

The 2023 International Workshop on the High Energy Circular Electron Positron Collider 27/10/23

Implementation of the ECFA Detector R&D Roadmap and Progress on Detector R&D (DRD) Collaborations

Phil Allport

(On behalf of the ECFA Detector R&D Roadmap Panel and ECFA Detector Panel)



Detector R&D Roadmap as Implementation of EPPSU

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, <u>https://europeanstrategyupdate.web.cern.ch/</u>

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

European Committee for Future Accelerators

Roadmap Organisation

"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/

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Roadmap Process

During 2021 the 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 Other Discipline TF topic specific contacts.

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Task Force 8 Integration: Frank Hartmann³⁵, Werner Riegler² (Conveners) Corrado Gargiulo², Filippo Resnati², Herman Ten Kate³⁶, Bart Verlaat², Marcel Vos³⁷ (Expert Members)

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https://indico **ECFADetector**

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		6 Martin Aleksa	Detector R&D requirements for future	high-energy had	ron colliders	Cyprus	Panos Razis	Netherlands	Niels van Bakel
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	Aparter Martine Sa Lega	10 Laura Baudis	Detector R&D requirements for future	dark matter exp	eriments			Romania	Mihai Petrovici
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	19th November 2021							Sweden	Christian Ohm
		Two days of Input Sessio	ns covered all the future facilities and	May 2021				Swtizerland	Ben Kilminster
		topic areas identified in	the EPPSU (see back-up).	CT May ECFA Dete	ctor R&D Roadmap Symposium of Task Force 6 Calorin	metry		Turkey	Kerem Cankocak
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		Common registration for participants by the end of	the symposia had logged 1359 of the last one.	March 2021	ctor R&D Roadmap Symposium of Task Force 8 Integra	tion			
		Received extensive feed	back during symposia and after by email.	25 Mar ECFA Date Processing	ctor R&D Roadmap Symposium of Task Force 7 Electro	onics and On-detector			
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		APOD appointed experts	consulted where needed by Task Force	Organisation nan	ie Contact name			Oth	er Disciplines
		convenors for advice on	developments in their disciplines.	APPEC NuPECC	Andreas Haungs (Chair) Marek Lewitowicz (Chair)		APPEC: Astro-Part	icle Physics Europ	ean Consortium
		19th November 2021	ECFA Detector R	LEAPS	Caterina Biscari (Chair)		LEAPS: League of	European Accelera	tor-based Photon Sources
				ESA	Guenther Hasinger (Director of Science)	LENS: League of a	dvanced Europear	Neutron Sources
The Task Force Convenor	's join those listed below to	compose the D	etector R&D Roadmap		Franco Ongaro (Director of Technology	, Engineering and Quali	ty) NUPECC: Nuclear I	Physics European	
	Panel.				Named expert contacts APPEC 171 Jennifer i, Ruaf (Fermilat)		112	Manfred Und	ser (MPI Heidelberg)
					172 Married Under (Wei Redetorg) 173 Fabrice Retiere (TRUMF) 174 Tra Polynam (Nichef)	Named contacts f	or each	Helmut Schol	er (ILL)
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	Tellx Seikow , Ian Sh	apacy			NuPECC 191 Laura Fabbietti (TUM Munich) Bernhard Ketzer 192	-	153	Brian Shortt Nick Nelms	
Ex-officio Pau	el members: Karl Jakob	s ⁴⁴ (Currept E	CFA Chair).		193 Luciano Masa (CEN) Michael Deveaux 194 (Fugerio Nappi (INFN Ran)	-	154	Alessandra Co Brian Shortt	estantino Mucio
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	cientific Secretary Suc	anne Kuchn ²			198 Nemer Reger (CINN) Lan Schwitt 199 Michael Deveaux,	-	186	Sarah Wittig Nick Neims Nick Neims Soerg Ter Haa	
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(https://cds.cern.ch/record/2784893)

Also 8 page synopsis document: https://cds.cern.ch/record/2784893/files/Synopsis%20of%20 the%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**

Furopean Committee

for Future Accelerators



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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.



