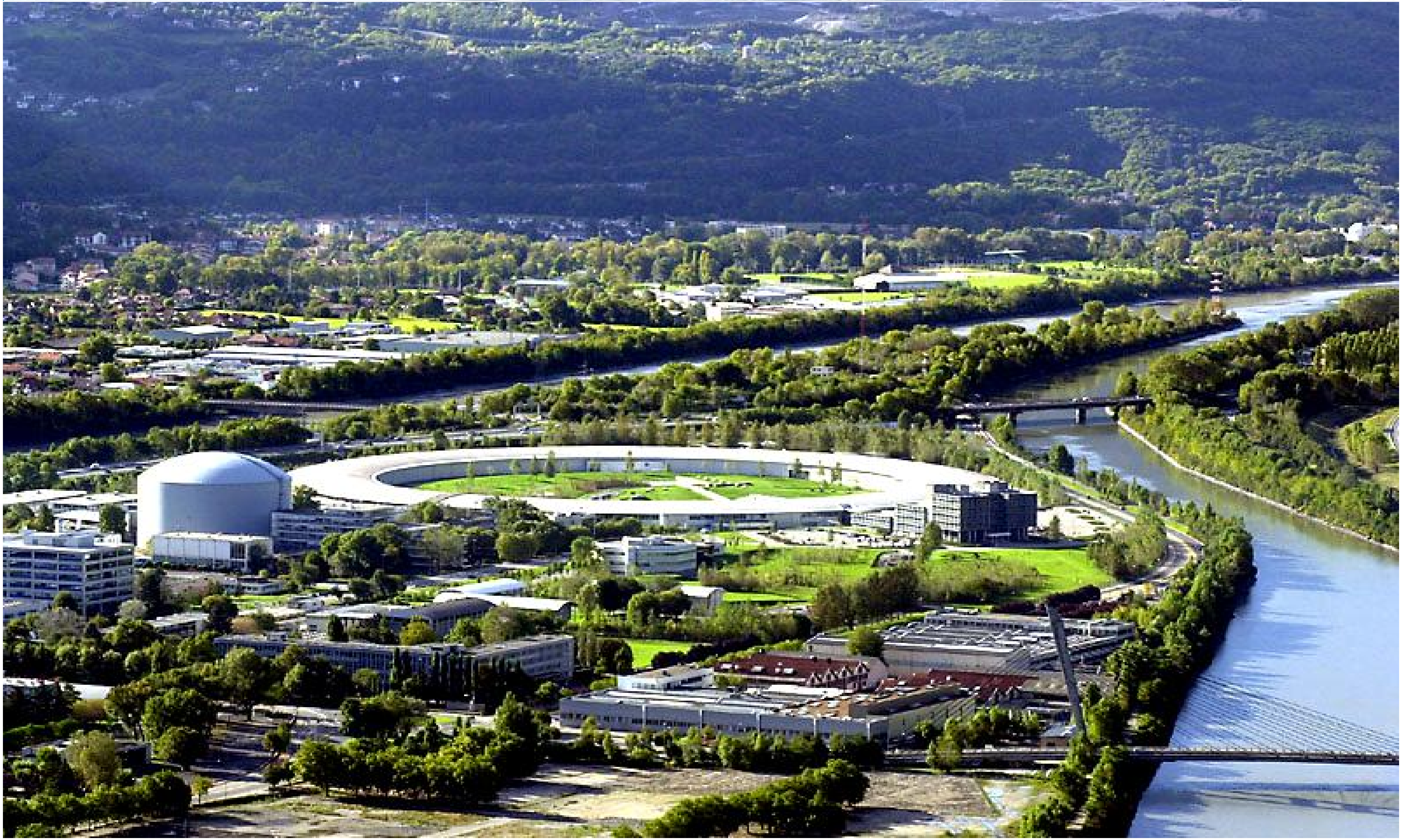
The ILL Millennium Programme - a Bridge to ESS

CENSC, Budapest 7-11 April 2003

Alan Hewat, ILL Grenoble, FRANCE

European Neutron & Synchrotron Sources
ILL & ESRF Grenoble



European Neutron & Synchrotron Sources
ILL & ESRF Grenoble

- World's most intense neutron source
- 1280 visiting scientists each year
- 300+ scientific papers each year
- physics, chemistry, biology, materials

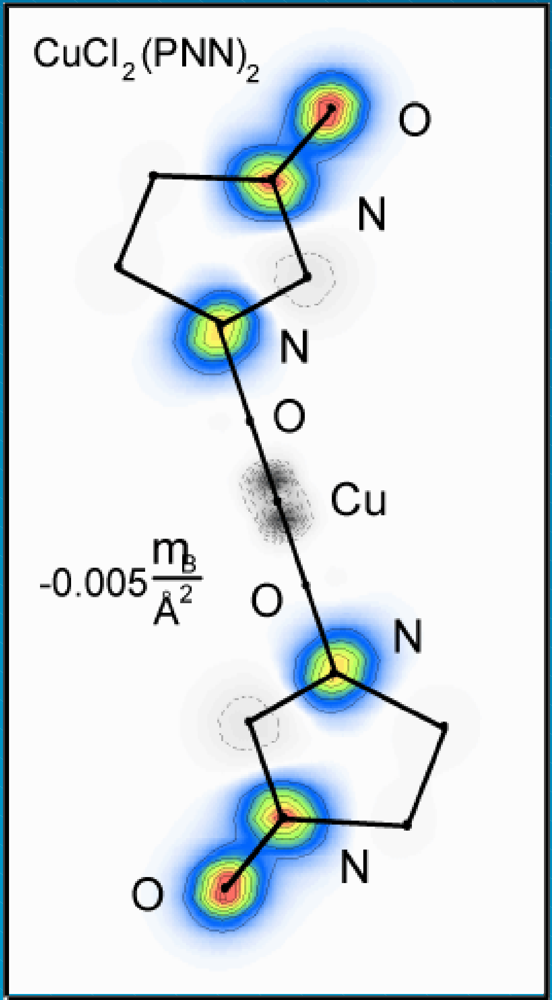
ILL member countries are shown in green

- New 10 year ILL extension contract just signed
- Millennium Programme -> ILL machines by x10 to x20
- New detector and neutron optic technology
- ILL seeking participation of more European countries

New Diffraction Instruments:

- D3c – He3 neutron spin filters and magnetic polarimetry
- Strain Scanner – mapping strain in engineering components
- VIVALDI – Laue Diffractometer with Neutron Image Plate
- D19 – a very large 2D PSD for protein/fibre diffraction
- D2B – high resolution powder diffractometer with linear PSDs
- DRACULA – Diffractometer for RApid Acquisition over Ultra Large Areas

