ECFA Detector Roadmap Implementation

Why?
Why now?
When?
How?
Where?

15th Terascale Detector Workshop

March 2, 2023

Felix Sefkow
DESY

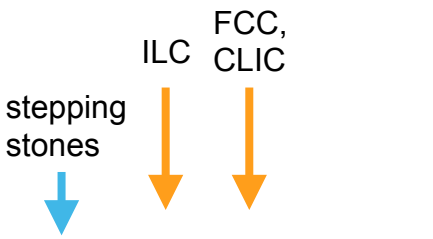
ECFA Detector Roadmap Summary

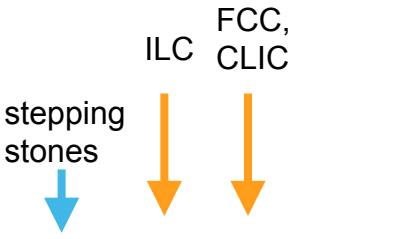
Relating Technology R&D to Major Drivers from Facilities

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

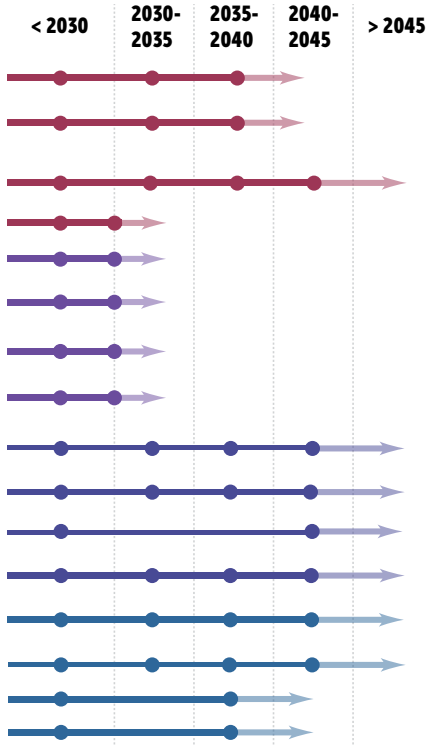
~ 200 pages
~ 1 year young

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

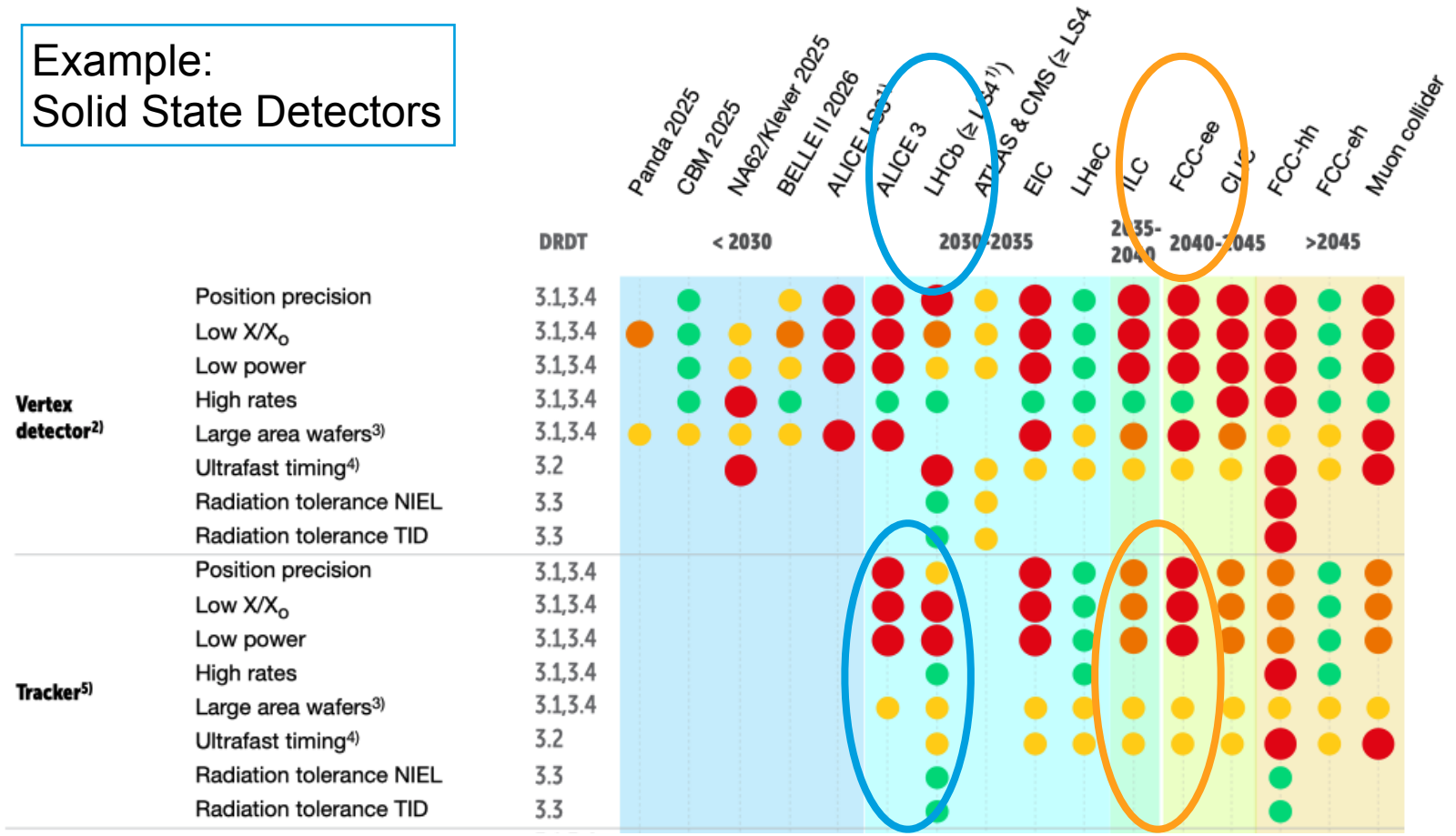
