Michael Tytgat
Belgian National ESPP Meeting
Feb. 5, 2025

DRD Collaborations & Activities

[The future collider at CERN according to ChatGPT]

VRIJE UNIVERSITEIT BRUSSEL
iihe BRUXELLES BRUSSEL

A brief history of Detector R&D collaborations

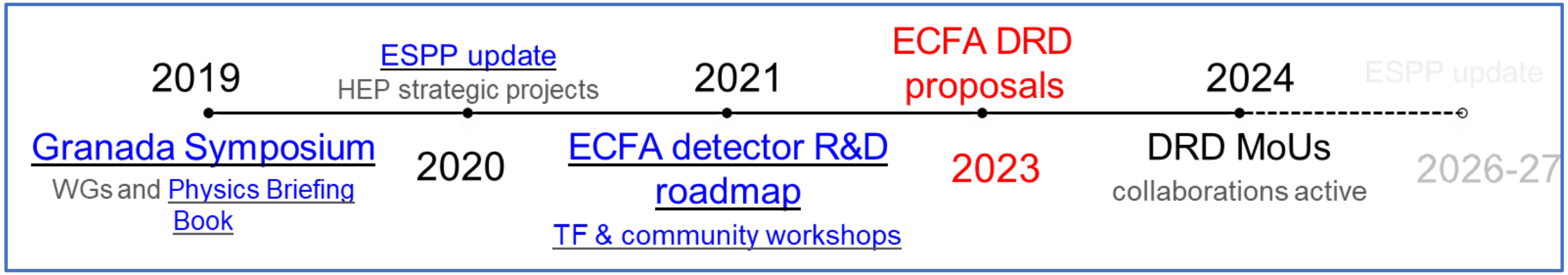
European Strategy on Particle Physics

- **ESPP Update 2013:** HL-LHC decision
- **ESPP Update 2020:** decisions for post-HL-LHC times, i.e.
  - ***Detector R&D programmes** and associated infrastructures should be supported at CERN, national institutes, laboratories and universities. **Synergies** between the needs of different scientific fields and **industry should be identified** and exploited to boost efficiency in the development process and increase opportunities for more **technology transfer benefiting society** at large. **Collaborative platforms and consortia** must be adequately supported to provide coherence in these R&D activities. The community should define a global detector R&D roadmap that should be used to support proposals at the European and national levels.*
  - *Europe should maintain its capability to perform innovative experiments at the boundary between particle and nuclear physics, and CERN should continue to **coordinate** with **NuPECC** on topics of mutual interest.*
  - ***Synergies** between particle and **astroparticle physics** should be strengthened through scientific exchanges and **technological cooperation** in areas of common interest and mutual benefit.*
- **ESPP Update 2026:** what input should we give concerning detector R&D ?

http://europeanstrategy.cern/

Towards a long-term detector R&D program

The 2020 ESPP update led to call on the European Committee for Future Accelerators (ECFA) to develop a global **Detector R&D Roadmap defining the backbone of detector R&D** required to deploy the community's vision; cover both near-term and longer-term needs, working **in synergy with neighboring fields** and with a view to **potential industrial applications**



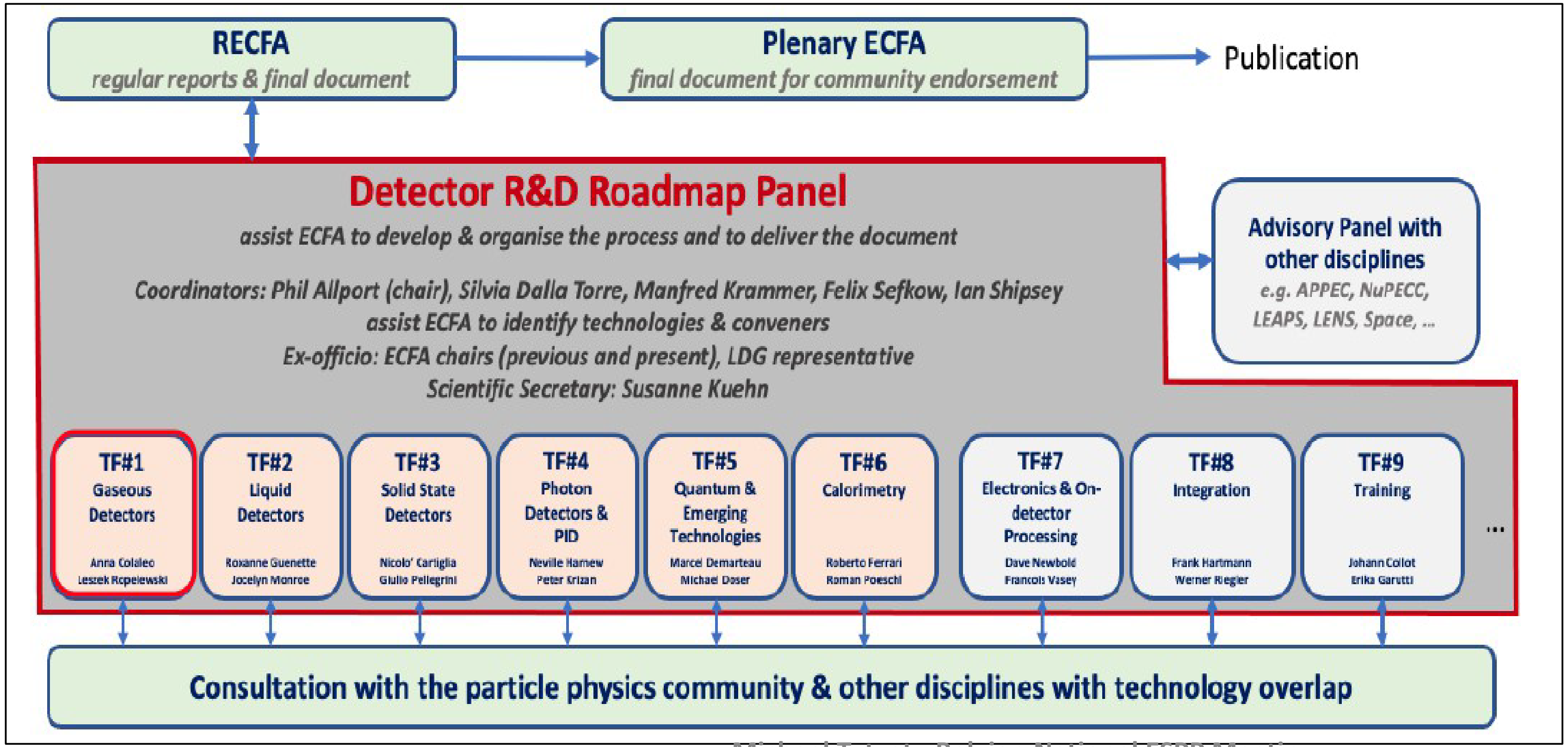
General 3-4 R&D themes in each TF
10 Global Recommendations
GR4: international coordination & organization of R&D activities
GR6: establish long term strategic funding program

→ Formation of international DRD collaborations
hosted at CERN (CERN/SPC/1190)

ECFA Detector Roadmap

Detector R&D Roadmap was released by ECFA in 2021, based on a community-driven effort

- Overview of **future facilities** (EIC, ILC, CLIC, FCC-ee/hh, Muon collider) or major **upgrades** (CMS, ATLAS, LHC-b, ALICE, Belle-II,…) and their **timelines**
- 10 "**General Strategic Recommendations**" + **9 Technology domains** with **Task Force** areas
- The **most urgent R&D topics** in each domain identified as **Detector R&D Themes** (DRDTs)



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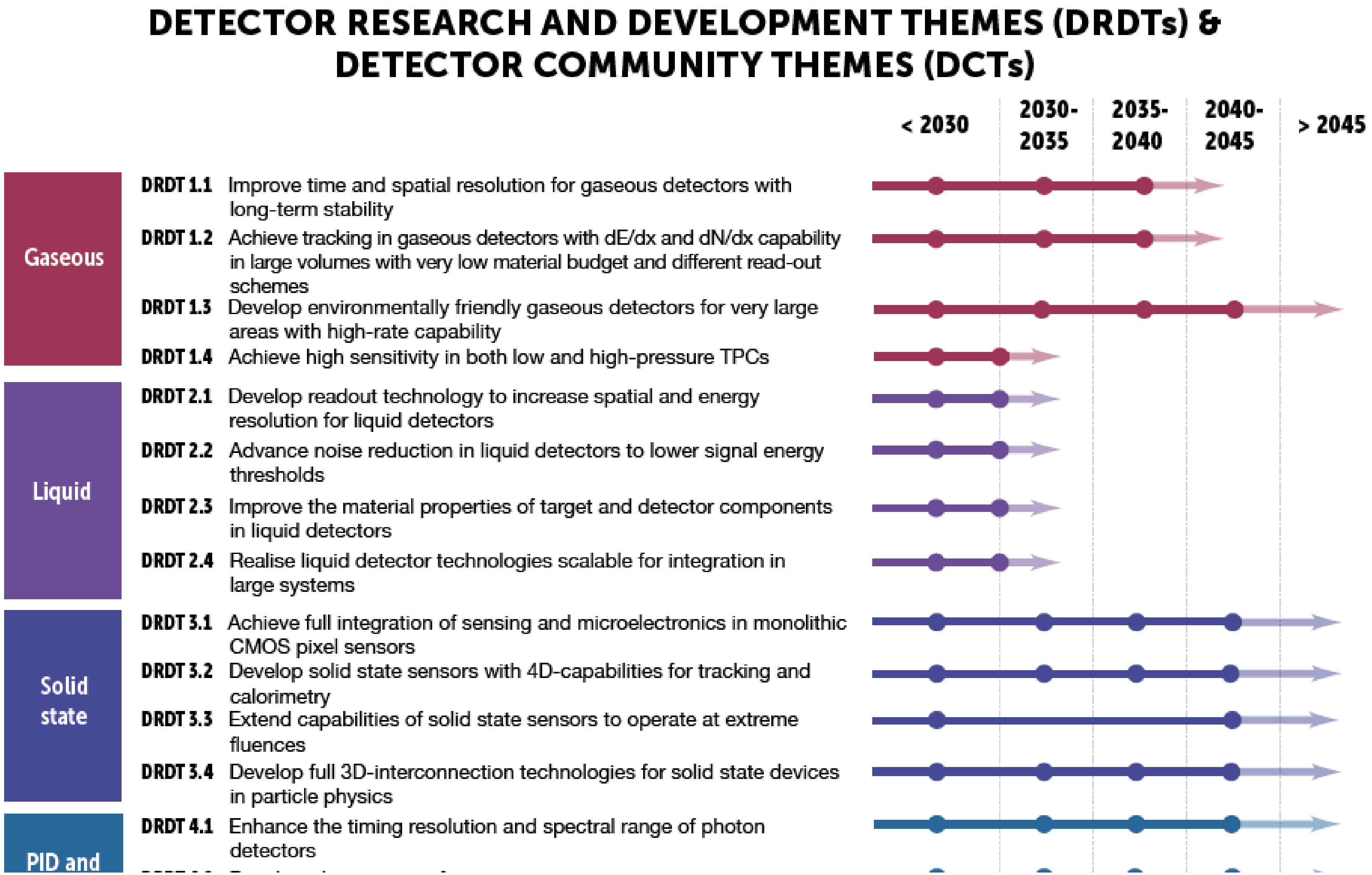
Detector R&D Themes



