13-14 May 2014 Double Crystal Monochromator Workshop @ESRF ,H. Ohashi (SPring-8)

Overview of double crystal monochromators at SPring-8 / SACLA

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JASRI / RIKEN
SPring-8

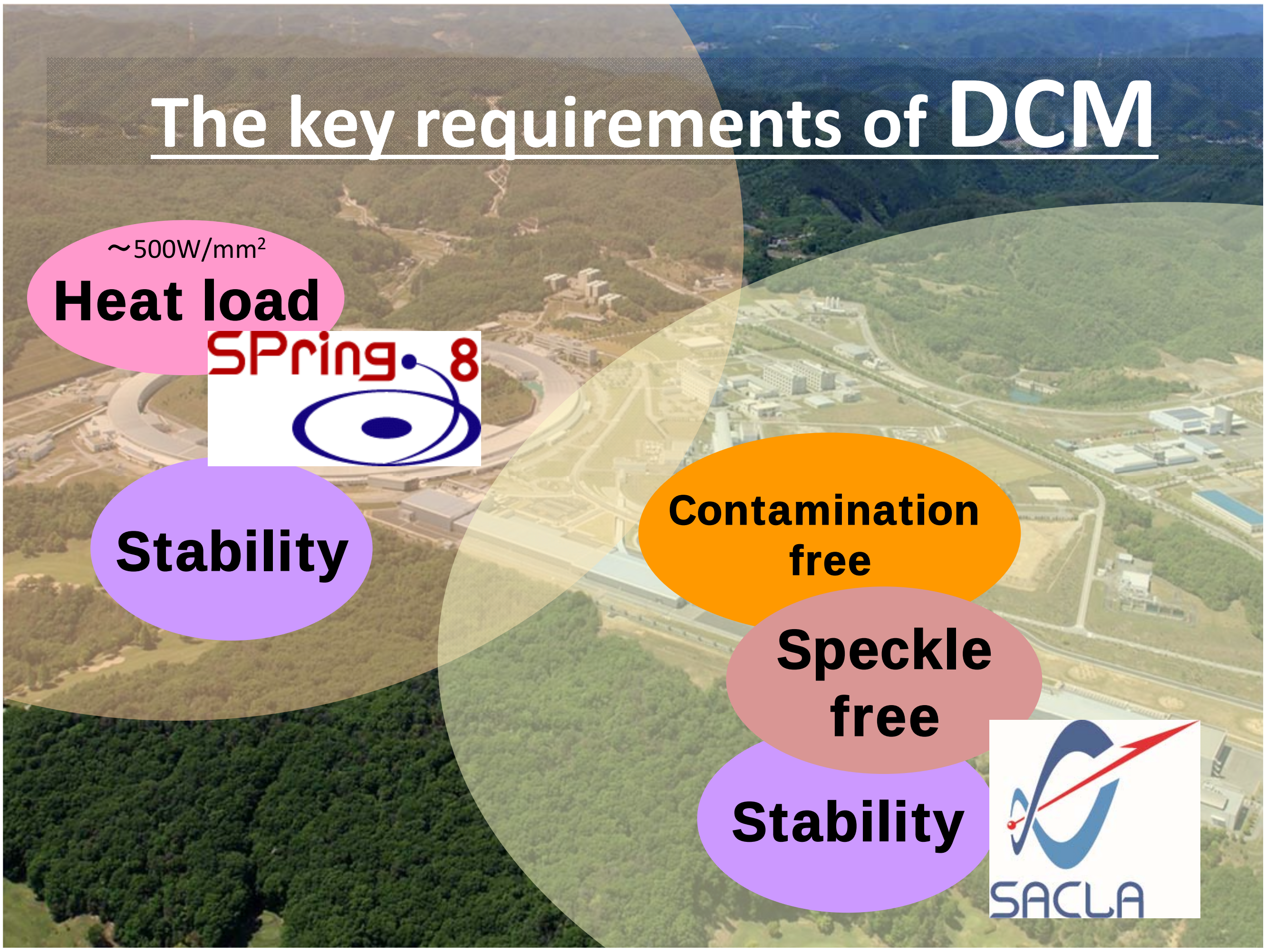
The significant properties of x-rays

	SACLA	vs SPring-8
Transverse coherence	100%	$\times 10^4$
Photons / pulse	5×10^{11}	$\times 10^6$
Pulse length	10 fs	$\times 0.001$
Peak power	29 GW	$\times 10^9$
Repetition rate	60 Hz	$\times 10^{-7}$
Average power	<1 W	$\times \frac{1}{500}$

SPring-8:
- ～500W/mm^2 **Heat load**
- **High repetition rate**

SACLA:
- **Pulsed nature**
- **Coherence**
- **Shot-to-shot fluctuation**

These properties impose DCM on the requirements.



