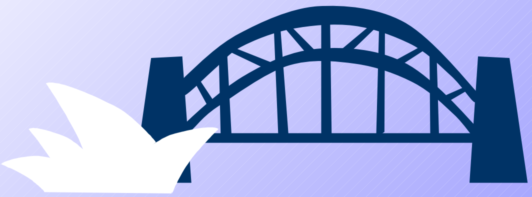
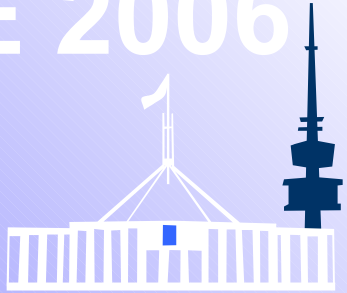
ATF & SNEAP CONFERENCE 2006



Sydney



Canberra

Welcome to the

5th Accelerator Technical Forum (ATF)

and

40th Symposium of North Eastern Accelerator Personnel (SNEAP)

Conference 2006

Australian Government

Australian Nuclear Science and Technology Organisation

David Garton

Australian National University

David Weisser

THE UNIVERSITY OF MELBOURNE

University of Melbourne

Roland Szymanski

With support from the

International Atomic Energy Agency (IAEA)

AVT Services P/L DANFYSIK SCITEK CMS Alphatech - Buckleys
National Ele cs Corporation Parker Hannifin Group 3
Technology J Services P/L DANFYSIK
SCITEK CMS Alphatech - Buckleys cs
Corporation Parker Hannifin Group 3 T ris
Sc DANFYSIK S h -
Bu ics Corporation Parker Hannifin Group
3 Technology John Morris Scientific AVT Services P/L DANFYSIK
SCITEK CMS Alphatech - Buckleys trostatics
Cor ration Parker Hannifin Group 3 T n Morris
Sci DANFYSIK S phatech -
Buckleys National Electrostatics Corporation Parker Hannifin Group
3 Technology John Morris Scientific AVT Services P/L DANFYSIK
SCITEK CMS Alphatech - Buckleys National E atics
Corpor er Hannifin Group 3 Technology orris
Scienti ervices P TEK CMS ech -
Buckle l Electr Parker Ha roup
3 Tech n Morris AVT Services P/L SIK
SCITE Alphatech - Buckleys National E atics
Corpor er Hannifin Group 3 Technology orris
Scientific AVT Services P/L DANFYSIK SCITEK

AVT Services P/L

scitek australia

DANFYSIK

Parker
anything possible

CMS alphatech
Certified to ISO9001

John Morris Scientific
50 Years Family Owned

Group3

Opening talk – SNEAP/ATF meeting Sydney
Monday 15 October 2006

Thanks for this opportunity to speak at the opening of the *40th Symposium of North Eastern Accelerator Personne*l and the *5th Accelerator Technical Forum*. Firstly, I want to welcome you all to Sydney and hope that over the next few days, both here and in Canberra, you have a very productive, satisfying and enjoyable meeting. In particular, I want to welcome our international visitors who have made the long trip down under and hope that you find it a very worthwhile experience. We Australians think we live in one of the best countries on earth so we are always happy when others come to find out for themselves.

The fact that this is the 40th SNEAP says something. For an annual meeting to make it to its ruby anniversary is very special. For that meeting to be here in Australia is very special indeed. Scientific and technical meetings come and go, so the fact that this one just keeps going demonstrates that it is fulfilling an important role, that people appreciate it and value its contribution to their field. But in addition to its influence over time, the symposium has also had a wide influence over space – expanding from its roots in the NE of the US to be seen in its field as a truly international meeting.

And like all good institutions it has not only exerted its presence in time and space, it has spawned and fostered similar meetings in other places – notably the ATF here in Australia. The need for a separate meeting in this part of the world partly reflects what many of you have just experienced – we are a long way away from much of the action in this particular field. The ATF, although occurring a lot less frequently than SNEAP, has met that need. Indeed, when for a year or two in the late 80's I was a user and operator of the old 3 MV Van Der Graaf accelerator at ANSTO, I attended an ATF meeting out at Lucas Heights.

But there are other ways of solving the problem of getting Australians to SNEAP – namely to bring SNEAP to Australia and I congratulate those from both sides who have worked to make that a reality.

What is special and unique about these meetings is that they are directed at the nitty gritty of the operation of these important scientific facilities. The idea is to bring together the technicians, engineers, scientists and suppliers involved in their construction, maintenance, operation and application to present their latest work, discuss developments and problems and, because it's always easier to solve other people's problems than your own, suggest solutions and to make new or renew old friendships. So this meeting not only has a wide geographic representation, it also has a very broad representation of operators, support staff, users and companies. It is good that the sharing of information is not just between those who work in the facilities but that there is also a significant transfer of knowledge from the facilities to the supplier companies whose role is to make that knowledge, embodied in equipment and devices, more broadly available.

Australia has a long history in the development and application of accelerators. Initially the focus was on basic nuclear physics but over the years, the utility of these facilities for an incredible range of applications has meant that they have become essential tools for researchers in fields ranging from archaeology to quantum computing. Accelerators provide vital information that influences our response to some of our planet's most pressing problems in climate change, environmental degradation, nuclear proliferation and energy sustainability.

Australia's expertise in ion beam accelerators is centred in three organisations:

In the Research School of Physical Sciences and Engineering at the Australian National University in Canberra where the Department of Nuclear Physics operates a 14UD Pelletron connected with a superconducting linear accelerator. Research is focussed on Nuclear Structure, Nuclear Reaction Dynamics, Accelerator Mass Spectrometry, Hyperfine Interactions such as amorphization and relaxation effects in semiconductors, and Materials Science using the full suite of ion beam analysis techniques and ion irradiation. This facility has a strong international user base with 48% of the user groups over the 5-years to 2005 coming from overseas and 63% of the 340 publications arising from use of the facility in the period 1998-2004 period including international authors.

Also at the ANU, the Department of Electronic and Materials Engineering operates two 1.7 MeV tandems, one for ion beam analysis and ion channelling and one for ion bema implantation and ion beam modification of materials.

At the University of Melbourne, the Microanalytical Research Centre (MARC) operates a 5U Pelletron which is home of the Melbourne Nuclear Microprobe used for nuclear microscopy on a wide range of materials, but which is also used for ion implantation and neutron irradiation.

At my own organisation, ANSTO, we have ANTARES, the 10 MV Australian National Tandem Accelerator for Applied Research complemented by the 2MV Tandetron STAR. Accelerator Mass Spectrometry is a major focus with applications including paleoclimatology, precision dating and nuclear forensics looking for actinides and fission products where they shouldn't be. Ion Beam Analysis contributes to a diverse range of activities in the fields of materials science, biological and environmental studies, as well as basic nuclear physics. Examples include the analysis of air pollution, heavy metals in biological systems, rock and soil specimens, thin films, archaeological artefacts, and engineering materials such as metal and polymer coatings.

On average 150 national and international researchers, student and staff per year access the ANSTO accelerator facilities. The five-year average of users is 20% industry, 45% universities and 35% in-house but 70% of publications included non-ANSTO researchers. At sometime or other, all 37 universities within Australia have accessed accelerator facilities and capabilities at ANSTO representing more than 60 separate University based projects every year in the AMS and IBA areas alone.

But Australia's interest in accelerators is broader than just heavy ion accelerators with the number of cyclotrons increasing rapidly around the country … for a long time the 30 MeV National Medical Cyclotron close to the centre of the city was the only one, but while it concentrates on the production of gamma-emitting radioisotopes such as thallium, gallium and iodine, there are 7 others scattered around Australia mostly dedicated to the production of fluorine-18 for positron emitting tomography and lots of others planned.

Most significantly, July this year saw first light produced at the 3 GeV Australian Synchrotron which will be open for customers in mid-2007. It's great to have Marc Boland from the Australian synchrotron accelerator group at this meeting.

The focus of this meeting is on accelerators that are used for research and the primary requirement of any research infrastructure is that it facilitates great research. This has been true for all the investments that have been made in accelerators in Australia over the last 50 years. A research accelerator represents a significant long-term investment and relies on there being excellent on-going maintenance, development, upgrade and management. To make this happen requires excellent support staff – the technicians, engineers and scientists who keep the facility operating, service the users and against all-odds (ie with limited funding resources) seek to maintain the facility close to the cutting edge. The innovations in this field do not usually come from people sitting in offices and laboratories removed from the facilities but from the people whose every day work is in ensuring that the existing facilities operate well. So it is fitting that this meeting is directed towards those support staff without whom the facilities would just be a pile of vacuum chambers, magnets, pumps, beamlines, power supplies and instrumentation.

The long-term nature of the investment in accelerators is evidenced by the age of the three main facilities in Australia. The ANU's 14UD Pelletron was commissioned in 1973, the 5U at Melbourne in 1975 and ANTARES in 1991. The fact that these facilities still contribute to cutting edge science is tribute to the men and women who work on them – many of whom are at this meeting.

It’s been said that old accelerators never die rather they go off and become the foundation of a facility elsewhere. ANTARES is a case in point – much of the accelerator had already spent 25 years at the Nuclear Physics Laboratory at Rutgers University. Earlier accelerators at the ANU have ended up in places as far afield as Western Australia and New Zealand. In some cases this has been a bit like grandpa’s axe which has been in the family for 4 generations but had 5 new heads and 4 new handles. However, it seems that the accelerator community were into rebirthing long before the shady side of the automotive industry.

While the accelerators themselves may go on for ever, the staff who operate and maintain them don’t. So an important task of a responsible operator is to ensure that the knowledge and experience is retained and developed. I know that Greg LeBlanc, leader of the accelerator physics group at the Australian Synchrotron is keen to develop an accelerator technology training program for the country and it would be great if the ion beam accelerators could also be involved. Education and training is another role for these meetings so it’s good to see a wide range of experience in the audience.

Over the last few year in Australia, there has been a renewed emphasis on the importance of the provision of good research infrastructure – without it is very difficult to do excellent research. In May 2003, the Australian Government established a taskforce to develop a nationally integrated research infrastructure strategy which reported in March 2004, recommending a set of principles and a national process to identify, prioritise and fund research infrastructure needs. In response, and as part of the *Backing Australia’s Ability* package, the Australian Government announced funding of $542 million over 5 years for a National Collaborative Research Infrastructure Strategy (NCRIS).

A Strategic Roadmap was developed that identified 16 capabilities that Australia should strive to develop for medium to large-scale research infrastructure investment (roughly defined as less than $60 million) over the next 10 years. The aim is to have a coordinated approach which will:

- concentrate effort nationally on areas of greatest strategic impact;
- increase collaboration within the research system, and between it and the wider community; and
- reduce the duplication and sub-optimal use of resources arising from lack of co-ordination.

We’ve just been through the process to determine the priorities for the first set of capabilities … Facilitators were appointed to work with the researchers interested in using the infrastructure and other stakeholders to develop investment plans. For some it’s been a harrowing process – researchers in Australia are more used to competing with one another and letting someone else (usually faceless) decide between them rather than coming to a consensus on how limited resources should be divided up for the optimal national benefit. These investment plans are being considered this week and funding announcements are expected soon.

Although not one of the first group to be funded, heavy ion accelerators are one of the 16 NCRIS capabilities and will be considered in the next year or so. I know the community has already started thinking about what it needs to ensure Australia remains at the forefront in accelerator-based research. Access to these facilities is an important issue along with user support but all of this depends on availability of the facility and the on-going development of new techniques and instrumentation.

Among the ideas being considered for the investment plan are

- Formal recognition of some of the accelerator facilities as National Facilities.
- Provision of funding to service users (Australian and International) at an appropriate level including operational and support staff.

- Development of the facilities to their full capacity and enhancement and development of beam-line instrumentation and support
- Closer links between the local institutions and expansion of links to international facilities
- Support of University-based training in Nuclear Physics and the Application of Nuclear Techniques - an issue that gained a significant profile in the debate that led to the Prime Minister's review on Uranium Mining, Processing and Nuclear Energy.

ANSTO itself is keen to develop its accelerator facilities and looks forward to progressing this in the context of NCRIS and in close collaboration with our national, regional an international colleagues.

But all that is still ahead of us … right now we have the program of the next 5 days. I hope the Australian representatives use this opportunity to discuss plans with our international guests and that they in turn will be generous in their advice and guidance. This is a great opportunity for the people in the facilities to learn from each other, to inform and meet with the suppliers and, as an international community, advance the use and application of accelerator based-techniques.

I wish you well and especially hope that you have a rewarding visit to our organisation on the way down to Canberra on Wednesday.

Have a great week!

ACCELERATOR BASED TECHNIQUES SOLVING NATIONAL AND INTERNATIONAL PROBLEMS

David D. Cohen
Institute for Environmental Research
Australian Nuclear Science and Technology Organization
Sydney, NSW, Australia

Ion beams from accelerators, with MV terminal voltages, can be tailored to study a range of applications from materials and environmental science to archeology. There are at least seven linear (n0n-electron) research accelerators in Australia. These are a Melbourne University, the Australian National University and ANSTO. The main advantages of heavy ion beams include high sensitivities and an ability to characterize very small sample sizes. Detection systems can detect individual atoms/ions emitted from target surfaces and, for slow heavy ions, target sample masses can be as small as a few picograms.

This talk will discuss two typical applications of MeV ion beams using several Ion Beam Analysis (IBA) techniques simultaneously to characterize fine particle air pollution. The first example is a15 year study of fine lead in Sydney's air and the second one is an international study, covering the east Asian region, looking at natural and anthropogenic trans boundary air pollution, its sources and movement around the globe.

Questions:

David Weisser (ANU): Where does the bromine in petrol come from?

David Cohen: It's part of the additive. Chlorine and lead are added as well as an anti-knocking agent. If you look at the ratio of lead to bromine, it's about 2.08 by mass and if you look at the gradient of that curve I showed you, it's about 2.1 which is another clue that it is the additives in the petrol.

Larry Lamm (Notre Dame): How do you generate the fingerprints that you show?

David Cohen: That's another talk in itself. There is a new technique that is being picked up by the U.S. EPA, that is called 'Positive Matrix Factorization'. It is basically a bit of matrix algebra. You start off with a huge matrix with a number of elements and hundreds of days you have run, and you have the mass, the concentration and the fingerprint. It's just three matrices multiplied together. You know the mass and measure the concentration, so you can find the fingerprint. A chap called Phil Hopke at Clarkson University developed this technique.

Graham Peaslee (Hope College): Do you know anything about the manganese additives because in the U.S. the EPA has come out the MMP but they are selling it somewhere. The manganese is a micro-particulate and it is a neurotoxin.

David Cohen: We have followed it for the past six years and have published a paper on it in 'Atmospheric Environment' on manganese in petrol in Sydney about six months ago. It's gone up from a few nano-grams per cubic metre background by factors of 3, 4 or 5 and it's coming back down again as the lead replacement in petrol disappears.

End of questions

Australian Government

Australian Nuclear Science and Technology Organisation

Accelerator Based Techniques Solving National and International Problems

David Cohen
ANSTO

Accelerator Applications

Accelerators in the MeV energy range typically do nuclear/ atomic physics, IBA and AMS.

Tailor the ion beam to suit the application.

This talk will discuss:-

- Accelerators and Ion Beam Techniques (not AMS)
- A national issue in Australia, Pb in air
- Natural and anthropogenic pollution and its transport across borders and internationally

Further info can be found at our WEB site

http://www.ansto.gov.au/nugeo/iba/

Australian MV Accelerators

Currently there are at least 7 research accelerators (linear, non-electron) in Australia:-

Melb Uni	- 5 MV NEC Pelletron	IBA, μ-Probe
ANU	- 16 MV Tandem/ booster	Nuclear Physics, AMS
	- 1.7 MV NEC Tandem	IBA, hi μA implanter
	- 1.7 MV NEC Tandem	IBA, RBS
ANSTO	- 10 MV Tandem, ANTARES	IBA, AMS
	- 2 MV Tandetron, STAR	IBA, AMS ^{14}C
	- 3 MV Van de Graaff	IBA (obsolete)

What is Ion Beam Analysis (IBA)

Pass relativistic ions from accelerators through targets

Nuclear Interactions;

γ-rays

Scattering

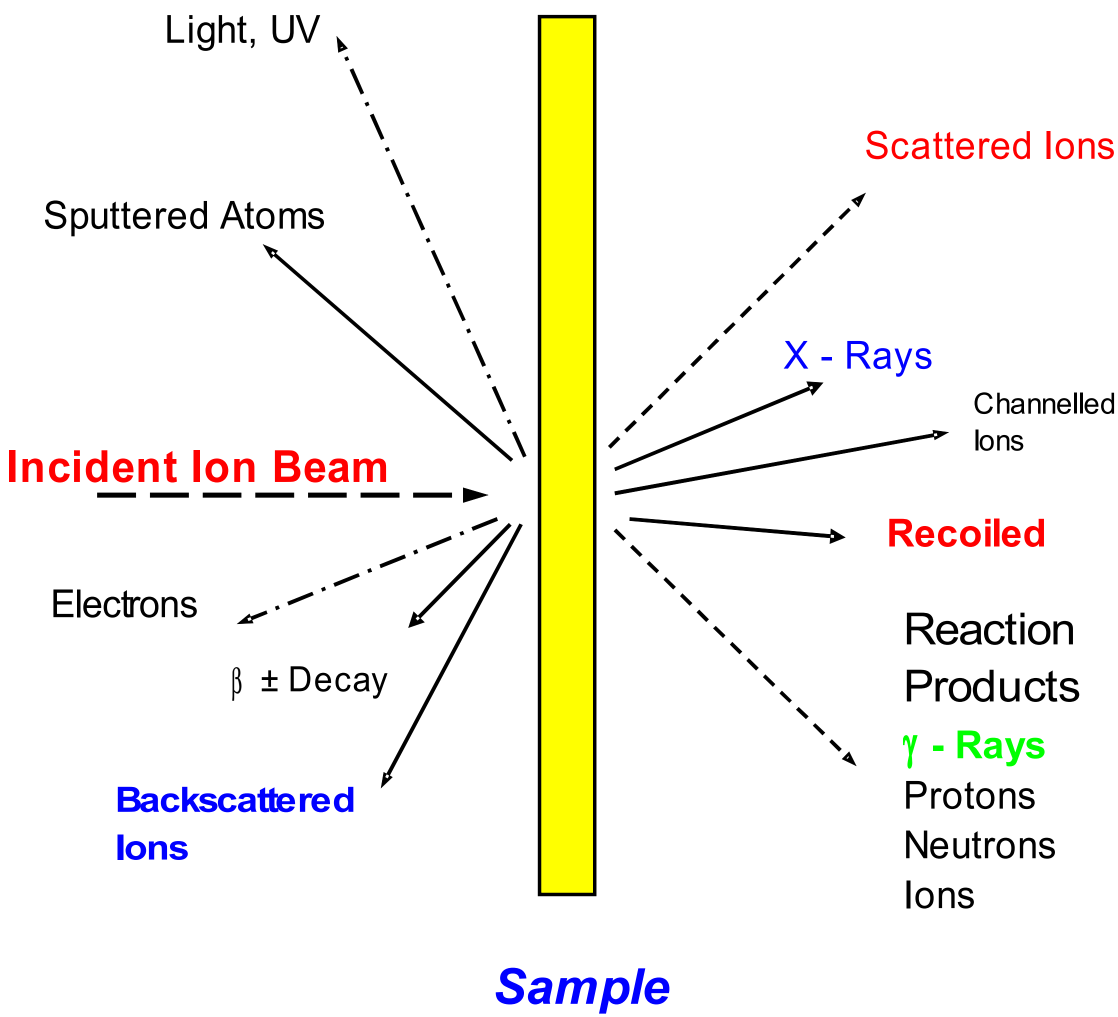
Recoil ….

