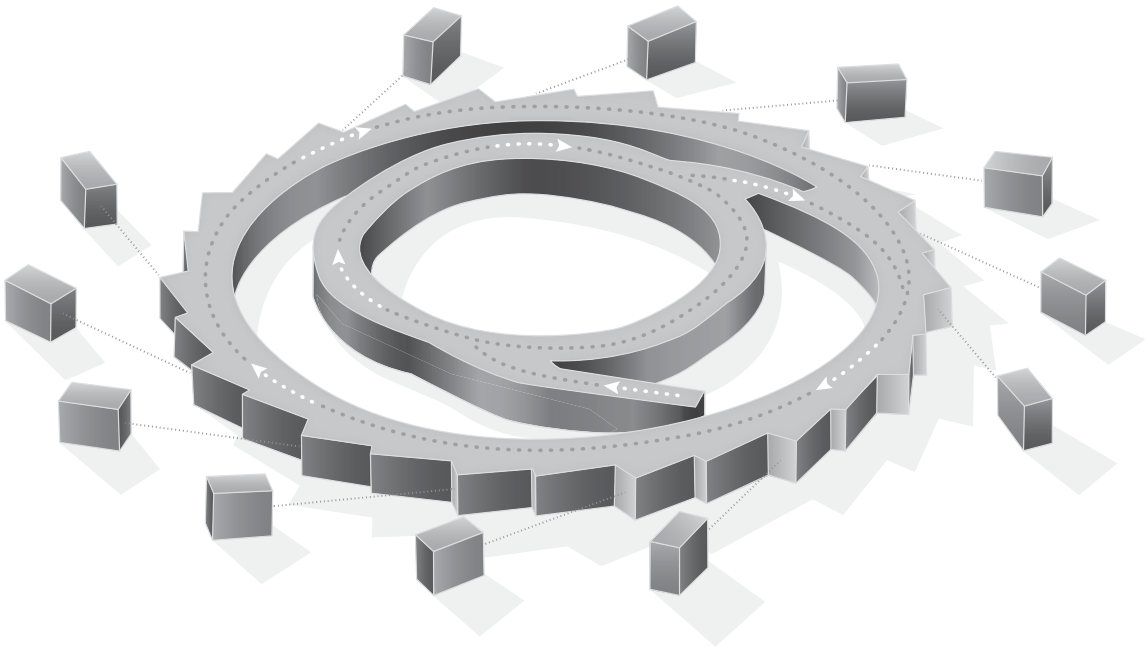
Kurt J. Lesker® Company

UHV Design

UHV MOTION AND HEATING

Vacuum Manipulation Products
for Synchrotron Applications



www.lesker.com

UHV Design motion products for synchrotron manipulation

UHV Design is now firmly established among the synchrotron community as the supplier of choice for UHV manipulation devices ranging from linear actuators through to complete multi-axis sample manipulators. By combining true UHV design principles with experience in demanding industry applications, UHV Design's products ideally suit the rigorous requirements of synchrotrons for precision, long-life and vacuum performance.

With control of all key disciplines in-house, from design to manufacture and test, UHV Design is able to rapidly and competitively customise its UHV manipulators, already the largest range in the world, to meet specific needs.

This brochure briefly outlines each product offered for synchrotron use, providing examples of their applications on **transfer paths**, **storage rings**, **beamlines** and **end stations**. For detailed product specifications, or to download 3D models, please visit our website or contact our team of experts.

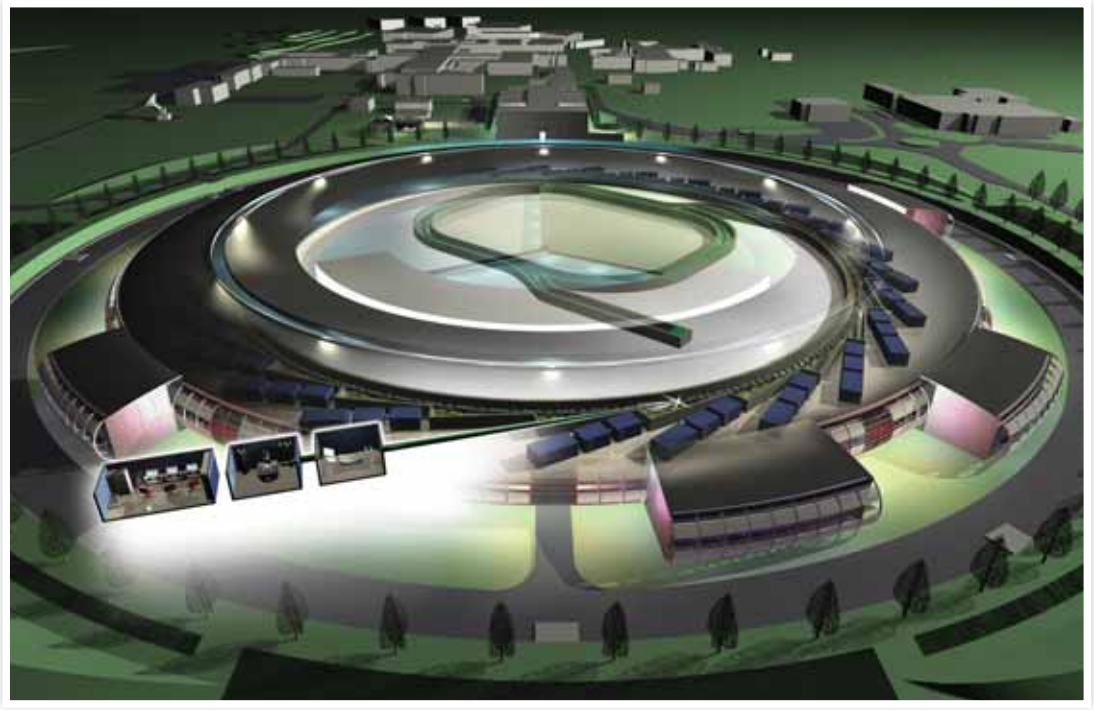


Image courtesy of the Diamond Light Source

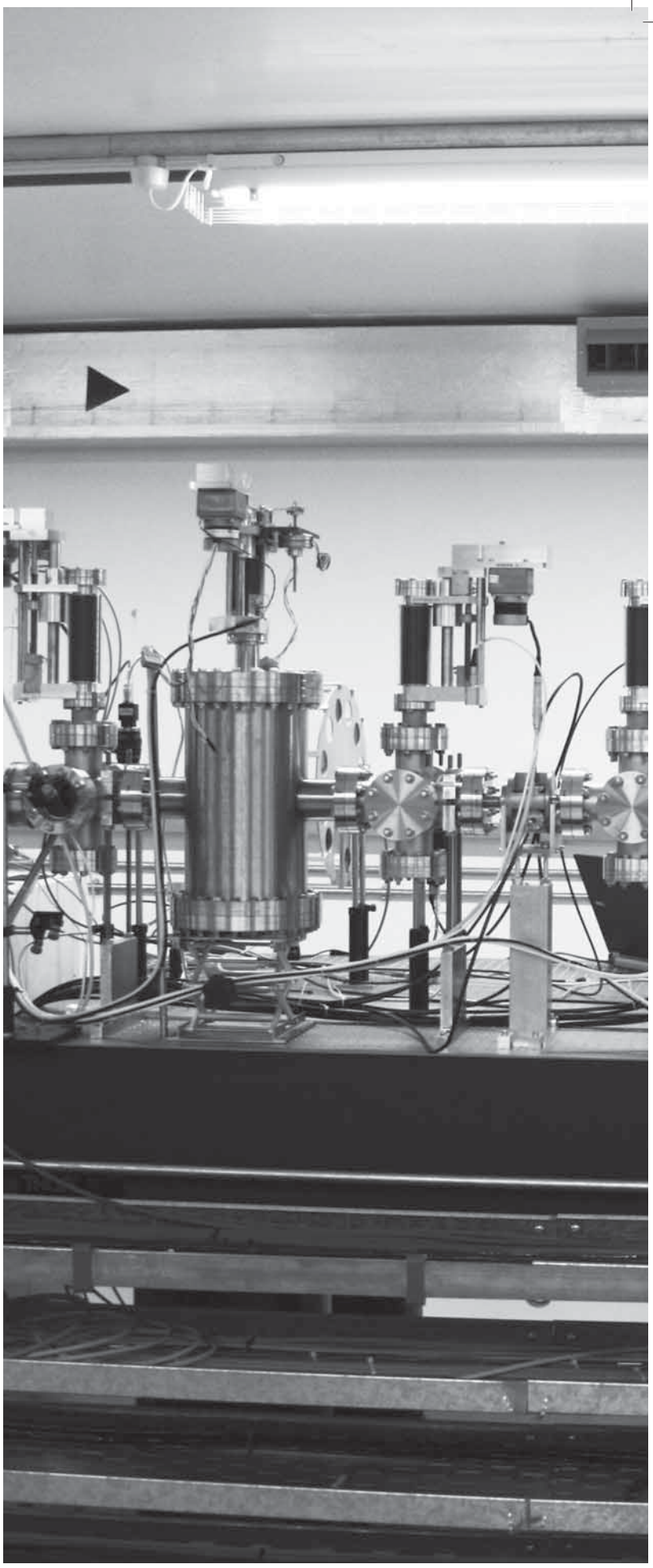
Front cover image courtesy of the Australian Synchrotron

LSM Series

The ultimate in Z-stage stability

The photograph adjacent shows Linear Shift Mechanisms, all of which are stepper motor actuated, mounted on the booster to storage ring (BTS) diagnostics test stand. Four of these LSM's are mounted on 6-way crosses which are also fitted with viewports, and are employed to move double screen holders in and out of the 3 GeV electron beam. The fluorescent screens are YAG:Ce on aluminium coated mylar foil, which acts as a 'Optical Transition Radiator'.

The large chamber shown in this photograph houses the filter actuator. The LSM mounted on this chamber moves a device, called a 'pepper pot', in and out of the beam. This device is an assembly of tungsten vanes which effectively slice the electron beam into small beamlets.



Standard Z range

Linear Shift Mechanisms (LSMs) provide linear motion along a port axis. Their true UHV performance, precise motion and robust design make them ideally suited for the positioning and manipulation of beam line diagnostics and stops etc.

The LSM range is the largest of its type in the world. Synchrotron-specific versions are tolerant of low level radiation and comply with low electrical 'noise' requirements.

The LSM design is truly kinematic, providing smooth, low wear, long life motion and is routinely used for high duty cycle production applications. The rigid construction provides a high load carrying capability, whilst retaining flange parallelism throughout the motion.

