A four-bounce crystal monochromator for the I20 beamline at Diamond

- Beamline I20
- Why we chose a 4BCM
- Specs and how they are being met;
- Key features
- Prototypes
- Test results to date

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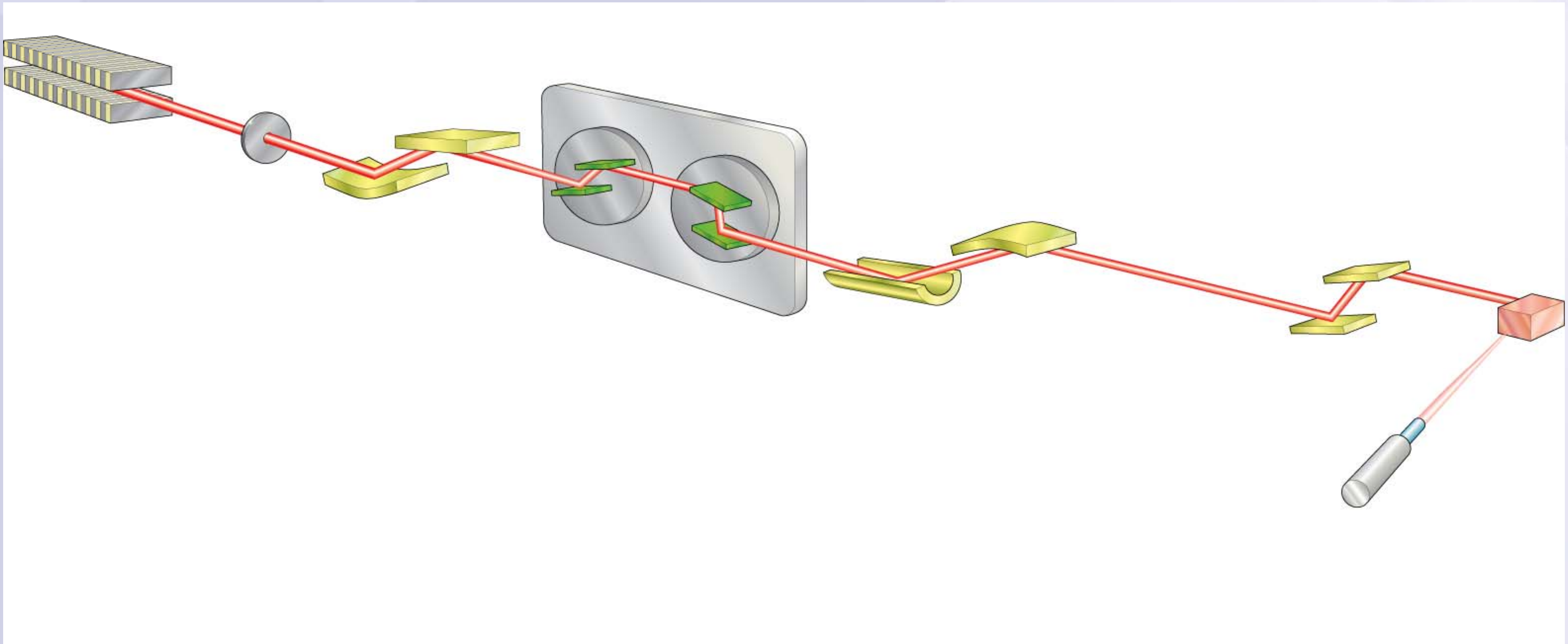
A four-bounce crystal monochromator for the I20 beamline at Diamond



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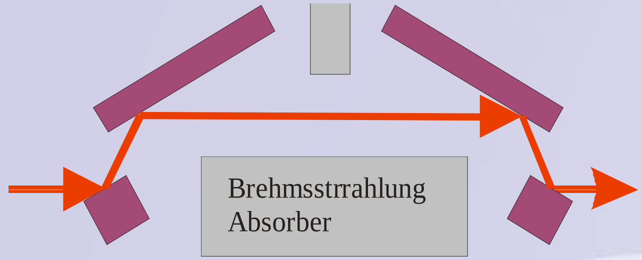
I20 scanning XAS specs

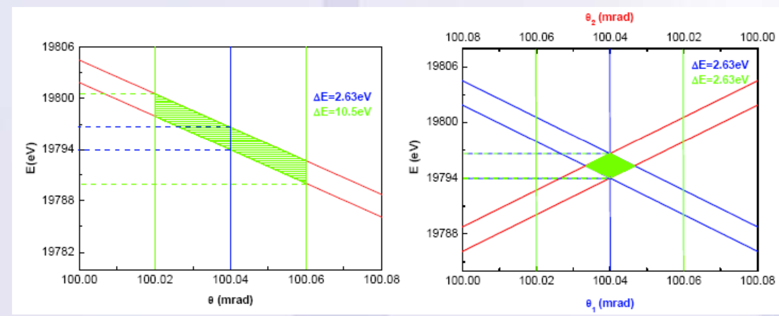
- Energy range : 4-34keV
- Band-pass (dE/E) : 10^{-4}-10^{-5} with Si(111) and Si(311)
- Beam size at sample : ~400μm x 300μm FWHM (hxv)
- Photon flux : ~10^{13} ph/s at 10keV with Si(111)
- Energy stability at sample : 10^{-4}-10^{-5} with Si(111) and Si(311)
- Source : 2Tesla Hybrid Wiggler, 2m long
- Aperture : 0.8mrad(h) x 0.12mrad(v)

Four bounces: high stability

- A fixed exit by geometry
- No ‘slave’ motions
- High stability
- High reproducibility
- Stable beam position; errors cause intensity variation, not position change



High quality photons



The energy resolution of the four-bounce monochromator is independent of the divergence of the incident beam, as shown in the DuMond diagrams.