Atomic Interactions;

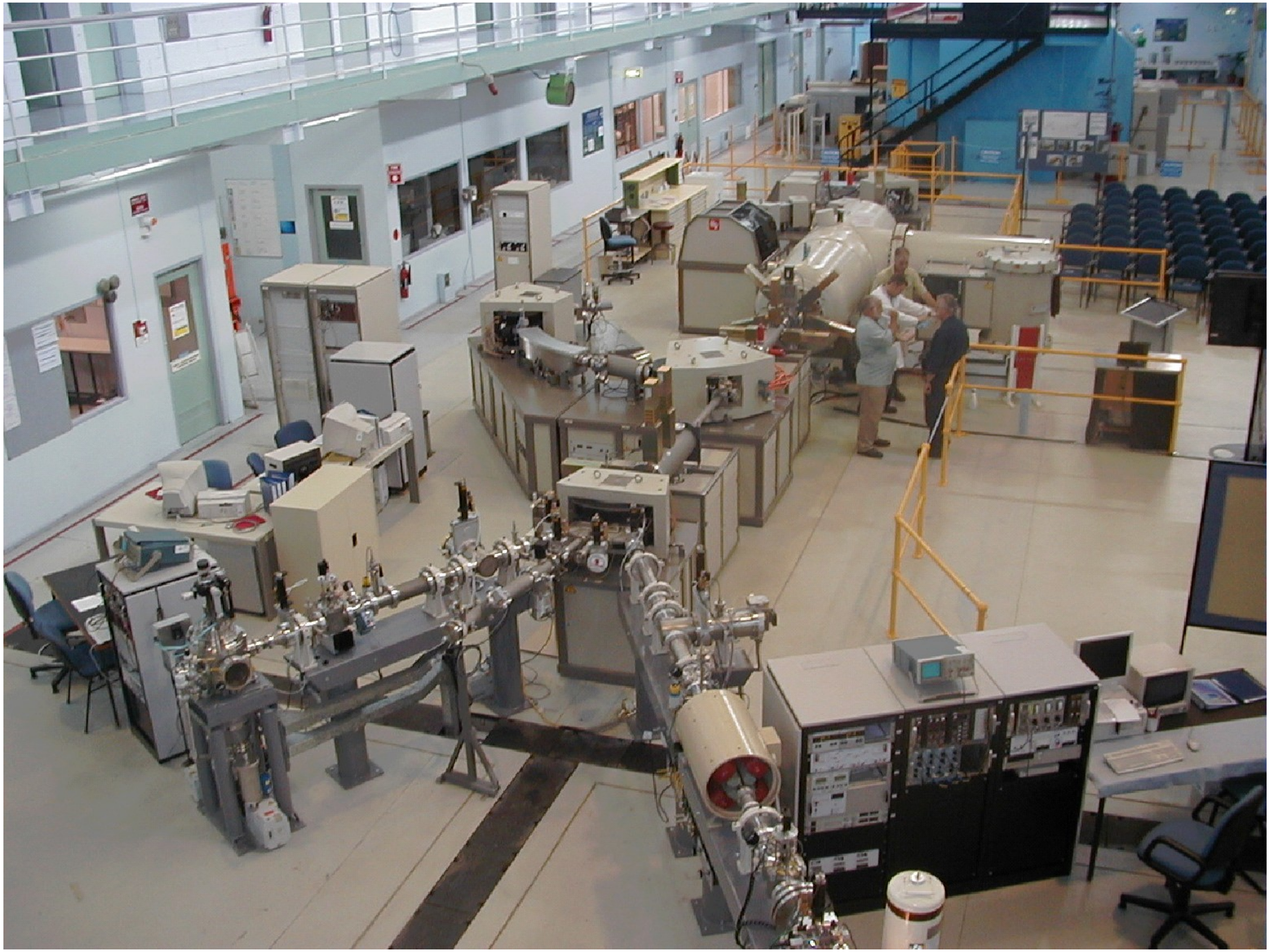
X-rays

Channelling

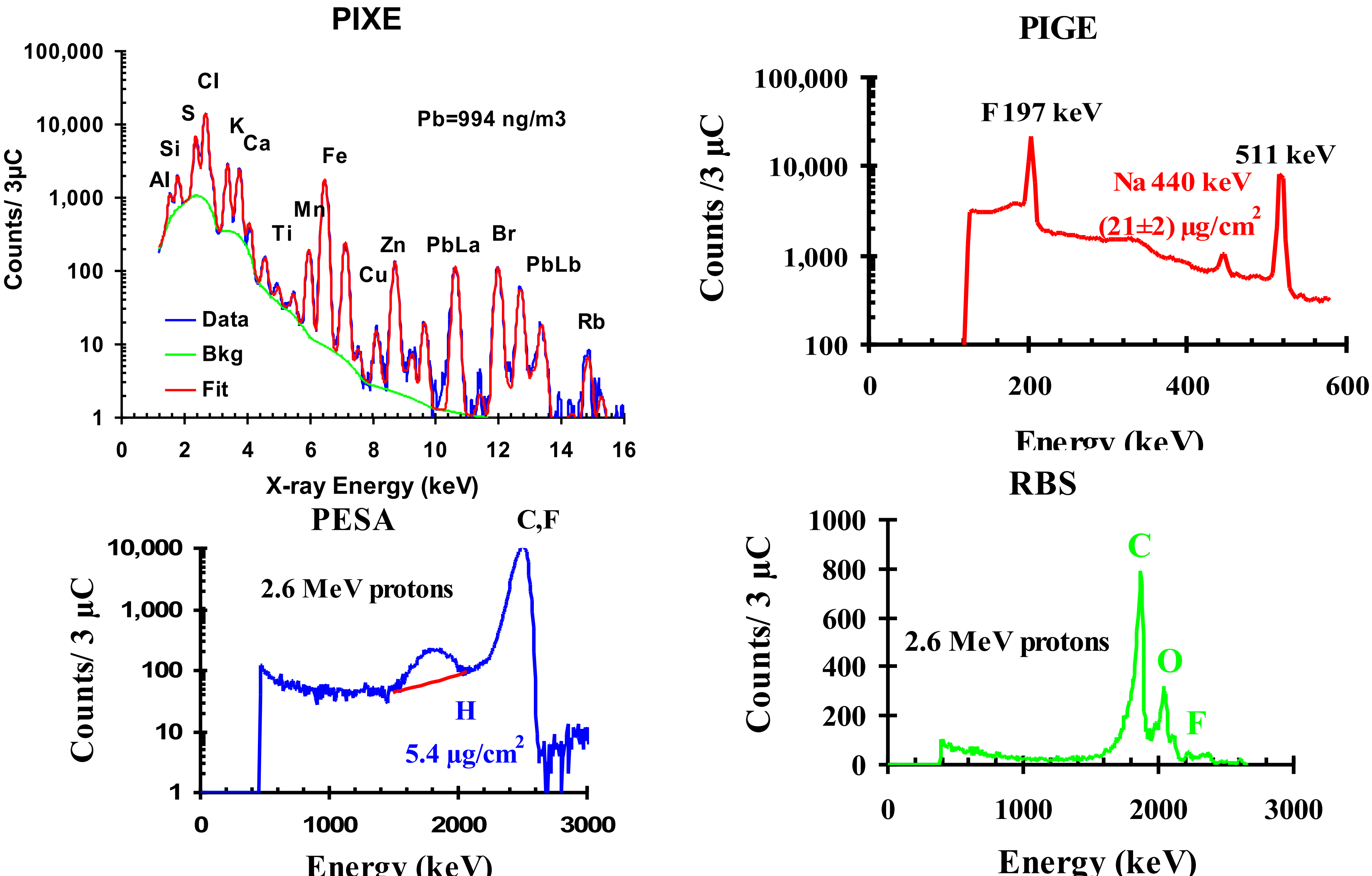
Electrons….



STAR 2MV Tandetron ANSTO



STAR 2MV Tandetron ANSTO



Four techniques cover most of the periodic table from H to U

Accelerator Applications

Basic advantages include:

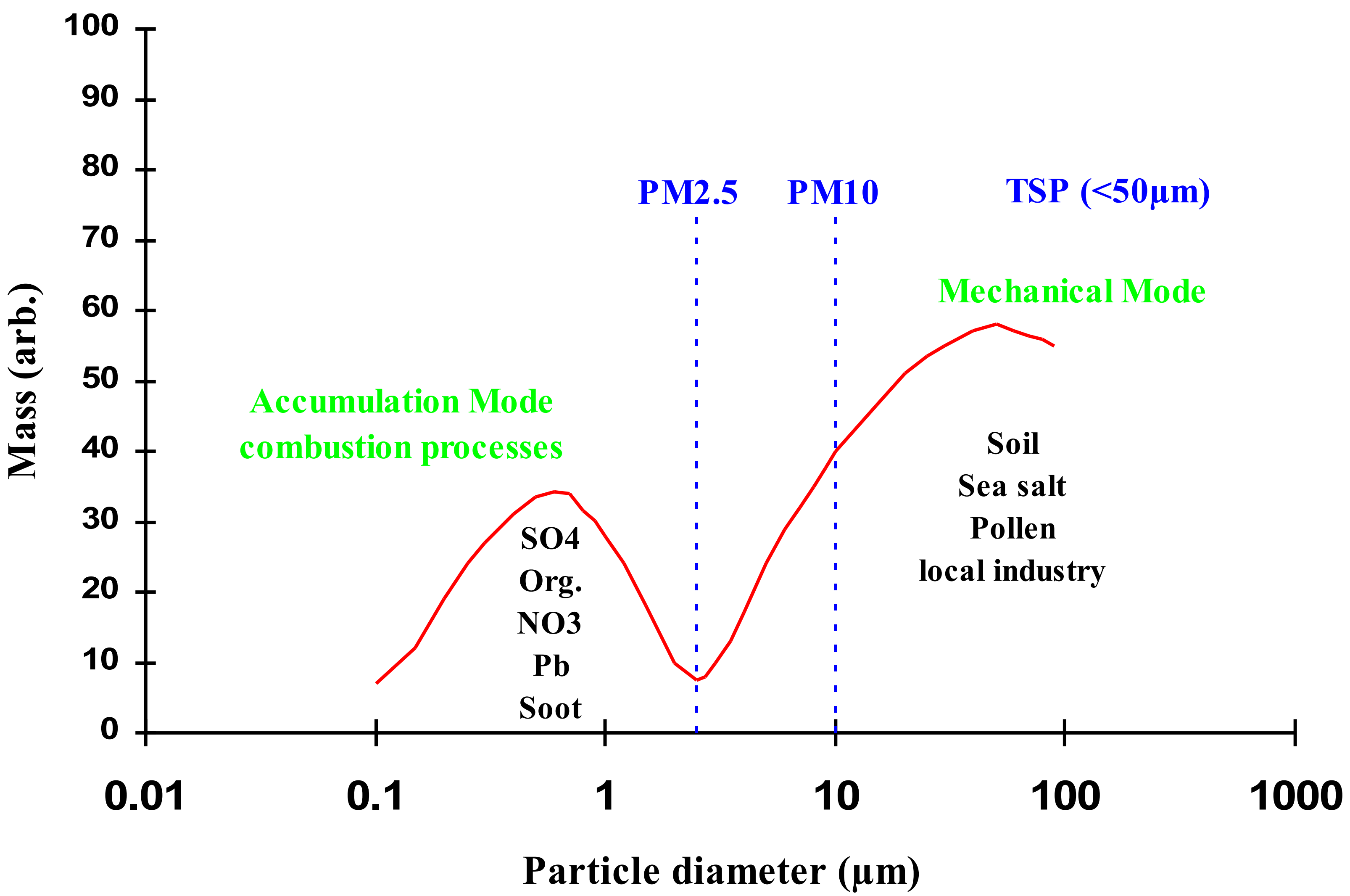
- High sensitivity (count individual atoms)
- Analyse small samples (IBA pg, AMS μm)

Applications in materials science, archaeology, environment, climate change, geology….

Today will look at study of fine particles as a typical example of the application of tailor ion beams to everyday problems.

What are fine particles?

Mass of Particle vs Size



Why Study Fine Particles?

Health implications

PM2.5 travel deep into the lungs, have direct access to the blood stream.

Absorb and scatter visible light

Fine particles are many times more efficient at scattering visible light than coarse particles. Public can see pollution!

Travel large distances

Fine particles stay in the atmosphere for days and weeks travel around the globe. Transported across countries.

Affect climate

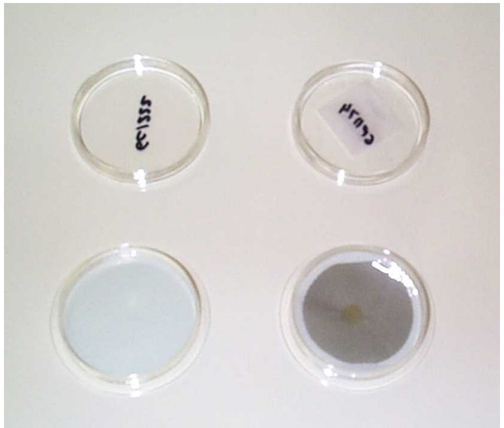
Fine particles may have a negative climate forcing effect comparable to the positive forcing of greenhouse gases. Better understanding needed for climate modelling.

How to collect them-what do the targets look like

Cyclone and Stacked filter samplers at Hong Kong

Stacked filter heads

Stacked filter cassette



Clean and exposed filters

Addressing National Issues

Through 1970,80s and 90s many countries had Pb in the atmosphere from leaded petrol- affecting health/ IQ/ children.

Added to stop engine knocking

USA removed Pb in 1970's

Metropolitan Sydney had Pb in petrol,

0.4g/litre pre Jan 93, (1,400 tonnes/yr)

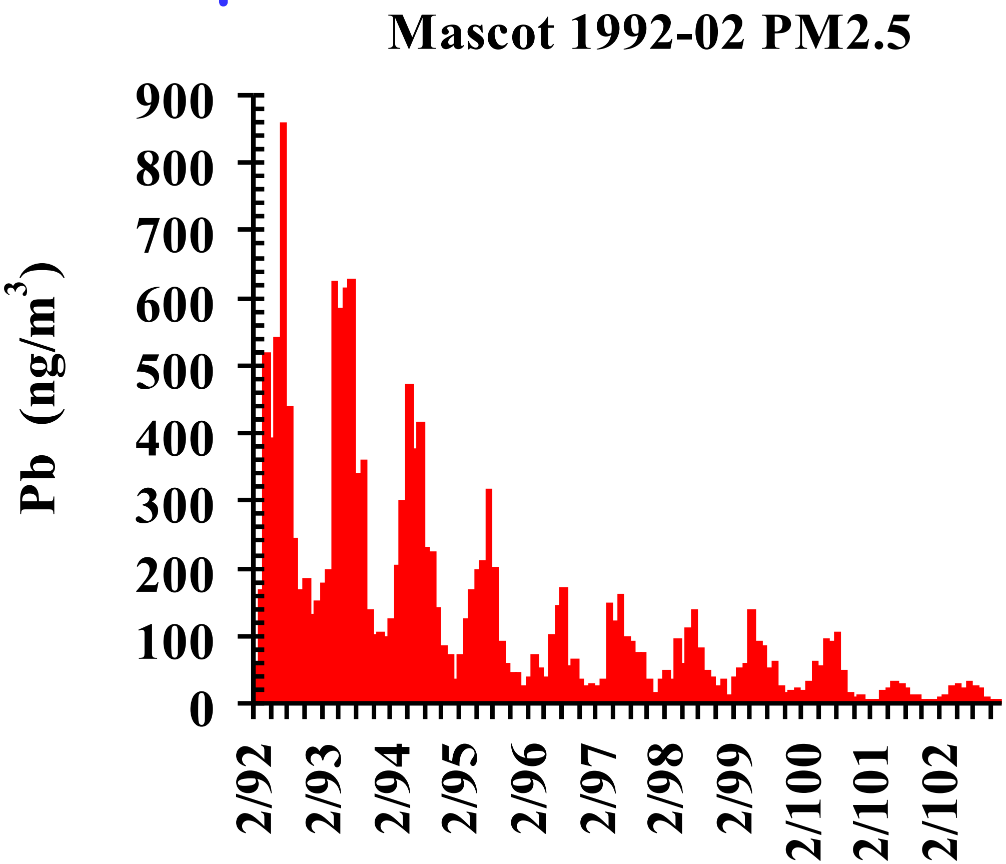
0.2 g/litre in Jan 95 and

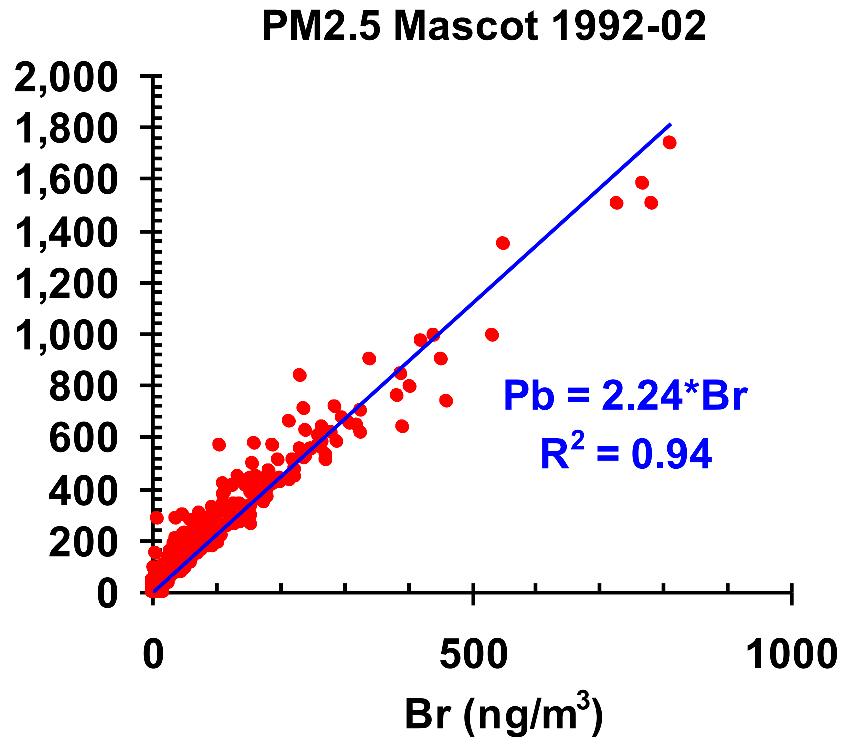
zero Pb post Jan 01 (<100 tonnes/yr)

Replaced leaded petrol with LRP (benzene, Mn!)

Fine Particulate PM2.5 Pb in Air

IBA systems at ANSTO obtained the first Australian long term quantitative data to follow PM2.5 over many years

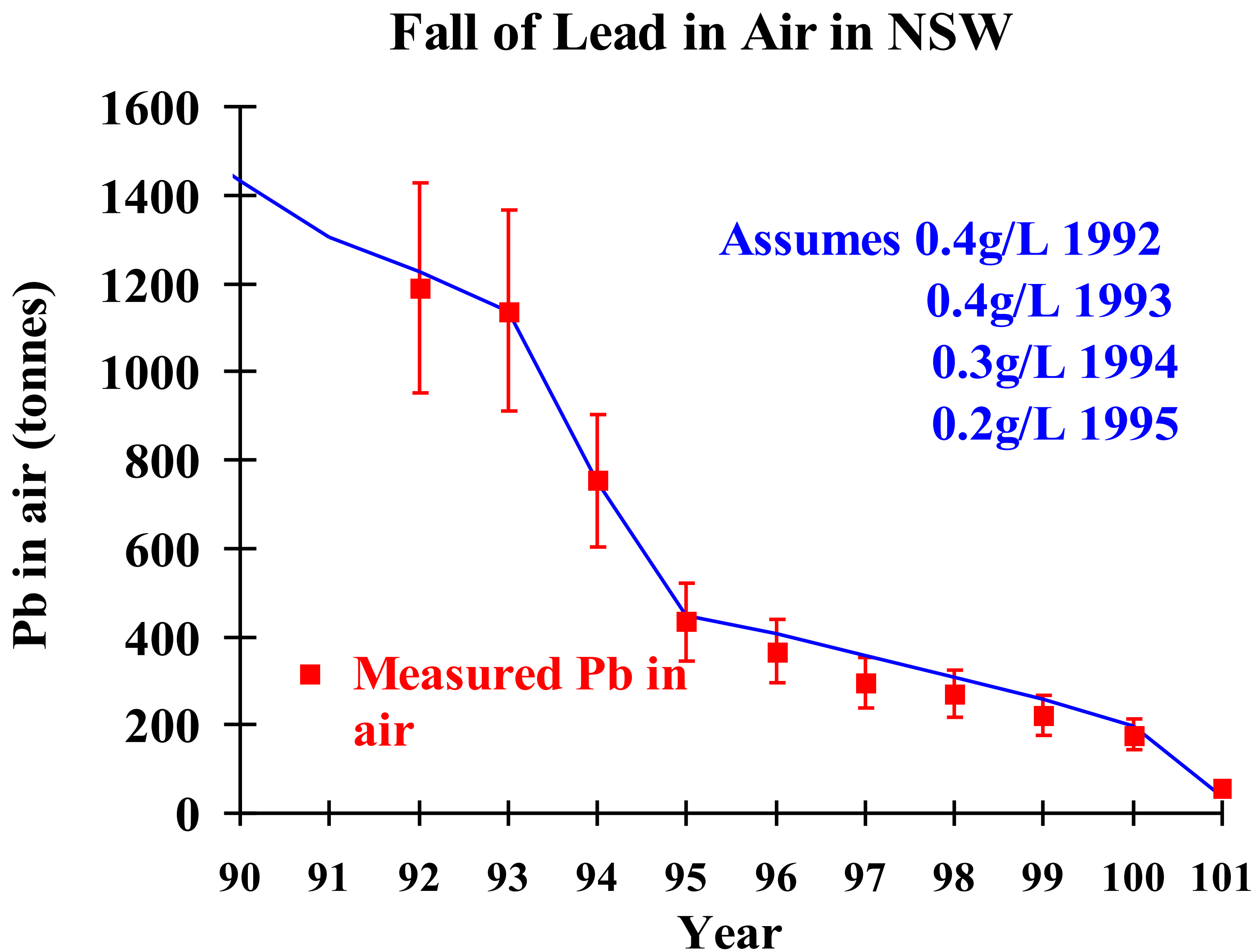




Levels of Pb with time

What was major source of Pb?

