C-band R & D status for SuperKEKB

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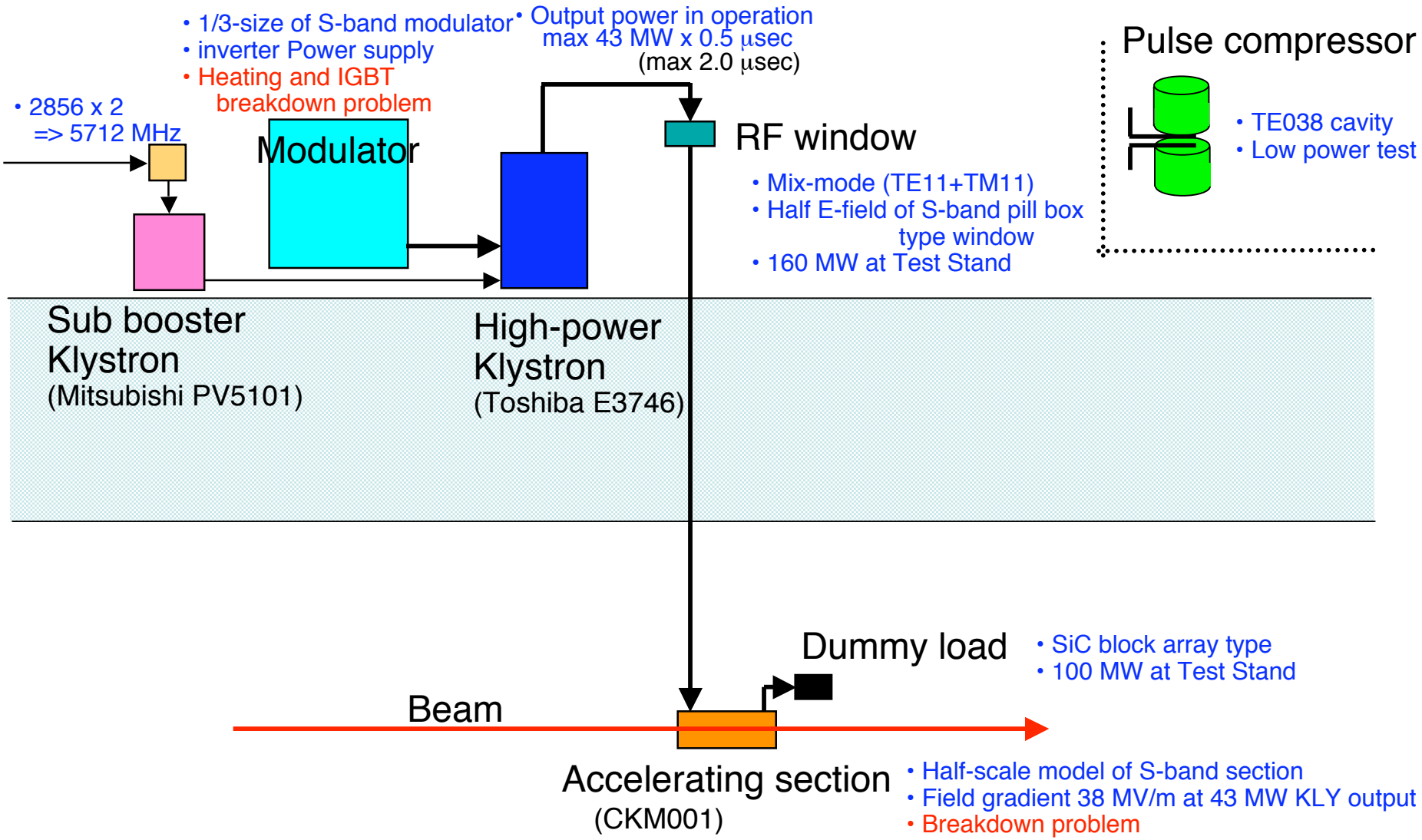
Status at the last KEKB Review (Feb-2004)

Linac C-band Test Module #4-4A

(C-band components was installed in Sep-2003 and had been operated for 5 months)

