Superbunch acceleration and Induction devices.

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KEK and Tokyo Inst. of Technology

1. Induction Synchrotron.
2. Superbunch Accleration.
3. Brief history of the Induction Accelerator at KEK.
4. R&D works on the magnetic core material and the switching device.
5. Proto-type bench test.
6. Demonstration plan.

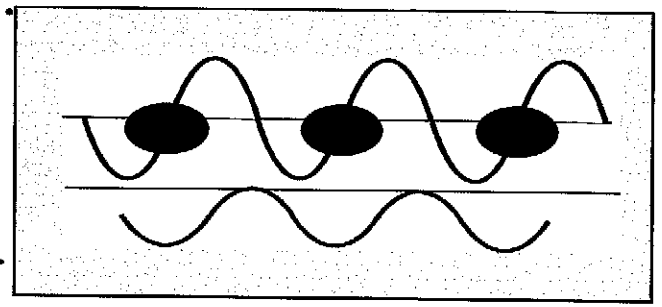
Summary.

Induction Synchrotron (I).

- Intensity up-grade of the accelerator.

  Strong space-charge effect
  large tune shift.
  space-charge induced resonance.

  → Restrict the charge density in the RF bucket.

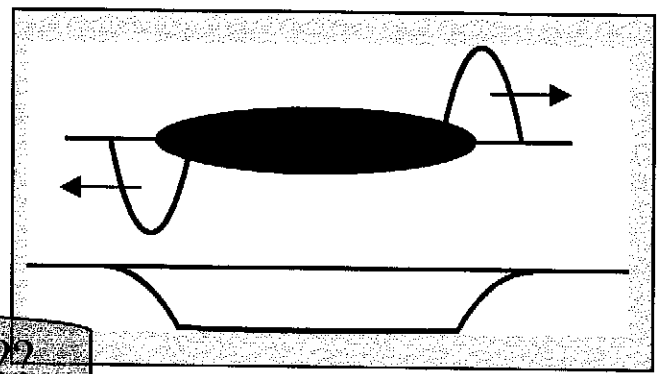


- Need more room for more charge.

  Vacancy between bunch-bunch in the RF accelerator is still an apartment for more habitants!!

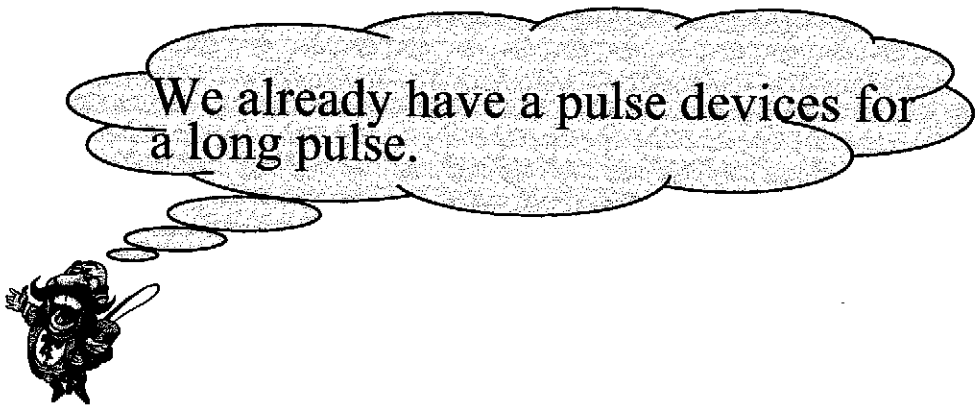
Aha!!

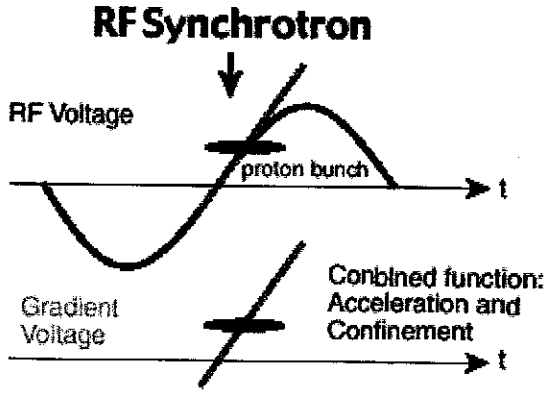
It is exactly the Barrier-bucket !!



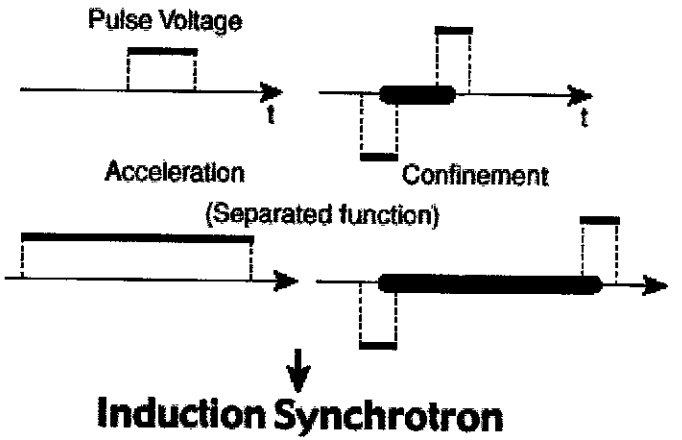
?? How do we accelerate the bunch keeping long??

Induction Synchrotron (II).



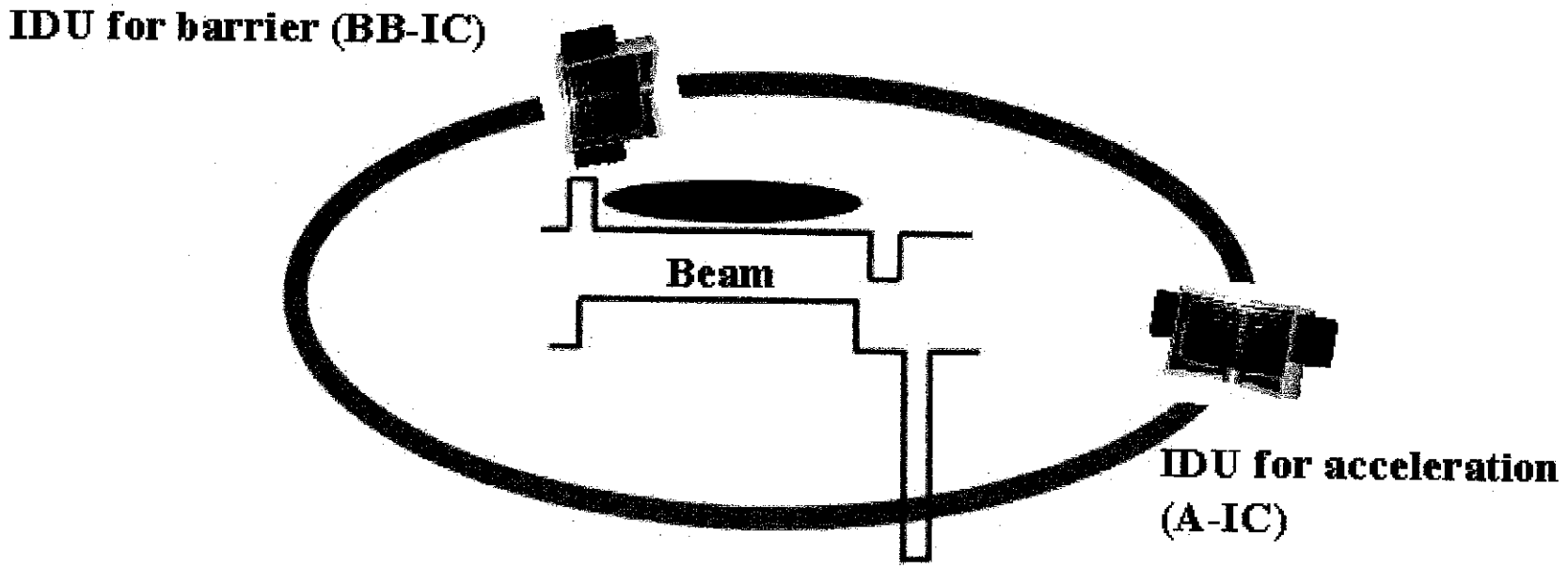


Longitudinal confinement and acceleration are independently achieved by the separated induction cells.



