MEDSI 2008

Double Crystal Cryo-Cooled Laué Monochromator for use on the I12 JEEP High Energy Beamline at Diamond Light Source.

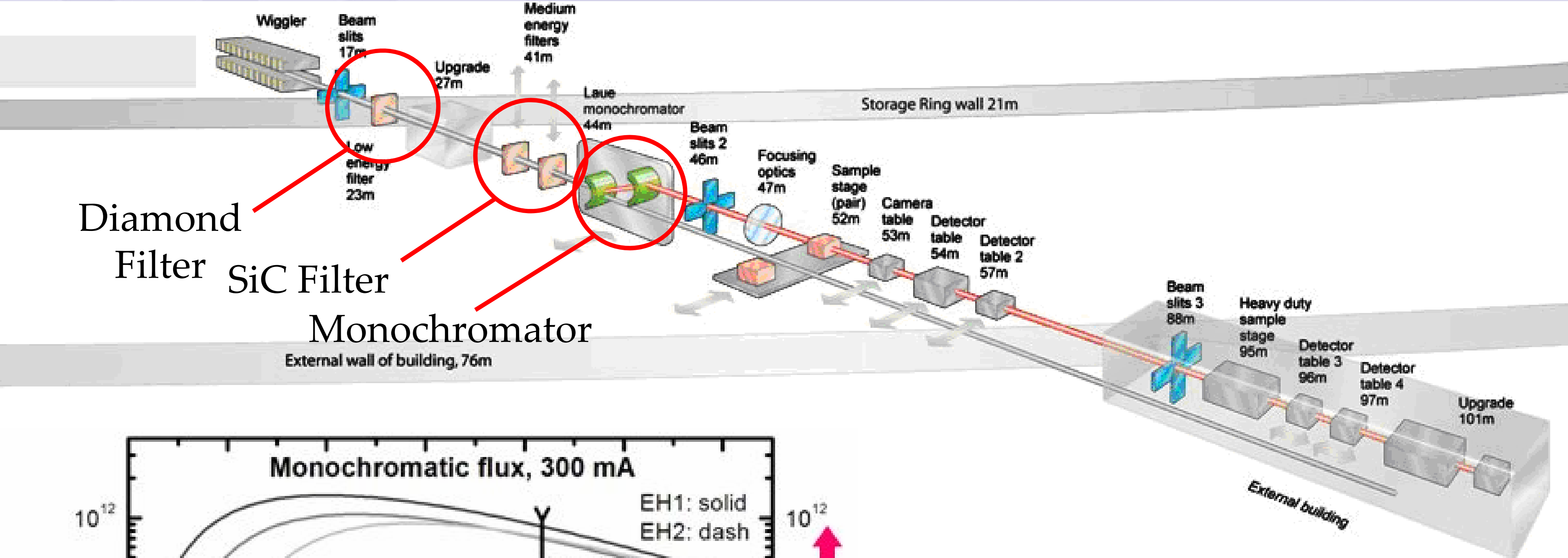
Presentation by

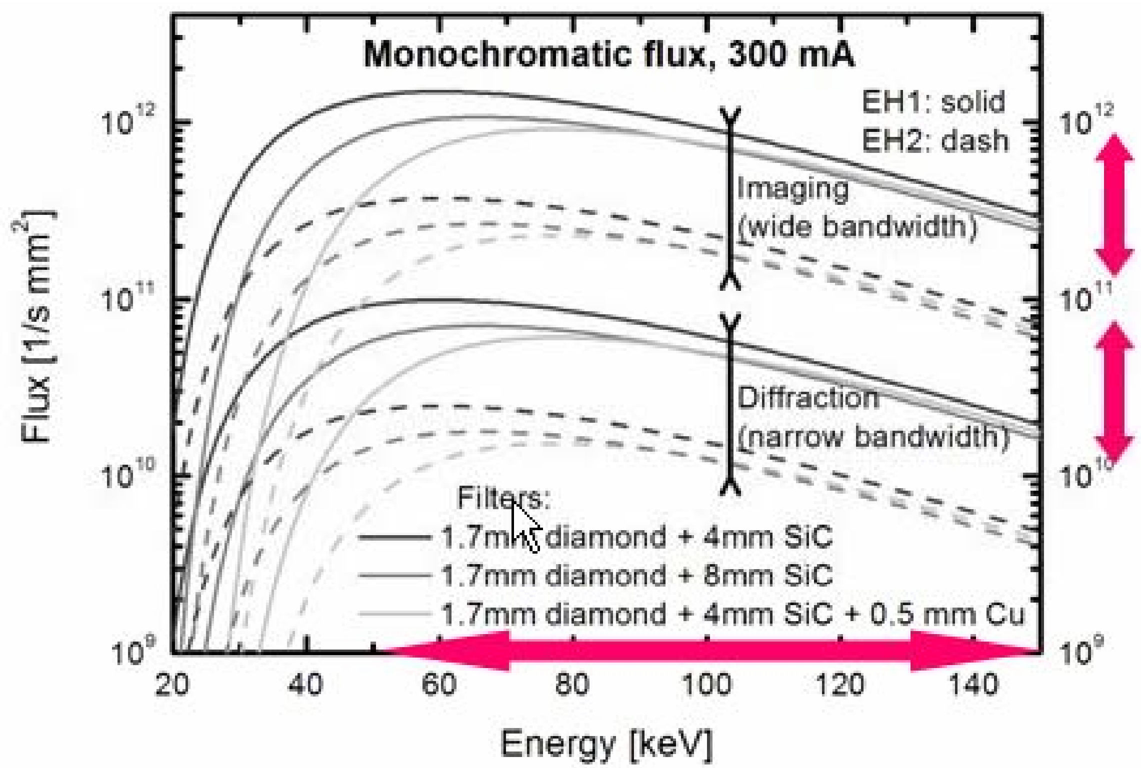
Tim Hill

Introduction

- Introduction to the JEEP Beamline
- Monochromator Specification
- Brief over of design features
- Thermo-Mechanical design of 1st Crystal
- Current status
- Questions?

