SPring-8 Monochromators: Issues of Stability and Cooling

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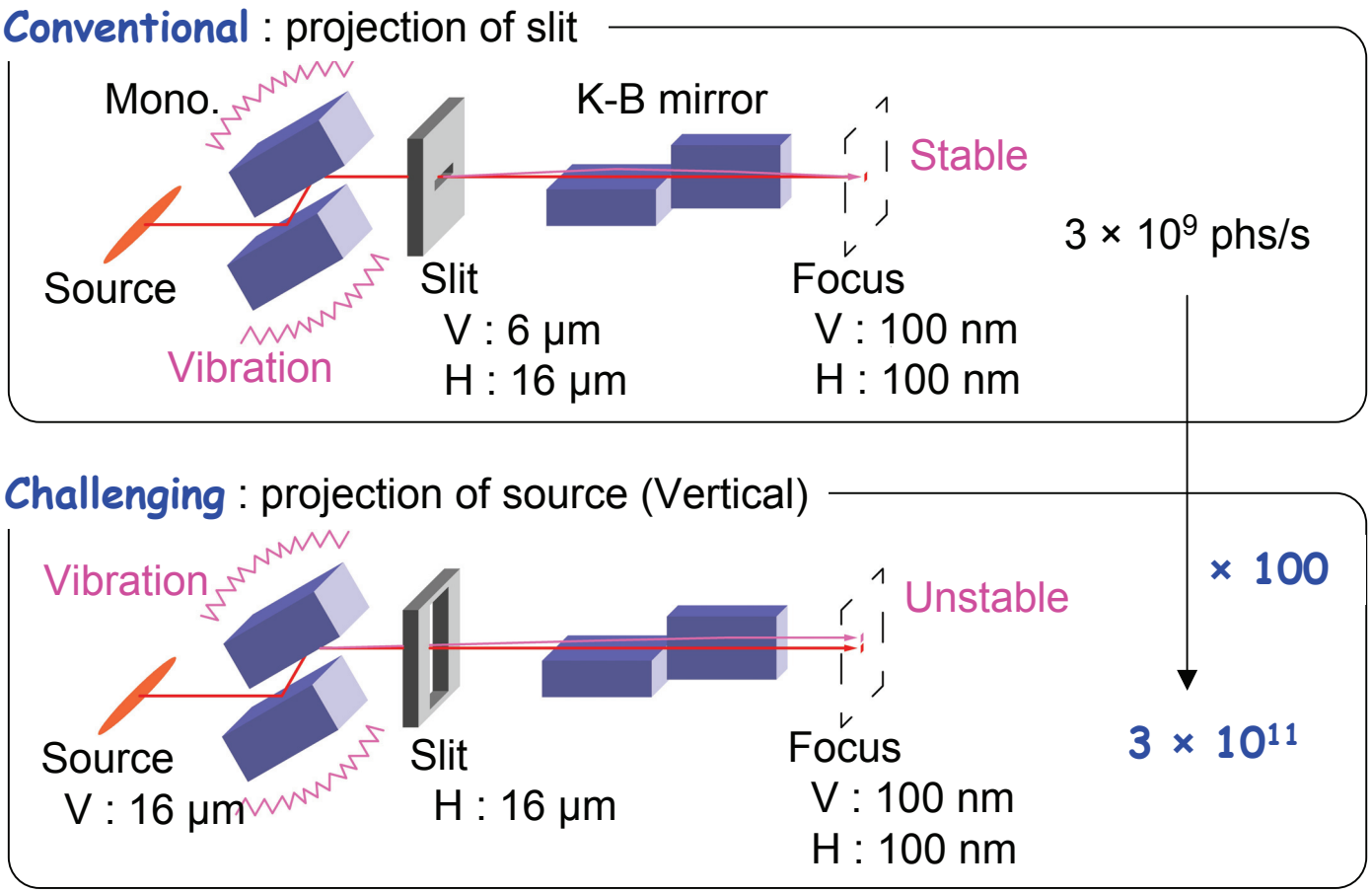
Improvements in Stability

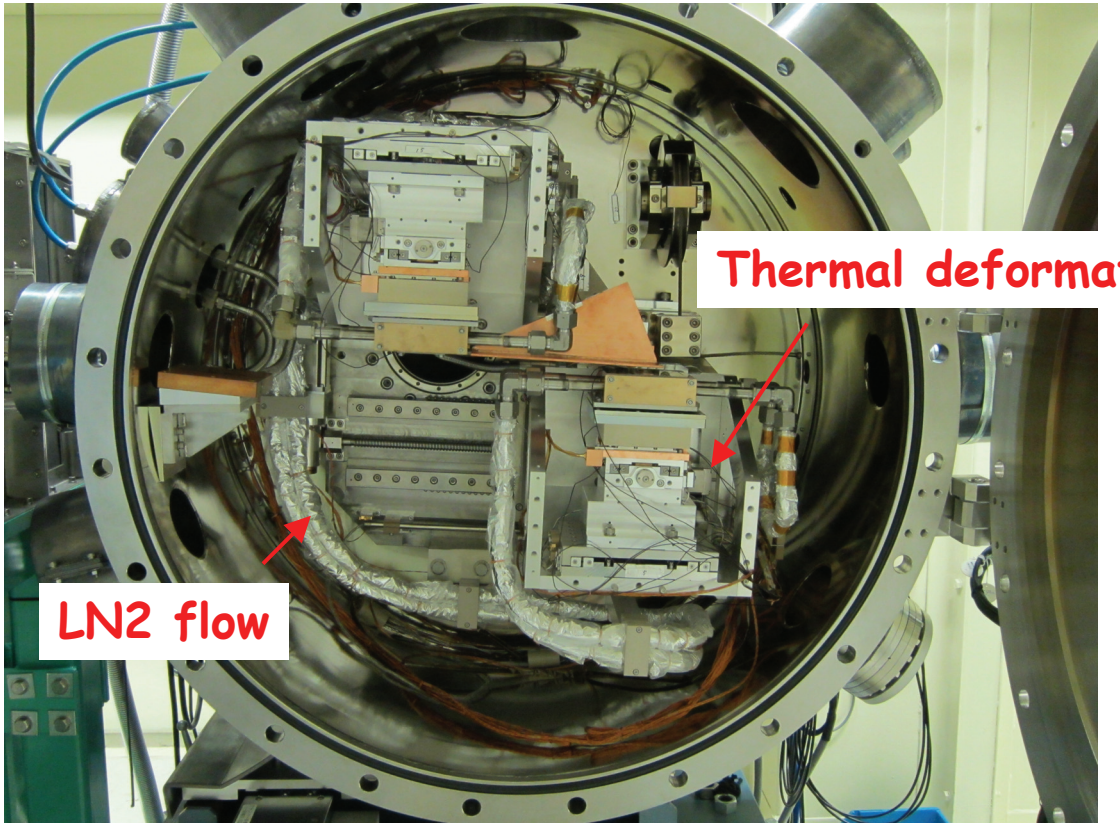
Motivation

Why do we require severe stability for the monochromators ?

We want intense nano-focused x-rays to facilitate green nanotechnology.



