KEKB Review030211

C-band R&D

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- Plan for C-band Linac for Super KEKB （General)
- Each Component

(2) Status of Developments

(3) Schedule up to the Accelerator Installation in Summer of 2003

Super KEKB Requirements to Injector

1. e+ Beam Energy ↑ 3.5 -> 8.0 GeV

   (for Charge Switch

   8.0 GeV e-/3.5 GeV e+ -> 8.0 GeV e+/3.5 GeV e-)

2. Injection Charge ↑ 1.0 -> 5.0 nC (e-)

   0.6 -> 1.2 nC (e+)

   (for Larger Stored Current

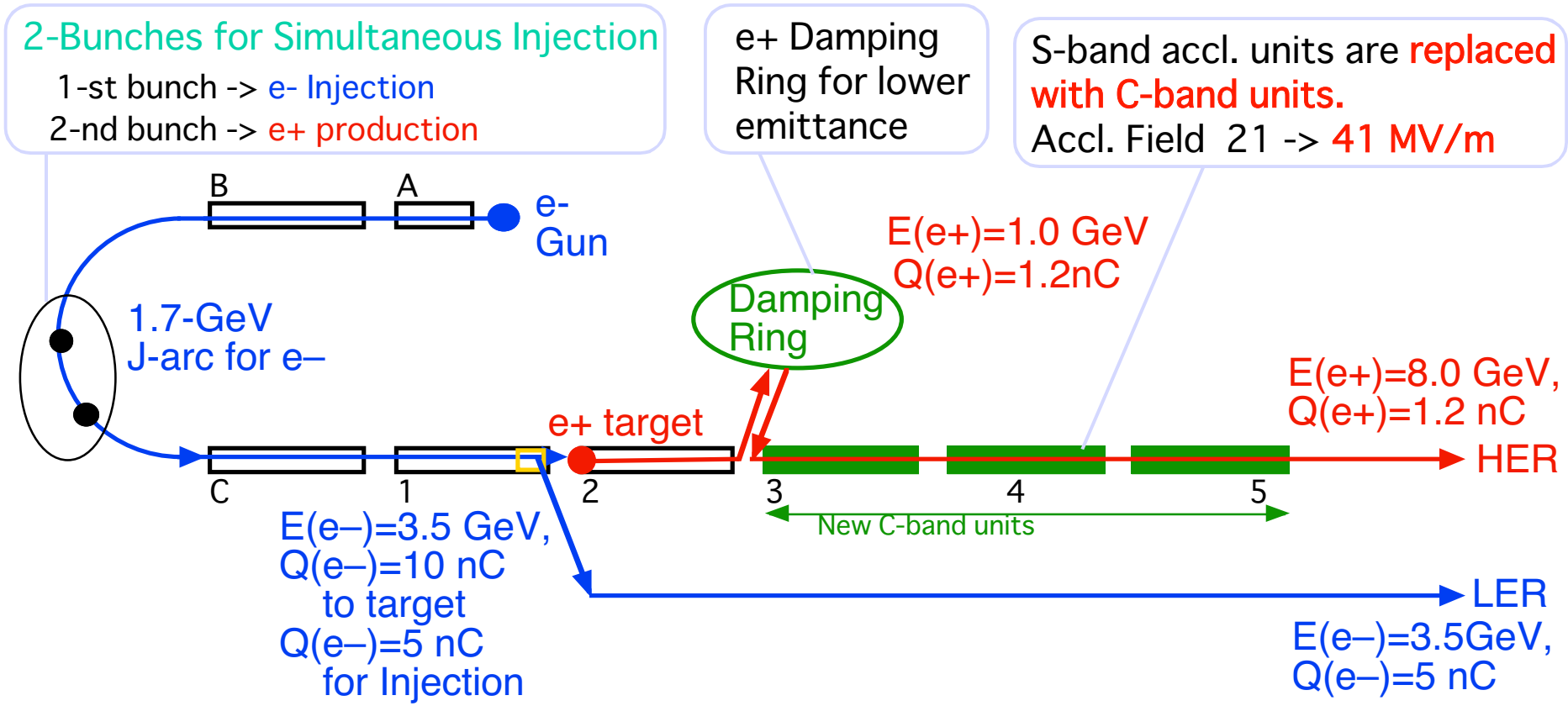
   1.1A e-/2.6 A e+ -> 9.4 A e-/4.1 A e+)

3. Simultaneous Injection (both e+/e-)

4. Smaller e+ emittance

Higher Acceleration Field scheme

for 8 GeV e+



Accelerator's Scheme

- Frequency is C-Band (2856MHz X 2 =5712MHz)
- ⇒Positron Energy Up to 8GeV with Using C-band RF Source, which Comprises 3 Sectors of #3、#4、#5.
- C-band Accelerator Design and Parameters were follows,
- ⇒2m-long Waveguide x 2、42MV/m
- Attenuation Factor 0.676, Filling Time 0.365 μs
- Usage of SLED Type Energy Doublers
- ⇒High Q SLED Cavity Using the TE038 Mode
- ⇒Pulse Width 2 μsec,

