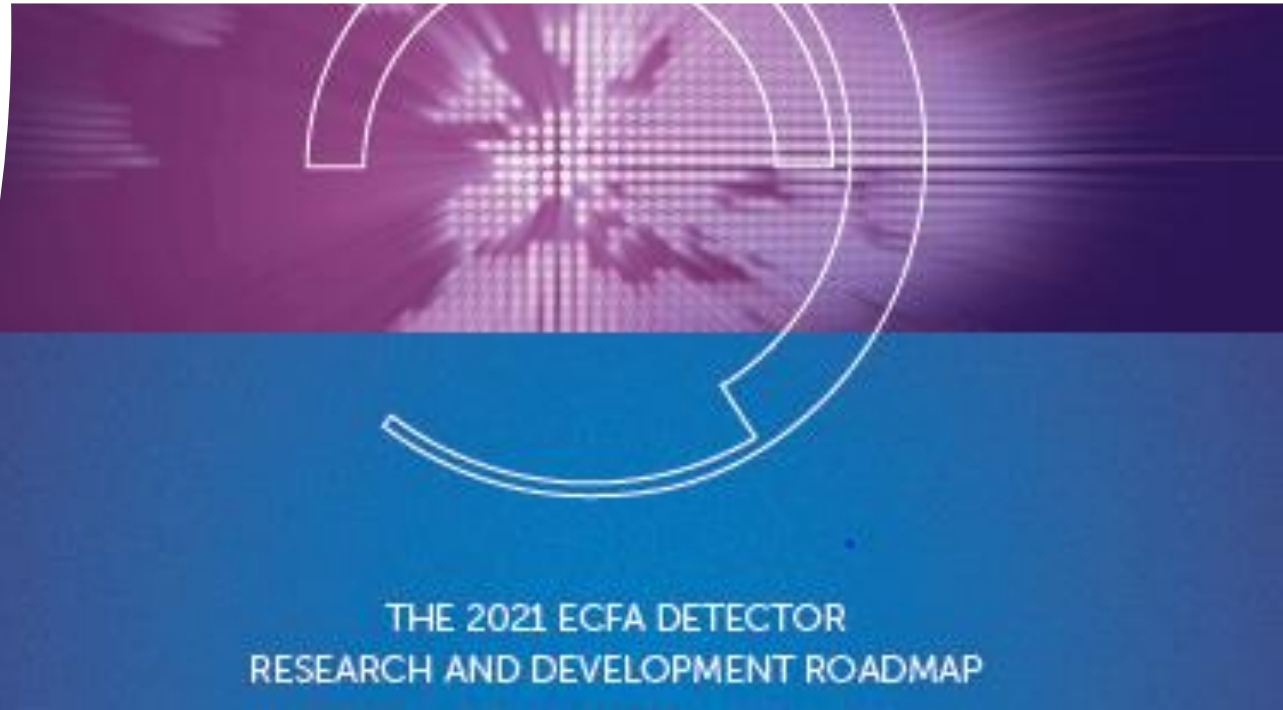
The 7th International Conference on
Micro Pattern Gaseous Detectors 2022

The ECFA Detector R&D Roadmap



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OUTLOOK

- The **ECFA Detector Roadmap** process in short words
- The **conclusive document** and **main messages** therein
- **Roadmap implementation**: the ongoing process

The RoadMap process

Update of the European Strategy for Particle Physics

4. Other essential scientific activities for particle physics

…

c) The ***success of particle physics experiments relies on innovative instrumentation and state-of-the-art infrastructures.*** *To prepare and realise future experimental research programmes, the community must* ***maintain a strong focus on instrumentation****.* ***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.***

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 roadmap should identify and describe a diversified detector R&D portfolio that has the largest potential to enhance the performance of the particle physics programme in the near and long term. …