Causes of instability



Double-crystal monochromator at BL13XU

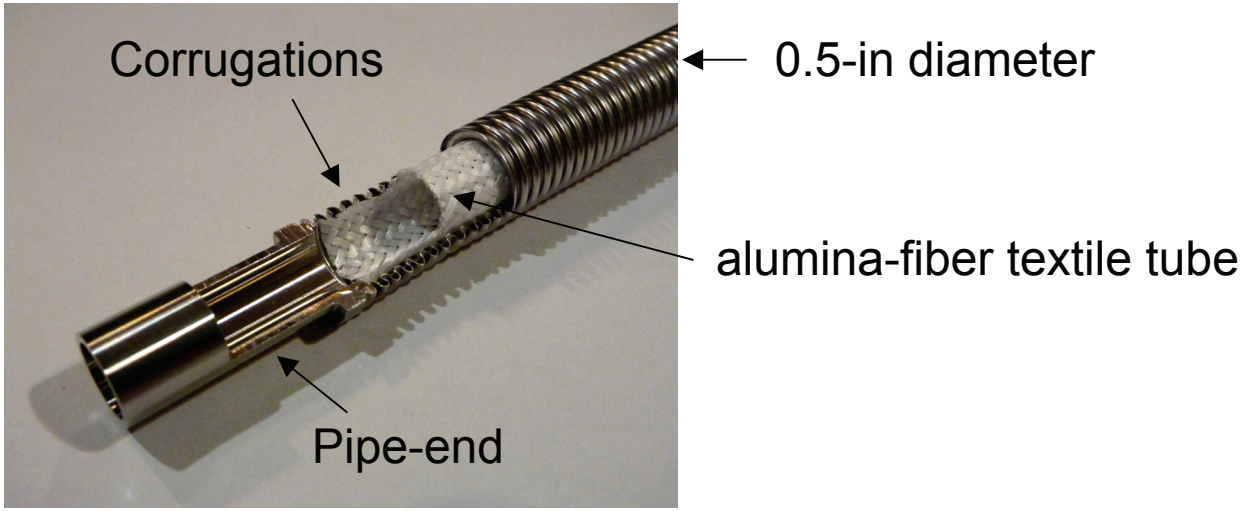
Improvement for LN2 flow (1/3)

Use of stainless-steel flexible tubes for LN2 flow in the monochromators

Flexibility, cold resistance, and radiation tolerance

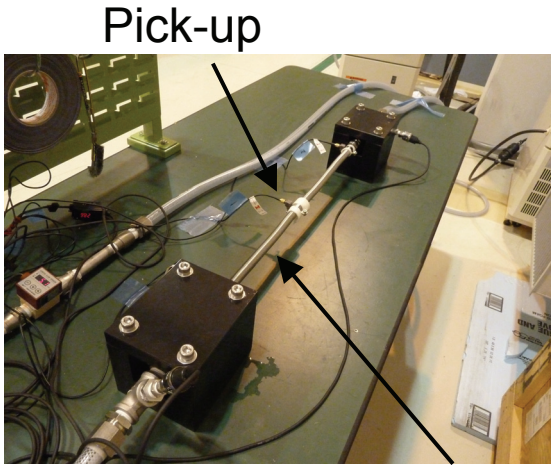
The corrugations of the tubes make turbulent LN2 flow → vibration.

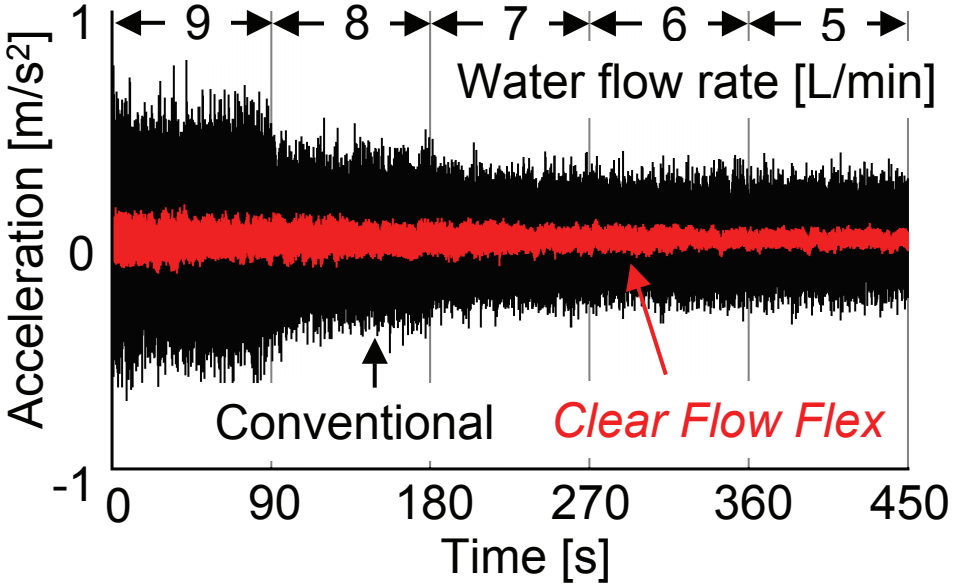
If the corrugations are hidden with something smoother, …



Improvement for LN2 flow (2/3)

Preliminary test of new flexible tube





"**Clear Flow Flex**", PAT. Pending

(JASRI / RIKEN / Osaka Rasenkan Kogyo)

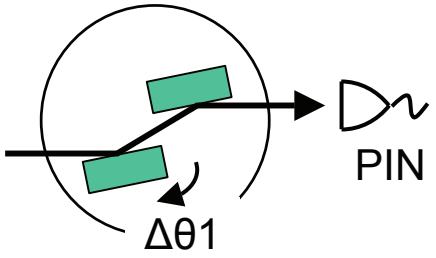
Improvement for LN2 flow (3/3)

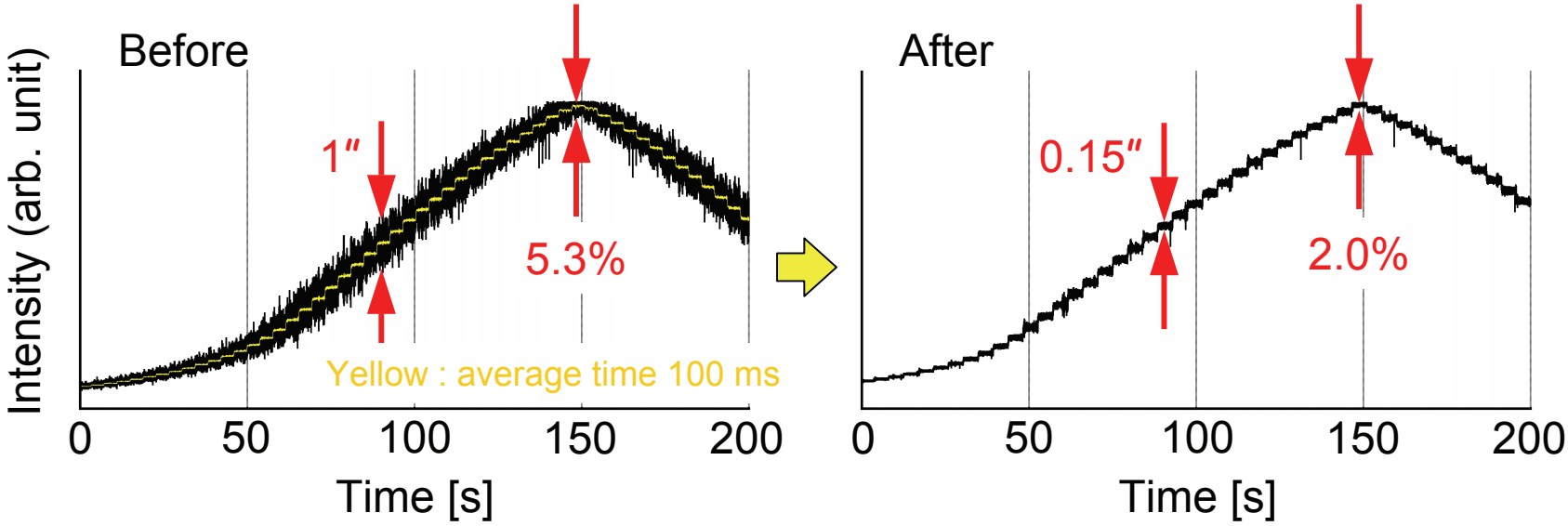
Measured Intensity fluctuation of 1 Å x-rays at BL13XU

