The ILL Millennium Programme - a Bridge to ESS

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ILL (neutrons) & ESRF (synchrotron) in Grenoble

The ILL Millennium Programme

- New 10 year ILL contract just signed
- Millennium Programme -> ILL machines by x10 to x20
- New detector and neutron optic technology
- Infrastructure renewal – super-mirror guides, hot source
- A bridge to new European initiatives such as ESS.
- More countries should actively participate
- ILL would welcome membership of the Nordic countries
- Strong background in neutron and x-ray scattering.

The ILL Millennium Programme

New Instruments:

- D2b – high resolution powder diffractometer with linear PSDs
- D20 – a large microstrip detector for chemical kinetics…
- D4c – a microstrip detector for liquids & amorphous materials
- Strain Scanner – for mapping strain using microstrip detectors
- D19 – an array of 2D-microstrips for protein/fibre diffraction
- VIVALDI – Laue Diffractometer with Neutron Image Plate
- D3c – He3 neutron spin filters and magnetic polarimetry
- IN20 –polarised neutron 3-axis
- D22 – fast Small Angle Neutron Scattering detector (5MHz)

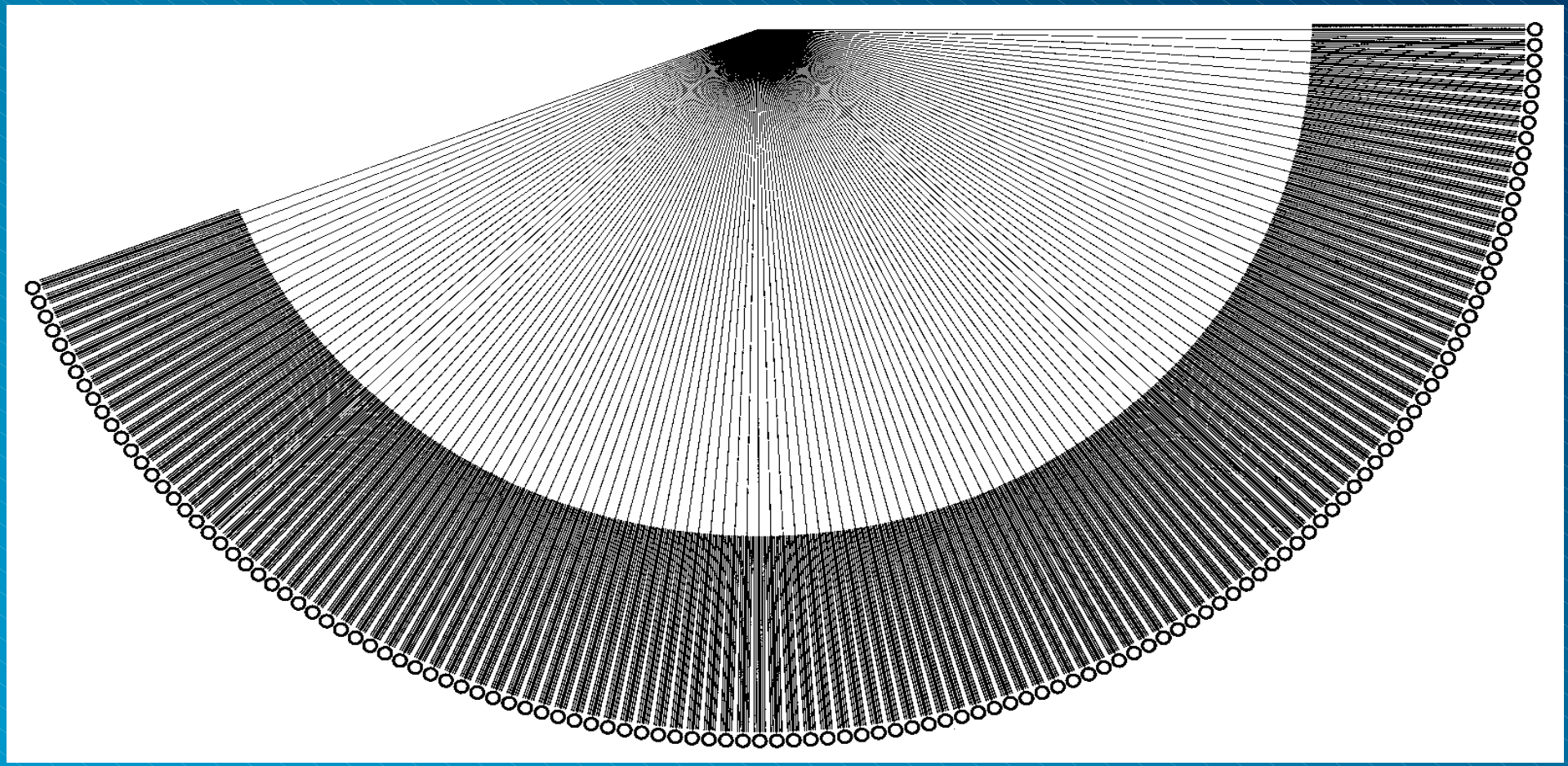
Super-D2B High Resolution Powder Diffractometer

High Resolution with Very Large Detector bank (D2B)

- 64 High Resolution Plastic Foil Collimators
- Large Composite Focussing Monochromator
- High Resolution
- Good Intensity

Super-D2B High Resolution Powder Diffractometer

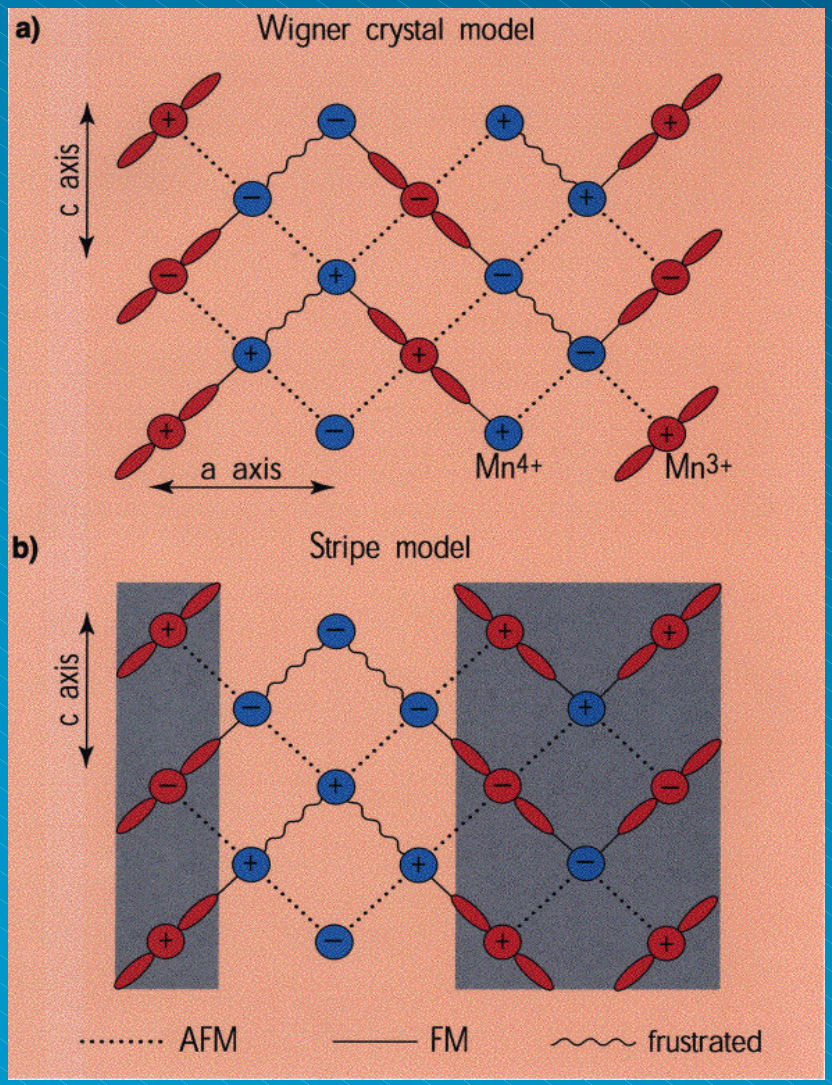
Large pseudo-2D PSD (array of linear-wire detectors)



- 2D detector allows both high efficiency & high resolution

GMR Stripes and Charge Ordering

1D-ordering ? Dimensionality important for theory.



- Expect instead Mn^{3+}/Mn^{4+} to be uniformly distributed (2D Wigner crystal model of Goodenough)
- The 1D-stripe model would have very important consequences for the theory of superconductors and GMR oxides

