Construction Status of the Damping Ring and the Beam Transport Lines

The new HER Abort System

5/Mar/2013

18th SuperKEKB Review Committee

Naoko Iida

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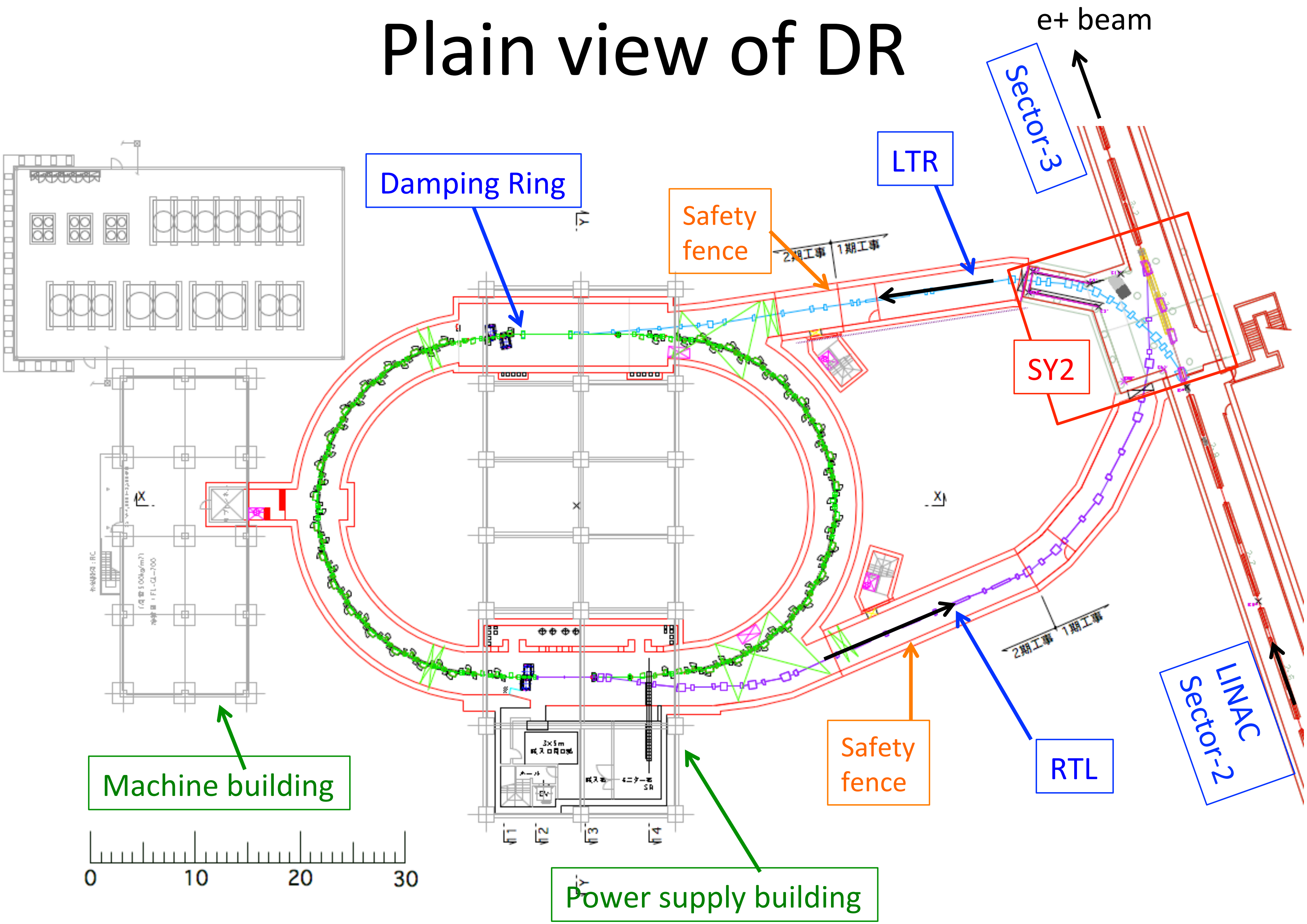
Construction status

of

the Damping Ring and

the Beam Transport lines

Plain view of DR



DR under construction on 18/Dec/2012

Inside DR tunnel

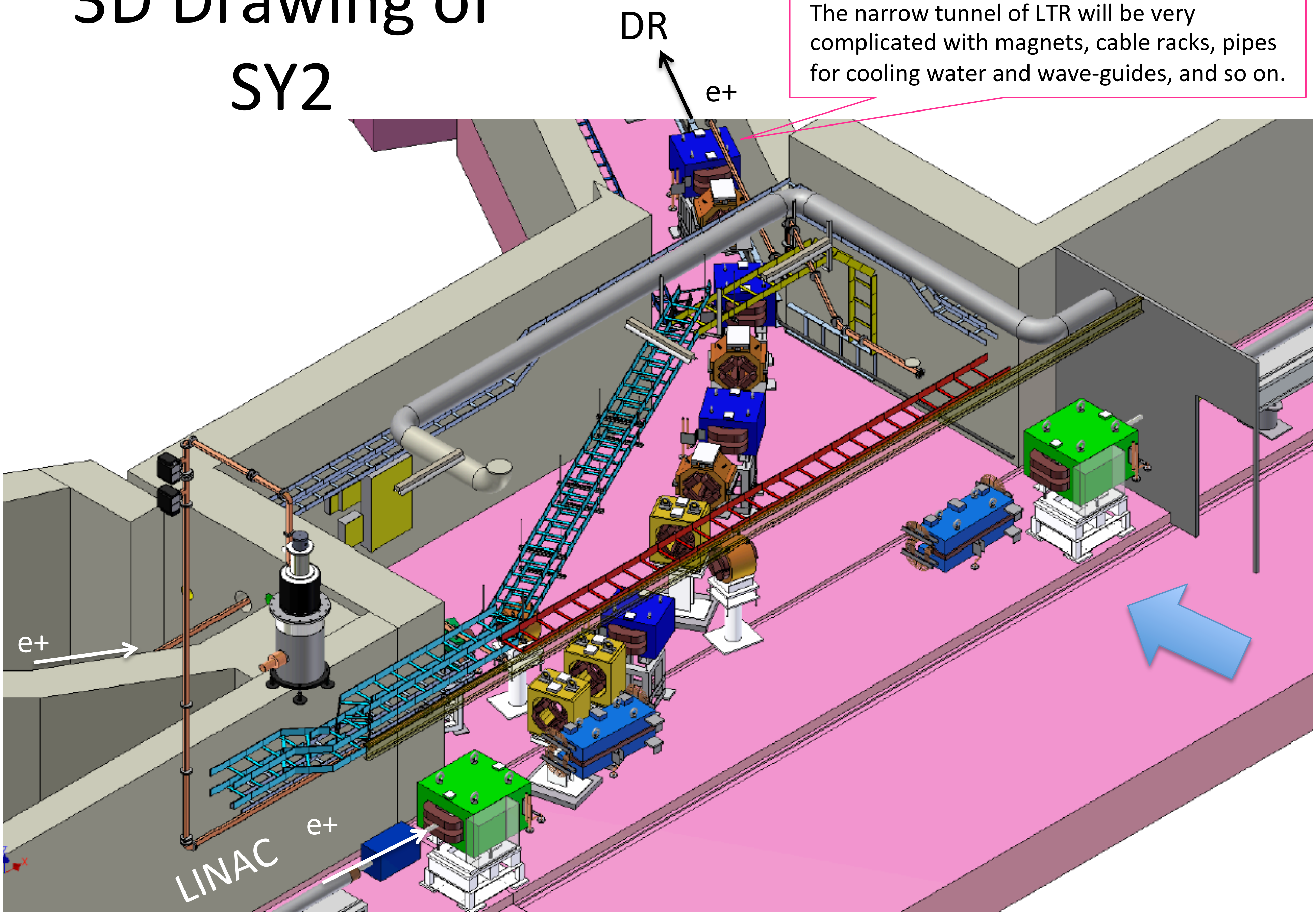
DR under construction on 26/Feb/2013

Now DR has been buried.
The construction of the building above the DR will start from April.

Inside DR tunnel

3D Drawing of SY2

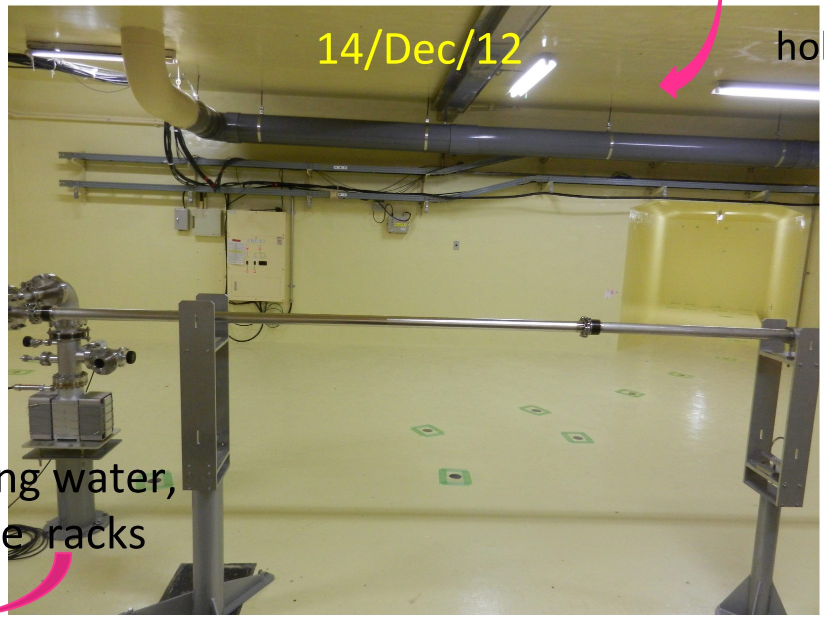
The narrow tunnel of LTR will be very complicated with magnets, cable racks, pipes for cooling water and wave-guides, and so on.



