C-Band Linac Development

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Upgrade Requirements

(1)	KEKB		SuperKEKB
Beam Energy (e^-)	8.0 GeV	----->	3.5 GeV
(e^+)	3.5 GeV	----->	8.0 GeV !!

-> C-band accelerator modules

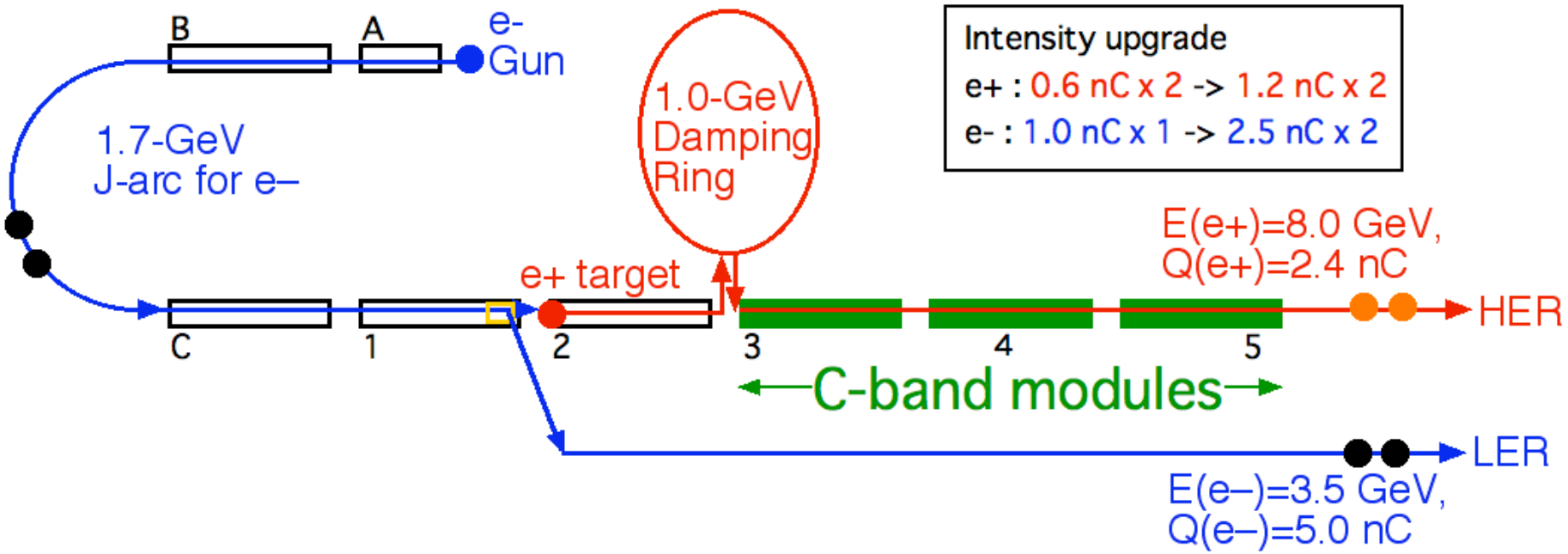
(2)	KEKB		SuperKEKB
Stored current (e^-)	1.1 A	----->	9.4 A !!
(e^+)	1.5 A --> 2.6 A	--->	4.1 A !

-> e^-: increase beam charge
-> e^+: flux concentrator (e^+ capture effic.)

(3) Smaller e^+ emittance to fit for IR & C-band module apertures
-> e^+ damping ring

(4) Faster e^+/e^- mode-switching for Continunous e^+/e^- Injection
-> separated e^+/e^- beam lines
-> non-destructive beam monitoring

Upgrade Scheme



- e^+ energy is boosted by the C-band (5712MHz) accelerator modules.

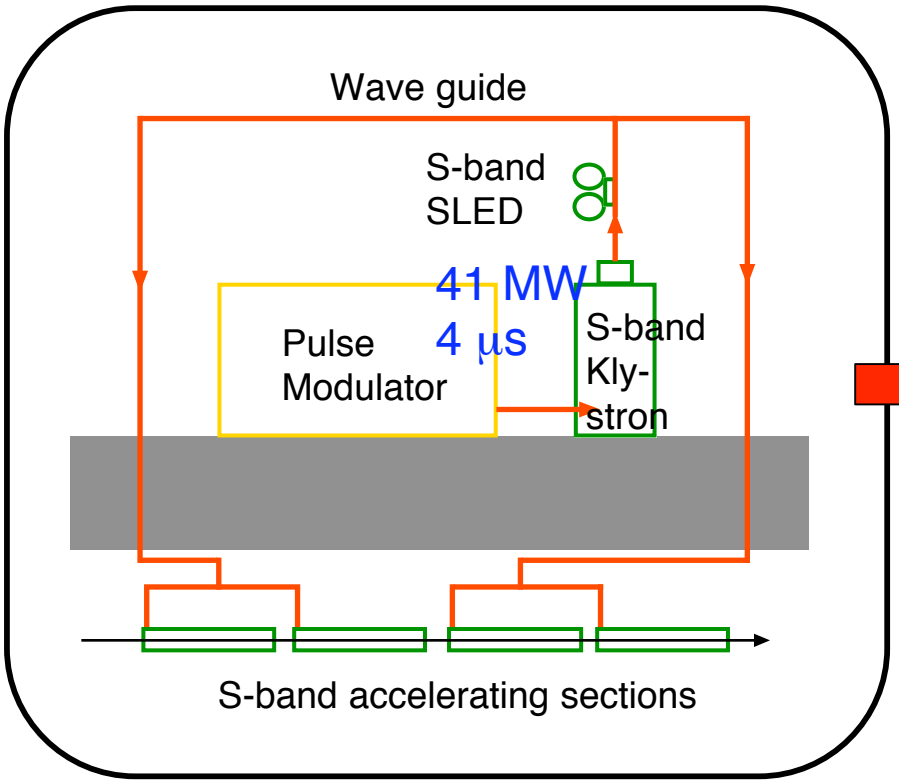
  –8.0 GeV ~ 21 MV/m (S-band modules) x 46 m

