Beam Abort System

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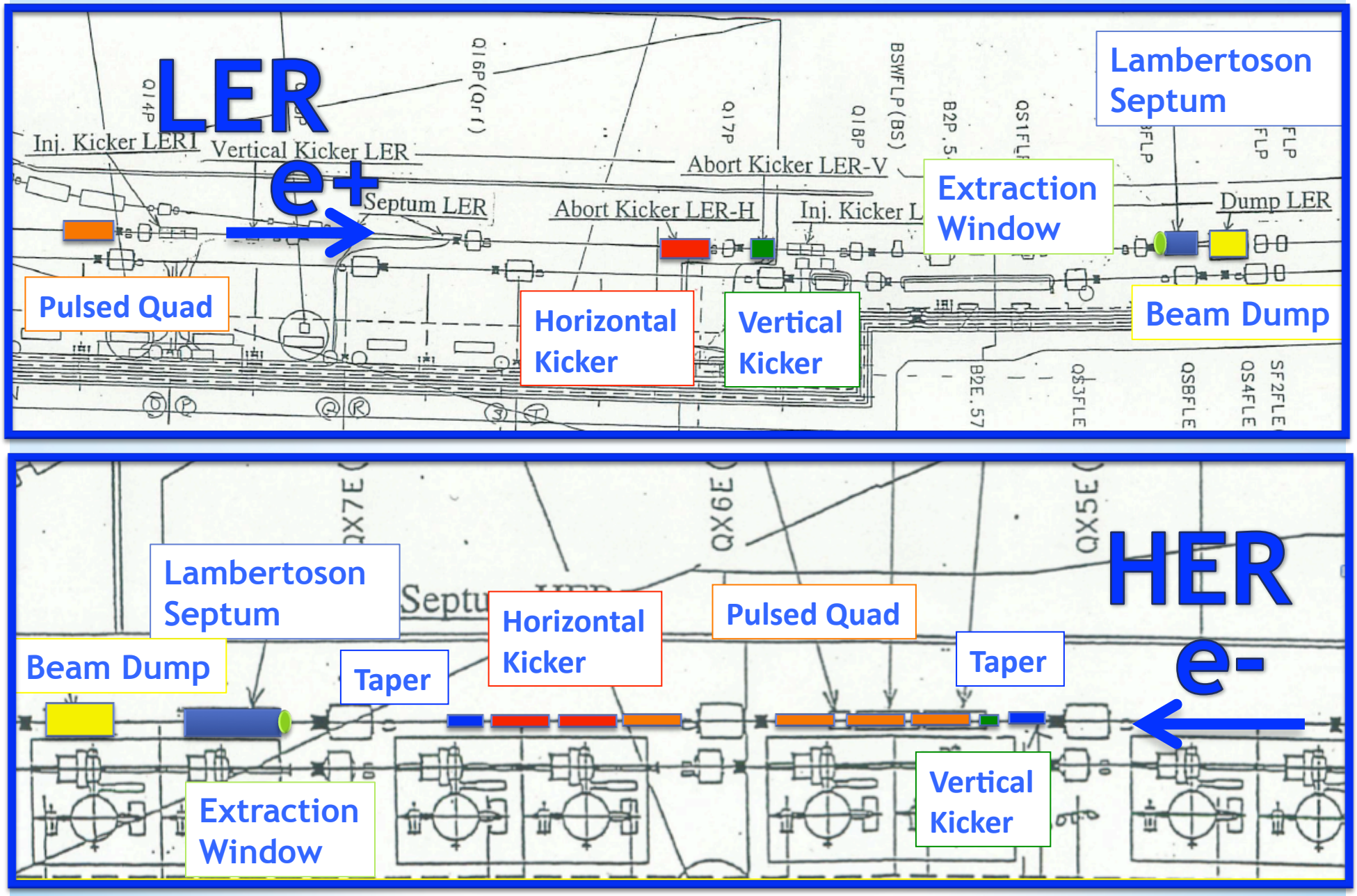


Beam Abort System

Requirements for Beam Abort System

- Very fast rise time (Requirement from RF group)
  - -> Abort Gap : dT < 200nsec (KEKB:500nsec)
- Make the beam size large @ extraction Window
- All or Nothing
  - -> One ring use one power supply

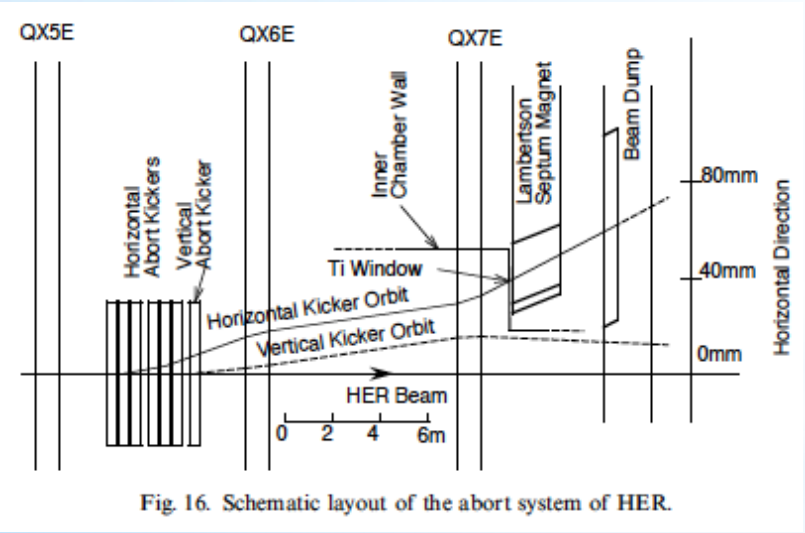
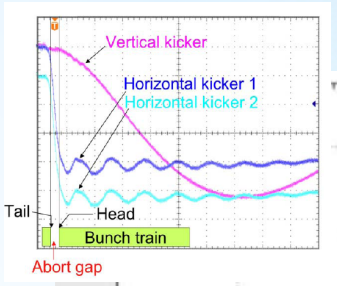
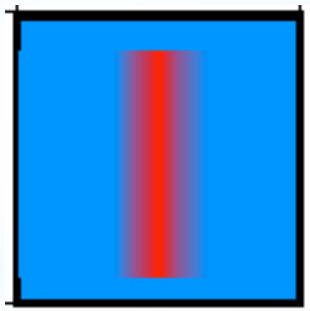
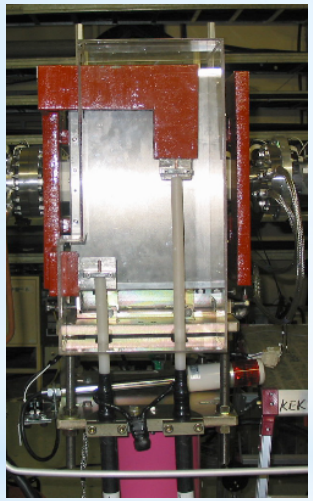


Fig. 16. Schematic layout of the abort system of HER.