  Field Multiplication Factor 1.84（at Q=130000）

Then Operating Required Klystron Output Power is **40MW.**

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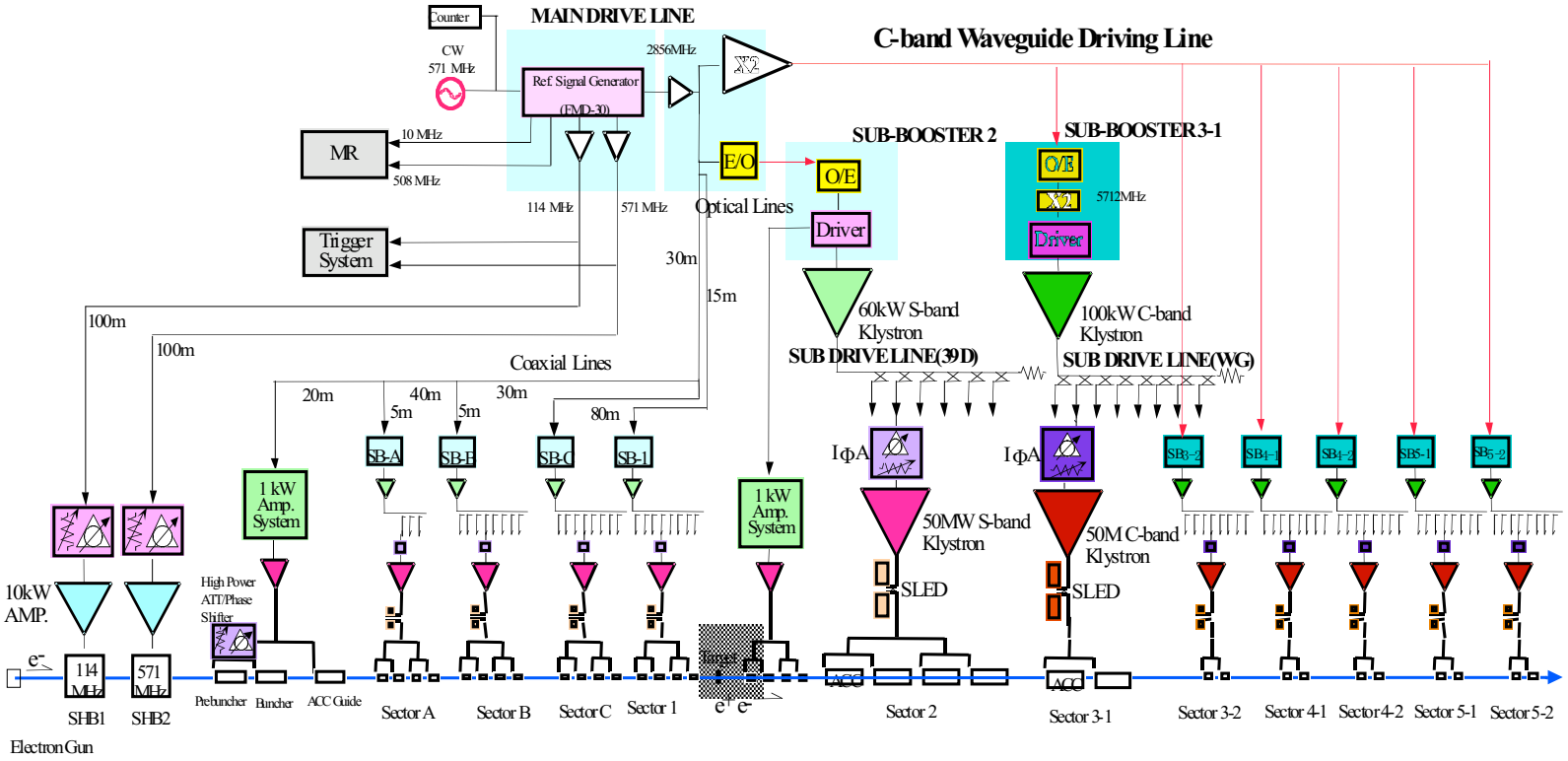
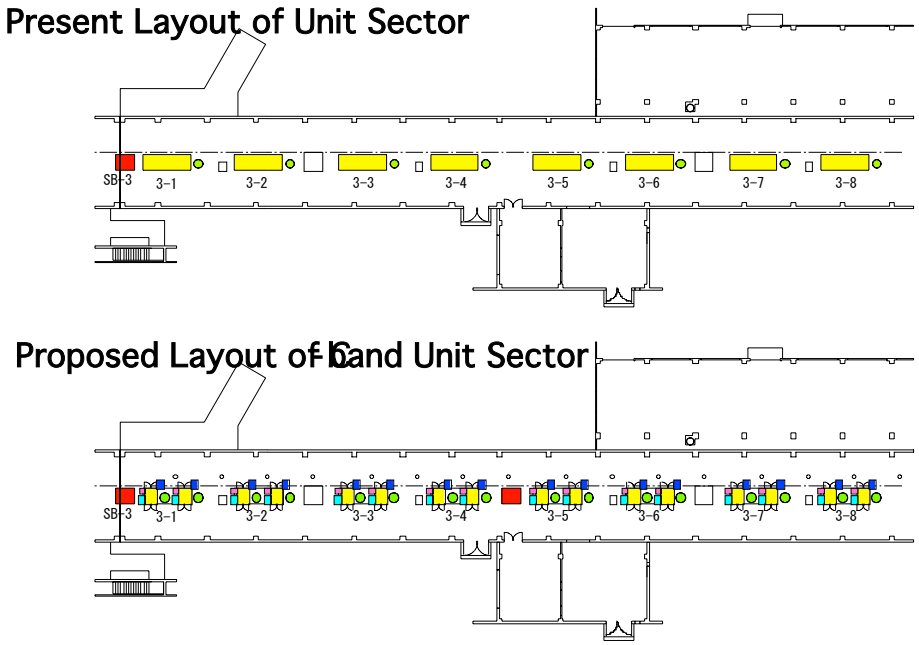
RF Block Diagram for C-band from #3 to #5 Sector

