



Towards Detector R&D Collaborations - Update on Implementation of the Detector R&D Roadmap

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(<https://cds.cern.ch/record/2784893>)

Also 8 page synopsis document:

<https://cds.cern.ch/record/2784893/files/Synopsis%20of%20the%20ECFA%20Detector%20R&D%20Roadmap.pdf>



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2021

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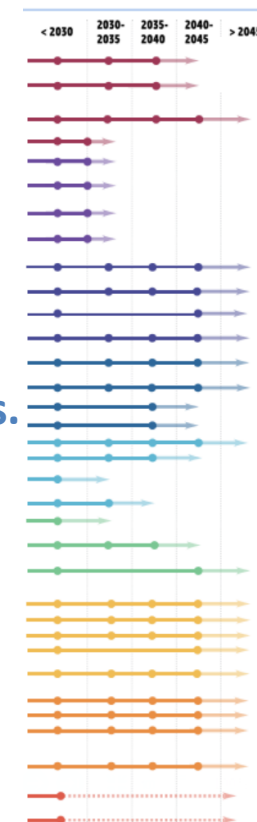
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Gaseous	DRDT 1.1	Improve time and spatial resolution for gaseous detectors with long-term stability
	DRDT 1.2	Achieve tracking in gaseous detectors with dE/dx and dN/dx capability in large volumes with very low material budget and different read-out 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

- The most urgent R&D topics in each Task Force area are identified as **Detector R&D Themes**.
- The **timeframe illustration for requirements in each DRDT area, in both the brochure and the main document, are based on the more detailed information and charts in the individual chapters.**

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





In addition to the Detector R&D Themes described above and discussed in each chapter the following General Strategic Recommendations were made under the following headings.

- 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**

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.

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.

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.

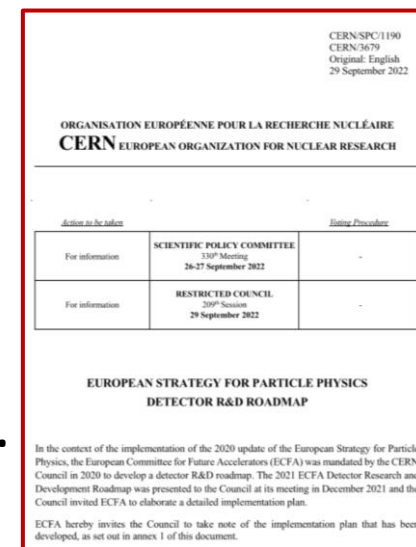
GSR 9 - Industrial partnerships

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.

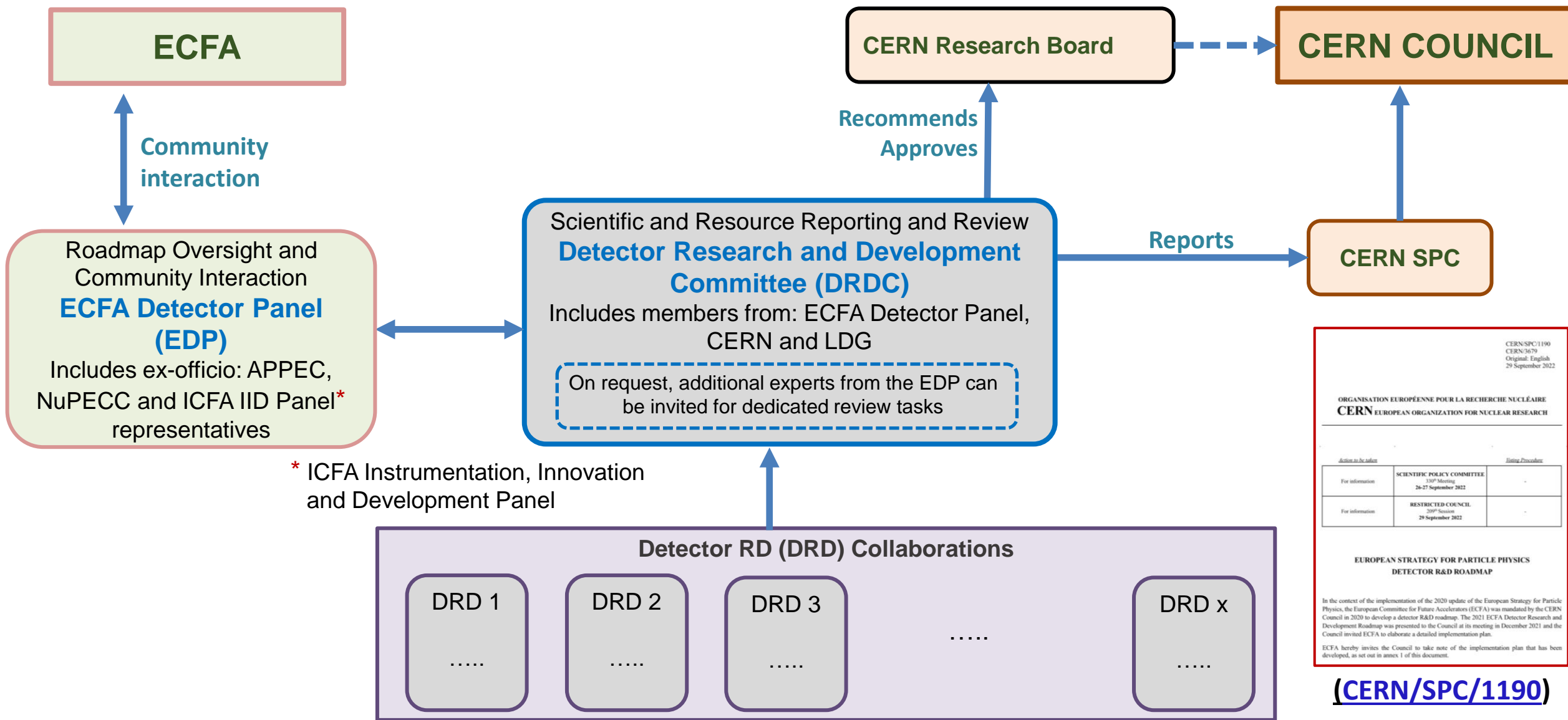
GSR 10 – Open Science

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 (SCOAP³) should explore ensuring similar access is available to instrumentation journals (including for conference proceedings) as to other particle physics publications.

- CERN Council charged ECFA with developing an implementation plan for the Detector R&D Roadmap recommendations.
- Initial proposals, worked out by the Roadmap Coordination Group, were presented and discussed in the Rome RECFA meeting in March 2022, followed by extensive discussions with Funding Agencies and further refinement of the proposals.
- The proposed Detector and Accelerator implementation plans were presented to all Funding Agencies at the April 2022 Plenary RRB <https://indico.cern.ch/event/1133070/timetable/> by ECFA and LDG Chairs (Karl Jakobs and Dave Newbold).
 - Given the diverse funding and costing models for different Funding Agencies it was decided to utilise the existing understood framework for funding long-term investments in particle physics experiments at CERN as the basis for supporting **Detector R&D (DRD)** collaborations to deliver the multi-decadal **Strategic** R&D programmes to meet requirements identified by the DRDTs in the Roadmap documents.
 - The clear need for “**strategic**” R&D was emphasised as separate from, but additional to, that for “**blue-sky**” and “**experiment-specific**” activities (*see also back-up*).
- Slightly updated implementation proposals were then presented during June 2022 Council Week and at Plenary ECFA on 22nd July 2022.
- Further refinements of the implementation plan for the Detector R&D Roadmap were discussed over the summer with the Roadmap Panel, CERN management plus RD50, RD51 and CALICE representation.
- **These led to the September 2022 SPC and Council approved implementation plan: [CERN/SPC/1190](https://cds.cern.ch/record/2811190).**



