Status of Japanese XFEL Project and SCSS Test Accelerator

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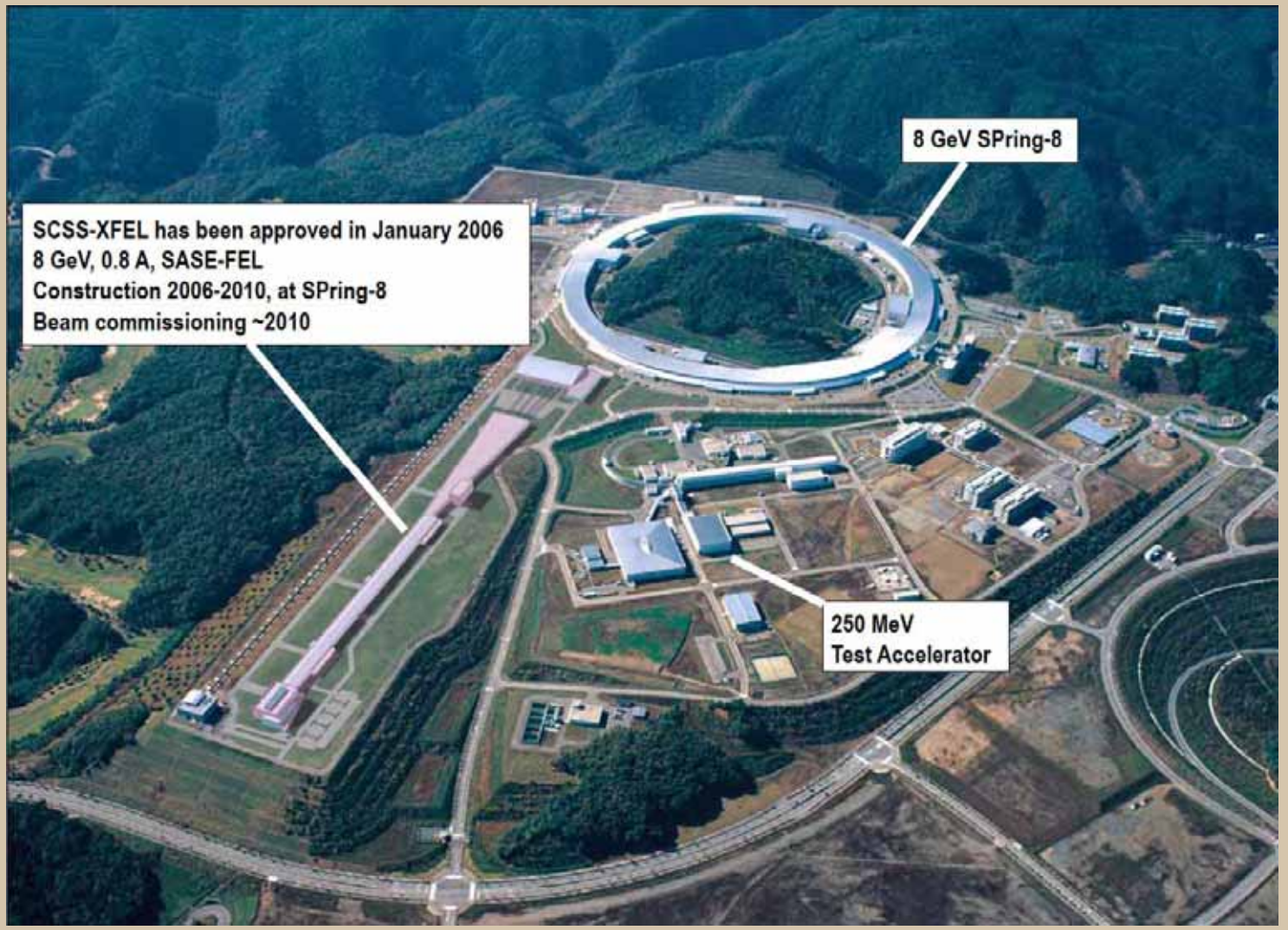
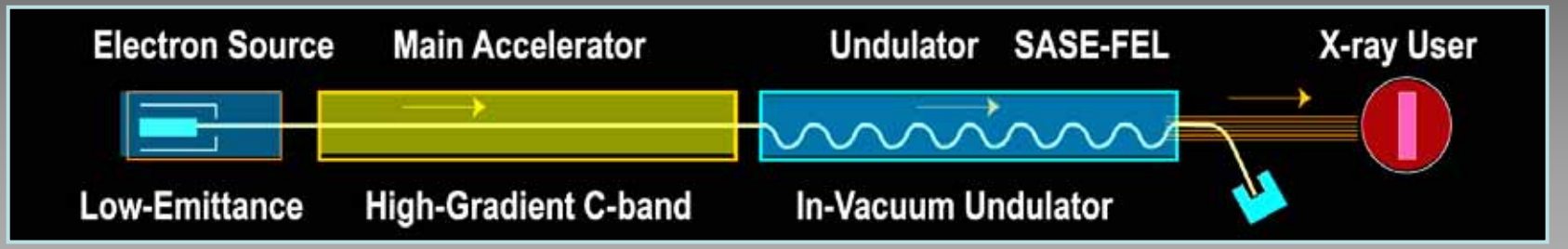
- **2001-2003 : R&D on electron gun, alignment devices, C-band,..**
- **2004~2005: Construction of 250 MeV Prototype Accelerator**
- **2006, June 20: *Lasing at 49 nm, in SCSS Prototype Accelerator***