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27th October 2023

European Committee for Future Accelerators,

Detector R&D Themes

seous	DRDT 1.1	Improve time and spatial resolution for gaseous detectors with long-term stability	• The mo	st urge
	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	are idei	ntified
	DRDT 1.3	schemes Develop environmentally friendly gaseous detectors for very large areas with high-rate capability	• The tim	efram
	DRDT 1.4	Achieve high sensitivity in both low and high-pressure TPCs	DRDT a	rea, in
	DRDT 2.1	Develop readout technology to increase spatial and energy resolution for liquid detectors	are bas	ed on t
hid	DRDT 2.2	Advance noise reduction in liquid detectors to lower signal energy thresholds	charts i	n each
luia	DRDT 2.3	Improve the material properties of target and detector components in liquid detectors		DRDT 6.1
	DRDT 2.4	Realise liquid detector technologies scalable for integration in large systems	Calorimetry	DRDT 6.2
	DRDT 3.1	Achieve full integration of sensing and microelectronics in monolithic CMOS pixel sensors		DRDT 6.3
olid	DRDT 3.2	Develop solid state sensors with 4D-capabilities for tracking and calorimetry		DRDT 7.1
tate	DRDT 3.3	Extend capabilities of solid state sensors to operate at extreme fluences	Electronics	DRDT 7.3
	DRDT 3.4	Develop full 3D-interconnection technologies for solid state devices in particle physics		DRDT 7.4
) and	DRDT 4.1	Enhance the timing resolution and spectral range of photon detectors		DRDT 7.5
oton	DRDT 4.2	Develop photosensors for extreme environments		DRDT 8.1
oton	DRDT 4.3	Develop RICH and imaging detectors with low mass and high resolution timing	Integration	DRDT 8.2
	DRDT 4.4	Develop compact high performance time-of-flight detectors		
	DRDT 5.1 DRDT 5.2	Promote the development of advanced quantum sensing technologies Investigate and adapt state-of-the-art developments in quantum		DRDT 8.4
antum	DRDT 5.3	technologies to particle physics Establish the necessary frameworks and mechanisms to allow	Training	DCT 1
	DRDT 5.4	Develop and provide advanced enabling capabilities and infrastructure		DCT 2

- 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 document, are based on the more detailed information and charts in each chapter (see backup for more details).

	DRDT 6.1	Develop radiation-hard calorimeters with enhanced electromagnetic energy and timing resolution
Calorimetry	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
	DRDT 7.1	Advance technologies to deal with greatly increased data density
	DRDT 7.2	Develop technologies for increased intelligence on the detector
Flectronics	DRDT 7.3	Develop technologies in support of 4D- and 5D-techniques
Liectronics	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
	DRDT 8.1	Develop novel magnet systems
	DRDT 8.2	Develop improved technologies and systems for cooling
Integration	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 Roadmap

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 <u>R&D</u> should be <u>supported with adequate mechanical and electronics engineering resources</u>, 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.



Detector R&D Roadmap

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, <u>consider more focused investment for</u> 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, <u>also long-term strategic funding</u> <u>programmes to sustain both research and development of the multi-decade DRDTs</u> 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.



Detector R&D Roadmap

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 <u>Sponsoring Consortium for Open Access</u> <u>Publishing in Particle Physics (SCOAP³) should explore ensuring similar access is available to instrumentation journals</u> (including for conference proceedings) as to other particle physics publications.

European Committee for Future Accelerators

Roadmap Implementation Brief History

- 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 <u>https://indico.cern.ch/event/1133070/timetable/</u> 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 <u>Detector R&D</u> (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 with the ECFA Detector Panel (EDP), CERN management plus RD50, RD51 and CALICE representation.
- These led to the September 2022 SPC and Council approved implementation plan: CERN/SPC/1190.

