Reflections on the atomic nucleus

Summary
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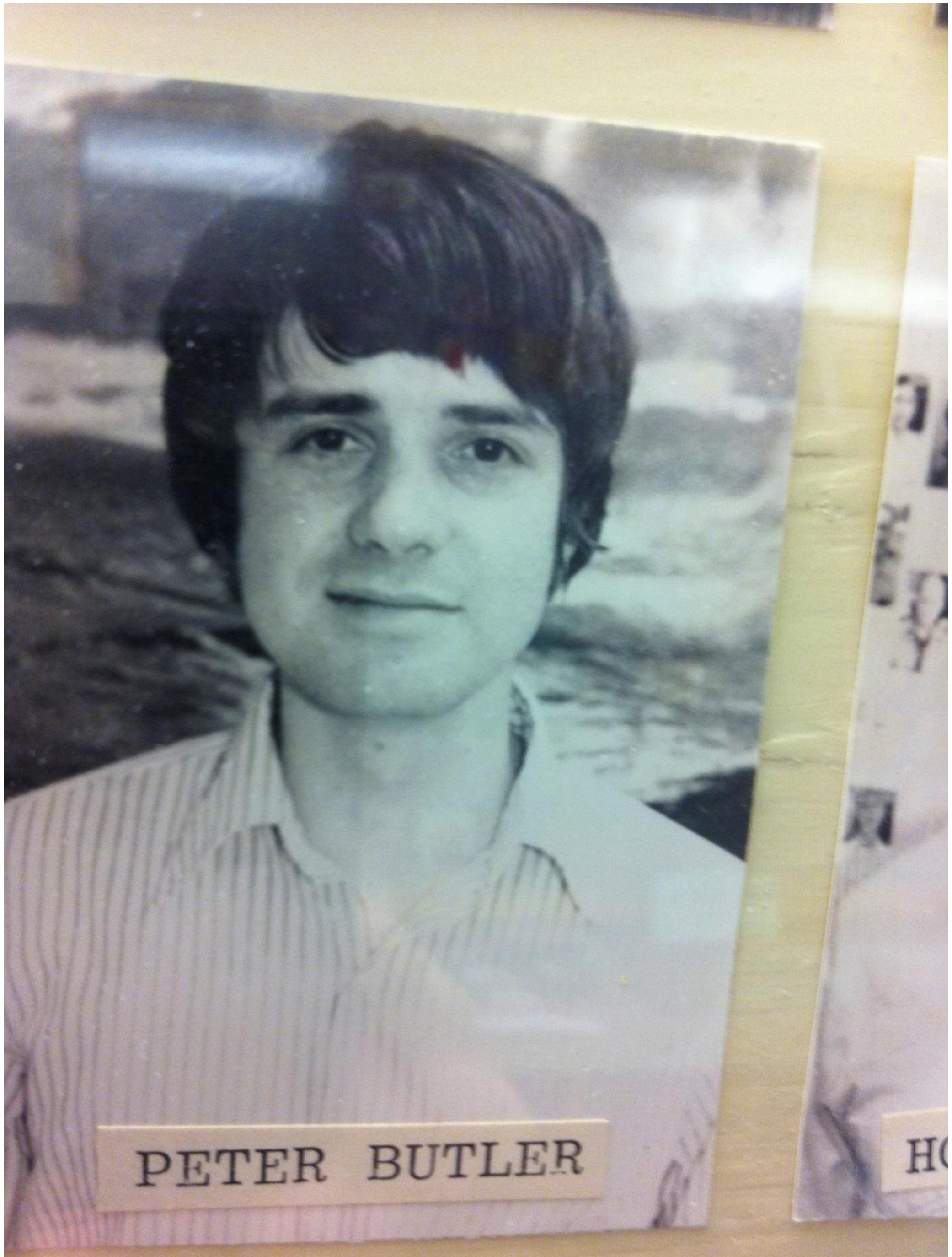
Nuclear Physics Group
STFC Daresbury Laboratory

Liverpool, July 2015

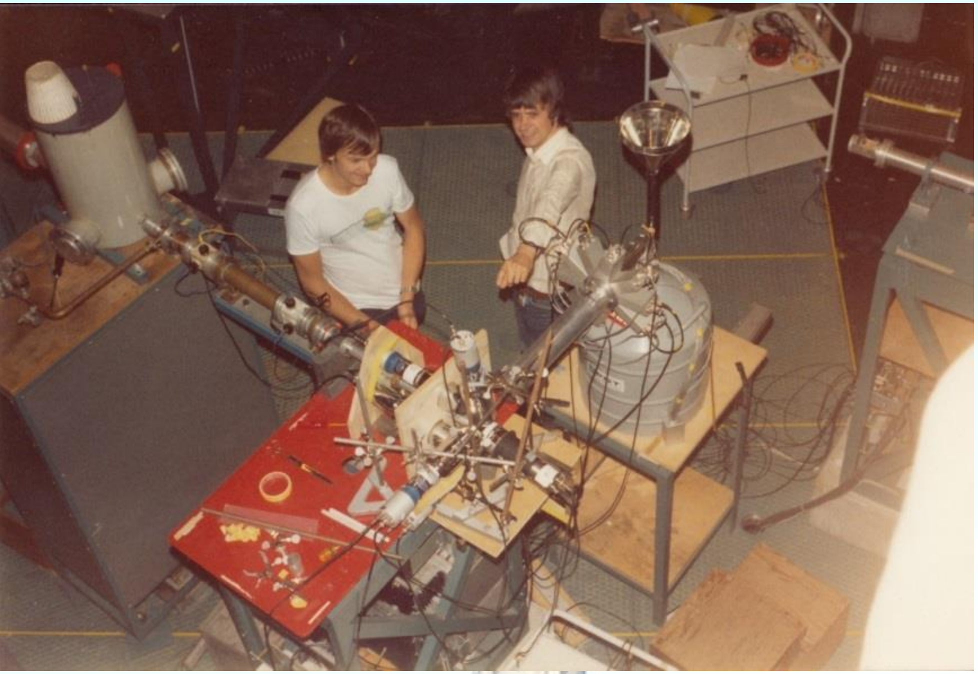
Themes

- Spectroscopy – structure
- Shapes – exotic – pears
- Heavy nuclei
- Experiments – powerful tools
- Beams – exotic probes