- **XFEL Project, 8 GeV, 1 Å has been approved, January 2006.**
  - **Construction 2006~2010.**
  - **First beam: ~2010**

XFEL Project at SPring-8/RIKEN



SCSS : SPring-8 Compact SASE Source



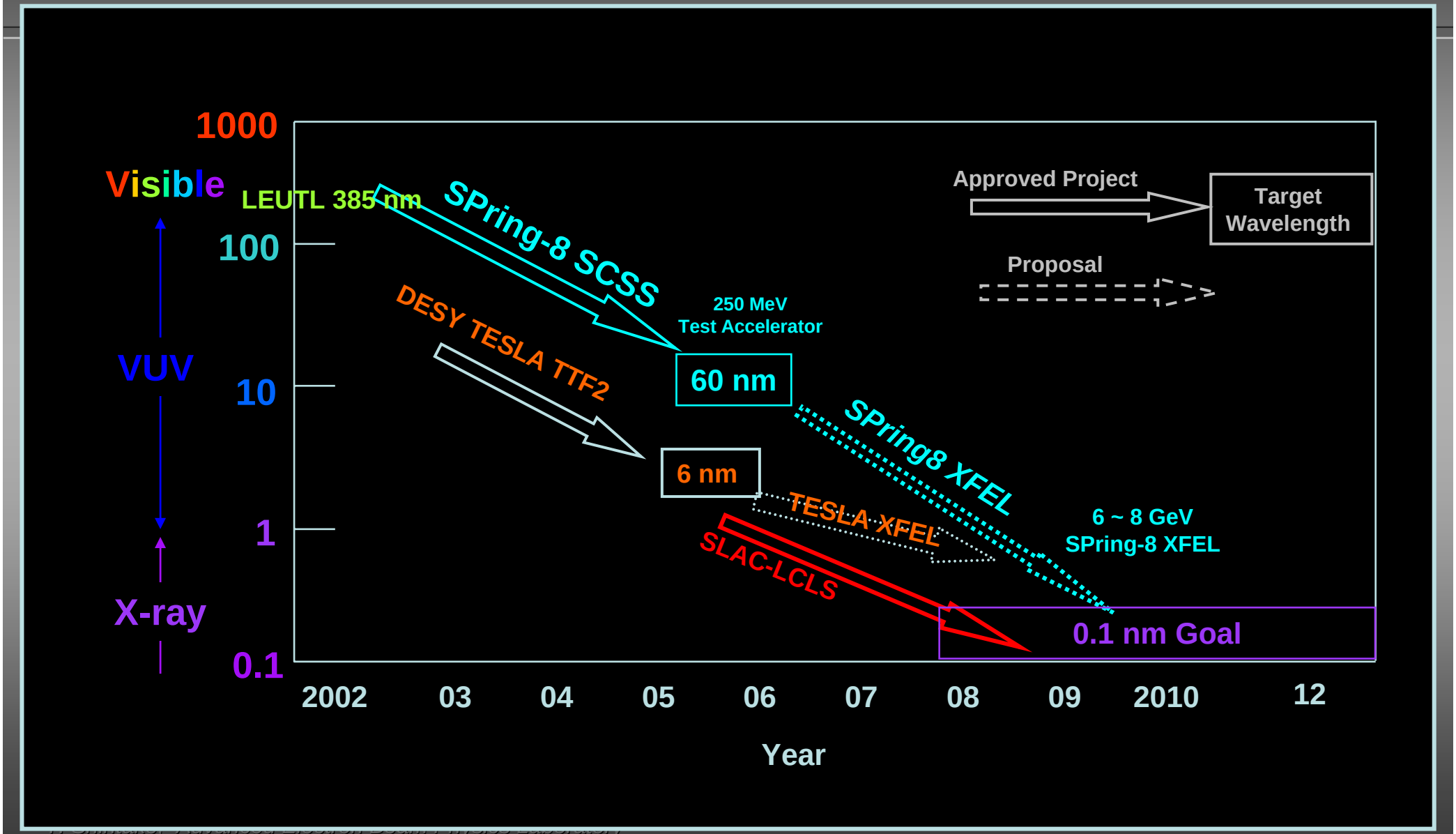
- **Low Emittance Injector** → **Short Saturation Length**
- **High Gradient Accelerator** → **Short Accelerator Length**