SY2 Construction

Cleaning

Painting,
Placing
anchor holes,
Drilling
holes to DR

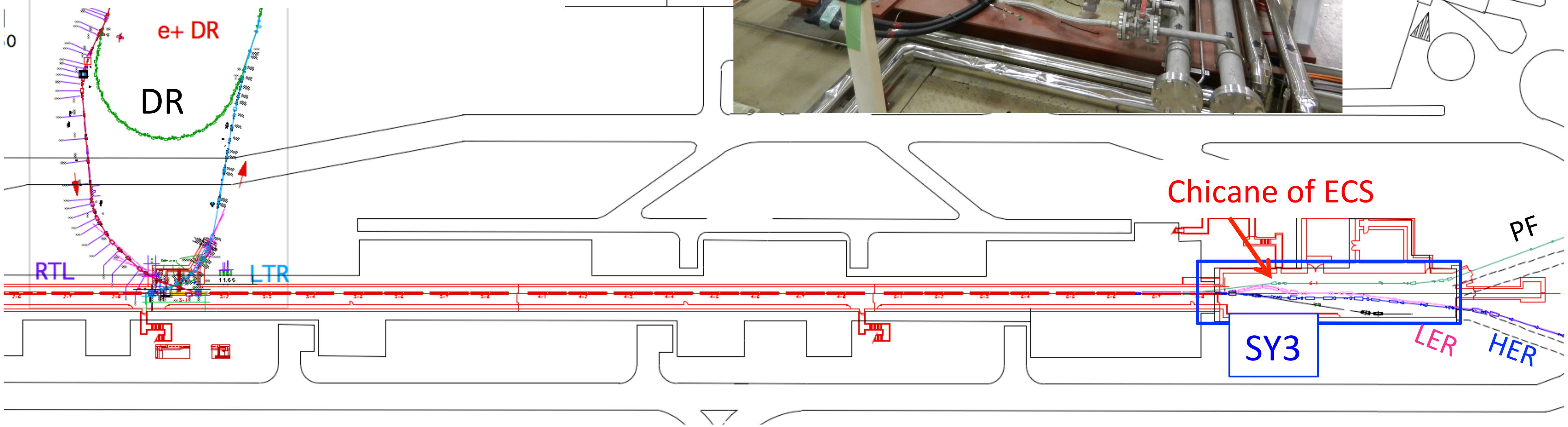


Piping for cooling water,
Installing cable racks

SY3 Construction

New Energy Compression System(ECS) of positron line at the end of LINAC is under construction, which is needed to change the energy of positron from 3.5 GeV to 4 GeV.

Magnets of ECS were removed and the new ones will be installed in this summer.



Construction of main Components

DR

Magnet

Magnet type	Full gap (mm)	No. of magnets	Delivery to KEK	Field Measurement
B1	46	33	✓	✓
B2	46	39	✓	✓
B3	46	5	✓	✓
B4	46	5	✓	✓
QF	46	29	✓	Mar/2013
QD/S	46	51	✓	Mar/2013
QR	110	4	Mar/2013	Mar/2014
QM	60	8	Mar/2013	Mar/2014
SFD	70	76	Mar/2014	Mar/2014
STH/V		8	Mar/2014	Mar/2014

Power supply

Type	No. of magnets	Output Power (A・V)	No. of PSs	Delivery to KEK
B1	32	900・700	1	Mar/2013
B2	38	880・500	1	Mar/2013
B3	4	800・70	1	Mar/2012
B4	4	800・70	1	Mar/2012
QF	28	330・210	1	Mar/2012
QD	28	250・160	1	Mar/2012
QS	1	330・15	18	Mar/2012
QR	1	500・30	3	Mar/2014
QM	1	300・15	7	Mar/2014
SF	30	150・200	1	Mar/2014
SD	30	150・200	1	Mar/2014
SX	1	150・ 15	14	Mar/2014
HB2	1	5・x	38	
VSD	1	10・x	30	
H	1	5・x	4	
V	1	5・x	4	

Vacuum chamber

Chamber type	Full gap (mm)	No. of chamber	Delivery to KEK	TiN Coat
B1	32H・24V	32	Mar/2013	Mar/2014
B2	32H・24V	30	Mar/2013	Mar/2014

Beam instrumentation

LTR, RTL

Magnet

Magnet type	Full gap (mm)	No. of magnets	Delivery to KEK	Field Measurement
BC1E	50	2	✓	Jun/2013
BNL	50	5	✓	Jun/2013
BRN	50	1	✓	Jan/2014
BS	28	8	✓	Jun/2013
QLN.1-3	110	3	Re-used	Mar/2013
QLN.4-8	108	8	Mar/2013	Mar/2013
QMN	48	7	Mar/2013	Jan/2014
QRN	39	8	Mar/2013	Jan/2014
QRS, QMS	30	12	Mar/2013	Jan/2014
QLS	64	8	Mar/2013	Jan/2014
SFS	84	2	Mar/2013	Jan/2014
SDM	52	4	Mar/2013	Jun/2013

Power supply

Type	No. of magnets	Output Power (A・V)	No. of PSs	Delivery to KEK
BC1E.1-2	2	480・70	1	✓
BC2E.1-2	2	290・50	1	✓
BL1N.1-4	4	490・120	1	✓
BL2N	1	490・40	1	✓
BRN	1	310・20	1	✓
BRS.1-3	3	430・40	1	✓
BL1S.1-2	2	550・40	1	✓
BL2S.1-3	3	550・50	1	✓
QLN.1-3	3	530・40	3	✓
QLN.4578	4	90・80	4	✓
QMN.1-5, QLF2S	6	50・40	6	✓
QMN,QRN,QS	28	30・30	28	✓
SFS, SDM	6	5・x	6	Re-used
HBN	5	5・x	5	Re-used
HBS	5	10・x	5	Re-used
HN	8	5・x	8	Re-used
VN	11	10・x	11	Re-used
HS	7	5・x	7	Re-used
VS	9	5・x	9	Re-used

Vacuum chamber

Chamber type	Full gap (mm)	No. of chamber	Delivery to KEK	
BC1E.1	58H・46V	1	Mar/2013	

Beam instrumentation

Kicker, Septum

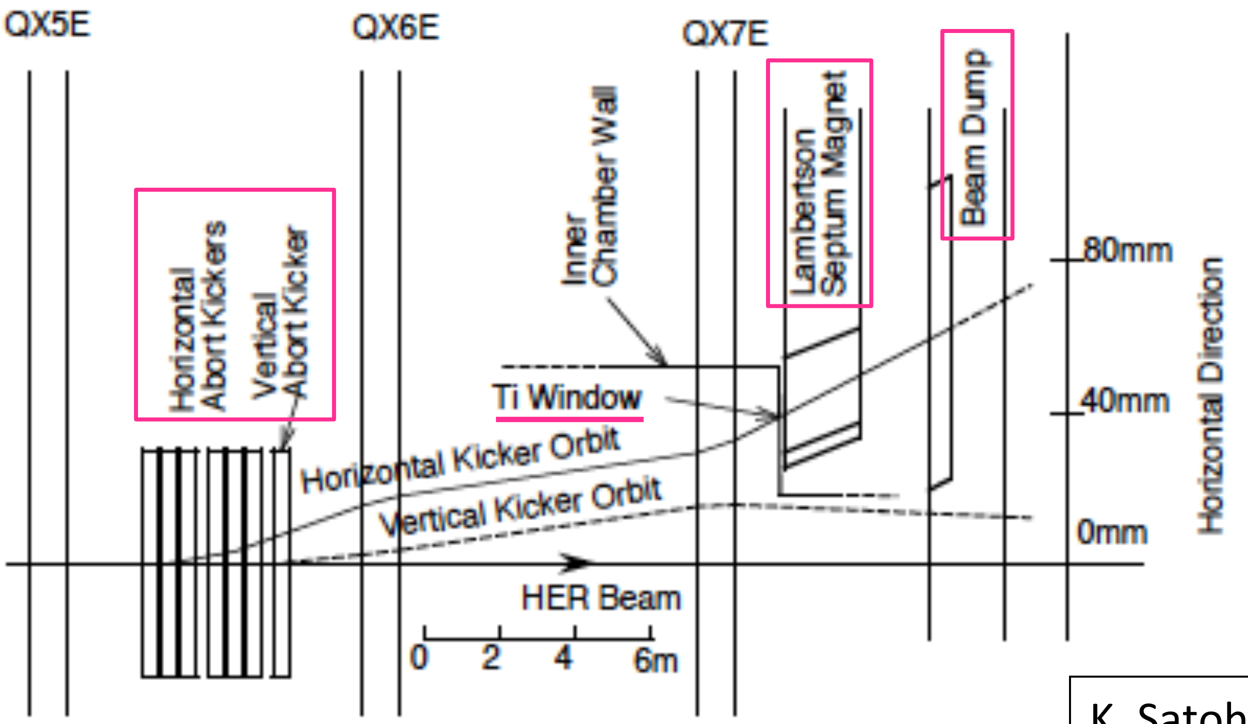
Milestones of DR, LTR, and RTL

- Sep/2014
  - LINAC commissioning will start.
  - Access to LTR and RTL area will be limited due to the LINAC commissioning.
  - By this time, the construction of LTR,RTL has to be completed.
- May/2015
  - The beam from DR will be injected to LER.

The New HER Abort System utilizing DC Sextupoles

Abort system of KEKB

1. The horizontal abort kickers kick the stored beam out of vacuum chamber (The rise time～500ns). The beam is extracted through Ti window to the atmosphere before entering the Lambertson magnet.
2. Power density on the Ti window is diffused by introducing vertical kicker that sweeps the beam vertically.
3. The beam comes out to the atmosphere from a vacuum through the Abort window(Ti) at the entrance of Lambertson magnet.
4. The beam is bent downward by Lambertson and leads to Dump.



