



Particle Physics, RAL, and Godfrey...

Norman McCubbin

Particle Physics Department (retired)

Rutherford Appleton Laboratory, STFC

Particle Physics: circa 1920

- I feel honoured to be invited to talk on this occasion.
- Godfrey's life span (1920-2013) is almost the same as that of "particle physics".
- In 1920:
 - (Almost) all scientists believed in atoms;
 - We had begun to understand their internal structure of atoms: Rutherford, the atomic nucleus, 1911;
 - We had the proton and the electron, but no neutron, and not even an inkling of the extended family of particles we have today;
 - We knew of the existence of cosmic rays: Victor Hess, 1912.



Particle Physics: circa 1950

- Until the 1950s, research in “particle physics” relied principally on naturally occurring phenomena, eg helium nuclei (alpha particles) produced in radioactive decay, or the cosmic rays.
- Godfrey’s first steps in research (MSc, University of Cape Town, 1941) were in cosmic rays. First published paper “The Second Maximum in the Rossi Curve” (Nature, April 1942). (A hot topic in cosmic rays for some time..)
- After WW2, during which Godfrey was based for a time on Robben Island, he returned briefly to South Africa, where he met and taught Franz Heymann.



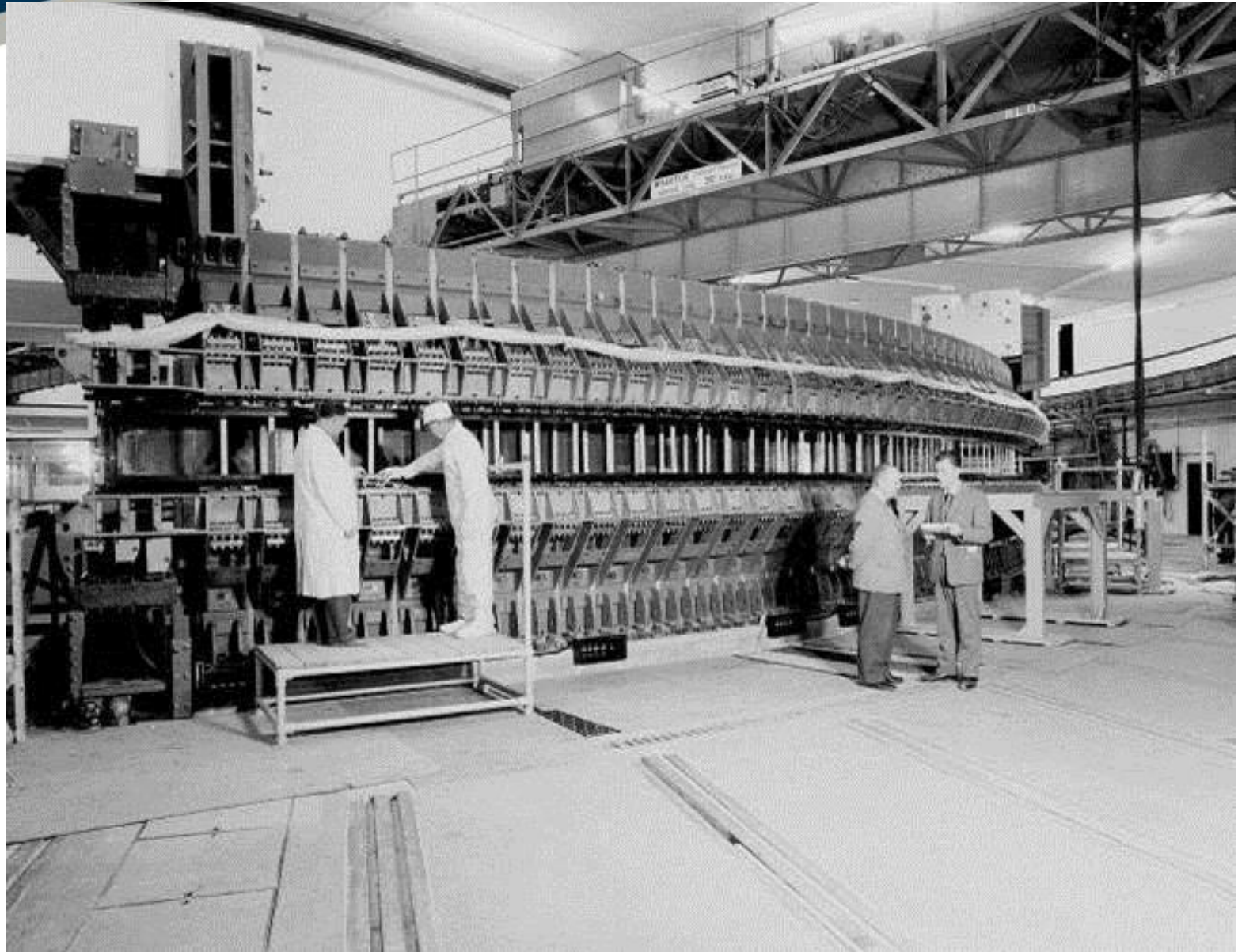
Cambridge, Harwell, South Africa, Harwell

