Status and Plans for Calorimetry DRD

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on behalf of the DRD TF6+ Task Force

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6th FCC Physics Workshop
Krakow, 24 Jan 2023

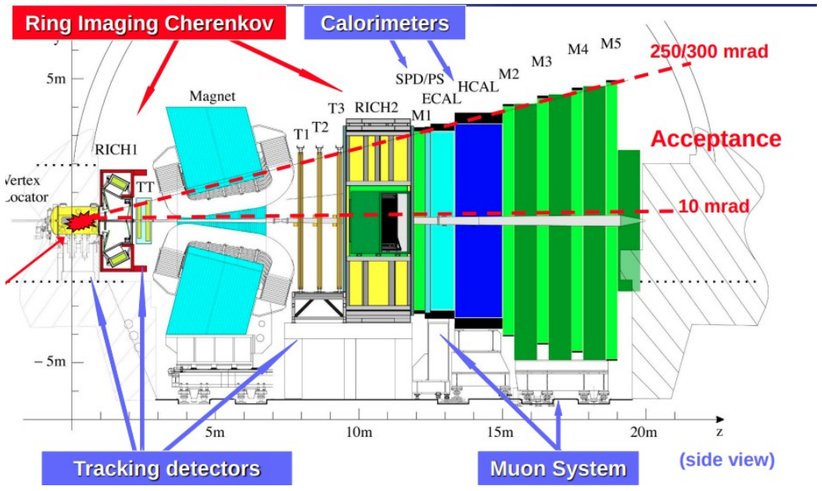
Many slides shown hereafter inspired by or stolen from talks by K. Jakobs, P. Allport and F. Sefkow

Outlook

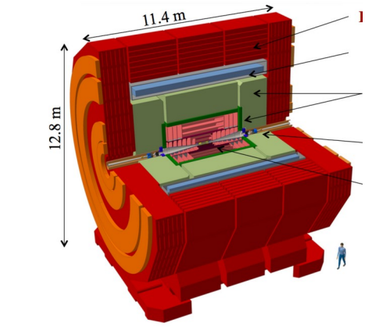
- Quick overview of ECFA R&D Roadmap
- Road toward implementation of Calorimetry DRD
- Outcomes of 1st Community Meeting
- Final considerations

