ECFA Detector Roadmap and Implementation

And

1st ECFA Higgs Factory Workshop
October 06, 2022

CALICE Collaboration Meeting
October 12, 2022

Felix Sefkow
DESY

heavily based on or directly using slides by Phil Allport and Karl Jakobs

DESY

Outline

This Talk

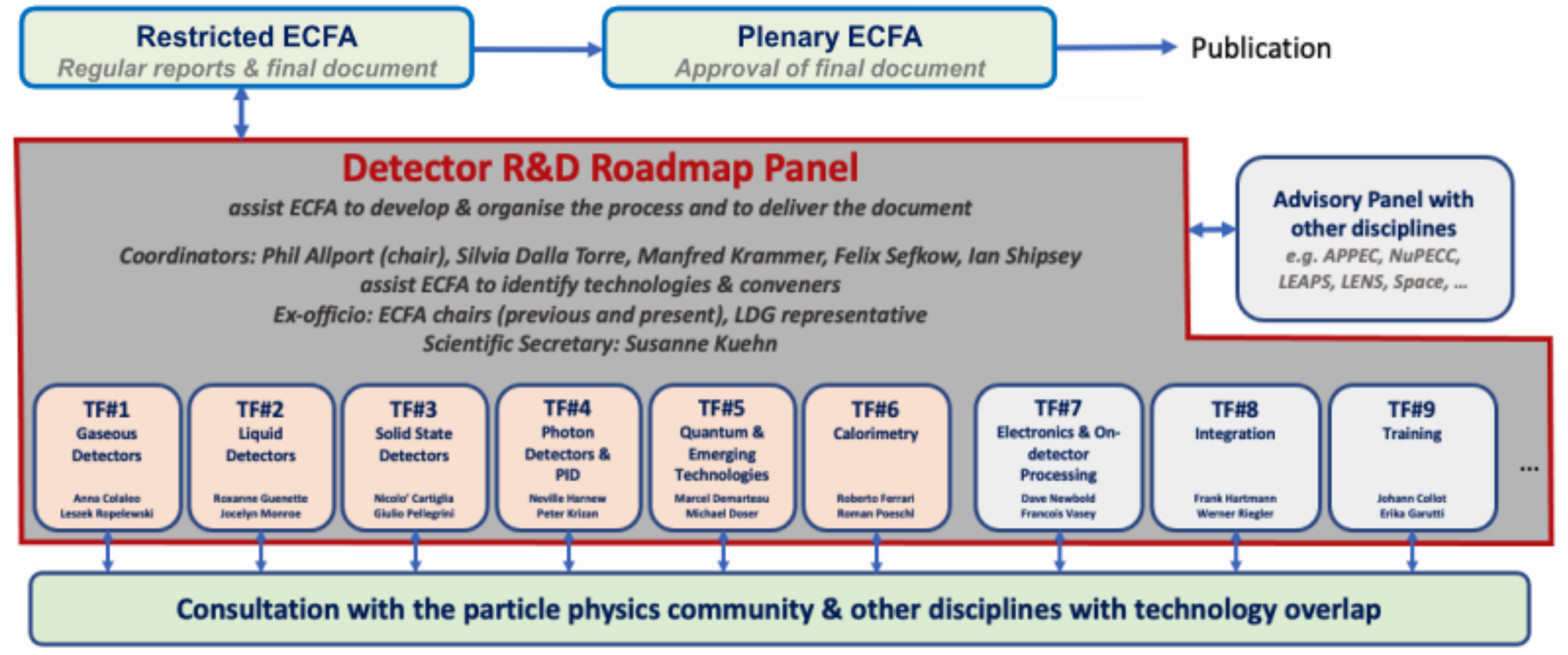
Reminder: Roadmap Process and Outcome

Implementation plan:

- **General approach**
- **First feedback**
- **Timeline**
- **Role of ECFA studies and Detector Concepts**

Roadmap Reminder

Roadmap Organisation

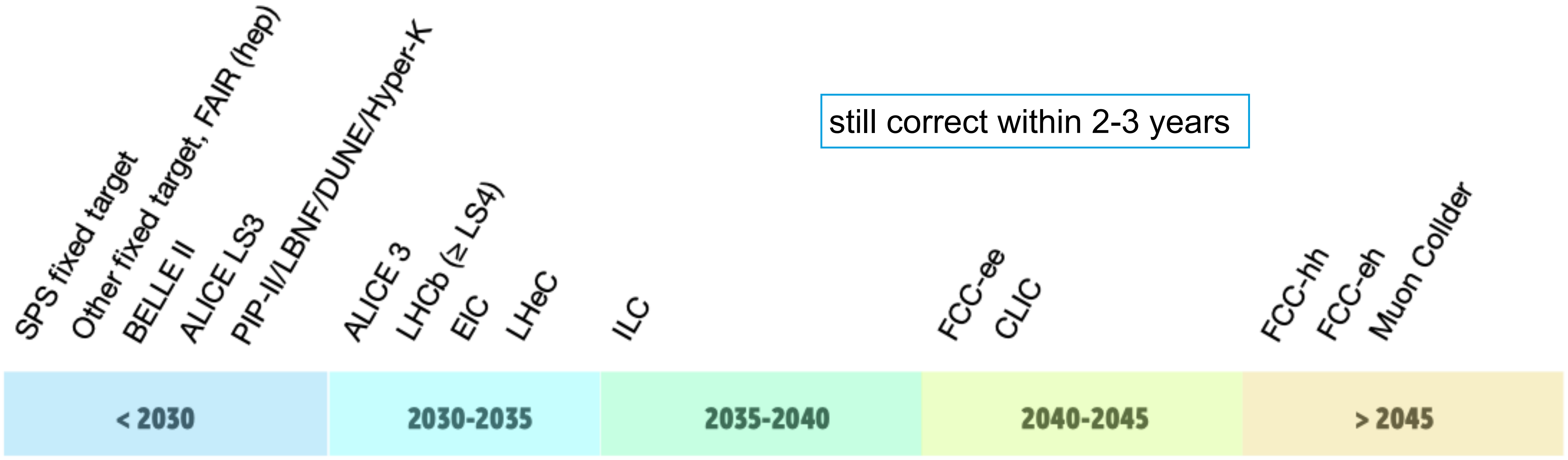


Information on the full process: [ECFA Detector R&D Roadmap]

P. Allport

Future Projects Timeline (Accelerator Roadmap)

Accelerator Roadmap - as seen by the Lab Directors Group



The dates shown in the diagram have low precision, and are intended to represent the earliest "feasible start date" (where a schedule is not already defined), taking into account the necessary steps of approval, development and construction for machine and civil engineering.

How Much Time Do We Need?

“Random” Examples - and NOT from the start of the R&D

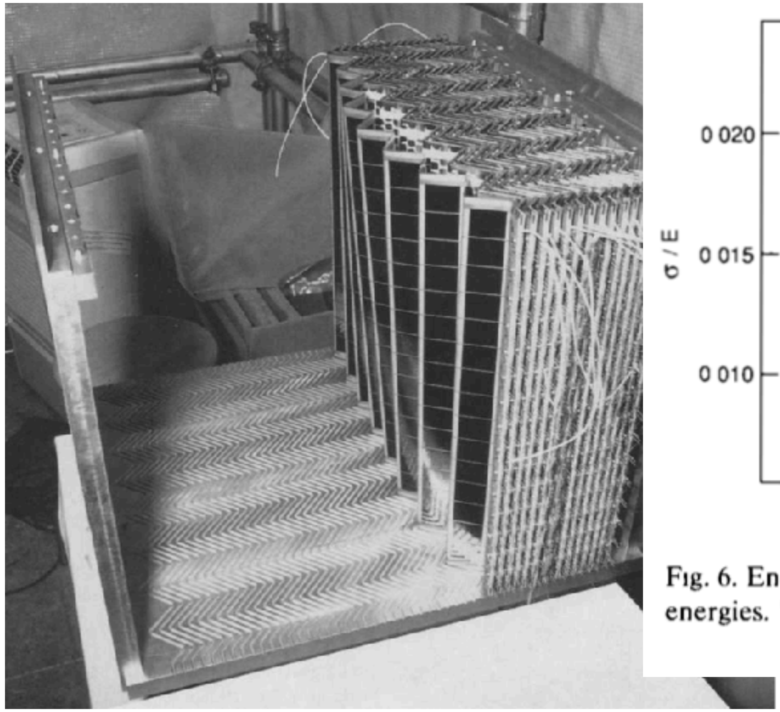
Nuclear Instruments and Methods in Physics Research A309 (1991) 438–449
North-Holland