- **Godfrey returned to UK in 1946 to start a PhD in nuclear physics at Cambridge, where he met and worked with the redoubtable Denys Wilkinson, who became a long-term colleague and ally.**
- **Godfrey's Phd used an ionization chamber (kV) filled with hydrogen at ~90 atmospheres (!) (Nature, 1948), and measured neutron cross-sections on Be, Al, S and Pb.**
- **After Cambridge Godfrey worked at Harwell, under Gerry Pickavance, but in 1951 returned to South Africa (Pretoria).**
- **In 1954 Pickavance offered him a job at Harwell in the Cyclotron Group, and he came back, and stayed! (3 children by now...)**

Accelerators: CERN, PLA, Rutherford Lab..

- By the 1950s, (man-made) accelerators were becoming the dominant tool in particle physics research.
- The UK was (after some characteristic dithering over matters European) a founding member of CERN in 1954, but until ~1970 concentrated on UK-based facilities.
- In ~1957 Godfrey was planning to carry out experiments at CERN, using the newly built synchro-cyclotron (SC), together with Franz Heymann (by then at UCL), but:
 - “I had to move to the embryo Rutherford Laboratory to finish the construction of the abbreviated 600MeV PLA which Metropolitan Vickers in its declining years had made a hash of.” (Godfrey, 2005)

Accelerators: Rutherford Lab, Nimrod



NIMROD OPERATION

Acceleration to ~ 7 GeV

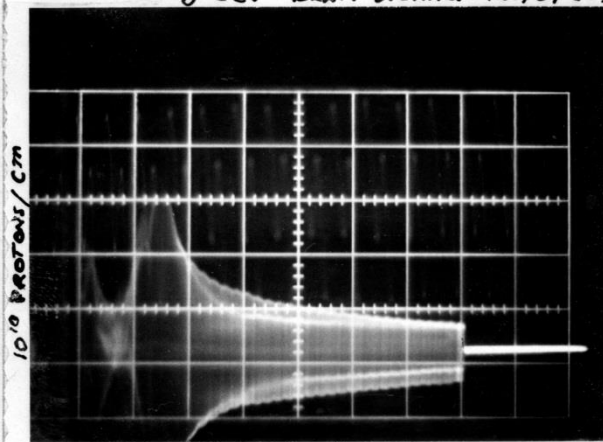
Tuesday 27th Aug. 1963

1723 hrs. Acceleration to 6.5 GeV.

1830 hrs Maximum Energy of 8 GeV attained. (see photo)

1900 hrs Acceleration of 10^{10} particles to 7 GeV.

8 GeV BEAM SIGNAL. (27/8/63)



● 0.1 SECS/CM

→
0.1 SECS/CM.

This photo shows the envelope of pulses from the induction electrodes, which are induced by circulating beam.

