
X_0[mm]	6000	88.9
CTE [µm/m•K]	2.5 !!!!	24
E_z [MPa] Compression Modulus	890	669
E_{xy} [MPa] Shear Modulus	380	310



Hand Lay-Up Honeycomb
Carbon fiber fabric M46J-EX-1515 [±45°]
HC length 70 mm
Wall thickness 0.15 mm
Cell size 20mm
Density 36 Kg/m3

Novel Technology developed by CERN

Honeycomb (Core)	CFRP		Aluminium			
Skin	CFRP		CFRP		Aluminium	
Wall	OWC	ICC	OWC	ICC	OWC	ICC
material budget X/X0	0.026	0.028	0.028	0.032	0.073	0.077
savings X/X0 [%]	-64%	-64%	-61%	-57%	REF	REF
Skin Th. [mm]	3.2	3.2	3.2	3.2	3	3
Core Th. [mm]	19.5	40	21.5	42	35	58
(Optimal)Total Th. [mm]	25.9	46.4	27.9	48.4	41	64
savings Th. [%]	-37%	-28%	-32%	-24%	REF	REF

Current Baseline: Material budget saving respect to traditional Solid Aluminum

R&D Baseline: full-carbon composite design for greater material budget savings

*CFRP: Carbon Fiber Reinforced Polymer
*CTE: Coefficient of Thermal Expansion

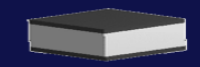
Results:

Buckling Sensitive *

Optimal Thickness calculated with FEA

	OWC	OCC	ICC	IWC
Wall Configuration	Sandwich	Solid	Sandwich	Sandwich
Skin Th. [mm]	3.2		3.2	1.6
Core Th. [mm]	19		40	30
(Optimal) Total Th. [mm]	25.4	27.2	46.4	33.2
Material Budget X/X0	0.026	0.105	0.028	0.015
Buckling Safety Factor	2.3	-	2.1	-
Min. Failure Safety Factor	2.7	5.1	2.38	4.7
SF Max Stress	7.47	6.64	2.6	7.3
SF Max Strain	15.9	6.59	5.5	5.4
SF Tsai-Wu	8.2	5.1	2.38	4.7
SF Core Failure	2.7	-	2.8	4.8
Max. total def. [mm]	1	4	2.6	1.7
Max. vertical def. [mm]	1	1.5	2	1.3
Equivalent Stress [Pa]	6.20E+07	7.33E+07	1.80E+08	9.60E+07
Shear YZ top skin [Pa]	4.39E+05	-	2.10E+03	6.80E+00
Shear XZ top skin [Pa]	4.39E+05	-	7.90E+05	2.20E+05
Shear YZ bottom skin [Pa]	4.39E+05	-	2.10E+03	5.00E+04
Shear XZ bottom skin [Pa]	4.39E+05	-	7.97E+05	2.50E+05

To calculate Material Budget
Radiation length X_0[mm]
Al = 88.9
HM CFRP = 260
Honeycomb Al= 6000
Honeycomb CFRP = 12545



Sandwich Shell

Skin [0,45,-45,90]s
Core : Honeycomb
Skin [0,45,-45,90]s

Maria Soledad Molina González | Carbon Composite Cryostat

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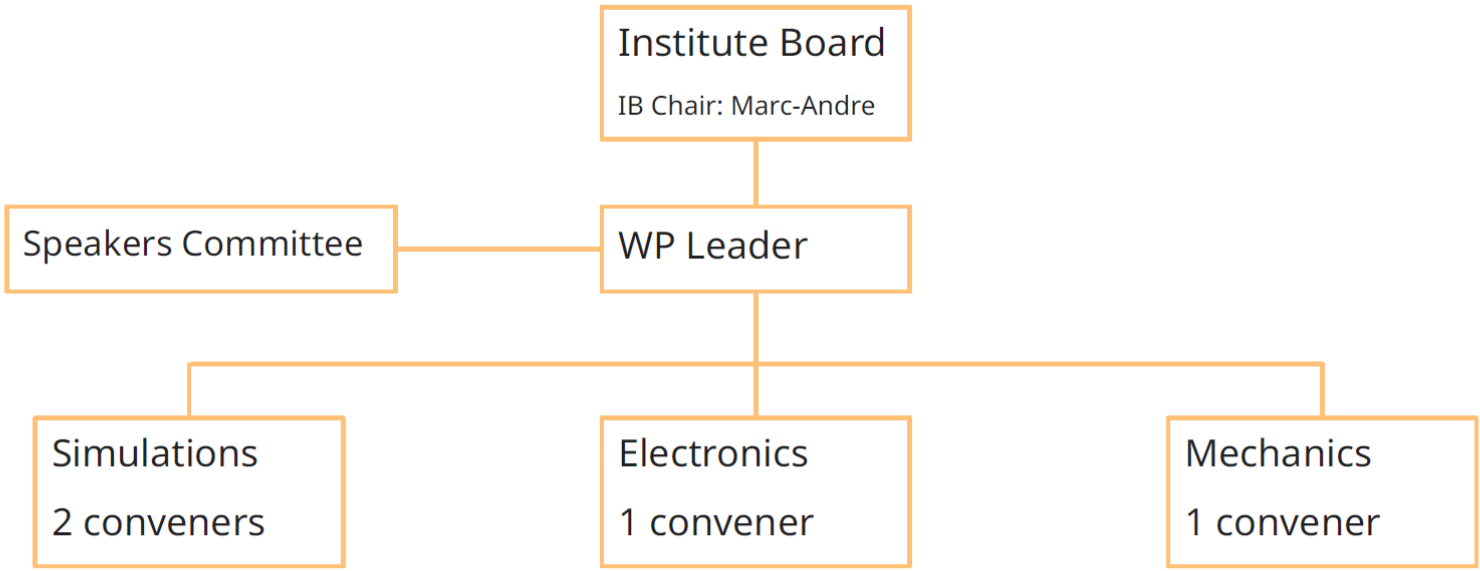
WP2 Open IB

Organizational Structure Proposal

Nicolas Morange

WP2 structure: Proposal



Designation of conveners:

- Nominations period to WP leader
- Names selected by WP leader, then endorsed by IB

Meetings

Monthly meetings: Thursday, 15:00-17:00 CERN time

Next three meetings (rest of the year to follow soon):

- May 16: **Kickoff Meeting**
  - Use first hour of the general meeting, followed by technical updates
  - A few slides with both short- and long-term interests for each institute
  - A template will be provided
- June 20 (yes, during ATLAS week)
- July 11

Activities will schedule additional meetings as needed

- Avoid proliferation of meetings, e.g. hold software technical meetings together with FCC software general meeting

Summary / Outlook

Significant technical progress reported in this meeting, lively discussions

- Regular monthly meetings to start (again) in May
- Central meeting to be augmented by activity meetings going forward
- New efforts welcome and needed!

Initial WP2 leadership team established

- Thank you for your support!
- Nicolas Morange endorsed yesterday by DRD6 CB.

WP2 organizational structure proposed

- Strongly inspired by ATLAS LAr community
- Further feedback and suggestions for activity leaders welcome!