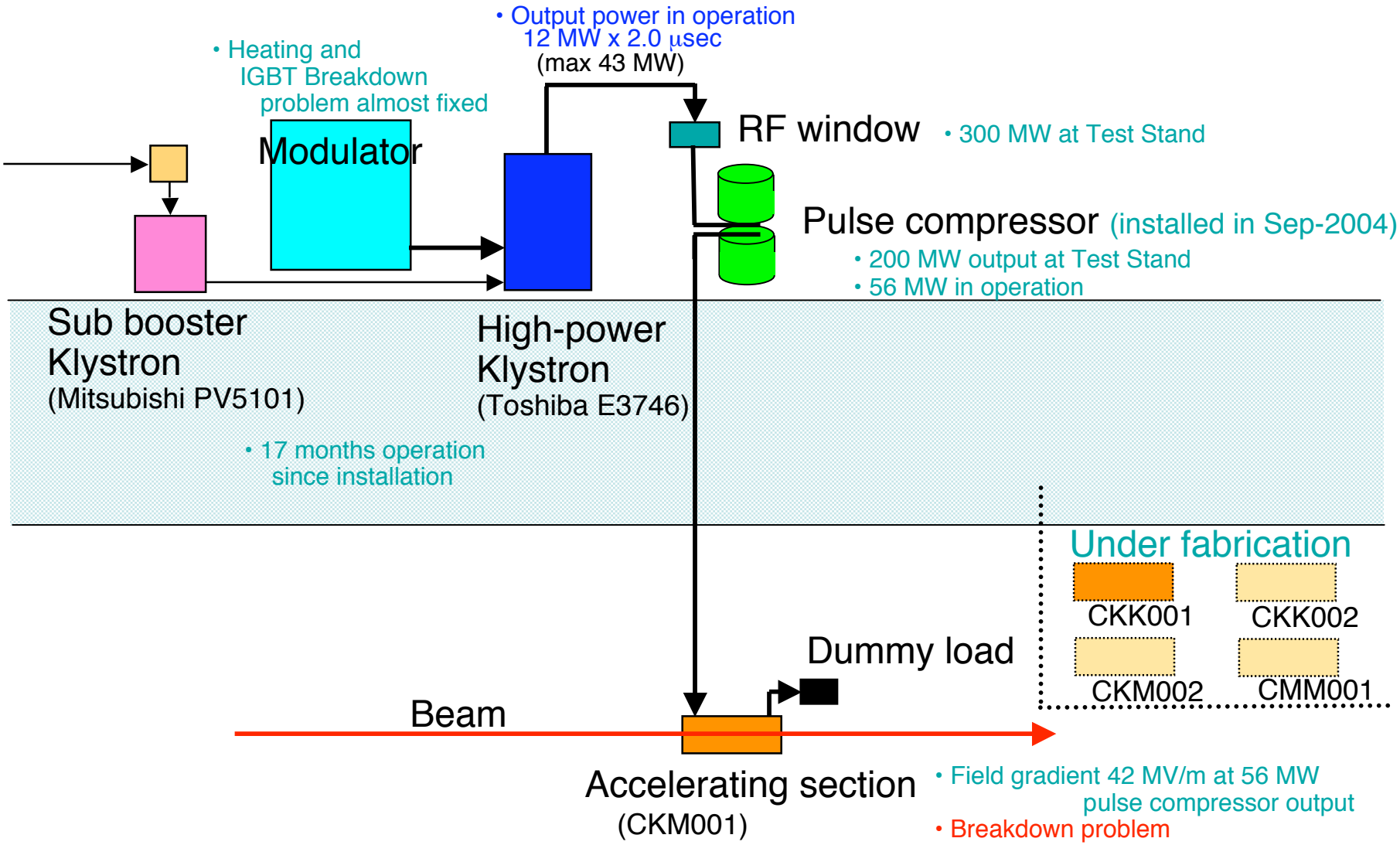


Present Status (Feb-2005)

• Things achieved in recent 12 months

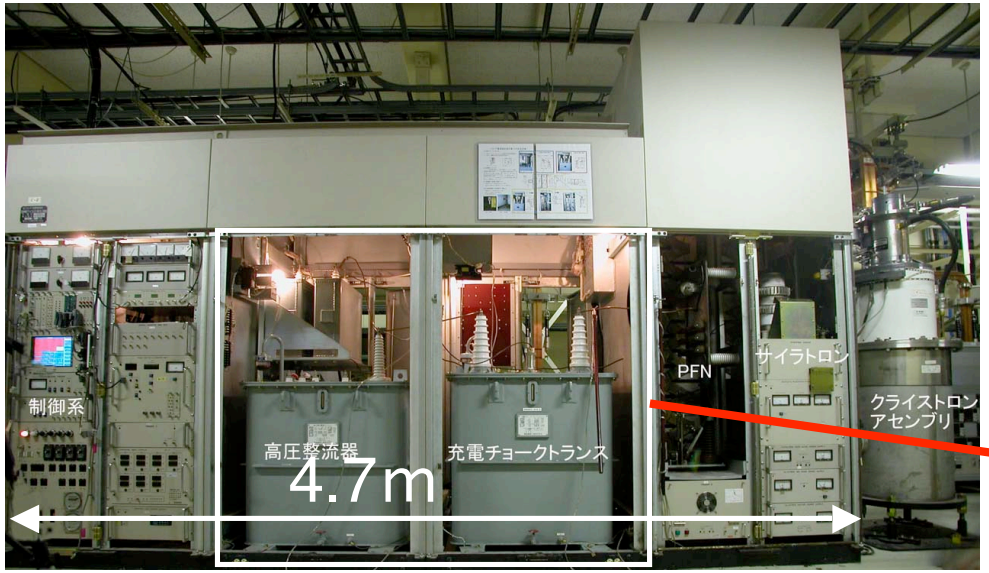
Linac C-band Test Module #4-4A

(Pulse compressor was installed in Sep-2004 and has been operated for 5 months)



Klystron & modulator

- Klystron and modulator have been operated since Sep-2003
- C-band modulator is 1/3 size of S-band modulator
  with inverter DC power supply.
- Heating => (1) Improve cooling, (2) Ohmic loss reduction
- IGBT breakdown => (1) Larger margin in current and voltage,
  (Insulated Gate Bipolar Transistor) (2) Improved gate driver circuit
- No trouble since Sep-2004



