ATLAS Silicon Tracker and BILPA

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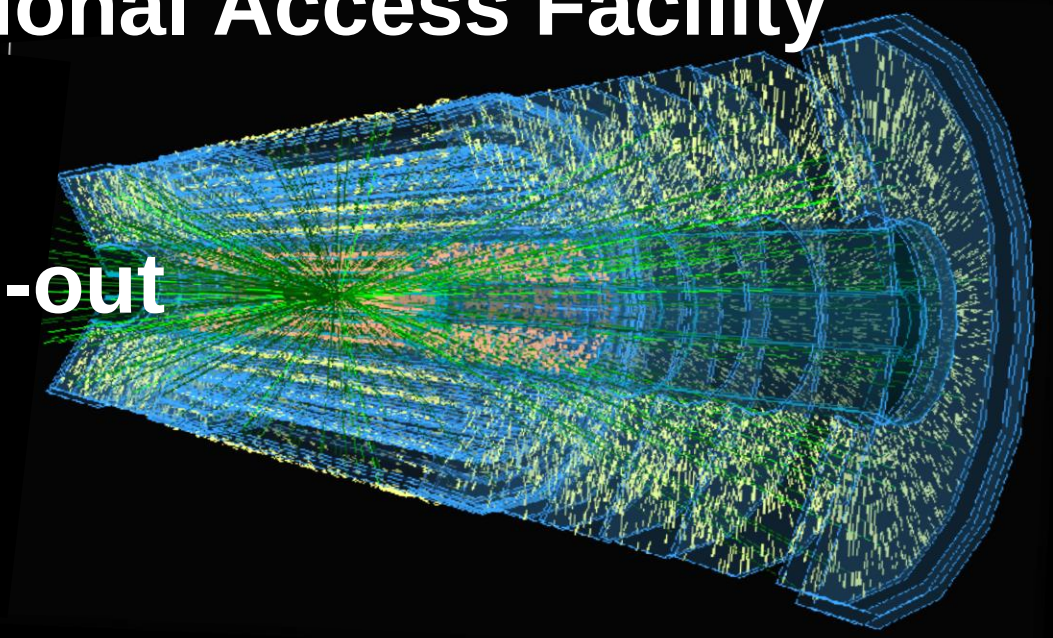
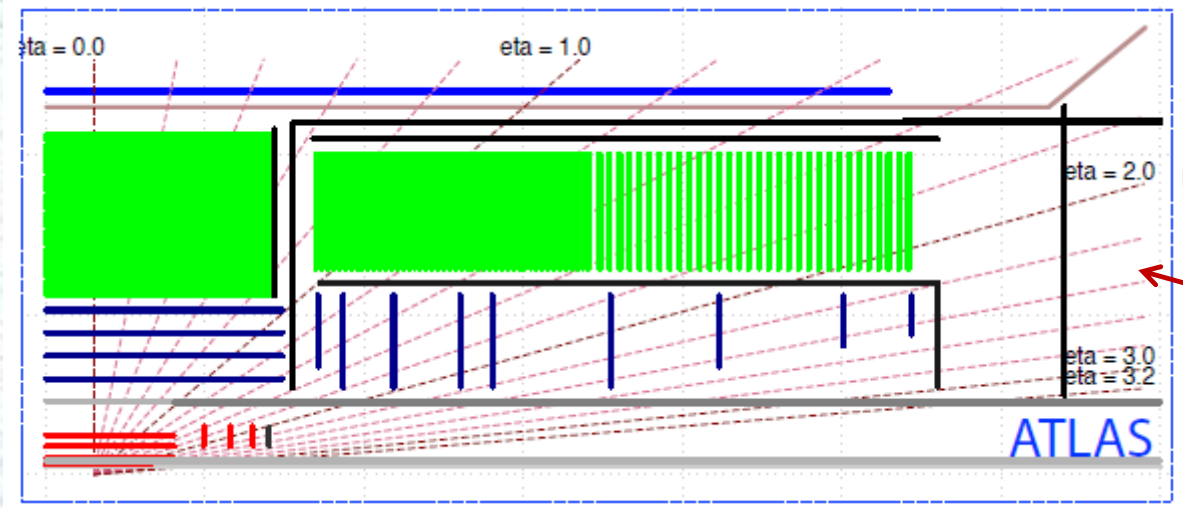