- Training – teaching – students
- Collaboration
- Fun


PETER BUTLER

Application of a Sectored Ge(Li) Detector as a Compton Polarimeter
J.Simpson, P.A.Butler and L.P.Ekström
Nucl.Instr.Meth. **204** (1983) 463-469. #49



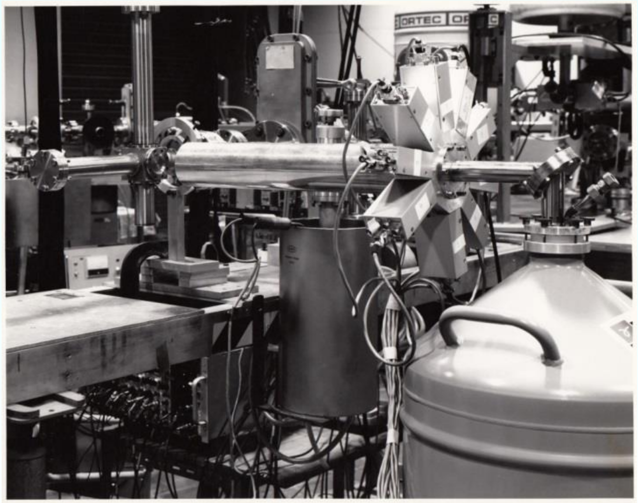
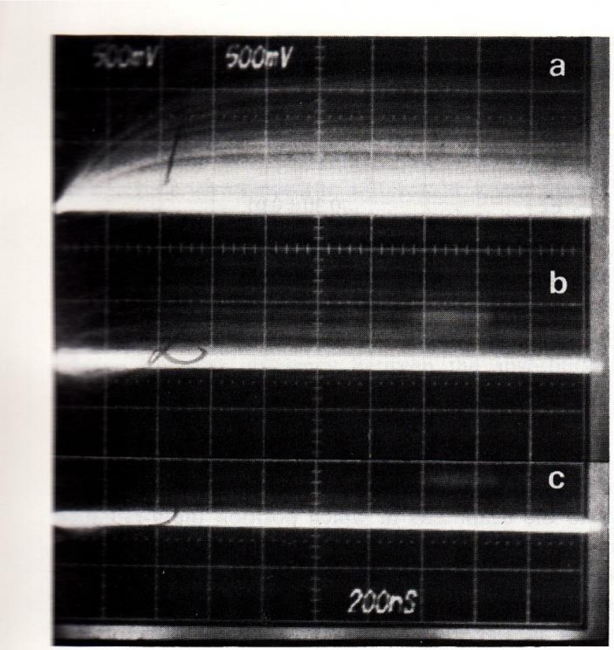
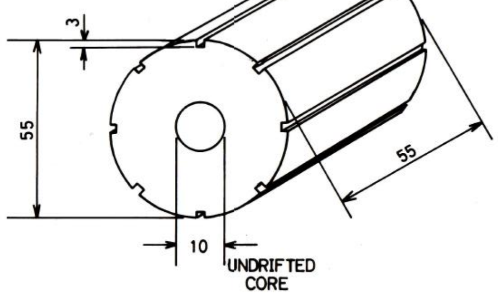