Longitudinally Separated Function Accelerator

Superbunch accleration.
--Induction cell arrangement--



For Barrie bucket

Pulse width	:	50～100*ns*
Voltage	:	140*kV*
Repetition rate	:	670～800*kHz*

For Acceleration

Pulse width	:	800～1200*ns*
Voltage	:	25*kV*
Repetition rate	:	670～800*kHz*

For KEK 12GeV PS.

Brief history of Induction LINAC at KEK.

FEL&IDU R/D project at KEK

High power rf source for TBA by X-band FEL

1985 Project start.

150kV, 1kA, 80ns.

1987 Second generation of IDU and MPC.

200kVx4, 4kA, 80ns.

1988 Single stage 800keV FEL.

1991 Third generation of IDU and MPC.

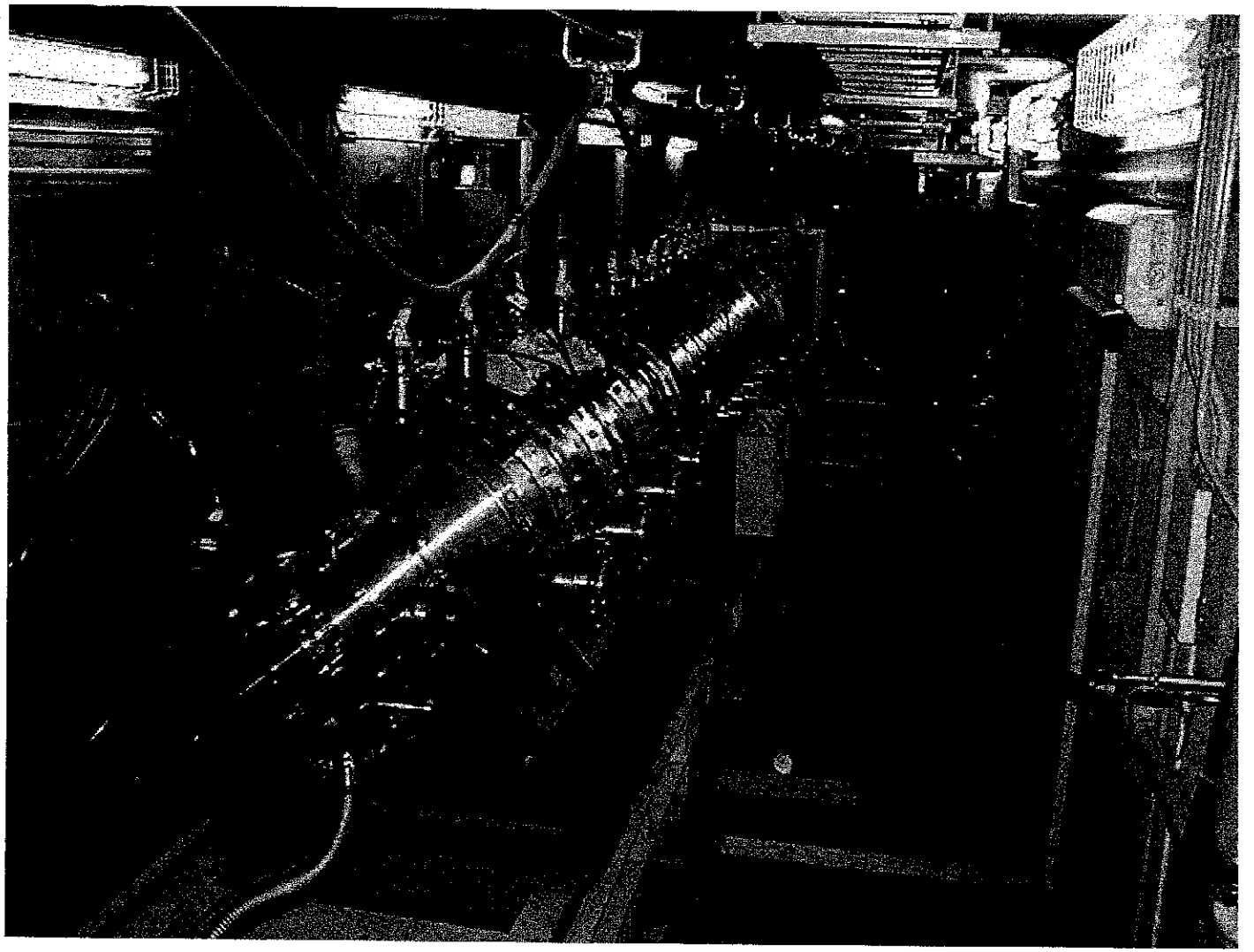
200kVx8, 4kA, 80ns.

1994 1.5MeV/600A 100MW@X-band FEL was achieved.

1996 Most of devices were moved to JAERI.

1998 3.6MeV Induction LINAC was assembled at JAERI.

3.6MeV Induction LINAC at KEK-JAERI.



R&D works.

- Magnetic loss.

  Selection of a Magnetic material.

- Cooling system.
- Fast Switching device.

  Switching speed,

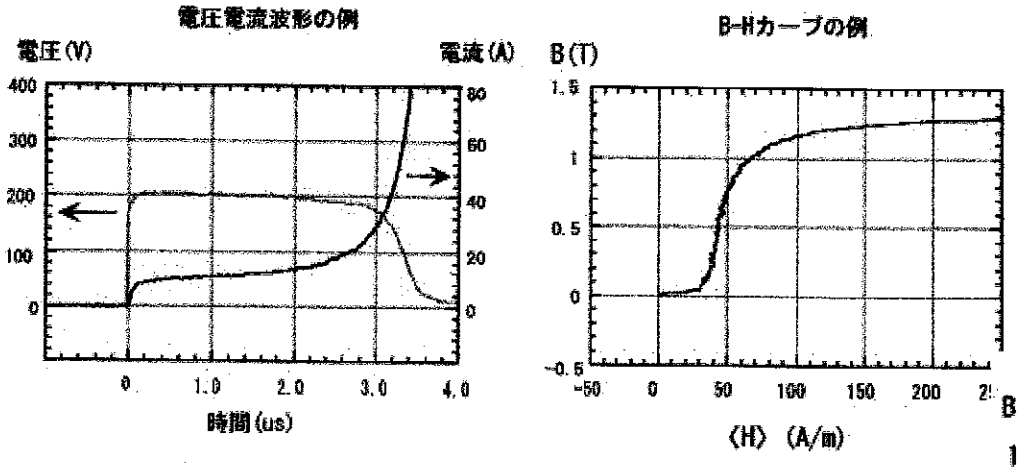
  Turn On & Off performance,

  On resistance.

- Timing & Voltage Control.

