CFS design status (based on Tohoku candidate site)

H. Hayano, KEK

History of ILC250 Design Discussion

ILC WG2 (Staging Plan) was initiated by S. Michizono
after the discussion at LCWS2016-Morioka

Discussion of WG2 (Staging Plan for CFS) has been done
by domestic(KEK, Tohoku) and international tele-conference.

Machine mapping research on Kitakami candidate site, and site-specific CFS design, in parallel. (by Tohoku, KEK, AAA and expert from univeristies)
(access portal location, IP location are included)

Discussion of WG2 was held at CFS@ALCW2017-SLAC

Cost review of WG2(derivation from TDR and Tohoku estimation)
at KEK Sep 26, 2017 (Lyn, Nakada, Steinar, J.Brau, Benno, etc)

Discussion of WG2 at CFS@LCWS2017-Strausburg

Discussion of ILC250 at CFS@ALCW2018-Fukuoka

Slide at AWLC2017(SLAC)

How to estimate the cost of each option

TDR cost

↓

WG2

Subtract cost reduction of
2014-2016 TDR cost reduction and design change

TDR-updated cost

Decide working assumptions,
and cryomodule configuration,
tunnel configuration.
cost estimation conditions.

→ Subtract cost reduction of each staging option

↓

Estimation of cost for each staging option

each option cost
in case of 31.5MV/m

↓

Subtract cost reduction by change of 31.5MV/m to 35MV/m, assuming success of 35MV/m Q_0=1.6x10^{10} SRF HG,HQ

WG3

35MV/m

decrease of RF unit,
Nb material cost reduction,
surface process cost-reduction,
cryogenics cost reduction,
HLRF cost-increase, etc

↓

Estimation of cost for each staging option

each option cost with HG HQ success
in case of 35MV/m

Slide at AWLC2017(SLAC)

Working assumption (1)

(1) **Considering collision timing adjustment, condition must keep in any option,**

option C = remove length between PM+10 and PM+12,
and remove TDR timing adjustment,
and adjust to n=6

option D = adjust to n=10, it is option C + simple tunnel of 6477m (total).
option D' =adjust to n=8, it is option C + simple tunnel of 3238m (total).

In **TDR(Ecm=500GeV)**, this equation is not satisfied as follows (additional 294m exist);

$$(L_1 + L_2 + L_3) - L_4 = 9 \times C_{DR} + 294\text{m}$$

Change Request is to adopt **n=10**;

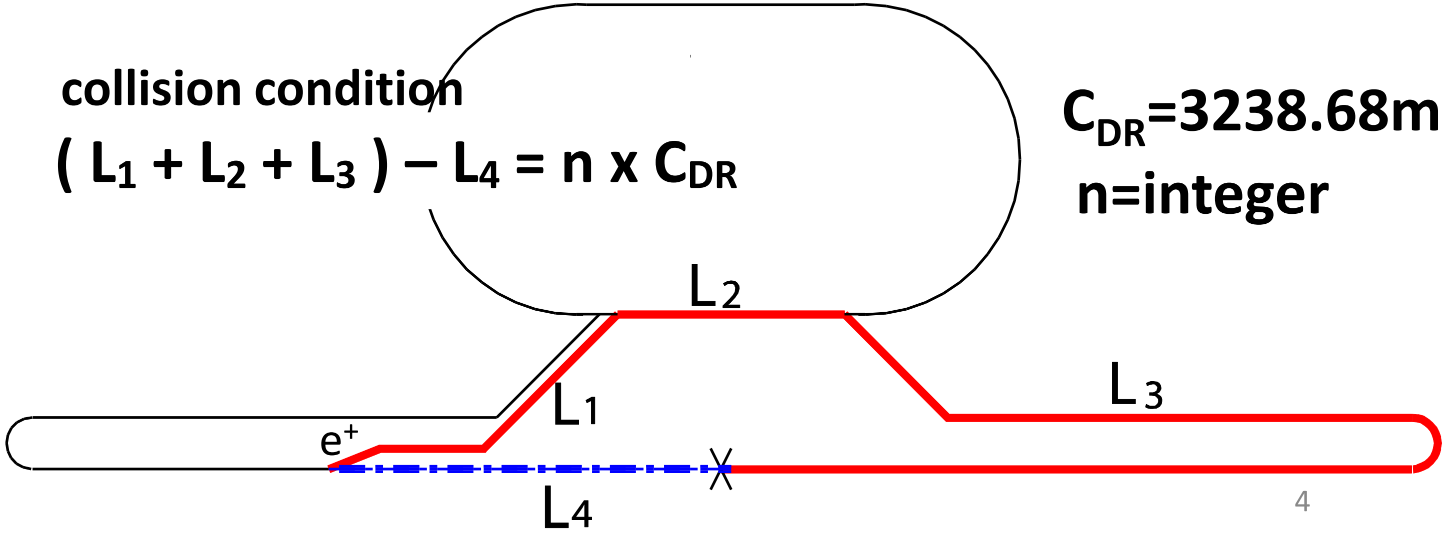
$$(L_1 + L_2 + L_3') - L_4 = 10 \times C_{DR}$$

with putting 1473m space
in both LINAC (updated TDR)

collision condition

$$(L_1 + L_2 + L_3) - L_4 = n \times C_{DR}$$

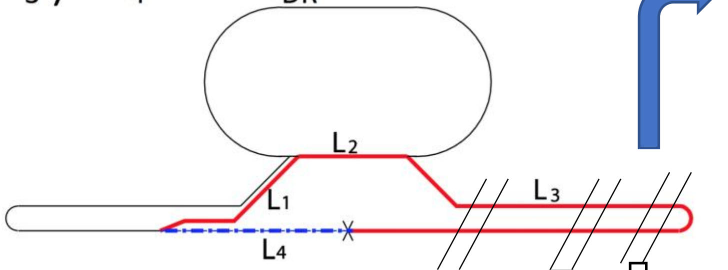
C_{DR}**=3238.68m**
n=integer



Slide at AWLC2017(SLAC)

In Option-C(Ecm=250GeV), required Linac length become half, then we can adopt n=6

- $(L_1 + L_2 + L_3) – L_4 = n \times C_{DR}$



Shortning the e^+ LINAC length is possible as a unit of C_{DR} /2 = 1619.34m.
Keep the same length of e^- LINAC for the symmetric collision energy.