I12 JEEP Beamline





Specifications:

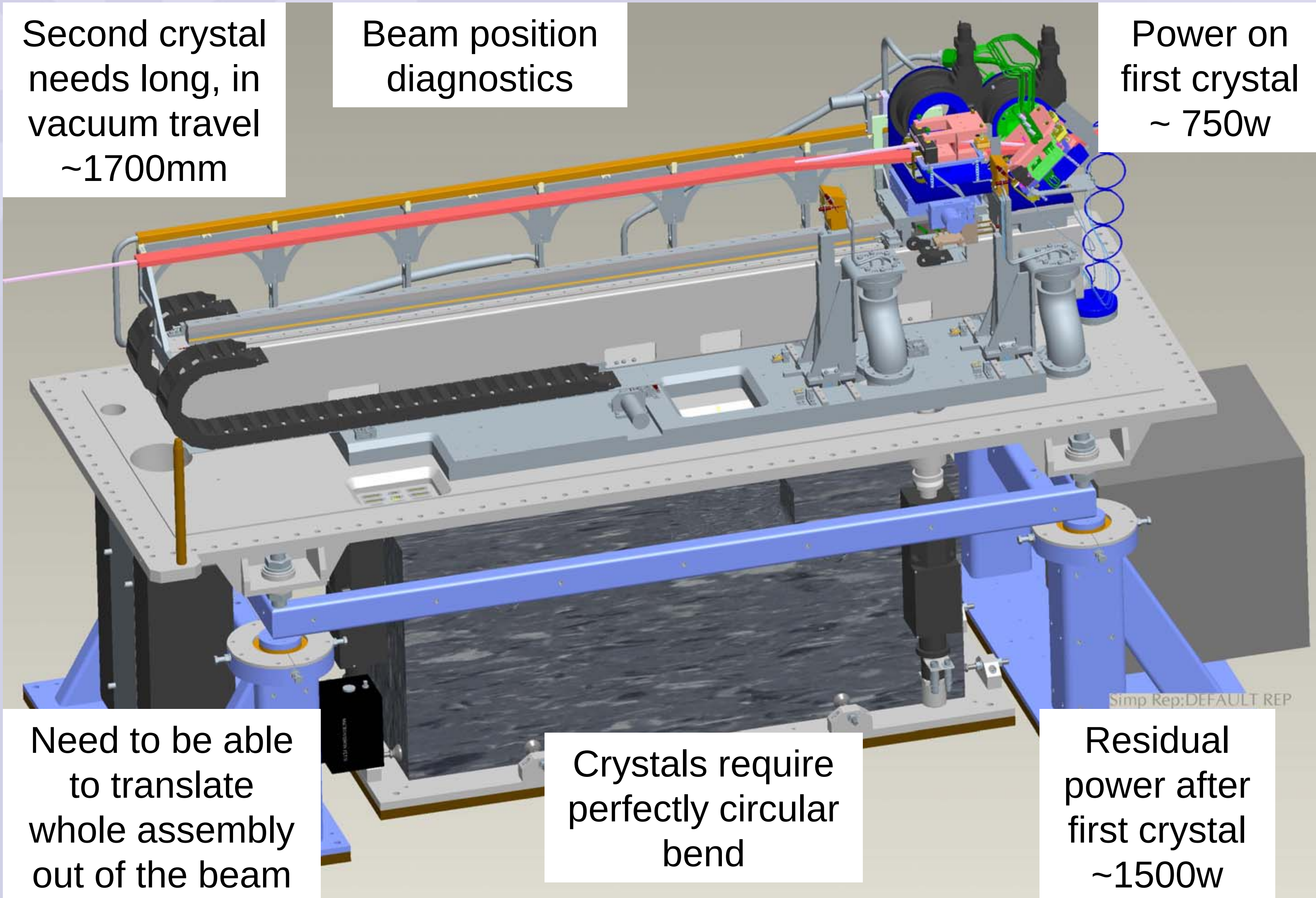
4.2T SCW ~ 9Kw of heat power in 1x0.3mrad

Flux at 50 keV: 1.8 x 10^{12} photons s-1

Flux at 150 keV: 9.4 x 10^{10} photons s-1

(DE/E = 0.001, in 0.025 mrad × 0.025 mrad)

Double Crystal Cryo-Cooled Laué Monochromator



Crystal Specifications

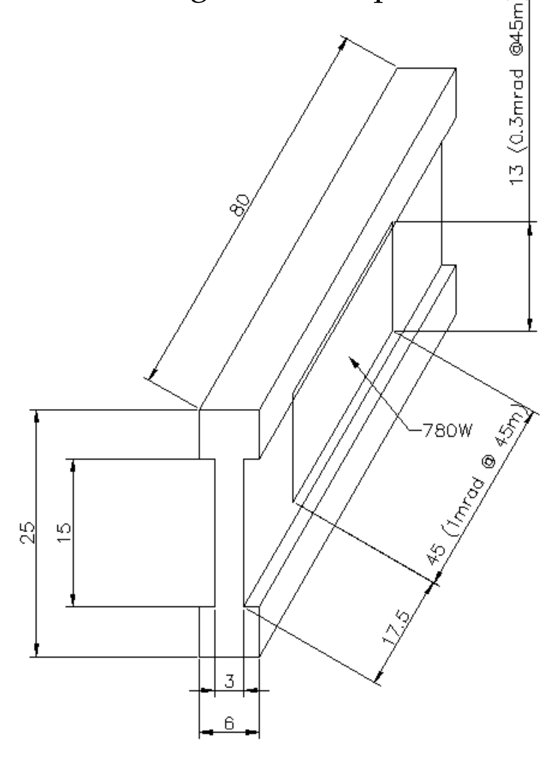
	1st Crystal	2nd Crystal
Circular bend radius	~60m	~60m
Circular bend quality	+/-2m	+/-2m
Heat Load at @ 500mA	750w	4.5w
Heat Load at @ 300mA	450w	2.7w
Maximum crystal temperature	120K	200K
Incidence angle	~45°	~45°

Notes:

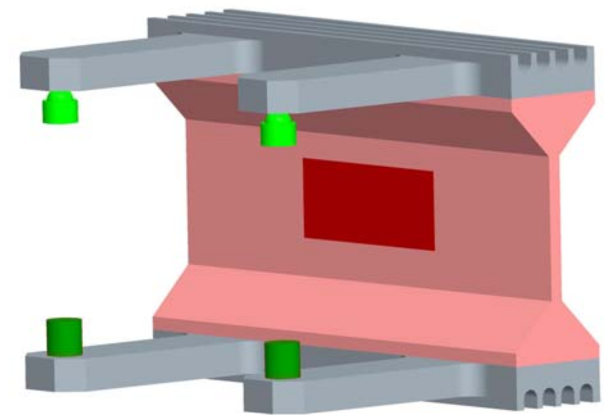
- Bend radius of both first and second crystals typically
- ~60m +/- 1m - This equates to a 1micron bow in the crystal surface!
- 1st Crystal requires cryo-cooling
- Crystal mounted at 45degrees = gravity issues

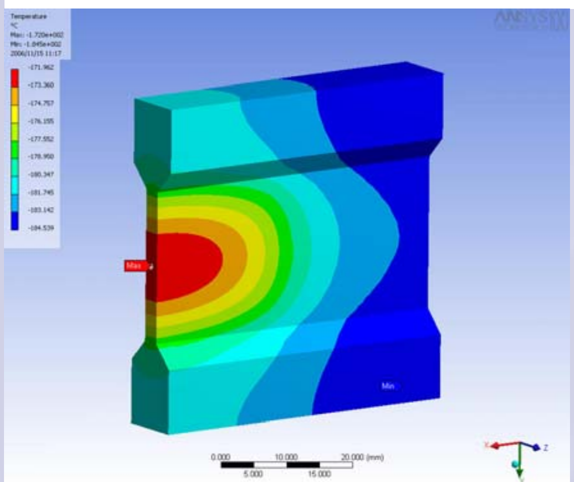
A brief review of the design development

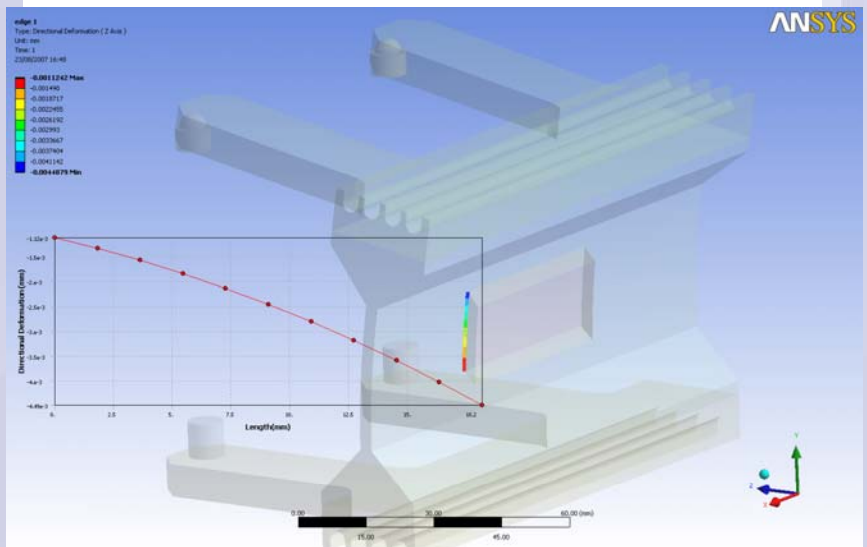
Original Concept



First Evolution







Features

- Duel moment bender
- Efficient thermal heat transfer
- Minimise anticlastic bending

Issues

- Differential thermal expansion
- Clamping strains
- Thermal gradients

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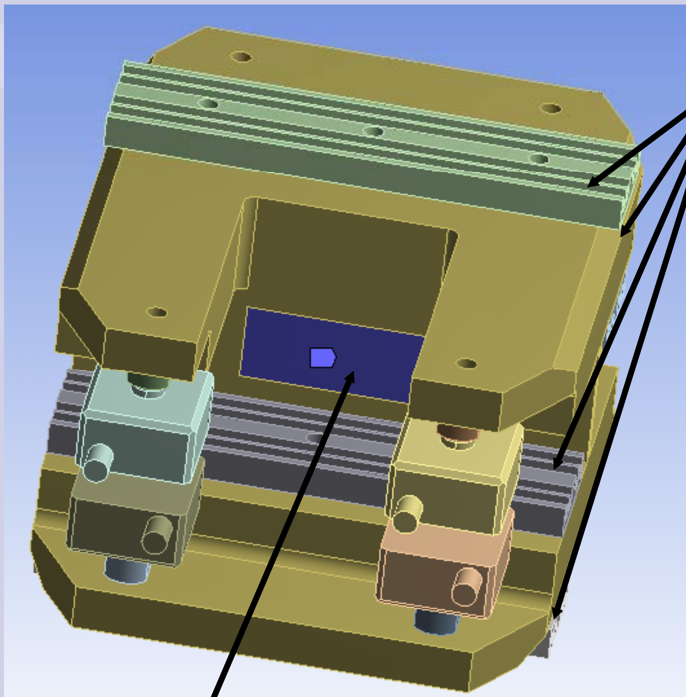
Thermal Performance