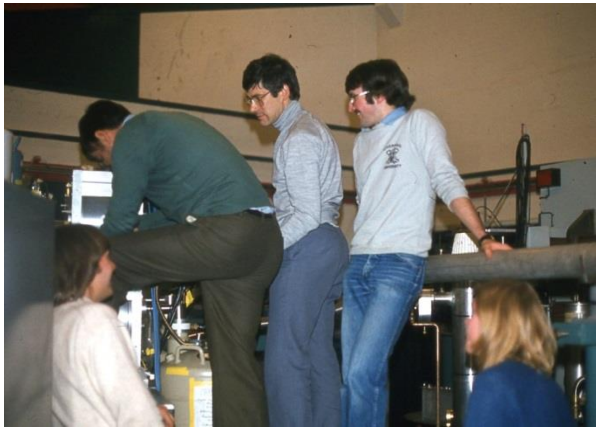
Image pulses

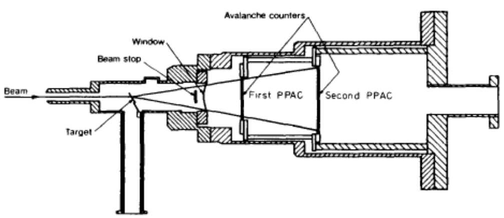


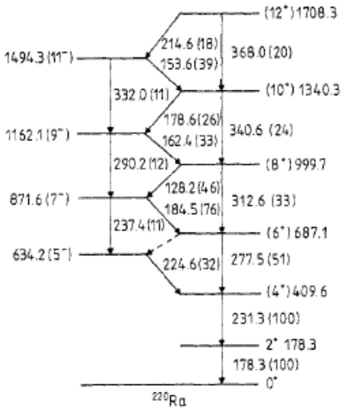


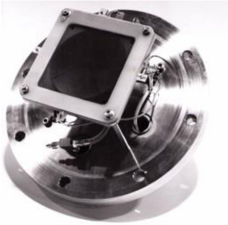
SECTORED GERMANIUM CRYSTAL

Gas counters and heavy nuclei









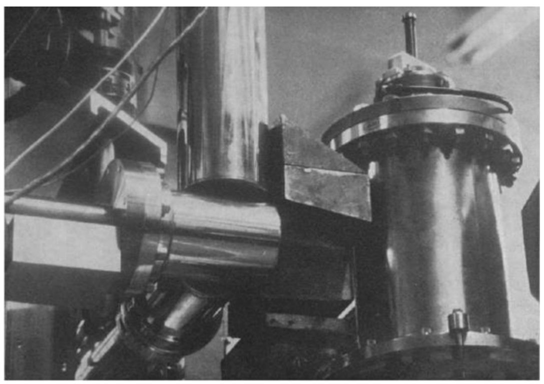
Relaxing

♫Watching the data role in ….♫

High-tech instrumentation

Oxford circa 1980

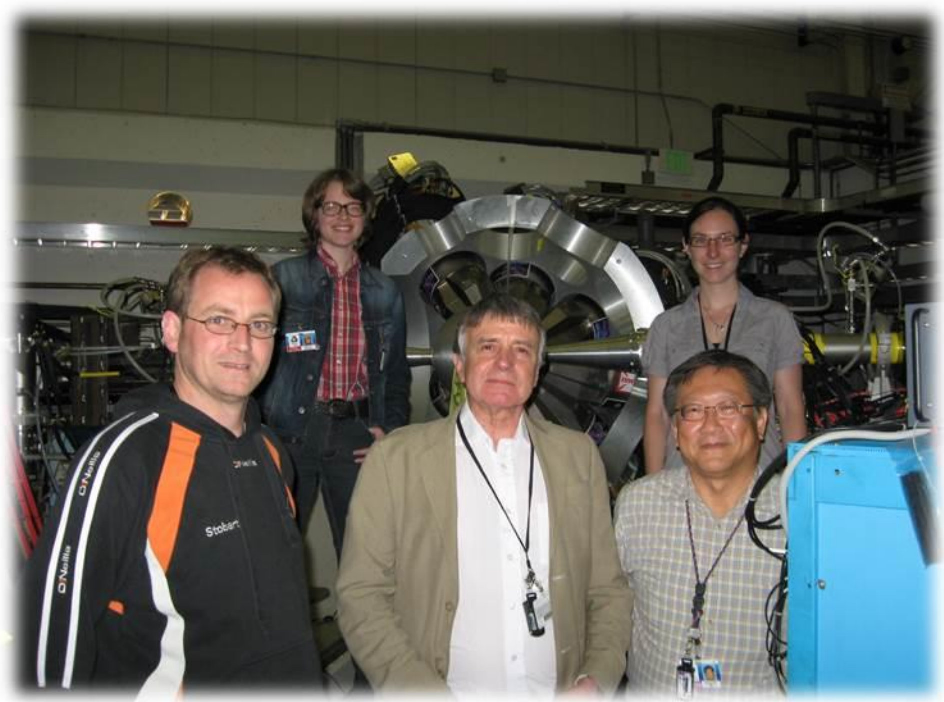
Gamma-ray spectroscopy



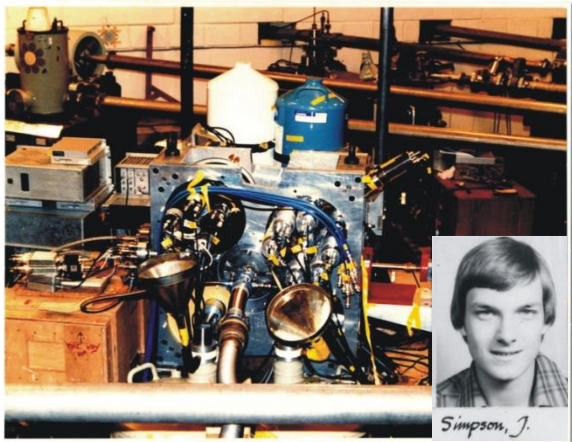
From Liverpool

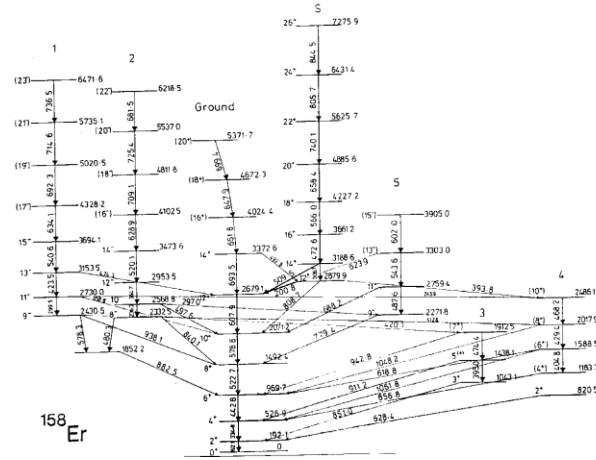
To NBI
TESSA

To MSU
Gretina

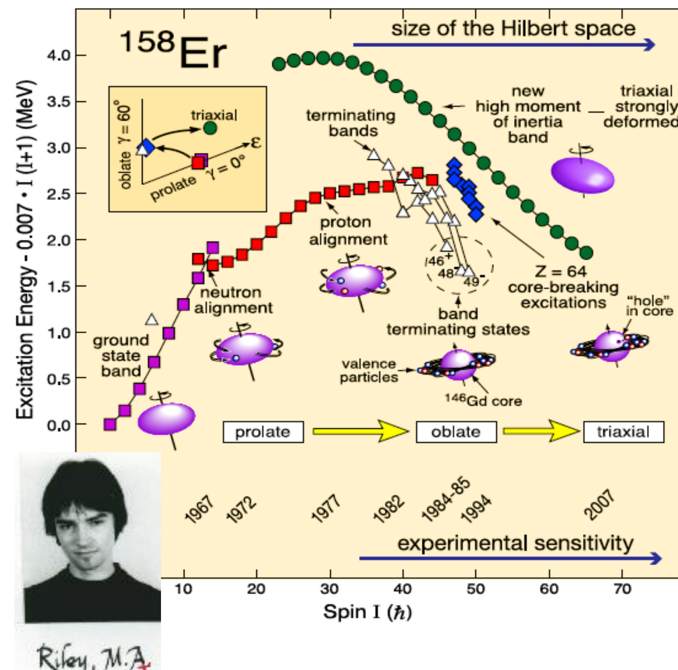


Spectroscopy Gamma and Electron





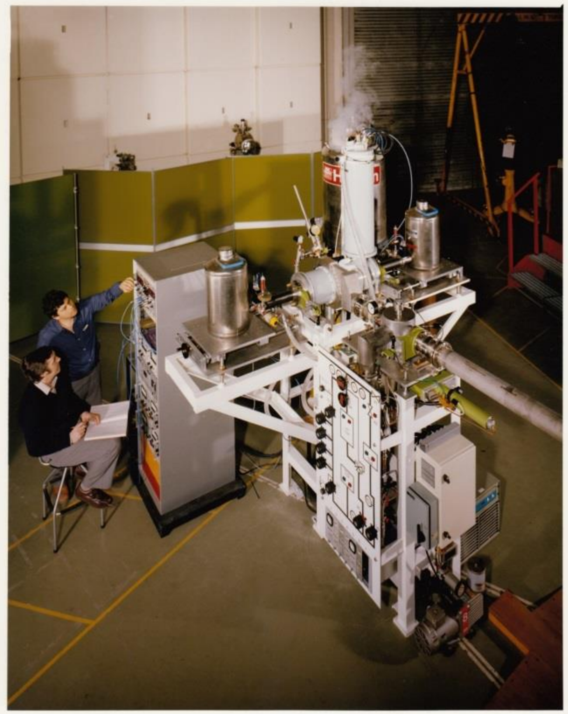
Internal conversion measurements



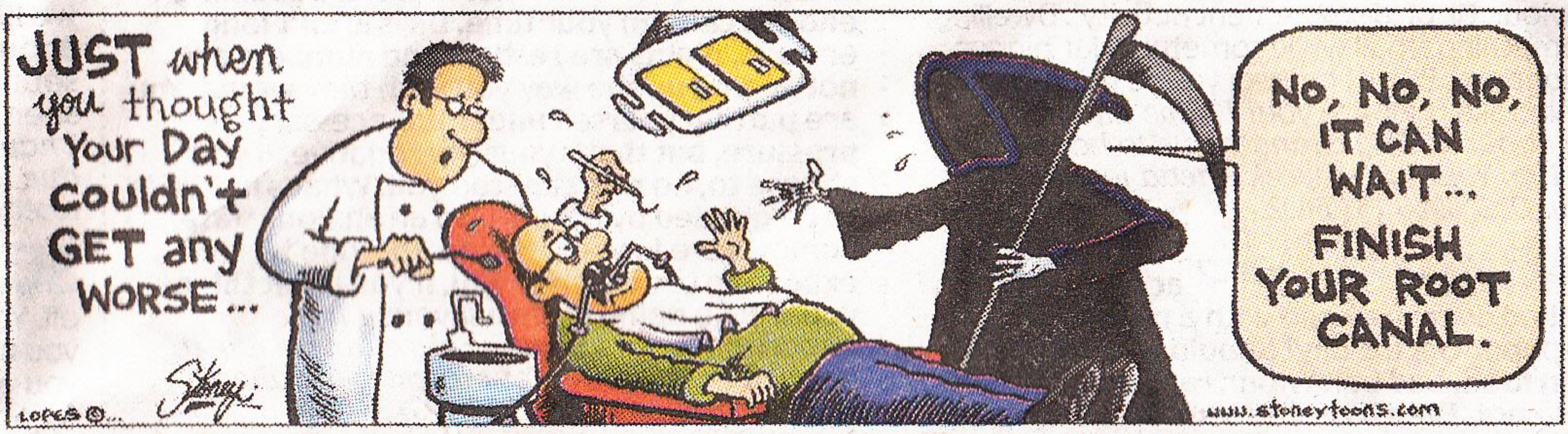
DARESBURY NEWS

No.184 Monday, 17th February, 1986

ELECTRONS AT THE NSF



Extensive experimental programmes are underway at the NSF to study nuclei far from stability, and thus gain a deeper insight into the complex behaviour of nuclei. The heaviest of these, the actinides, are the most challenging to study because of their tendency to fission very shortly after being formed in heavy-ion reactions. They are also difficult to investigate using the conventional techniques of γ-ray spectroscopy, since their excited states are more likely to decay by internal conversion than by γ-ray emission. Internal conversion is the process whereby an excited nuclear state gives its energy directly to an atomic electron, resulting in the emission of the electron from the atom. This process competes with γ-ray decay and is more favoured if the energy of the decay is low. It becomes increasingly important the heavier the nucleus and dominates the decays of actinide nuclei. Where internal conversion occurs, the measurement of competing electron and γ-ray decay enables particular fundamental nuclear properties such as the spin and parity of nuclear excitations to be determined.


JUST when you thought Your Day couldn't GET any WORSE...
No, No, No, IT CAN WAIT... FINISH YOUR ROOT CANAL.
www.stoneytoons.com

