Nextef high power establishment

Shuji Matsumoto
Accelerator Lab., KEK

What is Nextef?

Nextef stands for New X-band Test Facility. The “old” X-band facility in Assembly Hall was relocated to KEKB Injector Hall in 2007, in order to continue the high power test of the X-band accelerator structures.

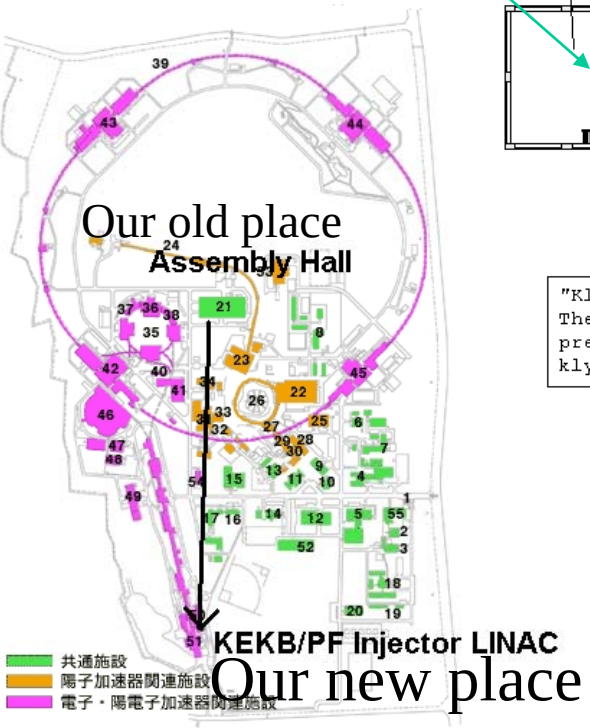
Key equipment such as a modulator or klystrons as well as other minor but essential materials were selected and moved to the new place. The construction work of Nextef started in May 2007 and mostly finished in Aug 2007.

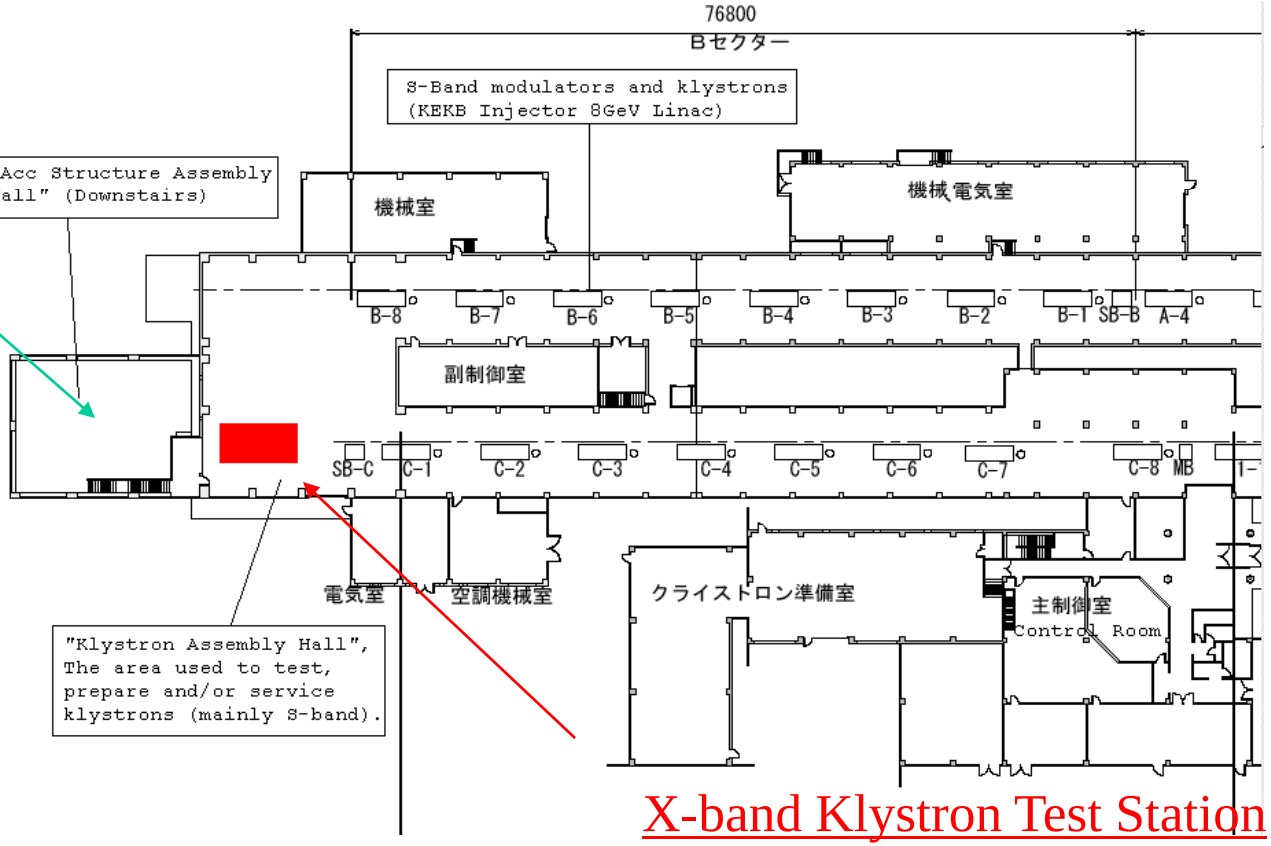
We expect the production of 100MW RF power, enough for the structure test, by combining the output power of two PPM klystrons.

