Construction Status of XFEL/SPring-8 (Its stability issue)

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The main presentation items, today, are

 # what we established about machine and instrument performance,

 # what is not enough performance of accelerator elements for XFEL, and

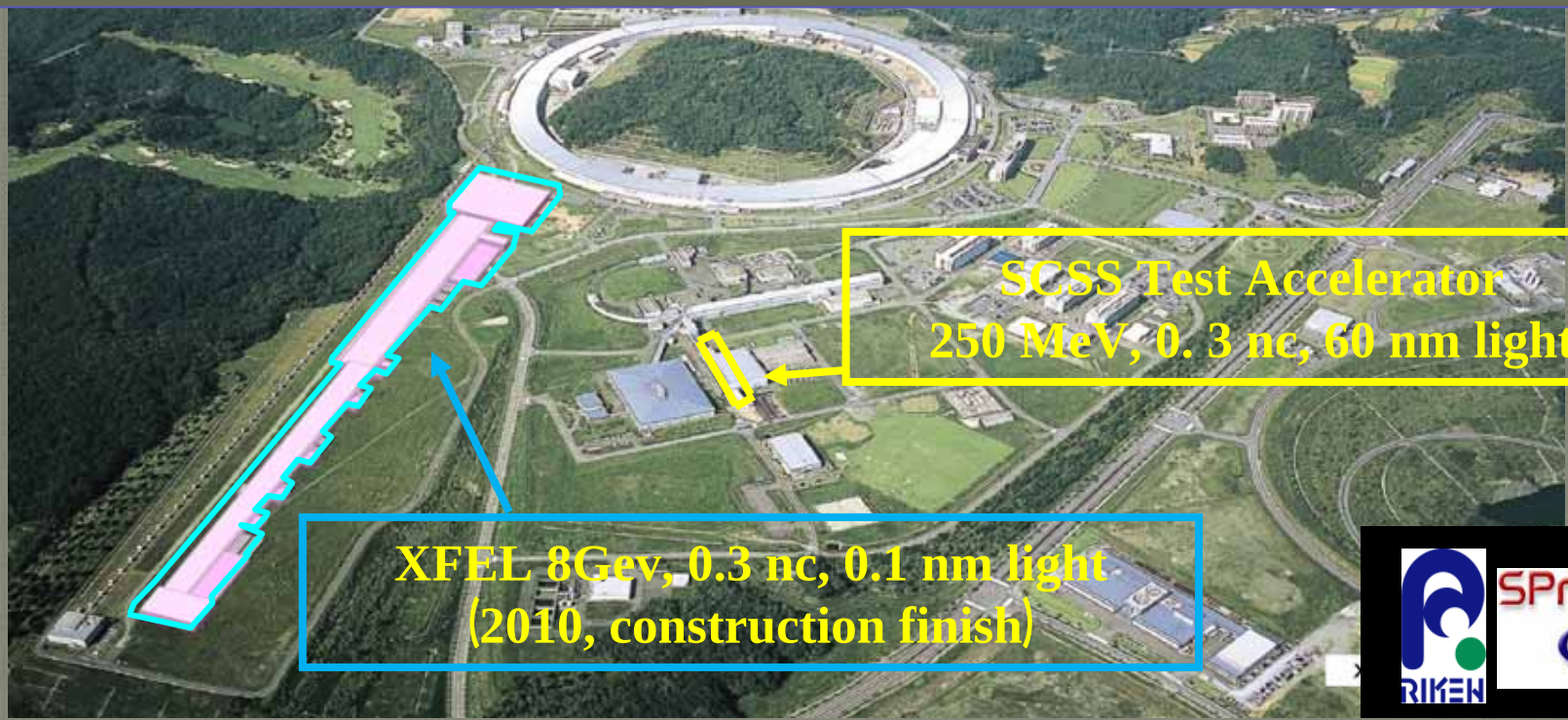
 # How to make up the difference between the target and the established one.

What do we build ?

