

# Towards DRD Calorimetry

## Introduction – Community Meeting

### TF6+ Task Force

Martin Aleksa, Etienne Auffray-Hillemanns, Dave Barney, Roberto Ferrari, Gabriella Gaudio, Roman Pöschl, Tommaso Tabarelli de Fatis, Felix Sefkow, Frank Simon

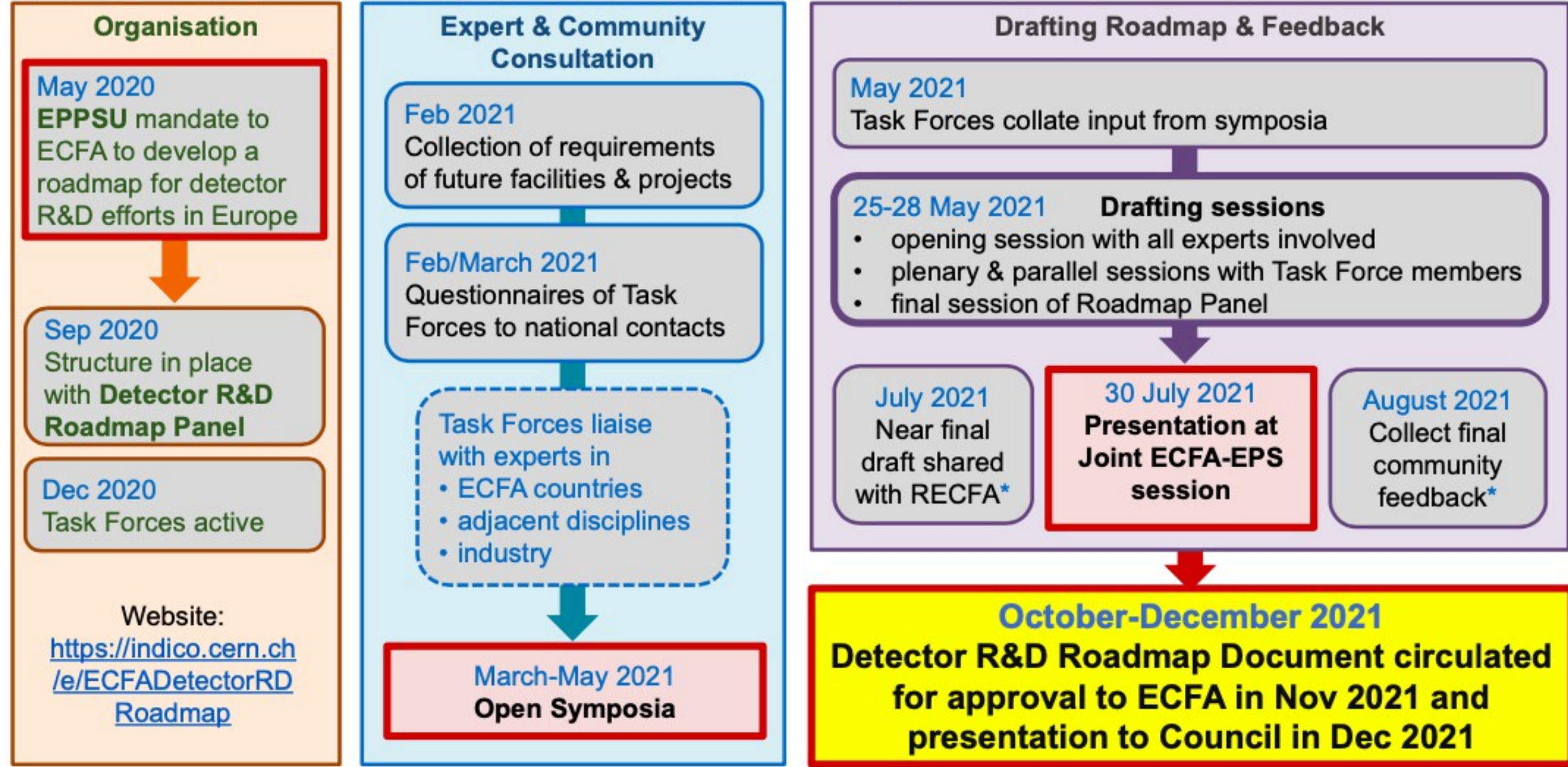
1<sup>st</sup> Calorimeter Community Meeting – January 2023

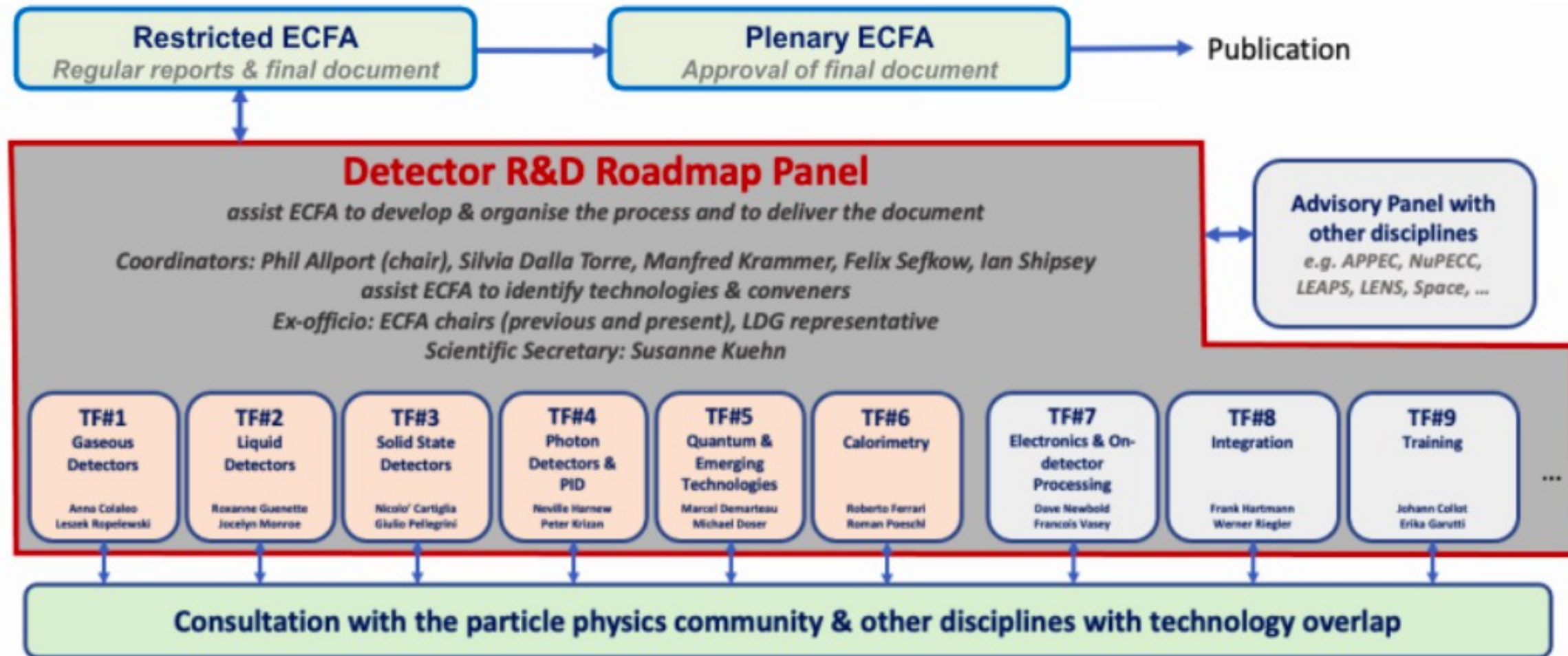
Many slides shown hereafter inspired by/stolen from talks by K. Jakobs, P. Allport and F. Sefkow

