

Strategic Detector R&D Proposal

▶ History to date: Europe

- ▶ European roadmap 2020 mandated new programme of strategic R&D
- ▶ Substantial work in 2021 / 22 to define an R&D roadmap
- ▶ Roadmap accepted by Council and new DRDC panel set up to evaluate proposals to form new collaborations – now under way

▶ History to date: UK

- ▶ PPTAP reported to TAAB on the scope and motivation of future R&D
- ▶ Proposal for strategic R&D presented to STFC via PPAP in September 2022
 - ▶ Deemed relevant / plausible, but not suitable for Infrastructure Fund submission
 - ▶ Broad community support for the proposal from both PP and PA communities
- ▶ After extensive discussion, there is opportunity for SoI in September 2023
 - ▶ Money *potentially* available in FY24/25, but we will need to make a very strong case
 - ▶ STFC will require an organised project that can be reviewed / tensioned by the PPRP

▶ DRD7 discussion points for today

- ▶ There is a problem to be solved: do we agree?
- ▶ There is likely to be money in the UK; do we have a community to access it?
- ▶ What are our priorities and focal points? What do we want to do?
- ▶ How do we get organised?

UK 'Electronics' Situation

- ▶ Historically, this area is a UK strength
 - ▶ Evidence: we lead / have led TDAQ for countless experiments
 - ▶ Today: CMS, ATLAS, DUNE, Hyper-K, plus substantial contributions to others
 - ▶ Genuine 'strength in depth' at UK universities and labs
 - ▶ Good cross-over with other big science activities (e.g. astro, light sources)
- ▶ Very little 'top down' organisation in recent years
 - ▶ Tends to be somewhat project-focussed
 - ▶ Exception may be FE ASICs, where capabilities at RAL and elsewhere are used across projects
 - ▶ Even here, the future prospects / needs are not well established
 - ▶ UK leads support (via Europractice) of CAD tools across the field
 - ▶ Age profile is worrying, new skills (e.g. online SW-HW interface) needed
- ▶ What can we do? What should we do?
 - ▶ Limited UK participation in TF7, but people have stepped up for DRD7
 - ▶ Urgently need a discussion on these topics before the coming DRD7 workshop
 - ▶ Not least because we will need to support developments in other DRDs

Strategic R&D

- ▶ A spectrum of R&D is needed to deliver projects
 - ▶ ‘Blue skies R&D’ (low TRL): new concepts, small demonstrators, small teams (with good support)
 - ▶ ‘Strategic R&D’ (mid TRL): developing systems and prototypes, investigating cost / performance, larger teams with involvement of industry
 - ▶ ‘Project R&D’ (high TRL): developing detector for specific experiments / applications, full collaborations with substantial funding, industry as suppliers
- ▶ This proposal does not replace or reproduce PRD
 - ▶ Blue skies R&D will be supported via other means
- ▶ Collective and coordinated work is needed
 - ▶ Cost / scale / complexity is growing beyond the capacities of any group
 - ▶ Effective / efficient access to specialised tools and facilities is needed
- ▶ We need to begin ‘now’
 - ▶ Yes, R&D is in tension with construction projects
 - ▶ However, these projects are now ending their R&D / setup phase and experts will need new roles
 - ▶ A ramp-up rather than a big bang is needed – though planning cannot wait
 - ▶ With tight resources, the value of a well-coordinated programme is evident

R&D Proposal: Objectives

- ▶ Develop and sustain a world-leading **capability** for advanced detector technology R&D in the STFC research community
- ▶ Facilitate continued UK **leadership** in the European R&D programme, and subsequent resulting leadership in next-generation experiments
- ▶ Construct and support specialised **facilities** at UK institutes, supporting international capability in detector development
- ▶ Identify routes for rapid **application** of new detector technologies across national facilities, academic disciplines, and industry
- ▶ Support co-development of technologies with UK **industry**, leading to enhanced economic return from international investments
- ▶ Transform skills development, training and career prospects for technology-focussed **early career researchers** in STFC core science

