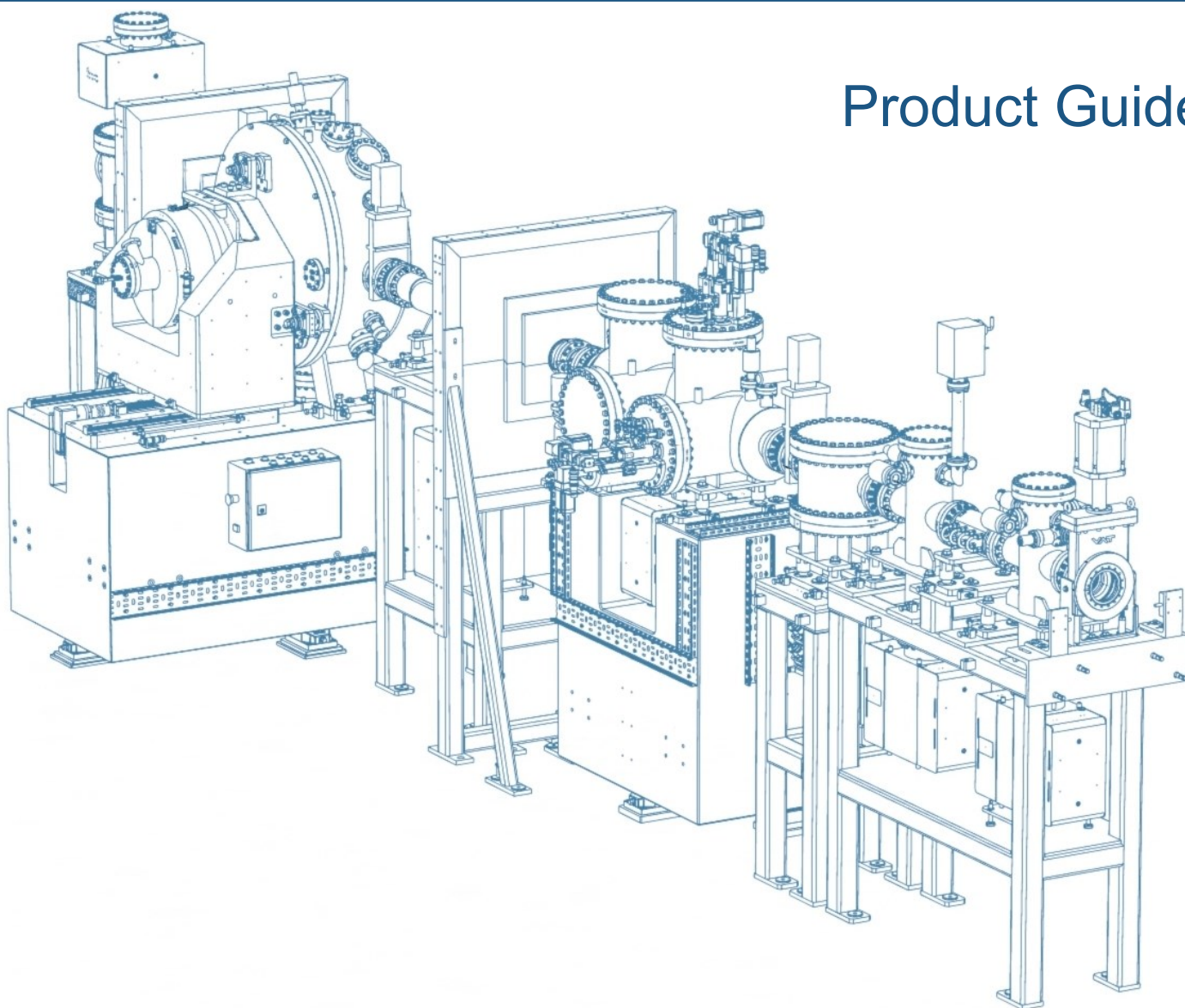


idt

instrument design technology

Product Guide



Beamline Engineering Excellence

Complete Beamlines

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Complete Beamlines

IDT have a proven capability in delivering complete beamlines as turnkey solutions. We can provide a variety of components and services including:

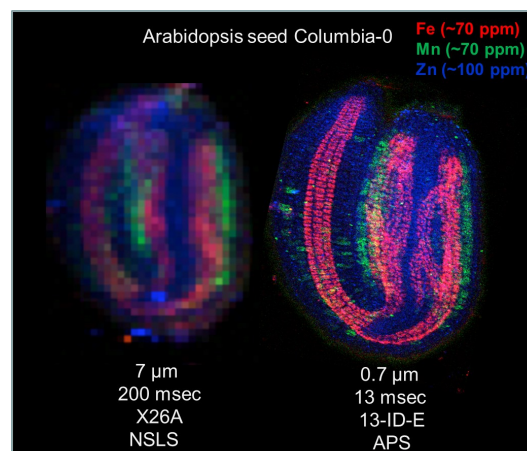
- Detailed beamline design & layout.
- Optical component design, including FEA and raytracing.
- Supply of beamline components, including, monochromators, mirrors, power management
- components, diagnostics, radiation safety components & experimental equipment.
- Controls hardware & EPICS software.
- Testing, installation & commissioning.

GSECARS Sector 13 Upgrade at the Advanced Photon Source

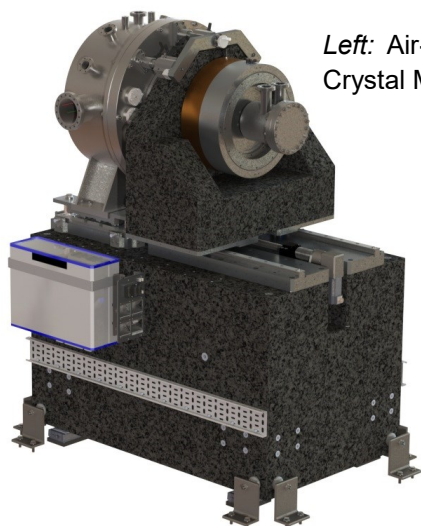
- Dual canted undulator primary slits.
- DCM upgrade for canted geometry.
- New air bearing DCM.
- Double horizontal mirror system.
- Beam stops, pinhole, secondary source apertures.
- Multi-function beam position monitors.
- Small KB mirror system.
- Measured beamline stability of **54 nrad** (see p21).

GSECARS has undergone an upgrade to a canted undulator layout. IDT have designed & built all the first optics enclosure components plus other beamline components as part of this upgrade.

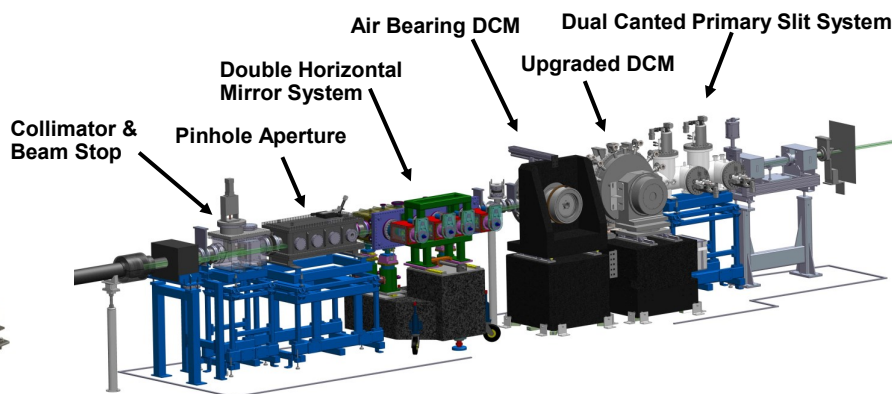
The first optics enclosure features a dual primary slit system for both canted beams which are suitable for operation at 200mA ring current, an upgrade to the existing DCM for the canted beam geometry plus a new air-bearing DCM, a double horizontal focusing mirror system as well as beam conditioning components. IDT also provided a Secondary Source Aperture, a family of multi-functional beam position monitors, and a Small KB Mirror System.



Above: XRF imaging data from upgraded GSECARS ID-E beamline. High spatial resolution (500nm) with high flux ($>10^{11}$ ph/s)



Left: Air-Bearing Double Crystal Monochromator.



X-Ray Fluorescence Microprobe Beamline

at the Australian Synchrotron

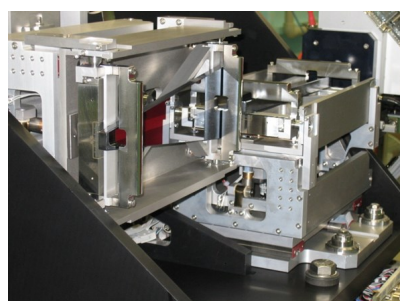
- Horizontally focusing striped mirror with novel water cooling for zero vibration transmission to optic.
- Cryo-cooled horizontally deflecting double crystal monochromator (Si(111) & Si(311)) with unique cooling interface for zero vibration transmission to crystals.
- High power slits & cooled mask for windowless interface to front end & undulator.
- Beam diagnostics including high resolution CCD camera & quad diode system.
- Horizontal & vertical secondary source aperture with sub-micron repeatability.
- Small KB mirrors (240mm long) in helium environment.
- 44 axis motion control & EPICS software.
- Measured stability of **18 nrad** (see page 13).

IDT designed, built & installed the X-ray fluorescence microprobe beamline at the Australian Synchrotron. This extensive turnkey project included the supply of all beamline optical components, beam transport & beamline control system. IDT were also responsible for on-site installation & full commissioning.

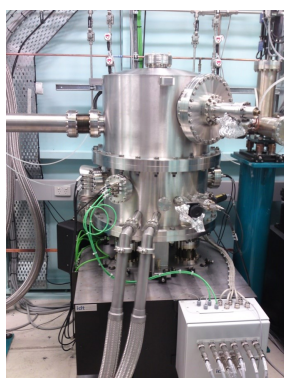
The beamline features a horizontally deflecting mirror & monochromator, each designed for maximum stability & minimum vibration.

Scope of supply:

- Design & layout of beamline & all components, including ray tracing and finite element analysis.
- Assembly & factory testing of optical components.
- EPICS based beamline control system.
- Delivery & on-site installation.
- Full commissioning of beamline.



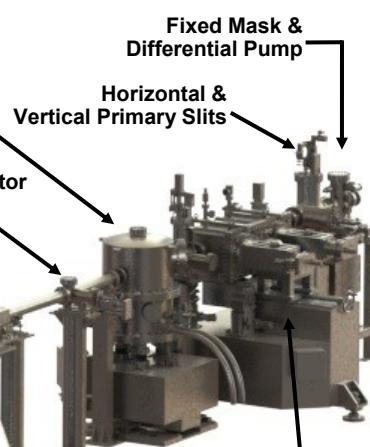
Small KB Mirror System
(in end station)



Horizontal Double
Crystal Monochromator

Multi-function
Beam Position Monitor

Beam Defining
Aperture

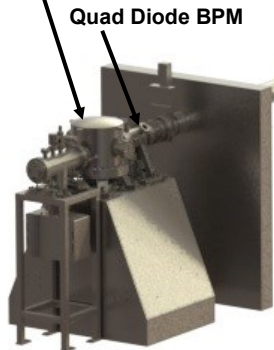


Fixed Mask &
Differential Pump

Horizontal &
Vertical Primary Slits

Secondary Source Aperture

Quad Diode BPM



Shielded Transport

Horizontally Focusing Mirror

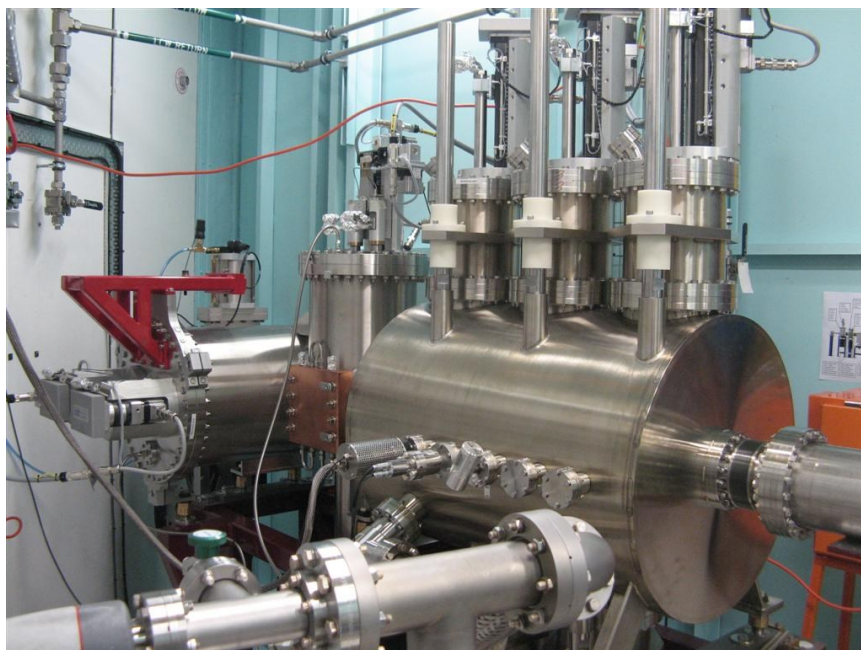


Imaging & Medical Beamline at the Australian Synchrotron

- Fixed 5mrad mask absorbing >8kW wiggler radiation.
- Very high heat load primary slits capable of absorbing >7kW per blade.
- 5-axis graphite filters capable of absorbing >6kW.
- Thermal photon stop.
- Safety shutter.
- Double Laue Monochromator with energy range 16keV - 100keV.

The Imaging & Medical Beamline at the Australian Synchrotron is a 150m long beamline for high-resolution, phase contrast x-ray imaging of biomedical samples. The beamline source is a superconducting multipole wiggler, with a total power output of >20kW.

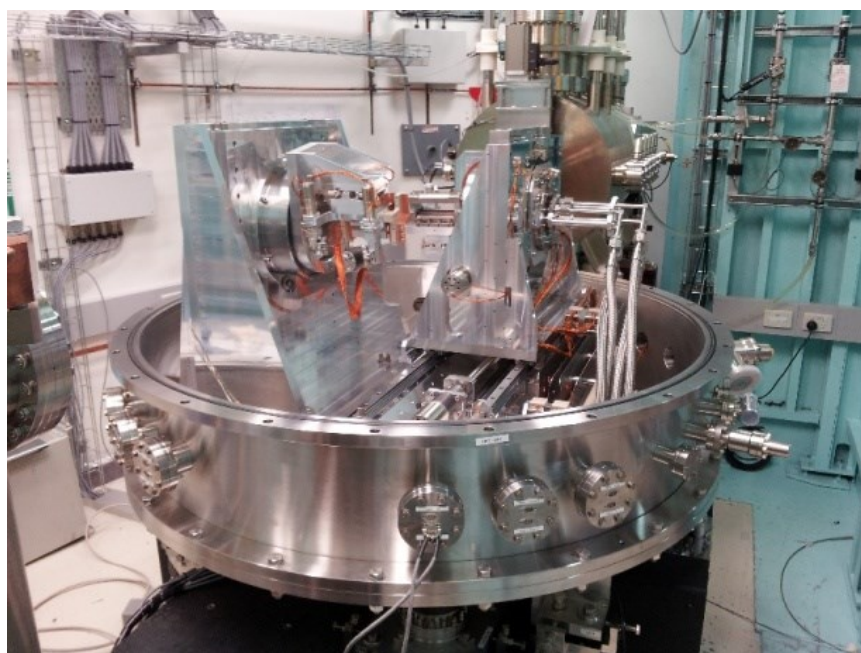
IDT designed, manufactured & tested the beam conditioning equipment in the first optics enclosure, including very high heat load slits, filters, fixed mask and beam stops, designed to handle the very high power output of the wiggler. IDT also designed, built, tested and installed a Double Laue Monochromator, designed for stability due to the large mono-to-sample distances involved.



Above: Primary slits and 5-axis filter system.

Below left: Very high heat load vertical slit system.

Below right: Double Laue Monochromator.



Hard X-Ray Micro Analysis Beamline

at the Canadian Light Source

IDT designed, built & installed the multi-function Hard X-Ray Micro Analysis (HXMA) beamline at the Canadian light source, used for a variety of techniques such as XAFS and powder diffraction.

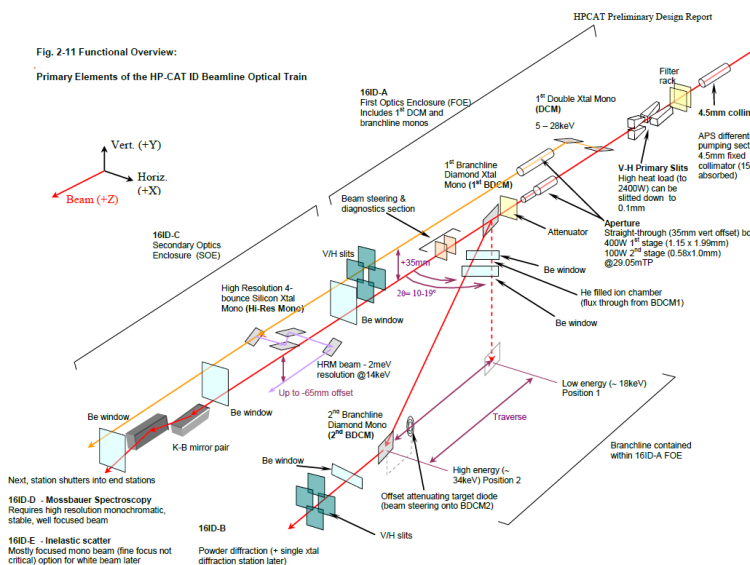
HXMA is a wiggler beamline requiring cutting-edge solutions for high heat load components.

The project included the design, assembly, testing and on-site installation of a collimating mirror, a double-toroidal focusing mirror, primary slits, filters, beam diagnostics (including tungsten vane monitors and fluorescent screen) and a family of experimental tables.



HPCAT Sector 16

at the Advanced Photon Source



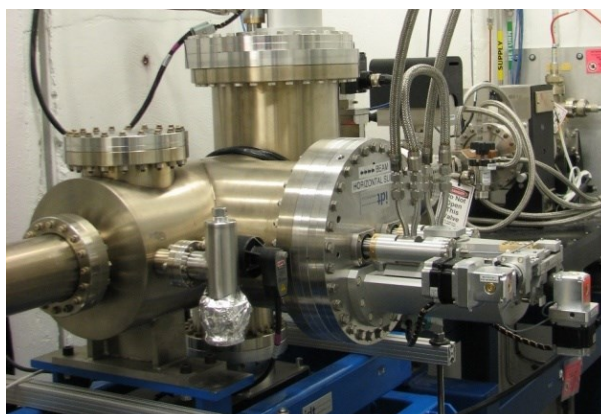
IDT were tasked with the full design of HPCAT (Sector 16) at the Advanced Photon source, from the optical concept stage through to full engineering solutions. The project scope was for a full sector layout, including hutch design.

HPCAT is a complex multi-function beamline sector with an insertion device and bending magnet source.

IDT also supplied many hardware systems including a large offset monochromator, a high resolution monochromator, a large KB mirror system, high heat load slits plus a full 3 metre spectrometer and several experimental tables.

HPCAT has since undergone an upgrade to a canted undulator layout. IDT have designed, built & tested the upgraded beam conditioning components, which are rated for 200mA ring current operation, including dual canted primary slit systems, beam apertures and beam stops.

Right: Canted undulator primary slit system installed on HPCAT.

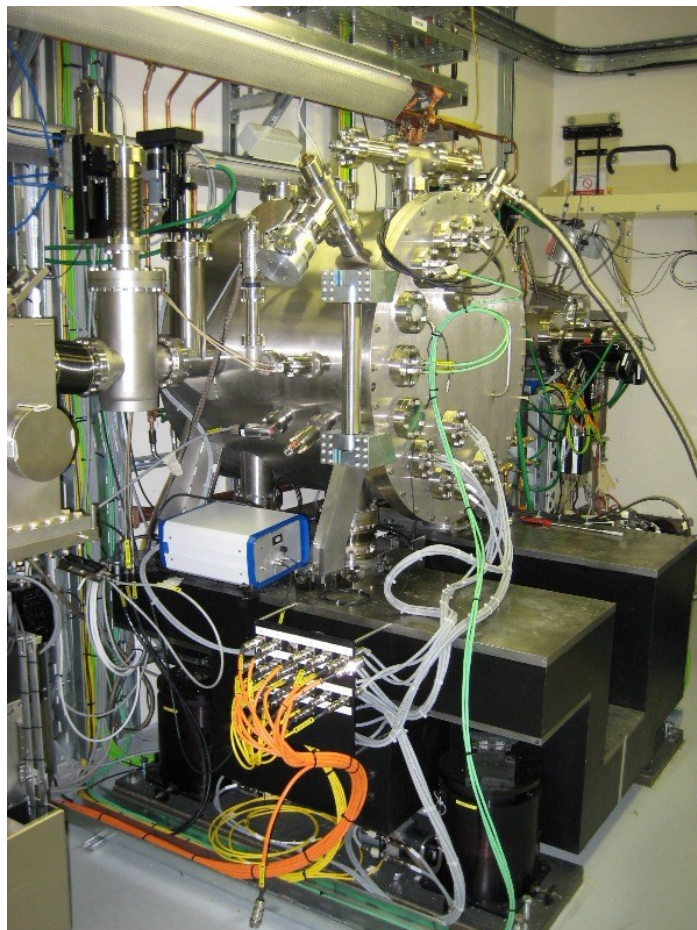


Monochromator Systems

IDT have developed a wide range of monochromators with market leading performance for synchrotron facilities around the world.

Key features of IDT Monochromators:

- Every monochromator is fully tailored to the specific individual needs of the customer.
- Unique thermal isolation approach for minimal thermo-mechanical drift, removing the need for water stabilisation circuits and/or heaters.
- Novel crystal cooling solutions designed for the specific beam profile & heat load.
- Ultra-stiff mechanics and rotary tables, with highly reliable mechanisms.
- Monochromator mechanics mounted directly onto granite base blocks and entirely decoupled from vacuum vessel.
- Multiple encoders on Bragg axis.
- UHV compatible DC servo motors, as options.
- Factory energy scan tests using custom laser quad diode system.



IDT monochromators in operation:

9-BM X-Ray Absorption Spectroscopy Beamline at the APS.

Air-bearing DCM with two direct water-cooled crystal sets.

MRCAT Sector 10 at the APS.

Air-bearing DCM with two cryo-cooled crystal sets, suitable for canted undulator geometry.

GSECARS Sector 13 at the APS.

Air-bearing DCM with two cryo-cooled crystal sets, suitable for canted undulator geometry.

I14 Hard X-Ray Nanoprobe beamline at Diamond Light Source.

Ultra-stable horizontally deflecting cryo-cooled DCM.

B18 Core EXAFS beamline at Diamond Light Source.

Fixed offset double crystal monochromator featuring two crystal sets (Si(111) & Si(311)) with direct water cooling & DC Servo bragg motor for quick EXAFS mode.

B21 SAXS beamline at Diamond Light Source.

Fixed offset double crystal monochromator featuring Si(111) crystals with direct water cooling and sagittal crystal bender.

Imaging and Medical beamline at the Australian Synchrotron.

Double Laue monochromator with variable mono beam offset.

X-ray Fluorescence Microprobe beamline at the Australian Synchrotron.

Cryo-cooled horizontally deflecting fixed offset double crystal monochromator with two crystal sets (Si(111) & Si(311)) and novel crystal cooling for zero vibration transmission to optic.

B16 Test beamline at Diamond Light Source.

Directly water cooled fixed offset double crystal monochromator.

I04.1 Monochromatic MX beamline at Diamond Light Source.

Branching monochromator with indirect water cooling for zero vibration transmission to optic.

I15 Extreme Conditions beamline at Diamond Light Source.

Cryo-cooled fixed offset double crystal monochromator.

Upgrade on GSECARS Sector 13 at the APS

Upgrade to existing double crystal monochromator for canted undulator geometry featuring new crystal cage with two cryo-cooled crystal sets.

Upgrade on DUBBLE CRG at the ESRF.

Upgrade to existing double crystal monochromator for bending magnet beamline featuring new crystal cage with two water-cooled crystal sets.

