Liverpool interest in vertex/tracking R&D for CLIC

We are very interested in the physics programme at a future CLIC e+e- collider and we are keen to contribute to the work preparing for and promoting such a machine.

Outline:

- brief summary of our recent activities/capabilities in detector R&D and construction.
- specific areas for R&D work for CLIC: CLICPix, mechanics(?), ..

Liverpool detector projects and R&D

We currently participate in:

ATLAS, LHC-b, T2K, SNO+, NA62, CTA, ALICE, g-2,..

Major recent detector projects:

- ATLAS Semi-Conductor Tracker endcap-C
- LHCb Velo modules
- T2K modules for near calorimeter

Ongoing projects:

- ATLAS upgrade strip tracker staves and pixel detector prototyping
- LHCb Velo upgrade
- smaller projects: g-2 straw tube tracker, barrel support for ALICE upgrade, contribution to NA62 Cedar refurbishment, CTA camera housing

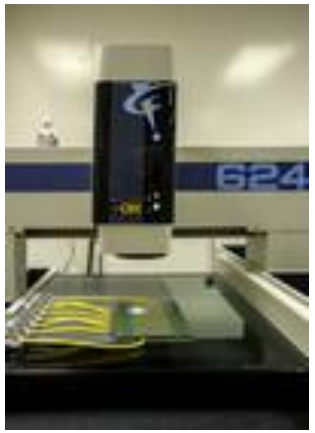
R&D activities:

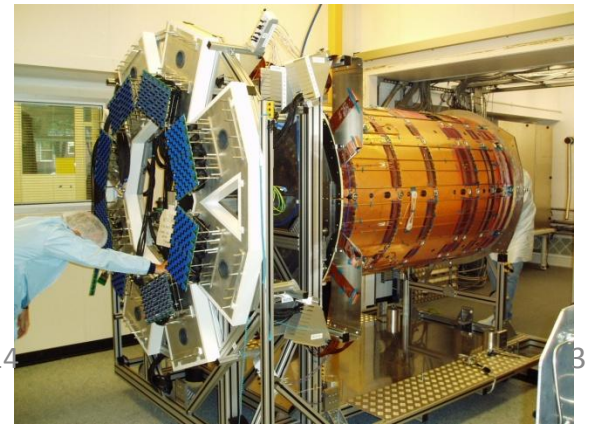
- Silicon (dedicated slide)
- Liquid Argon R&D for Laguna

(Silicon) detector production facilities

Liverpool Semi-Conductor Centre (LSDC)
Large area (450 m^2) clean room facilities

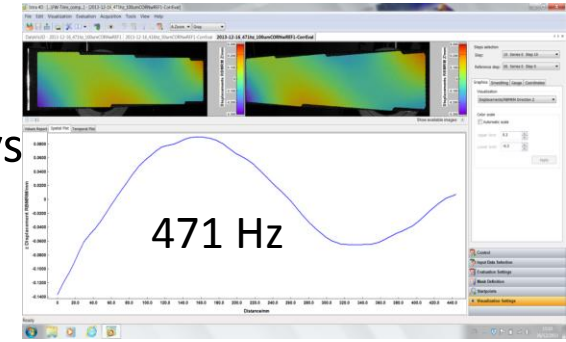
- 3 Wire bonders
  (K&S 2x710 & 820)
- 2 Probe station
- 2 Smart scopes
- Large CMM
  (mechanical and optical probes)
- Large environmental chamber





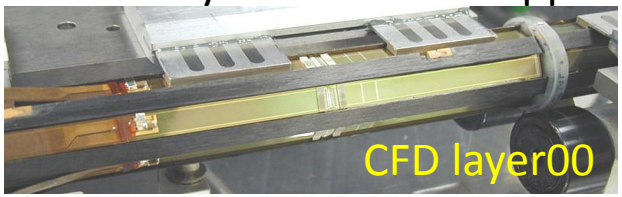
Mechanical Testing/Metrology/Workshop

- 3-point deformation tester and pull tester
- CMMs and FARO Laser Tracker
- Vibration measurements: work done in collaboration with Liverpool mech. Engineering.
  Dantec 2-camera system with Digital-Image-Correlation software, combined with 4ns laser pulse strobe and mechanical shaker to measure large field deformations. We submitted an AIDA2 EoI (as a sub-proposal to the mechanics EoI submitted by Marcel and Armin)
- Differential Scanning Calorimeter/Goniometer for analys
- Well equipped and staffed mechanical workshop:
  large object and 5-axis milling machines, wire eroder, 3D printer, ...