The tails of the reflectivity curves are also reduced giving improved data with thick samples

The compromise, of course, is fewer photons!

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4BCM Specifications

- Simulations carried out by DLS Optics Group*

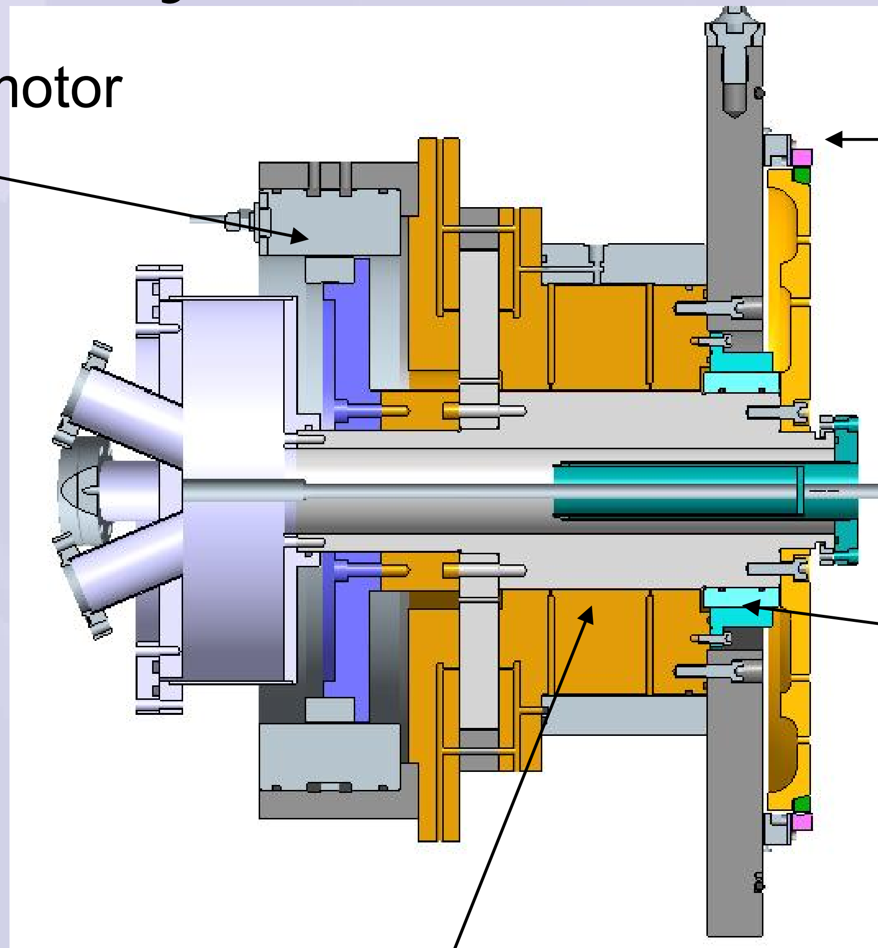
Parameter		
Energy range	4-34keV	
Band-pass (dE/E)	10^{-4}-10^{-5}	With Si(111) and Si(311)
Pitch error between axis 1 & axis 2	1.5μrad	From this is derived the static repeatability of each axis
Static repeatability of each axis	±0.3μrad	
Pitch error between crystal 1 & 2	0.2μrad	
Roll error between crystal 1 & 2	2μrad	
Roll error between first and second crystal pairs	1mrad	Must be aligned with opposite rolls to 100μrad
Pitch adjustment to correct for thermal variation of d-spacing	1.75μrad	

* Performance of multi-crystal Bragg X-ray spectrometers under the influence of angular misalignments
J.P. Sutter, G. Duller, S. Hayama, U. Wagner, S. Diaz-Moreno
NIMA 589 (2008) 118–131

