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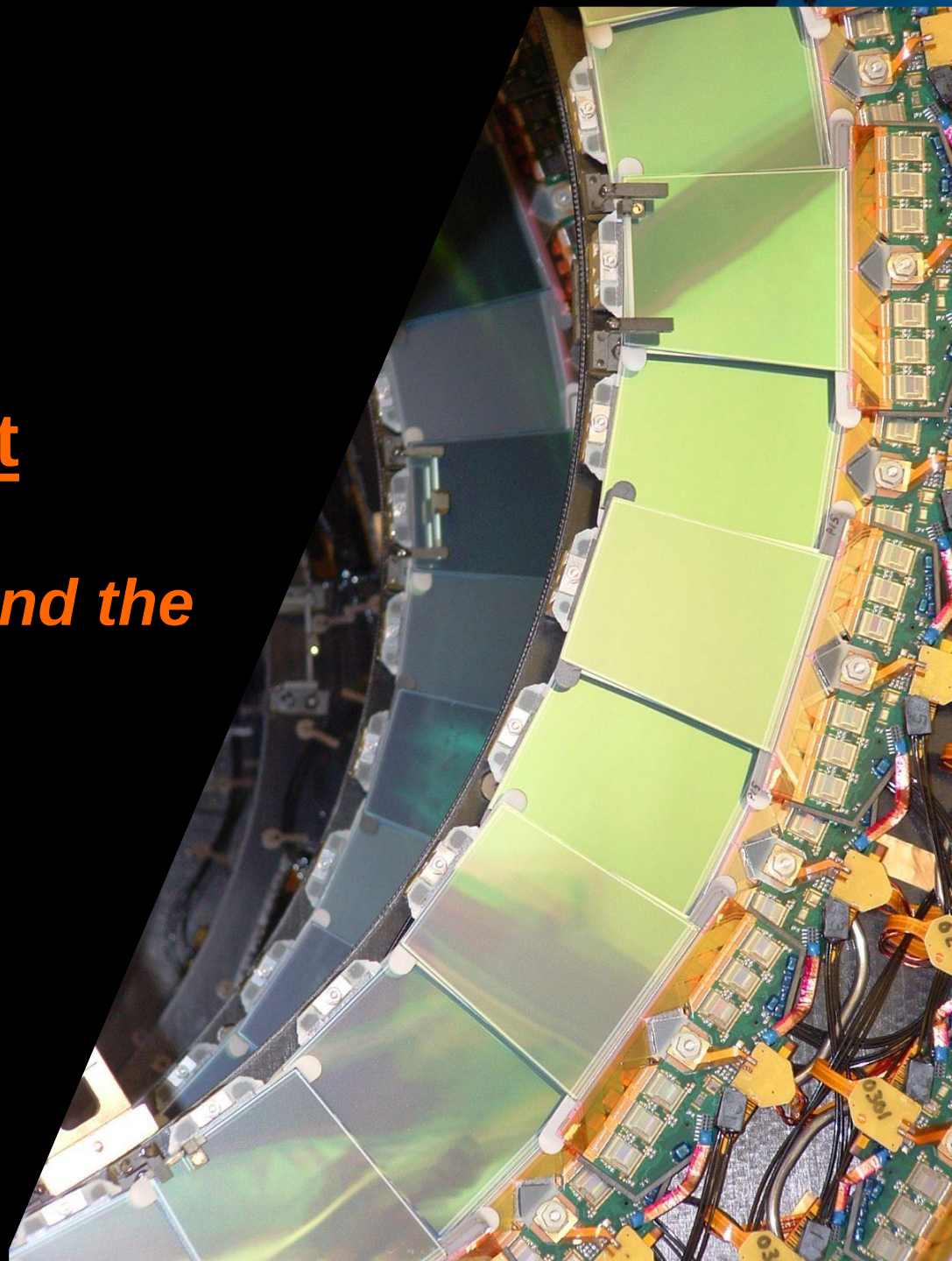
Phil Allport Fest

The ATLAS SCT and the Liverpool LSDC

Joost Vossebeld



Phil in Liverpool: 1993 - 2015

Phil joined the Liverpool Particle Physics group in 1993. The link came about through having worked with the then Liverpool team on Delphi, then led by Prof Paul Booth.

Initial work was on Delphi and on early silicon R&D for future hadron colliders (SSC and LHC). Soon R&D work became focussed on sensor development for ATLAS, which led to the Liverpool involvement in the construction of the ATLAS SCT.

Phil has made a major impact on the Liverpool Particle Physics group, through his work on silicon R&D, the ATLAS SCT and ITk upgrade and as director of the LSDC and Head of the Particle Physics cluster and many other things…!