Air Bearing DCM

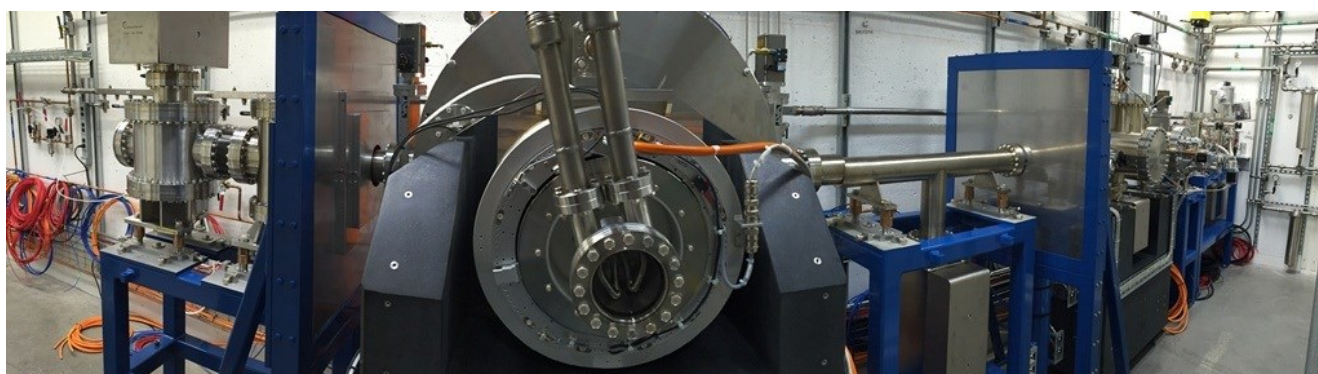
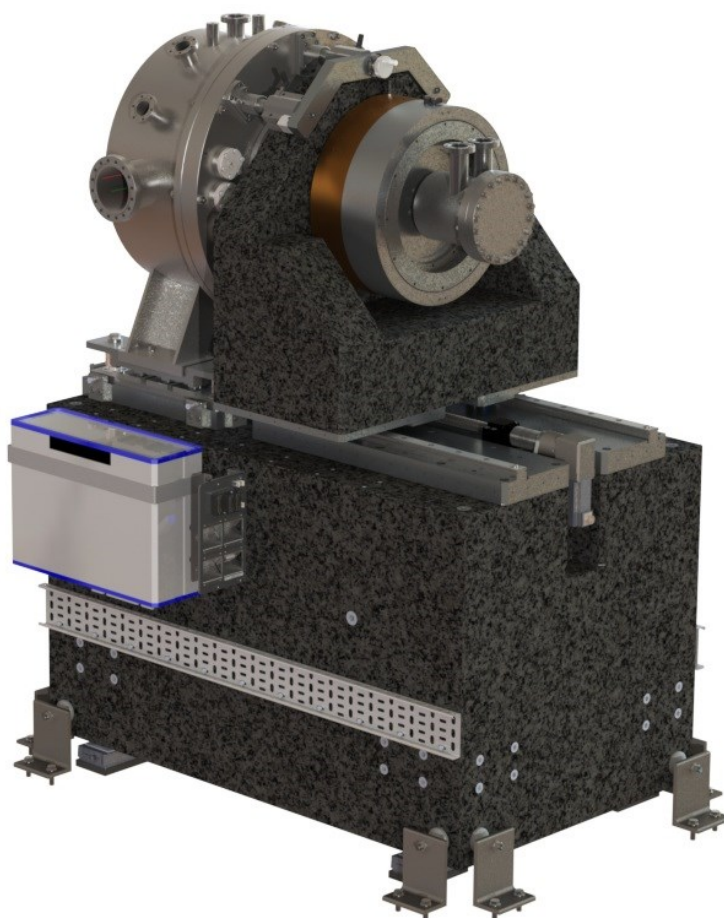
IDT have developed an air bearing rotary stage, based upon a licenced goniometer* from STFC, as part of our program of continuous development of cutting-edge monochromators

The combination of this air bearing goniometer with our proven ultra-stable crystal cage mechanics provides a world class platform for DCM operation and offers significant improvements over other mechanical goniometers, with a frictionless & ultra-smooth Bragg drive with no degradation or wear over time. Other features of the air-bearing goniometer include:

- Very high radial stiffness of 270N/μm created by 10μm air film.
- Zero backlash & no mechanical hysteresis.
- No contact points, only a 10μm air film.
- For mechanical tables the rotational speed is limited by the high ratio gearbox; with a direct drive air bearing the speed is limited by the motor torque.
- High speed direct drive torque motor with variable Bragg speed greater than 20°/sec achievable.
- External Bragg encoder with Renishaw DSI ring encoder technology.
- Measured angular stability of **54 nrad**.

The high Bragg speeds achievable are ideal for Quick EXAFS operation. The DCM can also be operated in step-scan mode with the distinct advantage of no wear or degradation over time.

IDT have installed air bearing monochromators on GSECARS, MR-CAT and 9-BM at the APS, SMI and XFM at NSLS-II and XAS at the Australian Synchrotron



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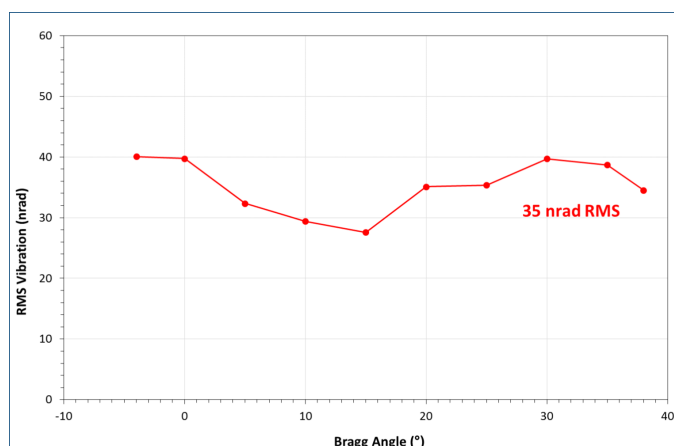
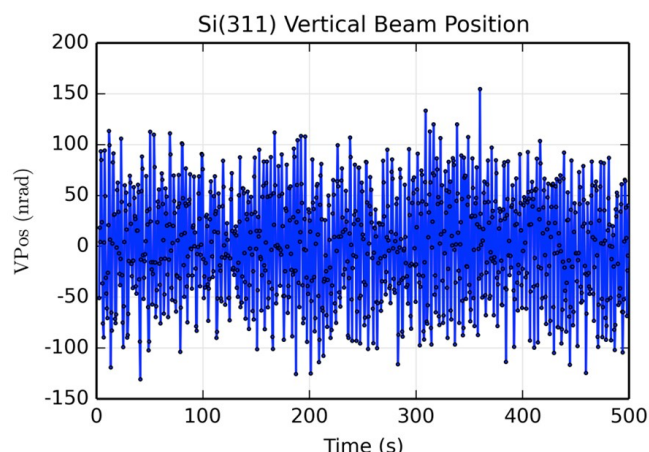
Technical Data of Air Bearing DCM:

AXIS	RANGE	RESOLUTION	REPEATABILITY
Bragg Angle <i>Direct drive motor</i>	<i>as required</i>	Encoder resolution <0.08 μ rad	$\pm 0.20\mu$ rad
2nd crystal gap <i>Used to maintain fixed offset</i>	<i>as required</i>	0.1 μ m /half step	$\pm 0.20\mu$ m
2nd crystal coarse pitch <i>Stepper motor driven</i>	$\pm 1^\circ$	0.45 μ rad /half step	$\pm 0.26\mu$ rad
2nd crystal fine pitch <i>Piezo driven</i>	320 μ rad	<50nrad	<<1 μ rad
2nd crystal coarse roll <i>Stepper motor driven</i>	$\pm 1^\circ$	0.63 μ rad /half step	$\pm 0.33\mu$ rad
2nd crystal fine roll <i>Piezo driven</i>	450 μ rad	<50nrad	<<1 μ rad
Horizontal crystal exchange <i>Entire air-bearing assembly is translated outside the vacuum</i>	<i>as required</i>	<5 μ m	$\pm 1\mu$ m

54 nrad measured stability

The stability of the GSECARS beamline has been measured to be 54nrad. This stability measurement included the effects of the air-bearing DCM as well as an IDT-built double horizontal mirror system. The plot to the right shows the beam position over 500 seconds, standard deviation of beam angle: **54 nrad**.

See pages 20 - 21 for more details.



Bragg axis static stability

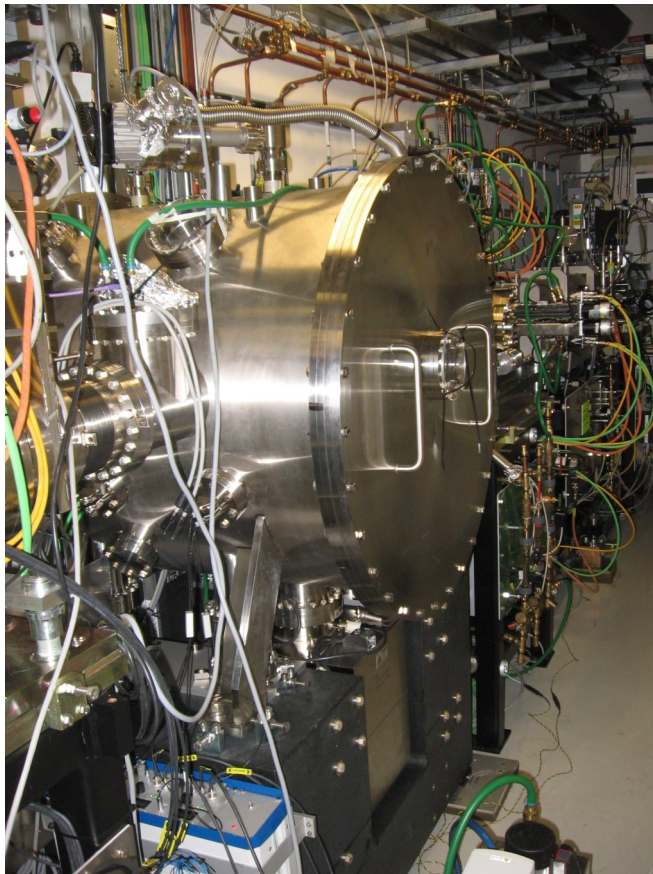
The many applications of an air bearing DCM (XAFS, pseudo channel-cut mode etc) rely fundamentally on the stability of the Bragg drive in maintaining its position once commanded to sit at a particular energy. IDT have been able to directly measure the static stability of our Bragg rotation stage by sampling the closed loop encoder output directly over a 10s time frame as a function of Bragg angle, yielding an average static stability of 35 nrad across the angular range of the DCM.

Bending Magnet DCM

The IDT Bending Magnet DCM features a direct water-cooled first crystal with a novel small bore cooling arrangement designed to match the specific beam footprint to minimise thermal gradients. Other features of the monochromator are:

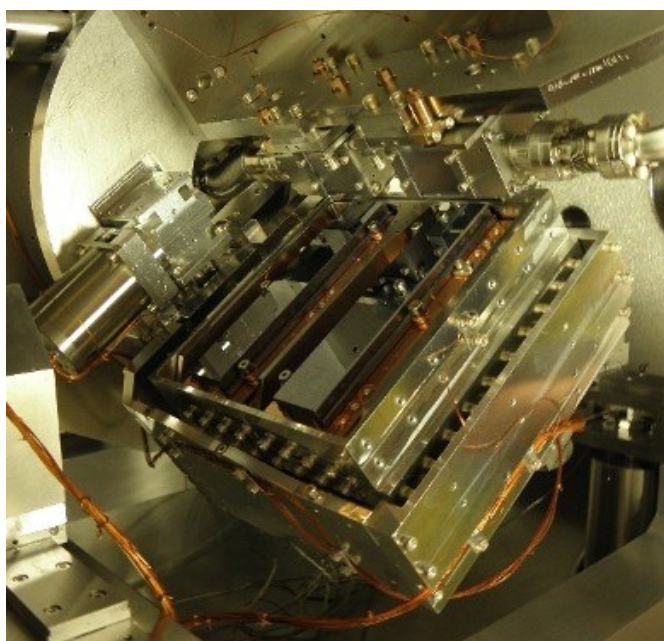
- High precision, ultra-stiff rotary table.
- Stepper or DC servo driven Bragg axis.
- Cooling circuits running via central bore of main rotary table.
- Guard vacuum on water cooling circuit to prevent water-to-vacuum joints.
- Access to crystal cage via sliding door.
- Full extraction of crystal cage on simple linear rails for maintenance.
- Very compact footprint in optics enclosure.
- High vacuum level 5×10^{-8} mbar.
- Very stable base block of natural granite.
- In-vacuum encoder system.
- EPICS control system.

IDT have installed bending magnet monochromators on beamlines B16, B18 and B21 at Diamond Light Source, and on the DUBBLE CRG at the ESRF.



The bending magnet DCM installed on beamline B18 at Diamond Light Source is designed to perform Quick EXAFS experiments and features a DC servo-driven Bragg axis for high Bragg speeds. The DCM is required to operate in scanning mode. Beam stability during the scan is therefore very important. The DCM has completed over 150,000 scans since installation.

- Energy range 2.05keV - 35keV
- Si(111) & Si(311) crystal sets in single chamber with automated crystal exchange.
- Step, quick & continuous scanning EXAFS mode.
- Vertically deflecting bounce-down geometry with 25mm fixed beam offset.
- High speed scanning mode of several °/sec.



Technical Data of Quick EXAFS DCM:

AXIS	RANGE	RESOLUTION	REPEATABILITY
Bragg Angle <i>DC Servo motor driven with speeds of several°/sec</i>	<i>as required</i>	0.16μrad /encoder step	±0.5μrad
2nd crystal gap <i>Translates 2nd crystal perpendicular to 1st crystal surface, used to maintain fixed offset</i>	<i>as required</i>	0.25μm /full step	±0.3μm
2nd crystal coarse pitch <i>Stepper motor driven</i>	±1°	0.55μrad /half step	±0.5μrad
2nd crystal fine pitch <i>Piezo driven</i>	400μrad	<50nrad	<<1μrad
2nd crystal roll <i>Stepper motor driven</i>	±1°	0.53μrad /half step	±0.4μrad
2nd crystal fine roll <i>Piezo driven</i>	400μrad	<50nrad	<<1μrad
Horizontal crystal exchange	<i>as required</i>	0.5μm /full step	±0.13μm

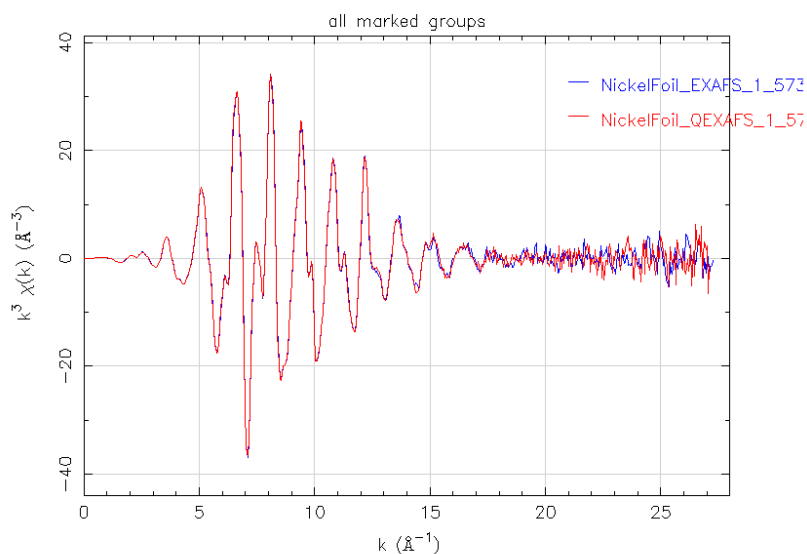
Right: Nickel foil Quick EXAFS scan with B18 DCM.

Blue is a standard 50 minute step scan, 1-5s per point.

Red is a Quick EXAFS scan in 1 minute, 25ms per point.

Measured spot stability was between 0.5μm - 1.0μm rms at a distance to sample of 14.5m.

Data courtesy of Diamond Light Source.



Cryo-Cooled Horizontally Deflecting DCM

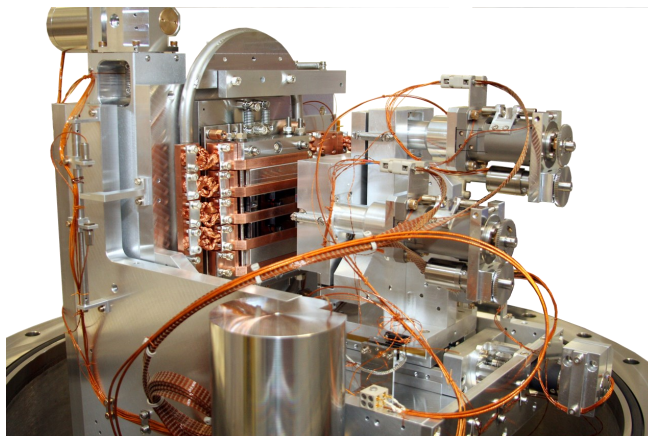
installed on XFM Beamline at the Australian Synchrotron

The IDT DCM installed on the X-ray Fluorescence Microprobe beamline at the Australian Synchrotron is a horizontally deflecting fixed-offset monochromator operating over an energy range of 4keV - 25keV, with Si(111) & Si(311) crystal sets in single chamber

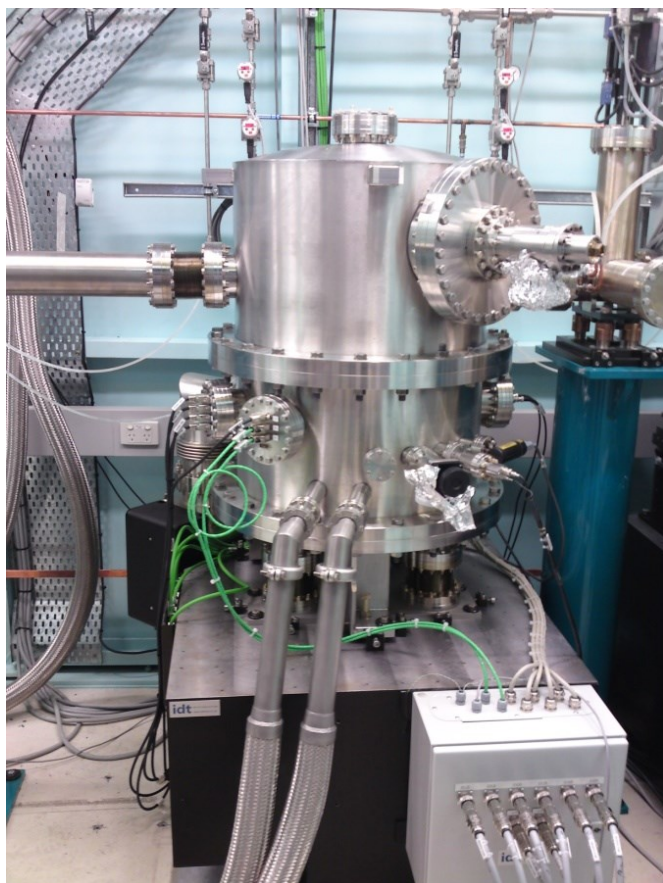
The DCM features a novel cryo-cooling system with soft annealed copper couplings giving minimal vibration transmission from the cooling circuit to the first crystal while maintaining excellent thermal contact.

Other features of the DCM include:

- Upgrade path for multilayers.
- Ultra stable horizontal deflecting geometry.
- Preservation of undulator coherence.
- High precision, ultra-stiff rotary table.
- Fast piezo feedback for fine control of 2nd crystal pitch & roll.



- Very compact footprint in optics enclosure.
- High vacuum level $<5 \times 10^{-8}$ mbar.
- Ultra stable base block of natural granite with measured amplification factor of 1.0.
- EPICS control system.
- Measured stability of **18 nrad**.



IDT's unique approach of multiple thermal barriers thermally isolates the crystals and cryogenic cooling circuit from the rest of the monochromator.

This prevents thermal leakage into the monochromator mechanics and minimises thermo-mechanical drift, removing the need for water stabilisation circuits and offering exceptional mechanical stability.

Below: DCM thermocouple readings

Double Crystal Monochromator									
DCM Bragg Motor Temp.	20.1	deg C	●						
DCM X Motor Temp.	8.4	deg C	●						
DCM Y Motor Temp.	7.1	deg C	●						
DCM Roll Motor Temp.	11.2	deg C	●						
DCM Pitch Motor Temp.	8.4	deg C	●						
DCM 2nd Xtal Holder T	-177.0	deg C	●						
DCM 1st Xtal Holder T	-180.2	deg C	●	-200.0	-200.0	-170.0	-170.0		
DCM Mask 1 Temp.	-156.3	deg C	●	-200.0	-200.0	-140.0	-140.0		
DCM Mask 2 Temp.	-155.0	deg C	●	-200.0	-200.0	-140.0	-140.0		
DCM 1st Xtal Plate T	3.0	deg C	●						
DCM Rotary Table Plate	6.5	deg C	●						
DCM Main Support Plate	11.3	deg C	●						
DCM Granite Block 1 T	24.1	deg C	●						
DCM Granite Block 2 T	23.8	deg C	●						
BPM Blade Temp.	25.8	deg C	●						
DCM Water Temp.	26.0	deg C	●	20.0	20.0	30.0	30.0		

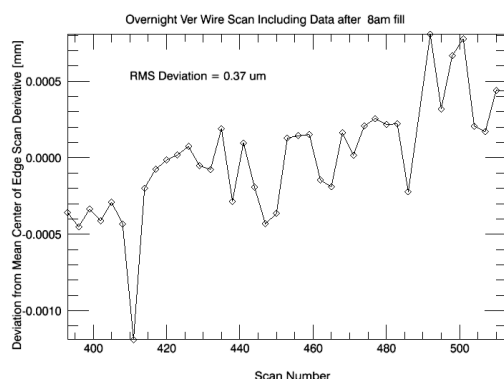
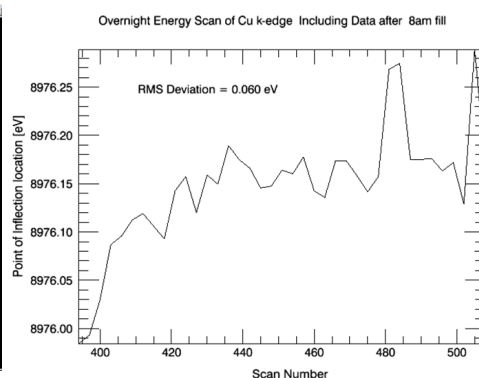
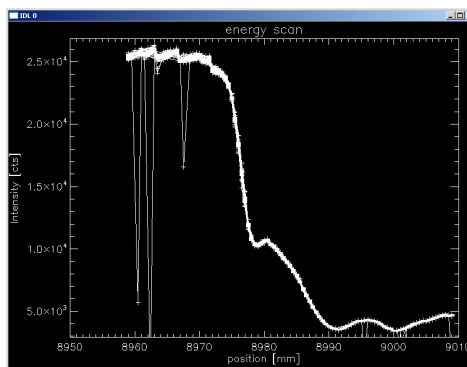
Technical Data of XFM horizontal DCM:

AXIS	RANGE	RESOLUTION	REPEATABILITY
Bragg	-5° to 30°	0.16μrad /encoder step	±0.5μrad
2nd crystal gap <i>Translates 2nd crystal perpendicular to 1st crystal surface, used to maintain fixed offset</i>	10mm	0.2μm /step	±0.7μm
2nd crystal coarse pitch <i>Stepper motor driven</i>	±1°	1.15μrad /step	±0.9μrad
2nd crystal fine pitch <i>Piezo driven</i>	400μrad	<50nrad	<<1μrad
2nd crystal coarse roll <i>Stepper motor driven</i>	±1°	1.29μrad /step	±2.7μrad
2nd crystal fine roll <i>Piezo driven</i>	400μrad	<50nrad	<<1μrad
Vertical crystal exchange	30mm	1.25μm /full step	±1.0μm

Beam stability measurements:

Right: The DCM energy axis was rocked over the Cu K edge 115 times in 10 hours.

The RMS deviation in edge position was 0.06eV.



Left: The beam was locked in the vertical direction at the sample position using the DCM roll piezo.

The position was measured using a wire scan over a 10 hour period. The RMS deviation was 0.37μm.

The DCM-sample distance was 22m, giving an angular stability of **18 nrad**.

Ultra-Stable Horizontal DCM

installed on I14 Hard X-Ray Nanoprobe beamline at Diamond Light Source

IDT have developed an ultra-stable horizontally deflecting Double Crystal Monochromator for the I14 Hard X-Ray Nanoprobe beamline at Diamond Light Source. I14 is a long beamline, extending beyond the main building for 175m. Due to the very long distances involved a highly stable DCM is critical to the beamline goal of a focused spot size of 30nm. The I14 DCM has been designed and engineered with stability as the primary goal.

The first crystal cage has a novel kinematic mounting system to support the crystal on a stable platform about the centre of rotation to ensure no out-of-balance forces, minimising strain in the first crystal.

The DCM is cryo-cooled. The cooling scheme has been carefully designed to minimise vibration effects of turbulent coolant flow.

