

# Future UK Silicon Vertex & Tracker Workshop Summary

Document prepared by Jens Dopke (RAL) and Laura Gonella (Birmingham).<sup>1</sup>

The “Future UK Silicon Vertex & Tracker R&D Workshop” was held at the University of Birmingham on the 7-8 September 2022. It was attended by more than 50 people from 17 institutes. The list of participating institutes is at the end of this document. The agenda of the meeting, including all presentations, can be found at:

<https://indico.stfc.ac.uk/e/UKTrackerRnD>

**The aim of the workshop was to converge on a common strategic R&D programme to develop new solid state detector technologies and attain UK leadership at future collider facilities.**

The following points emerged from the discussion:

- As the semiconductor industry moves towards smaller technology nodes, the increased cost and complexity of both design and required legal agreements for shared developments will dictate changes to the way sensor and ASIC technologies are developed by our community.
  - Develop **Intellectual Property (IP) blocks** to reduce project risk, cost, and design time.
  - The number of sensors and ASICs prototypes will need to be reduced.
  - The UK will need to work within international collaborations to increase the knowledge base, and to gain access to technologies at a negotiated price and within established legal collaboration agreements.
  - **We acknowledge it will be fundamental for the UK to carve out its own niche of specialism within those collaborations.**
- STFC-RAL has worked with TowerJazz for many years and this relationship can and should be exploited by UK groups (see below points on 3D integration and monolithic LGAD as examples).
- We recognise that there is a lot of UK effort in **MAPS** (ECFA DRDT 3.1) development but without UK leadership, with the exception of the CMOS development within RD50 that is UK led.
  - Many UK institutes participate in both design and characterisation activities in developments led by CERN and KIT.
  - There was general agreement that the UK, whilst heavily engaged in many projects, does not have a strong leadership position in MAPS for particle physics. It was agreed that greater focus, and an innovative step into a new area would be needed to change this position.
- **3D Integration** (ECFA DRDT 3.4) seems a tantalising future direction, not just for particle physics.

---

<sup>1</sup> The document has been circulated for comments to one contact person per participating institute. Comments that were received have been addressed.

- While the particle physics community has recognised the benefits of this technology for tracking applications, there have been few attempts of demonstrating it so far and nobody is currently leading in this research.
- TowerJazz offers wafer-to-wafer bonding on MPW. This would be a good starting point for a stacked prototype.
- Presentations on **4D tracking** (ECFA DRDT 3.2) indicate a significant UK interest in this topic.
  - UK groups are working with Micron and Te2v on the development of state-of-the-art and small pitch LGADs.
  - Following this work, both companies are now participating in the market surveys for the ATLAS and CMS timing layers at the HL-LHC. We note that this activity happens outside funded UK particle physics projects.
  - With the current level of resources, these developments do not contain elements of innovation with respect to what is being pursued internationally.
  - We recognise the importance of UK industry participation, and both Micron and Te2v have strong interest in LGAD technology.
  - UK institutes are also interested and involved in the TimeSpot development led by Italian groups with significant funding at INFN.
  - The possibility of developing monolithic LGAD sensors with TowerJazz is being discussed with the company. This could be an innovation with respect to state-of-the-art and ongoing R&D at international level.
- **Diamond sensors** remain a candidate for applications requiring high radiation hardness (ECFA DRDT 3.3) and the UK has unique capabilities for the fabrication of these sensors.
  - ElementSix Ltd UK is one of two companies worldwide to produce detector grade diamond.
  - The UK also has unique worldwide capability to process 3D graphitic wires in diamond.
- Development of **IP blocks in 28 nm for a standardised DAQ approach** seem a natural way forward based on the considerations on CMOS industry.
  - This work is coordinated internationally in the framework of CERN EP R&D WP5 and linked to the 28 nm community through the CERN 28 nm forum.

The workshop reached the following outcome:

- The community agrees to prepare a **strategic R&D proposal** to develop a flexible, agnostic solution for a **large, low mass, 4D tracking detector for future e+e- colliders**.
  - Whilst the proposed R&D programme will initially focus on addressing challenges of tracking at e+e- colliders, the community recognises the importance of already including **aspects of R&D on technologies specific to high radiation environments** in view of the hadron-hadron collider facilities planned for the further future.
- The proposal should aim at a **large-scale end-to-end demonstrator** to be built in 10 years.
  - Services, DAQ, mechanics are UK specialities, making a fully integrated system an achievable and sound ambition.
- This effort will put the UK community in a strong position to lead the targeted R&D and subsequent construction of an experimental facility at the chosen e+e- collider.