Key features

Multipole direct-drive motor

In-vacuum
encoder

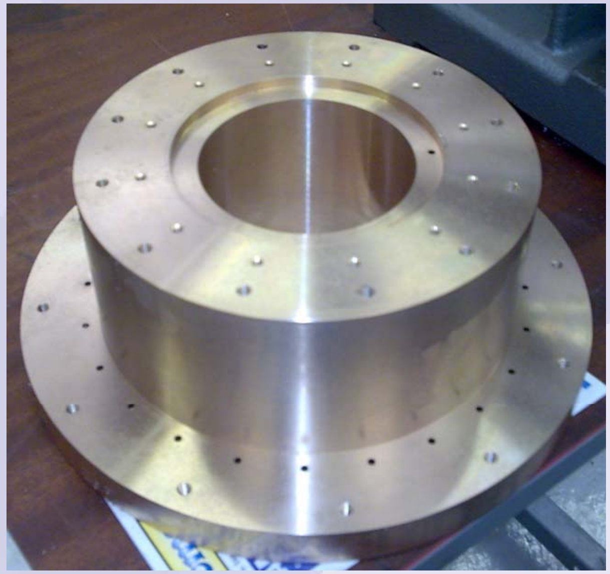


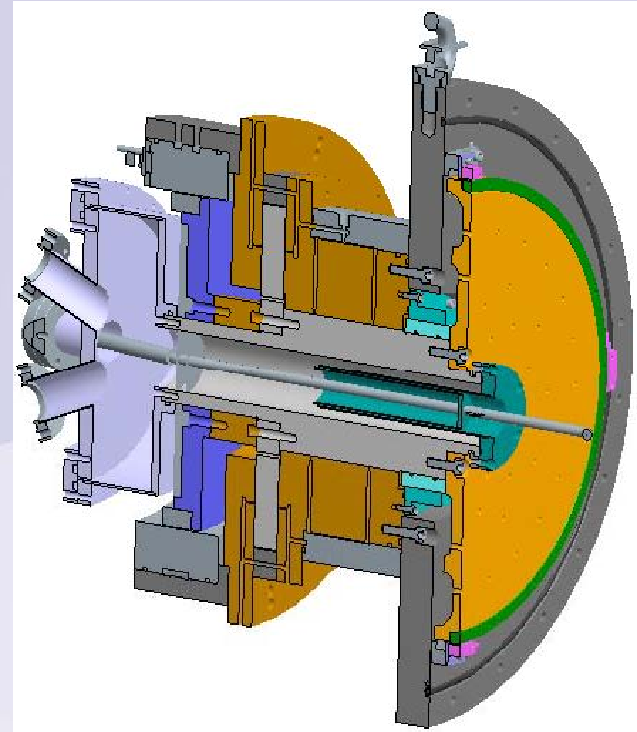
Ferrofluidic seal

Control
system

Air bearing

Air bearing

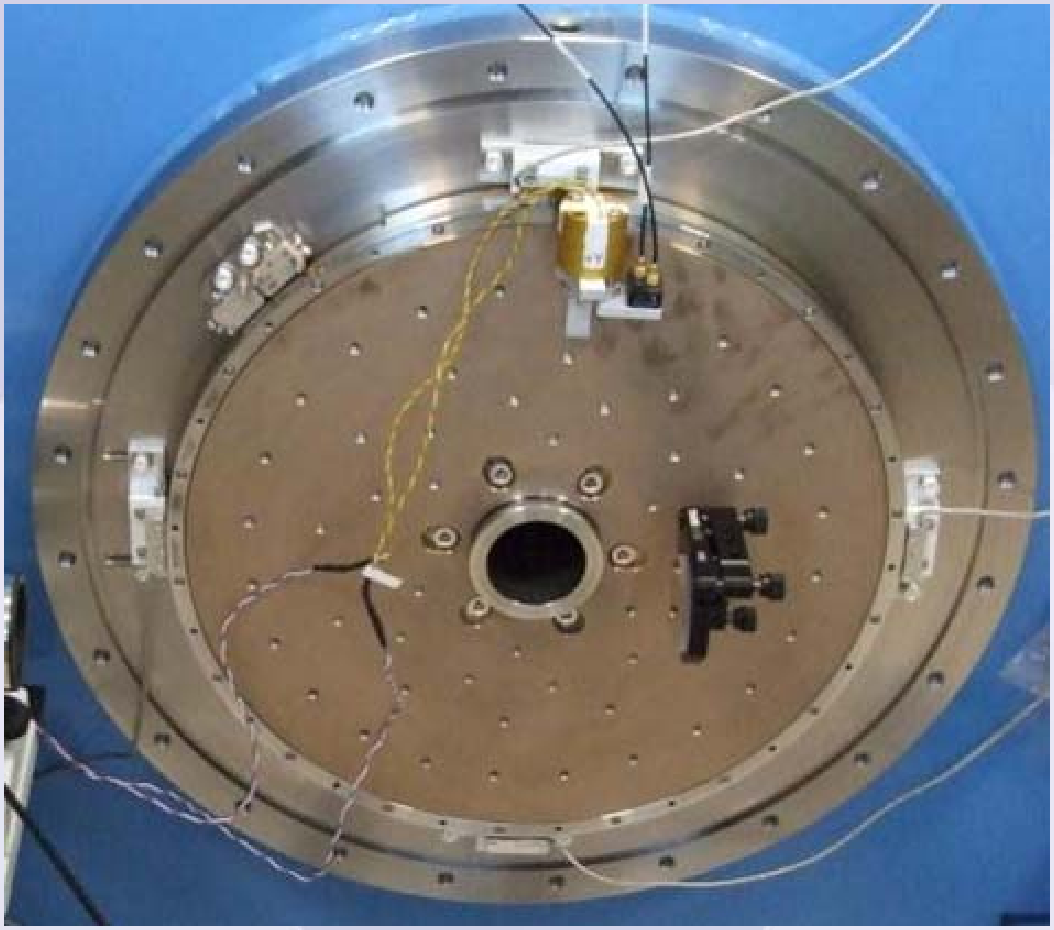




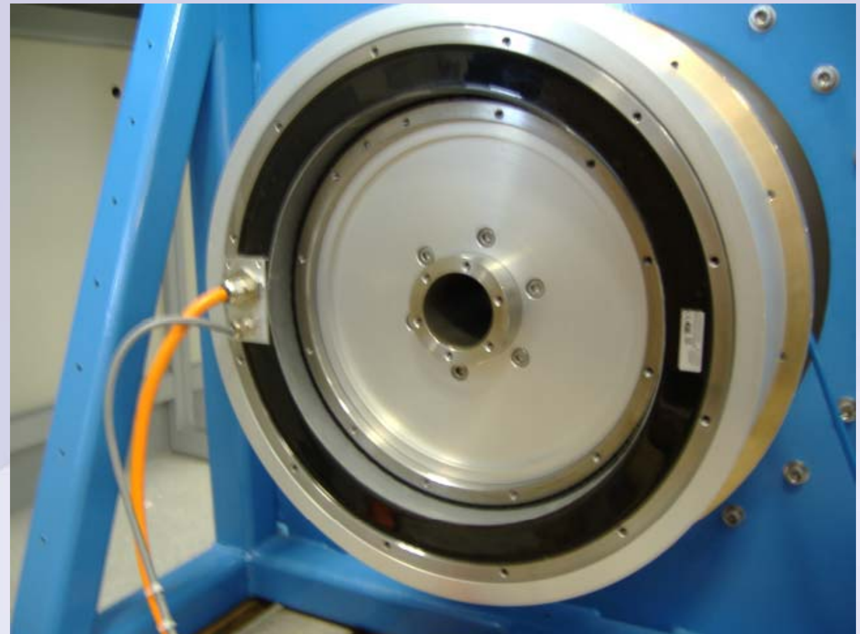
- A stiff bearing (radial, $2.6.10^{8}$N/m, tip 1.10^{7}Nm/rad) with virtually no friction or stiction
- No wearing parts, so no change in performance over very long periods
- Two-part bearing, a 125mm shaft for radial stiffness, and a large diameter disk bearing for axial and torsional stiffness