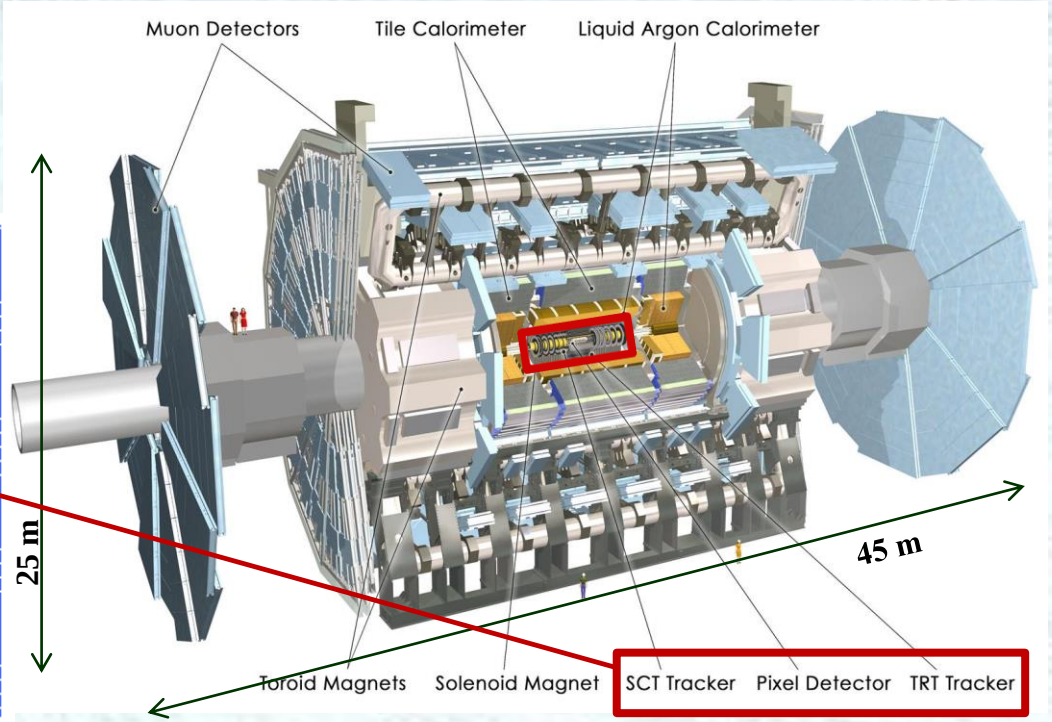
Introduction

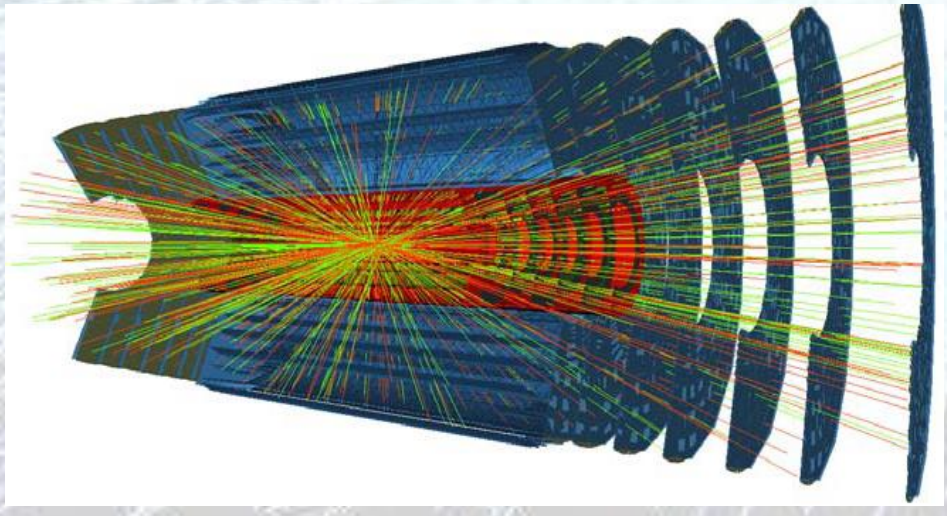
- The Birmingham group is a key player in the development and preparations for production of a significant fraction of the silicon micro-strip part of the new ATLAS inner tracker (the ITk) required for operation at the HL-LHC
- University of Birmingham operates the UK's only AIDA 2020 (EU funded) Transnational Access Facility for irradiations using the MC40 cyclotron
- With significant University investment we are building a new cleanroom facility (BILPA) suitable for the ATLAS construction activity and better able to support future activities based on semiconductor detector development
- New appointments are planned in support of this and medical applications where there is a long history of involvement in proton therapy activities (silicon strip modules for the PRaVDA consortium built at Birmingham)
- Longer term sensor interests include the development of radiation-hard monolithic pixel detectors as central to optimal outer tracking and digital calorimetry at future facilities. In this context we (incl Nige) are bidding (PRD) with RAL and Sussex to explore realising these in a common technology (HV-CMOS), emphasising particle flow capabilities and linking with CALICE and EM Calorimeter triggering expertise at Birmingham.