- Welcome to the Community Meeting
- Thanks to CERN for hosting us
- Thanks to the speakers for having agreed to the challenging task of introducing the plans of the different calorimeter “flavours”
- Thanks to you for your (active!) participation
  - 130 people from four regions registered for the meeting
- The purpose of the meeting is to remind on the roadmap process and to inform about the steps towards the formation of the **D**etector **R&D** (DRD) Collaborations
- Don't expect that everything is already settled and finally worked out today
- Your critical view, questions and comments about the process are very important
  - Bottom up process



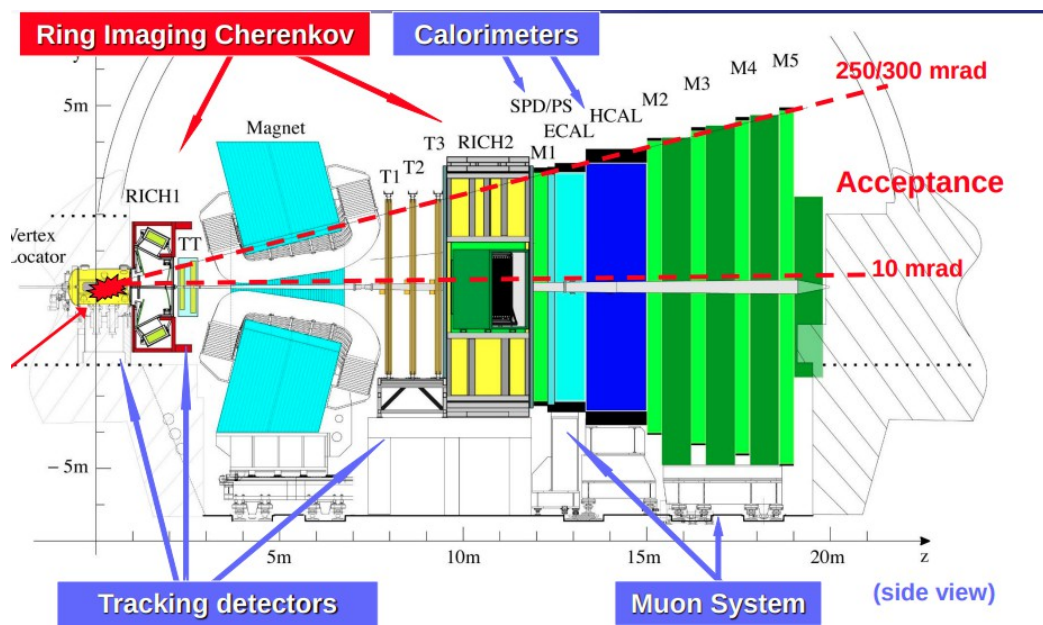
## Process and Timeline



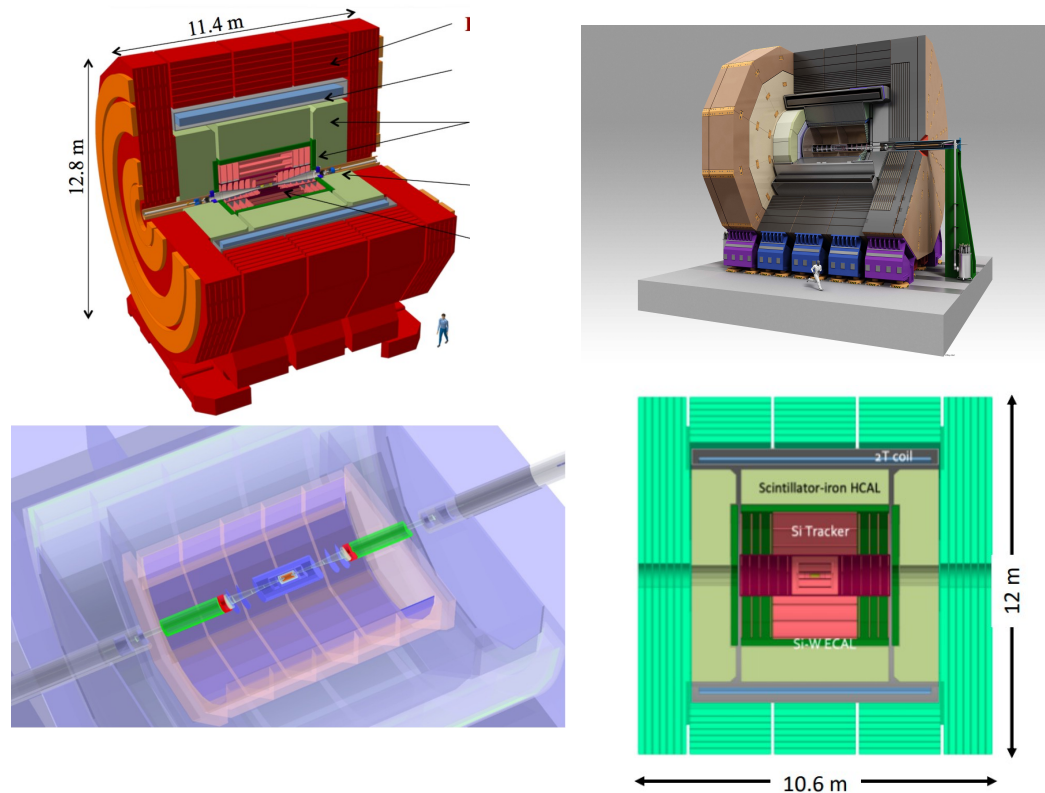


- 9 Taskforces including TF6 on Calorimetry
- Central events: Symposia
  - TF6 Symposium <https://indico.cern.ch/event/999820/>
- More on roadmap process <https://indico.cern.ch/event/957057/>