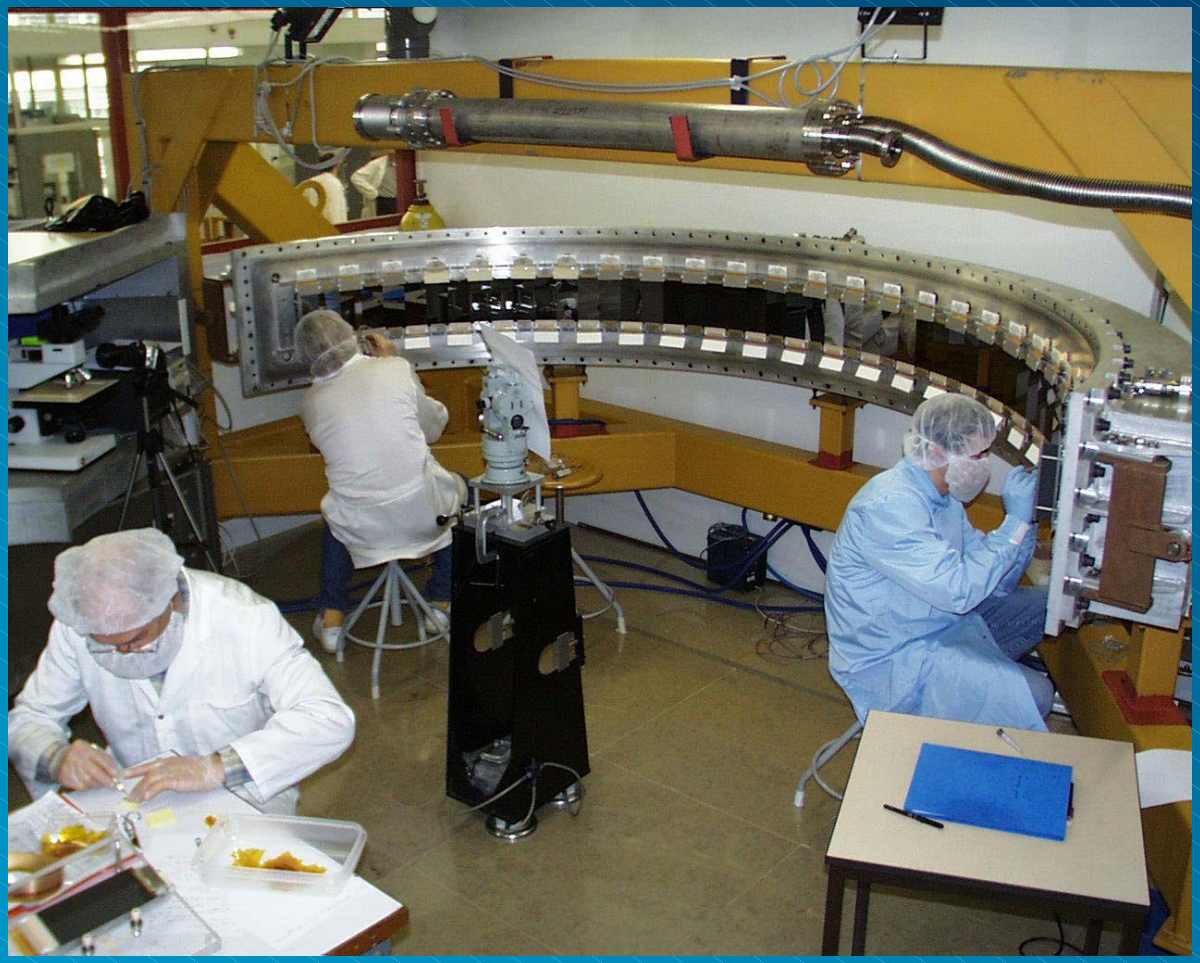
The ILL Millennium Programme

- D2B –very high resolution, good intensity (Rietveld)
- D20 – very high intensity, good resolution (kinetics)
  Microstrip detectors, high speed electronics, big focussing monochromators

What is a Microstrip Detector ?

Instead of wires, a printed circuit is used.
This allows high resolution, mechanical stability…

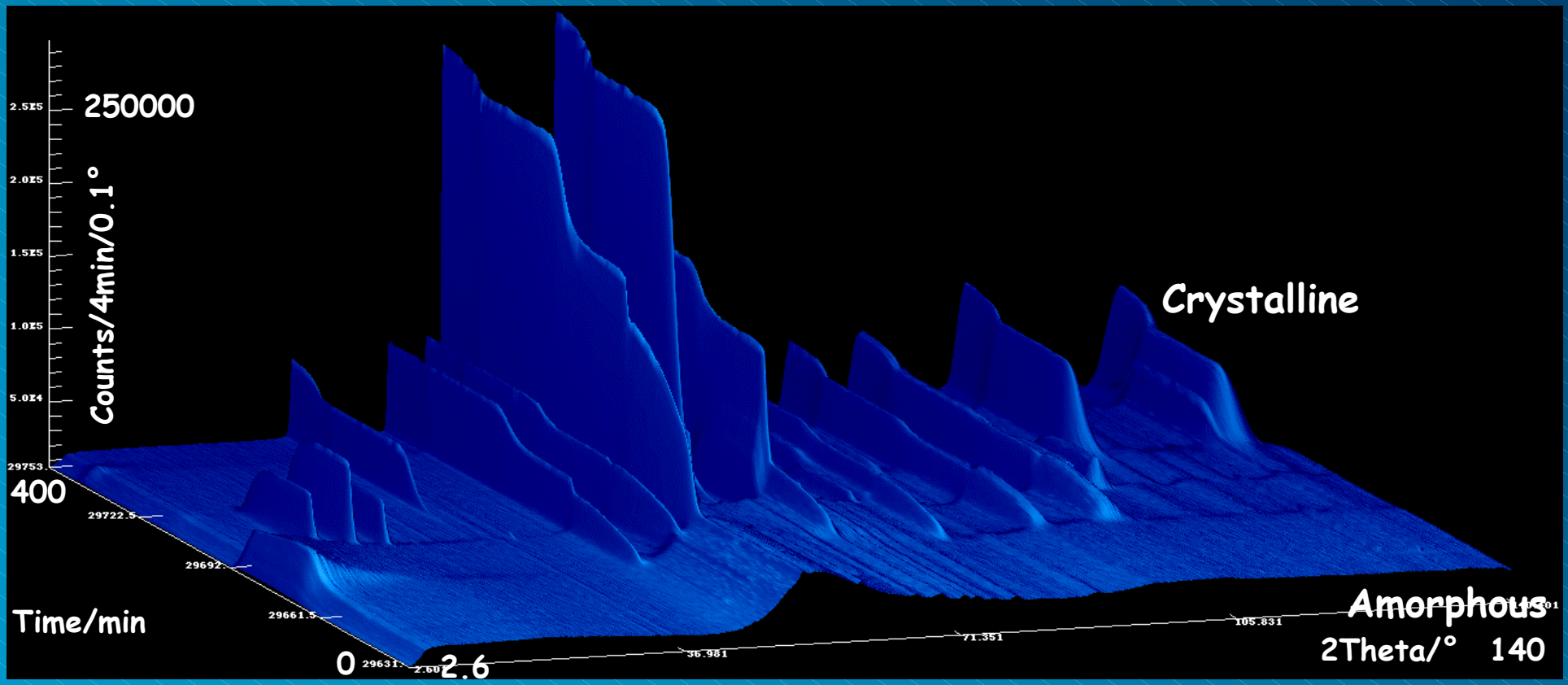
The 160° D20 Microstrip Array



25 plates of 64 electrodes are assembled to produce a 1600-wire detector covering 160°.

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



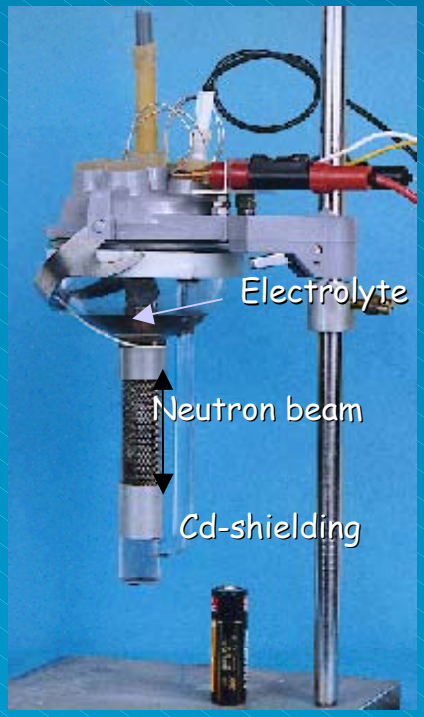
Complete diffraction pattern in minutes or seconds, scan through temperature

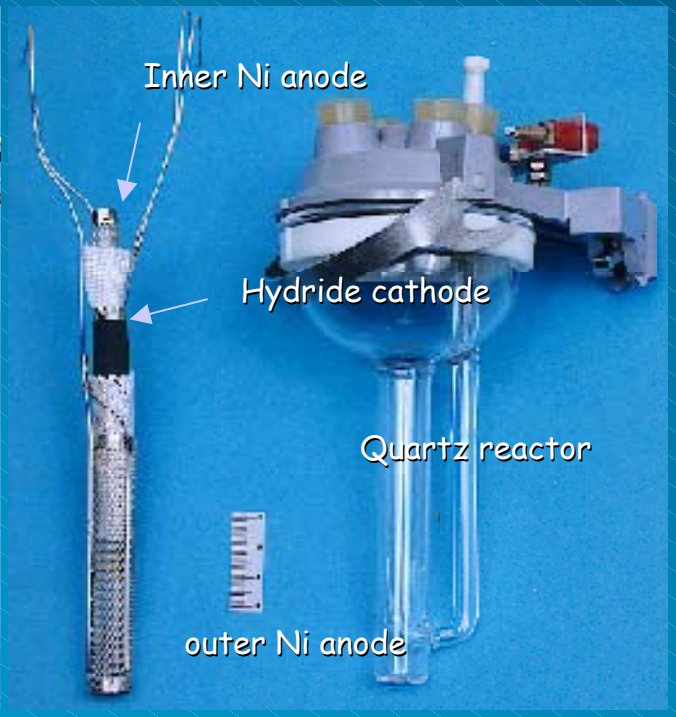
Applications of large fast detectors

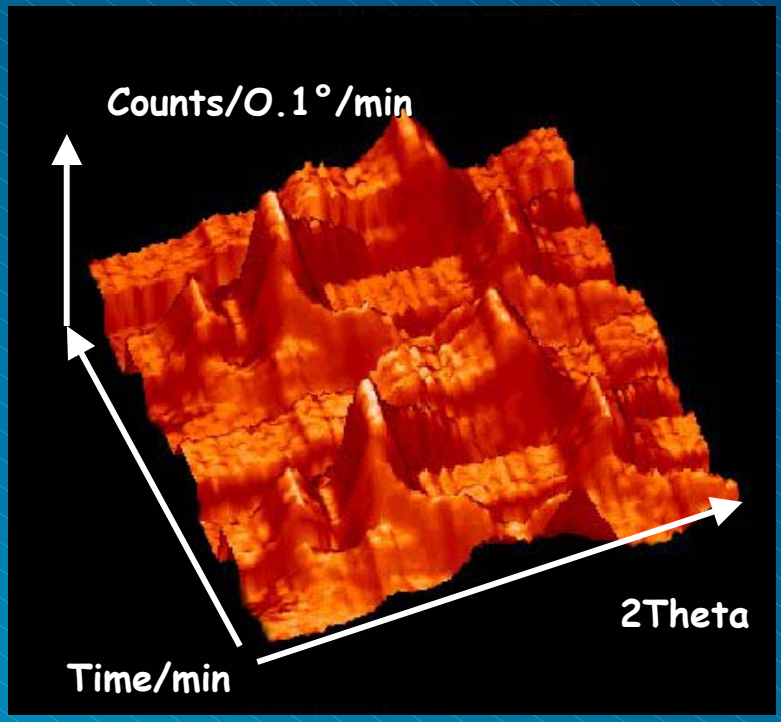
Real-time electro-chemistry

Latroche, Chabre et al.:

In-situ Charging and discharging of metal hydride electrodes LaNi5







- Follow chemical changes with battery charge/discharge cycle

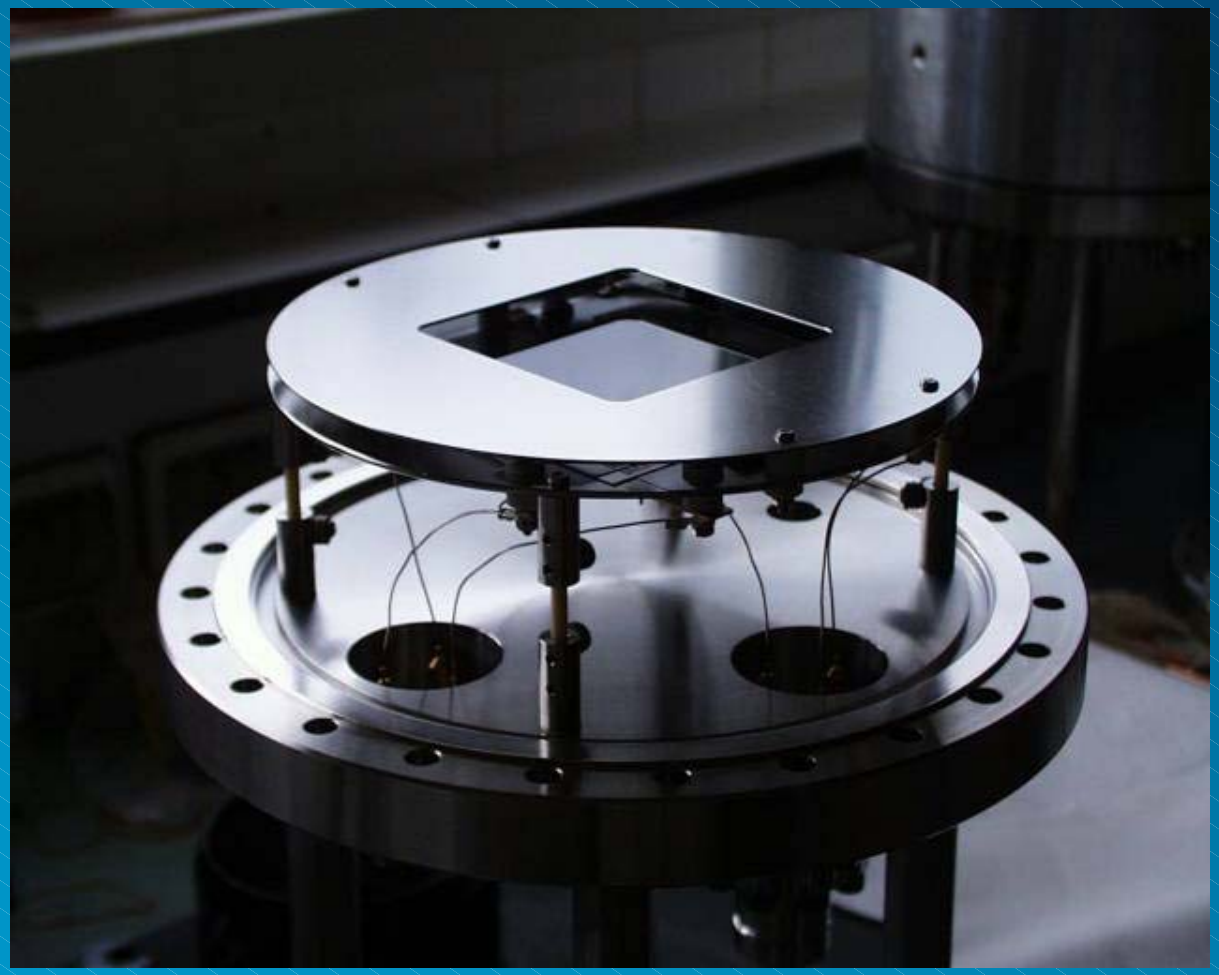
An array of Microstrip Detectors

New D4C Liquids & Amorphous Materials Diffractometer

Very high efficiency & stability needed for isotope replacement method

A 2D Microstrip Detector

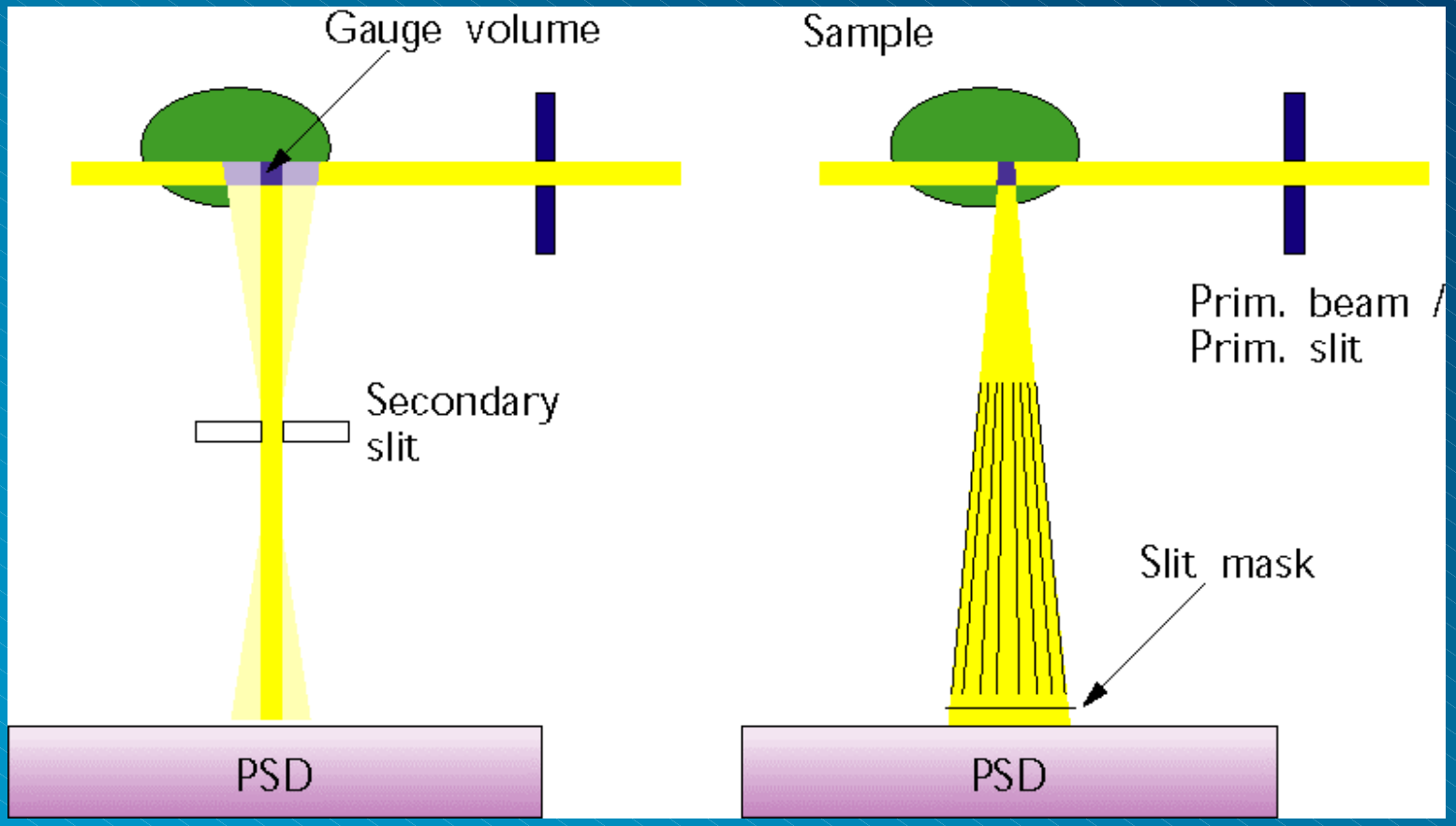
D9, D10, D15, Neutron Strain Scanner



A printed circuit on BOTH sides of the glass substrate

Neutron Strain Scanner

80x80 mm 2D Microstrip Detector

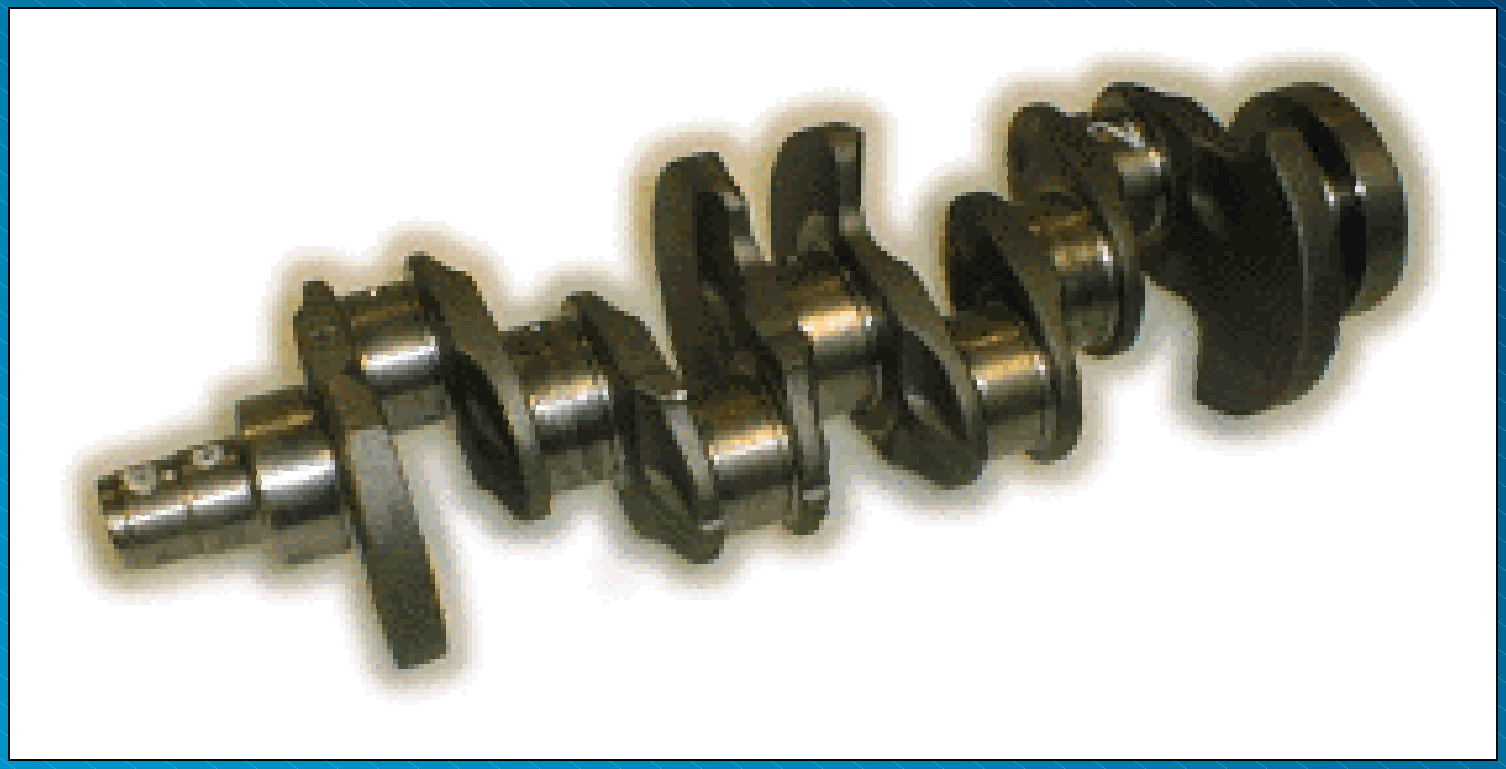


A large convergent collimator is used with the 2D microstrip detector

Note the very small sampling volume with this setup (right)