S-band modulator & klystron

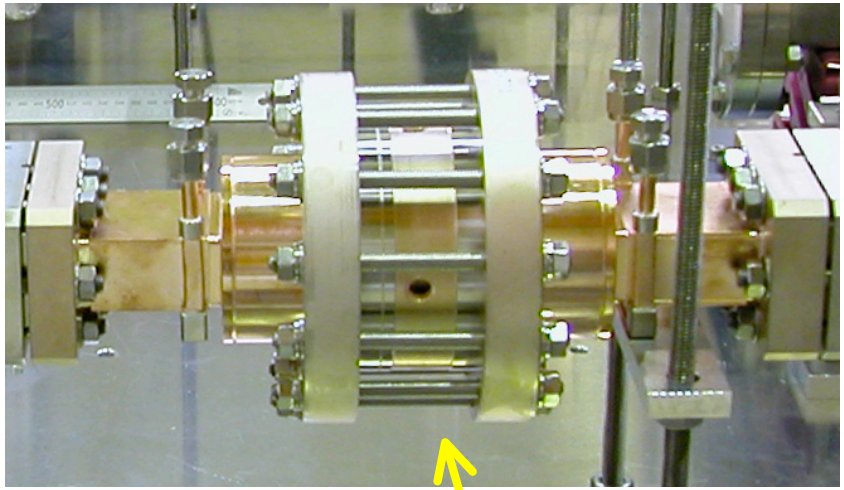
C-band modulator & klystron

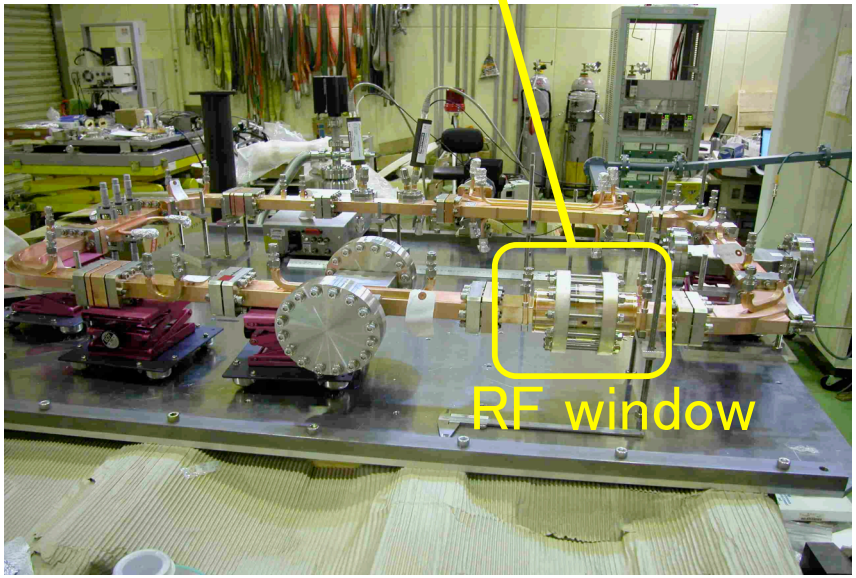
RF window

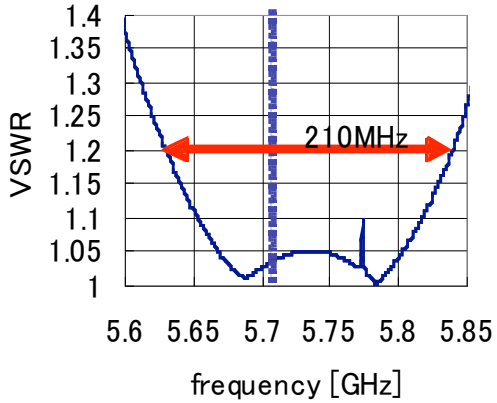
1. Mix-mode (TE11+TM11) RF window with traveling wave in ceramic part

2. Electric field strength is half of S-band pill box type RF window

3. 300 MW transmission power achieved with resonant ring



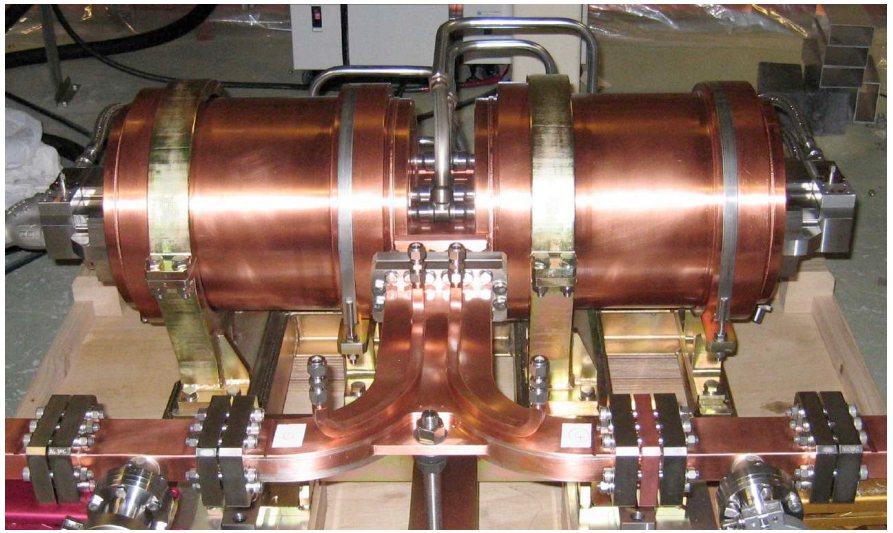




RF pulse compressor

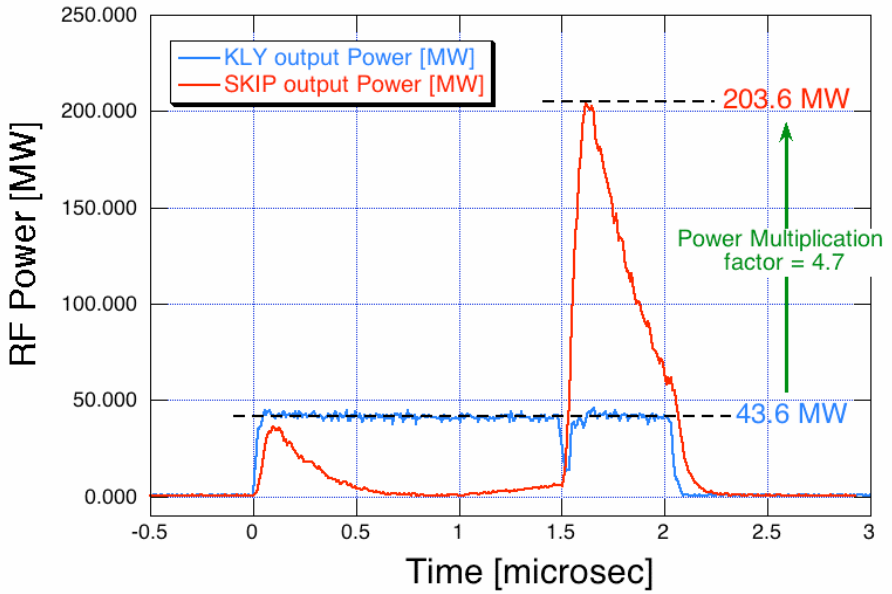
(SKIP: SuperKEKB Injector Pulse compressor)

1. SLED-type compressor, but TE038 mode cavity instead of TE015 (Q_0 = 132,000, coupling beta = 6.6).



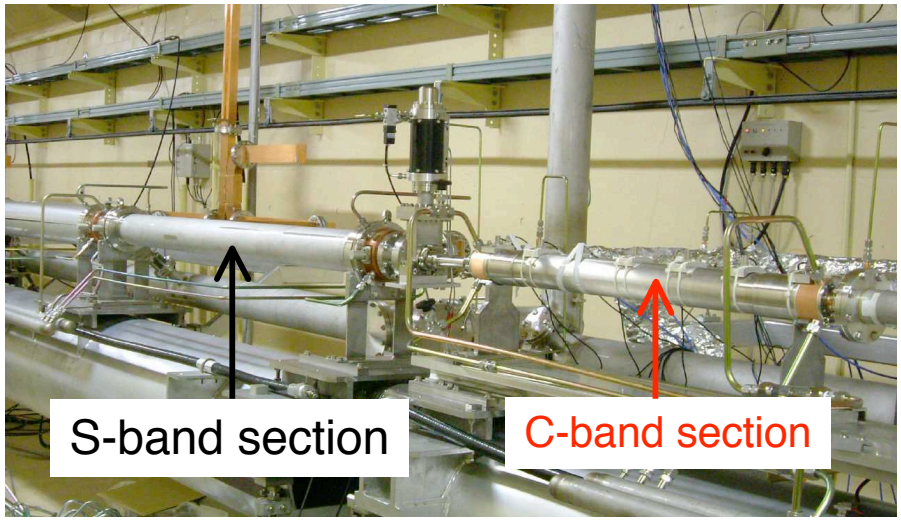
2. 200 MW output power is achieved at Test Stand.

