MANCHESTER 1824

The University of Manchester

European Strategy Update

ECFA European Committee for Future Accelerators

Detector Research & Development

DRD Collaborations

- Intro
  - See slides from this morning – in backup
  - https://indico.cern.ch/event/1388874/contributions/5860516/attachments/2834792/4953629/DRD-IOP-110424.pdf
- DRD1,4,5,6 convenor slides

UK DRD Annual Meeting

Thursday 11 Apr 2024, 14:00 → 17:30 Europe/London

Rotblat lecture theatre in the Chadwick building, Liverpool

Eva Vilella Figueras (University of Liverpool (GB)), Joost Vossebeld (University of Liverpool (GB))

Description The meeting is taking place on the afternoon after the end of the IOP Joint APP, HEPP and NP annual conference (https://indico.cern.ch/event/1388874/). a zoom connection is also provided.

The DRD-UK meeting is separate from the IOP conference, attendance at the DRD_UK meeting is open to all.

14:00 → 14:20 **Overview of DRD-UK** (20m)
DRD-UK plans, with contributions from all DRD-UK coordinators
Speaker: Chris Parkes (University of Manchester (GB))

14:30 → 14:50 **Funding opportunities for DRD [STFC speaker]** (20m)
Speaker: Grahame Blair

15:00 → 15:20 **Training & Industry: current activities & plans** (20m)
Speaker: Dr Richard Bates (University of Glasgow (GB))

15:30 → 15:50 **Semiconductor trackers (DRD3&8) : current activities & plans** (20m)
Speaker: Daniel Hynds (University of Oxford (GB))

16:00 → 16:20 **R&D for neutrinos, dark matter and opportunities at Boulby (DRD2)** (20m)
Speaker: Roxanne Guenette

16:30 → 16:50 **Electronics & DAQ: current activities & plans (DRD7)** (20m)
Speaker: Marcus Julian French (Science and Technology Facilities Council STFC (GB))

17:00 → 17:30 **Tea & Coffee** (30m)

DRD: 1-Gas; 2-Liquid; 3-Solid State; 4-PID; 5- Quantum; 6-Calo; 7-Electronics/DAQ; 8- integration + Training, Industry

DRD Collaborations (1-8)

1. Gaseous

e.g.
time/spatial resolution;

environment friendly gases

2. Liquid

e.g.
Light/charge readout;

low background materials

3. Semiconductor

e.g.
CMOS pixel sensors;

High time resolution (10s ps)

4. PID & Photon

e.g.
spectral range of photon sensors;

Time resolution

5. Quantum

quantum sensors
- R&D, incl. beyond QFTP in conventional detectors

6. Calorimetry

e.g.
Sandwich;
noble liquid;
optical

7. Electronics

e.g.
ASICs;
FPGAs;
DAQ

8. Integration

tracking detector mechanics

DRD-UK Organisation

Email list: uk-detector-rd@cern.ch

Please sign-up at: http://e-groups.cern.ch

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

Cordinators

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

DRD1 – Gaseous Detectors

Slides: Pawel Majewski & Oleg Brandt
UK groups:

Contributing institutes: Birmingham, Cambridge, Imperial, Liverpool, Manchester, RHUL, Warwick, York, STFC ISIS, STFC PPD

DRD1 UK & international overview

- Key technologies in UK:
  - Micropattern detectors
    - high spatial resolution O(μm), typically TPC read-out
  - Time Projection Chambers (pressures from 50 Torr to 10 bar)
    - low rate precision tracking applications (DM, neutrinos)
  - Resistive Plate Chambers
    - large scale, high rate, o(100 ps) timing resolution + ~100% efficiency

- UK involvement in key areas from several institutes:
  - Birmingham, Cambridge, Imperial, Liverpool, Manchester, Royal Holloway, Warwick, York, STFC ISIS, STFC PPD

- International DRD1 Collaboration formed
  - Most DRD1 Working Groups kicked off
    - Evaluating resources & making concrete plans
    - Very productive WP1 meeting (large scale detectors & challenges)
  - DRD1 management in place

UK Key Priority Areas in DRD1

- Five key priority areas identified by UK DRD1 community:
  - Development and optimisation of **micropattern detectors** across a range of pressures, using existing unique facilities, e.g., for glass-GEM fabrication (WP8)
  - Identification of novel **low-GWP gas mixtures** benefiting from synergy with ongoing activities at CERN for LHC experiments and beyond (WP1, WP6, WP7);
  - Advancement in **detector simulations** crucial for guiding the R&D activities across the full spectrum of DRD1 and especially low-GWP gasses (WG4);
  - Development and maintenance of an experimental platform for **gaseous detector testing** benefitting from ongoing developments for DUNE (WP4, WP8);
  - The development and characterisation of the next generation of **optical & charge readout systems** (WP1, WP5).

- → All crucial areas of R&D for future detectors covered!

UK DRD1 beneficiaries

- DRD1 support for a strategic variety of beneficiaries across various experiments & communities:
  - low background searches
    - DM, Migdal, DarkSphere, …
      - Requirements: high spatial resolution, dE/dx, PID
  - large-scale low-rate,
    - DUNE, neutrinos …
      - Requirements: large-scale (low-cost), high spatial resolution, dE/dx
  - large-scale high-rate
    - ANUBIS, HL-LHC, FCC etc
      - Requirements: large-scale (low-cost), high rate, precision timing

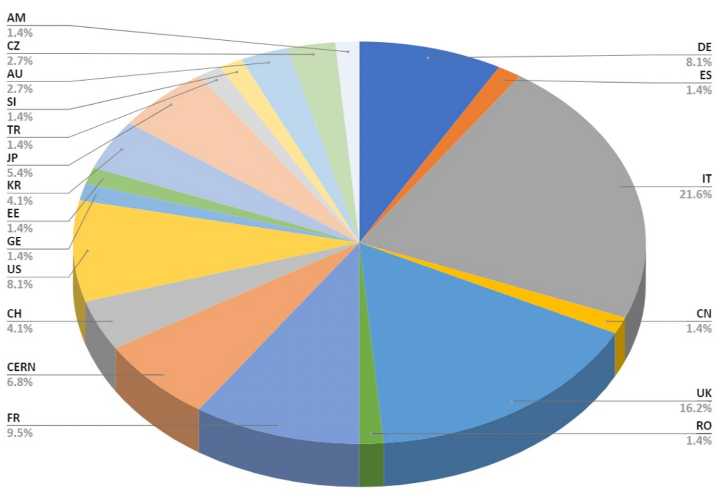
DRD4 – PID

Slides: Tom Blake, Angela Romano
UK groups:

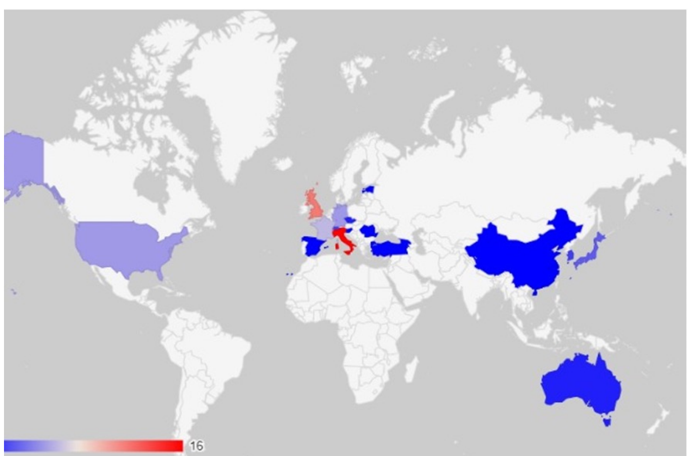
Contributing institutes: Birmingham, Bristol, Cambridge, Edinburgh, Imperial, Leicester, Oxford, STFC PPD, Warwick

DRD4 Collaboration

- Photon detectors are at the heart of most particle physics experiments
- PID is an essential tool of modern HEP experiments
- Coverage of momentum range may require combination of techniques
- Future projects e.g. LHCb, BELLE II, ALICE-3, EIC, FCC-ee,…
- Domain of application growing with the available photodetectors
- Precise timing information may bring a breakthrough in performance



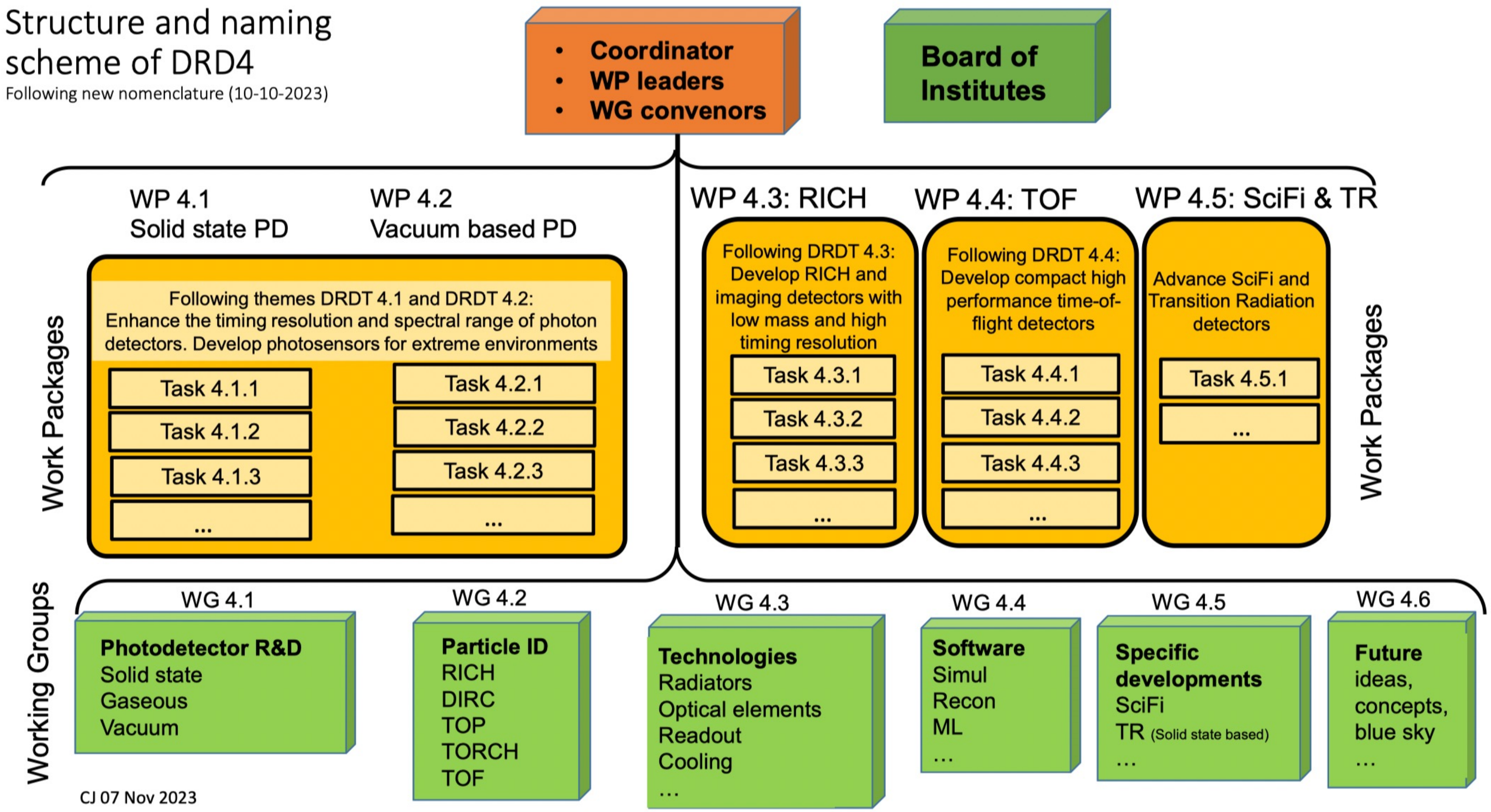
19 nationalities
Includes 7 industrial and semi-industrial partners (very important asset)



[Public talk from Massimiliano Fiorini @DRDC 04/03/2024]

76 institutes joined the DRD4 collaboration

DRD4 - R&D international collaboration on Photodetectors and Particle ID



- **Working groups – resources to be committed. Working Groups: Information exchange**
- Management in place
  - DRD4 Collaboration Board Chair: Guy Wilkinson (Oxford), WP4 Leader: Jon Lapington (Leicester), WG2 Convener: Sajan Easo (RAL), WP2 Deputy leader: Silvia Gambetta (Edinburgh), WG1 Deputy convener: Angela Romano (Birmingham)

DRD4 Key technologies of UK interest

To be developed under the first 3 years mandate

- **Photon detectors (PDs) - WPs 4.1, 4.2**
  - Solid-state PDs: Ultra-fast and radiation hard **SiPMs**
  - Vacuum-based PDs: Next-generation **MCP-PMT** with innovative techniques
  - Ultra-fast MCP with optimised readout electronics and spatial resolution.
- **RICH and other imaging detectors for future experiments - WP 4.3**
  - New concepts (**meta-materials** as Cherenkov radiators)
  - Single-Photon Sensitive module (sensor to DAQ), self-calibration systems (include cooling for SiPM)
  - Full conceptual design for ARC detector, prototype ARC cell (**FCCee**)
  - Software framework for fast tracing of Cherenkov optical photons and fast reconstruction
- **Time of Flight (TOF) detectors for future experiments - WP 4.4**
  - TOF detector prototype coupling thin radiator to single-photon detector array
  - SiPM array with mm-scale pixelation, suitable for use in TOF prototypes
  - Lightweight mechanical supports for DIRC-type TOF detectors
  - Protocol for measuring optical properties of optical components (polished quartz radiators) and coupling of optical elements in DIRC-style TOF detectors