  \+ 42 MV/m (C-band modules) x 185 m

Linac Accelerator module

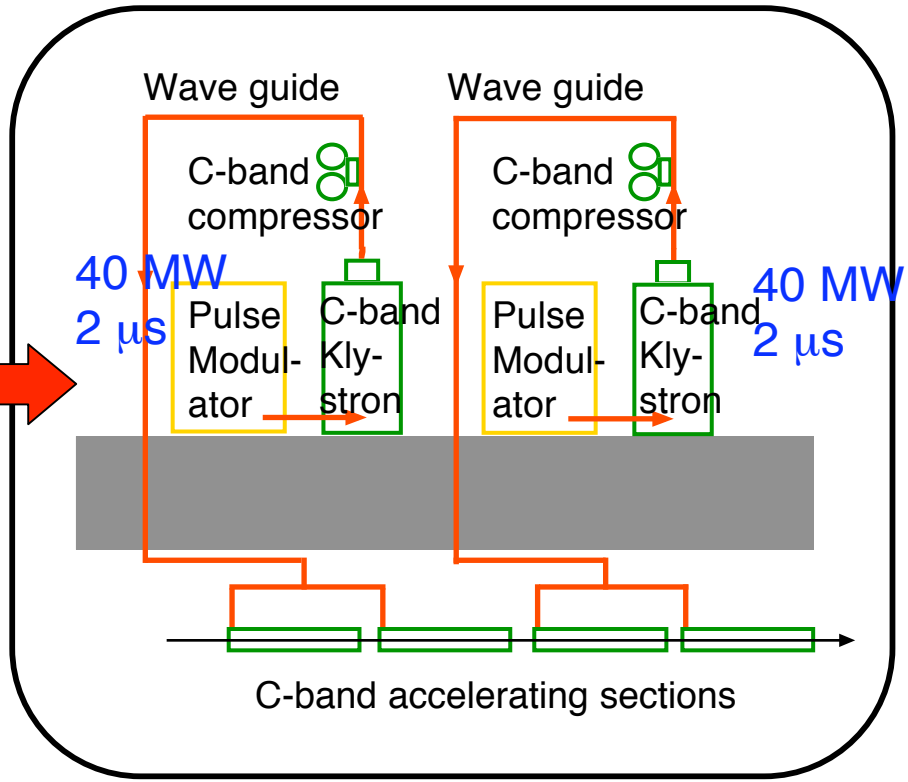
(From S-band To C-band)

Present S-band accelerator module



Accel. field gradient = 21 MV/m

New C-band accelerator module



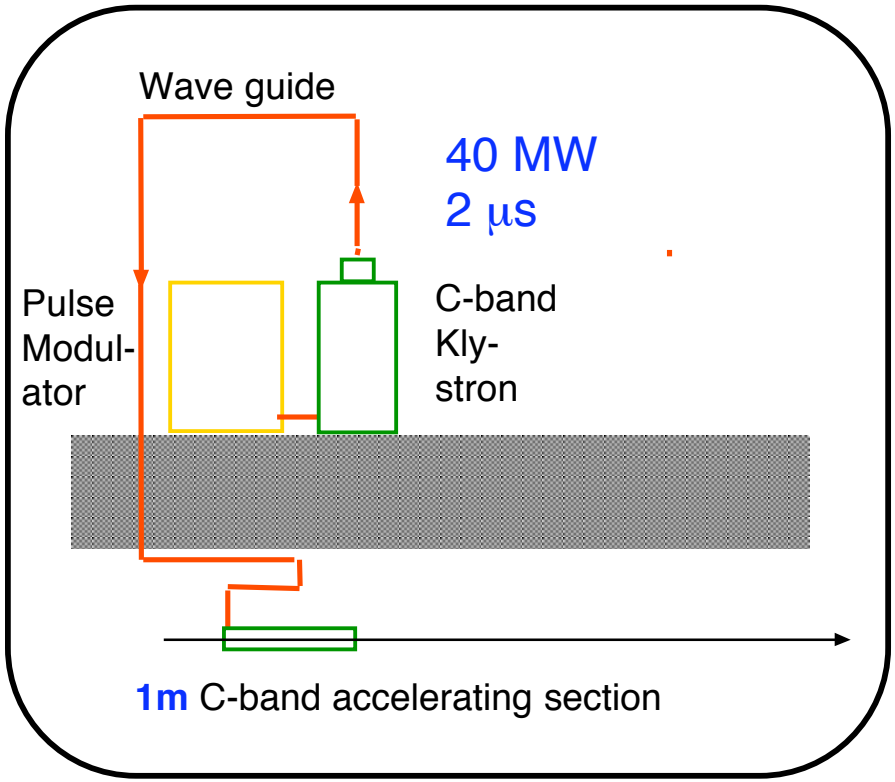
Accel. field gradient = 42 MV/m

C-Band Accelerator module

First acceleration test

Target field gradient = 42 MV/m

for e^+ 8 GeV injection



Accel. field gradient = 42 MV/m

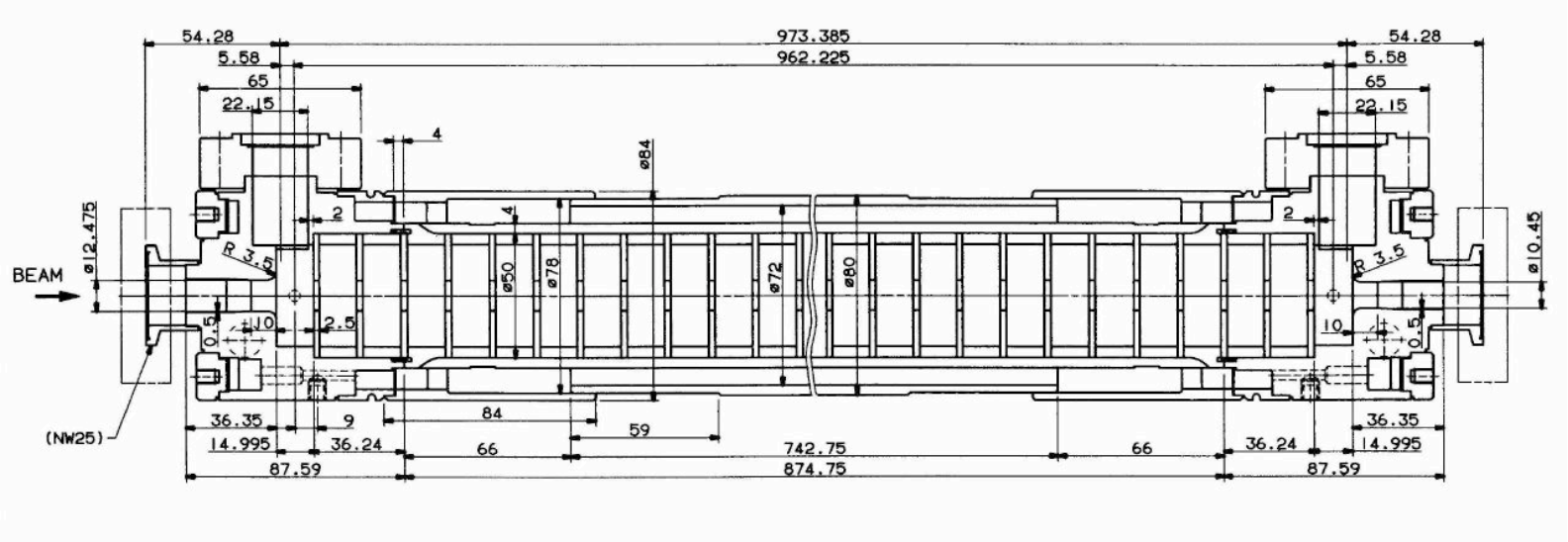
R & D strategy of accel. section

1. An accelerating section whose dimension is 1/2-scale of that of the present S-band section is adopted as a first prototype in order to take the shortest path to the high power test of all the components in the C-band accelerator module.
2. No special cure considered against multi-bunch wake field effects (like damped structure or choke mode cavity) because
   - the number of bunch is at most 2
   - e^+ bunch intensity is low (1.2 nC)
   - bunch interval is long (96 ns)

C-band accel. section (First prototype)