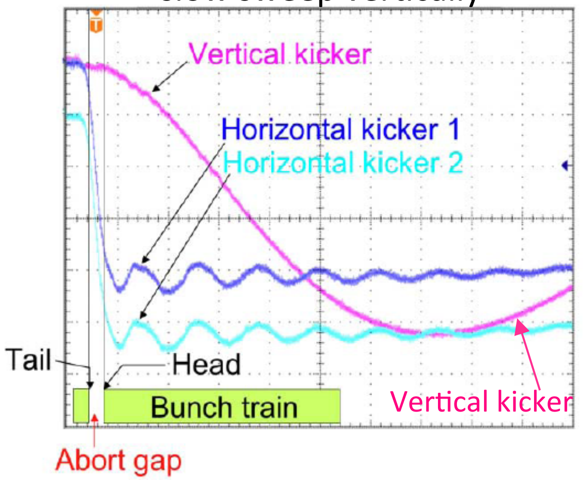
K. Satoh

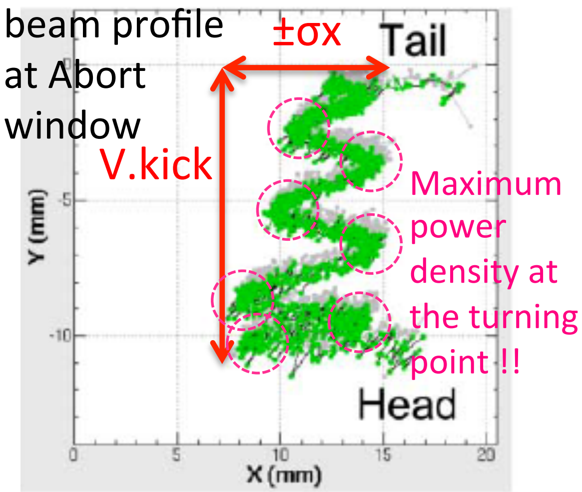
Fig. 16. Schematic layout of the abort system of HER.

Abort system of SuperKEKB

KEKB

Horisontal kicker :
fast kick to the Abort window
Vertical kicker :
slow sweep vertically





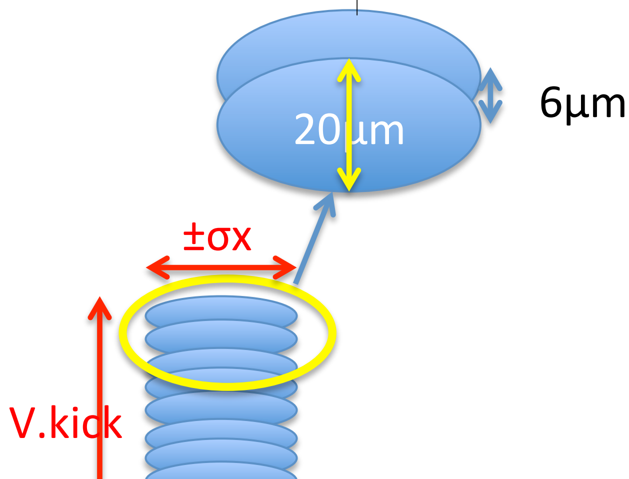
In SuperKEKB, the low emittance beam has a possibility of destroying the abort window more than KEKB.
Enlarging horizontal beam size is needed other than the vertical sweep.

SuperKEKB(LER)

Horisontal kicker :
fast kick to the Abort window
Vertical kicker :
slow sweep vertically
PULSEd quadrupole :
enlarge the horizontal beam size

SuperKEKB(HER)

Horisontal kicker :
fast kick to the Abort window
Vertical kicker :
slow sweep vertically
DC sextupole :
enlarge the horizontal beam size



T. Mimashi

17th KEKB Review by T. Mimashi

	HER(7 GeV)			LER		
	H	V	Q	H	V	Q
θ(mrad)	4.6	0.35	-	1.68	1.05	-
B (T,T/m)	6.7e-2	2.5e-2	1.5 (B')	3.3e-2	4.1e-2	1.5(B')
I total (kA) (/coil)	14.9 (2.5)	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	400x6	400x1	400x8	350x2	350x1	400x2
# of coil	6	1	8	2	1	2
L of Ceramic	500x6	500x1	500x8	500x2	500x1	500x2

Too many !

Abort Kicker and Pulsed Quadrupole magnet Specifications

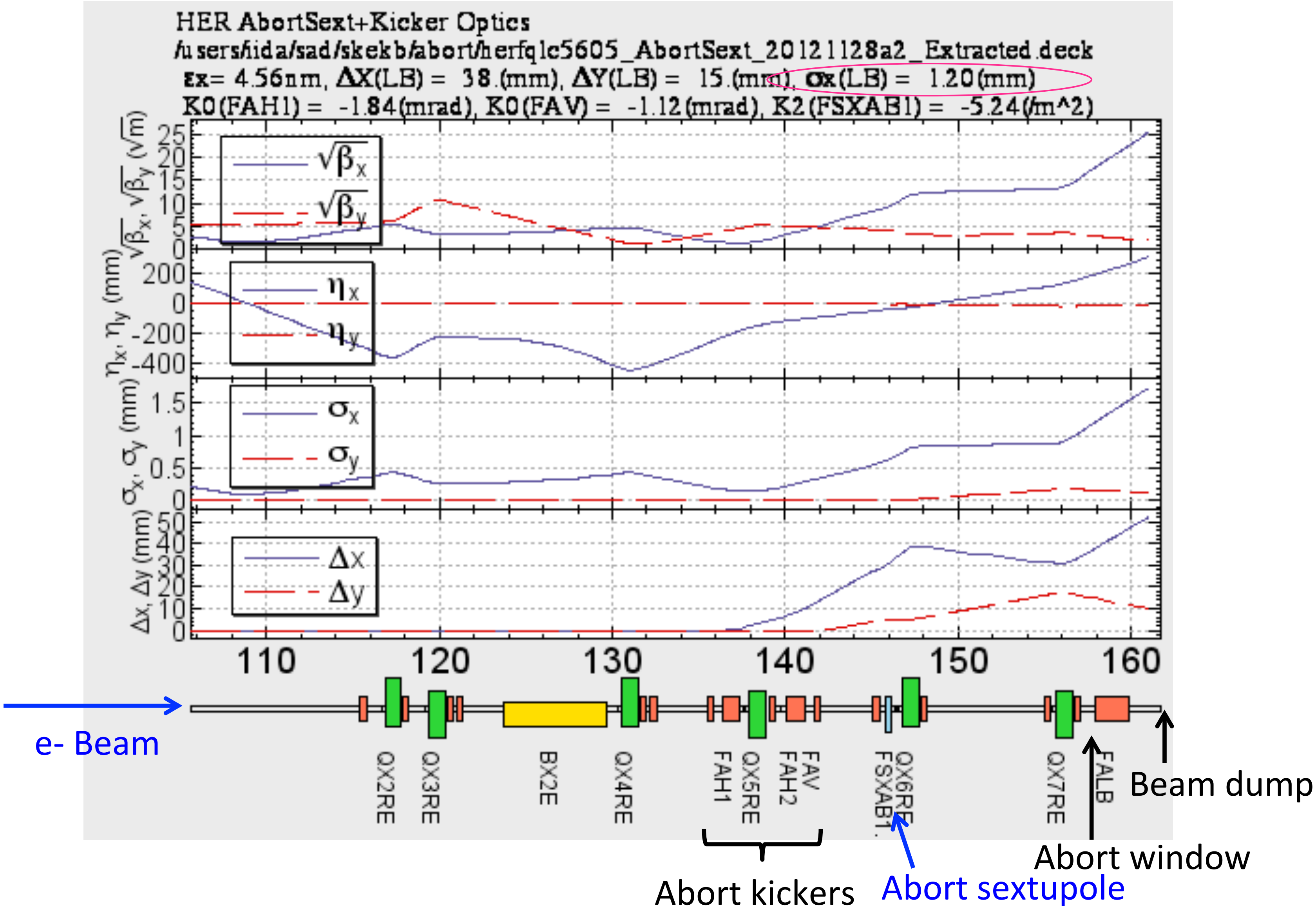
K. Oide

Abort optics with DC sextupole

- Instead of pulsed quadrupoles, a DC sextupole is used for enlarging the horizontal beam size.
- A DC sextupole is installed between the abort kickers and the abort window. The deflected beam feels an additional quadrupole kick effectively.
- Another DC sextupole is needed to make a pair of sextupoles for cancellation of the geometrical nonlinearity.
  The pair of Sextupoles is connected by *I* or - *I* transformation.

HER Abort beam parameters for the ring optics of the Synchrotron injection

herfqlc5605_AbortSext_20121128a2_Extracted.deck



HER Optics
for Synchrotron injection

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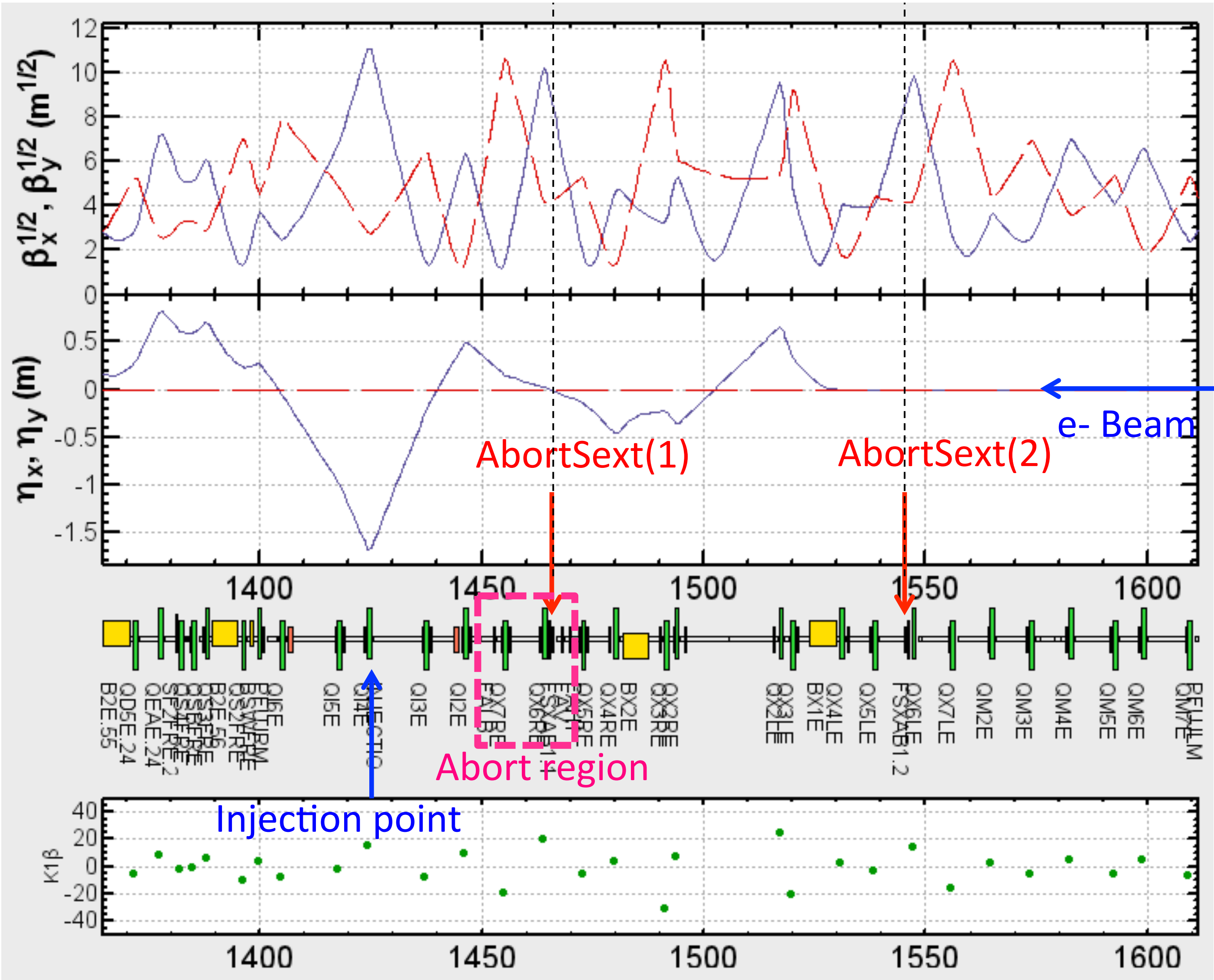