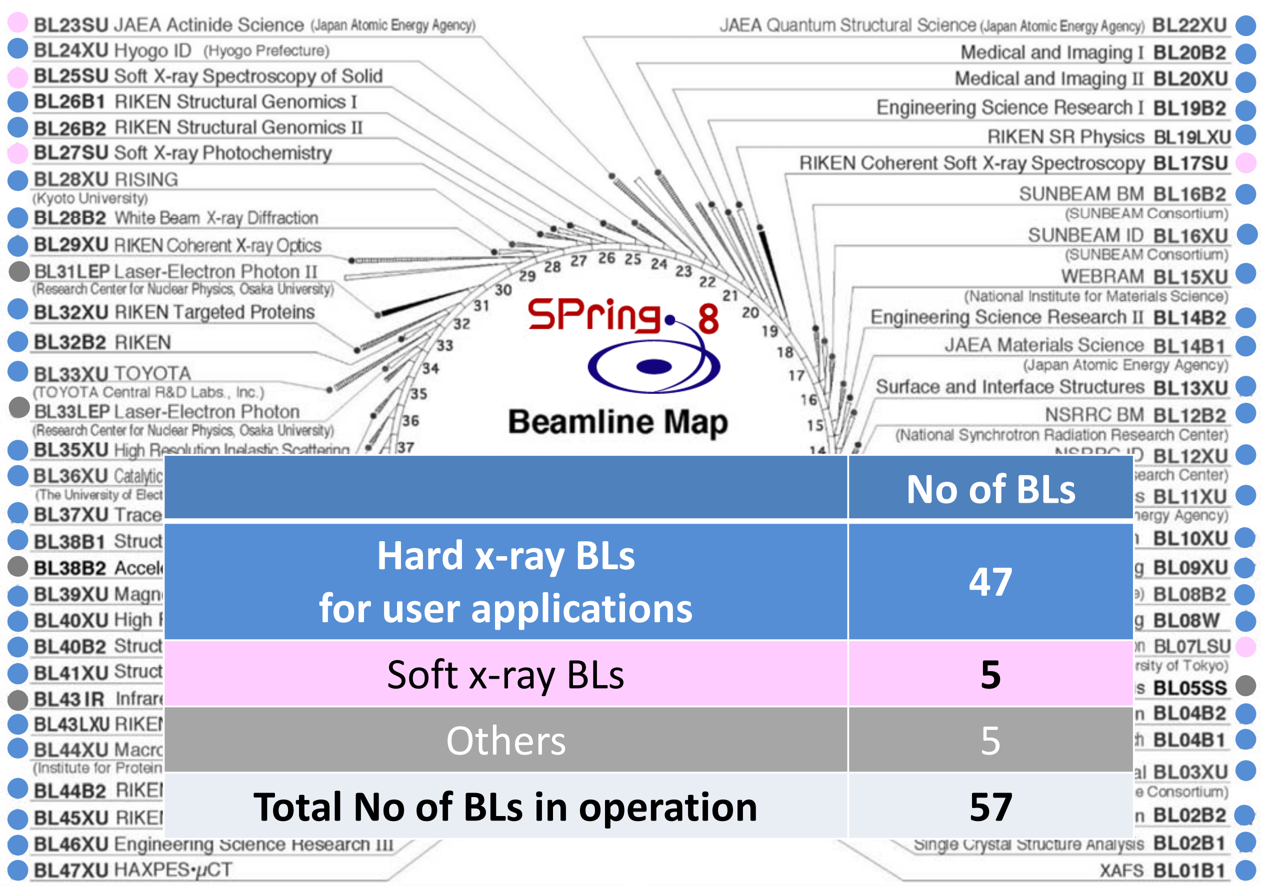
Contents

1. DCM at SPring-8
   - ✓ X-ray monochromators at SPring-8
   - ✓ Cooling of crystals for standard ID BLs at SPring-8
   - ✓ Stability improvement on SPring-8 Standard DCM
2. DCM at SACLA
3. Challenges on DCM for the next generation light source

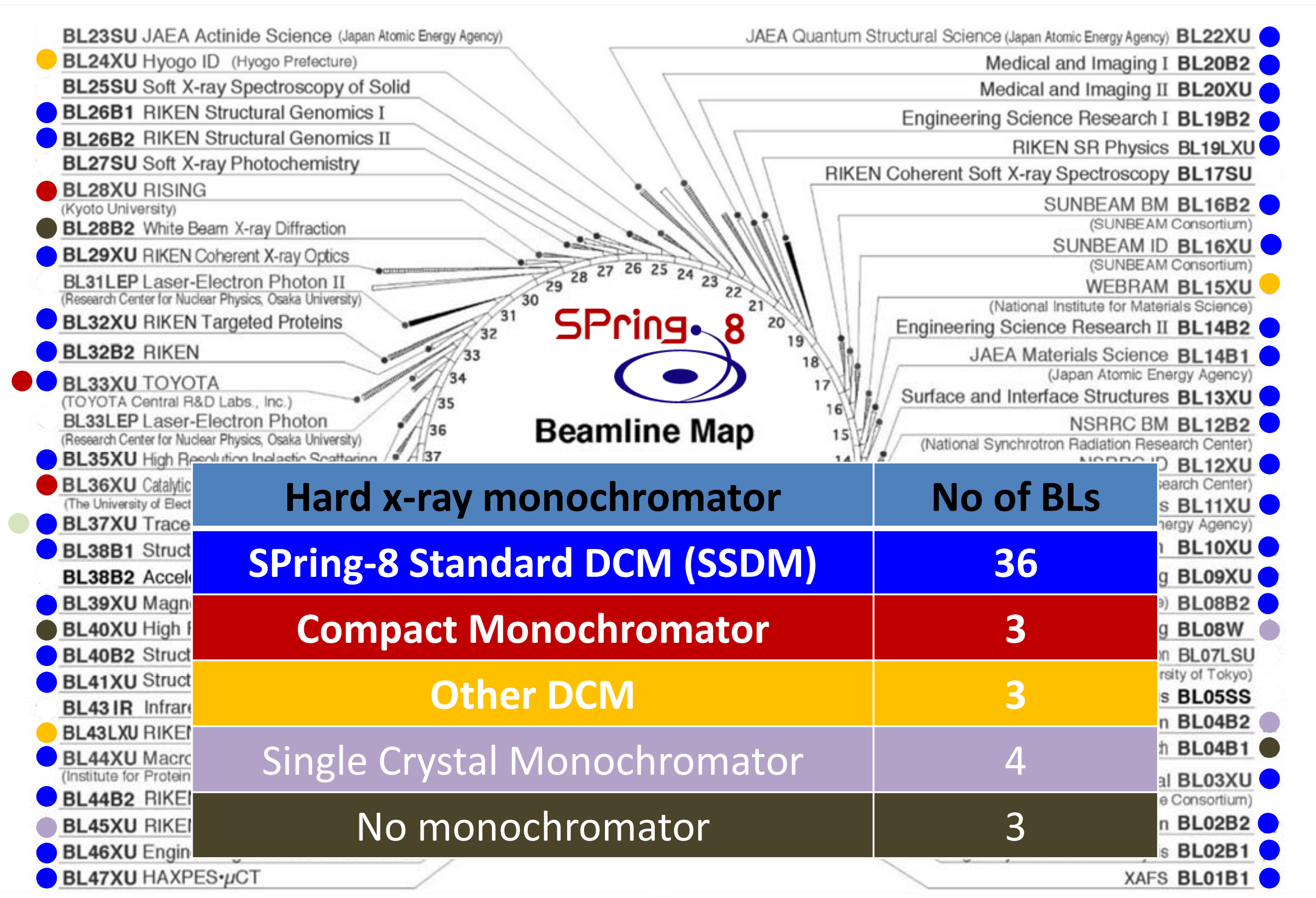
Collaborators

H. Yamazaki, Y. Senba, H. Yumoto, T. Koyama, T. Takeuchi, H. Kishimoto, T. Miura, Y. Matsuzaki, M. Tanaka, Y. Shimizu S. Goto, M. Yabashi and T. Ishikawa

(JASRI/RIKEN SPring-8)

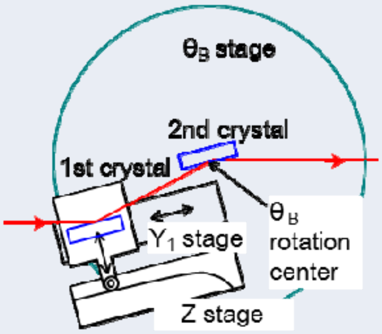
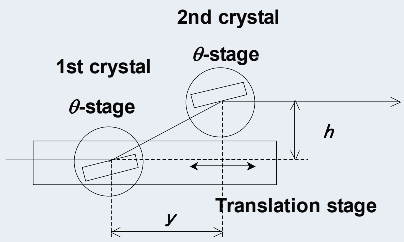
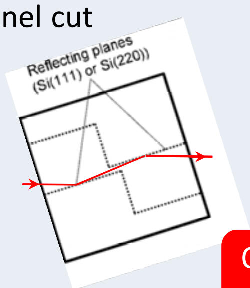
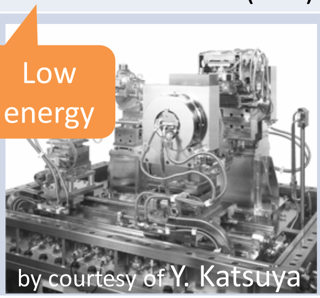
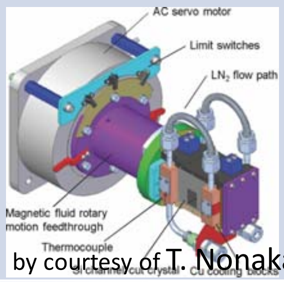