54 regular cells	1m-long			
iris diameter 2a:	12.44	~	10.41	mm
group velocity v_g:	1.9	~	1.0	%
shunt impedance r_0:	74.8	~	85.3	MΩ/m
field gradient E_{acc}:	41.2	~	39.0	MV/m

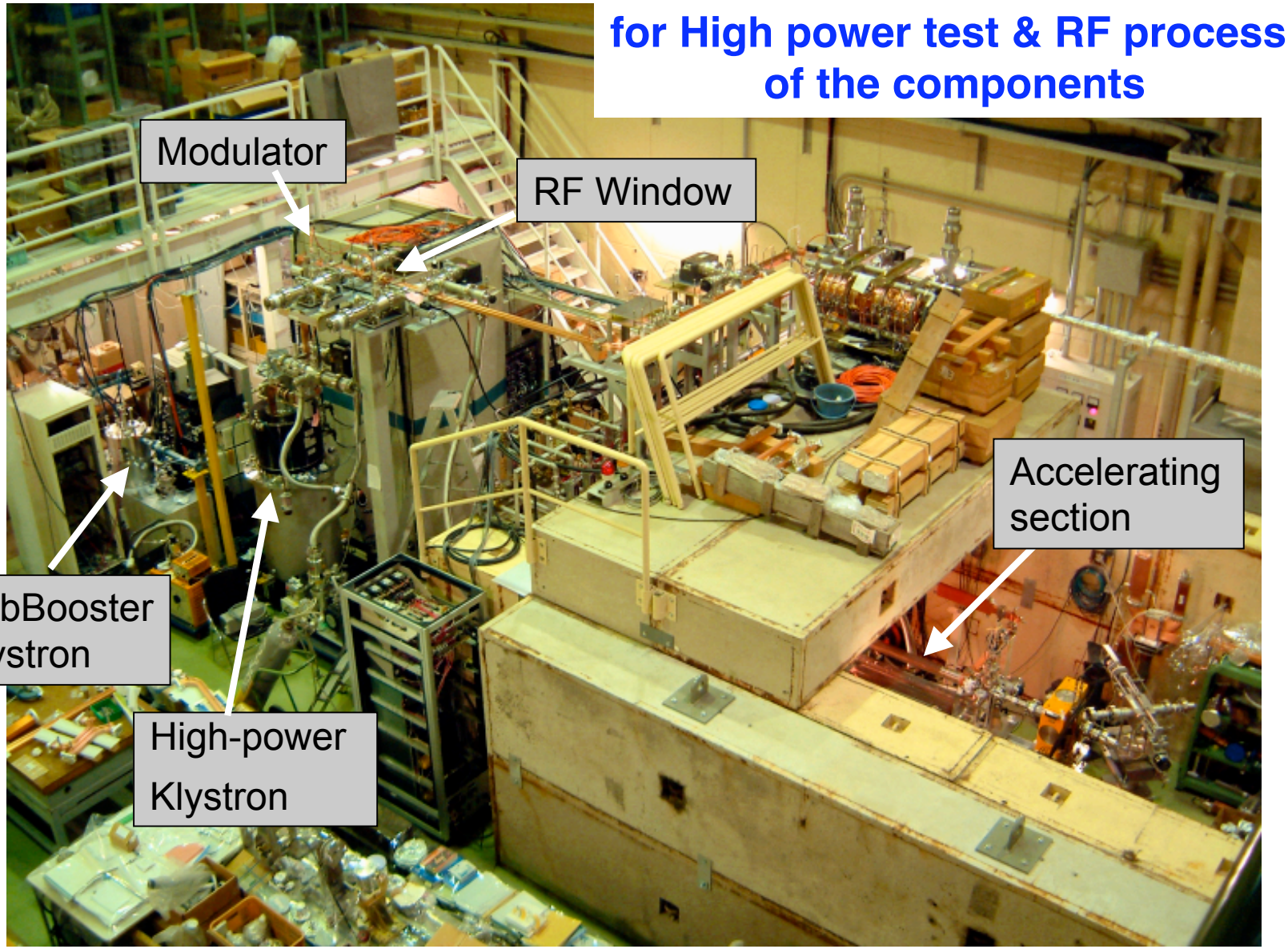
(assuming 40 MW klystron power)



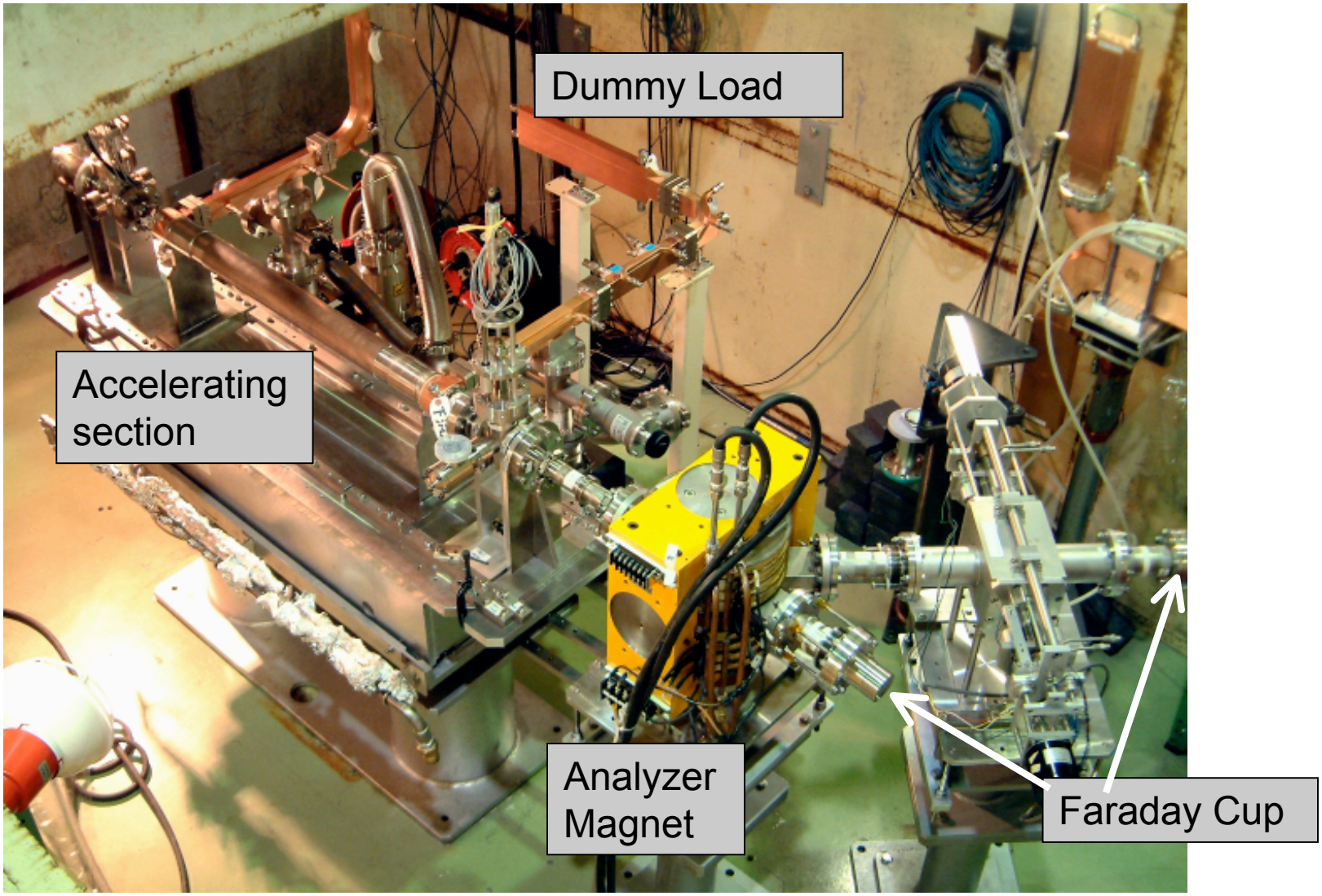
Filling Time t_F = 234 nsec
Attn. Constant τ = 0.434