Phil's job interview in Liverpool itself had a major impact on his life …

Phil met Karol (apparently, buying a suit for Phil's interview was the start of a their life together)

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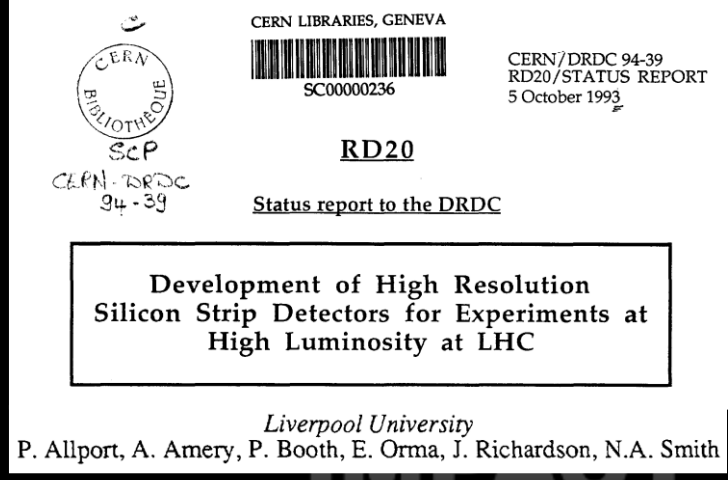
Silicon Detectors for the Large Hadron Collider

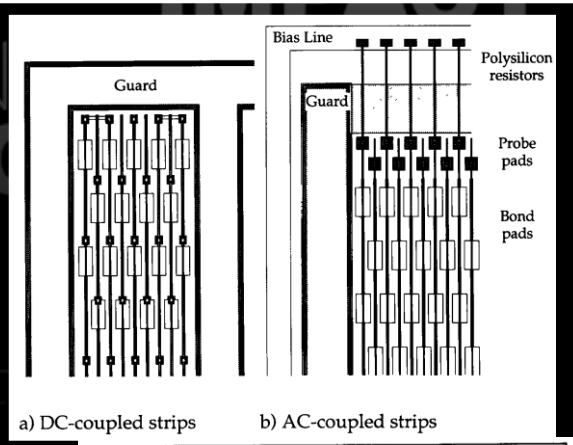
Tracking at the LHC would require small feature size and fast readout as well as ability to sustain radiation.

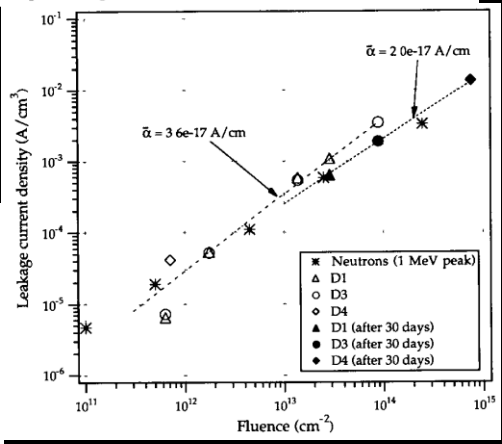
Early silicon detector R&D was done through the RD20 collaboration. Phil, first at Cambridge, and then in Liverpool, played a central part from these early day.

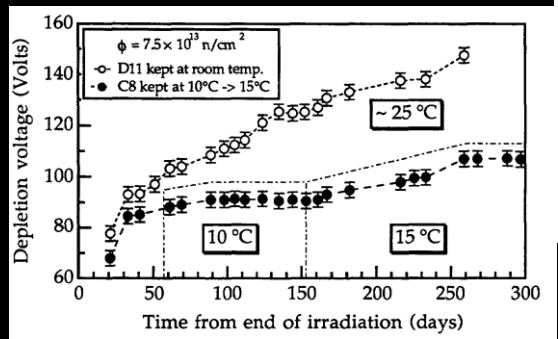
Focus of R&D

- understanding and modelling the effects of radiation (and annealing!) on the performance of sensors
- and on how to design and operate sensors to minimise these effects.
  - Capacitive readout strips
  - Guard rings for high bias voltage
  - Design for cold operation and avoiding thermal run-away









Early ATLAS proposal: competing technologies

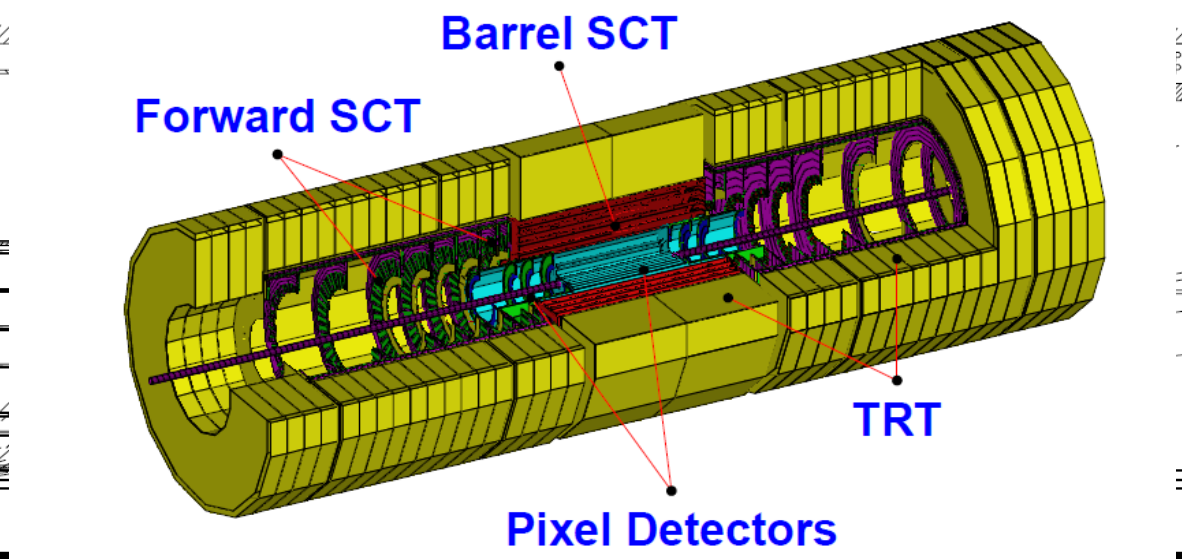
Micro strip gas detectors (MSGCs) and silicon detectors both offered the required small feature sizes and fast readout

