Towards DRD on Calorimetry
Draft of Proposal and Resource Table

DRD Calo Proposal Team

Meeting with input-proposal submitters – June 29th 2023

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) 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

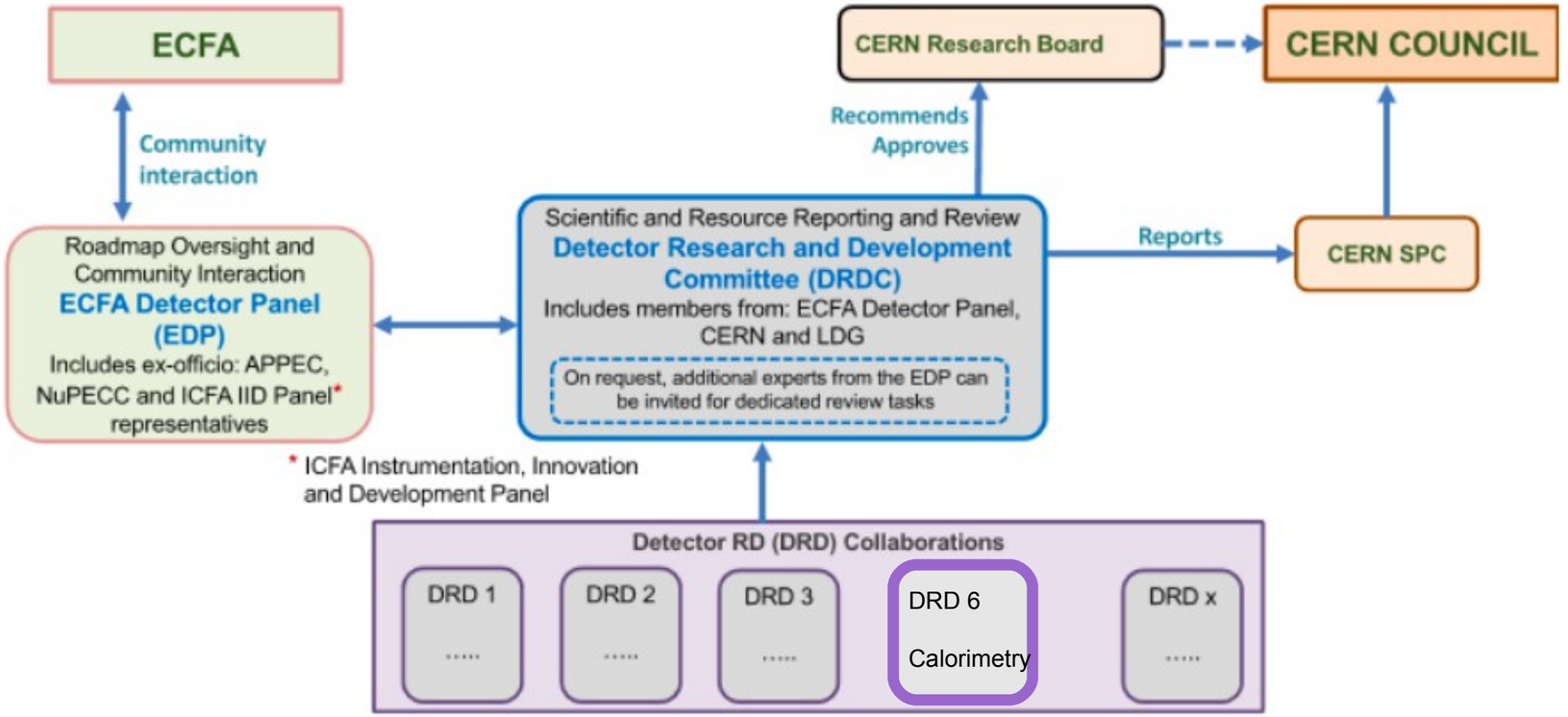
Developments in 2022

> *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
    - D. Contardo joined end of 2022
- Proposal went through discussions with RECFA, National ECFA Contacts, CERN SPC 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 organisation 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

Future Organisation of Detector R&D (in Europe)



- 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
  - World wide collaborations!
- 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
  - Hot News: Thomas Bergauer of ÖAW/Austria appointed as DRDC-Chair
- The funding will come from national resources (plus eventually supranational projects)

Towards Implementation of DRD Calorimetry

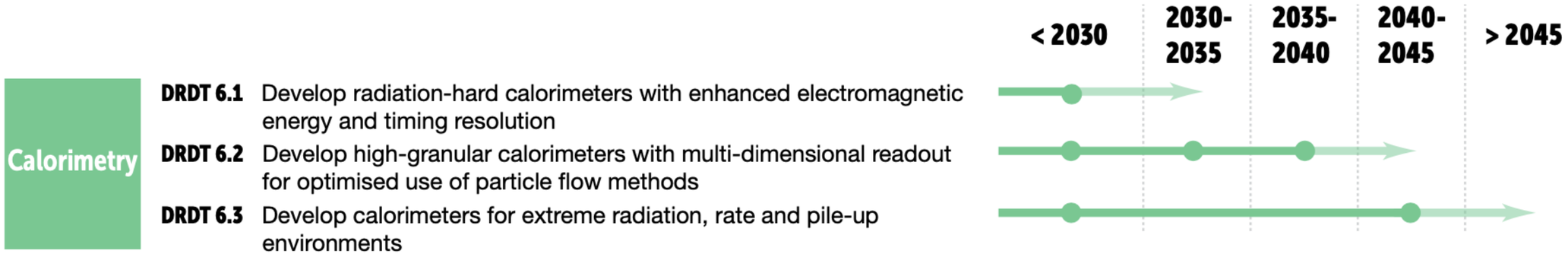
- **Entry point, "DRD Calo indico page": https://indico.cern.ch/category/12772/**
  - Information on important events and access to relevant documents
  - 233 people from four regions registered so far

