

drdcalo

Status and perspectives

Roberto Ferrari

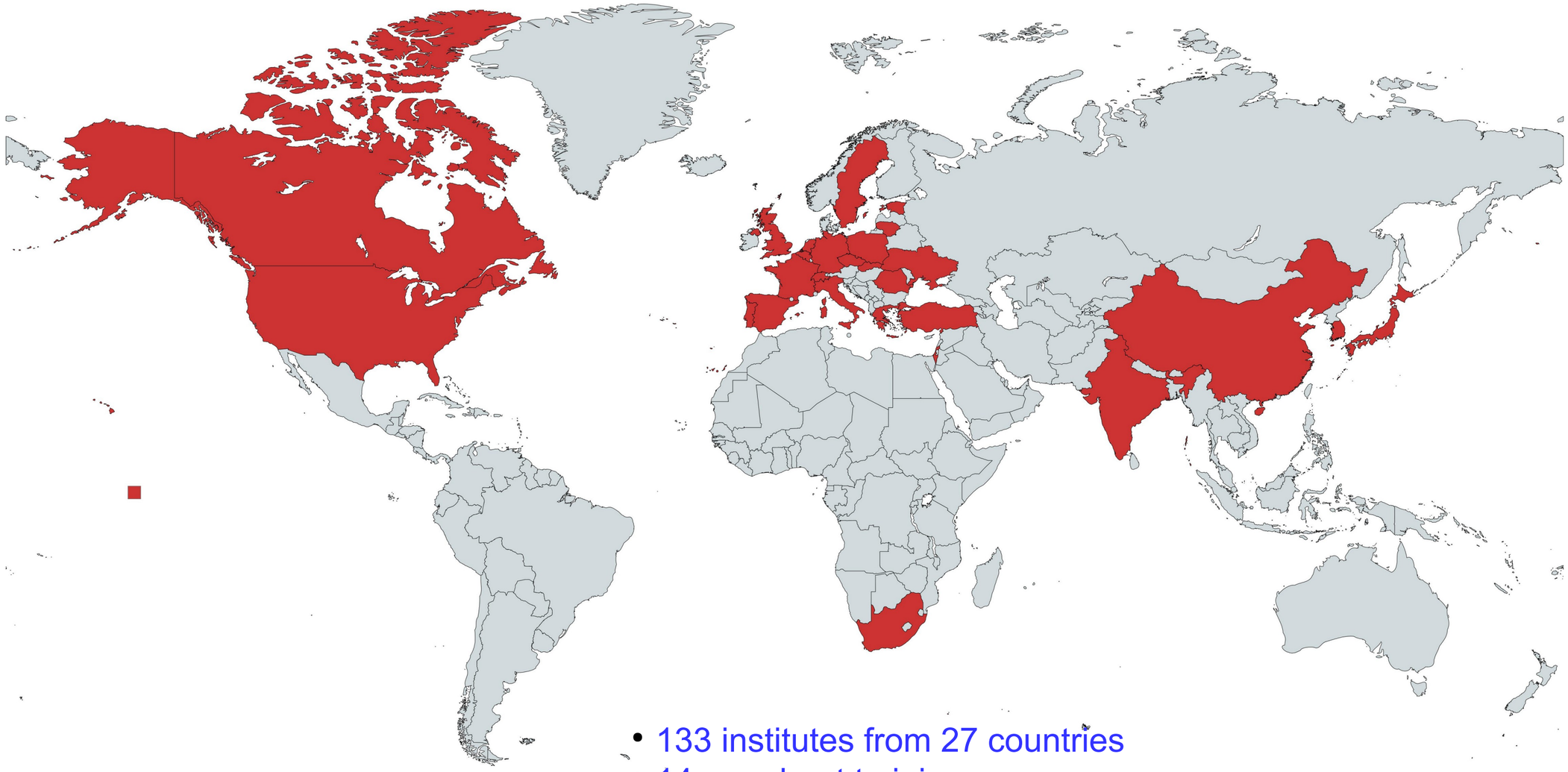
INFN PAVIA

Credits

… to Gabriella Gaudio and Roman Poeschl

DRD Calo – Who and where we are

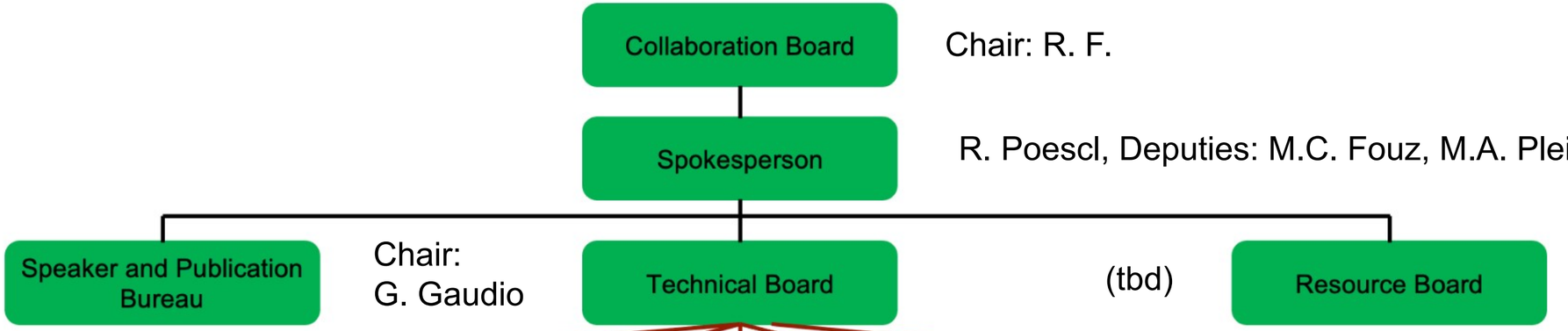
Webpage: https://drdcalo.web.cern.ch/



- 133 institutes from 27 countries
- 14 are about to join

Current structure

MANAGEMENT:



WORK PACKAGES:



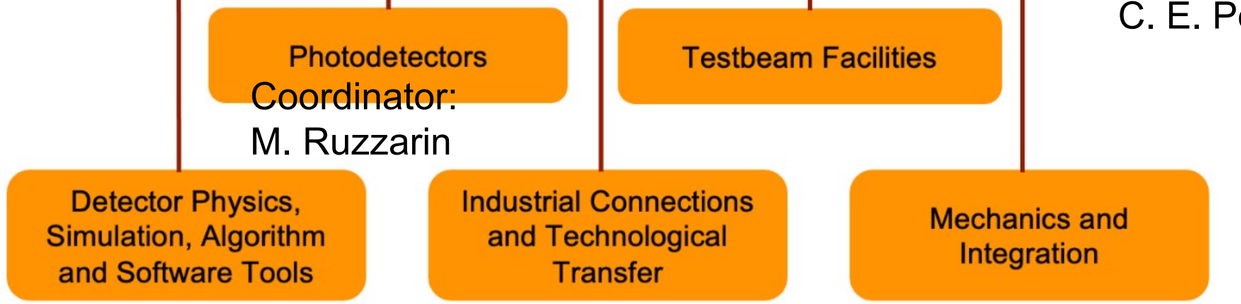
Coordinators:
L. Masetti
A. Irles

Coordinator:
N. Morange

Coordinator: Hwi Dong Yoo
Deputy: M. Lucchini

Coordinators:
C. de la Taille
C. E. Perez-Lara

WORKING GROUPS:

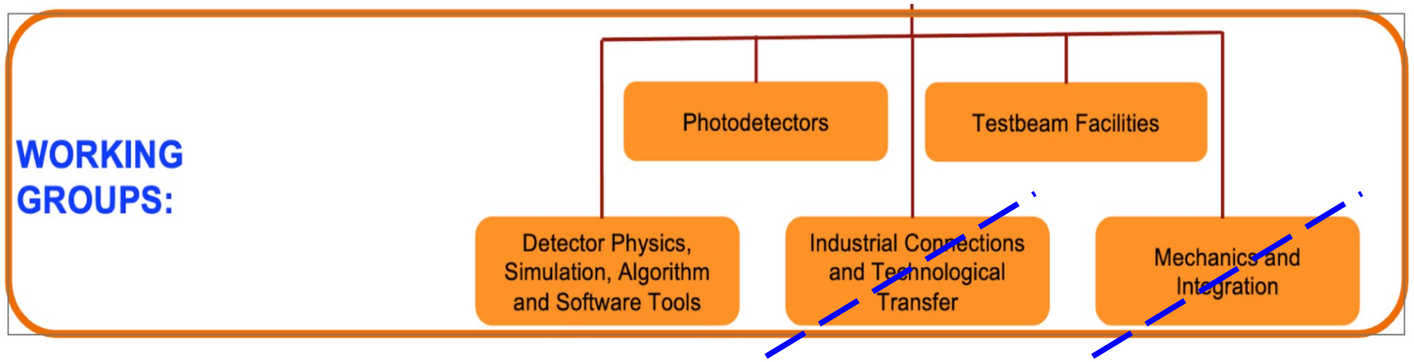


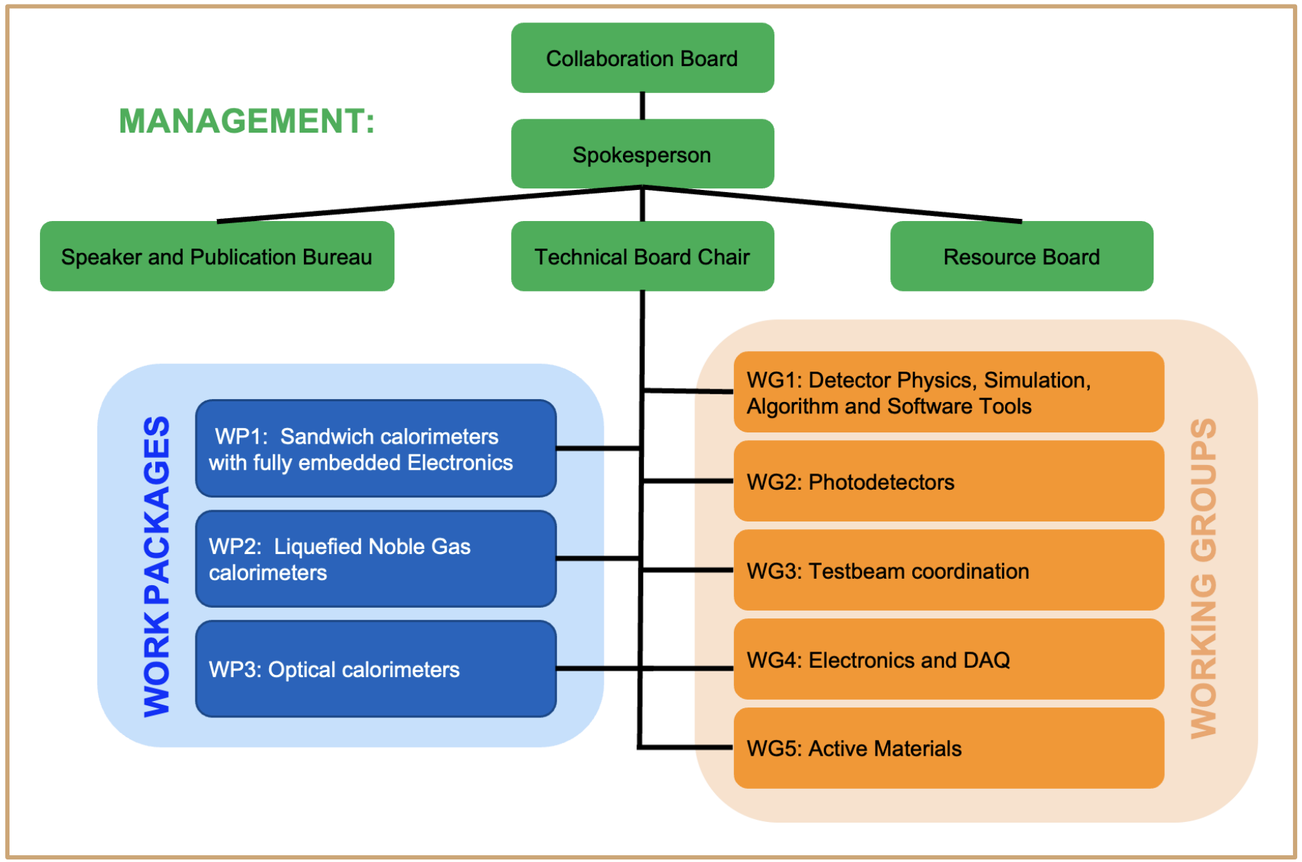
Coordinators:
B. Francois
F. Guo

Coordinator:
M. Ruzzarin

Subject to change → see later

Renewal of DRD Calo – New organigramme



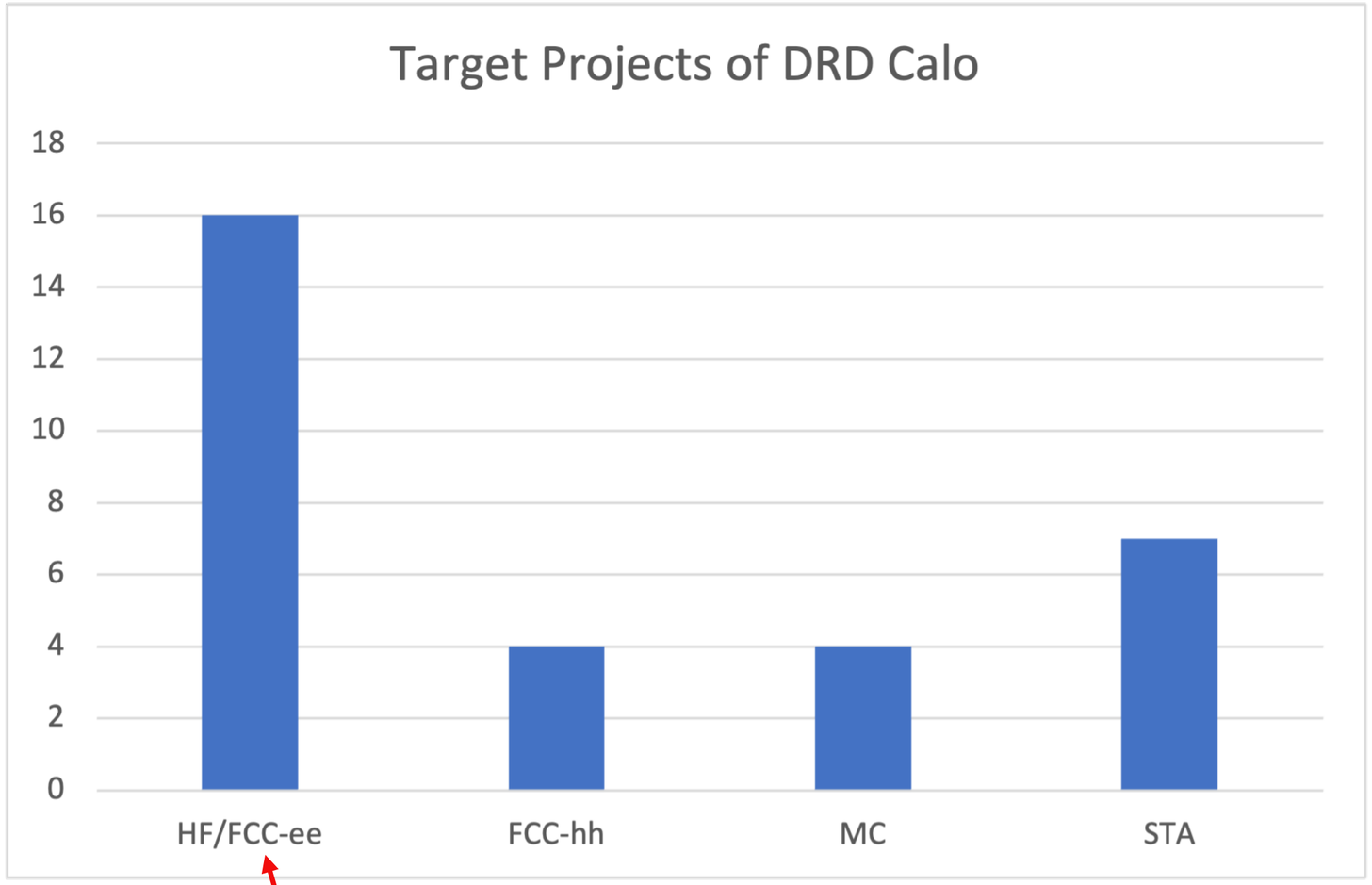


2027-2029 (proposal for renewal):

- WP4 → WG4 Electronics and DAQ
- WP3 task 3.4.1 → WG5 Active Materials

as in original proposal

Renewal of DRD Calo – Target projects



Well-aligned with EU Strategy Update

Renewal of DRD Calo – WP1

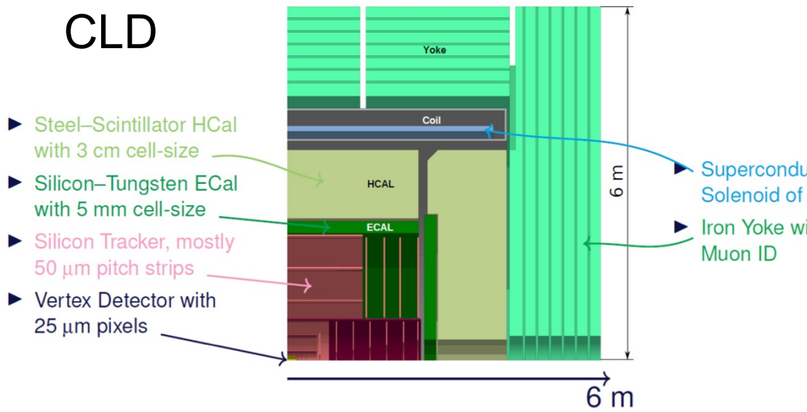
- 14 milestones and 14 deliverables in 2027 – 2029
- WP1 technologies mostly being adapted for FCC-ee
  - Calorimeters optimised for PF reconstruction originally developed in other context