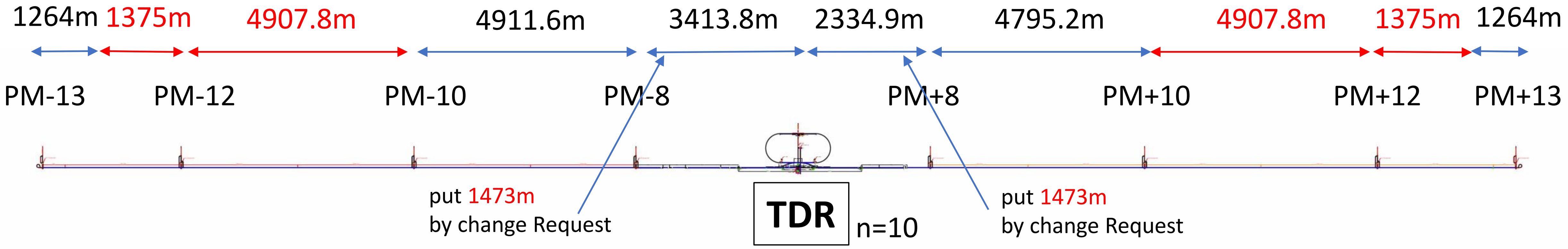
remove 1367.74m at BDS entrance (timing adjustment)

remove 202.02m at end of Linac area.

remove $L_{(PM+10 – PM+12)}$ = 4907.8m

$(-1367.74m - 4907.8m - 202.02m) \times 2 = -12955.12m = - 4 \times C_{DR}$

L_3 is shortened by $4 \times C_{DR}$, it means LINAC length is shortened by 6477.56m



Slide at AWLC2017(SLAC)

Working assumption (2)

(2) Keep Energy Reach Margin enough safe to reach target energy (250GeV).

for enough positron production and meaningful energy reach of Higgs physics

(1) Module margin : margin to reach the target energy of the target experiment (0% in TDR)

2.5% module margin(3.1GeV each) for Ecm=250GeV

(2) Availability margin : margin to compensate cryomodule trip (1.5% in TDR, ~3 RF unit trip)

3 RF unit margin correspond to 3% for Ecm=250GeV

(3) Space margin : cryomodule space to be installed more cryomodule in future.

*Anytime 0.5% is required in the operation with cavity phase offset.

Total margin: 1.5%+ 0.5% = 2% for TDR Ecm=500GeV
2.5% + 3% + 0.5% = 6% for Ecm=250GeV, Option C

(3) In case of HG,HQ R&D success;

HG HQ upgrade :from 31.5MV/m Q0=1E10 → 35MV/m Q0=1.6E10 by N-infusion.
Same RF unit configuration, but increase of klystron output to 11MW, 1.75ms.
Consider decrease of number of RF unit for 35MV/m.
The length of tunnel is kept the same as 31.5MV/m.

Slide at AWLC2017(SLAC)

Working assumption (3)

(4) Only 5Hz Linac operation is considered (not 10Hz).

(5) Maximum cryo-line length of one cryogenics is 2.5km+/-10%, the same as TDR.

This determines the interval of the access point, such as PM+/-8, PM+/-10, PM+/-12

(6) Adopt CR0009 and CR0014 for cryogenics. The access hall is re-considered with this design change. Angle cross with Linac tunnel and access tunnel for cryomodule carry in, is considered.

(7) Linac central shield wall is 1.5m thick. Total width of Linac tunnel is 9.5m.

(8) Two Vertical shaft access to detector hall is assumed.

(9) Design change of positron side BDS tunnel and injector-linac position are adopted.

(10) Number of beam dump and power of them proposed by Yokoya are adopted.

Slide at AWLC2017(SLAC)

Working assumption (4)

(11) TDR-undulator-based positron is kept in this study.
The length of undulator is streched to 230m from 147m with 125GeV beam.

This determines energy sensitivity of positron production

(12) Remove access tunnels at turn-around (PM-13 and PM+13) of TDR tunnel, not for staging tunnel.

(13) One water-drain-tunnel is considered in the collision point, not at PM-13/PM+13.

(14) Simple tunnel means: normal wall finish, but no central shield wall,
no AC power line, no cooling water line,
however air-condition, lighting and water drain are installed.

(15) Digging tunnel during accelerator operation without serious interference.

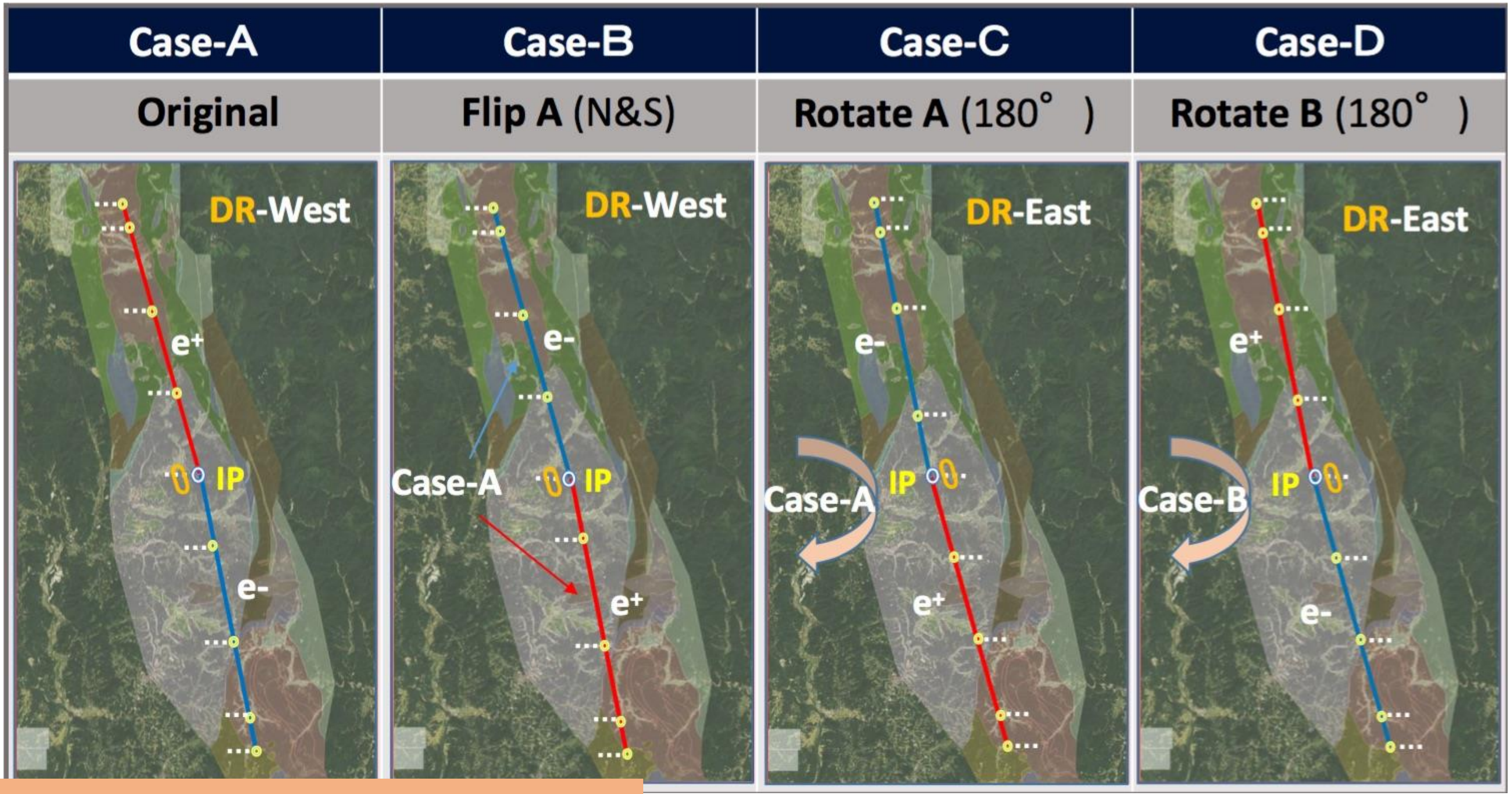
(16) Keep the Damping Ring circumference. No design change for DR.