- Kinematic design for longevity plus smooth, precise operation
- 25-300mm linear motion
- High quality 316L bellows guaranteed for 10K cycles
- >1m cycle option available
- High precision motion
- Beamline specific range
- Demountable bellows

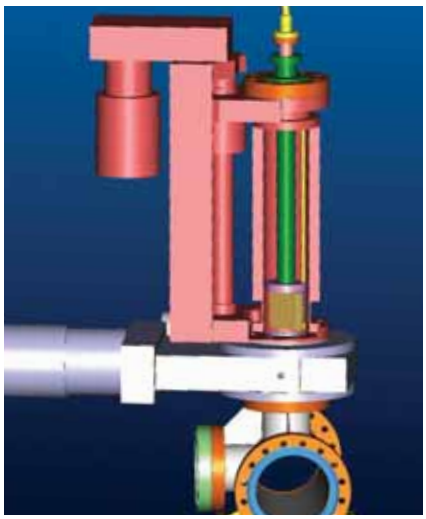
3D models & 2D drawings for standard products are downloadable from www.UHVDesign.com

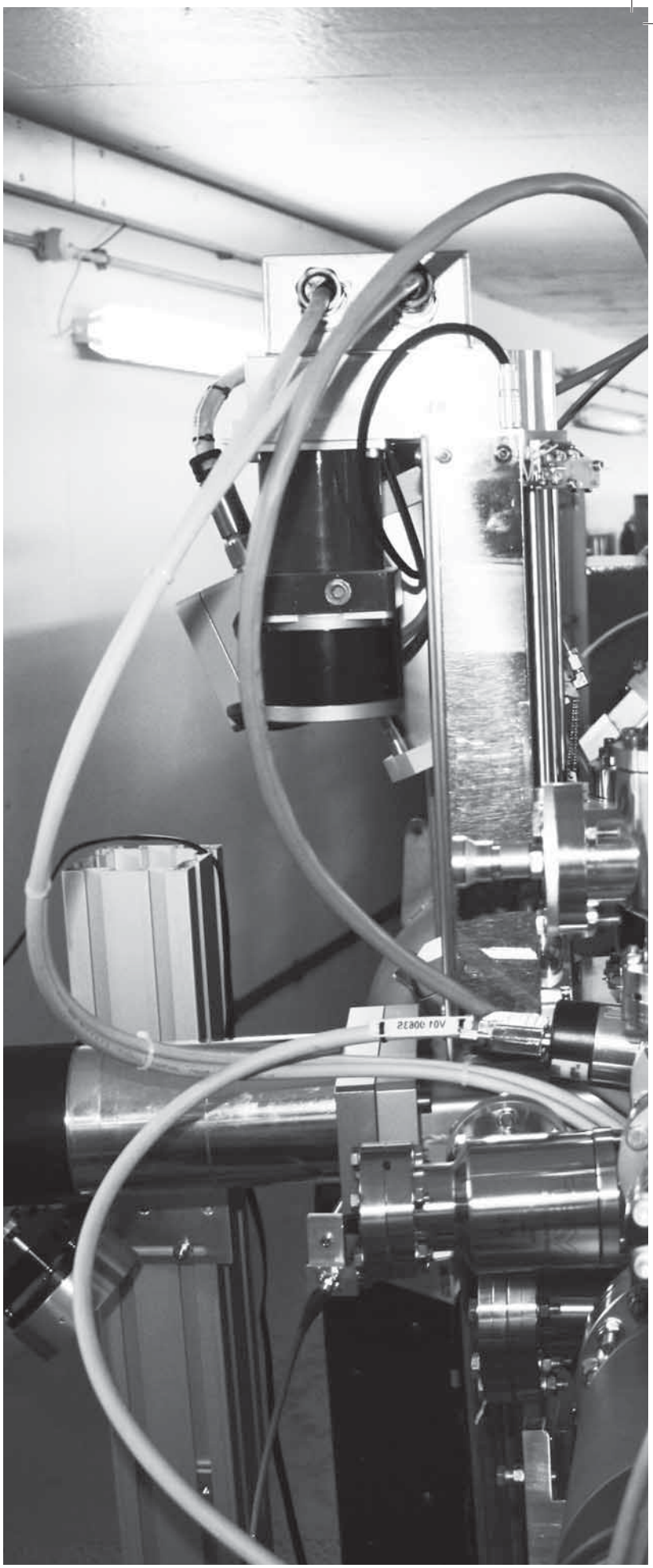
LSML Series

High Precision, High Stability, Up to 1m travel

The Long travel Linear Shift Mechanism (LSML) shown in this photograph is essentially a large vertical actuator which moves a mirror into the fan of light and x-rays which pass through the chamber underneath. Precise vertical positioning of the mirror is essential for collection of the maximum amount of visible light whilst also avoiding the 'hot' x-ray fan. To this end, a pair of thermocouples at the bottom tip of the mirror aid correct placement.

A gate valve fitted between the LSML and the chamber below enables complete withdrawal of the mirror for servicing purposes (see 3D view).





Long Z travel

The strengthened structure of the 'Long Travel' range guarantees ultimate precision throughout its linear motion of up to 1m. High speed and high duty cycle versions are available with >1m cycles guaranteed. As standard, motorised versions come pre-wired, fully bakeable with 'home' and 'limit' switches, terminated in screened bakeable connectors, all of which can be baked to 250°C.

- Up to 1m linear motion
- High stability rear spine structure
- Highest precision range

All LSMs include demountable and replaceable 316L stainless steel edge-welded bellows.

LSMT Series

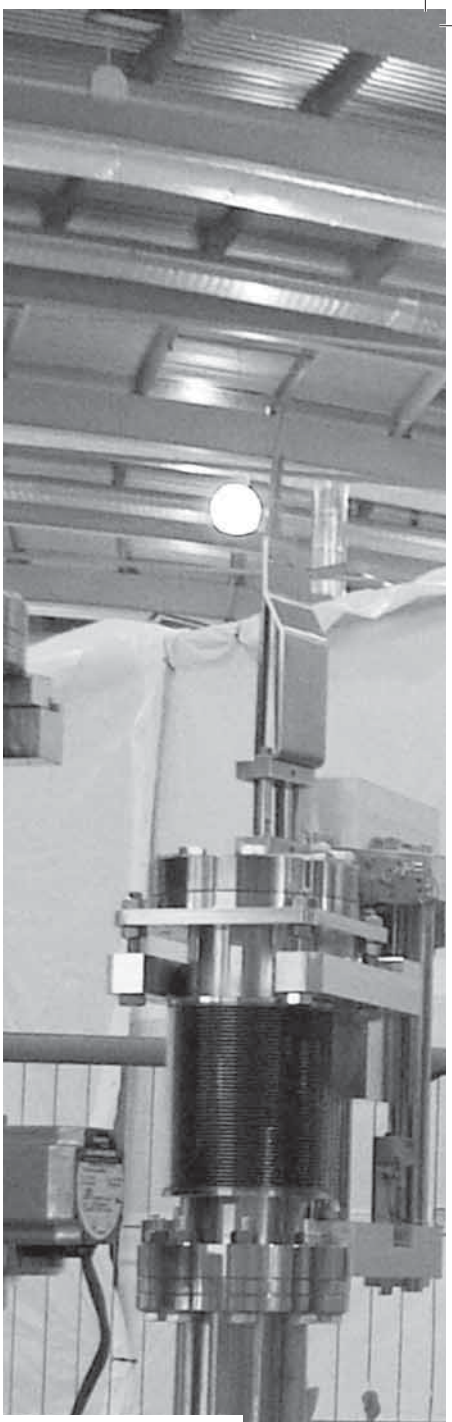
Z-shift stability with fine-tune angular alignment

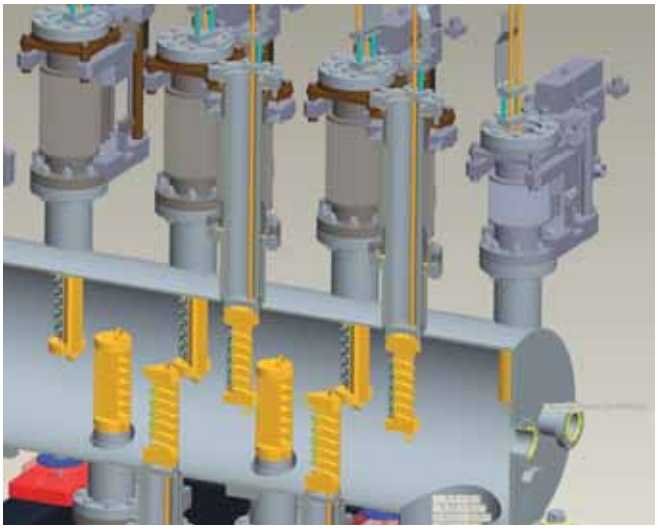
The photograph and associated model on this page show a number of stepper motorised Linear Shift Mechanisms with Tilt (LSMT) employed as Foil Stick Actuators. These actuators each hold up to 6 attenuation foils made of Aluminium, Chromium, Silver, Iron and Copper, of varying thicknesses. Other foil materials may also be used. These effectively remove non-diagnostic, low energy photons from the primary beam on Diamond beamline I13 and reduce the heat load on optical elements downstream. In addition, the absorption on the inner-shell edges will be used to calibrate the photon energy. Remote operation of these actuators enables various combinations of materials to be inserted so that the primary beam may be tailored for individual experiments.

Additional remotely controlled LSMT units on this beamline are used in the following applications:

Beam Absorber Sticks, which are used for reduction in the off-axis emission from the undulator. This is achieved using a water cooled copper absorber with a fixed aperture.

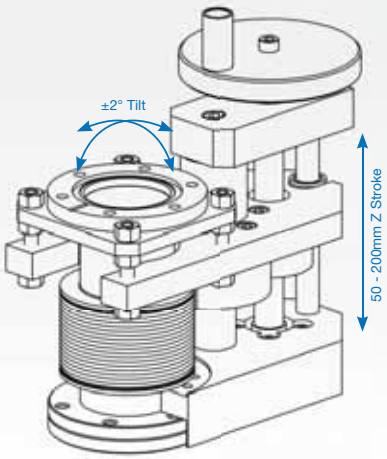
Compound Refractive Lens Stick (CRL Stick), which is a series of individual lenses mounted in a linear array for the focusing of x-rays in the energy range of 5-40 keV. The water cooled CRL Stick houses 6 sets of 10 CRL's. Combining the different focal length CRL assemblies with other focusing elements along the I13 Beam line enables different source magnifications to be achieved.

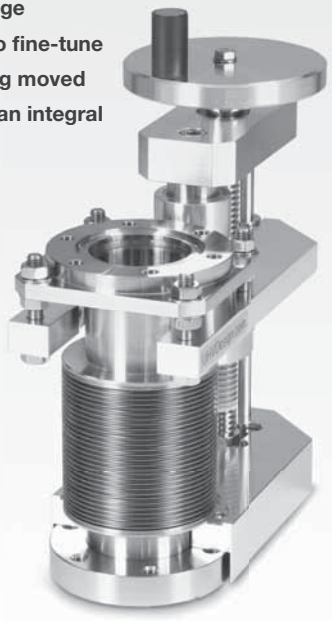




Z with 'tilt' alignment

For critical applications, the LSMT range provides a secondary axis of motion to fine-tune the angular alignment of the item being moved linearly, with respect to the beam, via an integral 'tilt' module.





- Integral +/-2° tilt for beam alignment
- Single bellows design
- Up to 200mm linear motion

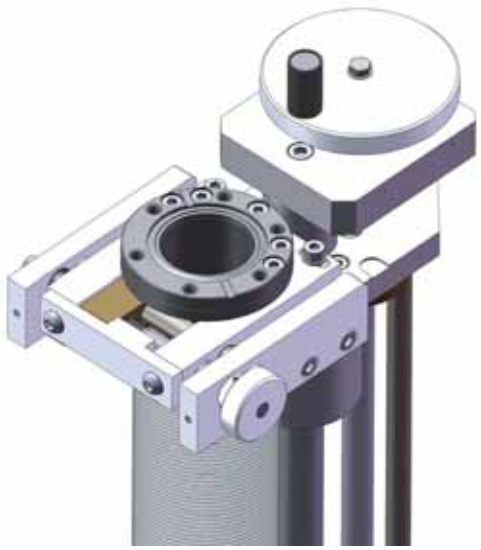
UHV Design offers the world's largest range of linear actuators.