- Clearances of 10micron +/-2micron
- Lead Bronze housings for its stability and ease of machining
- Stainless steel shaft, ground to suit housing
- Designed and built by FFD, Romsey, Hants

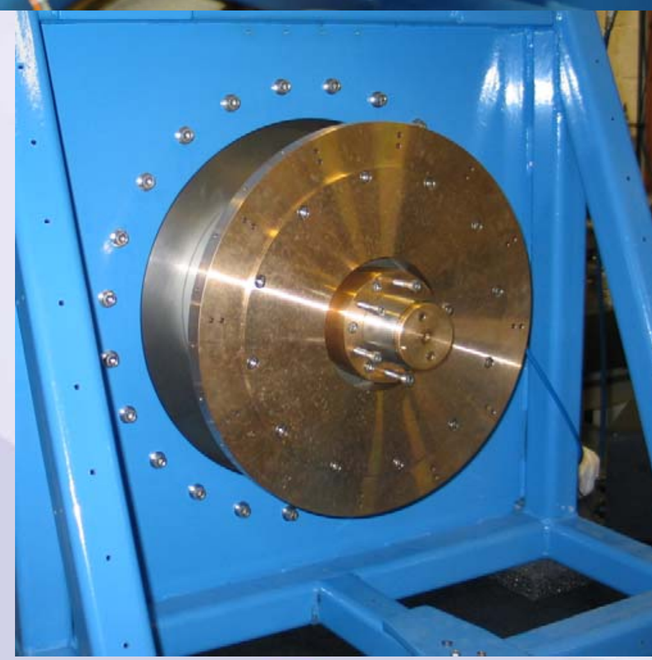
Encoders

- Renishaw encoder ring with 20micron line spacing
- Mounted to a lead bronze disk to ease alignment
- 63800 lines
- 2000:1 interpolation
- 4 readheads
- Smallest measurable step (1 readhead) 50nrad
- All standard parts
- Final decision on placing of readheads shortly