UK-DRD4 Draft list of Priority Projects

To be discussed and agreed upon

Projects/Areas with ongoing activities in UK and wish-list for funds

- **Design of Particle ID systems based on Cherenkov/TOF techniques for future experiments**
  Beneficiaries: LHCb, PID at future experiments (e.g. FCC).
- **Development of novel radiators for future PID detectors**
  Beneficiaries: LHCb, PID at future colliders.
- **Development of new photon detectors for Cherenkov/TOF applications in future experiments**
  SiPMs, MCP-PMT photon detectors, readout for fast-timing
  Beneficiaries: LHCb, Belle 2, PID and calorimetry at future experiments.
  UK Industry: Photek Ltd.
- **Development of accelerated computing for Particle ID applications in future experiments**
  Beneficiaries: LHCb, Belle 2, PID at future experiments.
  UK Industry: Graphcore.

DRD5 – Quantum

Slides: Ed Daw, Oliver Buchmuller
UK groups:

Contributing institutes: Cambridge, Imperial, Lancaster, Liverpool, Oxford, Queen Mary, RAL PPD, Royal Holloway, Sheffield, Sussex, University College London.

DRD5 – Quantum Sensors and Technology

quantum technologies for fundamental physics programme has funded several new experiments. These experiments are developing quantum technologies that are of broader interest. DRD5 aims to identify and progress such developments.

QTFP phase 1 projects

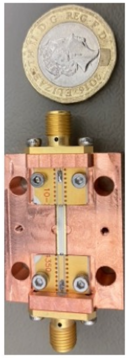
- **AION** – atom beam interferometry for ultra-light axion / mid band gravitational waves.
- **QSHS** – ultra-low-noise search for QCD axion / wave-like dark matter.
- **QTNM** – ultra-low-noise tritium endpoint neutrino mass by sensing cyclotron radiation.
- **QUEST-DMC** – superfluid ^{3}He particle-like dark matter detector, nanowire readout.
- **QI** – precision optical and squeezed light interferometry for ultra-light halo or produced axions/ALPS, probes of semiclassical gravity and quantum gravity.
- **QSIMFP** – superfluid helium simulators of general relativity, fundamental theory.
- **QSNET** – precision network of atomic clocks used to test for beyond-standard-model behaviour of fundamental constants.

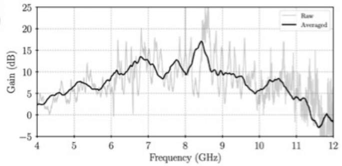
and, 17 smaller projects funded in QTFP phase 2, including many other interesting device R&D projects.

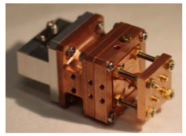
DRD5 - Technologies under development

See talk from Ian Shipsey in IOP meeting

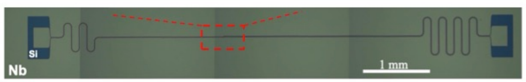
QSHS





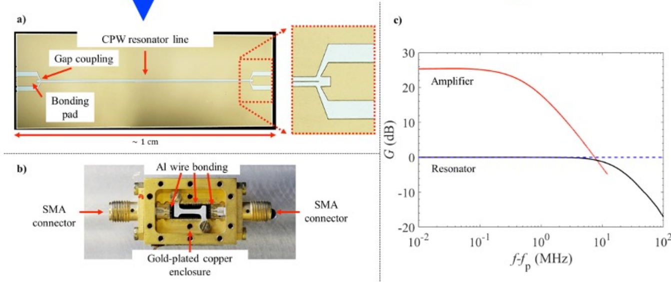


- Fabricating TWPAs, SLUGs, qubit arrays and homodyne detectors in 5-20 GHz band. 15dB gain observed.
- In-situ testing at 10mK this summer.



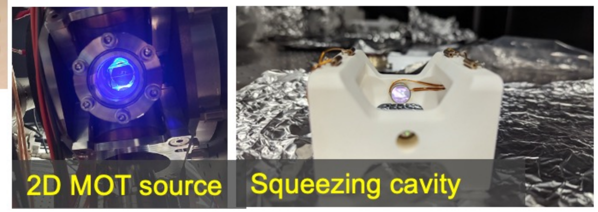
Common interest in GHz band low noise amplifiers

QTNM



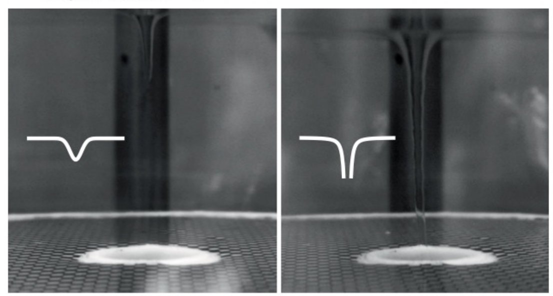
- NbN, Nb, Al, Ti paramps *fabricated* and *tested* at 18 GHz for QTNM . Operation at ~100mK and 4K possible for two-stage readout

AION



- Squeezing cavity, finesse of 200,000.
- Blue and red magneto-optic traps built.
- First large momentum transfer to ions achieved (many $\hbar k$) in strontium.

QSIMFP



Precision optical surface metrology and ultra low noise pulse detection for vortex characterization.

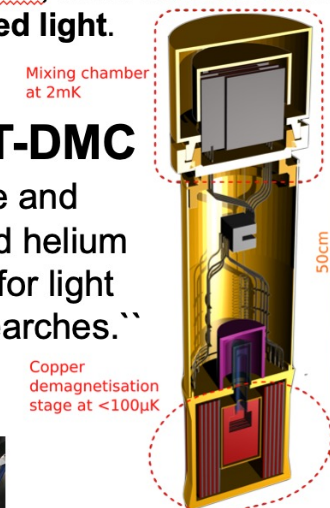
66 | Nature | Vol628 | 4April2024

QI

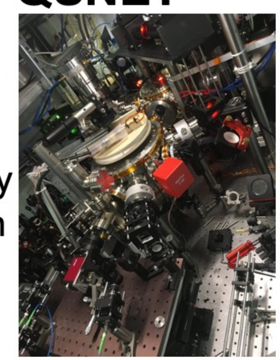
Precision interferometer measurements of macroscopic surfaces to probe ultralight hidden sector, halo axions, and space-time anomalies.
Key technogies, **laser interferometry**, and **squeezed light**.