CERNSPC1190
CERNSPC1190
CERNSPC190
Original: English
29 September 2022
ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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Cernspective
Cernspec

EUROPEAN STRATEGY FOR PARTICLE PHYSICS DETECTOR R&D ROADMAP

In the context of the implementation of the 2020 update of the European Strategy for Particle Physics, the European Committee for France Accelerators (ECRA vasa mathatabod by the CERN Oxoncal in 2020 to develop a detector R&D roadmap. The 2021 ECRA Detector Research and Development Roadmap was presented to the Council at its meeting in Docember 2021 and the Council invited ECRA to dalorate a detailed implementation plan.

ECFA hereby invites the Council to take note of the implementation plan that has been developed, as set out in annex 1 of this document.

27th October 2023



Detector R&D Roadmap

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, <u>there is a need to refresh the CERN RD programme</u> <u>structure and encourage new programmes for next generation detectors</u>, 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, <u>also long-term strategic funding</u> <u>programmes to sustain both research and development of the multi-decade DRDTs</u> 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 <u>new</u> ECFA Training Panel, the ECFA-LDG Infrastructure Working Group or other ECFA initiatives in consultation with key stakeholders.
- The emphasis for the EDP and Roadmap Panel in 2023 has been 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 CERN/3679 Original: English 29 September 2022
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detion to be taken For information	SCIENTIFIC POLICY COMMITTEE 330 th Meeting 28-27 September 2022	listing Procedure

EUROPEAN STRATEGY FOR PARTICLE PHYSIC DETECTOR R&D ROADMAP

In the context of the implementation of the 2020 update of the European Strategy for Particle Physics, the European Committee for Future Accelerators (ICFA) was mandated by the CEBN Council in 2020 to develop a detector R&D roadmap. The 2021 ECFA Detector Research and Development Roadmap was presented to the Council at its meeting in December 2021 and the Council invite ECFA to deborate a detailed implementation plan.

ECFA hereby invites the Council to take note of the implementation plan that has been developed, as set out in annex 1 of this document.

27th October 2023

European Committee for Future Accelerators

Reviewing Organisation

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/SPC/1190)

CERN provides rigorous oversight through wellestablished 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.

27th October 2023



Implementation Timelines

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.

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.

O1 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.

Proposals should use ECFA appointed or locally agreed national contacts to ensure funding requests per country are reasonable and informed by discussions with the Funding Agencies.

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 organizational structure to accommodate the ambitions of the community, with appropriate sub-structures where hey consider this necessary.

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

O3 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).

Overview	Implementation of the ECFA Detector R&D Roadmap
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.
Mandate for the Preparation of the Roadmap	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.
The Roadmap Document	As proposed in the document, topic specific community meetings will now be held in the course of the coming months.
Panel members and Task Forces	sign up to these and to register your interest in participating on the corresponding Kab Conaborations being developed please see the links below.
Input from future facilities	FT Cliquid Detectors https://indico.cem.ch/event/1214404/ FTS Solid State Detectors https://indico.cem.ch/event/1214410/
Symposia	TF4 Photon Detectors and PID https://indico.cern.ch/event/1214407/ TF5 Quantum and Emerging Technologies https://indico.cern.ch/event/1214411/
Registration to the symposia	FTF Calorimetry https://indico.cem.ch/event/1213733/ TF7 Electronics and On-detector Processing https://indico.cem.ch/event/1214423/ FTF8 Integration https://indico.cem.ch/event/1214428/
ECFA Detector R&D Roadmap Process	TF9 Training https://indico.cern.ch/event/1214429/

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Roadmap process Questionnaire

Relevant documents

CERN/SPC/1190

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Action to be taken		Hoting Procedure
For information	SCIENTIFIC POLICY COMMITTEE 330 th Meeting 26-27 September 2022	-
For information	RESTRICTED COUNCIL 209 th Session 29 September 2022	
EUROPE	AN STRATEGY FOR PARTICLI DETECTOR R&D ROADMAP	E PHYSICS
context of the imp cs, the European Co cil in 2020 to devel lopment Roadmap v cil invited ECFA to	lementation of the 2020 update of the Eur mmittee for Future Accelerators (ECFA) v op a detector R&D roadmap. The 2021 EC was presented to the Council at its meeting elaborate a detailed implementation plan.	opean Strategy for Particle vas mandated by the CERN FA Detector Research and in December 2021 and the

DRD proposals deadline was end July 2023 including estimates of resources. → MoUs to follow in 2024.