Operation of Nextef started in September 2007. We are (still) in a way to the ultimate goal: 100MW production with 400ns width, 50pps.

Where is it?

Nextef.





X-band Klystron Test Station

KT-1

Narrow Waveguide Test is ongoing here.

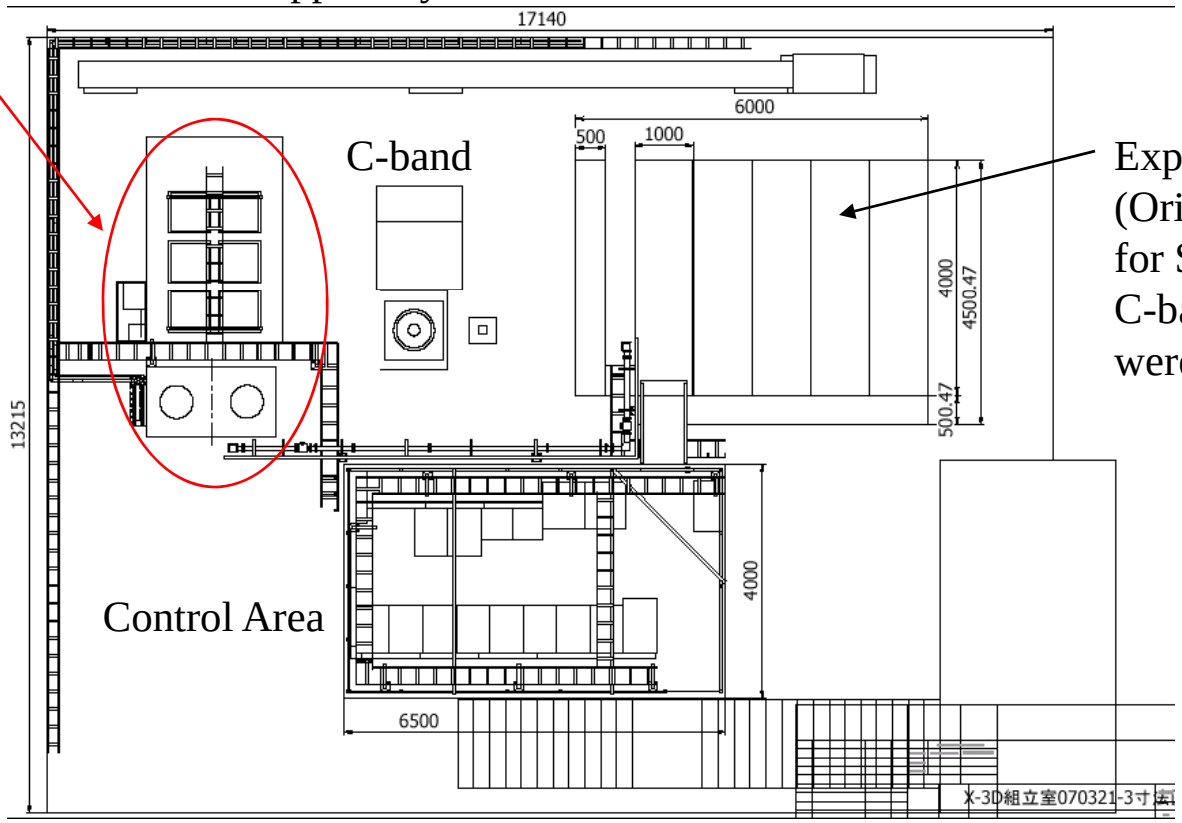
Plan view of KEKB Injector

Spec of the Facility

	Nextef	**KT-1**
Max Peak power	100MW	50MW
Max Pulse width	400ns	
Max Rep. Rate	50pps	
Operation Schedule	Linked with Injector Schedule.	24hr.
Possible use	Structure test in the bunker.	Klystron test, High field experiment