  - Adapting demonstrated concepts to FCC-ee environment
- Examples of common tasks:
  - Addition of active cooling
  - Readout to cope with continuous data taking
  - Addition of timing capabilities for better particle separation
  - Layout optimisation within specific detector concept

WP1 – Strategy toward FCC-ee

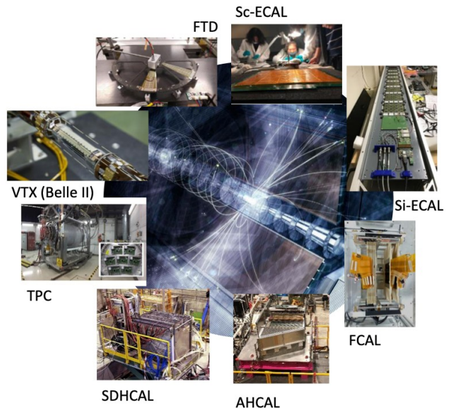
- Some technologies already adopted for HL-LHC upgrades
  - CMS HGCAL with silicon pads and scintillator tiles
  - ALICE FoCAL with MAPS

- Detector concepts for FCC-ee
  - CLD and ILD designed around PFA reconstruction principle
  - To be adapted to cope with continuous readout
  - AGORA: adaption from CEPC reference detector