	No of BLs
Hard x-ray BLs for user applications	47
Soft x-ray BLs	5
Others	5
Total No of BLs in operation	57



Hard x-ray monochromator	No of BLs
SPring-8 Standard DCM (SSDM)	36
Compact Monochromator	3
Other DCM	3
Single Crystal Monochromator	4
No monochromator	3

X-ray monochromators at SPring-8

SPring-8 Standard DCM	Wider range DCM	Compact Monochromator
θ_B + 2 translation	θ_1 + translation + θ_2	θ_B
		Channel cut  Quick scan
Offset h = 30mm, θ_B = 3～27°	Offset h = 100mm, θ_B = 5.7～72°	Offset h = 3mm, θ_B = 4～40° (～40°/sec)
4.4～36 keV Si(111)	2.2～20 keV Si(111)	4～28 keV Si(111)
 36BLs	Low energy  2 BLs by courtesy of Y. Katsuya	 3 BLs by courtesy of T. Nonaka

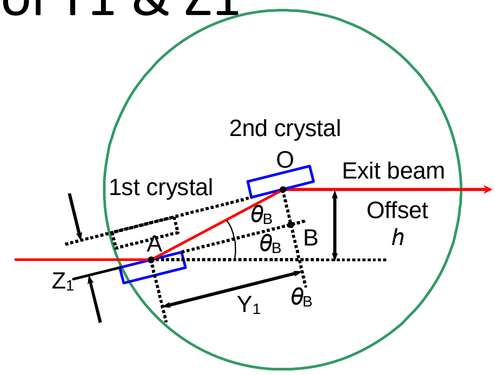
SPring-8 Standard DCM (SSDM)

a rotation (θ_B) + two translation (Y_1 + Z_1)

- ✓ The center of rotation (θ_B) on 2nd crystal
  - *2nd crystal NOT translated* → *NO pitch errors*
- ✓ Translation of 1st crystal on the ***θ_B stage***
  - *Slight rotation of 1st crystal* → *Energy defined by θ_B*
- ✓ Fixed exit beam → control Y1 & Z1

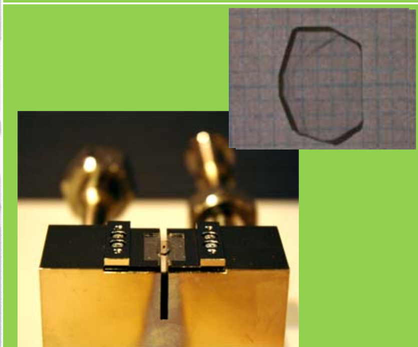
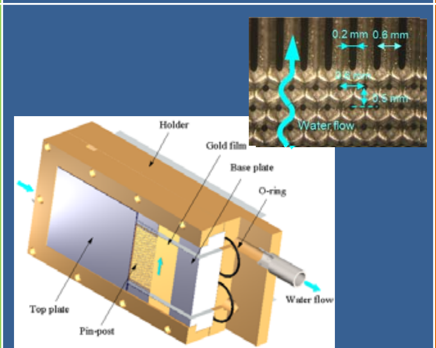
$$Y_1 = \mathrm{AB} = \frac{h}{2\sin\theta_B} \quad Z_1 = \mathrm{OB} = \frac{h}{2\cos\theta_B}$$

CAM mechanics type
Numerical control type



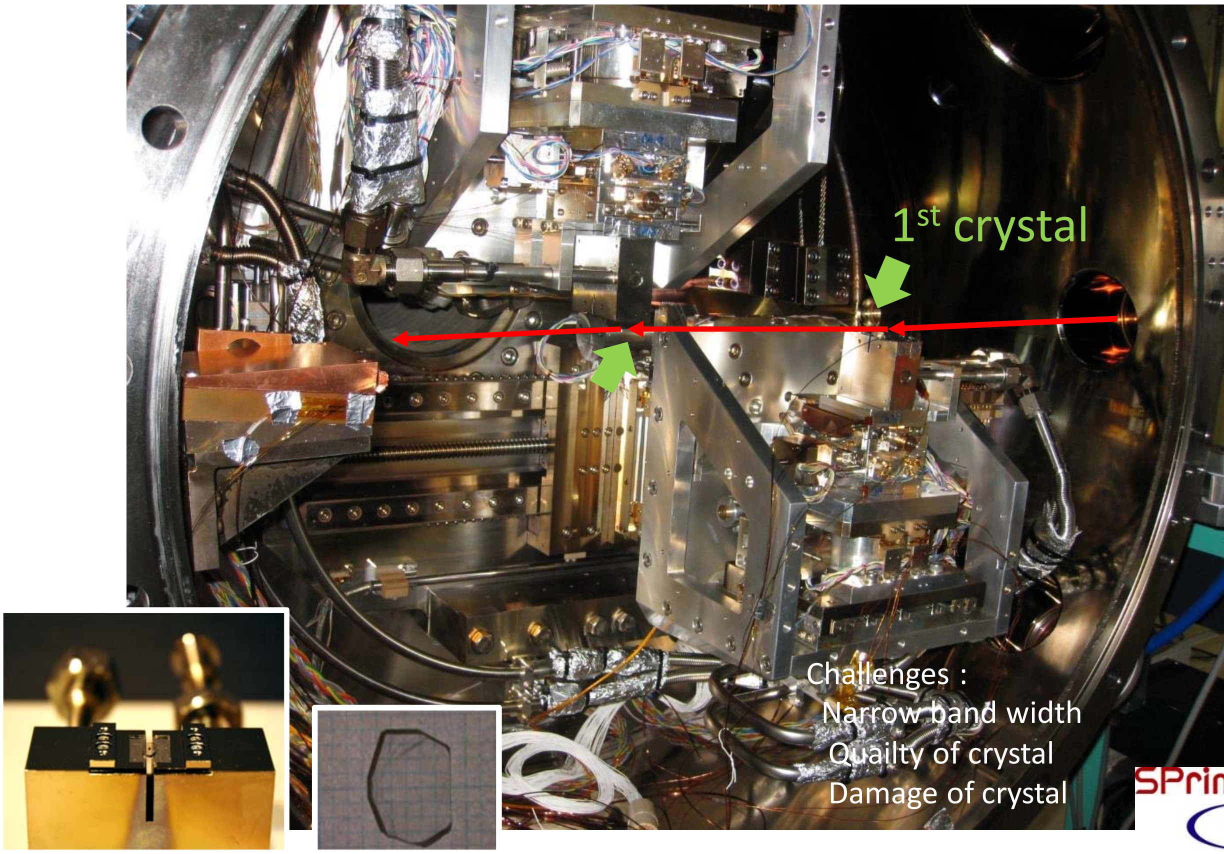
→ Yamazaki 

Cooling system of crystals for std-ID BLs

Diamond	Pin-post Si	Si
***Indirect water** cooling*	***Direct water** cooling*	***Indirect LN2** cooling*
Symmetry reflection	Rotated inclined	Symmetry reflection
		