- **DCT 1** Establish and maintain a European coordinated programme for training in instrumentation
- **DCT 2** Develop a master's degree programme in instrumentation

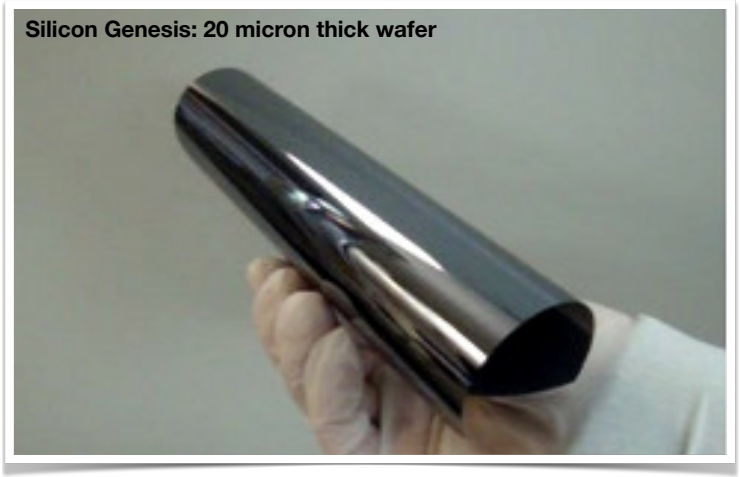
Detector R&D Themes (DRDTs) and Detector Community Themes (DCTs). Here, except in the DCT case, the final dot position represents the target date for completion of the R&D required by the latest known future facility/experiment for which an R&D programme would still be needed in that area. The time from 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).

