PPTAP Solid State Summary
My (quick) overview

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Particle Physics Technology Advisory Panel (PPTAP)

- **Aims**
  - Produce an evidence-based report and provide it to STFC
  - Overview the emerging R&D roadmaps
  - Understand the case for investment in R&D

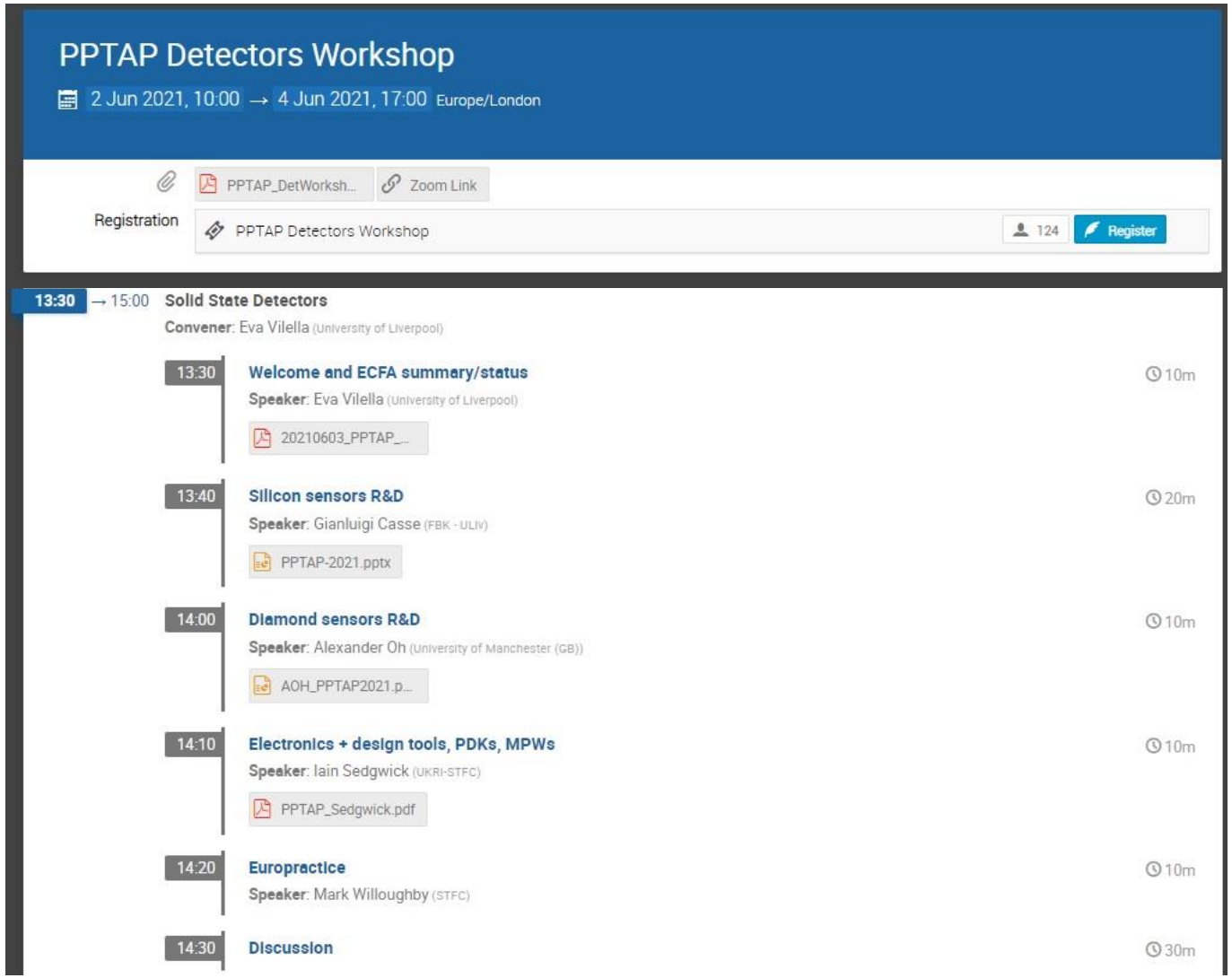
- **The challenge**
  - Identify where UK scientific interests and technological strengths lie
  - Understand where the main technological challenges and opportunities are and how the UK can contribute
  - Look for areas where there are commonalities with other UK science areas to boost this contribution

