KEKB INJECTOR LINAC AND UPGRADE FOR SUPERKEKB

S. Michizono

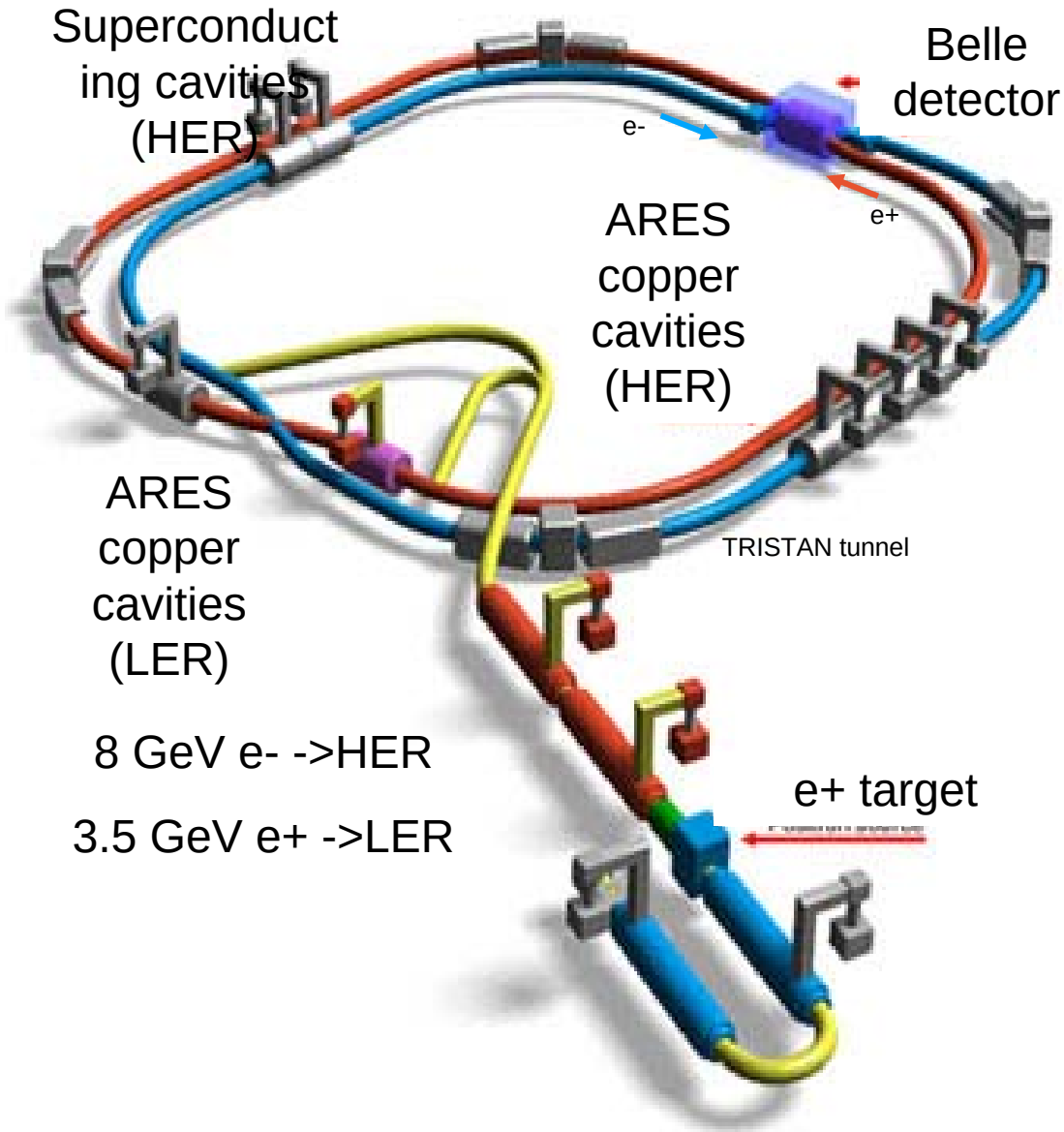
for the KEK electron/positron Injector Linac

and the Linac Commissioning Group

KEK

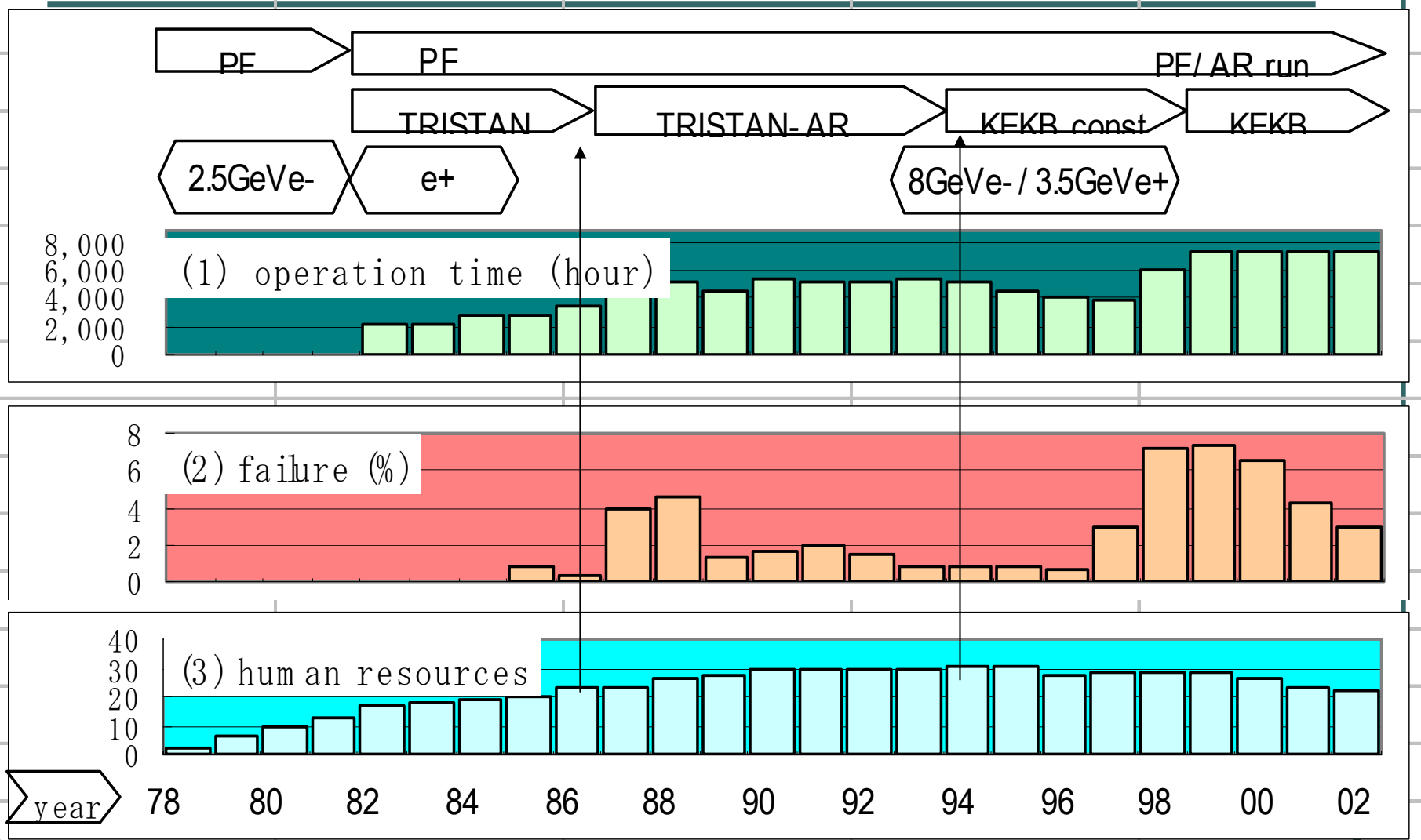
- **KEKB injector linac**
  - **Brief history of the KEK electron linac**
  - **Continuous injection (CI) scheme**
  - **Maintenance and R&D at CI scheme**
- **Upgrade for SuperKEKB**
  - **Schematic ------*MOP31 S.Ohsawa et al.***
  - **Rf source ------ *(rf window) THP58 S. Michizono et al.***
  - **SKIP ------*THP61 T.Sugimura et al.***
  - **Acceleration structure ------*THP29 T.Kamitani et al.***
  - **Dummy load**
- **Summary**