The mechanism is mounted on a massive granite block, which is supported on ultra-stiff adjustable wedges.

The I14 DCM features:

- 35mm fixed horizontal offset.
- Si(111) crystals with 4 keV - 26 keV energy range.
- Novel first crystal assembly for minimal crystal strain.
- Low mass & high stiffness components for high natural frequencies.
- High precision, ultra-stiff rotary table.
- Fast piezo feedback for fine control of 2nd crystal pitch & roll.
- High vacuum level $<5 \times 10^{-8}$ mbar.
- Mounting provisions for capacitance sensors.

The vibrational performance of the DCM has been measured with capacitance sensors and in-sit with an XBPM. No significant modes of vibration were found below 100 Hz. The first mode was found at 160 Hz with an amplitude of 25 nrad.



AXIS	RANGE	RESOLUTION	REPEATABILITY
Bragg <i>Stepper / rotary table driven</i>	$<0^{\circ}$ to 30°	$1.75\mu\text{rad}$	$0.2\mu\text{rad}$
2nd crystal coarse pitch <i>Stepper motor driven</i>	$\pm 0.7^{\circ}$	$0.73\mu\text{rad}$	$0.6\mu\text{rad}$
2nd crystal fine pitch <i>Piezo driven</i>	$80\mu\text{rad}$	$<50\text{nrad}$	$<<1\mu\text{rad}$
2nd crystal coarse roll <i>Stepper motor driven</i>	$\pm 1^{\circ}$	$1.12\mu\text{rad}$	$0.4\mu\text{rad}$
2nd crystal fine roll <i>Piezo driven</i>	$125\mu\text{rad}$	$<50\text{nrad}$	$<<1\mu\text{rad}$
2nd crystal gap <i>Used to maintain offset</i>	3mm	$0.20\mu\text{m}$	$0.5\mu\text{m}$

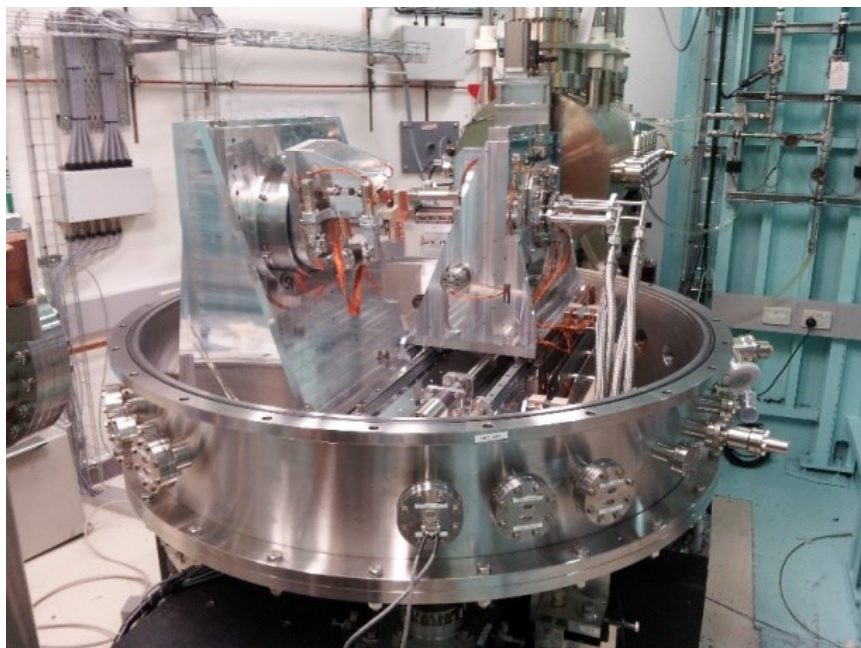
Double Laue-Crystal Monochromator

installed on the Imaging and Medical Beamline at the Australian Synchrotron

The Imaging & Medical Beamline Double Laue Monochromator, designed & built by IDT, is optimised for stability due to the very large sample-mono distance (>150m).

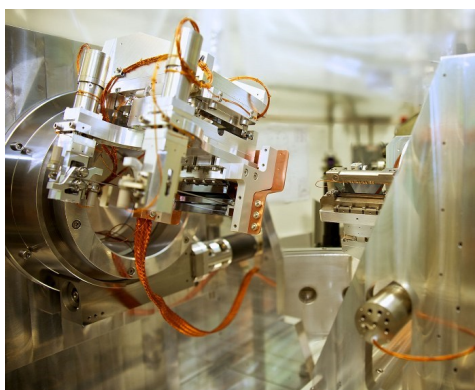
The monochromator is designed with a translating 1st crystal and a fixed 2nd crystal which acts as a fixed energy reference. The first crystal is mounted on a long linear slide with a straightness of $\pm 15\mu\text{m}$ over 500mm travel.

Both crystals are mounted on highly repeatable vertical slides, with precision tilt cradles for roll alignment of crystals. The first crystal can be fully translated out of the beam to allow the white beam to pass.



Other features of the monochromator include:

- Energy range 16keV - 100keV.
- Asymmetric crystal using [111] and [113] reflections.
- Variable mono beam offset 20mm to 25mm.
- Indirect water cooling of first crystal.
- High precision, ultra-stiff rotary tables.
- Precision tilt cradle for roll alignment of Laue crystals.
- High vacuum level 1×10^{-7} mbar.
- Ultra stable base block of natural granite with measured amplification factor of 1.0.
- Stationary 2nd crystal acts as a fixed energy reference.
- Highly repeatable bending moment actuators.



Above: IDT designed linear actuators installed on Australian Synchrotron crystal bending mechanism.

AXIS	RANGE	RESOLUTION	REPEATABILITY	SPEED
Bragg	-16° to 24°	<1μrad	±0.5μm	0.2°/s
Height	±30mm	<0.4μm	±0.5μm	1mm/s
Translation	560mm	<1μm	±1.0μrad	3mm/s
Tilt	±5°	<2μrad	±1.0μrad	0.2°/s

DCM Upgrades

IDT can offer a cost-effective upgrade of an existing DCM to our latest ultra-stable crystal cage technology. We have designed and implemented full upgrades of existing monochromators at the APS and ESRF.

Canted Undulator DCM Upgrade

installed on GSECARS at the Advanced Photon Source

IDT have designed and implemented a full upgrade to the existing 'Daresbury' DCM on GSECARS Sector 13 at the APS. This was part of an upgrade of the ID beamline to a 1mrad canted undulator geometry.

The original DCM has been in operation for 15 years and the mechanical Bragg axle & vacuum vessel were re-used.

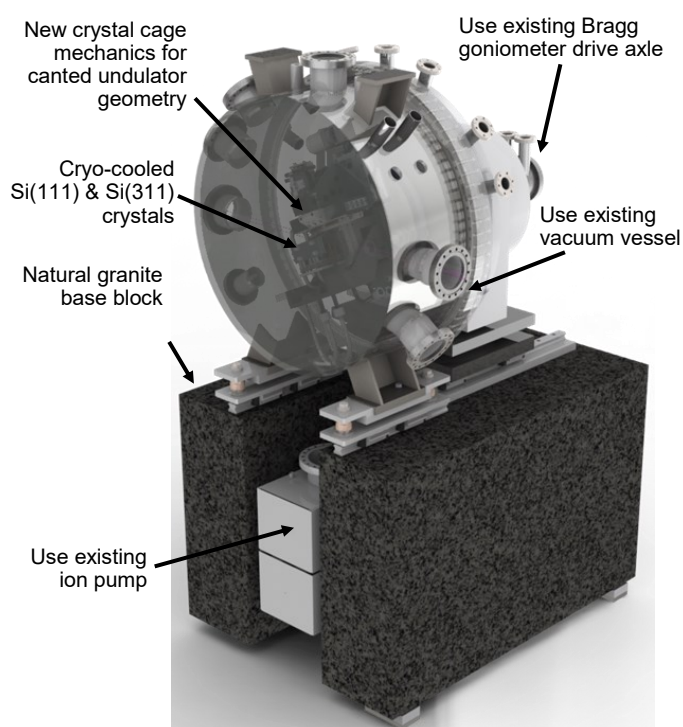
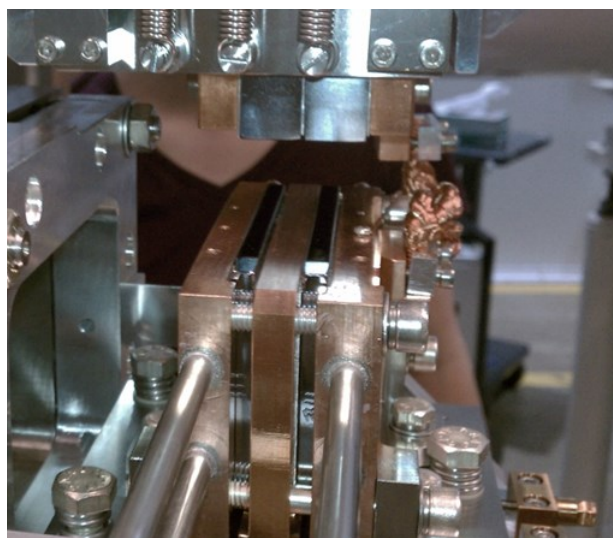
The upgraded DCM featured a new ultra-stable crystal cage designed for the 1mrad canted undulator beam geometry with indirect cryo-cooled Si(111) & Si(311) crystals, a new in-vacuum Bragg encoder using the latest Renishaw technology, and a new high-stability natural granite base block.

AXIS	RANGE	RESOLUTION	REPEATABILITY
2nd crystal coarse pitch <i>Stepper motor driven</i>	$\pm 0.9^\circ$	0.45 μ rad	$\pm 0.68\mu$ rad
2nd crystal fine pitch <i>Piezo driven</i>	210 μ rad	<50nrad	<<1 μ rad
2nd crystal coarse roll <i>Stepper motor driven</i>	$\pm 1.5^\circ$	0.63 μ rad	$\pm 0.51\mu$ rad
2nd crystal fine roll <i>Piezo driven</i>	160 μ rad	<50nrad	<<1 μ rad
2nd crystal gap <i>Used to maintain offset</i>	16mm	0.20 μ m	$\pm 0.18\mu$ m

Above: Technical data

Below: Upgraded DCM

Below: Cryo-cooled first crystals for canted undulator beam geometry.



Bending Magnet DCM Upgrade

installed on DUBBLE CRG at the ESRF

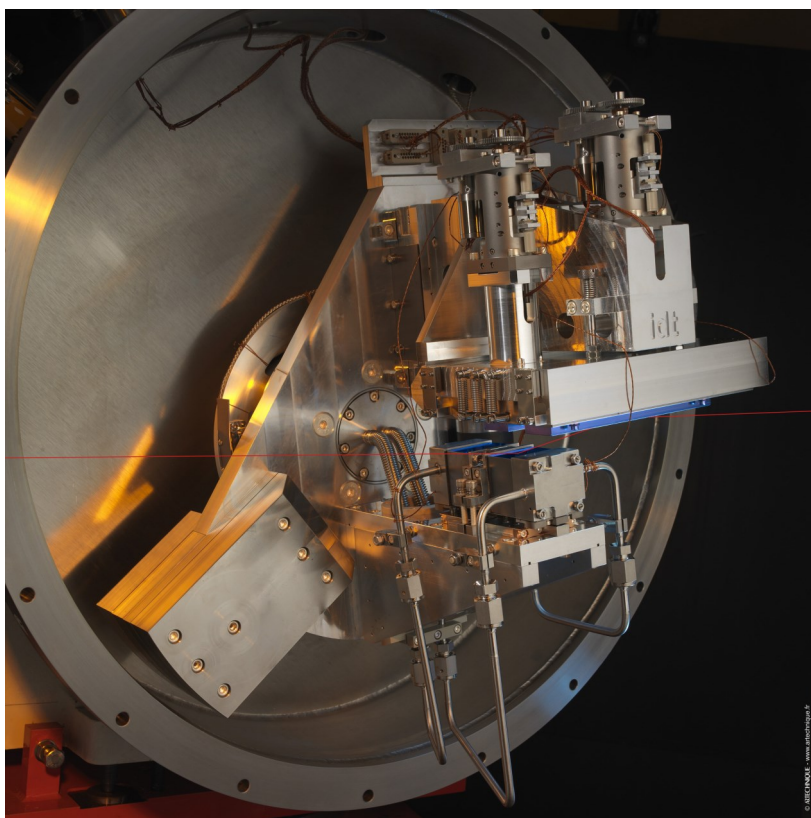
IDT have designed and implemented a full upgrade to the existing 'Daresbury' DCM on the DUBBLE CRG at the ESRF.

The original DCM featured a single Si (111) crystal set and has been in operation for 15 years.

The upgraded DCM features a new ultra-stable crystal cage Si(111) & Si(311) crystal sets with a novel direct water-cooling scheme optimised for the beam footprint, a new in-vacuum Bragg encoder using the latest Renishaw technology, and a new high-stability natural granite base block.

The existing goniometer and DC servo drive train, crystal cage extraction mechanism, and vacuum vessel & ion pump were reused.

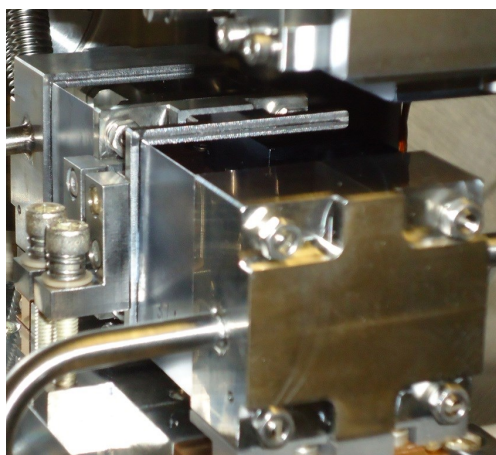
IDT have also upgraded the h-line SAXS DCM at DUBBLE, and a DCM on the Swiss-Norwegian Beamline.



Above: New crystal cage featuring 2 crystal sets on upgraded DCM.

Below: Direct water-cooled first crystals.

Below right : Technical data.



AXIS	RANGE	RESOLUTION	REPEATABILITY
2nd crystal coarse pitch <i>Stepper motor driven</i>	$\pm 1^\circ$	0.94 μ rad	$\pm 0.46\mu$ rad
2nd crystal fine pitch <i>Piezo driven</i>	400 μ rad	<50nrad	$\ll 1\mu$ rad
2nd crystal coarse roll <i>Stepper motor driven</i>	$\pm 1^\circ$	1.31 μ rad	$\pm 0.33\mu$ rad
2nd crystal fine roll <i>Piezo driven</i>	400 μ rad	<50nrad	$\ll 1\mu$ rad
2nd crystal gap <i>Used to maintain offset</i>	12mm	0.20 μ m	$\pm 0.20\mu$ m
Horizontal X translation	50mm	0.63 μ m	$\pm 0.50\mu$ m

Horizontally Deflecting Monochromator

installed on I04-1 Monochromatic MX Beamline at Diamond Light Source

Beamline I04.1 at Diamond Light Source is a dedicated facility for macromolecular crystallography experiments at a fixed wavelength. The beamline consists of a canted undulator geometry.

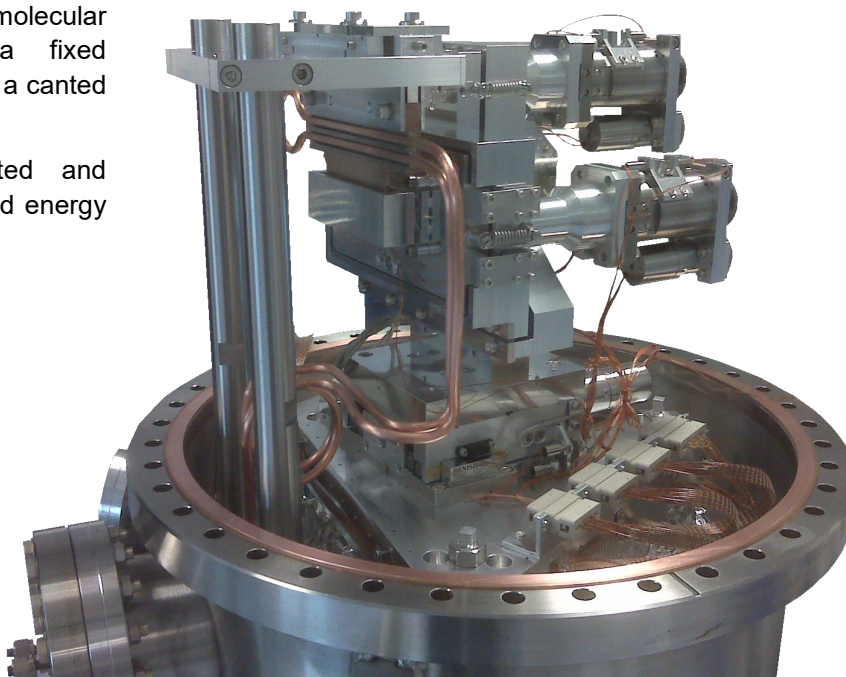
IDT designed, manufactured, tested and installed a horizontally deflecting, fixed energy monochromator on I04.1.

The monochromator features a single Si(111) crystal and operates at a fixed Bragg angle of 8.402° (giving a fixed energy of 13.53keV) and features coarse & fine pitch adjustment.

The crystal is indirectly cooled via a copper finger immersed in a gallium bath for vibration-free cooling.

The monochromator stability is further enhanced by thermally isolating the monochromator mechanics, preventing thermo-mechanical drift, and an ultra-stable base block of natural granite with measured amplification factor of 1.0.

- The monochromator operates at an Ultra High vacuum level of $<5 \times 10^{-9}$ mbar.

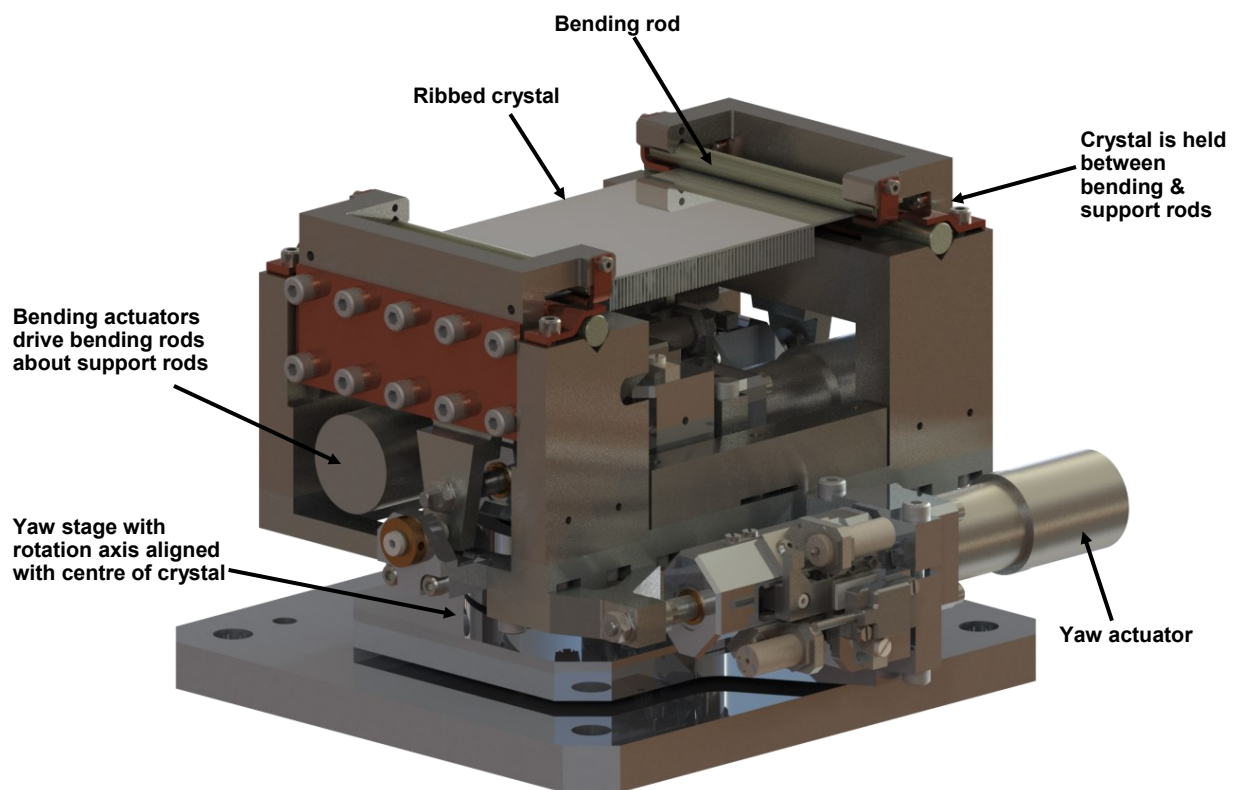


AXIS	RANGE	RESOLUTION	REPEATABILITY
Coarse pitch <i>Stepper motor driven</i>	$\pm 1^\circ$	1.14 μ rad	$\pm 0.7\mu$ rad
Fine pitch <i>Piezo driven</i>	400 μ rad	<50nrad	<<1 μ rad
Coarse roll <i>Stepper motor driven</i>	$\pm 1^\circ$	1.30 μ rad	$\pm 1.4\mu$ rad
Horizontal X translation	± 2 mm	0.1 μ m	$\pm 1.6\mu$ m

Sagittal Crystal Bender^{*}

- Based on ESRF Swiss-Norwegian Beamline design.
- Bend radius to 1.2m.
- Ribbed crystal to minimise anticlastic bending.
- High resolution repeatable bending moment actuators.
- Motorised yaw alignment adjustment.
- Horizontal beam acceptance 60mm.

IDT have developed a sagittal crystal bender based on a design from the Swiss-Norwegian Beamline CRG at the ESRF. The bender has been in routine operation since 2013 on B21 SAXS beamline at Diamond Light Source as part of the IDT-supplied DCM, while the original sagittal crystal bender was designed and built by SNBL during the construction phase of the beamline and has been in routine operation since 1995.



The highly repeatable design is based upon a very stable 4 bar bender. The crystal is bent by driving the tungsten bending rods about the support rods. The mount is wire EDM machined for the highest possible tolerances and alignment.

The crystal features a central multi-ribbed zone designed to minimise anticlastic bending, and two side flat sections that allow the crystal to be polished in a highly uniform manner to maintain parallelism of the crystal faces when mounting in the 4 bar bender.

^{*} built under licence from the Swiss-Norwegian Beamline

Monochromator Stability

The stability of a monochromator is the most important factor in beamline performance. IDT have invested great effort into ensuring our range of monochromators are exceptionally stable, allowing the full potential of beamline performance to be realised.

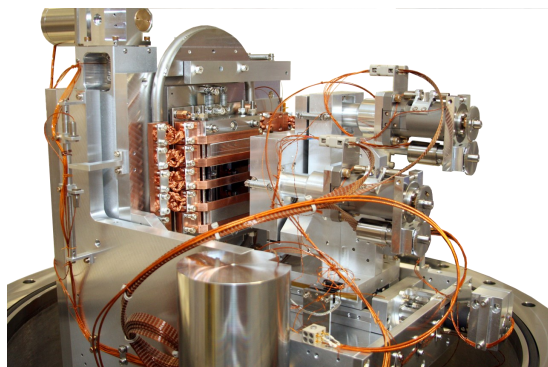
Cooling Techniques

A well engineered crystal cooling system is crucial to monochromator performance. Efficient cooling of the heat-loaded first crystal is essential for good optical performance. Poorly designed cooling schemes can lead to big thermal distortions of the crystals and introduce vibrational instabilities to the monochromator which can have detrimental effects on beam quality. Examples of cooling schemes which introduce large thermal gradients include indirectly back-cooled crystals and large bore directly cooled crystals.

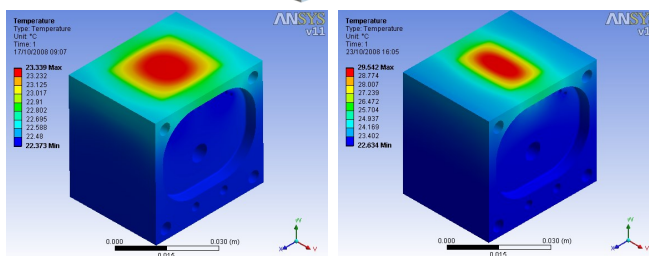
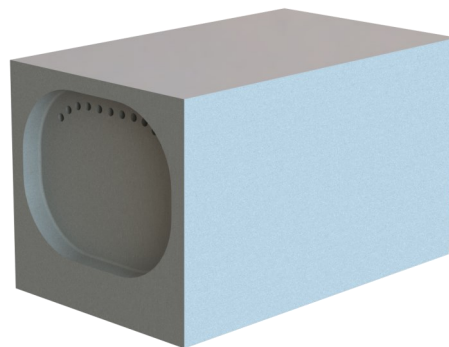
IDT monochromators feature crystal cooling schemes designed and engineered for the specific beam profile and heat load from the source of the beamline. Thorough design & FEA studies are carried out to determine the optimal cooling design for each individual monochromator.