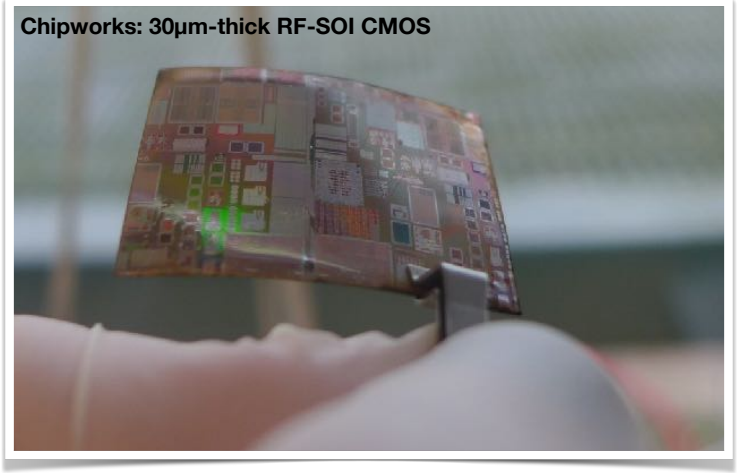
Synergies, Stepping Stones, R&D collaborations

Looking Across the Fence, and Beyond Tomorrow

Example:
Solid State Detectors







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

How Much Time Do We Need?

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

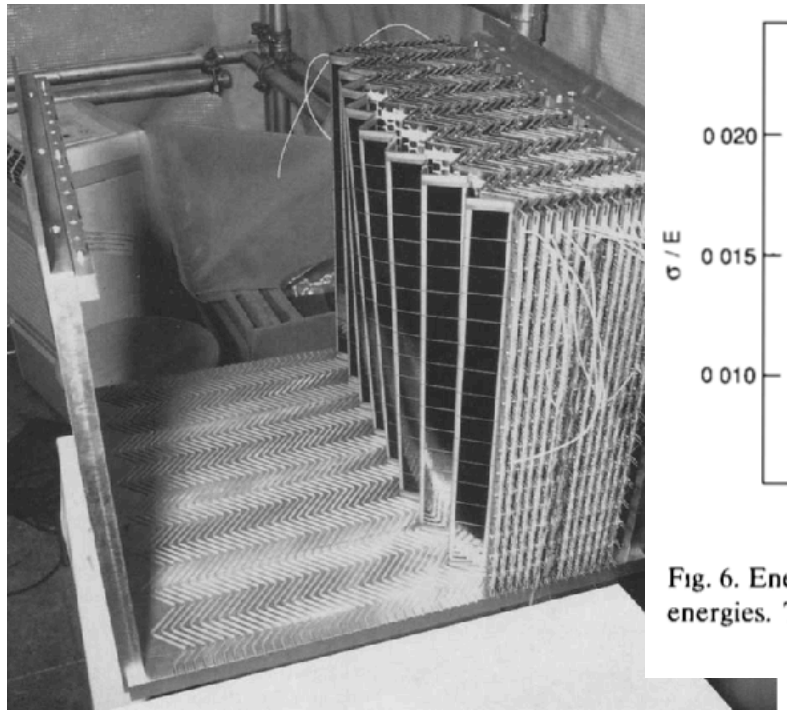
Nuclear Instruments and Methods in Physics Research A309 (1991) 438–449
North-Holland

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A

t0 -17y

Performance of a liquid argon electromagnetic calorimeter with an "accordion" geometry

