FIRST LASING OF MIR-FEL AT KYOTO UNIVERSITY

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Young Uk Jeong (KAERI)

DEVEOLPMENT HISTORY

- 1995: Prof. K. Yoshikawa started FEL study.
- 1998: FEL facility development was started by Prof. T. Yamazaki.
- 1998: First beam from 4.5-cell thermionic RF-gun.
- 2002: 40 MeV acceleration.
- 2004: FEL facility was built.
- 2006: Undulator installation.
- 2007: Radiation safety issues....
- 2008 Mar.: FEL lasing!
- 2008 May: FEL saturation.

CONFIGURATION OF KU-FEL

Gun

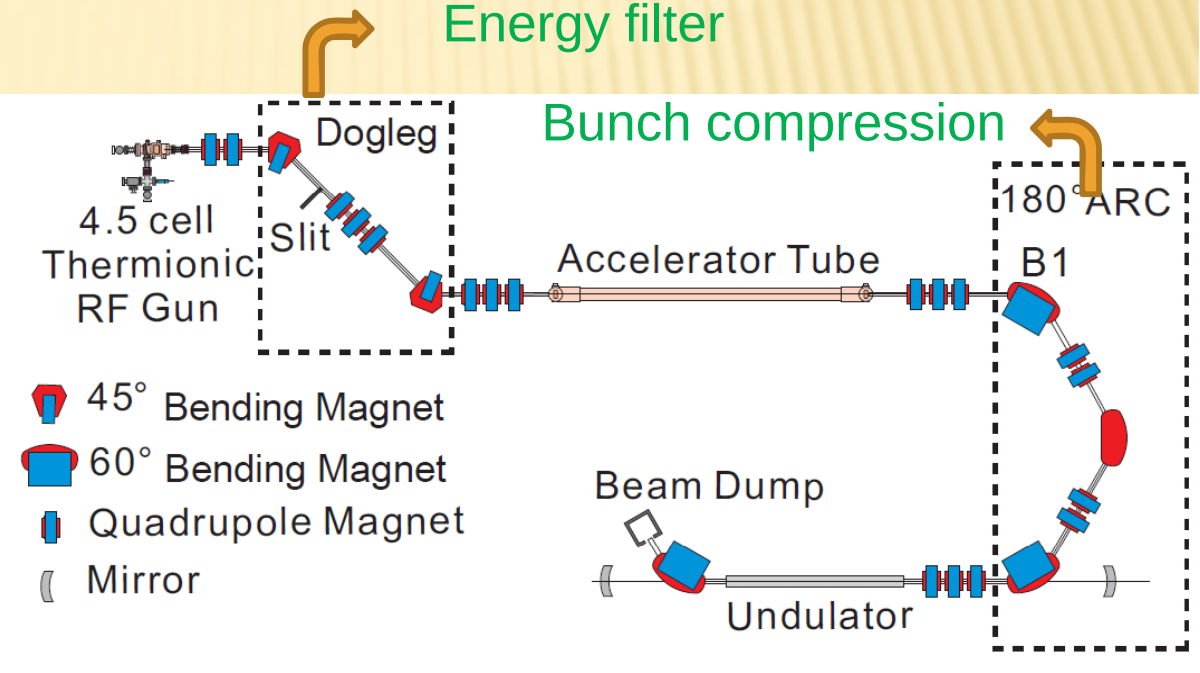
Frequency	S-band
Structure	4.5 cells
Thermionic cathode	LaB_6
Input RF	10 MW 10 Hz

Accelerator

Input RF	20 MW 10 Hz

Undulator

Type	Halbach
Length	1.6 m
Period Number	40
Period	40 mm
K-value	0.99-0.17

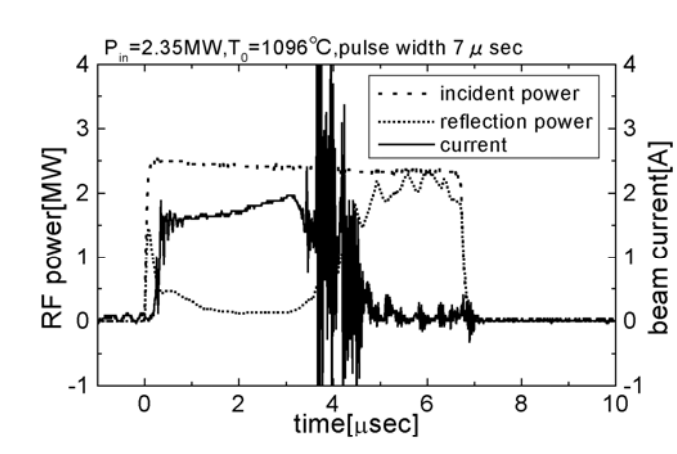


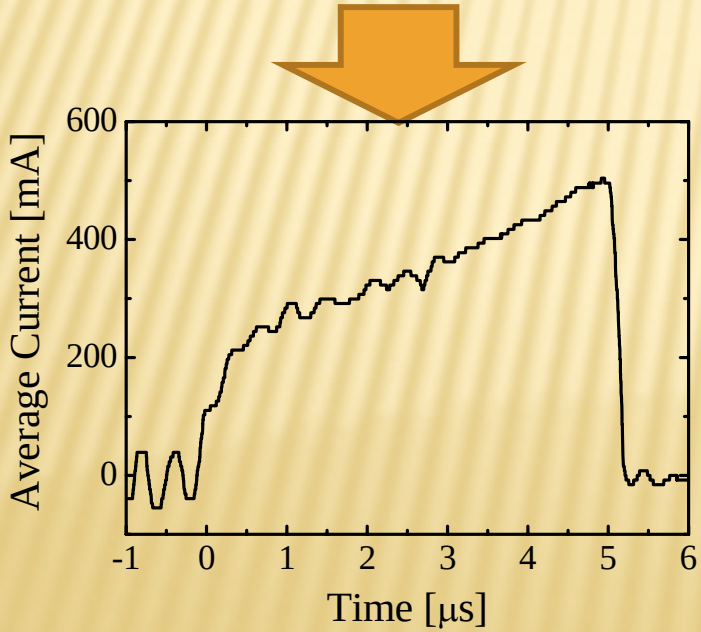
Optical Resonator

Cavity Length	4.516 m
Mirror	Au coated Cu
Mirror Curvature	3.03 m
upstream	2mmϕ coupling hole
downstream	1.87 m

ELECTRON BEAM CONDITIONING

COMBAT HISTORY AGAINST BACKBOMBARDMENT





Magnetic field on cathode surface △

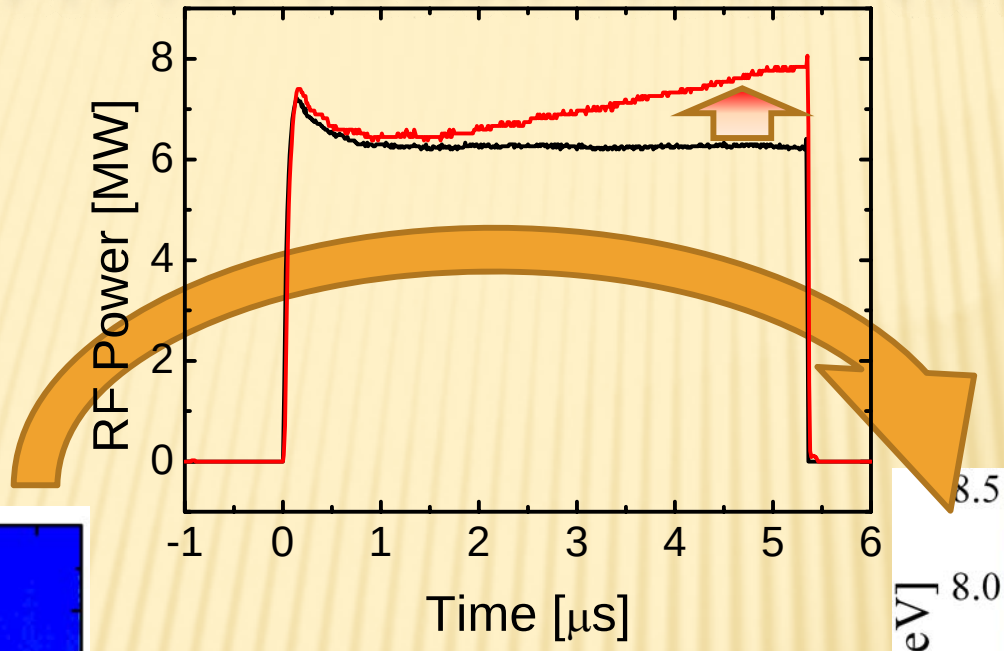
Slim or hollow cathode ×

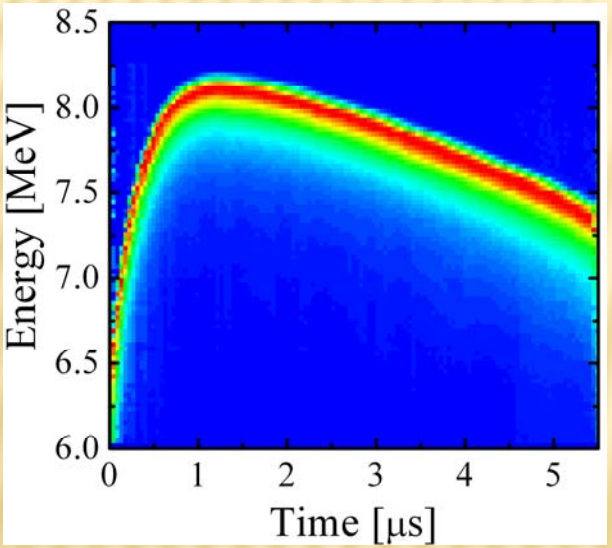
Ba dispenser type W => LaB_6 single crystal ○

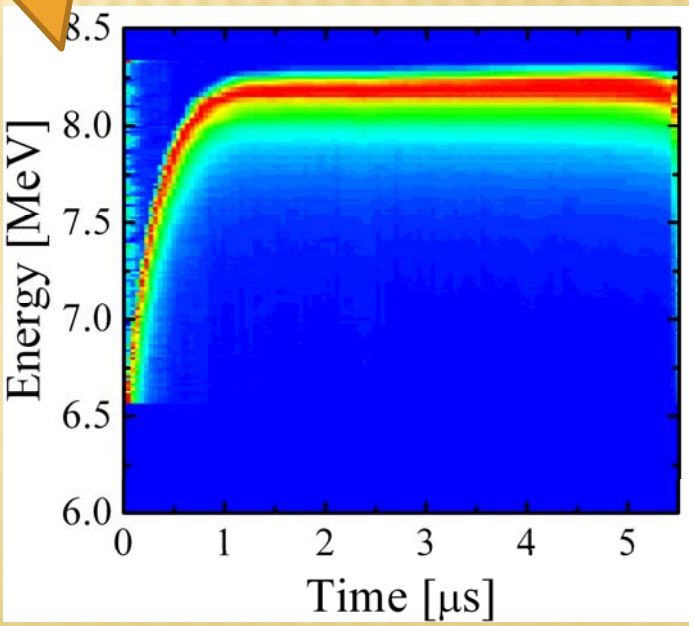
- Amplitude Modulated RF power for gun
- Phase stabilization for gun
- Modulated RF power for Acc ◎
- Phase stabilization for Acc