Liverpool had a strong gas detector group and was actively involved in the proposal to use MSGCs, but Phil and others saw a brighter future in silicon.

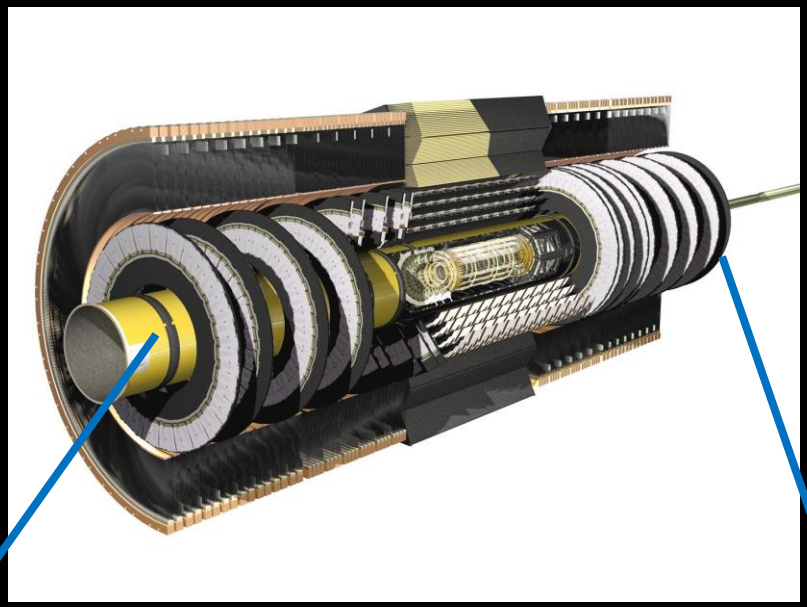
Early on, the main concerns with silicon were:

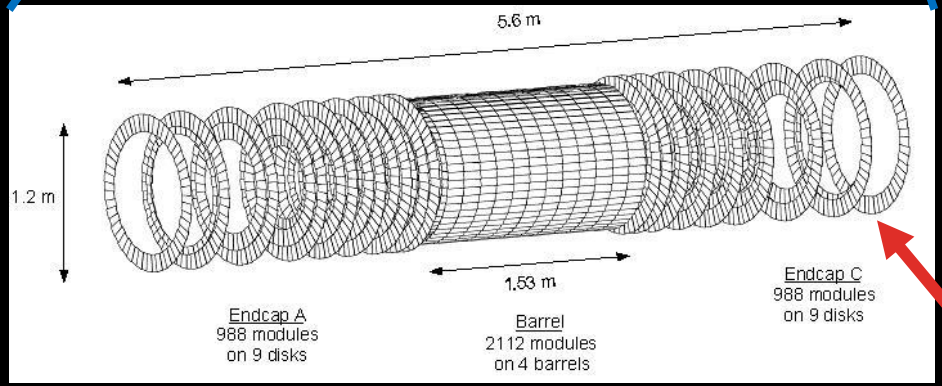
- Cost/Complexity → to cover larger areas with expensive and complex Silicon modules
- Material → silicon sensors require local readout electronics

ATLAS technical design report 1997



The ATLAS Semi-Conductor Tracker (SCT)





Large silicon microstrip tracker with over 4000 silicon modules, 60 m² of silicon and 6.3 million electronic channels.

UK proposed a major involvement in the construction of the SCT detector.

A joint project involving UK, Poland, Spain, Sweden, Germany, Japan, Netherlands, Norway, Australia, US, Czech Republic.

UK contributions to:

- sensor and module development,
- module production
- service and support structure engineering
- the assembly of SCT barrels and endcap-C disks.

