Injector Upgrade Overview & Positron Source

KAMITANI Takuya
e+/e- Injector Linac group, KEK

(1) Injector Upgade Overview

SuperKEKB Injector Linac Parameters

	KEKB (e+/e-) achieved	SuperKEKB (e+/e-) required
beam energy	3.5 GeV / 8.0 GeV	4.0 GeV / 7.0 GeV
stored current	1600 mA / 1200 mA	3600 mA / 2620 mA
beam lifetime	150 min / 200 min	10 min / 10 min
bunch charge	primary e^- e^+ e^- 10 -> 1.0 nC / 1.0 nC	primary e^- e^+ e^- 10 -> 4.0 nC / 5.0 nC
# of bunches	2 / 2	2 / 2
beam emittance $(\gamma\varepsilon)_{[1\sigma]}$	2100 μm / 300 μm	10 μm / 20 μm
energy spread σ_E/E	0.125 % / 0.05 %	0.07 % / 0.08 %
bunch length σ_z	2.6 mm / 1.3 mm	0.5* mm / 1.3 mm

*(assuming bunch compression after DR)

Injector Upgrade Strategy

(e-)

- High intensity
- Low emittance

→ **Photo-cathode RF gun**

Talk by T. Sugimura

(e+)

- High intensity

→ **New matching device & L-band capture section**

Talk by T. Kamitani

- Low emittance

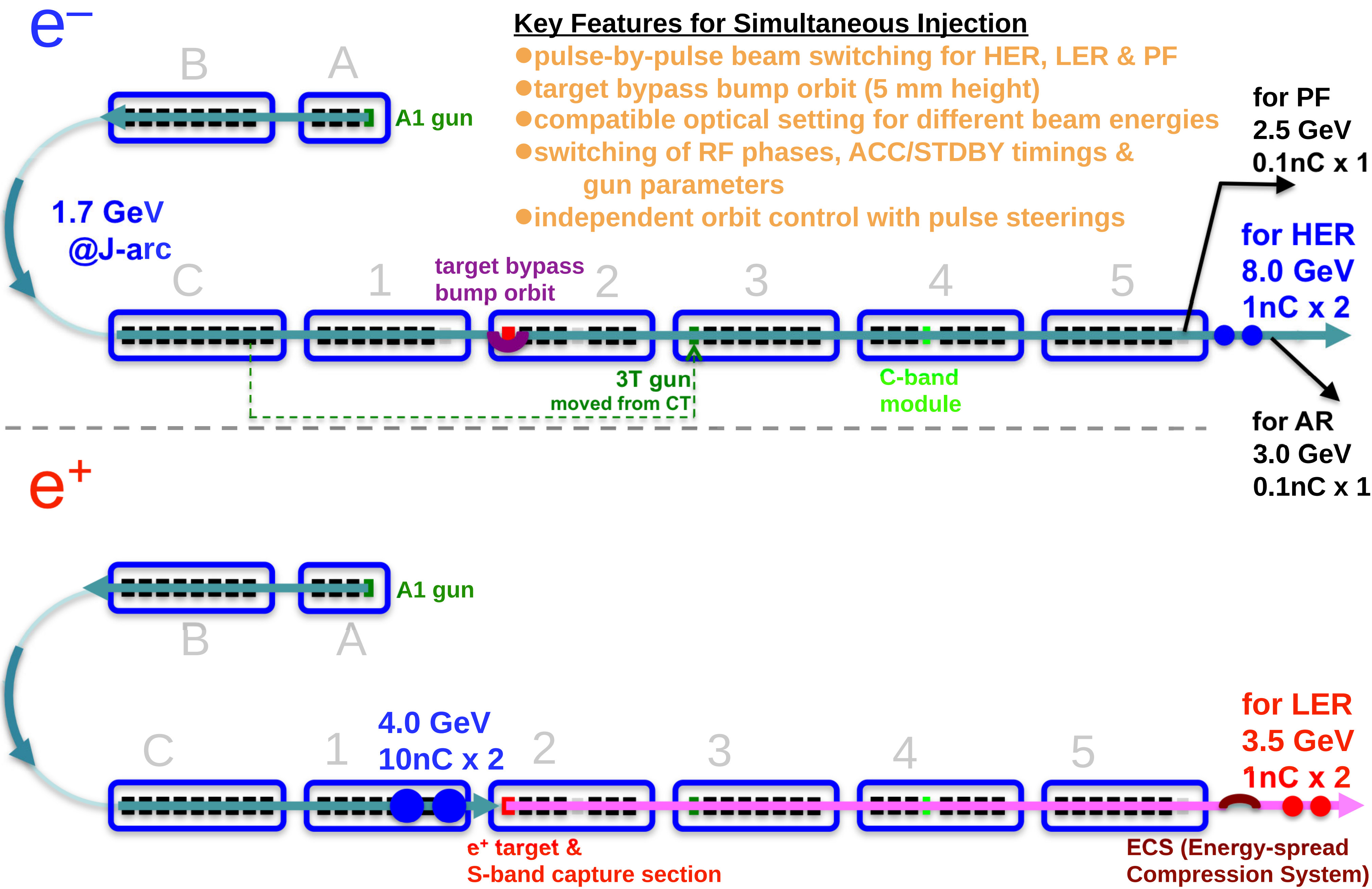
→ **Damping Ring**

Talk by M. Kikuchi & by N. Iida

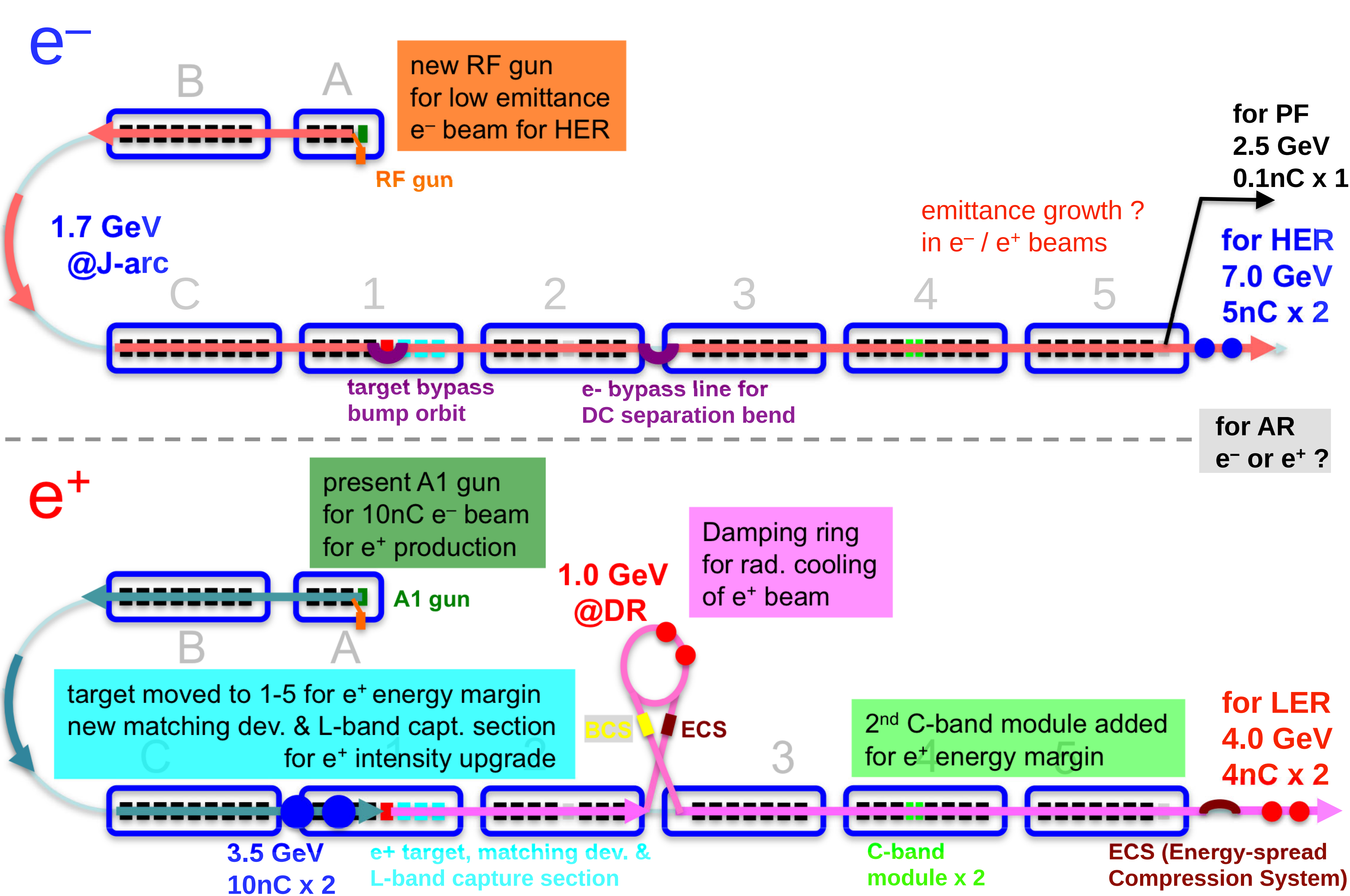
KEKB Injector

Key Features for Simultaneous Injection

- pulse-by-pulse beam switching for HER, LER & PF
- target bypass bump orbit (5 mm height)
- compatible optical setting for different beam energies
- switching of RF phases, ACC/STDBY timings & gun parameters
- independent orbit control with pulse steerings