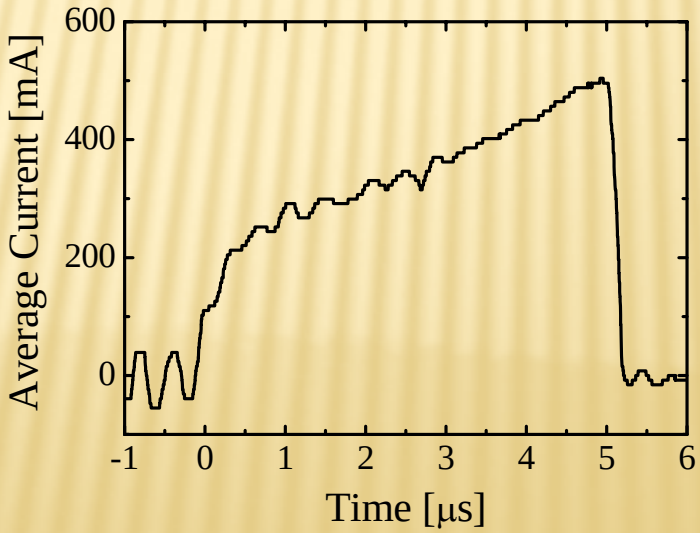
RF detuning in gun cavity ○

MODULATED RF POWER FOR GUN





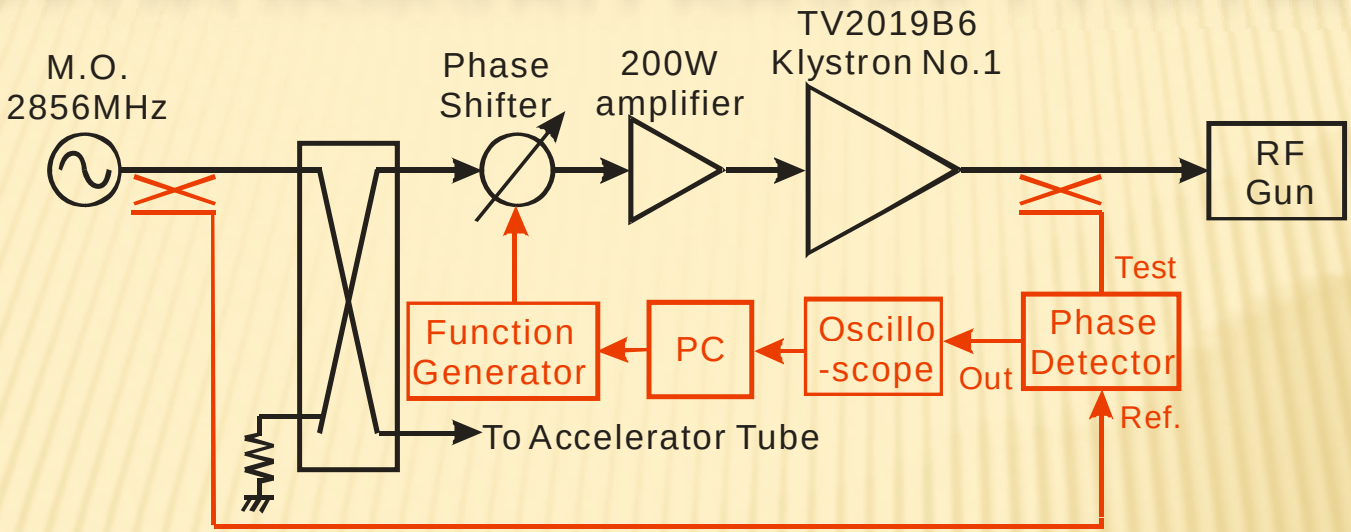


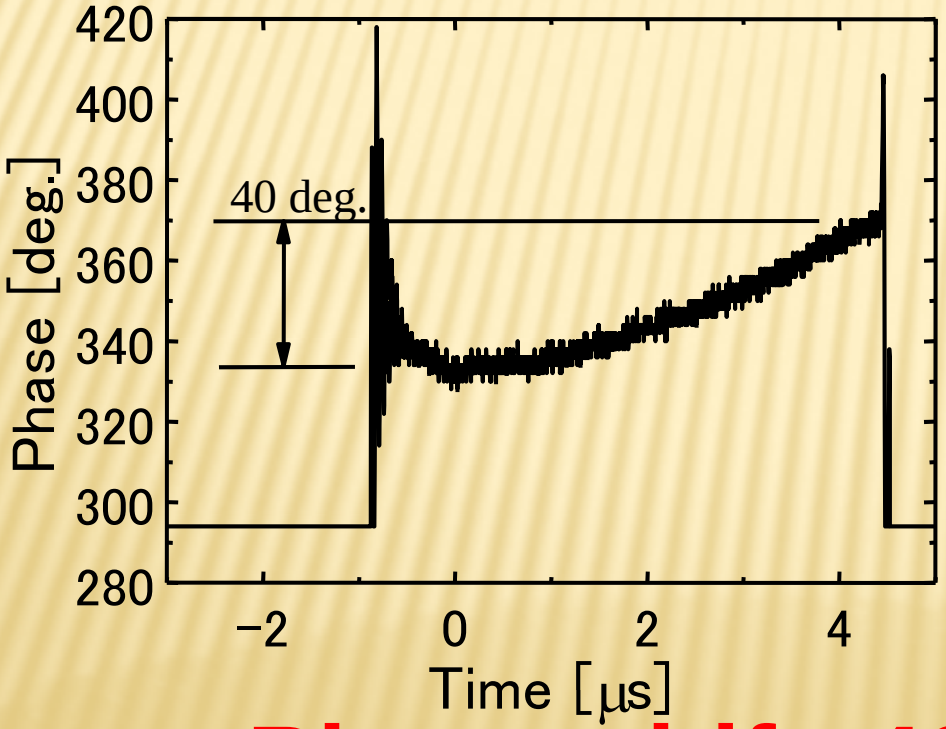


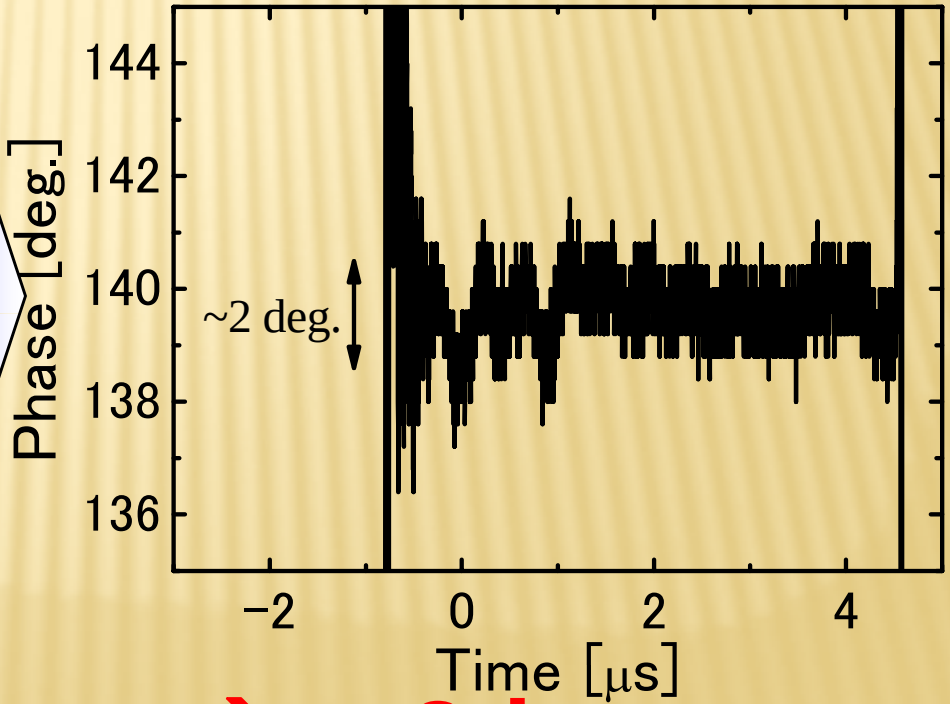
dE/Ee=9.4%
Beam charge = 56 nC
Macro-pulse duration = 0.8 μs

dE/Ee=2.5%
Beam charge = 420 nC
Macro-pulse duration = 4.2 μs

FEEDFORWARD PHASE CONTROL

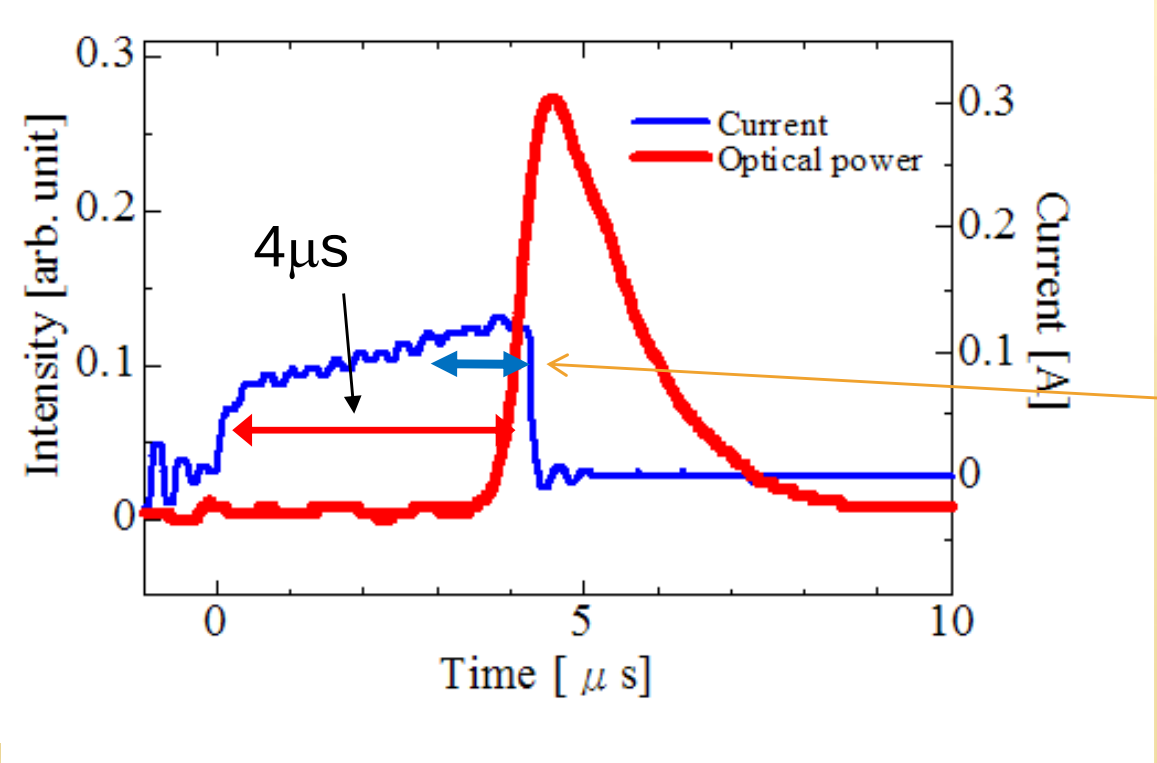






Phase shift : 40deg. → ~ 2deg.

FIRST LASING 2008 MARCH



Electron Beam	
Energy (MeV)	25
σ_E/E (%)	0.5 (~1μs)
Bunch length (ps in rms)	2
Macropulse length (μs)	4
Average current (mA)	90
Peak current (A)	17

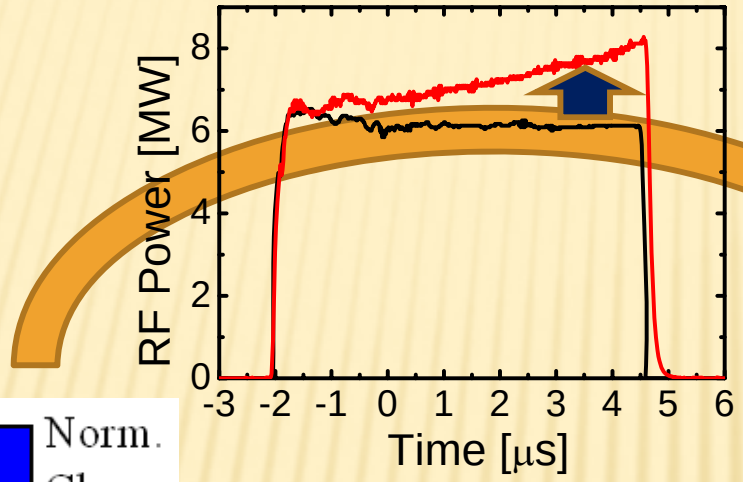
FEL gain was deduced from waveform.