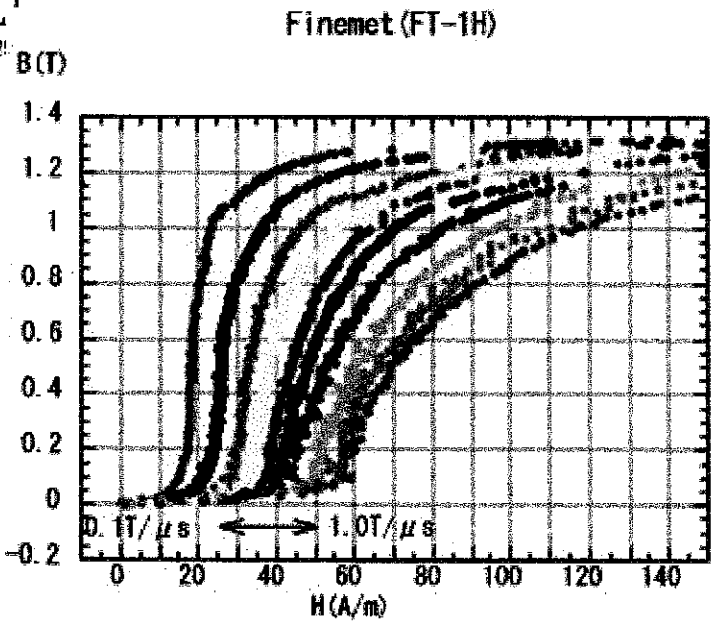
Magnetic Characteristics measurement.

Finemet (FT-1H)



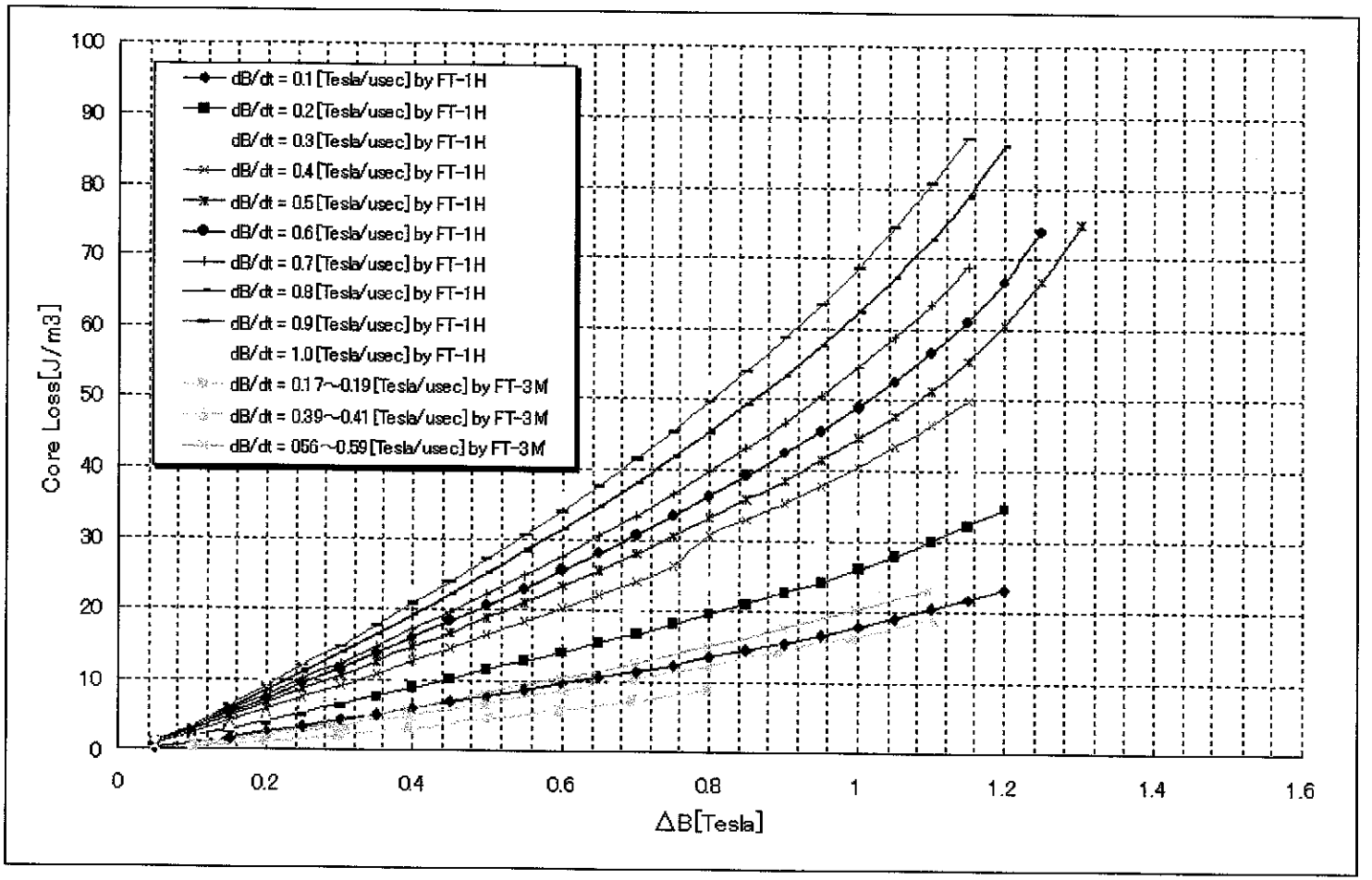
Exact measurements:

- Magnetic material loss,
- Rise time dependence,
- Minor loop behavior,
- Modeling.

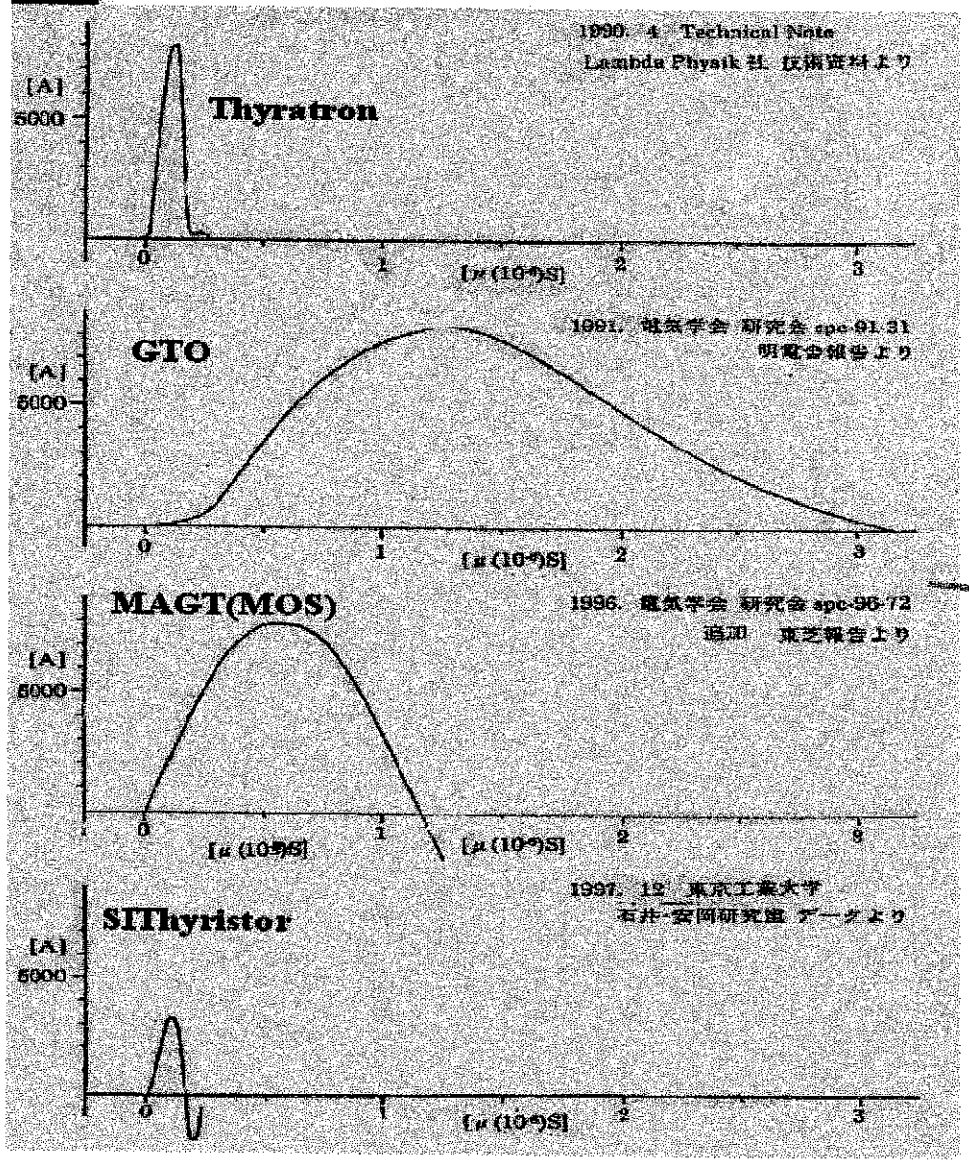


Core loss *vs.* excitation rate.