C-band Test Stand

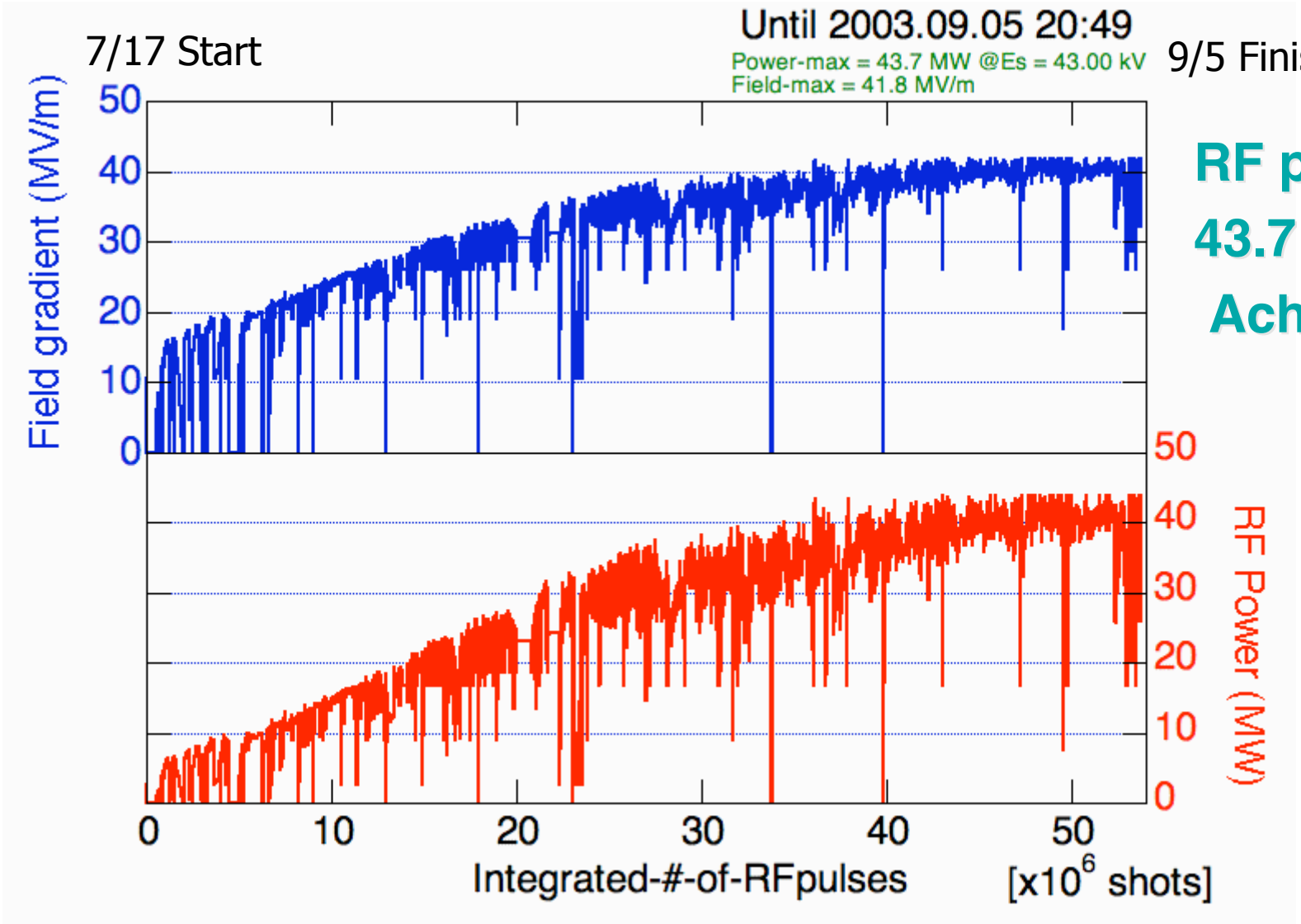
for High power test & RF processing of the components



Test Stand (inside)