Horizontal



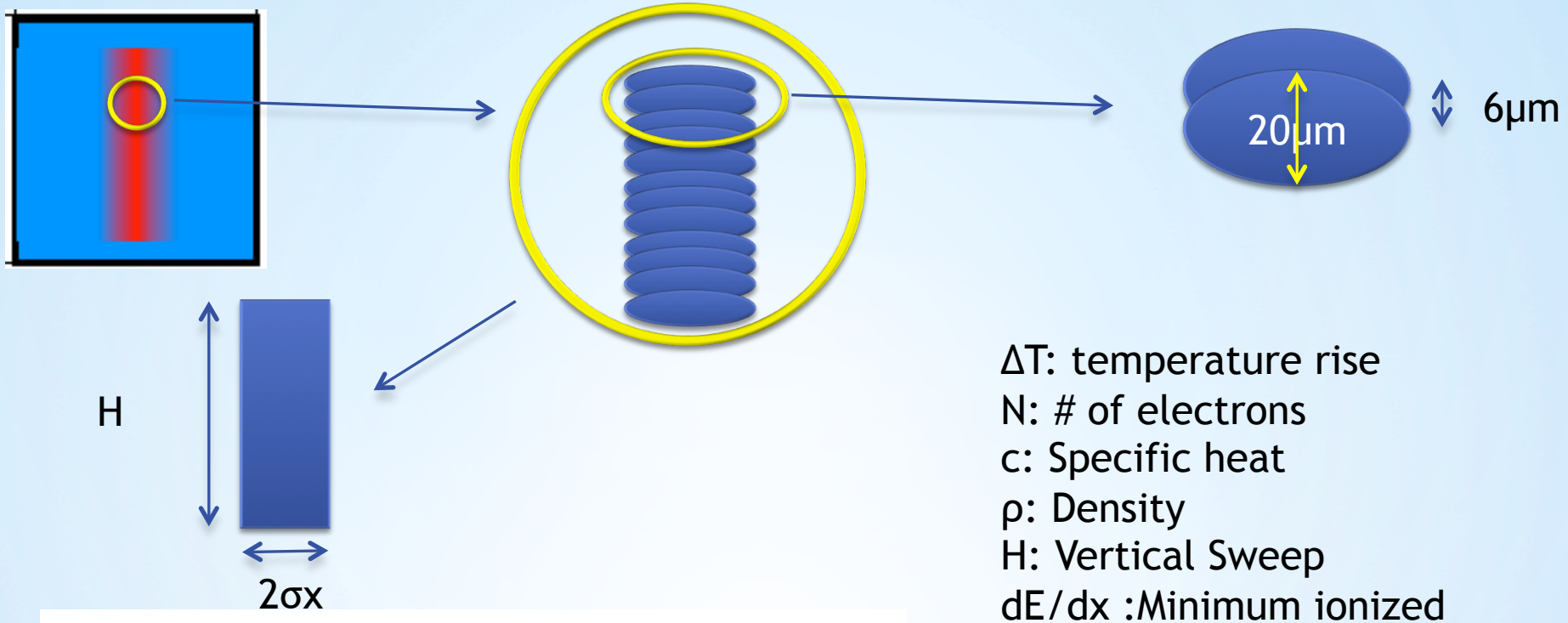
Vertical

	LER	HER
Horizontal Kicker	1	2
Vertical Kicker	1	1
Pulsed Quadrupole	1	4
Lambertson Septum	1	1
Power Supply	1	1
Pulse Compression	2	6
Beam Dump	1	1
Extraction Window	1	1
Water Cooling Ceramic	3	7

(1)Add Pulsed Quadrupole Magnets to enlarge the beam size @window

(2)Fast rise time of the Horizontal Kicker magnet (Abort Gap 500nsec -> 200nsec)

Components of abort System



$$\Delta T = \frac{N}{c}\left(-\frac{1}{\rho}\frac{dE}{dx}\right)\frac{1}{\sqrt{2\pi}\sigma_x H}$$

ΔT: temperature rise
N: # of electrons
c: Specific heat
ρ: Density
H: Vertical Sweep
dE/dx :Minimum ionized energy deposit
σx:Horizontal Beam size

ΔT dose not depend on window thickness. (Lowest order)

Basic Idea

	KEKB (LER)	SKEKB (LER)	SKEKB (HER)
E (GeV)	3.5	4 (4.16)	7 (8.6)
ε_x (nm)	24	3.2	4.6
σ_x(mm)@window	0.68	1.22	0.88
Vertical Sweep (mm)	10	10 (15)	10(15)
I (A)	2	3.6	2.6
I/σ_x (A/mm)		3	

Abort System Parameter

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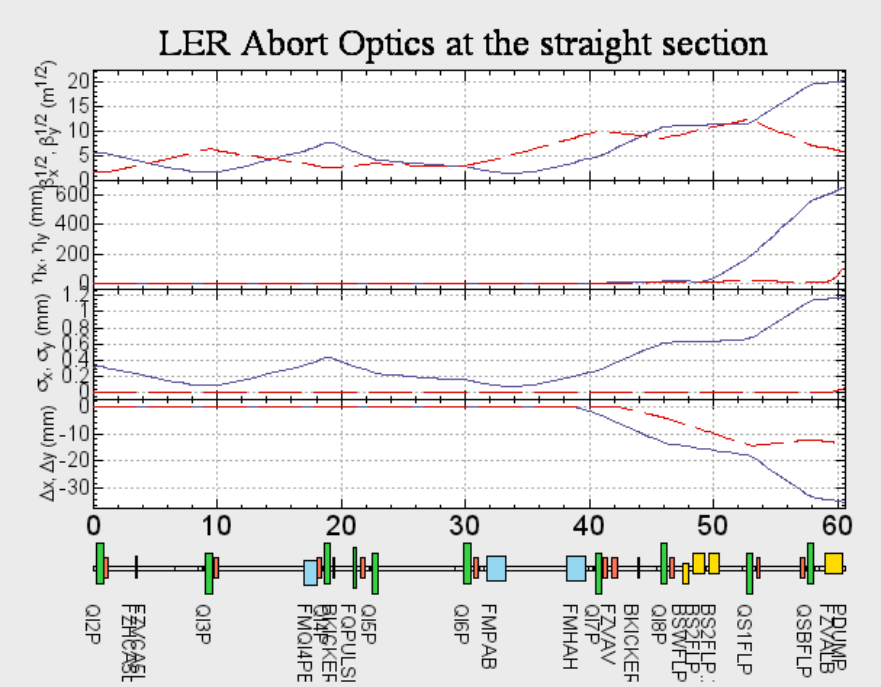
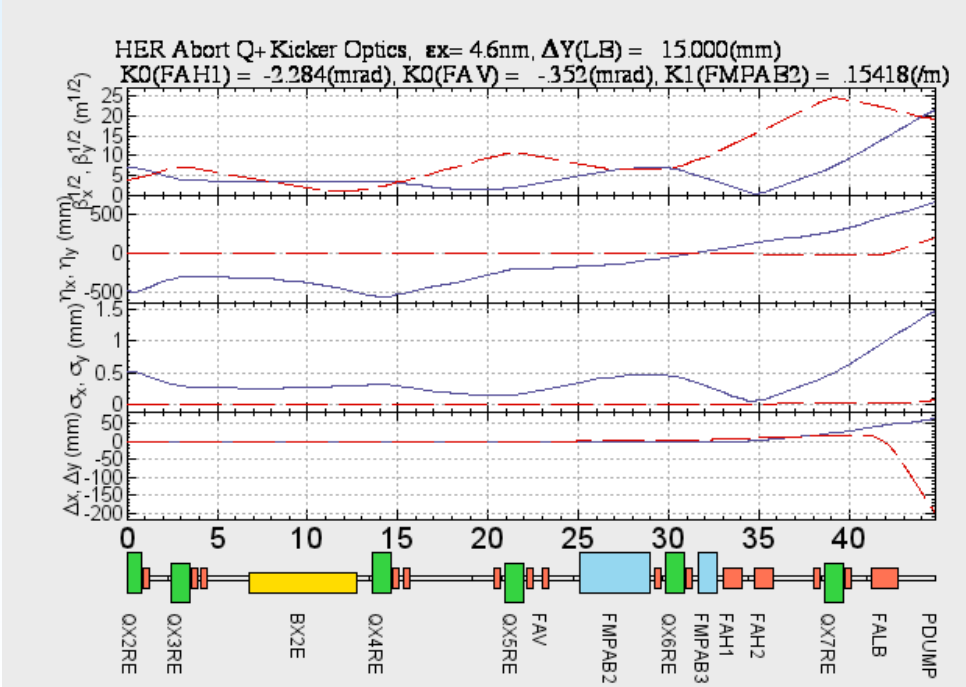




LER

HER

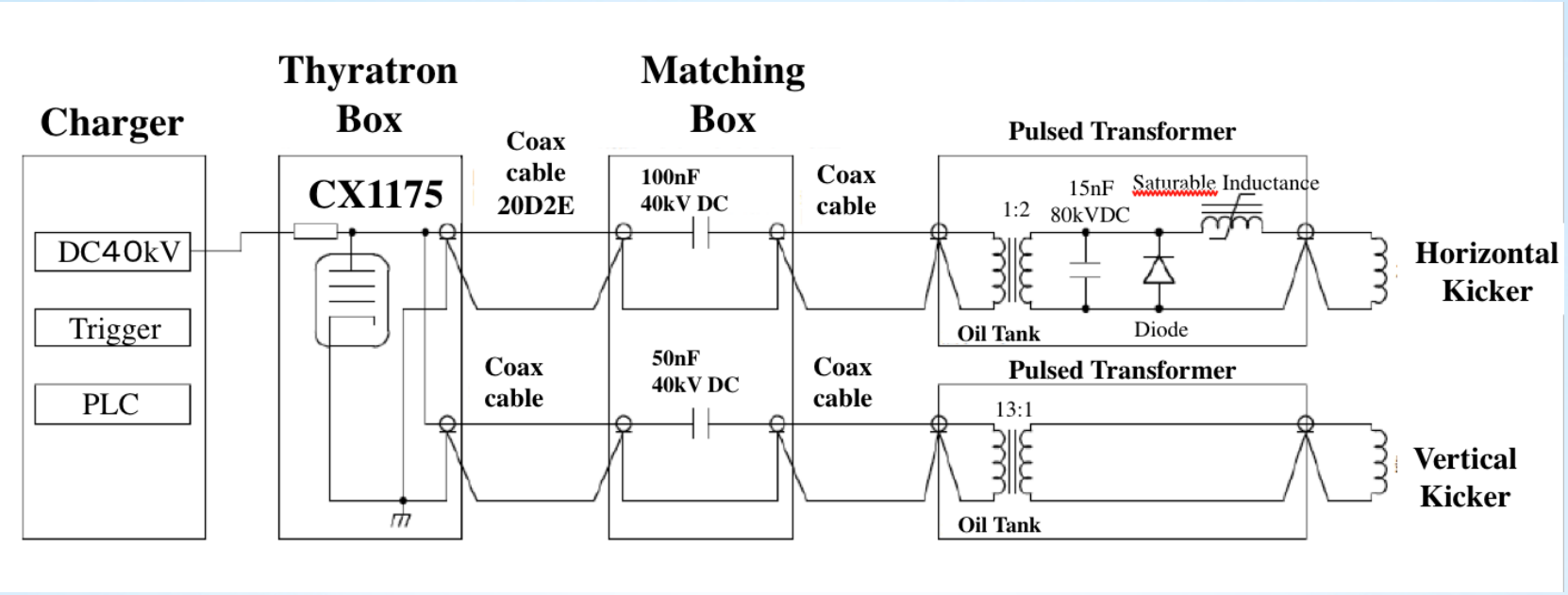
Optics

- Kicker and Pulsed Quadrupole Magnets
- Power Supply
- Ceramic Chamber
  - -> Spattering
- Extraction Window