This determines the requirement of collision timing condition.

Tunnel Optimization Tool development (1)

TOT(Tunnel Optimization Tool): CERN-KEK-ARUP development during 2015-2016
(originally developed for FCC)

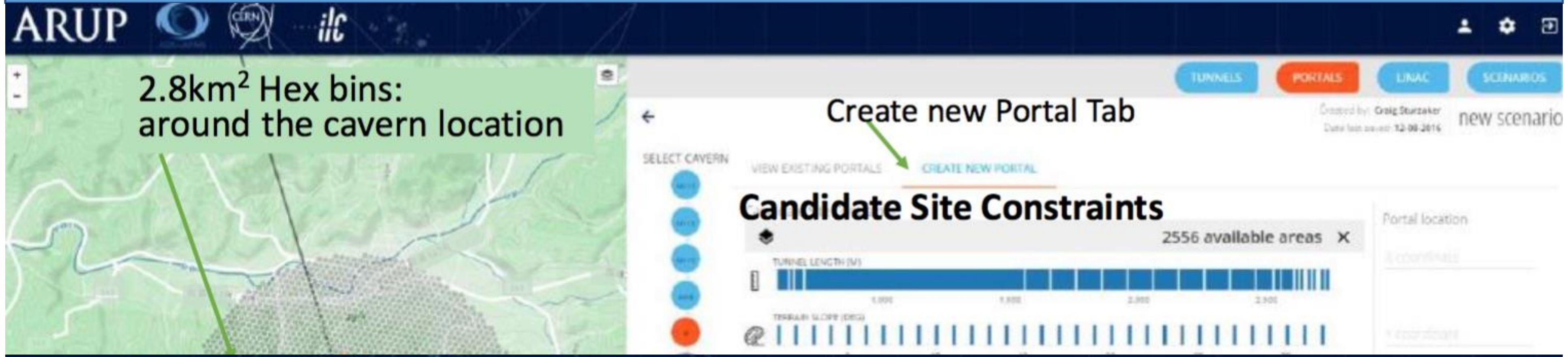
Layout of accelerator tunnel into detailed geology & topography map
(1) optimize accelerator layout
(2) search access tunnel portal location

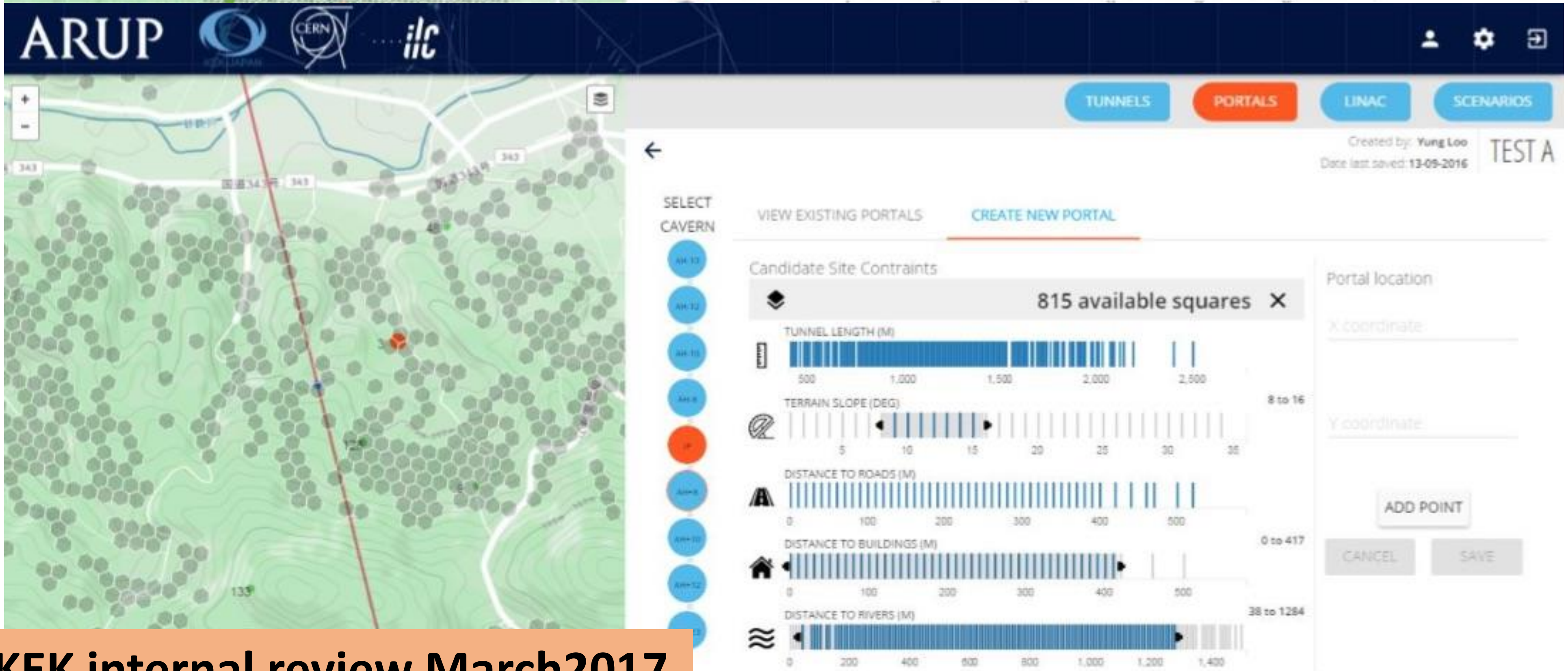


Slide from KEK internal review March2017

e of accelerator layout

Tunnel Optimization Tool development (2)





Slide from KEK internal review March2017

Tunnel Optimization Tool development (3)

Slide from KEK internal review March2017

Most updated ILC250 Design was reported in AWLC2018 Fukuoka

The International Linear Collider Machine Staging Report 2017

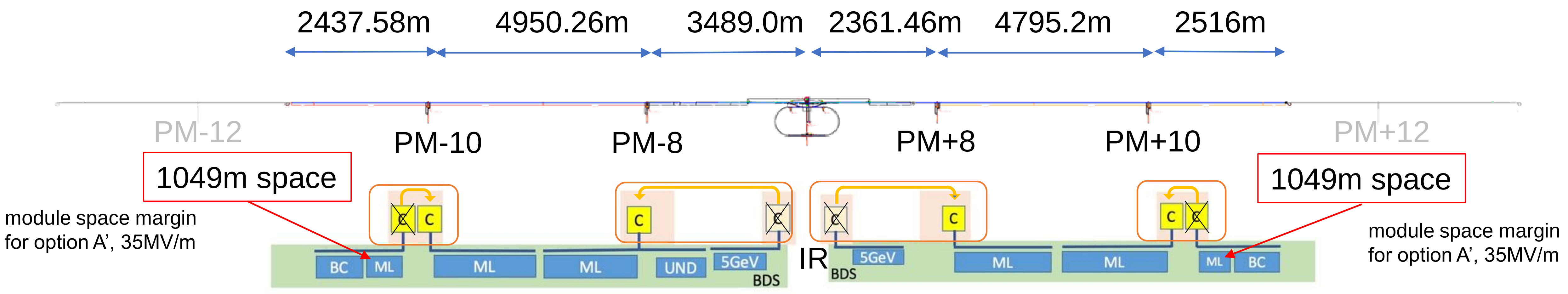
Addendum to the International Linear Collider Technical Design Report published in 2013