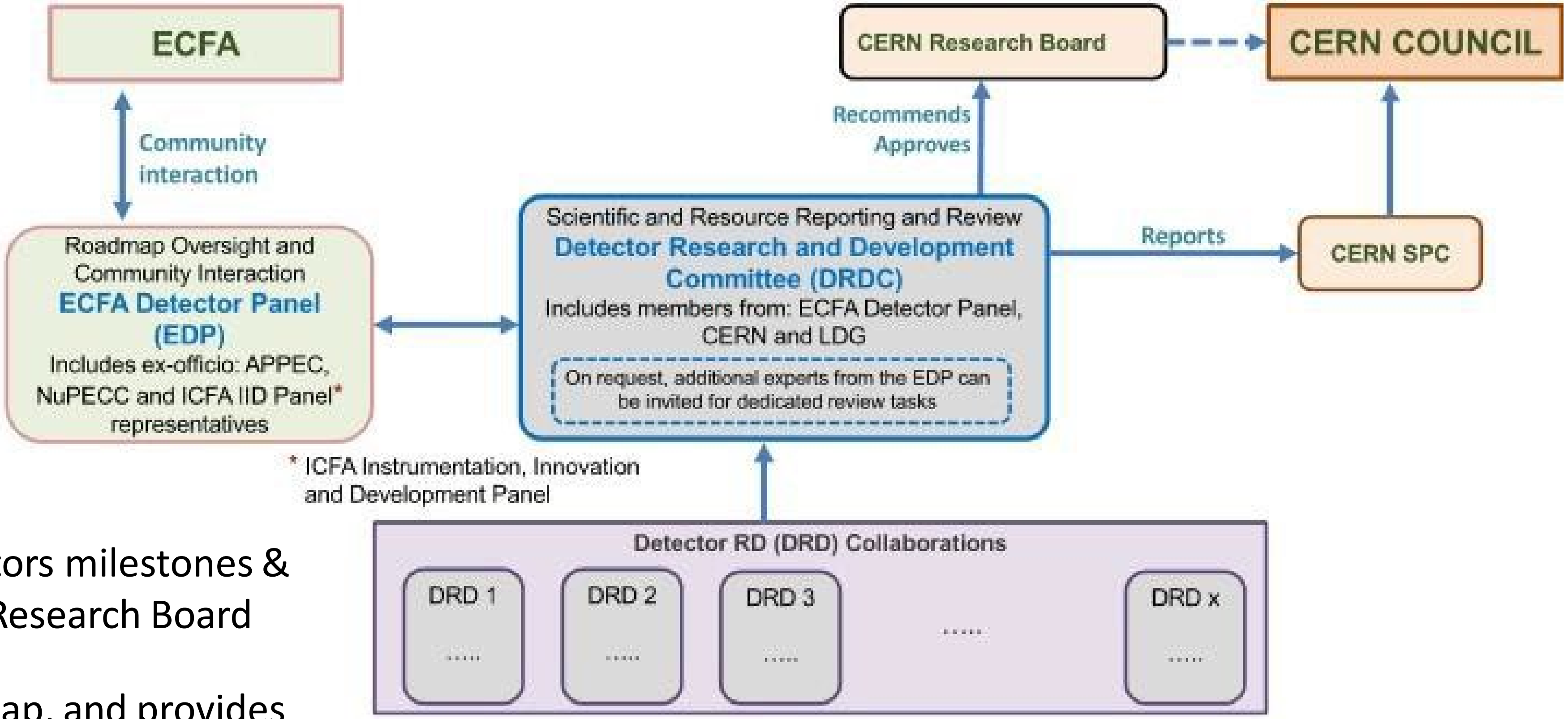
- DRDTs, including rough timeline, formulated by each Task Force
- Basis for the formation of corresponding **Detector R&D Collaborations**

Roadmap implementation plan

Approved by CERN SPC and Council in fall 2022 (CERN/SPC/1190 ; CERN/3679)

CERN is hosting DRD collaborations; in alignment with the general conditions for experiment execution at CERN, a dedicated **Detector R&D Review Committee (DRDC)** has been put in place, along with the need for formalized MoUs with various Funding Agencies

- Interaction between DRD collaborations and committees through DRDC
- Interface to ECFA via ECFA Detector Panel (EDP): https://ecfa-dp.desy.de



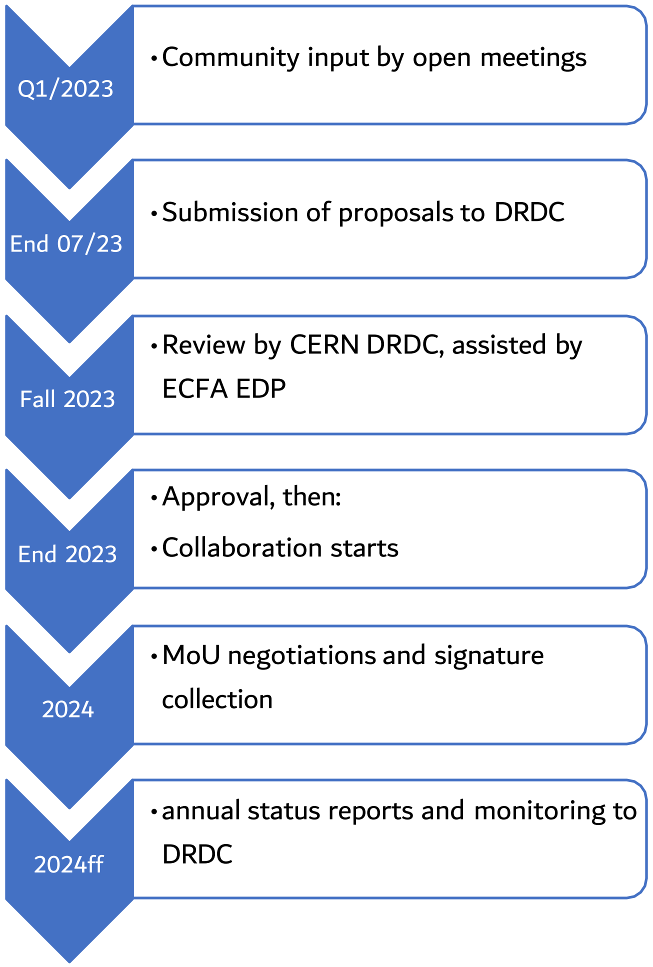
Distinction between reviewing & advising body

- DRDC reviews DRD progress, monitors milestones & deliverables, and reports to CERN Research Board
- EDP monitor ECFA Detector Roadmap, and provides input to the next Strategy update

DRD Collaborations

New DRD Collaborations have been implemented in the past two years

- Along with selected community members, Task Force chapters convenors from ECFA Roadmap became part of Proposal Writing Teams for new DRD collaborations
- Collected input from the communities in open meetings happening in the beginning of 2023
- Summer 2023: Initial **submission deadline of DRD proposals**
  - The DRDC (DRD Committee) was appointed at the same time only
  - Review of first DRD proposals by DRDC in autumn 2023
  - Intense phase of work as also DRDC mandate and tasks had to be defined first
- **Approval of first DRD collaborations in December 2023 RB**
  - Once approved, DRD collaborations started in 2024; collaborations have kick-off meetings, elect management positions,…
  - Setting up MoU and collecting signatures from Funding Agencies is delayed …



Overview of DRD Collaborations

https://indico.cern.ch/category/6805/

Fully Approved for an initial period of 3 years by CERN Research Board in December 2023

- Gaseous Detectors (DRD1) [ex RD51]
- Liquid Detectors (DRD2)
- Photodetectors & Particle ID (DRD4)
- Calorimetry (DRD6) [ex CALICE]

Fully Approved for an initial period of 3 years by CERN Research Board in June 2024

- Semiconductor Detectors (DRD3) [ex RD50, RD42,..]
- Quantum Sensors (DRD5)
- Electronics (DRD7)

Letter of Intent submitted

- Integration (DRD8)

Full Proposal submitted by 31 Oct 2024

Expect written status reports in 2026, i.e. ”prolongation requests”, as DRDs are approved for 3 years initially

DRDs in practice

What do they offer, and what not ?

- **Main objective is long-term strategic R&D**, i.e.
  - *to boldly go where no one has gone before in terms of detector technologies*
  - in principle not experiment-specific R&D (as opposed to experiment-driven and “Blue-sky” R&D)
  - main focus is not really on projects in their production phase, or application of already existing technology in the context of experiments, but it’s nonetheless beneficial to join the community

- **No running experiment in the collaboration**
  - no large annual membership fees, only small common fund to cover central expenses of the collaboration
  - no collaboration-wide scientific publications

- **Discussion forum and networking for R&D groups, interface with industry**

- **Common projects**
  - possibilities to get support for small-scale projects of common interest to the community
  - blue-sky and generic R&D

- Organization and support for **common test beam efforts;** organization of **detector schools**

RDCs in the US

As part of US Snowmass process, recommendation to **create Detector R&D collaborations in the US**

- Organized by CPAD (Coordinating Panel for Advanced Detectors) of the APS/DPF
- 11 RDCs (R&D Collaborations) were created (see https://cpad-dpf.org/?page_id=1549)
- Reached out to the community and worked on detailed planning at CPAD workshop 7-10 Nov 2023

DRD collaborations are open for US participation

- No competition intended, but synergy
- Overlap to DRDs through people/groups involved in both and liaisons

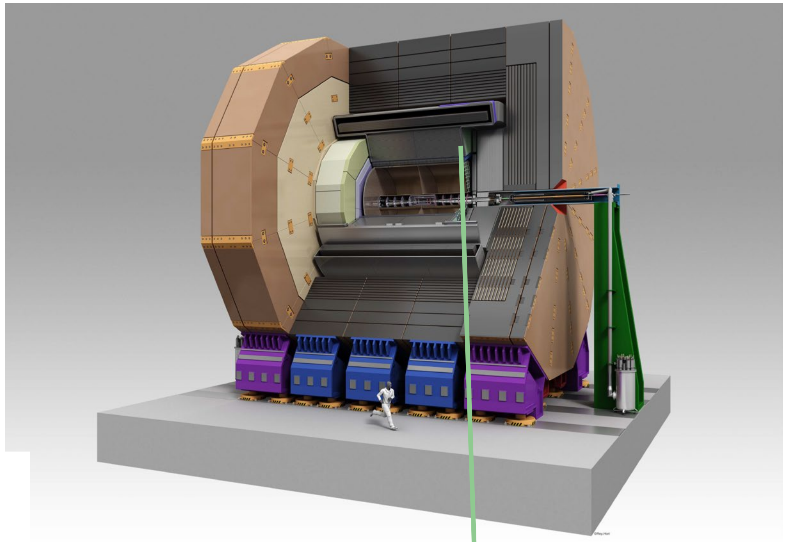
RDC#	TOPIC
1	Noble Element Detectors
2	Photodetectors
3	Solid State Tracking
4	Readout and ASICs
5	Trigger and DAQ
6	Gaseous Detectors
7	Low-Background Detectors
8	Quantum and Superconducting Sensors
9	Calorimetry
10	Detector Mechanics
11	Fast Timing

