Current Status of Development of XFEL Optics in Japan

Makina Yabashi

SCSS/SPring-8/JASRI/RIKEN

2nd meeting on Future XFEL optics:
"Damage threshold of Mirrors and Multilayers"
@ Prague, Nov. 23, 2006

Collaborators

Diamond crystal: K. Tamasaku, Y. Shimizu, H. Sumiya (Sumitomo Electric Industry)

Beryllium window: S. Goto

X-ray Mirror: K. Yamauchi, H. Mimura, S. Matsuyama, H. Yumoto, ... (Osaka Univ.)

& SCSS team

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1. XFEL project at Japan
2. Dose estimation
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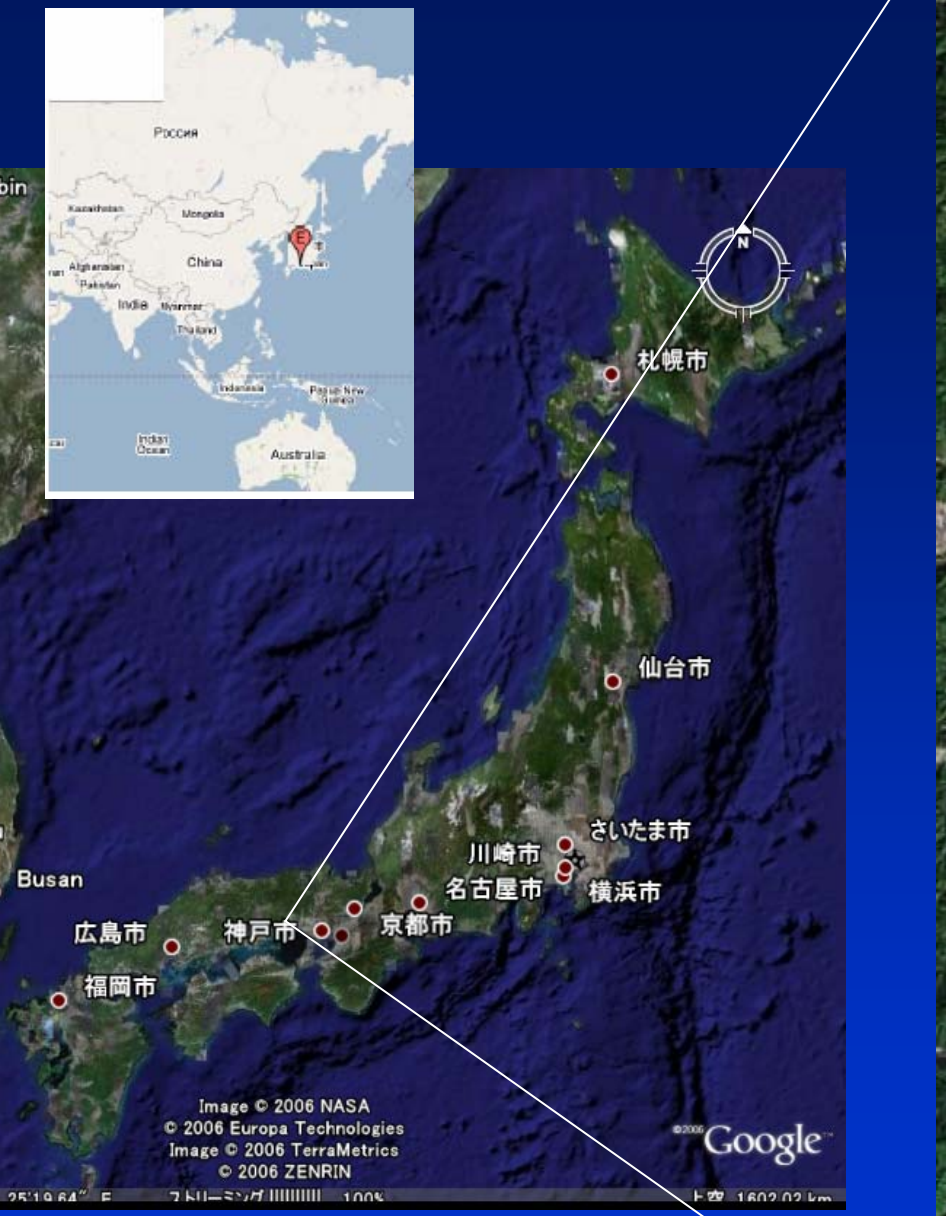
Россия
Kazakhstan
Mongolia
China
Afghanistan
Pakistan
India
Myanmar
Thailand
Indonesia
Papua New Guinea
Indian Ocean
Australia
札幌市
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さいたま市
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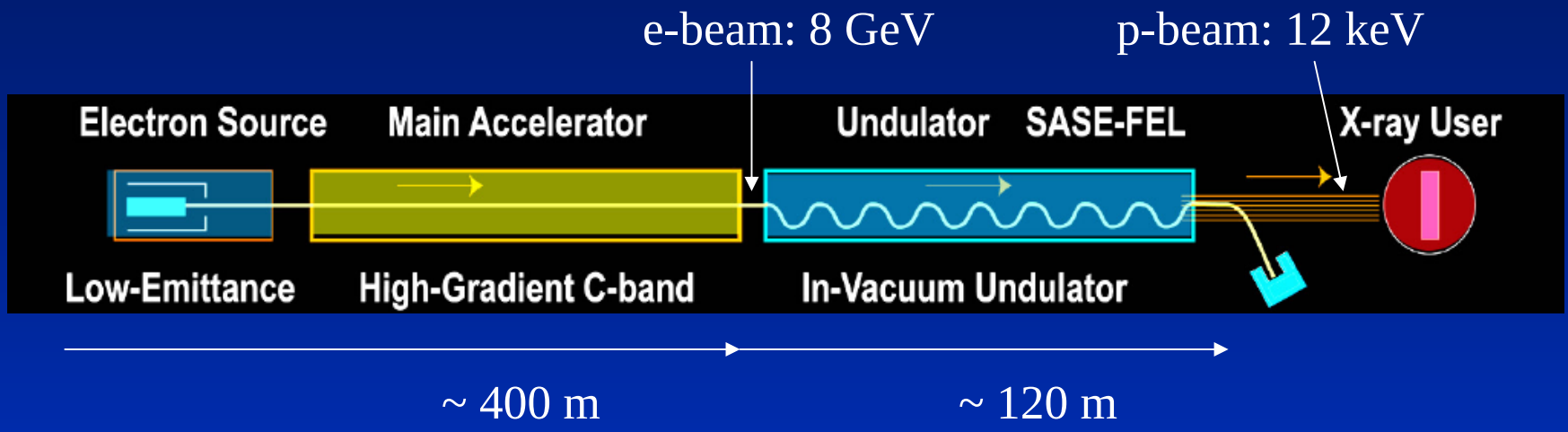
SPring-8
SPring-8 (1436 m)
since 1997
XFEL (700 m)
from ~2011

XFEL at Japan
(SCSS: SPring-8 Compact SASE Source)

