Towards DRD1 Collaboration:
scientific organization and the timeline

Anna Colaleo (University and INFN Bari), Leszek Ropelewski (CERN)

On behalf of DRD1 coordinators and Working Group conveners

Community meeting 23/6/2023

DRD1 proposal implementation timeline

- **March- 5 May**: **draft document** preparation including a preliminary definition of Work Package
- **15 May:** Start the community consultation. **1st Draft** shared with Institute Contacts.
- **15 May - 1 June**: Proposal Team works on the draft document within working groups, implementing the feedback from the community and preparation of the preliminary version of the Executive Summary with WP tables.
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- **16 June:** Approval of the document for the community-wide discussion and release to the **2nd draft** whole community.
- **22-23 June: DRD1 Community workshop** - wide discussions during the community workshop
- **June- July: -** Definition of the required resources for the outlined programme need (split into personel effort (FTEs) and material plus services (non-FTE) costs. – institute's inputs; executive summary
- **End-July: Submission of the proposal**

DRD1 Proposal

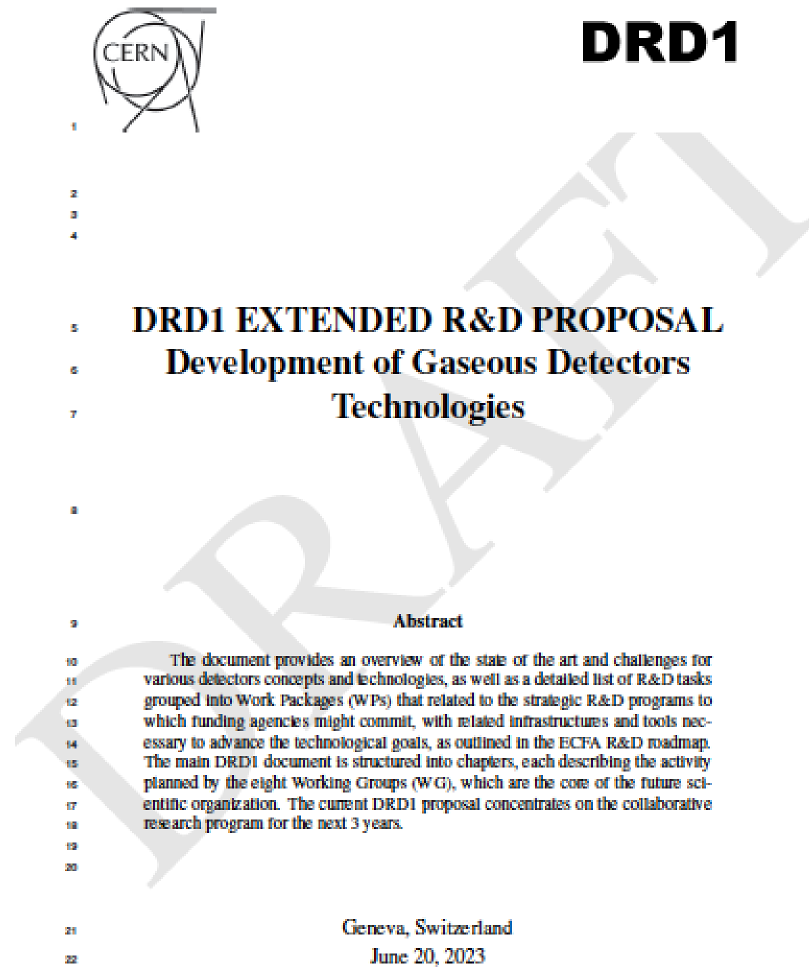
DRD1 document in the making

Structure of the document:

- Executive summary
- Scientific organization of DRD1 Collaboration

- Research topics and Work plan
  - 8 sections: one per Working Group
  - WorkPackages described in 4.2

- Collaboration organization
- Resource and infrastructures



CERN

DRD1

DRD1 EXTENDED R&D PROPOSAL
Development of Gaseous Detectors
Technologies

Abstract

The document provides an overview of the state of the art and challenges for various detectors concepts and technologies, as well as a detailed list of R&D tasks grouped into Work Packages (WPs) that related to the strategic R&D programs to which funding agencies might commit, with related infrastructures and tools necessary to advance the technological goals, as outlined in the ECFA R&D roadmap. The main DRD1 document is structured into chapters, each describing the activity planned by the eight Working Groups (WG), which are the core of the future scientific organization. The current DRD1 proposal concentrates on the collaborative research program for the next 3 years.