Linear Collider Collaboration / October, 2017

Editors:Lyn Evans and Shinichiro Michizono

Slide at AWLC2018(Fukuoka)

Option A' **ECM=250GeV** **SRF 35MV/m**



	BC				e+inj	Ecm=250GeV	e-inj				BC	
	51	90	189	189	24	module space	24	180	189	90	51	
	51	4.5	189	189	24	cryomodules	24	180	189	4.5	51	
	17	1	42	42	8	RF unit	8	40	42	1	17	
e^- 135.6GeV =	10.0	1.4	59.6	59.6	5.0	E gain (GeV)	5.0	56.7	59.6	1.4	10.0	= e^+ 132.7GeV +6.2%margin

Total tunnel length = 20549.5m (20.5km)

The International Linear Collider Machine Staging Report 2017
Addendum to the International Linear Collider Technical Design Report published in 2013

Linear Collider Collaboration / October, 2017
Editors:Lyn Evans and Shinichiro Michizono

Slide at AWLC2018(Fukuoka)

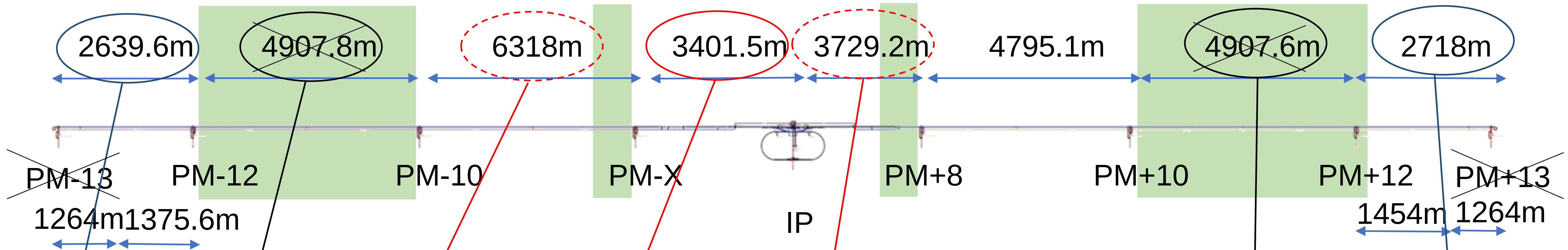
Acc. length manipulation from TDR Recent Optics Deck

Ecm = 500GeV

Total length of TDR accelerator = 17266.9m+16149.9m=33417m

timing path length is matched with n=10

2639.6m | ~~4907.8m~~ | 6318m | 3401.5m | 3729.2m | 4795.1m | ~~4907.6m~~ | 2718m



1264m 1375.6m

1454m 1264m

remove this length for option-A
delta-L = -4907.6m

3401.5m + 87.5m = 3489m
Vertical bend

(2015 Okugi BDS) + 87.5m = 2361.46m
Vertical bend
delta-L = -1367.74m
remove TDR timing adjust

Option A' with n=6

2718m – 404.04m/2
=2516m
Timing adjust

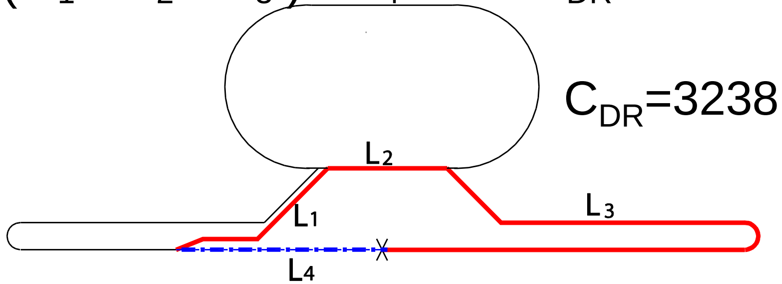
2639.6m
– 404.04m/2
=2437.48m
Timing adjust

remove TDR timing adjust
6318m – 1367.74m = 4950.26m

remove this length for option-A
delta-L = -4907.6m

collision condition

$$(L_1 + L_2 + L_3) – L_4 = n \times C_{DR}$$



C_{DR}=3238.68m

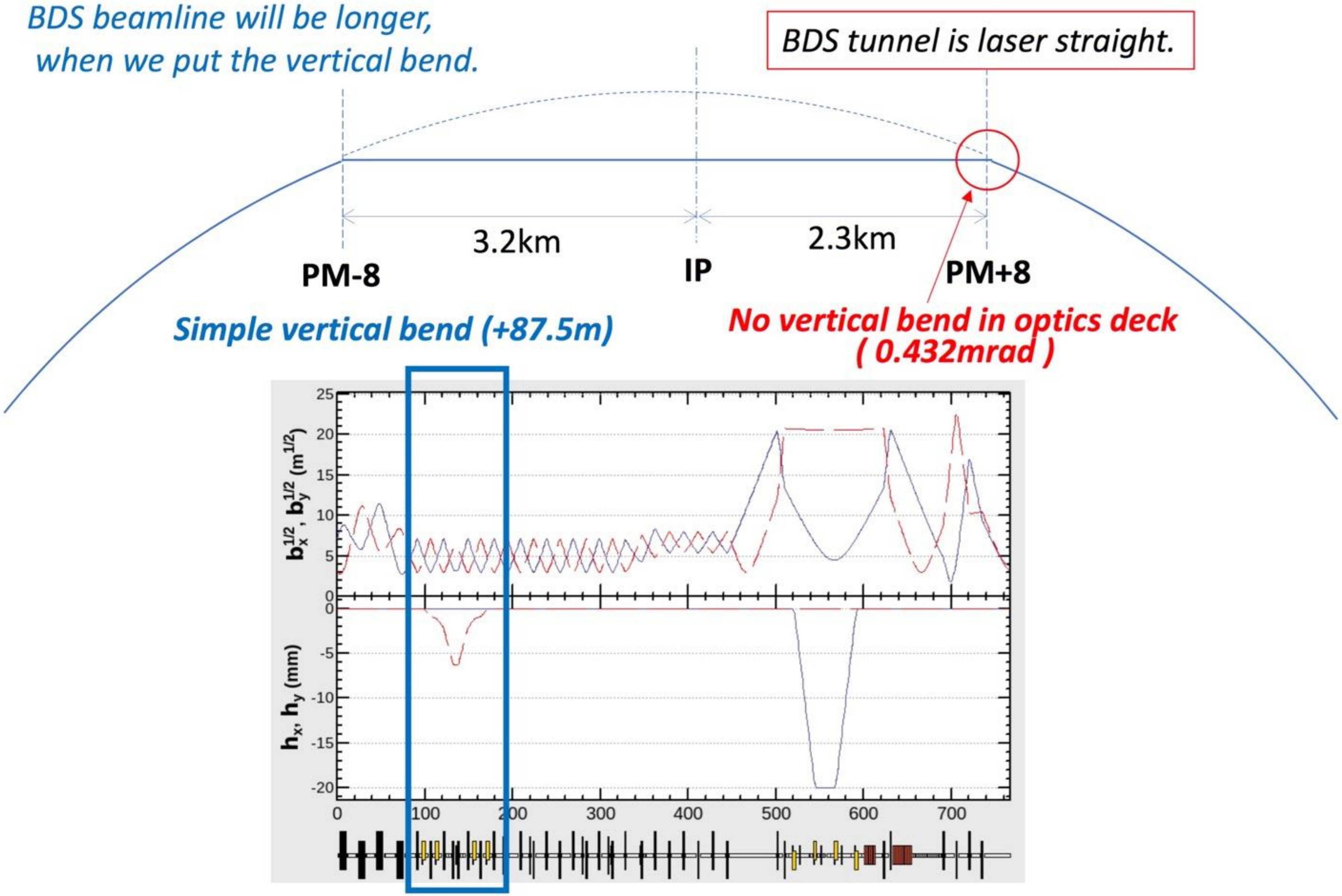
$$(L_1 + L_2 + L_3) – L_4 =(L_1'+87.5)+L_2+(L_3'-1367.74\times 2-4907.6\times 2 -X) – (L_4'+87.5)$$
$$=(L_1'+L_2+L_3')-L_4'-(12550.68m +X)$$
$$=10 \times C_{DR} - 4 \times C_{DR}$$
$$= 6 \times C_{DR}$$