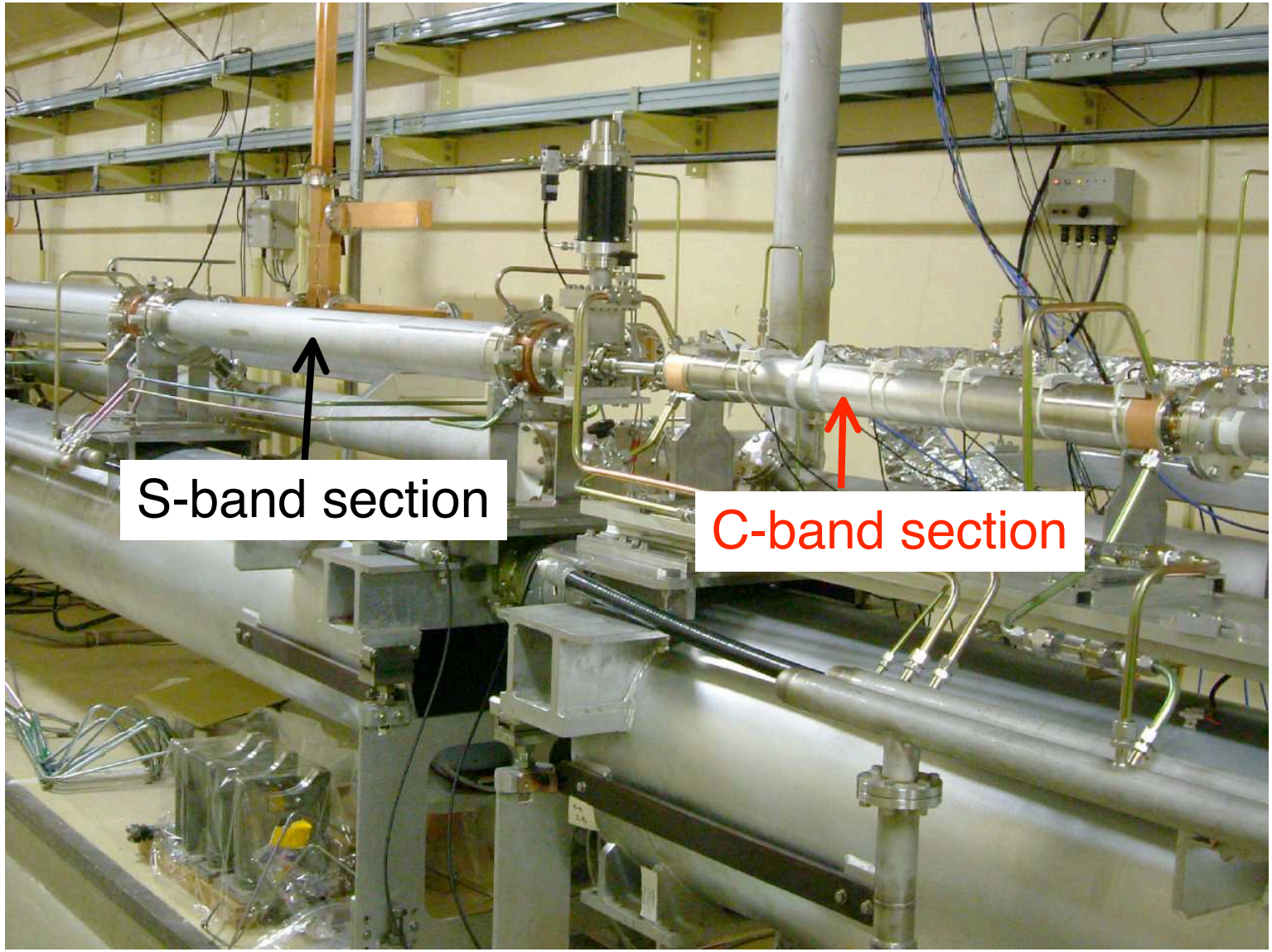


RF processing History



RF power 43.7 MW Achieved!

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



High power C-band (5712MHz) rf system

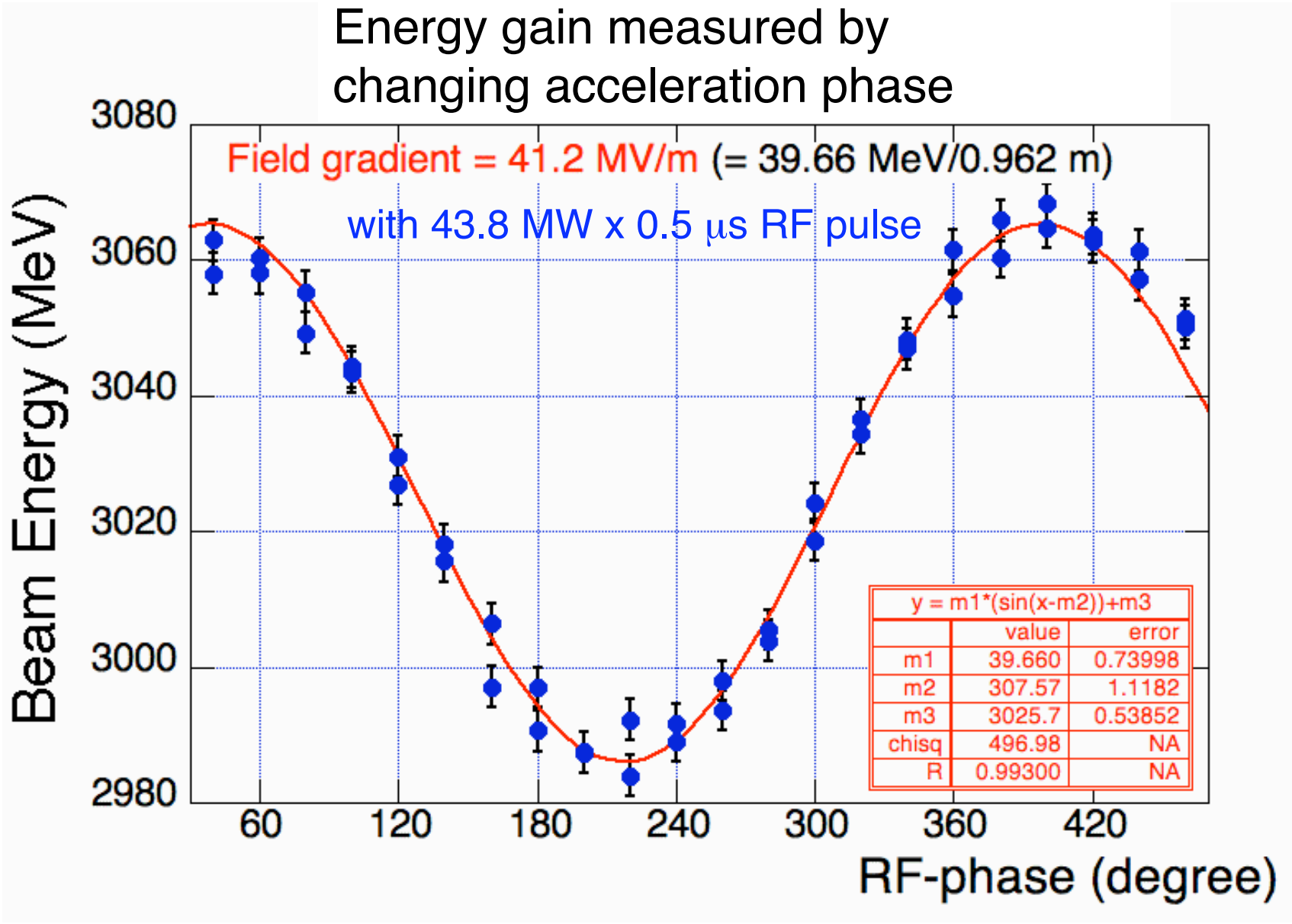
(A) Compact pulse modulator for klystron (350kV, 310A, 2μsec. (flat top), 50Hz).

(B) 50MW high-power klystron (Toshiba E3748) assembly.

(C) Waveguide to the C-band accelerator section.

Beam acceleration study

Energy gain measured by changing acceleration phase



C-band R & D items

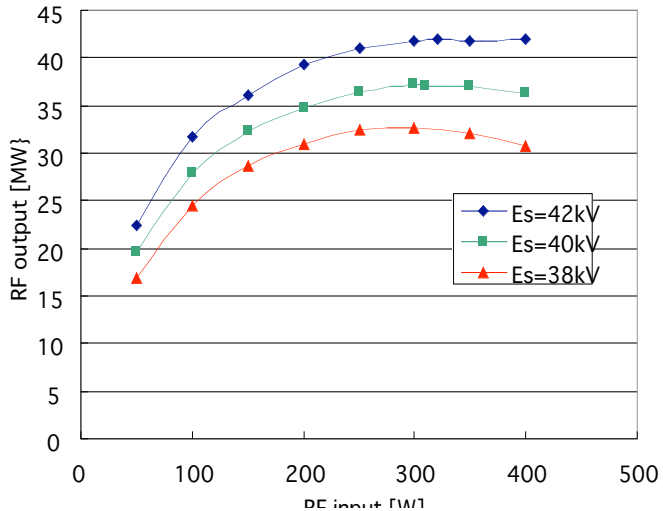
- Klystron -> Toshiba E3746, High Power Test OK
- Modulator -> compact (1/3 size), OK except inverter P.S. trouble
- Low power RF -> sub-booster OK, solid-state amp.?
- RF pulse compressor -> HPT in July 2004
- Accelerating section -> 1st prototype 41 MV/m,
  breakdown at input coupler
  2nd prototype HPT in July 2004
- Other RF components
  - RF window — HPT OK
  - Dummy load — HPT OK
  - 3-dB hybrid power divider — HPT OK
  - Wave guide flange — HPT OK
  - RF gate valve — under consideration

