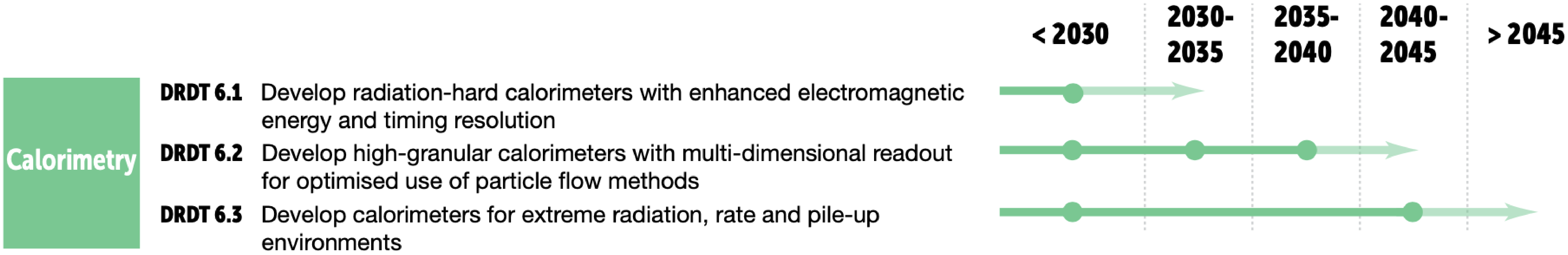
Status of DRD-on-Calorimetry

Roman Pöschl

DRDC Meeting November 2024

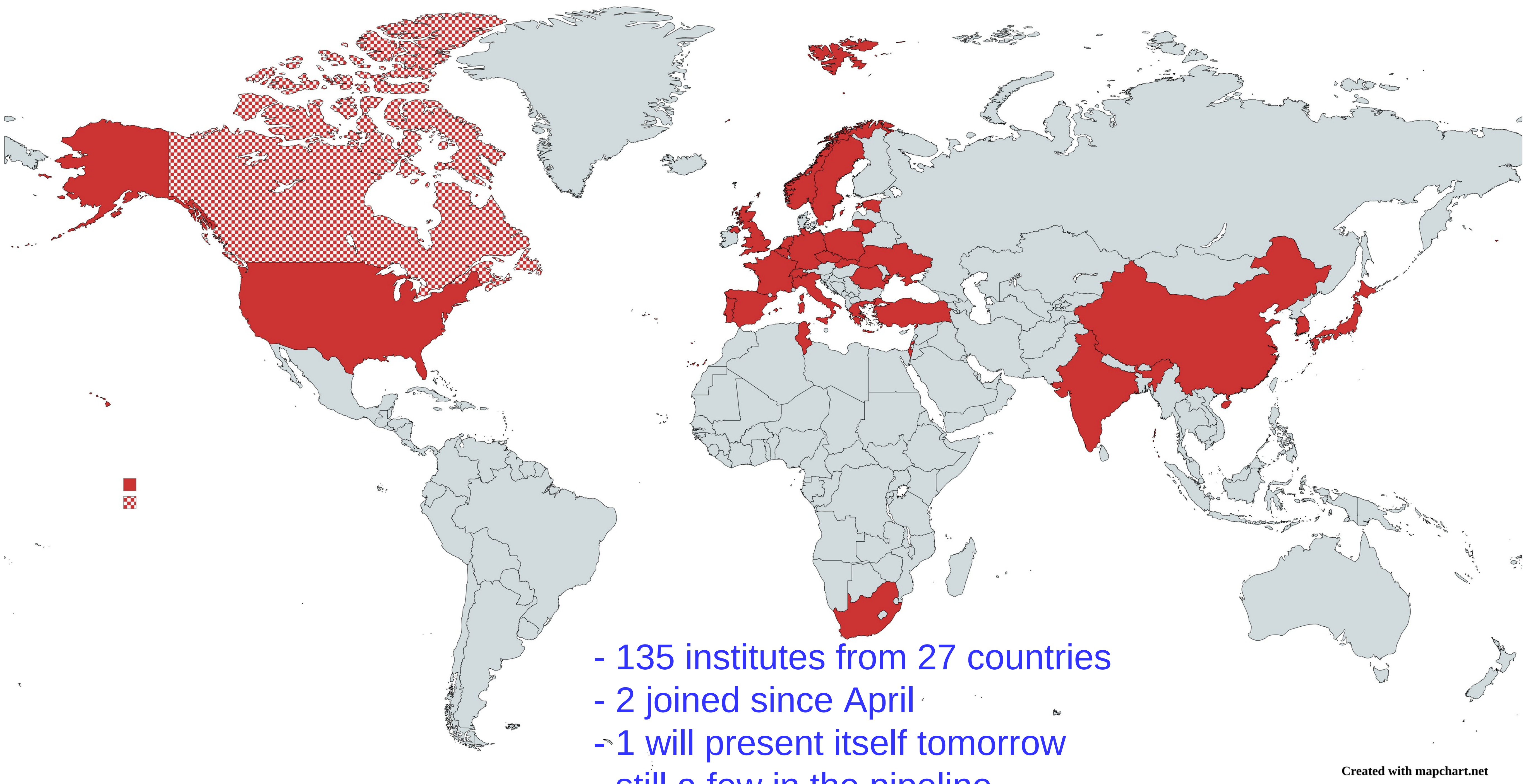
Most slides provided by G. Gaudio, L. Masetti, G. Marchiori, M. Mlynarikova, C. De la Taille, W. Ootani
For a full overview please consult: https://indico.cern.ch/event/1449522/

Future Facilities and DRDT for Calorimetry



- The **D**etector **R**&**D** **T**hemes and the provisional time scale of facilities set high-level boundary conditions
  - See backup slides for detailed R&D tasks

DRD Calo – Who and where we are



- 135 institutes from 27 countries
- 2 joined since April
- 1 will present itself tomorrow
- still a few in the pipeline

Collaboration Meetings 2024

- 9th - 11th of April 2024 at CERN
- https://indico.cern.ch/event/1368231/overview
- 133 participants, 67 on-site

- 30th of October - 1st of November 2024 at CERN
- https://indico.cern.ch/event/1449522/
- 184 participants, 54 on-site

IJCLab Irène Joliot-Curie Laboratoire de Physique des 2 Infinis

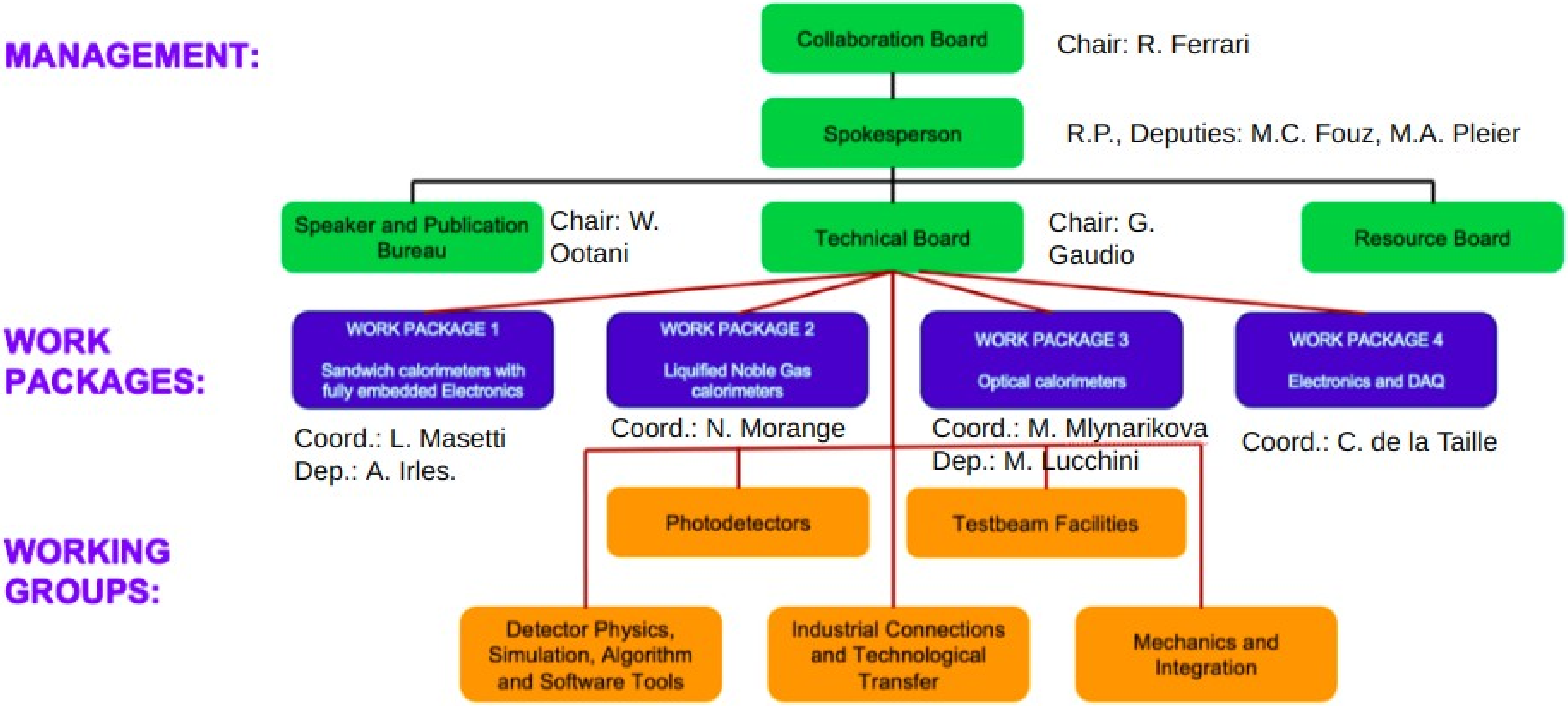
Setting up the Collaboration

- Settiing up of management team (actions since last collaboration meeting)
  - Election of Spokesperson (R.P., IJCLab)
  - Election of two deputy spokespersons: Mary-Cruz Fouz (CIEMAT), Marc-Andre Pleier (BNL)
  - Election of Technical board Chair: Gabriella Gaudiao (INFN-Pavia)
  - Election of Speakers and Publication Bureau Chair: Wataru Ootani (ICEPP)
  - Reminder – CB Chair Roberto Ferrari (INFN-Pavia)

- Workpackage Coordinator
  - WP1: Lucia Masettti (JGU, lead), A. Irles (IFIC, deputy)
  - WP2: Nicolas Morange
  - WP3: Michaela Mlynarikova (CERN), Marco Lucchini (deputy, University and INFN Milano-Bicocca)
  - WP4: Christophe de la Taille (OMEGA)

- With these elections the collaboration is operational
  - ... and we can move out from the setup phase into the working phase

Current structure



Speakers and Publication Bureau

Oversees the implementation of the publication policy that will be defined in a separate document approved by a vote of the CB.

The publication policy will ensure common standards on publications like review procedures and include dedicated rules for publications in common with other DRDs and experiments;

Implements the policy of access to data produced by the Collaboration that will be defined in a separate document approved by a vote of the CB. Provides a single contact point for conference organisers for DRD-on-Calorimetry talks.

Maintains a record of the talks given and ensures that the material presented remains accessible to the Collaboration.

Ensures the equal distribution of talks given on behalf of the whole collaboration among the collaboration members.

Solicits new opportunities for conference talks by members of the DRD-on-Calorimetry.

Supports the Spokesperson in the preparation of reviews of the scientific results.

DRD Calo – Governance Rules

The DRD-on-Calorimetry Collaboration - Governance

History of the document:

- *Draft v0 23.10.2023*
- *Draft v1 17.5.2024*
- *Draft v2 4.6.2024*
- *Update v2 R.P. 27/7/24*
- *v3 for Collaboration Board review*

- The Governance Rules
  - ... are "by laws" in MOU language --> part of Annex
  - ... make statements on goals and general policy of Collaboration
  - ... define the roles of the different positions and panels in the Collaboration
  - ... define membership to the collaboration
    - ... in coherence with MOU provisions
- Elaborated by Proposal Team
- Approved on 31/10/24 by Collaboration Board
- The rules will be modified, updated or amended when needed

From Proposal to Reality

DRD 6: Calorimetry

Proposal Team for DRD-on-Calorimetry

July 31, 2024

Martin Aleksa[1], Etiennette Auffray[1], David Barney[1], James Brau[2], Sarah Eno[3], Roberto Ferrari[4], Gabriella Gaudio[4], Alberto Gola[5], Adrian Irles[6], Imad Laktineh[7], Marco Lucchini[8], Nicolas Morange[9], Wataru Ootani[10], Marc-André Pleier[11], Roman Pöschl[9], Philipp Roloff[1], Felix Sefkow[12], Frank Simon[13] Tommaso Tabarelli de Fatis[8], Christophe de la Taille[14], Hwidong Yoo[15] (**Editors**)

[1]CERN, Geneva, SWITZERLAND
[2]University of Oregon, Eugene, OR USA
[3]University of Maryland, College Park, MD USA
[4]INFN, Pavia, ITALY
[5]FBK, Povo, ITALY
[6]IFIC, CSIC-Unversity of Valencia, Valencia, SPAIN
[7]IP2I Lyon, Villeurbanne, FRANCE
[8]University and INFN Milano-Bicocca, Milano, ITALY
[9]IJCLab, Université Paris-Saclay, Orsay FRANCE
[10]University of Tokyo, Tokyo, JAPAN
[11]Brookhaven National Laboratory, Upton, NY USA
[12]Deutsches Elektronen-Synchrotron DESY, GERMANY
[13]Karlsruhe Institute of Technology, Karlsruhe, GERMANY
[14]OMEGA, Palaiseau, FRANCE
[15]Yonsei University, Seoul, SOUTH-KOREA

Contents

- Proposal: CERN-DRDC-2024-004; DRDC-P-DRD6: http://cds.cern.ch/record/2886494
  - Very minor corrections since deposit in January

- Proposal defines 40 Milestones (MS) and 39 deliverables (D)
  - MS and D are resource loaded
  - Rough estimation (desiderata) of resources for proposal (confidential version)

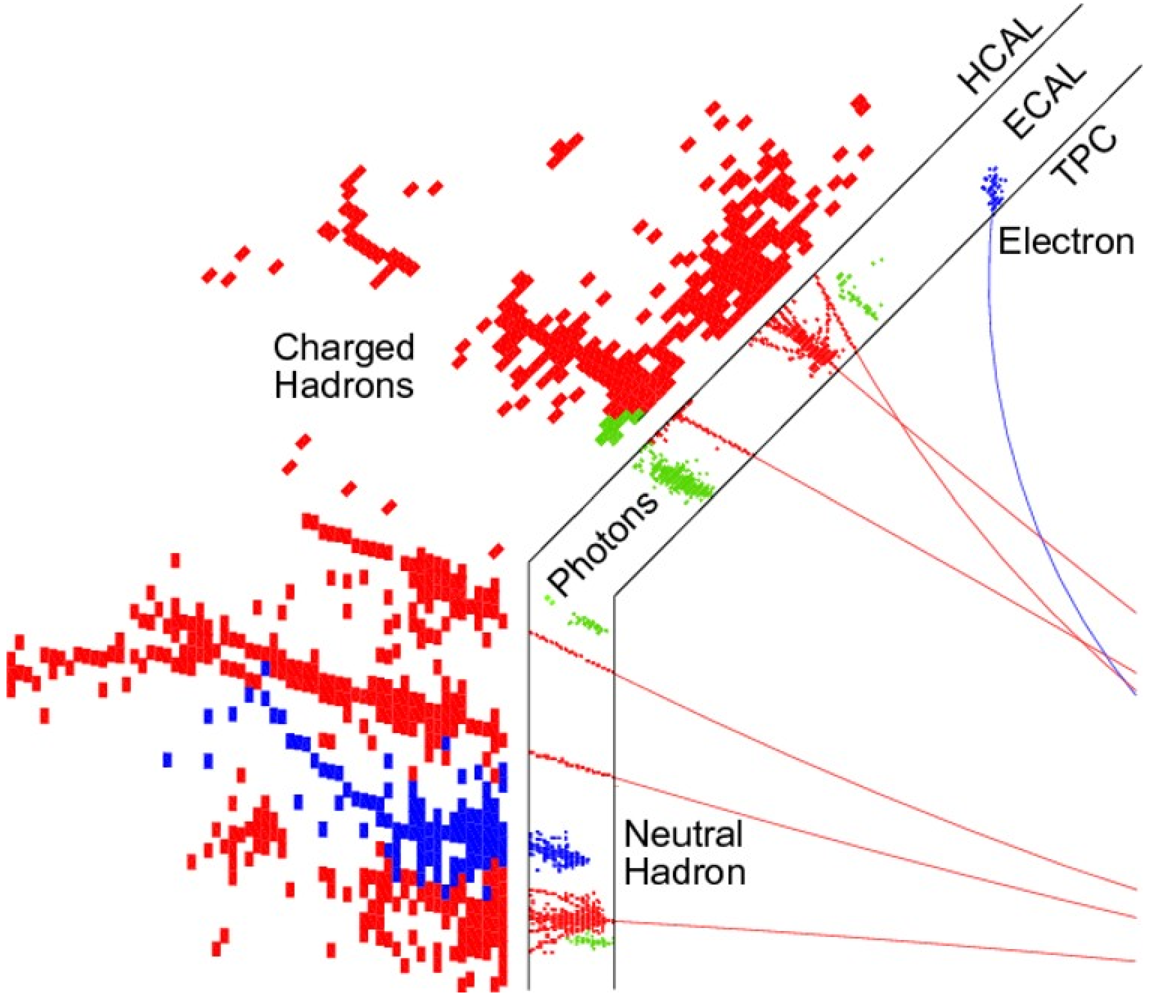
- MS and D and the associated resources will be subject to revision
  - New D can be added (e.g. OREO project)
  - The revised list of D will be entered in Annex 7 of MOU

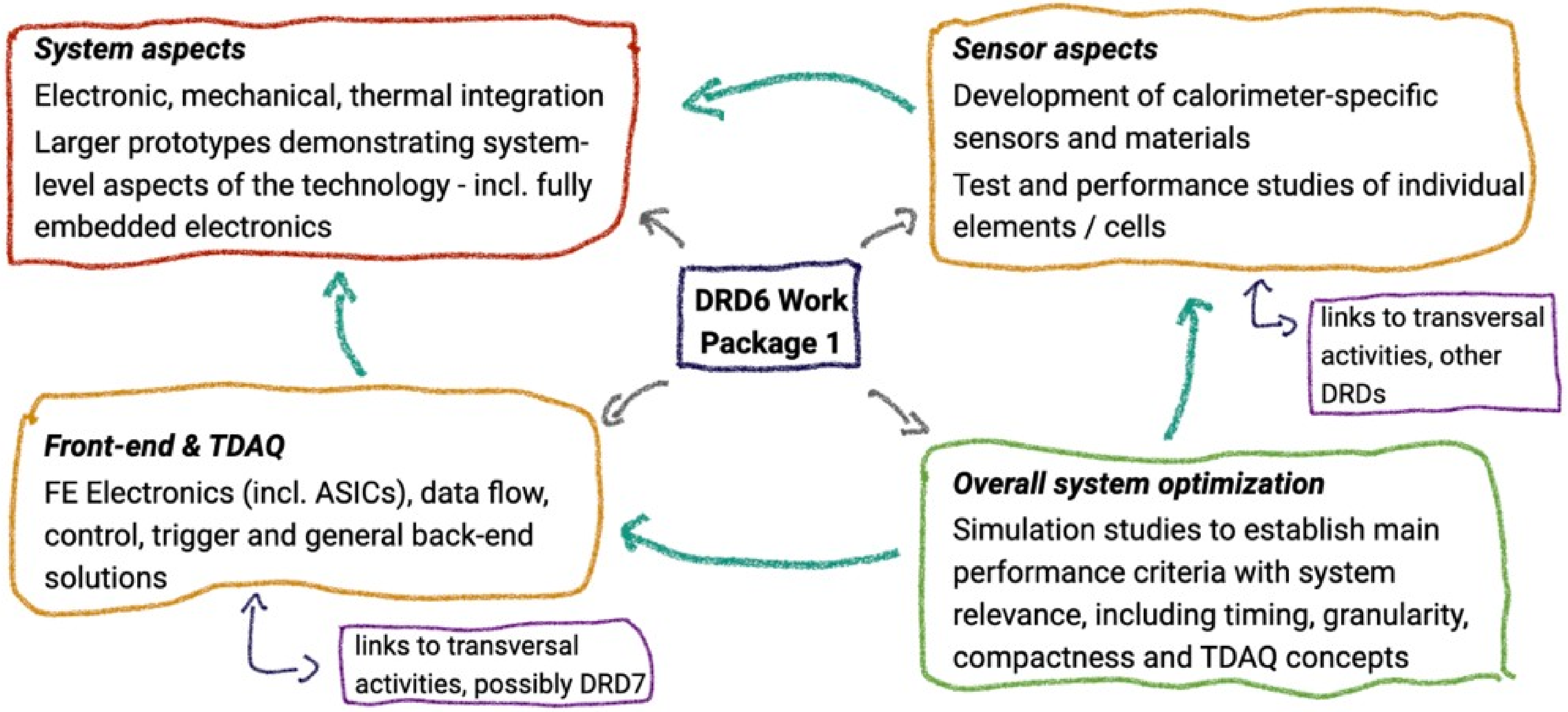
- Revision kicked-off at recent Collaboration Meeting

Scientific Programme - Prologue

- The recent collaboration meeting showed that the scientific programme is already in full swing
- Will concentrate today on those projects that have planned for a deliverable in 2024
  - Based on resources that were already granted before the start of the DRD

Work Package 1 in a nutshell





- Challenges:
  - High pixelisation, 4π hermetic -> little room for services
    - Detector integration plays a crucial role

- New strategic R&D issues
  - Detector module integration
  - Timing
  - High rate e+e- collider (such as FCC-ee)

- Imaging calorimeters live on the high separation power for Particle Flow
- One calorimeter - Subdivided into electromagnetic and hadronic sections