KEKB B-Factory



KEKB schematic

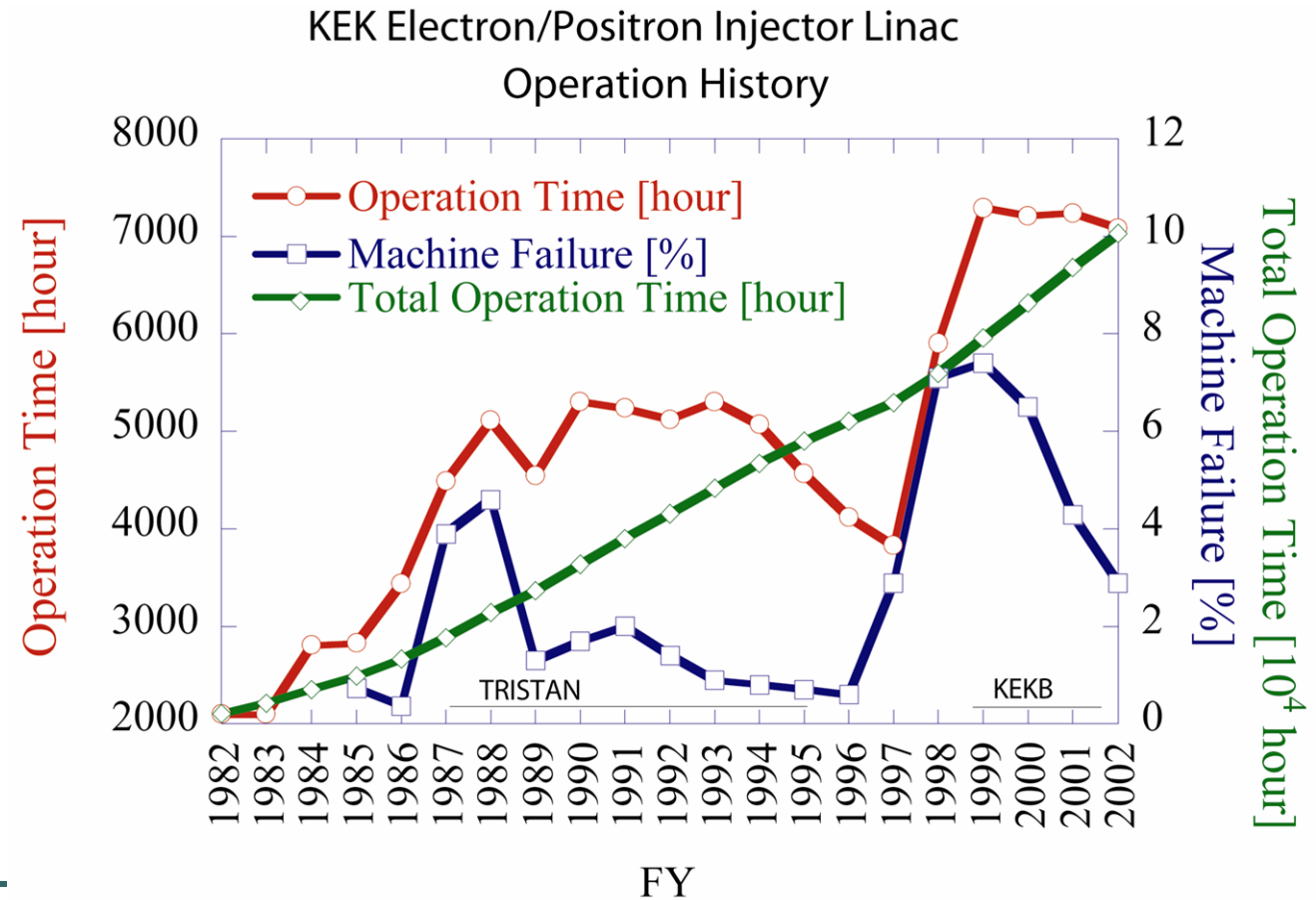
Operation Statistics



100,000 hours operation since 1982

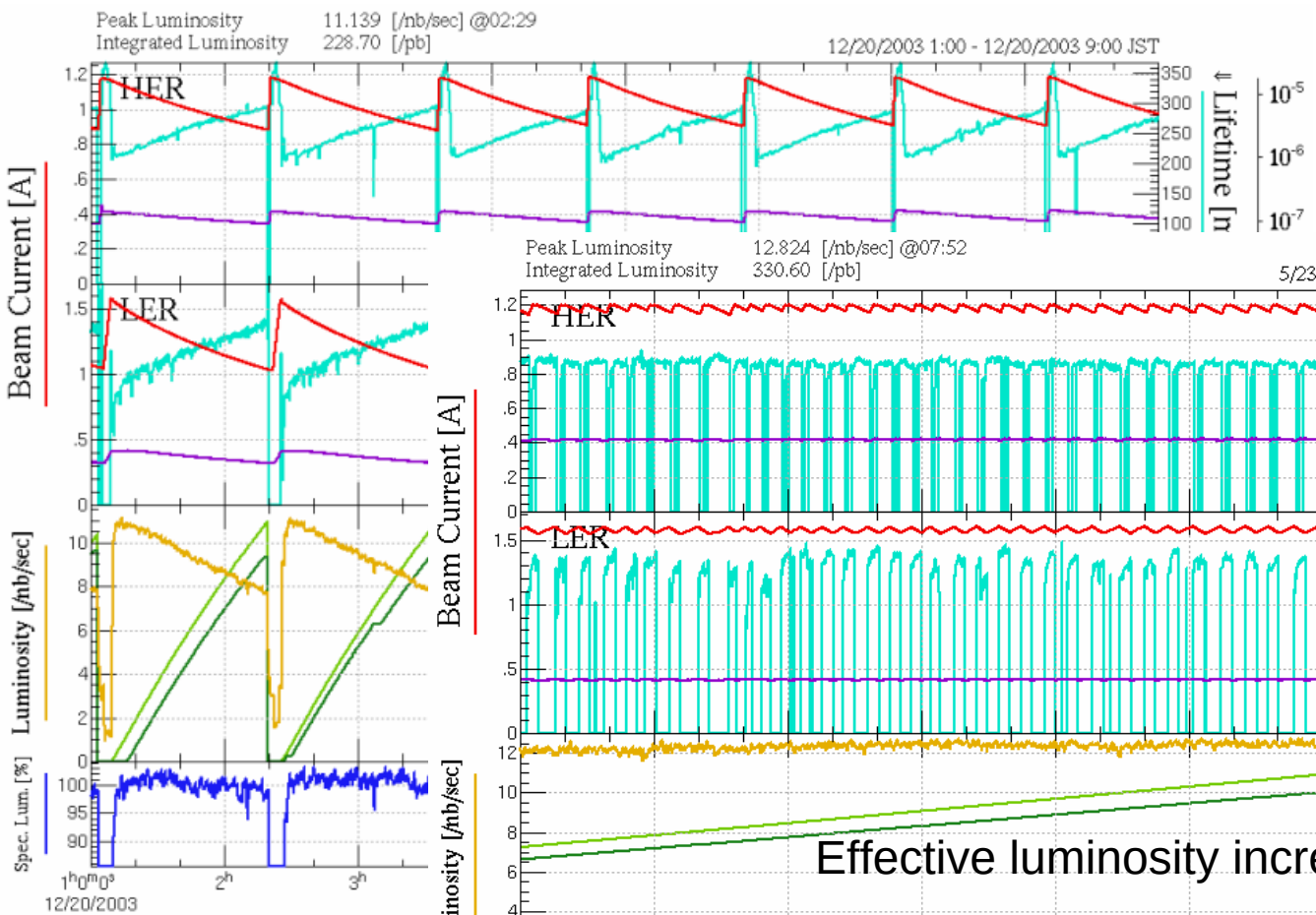
Operation status

- Total operation time reached 100,000 hours on March,2003.
- Machine failure is limited less than 5 %.



Continuous Injection (CI) Scheme

traditional



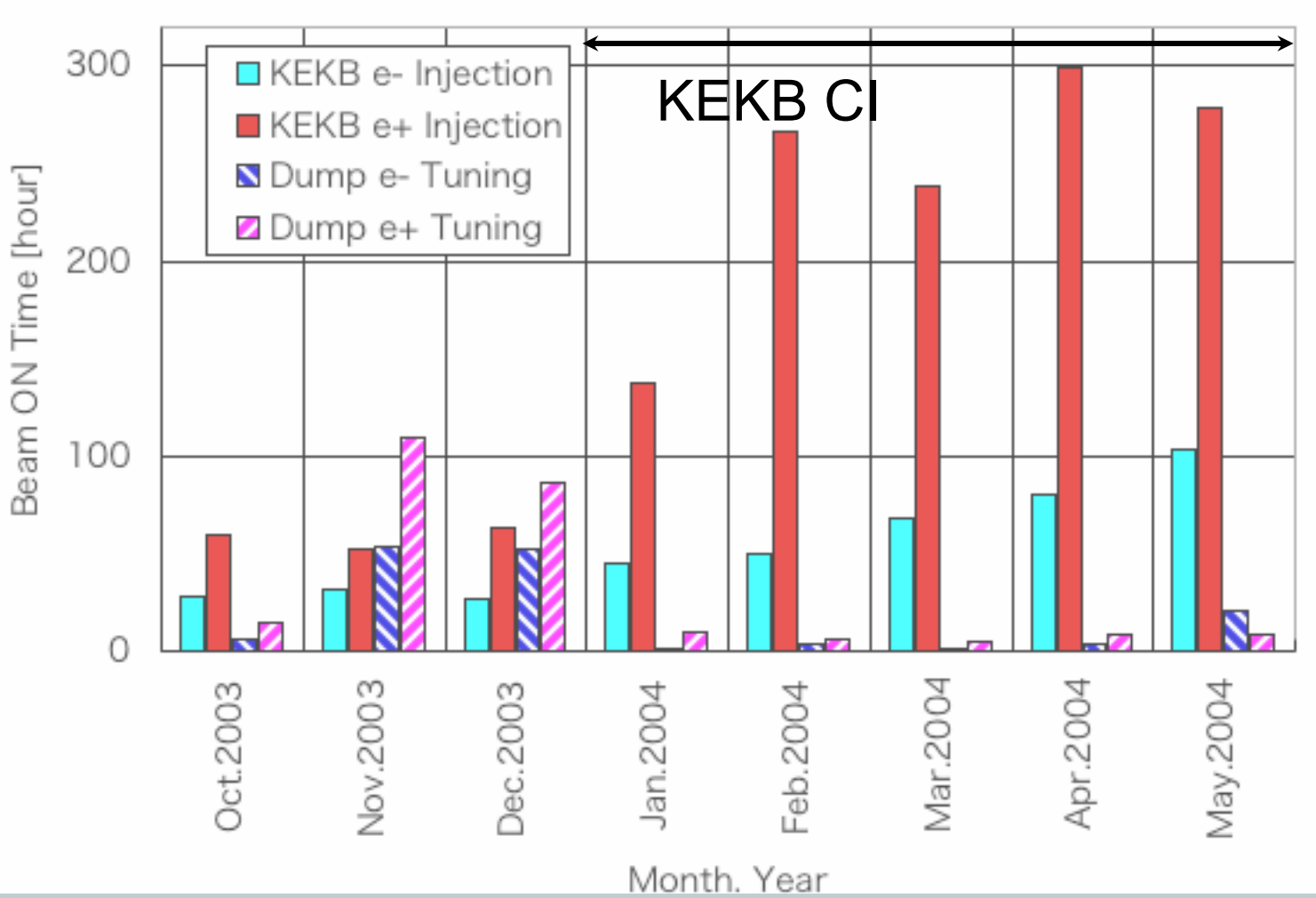
CI since Jan.,2004

Effective luminosity increases ~20%

WE205

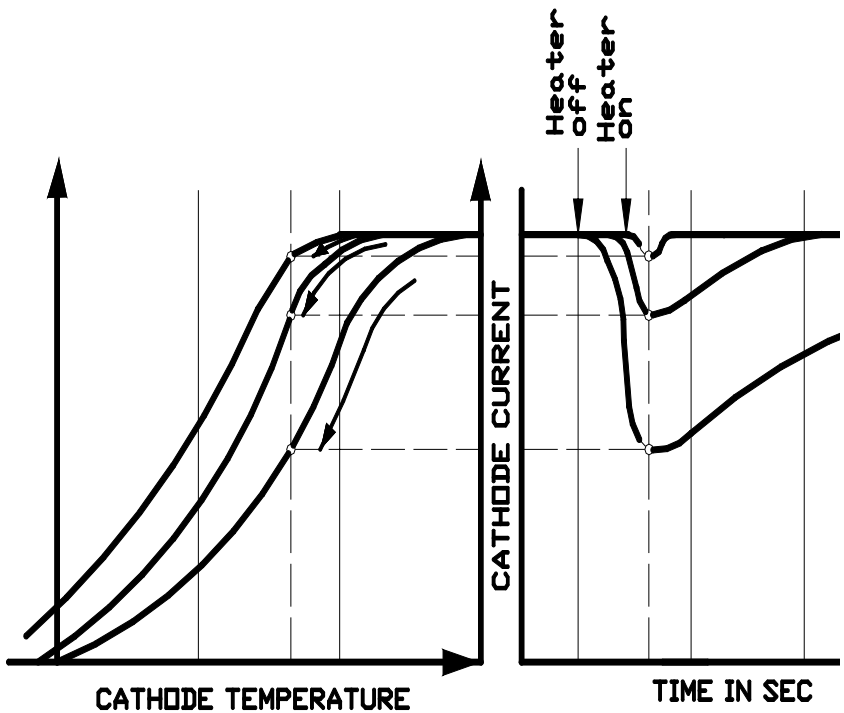
Beam on time after CI scheme

Careful beam tuning and short maintenance are required at CI.