C-band 35 MV/m x 180 m (active length) = 6 GeV

- **Short Period Undulator** → **Lower Beam Energy and Short Saturation Length**

In-Vacuum Undulator : E = 6GeV, λu = 15 mm, λx = 0.1 nm

Milestone of SPring-8 X-FEL



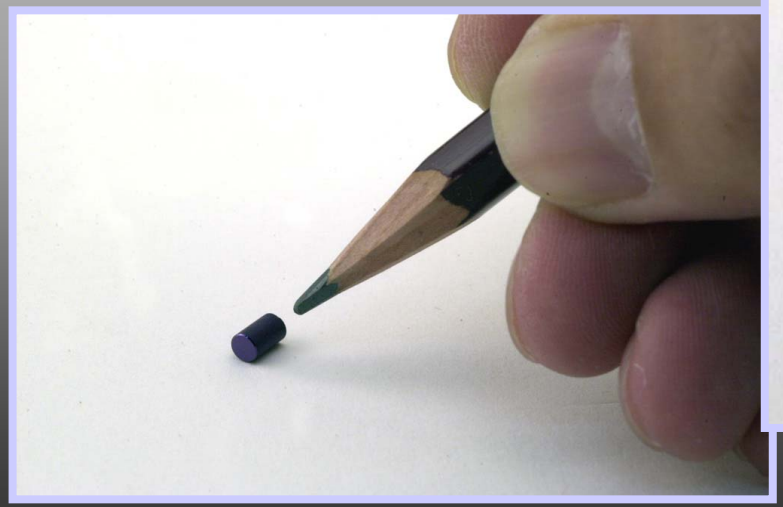
SCSS & X-ray FEL Beam Parameter

at undulator section

		Prototype	X-ray FEL	
Beam Energy	E	0.25	8.0	GeV
X-ray Wavelength	λ	60	0.1	nm
Beam Emittance	ε_n	2	1.0	πmm.mrad
Bunch Length	Δz	150	75	μm
	FWMH	0.5	0.25	psec
Transverse Beam Size	$\sigma_{x,y}$	100	25	μm
Peak Current	I_p	1	4	kA
Charge per bunch	q	0.5	1	nC
Undulator Parameter	λu	15	18	mm
	K	1.3	1.3	
Length	L	9	80	m
FEL Saturation Length	L_{sat}	10	80	m

CeB_6 Cathode & Heater Assembly

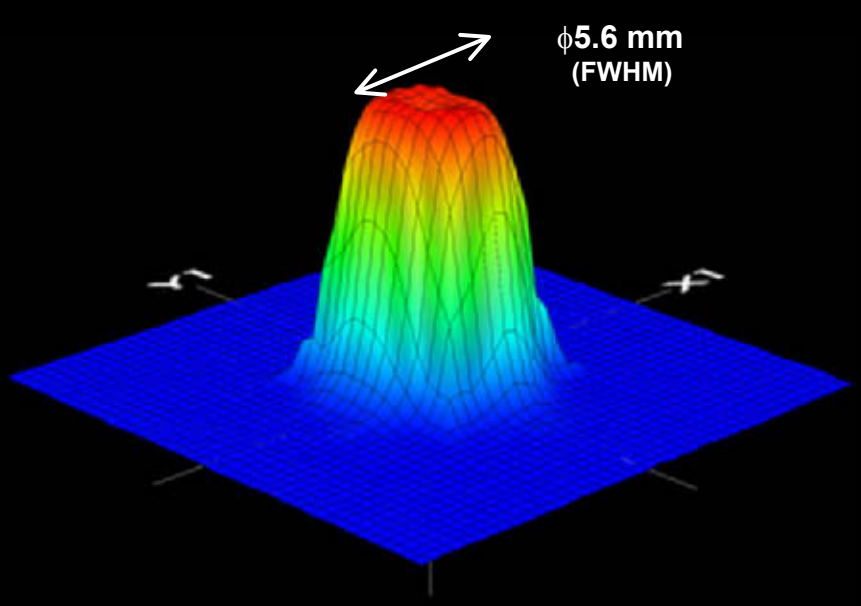
- CeB_6 Cathode 3 mm Diameter
- Emittance 0.4 π.mm.mrad
  (thermal emittance, theoretical)
- Beam Current 3 Amp. at 1450 deg.C
  (using graphite heater)
- Current Density > 40 A/cm^2