XTF modulator and X-band ppm Klystrons

Plan view of Nextef

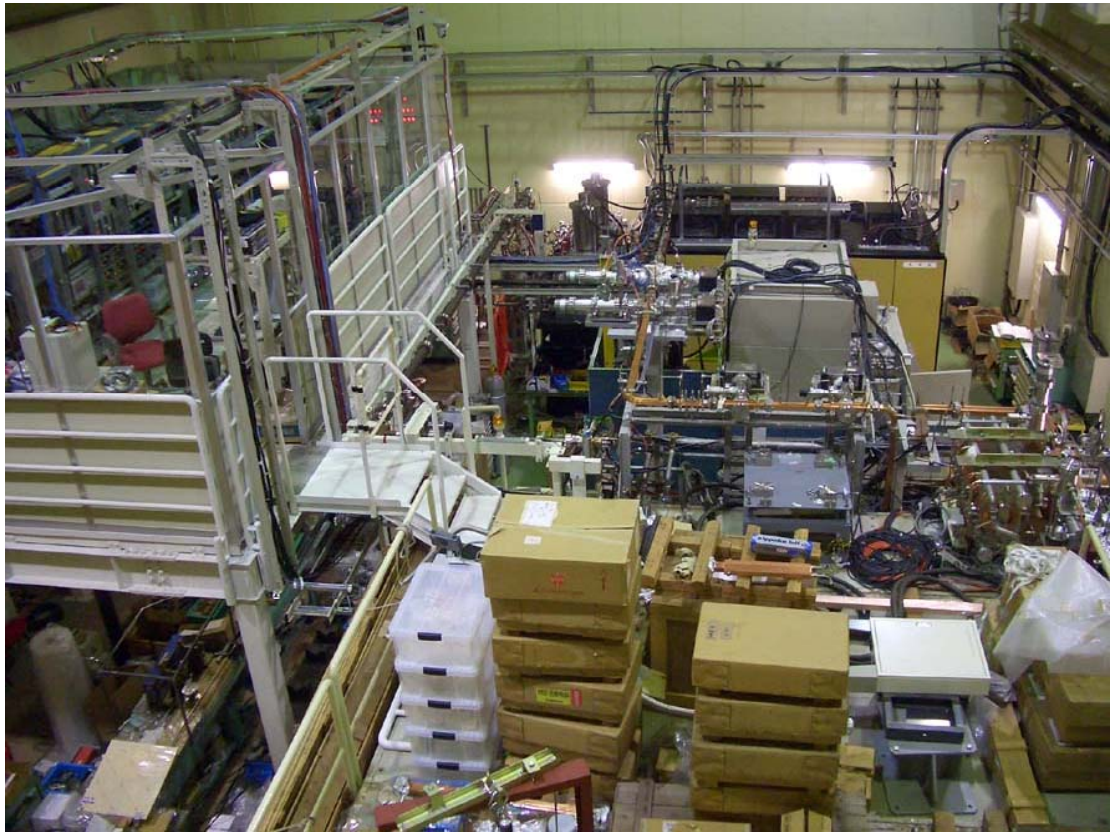


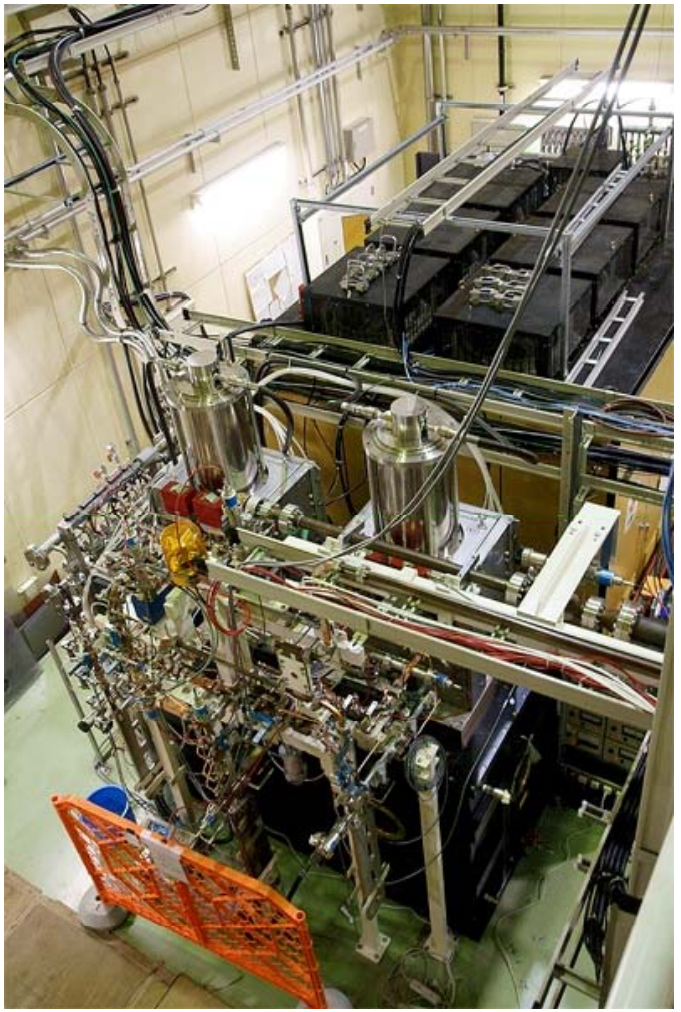
Exp. Area (bunker)
(Originally constructed for S-band structure test. C-band structure tests were also done here.)

- XTF Modulator drives two PPM X-band klystrons.
- The combined power from the klystrons is guided into the experimental area (bunker).
- The control/monitor station is located between the power source and the bunker.

Nextef progress

Establishing power generation and transport in 2007





We use the PPM klystrons in Nextef. Why?

The space and utility for Nextef are limited (as you will see in the tour). We found it very difficult to use our solenoid-focussed klystron due to these limitations.

Required power is 100MW, 0.4us, 50pps for the structure test. We are confident to that a single ppm klystron can produce stable 50MW 0.4us RF from the test result.
The power of 100MW should be possible by combining the power of the two ppm klystrons.

We have experienced to operate X-band Test Facility in Assembly Hall for the structure tests for almost one year with two ppm klystrons, although the maximum combined power was some 70MW 0.4us 50pps at that time. We have had no problem with the klystrons then.

We decided to employ ppm klystrons in Nextef eventually.

KEK-Toshiba X-band PPM Klystron

PPM=Periodic Permanent Magnet

PPM4A (built in 2003)

Originally developed for GLC (Global Linear Collider) project, formerly known as 75MW klystron.