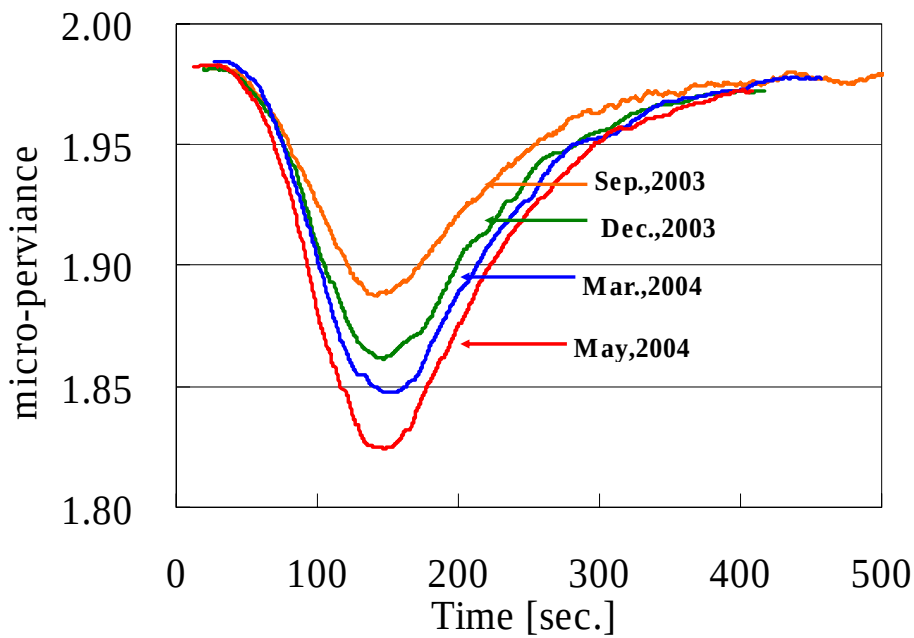


Dip test

- In order to find out the emission decrease of the klystrons, dip tests are applied to all the klystrons.
- Deeper dip -> operation near the shoulder.
- heater off time: 60 sec.
- Total measurements: within 10 min.



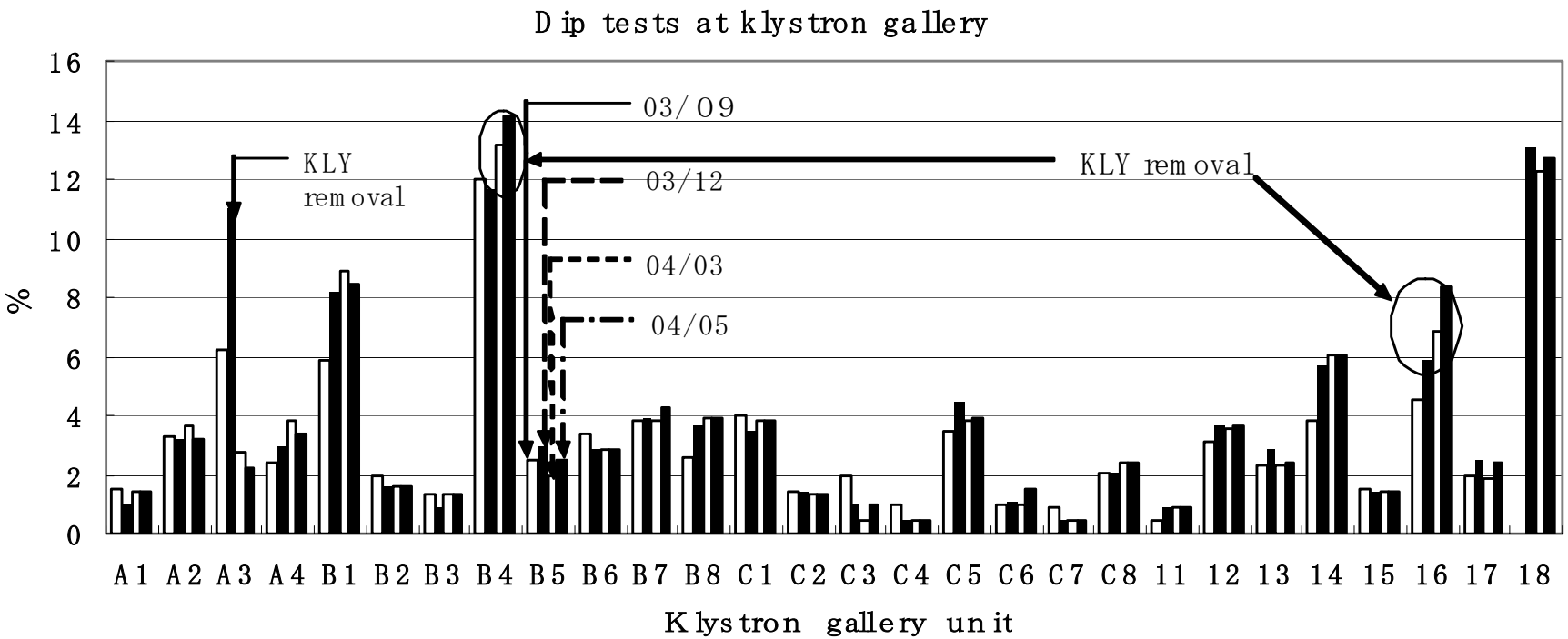
Example of emission decrease



Dip test

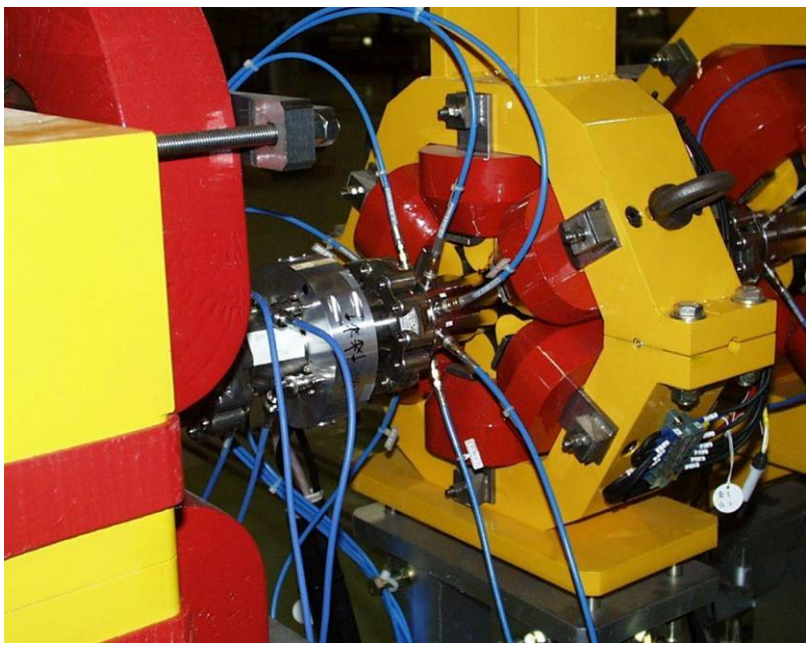
- Periodical measurements of the dip

  -> find out the emission decrease with time



Energy spread feedback

- Feedback systems
  - Energy feedback -> done
  - Position feedback -> done
  - Energy spread feedback -> tested with 8 electrodes BPM



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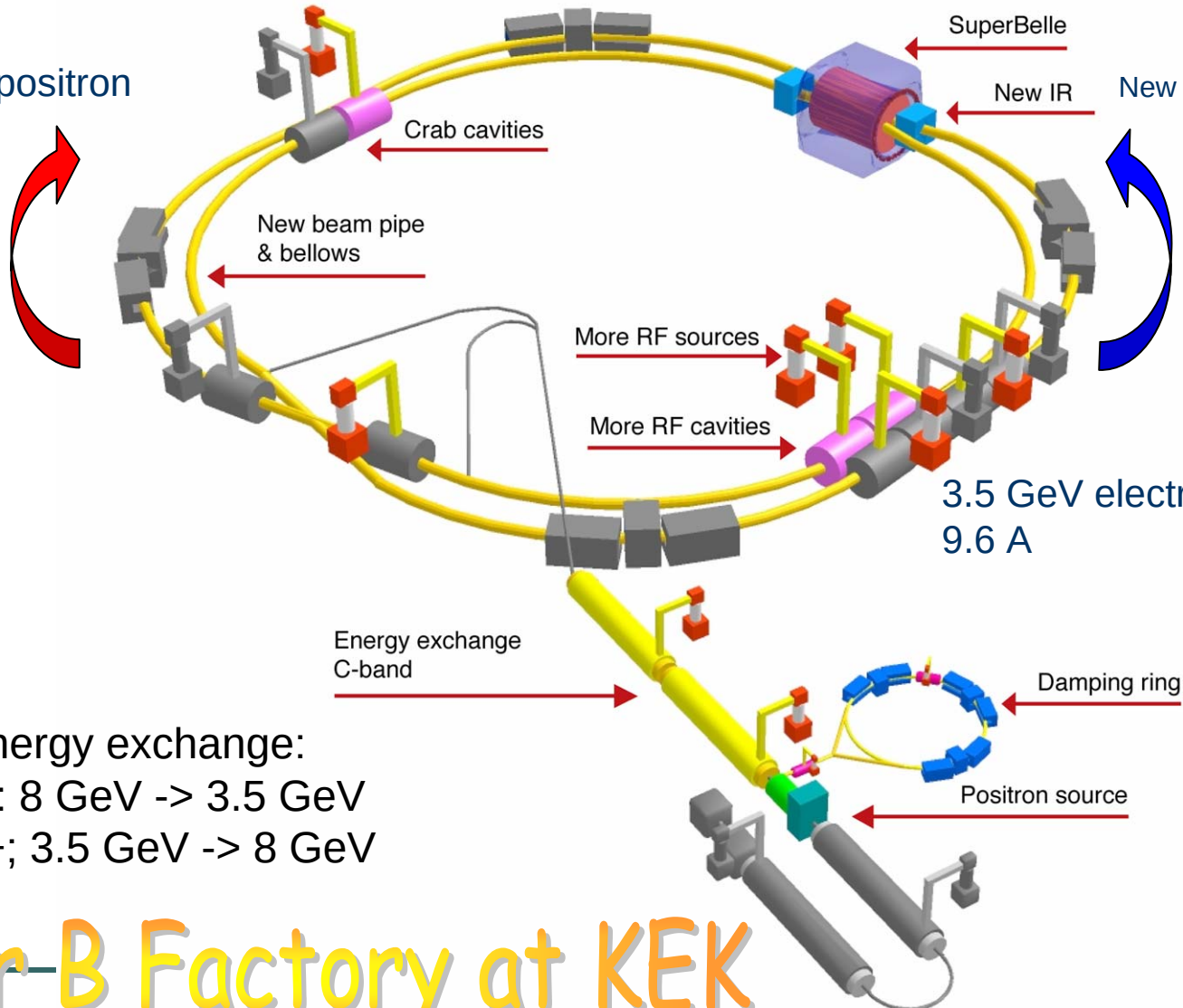
  - **Schematic**
  - **Rf source**
  - **SKIP**
  - **Acceleration structure**
  - **Dummy load**
- **Summary**