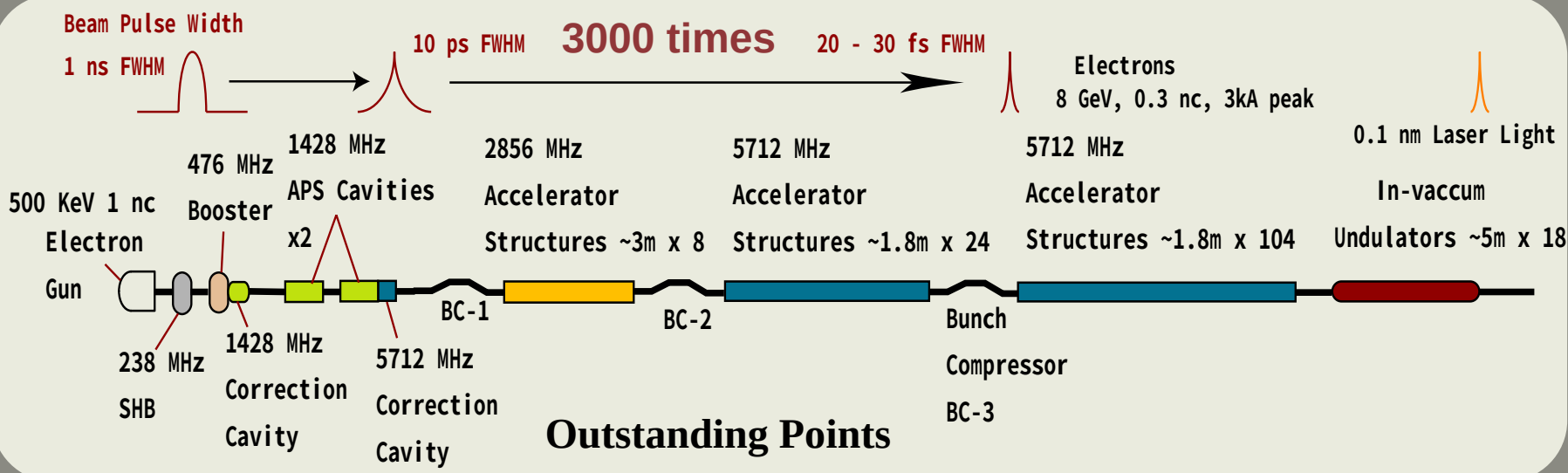



CeB6 Electron Gun, Velocity Bunching, C-band 37 MV/m High Gradient Acceleration, In-vacuum Undulator

This technology is to support SPring-8 Compact SASE Source (SCSS) Concept. (Compactness)