3. Power multiplication factor is 4.7 at peak.

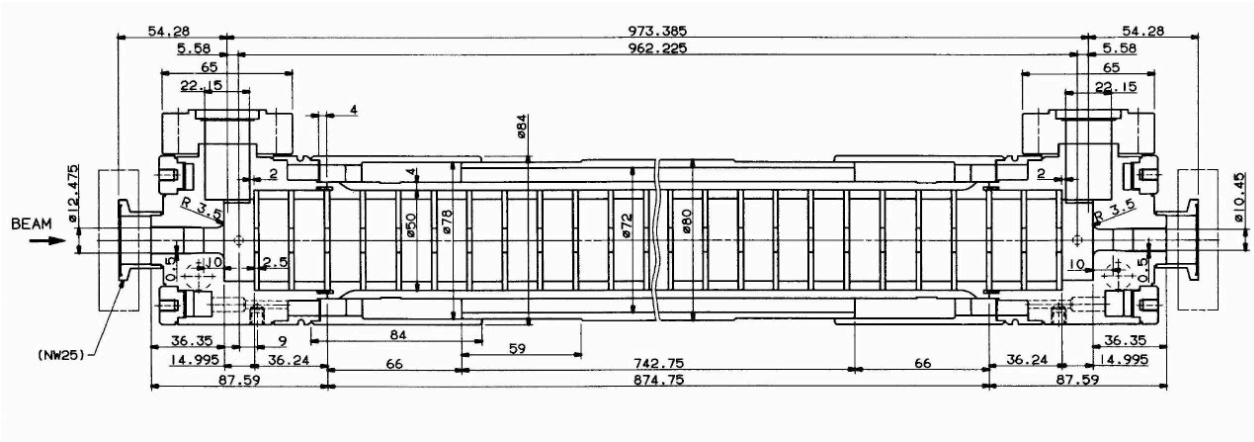


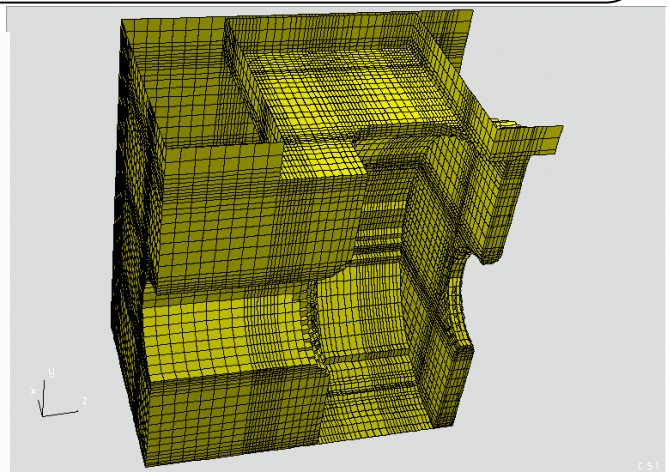
Accelerating section (CKM001; ser#=1)

1. Fabricated at Mitsubishi Heavy Industry
2. Installed in linac #4-4A module (Aug-2003)
3. Operated with RF power directly from klystron (till Jun-2004)
4. Pulse compressor installed (Aug-2004)
5. Operated with Pulse compressor (until now)



- Half-scale model of S-band section (1-m long, 54 cavity cells)
- traveling-wave, disk-loaded structure
- 2/3-π phase advance per cell
- quasi-constant gradient
- formed by cupper electroplating
- single-port coupler (field asymmetry not corrected)
- thin (1mm) coupler iris



