The University of Manchester

European Strategy Update | ECFA European Committee for Future Accelerators

Detector Research & Development

DRD Collaborations

- DRD Concept
- International Status
- UK Status

Thanks: Thomas Bergauer, Phil Allport, Didier Contardo

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

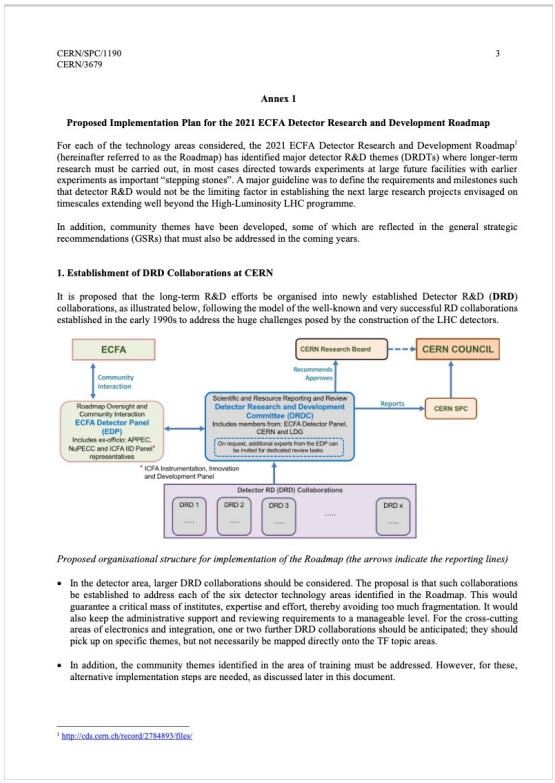
Concept

"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 3
CERN/3679

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

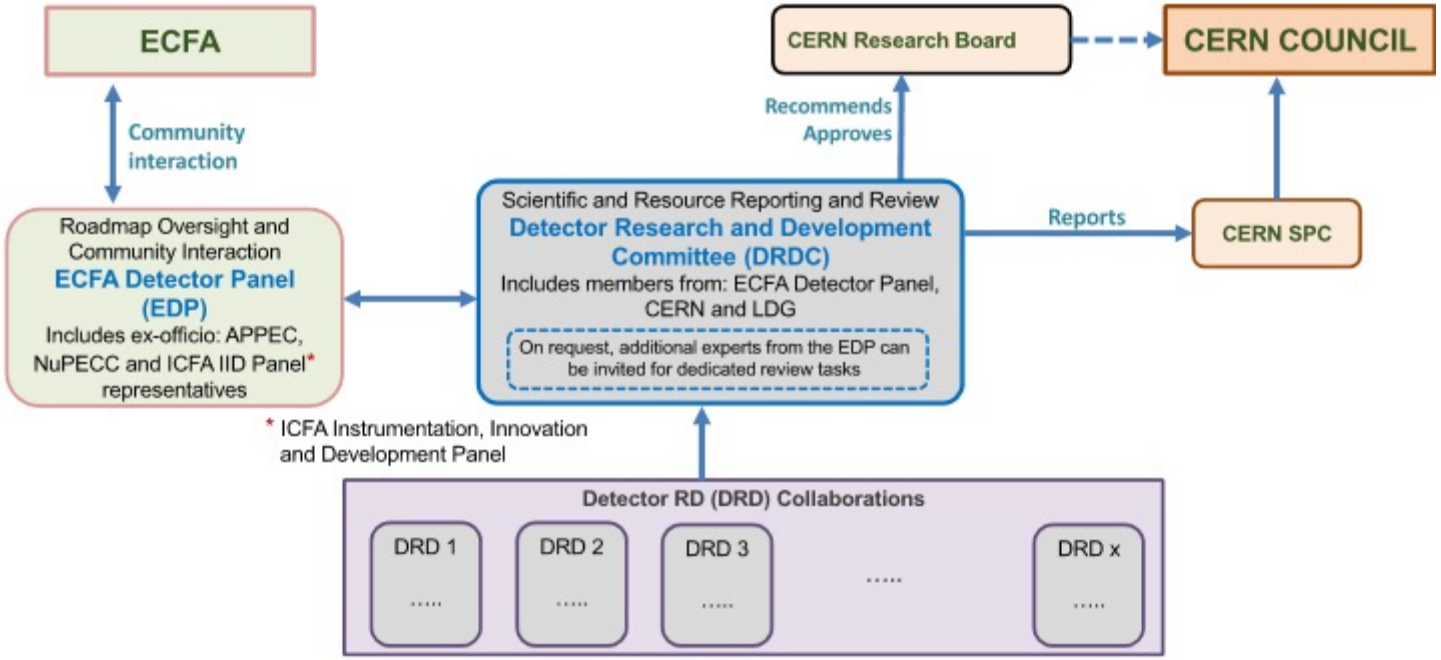
R&D programme will:

- 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
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APPROVED
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friendly gases

2. Liquid

e.g.
Light/
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3. Semiconductor

e.g.
CMOS
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(10s ps)

4. PID & Photon

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6. Calorimetry

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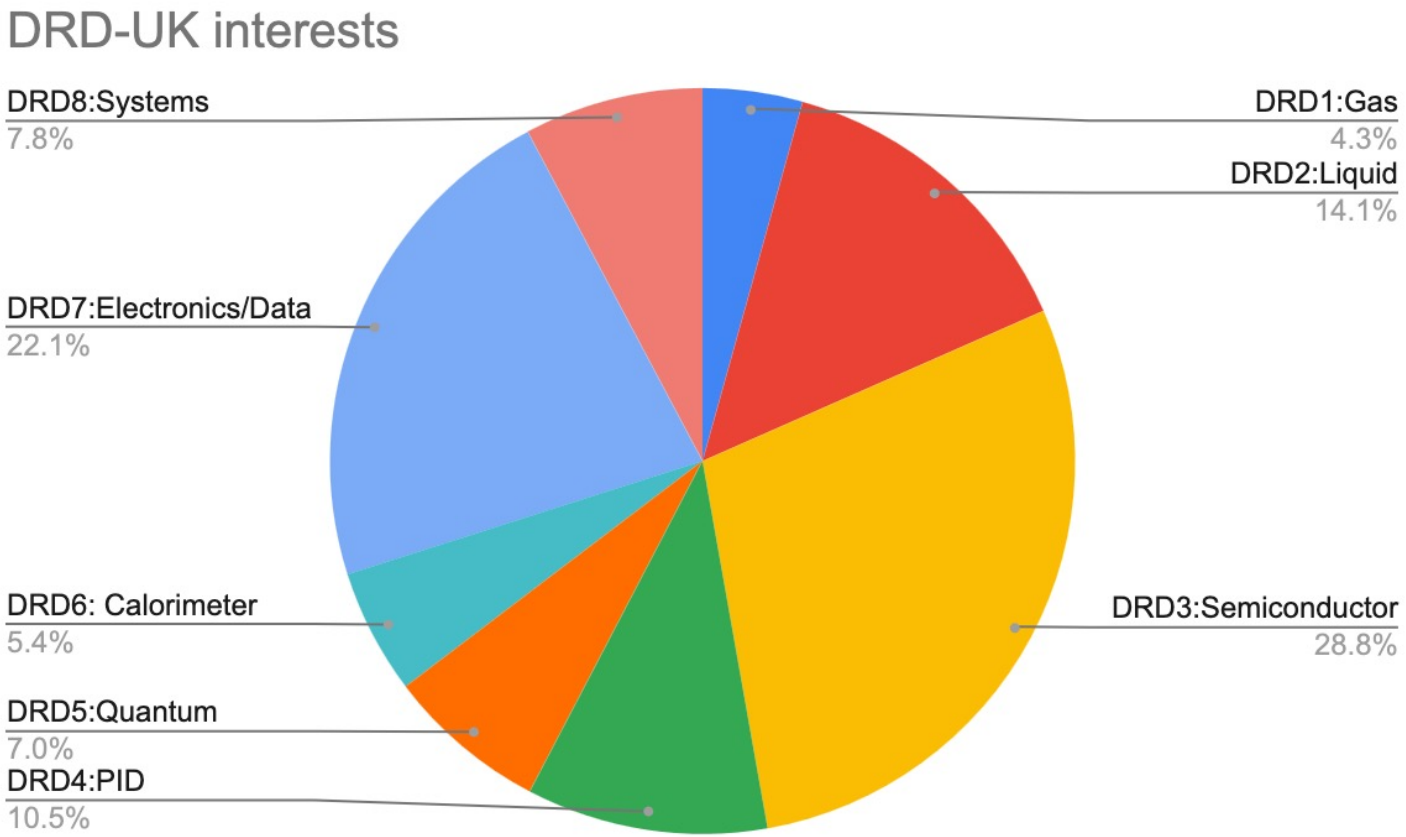
8. Integration