R&D Proposal: Scope and Outcomes

▶ Scope

- ▶ Matched (in principle) to the scope of the European Roadmap
- ▶ Accepts that some prioritisation will be needed, but does not make recommendations on which R&D topics are the priorities
 - ▶ This is for peer review, look at a wide range of practical and strategic criteria
 - ▶ Clearly the question of focus and 'critical mass' comes into this – this is not PRD
- ▶ Explicitly covers both PP (collider, flavour, neutrinos) and PA (DM, quantum)
- ▶ Focussed on both people and the required facilities in labs and institutes

▶ Outcomes (other than the R&D deliverables themselves)

- ▶ Proposals via the STFC Visions process for follow-up project R&D and construction of new instruments
- ▶ Supply of high-technology deliverables to international projects, either as UK buy in or via contracts
- ▶ Interdisciplinary proposals for application of technology in non-STFC areas, either via the UK's national facilities or within institutes
- ▶ Exploitation of IP within industry via licenses and other agreements
- ▶ Direct employment of trained people in industry.

R&D Proposal: Plan and Resources

▶ Three main threads

- ▶ Medium-scale R&D projects, within the context of the European Roadmap
 - ▶ i.e. facilitating and supporting UK leadership in the DRD collaborations
 - ▶ 'Medium scale' means £1M+ per year per project, sustained in the long term
- ▶ Funding stream explicitly for interaction with industry
 - ▶ Including development of a coherent and focussed 'offer' to UK industry
- ▶ Distributed CDT in detector technology and data-handling
 - ▶ CDT in the sense of cohort training and industry involvement; but across many institutes

▶ Resources

- ▶ Some new money is clearly needed to get going – estimate £3M pa
 - ▶ Note that we do NOT need money in the coming year other than travel, etc
- ▶ Since there are no new core-funded construction projects on the roadmap, addition resources will become available post-2026
- ▶ Estimate that a sustained level of £10M per year would allow UK leadership in targeted areas
- ▶ Note that other comparable countries are already spending far more than this
 - ▶ And planning additional investment in the context of the European Roadmap

Pause

DRD7 Outlook

▶ DRD7 = Electronics and Data Processing

		DRDT	< 2030	2030-2035	2035-2040	2040-2045	> 2045
Data density	High data rate ASICs and systems	7.1	● ● ●	● ●* ●	● ●	● ● ●	● ● ●
	New link technologies (fibre, wireless, wireline)	7.1	● ● ●	● ● ● ●	● ● ●	● ● ● ●	● ● ● ●
	Power and readout efficiency	7.1	● ● ●	● ●* ● ●	● ● ●	● ● ● ●	● ● ● ●
Intelligence on the detector	Front-end programmability, modularity and configurability	7.2				● ● ●	● ● ● ●
	Intelligent power management	7.2	●	● ●*	● ● ●	● ● ● ●	● ● ● ●
	Advanced data reduction techniques (ML/AI)	7.2				● ● ●	● ● ● ●
4D-techniques	High-performance sampling (TDCs, ADCs)	7.3	● ●	● ● ● ●	● ● ●	● ● ● ●	● ● ● ●
	High precision timing distribution	7.3	● ●	● ● ● ● ●	● ● ● ●	● ● ● ● ●	● ● ● ● ●
	Novel on-chip architectures	7.3	● ●	● ● ● ●	● ● ● ●	● ● ● ● ●	● ● ● ● ●
Extreme environments and longevity	Radiation hardness	7.4	● ● ●	● ● ● ●	● ● ●	● ● ● ●	● ● ● ●
	Cryogenic temperatures	7.4		●			● ● ● ●
	Reliability, fault tolerance, detector control	7.4	● ● ●	● ● ● ●	● ● ● ●	● ● ● ● ●	● ● ● ● ●
	Cooling	7.4		● ●* ● ●	● ● ●	● ● ● ●	● ● ● ● ●
Emerging technologies	Novel microelectronic technologies, devices, materials	7.5	● ● ●	● ● ● ●	● ● ● ●	● ● ● ● ●	● ● ● ● ●
	Silicon photonics	7.5		● ● ● ●	● ● ● ●	● ● ● ● ●	● ● ● ● ●
	3D-integration and high-density interconnects	7.5	● ● ●	● ● ●* ●	● ● ● ●	● ● ● ● ●	● ● ● ● ●
	Keeping pace with, adapting and interfacing to COTS	7.5	● ● ●	● ● ● ● ●	● ● ● ●	● ● ● ● ●	● ● ● ● ●