ECFA Detector R&D Roadmap Process

May 2020 – Dec 2020

Structuring the process

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

Jan 2021 – May 2021

Collecting the scientific input

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

May 2021 – Oct 2021

Collating the scientific input and drafting the document

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

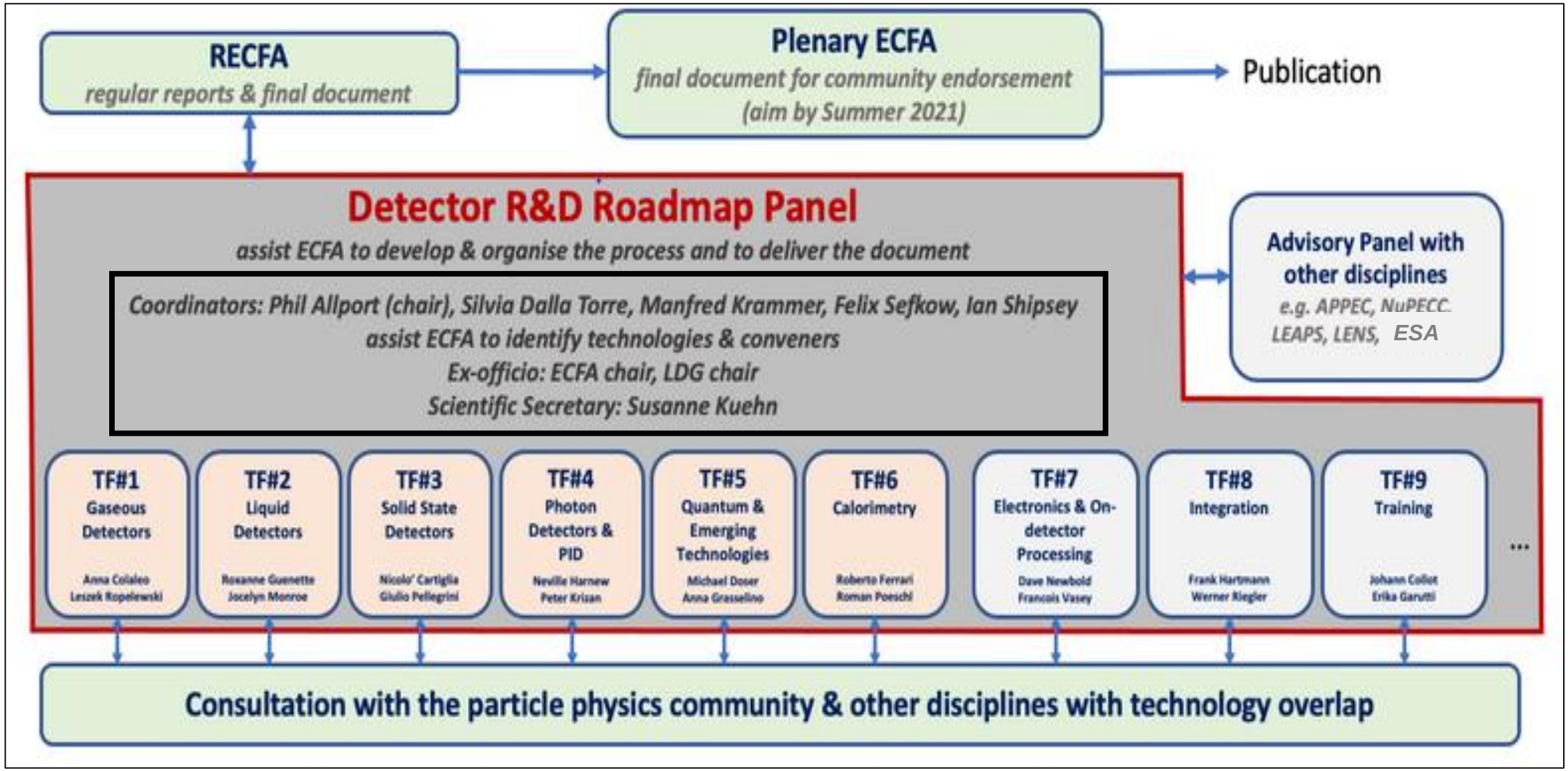
July 2021
Near final draft shared with RECFA*