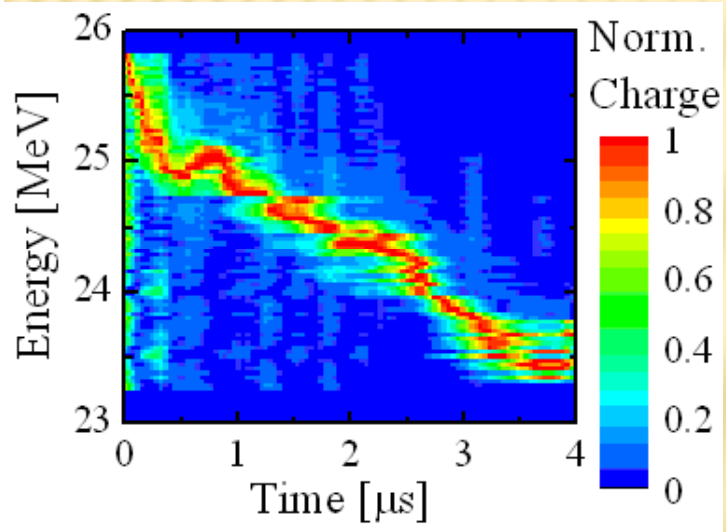
Gain : 16.0%

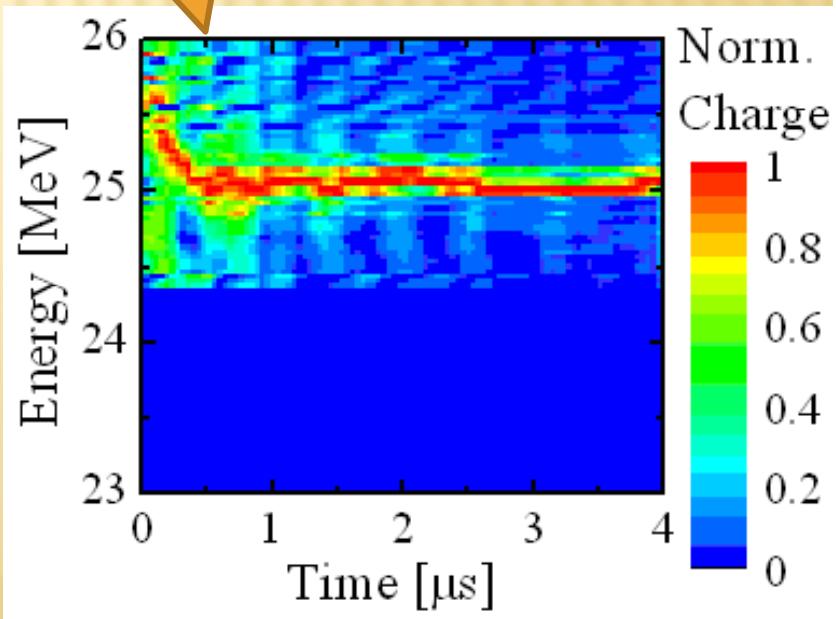
but,・・・was not saturated
Optical power was only 50 times as large as spontaneous radiation.

NEED THE SAME CURES FOR ACC.

Modulated RF power for Acc

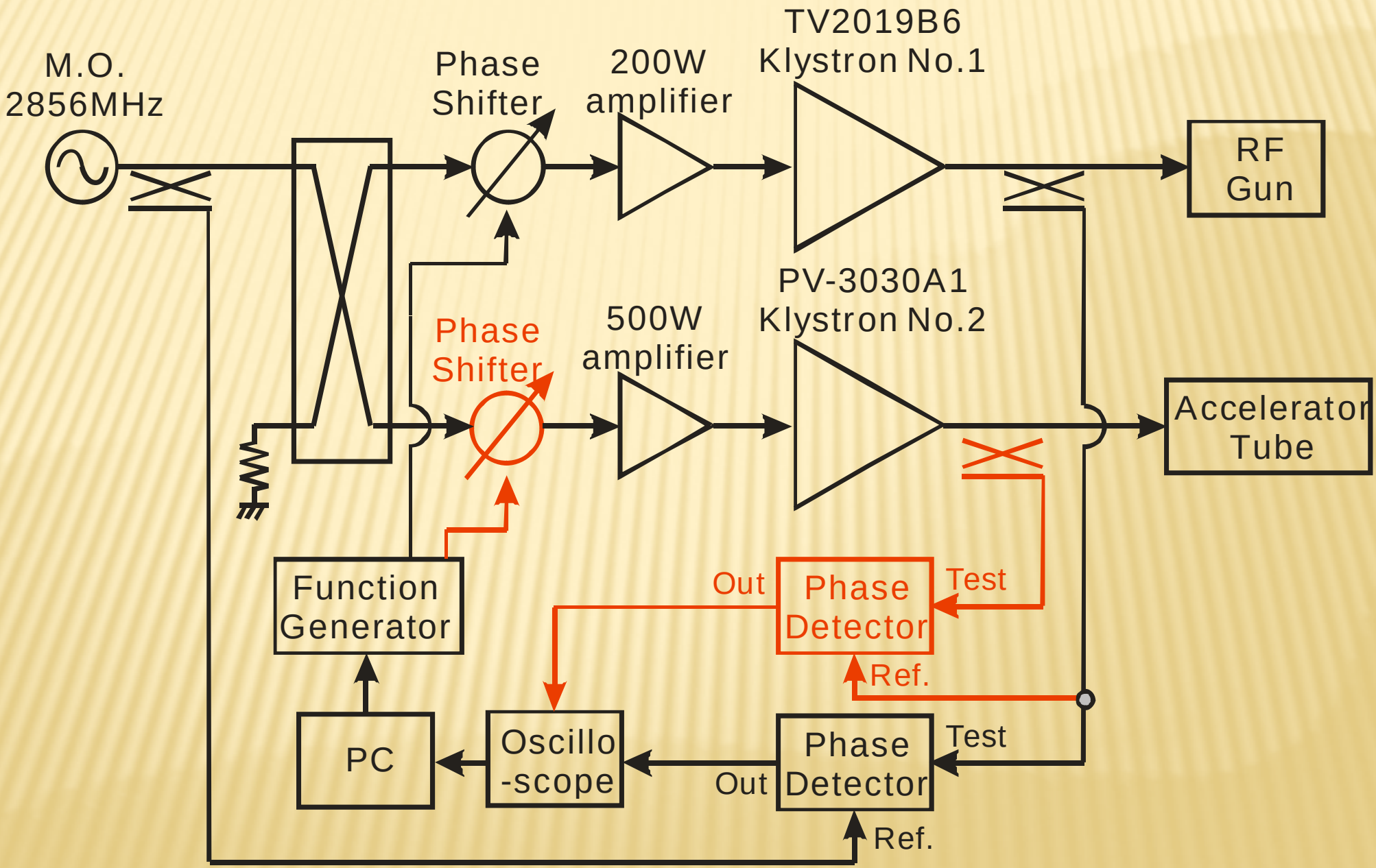




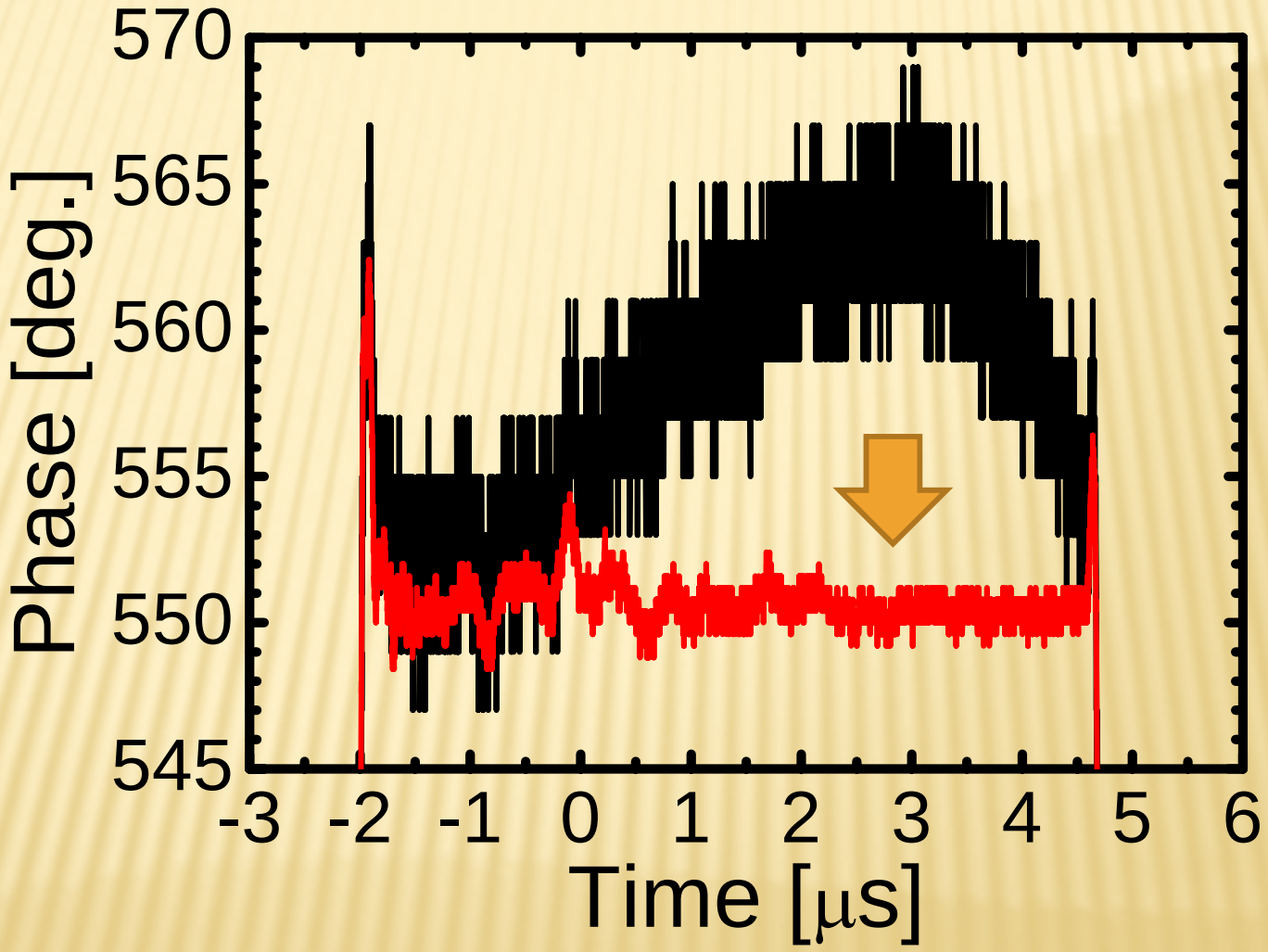


$\Delta E/E$: 6% ⇒0.8%

FEEDFORWARD PHASE CONTROL



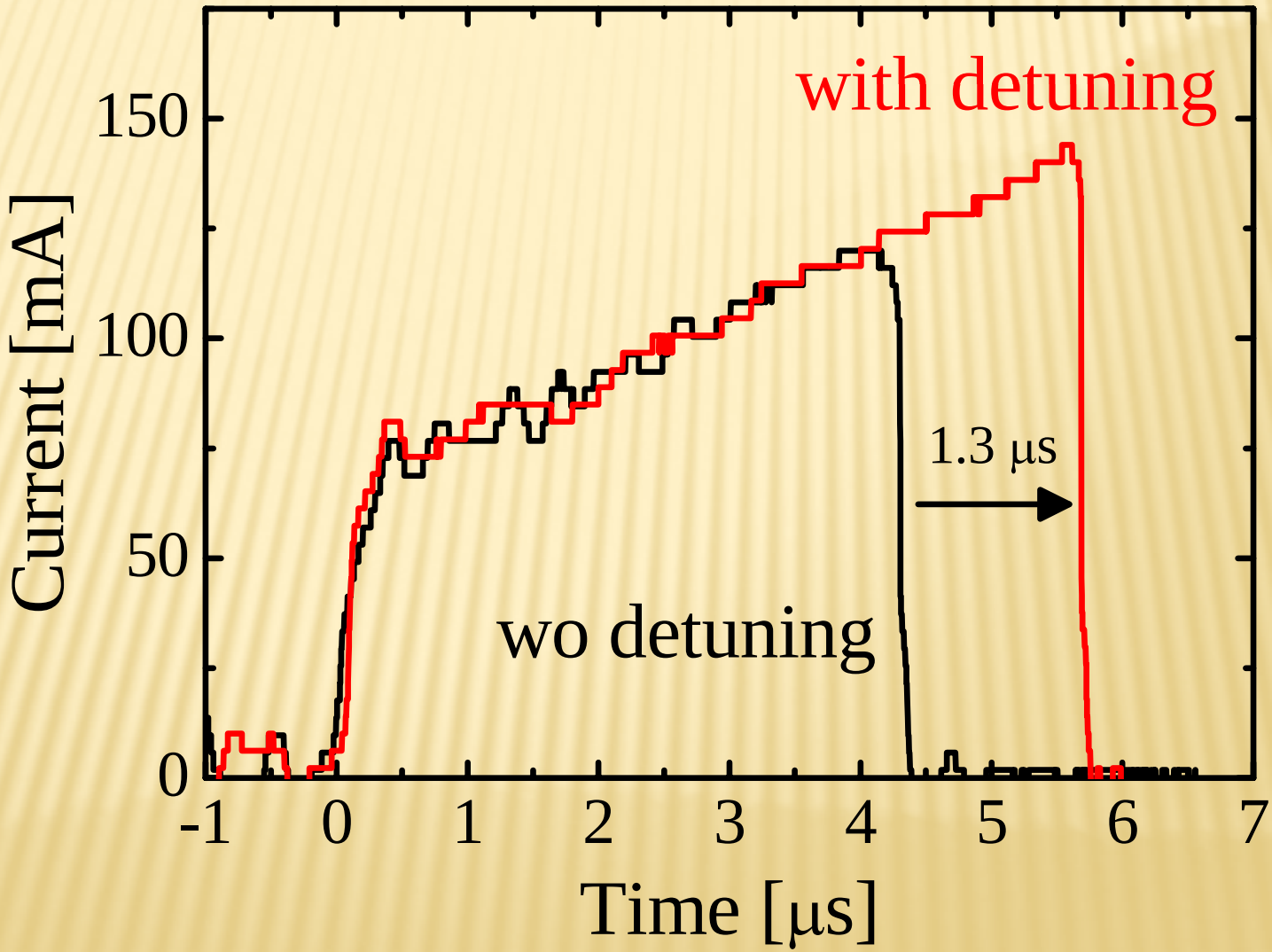
PHASE STABILIZATION FOR ACC.