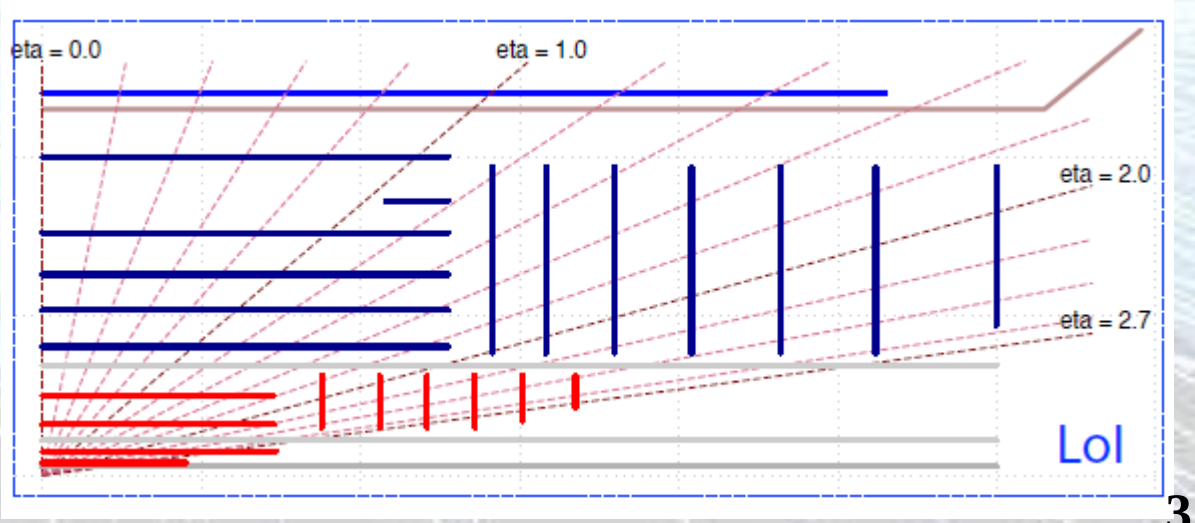
ATLAS UK Tracker Upgrade

- HL-LHC: 10× LHC integrated luminosity, 7.5× LHC nominal instantaneous luminosity
  - ➢ 10× radiation levels, data volumes and data rates
  - ➢ 7.5× hit densities (pile-up) per beam crossing
  - → Need major upgrades and new tracker
  - → Opportunity for tracking in Level-1 trigger