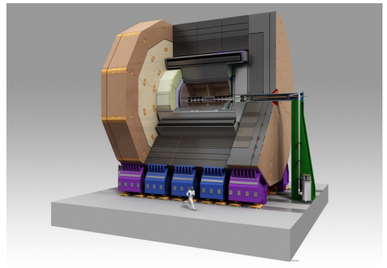
(Main) Target Projects of Detector R&D

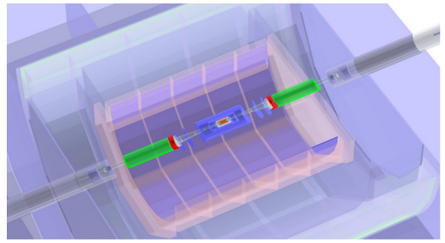
HL-LHC after LS4

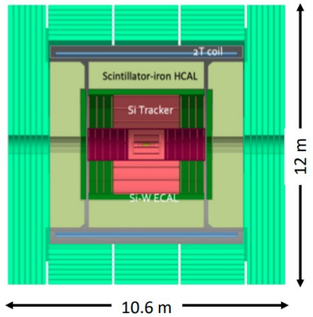


Higgs Factories

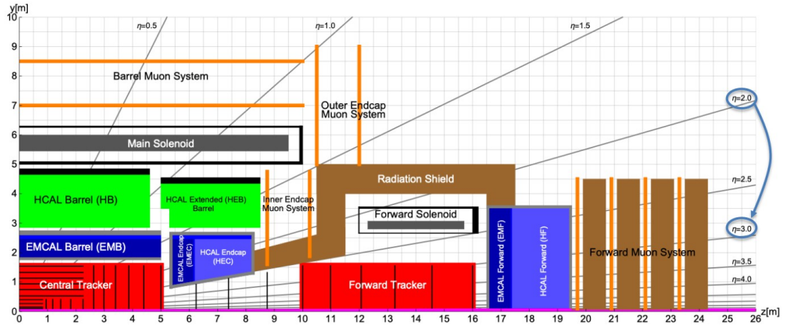




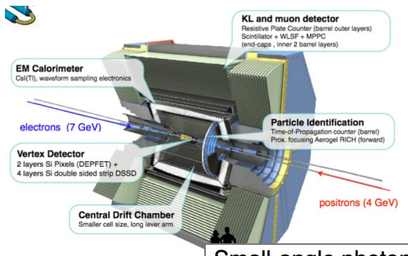


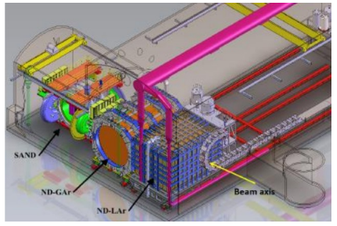


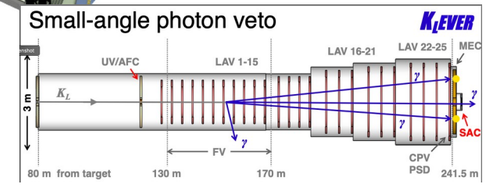
Future hadron colliders (including eh colliders)



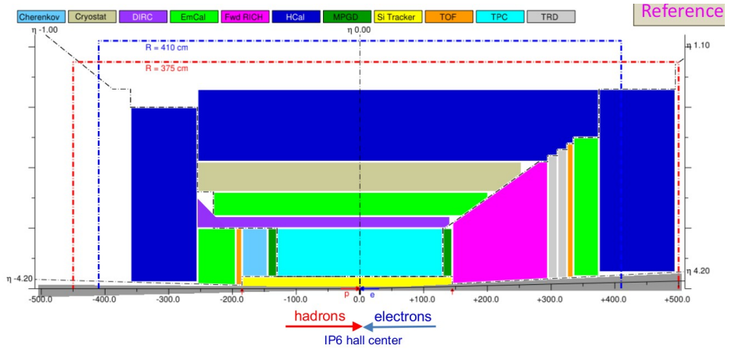
SuperKEKB, DUNE ND and Fixed Target



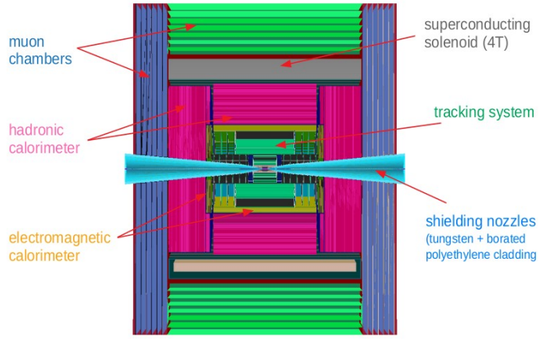




EiC



Muon Collider



Calorimetry Overview Table

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	“continous”		✔	✔	✔		✔
Neutrino Exp.	2030		✔				(✔)

in most cases, final choices still to be made

Roadmap document(s)