$\Delta\phi$: 15 deg. ⇒ 2 deg.

RF DETUNING FOR GUN CAVITY

Resonant frequency: 2856 MHz → detuned +290 kHz



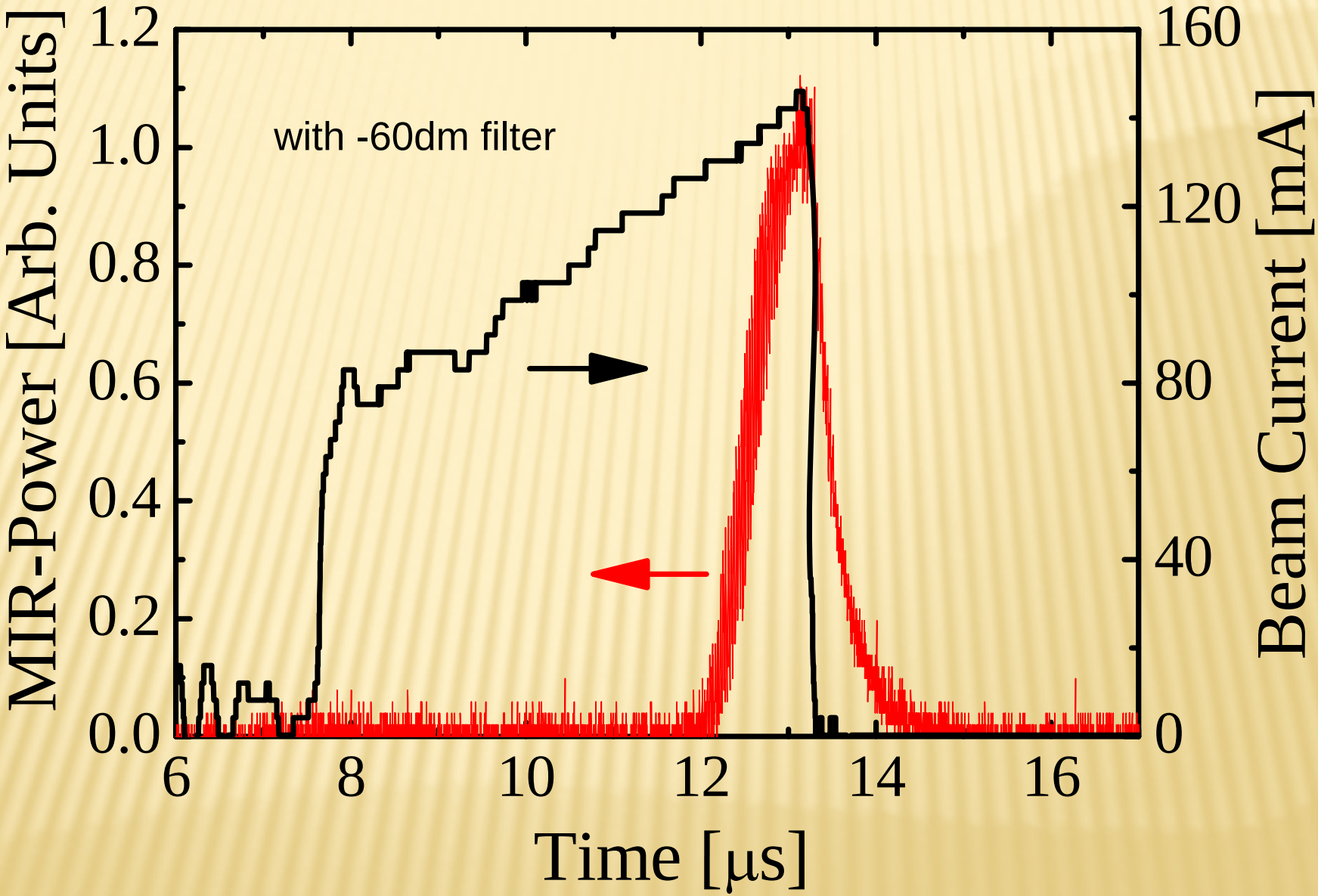
Details will be presented by H. Zen, TUPPH052.

BEAM CONDITIONING SUMMARY

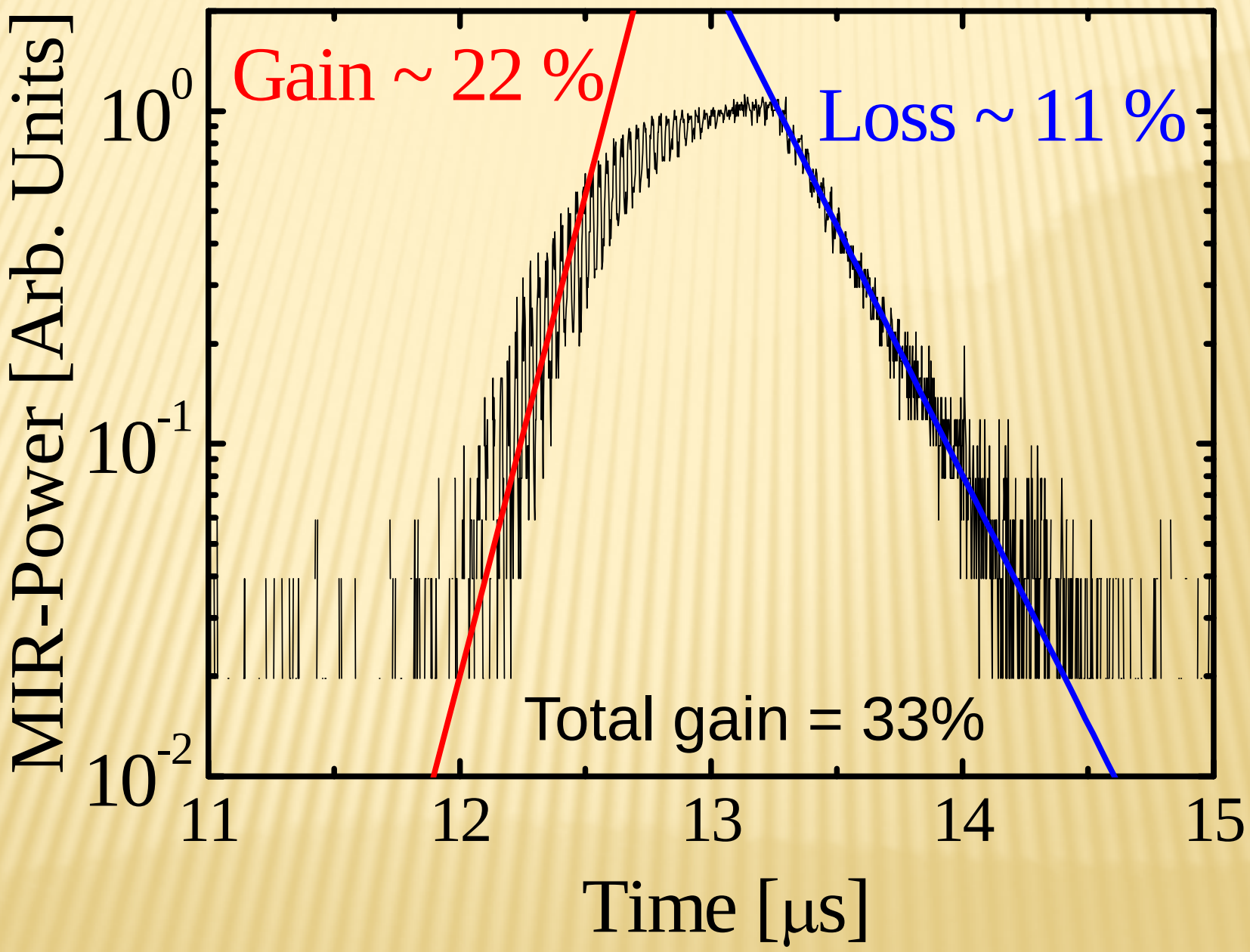
	Sweep Magnet, LaB_6	+ RF amplitude modulation	+ RF detuning
Macro-pulse duration (μs)	0.8	4.0	5.5
Average Current (mA)	70	100	115
Total Charge (nC)	56	400	630
Peak Current (A)	-	17*	21*

*deduced from FEL gain by use of GENESIS calculation

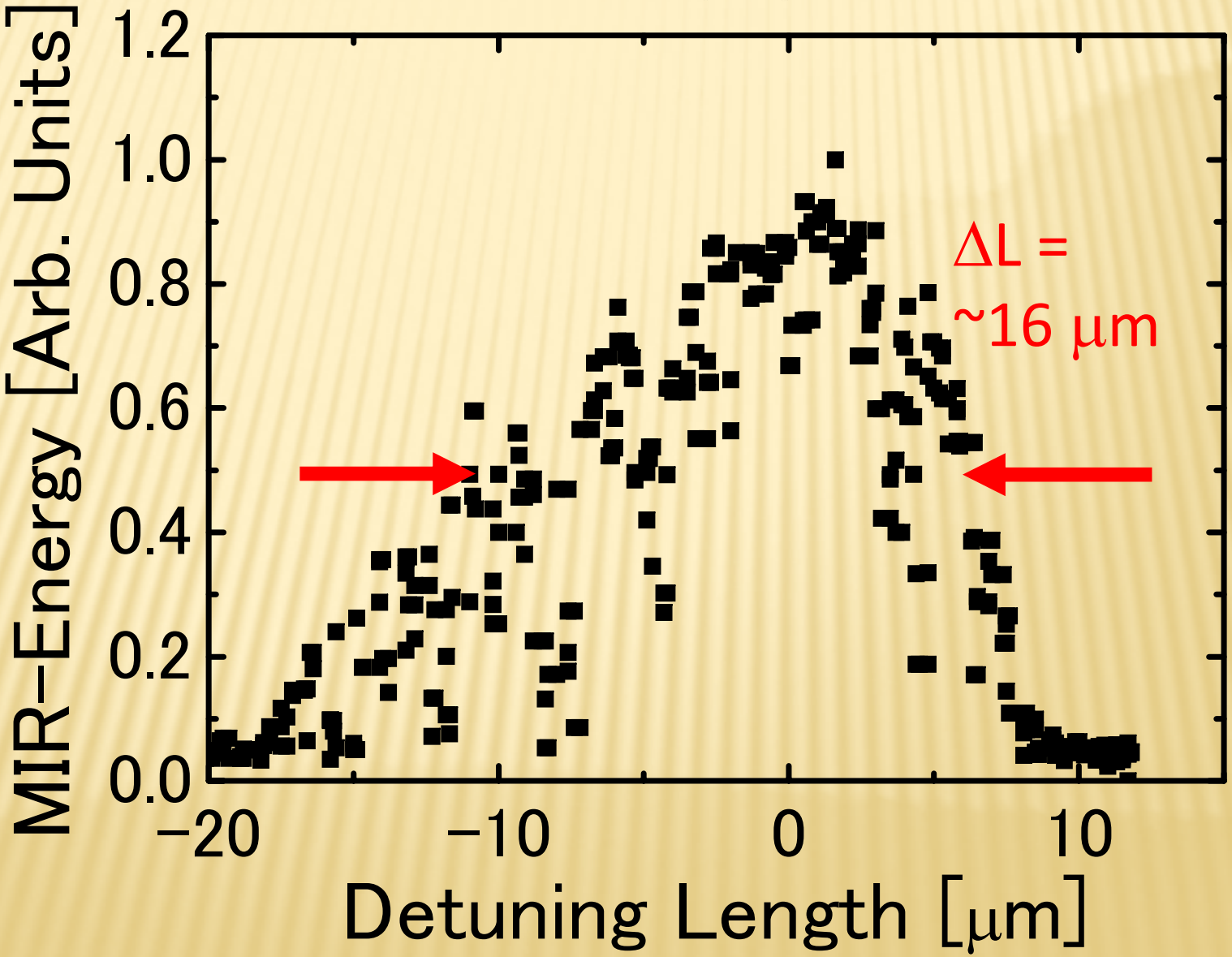
FEL GAIN SATURATION 2008 MAY



Measured with high speed MCT(τ=10 ns)