Matching :

$\beta x_1 = \beta x_2$

$\beta y_1 = \beta y_2$

$\nu_{x1} - \nu_{x2} = 1.5$

$\nu_{y1} - \nu_{y2} = 1.0$

1: AbortSext(1)

2: AbortSext(2)

$\eta x = 0$

at the center of the sexts.

$\varepsilon x = 4.646$nm

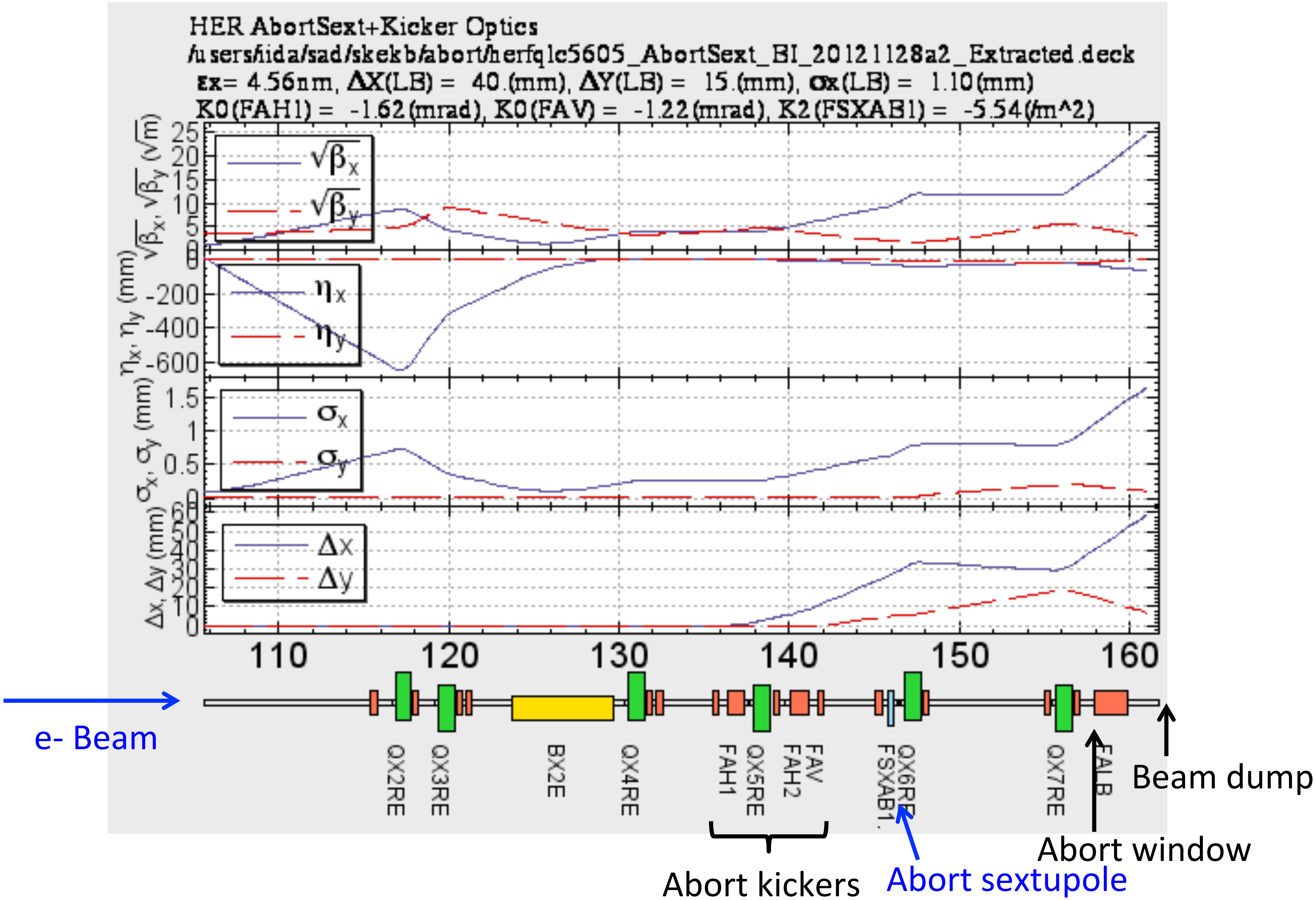
$\varepsilon y = 11.62$pm

Emittance changes are negligible.

HER

Abort beam parameters for the ring optics of the Betatron Injection

herfqlc5605_AbortSext_BI_20121128a2_Extracted.deck



HER Optics
for Betatron injection

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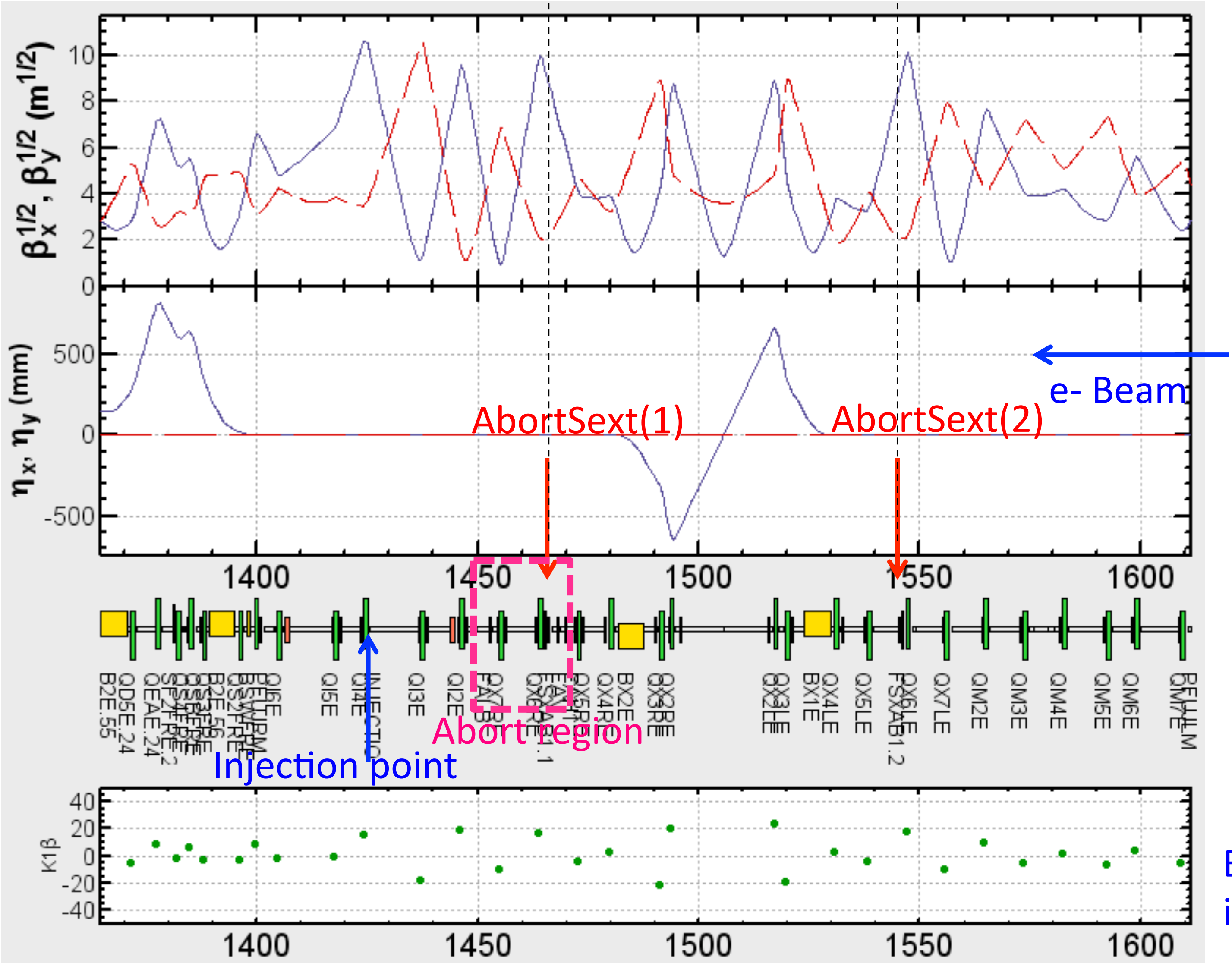


Matching :

$\beta x_1 = \beta x_2$

$\beta y_1 = \beta y_2$

$\nu_{x1} - \nu_{x2} = 1.5$

$\nu_{y1} - \nu_{y2} = 1.0$

1: AbortSext(1)

2: AbortSext(2)

$\eta x = 0$

at the center of the sexts.