- The aim is for the DRDs to be up and running as entities by **2024** and to be ready for having a ramp up of the proposed resources awarded for **Strategic R&D** through **2025** to a steady state by **2026**.
- The timescales are set by the necessity to prioritise HL-LHC deliverables, to take account of existing CERN RD collaborations not being expected to continue in their current form beyond **2023**, and to allow a timely completion or transfer of existing funded R&D into this new framework.
- The **formation of the new DRD collaborations** should clearly adopt a **community-driven approach**. We are therefore:
 - proceeding using existing ECFA Detector R&D Roadmap TFs due to their extensive contacts with the community;
 - are engaging existing CERN RDs, and other collaborations covering several DRDT topics, to help nucleate the process;
 - Inviting the different communities to sign up to the topics where they wish to be involved at <https://indico.cern.ch/event/957057/page/27294-implementation-of-the-ecfa-detector-rd-roadmap>.
- Research topics, budget, milestones, etc., to be **adapted as rolling grants for long-term R&D lines** with flexibility for adapting to the changing international landscape and new R&D opportunities (for example coming from “*blue-sky*” R&D funded through resources outside those awarded for DRDT-specific strategic R&D).
- The needs of the next European Strategy update and any subsequent revision of the Roadmap should not be forgotten.



(CERN/SPC/1190)



DRDC:

- provides financial, strategic and (with EDP) scientific oversight;
- evaluates initial DRD resources request with focus on required effort matching to pledges by participating institutes (including justification, given existing staff, infrastructures and funding streams);
- decides on recommending approval;
- conducts progress reviews on DRDs and produces a concise annual scientific summary encompassing the full detector R&D programme;
- be the single body that interacts for approvals, reporting etc with the existing CERN committee structure.

The draft of an updated mandate for the EDP to reflect its new role in the implementation plan ([CERN/SPC/1190](#)) has been prepared, circulated within RECFA and formally presented for approval to RECFA yesterday.

- The EDP is a subcommittee of ECFA hosted at DESY.
- It provides a broad representation of the HEP scientific community in Europe.
- The EDP also contains representation from the neighbouring fields of nuclear and astroparticle physics, through the presence of observers from APPEC and NuPECC and invites the chair of the ICFA Instrumentation, Innovation and Development Panel to its meetings in order to provide a global detector R&D perspective.
- It provides direct input on the review of DRD proposals, through the appointment of members to the DRDC, in terms of the Roadmap's R&D priorities (as encapsulated in the Detector R&D Themes);
- The EDP assists, particularly via topic-specific expert members, in the conduct of annual DRDC reviews of the scientific progress of DRD collaborations, and monitors the overall implementation of the ECFA detector roadmap and the specific DRDTs;
- It follows up targets and achievements in the light of evolving specifications from experiment concept groups, as well as proto-collaborations for future facilities, and helps plan for future updates to the Detector R&D Roadmap.

The EDP membership should adequately cover the detector technology areas discussed in the Roadmap ([see next slide](#)).

The area of Training will be addressed by the new dedicated ECFA Training Panel.

The membership of the EDP reflects the needs to provide expertise in each of the key detector areas identified in the Roadmap: Gaseous Detectors; Liquid Detectors; Solid-State Detectors; Photon Detectors and Particle Identification; Quantum and Emerging Technologies; Calorimetry; Electronics and On-detector Processing; and Integration.

- The EDP is proposed to have two Co-chairs (as worked well for the Roadmap TFs) who could also be permanent members of the DRDC to advise and regularly report on EDP deliberations.
- It is proposed that the terms of the Co-chairs be defined as three years with periods in office to run eighteen months out of phase with each other to provide continuity. The mandate of each Co-chair can be renewed once, for a maximum period of six years.
- It is proposed that the positions of Scientific Secretary and Member have terms of three years, renewable once, but also staggered in time to ensure reasonable overlaps of experience when terms come to an end.
- The updated membership includes the **current EDP** augmented with the following **new members**:
 - Co-chairs: **Phil Allport (Birmingham)** and **Didier Contardo (IP2I Lyon)**
 - Scientific Secretary: **Doris Eckstein (DESY)** Solid State Detectors

Silvia Dalla Torre (INFN Trieste) Gaseous Detectors; **Inés Gil Botella (CIEMAT)** Liquid Detectors; **Roger Forty (CERN)** PID & Photon Detectors; **tb** Quantum and Emerging Technologies; **Laurent Serin (Orsay LAL)** Calorimetry; **Arno Straessner (Dresden)*** Electronics; **Valerio Re (Bergamo)** Electronics;

- **Karl Jakobs (Freiburg)** ex-officio (ECFA Chair); **Ian Shipsey (Oxford)†** ex-officio ICFA IIDP Chair;
- APPEC and NuPECC appointed Observers.

* Leaving 2023

† Quantum and Emerging Technologies expertise

- Assuming the new DRDs need to come into existence **by the start of 2024**, the Detector R&D Roadmap Panel, with invited representation from CERN, RD50, RD51 and CALICE management, has started organising open meetings to establish the scope and scale of the communities wishing to participate in the corresponding new DRD activities with a call sent on 25th October 2022 to sign up to the different Task Force areas at <https://indico.cern.ch/event/957057/page/27294-implementation-of-the-ecfa-detector-rd-roadmap>. (In parallel suggested guidance for the DRD proposals is being drafted.)
- Through 2023**, mechanisms will need to be agreed with funding agencies, in parallel to the below, for country specific DRD collaboration funding requests for Strategic R&D and for developing the associated MoUs.
- By Spring 2023**, the DRDC mandate would need to be formally defined and agreed with CERN management; Core DRDC membership appointed.
- To allow sufficient time for reviewing and iteration, DRD proposals will need to be submitted by **end of July 2023**.
- Formal approval should be given by the CERN Research Board **in Autumn 2023**.
- New structures operational and new R&D programmes underway **from beginning 2024**.
- Through 2024**, collection of MoU signatures will need to take place, with defined contribution areas per institute.
- Ramp up of new strategic funding and R&D activities **2024-2026** in parallel to completion of current deliverables.

Overview
Implementation of the ECFA Detector R&D Roadmap
Mandate for the Preparation of the Roadmap
The Roadmap Document
Panel members and Task Forces
Input from future facilities
Symposia
Registration to the symposia
ECFA Detector R&D Roadmap Process
└ Timeline of the Roadmap process
└ Questionnaires
└ Relevant documents
└ Internal

Implementation of the ECFA Detector R&D Roadmap

After the publication of the ECFA Detector R&D Roadmap, CERN Council requested ECFA to develop the plan for its implementation.

The document approved by the SPC and CERN Council in September 2022 can be found at https://indico.cern.ch/event/1197445/contributions/5034860/attachments/2517863/4329123/spc-e-1190-c-e-3679-Implementation_Detector_Roadmap.pdf.

As proposed in the document, topic specific community meetings will now be held in the course of the coming months. To sign up for these and to register your interest in participating on the corresponding R&D Collaborations being developed please see the links below.