Hitachi FINEMET core



Switching elements.



Comparison of on-characteristics.

The switching speed is measured with the same load.

GTO:	Gate turn-on-thristor
MAGT:	MOS Assisted Gate-triggered Thyristor
SIT:	Static Induction Thyristor

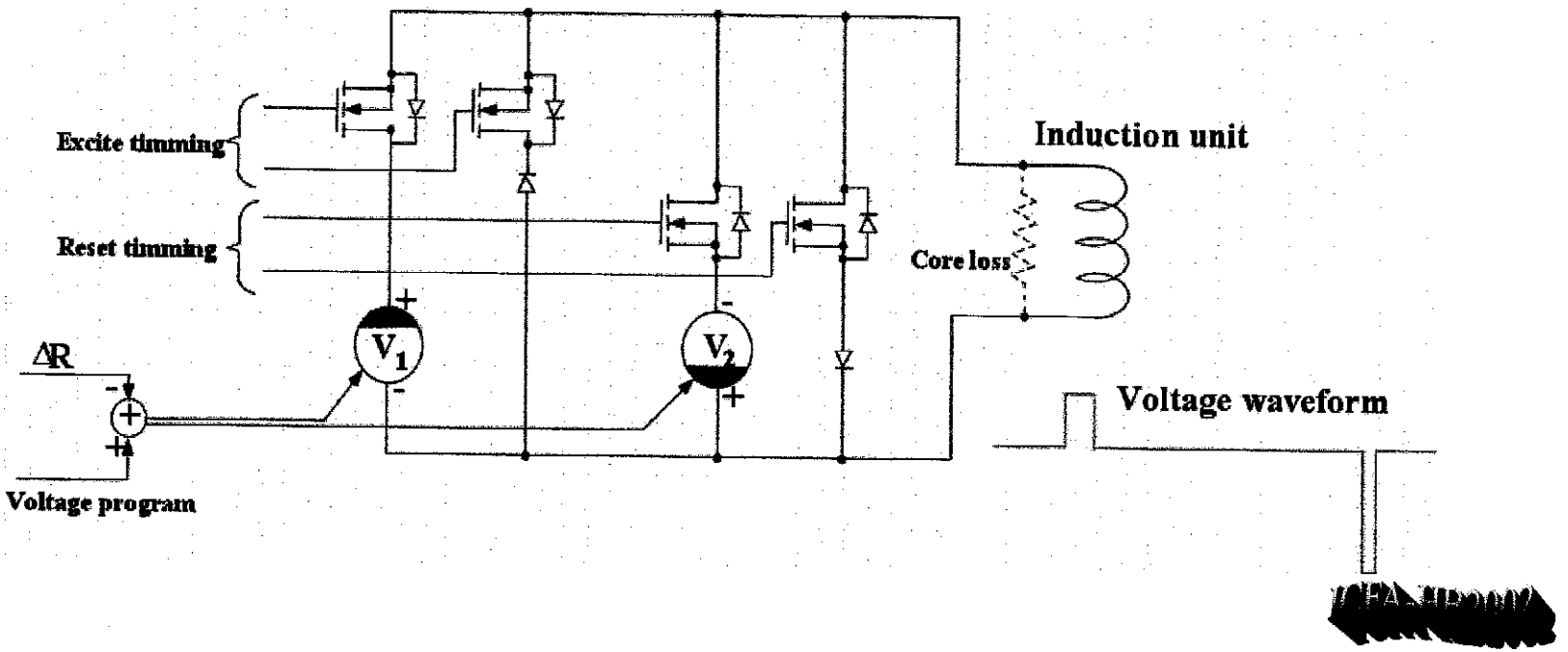
SI-Thyristor shows faster switching.

High speed pulse modulator.

FET modulator

Independent trigger for
excite,
magnetic reset.

Voltage feedback for
beam tracking,
phasing.

