INSTITUT LAUE_LANGEVIN
1997-2011
The Philosopher’s Boat

John W White

Research School of Chemistry
Australian National University
Canberra, Australia

First AOCNS, Tsukuba
November 2011
2011 UK Neutron and Muon Users’ Meeting
RAL, April 6th 2011 (Professor Andrew Harrison)
Reactor refit and reliability

• 2009: no days lost (4 cycles)
• 2010: half-cycle lost (pump failure)
• 2011: delayed start-up (5 days – 4 cycles)
• 2013-2014: 11 months work on reactor (3+3 cycles)

Andrew Harrison 2011 Neutron and Muon Users' Meeting
ILL Today: world-leader for 40 years

- 600 experiments *per annum* on 30 instruments
- 1500 visiting scientists and over 600 papers *per annum*
Brilliant young people

ILL PhD clip session April 2011
J-PARC Facility, Tokai, Japan

J-PARC = Japan Proton Accelerator Research Complex
J-PARC – SHARING of CULTURES

Two Great Japanese Research Institutions

KEK-Japanese High Energy Accelerator Laboratory

JAEA- Japanese Atomic Energy Agency

A Daring Experiment by the Japanese Government
Pulsed Neutron Source of Highest Quality
Thank you all IAC members for your enthusiastic supports!!

It is a breath more!
The Asia-Oceania Neutron Scattering Association (AONSA)

1500 Neutron users in Asia–Oceania
THE OPPORTUNITY FOR AONSA

AONSA submission to ICSU Foresight Consultation
25 January 2010

The current and projected, advanced neutron scattering facilities in the Asia-Oceania region offer potential for international cooperation which closely resembles that present in Europe in the 1960s and 1970s.

*ILL became a major focus* bringing their *scientists and nations* together in the early stages of the European Community.
The Neutron Discovered 1932

Bothe and Becker
Heidelberg 1930
Z. Phys. 1930

Frederic Joliot & Irene Curie

See “The Neutron” J. W. White & A. B White
Australian J. Chemistry 2011, 64, 1–9

Chadwick’s Proton
Ionisation chamber
Nature 1932, 129, 312
Chadwick later confessed that not all of the experiments he did were based on a logical approach, many were ‘fishing’ for leads:

‘In fact I'd done a lot of experiments about which I never said anything. Some of them were quite stupid.

I suppose I got that habit on impulse, or whatever you like to call it from Rutherford. We would do some damn silly experiments at times. We did some together. They were really damn silly.

But if we'd got a positive result, they wouldn't have been silly.’
CONSTRUCTION PHASE 1967-1973

Fertile Ground

Political Will & Commitment

University Culture

Strengths of both nations

“Clever, nice young people” HML
DES NEUTRONS POUR LA SCIENCE

Bernard Jacrot
SHARING - UK & FRANCE

1958 First Cold Neutron Source in BEPO Reactor (Harwell, UK Peter Egelstaff) then close collaboration with Cribier and Jacrot (Saclay)
1959 First Cold source at EL3 Saclay Reactor
1960-61 New cold source in DIDO (Harwell) Egelstaff
1960-61 OECD meeting CERN Kowarski chairman – for a European project -British interest in heavy water, 25MW UK HFBR described (M. Vick)- counterpart to BNL HFBR

1962 British Government does not accept to join Common Market. – end of British- French – German project.

1962 Discussions for Franco - German project begin.
1966 Santa Fee conference on HFBR alternatives
1967 ILL convention signed 19 January 1967
1967 Professor Maier-Leibnitz appointed Director
Convention for ILL
Signature, 19 January 1967
Ministers von Stollenberg & Peyrefitte
Template for the New Institute
Maier-Leibnitz Memo 1967

- New types of Instrument.
- number of researchers about 200 of which 50% to 70% are visitors.
- An annual budget for science beyond that for the reactor.
- a design office and workshop.
- a welcoming structure to give all assistance needed to visitors.
- a group of theoreticians.
Director + Adjoint Director
Science Council of Scientists

10 Colleges of Scientists + Students

Theory at Garching & Grenoble
Nuclear Physics
Properties of pure crystals
Crystalline and magnetic structures
Liquids, gases and amorphous substances
Imperfections in crystals
Biology and polymers, Chemistry
new projects
The Maier-Leibnitz Legacy 1972

A Research Culture

(Jacrot page 64) “this absence of a rigid hierarchy and youthfulness of most of the “Actors” allowed an atmosphere to be created which was at the same time studious and relaxed”.