The envelope is seen to extend to 0.8 secs after injection. The measured field at this time is 15.9 Kgauss, which is the field level corresponding to 8 GeV.

M.B.



Rutherford Lab: the Nimrod years (2)

- The Nimrod experimental programme started in 1964, and over its 15 years would produce over 200 papers and ~130 PhDs (several here today) from 77 experiments, with involvement from all UK University groups and several from abroad.
- Nimrod made major contributions to the physics of hadronic resonances, which was a large part of particle physics at that time.
- Initially Godfrey was an active experimentalist, and I believe we may hear something of that time later.



Rutherford Lab: the Nimrod years (3)

- **Godfrey became Deputy Director in 1966 and Director in 1970, when Gerry Pickavance moved to SRC. (The successor to the much lamented NIRNS.)**
- **Nimrod started operation ~10 years after the BNL machine of similar energy, and 4 years after CERN's 25 GeV machine (PS).**
- **By 1976 CERN also had the SPS (400 GeV) and ISR (31+31 GeV collider) operational, and UK physicists were moving there, and elsewhere.**
- **So, in 1978 Nimrod was closed, and the laboratory made the transition to the multi-disciplinary laboratory it is today. (See other talks!!)**

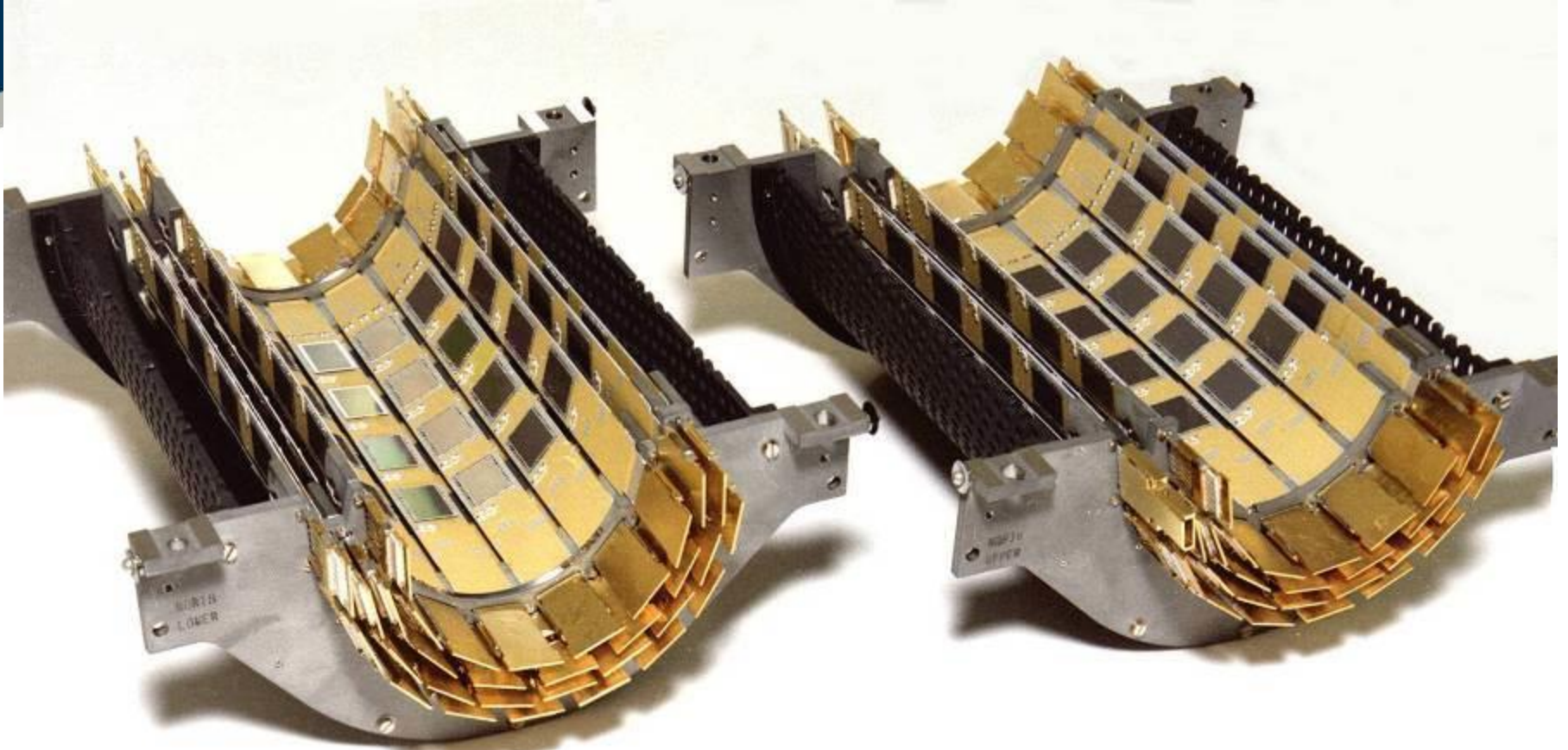


Particle Physics Department (PPD) after Nimrod

- **For Particle Physics at RAL (Rutherford Appleton Lab after 1978), the Nimrod closure completed in effect a transition to the role we still have today:**