Liverpool Advanced Materials Lab

Liverpool composites activity started with support for CDF layer00



Recent projects:

- Support wings LHC-b VeLo
- ATLAS upgrade stave (co-curing CFRP/Cu-capton)
- CTA camera lids,
- R3b spars,

Equipment:

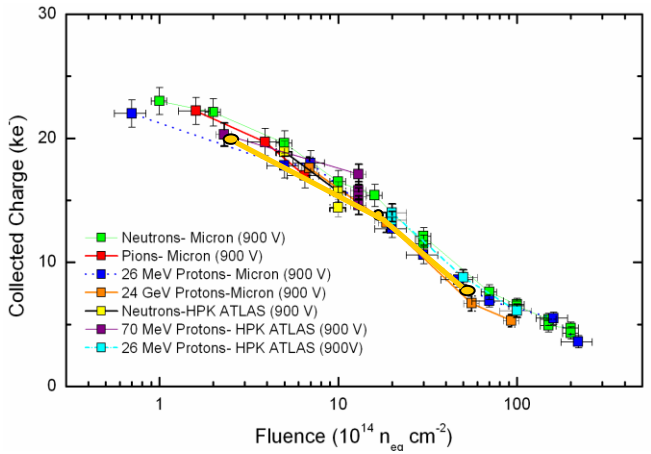
- Small dedicated lab, pattern cutter, etc.
- Large autoclave for pieces up to ~1.8m length

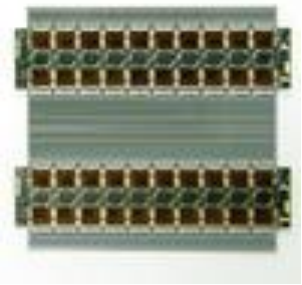
Technologies:

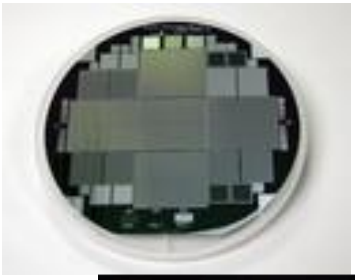
- Standard CFRP pre-preg. assemblies
- co-curing of services (cooling and electrical)
- resin infusion for 3D components, small services
- Surface coating (CF beam-pipe)

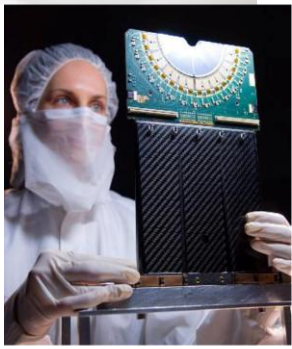
Sensor R&D

- Development rad. hard silicon
  (co-lead RD50) to few times 10^{16} neq
- Several read-out kits
  (MediPix, FEI4, Alibava, ABCN)
  and other characterisation equipment
- Sensor design
  - ATLAS upgrade strips and pixels
  - Sensors for VeLo (and Velo upgrade)
  - Thinned Micron sensors for TimePix (and CLICPix)
- Access irradiation facilities (B'ham, Ljubljana, CERN,..)
- Hybrid design for ATLAS strip and pixel and LHCb VelO
- New R&D on HV-CMOS (dedicated slide)





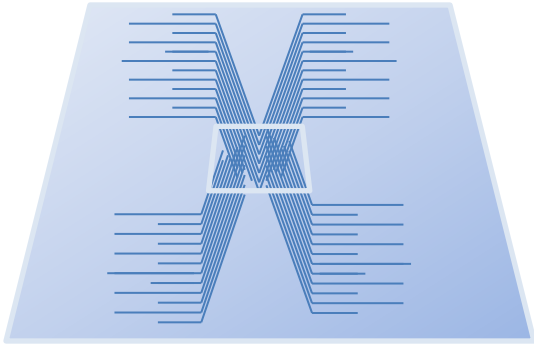




Liverpool HV-CMOS plans

We recently obtained a grant to start an R&D on the development of HV-CMOS sensors.

- We are advertising (next week) for a CMOS design engineer.
- main aims of the grant:
  - Development of pixel and strip sensors in HV-CMOS
  - Explore the possibility of integrated pitch adaptor in metal layers to achieve a larger area sensor read out by a single pixel ASIC (HV-CMOS for strip or large-pixel tracker)
  - Explore use of TSVs, position encoding, AC coupling, ...
- Potential application HV-CMOS detectors
  - LHC (high rate performance and radiation tolerance)
  - CLIC (high rate performance)
  - short strip/ large-pixel tracker for LHC, ILC, CLIC, ..



We are in the process of building collaboration with institutes already active in HV-CMOS.

Collaboration CERN CLICPix group

- We already provided planar sensors for TimePix3
  (Sensor layout done in Liverpool manufactured by Micron)
- Will do the same for CLICPix prototype
- Contribute to characterisation work on planar and the new HV-CMOS sensors for TimePix/CLICPix with a student jointly appointed between Liverpool and CERN CLIC group
- With our CMOS designer work on design further HV-CMOS sensors for CLICPix
  - Pixel sensors for 25x25 um
  - Test position encoding achieving finer effective pixel pitch
- TCAD simulation work to optimise deep N and P well structures to optimise performance and achieve modest gain through charge amplification
- Slightly longer term very interested to test CLICPix with a large strip or strixel sensor with integrated pitch-adaptor.

Summary

Liverpool PP group is keen to join the efforts making the case for CLIC.

We have a range of facilities and expertise which may benefit the R&D work for CLIC detectors. Interested to do some work on vibrational deformation of light structures.

We have a specific interest in HV-CMOS sensors which we hope to develop for application in combination with the CLICPix ASIC.

We are proposing to sign the CLICdp MoC.