$4 \times C_{DR}=4 \times 3238.68m = 12550.68m + X$
$X = 404.04$ m
Timing adjust

Slide at AWLC2018(Fukuoka)

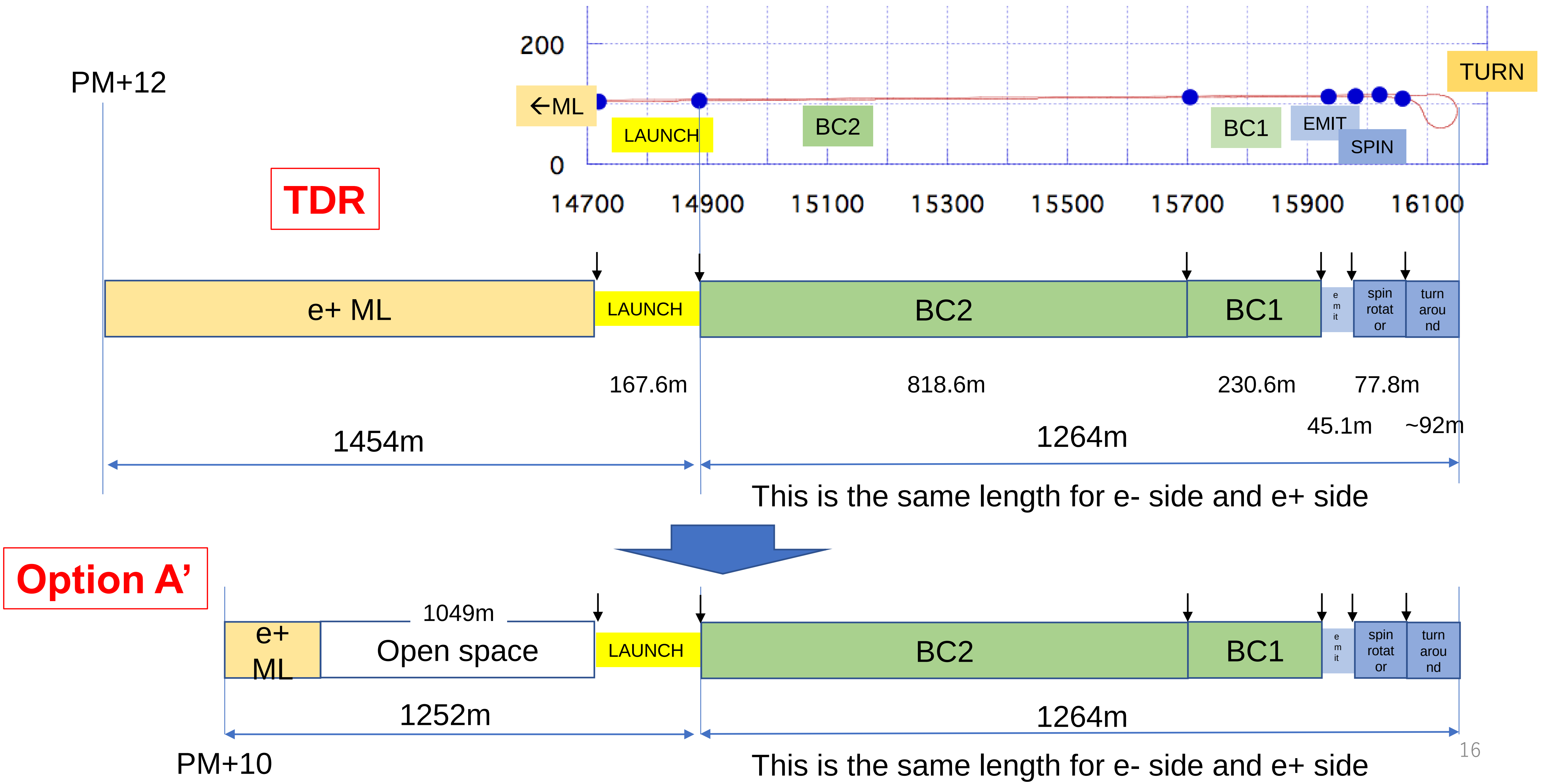
Keep BDS tunnel length as TDR, but put verical bend 87.5m on both entrance of BDS

There is no vertical bend in the optics deck.