Reduction of Pb in Sydney Air



Our children's IQ is now safe!!!

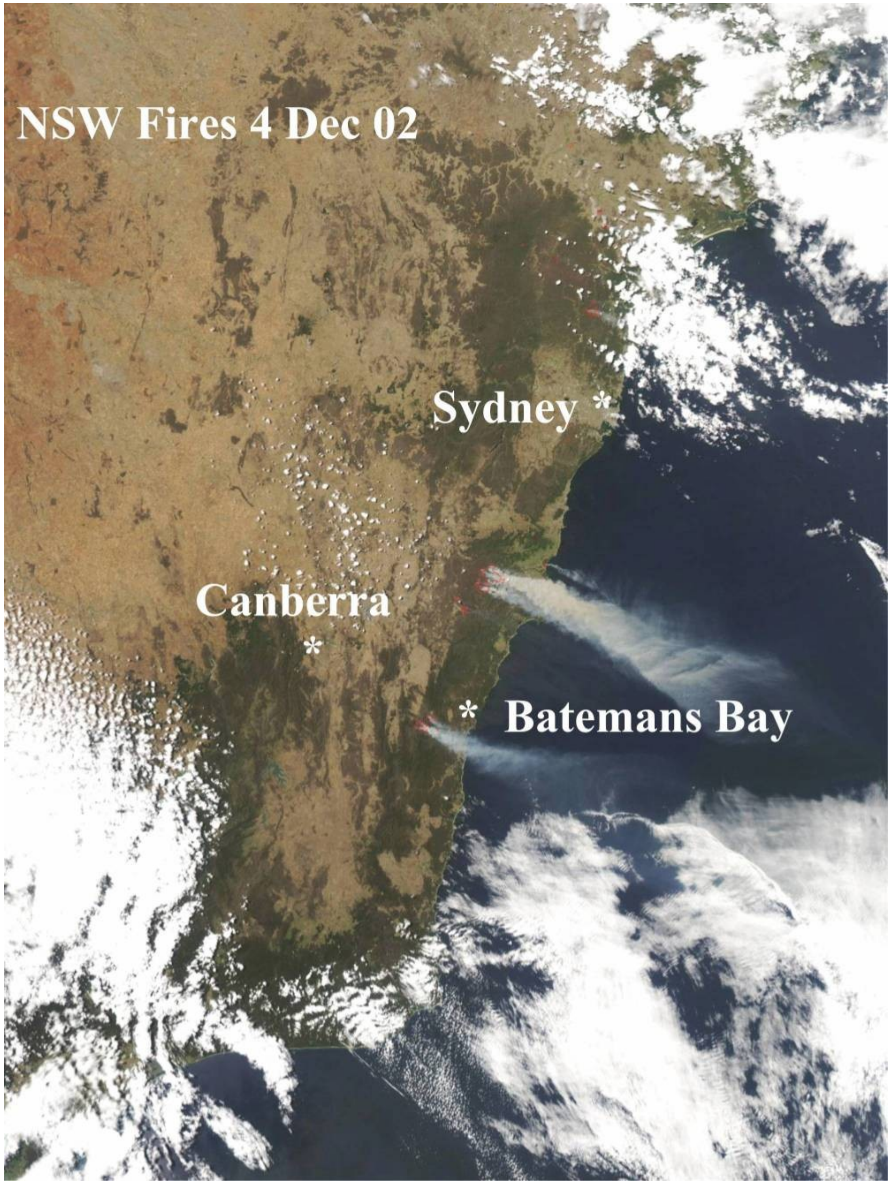
Fine Particle Pollution Travels Large Distances

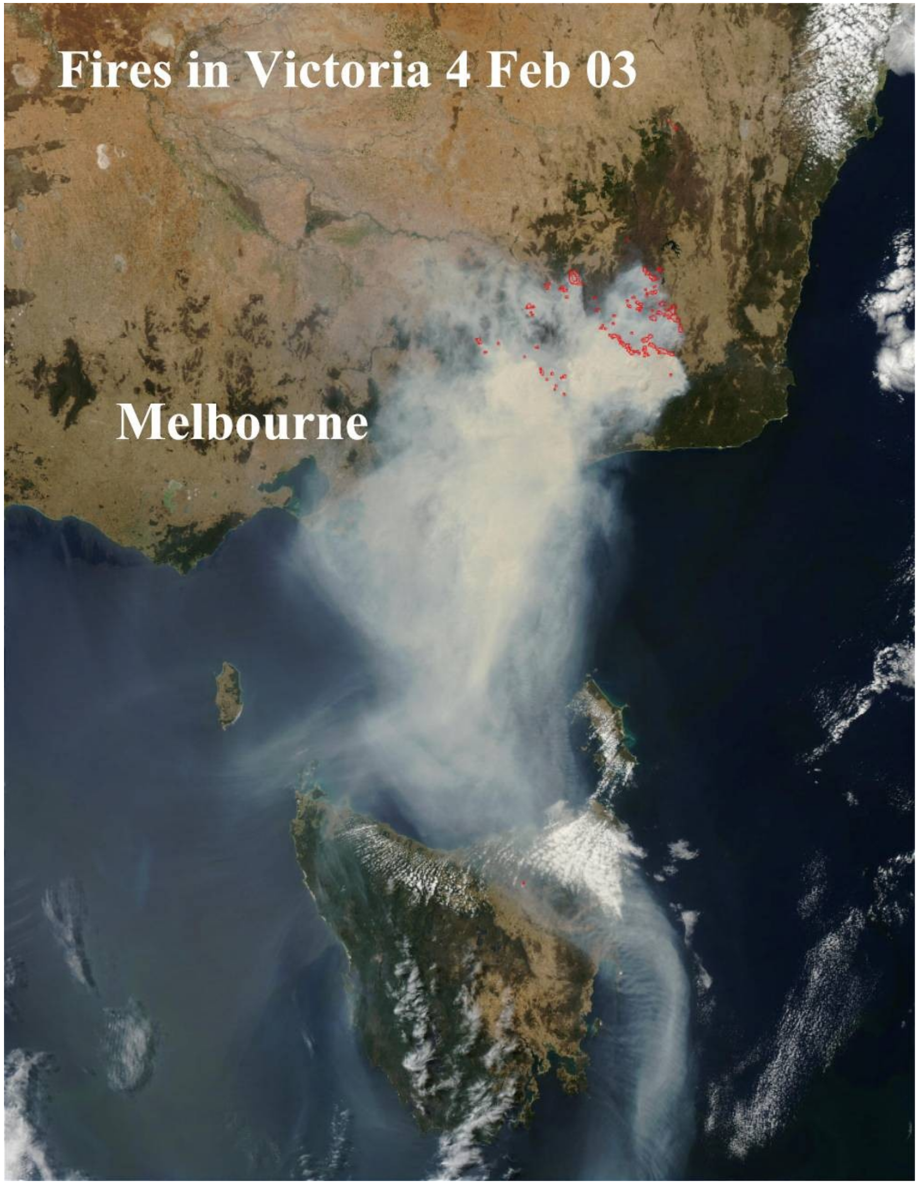
Natural pollution like smoke from bush fires or wind blown sea spray travels hundreds if not thousands of kilometres.

Manmade pollution like sulfate haze from coal burning, industry and cars travels between countries in Europe and even across oceans between China and Korea/ Japan

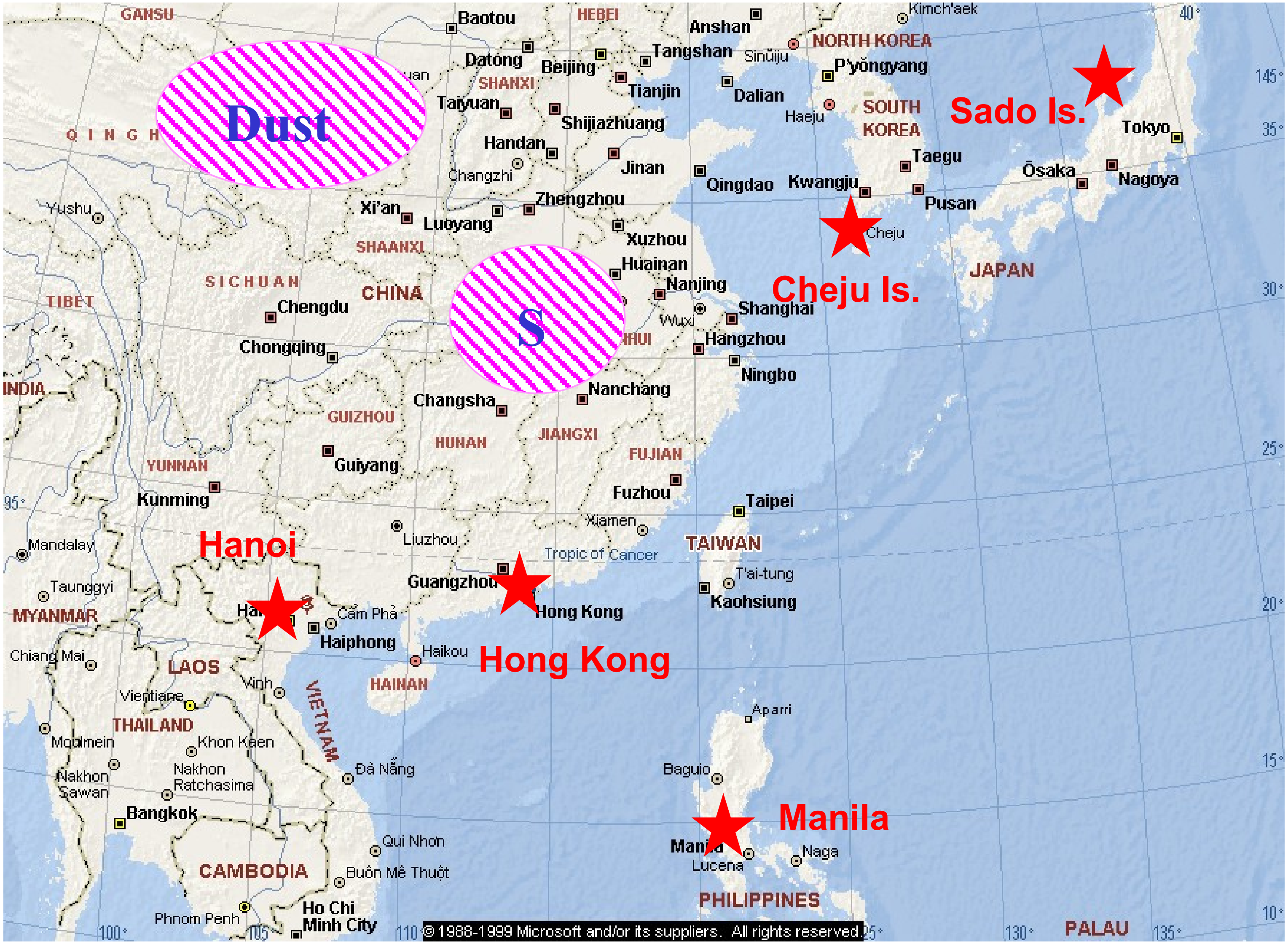
Can accelerator based methods help?
Do we measure any key components well?
Can we quantify source contributions?

Australian Bushfire Smoke Dec 2002 to Feb 2003

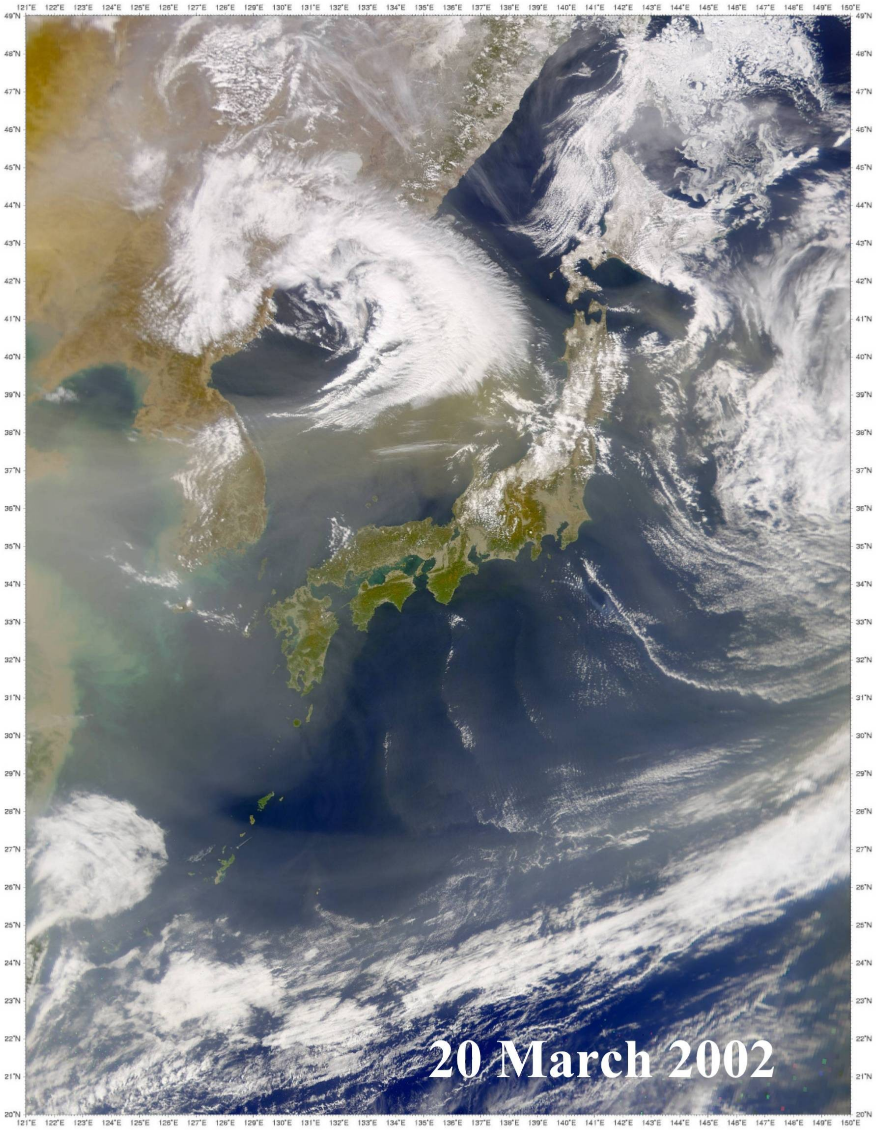


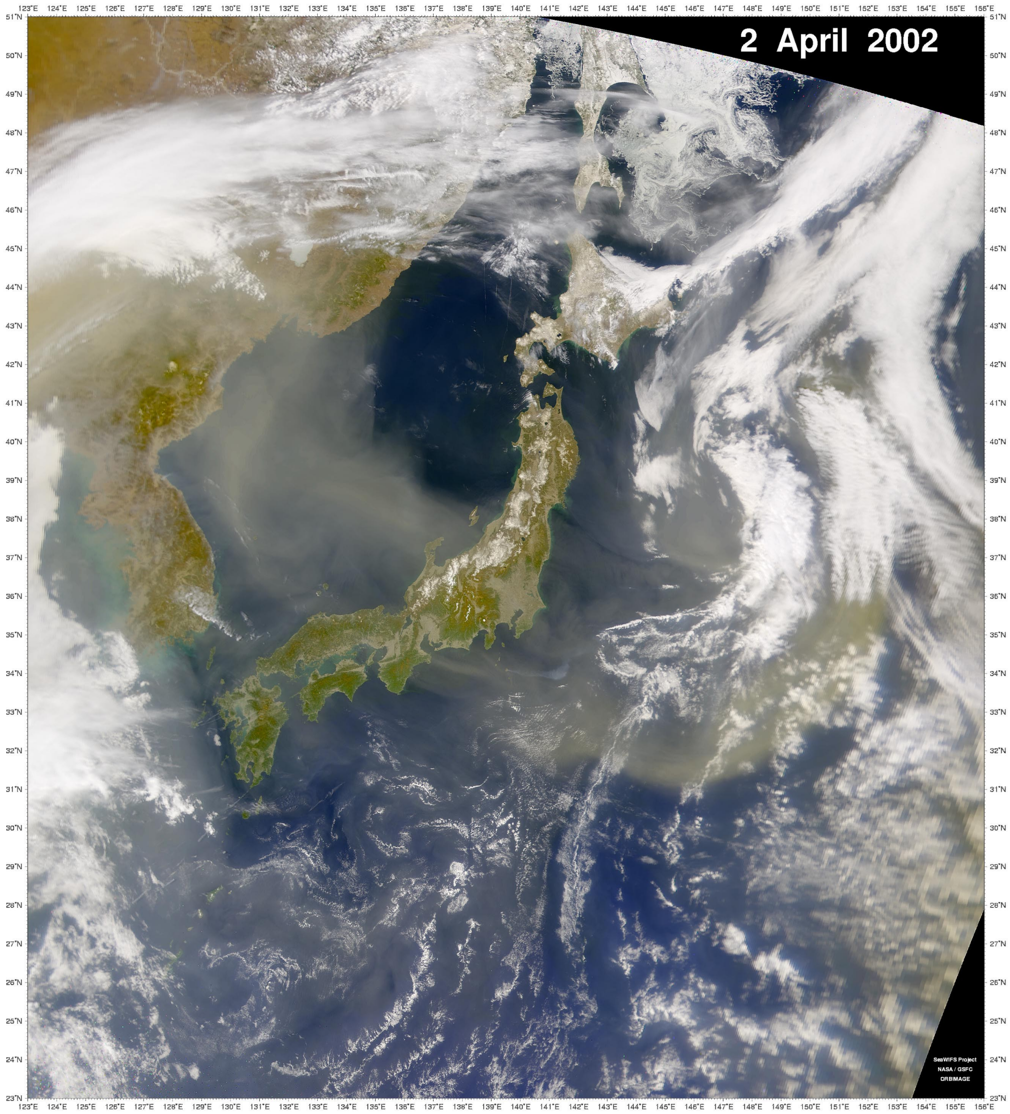


Asian PM2.5 Sampling Sites (2001-2005)

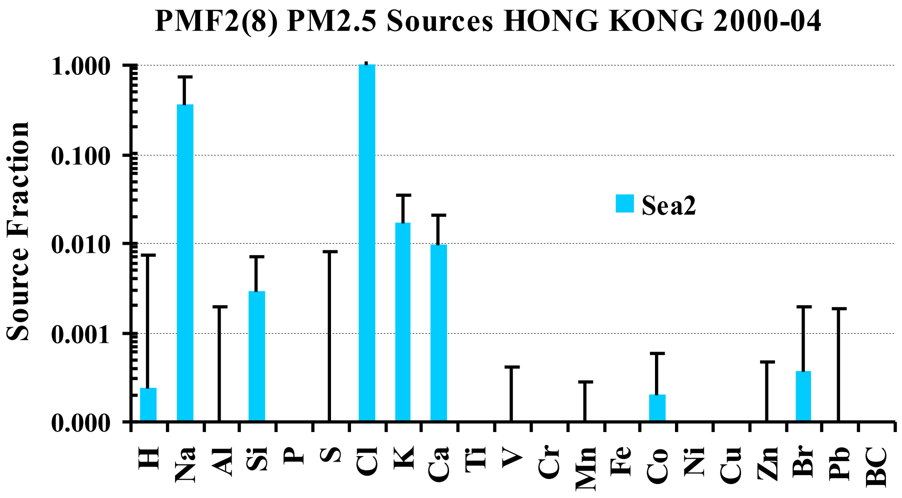


Dust Out of China in 2002

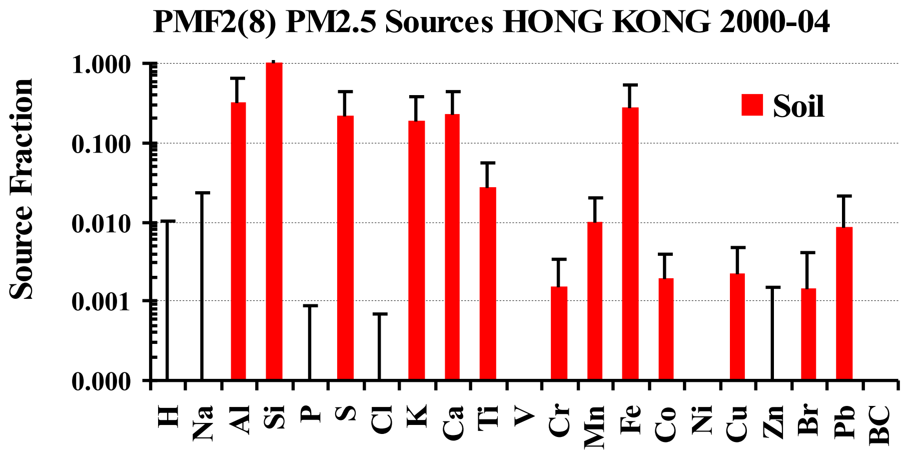




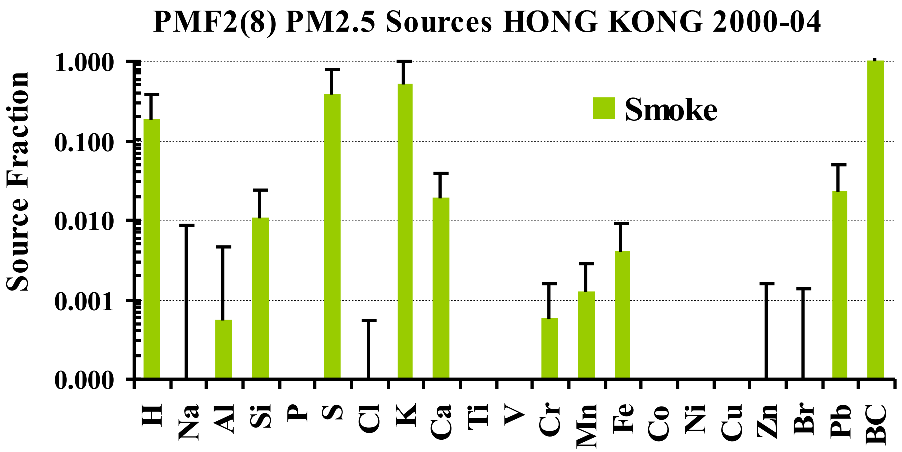
Some Typical Source Fingerprints using IBA