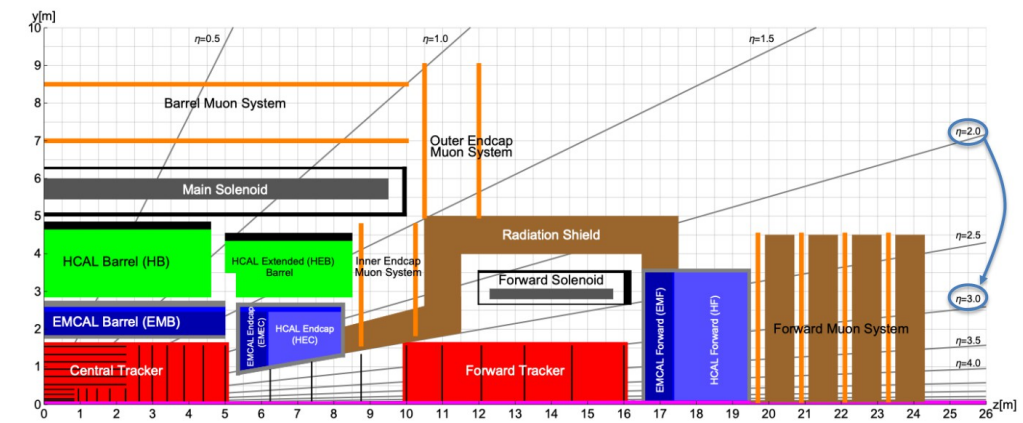
## HL-LHC after LS4



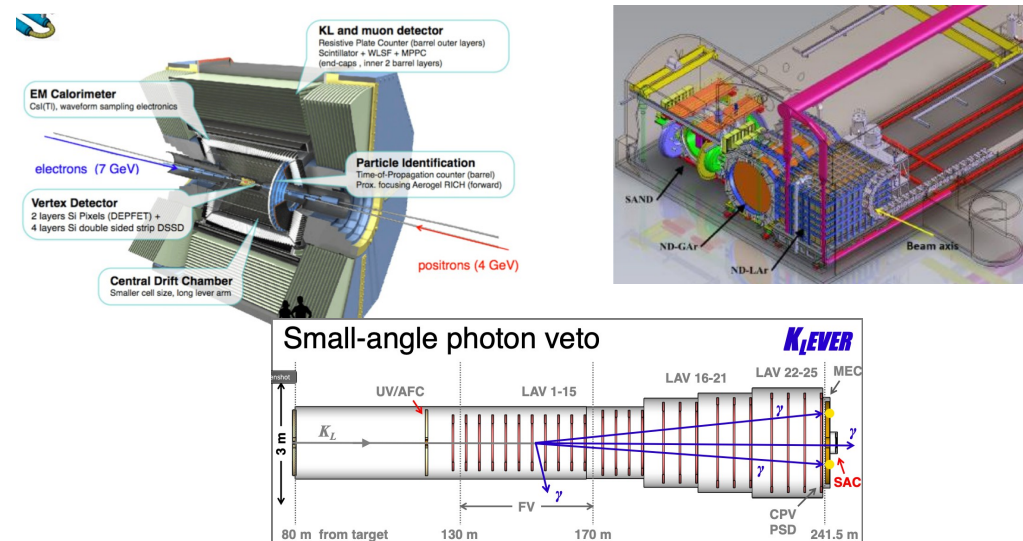
## Higgs Factories



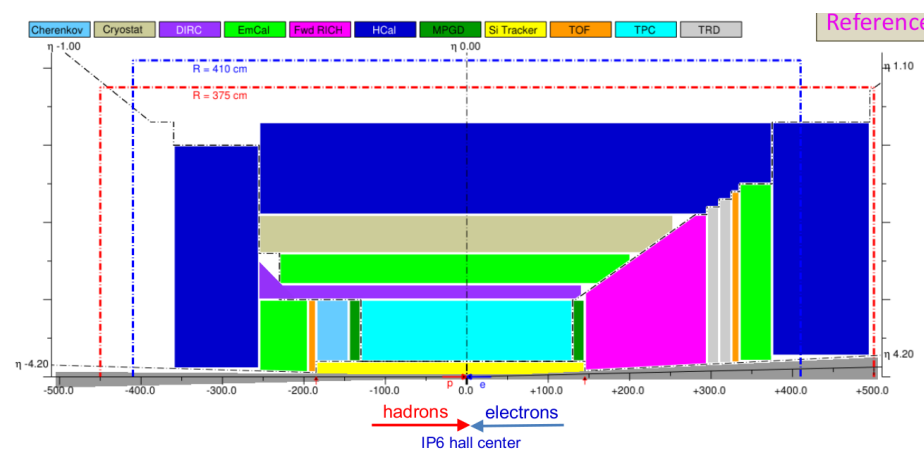
## Future hadron colliders (including eh colliders)



