Progress in ECFA Detector Roadmap Implementation Planning

Phil Allport

(University of Birmingham)

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

ECFA
European Committee for Future Accelerators

Process and Timeline

Organisation

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

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

Dec 2020
Task Forces active

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

Expert & Community Consultation

Feb 2021
Collection of requirements of future facilities & projects

Feb/March 2021
Questionnaires of Task Forces to national contacts

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

March-May 2021
Open Symposia

Drafting Roadmap & Feedback

May 2021
Task Forces collate input from symposia

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

July 2021
Near final draft shared with RECFA*

30 July 2021
Presentation at Joint ECFA-EPS session

August 2021
Collect final community feedback*

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

Roadmap Process

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 Colaleo[1], Leszek Ropelewski[2] *(Conveners)*
Klaus Dehmelt[3], Barbara Liberti[4], Maxim Titov[5], Joao Veloso[6] *(Expert Members)*

Task Force 2 Liquid Detectors: Roxanne Guenette[7], Jocelyn Monroe[8] *(Conveners)*
Auke-Pieter Colijn[9], Antonio Ereditato[10,11], Ines Gil Botella[12],
Manfred Lindner[13] *(Expert Members)*

Task Force 3 Solid State Detectors: Nicolo Cartiglia[14], Giulio Pellegrini[15] *(Conveners)*
Daniela Bortoletto[16], Didier Contardo[17], Ingrid Gregor[18,19] Gregor Kramberger[20],
Heinz Pernegger[2] *(Expert Members)*

Task Force 4 Particle Identification and Photon Detectors: Neville Harnew[16], Retired and replaced by Christian Joram (CERN)
Peter Krizan[20] *(Conveners)*
Ichiro Adachi[21], Eugenio Nappi[1] Christian Joram[2],
Christian Schultz-Coulon[22] *(Expert Members)*

Task Force 5 Quantum and Emerging Technologies: Marcel Demarteau[23],
Michael Doser[2] *(Conveners)*
Caterina Braggio[24], Andy Geraci[25], Peter Graham[26], Anna Grasselino[27],
John March Russell[16], Stafford Withington[28] *(Expert Members)*

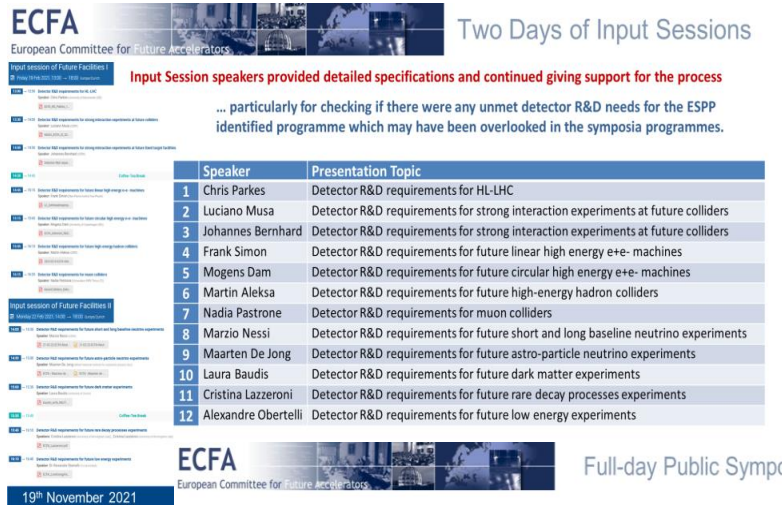
Task Force 6 Calorimetry: Roberto Ferrari[29], Roman Poeschl[30] *(Conveners)*
Martin Aleksa[2], Dave Barney[2], Frank Simon[31],
Tommaso Tabarelli de Fatis[32] *(Expert Members)*

Task Force 7 Electronics: Dave Newbold[33], Francois Vasey[2] *(Conveners)*
Niko Neufeld[2], Valerio Re[29] Christophe de la Taille[34], Marc Weber[35] *(Expert Members)*

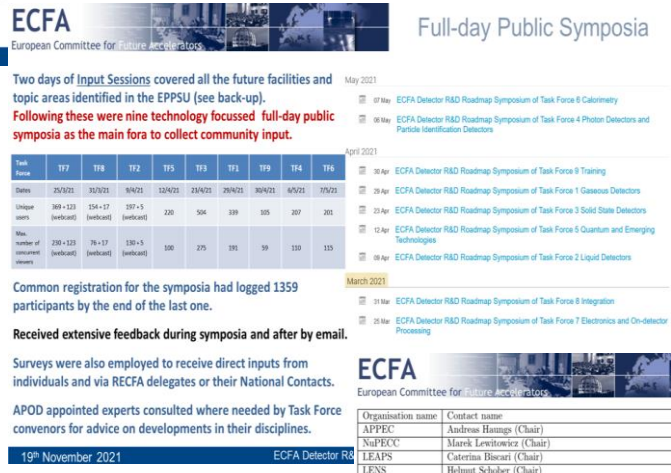
Task Force 8 Integration: Frank Hartmann[35], Werner Riegler[2] *(Conveners)*
Corrado Gargiulo[2], Filippo Resnati[2], Herman Ten Kate[36], Bart Verlaat[2],
Marcel Vos[37] *(Expert Members)*