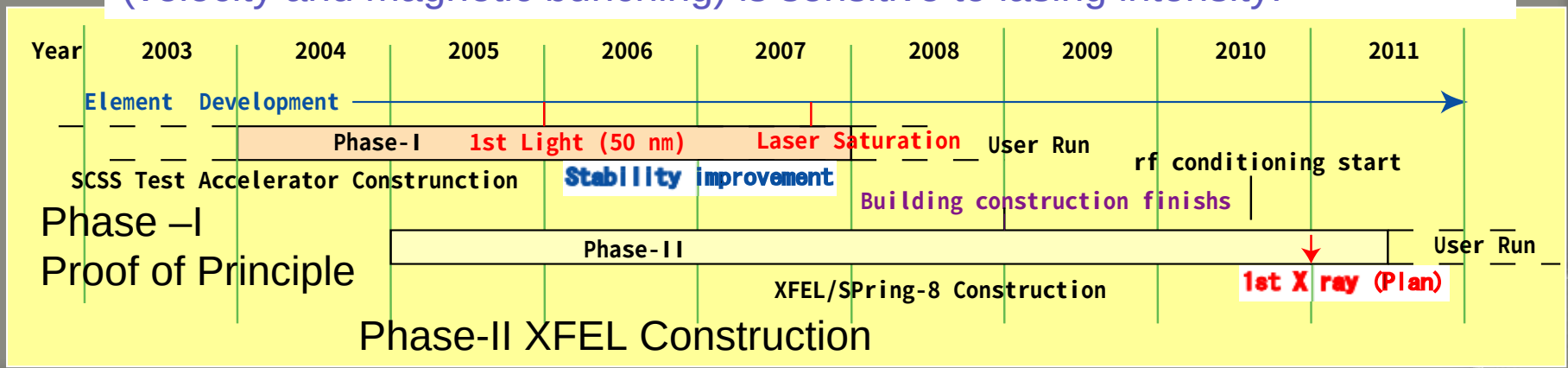


Configuration of XFEL/SPring-8 and Its Development/Construction Schedule



Outstanding Points

Because of the SCSS concept, we must use velocity bunching in low –β and magnetic bunching in high-β. Our bunch compression scheme (velocity and magnetic bunching) is sensitive to lasing intensity.



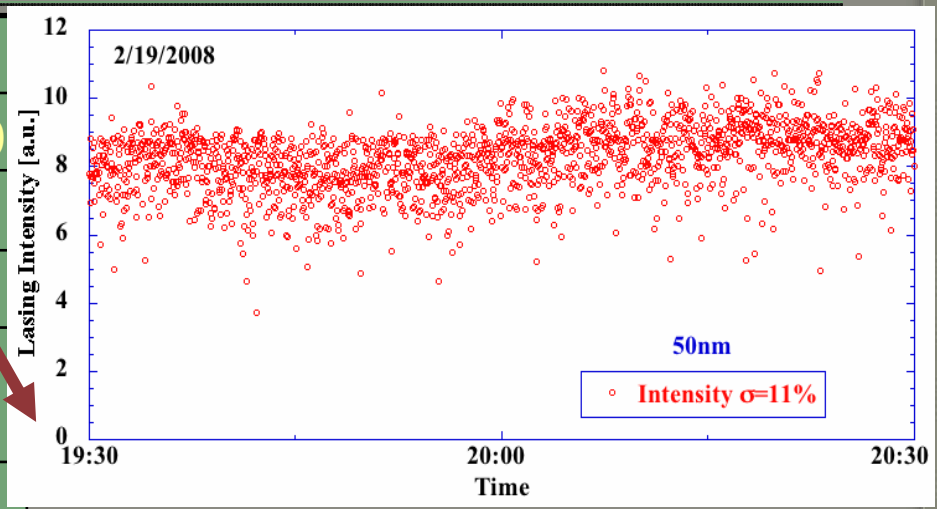
Phase-II XFEL Construction

General future of XFEL/SPring-8 vs. the SCSS test accelerator.

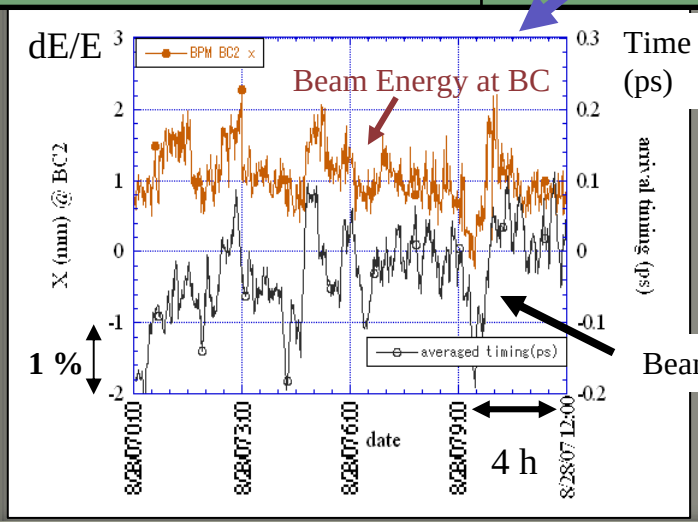
	XFEL/SPring-8 (Desgin)	SCSS (Achieved)
Energy	~8 GeV	250 MeV
Charge amount	~ 0.3 nC	~ 0.3 nC
Peak current	~ 3kA	300 A
Emittance	~ 1 πmmmrad	~ 0.7 πmmmrad
Size	~ 50 μm (rms)	~ 100 μm (rms)
Laser energy/ pulse		30 μmJ at 60 nm
Pulse width for SASE generation	~ 40 fs (rms)	300 fs
Wave length of SASE	0.1 nm	60 nm ~ 50 nm