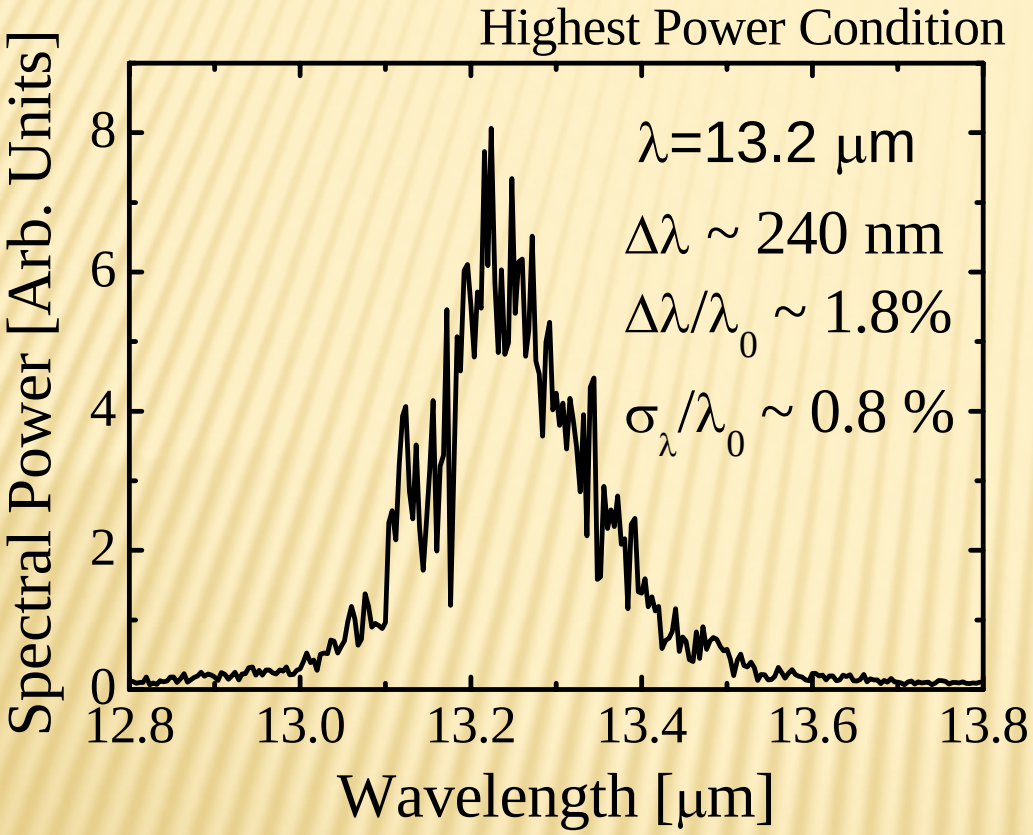

Gain ~ 22 %
Loss ~ 11 %
Total gain = 33%
MIR-Power [Arb. Units]
10^{0}
10^{-1}
10^{-2}
11
12
13
14
15
Time [μs]

POWER DEPENDENCE ON OPTICAL-CAVITY DETUNING

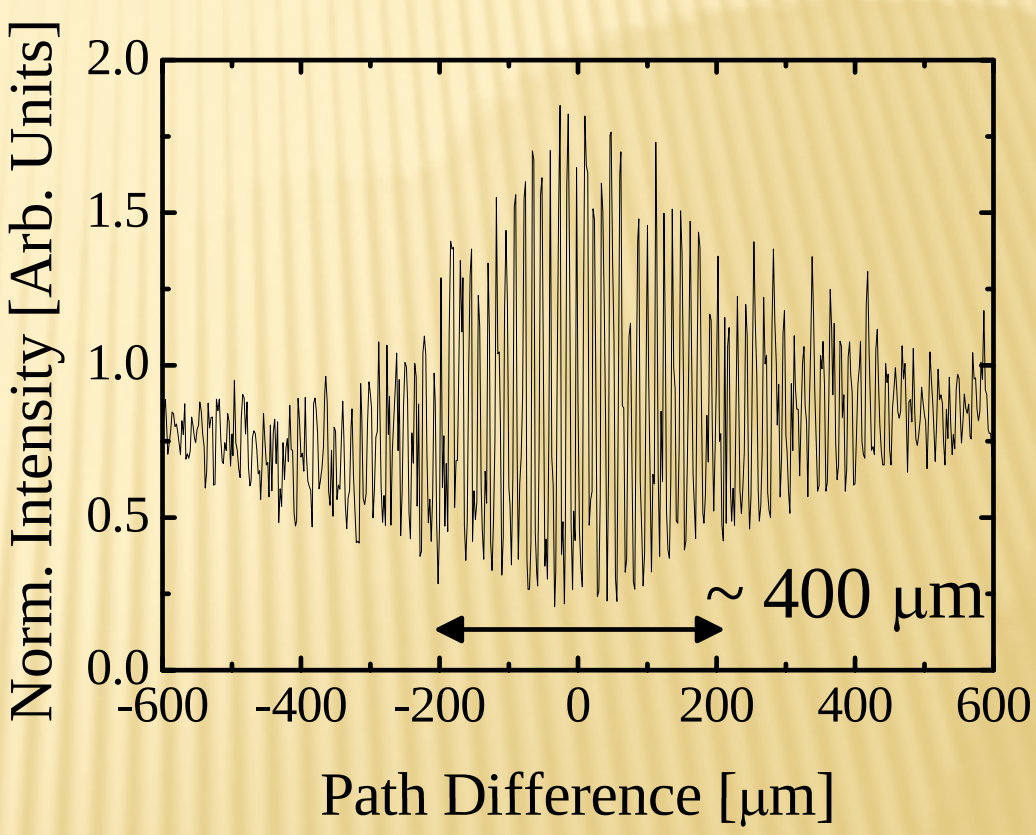


OPTICAL PROPERTIES

Wavelength Spectrum

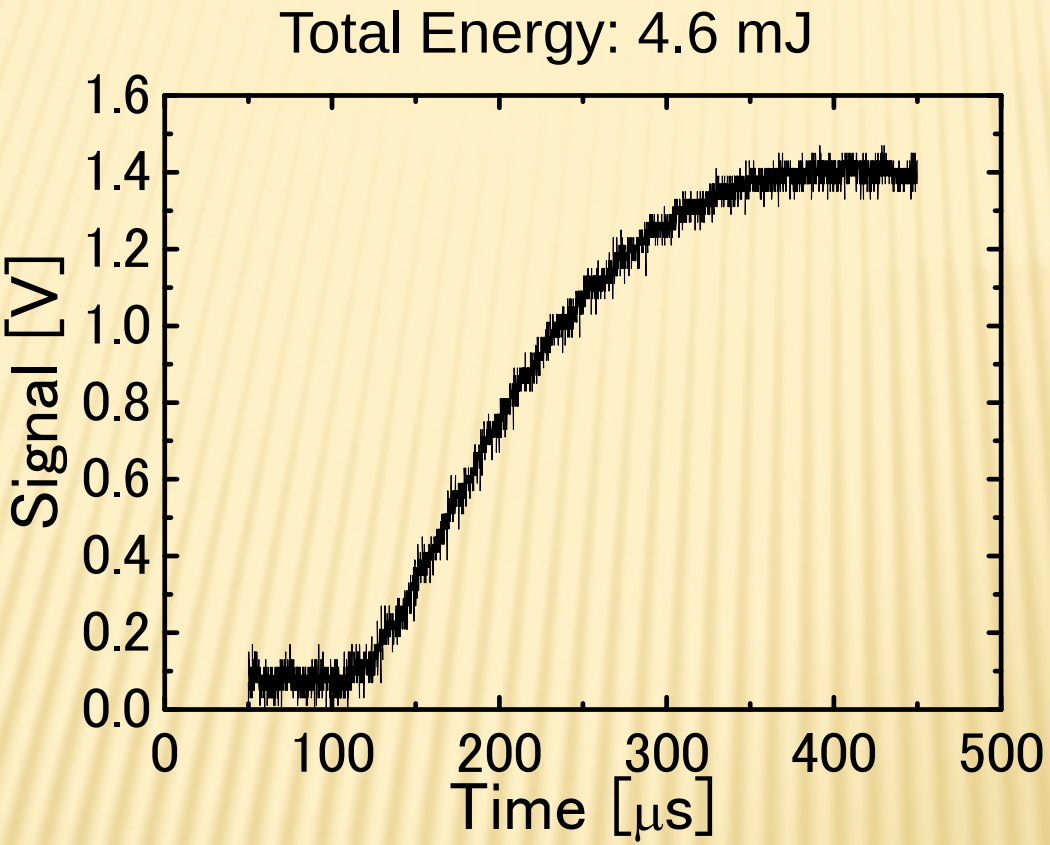


Interferogram



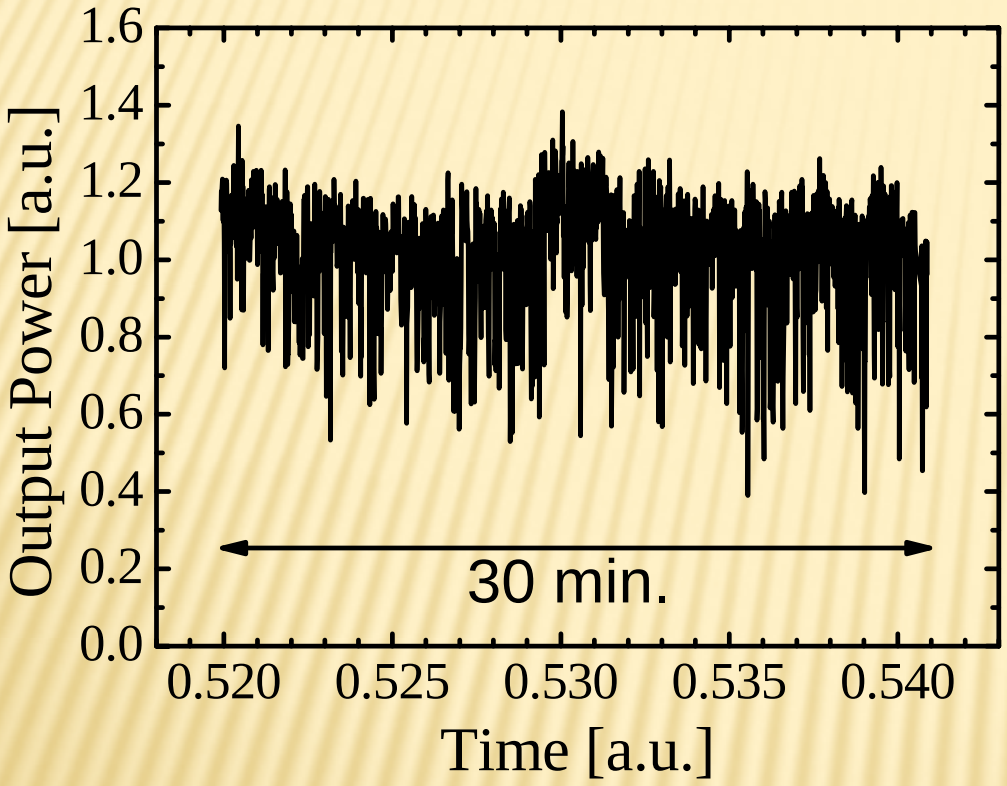
400 μm path difference
→~700 fs coherent length