RF System Diagram C-band Plan(example)





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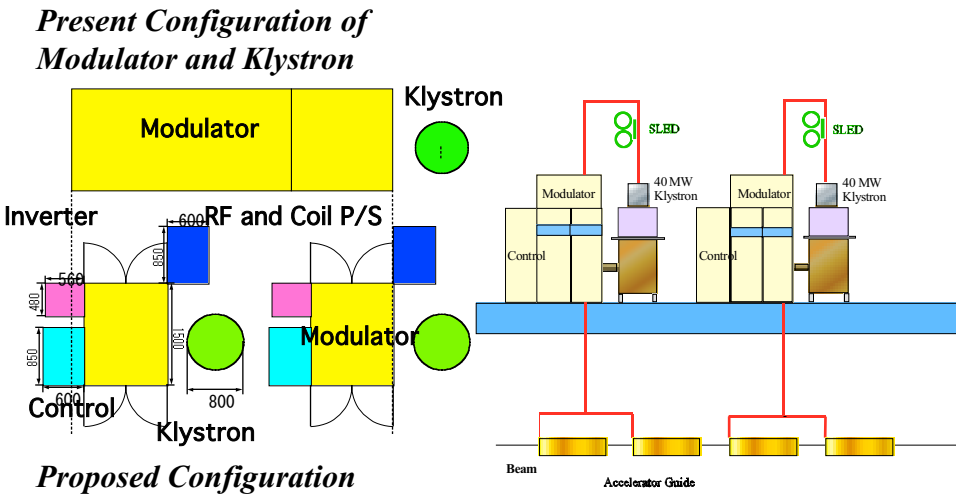
Gallery Layout Plan

Compact Modulator using Inverter DC Power Supply (Below)

Proposed Klystron Gallery Layout (Up)

Proposed C-band Modulator Configuration



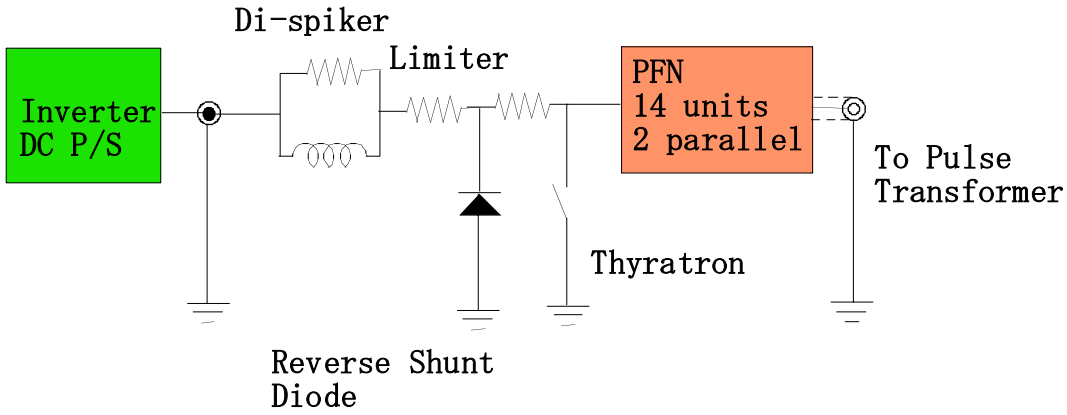
Items for Developments

- **RF-Source** **(50MW Klystron was already developed)**
- (1) Compact Modulator's Development
- (2) Driver 100kW Klystron Development
- (3) Development for an RF Window Capable to feed 50MW with one window.
- Need to Construct Resonant Ring to test.
- (4) **Total Performance Test for 50-MW Operation**