Selected ongoing R&D that fits into these DRDs

Semi-Digital Hadron CALorimeter

The SDHCAL is

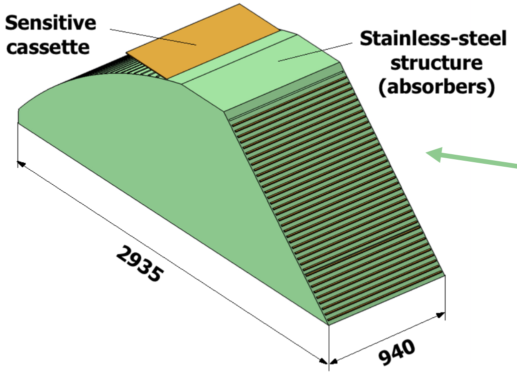
- **a gaseous detector based, highly-granular option for a HCAL based on PFA**
- part of the **International Large Detector (ILD)** baseline detector option, originally proposed for ILC/CEPC, and now also submitted to **FCCee**

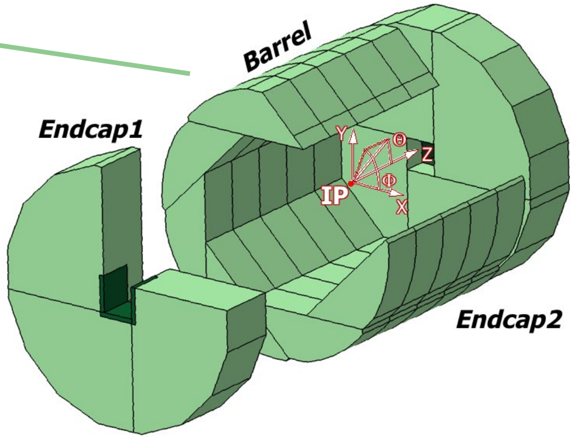


The SDHCAL structure:

- very **compact** with negligible dead zones
- eliminates projective cracks
- minimizes barrel / endcap separation

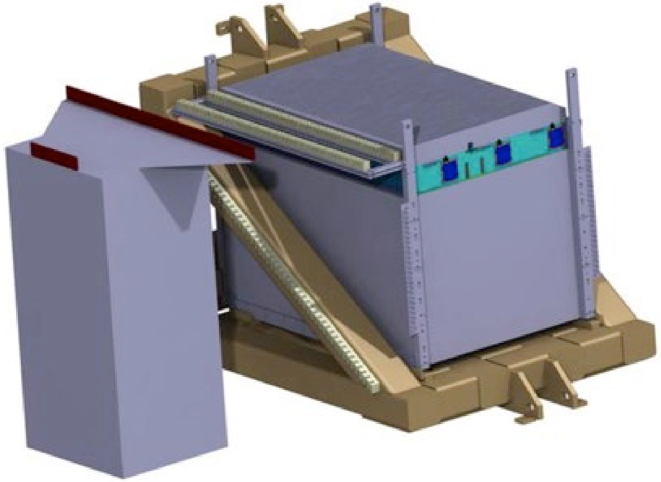
  (services leaving from the outer radius)





The **SDHCAL technological prototype** should be as close as possible to the ILD modules, with the ability to study **hadronic showers; challenges include:**

- Homogeneity for large surfaces (up to 3m length)
- Thickness of only few mms
- Lateral segmentation of 1 cm x 1 cm
- Services from one side
- Embedded (power-cycled) electronics
- Self-supporting mechanical structure

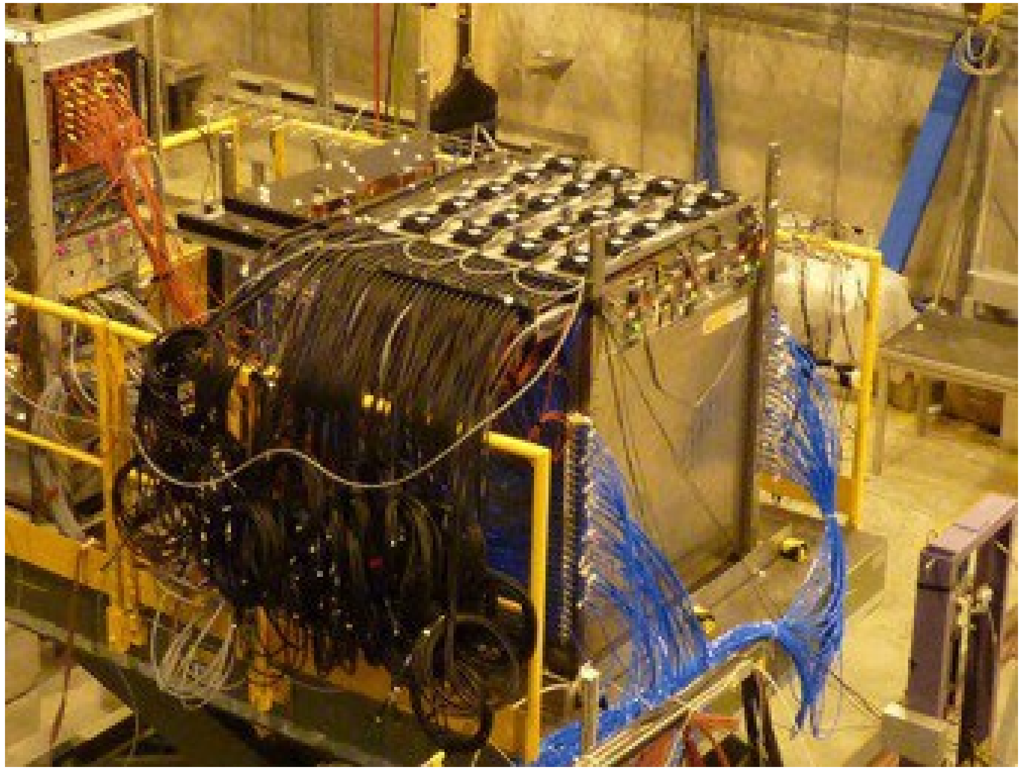


M. Tytgat member of ILD since 2014

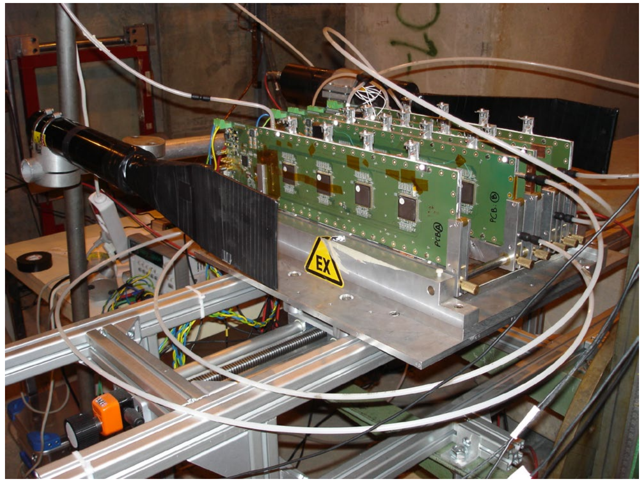
SDHCAL prototype

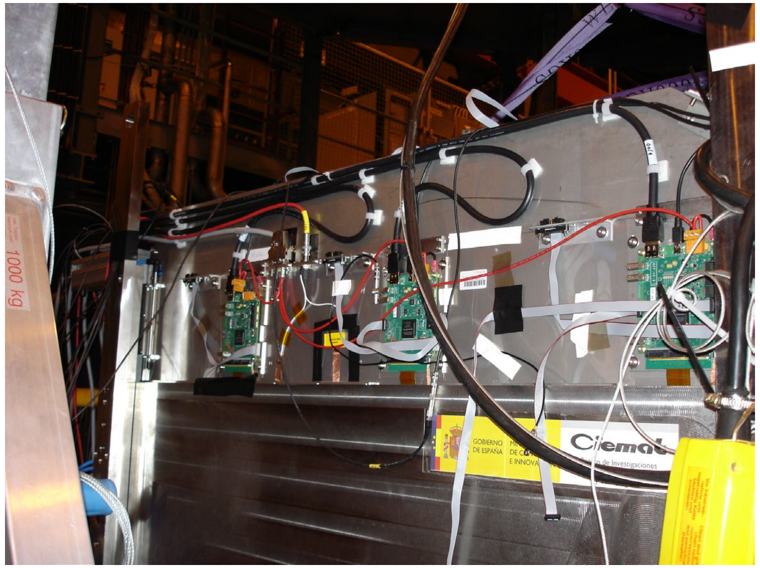
SDHCAL was developed inside CALICE Collaboration:

- **sampling calorimeter, i.e. stainless steel absorber alternated with single-gap glass resistive plate chambers**
- 48-50 layers (-6λ_I); ~1.3m^3 prototype
- 1 cm x 1 cm readout granularity with pads; ~450k channels (more than full CMS calorimeter system a;ready …)
- 3-threshold readout with 64-ch HARDROC ASICs
- Triggerless DAQ system using power-pulsing scheme tailored to ILC (to be modified for FCCee)
- Self-supporting mechanical structure made with stainless steel plates
- Collaborators mainly from France, Spain, Belgium, Korea, China



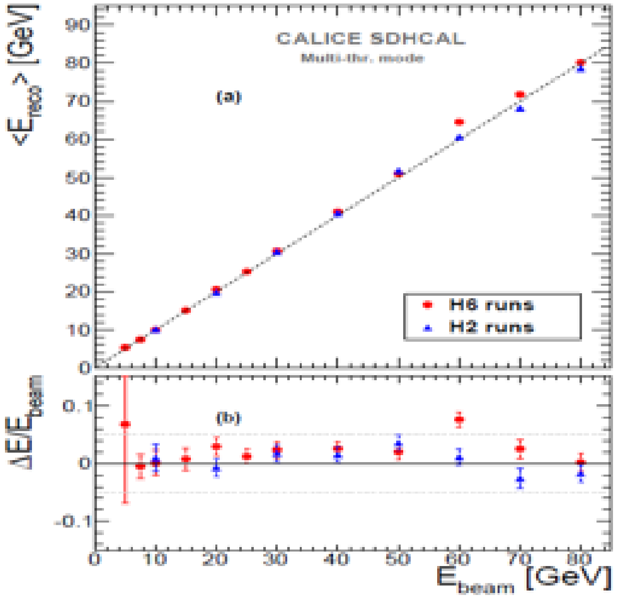
M. Tytgat
member of CALICE SDHCAL
since 2009

