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High Heat load Analysis and Design

Design of the Extreme Conditions Beamline at Diamond Light Source

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Beamline Science

The study of materials under high pressures and temperatures is a rapidly-expanding field, impacting on a diverse range of fields, including fundamental physics and chemistry, earth and planetary science, bio-molecular science, and research into novel materials.
Synchrotron diffraction experiments are fundamental to the study of material properties under extreme conditions. Intense, very high-energy X-rays from a 3rd generation source can penetrate into complex sample assemblies, and can be collimated to a few μm, permitting detailed mapping of structural order or disorder, chemical fingerprint, or single crystal structure determination.
This beamline will provide both white and monochromatic high-energy X-rays in both focused and unfocused mode in the range up to 100 keV range.

Beamline Design

Central beam for Day 1 operation

Side beams for later side stations

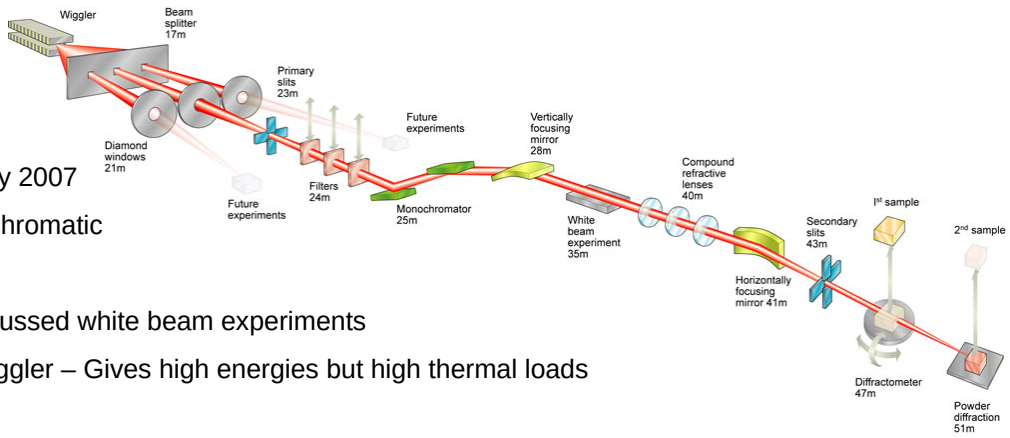
Planned Operational Date January 2007

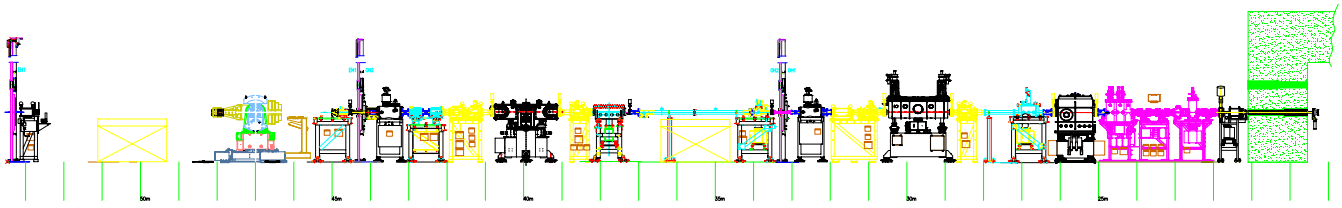
Energy Range 18- 80 KeV Monochromatic

Two experimental stations

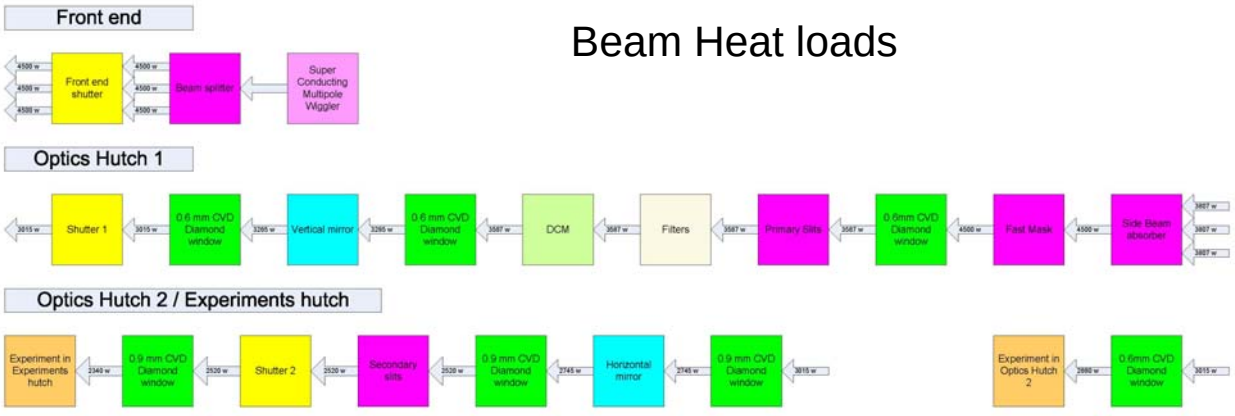
Designed for focussed and unfocussed white beam experiments

Insertion Device is a Multipole Wiggler – Gives high energies but high thermal loads