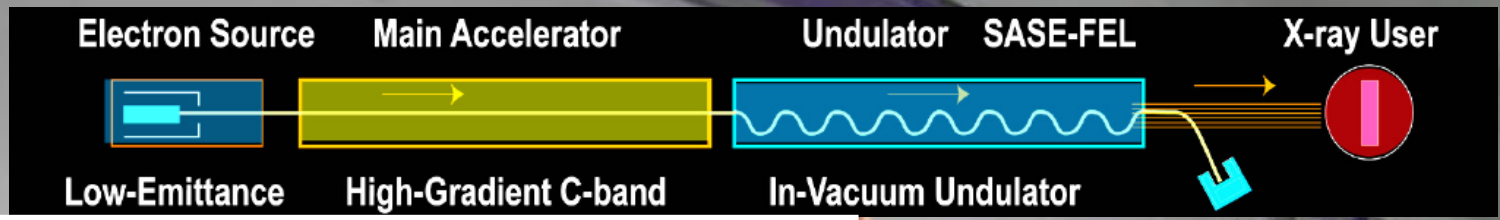


	e-gun	Main linac	Undulator
SCSS:	DC thermionic	Normal-conducting C-band	In-vacuum short period

Not RF-photocathode Not Superconducting Not out-of vacuum
Not L-band

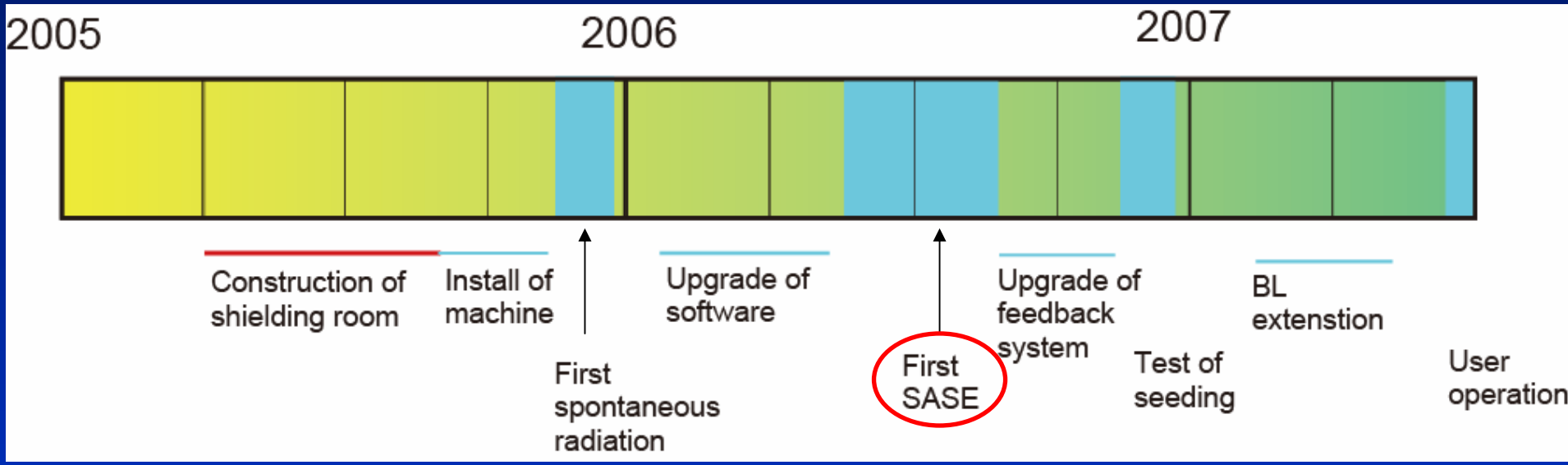
SPring-8

SCSS Prototype Accelerator (250 MeV, λ ~ 50 nm)
construction in 2005



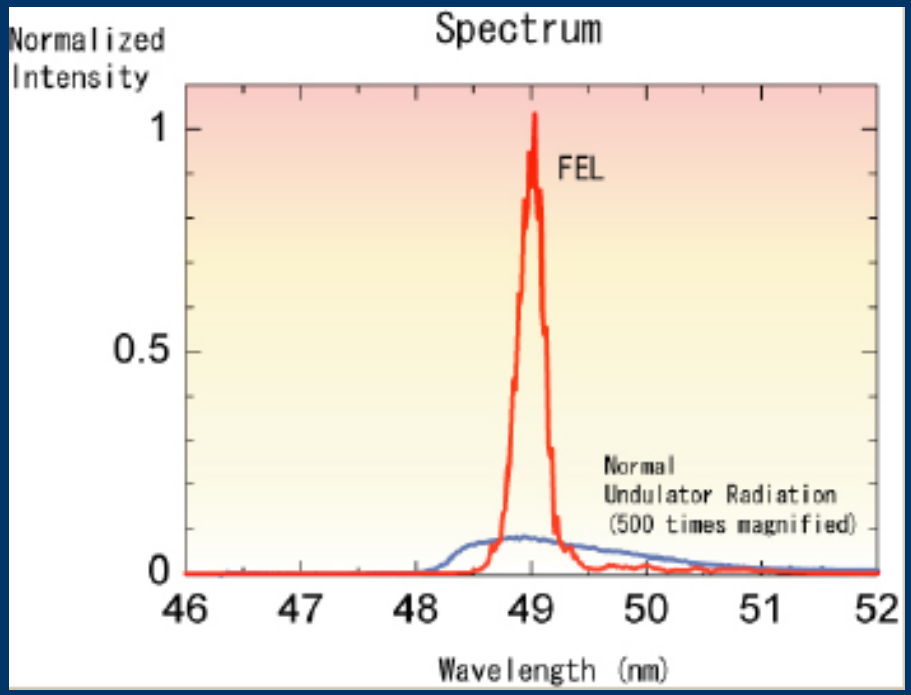
500 keV 50 MeV 250 MeV

Schedule summary

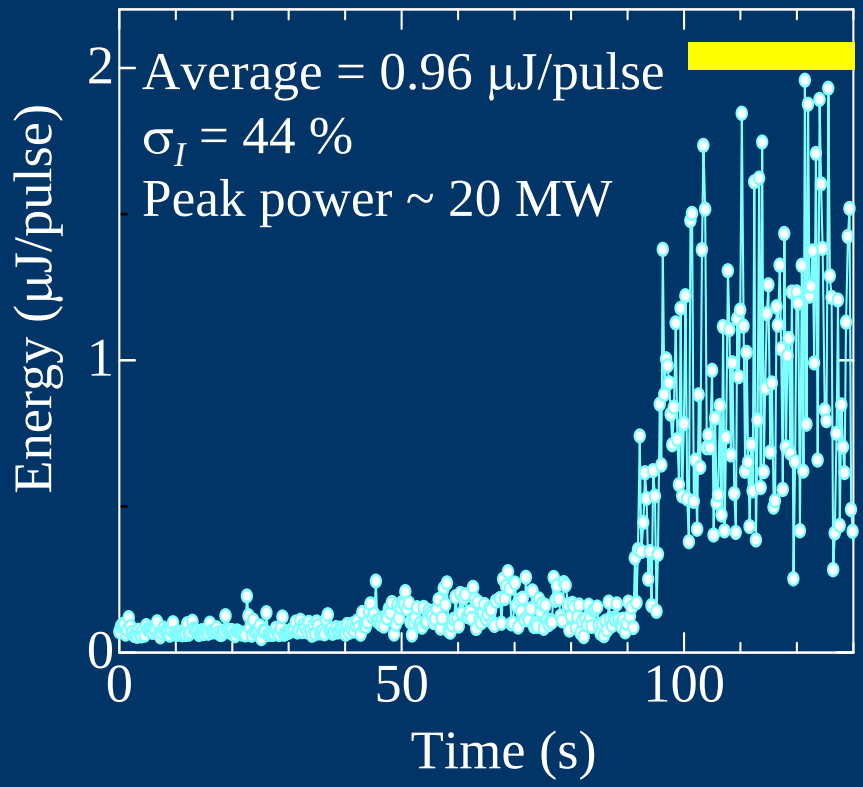


First Lasing (June, 2006)