Work Package 1 - Tasks

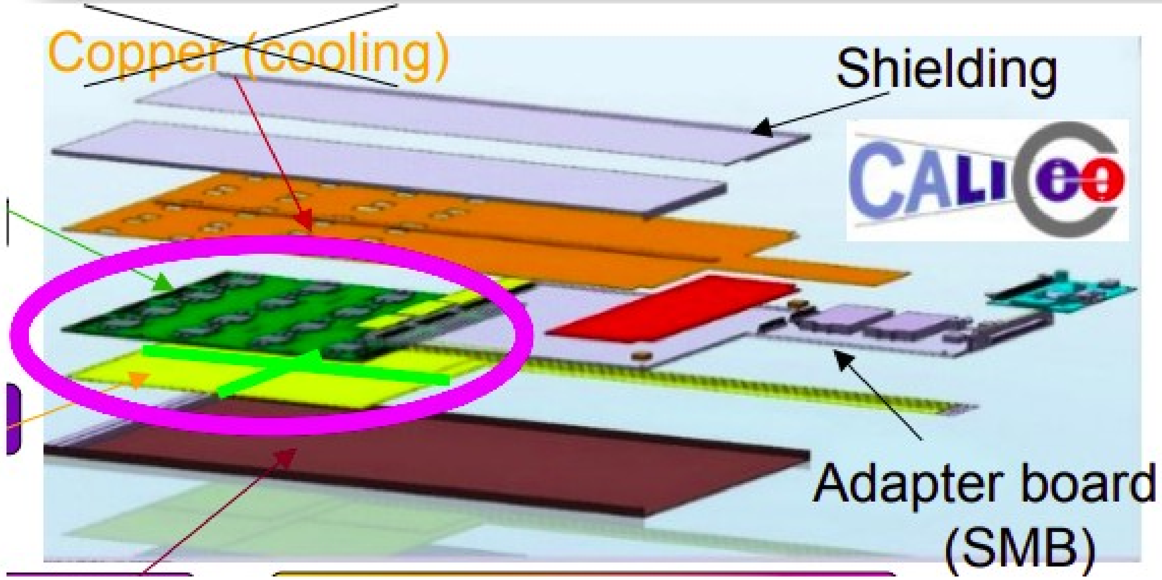
Elm. sections

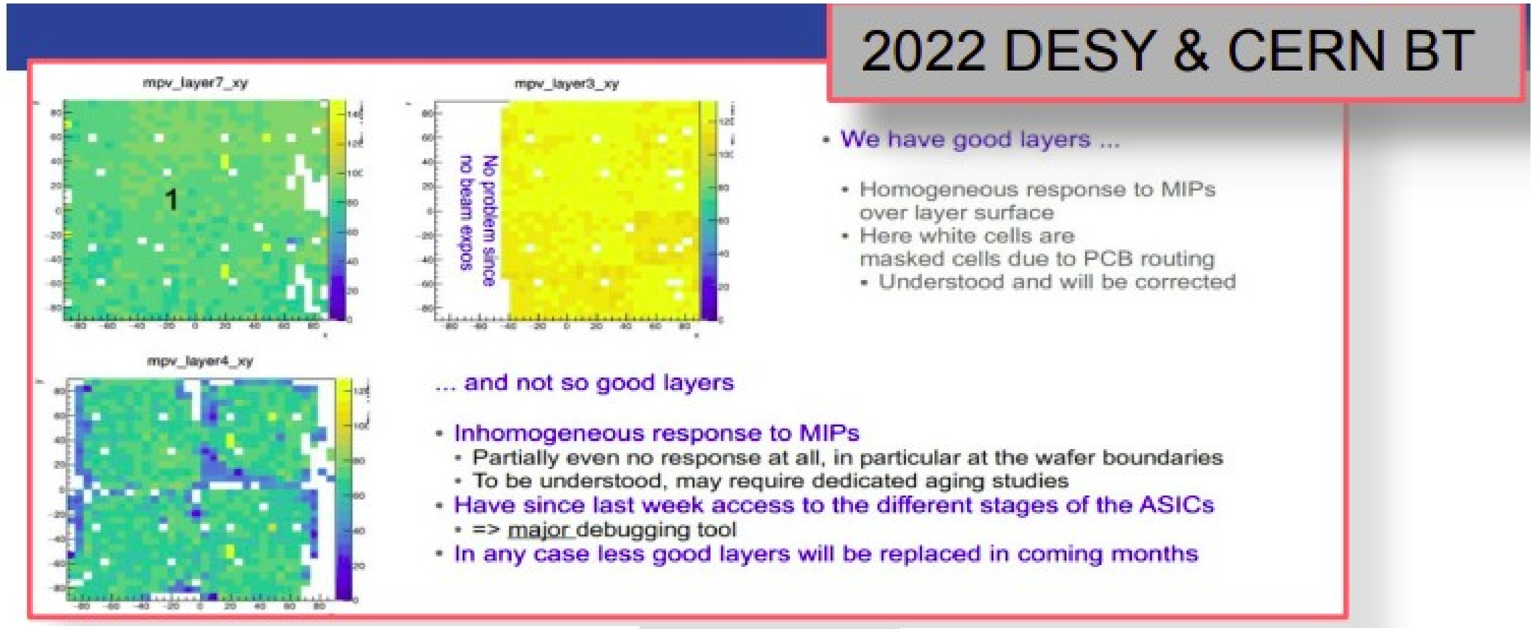
Hadronic sections

Task/Subtask	Sensitive Material/ Absorber	DRDT
Task 1.1: Highly pixelised electromagnetic section		
Subtask 1.1.1: SiW-ECAL	Silicon/ Tungsten	6.2
Subtask 1.1.2: Highly compact calo	Solid state (Si or GaAs)/Tungsten	6.2
Subtask 1.1.3: DECAL	CMOS MAPS/Tungsten	6.2, 6.3
Subtask 1.1.4: Sc-Ecal	Scintillating plastic strips/Tungsten	6.2
Task 1.2: Hadronic section with optical tiles		
Subtask 1.2.1: AHCAL	Scintillating plastic tiles/Steel	6.2
Subtask 1.2.2: ScintGlassHCAL	Heavy glass tiles/Steel	6.2
Task 1.3: Hadronic section with gaseous readout		
Subtask 1.3.1: T-SDHCAL	Resistive Plate Chambers/Steel	6.2
Subtask 1.3.2: MPGD-HCAL	Multipattern Gas Detectors/Steel	6.2, 6.3
Subtask 1.3.3: ADRIANO3	Resistive Plate Chambers+Scintillating plastic tiles/ Heavy Glass	6.1, 6.2, 6.3

WP1 – Subtask 1.1.1 – SiW ECAL

toward D1.1





First CALICE/DRD6 beam tests

- Initially scheduled for June at DESY
- Moved from ~~Fall 2024~~, Spring 2025 (to be submitted, in disc. with AHCAL)

Reason: careful revisitation of the gluing (hydridization) procedure:

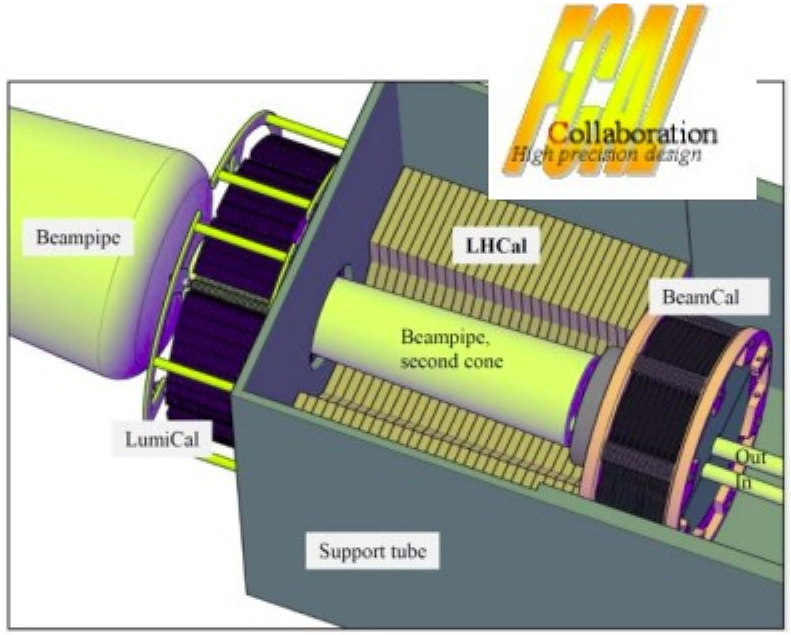
- Deformation of the FEV under
  - Heat : expected
  - Humidity : Not expected
- Need to understand before gluing expensive sensors on them

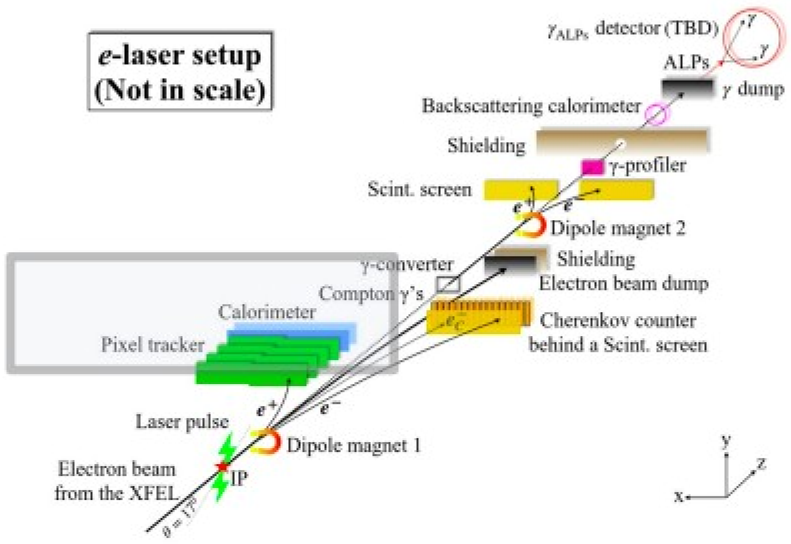
2025–27 : Blue-print for a SiW-ECAL detector for the next ee collider

➡ planning for a pilote module @ T_0 collider-8y -5y (1 Mch, 1/60th of real detector)

WP1 – Subtask 1.1.2 – Highly Compact Calo

toward D1.2





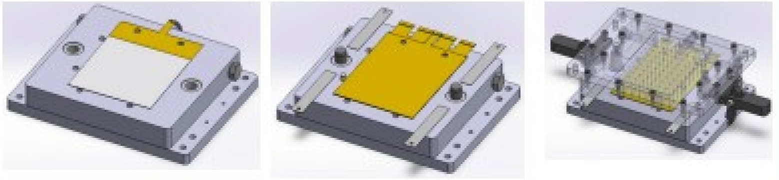
▷TB2022 at DESY-II **Stay tuned for publication**

▷Two types of sensors

- GaAs - 4.7x4.7 mm², 0.3mm gap, Al traces in the gaps
- Si (Hamamatsu, CALICE) 90x90mm², 256 pads of 5.5x5.5mm², 320um thick.

▷90 (CALICE) sensors acquired to Hamamatsu by TAU

- 256 pads, 90x90mm², 320um thick
- PiN diodes, 3kOhm resistivity, n-doping



Optimized tooling and procedure

▷Characterization using HGCAL-matrix board with adapted probe card

▷All of them have been characterized

TB2025 plans (DESY)

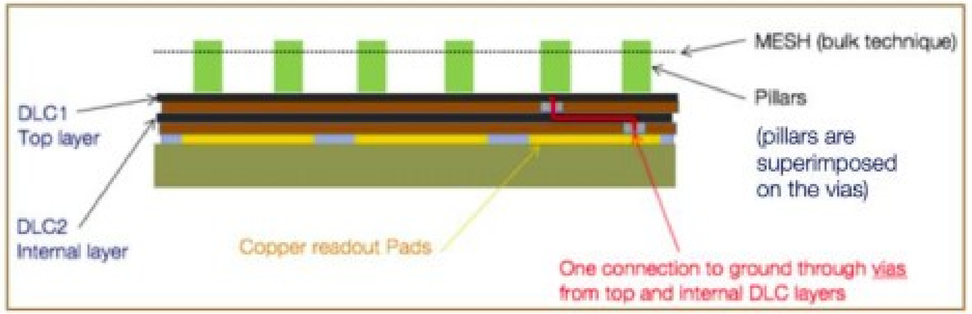
▷ 6 layers with 2 CSIS partially instrumented each.

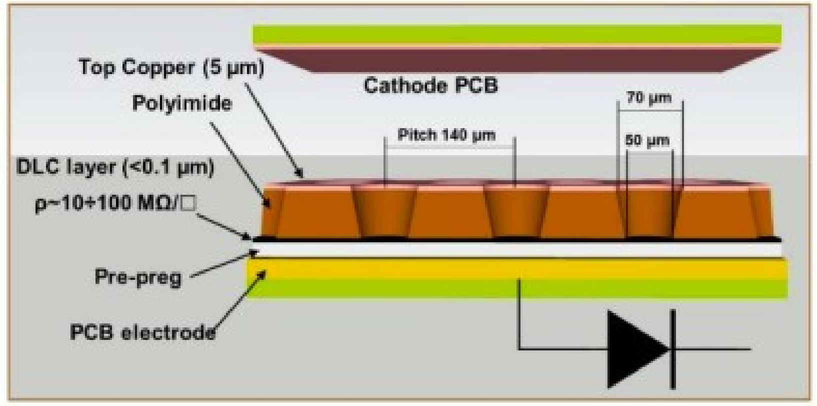
▷Using TB2022 readout with adaptations.

▷Wrt TB2022: new mechanics, new CSIS, new gluing process.

D1.13 achieved

Micromegas (MM)

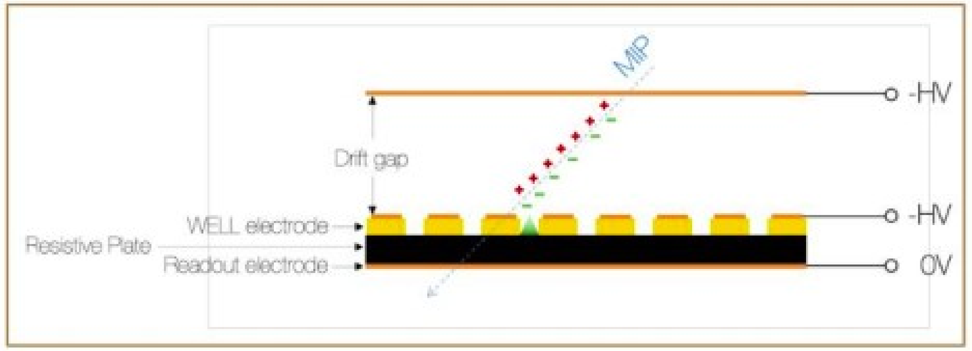


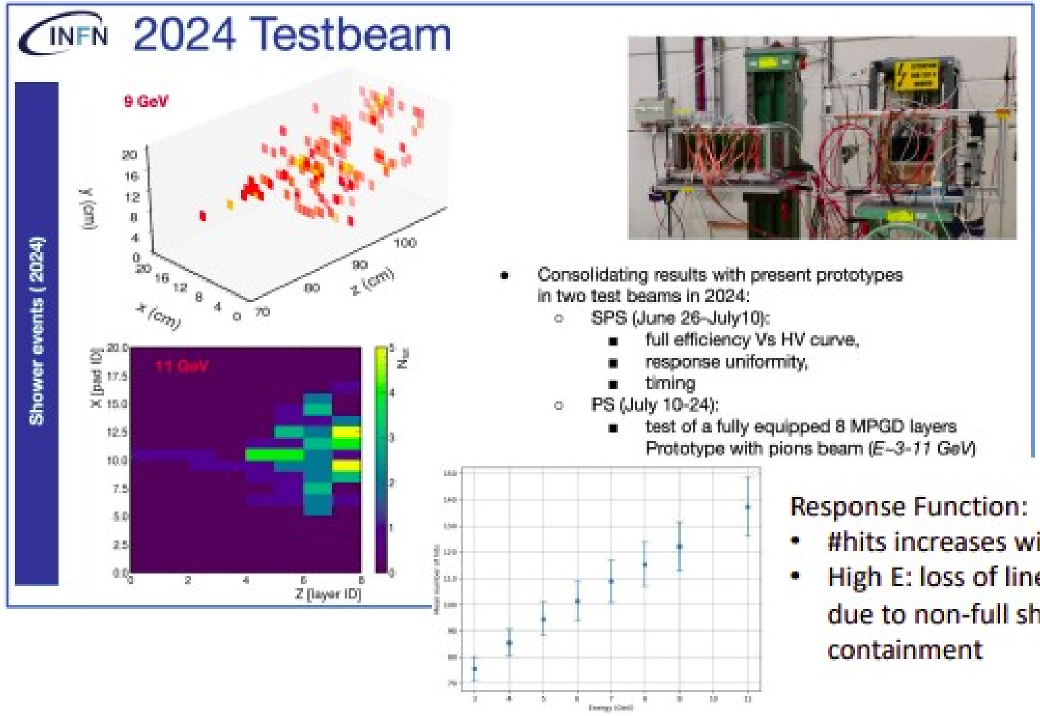


µRWELL

S

RPWELL



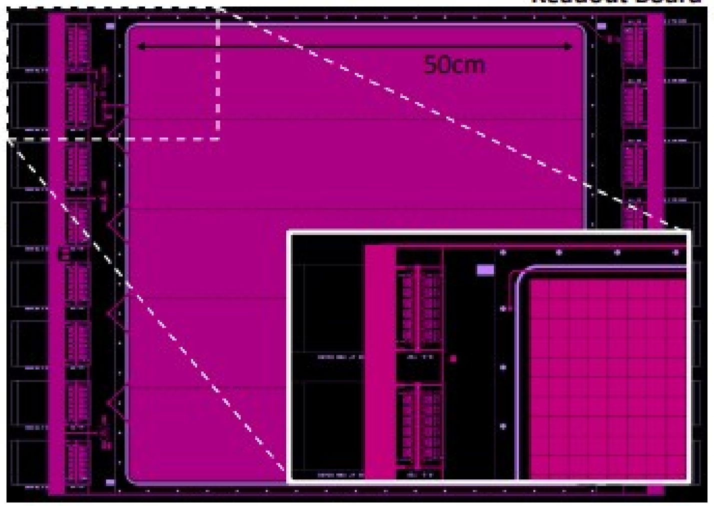


Response Function:
- #hits increases with E
- High E: loss of linearity due to non-full shower containment

Scale Detectors up to 50x50cm²

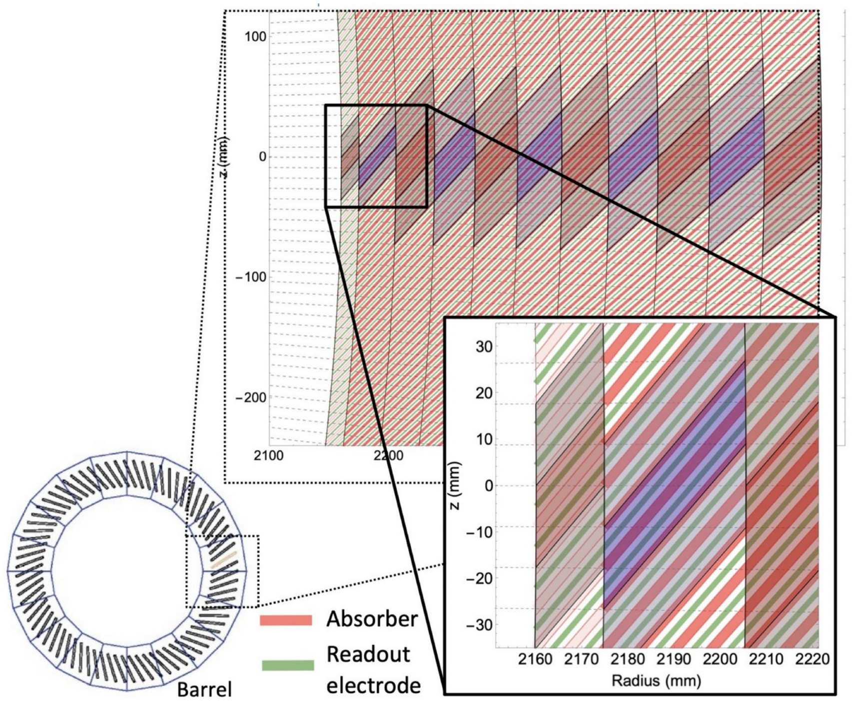
- 2025-2026 Plans: Increase to 50x50cm² - reach 2λ
  - 2 uRWELL + 2 res-MM with active area 50 x 50 cm²
  - 121mm² pads
  - 16 HRS conn
  - 11mm height
- Readout:
  - 16 APV cards/ 16 VMM cards
  - SRS DAQ
- Schedule:
  - Production: Spring '25
  - Testbeam: Summer '25