Geneva, Switzerland
June 20, 2023

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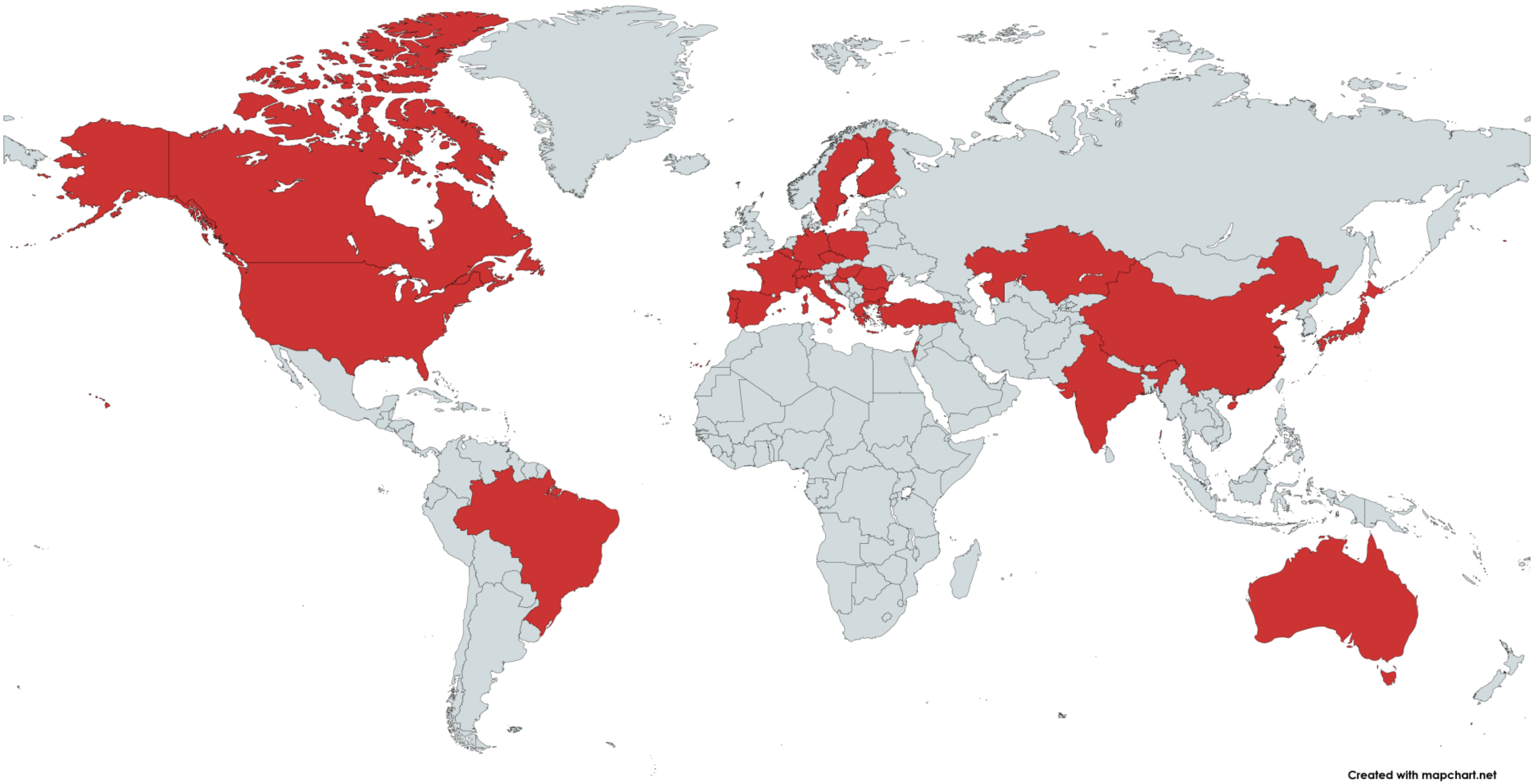
Many thanks to all editors for the extraordinary effort!

Many thanks to the institute contact persons for providing prompt feedback!

DRD1 Proposal: country maps

108 institutions in 4 continents expressed interest to join the DRD1 Collaboration



DRD1 Proposal

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Geneva, Switzerland
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Executive summary

Contents

Scientific organization of DRD1 Collaboration

Research topics and Work plan

Collaboration organization
Resource and infrastructures

Scientific organization of DRD1: the pillars

The DRD1 Collaboration aims to promote the development, diffusion, and applications of gaseous detectors, following the General Strategic Recommendations* (GSR) outlined in the ECFA Detector R&D Roadmap Document.

<u>The following pillars form the foundation of this Collaboration:</u>

- **Community-Driven Collaboration:** The Collaboration is driven by the community, providing a vital forum for exchanging ideas and establishing synergies to minimize duplicated efforts.

- **Recognition and Support for Young R&D Experts:** The Collaboration will promote proper recognition and support for the careers of instrumentation R&D experts. This support will be facilitated through the member institutes and their interface with the scientific community and institutions.

- **Dynamic and Open R&D Environment:** The Collaboration will strive to create and maintain an up-to-date, dynamic, and open R&D environment. This environment will support the development of necessary tools such as simulation and electronics, as well as the infrastructure required to undertake R&D on novel detectors and to validate their performances against the demanding specifications of future facilities and applications.