Multipole direct drive motor

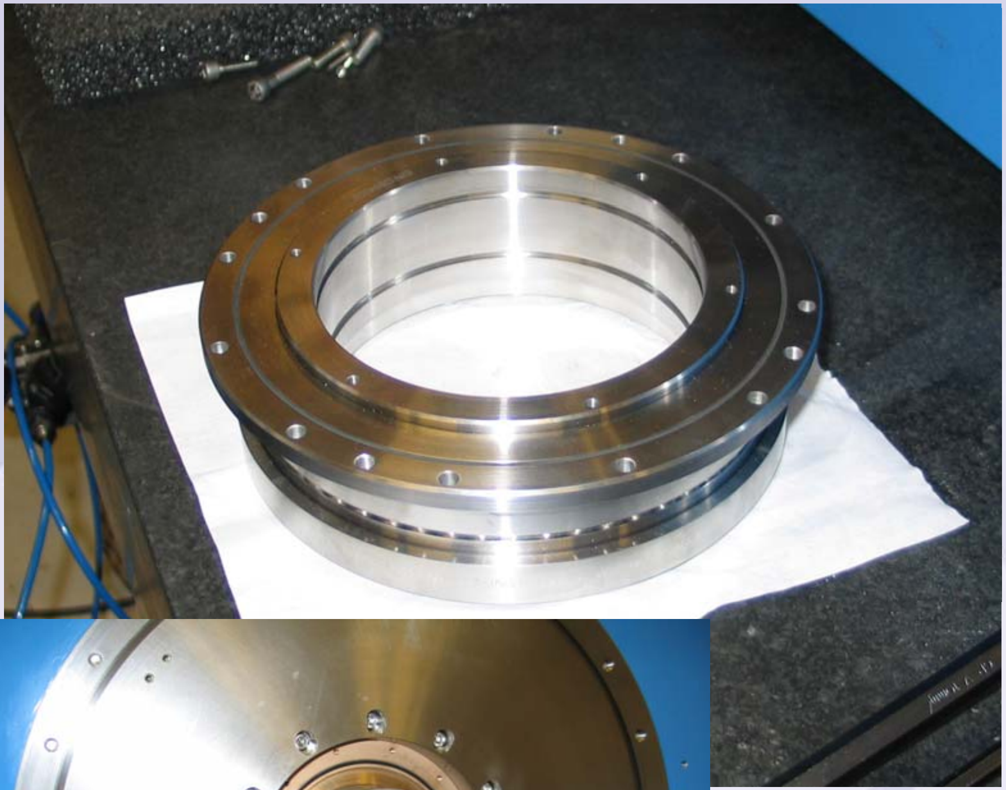


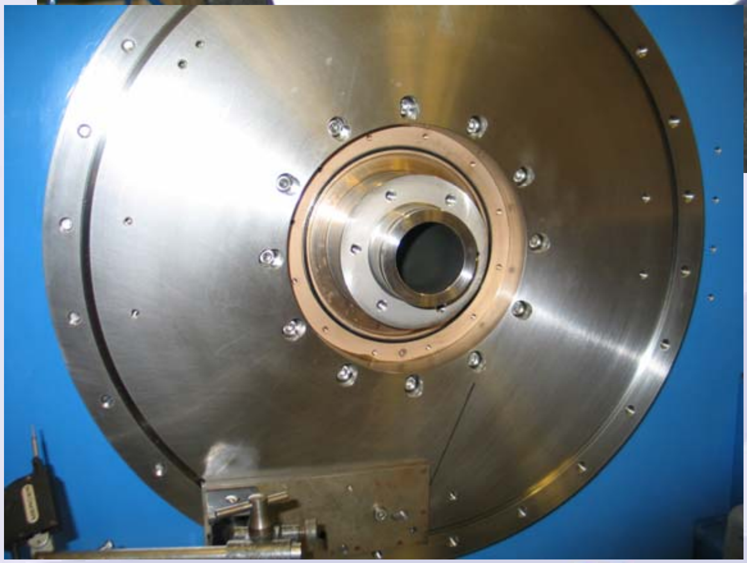


- High polecount (66) for improved resolution
- Potential for water cooling (if required for thermal stabilisation)
- Standard Etel component, generally used for high torque positioning duties or low speed rotation (windings are different for high speed devices)

Ferrofluidic seal

- Pre-assembled cartridge seal
- Ferrofluid suitable for 10^{-10}mbar operation, at 1bar differential
- O-ring sealed to shaft and to air bearing housing
- 100micron radial clearance
- Requires only very short nose extension to shaft
- Viscous damping appears to assist the control system
- Custom design by Ferrotec