 - **physics driven;**
 - **close collaboration with UK university groups, as full and equal partners in the experiments;**
 - **enabling and facilitating access to and use of RAL's technical, engineering and computing resources;**
 - **benefit (usually!) of centralised administrative and financial management;**
 - **preparation of equipment for experiments to be carried out at CERN, DESY (Germany), FNAL (USA), SLAC (USA), KEK (Japan), ...**

Particle Physics Department (PPD) after Nimrod

- **My subjective (by definition) list of major achievements over last 30 years to which PPD has contributed in a major way includes:**
 - **Discovery of jets in hadronic collisions, discovery of W and Z particles; definitive studies of proton structure functions and their parameterization; definitive study of properties of W and Z; world-leading limits on neutron edm; wide-ranging and precise tests of Standard Model; crucial measurements in neutrino sector;..**
 - **Pioneering developments in: vertex detectors and detectors for dark matter; large volume track chambers + triggering; scintillators; three of the largest superconducting solenoids ever built;...**
 - **Major contributions to use of computing in HEP; accelerator studies for PP;.....**
 - **..and I haven't got to the LHC yet!**



Tim Du



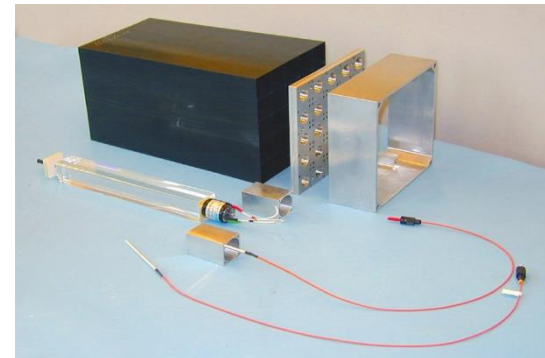
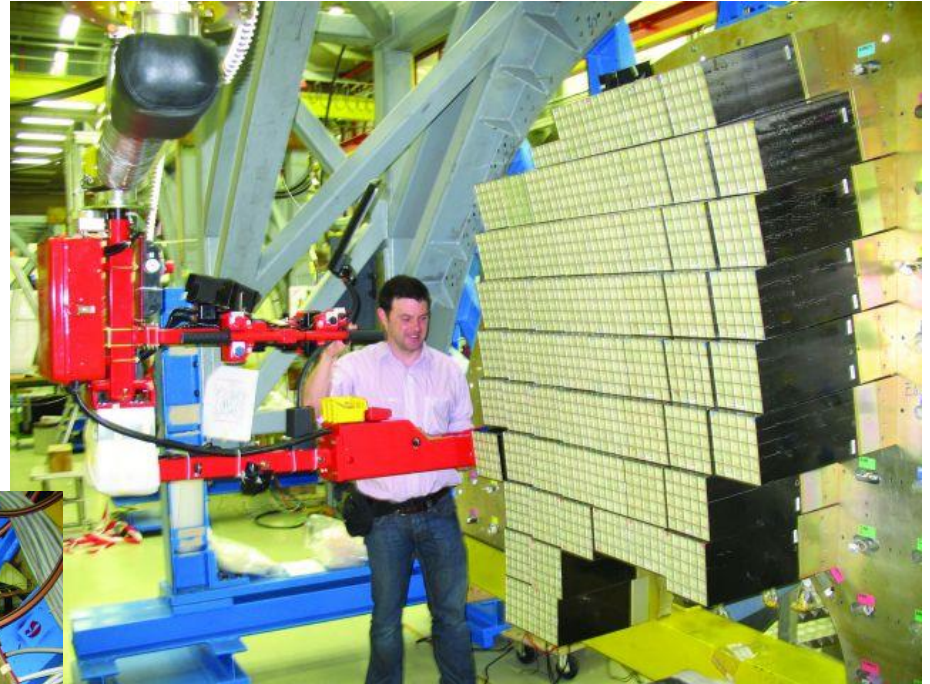
Meanwhile.....