* See backup for details

Scientific organization of DRD1: the pillars

The DRD1 Collaboration aims to promote the development, diffusion, and applications of gaseous detectors, following the General Strategic Recommendations* (GSR) outlined in the ECFA Detector R&D Roadmap Document.

The following pillars form the foundation of this Collaboration:

- **Global Network and Access to Facilities:** Leveraging its worldwide international network, the DRD1 Collaboration will facilitate access to testing facilities and advanced engineering support, available at DRD1 research laboratories and institutes.

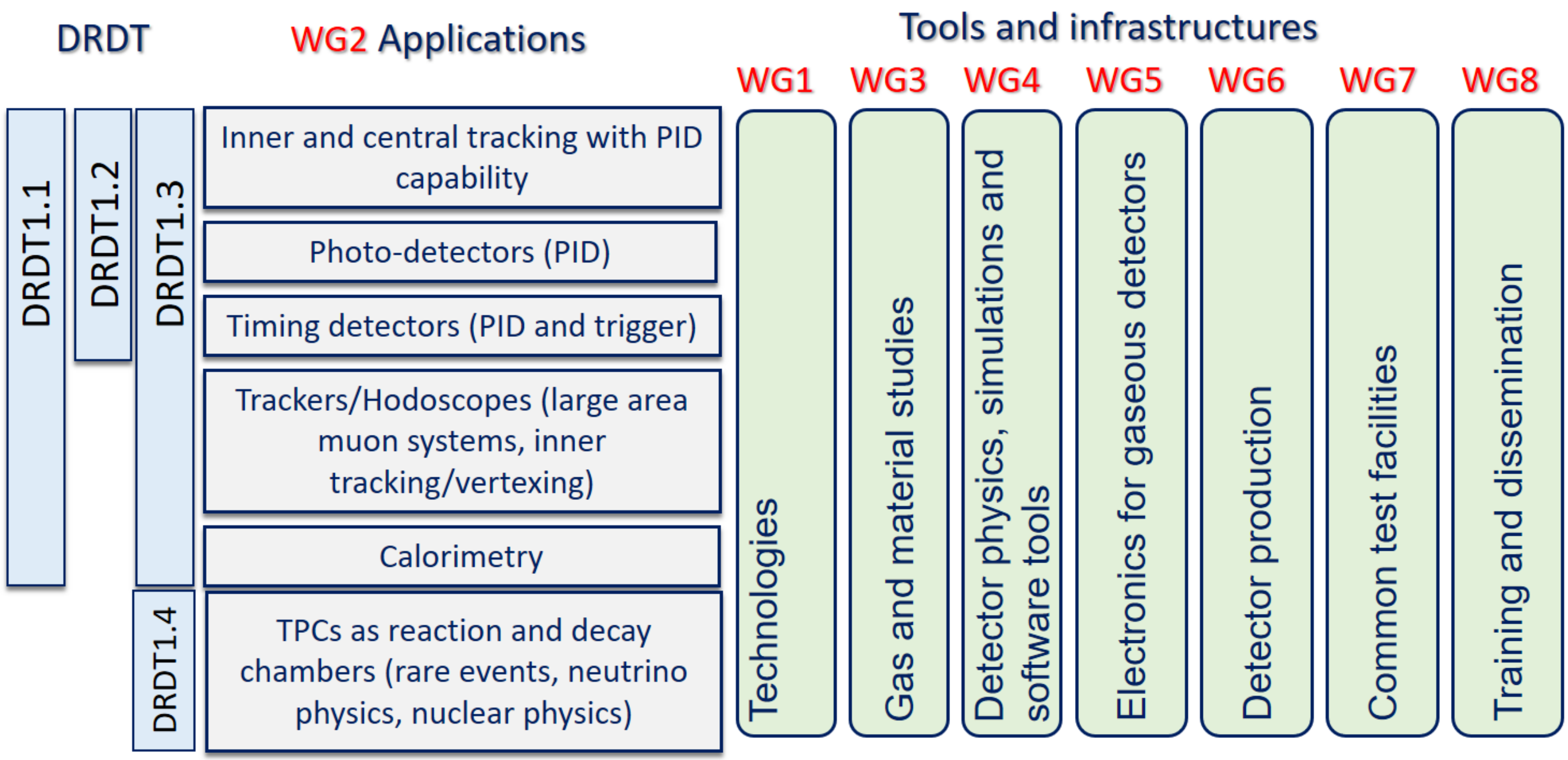
- **Support for "Blue-Sky" R&D:** The Collaboration will actively support "Blue-sky" R&D, which can lead to breakthroughs driven by technology. Common resources will be allocated, leveraging the aforementioned R&D environment.