30 July 2021
Presentation at Joint ECFA-EPS session

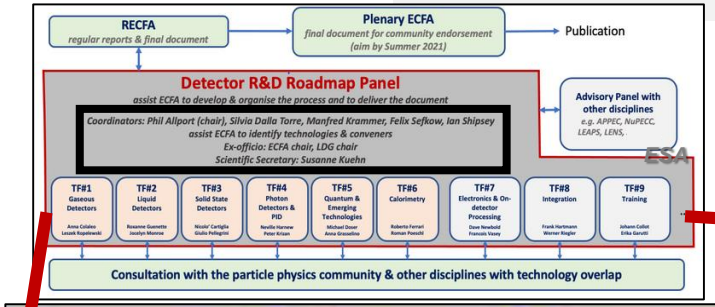
August 2021
Collect final community feedback*

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

Structuring the process



Structuring the process



Task Forces by **TECHNOLOGY**

- 6 TKs dedicated to detector technologies
- 3 TKs transversal to the others
  - Please, do not regard TF#9 "Training" as minor
- Each taskforce leaded by typically 2 conveners and a pool of ~4 experts
  - Selected from Europe, but also worldwide

Collecting the scientific input 1/2

- **Input from future facilities**
  - **2 sessions in Feb 2021**

Session I (in general collider oriented), afternoon 19 February 2021: Input Session I

- Talk I: HL-LHC (incl. flavour physics)
- Talk II: strong interactions at future colliders
- Talk III: strong interactions at future fixed target facilities
- Talk IV: future linear high energy e+e- machines
- Talk V: future circular high energy e+e- machines
- Talk VI: FCC-hh
- Talk VII: muon collider

Session II (in general non-collider oriented) afternoon 22 February 2021: Input Session II

- Talk I : neutrino short and long baseline
- Talk II: astro-particle neutrinos
- Talk III: DM-like facilities
- Talk IV: decay facilities
- Talk V: low energy facilities

to reach the whole scientific material:
https://indico.cern.ch/e/ECFADetectorRDRoadmap

Collecting the scientific input 2/2

to reach the whole scientific material:
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Task Force 1: Gaseous Detectors

Symposium date: Thursday 29.4.2021
Indico link to agenda

Task Force 2: Liquid Detectors

Symposium date: Friday 9.4.2021
Indico link to agenda

Task Force 3: Solid State Detectors

Symposium date: Friday 23.4.2021
Indico link to agenda

- **Detector symposia**
  - **9 symposia in Feb-May 2021:**
    Major source of information!