Readout Board

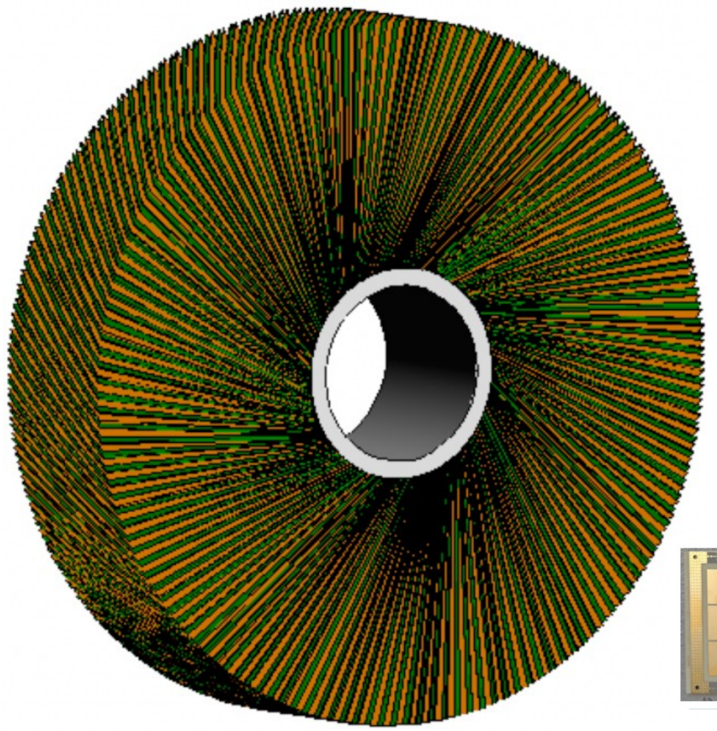


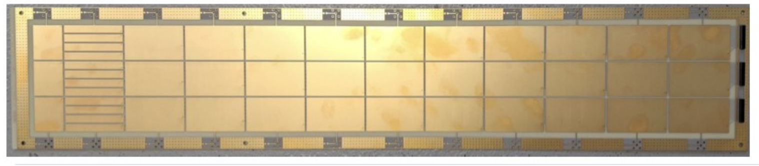
WP2 – Overview

- Focused on R&D on noble-liquid calorimetry
- Main target on foreseeable future: sampling EM calorimeter for e+e- factories - one of key features of “ALLEGRO" detector concept for FCC-ee (https://allegro.web.cern.ch/)
  - highly granular calorimeter with absorber planes inclined in r-phi (barrel) / arranged in turbine-like structure (endcap)
  - readout by segmented PCB planes alternated to Pb (or W) absorbers, gaps in between filled with LAr (or LKr)



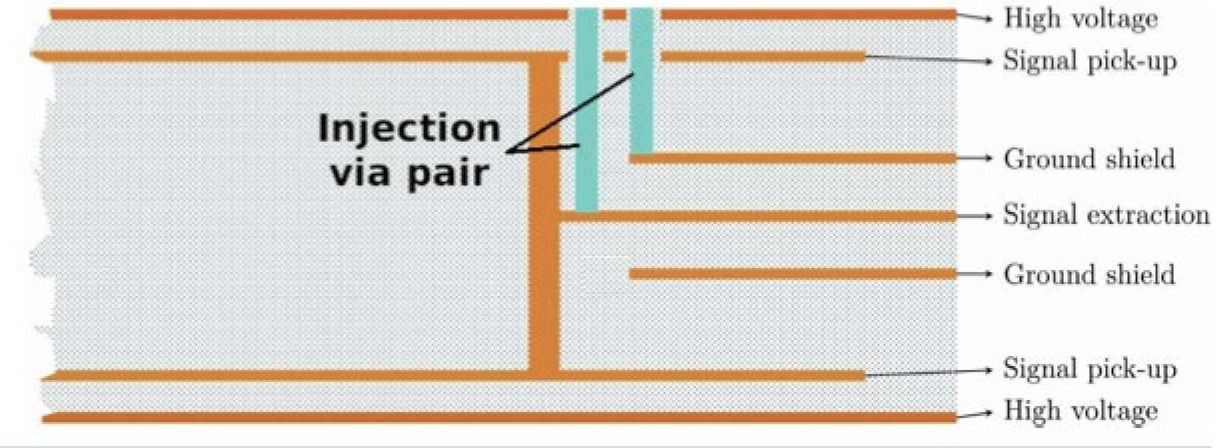
barrel

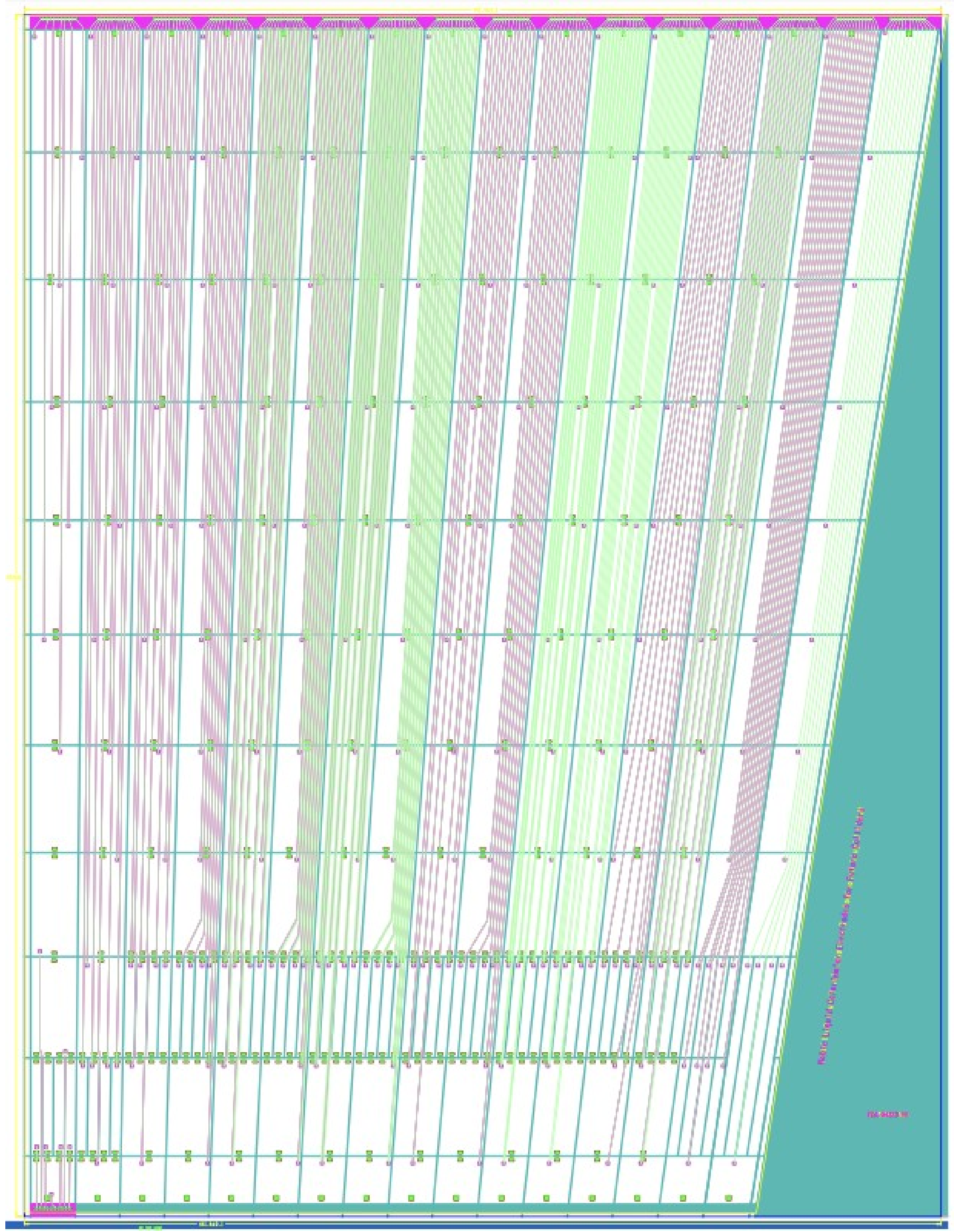

endcap


PCB (readout)

WP2 – Overview

- **New PCB prototype design implemented, now ~frozen**
  - Projective cells in cells, 11 layers - matching current model in full sim
  - Readout from back, to reduce material budget upstream
  - Ground shields connected inside PCB
  - Multiple variations of parameters e.g.
    - Position of strip cells (2nd, 3rd or 2nd+3rd layer)
    - Configuration of lateral shields to reduce capacitive x-talk
    - Trace ordering (-> inductive x-talk)
  - Injection pairs added to some cells for injection studies
- **Next: ~2 weeks for polishing/verification of drawings, 1 month of production at CERN PCB lab (3 prototypes to start with)**

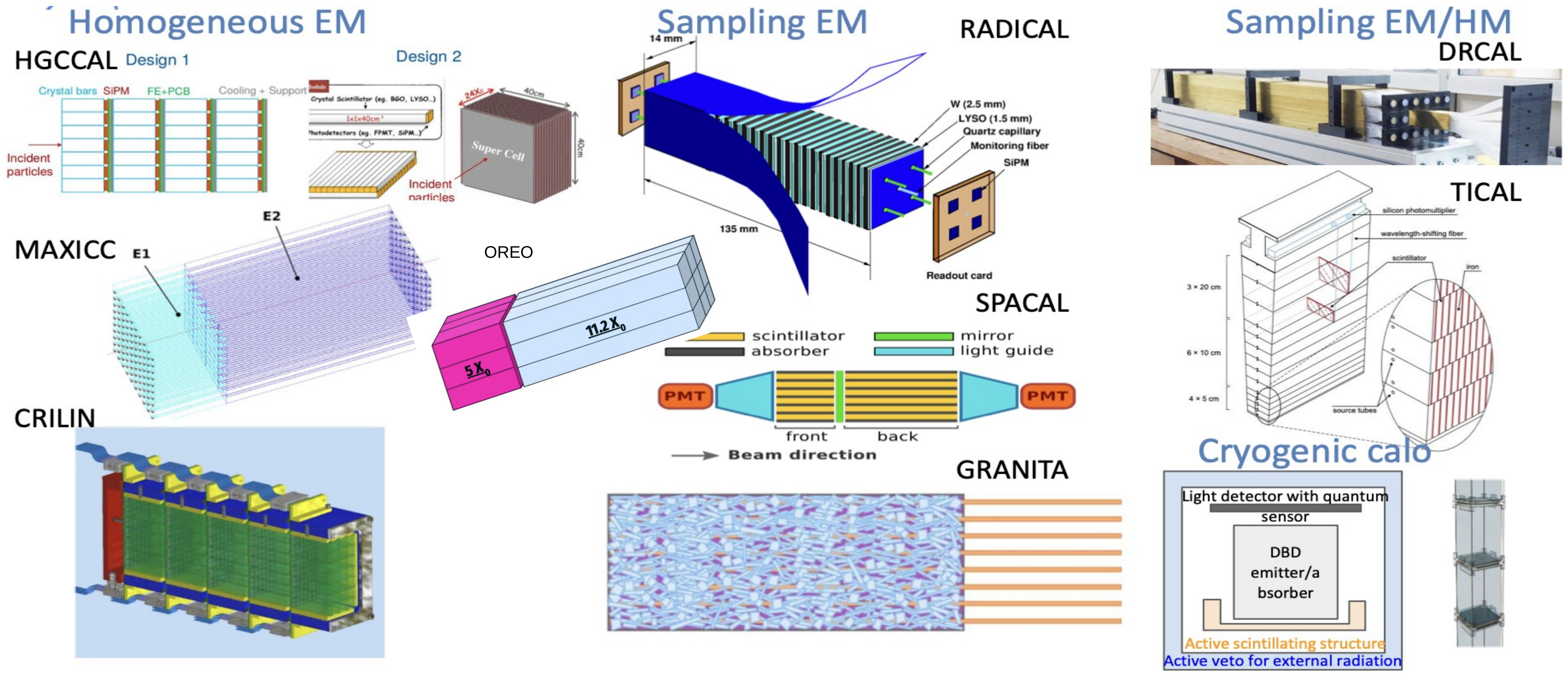




[J. Pekkanen]

Work Package 4 – Overview

- Involvement from ~70 institutes working on 11 different projects
- **The goal**: explore, optimise and demonstrate with full shower-containment prototypes, new concepts of sampling and homogeneous calorimeters based on scintillating materials



18

WP3 – Projects

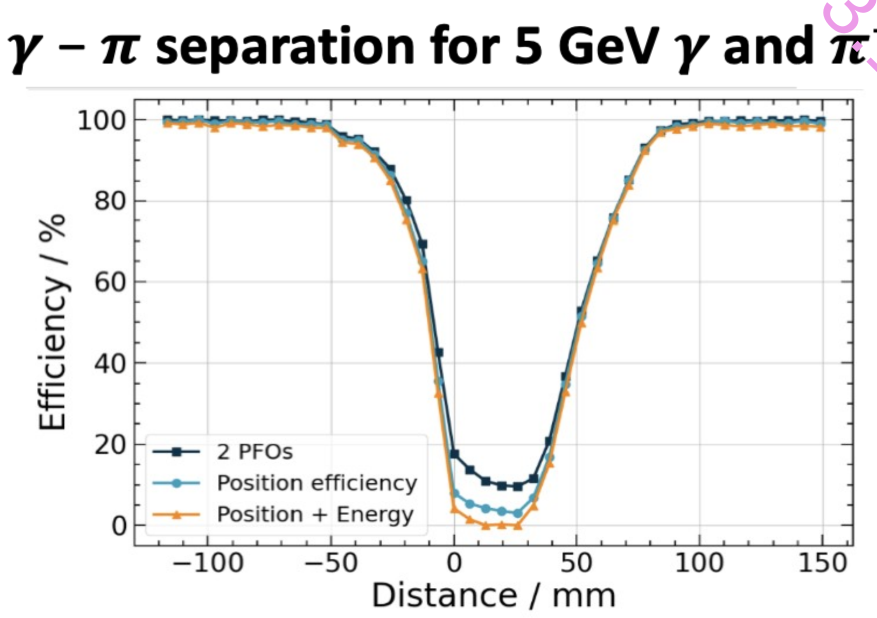
Project	Scintillator/WLS	Photodetector	DRDTs	Target
Task 3.1: Homogeneous and quasi-homogeneous EM calorimeters				
HGCCAL	BGO, LYSO	SiPMs	6.1, 6.2	e^+e^-
MAXICC	PWO, BGO, BSO	SiPMs	6.1, 6.2	e^+e^-
Crilin	PbF_2, PWO-UF	SiPMs	6.2, 6.3	$\mu^+\mu^-$
Task 3.2: Innovative Sampling EM calorimeters				
GRAiNITA	$ZnWO_4$, BGO	SiPMs	6.1, 6.2	e^+e^-
SpaCal	GAGG, organic	MCD-PMTs,SiPMs	6.1, 6.3	e^+e^-/hh
RADiCAL	LYSO, LuAG	SiPMs	6.1, 6.2, 6.3	e^+e^-/hh
Task 3.3: (EM+)Hadronic sampling calorimeters				
DRCal	PMMA, plastic	SiPMs, MCP	6.2	e^+e^-
TileCal	PEN, PET	SiPMs	6.2, 6.3	e^+e^-/hh
Task 3.4: Materials				
ScintCal	-	-	6.1, 6.2, 6.3	$e^+e^-/\mu^+\mu^-$/hh
CryoDBD Cal	TeO, ZnSe, LiMoO NaMoO, ZnMoO	n.a.	-	DBD experiments

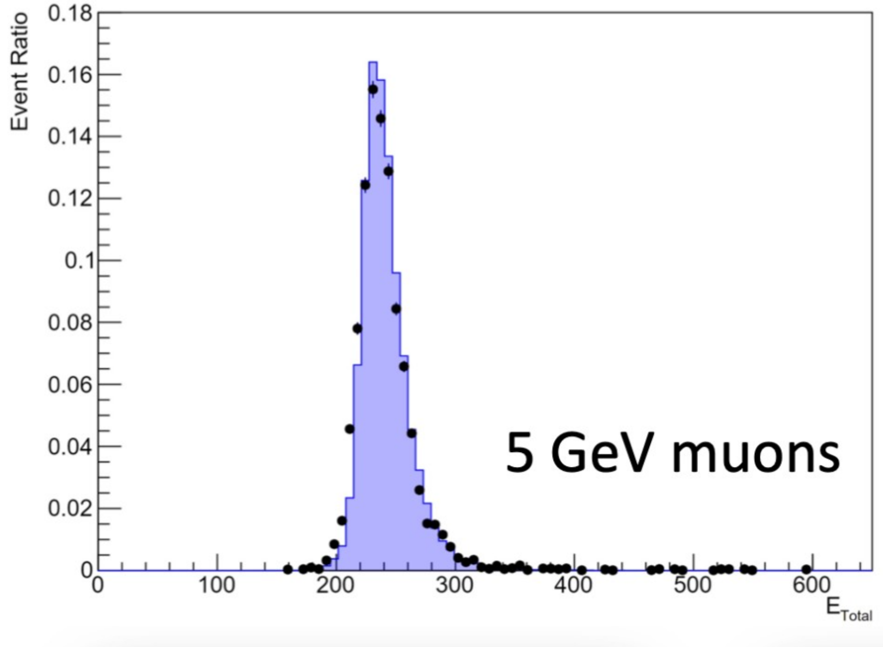
+ OREO in Task 3.1

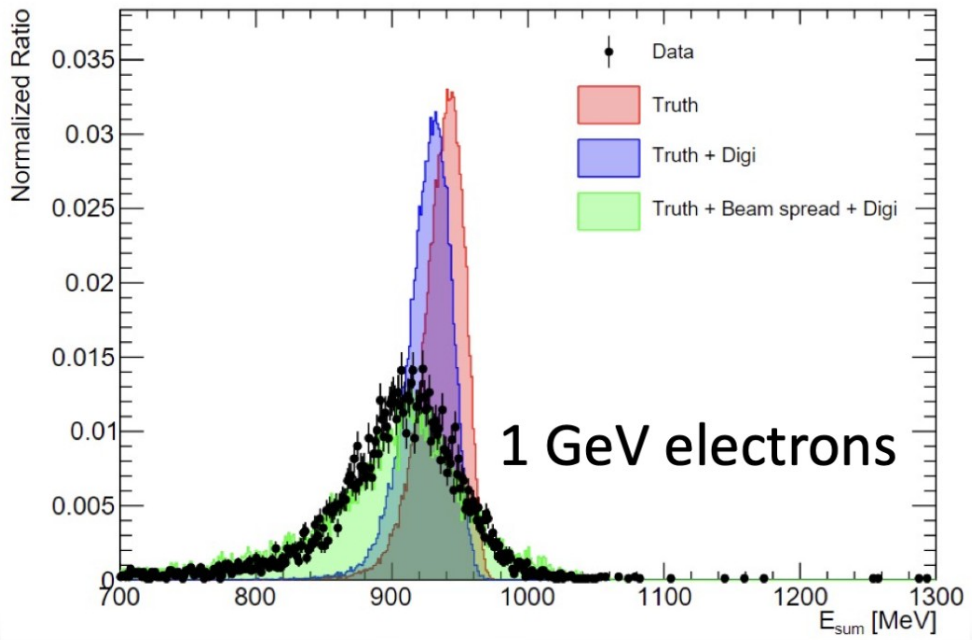
WP3 – Subtask 3.1.1 – HGCCAL

D3.1 achieved

- Crystal bars arranged in a grid structure
  - Optimal EM resolution: 2-3%/√E
  - Fine segmentation for particle flow algorithms
- Some of 2024 highlights
  - Well on track for (not only) 2024 milestones and deliverables
  - A full HGCCAL physics prototype developed and tested
  - New PFA reconstruction software for the long-bar design





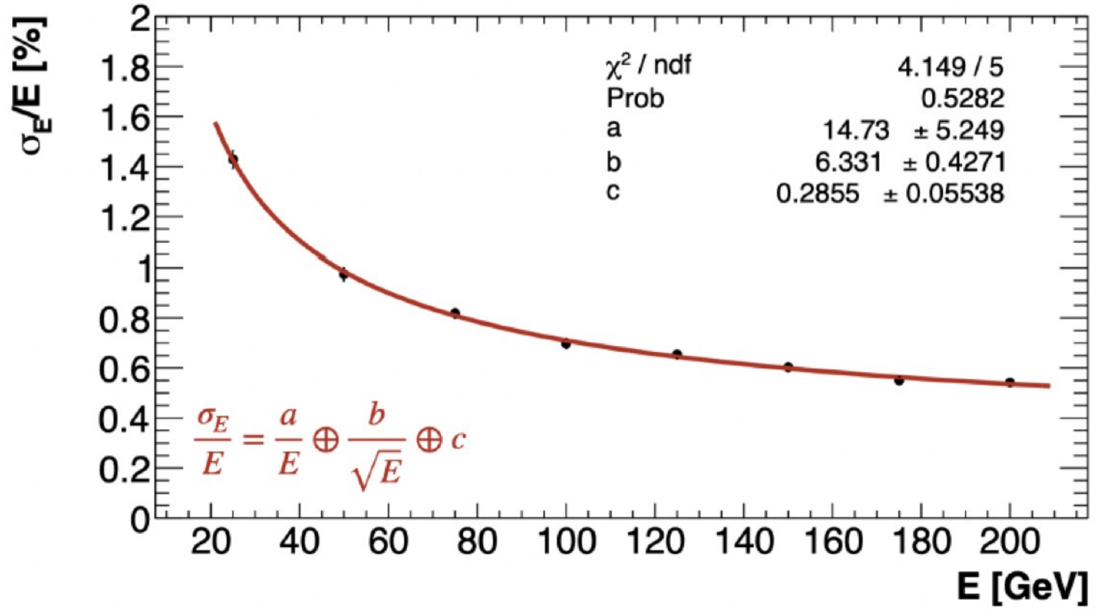


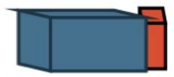
WP3 – Subtask 3.1.3 – CRILIN

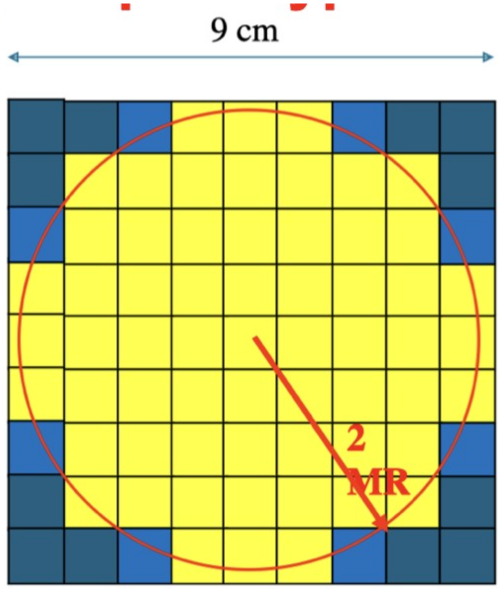
DRD Calo

D3.4 achieved

- A CRystal calorimeter with Longitudinal InformatioN for the future Muon Collider
  - EM calorimeter: semi-homogeneous based on Lead-Fluorite (PbF_2) crystals and SiPMs
- Targets EM resolution: 5-10%/√E
  - Limited by beam induced background (BIB) and SiPM noise (due to radiation damage)
- First prototypes tested in beam tests
- Some of 2024 highlights
  - Optimised number of crystals and layers using Geant4 simulations
  - Work ongoing towards a large scale prototype
    - Completion may be delayed due to delays in the funding