- 1st Community Meeting 12/1/23
  - https://indico.cern.ch/event/1212696/

- Proposal phase until 31st of July 2023
  - **Input-proposals collected until latest 1st of April 2023**
  - 2nd Community Meeting 20th April
    - https://indico.cern.ch/event/1246381/
    - Presentation of summaries of input-proposals (w/o disclosing confidential information)
    - Presentation of a WP Structure of DRD Calorimetry

  - Input-proposals are about to be condensed into a DRD on Calorimetry proposal
    - Further iteration with stakeholders, community and higher level bodies
    - e.g. Today

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 – From input proposals to working structure

The Proposal Team

Track 1: Sandwich calorimeters with fully embedded Electronics – Main and forward calorimeters
Track conveners:
Adrian Irles (IFIC), **Frank Simon** (KIT), **Jim Brau** (U. of Oregon), **Wataru Ootani** (U. of Tokyo)

Track 2: Liquified Noble Gas Calorimeters
Track Conveners:
Martin Aleksa (CERN), **Nicolas Morange** (IJCLab), **Marc-André Pleier** (BNL)

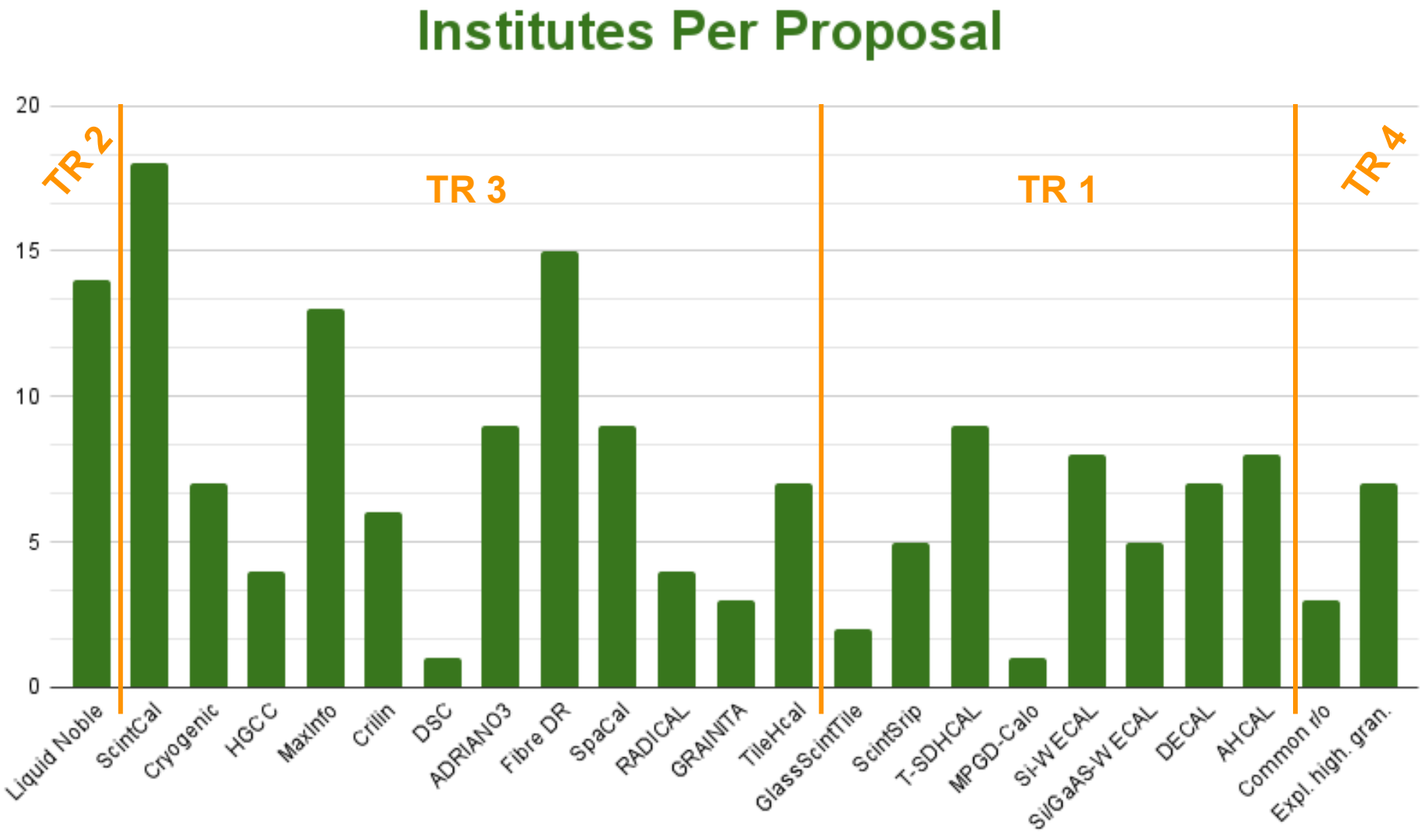
Track 3: Optical calorimeters: Scintillating based sampling and homogenous calorimeters
Track Conveners:
Etiennette Auffray (CERN), **Gabriella Gaudio** (INFN-Pavia), **Macro Lucchini** (U. and INFN Milano-Bicocca), **Philipp Roloff** (CERN), **Sarah Eno** (U. of Maryland), **Hwidong Yoo** (Yonsei Univ.)