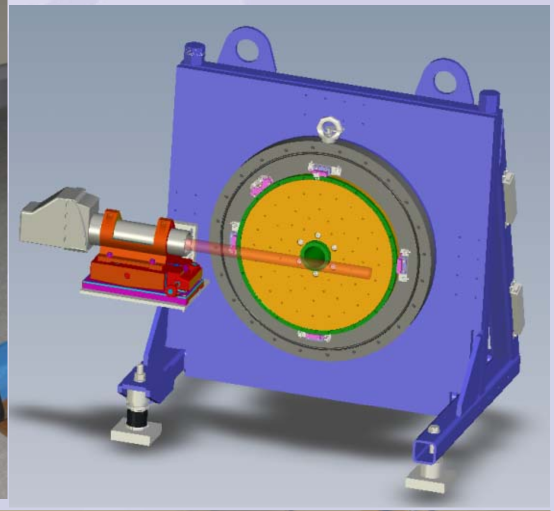


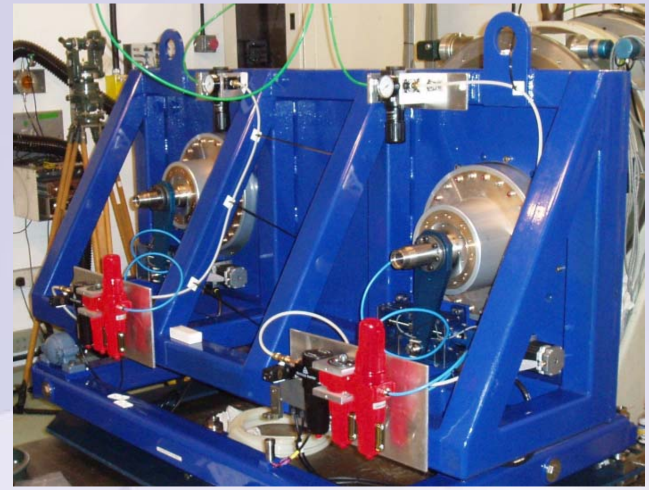


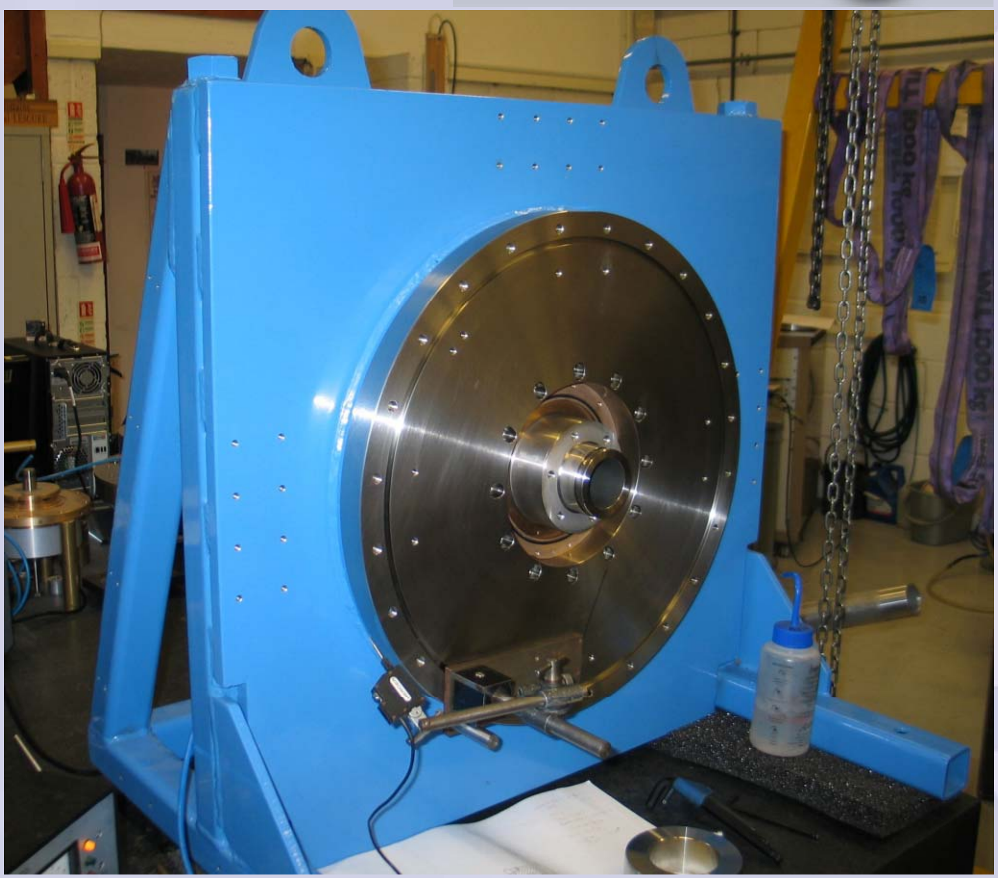
Prototyping

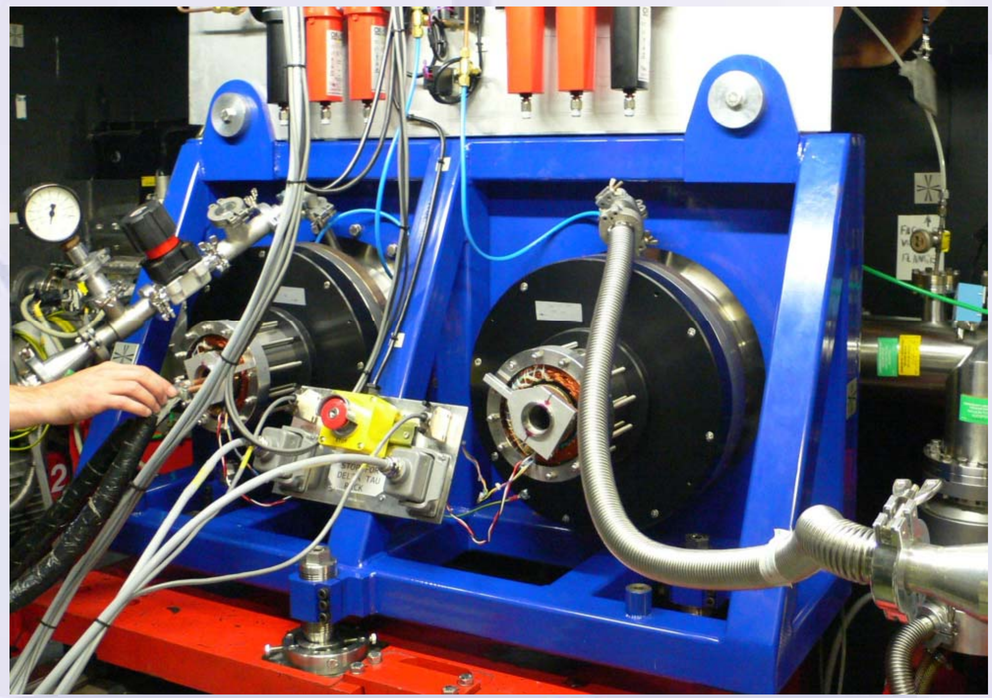
- STFC produced a prototype 4BCM with small direct drive motor, water-cooled Si(111) channel-cut crystals, and with differentially pumped seal. Recently tested with X-rays on Diamond's test beamline, B16.
- This has lead us to develop a prototype single axis to test some of the enhancements planned;
  - High pole-count motors
  - Very large diameter encoders with multiple readheads
  - Ferrofluidic vacuum sealing
- DLS prototype axis is complete, and has been tested in optics lab conditions