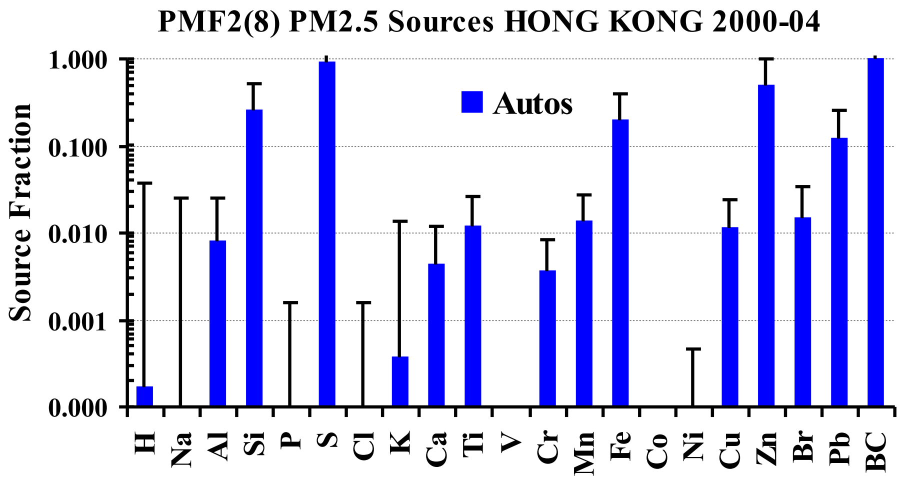
Sea Salt



Wind Blown Soil



Smoke, biomass burning

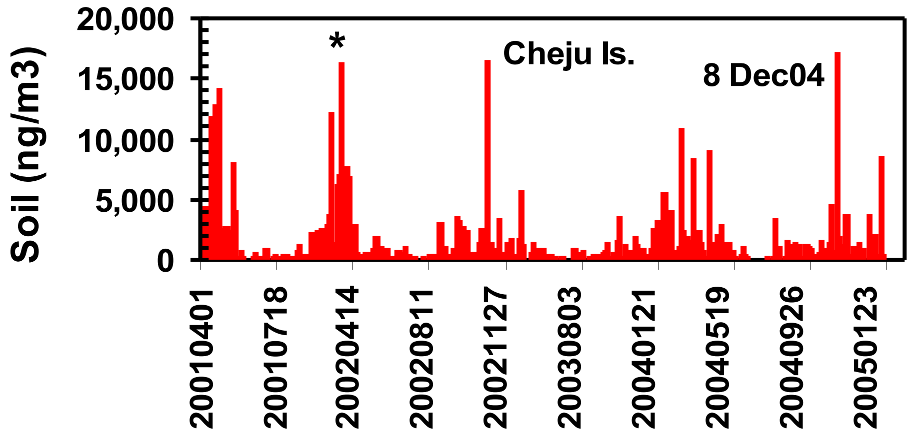


Automobiles

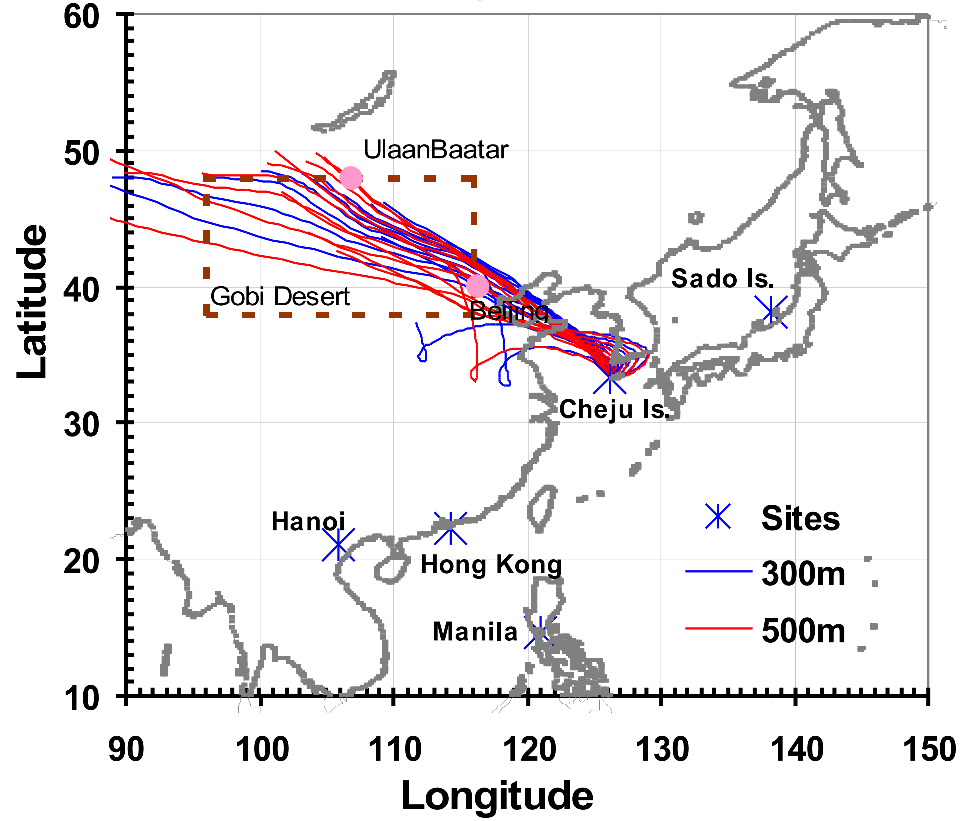
Long Range Transport of Fine Soils

HYSPLIT 3 day back trajectories every 4 hours show high soil measured on 8 Dec 04 at Cheju Island originates from Gobi Desert regions in northern China some 3,000 km to NW.

Fine soil at Cheju Island estimated from IBA Al, Si, Ti, Ca and Fe concentrations measured over 24 hours.



8 Dec 04



Navel Research Laboratories, Monterey, USA

Movie of Sulfate and Soil Over East Asia

For 18-25 March 2002, 6 hours per frame

(see * in previous Soil graph)

Go

Summary

Accelerator based IBA techniques, in particular, are ideal for generating large data sets containing many elements needed for characterisation and source modeling of air pollution.

20-40 elements are not uncommon. The larger the number of elements the better the sources are characterised.

Generally nuclear analytical methods (NAA, IBA, NRA, RBS, PESA etc) are accurate, precise, fast and non destructive on microgram-picogram samples.

In many cases this is the only way this data can be obtained!

Acknowledgements

All the accelerator staff at ANSTO including:-

Ansary, Kevin
Bond, Peter
Button, David
Cooke, Greg
Drewer, Peter
Evans, Oliver
Garton, David
Ionescu, Mihail
Lynch, Damien
Mann, Michael
Sarbutt, Adam
Siegele, Rainer
Stelcer, Eduard
Thompson, Craig

THE NEUTRON SCATTERING FACILITIES AT THE NEW OPAL RESEARCH REACTOR

Andrew Nelson

Australian Nuclear Science and Technology Organization
Sydney, NSW, Australia

The neutron scattering facilities at the new OPAL research reactor (which is nearing completion, and which will come fully on line in 2006) will place Australia at the leading edge of the neutron beam community, rivaling the best facilities in North America and Europe.

There are eight instruments currently being built with several more in future expansion plans. The capability offered by these instruments is extensive, allowing cutting edge experiments to be performed in areas such as:

- Ultra-fast diffraction measurements in combustion synthesis
- Interactions of proteins with biological cell membranes
- Dynamics in Hydrogen Storage materials
- Nanomaterials

In this talk an overview of the facility will be given, with a description of each instrument being constructed and the science that will be performed on each of the instruments.

Questions:

Nikolai Lobanov (ANU): What is a typical transmission coefficient of the neutron guides?

Andrew Nelson: I don't know precisely what the transmission is, but the neutron guides have typically a reflectivity of around eighty percent up to the critical angle. The critical angle is the angle above which the signal drops off. If you have got neutrons going down a trajectory at less than the critical angle. Each time they make a reflection, the probability of getting reflected is about 0.8 basically.

Inaudible:

Andrew Nelson: The flux is about 10^{10} , 8^{10} at the target.

Nikolai Lobanov (ANU): Reaction kinetics, what is the typical typical time resolution?

Andrew Nelson: In that titanium silicon carbide example that I showed you, those time slices were 0.5 seconds but you could go faster. [Under some circumstances] you can look at things on the order of milliseconds.

David Garton (ANSTO): What is the physical size of the space where you mount the samples? We're used to sized like that of a water bucket and you seem to be talking about much larger spaces.

Andrew Nelson: Yes, that was a big design criterion in all the instruments. Typically we've designed all the sample areas to be standardized so all the mountings and so on are standardized and we've said basically if you are going to use the ancillaries on all the sample areas, they have to be the same size Probably about a metre or so that we have designed in so that you can work in there.

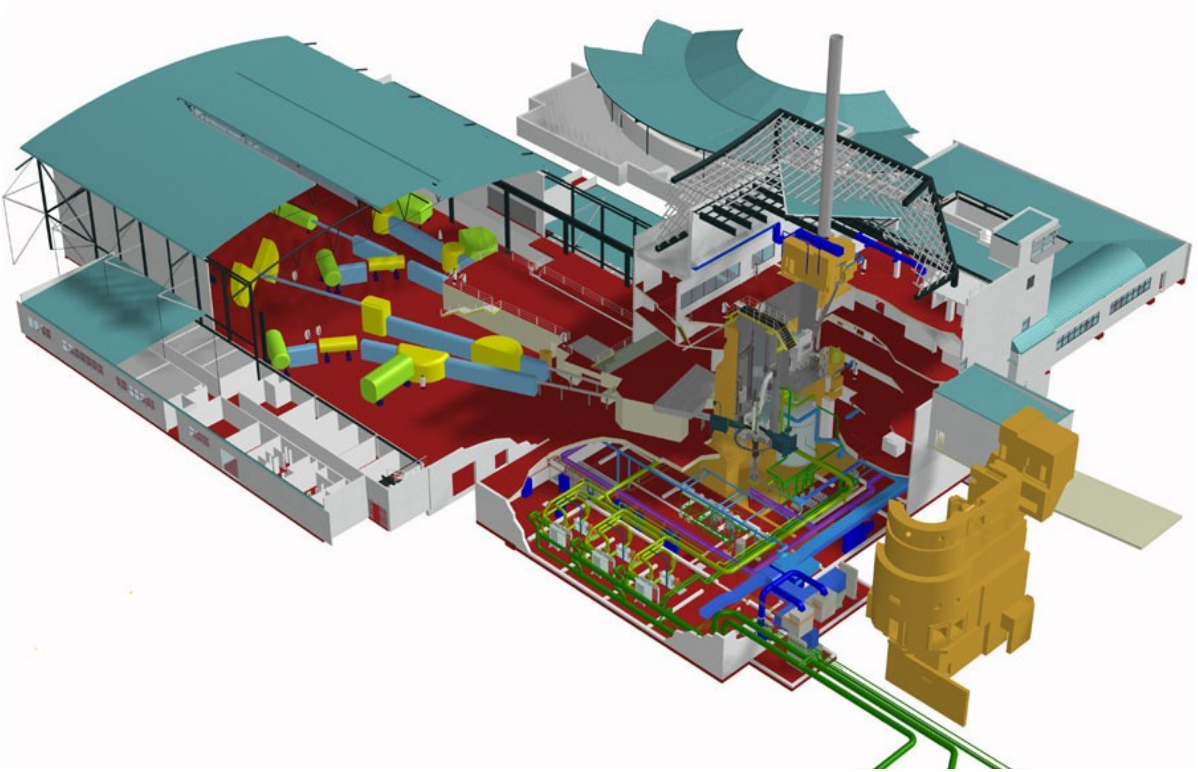
Fred: What is a Kowari?

Andrew Nelson: I'll have to pass that on to an Australian. I think that a Kowari is a little mouse.

???????: So I can select beam-line, have cryogenic space and I can have eight Tesla magnetic field and technical support and this is all for free?

Andrew Nelson: Yes. With regard to ancillaries, there is a stock of standard ancillaries, and if there is not something in there that meets you needs, we could probably design something to put in there. We just need to know what you need and we can tell you what we need so. For example, we'll tell you what the neutron parts of the instrument needs, and you design your electro-chemical cell around it.

The future of neutron beam science in Australia – techniques and opportunities



bragg institute
ansto in partnership

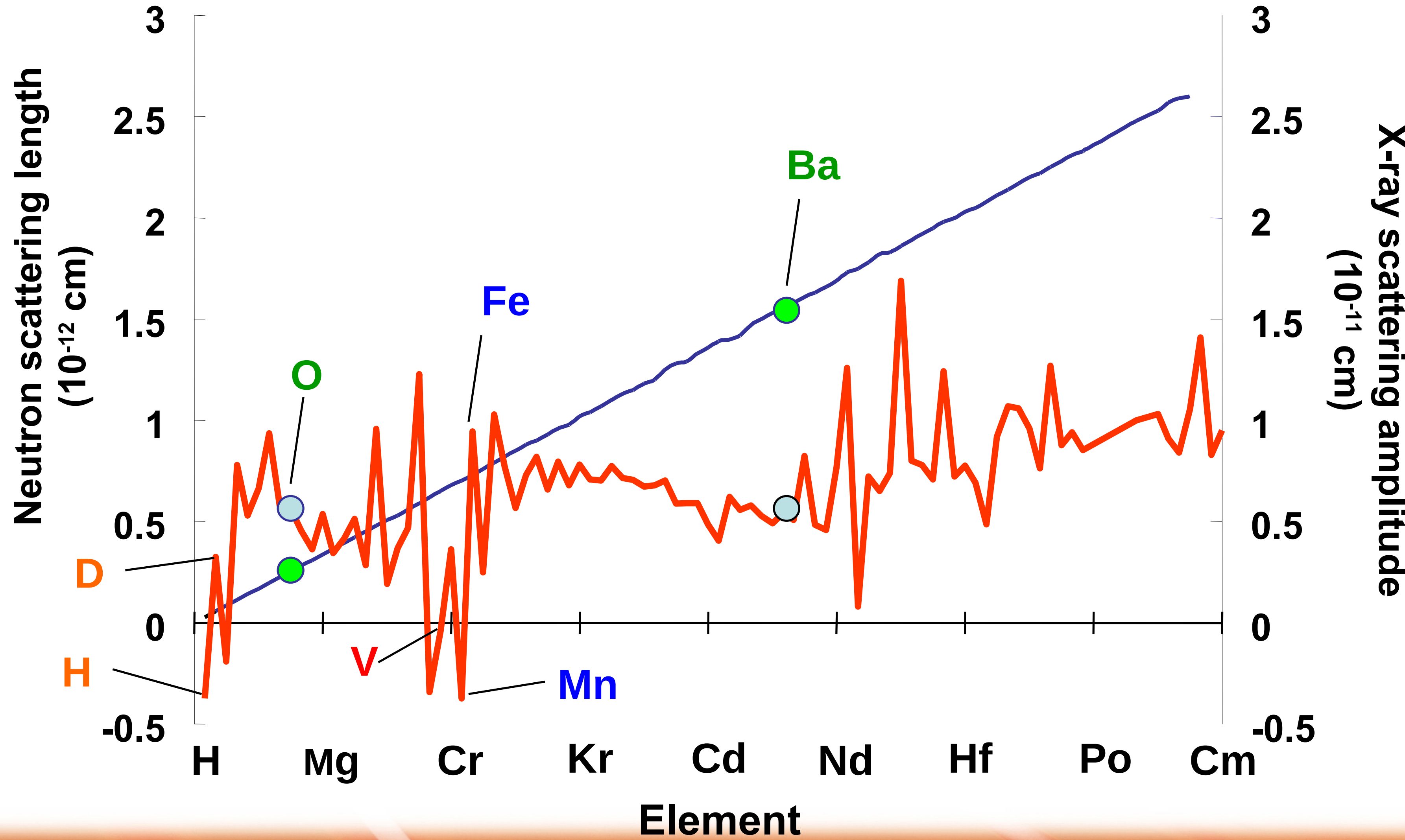
Dr Andrew Nelson

andrew.nelson@ansto.gov.au

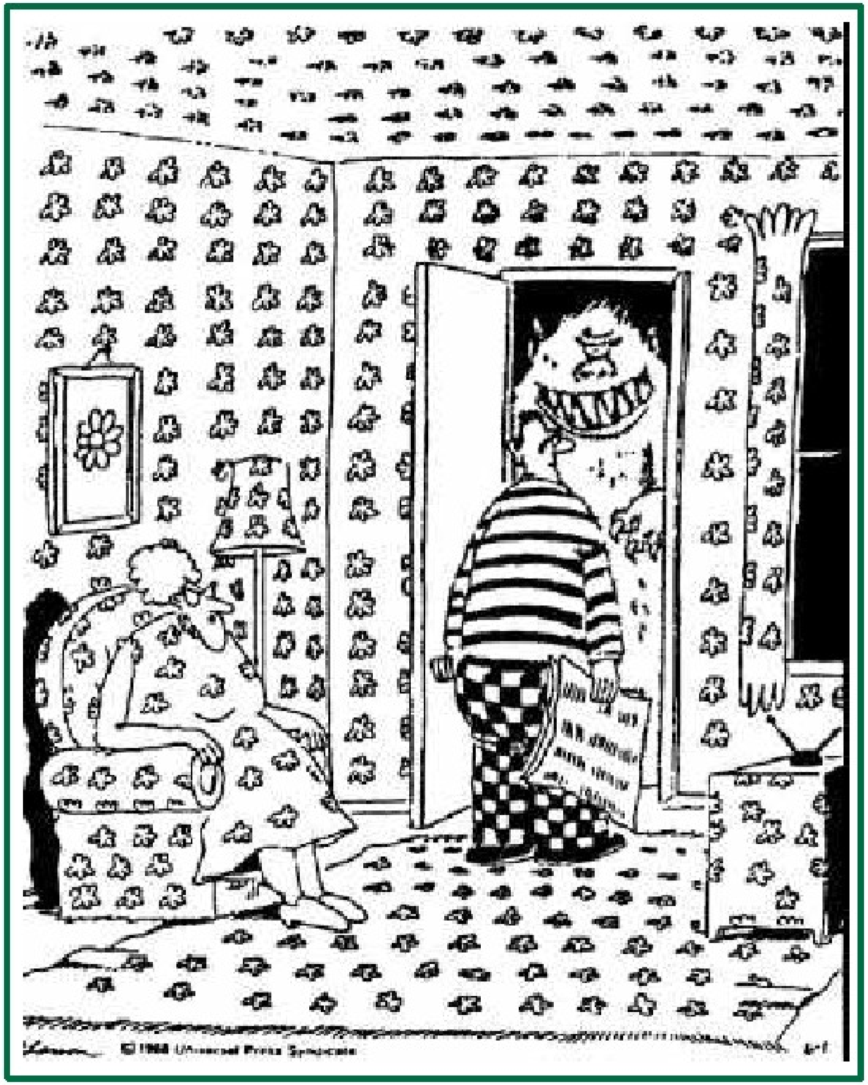
What's so special about neutrons ?