Successfully demonstrated 75MW peak power with 1.6 us pulse width although its stability was not so good at these ultimate peak power.

We have 4 ppm klystrons alive. Among these, 1 tube is now being repaired. Rest of all are working.

Performance
of the recent KEK-Toshiba Xband PPM tubes

Frequency	11.424GHz
Peak Power	50MW
Cathode Voltage	460kV
Cathode Current	237A
Perveance	0.76 μK
Efficiency	46%
Gain	53dB
RF pulse length	0.4 μsec
Repetition Rate	50pps
Band Width	80MHz (-1dB)
# of cavities	7

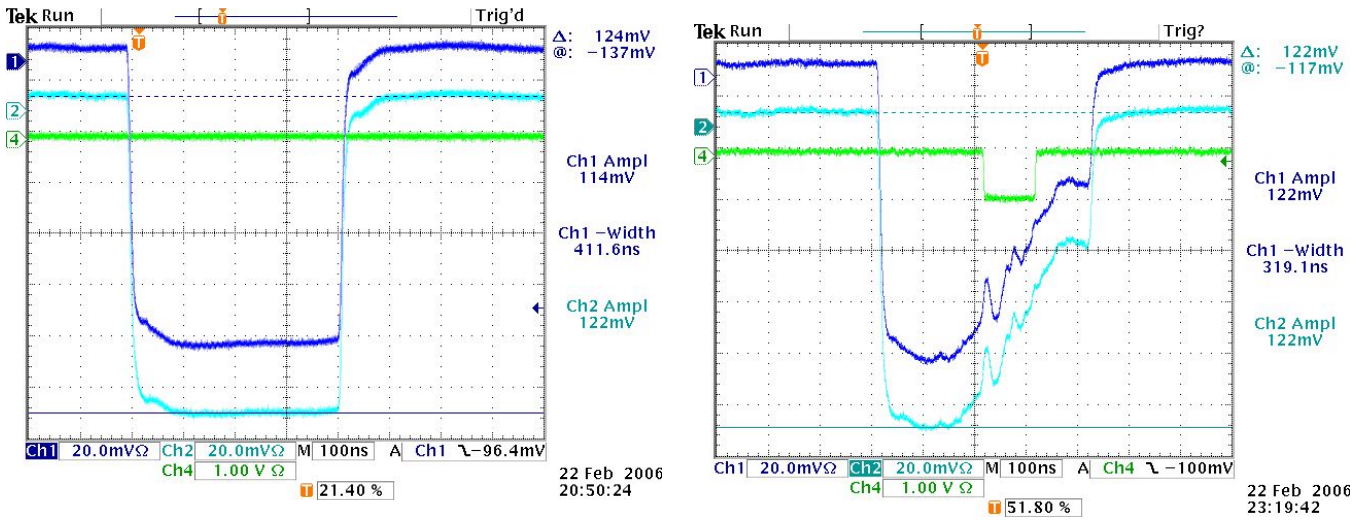
Length	1900mm

Cathode	Scandate
Cathode Load	<10A/cm^2
Heater Voltage	67Volts
Heater Current	3.0A