RD3 Collaboration



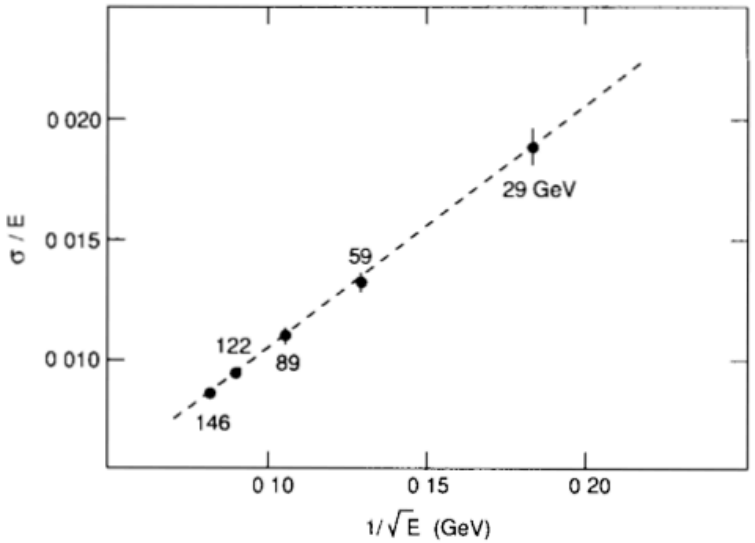


Fig. 6. Energy resolution of the prototype at different electron energies. The dashed line is a linear fit to the experimental points.

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

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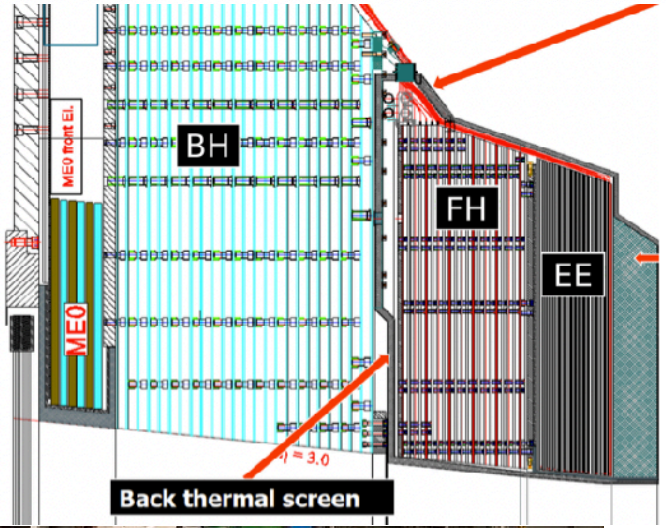
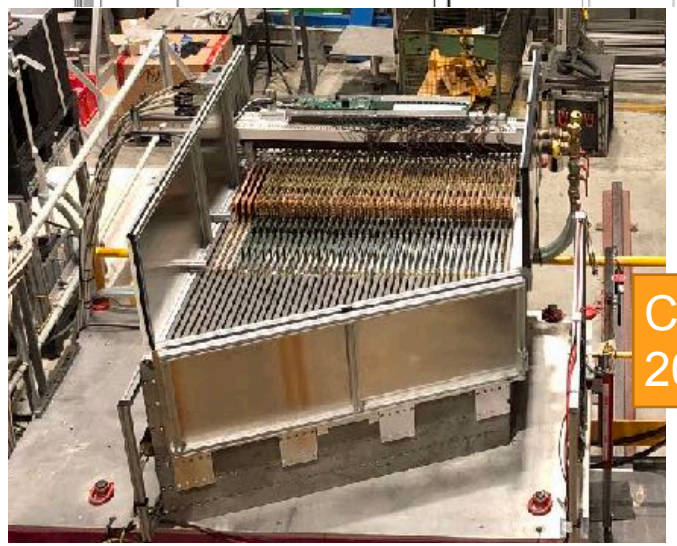




CALICE
2006-2018

DRD: Detector R&D Collaborations

Anchored at CERN

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

- invite proposals, moderate process, timeline 1-2 years

Reasonably dimensioned review process (ECFA and CERN)

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

Process approved by CERN Council

- following extensive consultations with funding agencies
- Document: https://indico.cern.ch/event/1197445/contributions/5034860/attachments/2517863/4329123/spc-e-1190-c-e-3679-Implementation_Detector_Roadmap.pdf