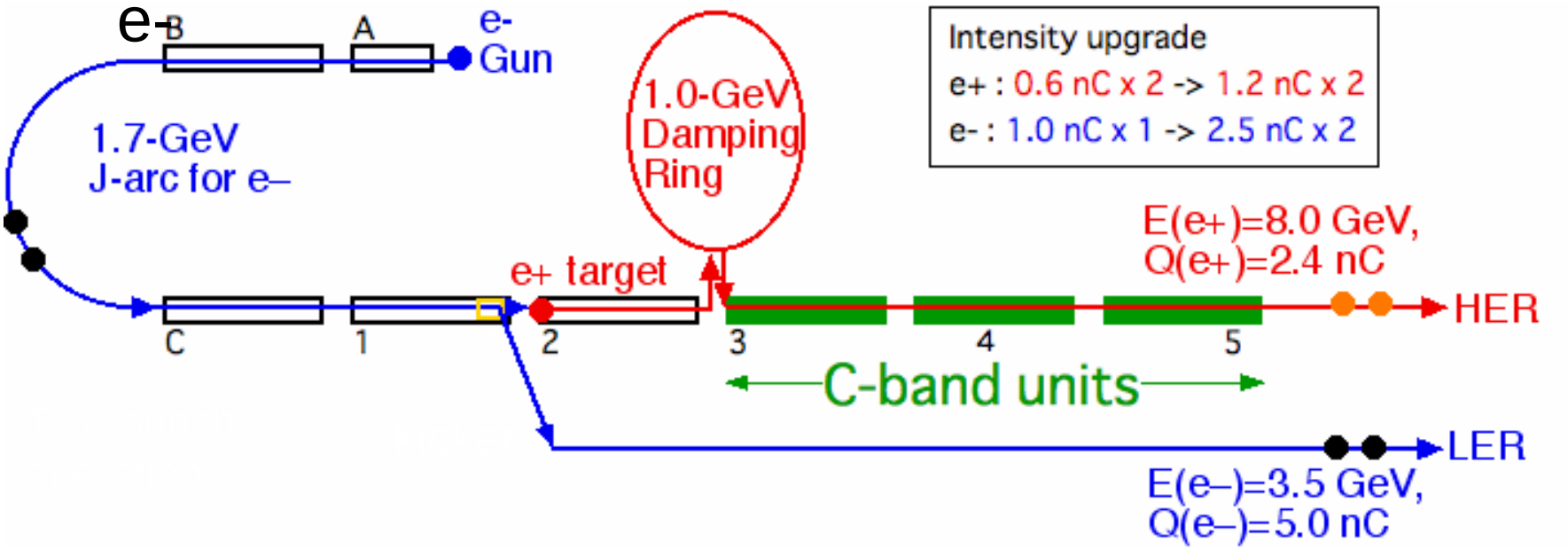
Schematic of SuperKEKB



Energy exchange:
e-: 8 GeV -> 3.5 GeV
e+; 3.5 GeV -> 8 GeV

Upgrade of the injector linac

- 8 GeV e- / 3.5 GeV e+⇒8 GeV e+ / 3.5GeV



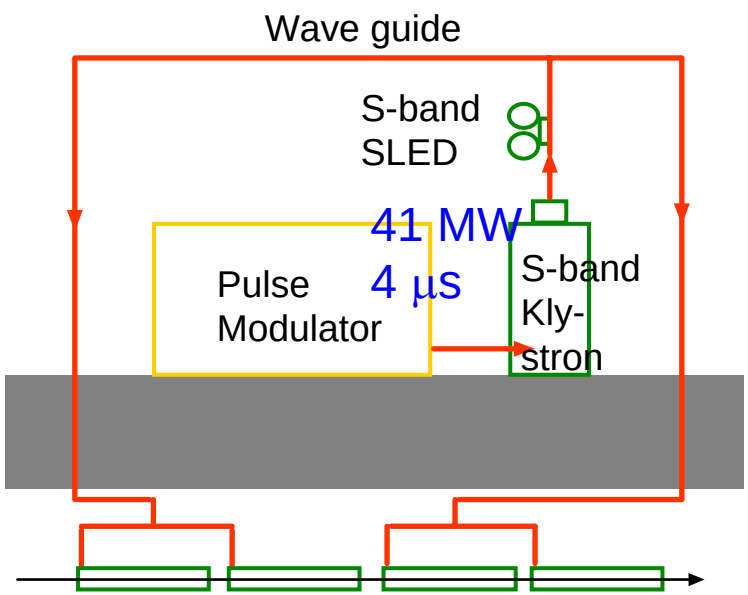
- S-band (2856 MHz) ⇒C-band(5712 MHz) (#3 ~ #5 sectors)

Linac Accelerator module

(From S-band To C-band)

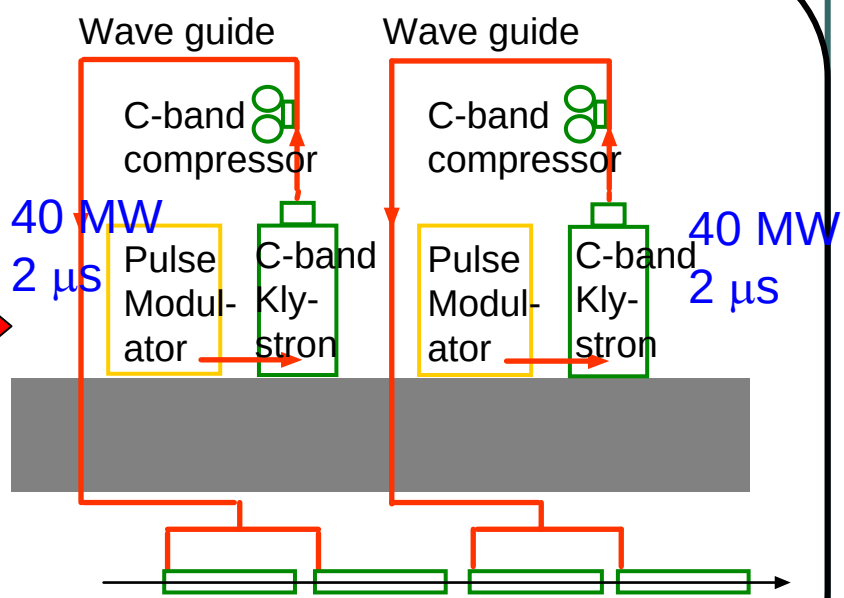
- *MOP31 S.Ohsawa et al.*

Present S-band accelerator module



Accel. field gradient = 21 MV/m

New C-band accelerator module

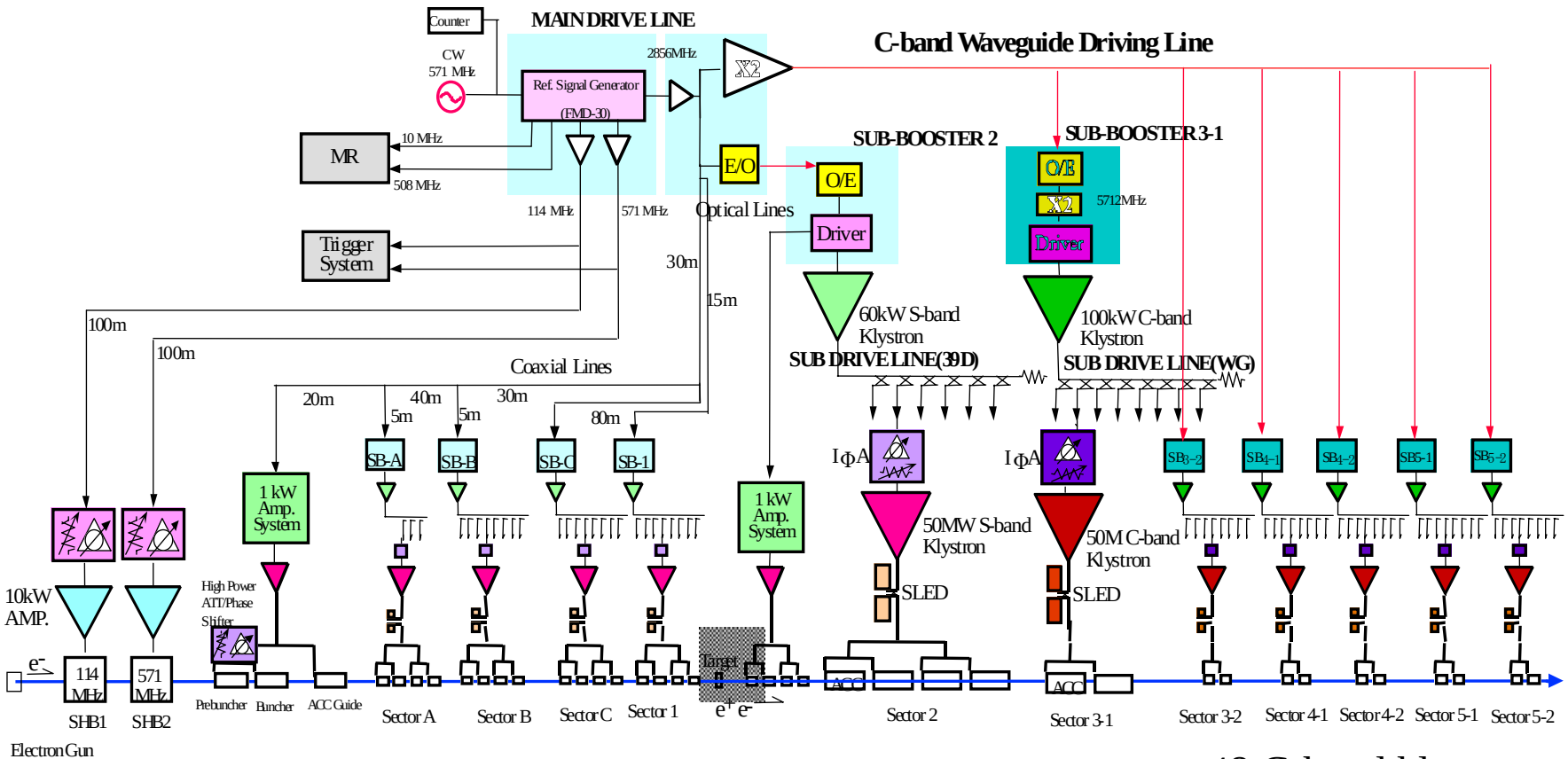


Accel. field gradient = 42 MV/m

Overview of C-band rf system

- C-band rf system from #3 to #5 sector
- Forty eight klystrons are installed (instead of 24 S-band klystrons)

RF System Diagram C-band Plan(example)