Track 4: Transversal Activities
Christophe de La Taille (Lab. Omega)

Input proposals

23 comprising 110 institutes/labs received

From all over the world!!!

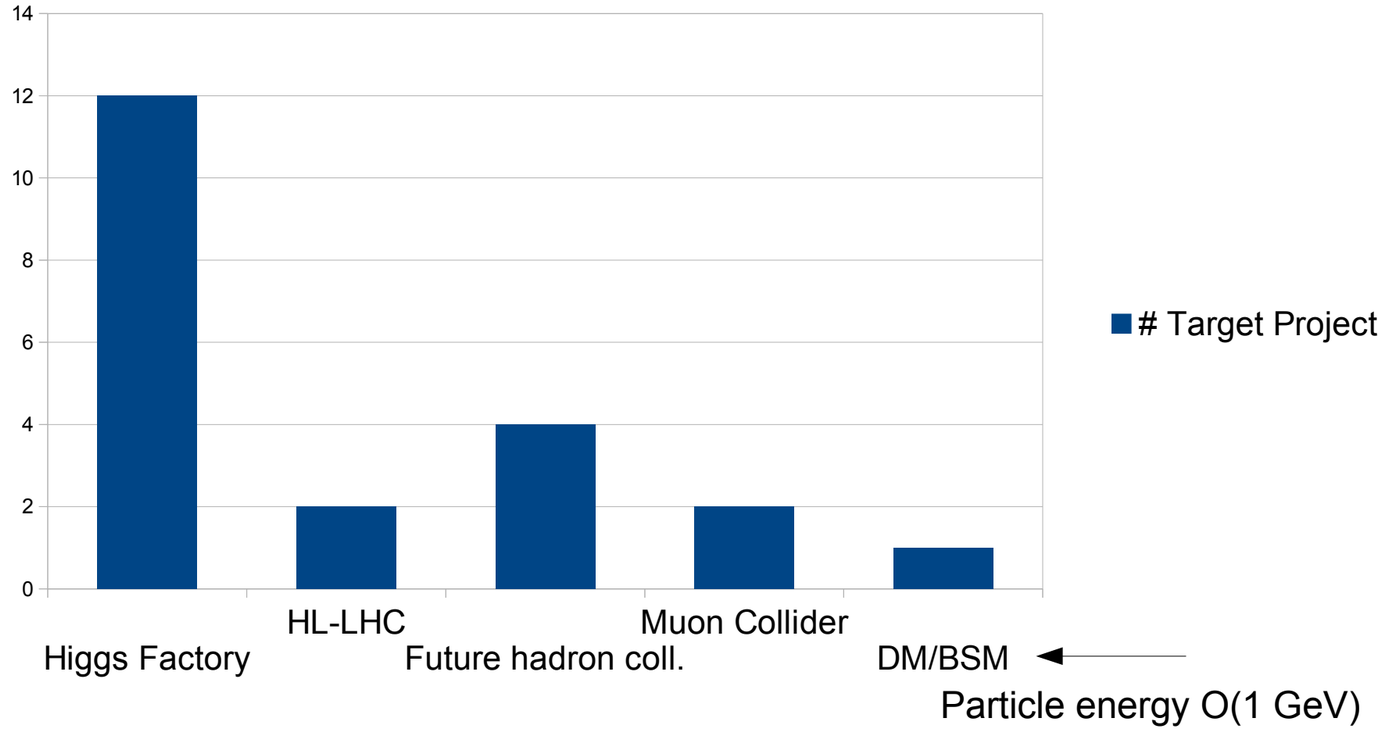


For further details of input-proposals and formation of DRD Calo see:

https://indico.cern.ch/event/1246381/

G. Gaudio
2nd Calorimeter Community Meeting

DRD Calo - Input proposals and target projects



- Higgs factories dominate
  - HF includes heavy flavor that target superb elm. energy resolutions
- (Already now) orientation towards future hadron collider and muon collider

DRD Calo – Basic structure

MANAGEMENT:

Governmental and executive bodies including Speakers Bureau

WORK AREAS:

- TRACK 1: Sandwich calorimeters with fully embedded Electronics
- TRACK 2: Liquified Noble Gas calorimeters
- TRACK 3: Optical calorimeters

TRANSVERSAL ACTIVITIES: (common collaboration interest & liaison with other DRD)

- Materials
- Photodetectors, Electronics and DAQ
- Testbeam Facilities
- Detector Physics, simulation, algorithm and software tools
- Industrial Connections and technological transfer

Complementation with TA on Mechanics under discussion

Drawing: G. Gaudi

DRD Calo – Basic structure

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WORK AREAS:

TRACK 1

Sandwich calorimeters with fully embedded Electronics

TRACK 2

Liquified Noble Gas calorimeters

TRACK 3

Optical calorimeters

TRANSVERSAL ACTIVITIES:
(common collaboration interest & liaison with other DRD)

Materials

Photodetectors, Electronics and DAQ

Testbeam Facilities

Detector Physics, simulation, algorithm and software tools

Industrial Connections and technological transfer

Complementation with TA on Mechanics under discussion

- Transversal Activities are vital for the success of the collaboration
- Transversal Activities will also ensure relations with other DRD

Drawing: G. Gaudi

Toward the proposal

- Proposal with plans and general overview on resources (~20 pages per DRD)
  - Free format
  - Short overview of projects/activities with very mild ranking on maturity level
  - **Draft (v1.0) on indico page is work in progress**
  - Still comments by you are invited either today or until 5th of July such that we can take them into account for the draft to the wider community

- Resource table
  - **We followed largely the guidance by the coordination team**
  - Maybe the most delicate and difficult part of the exercise for you and for us
  - More explanations on this on the next slides

- Both document draft and resource-table have been written/filled to the best of our understanding
  - This is the step to consult with the community on these documents
  - Please provide feedback and/or updates (already happened since yesterday evening, thanks!)