Particle Physics Technology Advisory Panel (PPTAP)

- **Process**
  - PPTAP started in late 2020
  - Panel composed of several researchers from across the different disciplines of accelerator and particle physics detectors
    - 15 areas of expertise, with one representative per area
    - One area dedicated to Solid State Detectors
  - Panel met regularly during the first half of 2021
  - **Consultation process with the community**
    - Gather input from the community to draft the roadmap
    - Questionnaire
    - **PPTAP Detectors-wide WS, with one session dedicated to Solid State Detectors**
    - **Dedicated additional discussions with the Solid State community**
  - **PPTAP report published in Summer 2022**

PPTAP Detectors WS – Solid State session

- **The talks were good…**
  - **Silicon sensors R&D (Gianluigi Casse)**
    - Several options on the menu (hybrids, monolithics and other sensors)
    - But with major challenges to solve on key areas (time resolution, speed, granularity, radiation tolerance and mass)
    - Manufacturers and strategy to follow –example of SiPM R&D for physics but with direct industrial interest (read money input)
  - **Diamond sensors R&D (Alexander Oh)**
  - **Detector design dependencies (Iain Sedgwick)**
    - Design tools & foundry access
    - IP development, testing & quality control
    - Staff
  - **Europractice (Mark Willoughby)**



- **Link →** https://indico.stfc.ac.uk/event/316/

PPTAP Detectors WS – Solid State session

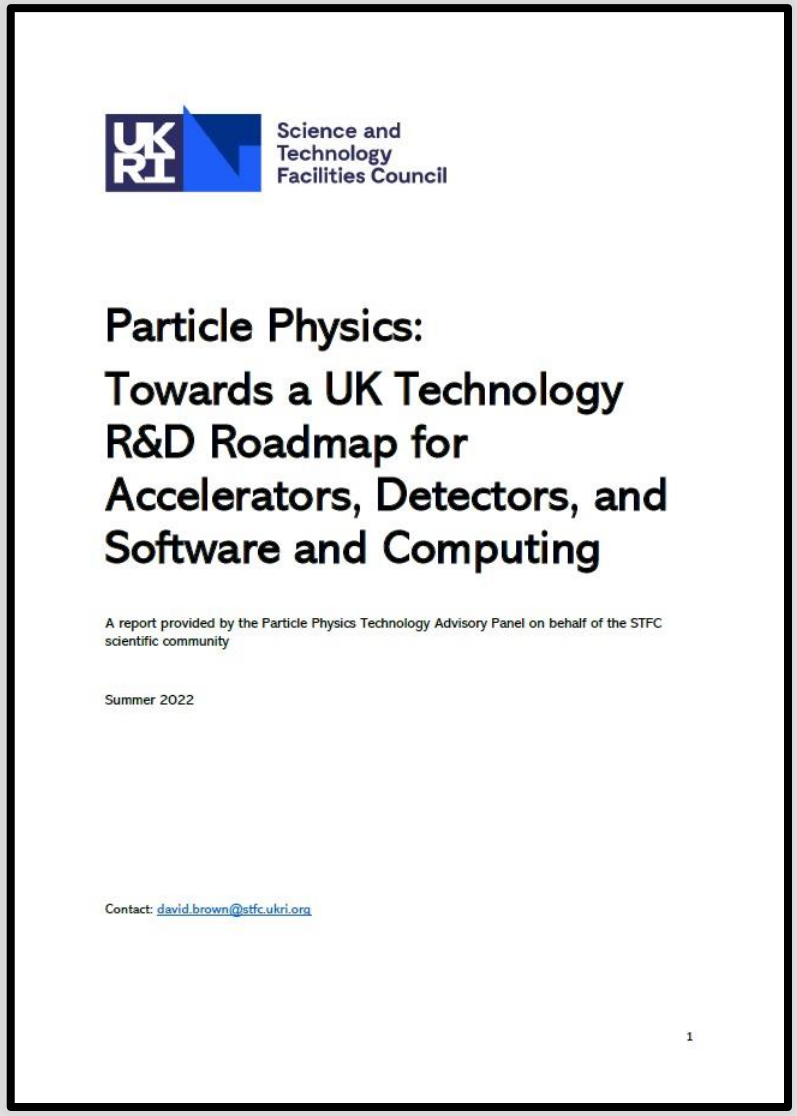
- **The discussion…**
  - Complaints about the number of ASIC designers we do NOT have in the UK
  - Complaints about the lack of R&D funding schemes that would allow for more continuity
  - Suggestion to get monies also from industry (e.g. industry and particle physics community develop a new detector together)
  - Interest in resurrecting and updating the HV/HR-CMOS R&D roadmap (2016)
  - Awareness of synergies between Solid State Detectors and Electronics & Integration
  - Neglected what R&D we want to do in the coming years and strategy for getting funding going