~ 300 W	~ 300 W	~ 500 W

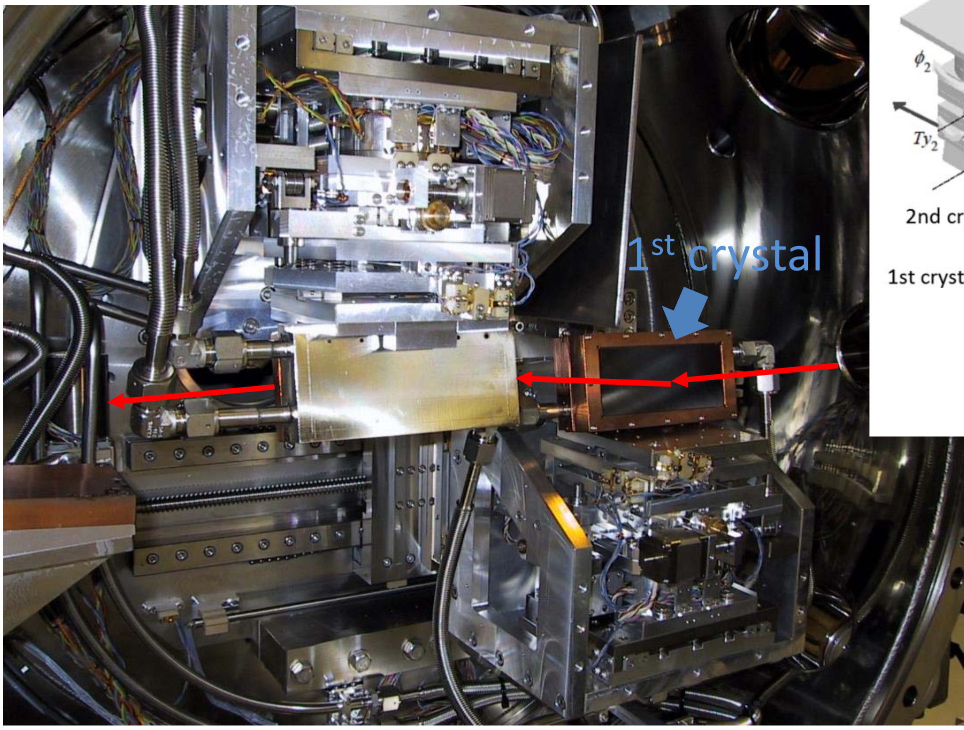
These cooling system can be installed in SSDM.

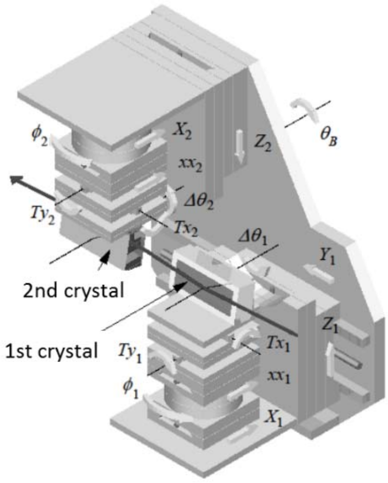
Diamond (direct water cooling)



Challenges :
- Narrow band width
- Quailty of crystal
- Damage of crystal

Pin-post Si (direct water cooling)

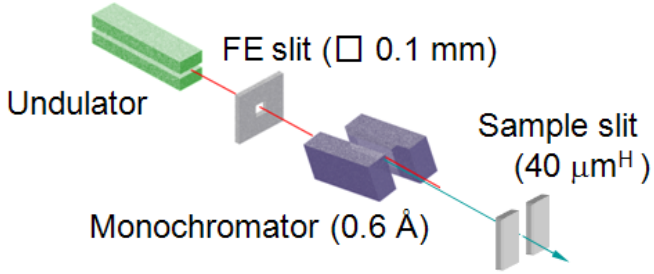




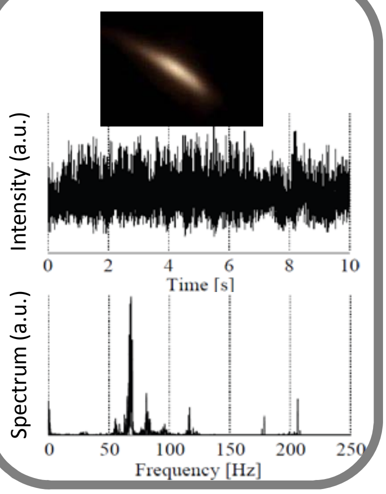
16 axes

Challenges :
- Not easy alignment
- Availability of pin-post Si
- Damage of crystal

Pin-post Si (direct water cooling)

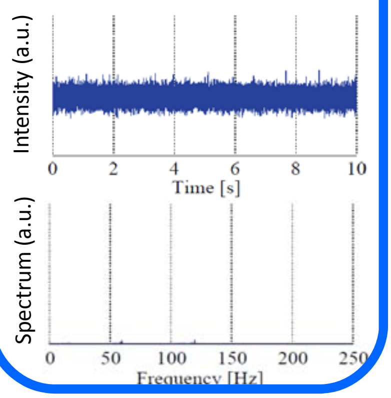


Early type

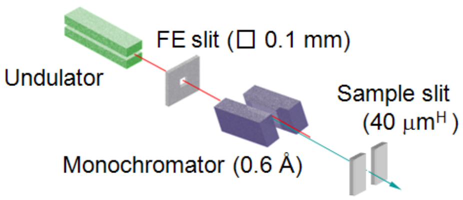


Background

Chiller and vac. pumps are temporarily turned off.