● Must happen or main physics goals cannot be met
 ● Important to meet several physics goals
 ● Desirable to enhance physics reach
 ● R&D needs being met

▶ Electronics is needed for everything, everywhere

- ▶ But: the technologies, systems, and the way we build them may look quite different in the future
- ▶ Combination of short-term, medium-term, and long-term R&D

DRD7 Workshop

09:00	Introduction <i>Prof. Dave Newbold et al.</i>	40/S2-D01 - Salle Dirac, CERN	09:00 - 10:00
10:00	Coffee Break	40/S2-D01 - Salle Dirac, CERN	10:00 - 10:30
11:00	Data Density (DRDT7.1) <i>Dr Christophe FLOUZAT, Jeffrey Prinzie, Szymon Kulis</i>	40/S2-D01 - Salle Dirac, CERN	10:30 - 12:00
12:00	Lunch break		

09:00	Extreme environments and longevity (DRDT7.4) <i>Giulio Borghello, Manuel Dionisio Da Rocha Rolo, Oscar Francisco</i>	40/S2-C01 - Salle Curie, CERN	08:30 - 10:00
10:00	Coffee Break	40/S2-D01 - Salle Dirac, CERN	10:00 - 10:30
11:00	Emerging technologies (DRDT7.5) <i>Conor Fitzpatrick, Jan Troska, Dr Michele Caselle, Niko Neufeld</i>	40/S2-C01 - Salle Curie, CERN	10:30 - 12:00
12:00	Lunch break		

► <https://indico.cern.ch/event/1214423/>, 14th-15th March 2023

12:00 - 13:30			
14:00	Intelligence on detector (DRDT7.2) <i>Davide Ceresa, Francesco Crescioli, Frederic Magniette</i>	40/S2-D01 - Salle Dirac, CERN	13:30 - 15:00
15:00	Coffee Break	40/S2-D01 - Salle Dirac, CERN	15:00 - 15:30
16:00	4D techniques (DRDT7.3) <i>Adriano Lai, Marek Idzik, Patrick Robbe, Sophie Baron</i>	40/S2-D01 - Salle Dirac, CERN	15:30 - 17:00
17:00			

12:00 - 13:30			
14:00	Monolithic sensor ASICs (DRDT7.6) <i>Iain Sedgwick, Marlon B. Barbero, Walter Snoeys</i>	40/S2-C01 - Salle Curie, CERN	13:30 - 15:00
15:00	Coffee Break	40/S2-C01 - Salle Curie, CERN	15:00 - 15:30
16:00	Technologies and tools (DRDT7.7) <i>Kostas Kloukinas, Mark Willoughby, Xavi Llopart Cudie</i>	40/S2-C01 - Salle Curie, CERN	15:30 - 17:00
17:00	Closeout <i>Prof. Dave Newbold, Francois Vasey</i>	40/S2-C01 - Salle Curie, CERN	17:00 - 17:30

What Next?

- ▶ Engage wider UK community
 - ▶ Find those in the 'next generation' who want to play a part
 - ▶ Encourage analysis and questioning of the roadmap
 - ▶ Ask people to attend (preferably in person) the DRD7 workshop
- ▶ UK preparatory workshop needed before 14th March
- ▶ Identify a UK set of strategic priorities
 - ▶ Which capabilities and skills do we have? Which do we want?
 - ▶ What are the needs of future UK R&D activities and experiments?
 - ▶ Why are developments so difficult and expensive? How must we work together?
 - ▶ DMN view: more explicit cooperation and sharing of IP needed across groups / projects
 - ▶ Is there crossover with other projects of interest to universities and labs?
- ▶ Goal
 - ▶ UK leadership in a few key selected areas
 - ▶ World-class support via engineering, facilities and tools
 - ▶ Full integration with parallel DRD activities (as for DRD7 itself)
 - ▶ Perhaps important: development and support of the **next generation of experts**

Backup

What Now?