Main Focus	PPM
Max B/period	0.32T / 30mm
Magnet Material	NdFeB

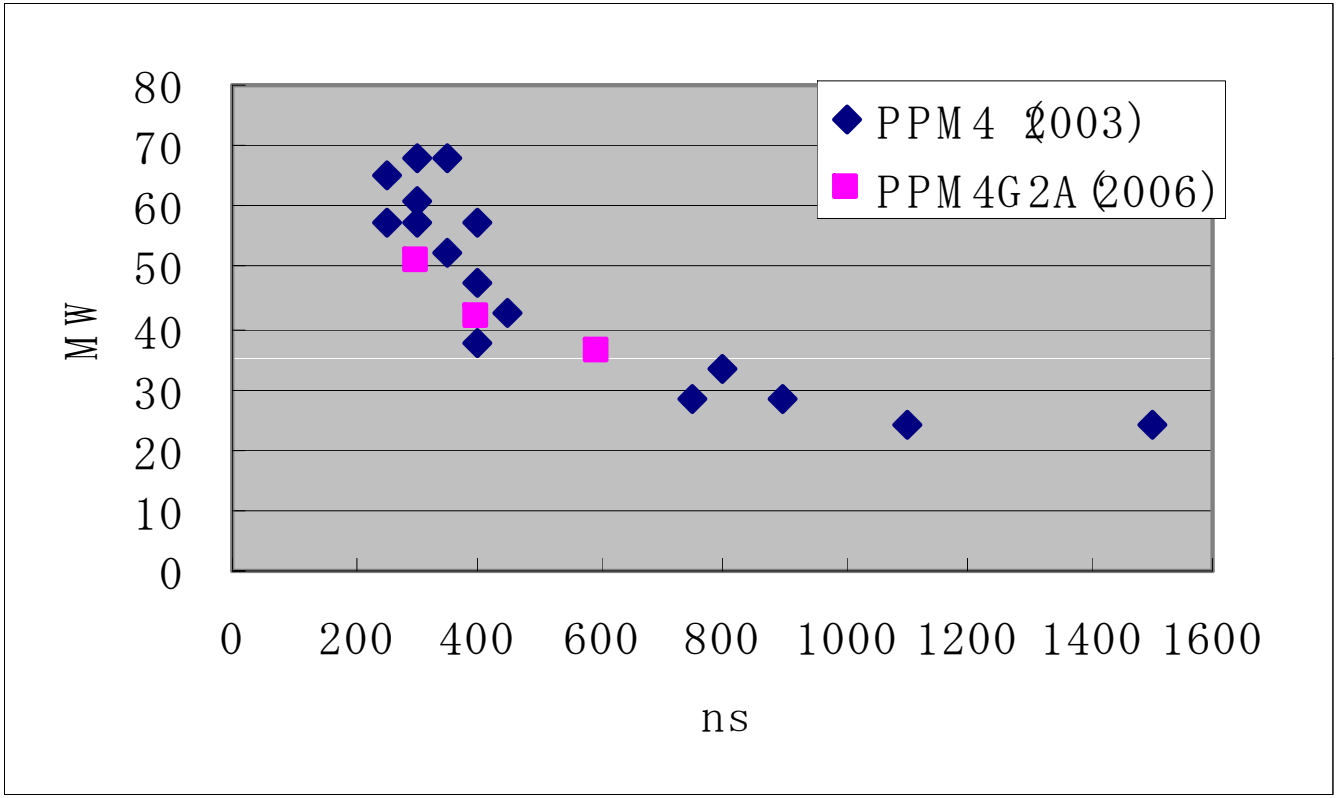
Availability of the ppm klystron

The availability of ppm klystron depends on the required RF quality. Empirically we have known that RF pulses were often broken when the product of the pulse width and peak power is large.



Example of RF Pulse Waveforms:
Normal(Left) and Pulse Shortening (Right).

Empirical threshold curve of pulse shortening of the ppm klystron



Plots of Pulse Shortening Events on Power / Width plane.

XTF Modulator

• Line-type modulator combined with Inverter charging, Thyratron switched and Pulse Transformer. Conventional design, high reliability.