Neutron Strain Scanner

80x80 mm 2D Microstrip Detector

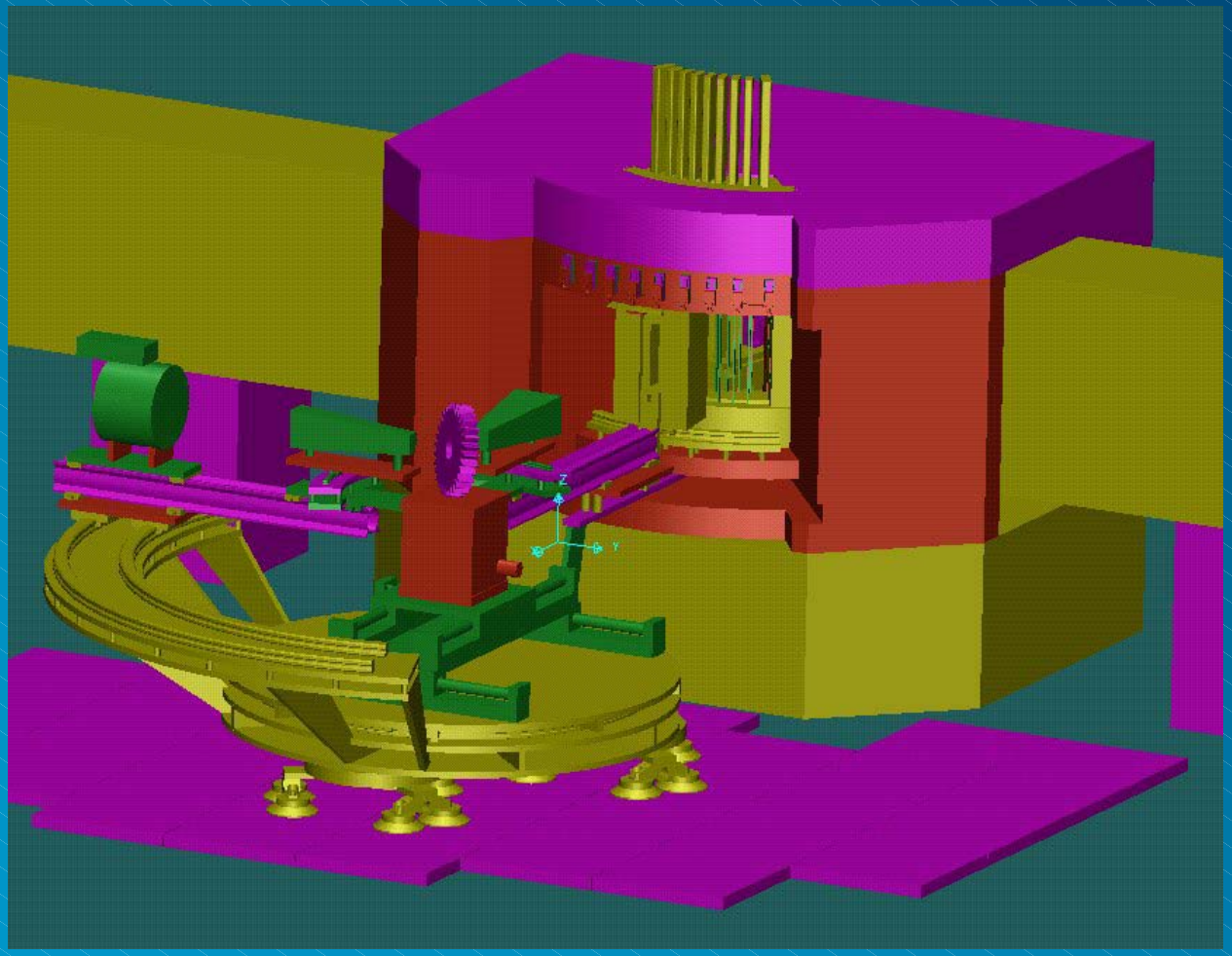


The stress distribution in critical regions of this experimental crankshaft from Volkswagen was determined on the strain scanner at ILL.