- **Godfrey stepped down as Director of RAL in 1981, but this was of course in no sense the end of his active career! (St Cross; EPS, IoP,..)**
- **From the perspective of particle physics his major contribution at around this time was as Chairman of CERN's Scientific Policy Committee (SPC) from 1978-1980.**
- **Hence he chaired key discussions on CERN's future, and in particular the momentous SPC meeting of September 1979 that “..unanimously decided to recommend LEP to the Council as the next major accelerator for Europe.”**
- **(“ADAMS said that it was thought that a tunnel with a cross-section of 4 metres was adequate for the LEP machine, and possibly a proton machine later on.”)**

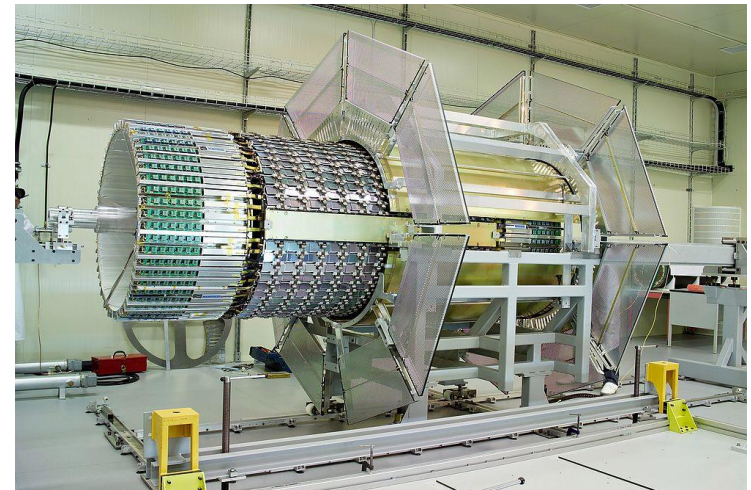
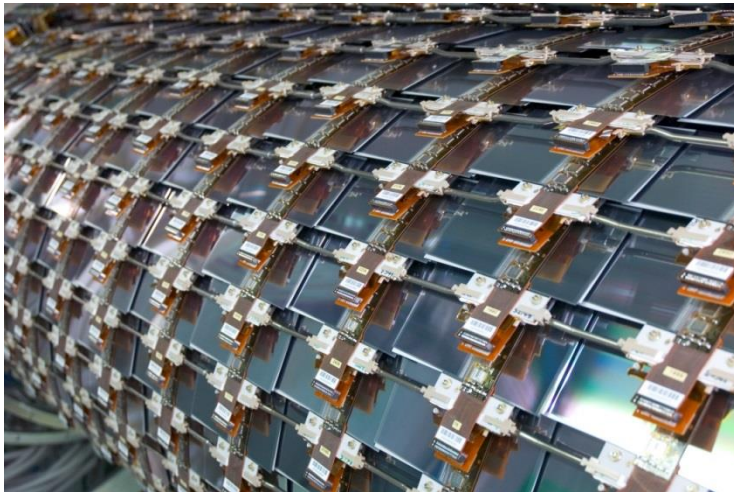
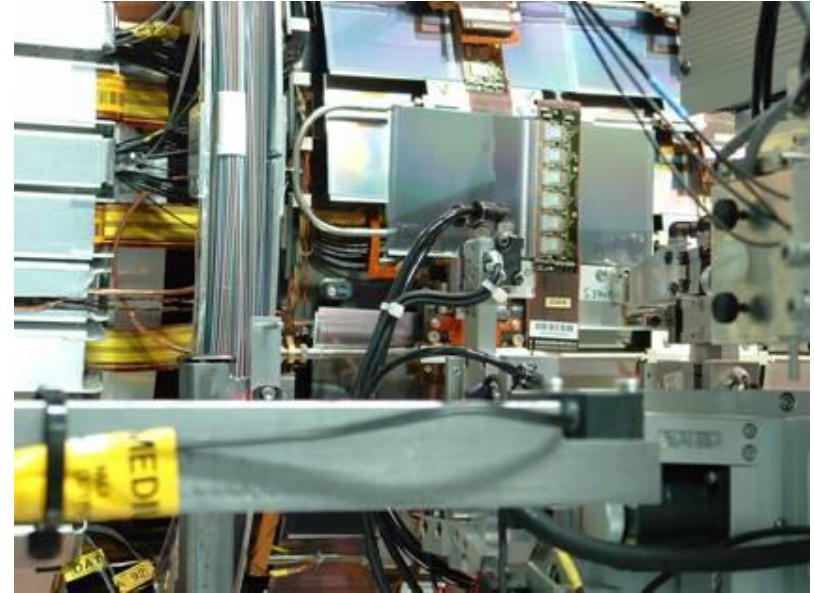
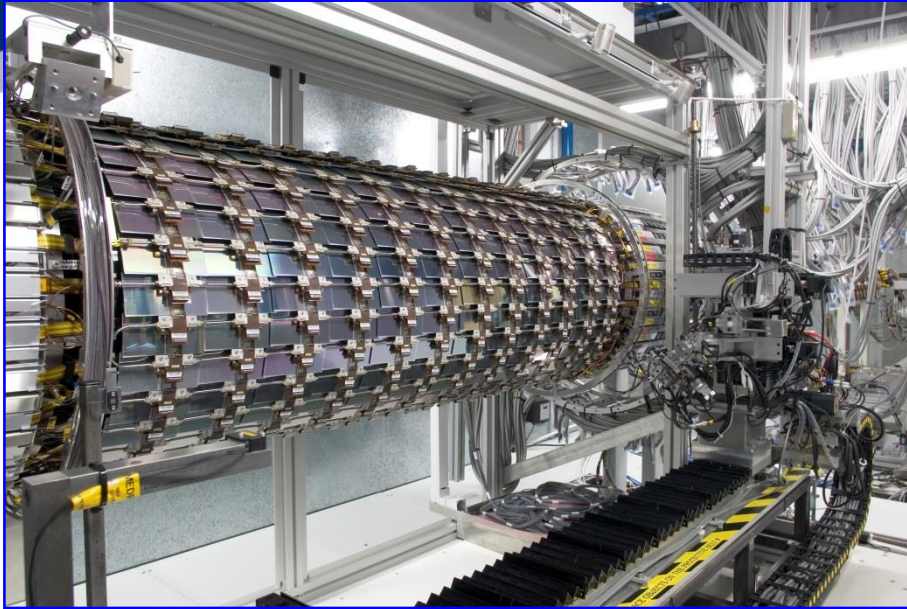
LHC