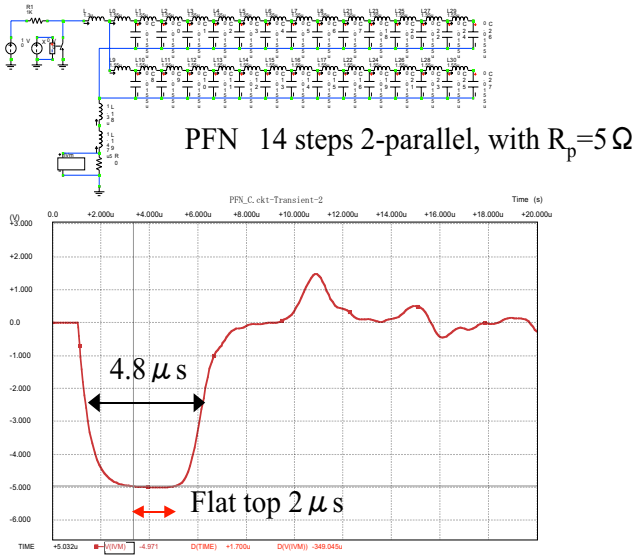
- **Accelerator Guide**
- (1) Design and Manufacturing the half-scale c-band 1-m long accelerator guide.
- (2) Design and Manufacturing a CERN-LIPS type SLED.
- (3) Development of necessary waveguide components, such as the Beathe-hole coupler, waveguide with vacuum port, 3 dB hybrid, SiC dummy load etc..
- (4) High-power test in the test bench
- (5) **Installation to the beam line and acceleration test**

Modulator Design

Basically the same pulse-forming circuit is applied to the new modulator.
The rectifier and charging circuits are replaced to the compact inverter dc power supply.



Circuit Diagram



Simulation of output pulse

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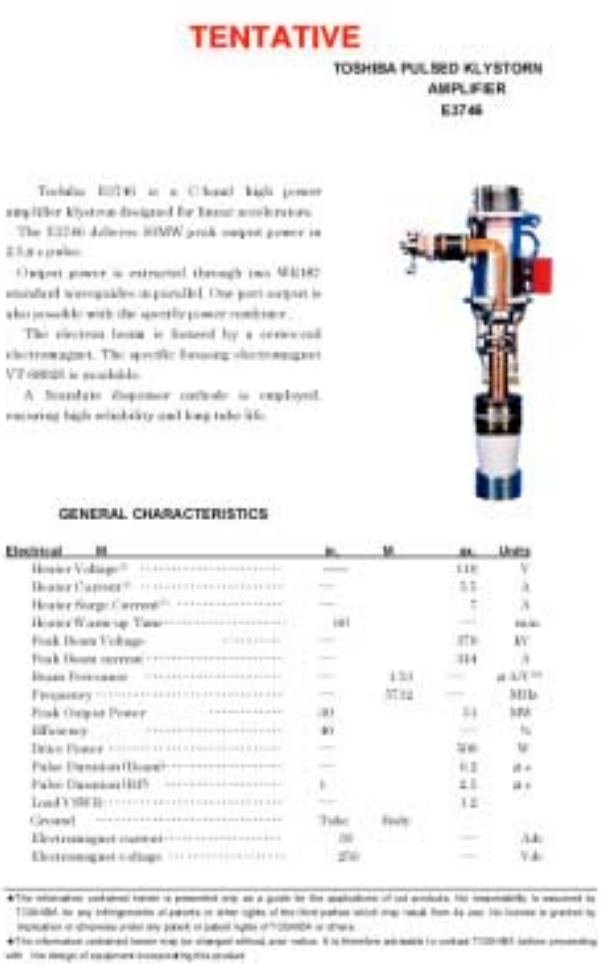
Klystron Assembly Using Old 60-MW Klystron Tank


TENTATIVE

TOSHIBA PULSED KLYSTRON AMPLIFIER E3746

GENERAL CHARACTERISTICS

- 50MW Klystron(left)
- Coil OD 600ϕ
- Core Window Size for 330kV

  -We have an experience, but reliable? Maybe OK
- For test in this year, old 60MW klystron tank is usable at first.

  Tank OD 700ϕ

  Flange OD 850ϕ

  (Example⇒center drawing)
- Existing Tank OD 600ϕ

  Flange of tank OD 750ϕ

  ⇒Redesign of tank or **try to fit the coil to old tank**

SB Klystron

Existing C-band 200kW klystron for weather observation station (MELCO) :5.3GHz

⇒Retune to **5.712GH z**

Similar operating scheme performed by the present sub-booster（100kW at the 30kV) is expected.

It is possible to feed C-band klystrons if the rectangular waveguide (WRJ-5) is used.

⇒Good cost performance

Constant-temperature water is necessary to keep the drive line constant.

(±0.1 degree fine controlled water)

Phase stability, Minimum phase jitter is required for the C-band case.

⇒It is necessary to study the phase stability intensively.

Design Guide of C-band Accelerator

(Basic Design of C-band Unit)

Output Power from C-band Kly. 40 MW		
Loss in the Waveguide	0.94	*
Multiplication Factor of SLED	3.41	*
Divide the power to two-Acc.	1/2	=
Required Power in for an Acc. Guide	58.8 MW	

(For Beam Study in Summer) of

Output Power from C-band Kly.	40 MW	*
Loss in the Waveguide	0.94	*
No SLED in Summer	1.00	*
Use only one 1.8m ACC.	1/1	=
Input Power for one ACC. Guide	34.4 MW	

Tentative C-band 2m-Acc. Guide Design

	2a	v_g/c	r_0	Power
Top	14.00	2.8%	67.5	58.8
Middle	12.27	1.8%	75.6	34.8
End	10.51	1.0%	84.8	14.4

Accl. Field = 42.6 ~ 38.1 MV/m
Filling Time t_F = 380 nsec
Attn Constant τ = 0.703

A-type 1/2 scale Design

	2a	v_g/c	r_0	Power
Top	12.44	1.9%	74.8	34.4
End	10.41	1.0%	85.3	14.5

Accl. Field = 41.2 ~ 39.0 MV/m
Filling Time t_F = 234 nsec
Attn Constant τ = 0.434

Manufacturing Principle for a C-band No.1 Accelerator Guide

- Scaling-down of Existing S-band Acc. Guide (Disk-Loaded Structure) to half size

  Utilizing the technology accumulated in the S-band project Effectively.
  If Scaling-down is not enough, additional modification is carefully introduced.