ILL is part of the EU-RESTAND project with Volkswagen, Rolls-Royce, Airbus etc

A New ILL-EPSRC Strain Scanner

EPSRC grant of ~ 1M Pounds Sterling



Artists impression of the new ILL-EPSRC strain scanner behind D1A/D1B

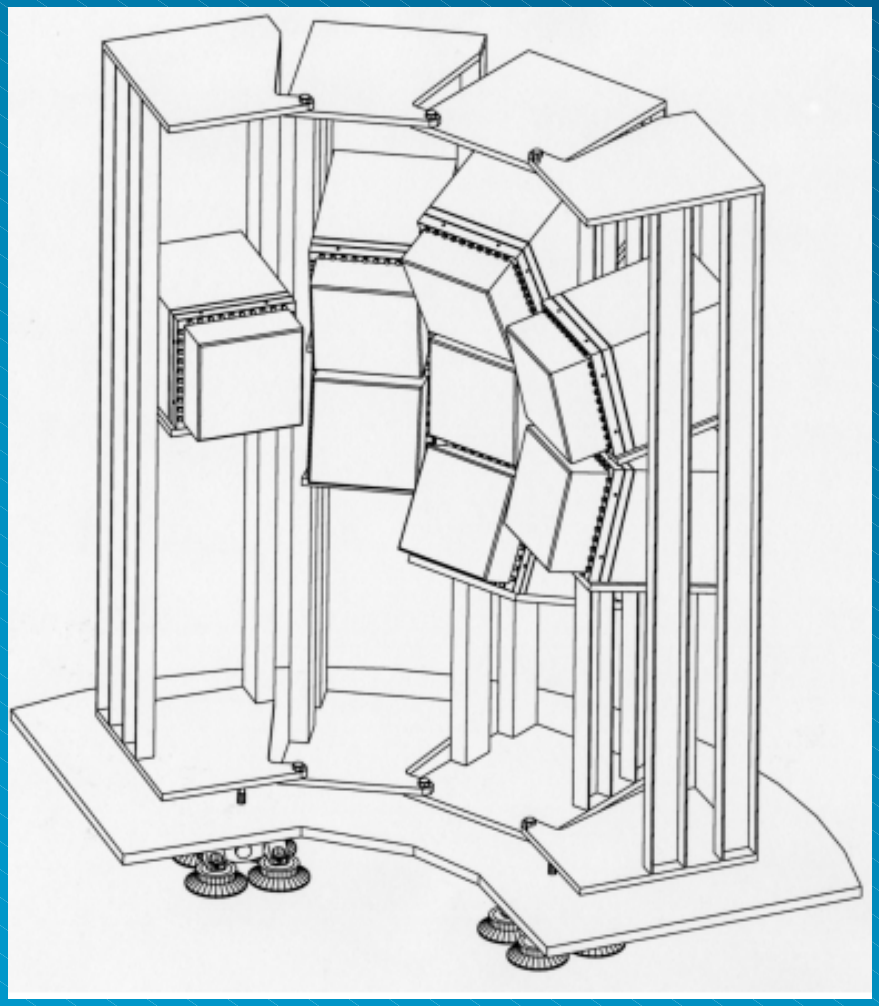
An Array of 2D Microstrip Detectors

D19 Fibre & Protein Diffractometer

200x200 mm 2D microstrip detector for D19 fibre & protein diffractometer

An Array of 2D Microstrip Detectors

D19 Fibre & Protein Diffractometer

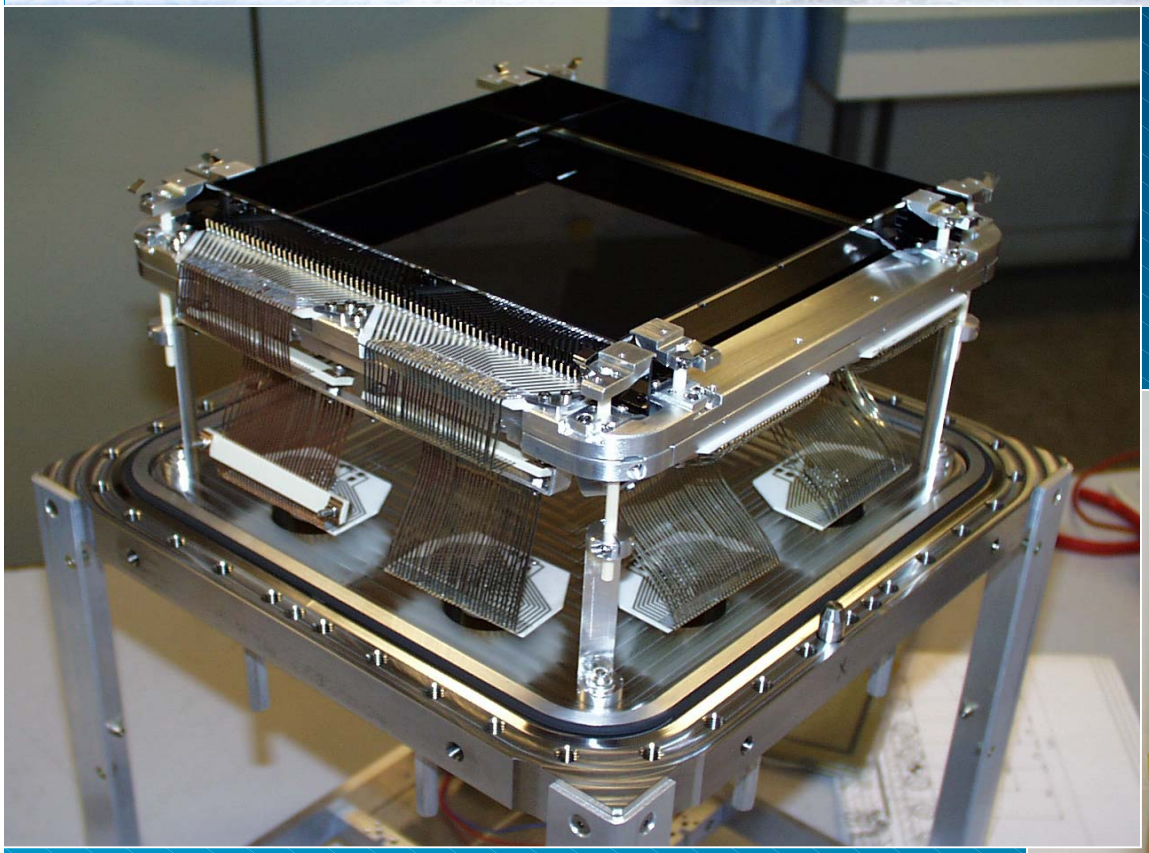


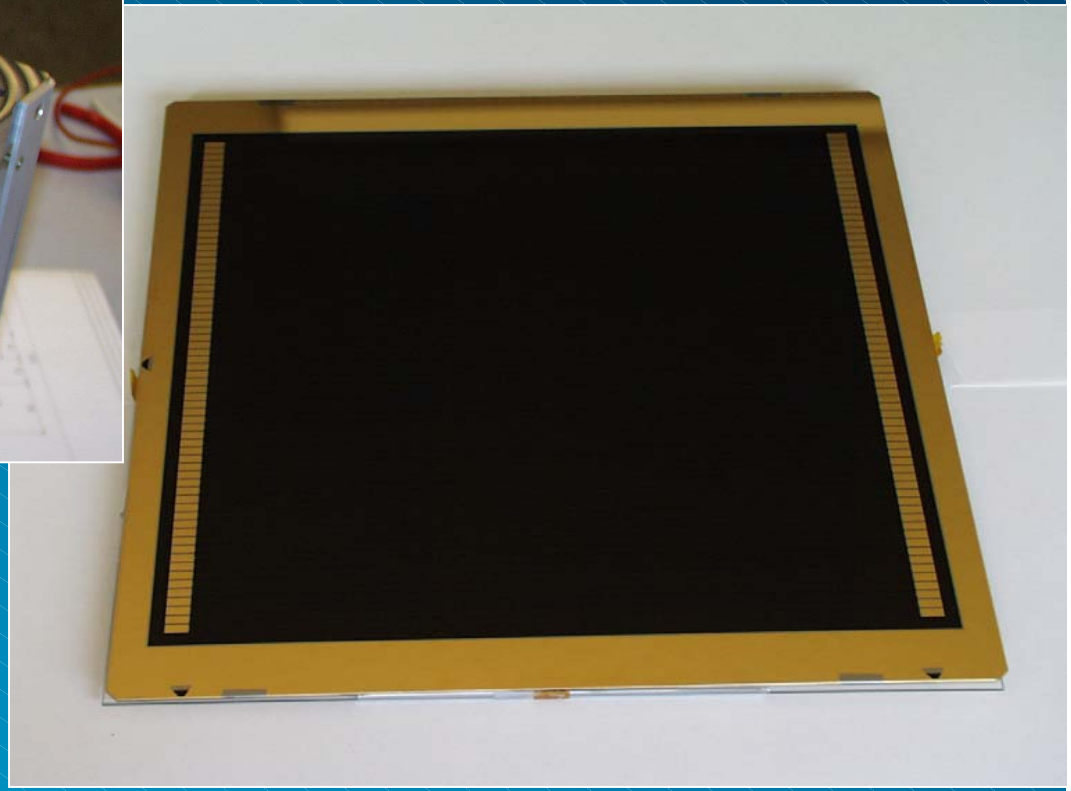
9 Independent 2D microstrip detectors

- 15 year old D19 detector covers only a thin 2D strip
- Replace with an array of high resolution 2D modules
- Increase efficiency x20
- Fibre Diffraction
  Small protein structures
  In-situ hydration studies.