For insertion device monochromators IDT can offer vibration-free cooling using soft annealed copper couplings, giving excellent thermal conduction and zero vibration transmission.

For bending magnet monochromators IDT have developed a direct water cooling system which can be adapted to the specific bending magnet beam profile.



Above: Cryo-cooled first crystal assembly, featuring novel cooling design with soft annealed copper couplings connecting crystals to cryo lines giving excellent thermal conduction and zero vibration transmission from cryo lines.



Above: Direct Water Cooled Crystal, featuring cooling hole pattern designed to match the beam profile giving optimum cooling over the entire bragg angle range.

Proven Thermal Isolation Approach

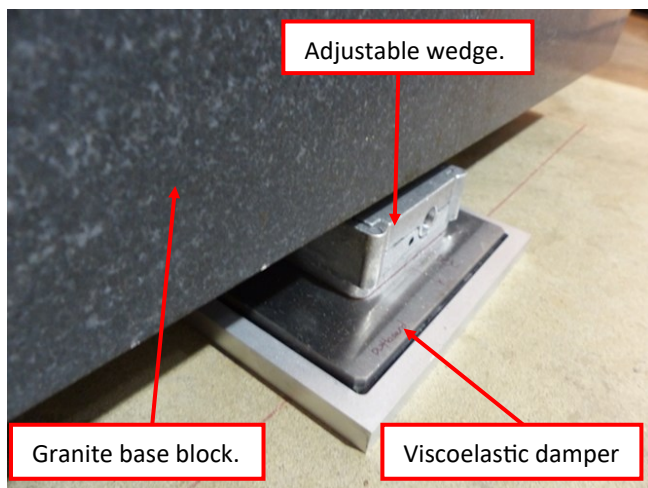
IDT adopt a unique thermal isolation approach in monochromator design to minimise thermal drift and maximise stability in the mechanics.

Thermal drifts in monochromators can result in a dramatic loss of beam intensity and stability. The thermal stability of the mechanics is a crucial factor in the performance of any monochromator.

Vibrations from water flow in cooling circuits, which are often used to thermally stabilise monochromator mechanics, can introduce further instabilities into the beam.

Our approach involves thermally isolating all components subjected to temperature fluctuations (crystals, motors etc) from the monochromator mechanics, and removes the need for water stabilisation circuits or heaters.

Point contacts, thermal insulators and machined thermal barriers are used throughout the monochromator design to provide multi-layer thermal isolation and offer excellent monochromator stability.



Vibration Isolation & Mitigation

Minimising the transmission of vibration from motors, cooling lines and external sources to the crystals is critical to monochromator stability.

Our design philosophy of low mass, high stiffness components leads to very stable devices with high natural frequencies.

We have developed proven cooling schemes specifically engineered to minimise the transmission of vibrations from the cooling lines to the optic.

We have also developed a proven method of isolating a monochromator from external environmental vibrations, using viscoelastic dampers in the monochromator support system.

This approach has yielded a measured beamline stability of 54 nrad on GSECARS at the APS (see below).

54 nrad Measured Beamline Stability

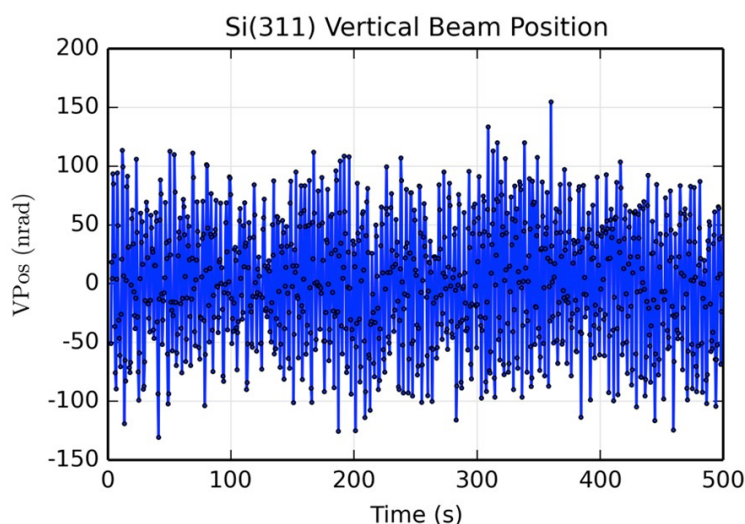
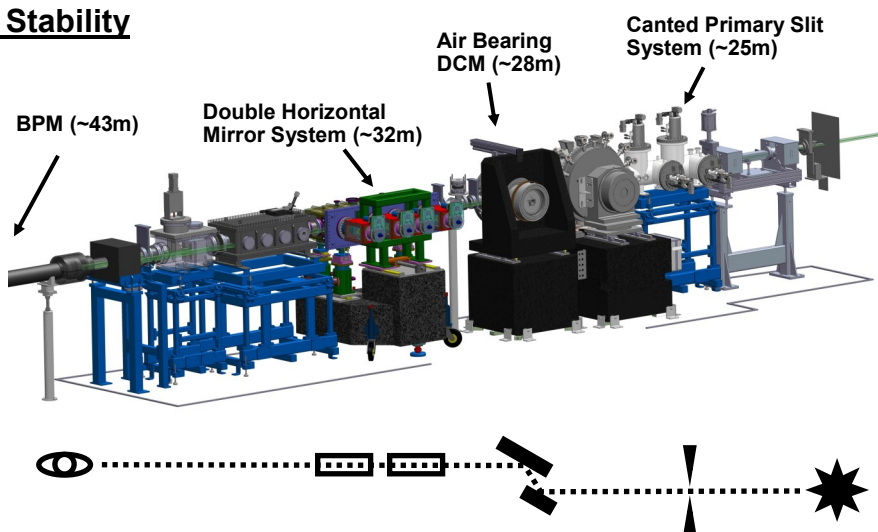
The stability of the IDT-built GSECARS Beamline at the APS has been measured.

The beamline consists of a primary slit system, an air-bearing DCM and a double horizontal mirror system. The quad-diode beam position monitor, located downstream of the double mirror system, is used to measure fluoresce signal onto the top and bottom diodes to determine X-ray beam position far from source.

Beam energy at 7.2 keV, no active feedback, sampling position every 0.5 sec for 500 sec.

BPM vertical position is recorded and converted to an angle. The vibrations observed are the net effect from the source, DCM and double mirror system.

Standard deviation of beam angle:
54 nrad

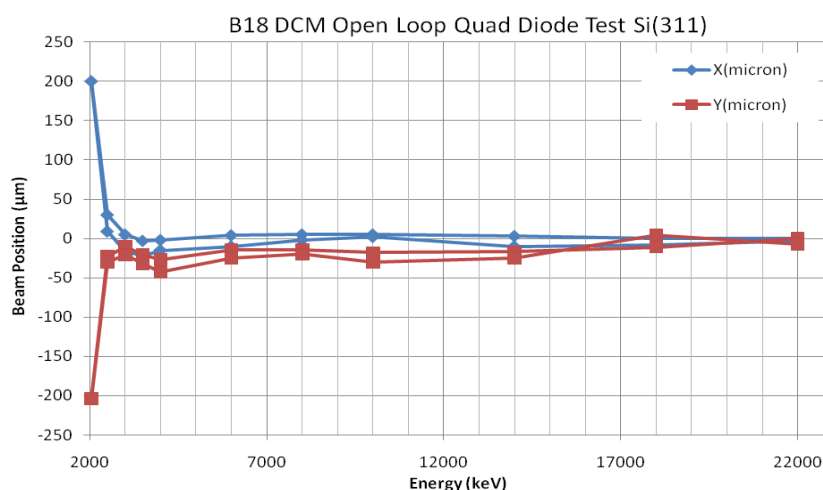


Monochromator Quad Diode Scan Testing

IDT have developed a unique factory testing procedure for scanning Double Crystal Monochromators.

A laser beam is shone through the DCM to simulate an x-ray beam. The laser illuminates the crystals and the position of the transmitted beam is measured with a custom quad diode detector placed several meters away from the monochromator.

The scanning performance of the DCM can be tested by driving the DCM through the energy range and measuring the exit beam angle with the quad diode detector. This can be done under vacuum conditions at a fixed beam offset with coolant flowing, giving a very close indication of the true DCM beamline performance.

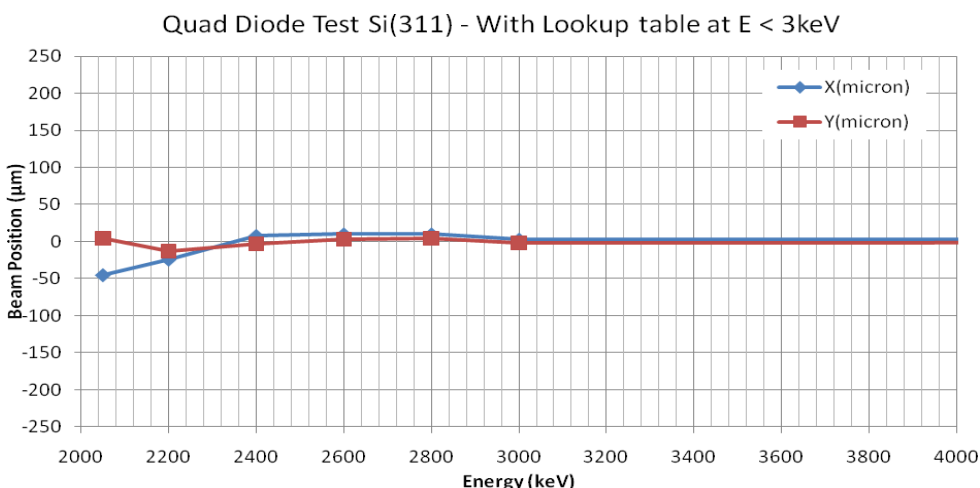


Above: Factory quad diode test set-up on Quick EXAFS DCM for B18 at Diamond Light Source.

Left: Quad diode test results of B18 DCM, showing open loop performance over energy range.

Below: Repeat of B18 quad diode test at low energy using a pitch & roll look-up table to correct for low energy movement.

Our monochromator quad diode testing makes it possible to obtain the parasitic beam walk effects at the factory and to optimise for x-rays before delivery to site. It allows measurement and implementation of lookup tables for pitch & roll correction as part of factory acceptance.



X-Ray Mirror Systems

IDT have built a range of large vertically and horizontally focusing mirror systems. These are available in mirror lengths up to 1.4m and offer a unique cooling approach for minimal vibration transmission from the cooling system to the mirror optic. Our 2 moment differential bender uses a closed-loop force bar system with bending along the neutral axis of the mirror giving zero strain on the optical surface.



IDT Large Mirror Systems* in operation:

Dynamic Compression Sector at the APS.

A large horizontal and vertical mirror pair in a KB geometry.

I20 LOLA X-ray Spectroscopy beamline at Diamond Light Source.

Six vertically deflecting large mirror systems.

X-ray Fluorescence Microprobe beamline at the Australian Synchrotron.

Horizontally deflecting large mirror system.

HXMA beamline at the Canadian Light Source.

Two vertically deflecting mirror systems, including a toroidal mirror.

X05L MicroXAS beamline at the Swiss Light Source.

Horizontally deflecting toroidal mirror system.

HPCAT Sector 16 at the Advanced Photon Source.

Two sets of large vertical and horizontal mirrors, arranged in a KB geometry.

I15 Extreme Conditions beamline at Diamond Light Source.

A large horizontal and vertical mirror pair in a KB geometry.

BL11 Non-Crystalline Diffraction beamline at ALBA.

A large toroidal mirror and a small collimating mirror.

I18 Microfocus Spectroscopy beamline at Diamond Light Source.

A large horizontal mirror with differential bender & gallium cooling system.

** built under licence from the University of Chicago*

IDT are a leading supplier of Small KB mirror systems. Our Small KB Mirror system offers dynamic figuring with sub- μ rad slope error, a highly repeatable sub- μ m focused spot size, and a low cost of ownership.

IDT Small KB Mirror Systems** in operation:

I18 Microfocus Spectroscopy beamline at Diamond Light Source.

XFM beamline at the Australian Synchrotron.

Micro XAS beamline at the Swiss Light Source.

Sector 7 at the Advanced Photon Source (2 systems).

Sector 9 at the Advanced Photon Source.

Sector 33 at the Advanced Photon Source.

Hard X-Ray Microfocus beamline at the Shanghai Synchrotron.

BioCARS at the Advanced Photon Source.

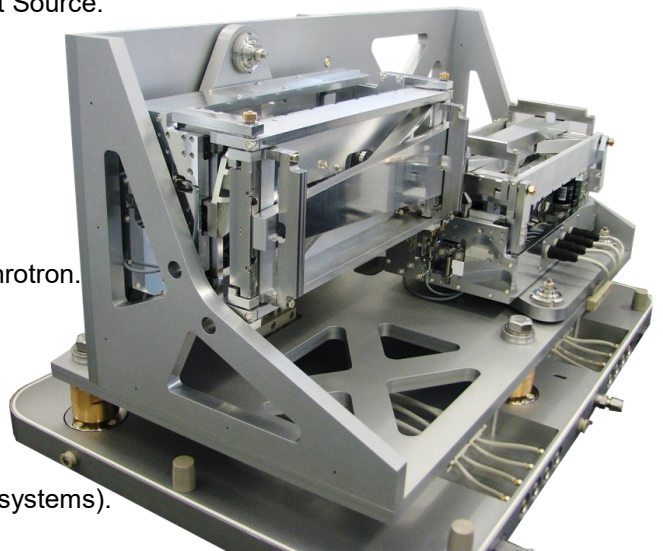
HPCAT at the Advanced Photon Source (2 systems)

GSECARS at the Advanced Photon Source (2 systems)

Phoenix beamline at the Swiss Light Source

P02 Extreme Conditions beamline at Petra III, DESY (2 systems).

*** developed by IDT with a grant from the North West Development Agency*



Large Mirror Systems*

- Available in horizontal & vertical deflecting geometries with mirror lengths from 0.6m to 1.4m.
- Differential 2 moment bender for ideal dynamic elliptical figuring using unique closed-loop force bar bender with resolution to 0.01%R.
- Mechanically decoupled water cooling system via liquid gallium grooves in mirror optic.
- Ultra stiff vacuum tank comprising inch thick plate and ribs forms an integral mounting platform with very high natural frequency.
- Large through-vacuum linear actuators provide pitch (grazing angle) control to $<1\mu\text{rad}$ with $0.1\mu\text{rad}$ resolution.
- Optional pitch piezo stage can be retro-fitted.
- Precision actuators & kinematic jacks provide yaw and parallel positioning to the beam.
- All motorised axes may be fitted with optional encoders for further improved repeatability.
- UHV compatible to $<10^{-9}$ mbar.

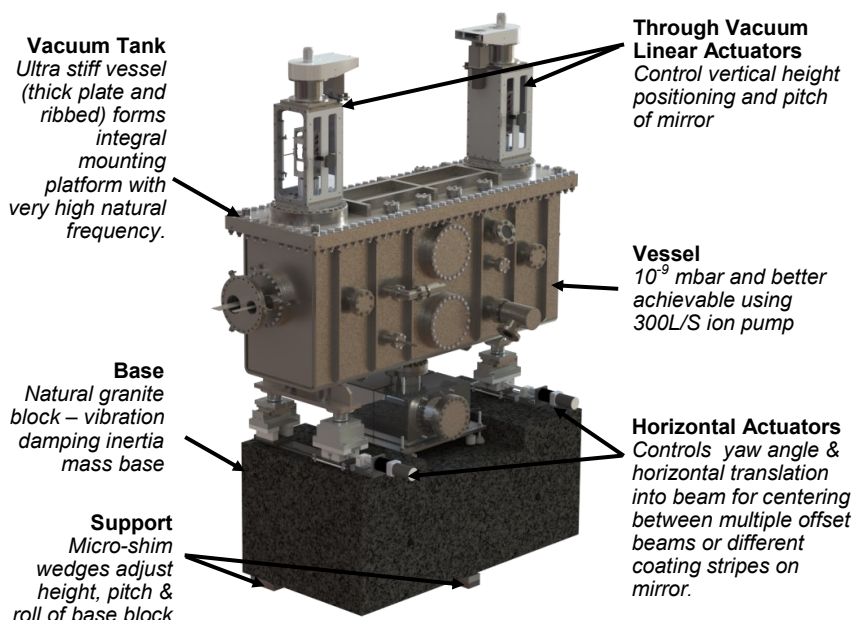
The IDT large mirror system was originally developed and proven at GSECARS (Sector 13 APS), and offers a high-precision differential moment bender on a multi degree of freedom platform.

At the heart of the system is a two moment bender - a unique self-contained closed force loop system for μrad control of the mirror.

The pitch (grazing angle) is controlled by two very large and rigid through-vacuum linear actuators fitted through the ultra stiff flange lid mounting platform, which is integrally designed as part of the vessel.

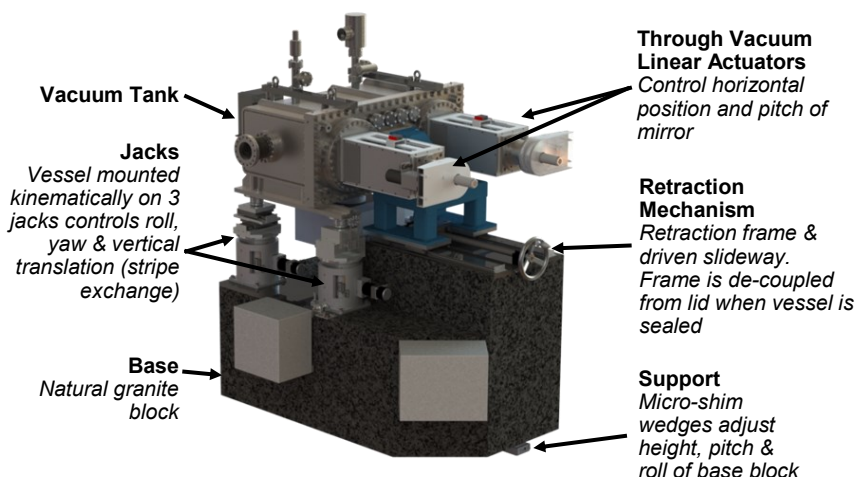
The ultra stiff vessel (with a very high natural frequency) and massive granite base block give good resistance to ground vibration.

For vertically deflecting mirrors the yaw (angle about mirror optic normal) is controlled by precision horizontal actuators. For horizontally deflecting mirrors this is controlled by three kinematic jacks, which also control roll (angle about beam axis). These also control the translation of the mirror across the beam (stripe translation) with μrad and μm precision.



Above: Vertically deflecting mirror.

Below: Horizontally deflecting mirror.



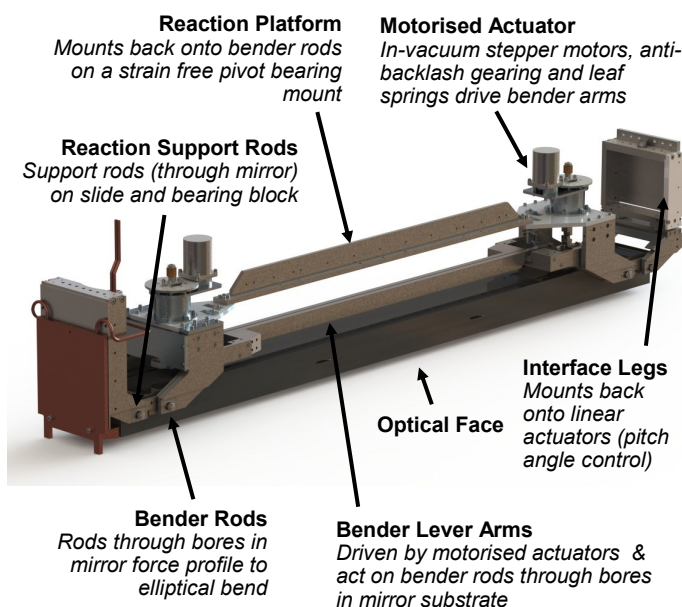
* built under licence from the University of Chicago

Motion	Range	Resolution	Repeatability	Notes
Vertical translation & pitch (grazing) angle	100mm $\pm 1^\circ$	0.04 μ m 0.04 μ rad	0.3 μ m <1 μ rad	Through vacuum linear actuators control vertical position and pitch
Horizontal translation	50mm	0.3 μ m	<2 μ m	2 actuators driven simultaneously
Yaw angle	± 10 mrads	0.3 μ rad	<5 μ rad	Actuators driven in opposite direction

Motion	Range	Resolution	Repeatability	Notes
Horizontal translation & pitch (grazing) angle	100mm $\pm 1^\circ$	0.04 μ m 0.04 μ rad	0.3 μ m <1 μ rad	Through vacuum linear actuators control horizontal position and pitch
Vertical (Height)	50mm	0.3 μ m	<2 μ m	3 jacks (simultaneously) control height
Roll angle	± 20 mrads	0.8 μ rad	<5 μ rad	1 jack controls roll
Yaw angle	± 10 mrads	0.3 μ rad	<5 μ rad	3 jacks (differentially) control yaw

Above: Typical motions for vertical (left) & horizontal (right) mirror systems.

Bender Mechanism



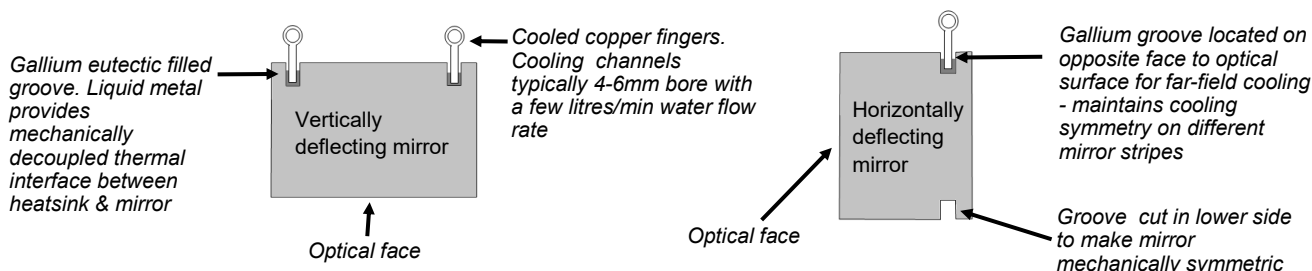
Motion	Range	Resolution	Repeatability	Notes
In-Vacuum Bender & Bend Radius	-10mm to +30mm R = ∞ to <1km	0.17 μ m <0.01% R	Typ. < 1%R @R = 5km	Independent actuators provide differential moment to achieve ideal elliptical profile

The bender is a unique self-contained closed force system that exerts no external forces or experiences no reactions from the external mounting environment. Lever arms, driven by in vacuum stepper motors, act on 2 rods, seated into custom fitted annealed copper bushes through bores in the optic substrate, to bend the mirror to shape. A set of reaction rods support the mirror & bender onto interface legs at either end (through a system of radial & linear bearings that permit no distorting reaction forces from the interface back to the mirror). The interface legs attach to through-vacuum linear actuators which controls the pitch of the mirror.

Mirror Cooling

A liquid gallium groove based cooling configuration decouples the mirror from potential water vibrations. These carefully designed and tested features of the mirror bender and platform ensures that the mirror optic is isolated from any external mechanical forces that may potentially act to disturb the ideal optic profile.

IDT also offer integrally cooled mirrors, with water flowing directly through a channel in the mirror substrate.



Medium KB Mirrors

installed on the Dynamic Compression Sector at the APS

- 840mm length horizontal mirrors allow full APS horizontal source to be captured.
- 380mm length vertical mirrors.
- Highly repeatable sub- μm focused spot size.
- High stability dynamically figured mirror with sub- μrad slope error.
- Two moment elliptical bending with trapezoidal shaped mirrors for near-perfect bending.
- Stripe translation for multiple mirror coatings.
- Available in vacuum and helium variants.

IDT have developed a novel medium-length KB mirror system for the Dynamic Compression Sector (DCS) at the APS. The system is an evolution of our highly successful Small KB Mirror system and features trapezoidal mirrors in a two-moment elliptical bender for sub- μm focusing, with a 840mm length horizontal mirrors allowing the full APS horizontal source size to be captured and focused.



Ultra-Low Strain Mirror Mount

- Mirror mount induces very little strain in mirror optic.
- Vibration-free mirror cooling via liquid gallium bath.
- Up to 100W absorbed heat load.
- Optic thermally isolated from mechanics.
- Piezo-driven fine pitch control.
- 200mm mirror length.
- Mount scalable with mirror length.
- UHV compatible to 5×10^{-10} mbar.
- Mounted on 5 degree-of-freedom platform.