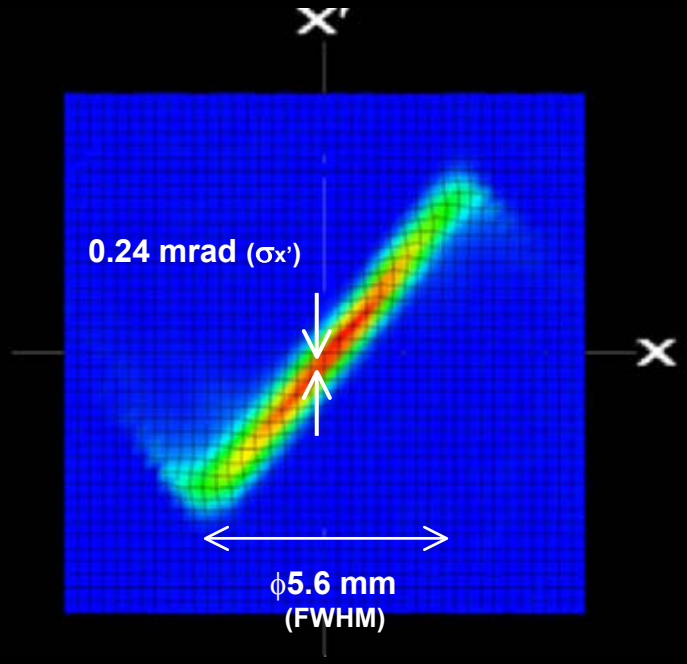
APAC2004 MOP-20006
K. Togawa (SPring-8/RIKEN) et.al.

Emittance Measurement for the SCSS Electron Gun

Beam Profile



Phase Space



Beam Energy : 500 keV
Beam Current : 1.0 A (peak)
Pulse Width : 3 μs (FWHM)

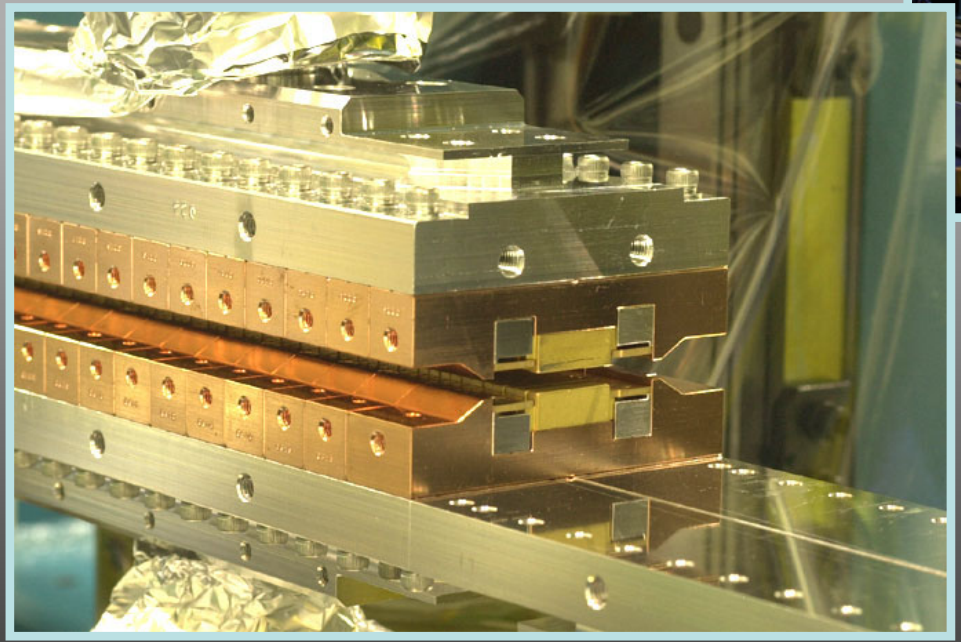
Normalized Emittance (εn,RMS)