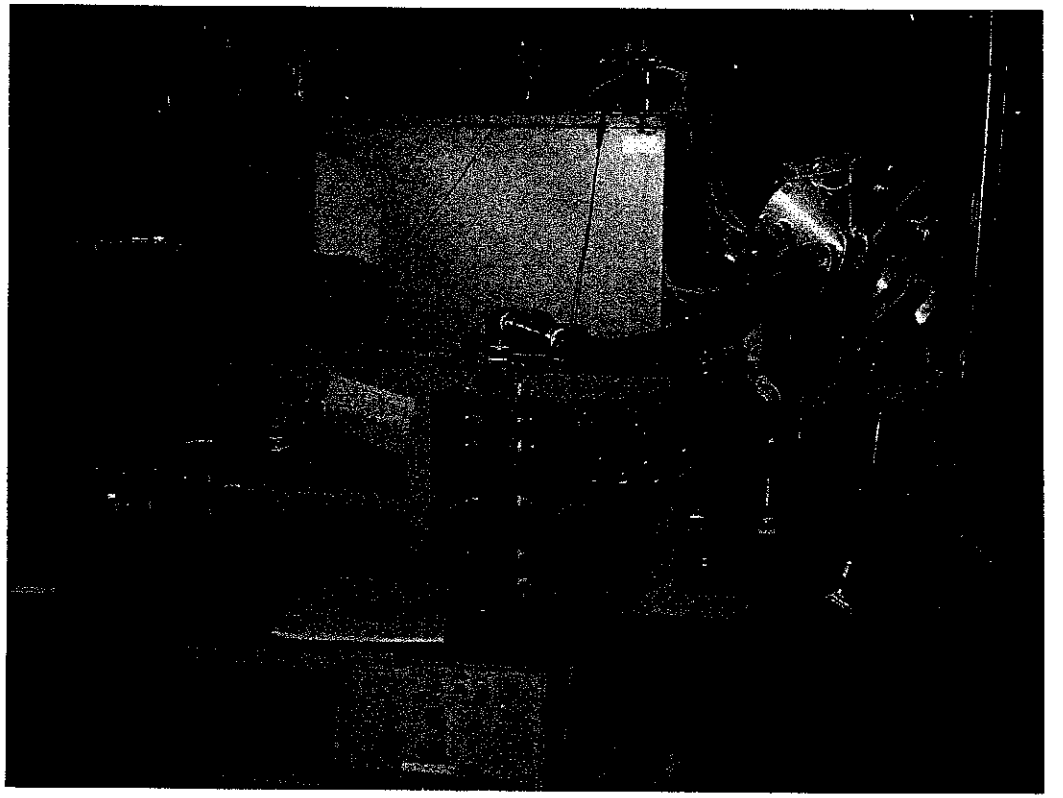


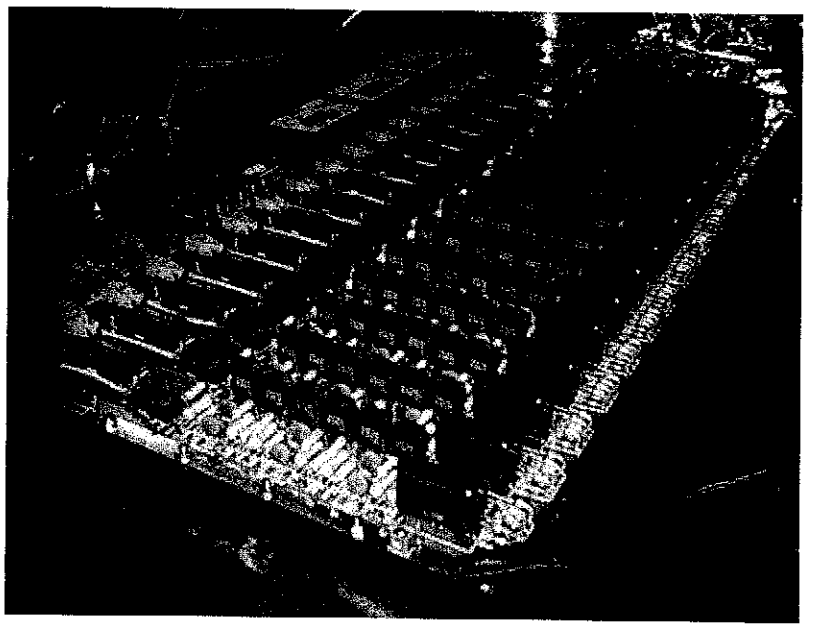
Modulator (First prototype).

Design target

5kV, 100A, 100kHz

With set/reset operation.



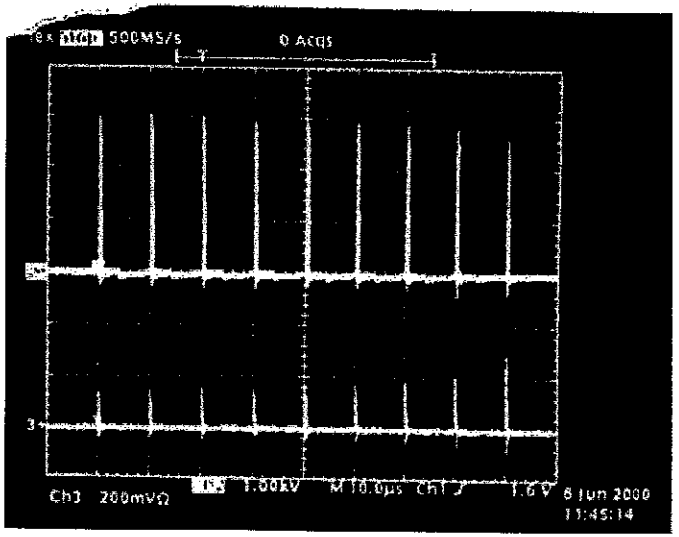


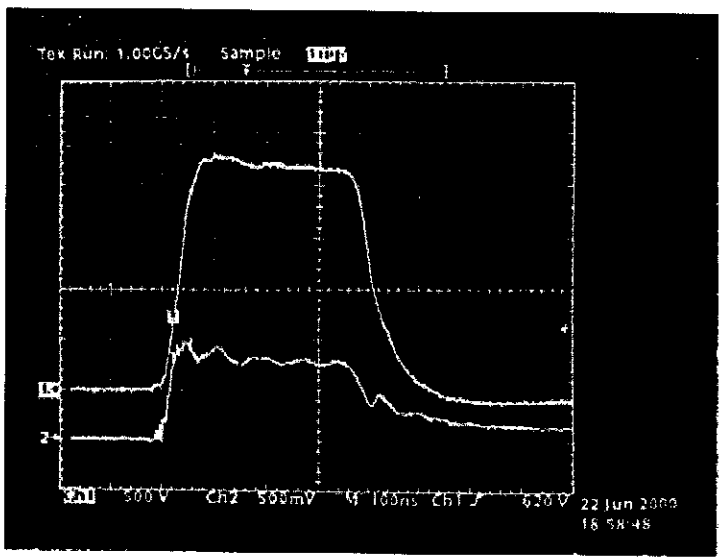
(FET 6-pallarel x 16-series) x 4-boards,

Oil impregnated cooling system,

Voltage stabilization.

First prototype Induction test.





We successfully achieved the operation of 3.8kV,40A, 100kHz.

Some problems causing from

Noise,

Stray-capacity,

Cooling system, *etc.*

Modulator (Second prototype).

High speed switching test on
Static Induction Thyristor(SIT).

Current Rise time < 50ns,
Fall time ・・・・will be <50ns,
Current ~200A,
Voltage 4kV,
Repetition rate ・・・・・>500kHz (examining) .

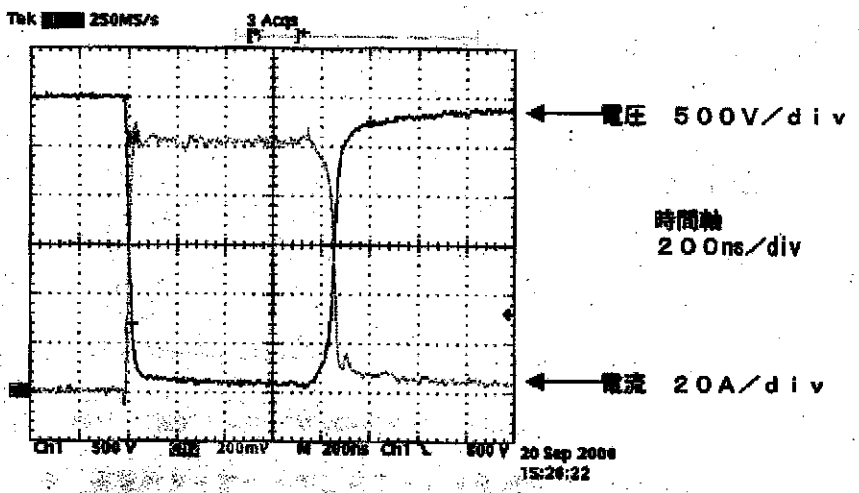
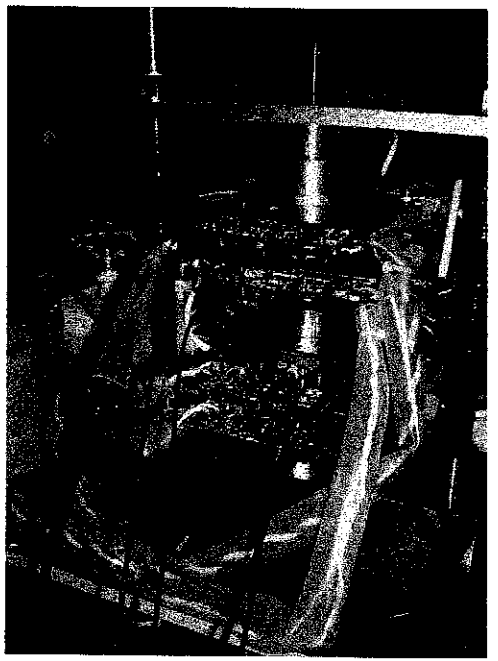