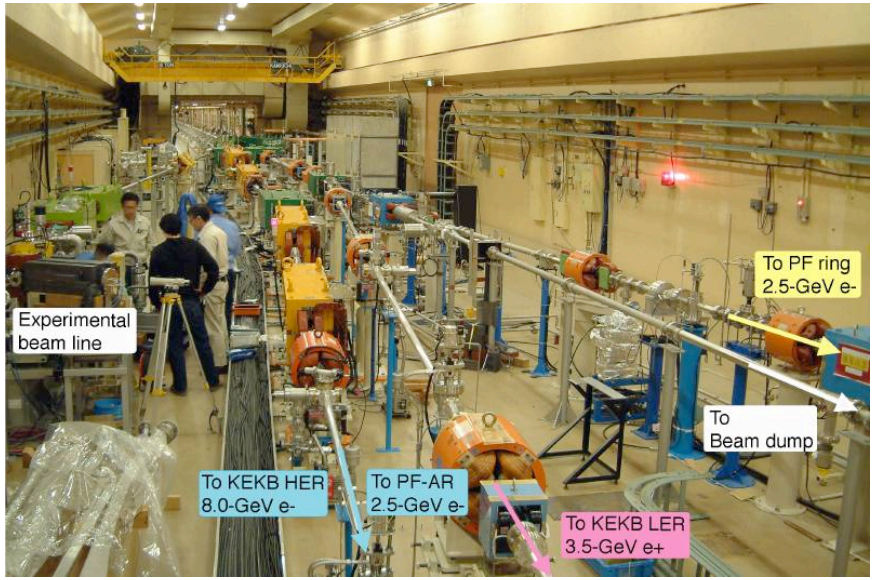


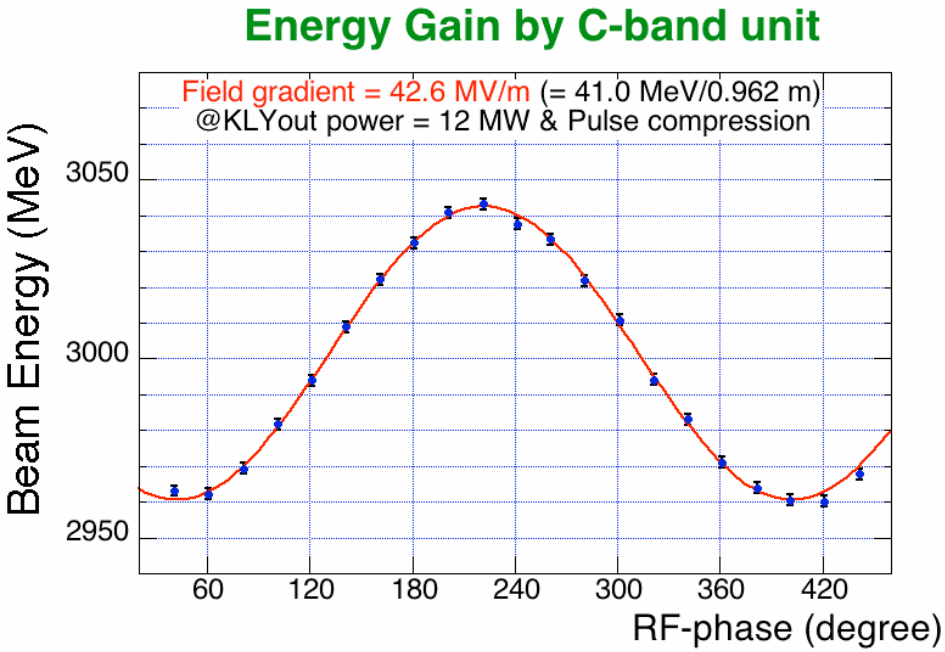
Energy gain measurement

1. Field gradient is estimated by measuring energy gain of the C-band module with 3-GeV e^- beam at the Linac end

2. Field gradient ~ 38 MV/m at KLY output power 43 MW without pulse compressor
   in Jun-2004

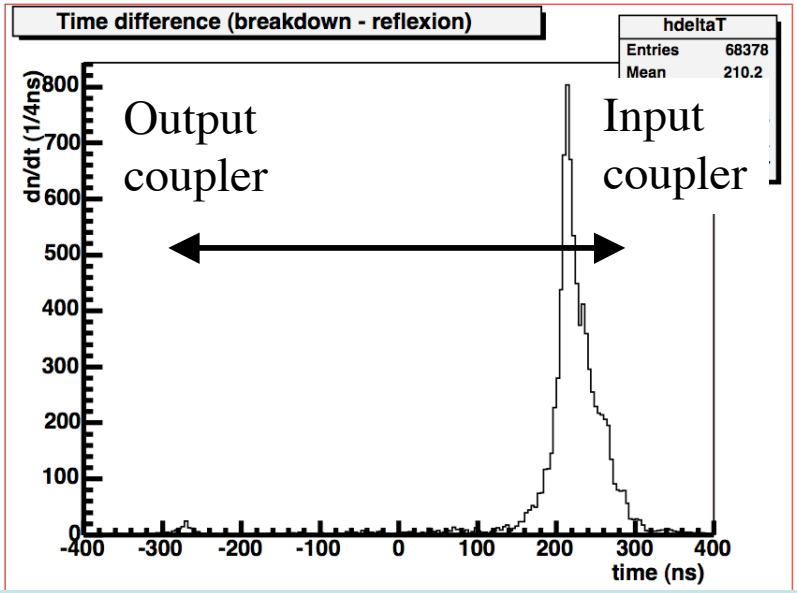
3. Field gradient ~ 42 MV/m at KLY output power 12 MW with pulse compressor
   (peak power ~ 56 MW)
   in Dec-2004





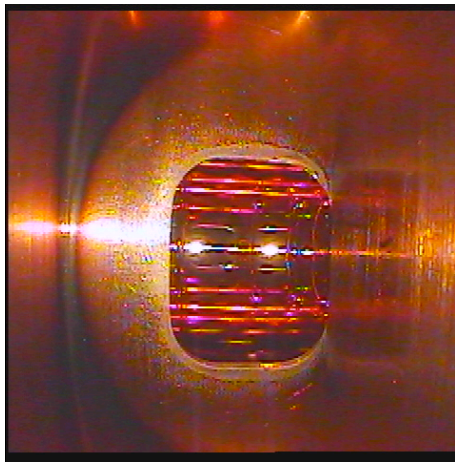
RF breakdown (CKM001)

1. Breakdown occurs typically 5 times/hour @ 43 MW
2. It mostly occurs around the input coupler
3. Surface damage was observed around the iris of the input-coupler, the 1st disk and a the bottom of the coupler cavity (metallic dust ?)