Average time : 1 ms ··· very sensitive

Measurement frequency : 1 kHz

Δθ1 stage : 0.2″ stepping at a time interval of 5 s

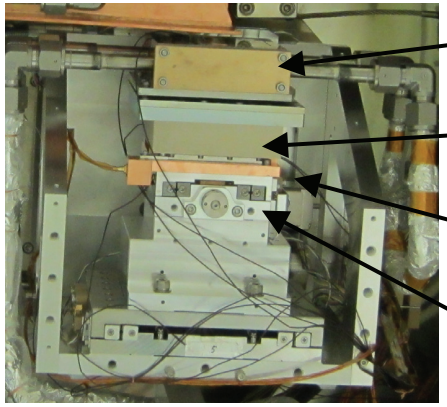




Angular fluctuation between the crystals : 1″ → 0.15″

Intensity fluctuation of 1 Å x-rays : 5.3% → 2.0%

Improvement for Thermal deformation



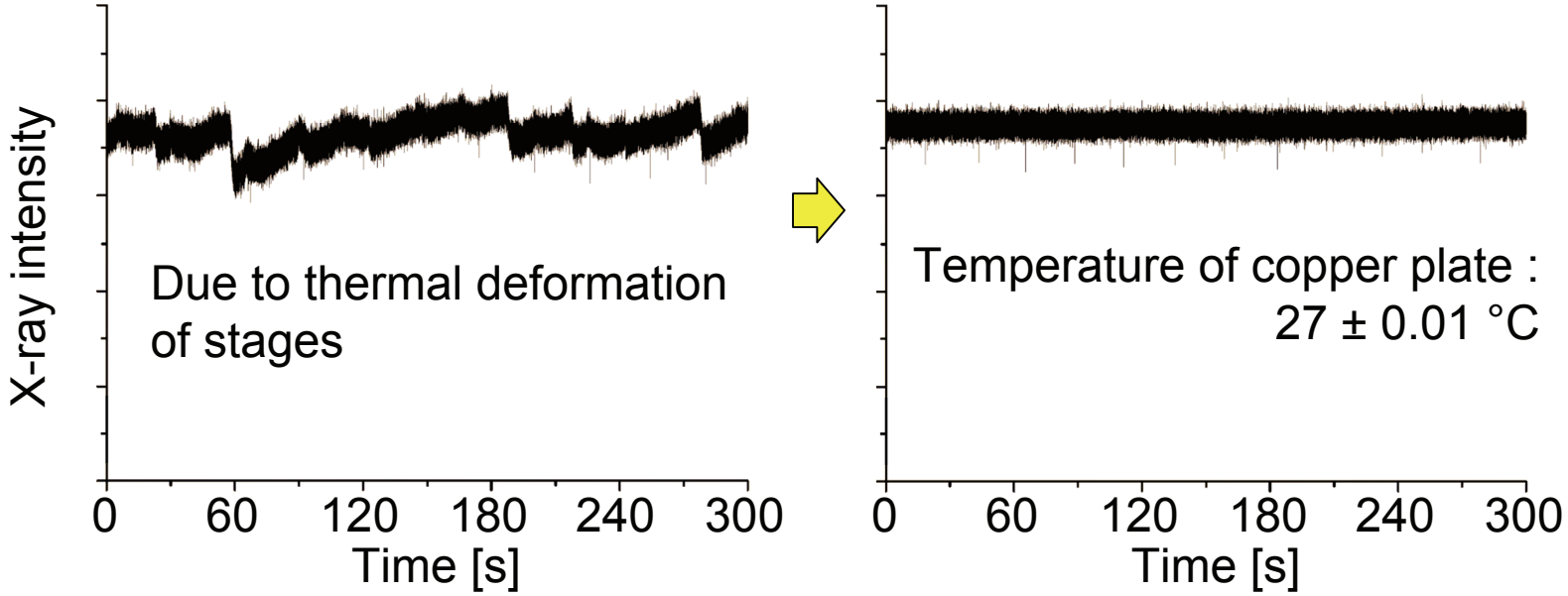
1st crystal holder with LN2 paths

Machinable ceramic block

Copper plate with sheet heater

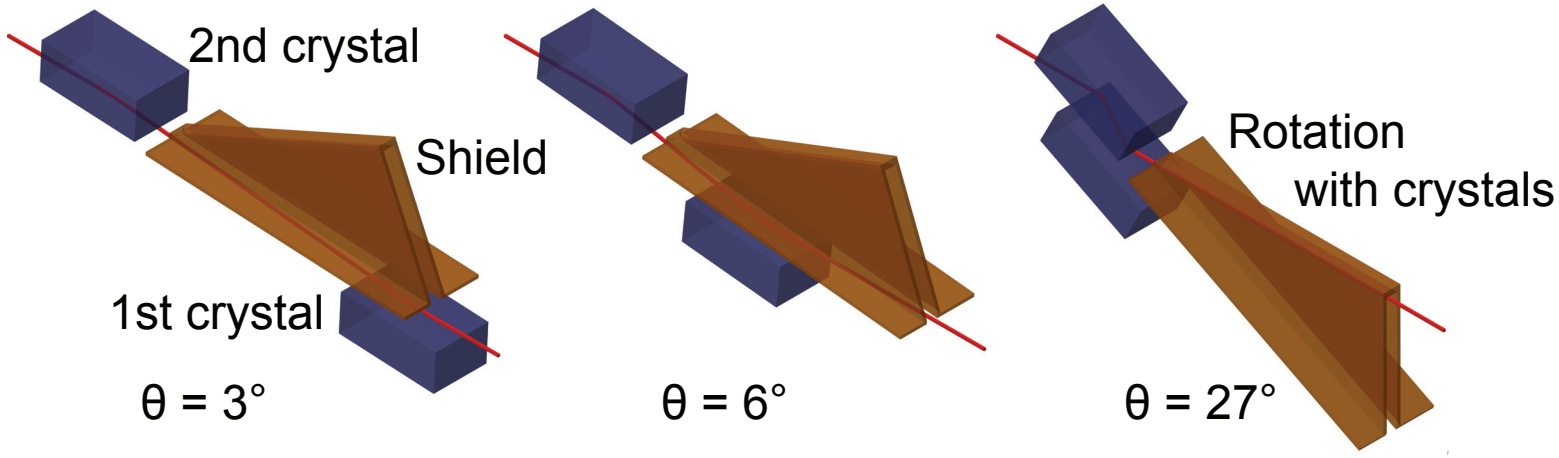
Tilt stage

Heater current control : ON/OFF → PID



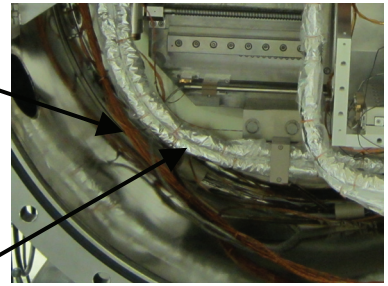
Other improvements

Radiation shield to block secondary radiations from the first crystal



Material of cable jacket :

cross-linked plastic → polyimide
(for **Radiation tolerance**)

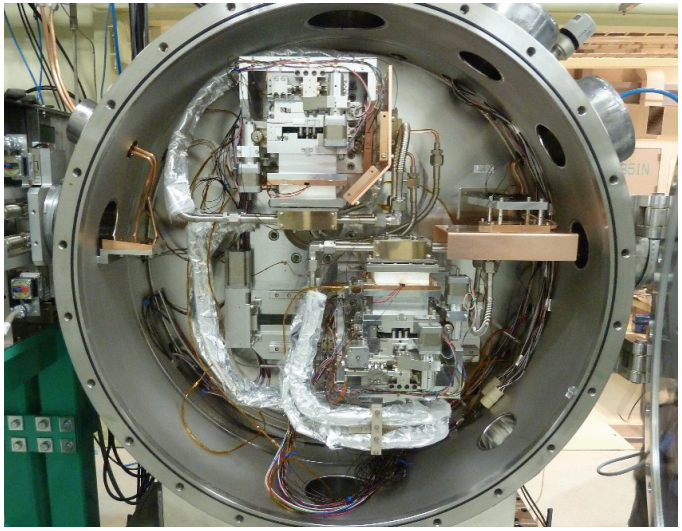


cryogenic insulator for **thermal insulation** from LN2 paths

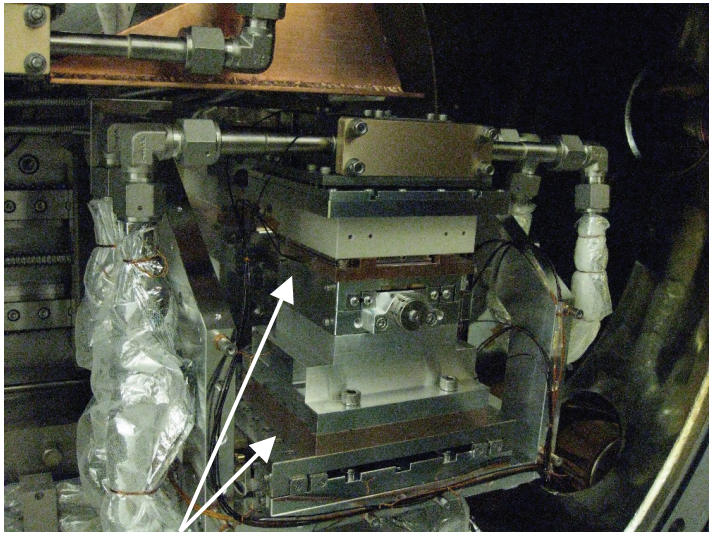
ten-layer aluminum-deposition films spaced with nets