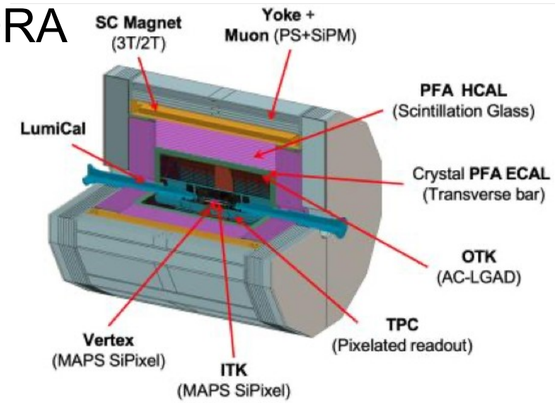
CLD



ILD



AGORA



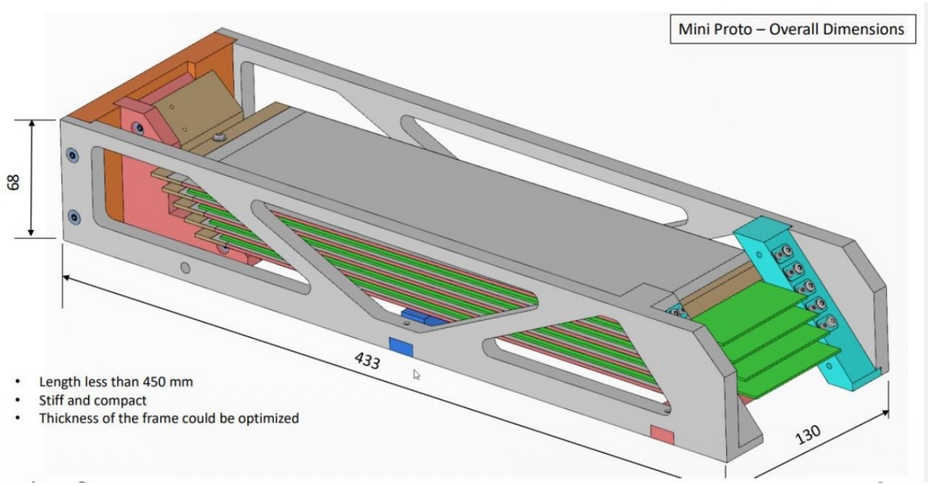
Renewal of DRD Calo – WP2

Main challenge – Cold electronics



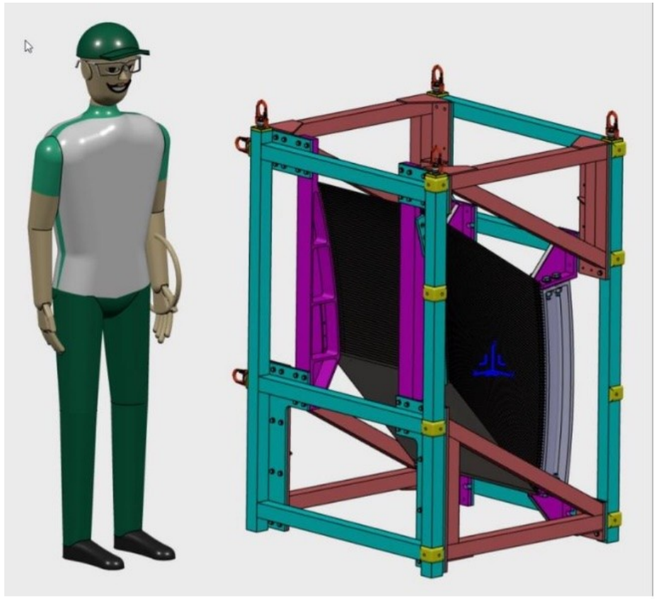
- Would dramatically reduce impact of capactive noise
- Would facilitate detector design (less feedthroughs)
- Requires very low power electronics …
  to prevent liquid noble gas from boiling

Next step – Mini prototype



- 2027 - 2028
- 4-5 layers
- Study of detector integration
- First testbeam experience with new electrodes (e.g. DESY)

R&D Goal – Prototype module

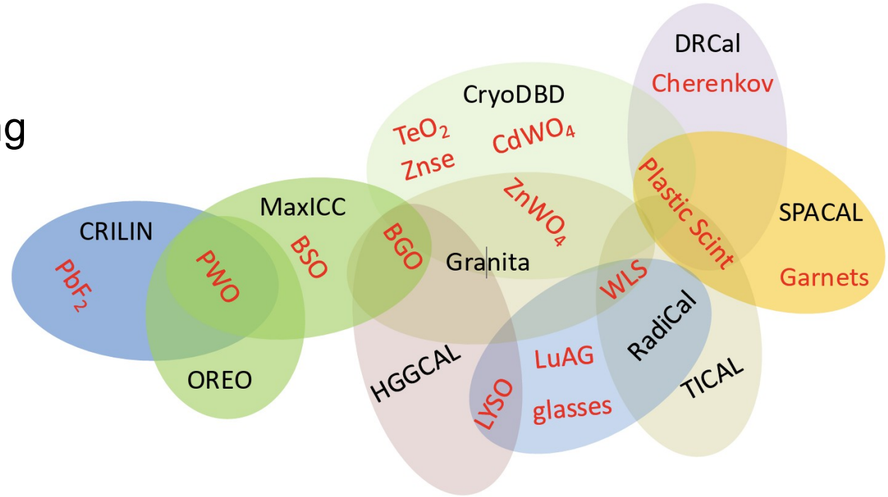


- For reopening of CERN testbeams
- 65 layers (5000 cells)
  → full em shower containment
- Realistic mechanical structures

1 milestone and 4 deliverables in 2027 – 2029

WP3 – Summary and outlook

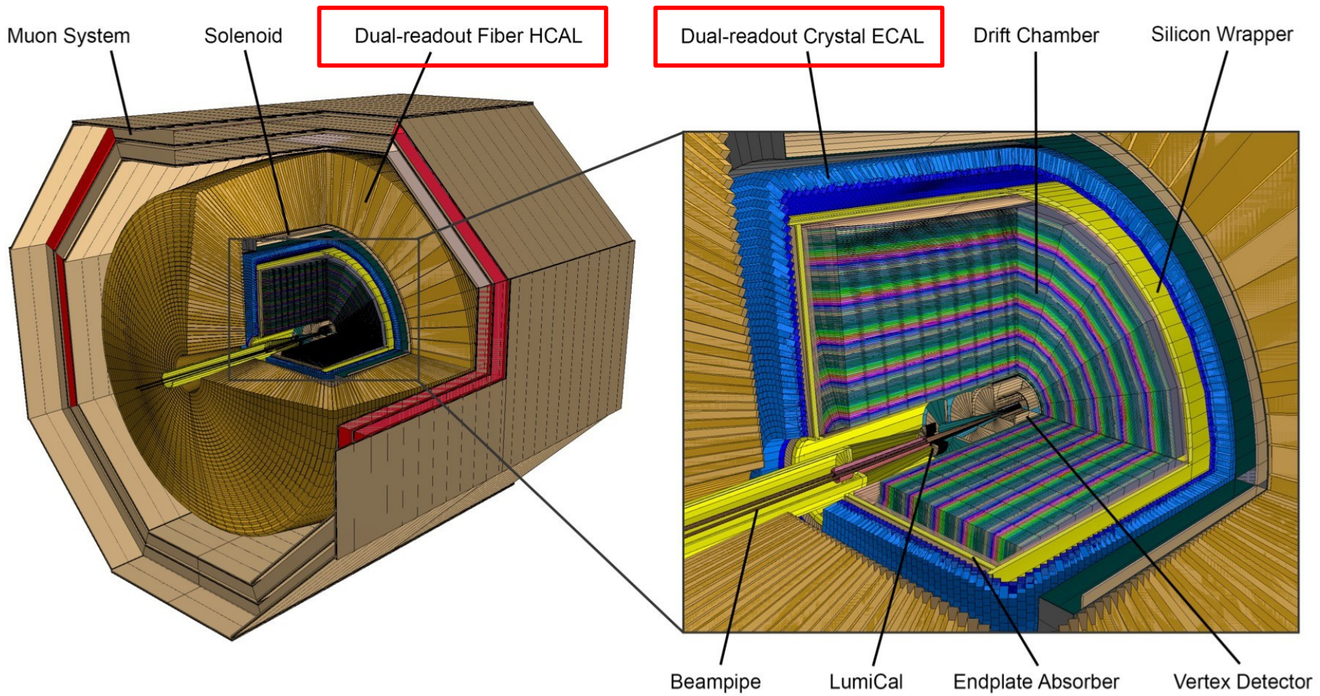
- **Broad Portfolio**: 12 active subtasks driving future of optical calorimetry
- **Excellent Performances**: Demonstrating high precision in energy resolution, PID, and ps-level timing across multiple detector concepts
- **Cutting-Edge Innovations**: Successful validation of novel materials, manufacturing techniques, and software integration
- **Solid Path to 2027 – 2029**: Transitioning from component-level R&D to system-wide scalable prototypes and joint beam-test campaigns
- **Stay tuned for more exciting progress**