SuperKEKB Injector



(2) Positron Source Upgade

Positron capture section upgrade

	present capt. section	L-band capt. section
accelerating structures	1m x 2 + 2m x 2 (=6m)	2m x 2 + 2m x 4 (=12m)
RF frequency	2856 MHz (λ=10.5cm)	1298 MHz (λ=23.1cm)
aperture of the structures	20 mm in diameter	30 mm in diameter
accel. field gradient	14.0 ~ 13.2 MV/m	10.0 MV/m
accel. phase	-30 deg	-30 deg
solenoid field (strong)	2.0 T x 45 mm QWT	6.0 T x 220 mm AMD
solenoid field (weak)	0.4 T x 7.9 m	0.4 T x 13.1 m
energy after capt. sec.	~ 80 MeV	~ 120 MeV

Increase e+ capture efficiency by enlarging these acceptances !

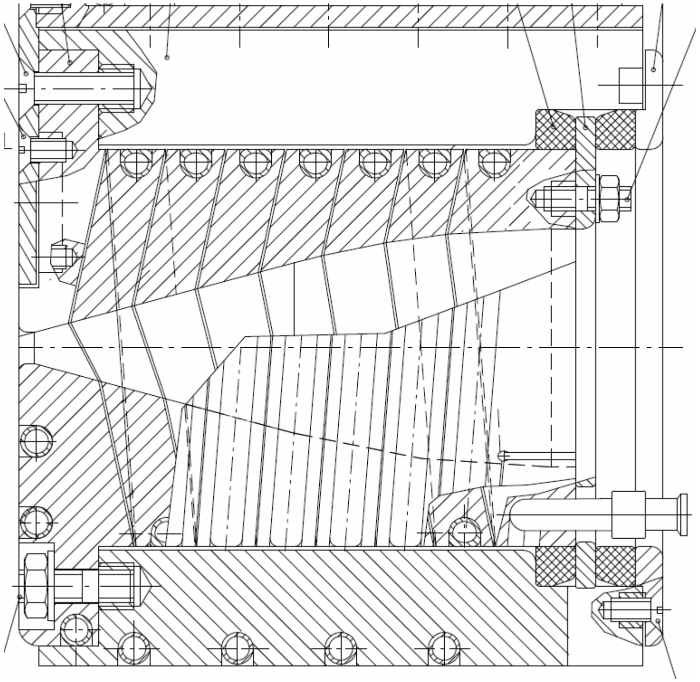
- longitudinal acceptance by longer wave length of L-band RF
- transverse acceptance by larger aperture of L-band structure
- energy acceptance by adiabatic matching device
  => Flux concentrator or SuperConducting solenoid

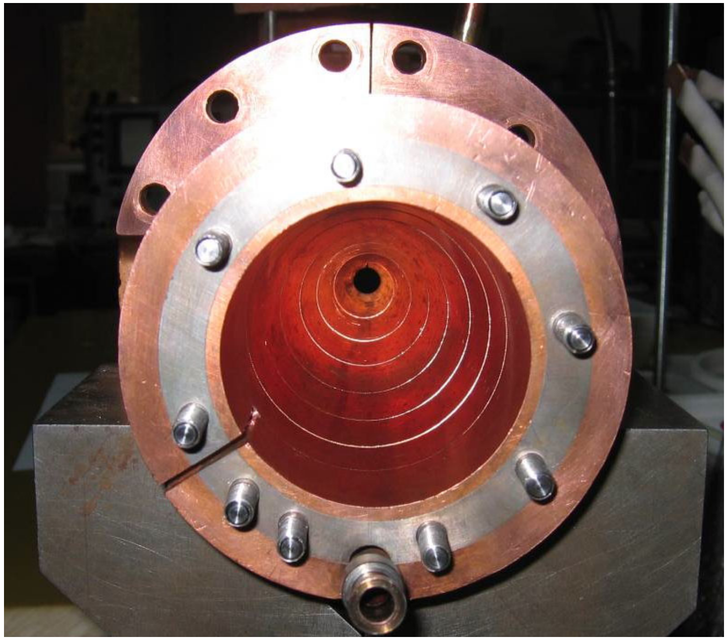
Q_{e+} = 1 nC → 4 nC

prelim. simulation result by N. Iida suggests Q_{e+} ~ 8 nC @ DR

flux concentrator (FLC) R&D

- R&D in collaboration with BINP
- prototype magnet, vacuum chamber & power supply
  fabricated at BINP
- operation test at BINP
  15×10^6 pulses ~ 1 week
  No mechanical failure !!