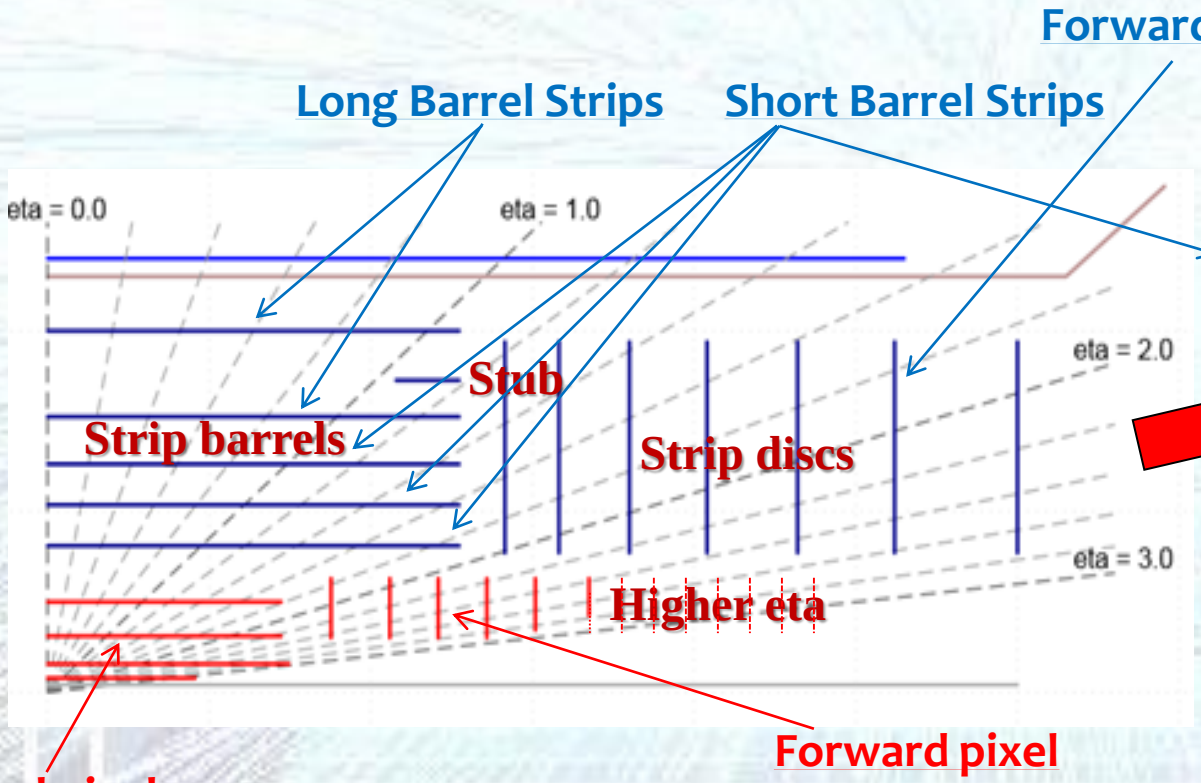


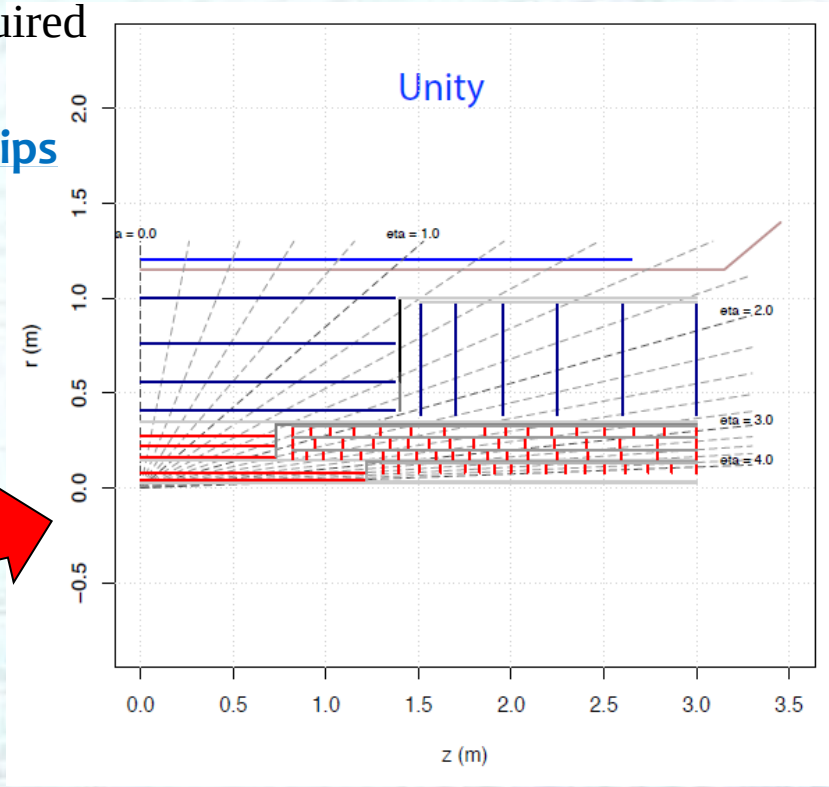




ATLAS UK Tracker Upgrade

- The most recent public description of the ATLAS upgrade plans can be found at https://cds.cern.ch/record/2055248/
- Note the layout of the tracker continues to evolve with an expectation that the barrel will be formed of 5 pixel and 4 strip layers, but the strip layers will be longer, resulting in a small decrease in total number of modules required
- The desire is also to increase the pixel coverage in η





UK originally built 600 barrel strip modules for current ATLAS with 60m^2 of silicon strips.

New tracker 200m^2 of silicon strips (20,000 modules)

ATLAS UK Tracker Upgrade

- For the UK, the contribution is expected to be half the total strip barrel of area (~6000 modules)

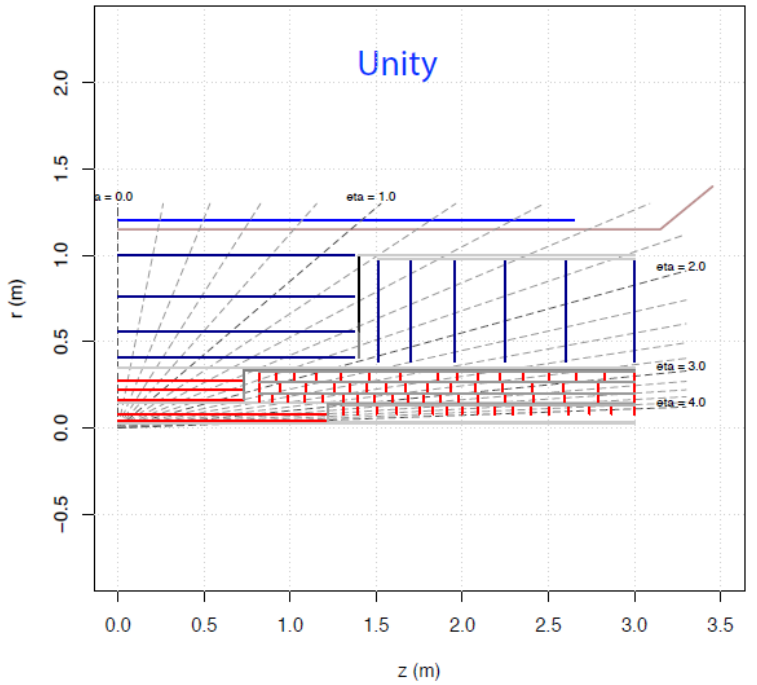
The agreed scope is:

- Provide 128 short strip and 108 long strip assembled and tested strip staves. This is half the barrel strip project.
  - A stave is a 1.3m long 10cm wide object with 13 modules on each side
- Provide mechanical supports and service modules for these staves
  - Support modules are an integrated block of services pre-assembled serving a group of sensors.
- Provide read-out, powering and DAQ for the staves (half the total required).
- Provide one complete pixel forward region
  - Assumes a particular scale for the forward region (1250 modules, 25 rings)
- Provide the DAQ and services associated with the pixel forward region
- Provide relevant equipment associated with strip assembly at CERN

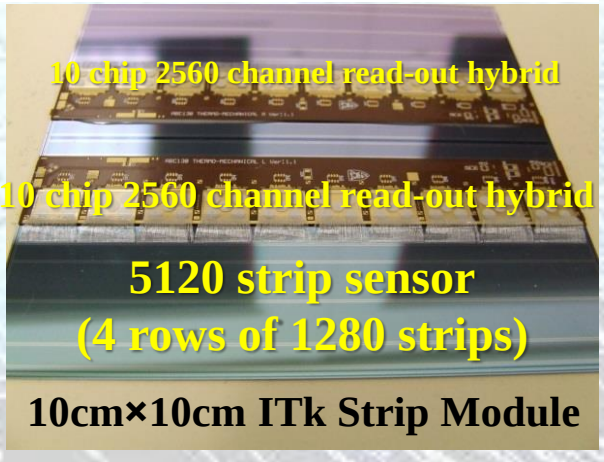
In addition to providing these major parts for the tracker, it is expected that ATLAS-UK will take a leading role in the assembly and commissioning of the tracker at CERN.

It is also understood there will be ongoing effort on simulation, both of the detector, and of the radiation environment.

International collaborators will be sought to provide elements of the deliverables.