- 33 milestones and 33 deliverables in 2027 – 2029
- New subtask OL3D (opaque liquid scintillator) under discussion, awaiting approval
  - Complementary to 3DNu and GRAINITA

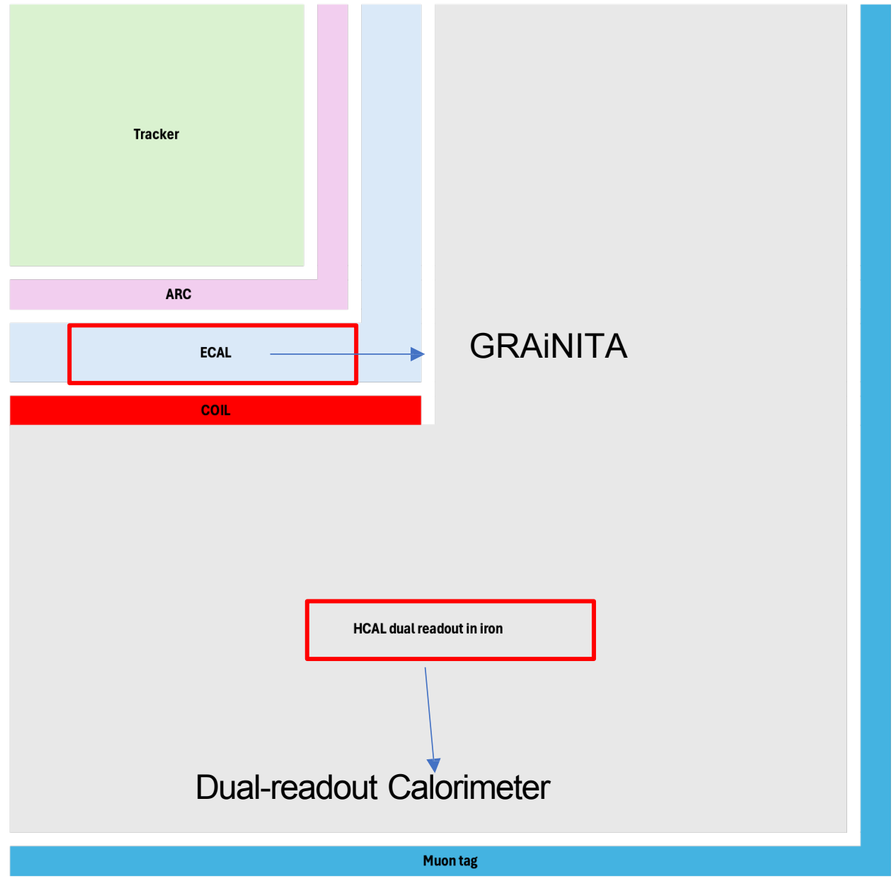
WP3 – Strategy toward FCC-ee

- Participate in IDEA and ALFA detector concepts



IDEA concept

ALFA concept



WG1 – Software, Simulation, and Data Analysis

Mandate:

- harmonise software efforts, exploiting synergies, pooling expertise, avoiding duplicate work, ensurie long-term scalability and data preservation
- steer offline activities, provide guidelines and training, discuss physics results
- ensure adequate computing and storage resources are available

WG1 – Software, Simulation, and Data Analysis

2024-2026:

- Key4hep identified as common software framework, for all DRD Calo development
- Already used for studies across future-collider community
- Possibility to transfer test-beam simulation into full 4π sub-detector simulation
- Creation of common GitHub organisation, DRD Calo
- Provision of shared storage on CERN EOS
- Organisation of software tutorials covering DD4hep and Gaudi
- Creation of DRD Calo Virtual Organisation, as first step toward GRID-based job submission

WG1 – Software, Simulation, and Data Analysis

2027-2029 targets:

- Strengthen Key4hep adoption
- Bridge online and offline software worlds
  - translate data to EDM4hep format after or during data taking
  - integrate raw DAQ tools such as EUDAQ with Key4hep
- Develop common test beam offline software
  - provide centralised descriptions of common beam-line components
- Finalise GRID submission infrastructure
- Harmonise and advance development of ML approaches for calo algorithms
- Define data preservation policy and infrastructure
- Strengthen feedback from test data to G4 simulation → G4 validation

WG2 – Photodetectors

Mandate:

- Support calorimeter R&D activities based on light detection technologies
- Collect and consolidate sensor requirements from all DRD Calo work packages



- Photodetectors with fast response, rapid pixel recovery, large dynamic range, radiation tolerance, low crosstalk, and sensitivity from UV to IR region
- Achieve very small cell sizes (around 5 μm) to increase dynamic range while maintaining high photon-detection efficiency (PDE) and stable gain after irradiation

WG2 – Photodetectors

Mandate:

- Support calorimeter R&D activities based on light detection technologies
- Collect and consolidate sensor requirements from all DRD Calo work packages

2024-2026:

- Strengthen communication through newsletters, collaboration meetings, and improved interaction among working groups
- Establish collaboration with DRD4 to channel common detector needs toward dedicated photodetector R&D activities

WG2 – Photodetectors

2027-2029 targets:

- Transform WG2 into coordination body capable of guiding photodetector developments toward needs of future calorimeter prototypes
- Increasing interest → adding one more coordinator
- Reinforce role of interface between detector developers, photodetector experts, elx teams, and industrial partners
- Strengthen connection with DRD4 through joint workshops, participation in technical reviews, and regular exchanges
- Reinforce and formalise collaboration with leading photodetector manufacturers
- Stay open to emerging suppliers and novel technological developments
- Organise periodic meetings with vendors and technology providers