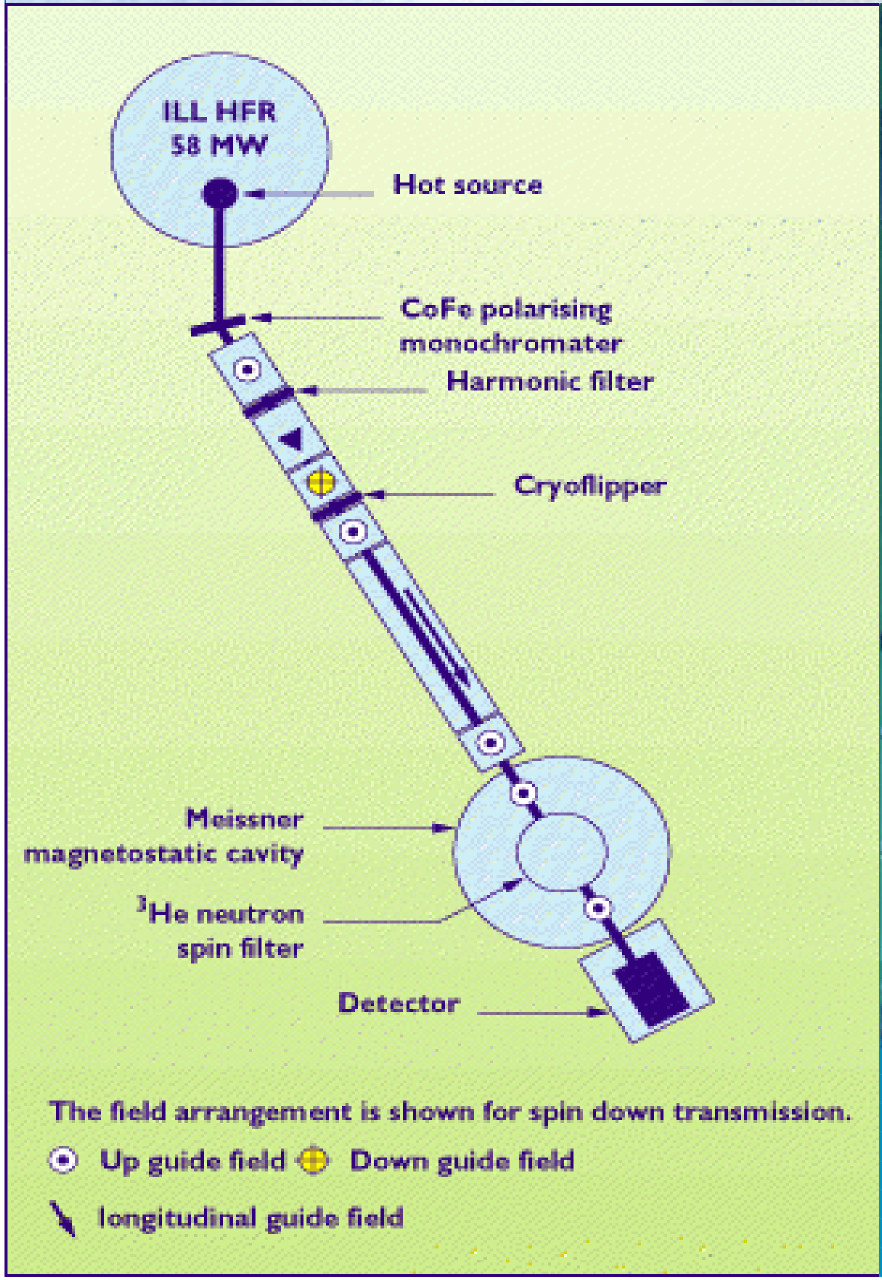
Molecular magnets

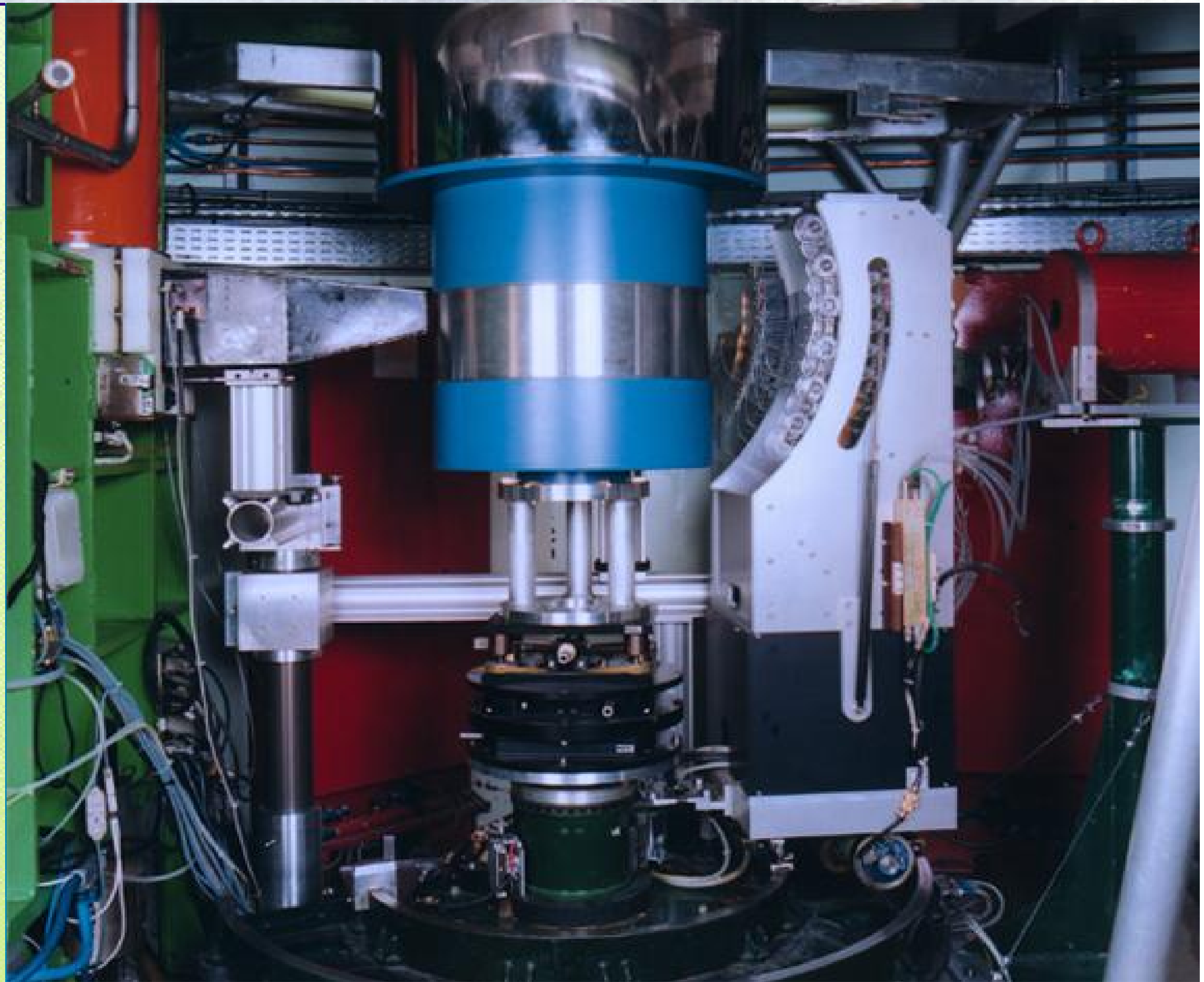


- Molecular magnets can be light, transparent, magneto-optic, bio-compatible etc…
- Neutrons are unique for mapping the magnetisation density on an atomic scale
- The first organic ferromagnet (left) - the magnetic density is on nitrogen & oxygen

