

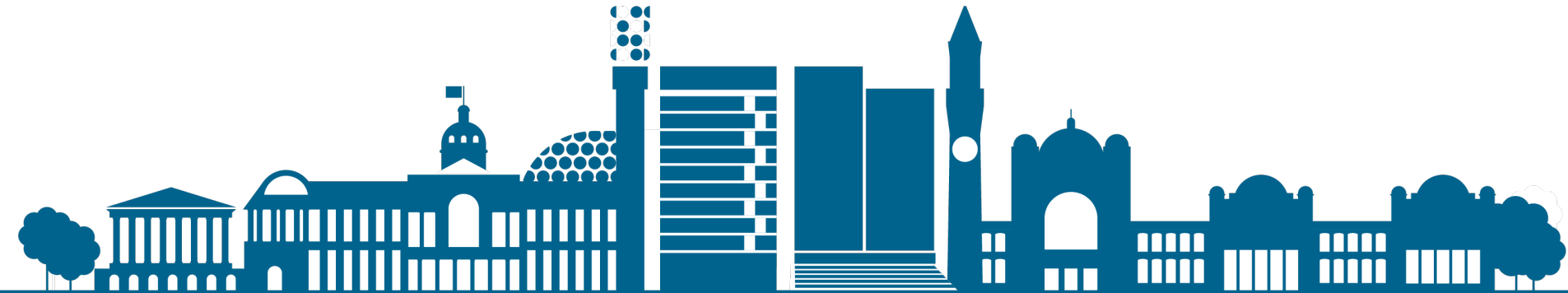


UNIVERSITY OF
BIRMINGHAM

Birmingham R&D interests and facilities

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Future UK Silicon Vertex & Tracker R&D Workshop, 7 – 8 September 2022



R&D interests in silicon technologies

□ 4D trackers

- Generic UFSD sensor R&D
 - Small pitch UFSD (Trench isolated, resistive)
- TimeSpot project, full module development
 - Stitched 3D sensor, connection to ASIC, module electrical interface
- Readout systems for 4D trackers
- Development of UFSD fabrication capability for UK industrial partners

□ MAPS

- MALTA sensor development
 - Process modifications for radiation hardness, asynchronous readout architecture for low power
- 65 nm MAPS developments
 - Technology exploration, wafer-scale stitched sensors, low-power/high-resolution and fast/rad hard sensor
- Reconfigurable MAPS for outer tracking, pre-shower and EM calorimeter

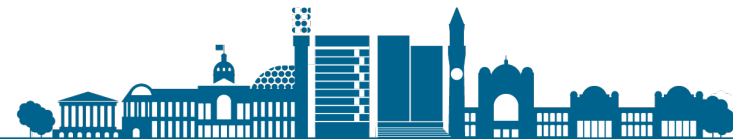
□ 3D integration

- Technology exploration and prototype 3D stack for particle detection



Birmingham Instrumentation Laboratory - BILPA

- The [Birmingham Instrumentation Laboratory for Particle Physics and Applications](#) (BILPA) has been established in 2016 through a University funded initiative aimed at consolidating and expanding its capabilities in [semiconductor detector systems R&D and production](#)
- The laboratory consists of [200 m² of open-plan cleanroom](#) space (ISO5 and ISO7) and is designed to accommodate work in three main areas
 - Detector development for the High-Luminosity upgrade of the LHC ([HL-LHC](#))
 - [Generic R&D on semiconductor detectors](#) for future international collider experiments
 - [Medical application](#) of particle physics technology
- This facility is complemented by a [high intensity proton irradiation line](#) and a [low intensity sensor testing line](#) at the Birmingham MC40 cyclotron + upcoming [neutron source](#) (ADNIF facility)



BILPA equipment

□ ISO5 - Detector assembly

- Cascade Tesla Semi-automatic [Probe station](#)
- Cascade Microtech REL 4800 Manual Probe Station
- Tresky T-3002-M manual [die bonder](#)
- Two Hesse & Knipps BondJet 820 automatic [wire bonders](#)
- Dima Dispense Master
- Dage 4000 Multipurpose Bondtester
- OGP [SmartScope](#) Flash 500
- [Keyence digital microscope](#)