“Very intense work was compensated by celebrations which were more or less improvised”.

“Skiing between 12.00 and 14.00 occurred”.

BRITISH NEGOTIATION TO JOIN (1970-73)

Maier Leibnitz

(a) Very friendly welcome
(b) The importance of phase space design
(c) “The young scientists are clever and nice”.

INSTITUT LAÜE LANGEVIN 1970
DÉMARRAGE!

Reactor Start-up 31-8-1971

Reactor Critical 31-8-1971
Maier-Leibnitz Instrument Legacy

phase space considerations to underpin instrument designs

- Cold source (PS-transformer)
- Hot Source (PS-transformer)
- Guides (PS conductor)
- Focusing (PS-transformer)
- Multidetectors & New ToF
- Polarisation & Pol’n Analysis
- Small Angle Scattering
- *Fundamental Physics*
- *Nuclear Physics*
Operation Phase Begins
1972-1975

Orientation Towards Users
Central Computer
Internal Structures
ILL Proposal & Instrument Development

**Annual Report 1979**

**Annual Report 1975**

1973 1976
OPERATION PHASE 1972-....

- Novel Instruments
- National Attributes
- User Impact Theory
- Broad Science Agenda
- Continued Renewal
Welcome back: D11

- **D11** – small-angle scattering to very low Q
  - Complete rebuild from guide to detector
  - Flux gain at sample approximately 3 x
  - Detector: dynamic range and resolution 2 x
  - Detector electronics max count
    
    $100 \text{ kHz} \rightarrow 1 \text{ MHz}.$
  - First users back last week

ILL symposium planned for mid 2009:
"D11 Reloaded - Status and Perspectives of SANS"
D11 Strong Impact on Science 1973 onwards

Materials Science, Colloid Chemistry and Biology


Ibel, K.; Sturhmann, H. B. *J. Mol. Biol.* 1975, 93, 255

First Virus Experiment, 1973
Institut Laue Langevin, Grenoble, France

Fig. 23 A drawing of the structure of tobacco mosaic virus incorporating the results of the last X-ray studies of Rosalind Franklin (posthumous paper in preparation). For dimensions and explanations, see Fig. 1.
TOBACCO MOSAIC VIRUS
Bernal and Fancucken 1942

Tactoids Swelling
First Virus experiment, 1973
Institut Laue Langevin, Grenoble, France
4.2 Inelastic Scattering and Diffraction from Oriented Tobacco Mosaic Virus Solutions

Investigators: J W White and A M Hecht (Cermno, Grenoble; Royal Society Visitor)
University of Oxford.

We are interested in the general field of oeditic processes and especially the relationship between these phenomena in simple inorganic structures and in biology. At concentrations above 1.8% by weight tobacco mosaic virus solutions in water spontaneously order with the long axes of the cylindrical virus molecules almost exactly parallel. The virus particles form an ordered colloidal gel with hexagonal close packing of the rods \(^ {1} \). This gel swells in very much the same way as the clay layers and the lamellar liquid crystals, also studied by us. The oedesis involves a change in the thickness of the water layer between the charged protein molecules only and not a swelling of the molecule itself.

fd Virus Aligned in 10T Magnetic Field
ILL 2010
THE START OF SPIN ECHO
August 1974 F. Mezei
OPERATION & RENEWAL
1975 – 1980s

Orientation Towards Users

COMPUTERS  Experiments ≠ measurements
More New Instruments + EMBL
Fundamental Physics
BIOLOGY & CHEMISTRY GROW

- VIRUS
- NUCLEOSOME CORE STRUCTURE
- RIBOSOME 50S and 30S STRUCTURE PROJECT
- MEMBRANES
- COLLOIDS
- POLYMERS
- ADSORPTION ON SURFACES
- TUNNELLING and LOCAL POTENTIALS
ACADEMICIAN FLEUROV VISIT
1977
TOMATO BUSHY STUNT VIRUS
Chauvin, Jacrot & Witz 1977