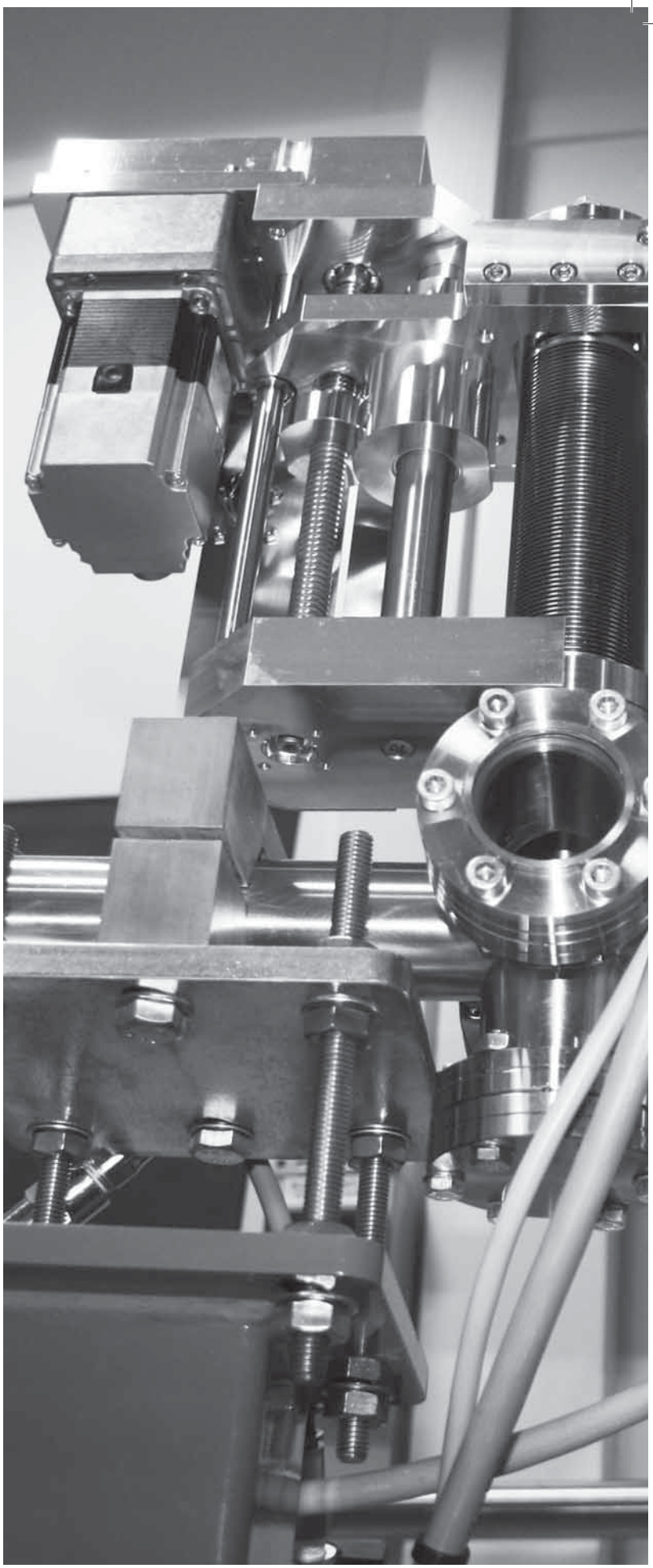
LSMX Series

Z-shift stability with x-axis motion

This photograph shows two Linear Shift Mechanisms with integral +/-5mm X-motion (LSMX) mounted on a branchline of the Diamond Nanoscience Beamline (I06) where they provide manipulation for beam diagnostics. Both LSMX units have stepper motorised linear motion and manually actuated X motion. Both units will additionally be fitted with MagiDrives on the travelling flange, for rotation.

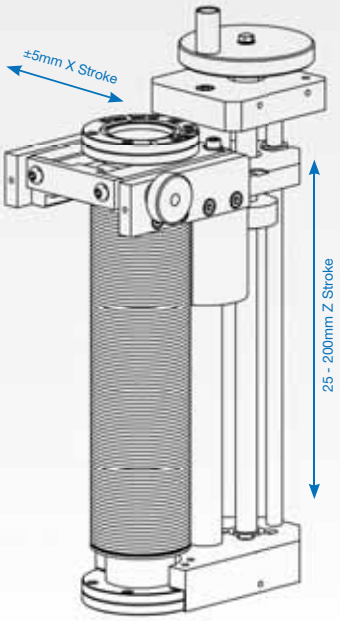
The unit on the right-hand side is used for incoming photon flux measurements and the unit on the left-hand side is used for energy calibration purposes.





Z with 'X' alignment

In addition to precise linear motion, the lateral alignment of beam diagnostics, with respect to a beam, is often essential. Where critical fine-tuning is required to optimise position, the LSMX range provides +/-5mm lateral motion along the X axis (side to side across the beam).



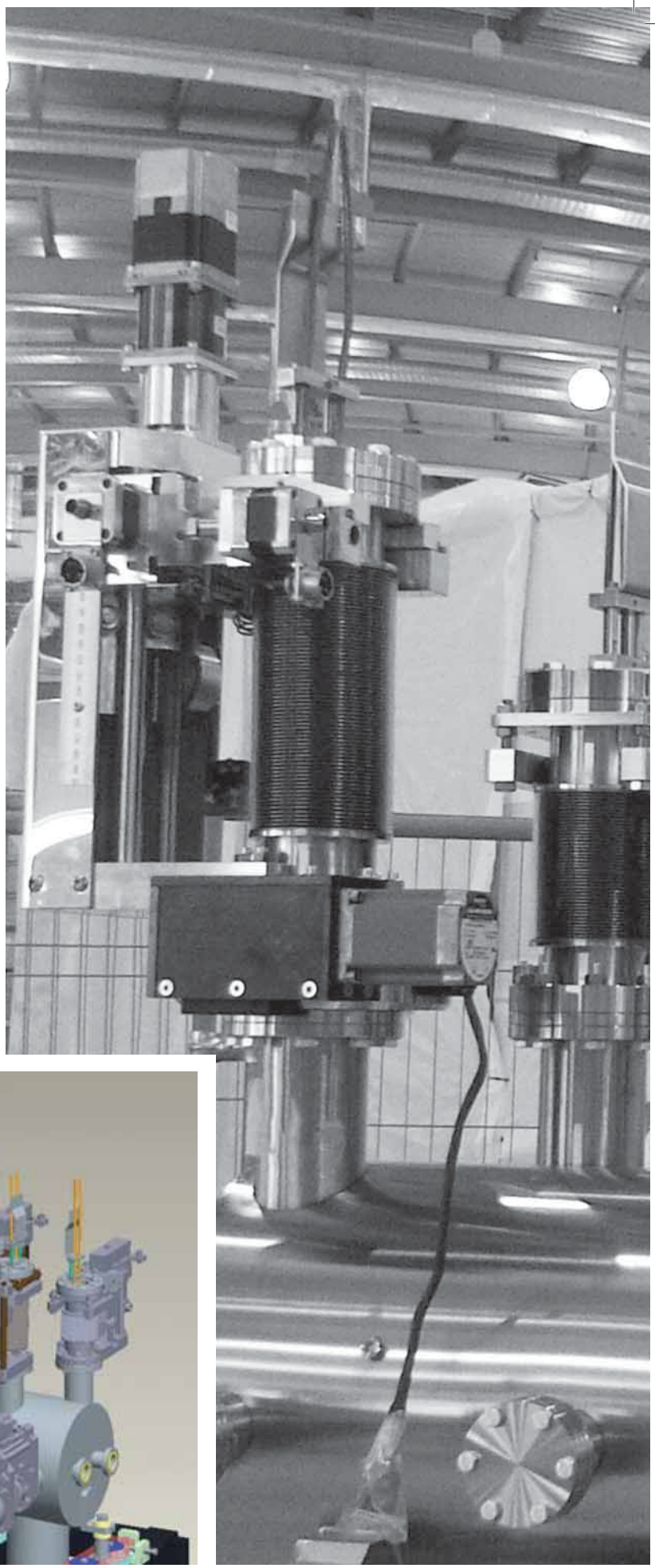
- Integral +/-5mm 'X' axis motion for beam alignment
- Single bellows design
- Up to 200mm linear motion

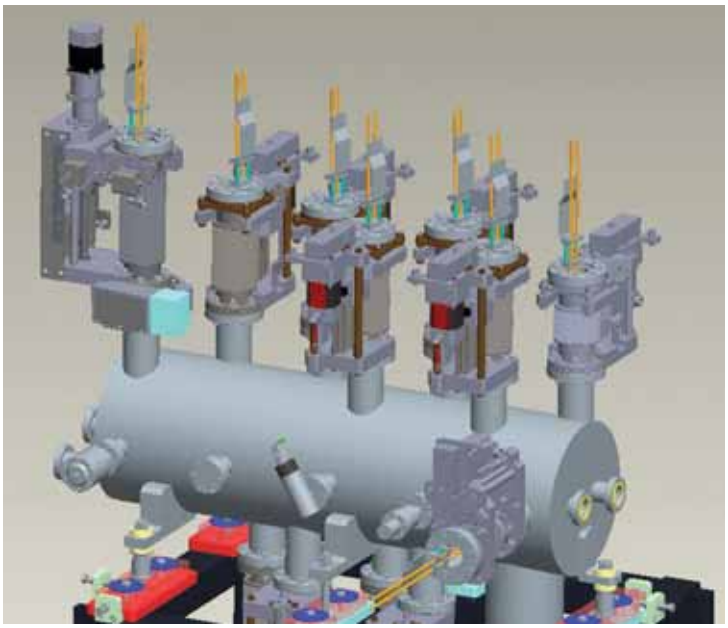
Synchrotron specific design ensures prolonged operation in low radiation environment.

XYZT Series

3-axis precision with tilt alignment

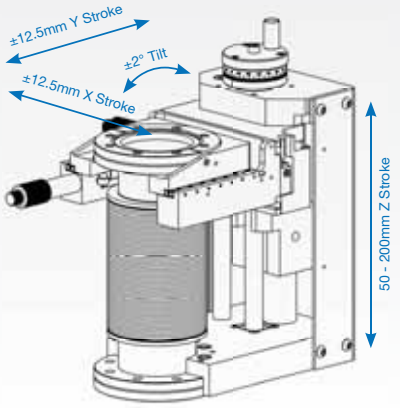
The fully motorised XYZT MultiMotion manipulator shown in this photograph supports a stick containing a series of Compound Refractive Lens (CRL) arranged to focus the X-rays downstream, and works on the I13 beamline in conjunction with the LSMT-actuated CRL Stick series already outlined on page 6. The XYZT offers three separate motorised linear movements together a manually actuated +/-2° of tilt for final alignment purposes.





XYZ with tilt alignment

The XYZT manipulator enables beam line components, such as diagnostics, filters and slits, to be precisely manipulated in the X, Y & Z axes. An integral +/-2° 'tilt' mechanism then enables final angular alignment of the diagnostics in the Y-Z plane.



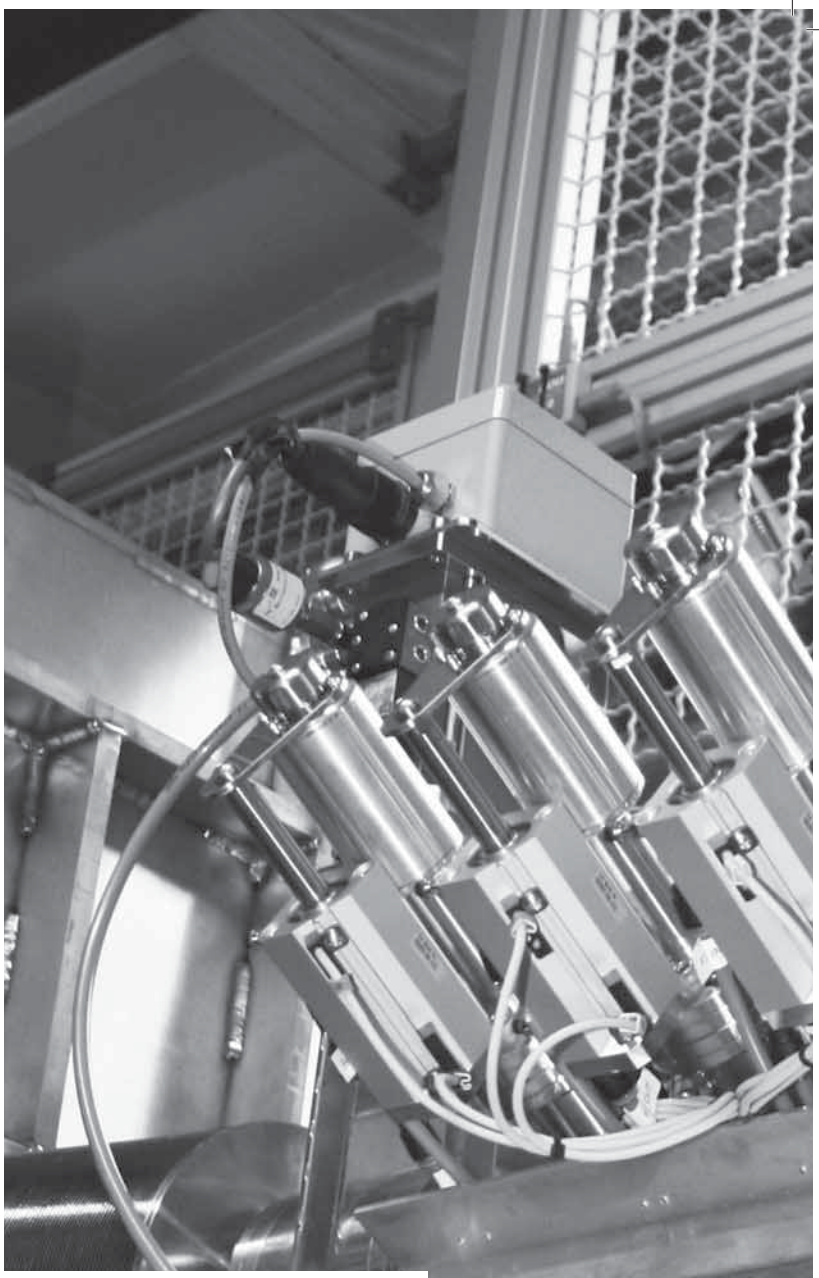
- +/-12.5mm X & Y motion
- Up to 200mm Z motion
- +/-2° of tilt for beam alignment
- Single bellows design
- High precision stage