□ ISO7 – Detector testing

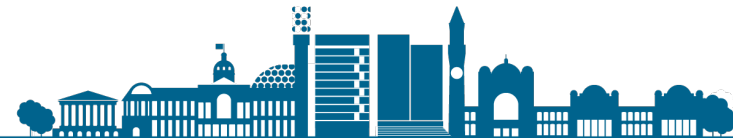
- Particulars, Advanced Measurement Systems, scanning Transient Current Technique ([TCT](#)) apparatus
- ALiBaVa setup
- WeissTechnik L C/150/70/3 [Climate Test Chamber](#)



Current BILPA R&D programme

- **ATLAS Inner Tracker (ITk) upgrade** at the HL-LHC
 - The UK will deliver 50% of the ITk strip barrel (~ 6000 modules)
 - Birmingham is one of two UK hybrid production sites, and one of five UK module production sites
 - The Birmingham irradiation facility is the only international proton irradiation site for regular strip sensor QA

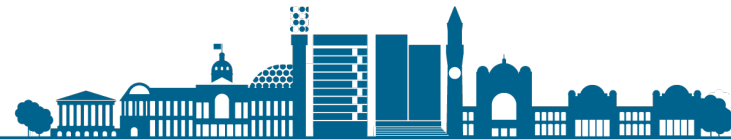
- **Generic R&D on semiconductor detectors for future international collider experiments**
 - Reconfigurable MAPS in radiation-hard Technology for outer outer tracking, pre-shower and EM calorimeter at an FCC facility (**DECAL sensor**)
 - R&D on CMOS sensors: **MALTA & 65 nm stitched CMOS sensor**
 - Precision Central Silicon **Tracking & Vertexing for the EIC**
 - Development of radiation tolerant **Low Gain Avalanche Detectors** for fast timing application (**Te2v and Micron**)
 - **RD50** R&D projects for radiation-hard novel silicon technologies (**CMOS sensors, TI-LGAD**)



Current BILPA R&D programme

□ Medical applications

- [OPTIma](#) (Optimising Proton Therapy through Imaging) with University Hospitals Birmingham, Christie Hospital, the Universities of Lincoln and Manchester.
- "LhARA End station development and instrumentation"
- STFC+NPL Enhancement of the [UK Primary Standard for Absorbed Dose for Proton Radiotherapy](#) with NPL, vivaMOS and STFC CMOS Sensor Design Group
- [DMAPS tracking](#) in pCT and beam profiling (with University of Bonn)
- Sensors for Hadron Therapy [Micro-beam and FLASH](#)
- [ENLIGHT](#) (CERN led hadron therapy consortium)
- [STFC Network+](#) in Advanced Radiotherapy
- [MonteCarlo tools](#) for medical applications



Birmingham inputs to PPTAP solid state task force

Key technical challenges & technology R&D...

- Large area, low cost silicon detectors
 - Replace strip technology; digital ECAL.
 - MAPS in 65 nm CMOS imaging technology.
 - Innovative technologies for detector assembly, cooling and mechanics.
- ASICs for vertex layers
 - Low power (few 10 mW/cm²), high granularity (down to a few um), radiation hardness (10¹⁸ n_{eq}/cm², 10-100 Grad), high speed links (tens of Gbit/sec).
 - 28 nm CMOS technology.
- 4D tracking
 - Finely segmented silicon sensor with gain (e.g. AC-LGAD).
 - Dedicated ASIC development with optimised power density for high-speed readout (28 nm ASIC).
 - Increased LGAD volume production/throughput capability.

...to be addressed by the UK particle physics community to

- Become a leading contributor to the development of future collider facilities and establish leadership in key aspects of their science programme.
- Develop IP and UK expertise in the design of sensors and ASICs for broad science applications and commercialisation.



Birmingham inputs to PPTAP solid state task force

Supporting strategy

- **Coordinated technology R&D roadmap**
 - Selected cutting-edge projects, clusters of institutes with complementary skills and infrastructure.
 - Matched to planned UK participation in future particle physics experiments.
 - Identified links with UK industry, potential applications in other scientific fields and opportunities for commercialisation.
- **Continuous stream of funding for generic technological R&D**
 - sustained funding for R&D that also allows us to build meaningful relationships with industry.
 - Structured to support seeding projects/proof of concepts/feasibility studies and IP development followed by the development of full products for different applications.
- **Community engagement, training, skills development**
 - Regular review of the strategy in light UK/international/technology developments.
 - Regular workshops involving scientific and industrial partners.
 - PHD scholarships designed around the strategy, complemented by an annual school on detectors.
 - Training for on aspects of commercialisation and IP exploitation.
 - Summer internships for undergraduate students.

