



Overview of Detector R&D RoadMap Implementation Process

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and ECFA Detector Panel)

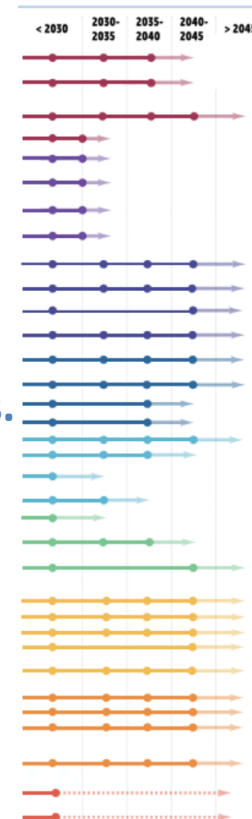


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Gaseous	DRDT 1.1	Improve time and spatial resolution for gaseous detectors with long-term stability
	DRDT 1.2	Achieve tracking in gaseous detectors with dE/dx and dN/dx capability in large volumes with very low material budget and different read-out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



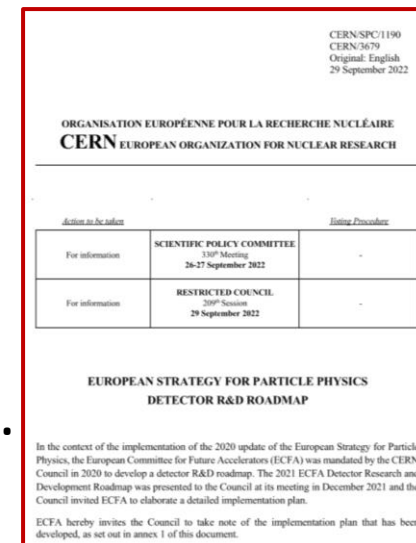
<https://cds.cern.ch/record/2784893>



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**

- 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.
- Slightly updated implementation proposals were then presented during June 2022 Council Week and at Plenary ECFA on 22nd July 2022. (See also Plenary ECFA 18th November 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://cern.ch/spc/1190).**



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

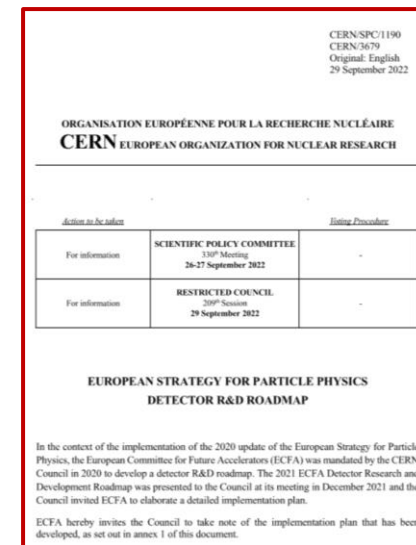
With a view to creating a vibrant ecosystem for R&D, connecting and involving all partners, there is a need to refresh the CERN RD programme structure and encourage new programmes for next generation detectors, where CERN and the other national laboratories can assist as major catalysers for these. It 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 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.

→ **New DRD Collaborations - main focus of the September 2022 implementation plan**