Pin-post Si (direct water cooling)

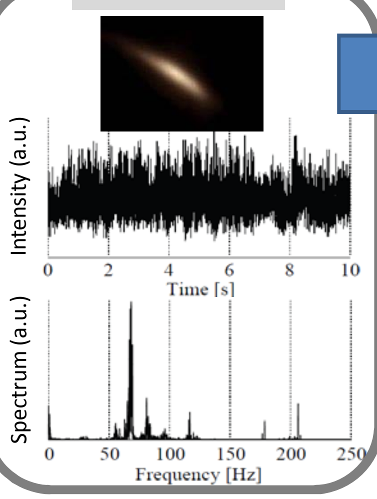


To stabilize x-rays :

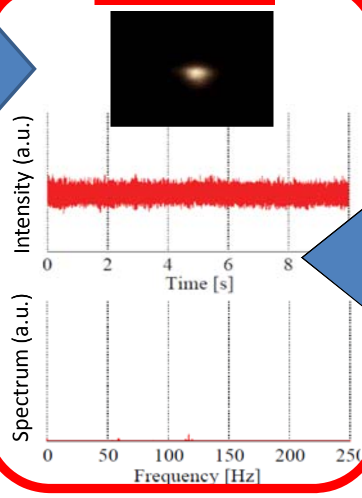
- ✓ accumulators to reduce pulsation from chiller
- ✓ polyurethane tubes to smooth water flow
- ✓ radiation shield to stabilize temperature of stages

…

Before



After



Background

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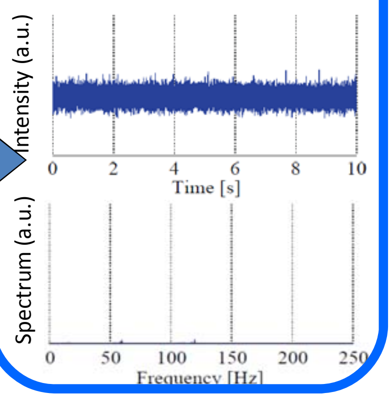
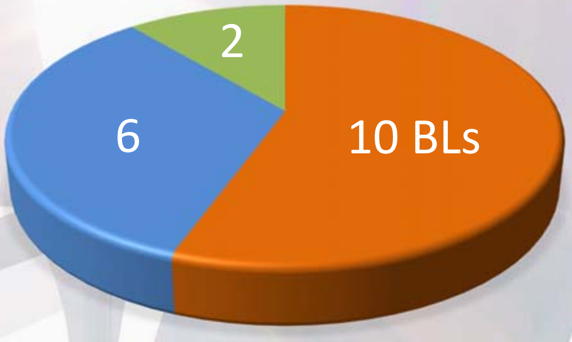


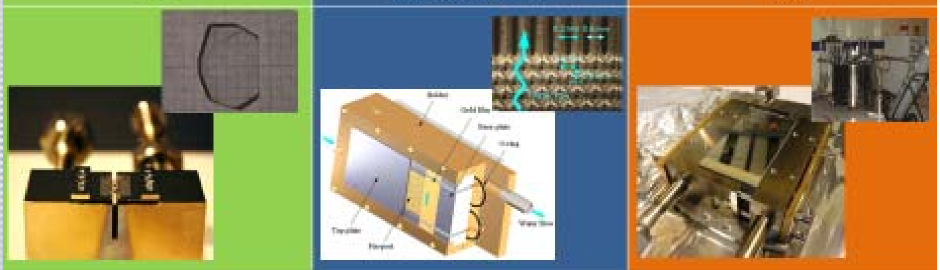
Cooling system of DCM on std-ID BLs



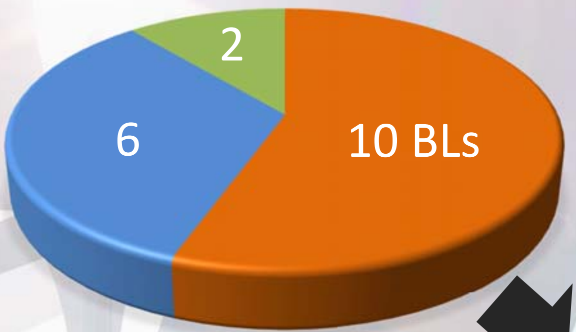
Indirect Water Diamond
Direct Water Si(pin-post)
Indirect LN2 Si

2005

Diamond	Pin-post Si	Si
Indirect water cooling	*Direct water cooling*	*Indirect LN2 cooling*
flat	Rotated inclined	flat
~ 300 W	~ 300 W	~ 500 W



Cooling system of DCM on std-ID BLs



Indirect Water Diamond
Direct Water Si(pin-post)
Indirect LN2 Si

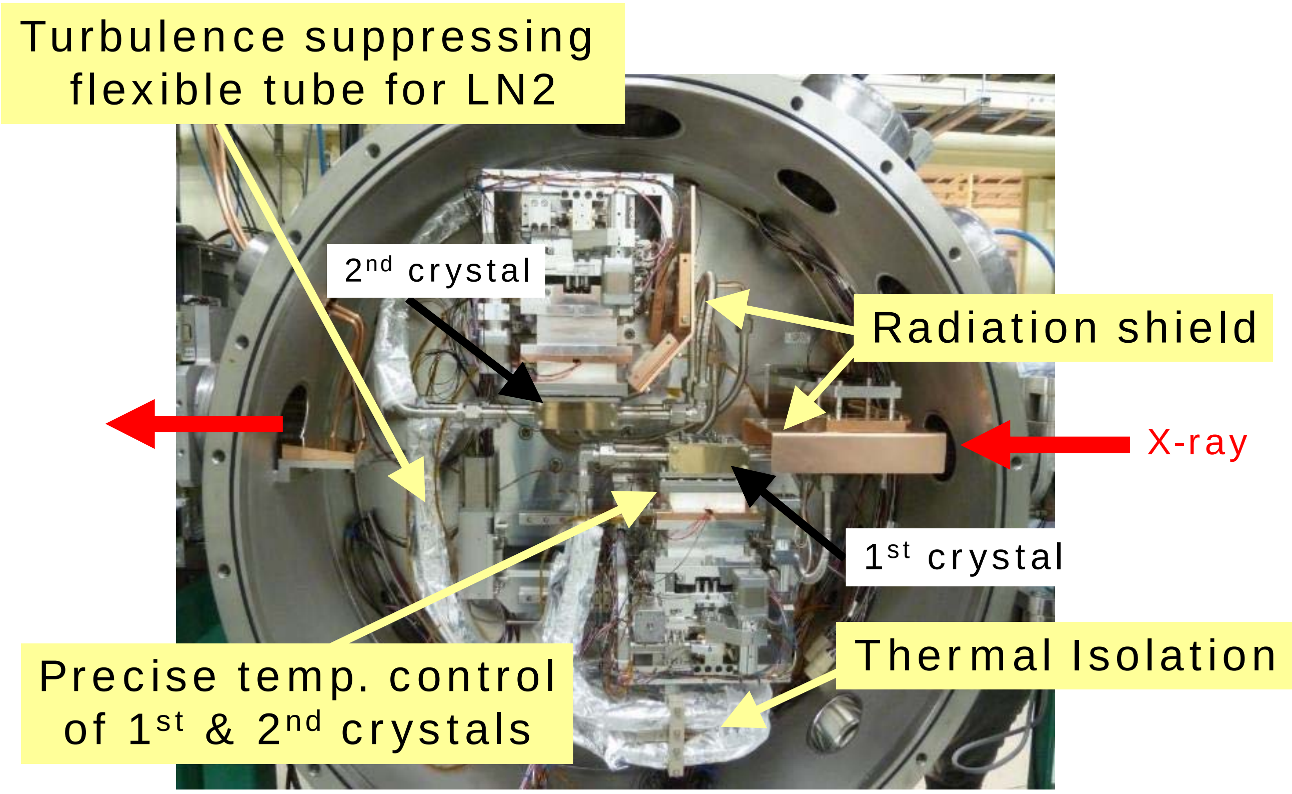
2005

The bonding technique has been maintained at another company in Japan.