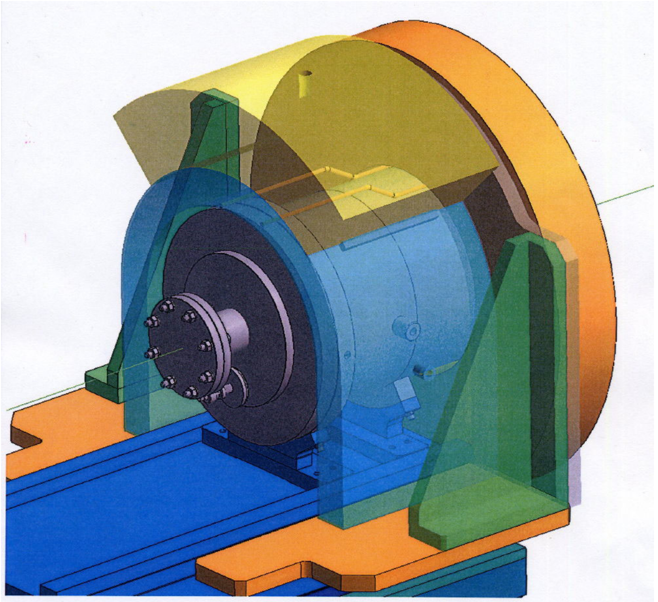


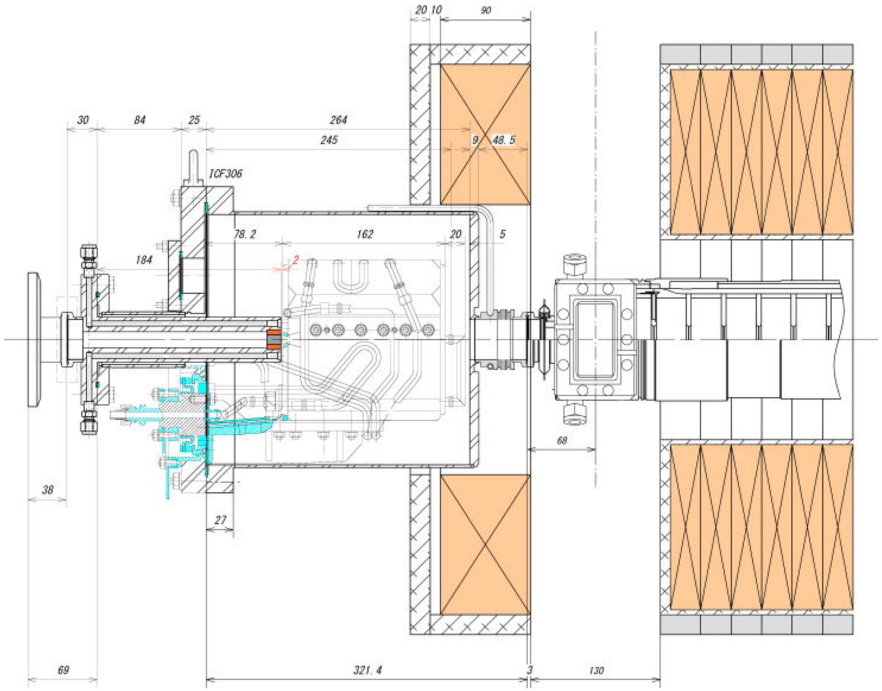


FLC operation test at KEK

- prototype magnet, vacuum chamber & power supply are sent to KEK in Apr. 2010
- stand-alone operation test & field distribution measurement at KEKB linac klystron gallery in May-June 2010
- installation of FLC magnet into KEKB linac e+ source in Aug. 2010
- operation test from Sep. 2010 to Mar. 2011

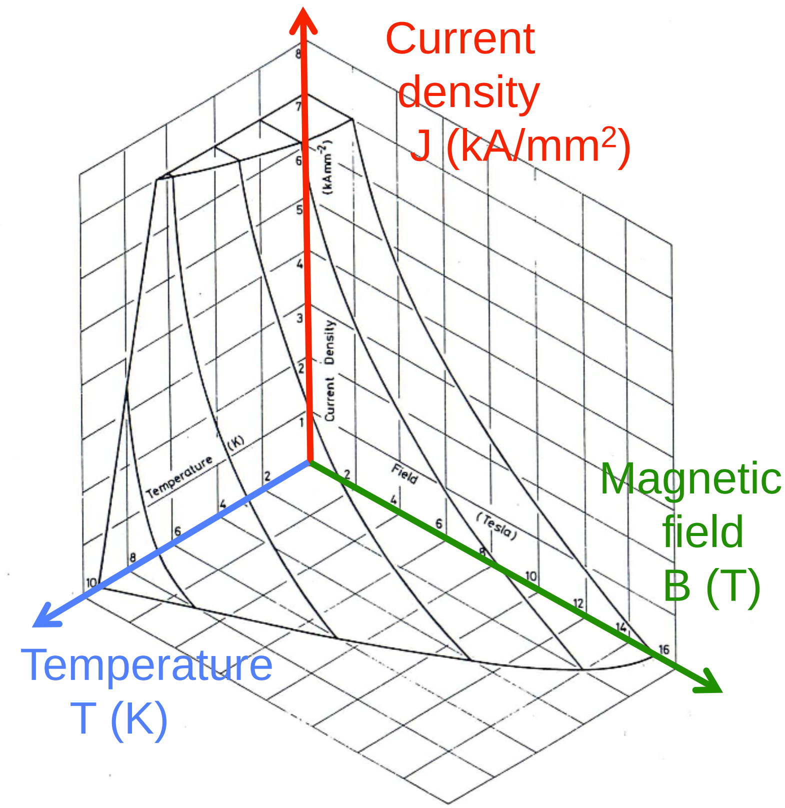
mechanical stability will be tested and e^+ yield performance will be studied with real KEKB linac 10 nC e^- beam