WG3 – Testbeams

Coordinating test beam requests at different facilities – contacts:

- CERN: Technical Board Chair (G. Gaudio, ad interim)
- DESY: K. Kruger
- USA (Fermilab, SLAC): G. Cummings
- KEK: W. Otani

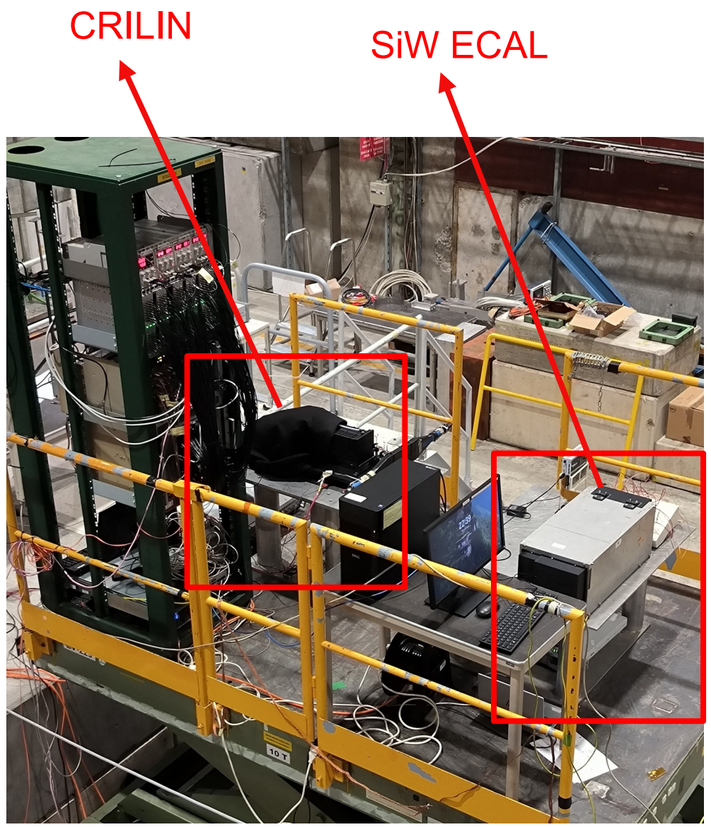
TB @ DESY
2024. 1w
2025 5w
2026 1w

Testbeam @ CERN
2024: beam request too early wrt DRDCalo start
2025: 4 weeks @PS and 11 weeks @SPS
2026: 5 weeks @PS and 10 weeks @SPS

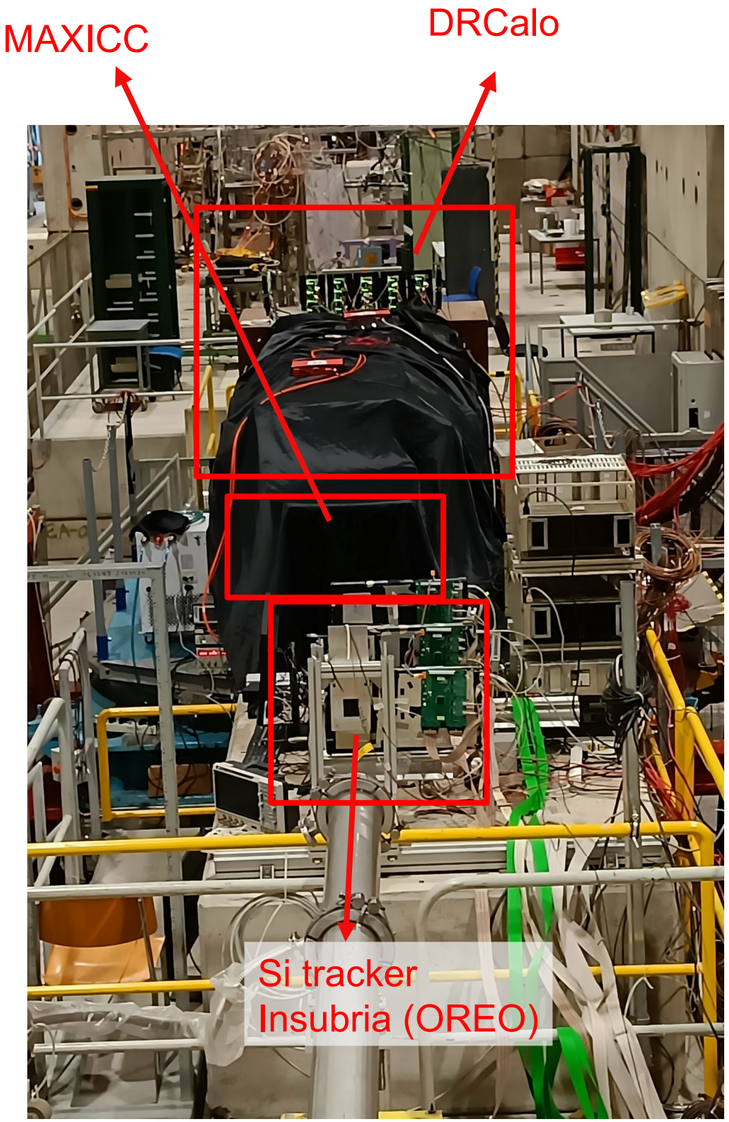
More test beam periods handled by groups “outside” DRDCalo coordination
e.g., synergy with other experiments