1st Crystal Final Design

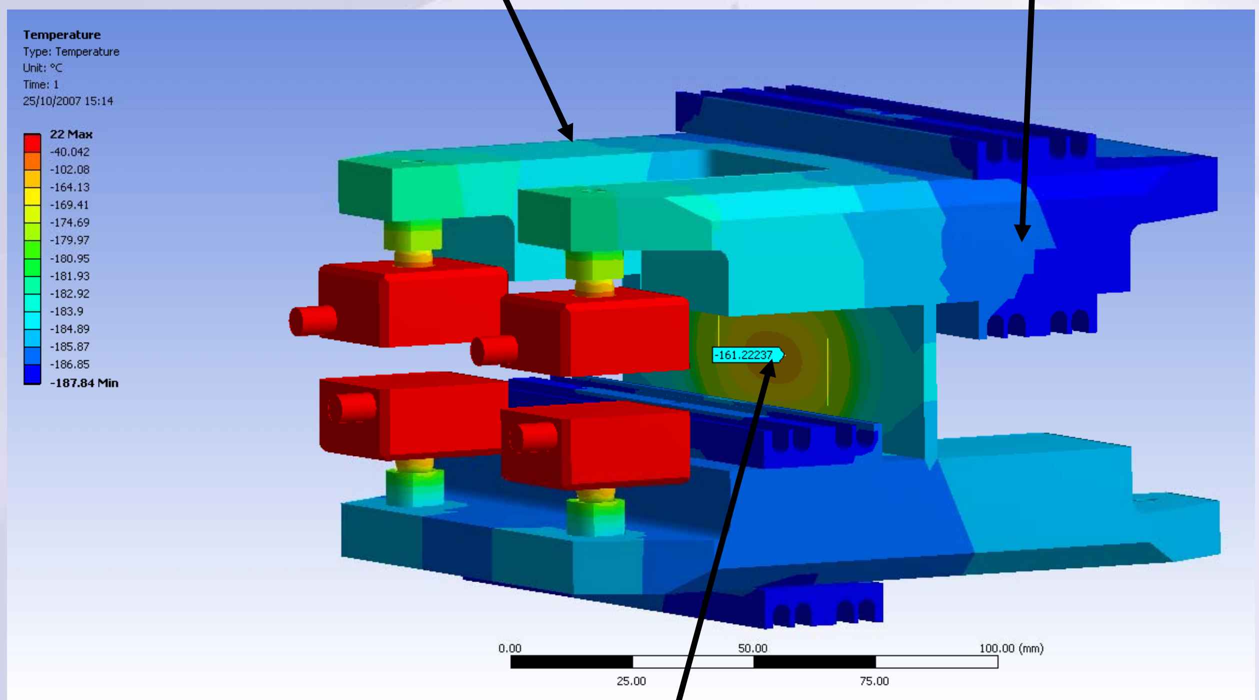
Convection 5000w/mm^2

Near Iso-thermal structure

Copper clamped in inactive region



Internal heat generation 450W



Max crystal temp in imaging section 112K (-161C)

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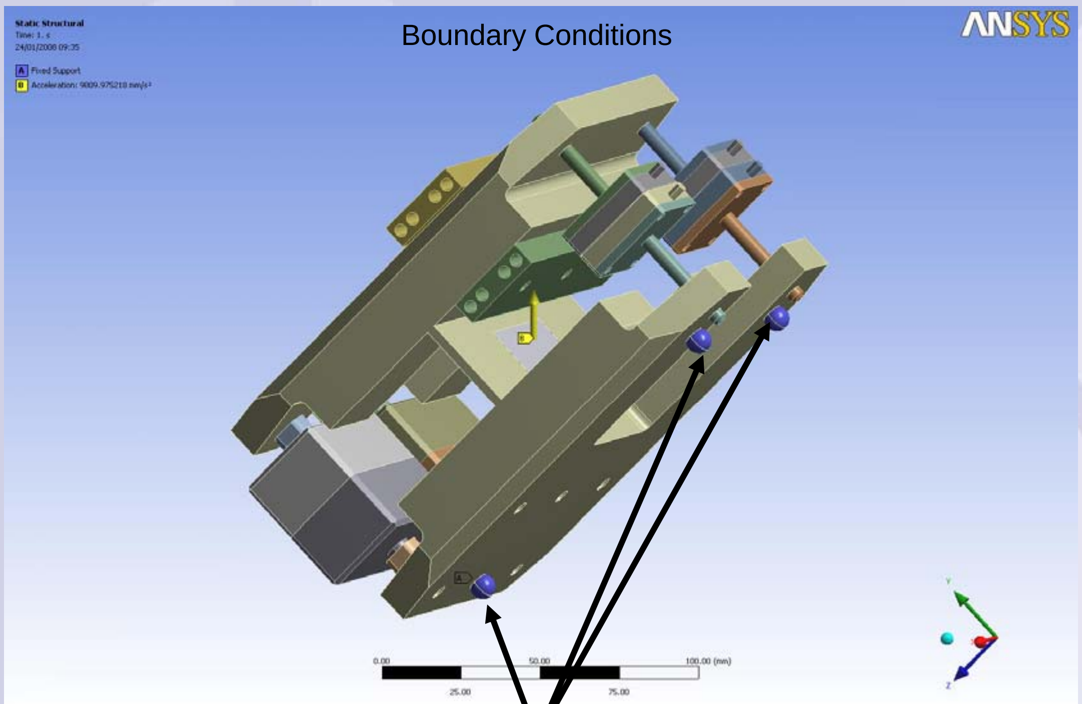
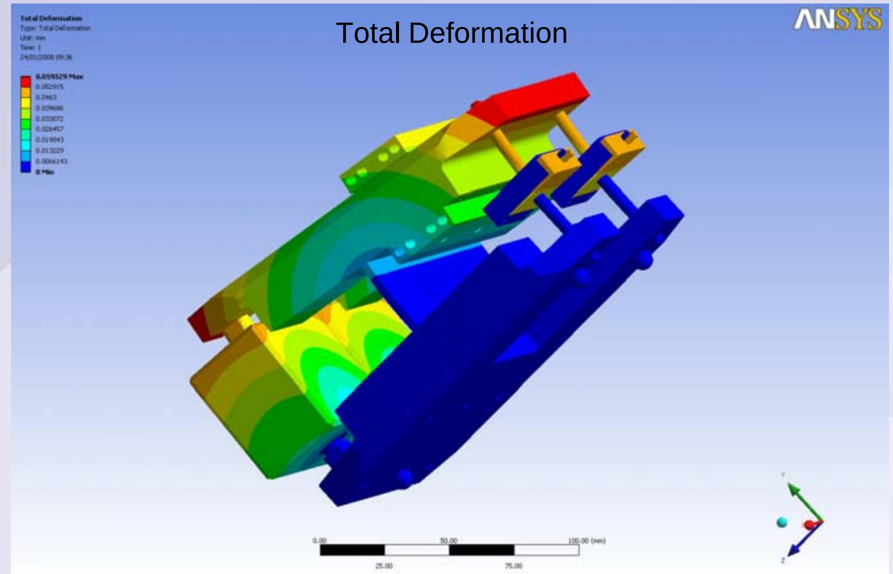
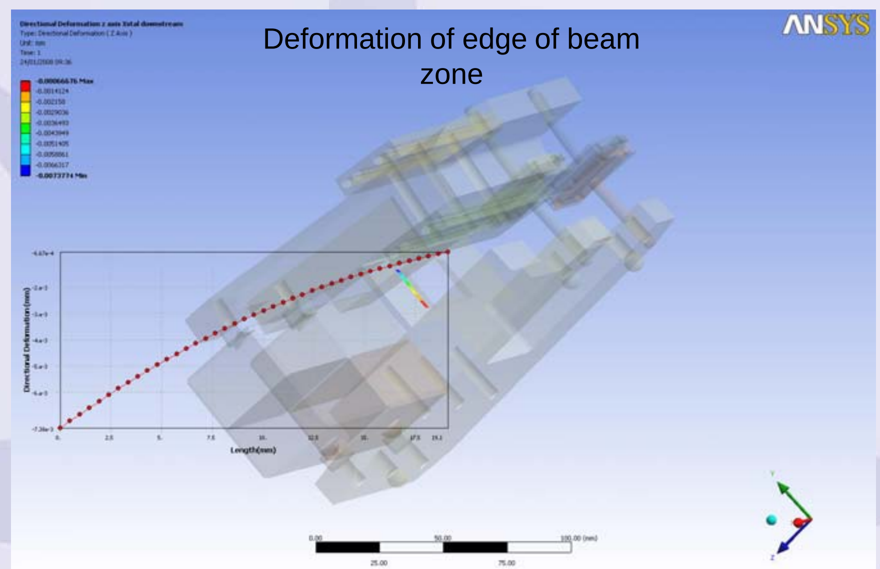
Bending Performance including Gravity (Without thermal loading)