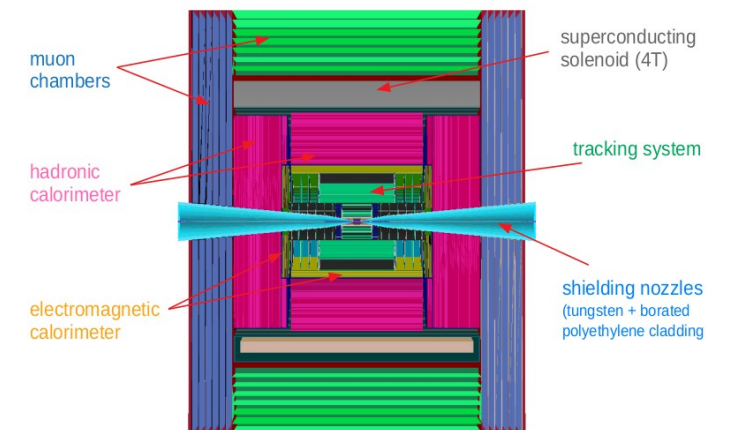
## SuperKEKB, DUNE ND and Fixed Target



## EiC



## Muon Collider



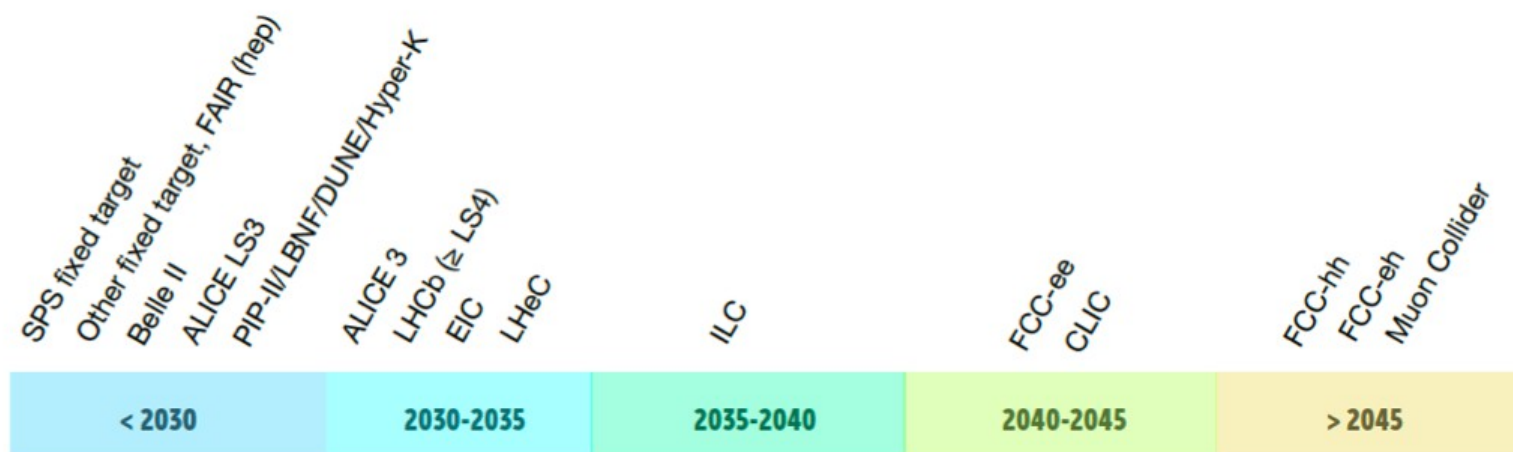
Project	~Earliest Start of data taking	Current Calorimeter options					
		Solid state	Scintilling tiles/strips	Crystals	Fibre based r/o (including DR)	Gaseous	Liquid Noble Gas
HL-LHC (>LS4)	2030			✓	✓		
SuperKEKb (>2030)	2030			✓			
ILC	2035	✓	✓			✓	
CLIC	2045	✓	✓				
CEPC	2035	✓	✓	✓	✓	✓	✓
FCC-ee	2045	✓	✓	✓	✓	✓	✓
EiC	2030		✓	✓	✓		
FCC-hh (eh)	>2050	✓	✓				✓
Muon Collider	> 2050	✓	✓	✓	✓	✓	
Fixed target	“continuous”		✓	✓	✓		✓
Neutrino Exp.	2030		✓				(✓)

In most of the cases final choices have still to be made

- **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) for each of the taskforce topics
  - 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**