Updates

Apr. 2011 : BL37XU / 39XU
Sep. 2011 : BL13XU
Apr. 2013 : BL29XU / 41XU / 46XU
Sep. 2013 : BL10XU
Apr. 2014 : BL19XU / 09XU



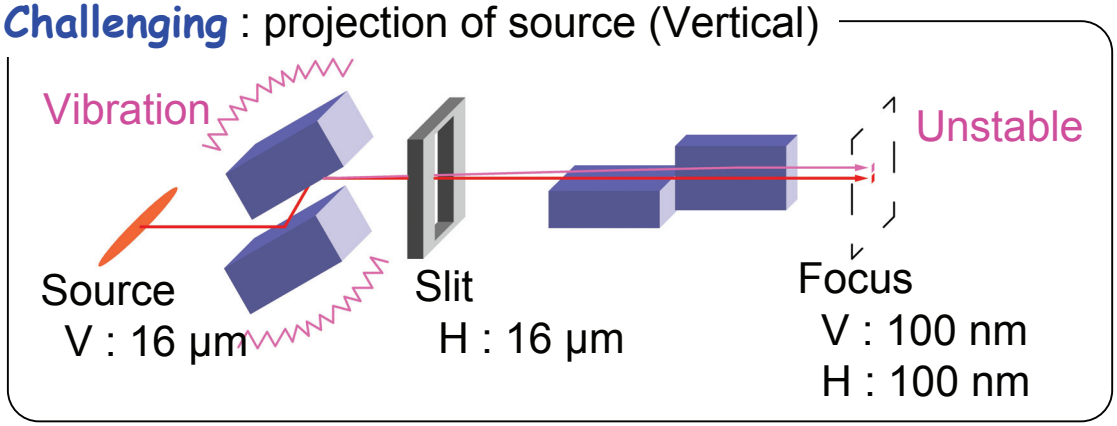
BL37 / 39XU mono



Double heater (29/41/46)

Next target

Challenging : projection of source (Vertical)



Present status @ BL37XU		Next Target
Vibration of mono. : 0.2″	⇨	0.05″
Vertical focus size : 230 nm	⇨	120 nm

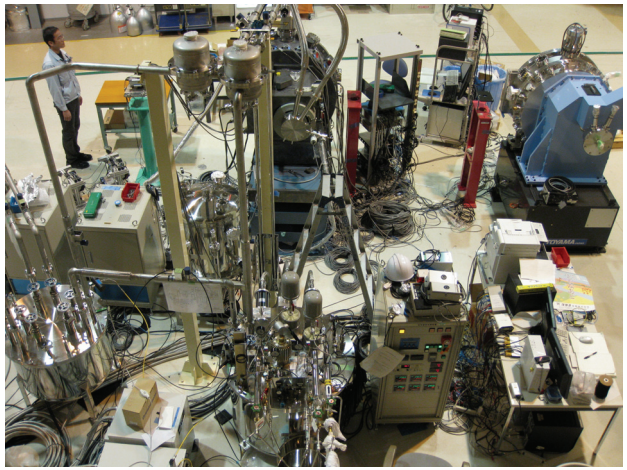
Optimization of Low-vibration flexible tubes

Diameter : 1/2 inch → larger ?

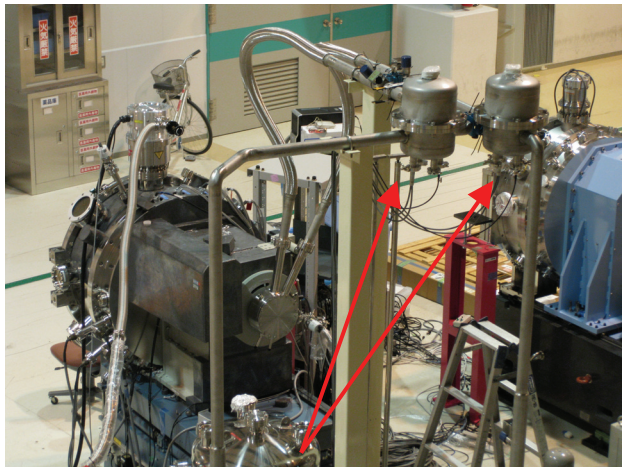
Flexibility : harder or softer ?

Test bench

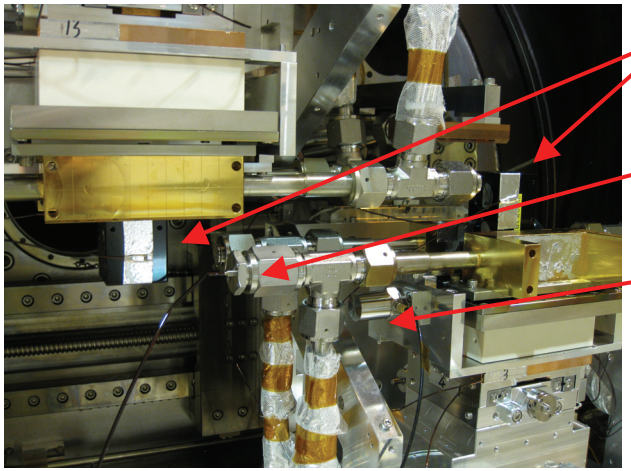
Mono.1 Mono.2



LN2 pump



Measurement units (P, T, vib.)



Interferometer (angular vib.)

Pressure gauge

Pick-up (vib.)

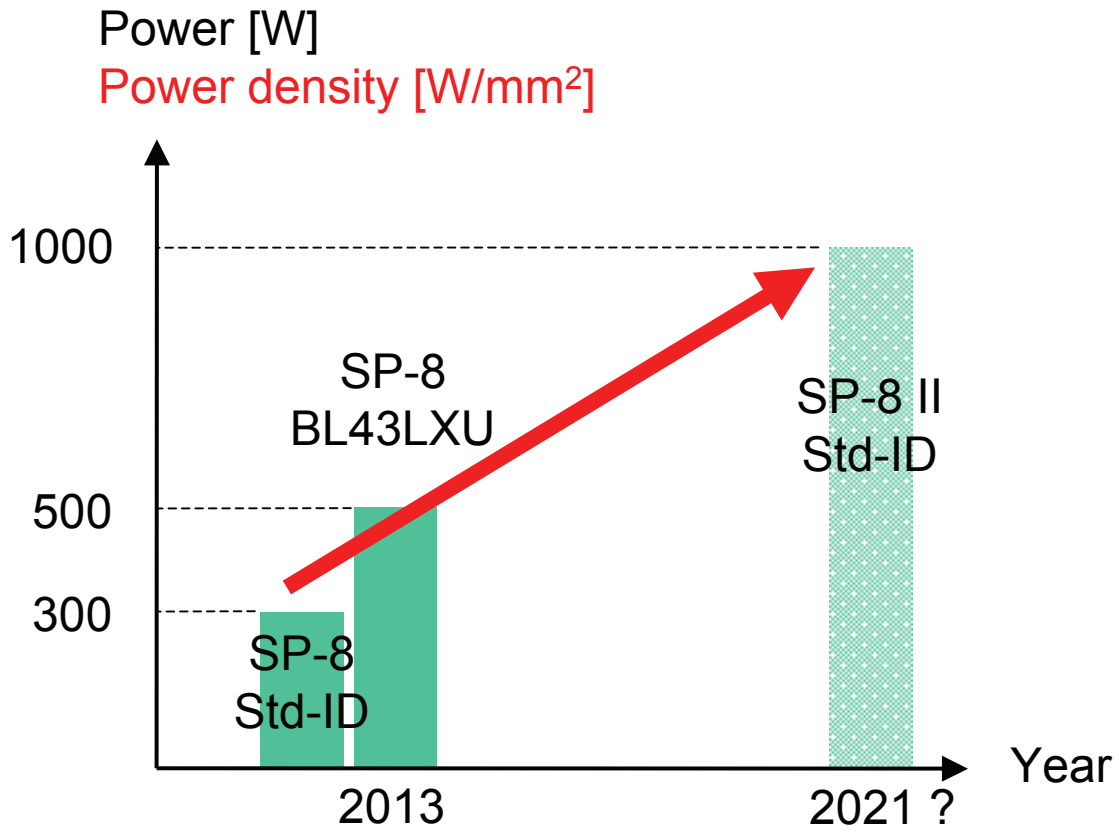
Inside of mono.