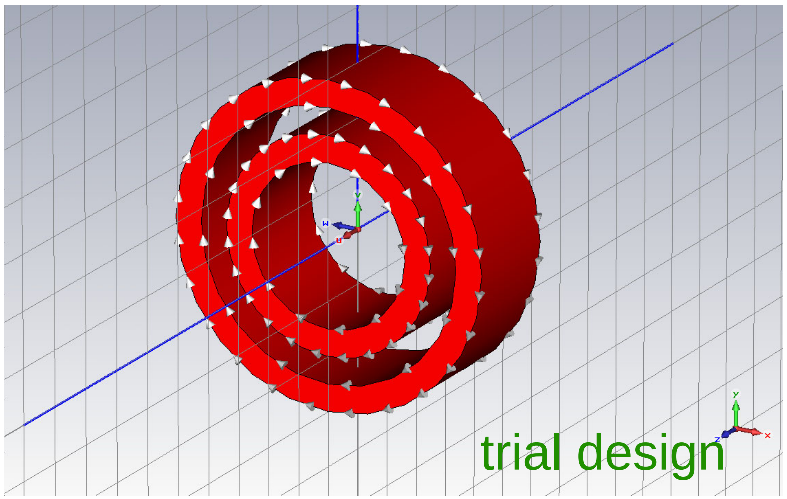




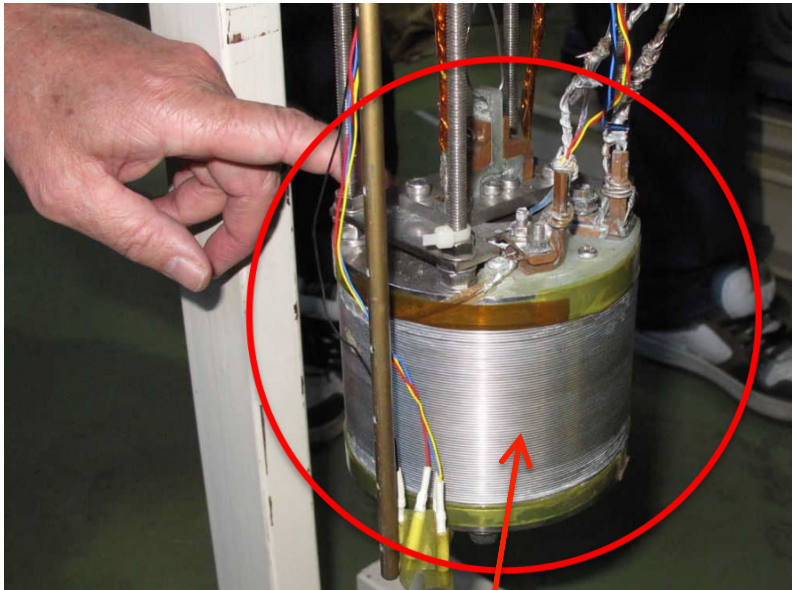
Superconducting (SC) solenoid R&D

- SC solenoid can yield high magnetic field as 6 Tesla.
- Superconducting state can be maintained only if J, B, T are below quench limit curve.
- Can SC solenoid survive under heating by intense radiation from e^+ production target ?
- Is SC solenoid sensitive to instantaneous heating by pulsed linac beam ? (10 ps/20 ms)
- Which kind of SC wires to be used ?
  - NbTi, Nb_3Sn
  - high Tc material ? (Bi, YBCO)