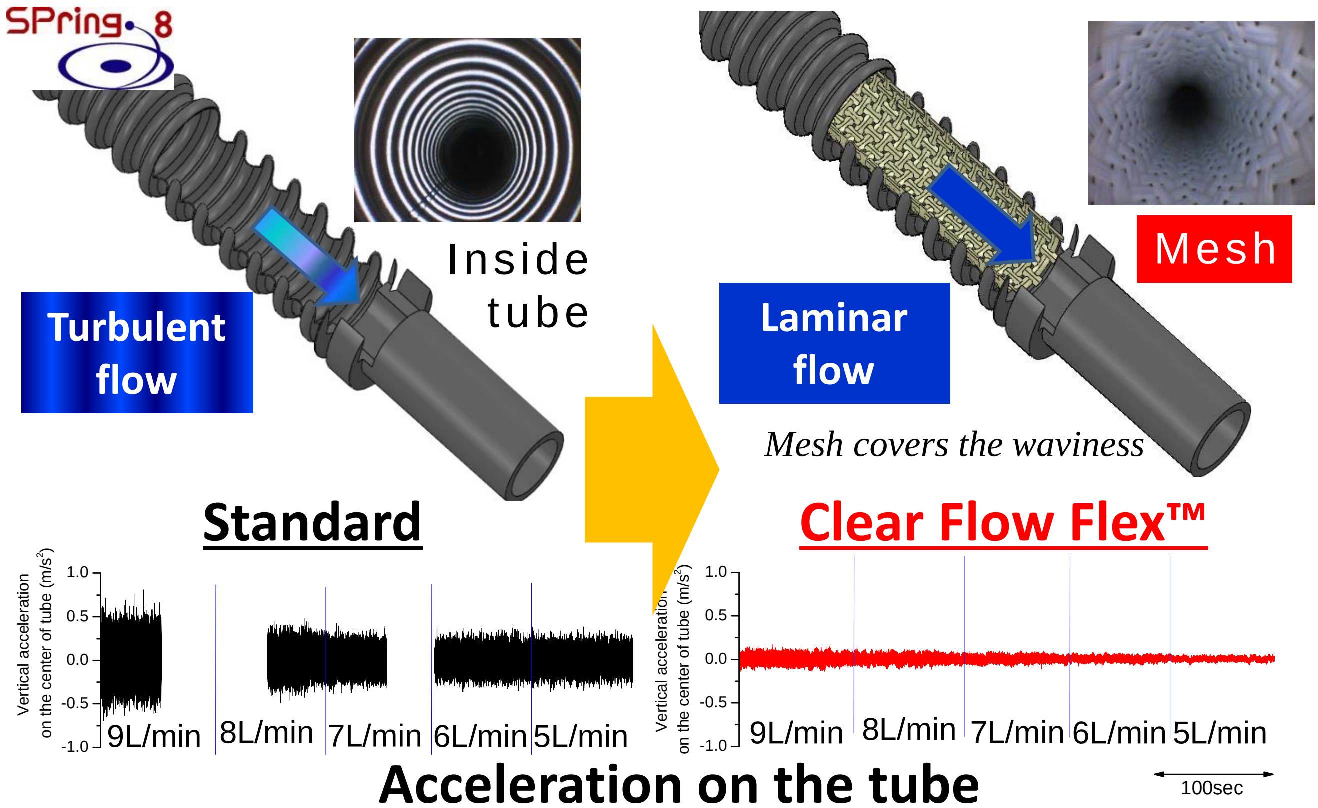
SSDM 20
Others 4

2014

New Stable SSDM with LN2 cooling for std-ID BLs



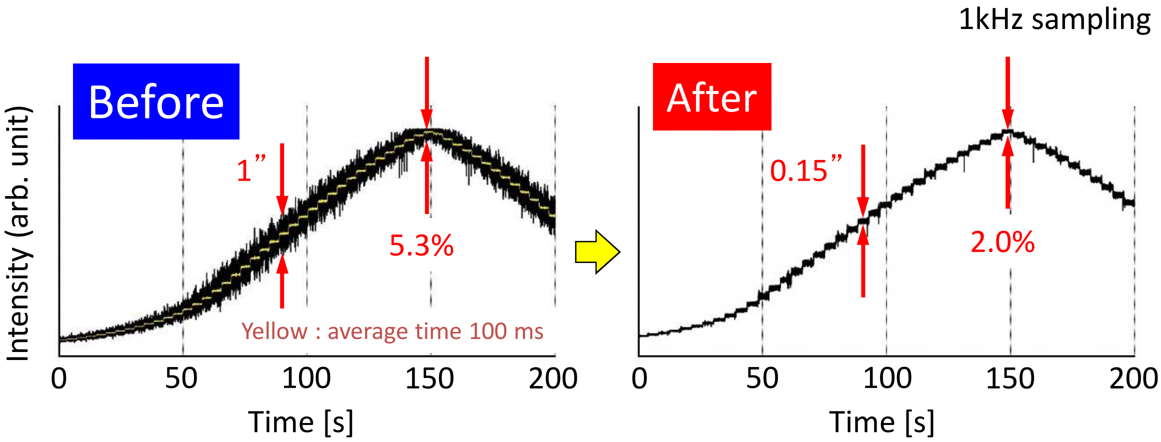
Turbulent suppressing flexibule tube "Clear Flow Flex"



The vibration is reduced for all flow rate.

Clear Flow Flex : patent-pending RIKEN, JASRI, ORK

New stable SSDM with LN2 cooling for std-ID BLs



After upgrading LN2-DCM

Angular fluctuation between the crystals : 1" → 0.15"