48 C-band klystrons

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  - **Schematic**
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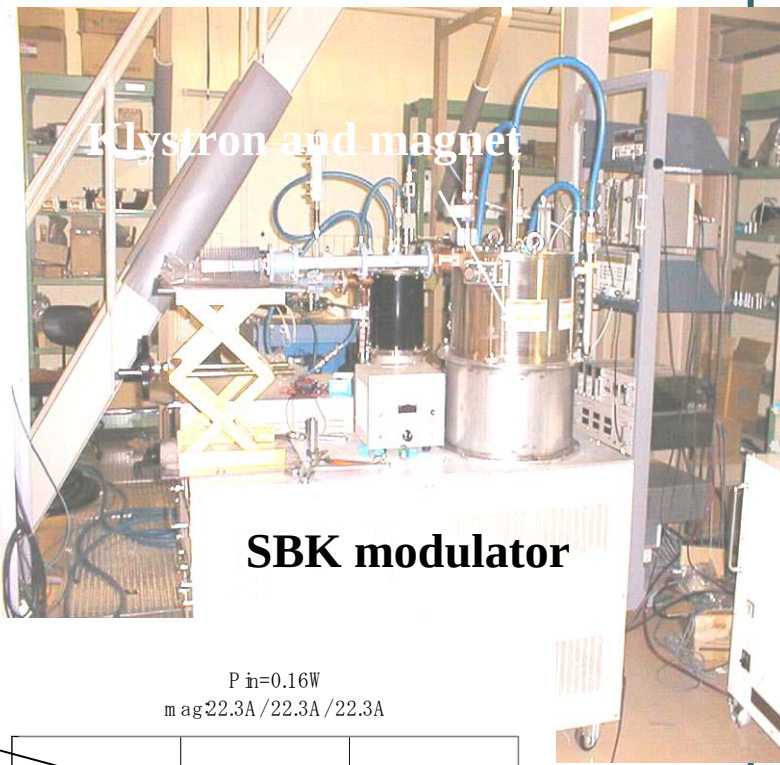
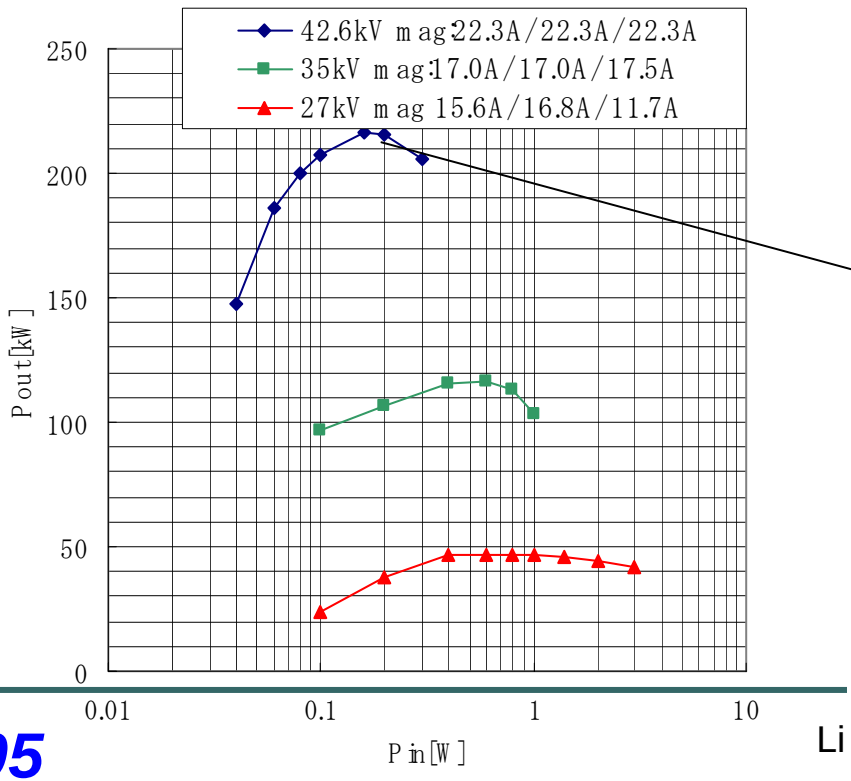
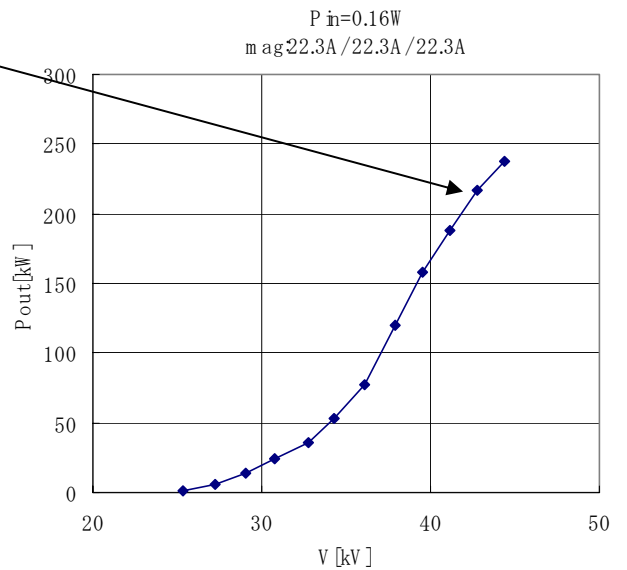
  - **Dummy load**
- **Summary**

Driver klystron

- Retune the existing C-band 200 kW klystron for weather observation station (MELCO).
- Driver klystron (SB) can deliver >100 kW (35 kV)
- Same modulator and HV supply to S-band syster used.

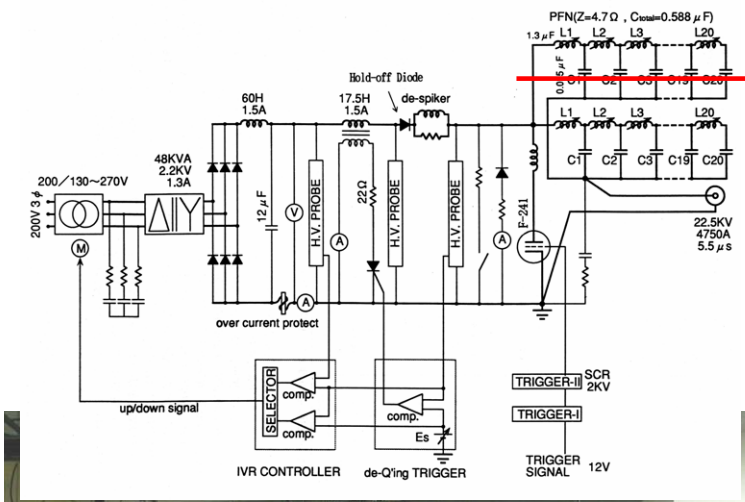


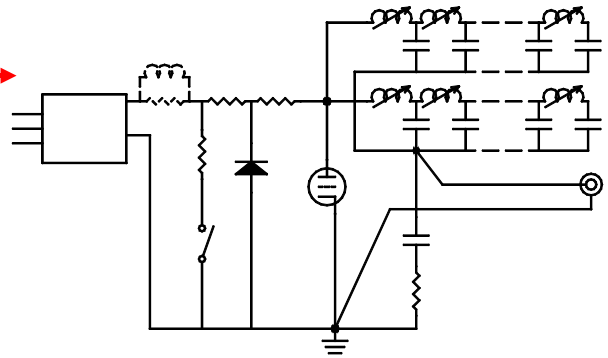


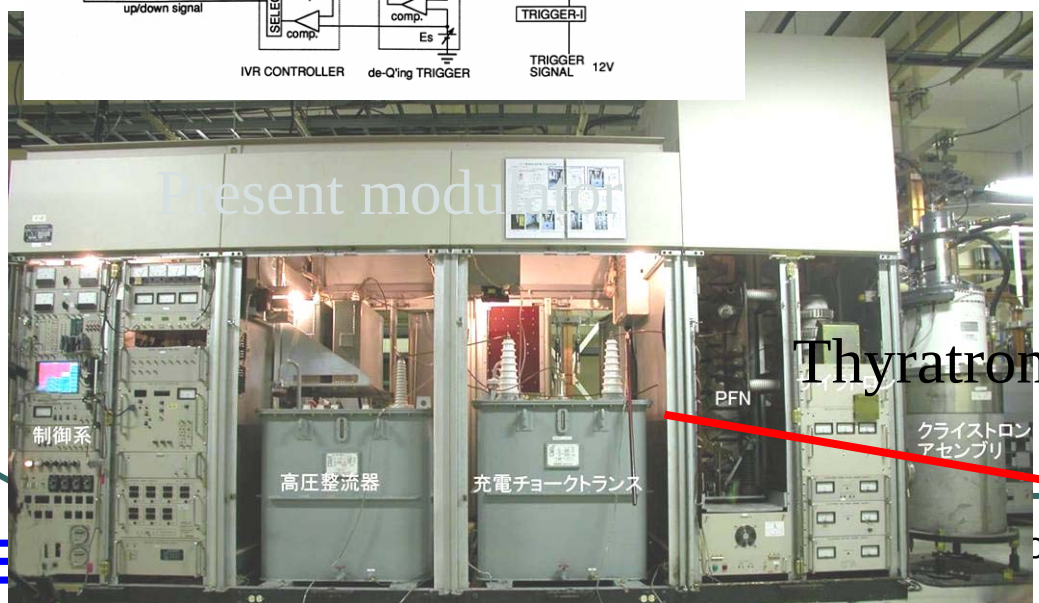


Compact modulator

- By using invertor P.S., the modulator size can be 1/3 (4.7 m->1.8 m).
- Present PFN and Thyratron are reused at new modulator.







Thyratron

C-band klystron

- C-band 50 MW klystron is commercially available. (developed by KEK for linear collider)

TENTATIVE

TOSHIBA

Display Devices & Components Company

TECHNICAL DATA

TOSHIBA PULSED KLYSTORN AMPLIFIER E3746

Toshiba E3746 is a C-band high power amplifier klystron designed for linear accelerators.

The E3746 delivers 50MW peak output power in 2.5 s pulse.

Output power is extracted through two WR187 standard waveguides in parallel. One port output is also possible with the specific power combiner .

The electron beam is focused by a series-coil electromagnet. The specific focusing electromagnet VT-68926 is available.

A Scandate dispenser cathode is employed, ensuring high reliability and long tube life.

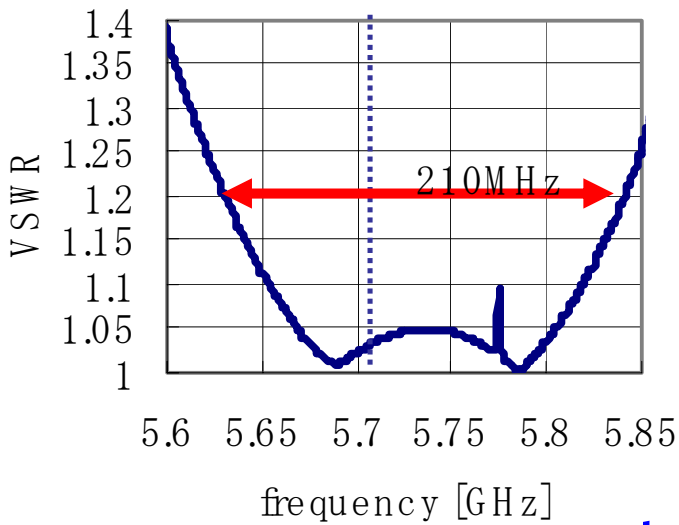
Y. Ohkubo, H. Yonezawa, T. Shintake, H. Matsumoto and N. Akasaka, "HighTHE C-BAND 50MW KLYSTRON USING TRAVELING-WAVE OUTPUT STRUCTURE", Linac98, Chicago, p.932.

GENERAL CHARACTERISTICS

R&D of c-band rf window

- Requirements: 50 MW 2 μs (⟷ S-band 50 MW 4 μs)
- About Sixty S-band rf windows are successfully operated in KEKB linac. (MTBF > 40,000 h.)
  Electric fileds should be less than rf windows used in S-band linac.
- Mix-mode window (TE11+TM11) enables to lower the edge electric field.