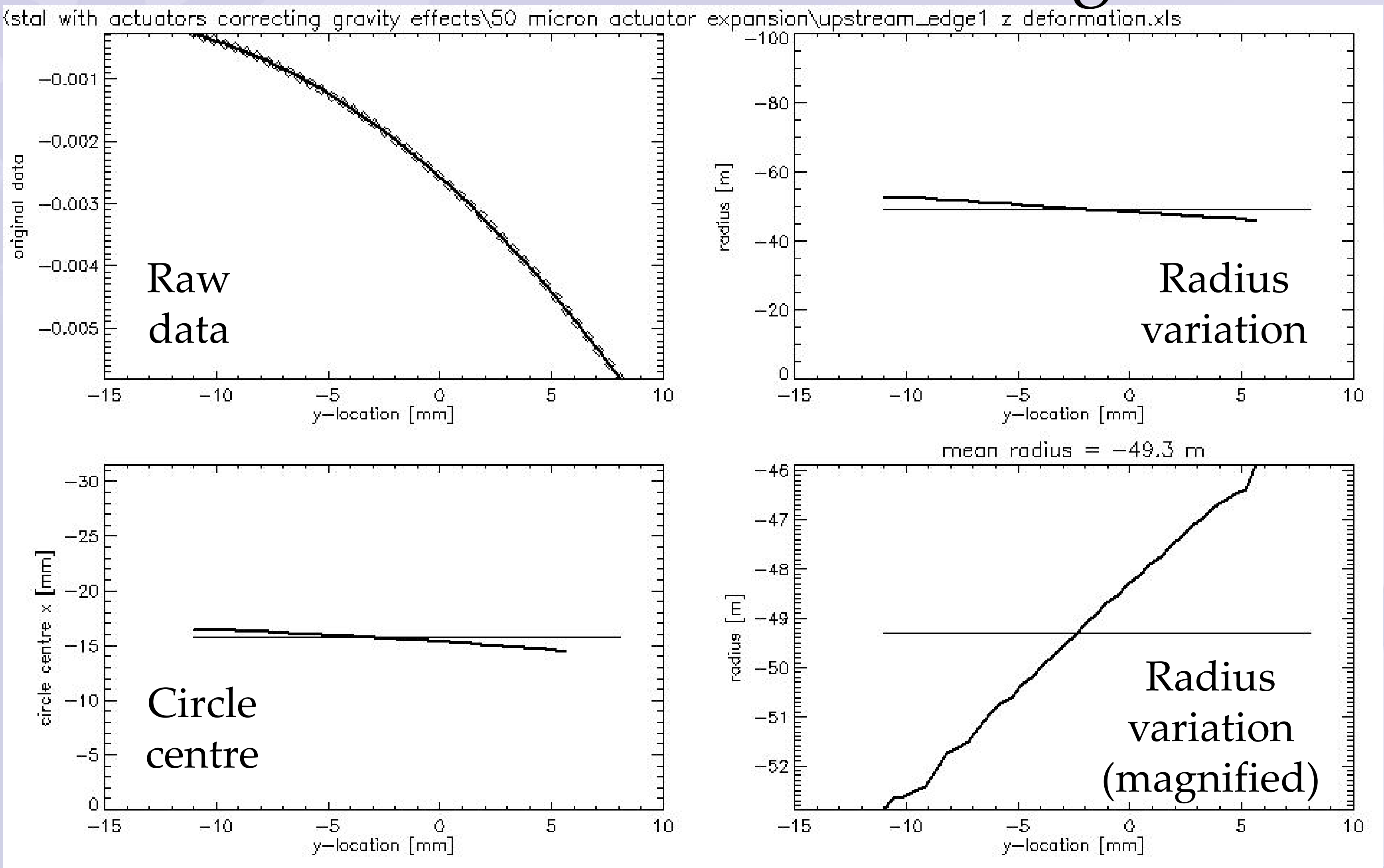


Crystal simply supported on three kinematically located balls

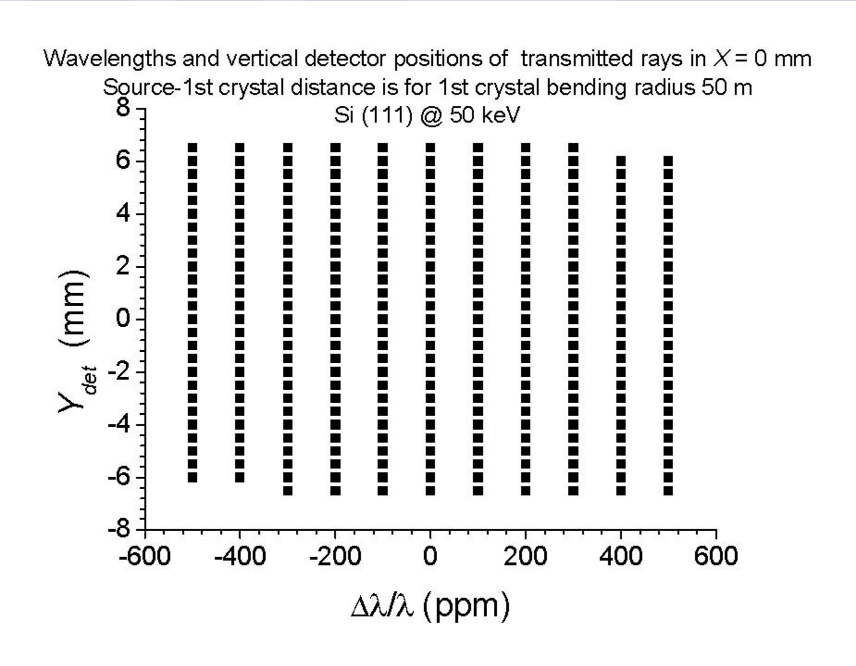


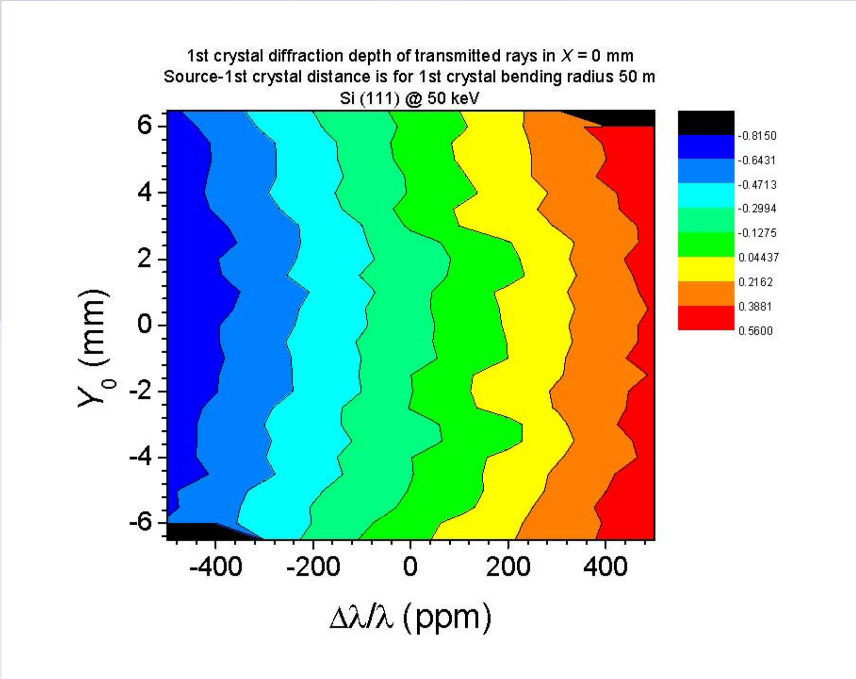


Analysis of Bend radius achieved without thermal loading



Analysis of Crystal X-ray Performance





