

Detector Research & Development

DRD Collaborations UK

- DRD Concept
- DRD-UK Structure
- DRD-UK Plans



DRD: 1-gas; 2-liquid; 3-solid state; 4-PID; 5-quantum; 6-calor; 7-elect/data; 8-systems
+ training, industry

Concept

“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...The community should define a global detector R&D roadmap.”

European Particle Physics Strategy 2020 Update

Roadmap



Implementation

CERN/SPC/1190
CERN/3679

3

Annex 1

Proposed Implementation Plan for the 2021 ECFA Detector Research and Development Roadmap

For each of the technology areas considered, the 2021 ECFA Detector Research and Development Roadmap¹ (hereinafter referred to as the Roadmap) has identified major detector R&D themes (DRD1s) where longer-term research must be carried out, in most cases directed towards experiments at large future facilities with earlier experiments as important “stepping stones”. A major guideline was to define the requirements and milestones such that detector R&D would not be the limiting factor in establishing the next large research projects envisaged on timescales extending well beyond the High-Luminosity LHC programme.

In addition, community themes have been developed, some of which are reflected in the general strategic recommendations (GSRs) that must also be addressed in the coming years.

1. Establishment of DRD Collaborations at CERN

It is proposed that the long-term R&D efforts be organised into newly established Detector R&D (DRD) collaborations, as illustrated below, following the model of the well-known and very successful RD collaborations established in the early 1990s to address the huge challenges posed by the construction of the LHC detectors.

Proposed organisational structure for implementation of the Roadmap (the arrows indicate the reporting lines)

- In the detector area, larger DRD collaborations should be considered. The proposal is that such collaborations be established to address each of the six detector technology areas identified in the Roadmap. This would guarantee a critical mass of institutes, expertise and effort, thereby avoiding too much fragmentation. It would also keep the administrative support and reviewing requirements to a manageable level. For the cross-cutting areas of electronics and integration, one or two further DRD collaborations should be anticipated; they should pick up on specific themes, but not necessarily be mapped directly onto the TF topic areas.
- In addition, the community themes identified in the area of training must be addressed. However, for these, alternative implementation steps are needed, as discussed later in this document.

¹ <http://cds.cern.ch/record/274893/files/>

- Strategic R&D in detector systems for particle physics, particle astrophysics, and related nuclear physics activities.
- Setup under the auspices of ECFA, with CERN as host.
- Much expand upon and replace existing CERN RD collaborations
- First collabs start Jan. 2024

Why ? And why not ?

Entering new Era –post-ATLAS/CMS U2 construction

Medium/small scale projects and FCC on 20+ yr horizon

Needs:

- **Costs:** technology costs are rising rapidly while the field remains – by commercial standards – a low-volume, niche market with complex requirements.
- **Complexity:** pooling of resources needed, and negotiation with vendors as larger-scale organisations.
- **Long-term strategic** funding programmes to sustain research and development in order for the technology to mature for FCC and other large-scale longer term projects
- **DRD structures will have the necessary critical mass**

Risks:

- Must ensure that **creativity** is maintained
- Must benefit the **medium-term** experiments
 - keep thriving community, learn through deploying technology

DRD-UK Aims

R&D programme will:

- Provide **international coordination** to identify and target common technological goals that will underpin the next generation of experiments facilitating long-term developments
- Provide and coordinate instrumentation **training and skill development** for the next generation of experimental particle physicists, engineers and technical staff
- Provide methods of establishing meaningful longer-term relationships with **industrial partners**