$\varepsilon x = 4.511$nm

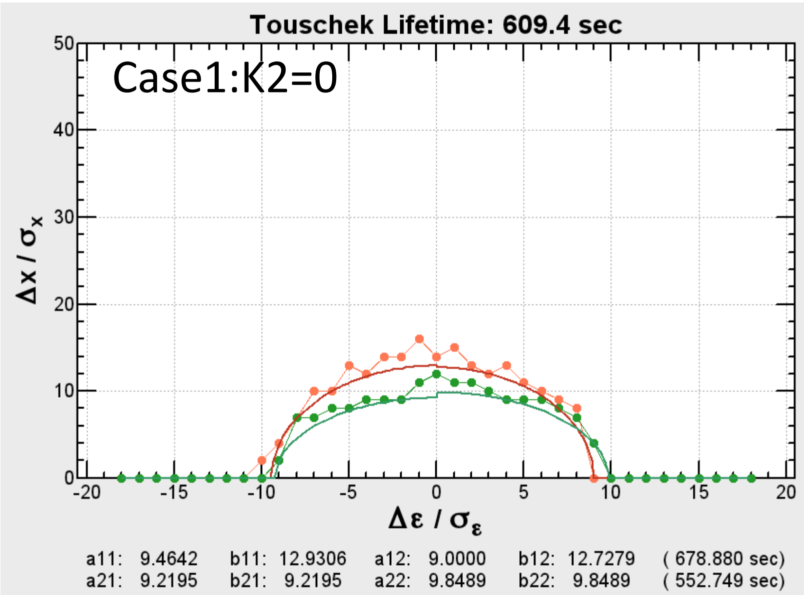
$\varepsilon y = 11.28$pm

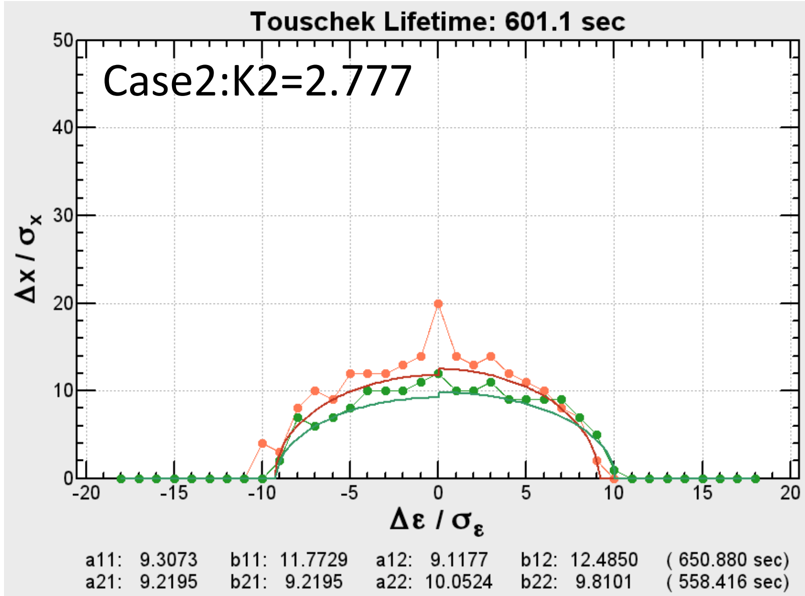
Emittance change is negligible.

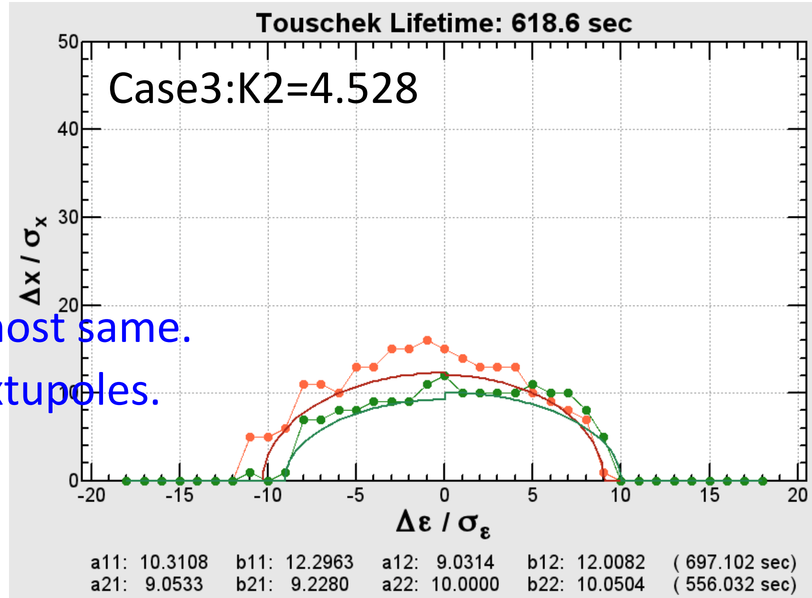
Dynamic aperture

Y. Ohnishi

The life time is optimized for each sextupoles.
Case1: SEXT FSXAB1 =(L =.334 K2 =0) -> 610 sec
Case2: SEXT FSXAB1 =(L =.334 K2 =2.777278350689298) -> 600 sec
Case3: SEXT FSXAB1 =(L =.334 K2 =4.52820764294694) -> 620 sec







At the several values of K2, tousheck life times are almost same.
No adverse effect due to the insertion of the Abort sextupoles.

Magnet design of the sextupole

The specification is not special.

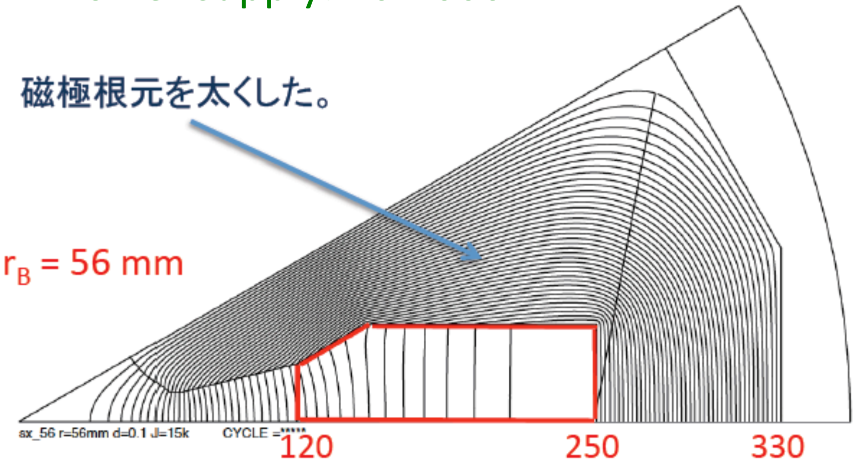
K. Egawa

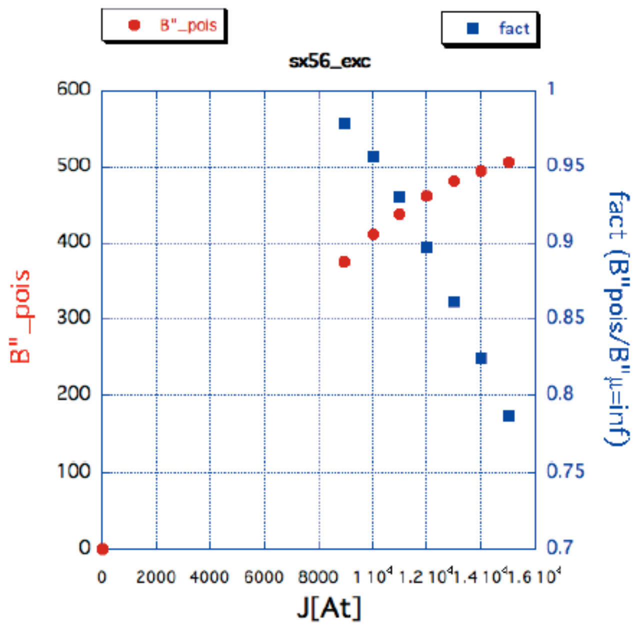
Power supply: 20V 600A

skb_HSL study

coil slot area : ~ 4500 mm^2
assuming efficiency 0.6
$4500 \times 0.6 \approx 2700\ mm^2$
assuming 5 A/mm^2 ⇨ 13500 A/pole

取り敢えず、***13000 A/pole*** を仮定
⇨ ***B" ≈ 480 T/m²***



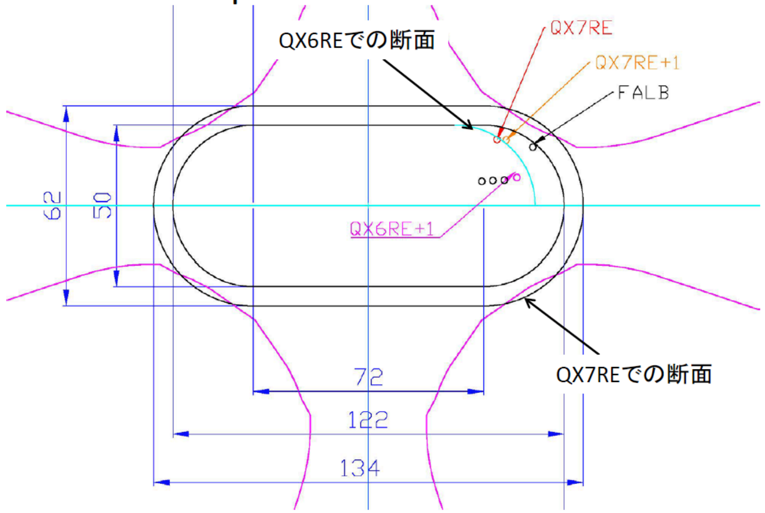


J [At]	B3[50mm] _harm	B"_poisson	B"_μ∞	B"pois/ B"_μ∞
8925	−4685.1	374.81	383.18	0.97815
10000	−5136.5	410.92	429.34	0.95711
11000	−5489	439.12	472.27	0.92981
12000	−5780.2	462.42	515.2	0.89755
13000	*−6013.7*	*481.1*	*558.14*	*0.86198*
14000	−6193.8	495.5	601.07	0.82436
15000	−6330.3	506.42	644	0.78636
0	0	0	0	