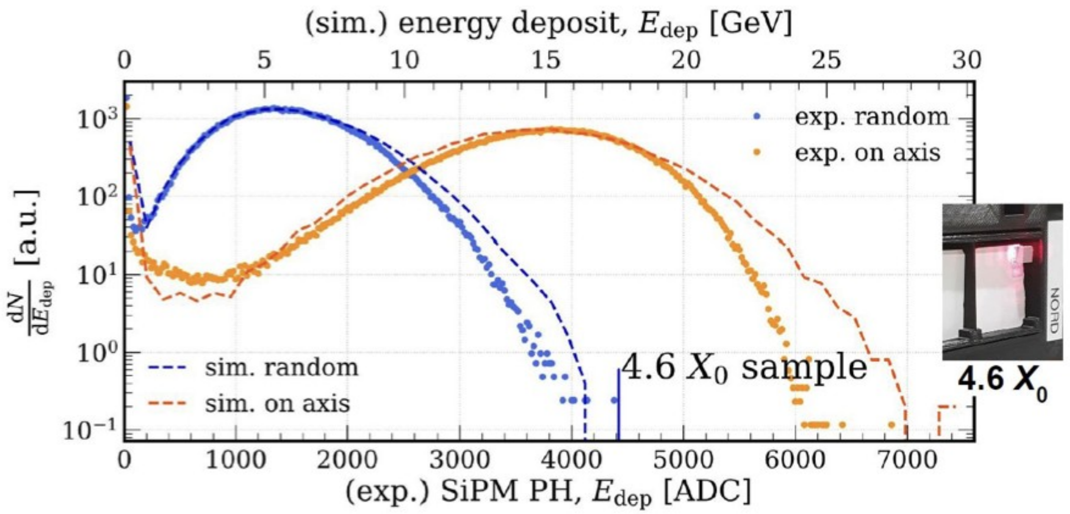
publication

L. Bandiera, V.V.Haurylavets, V. Tikhomirov NIM A 936 (2019) p.124-126
L. Bandiera et al., Front. Phys. 2023 11:1254020. doi: 10.3389/fphy.2023.1254020
M. Soldani et al., arXiv:2404.12016v1

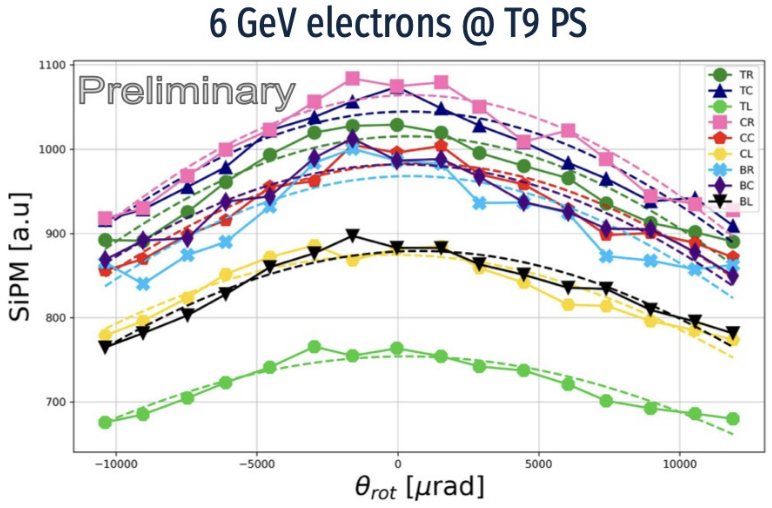
D3.18 achieved

OREO joined DRD Calo during 2024

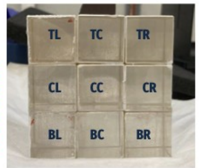
- Idea: Use oriented crystals
  - The input photon or electron/positron showers can fully develop in a much lower thickness with respect to the current state-of-the-art detectors, with the same light yield
- Some of 2024 highlights
  - Two layer PWO-UF prototype fully assembled
  - First experimental tests at CERN and data analysis

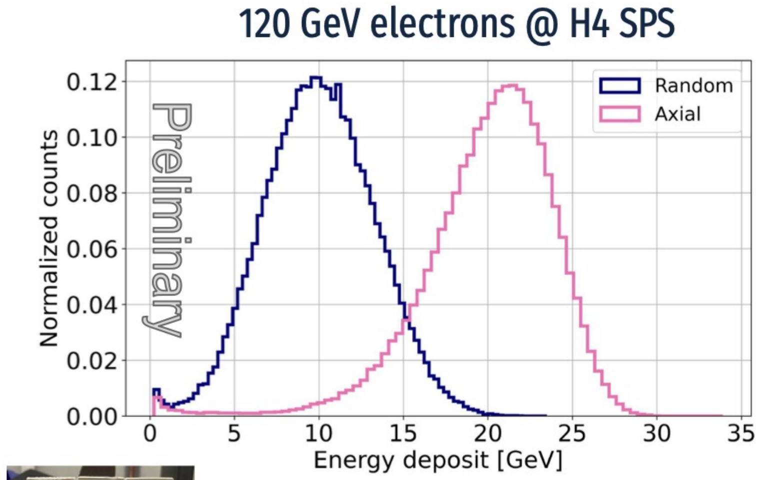


Alessia Selmi



The crystals are well inter-aligned!

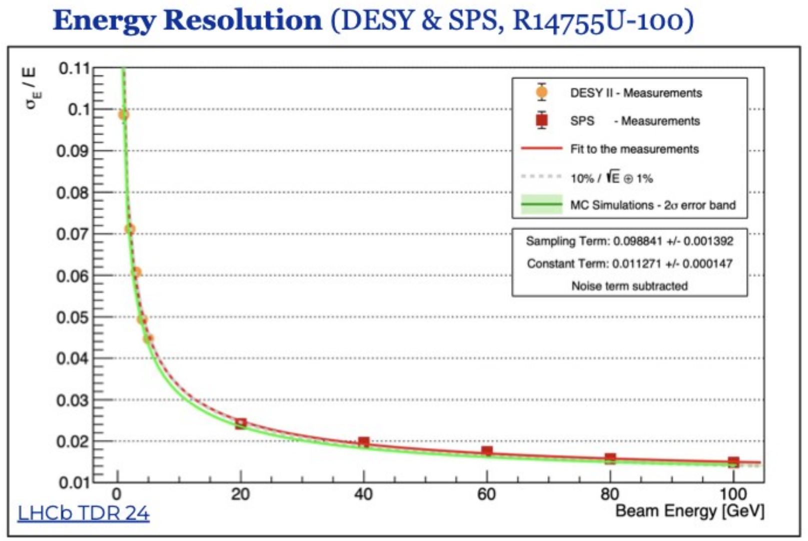


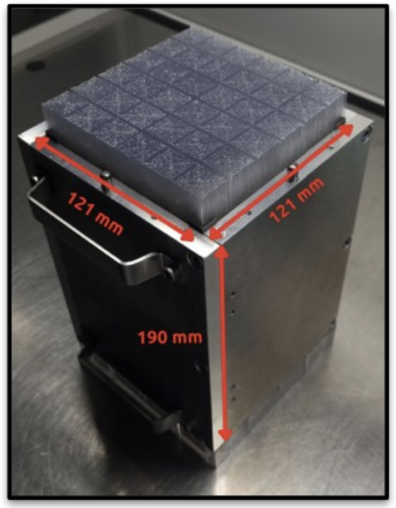


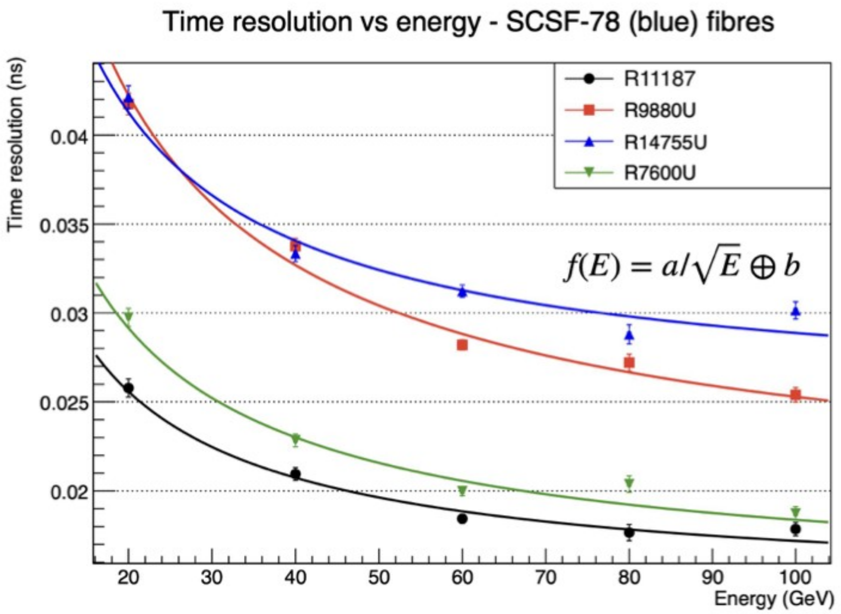
WP3 – Subtask 3.2.1 – SpaCal

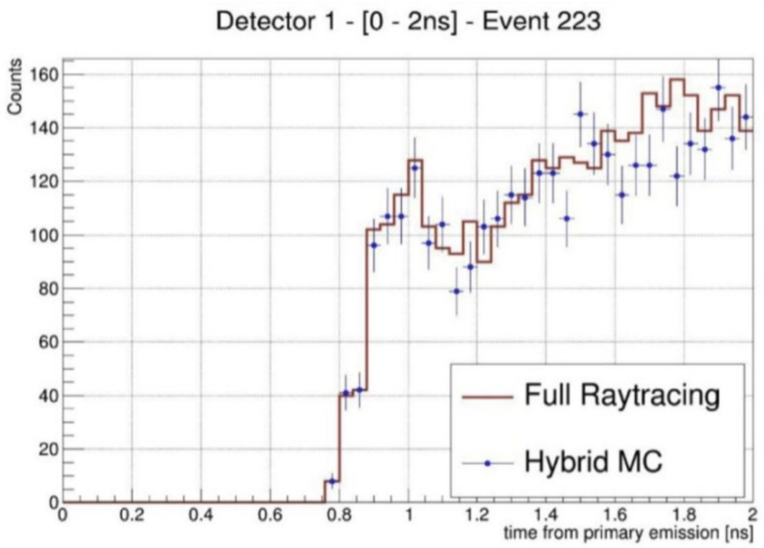
arxiv:2205.02500

- Sampling EM calorimeter: scintillating fibres inserted in a high-density absorber material
  - Tunable energy resolution and time resolution of O(10-20) picoseconds
- Some of 2024 highlights
  - Tested prototypes with tungsten and lead absorbers
    - Deliverable D3.7 achieved!
  - **Time resolution** better than 20 ps for high-energy electron beams





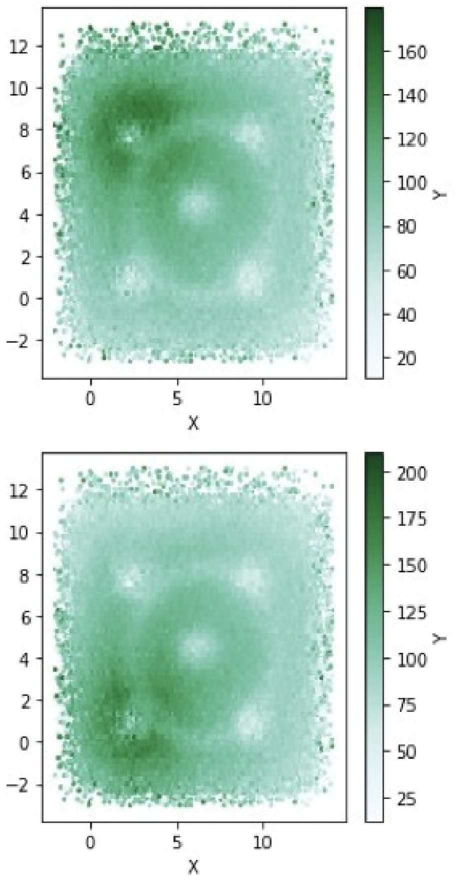


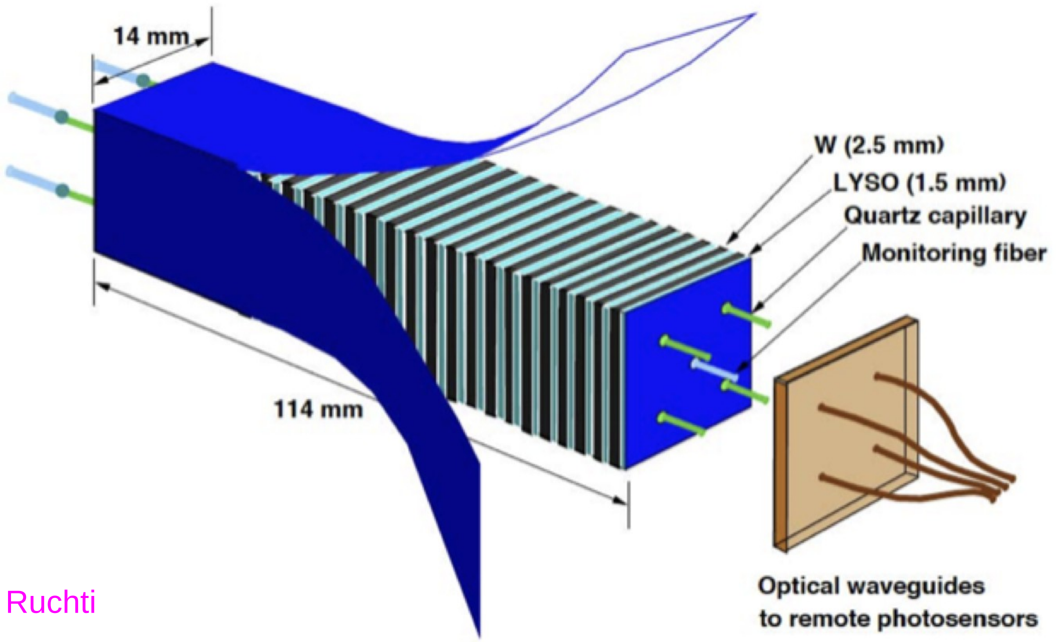


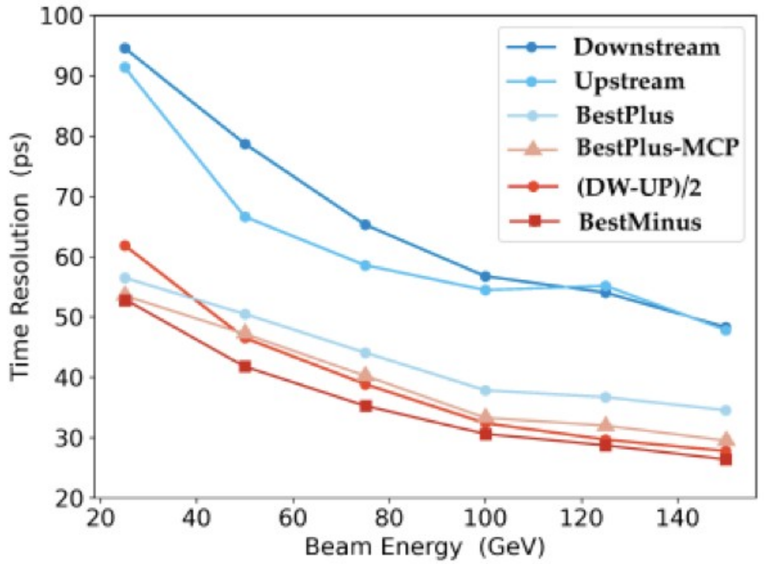
https://doi.org/10.1016/j.nima.2024.169737

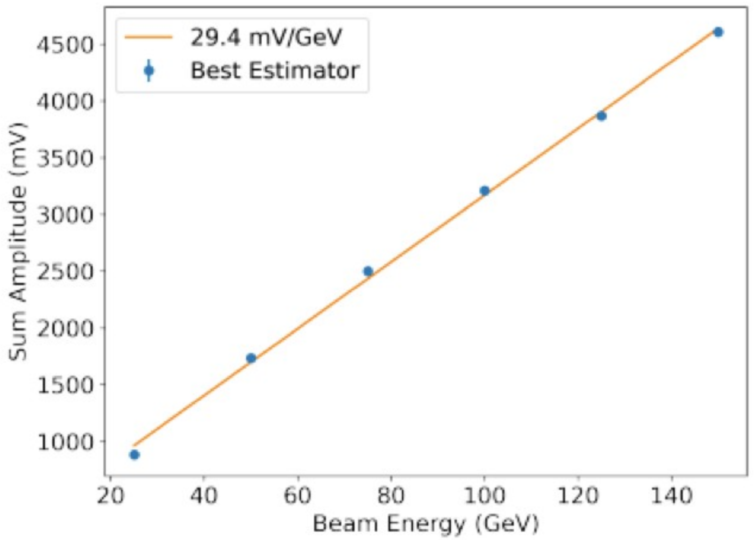
D3.10 achieved

- Shashlik-type: crystal plates, tungsten plates, quartz capillaries with WLS material
  - Uses the scintillation and Cherenkov light
  - Compact EM calorimeter with fast-timing
- Some of 2024 highlights
  - Prototypes successfully measured at beam tests
  - Tested different wavelength shifters for timing measurements at shower max





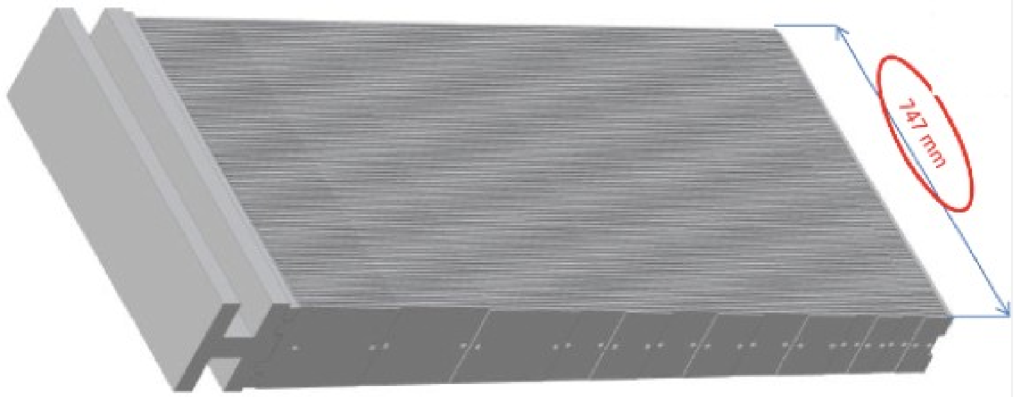




Randy Ruchti

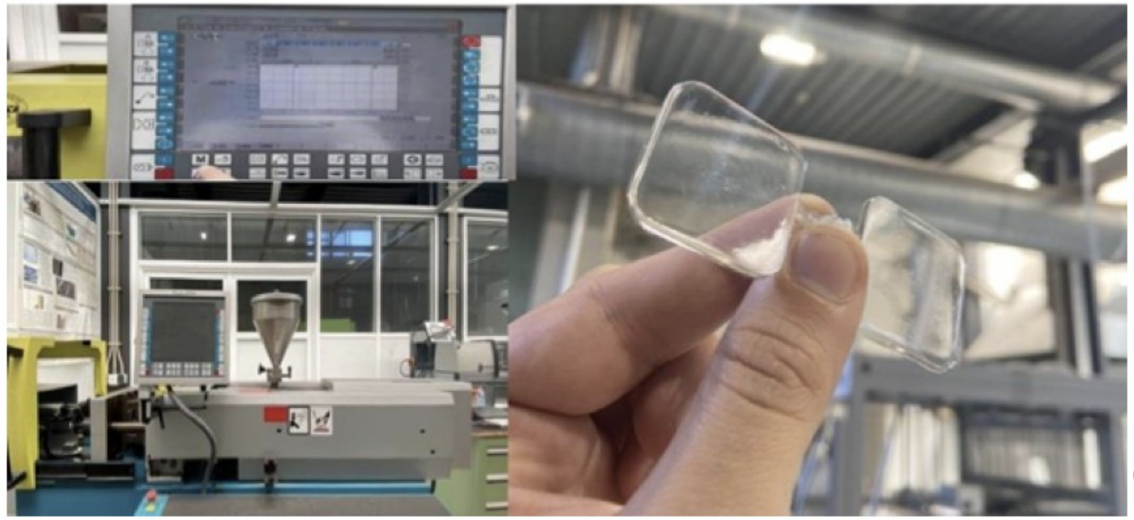
WP3 – Subtask 3.3.2 – TileCal

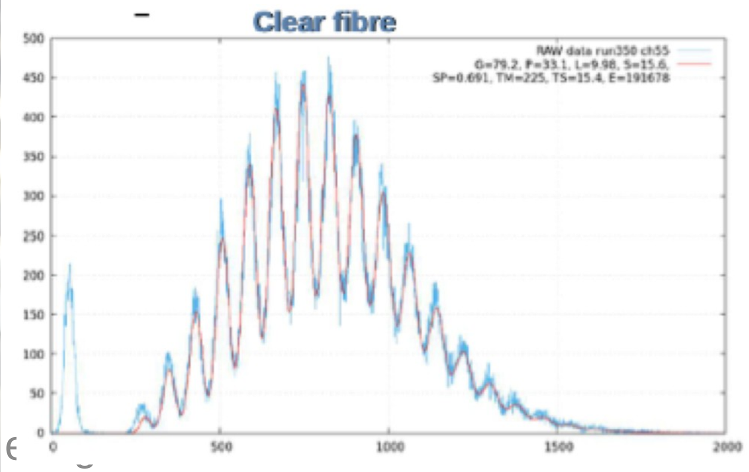
Henric Wilkens

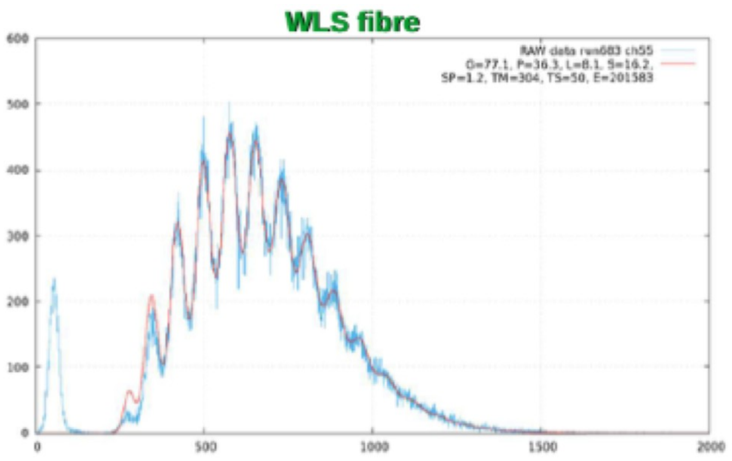


- High-granularity version of ATLAS TileCal hadronic calorimeter
  - 5mm steel absorber plates alternating with 3mm scintillators
  - SiPM readout through WLS
  - Part of ALLEGRO → close collaboration with WP2