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH
Section A

t0 -17y

Performance of a liquid argon electromagnetic calorimeter with an “accordion” geometry

RD3 Collaboration



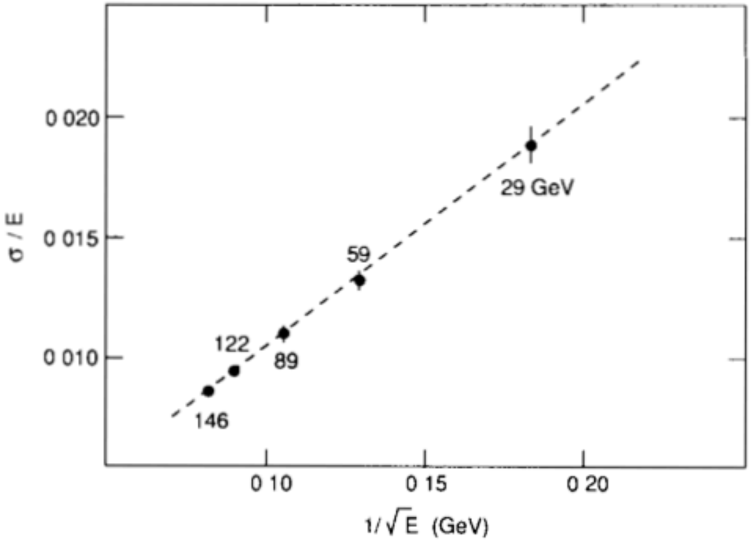
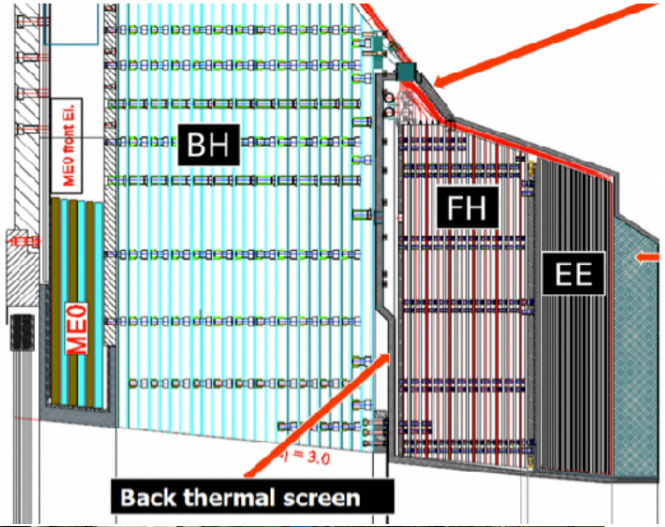


Fig. 6. Energy resolution of the prototype at different electron energies. The dashed line is a linear fit to the experimental points.

CMS
CERN-LHCC-2015-10
LHCC-P-008
CMS-TDR-15-02
ISBN 978-92-9083-417-5
1 June 2015



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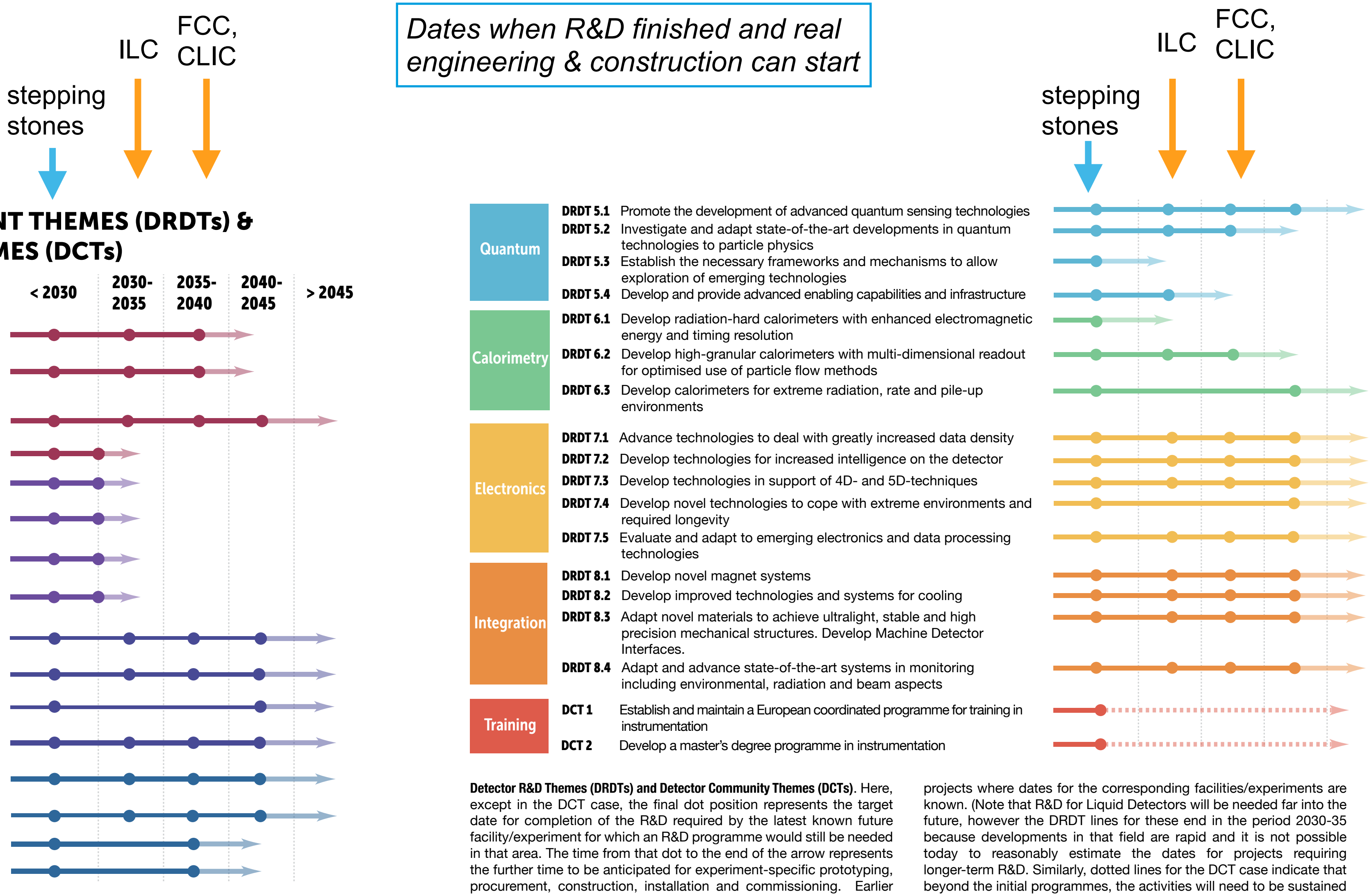
CALICE 2006-2018

ECFA Detector Roadmap Summary

Relating Technology R&D to Major Drivers from Facilities

Dates when R&D finished and real engineering & construction can start

DETECTOR RESEARCH AND DEVELOPMENT THEMES (DRDTs) & DETECTOR COMMUNITY THEMES (DCTs)