Prototyping





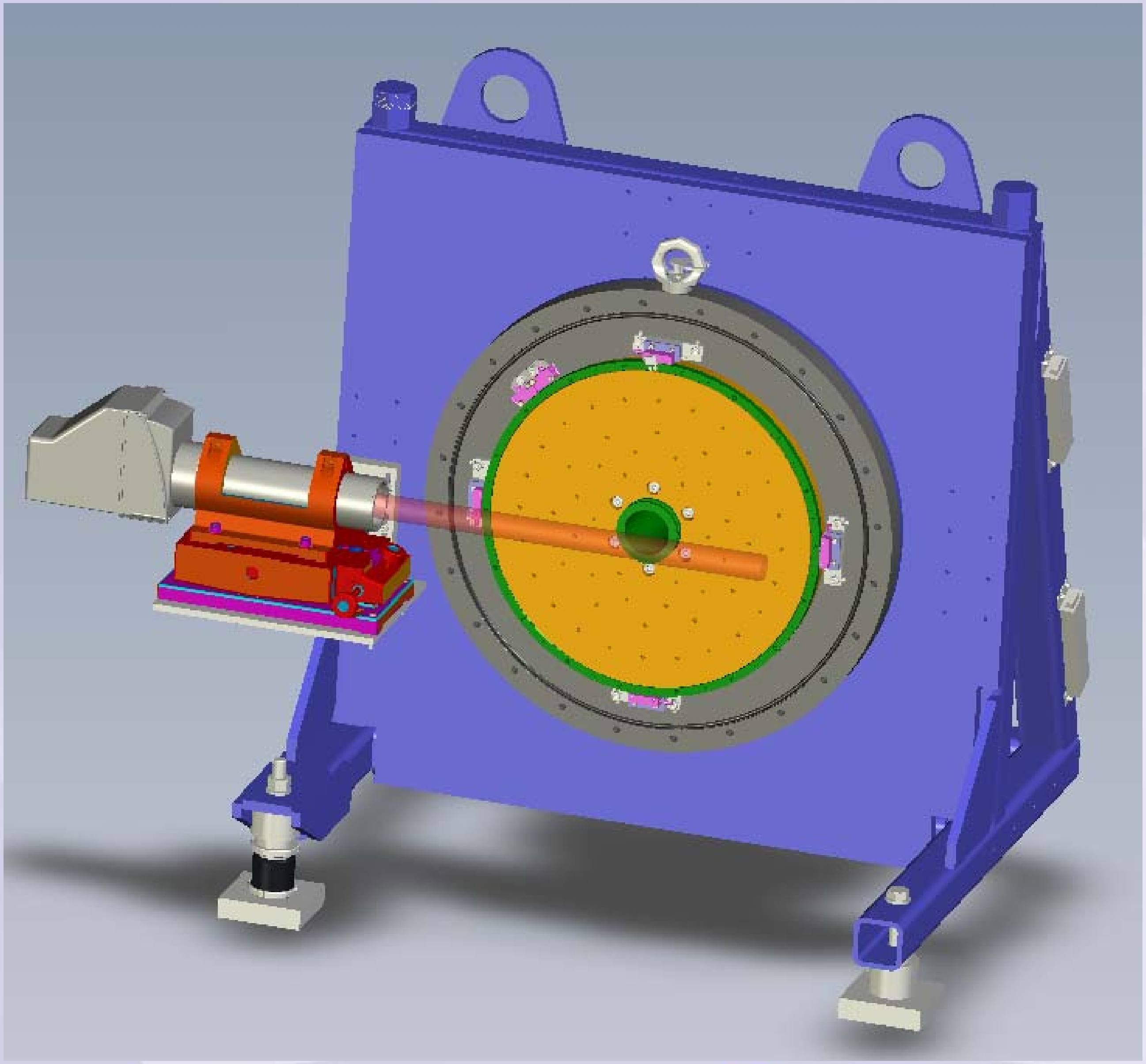




diamond

Testing

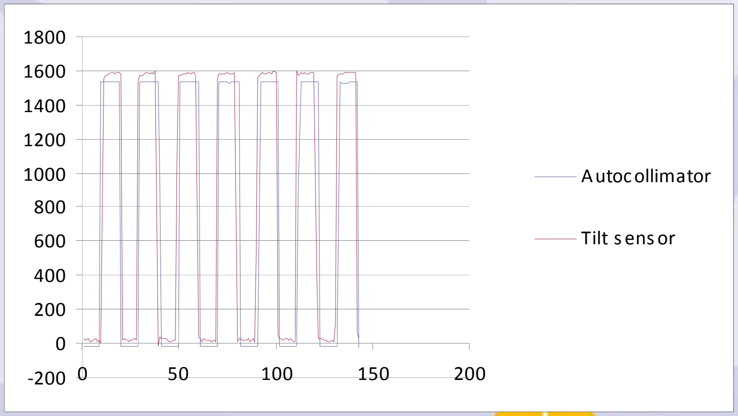
- Instrumentation;
  - Autocollimator
  - Readheads
  - Tilt sensor
  - Seismometers
- Measurements;
  - Repeatability
  - Resolution & Linearity
  - Stability
  - (Stiffness & vibration performance) not yet complete