- Some of 2024 highlights
  - Exploration of new scintillator materials
  - Optimisation of WLS and SiPMs for readout efficiency
  - Mechanical studies of the testbeam module
    - First period of master and filler plate produced







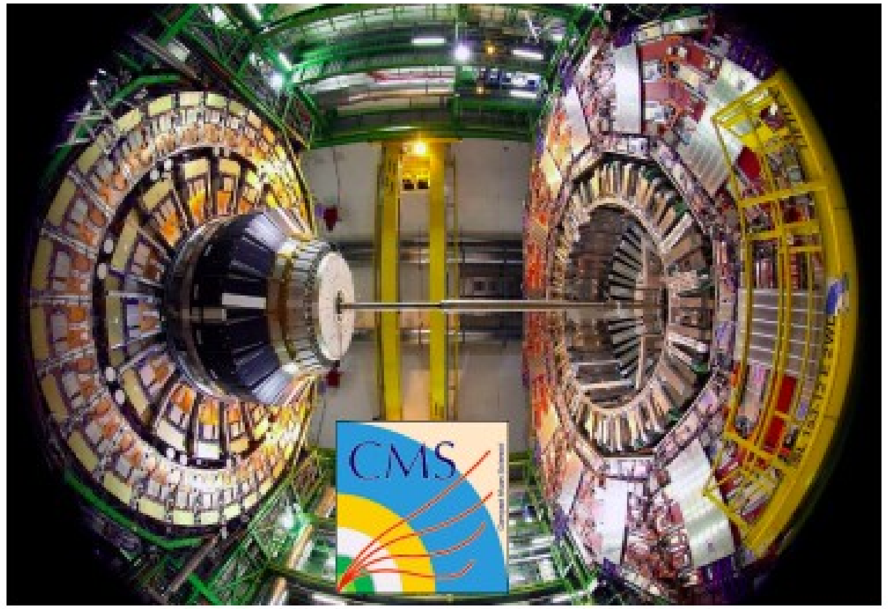
WP4 – Electronics and DAQ

H2GCROC for the endcap calorimeter – Phase II → CALOROC for EIC

6M of Silicon channels
(+ 240k of SiPM)

Radhard (200 Mrad)
Low Power (15 mW per chn)
Precise timing (25 ps)

Total of 150k ASICs needed
Pre-prod this year



Same ASIC structure (floorplan)
Same ADC and TDC
Same readout

Common interfaces

HEP trend => imaging calorimetry
- ❑ High number of channels
- ❑ Charge and precise timing (<100 ps)
- ❑ Low power + System-On-Chip

Based on H2GCROC, CALOROC will provide a versatile and low-power solution for SiPM readout

WP4 – Electronics and DAQ

CALOROC is a 36 chip to read out SiPMs for EIC calorimetry

– Streaming readout

– will pave the way for DRD6

• 2 variants

– CALOROC1A : conservative « à la H2GCROC » (SiPM)

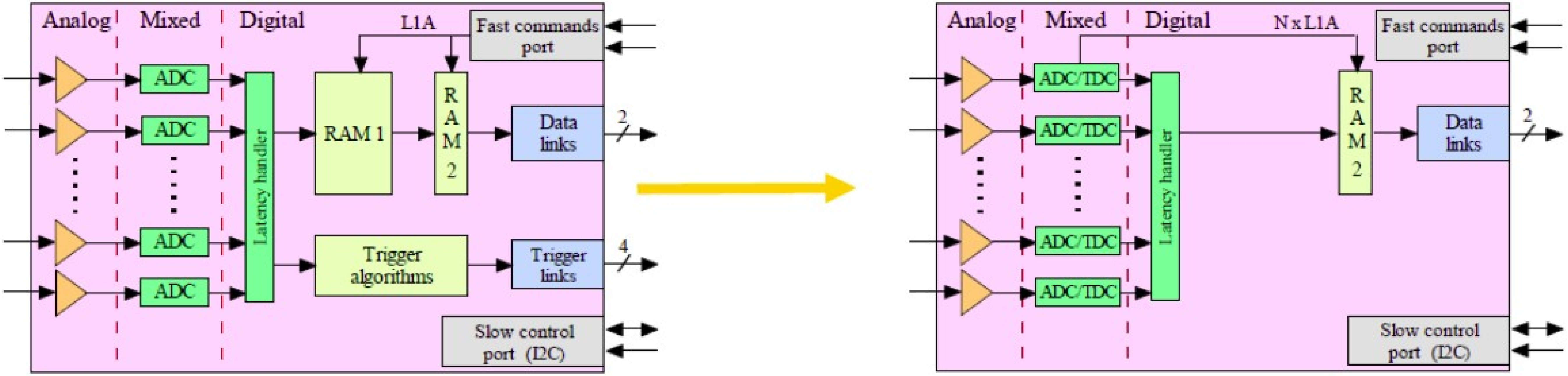
– CALOROC1B : innovative « à la SPIROC » with auto-gain

• Study of a possible variant « à la HGCROC » for Si and LAr

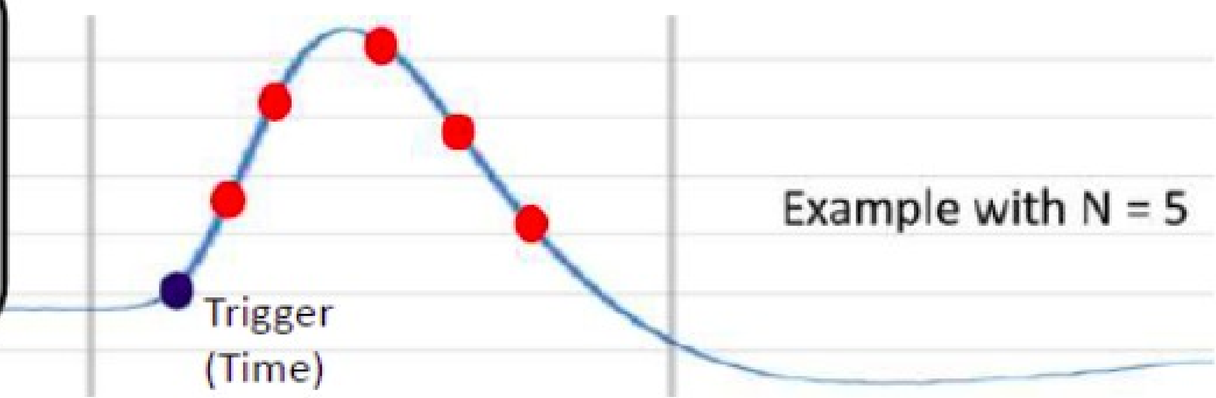
• R&D proposal by ADRIANO3 collaboration to develop R/O with CALOROC and FPGA concentrator (to be followed up)

WP4 – From pp -> eA, pp

- No more LVL1 : data streaming => auto-trigger and zero-suppress
  - very interesting for future DRD6 readout ASICs !



- Each event passing the threshold is readout
- Auto-trigger with N "samples" (1 to 7)
- Can be exercised with present HGCROC (multiple L1A-triggers)



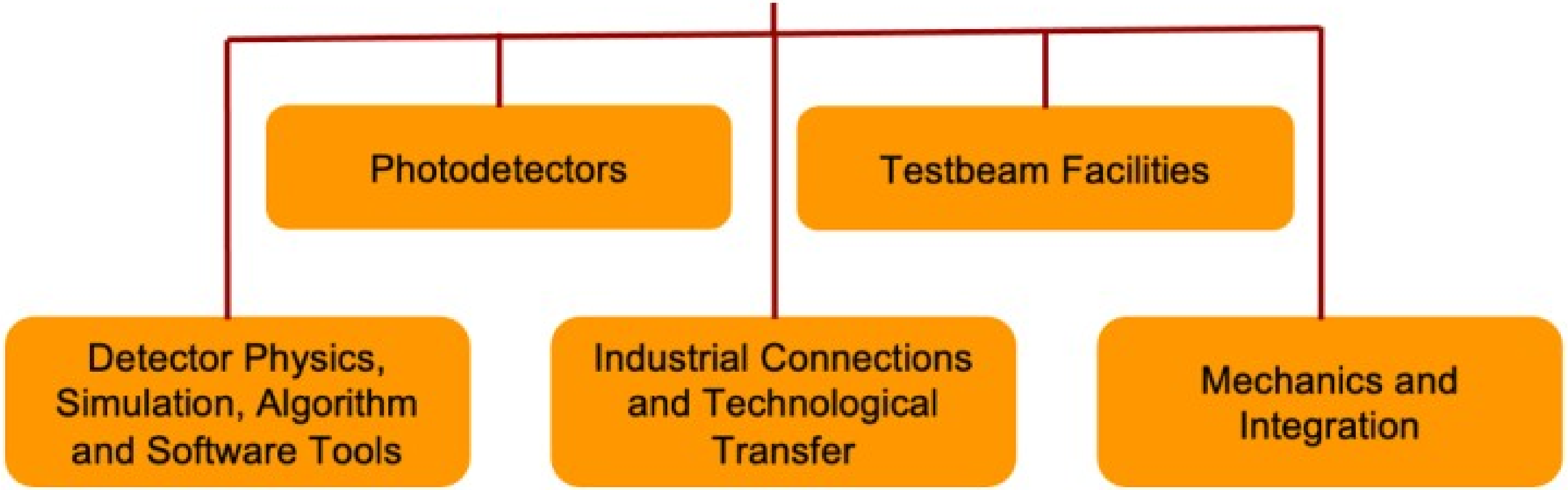
DRD6 WP4 30 oct 2024 EIC 2023 5 3

Working Groups

Our (DRD6) definition:

transversal activities needed by all the sub-tasks in the DRD6 collaboration

- Avoid duplications (=> Save time and money)
- Share experience (=> Progress faster and better)
- Built the collaboration (=> connect people from different groups, projects, institutes)
- WGs are established progressively



WG1 – Detector Physics, Simulation, Algorithms and SW Tools *DRD Calo*

Complete overview of the Software ecosystem by Brieuc Francois at April Collaboration Meeting

https://indico.cern.ch/event/1368231/contributions/5885955/attachments/2831323/4954790/20240411_SW_ecosystem_Brieuc_Francois_DRD6.pdf

Good starting point for the WG building up

Summary

- DRD6 has important software needs
- Using a common software ecosystem will allow us to leverage synergies
  - Across DRD's, across DRD6 WP's and across WP phases
- Data persistency must be a central consideration (valuable datasets will be produced)
- Key4hep is a very good candidate to be the common software base for (most) DRD6 activities
  - Wide (and growing) adoption by the Future Collider Community (but built with LHC experience)
  - Already meets most DRD6 needs (except for online software, likely not integrated in Key4hep, but for which we should still have common standards)
  - Under active development: can be adapted/complemented if needed
- The Key4hep team warmly welcomes new contributors
  - Good opportunity for the DRD6 Transversal Software Working Group!
- Next important step: agree on the set of software tools that we want to set as standards

Thanks to the Key4hep team for the useful feedback and discussions!

SW ecosystem for DRD6 Brieuc François 24

WG2 – Testbeam Facilities

- Test beam dedicated area
  - Resource optimisation
  - Both HW and SW setting up
- Starting from CERN NA
  - Discussion starting with SPS coordinator
  - extend to other facilities?
- Test beam request organization
  - coordinating requests among different projects and different facilities
  - => find needed time for anyone
  - exploit synergies
  - combined ECAL+HCAL performance

Testbeam requests 2025 organised via Technical Board

7 requests connected to DRD6 @ CERN

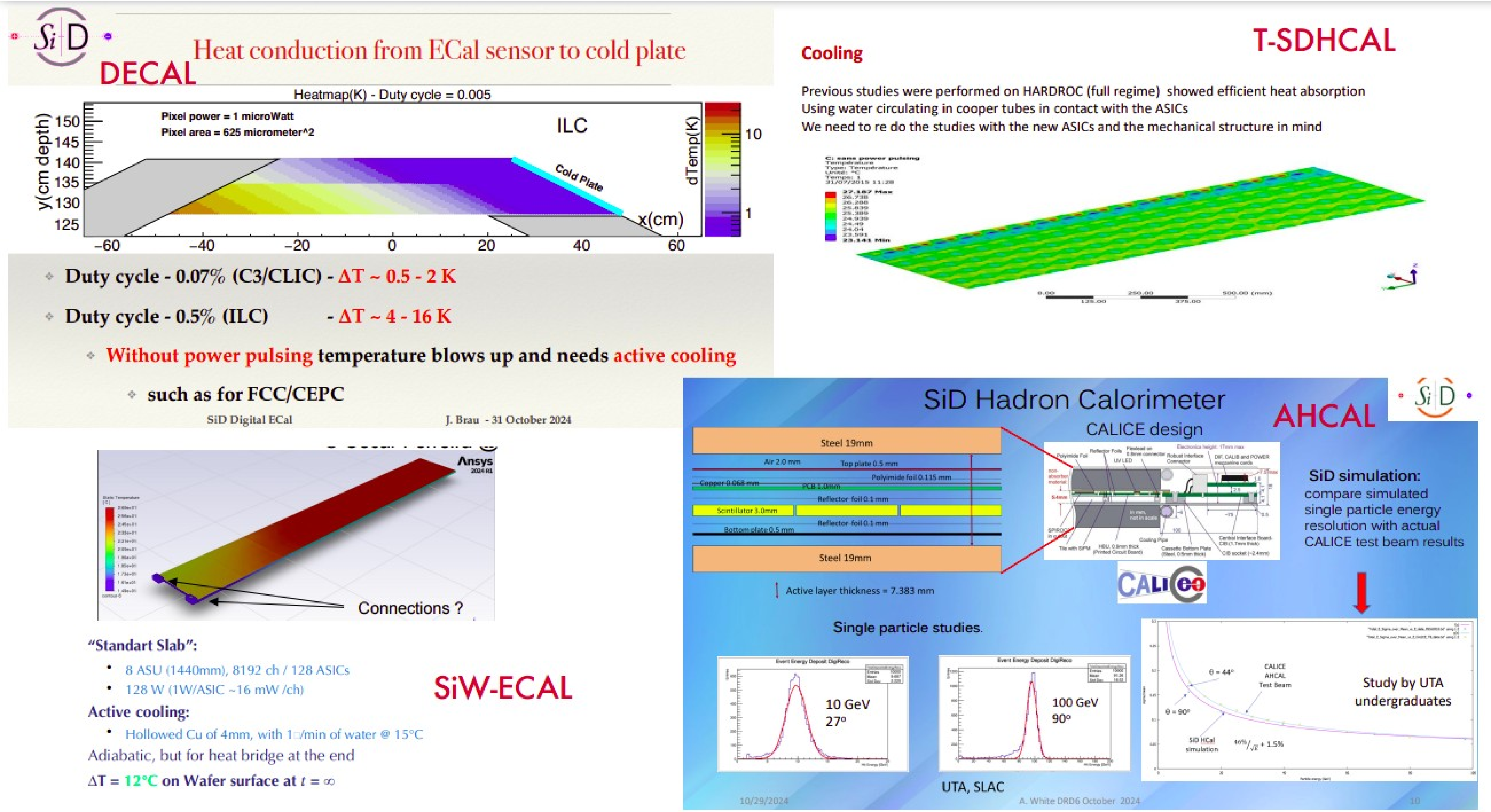
WP/task	Task	Beam	Location	Duration (d)
1.3.2	MPGDCAL	pion	PS	14
3.1.1	HGCCAL	e, pion, muon	PS - SPS (H2/H4)	14 + 7
3.1.2	MAXICC	high purity e	SPS (H6)	14
3.1.3	CRILIN	high purity e	SPS (H2/H4)	7 + 7
3.1.4	OREO	high purity e, mixed particles	SPS (H2/H4)	14
3.2.3	RADICAL	high purity e	SPS (H6)	7
3.3.1	DRCal	e, pion, muon	SPS (H8)	7+7+14

DESY beam request open until Nov. 9th

Other facility “census”

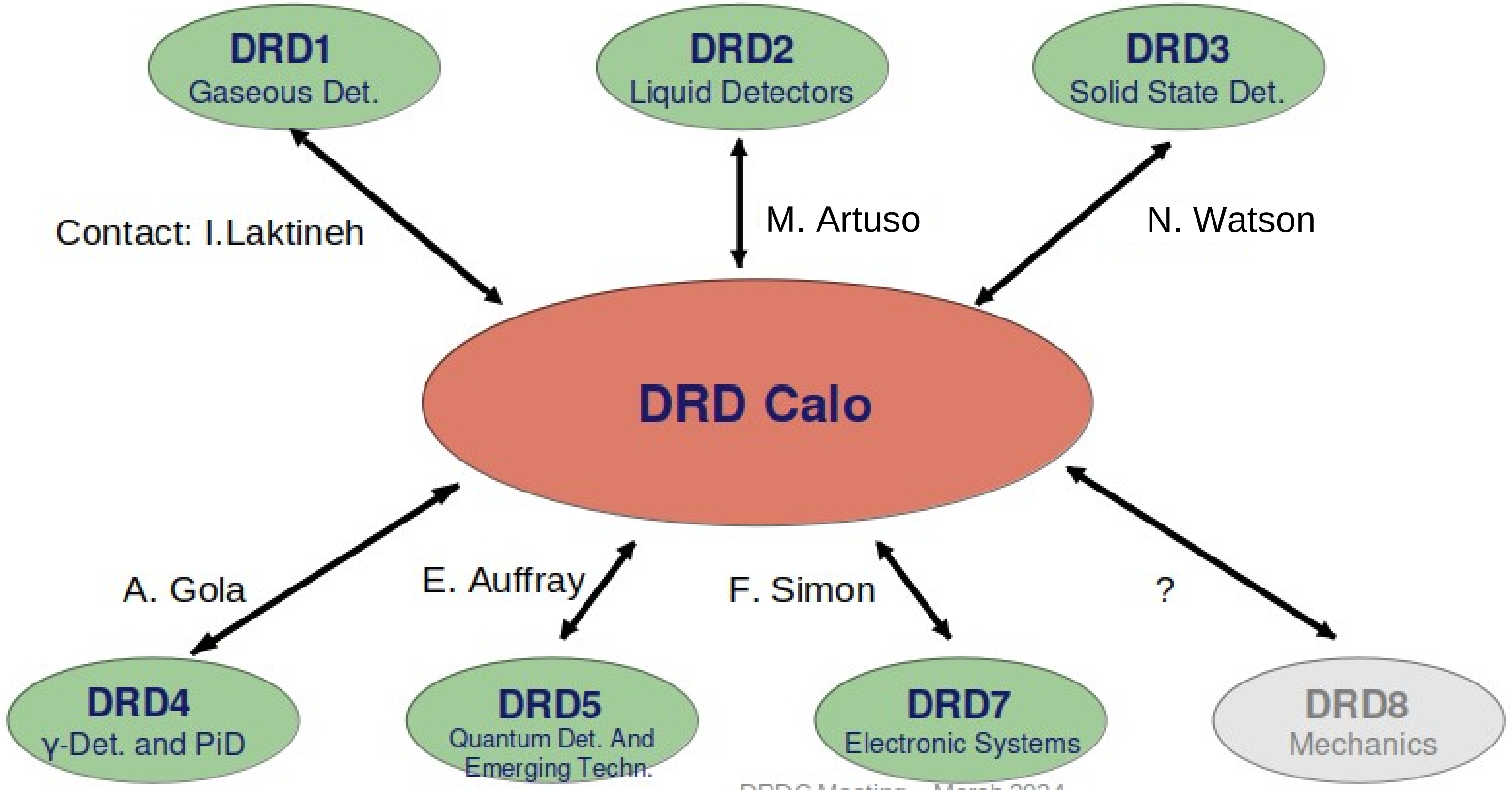
WG5 – Mechanics (?)