- **John Adams’ “proton machine” was of course the CERN Large Hadron Collider (LHC).**
- **The UK, and hence RAL, was and is a major contributor to ATLAS, CMS, and LHCb, and also to ALICE (through EPSRC).**

Construction



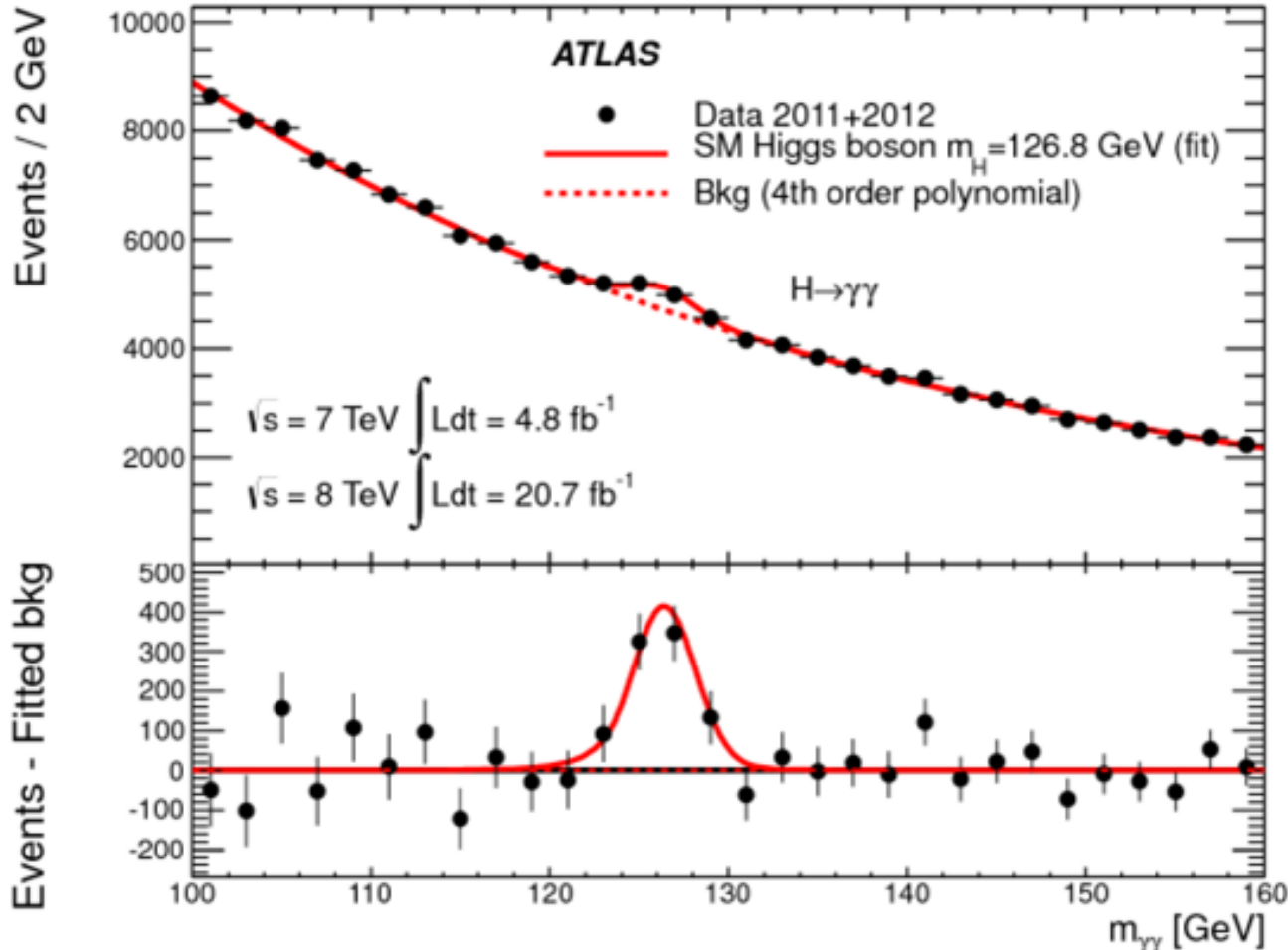
SemiConductor Tracker (SCT)