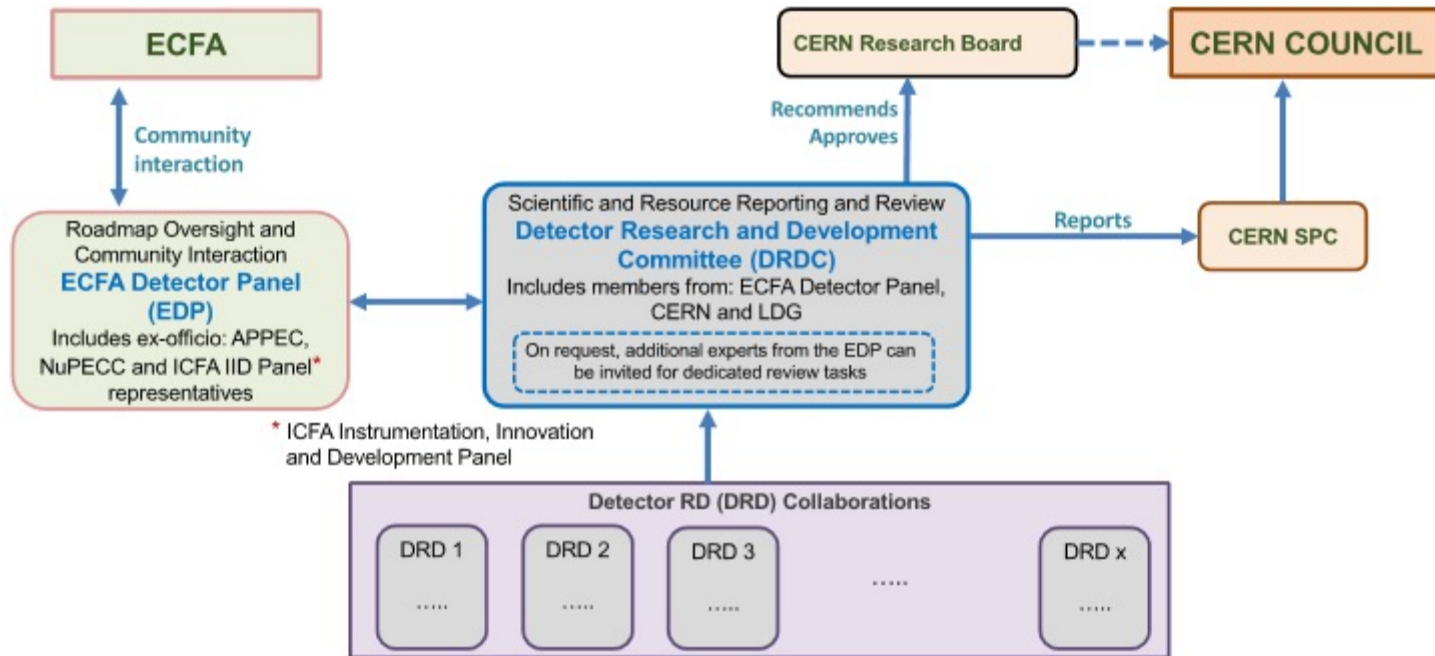
TECHNOLOGY READINESS LEVEL (TRL)

RESEARCH DEVELOPMENT DEPLOYMENT	9	ACTUAL SYSTEM PROVEN IN OPERATIONAL ENVIRONMENT
	8	SYSTEM COMPLETE AND QUALIFIED
	7	SYSTEM PROTOTYPE DEMONSTRATION IN OPERATIONAL ENVIRONMENT
	6	TECHNOLOGY DEMONSTRATED IN RELEVANT ENVIRONMENT
	5	TECHNOLOGY VALIDATED IN RELEVANT ENVIRONMENT
	4	TECHNOLOGY VALIDATED IN LAB
	3	EXPERIMENTAL PROOF OF CONCEPT
	2	TECHNOLOGY CONCEPT FORMULATED
	1	BASIC PRINCIPLES OBSERVED

- DRD primarily aimed at mid-TRL levels
- Development of technology to a level where it can then be applied by specific experiments

Organisation - International

- DRD Collaborations – with coordinators
- DRDC Review committee



Replaces collaborations such as:

RD50: underpinned most silicon developments that enabled LHC detectors and beyond

RD53: where a common ATLAS/CMS Upgrade II pixel chip basis was developed

RD42: Diamond detectors, RD51: gaseous detectors...