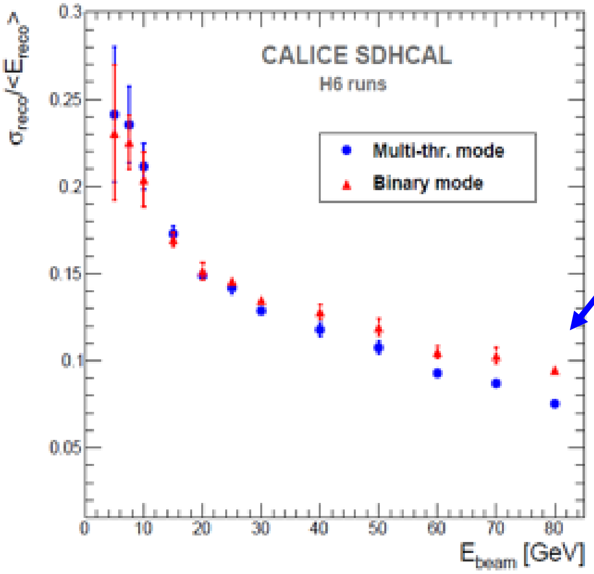




SDHCAL performance

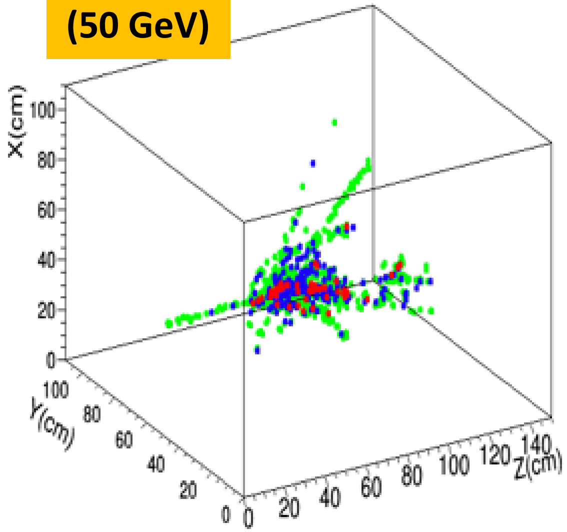
Initial beam tests with small gRPCs in 2009; SDHCAL prototype was exposed to beam particles at CERN PS, SPS in 2012, 2015, 2017,2018 and 2022

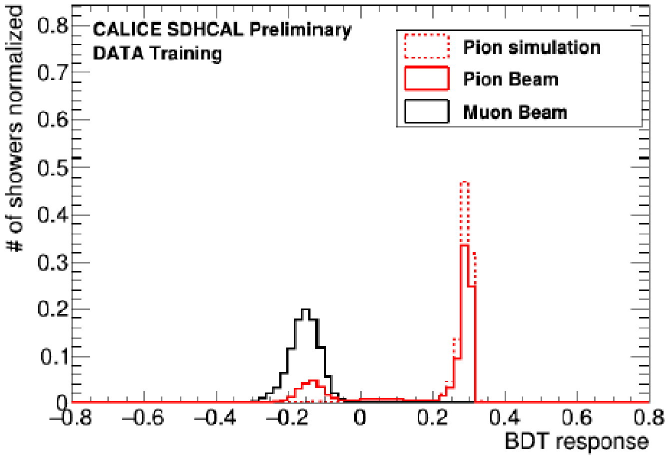


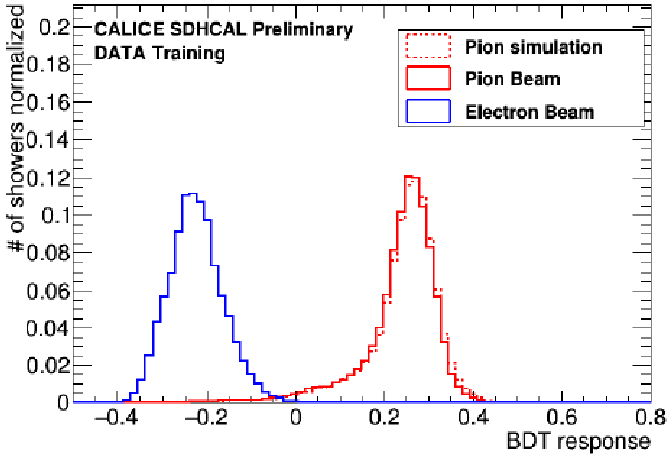


multi-threshold mode (semi-digital) does help at high energy !

Pion (50 GeV)

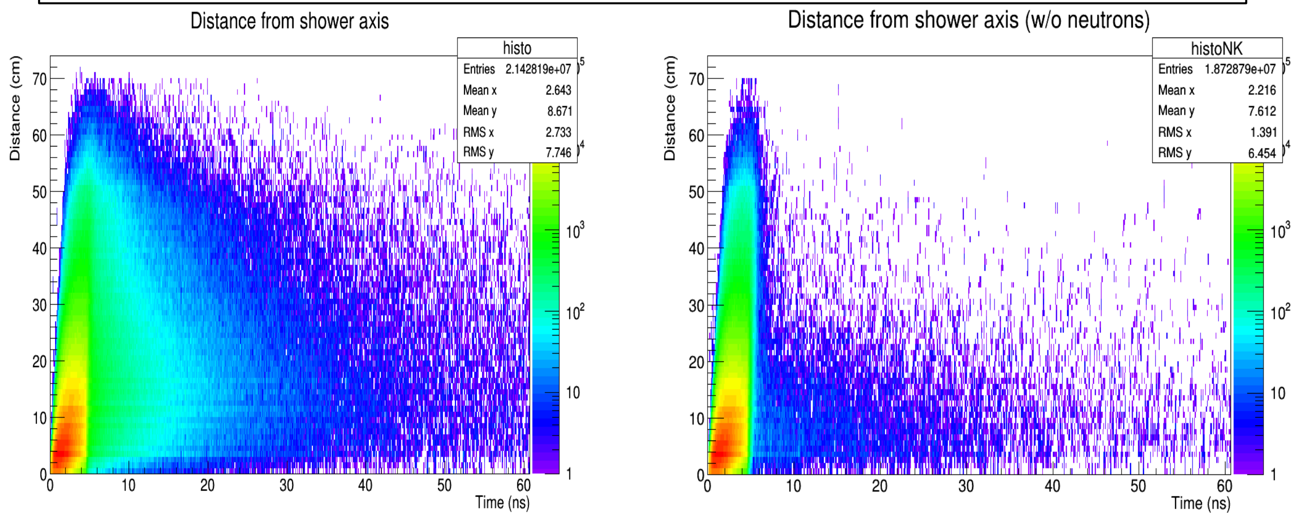






Timing-SDHCAL

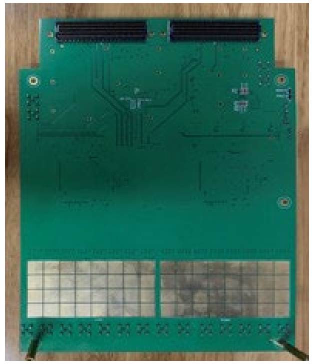
Separate delayed neutrons for better energy reconstruction

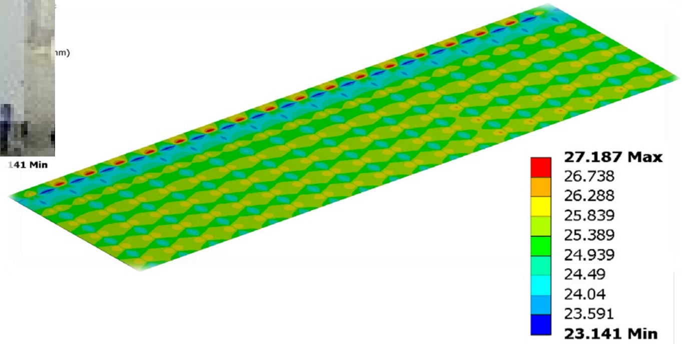


Next step: **Timing-SDHCAL (5D calorimetry)**, i.e. timing capabilities of calorimeter systems open up new possibilities for TOF, LLP, shower reconstruction …; hadronic showers show a complex time structure, with late components connected to neutron-induced processes; e.g. 100ps timing precision could aid in shower energy reconstruction and shower separation

→ replace single-gap RPCs in SDHCAL with **advanced 100ps multi-gap RPCs**; R&D on:

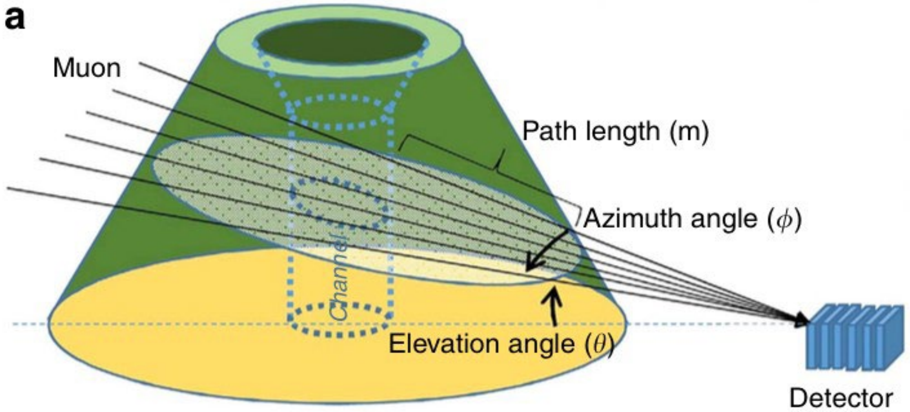
- large-area detectors for ILD-like concept
- optimization of timing precision, rate capability (new materials ?)
- new front-end electronics, i.e. high time precision + continuous readout for circular colliders
- new detector cooling system

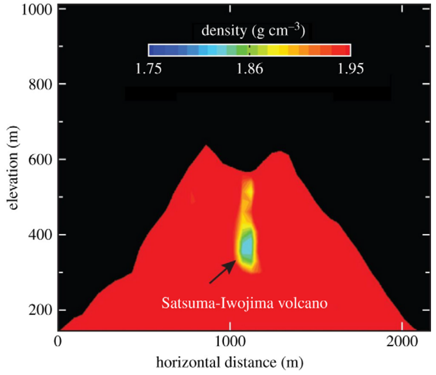


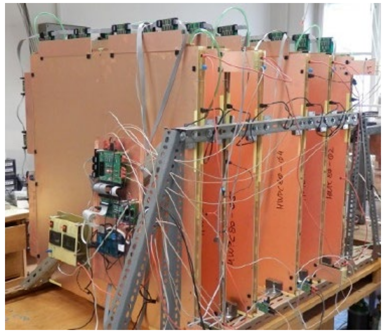


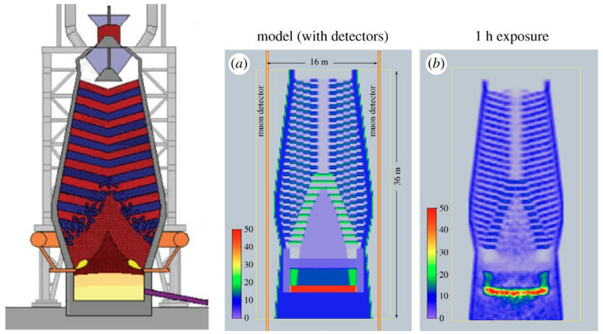
Muon Radiography

Principle: measuring the differential **attenuation of the muon flux as a function of the amount of material crossed along different directions**, allows to determine the density distribution of the interior of a large object