27th October 2023

ECFA Detector R&D Roadmap

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European Committee for Future Accelerators

Reviewing Organisation

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

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(CERN/SPC/1190)

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- 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.

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European Committee for Future Accel

Implementation Timelines

- Links to where the DRD proposal teams public pages and sign-up areas can be found are at https://indico.cern.ch/event/957057/page/ 27294implementation-of-the-ecfa-detector-rd-roadmap.
- The most recent public status report was at the EPS-HEP2023 Conference given by Didier Contardo (co-chair of ECFA Detector Panel) https://indico.desy.de/event/34916/contributions/142202/.

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.

	Co-chairs:	Phil Allport (Birmingham) Didier Contardo (IP2I Lyon)
	DRDC chair, ex-officio:	Thomas Bergauer (HEPHY Vienna (OEAW
ECFA Detector	Scientific secretary:	Doris Eckstein (DESY)
Panel (EDP)		
	Gaseous Detectors:	Silvia Dalla Torre (Torino)
(Hostod at DESV)	Liquid Detectors:	Inés Gil Botella (CIEMAT, Madrid)
(HOSLEU at DEST)	Solid State Detectors:	Doris Eckstein (DESY)
		Phil Allport (Birmingham)
(https://ecfa-	PID & Photon Detectors:	Roger Forty (CERN)
dn dosy do/)	Quantum and emerging Technologies.:	Steven Hoekstra (Groningen)
up.uesy.ue/	Calorimetry:	Laurent Serin (IJCLab)
	Electronics:	Valerio Re (Bergamo)
	Ex Officio:	Karl Jakobs (ECFA Chair)
		lan Shipsey (ICFA Detector Panel)
	Observer for APPEC	Aldo Ianni (INFN, LNGS)
	Observer for NuPECC	Eugenio Nappi (INEN, Unit of Bari)

EDP mandate and membership updated February 2023; DRDC ready in time to influence final proposals and submissions.

Detector R&D Committee (DRDC)

(Hosted at CERN)

(https://committees .web.cern.ch/drdc)

	Implementation of the ECFA Detector R&D Roadmap
n of the R&D	After the publication of the ECFA Detector R&D Roadmap, CERN Council requested ECFA to develop the plan for its Implementation.
e the	The document approved by the SPC and CERN Council in September 2022 can be found at https://indico.cern.ch/even /1197445/contributions/5034860/attachments/2517863/4329123/spc-e-1190-c-e-3679- Implementation_Detector_Roadmap.pdf.
Document	As proposed in the document, topic specific community meetings will now be held in the course of the coming mont sign up for these and to register your interest in participating on the corresponding R&D Collaborations being develo
s and Task	please see the links below.
ure	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/121410/ TF4 Photon Detectors and PID https://indico.cern.ch/event/121410/
the	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/
R&D ess	TF9 Training https://indico.cem.ch/event/1214429/
the	

BERGAUER, Thomas	HEPHY, Vienna, Chairperson
TROSKA, Jan	CERN, Scientific Secretary
Members - Referees	
BENTVELSEN, Stan	NIKHEF
BRESSLER, Shikma	Weizmann Institute of Science
BUDKER, Dimitry	Helmholtz Institute Mainz and Johannes Gutenberg University
FORTY, Roger	CERN
GEMME, Claudia	INFN and University, Genoa
GIL BOTELLA, Ines	CIEMAT
MERKEL, Petra	Fermilab
PESARESI, Mark	Imperial College
SERIN, Laurent	IJCLab - Laboratoire de physique des 2 infinis
Members Ex-officio	
ALLPORT, Phil	ECFA Detector Panel (EDP) Co-Chair
CONTARDO, Didier	ECFA Detector Panel (EDP) Co-Chair

Overview

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Preparation of Roadmap

The Roadma

Panel membe Forces

Input from fu facilities Symposia

Registration to symposia

ECFA Detecto Roadman Pro

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Roadmap p

Internal

Questionnaires

Relevant documents

27th October 2023

ECFA Detector R&D Roadmap

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DRD Collaboration Status Overview

Distribution in the Different Continents

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 and finalised proposal submitted 30th July to DRDC.