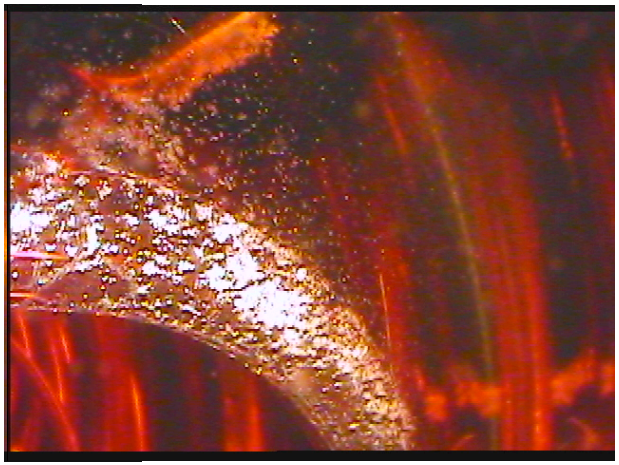


Breakdown location estimated from the timings of transmitted and reflected waves

coupler–iris inside

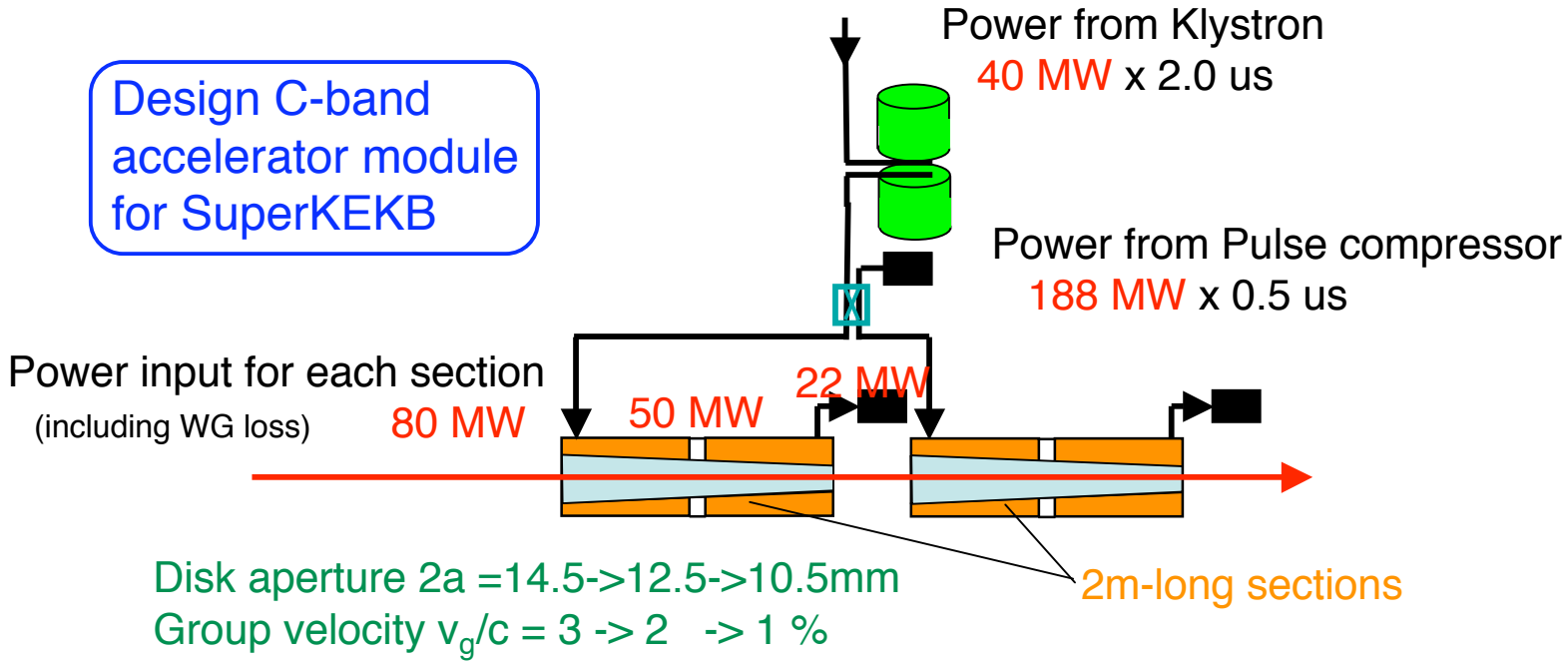


coupler–iris outside



first disk

Strategy of accelerating section development



1. Development of coupler structure / regular cell cavities

2. Demonstration of operation as a whole C-band module

   (installation only in summer shutdown)

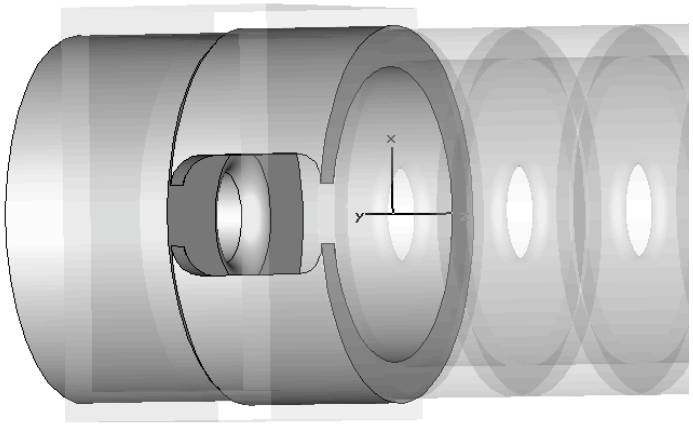
3. Establish fabrication technique at KEK

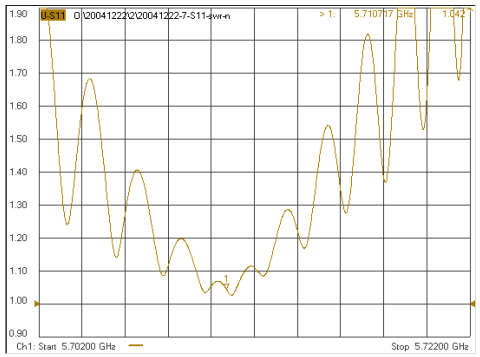
Forthcoming accelerating sections

	Fabri cator	Disc 2a	Coupler	Cupper Electroplating	Completion
(1) CKM001	MHI	12.5 -> 10.5	1-port, Edge iris 1-mm thick, 2π/3 mode cell coupler (S-band section half-scale model)	High speed MHI	July-2003 Now in operation
(2) CKK001	KEK	12.5 -> 10.5	1-port, Edge iris 4-mm thick, arched end, non-standard cell coupler full-length iris => wave guide width	Low speed Nomura	Mar-2005
(3) CKK002	KEK	14.5 (CI)	1-port, Smooth iris 4-mm thick, axis-offset, full-length iris => 2π/3 mode cell coupler Electropolishing of coupler surface	Low speed Nomura	May-2005
(4) CKM002	MHI	12.5 -> 10.5	1-port, Partly smooth iris 3-mm thick, 2π/3 mode cell coupler	High speed MHI	Jun-2005
(5) CMM001	MHI	12.5 (CI)	1-port, Partly smooth iris 3-mm thick, 2π/3 mode cell coupler	Periodic Reverse MHI	Jun-2005

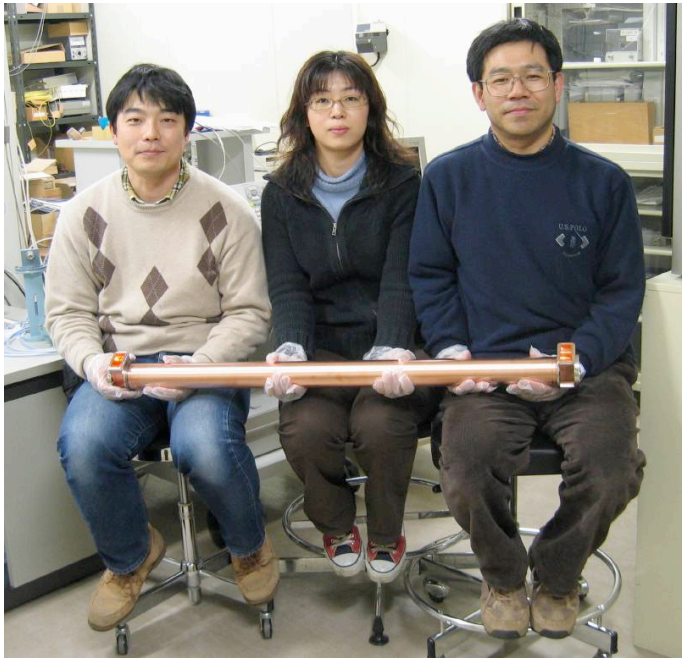
Accelerating section (CKK001; ser#=2)