▶ Current events

- ▶ DRD collaborations starting to take shape
- ▶ Workshops and surveys being conducted to establish a work plan
- ▶ ECFA seeking input on 'funding agency positions'

▶ Chicken and egg

- ▶ UK cannot seek to define a leading contribution without commitment from STFC
- ▶ STFC cannot commit funding until the scope and scale of the programme is known
- ▶ **SoI invitation is designed to break this cycle, allowing us to proceed**

▶ What we need to do in the UK in the next six months

- ▶ Debate / agree the broad intent of the R&D proposal and the timeline
- ▶ Review our interests and interactions with DRD collaborations – today
- ▶ Establish coordination structures and seek volunteers to take leadership
 - ▶ **Both at 'WP level' <-> DRDs and 'Steering level'**
- ▶ Set up task forces on training (CDT) and industry engagement
- ▶ Provide an initial update to STFC Programmes before the town meeting (April)
 - ▶ **And allow our ECFA contacts to report back on our planning / progress**

Discussion Points

▶ Breadth vs depth

- ▶ Focus efforts on a few areas or maintain a broad scope?
- ▶ Which DRDs does we plan to engage in? Critical mass?

▶ Interaction with DRDs

- ▶ Do we present ourselves as 'the UK project' or as institutes?

▶ Organisation

- ▶ Are we happy with the 'classic' STFC project organisation: i.e. parallel WPs with thin top layer?
- ▶ How do we achieve a costed outline plan by September?
- ▶ What is the interaction of UK approval steps with the DRDC process?

▶ What is the specific role of the national labs?

- ▶ Do we wish to propose / request new facilities or engineering capabilities?

▶ Are we happy with the proposed training model?

- ▶ How much emphasis should be put on this vs PDRAs and engineers?

▶ How should we organise ourselves?

- ▶ A lot of work to do in the next few weeks / months – need people to take responsibility
- ▶ **This is the opportunity for a new generation of experts to come forward and take leadership**
 - ▶ **But we also need to incorporate the wisdom / experience of the generation that built the LHC detectors**

We have views - but we need to hear yours

PPTAP

- ▶ STFC set up an advisory panel to consider our response
 - ▶ Aably chaired by Paula Chadwick, ~12 particle physicists involved
 - ▶ “The purpose of the Particle Physics Technology Advisory Panel (PPTAP) is to ...produce a coherent UK position on the development of the R&D roadmaps related to the European Strategy for Particle Physics Update. ... the UK will benefit from a coherent and strategic approach to future R&D in these fields”
- ▶ Key recommendations
 - ▶ The UK must respond to complement the implementation of the ... R&D roadmaps by undertaking an STFC-funded programme of long-term ADSC technology R&D
 - ▶ A funded framework be implemented by STFC to both direct and respond to community and STFC requirements... with a selection of directed responsive mode funding opportunities available for HEIs, National Laboratories, and other PSREs, and encourage low-TRL co-development with industry.
 - ▶ Any funding ... should be in addition to funding allocated to current and future activities within the broader PP programme
- ▶ TAAB endorsement (on a par with Science Board, for Technology)
 - ▶ TAAB urges STFC to initiate a call in the coming months for R&D specifically targeted at the roadmaps and participating in European or global R&D programmes, aimed at (re)directing future funds (in-house and programmes directorate) in a more strategic manner.

UK Roadmaps

▶ PPAP

- ▶ Essential to have a **broad portfolio of projects** to efficiently balance R&D phases for future programmes from the dedicated production builds
- ▶ Maintaining a **balanced portfolio** is key to enabling technology and skills exchange
- ▶ The R&D activities relevant for the HL-LHC should serve as a basis for the detector development relevant for **future colliders**
- ▶ Investment in **appropriate R&D** on detector and accelerator technologies / systems ... will position us to take a **leading role** in e^+e^- collider physics
- ▶ Should maintain leadership during R&D, construction and exploitation of **Direct DM Detectors**
- ▶ STFC should facilitate **access to funding opportunities** for [basic R&D], where possible using external funding streams

▶ PAAP

- ▶ An effective and cost efficient mechanism could be to provide funding for **long-term technology development** in areas applicable to a larger number of the upcoming projects... **larger, technology-focussed grants** which could fund centres of excellence comprising either single or a **distributed network of institutes**.
- ▶ A new mode of **larger scale technology programmes** which would assemble expertise to develop high impact technologies with application across **multiple projects and fields**