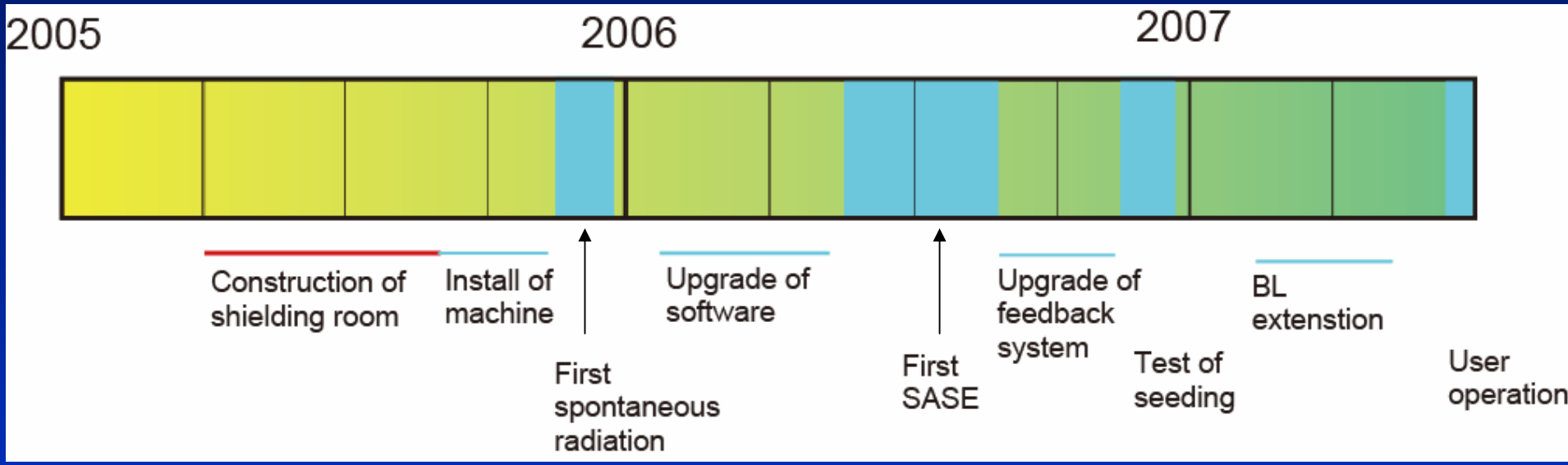
Energy Spectrum



Pulse Energy



Schedule summary



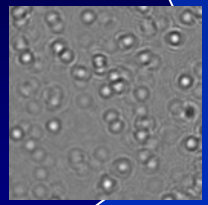
XFEL: construction of machine building

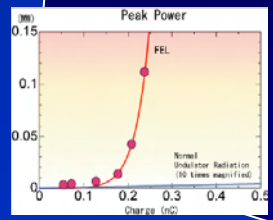
Photon Optics for XFEL

XFEL

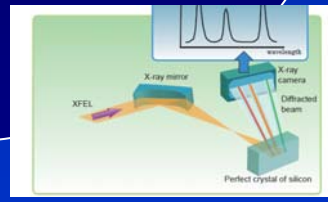
Dose
Spatial coherence

Photon Beam Conditioning





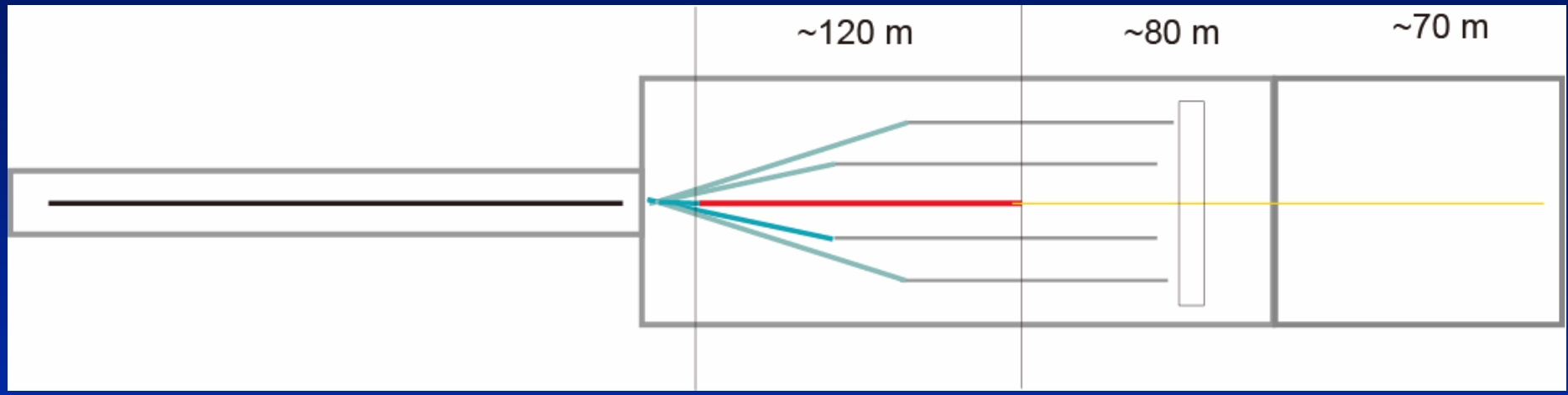
Photon Beam Diagnostics



3rd gen. SR

VUV FEL

Plan of 8 GeV machine

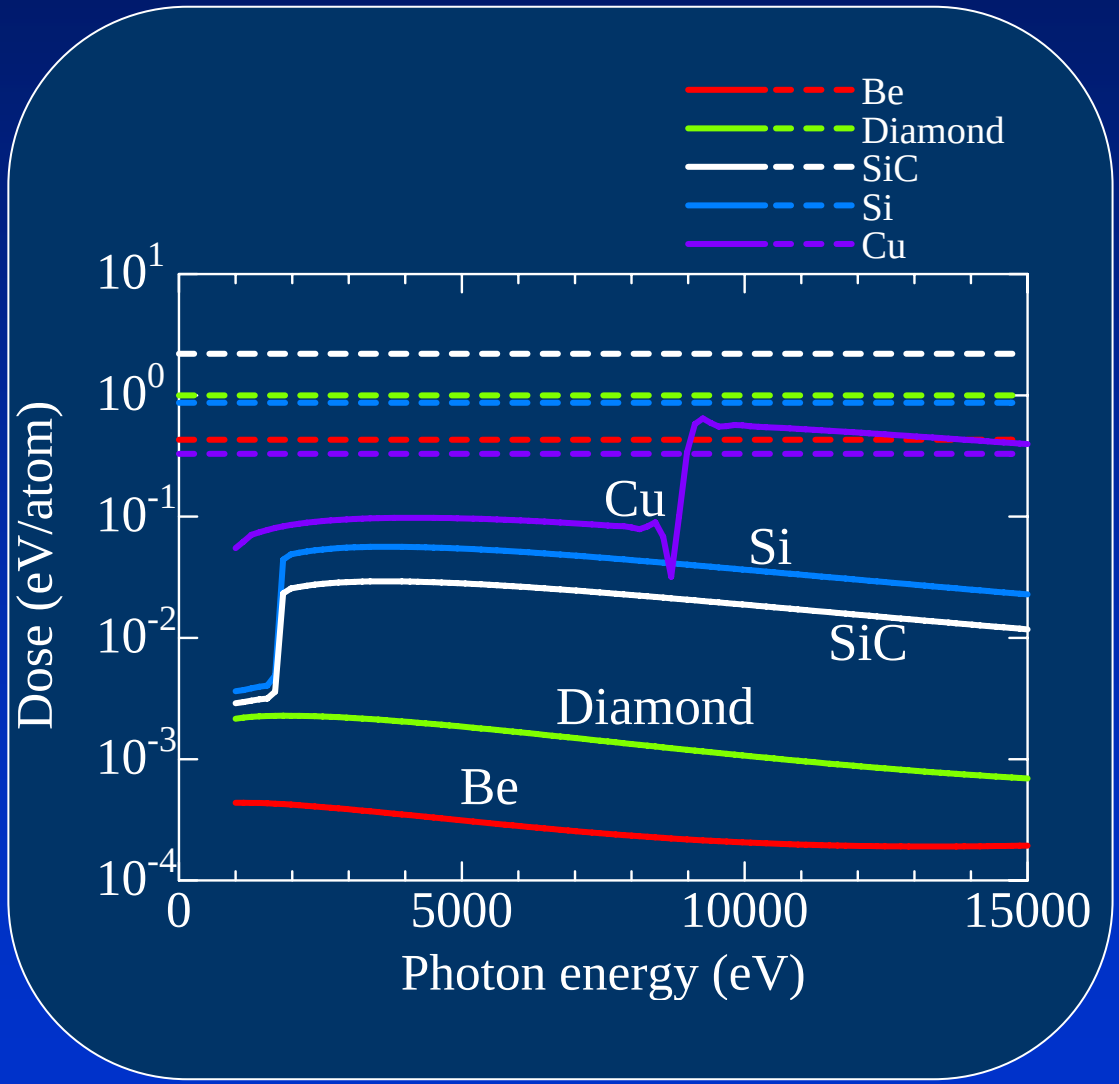


Accelerator tunnel Undulator tunnel Exp. hall

Repetition rate of 60 Hz: No need for considering thermal issue