Stability of the SCSS test accelerator

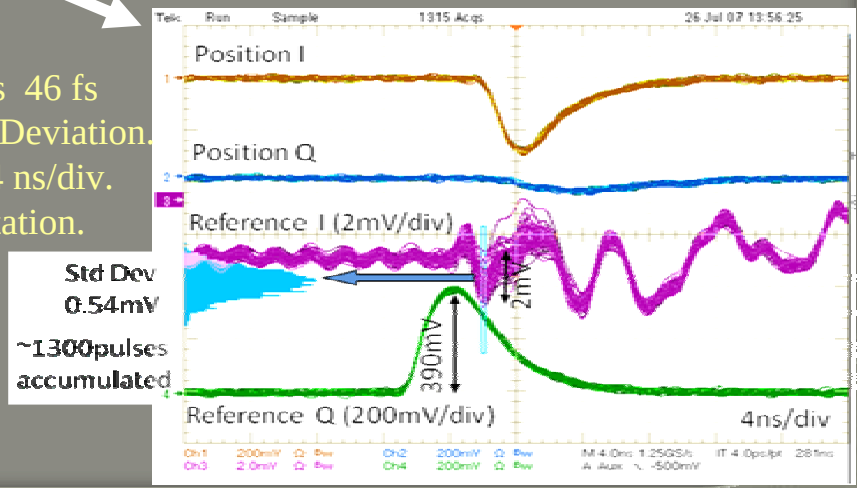
Beam Energy stability	~0.06 % (rms)
Beam Current stability	10 ~ 20 % (full width)
Beam pointing stability	~ 30 μm (rms)
Laser stability (60 nm)	~ 11 % (rms)
Laser pointing stability (60 nm)	~ 5 % (rms) of 3 mm in size
Time jitter between rf and beam	~ 46 fs (rms)



R56, 20 mm (BC) Beam energy jitter value about 0.06 % (rms)



Beam Time jitter is 46 fs
0.54 mV Standard Deviation.
Horizontal Scale. 4 ns/div.
10 pps Beam Reptation.



Time Jitter Tolerances of RF Cavities at the XFEL/Spring-8 & Established Performance