- Birmingham R&D has focussed on glue studies, assembly techniques, development of strip module read-out and Quality Assurance
- Birmingham currently involved in 3 production programme areas:
  - Barrel Hybrid assembly and QA (with Liverpool)
  - Barrel Module assembly and QA (with Cambridge, Glasgow, Liverpool, Oxford, RAL, Sheffield)
  - Radiation testing (with Sheffield)

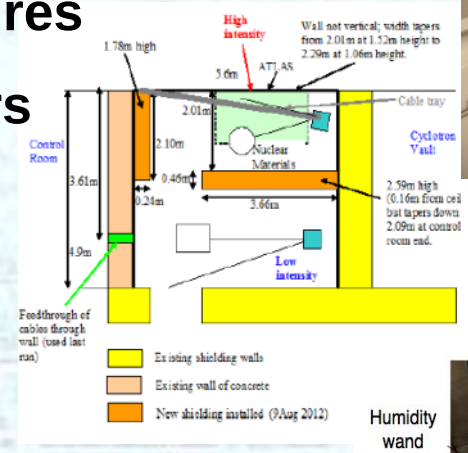


AIDA-2020 UoB MC40

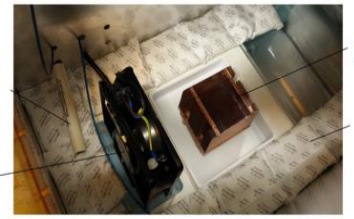
- The MC40 cyclotron at the University of Birmingham is primarily used for overnight radio-isotope production for mainly medical applications. However, thanks to a joint activity initiated by **Sheffield**, **Liverpool** and **Birmingham**, it can now provide irradiations for particle physics during daytime.
- Irradiation facility was commissioned in early 2013 and has irradiated ~300 samples in total.
- Now a Transnational Access Facility

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement no. 654168.

- Samples studied so far include:
  - ✓ Composites, carbon fibre support structures
  - ✓ Pixel (hybrid and CMOS) and strip sensors
  - ✓ ASICs. microelectronics, optical fibres
  - ✓ Hybrid and PCB materials
  - ✓ JFETs, HV-switches, …



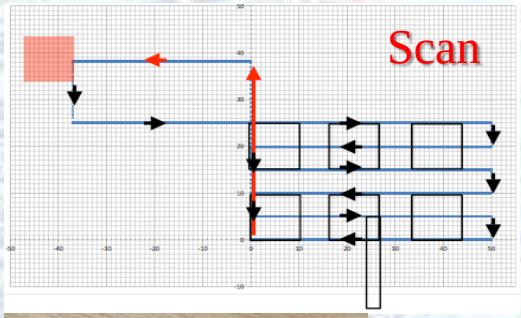
Layout of Radiation Zone

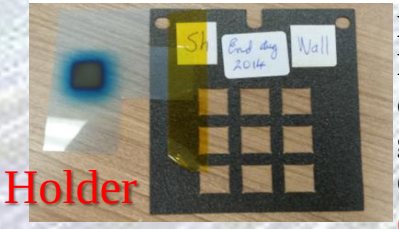


- 27 MeV continuous 1cm^2 proton beam can achieve HL-LHC fluences of inner layer strip system (10^{15} 1 MeV n_{eq} cm^{-2}) in 80 s with 1 μA beam current (max energy of 37 MeV, max current of ~2 μA)
- See AIDA 2020 link: http://aida2020.web.cern.ch/content/uob#contact

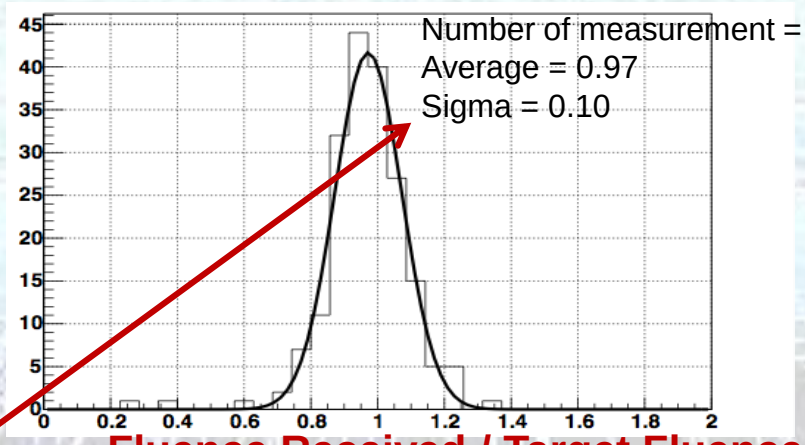
AIDA-2020 UoB MC40

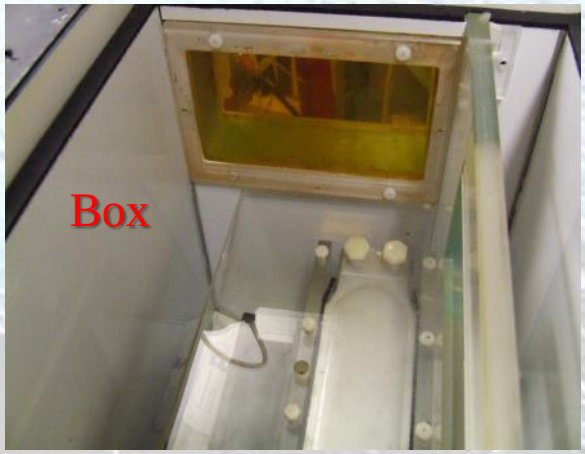
- **XY-axis (45cm×40cm) scanning system installed in the irradiation area to allow areas of 15cm×15cm (orthogonal) to be uniformly irradiated at low temperatures**
- **Samples are suspended from the lid in the thermal chamber which is mounted on the scanning system operating down to -50ºC**
- **Sealed feed-throughs allow external read-out and monitoring to be connected or space in the box can house shielded electronics**
- **Similar arrangement provided for use at CERN PS by UK Irradiation Group**