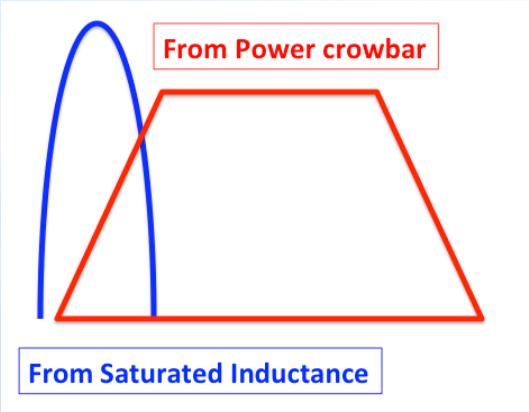
Developments of Hardware

	HER			LER		
	H	V	Q	H	V	Q
θ(mrad)	2.3	0.35	-	1.68	1.05	-
B (T,T/m)	4.09e-2	2.5e-2	1.5 (B')	3.3e-2	4.1e-2	1.5(B')
I total (kA) (/coil)	9.2 (2.3)	0.47	11.7 (2.2)	3.6 (1.8)	0.8	4.3 (2.15)
Gap (mm)	70	70	35 Bohr Rad	70	70	42.5 Bohr rad
L of Ferrite	400x4	400x1	400x8	350x2	350x1	400x2
# of coil	4	1	8	2	1	2
L of Ceramic	500x4	500x1	500x8	500x2	500x1	500x2

Abort Kicker and Pulsed Quadrupole magnet Specifications



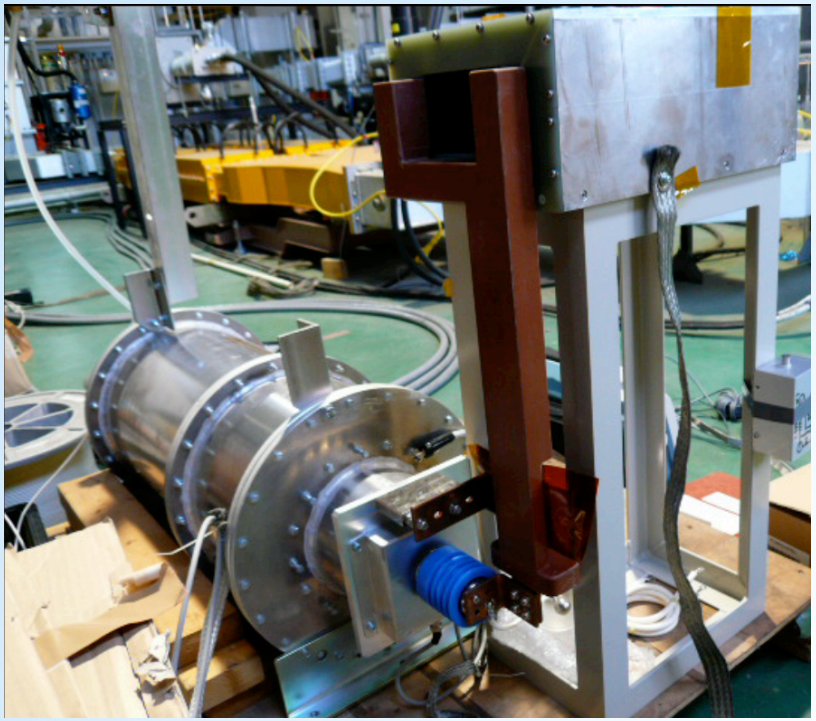
Saturable Inductance + Power Crowbar Circuit

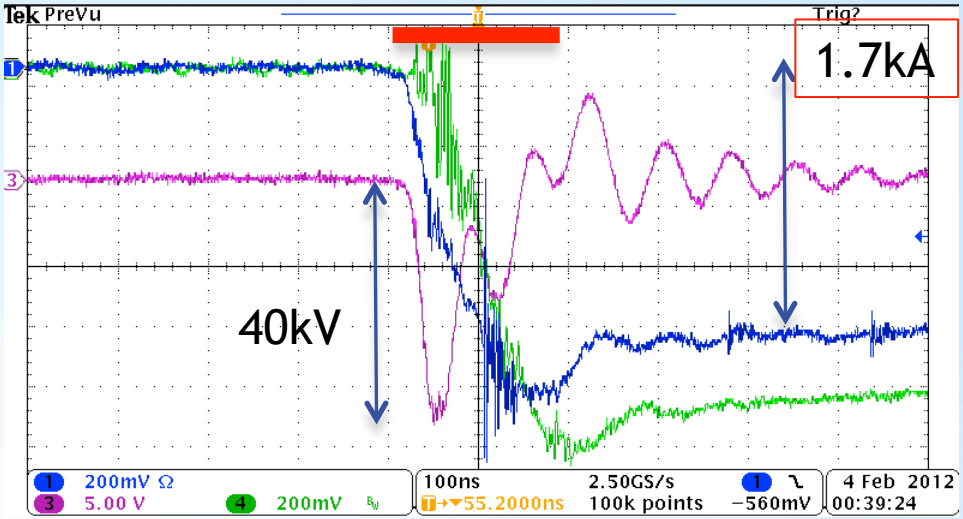


Free-wheeling diode, which reduces the pulse through the primary switch quite a lot

*Rise Time 120nsec

Magnet and Power Supply

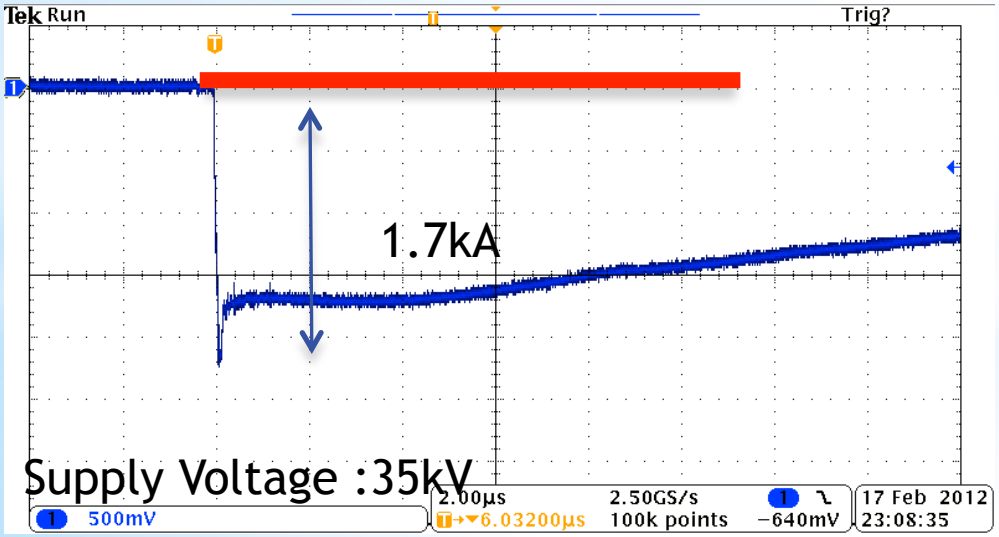




Magnet Current = 1.7kA (Flat Top)

Magnetic Field

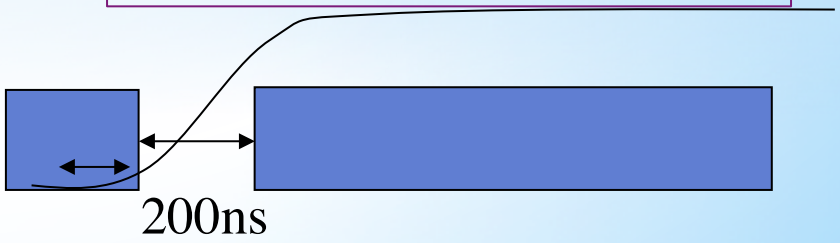
Coil Voltage (40kV)



Issues:

(1) Response time of power crowbar circuit is still slow

(2) Diode “ON” resistance of the power crowbar is still large



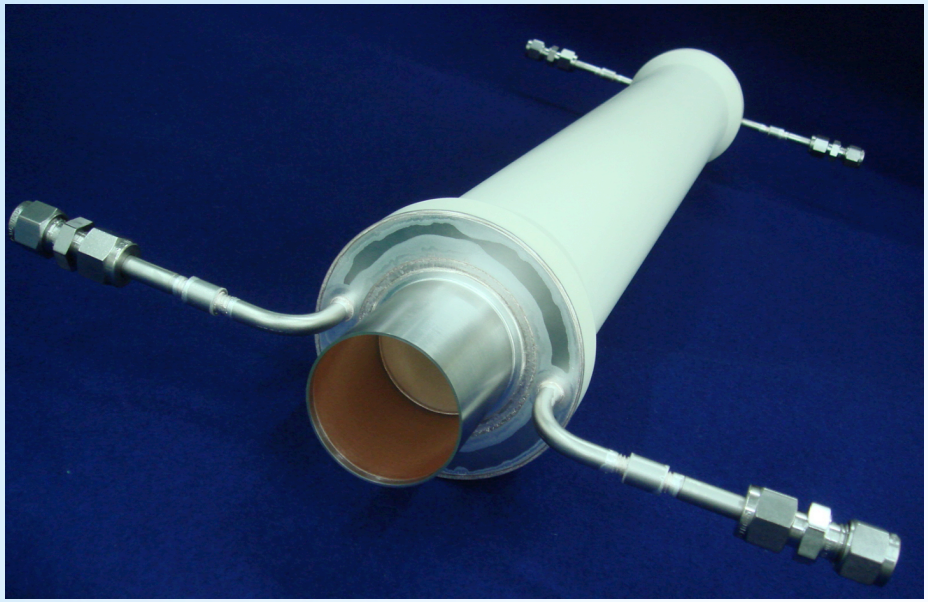
Development of water cooling ceramic chamber

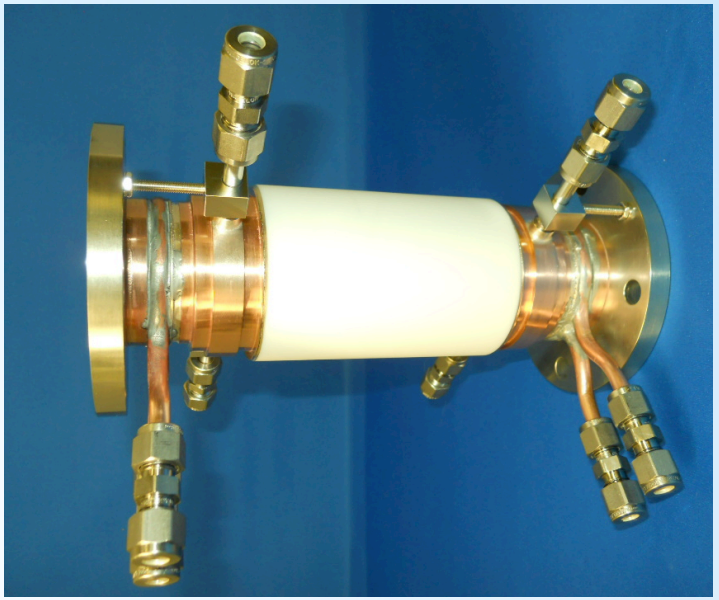
-> Compact Chamber (Kicker Gap 90mm->70mm)

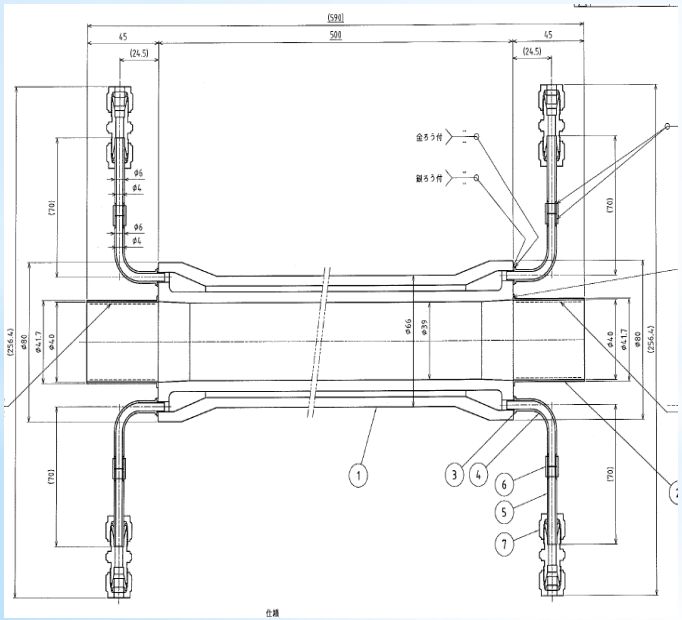
-> Cu coating in side the Kovar sleeve (100um)

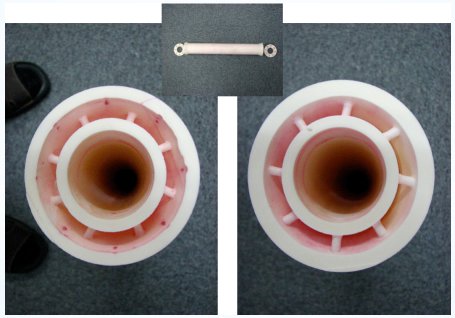
Length of Ceramic	**500mm**
Estimated power loss	～1kW
Ti coating thickness (Inner wall of Ceramic)	6μm
Cu coating thickness (Inner wall of Kovar sleeve)	>100μm
Inner wall	Race Track 60x40 (LER)
	Circle r=40 (HER)