	S-band	C-band
Electric field at center of the ceramics [MV/m@50MW]	3.7	3.1
Electric field at edge of the ceramics [MV/m@50MW]	1.7	***0.8***
Maximum electric field on the ceramics [MV/m@50MW]	5.5	3.7
Band width [MHz] (VSWR<1.2)	600	210



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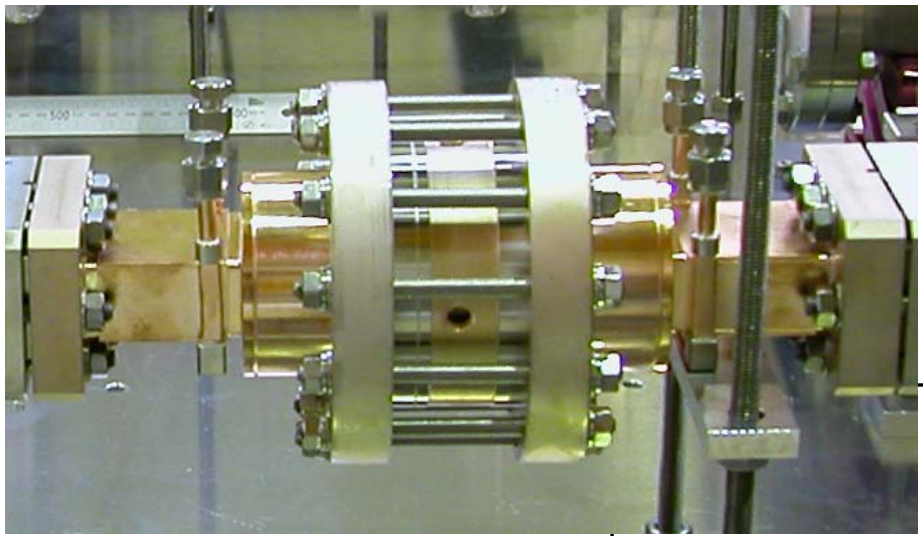
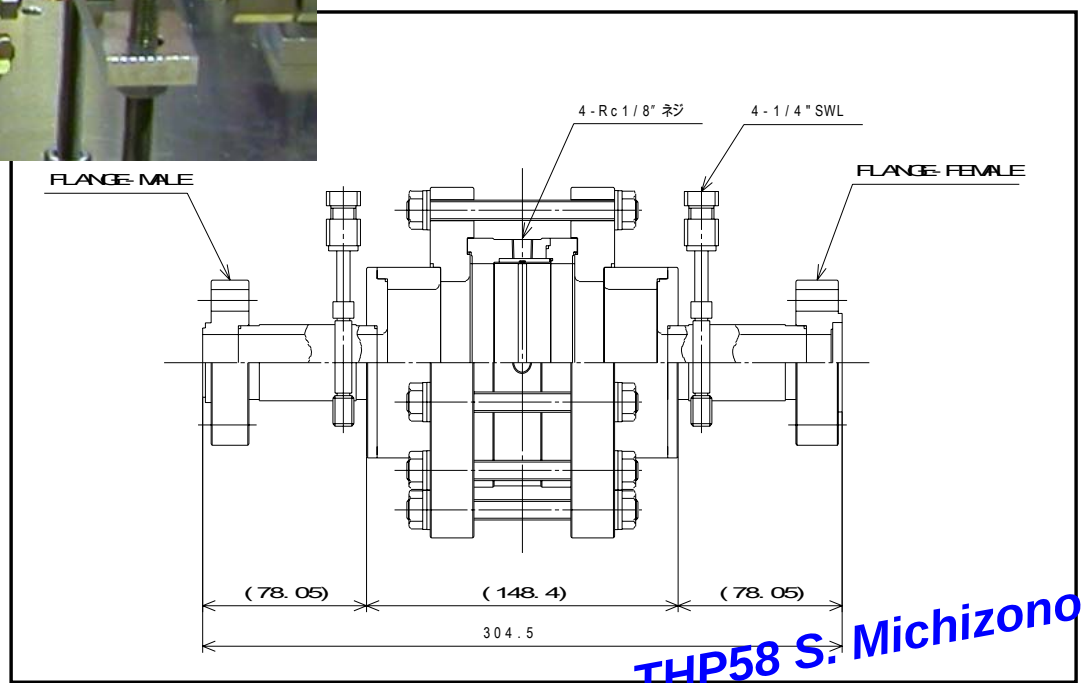
Mix-mode rf window





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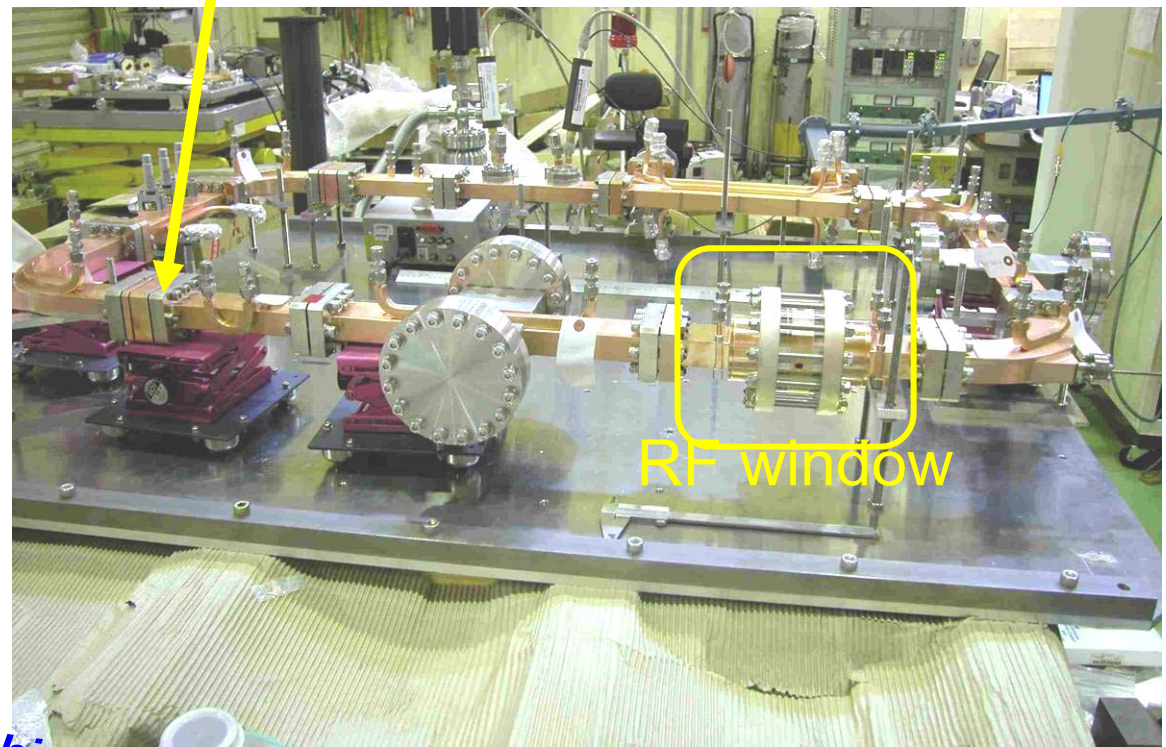
Resonant ring in the shield

- High power tests of the window was carried out by resonant ring.
- Rough tuning: spacer
- Fine tuning: operation frequency (5712->5710.2 MHz)



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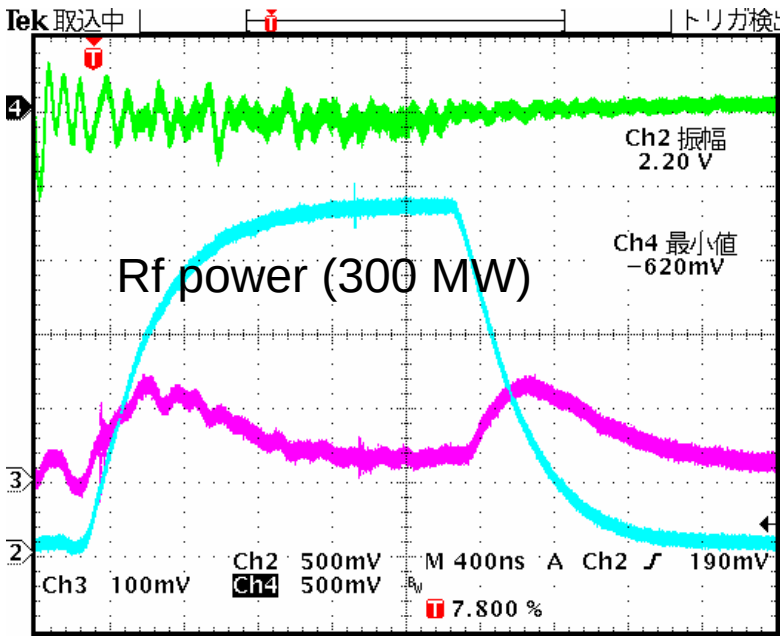
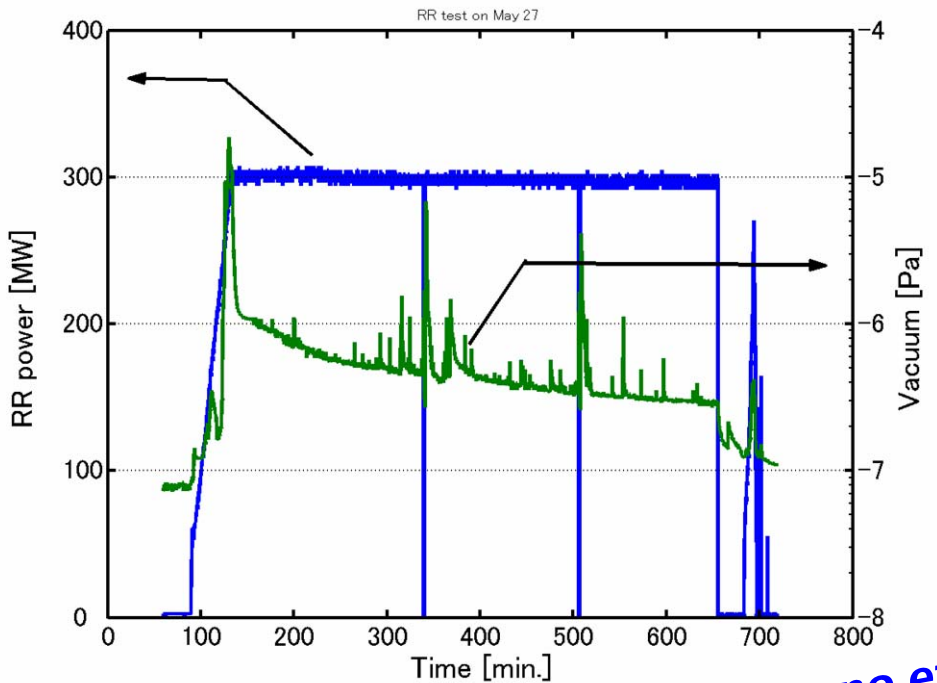
Results at resonant ring

- Maximum operation power of 300 MW (2 μ s), corresponding to 6-times larger than specification (50 MW).
- Only 3-times rf trips during 8 hours operation at 300 MW.