Typical length from source: ~ 100 m

Dose for normal incidence

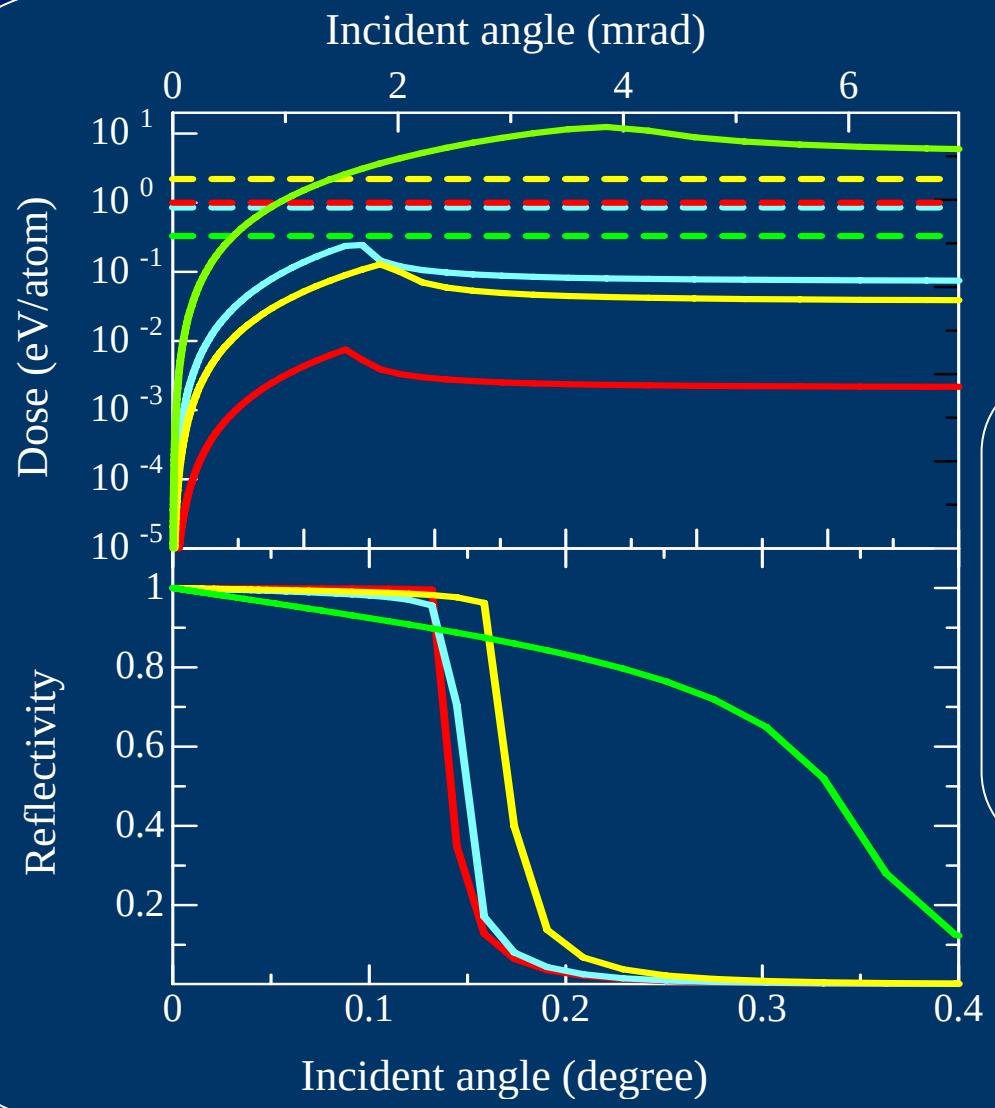


Parameters:

7.6e11 photons/pls
Source size: 50 um ϕ (STD)
Divergence: diffraction limited
e.g. 0.4 urad (STD)
@ E=12.4 keV
Distance: 100 m

Diamond, Be is OK
Si would be tolerable

Dose for grazing incidence



C
SiC
Si
Au

Parameters:

7.6e11 photons/pls

Source size: 50 um ϕ (STD)

Divergence: diffraction limited

e.g. 0.4 urad (STD)

@ *E*=12.4 keV

Distance: 100 m

C, SiC would be OK

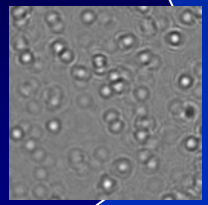
Si ??