IDT have developed an ultra-low strain mirror mount for beamline I08 STXM at Diamond Light Source.

The mirror is kinematically mounted and thermally isolated from the mechanics.

The mirror optic can be cooled via a liquid gallium / copper finger arrangement for vibration-free cooling. The absorbed power load is 100W.

The mechanism features fine piezo-driven mirror pitch control.

The mirror mount is UHV-compatible to 5×10^{-10} mbar.

The mirror vessel is mounted on a 5 degree-of-freedom mount with high lateral stiffness.

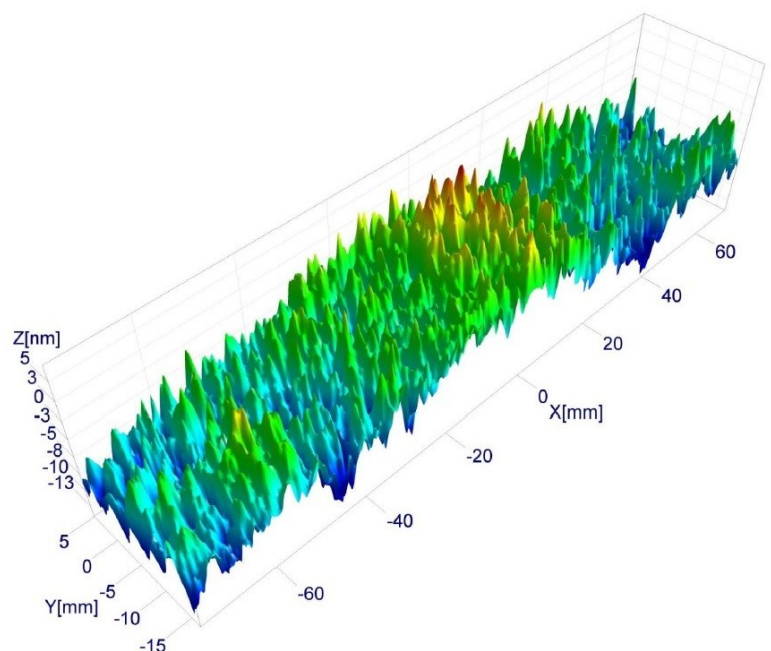


Right: residual surface deformation of mounted mirror.

The profile of the mirror optic surface in an unmounted and mounted state was measured in the Optics Lab at Diamond Light Source using an interferometer. The profile of the unmounted mirror was then subtracted from that in the mounted state.

The deformation induced by mounting the mirror was found to be only a few nanometres.

Data courtesy of Diamond Light Source.

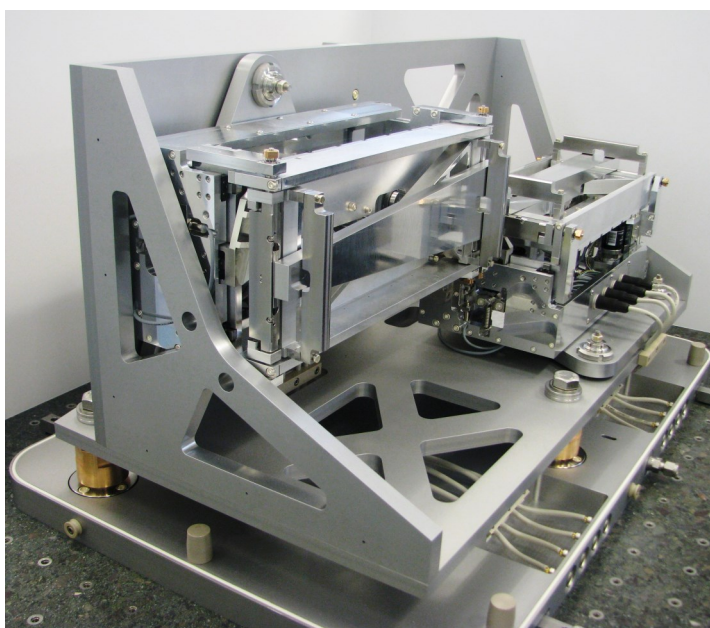


Small KB Mirror System*

- Highly repeatable sub- μm focused spot size.
- High stability dynamically figured mirror with sub- μrad slope error.
- Mirror lengths 170mm - 320mm.
- Multiple mirror coatings (Silicon, Rhodium, Platinum).
- 2 moment elliptical bending with trapezoidal shaped mirrors for near perfect bending.
- High accuracy homing and repeatability.
- Various motor and control options.
- Ultra-high vacuum, high vacuum, low vacuum and helium variants.
- Low cost of ownership.
- Easy mirror coating maintenance.

The IDT Small KB Mirror is based on a well established approach of dynamically figuring the mirror shape by applying two adjustable moments to a trapezoidal shaped mirror. By correctly tapering the longitudinal width of the mirror and applying a linear moment distribution a nearly perfect approximation to the ideal focusing ellipse can be achieved. The slope errors from bending are negligible, well under $0.1\mu\text{rad}$ (typically $<0.05\mu\text{rad}$) and the mirror surface given a properly designed bender can be formed to nearly perfect ellipses.

Successful dynamically figured optics requires bending mechanics that are capable of precisely applying a linear moment distribution without causing residual distortions or drifts in time due to temperature variations and system relaxations. The IDT Small KB Mirror bender is designed to apply only the minimum force necessary to achieve the required figure resulting in maximum useful mirror length and avoiding distortions caused by benders that clamped to the mirror. The bender is designed to utilise mirrors with simple shapes that are easy to install and capable of accepting a range of mirror thicknesses and tapers. This approach reduces the cost for manufacturing the mirrors and provides rapid flexibility so that a single system can be reconfigured to optimally provide focusing for a wide range of experiments.



MOTION	RANGE	RESOLUTION	REPEATABILITY	Notes
Pitch	$\pm 25\text{mrad}$	$1.07\mu\text{rad}$	$0.31\mu\text{rad}$	<i>Pitch actuators driven differentially. Linear range of actuators is $\pm 4\text{mm}$. Angular range dependent on mirror length, values quoted are for 320mm mirror.</i>
Height	$\pm 4\text{mm}$	$0.36\mu\text{m}$	$0.18\mu\text{m}$	<i>Pitch actuators driven simultaneously</i>
Translation	10mm	$0.23\mu\text{m}$	$0.24\mu\text{m}$	<i>Used for mirror stripe exchange</i>
Bend	-	$0.013\mu\text{rad}^{**}$	$1.12\mu\text{rad}$	<i>**Bend dependent on mirror design & leaf spring thickness. Values quoted are for 320mm length mirror with 20mm linear travel on bend actuator.</i>

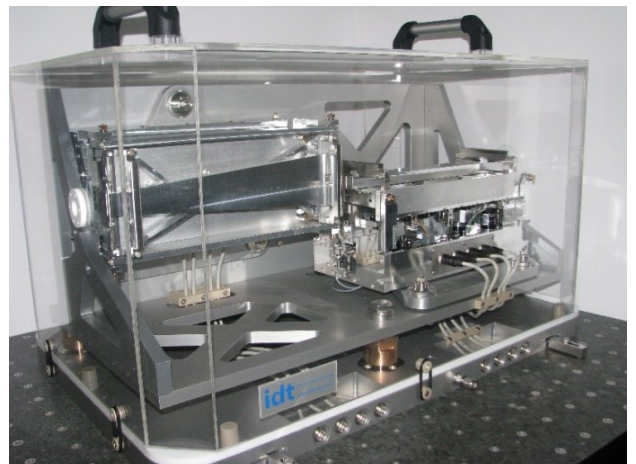
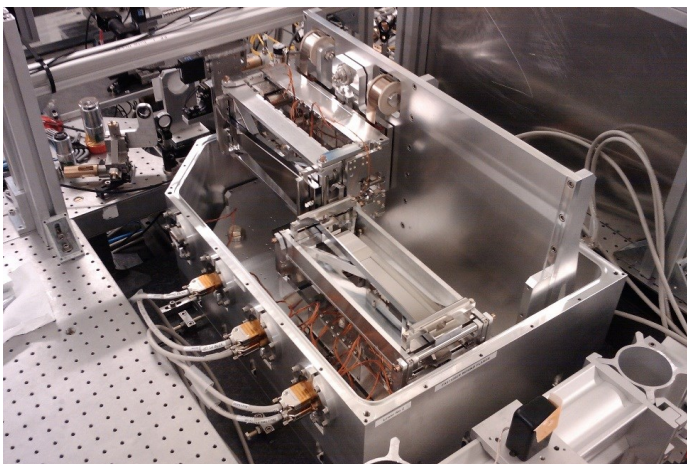
* developed by IDT with a grant from the North West Development Agency

The upstream and downstream moments are applied through the use of a crossed arm arrangement where the forces applied to the lever arms are achieved by pushing off the back surface of the mirror on opposite ends. This results in a closed loop force system that insulates the mirrors figure from external thermo-mechanical variations in the support mechanism. The lever arms are parallel to the length of the mirror and the applied actuator forces are perpendicular to the lever arms effectively de-coupling thermal expansion effects of the lever arms from the applied moment. The lever arms couple to each end of the mirror through a pair of leaf springs and inner and outer bending bars. The leaf springs de-amplify thermo-mechanical drifts of the crossed arms and actuators and allow the mirror contacts to conform to the natural shape of the mirror, keeping residual contact stresses to a minimum.

The moments are controlled with two stepper motor and gear head combinations. The actuators utilise a scissor jack arrangement that results in a constant stepper motor torque as a function of bending moment keeping the systems drive friction independent of radius of curvature and allowing fine figure adjustability at high bending load. The actuators are capable of adjusting figure to one part in 10^4 of the final curvature which is sufficient to achieve figure errors under $0.1\mu\text{m}$.

Below left: High Vacuum KB mirror system installed on Extreme Conditions beamline at Petra III.

Below Right: Helium-environment KB mirror system.



Results from Small KB Mirror System installed on P02 Extreme Conditions beamline at Petra III at DESY:

Right: Vertical wire scan.

Far Right: Horizontal wire scan.

Beam energy = 25keV.

Pitch = 2mrad.

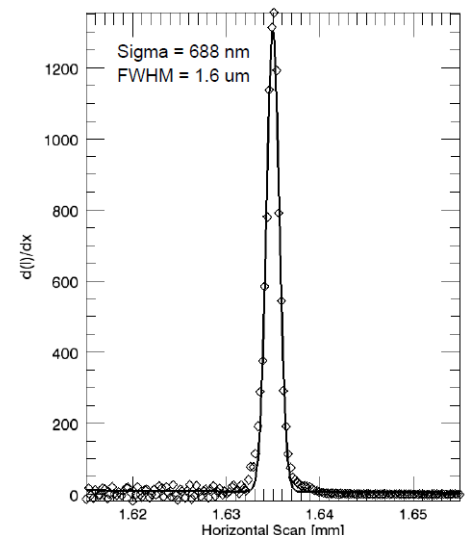
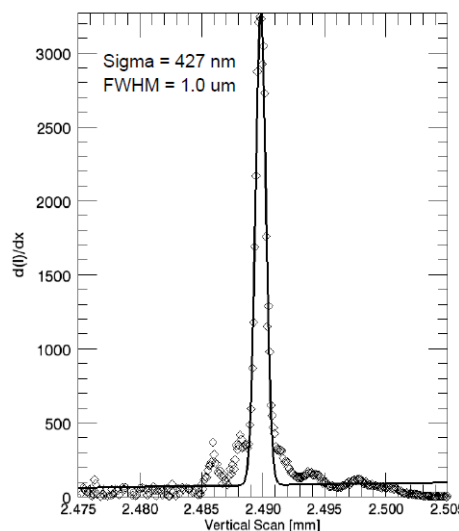
Mirror optical length = 280mm.

Entrance aperture = $560\mu\text{m} \times 560\mu\text{m}$ (22% of Undulator 3rd Harmonic).

Net reflectivity 80%.

Metrology slope error $<1\mu\text{rad}$, surface roughness $\leq 1\text{\AA}$.

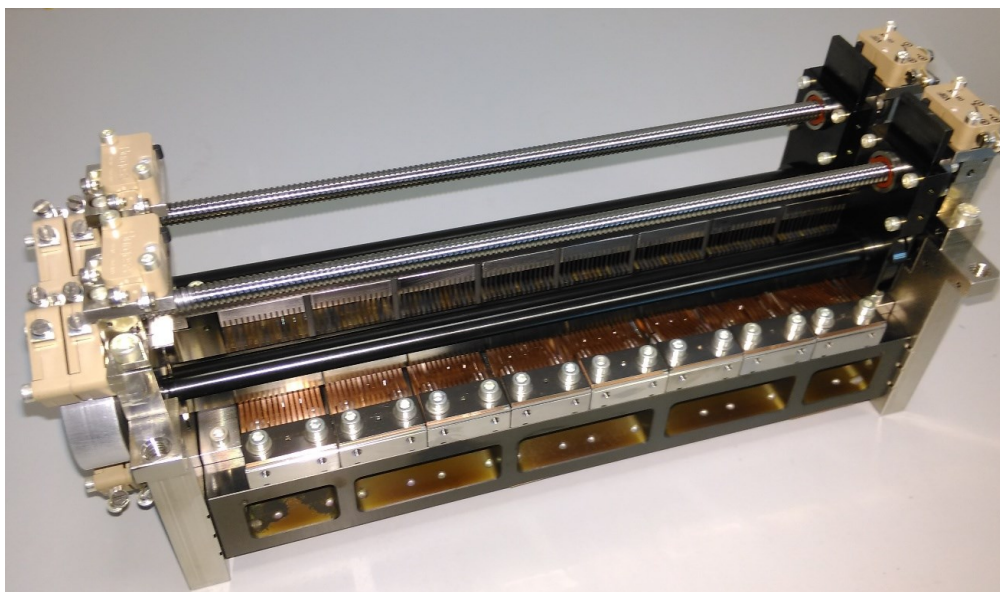
Measured slope error of system with x-rays = $0.25\mu\text{rad}$.



F-Switch System*

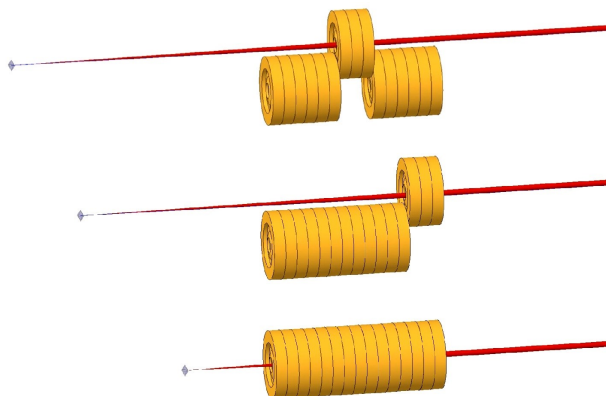
Fast Compound Refractive Lens system with four-axis manipulator

IDT are pleased to offer the F-Switch, a novel compound refractive lens system built under licence from Diamond Light Source.



The F-switch system is a new concept for the manipulation of a large array of lenses. Unlike a translocator, each of the 120 positions in the array are individually selectable. This allows each of the 120 lenses to be uniquely manipulated in and out of the monochromatic beam, allowing very fine adjustment of the focal spot and focal length.

The image to the *right* shows the change in focal length when different lenses in an array are inserted into the beam. The ability of the F-Switch to individually insert each of the 120 lenses into the beam gives much finer control of the focal length compared to a translocator.



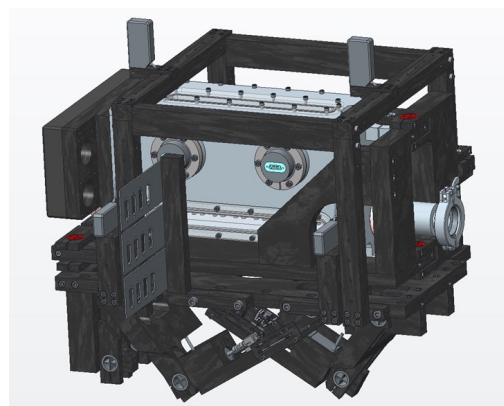
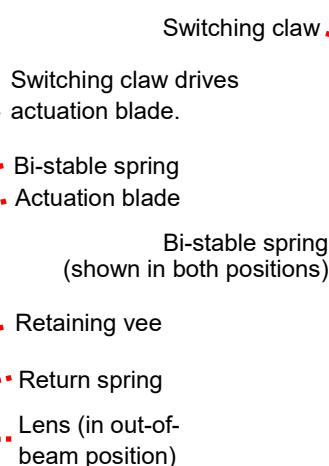
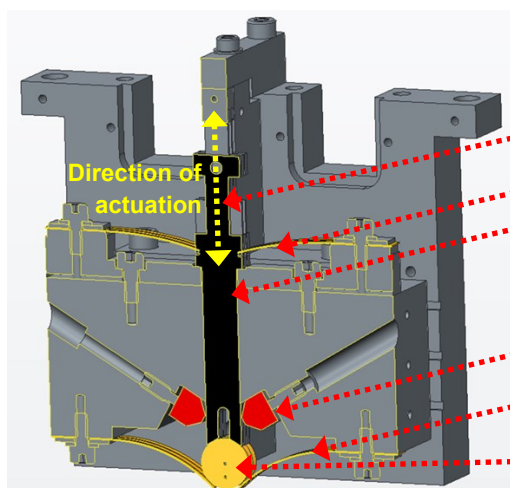
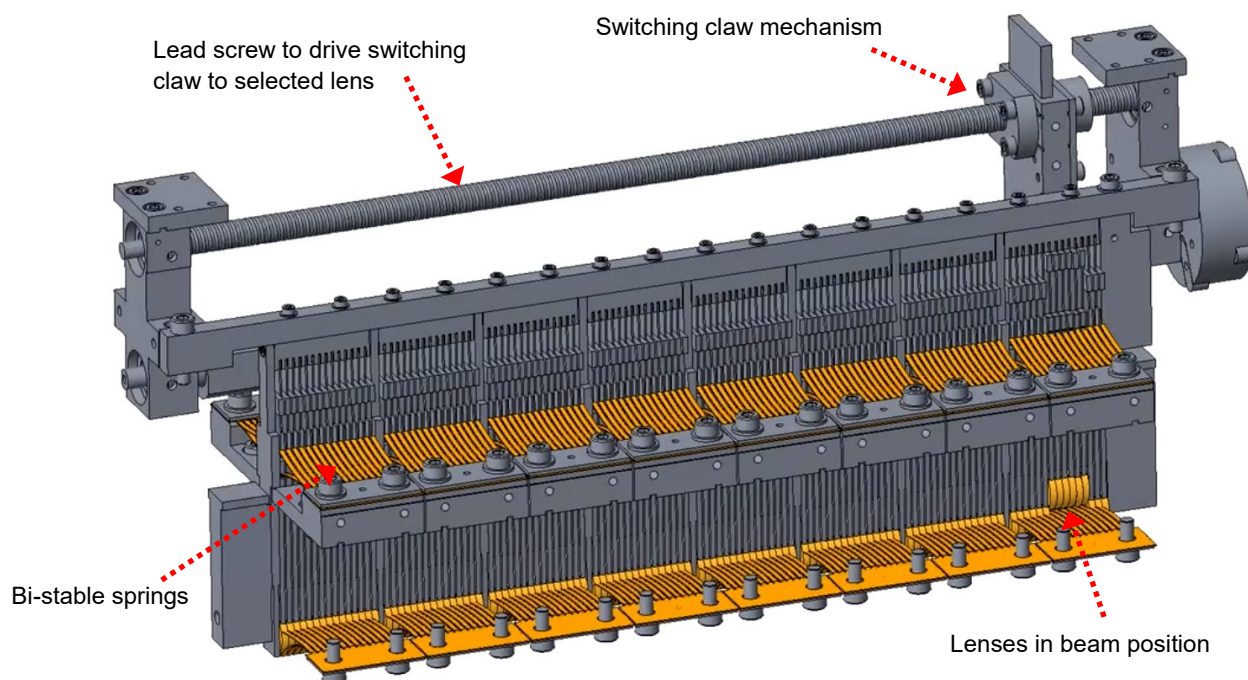
The F-switch operates in vacuum and requires just two actuators. The first drives a translation mechanism which translates a switching claw to the lens of interest, the second drives the switching claw which engages with the lens mechanism to drive the lens in and out of the beam.

Each 2D lens, available from RX Optics, is mounted in a disk 2mm thick, 12mm diameter. The lens is inserted and removed from the beam via an actuation blade, supported by a bi-stable leaf spring. The lens is retained against the actuator blade by a second pair of leaf springs.

When in the beam the lens is held against a vee, ensuring the alignment of the lens is repeatable (see diagram on opposite page).

It is also possible to expand the capabilities of the F-Switch by utilising filters or reference foils in some positions in the array.

*© Copyright Diamond Light Source Ltd, manufactured by Instrument Design Technology



A purpose-built four-axis positioning device, the F-Switch Manipulator (shown *left*) has been developed by Diamond Light Source to align the F-Switch in the beam. The manipulator features vertical and horizontal (inboard-outboard) degrees of freedom, along with pitch and yaw adjustments with Heidenhain-Metro MT12 length gauges.

The F-Switch system is also compatible with other methods of support and manipulation.

See the following paper for more information:

G.M.A. Duller, D.R. Hall, and A. Stallwood, "F-Switch: Novel 'Random Access' Manipulator for Large Numbers of Compound Refractive Lenses", in *Proc. 9th Edition of the Mechanical Engineering Design of Synchrotron Radiation Equipment and Instrumentation Conf. (MEDSI'16)*, Barcelona, Spain, Sep. 2016, paper WEPE22, pp. 345-347, ISBN: 978-3-95450-188-5, <https://doi.org/10.18429/JACoW-MEDSI2016-WEPE22>, <http://jacow.org/medsi2016/papers/wepe22.pdf>, 2017.

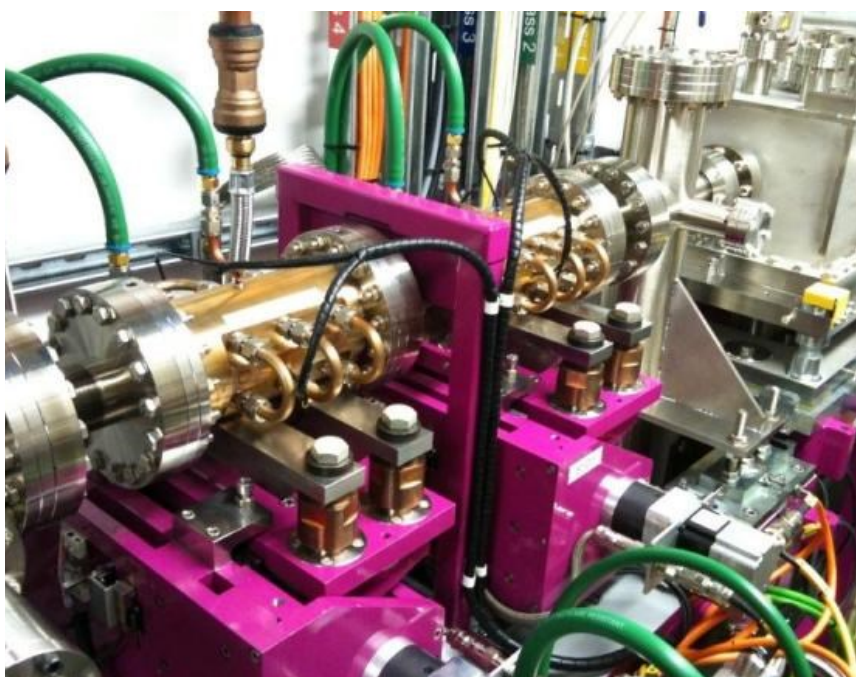
Primary Slits

IDT have developed a proven range of undulator primary slits.