\sqrt{I_o} vs \% D_2O gives whole virus contrast match point

SPHERICAL VIRUS
TOMATO BUSHY STUNT VIRUS
Chauvin, Jacrot & Witz 1977

Radial Density Functions
Nucleosome Core Particle (Finch, Lewit-Bentley, Timmins)
THE FUTURE

• CONTROLLED DEUTERATION IN BIOLOGY

• HIGH PRECISION ABSOLUTE SCALE

• NEW INSTRUMENTS- D33 (Pol’n)
PSB & Deuteration Laboratory

- C-Lab
- D-Lab - strong contributor to bio growth (7-14%)
- CIBB – 100 in-house;
- 200 more associates
Highlight H (D)

X-ray map

A-DNA in \(d(AGGGGCCCT)_2\)

Neutron map
Effect of amphiphilic block copolymers on the structure and phase behavior of oil–water-surfactant mixtures

H. Endo, M. Mihaiilescu, M. Monkenbusch, J. Allgaier, G. Gompper, and D. Richter
B. Jakobs, T. Sottmann, and R. Strey I. Grillo


Double contrast variation
Three component microemulsions

Interfacial Polymer scattering in may be observed, if the scattering length densities of water, oil and surfactant are matched precisely.

Then a single protonated chain in the deuterated environment will give rise to the signal from the individual polymer chains.
Effect of amphiphilic block copolymers on the structure and phase behavior of oil–water-surfactant mixtures

H. Endo, M. Mihailescu, M. Monkenbusch, J. Allgaier, G. Gompper, and D. Richter
B. Jakobs, T. Sottmann, and R. Strey I. Grillo


A “tour de Force” on the Absolute Scale
Novel Instruments 2
Super mirrors
Spin-Echo
Reflectivity versus incident angle for Fe-Ag supermirrors (θ_c is the critical angle for a simple Ni mirror). The structure in the curves results from interference effects in the multilayer system.
CONSTRUCTION OF IN11 1975-1980

October 1975

September 1976

April 1983
Early Fresnel coils

- Fourier time proportional to $\lambda^3 \times$ field integral ($\int Bdz$)
- Inhomogeneity in field integral (diff. trajectories) limits signal
- Fresnel coils used to correct for inhomogeneities
  - number of turns increases as $r$
Root of limitations

- Fourier time proportional to $\lambda^3 \times$ field integral ($\int Bdz$)
- Inhomogeneity in field integral (diff. trajectories) limits signal
- Fresnel coils used to correct for inhomogeneities
  - number of turns increases as $r$
Putting in place...
Polymer Relaxation in Solution and Melt Studied by Quasielastic Neutron Scattering

Experimentally, this field has been opened up to neutron scattering by the application of the neutron spin-echo (NSE) technique. Uniquely, it provides the necessary energy resolution (20 neV) at sufficiently small scattering vectors (q \geq 0.02 \, \text{Å}^{-1}). It is worth mentioning that NSE as a Fourier
Figure 50: Relaxation spectra $S(q,t)/S(q,0)$ as a function of the time for a dilute solution of PDMS in chlorobenzene taken at the $\theta$-temperature. Thereby $S(q,t)/S(q,0)$ is given by the neutron polarization and $t$ by the value of the guide field $H$ in a spin echo set-up.
Figure 51: Concentration cross-over in PDMS/D-benzene. Characteristic frequencies $\Delta \omega / q^2$ for different polymer concentrations at 70°C as a function of momentum transfer $q$. The solid line represents the low concentration $q^2$-dependence due to Zimm relaxation, the dashed lines show the $q^3$-behaviour characteristic for collective diffusion.
Real 550 nsec resolution

More than just a demonstration measurement
and.....

0.994 μs!

reaching 1 μs!

Plus signal gains: factor 1.66 @ 15Å and 2.0 @ 22Å
ULTRACOLD NEUTRONS 9 -1978

Vue générale de la plate-forme UCN avec les expériences Nestor (S 23) et de moment dipolaire (S 22) sept. 78 N.B A 109018-5 Coul. A 109 083-2

MAMPE
AGERON

RAMSEY

SUSSENX
GROUP

RUSSIAN
STIMULUS
Neutron Whispering Gallery

- Known for a long time that sound waves can be localised near curved surface
- Applies to other waves/particles
- Collaboration across ILL (large-scale structures with nuclear and particle physics) and outside to explore whether it can be seen with neutrons
- **Observe quantised states dependent on mass** – new surface probe?