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

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

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

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

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

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

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

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

Training

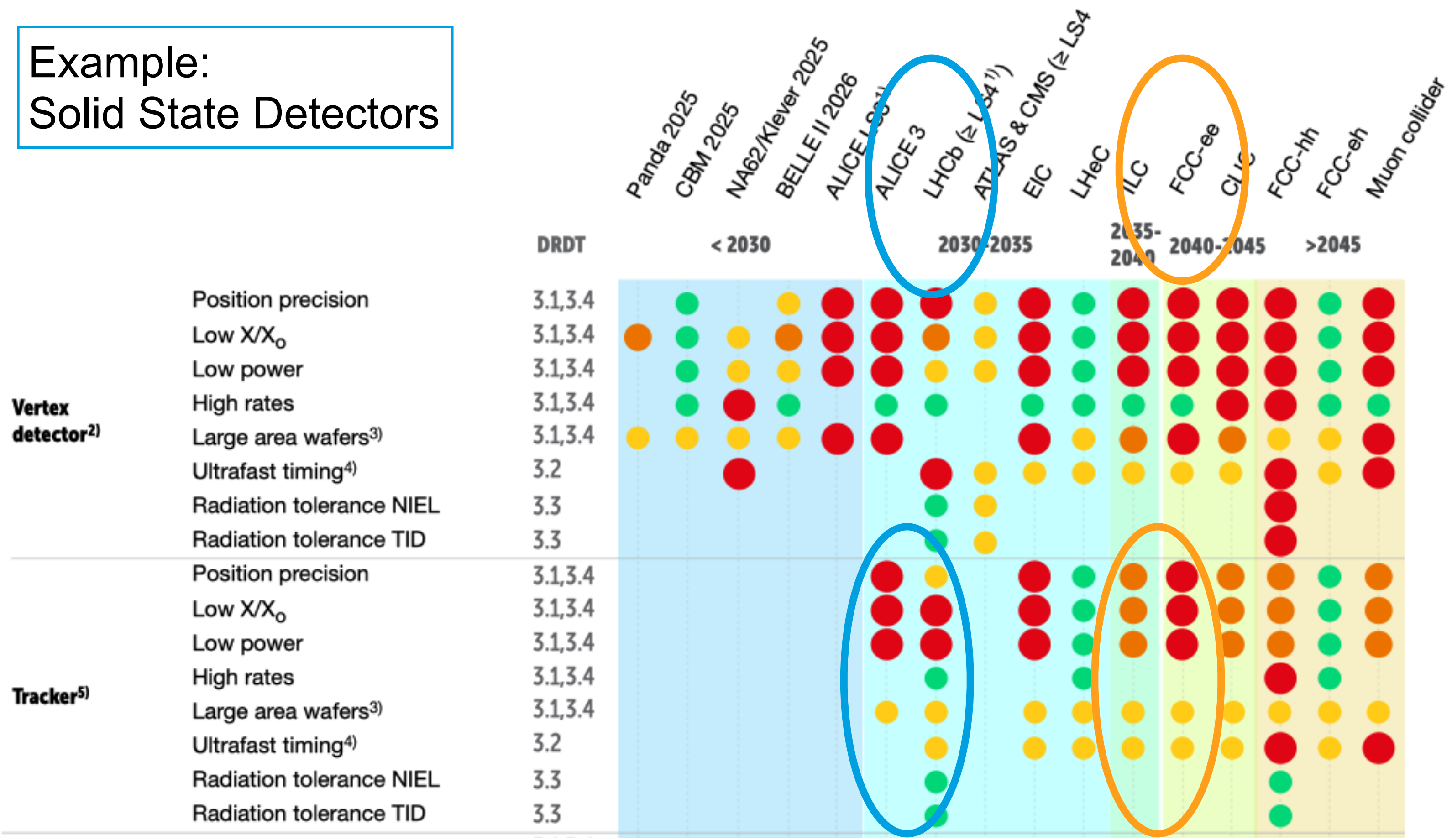
- **DCT 1** Establish and maintain a European coordinated programme for training in instrumentation
- **DCT 2** Develop a master's degree programme in instrumentation

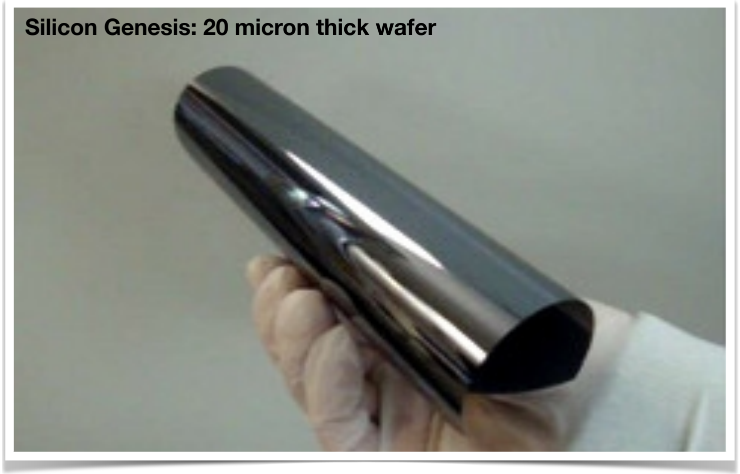
Detector R&D Themes (DRDTs) and Detector Community Themes (DCTs). Here, except in the DCT case, the final dot position represents the target date for completion of the R&D required by the latest known future facility/experiment for which an R&D programme would still be needed in that area. The time from that dot to the end of the arrow represents the further time to be anticipated for experiment-specific prototyping, procurement, construction, installation and commissioning. Earlier dots represent the time-frame of intermediate "stepping stone" projects where dates for the corresponding facilities/experiments are known. (Note that R&D for Liquid Detectors will be needed far into the future, however the DRDT lines for these end in the period 2030-35 because developments in that field are rapid and it is not possible today to reasonably estimate the dates for projects requiring longer-term R&D. Similarly, dotted lines for the DCT case indicate that beyond the initial programmes, the activities will need to be sustained going forward in support of the instrumentation R&D activities).

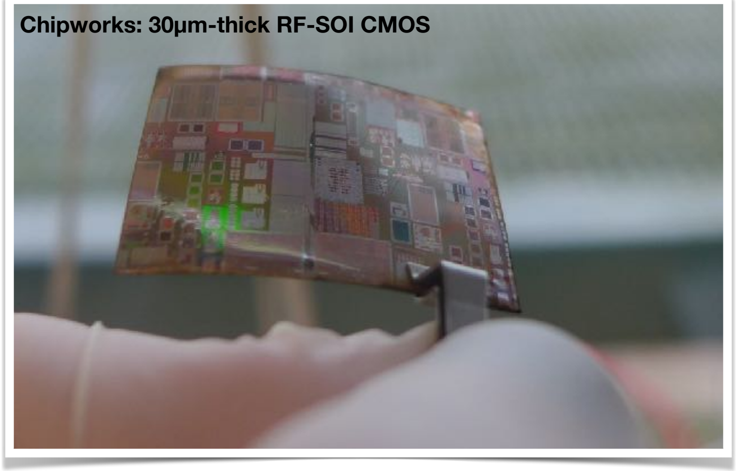
Synergies, Stepping Stones, R&D collaborations

Looking Across the Fence, and Beyond Tomorrow

Example:
Solid State Detectors




Silicon Genesis: 20 micron thick wafer


Chipworks: 30µm-thick RF-SOI CMOS

Magnus Mager (CERN) | ALICE ITS3 | CERN detector seminar | 24.09.2021 | 9

Must happen or main physics goals cannot be met · Important to meet several physics goals · Desirable to enhance physics reach · R&D needs being met

Detector Roadmap: Strategic Recommendations

General Needs of the Field

GSR 1 - Supporting R&D facilities
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

R&D Collaborations

Capture many of the guiding principles of AIDA projects

***Aim**: Propose mechanisms to achieve a **greater coherence across Europe** to better streamline the local and national activities and make these more effective.*

*Give the area **greater visibility and voice** at a European level to make the **case for the additional resources** needed for **Europe to maintain a leading role in particle physics** with all the associated **scientific and societal benefits** that will flow from this.*

K.Jakobs

approved by ECFA
and presented to Council
end of 2021

Contents

8 page synopsis brochure also prepared for less specialist audience

https://cds.cern.ch/record/2784893

Roadmap Implementation

Implementation of the 2021 ECFA Detector R&D Roadmap

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***

- ECFA **Roadmap Coordination Group** has worked out a proposal
  (P. Allport, S. Dalla Torre, J. D'Hondt, K. Jakobs, M. Krammer, S. Kuehn, F. Sefkow and I. Shipsey)

- Discussed and iterated with RECFA, national contacts for detector R&D, CERN management, managements of existing RD Collaborations, SPC and Council, and with Funding Agencies

- Open presentation at the July Plenary ECFA meeting by Phil Allport
  https://indico.cern.ch/event/1172215/

- Document describing the proposed implementation plan was sent to SPC and Council
  (attached to the agenda page)

endorsed by Council last week

Implementation of the ECFA Detector R&D Roadmap

In a Nutshell

European Strategy stresses importance of a strong focus on instrumentation

- Relevant R&D issues must be addressed **in time**
- Common R&D lines with near- and mid-term projects - exploit **synergies and stepping stones**

Successful completion of High-Luminosity LHC must remain key focus

- start up the process now, but only gradually ramp-up
- larger involvement of many groups only after phase II construction completed

Offer long-term perspectives for instrumentation physicists / engineers

Two components

- Establishment of **R&D collaborations** anchored at CERN
- Implementation of General Strategic Recommendations

R&D Collaborations

Reloaded.