Our centre opening & scanning primary slits (*shown right*) offer exceptional performance:

- Angled water-cooled copper blades (OFHC or Glidcop) with tungsten hard edge defining the beam.
- Thermally isolated design for maximum thermal stability and minimal drift.
- One stepper motor is used to set the slit blade gap and a second motor used to scan the slits in the beam.
- Precision actuator resolution can be controlled to $0.1\mu\text{m}$ with $5\mu\text{m}$ repeatability in open loop, $<1\mu\text{m}$ repeatability when fitted with an encoder.
- Slit blade design optimised for specific power requirements of beamline

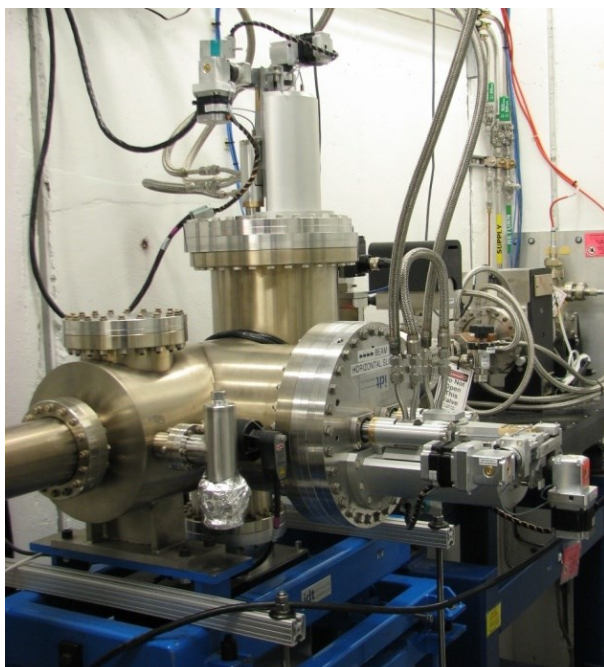
Our 'L' aperture slits are ideally suited for high-power applications, with a horizontal and vertical travel range of $\pm 5\text{mm}$ and sub- μm resolution and repeatability (*shown below*). These slits are also suitable for use in a canted undulator geometry as they can feature an additional bypass aperture.



Canted Undulator Slits

installed on GSECARS and HPCAT at the Advanced Photon Source

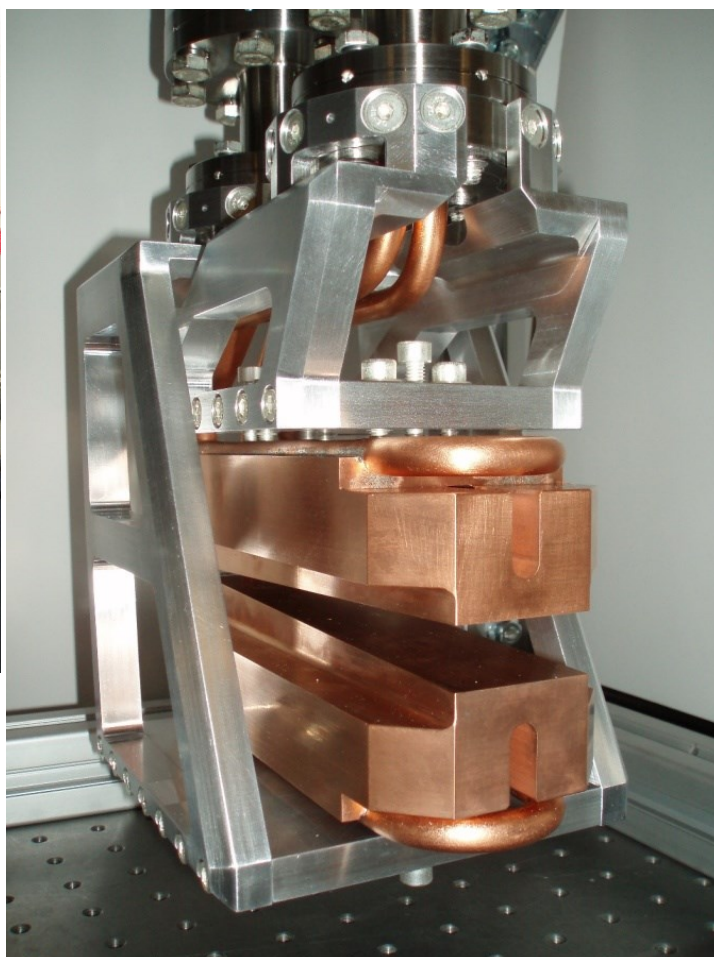
- Designed for canted undulator beamlines, with bypass aperture in horizontal slits for adjacent canted beam.
- Proven centre-opening & scanning design, with one motorised axis used to set the slit gap and another used to scan the undulator cone.
- Designed for APS 200mA ring current operation.
- Tungsten beam-defining hard edge thermally decoupled from glidcop body.
- Glidcop slit blade design satisfies new APS
- Glidcop temperature and stress limits (300°C and 400MPa).
- Water cooled.
- Precision actuator resolution can be controlled to 0.1µm with 5µm repeatability when operated in open loop, sub-micron when fitted with encoder.
- Operational on both Sector 13 GSECARS & Sector 16 HPCAT at the APS. Reported as highly stable and repeatable.



Above: Centre-opening & scanning slit system, with horizontal and vertical slits, installed on HPCAT at the Advanced Photon Source.

Right: Centre opening & scanning slits featuring bypass aperture for adjacent canted undulator beam.

Below: Typical performance data for Canted Undulator Slit system.



AXIS	RANGE	RESOLUTION	REPEATABILITY	NOTES
Slit Translation	±4mm	0.5µm /step	±0.66µm	<i>Translates both slits with one drive, allows scanning of undulator cone</i>
Slit Gap	4mm to -0.2mm	0.2µm /step	±0.16µm	<i>Control aperture size with one drive, allows closed aperture with blade overlap</i>

Very High Heat Load Slits & Filters

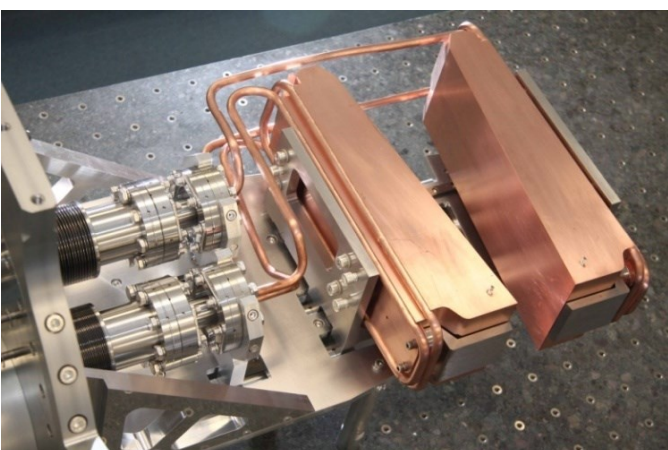
installed on the Imaging and Medical Beamline at the Australian Synchrotron

Slits

- Designed for superconducting multipole wiggler (with white beam power densities $>120 \text{ W/mm}^2$).
- Horizontal slits capable of absorbing $>10\text{kW}$ per blade, vertical slits $>7\text{kW}$ per blade.
- Explosion bonded OFHC-Glidcop design for superior strength & thermal performance.
- Vertical slits use one motor to set the slit gap and a second is used to scan the beam.
- Horizontal slit blades are driven independently on separate motors.
- Precision actuator resolution can be controlled to $0.1\mu\text{m}$ with $5\mu\text{m}$ repeatability when operated in open loop, sub-micron when fitted with encoder.
- Tungsten beam-defining hard edge is precision lapped to protrude 0.1mm above edge of copper slit body and is thermally decoupled from slit body.
- System can be baked up to 120°C .

Filters

- Designed for superconducting multipole wiggler (with white beam power densities $>120 \text{ W/mm}^2$).
- Graphite filters up to $500\mu\text{m}$ thick, capable of absorbing $>6\text{kW}$ power.
- 3 graphite foils & bypass aperture for unfiltered beam transmission on each filter paddle.
- 5 filter paddles in system, giving many possible filter combinations.



Above Left: Vertical slit system with one motor used to drive slit gap and a second motor used to scan the beam.

Above Centre: Translatable filter paddle design with 3 graphite foils & bypass aperture.

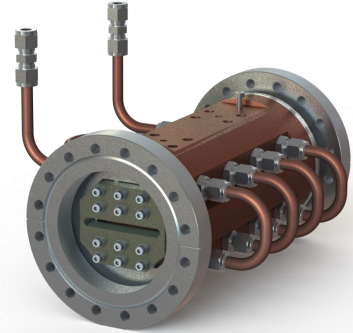
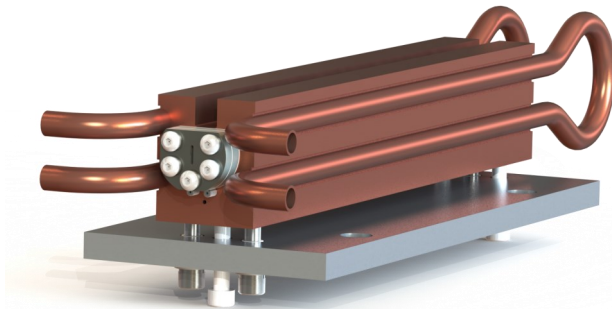
Above Right: Primary slit and 5-axis filter system installed on Imaging & Medical Beamline.

Left: Horizontal slit system, with independently driven slit blades.

Power Management Apertures

IDT have developed a range of masks and apertures for beam conditioning and power management.

Below: Beam defining pinhole aperture installed on GSECARS at the Advanced Photon Source. The aperture features a long tapered water-cooled glidcop section to absorb >2kW power from the white beam, with an exit aperture size of 1.1mm × 0.7mm to allow only the central 100W of the undulator cone to pass downstream.

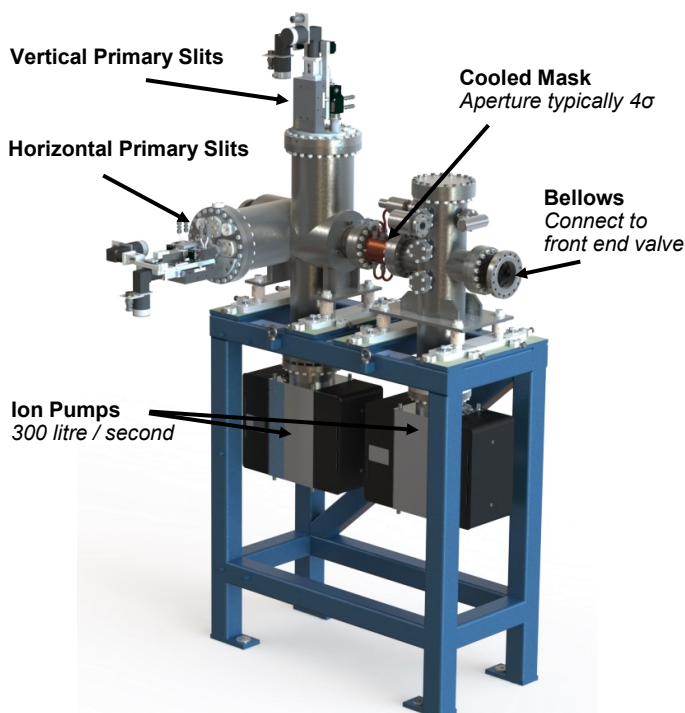


Above: Fixed mask installed on Imaging and Medical Beamline at the Australian Synchrotron. Mask features a glidcop body explosion bonded to stainless steel flanges and limits beam fan from wiggler to 5mrad, absorbing >8kW power.

Fixed Mask & Differential Pump

Windowless Interface for Undulator Beamlines

A water-cooled fixed mask can be incorporated into a windowless interface to the front end for undulator beamlines, with differential pumping across the mask via a pair of ion pumps. This is a proven solution by IDT, installed on the XFM beamline at the Australian Synchrotron and on HPCAT & GSECARS at the Advanced Photon Source.



Above: Fixed mask and primary slit assembly shown in position in the first optics enclosure on the X-ray Fluorescence Microprobe beamline at the Australian Synchrotron.

Beam Position Monitors

Undulator multi-use beam position monitor:

- Tungsten vane monitor for white beam use.
- Doped CVD diamond screen for white/pink beam use.
- YAG fluorescent screen for mono beam use.
- BPM head mounted at 45° to incident beam allowing beam to be imaged.
- High resolution CCD camera & optics for beam imaging.
- Bypass aperture.
- Water-cooled copper mount.
- Through-vacuum linear actuator to select mode of operation.

Also available:

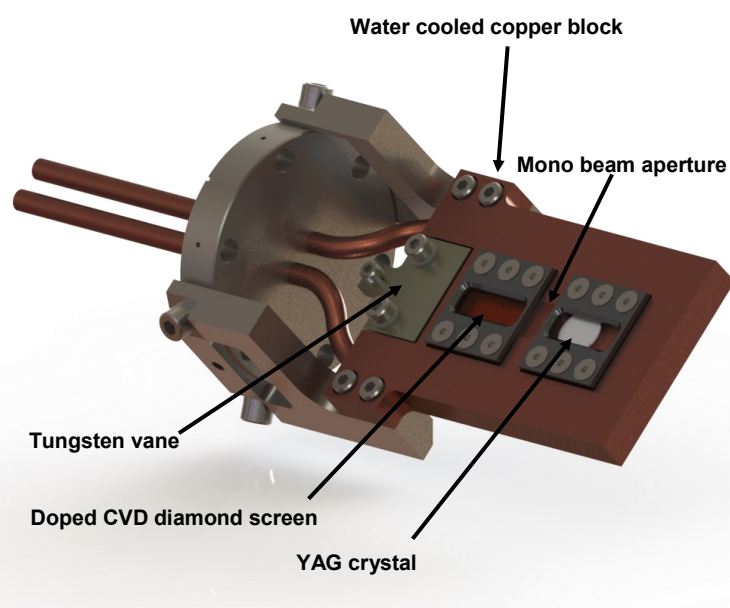
- Fluorescent screen & CCD camera suitable for wiggler beamlines.
- Tungsten vane monitor suitable for wiggler beamlines.

IDT have developed a multi-use BPM for undulator beamlines which functions in a white, pink and mono beam. The BPM features a white beam tungsten vane monitor, a white/pink beam doped CVD diamond screen, a mono beam YAG screen and a bypass aperture as part of a single water-cooled assembly.

The BPM head is mounted at 45° to the incident beam, allowing the beam image on the CVD diamond screen/ YAG crystal to be imaged with a CCD camera mounted perpendicular to the beam.

The BPM head is mounted on a through-vacuum linear translation drive, allowing different modes of operation.

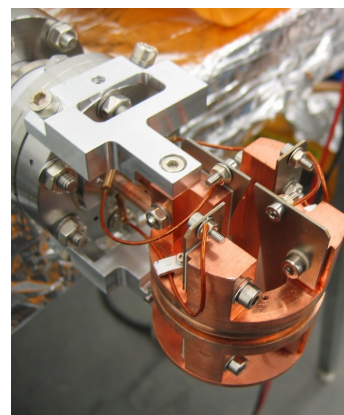
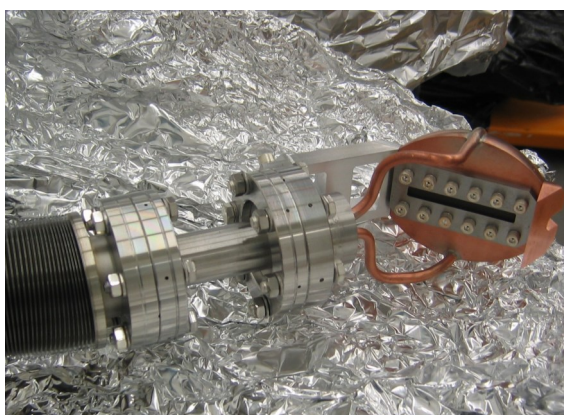
IDT have installed multi-use undulator BPM's on GSECARS Sector 13 at the APS and on XFM beamline at the Australian Synchrotron.



IDT have also developed a range of beam position monitors suitable for the wider beam fans of wiggler beamlines.

Right: Cooled fluorescent screen on pneumatic actuator. Screen is angled at 45° to beam, allowing beam to be imaged on a CCD camera.

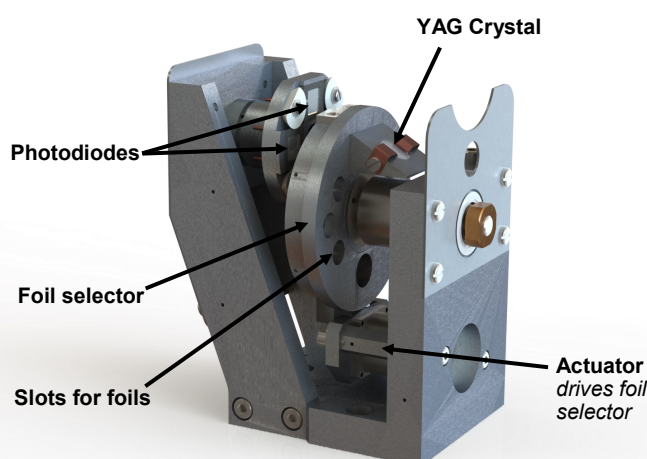
Far Right: Tungsten vane monitor on motorised actuator.



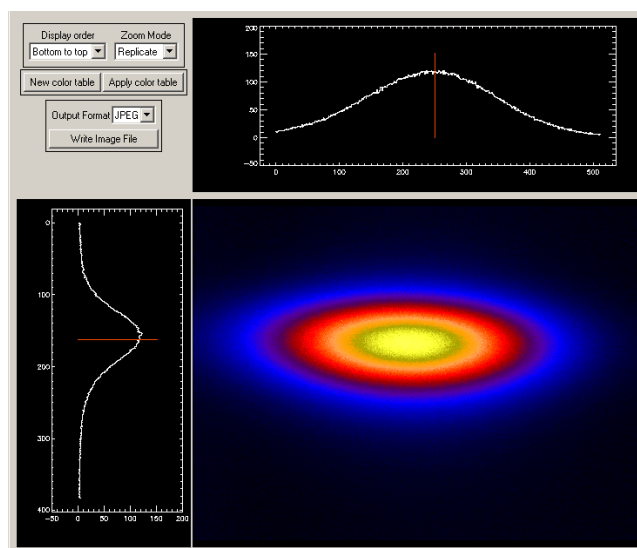
Quad Diode^{*} & Fluorescent Screen BPM

- Quad diode system for intensity & beam position measurements.
- Rotatable foil selector with wide energy range 4keV - 25keV.
- Nickel, chromium, titanium & copper foils.
- Ultra-flat foils with sub- μm thickness.
- Built-in fluorescent YAG screen with high resolution CCD camera & optics for beam imaging.
- EPICS driver for CCD camera.
- Fast positional feedback to primary optical components.
- Focus & align beam using optical components.
- Can be integrated with Secondary Source Aperture for mono beam viewing at secondary source.
- Mounted on an ultra stable granite block with a measured amplification factor of 1.0.

The IDT quad diode beam position monitor is designed for use in monochromatic beam, and consists of a motor-driven multi-foil selector, with up to 4 different foils plus a bypass aperture and a fluorescent YAG screen with high resolution CCD camera and optics. Downstream of the foil selector are 4 diodes for intensity and beam position measurements from radiation scattered off the foils. The quad diode BPM can be used to provide positional feedback to piezos installed in upstream monochromators and mirrors.



Above: Quad diode & secondary source aperture assembly installed on XFM beamline at the Australian Synchrotron.



Above: Focused undulator beam image on YAG crystal viewed using CCD camera.

^{*} not for sale in the USA

Secondary Source Aperture

- Ultra-stable flexure driven slit system.
- Slit gap controlled by one motor, with translation controlled by a second motor.
- Slit gap range of -0.1mm to +2.0mm with sub- μm accuracy.
- Translation travel range 8mm.
- Ground tungsten slit blades with parallelism to $<5\mu\text{m}$.
- Installed on an ultra-stable granite block with a measured amplification factor of 1.0.
- Optional photo diode array can be installed to create an integrated back scatter beam position monitor from blades.

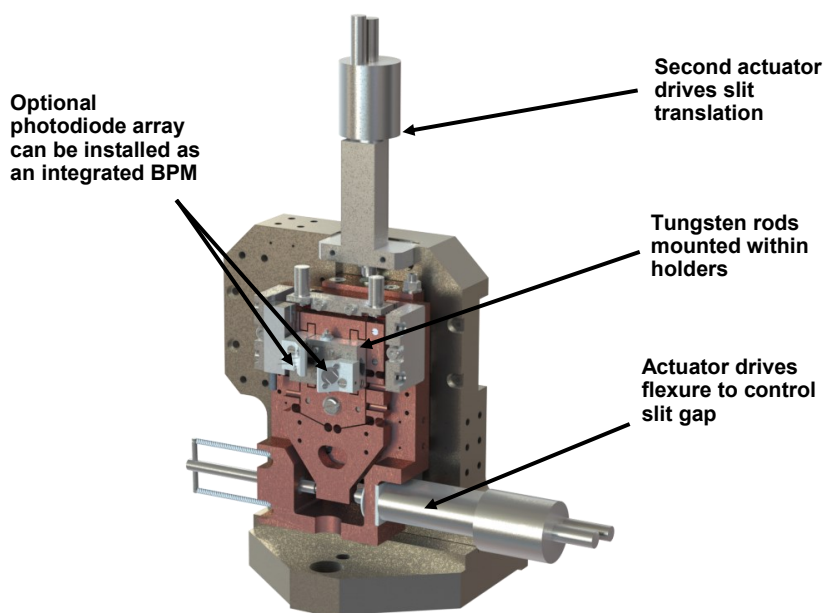
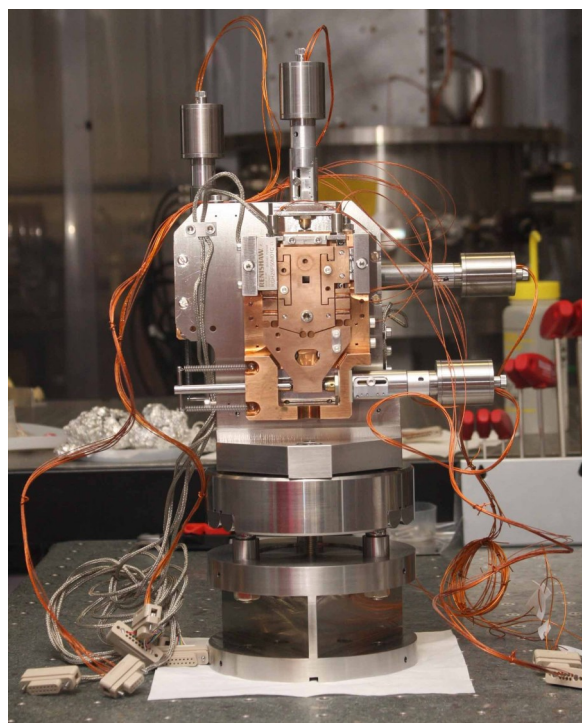
The IDT Secondary Source Aperture (SSA) is a highly stable motorised slit with polished tungsten rods as slit blades. The SSA is a proven design with high stability, highly parallel blades and ultra-stable operation.

A stepper motor is used to open the slit gap by moving the blades in equal increments, driven by a flexure design. A second stepper motor is used to translate the pair of slit blades so that the beam profile can be scanned.

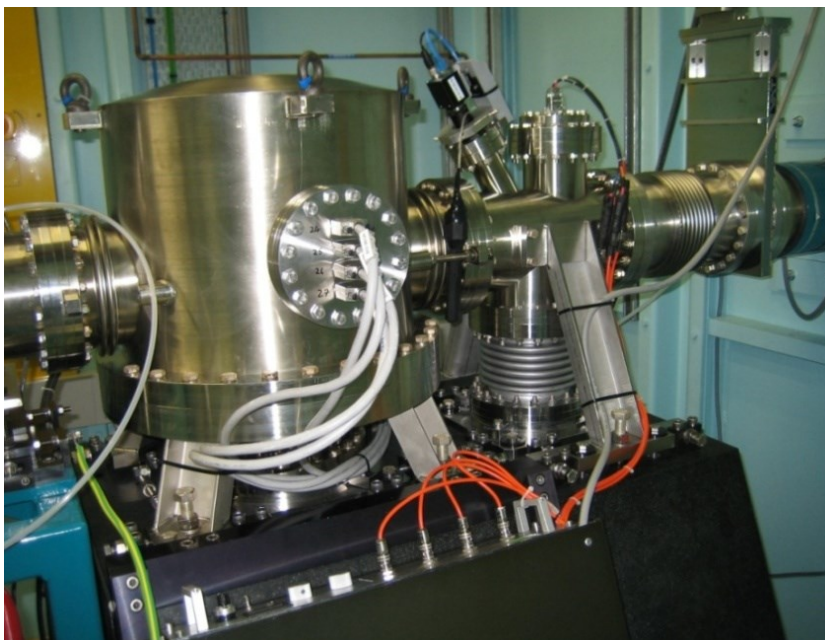
The flexure and the back plate are made of beryllium copper and are thermally matched. The stepper motors are thermally isolated from the flexure to prevent thermal drift. Each motion is encoded and can be driven in closed loop.

A second aperture can be mounted orthogonally to provide a horizontal and vertical SSA.

The ability to drive the slit position independently of the slit gap is a key advantage of the IDT SSA design. This provides the ability to scan the monochromatic beam.