PPTAP Detectors WS – The after-parties

- We had a couple of productive follow-up discussions
- We drafted a very nice and detailed document that covers
  - What has been done before and other roadmaps
  - Short/Medium/Long-term challenges, requirements and priorities
  - UK's strengths and how these relate to priorities
  - Synergies with other areas
  - Framework of funding ideally required/most beneficial
  - Skills, training and career development needs
  - Rationale: benefits to physics and benefits to UK
- I submitted the draft to the PPTAP Writing Team, who used it as input to the PPTAP report

PPTAP report (available here)

- **Introduction**
  - Background and Context
  - International Roadmapping Activities
  - UK Particle Physics Technology Advisory Panel
- **Science Drivers**
  - Recent UK Activity
  - UK Challenges, Requirements and Priorities
- **UK Technology R&D Options**
  - UK strengths
  - Synergies with Neighbouring Disciplines
- **UK Implementation and Outcome**
  - Funding Framework Considerations
  - Skills, Training, and Career development
  - Realising Benefits
- **Final remarks**



UKRI Science and Technology Facilities Council

Particle Physics:

Towards a UK Technology R&D Roadmap for Accelerators, Detectors, and Software and Computing

A report provided by the Particle Physics Technology Advisory Panel on behalf of the STFC scientific community

Summer 2022

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PPTAP report – UK strengths

Table 2: Strengths, weaknesses, opportunities, and obstacles analysis of the UK accelerator and detector particle physics community regarding current and potential technology R&D

Strengths	Weaknesses
Multiple including, beam dynamics, RF systems, beam instrumentation, feedback and control, plasma, surface science ERL, muons, permanent magnets, thin-film SRF, mm-wave & THz, particle sources	Links with industry under-developed Discontinuity in funding projects
Multiple including DAQ, Silicon, Quantum	Approach to dependencies not joined up (performance requirements) Lack of investment in electronics Quantum – no project/facility to scale up
Well-established expertise Leadership roles Training and hands-on opportunities Well-established track record of R&D in a number of areas Strong input into R&D roadmaps Integration Software and computing expertise	Lack of access to R&D facilities/beamlines Disparate small groups in some areas (novel acceleration, calorimetry, integration, gaseous detectors) Lack of career paths for technical experts Lack of coordinated computing & software training Little early TRL collaboration with industry
Opportunities	**Obstacles**
Expertise in areas of growing importance (thin film, ERL, permanent magnets, MM-wave, sustainable design) STFC facilities (CLARA, EPAC) leading to international opportunities (EuPRAXIA) Future UK facilities (UK XFEL, ISIS II)	Little UK R&D underway Funding – often just project related, lack of investment for co-creation and early-stage R&D Industry not well plugged in Overall cost of end goal Sustainability of end goal
Expertise in essential, as yet unfilled and needed, areas	
International R&D underway Low-cost test stands and bench-top experiments Long-standing experienced communities (DAQ, integration, beam dynamics) Leadership building from expertise (muon, ERL, beam dynamics) Partnership with industry Greater coordination of computing and software training and expertise	