- Non-destructive
- Highly Penetrating
- Magnetic Moment
- Wavelength ~ atomic spacings (1 - 10 Å)
- Energies ~ atomic and molecular vibrations
  (ΔE ~10 μeV - 100 meV)
- Isotopically variable scattering power

Scattering Power of Neutrons / X-rays



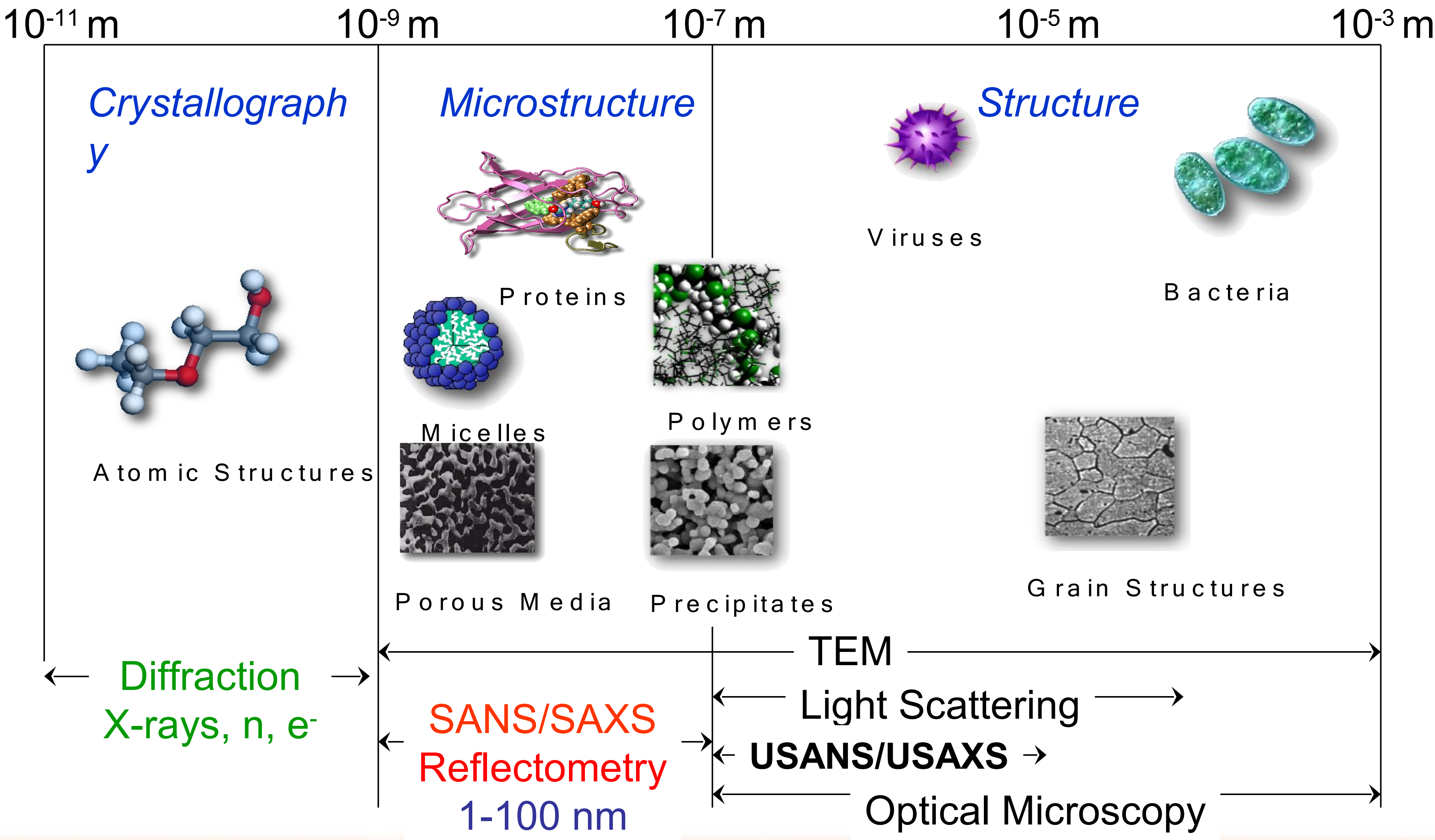
Neutron Contrast $= (\rho_{particle} - \rho_{bulk})^2$



When the monster came, Lola remained undetected.

Harold, of course, was immediately devoured.

Size Scales Probed by Scattering Techniques



OPAL (Open Pool Australian Light water) Reactor

20 MW, LEU, light water-cooled, D_2O reflector, > 4 x 10^{14} $ncm^{-2}s^{-1}$

September 1997
Fed. Govt. announces RRR

August 1999
Reactor tender issued

July 2000
Reactor contract awarded

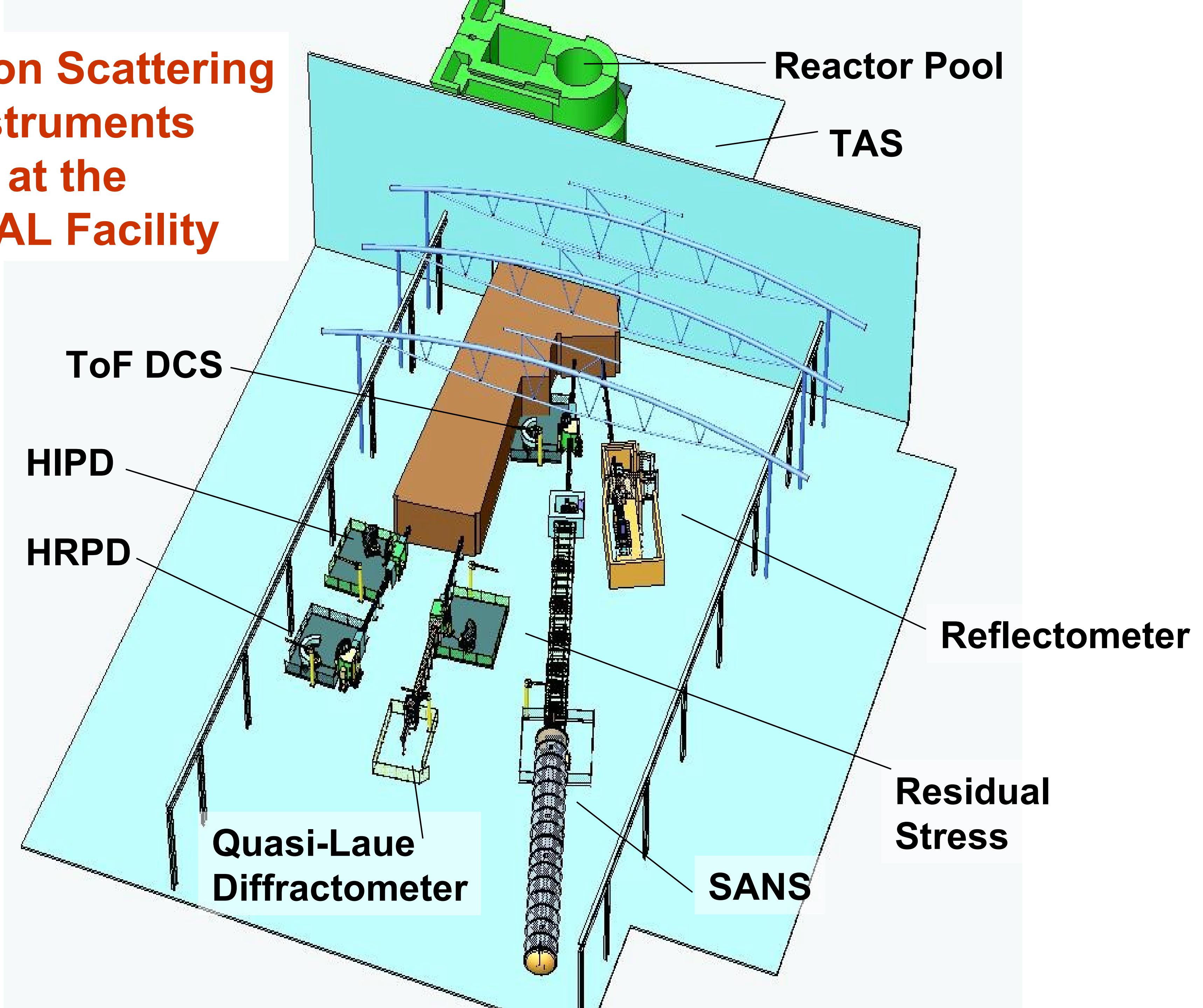
September 2000
Neutron Beam Inst. defined

May 2002
Construction commenced

July 2006
Reactor goes critical

June 2007
User operation

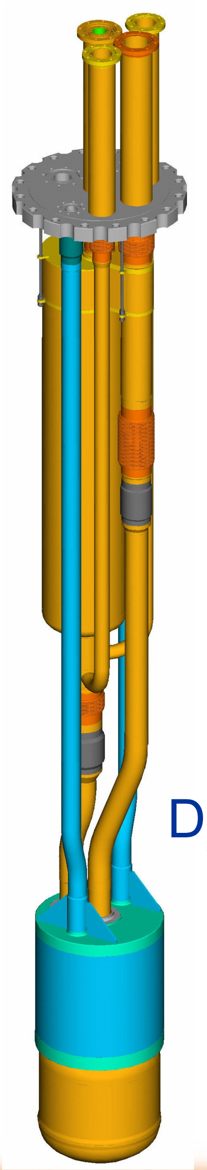
Neutron Scattering Instruments at the OPAL Facility



OPAL's Cold Neutron Source: producing long wavelength neutrons

The D_2 moderator

Volume: 20 litres
Temperature: ~25K
Heat load: <4.5 kW



Helium circuit, enclosing deuterium circuit

D_2O compensation chamber

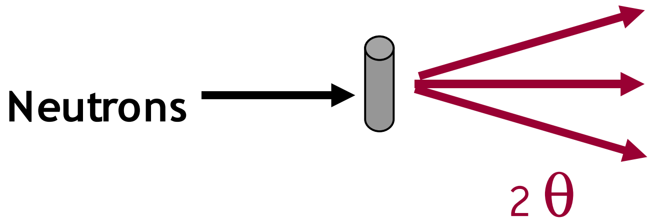
Supermirror Coated Neutron Guides

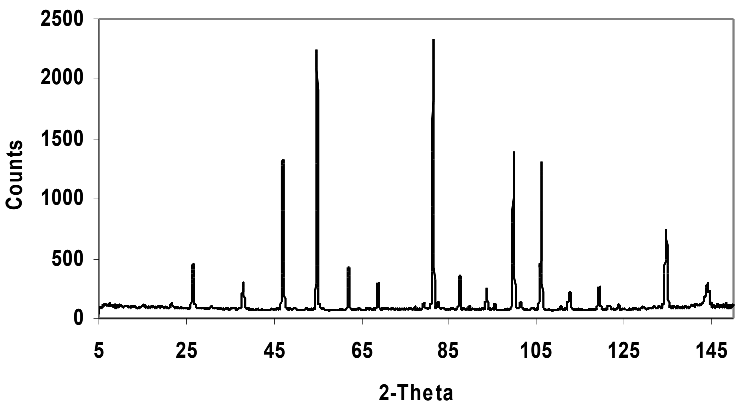
Evacuated (rectangular) pipe: internal surfaces coated with Ni/Ti supermirrors

Transmits neutrons up to 50 m from the reactor

(behaves like a fibre-optic for neutrons)

Neutron Powder Diffraction

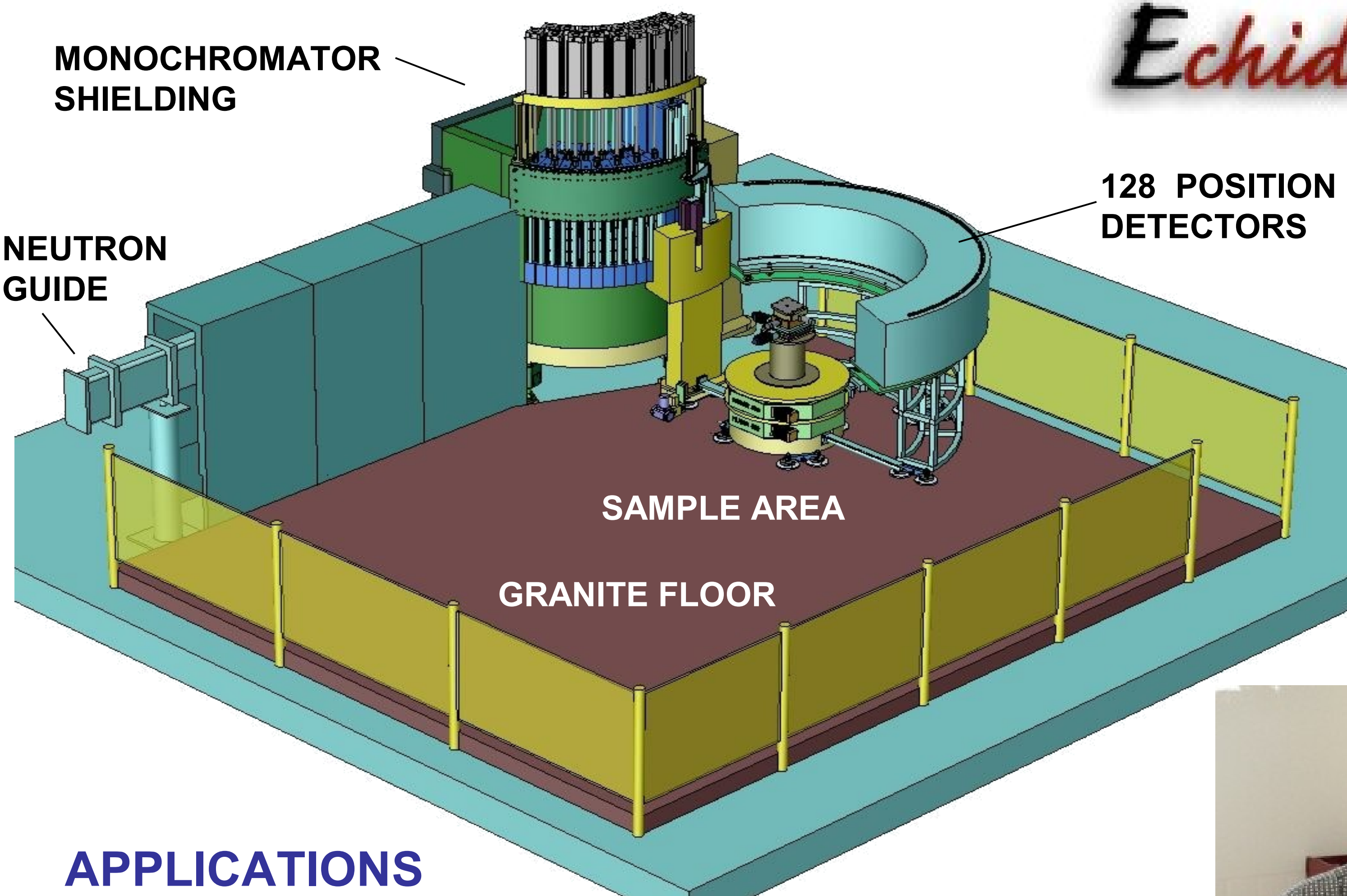




- Complex crystal structures
  - metal hydrides; hydrogen bonding;
  - location of water and hydroxyls
- Location of light anions or oxygen vacancies
- Cation ordering
- Magnetic structures
- Phase transitions (vs T, P, H)
- High pressure studies
- Solid state chemical reactions

High Resolution Powder Diffractometer

Echidna

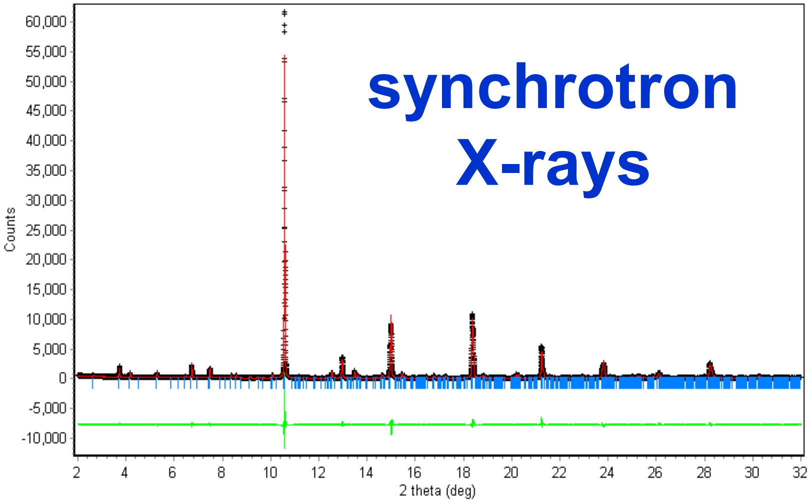


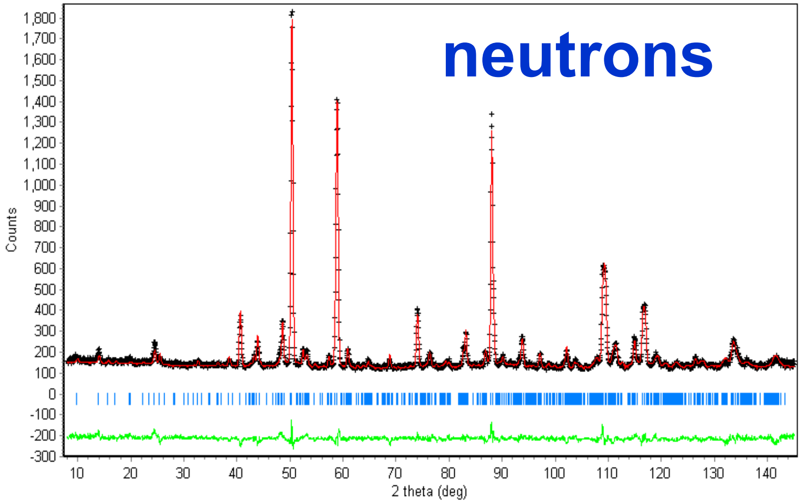
APPLICATIONS

- Materials with complex crystal structures
- Subtle phase transitions
- Peak shape variation
  - strain, crystallite size, and defects