E. LeLievre-Berna, E. Ressouche, J. Schweizer (ILL & CENG)

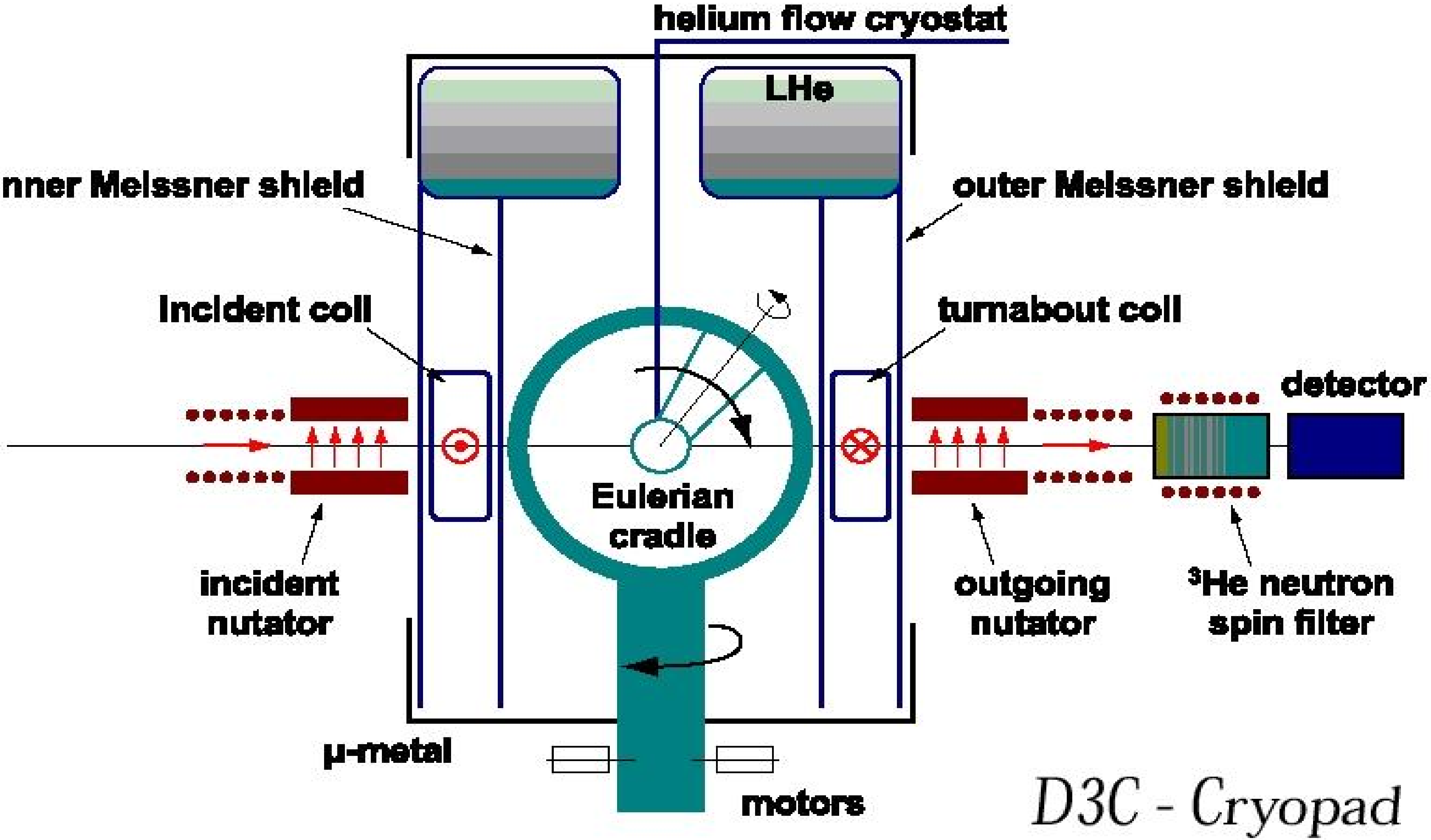
D3 – Polarised Neutron Diffractometer



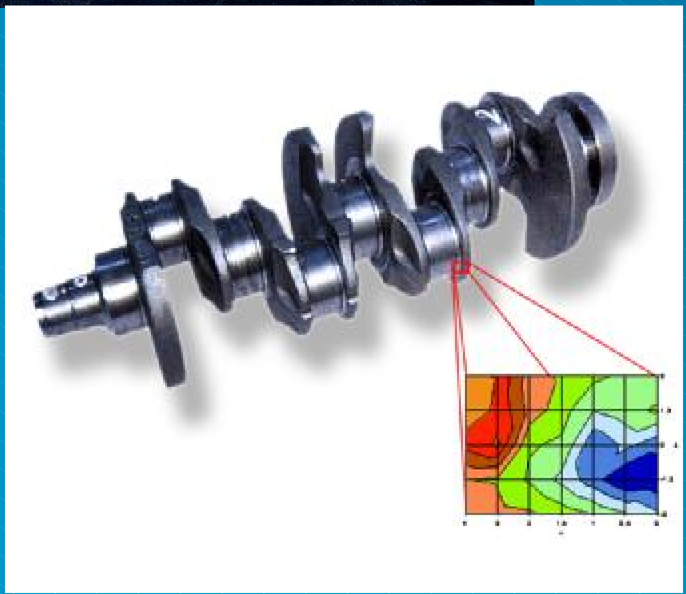


- Complex magnetic structures
- Magnetisation density

D3c – He3 neutron spin filters & magnetic polarimetry



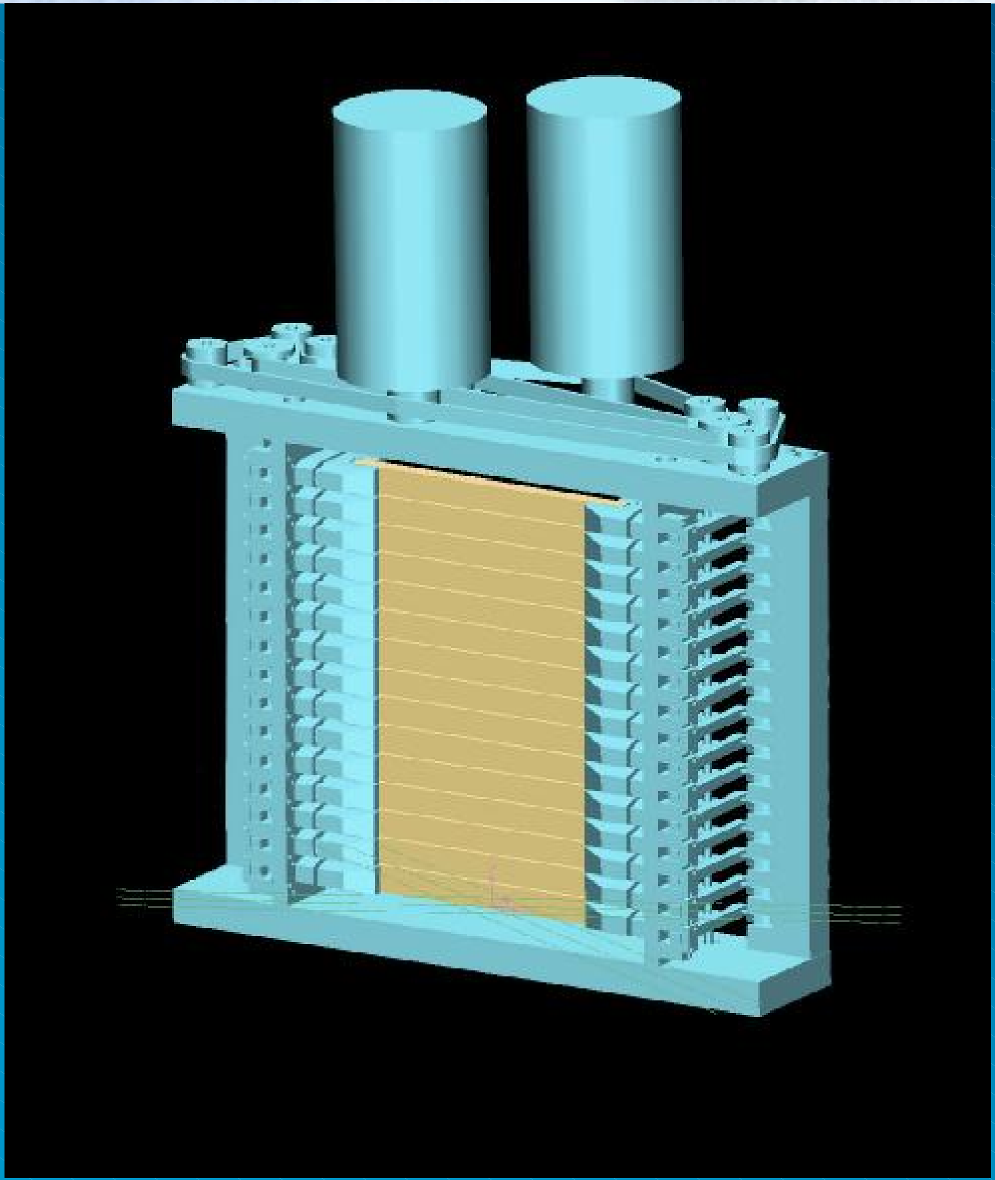
SALSA- Strain Analysis of engineering components



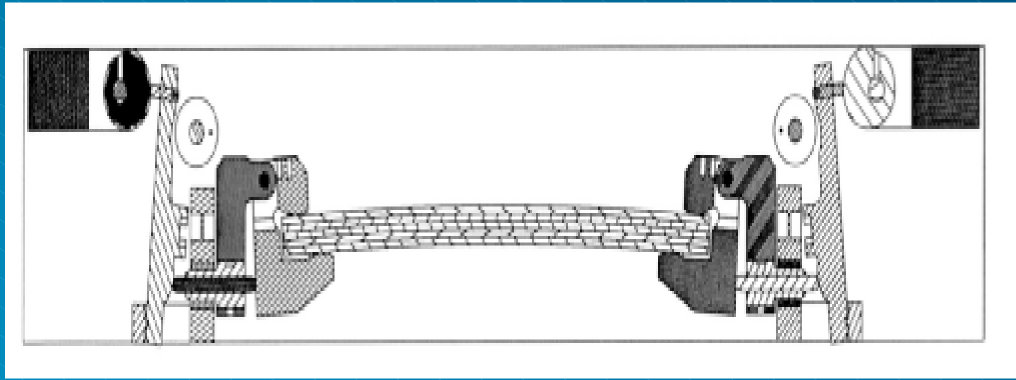
- Tensile stress can produce cracks
- Compressive stress toughens materials
- Neutrons can penetrate deep inside materials (~10cm) and measure stress by changes in atom spacings
- The compressive stress (blue) deep inside a VW crankshaft
- Design of stronger, lighter engines

T. Pirling, G. Bruno (ILL & Manchester)

SALSA- Strain Analysis of engineering components



- Elastically-bent Si-monochromator
- Bending radius: 5 - 10 m
- Take off angle 55-125°
- Wavelength 1.3-4.5 Å
- $\Delta 2\Theta$ ~ 0.1°-0.5° ($\Delta d/d$ ~ 2×10^{-3})



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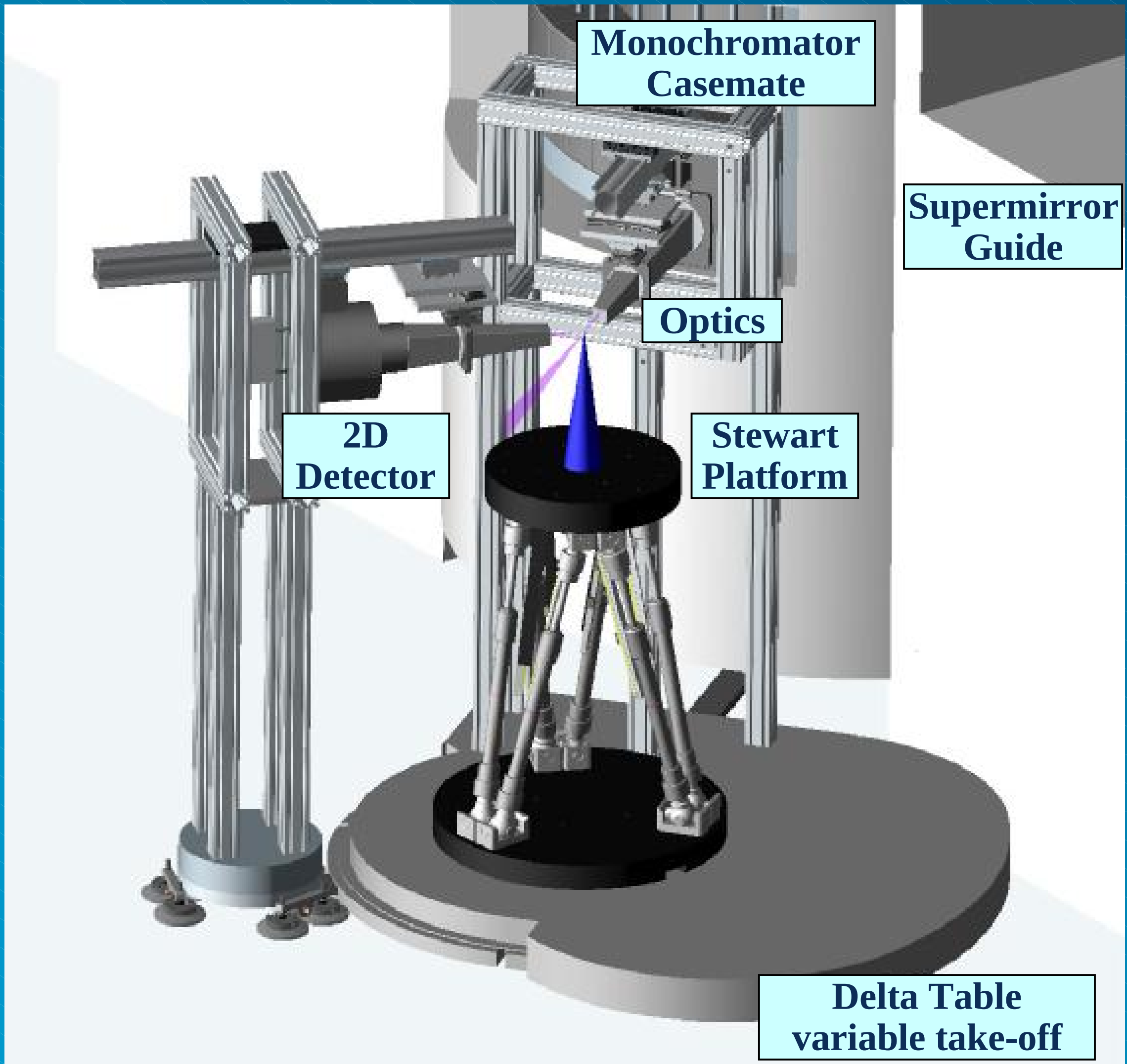
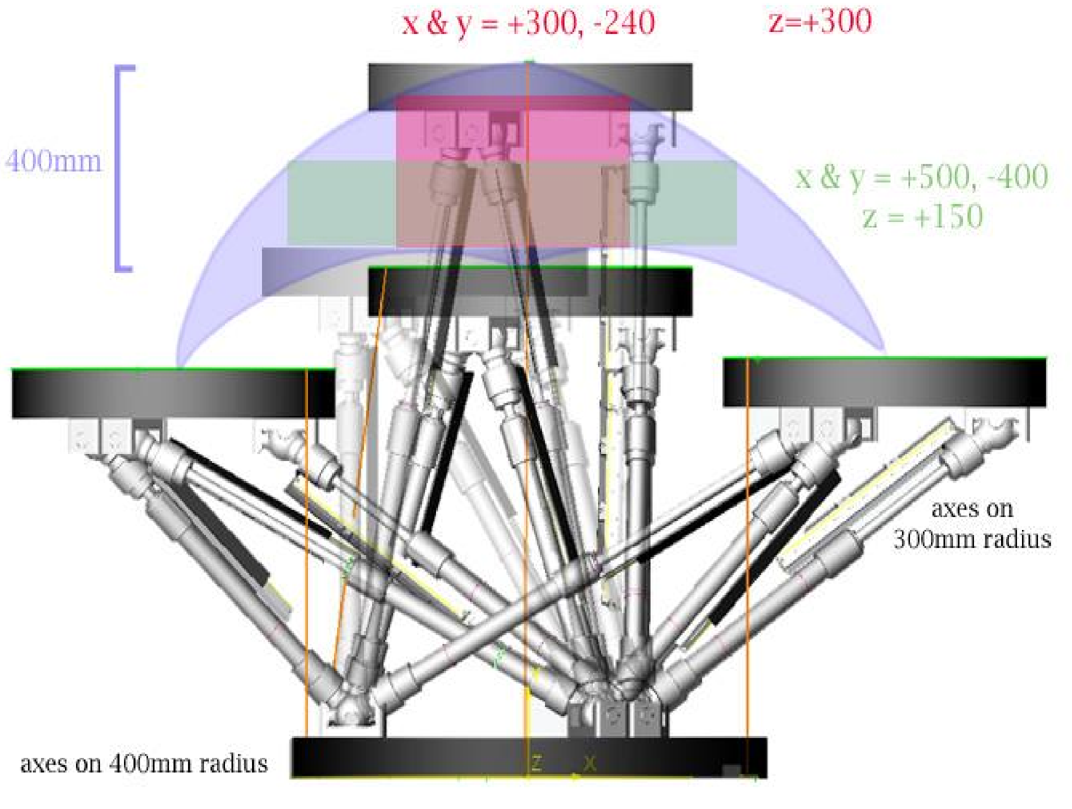
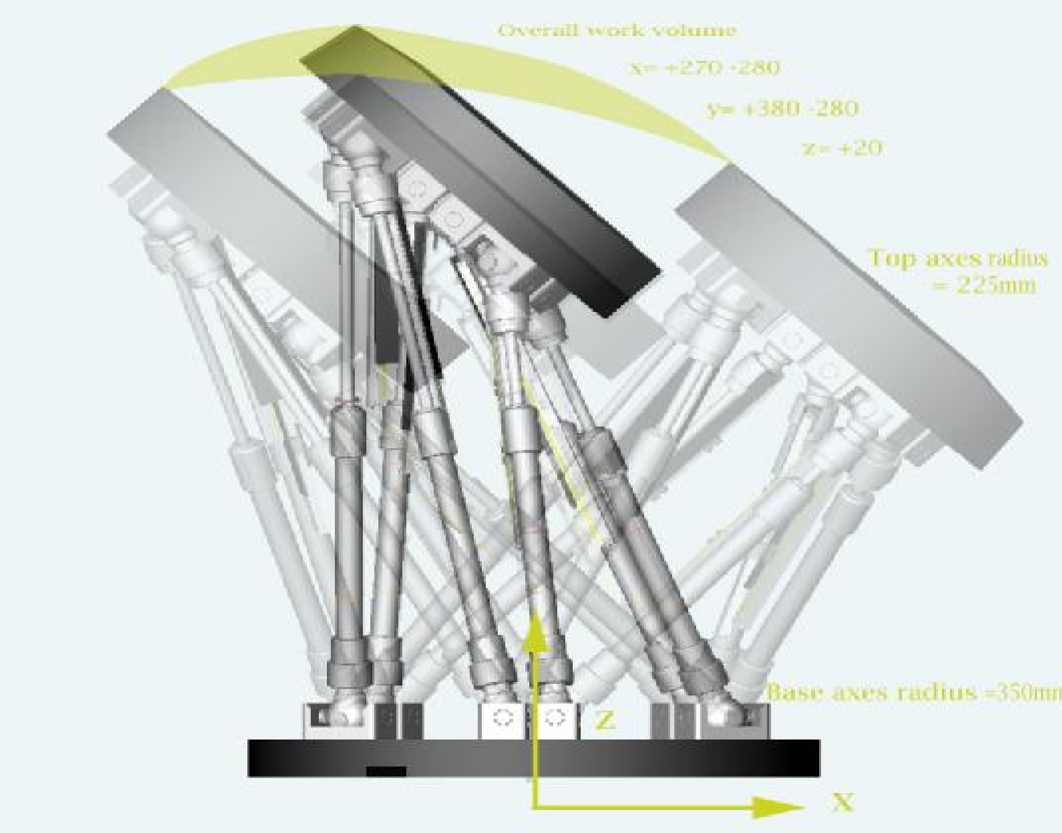