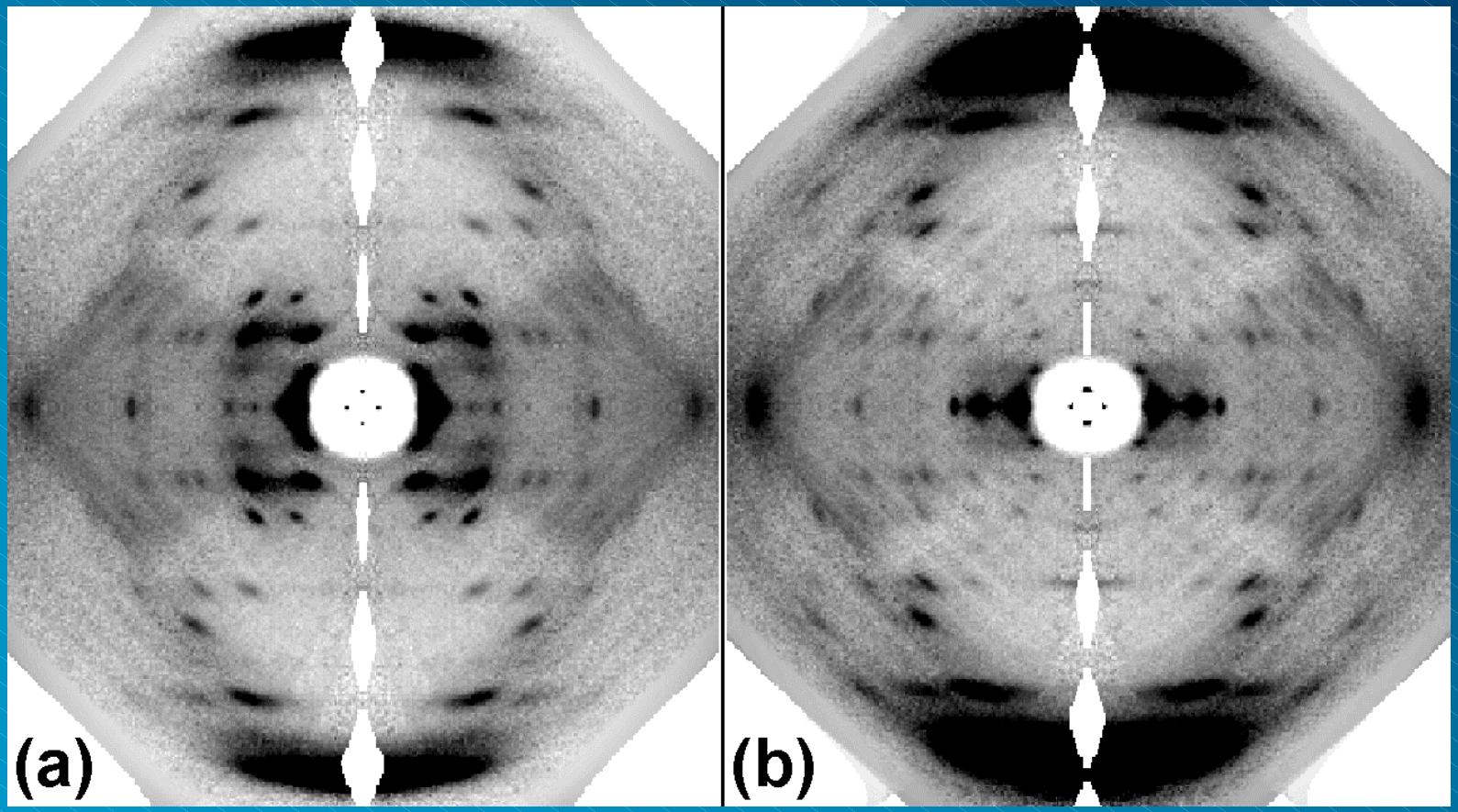
An Array of 2D Microstrip Detectors

D19 Fibre & Protein Diffractometer



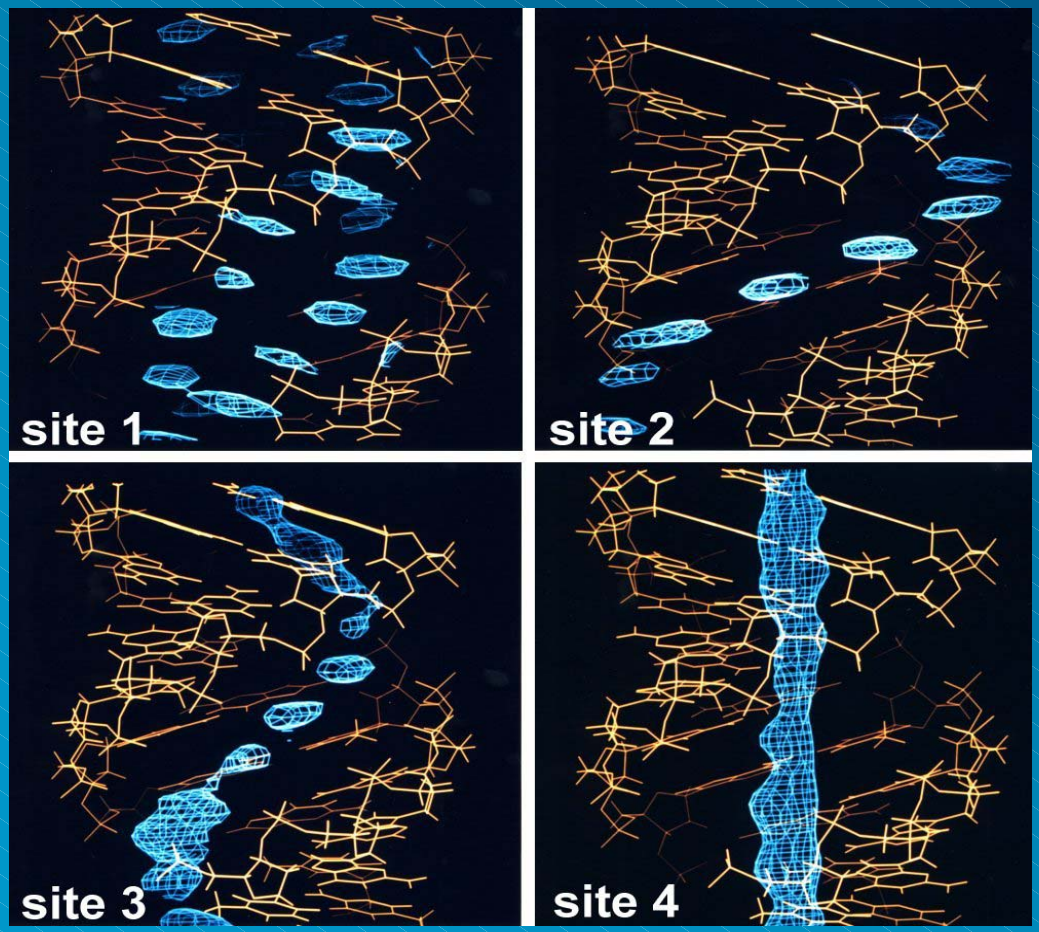


Water in DNA sheets on D19



(a) with H_2O (b) with D_2O

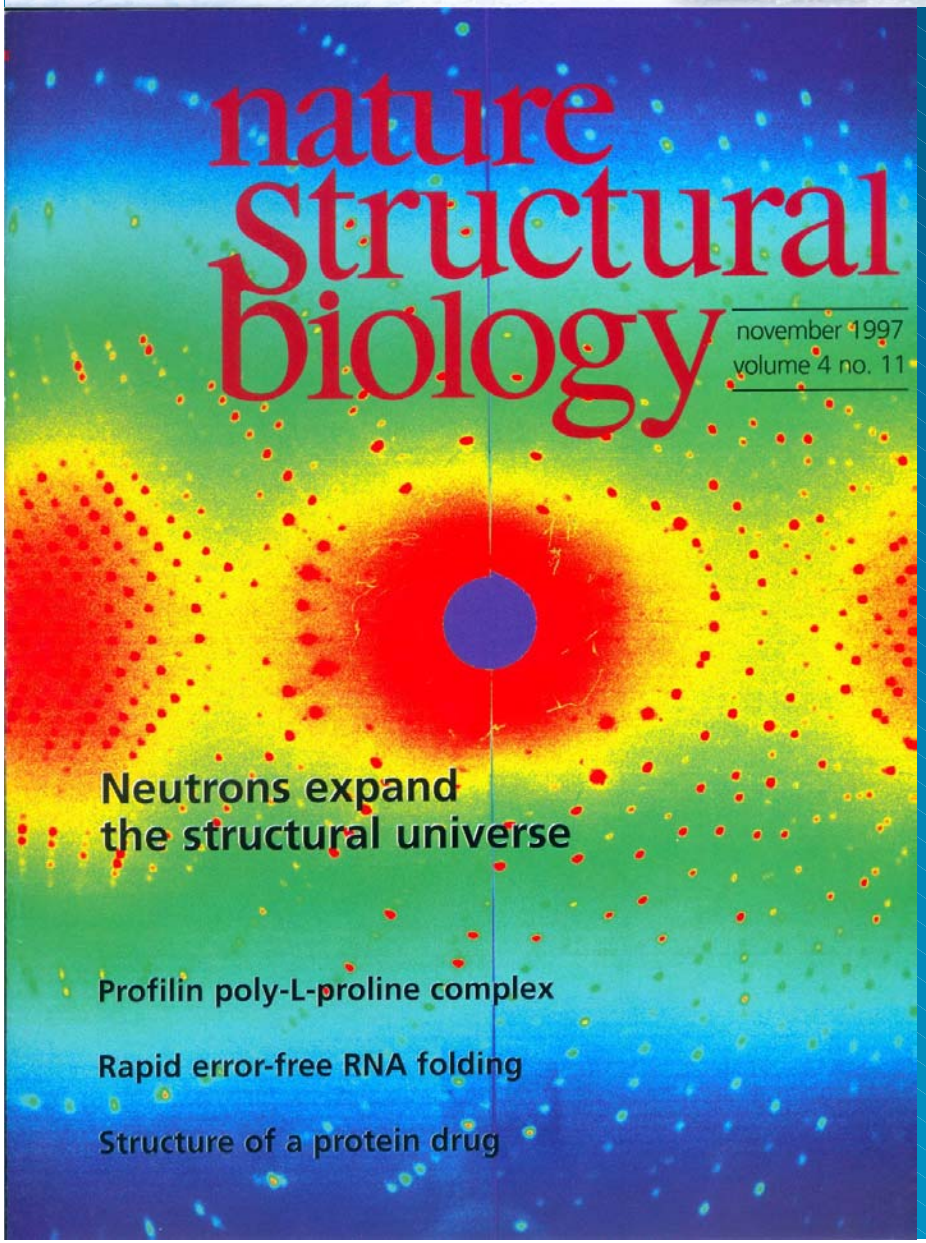
Water in A-DNA Fibres on D19



- 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

1) Bridging phosphate groups
2) Center of opening of major groove
3) Deep inside the major groove
4) Disordered string along helix axis

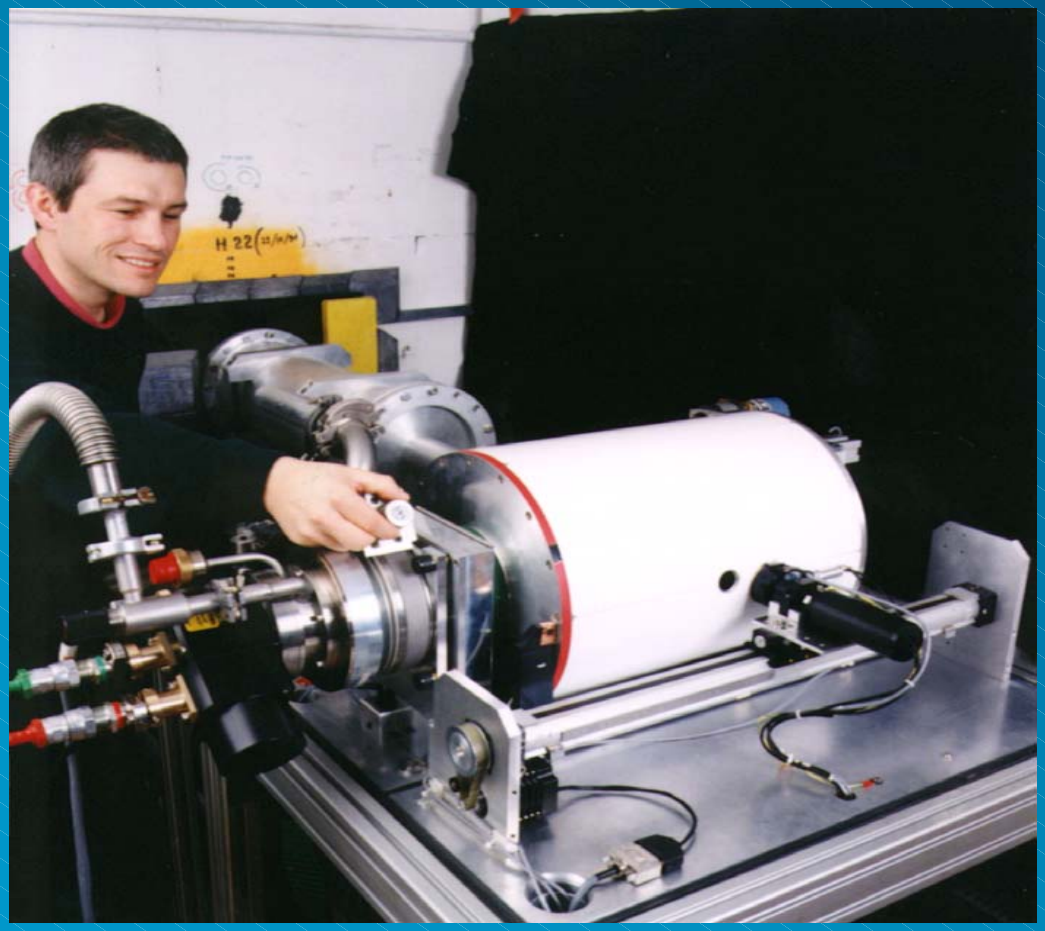
Neutron Image Plates & Microstrip Detectors



Nature (1997) Cover showing LADI data

(LAue Diffractometer with Image plates)