Experiment: 1.1 π.mm.mrad at Gun

In-Vacuum Undulator for SCSS X-FEL

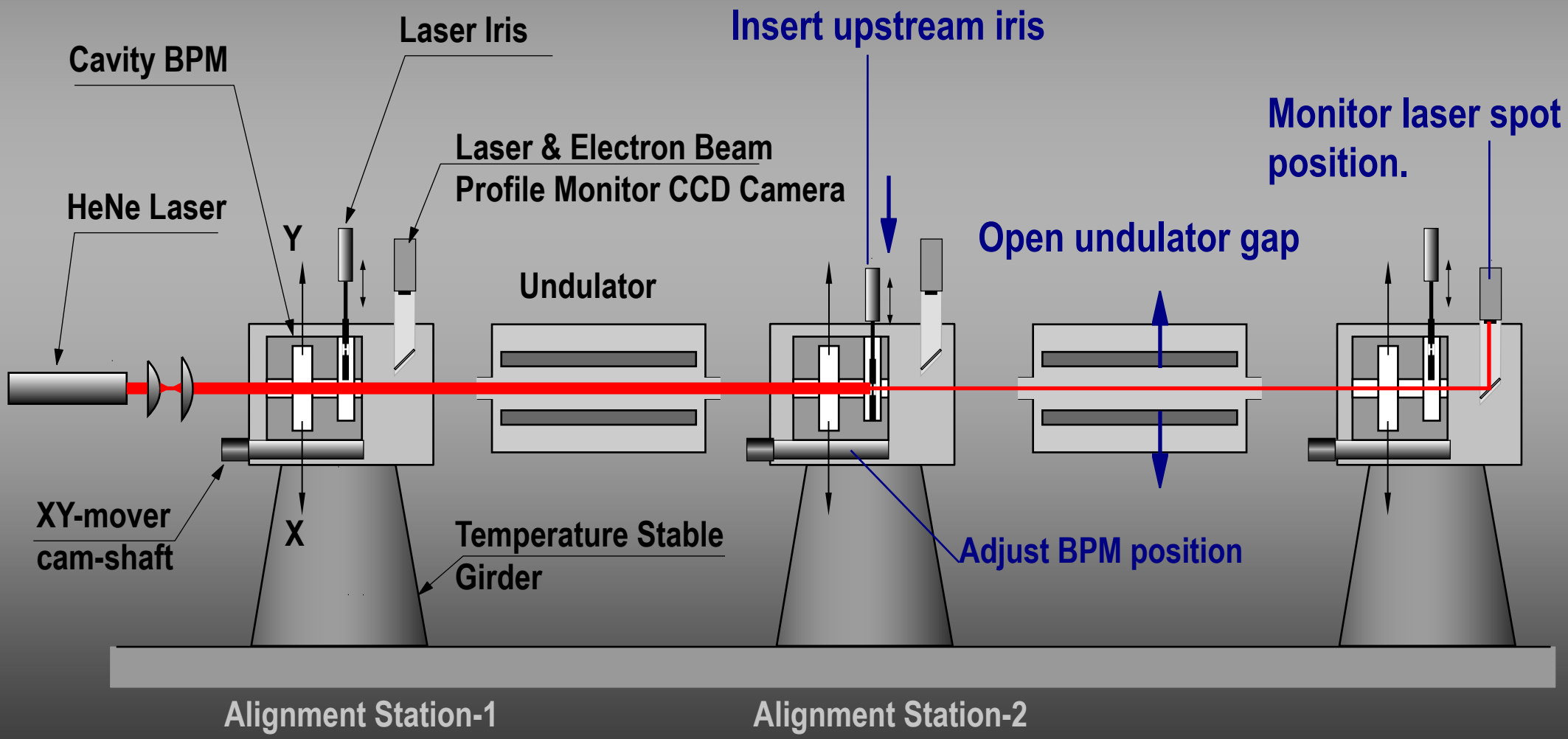
- Segment length 4.5 m
- N = 300/segment, λ_u=15mm
- K~1.3, at Nominal gap 3.5 mm
- Mechanical minimum gap = 2mm
- 45-deg. tilted Halbach type
- More compact than ordinary ones