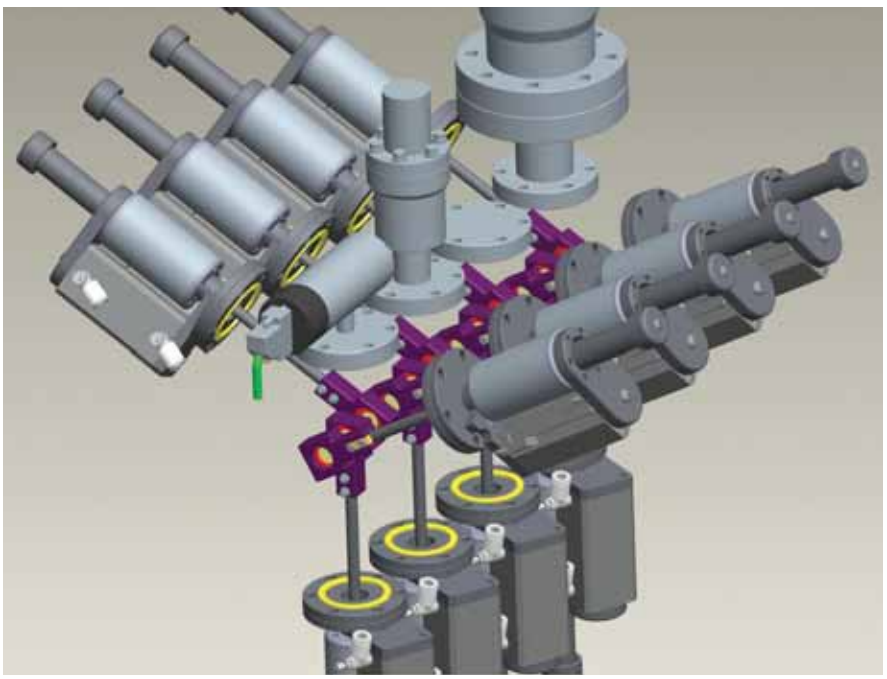
Bellows guaranteed for 10,000 cycles with >1,000,000 available.

MPPRL Series

Provides fast axial motion in a range of travels

The photographs and models shown on these pages show an array of 12 Magnetic Push Pulls (MPP's), each of which supports a single attenuation foil made of either Aluminium or Molybdenum of varying thickness. This array provides attenuation of the main x-ray beam on Diamond beamline I07. Remote operation of the filters enable the direct beam and very weakly scattered x-rays to be directed onto the same detector, extending its dynamic range significantly.

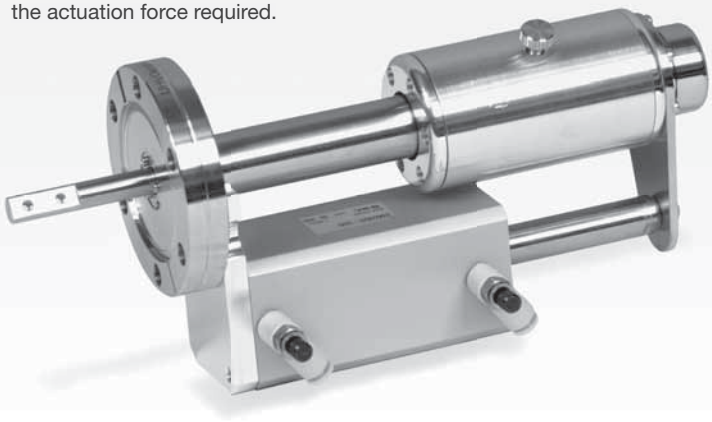




Magnetic Push Pulls

'Push Pull' devices provide fast in/out axial motion along a port axis, typically employed on synchrotrons to remotely insert beam filters.

Push Pulls benefit from a bakeable, high power magnetic coupling, removing the need for edge-welded bellows, providing an intrinsically safe and robust solution. The absence of any bellows negates the need to overcome the thrust due to vacuum, reducing the actuation force required.



- Ideal for beam shutters/filters
- Long life, bellows-free design
- High power to size ratio
- Fully bakeable to 250ºC
- No thrust due to vacuum

UHV Design - quality assured through in-house control of design, manufacture, assembly and test.

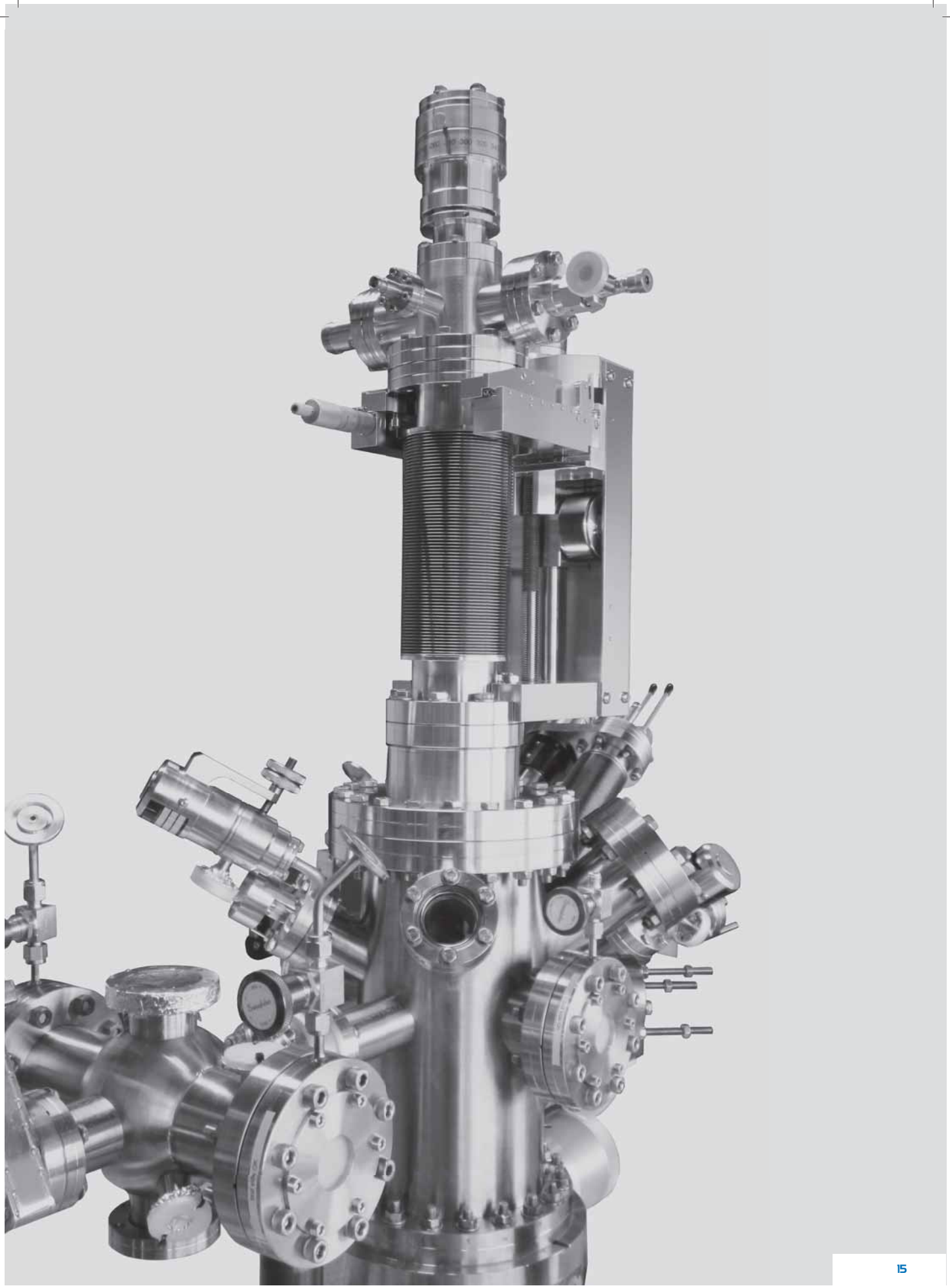
End Stations

UHV Design manufactures a range of transfer devices and high precision cryogenic manipulation for synchrotron end stations. At the heart of the transfer range are the Power Probe series which offers both single & dual axis motions with the option of industry standard sample transfer. Standard travel lengths of up to 1.5m are available but customised options can be supplied upon request. New to the transfer range is the RTTA – “Radial Telescopic Transfer Arm” which is the latest advance in automated radial distribution with up to 760mm of linear extension.

For the ultimate in cryogenic manipulation, UHV Design offers a complete range of 3,4 & 5 axis high precision devices, all available with polar or continuous azimuthal rotation, with heaters of SiC for use in oxidising/corrosive atmoshere, LN_2 / LHe cooling plus industry standard sample transfer.

Whatever your requirements are for end station cryogenic manipulation and sample transfer, UHV Design can provide the solution.

- Multi-axis sample stages with a complete range of heating and cooling options
- Non-magnetic materials for sample stages
- Industry standard transfer solutions
- Linear or radial transporters
- Manual or motorised options
- True UHV compatibility



Multi-Axis Sample Stages

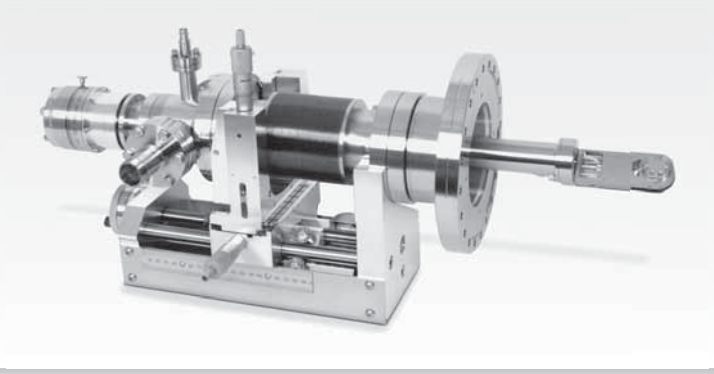
MultiCentre stages provide high stability multi-axis sample manipulation for synchrotron end stations and surface analysis systems.

Capabilities include precise motion in up to five axes, combined with high temperature heating and sample cooling to LN_2 or LHe temperatures. For applications such as sputter depth profiling, the ability to simultaneously LN_2 cool and **continuously rotate** the sample is particularly useful.

MultiCentres are configured to accept industry standard sample holders, as used on leading surface analysis and STM systems. A particularly compact 'swept radius' (the clear volume required during sample tilt) provides maximum access to the sample for sources and detectors etc. during angle resolved measurements.