Target Performance

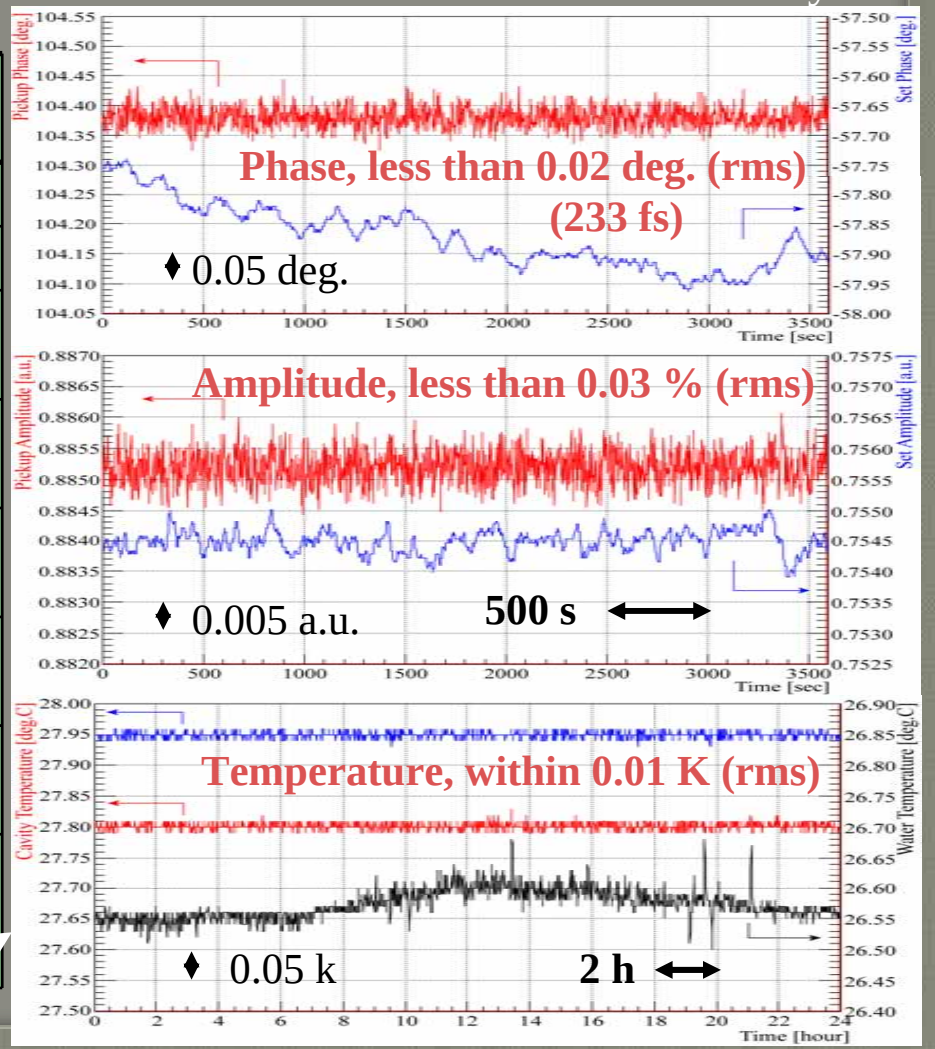
To attain an energy stability of 10^{-4} and 10 % fluctuation of 3 kA peak current.

Cavity	DV/V(%rms)	Df (deg. rms)	Dt (ps rms)
238 MHz SHB	± 0.01	± 0.01	± 0.12
476 MHz Booster	± 0.01	± 0.02	± 0.12
L-band Cor. Cavity	± 0.03	± 0.06	± 0.12
L-band APS Cavity	± 0.01	± 0.06	± 0.12
C-band Cor. Cavity	± 0.1	± 0.06	± 0.049
S-band Accelerator	± 0.01	± 0.1	± 0.097
24C-band Accel. (up-stream)	± 0.01	± 0.2	± 0.097
104 C-band Accel. (Down-stream)	± 0.01	± 0.5	± 0.24

Achieved Several Hundred fs

Established Performance

Stabilities of the 238 MHz SHB cavity.



How to make up the difference between the established and the target performance for the XFEL

- Key points to improve the instruments for making up.

- High-voltage stability issue (C, S, L-band Klystron .Electron Gun, IOT for 476 MHz booster).
- Precise rf phase control issue (fs control).
- Environment temperature control issue (Instrument enclosure, building).

The difference is probably a factor of 2 or 3.