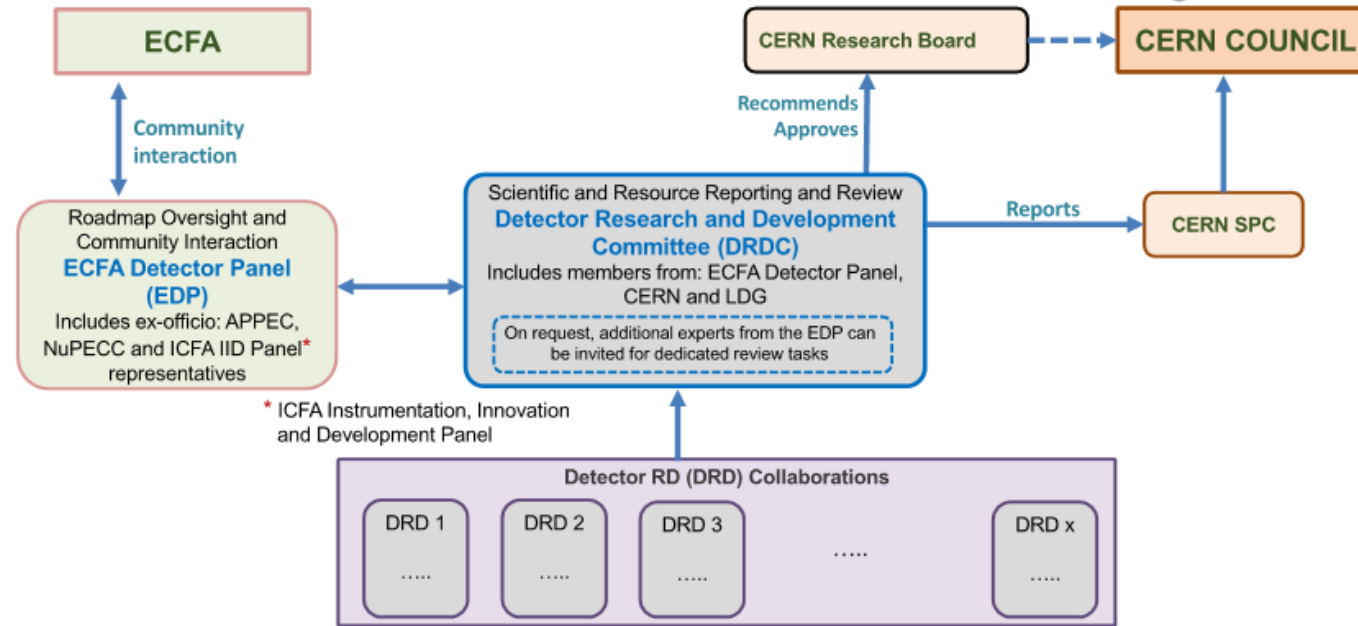
- Other GSRs are not forgotten and are being addressed by the new **ECFA Training Panel**, the **ECFA-LDG Infrastructure Working Group** or other ECFA initiatives in consultation with key stakeholders.
- The emphasis of the current activities of the EDP and Roadmap Panel are more to establish the new Detector R&D (DRD) collaborations needed in support of **“strategic” R&D and to put in place the required reviewing processes**. (This should be emphasised again as being separate from, and additional to, that for **“blue-sky”** and **“experiment-specific”** activities.)



(CERN/SPC/1190)

ECFA (through RECFA and PECFA) maintains broad links to the wider scientific community.

EDP engages with other scientific disciplines and also communities outside Europe through close links with the ICFA IID Panel.



CERN provides rigorous oversight through well-established and respected reviewing structures.

DRDs able to benefit from CERN recognition in dealings with Funding Agencies and corporations.

EDP:

- provides direct input, through appointed members to the DRDC, on DRD proposals in terms of Roadmap R&D priorities (DRDTs);
- assists, particularly via topic-specific expert members, with annually updated DRDC scientific progress reviews of DRDs;
- monitors overall implementation of ECFA detector roadmap/DRDTs;
- follows targets and achievements in light of evolving specifications from experiment concept groups as well as proto-collaborations for future facilities;
- helps plan for future updates to the Detector R&D Roadmap.

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.

- Given the timeline presented in CERN/SPC/1190, work on draft guidelines for DRD proposals was also initiated last Autumn and has been iterated several times now with the community.

- 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

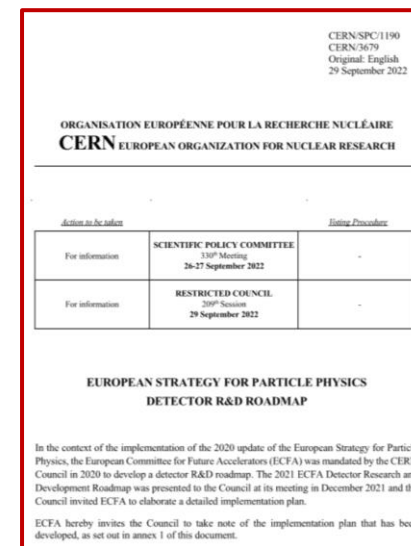
After the publication of the ECFA Detector R&D Roadmap, CERN Council requested ECFA to develop the plan for its implementation.