First prototype model



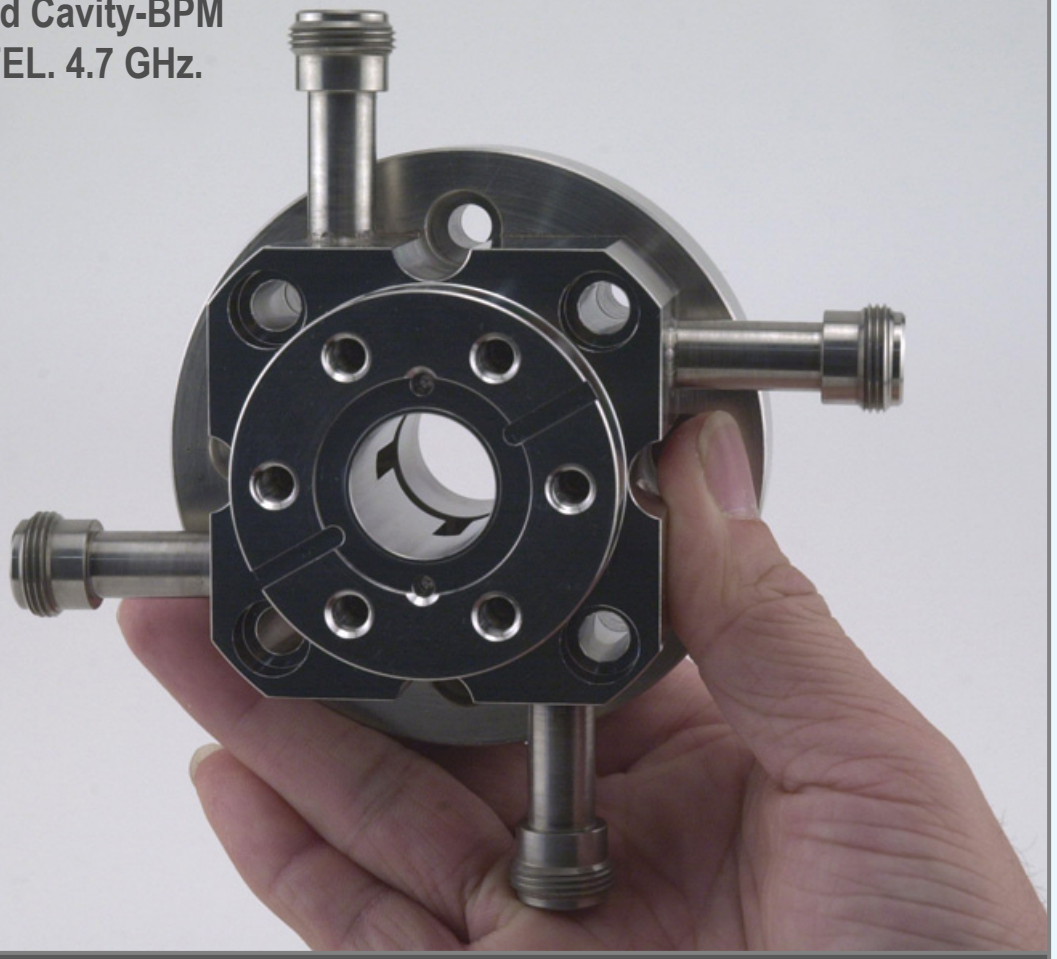
Gap can full-open 25 mm, which
provides optical alignment laser pass,
and enough beam acceptance
at the beam commissioning time.

BPM Alignment System for SASE FEL



Cavity-BPM (Beam Position Monitor)