LADI Neutron Image Plate LAue Diffractometer

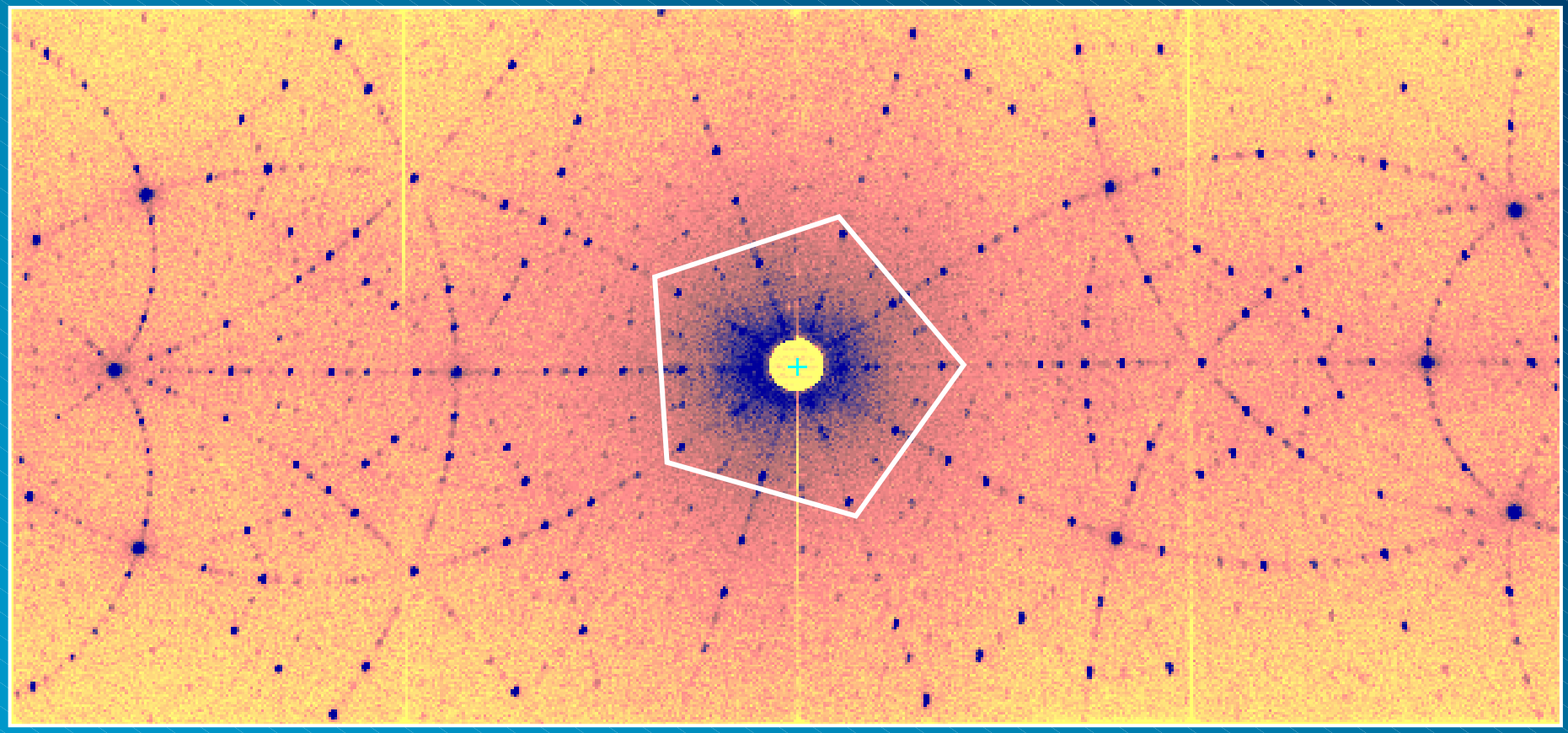


- Neutron guide
- Band of neutron energies
- View reciprocal space
- In-situ laser readout
- Unique survey of P/T
- Phase T/Ns, superstruct.

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

T-LADI Neutron Image Plate
5-fold symmetry of quasi-crystal

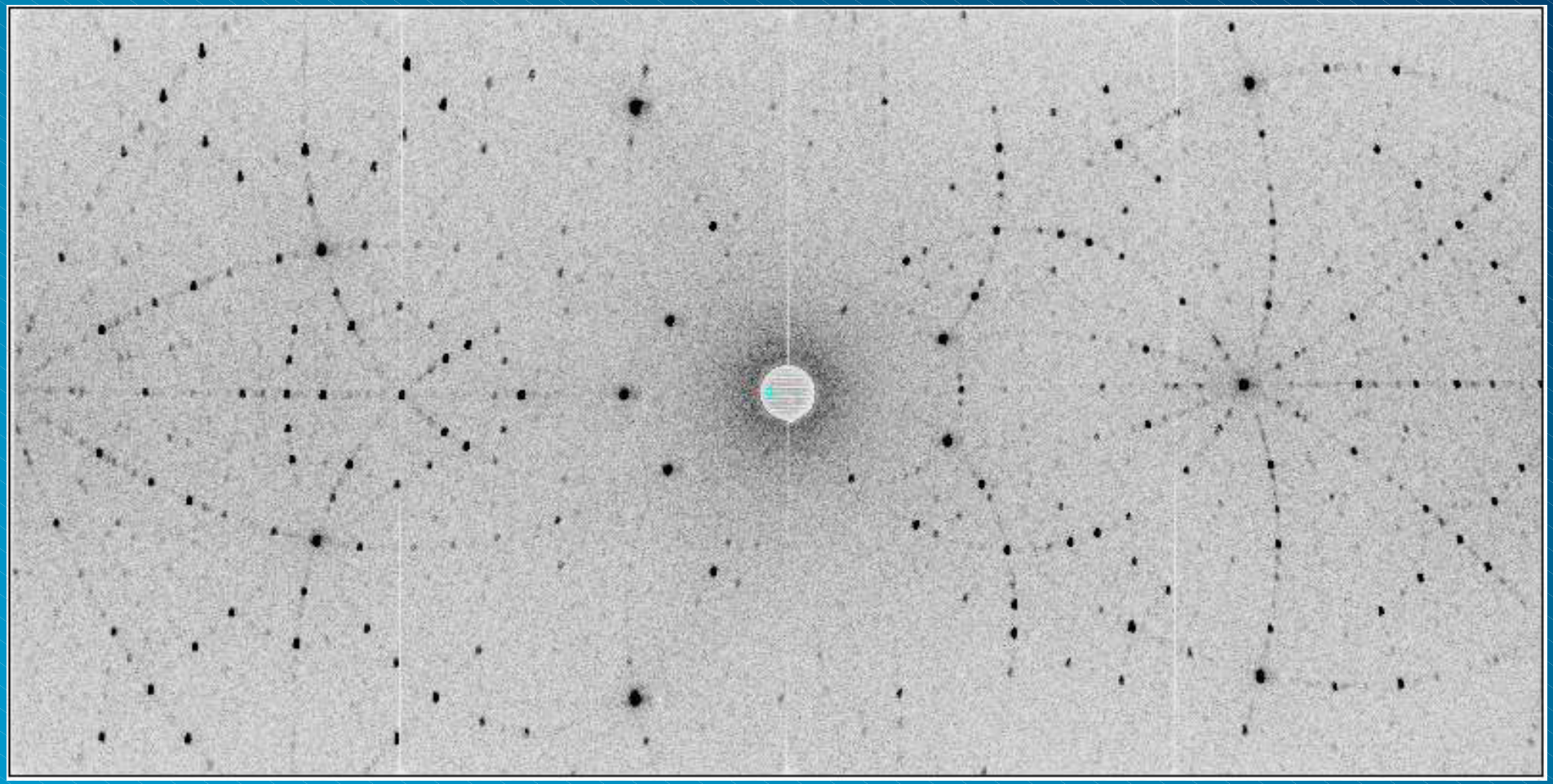
5-fold symmetry axis in ZnMgY quasi-crystal - De Boissieu et al. (1999)



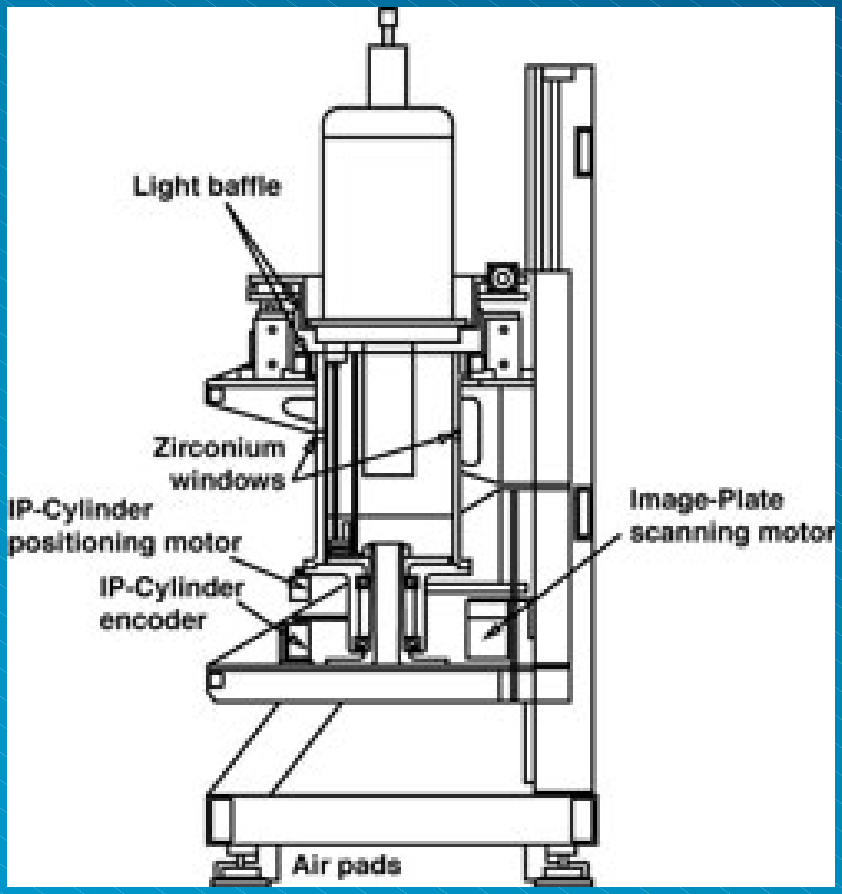
T-LADI neutron image plate photo courtesy of G. McIntyre, Oct 1999

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

Rocking the ZnMgY quasi-crystal (Dynamics) – McIntyre, Cowan (1999)



T-LADI Neutron Image Plate
Why Image-plates + Microstrips ?



Disadvantages of Image-plates

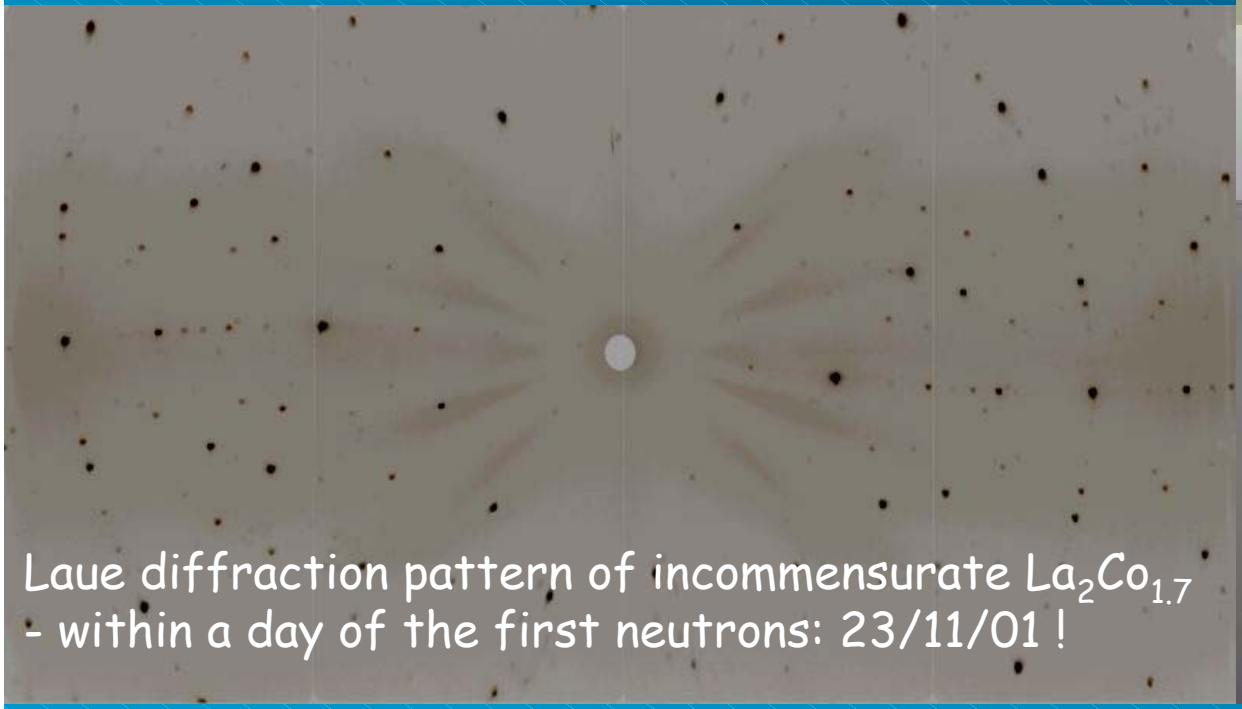
- Photographic technique
- Accumulate background
- Background from all λ (wide $\Delta\lambda$)
- H-background