Follow the successful model of R&D collaborations for the LHC

- funding in place since ~1986, R&D collaborations established in 1990
- Aim at few large DRD collaborations, to keep it manageable

Take full account of existing, successful and well managed R&D coll.

- Integrate with CERN EP R&D, AIDAinnova, RDxy, CALICE,…

Community-driven approach, supported by ECFA Roadmap Task Forces

- call for proposals, moderate process, timeline 1-2 years

Reasonably dimensioned review process (ECFA and CERN)

- addressing needs of future experiments is important criterion
- worldwide perspective

ECFA Higgs factory study WG 3 established: MC Fouz, G.Marchiori, FS

- as a forum for the interplay between physics and detector studies and R&D efforts
- This is also relying on functional detector concepts

For more details:
see talk by Phil Allport
at plenary ECFA in July:
https://indico.cern.ch/event/1172215/

Review and Approval Process

Lightweight and commensurate with effort

Scientific and Resource Reporting and Review by a Detector Research and Development Committee (DRDC)

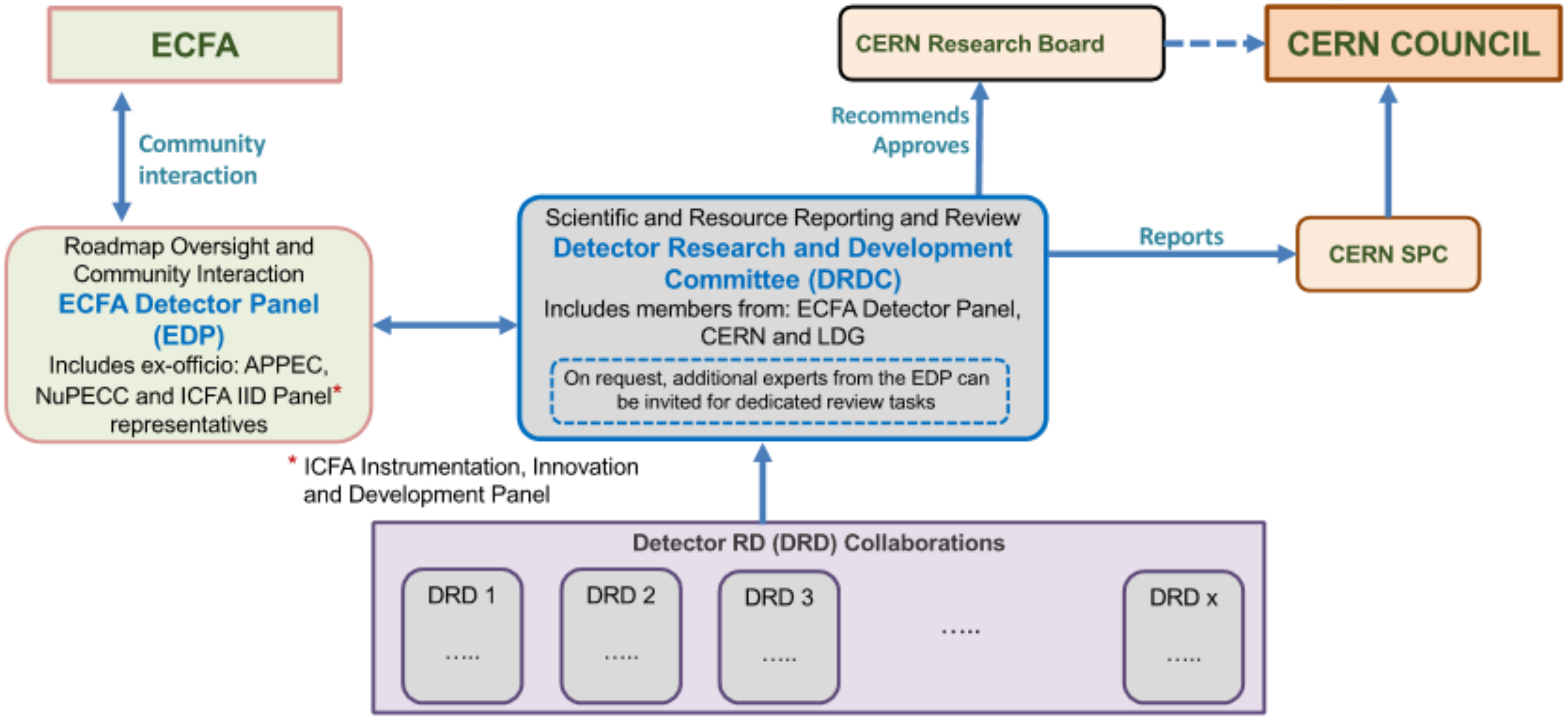
- yearly follow-up
- report via SPC to Council

Assisted by the ECFA Detector Panel (EDP):

- the scope, R&D goals, and milestones should be vetted against the vision encapsulated in the Roadmap.
- EDP exists, hosted at DESY: http://cds.cern.ch/record/2211641/files/

Funding Agency involvement via a dedicated Resources Review Board

- once every two years



resources awarded to and held by institutes

Categories of R&D

And Sources of Funding

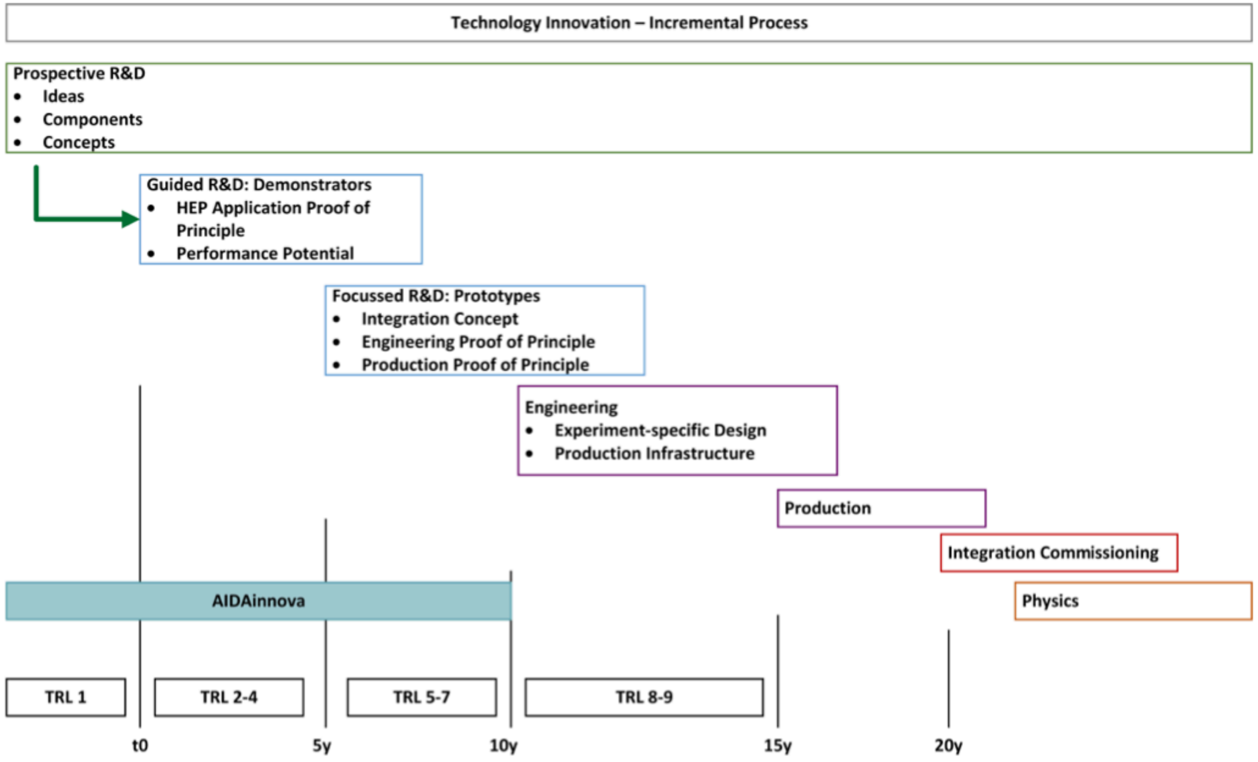
1. Strategic R&D via DRD Collaborations
   (long-term strategic R&D lines)
   (address the high-priority items defined in the Roadmap via the DRDTs)
2. Experiment-specific R&D
   (with very well defined detector specifications)
   (funded outside of DRD programme, via experiments, usually not yet covered within the projected budgets for the final deliverables)
3. ”Blue-sky” R&D
   (competitive, short-term responsive grants, nationally organised)

vision

focus

agility

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



Status of implementation:

- Discussions with existing RD50 and RD51 Collaborations (semiconductor and gaseous detectors, respectively) have been held (July, follow-up in September), on how the transition can be realised

- Consensus by all that new structure is needed and should be in place when HL-LHC detector construction is completed (HL-LHC deliverables have to be prioritised by many / all institutes);

  - Start-up of DRD Collaborations: January 2024 (also linked to end of approval of RD50/51 in Dec. 2023)
  - Ramp-up of the proposed resources (personnel, money) through 2025
  - Steady state by 2026

- Same start-up dates targeted for most of the DRD collaborations in the other areas

- Setting up: bottom-up approach involving the full community; (→ timeline on separate slide)

  To be coordinated by the **ECFA Task Force leaders with strong participation of existing RD managements**
  (First meeting with full Roadmap Panel (TF leaders) was held on 23 August)

- ECFA will accompany this process
  (regular meetings to discuss progress and upcoming issues every 6-8 weeks;
  RD50/51 management, CALICE management invited, together with Joachim Mnich and Manfred Krammer)

Further Feedback

And Progress

TF1: Gas

- see RD51, to integrate RPCs and large volumes

TF2: Liquids

- support and welcome the opportunity to realise a structures program

TF3: Silicon

- see RD50

TF4: PID and Photodetetors

- on boards, sub-structure to reflect 2 different areas

TF5: Quantum and Emerging

- needs more work, identify strategic targets in view of European Strategy for Particle Physics

TF6: Calorimeter

- constructive attitude of CALICE and other communities

Transverse activities TF7 and TF8

- discussions with CERN EP and LDG

TF7: Electronics

- contacted big labs on ASICs and off-detector electronics

TF8: Integration

- initiative on detector magnets and micro-channel cooling
- substructure likely

TF9: Training

- dedicated ECFA Panel proposed

Suggested Implementation Timeline

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	Outline structure and review mechanisms agreed by CERN Council. Detector R&D Roadmap Task Forces organise **community meetings** to establish the scope and scale of community wishing to participate in the corresponding new DRD activity. (Where the broad R&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.)
Q1 2023	**DRDC mandate formally defined** and agreed with CERN management; Core DRDC membership appointed; and EDP mandate plus membership updated to reflect additional roles.
Q1-Q2 2023	**Develop the new DRD proposals** based of the detector roadmap and community interest in participation, including light-weight organisational structures and resource-loaded work plan for R&D programme start in 2024 and ramp up to a steady state in 2026.
Q3 2023	**Review of proposals by DRDC** leading to recommendations for formal establishment of the DRD collaborations.
Q4 2023	DRD Collaborations receive formal **approval from CERN Research Board**.
Q1 2024	New structures operational for ongoing review of DRDs and R&D programmes underway.

Through 2024, collection of MoU signatures

In short

In AIDA Terminology - with a Grain of Salt

Similarities to AIDA process

- concrete plans, deliverables, resource-loaded (not a wish list)

Differences

- funding not exactly known - but cost projections should be backed by Funding Agencies
- interaction with Agencies needed in parallel to proposal preparation

Steps:

- community input (via existing R&D bodies where possible) by **~end of 2022**
- Work Package structure (Tasks, Participants, Resources, Deliverables, Milestones) by **spring 2023**
- Written proposal by **mid 2023**
    - do not repeat roadmap
    - aim at 20 pages per each of 9 the DRDs (or not much more)
- Review in **fall 23**
- “Grant Agreements” (MoU) in **2024**

Role of Detector Concepts

In the ECFA Study and in the Roadmap Implementation

Primary goal of the detector WG is to demonstrate, as input to the next EPPSU, that detectors can be built that match the precision physics potential of future Higgs factories

- The level of realism of such demonstrations should be comparable between different Higgs factory proposals

The other main goal is to provide guidance for coherent detector R&D efforts to address the priority requirements of Higgs factory experiments

- And to support their funding requests

Software is the underlying tissue

- Detector models for performance evaluation, physics benchmarking and optimisation studies
- Validation and proof of feasibility from R&D

But some Engineering advice and inspiration is also needed:

- Rate, occupancy and bandwidth estimates
- Powering and cooling requirements
- Mechanical constraints

Indispensable ingredient to strategic detector R&D

Support for detector concepts
(software development, engineering advice)
not part of DRD funding
(in the past: big labs)

ECFA Study WG3 Plans

For the next year

The Roadmap implementation process with its ambitious timescale challenges the detector R&D community

- Meetings, proposals, coordination - heavy load
- Resources for actual work are still at a very low level, and progress moderate

Main priority of WG3 is to support this process

- provide input on detector requirements
- provide a forum for feedback on R&D plans
- help R&D groups to convincingly make their case for a strategic R&D program
- make sure that Higgs factories well represented among other targets of DRDs

Plan a series of workshops

- Tracking and Vertexing for Higgs factories (TF1, TF3)
- Calorimetry and Particle ID for Higgs factories (TF4, TF6)
- Electronics and integration (TF7, TF8) separate or interleaved, t.b.d.

Will also be discussed in individual projects (ILC, FCC), but keep global view and ensure coherence here

Back-up

Process and Timeline

Organisation

May 2020
EPPSU mandate to ECFA to develop a roadmap for detector R&D efforts in Europe

Sep 2020
Structure in place with **Detector R&D Roadmap Panel**

Dec 2020
Task Forces active

Website: https://indico.cern.ch/e/ECFADetectorRDRoadmap

Expert & Community Consultation

Feb 2021
Collection of requirements of future facilities & projects

Feb/March 2021
Questionnaires of Task Forces to national contacts

Task Forces liaise with experts in
- ECFA countries
- adjacent disciplines
- industry

March-May 2021
Open Symposia

Drafting Roadmap & Feedback

May 2021
Task Forces collate input from symposia

25-28 May 2021 **Drafting sessions**
- opening session with all experts involved
- plenary & parallel sessions with Task Force members
- final session of Roadmap Panel

July 2021
Near final draft shared with RECFA*

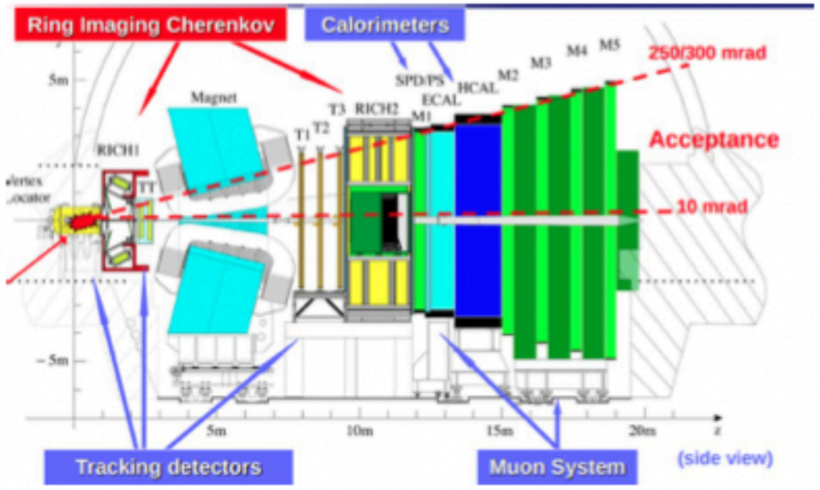
30 July 2021
Presentation at Joint ECFA-EPS session

August 2021
Collect final community feedback*

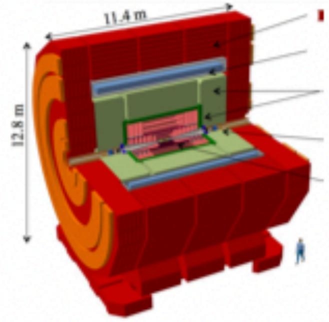
October-December 2021
Detector R&D Roadmap Document circulated for approval to ECFA in Nov 2021 and presentation to Council in Dec 2021