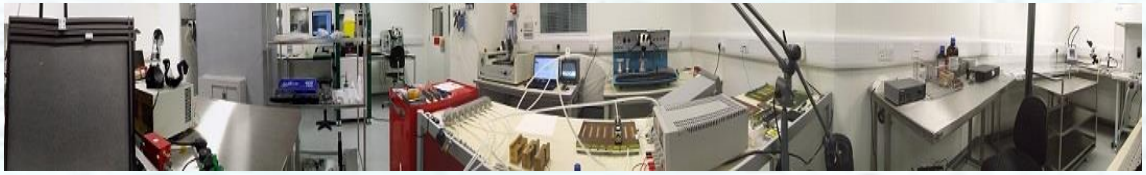


Dosimetry using Faraday cup and cross-check using gamma spectroscopy of irradiated Ni foils (10% accuracy)





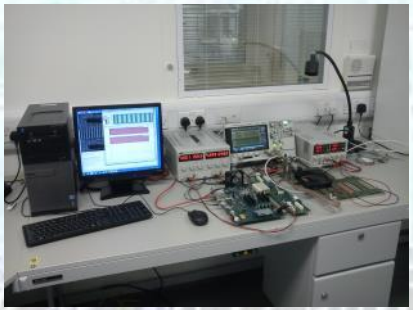
Current Cleanroom Facilities



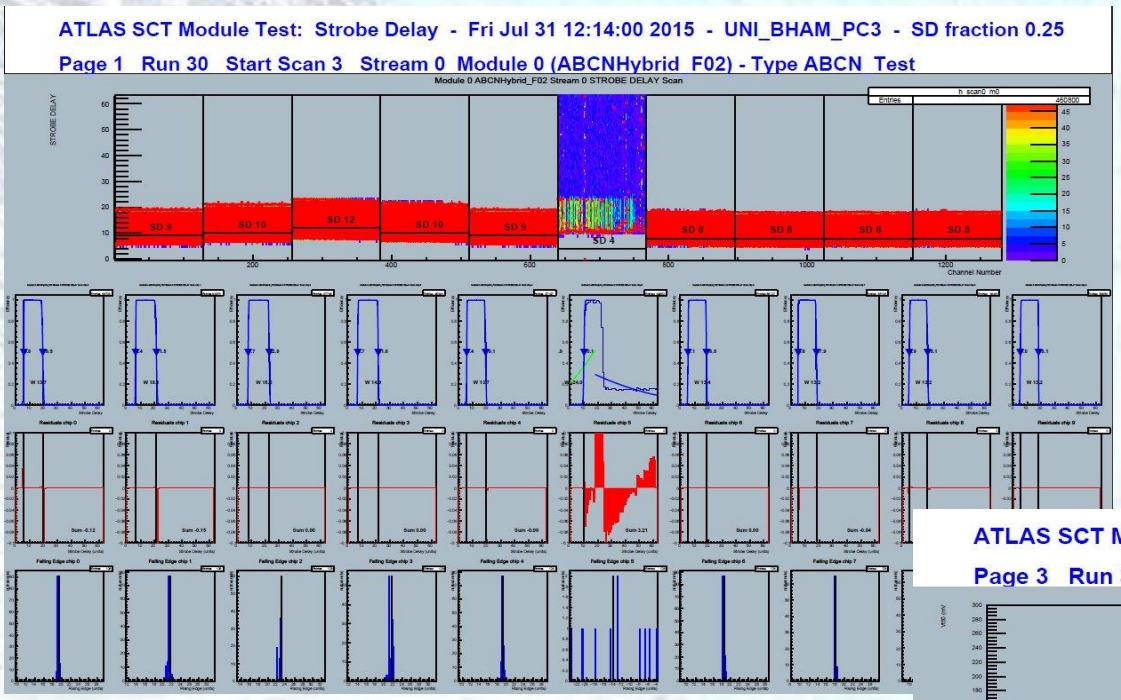
- Hesse & Knipps BondJet 820 automatic wire bonder
- Delvotec 5430 semiautomatic table top wire bonder
- Dage 4000 wire-pull and shear strength tester
- Dima Dotmaster with the DD-5097 upgrade
- Cascade Microtech REL 4800 manual probe station
- Cammax Precima DB600 die bonder pick and placer
- Inspection microscopes, electrical test equipment, N_2 storage, environmental chamber, precision scales, …
- Access to shared facilities with astrophysics group

- Readout for ATLAS ABC250 ASICs, hybrids and modules: HSIO DAQ system

- For ABC130 hybrid plus module read-out: have successfully commissioned Digilent Atlys board