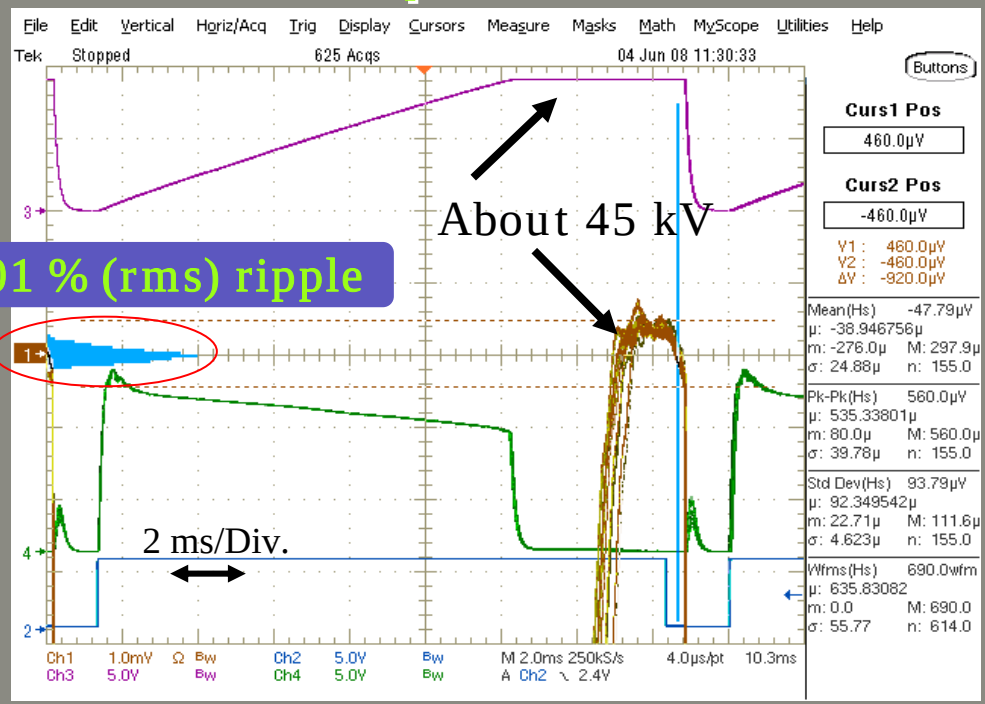
Precise Voltage Regulation of Inverter Power Supply for Klystron and Electron Gun

The combined inverter power supplies includes a 20 kHz switching main power supply for rough voltage control and an 80 kHz auxiliary power supply for precise voltage control.

Achieved 0.002 % (rms) at the test accelerator.

Improved an electrical shield for the control error amplifier, Optimized feedback control parameters, etc.

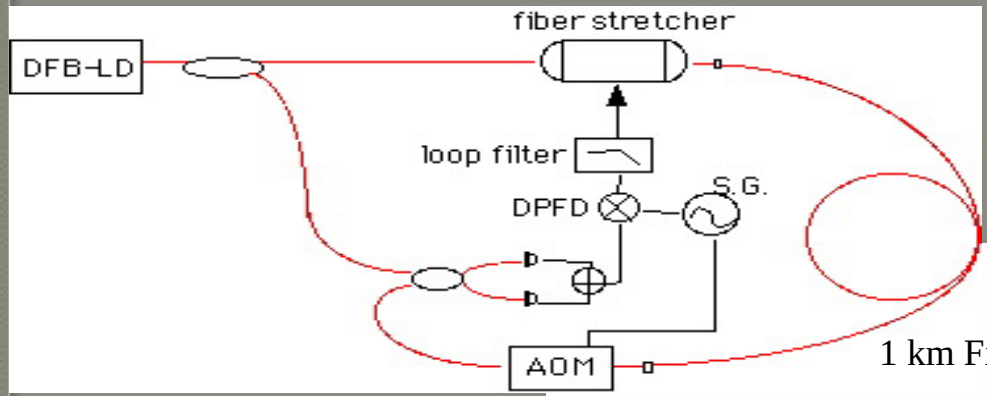
Improved



Newly developed inverter power supply

Fiber Optical Length Control

From 46 fs jitter at the test accelerator to several fs at the XFEL.