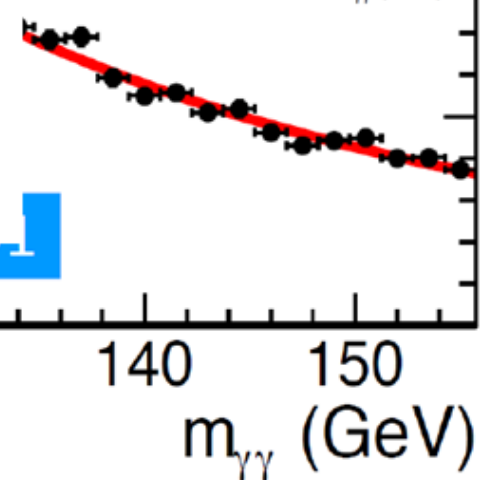
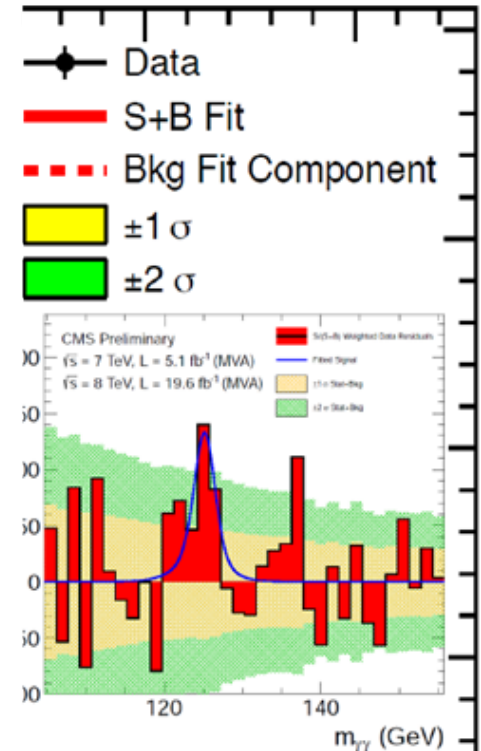
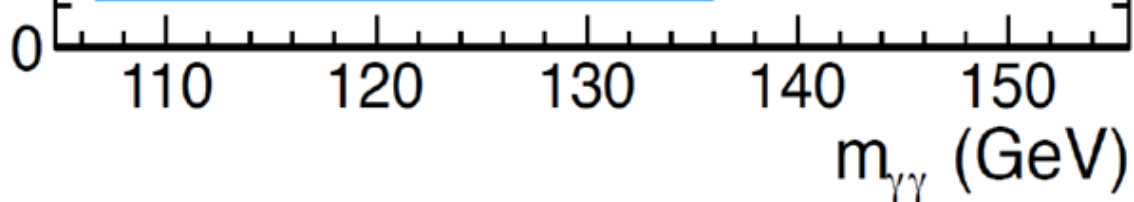
Discovery of the Higgs ¹⁸
Boson



The Higgs is clearly seen!



S/S



Nobel Prize 2013



The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs *"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the **ATLAS and CMS experiments** at **CERN's Large Hadron Collider**.*

Godfrey's Legacy...

- **Sir Harry Massey at the Nimrod commemoration, 27th June 1978:**
 - “Any success Nimrod has had, so far as producing science is concerned, is amplified by the success it has had in bringing the community together.... (The high energy physics community) is the most closely knit, and one which really can talk with one voice in a way that many others do not. There is no doubt that a very great deal of credit is due to the existence of the Laboratory and its Nimrod activities.”