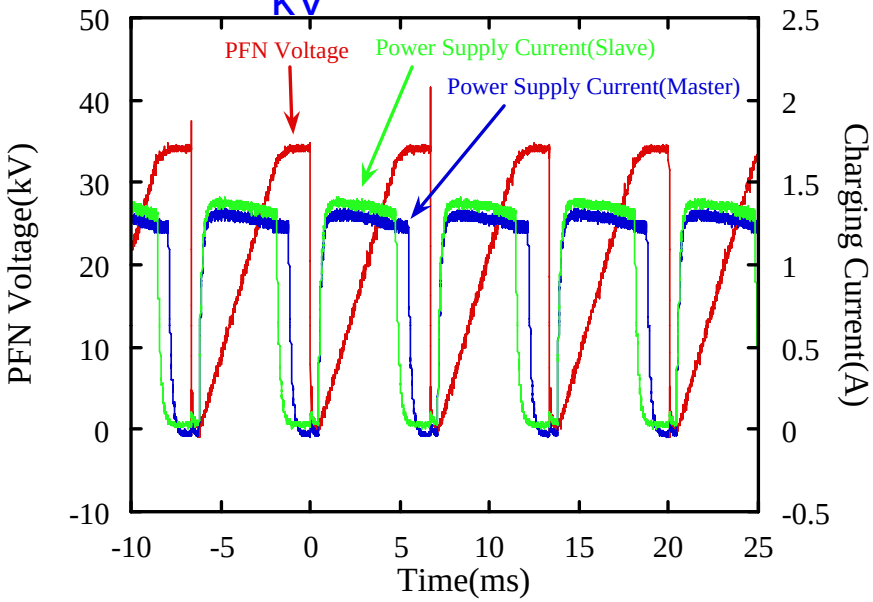
•The modulator installs two PFNs and thyratrons in parallel. It enables to drive two klystrons simultaneously.

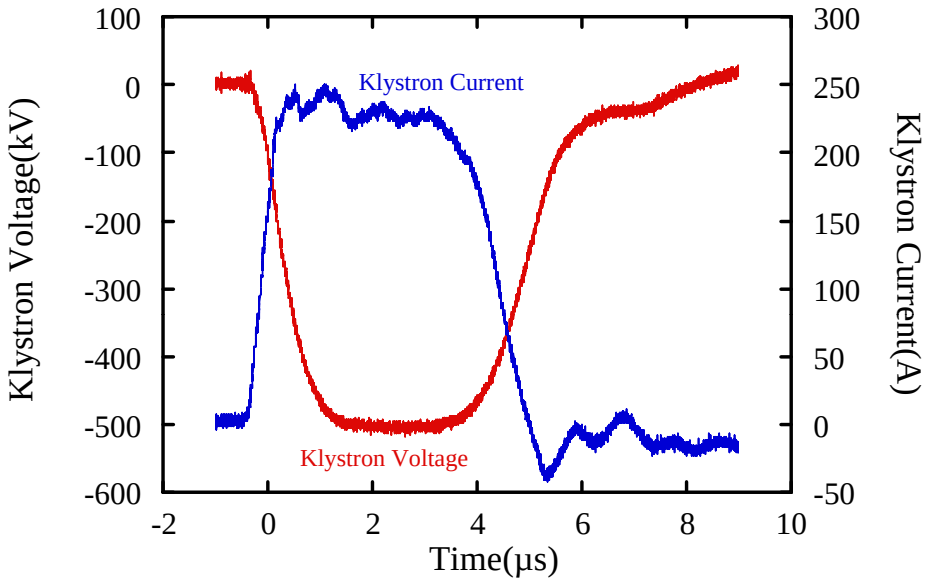
•The first modulator was made in 2003 *in full spec*, while the second one in 2004 mounts a single PFN and is “half” spec.

•The first will be used for Nextef. The second runs at KT-1 to drive a single klystron.

XTF Modulator (test result and operation)

Klystron : 1, Inverter PS : 4, Repe. Rate : 150 Hz, Vpfn : 35 kV





Pule width : 4.5 μs
Flat-top width : >1.6μs(±0.5%)
Rise time : 0.9μs(10-90%)
Pulse voltage stability : ±0.15%

- We have operated both of the modulators for past a few years. So far, the operation has been fairly good.
- The two-tube operation is now ongoing in Nextef.

Summary

•The construction work of Nextef has been successfully done almost on schedule.

•Operation of Nextef started in September 2007. Power generation and RF transmission from the klystrons into the shield room has been done. We are in a way to the ultimate goal: 100MW production, 400ns, 50pps.

•50MW 400ns RF with 25pps is available now. We start to consider the actual test (refer to the next talk).

•The power is limited by the breakdowns in the waveguides and/or some RF components.