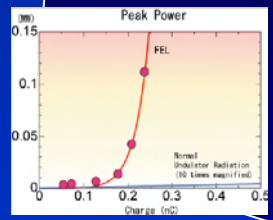
Photon Optics for XFEL

XFEL

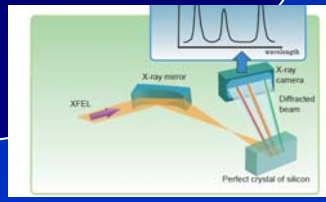
Dose
Spatial coherence

Photon Beam Conditioning





Photon Beam Diagnostics



3rd gen. SR

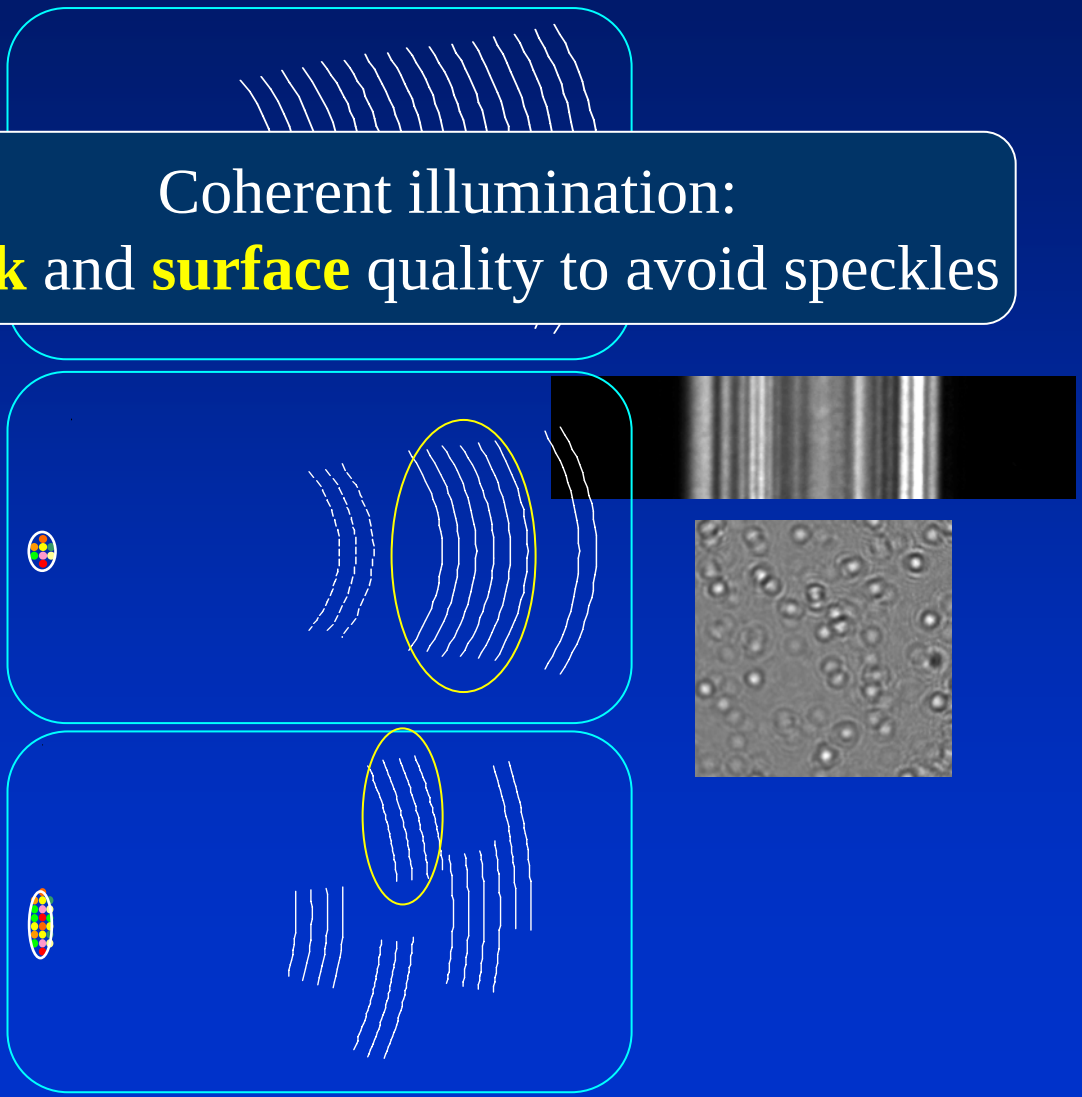
VUV FEL

Wave field

Coherent illumination:
Bulk and **surface** quality to avoid speckles

SASE-FEL

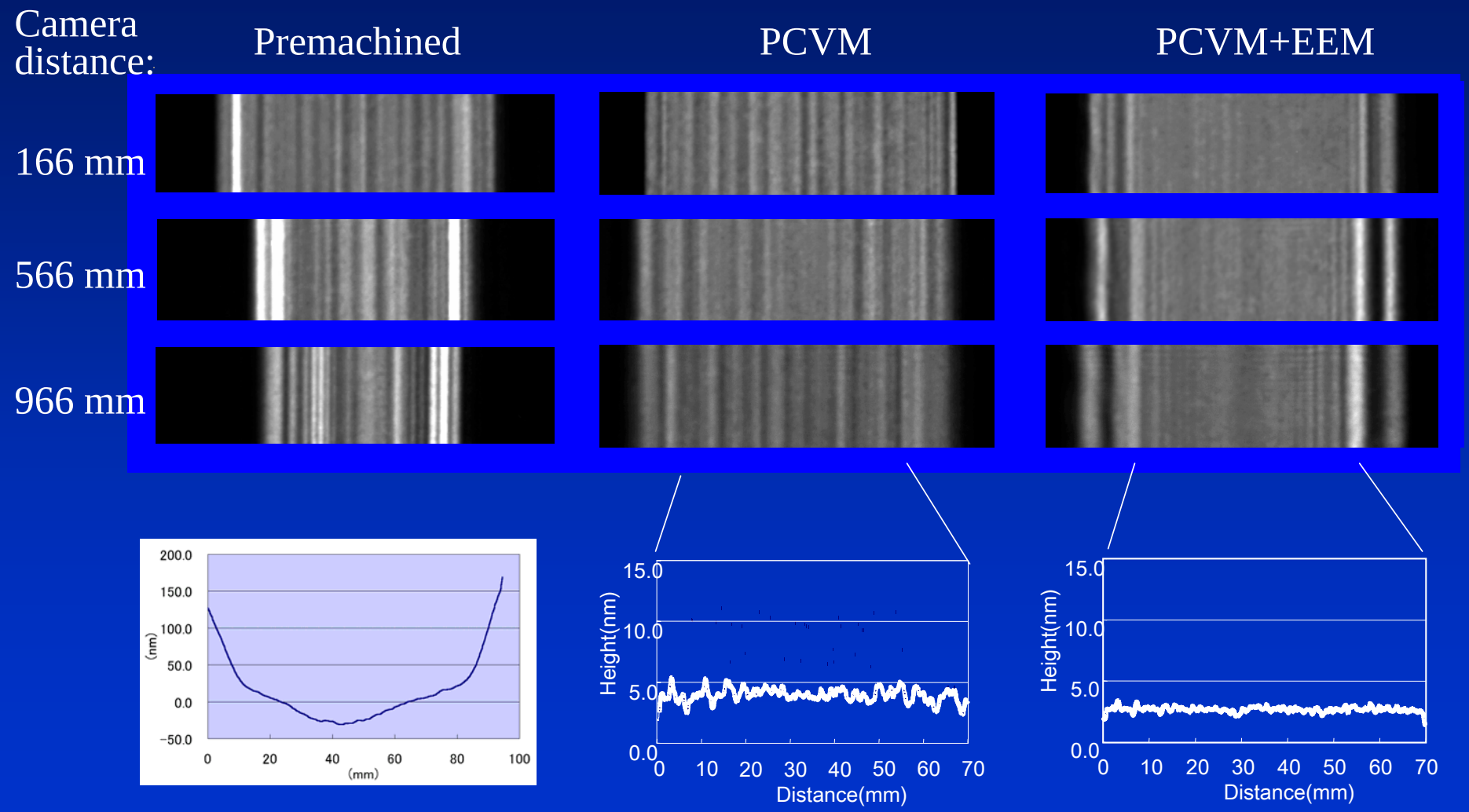
SR




SPring-8
SPring-8 (1436 m)
since 1997
1km BL
since 2000

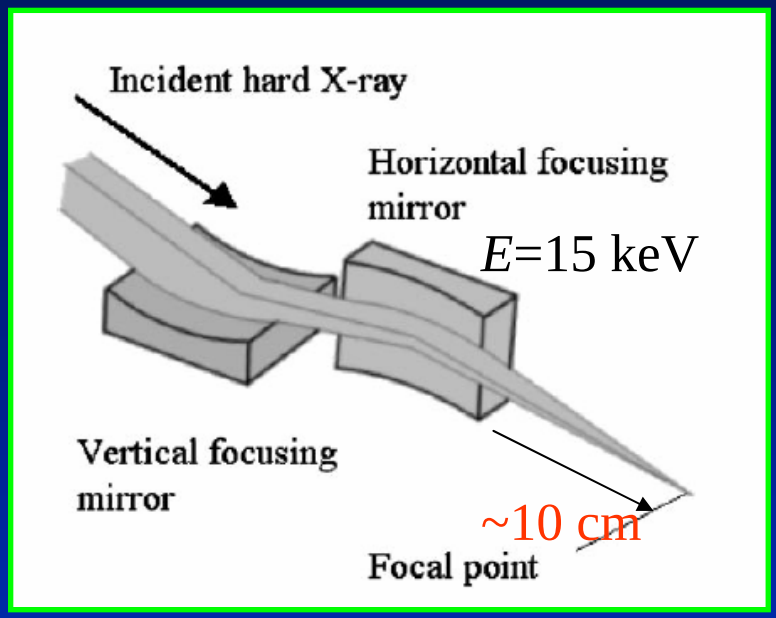
Mirror: SP8 - Osaka Univ. collaboration

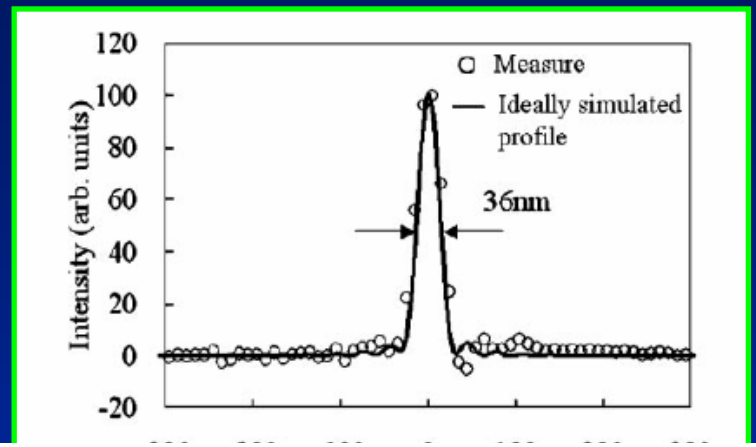