- Manufacture a C-band 1m-long Acc. Guide, based on a KEK S-band A-type 2m-long Acc.

  2m-long Acc. Guide is desired in future, but at first 1m-long Acc. Guide will be manufactured considering the manufacturing process. There is a possibility that 2m-long Acc. Guide = 1m+1m.
  We have a rich manufacturing Documents of S-band 2m-long Acc. Guide.

RF Pulse Compressor

- Parameter Comparison between KEKB-SLED and Proposed LIPS-type SLED

	KEKB-SLED	LIPS-type
Resonant Mode	TE015	TE038
Diameter	20.51cm	22.17cm(Scaled)
Length	33.59cm	29.8cm(scaled)
Frequency	2856.00 MHz	5712MHz
Cavity Q(theory)	107000	146970(Expected)
Cavity Q(Mes)	97000	127800(Expected)
Coupling β	6.4	9～11

Both sizes are almost the same and previous experiences are utilized to this new compressor. Install to Gallery is easy.

C-band components R&D status

•Toward 2003 Summer Beam test at KEKB Linac

(1 Pulse Modulator + 1 Klystron + 1 Accl. structure 1m-long)

- Klystron (Toshiba 50 MW C-band Klystron)
- Pulse Modulator (Compact type)
- Sub-booster klystron (weather observation 200 kW Klystron is modified to 5712 MHz)

  Already Fabricated
- Accelerating structure #1 (2pi/3-mode, scaled down from S-band)

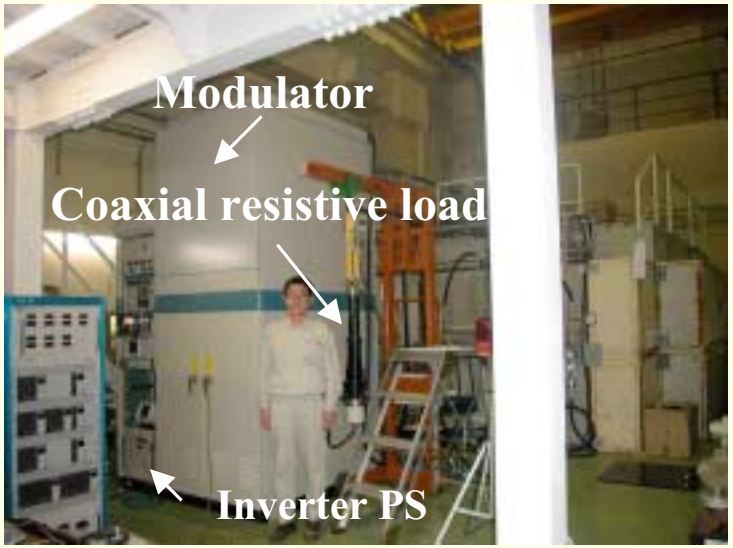
  Under Engineering design (parameter tuning)
- Wave guides, RF Window, Flange

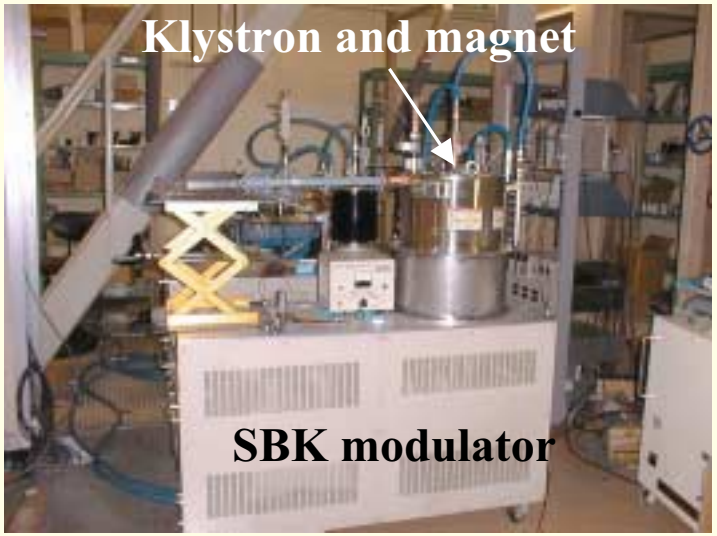
  Under fabrication, partly finished
- 3-dB Hybrid, Dummy load

  Under Engineering design (parameter tuning)

Current Status （1） (at Feb. 5, 2005)

- **Compact Modulator with an inverter DC power supply was installed and the test was started from Feb. 3, 2003.** （right top photo）。Resistive load test first and then klystron load test. Running and Durations for noise will be evaluated.
- **100kW SB-Klystron for C-band was tested at beam voltage of 28.5 k V.**（right bottom photo）. Output power of 1.5kW (factory data was 4kW) was obtained and it is enough at the first test. Transistor 8W amplifier of NEC was also tested in this operation.