DRD Calo

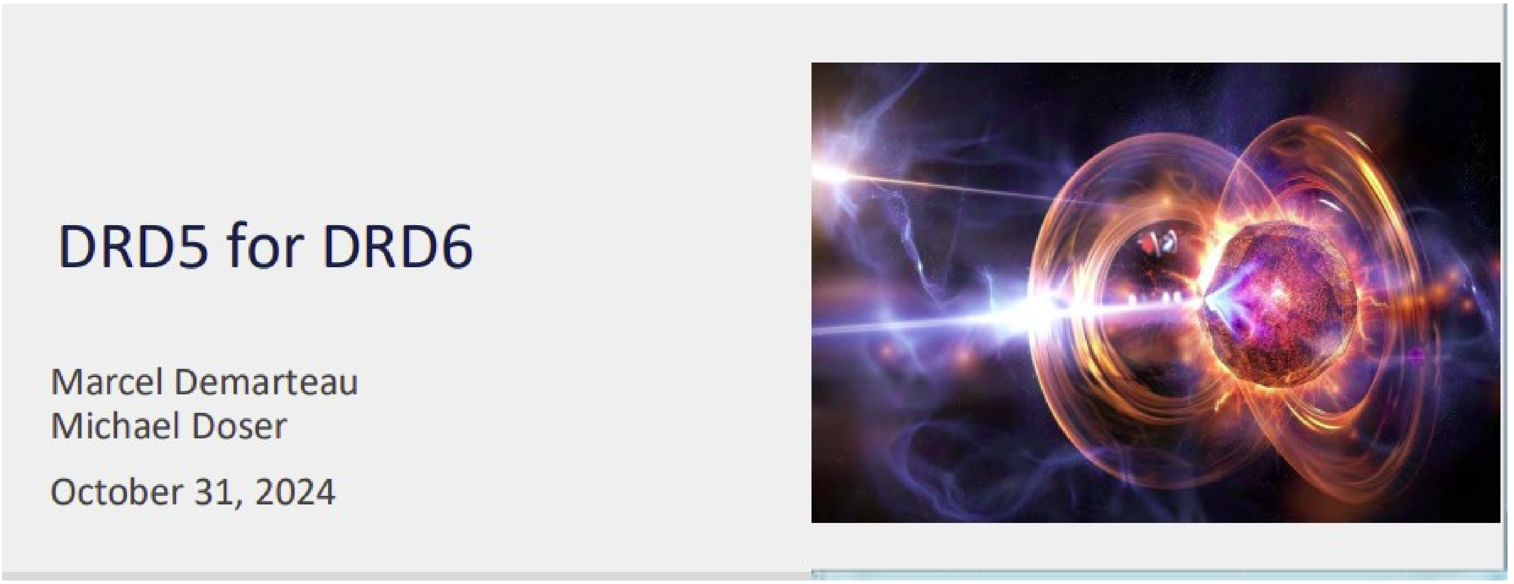


- Cooling seems to be a common topic for many projects (here WP1 but also relevant for WP3)
- Could be used to kick-off WG5

Link Persons to other DRD



DRD5 talk at DRD6 Meeting



Plan to have regular guest talks at our Collaboration Meetings

Conclusions

- DRD-on-Calorimetry will pursue strategic R&D for calorimeters for future colliders
  - Partially new efforts, partially capitalising on existing activities

- Collaboration structure is being put in place
  - Chairs of Boards in place
    - ... except Resource Board (discussion ongoing)
  - Work has started (e.g. 1st Technical Board Meeting, Draft on Publication Policy, ...)
  - Governance Rules voted

- Scientific Programme has started
  - All four work packages fully active
  - First deliverables either completed or in sight
  - Working Groups are about being formed

- The main goal of the next months is everyone will quickly feel the added value of being member of the DRD

Backup

DRD-on-Calorimetry – Communication

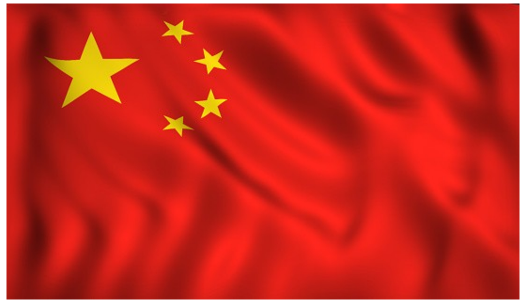
- In general we will use CERN e-groups as main communication channel

- Tree structure for general DRD Calo e-group
  - This means that **each institute** creates and maintains its own e-group
  - drdcalo-cern, drdcalo-pavia, drdcalo-ijclab, drdcalo-desy, ...
  - Only these e-groups will be included into the general e-group drdcalo-general@cern.ch
    - drdcalo-general exists since 22/2/24
    - Remark: It will take some time until all institutes have created their e-group
      - Until this happens the corresponding group leader will be explicitly part of drdcalo-general@cern.ch and will be responsible for propagating relevant information to his/her group
      - As soon as the e-group is created the group leader will be removed from the general e-group
      - As of today 43 institute e-groups exist, further reminders will be sent regularly to the Collaboration Board

- We need a web page ...

- We need a logo (and another name?)

The bigger picture



- DRD implements and/or connects to strategies in Europe, US and Asian Countries
- Interlink with US programme see next pages

DRD Calo - Proposal Team

Coordinators: Roberto Ferrari, Gabriella Gaudio (INFN-Pavia), R.P. (IJCLab)

Representative from ECFA Detector R&D Roadmap Coordination Team: Felix Sefkow (DESY)

Deputy spokesperson: Mary Cruz Fouz (mcruz.fouz@ciemat.es)

WP 1: Sandwich calorimeters with fully embedded Electronics – Main and forward calorimeters
Conveners: Adrian Irles (IFIC, adrian.irles@ific.uv.es), Frank Simon (KIT, frank.simon@kit.edu), Jim Brau (University of Oregon, jimbrau@uoregon.edu), Wataru Ootani (University of Tokyo, wataru@icepp.s.u-tokyo.ac.jp), Imad Laktineh (I2PI, imad.laktineh@in2p3.fr), Lucia Masetti (masetti@physik.uni-mainz.de)

WP 2: Liquified Noble Gas Calorimeters
Conveners: Martin Aleksa (CERN, martin.aleksa@cern.ch), Nicolas Morange (IJCLab, nicolas.morange@ijclab.in2p3.fr), Marc-Andre Pleier (mpleier@bnl.gov)

WP 3: Optical calorimeters: Scintillating based sampling and homogenous calorimeters
Conveners: Etiennette Auffray (CERN, etiennette.auffray@cern.ch), Macro Lucchini (University and INFN Milano-Bicocca, marco.toliman.lucchini@cern.ch), Philipp Roloff (CERN, philipp.roloff@cern.ch), Sarah Eno (University of Maryland, eno@umd.edu), Hwidong Yoo (Yonsei University, hdyoo@cern.ch), Michaela Mlynarikova (michaela.mlynarikove@cern.ch)

WP 4: Electronics and DAQ
Christophe de la Taille (OMEGA, taille@in2p3.fr)

Transversal Activitiies

DRD Calo - Proposal Team

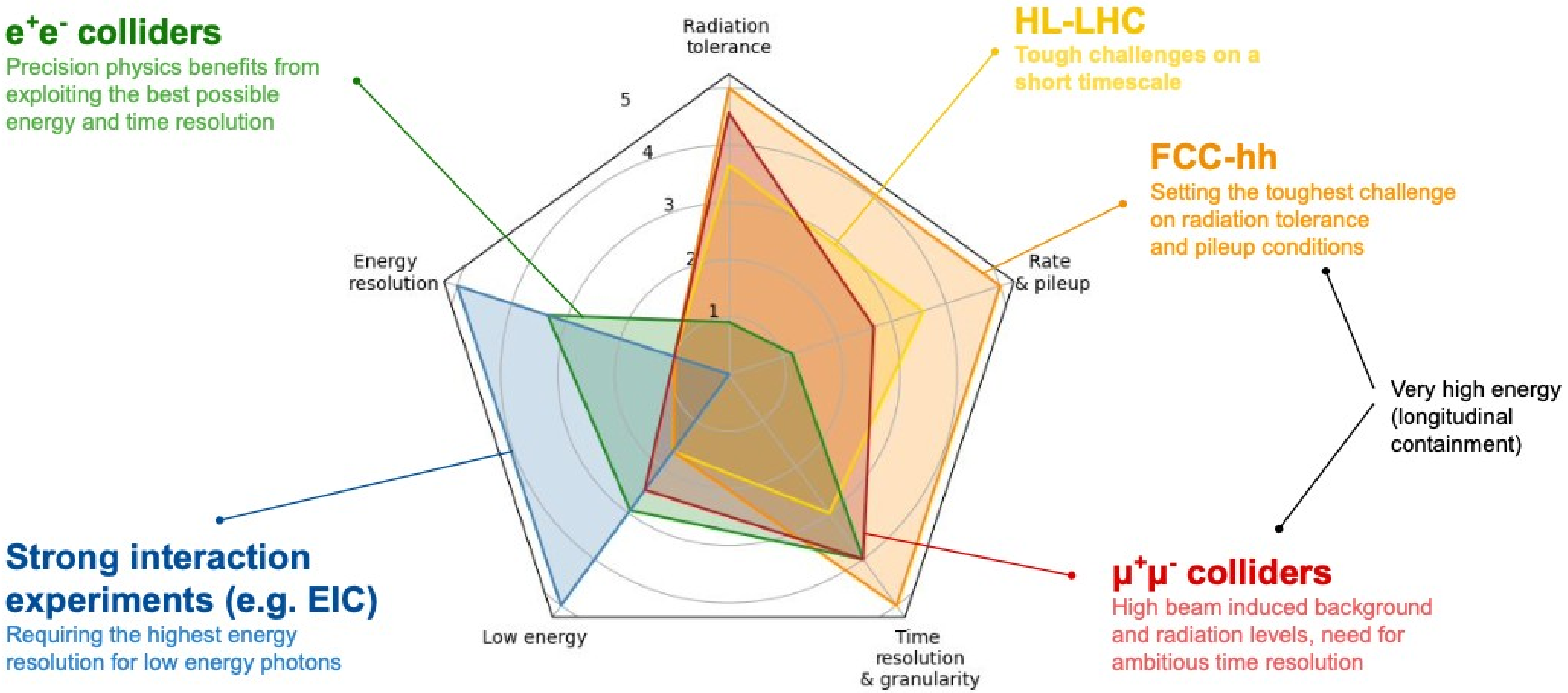
- With the management in place and the vote of the Governance Rules the mandate of the Proposal Teams will end
  - All of them will remain active to the benefit of the collaboration and are our wise people

- It played a pivotal role in setting up the Collaboration
  - We had 41 Meetings since February 2023

- It was my personal pleasure to work with so many distiguished colleagues to put the Collaboration on the rails
  - The endeavour actually started with the Roadmap Document

- Thank you very much

Requirements for calorimetry at future colliders

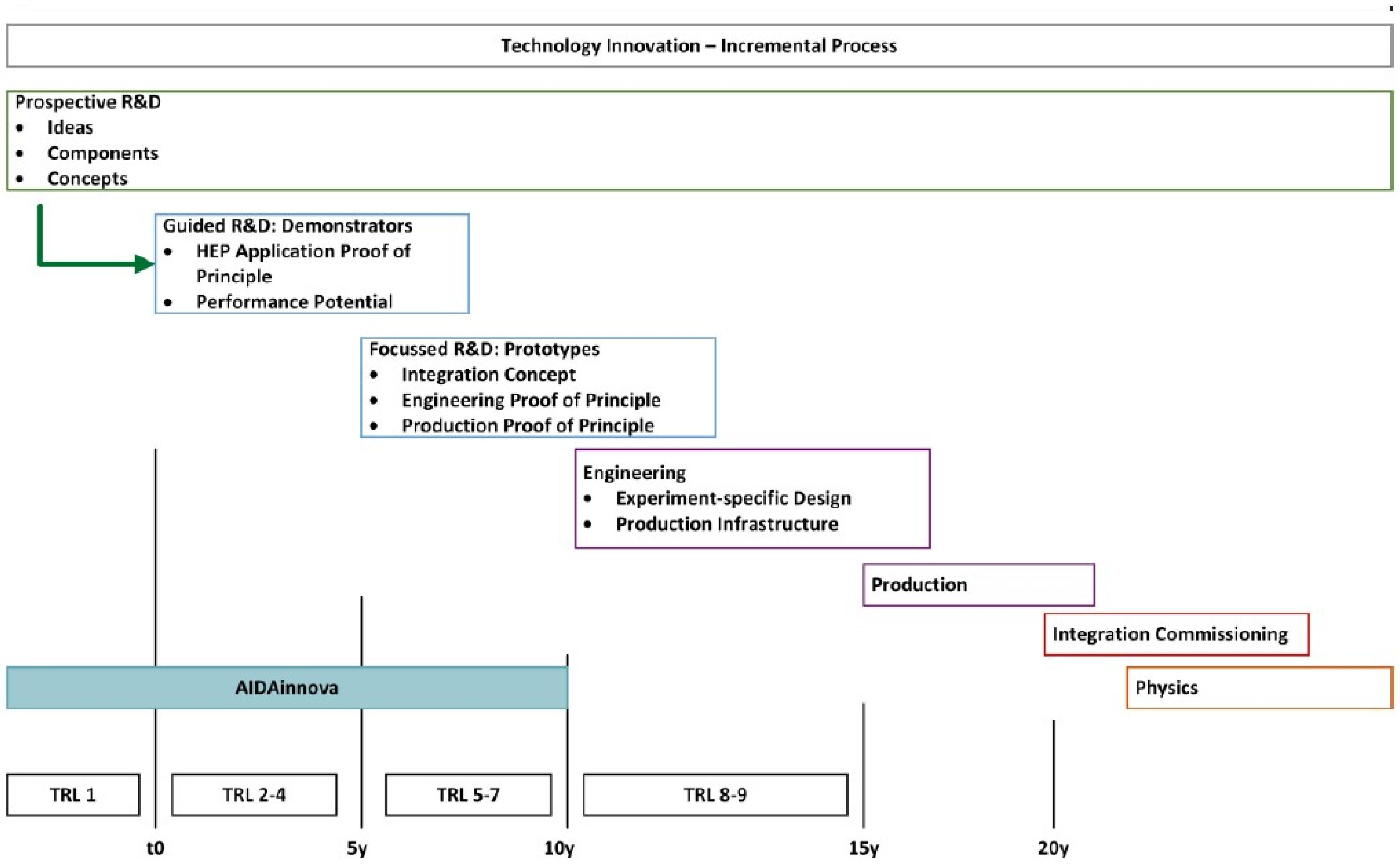


Inspired from https://indico.cern.ch/event/994685/

Categories of R&D

1. Strategic R&D via DRD Collaborations **vision**
   (long-term strategic R&D lines)
   (address the high-priority items defined in the Roadmap via the DRDTs)
2. Experiment-specific R&D **focus**
   (with very well defined detector specifications)
   (funded outside of DRD programme, via experiments, usually not yet covered within the projected budgets for the final deliverables)
3. "Blue-sky" R&D **agility**
   (competitive, short-term responsive grants, nationally organised)

Transitions Blue-sky → Strategic → Specific expected
Cross-fertilisation desired



F. Sefkow, CALICE Meeting and ECFA Higgs/top/EW Factory Meeting

The roadmap document(s)

- ECFA R&D Roadmap
  - CERN-ESU-017 https://cds.cern.ch/record/2784893
  - 248 pages full text and 8 page synopsis

- Endorsed by ECFA and presented to CERN Council in December 2021

The Roadmap has identified

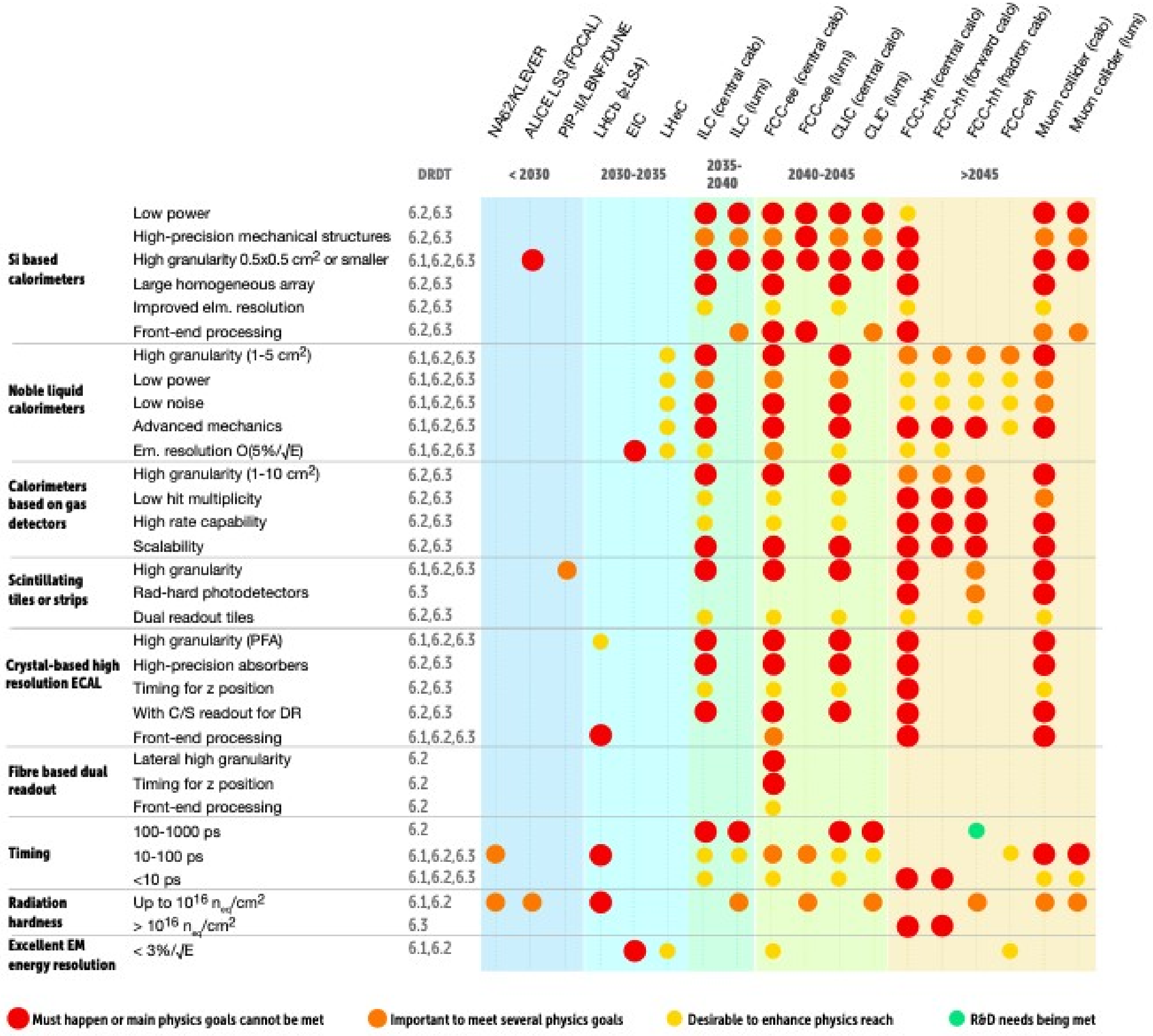
- General Strategic Recommendations (GSR)
- Detector R&D Themes (DRDT)
- Concrete R&D Tasks

- Timescale of projects as approved by European Lab Director Group (LDG)

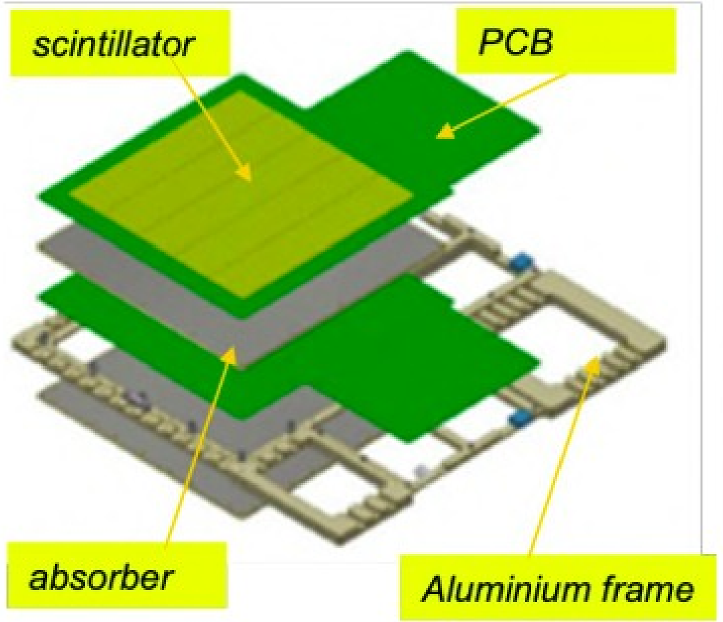
Guiding principle: Project realisation must not be delayed by detectors

Calorimetry- Identified Key Technologies and R&D Tasks

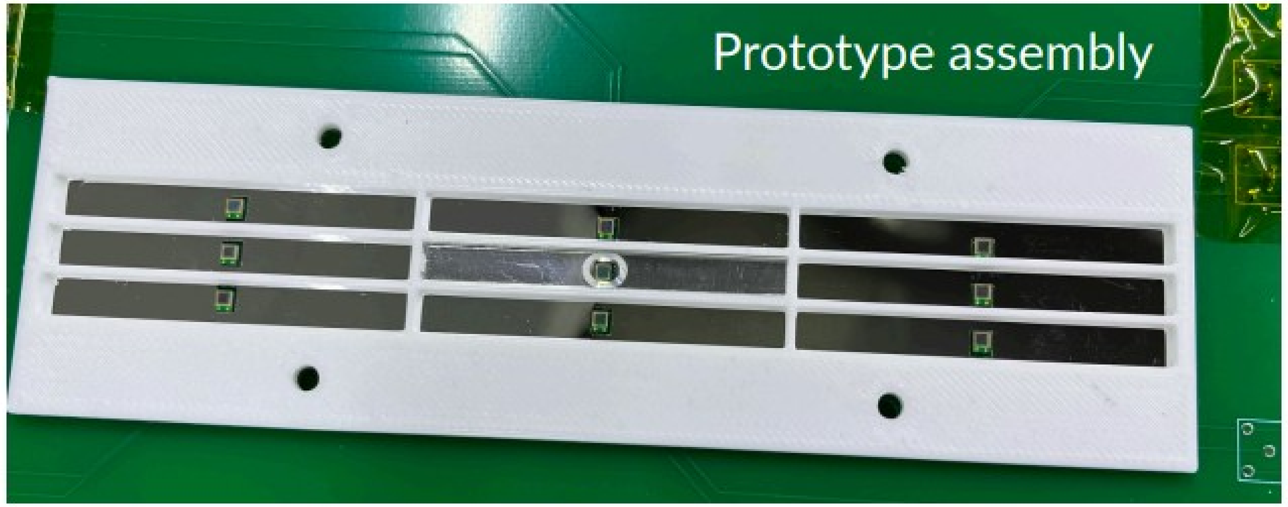
- Key technologies and requirements are identified in ECFA Roadmap
  - Si based Calorimeters
  - Noble Liquid Calorimeters
  - Calorimeters based on gas detectors
  - Scintillating tiles and strips
  - Crystal based high-resolution Ecals
  - Fibre based dual readout
- R&D should in particular enable
  - Precision timing
  - Radiation hardness
- R&D Tasks are grouped into
  - Must happen
  - Important
  - Desirable
  - Already met