Task Force 4: Photon Detectors and Particle Identification Detectors

Symposium date: Thursday 6.5.2021
Indico link to agenda

Task Force 5: Quantum and Emerging Techologies

Symposium date: Monday 12.4.2021
Indico link to agenda

Task Force 6: Calorimetry

Symposium date: Friday 7.5.2021
Indico link to agenda

Task Force 7: Electronics and On-detector Processing

Symposium date: Thursday 25.3.2021
Indico link to agenda

Task Force 8: Integration

Symposium date: Wednesday 31.3.2021
Indico link to agenda

Task Force 9: Training

Symposium date: Friday 30.4.2021
Indico link to agenda

Conclusive Document

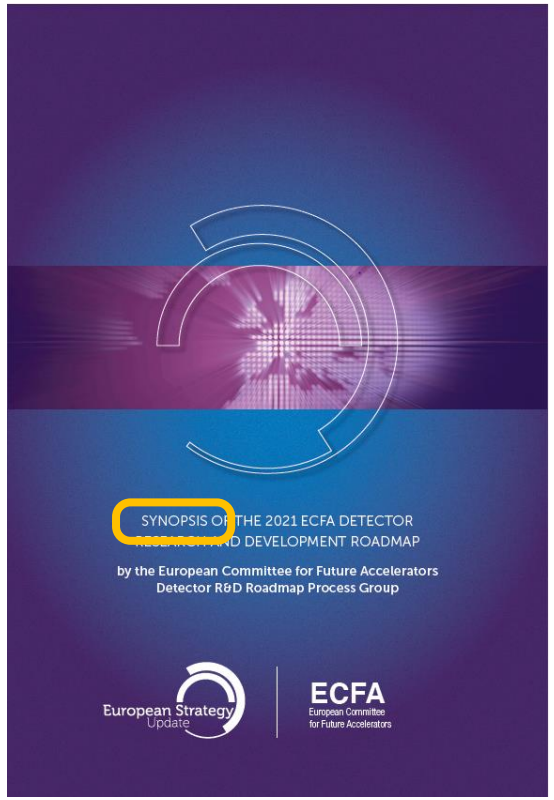
Basic information

- ~ 250
- Document structure
  - ➢ Introduction
  - ➢ A chapter per TF (9 FTs)
    - Introduction
    - Main drivers from the facilities
    - Key technologies
    - Observations
    - Recommendations
    - References
  - ➢ General Observations and Considerations
    - ➢ Including recommendations
  - ➢ Authors

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

https://indico.cern.ch/event/957057/page/23281-the-roadmap-document

- Available also a synopsis for external readers
  - 8 pages, colourfull
  - Available in printed form



Goals

- Match EPPSU prescriptions:
  - "Identify and describe a **diversified detector R&D portfolio** that has the largest potential **to enhance** the performance of **the particle physics programme in the near and long term**"
  - Considering projects listed in the Deliberation Document of the EPPSU "**High-priority** future initiatives" or "**Other essential scientific activities** for particle physics"
- Create a **time-ordered technology requirements** driven R&D roadmap
- Other aspects to be considered:
  - Bring out **synergies** and stress **interconnections** between developments of similar technologies needed at different times by **different programmes**
  - **Facilities needed for detector evaluation**, including test beams and different types of irradiation sources, along with the advanced instrumentation required for these;
  - **Infrastructures facilitating detector developments**, including technological workshops and laboratories, as well as tools for the development of software and electronics;
  - **Networking structures** in order to ensure *collaborative environments*, to help in the *education and training*, *for cross-fertilisation* between different technological communities, and in view of *relations with industry*;
  - **Overlaps with neighbouring fields** and key specifications required for exploitation in other application areas;
  - **Opportunities for industrial partnership** and technical developments needed for potential commercialisation.

Report & timelines

- Reference timelines used in the report, as dictated from CERN, ECFA and other external bodies

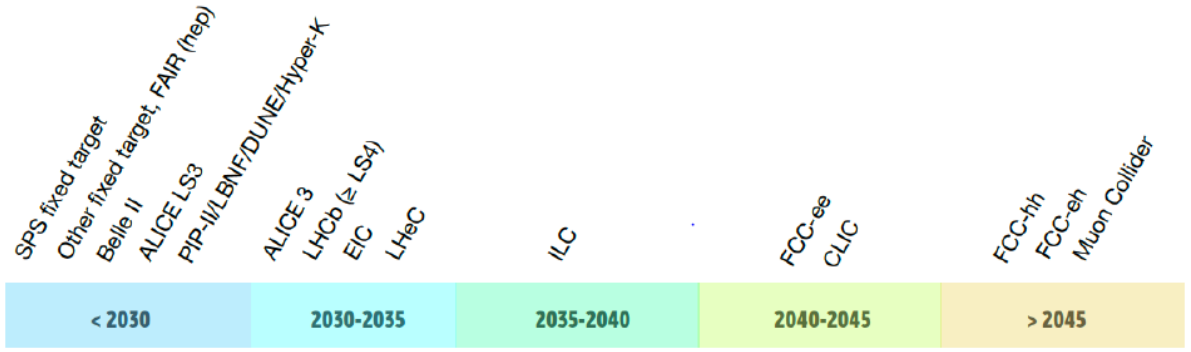


Figure 3: Large Accelerator Based Facility/Experiment Earliest Feasible Start Dates.