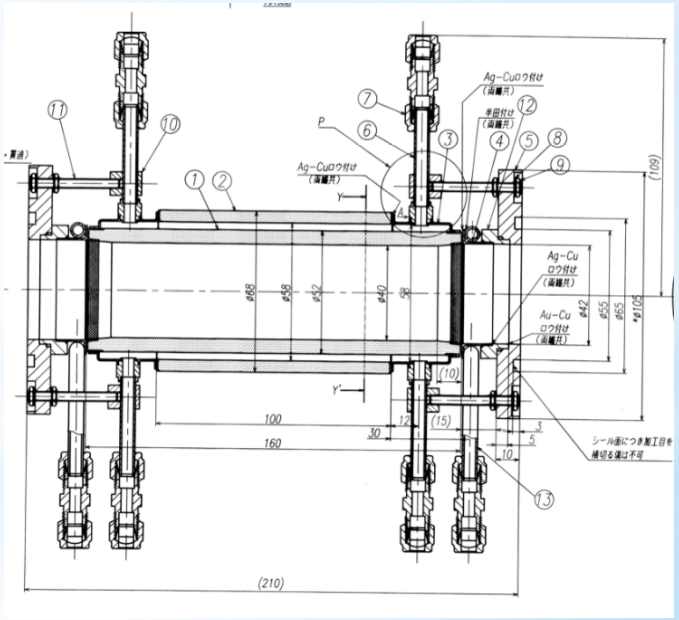
Ceramic Chamber









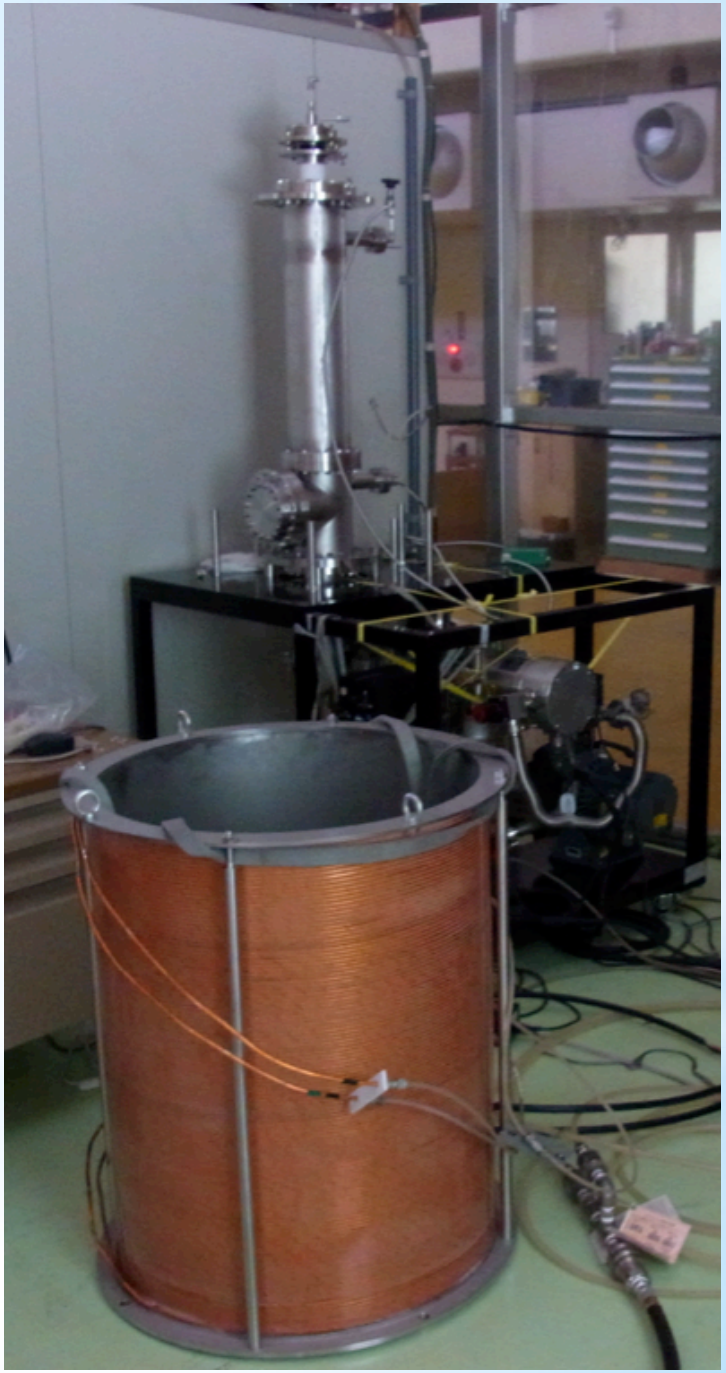


Single Ceramic：Hollow Type ceramic

Double tube structure
brazing side of ceramic.

For the Ti coating of inner wall
of the ceramic chamber

Spattering



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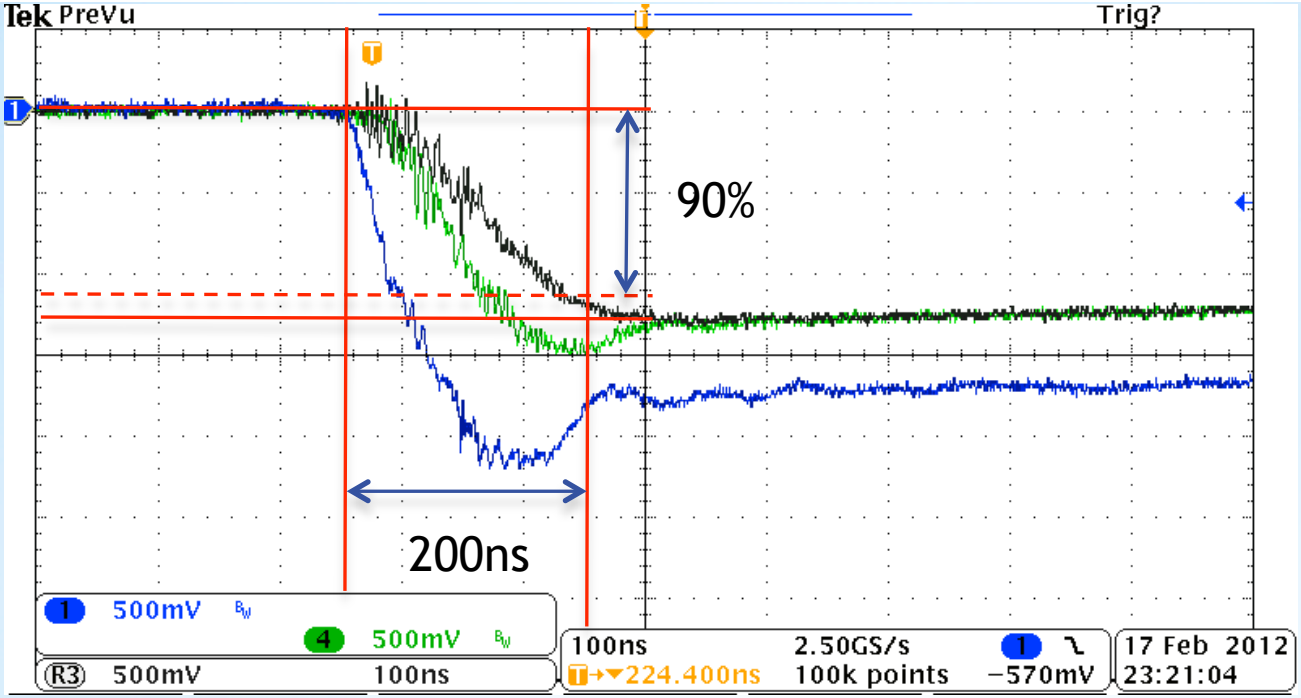
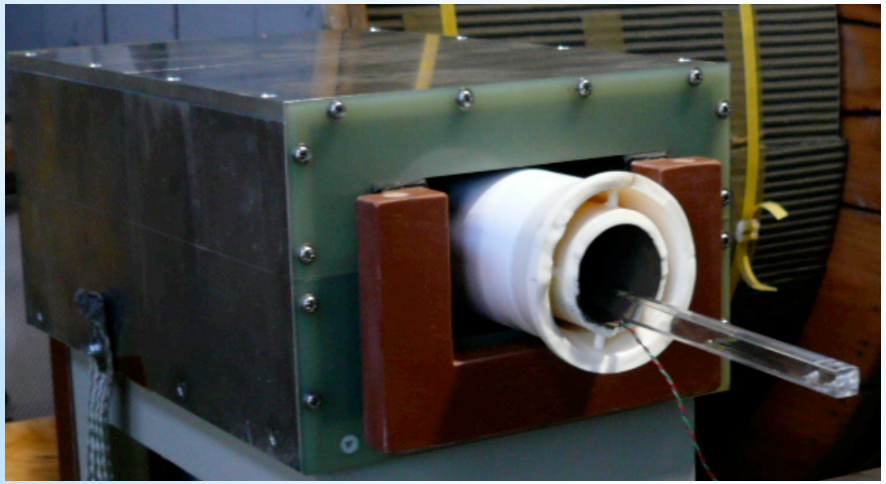
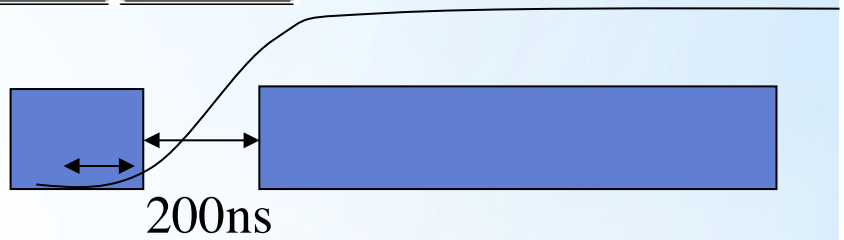