- TF1 Gaseous Detectors <https://indico.cern.ch/event/1214405/>
- TF2 Liquid Detectors <https://indico.cern.ch/event/1214404/>
- TF3 Solid State Detectors <https://indico.cern.ch/event/1214410/>
- TF4 Photon Detectors and PID <https://indico.cern.ch/event/1214407/>
- TF5 Quantum and Emerging Technologies <https://indico.cern.ch/event/1214411/>
- TF6 Calorimetry <https://indico.cern.ch/event/1213733/>
- TF7 Electronics and On-detector Processing <https://indico.cern.ch/event/1214423/>
- TF8 Integration <https://indico.cern.ch/event/1214428/>
- TF9 Training <https://indico.cern.ch/event/1214429/>

<https://indico.cern.ch/e/ECFADetectorRDRoadmap>

- The ECFA Detector R&D Roadmap has been approved and its implementation was trusted to ECFA to organise by CERN Council.
- An implementation plan has been worked out, shared with the community at Plenary ECFA meetings, iterated with key stakeholders and presented for approval to the CERN SPC and Council in September.
- It builds on the well understood and successful model for making long-term investments in support of experimental collaborations at CERN for which many mechanisms already exist with Funding Agencies which can be translated into similar arrangements for providing resources for the new DRD Collaborations.
- The structure is designed to take better advantage of the multiple synergies that exist across the many particle physics (and neighbouring discipline) detector development programmes to reduce duplication of effort and encourage more efficient use of limited resources.
- The overall framework is needed to secure longer-term R&D resources for LHC post-LS3 programmes, non-LHC activities and the post-LHC future – **otherwise a substantial community of experts and funding to support their activities risk being lost by our community.**
- Please support the process and sign up at <https://indico.cern.ch/event/957057/page/27294-implementation-of-the-ecfa-detector-rd-roadmap> to help to pull the communities together over the coming months to converge on the DRD organisation and proposals which can also help secure some of the resources that should start becoming available as the major HL-LHC deliverables begin to be completed and final integration gets underway in 2026.

Back-up

Process involved: 67 authors; 12 expert Input Session speakers; ECFA National Contacts; respondents to the Task Force surveys; 121 Symposia presenters; 1359 Symposia attendees and 44 APOD TF topic specific contacts.

Task Force convenors, Task Force expert members and Panel members of the ECFA Detector R&D Roadmap Process

Task Force 1 Gaseous Detectors: Anna Colaleo¹, Leszek Ropelewski² (*Conveners*)
Klaus Dehmelt³, Barbara Liberti⁴, Maxim Titov⁵, Joao Veloso⁶ (*Expert Members*)

Task Force 2 Liquid Detectors: Roxanne Guenette⁷, Jocelyn Monroe⁸ (*Conveners*)
Auke-Pieter Colijn⁹, Antonio Ereditato^{10,11}, Ines Gil Botella¹²,
Manfred Lindner¹³ (*Expert Members*)

Task Force 3 Solid State Detectors: Nicolo Cartiglia¹⁴, Giulio Pellegrini¹⁵ (*Conveners*)
Daniela Bortoletto¹⁶, Didier Contardo¹⁷, Ingrid Gregor^{18,19}, Gregor Kramberger²⁰,
Heinz Pernegger² (*Expert Members*)

Task Force 4 Particle Identification and Photon Detectors: Neville Harnew¹⁶,
Peter Krizan²⁰ (*Conveners*)
Ichiro Adachi²¹, Eugenio Nappi¹, Christian Joram²,
Christian Schultz-Coulon²² (*Expert Members*)

Task Force 5 Quantum and Emerging Technologies: Marcel Demarteau²³,
Michael Doser² (*Conveners*)
Caterina Braggio²⁴, Andy Geraci²⁵, Peter Graham²⁶, Anna Grassellino²⁷,
John March Russell¹⁶, Stafford Withington²⁸ (*Expert Members*)

Task Force 6 Calorimetry: Roberto Ferrari²⁹, Roman Poeschl³⁰ (*Conveners*)
Martin Aleksa², Dave Barney², Frank Simon³¹,
Tommaso Tabarelli de Fatis³² (*Expert Members*)

Task Force 7 Electronics: Dave Newbold³³, Francois Vasey² (*Conveners*)
Niko Neufeld², Valerio Re²⁹, Christophe de la Taille³⁴, Marc Weber³⁵ (*Expert Members*)

Task Force 8 Integration: Frank Hartmann³⁵, Werner Riegler² (*Conveners*)
Corrado Gargiulo², Filippo Resnati², Herman Ten Kate³⁶, Bart Verlaet²,
Marcel Vos³⁷ (*Expert Members*)

Task Force 9 Training: Johann Collot³⁸, Erika Garutti^{18,39} (*Conveners*)
Richard Brenner⁴⁰, Niels van Bakel⁹, Claire Gwenlan¹⁶, Jeff Wiener²,
ex-officio Robert Appleby⁴¹ (*Expert Members*)

<https://indico.cern.ch/e/ECFADetectorRDRoadmap>

The Task Force Convenors join those listed below to compose the Detector R&D Roadmap Panel.

Panel coordinators: Phil Allport⁴² (Chair), Silvia Dalla Torre⁴³, Manfred Krammer²,
Felix Sefkow¹⁸, Ian Shipsey¹⁶

Ex-officio Panel members: Karl Jakobs⁴⁴ (Current ECFA Chair),
Jorgen D'Hondt⁴⁵ (Previous ECFA Chair), Lenny Rivkin⁴⁶ (LDG Representative)

Scientific Secretary: Susanne Kuehn²

ECFA
European Committee for Future Accelerators

Input Session speakers provided detailed specifications and continued giving support for the process

... particularly for checking if there were any unmet detector R&D needs for the ESPP identified programme which may have been overlooked in the symposia programmes.

Speaker	Presentation Topic
1 Chris Parkes	Detector R&D requirements for HL-LHC
2 Luciano Musa	Detector R&D requirements for strong interaction experiments at future colliders
3 Johannes Bernhard	Detector R&D requirements for strong interaction experiments at future colliders
4 Frank Simon	Detector R&D requirements for future linear high energy e+e- machines
5 Mogens Dam	Detector R&D requirements for future circular high energy e+e- machines
6 Martin Aleksa	Detector R&D requirements for future high-energy hadron colliders
7 Nadia Pastrone	Detector R&D requirements for muon colliders
8 Marzio Nessi	Detector R&D requirements for future short and long baseline neutrino experiments
9 Maarten De Jong	Detector R&D requirements for future astro-particle neutrino experiments
10 Laura Baudis	Detector R&D requirements for future dark matter experiments
11 Cristina Lazzeroni	Detector R&D requirements for future rare decay processes experiments
12 Alexandre Obertelli	Detector R&D requirements for future low energy experiments

19th November 2021

Two Days of Input Sessions

ECFA
European Committee for Future Accelerators

Two days of **Input Sessions** covered all the future facilities and topic areas identified in the EPPSU (see back-up).
Following these were **nine technology focussed full-day public symposia as the main fora to collect community input.**

Task Force	T17	T18	T19	T20	T21	T22	T23	T24	T25
Dates	20/21 Nov	22/23 Nov	24/25 Nov	26/27 Nov	28/29 Nov	30/01 Nov	01/02 Nov	02/03 Nov	03/04 Nov
Topics	200 + 120 (GeV/c)	100 + 17 (GeV/c)	100 + 1 (GeV/c)	200 504 339 305 307 301					
Max. number of participants	200 + 120 (GeV/c)	70 + 17 (GeV/c)	100 + 1 (GeV/c)	100 275 191 99 100 105					

Common registration for the symposia had logged 1359 participants by the end of the last one.