Liverpool developed a major role in the construction of the forward STC endcap-C

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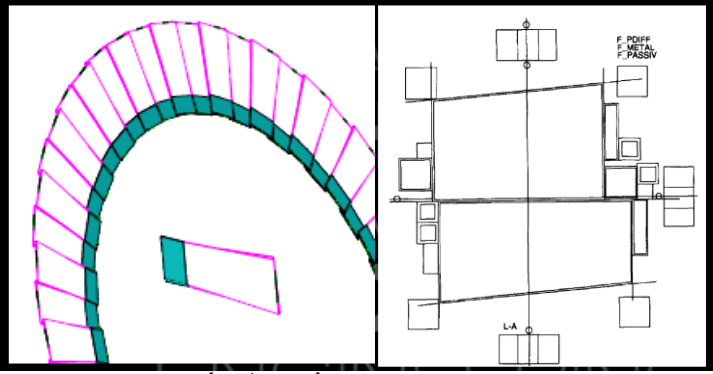
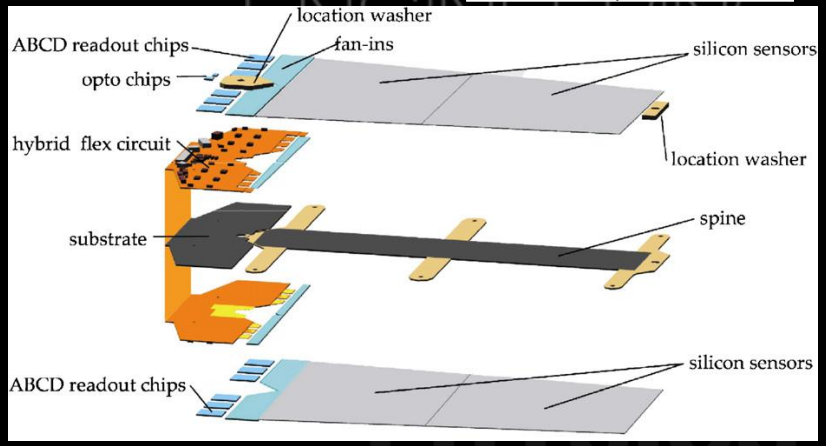
6 Development of the forward SCT module



Key challenges:

- Layout of wedge shaped detectors
- Design of the compact readout flex circuit.
- Thermal separation sensor and electronics
- Design suitable for mass production



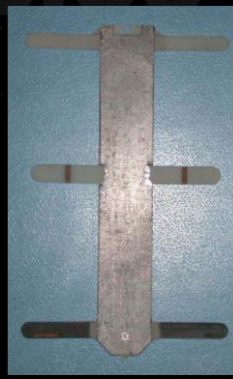
Module concept

Evaluation

- demonstration of the wedge strip sensors
- Manufacture and testing of first sensor prototypes

Early wedge detector with readout board

Endcap module prototype



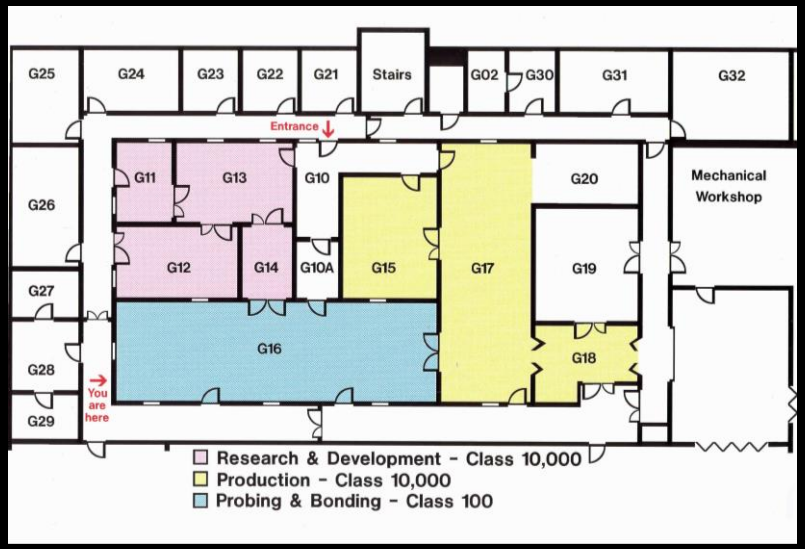
thermolithic pyro graphite spine

The Liverpool Semi-Conductor Centre - LSDC

The construction of large are silicon arrays for the LHC required an investment in state-of-the-art facilities.

In 1998, the University of Liverpool won £3.1M funding from the Joint Infrastructure Fund to establish build a 450m^2 clean room facility equipped with state-of-the-art wire-bonding, wafer-probing and metrology equipment.

JIF was a call for transformative bids the working environment, and enhance the research capability of the UK research community by creating a flexible scheme that can respond to the real needs of the academic research community.



LSDC floorplan

Oliver lodge ground floor from courtyard

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PARTICLE PHYSICS FUNDAMENTAL SCIENCE ENGINEERING

8 Construction of the LSDC







Different stages of LSDC construction project

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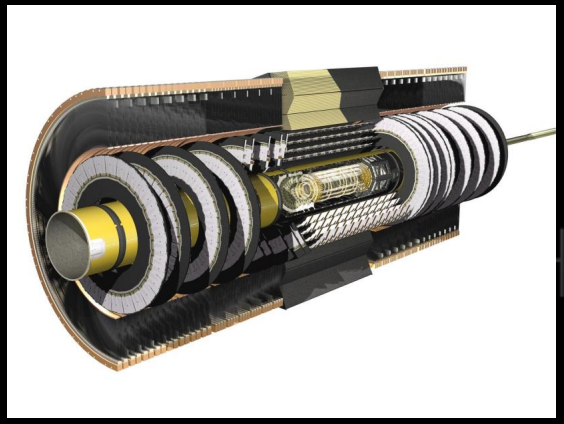
9 Official opening

Officially opened on 11th September 2003 by Sir David King, the government's Chief Scientific Advisor.