- The proposal will define the **technologies to be developed**, some of which emerged during the workshop:
  - 3D integration, ultimately leading to stacked, reconfigurable, 4D sensors.
  - IP blocks in 28 nm CMOS technology for standardised detector DAQ solutions.
  - Low power front-end electronics for circular colliders without power pulsing.
  - Low mass cooling and support structures.
- The programme of technological R&D towards the demonstrator will include the definition of an overall **detector concept/strawman design** bringing all aspects of the development together. The concept should be drafted adequately before the large-scale demonstrator to guide the community towards this milestone and evolve alongside the technological progress.
- Aspects of **scalability**, fundamental for the construction of a full tracking system, will be considered as part of the R&D programme.
- As the international community proceeds towards the choice of a collider implementation, technologies selected for the particular application will be further developed within a targeted R&D programme for that facility.
- Involvement of **UK industry** in the R&D programme will be an important component of the proposal and the community will consider ongoing collaborations in light of scope for innovation within international competition.
- The technology R&D programme will exploit **synergies with projects happening on a shorter time scale** where there is UK involvement (e.g. LHCb upgrade, EIC).
- The technology R&D programme will be **embedded into the ECFA DRDTs** and the proposal will map the proposed R&D activities onto these. Participation in ECFA DRDs will give international visibility to the UK developments and the possibility for the UK to lead aspects of the intentional strategic R&D programme.
- Application of the developed technologies in **neighbouring fields** will be identified in the proposal.
- A **resource loaded schedule** will be produced to define the needed resources to complete the project.
- The structure of the collaboration will be defined, and a name will be chosen to brand the activity, where it is recognised that the CALICE model would be a good example on how to organise this effort.
- To facilitate collaboration, the community will setup a **network of specialised infrastructure for shared use**. A facility sharing platform will be setup to collect technical and access information for specialised UK facilities.
- The proposal will include aspects of **training**, starting from the existing “Advanced UK Instrumentation training” complemented by new initiatives such as hands-on training at research facilities.
- When technologies are sufficiently mature and applicable to other experiments or scientific fields, the programme will **branch-off onto other funding streams**, for instance the Infrastructure Fund, for developments targeted to a specific application.

Funding aspects were also discussed at the workshop. The “UK Strategic Detector R&D Programme” (attached to the agenda) was submitted to PPAP and PAAP at the beginning of August in response to the call for proposals for Infrastructure Fund preliminary activities. PPAP/PAAP did not consider it for submission to the IF. We discussed this point, what STFC bids the IF funded recently (e.g. LHCb upgrade, EIC R&D), and how a network of

universities and laboratories, as an infrastructure, would compete with proposals from STFC and other councils, noting that various networks have been funded by the IF.

**There was no objection that exploring funding through STFC core programme seems a better way forward.** We acknowledge this route to funding would necessarily imply less money for other projects. On the other hand, the IF seems to be establishing as the way to fund targeted R&D and construction of experiments, which would relieve the pressure on STFC core programme and release funding for other activities. We could not identify projects that would be impacted by this choice. A suggestion was made to put forward an SOI to Science Board directly, which could run along the lines of the existing proposed Strategic Detector R&D.

**We also agreed strongly that funding for the proposed strategic R&D programme is needed now as the time to seize the opportunity to lead on a new development is in the next year.** If we cannot engage with substantial resources in the ongoing ECFA roadmap implementation and join DRDT working groups, we will not be able to lead innovation and position ourselves at the forefront of the development of experimental facilities at future colliders.

## Institute attendance

Brunel University,  
Queen Mary University,  
STFC-RAL,  
STFC-Daresbury,  
The Open University,  
University College London,  
University of Birmingham,  
University of Bristol,  
University of Cambridge,  
University of Edinburgh,  
University of Glasgow,  
University of Lancaster,  
University of Liverpool,  
University of Manchester,  
University of Oxford,  
University of Sheffield,  
University of Warwick.