QUEST-DMC

Nanowire and superfluid helium detector for light WIMP searches.``



QSNET



Calcium monofluoride molecular clock, complementing and extending the existing network for precision tests of new physics.

DRD5- Work packages

- DRD5.0 – Coordination
- DRD5.1 – **Atom Interferometry** – further development of technologies including new beam optics, laser atom interaction studies.
- DRD5.2 – Coherent ultra **low noise electronics**, targeting 1-20GHz. for wave-like dark matter, neutrino mass, quantum instrumentation and quantum computing.
- DRD5.3 – Incoherent ultra low noise electronics, targeting 1-20GHz. **Bolometry, homodyne detectors**, relevant to wideband wavelike dark matter searches.
- DRD5.4 – **Qubit sensors** – alternative technology for wave-like dark matter, also of interest for more general quantum instrumentation.
- DRD5.5 – **CryoMult**i – multi-channel quantum detectors.
- DRD5.6 – **CryoFPGA** – cryogenic control for quantum systems.

Opportunities to apply quantum technologies in conventional detectors
low dimensional materials (nanodots, atomically thin monolayers)
for scintillating materials or gaseous detectors,
nanoengineered semiconductor devices,
nanophotonics and optical tracking TPCs.

DRD6 – Calorimeters

Slides: Nigel Watson, Fabrizio Salvatore
UK groups:

Contributing institutes: Birmingham, Imperial, STFC PPD, Sussex

Digital ECAL Concept

- Calorimeter samples energy between ~30 W absorber layers
- Analogue, e.g. CMS HGCAL (~ex-ILC), **sum energy** in 5x5 mm² Si cells
- Digital: **count every individual particle** in EM shower

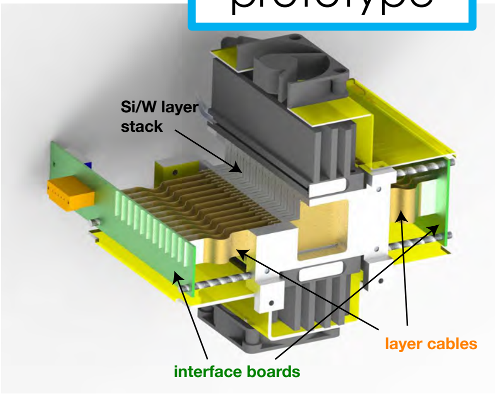
Need ultra-small pixels! Ideally 1 particle/pixel → binary approach

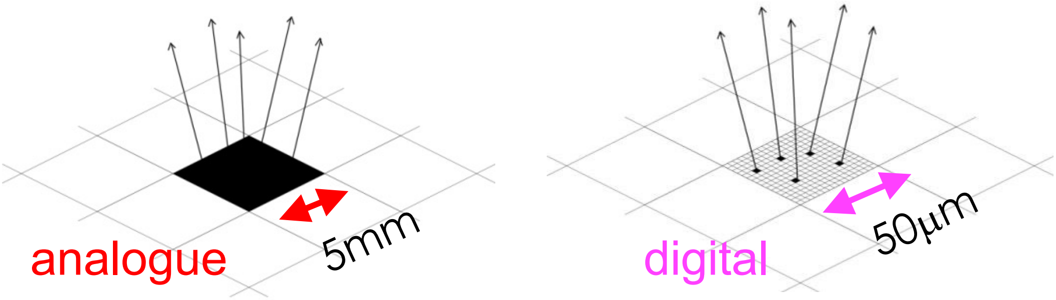
EM shower core density at 500GeV ~100/mm²

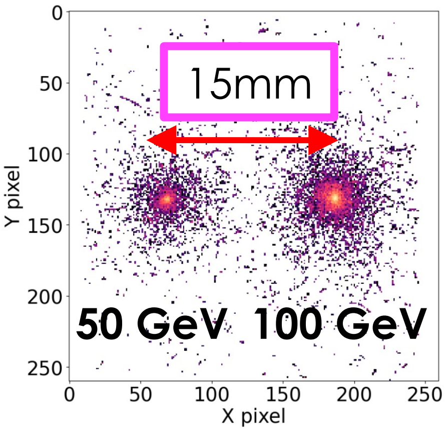
Pixels <100x100µm² for no saturation

~10^{12} pixels for ECAL barrel

EPICAL-2 prototype







- Using CMOS MAPS, simpler construction,

+ expect lower cost

- A `tracking calorimeter', separates boosted decays, e.g. $\tau, \pi^0 \rightarrow \gamma\gamma$ …
- 20 X_0 prototype calorimeter in testbeams

(UK) DECAL Sensor Plans

- Original UK idea enabled use of fully efficient MAPS sensors
- Potentially reconfigurable sensor technology: outer tracker/preshower/ECAL
  - I.Kopsalis et al, NIM A1038 (2022) 166955 and P.P.Allport et al, Sensors 2022, 22(18) 6848
- Main goals

  Reduce ~20-100mW/cm^2 power consumption (collider-specific pulsing or …)

  Resolve identified issues with current DECAL sensor design
- Other ideas

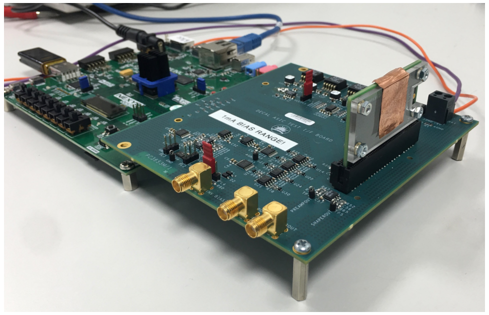
  3d stack + semi-digital approach

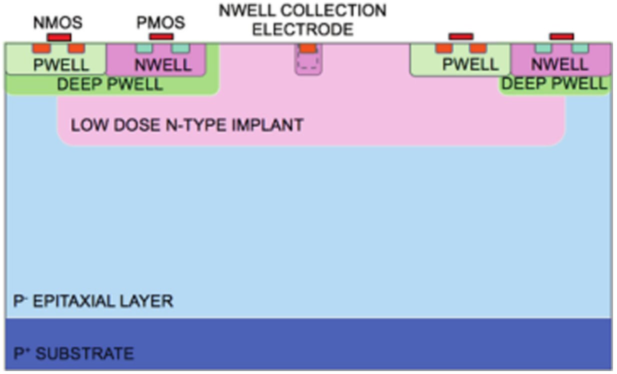
  Multi-threshold pixels

  Increased configurability

  Configurability, chip → FPGA

  Modelling



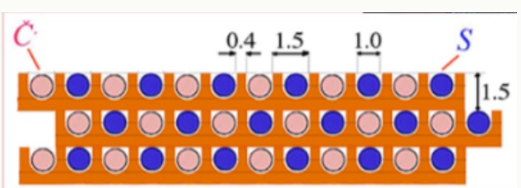


- Collaborate with SLAC/Oregon, review overlaps/division of fundamental R&D goals
- Designer effort critical, cannot rely on effort from outside UK, e.g. Germany