Task Force 9 Training: Johann Collot[38], Erika Garutti[18,39] *(Conveners)*
Richard Brenner[40], Niels van Bakel[9] Claire Gwenlan[16], Jeff Wiener[2],
ex-officio Robert Appleby[41] *(Expert Members)*

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



	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



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

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

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

Panel coordinators: Phil Allport[42] *(Chair)*, Silvia Dalla Torre[43], Manfred Krammer[2], Felix Sefkow[18], Ian Shipsey[16]

Ex-officio Panel members: Karl Jakobs[44] *(Current ECFA Chair)*, Jorgen D'Hondt[45] *(Previous ECFA Chair)*, Lenny Rivkin[46] *(LDG Representative)*

Scientific Secretary: Susanne Kuehn[2]

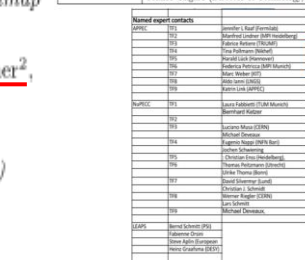
ECFA National Contacts

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

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)

Advisory Panel with Other Disciplines

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



Restricted ECFA

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. Mariyan Bogomilov	Appointed July 2022
Croatia	Prof. Mirko Planinic	Appointed July 2020
Cyprus	Prof. Panos Razis	Appointed Oct. 2017
Czech Republic	Dr Jana Bielcikova	Appointed Jan. 2022
Denmark	Prof. Mogens Dam	Appointed Jan. 2018
Finland	Dr Kati Lassila-Perini	Appointed Jan. 2018
France	Dr Gregorio Bernardi	Appointed Jan. 2023
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 Conde Muino	Appointed July 2020
Romania	Dr Gabriel Stoicea	Appointed July 2021
Serbia	Prof. Lidija Zivkovic	Appointed Jan. 2022
Slovakia	Dr Pavol Stríženec	Appointed May 2016
Slovenia	Prof. Marko Mikuž	Appointed July 2018
Spain	Prof. Celso Martinez Rivero	Appointed Jan. 2021
Sweden	Prof. David Milstead	Appointed Jan. 2018
Switzerland	tbc	Appointed Jan. 2023
Turkey	Prof. Erkcan Özcan	Appointed Jan. 2022
United-Kingdom	Prof. Daniela Bortoletto	Appointed July 2022
Ukraine	Prof. Mykola Shul'ga	Appointed July 2018
CERN	Dr Christian Joram	Appointed Jan. 2022
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	Dr Mauro Mezzetto	Appointed Aug. 2021
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

(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

European Strategy Update | ECFA European Committee for Future Accelerators

Contents

ECFA

European Committee for Future Accelerators

Detector R&D Roadmap

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

Topic urgency 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.

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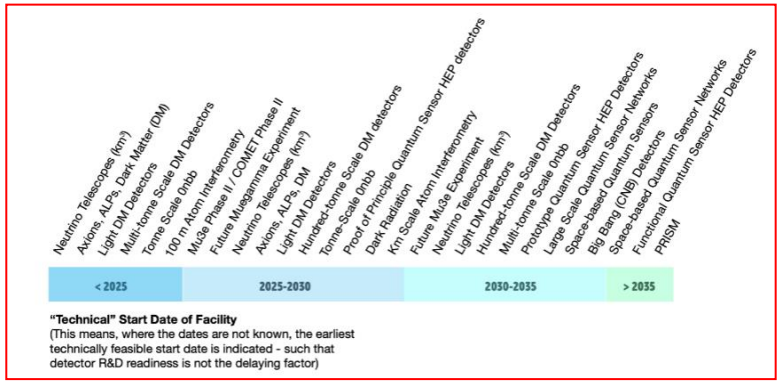
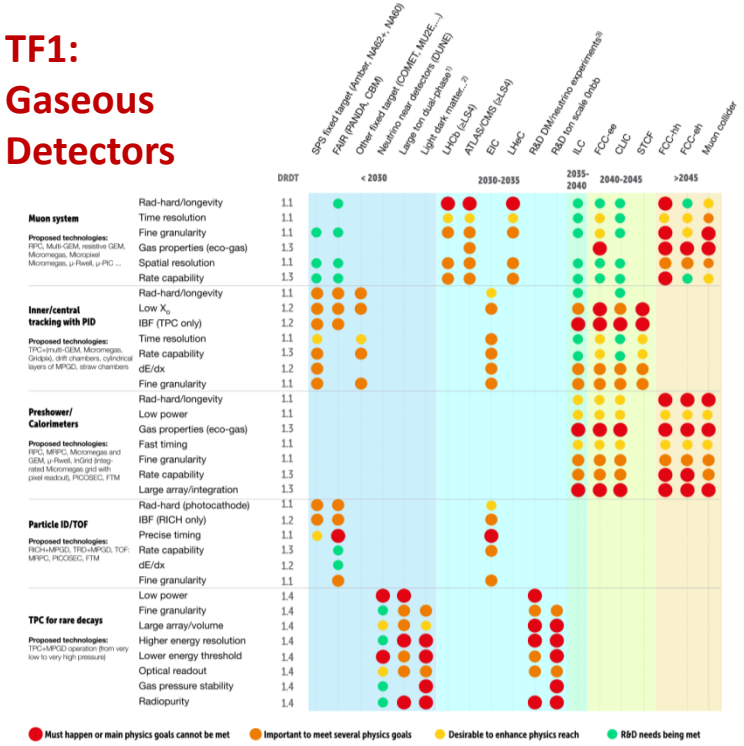
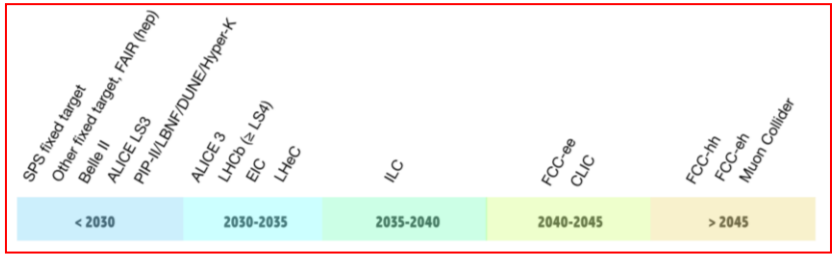
Example non-accelerator dates (not complete)



