Bid for STFC HEP-DRD Summer School 2025

Course organisers/School directors: Dr R.Bates, Dr J.Dopke, Prof C.Lazzeroni
Date and venue: Summer 2025, at RAL and Cosener's House
School duration: 9-days residential course
School size: Places for 25 PhD students, of which 21 will be reserved for STFC-funded PhD students

Outline

The delivery of world-class science in particle physics, astro-particle physics and nuclear physics research is foundational to the purpose of STFC. Particle physics will enter a new era as ATLAS and CMS phase II R&D ends and we, in the European community, update our strategy for particle physics in 2025. Enabling science by the development of novel instrumentation is part of the mission. The development of cutting-edge instrumentation has a proven track record in providing some of the strongest STFC engagements with other discipline areas and the associated benefits to society. This includes benefits to national facilities (ISIS, Diamond, RAL Space) and medical and security applications.

The detector R&D for the next decade is focused on providing the innovative technologies, infrastructure and staff skills that will enable a set of medium and smaller scale projects with more diverse aims until the next major projects (i.e. the next future collider) take over. An international programme of strategic R&D in detector systems is being setup, known as DRD. The UK community (particle, astro-particle and relevant nuclear physics) is fully engaged in this process, which it has helped shape, and provides several of the international leaders of the DRD process and collaborations.

However, there is a lack of younger expertise in detector technology development and difficulties in recruitment and retention are encountered. Additionally, experimental particle physics PhD students often do not have the opportunity to gain hands-on experience in the detectors used to collect the data they analyse. This was raised during the PPAP and PPTAP discussions, where the loss of UK expertise in instrumentation was further highlighted. The UK has a strong presence and commitment to the DRD programme, with world-leading R&D in many areas. To sustain and capitalise on this effort and expertise, and prepare young physicists for the detector challenges of the future, we propose a dedicated PhD Summer School on instrumentation that is focused on all UK DRD activities. The school is an opportunity to up-skill a generation of particle physicists to assure the future success of the field and lay the foundations for the next generation of leadership within the UK.

Examples from existing initiatives of this kind both demonstrate the appetite for it, and the existing gap that we are addressing with this proposal. The long-running successful HEP Summer School on theory and phenomenology provides a template for the DRD-UK residential component. This bid has been discussed with the HEP Summer School organisers and is designed to be complementary. The successful silicon UK-HEP Summer School (first school happened in 2024 in Oxford, 24 students) demonstrated the interest from one element of the community, and the present bid will build on the experience accumulated here. However, in UK and internationally there is a lack of a Summer School covering R&D work across all technologies.

To address this gap, we propose this school that will have a substantial laboratory and practical component. The school will take the material covered in the previously-running RAL Graduate Lectures, complement it with further lectures tailored on the DRDs, and develop key aspects in the laboratory setting during "Lab days" particularly related to DRD research. This will allow students to deepen and broaden their understanding of the field, alongside gaining practical skills in the tools and techniques required for advanced studies.

The school will be hosted at RAL and Cosener's House. Lecturers, demonstrators, as well as the directors, will be drawn from the UK-HEP community. The school will prioritise STFC students; and be open to international participants and to self-funded or non-STFC funded students, at a suitable cost.

Course description

The course will be arranged over 9 days, starting Saturday lunchtime and ending at lunchtime the following Sunday. Lectures will be held at Cosener's House, and laboratory work will be conducted at RAL. The first half

day will be mostly dedicated to socialising, and orientating, with a general introduction to the school, its aims and methodology. It will include a poster session where the students will present their PhD work to their peers.

Lectures will be concentrated at the start of the course, to prepare the necessary background knowledge for the laboratory hands-on work during the rest of the week. The general approach will follow the design of key experiments: a couple of past examples looked at in detail will offer a practical link between physics aims and detectors, and prepare for the high-level introduction of instrumentation in HEP as driven by the needs of specific physics measurements. Lectures on fundamentals of instrumentation modalities will follow, which will be later applied in laboratory work. The laboratories will be dedicated each to the research done in one DRD group, with 5 labs running in parallel and having 5 students each: DRD1 (gas), DRD2 (liquid), DRD3+DRD8 (silicon and low mass mechanics), DRD4 (PID), DRD7 (DAQ and electronics). Students will rotate between the labs in each half day, covering all labs by the end of the school. Included in the school will be how to organise, run and make the most of a testbeam. Friday afternoon will be spent in a tour of RAL major research infrastructure and facilities, where the theory of testbeams, accelerators, and experiments will come to life. On Saturday, a group exercise, including student presentations, designing a detector demonstrator for an experiment planned around key physics channels will be conducted, using the knowledge acquired at the school. The last session of the school will be a collection of short talks, dedicated to future planned experiments and their technology challenges. The overall schedule is presented in Figure 1.

Practical considerations were included into the timetabling, such as: off-peak travel for delegates; opportunity for lab demonstrators to setup on Mon-Tue before lab work starts on Wed, and to dismount and leave after Fri lunchtime. We present here two examples of current research in DRD2 and DRD4, that will be incorporated into lectures and laboratory work:

- Characterising the radioactivity of materials is key in understanding expected background in rare event searches. Students will gain an understanding of how germanium detectors work and how to interpret data taken using them. Students will also be given access to data taken using one of the high purity Germanium detectors at the Boulby Underground Laboratory and challenged to determine the levels of Uranium, Thorium and Potassium in the sample. The theory behind the functioning of the Germanium detectors will be explained in preparatory lectures.