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

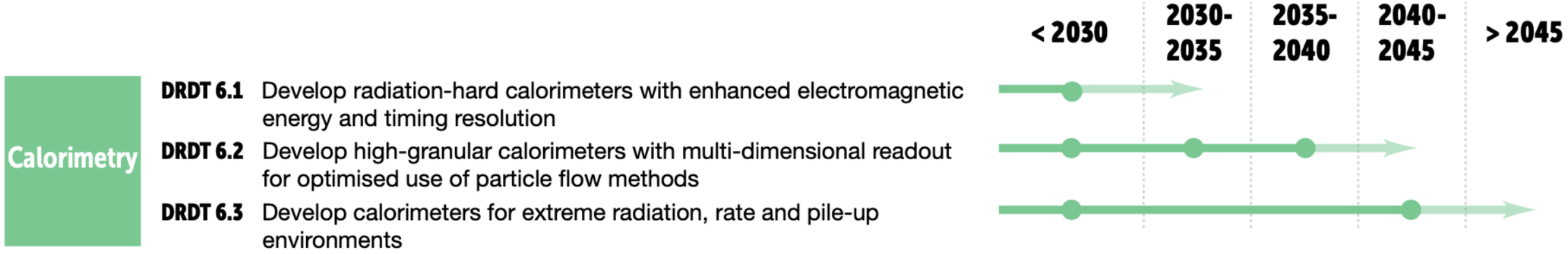
- Endorsed by ECFA and presented to CERN Council in December 2021

Roadmap identified:
  - General Strategic Recommendations (GSRs)
  - Detector R&D Themes (DRDTs) per task-force topic
  - 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

Future Facilities and DRDTs for Calorimetry



- DRDTs and (provisional) time scale of facilities set high-level boundary conditions
- Both as well as GSRs should be taken into account when formulating R&D proposals