Current of the coil

Magnetic Field
With chamber

Magnetic Field
Without chamber

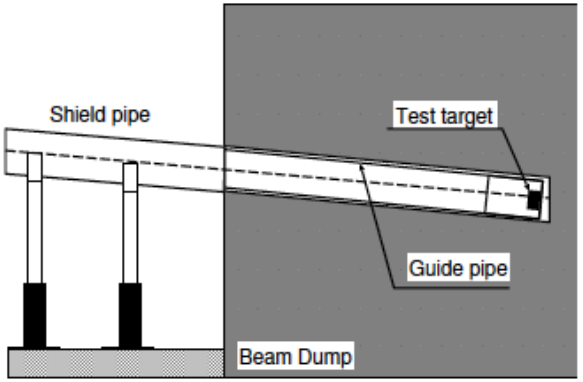




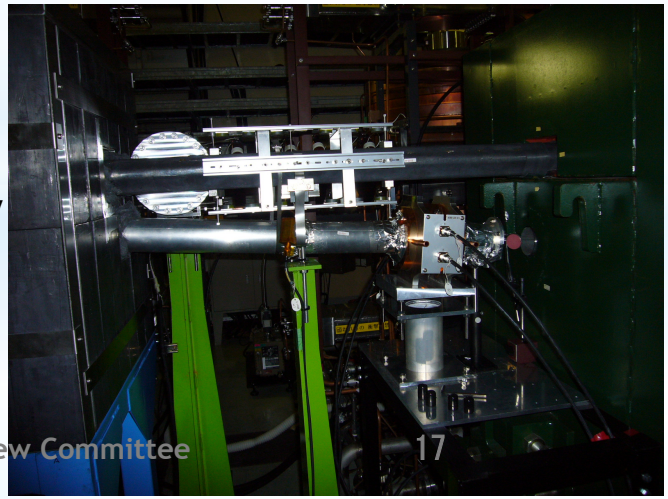
Delay of the Magnetic Field

An Accelerator Study for Ti Extraction Window

1100mA 7GeV



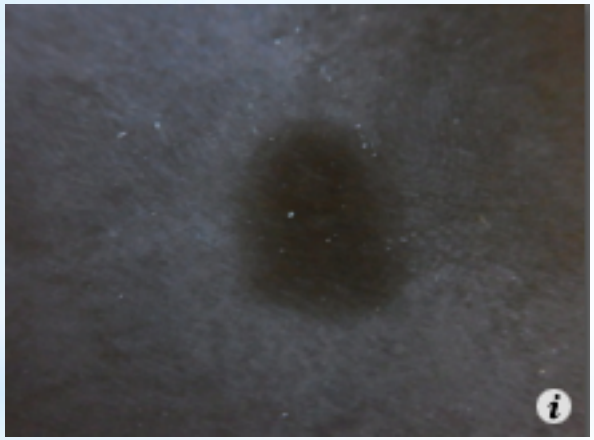
Ti
And
Ti Alloy



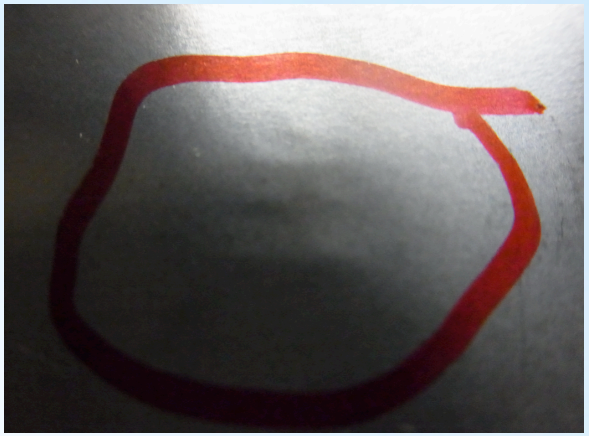
Ti Plate #7

Ti alloy 0.1mm

Ti Plate #8



Ti alloy 1 mm



Ti 0.1mm

Ti Plate #7

Ti 1mm

Ti Plate #8

Ti VS Ti Alloy

Damages of Ti Plate

@1.1A HER

# Ti Plate	Radiation Length (Fe)	Energy Deposit	δX	δT Ti	Current Density	Ti Alloy (1mm)	Ti (1mm)
	0	4.9	1.17	58	0.5	○	○
	0.25	6.8	1.17	80	0.8	-	-
0	0.5	11.4	1.17	134	1.3	○	○
1	0.75	18.7	1.17	220	2.1	○	○
2	1.0	28.6	1.17	338	3.3	○	○
3	1.25	41.2	1.17	485	4.8	○	△
4	1.5	56.5	1.17	666	6.5	△	×
5	1.75	74.5	1.17	880	8.4	△	×
6	2.0	95.2	1.17	1123	10.9	△	×
7	2.25	118.5	1.17	1399	21.2	△	×
8	2.5	144.6	1.17	1705	25.8	△	×

×:Damaged （uneven） ○: OK

△ : There is a mark but not bulge.(Flat surface)

Ti 1mm

Ti 0.5 mm

Ti 0.2mm

Damage of Ti Plate Thickness dependence

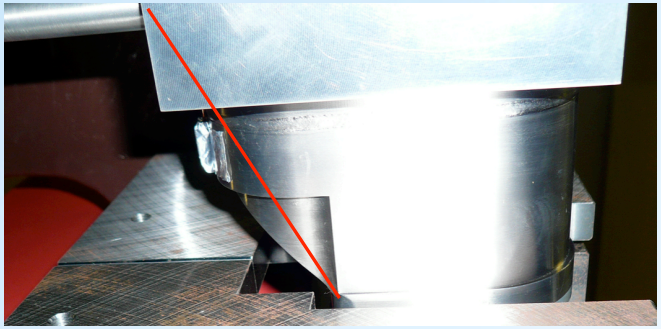
	Ti
melting point	1941
boiling point	3560
specific heat	0.52

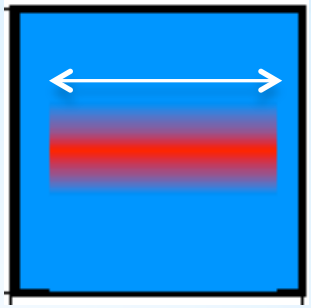
Thickness Dependence of Ti Plate Damage

# Ti Plate	δT Ti	Ti Alloy (mm)				Ti (mm)			
		1	0.5	0.2	0.1	1	0.5	0.2	0.1
	58	○	-	-	-	○	-	-	-
	80	-	-	-	-	-	-	-	-
0	134	○	-	-	-	○	-	-	-
1	220	○	-	-	-	○	-	-	-
2	338	○	○	△	△	○	○	○	○
3	485	○	○	-	-	△	△	-	-
4	666	△	○	×	×	×	△	×	×
5	880	△	-	×	-	×	-	×	×
6	1123	△	△	-	-	×	△	×	×
7	1399	△	-	-	×	×	-	-	×
8	1705	△	△	×	×	×	△	×	×

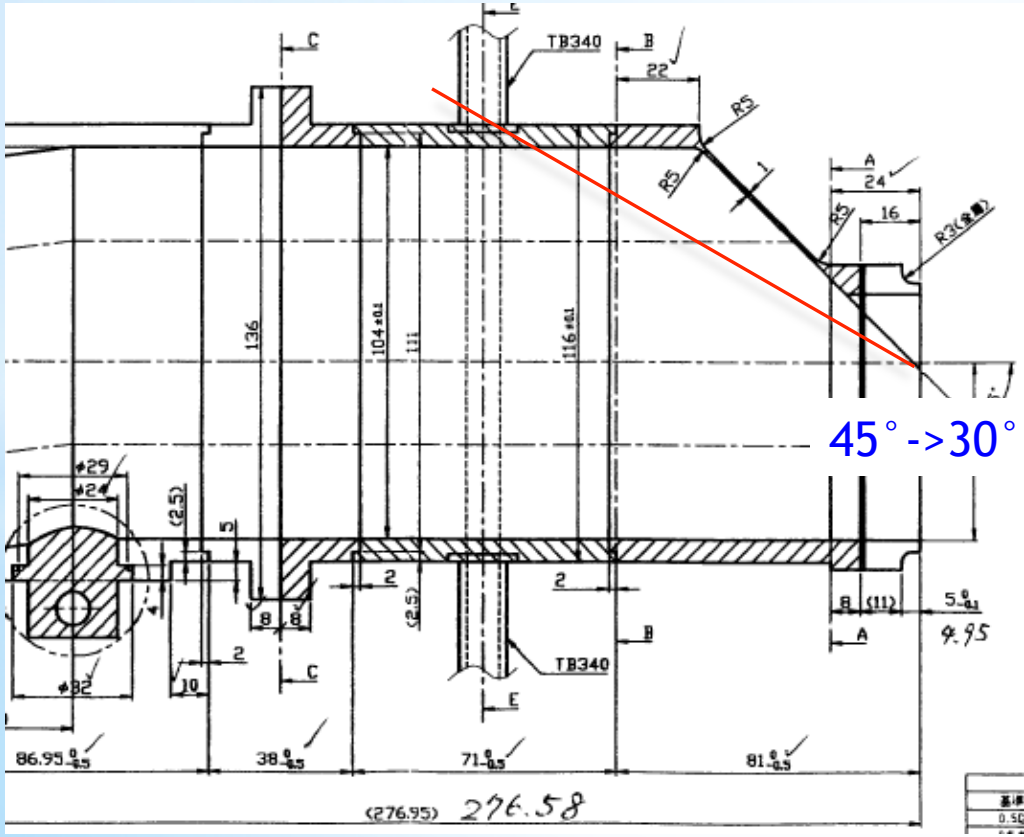
×:Damaged ○: OK

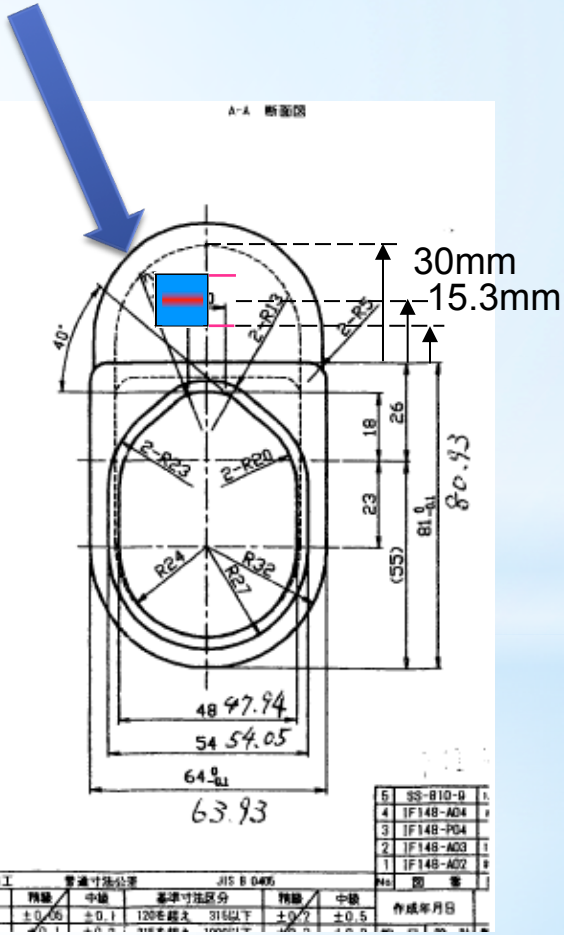
△ : There is a mark but not bulge.