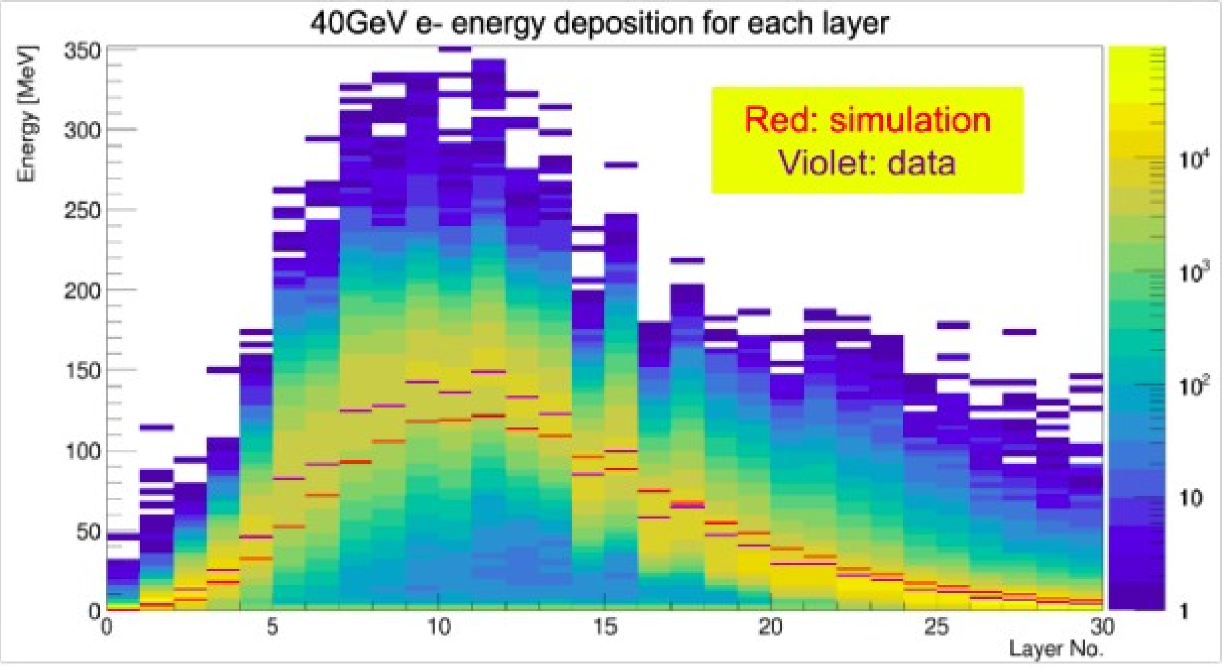


WP1 – Subtask 1.1.4 – ScECAL

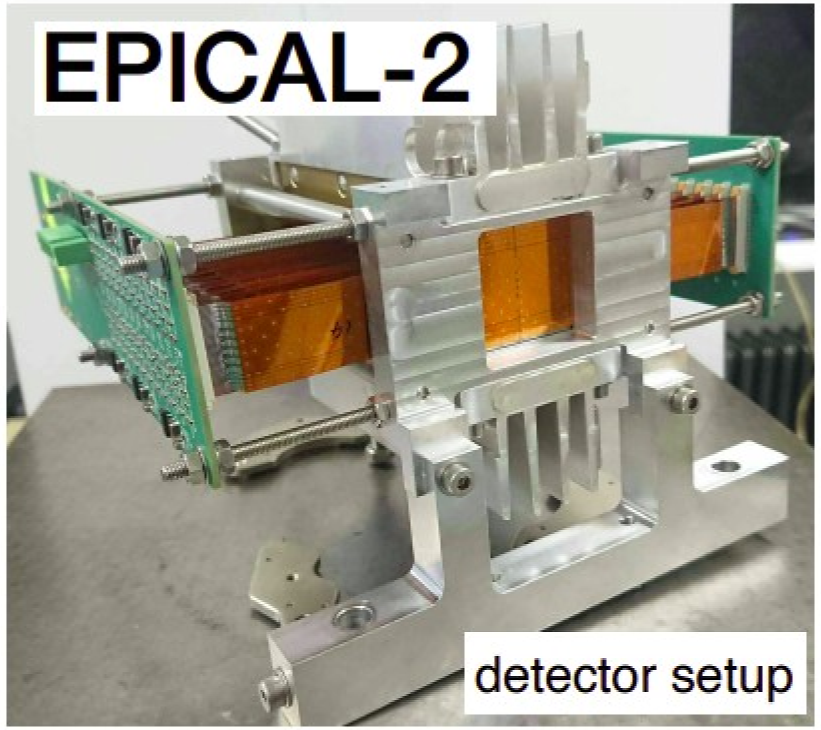


- ScW-ECAL **technological prototype**
  - Full layers (32 layers)
    - Detection layer of 210×225mm² with 210 scintillator-strips
      - 30 layers with single SiPM readout
      - 2 layers with double SiPM readout
    - Absorber plate (3.2mm-thick 15%-85% Cu-W alloy)
    - Total material thickness $23.4\, X_0$
- Beam test campaign at CERN in 2022/2023 (combined test with CEPC-AHCAL)

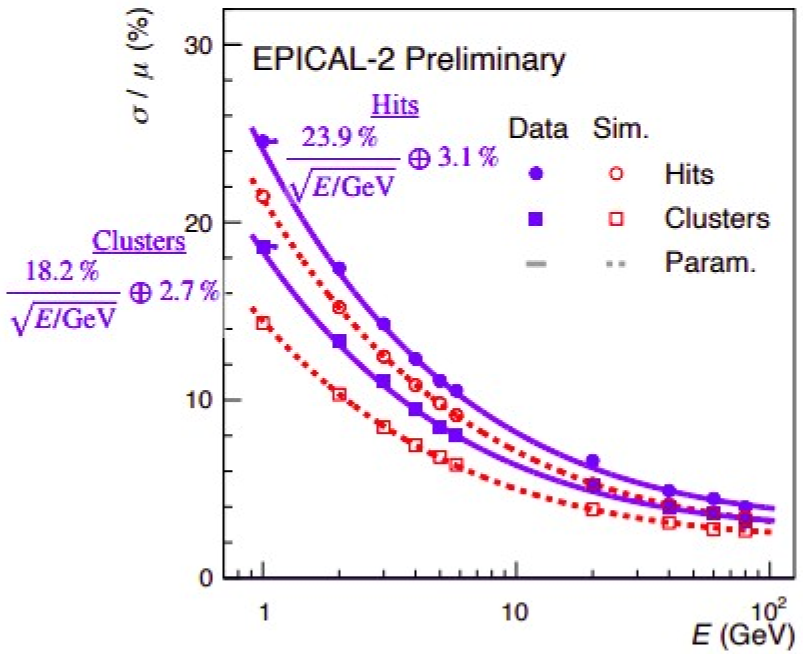


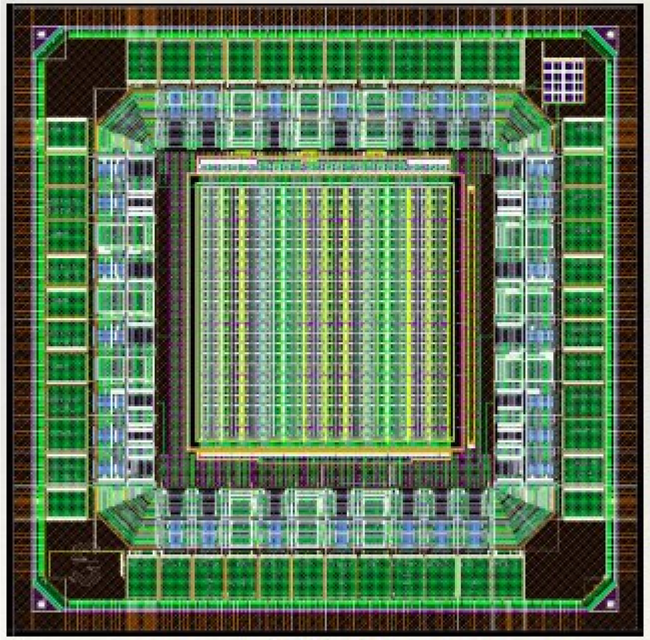


WP1 – Subtask 1.1.3 – DECAL

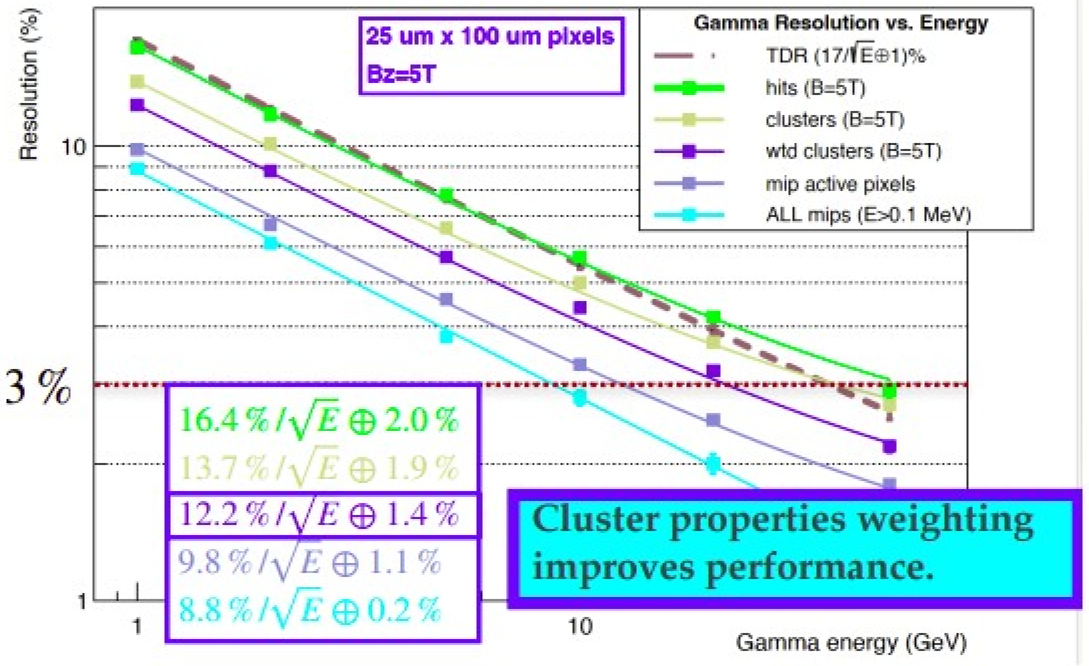


- Major challenges
  - Development of dedicated sensor
    - Local dynamic range: optimise granularity and bit depth
    - Power consumption, rate capabilities, data reduction, radiation, trigger capability(?), timing(?)
  - Integration: preserve compactness for small R_M
    - Cooling, cabling, etc.

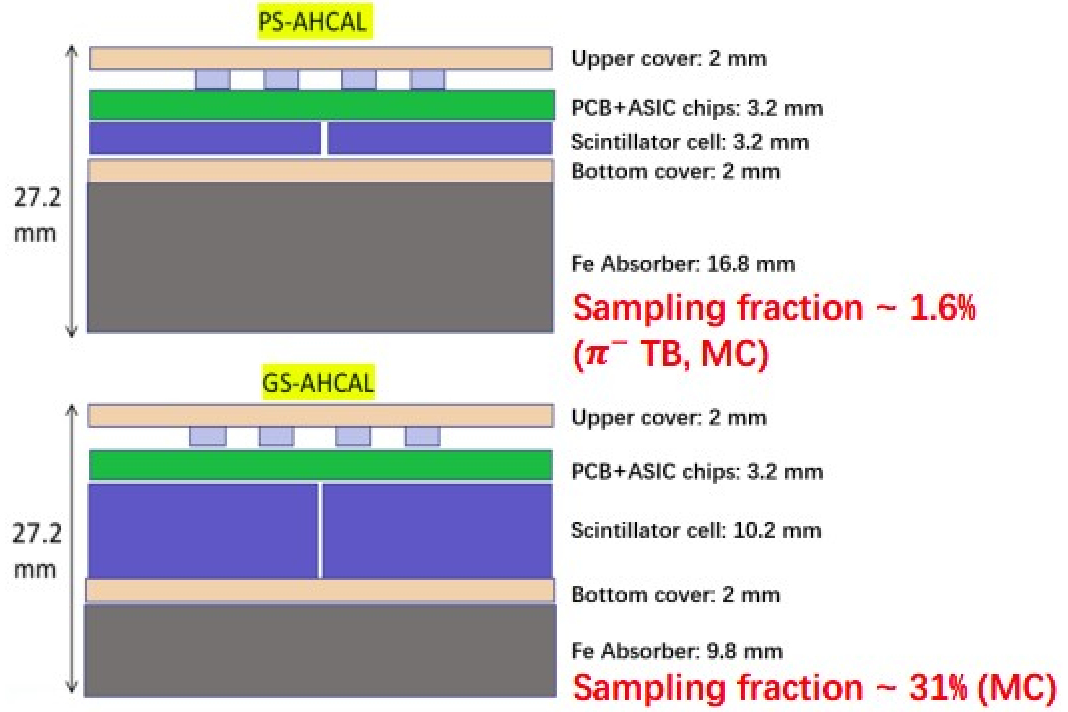




Layout of SLAC prototype for WP1.2 2022 shared submission on TowerSemi 65nm



WP1 – Subtask 1.2.2 – ScintGlassHCAL

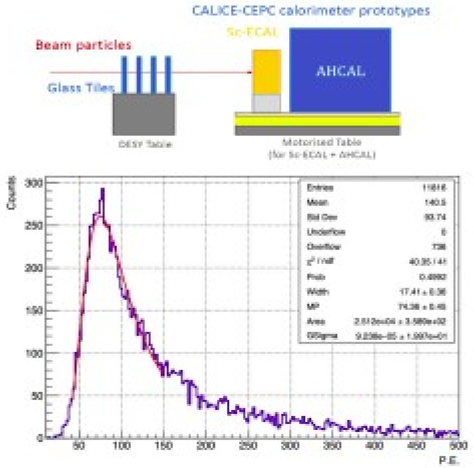


Glass scintillator R&D: Light yield

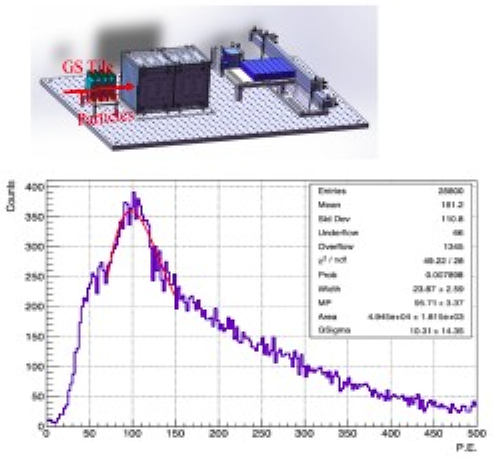
CERN Muon-beam (10 GeV muon)
11 glass tiles tested at CERN (2023/5)

DESY Electron-beam (5 GeV electron)
9 glass tiles tested at DESY (2023/10)

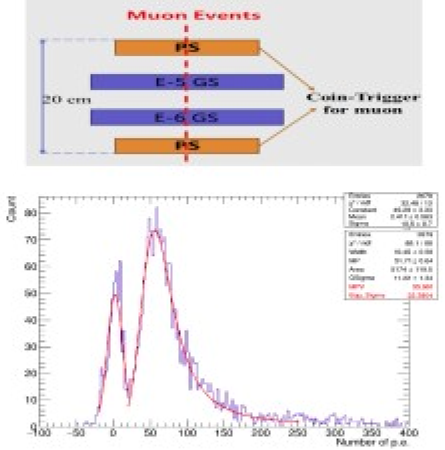
IHEP Cosmic Muon (3 GeV muon)
4 glass tiles tested at IHEP (2024/4)



- Typical Light Yield: 500 – 600 ph/MeV
- Typical MIP response: 60 – 70 p.e./MIP



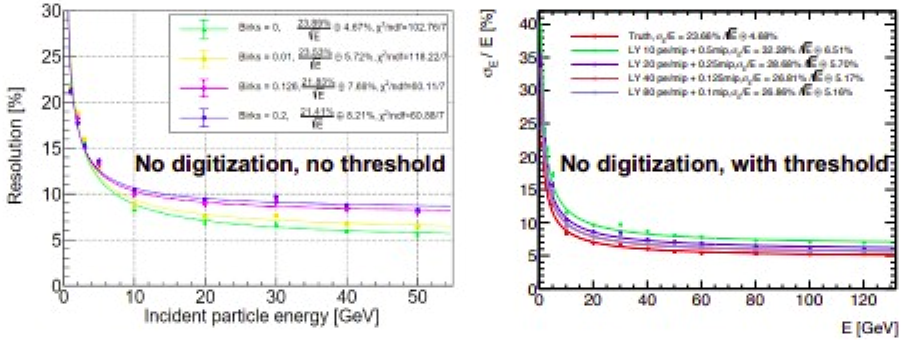
- Typical Light Yield: 600 – 700 ph/MeV
- Typical MIP response: 70 – 80 p.e./MIP



- Typical Light Yield: 500 – 700 ph/MeV
- Typical MIP response: 60 – 80 p.e./MIP

GS-HCAL performance simulation

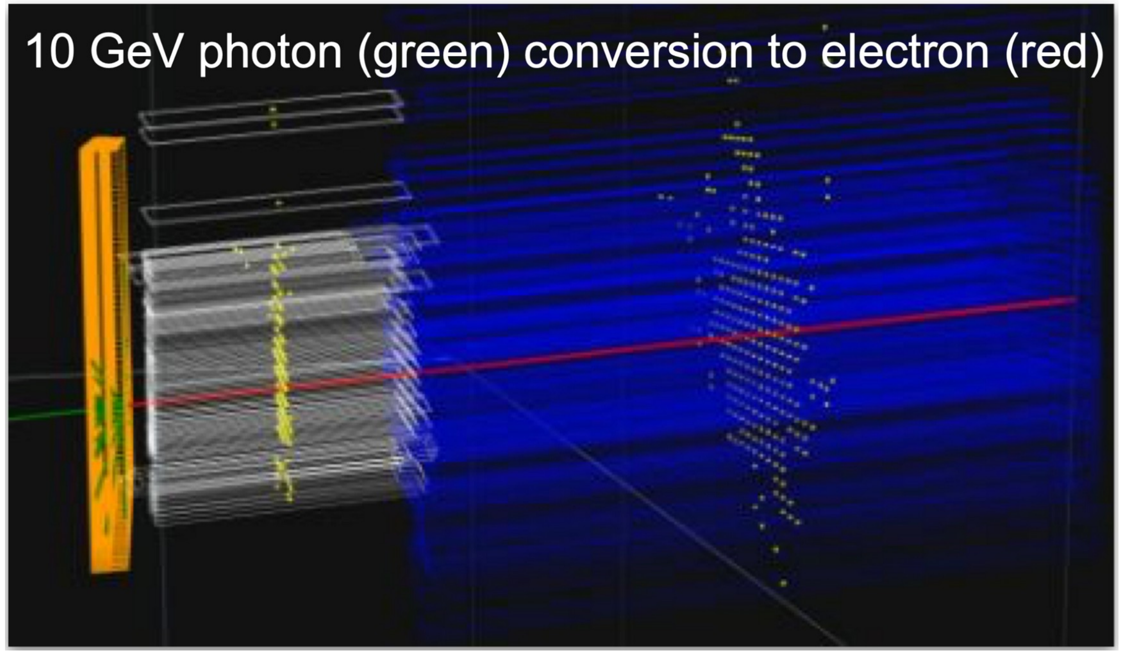
- Key parameters to energy resolution are studied: light yield, threshold, Birks constant, attenuation length.