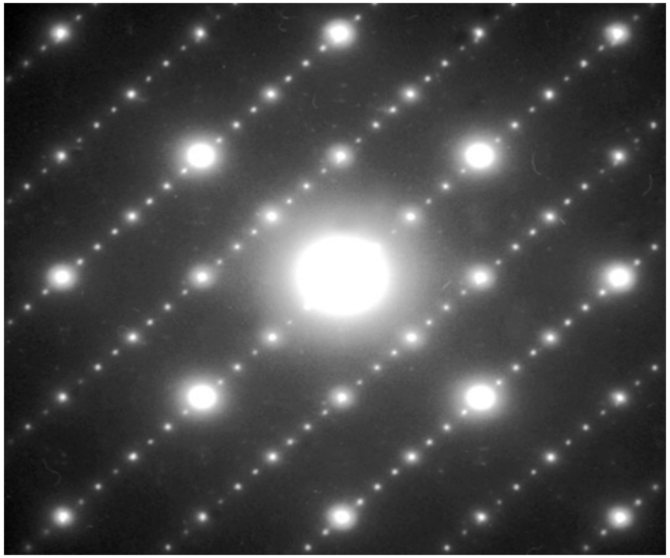
Dr Klaus-Dieter Liss

Cation and vacancy ordering in $Ho_{0.2}Sr_{0.8}CoO_{3-\delta}$



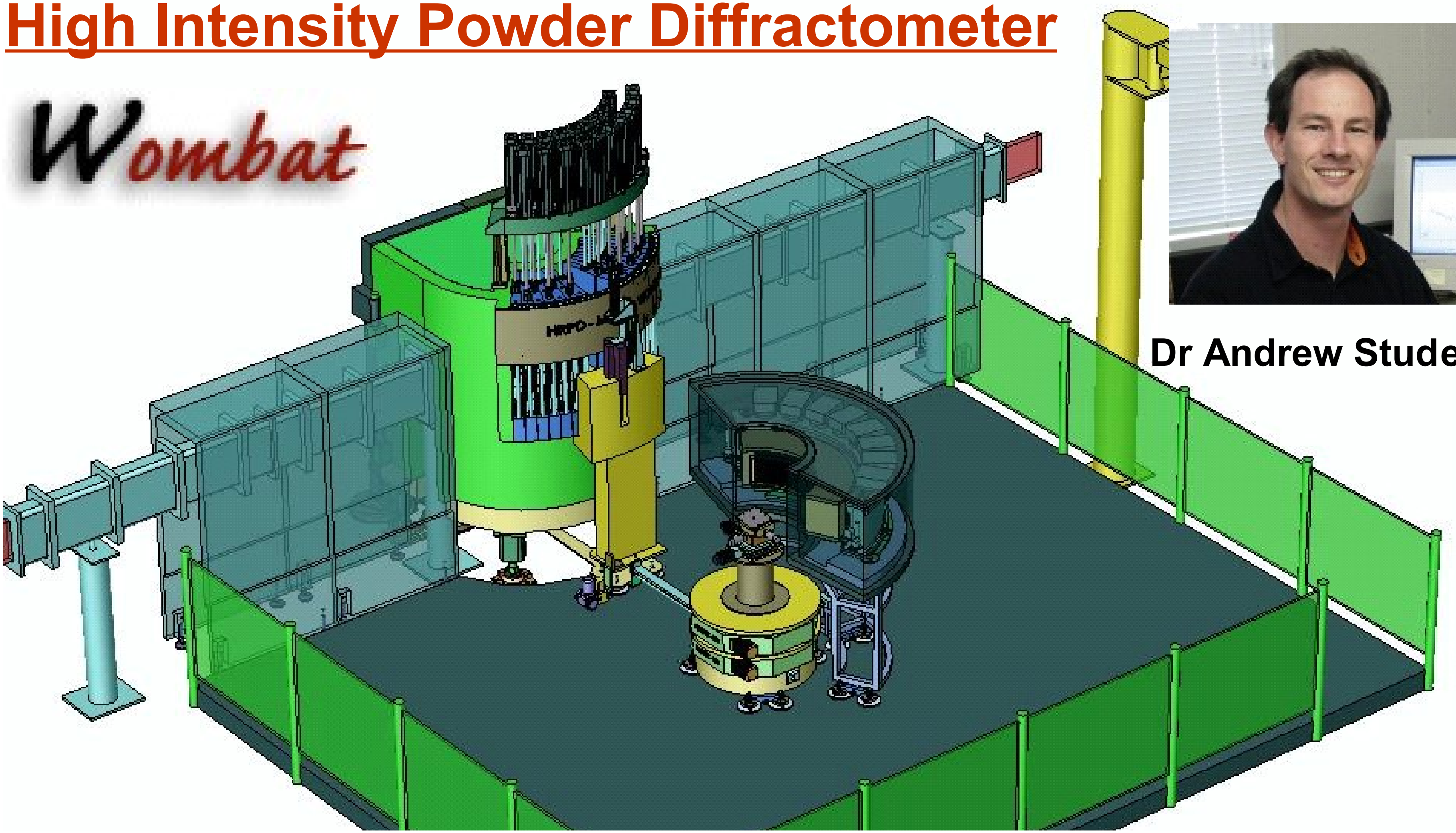


electrons



High Intensity Powder Diffractometer

Wombat



Dr Andrew Studer

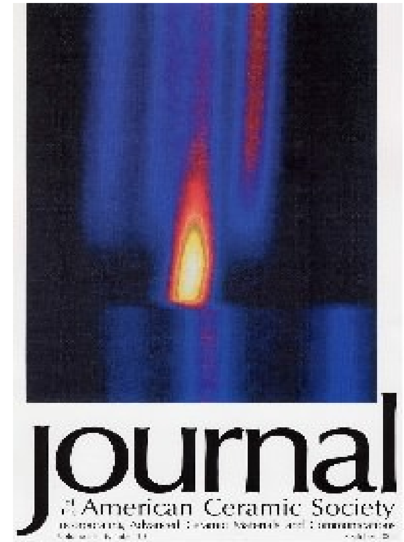
APPLICATIONS

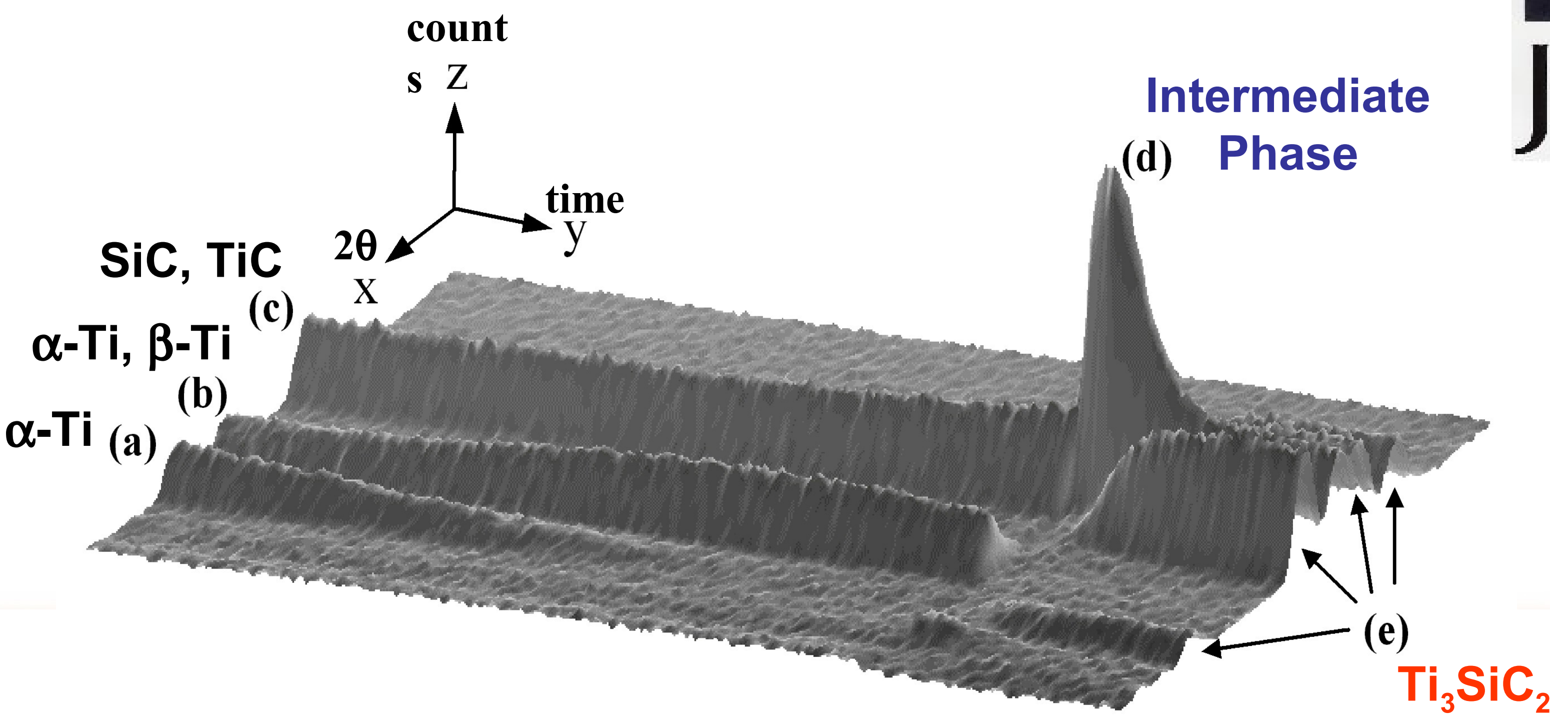
- Real time: Single shot (kinetic) measurements
- Real time: Stroboscopic (cyclic, periodic) measurements (reversible)
- Small sample volumes
- Magnetic studies at “long” wavelengths (2.36 Å and 4 Å)

Reaction Kinetics: Combustion Synthesis of Ti_3SiC_2

Eric Kisi – U. Newcastle D20 (ILL)

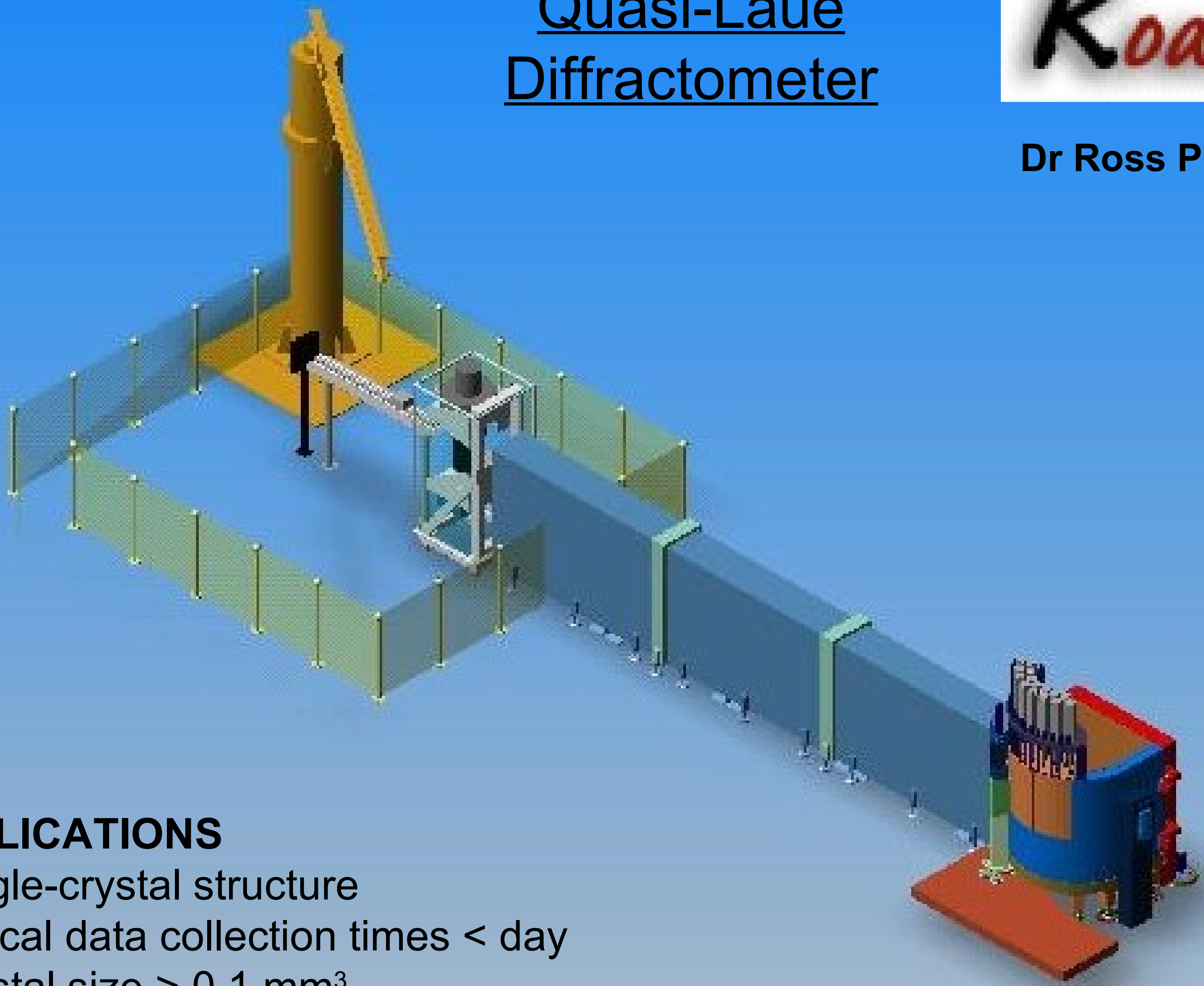
3Ti + SiC + C heated at 30°C/min
Once initiated, reaction enthalpy provides the energy source
High speed reaction - previously unknown mechanism
Diffraction patterns with 0.5s time slices





Quasi-Laue Diffractometer

Dr Ross Piltz

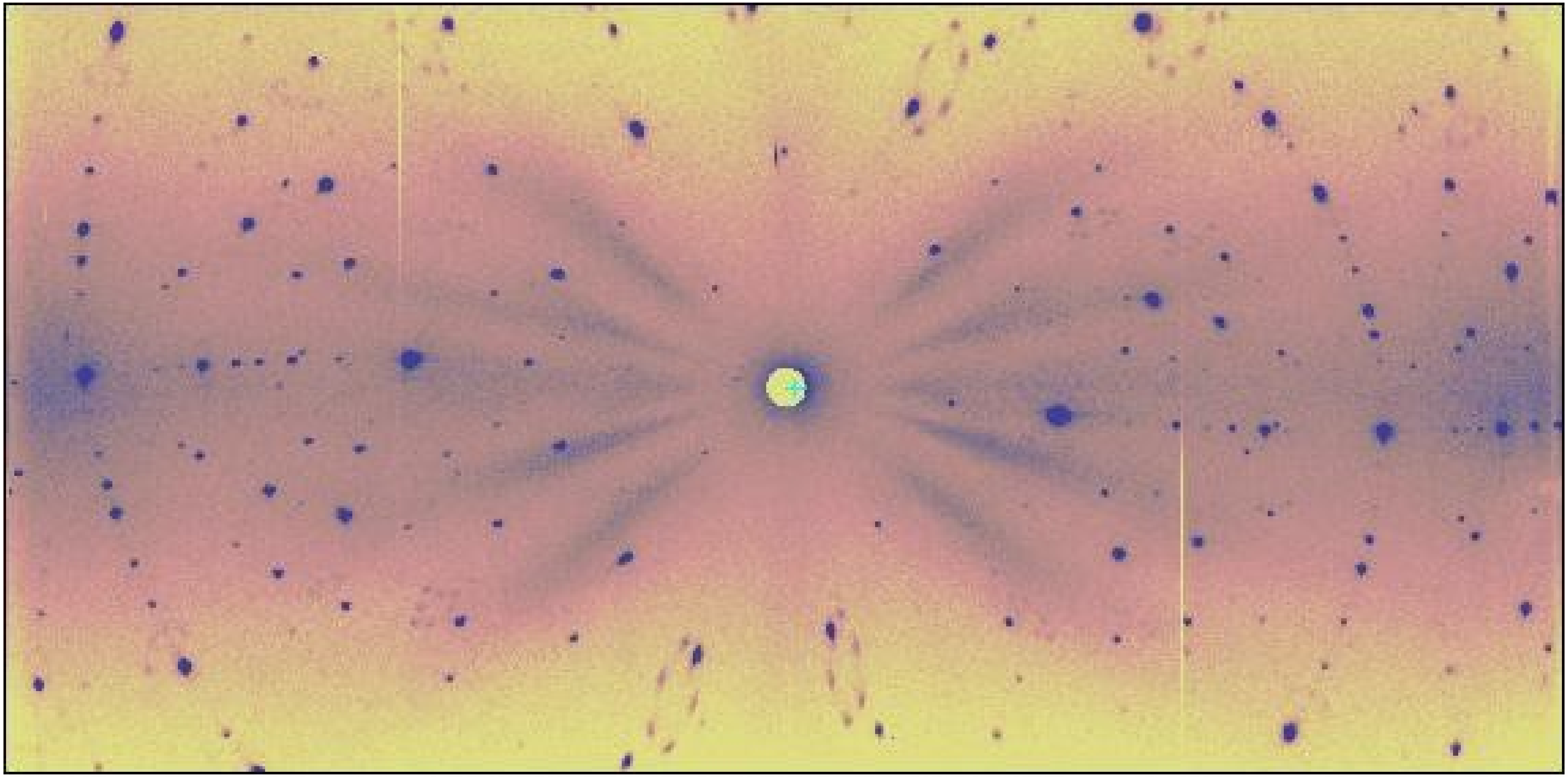


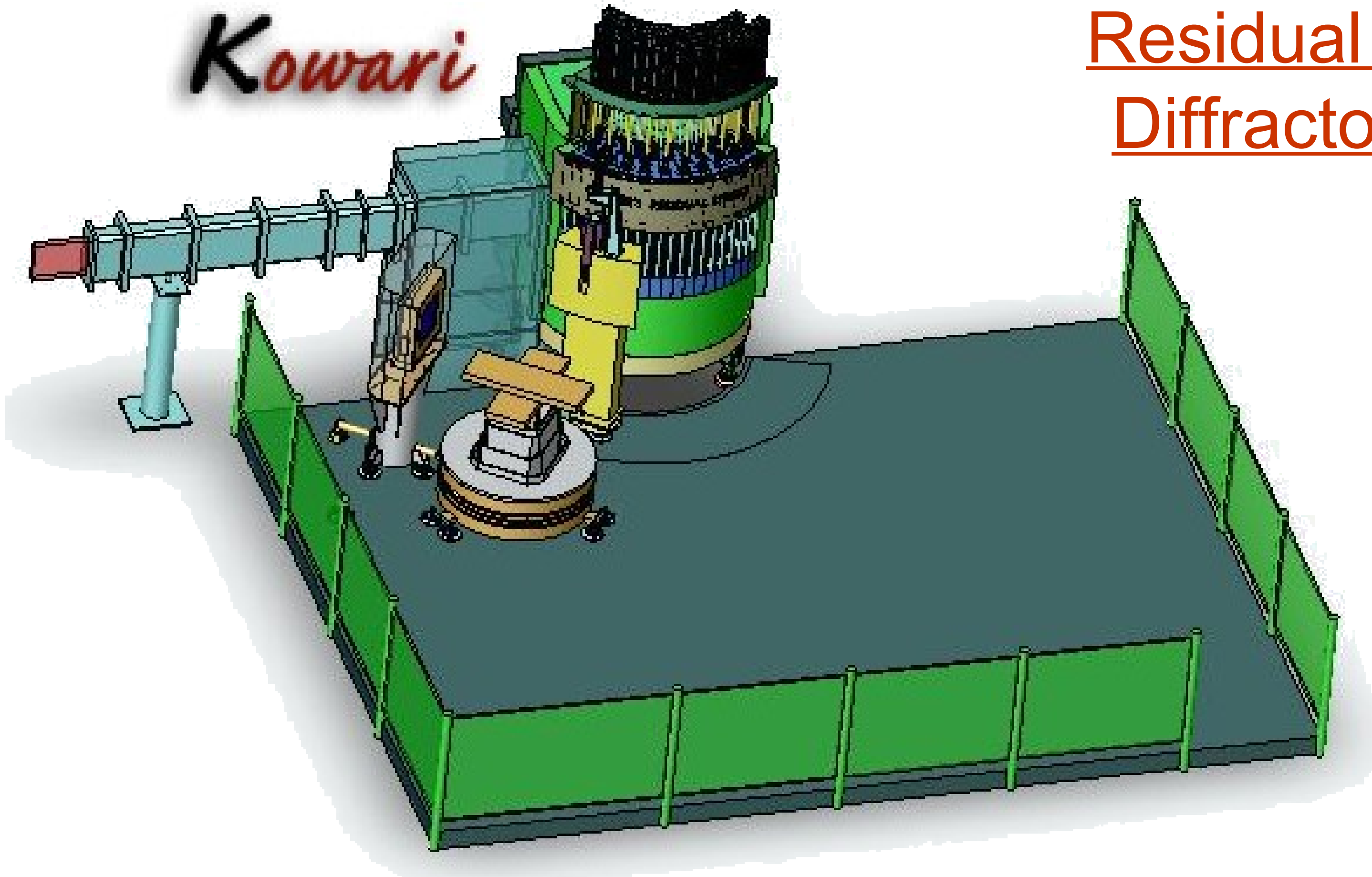
APPLICATIONS

- single-crystal structure
- typical data collection times < day
- crystal size > 0.1 mm^3

Quasi-Laue Diffraction Pattern of Incommensurate $La_2Co_{1.7}$

(Garry McIntyre, ILL)





Residual Stress Diffractometer

Dr Oliver Kirstein

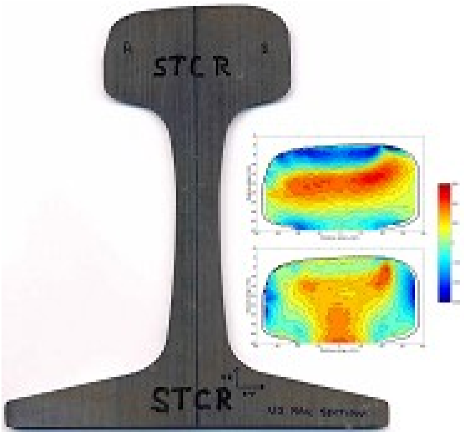
APPLICATIONS

Internal and residual stresses:
effect on material properties including
fatigue resistance, creep resistance, fracture toughness and strength.