Mirror: Silicon (001) / Incident angle 1.2 mrad / Mirror length 100 mm

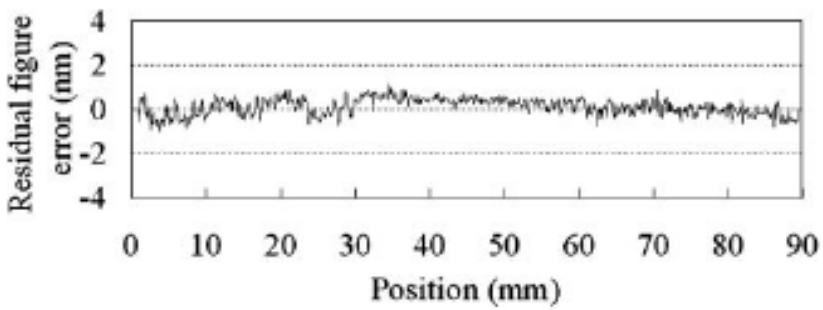


Y. Mori *et al, Proc. SPIE* (2001)

Nano focusing



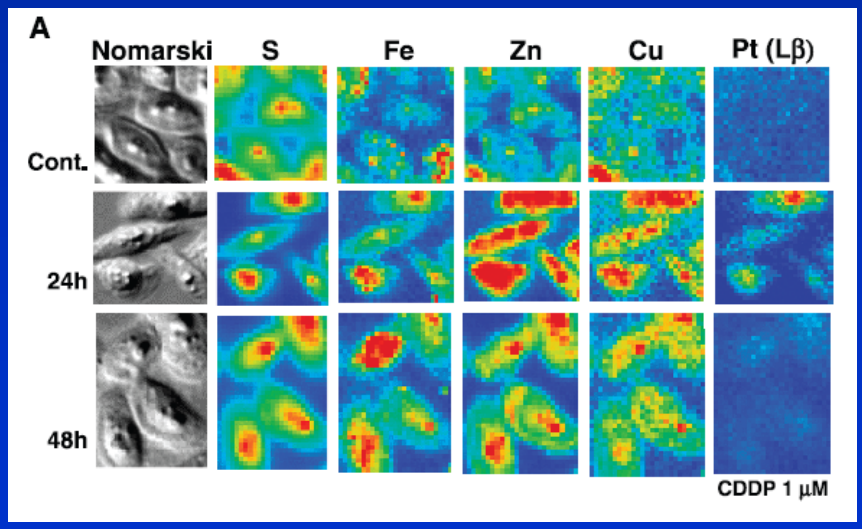




accuracy of 2 nm along whole surface

Fig. 2. (a) Figure profiles and (b) horizontal and (c) vertical focusing mirror reflective surface residual figure error profiles. The surfaces of the mirrors were figured such that the measured profiles are transformed into the designed surfaces. An unprecedentedly accurate surface of approximately 2 nm in peak to valley height was achieved on both mirror surfaces.