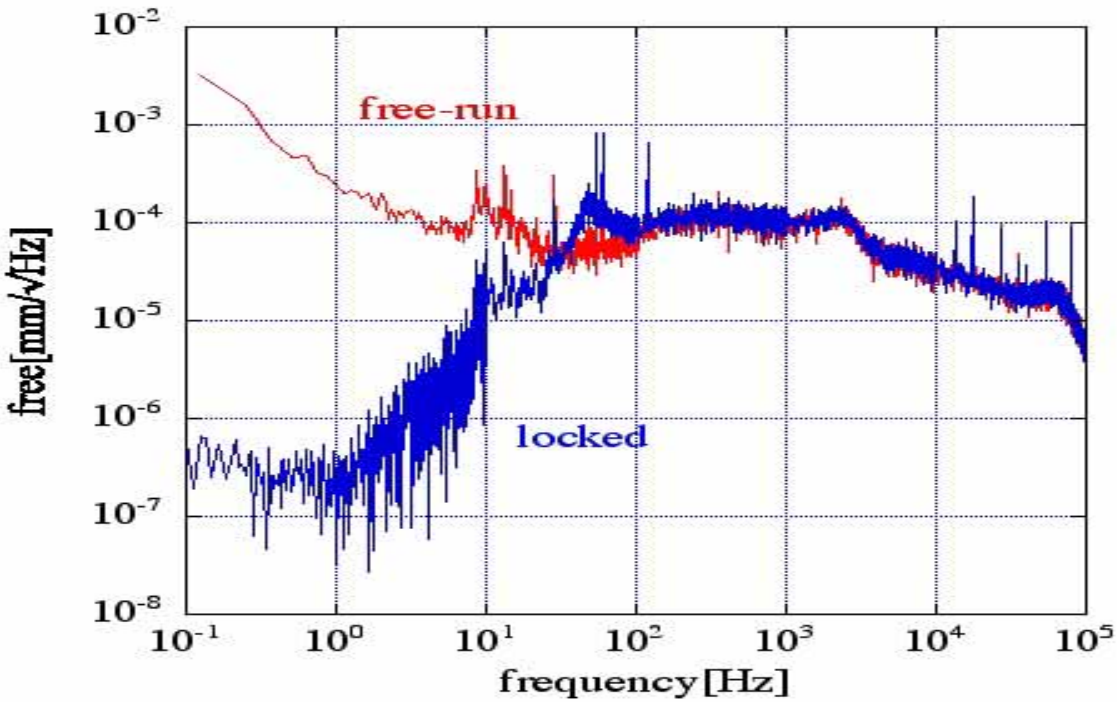


The original system was developed for ALMA. (Controlled its optical length within 3 μm for 25 km.)

Experimental Apparatus

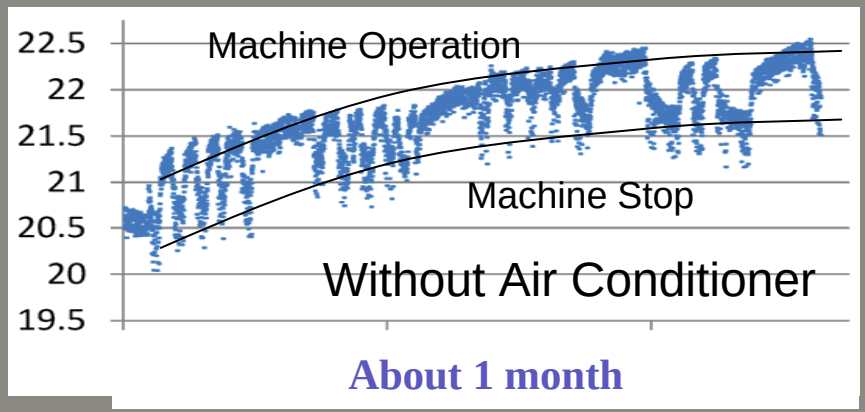
Use the 1 km phase stabilized optical fiber cable settled along the circumference of the SPring-8 ring