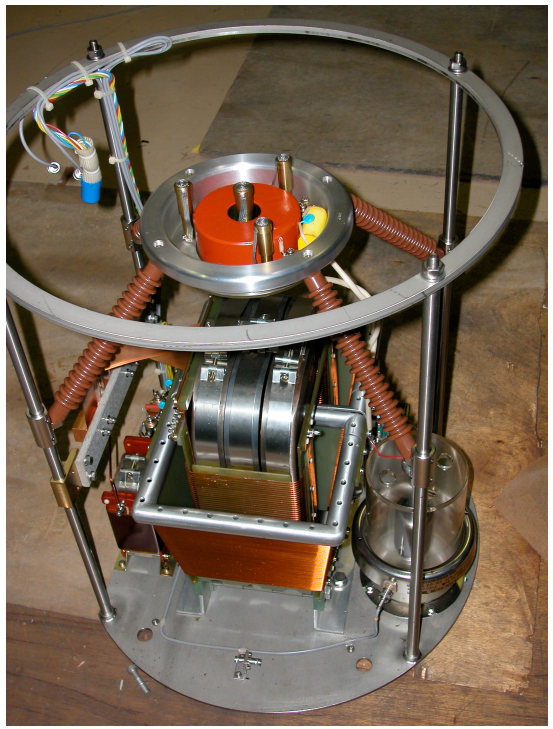
Toshiba E3746 klystron assembly

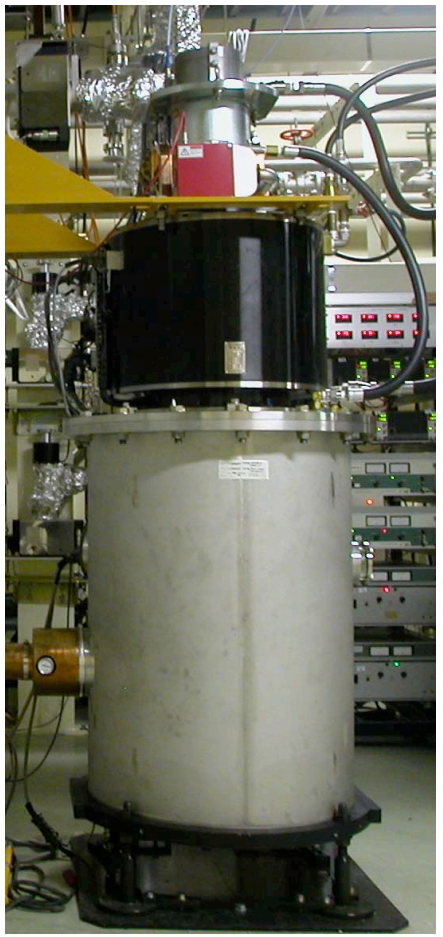
- Toshiba E3746 klystron (50MW) is adopted.
- Conventional 1:15 pulse-transformer (used at klystron gallery) is reused.

Requirements for rf source

	S-band	C-band
RF output	41 MW	40 MW
Typical charging voltage	42 kV	41 kV
Typical applied voltage	290 kV	325 kV
Pulse duration	4 μs	2 μs
Accelerating gradient	(21 MV/m)	(42 MV/m)