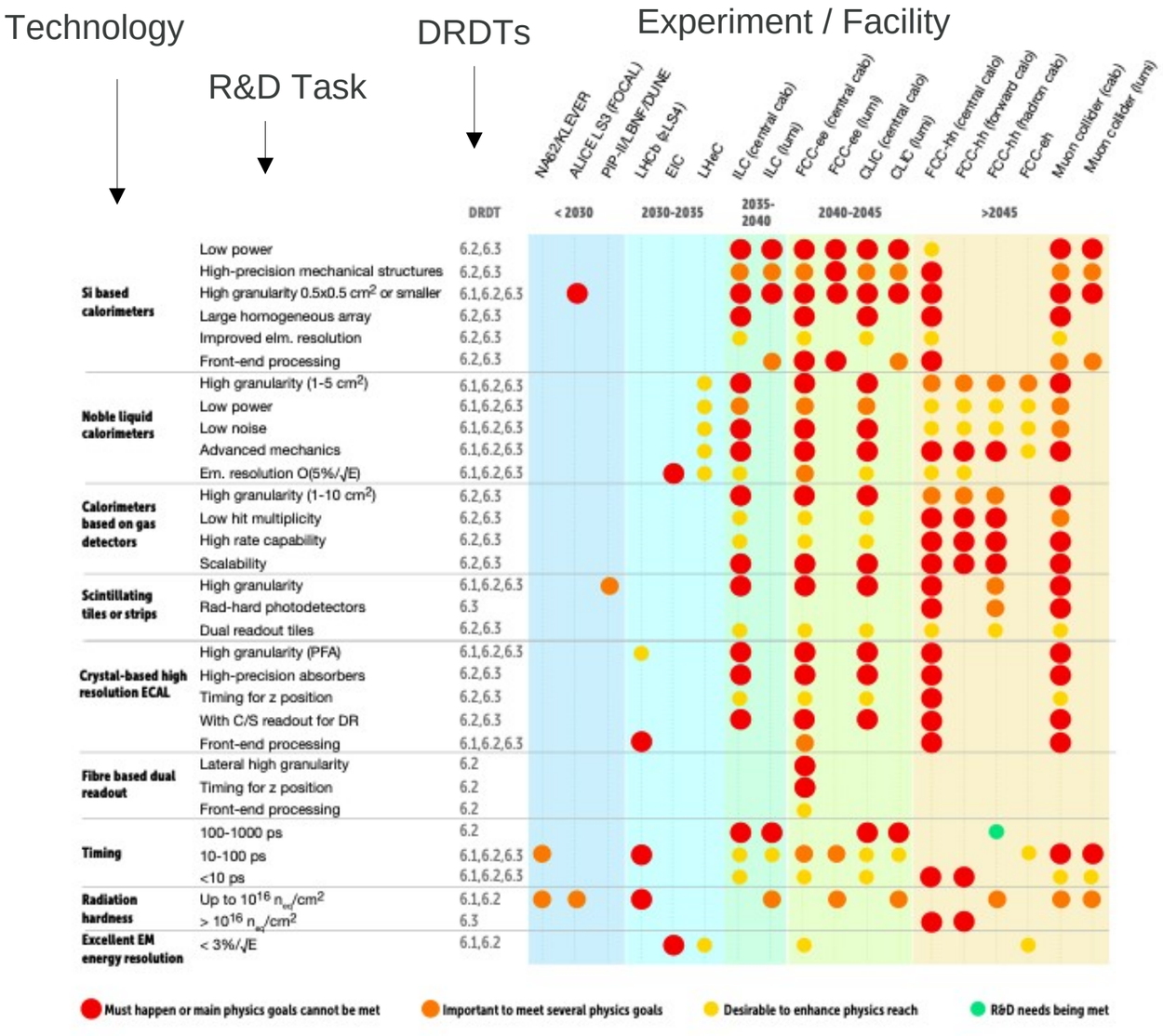
few details in next slides

Identified Key Technologies and R&D Tasks

- Key technologies and requirements identified in roadmap
  - Si based calorimeters
  - Liquid Noble Gas calorimeters
  - Calorimeters based on gas detectors
  - Scintillating tiles and strips
  - Crystal based high-resolution ECal.s
  - Fibre-based dual readout

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

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



General Strategic Recommendations

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

More details in:
CERN/SPC/1190
EUROPEAN STRATEGY FOR PARTICLE PHYSICS
DETECTOR R&D ROADMAP

Reminder on today's “eco system” for calorimetry

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

→ongoing DRD process must successfully integrate existing R&D activities

Towards Implementation of Calorimetry DRD

- Entry point, “DRD Calo indico page”: https://indico.cern.ch/event/1213733
  - Information on important events and access to relevant documents
  - Note also the Q&A doc (still empty) → please, use it if you need clarifications or details

- First Community Meeting on January 12th, 2023 → more than 100 people participating
  https://indico.cern.ch/event/1212696
  - Presented actual plans for different key technologies
  - Got feedback/input on roadmap process and implementation
  - Very interesting and positive attitude, community looks very open to collaborate

  - Conveners and speakers also entry points for people/groups willing to join

Towards Implementation of DRD Calorimetry (2)

- Proposal phase until July 1s, 2023:
  - Collect input (until April 1st)
    - Proposal team will contact stakeholders
    - Contact persons assigned for different topics
  - 2nd community meeting around middle of April
    - Presentation of input proposals (w/o disclosing confidential information)
    - Presentation of proposed WP Structure of DRD Calorimetry
      → NOT reinvent wheel: learn from existing R&D collaboration experience
  - Input proposals condensed into DRD Calorimetry Proposal until (about) June 1st
    - Further iterations with stakeholders, community and higher level bodies

about input proposals

- Proposal Team:
  on first approach, TF6+ Task Force

- Stakeholders:
  existing R&D collaborations and communities in coordination with funding agencies

- Draft of guidelines for pre-proposals and final proposal already exists
  still open for comments and modifications
  → please, take care: feedback more than welcome

  what follows oriented at that draft

about input proposals (2)

- Content
  - Brief description of R&D project including reference to roadmap
  - Where applicable, sketch of synergies inside and outside of DRD Calorimetry
  - “External needs” like test facilities, software, etc.