LSDC “class 100” area in 2003

Professor Phil Allport, director of the new centre, reports:
"The Semiconductor Detector Centre is equipped with state of the art microelectronics assembly equipment. It makes possible the construction and testing of detector systems of areas of many square metres, built from hundreds of individual sensors, measuring with a spatial resolution of typically a few thousandths of a millimetre."

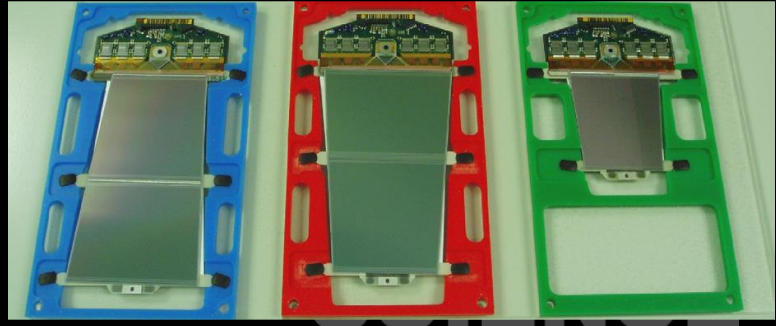
The UK construction of the SCT



Within the UK the SCT detector as proposed as one of the major contributions to the construction of the ATLAS experiment with module production across the UK, endcap-C disk assembly in Liverpool and barrels in Oxford.

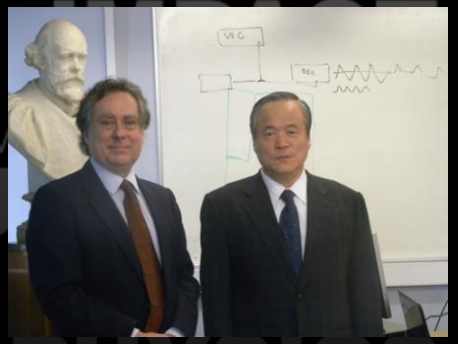
For the endcap-C, following the completion of the LSDC facilities, a decision was taken to do the full endcap assembly in Liverpool → a very important decision for Liverpool.

The forward SCT modules



SCT forward long, middle and short modules

The construction of the SCT endcaps required the manufacture and qualification of ~2,500 forward modules (4 variants)



Phil with Hamamatsu CEO Yamamoto

Phil, together with Carlos Lacasta (Valencia), coordinated this from early qualification, through pre-production and production.

- Qualifying sensor suppliers and coordination of the procurement process.
- Coordinating module production across multiple production sites *(Glasgow, Liverpool, Valencia, MPI, Melbourne, NIKHEF, Geneva, Prague)*
- Quality control during production (next slide)

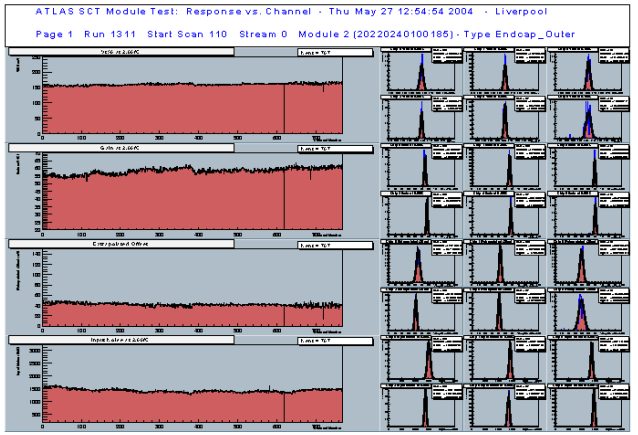
Phil also spent a sabbatical in Valencia working with the team there to set up for module production at IFIC.

Module production and quality control in Liverpool

Module wire bonding (~5,000 bonds per module

Module metrology

In Liverpool 300 modules were built and 1,000 modules were tested.



Detailed electronic testing

The SCT was specified to operate for 10 years at the LHC without intervention. Ensuring high quality was key to the future success of the SCT and ATLAS.

The failure rate today, at the module level, is still only a fraction of a percent, nearly 20 years after module production was completed.

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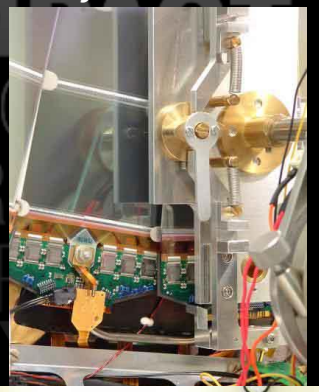
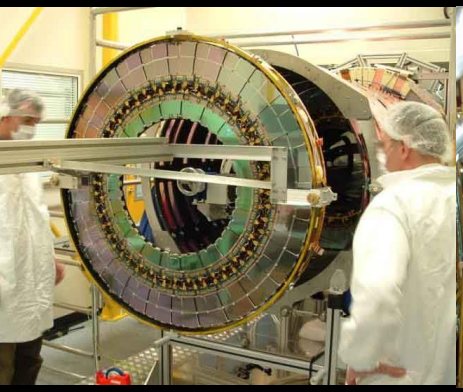
The construction of Endcap-C