- **Efficient Resource Pooling:** The Collaboration aims for the most efficient pooling of resources through joint projects that will undergo international review. It will promote and support research plans that attract long-term funding, enabling the community to effectively address future technical challenges. These efforts will also help to build strong relationships between institutes and industrial partners.

- **Increasing Research Potential**: By adding critical mass to the needs of individual institutes, the Collaboration aims to reduce research costs and enhance potential and results.

DRD1 Scientific organization: Working groups

- **Structure in Working Groups, forum for scientific discussions, coordinated by conveners:**
  - aligned with the scientific program of the ECFA roadmap through the applications related to future facilities challenges, outlined by R&D Themes (DRDTs*), but also to the GSRs



* See backup for details

Note: Applications Beyond HEP recently added

DRD1 scientific organization: Working groups

Working Groups are the core of the scientific collaboration

- supporting the development of novel technologies and the consolidation of existing ones.
- facilitating the exchange of ideas and foster synergies between institutes
- playing a crucial role in identifying, guiding, and supporting strategic detector R&D directions, facilitating the establishment of joint projects between institutes
- serving as a knowledge and technology hub for developing gaseous detector technologies:
  - Technological Aspects and Developments of New Detector Structures, Common Characterization and Physics Issue
  - Applications
  - Gas and material studies, and link to the novel technologies
  - Detector Physics, Modelling and Simulation frameworks
  - Electronics for gaseous detectors
  - Production and Technology Transfer
  - Common Test Facilities and Infrastructures
  - Training and dissemination

➡ **WG will be recognized as a scientific reference for the community.**

Organization of the collaboration activities

Following the indication of ECFA Detector Panel (*) two areas of Detector R&D :

- ”Blue-sky” R&D (competitive, short-term responsive grants, nationally organised)
- Strategic R&D via DRD Collaborations (long-term strategic R&D lines) (address the high-priority items defined in the Roadmap via the DRDTs)

Two types of DRD1 joint projects will be implemented:

Common projects

For low-TRL (blue sky) R&D, or other short term generic projects

Funding method:

- Metabolism of each group
- EU, National projects
- DRD1 common fund

Work Packages

Strategic R&D targeting the priority programmes outlined in the updated European Strategy for Particle Physics.

Funding method:

Each institute asks its funding agency and controls the funds

* See backup for details

Common projects

Common Projects (CP) support **low TRL (blue-sky) R&D** considered of interest by the collaboration, **or generic projects (not related to experiments) that are vital for the community and require** special backing:

- Technology R&D projects towards developments of novel techniques, improvements of existing technologies, characterization methods and dedicated tools;
- Development and optimization for novel applications;
- Improvement of the technology transfer to industry.

This is a well-defined path (RD51 experience)

DRD1 Common Fund (details will be clearly defined in the MoU) supports CP with matching resources from participating Institutes.

- a minimum number of participating Institutes to encourage collaborative effort between groups.
- limited in time
- limited funding support from the collaboration (example 20-30k/y)

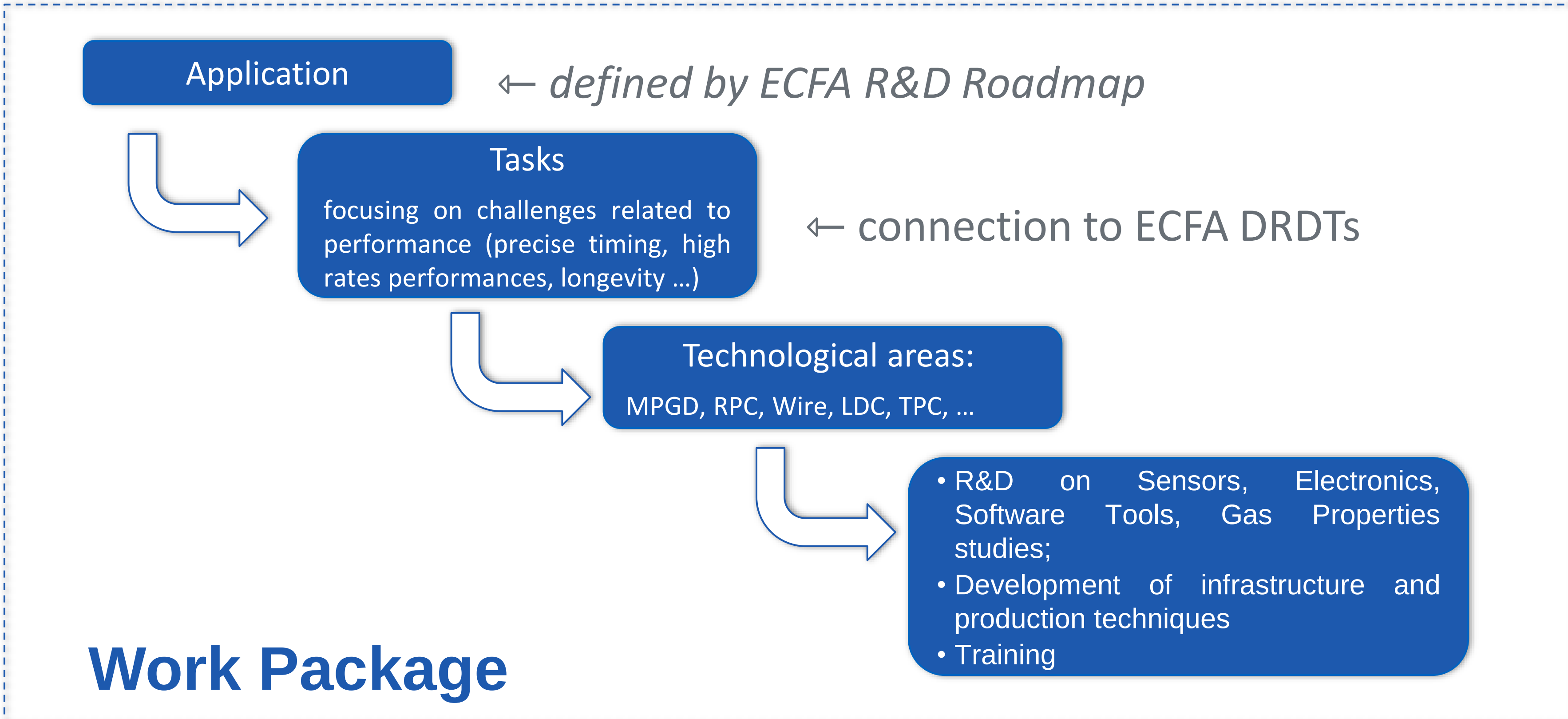
➔ large number of groups in DRD1 ensures strong R&D