- The deadline for proposal submission is the 31st of July 2023

On the proposal draft ...

DRD 6: Calorimetry

June 29, 2023

Contents

- Currently 18 pages
  - Fairly complete
  - With some missing parts and and the final resource-table we will end up with ~22-25 pages
- Short description of goals, projects and organisation
  - organisational chart, see above
  - Example for table from Work Area 3 with short description

Table 2: Overview of R&D activities on optical calorimeter concepts.

Name	Calorimeter type	Application	Scintillator/WLS	Photodetector
HGCCAL	EM / Homogeneous	e^+e^- collider	BGO, LYSO	SiPMs
MAXICC	EM / Homogeneous	e^+e^- collider	PWO, BGO, BSO	SiPMs
CRILIN	EM / Quasi-Homog.	$\mu^+\mu^-$ collider	PbF_2, PWO-UF	SiPMs
GRAINITA	EM / Quasi-Homog.	e^+e^- collider	$ZnWO_4$, BGO	SiPMs
SPACAL	EM / Sampling	e^+e^-/hh collider	GAGG, organic	MCD-PMTs, SiPMs
RADICAL	EM / Sampling	hh collider	LYSO, LuAG	SiPMs
DRCAL	EM+HAD / Sampling	e^+e^- collider	PMMA, plastic	SiPMs, MCP
TILECAL	HAD / Sampling	e^+e^-/hh collider	PEN, PET	SiPMs

- Maybe a few lines on how input has been collected Including link to the input proposals should be added
  - ... to underline that's a community effort
  - Author list/contributors?
  - Maybe even a map of contributing institutes makes sense

- We are getting now in a position to take a step back and harmonise the draft

On the resource table

The (first page) of the resource-table is subdivided into seven blocks blocks

1) Deliverables or milestones

Should concentrate here on high level M and D

2) Total FTE estimated to be required to deliver the R&D programme

3) Total non-FTE funds estimated to be required to deliver the outlined R&D programme

4) Estimate of expected total FTE from existing sources (not requiring new "strategic" support)

5) Estimate of expected total non-FTE funds from existing sources (not requiring new "strategic" funding)

6) Estimate of total R&D programme FTE (sum of existing and hoped for given realistic assumptions)

7) Estimate of total R&D programme non-FTE funding (sum of existing and hoped for given realistic assumptions)

The info is to be provided for the years 2024-2026, 2027-2029 and >= 2030

Resource table and your input

- For the input-proposal we have asked you to provide information that was suggested to collect back in February
  - Table for 2024-2026, outlook as free text for > 2026
- We have mapped this information onto the resource-table
  - Essentially we set equal “Existing+requested” to “existing and hoped for” (i.e. Blocks 6 and 7)
- We are also wondering what to put in Block 2 and 3
  - At the moment we leave it blank, exceptionally for projects that laid out (major) plans for > 2026 and for which resources are unclear (or more unclear than for others)
- Given the current format that will accompany the actual proposal ...
  - ... we hope that our first pass of interpretation of the provided information is about right
  - ... we ask you to check and eventually revise the information of your project
    - ... if possible until 10th of July at the latest

DRD Calo – Next Steps

- Now until end of July: Scrutinisation of scientific program and indicated resources
  - We are happy to see the interregional coordination that is taking place
  - e.g. coordination with P5 process in US and with activities in Asia

- Draft of DRD Proposal until end of June
  - Circulation among proposal team and submitters

- Draft for larger community until middle of July
  - Presenting to higher level bodies?

- 31st July 2023 – Submission of DRD Calo proposal

- Summer/Early Autumn
  - Implementation of feedback from proposal review
  - Detailed structure of work areas and transversal activities
  - Consolidation of organisation
    - Management structure
    - Including roadmap on assigning names to the different boxes
  - Understanding of which kind of documents we will need (MoU/MoA) and when
  - Maybe a 3rd Community Meeting

- 1st January 2024 – DRD on Calorimetry in place
  - Kick-off Meeting Spring 2024

Summary and Outlook

- Heading towards finalisation of proposal of DRD on Calorimetry
  - We are about to form a worldwide collaboration with a rich scientific programme

- Drafts of DRD Proposal and resource table do exist
  - Need revision, completion and scrutinisation
  - All mistakes are ours (up to now ;-))

- Still one month to finish
  - Not much but also not nothing
  - Hopefully enough time to correct, rectify and update information
  - Your help and the ones of your project members is needed

- Proposal team will work on proposal of schedule and actions toward the creation of the DRD on Calorimetry

Your Questions !

Please send questions, feedback coming up after today's meeting to Roberto (roberto.ferrari@cern.ch), Gabri (gabriella.gaudio@pv.infn.it) and Roman (roman.poeschl@ijclab.in2p3.fr).