Comparison of measured muon transmission spectra with free sky muon data or Monte Carlo simulations; model/contours of object needed to determine traversed muon path length, e.g. Digital Terrain Model

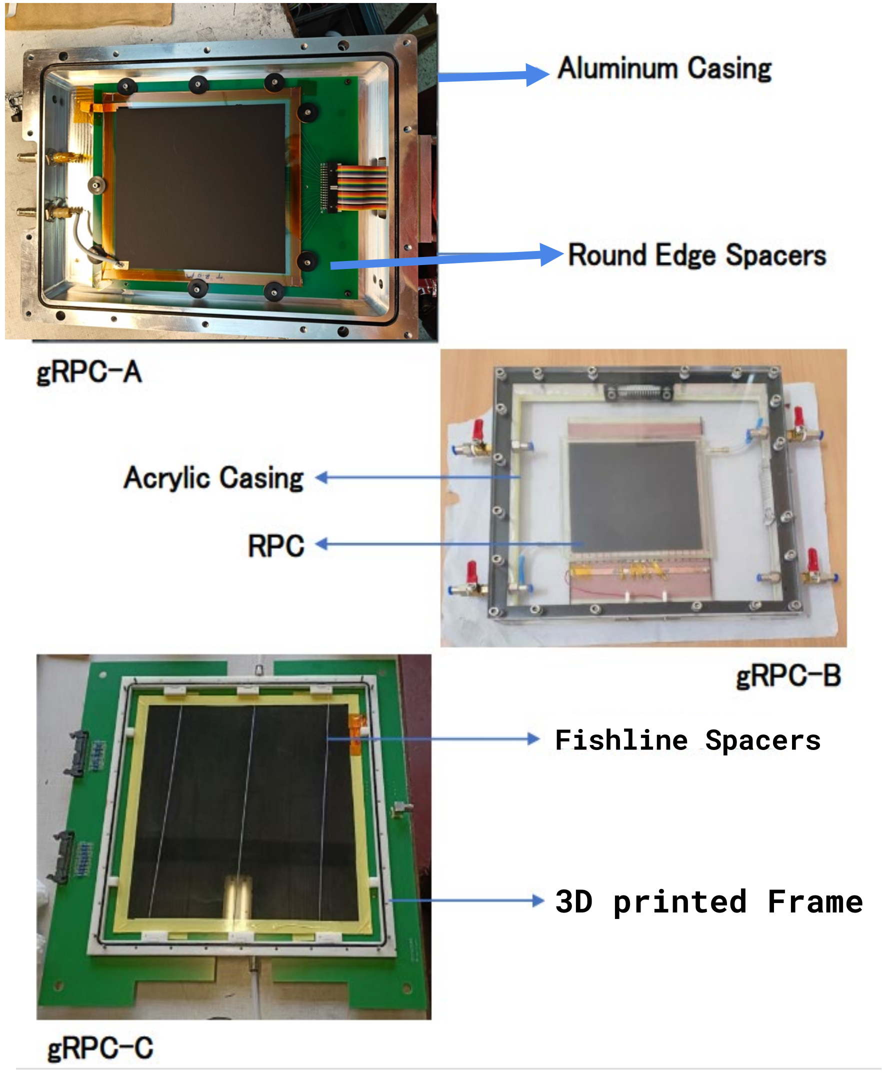
A low density region, in particular a cavity, shows up in the data as an excess in the muon Transmission data, while high density region will cause deficit; 3D information when using multiple viewpoints

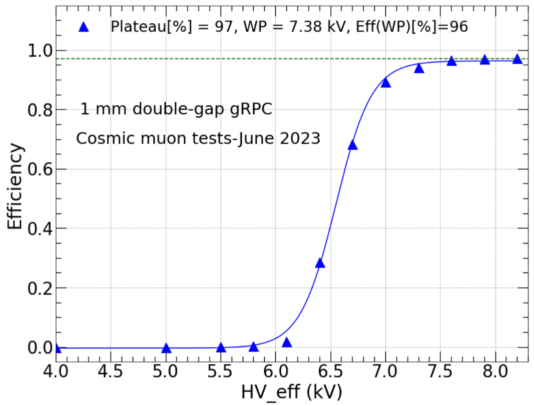
- Requires a muon telescope, i.e. multiple layers of position sensitive muon detectors
- Common detector technologies:
  - Plastic scintillators
  - Nuclear emulsions
  - Gaseous detectors (MWPC, Micromegas, RPC …)
- **HEP technology for the benefit of society**

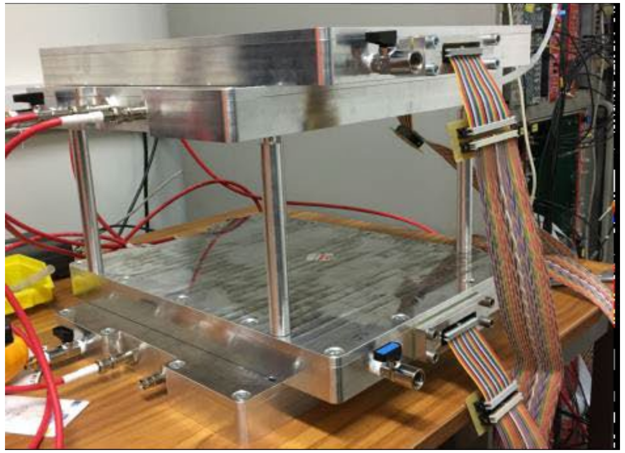
Portable Muoscope Project

Develop a **general-purpose, portable gaseous detector based muon telescope for muography applications in confined/remote environments** (geology, archaeology, civil engineering, and industrial safety ...):

- glass-RPC based detector
- design featured by compactness, portability, robustness, autonomous operation, low power consumption, gas tightness, modular geometry …
- Collaborators from Belgium & India





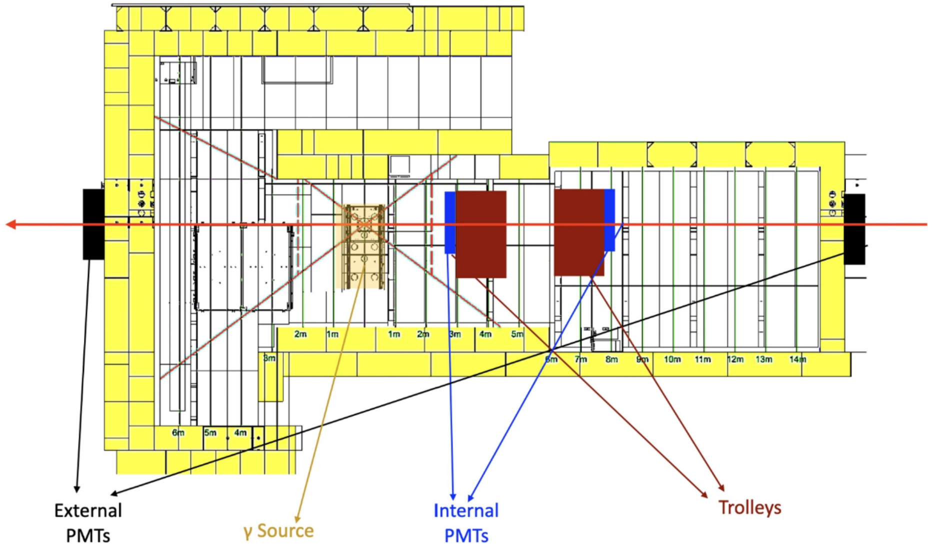


A. Giammanco, E. Cortina, M. Tytgat
since 2017

RPC ecogas studies

Standard RPC gas mixture, $C_2H_2F_4$ (~95%)/ C_4H_{10} / SF_6 needs to be revised due to European restrictions on greenhouse gases (high GWP gases)

Gas	GWP* values 100-year time horizon
CO_2	1
CH_2FCF_3	1430
SF_6	22800



Non-trivial problem since gases are the heart of gas-filled detectors …
Need to:

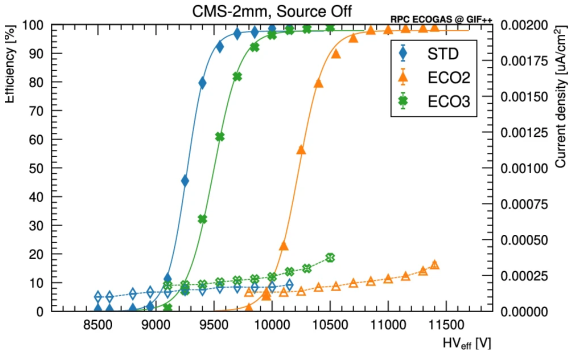
- achieve same performance as with standard mixtures
- not to change the electronics and HV for existing systems (e.g. LHC)
- study ageing effects to ensure long-term stable operation

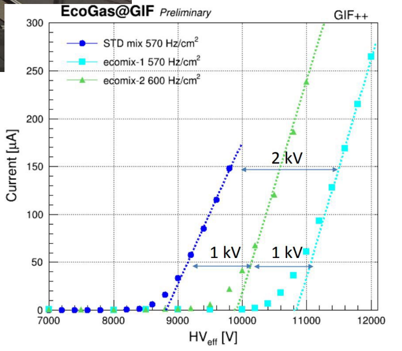
Current common scenario:

$C_2H_2F_4$ (GWP=1430)→ $C_3H_2F_4$ze (GWP=4) + CO_2 (GWP=1) or He

RPC EcoGas@GIF++ Collaboration (since 2018, with members from ALICE, ATLAS, CERN EP-DT, CMS and LHCb) perform aging tests of potential candidates of eco-friendly gas mixtures with different detectors and electronics:

- 12.5 TBq ^{137}Cs source to generate background (high rate) and accelerate aging processes
- 100 GeV muon beam to assess detector performance





M. Tytgat since 2018

Belgium in the DRDs

DRD1- Gaseous Detectors

- Most advanced collaboration in terms of organization and activities
- Initial period 2024-2026; collaboration and management have been implemented in 2024; MoU about to be signed soon

Gaseous

DRDT 1.1 Improve time and spatial resolution for gaseous detectors with long-term stability

DRDT 1.2 Achieve tracking in gaseous detectors with dE/dx and dN/dx capability in large volumes with very low material budget and different read-out schemes

DRDT 1.3 Develop environmentally friendly gaseous detectors for very large areas with high-rate capability