DRD Collaborations (1-8)

DRD1	Gaseous	e.g. time/spatial resolution; environment friendly gases	Gaseous
DRD2	Liquid	e.g. Light/charge readout; low background materials	Liquid
DRD3	Solid state	e.g. CMOS pixel sensors; High time resolution (10s ps) sensors	Solid state
DRD4	PID and Photon	e.g. Time resolution & spectral range of photon sensors	PID and Photon
DRD5	Quantum	Forming – quantum sensors	Quantum
DRD6	Calorimetry	e.g. Sandwich; noble liquid; optical	Calorimetry
DRD7	Electronics	e.g. ASICs; FPGAs; DAQ	Electronics
DRD8	Integration	e.g. Tracking detector mechanics Forming - Community Meeting on December 6	Integration

Industry / Infrastructure / Training

- Industrial links

- CERN to UK return poor
- Share experience groups

- Training

- UK system often generating physicists with limited hardware experience

- Major Infrastructure survey:

<https://www.surveio.com/survey/d/S6X/ECFA-LDG-infra-LabsSurvey>

Needs & availability of major facilities

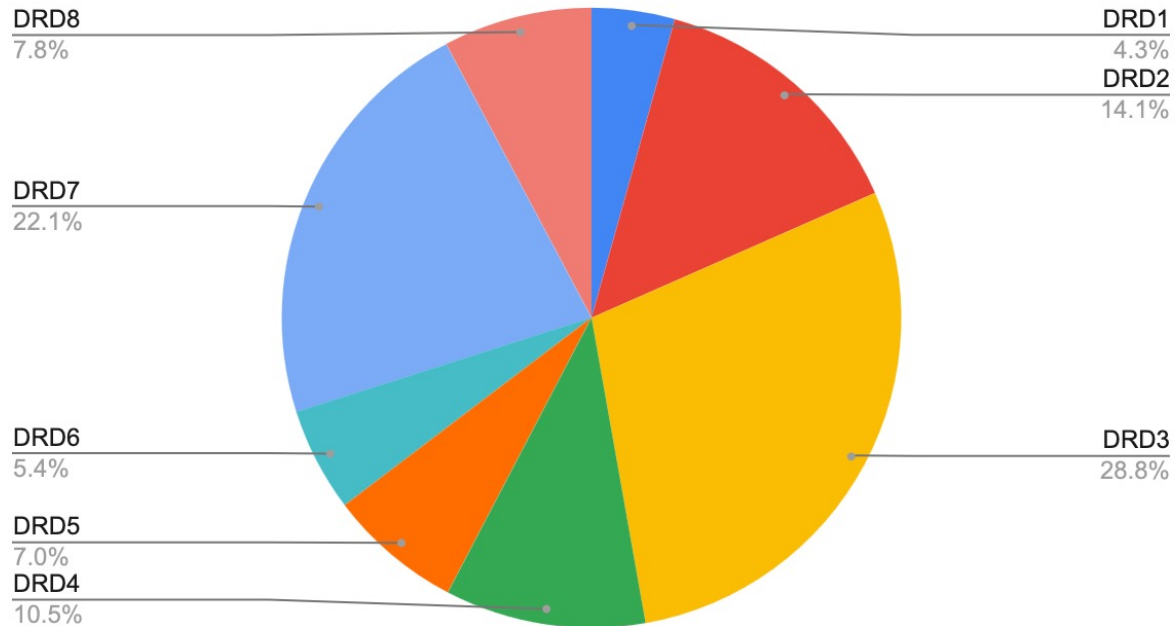
- You can still complete for your institute

- 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

UK Interests

Survey of UK particle physics groups through steering board

DRD-UK interests



1-gas; 2-liquid;3-solid state;4-PID;
5-quantum; 6-calo; 7-elect/data;8-systems.

Caveats: DRD5&8 at earlier stage, numbers may not be representative
New opportunities - we do not have to keep doing what we did before !

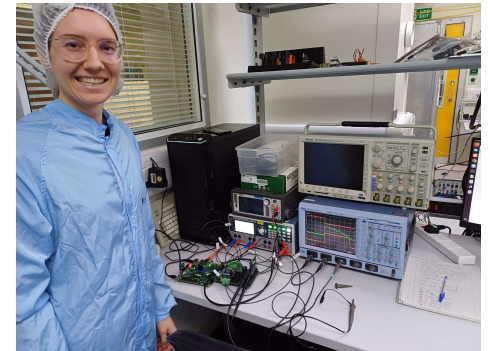
Example UK project- 1: ASIC

- **Case Study 1 : Common interface ASIC for readout, timing, and control**
- **Issue:**
 - ASIC development major source of schedule slippage in experiments.
 - Iteration time of the order 12-18 months.
 - high production costs of smaller feature size ASICs
- **Aim:**
 - Develop ASIC family & common blocks for front-end chain:
 - Intelligence/Processing capability;
 - the ability to distribute precision timing;
 - Single Event Upset tolerance;
- **UK DRD Activity:**
 - Strong experience in DAQ systems.
 - EURORACTICE Microelectronics Support Centre.
 - UK in Engineering design, emulation, simulation, and testing are expected, as part of co-developments with CERN and the international DRD consortia.