Test results Prototype axis

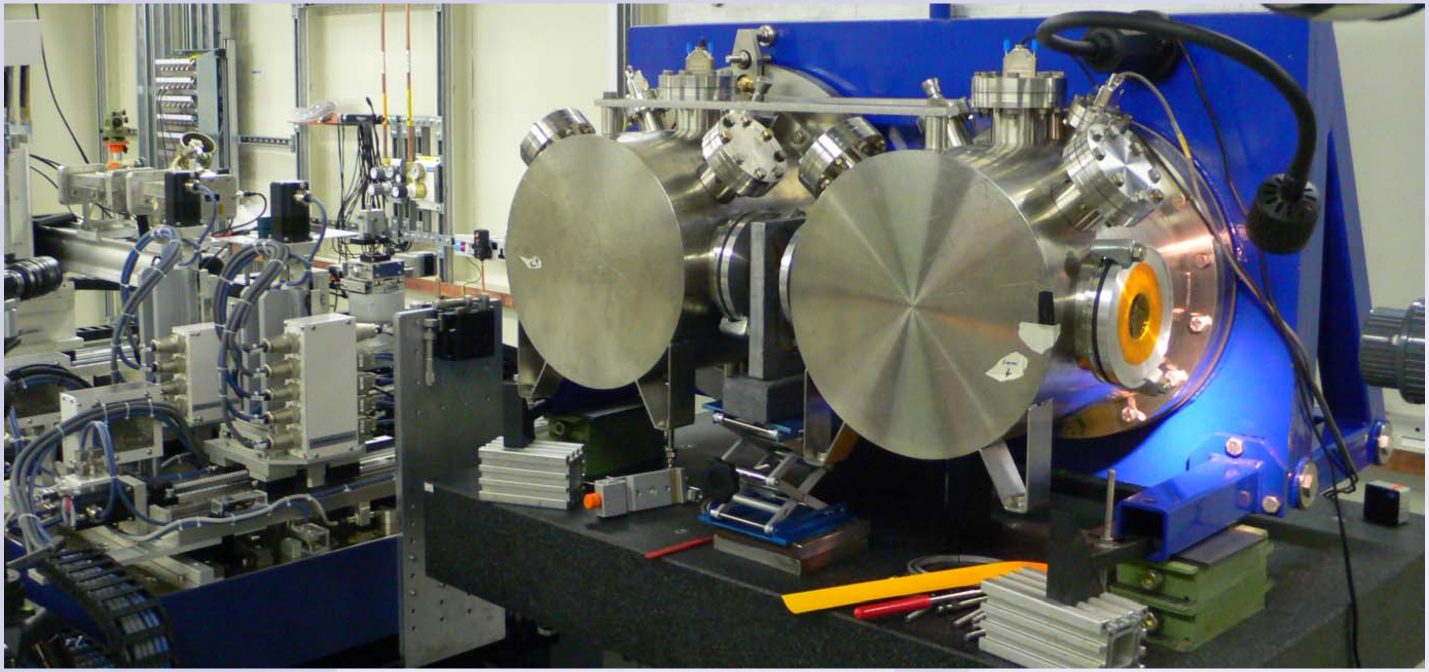
Stability test. Data from control system. >90% within +/-100nrad

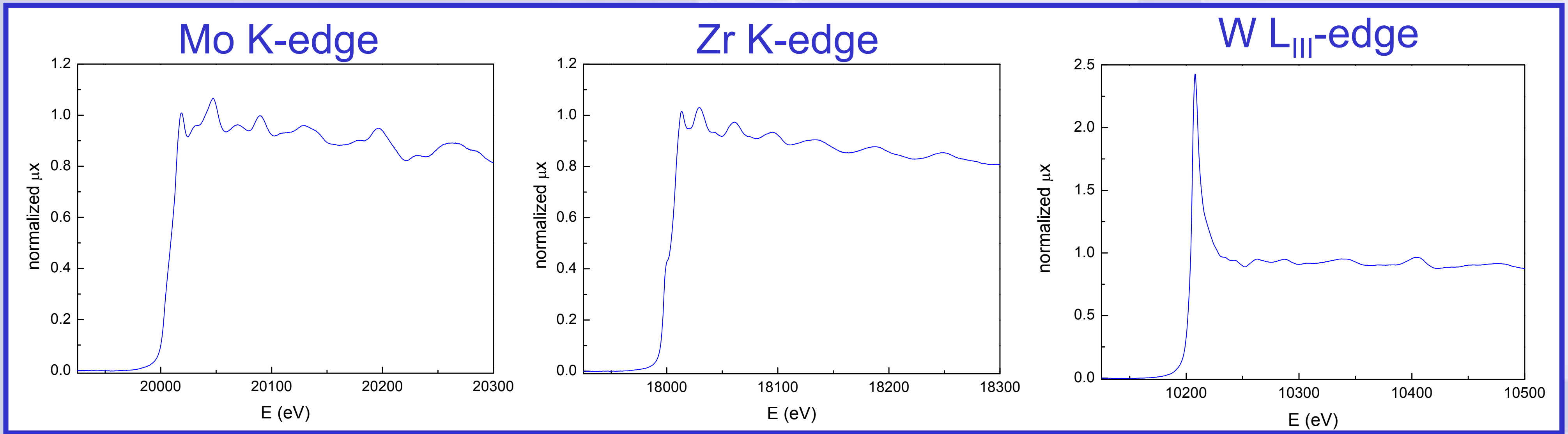
Step & return test results from autocollimator and tilt sensor.
Data in μrad, step commanded, 1551.4μrad.
Step measured by autocollimator; 1551.6μrad



Test results STFC prototype 4BCM

STFC 4BCM installed in B16 EH, May'08





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Thanks

- Beamline staff; Sofia Diaz-Moreno & Shusaku Hayama
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- Data Acq; Stuart Campbell