Module assembly to disk

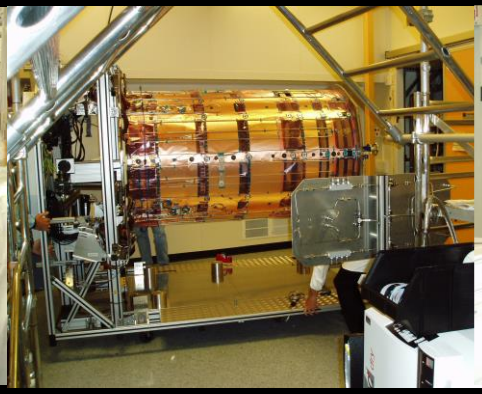
Following the completion of the LSDC facilities, a decision was taken to do the full endcap assembly in Liverpool → a very important decision for Liverpool.

- 9 disks were assembled, mounting up to 132 silicon modules each and connected these to electrical services and cooling.
- Each disk was mounted into the endcap cylinder and connected to the on-cylinder services
- Extensive cooling and read-out infrastructure was set up in the LSDC to fully test all disk after installation.

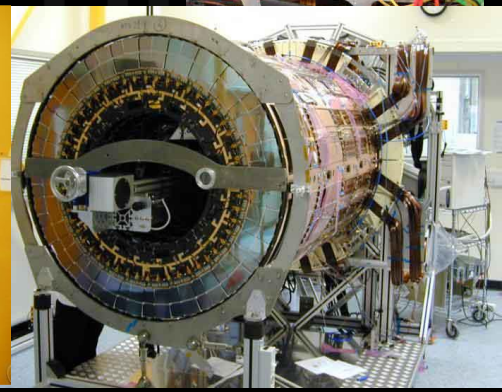




Disk installation



Connecting and testing



endcap-C completion

The assembly of the SCT Endcap-C in Liverpool completed was in 2004!

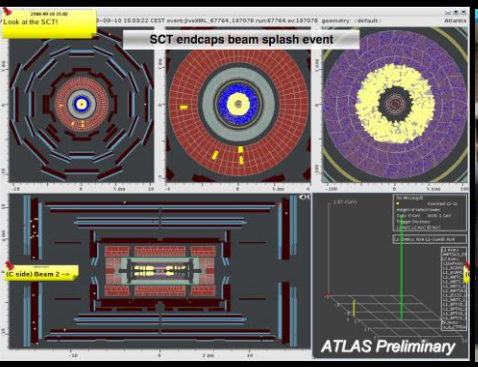
Delivery to CERN, installation and start up

Arrival at CERN

Endcap-C in CERN clean room

Installation in ATLAS

LHC start-up 10/9/08



First particles seen in SCT on day 1

Celebrations in Liverpool (with pro-VC Steve Holloway)

but followed by this a few days later…!

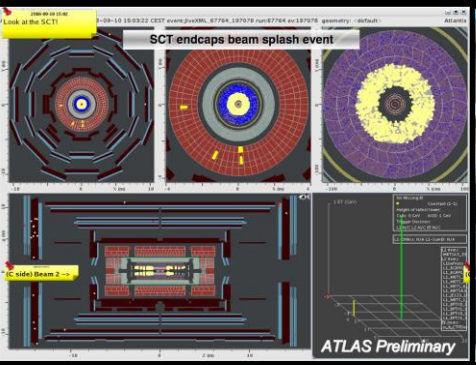
Delivery to CERN, installation and start up

Arrival at CERN

Endcap-C in CERN clean room

Installation in ATLAS

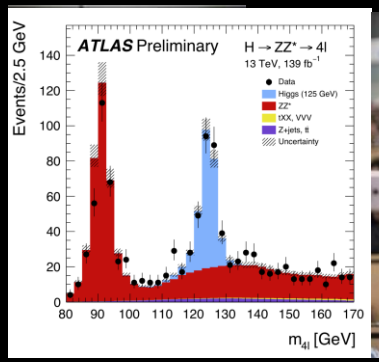
LHC start-up 10/9/08



First particles seen in SCT on day 1

Celebrations in Liverpool

.., but luckily in the end got much better..



Promoting Science and inspiring people

Phil & Karol jointly organised many Neston High School trips to CERN.

Major impact on many young people

- many students went on to do physics degrees
- some are today working in particle physics!

Neston High School visit to CERN

The Merseyside Skeptics Society

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« Newspapers Wake Up From A Coma Speaking Fluent Bullshit — Bad PR: Schrödinger's Cock! »

Skeptics in the Pub: Phil Allport

Liverpool and the Large Hadron Collider

by Phil Allport
When: Thu, Jun 17, 2010 8.00 - 11.00 PM
Where: The Vines (aka the Big House), 81 Lime Street, Liverpool

Summary

The Large Hadron Collider is the world's largest and highest-energy particle accelerator. It was built by the European Organization for Nuclear Research (CERN) with the intention of testing various predictions of high-energy physics, including the existence of the hypothesized Higgs boson.

Dr Phil Allport will be talking to the MSS about the involvement of Liverpool and other UK universities in the design and construction of

Talks to the wider audience on many occasions.