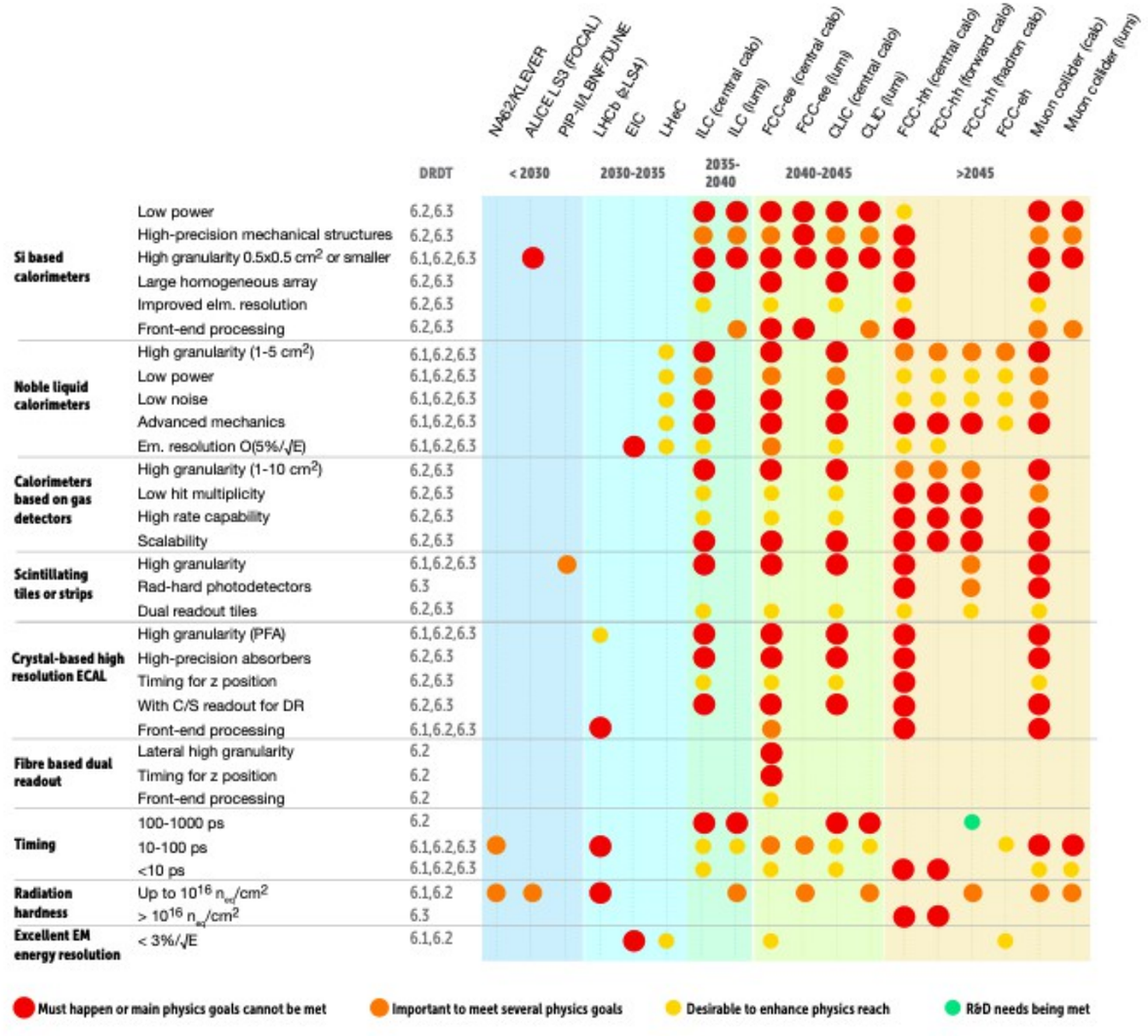
Backup

Calorimetry- Identified Key Technologies and R&D Tasks

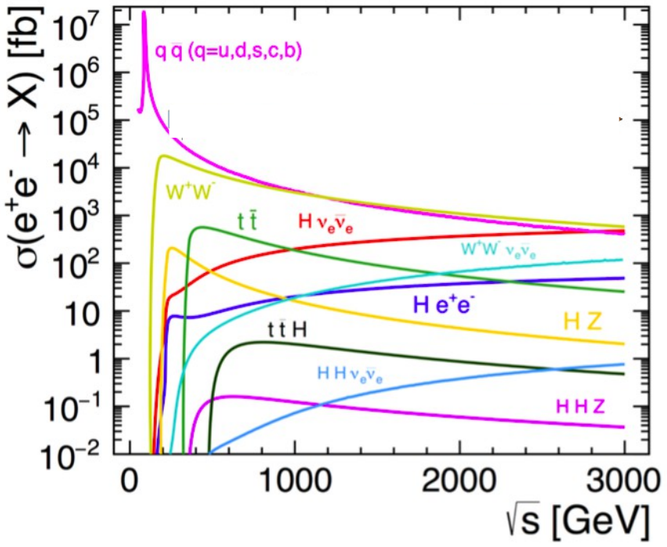
- Key technologies and requirements are identified in ECFA Roadmap
  - Si based Calorimeters
  - Noble Liquid Calorimeters
  - Calorimeters based on gas detectors
  - Scintillating tiles and strips
  - Crystal based high-resolution Ecals
  - Fibre based dual readout