Review and Approval Process

Lightweight and commensurate with effort

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

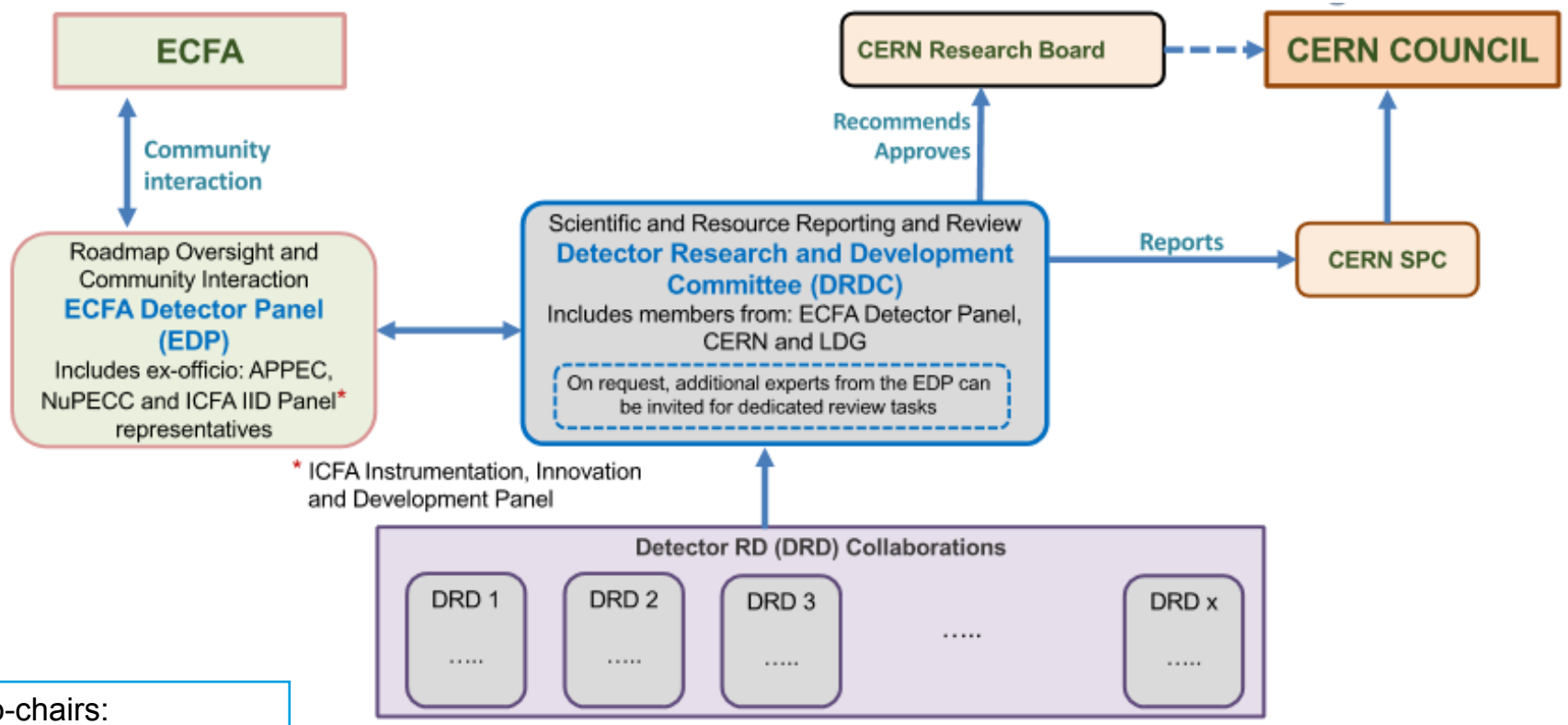
- yearly follow-up
- report via SPC to Council