Accelerators | Detectors | Both

PPTAP report – UK strengths

Table 4: UK detector particle and particleastro physics community areas of current and potential technology R&D expertise and applicable projects within the ECFA panel themes

ECFA TASK FORCE	AREAS OF EXPERTISE	EXAMPLES
GASEOUS DETECTORS	-	-
LIQUID DETECTORS	Liquid Argon TPC	Darkside, DUNE
	Liquid Xenon TPC	LZ
	Photosensor operation at low temperature	LZ, Darkside
	Radio assay	
	Training in R&D, operation, and analysis	all
SOLID STATE DETECTORS	Integration of large detector systems	ALICE ITS3, ATLAS SCT (barrel & endcaps), CERN-RD50, LHCb Velo tracker, Mighty Tracker, Mu3e
	R&D	
	- Depleted CMOS sensors	
	- Diamond sensors	
	- High resolution large-area pixel sensors	
	- LGAD for fast timing detectors	
	- Low mass (thinned) sensors	
	- Multipurpose pixel sensors	
	- Radiation hard Si strip sensors	
	- 3d pixel sensors	
	- Sensor characterisation	
PHOTON AND PARTICLE IDENTIFICATION DETECTORS	SiPM	Large scale dark matter searches using noble gas – Darkside, DUNE, CTA
	MCP-PMT	LHCb, TORCH, NA62
	RICH detectors	LHCb
	Time of Flight	TORCH
QUANTUM AND EMERGING TECHNOLOGIES	Commercialisation and links to industry	
	Quantum Technology for Fundamental Physics (only one in Europe)	QSNET
		Quantum enhanced interferometry
		QUEST
		AION
	Facilities	Tritium production (Culham), Boulby mine
CALORIMETRY	High-Granularity calorimeters backend	CMS HGCal
	Single sensor development	EPICAL/FOCAL/DECAL
	Optical crystal calorimetry	CMS barrel & endcap
	Dual readout optical fibres – development & software	Dual readout TB, AIDAinnova
ELECTRONICS AND ON-DETECTOR PROCESSING	Board design	ATLAS, CMS, DUNE

PPTAP report – My remarks

- The report acknowledges that having produced the European Strategy for Particle Physics Update R&D roadmaps, CERN and the European communities will now be looking at how to respond, and the **UK should do the same with thought given as to how much to adopt the technology-driven approach established within the roadmaps**.

- **The report encourages a shift from the current funding model of experiment-construction-project driven Accelerators, Detectors, Software and Computing technology R&D to that of technology R&D driven programmes.**
  - A desire for longer-term stable funding for ADSC technology R&D
  - A different and broader approach to detector R&D to complement the construction project funding might be beneficial

- The report also says that cross-experimental R&D projects can be beneficial, allowing the sharing of expertise and producing enhanced solutions for the same cost.

PPTAP report – Final remarks

- PPTAP recommends that the UK must respond to complement the implementation of the ECFA and ELDG R&D roadmaps by undertaking an STFC-funded programme of long-term ADSC technology R&D, at least within the constraints, but not necessarily within all, of the activity areas identified in the ECFA and ELDG Roadmaps.

- PPTAP recommends that a funded ADSC R&D framework be implemented by STFC to both direct and respond to community and STFC requirements. This should provide a breadth of funding opportunities with regard to length and monetary value, 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.

- PPTAP recommends that any funding of the implementation of an ADSC technology R&D framework should be in addition to funding allocated to current and future activities within the broader PP programme.

- PPTAP recommends that both initial and ongoing peer review mechanisms and agreed assessment criteria must play an important role in evaluating ‘singular’, cross-community or ‘multiple’, and ‘blue skies’ low-TRL, ADSC technology R&D options, and that they promote outcomes towards a resilient and sustainable PP programme.

- PPTAP recommends that an STFC roadmap, rather than framework, for underpinning technology R&D direction is necessary in order to make strategic future choices.