Letter of
Intent

UK Interests

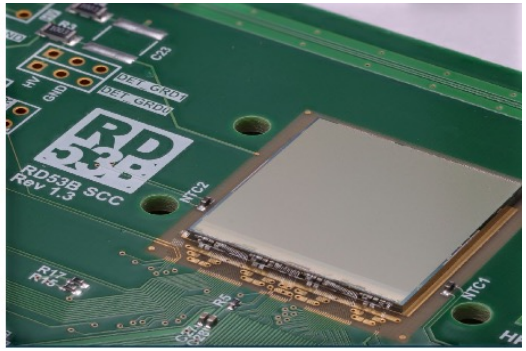
Survey of UK particle physics groups through steering board



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

Example UK project- 1: ASIC

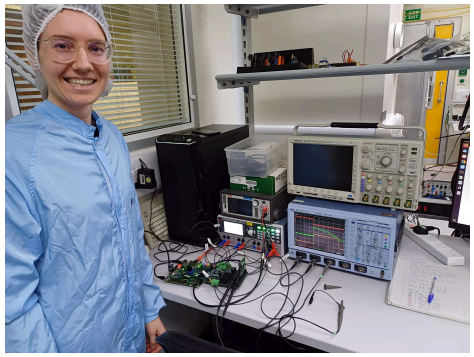
- **Case Study 1 : Common interface ASIC for readout, timing, and control**
- **Issue:**
  - ASIC development major source of schedule slippage in experiments.
  - Iteration time of the order 12-18 months.
  - high production costs of smaller feature size ASICs
- **Aim:**
  - Develop ASIC family & common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

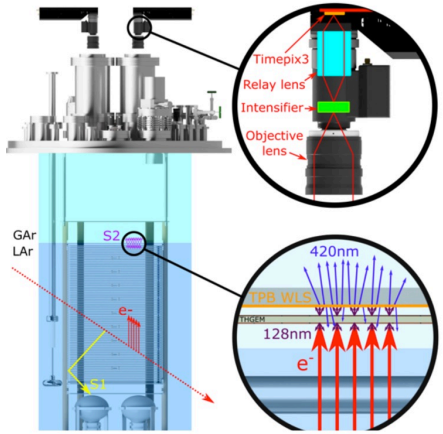
Example UK project-2: CMOS

- **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

Alignment with UK CERN strategy

- 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

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

CNM/FBK style facility

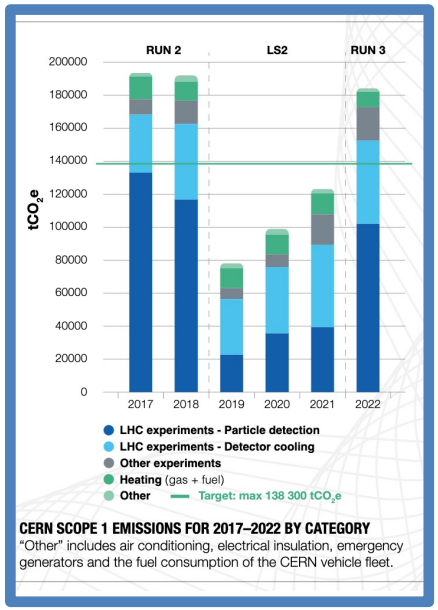
- Access to UK sensor manufacturing companies.
- Infrastructure for prototyping/testing sensor technologies.
- ASIC design tools, training and skills.
- ASIC foundry facilities in Europe or Far East.
- Financial support to prototype technologies.