Activity for high-efficiency cooling

SPring-8 upgrade plan

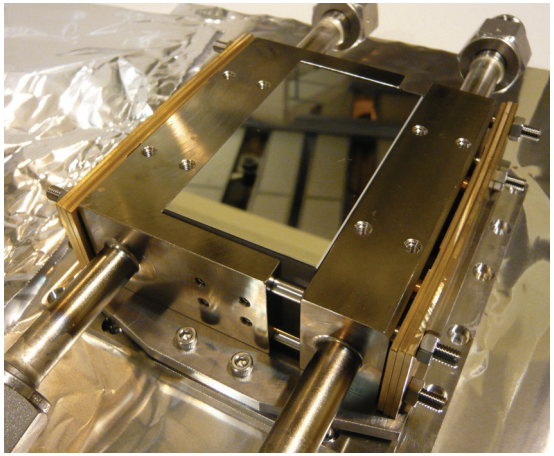
The storage ring providing highest brilliance and coherence x-rays

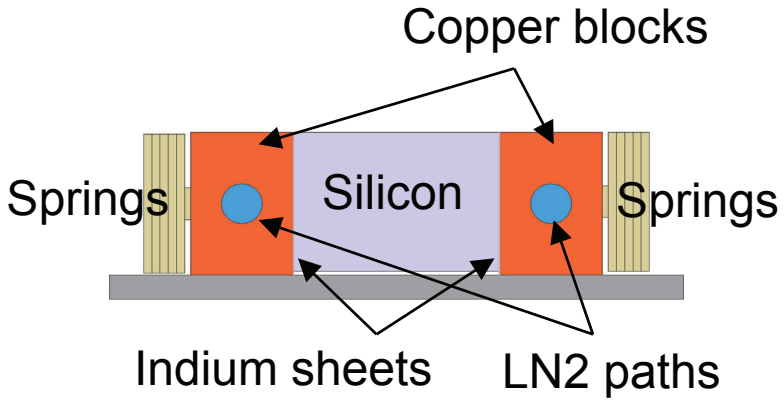
First crystals will suffer heat load in the kilowatt range.



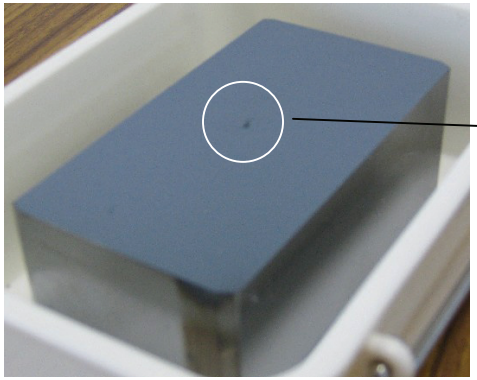
Present crystal cooling

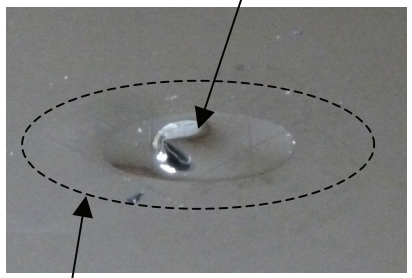
Indirect cooling with LN2





For 2 kW incidence,





Upgrade of crystal cooling

Phase 1 : Development of crystal cooling

Direct cooling
LN2 seal
LN2 paths for high efficiency heat exchanger
Less deformation

Target : 500 W (end of 2013fy)
1000 W (2019)