- Photo-detectors play a central role in collecting photons from large liquid detectors, and a variety of particle-identification detectors. Introductory lectures will explain the working principle and applications of photo-multipliers (PMT), silicon PMT, and MCP-PMT, including the latest technology challenges. In the lab, students will first operate small devices to become familiar with the equipment and their basic functioning, including a readout system. Basic quantities will be measured, such as number of photo-electrons, quantum efficiency and gain. Later on, more complex measurements, for example time performances and uniformity of response will be performed. These lectures and exercises teach students the basic operation principles of photo-detectors and their applications, and the nature of photon statistics.

The school is committed to the UKRI equality and diversity policy. The location of the school is compatible with disability access, with no barriers to participation from any of the protected groups. Week-end childcare for 4 children is included in the costing.

Evening sessions

Evening sessions will be organised to extend the school's utility beyond the direct subject matter. These will be focused around guests from industry and academia. Specifically, evening sessions will cover academic career opportunities, presentations by the industrial sponsors on a career in industry, public engagement and how to best communicate scientific results, and broader issues associated with carrying out a PhD in particle physics instrumentation (including mental health care). We plan to invite CERN/STFC alumni guests for an after-dinner event (see below, in-kind contribution). These activities will encourage interaction between participants outside of the scheduled programme.

Laboratory leaders and demonstrators

Each laboratory course will have a dedicated lecturer who is an expert in the field working in the UK DRD research. They will be resident during the course and available for discussion outside of the laboratory sessions. Additional assistance will be provided by demonstrators in laboratory session, who will be experts working on that particular area of research. Both lecturers and demonstrators will come from UK Universities, highlighting the collaborative nature of the DRD research programme. The course directors will provide teaching. As with the online lecture programme, relevant UK FLF and ERF fellows will be asked to teach on their research areas.

Summer school costs

Table 1 details the costs of the school. Accommodation for both staff and students will be at Cosener's House in Abingdon. To facilitate logistics, we foresee full days of laboratory activities at RAL between days of lectures, group activities and evening events at Cosener's. This will encourage interaction between participants, and between participants and evening guests. Transportation will be arranged between RAL and Cosener's House on the laboratory days. Due to the lab-based nature of the school, the total number of students is restricted, and a higher ratio of tutors to students is required. The resulting cost to STFC per student is therefore around 40% higher than a purely lecture-based school. Instrumentation costs were requested in the CG2024 round, budgeted at £35k for the first cohort. We budget for 60 staff days with 16 staff members to cover the lectures and laboratories; travel is reduced assuming 4 local staff. Week-end childcare costs for 4 children is included inline with our EDI policy. The school will aim to obtain commercial sponsorship from UK instrumentation companies,

	Cost per person/day/unit (£)	TOTAL (£)
Lecturers/Demonstrators (16)		
Fees	170	10,200
Travel Expenses (12 staff)	200	2,400
Accommodation/Day Rate (60 nights)	77	4,620
Meals/Refreshments	50	3,000
Conference Dinner	50	500
Student Delegates (25)		
Accommodation/Day Delegate Rate	77	15,400
Conference Dinner	50	1,250
Meals/Refreshments	50	10,000
Other Costs (assumed 33 people)		
Room booking at Coseners (7.5 days)	500 (per 1/2 day)	3,750
Travel between RAL and Coseners (3 days)	15	1485
Consumables/Admin		750
Secretarial/Technical Support		750
Child care		1600
Contingency		1500
Total cost		57,205
Income (paying students/sponsorship)		8,000
Total funds requested from STFC		49,205

Table 1: STFC HEP-DRD Summer School 2025: cost estimate.

such as Photek, Agilent and Teledyne e2V. Sponsors may supply marketing materials to the students and present during the Careers in Industry evening session. We will request £500 from each company. Laboratory space and consumables will be provided by the host (RAL). In future years the school might rotate between leading UK institutes who have contributed significant material to the programme and have the laboratory facilities. The online lecture programme represents a significant in-kind contribution from across the UK. We will also investigate sponsorship from CERN (alumni involvement for the after-dinner event).

	Morning	Afternoon	Evening
Saturday	Arrive	Getting to know each other, Poster Session	Instrumentation Quiz
Sunday	Overview of HEP insturmentation	Why we build them the way we do	Undertaking a PhD journey
Monday	Silicon Detectors and Low Mass Mechanics	Particle Identification	Gas Detectors
Tuesday	Liquid Detectors	DAQ/Electronics	Careers in Academia
Wedneday	Lab day at RAL	Lab day at RAL	Running a Testbeam
Thursday	Lab day at RAL	Lab day at RAL	Careers in Industry
Friday	Lab day at RAL	RAL & Diamond facilities tour	School Formal Dinner - CERN/STFC alumni
Saturday	Group Exercise - Experiment design - Part I	Group Exercise - Experiment design - Part II	Public engagement
Sunday	State-of-the-art experiments	Depart	

Experiment Design Lectures	Hands on Laboratories	Networking events
Detector Technology Lectures	Group Exercise	Broader Lectures

Figure 1: Proposed schedule of the STFC HEP-DRD Summer School 2025. The key below the table explains the six different styles of activity incorporated in the school design.