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/>

CERN/SPC/1190



Proposers are suggested to use national contacts to ensure funding requests per country are reasonable and informed by discussions with the Funding Agencies.

3. Timeline for Establishing DRD Collaborations

The proposed timeline takes into account the fact that current R&D collaborations at CERN would need to seek an extension for continuation beyond the end of 2023 and that the most labour-intensive aspects of the general-purpose detectors for the HL-LHC deliverables should be completed by the end of 2025, allowing a significant number of experts to become available for new initiatives. This suggests that DRD collaborations need to come into existence in 2023, and requests for new resources would typically anticipate a ramp-up of requirements through 2024/25 before a reasonably steady state is reached in 2026.

It is proposed that this could be achieved according to the following timeline:

Q4 2022:

- Through the ECFA roadmap, task forces identify key players and stakeholders from the wider international community who are interested in pursuing the DRDT topics identified in the ECFA roadmap. Where current relevant detector R&D collaborations exist, their managements need to be fully involved from the beginning of this process.
- The stakeholders to be contacted in each area covered by one of the task forces should also include:
 - representatives of those involved in nearer-term facilities where these are clear “stepping stones” towards the longer-term ambitions;
 - those engaged in establishing detector concepts for the longer-term experimental programmes identified as “high-priority future initiatives” in the European Strategy for Particle Physics;
 - proponents of activities beyond the immediate horizon that are advocated as “other essential scientific activities for particle physics” in the European Strategy;
 - where relevant, the primary contact persons for other existing funded international detector R&D programmes (including activities supported by the EU and CERN).
- With the help of this wider group, one or more community workshops should be organised to gather input on how the relevant communities consider that a strategic R&D programme should be organised and to discuss the proposed structure with the ECFA R&D roadmap coordinators.

Q1 2023:

- Outcomes of community workshops are collated and each **DRD proposal team** calls for expressions of interest from institutes (or groups of institutes) wishing to bid for strategic R&D in the corresponding areas identified in the DRDTs. These institutes would also need to organise themselves nationally to initiate discussions with their corresponding funding agencies.
- DRDC mandate formally defined and agreed with the CERN Management; DRDC membership appointments begin; EDP mandate plus membership updated to reflect additional roles.

Q2 2023:

- Through the **DRD proposal teams**, and based on the input from the community consultation, coordinate community-led bids for bottom-up roughly costed “strategic R&D” proposals (materials and total FTE), from consortia around technologies that can address one or more of the DRDTs, identifying the required materials costs and effort going forward. For the latter, it would be necessary to further separate existing staff or possible in-kind contributions from posts requiring additional resources. Funded activities in the context of supported experiments should be reported where potentially relevant (as stepping stones), but the resources included as in-kind contributions should focus on R&D that is not specific to individual approved experiments. As explained above, the primary aim is to create a dedicated funding line for *Strategic R&D*. The general case and motivation for such long-term strategic R&D can be found in the GSRs of the published Roadmap document.
- Proposals specific to the sub-areas should be evaluated for their relevance to DRDTs and possible overlaps or gaps with respect to them, and resources should then be matched to the stated goals. Each **DRD proposal team** should formulate a lightweight DRD organisational structure to accommodate the ambitions of the community, with appropriate sub-structures where they consider this necessary.

Mechanisms agreed with funding agencies for structuring country-specific DRD collaboration funding requests.

Q3 2023:

- The **DRD proposal teams** submit full DRD proposals at the start of Q3 (July 2023), indicating estimates of the resources needed (including both those requested and those that are already available, as well as details of who covers what, i.e. pledges by institutes/ funding agencies).

DRD proposals to be submitted July 2023 including estimated requirements. → MoUs to follow in 2024.