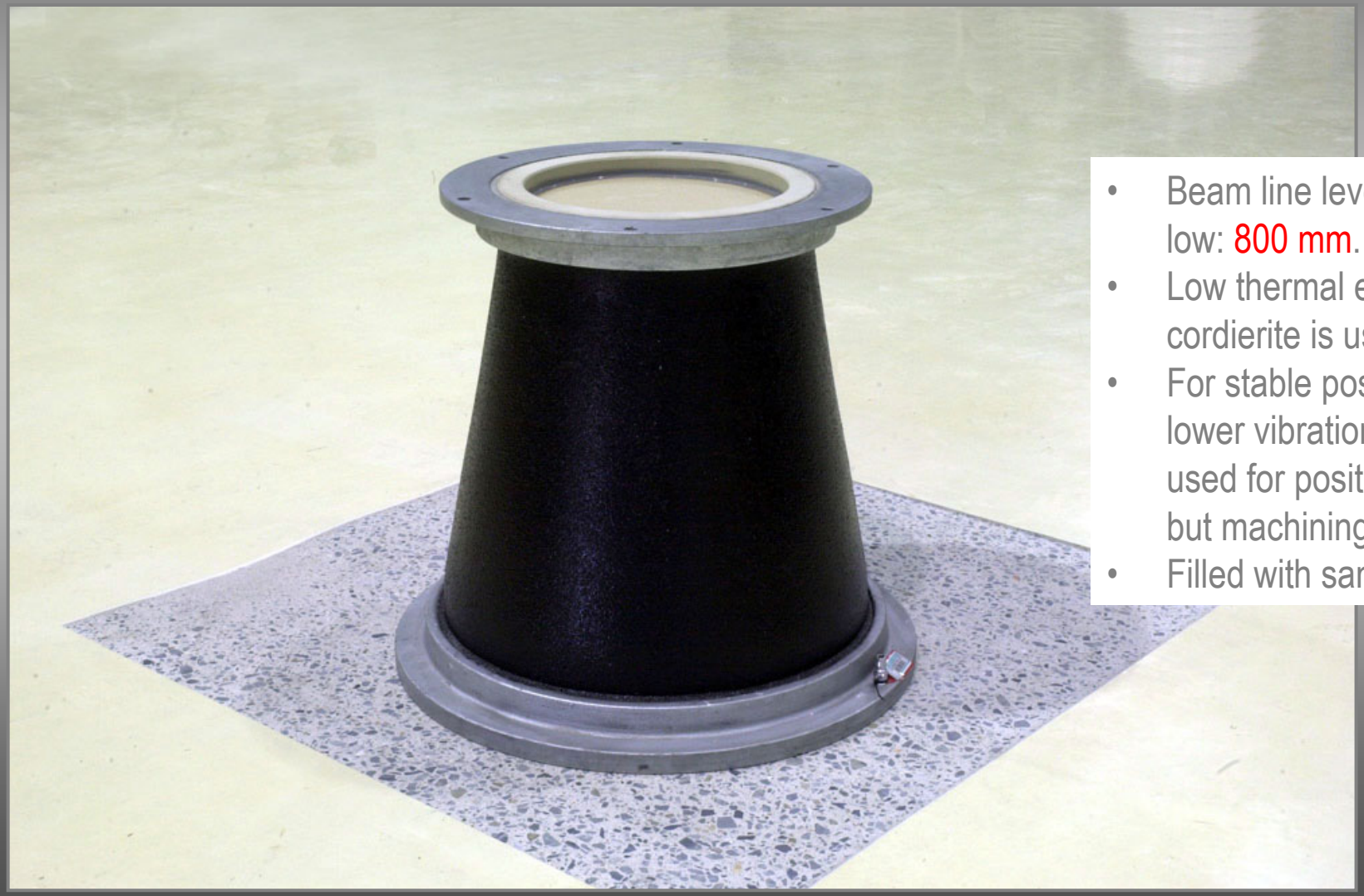
Newly developed Cavity-BPM
For SPring-8 XFEL. 4.7 GHz.



- TM110 mode excitation amplitude provides very linear beam position information.
- Slot-coupling design isolates TM110 BPM signal from TM010 common-mode mixing, which cause position offset.
- Electrical center meets very accurately with mechanical center in a few micron-meter (insensitive to variation of cable length, or detection circuit details).

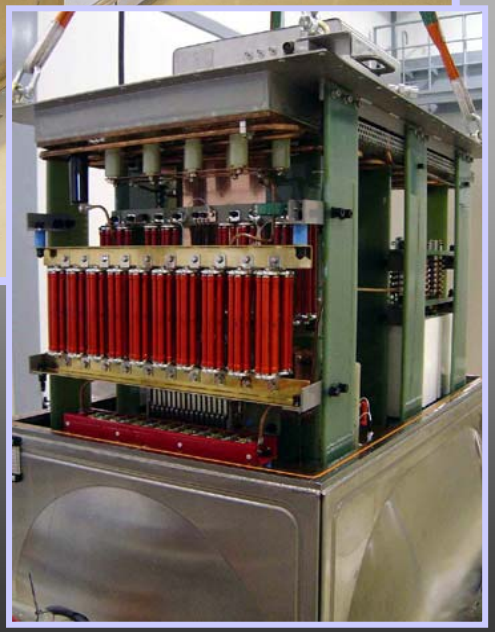

RF-BPM (61.6)

Stable Support using Cordierite Ceramic



- Beam line level is designed low: 800 mm.
- Low thermal expansion cordierite is used.
- For stable positioning and lower vibration, No screw is used for position adjustment, but machining the spacer.
- Filled with sand for damper.