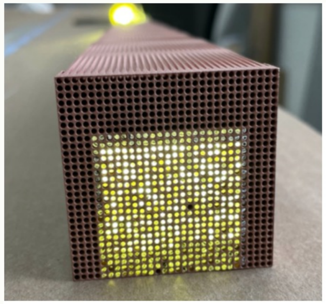
  If we want to be involved in this activity in future, need access to resources

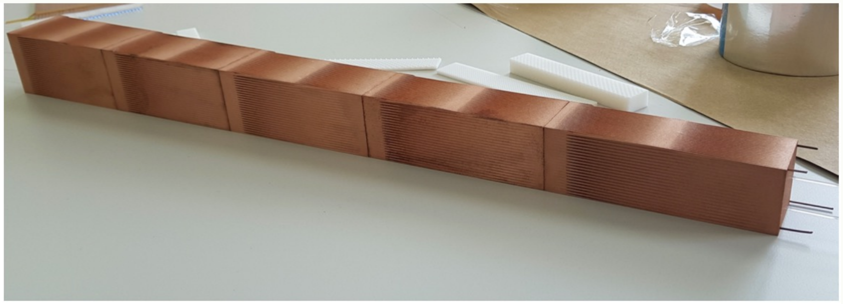
Dual readout - the principle

- Single device for EM and HAD calorimetry
- Resolution of hadronic energy measurement affected by fluctuations
  - % energy carried by $\pi^0 \rightarrow \gamma\gamma$ (f_{em})
- Two readouts with different EM/hadronic response
  - Determine f_{em} and incident energy E.
- How? e.g. IDEA detector concept (FCC and CEPC CDRs)
- Spaghetti calorimeter, alternating clear (Cherenkov) and doped (Scintillating) fibres.
  - Cu absorber, 1 mm fibres, 1.5 mm pitch, readout by SiPM



[c/o Iacopo Vivarelli]





Sustainability

See also talk of Veronique Boisvert at this meeting

- STFC considering sustainability policy, SOI options
- 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+

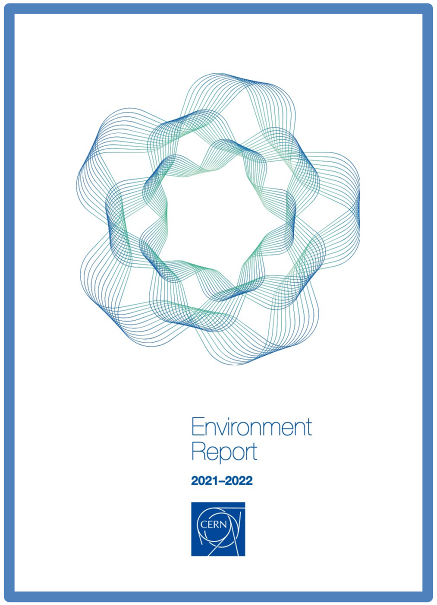
Sustainable HECAP+ Initiative

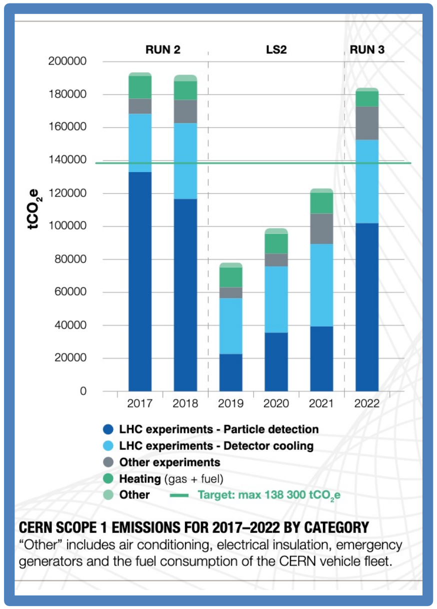
Abstract

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.





CERN SCOPE 1 EMISSIONS FOR 2017–2022 BY CATEGORY
"Other" includes air conditioning, electrical insulation, emergency generators and the fuel consumption of the CERN vehicle fleet.

STFC - DRD

Science and Technology Facilities Council

Funding opportunity

Early stage research and development scheme 2024

- Prepare and prioritise DRD proposals in community

SOI in discussion for Science Board

- Provide input to STFC from community

DRD-UK Summary

- New era – DRD to drive strategic community R&D
  - Medium scale medium-term projects
  - Longer timescale FCC
- Many exciting proposals for instrumentation development from UK community, with collaboration internationally

We don’t have a logo yet so this is what AI suggests.

- Realise that will need to heavily prioritise to extract key projects on which the UK can make impact

Backup – slides from IOP presentation

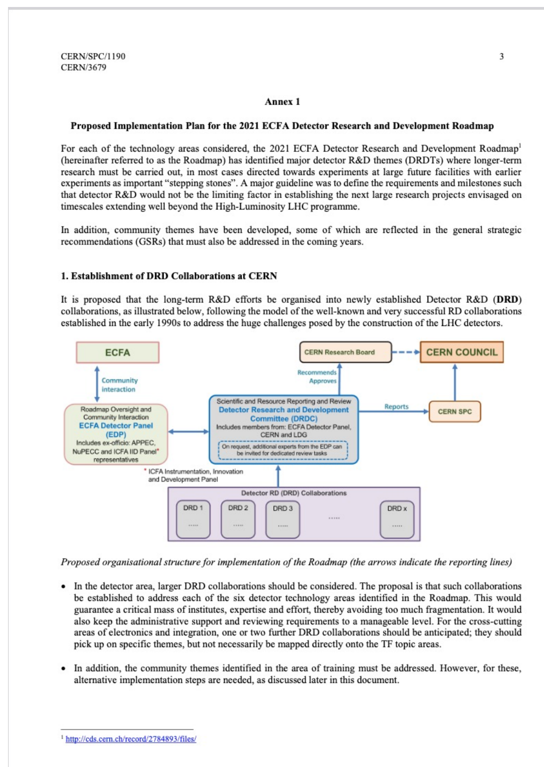
Concept

"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



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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 Roadmap[1] (hereinafter referred to as the Roadmap) has identified major detector R&D themes (DRDTs) 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/2784893/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.
- Expand upon and replace existing CERN RD collaborations
- First collabs started 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**