Reviewed by the DRD1 Collaboration

Strategic R&D = Work Package

Strategic R&Ds (according to ECFA Detector R&D Roadmap) **organized in Work Packages**

- group activities of the Institutes with **shared research interests** around **Applications** with a focus on a **specific task(s)** devoted to a specific DRDT challenge, typically related to specific **Detector Technologies** and to the development of **specific tool or infrastructure**



Work Packages

WPs are organized and coordinated internally by participating Institutes:

It is **required** to be a member of DRD1 to contribute to a WP

- should pursue implementation of the milestones and deliverables and execute the workplan outlined in the approved scientific proposal

- funds are **fully controlled and operated by participating Institutes.**
  - **The formal agreement** between participating Institutes, DRD1 management, and the host lab (CERN) is being sorted out by CERN management

Work Packages **take full advantage and contribute** to the DRD1 scientific program, R&D environment, infrastructure, and R&D tools (electronics, software).

WP can be created at any time in the future

The strategic R&D will be in the focus of the DRDC* reviews.

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Note: It is not required to be involved in a WP to be a member of DRD1

DRD1 Work Packages

For each Work-package associate to a specific application, the preliminaly list of tasks is being prepared according to the feedback received by the community

DRDT	Applications	Link to WG activities	Milestones/interested institutions
DRDT1.3, DRDT1.2, DRDT1.3	Inner and central tracking with PID capability	• Tools/infrastructures (WGs)	• Task1 – Milestones, Institutions • Task2 – Milestones, Institutions • ....
DRDT1.3, DRDT1.2, DRDT1.3	Photo-detectors (PID)	• Tools/infrastructures (WGs)	• Task1 – Milestones, Institutions • Task2 – Milestones, Institutions • ....
DRDT1.3, DRDT1.2, DRDT1.3	Timing detectors (PID and trigger)	• Tools/infrastructures (WGs)	• Task1 – Milestones, Institutions • Task2 – Milestones, Institutions • ....
DRDT1.3, DRDT1.3	Trackers/Hodoscopes (large area muon systems, inner tracking/vertexing)	• Tools/infrastructures (WGs)	• Task1 – Milestones, Institutions • Task2 – Milestones, Institutions • ....
DRDT1.3, DRDT1.3	Calorimetry	• Tools/infrastructures (WGs)	• Task1 – Milestones, Institutions • Task2 – Milestones, Institutions • ....
DRDT1.4	TPCs as reaction and decay chambers (rare events, neutrino physics, nuclear physics)	• Tools/infrastructures (WGs)	• Task1 – Milestones, Institutions • Task2 – Milestones, Institutions • ....