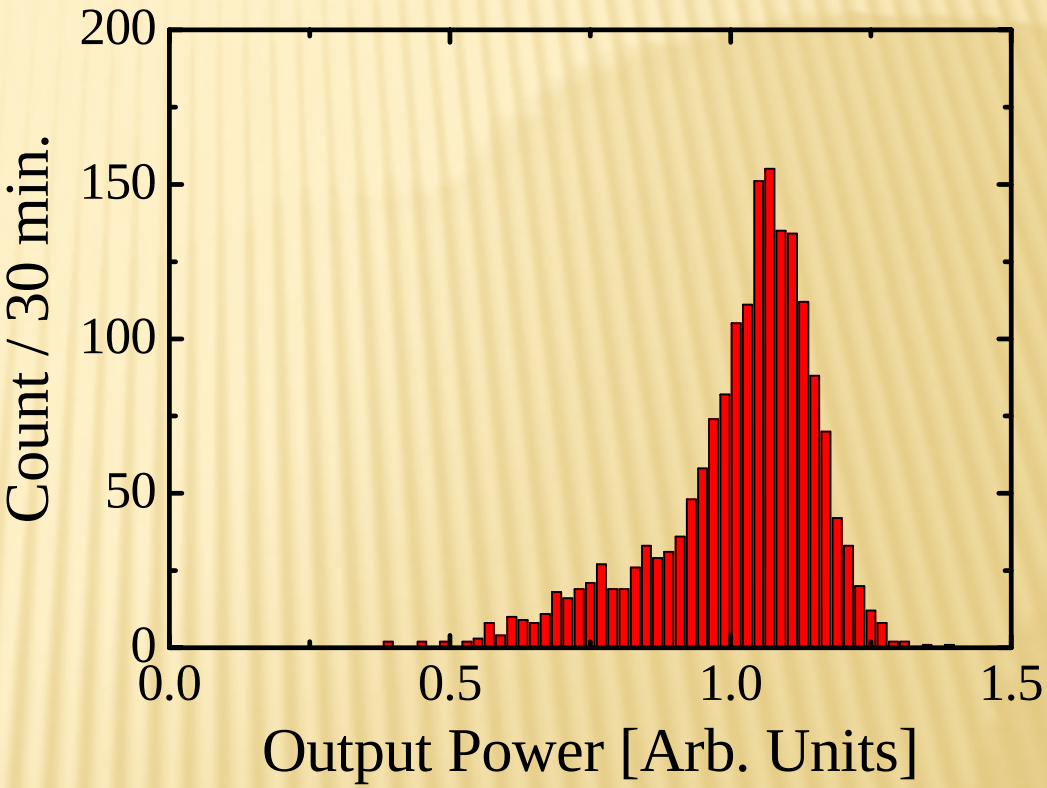
FEL POWER MEASUREMENT



Average Power : 4.6 mW (1 pps)
Peak Power : 2.9 MW
Micropulse Duration : ~700 fs

POWER STABILITY

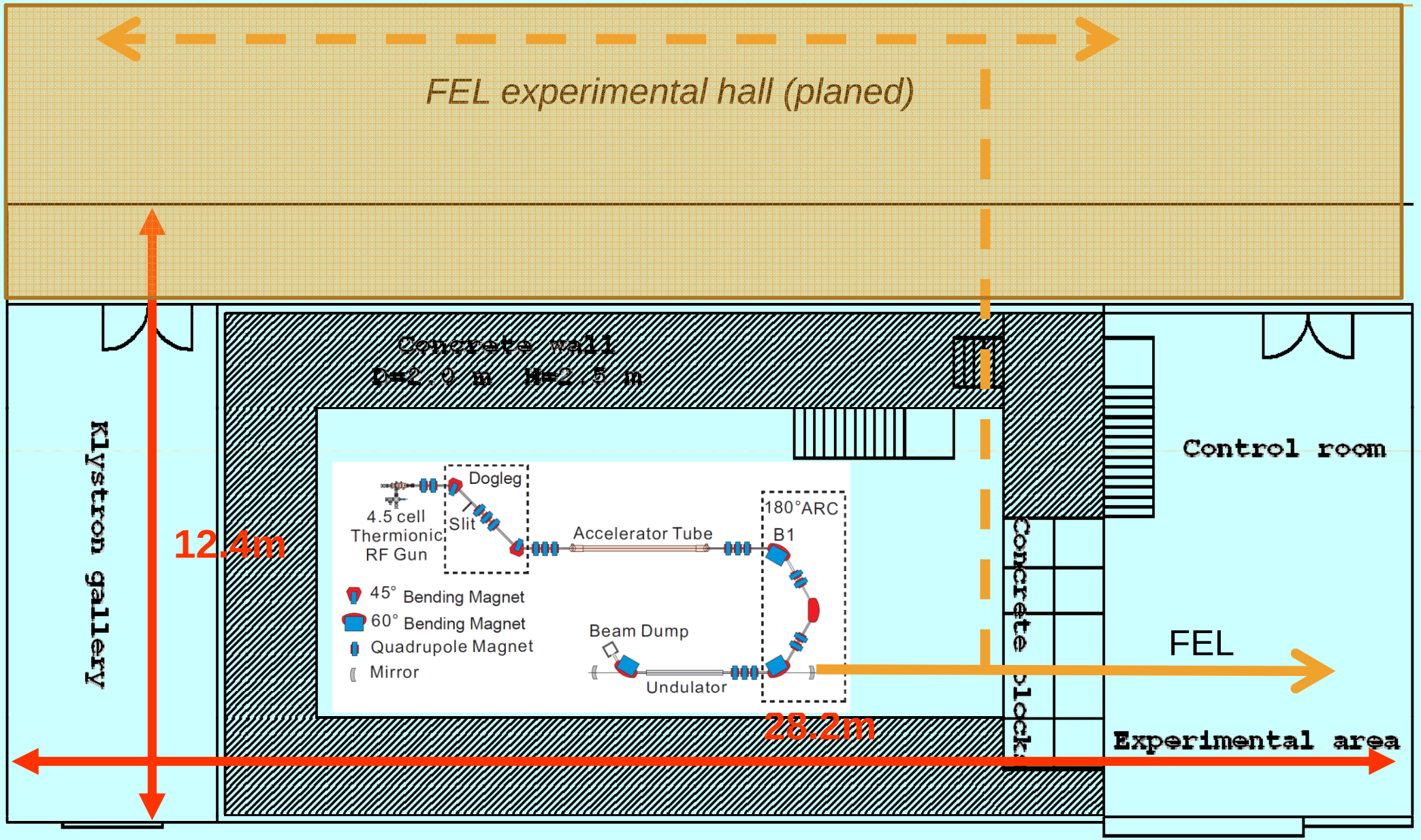




Power Stability (rms) = 14 %

CONCLUSION

- First lasing in 12.4 μm was observed in KU-FEL in 2008 March.
  - RF modulation, phase control for Gun and Acc.
  - RF detuning for Gun.
- FEL power saturation was achieved in 2008 May.
- FEL parameter
  - wavelength: 12 – 14 μm (Goal : 4-14 μm)
  - spectral width: ~1%
  - pulse duration: ~700 fs
  - peak power: 2.9 MW
  - average power: 4.6 mW (1 pps)


FEL experimental hall (planed)
Concrete wall
D=2.0 m H=2.5 m
Klystron gallery
Control room
12.4m
Dogleg
4.5 cell
Thermionic
RF Gun
Slit
Accelerator Tube
180°ARC
B1
45° Bending Magnet
60° Bending Magnet
Quadrupole Magnet
Mirror
Beam Dump
Undulator
FEL
28.2m
Experimental area

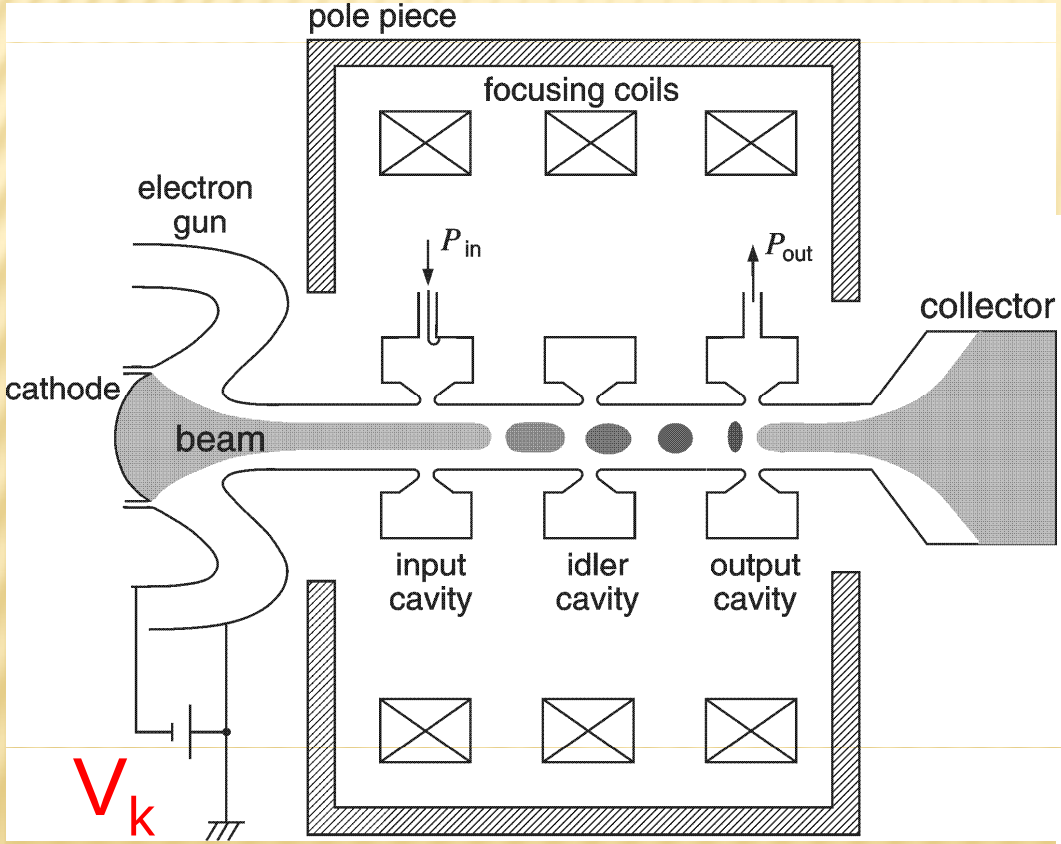
Phase shift due to amplitude modulated RF method