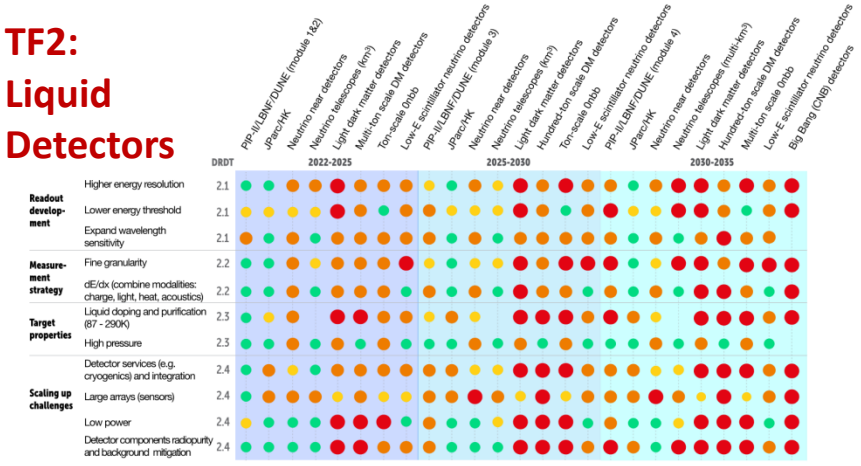
TF1: Gaseous Detectors



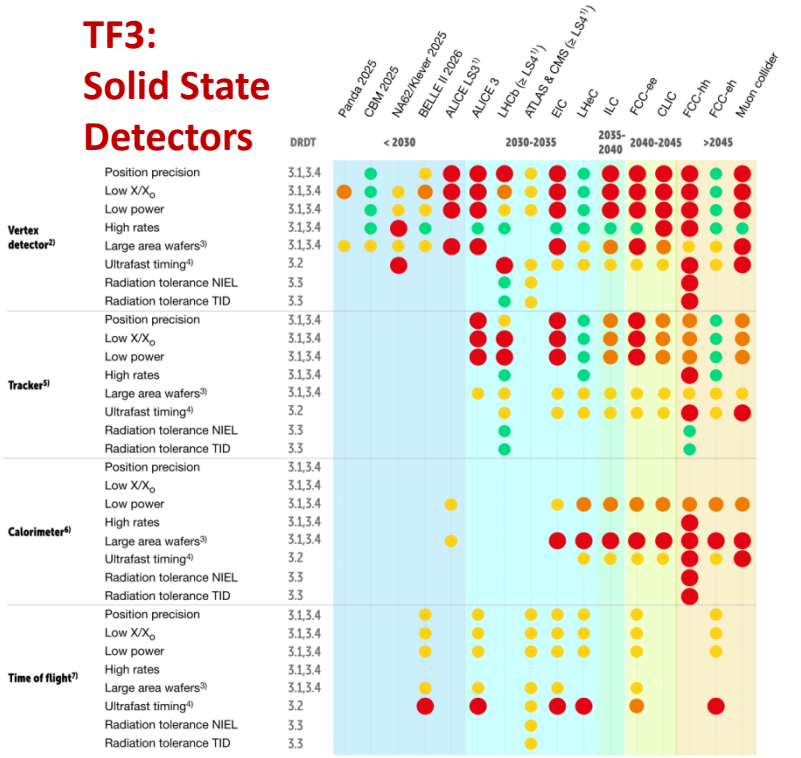
1) Large ton dual-phase (PandaX-4T, LZ, DarkSide -20k, Argo 200k, ARIADNE, ...)
2) Light dark matter, solar axion, 0nbb, rare nuclei&ions and astro-particle reactions, Ba tagging)
3) R&D for 100-ton scale dual-phase DM/neutrino experiments