The not so good times…

As head of Liverpool Particle Physics group:

- Severe funding crisis in PP following merger of PPARC and CCLRC into STFC.
- The UK withdrew from the ILC and even looked at a possible withdrawal from CERN.
- PP groups faced funding being removed from already active grants.
- Very painful situations where research activities were abruptly ended and contracts to some staff could not be honoured.

Phil worked incredibly hard to help achieve ensure the best possible outcome for all involved.

As head of Liverpool PP and also chair of the IOP high energy particle physics section Phil co-organised the community campaign to fight against these severe cuts.

Particle Physics Action Group (2009-2011): Phil Allport, Brian Cox, Mark Lancaster, Brian Foster (with support from James Stirling)

Particle Physics is still here!

Press Release from the Particle Physics Action Group in response to the IUS Select Committee Report

Embargoed until 00.01 on Wednesday 30th April 2008

We very much welcome the Innovation, Universities, Science and Skills Committee report into the science budget allocations and the handling of the allocation by the Science and Technology Facilities Council (STFC).

The report vindicates the strong and near-unanimous criticism by the UK scientific community of both the government's initial budget allocation to STFC and the mismanagement of the ensuing crisis by STFC senior management.

The challenge now is to move forward to repair the damage done to the UK's international reputation and to the image of our science nationally, particularly in the eyes of the young scientists and school children who are the future of our field.

It is also essential that further cuts in staffing levels at the Rutherford Appleton and Daresbury Laboratories are halted immediately, as the report recommends, to prevent further loss of the highly skilled personnel who will play a vital role in the recovery from the current crisis. The unprecedented withdrawal of already issued university grants should stop.

To this end, we call on the government to demonstrate its stated commitment to fundamental science and take the Committee's recommendations seriously, reform the senior management structure of STFC and address the serious funding shortfall explicitly recognised in the report.

Professor James Stirling, Pro-Vice-Chancellor for Research at Durham University said:

"The Select Committee's report reserves particularly strong criticism for the way in which STFC has handled communications: with its own staff, with members of the research community and with international partners. It has been left to researchers themselves to reassure young people that fundamental science is still important and to rebuild the bridges with our international collaborators. Both the Government and the research community have been badly let down by the research council - what is needed now is a fresh start."

Professor Brian Foster, head of Particle Physics at Oxford University, said:

"I am immensely impressed that the Select Committee has put its finger on the four main factors that have contributed to the current problems: the hasty and ill-conceived formation of STFC; Government overcommitment to full economic cost of research and cross-council programmes at the expense of world-class science; poor advice to Ministers from within DIUS; and mistakes and weakness in STFC management. This report is a bombshell."

The legacy of the work on the SCT

Building detectors like the SCT to the highest possible standard has been key to the physics successes of the LHC → more than a thousand published physics papers from ATLAS alone!

The R&D and expertise gained established silicon detectors as the leading technology option a for vertex and tracking detectors for may future experiments and upgrades.

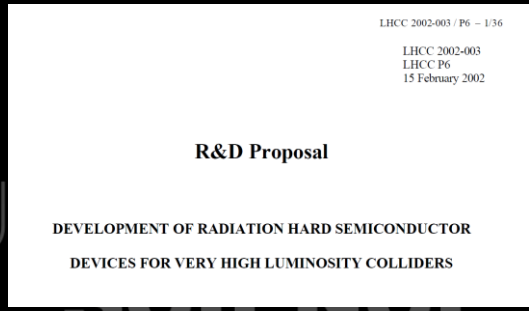
Sensor R&D from early 2000s R&D focussed on the upgrades of the ATLAS detector for the super-LHC (HL-LHC)

- Collaborative R&D found a new home in RD50
- **n-in-p sensors:** with others in Liverpool, Phil focussed on developing radiation tolerant n-in-p silicon sensors -- now the baseline technology choice for the HL-LHC tracker upgrades.
- **Monolithic pixel sensors:** discussions with Phil and others around 2012 to join a new R&D on High Voltage monolithic CMOS sensors, a technology we are now deploying in Mu3e for the first time.

ATLAS HL-LHC Tracker upgrade The ITk proposal was built on the expertise gained and construction infrastructure developed for the SCT and similar projects.

Very soon after delivering the SCT, Phil initiated in Liverpool the work starting to develop the detector solutions for the ATLAS ITk tracker upgrade:

- Large project on ITk strip barrels and pixel endcap in the UK.
- Leadership Phil of the International ITk project

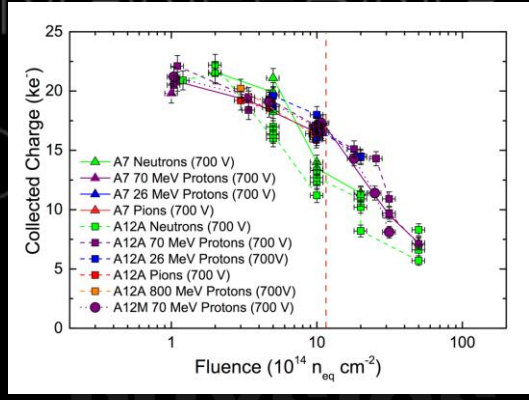

LHCC 2002-003 / P6 – 1/36

LHCC 2002-003
LHCC P6
15 February 2002

R&D Proposal

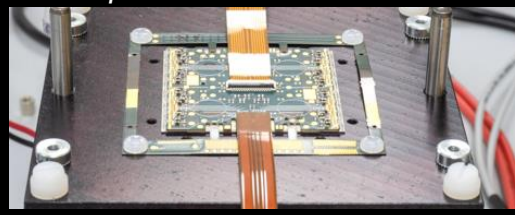
DEVELOPMENT OF RADIATION HARD SEMICONDUCTOR DEVICES FOR VERY HIGH LUMINOSITY COLLIDERS