Resultant beam after passing through the distorted crystal. Each black dot represents a correctly diffracted ray.

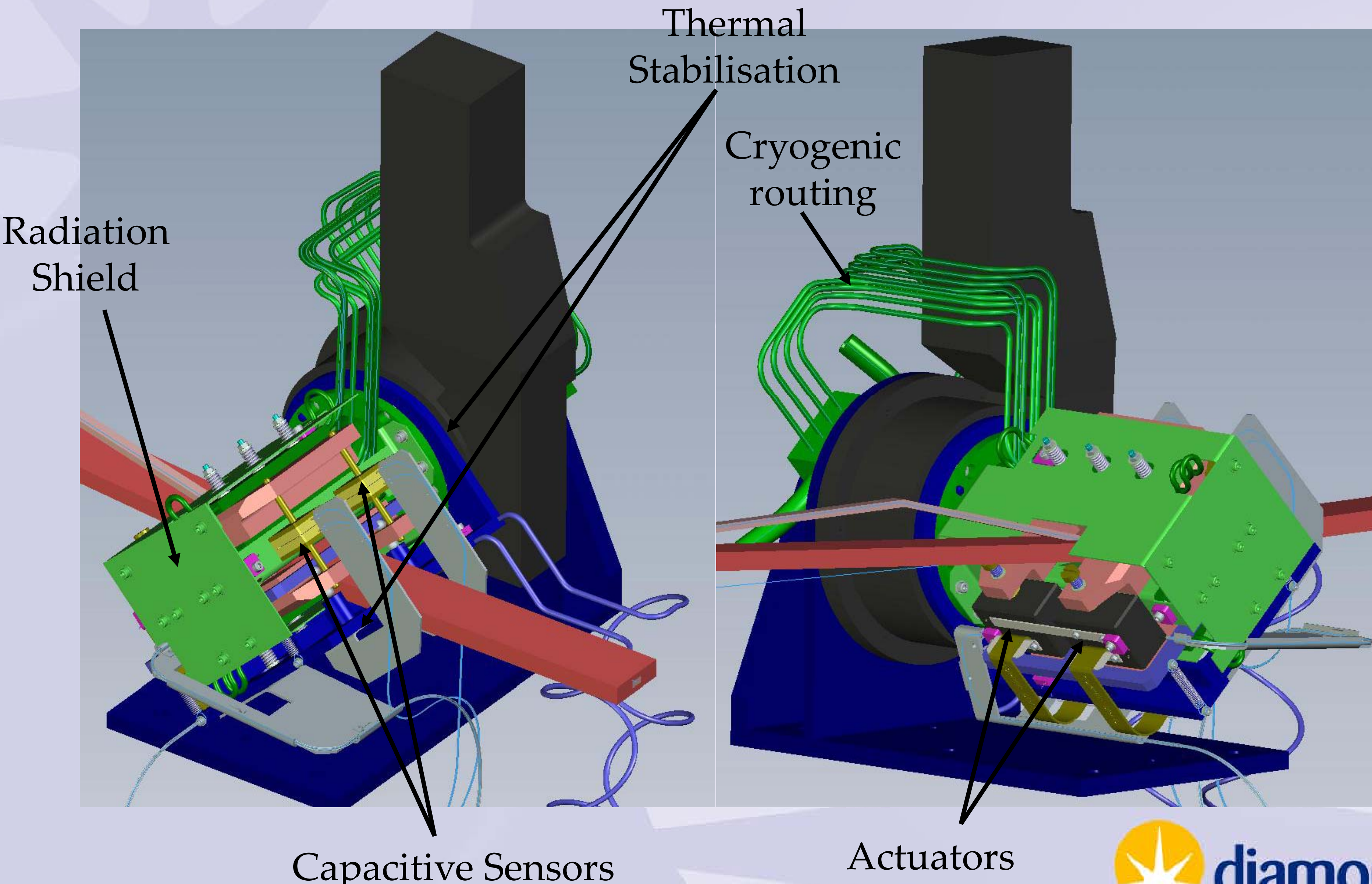
Diffraction depth of the transmitted rays after passing through the distorted crystal. Note only in the two extreme corners is the beam distorted outside of the acceptable tolerance.