International collaboration

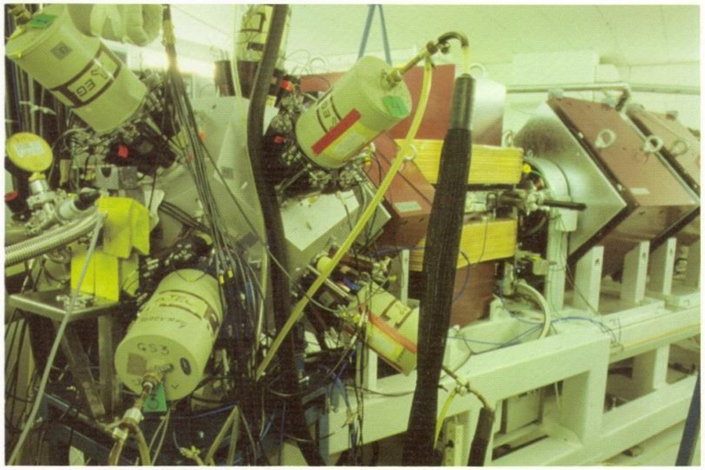
Go to Finland

Finnish-UK collaboration

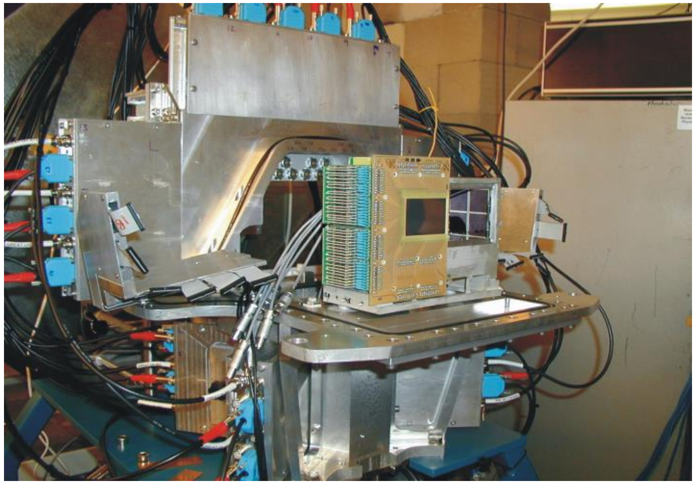
Collaboration circa 1994

TARDIS

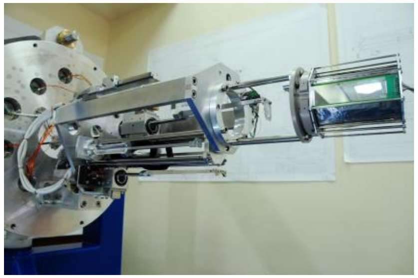
Doris+RITU



GREAT

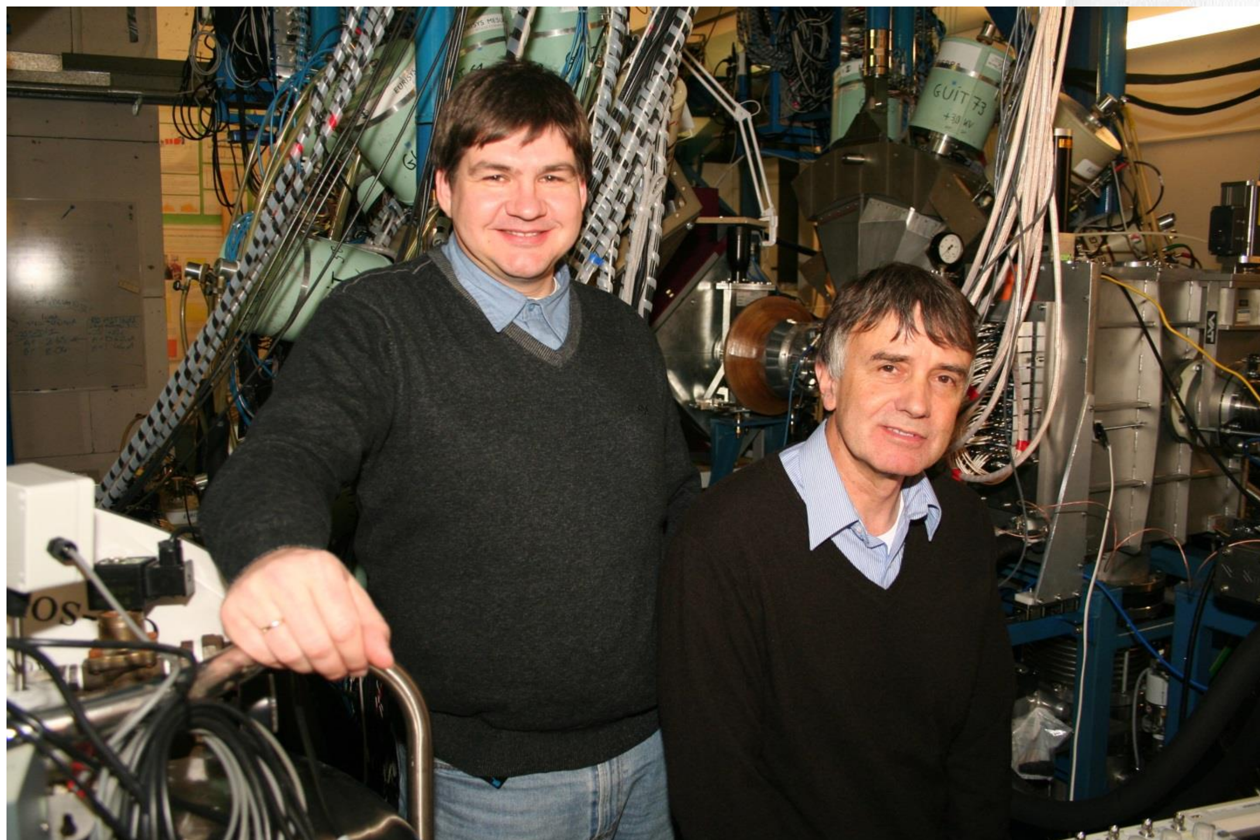


EXOTAG -EU

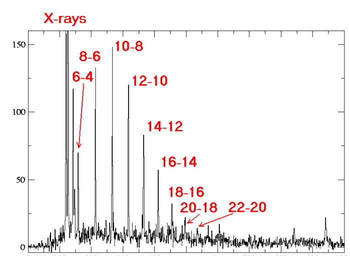


LISA

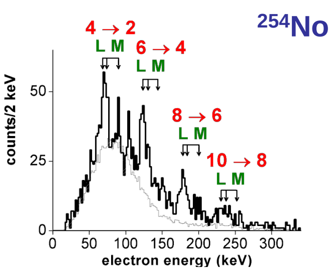
Greenlees P.J.



SAGE



X-rays
10-8
8-6
6-4
12-10
14-12
16-14
18-16
20-18
22-20



254No
4 → 2
L M
6 → 4
L M
8 → 6
L M
10 → 8
L M
counts/2 keV
electron energy (keV)

The news

1994

Finnish-UK collaboration

Even STFC news

UK-Finland collaboration: a celebration

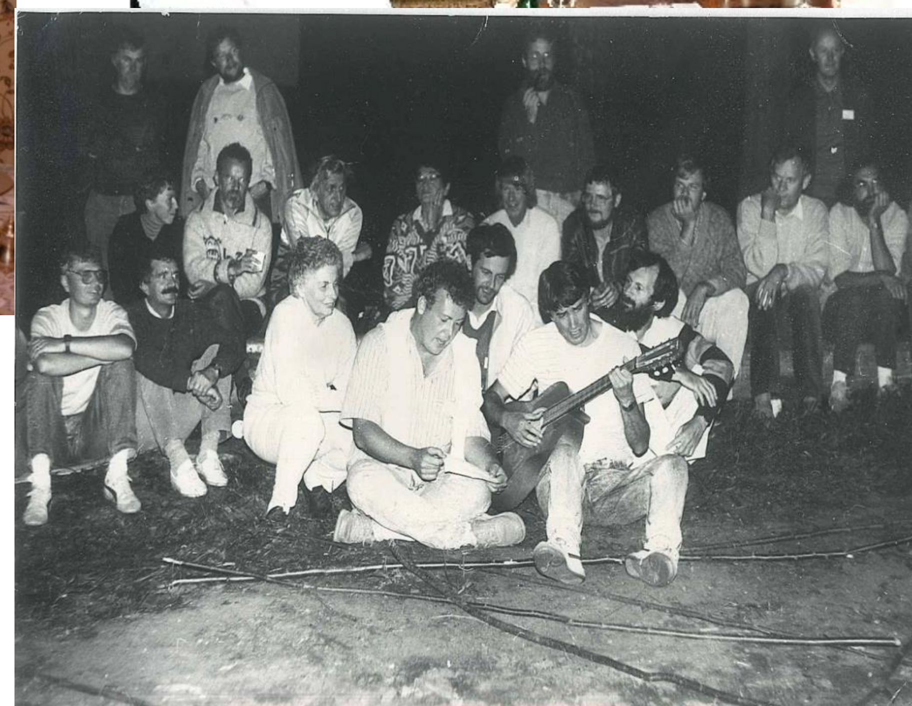
11 April 2012

Event

A celebration of two decades of UK-Finnish collaboration in nuclear physics research took place at the Accelerator Laboratory of the University of Jyvaskyla, Finland.