- 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)



DRD-UK Organisation

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

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

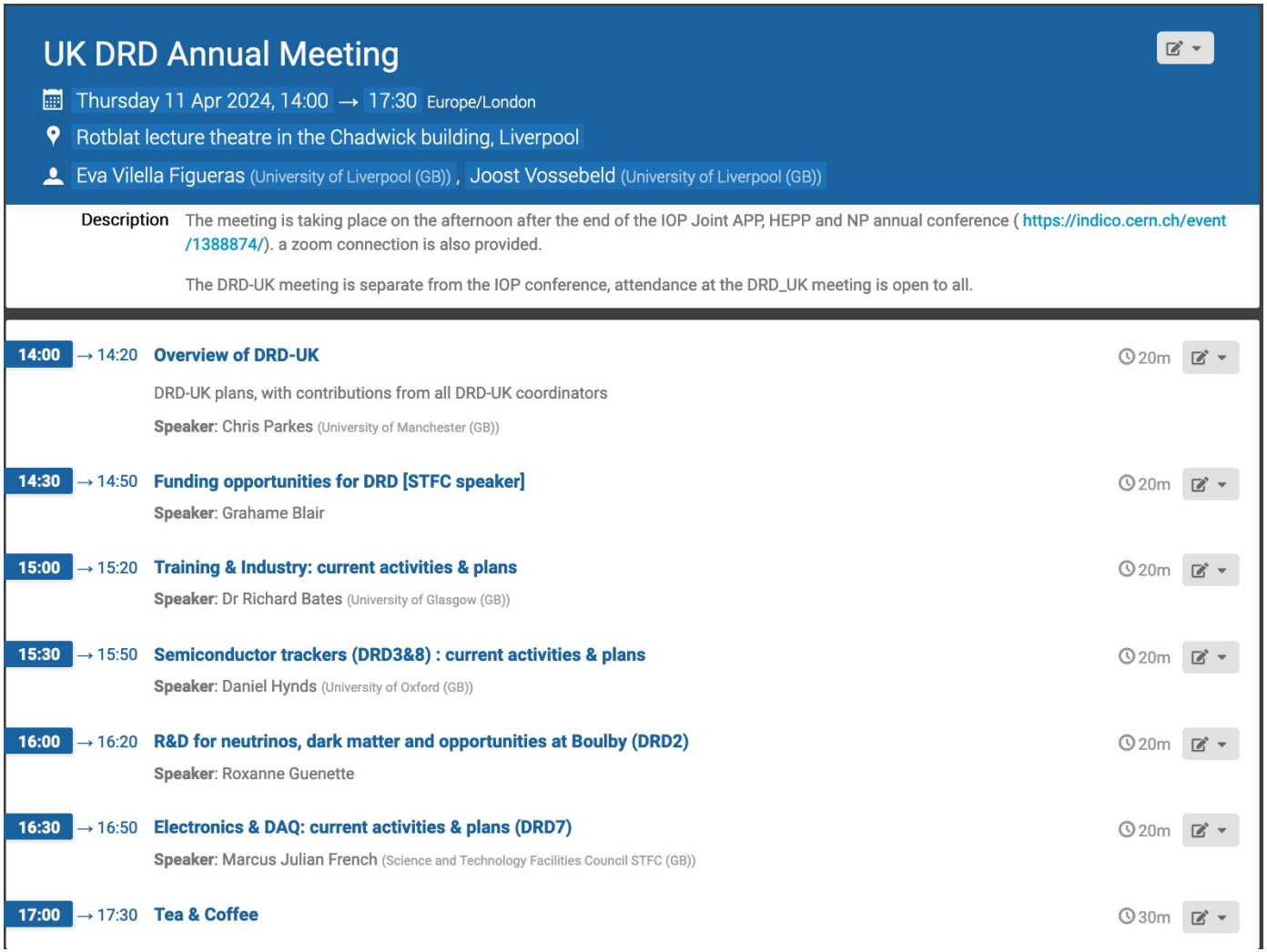
Steering Board

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

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