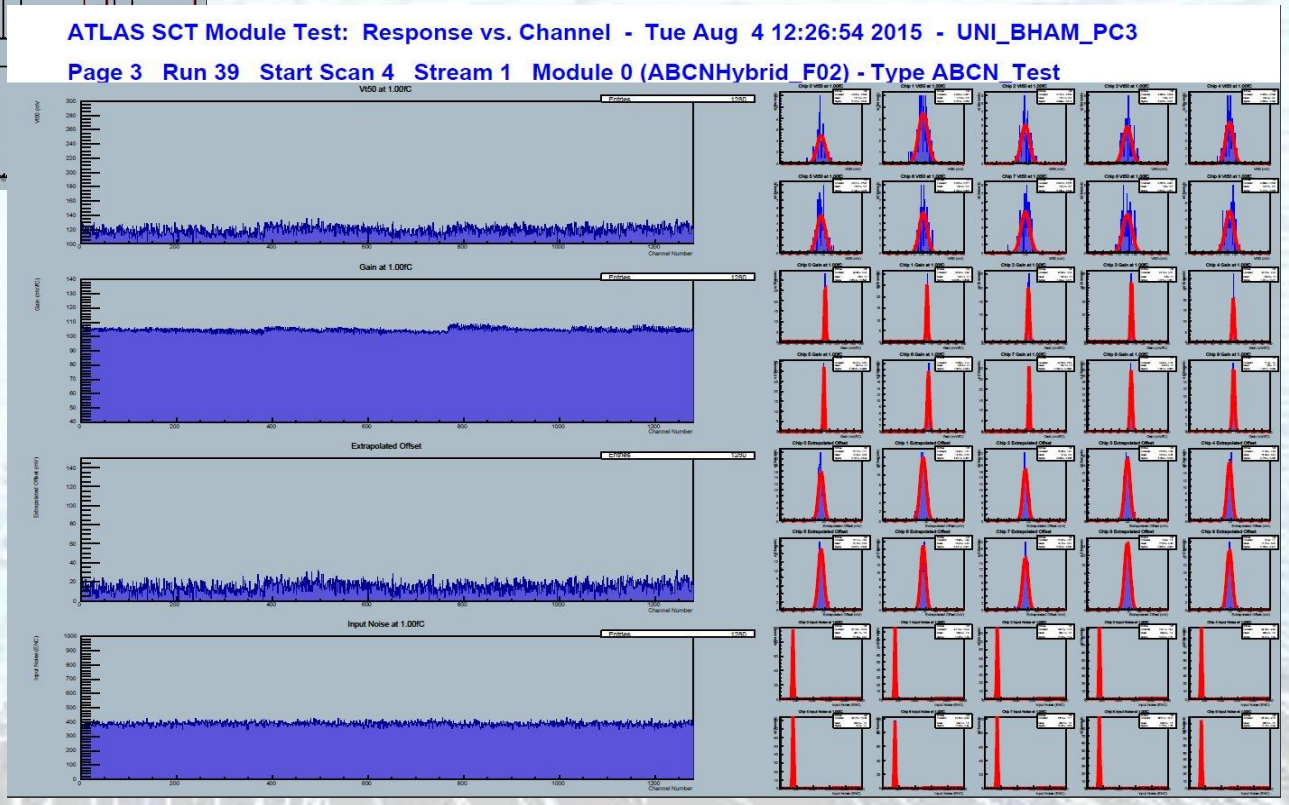


ITk Hybrid and Module Readout



- *(left):* Output from StrobeDelay 0.25, using ABCN250 hybrid, *(bottom):* 3PointGain 1fC, second row of hybrid

Ready for electrical ABC130 hybrids and modules

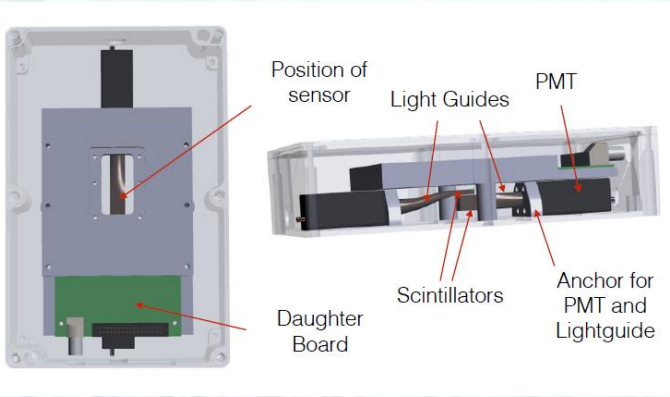


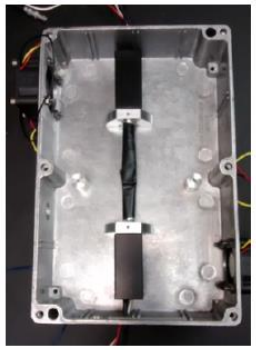
- Good preparation for ABC130 hybrid tests: Synchronisation with SVN, compiling, Root6
- Can easily swap between SLC6 and Win7 PCs: Swap ethernet cable into Atlys
- Run tests from office desktop

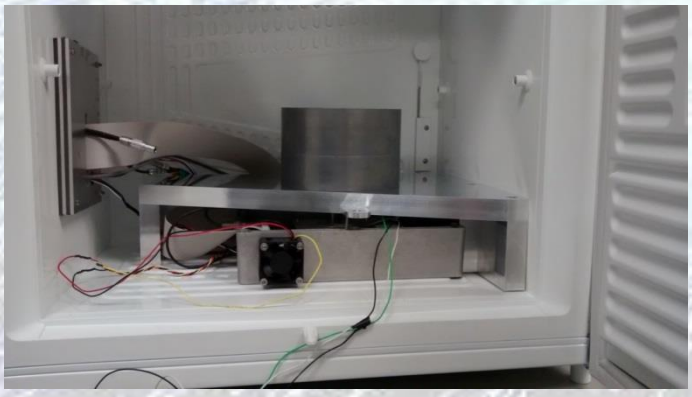
ALiBaVa Set-up

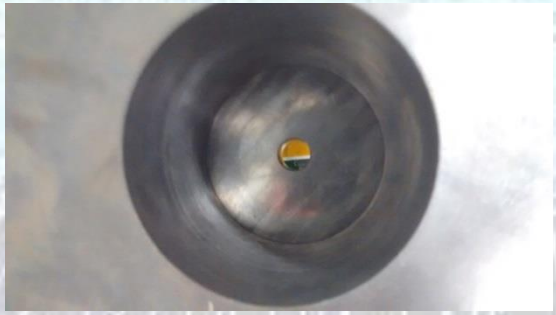
Purchased thanks to Miriam's Royal Society grant