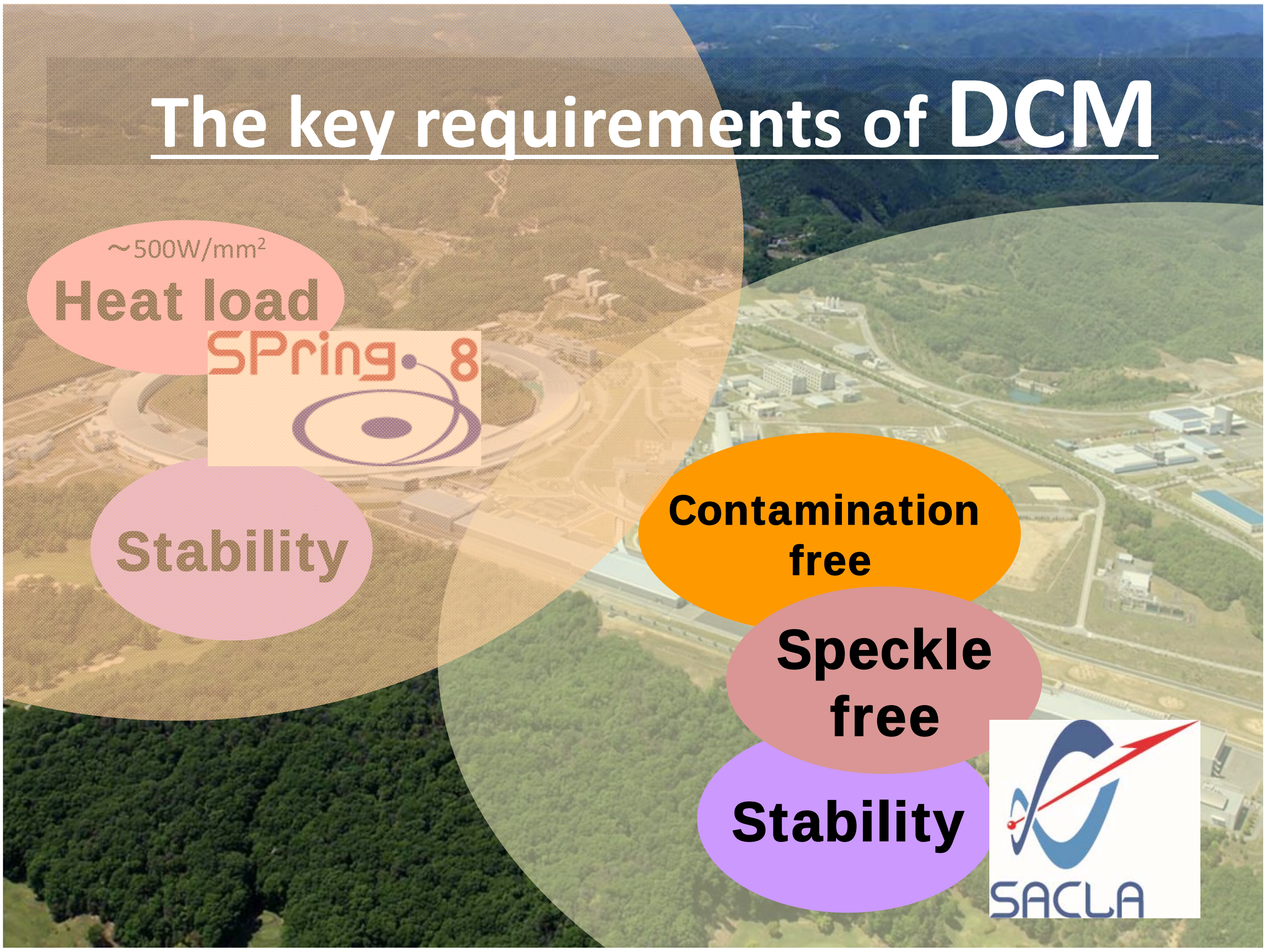
Intensity fluctuation of 1 Å x-rays : 5% → 2%

Upgrade of SSDM with LN2 to provide stable x-rays

- ✓2010 BL37XU, 39XU
- ✓2011 BL13XU
- ✓2012 BL29XU-L, 41XU, 46XU, 32XU, 05SS
- ✓2013 BL09XU, 10XU, 19LXU, 44XU

Newly installed KB mirror, newly installed LN2 system

13 SSDMs have been upgraded by 2013FY.



DCM for SACLA : Conceptual design

Contamination-free condition & High stability

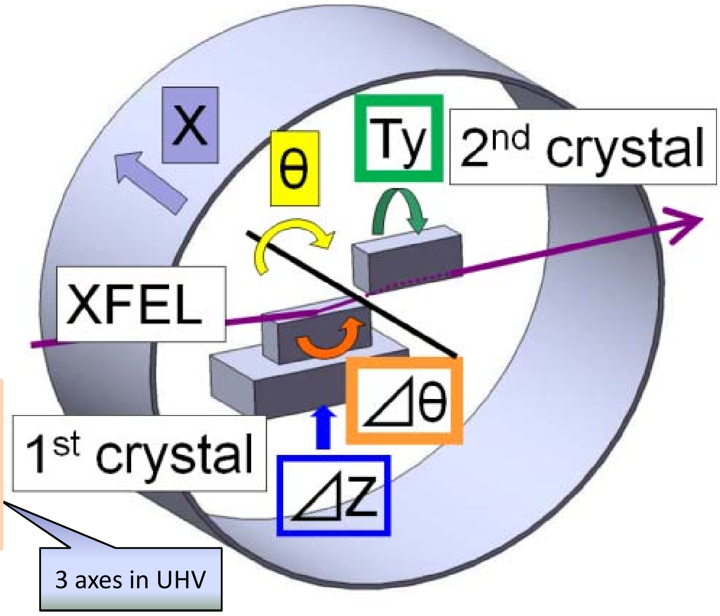
→ **UHV & Limited No. of axes and range**

Optical design

Use of large (90mm) Si

with small offset (20mm)

Axis	Range	Resolution
θ	-1～30 [deg]	1 [μrad]
X	60 [mm]	0.1 [mm]
⊿θ	±0.5 [deg]	0.1 [μrad]
⊿Z	±1 [mm]	10 [μm]
Ty	±0.5 [deg]	1 [μrad]