Phase 2 : Design of LN2 supply / circulation system

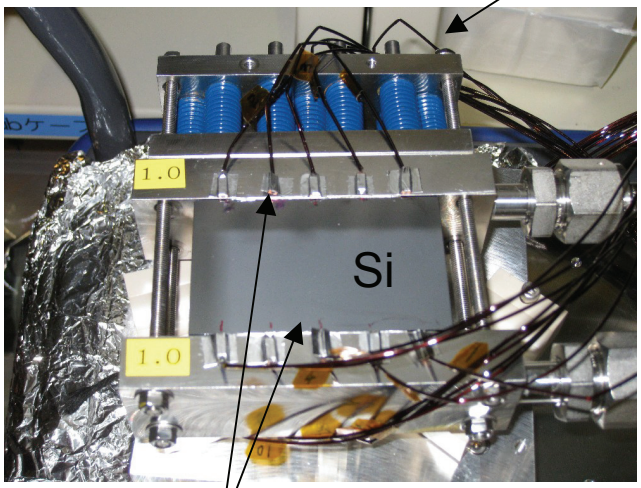
Phase 3 : Validation tests at beamlines

Phase 4 : Install

LN2 seal test

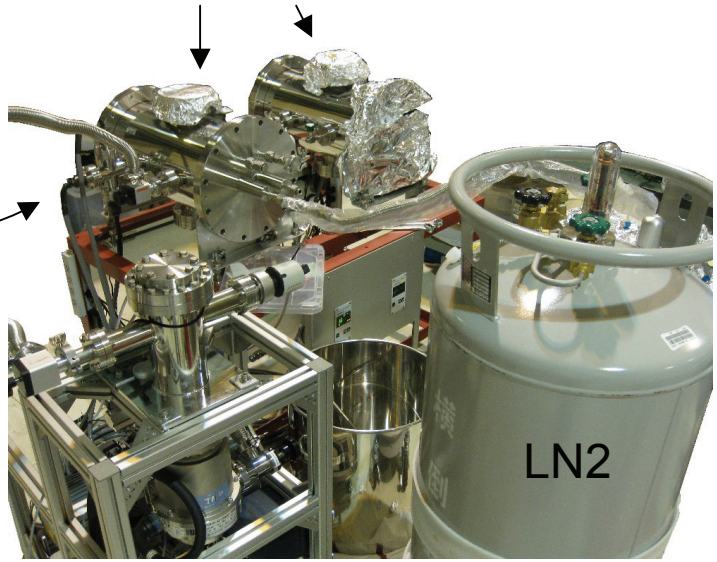
Preparation

Clamp
- Force ? ・・・ as week as possible



LN2

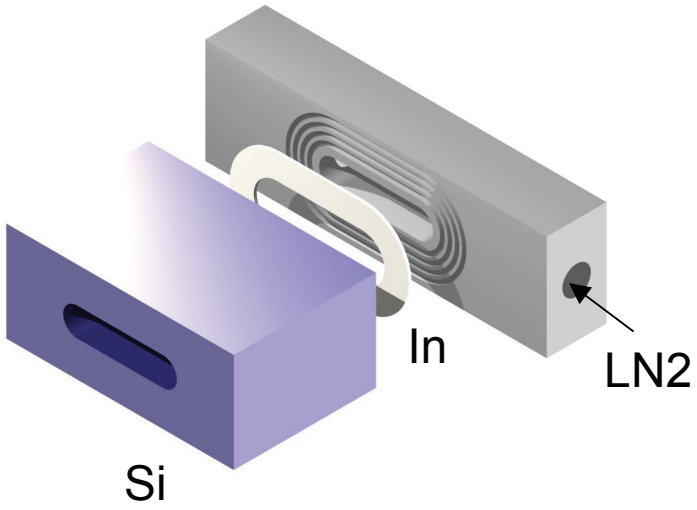
Seal test benches

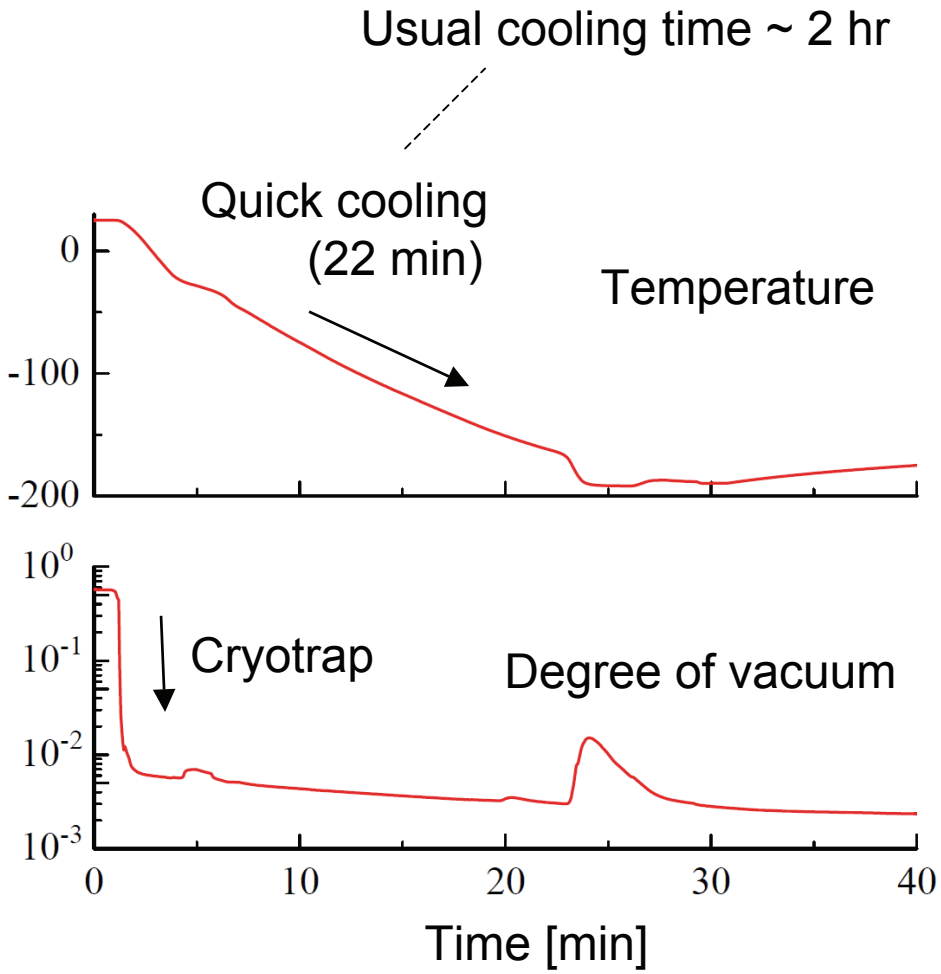


LN2 seal
- Material ?
- Size ?
- Thickness ?