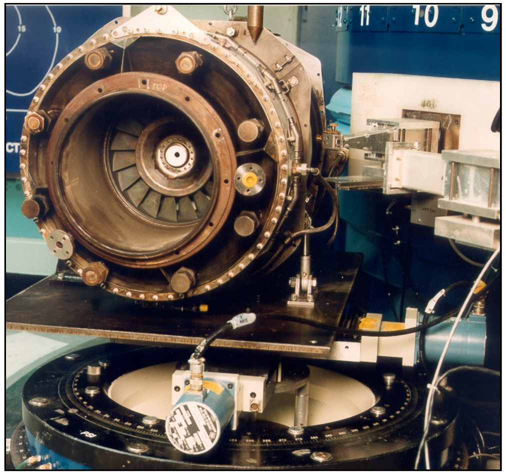
Residual Stress Diffraction

NTD of cracks and stresses in engineering components

Pipeline Welds



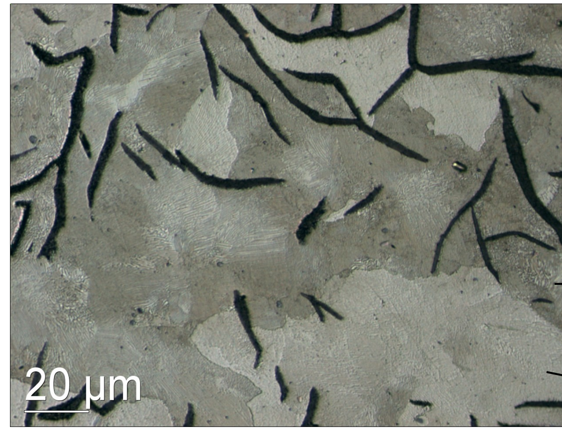
Rolling Stock



Turbine Blades

Residual Stresses in Cast Iron Disc Brake Rotors

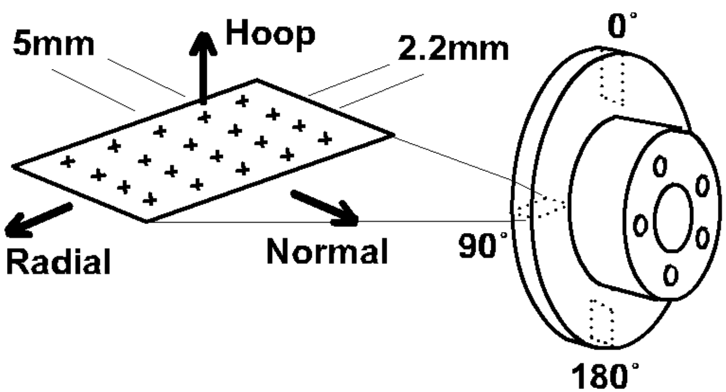
O. Kirstein (Bragg)



Flake graphite

cementite (Fe_3C)

Ferrite (α-Fe)



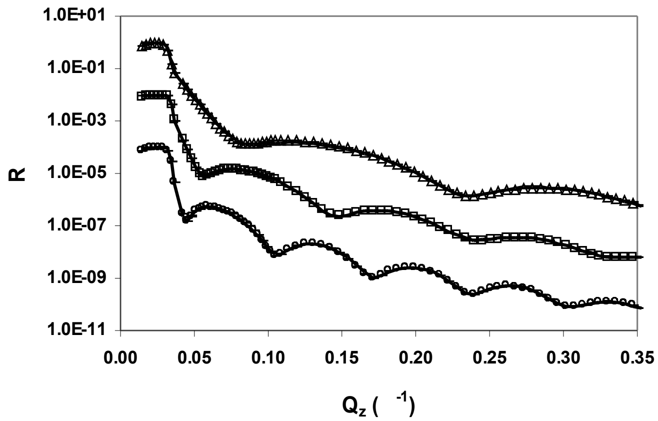
Average stress gradient ~313 MPa

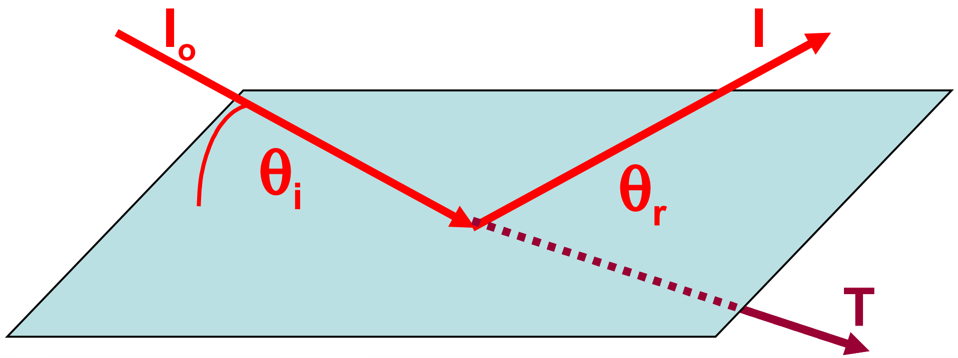
Thermally induced stresses that build-up during braking act to bend rotor away from the hub

Strains lead to distortion, brake run-out, and judder

Neutron Reflectometry

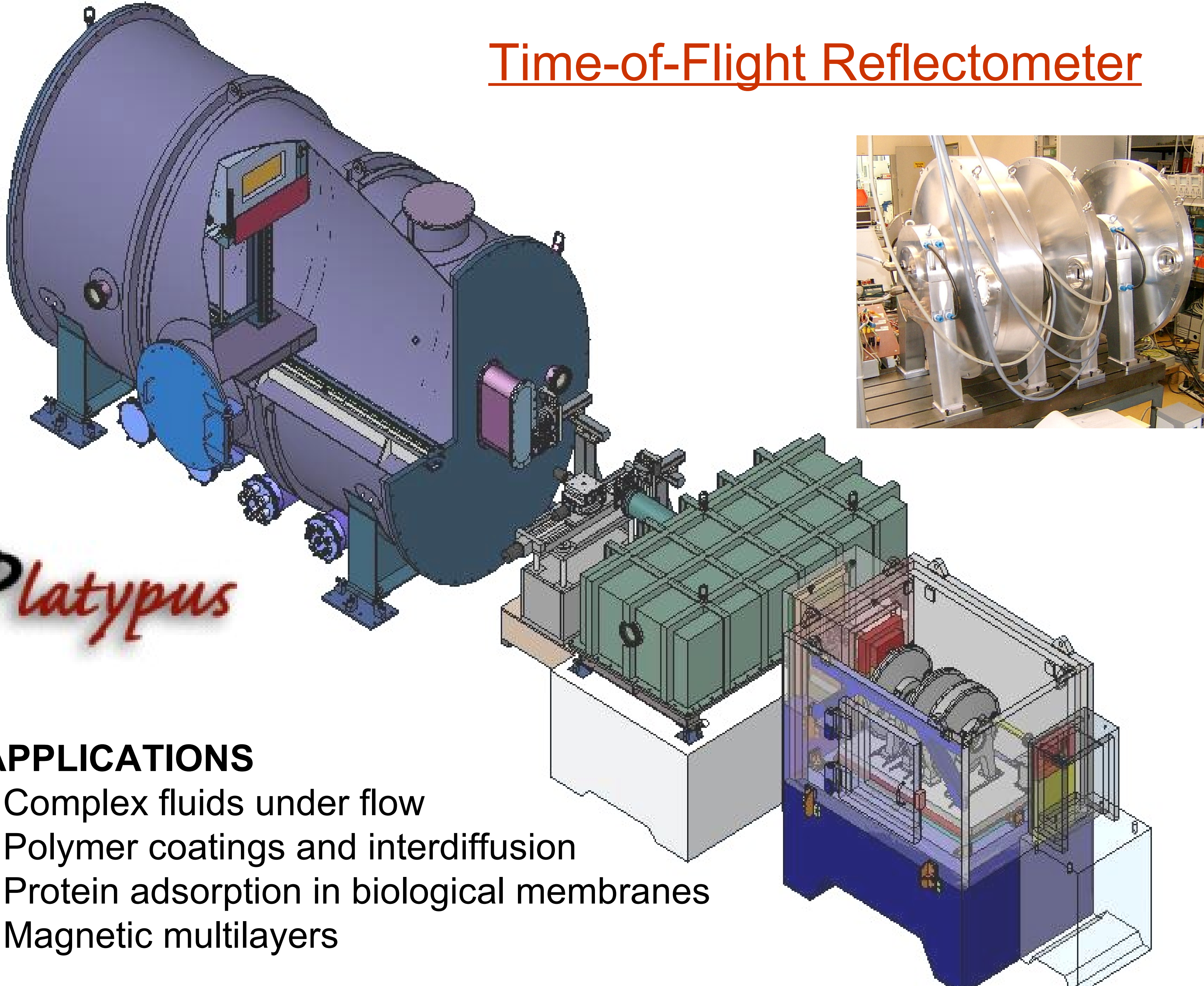
- Film thickness (1 nm - 100 nm)
- Film composition (normal to surface)
- Surface roughness





$$\text{Reflectivity} = R = \frac{I}{I_o}$$

Time-of-Flight Reflectometer

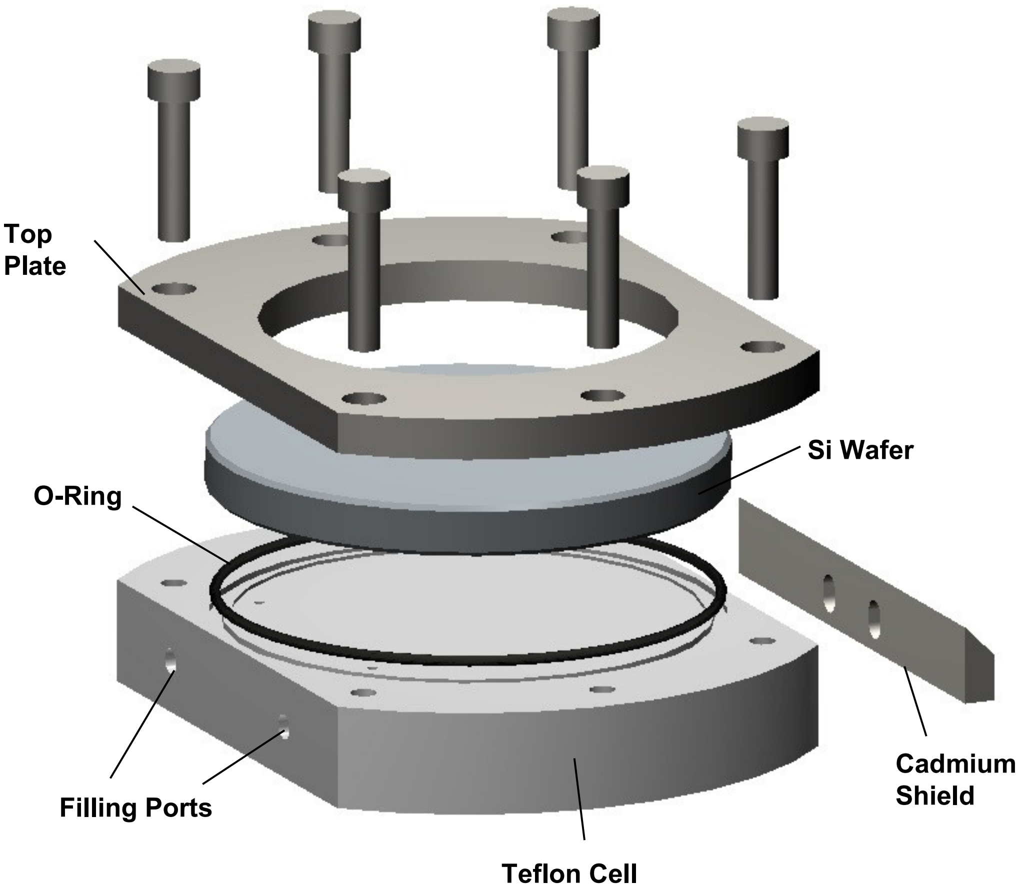


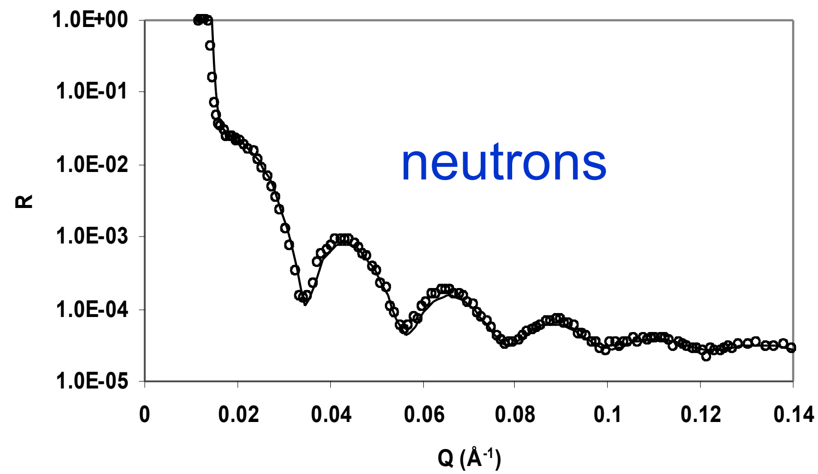
Platypus

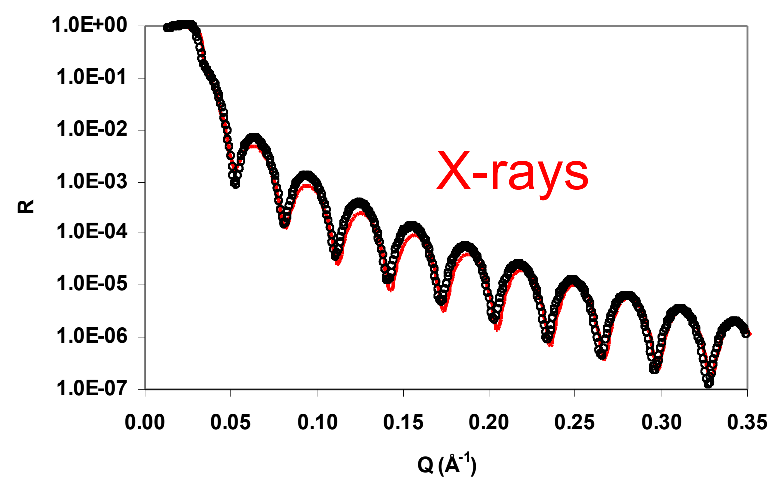
APPLICATIONS
- Complex fluids under flow
- Polymer coatings and interdiffusion
- Protein adsorption in biological membranes
- Magnetic multilayers

Plasma Polymer / Solution Interactions

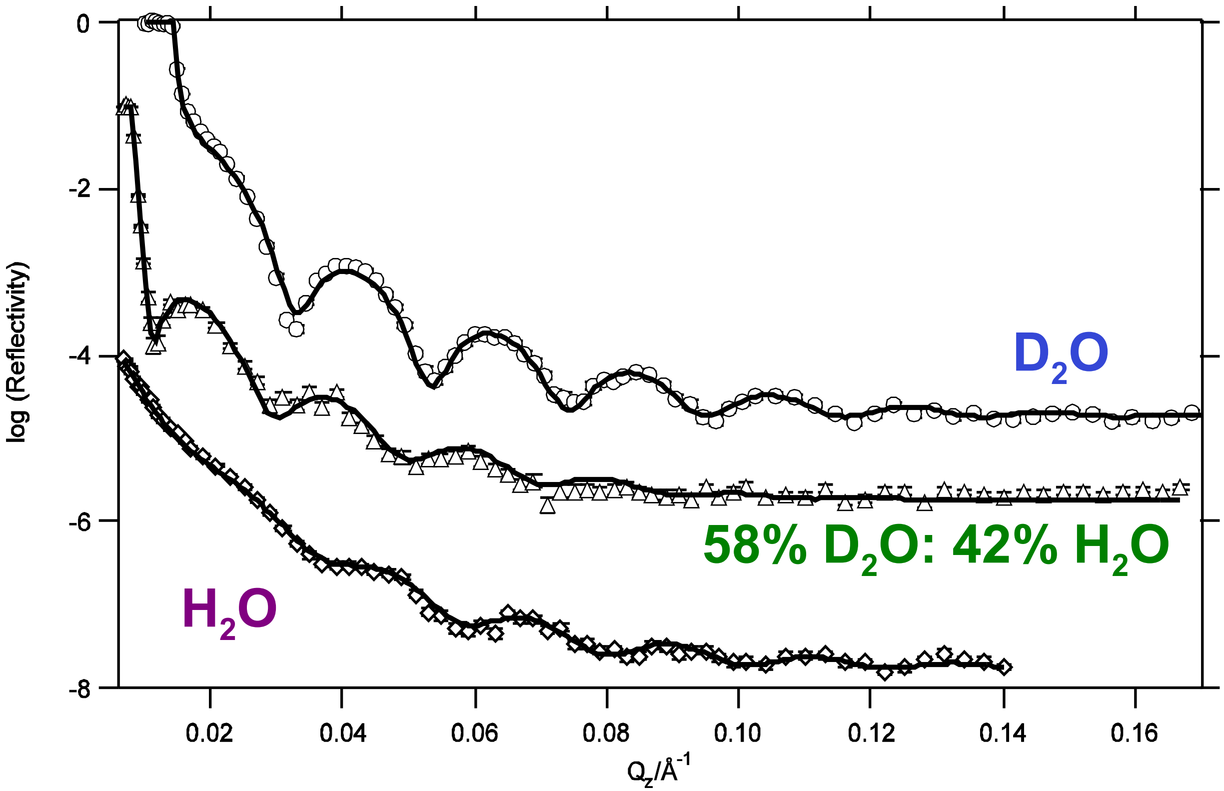
A. Nelson. (ANSTO). P. Hartl







"Wet" Allylamine Plasma Polymers



3% Water Penetration

Film swells to 293 Å

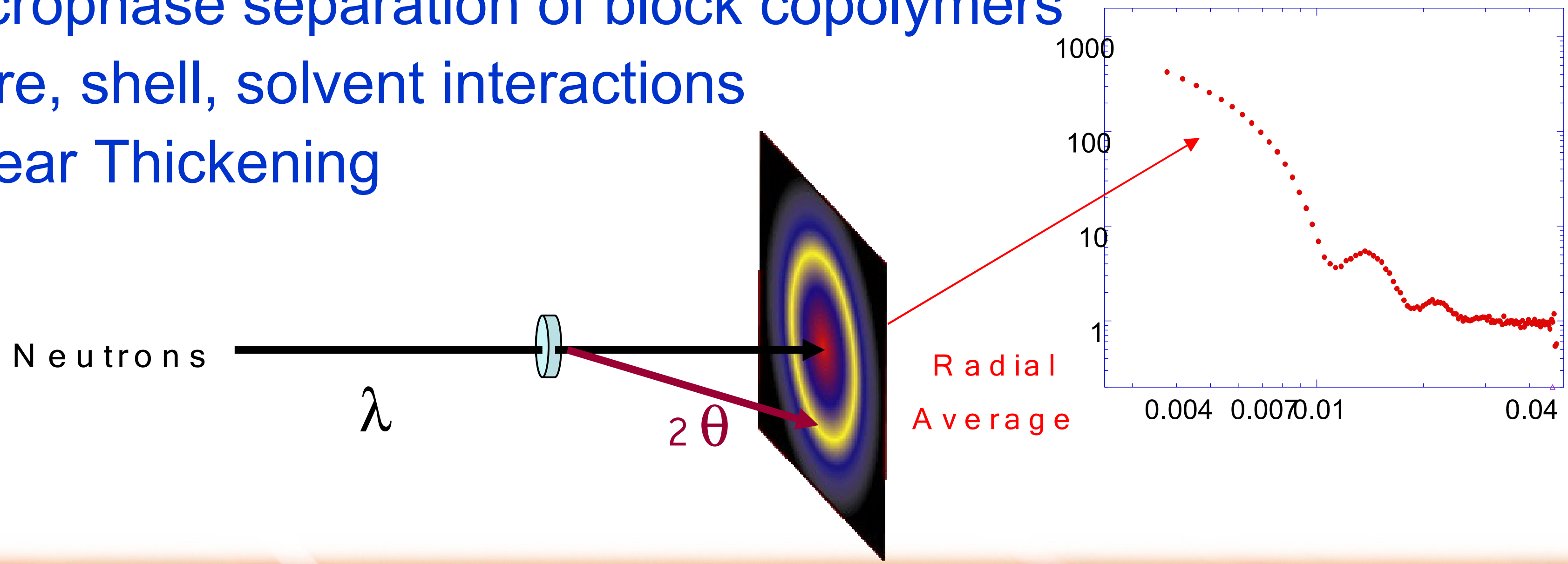
Labile Protons

$C_{162}O_{27}N_{11}H_{156}D_{49}$

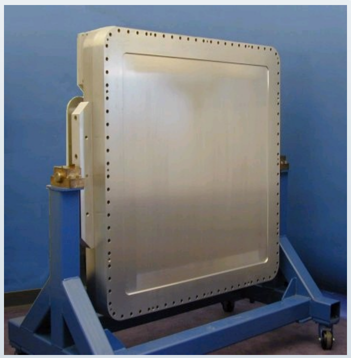
A. Nelson, *et al.*, *Langmuir*, (2005).