TF2: Liquid Detectors



TF3: Solid State Detectors



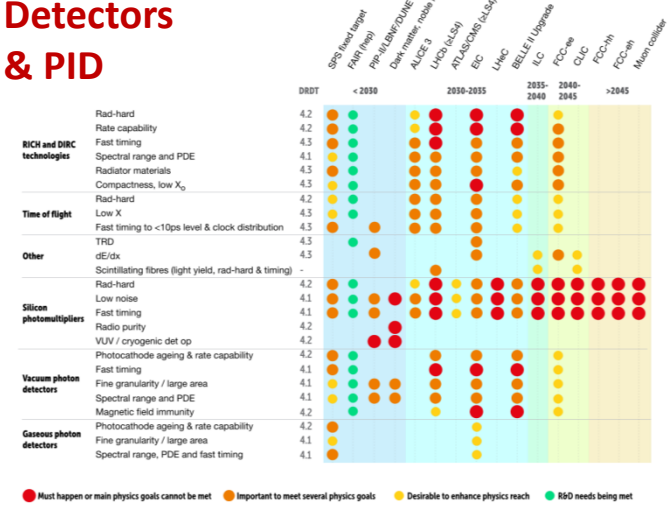
Must happen or main physics goals cannot be met | **Important to meet several physics goals** | **Desirable to enhance physics reach** | **R&D needs being met**

ECFA

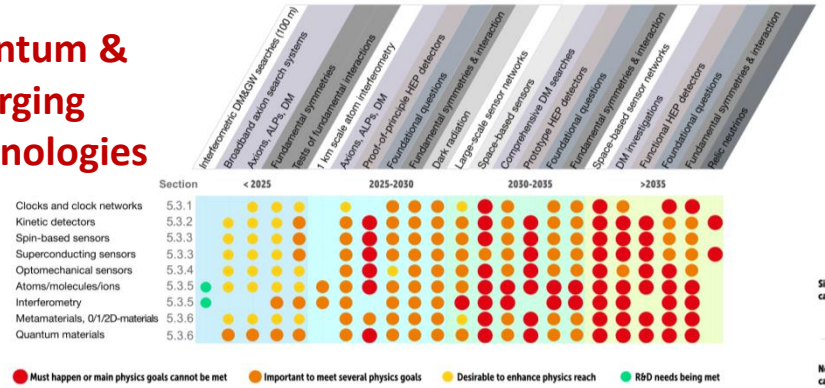
European Committee for Future Accelerators