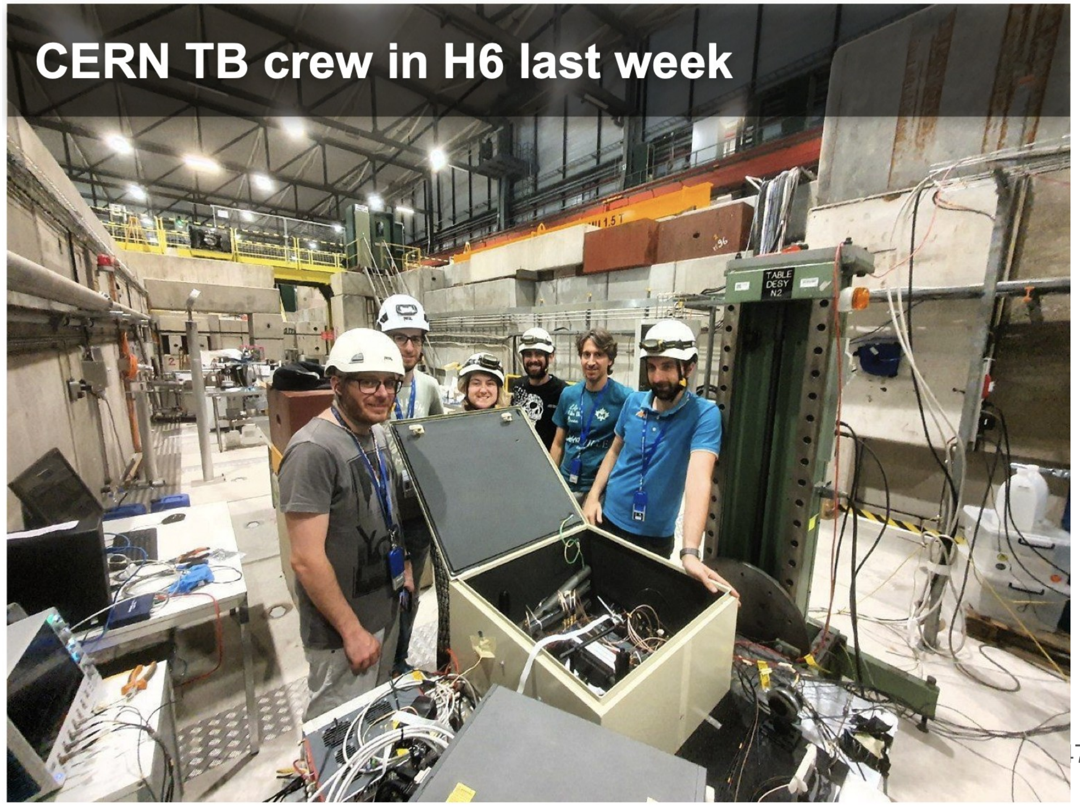


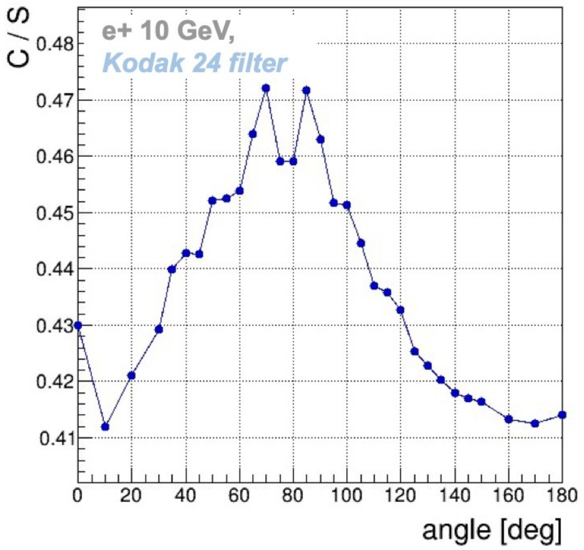
- **Plan in next years: follow DRD6 and CEPC Ref-Det TDR timeline.**
  - 2024 - 2025: detector design and optimization, $4\times4\times1\ cm^3$ tile R&D, SiPM and electronics performance test
  - 2026 - 2027: prototype construction and test.

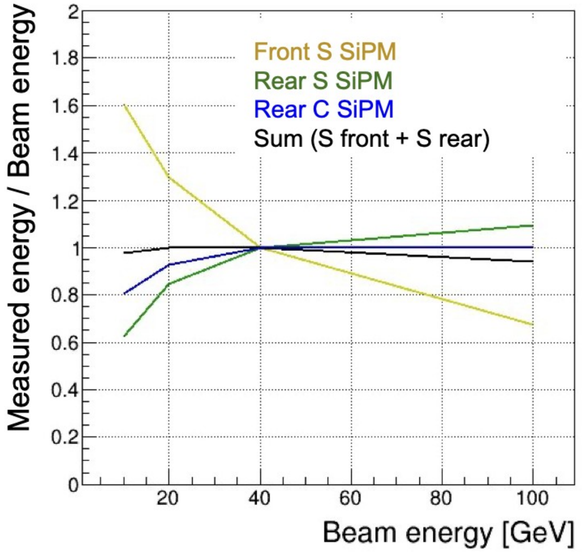
WP3 – Subtask 3.1.2 – MAXICC

- Homogeneous EM calorimeter based on segmented crystals with dual-readout
  - High density scintillating crystals with good cherenkov yield, use
  - Promise 3%/√E + DR capability
- Some of 2024 highlights
  - Implementation in key4hep gearing up
  - **R&D to optimize dual-readout** in scintillating crystals using optical filters and SiPM **progressing well** thanks to successful beam tests in 2024







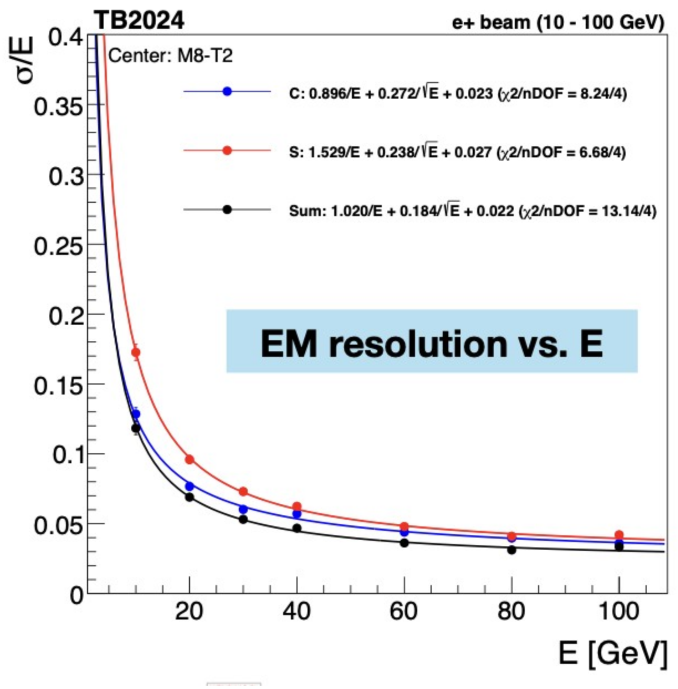


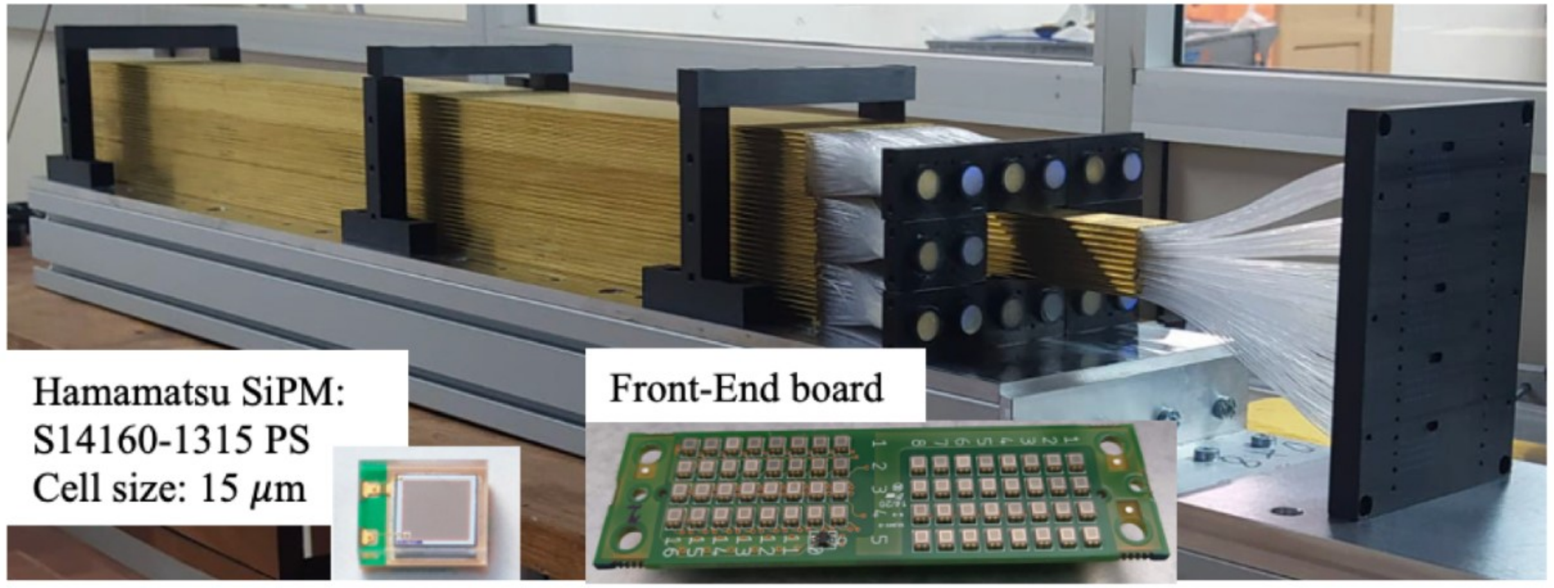
Marco Lucchini

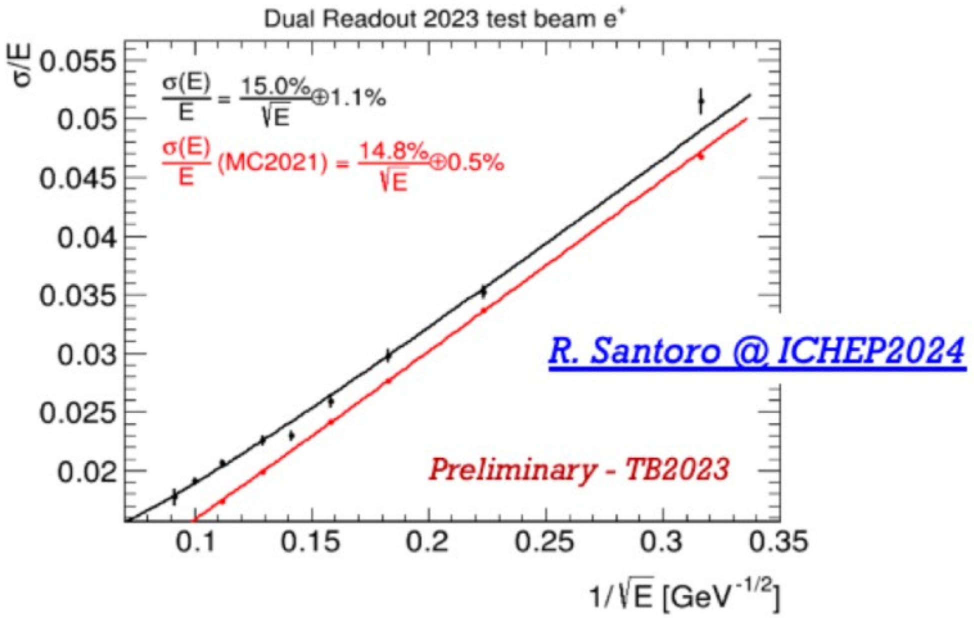
- Longitudinally unsegmented dual-readout sampling calorimeter
  - Scintillation and Cherenkov fibres inside an absorber groove
  - Reaches 30%/√E for single hadrons
- Some of 2024 highlights
  - Lots of R&D activities are ongoing as well as successful beam tests

30x30x250 cm

TB 2022 module





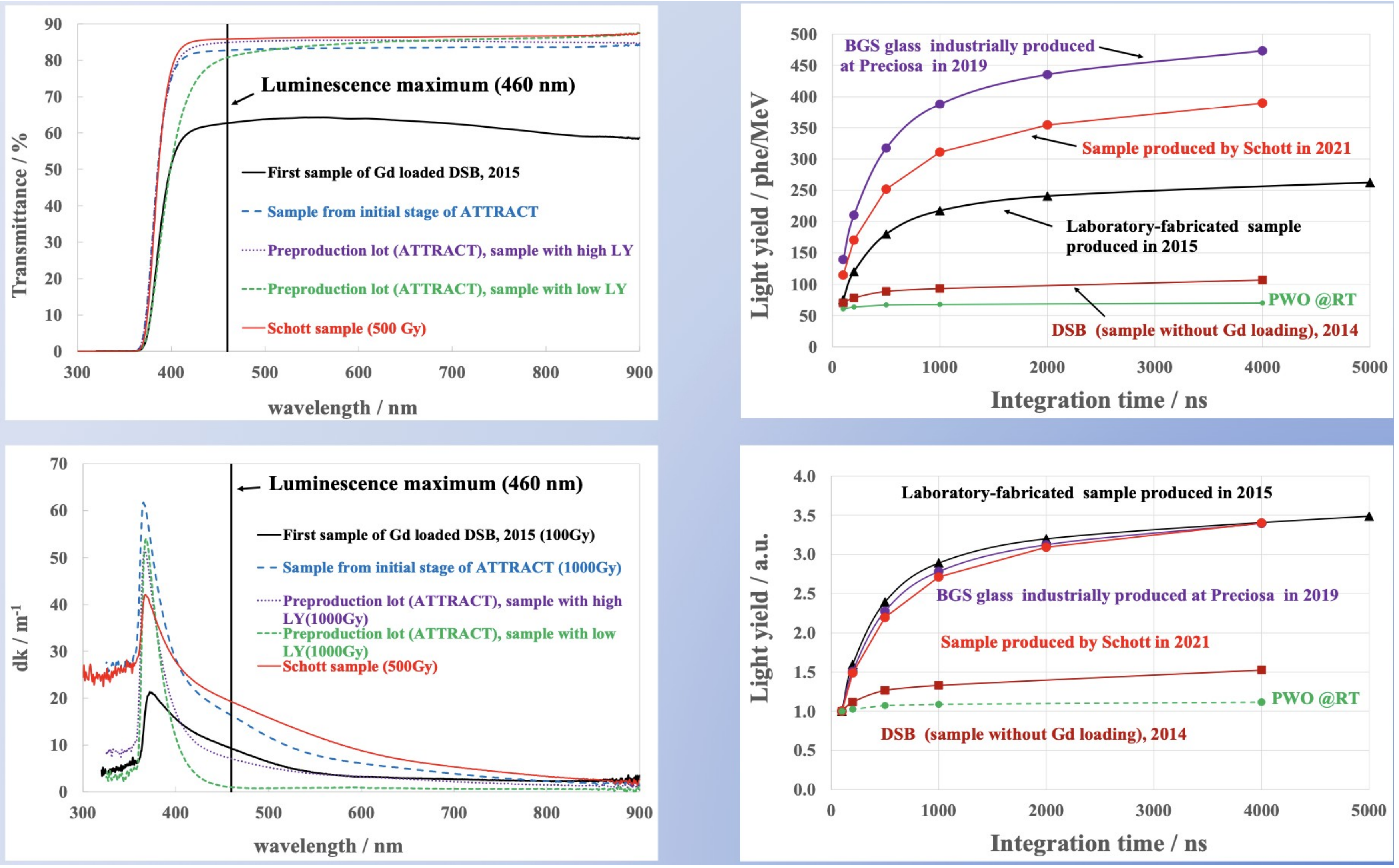


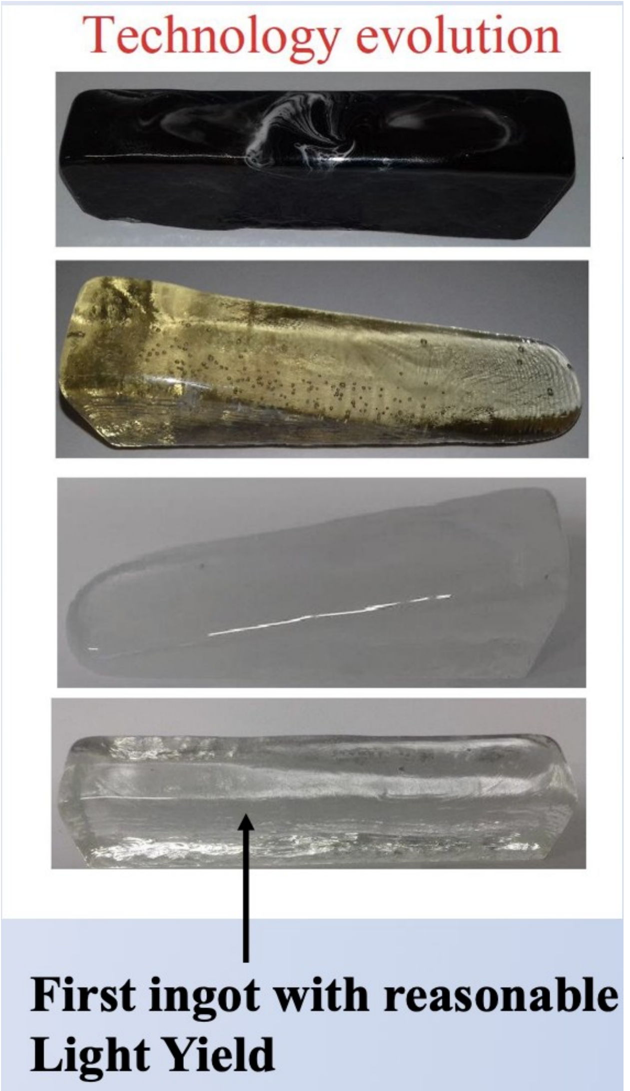
48

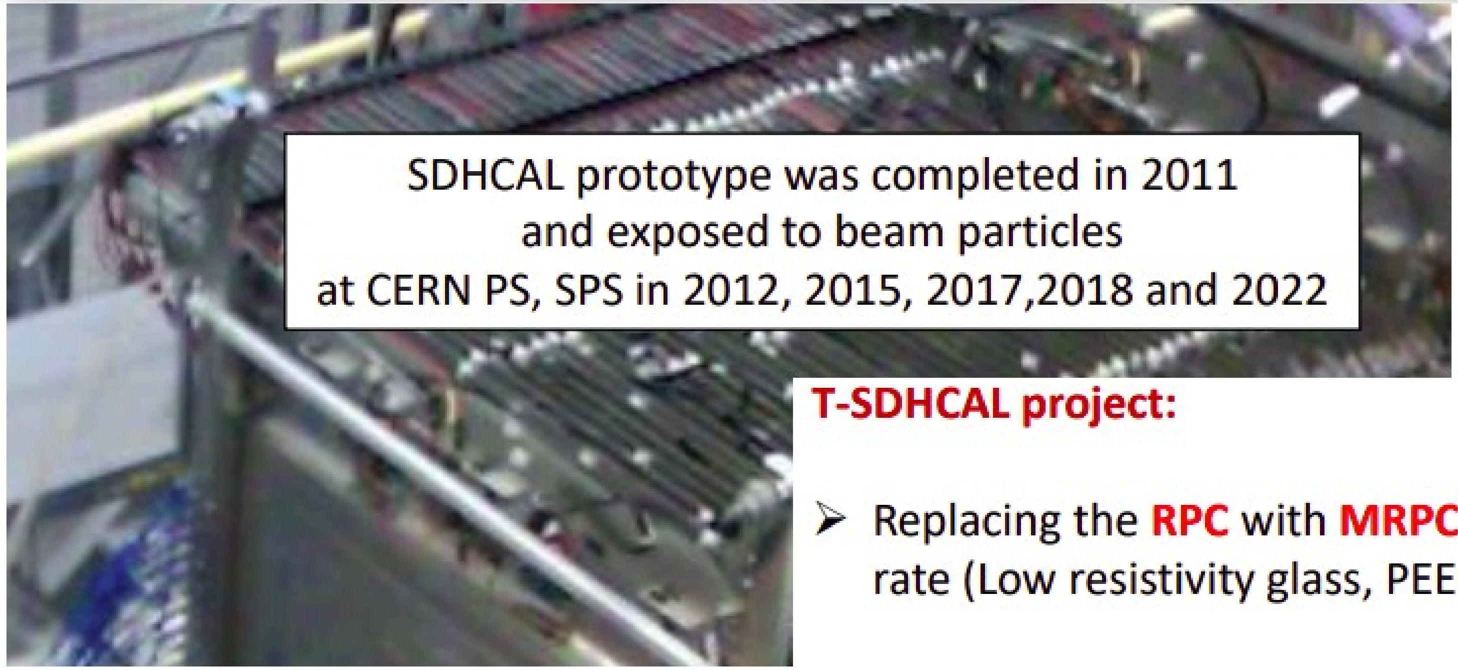
Development of cost-effective glass scintillators

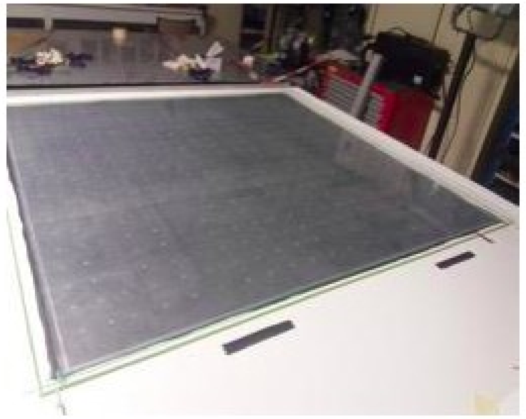
Valerii Dormenev

- Glass scintillators based on barium disilicate BaO-2SiO2
  - Low-cost material, light yield was increased thanks to optimization of the manufacturing process, but macro-defects are still a limiting factor particularly for blocks of large volume









T-SDHCAL project:

- Replacing the **RPC** with **MRPC**. Low resistive materials could be used to increase the rate (Low resistivity glass, PEEK doped with Carbon Nanoparticles)

  →We need to study how many gaps are needed to reach **100 ps** taking into account the cost on the cassette thickness.

- Replacing the **HARDROC** ASIC with a new ASIC

  →We started with **PETIROC** as a first step but we will go for **CALOROC** in the near future.

- Developing a **cooling system**.
  The cooling system should not add too much dead zone. Could we use it with the present SDHCAL mechanical with limited efforts?

  → we have done already some studies on this topic

WP1 – Subtask 1.3.3 – MPGD-HCCAL

- Cerenkov radiator: 3x3x2 cm^3 lead-glass tiles (typical size)
- Scintillator component: 3x3x 0.5 cm^3 scintillating tiles (typical size)
- Neutron component: 10x10x1 cm^3 doped RPC
- Tiles readout: on-tile sipm
- RPC readout: pads

Presentation in April

Since then: funding application submitted to DOE