Received extensive feedback during symposia and after by email.

Surveys were also employed to receive direct inputs from individuals and via ECFA delegates or their National Contacts.

APOD appointed experts consulted where needed by Task Force convenors for advice on developments in their disciplines.

19th November 2021 ECFA Detector R&D

Organisation name	Contact name
APPECC	Andrew Hearnings (Chair)
NoPECC	Mark Lewkowicz (Chair)
LEAPS	Caterina Biscari (Chair)
LENS	Holmut Schubert (Chair)
ESA	Guenther Hoelinger (Director of Science)
	Franco Ongaro (Director of Technology, Engineering and Quality)

Full-day Public Symposia

17 Nov	ECFA Detector R&D Roadmap Symposium of Task Force 6 Calorimetry
18 Nov	ECFA Detector R&D Roadmap Symposium of Task Force 4 Photon Detectors and Particle Identification Detectors
19 Nov	ECFA Detector R&D Roadmap Symposium of Task Force 9 Training
20 Nov	ECFA Detector R&D Roadmap Symposium of Task Force 1 Gaseous Detectors
21 Nov	ECFA Detector R&D Roadmap Symposium of Task Force 3 Solid State Detectors
22 Nov	ECFA Detector R&D Roadmap Symposium of Task Force 5 Quantum and Emerging Technologies
23 Nov	ECFA Detector R&D Roadmap Symposium of Task Force 2 Liquid Detectors

24 Nov	ECFA Detector R&D Roadmap Symposium of Task Force 8 Integration
25 Nov	ECFA Detector R&D Roadmap Symposium of Task Force 7 Electronics and On-detector Processing

ECFA

European Committee for Future Accelerators

Organisation name	Contact name
APPECC	Andrew Hearnings (Chair)
NoPECC	Mark Lewkowicz (Chair)
LEAPS	Caterina Biscari (Chair)
LENS	Holmut Schubert (Chair)
ESA	Guenther Hoelinger (Director of Science)
	Franco Ongaro (Director of Technology, Engineering and Quality)

Named expert contacts	Named contacts for each TF where appropriate
APPECC	Andrew Hearnings (Chair)
NoPECC	Mark Lewkowicz (Chair)
LEAPS	Caterina Biscari (Chair)
LENS	Holmut Schubert (Chair)
ESA	Guenther Hoelinger (Director of Science)
	Franco Ongaro (Director of Technology, Engineering and Quality)

ECFA National Contacts

Country	Name	Finland	Panja Lukka
Austria	Manfred Jeitler	France	Didier Contardo
Belgium	Gilles De Lentdecker	Germany	Lutz Feld
	Venelin Koshuharov	Greece	Dimitris Loukas
Bulgaria	Tome Anticic	Hungary	Dezso Varga
Croatia	Panos Razis	Italy	Nadia Pastrone
Cyprus	Tomáš Davidek	Israel	Erez Etzion
Czech Republic	Mogens Dam	Netherlands	Niels van Bakel
Denmark		Norway	Gerald Eigen
		Poland	Marek Idzik
		Portugal	Paulo Fonte
		Romania	Mihai Petrovici
		Serbia	Lidija Zivkovic
		Slovakia	Pavol Strizenec
			Gregor
		Slovenia	Kramberger
		Spain	Mary-Cruz Fouz
		Sweden	Christian Ohm
		Switzerland	Ben Kilminster
		Turkey	Kerem Cankocak
		United-Kingdom	Iacopo Vivarelli
		Ukraine	Nikolai Shulga
		CERN	Christian Joram

Advisory Panel with Other Disciplines

APPECC: Astro-Particle Physics European Consortium
ESA: European Space Agency
LEAPS: League of European Accelerator-based Photon Sources
LENS: League of advanced European Neutron Sources
NoPECC: Nuclear Physics European Collaboration Committee

APPECC	Andrew Hearnings (Chair)
NoPECC	Mark Lewkowicz (Chair)
LEAPS	Caterina Biscari (Chair)
LENS	Holmut Schubert (Chair)
ESA	Guenther Hoelinger (Director of Science)
	Franco Ongaro (Director of Technology, Engineering and Quality)



- **Detector technology areas:** larger DRD collaborations were specified given concerns about the review and administrative overheads with too many entities covering too fine-grained topics, the synergies that can be better exploited by larger organisations and the advantages of scale in terms of dealing with external bodies.
- It is proposed that DRD Collaborations should be anchored at CERN → CERN recognition; DRD label.
- **The new DRDs should take full account of existing, well-managed and successful ongoing R&D collaborations and other existing activities** (current RDs, CERN EP R&D programme, EU-funded initiatives, collaborations exploring particular technology areas for future colliders, ...).
- Strategic funding is here intended to be additional to continued funding opportunities to support of more exploratory **Blue-Sky R&D** through shorter-term “responsive mode” schemes (often nationally organised with broader peer review looking across applications in a range of scientific communities).
 - Such funding should be expected to continue being sought by participating researchers where it is more appropriate for speculative ideas whose impact is much wider than that defined by the currently understood detector R&D needs of the future particle physics programme (as encapsulated in the DRDTs).
- As currently, highly **Experiment Specific R&D** is expected to be covered within the funding envelope for approved projects where detailed specifications call for a much more targeted approach.
- Mechanisms should be established to maximise flow of ideas and experience between these **three different modes of R&D**.

European Particle Physics Strategy Update

Main report: *“Recent initiatives with a view towards strategic R&D on detectors are being taken by CERN’s EP department and by the ECFA detector R&D panel, supported by EU-funded programmes such as AIDA and ATTRACT. Coordination of R&D activities is critical to maximise the scientific outcomes of these activities and to make the most efficient use of resources; as such, there is a clear need to strengthen existing R&D collaborative structures, and to create new ones, to address future experimental challenges of the field beyond the HL-LHC. Organised by ECFA, a roadmap should be developed by the community to balance the detector R&D efforts in Europe, taking into account progress with emerging technologies in adjacent fields.”*

Deliberation document: *“Detector R&D programmes and associated infrastructures should be supported at CERN, national institutes, laboratories and universities. Synergies between the needs of different scientific fields and industry should be identified and exploited to boost efficiency in the development process and increase opportunities for more technology transfer benefiting society at large. Collaborative platforms and consortia must be adequately supported to provide coherence in these R&D activities. The community should define a global detector R&D roadmap that should be used to support proposals at the European and national levels.”*