Raytrace performed using custom software written by John Sutter to analyse the beam as it passes through the monochromator crystals.

Ray traces of an arbitrarily deformed double-crystal Laue X-ray monochromator

John P. Sutter, Thomas Connolley, Michael Drakopoulos, Timothy P. Hill, Doug W. Sharp
Diamond Light Source Ltd, Harwell Science and Innovation Campus, Chilton, Didcot, Oxfordshire, United Kingdom

Crystal Cage Assembly – 1st Crystal



Actuators

Performace Specification:

- Load capacity 30N
- Range 500microns
- Resolution <1micron (probably achieve <10nm)
- Stiffness – flexure based
- Operating tempertaure 22C (77K prefered)
- Built in feedback (capacitive probes)
- Vacuum compatable (1e-6mbar)
- Radiation Hard (20Kgreys/hour max dose)

2 suppliers considered

PI Queesngate

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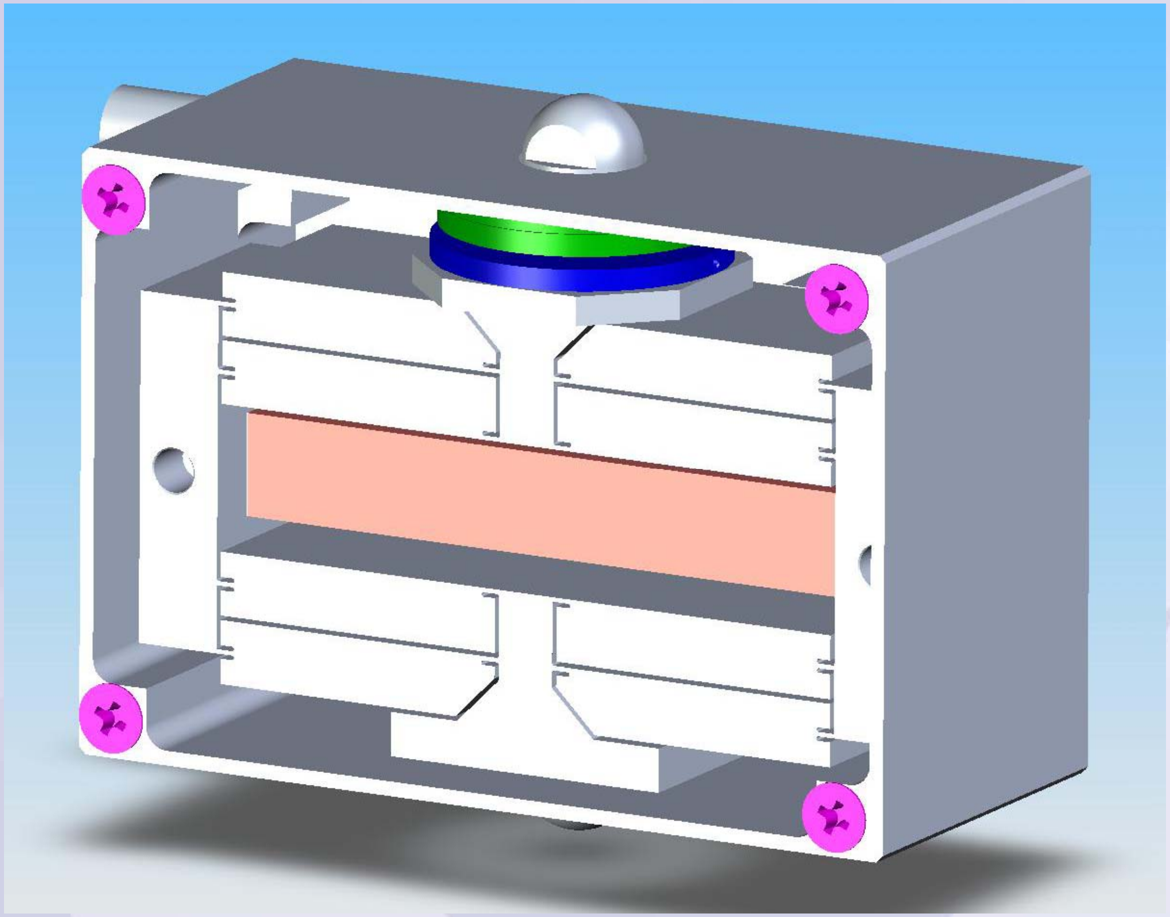
Actuators

Queensgate chosen
Decision based on:

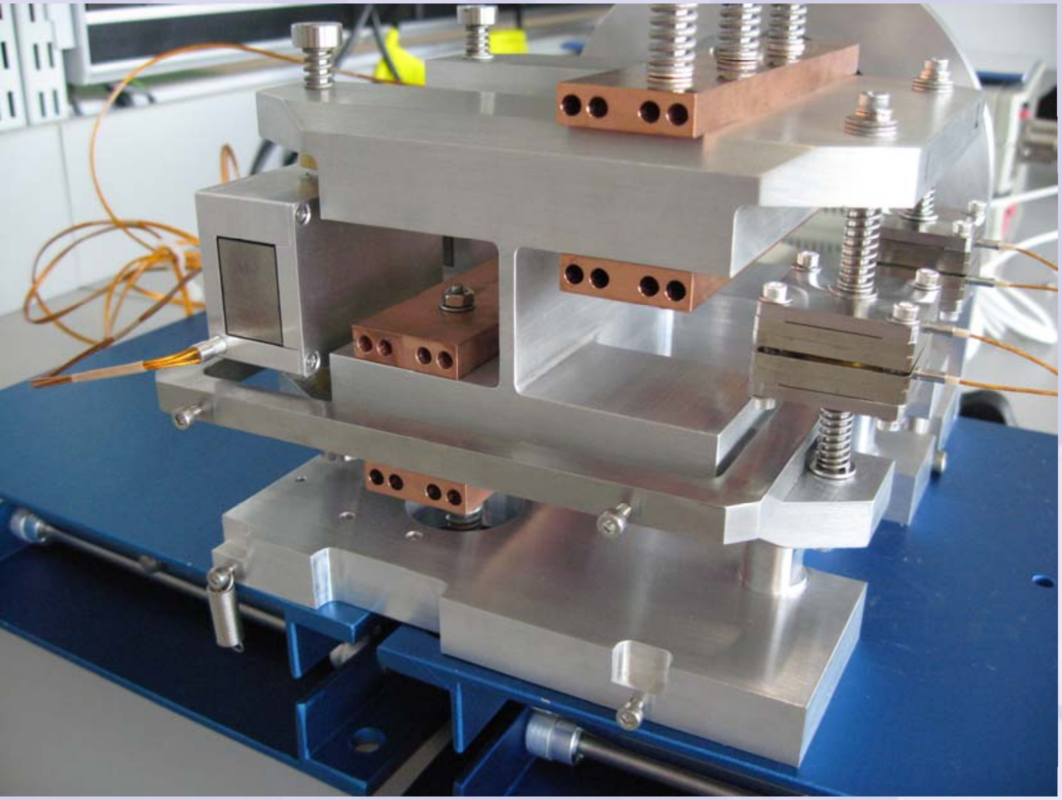
- Price
- Specification
- Delivery
- Support

Requested Modifications:

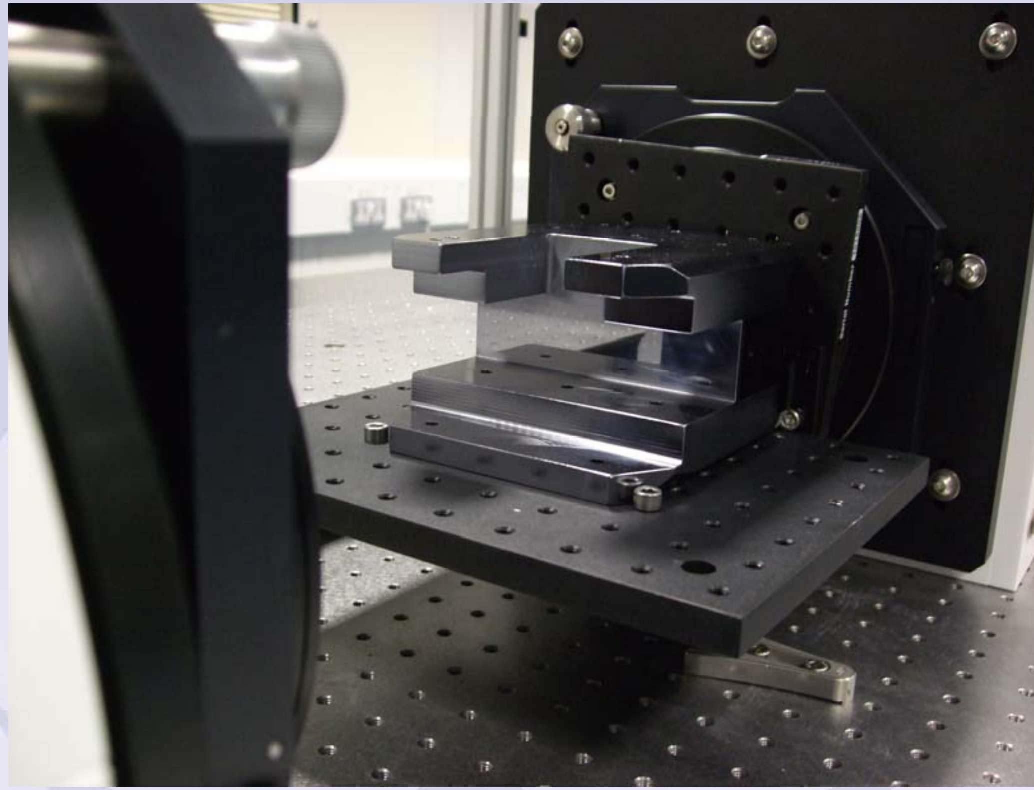
Change materials to titanium for the flexure and Al alloy for the housing. This is to reduce mass and hence the gravitational effect to the bending.



Crystal Testing



Dummy Crystal
with Actuators, cap sensors
and cooling blocks



Silicon Crystal #1
Undergoing
Interferometric inspection

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This project has been a real team effort and I'd like to acknowledge the efforts of everyone involved with the I12 project.

Adrian Birt
Michael Drakopoulos
Mark Harman
Bob Humpherys
Brian Nutter
Allan Ross
John Sutter
Thomas Connolley
John Emmins
Tim Hill
Sid Meyer
Ulrik Pedersen
Doug Sharp
Guy Wilkin

Questions?

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