図3－6 RT104使用時（100A）

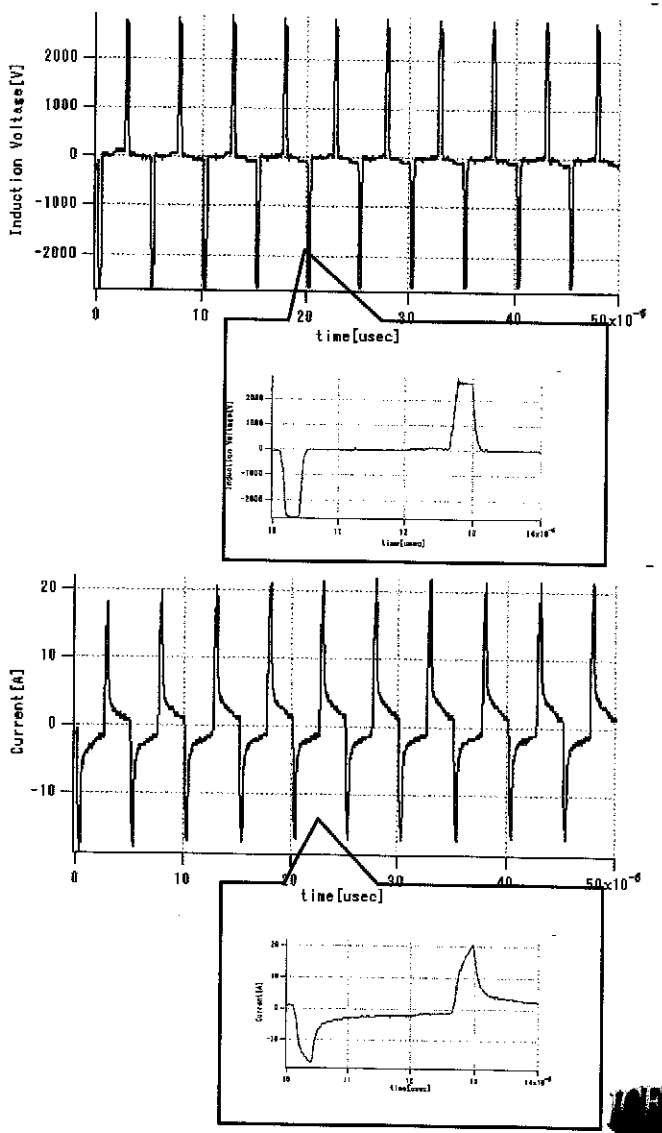
Advantages:
A single element,
Low output impedance,
Compact.



Second prototype Induction test.

SI-Thyristor modulator.

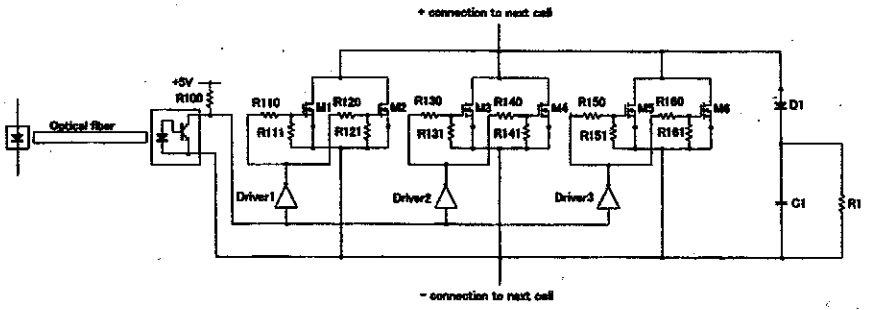
2.5kV, 200kHz operation
was successfully achieved.



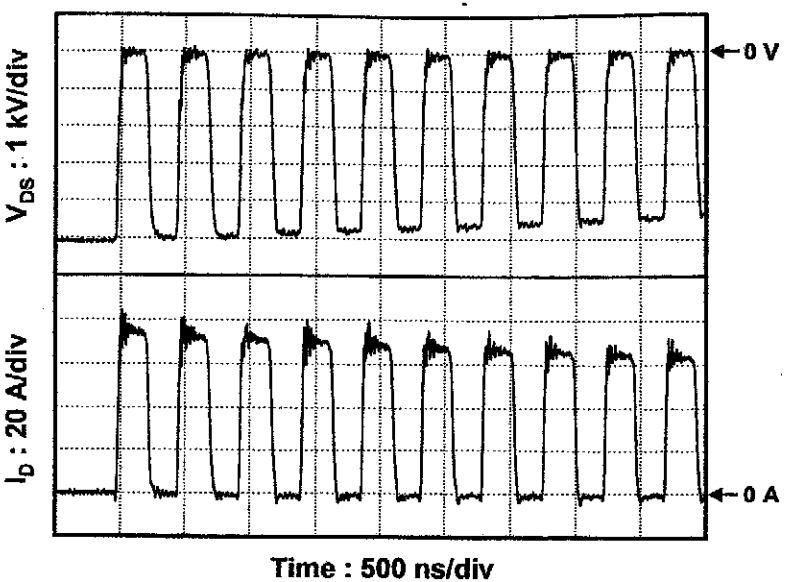
High repetition switching circuit test.

2MHz FET switching assembly was examined.

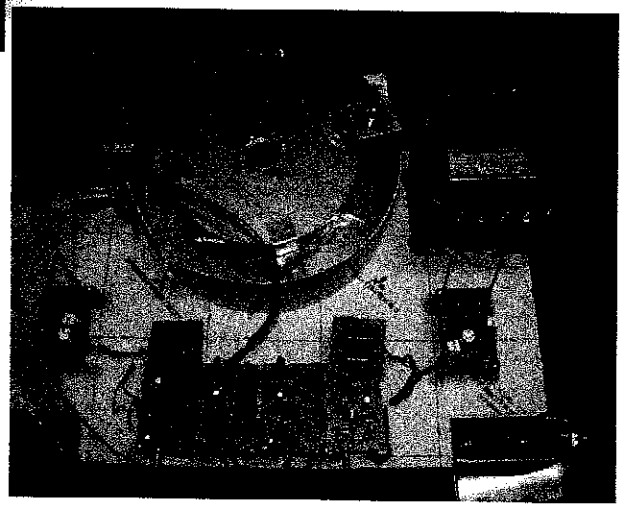
6 parallel, 8 series FETs are assembled.



5kV, 2MHz operation was successfully achieved.