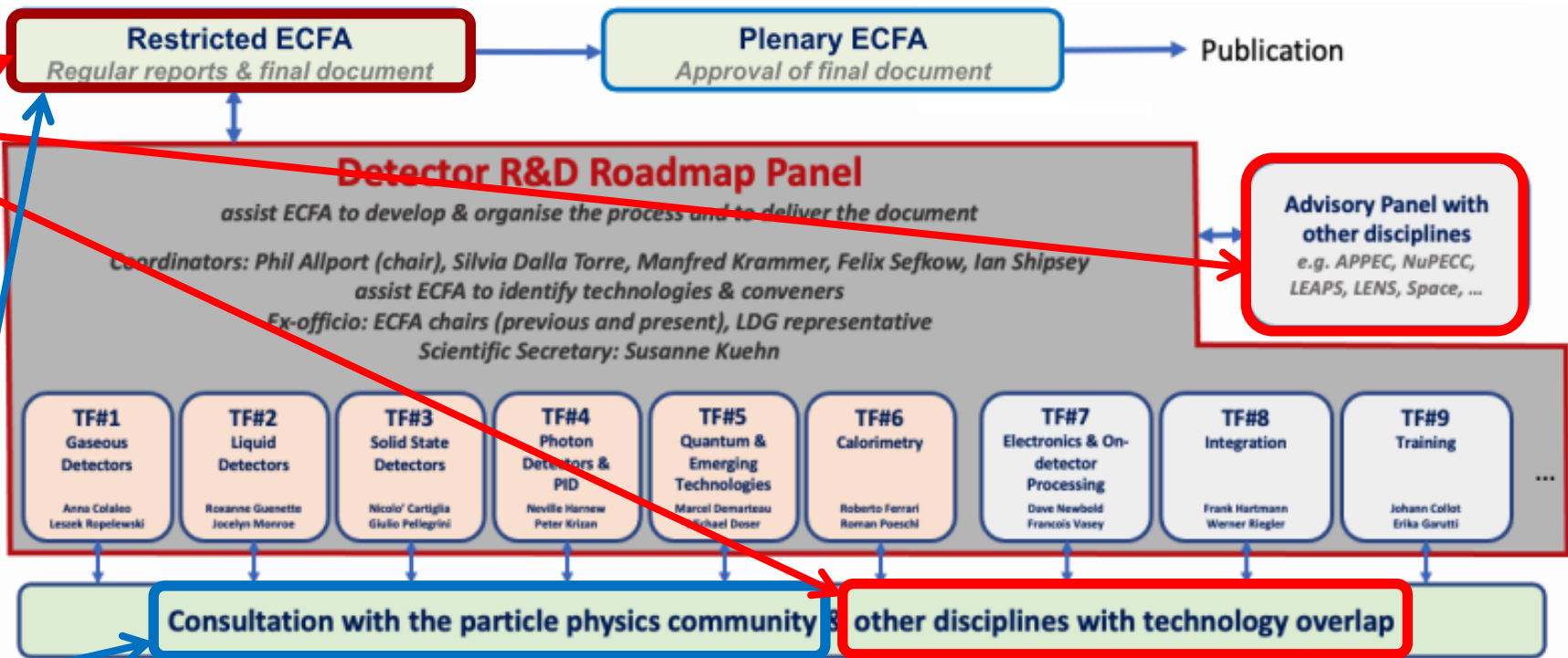
Extracted from the documents of 2020 EPPSU, <https://europeanstrategyupdate.web.cern.ch/>

More roadmap process details at: <https://indico.cern.ch/e/ECFADetectorRDRoadmap>



*“Organised by ECFA, a roadmap should be developed by the community to balance the detector R&D efforts in Europe, taking into account progress with emerging technologies in adjacent fields” **

*“The community should define a global detector R&D roadmap that should be used to support proposals at the European and national levels” **



ECFA Detector R&D Roadmap Panel web pages at:
<https://indico.cern.ch/e/ECFADetectorRDRoadmap>

* 2020 European Particle Physics Strategy Update
<https://europeanstrategyupdate.web.cern.ch/>

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/ECFADetectorRD>
[Roadmap](#)

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

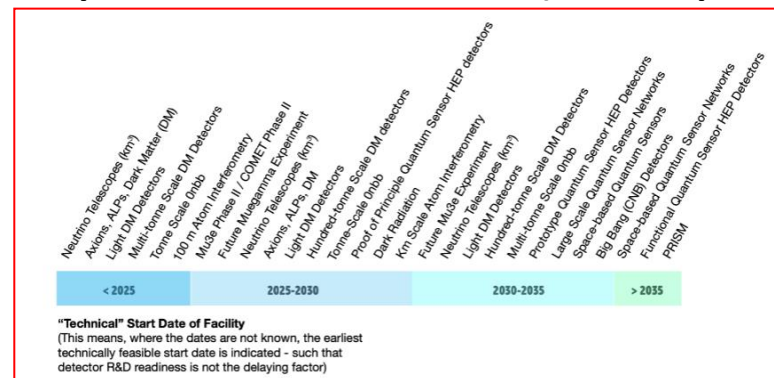
Detector R&D Roadmap Document circulated for approval to ECFA in Nov 2021 and presentation to Council in Dec 2021

Process at <https://indico.cern.ch/e/ECFADetectorRDRoadmap> ran from May 2020 to December 2021. It involved 67 authors; 12 expert Input Session speakers; ECFA National Contacts; all the respondents to the Task Force surveys; 121 Symposia presenters; 1359 Symposia attendees; as well as 44 Advisory Panel with Other Disciplines TF topic specific contacts.

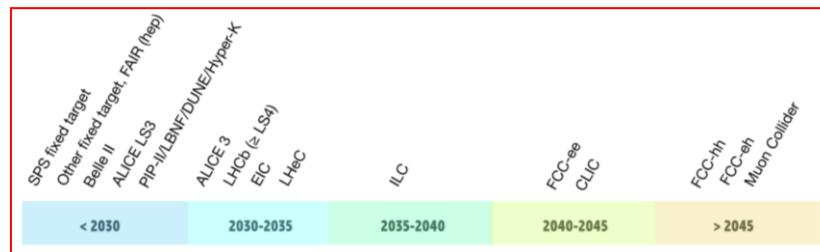
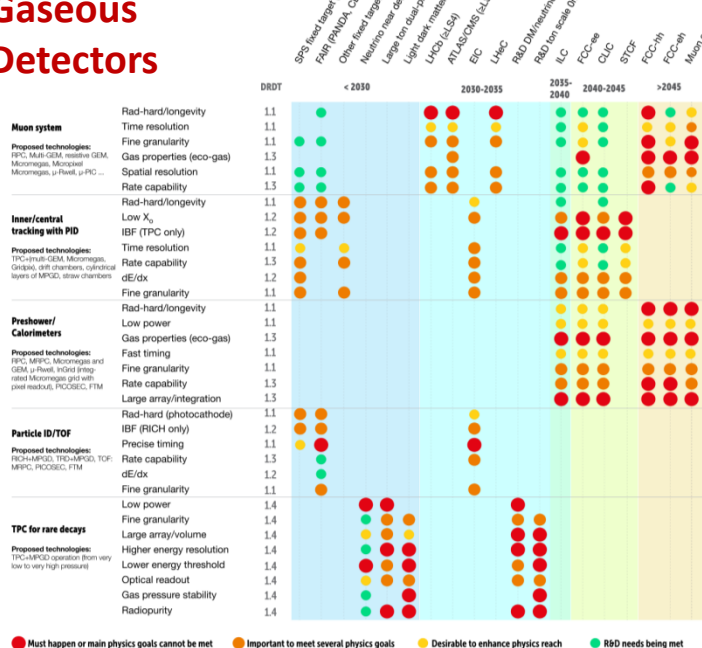
248 page report and 8 page synopsis document identifying the most urgent R&D topics or activities for meeting the EPPSU listed programme in the 9 TF Areas.