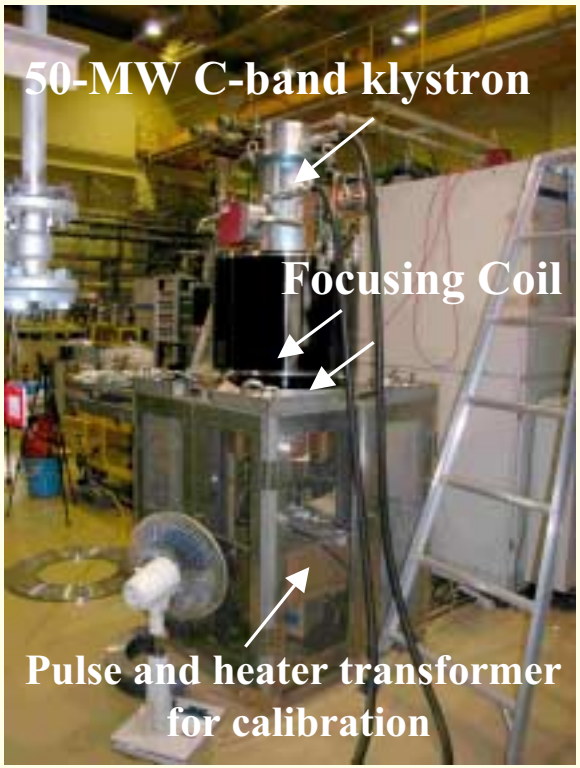


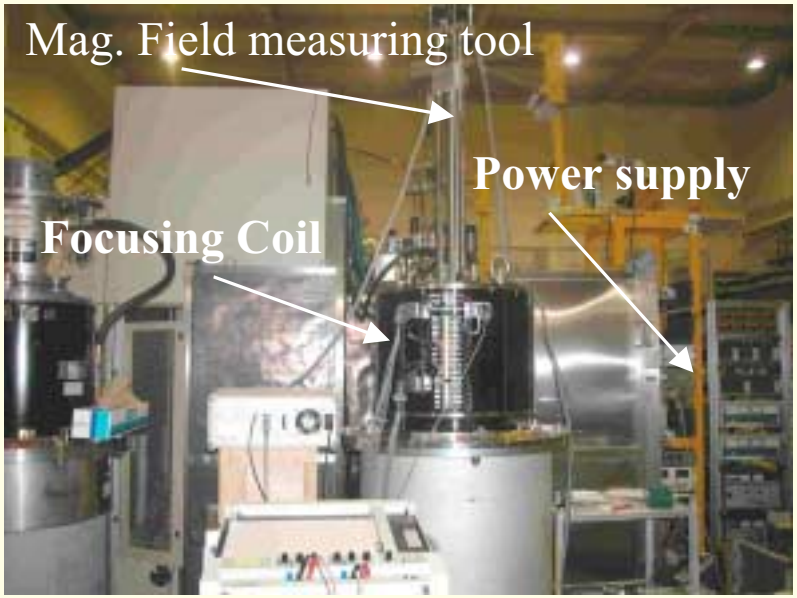
Current Status(2) (at Feb.5, 2003)

- **Heater test** and **low voltage emission test** of the **50MW C-band klystron** （Top of right photo）, and **magnetic field measurement of focusing coil** of the klystron (Bottom of right photo) were finished.

- From Feb. 10, 2003, assembling the klystron on the pulse transformer tank and beam test will be started.

  Then reassembling and rf-test will be scheduled from Feb. 17, 2003.





Mix-Mode RF Window （By Kazakov)

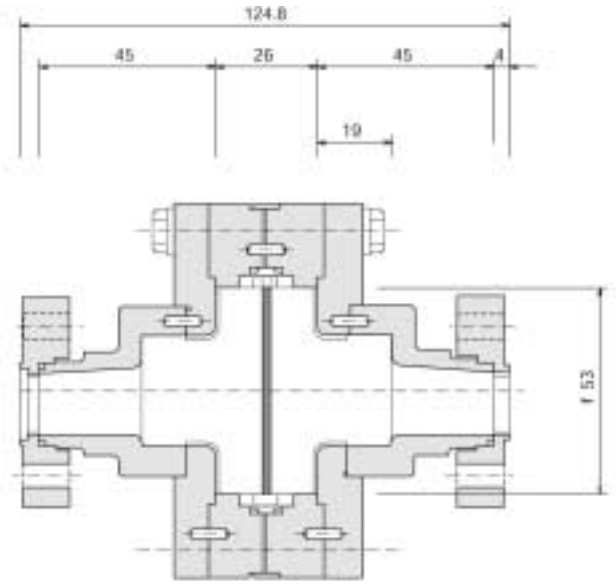
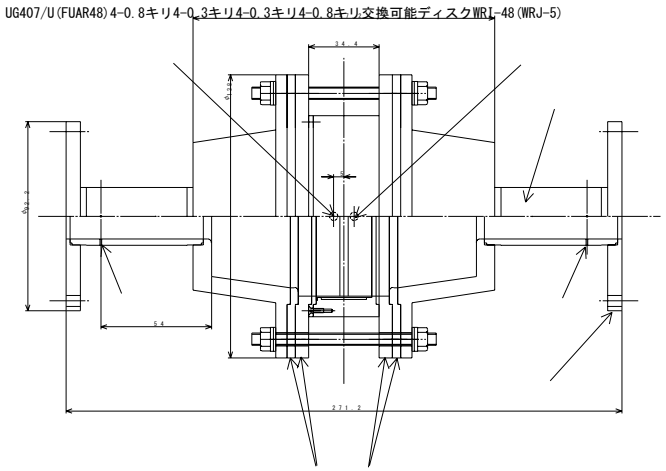