Slide at AWLC2018(Fukuoka)

e+ Main Linac end region details

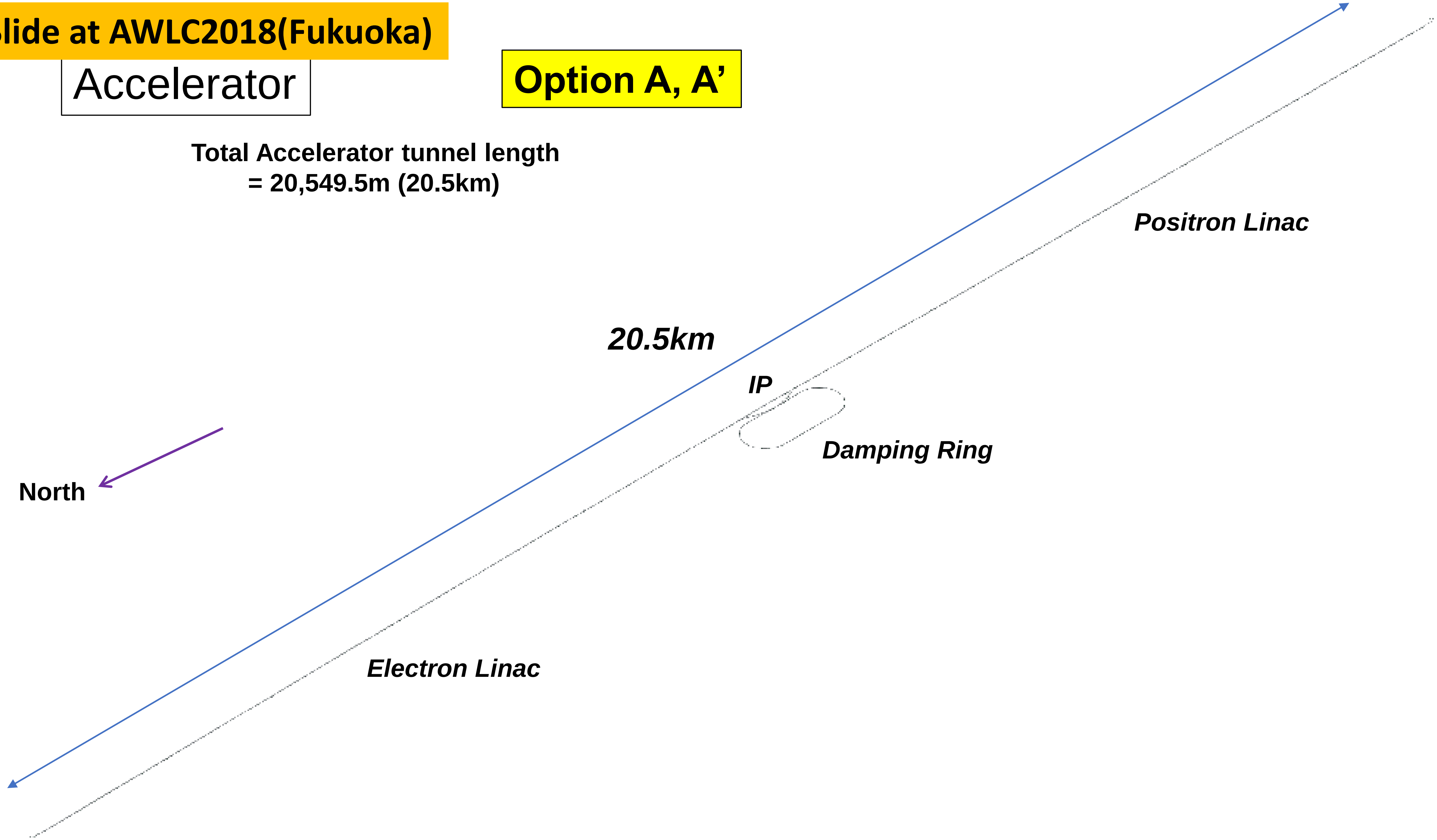


Slide at AWLC2018(Fukuoka)

Accelerator

Option A, A'

Total Accelerator tunnel length
= 20,549.5m (20.5km)

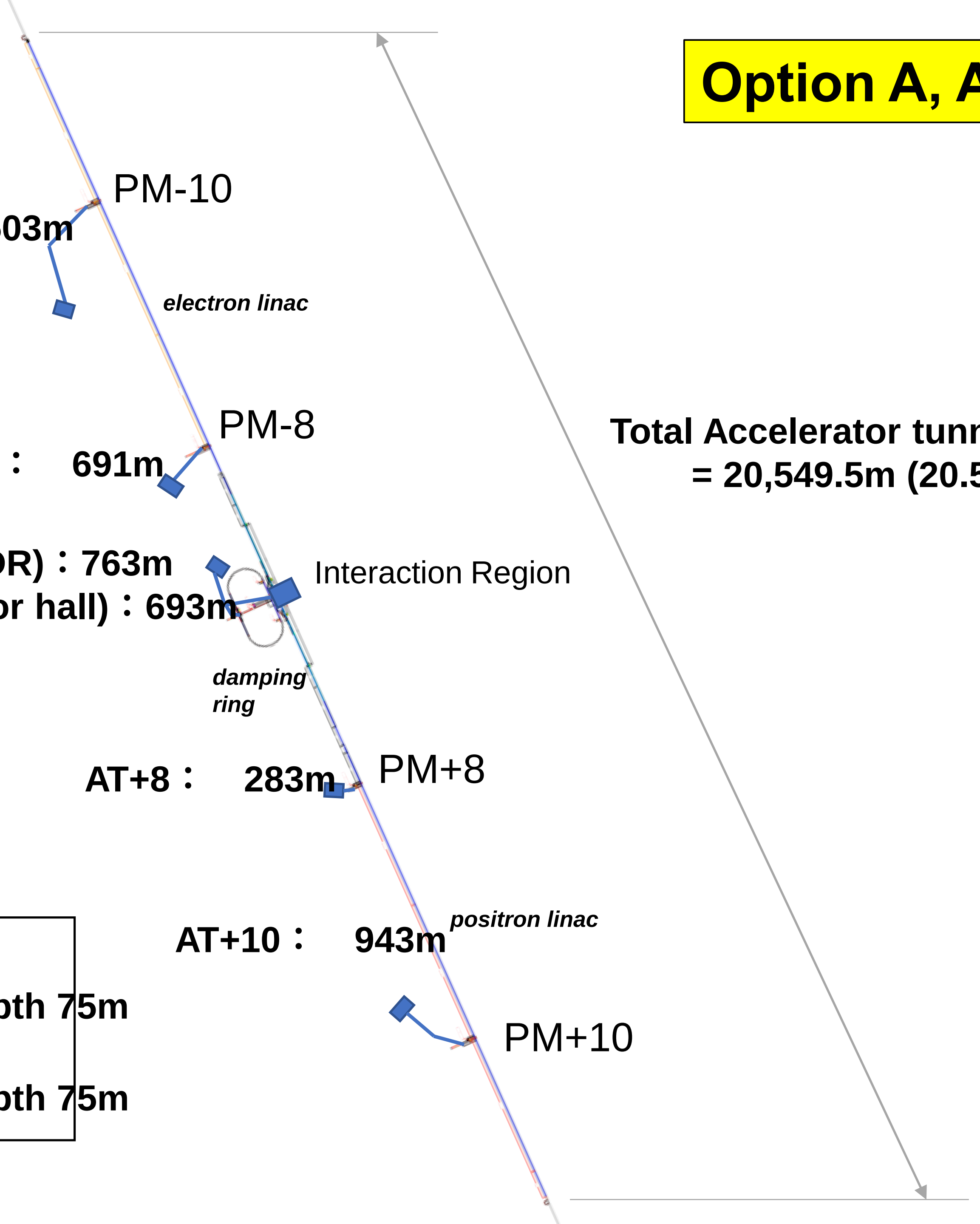


Slide at AWLC2018(Fukuoka)