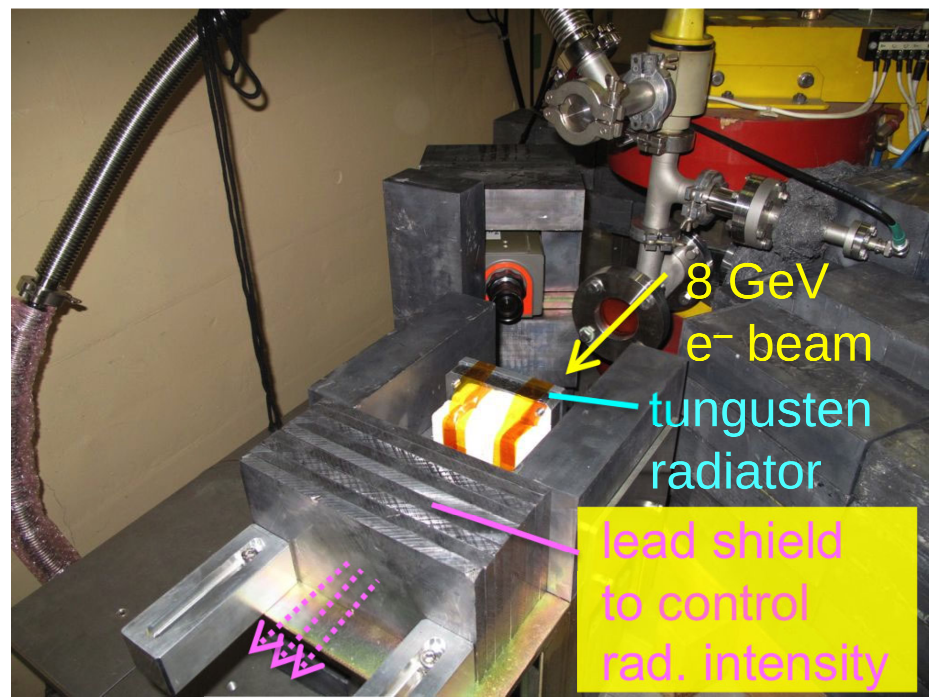




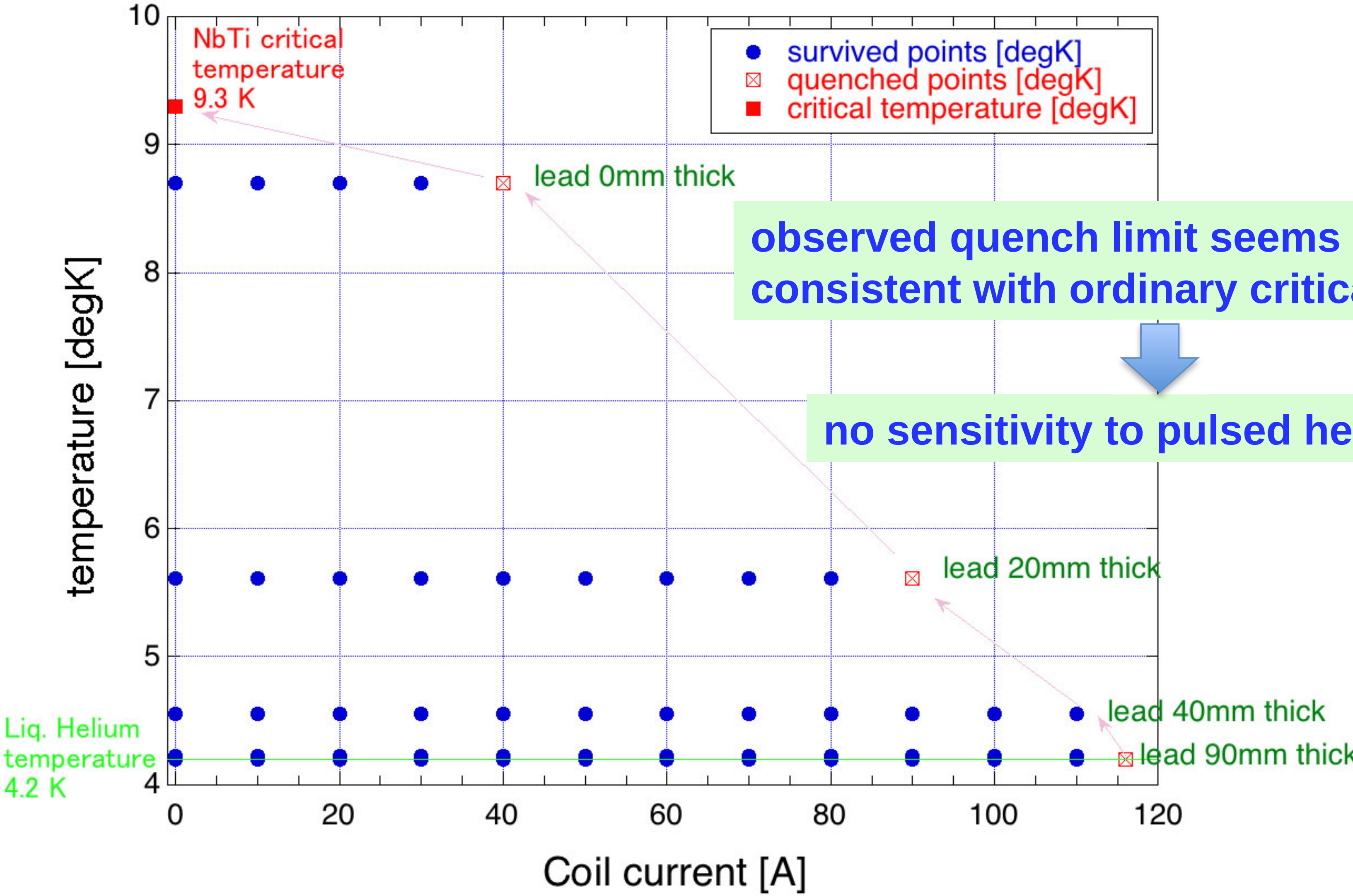
SC solenoid beam irradiation test



- a sample SC solenoid is irradiated by shower from tungsuten radiator at KEKB linac test-beam line.
- quench limit property is studied.



SC solenoid beam test result



observed quench limit seems to be consistent with ordinary critical limit.

no sensitivity to pulsed heating !!

More detailed beam studies are necessary with more practical prototype solenoid and with more practical beam line configuration. They will be performed in 2010, 2011. 2nd beam test is planned in 2010 March.

Comparison of matching devices

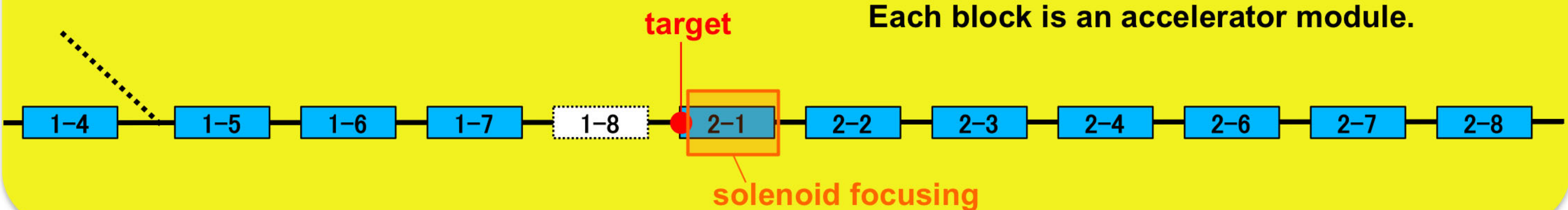
(merits & demerits)

	air-core coil	flux concentrat.	SC solenoid
field strength	2.3 T	6 ~ 10 T	6 T
field length	45 mm	90 mm	> 220 mm
field shape	difficult to make long slope	defined by conductor shape	flexible in design