Detector R&D Roadmap

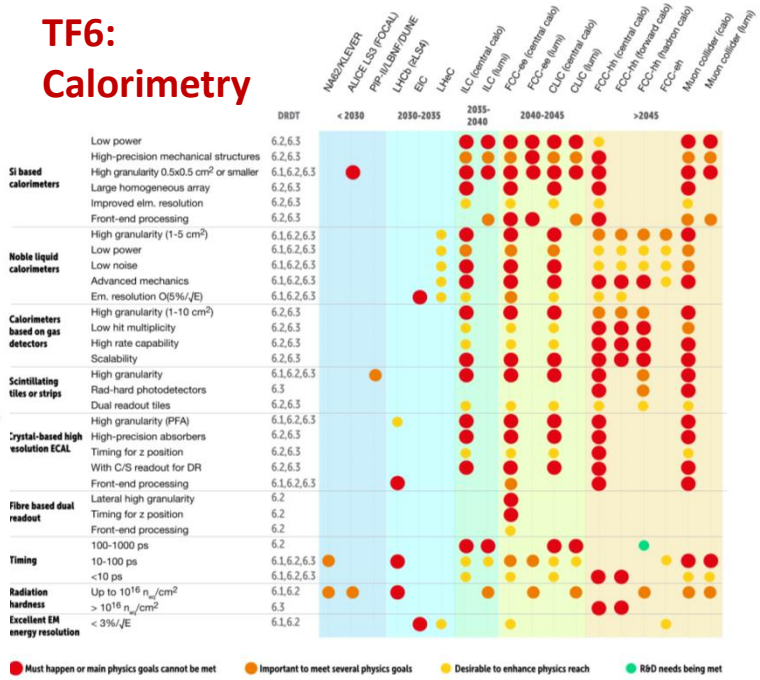
TF4: Photon Detectors & PID



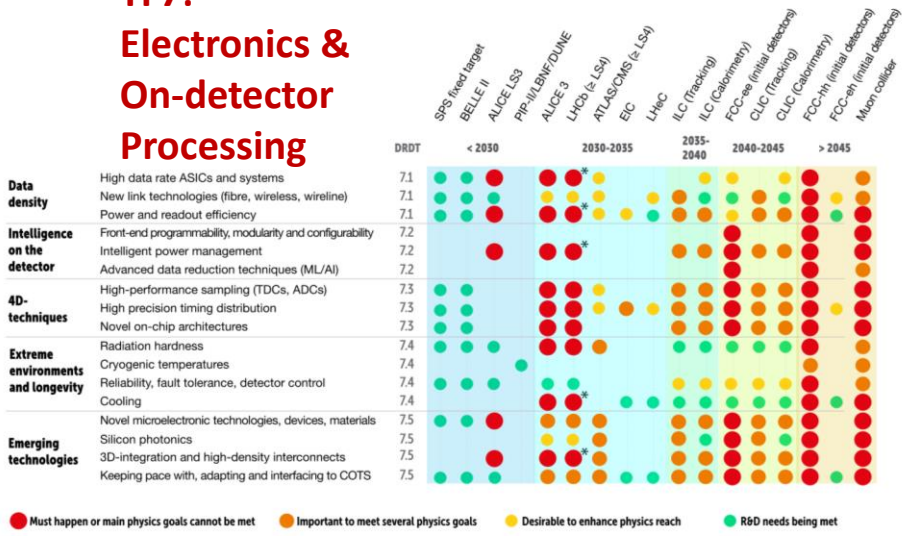
TF5: Quantum & Emerging Technologies



TF6: Calorimetry

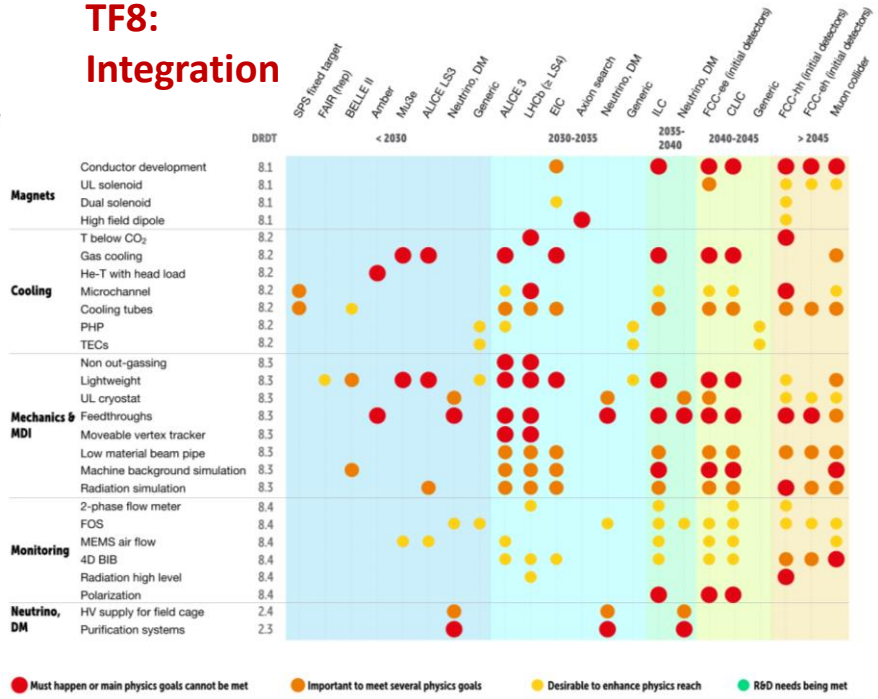


TF7: Electronics & On-detector Processing



* LHCb Velo

TF8: Integration



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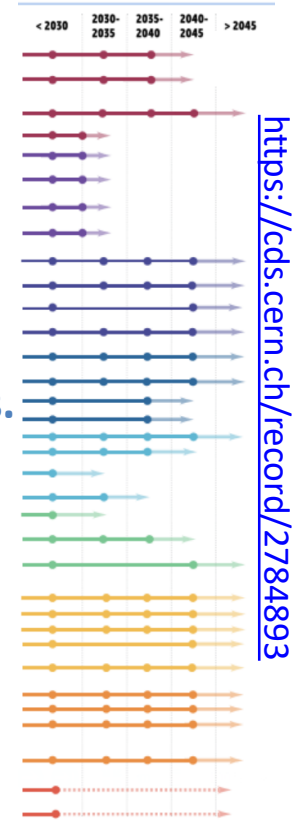
Detector R&D Themes

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

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 (SCOAP^3) should explore ensuring similar access is available to instrumentation journals (including for conference proceedings) as to other particle physics publications.

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 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.**

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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 September 2022 implementation plan**

- **Other GSRs are not forgotten and are being either addressed by the new ECFA Training Panel, the ECFA-LDG R&D Taskforce or other initiatives by ECFA in consultation with key stakeholders.**
- **The emphasis of the current activities of the EDP and Roadmap Panel are 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.)**