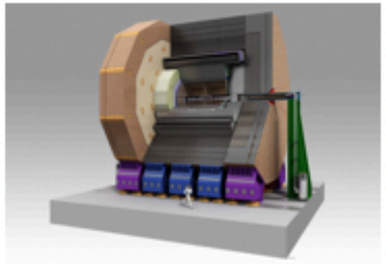
TF6 (Main) Target Projects

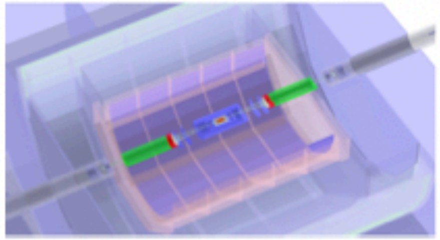
HL-LHC after LS4

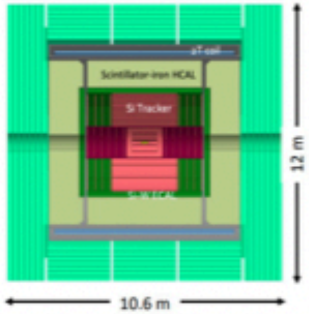


Higgs Factories

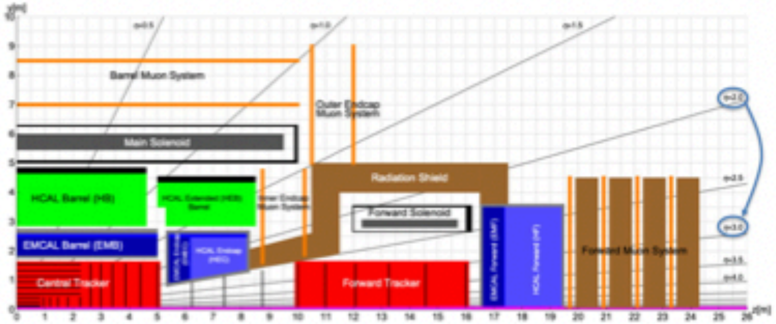




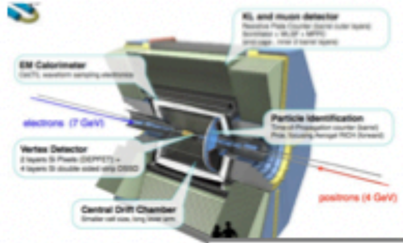


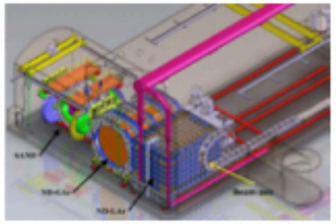


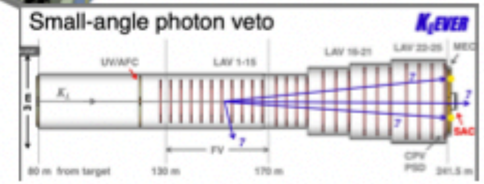
Future hadron colliders (including eh colliders)



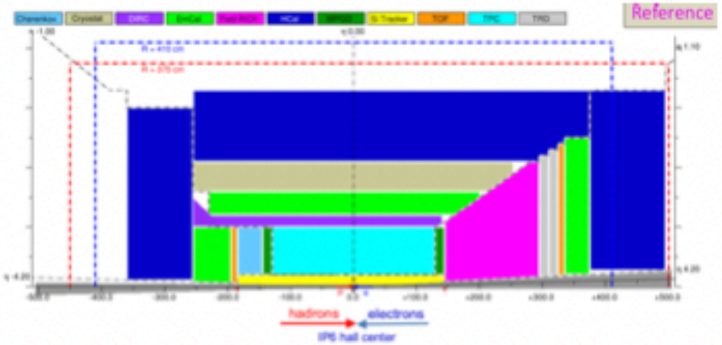
SuperKEKB, DUNE ND and Fixed Target



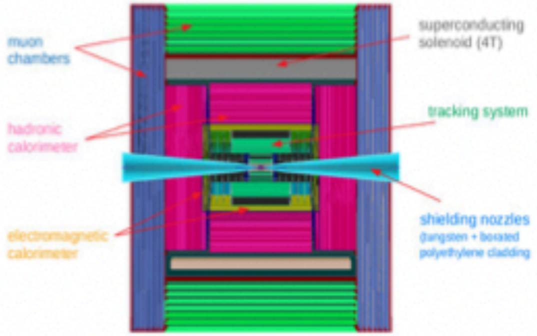




EiC



Muon Collider

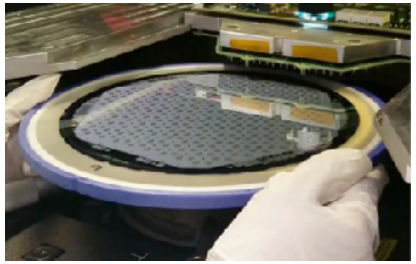


Calorimeter Symposium

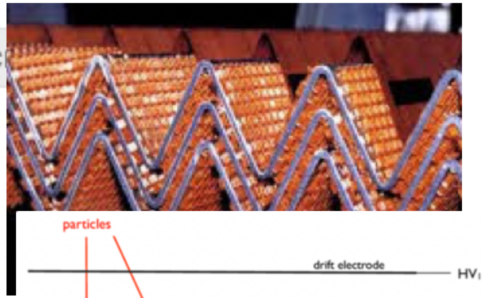
Orthogonal Views

Lessons learned: calorimeter upgrade R&D for HL-LHC & by Calice
Speaker: David Barney (CERN)
ECFA_TF6_LessonsL... ECFA_TF6_LessonsL...

Precision timing and their applications in calorimetry
Speaker: Nural Akchurin (Texas Tech University (US))
ECFA_PrecisionTimi... ECFA_PrecisionTimi...

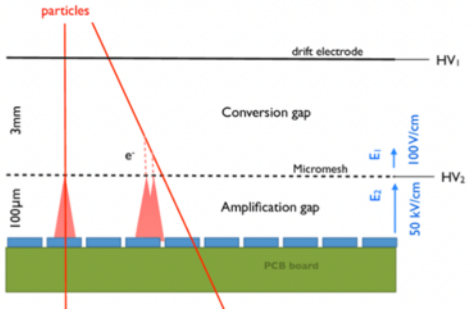


Si based highly and ultra-highly granular calorimeters
Speaker: Vincent Boudry (LLR – CNRS, École polytechnique, Institut P
ECFA_TF6_SiHGCalo... ECFA_TF6_SiHGCalo... EC

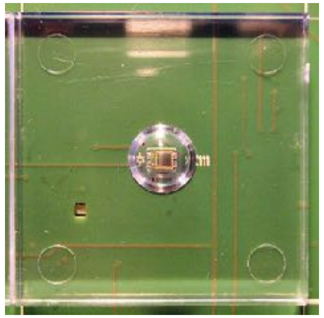


Future Noble Liquid Systems
Speaker: Brieuc Francois (CERN)
ECFA_TF6_NobleLiq...

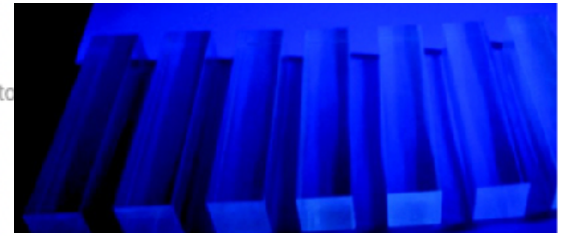
Gaseous calorimeters
Speaker: Maria Fouz Iglesias (Centro de Investigaciones Energéti ca
ECFATF6_GaseousD...



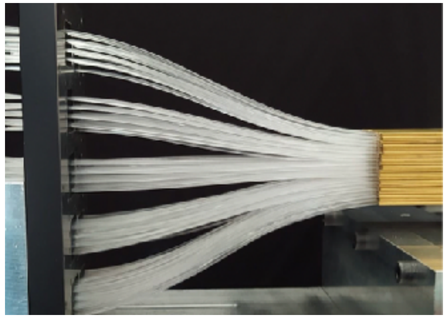
Tile and strip calorimeters
Speaker: Katja Kruger (Deutsches Elektronen-Synchrotron (DE))
TF6_Tiles_strips_v2....



Crystal calorimetry
Speaker: Marco Toliman Lucchini (Princeto
2021_05_07_ECFA_T...



R&D for Dual-Readout fibre-sampling calorimetry
Speakers: Gabriella Gaudio (INFN-Pavia), Gabriella Gaudio (
20210407_DualRead...



Compact and high performant readout systems
Speaker: André David (CERN)
20210507 ECFA TF6 ...