aperture diameter	22 mm	8 mm	> 30 mm
power supply	high-power pulse modulator	high power pulse modulator	low-power DC power supply
vibration	large	large	none
transvers field	small	large	small
target in mag. field	out of field peak	out of field peak	at field peak
component in vacuum	none	magnet & cooling	none
quenching	none	none	possible
top merit	working now	high field strength	adiabatic field
top demerit	low & short field	e+ bypass line	quenching

L-band capture section layout

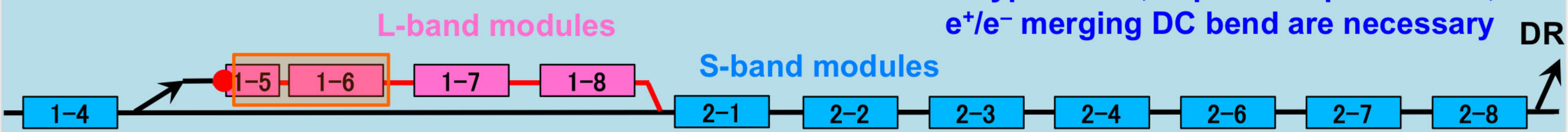
present layout around e^+ target

Each block is an accelerator module.



layout with L-band capt. section (FLC case)

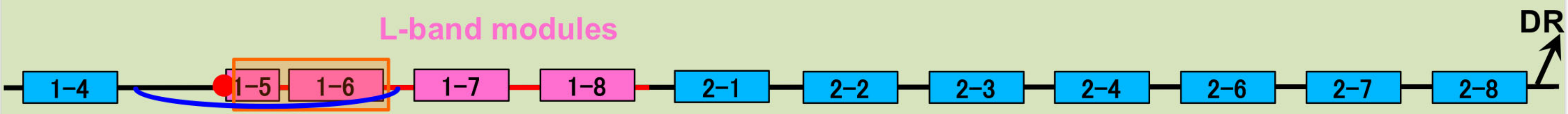
- target moved for DR inj. energy margin
- e^+ bypass line, separation pulse bend, e^+/e^- merging DC bend are necessary



or

layout with L-band capt. section (SCS case)