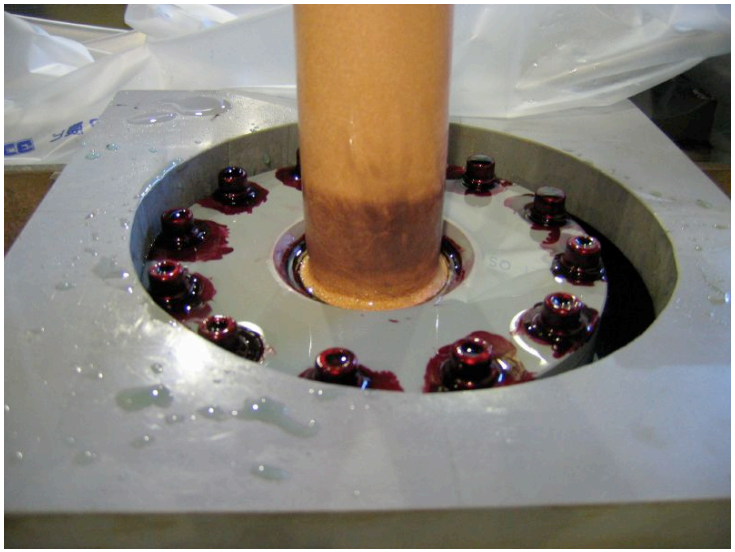
1. Fabricated at KEK
2. Thick (4 mm) iris
3. Arched waveguide end
4. Non-standard coupler cell length (full length iris)





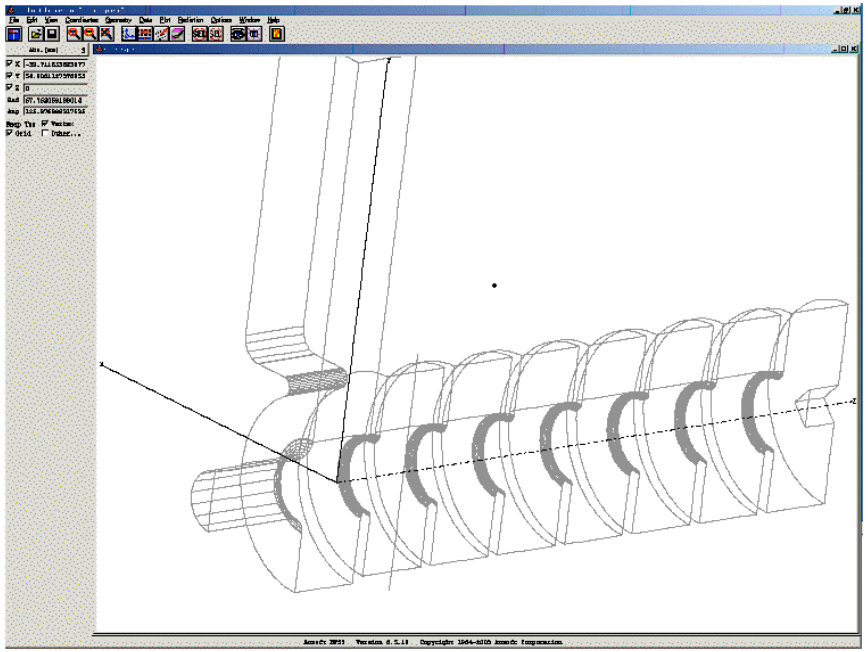
VSWR ~ 1.05
(after electroplating)
→1.17

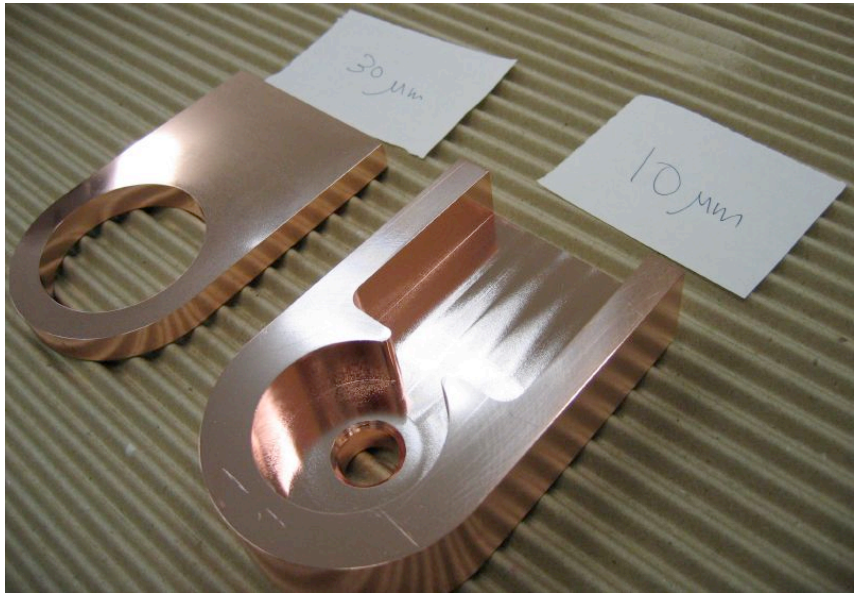




Accelerating section (CKK002; ser#=3)

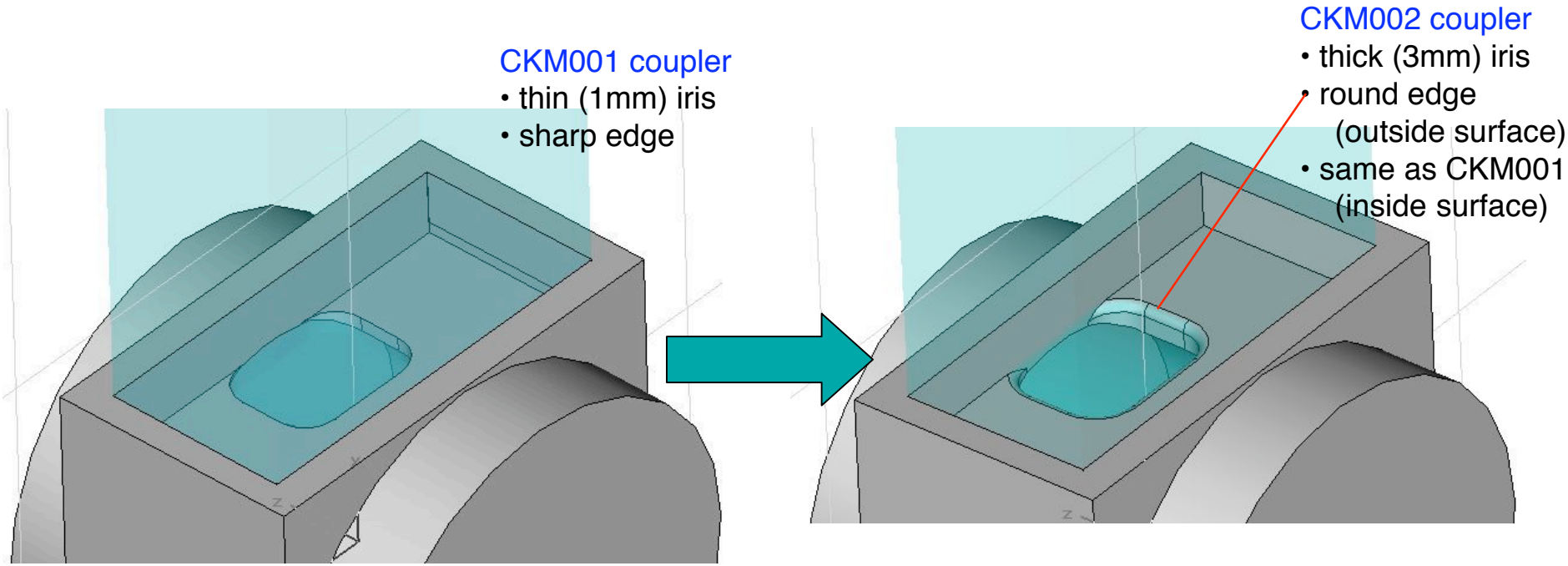
1. Under fabrication at KEK
2. Smooth shape coupler iris
3. Standard coupler cell length and full length iris
4. Coupler axis offset
   for field asymmetry correction
5. Coupler cavity surface treatment
   by Electropolishing
6. For highest power input
   largest disk aperture cells
   group velocity v_g/c = 3 %
   (for CKM001 v_g/c = 1 ~ 2 %)
7. Constant impedance