GSR1- Supporting R&D facilities

GSR2- Engineering support for detector R&D

GSR3- Specific software for instrumentation

GSR4- International coordination and organisation of R&D activities

GSR5- Distributed R&D activities with centralised facilities

GSR6- Establish long-term strategic funding programmes

GSR7- 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

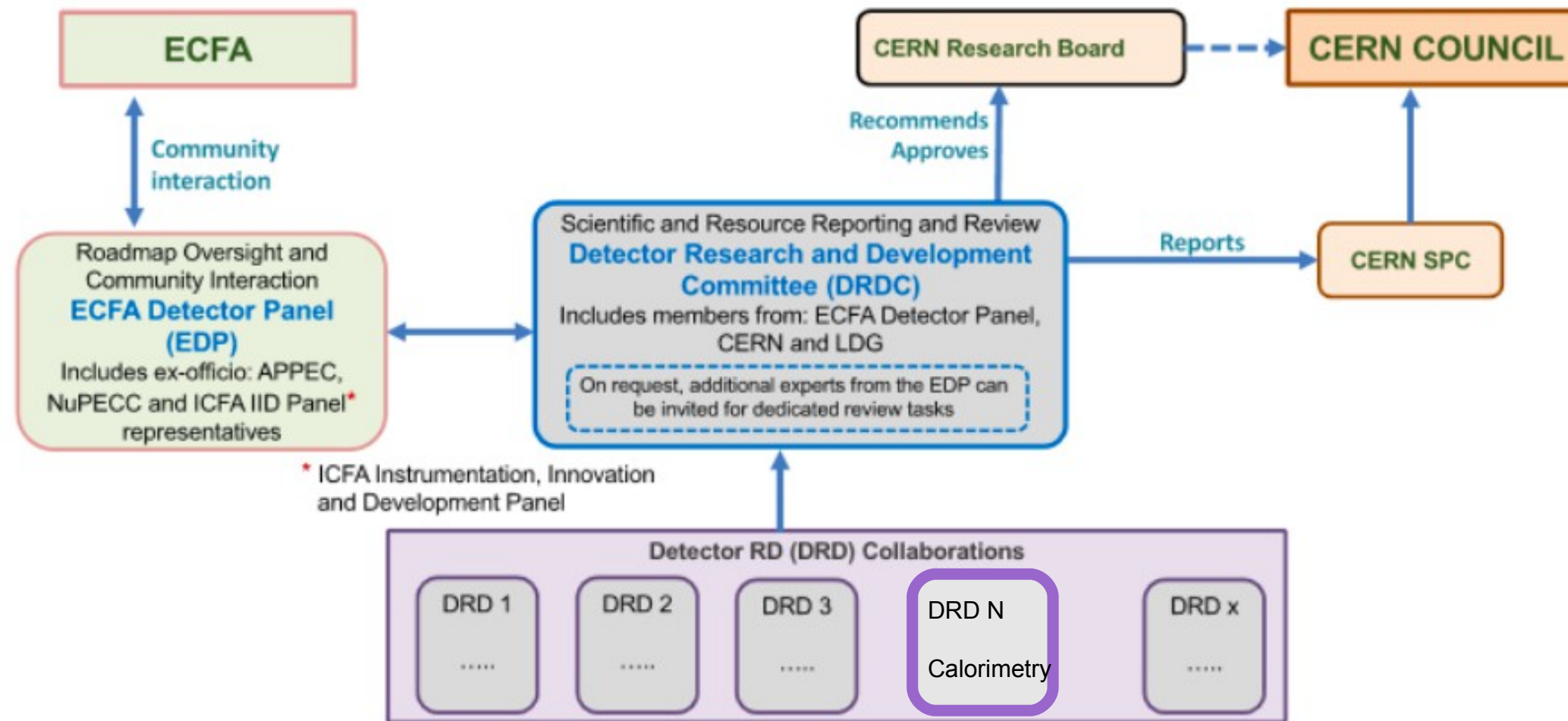


*In December 2021, ECFA was invited by CERN Council to elaborate, in close contact with the SPC, funding agencies and relevant research organisations in Europe and beyond, a **detailed implementation plan***

*Likewise, the European Lab Director Group (LDG) was mandated to work out an implementation plan for the **Accelerator R&D Roadmap***

*K. Jakobs, ECFA Meeting, November 2022*

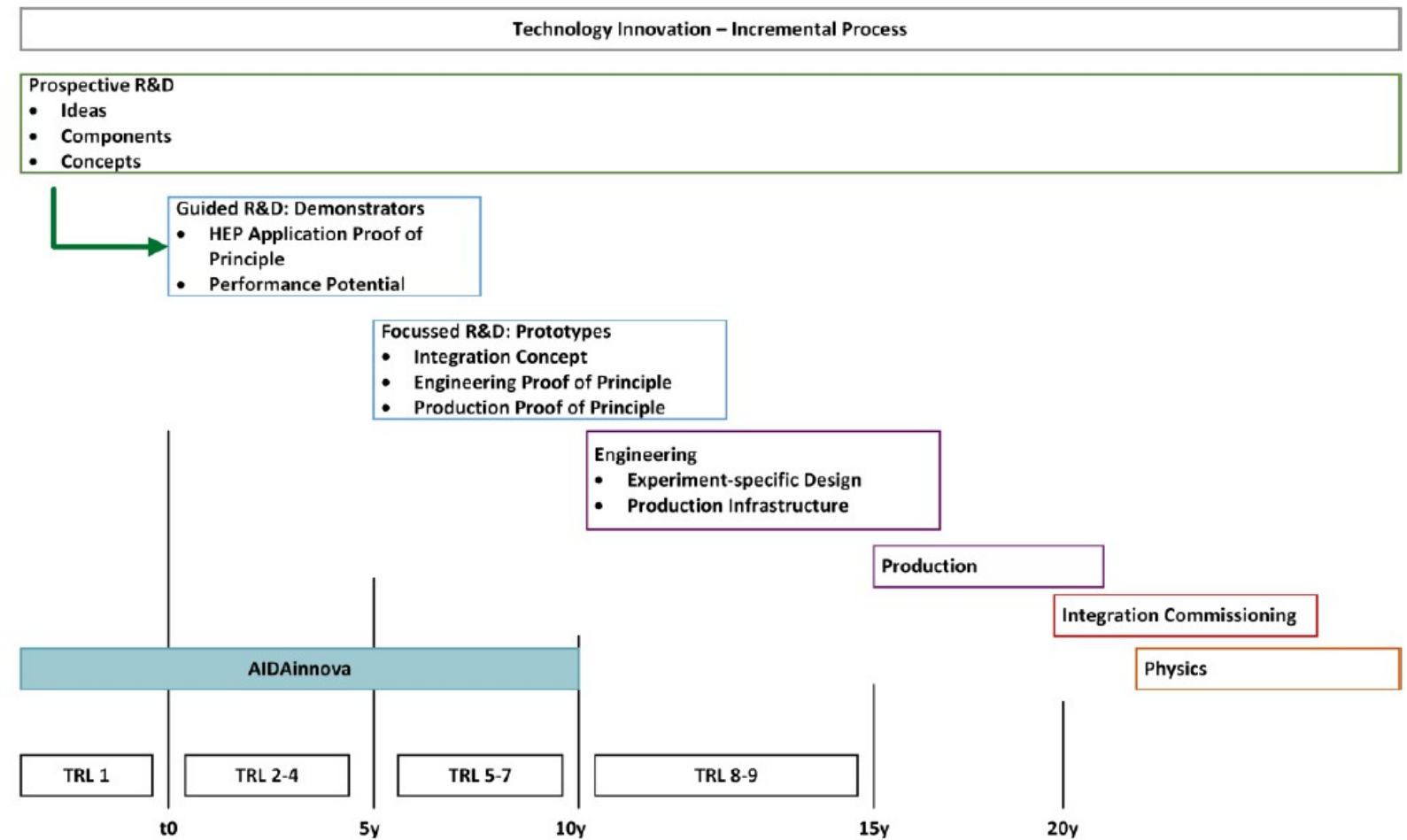
- ECFA Roadmap Coordination group has worked out a proposal
  - P. Allport, S. Dalla Torre, J. D'Hondt, K. Jakobs, M. Krammer, S. Kühn, F. Sefkow and I. Shipsey
- Proposal went through discussions with RECFA, National ECFA Contacts, CERN SPS and Council as well as with existing R&D Collaborations
- Document sent to and endorsed by CERN Council in September 2022 (CERN/SPC/1190)
- Main outcomes are the organization of the Detector R&D in form of DRD Collaborations, the overall Organisation of the detector R&D and an outline of the way towards the formation of the DRD