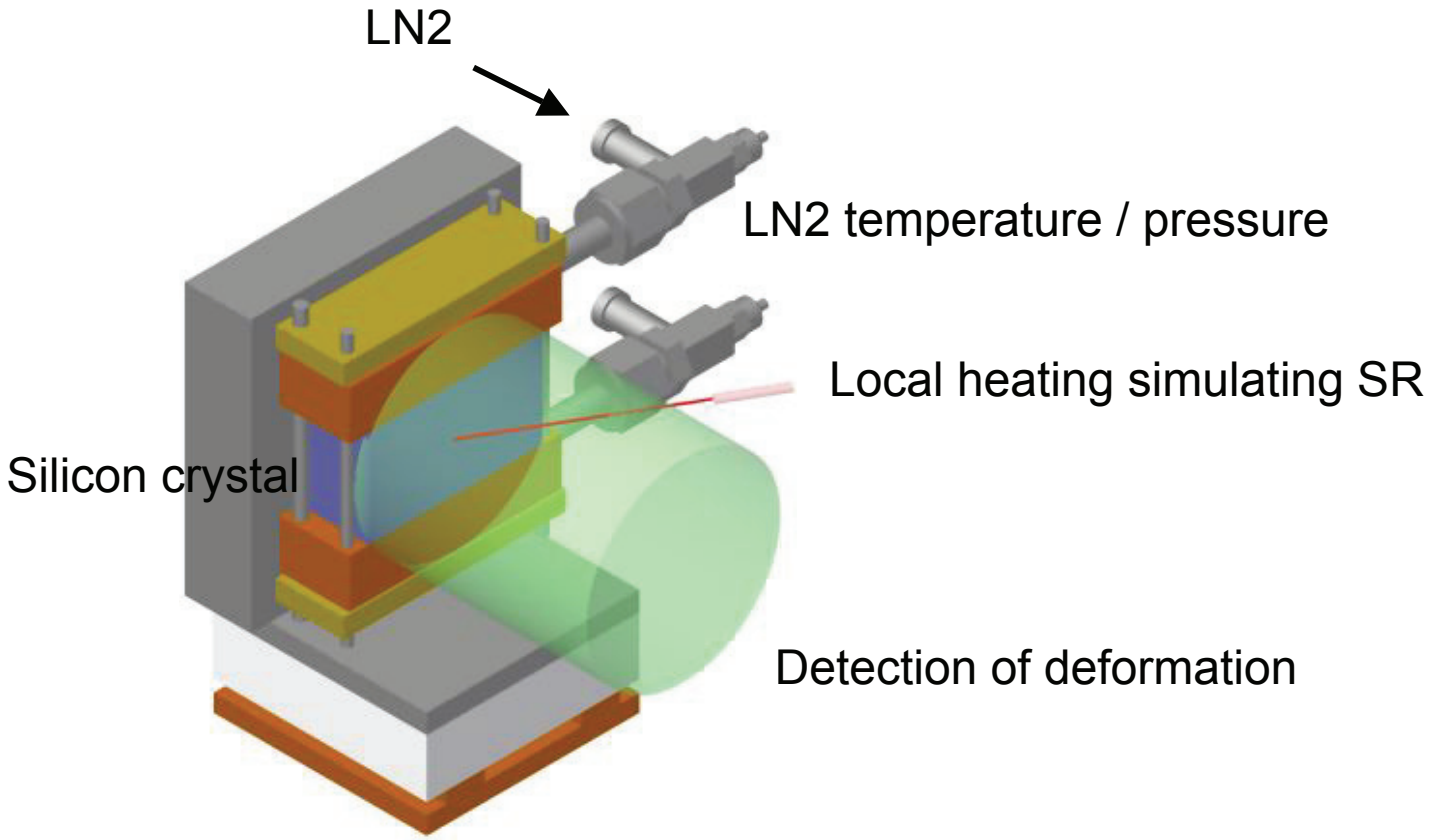
Vacuum pump

A test result





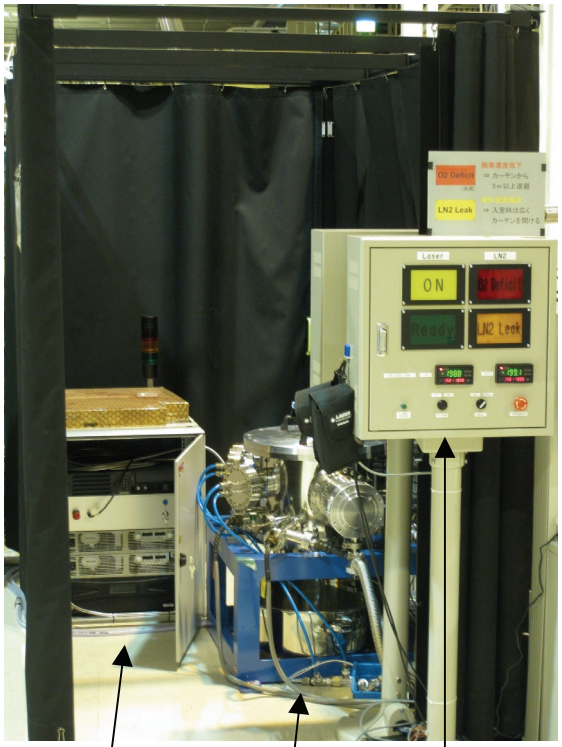
Schematic of heat-load test



Test bench for Heat load test

Test room

Laser-shield curtain

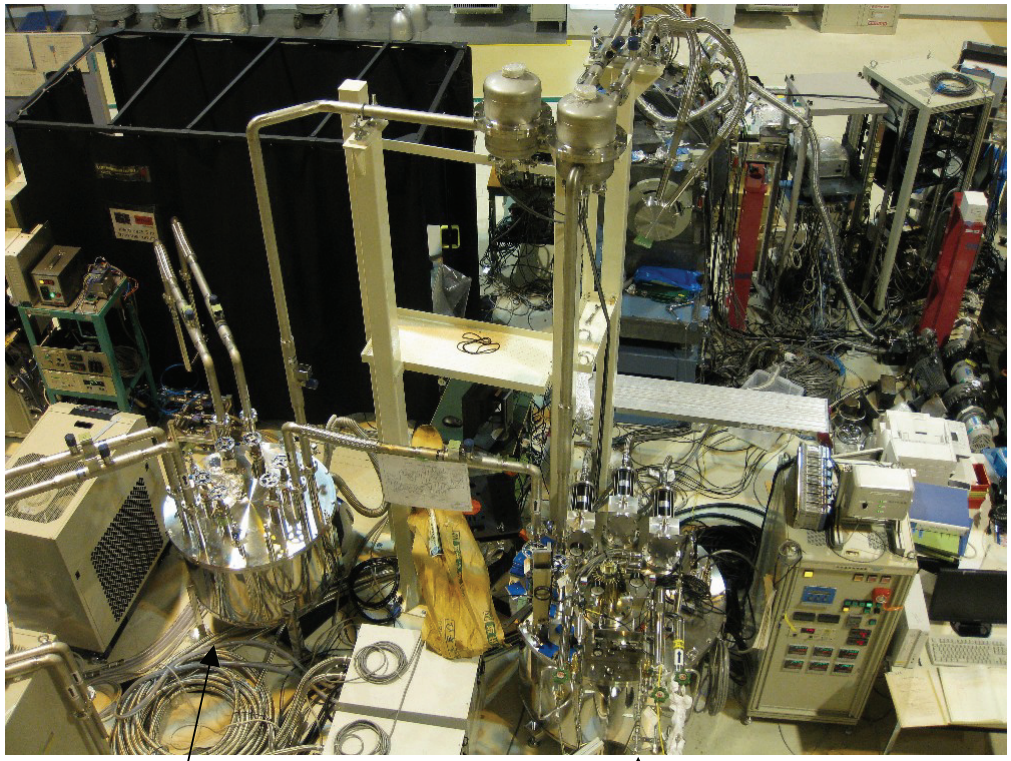


Laser unit

Test chamber

Interlock

Mono. test bench



LN2 distribution unit

LN2 pump

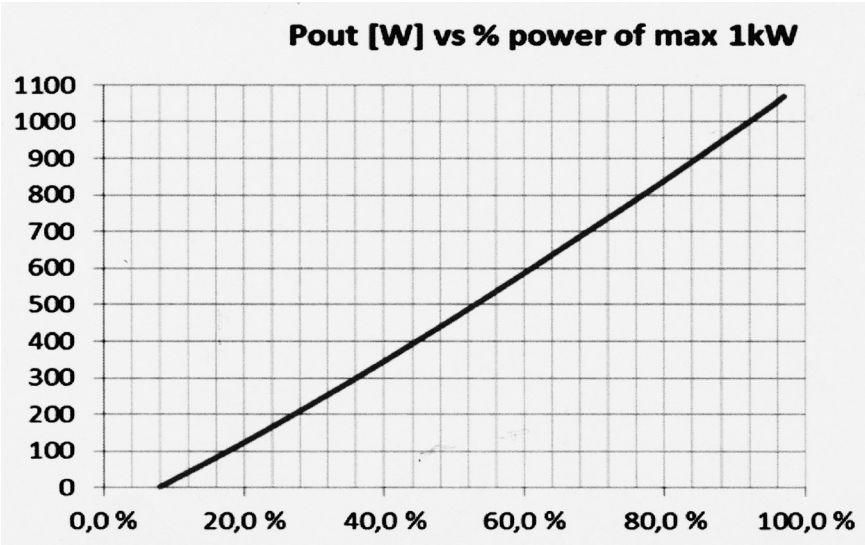
Local heating

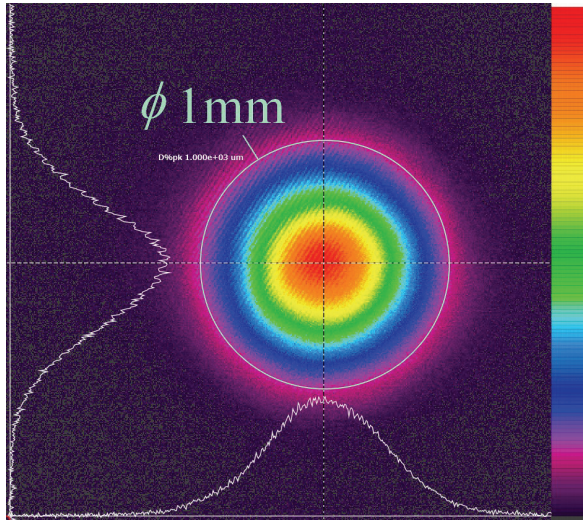
Laser specification

Fiber laser : 1070 nm
CW, Single mode
Maximum power : 1 kW

+ Optics (collimator)
Beam diameter (D4σ) : 0.5 ~ 2.5 mm

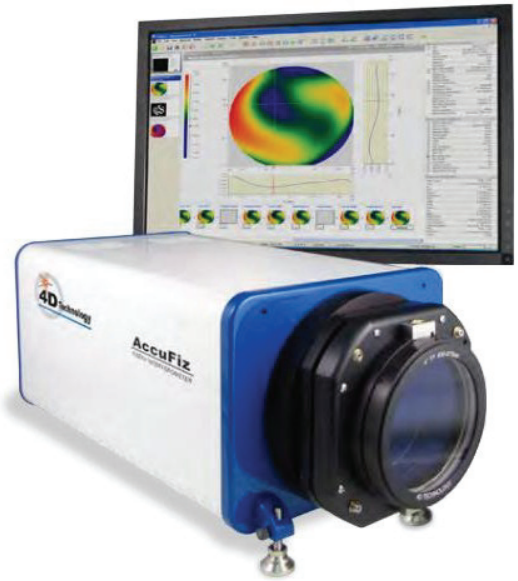
FO-1000 (Mitsui Electronics Inc. OEM)



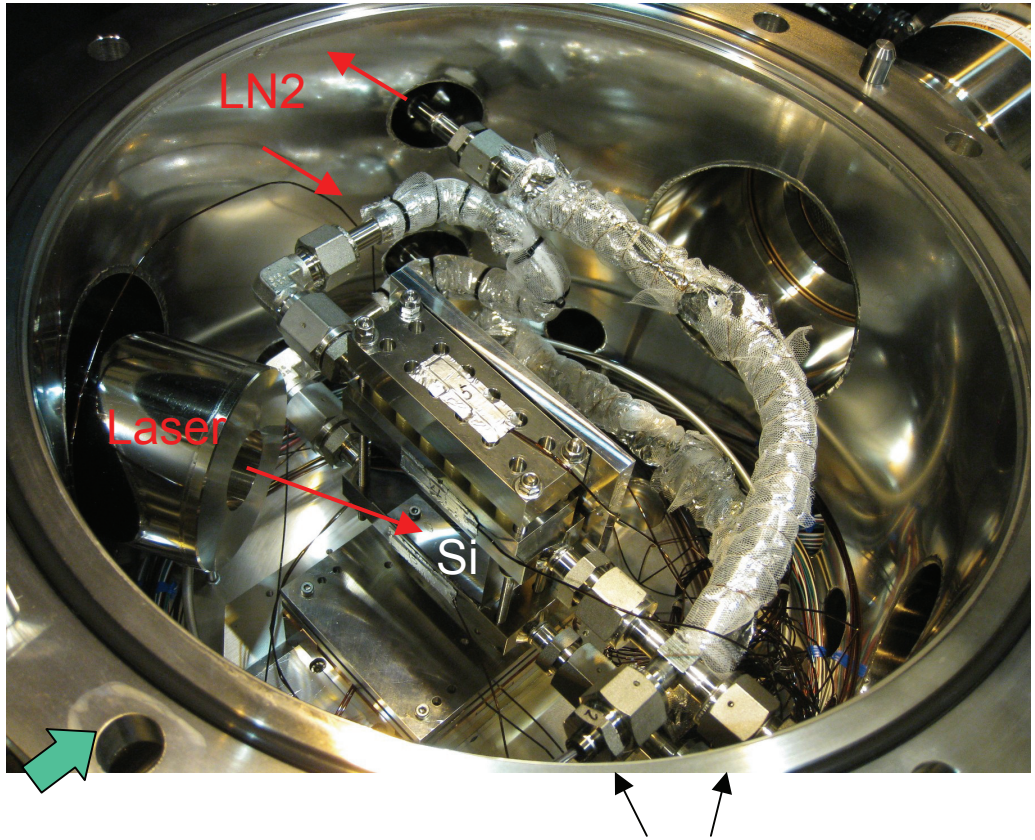


Test chamber + interferometer

Fizeau interferometer



AccuFiz (4D Technology)