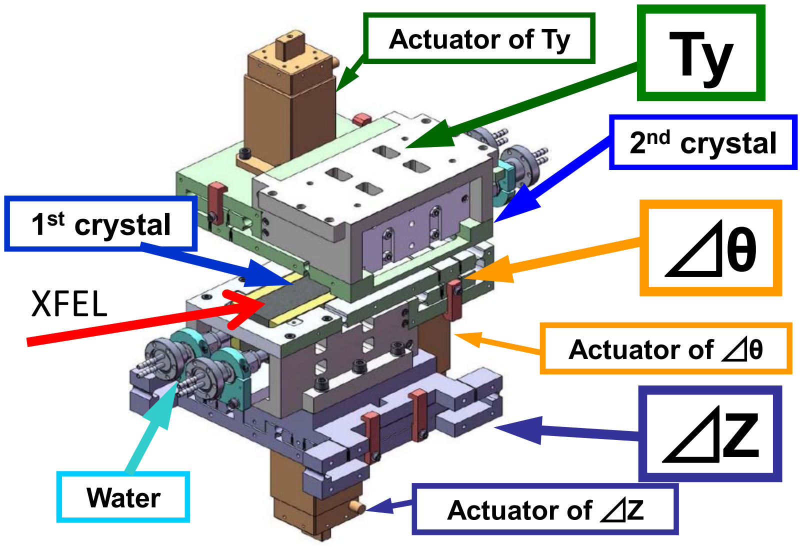


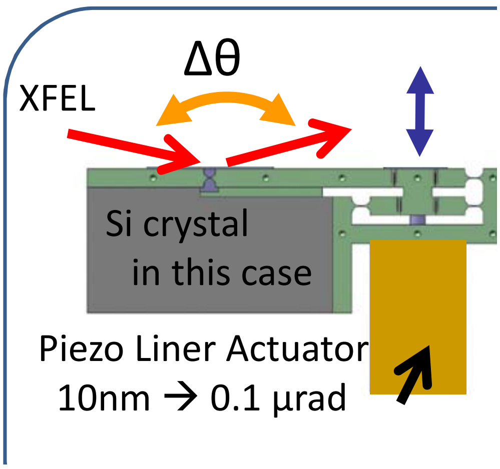
DCM for SACLA : Axes in vacuum

Contamination-free condition & High stability

→ **UHV & Limited No. of axes and range**

New design of stages using flexure hinges





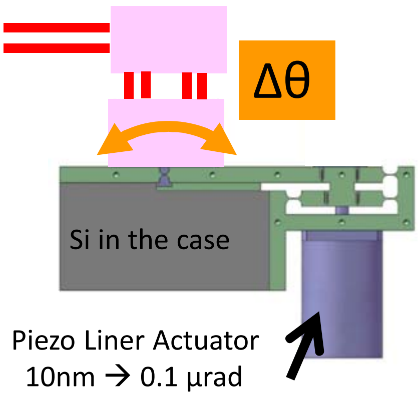
DCM for SACLA : performance test of Δθ

Requirements of Δθ

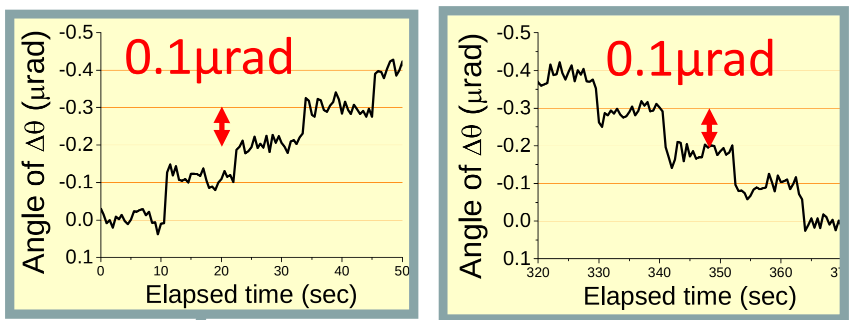
» Resolution 0.1 μrad
» Range ±0.5 deg
» Stability <0.1 μrad / 0.5 hr

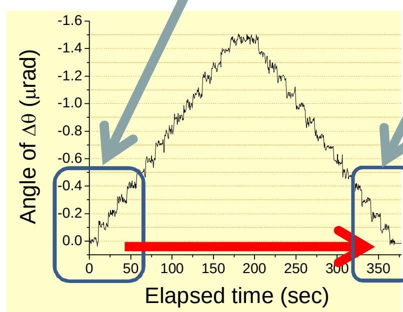
Measurement

» Laser interferometer
Renishaw plc (XL-80)

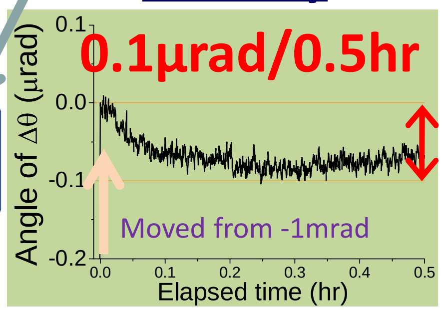


Resolution



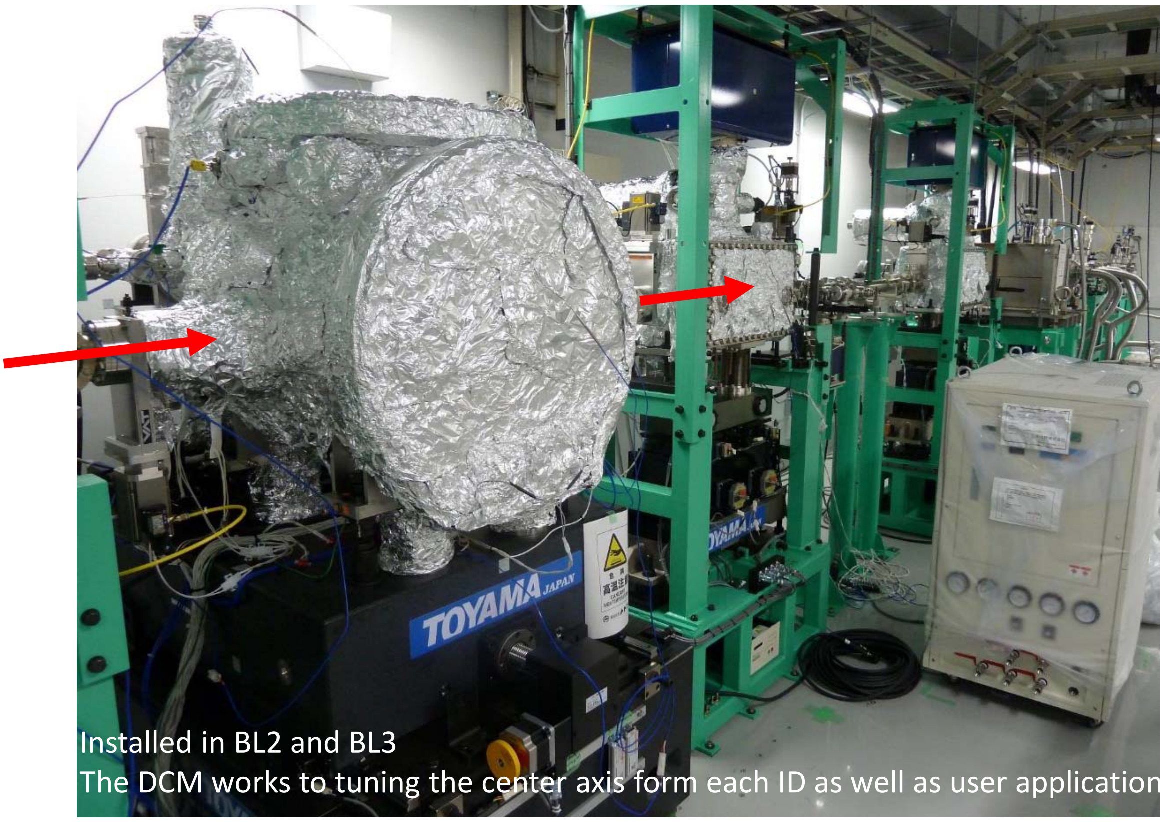


Stability



High precise and high stabe stage

Standard DCM of SACLA



Installed in BL2 and BL3
The DCM works to tuning the center axis form each ID as well as user application

Towards NGLS

Mirror manipulator

Monochromator,
Environment

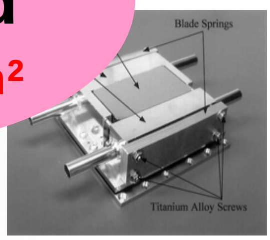
Stability
~10 nrad

BL optics for NGLS

Mirror, Window,
Crystal

Coherence
speckle free
Contamination free

Heat load
~500W/mm^2



SPring-8

Acknowledgement

Fabienne Mengoni, Raymond Barrett
and organizing committee