International Detector R&D (DRD) Collaboration Progress

DRD1 Gaseous Detectors (TF Convenors: *Anna Colaleo (INFN Bari (IT))*, *Leszek Ropelewski (CERN)*)

Scientific organisation well defined with eight Technology/Activity Working Groups and work-packages of sub-groups of institutes towards common deliverables, workplans and sharing of resources.

Draft proposal release followed by community meeting to **finalise proposal in mid-June** with submission in July.

Community meeting: 1st-3rd March 2023 <https://indico.cern.ch/event/1245751/>

Organisation and workplan at <https://indico.cern.ch/event/1214405/>

(Also, for RD51 see <https://rd51-public.web.cern.ch/>)

DRD2 Liquid Detectors (TF Convenors: *Jocelyn Monroe (RHUL (GB))*, *Roxanne Guenette (Manchester (GB))*)

Four main work-packages defined with sub-projects.

Technical Areas (TAs) clearly established and supported by community feedback.

Deliverables tables for each TA being finalized. Most FTE/resources/facility (both available and needed) have been collected. Proposal writing underway with goal to have **full draft early June**.

Community meeting: 20th April 2023 <https://indico.cern.ch/event/1214404/timetable/#20230420>

Organisation and workplan at <https://indico.cern.ch/event/1214404/>

DRD3 Solid State Detectors (TF Convenors: *Giulio Pellegrini (IMB-CNM-CSIC) (ES)*, *Nicolo Cartiglia (INFN Torino (IT))*)

Detector R&D Themes (DRDTs) define the work-packages with seven Working Groups to organise the proposal deliverables with WG milestones already defined.

First full draft of proposal targeted for end of May, with further iterations on resources estimates with institutes before proposal preparation process aimed to conclude around the **end of June.**

Community meeting: 22nd-23rd March 2023 <https://indico.cern.ch/event/1214410/timetable/#20230322.detailed>

Further organisation information at <https://indico.cern.ch/event/1214410/>

(Also, for RD50 see <http://rd50.web.cern.ch/> and for RD42 see <https://rd42.web.cern.ch/rd42/>)

DRD4 Particle ID and Photon Detectors (TF Convenors: *Christian Joram (CERN)*, *Peter Krizan (JSI (SI))*)

Community meeting discussed draft collaboration structure.

Work on the proposal and MoU underway for **July 2023.**

Community meeting: 6th-17th May 2023 <https://indico.cern.ch/event/1263731/>

Further background at <https://indico.cern.ch/event/1214407/>

DRD5 Quantum and Emerging Technologies (TF Convenors: *Marcel Demarteau (ORNL)*, *Michael Doser (CERN)*)

Very different and diverse community with many interfaces to other programmes and science areas.

“White paper” document prepared and in circulation for comments until **mid-June with **LoI** targeted for **July 2023** with full proposal before the end the year, given specific issues of overlaps etc with funded initiatives outside PP.**

Draft of web pages explaining six quantum sensing families at <https://doser.web.cern.ch/>.

DRD6 Calorimetry (TF Convenors: Roberto Ferrari (INFN Pavia (IT)), Roman Poeschl (Université Paris-Saclay (FR)))
Scientific organisation well advanced with four separate tracks defined and required resources identified including significant test-beam availability after 2025.

Draft proposal ready by start of June, **second draft mid-June**, target proposal readiness in mid July.

Community meetings: 12th January 2023 <https://indico.cern.ch/event/1212696/> and 20th April 2023 <https://indico.cern.ch/event/1246381/> .

Organisation, workplan and proposal status at <https://indico.cern.ch/event/1213733/>

(Also for CALICE see <https://twiki.cern.ch/twiki/bin/view/CALICE/WebHome>, for Crystal Clear see <https://crystalclearcollaboration.web.cern.ch/> and for RD52 see <http://www.phys.ttu.edu/~dream/index.html>.)

DRD7 Electronics (TF Convenors: Dave Newbold (STFC (GB)), Francois Vasey (CERN))

With TF8, TF9 and “Transversal” topic area with seven Working Groups whose scope depends on the content of other DRD proposals.