Beam Heat loads



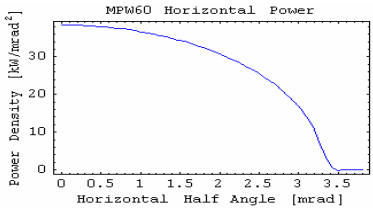
Source

Super Conducting Multipole Wiggler

Field Strength	3.5T Max
Period length	60mm
No of periods	24
K Gamma	19.6

Central Beam size 0.5mrad(H). 0.4mrad (V)

Supplier Budker Insitute of Nuclear Physics



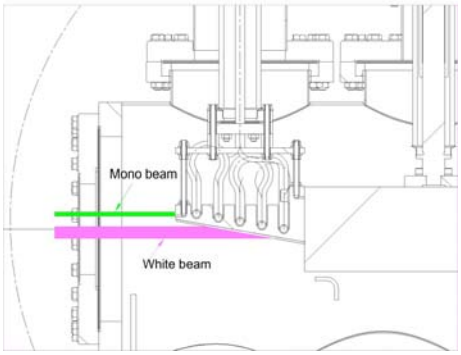
Shutters

Component – Shutter

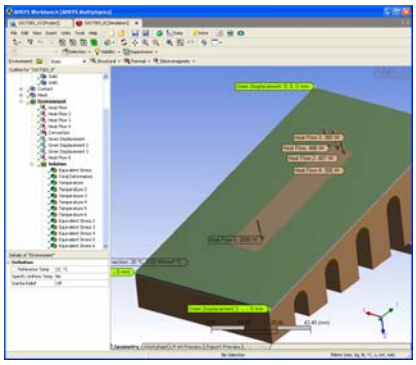
Problem – Focussed heat load

Solution – Beryllium brazed to copper to allow heat load through thickness of beryllium

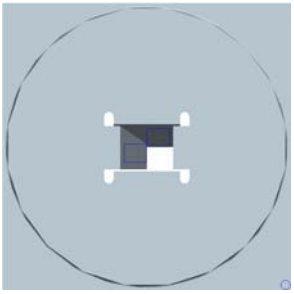
- 2mm thick Beryllium layer brazed to copper absorber
- Suitable for line focussed beam and full white beam.
- 2mm gives 11.5mm along beam direction, absorbs 41.1% of beam power



Layer	Heat load (W)	Max Temp (°C)	Max stress (MPa)
Be 1	488	152	289
Be 2	407	151	276
Be 3	350	149	262
Be 4	305	146	250
Copper	2699	144	152



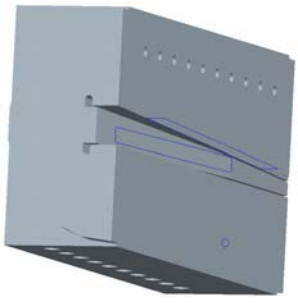
Slits



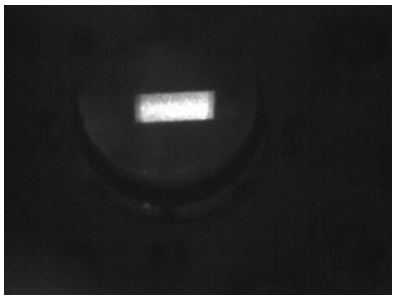
Component – Slits

Problem – High heat causes high stresses at corner

Solution - Novel design of edge profile with key hole slots gives sharp corner edges and reduced thermal stresses



Windows

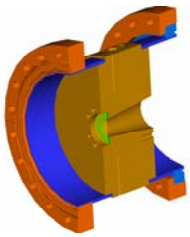


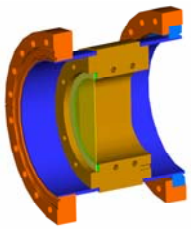
Component – Window

Problem – Removal of low energy photons from beam

Solution – CVD Diamond disc diffusion bonded via molybdenum ring to water cooled copper absorber.

Also acts as a visual Beam position monitor, electronic beam position monitor and vacuum boundary component





Three sizes of windows, 105mm Dia 0.9 mmThk,

63mm 0.6mm Thk, 34mm Dia 0.6mm Thk.

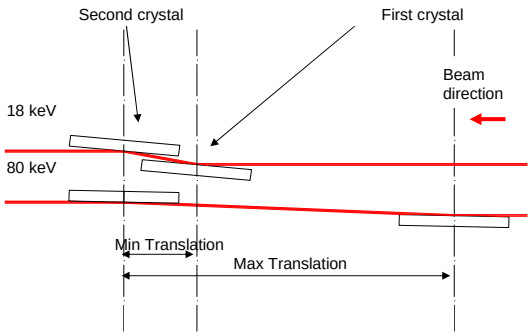
Each using Thermal Grade CVD Diamond produced by element6

Diffusion bonded via molybdenum ring to Copper absorber

Designed to absorb (810w) 18% of incident power

DCM

Energy	Bragg Angle	Darwin width
18 KeV	6.3 degrees	14.6 µRad
80 Kev	1.4 degrees	3.24 µRad



Silicon (1,1,1)

Crystal rotation limited to 11 degrees

Crystals rotated by micro-pusher operating stiff tangent arm located in stiff bearings

Angle measured using Renisaw RESR 413 ring and RGH readhead to give 0.05 µRad resolution

Crystals cooled by LN2

First crystal bragg rotation stage mounted on linear stage

1st Crystal is 172mm long, 50mm wide, 70mm deep. Sandwiched between LN 2 cooled copper blocks

FEA of Heat load gives a combined thermal and structural slope error of 1 µRad when limited to a beam load of 550watts. Equivalent to 0.16mRad x 0.16mRad beam size at 300mA