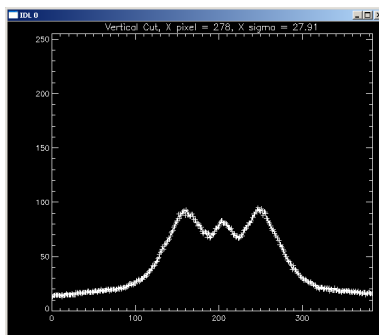
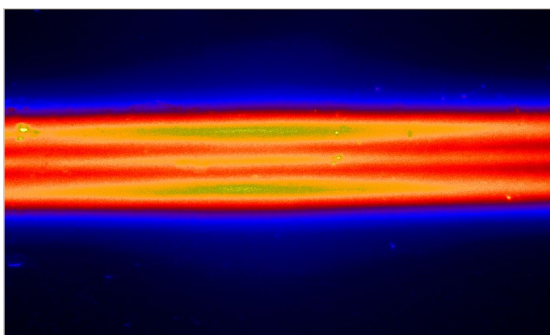
AXIS	ACTUATOR	RANGE	RESOLUTION	REPEATABILITY	NOTES
SSA Slit Translation	Stepper	8mm	<1 μ m	<1 μ m	<i>Allows slit position to be driven independently of slit gap</i>
SSA Slit Gap	Stepper	-0.1mm to 2mm	<0.2 μ m	<0.2 μ m	<i>Control slit gap via flexure design</i>



Above: SSA installed on GSECARS at the Advanced Photon Source.

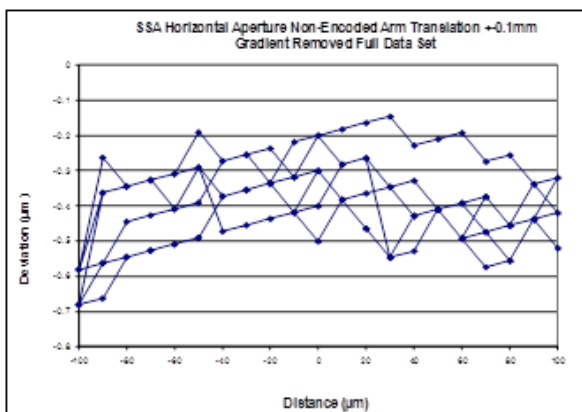
Left: SSA installed immediately downstream of the Quad Diode BPM on XFM beamline at the Australian Synchrotron.

XFM beamline SSA performance data:



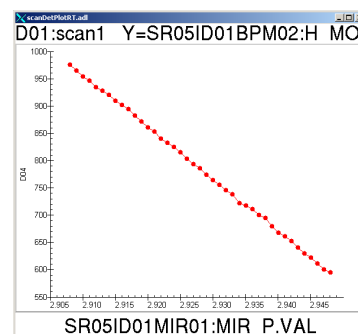
Left: This is a diffraction pattern produced by an 88 μ m vertical SSA slit, viewed at the sample position. This demonstrates the fantastic slit blade alignment.

Image of beam using a YAG screen on table 5x objective. Camera resolution = 3.75 μ m/pixel.



Left: Accuracy measurement for slit aperture mechanism demonstrating the fantastic performance over 3 $\pm$ 100 μ m cycles. Unidirectional accuracy of 0.15 μ m.

Right: Demonstration of integrated photo diode beam position monitor linearity. The beam was scanned $\pm$ 170 μ m across a 100 μ m slit aperture. This response is clearly ideal for a closed loop feedback.



Versatile Five Degree-of-Freedom Tables

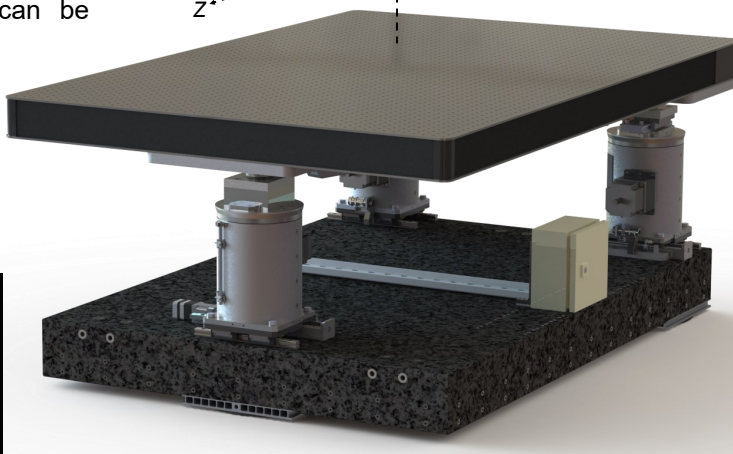
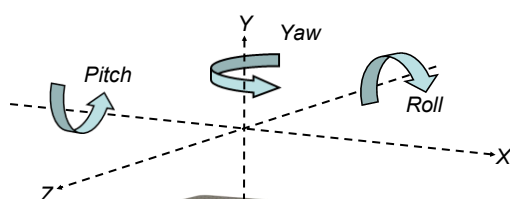
Experimental Tables; Diffractometer Supports; Detector Mounts

- Platforms are fully customised and tailored to the specific requirements of each beamline.
- Up to 7.5 tonne load capacity available.
- Sizes up to 2.5m × 3.0m.
- Kinematic mount interface to breadboard or diffractometer base.
- Vertical translation ranges up to 150mm.
- Platforms can be mounted on airpads for easy installation and movement.
- High accuracy ($\pm 1\mu\text{m}$) limit switches can be used as hard limits and/or home switch on each motion.
- Optical linear encoder to $\pm 0.1\mu\text{m}$ precision.
- Optional over roll/tilt switches can be fitted.
- Single jacks with 1 tonne - 2.5 tonne load capacity, with up to 150mm travel available.

IDT have developed a comprehensive range of experimental table configurations which can be used to provide a stable support to optical components, experimental equipment and diffractometers. Tables are fully motorised with pitch, roll & yaw, vertical and lateral degrees of freedom (Z-translation can be included as an option).

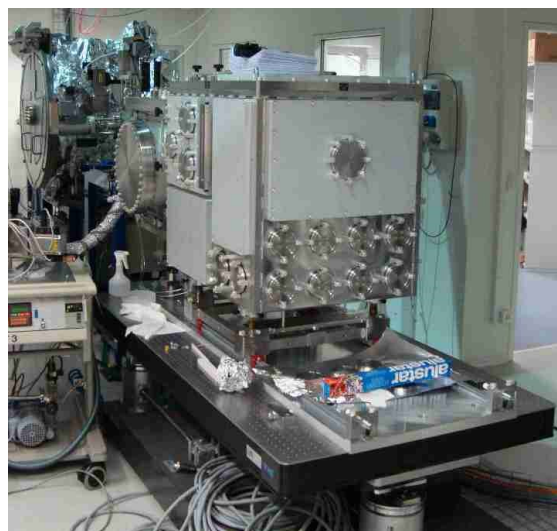
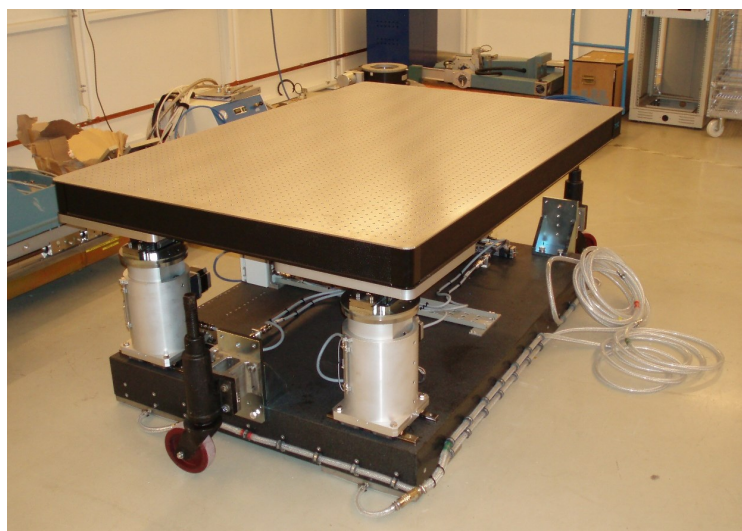
IDT have installed more than 20 experimental tables at DESY, Swiss Light Source, Canadian Light Source, Diamond Light Source & HP-CAT at the Advanced Photon Source.

Motion	Resolution	Repeatability
X	$<0.1\mu\text{m}$	$\pm 0.5\mu\text{m}$
Y	$<0.3\mu\text{m}$	$\pm 0.5\mu\text{m}$
Pitch	$<0.5\mu\text{rad}$	$\pm 1.0\mu\text{rad}$
Roll	$<1.0\mu\text{rad}$	$\pm 1.0\mu\text{rad}$
Yaw	$<5.0\mu\text{rad}$	$\pm 1.0\mu\text{rad}$



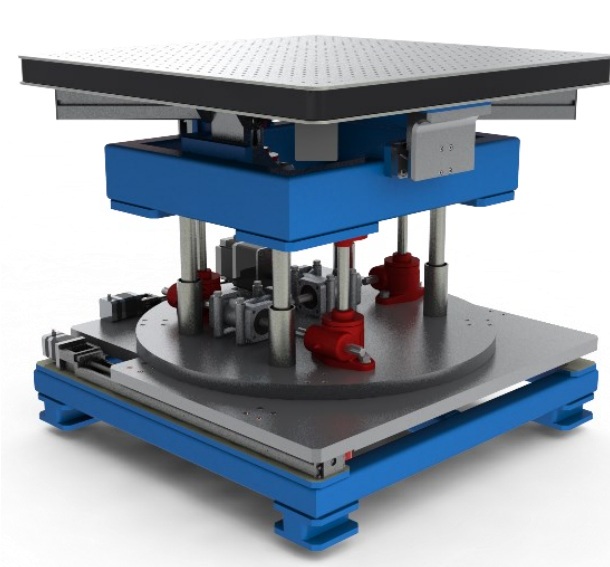
Below left: Experimental table with airpads for easy in-hutch movement at Petra III, DESY.

Below right: Large experimental table supporting experimental equipment installed at Swiss Light Source.



Sample Tables

- Ultra stable sample tables with breadboard size 750mm × 750mm (larger sizes possible).
- X, Y, Z, Pitch/Roll & Yaw translations available.
- Long Z travel (>10m) via rack & pinion rail system, with independent fine adjustment stage.
- Vertical translation ranges up to 200mm.
- High accuracy ($\pm 1\mu\text{m}$) limit switches can be used as hard limits and/or home switch on each motion.
- Optical linear encoder to $\pm 0.1\mu\text{m}$ precision.
- Sample tables are fully customised to the requirements of each beamline.



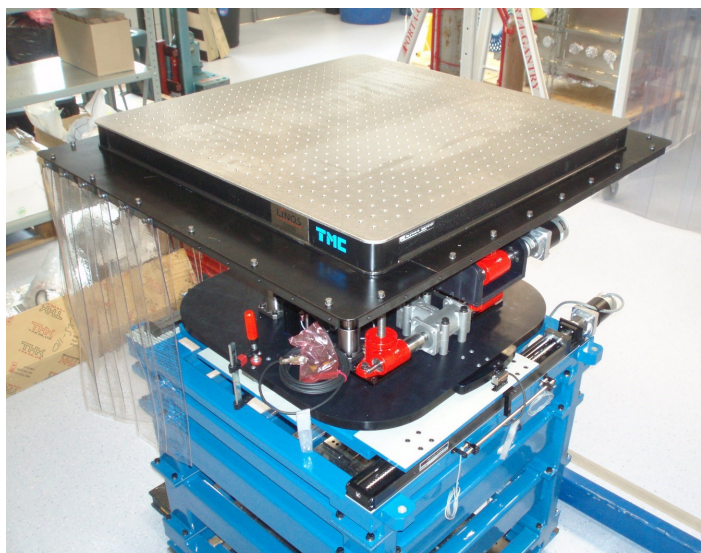
The IDT sample table features horizontal X & Z travel, vertical adjustment, and pitch and yaw adjustment. A long Z (upstream/downstream) travel can be incorporated via a rack & pinion rail system, with a stepper-driven fine Z adjustment accessible anywhere within the long travel range.

Motion	Range	Resolution	Repeatability
X	$\pm 100\text{mm}$	$0.83\mu\text{m}$	$\pm 0.9\mu\text{m}$
Y	200mm	$0.28\mu\text{m}$	$\pm 0.32\mu\text{m}$
Z	$\pm 75\text{mm}$	$0.83\mu\text{m}$	$\pm 0.6\mu\text{m}$
Pitch	$\pm 5^\circ$	$1.4\mu\text{rad}$	$\pm 0.8\mu\text{rad}$
Yaw	$\pm 10^\circ$	$0.4\mu\text{rad}$	$\pm 0.7\mu\text{rad}$

Above right: Typical performance data for sample table.

Right: Sample table mounted on motorised rails (>10m) on NCD beamline at ALBA.

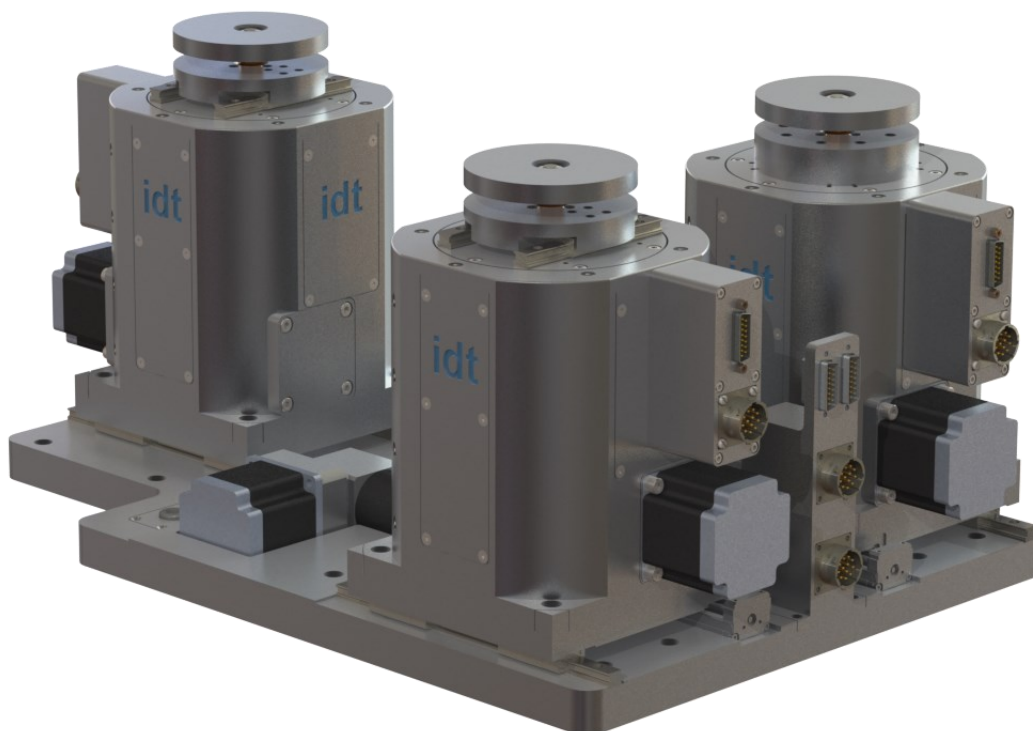
Below: Sample table used on I22 NCD beamline at Diamond Light Source.



Compact Manipulator System

Mini five degree-of-freedom manipulator

IDT have developed a miniature version of our high load experimental table. This compact manipulator system is highly versatile and has several features that make it ideal for sample environments with limited space.



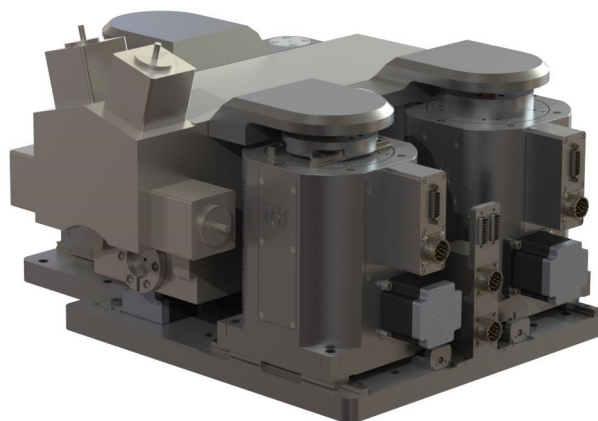
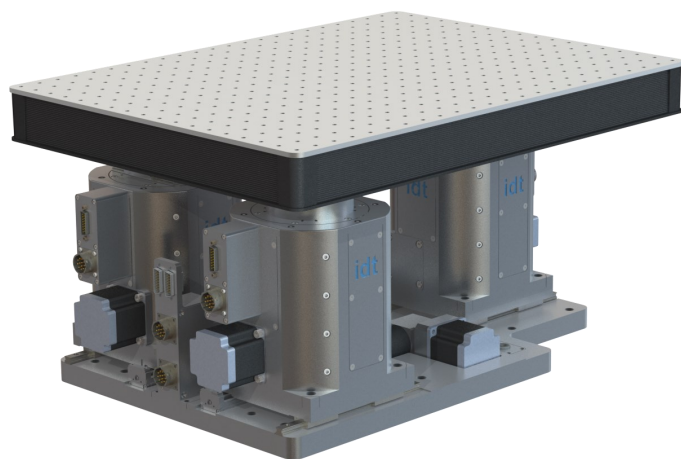
- Small footprint, typically 375 mm x 600 mm x 270 mm.
- Flexible orientation & mounting options.
- High load capacity, up to 500 kg.
- Caters for small breadboards, X95 rails and other beamline components such as the F-Switch compound refractive lens.
- Pitch, roll, yaw, height & horizontal translation degrees of freedom.
- Positioning to sub- μ rad & sub- μ m repeatability.
- All degrees of freedom encoded with Renishaw VIONiC encoders.
- Highly repeatable limits ($\pm 1 \mu$ m).
- Range of motions 0 - 25 mm.
- EPICS control software available.

Motion	Resolution	Repeatability
Horizontal	$< 0.1 \mu$ m	$\pm 0.5 \mu$ m
Height	$< 0.3 \mu$ m	$\pm 0.5 \mu$ m
Pitch	$< 0.5 \mu$ rad	$\pm 1.0 \mu$ rad
Roll	$< 1.0 \mu$ rad	$\pm 1.0 \mu$ rad
Yaw	$< 5.0 \mu$ rad	$\pm 1.0 \mu$ rad

Versatile Mounting Options

The compact manipulator system is designed to be highly versatile with several mounting modes available, and is ideal for environments where space is limited, owing to the very small footprint of the system.

For the ultimate low-footprint set-up the working piece can be mounted inline on the compact manipulator system. The image *right* shows the F-Switch CRL mounted inline.

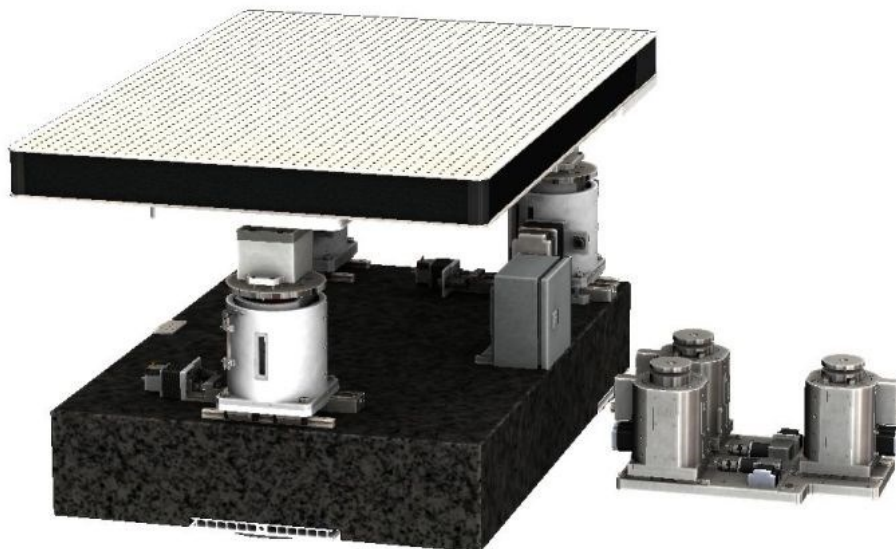


Alternatively the working piece can be mounted on top of the compact manipulator system, as shown in the image *left*, which has a 600 mm x 450 mm breadboard mounted on top of the system.

Ultra-low Footprint

The compact manipulator system is ideal for environments where space is limited, owing to the very small footprint of the system.

To illustrate the size of the compact manipulator system, the image *below* shows the system alongside our five degree-of-freedom table. For scale, the breadboard on the large table is 1.5 m x 1.0 m.



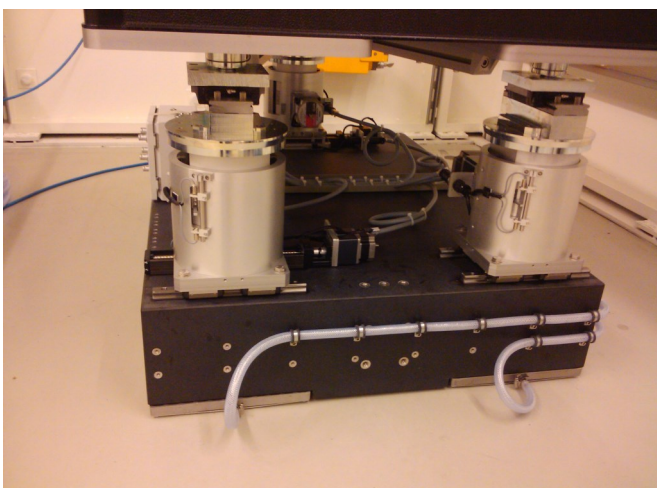
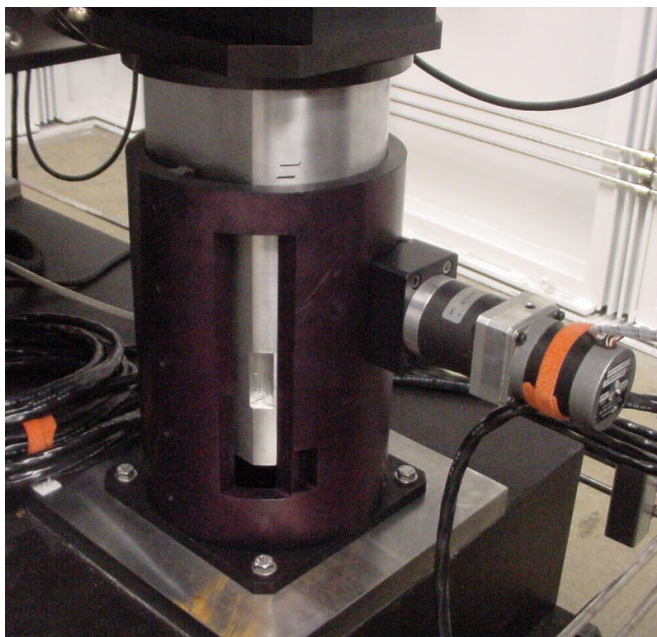
Vertical Jacks

- 1 tonne & 2.5 tonne load capacities available.
- Ultra-stiff Jacks.
- Mounting interface can be a cone, vee or flat using a spherical bearing.
- Vertical translation range to 150mm available.
- High accuracy ($\pm 1\mu\text{m}$) limit switches can be used as hard limits and/or home switch on each motion.
- Optical linear encoder to $\pm 0.1\mu\text{m}$ precision.
- Optional horizontal translation stages.

IDT's unique guided jacks, which can be used for a number of applications, have a compact design and a very high mechanical stiffness. Customisation is possible to suit specific requirements. The single jack's motion is highly repeatable. IDT jacks have been used on experimental tables, detector mounts, large mirror system supports and monochromator supports.