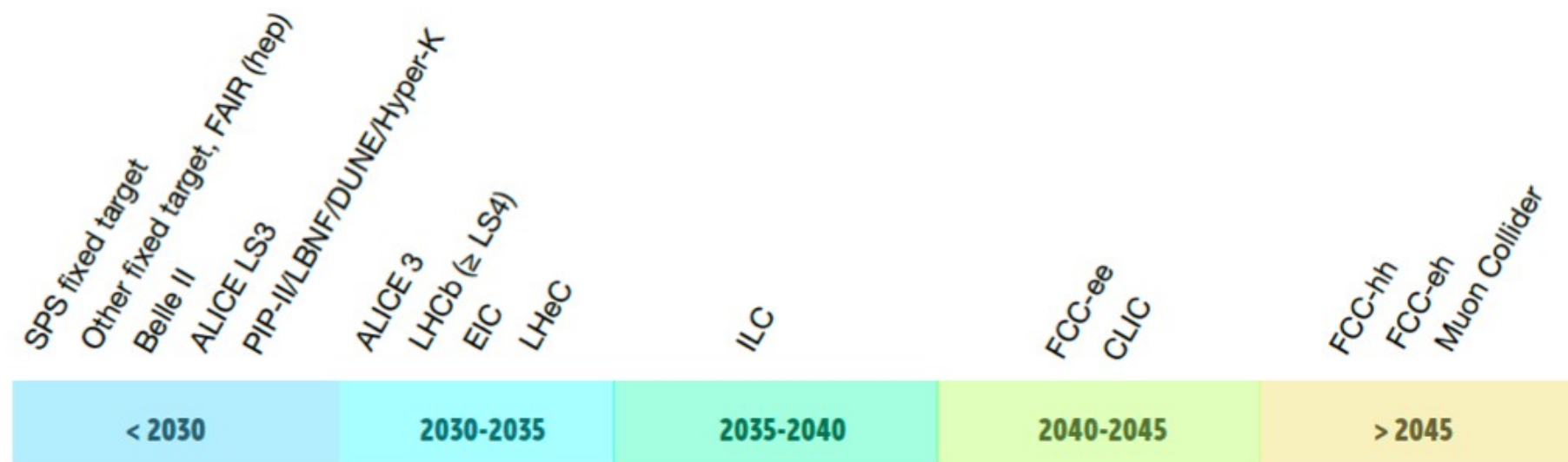
- DRD will have a CERN recognition but they **will not be** CERN Collaborations (“anchored at CERN”)
  - Significant participations by non-European groups is explicitly welcome and needed
- The progress and the R&D will be overseen by a DRDC that is assisted by ECFA
  - Availability and usage of resources, monitoring of progress, vetting against Roadmap objectives
  - CERN Research Director is preparing setting up the DRDC
- The funding will come from national resources (plus eventually supranational projects)

1. Strategic R&D via DRD Collaborations  
(long-term strategic R&D lines)  
(address the high-priority items defined in the Roadmap via the DRDTs) vision
2. Experiment-specific R&D  
(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 ) focus
3. "Blue-sky" R&D  
(competitive, short-term responsive grants, nationally organised) agility

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

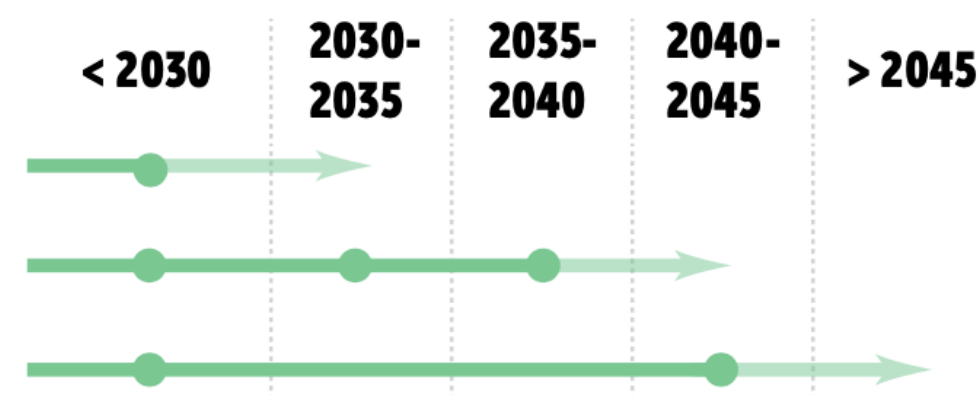


*F. Sefkow, CALICE Meeting and ECFA Higgs/top/EW Factory Meeting*



### 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



- The DRDT and the provisional time scale of facilities set high-level boundary conditions
  - See next slide for detailed R&D tasks
- Both as well as the GSR should be taken into account when formulating the R&D proposal(s)

- Key technologies and requirements are identified in Roadmap

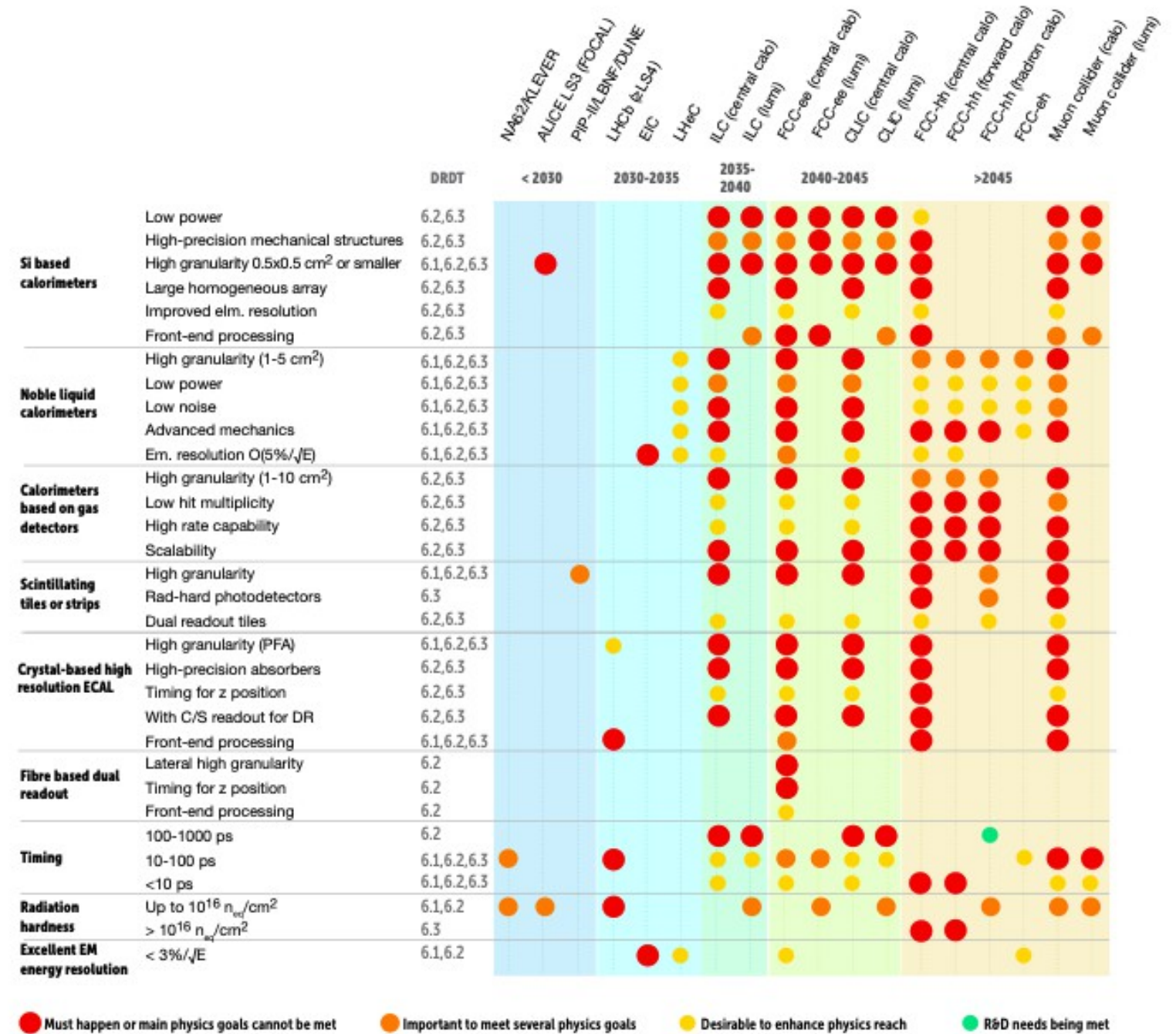
- Si based Calorimeters
- Noble Liquid Calorimeters
- Calorimeters based on gas detectors
- Scintillating tiles and strips
- Crystal based high-resolution Ecals
- Fibre based dual readout