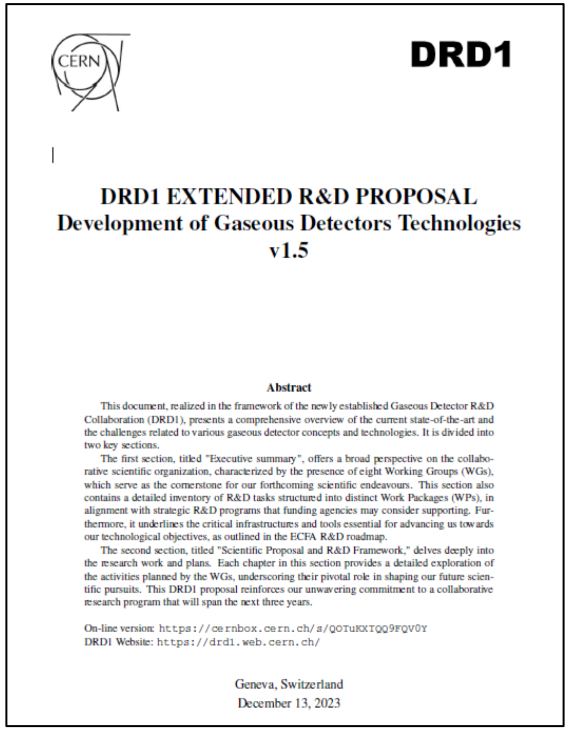
DRDT 1.4 Achieve high sensitivity in both low and high-pressure TPCs

DRDTs

Work Packages	1.1	1.2	1.3	1.4
Trackers/hodoscopes	●		●	
Drift chambers	●	●	●	
Straw chambers	●	●	●	
Tracking TPCs	●	●	●	●
Calorimetry	●		●	
Photon detection (PID)	●	●	●	
Timing detectors	●		●	
Reaction/decay TPCs	●	●	●	●
Beyond HEP	●		●	

Forum for discussion on common topics

- WG1: Technologies
- WG2: Applications
- WG3: Gas and material studies
- WG4: Detector physics, simulations and software tools
- WG5: Electronics for gaseous detectors
- WG6: Detector production
- WG7: Common test facilities
- WG8: Training and dissemination


DRD1

DRD1 EXTENDED R&D PROPOSAL
Development of Gaseous Detectors Technologies
v1.5

Abstract

This document, realized in the framework of the newly established Gaseous Detector R&D Collaboration (DRD1), presents a comprehensive overview of the current state-of-the-art and the challenges related to various gaseous detector concepts and technologies. It is divided into two key sections.

The first section, titled "Executive summary", offers a broad perspective on the collaborative scientific organization, characterized by the presence of eight Working Groups (WGs), which serve as the cornerstone for our forthcoming scientific endeavours. This section also contains a detailed inventory of R&D tasks structured into distinct Work Packages (WPs), in alignment with strategic R&D programs that funding agencies may consider supporting. Furthermore, it underlines the critical infrastructures and tools essential for advancing us towards our technological objectives, as outlined in the ECFA R&D roadmap.

The second section, titled "Scientific Proposal and R&D Framework," delves deeply into the research work and plans. Each chapter in this section provides a detailed exploration of the activities planned by the WGs, underscoring their pivotal role in shaping our future scientific pursuits. This DRD1 proposal reinforces our unwavering commitment to a collaborative research program that will span the next three years.

On-line version: https://cernbox.cern.ch/s/QOTuKXTQQ9FQV0Y
DRD1 Website: https://drd1.web.cern.ch/

Geneva, Switzerland
December 13, 2023

https://cds.cern.ch/record/2885937

Large community of ~170 institutes from 33 countries

https://drd1.web.cern.ch/
https://indico.cern.ch/category/17385/

DRD6 - Calorimetry

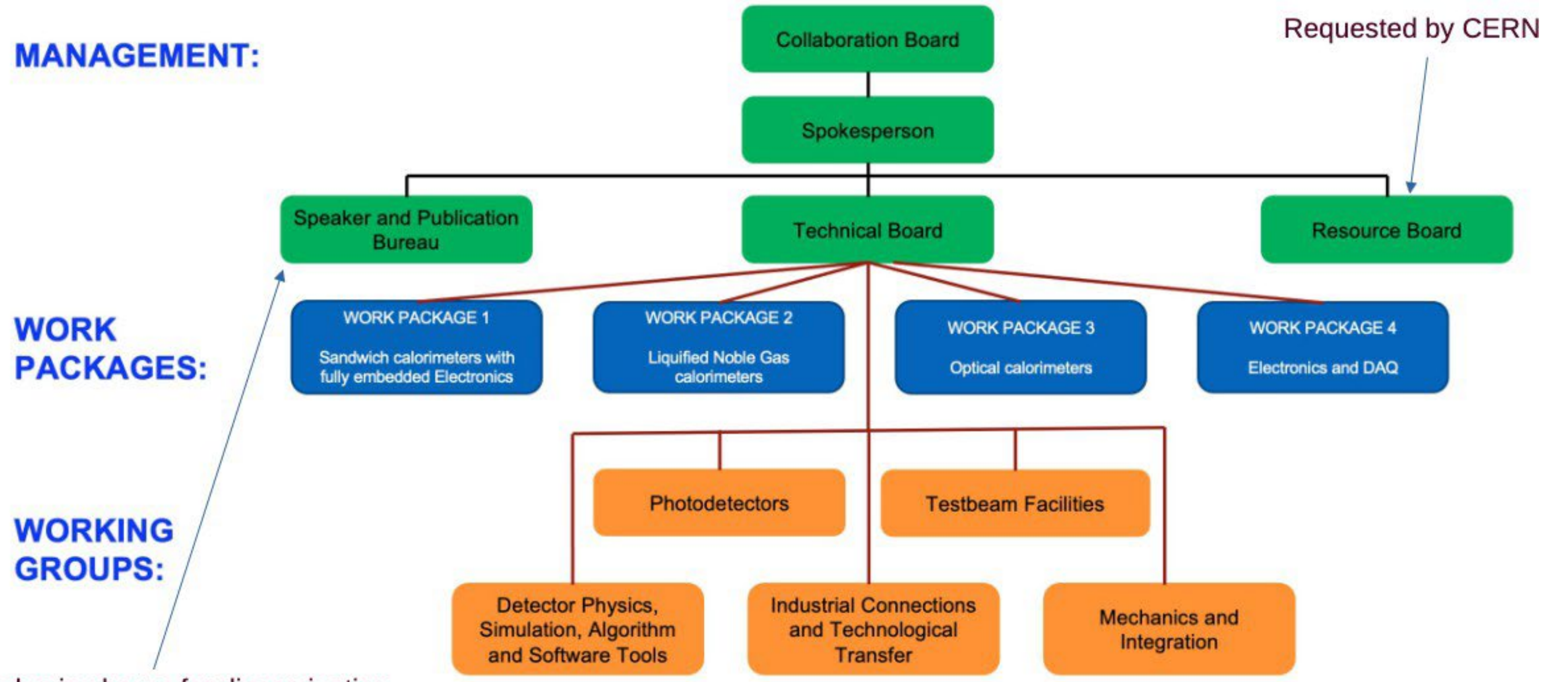
- Initial period 2024-2026; collaboration and management have been implemented in 2024; MoU about to be signed soon

Calorimetry

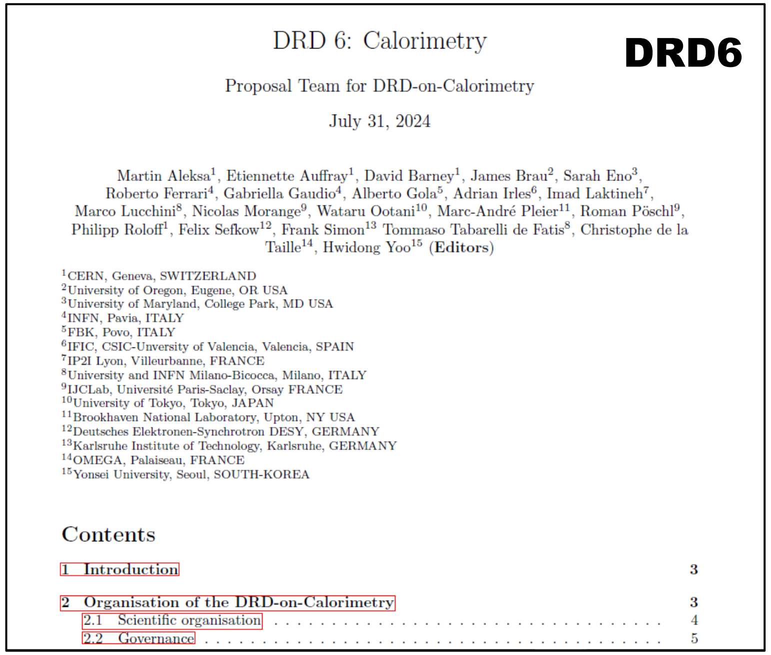
DRDT 6.1 Develop radiation-hard calorimeters with enhanced electromagnetic energy and timing resolution

DRDT 6.2 Develop high-granular calorimeters with multi-dimensional readout for optimised use of particle flow methods

DRDT 6.3 Develop calorimeters for extreme radiation, rate and pile-up environments



*SPB also in charge for dissemination



DRD 6: Calorimetry

DRD6

Proposal Team for DRD-on-Calorimetry

July 31, 2024

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[8]University and INFN Milano-Bicocca, Milano, ITALY
[9]IJCLab, Université Paris-Saclay, Orsay FRANCE
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2.2 Governance 5

https://cds.cern.ch/record/2886494

Community of ~130 institutes

https://indico.cern.ch/category/17390/

Belgian involvement in DRDs

DRD1 (→ VUB, UCLouvain, UGent and ULB)

- Management: M. Tytgat member of Management Board; co-convenor of WG1
- Specific activities (i.e. our interest is larger than what we can do …)
  - WG1: Technological Aspects and Developments of New Detector Structures, Common Characterization and Physics Issues → general interest to all
  - WG2: Applications / Work Packages
    → Trackers/hodoscopes/large area systems (VUB: RPC)
    → Calorimetry (VUB: large area systems, timing in calorimetry)
    → Timing detectors (VUB: MRPC)
    → Beyond-HEP in muography, medical applications, neutron science …
    (VUB, UCLouvain:outdoor detectors, portability, low power …)
  - WG3: Gas and Material studies
    → gas properties, gas systems, novel materials … (UGent: RPC; VUB: EcoGas@GIF++)
  - WG4: Detector physics, simulation and software tools
    → Garfield++ (UGent: running on GPU)
  - WG5: Electronics for Gaseous Detectors → ULB
  - WG6: Detector production
  - WG7: Collaboration Laboratories and Facilities
    → Test Beam Common Facilities (all)
  - WG8: Knowledge Transfer, Training, Career

Belgian involvement in DRDs

DRD6 (→ VUB)

- Specific activities:
  - WP1 on Sandwich calorimeters with fully embedded electronics
    - → Highly pixelised electromagnetic section
    - → Hadronic section with optical tiles
    - → Hadronic section with gaseous readout (VUB: (T-)SDHCAL)
  - WP2 on Liquified Noble Gas calorimeters
  - WP3 on Optical calorimeters
  - WP4 on Electronics and Readout

  - Working Groups on
    - Photodetectors
    - Test beams and infrastructure
    - Detector physics, simulation, algorithms, software tools
    - Tech transfer
    - Mechanics and integration

Belgian input on DRDs to ESPP Update ?