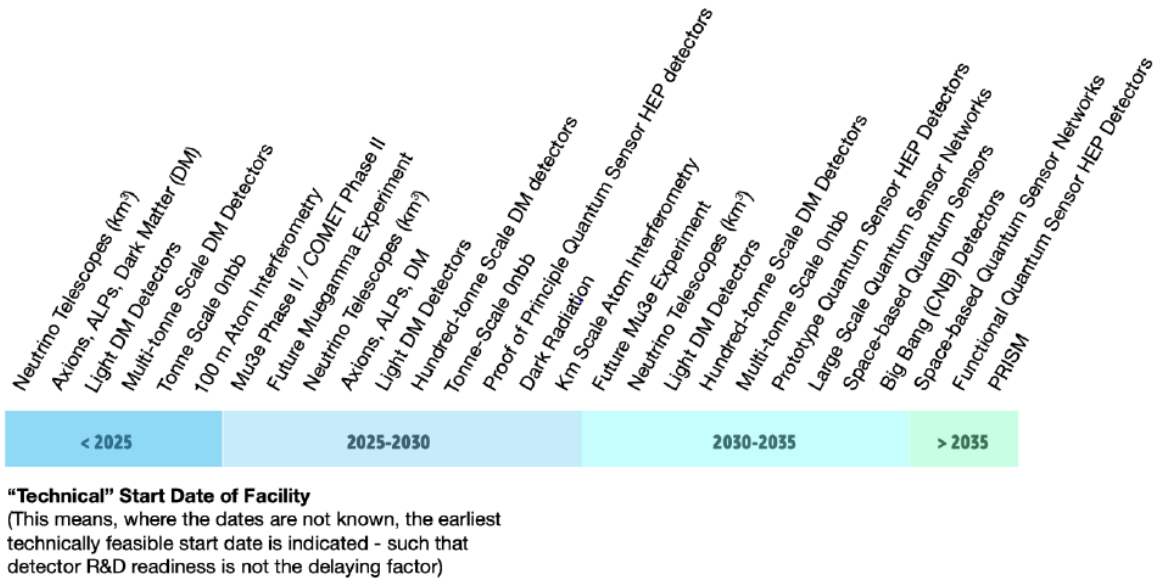


Figure 4: (Representative) Smaller Accelerator and Non-Accelerator Based Experiments Start Dates (*not intended to be at all an exhaustive list*).

Report & timelines

just an example

- How reference timelines are used in the report (e.g.)
  - A similar table for each TF
  - The timelines indicate when a certain technology/technological achievement is needed and the relevance it has for the project
  - **These tables are not detector development timelines**, as dictated by technical/technological considerations

Much more than facility-functional timelines

- **Deep analysis** of
  - **Requirements** to the detector sector
  - **Status and perspectives of detector R&D**
    - Including novel ideas
  - Global approaches and requirements to guarantee a successful future to detector R&D
- Resulting in
  - A confirmation of the scientific value of detector R&D studies
  - Underlaying the role that detector novelty has in opening new perspective to science

A special and strategic TF: «training» (TF9)

TF9 – Training

Needs of the community

- **Stimulate** and **recognise the field of instrumentation** in particle physics and specifically the importance of innovation, detector development and operation
  - **Need of training at all levels**, from initial university studies up to continuous update of professionals: **presently, perception of insufficient training opportunities (from ECFA - Early Career Researchers Panel survey)**
  - Role of Universities (bachelor and dedicated masters), Schools, Lab training, Virtual labs, Academia meats Industry
- **Attract and train** outstanding talented individuals in physics and engineering
  - **Recognition** at all stages (dedicated scholarships, stipends, awards)
  - Opportunity for publications **in high-ranked journals** of technology and experimental methods
  - Attractive **career prospects: presently, negative perception (from ECFA - Early Career Researchers Panel survey)**
- Recognise the **diversity of skills needed** in the field
- Find an appropriate **balance between specialisation and breadth**

Observations

- **VITAL for HEP**: w/o implementing a strategic promotion of instrumentation→ missing the continuity of highly qualified detector experts from R&D to construction and to operation of HEP detectors
- Need of a coordinated European training programme

Recommendations

- **Each point above can be directly translated into corresponding recommendations**

GENERAL STRATEGIC RECOMMENDATIONS

GSR 1: Supporting R&D Facilities

GRS 2: Engineering support for detector R&D

GRS 3: Specific software for instrumentation

GRS 4: International coordination and organisation of R&D activities

GRS 5: Distributed R&D activities with centralised facilities

GRS 6: Establish long-term strategic funding programmes

GRS 7: “Blue-sky” R&D”