- R&D should in particular enable

- Precision timing
- Radiation hardness

- R&D Tasks are grouped into

- Must happen
- Important
- Desirable
- Already met



Through 2023, mechanisms will need to be agreed with funding agencies in parallel to the process below for country specific DRD collaboration funding requests for Strategic R&D and for developing the associated MoUs.

- |            |  |
|------------|--|
| Q4 2022    | <p>Outline structure and review mechanisms agreed by CERN Council.</p> <p>Detector R&amp;D Roadmap Task Forces organise <b>community meetings</b> to establish the scope and scale of community wishing to participate in the corresponding new DRD activity.</p> <p>(Where the broad R&amp;D topic area has one or more DRDTs already covered by existing CERN RDs or other international collaborations these need to be fully involved from the very beginning and may be best placed to help bring the community together around the proposed programmes.)</p> |
| Q1 2023    | <p><b>DRDC mandate formally defined</b> and agreed with CERN management; Core DRDC membership appointed; and EDP mandate plus membership updated to reflect additional roles.</p>  |
| Q1-Q2 2023 | <p><b>Develop the new DRD proposals</b> based of the detector roadmap and community interest in participation, including light-weight organisational structures and resource-loaded work plan for R&amp;D programme start in 2024 and ramp up to a steady state in 2026.</p>   |
| Q3 2023    | <p><b>Review of proposals by DRDC</b> leading to recommendations for formal establishment of the DRD collaborations.</p>   |
| Q4 2023    | <p>DRD Collaborations receive formal <b>approval from CERN Research Board</b>.</p>   |
| Q1 2024    | <p>New structures operational for ongoing review of DRDs and R&amp;D programmes underway.</p>  |

Through 2024, collection of MoU signatures

- European projects such as AIDAInnova and EURO-Labs
- CERN EP R&D Programme
- Existing collaborations (LHC Experiments, Belle II, DUNE, NA62, KLEVER, ...)
- R&D Collaborations and communities (CALICE, FCAL, CrystalClear, GranuLAr, CalVision ...)
- Detector concept groups (ILD, SiD, CLICdp, FCC Detector with LAr, IDEA, EpiC, ...)



- **Entry point, “DRD Calo indico page”:** <https://indico.cern.ch/category/12772/>
  - Information on important events and access to relevant documents
  - Note also the Q&A Doc
  - 184 people from four regions registered so far
- **Organisation of 1<sup>st</sup> Community Meeting (today)**
  - Get impression on plans for different key technologies
  - Get feedback/input by community on roadmap process and the implementation
  - Conveners and speakers of today's sessions are also entry points for interested groups to join the DRD calorimetry
- **Proposal phase until 1<sup>st</sup> of July 2023**
  - Input-proposals (until 1<sup>st</sup> of April 2023)
    - Proposal team will get in contact with stakeholders and ask for input-proposals
    - Contact persons will be assigned for the different topics
  - 2<sup>nd</sup> community meeting around middle of April
    - Presentation of input-proposals (w/o disclosing confidential information)
    - Presentation of a WP Structure of DRD Calorimetry
      - Existing R&D collaborations may serve as guidance
  - Input-proposals will be condensed into a DRD Calorimetry proposal until (about) 1<sup>st</sup> of June 2023
    - Further iteration with stakeholders, community and higher level bodies



- **Proposal Team:** In first approach the TF6+ Task Force
- **Stakeholders:** Existing R&D Collaborations and communities in coordination with the corresponding funding agencies
- **There exists already a draft of guidelines for the input-proposals and the final proposal**
  - The following is oriented at this draft
  - The draft is still open for comments and modification, please provide feedback
- **Input-proposals: Content**
  - Brief description of R&D project including a reference to the roadmap
  - Where applicable a sketch of synergies inside and outside of DRD Calorimetry
  - “External needs” like test facilities, software framework etc.
- **Input-proposals: Important Formalities**
  - Set of tables on R&D projects with Deliverables (and most likely Milestones)
  - A list of interested institutes associated with the R&D projects (confidential information)
    - This can be European and also Non-European Groups
  - An overview on (eventually) existing and needed resources (confidential information)
    - Again can cover European and non-European resources
  - The length of these input-proposals should be of the order of 5-10 pages
- **Proposal with plans and general overview on resources (20 pages for DRD Calorimetry)**