- DRDs may (at least DRD1 will) submit their own input to the Strategy Update process
- Suggestion to include summary of DRD activities in our national input, and express our support to the continuation of DRD collaborations
- Belgium currently involved in
  - DRD1 on gaseous detectors (UCLouvain, UGent, ULB & VUB)
  - DRD6 on calorimetry (VUB)
  - Other DRDs in future ?

BACKUP

General Strategic Recommendations

The General Strategic Recommendations (GSR) topics are:

- GSR 1: Supporting R&D facilities (**test beams, large-scale generic prototyping and irradiation)**
- GSR 2: **Engineering support** for detector R&D
- GSR 3: Specific **software** for instrumentation
- GSR 4: **International coordination** and organisation of R&D activities
- GSR 5: Distributed R&D activities with **centralised facilities**
- GSR 6: Establish long-term strategic **funding programmes**
- GSR 7: "**Blue-sky**" R&D
- GSR 8: Attract, nurture, recognise and sustain the **careers of R&D experts**
- GSR 9: **Industrial** partnerships
- GSR 10: **Open Science**

DRD MoU template

- CERN provides templates for the Memorandum of Understanding
  - ✦ To be in agreement with CERN's *General Conditions for the execution of experiments*, legal service, KT office
  - ✦ Should be almost identical for all DRD collaborations
- Main MoU (previously called "lightweight") is the only one which is physically/electronically **signed by each collaborating institution/Funding Agencies**; Contains: Obligations of CERN as host laboratory, industrial involvements, common fund, definitions:
  - ✦ **Working Groups** shall reflect the internal structure of the Collaboration. They are expected to be long-lasting
  - ✦ **Work Packages** shall reflect time-limited resource-loaded activities with clearly defined **objectives** and **deliverables**
- Annexes: everything that can change over time
  - ✦ Does not necessarily need a physical signature by funding agencies, but agreement/vote at finance committee meeting (with representatives of funding agencies)
- Status: First draft of MoU Template is available for CERN-internal review (legal service, DRC,…)

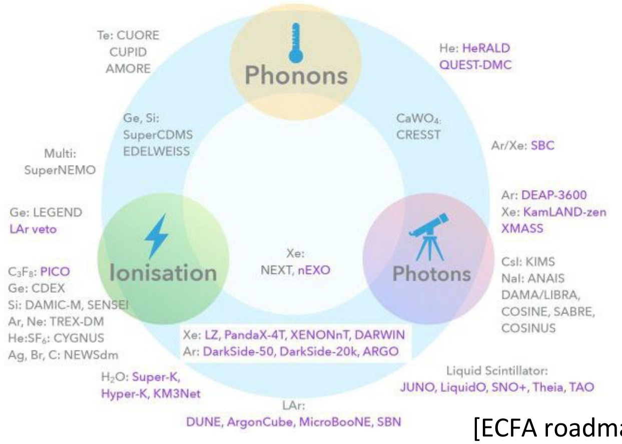
- Annex 1: Collaborating Institutions and their Contact Persons
- Annex 2: Funding Agencies and their Representatives
- Annex 3: Organisational Structure of the Collaboration
- Annex 4: Financial Participation of the Funding Agencies
- Annex 5: Working Groups
- Annex 6: Work Packages and their sub-units ("work units")
- Annex 7: Background IP
- Annex 8: CERN General Conditions Applicable to Experiments

DRD2: Liquid Detectors

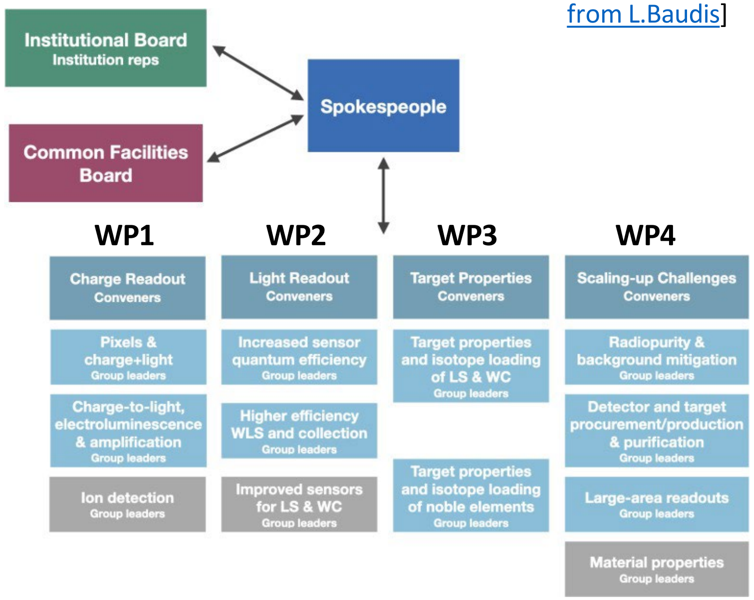
- Covers **Dark Matter** and **Neutrino** experiments, accelerator and non-accelerator-based
- Several large-scale and many small-scale experiments running or foreseen with liquid detectors
- Technology: Noble Liquids (e.g. DUNE), Water Cherenkov (e.g. Super/Hyper-K) and Liquid Scintillator with light and ionization readout
- Underground Dark Matter Experiments – small and rare signals R&D for multi-ton scale noble liquids:
  - ✦ Target doping and purification
  - ✦ Detector components radiopurity and background mitigation
- **Feb. 5-7, '24: inaugural DRD2 Collaboration Meeting at CERN** https://indico.cern.ch/event/1367848/
  - ✦ Exciting scientific programme! 156 participants, 91 contributed talks, from 71 institutes ,in 15 countries
  - ✦ Governance working group plan for definition of Collaboration Board (CB) and call for CB chair nominations
- CB Board chair election 1 March 2024 resulted in CB board chair W. Bonivento

Liquid

DRDT 2.1	Develop readout technology to increase spatial and energy resolution for liquid detectors
DRDT 2.2	Advance noise reduction in liquid detectors to lower signal energy thresholds
DRDT 2.3	Improve the material properties of target and detector components in liquid detectors
DRDT 2.4	Realise liquid detector technologies scalable for integration in large systems



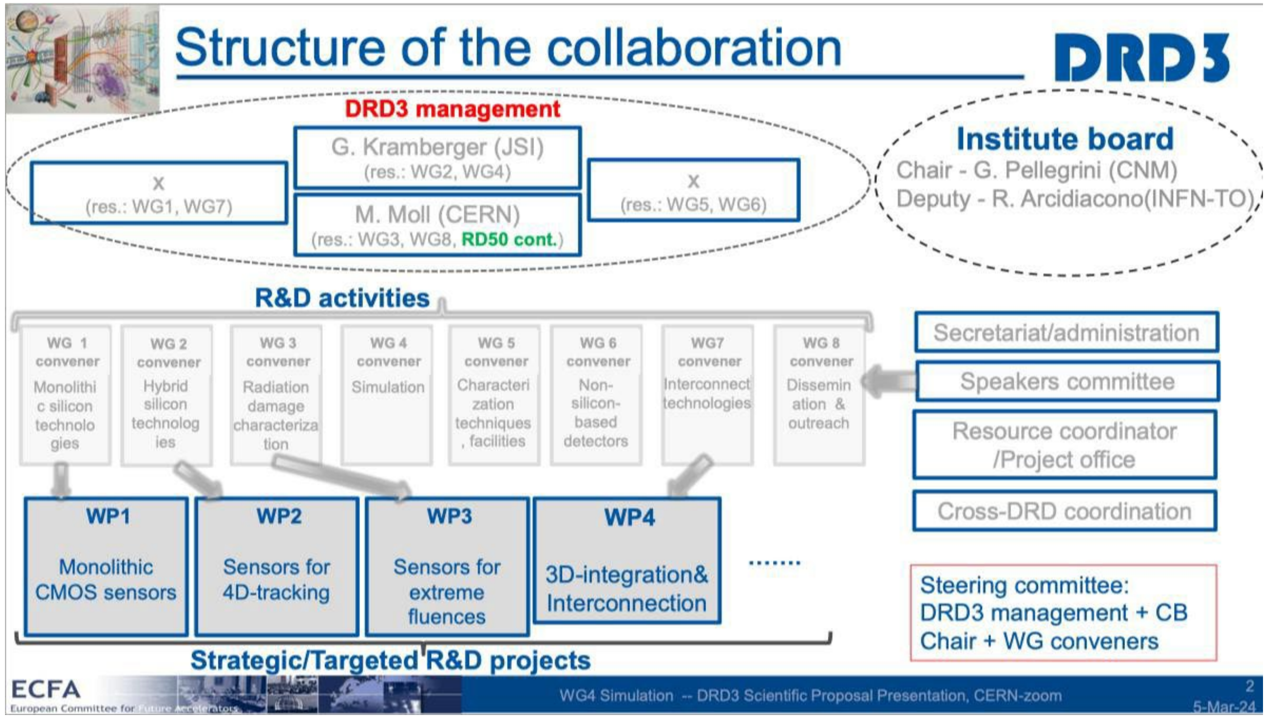
[ECFA roadmap, Modified from L.Baudis]



DRD3: Semiconductor Detectors

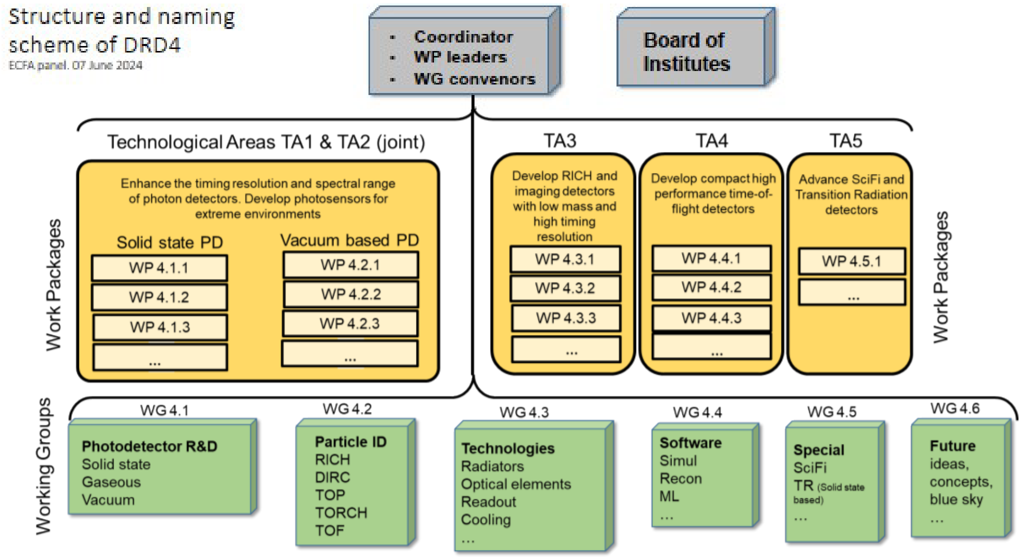
- DRD3 benefits from existing RD50 collaboration
  - ✦ Extended by diamonds (RD42) and 3D integration
  - ✦ Large interest in CMOS (DMAPS) sensors
- Large Collaboration: 132 institutes, 28 countries, ~900 interested people
  - ✦ ~ 70% are from Europe, 15% from North America,
  - ✦ Compare: RD50: 65 institutes and 434 members
- Budget:
  - ✦ ~5 MCHF/y (existing), ~8 MCHF/y (requested)
  - ✦ 327 FTE (existing), 170 FTE (requested)
- CB Board chair elected: Giulio Pellegrini (CNM Spain), deputy Roberta Arcidiacono (INFN Torino) nominated
- Spokesperson elected: Gregor Kramberger (JSI Slovenia)
- Main work is planned to be performed in Working Groups, WP not yet well integrated, but they plan to call for WP projects