- target moved for DR inj. energy margin
- e^- bypass through target hole



L-band component R&D

$f_{L\text{-}band}$ = 2856 [MHz] x (5/11) = 1298 [MHz]

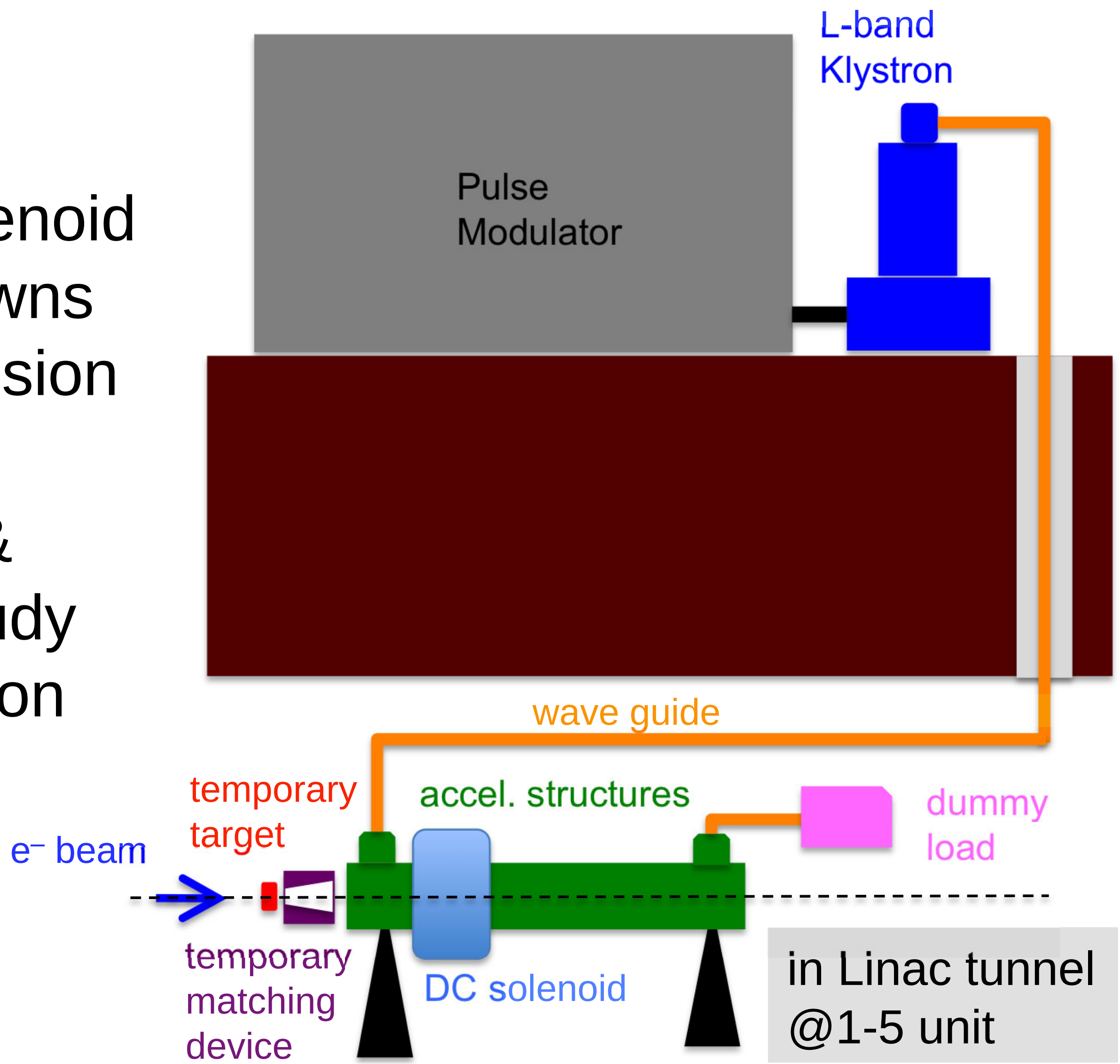
- **klystron**
  - developping 40 MW klystron (30 MW in operation), 4.0 μs width
  - 1st klystron will be completed in May 2010 and tested in a test-stand
- **pulse modulator**
  - with suitable design of the klystron, S-band modulator can be used for L-band without modification
- **accelerating structure**
  - breakdown issue
    - spiralling field emission in solenoidal field
    - shower particle bombardment
  - travelling wave or standing wave structure ?
    shorter RF pulse width   higher accelerating field
  - 1st TW structure (2m long, 10 MV/m acc. field) will be completed in Feb. 2011 and tested in a test-stand

L-band teststand

1) klystron + accel. structure high power test

2) operation with DC solenoid field to study breakdowns by spiralling field-emission

3) operation with target & matching device to study breakdowns by radiation from target



1st stage high power test will begin in Apr. 2011.

(3) Injector Upgade Schedule

Injector upgrade schedule