Example UK project-2: CMOS

- **Case Study 2** : Monolithic pixel sensors for future trackers
- **Issue:**
 - radiation hardness requirements
 - precision timing, new opportunities - 4D tracking.
- **Aim:**
 - pixel sensors for medium term future experiments
 - monolithic sensors, CMOS technologies
 - large volume, low-cost production.
 - High granularity (25x25 μm)
 - & high radiation tolerance (10^{17} 1 MeV neq/cm²)
 - combined LGAD MAPS detector, time resolution of order 10 ps.
- **UK DRD Activity:**
 - existing UK expertise on LGAD and CMOS sensor development
 - put the UK back at the forefront of what will be the leading technology for the next decade, work with the leading international groups



Strategic Review Particle Physics, December 2022

73. The UK should have an R&D portfolio that contains elements that are generic, i.e. not specialised to a specific project proposal while aligning with the European technology roadmaps. It should also include targeted involvement in feasibility studies for new projects at modest cost. The UK should invest in research projects in sustainable energy usage, e.g. in accelerator R&D. The portfolio should have both low- and high-risk elements.

77. There should be an increase in resources available for generic R&D for detectors and accelerators. An indicative goal would be to approach a minimum of 5% of the core programme. [core ~£55m per annum thus 5% is £2.75m]

Consolidated Grant Guidance for 2024

Part C: PPGP guidelines for bids to support the coordination of large-scale research and development (R&D) activities

8 R&D Submissions

8.1 Scope

8.1.1 This is a new opportunity to request funding to support the coordination of large-scale research and development activities. The purpose of this funding is to encourage strategic planning and to foster a sense of community among those involved in the R&D activity, beyond what can be reasonably expected through the CG funding provided to individual institutes.

Funding opportunity

Early-stage research and development scheme 2023

Opportunity status:	Closed
Funders:	Science and Technology Facilities Council (STFC)
Funding type:	Grant
Maximum award:	£600,000

**Recognition of need – big success of community efforts
need to translate into funding – with longterm strategy**

DRD-UK funding bids

- CG submission
 - Fractions of posts to support detector R&D
 - Extremely relevant to FCC
 - List of UK project activities (draft next week)
 - Reference these in your CG posts
 - M&O style **coordination activities** (travel, training, workshops, sustainability, EDI), consumables ?
- Early stage R&D call
 - STFC increasing funds for call
 - Bids for ~ 5 projects from DRD-UK
 - To be decided by steering board in early '24

Sustainability

- STFC considering sustainability policy
- DRD-UK:
 - low-GWP gases for detectors
 - Low-GWP and non-PFAS liquid coolants
 - (Computing farm power consumption)

arXiv:2306.02837v2 [physics.soc-ph] 18 Aug 2023

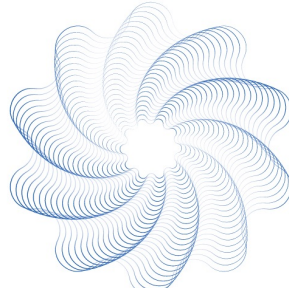
Environmental sustainability in basic research