Time varied HV for klystron

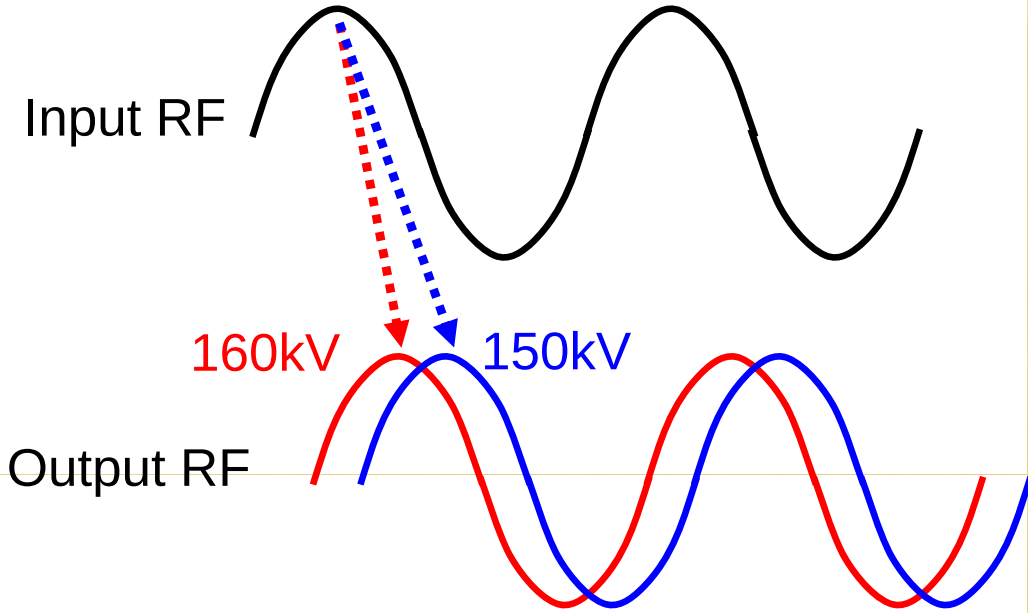
Amplitude modulated RF

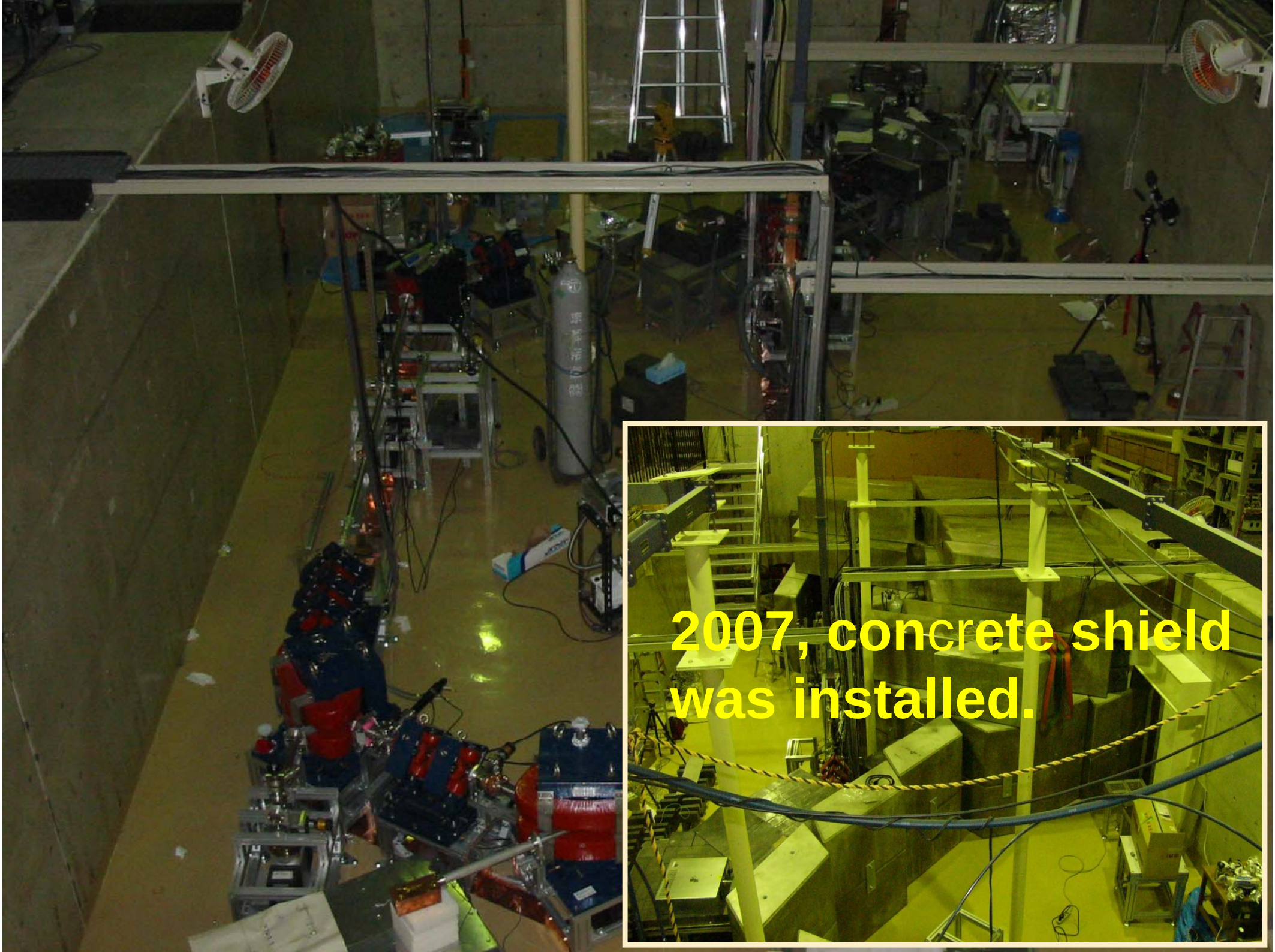
Electron speeds also varied.

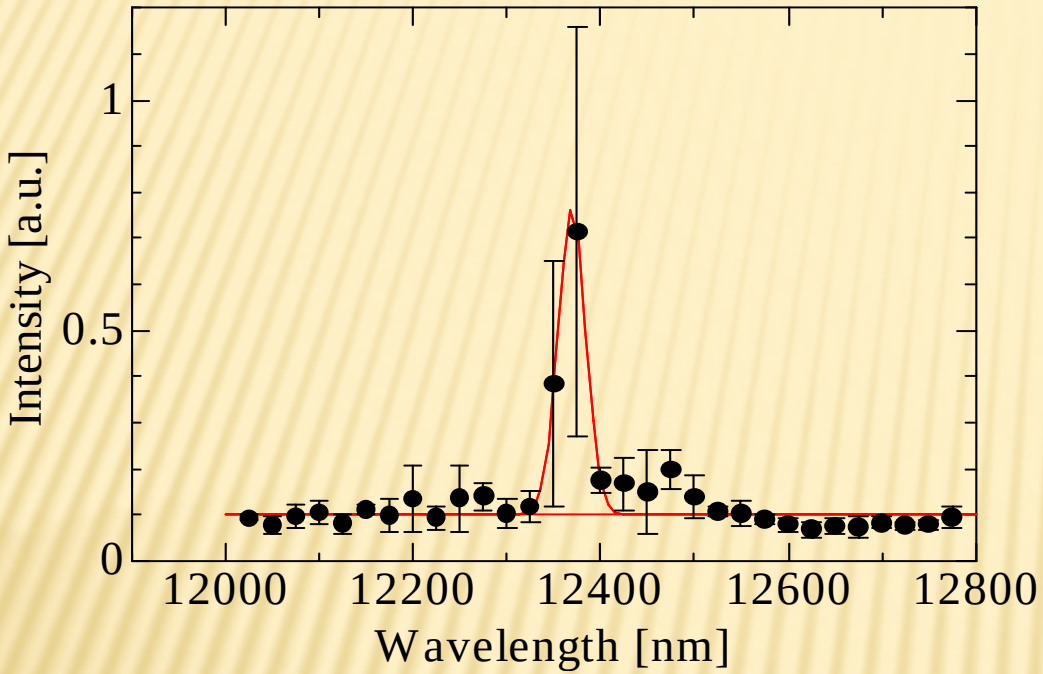
Phase shift in RF power

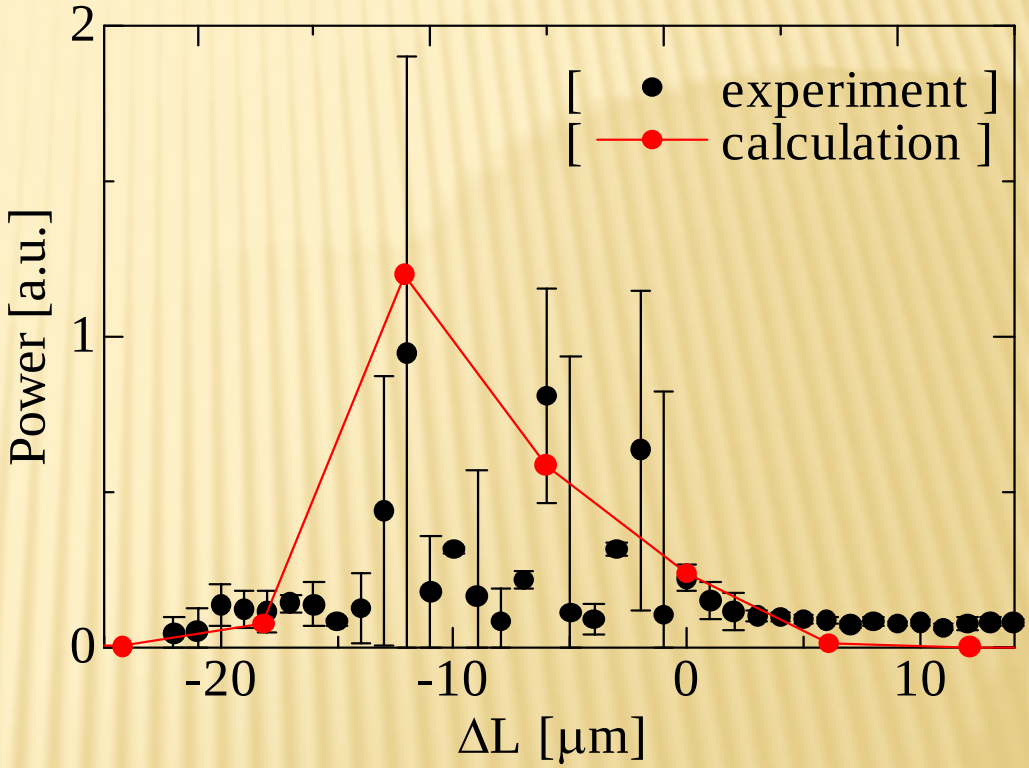


Schematic view of Klystron



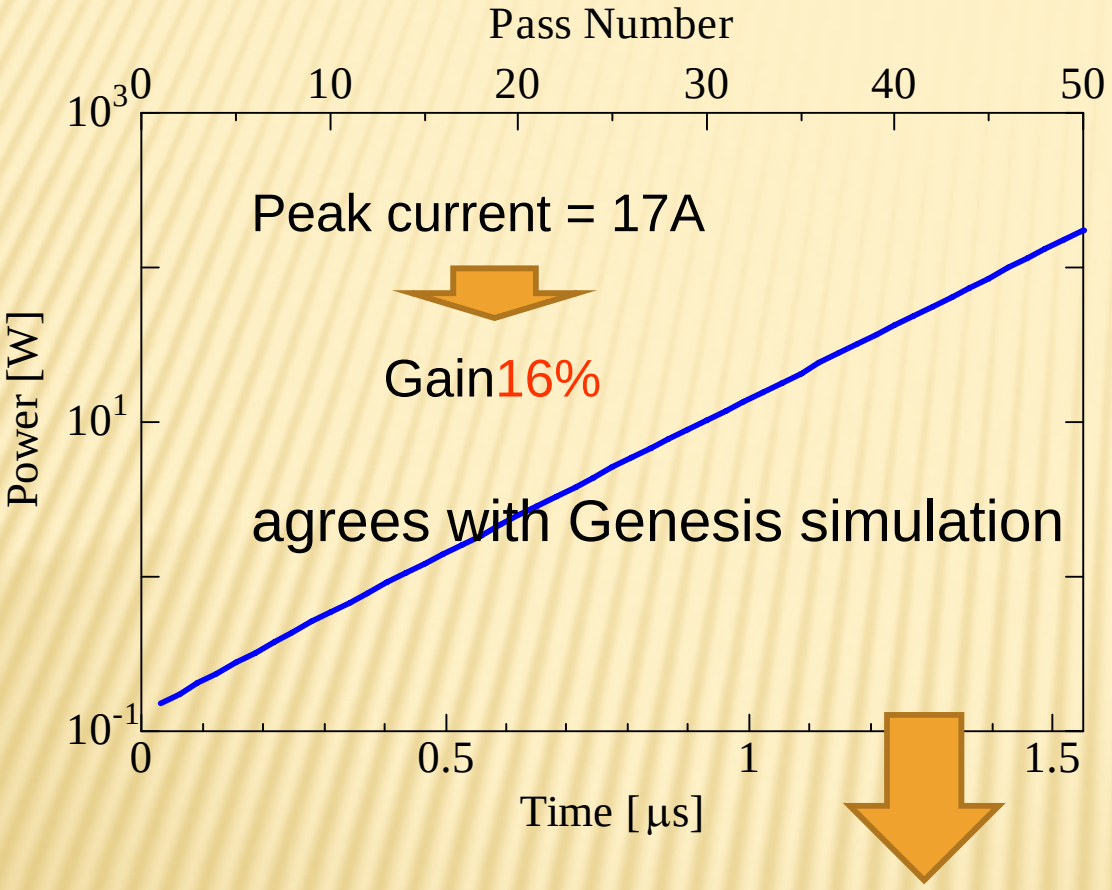

2007, concrete shield
was installed.

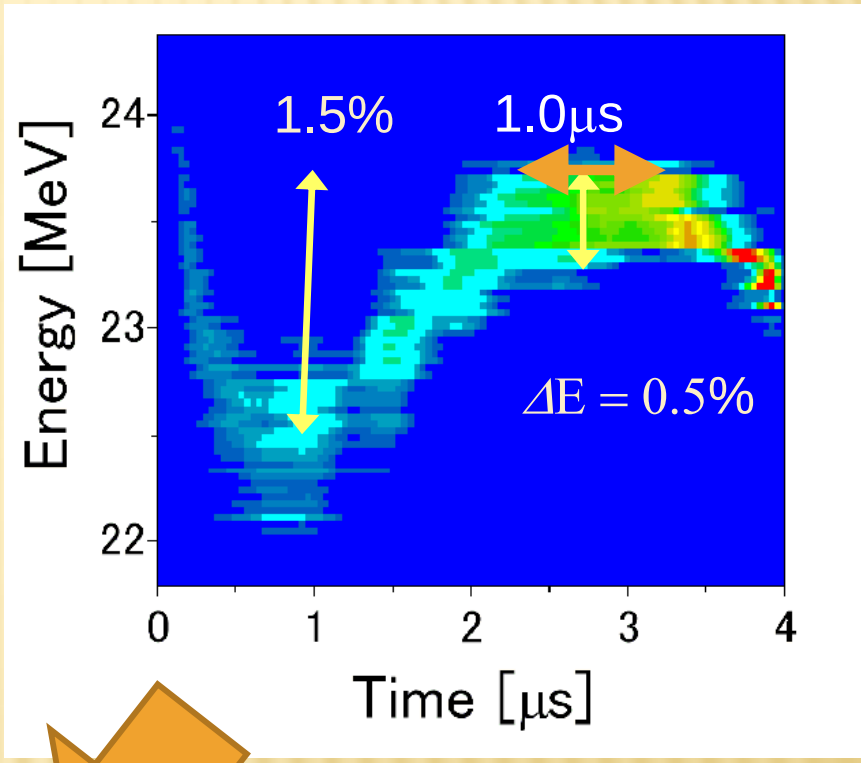




Lasing at 12.4 μm, but very unstable…

WHY SO SMALL OUTPUT?