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



Co-chairs:
P. Allport. D. Contardo

resources awarded to and held by institutes

Implementation Timeline

Ambituous Schedule

Goal: Transition to new scheme during 2023

- approval of LHC-oriented RD50 (silicon), RD51 (gas detector) collaborations expires Dec 2023

Major Steps:

- **community input** (via existing R&D bodies where possible) by **Q1 2023**
  - To get involved, register at https://indico.cern.ch/event/957057/page/27294-implementation-of-the-ecfa-detector-rd-roadmap
- Work Package **structure** (Tasks, Participants, Resources, Deliverables, Milestones) by **spring 2023**
- In parallel, **DRDC** mandate and membership defined
- Written **proposals**, based on ECFA Detector Roadmap, by **mid 2023**
  - do not repeat roadmap; concrete plans, deliverables, resource-loaded (not a wish list) for **period 2024-2030**
  - aim at 20 pages per each of 9 the DRDs
- **Review** (by DRDC, assisted by EDP) in **fall 23,** approval by **end 2023**
- R&D collaborations **operational**, “Grant Agreements” (**MoU** signatures) through **2024**

Challenge

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

Proposal Guidelines

Preliminary Templates

To be finalised by DRDC

- currently being set up

Proposal structure

- length < 20 pages - do not repeat Roadmap

  - Introduction (objectives of the DRD collaboration)
  - Planning technology area 1 (including a task/deliverable synoptic, resources and list of contributing institutes)
  - …
  - Planning technology area n (including a task/deliverable synoptic, resources and list of contributing institutes)
  - Common simulation tools and test facilities
  - Partnerships (industrial, other research areas, other applications)
  - Networking and training
  - Proposal for the collaboration structure
  - Resources (as discussed below) both existing and anticipated
  - Summary (high level planning synoptic by DRDT broken-down to sub-areas)

Deliverables, Milestones, Required Resources, Institutes

Preliminary

Timeline of milestones and major deliverables per DRDT and technology					
Deliverables or milestones in appropriate years	**2024**	**2025**	**2026**	**2027-2029**	**≳ 2030**
DRDT 1					
Technology 1	List of deliverables in year due (if any)				
…					
Technology n	List of deliverables in year due (if any)				
…					
DRDT n					
Technology 1	List of deliverables in year due (if any)				
…					
Technology n	List of deliverables in year due (if any)				

Personnel to be further broken down in categories

Timeline of FTE per DRDT and technology					
Total FTE estimated to be required to deliver the outlined R&D programme	**2024**	**2025**	**2026**	**2027-2029**	**≳ 2030**
DRDT 1					
Technology 1	Total required FTE				
…					
Technology n	Total required FTE				
…					
DRDT n					
Technology 1	Total required FTE				
…					

List of deliverables per technology and DRDT				
List of Contributing Institutes	**Technology 1**	**…**	**…**	**Technology n**
DRDT 1	List of contributors			
…				
DRDT n	List of contributors			