GRS 8: Attract, nurture, recognise and sustain the careers of R&D experts

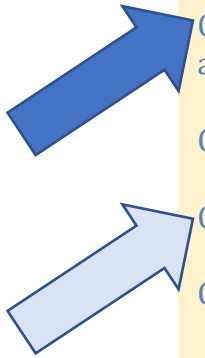
GRS 9: Industrial partnerships

GRS 10: Open Science

RoadMap implementation

Characteristics of the implementation process

- The Roadmap process was built up in consultation and with the support of the European (and beyond) R&D community
- The implementation process has largely been driven from top, with the R&D community informed and called to contribute after taking the major initial decisions
- It has been identified as first urgencies the need of **organisational structures** and **adequate resources, therefore privileging GRS4 to leverage also on GRS6**
- So far, the implementation is related to these two GRSs only
- In concrete: "establish the **DRD collaborations**, which should **start work in January 2024**, with a ramp-up of resources through 2024/2025, reaching a steady state by 2026" (CERN/SPC/1190/RA CERN/3679/RA)



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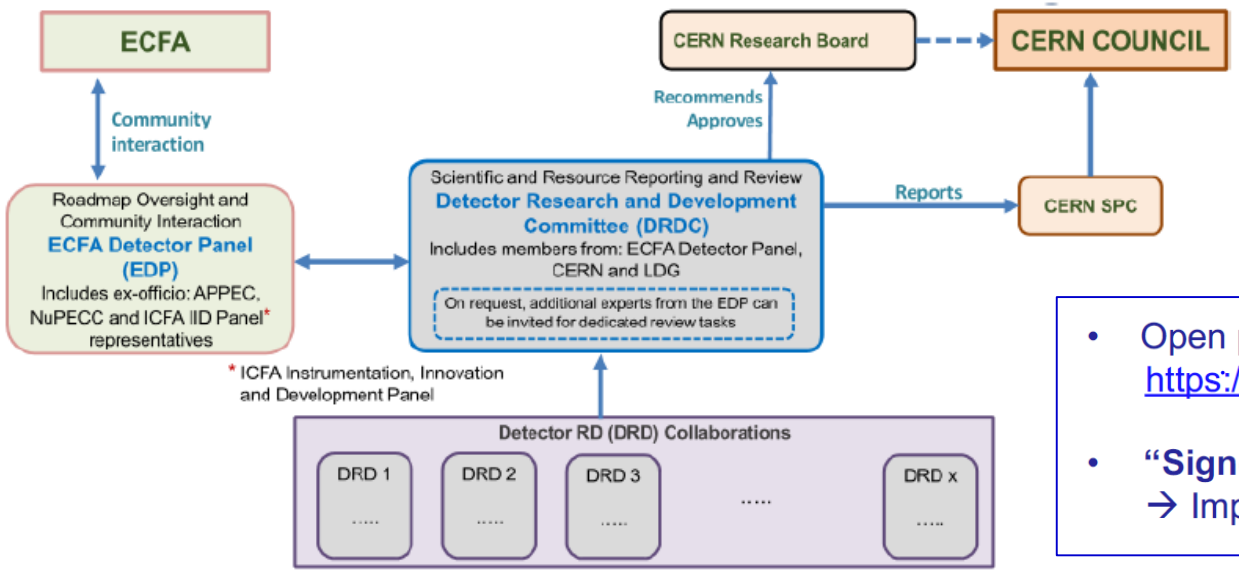
Implementing GRS 4:
"international coordination and organization of R&D activities"

- Newly established **Detector R&D (DRD) Collaborations**, one for each TF of the Roadmap process
- DRD Collaborations should be **anchored at CERN** → CERN recognition, DRD label
- The formation of new DRD collaborations should adopt a **community-driven**
- Taking **full account of existing, well-managed and successful ongoing R&D collaborations** and other existing activities
  - RD50, RD51, …, CERN EP R&D programme, EU-funded initiatives, collaborations exploring particular technology areas for future colliders
- **Non-European collaborators** are welcome
- Suggested **timelines**: DRDs implemented by 2024-Q1