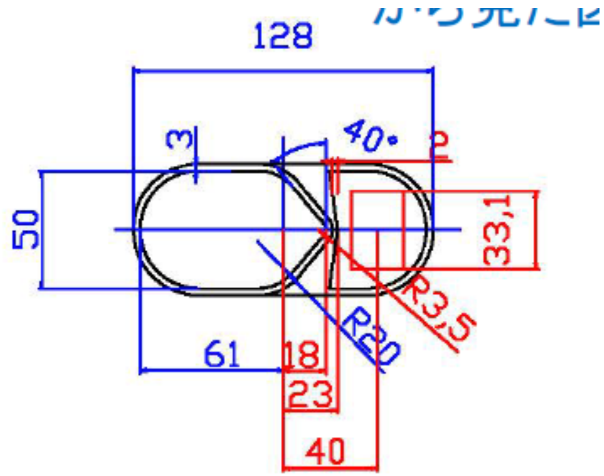
Chamber in the abort region

Y. Suetsugu

- Vertical acceptance: HER: 3.8E-8 m



Abort window



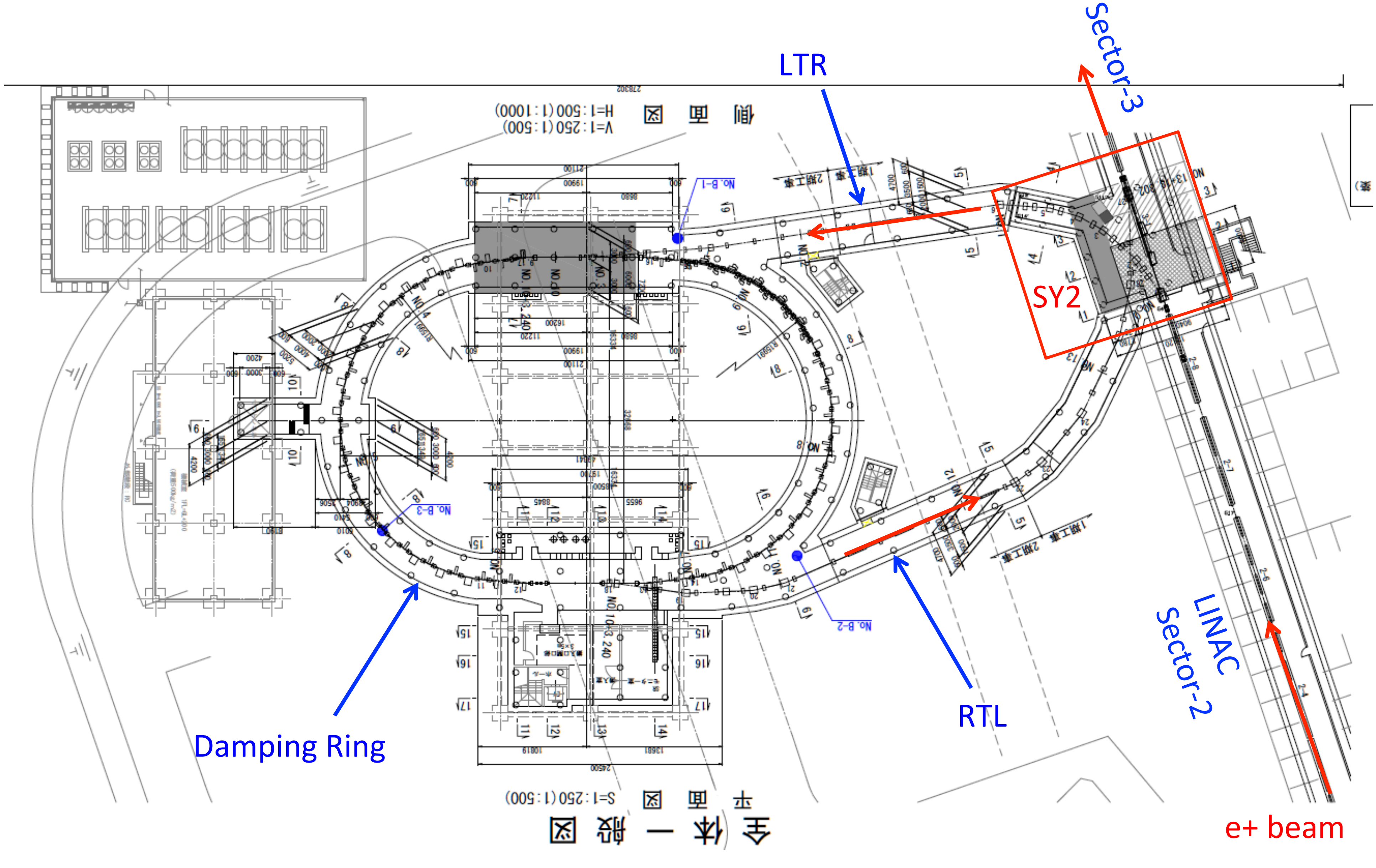
- The coherent betatron oscillation is considered.
  - The chamber apertures have been designed so that the aborted beam with the coherent oscillation is accepted.
  - When the amplitude of coherent betatron oscillation is expected to be larger than the aperture of the window, the beam must be aborted.
    The detection of beam oscillation should be faster than the growth rate of the oscillation.
  - This is still under undergoing now.

Construction of the Abort systems

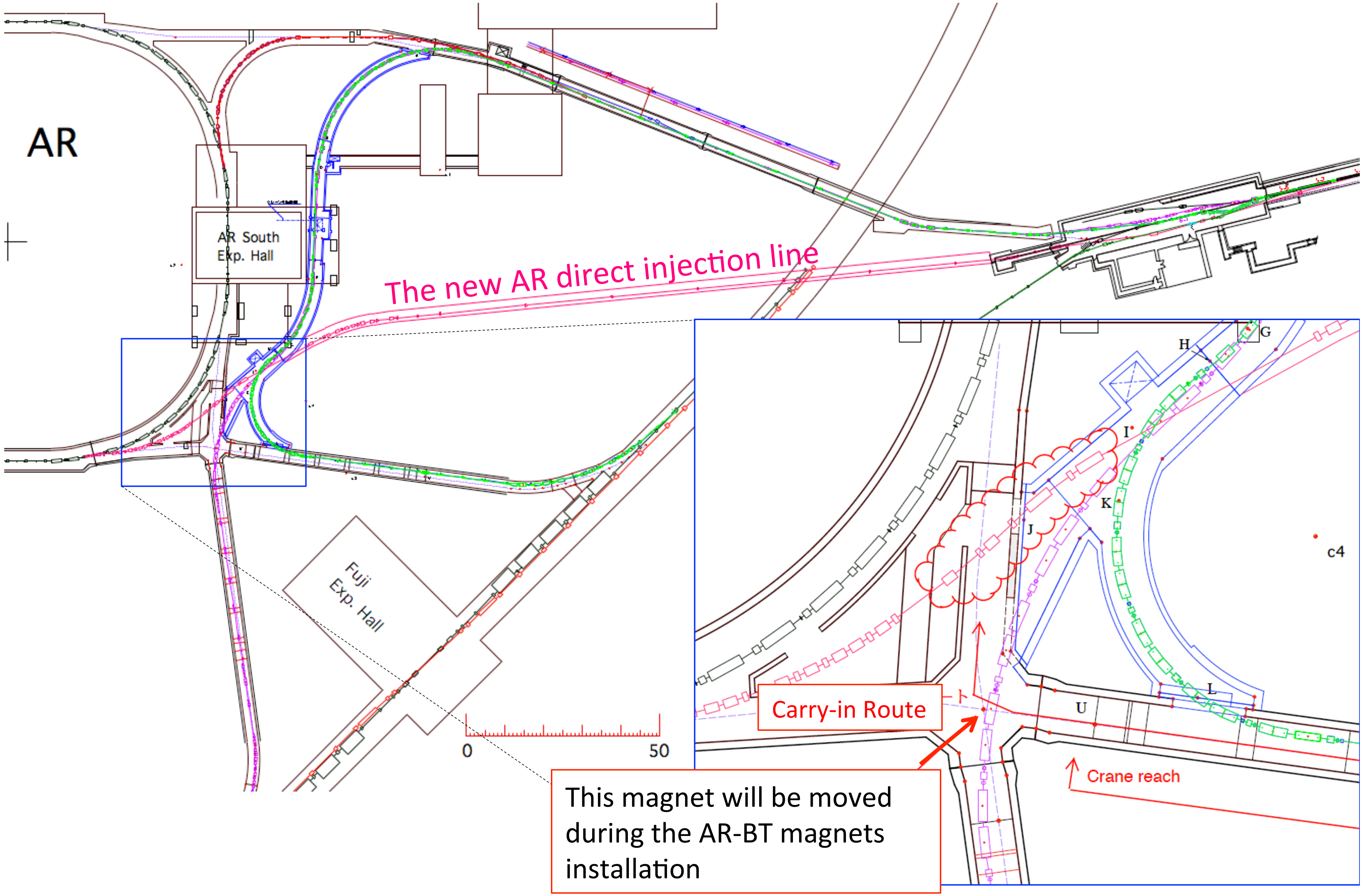
- **Phase *1***
  - The new HER abort system is installed.
  - The chambers of Fuji straight section
    - The chambers near the injection (kickers and abort kickers) will be smaller than those of KEKB.
  - The LER abort system is still old.
    - Since DR is not completed at the beginning of Phase 1,
      the emittance of the injected beam is large.
    - All of the new LER chambers in the abort section and the new injection chamber with a narrow slit have smaller apertures than those of KEKB.
      The slit is for improving the vacuum pressure around the septum.
    - They should be installed at the same time in order to avoid a cavity structure.
      The larger beam without damping ring can not pass through the narrow slit.
    - So at the time the abort system is still old.
  - The stored current of LER must be low to protect the abort window. (500mA max)
- **Phase *2***
  - The new LER abort system is installed.