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Reviewing Organisation

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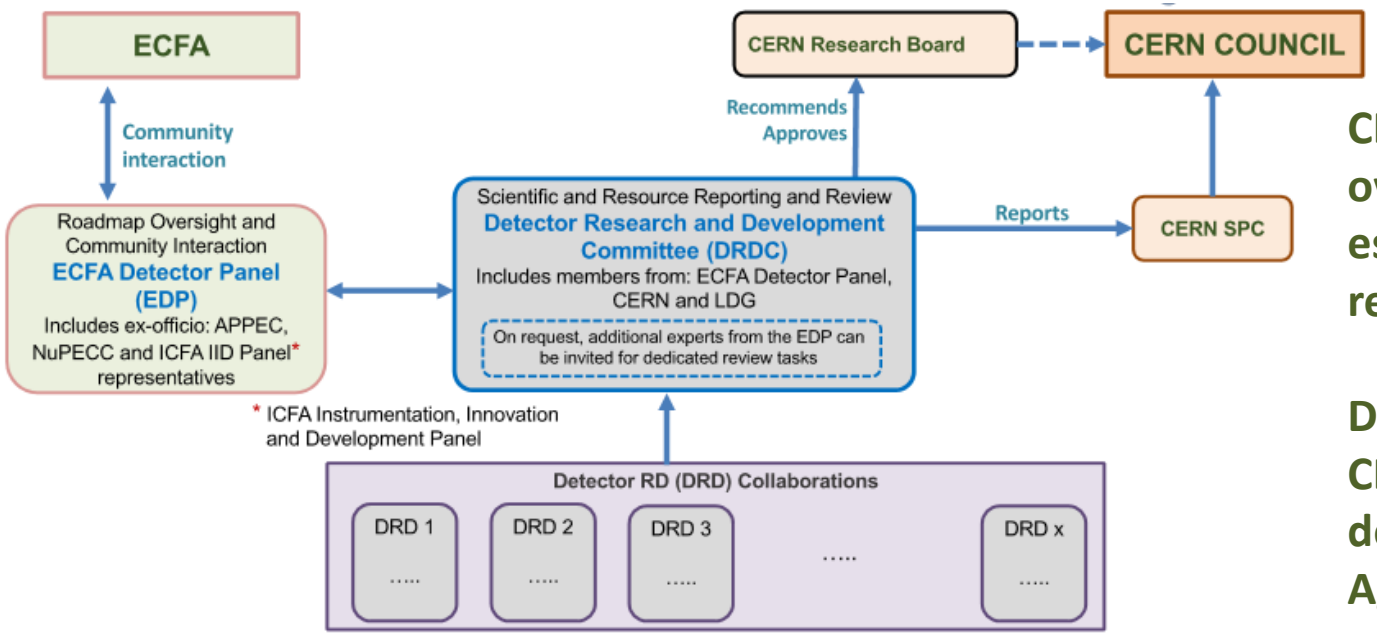
ECFA (through RECFA and PECFA) maintains broad links to the wider scientific community.

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.

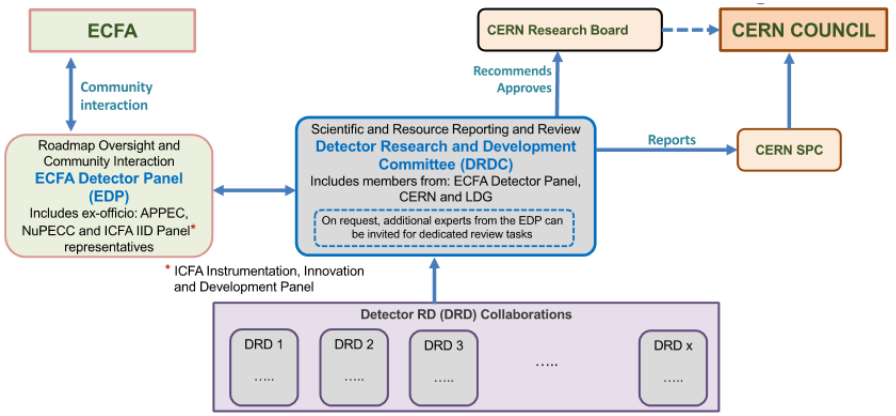
EDP:

- 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.

Detector Panel Membership



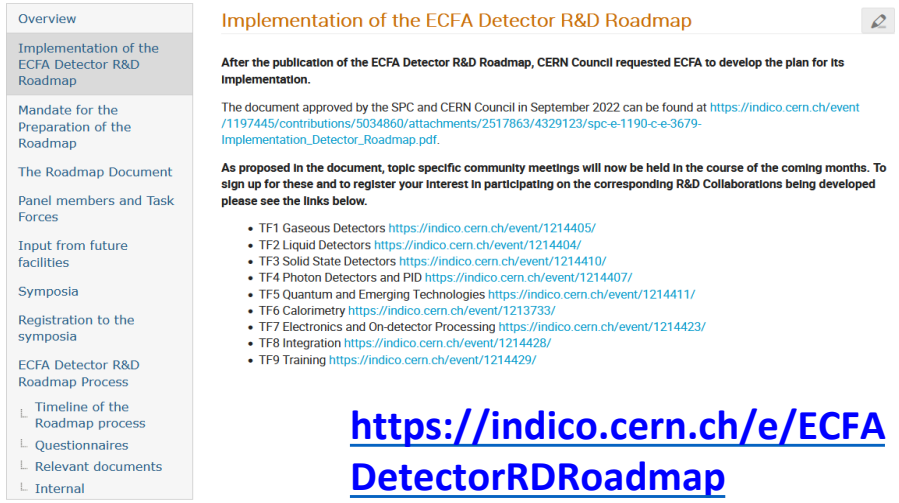
The membership of the EDP reflects the needs to provide expertise in each of the key detector areas identified in the Roadmap: Gaseous Detectors; Liquid Detectors; Solid-State Detectors; Photon Detectors and Particle Identification; Quantum and Emerging Technologies; Calorimetry; Electronics and On-detector 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 and Photon Detectors; Steven Hoekstra (Groningen) Quantum and Emerging Technologies; Laurent Serin (Orsay LAL) Calorimetry; 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: Aldo Ianni (INFN, LNGS) and Eugenio Nappi (INFN, Bari).**