Additional Confidential Information

Only visible to Core Team and Reviewers

expected to be available from existing sources

proposed resources being sought as new “strategic” funding

Expect that assumptions are realistic

- by consultations with funding agencies

However no guarantee of commitment

- further iteration towards MoU in 2024

Timeline of FTE per DRDT and technology				
Estimate of expected total FTE from existing sources (not requiring new "strategic" support)	2024	2025	2026	≥ 2027
DRDT 1				
Technology 1	Total estimated FTE from existing sources			
...				
Technology n	Total estimated FTE from existing sources			
...				
DRDT n				
Technology 1	Total estimated FTE from existing sources			
...				
Technology n	Total estimated FTE from existing sources			
Timeline of Materials and Services (non-FTE) Funding per DRDT and technology				
Estimate of expected total non-FTE funds from existing sources (not requiring new "strategic" funding)	2024	2025	2026	≥ 2027
DRDT 1				
Technology 1	Total estimated funds from existing sources			
...				
Technology n	Total estimated funds from existing sources			
...				
DRDT n				
Technology 1	Total estimated funds from existing sources			
...				
Technology n	Total estimated funds from existing sources			
Timeline of FTE per DRDT and technology				
Estimate of total R&D programme FTE (sum of existing and hoped for given realistic assumptions)	2024	2025	2026	≥ 2027
DRDT 1				
Technology 1	Total number of FTE proposed			
...				
Technology n	Total number of FTE proposed			
...				
DRDT n				
Technology 1	Total number of FTE proposed			
...				
Technology n	Total number of FTE proposed			
Timeline of Materials and Services (non-FTE) Funding per DRDT and technology				
Estimate of total R&D programme non-FTE funding (sum of existing and hoped for given realistic assumptions)	2024	2025	2026	≥ 2027
DRDT 1				
Technology 1	Total funding proposed			
...				
Technology n	Total funding proposed			
...				
DRDT n				
Technology 1	Total funding proposed			
...				
Technology n	Total funding proposed			

FTE

non-FTE

FTE

non-FTE

Table 3 Confidential Compilation of Available and Required Resources

Implementation Process Has Started

Meetings

DRD6 Calorimeters made a start

- Jan 12 at CERN: https://indico.cern.ch/event/1212696/
- 120 participants, 60 in person, lively and constructive discussions
  - participation from Americas and Asia; DOE was connected and voiced support
  - **worldwide** (non-European) representation in proposal team: J. Brau (Oregon), S. Eno (Maryland), M.-A. Pleier (BNL), W.Ootani (Tokyo), H.Yoo (Seoul)
- large part of proposed R&D is targeted at Higgs Factories, but more near-term projects as well, e.g. LHCb
- 2nd community Meeting **April 20:** WP structure,… input due **March 25**

More meetings scheduled

- **DRD1 Gas detectors** March 1-3 at CERN https://indico.cern.ch/event/1245751/
- **DRD7 Electronics** March 14-15 at CERN https://indico.cern.ch/event/1214423/
- **DRD3 Solid State detectors** March 22-23 at CERN https://indico.cern.ch/e/1214410
- **DRD4 Photodetectors and PID** t.b.a., coordinators C. Joram (CERN), P. Krizan (JSI, Ljubljana)
- **DRD8 Integration:** discussions on on one-to-one basis, coordinators F.Hartmann (KIT), W.Riegler (CERN)

How to get involved:

- register at https://indico.cern.ch/event/957057/page/27294-implementation-of-the-ecfa-detector-rd-roadmap

Back-up

ECFA Calorimeter Proposal Team – Composition Feb. 14 2023

updated

European Strategy Update

Coordinators:
Roman Poeschl (IJCLAB Orsay)
Roberto Ferrari (INFN Pavia)

Track 1: Sandwich calorimeters with fully embedded Electronics – Main and forward calorimeters

Track conveners: Adrian Irles (IFIC, adrian.irles@ific.uv.es), Frank Simon (KIT, frank.simon@kit.edu), Jim Brau (University of Oregon, jimbrau@uoregon.edu)

+ Wataru Ootani (Tokyo)

Track 2: Liquified Noble Gas Calorimeters

Track Conveners: Martin Aleksa (CERN, martin.aleksa@cern.ch), Nicolas Morange (IJCLab, nicolas.morange@ijclab.in2p3.fr)

+ Marc-André Pleier (BNL)

Track 3: Optical calorimeters: Scintillating based sampling and homogenous calorimeters

Track Conveners: Etiennette Auffray (CERN, etiennette.auffray@cern.ch), Gabriella Gaudio (INFN-Pavia, gabriella.gaudio@pv.infn.it), Macro Lucchini (University and INFN Milano-Bicocca, marco.toliman.lucchini@cern.ch), Philipp Roloff (CERN, philipp.roloff@cern.ch), Sarah Eno (University of Maryland, eno@umd.edu)

+ Hwidong Yoo (Yonsei U, Seoul)

Track 4: Alternatives or transversal proposals.