Error Length Spectrum of Control



Temperature Control for XFEL/Spring-8

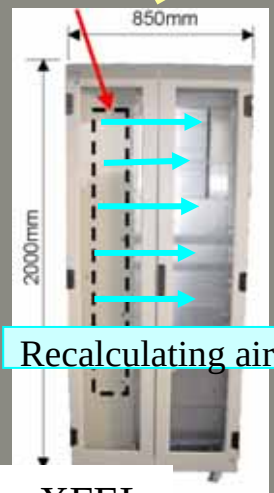
Established Performance



Accelerator Tunnel Temperature Drift at SCSS Test Accelerator, **Enough**

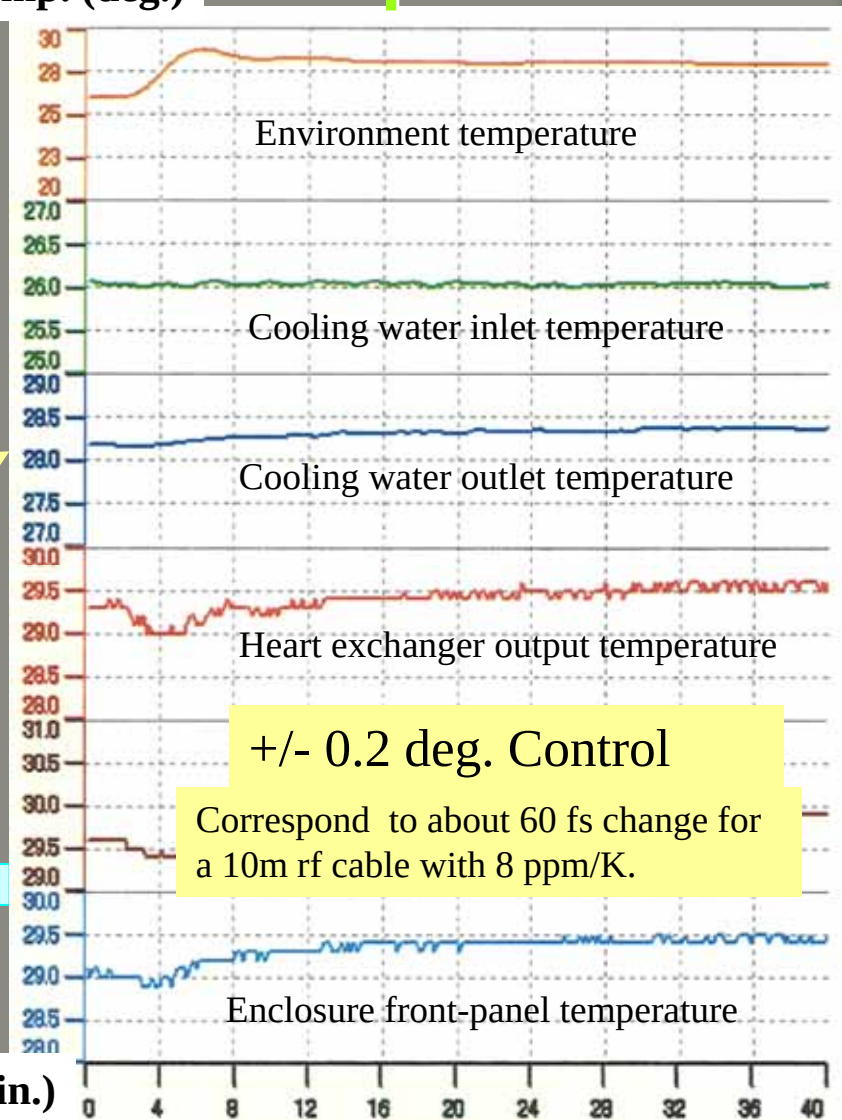
The klystron Gallery temperature stability is +/- 2 K at the test accelerator.

Not Enough



Thermally controlled 19” enclosure for the XFEL with a 1 kW constant inner heat source.

Improved



+/- 0.2 deg. Control

Correspond to about 60 fs change for a 10m rf cable with 8 ppm/K.

SUMMARY

* Finished the construction stage of phase-I to confirm the feasibility of the XFEL/SPring-8.
* Lasing stability of 11 % (rms) at the test accelerator.
* Make up the difference between the present phase stability and the target for the XFEL. --> Inverter power supplies for the klystron and the IOT having a voltage regulation of less than 20 ppm (rms) was developed.
* Optical length control of the fiber was developed with performance of its length control of 1 μm for 1 km.
* XFEL building equips the double surface walls with the air conditioned space between the walls.
* 19” enclosure with water cooled recalculating air within +/- 0.2 K was specially developed.
* The realized performance as mentioned above is almost satisfy our demand, and has possibility over coming the designed performance.