- 1 Mio EPSRC grant to build a new high flux strain scanner "SALSA"
- 1.6 Mio EPSRC grant to set up an engineering support lab "Fame38"

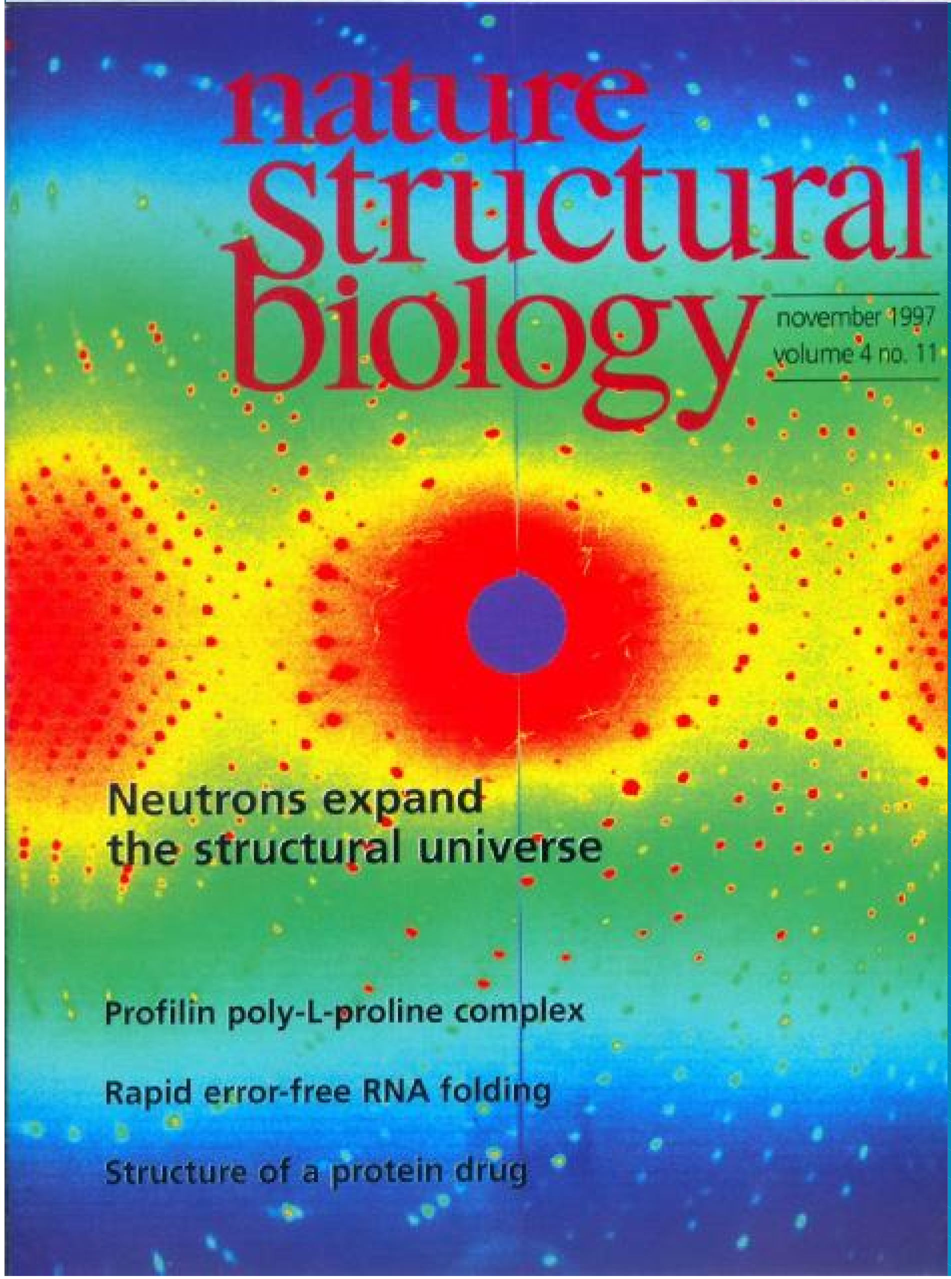
SALSA- Strain Analysis of engineering components





- "Hexapod Platform" - Large x,y,z displacements of heavy components
  - Large angular range of rotations

Neutron Image Plates & Microstrip Detectors



Nature (1997) Cover showing LADI data

(LAue Diffractometer with Image plates)

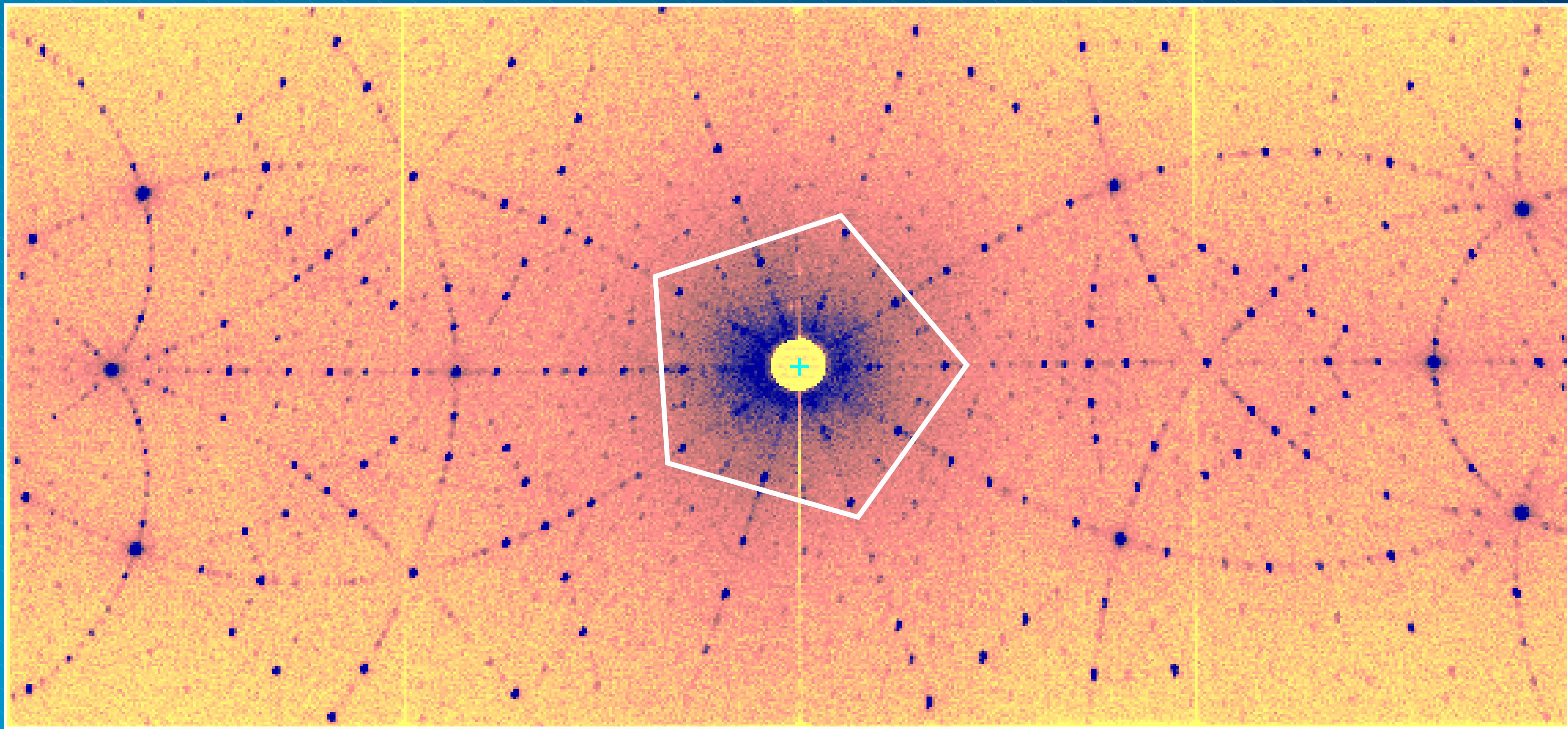
LADI Neutron Image Plate LAue Diffractometer

- Neutron guide
- Band of neutron energies
- View reciprocal space
- In-situ laser readout
- Unique survey of P/T
- Phase T/Ns, superstruct.