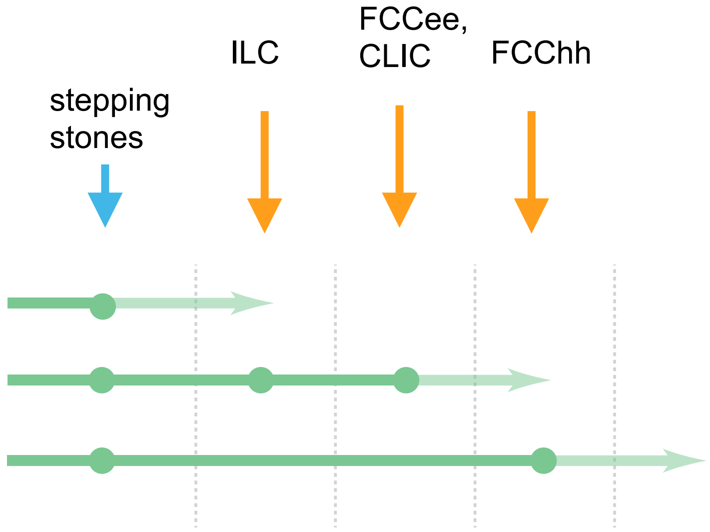
Symposia shed light along the technological direction
https://indico.cern.ch/event/999820/

ECFA Detector Roadmap Summary: TF6

Relating Technology R&D to Major Drivers from Facilities

Example:
Calorimeters

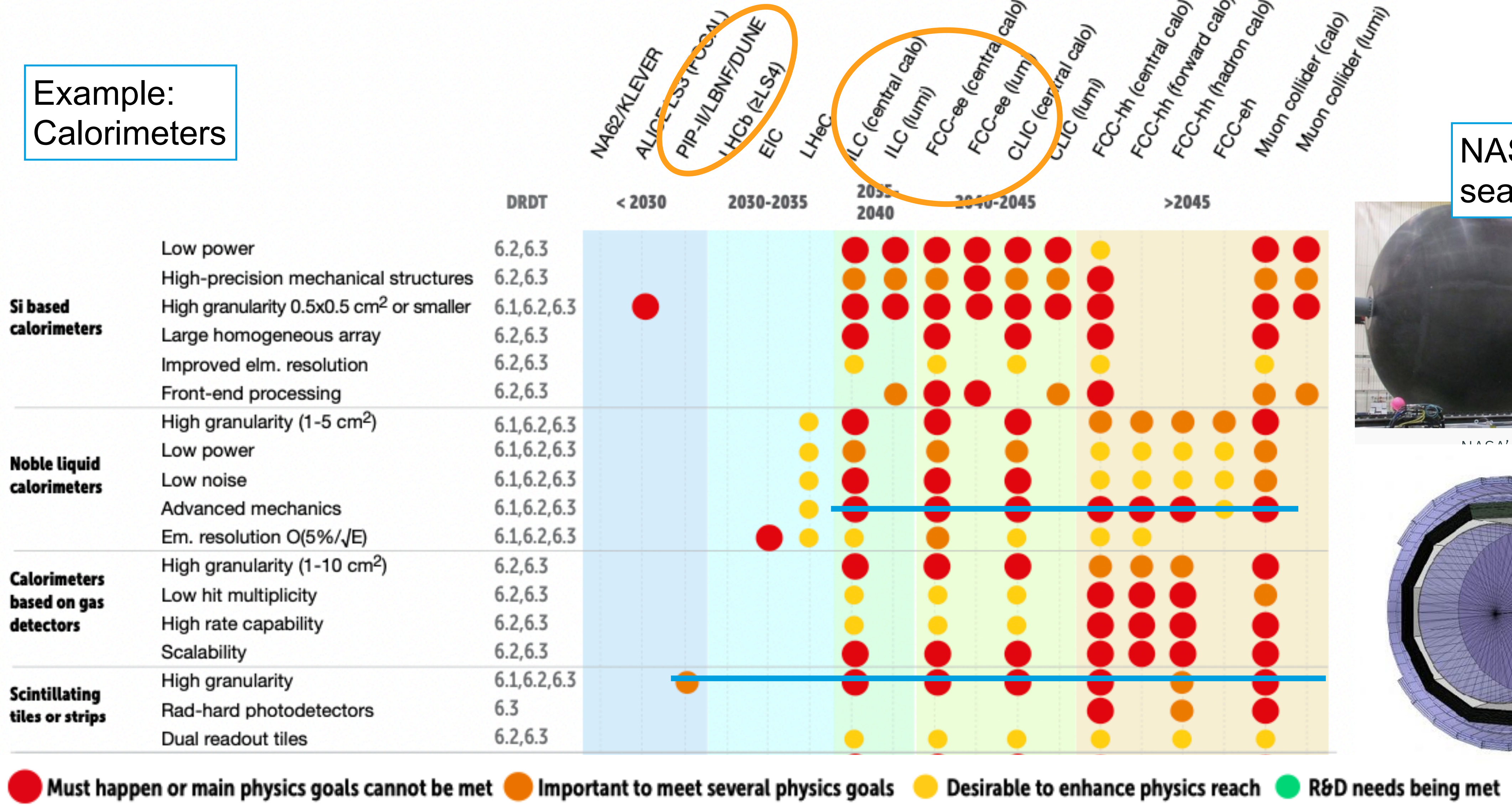
Calorimetry	**DRDT 6.1**	Develop radiation-hard calorimeters with enhanced electromagnetic energy and timing resolution
	DRDT 6.2	Develop high-granular calorimeters with multi-dimensional readout for optimised use of particle flow methods
	DRDT 6.3	Develop calorimeters for extreme radiation, rate and pile-up environments



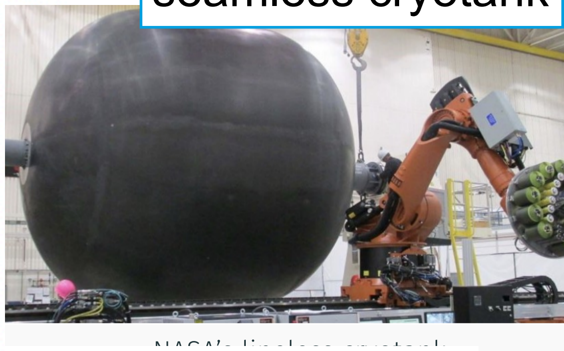
Synergies, Stepping Stones, R&D collaborations

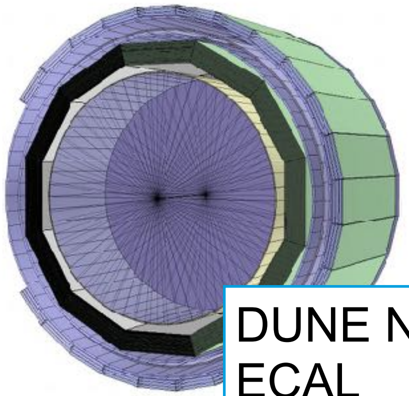
Looking Across the Fence, and Beyond Tomorrow