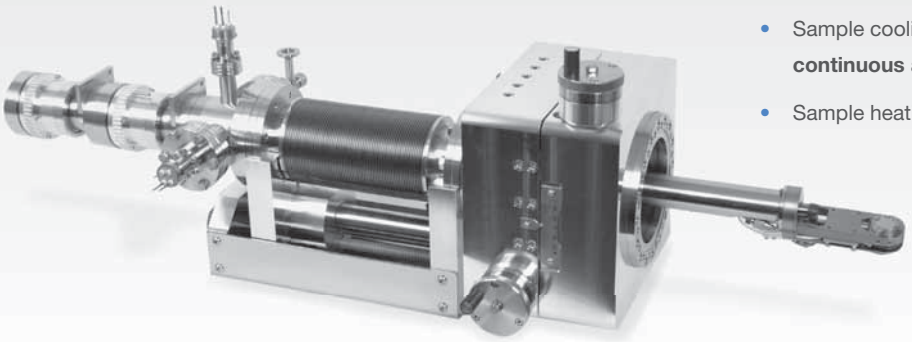
- Up to five axes of motion, manual or motorised
- High temperature sample heating
- LN_2 sample cooling with simultaneous and continuous azimuthal rotation
- LHe sample cooling
- Compact – small swept volume
- Low residual magnetic fields
- Up to 1m Z travel and up to +/-57mm X & Y

4 Axis + LN_2 Cooling + LHe Cooling



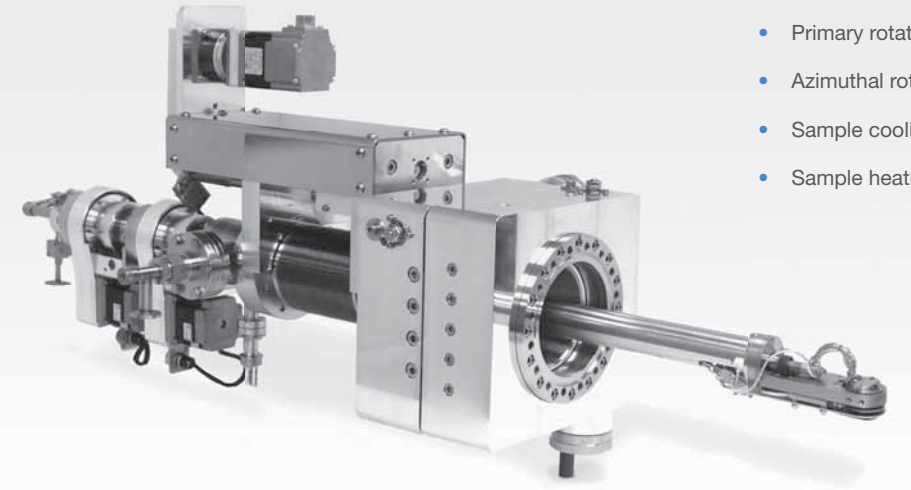
- X&Y travel up to +/-57mm
- Z travel up to 1,000mm
- Primary rotation +/-180°
- Sample cooling to 30k
- Sample heating to 900°C

5-Axis + LN_2 Cooling



- Sample cooling to -150°C with **continuous** azimuthal rotation
- Sample heating to 900°C

5-Axis + LN_2 Cooling + LHe Cooling



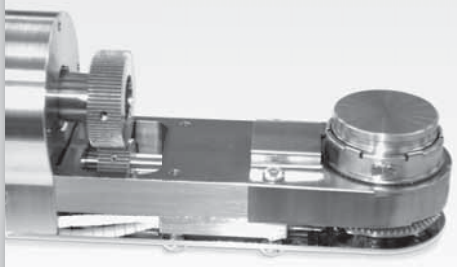
- Primary rotation +/-90°
- Azimuthal rotation +/-90°
- Sample cooling to 30K
- Sample heating to 900°C

Industry Standard Transfer Solutions

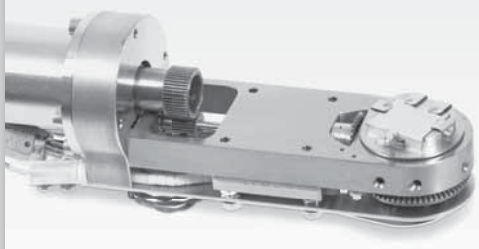
Compatible sample handling throughout all experimental modules is essential to maintain full system integration. UHV Design offers a range of Industry Standard Transfer Solutions which includes Flag-style, Puck-style and ESCA Stub options, all three of which can be fitted to either wobble stick, long travel PowerProbe magnetic transporters or indeed the RTTA “Radial Telescopic Transport Arm” (patent pending) which offers 360 degrees & 700mm of radial and linear displacement respectively.

- Wobble stick, PowerProbe transporter or RTTA radial distribution arm
- Full range of travel lengths
- Rotary and Linear motion
- Manual or motorised options
- Sample carriers available in a range of materials
- True UHV compatibility
- Bakeable to 250°C

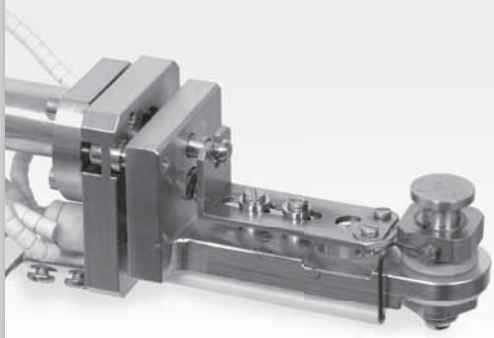
Puck Style



Flag Style



ESCA Stub



Transfer / Transport

PowerProbe Sample Transfer

PowerProbe sample transfer arms enable secure transfer of samples within UHV. This is a consequence of their unrivalled magnetic coupling strength.

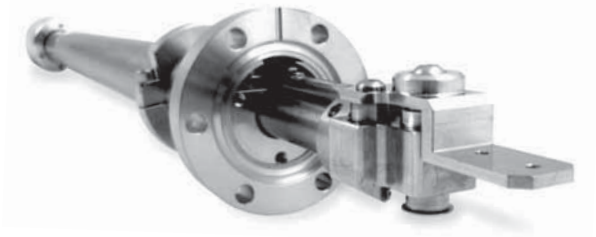
In addition to linear and linear/rotary probes, this extensive range includes the Elevating PowerProbe and the Dual-Axis Probe designed to transfer specific 'industry standard' sample holders using a variety of actuation methods.

- Comprehensive range with 'elevating' and sample 'gripping' probes
- 10x the thrust & 4x the torque of conventional designs
- Bakeable to 250ºC without removal of magnets
- Motorised solutions

Linear Only

Linear and Rotary

Dual Axis



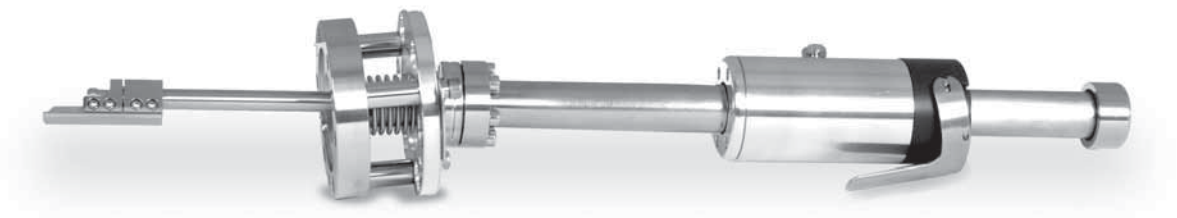
Elevating Power Probe

Wobble Sticks

Wobble sticks are a convenient and cost-effective solution for sample transfer, particularly in situations where additional motions are not practicable.

The UHV Design wobble stick range offers extreme flexibility and incorporates linear, rotary and tilt motions, with optional trigger-actuated pincer grip, within a very compact envelope. The benefits of high power magnetic coupling for the linear, rotary and pincer grip motions are fully realised in that these actuations do not have to overcome any vacuum forces, making for extremely smooth operation throughout.

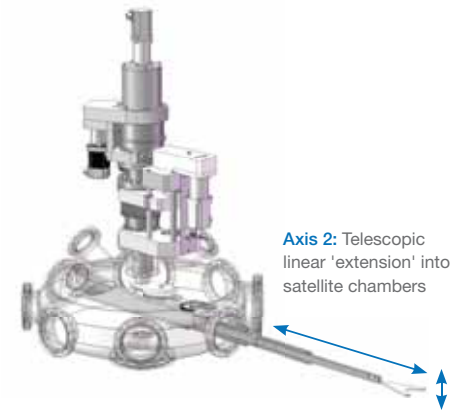
- Linear strokes up to 450mm
- +/-22º tilt
- Unlimited rotation
- Pincer grip and other actuation options
- Compatible with most sample holders
- Customised versions possible
- Fully bakeable to 250ºC without magnet removal.



Radial Telescopic Transfer Arm

The Radial Telescopic Transfer Arm (RTTA) represents a step-change advance in radial distribution technology offering unrivalled performance over conventional designs (patent applied for). Its true UHV mechanism provides up to three axes of motion, as shown to the right, to securely distribute samples from a central 'distribution chamber' to surrounding 'satellite chambers', as shown in figure 4.

Axis 1: Precise radial arm rotation for alignment with 'satellite' chambers



Axis 2: Telescopic linear 'extension' into satellite chambers

Axis 3: Lift/lower to facilitate sample transfer (optional)

Telescopic 'extension'

The RTTA's 'telescopic arm' provides greater flexibility for system designers, namely the ability to:

1. Extend 2.5 times further than conventional designs, with the same size distribution chamber (Fig. 1).
2. Reduce the overall system footprint, by using a smaller distribution chamber, whilst retaining the same 'extension' (Fig. 2). In doing so, chamber and pump costs are reduced, alongside the pump-down time, improving throughput.
3. Gain greater access to satellite chambers. This derives from the fact that the smaller distribution chamber subtends a smaller angle from the satellite chamber (Fig. 3).

This unique capability derives from the novel use of a telescoping arm, driven by a hypocycloid mechanism and is patent protected.

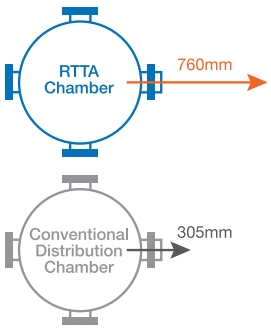


Fig. 1: 2.5x more extension

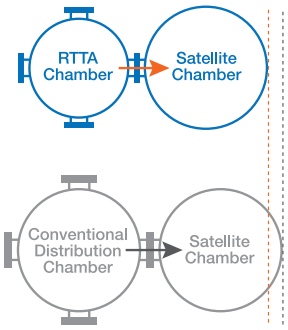


Fig. 2: Reduced system footprint

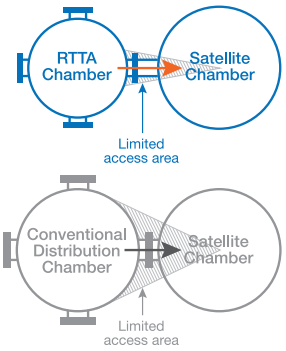
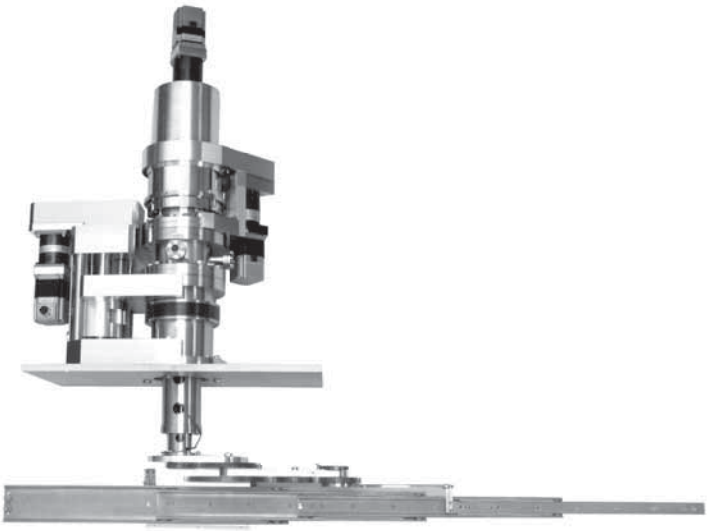


Fig. 3: Greater access to satellite chamber

RTTA when retracted



RTTA when fully extended

True UHV rotation with no oil, slip rings, bellows* or differential pumping

The RTTA is actuated by MagiDrive magnetically-coupled rotary feedthroughs, providing true UHV, failsafe performance, without any bellows, oil, slip rings or differential pumping. A high torque MagiDrive provides an extremely stiff coupling for the radial motion (Axis 1), providing an angular reproducibility of <0.2mRad. A secondary MagiDrive then actuates the mechanism to drive the arm in and out of satellite chambers, with a linear reproducibility of <0.1mm when extended.