- Important formalities
    - Tables with Deliverables (and likely Milestones)
    - List of associated institutes (confidential information)
        - European as well as non-European groups
    - Overview on needed and (eventually) existing resources (confidential information)
        - again should cover both European and non-European resources
    - Length of these input proposals O(5-10) pages

- Proposal with plans and general overview on resources (20 pages for DRD Calorimetry)

Community Meeting of January 12th

Present breakdown: three main R&D packages:

- Sandwich calorimeters with fully embedded electronics
- Liquid-noble-gas calorimeters (was only for FCC-hh, now looking also at FCC-ee)
- Optical, scintillation-based, sampling and homogeneous calorimeters

all consolidated historical activities

Many open challenges over different time scales → depend on physics case and machine

Many common issues → pretty long shopping list ...

Many different specific issues → not entering in any details

Many synergies with (or dependence on) other TFs → need transversal collaboration(s)

calorimeters both at top and bottom of chain

Personal comment: very positive and constructive attitude of all players

DRD process looks to be felt as opportunity to foster progress

Few common keywords

High granularity → critical for PFA (but not only)

Timing resolution → critical for hadron colliders (but not only)

Hadronic energy resolution → critical for lepton colliders

Common issues – lot of room for collaboration

New active materials:

- Fast, high-density, low-cost, scintillating materials
- Fast and rad-hard WLS fibres

Sensors + FE elx:

- Low x-talk, low-noise, low-power budget
- High granularity → high integration → embedded FE elx
- High-precision timing → from O(100) ps down to O(10) ps
- Radiation hardness
- Si/GaAs sensors: high integration, very-front-end integration, sensor bonding
- CMOS sensors: MAPS, digital SiPMs
- Photosensor architecture: MCP-PMTs, SiPMs, LGADs, ...,
- Photosensor performance: dynamic range, light yield, timing, UV sensitivity, ...
- ASICs: architecture, timing performance
- Components / connectors reliability
- High data rate → on-chip processing (DNN) for data selection and compression

Common issues – lot of room for collaboration (2)

Mechanics / production issues:

- Low-material budget
- High mechanical precision
- Industrialisation, engineering, scalability → relation w/ industry
- High-density absorber (e.g. W) production → (e.g.) 3D-printing

Services:

- Cooling
- Powering and control
- Clock distribution for O(10) ps timing

Others:

- Beam test infrastructure, setup & DAQ software (EUDAQ)
- Beam line features + common beam requests
- MC samples → common benchmarks
- Software tools (DD4hep, EDM4hep, Key4hep, ...), event-data format (?)
- Test benches, but also ... PFA and dual readout

add transversal package to cover overarching topics?

External synergies

With respect to other DRDs:

- Gaseous Detectors (TF1) for hadron calorimetry
- Solid State Detectors (TF3) for CMOS sensors
- PID and Photon Detectors (TF4) for all optical readout calorimetry
- Electronics and On-detector Processing (TF7)
- Integration (TF8) for cooling

Other fields: above all, medical imaging

Short-term applications

Several Phase-II and Phase-III HL-LHC upgrades:

CMS ECAL, LHCb ECal, ALICE FoCal

and also:

LUXE (XFEL), BELLE II ECal, EIC EEMCal

but ... all, except FoCal, EM calorimeters

Short-term applications (2)

High-performance hadron calorimetry only relevant for future Higgs/EWK factories?

Only rate capability and radiation hardness look to matter for hadron colliders (not surprising)

We urgently need any linear or circular e+e- collider to test our new fantastic hadron calorimeters
(don’t tell the funding agencies)

Few final considerations

- Implementation of ECFA Detector R&D Roadmap over this year
- Strategic DRDs expected to be in place within end of year → bottom–up process
- Implementation built upon confirmed panels and established detector R&D Communities
  - However, no real blueprint over it
  - Each DRD will decide on its own structure
  - Need to build attractive R&D programme to motivate joining it
  - Get non-European people/groups fully on board – interest looks to exist
  - Many synergies to be exploited both internally to Calo DRD and wrt other DRDs
  - Continuous and effective communication is crucial
  - Must be sure no one is forgotten and no important topic is missed
- Communication:
  - News will be spread through mailing function of DRD-Calo indico page
  - Setting up dedicated DRD-Calo work environment