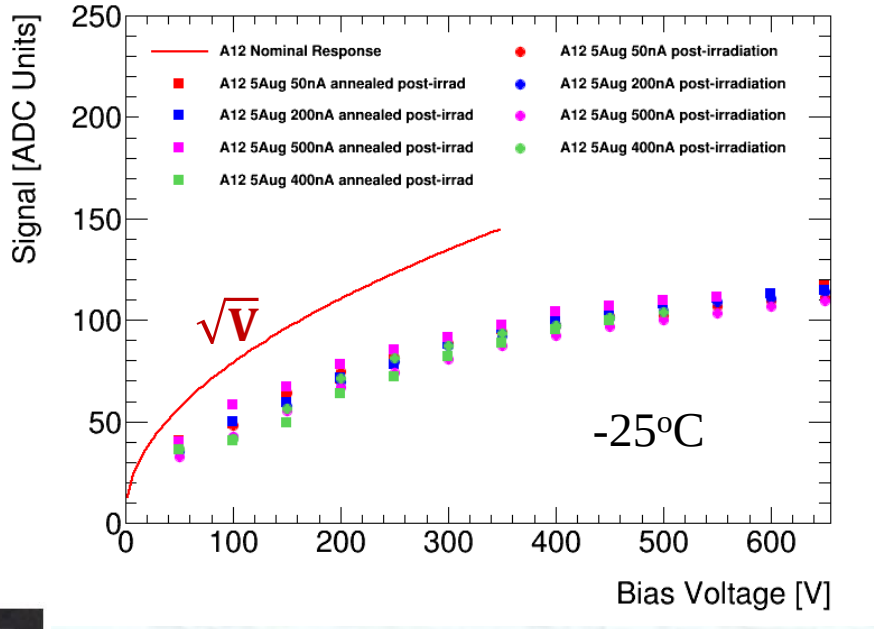
- Typical irradiation to doses of order (5-10 × 10^{14} 1 MeV n_{eq} cm^{-2})
- See expected signal(V) unirradiated and for some dosed samples with cold operation with N_2 flush of enclosure
- 80MBq ^{90}Sr source allows very high data taking rate



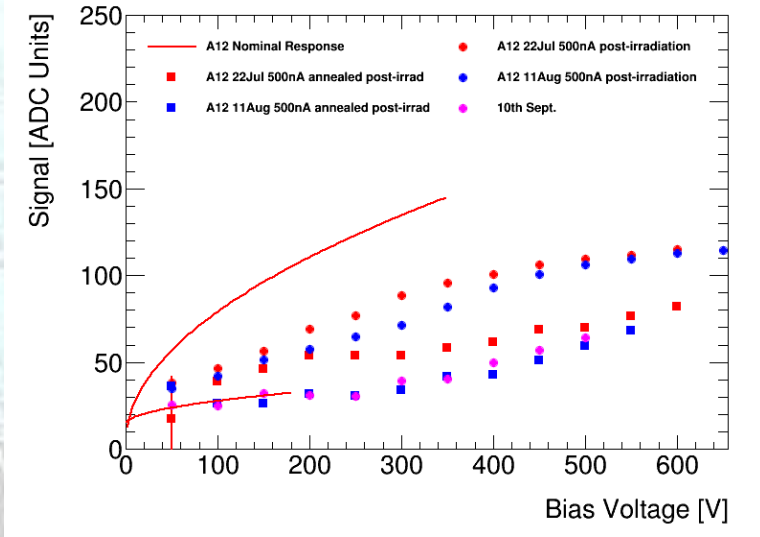






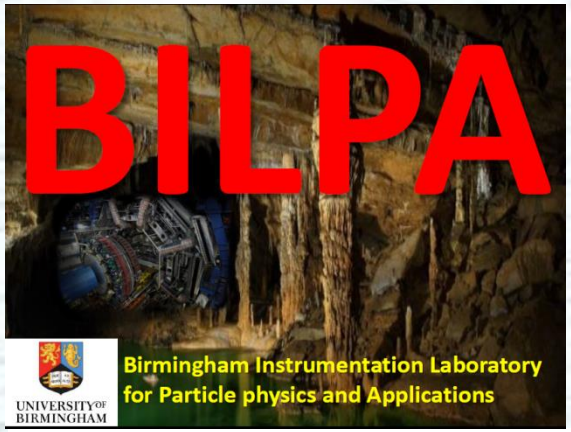


However, sometimes results are not as we expect so further work is needed ….



Future Capabilities

- **Major University investment in academic staff and capabilities linked to concept of Birmingham Instrumentation Laboratory for Particle physics and Applications**
- **~ 170m^2 of new and reconditioned cleanroom laboratory space for both ITk strip module production and R&D on novel radiation-hard detectors**



Hope will be like the caves, only cleaner …