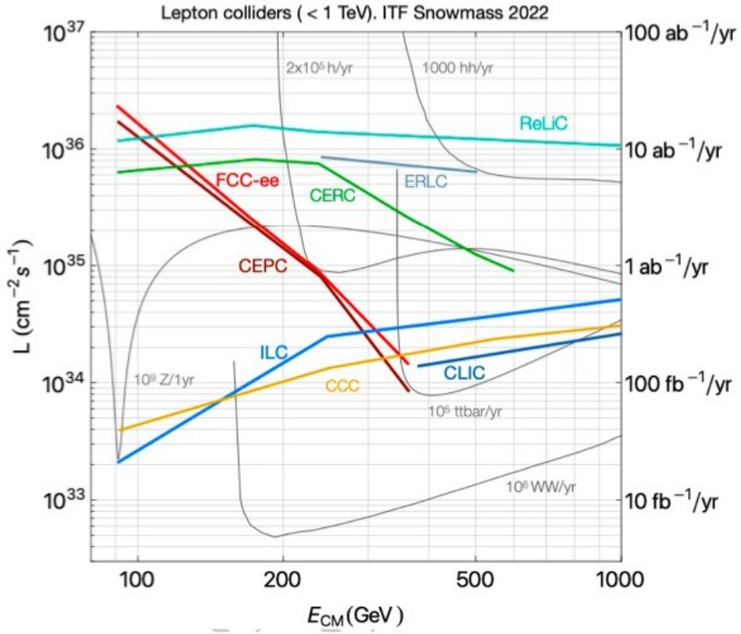
- R&D should in particular enable
  - Precision timing
  - Radiation hardness

- R&D Tasks are grouped into
  - Must happen
  - Important
  - Desirable
  - Already met



Future direction of R&D - Impact of event rates





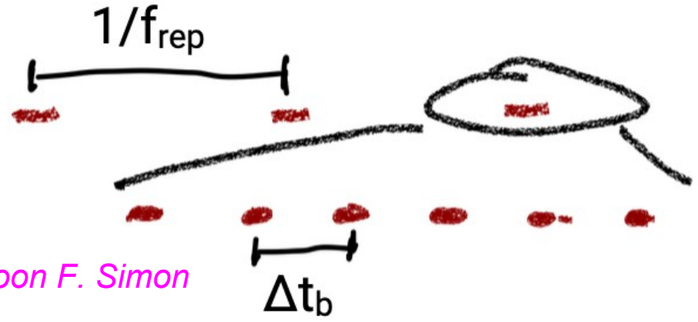
High energy e+e- colliders:

- Physics rate is governed by strong variation of cross section and instantaneous luminosity
- Ranges from 100 kHz at Z-Pole (FCC-ee) to few Hz above Z-Pole
- (Extreme) rates at pole may require other solutions than rates above pole

- Event and data rates have to looked at differentially
  - In terms of running scenarios and differential cross sections
  - Optimisation is more challenging for collider with strongly varying event rates
    - Z-pole running must not compromise precision Higgs physics

Operation mode- pulsed or continous

- Linear Colliders operate in bunch trains



Cartoon F. Simon

CLIC: Δt_b ~ 0.5ns, frep = 50Hz

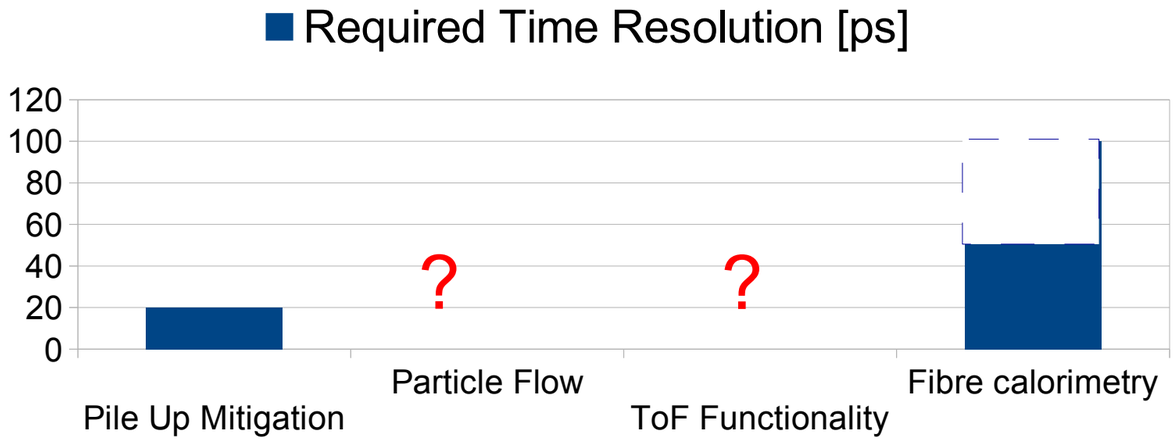
ILC: Δt_b ~550ns, frep = 5 Hz (base line)

- Power Pulsing reduces dramatically the power consumption of detectors
  - e.g. ILD SiECAL: Total average power consumption 20 kW for a calorimeter system with 10^8 cells
- Power Pulsing has considerable consequences for detector design
  - Little to no active cooling
  - => Supports compact and hermetic detector design

- Upshot: Pulsed detectors face other R&D challenges than those that will be operated in “continuous” mode
  - R&D Goal: Avoid/minimise active cooling also in continuous mode
  - Challenge differs depending on where the electronics will actually be located