Mimura et al., JJAP, **44** (2005) L539



Shimura et al., Cancer Research, **65** (2005) 4998

10 GW/(10 nm)^2 = 1e21 W/cm^2

Monochromator

Bandwidth $\Delta E/E$

XFEL : 6e-4

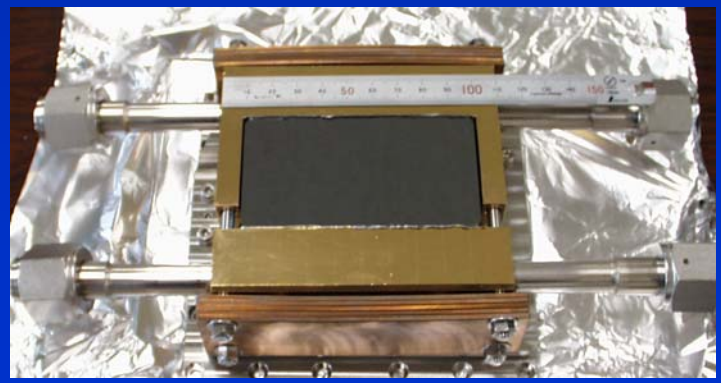
Silicon : 1e-4 with (111) Diamond: 6e-5 with (111)

8e-9 with (11 5 3) K. Tamasaku et al., J Phys. D **38** (2005) A61

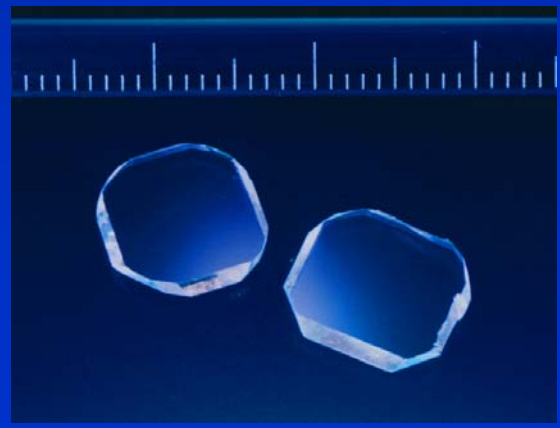
Yabashi et al., RSI **72** (2001) 4080

Yabashi et al., PRL 87 (2001) 140801; PRL 88 (2002) 244801

Single-crystal silicon
with cooling holder

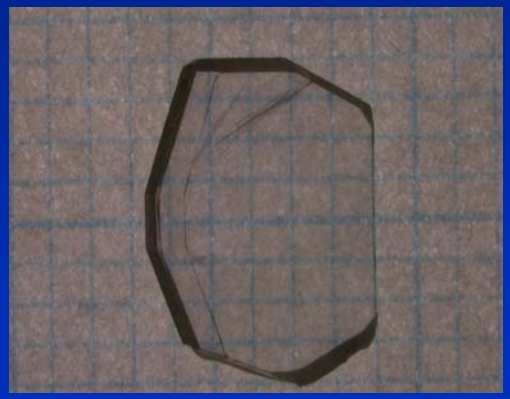


Single-crystal diamond: Type IIa
Collaborated with
Sumitomo Electric Industry

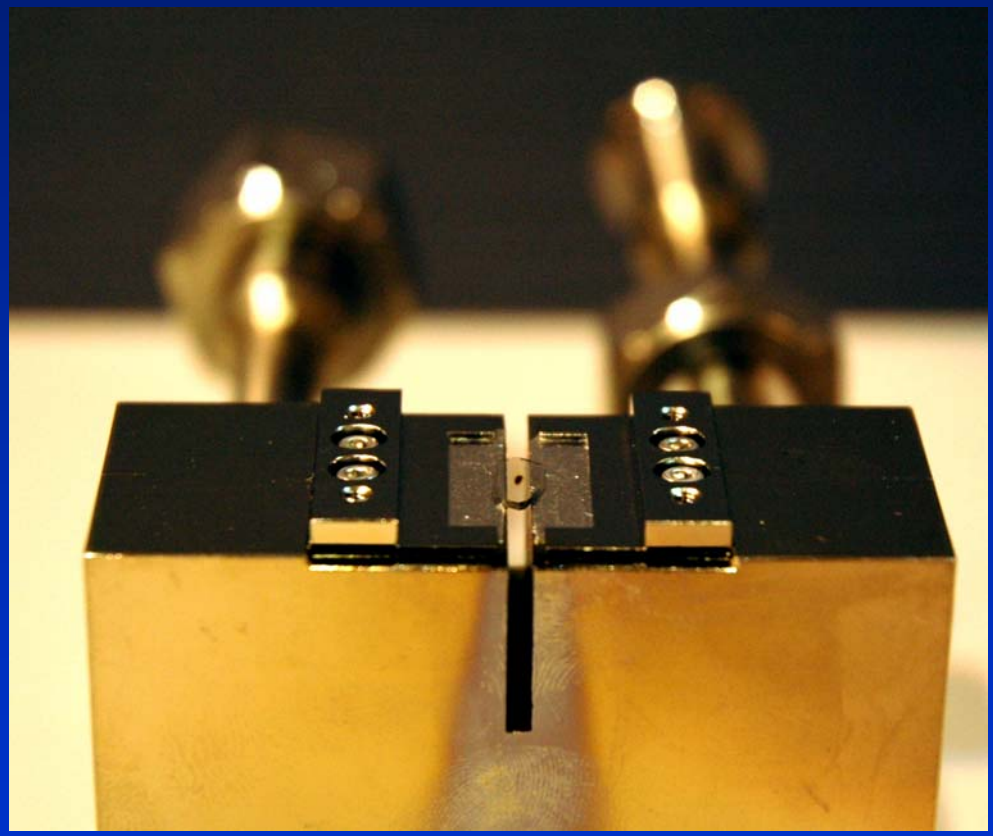


Diamond monochromator

(111)