Main proposal community meeting: 1st-3rd March 2023 <u>https://indico.cern.ch/event/1245751/</u>

Most up to date material on DRD1 at <u>https://drd1.web.cern.ch/</u>.

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



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DRD Collaboration Status Overview

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 and FTE/resources/facility (both available and needed) have been collected.

Proposal submitted 14th August to DRDC after several iterations with the relevant communities.

Main proposal community meeting: 20th April 2023 <u>https://indico.cern.ch/event/1214404/timetable/#20230420</u> Organisation and workplan at <u>https://indico.cern.ch/event/1214404/</u>



27th October 2023



DRD Collaboration Status Overview

DRD3 Solid State Detectors (TF Convenors: Giulio Pellegrini (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. Multiple meetings through spring and summer followed by proposal submission on 21st September to DRDC. Main proposal community meeting: 22nd-23rd March 2023 <u>https://indico.cern.ch/event/1214410/timetable/#20230322.detailed</u> Further organisation information at <u>https://indico.cern.ch/event/1214410/</u> (Also, for RD50 see <u>http://rd50.web.cern.ch/</u> and for RD42 see <u>https://rd42.web.cern.ch/rd42/</u>)



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DRD Collaboration Status Overview

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

Five themes being addressed by six working groups addressing work-packages in the following topic area: *solid-state photodetectors, Vacuum-based photodetectors, Develop RICH and imaging detectors with low mass and high- resolution timing, Develop compact high-performance time-of-flight detectors, Advance the performance of Scintillating Fibre trackers and solid-state Transition Radiation detectors.*

Community for this area created through several surveys and meetings with proposal submitted 31st July to DRDC. Main proposal community meeting: 6th-17th May 2023 <u>https://indico.cern.ch/event/1263731/</u> Further background at <u>https://indico.cern.ch/event/1214407/</u>

- WG 4.1 Photon Detectors
- WG 4.2 Particle ID
- WG 4.3 Technological activities
- WG 4.4 Software
- WG 4.5 Scintillating Fibres and Transition Radiation Detectors
- WG 4.6 Novel ideas and far-future R&Ds
- Collaboration of 56 research institutes from 17 countries with connection to six industrial partners.



TA2



DRD Collaboration Status Overview

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 very large science areas outside high energy physics.

"White paper" document describes six Work Package areas with Letter of Intent targeted soon and full proposal before the end the year, given specific issues of overlaps with already funded initiatives outside particle physics.

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

WP1: Network of atomic clocks and global sub-ns time stamping - portable reference

TA1 clocks and clock networks - for single worldwide multi-modal observations

WP2: Exotic systems in traps and beam

- TA5 atoms/ions/molecule and atom interferometry link to TA1/WP1
- WP3: Cryogenic systems solid state superconducting materials electronics integration
 - TA2 kinetic and TA3 spin based superconducting

WP4: Theory

• match sensor sensitivity - evaluate physics reach impact TA1, TA4 (optomechanical) and TA5

WP5: Scaling to larger systems preserving quantum properties

 spin polarized sensors - scintillators - heterostructures for sensor families TA2/3/4/5 (nanoengineered materials)

WP6: Capability driven design

• networking - test infrastructures - education, all TAs



Expressions of Interest

40 institutes in 15 countries



DRD Collaboration Status Overview

DRD6 Calorimetry (TF Convenors: Roberto Ferrari (INFN Pavia (IT)), Roman Poeschl (Université Paris-Saclay (FR)))

Scientific organisation well advanced with three main Work Areas defined, along with seven transversal areas, and required resources identified including significant test-beam availability needs after 2025.

Draft proposal ready by start of June, second draft mid-June, final proposal submitted 28th July to DRDC.