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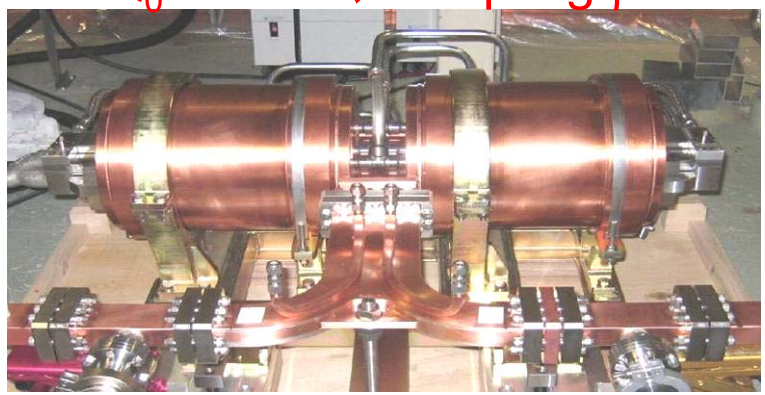
SKIP (SuperKEKB Injector Pulse compressor)

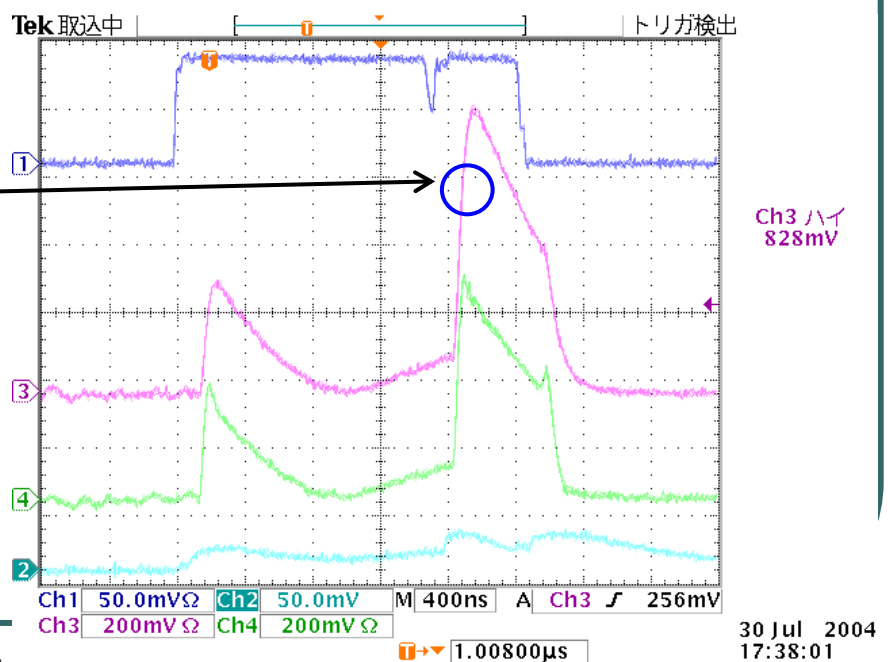
- Mode:

  TE015(SLED)-> TE038(LIPS)
- Similar cavity size to present S-band SLED.
- Higher Q value.
- Output 200 MW @43 MW input
- Power magnification:4.7

(lower than calculated value(5.5) due to slower switching time)

Q_0=13200、coupling β = 6.6





THP61 T.Sugimura et al.

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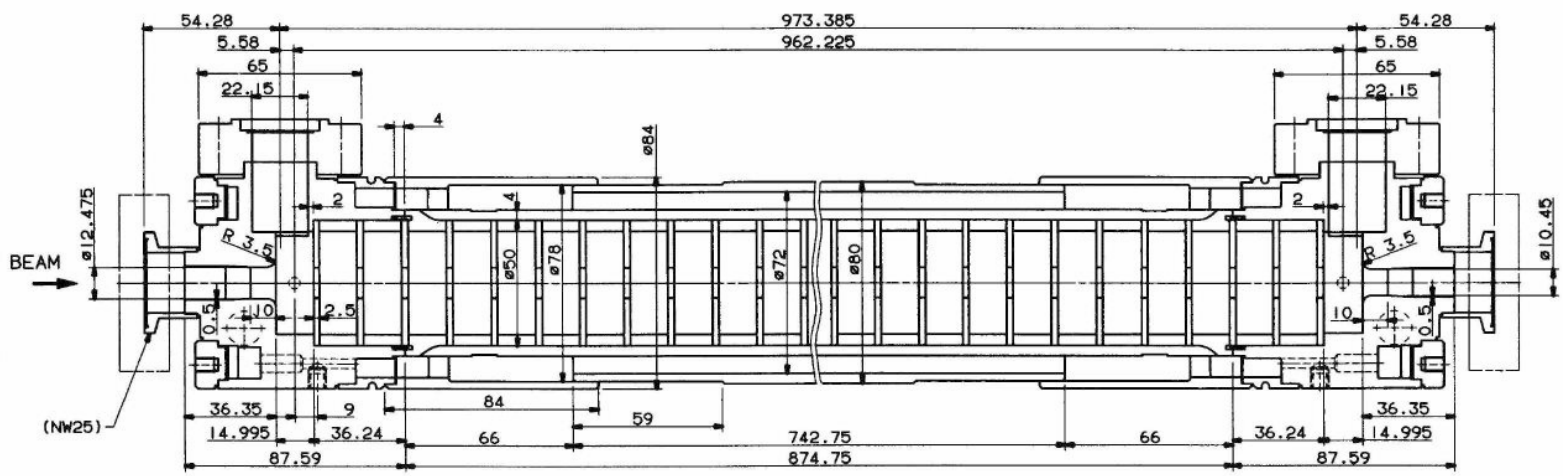
  - **Schematic**
  - **Rf source (LLRF, Modulator, high-power klystron, rf window)**
  - **SKIP**
  - **Acceleration structure**
  - **Dummy load**
- **Summary**

C-band accel. section (First prototype)

54 regular cells 1m-long

iris diameter 2a: 12.44 ~ 10.41 mm

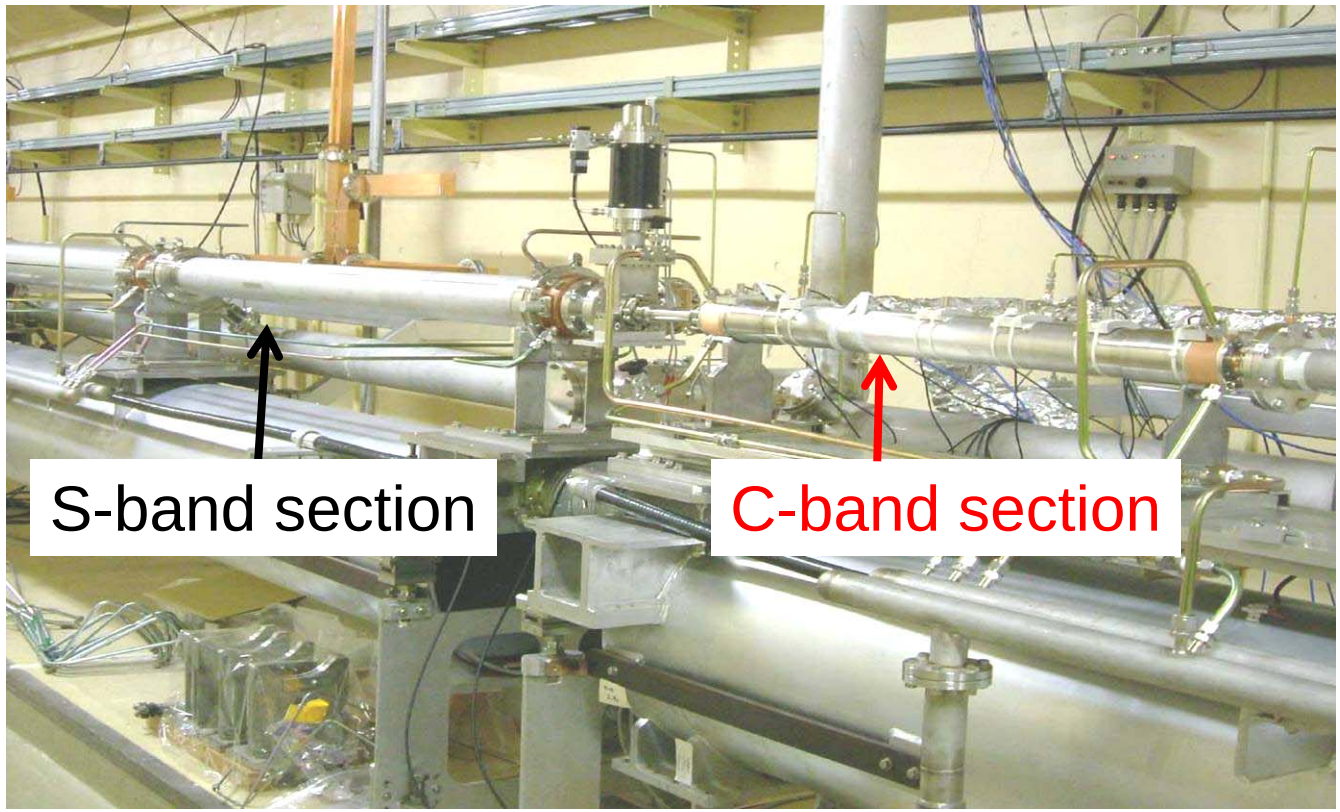
Based on present S-band acceleration structure



Filling Time t_F = 234 nsec

THP29 T.Kamitani et al.

C-band accel. section installed in KEKB linac (2003 September)



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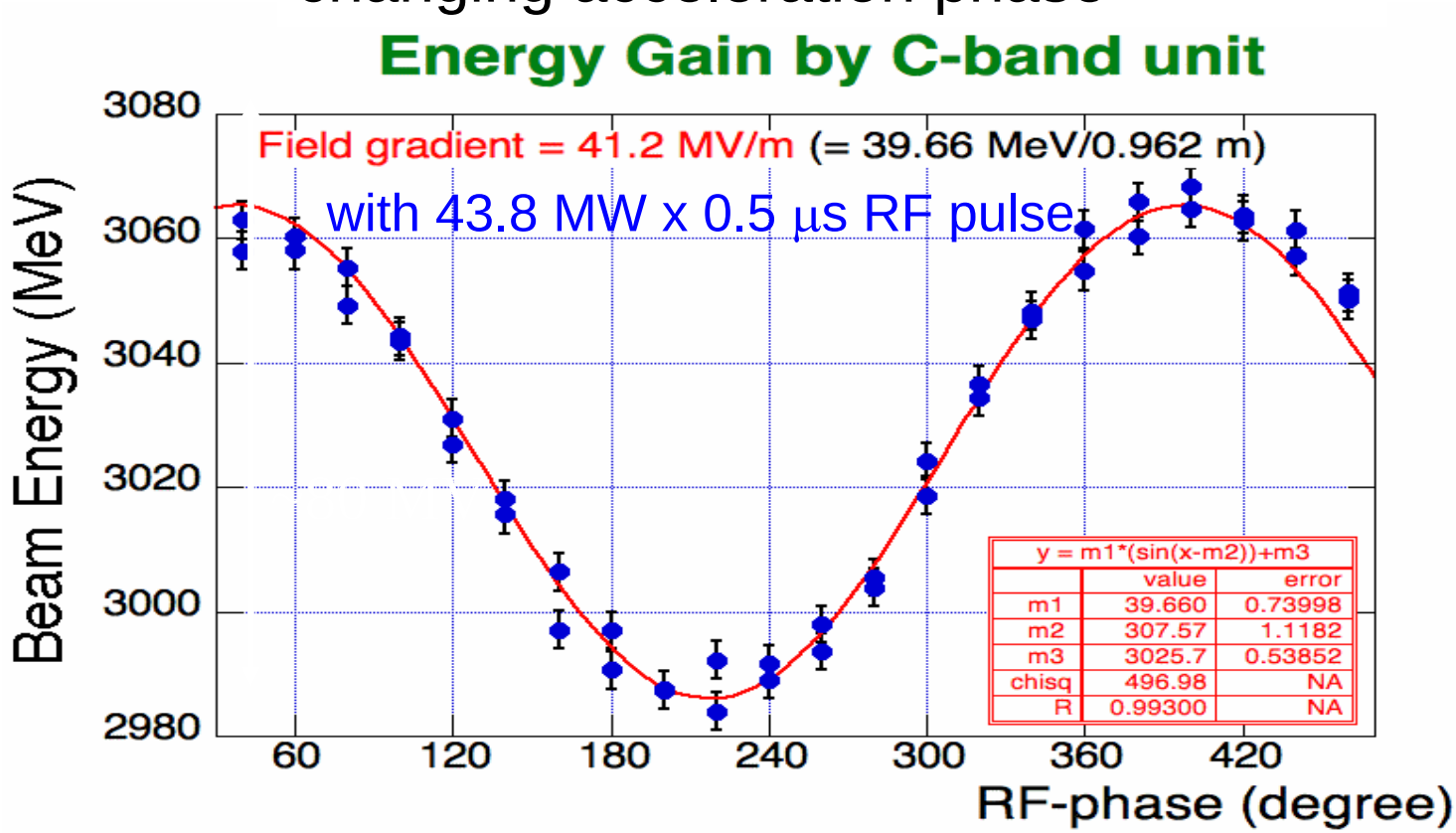
Beam acceleration study