Peter Butler said that “the science output from Jyvaskyla has been phenomenal being one of the most productive of all the overseas laboratories for the UK programme in the last 15 years. This is a result of UK researchers pioneering novel instrumentation in order to address the most pressing outstanding questions of nuclear science. It is particularly exciting to see continuing advances in technology with new UK-built devices now coming into operation, and that the collaboration is still vibrant.”

Vocal contribution

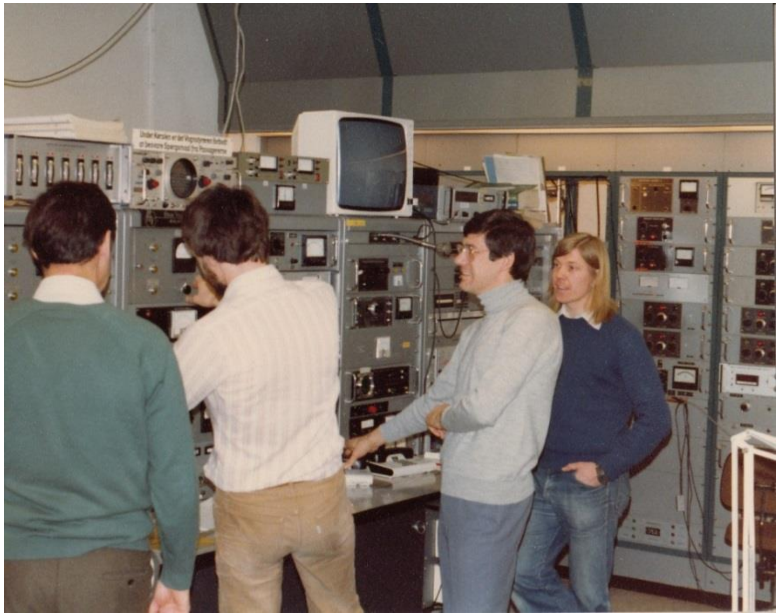


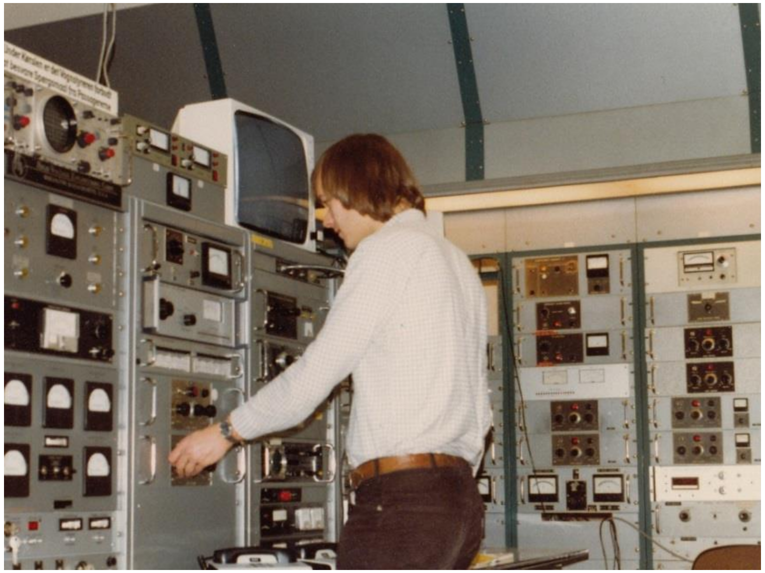