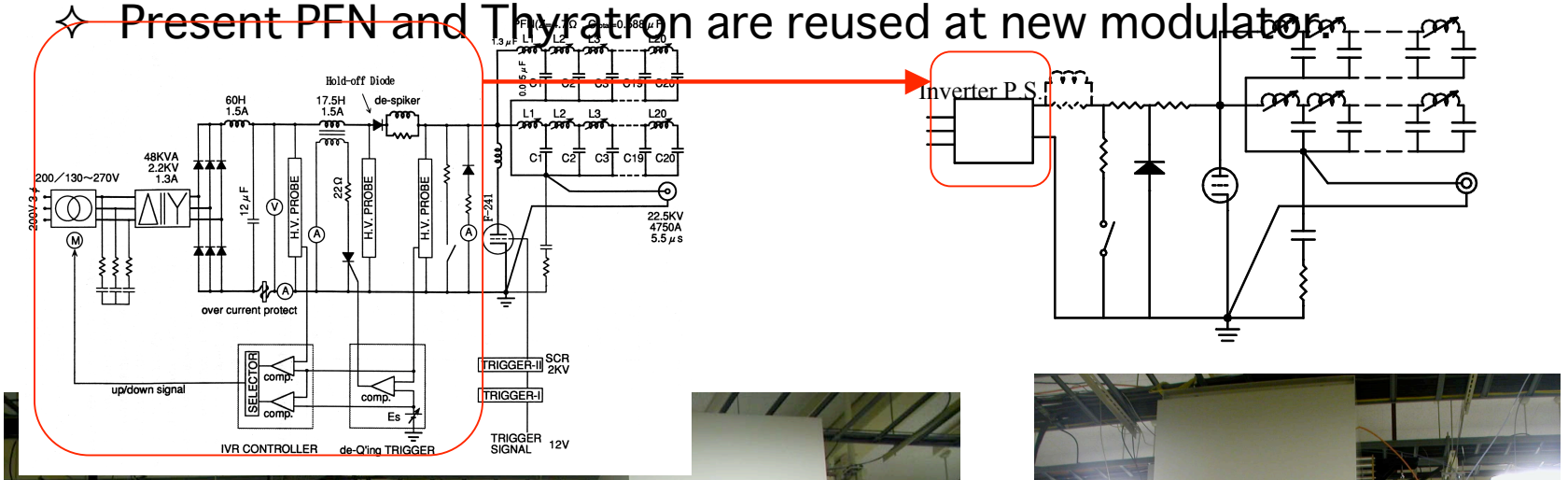


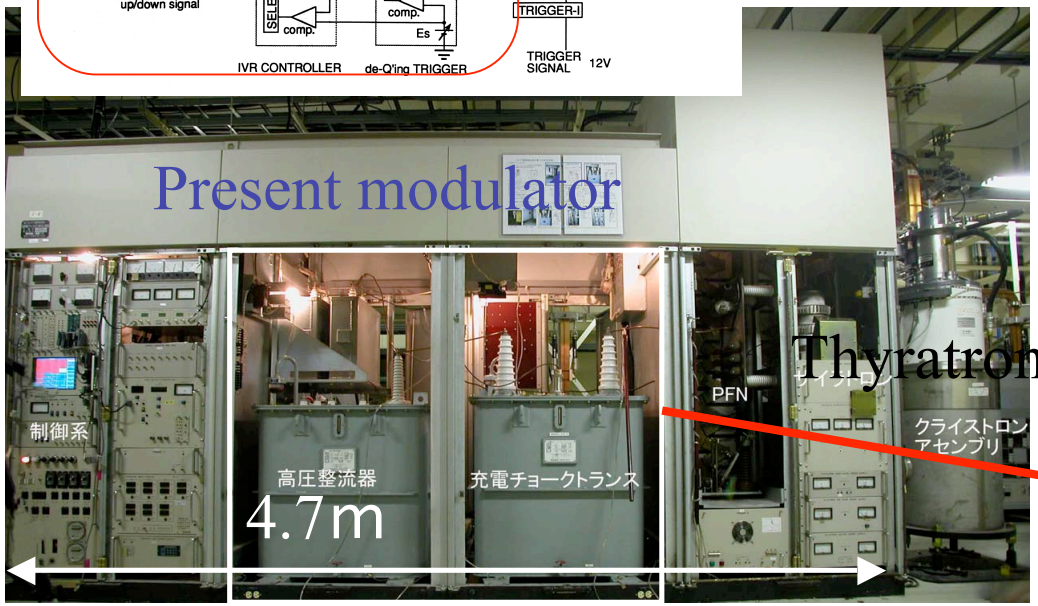


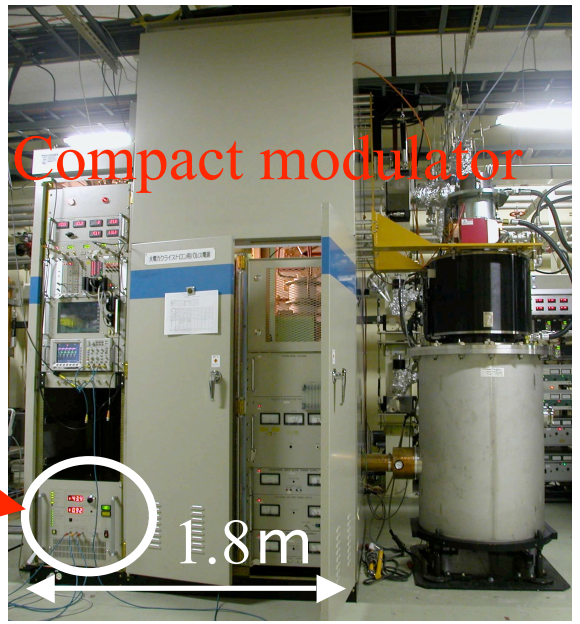


Compact modulator

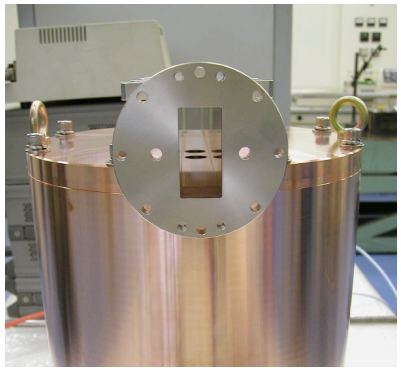
- By using invertor P.S., the modulator size can be 1/3 (4.7 m->1.8 m).
- Present PFN and Thyratron are reused at new modulator.