Dean Myles with LADI and cryo-refrigerator on thermal guide H22

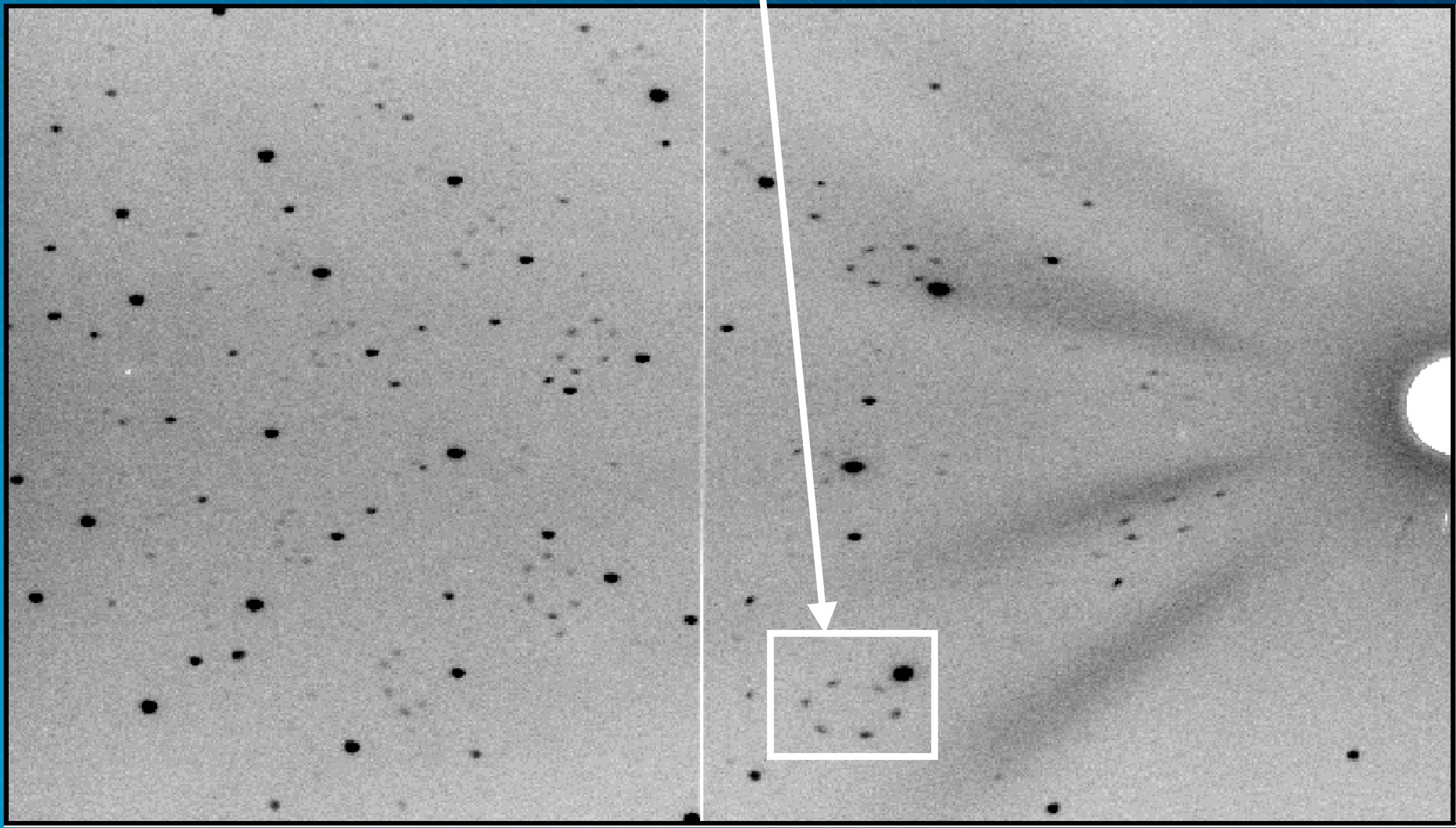
VIVALDI Neutron Image Plate
5-fold symmetry of quasi-crystal

5-fold symmetry axis in ZnMgY quasi-crystal - De Boissieu et al.



T-LADI neutron image plate photo courtesy of G. McIntyre

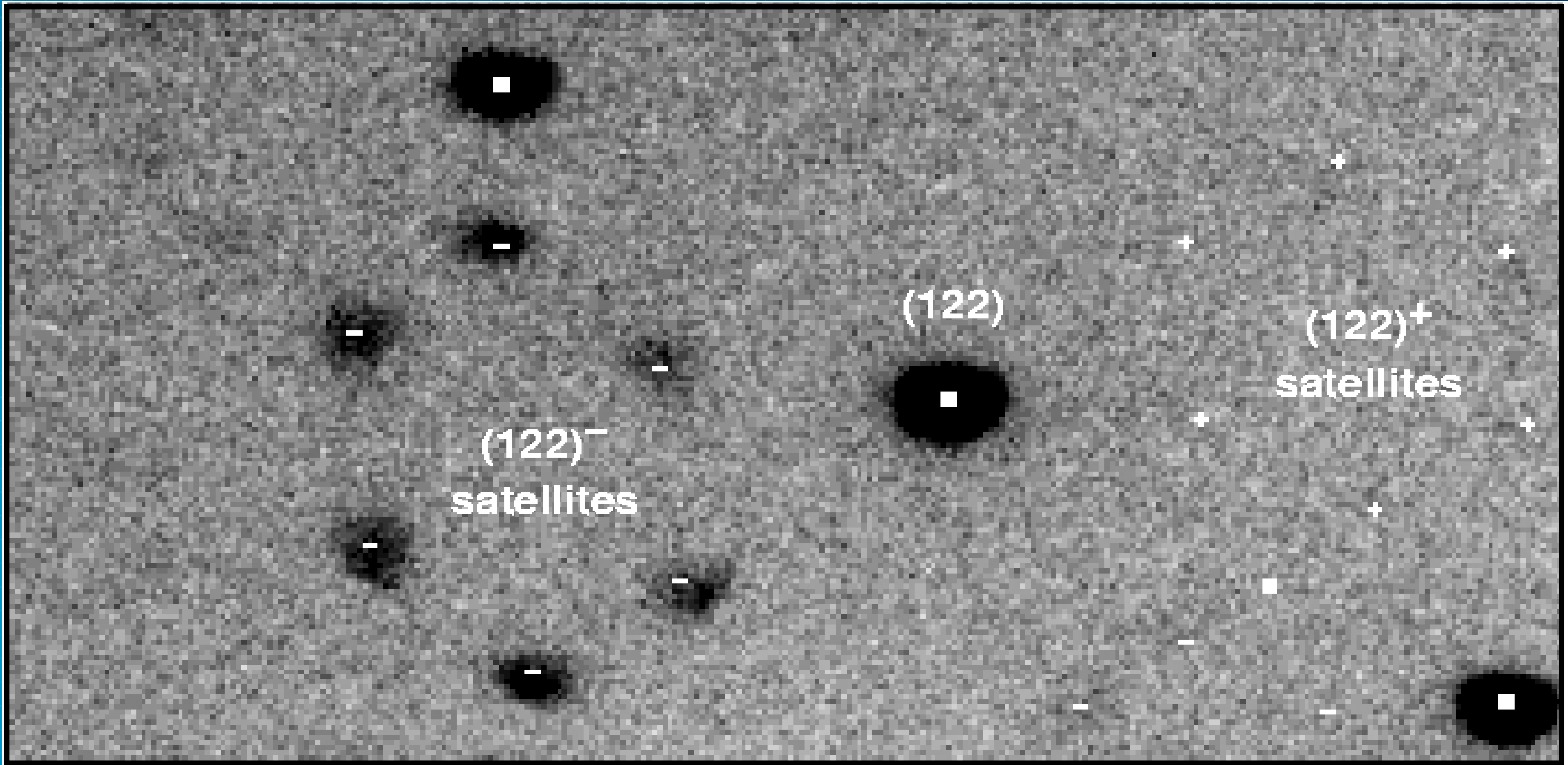
Neutron Image Plate Superstructure in $La_2Co_{1.7}$