Conferences

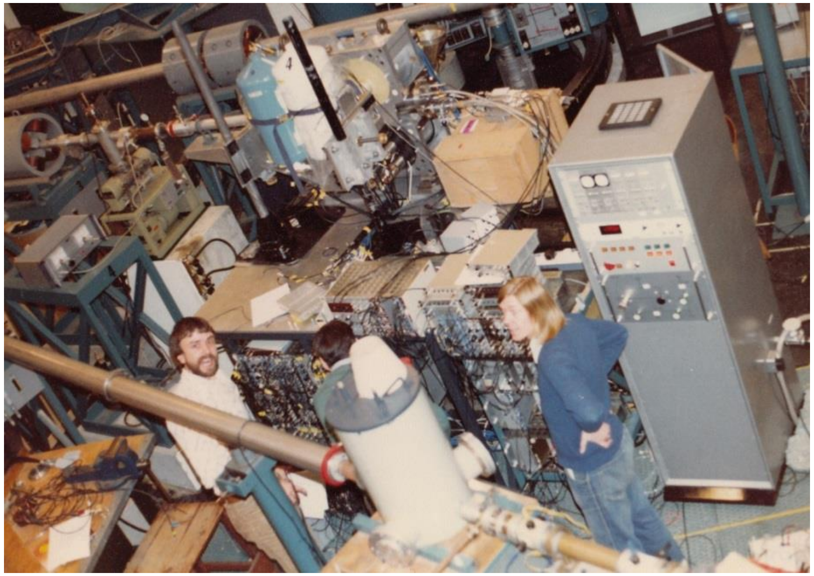
Conferences

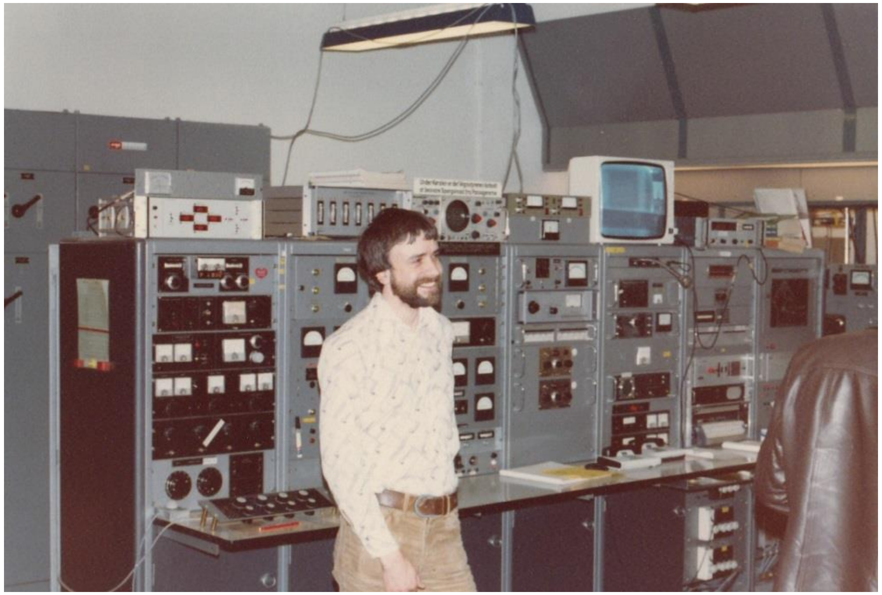
Stalking

Training





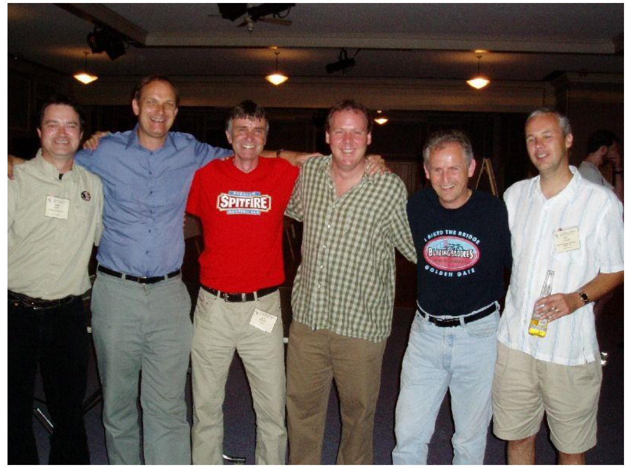


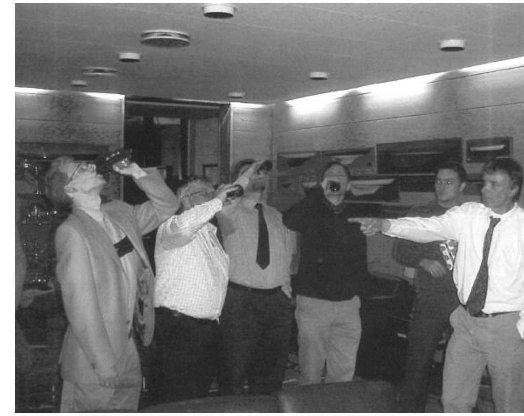


Students

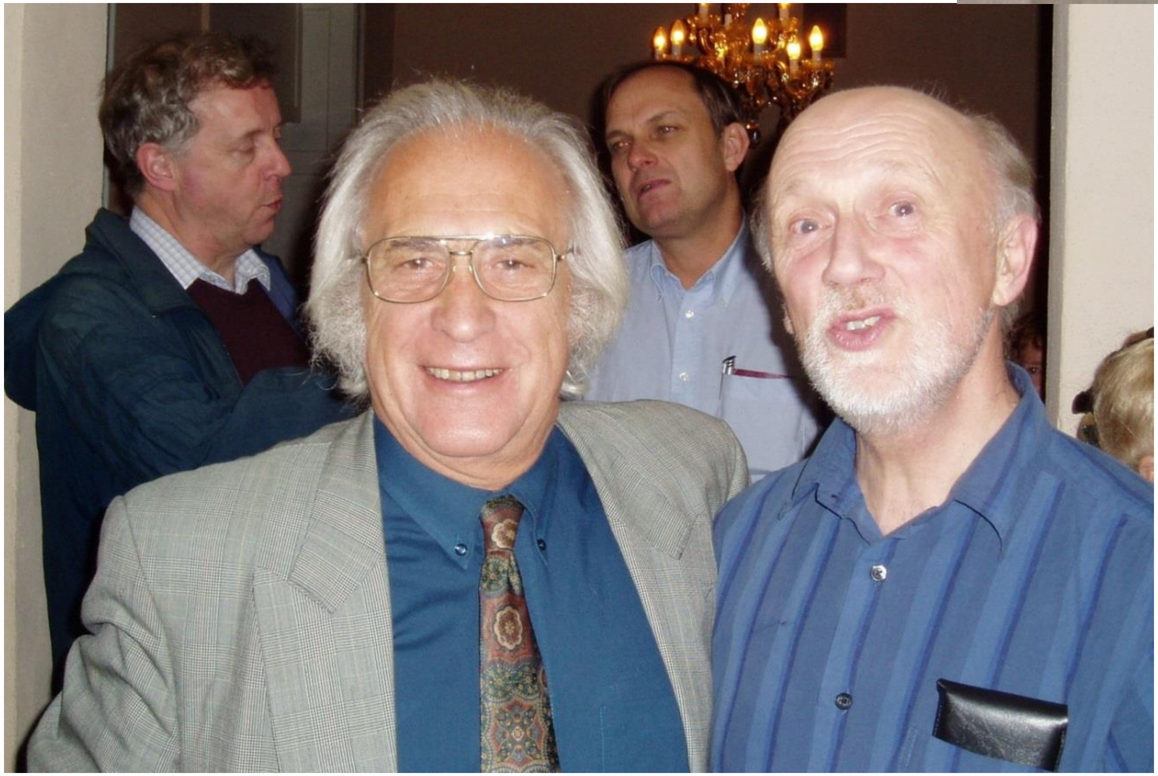
Kevin Cann
James Cocks
Neil Hammond
Paul Greenlees
Pete Jones
Cath Scholey
Nora Amzal
Debbie Hawcroft
+ John Smith, Rich Humphreys

Fun





Double acts



Circa 1973

Summer 1983

The IOP Rutherford Medal

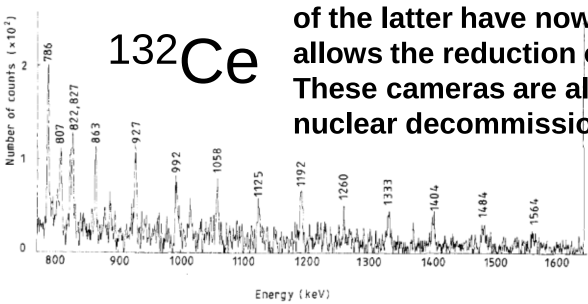
The award shall be made for distinguished research in nuclear physics or nuclear technology.