Access Tunnels

Option A, A'

Site-specific design of
Access tunnels



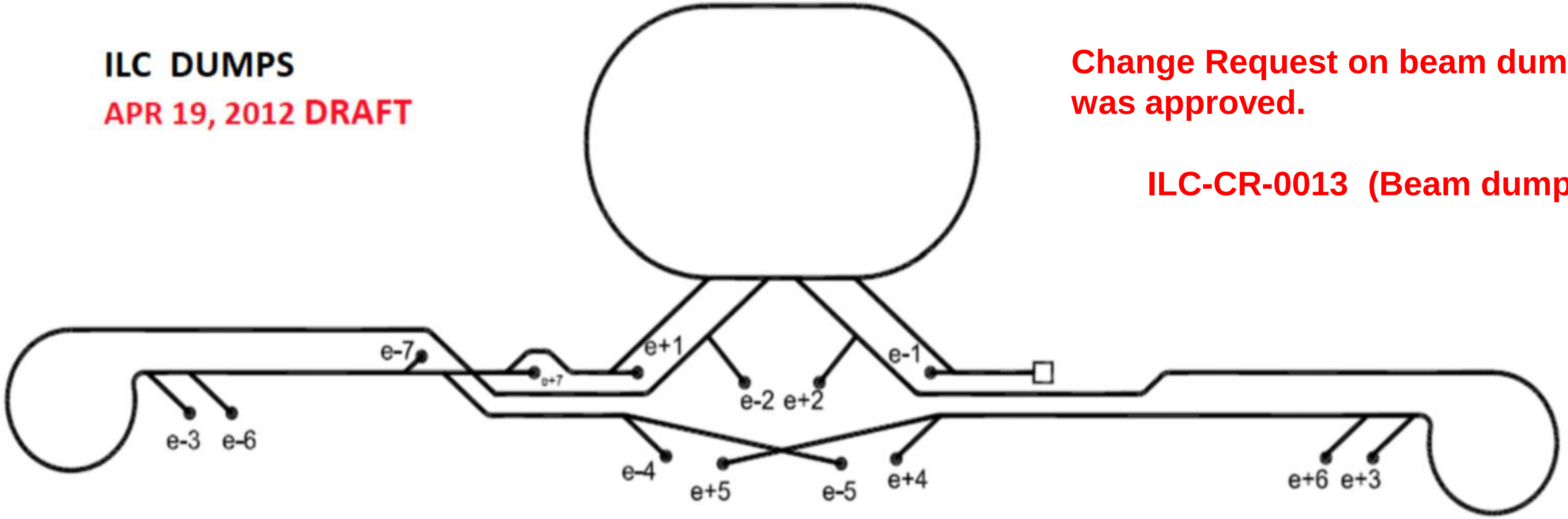
access tunnels 5		Detector shaft	1
total length	4876m	φ18m	depth 75m
		Utility shaft	1
		φ10m	depth 75m

Slide at AWLC2018(Fukuoka)

Beam Dump

ILC DUMPS

APR 19, 2012 DRAFT



Change Request on beam dump in 2016 was approved.

ILC-CR-0013 (Beam dump)

MPD	e-1	SC TUNE UP DUMP	~~311 KW~~ 60kW	MPD	e+1	SC TUNE UP DUMP	~~311 KW~~ 60kW
MPD	e-2	EDRX TUNE UP DUMP	~~220 KW~~ 60kW	MPD	e+2	PDRX TUNE UP DUMP	~~220 KW~~ 60kW
MPD	e-3	RTML TUNE UP DUMP	~~220 KW~~ 60kW	MPD	e+3	RTML TUNE UP DUMP	~~220 KW~~ 60kW
~~HPD~~	e-4	BDS TUNE UP DUMP	~~14 MW~~ 400kW	~~HPD~~	e+4	BDS TUNE UP DUMP	~~14 MW~~ 400kW
HPD	e-5	PRIMARY e-DUMP	~~14 MW~~ 17MW	HPD	e+5	PRIMARY e+DUMP	~~14 MW*~~ 17MW
MPD	e-6	RTML TUNE UP DUMP	~~220 KW~~ 60kW	MPD	e+6	RTML TUNE UP DUMP	~~220 KW~~ 60kW
MPD	e-7	electron fast abort dump	~~250 KW~~ 60kW	MPD	e+7	TARGET DUMP	~~200 KW~~ 300kW
	e-8	**electron 10Hz dump**	8MW				

MPD =HIGH POWER DUMPs (1e-; 3e+; 6 RTML)

HPD =MEDIUM POWER DUMPs (4 BDS)

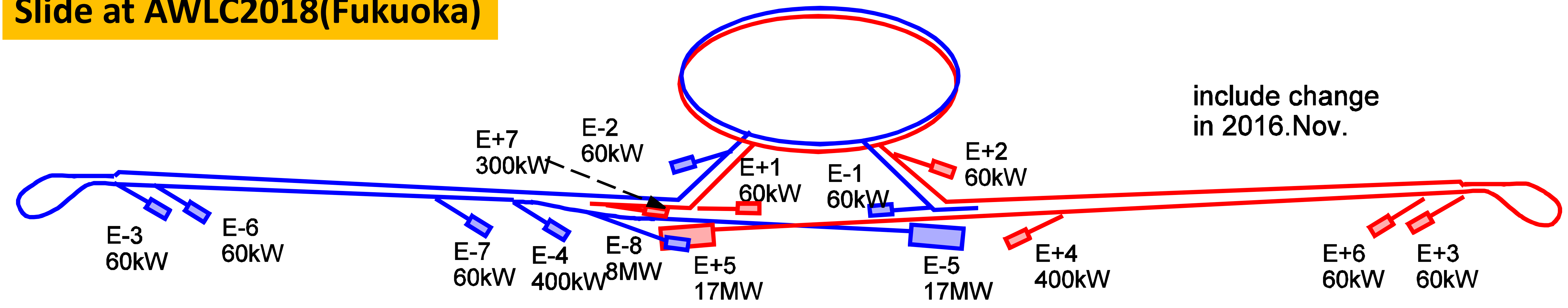
** = indicate non-stop dump (always on)*

***= indicate 45KW always on*

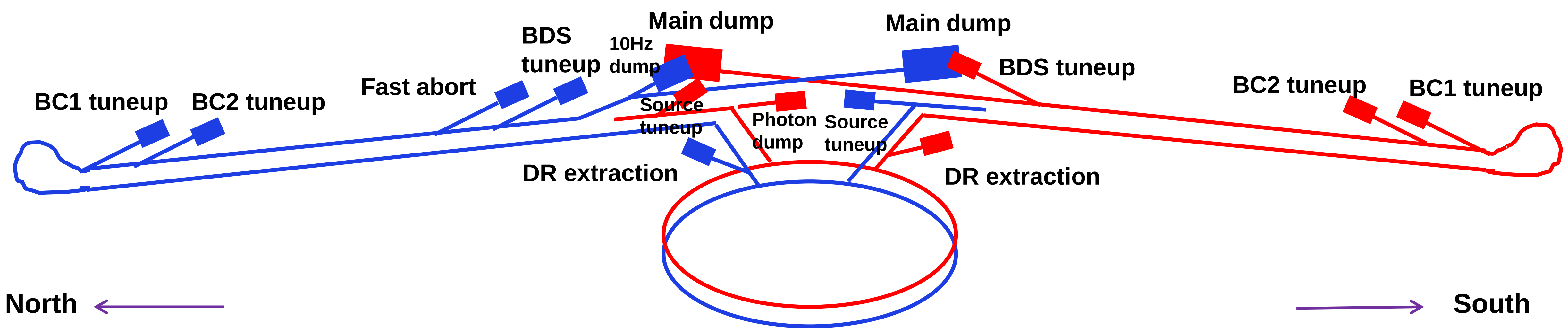
Slide at AWLC2018(Fukuoka)