Implementation Timelines

- **Assuming the new DRDs need to come into existence by the start of 2024, the call was sent on 25th October 2022 to the communities wishing to participate in the corresponding new DRD activities with sign up for the different Task Force areas at https://indico.cern.ch/event/957057/page/27294-implementation-of-the-ecfa-detector-rd-roadmap.**

- **Given the timeline presented in CERN/SPC/1190, work on draft guidelines for DRD proposals was initiated last Autumn and circulated to those leading international proposal preparation.**



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

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.

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Implementation Timelines

- 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.

- **DRD proposal teams,** to lead the preparation of the more detailed DRD proposals in each area, should be identified as a result of this process.

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.*

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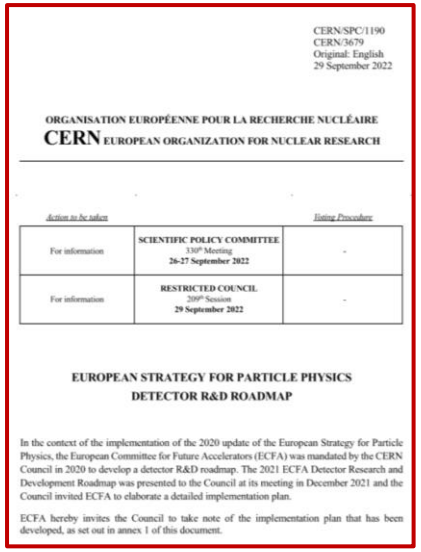

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Implementation Timelines

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).

- *The DRDC reviews proposals in terms of their scientific scope, milestones and technical feasibility, with the help of topic-specific experts from the EDP, and critically examines all financial aspects of the strategic R&D part of the DRD programme.*

Q4 2023:

- Where part of the new DRDs already has resources allocated for particular R&D deliverables (for example, through a pre-existing R&D collaboration covering a significant fraction of the DRD topic areas), mechanisms to carry funding and activities forward into the new DRD context need to be established.

- *Following the review and revision (if required) of proposals, the DRDC recommends the formal establishment of the DRD collaborations.*

- *Formal approval is given by the CERN Research Board.*

2024:

- Collection of MoU signatures. The areas of interest per institute and the expected support for the long-term commitments involved should be specified in the MoUs.

Note: suggested proposal lengths are ~20 pages (case for R&D provided by the Roadmap itself) and the request is for *reasonable estimates informed by discussions with the Funding Agencies*.

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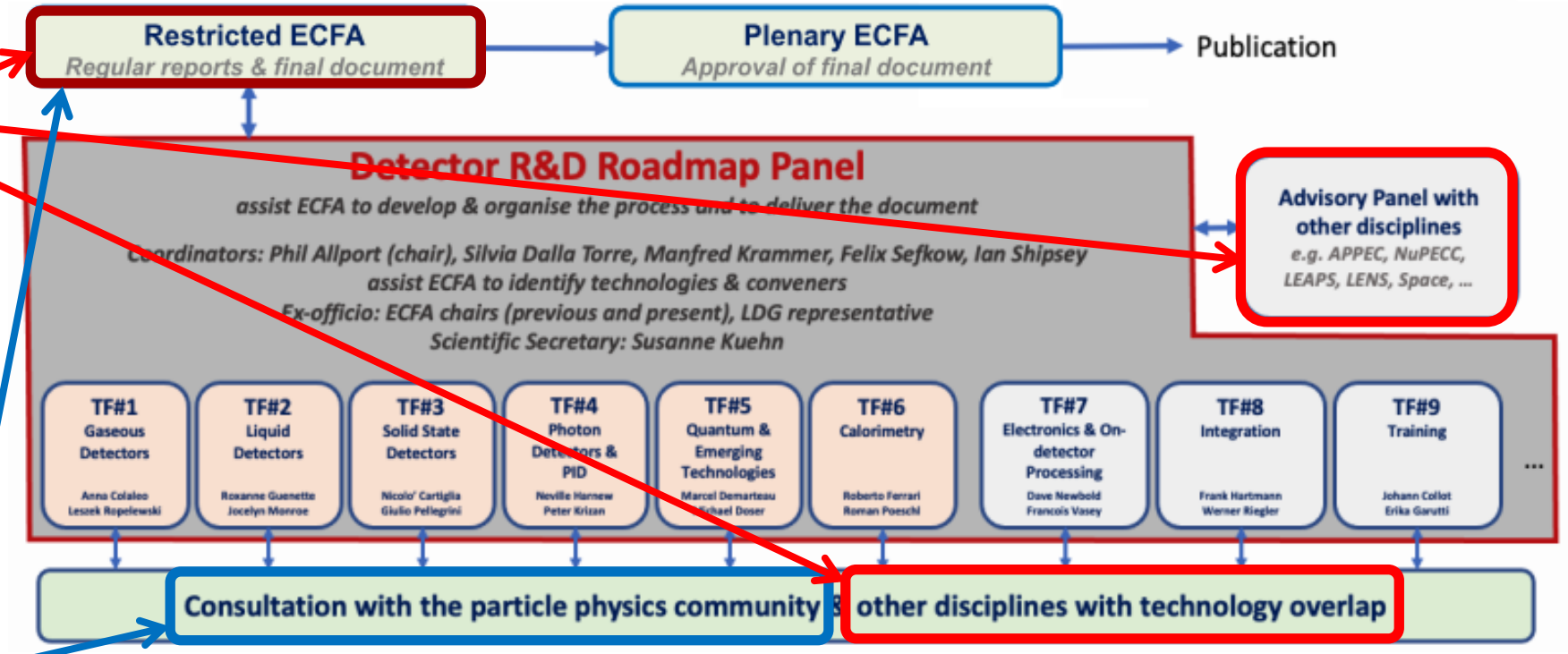
Back-up