High stability, low deflection

The RTTA benefits from a rigid construction, which is critical to securing reliable sample transfer. With a load of 1kg, for example, the arm deflects by less than 1mm when fully extended to 760mm.

'Talk free' design

The next-generation RTTA removes the 'cross-talking' problem suffered by traditional designs. This is where actuation of Axis 1 (radial rotation) causes unwanted motion of Axis 2 (arm extension), losing the sample position. For automated systems, complex software programming is required to 'unwind' Axis 2 in proportion to the motion of the Axis 1. The innovative RTTA design completely eradicates this problem, through an innovative mechanical design, removing the need for complex position correction.

*Bellows used for raise/lower motion only.

- 2.5x more extension
- Reduced system footprint
- Increased satellite chamber access
- Smaller, lower cost chamber
- Quicker pump down
- Lower cost pumps

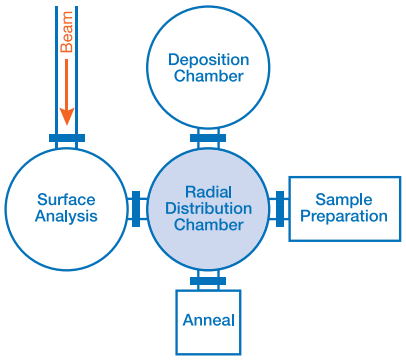


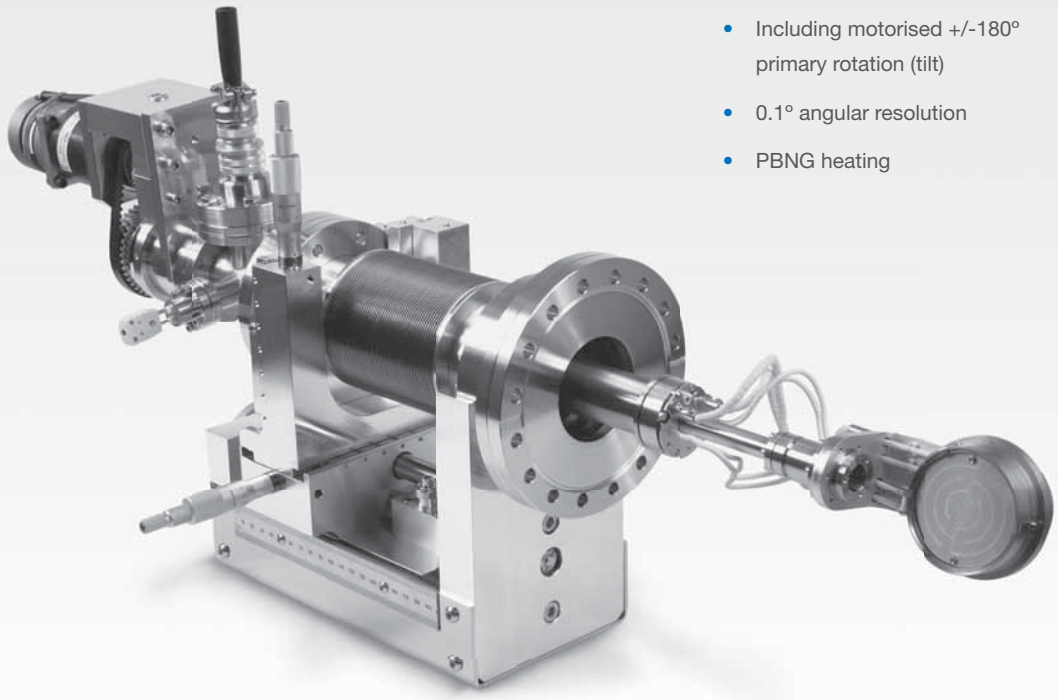
Fig. 4: Typical Radial Distribution Chamber system

Custom Surface Analysis Sample Stages

UHV Design offers a complete range of customised precision sample stages to meet the ever increasing demands of surface science applications. Using the high precision Multi-Centre manipulator as the base, customised precision stages can be supplied in a range of non-magnetic materials and accommodate sample sizes up to 75mm in diameter. PBN heating and either LN_2 / LHe cooling is available with a choice of thermocouple materials for accurate temperature measurement.

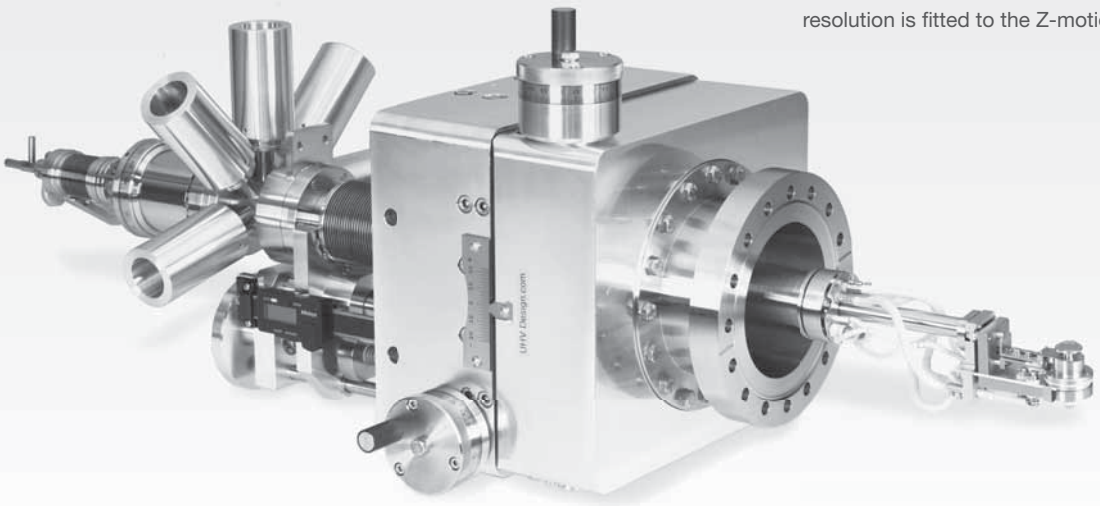
- Non-magnetic material options
- Samples up to 75mm diameter
- PBN Heating
- LN_2 / LHe cooling
- High precision polar and azimuthal rotations
- Manual or motorised options
- True UHV compatibility
- Bakeable to 250°C

Customised 4-axis 2” wafer manipulator



- Including motorised +/-180° primary rotation (tilt)
- 0.1° angular resolution
- PBNG heating

Customised 4-axis sample manipulator



- Sample heating and LN_2 cooling
- Digital Linear Scale with 10µm resolution is fitted to the Z-motion

Multicentre in Use

Infrared Spectroscopy

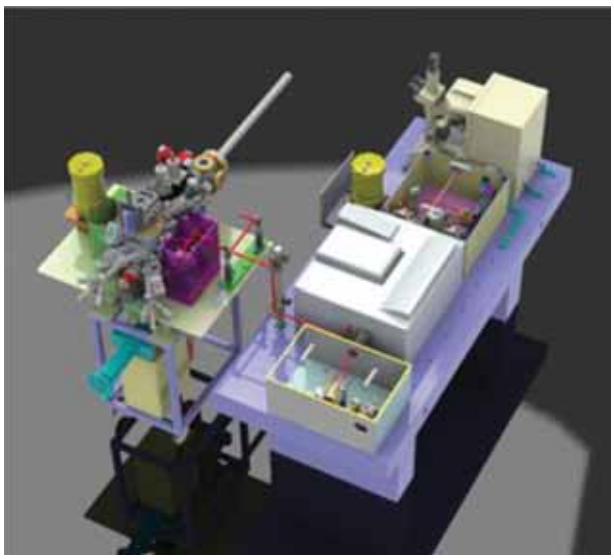
This UHV Design XYZT manipulator stage is mounted on a chamber at Synchrotron Soleil which enables the study of surfaces by means of infrared spectroscopy, using the synchrotron source.

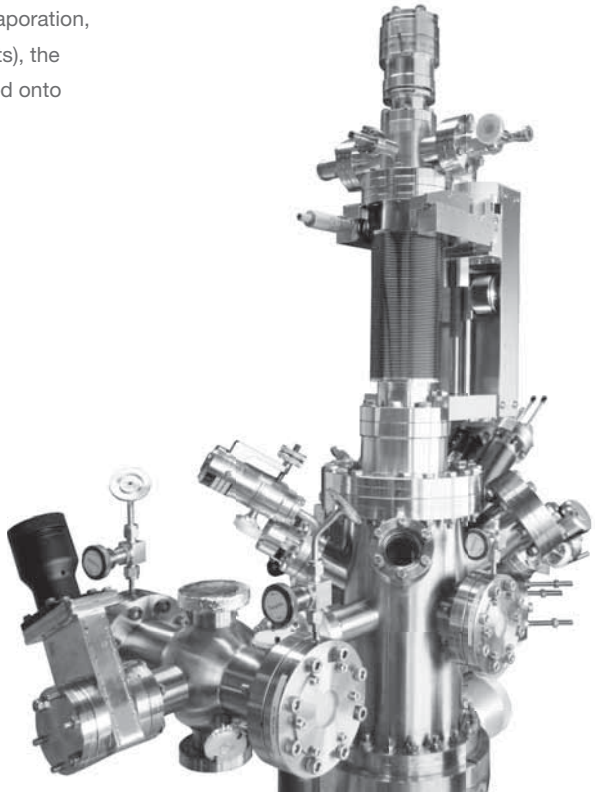
In essence, the nature of interfacial relationships can be understood and identified by their spectroscopic signature (also called ThZ) in the far infrared region (roughly speaking for wavelengths of 20 microns and beyond). The density of photons required for these studies necessitates the use of a synchrotron source, the synchrotron source having a brightness which is approximately two orders of magnitude greater than a laboratory heat source.

The chamber shown in the photograph has two viewports which are transparent in this wavelength region (high density polyethylene and soon films of synthetic diamond). After transfer and preparation (i.e. evaporation, thickness measurements), the infrared beam is directed onto the sample through these viewports, either by transmission at the Brewster angle for semiconductors or insulators, or by grazing incidence for metallic surfaces.

A helium cooled bolometer will be used as a detector for these types of experiment.

Acknowledgement:
Dr. Paul Dumas, Synchrotron SOLEIL



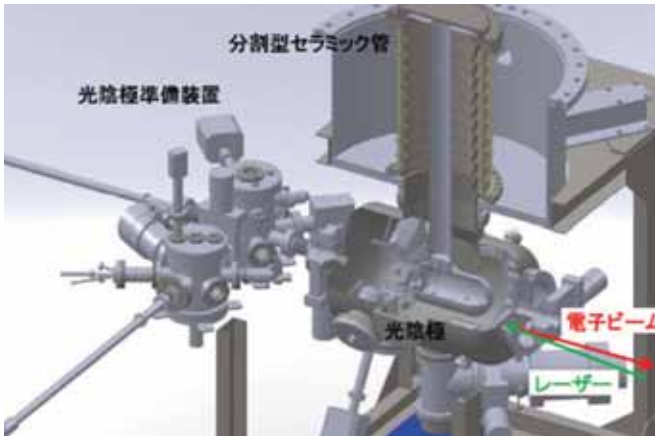


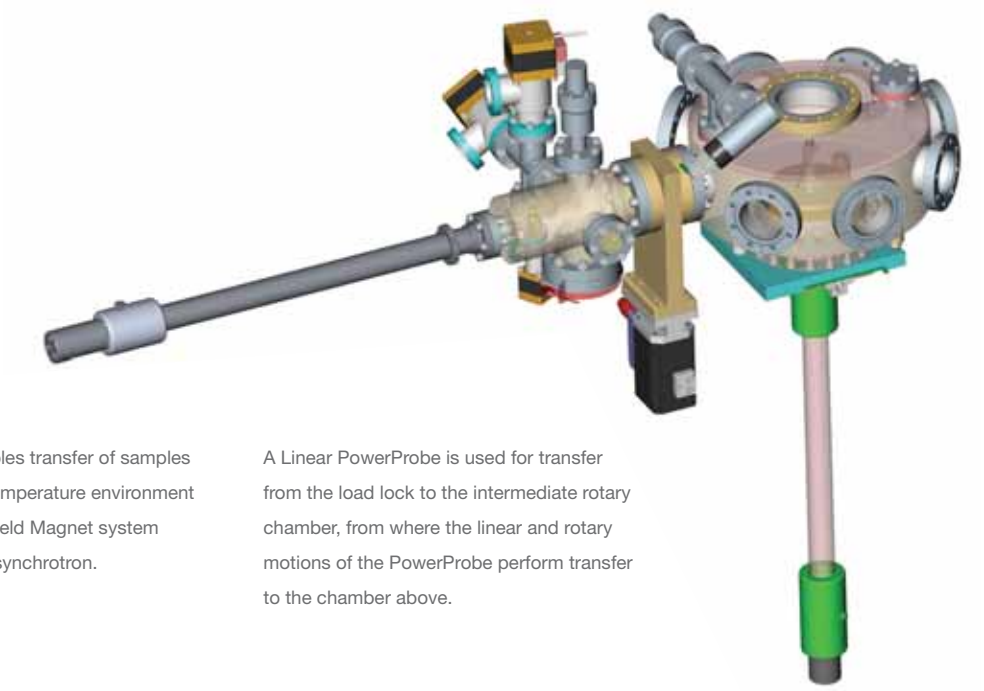
PowerProbe for Sample Transfer

A very long stroke (1500mm) PowerProbe is shown employed on the Advanced Photon Research Centre in Kansai, Japan, where its very smooth movement, noise-free operation and low outgassing rates are greatly appreciated.