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

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 <a href="https://twiki.cern.ch/twik



27th October 2023



DRD Collaboration Status Overview

DRD7 Electronics (TF Convenors: Francois Vasey (CERN), Frank Simon (Karlsruhe Institute of Technology (DE)))

As with TF8, TF9 is a "Transversal" topic area with six Technology Working Groups whose scope has elements that also depend on the content of other DRD proposals - so DRD7 can only submit full proposal after these.

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

Letter of Intent submitted 15th September 2023 (with ballpark resource estimates) and full proposal before the end of the year. Main community meetings: 14th-15 March <u>https://indico.cern.ch/event/1214423/timetable/#20230314</u> and 25th-26th September 2023 at <u>https://indico.cern.ch/event/1318635/timetable/#20230925</u>.



 Data Density & Power efficiency
 Intelligence On-Detector
 4D & 5D Techniques
 Extreme Environments
 Backend systems & COTS
 Complex imaging ASICs & technologies

 Conveners 1
 Conveners 2
 Conveners 3
 Conveners 4
 Conveners 5
 Conveners 6

 Projects
 Projects
 Projects
 Projects
 Projects
 Projects
 Projects

Currently 64 institutes from 15 countries contributing on 16 defined projects



DRD Collaboration Progress Overview

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 but currently <u>no strong push to create a DRD7 collaboration</u>. 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 this specific area.

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

Now the topic of the dedicated new ECFA Training Panel Kick-off meeting on 7th March 2023 with agenda at <u>https://indico.desy.de/event/38365/</u> and further meeting 5th October 2023 (<u>https://indico.desy.de/event/41752/</u>).

Web pages at <u>https://indico.cern.ch/event/1270365/</u>.

Membership still being finalised.

ECFA particle physics	Erika Garutti	Universität Hamburg	
ECFA particle physics	Claire Gwenou	University of Oxford	
ECFA particle physics	Paolo Martinengo	CERN	
ECFA particle physics	Richard Brenner	University of Uppsala	
ECFA particle physics	Niels van Bakel	NIKHEF	
ECFA accelerator	Robert Appleby	Manchester University	
ECFA accelerator	Elias Metral	CERN	
ECFA ECR	Armin Ilg	University of Zürich	
ICFA	Ian Shipsey	University of Oxford	
NUPEC	Paola Gianotti	INFN Frascati	
APPEC	-	-	



DRD Collaboration Outlook

The DRDC has reviewed all submitted proposals in dedicated internal meetings on: 21/9/23 (DRD1); 9/10/23 (DRD2); 13/10/23 (DRD3); 4/10/23 (DRD4) and 2/10/23 (DRD6).

The DRDC will make recommendations based on <u>revised</u> proposals (*so expect some of the material in the previous slides to be updated*) to the CERN Research Board meeting on 6th December 2023 for DRD1, DRD2, DRD3, DRD4 and DRD6 and on 13th March 2024 for DRD5 and DRD7.

DRDs are in parallel expected to define their collaboration structures in accordance with CERN's usual procedures defined at https://cds.cern.ch/record/2728154/files/General-Conditions_CERN_experiments.pdf

CERN is preparing template Memoranda of Understanding (MoUs) to allow DRD collaborations to formalise resource allocations through each having a Collaboration Board of collaborating institutions and Resources Board of funding bodies (usually Funding Agencies). MoU Annexes will define Working Groups and Work Packages with the corresponding commitments for deliverables, personnel and financial resources.

MoU submission for all DRDs to start in 2024

Other useful Detector R&D Roadmap related links include:

ECFA Roadmap Task Force membership at: <u>https://indico.cern.ch/event/957057/page/20875-panel-members-and-task-forces</u>; CERN EP R&D Programme links at: <u>https://ep-rnd.web.cern.ch/</u>; AIDAinnova web pages: <u>https://aidainnova.web.cern.ch/</u>; EURO-LABS information at <u>https://web.infn.it/EURO-LABS/</u> and the US Coordinating Panel for Advanced Detectors (CPAD) <u>https://cpad-dpf.org/</u> and <u>http://doe-brn-hep-detectorrandd.physics.ox.ac.uk/</u>.