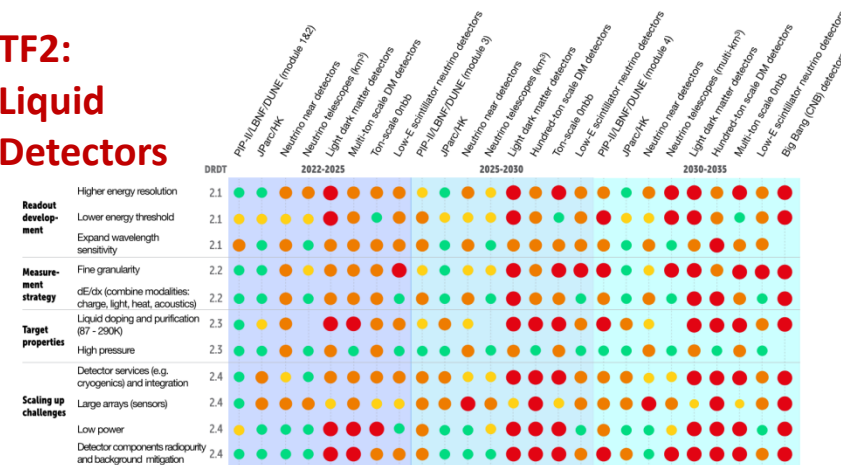
Example non-accelerator dates (not complete)



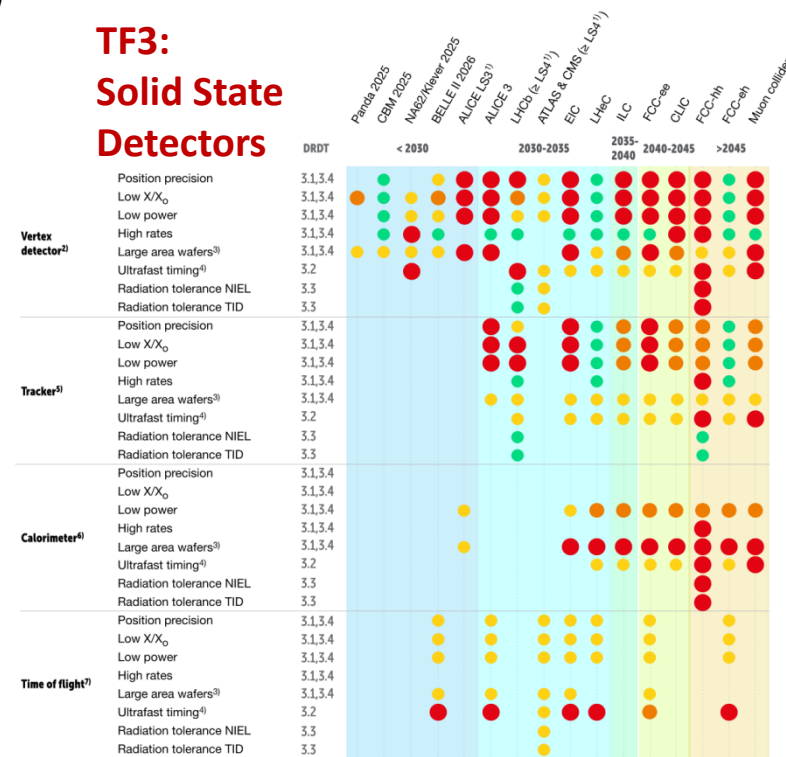
TF1: Gaseous Detectors



TF2: Liquid Detectors



TF3: Solid State Detectors



1) Large ton dual-phase (PandaX-T, LZ, DarkSide-20k, Argo, 2020s, ARIADNE, ...)
2) Light dark matter, solar axion, Omb, rare nucleons and astro-particle reactions, Be tagging
3) R&D for 100-ton scale dual-phase DM/Neutrino experiments

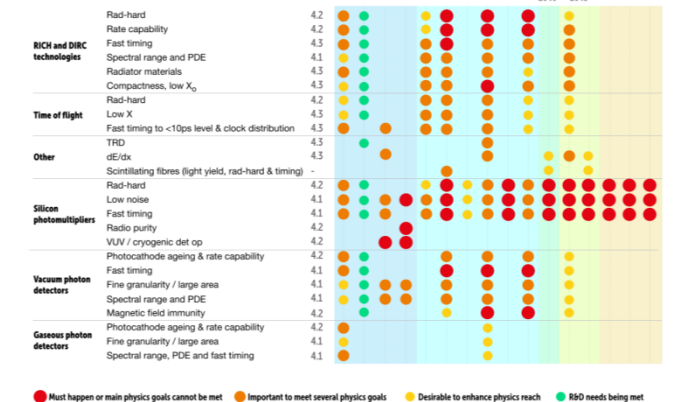
Must happen or main physics goals cannot be met

Important to meet several physics goals

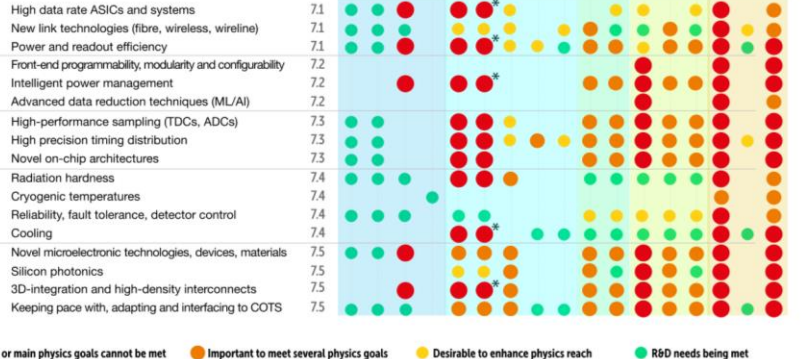
Desirable to enhance physics reach

R&D needs being met

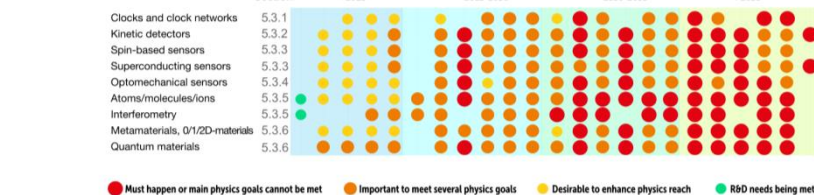
TF4: Photon Detectors & PID



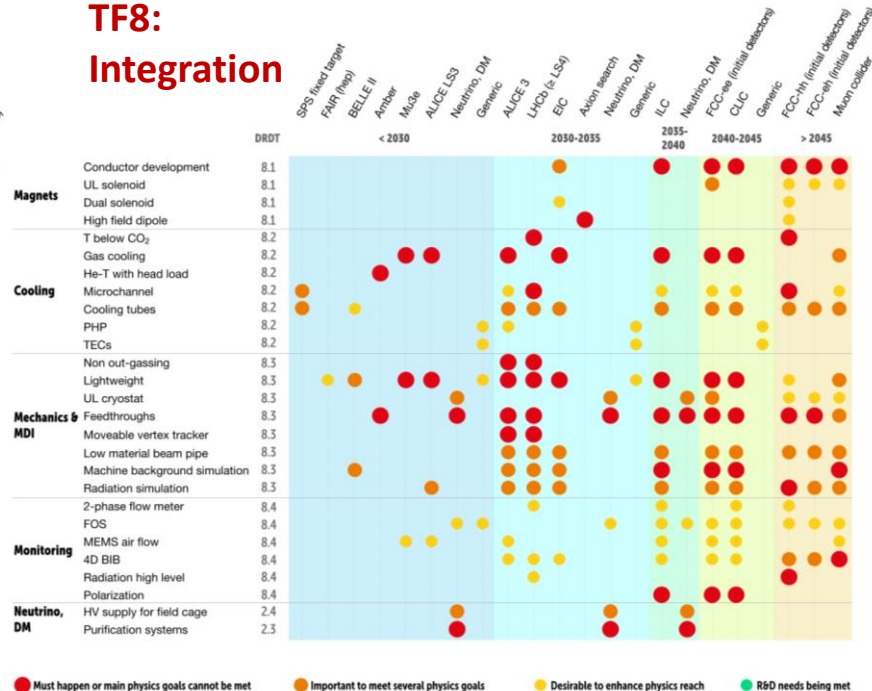
TF7: Electronics & On-detector Processing