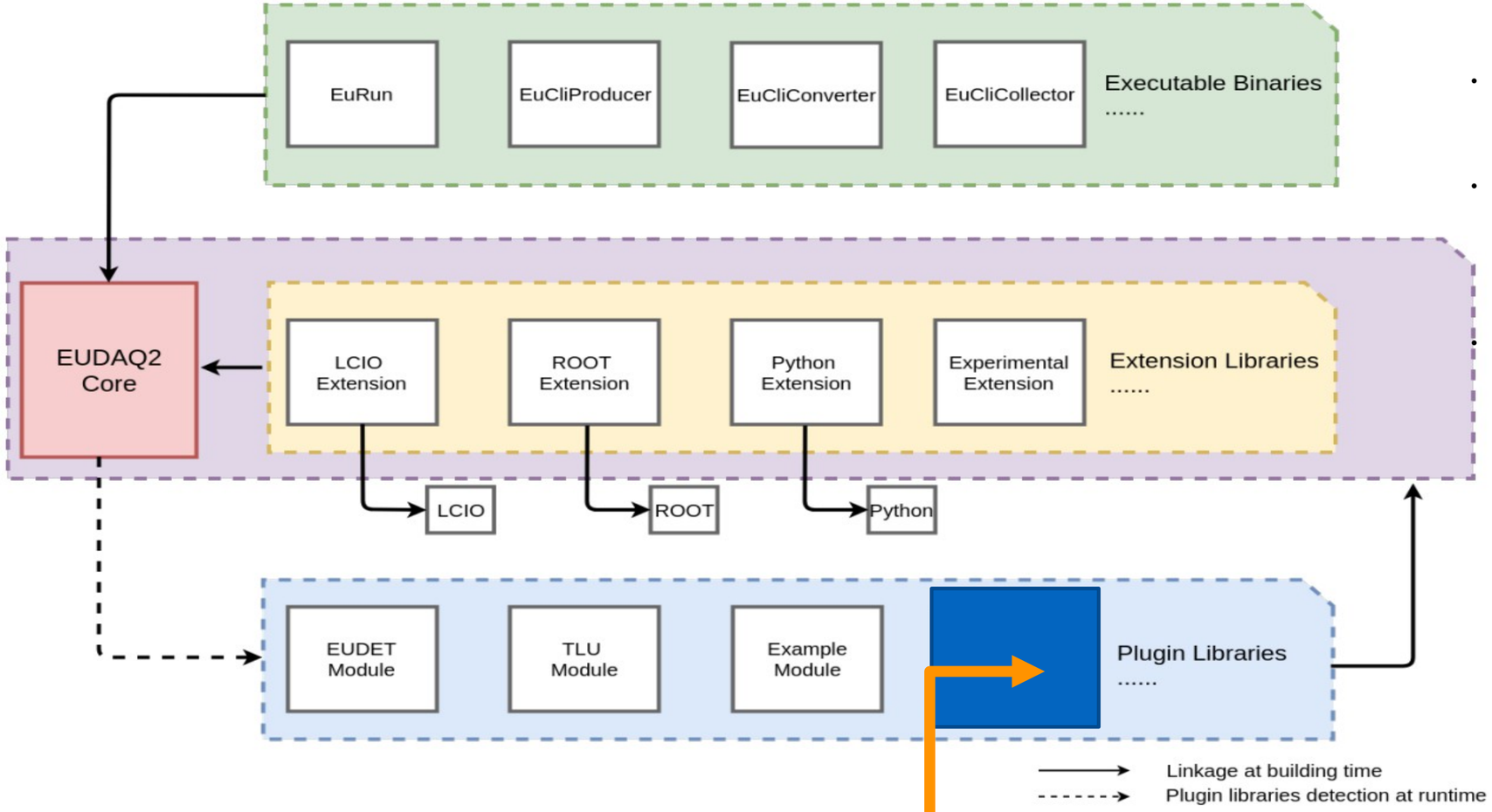
Timing ?

- Timing is a wide field
- A look to 2030 make resolutions between 20ps and 100ps at system level realistic assumptions
- At which level: 1 MIP or Multi-MIP?
- For which purpose ?
  - Mitigation of pile-up (basically all high rate experiments)
  - Support of PFA – unchartered territory
  - Calorimeters with ToF functionality in first layers?
    - Might be needed if no other PiD detectors are available (rate, technology or space requirements)
    - In this case 20ps (at MIP level) would be maybe not enough
  - Longitudinally unsegmented fibre calorimeters



- A topic on which calorimetry has to make up it's mind
  - Remember also that time resolution comes at a price -> High(er) power consumption and (maybe) higher noise levels