Example: Calorimeters



NASA seamless cryotank





DUNE ND ECAL

Synergies, Stepping Stones, R&D collaborations

Looking Across the Fence, and Beyond Tomorrow

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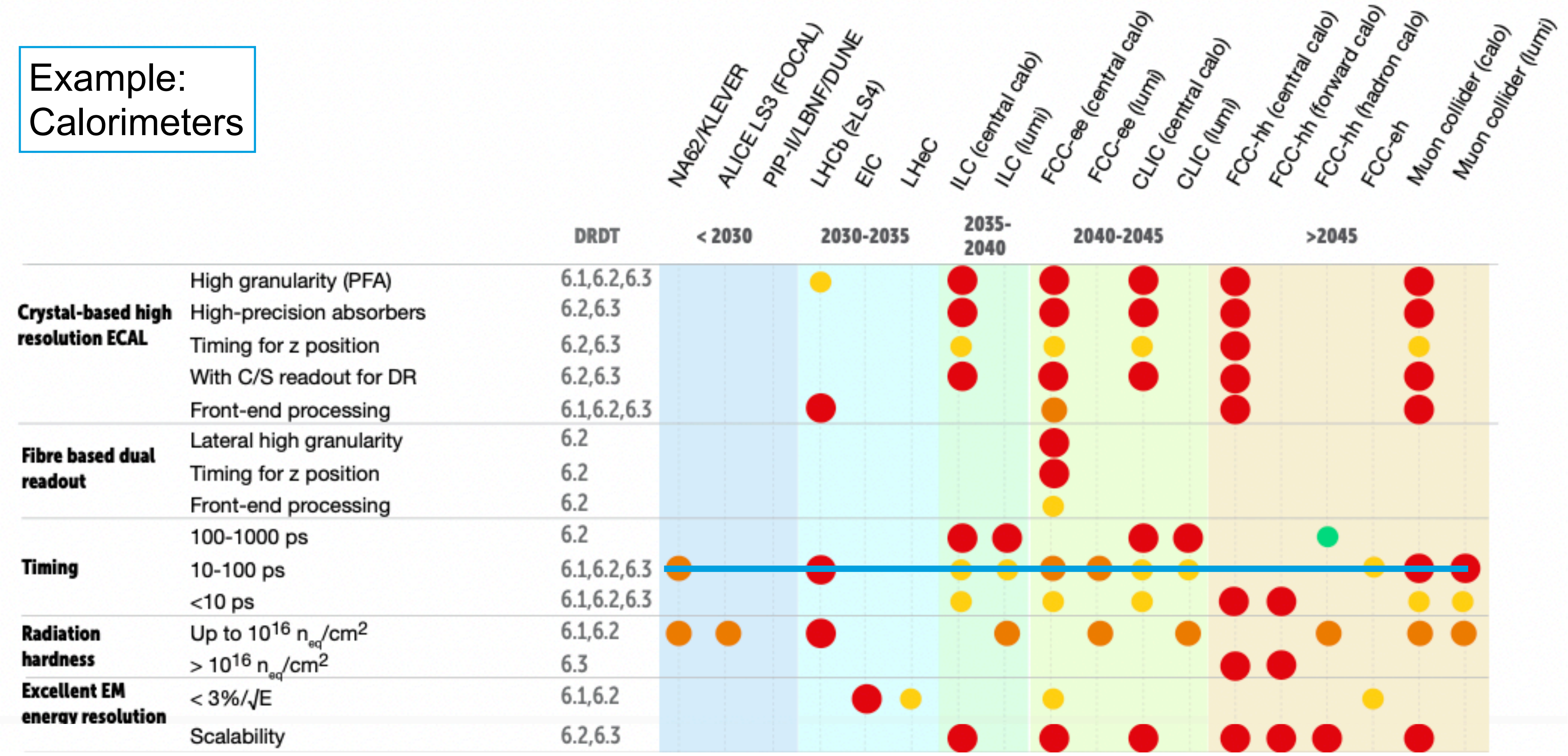

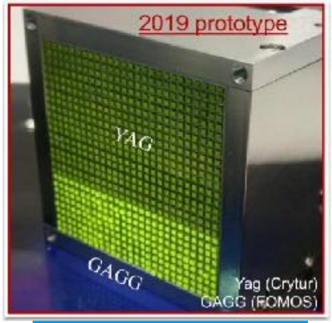

Fast timing SPACAL

Must happen or main physics goals cannot be met | Important to meet several physics goals | Desirable to enhance physics reach | R&D needs being met

General Strategic Recommendations

GSR 1 - Supporting R&D facilities

It is recommended that the structures to provide Europe-wide coordinated infrastructure in the areas of: test beams, large scale generic prototyping and irradiation be consolidated and enhanced to meet the needs of next generation experiments with adequate centralised investment to avoid less cost-effective, more widely distributed, solutions, and to maintain a network structure for existing distributed facilities, e.g. for irradiation

GSR 2 - Engineering support for detector R&D

In response to ever more integrated detector concepts, requiring holistic design approaches and large component counts, the R&D should be supported with adequate mechanical and electronics engineering resources, to bring in expertise in state-of-the-art microelectronics as well as advanced materials and manufacturing techniques, to tackle generic integration challenges, and to maintain scalability of production and quality control from the earliest stages.

GSR 3 - Specific software for instrumentation

Across DRDTs and through adequate capital investments, the availability to the community of state-of-the-art R&D-specific software packages must be maintained and continuously updated. The expert development of these packages - for core software frameworks, but also for commonly used simulation and reconstruction tools - should continue to be highly recognised and valued and the community effort to support these needs to be organised at a European level.

GSR 4 - International coordination and organisation of R&D activities

With a view to creating a vibrant ecosystem for R&D, connecting and involving all partners, there is a need to refresh the CERN RD programme structure and encourage new programmes for next generation detectors, where CERN and the other national laboratories can assist as major catalysers for these. It is also recommended to revisit and streamline the process of creating and reviewing these programmes, with an extended framework to help share the associated load and increase involvement, while enhancing the visibility of the detector R&D community and easing communication with neighbouring disciplines, for example in cooperation with the ICFA Instrumentation Panel.

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GSR 5 - Distributed R&D activities with centralised facilities

Establish in the relevant R&D areas a distributed yet connected and supportive tier-ed system for R&D efforts across Europe. Keeping in mind the growing complexity, the specialisation required, the learning curve and the increased cost, consider more focused investment for those themes where leverage can be reached through centralisation at large institutions, while addressing the challenge that distributed resources remain accessible to researchers across Europe and through them also be available to help provide enhanced training opportunities.

GSR 6 - Establish long-term strategic funding programmes

Establish, additional to short-term funding programmes for the early proof of principle phase of R&D, also long-term strategic funding programmes to sustain both research and development of the multi-decade DRDTs in order for the technology to mature and to be able to deliver the experimental requirements. Beyond capital investments of single funding agencies, international collaboration and support at the EU level should be established. In general, the cost for R&D has increased, which further strengthens the vital need to make concerted investments.

GSR 7 – "Blue-sky" R&D

It is essential that adequate resources be provided to support more speculative R&D which can be riskier in terms of immediate benefits but can bring significant and potentially transformational returns if successful both to particle physics: unlocking new physics may only be possible by unlocking novel technologies in instrumentation, and to society. Innovative instrumentation research is one of the defining characteristics of the field of particle physics. "Blue-sky" developments in particle physics have often been of broader application and had immense societal benefit. Examples include: the development of the World Wide Web, Magnetic Resonance Imaging, Positron Emission Tomography and X-ray imaging for photon science.

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GSR 8 - Attract, nurture, recognise and sustain the careers of R&D experts

Innovation in instrumentation is essential to make progress in particle physics, and R&D experts are essential for innovation. It is recommended that ECFA, with the involvement and support of its Detector R&D Panel, continues the study of recognition with a view to consolidate the route to an adequate number of positions with a sustained career in instrumentation R&D to realise the strategic aspirations expressed in the EPPSU. It is suggested that ECFA should explore mechanisms to develop concrete proposals in this area and to find mechanisms to follow up on these in terms of their implementation. Consideration needs to be given to creating sufficiently attractive remuneration packages to retain those with key skills which typically command much higher salaries outside academic research. It should be emphasised that, in parallel, society benefits from the training particle physics provides because the knowledge and skills acquired are in high demand by industries in high-technology economies.

GSR 9 - Industrial partnerships

It is recommended to identify promising areas for close collaboration between academic and industrial partners, to create international frameworks for exchange on academic and industrial trends, drivers and needs, and to establish strategic and resources-loaded cooperation schemes on a European scale to intensify the collaboration with industry, in particular for developments in solid state sensors and micro-electronics.

GSR 10 – Open Science

It is recommended that the concept of Open Science be explicitly supported in the context of instrumentation, taking account of the constraints of commercial confidentiality where these apply due to partnerships with industry. Specifically, for publicly-funded research the default, wherever possible, should be open access publication of results and it is proposed that the Sponsoring Consortium for Open Access Publishing in Particle Physics (SCOAP^3) should explore ensuring similar access is available to instrumentation journals (including for conference proceedings) as to other particle physics publications.

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- **The detector roadmap depicts a rich landscape of connected R&D activities**

- **It exhibits synergies between parallel activities targeted at different future projects at different facilities**

- **Opportunities appear where near-term projects with less demanding conditions may serve as stepping stones for a strategic R&D targeting more aggressive requirements**

- **General strategic recommendations capture the needs of an evolving field with central importance for our future ambitions**

Scope

AIDAinnova focusses on Strategic R&D in the pre-TDR phase

- Technology Readiness Levels 2-7
- Not yet experiment-specific: potential to unfold synergies

Include some prospective R&D

- competitive call at start of project
- “Blue Sky”, quantum sensors,…

Targeted applications

- Higgs Factories
- ALICE, LHCb LS3 pre-TDR, ATLAS & CMS LS4
- Accelerator-based neutrino experiments
- and others