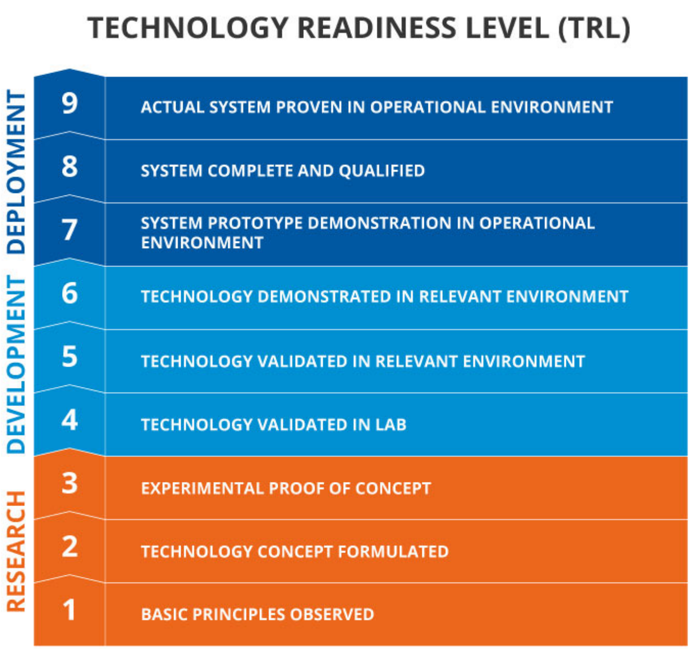
Risks:

- 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:

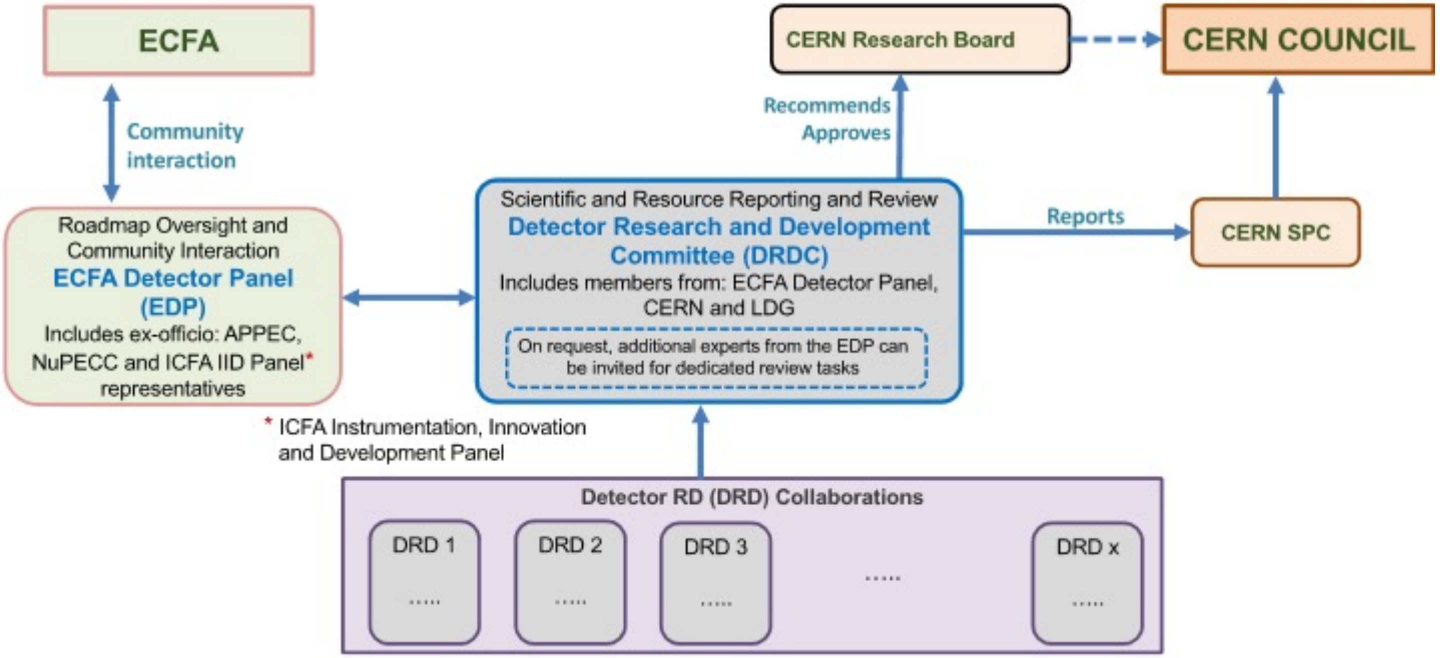
- Provide **international coordination** to identify and target common technological goals that will underpin the next generation of experiments facilitating long-term developments
- Provide and coordinate instrumentation **training and skill development** for the next generation of experimental particle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



- DRD primarily aimed at mid-TRL levels
- Development of technology to a level where it can then be applied by specific experiments
- UK strong in recent / current construction
- Falling behind international competitors in instrumentation development
- DRD is opportunity to catch-up
  - Lack of longterm R&D funding at this TRL level

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)

1. Gaseous

e.g.
time/spatial resolution;

environment friendly gases

2. Liquid

e.g.
Light/charge readout;

low background materials

3. Semiconductor

e.g.
CMOS pixel sensors;

High time resolution
(10s ps)

4. PID & Photon

e.g.
spectral range of photon sensors;

Time resolution

5. Quantum

quantum sensors
- R&D, incl. beyond QFTP in conventional detectors

6. Calorimetry

e.g.
Sandwich;
noble liquid;
optical

7. Electronics

e.g.
ASICs;
FPGAs;
DAQ

8. Integration

tracking detector mechanics

DRD Collaborations (1-8)

1. Gaseous

e.g.
time/s
re
vironment
friendly gases

APPROVED

2. Liquid

e.g.
Light/
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aterials

APPROVED

3. Semiconductor

e.g.
CMOS
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resolution
(10s ps)