Typical performance data for vertical jack:

Range	Resolution	Repeatability
150mm	0.125 μm	$\pm 0.2\mu\text{m}$
Straightness		1 $\mu\text{m}/\text{mm}$
Stiffness		450nm/N



Multi-Purpose Diffractometer Detector Mount

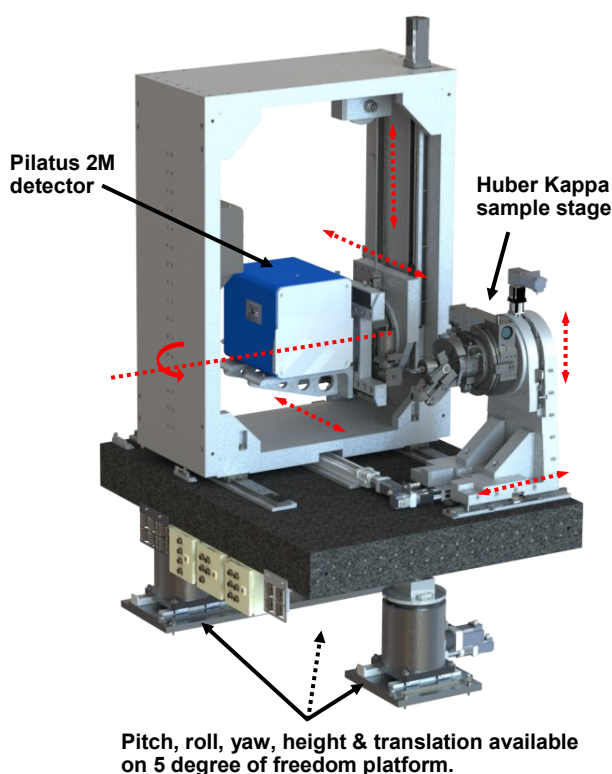
installed on the Swiss-Norwegian beamline at the ESRF

- Independent detector support frame & sample goniometer on common platform.
- Detector support with 4 degrees of freedom.
- Common platform with 5 degrees of freedom.
- Huber Kappa sample stage mount with 3 degrees of freedom.
- Counterweight safety system to protect detector from mechanical failures.

In conventional single crystal diffractometers, the X-ray detector is attached via a rigid arm to a rotary table. The diffraction angle (2θ) is then defined by the mechanical movement of the rotary table. With the advent of area detectors, the size and weight of X-ray detectors has increased dramatically. It has therefore become more and more difficult to mount heavy and bulky detectors on a rotary arm. The situation is particularly difficult when using synchrotron radiation, since the horizontal polarisation of the incoming X-ray beam favors a vertical diffraction plane.

The alternative solution is to mount the detector on a separate support frame, but to place the detector support and the sample goniometry on a common platform. Precision mechanics are essential in order to allow the detector to be positioned accurately and reproducibly relative to the sample. This alternative solution was realised by IDT for the Pilatus 2M detector installed on the Swiss-Norwegian beamline at the ESRF. The detector is bulky and weighs 42kg, but it is nevertheless possible to position the center of the detector at a diffraction angle of up to 45° (at the closest position) and to vary the sample-to-detector distance from about 150mm to almost 1000mm. The support frame for the detector and the sample goniometry are both mounted on a common granite base, which in turn can be aligned relative to the incoming beam using a system of jacks and slides with 5 degrees of freedom. A total of 15 motorised movements allow the sample and the detector to be precisely positioned and aligned relative to the synchrotron beam.

Below: Illustration of degrees of freedom on diffractometer detector mount.



Above: Diffractometer detector mount installed on Swiss-Norwegian beamline at the ESRF.

Vacuum Actuators & Stages

IDT have designed & built a range of monochromators with outstanding performance. To achieve such excellent performance has required the development of a series of high performance actuators & stages capable of operating in a high vacuum (HV) & ultra-high vacuum (UHV) environment. UHV compatibility was the initial design goal for all these items from their conception. We are delighted to now offer these actuators & stages as products in their own right.

The ability to operate actuators & stages in HV & UHV is dependent upon a variety of factors as follows:-

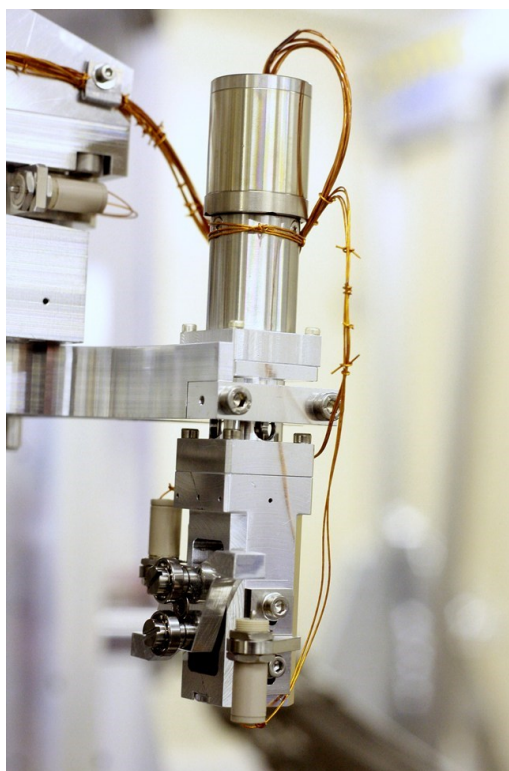
- Use of vacuum compatible materials.
- Vacuum motors & wiring rated for correct vacuum level.
- Linear & angle encoders being vacuum compatible.
- Vacuum limit switches.
- Vacuum lubricants.
- Vacuum cleaning & bake out processes.
- Residual outgassing rates.

By employing good vacuum practice IDT ensure that our actuators and stages are of the highest quality and fully HV/UHV compatible, with the following used in manufacture & assembly:

- Vacuum step motors, HV or UHV grade.
- Aluminium alloys throughout.
- Stainless steel ball screws with ceramic balls & end support bearings.
- Machined screws with phosphor bronze drive nuts.
- Vacuum compatible limit switches.
- Vented silver plated screws.
- Optional encoders.

Additionally all our actuators and stages are tested and vacuum prepared to keep outgassing rates to a minimum:

- Fully tested and calibrated with our comprehensive metrology suite.
- UHV cleaning processing followed by bake out to 120°C. IDT operate several vacuum bake-out rigs for processing products to achieve HV & UHV.
- RGA 0-200amu gas scans to measure outgassing of products and rates of outgassing after bake-out.



The motor/gearbox is the limiting factor of actuator & slide vacuum performance:

- High Vacuum stepper motors are rated for 5×10^{-8} mbar (after water bake).
- Ultra High Vacuum stepper motors are rated to 10^{-11} mbar.

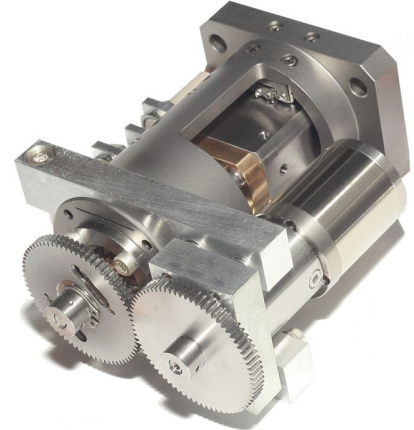
Outgassing

Careful design and manufacture, plus the cleaning processes used throughout the build of any vacuum device leads to the highest quality product. It is important to realise that the nature of the system is such that in a HV or UHV environment the motorised stage or actuator will experience outgassing. Vacuum motors & stages will always outgas during initial commissioning which will reduce over time. All vacuum prepared actuators & stages will have residual outgassing during operation at HV or UHV. The vacuum preparation processing will keep this outgassing to a minimum suitable for HV or UHV operation but please note the products are not outgassing free.

High Performance Hybrid Actuator

IDT have developed a hybrid actuator using the best available components all carefully selected for the highest performance. The hybrid actuator provides coarse sub-micron precision plus nanometre level positioning using an inline piezo. General actuator features are as follows:-

- 175N linear load.
- HV & UHV compatible.
- Encoded using latest technology from Renishaw & other encoders from Jena & Mercury .
- 2-3µm accuracy limit switches.
- Coarse motion range up to 6mm with sub micron repeatability.
- Fine motion range 60µm with high stiffness piezos and <10nm repeatability.
- Lowest Abbe errors with inline piezo.
- Offset drives for compact actuator.
- Thermal breaks fitted throughout to minimise drift.
- Spherical end.
- In-line drive versions also available.



Coarse stepper-motor driven motion performance:

Resolution	0.18µm
Repeatability	0.18µm

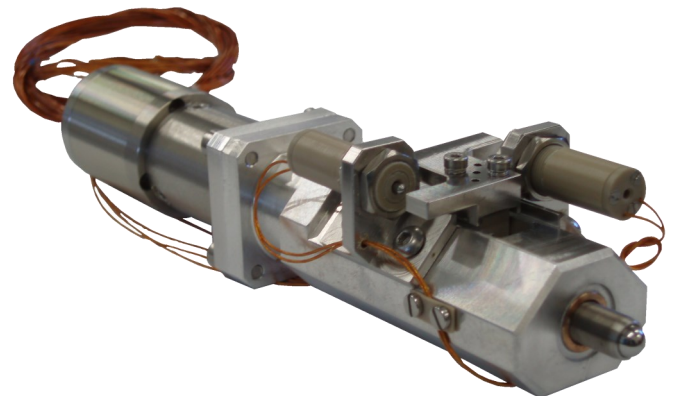
Fine piezo driven motion performance:

Resolution	<1nm
Range Piezo range accessible anywhere in 6mm coarse range	60µm

Low Load Actuator

This device has been developed with cost and compactness of footprint in mind. The actuator has excellent repeatability plus many other features:-

- 100N linear load.
- HV & UHV compatible.
- Encoded using latest technology from Renishaw & other encoders from Jena & Mercury.
- 2- 3µm accuracy limit switches.
- Compact footprint.



Low load actuator performance:

Resolution	0.03µm
Repeatability	0.5µm

Linear Slides

IDT have developed a series of high quality linear slides with varying travel ranges from 25mm up to 150mm in 25mm increments. The unique feature of these slides is the extremely low pitch errors of the order of $<10\mu\text{rad}$ per 10mm linear travel. Other parasitic angular errors are equally impressive with yaw errors of the order of $<10\mu\text{rad}$ per 10mm linear travel.

The slides have excellent positional repeatability $<1\mu\text{m}$ plus many other features:-

- HV & UHV compatible.
- Repeatable to $<0.15\mu\text{m}$.
- Load capability up to 200N.
- Encoded using latest technology from Renishaw & other encoders from Jena & Mercury.
- 2-3 μm accuracy limit switches.
- Backlash $<1\mu\text{m}$.
- Compact footprint.
- Inline gearbox for high loads.
- Very smooth ball screw drive.
- Ceramic bearings throughout.
- Ultra low parasitic yaw errors $<10\mu\text{rad}$ per 10mm linear travel.



Above: 25mm travel linear slide

Below: 130mm travel linear slide



Linear slide performance:

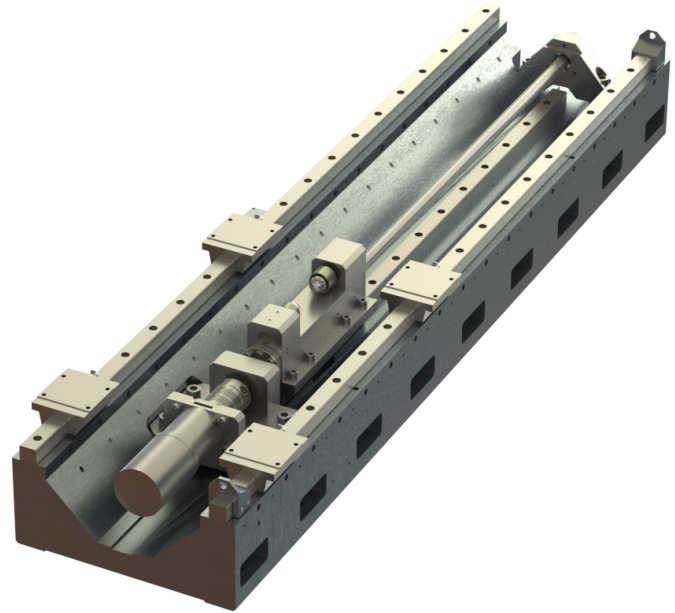
Resolution	0.2 μm
Repeatability	0.13 μm
Backlash	0.7 μm

Custom Engineered Slides

IDT are capable of designing and building customised slides to meet specific requirements.

IDT have designed & built a high load slide in HV environment with 560mm travel, outstanding straightness and ultra low pitch & yaw errors. This custom slide has excellent positional repeatability $<1\mu\text{m}$ plus many other features:-

- HV compatible.
- Repeatability to $<0.15\mu\text{m}$.
- High Load capability $>2000\text{N}$.
- Fitted with Renishaw encoders.
- $2\text{-}3\mu\text{m}$ accuracy limit switches.
- Very low backlash $<1\mu\text{m}$.
- Inline gearbox for high loads.
- Excellent straightness.
- Ultra low parasitic yaw errors $<1\mu\text{rad}$ per 10mm linear travel.
- Zero measured encoder following error.



Long 560mm travel slide motion performance:

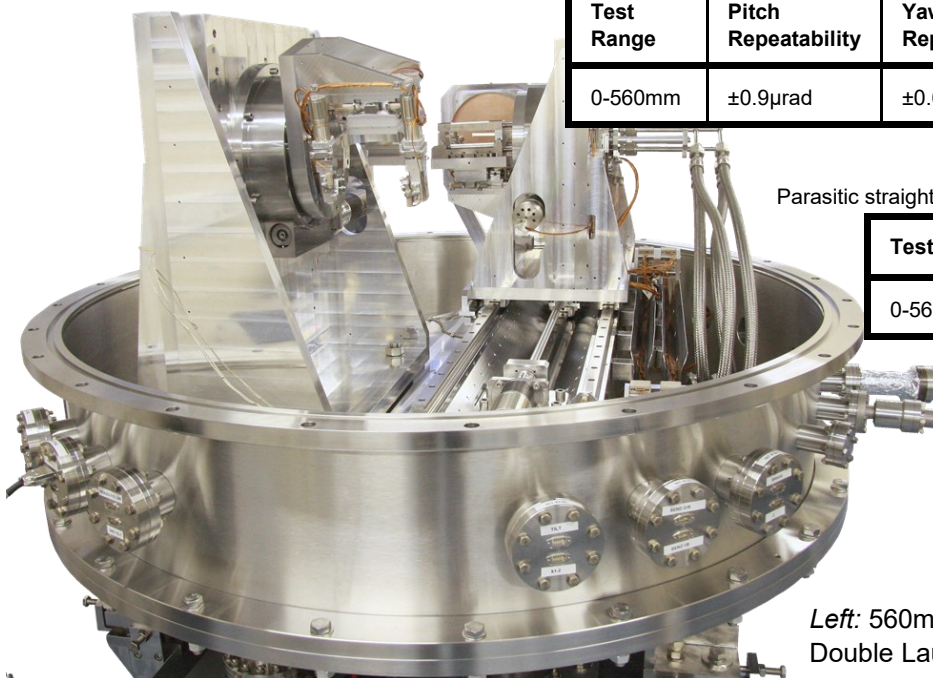
Resolution	1.5 μm
Repeatability	0.1 μm

Parasitic angular data obtained with Laser Autocollimator:

Test Range	Pitch Repeatability	Yaw Repeatability	Pitch Range	Yaw Range
0-560mm	$\pm 0.9\mu\text{rad}$	$\pm 0.6\mu\text{rad}$	50 μrad	24 μrad

Parasitic straightness data obtained with FARO arm CMM:

Test Range	Z Range	Y Range
0-560mm	$\pm 13\mu\text{m}$	$\pm 16\mu\text{m}$



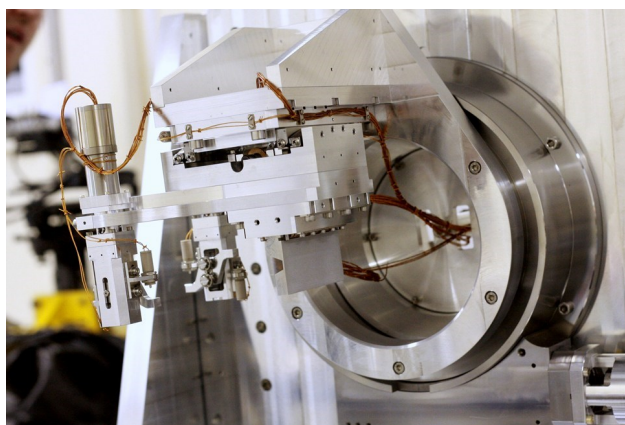
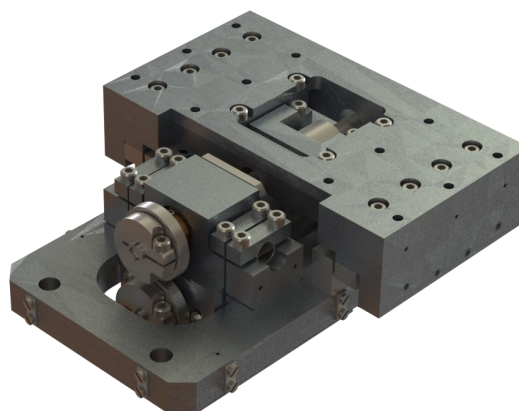
Left: 560mm travel linear slide on Double Laue-Crystal Monochromator.

Goniometers

IDT have developed a goniometer with angular range of $\pm 5^\circ$, proven on the Double Laue Monochromator installed on the Imaging & Medical beamline at the Australian Synchrotron.

The goniometer has excellent repeatability plus many other features:-

- HV & UHV compatible.
- Unidirectional repeatability to $<1\mu\text{rad}$.
- High resolution $<2\mu\text{rad}$ per step.
- Load capability up to 500N.
- Fitted with standard encoders.
- 2-3 μm accuracy limit switches.
- Compact footprint.
- Inline gearbox for high loads.
- Very smooth ball screw drive.
- Ceramic bearings throughout.
- Low parasitic errors.
- Larger angular ranges possible to $\pm 10^\circ$.
- Orthogonal arcs with common rotation centre possible.



Above: Goniometer built into multi-degree of freedom stage & bender mechanism on Double Laue Monochromator installed on Imaging & Medical Beamline at the Australian Synchrotron.

Accessories

IDT can also supply all our actuator & stages fitted with instrumentation feed-through cables and accessories:-

- Local Peek connectors wired on actuator or stage.
- Kapton ribbon cables, 9-pin for bipolar stepper motor, or 4-pin for unipolar.
- Radiation resistant Kapton cables .
- D-type or C-type multi-pin feed-throughs in a variety of Conflat flange configurations.
- Mating air side connectors.

Right: A range of C-type and D-type feed-throughs, manufactured by Accu-Glass Products, Inc.



Services

The staff of IDT have decades of combined experience in professional engineering design, planning and construction of innovative instrumentation at the very highest level of scientific facility development.

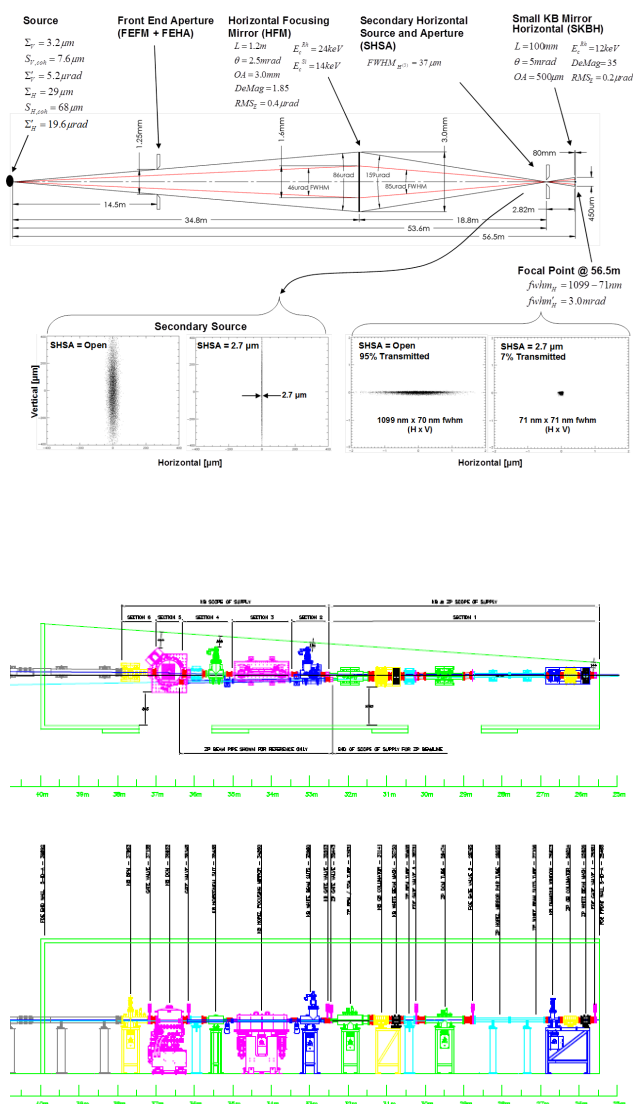
IDT can therefore genuinely offer highly effective services in all of the key areas and stages involved in the design, manufacture & procurement of precision mechanical systems for synchrotron beamlines and other related scientific instruments.

From fundamental feasibility studies of key optical parameters in beamline design, through to advising on diagnostic feedback & motion control of precision multi degree-of-freedom instruments, IDT have the expert knowledge and skills that you can rely on to deliver world-class instrumentation.

Design & Analysis

By using the leading design & analysis software, and with our staff possessing many decades of accumulated experience in the field, IDT can offer a comprehensive beamline design service, including:

- Full beamline conceptual layout.
- Detailed design of beamline components.
- Analysis of optical criteria for maximum beamline performance.
- Heat load calculations and power analysis.
- FEA analysis of heat-loaded components to maximise cooling efficiency.
- Optical ray tracing to indicate beamline performance.
- Bremsstrahlung ray tracing.
- Beam diagnostic schemes.
- Vacuum schemes.
- Budgetary estimations.



Assembly & Testing

IDT use a wide range of external suppliers for the supply of the highest quality machined components and vacuum vessels. These suppliers are compliant with our approved suppliers list and are continuously reviewed to ensure the highest possible quality levels are maintained. The UK is uniquely placed with very high quality precision engineering machine shops supplying Airbus, Rolls Royce Aerospace, BAE Systems plus the majority of the worlds Formula 1 teams. IDT make extensive use of this network.

We have vigorously invested in our in-house facilities allowing us to offer a professional assembly & test service to our customers.

We employ a full suite of state of the art motion control & metrology hardware, with comprehensive test reports in accordance with latest ISO standards provided for the customer to review and approve before shipping.

Our facilities include:-

- Extensive Class 10000 clean assembly areas for construction and testing of ultra high vacuum components and assemblies.
- UHV cleaning, including ultrasonic cleaning, rinse and bake facilities plus two bake-out rigs fitted with MKS RGA heads (0-200amu).
- Leak detector Leybold UL200.
- Two Edwards turbo-scroll pumping carts.
- Two large 3 tonne granite inspection benches and two anti-vibration Newport breadboard mounting tables for precision metrology testing.
- Three Newport XPS stepper & DC servo motor control test rigs for motion control testing (featuring standard stepper motor and micro-stepping control).
- Two Newport laser autocollimators for dynamic measurement with μrad (0.2 arcsec) resolution.
- Wyler inclinometers & Leica Auto level with parallel plate micrometer.
- Rank Taylor Hobson micro-alignment telescope.
- Custom laser quad diode measurement hardware for full characterisation of scanning DCM systems.
- Portable CMM Faro arm & Delcam Power Inspect software.
- One tri-axial and two seismic single axis PCB Piezotronics accelerometers.



Post Sales Support

IDT provide post warranty field support to our clients. Our instruments are thoroughly tested at IDT before delivery and as part of site acceptance tests.

The extreme working environment of Synchrotrons coupled with demanding cycles of operation by the users puts strains on the very best instruments.

IDT has minimal call outs in the field however when they are required we respond in a very timely fashion and keep customers downtime to an absolute minimum.



About Us

Instrument Design Technology are an established leading supplier of complete beamlines, systems & components to the global synchrotron community.

We consist of a team of highly trained scientists, engineers and technicians with many years experience at synchrotron facilities around the world, creating a unique combination of skills and expertise in the synchrotron radiation environment.

Our preferred mode of working is in close collaboration with the scientists and engineers who will be the users of the beamlines and beamline components we supply. Thanks to the range of experience within the IDT team we are able to communicate effectively with both the engineers and and the researchers whom depend on our products to obtain the optimum results in their experiments.

IDT's customer philosophy is not just about the cutting edge quality and design of our products, it's about the integrity of the business as a whole , the services we offer and the fact that we stand by our products and our values.

IDT are an ISO 9001:2015 accredited company.



Certificate Number 3954
ISO 9001:2015



IDT started trading in 2000 at the University of Manchester. In 2005 we moved to larger premises at Daresbury Innovation Centre; then in March 2009 we moved to new hybrid premises in Widnes, Cheshire, local to Daresbury Laboratory. Our floor space was further expanded in 2011 with the acquisition of the adjacent unit, giving IDT a total of 4300 sq ft (approx. 430m²) of lab space and 1500 sq ft (150m²) of office space.

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Widnes is the birthplace of Charles Glover Barkla, winner of the Nobel Prize in Physics in 1917 for his discovery of the characteristic X-rays of elements and the development of X-ray spectroscopy.



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