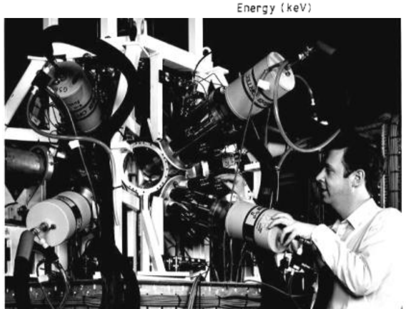
2012 **2014**

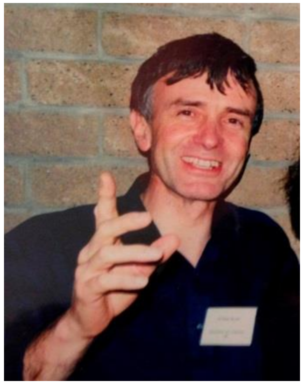
Professor Paul Nolan, University of Liverpool.

For his outstanding contributions to Nuclear structure at extremes of angular momentum and his leading role in the development of segmented Germanium detector technology.

The nucleus at high angular momentum is a unique many body quantum system which can now be studied in great detail, in no small part due to the developments in experimental technique led by Paul Nolan.
Paul has made outstanding contributions to high spin physics throughout his career,
from the study of superdeformation in heavy nuclei to a detailed understanding of the processes that happen when angular momentum can no longer be generated from the alignment of nucleons.
This research has prompted the construction of large gamma ray spectrometers using composite and later segmented germanium detectors. Paul has been a driving force behind the worldwide effort to create the EUROBALL spectrometer- a powerful gamma-ray spectrometer for nuclear spectroscopy,
and now the AGATA Advanced GAmma Tracking Array. AGATA, and its US counterpart GRETINA, will allow unprecedented insights into nuclear structure. Paul's instrumentation expertise also found application in the development of the ALPHA detector at CERN, used to study anti-hydrogen. Paul Nolan has also applied the technology developed for nuclear physics to other fields. He has led the development of Compton Cameras for medical imaging, homeland security and nuclear decommissioning. These cameras are under investigation for positron emission tomography and singe photon emission computed tomography – studies of the latter have now progressed to pre-clinical trials. The position and energy sensitivity of the detectors allows the reduction of the dose delivered to patients during imaging and provides improved image quality. These cameras are also being investigated for cargo scanning at sea and air ports and remote imaging of nuclear decommissioning sites, just a few of the potential further applications.

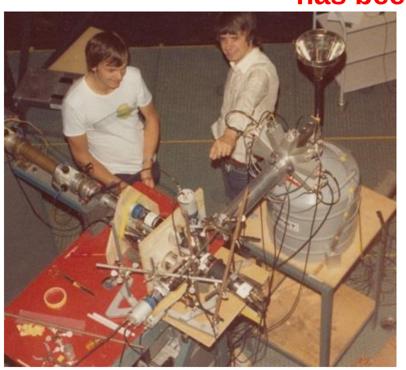


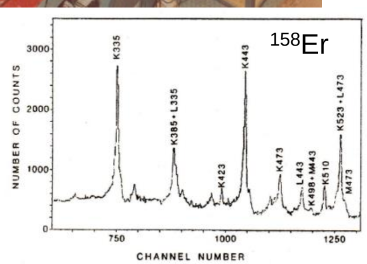


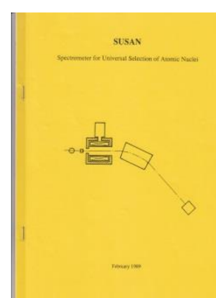


For his outstanding work in the field of experimental nuclear physics and his dynamic contributions to the future direction of the field.

Peter Butler has made an outstanding contribution to our understanding of nuclear structure, especially properties of nuclei far from the line of beta stability, elucidating many aspects of nuclear behaviour. He is most closely associated with investigations of nuclear shapes and deformations, from fission isomers to octupole deformation, where he has led some of the most important experiments on octupole deformation and reflection asymmetry. He pioneered the technique of collinear conversion-electron spectroscopy and led the construction of the SACRED system at the University of Jyväskylä, Finland. This device has proven extremely important in the study of heavy nuclei. Peter has been leading experiments over the last 25 years to study such nuclei. Amongst many achievements, he found evidence of reflection-asymmetric intrinsic states in atomic nuclei, including pear-shapes that give rise to transitions with large electric dipole and octupole moments. The nuclei with pear-like shapes may have enhanced Schiff moments, the quantity that determines the static electric-dipole moment of the corresponding atom if time-reversal invariance is violated. He observed strongly-converted transitions between deformed excitations in the heaviest elements, up to high angular momentum. These observations confirm that the stability of transfermium nuclei, nuclei with atomic number beyond 100, is partly derived from deformation. The stability of nuclei around Nobelium-254 to rotation means that their fission barriers persist to unexpectedly high angular momentum. His team's studies of isomers in this region are crucial for understanding the single-particle structure of super-heavy elements. He has been a key figure in defining the future directions of nuclear physics worldwide.

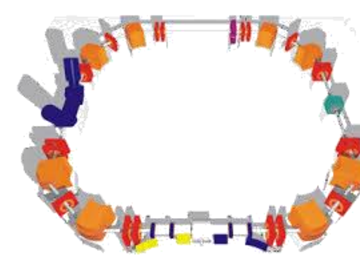





SUSAN

Spectrometer for Universal Selection of Atomic Nuclei

February 1989



Thanks











Reflections on the atomic nucleus