Conditionally APPROVED

4. PID & Photon

e.g.
spect
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Time
resolution

APPROVED

5. Quantum

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In Review

6. Calorimetry

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7. Electronics

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DAQ

In Review

8. Integration

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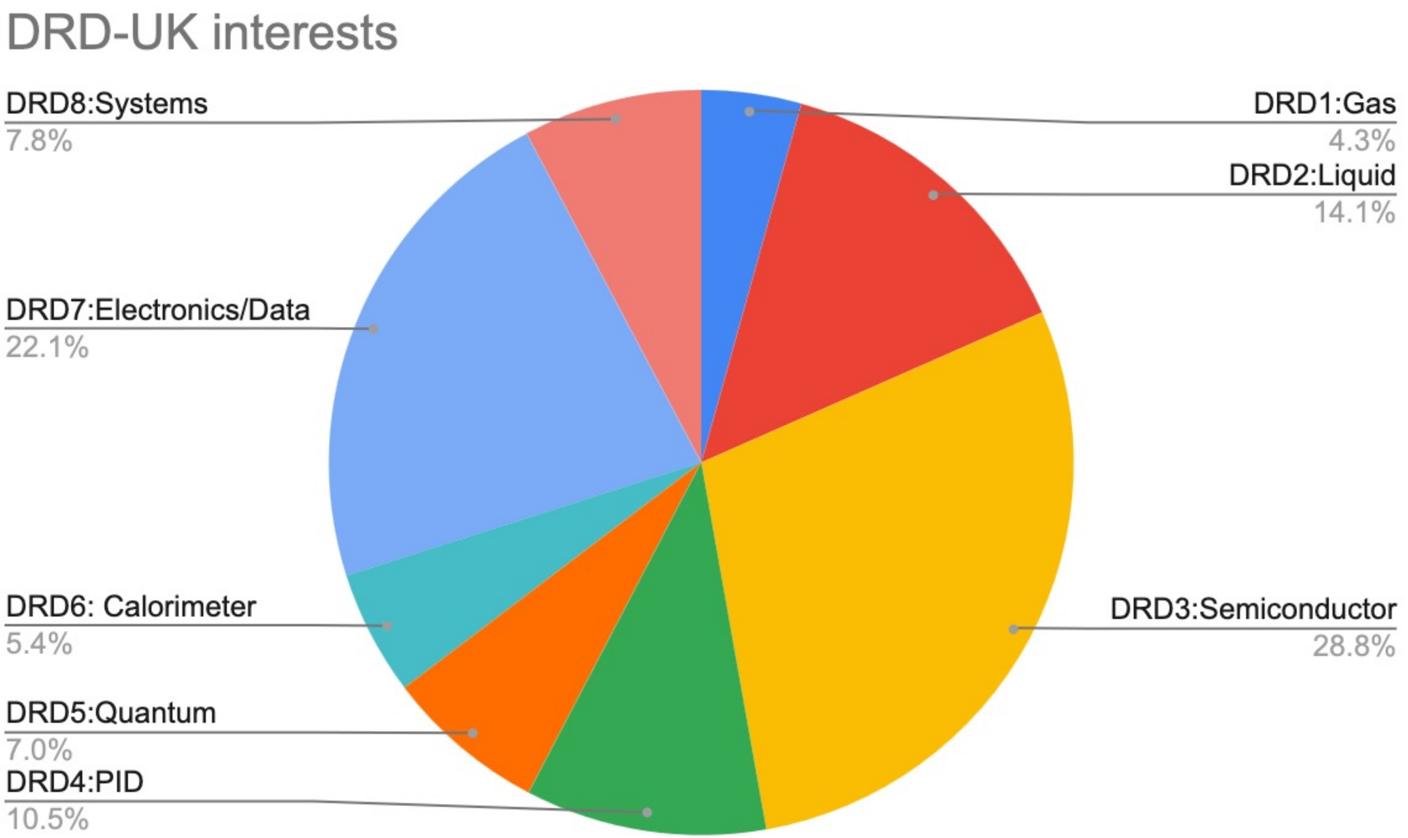
Letter of Intent

UK Interests

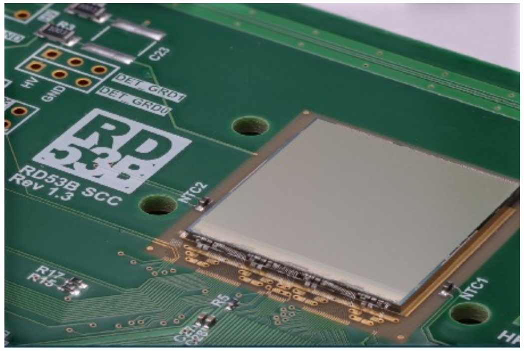
Survey of UK particle physics groups through steering board



Caveats: DRD5&8 at earlier stage, numbers may not be representative
Opportunity to develop new areas

Example UK project- 1: ASIC

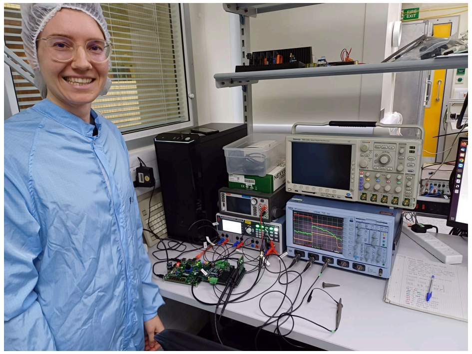
- **Case Study 1 : Common interface ASIC for readout, timing, and control**
- **Issue:**
  - ASIC development major source of schedule slippage in experiments.
  - Iteration time of the order 12-18 months.
  - high production costs of smaller feature size ASICs
- **Aim:**
  - Develop ASIC family & common 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.
  - EUROPRACTICE 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

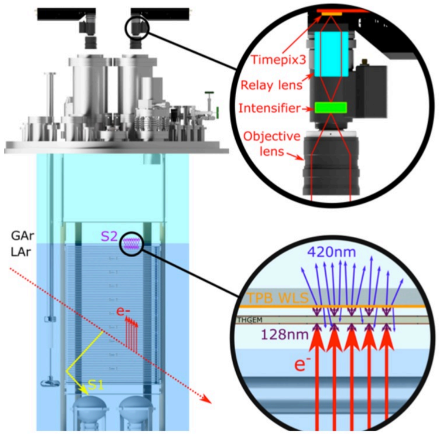
- **Case Study 2 :** Monolithic pixel sensors for future trackers
- **Issue:**
  - radiation hardness requirements
  - precision timing, new opportunities - 4D tracking.
- **Aim:**
  - pixel sensors for medium term future experiments
    - monolithic sensors, CMOS technologies
      large volume, low-cost production.
    - High granularity (25x25 µm)
      & high radiation tolerance (10^{17} 1 MeV neq/cm^2)
    - 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

Example UK project-3: light detection

- **Case Study 3 :** Increased light detection in liquid detectors
- **Issue:**
  - Increased light detection for neutrino & dark-matter experiments
- **Aim:**
  - Sensors for future experiments
    - Develop light sensors
      - Increase eff. in VUV wavelengths
    - Develop charge-to-light and charge+light readouts
      - Lower energy thresholds, better energy thresholds, 4D imaging
    - Reduce backgrounds
      - Improve material screening, novel materials