Example for Work Package: Inner and central tracking

#	Task	Performance Goal	DRD1 WGs	ECFA DRDT	Comments	Deliv. next 3y	Interested Institutes
T1	IBF reduction	- Gain$\times$IBF $\approx$ 1-2 - IBF optimization together with energy resolution and discharge stability	WG4, WG7 (7.1-2,5)	1.2	- Hybrid stacks - Gating GEM - Distortion corrections - Space-charge monitoring - Development of simulation tools - Operation in magnetic fields	- Provide a large-area prototype with a uniform IBF distribution of G*IBF=5 keeping the energy resolution at a tolerable level - Present a structure with stable settings for G$\times$IBF of 1-2 - Determine the ion blocking power of a GEM-based gate - Provide systematic studies and simulations of IBF performance for the most common structures in (high) magnetic fields - Introduce an IBF calculator (Garfield-based) for optimization of the HV parameters	IFUSP, GSI, U Bonn, IRFU/CEA, USTC, KEK-IPNS, DESY, GANIL, RWTH Aachen, INFN-PD, IP-PLM, CERN, PSI, U Bursa, SBU, WIS, U Coimbra, U Aveiro, Wigner, SINP Kolkata
T2	Pixel-TPC development	- Produce 50000-60000 GridPixes to read out a full TPC - Achieve dN/dx counting-resolution < 4%	WG5, WG7 (7.1-2,5)	1.1	- InGrids (grouping of channels) - Low-power FEE - Optimization of pixel size (>200 µm) or cost reduction	- Provide a large-area pixel-based (InGrid) readout module - Measuring IBF for GridPix. Reduction with double-mesh - Present dN/dx measurements in beam - Small area prototypes of MPGD/TimePix hybridisation.	U Bonn, U Carleton, WIS, CERN
T3	Optimization of the amplification stage and its mechanical structure, and development of low X/X_0 field cages (FC)	- Uniform response across a readout unit-area. - Keep $\sigma_{dE/dx} \approx 4\%$ - Point resolution of <100 µm - Minimize static distortions by reducing insensitive areas - Minimize $E \times B$ - Achieve E-field homogeneity at $\sim 10^{-4}$ level	WG1, WG4, WG6, WG7 (7.1-2,5)	1.1 1.2	**Minimization of static distortions:** - Algorithms for distortion corrections - Field shaping wires - Minimize GEM frame area (use thicker GEMs) - Laser systems **Main ampl. stages:** - Encapsulated resistive-anode MMG - Multiple GEM - GridPix - Hybrids **FC:** - high-quality strips, suspended strips - module flatness	- Provide a solution for a large-volume TPC with $\mathcal{O}(10^6)$ pad-readout by means of pre-production of several readout modules of comparable quality	IRFU/CEA, U Bonn, IHEP CAS, USTC, GANIL, CNRS-IN2P3/IJCLab, GSI, RWTH Aachen, INFN-RM1, INFN-PD INFN-BA, IPPLM, PSI, U Bursa, SBU, BNL, WIS, IFAE
T4	Low-power FEE	- <5 mW/ch for >10^6 pad TPC - ASIC development in 65 nm CMOS	WG5	1.3	- Continuous vs. pulsed	- Present stable operation of a multi-channel TPC prototype with a low-power ASIC	IHEP CAS
T5	FEE cooling	- Operate 10^6 channels per end-plate	WG5	1.2	- Two-phase CO_2 cooling - Micro-channel cooling with 300 µm pipes in carbon fiber tubes - 3D printing: complex structures, performance optimization, material selection	- Present a prototype of a cooling system for the 10^6 pad TPC option	IRFU/CEA, U Lund, INFN-PI, INFN-LE, INFN-PD
T6	Gas mixture	Optimize: - Longevity - Ageing - Discharge probability - Drift velocity - Ion mobility	WG1, WG3 (3.1D, 3.2A, 3.2B), WG4, WG7 (7.1-3,5)	1.1	- Discharge probability, ageing, gas properties - Optimization of the HV working point - Optimization wrt. the expected resolution (aim for <100 µm) - Cluster ions	- Lower the discharge probability of readout units by 1-2 orders of magnitude down to $\sim 10^{-14}$ per hadron - Avoid secondary discharges in MPGD stacks	CERN, IFUSP, GSI, TUM, IHEP CAS, GANIL, USTC, CNRS-IN2P3/IJCLab, IRFU/CEA, CNRS-LSBB, RWTH Aachen, U Bonn, Bose, INFN-RM1, INFN-LE, INFN-PD, INFN-BA, IPPLM, USC/IGFAE, U Bursa, SBU, U Warwick, U Aveiro, U Bolu-Abant

Challenges for the TPC at colliders

- Good dE/dx resolution, partly driven by a good gain uniformity;
- very low (gain x Ion Back Flow) to drastically reduce space charge distortions;
- high readout granularity to cope with the particle multiplicity;
- electronics with low power dissipation to meet the increased density of readout channels.
- large area coverage at reduced low cost, relying on lightweight mechanical structures based on composite materials.

Area of application: future electron colliders (ILC, FCC-ee, CEPC). Timeline: 2035-2040, most of the R&D goals should be reached by 2030 to allow for timely construction.