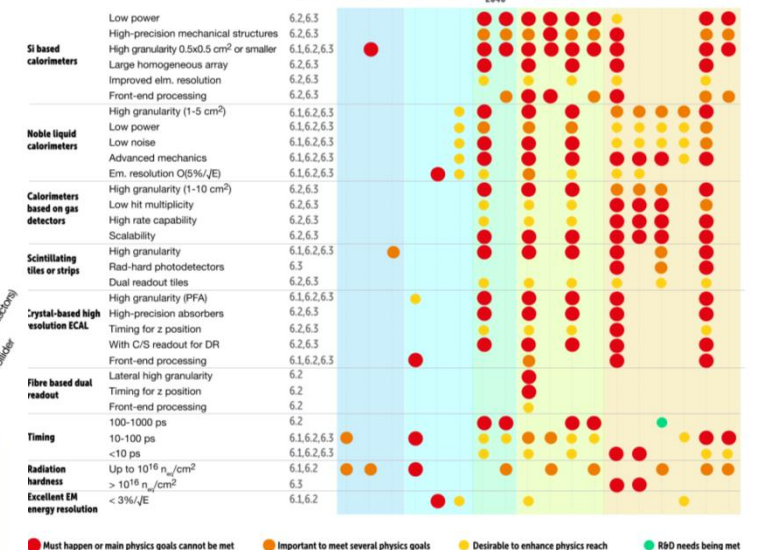
TF5: Quantum & Emerging Technologies



TF8: Integration



TF6: Calorimetry



(<https://cds.cern.ch/record/2784893>)

Restricted ECFA Composition

<https://ecfa.web.cern.ch/restricted-ecfa>

Chair	Prof. Dr Karl Jakobs	Appointed Jan. 2021
Secretary	Prof. Patricia Conde Muino	Appointed July 2021
Members		
Austria	Dr Manfred Jeitler	Appointed Jan. 2018
Belgium	Prof. Nick van Remortel	Appointed July 2018
Bulgaria	Prof. Plamen Iaydjiev	Appointed Jan. 2016
Croatia	Prof. Mirko Planinic	Appointed July 2020
Cyprus	Prof. Panos Razis	Appointed Oct. 2017
Czech Republic	Dr Marek Tasevsky	Appointed Jan. 2019
Denmark	Prof. Mogens Dam	Appointed Jan. 2018
Finland	Dr Kati Lassila-Perini	Appointed Jan. 2018
France	Dr Jean-Claude Brient	Appointed Jan. 2020
Germany	Prof. Heiko Lacker	Appointed July 2021
Greece	Prof. Paris Sphicas	Appointed July 2018
Hungary	Dr Ferenc Siklér	Appointed Jan. 2021
Italy	Prof. Chiara Meroni	Appointed July 2020
Israel	Prof. Eilam Gross	Appointed Jan. 2018
Netherlands	Prof. Stan Bentvelsen	Appointed Jan. 2015
Norway	Prof. Alexander Read	Appointed Jan. 2018
Poland	Prof. Justyna Łagoda	Appointed Jan. 2021

Portugal	Prof. Patricia Condes Muino	Appointed July 2020
Romania	Dr Alexandru-Mario Bragadireanu	Appointed Jan. 2019
Serbia	Prof. Peter Adžić	Appointed July 2012
Slovakia	Dr Pavol Stríženec	Appointed May 2016
Slovenia	Prof. Marko Mikuž	Appointed July 2018
Spain	Prof. Celso Martinez	Appointed Jan. 2021
Sweden	Prof. David Milstead	Appointed Jan. 2018
Switzerland	Dr Mike Seidel	Appointed Jan. 2019
Turkey	Prof. Mehmet Zeyrek	Appointed July 2018
United-Kingdom	Prof. Max Klein	Appointed Jan. 2021
Ukraine	Prof. Mykola Shul'ga	Appointed July 2018
CERN	Dr Roger Forty	Appointed Sept. 2015
Ex-Officio Members		
CERN	Dr Fabiola Gianotti Prof. Joachim Mnich	Appointed Jan. 2016 Appointed Jan. 2021
LDG	Prof. Dave Newbold	Appointed Jan. 2021
Observers		
EPS-HEPP Board Chair	Prof. Thomas Gehrman	Appointed Sept. 2019
ApPEC Chair	Dr Andreas Haungs	Appointed Jan. 2021
NuPECC Chair	Prof. Marek Lewitowicz	Appointed March 2018
Russian Federation	Prof. Victor Matveev	Appointed Jan. 2007
Early Career Researchers (ECR)	Lydia Brenner	Appointed Feb. 2021

Input session of Future Facilities I

Friday 19 Feb 2021, 13:00 → 18:00 Europe/Zurich

13:00 → 13:30	Detector R&D requirements for HL-LHC Speaker: Chris Parkes (University of Manchester (GB)) ECFA_RD_Parkes_1...
13:30 → 14:00	Detector R&D requirements for strong interaction experiments at future colliders Speaker: Luciano Musa (CERN) MUSA_ECFA_IS_20...
14:00 → 14:30	Detector R&D requirements for strong interaction experiments at future fixed target facilities Speaker: Johannes Bernhard (CERN) Detector R&D requir...
14:30 → 14:45	Coffee-Tea Break
14:45 → 15:15	Detector R&D requirements for future linear high energy e+e- machines Speaker: Frank Simon (Max-Planck-Institut fuer Physik) LC_DetRoadmapip...
15:15 → 15:45	Detector R&D requirements for future circular high energy e+e- machines Speaker: Mogens Dam (University of Copenhagen (DK)) ECFA_Detector_R&D...
15:45 → 16:15	Detector R&D requirements for future high-energy hadron colliders Speaker: Martin Aleksa (CERN) 20210219-ECFA-Det...
16:15 → 16:35	Detector R&D requirements for muon colliders Speaker: Nadia Pastrone (Universita e INFN Torino (IT)) MuonColliders_Dete...

Input session of Future Facilities II

Monday 22 Feb 2021, 14:00 → 18:00 Europe/Zurich

14:00 → 14:30	Detector R&D requirements for future short and long baseline neutrino experiments Speaker: Marzio Nessi (CERN) 21-02-22-ECFA-Neut... 21-02-22-ECFA-Neut...
14:30 → 15:00	Detector R&D requirements for future astro-particle neutrino experiments Speaker: Maarten De Jong (Rijksbureau voor subatomische fysica (NL)) ECFA - Maarten de ... ECFA - Maarten de ...
15:00 → 15:30	Detector R&D requirements for future dark matter experiments Speaker: Laura Baudis (University of Zurich) baudis_ecfa_feb21...
15:30 → 15:40	Coffee-Tea Break
15:40 → 16:10	Detector R&D requirements for future rare decay processes experiments Speakers: Cristina Lazzeroni (University of Birmingham (GB)), Cristina Lazzeroni (University of Birmingham (GB)) ECFA_Lazzeroni.pdf
16:10 → 16:40	Detector R&D requirements for future low energy experiments Speaker: Dr Alexandre Obertelli (TU Darmstadt) ECFA_LowEnergyFa...