$La_2Co_{1.7}$ on T-LADI showing incommensurable superstructure

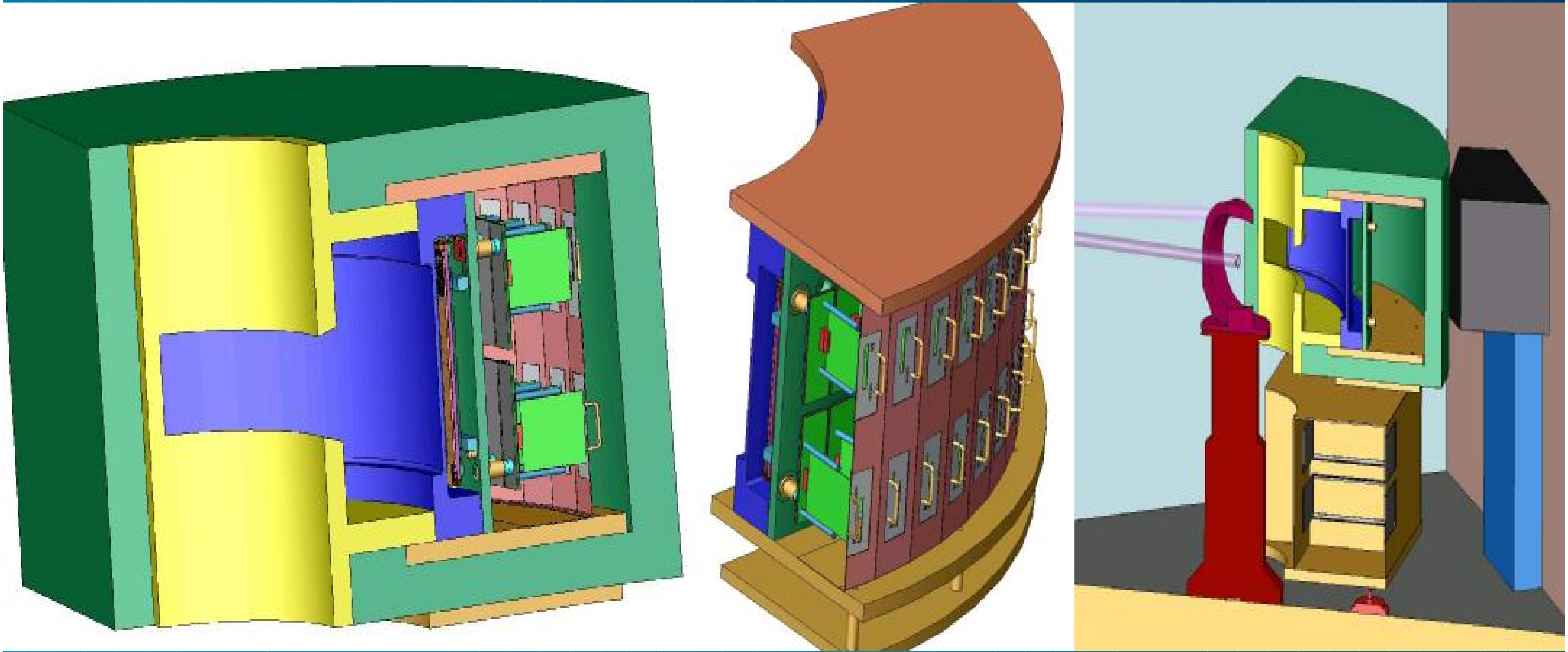
Neutron Image Plate Superstructure in $La_2Co_{1.7}$

- 6-domain ring of $(122)^-$ superstructure



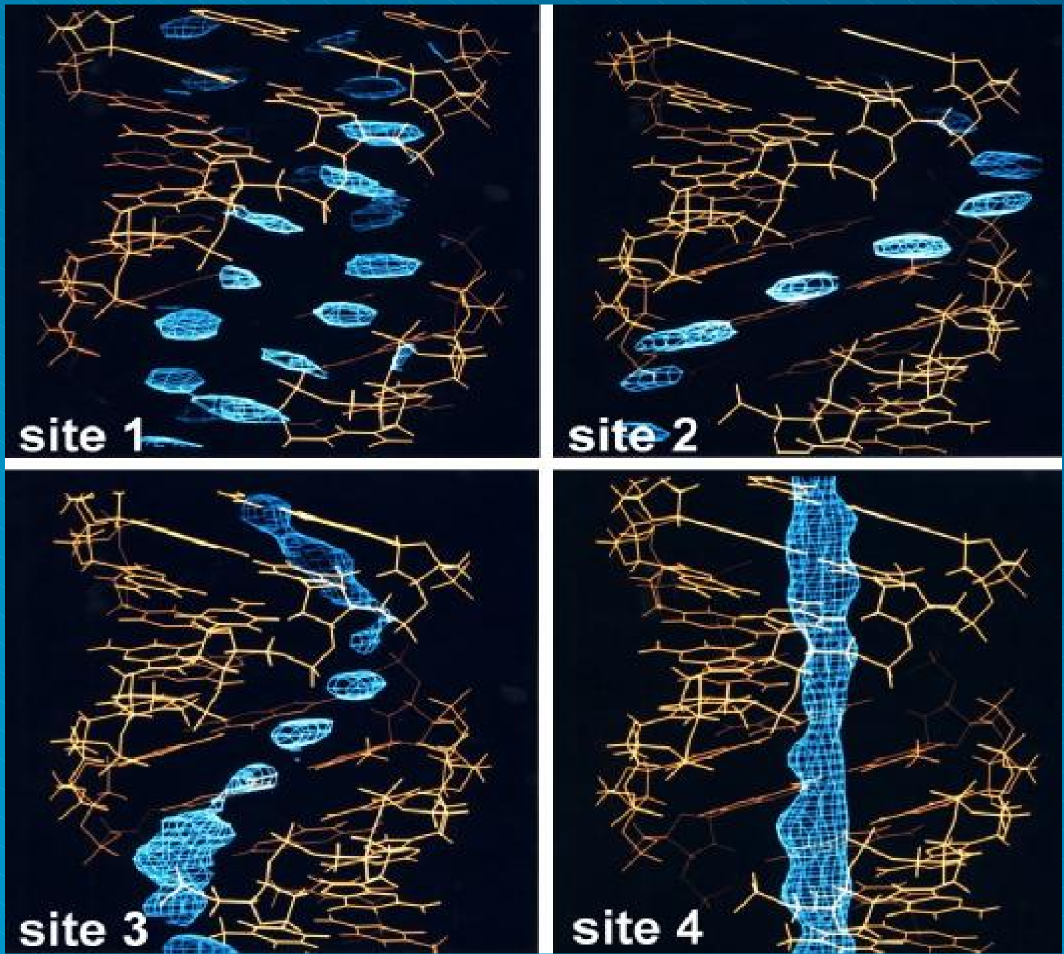
$La_2Co_{1.7}$ on VIVALDI showing incommensurable superstructure

New very large 2D resistive wire detector (D19)



- 400 mm high resistive wires (2D), very large solid angle – 30° x 120°
- Medium resolution, 0.2° in both horizontal and vertical directions

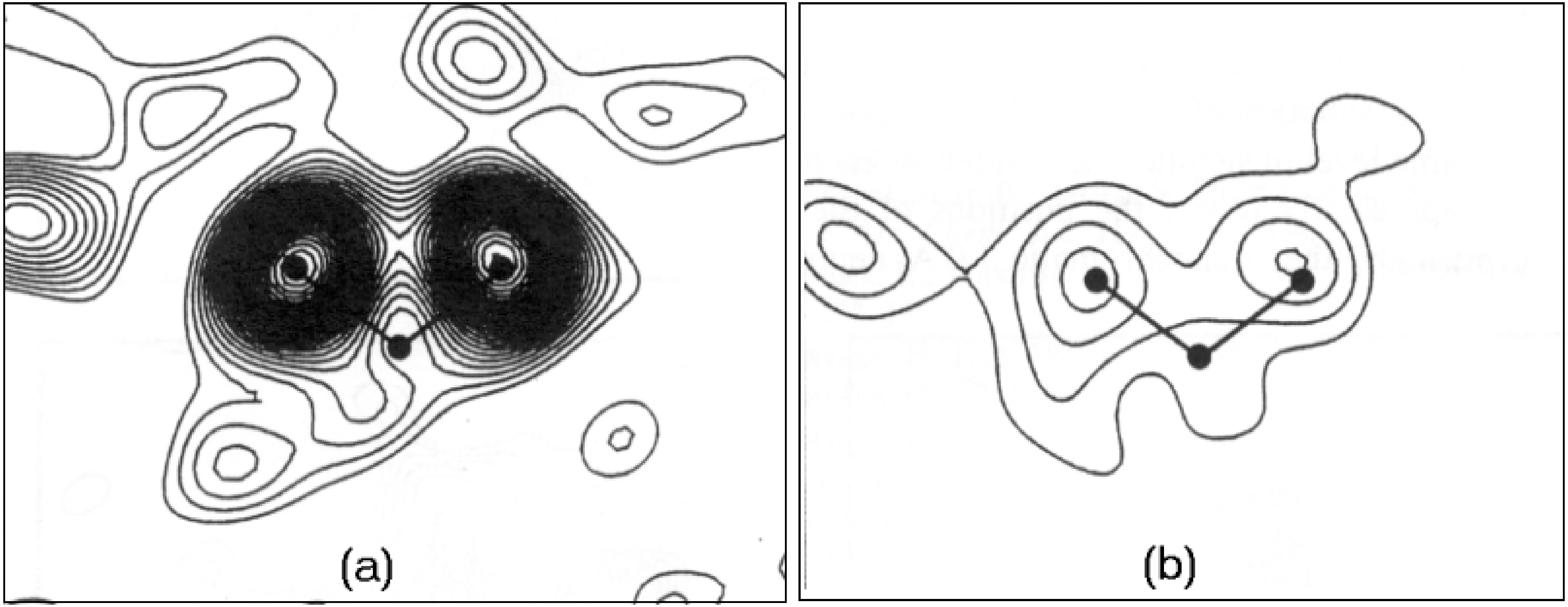
Water in A-DNA Fibres on D19



- B-DNA sheets, but A-DNA fibres
- 100 individual DNA fibres in D_2O
- Diffuse fibre diffraction patterns from D19 used to locate water
- 4 distinct water sites located along double helix backbone

Why can't we do it with X-rays ?