Figure 5.15: High power model of 53mm mixed-mode window.

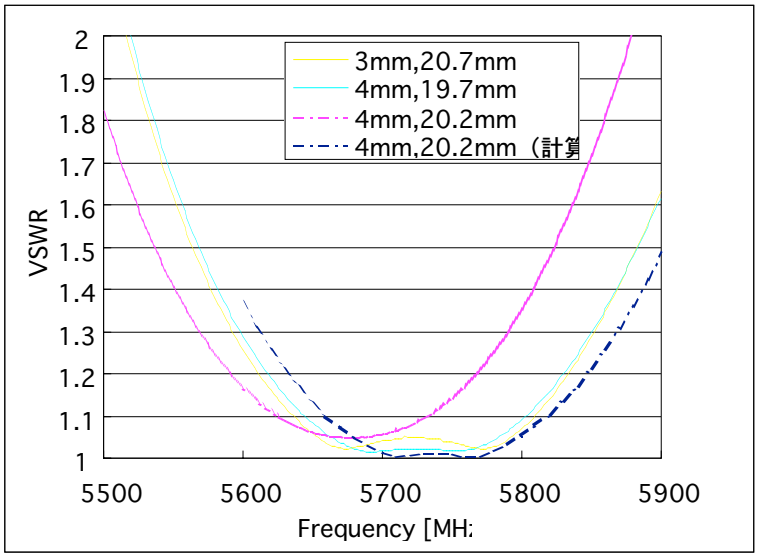
- Reduced Electric-field at the edge combing a TE11-mode and a TM11 mode.
- Possible to use the large diameter ceramic, though structure is more complicated. (Diameter of 53mm for X-band).
- One window configuration for 50 MW output power.

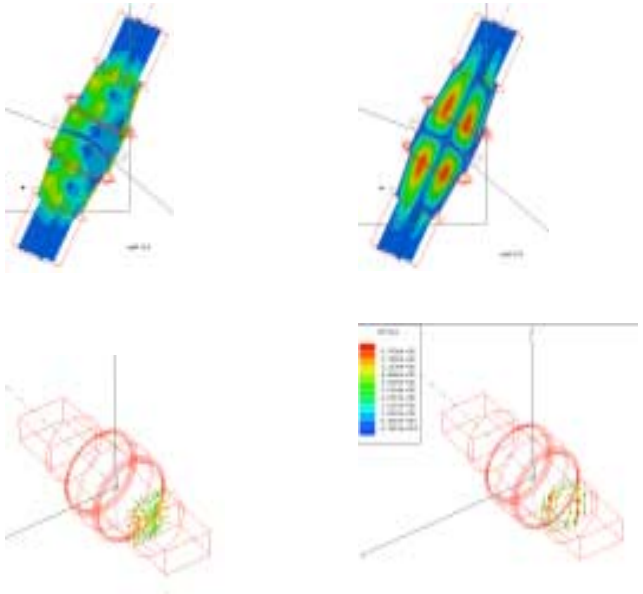
Calculation and Measured Results



Designed Window and Cold Measurement (Left top and bottom)

Analysis of Ghost Mode in Window (Below)