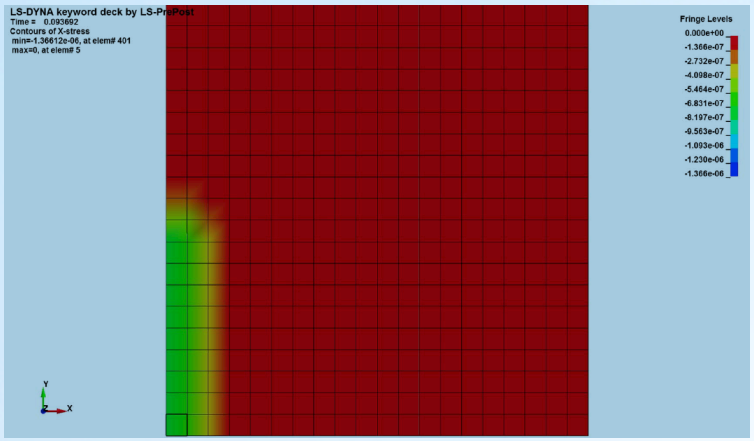




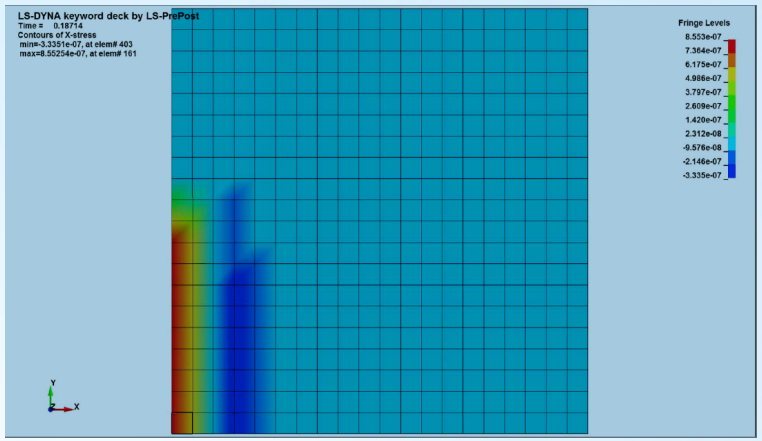
10mm -> 15mm


TB340
22
R5
R5
1
24
16
R3
136
104
111
116
45°->30°
TB340
276.58
(276.95)

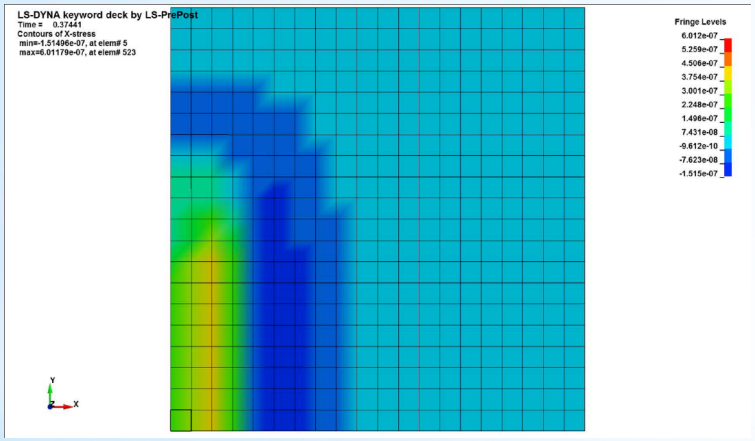

30mm
15.3mm
40°
2-R23
2-R20
2-R3
18
26
23
(55)
R24
R32
R27
48
47.94
54
54.05
64
63.93
80.93



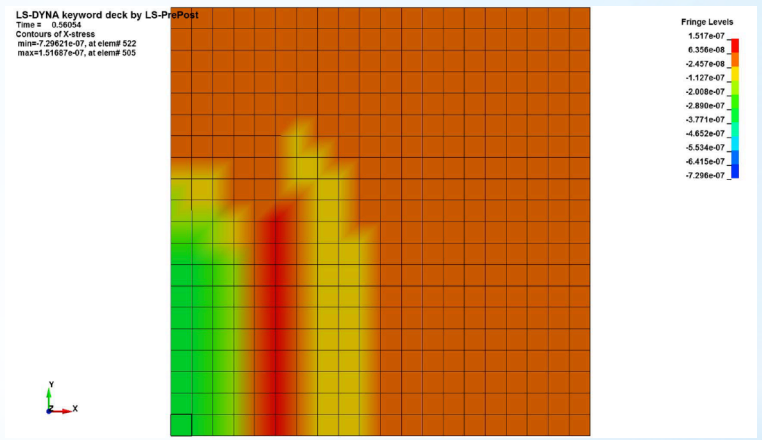
T=0.093



T=0.187



T=0.374



T=0.581

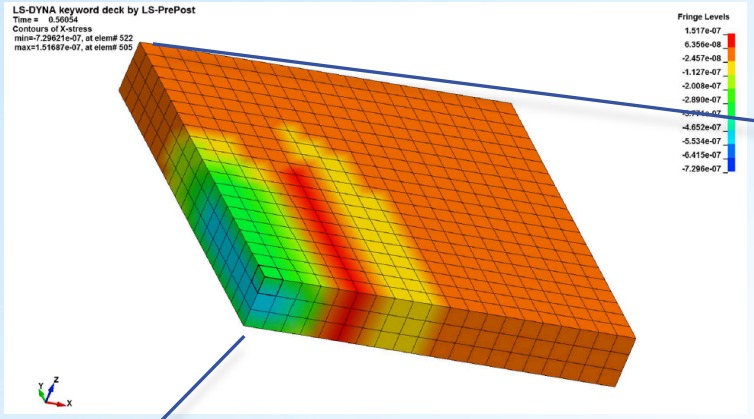
1/4 Model

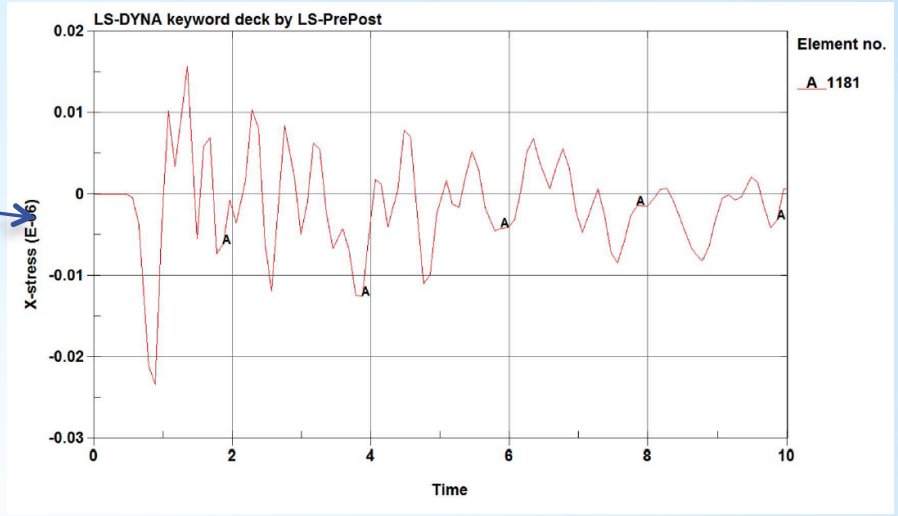
Terui

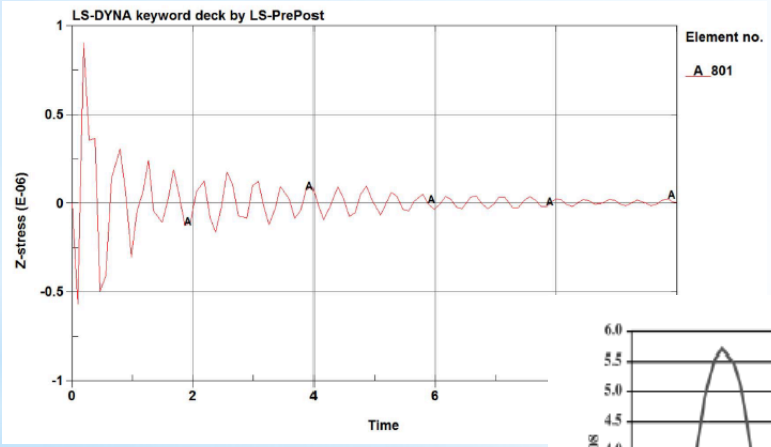
Gives 500℃ heat to the 1x10 mm area (T=0) and calculate stress propagation

Simulation of the window

From Mr. Terui







Z-direction Stress

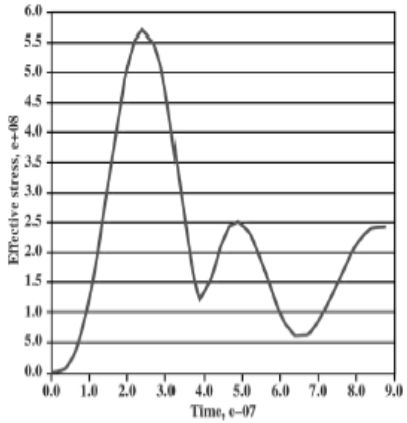


Figure 5: Peak Von Mises stress, Pa, versus time, s, plot.