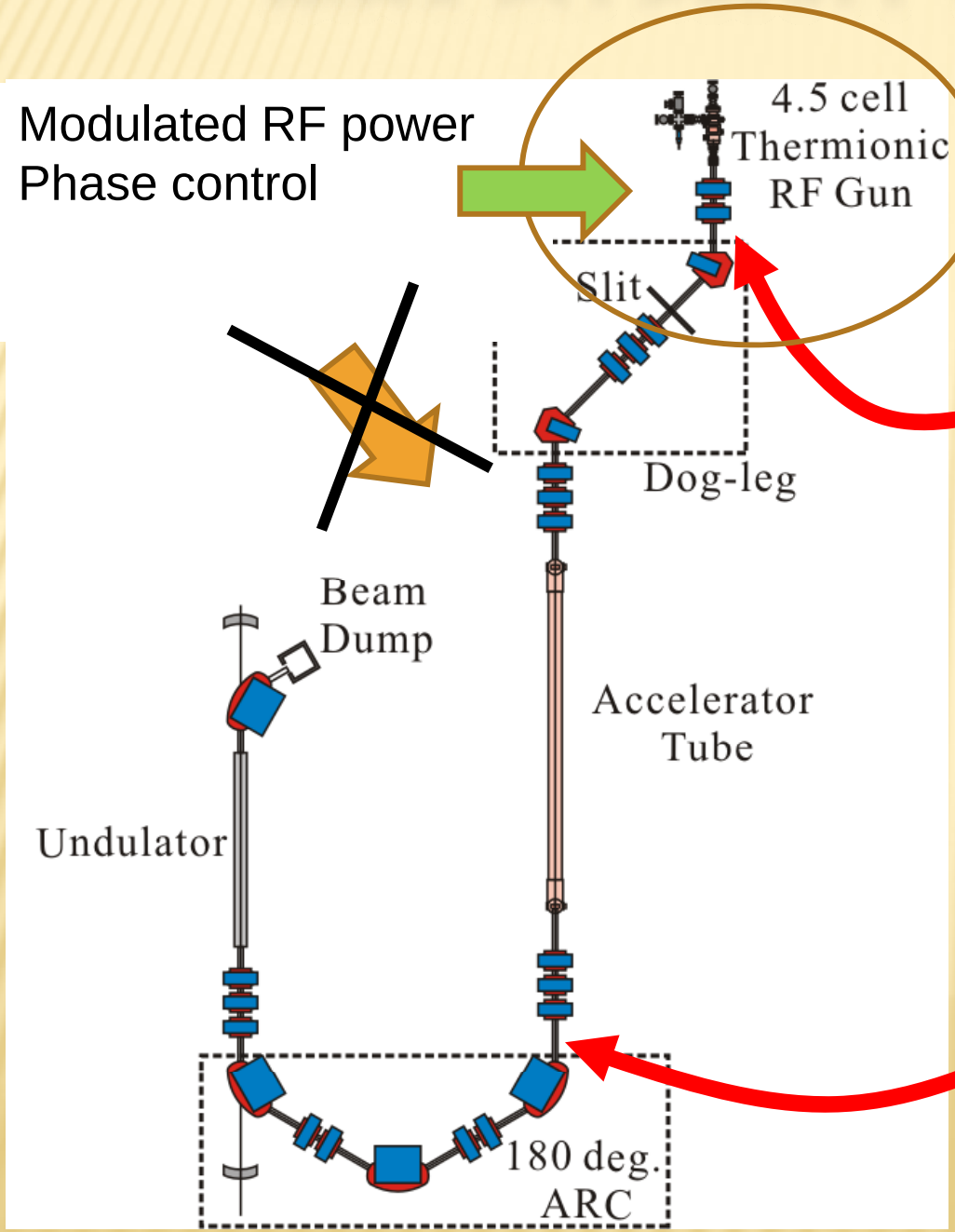


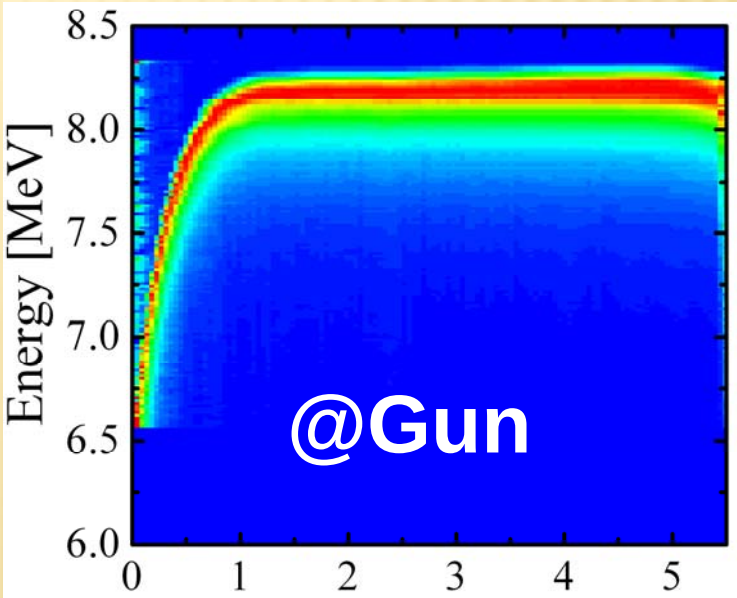


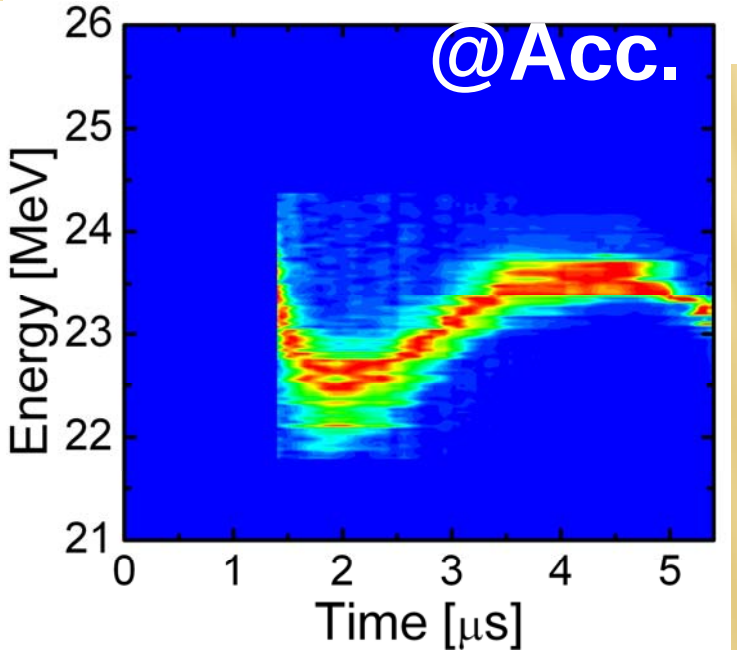
Buildup time <1.0μs

A <1.0μs electron beam contributed for lasing.

WHY SO SMALL OUTPUT?

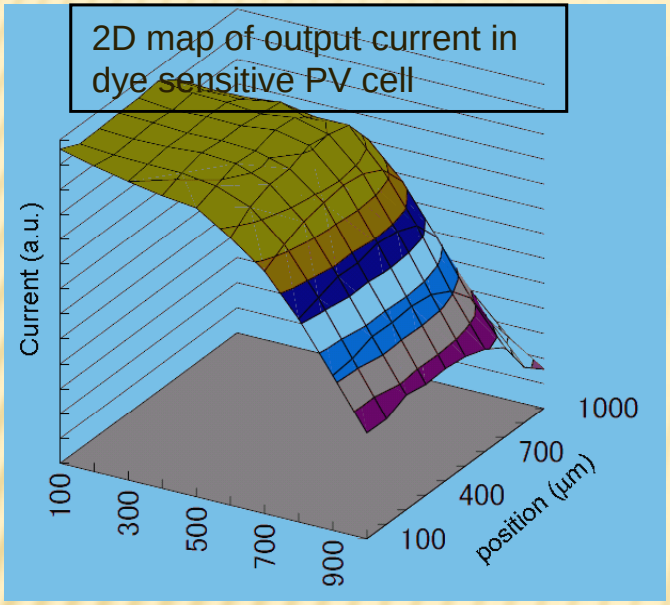




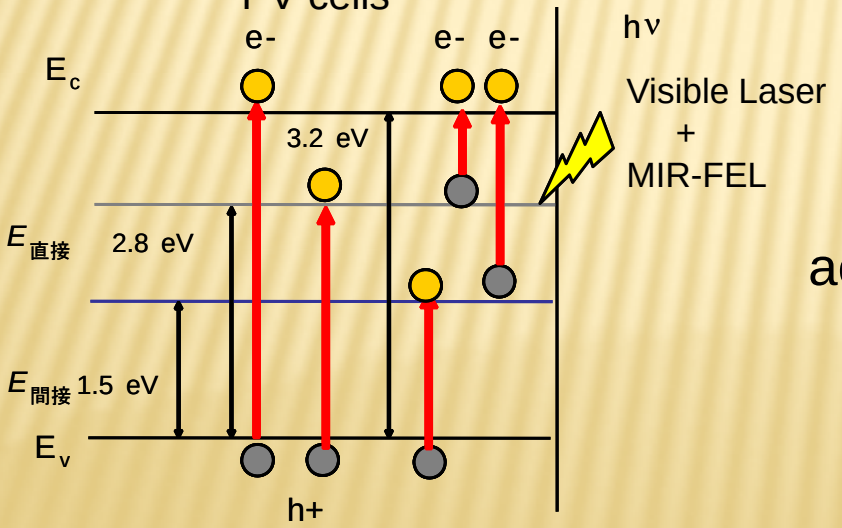


Photovoltaic Cell

∗ Non-destructive evaluation of Photovoltaic cells by use of Laser Beam Induced Current Method

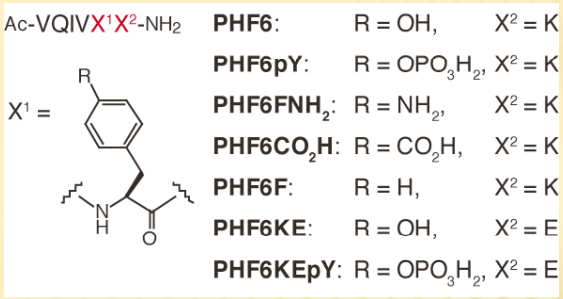


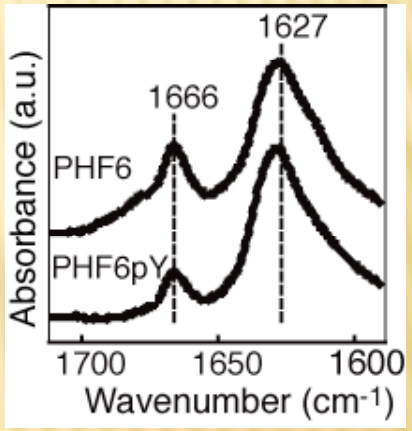
∗ Study on intermediate band in PV cells

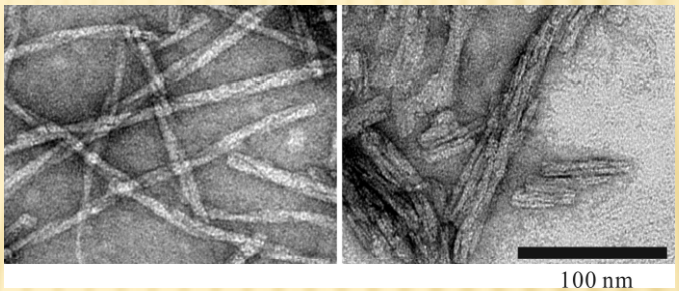


Biochemistry

∗ Selective excitation of amyloid-beta derived diffusible ligands







Environment

∗ Aerosol analysis by MIR-FEL