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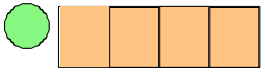
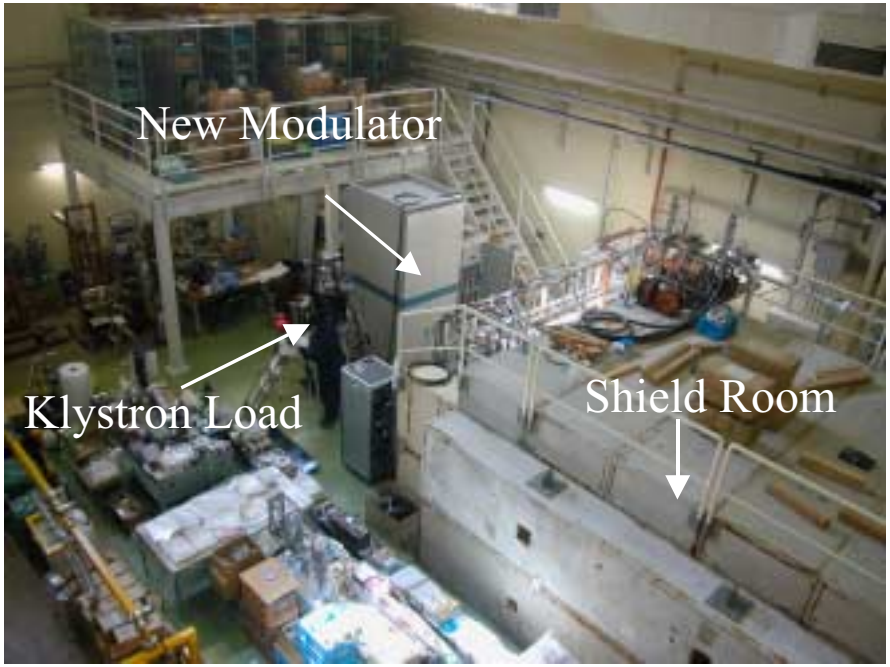
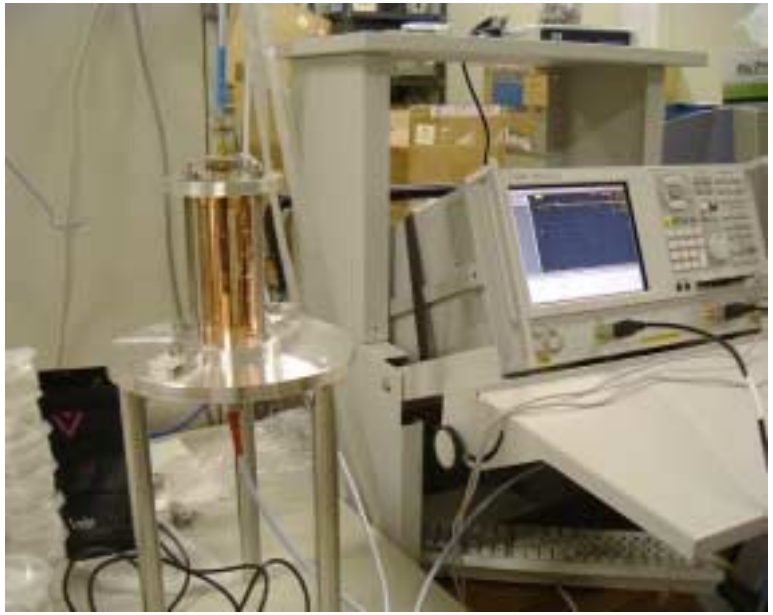
Test Layout of C-band Accelerator Processing in Accelerator Construction Hall



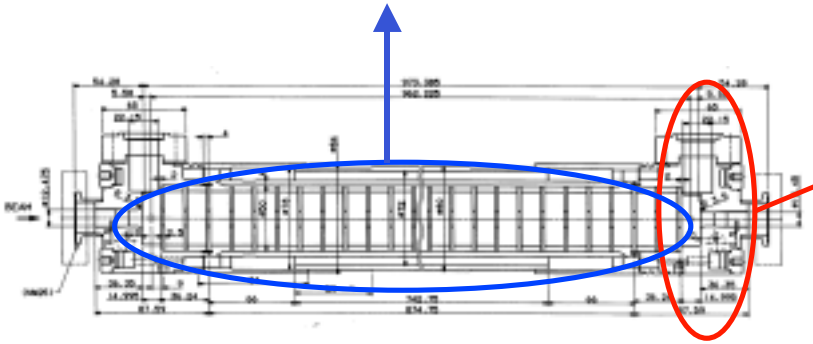


RF Measurement of Standard Cavity for the Acc. Guide in KEK



Left photo shows the standard cavity to give the standard frequency for other manufactured Cavity.

Accelerator Manufacturing Status in MHI and KEK



Due to the super-fine lathe trouble of MHI, final machining of the disks will be finished in KEK.

Left: first machined disks in MHI

Below:Coupler and measuring jig

Schedule up to Summer

We have a schedule to install an 1m-long accelerator guide in the beam line of S-band KEKB linac making use of the summer shut-down (**only a chance** to install it in this year). Necessary tests are planed with this schedule.

50-MW Klystron test will be started from February 17, 2003 for 2 weeks.
Evaluate the modulator performance, check the tank assembly and waveguide components. Evaluate the driving system from the master oscillator to SB klystron.
Resonant Ring Test will be started from end of the March for about a month.
Evaluate the capability of a Kazakov window with 50-MW power.

High-power test of 1m-long accelerator guide up to 40MV/m will be started from the beginning of July for 1 month.

SiC-dummy load and hybrid are also planed at the same time.

Then 1m-long accelerator guide is installed in the #4-4 unit of the KEKB linac.

All test stand components are moved to #4-4 in the Klystron gallery.

Beam acceleration test will be proceeded in this fall.

Toward 2004 Spring Beam test at KEKB Linac

(1 Pulse Modulator + 1 Klystron + 1 RF compressor + 2 Accl. structures 1m-long)

and new RF test stand

- Accelerating structure #2 (New power coupler design)

  Under basic design
- RF pulse compressor (LIPS-type TE038-mode)

  Under basic design
- New RF test stand construction

  (Because all components of the test stand are moved to #4-4 in Klystron Gallery)

  Demanding the budget for new bench
- High Power test of accelerator structure #2 in the new RF test stand
- High power test of pulse compressor in the new test bench?

  Or directly install in the klystron gallery?

- Beam test using the pulse compressor in 2004 spring.