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/

Implementation Organisation

ECFA

Community interaction

Roadmap Oversight and Community Interaction
ECFA Detector Panel (EDP)
Includes ex-officio: APPEC, NuPECC and ICFA IID Panel* representatives

* ICFA Instrumentation, Innovation and Development Panel

Scientific and Resource Reporting and Review
Detector Research and Development Committee (DRDC)
Includes members from: ECFA Detector Panel, CERN and LDG

On request, additional experts from the EDP can be invited for dedicated review tasks

Detector RD (DRD) Collaborations

DRD 1 …..
DRD 2 …..
DRD 3 …..
…..
DRD x …..

Recommends
Approves

CERN Research Board --> **CERN COUNCIL**

Reports

CERN SPC

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Roadmap Implementation More Details

- **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.**

Roadmap Implementation

Extracts from Plenary ECFA Presentation

- **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).**
- **Note the Accelerators R&D Roadmap Document at https://arxiv.org/abs/2201.07895 already provided proposals for R&D timelines in each section along with an overall indicative cost of the proposed programme.**
- **DRD proposals will need to be able to also provide estimates of required total resources as well as outlining what can be expected to be available as already supported, to make the case for the requested additional strategic funding.**

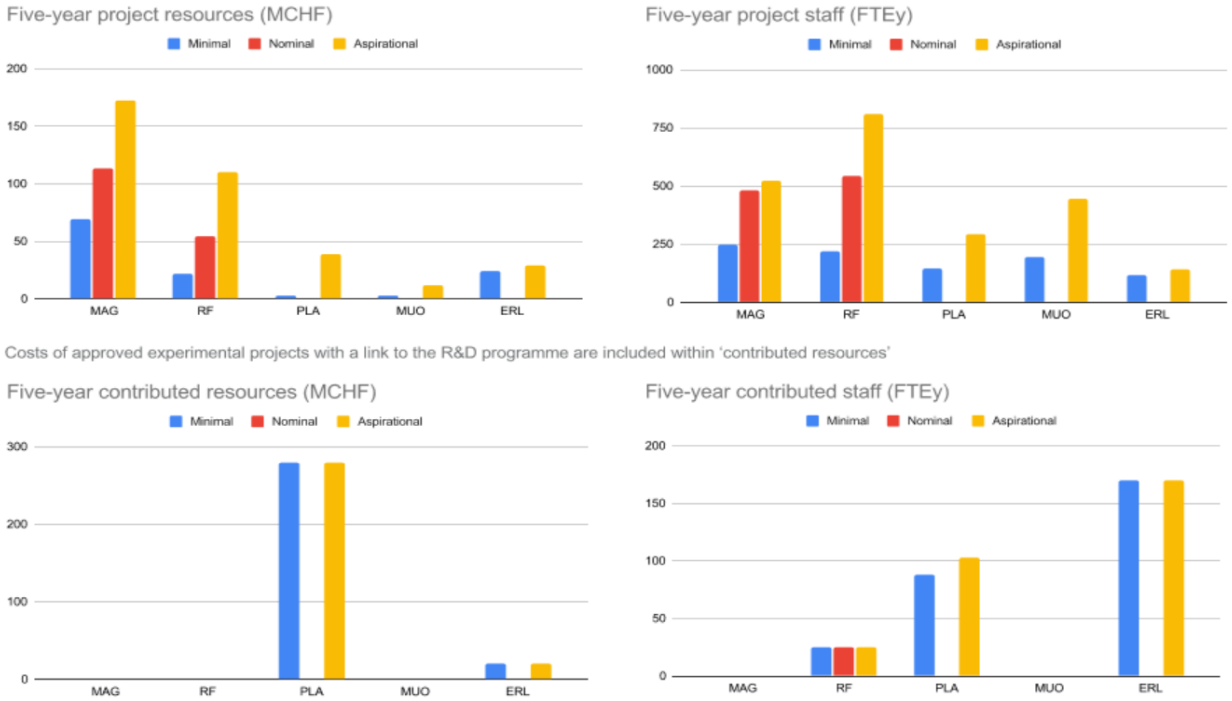

Fig. 9.1: Indicative cost of the R&D programme.