Compact HV Pulse Modulator Supply



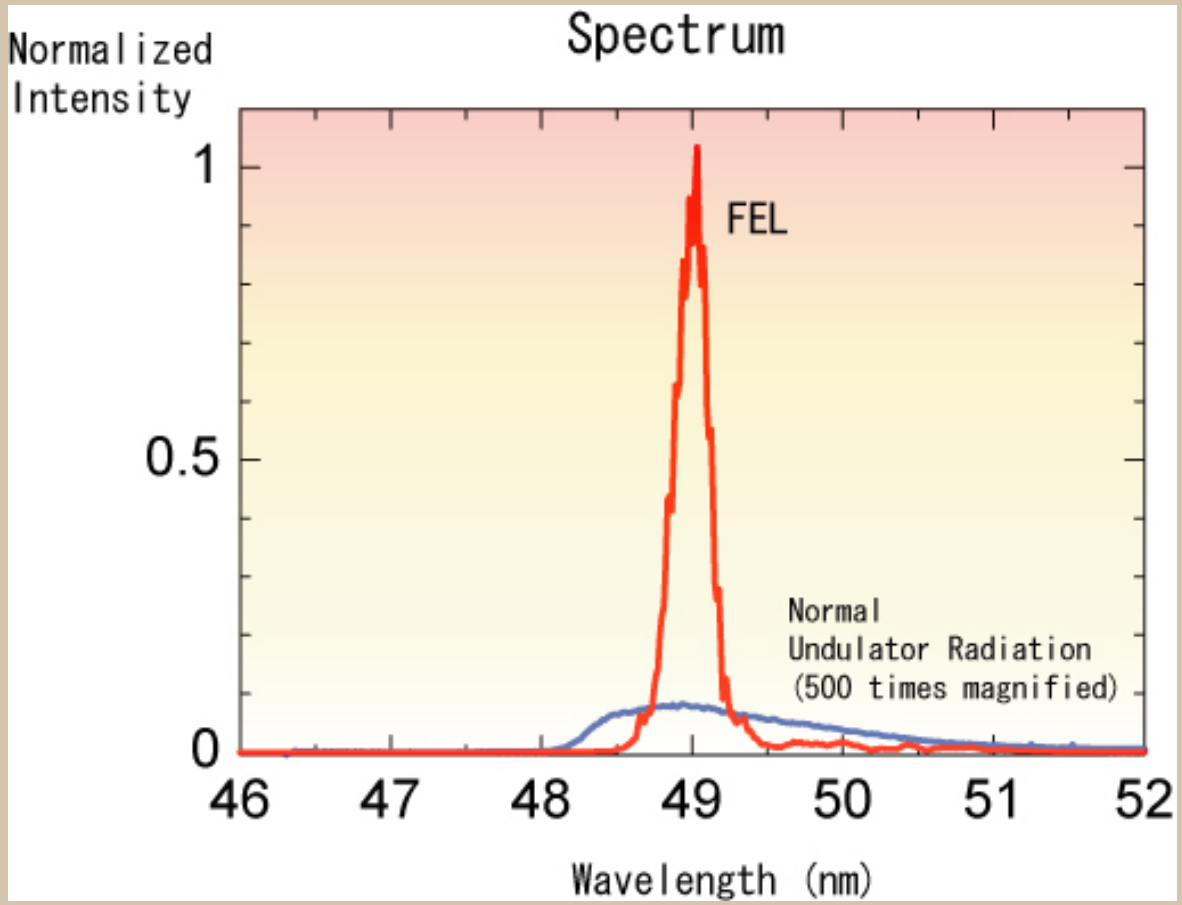
- Driving 50 MW klystron,
  and 500 kV electron gun.
- Compact, Oil Filled Design
  W 1.7 m x D 1.2 m x H 1m.
- Good EMI shield.
- Better cooling for HV component.
- Eliminating cooling air fan.
- No dust accumulation
  due to high voltage in air.
- No environmental effects:
  moisture and temperature variation.

SCSS Test Accelerator

- C-band Accelerator
- 50 MW Klystron x 2
- Acc Structure 1.8 m x 4
- 250 MeV

- Undulator 4.5 m x 2 unit
- 15 mm period
- 4 mm gap

First Lasing at SCSS Prototype Accelerator.



- **The first lasing: 49 nm**
- **E-beam energy : 250 MeV**
- **Bunch charge: 0.25 nC**
- **Bunch length: (< 1 pse)**
- **Peak Current (> 300 A)**

- **At moment spectrum width 0.5 nm is dominated by e-beam energy fluctuation ~ 0.2%.**

Schedule & Conclusion

- SCSS Prototype Test Accelerator:
  - HHG seeding test 60 nm. Autumn 2006, *G. Lambart, this EPAC06.*
  - UVU user run will start 2007.

- XFEL Construction 2006 – 2010
  - **Big construction, 80 klystrons**
  - **400 m C-band Accelerator**

- Remain R&D Items
  - Power supply stability improvement 0.1 % → 0.01 %
  - L-band buncher accelerator (L-band APS 1m x 2, 20 MW klystron)
  - C-band or X-band flat-topping accelerator → increase charge.
  - LORA bunch length monitor.
  - In-situ field measurement tool for undulator.

Thank you very much!