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WP definition: next step

- **WP Coordinators will contact ALL institutes which shared their interest in given WP topics in the survey and/or community feedback**
- **Institutes can still be added/removed from the individual WP and their tasks**
- **”Extended WP tables” will be created together with institutes which declare their contribution to specific WPs**
  - “WP projects” with well defined tasks will cluster institutes interested in common goals;
  - Final DRD1-proposal WP tables will be a compilation of such “WP projects”
  - The institutes interested to contribute to a given WP need to provide FTE and non-FTE resources in the extended WP tables
  - We differentiate between “existing” and “requested” resources.
  - WP can help in acquiring strategic funding, however, it is not mandatory for an institute to apply for extra funding. One can contribute with the exiting resources only

Community meeting agenda

Thu 22/06

09:00	1 - DRD1 Collaboration: Scientific organization and the timeline — *32/3-004 - IT Amphitheatre, CERN*
10:00–12:00	2 - Working Groups — *32/3-004 - IT Amphitheatre, CERN*
12:00	3 - Work Packages — *CERN*
13:00	
14:00–18:00	3 - Work Packages — *CERN*

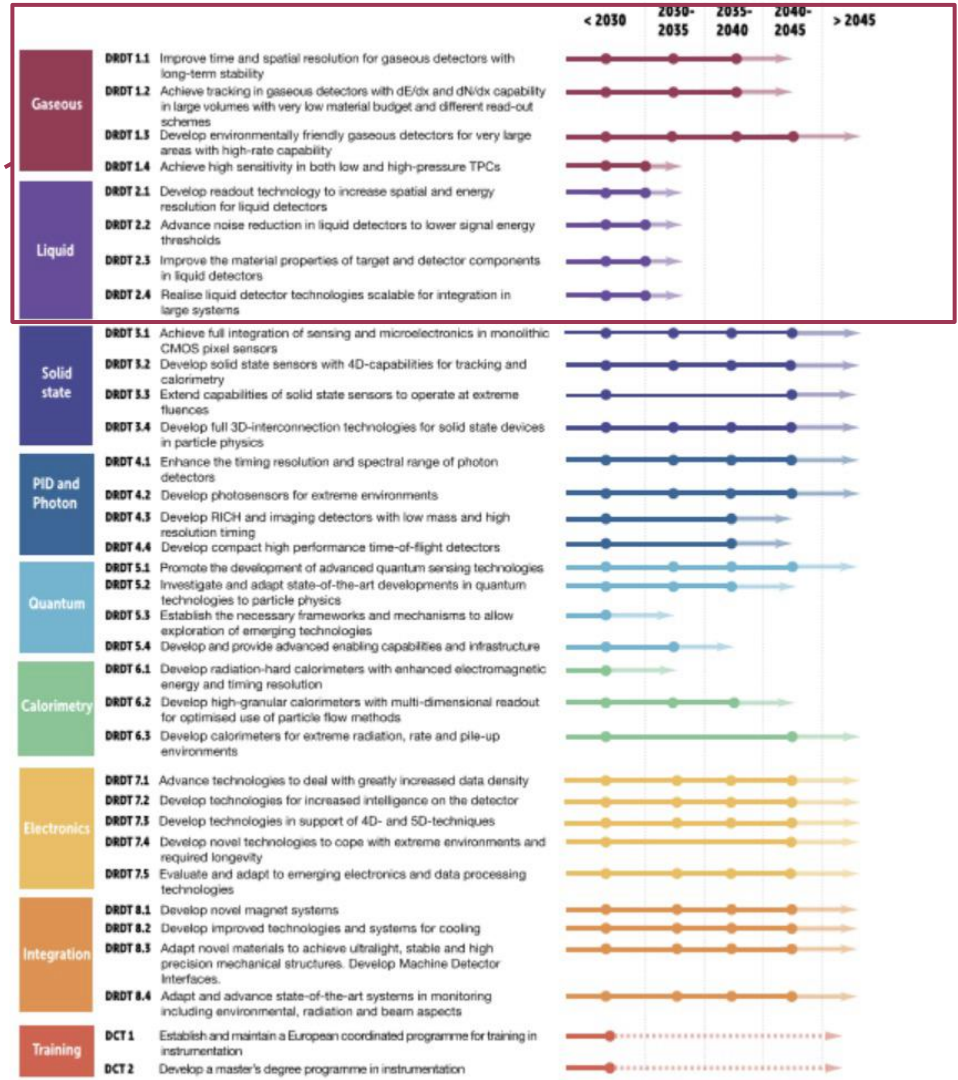
Fri 23/06

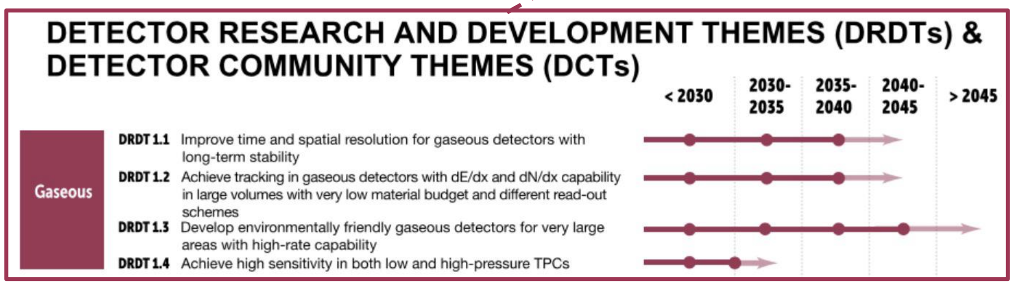
09:00	4 - Interplay with other DRDs — *CERN*
10:00–11:00	1 - DRD1 Collaboration — *CERN*
11:30–12:00	5 - Discussion — *CERN*
13:00	

BACKUP

DRD Themes

DETECTOR RESEARCH AND DEVELOPMENT THEMES (DRDTs) &
DETECTOR COMMUNITY THEMES (DCTs)