Backup slides

Plan view of DR



Work for AR/BT in 2015



Recent discussion of DR

- Beam abort of MR
  - When the beam in LER is aborted, the 2 or 4 positron bunches are still stored in the DR.
    - The interval of the extraction trigger signal is 20 ms in minimum.
    - Time from the abort trigger to the working of the abort system is a few 100 μs.
  - What do we do with them ?
    - Wait for injection ready and inhibit the extraction signal.
      - A. Inject to LER and continue the experiment.
      - B. Inject to LER and abort again after 1 minute for charging the abort magnet.
      - C. Make a small beam dump in the RTL or LINAC using a pulsed steering magnet or DC steering magnet.

KEKB Abort system

1. Abort (pulsed) kickerで周回ビームを水平に蹴る(立ち上がり時間～500ns)。
   同時に垂直にゆっくりSweepすることで、Abort窓でビームが１点に集中しないようにする
2. Abort窓(Lambertson magnet入口)で真空から大気に出る。
3. Lambertsonで大きく下に曲げてDumpに導く。

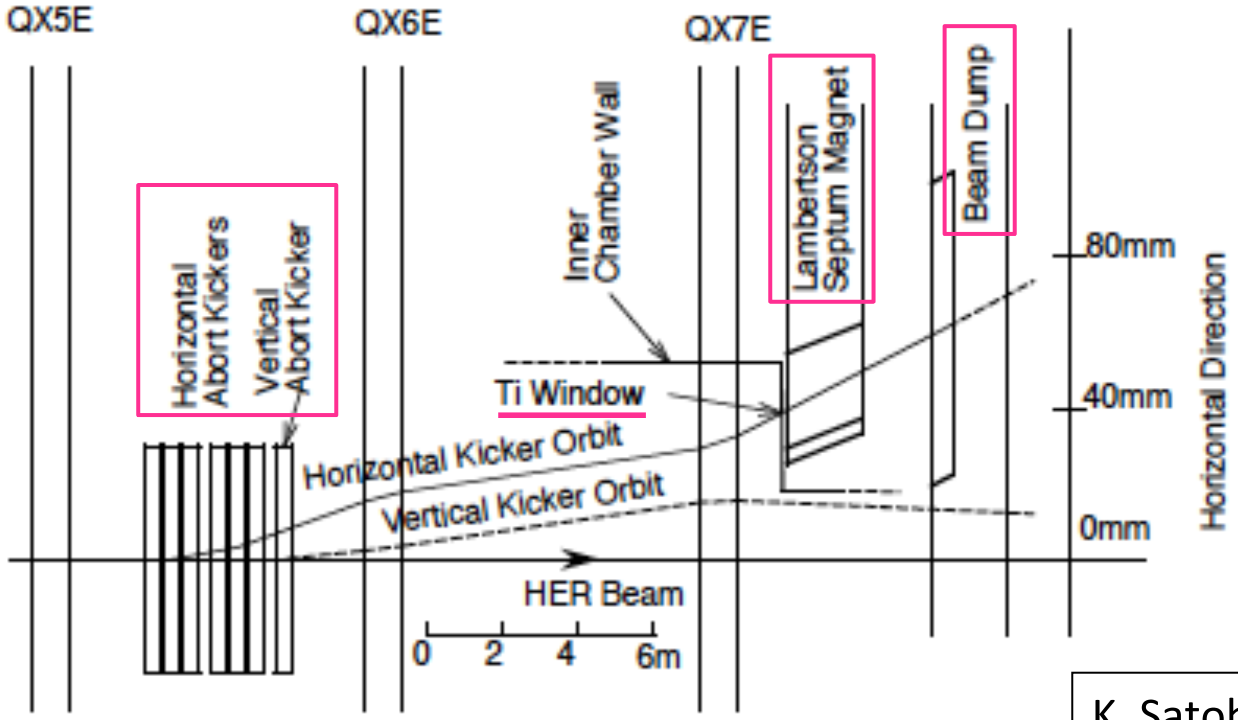


Fig. 16. Schematic layout of the abort system of HER.

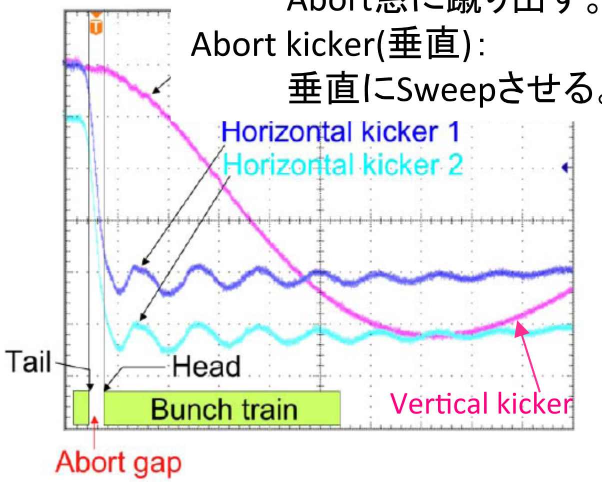
K. Satoh

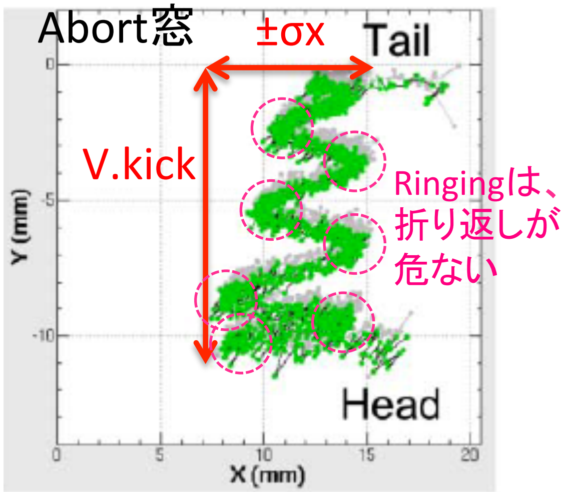
SuperKEKB Abort system

1. Abort (pulsed) kickerで周回ビームを水平に蹴る。
2. Abort窓(Lambertson magnet入口)で真空から大気に出る。
3. Lambertsonで大きく下に曲げてDumpに導く。

KEKB

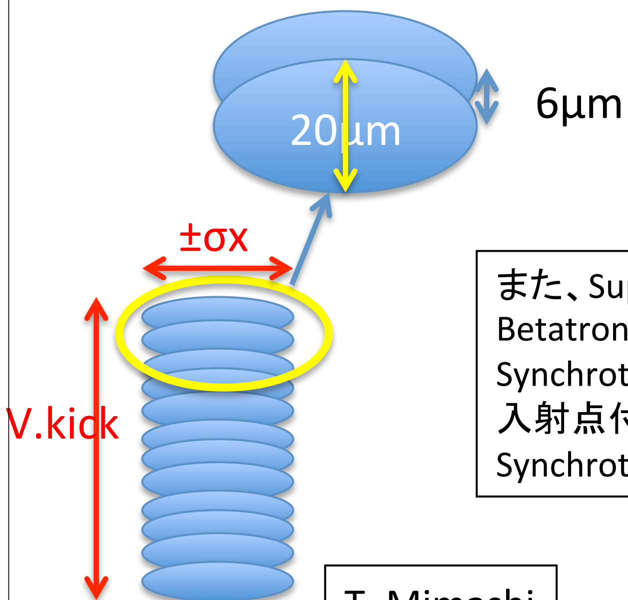
Abort kicker(水平):
Abort窓に蹴り出す。
Abort kicker(垂直):
垂直にSweepさせる。





SuperKEKB(w AbortQ)

Abort kicker(水平):
Abort窓に蹴り出す。
Abort kicker(垂直):
垂直にSweepさせる。
Abort quad:
Abort窓での水平ビームサイズを大きくする。



SuperKEKB(w DC-Sext)

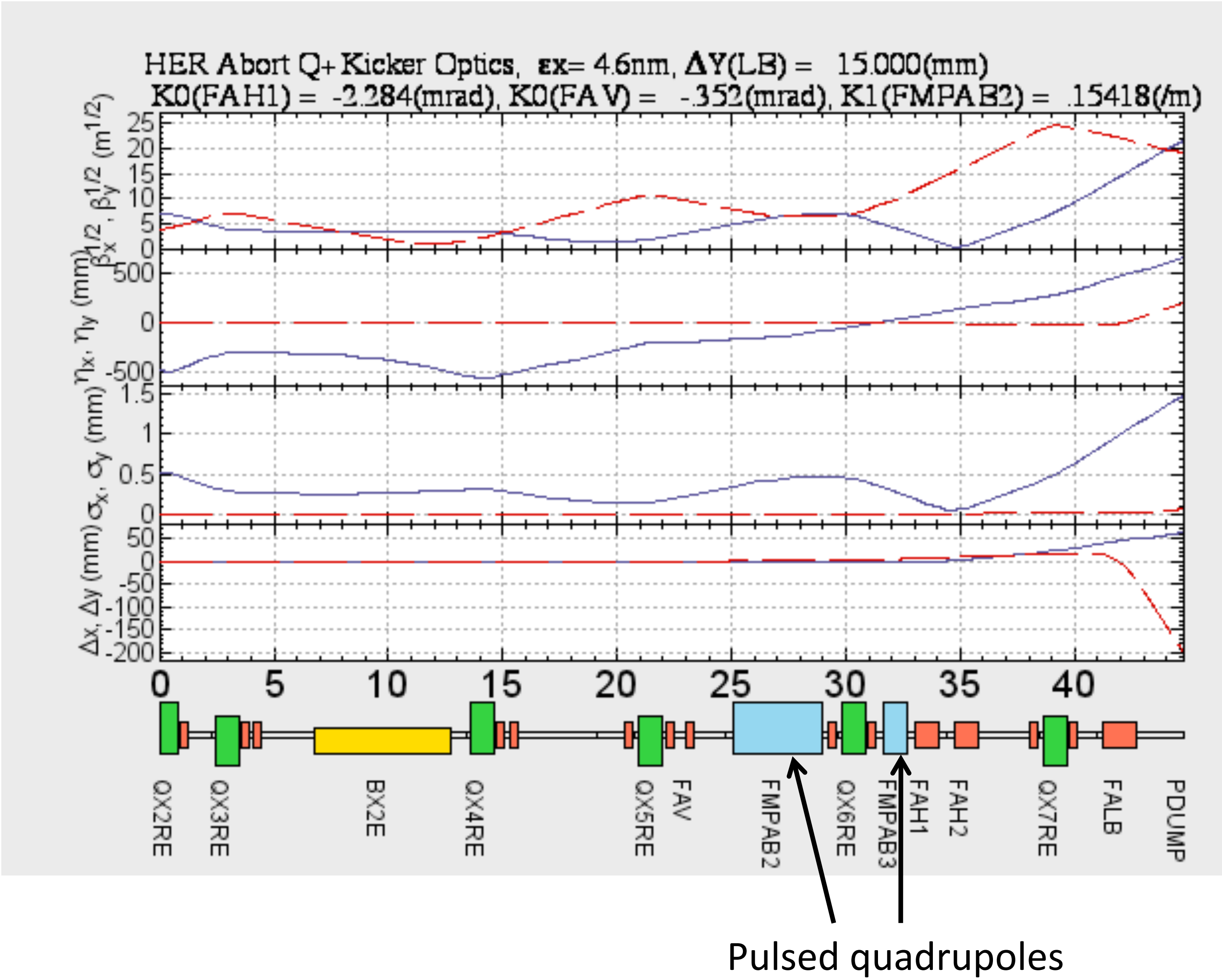
Abort kicker(水平):
Abort窓に蹴り出す。
Abort kicker(垂直):
垂直にSweepさせる。
DC Sext:
kickerによってΔX蹴られた場所にDCの六極を設置することで、四極成分を感じAbort窓での水平ビームサイズを大きくする案(生出さん)。
kickerがFireしない場合、ビームは六極の中心を通り、四極を感じない。-Iの場所に対の六極を置くことでNon-linear成分をCancelする。