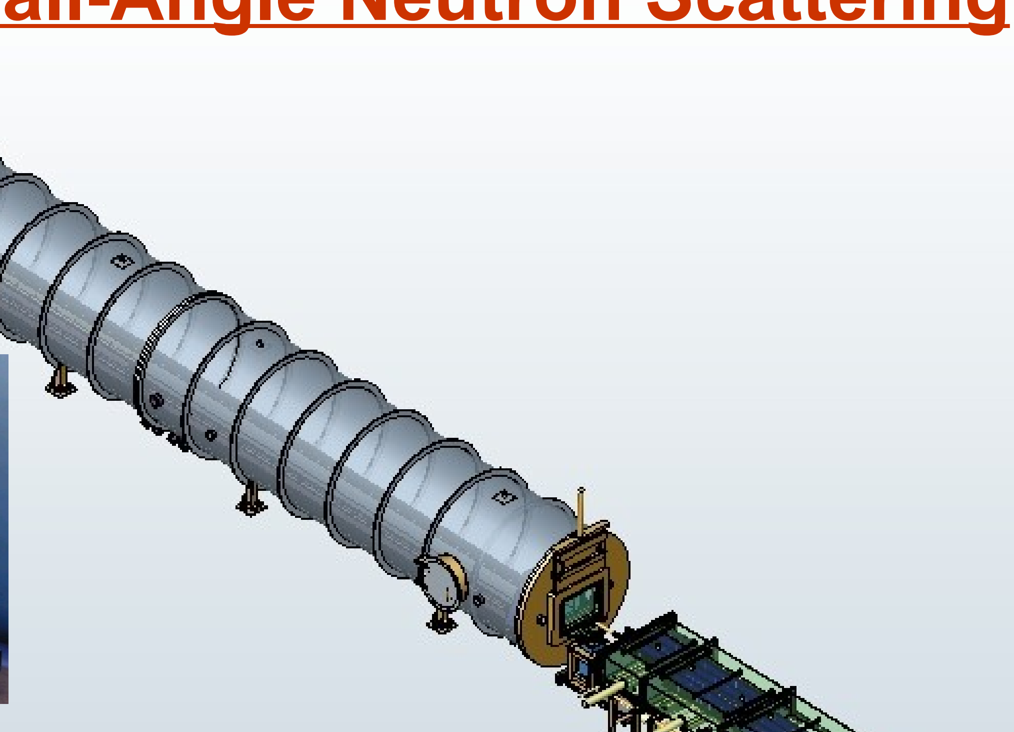
Small Angle Neutron Scattering

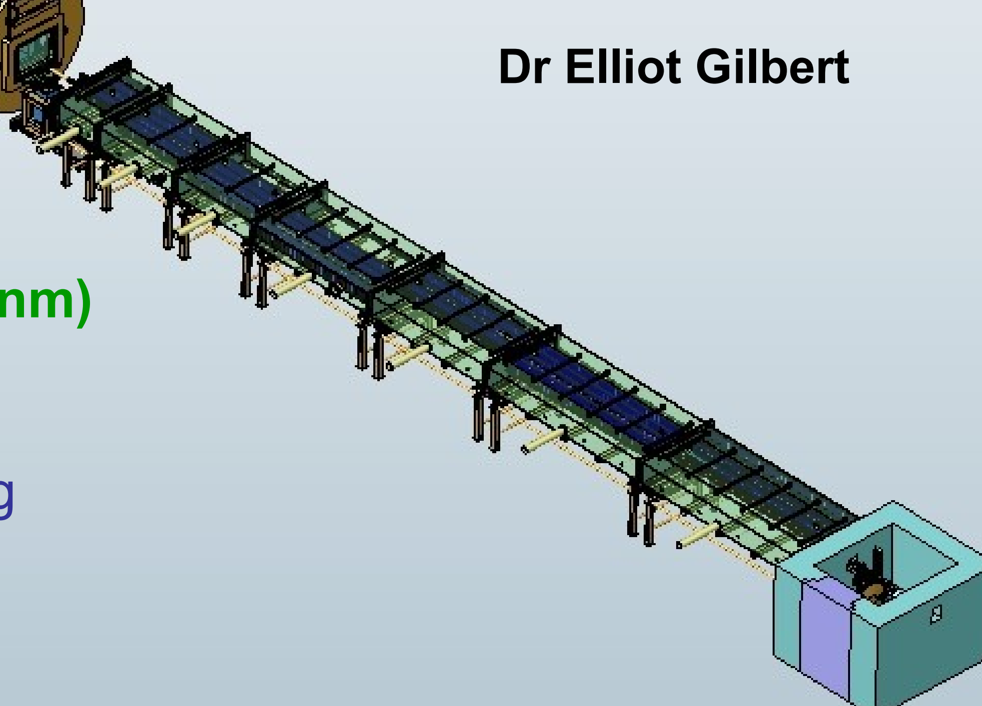
- Inhomogeneities in a medium
- Particles in liquids (micelles, colloids)
- Large-scale structure (particle ordering and alignment)
- Porosity
- Polymer chain conformations (R_g)
- Microphase separation of block copolymers
- Core, shell, solvent interactions
- Shear Thickening



Small-Angle Neutron Scattering







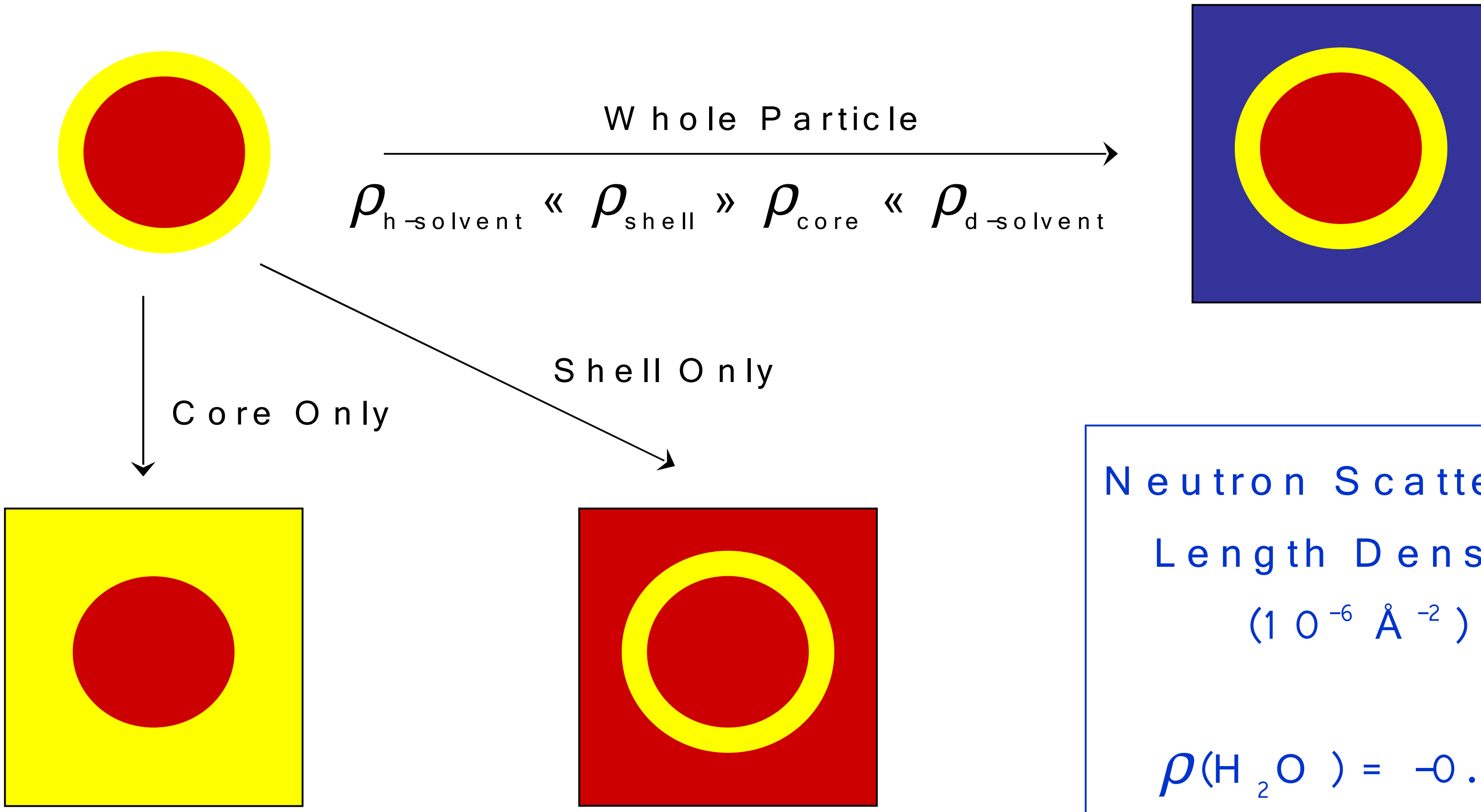
Dr Elliot Gilbert

APPLICATIONS

Large scale structures (1 - 100 nm)

Colloids/emulsions/micelles
Nanomagnetic materials
Polymers and polymer processing
Biomineralisation & biomimetics
Biomembrane physics
Zeolites & mesoporous materials

SANS Contrast Variation



Neutron Scattering Length Density (10^{-6} Å^{-2})

$\rho(H_2O) = -0.56$

$\rho(D_2O) = 6.36$

Isotopic labelling through synthesis is expensive

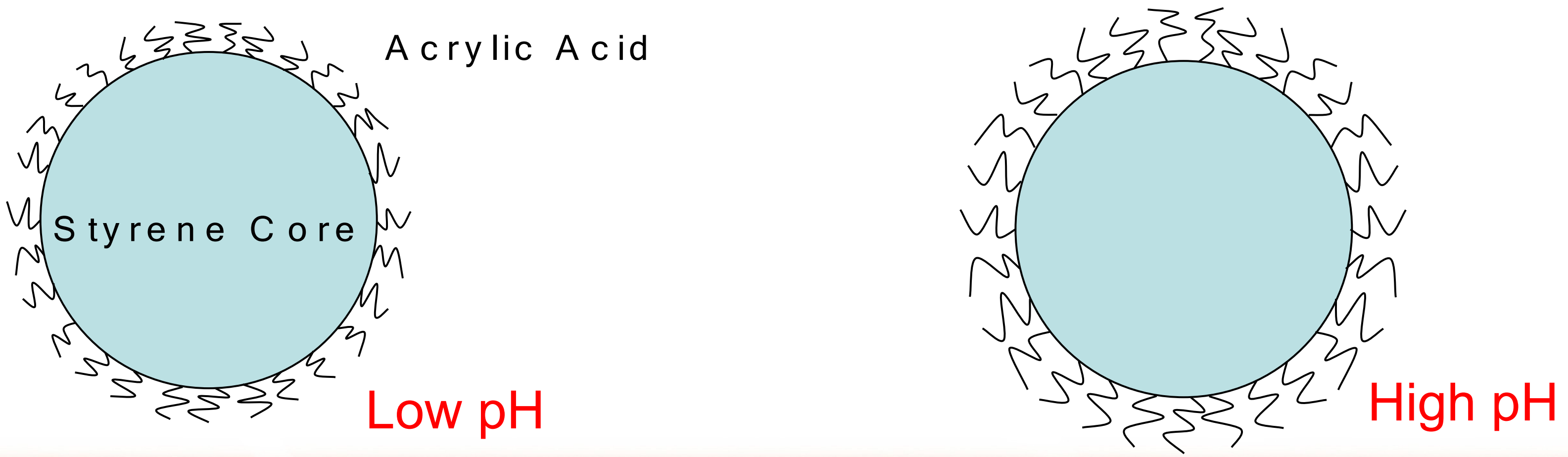
Hairy Latex Particles
(Jamie Schulz (Bragg Inst.))

Electrosterically stabilised latices

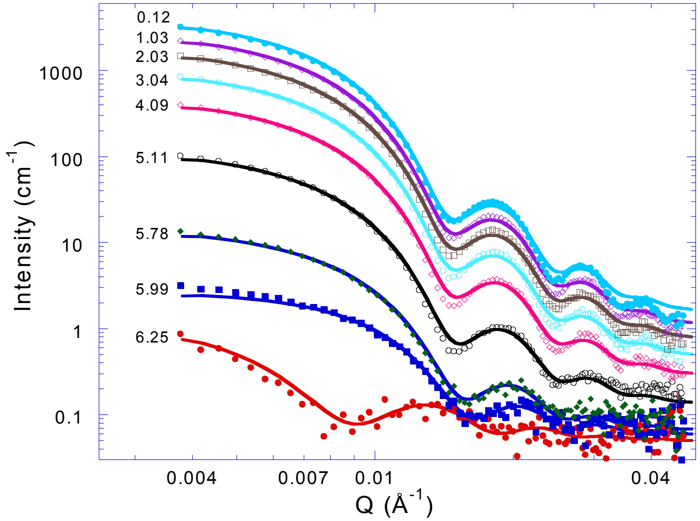
Styrene/acrylic acid copolymerisation

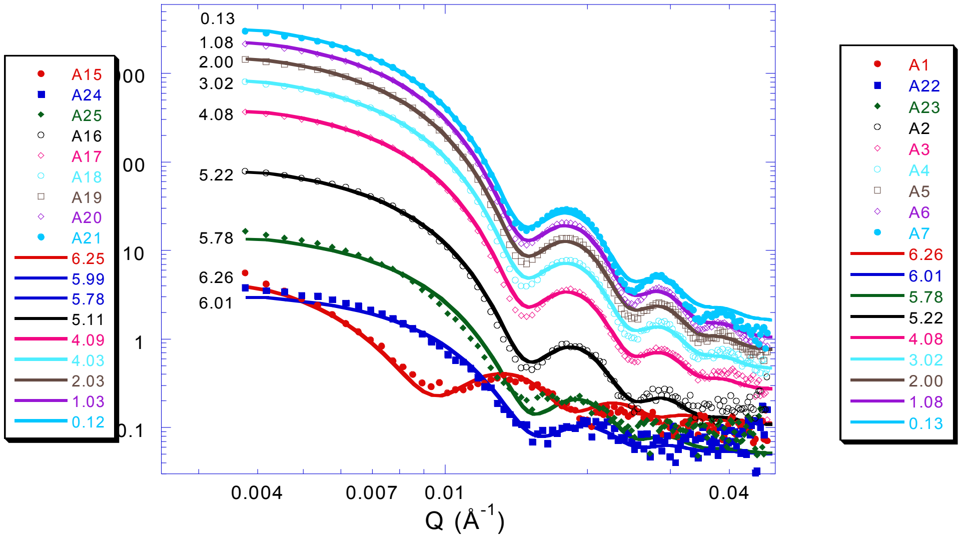
Produces a styrene core and an acrylic acid shell

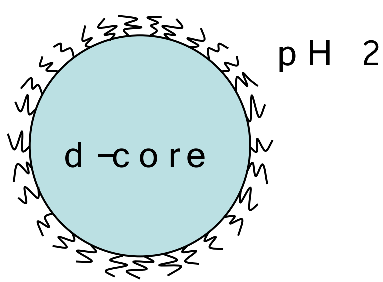
What effect does pH have upon the shell hydration and thickness?

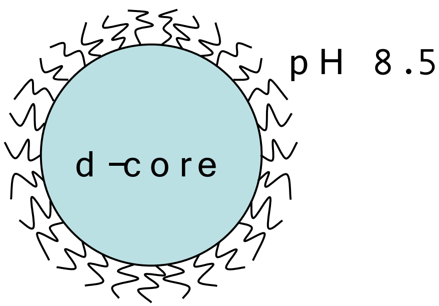


SANS Data Modelling









Shell: 3.5 nm

Shell: 5.0 nm

Core (radius: 31.8nm) contains 2% acrylic acid

Inelastic Neutron Scattering

Where the energy and momentum of the neutron changes as a result of the scattering process.

Three Axis Spectrometers; Disc Chopper Spectrometers; Spin Echo Spectrometers; Backscattering Spectrometers...

Applications

Low energy vibrational excitations

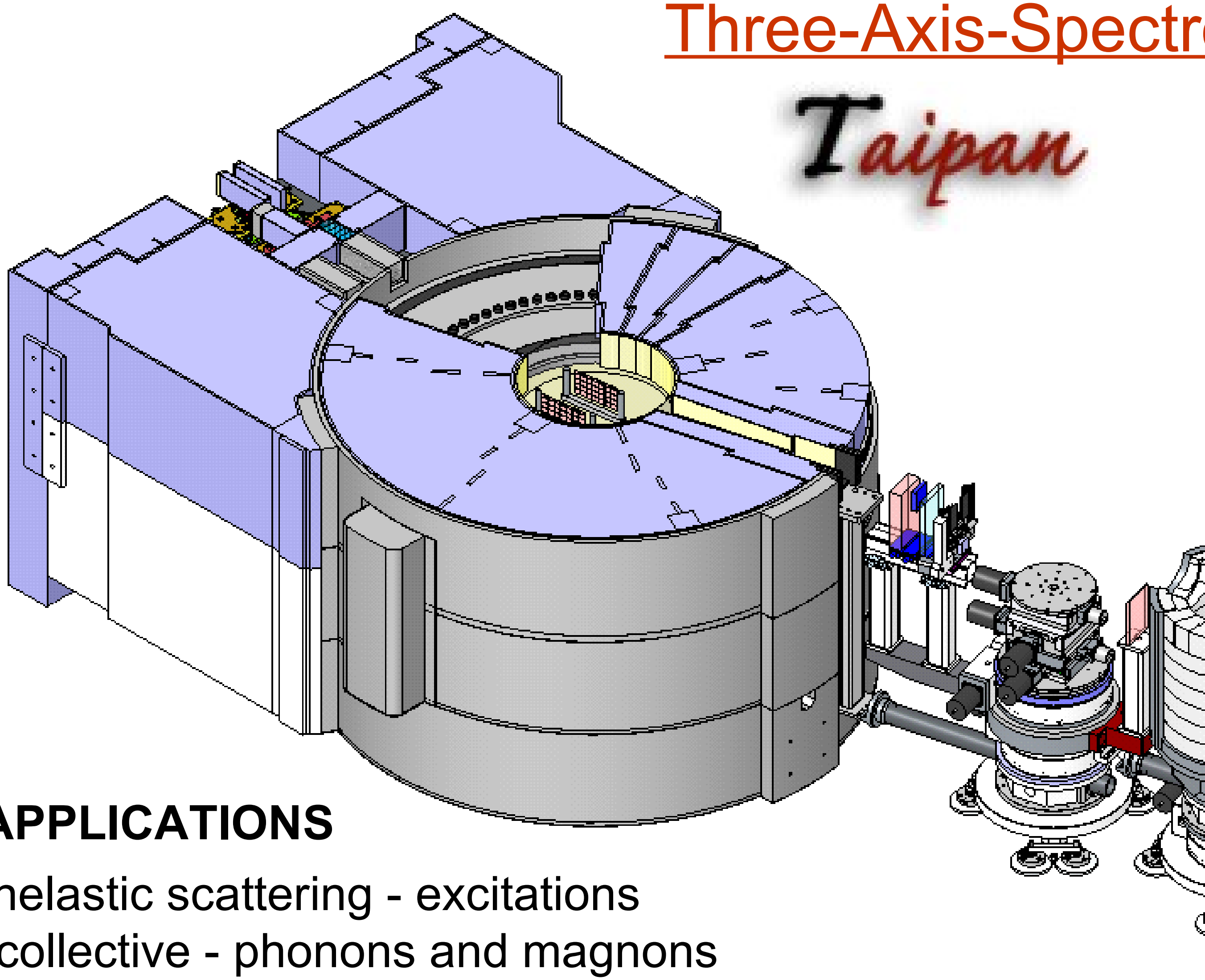
Densities of states

Tunnelling phenomena

molecular and porous systems, layered materials, catalysts, glasses, polymers, metal-hydrogen systems, and biological and magnetic systems

Three-Axis-Spectrometer

Taipan



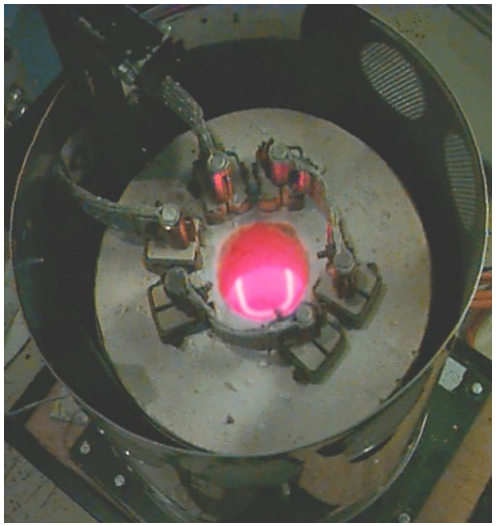
Dr Sergey Danilkin

APPLICATIONS

Inelastic scattering - excitations

- collective - phonons and magnons
- diffusive - spin fluctuations
- localised - crystal-field levels

In situ neutron scattering experiments (temperature, pressure, magnetic/electric field, gas environment …)

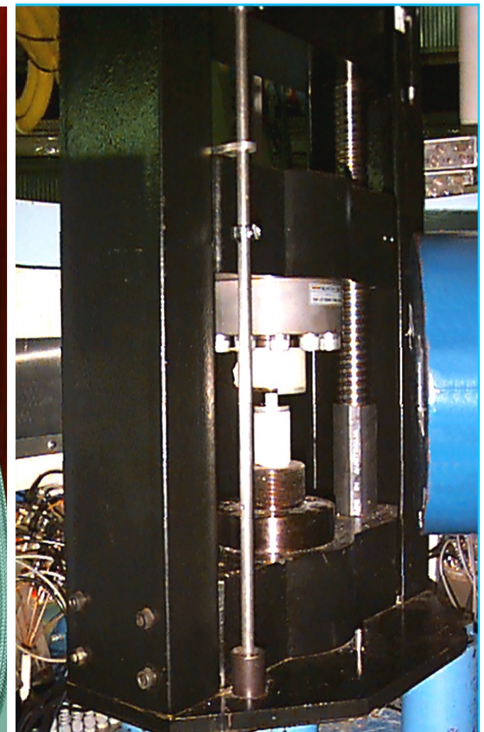


Ceramic tube furnace

T ≤ 1650 °C

Cryogen-free cryofurnace

4 K ≤ T ≤ 527 °C



20 tonne load frame

P ± 2 GPa for typical NPD samples, with split furnace for T ≤ 950 °C

Cryogen-free cryomagnet

H ≤ 8 Tesla

X-ray Scattering @ OPAL

SAXS

Dr Tracey Hanley

Reflectometer