- **UK DRD Activity:**
  - Noble liquid detectors, water Cherenkov detectors, liquid scintillator detectors – neutrinos, dark matter, neutrinoless double beta
  - world-class facilities at the Boulby underground laboratory
    - Prospects for hosting world-leading science in UK

STFC - DRD

Science and Technology Facilities Council

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 Submission

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 2024

SOI in discussion for Science Board

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

Institute	DRD Collaboration 1	2	3	4	5	6	7	8	Other
Total	9.2	17.3	55.1	15.3	19.7	2.1	23.3	15.3	9.6

FTE yrs

Will need dedicated project funds to effectively leverage

  - List of UK project activities for all DRDs
  - Travel
    - DRD workshops
    - Coordinators
    - Testbeam & irradiation
  - Training
  - Industry links

European Strategy Update | ECFA European Committee for Future Accelerators

February 18, 2024

DRD-UK Consolidated Grant Submission 2025-2029

On behalf of University of Birmingham, University of Bristol, Brunel University London, University of Cambridge, University of Edinburgh, University of Glasgow, Imperial College London, King's College London, University of Lancaster, University of Leicester, University of Liverpool, University of Manchester, University of Oxford, Queen Mary University of London, Royal Holloway University of London, STFC Particle Physics Department, STFC Technology Department, STFC ISIS, University of Sheffield, University of Sussex, University College London, University of York, University of Warwick.

Industry / Infrastructure / Training

- Training
  - UK system often generating physicists with limited instrumentation experience
  - CG submission expresses need for **Centre for Doctorate Training** (CDT), **graduate training programme** – summer school.
- Industrial engagement
  - CERN to UK industry return not well balanced
  - CG submission recommends UK **industry programme board**, **database** UK 'trusted' **suppliers**, proof of concept **technology fund**
- Major Infrastructure identified
  - e.g. Diamond, ISIS, B'ham Cyclotron, Boulby

General Recommendations

- 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

National Semiconductor Strategy

- Commitment made for up to £1bn investment in next decade.
  - 30M announced

Department for
Science, Innovation
& Technology

Policy paper

National semiconductor strategy

Published 19 May 2023

DRD input to STFC (CP, Gianluigi Casse, Richard Farrow):

CNM/FBK style facility

- Access to UK sensor manufacturing companies.
- Infrastructure for prototyping/testing sensor technologies.
- ASIC design tools, training and skills.
- ASIC foundry facilities in Europe or Far East.
- Financial support to prototype technologies.

- STFC engaged with DSIT
- DSIT visited RAL to discuss options Feb 24

Sustainability

See also talk of Veronique Boisvert at this meeting

- STFC considering sustainability policy, SOI options
- 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+

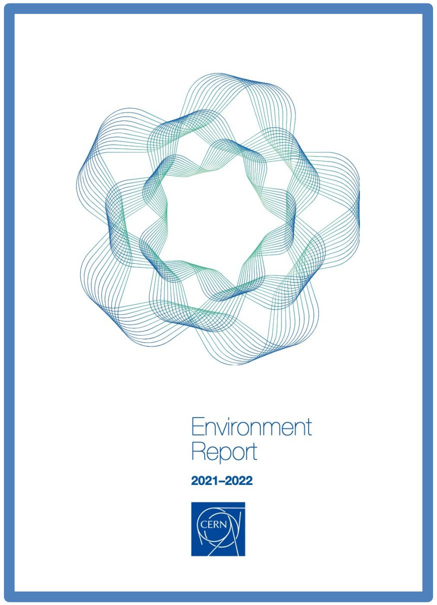
Sustainable HECAP+ Initiative

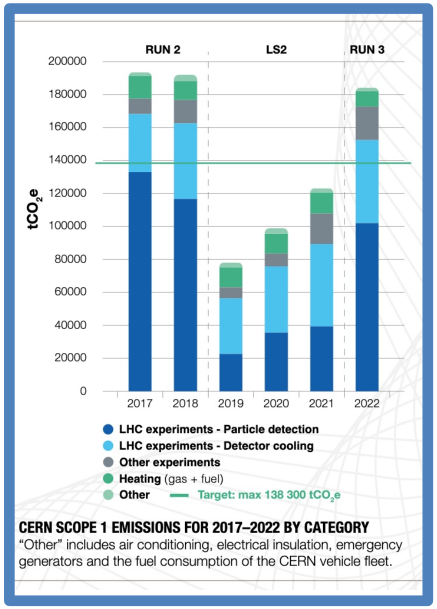
Abstract

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.





CERN SCOPE 1 EMISSIONS FOR 2017–2022 BY CATEGORY

"Other" includes air conditioning, electrical insulation, emergency generators and the fuel consumption of the CERN vehicle fleet.

DRD-UK Meeting today

UK DRD Annual Meeting

Thursday 11 Apr 2024, 14:00 → 17:30 Europe/London

Rotblat lecture theatre in the Chadwick building, Liverpool

Eva Vilella Figueras (University of Liverpool (GB)) , Joost Vossebeld (University of Liverpool (GB))

Description The meeting is taking place on the afternoon after the end of the IOP Joint APP, HEPP and NP annual conference (https://indico.cern.ch/event/1388874/). a zoom connection is also provided.

The DRD-UK meeting is separate from the IOP conference, attendance at the DRD_UK meeting is open to all.

14:00 → 14:20 **Overview of DRD-UK** 20m

DRD-UK plans, with contributions from all DRD-UK coordinators

Speaker: Chris Parkes (University of Manchester (GB))

14:30 → 14:50 **Funding opportunities for DRD [STFC speaker]** 20m

Speaker: Grahame Blair

15:00 → 15:20 **Training & Industry: current activities & plans** 20m

Speaker: Dr Richard Bates (University of Glasgow (GB))

15:30 → 15:50 **Semiconductor trackers (DRD3&8) : current activities & plans** 20m

Speaker: Daniel Hynds (University of Oxford (GB))

16:00 → 16:20 **R&D for neutrinos, dark matter and opportunities at Boulby (DRD2)** 20m

Speaker: Roxanne Guenette

16:30 → 16:50 **Electronics & DAQ: current activities & plans (DRD7)** 20m

Speaker: Marcus Julian French (Science and Technology Facilities Council STFC (GB))

17:00 → 17:30 **Tea & Coffee** 30m

Held series of meetings with steering board and coordinators and PIs of many future experiments with large UK involvement

Take-away messages

- **DRD** – new initiative for Detector Research & Development across particle, astroparticle & (some) nuclear physics
- International & UK organization
  in place across 8 areas
- Specific projects to be priortised
  – not just a discussion forum
  – International MoUs

- CG funding requested, STFC encouraged
- Dedicated project requests to follow