THE DEUXIEME SOUFFLE 1977-1979
ENSURING THE FUTURE

ILL Finances
1977 Budget down
Operating & Personnel Costs rising
The Philosophers Boat

Let's say that a man named Plato had a boat which he called the Ship of Theseus.

Now, in the upkeep of this boat, Plato is forced to replace planks as they rot or become damaged. So, is it still the Ship of Theseus after he has replaced one plank?

How about 5? Let us suppose that there are 100 planks on the boat, and that each day, our man Plato has to replace a single plank.

Is it still the original Ship of Theseus at the end of the 100 days, after all of the planks have been replaced? If it is not, then at what point does it cease to be the original Ship, and become something different? 50 planks? More, or less?
THE DEUXIEME SOUFFLE

REACTOR LIFETIME
NO COMPROMISE
COMPUTING
COMPLMENTARITY
Continuation of Institute past 1982

Reactor Study & Upgrades

- Second Cold source
- Establish EMBL on ILL site
- Chemistry & Biology Laboratories
- Computing
SUPPORT SCATTERING PROJECTS

Replace under performing instruments and centralised computers - NO COMPROMISES

Use powerful microcomputers at Instruments

Increase development and standardise
• Monochromator, multidetector, sample environment

Continue & Start new Instruments:
  Spin Echo
  Interferometer
  IN12 Cold Neutron High Resolution 3 Axis
  IN6 Focusing Time of Flight Spectrometer
  D3 and Powder Diffraction
Instrument Renewal 1976 -1982

D6 Multidetector for Protein Crystallography

IN3 Focussing Thermal 3 Axis
New Ideas - Polarisation Analysis

IN 9 Polarised Proton Spin Filter 1976

Optically Pumped $^3$He polarisation Filter Team 2009
The BEGINNINGS of IN6

Barbeque at Til von Egidy’s House in Meylan, Grenoble 1977

Andreas Freund + Jens Suck, Jose Dianoux

MANY OTHERS
Phase Space Capture by a Rotating Crystal

"Doppler Effects & Storage Effects described Quantitatively"

THE ROTATING CRYSTAL TIME-OF-FLIGHT SPECTROMETER FOR SCATTERING LAW MEASUREMENTS WITH SLOW NEUTRONS

Theoretical analysis and design considerations

F. CARVALHO*, G. EHRET and W. GLÄSER

Institut für Angewandte Kernphysik, Kernforschungszentrum Karlsruhe, Germany

Received 28 September 1966

NUCLEAR INSTRUMENTS AND METHODS 49 (1967) 197-216
Phase Space Capture in IN6

IN6 Scherm, Carlile, White, Suck, Dianoux ?1976
Phase Space Design - IN6

Then

Dianoux & Blanc ?1979

Then

White and Zbiri 2011

Now
Emerging ideas 2011

2011 Neutron and Muon Users’ Meeting

Andrew Harrison
THE DEUXIEME SOUFFLE
1977- 1980

Fig. 31: Implementation of the budget (actual expenditure 1979-1981/forecast 1982-1985).
ILL Governance
Deuxième Soufflé Extensions

Fig. 3 : Possible arrangement of the ILL buildings after the modernization programme. The shaded parts represent the new building foreseen in the renewal programme.

Instrument Productivity Issues

D2 1973

Guide tube D1A

D2B 1987
Instrument Evolution

IN12 1979 Bill Stirling & Judith Howard

IN8 1981 + Bruno Dorner
Renaissance 2002-2016
Dubbers, Carlile, Wagner, Harrison

Andrew Harrison
2011 Neutron and Muon Users’ Meeting
Science Structure at ILL 2009

Percentage of proposals by subject area (2009)
Science Structure AOCNS 2011

Papers and Posters Presented

- Instruments: 30%
- Magnetism, Superconductivity: 22%
- Materials, Industry: 11%
- Chemistry: 15%
- Biology: 5%
- Polymers: 7%
- Other Solid State Phys.: 10%