RF pulse compressor

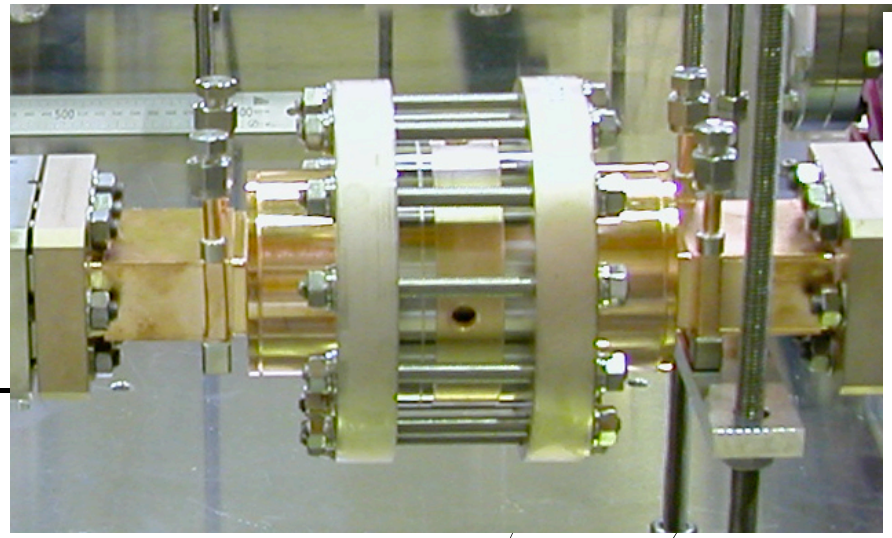


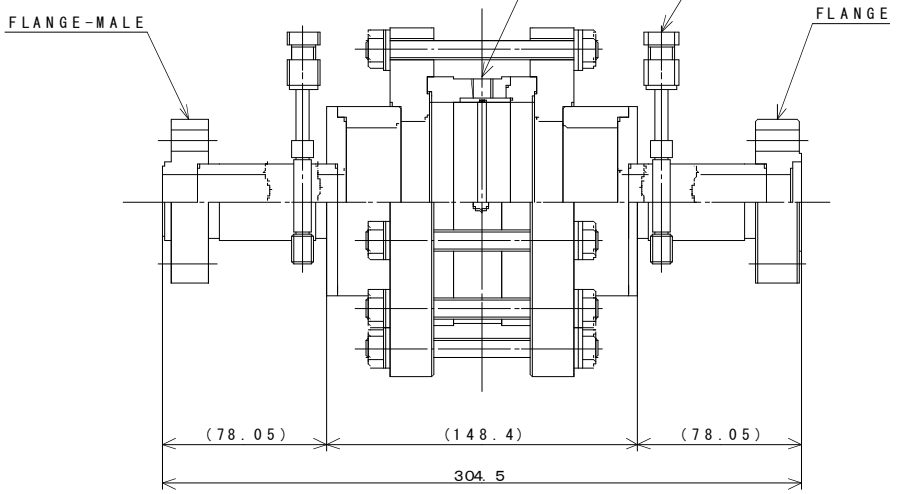
Low power model

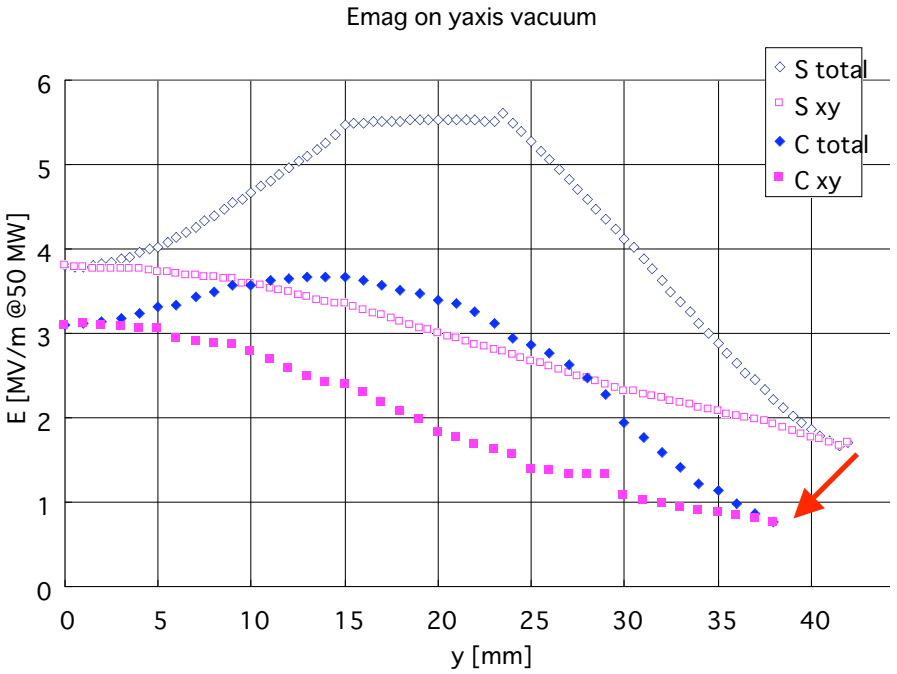
- CERN-LIPS type of pulse compressor (TE038-mode cavity)
- Q_0 = 142,000 (measured)
- Coupling beta = 6 ~ 7
- Power multiplication ~ 3.4
- Study with low power model is under way to fix coupling hole dimension.
- High power test in July 2004

Mix-mode rf window

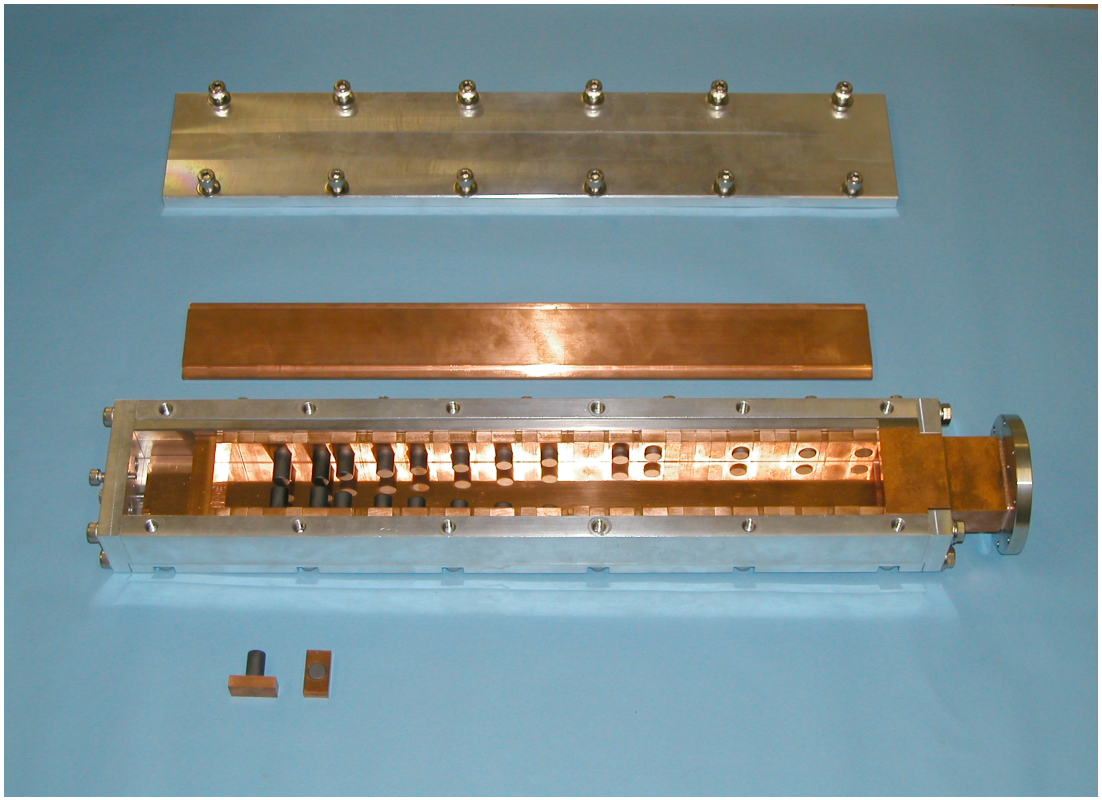
- Mix-mode (TE11+TM11) window with traveling wave in ceramic.
- The electric field at the periphery is half of the S-band window.

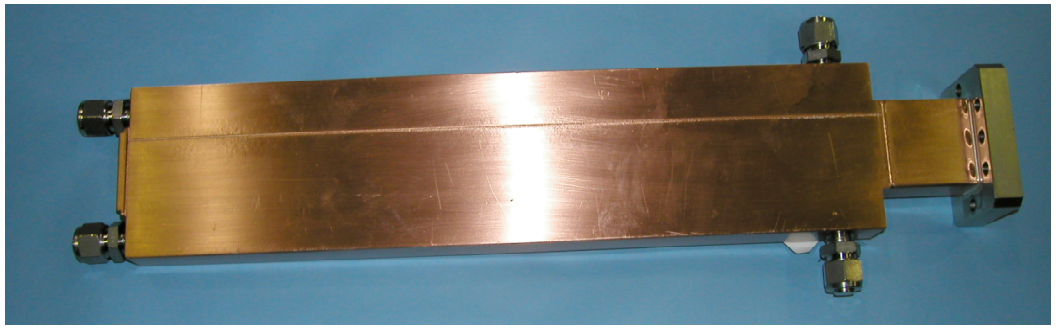






Dummy load

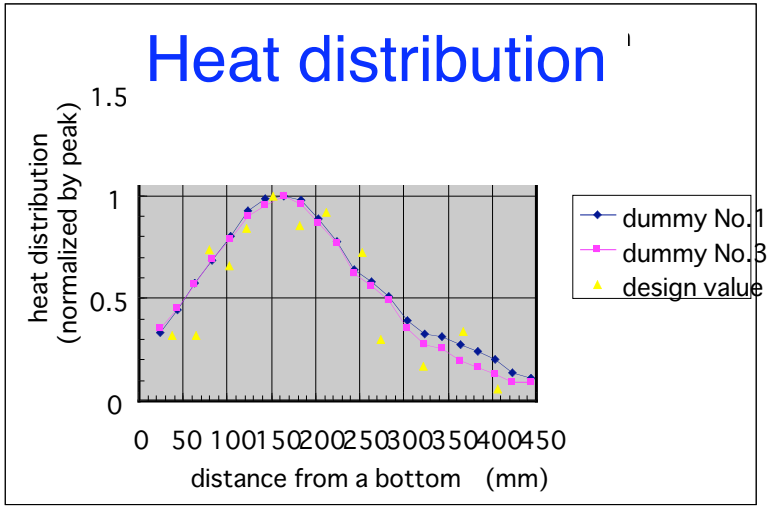




Newly designed 2kW Matsumoto-type dummy load

- 26 SiC cylinders
- SiC diameter 12 mm

High power test OK up to 2 kW !



Summary

- 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

  2nd prototype HPT in July 2004

  Inverter P.S. troubles

  RF pulse compressor

  HPT in July 2004