This experimental configuration is used in the development of a 500kV optical cathode electron gun.

Acknowledgement:
Nobuyuki Nishimura, APRC, JAEA.





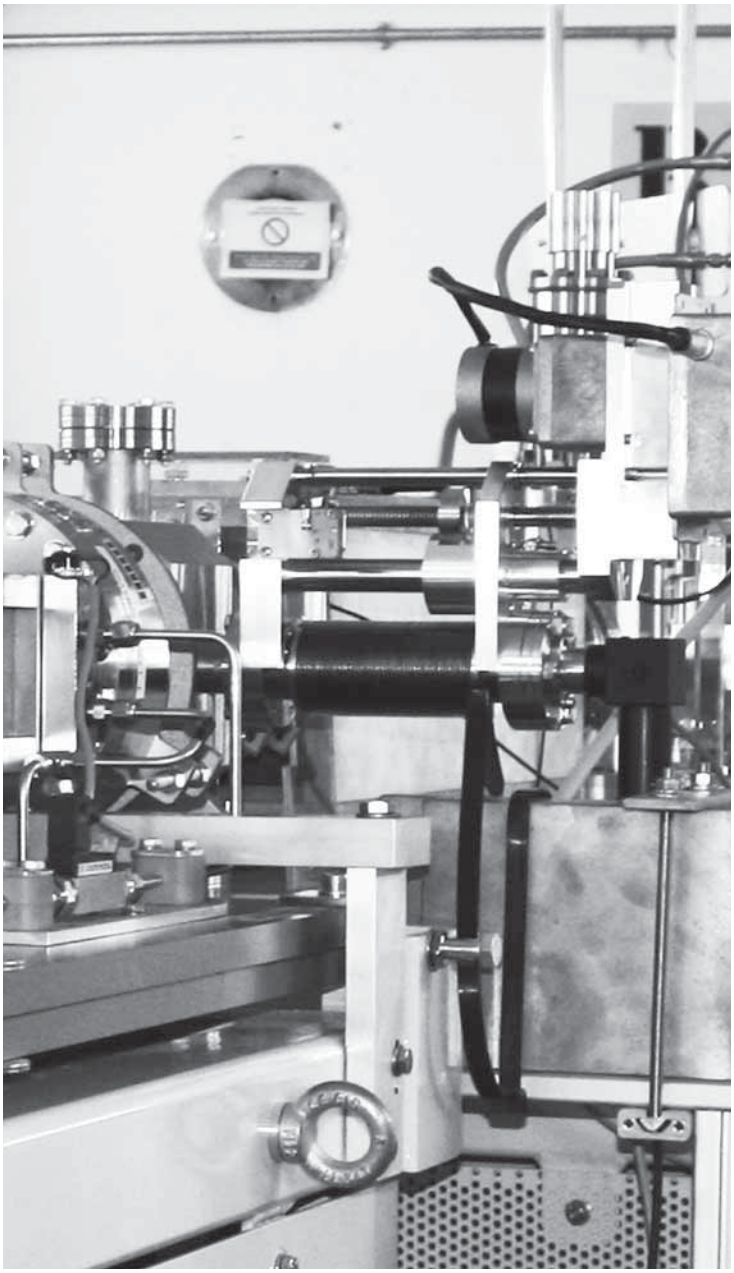
This system enables transfer of samples to the ultra low temperature environment inside the High Field Magnet system on the Diamond synchrotron.

A Linear PowerProbe is used for transfer from the load lock to the intermediate rotary chamber, from where the linear and rotary motions of the PowerProbe perform transfer to the chamber above.

True kinematic LSM design ensures smooth motion, low wear and long life.

Injection Screen

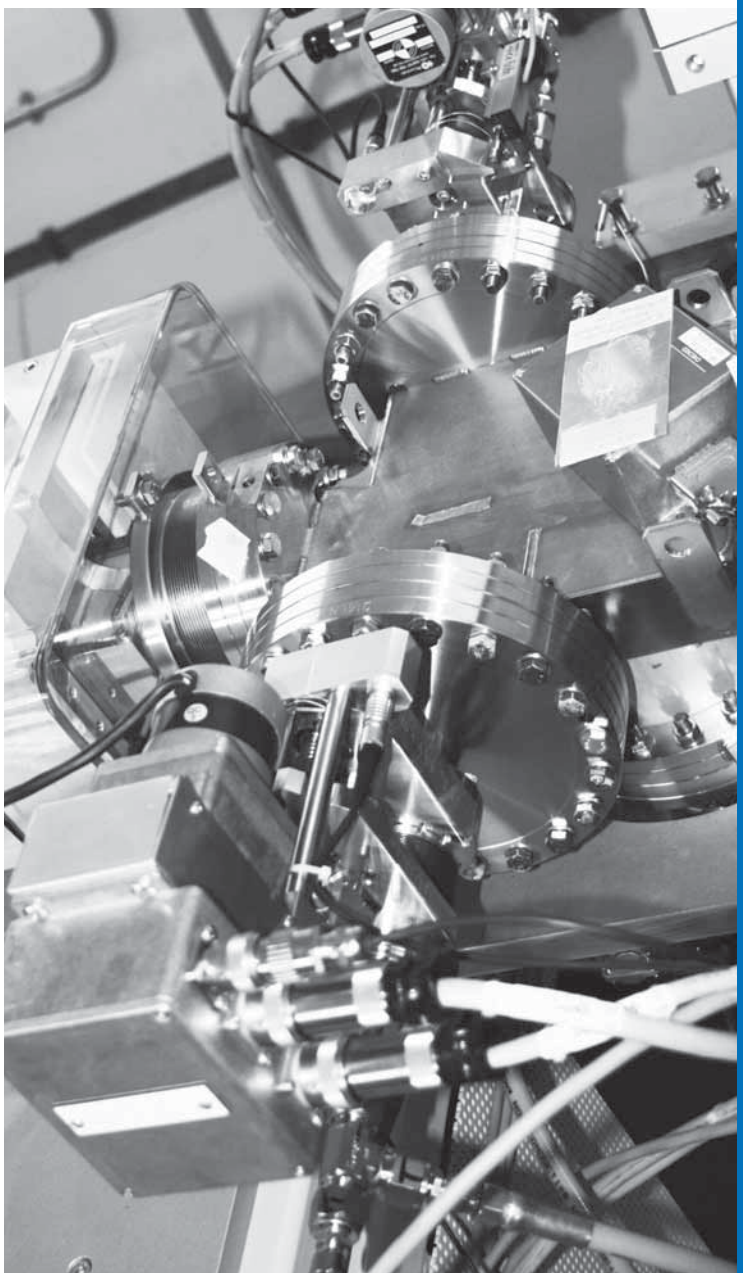
This photograph shows a horizontally mounted stepper motorised Linear Shift Mechanism (LSM) which is used to insert a thin stainless steel tube into the injected electron beam. The tube is capped, with vacuum on the OUTSIDE and atmospheric pressure on the INSIDE. Also located on the inside of this tube is a YAG:Ce screen which is used for imaging of the electron beam after it has passed from vacuum, through the steel tube wall, into atmosphere. This construction removes the need for a viewport and also ensures that the screen is easily serviceable. The screen is viewed by a camera which is attached via a mirror (the black box). Accurate and reproducible placement of the tube/ screen by the LSM is essential for reliable observation of the shape and position of the injected electron beam.



LSM flange parallelism of <2mrad maintains alignment from atmosphere to vacuum.

Horizontal Collimator

The two stepper motor actuated Linear Shift Mechanisms shown in this photographs support water cooled copper jaws which are inserted into the electron beam for collimation purposes. In this case both LSMs are fitted with linear potentiometers attached to the frames, such that they may be easily removed for bakeout. The linear potentiometer option provides positional feedback for closed loop control of the LSM position, offering resolution and repeatability figures of 2µm.



Rigid LSM construction offers twice the load carrying capability of other designs.

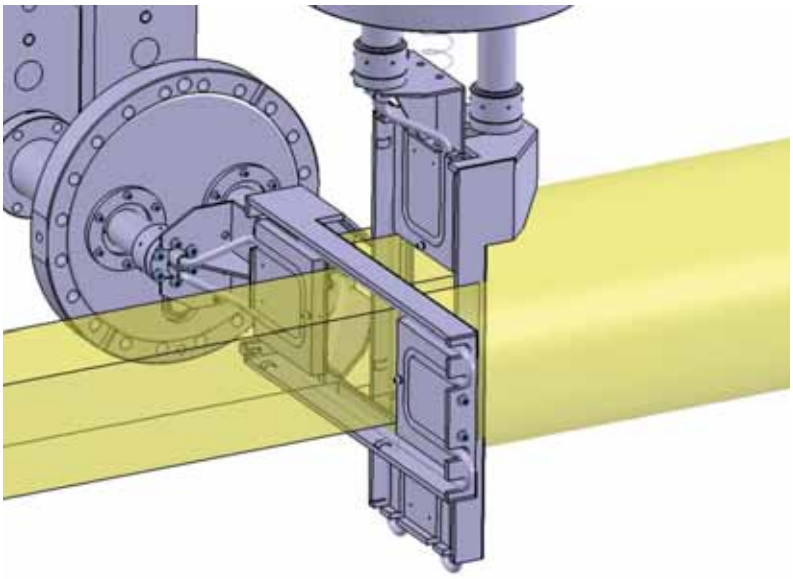
Beam Cleaner

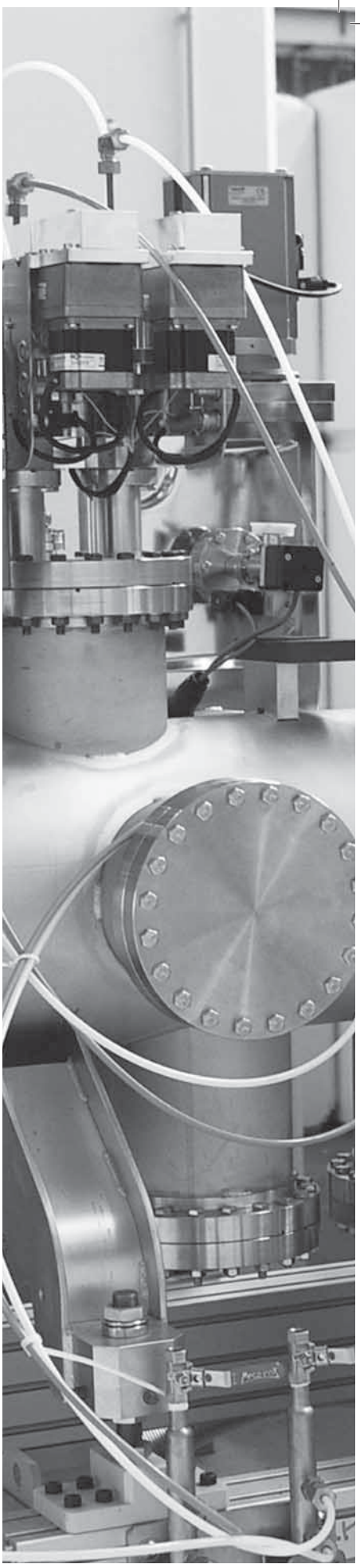
The stepper motor actuated Linear Shift Mechanisms (LSM's) shown on this page are a section of an array of 14 such LSM's which are mounted on the SPIRAL 2 accelerator in France.