5 mm

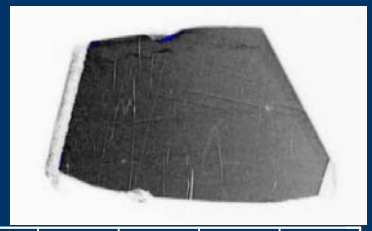


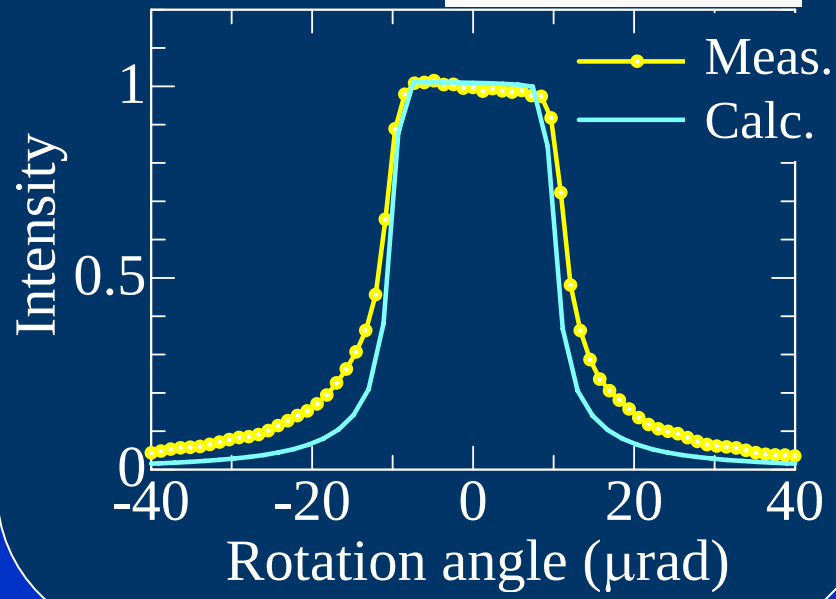
Diamond attached on Cu holder

Diamond monochromator

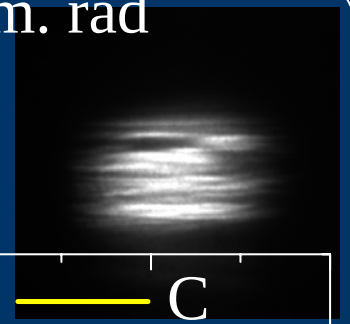
M. Yabashi et al., Proc. SRI 2006 (in press)

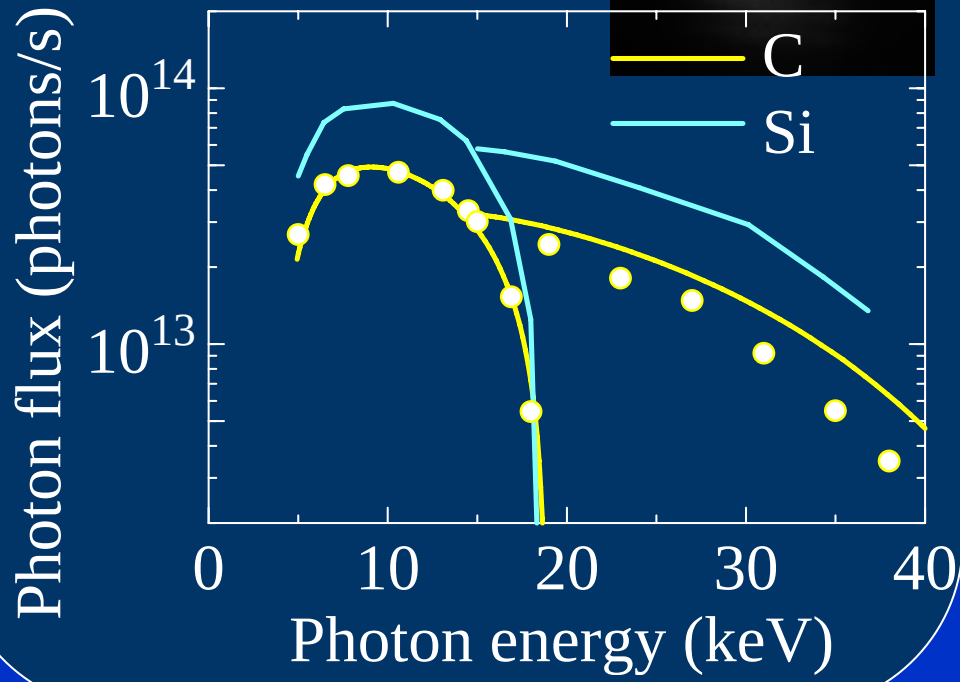
(111) polished crystals
~8x4x0.4 mm^3
@ 1km BL





I_b = 100 mA, ε = 3 nm. rad
@ BL39XU



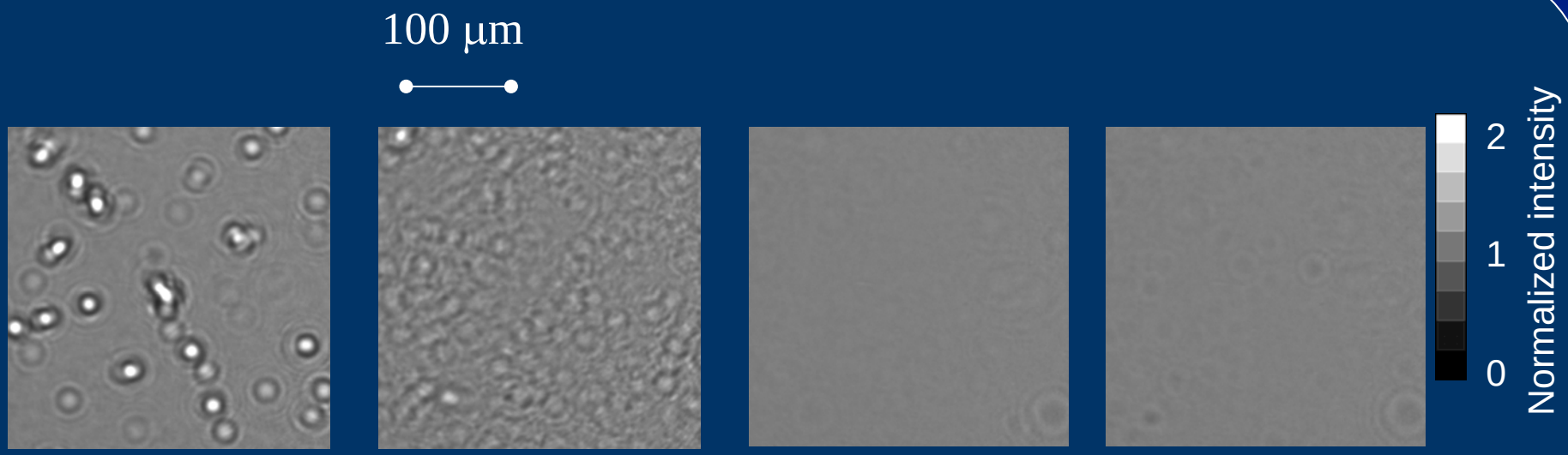


Surface polish is required for improving image quality

Be window

S. Goto et al., AIP conf. proc. **705** (2004) 405;
S. Goto et al., Proc. SRI 2006 (in press)

@1-km beamline (29XU), E=12.4 keV, d= 1400 mm



Polished O-30 (HIP powder foil) 100 nm p-v

Polished IF-1 (Ingot foil) 100 nm p-v

Polished PVD 50 nm p-v

Kapton

Summary

- XFEL construction
  - Machine scale is now being finalized
  - Construction of machine building will be started in 2007
  - User operation of test accelerator will be started in 2007
- X-ray optics
  - Dose issue: need further study (& collaboration), especially for mirror and low-energy optics
  - Mirror: speckleless plane mirror & diffraction limited focusing
  - Diamond: Flux OK, Image need to more developm
  - BeW: Polished PVD OK