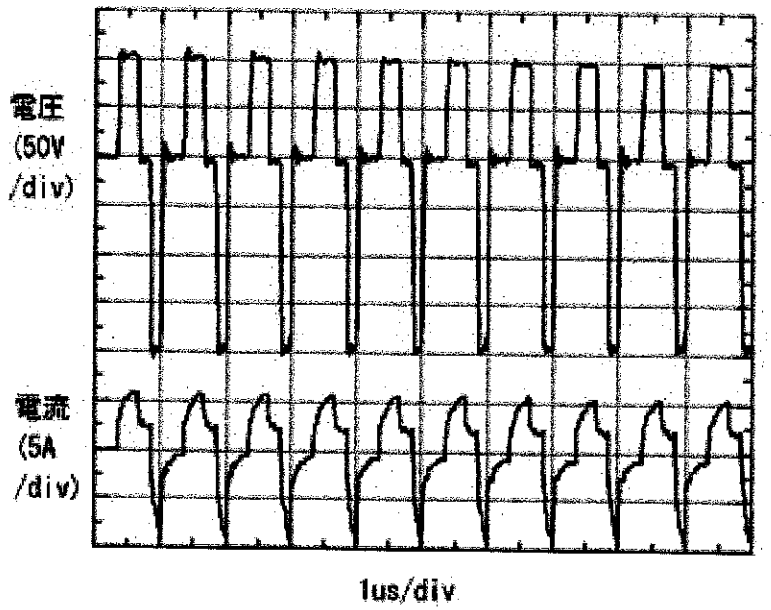


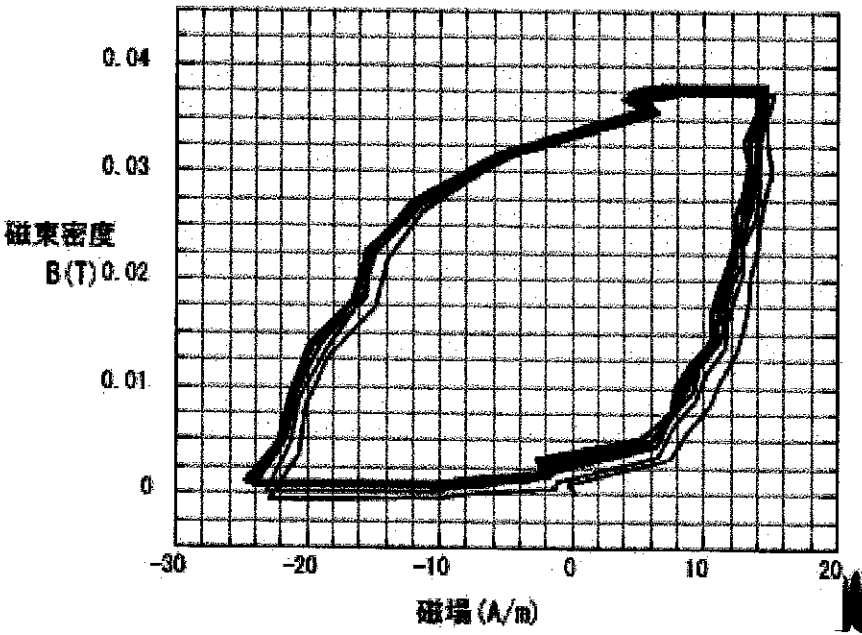
Small size performance test.



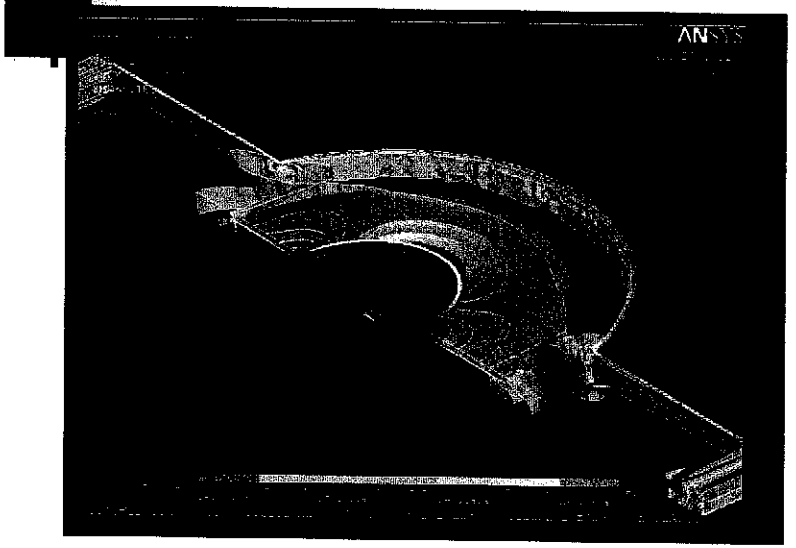
100V, 1MHz operation with set/reset.

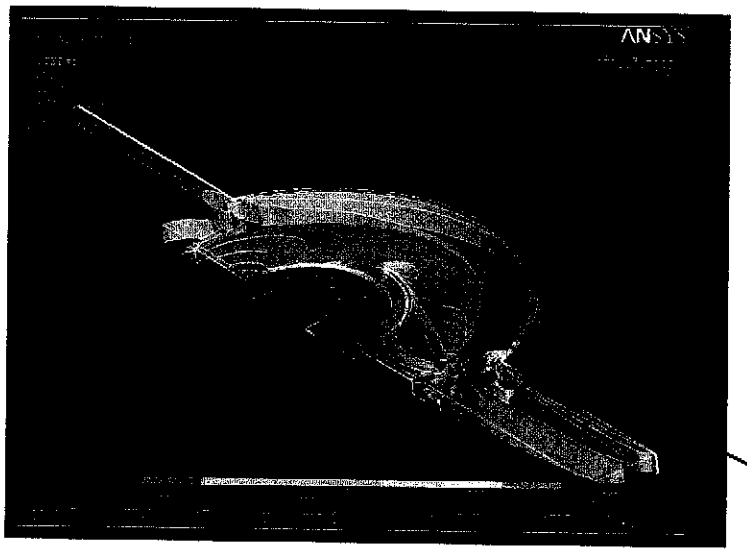
Exact B-H loop tracking to *investigate the stability of the mag.-loop.*





Cooling design.

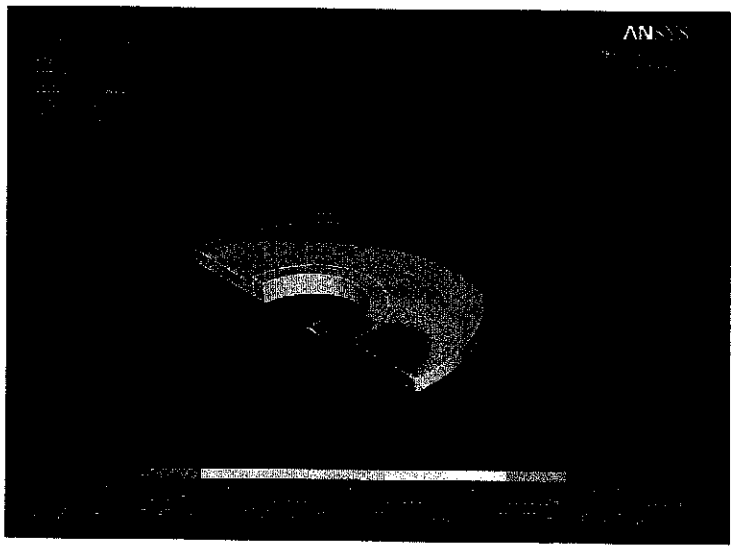




Flow stabilizer.

Modeling for ANSYS,

simulate the coolant flow
and heat deposition.



Temperature on the core surface.

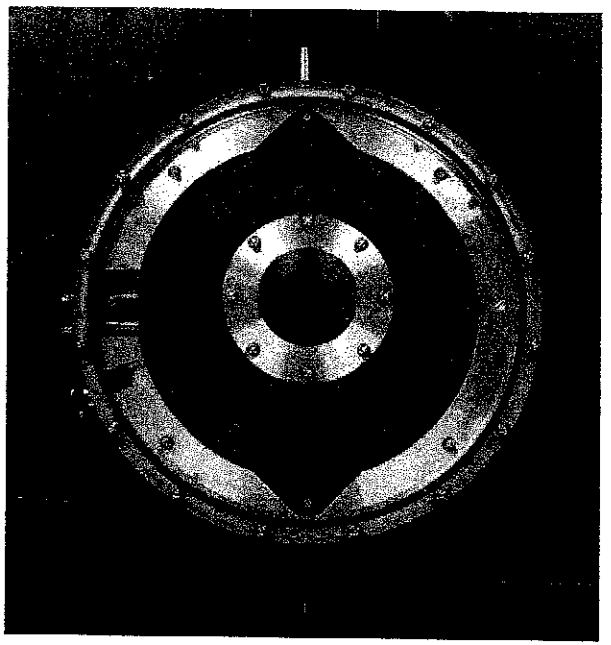
Cooling bench-test.