Department of Physics, University of Liverpool, United Kingdom
P.P.Allport, G.Casse



charge collection vs fluence at 700V

ITk strip barrel module



ITk quad pixel module

The LSDC today

The SCT was the first major project hosted in the facility.

- Extensive expertise and infrastructure was developed under Phil's lead
- and was grown and kept up-to-date since then, through the hosting many projects including Liverpool ITk work.

Over the 20 years since it was established the LSDC hosted:

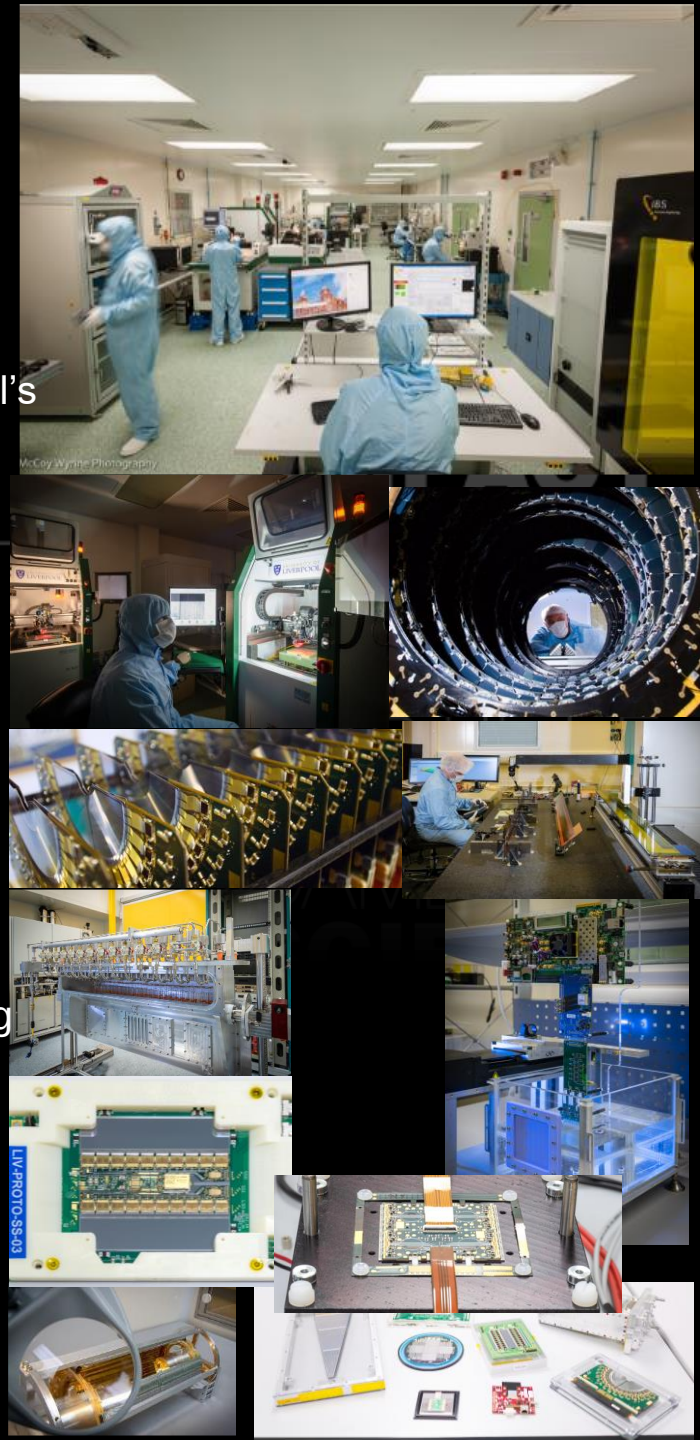
ATLAS: SCT, ITk strip barrel and ITk pixel endcap, **LHC-b:** Vertex Locator and Velo pixel upgrade, **T2K/ND280:** ECAL, **g-2:** straw tracker, **LZ**: optical calibration system, **SBND:** Cathode planes, **Mu3e:** HV-MAPS Tracker, **DarkSide20k:** SiPM tiles, NP: **ALICE:** ITS and the **ALPHA**, **R3B** and **HI-ISOLDE** silicon detectors

Silicon R&D: radiation tolerance, HV-MAPS, Proton therapy applications

Calorimetry: MODEs-SNM security and **VIDAR** reactor monitoring

Lar R&D: ARIADNE

Much of the work on these projects could not have been done in Liverpool without the LSDC and the work on the SCT.



SCT team on completion SCT Endcap-C in 2004

A big thank you, Phil, for the major impact you have had on the Liverpool PP group!