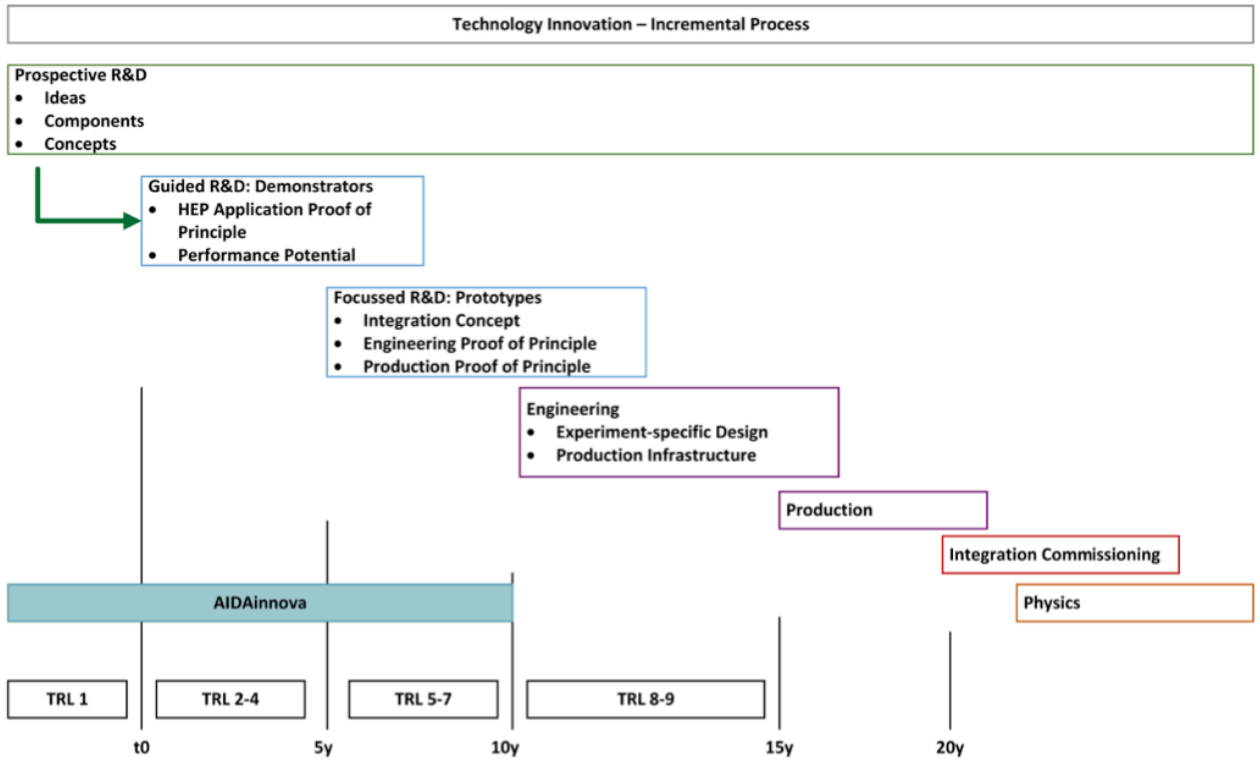
Watched by entire proposal team

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)
   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



From the AIDAinnova proposal

ECFA Higgs Factory Study WG3 Detectors: Plans

For this 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 (apart from exceptions)

Main priority of ECFA WG3 is to support this process

- provide input on detector requirements and needed R&D
- 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

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

Plan a series of workshops: bring together DRDs and studies / concepts

- Tracking and Vertexing for Higgs factories (TF1, TF3) **May 30 - June 1 at CERN**
- Calorimetry (and PD/PID?) for Higgs factories ((TF4,) TF6): **May 3-5 at CERN**
- Electronics and integration (TF7, TF8)
- Systematics, Alignment and Calibration