Accelerating section (CKM002; ser#=4)

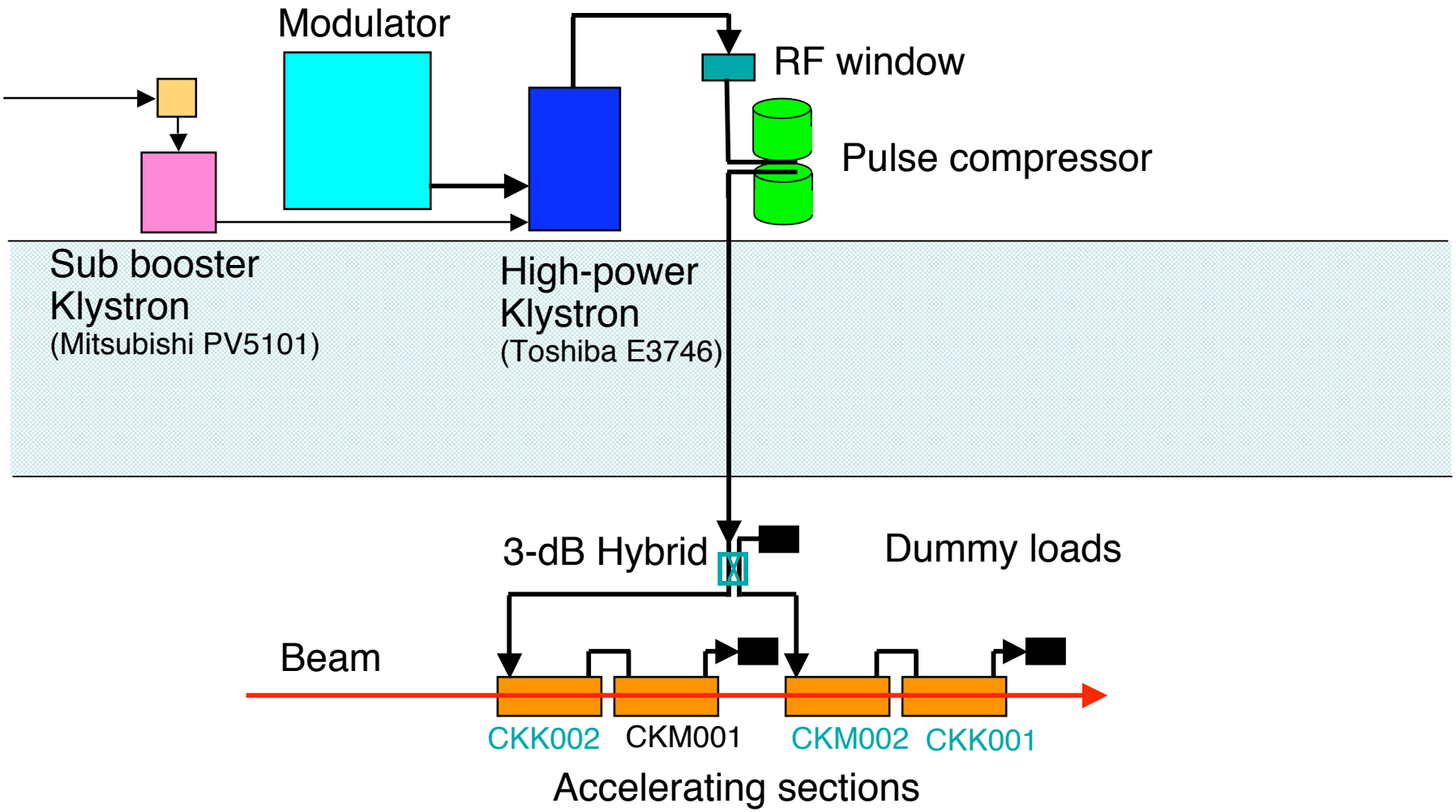
1. Slight modification of CKM001 (#1) in coupler iris shape
   => thick and round edge
2. Under fabrication at MHI
3. To be completed in June-2005



- CMM001 (ser#=5) is almost same as CKM002 except for electroplating method and constant impedance

Planned configuration (Aug-2005)

Linac C-band Test Module #4-4A
(will start operation in this configuration in Aug-2005)



Summary (Things achieved in recent 12 months)

1. Heating and IGBT breakdown problem of the inverter power supply is almost fixed and the modulator has been operating for 5 months with no trouble.

2. Mix mode RF window achieved 300 MW transmission power at Test Stand.

3. RF pulse compressor has been fabricated, achieved 200 MW output power at Test stand and installed in C-band test module #4-4A in the KEKB linac.

4. Field gradient in the accelerating section is estimated by beam acceleration study to be 42 MV/m with klystron output power 12 MW and with rf power compression (x 4.7 times at peak).

5. Four new accelerating sections are in fabrication and will be installed in Sep-2005

Future development in accelerating section

1. Two port coupler,
   if single port coupler is not satisfactory against breakdowns even with smooth-shaped iris.

2. New types of coupler structure
   if smooth-shaped iris coupler is not satisfactory.
   - A) mode converter type coupler
   - B) wave guide coupler

3. 2m-long structure
   - A) one 2m-long structure
     => difficult in fabrication and RF measurement
   - B) two 1m-long structures connected with couplers and waveguides
     => present design layout but expensive
   - C) two 1m-long structures directly connected with cavity cells