The underlaying model assumed proposing DRDs

Three areas of Detector R&D:	
Strategic R&D via DRD Collaborations (long-term strategic R&D lines)	• address the high-priority items defined in the Roadmap via the DRDTs
Experiment-specific R&D (with very well defined detector specifications)	• funded outside of DRD programme, via experiments, usually not yet covered within the projected budgets for the final deliverables
”**Blue-sky**” R&D	• competitive, short-term responsive grants, nationally organised

Approving and reviewing DRDs



- Open presentation at the July Plenary ECFA meeting by Phil Allport https://indico.cern.ch/event/1172215/
- **"Sign-off" by SPC and Council in their Sept. meetings (26 – 30 Sept.)**
  → Implementation should start!

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

   Assisted by the ECFA Detector Panel (EDP): the scope, R&D goals, and milestones should be vetted against the vision encapsulated in the Roadmap. (EDP: http://cds.cern.ch/record/2211641/files/, exists, hosted at DESY)

2. Funding Agency involvement via a dedicated Resources Review Board (~once every two years)

3. Yearly follow-up by DRDC → report to SPC → Council

The implementation process, *next steps*

Implementation guided by bthe ECFA-LDG WG

More recently, **ECFA Training Panel** under study

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The implementation process, *a single slides of personal considerations*

- Driving community **attention to Detector R&D is great**
- Starting from **organisational structures**, **can help in ensuring resources**, even if the resource model is an open and it can come at different time and via different mechanism in the different agencies/countries
- I believe that **cultural revolutions can have even a larger impact**: I look forward having attention and dedication to GRS 8, and, more in general, to the global set of GRSs

- The delimitation in **3 distinct areas**:
  - The Strategic R&D via DRD Collaborations (DRDs)
  - Experiment-specific R&D
  - ”Blue-sky” R&D

  Can represent an obstacle for the transversal spirit of creativity, which is driving the R&D domain

  → Up to all of us to overcome the potential difficulties of internal barriers in the world of Detector R&D

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More recently,
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TOWARDS DRD1 – Gaseous Detectors

- **DRD1 formation** promoted by the TF1 conveners : Anna Colaleo and Leszek Ropelevski
- Taking advantage of RD51 experience
- A dedicated WG has been formed:
  - ECFA TF1 Conveners : Anna Colaleo, Leszek Ropelewski; TF1 Members: Klaus Dehmelt, João Veloso
  - ECFA Coordinators Group Member: Silvia Dalla Torre
  - MPGDs: Eraldo Oliveri, Fulvio Tessarotto, Maxim Titov
  - RPCs: Ingo Deppner, Giuseppe Iaselli, Barbara Liberti
  - TPCs: Esther Ferrer Ribas, Jochen Kaminski
  - Large volume detectors: Marco Panareo, Francesco Renga
  - Straw tubes, TGC, CSC, drift chambers, and other wire detectors: Peter Wintz
  - Infrastructure, detector R&D programmes (CERN EP R&D, AIDAinnova): Roberto Guida, Beatrice Mandelli

- In the following slides the **current <u>proposal</u>**
- **a major effort**: reaching out to as many major groups in the field as possible (short timelines!)

DRD1 current proposal (slides from L. Ropelewski)

WG1: Technologies, limitations and challenges
Includes detector physics aspects

- MPGDs
- RPCs, MRPCs
- Large Volume Detectors (drift chambers, TPCs)
- Straw tubes
- New amplifying structures

WG2: Applications
full alignment with the ECFA detector R&D roadmap

- Muon systems
- Inner and central tracking with particle identification capability
- Calorimetry
- Photon detection
- Time of Flight systems
- TPCs for rare event searches
- Fundamental research applications beyond HEP
- Medical and industrial applications