27th October 2023

European Committee for Future Accelerators

Process and Timeline



European Committee for Future Accelerators

Detector R&D Roadmap

- The most urgent R&D topics in each Task Force area are identified as Detector R&D Themes.
- The timeframes for activities in these areas are illustrated in this figure from both the brochure and the main document.
- <u>Stepping stones</u> are shown to represent the R&D needs of facilities intermediate in time.
- The faded region acknowledges the typical time needed between the completion of the R&D phase and the readiness of an experiment at a given facility.

→ See "Results of the 2021 ECFA Early-Career Researcher Survey on Training in Instrumentation" <u>ECFA</u> <u>ECR Panel</u> *arXiv:2107.05739*



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

27th October 2023

ECFA Detector R&D Roadmap

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European Committee for Future Accelerators

8 page synopsis document and 248 page report with chapters covering the 9 TF Areas and 3 further chapters of Introduction, General Observations and Considerations, and Conclusions.

Topic urgency in each TF area has been identified through the requirement that, given the earliest reasonable start date* for an EPPSU supported possible future facility/experiment, the detector R&D should not be the time-limiting factor.

TF1: Gaseous Detectors



 Image: constraint of the second of the se

*as at the time of writing

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ECFA



Detector R&D Roadmap

Example non-accelerator dates (not complete)



	TF3: Solid State		$P_{mag}^{2n} = P_{mag}^{2n} = P_{m$	LHCD & CMS & LS41) HTAS & CMS & LS41) ETC & CMS & LS41), LH-	
	Detectors	DRDT	< 2030	2030-2035	2035- 2040-2045 >2045
Vertex detector ²⁾	Position precision Low X/X ₀ Low power High rates Large area wafers ³⁰ Ultrafast timing ⁴⁰ Radiation tolerance NIEL Radiation tolerance TID	3.1,3.4 3.1,3.4 3.1,3.4 3.1,3.4 3.1,3.4 3.2 3.3 3.3			
Tracker ⁵⁾	Position precision Low XX ₀ Low power High rates Large area wafers ³⁰ Ultrafast timing ⁴⁰ Radiation tolerance NIEL Radiation tolerance TID	3.1,3.4 3.1,3.4 3.1,3.4 3.1,3.4 3.1,3.4 3.2 3.3 3.3			
Calorimeter ⁶⁾	Position precision Low X/X _o Low power High rates Large area wafers ⁽³⁾ Ultrafast timing ⁴⁾ Radiation tolerance NIEL Badiation tolerance TID	3.1,3.4 3.1,3.4 3.1,3.4 3.1,3.4 3.1,3.4 3.2 3.3 3.3	:	••	
Time of flight ⁷⁾	Position precision Low XX ₀ Low power High rates Large area wafers ³⁰ Ultrafast timing ⁴⁰ Radiation tolerance NIEL Radiation tolerance TID	3.1,3.4 3.1,3.4 3.1,3.4 3.1,3.4 3.1,3.4 3.1,3.4 3.2 3.3 3.3	••	••	

Large ton dual-phase (PandaX-4T, LZ, DarkSide -20k, Argo 200k, APIADNE, ...)
 Light dark matter, solar axion, Orbb, rare nuclei&lors and astro-particle reactions, Ba tagging)
 BAB for 100-no neade dual-phase DM/neutrino experiments.

Identifying the Tools

1120

European Committee for Future Accel erato

Detector R&D Roadmap



TF4: Photon Detectors & PID Rad-hard Rate capability **RICH and DIRC** Fast timing Spectral range and PDE Radiator materials Compactness, low X Rad-hard Low X Time of fligh Fast timing to <10ps level & clock distribution dE/dx Scintillating fibres (light yield, rad-hard & timing Rad-hard Low noise Fast timing Radio purity VUV / cryogenic det or Photocathode ageing & rate capability Fast timing acuum nhoto Fine granularity / large area Spectral range and PDE Magnetic field immunity Photocathode ageing & rate capability Fine granularity / large area Spectral range, PDE and fast timing

🔴 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

TF7: Electronics & On-detector