EUDAQ Data Acquisition Systems

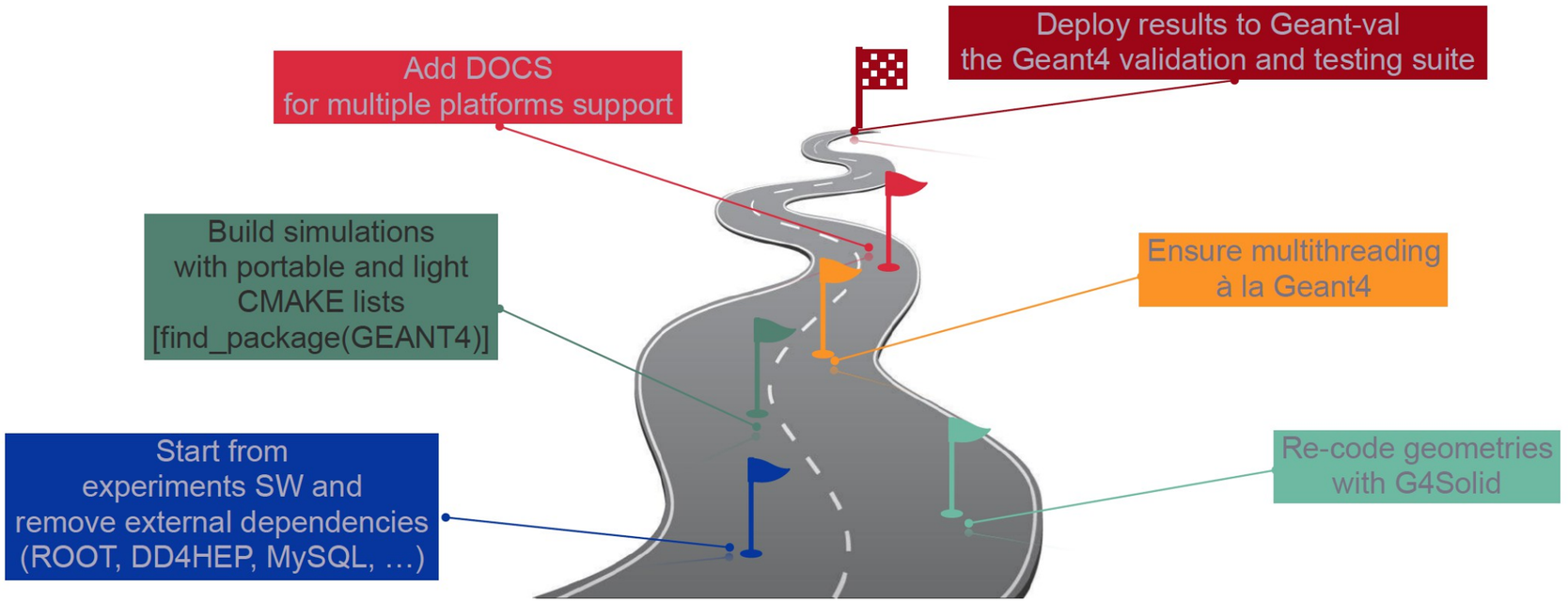


PUT your calorimeter library here!

- Implementation of custom producers is rather simple
- easier integration with other eudaq producers (TLU, Telescopes)
- Already a long list of custom producers integrated:
  - CALICE SiWECAL,
  - CALICE AHCAL,
  - CALICE SiWECAL + AHCAL,
  - CMS HGCAL silicon prototype + CALICE AHCAL, ...

... and once the data are recorded

From experiments to geant-val, a winding road



geant-val.cern.ch

Geant-val is the Geant4 validation and testing suite.

For the Community, it allows to deploy results on a common data-base and fetch the information via a web-interface.

For the developers, it allows to Create multiple jobs over beam energies, particle types, physics lists

Better to involve G4 collaboration at the beginning of the testbeam. G4 collaboration available to help with the geant4-val inclusion

ECFA Complex Calorimeters – A playground for modern algorithms

Tommaso Dorigo and MODE Collaboration

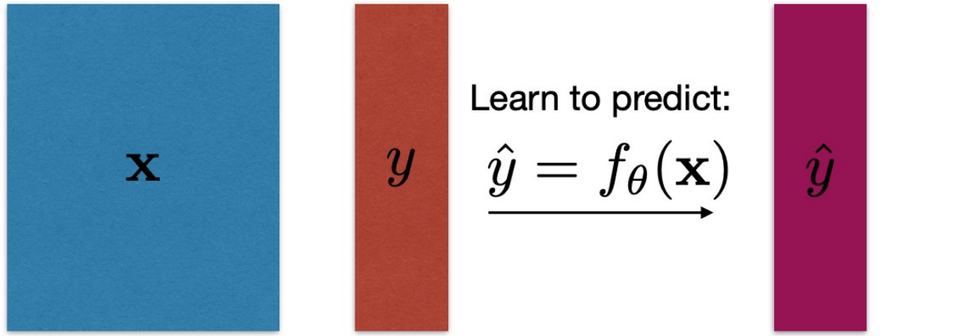
Machine Learning approach is gaining more and more importance in HEP and in calorimetry in particular

highly complex data with large number of detailed information

Simulation provides tagged data for supervised learning

Tracking, clustering, particle ID ...

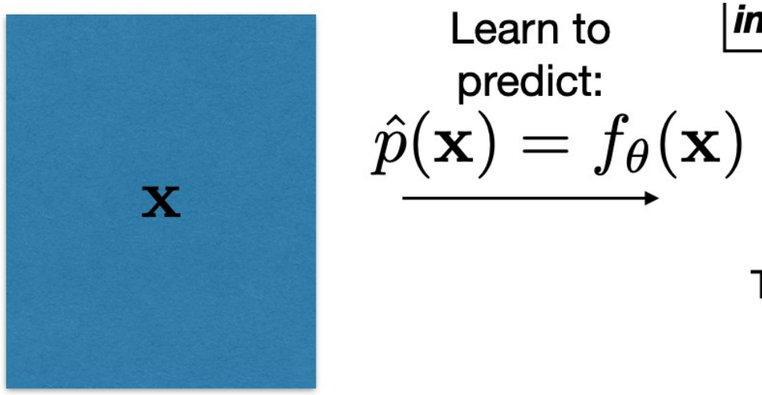
Use training data with known labels
(often from Monte Carlo simulation)



observable features such as kinematics, tracks,…

truth label (e.g. true energy)

predicted energy



True probablity density

important for now.

CERN Schedule according to recent MTP