Density of water in co-enzyme B12



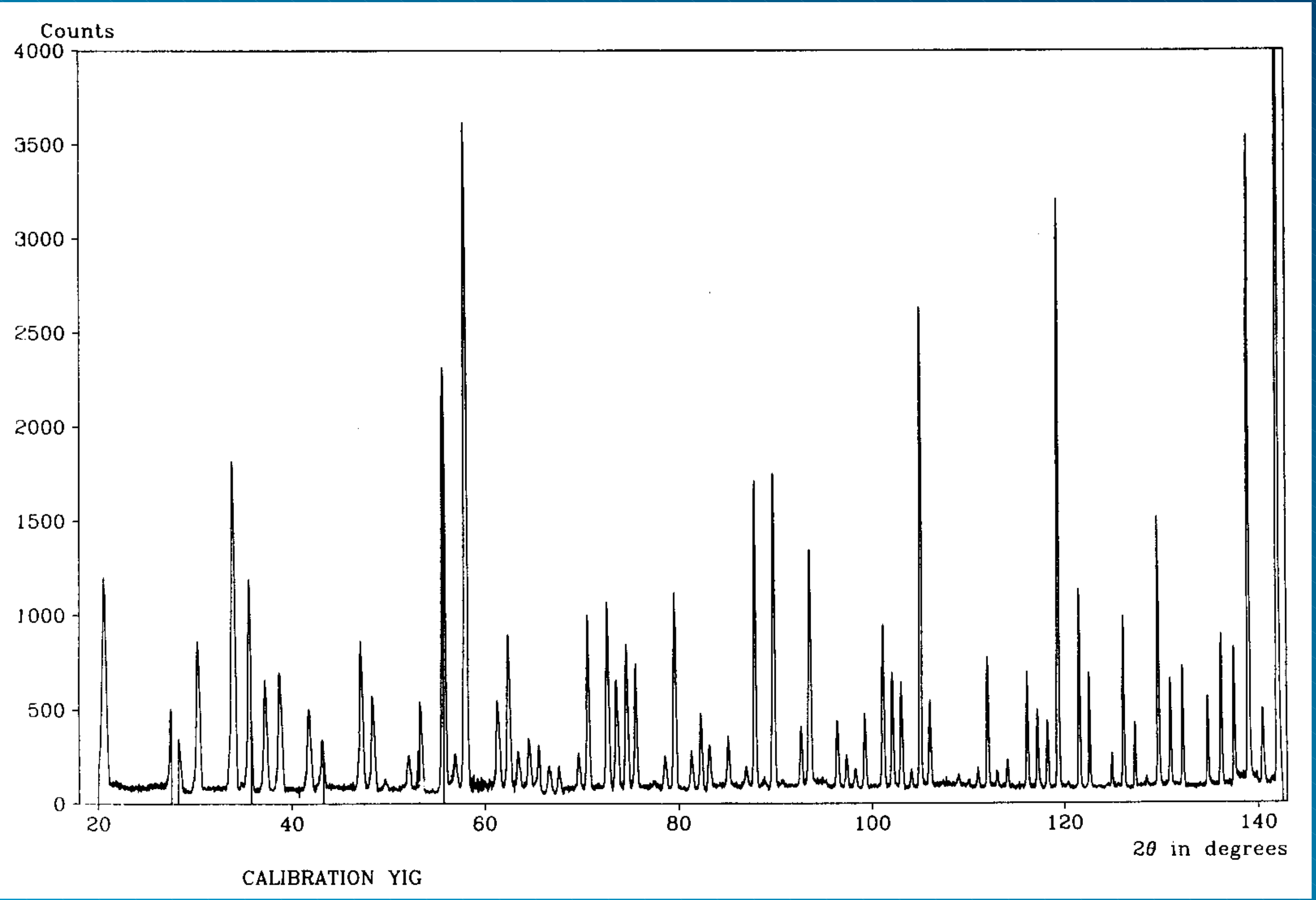
D19 Neutron data | Synchrotron data

Langan, Lehmann, Wilkinson, Jogl, Kratky (1999) Acta Cryst D55, 51

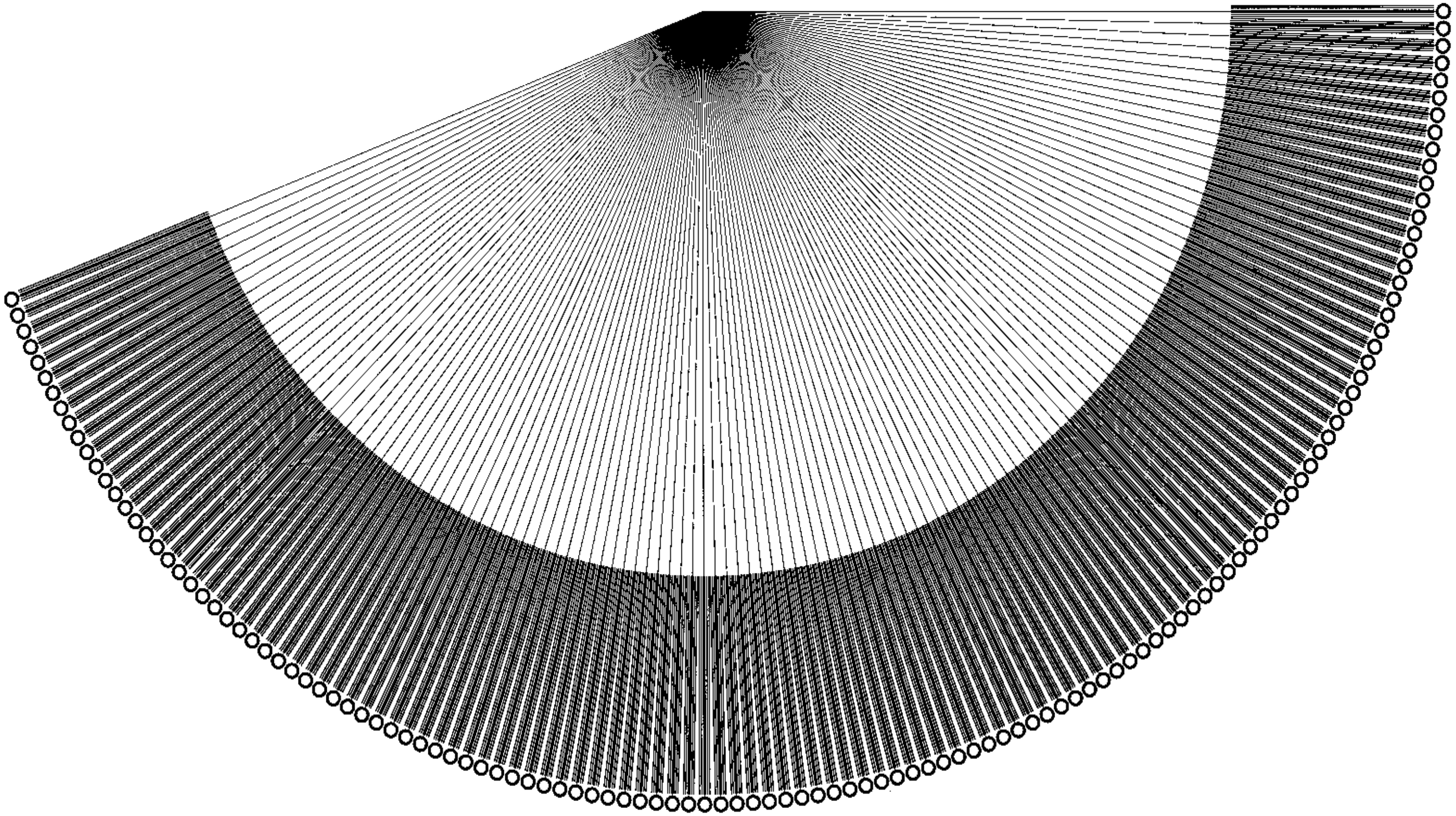
Super-D2B high resolution 2D linear wire detector