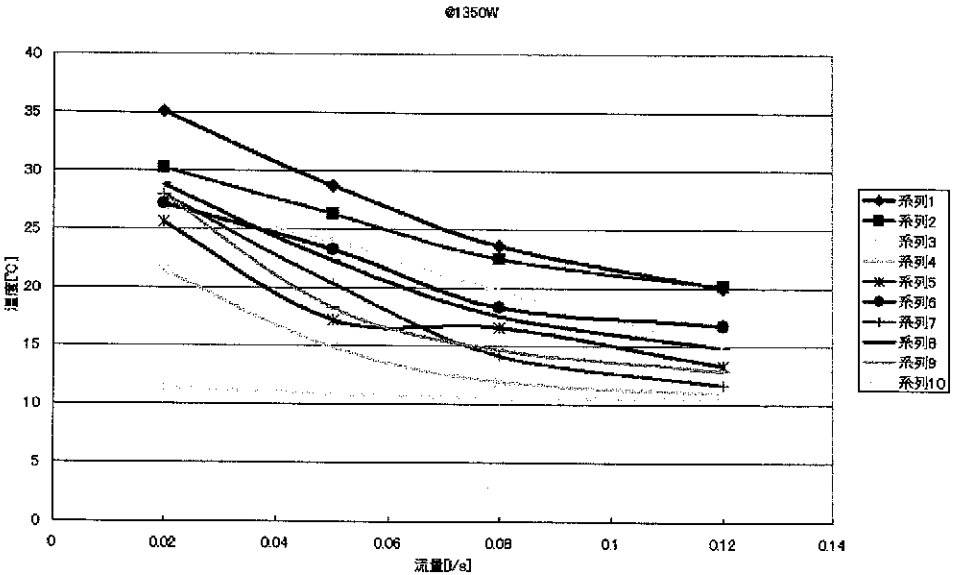
3kW heater impregnated disk.

Water cooling channel.

Water flow monitoring.

Temperature monitoring.

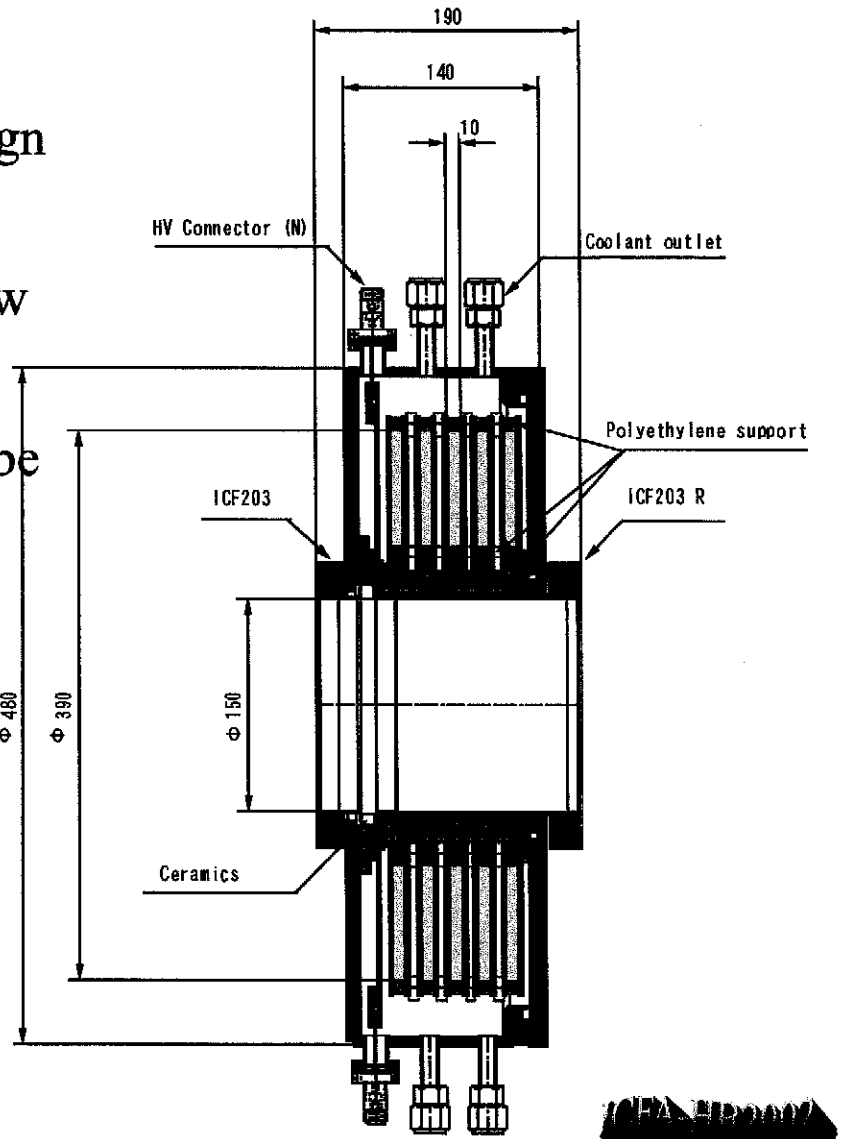




1MHz induction design.

- 2~2.5 kV, 1MHz induction unit design is now undergoing.
- 1MHz 2.5kV 350ns modulator is now building-up in an industry.
- 1MHz long-term test operation will be started by May 2002.

The unit will be installed in the KEK 12GeV PS by the end of March 2003.



Demonstration plan of the Superbunch acceleration in KEK PS.

Step1:

Three RF buckets are stacked.

Accelerate by the induction voltage, keeping the bunch by the conventional RF bucket (because of the financial problem).

Step2:

Five RF buckets are stacked.

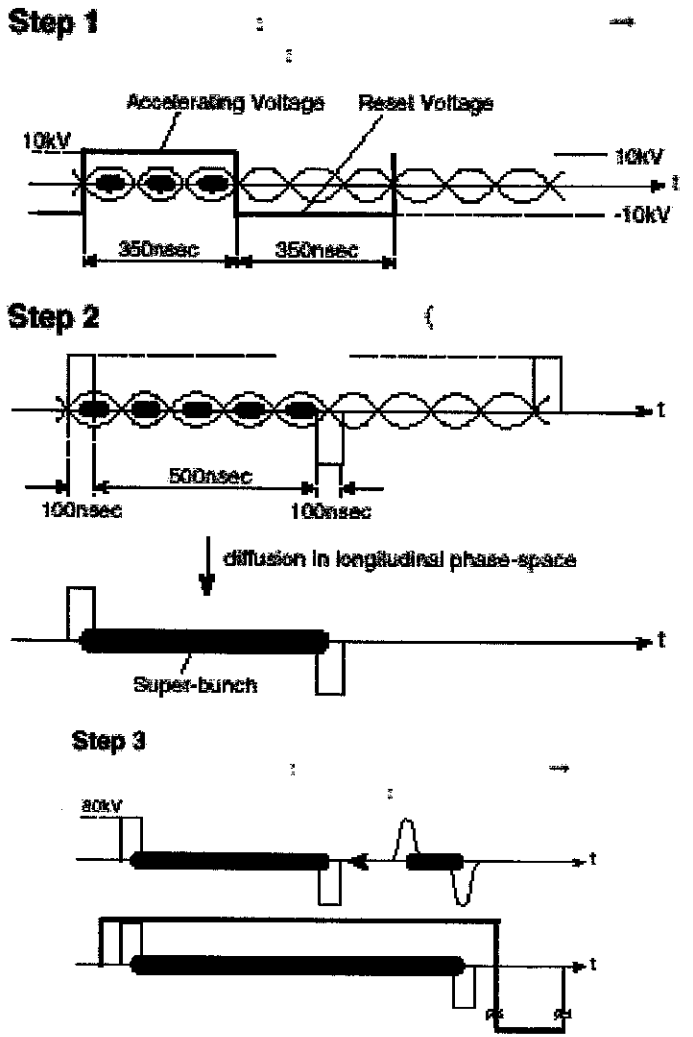
Stacking is changed from the RF to barrier by the short pulse induction unit.

Accelerate by the long pulse induction unit.

Step3:

The injected bunch is merged by a pulse diagnostics.

Accelerates by the long pulse induction unit.



Summary.

- The concept of Induction Synchrotron has been briefly reviewed.
- The Superbunch acceleration scheme has discussed to increase the beam intensity in the current/future accelerators.
- R&D works to realize the superbunch acceleration has been introduced, providing key basic information.

Real size induction units driven by the high repetition rate modulator will be tested soon.

The first demonstration of superbunch acceleration is scheduled in the KEK 12GeV PS.