また、SuperKEKBのHERでは、今までのBetatron injectionではなく、Synchrotron injectionを試みる予定である。入射点付近に設置しているAbort systemも、Synchrotron injectionのOpticsで検討した。

T. Mimashi

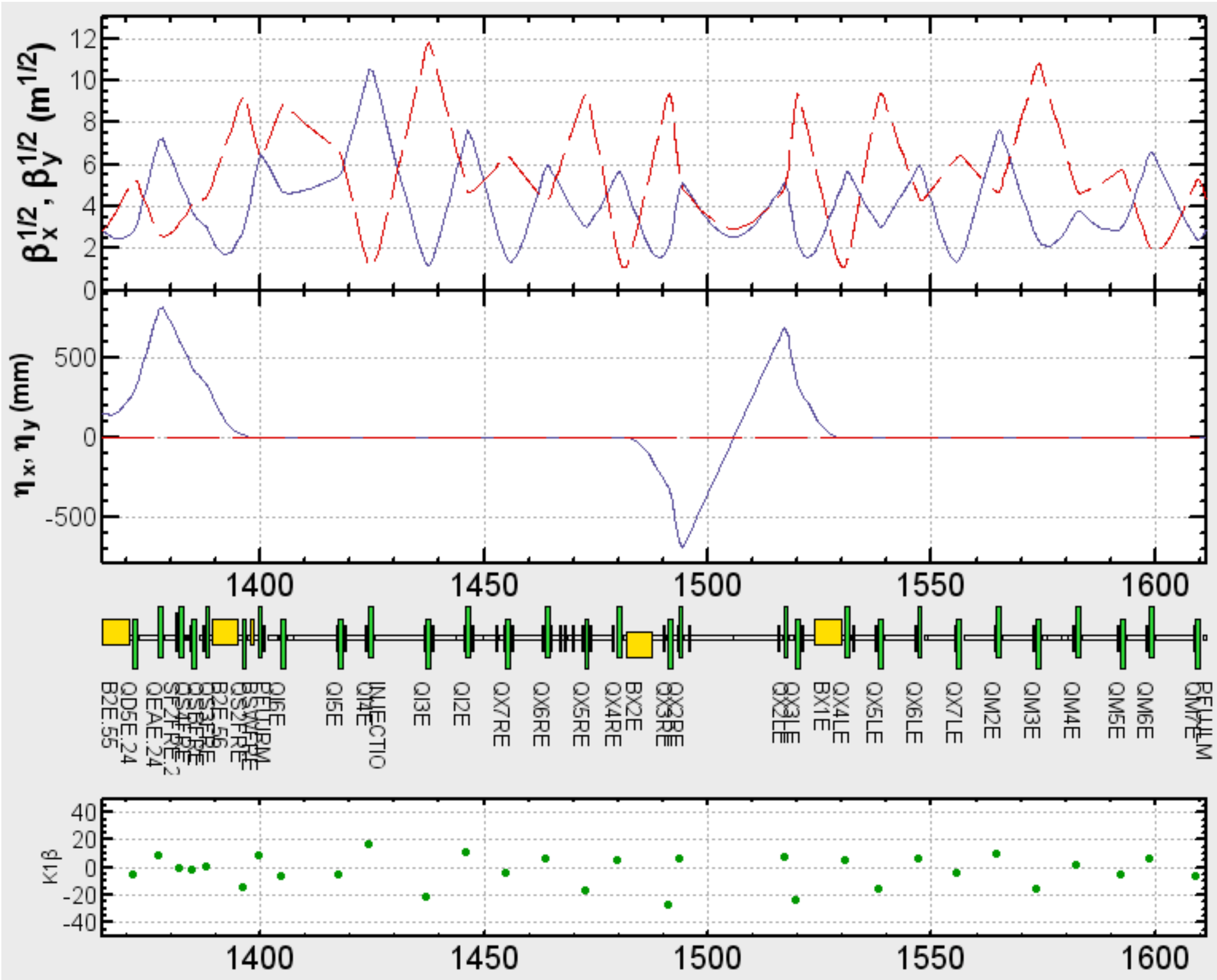
N.Iida et al

HER Abort optics with Pulsed Quadrupoles



Betatron Injection

HER Optics
for betatron injection

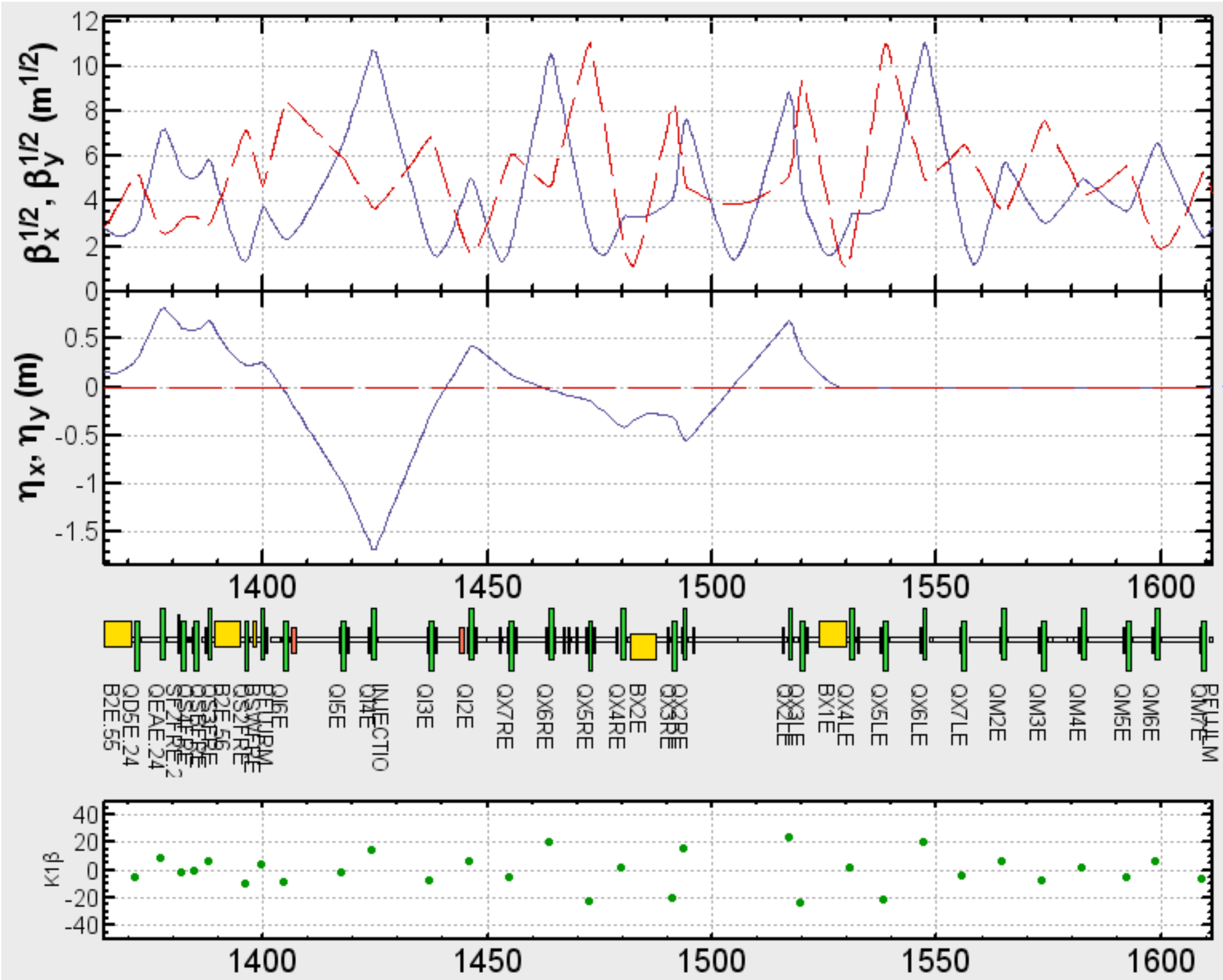


εx=4.559nm
εy=11.40pm

e- Beam

HER Optics for Synchrotron injection

T. Mori et al.



εx=4.644nm
εy=11.61pm

e- Beam