High resolution neutron powder diffractometers – D2B at ILL

Strong peaks at high angles give high precision structures of materials



Super-D2B high resolution 2D linear wire detector

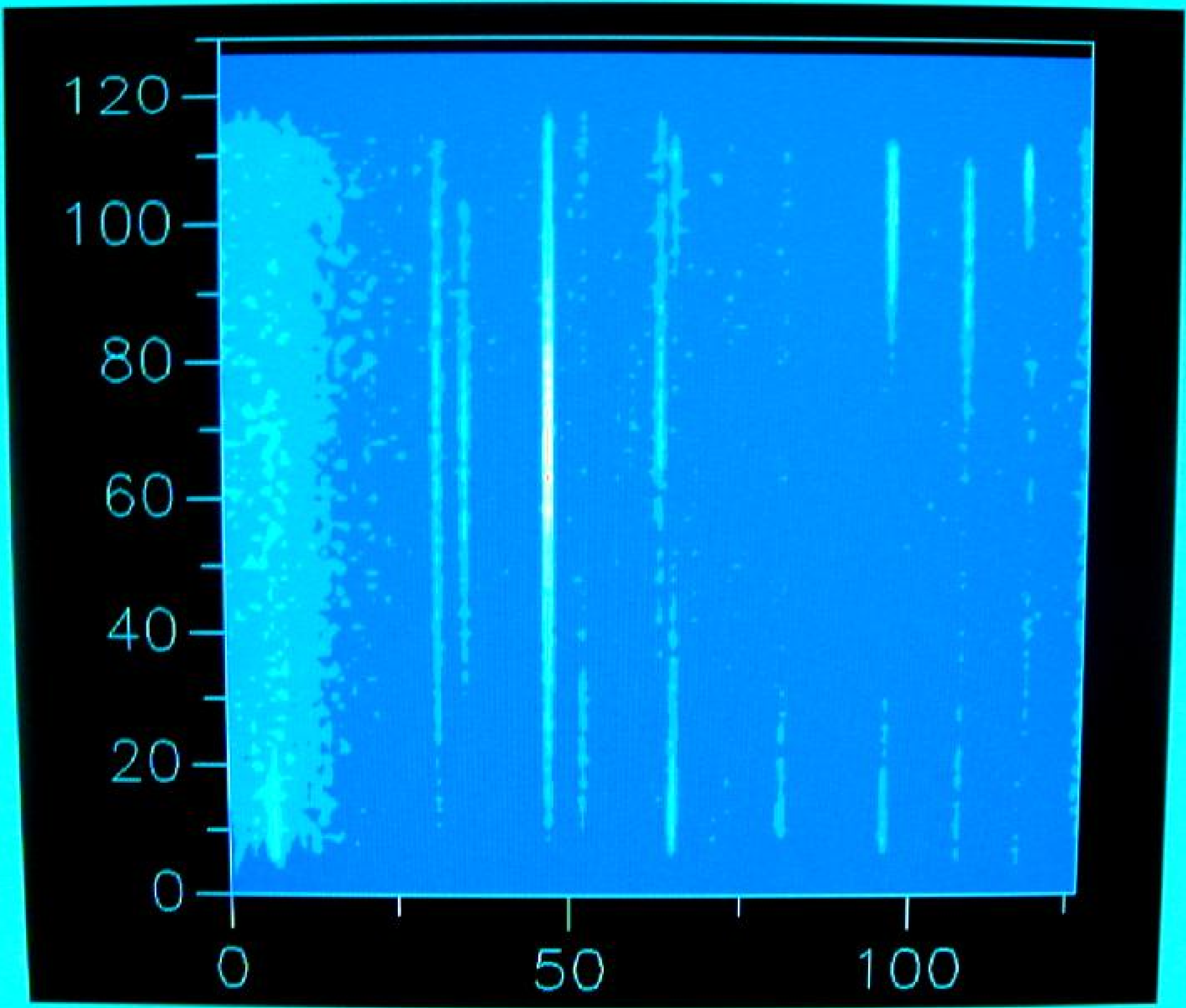


- 128 x 300 mm high resistive wire detectors, high resolution collimators

Super-D2B high resolution 2D linear wire detector

- 128 x 300 mm high resistive wire detectors, high resolution collimators

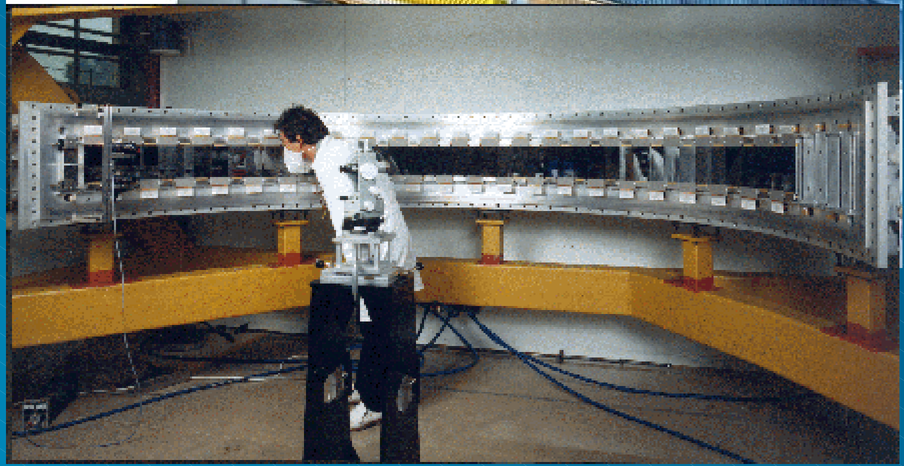
Super-D2B high resolution 2D linear wire detector



First Neutrons
3 April 2003

Applications of large fast detectors

D20 - high intensity medium resolution ($4x10^{-3}$) PSD; runs ~secs



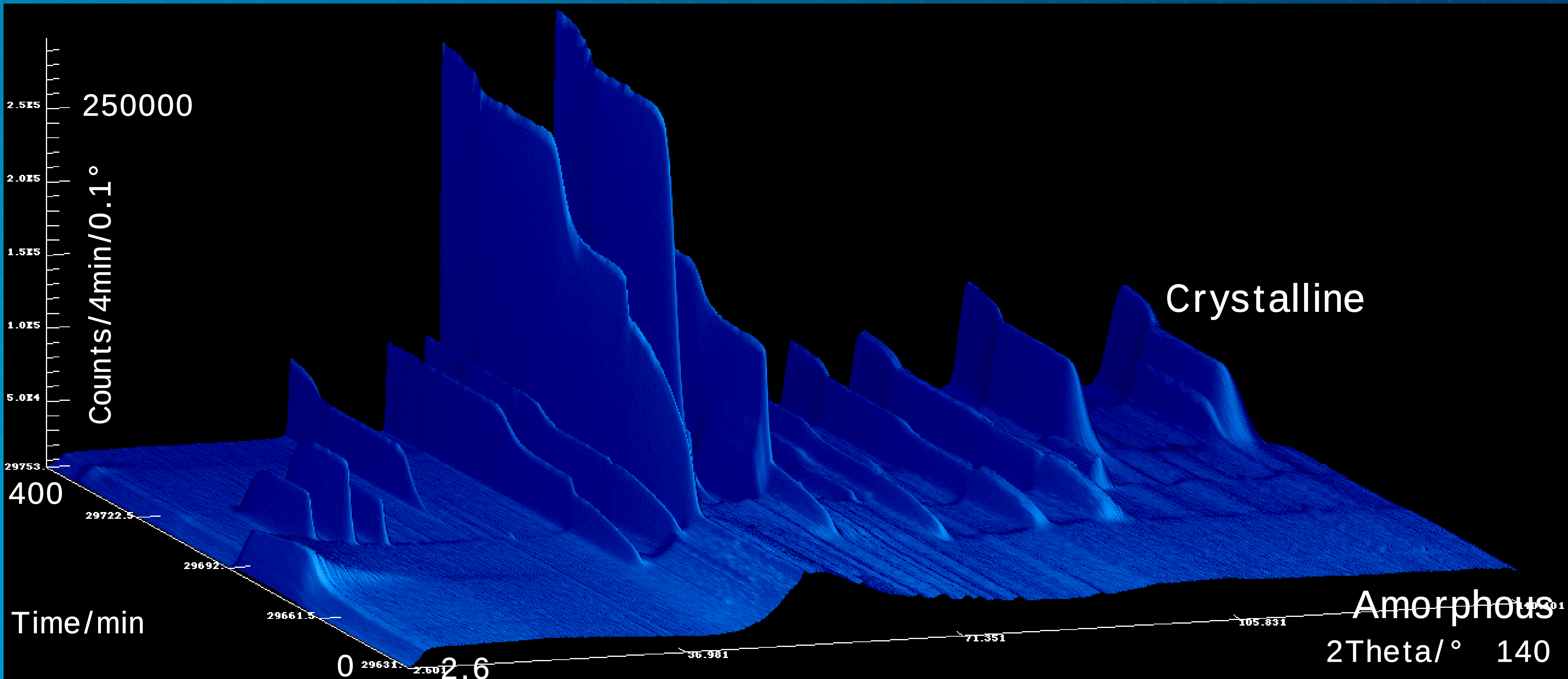
- Very large monochromator and micro-strip detector (printed circuit)
- Extremely fast (300 msec real time expts) but only medium resolution

Applications of large fast detectors

Real-time Reactions

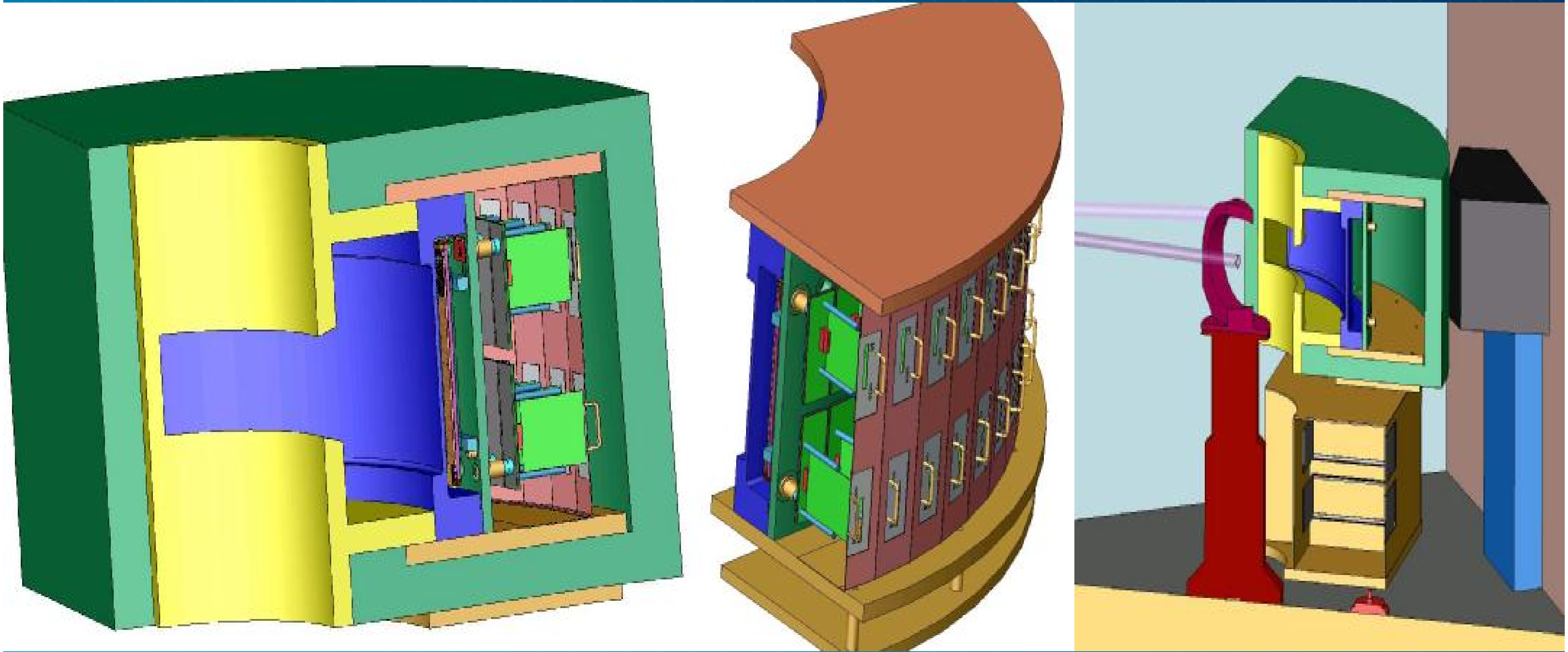
Sue Kilcoyne, Bob Cywinski et al.

Crystallisation of amorphous alloys $Y_{67}Fe_{33}$ with increasing temperature



Complete diffraction pattern in minutes or seconds, scan through temperature

DRACULA, a super-D20 2D resistive wire detector



- Order of magnitude faster than D20
- Extremely fast reactions
- Extremely small (eg isotopic) samples and extreme conditions (high P)

Advantages of continuous neutron sources

- Shelter Island Workshop on Advanced Neutron Sources, Oct. 22-26 (1984)

- Efficiency for a given resolution = time averaged flux on the sample
  * sample volume
  * detector solid angle

- As on pulsed sources, reactor machines will increase the detector solid angle
- Reactor machines already have an advantage, with high flux at the sample

Advantages of continuous neutron sources

Example: A proposal for a new ILL high flux powder diffractometer DRACULA

(Diffractometer for Rapid Acquisition over Ultra-Large Areas)

	ILL-D20	ISIS-GEM	ILL-DRACULA	ESS
time averaged sample flux	$>5x10^{7}$	$\sim 2x10^{6}$	$>5x10^{7}$	$\sim 10^{8}$
detector solid angle	0.5 sr	3.5 sr	3.0 sr*	3.0 sr

* Based on new D19 detector: R=730 mm, h=400 mm, 800 linear resistive wires covering 160º

The ILL Millennium Programme in Diffraction

- The ILL Millennium Programme will improve the efficiency of many ILL-Grenoble instruments by more than an order of magnitude.

- This is a cost-effective way of meeting the challenge of the new US and Japanese spallation neutron sources in the next 10 years.

- The time averaged neutron flux on the sample at the ILL reactor will remain competitive with these new sources

- For powder instruments it remains to increase the size of detectors and use more efficient monochromators

- New ILL machines Super-D2B and DRACULA are proposed