Each WG hosts projects to implement its objectives which then need to be aggregated into a coherent proposal to be submitted to DRDC.

Before reaching the proposal an **LoI** will be submitted in **July 2023** which also contains ballpark resource estimates with full proposal before the end of the year.

Community meeting: 14th-15 March 2023 <https://indico.cern.ch/event/1214423/timetable/#20230314>.

Organisation and planning are also detailed in the draft [“Organisation of the DRD7 Collaboration. Version 5”](#)

TF8 Integration (TF Convenors: Frank Hartmann (KIT (DE)), Werner Riegler (CERN))

Survey launched to gauge community appetite for DRD in the areas on 23rd March 2023 to all those who registered interest. Results are returned and have been analysed.

[Forum on Tracking Detector Mechanics 2023](#) 31st May to 2nd June seen as opportunity for the mechanics and local colling community to discuss possible interest in forming a DRD for their specific area.

Other DRD7 topics seen as equally important to the future of the field and funding mechanisms for these are needed, but they are not thought to be appropriate subjects for a DRD collaboration.

TF9 Training (TF Convenors: Erika Garutti (Hamburg University (DE)), Johann Collot (university Grenoble Alpes (FR)))

Now the topic of the dedicated new **ECFA Training Panel**

Kick-off meeting on 7th March 2023 with agenda at <https://indico.desy.de/event/38365/>.

Web pages etc are being constructed at <https://indico.cern.ch/event/1270365/>.

CERN EP R&D Programme links at: [Homepage | ep-rnd.web.cern.ch](#).

AIDAInnova web pages: <https://aidainnova.web.cern.ch/>

EURO-LABS information at <https://web.infn.it/EURO-LABS/>

Task force membership at: <https://indico.cern.ch/event/957057/page/20875-panel-members-and-task-forces>.

BACKUP

European Particle Physics Strategy Update Recommendations

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/>

Detector R&D Roadmap process details at: <https://indico.cern.ch/e/ECFADetectorRDRoadmap>



<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>



THE 2021 ECFA DETECTOR
RESEARCH AND DEVELOPMENT ROADMAP

The European Committee for Future Accelerators
Detector R&D Roadmap Process Group



ECFA
European Committee
for Future Accelerators

CERN-ESU-017
ECFA/RC/21/510

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We ought, in every instance, to submit our reasoning to the test of experiment, and never to search for truth but by the natural road of experiment and observation.

Antoine Lavoisier
Traité élémentaire de chimie, 1789



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<https://europeanstrategy.cern>
<https://indico.cern.ch/e/ECFADetectorRDRoadmap>
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The organisation of DRDs is expected to be largely up to the relevant communities to define (given their various traditions in the different areas), but it will be important that there is some commonality of language and information provided in the different proposals, to avoid confusing both reviewers and Funding Agencies.

A document “Suggested Guidelines for DRD Proposal Preparation” has been prepared by the chairs of the ECFA Detector Panel which covers many of these aspects, but a number of further points have come up in the recent DRD community meetings.

The language around Memoranda of Understanding (MoUs) has been confused by the use of the term “**Light-Weight-MoU**” by RD50/51 to describe agreements signed by **institutes** as collaboration members with commitments which include an annual levy of ~few kCHF/annum for administrative support and collaborative blue-sky R&D.

However, the document [CERN/SPC/1190](#) refers to Memoranda of Understanding (**MoUs**) in the context of **agreements of Funding Agencies to support Strategic R&D** through commitments to provide funding through their institutes towards the achievement of the DRD work-package milestones and deliverables.

Furthermore, DRD7 (electronics) will require member institutes to sign **Memoranda of Agreement** giving a range of agreed practices and possible issues around IP, NDAs etc that will need to be formally defined.

It has been agreed to instead, more generally, use the term **MoA** for **agreements between individual institutes and DRDs** such as those for some small annual membership levy per institute.

The preparation of **MoUs** will require a common format to be developed by CERN as these will be agreements ultimately signed between the **Funding Agencies and the host laboratory** which also provides the formal programme oversight.