Energy gain measured by changing acceleration phase



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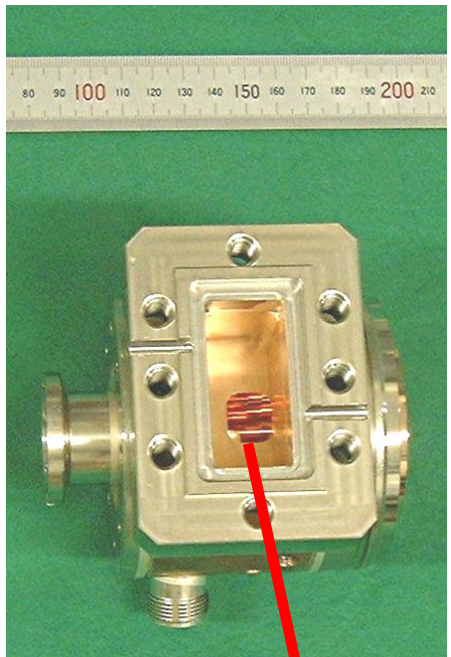
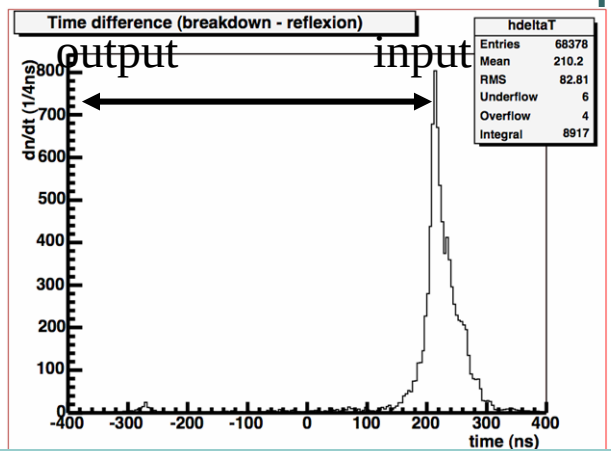
Inside of the acceleration structure

- Discharge every 10 min. even after conditioning.
- It took place around input coupler (rf wave analysis).
- Discharge traces observed input coupler and first disk.





Discharge location analyzed by rf waves.

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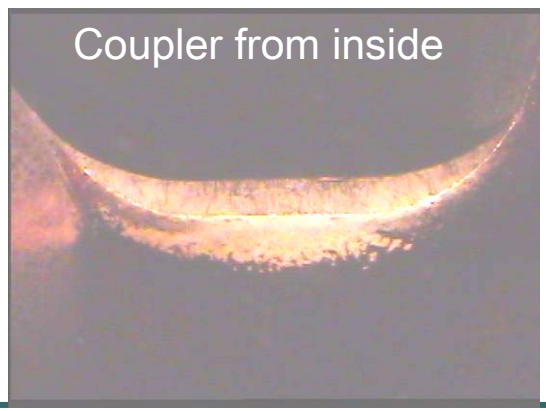
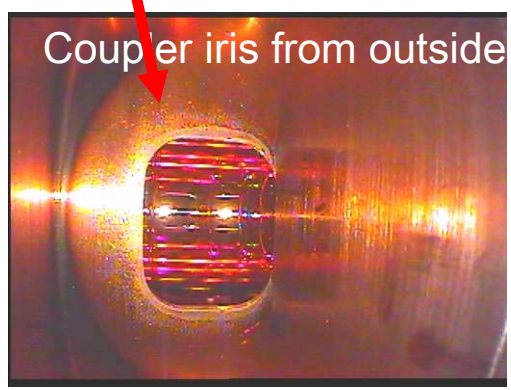
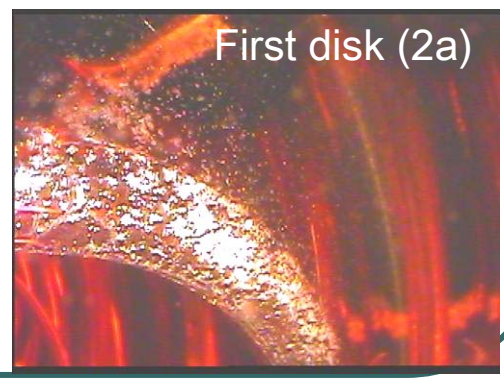
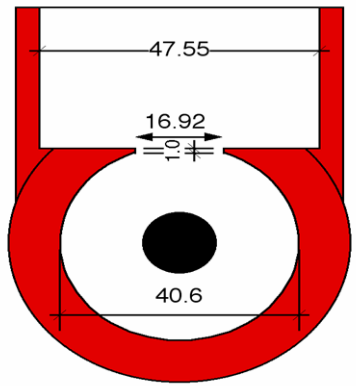




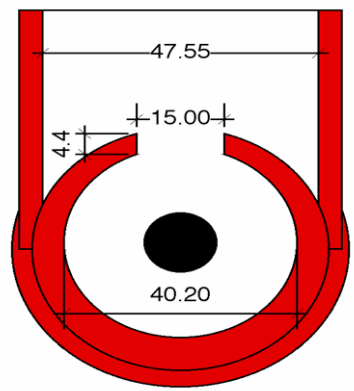


Second acceleration structure

- Thicker iris
- Wider coupler length @ 2nd acceleration structure
- High power test @ Aug.,2004.



1st coupler



2nd coupler

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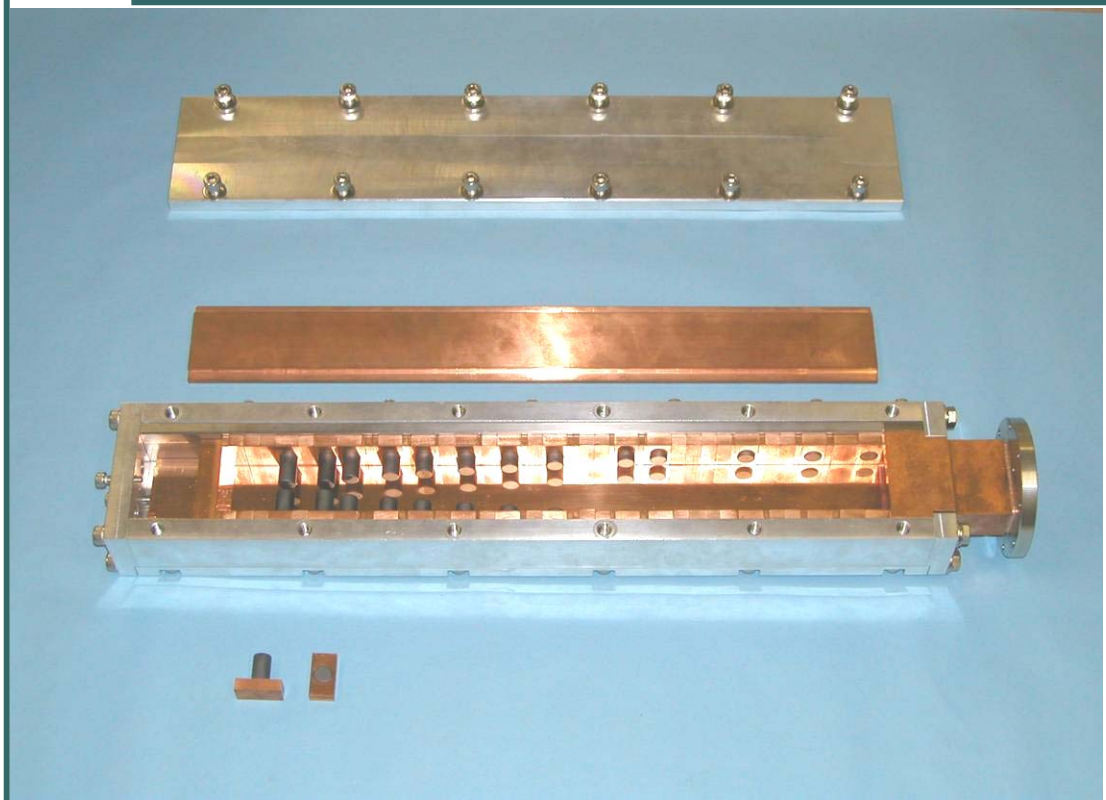
Dummy load



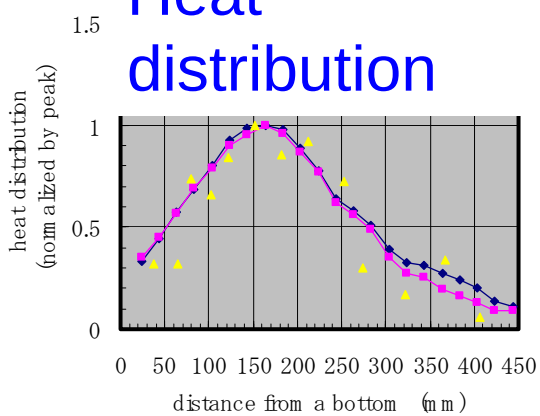
Newly designed 2kW

Matsumoto-type dummy load

- 26 SiC cylinders
- SiC diameter 12 mm

High power test OK
up to 2 kW (100 MW peak)

Heat distribution



Summary

- S-band linac has been operated > 100,000 hours.
- The failure rate is about 5% and it contributes to the stable KEKB operation.
- C-band R & D is in progress.
- High power test of the prototype C-band accelerator module has been performed since October 2003.
- Most of the components are working well.

  (Remaining issues)

  Breakdown at input coupler -> improve @ 2nd acc. structure

  inverter P.S. troubles -> long term operation

(related presentations tomorrow)

- **Rf *window :*** ***THP58 S. Michizono et al.***
- **SKIP:** ***THP61 T.Sugimura et al.***
- **Acc. structure** ***THP29 T.Kamitani et al.***