General Strategic recommendations

- **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.

General Strategic recommendations

- **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.

General Strategic recommendations

- **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.

ECFA DETECTOR R&D ROADMAP IMPLEMENTATION PLAN

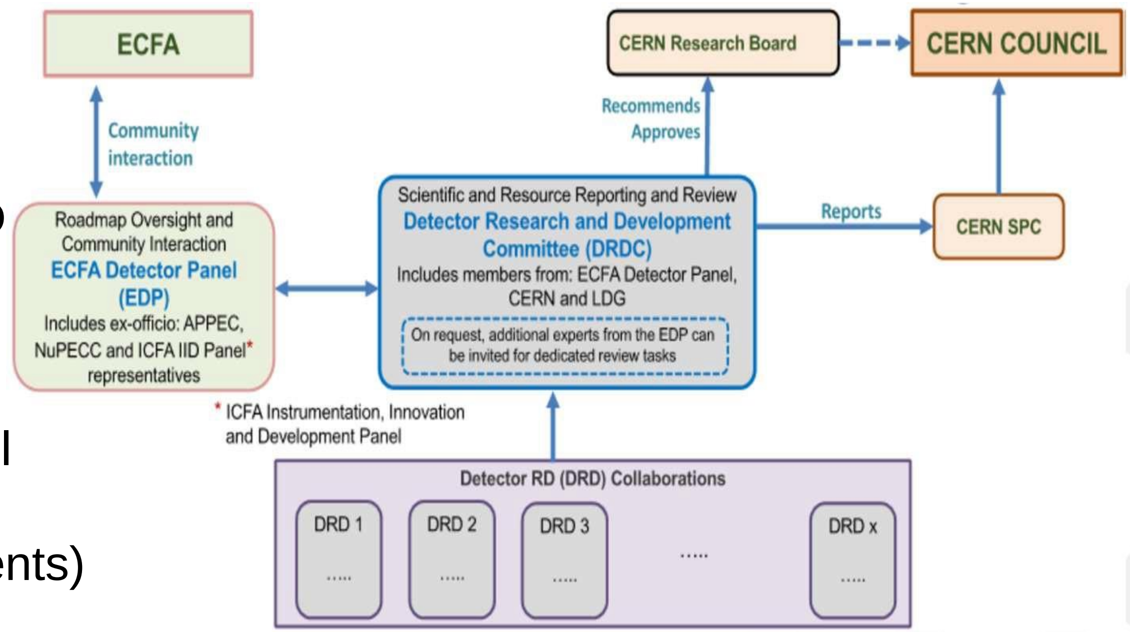
Requested by the CERN Council ECFA Roadmap Coordination Group worked out a proposal to organize long-term R&D effort into: new established **Detector R&D Collaboration anchored at CERN**

Three areas of Detector R&D:

1. **Strategic R&D** (long term strategic R&D (address the high priority items defined in the Roadmap via the DRDTs)

2. **Experiment specific R&D** (with very well defined detector specifications) (funded outside of DRD programme, via experiments)

3. **"Blue-sky" R&D** (competitive, short term responsive grants, nationally organised)



7 DRDs

https://cds.cern.ch/record/2838406?ln=en

DRD9 is taken care of by a new ECFA Training Panel
DRD8 felt their area is too experiment specific to be the topic of a "Strategic R&D" bid.

Beyond HEP

- No Beyond WP in the first draft
- Community feedback: clear need of Beyond HEP WP definition

- **Preliminary list of tasks identified:**
  - muongraphy and large area applications;
  - dosimetry/beam monitoring and medical imaging applications (PET, CT, X-ray, SPECT, Gamma cameras, or X-ray fluorescence imaging);
  - fast/thermal neutron imaging (MPGD-based readout with solid converter for tomography and nuclear waste monitoring;
  - X-ray polarimetry and space applications;