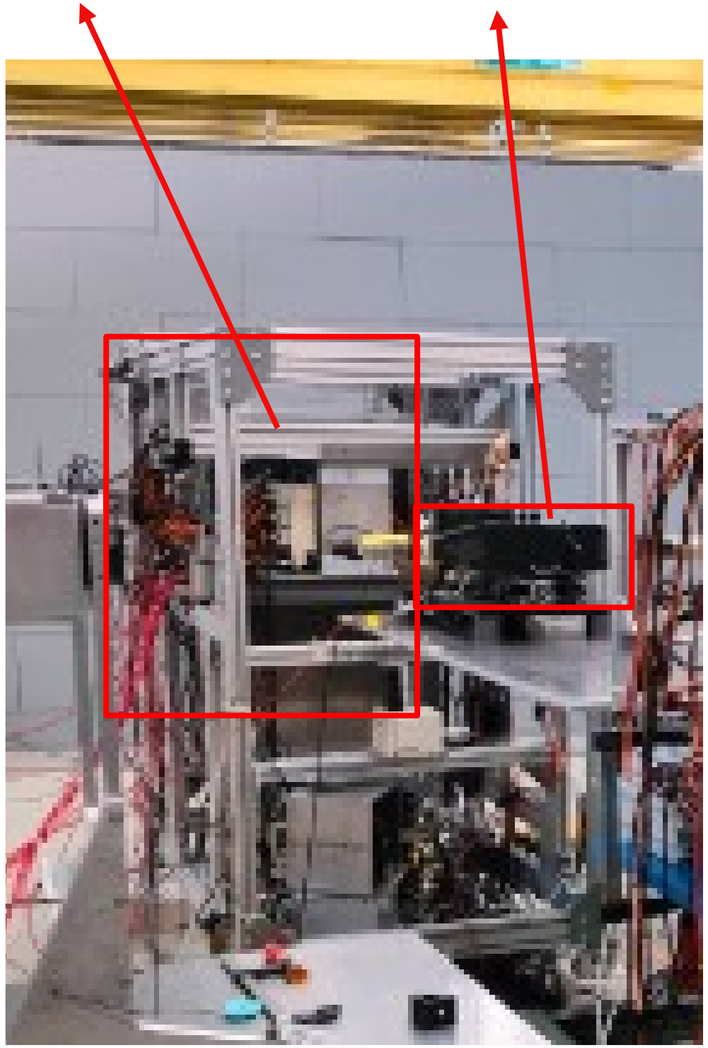
WG3 – Testbeams

Combined beam tests (2026):



Shared a 2w period (9+5 days)
Early installation of CRILIN allowed more beam time to be exploited





WG3 – Testbeams

2027-2029 targets:

- Keep/improve coordination effort to grant DRDCalo prototypes test-beam time
  - Hard period for hadronic calos until PS restart
  - Exploit as much as possible DESY, KEK and LESA (SLAC)

- Take advantage of SPS shutdown to setup dedicated area for DRDCalo beam tests
  - Originally proposed at end 2024
  - Document sent out to SPS coordination in 2025
  - Few iterations but no concrete steps
    - People in DRDCalo busy with «their» prototypes
    - Beam lines busy all the time

- Get/provide support from/to FCC PED (TB necessary steps to reach maturity for FCC-ee experiments)

WG4 – Electronics and DAQ

Mandate:

- Optimise commonalities between readout chips or DAQs, enable common test beams
- Foster exchanges on designs and architectures between Wps
- Share engineering runs whenever possible to get large quantities at affordable price

Recent evolution of technologies @ TSMC:

- Phasing out 130 nm @ Fab 12 & 14 in 2026, possibly keeping access in Fab 6 for a few years
- Discouraging new projects in 65 nm (and 28) in next few years
- Policy rapidly evolving (towards 2 nm AI chips) and becoming more unpredictable

××× Reminder ×××

TSMC produces 17 M wafers/year, particle physics buys at most 1 k (DRD6 bought 6)

Need to find alternative manufacturers – however:

- Long time needed for development and qualification for radiation
- Perennity is our leading factor
- Potential big problem

Technology matrix for calorimetry (CdLT):

TSMC130, DRAM	TSMC65	UMC110	XFAB130	VIS130
5M 1T 1U RDL C4	5M 2T 1U RDL C4	5M 1T 1U no C4?	4M 2T 2U	As TSMC130
Radhard 200 Mrad	Radhard 200 Mrad	Bump @ 5 Mrad	N/A	Which fab ?
ER : 300 k$	ER : 750 k$	ER : 300 k$?	ER < 300 k$	
EIC	EIC, LHCb	EIC, LHCb, ALICE		
AGH, Lisbon,SLAC	FNAL,BNL,CERN	Torino	Weeroc	
Only @ Fab 6, no C4	Perennity ?	Low volume	6-9 months fab	Available when ?
Taiwan	Taiwan	Taiwan	Malaysia	Singapore
ADC, TDC, DRAM	ADC			
DNW, HiR, CMIM	DNW, HiR, CMIM		CMIM	

WG4 – Electronics and DAQ

2027-2029 targets:

- For DRDCALO now:
  - Complete prototype chips so that WP calo prototypes can be tested
  - Exercise streaming readout in calorimetry
  - Profit from upcoming engineering runs (EIC mid 2027 in 130 nm Fab 6) or 65 nm
- For DRDCALO next
  - Evaluate alternative technologies to TSMC (UMC, XFAB…)
  - Unlikely to move to TSMC 22 nm as recommended
  - FCC-oriented chips will be low power, low radiation, low occupancy
- For DAQ
  - Try to find continuation of EUDAQ or equivalent → Constellation (?)
  - Try to find/build team for supporting and maintaining DAQ for DRDCalo

WG5 – Active Materials

All proposed detector concepts in WP 3 and some in WP 1 use (organic or inorganic) scintillating materials (link to DRD5)

- R&D on radiation-hard fast scintillators
- Intrinsic dense scintillators with simultaneous Cherenkov and scintillation emission
- Ultrafast inorganic scintillators for timing layers or calorimeters requiring very good timing resolutions
- Cost-effective scintillators (plastics, glasses) for large volume detectors
- New scintillating materials using nanoscintillators
- Look at new production technologies like e.g. 3D printing, micropulling down and low-cost crucibles

WG5 – Active Materials

2027-2029 targets:

- Survey needs and requirements of all subtasks using scintillators
- Identify synergies between requirements of different subtasks to optimise common and transversal R&D
- Help subtasks in scintillator choice or in development of new materials → ensure connection with experts in scintillator development and characterisation (crystal growers, chemists, physicists, etc.)
- Provide access to dedicated characterisation setups
- Ensure connection between HEP and scintillator communities to:
  - in one way, keep up-to-date DRD Calo members about new scintillator developments
  - in other way, keep informed scintillator community about HEP needs
- Promote innovative and blue-sky developments for long-term future detectors

WG5 grew out of WP3 subtask focused on optical materials

- In future, investigation of innovative materials will also include studies of, e.g., semi-conductors in cooperation with DRD3

The Long March toward the MoU

- Approval of updated version of Governance Rules (ongoing)
- Additional CB Meeting on MoU @ end of October / beginning of November
    - Approval of renewal document → Integration into Annex 6

      → freezing of MoU Annexes including member list

      → new subtasks and/or new members can apply to join at any time
- November 16th: start of circulation of MOU and its annexes for signatures

Summary and outlook

- Successful first three-year cycle close to end
  - Almost entire planned programme executed
  - Good organisation and efficient use of available funding

- Scientific harvest starting
  - Coordination by Speakers Bureau
  - 76 conference talks and seminars, 10 conference proceedings and 5 papers referring to DRD Calo

- Renewal process in full swing
  - Kick-off at Collaboration Meeting in April
  - Report(s) submitted to DRDC
  - Consolidation phase ongoing
  - New WGs on Elx & DAQ and on Optical Materials to better exploit sinergies

- DRD Plans well in phase with ESG recommendations
  - Visible support for and involvement in FCC-ee activities
  - DRD Calo has and will maintain broad portfolio of activities

BACKUP

To-do-list

Renewal document:

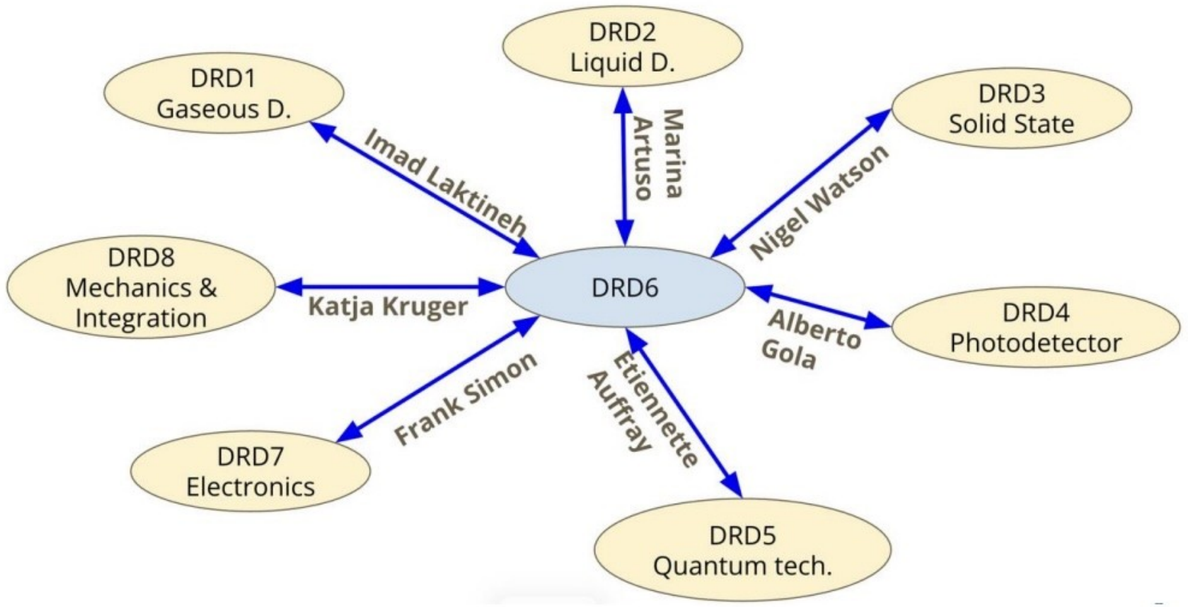
- ECR Forum
  - Promote young scientist
  - May become regular event at collaboration meeting
- Diversity, equity and inclusion
  - Adopt DEI policy

Scientific achievements

- Summary of publications since the collaboration started on Jan. 1, 2024 (not exhaustive)
  - Conference presentations: 76
  - Conference proceedings: 10
  - Papers: 5
  - First collaboration wide paper under review

- Full list is here
  - Will be migrated to CERN CDS

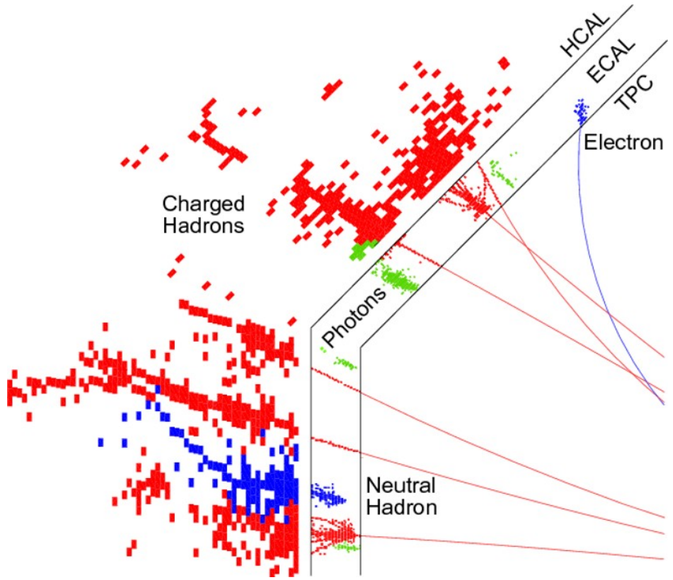
Connections to other DRDs



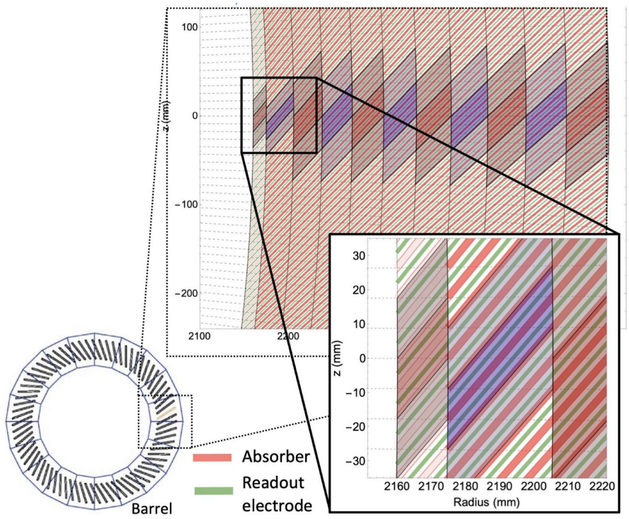
Scientific organisation

- Scientific programme organised around four Work Packages
  - Subdivided in tasks and substasks
  - Subtasks loaded with milestones and deliverables

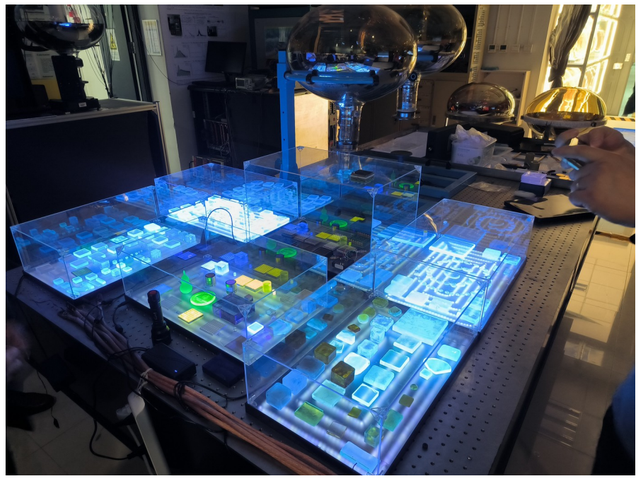
Sandwich calorimeters with embedded electronics



Liquefied Noble Gas Calorimeters



Optical Calorimeters



Electronics and DAQ

- Coherence ensured by five Working Groups

European Strategy

- DRD mandate:
  ANY possible future facility program should not be delayed by detector developments not on track

- Well-aligned with EU Strategy Update
  - Many projects target future Higgs factories

- However keep broad portfolio of activities - future flagship projects still ~20 years ahead of us
  - Possibly validate developed technologies before, e.g.:
    - Spacal in LS4
    - DUNE ND
    - Fixed target experiments coming online in early ‘30s (maybe even earlier)