For X-rays, photographic techniques are now replaced by electronic PSD's

New T-LADI uses thermal neutrons, more efficient interior read-out optics, vertical geometry allowing use of cryostats, furnaces, magnets, pressure cells

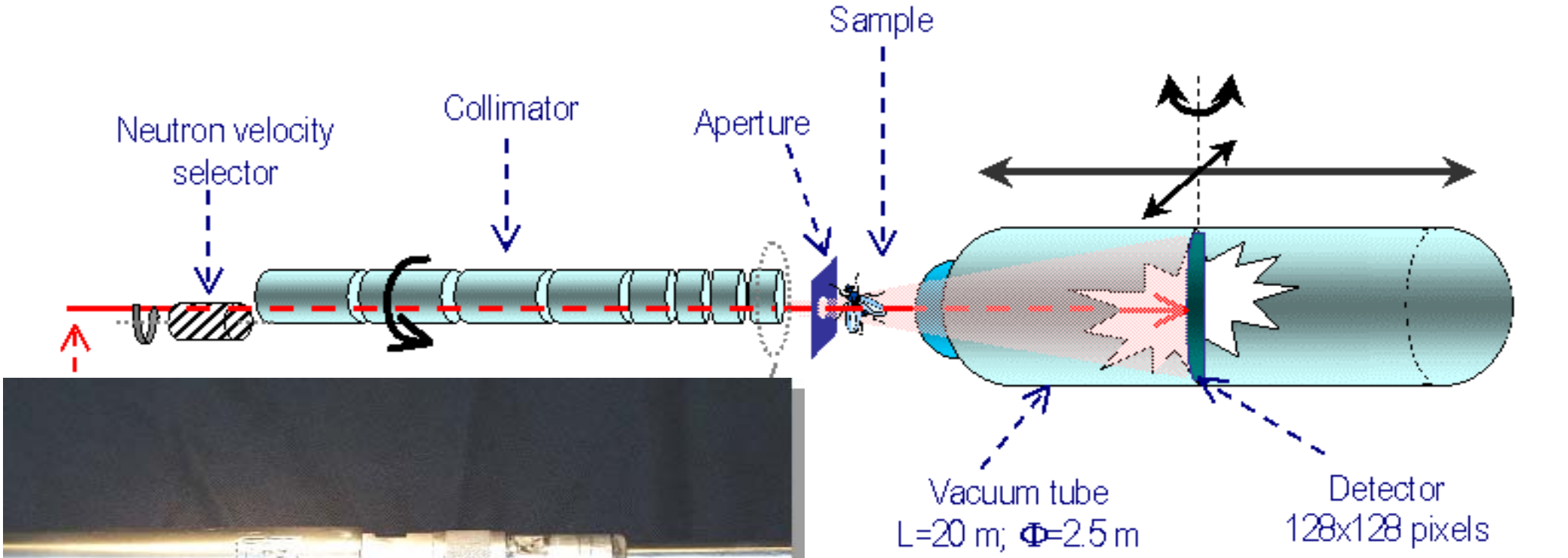
VIVALDI – Thermal neutron image-plate for physics, chemistry and materials science

- vertical detector to allow extreme sample environments
- single-crystal diffraction will be as 'easy' and as fast as powder diffraction



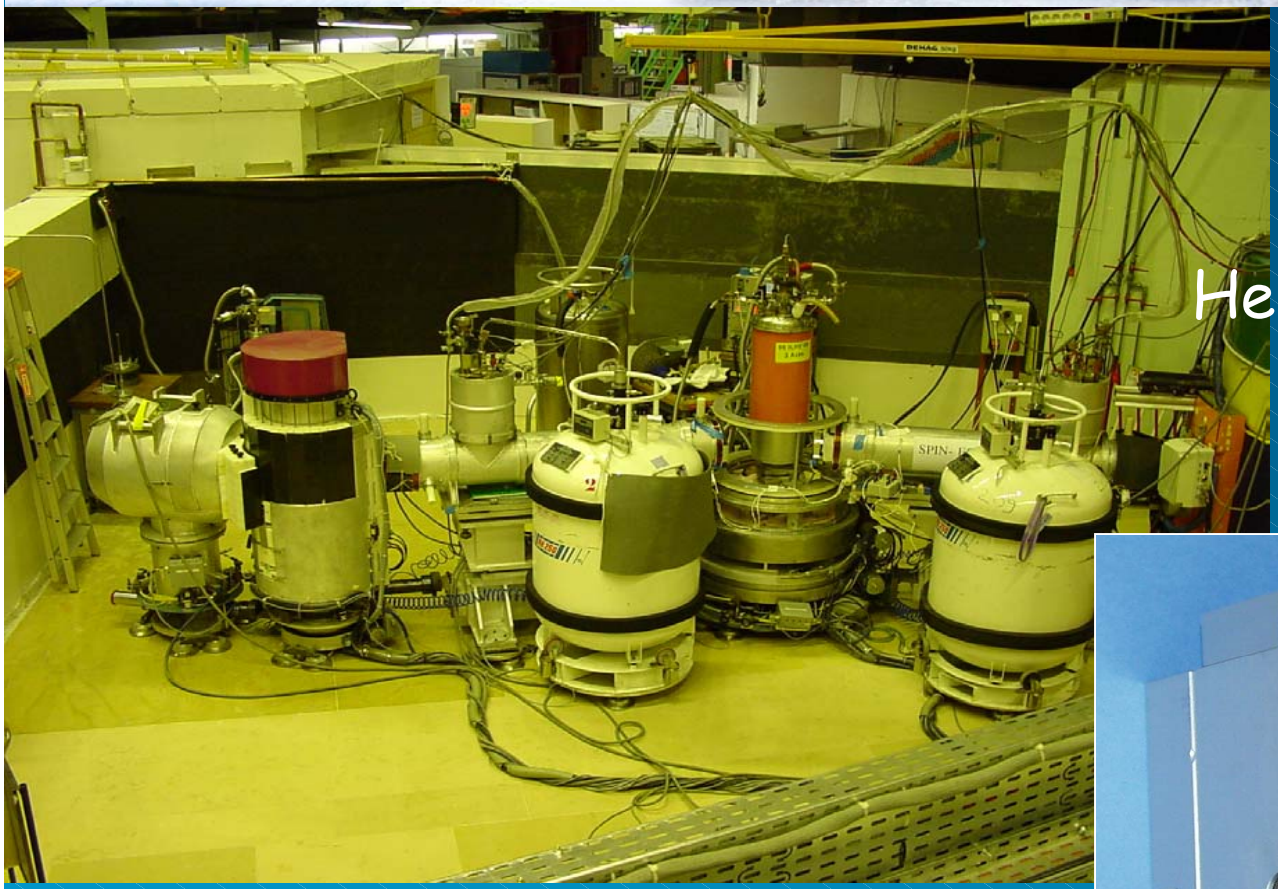
Laue diffraction pattern of incommensurate $La_2Co_{1.7}$ - within a day of the first neutrons: 23/11/01 !

D22 High Speed SANS Detector (5 MHz)

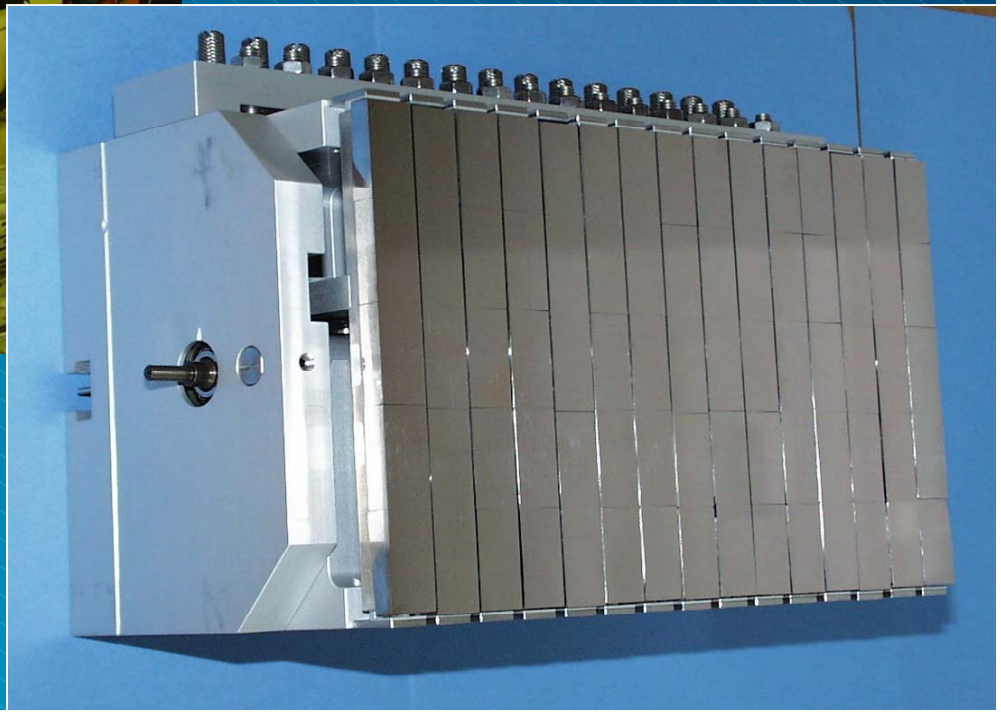


A 2D array of fine linear wire detectors

IN20 3-axis Polarisation Analysis



Heusler Monochromator



X10 increase in polarised flux