Stress versus time

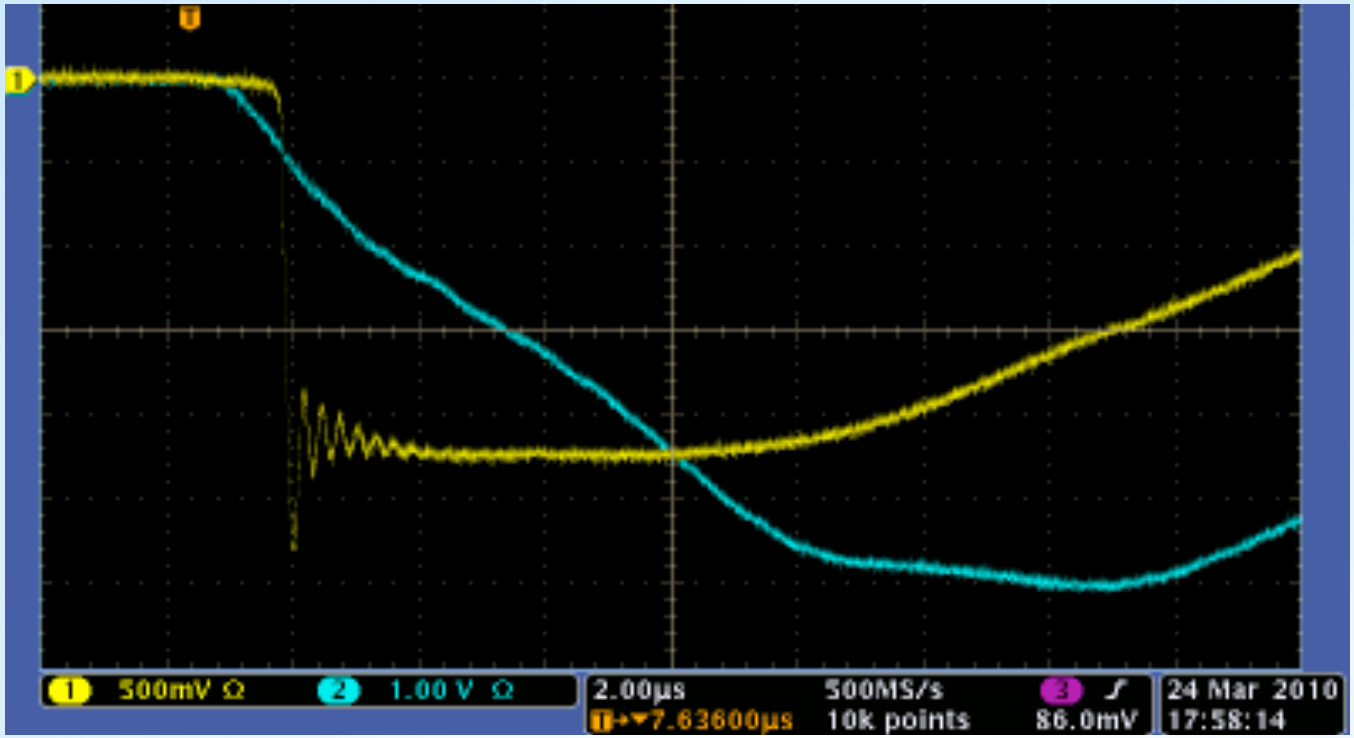
(W.Stein et al Proc. Of the 2001 PAC, Chicago)

- ★Energy deposit - psec
- ★Temperature rise - nsec
- ★Stress - 200-300nsec
- ★The temperature profile of a spot requires about 1 sec to relax down to initial temperature

- Possibility to use two Sextuple Magnets instead of Pulsed magnets to enlarge the horizontal beam size at the extraction window
- Optimize the thickness of the inner Ti coating of the ceramic chamber
- Need to understand the Ti window damage process.
- The vertical beam moving is necessary to diffuse heat on the window, and do we need the horizontal beam moving ?
- Because of bad economic situation, the company TDK won't produce Ferrite core any more. We have to look for the company that make ferrite core for us. We hope our government won't cut 7.8 % of our salary, we will buy the product of TDK.

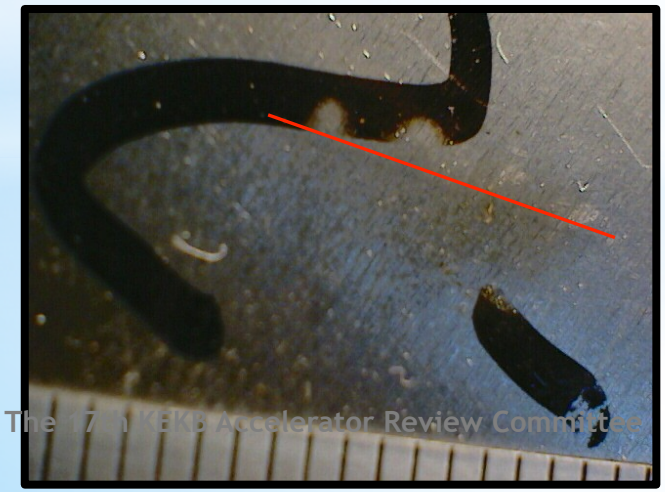
Issues and Discussions

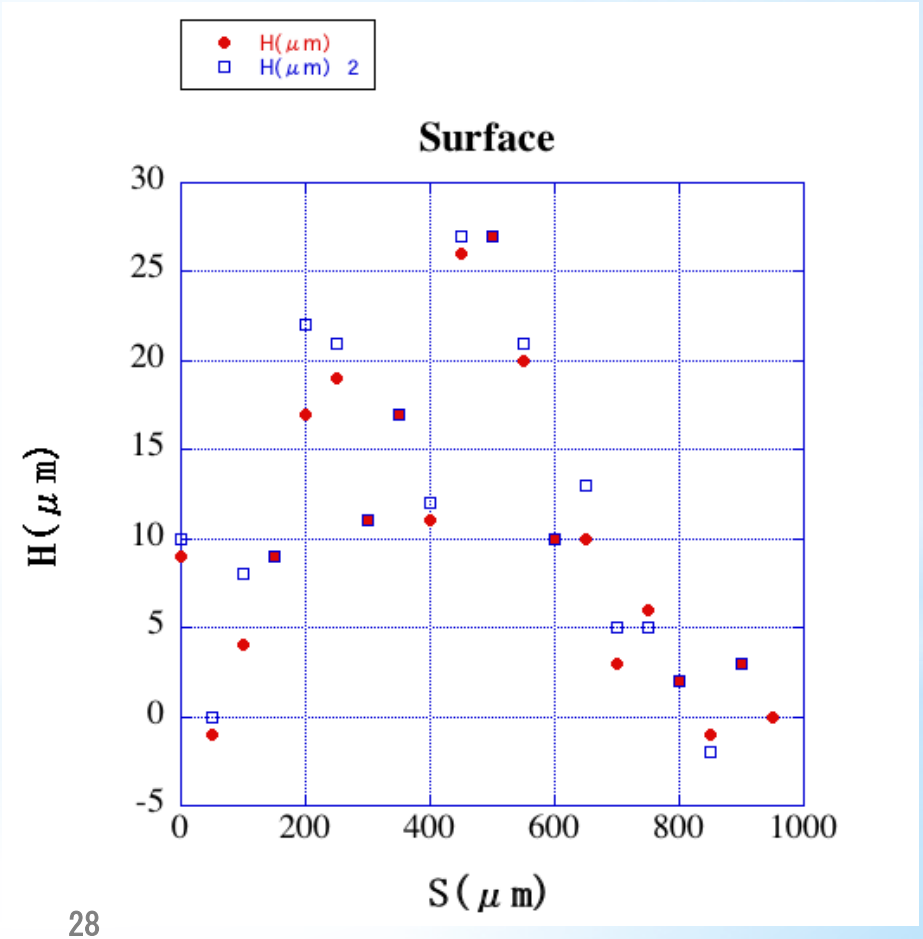
*Backup



Vertical Kicker and Horizontal Kicker current

*Damage of Ti plate





Shower development （EGS５）