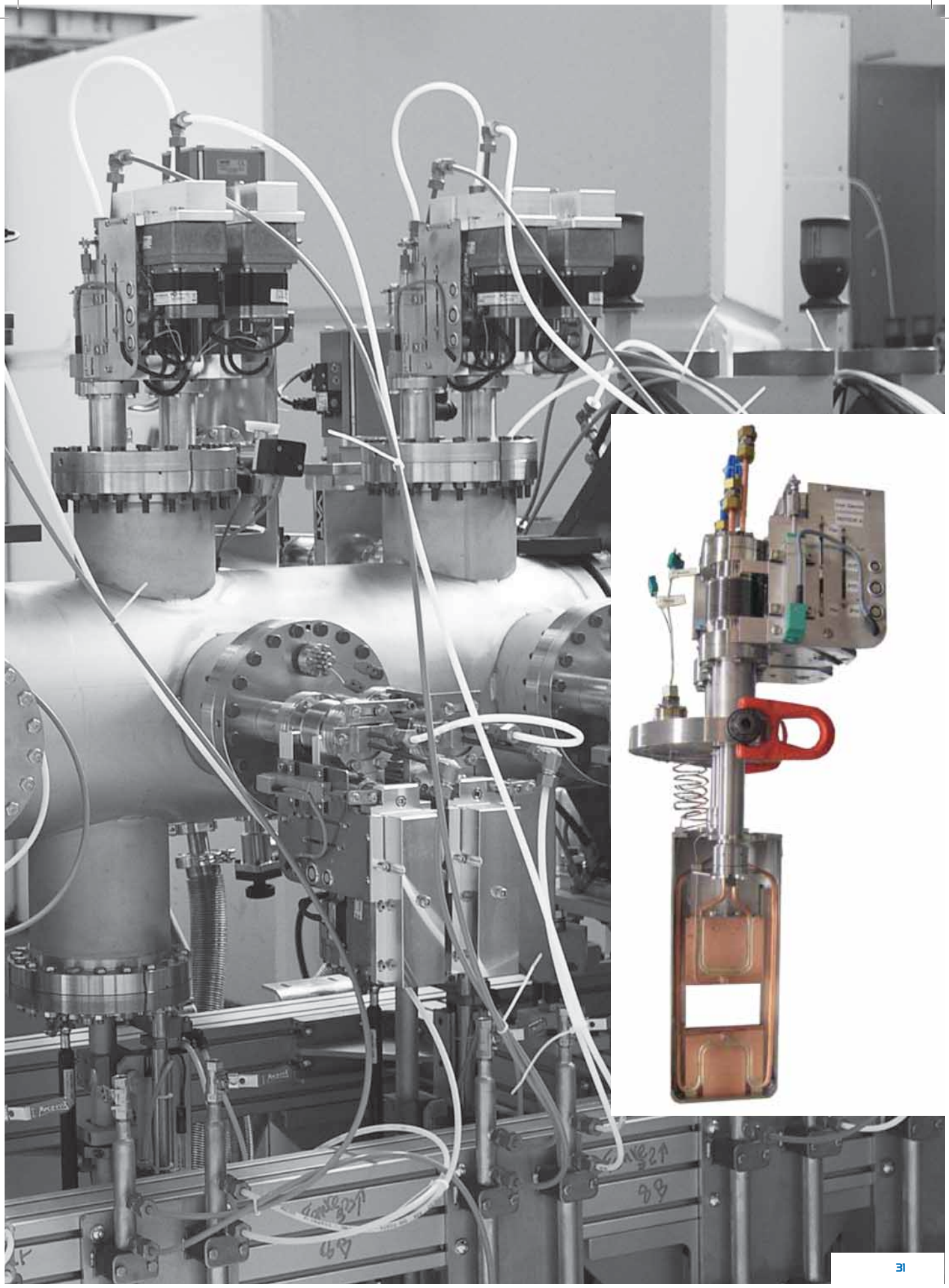
The LSM's, each of which supports a water cooled copper slit assembly, operate in pairs and are used for cleaning of the beam halo.

SPIRAL 2 is a linear particle accelerator project for the study of fundamental nuclear physics and multidisciplinary research. It will produce light and heavy exotic nuclei at extremely high intensities. These entirely new particle beams will make it possible to explore the boundaries of matter.

Acknowledgement:
Olivier Corpace, GANIL







The LSMX range includes a secondary 'X' motion for fine lateral alignment.

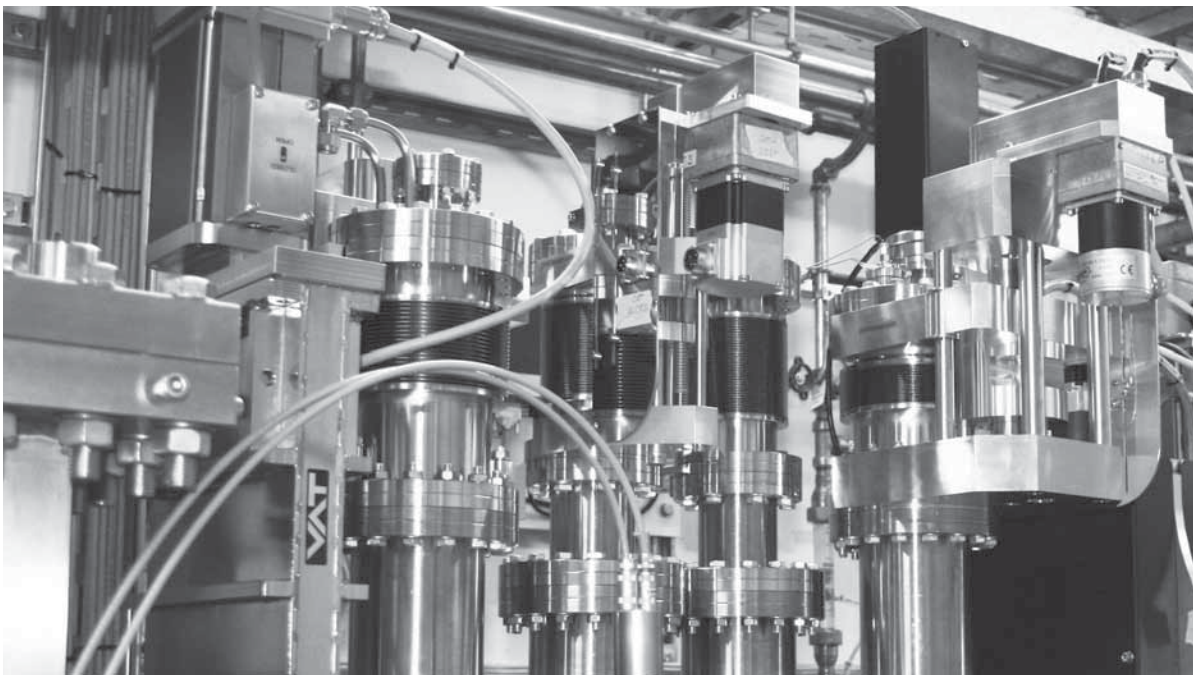
Beam Conditioning

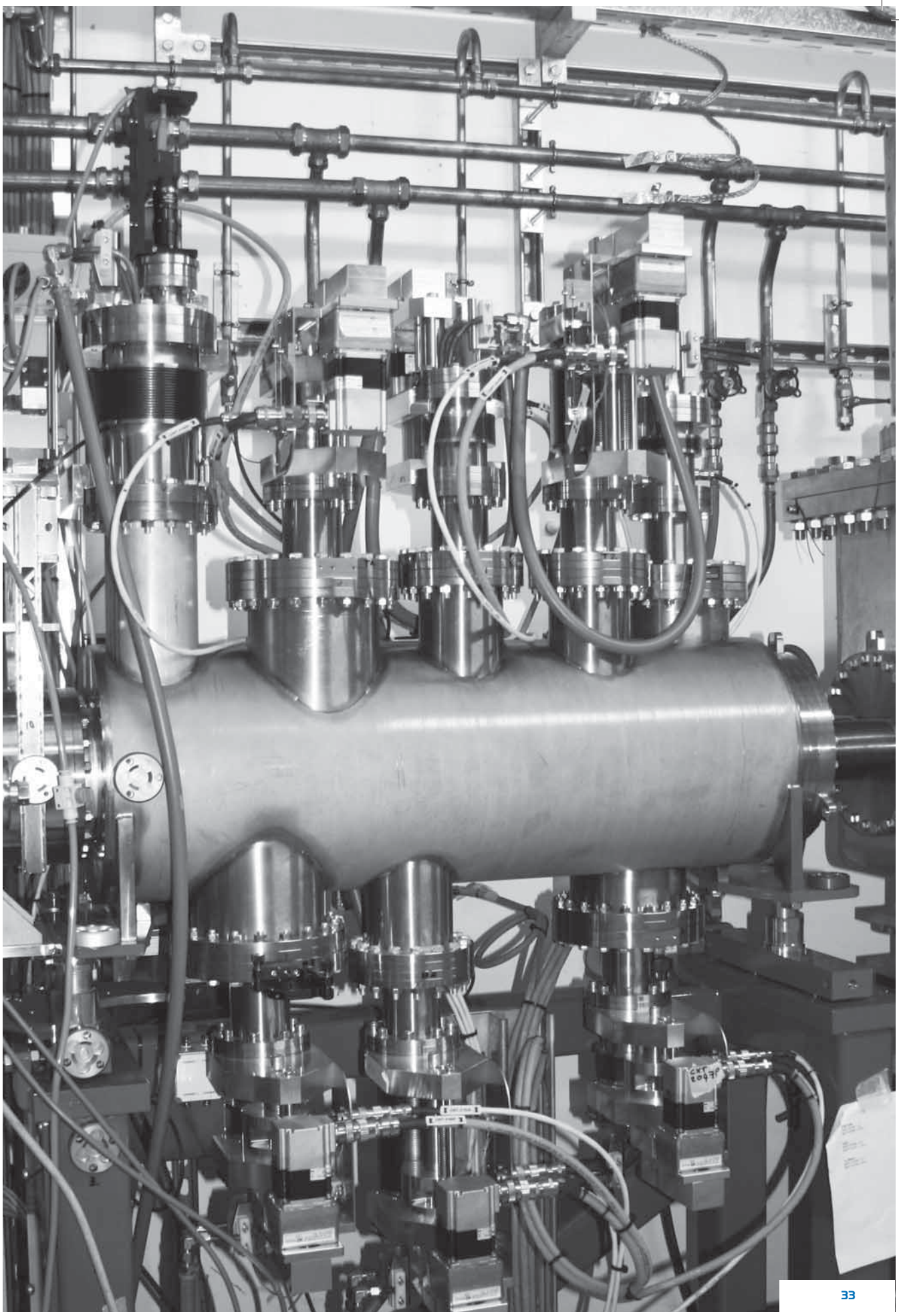
The photographs on this page show sections from two diagnostic units for I20, the wiggler EXAFS beamline at Diamond Light Source.

The vessels contain several optical elements which condition the two parallel x-ray beams produced in the beamline. In the first branch of the beamline, a set of two horizontal blades and two vertical blades, moving independently, are used as primary slits to define the beam size before entering the first focussing mirror.

In the second branch, a set of three filter holders attenuate the power of the x-ray beam before entering the monochromator and, in addition, a set of vertical blades and a diamond screen allow the precise alignment of the first mirror of the beamline.

All of the above mentioned diagnostics are positioned and aligned with respect to the beam using UHV Design's stepper motor actuated Linear Shift Mechanisms.





Credits

With special thanks to the following people for their assistance in putting this brochure together:

Images

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