Input Session speakers provided detailed specifications and continued giving support for the process

... particularly for checking if there were any unmet detector R&D needs for the ESPP identified programme which may have been overlooked in the symposia programmes.

	Speaker	Presentation Topic
1	Chris Parkes	Detector R&D requirements for HL-LHC
2	Luciano Musa	Detector R&D requirements for strong interaction experiments at future colliders
3	Johannes Bernhard	Detector R&D requirements for strong interaction experiments at future colliders
4	Frank Simon	Detector R&D requirements for future linear high energy e+e- machines
5	Mogens Dam	Detector R&D requirements for future circular high energy e+e- machines
6	Martin Aleksa	Detector R&D requirements for future high-energy hadron colliders
7	Nadia Pastrone	Detector R&D requirements for muon colliders
8	Marzio Nessi	Detector R&D requirements for future short and long baseline neutrino experiments
9	Maarten De Jong	Detector R&D requirements for future astro-particle neutrino experiments
10	Laura Baudis	Detector R&D requirements for future dark matter experiments
11	Cristina Lazzeroni	Detector R&D requirements for future rare decay processes experiments
12	Alexandre Obertelli	Detector R&D requirements for future low energy experiments

Many thanks to all these key experts for their time and help with this process

Two days of Input Sessions covered all the future facilities and topic areas identified in the EPPSU (see back-up).

Following these were nine technology focussed full-day public symposia as the main fora to collect community input.

Task Force	TF7	TF8	TF2	TF5	TF3	TF1	TF9	TF4	TF6
Dates	25/3/21	31/3/21	9/4/21	12/4/21	23/4/21	29/4/21	30/4/21	6/5/21	7/5/21
Unique users	369 + 123 (webcast)	154 + 17 (webcast)	197 + 5 (webcast)	220	504	339	105	207	201
Max. number of concurrent viewers	230 + 123 (webcast)	76 + 17 (webcast)	130 + 5 (webcast)	100	275	191	59	110	115

Common registration for the symposia had logged 1359 participants by the end of the last one.

Received extensive feedback during symposia and after by email.

Surveys were also employed to receive direct inputs from individuals and via ECFA delegates or their National Contacts.

APOD appointed experts consulted where needed by Task Force convenors for advice on developments in their disciplines.

May 2021

- 07 May ECFA Detector R&D Roadmap Symposium of Task Force 6 Calorimetry
- 06 May ECFA Detector R&D Roadmap Symposium of Task Force 4 Photon Detectors and Particle Identification Detectors

April 2021

- 30 Apr ECFA Detector R&D Roadmap Symposium of Task Force 9 Training
- 29 Apr ECFA Detector R&D Roadmap Symposium of Task Force 1 Gaseous Detectors
- 23 Apr ECFA Detector R&D Roadmap Symposium of Task Force 3 Solid State Detectors
- 12 Apr ECFA Detector R&D Roadmap Symposium of Task Force 5 Quantum and Emerging Technologies
- 09 Apr ECFA Detector R&D Roadmap Symposium of Task Force 2 Liquid Detectors

March 2021

- 31 Mar ECFA Detector R&D Roadmap Symposium of Task Force 8 Integration
- 25 Mar ECFA Detector R&D Roadmap Symposium of Task Force 7 Electronics and On-detector Processing

Materials from past Symposia, Input Sessions and other components of the ECFA Detector R&D Roadmap Process can be found at <https://indico.cern.ch/e/ECFADetectorRDRoadmap>

Many thanks to the 121 presenters, the 1359 attendees and all who provided feedback

Organisation name	Contact name
APPEC	Andreas Haungs (Chair)
NuPECC	Marek Lewitowicz (Chair)
LEAPS	Caterina Biscari (Chair)
LENS	Helmut Schober (Chair)
ESA	Guenther Hasinger (Director of Science) Franco Ongaro (Director of Technology, Engineering and Quality)

APPEC: Astro-Particle Physics European Consortium
ESA: European Space Agency
LEAPS: League of European Accelerator-based Photon Sources
LENS: League of advanced European Neutron Sources
NuPECC: Nuclear Physics European Collaboration Committee

Named expert contacts		
APPEC	TF1	Jennifer L Raaf (Fermilab)
	TF2	Manfred Lindner (MPI Heidelberg)
	TF3	Fabrice Retiere (TRIUMF)
	TF4	Tina Pollmann (Nikhef)
	TF5	Harald Lück (Hannover)
	TF6	Federica Petricca (MPI Munich)
	TF7	Marc Weber (KIT)
	TF8	Aldo Ianni (LNGS)
	TF9	Katrin Link (APPEC)
NuPECC	TF1	Laura Fabbietti (TUM Munich) Bernhard Ketzer
	TF2	
	TF3	Luciano Musa (CERN) Michael Deveau
	TF4	Eugenio Nappi (INFN Bari) Jochen Schwiening
	TF5	: Christian Enss (Heidelberg),
	TF6	Thomas Peitzmann (Utrecht)
		Ulrike Thoma (Bonn)
	TF7	David Silvermyr (Lund) Christian J. Schmidt
	TF8	Werner Riegler (CERN) Lars Schmitt
	TF9	Michael Deveau,
LEAPS		Bernd Schmitt (PSI)
		Fabienne Orsini
		Steve Aplin (European)
		Heinz Graafsma (DESY)

Named contacts for each TF where appropriate

Many thanks to these experts for their advice and availability

LENS	TF1	Bruno Guerard (ILL)
	TF2	Manfred Lindner (MPI Heidelberg)
	TF3	
	TF4	
	TF5	Helmut Schober (ILL)
	TF6	
	TF7	Bruno Guerard (ILL)
	TF8	
	TF9	
ESA	TF1	Nick Nelms
	TF2	
	TF3	Brian Shortt Nick Nelms Giovanni Santin Alessandra Constantino Mucio
	TF4	Brian Shortt Peter Verhoeve Sarah Wittig Nick Nelms Giovanni Santin Peter Verhoeve Sarah Wittig Nick Nelms
	TF5	Peter Verhoeve Sarah Wittig Nick Nelms
	TF6	Nick Nelms
	TF7	Joerg Ter Haar Christophe Honvault Nick Nelms Alessandra Constantino Mucio
	TF8	Massimo Braghin
	TF9	Christophe Honvault



<https://indico.cern.ch/event/957057/page/21633-mandate> (Panel Mandate document)

<https://indico.cern.ch/event/957057/page/21653-relevant-documents>

<https://home.cern/resources/brochure/cern/european-strategy-particle-physics>

<https://arxiv.org/abs/1910.11775> (Briefing Book)

https://science.osti.gov/-/media/hep/pdf/Reports/2020/DOE_Basic_Research_Needs_Study_on_High_Energy_Physics.pdf

<https://ep-dep.web.cern.ch/rd-experimental-technologies> (CERN EP R&D)

<https://aidainnova.web.cern.ch> (linking research infrastructures in detector development and testing)

<https://attract-eu.com/> (ATTRACT: linking to industry on detection and imaging technologies)

https://ecfa-dp.desy.de/public_documents/ (Some useful documents from the ECFA Detector Panel)