- This year will see the implementation of the ECFA Detector R&D Roadmap
- Formation of DRDs that conduct the strategic R&D formulated in the roadmap
  - DRD are expected to be in place in one year from now!!
- The Implementation process builds upon confirmed panels and established detector R&D Communities
  - However, there is no real blueprint for what we are doing (at least what concerns Detector R&D)
  - Each DRD will decide on its own structure, likely starting from the experience of existing collaborations and working groups
  - It is important that we will formulate an attractive R&D programme that motivates to join the DRD Calo
  - For all this the continuous communication with the community is essential
- Today is an important milestone in the process!!!
- Communication:
  - News will be spread through the mailing function of the DRD Calo indico page
  - Discussions will (hopefully) happen among colleagues, at institute and national levels, within existing communities
  - Set up of a dedicated DRD-Calo work environment, stay tuned

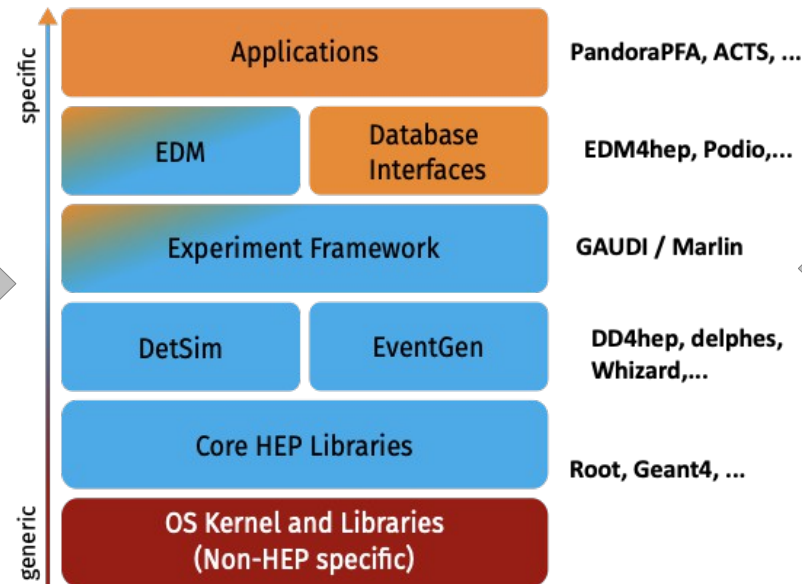
Backup

- Let us first thank the beam test and radiation facilities operators and the lab and institute managements for the availability of the facilities
- The importance of beam tests during detector development cannot be overrated
  - Recent refurbishment of various beam test sites witness that this is recognised by the lab managements
- Maybe more than other detectors calorimeters need a large variety of particle momenta, particle types and beam rates
- The portfolio of the EPPSU comprises projects supposed to run between now and 2080-2090
  - During all these decades we need versatile beam test and radiation facilities to accompany the R&D program
  - ... including competent staff to run these facilities (-> investment in accelerator and instrumentation experts)
  - CERN will continue to be the only side with real high energy beam
  - Maybe some steps can be executed with powerful computing, AI or whatever the future brings
  - However, it can never be desirable that the first beam a detector sees is the beam in the final experiment
    - Despite the fact that the return vessel of Apollo 11 has also never been tested before ;-)
- A future hadron collider would require to make a test beam facility part of the LHC programme

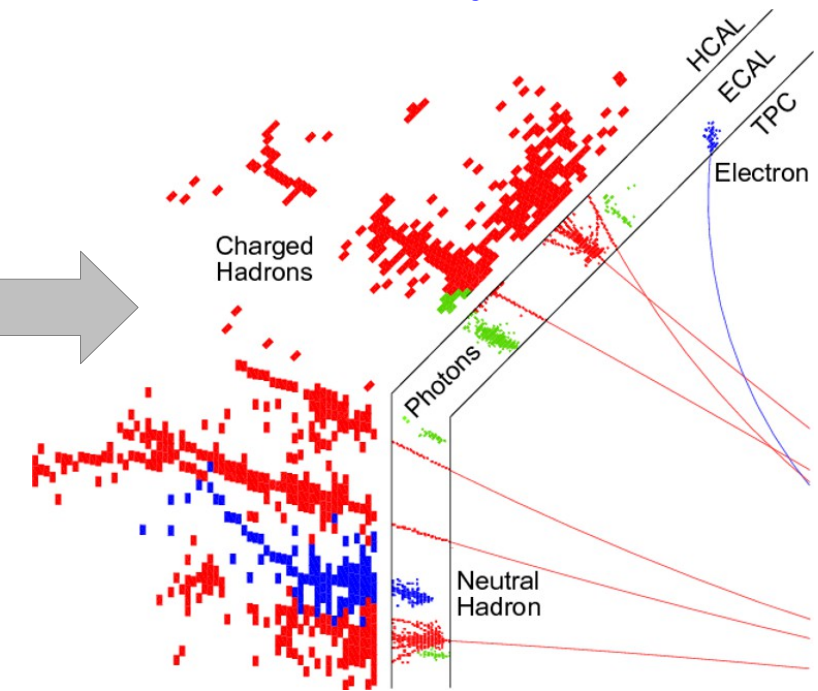
Beam test



Software framework



Detector/physics studies



- Software plays a central role in calorimeter development
- Validation of hadronic cascades in beam tests to guide full detector/full simulation studies
- In turn, realistic event reconstruction guides the technical choices
- It is important that Calorimeter R&D projects integrate into common software frameworks as Key4HEP
  - Better comparability of results
  - Facilitates porting of e.g. beam test results to full simulation studies
  - Facilitates switching between beam test studies and physics studies

- European projects such as AIDAInnova (start 4/2021)
- CERN EP-Programme
- Existing collaborations (LHC Experiments, Belle II, DUNE, NA62, KLEVER, ...)
- R&D Collaborations (CALICE, FCAL, CrystalClear)
- Proto collaborations (ILD, SiD, CLICdp, FCC, IDE)



- **Detectors at future high energy lepton colliders**
  - Relative benign environment in terms of radiation (well, maybe less true for Muon Collider)
  - Physics program span between Z-pole and few TeV
    - At same machine in case of LC
  - Consequences for detector design?
  - This is particularly important for calorimeters since **calorimeters require significant human resources and material during construction and during maintenance**
- **Detectors at future hadron colliders**
  - However,
    - Harsh radiation environments from the beginning
    - ... amplified by potential luminosity upgrades
  - Requires calorimeters that can stand severe conditions w/o degradation (or upgrades are priced in from the beginning)
  - Again calorimeters are huge and require sustained long term support
- **Most other projects have constraints that are subsets of the above but in different combinations and on different time scales**