WG3: Gas and material studies
Interdisciplinary working group

- Ageing
- Radiation hardness
- Eco-gases searches
- Light emission in gases
- Light (low material budget) materials
- Resistive electrodes
- Precise mechanics
- Photocathodes (novel, ageing, protection)
- Solid converters
- Novel materials (nanomaterials)

WG4: Detector physics, simulations, and software tools

- Detector properties studies (simulations)
- Software tools development and maintenance
- Detector design tools
- Gas cross-section data bases maintenance

DRD1 current proposal (slides from L. Ropelewski)

WG5: Electronics for gaseous detectors

- Readout electronics (SRS, ASICs, fast electronics, pixel, and optical readout)
- HV systems
- Dedicated lab instrumentation

WG6: Detector production

- CERN MPT workshop
- Saclay MPGD workshop
- Novel detector production methods
- Industrialization

WG7: Common test facilities

Incudes development of common detector characterization standards

- General purpose detector development labs
- Ageing facilities
- Irradiation facilities
- Gas studies facilities
- Test beam facility

WG8: Training and dissemination

- Schools and trainings
- Topical workshops
- Knowledge transfer

Thank you

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SPARE SLIDES

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Overview of the Panel members and Task Forces

- TF1 Gaseous Detectors
  - Convenors: Anna Colaleo (INFN Bari), Leszek Ropelewski (CERN)
  - Expert members: Klaus Dehmelt (Stonybrook), Laura Fabbietti (TUM Munich), Barbara Liberti (INFN Roma), Joao Veloso (Aveiro)
- TF2 Liquid Detectors
  - Convenors: Roxanne Guenette (Harvard), Jocely Monroe (RHUL)
  - Expert members: Auke-Pieter Colijn (NIKHEF), Antonio Ereditato (Yale/Berne), Ines Gil Botella (CIEMAT), Manfred Lindner (MPI Heidelberg)
- TF3 Solid State Detectors
  - Convenors: Nicolo Cartiglia (INFN Turino), Giulio Pellegrini (IMB-CNM-CSIC)
  - Expert members: Daniela Bortoletto (Oxford), Didier Contardo (IN2P3-IP2I), Ingrid Gregor (DESY and Bonn), Gregor Kramberger (Jozef Stefan Insitute), Heinz Pernegger (CERN)
- TF4 Photon Detectors and Particle Identification Detectors
  - Convenors: Neville Harnew (Oxford), Peter Krizan (Jozef Stefan Insitute)
  - Expert members: Ichiro Adachi (KEK), Christian Joram (CERN), Eugenio Nappi (INFN Bari), Christian Schultz-Coulon (Heidelberg)
- TF5 Quantum and Emerging Technologies
  - Convenors: Michael Doser (CERN), Anna Grasselino (Fermilab)
  - Expert members: Caterina Braggio (Padova), Marcel Demarteau (ORNL), Andy Geraci (NWU), Peter Graham (Stanford), John March Russell (Oxford), Stafford Withington (Cambridge)
- TF6 Calorimetry
  - Convenors: Roberto Ferrari (INFN Pavia), Roman Poeschl (IN2P3-IJCLab)
  - Expert members: Martin Aleksa (CERN), Dave Barney (CERN), Frank Simon (MPP Munich), Tommaso Tabarelli de Fatis (INFN Milano-Bicocca)
- TF7 Electronics and On-detector Processing
  - Convenors: Dave Newbold (RAL), Francois Vasey (CERN)
  - Expert members: Niko Neufeld (CERN), Valerio Re (INFN Pavia), Christophe de la Taille (IN2P3-OMEGA), Marc Weber (KIT)
- TF8 Integration
  - Convenors: Frank Hartmann (KIT), Werner Riegler (CERN)
  - Expert members: Corrado Gargiulo (CERN), Filippo Resnati (CERN), Herman Ten Kate (Twente), Bart Verlaat (CERN), Marcel Vos (IFIC Valencia)
- TF9 Training
  - Convenors: Johann Collot (IN2P3-LPSC), Erika Garutti (DESY and Hamburg)
  - Expert members: Richard Brenner (Uppsala), Niels van Bakel (Nikhef), Claire Gwenlan (Oxford), Jeff Wiener (CERN)