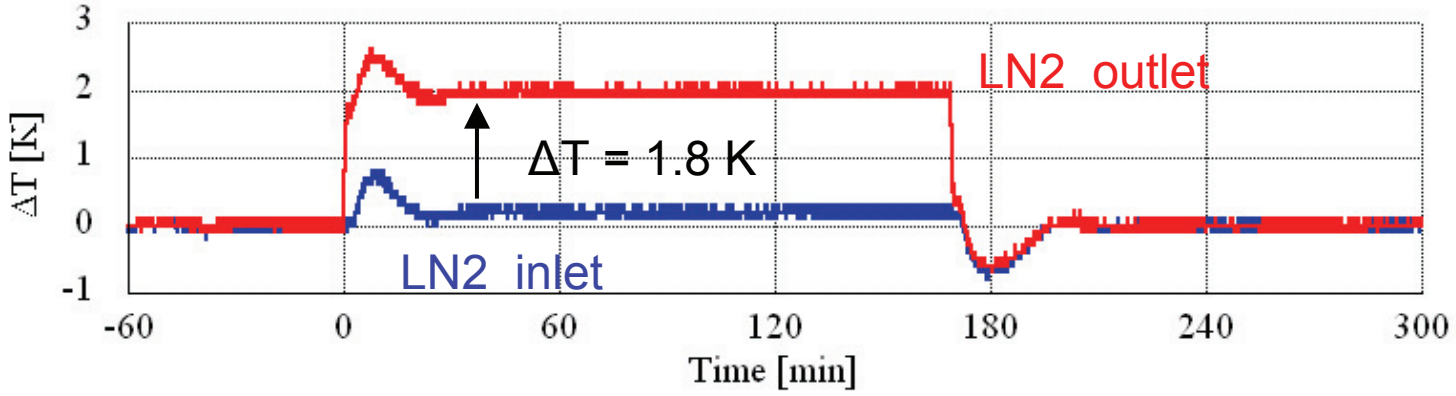
LN2 pressure / temperature

Preliminary test

Radiation of 300 W laser into indirect cooled silicon crystal

(used in the SP-8 beamlines)

Temperatures of LN2



Temperature difference 1.8 K → 250 W absorption into LN2

Radiation of 300 W laser ~ radiation of 300 W SR

The crystal can stably manage radiation of 300 W SR.

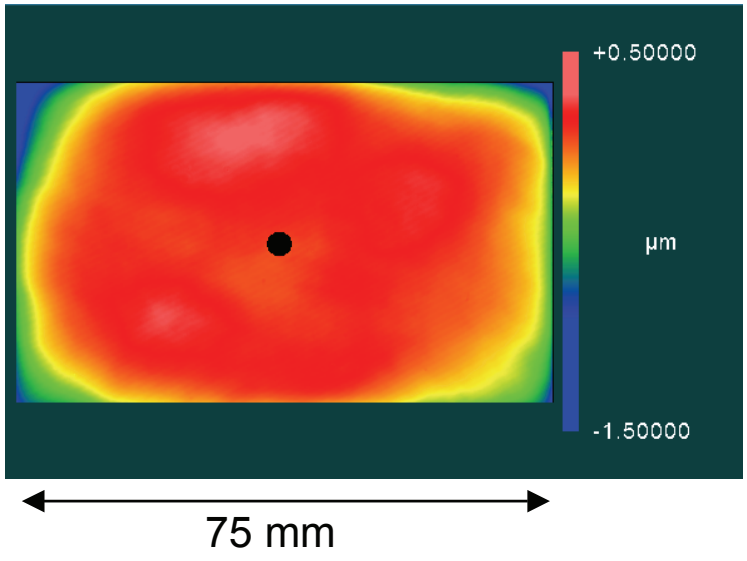
→ A degree of deformation for 300 W is usable as a criterion for determining the acceptability.

Preliminary test

Change of crystal surface

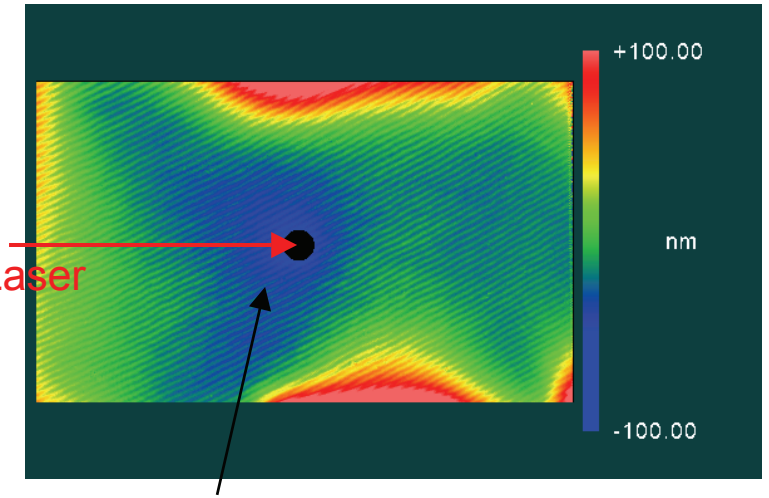
Radiation of 300 W laser

Original image



75 mm

Differential image

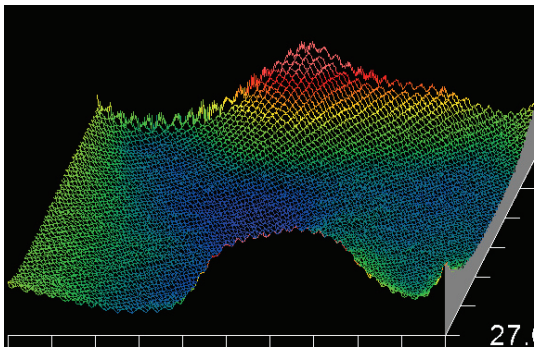


Negative thermal expansion

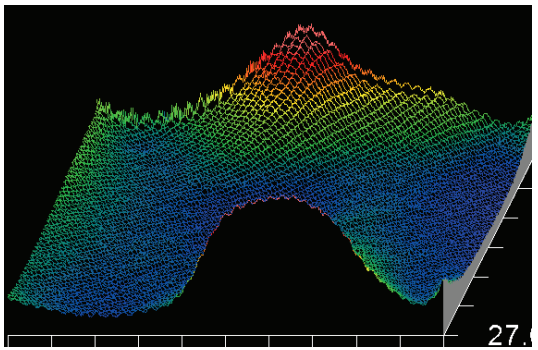
The deformation is detectable with the Fizeau interferometer.

Higher heat load

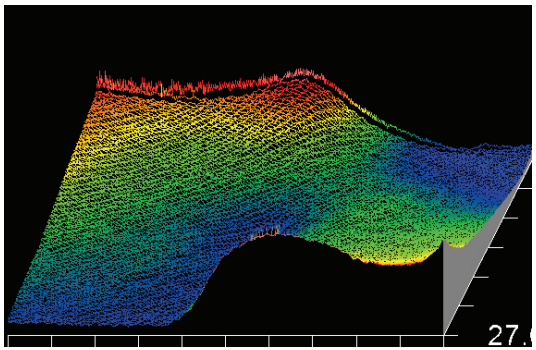
300 W



500 W

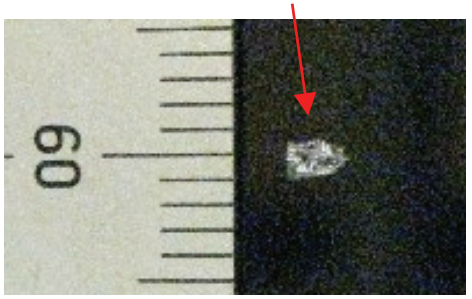


1000 W



Larger deformation

Twist & damage



Next step : design of LN2 paths in crystal for high efficient heat exchange

Acknowledgement

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