Solid state		
	DRDT 3.1	Achieve full integration of sensing and microelectronics in monolithic CMOS pixel sensors
	DRDT 3.2	Develop solid state sensors with 4D-capabilities for tracking and calorimetry
	DRDT 3.3	Extend capabilities of solid state sensors to operate at extreme fluences
	DRDT 3.4	Develop full 3D-interconnection technologies for solid state devices in particle physics



DRD4: Photodetectors & Particle ID

- **Developments** on PMTs, MCP-PMTs, SiPMs, APD, HPD, quantum devices, SciFi,
    - ✦ Challenges for example for SiPMs: rad hard, dark rate, timing
- **Applications** in Ring Imaging Cherenkov Detectors (RICH), Time-of-Flight (ToF), TRD
- Connection to almost every other DRD collab. (gas, Silicon, Calo, electronics, SiPM at cryogenic temp.)
- **Collaboration**: 74 institutes from 19 countries, 7 (semi-) industrial partners
- **DRD4 constitutional meeting** happened at CERN (23-24 January): https://indico.cern.ch/event/1349233/
    - ✦ CB board chair: Guy Wilkinson
    - ✦ Spokespersons: Massimiliano Fiorini
    - ✦ Most WP/WG chairs were elected as well



PID and Photon	**DRDT 4.1**	Enhance the timing resolution and spectral range of photon detectors
	DRDT 4.2	Develop photosensors for extreme environments
	DRDT 4.3	Develop RICH and imaging detectors with low mass and high resolution timing
	DRDT 4.4	Develop compact high performance time-of-flight detectors

DRD5: Quantum Sensors

Quantum

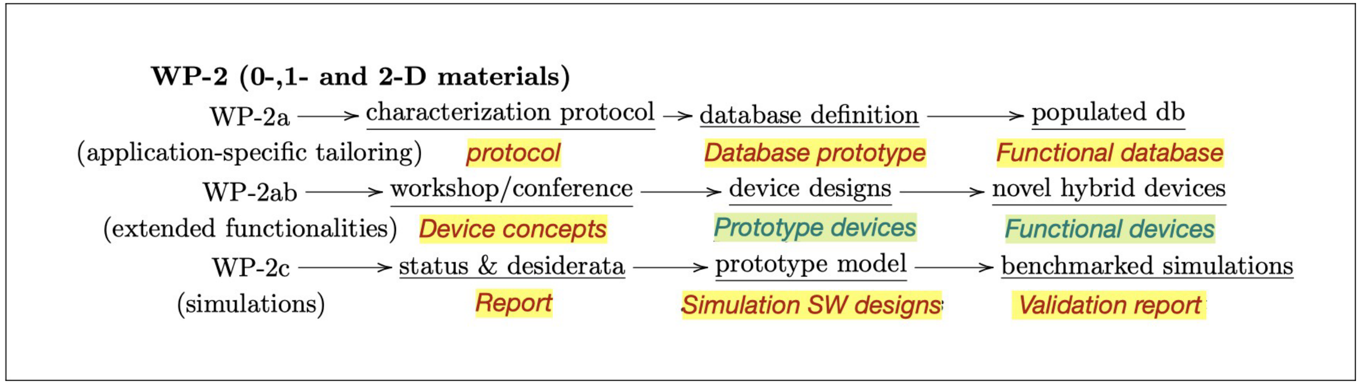
- **DRDT 5.1** Promote the development of advanced quantum sensing technologies
- **DRDT 5.2** Investigate and adapt state-of-the-art developments in quantum technologies to particle physics
- **DRDT 5.3** Establish the necessary frameworks and mechanisms to allow exploration of emerging technologies
- **DRDT 5.4** Develop and provide advanced enabling capabilities and infrastructure

- Quantum Technologies are a rapidly emerging area of technology development to study fundamental physics
  - ✦ development of HEP detectors on the long term
- Full proposal developed in the last year
  - ✦ Effort driven by Michael Doser (CERN) and Marcel Demarteau (Oak Ridge)
  - ✦ Two community workshops [link]
- Re-structured the Roadmap topics into WPs
  - ✦ Many reports and documents as deliverables, but this is in the nature of this proposal (early TRL)
- Draft proposal was submitted to DRDC end of February 2024 and sent to interested institutions; 67 signed up within two weeks
  - ✦ **Aim to be approved in June 2024**

Roadmap topics

Proposal WP's

Sensor family → / Work Package ↓	clocks & clock networks	superconducting & spin-based sensors	kinetic detectors	atoms / ions / molecules & atom interferometry	opto-mechanical sensors	nano-engineered / low-dimensional / materials
WP1 *Atomic, Nuclear and Molecular Systems in traps & beams*	X			X	(X)	
WP2 *Quantum Materials (0-, 1-, 2-D)*		(X)	(X)		X	X
WP3 *Quantum superconducting devices*		X				(X)
WP4 *Scaled-up massive ensembles* (spin-sensitive devices, hybrid devices, mechanical sensors)		X	(X)	X	(X)	X
WP5 *Quantum Techniques for Sensing*	X	X	X	X	X	
WP6 *Capacity expansion*	X	X	X	X	X	X



DRD7: Electronics

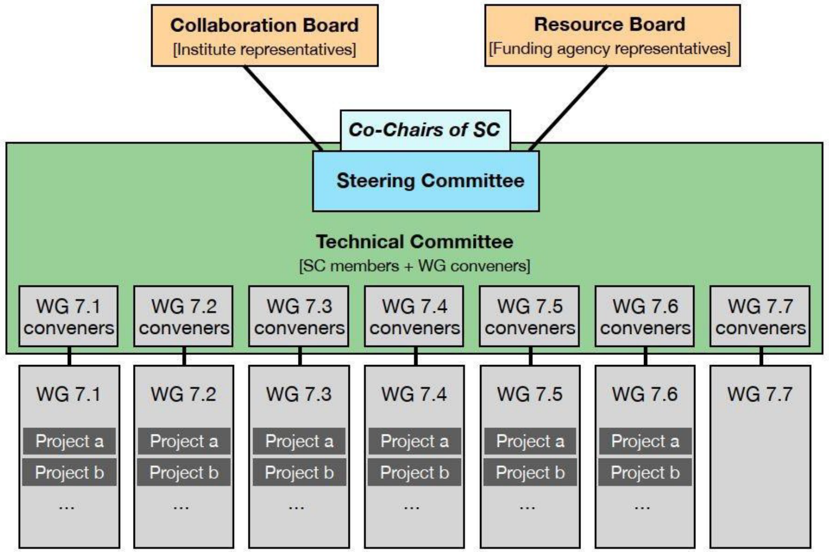
- Full proposal received by 29 February 2024; **aiming approval in June 2024**
- Objectives: Carry out strategic R&D in electronics, fulfilling DRDTs, Coordinate cross-European access to technologies, tools and knowledge, Interface with other DRDs
- Organization:
  - ✦ 19 countries, 68 institutes
  - ✦ Somehow CERN-centric at present, e.g. 9/19 WG conveners
  - ✦ 1st workshop happened in March, 2nd workshop 25-27 September 2023

Electronics

DRDT 7.1 Advance technologies to deal with greatly increased data density
DRDT 7.2 Develop technologies for increased intelligence on the detector
DRDT 7.3 Develop technologies in support of 4D- and 5D-techniques
DRDT 7.4 Develop novel technologies to cope with extreme environments and required longevity
DRDT 7.5 Evaluate and adapt to emerging electronics and data processing technologies

WG 7.6 Complex imaging ASICs and technologies

WG 7.7. Transversal Tools and Technologies



Nomenclature to be adapted

DRD8: Integration

- Initial TF convenors did not continue as proposal preparation team
- New proponents had to be searched for, which were found by the group around the "Forum on Tracker Mechanics" workshop organizers
- Community survey replied that there is an interest in going forward
- Community Meeting on December 6, 2023
- LoI received by end of February 2024 with the aim to write a full proposal by the end of this year
  - ✦ LoI does not cover all DRDTs, as they are quite diverse
  - ✦ Focus on vertex detector mechanics and cooling
  - ✦ 22 institutes in 7 countries, 32 FTE at the moment

Integration	**DRDT 8.1**	Develop novel magnet systems
	DRDT 8.2	Develop improved technologies and systems for cooling
	DRDT 8.3	Adapt novel materials to achieve ultralight, stable and high precision mechanical structures. Develop Machine Detector Interfaces.
	DRDT 8.4	Adapt and advance state-of-the-art systems in monitoring including environmental, radiation and beam aspects

Committee Members

ECFA Detector Panel (EDP):

- Co-chairs: ***Phil Allport*** *(Birmingham),* ***Didier Contardo*** *(Lyon)*
- Scientific secretary: *Doris Eckstein (DESY)*
- Gaseous Detectors: *Silvia Dalla Torre (Torino)*
- Liquid Detectors: ***Inés Gil Botella*** *(CIEMAT)*
- Solid State Detectors: *Doris Eckstein, Phil Allport*
- PID & Photon Detectors: ***Roger Forty*** *(CERN)*
- Quantum and emerging Technologies.: *Steven Hoekstra (Groningen)*
- Calorimetry: ***Laurent Serin*** *(IJCLab)*
- Electronics: *Valerio Re (Bergamo)*
- Ex Officio: *ECFA Chair (Paris Sphicas), ICFA Detector Panel (Ian Shipsey), DRDC chair (**Thomas Bergauer**), APPEC & NuPECC observers*

Detector R&D Committee (DRDC):

- ***Thomas Bergauer*** (HEPHY Vienna), Chairperson
- *Jan Troska* (CERN), scientific secretary
- *Stan Bentvelsen* (NIKHEF; LDG contact)
- *Shikma Bressler* (Weizmann)
- *Dimitry Budker* (Mainz)
- ***Roger Forty*** (CERN; RB contact)
- *Claudia Gemme* (INFN and U. Genoa)
- ***Inés Gil Botella*** (CIEMAT)
- *Petra Merkel* (Fermilab; US contact)
- *Mark Pesaresi* (Imperial College)
- ***Laurent Serin*** (IJCLab)
- Ex-officio: **P. Allport, D. Contardo** (EDP)

Names in bold in both committees

The Post HL-LHC Future ?