A perspective from HECAP+


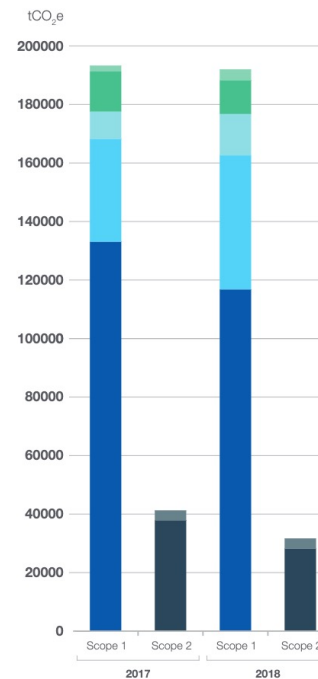
Sustainable HECAP+ Initiative

Abstract
 The climate crisis and the degradation of the world's ecosystems require humanity to take immediate action. The international scientific community has a responsibility to limit the negative environmental impacts of basic research. The HECAP+ communities (High Energy Physics, Cosmology, Astroparticle Physics, and Hadron and Nuclear Physics) make use of common and similar experimental infrastructure, such as accelerators and observatories, and rely similarly on the processing of big data. Our communities therefore face similar challenges to improving the sustainability of our research. This document aims to reflect on the environmental impacts of our work practices and research infrastructure, to highlight best practice, to make recommendations for positive changes, and to identify the opportunities and challenges that such changes present for wider aspects of social responsibility.

Version 2.0, 18 August 2023
 Please read this document in electronic format where possible and refrain from printing it unless absolutely necessary. Thank you.



Environment Report
 2019 - 2020

- LHC experiments - Particle detection
- LHC experiments - Detector cooling
- Other experiments
- Heating (gas + fuel)
- Other
- Electricity consumption (EDF)
- Electricity consumption (Hungary)

Framework LHCb Upgrade II DR
 Technical Design Report

DRD-UK Steering Board

Institution	Representative
Birmingham	ALLPORT, Philip Patrick
Bristol	GOLDSTEIN, Joel
Brunel	KHAN, Akram
Cambridge	WILLIAMS, Sarah
Edinburgh	GAO, Yanyan
Glasgow	BATES, Richard
Imperial	TAPPER, Alex
King's	DI LODOVICO, Francesca
Lancaster	O'KEEFFE, Helen
Liverpool	VOSSEBELD, Joost
Manchester	PARKES, Chris (UK PI)
Oxford	BORTOLETTO, Daniela (UK Steering board Chair)
QMUL	HOBSON, Peter
RAL - PPD	WILSON, Fergus
RAL - TD	FRENCH, Marcus Julian
RHUL	BOISVERT, Veronique
Sheffield	VICKEY, Trevor
Sussex	HARTNELL, Jeffrey John
UCL	THOMAS, Jenny
Warwick	RAMACHERS, Yorck

Please liaise with your group member for CG bids

- Meetings:
UK DRD projects & arrangements with STFC

R&D needs of future UK experiments

Sept: large scale nuclear
– ALICE/EIC

Oct: Neutrino & dark matter

Next week: quark flavour
– LHCb/HIKE

DRD-UK Coordinators

Institution	Representative
DRD-1 [Gas]	BRANDT, Oleg; MAJEWSKI, Pawel;
DRD-2 [Liquid]	GUENETTE, Roxanne; MONROE, Jocelyn; SAAKYAN, Ruben; SCOVELL, Paul;
DRD-3 [Si]	DOPKE, Jens; GONELLA, Laura; HYNDS, Daniel; VILELLA FIGUERAS, Eva
DRD-4 [PID]	BLAKE, Thomas; ROMANO, Angela
DRD-5 [Quantum]	BUCHMULLER, Oliver; DAW, Ed
DRD-6 [Calo]	SALVATORE, Fabrizio; WATSON, Nigel
DRD-7 [Electronics]	FITZPATRICK, Conor; FRENCH, Marcus; POTAMIANOS, Karolos; PRYDDERCH, Mark; ROSE, Andrew
DRD-8 [Systems]	GOLDSTEIN Joel; VIEHHAUSER, Georg
Training	LAZZERONI, Cristina; BATES, Richard
Industry Engagement	FARROW, Richard; CASSE, Gianluigi

- UK Coordinators for each DRD activity
- We have several UK members that have international coordination roles
 - Please do contact those for your areas of interest

Take-away messages

- CG post fractions for DRD
- Bids for specific projects
- Sign up to email list

uk-detector-rd@cern.ch

<https://e-groups.cern.ch/e-groups/EgroupsSearchForm.do>

- DRD-UK meeting with IoP meeting April 2024
- Will ask FCC-UK to speak on R&D needs at future DRD-UK Steering board meeting

Unsurprisingly, “DRD” used by multiple organisations – logo inspiration ?