	Dump	e±1	e±2	e±3	e-4	e+4	e±5	e±6	e-7	e+7	e-8
Quantity	**Unit**	Source Tune-Up Dump	DR extraction dump	BC1 tune-up dump	Electron BDS tune-up dump	Positron BDS tune-up dump	Main dump	Electron BC2 tune-up dump	Electron fast abort dump	Undulator photon dump	Electron 10 Hz dump
Particle type		e±	e±	e±	e-	e+	e±	e±	e-	gamma	e-
Absolute Maximum Ratings											
Particle energy	GeV	5	5	5	750	750	750	15	750	N/A	150
Bunch charge	nC	6.0	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**
Bunch energy	J	30	20	20	3004	3004	3004	60	3004	18	600
Abort Dump Maximum Ratings											
Dumped pulse length	μs		10.8	113	1.7	113	1201	3.3	113		
Dumped bunches			3000	310	5	310	2888	9	310		
Dumped pulse energy	**kJ**		**60**	**6.2**	**15**	**931**	**4261**	**0.5**	**931**		
Continuous Beam Maximum Ra											
Particle energy	GeV	5	5	5	750	750	750	15	500	0.12	150
Pulse energy	kJ	79	53	53	4261	4261	4261	158	158	32	1577
Repetition rate	Hz	10	10	10	10	10	10	10	10	10	5
Average beam power	kW						**17046**			**315**	**7886**
Typical Tune-up Operational Parameters											
Particle energy	GeV	5	5	5	250	250	500	15	250	0.12	150
Bunch charge	nC	4.8	3.2	3.2	1.6	1.6	2.8	3.2	1.6	3.2	3.2
Bunches per pulse		1250	1312	1312	500	500	2450	1312	500	2625	2626
Pulse energy	kJ	30.0	21.0	21.0	200	200	3409	63.1	200.0	25.2	1262
Collision rate	Hz	2	3	3	2	2	4	1	N/A	10	5
Average beam power	kW	60	63	63	401	401	13637	63	N/A	252	6309
Nominal Power Rating	**kW**	**60**	**60**	**60**	**400**	**400**	**17000**	**60**	**60**	**300**	**8000**
TDR Power Rating	kW	311	220	220	14000	14000	14000	220	250	200	N/A

Slide at AWLC2018(Fukuoka)

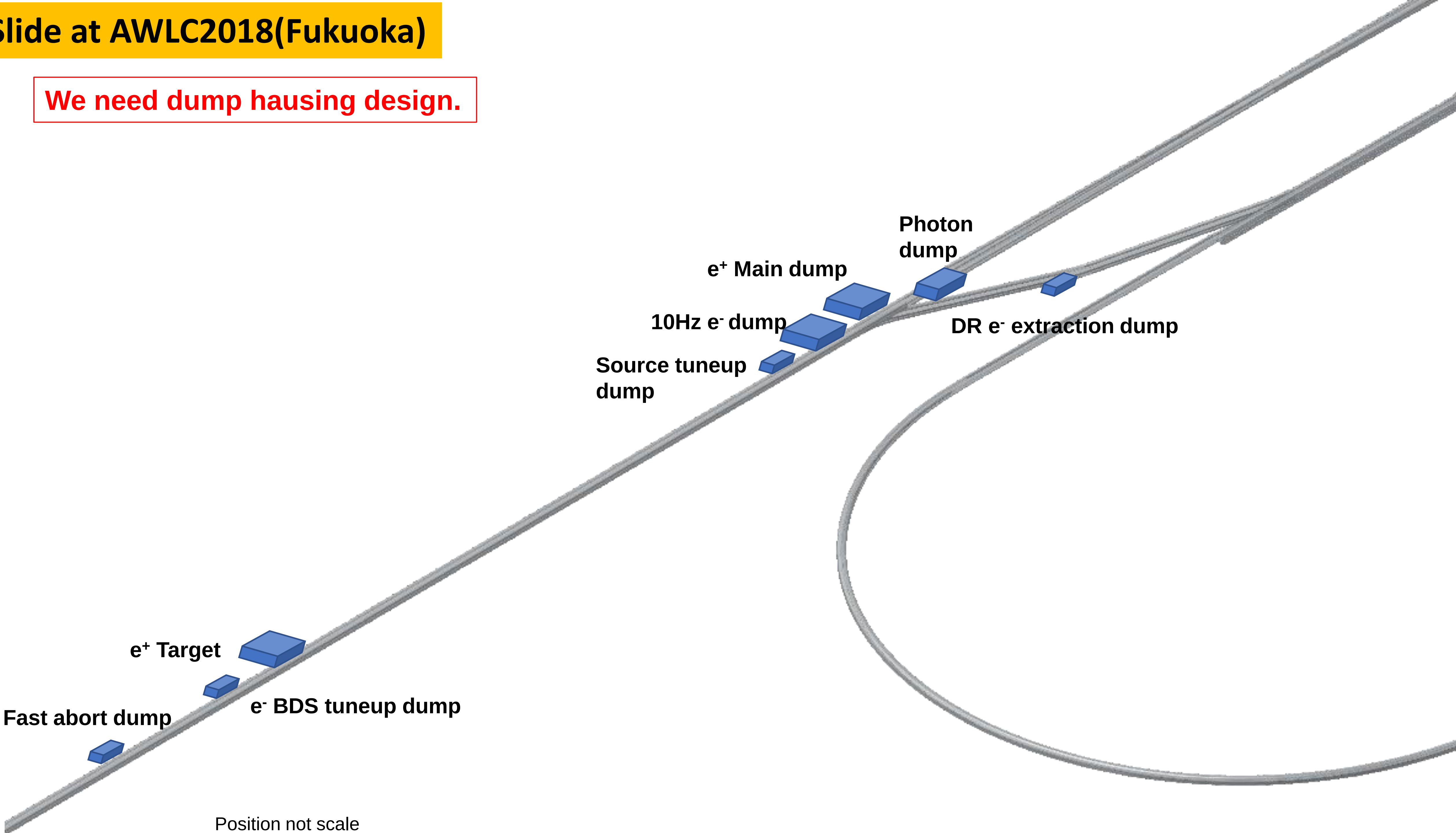


Kitakami Site-specific design



Slide at AWLC2018(Fukuoka)

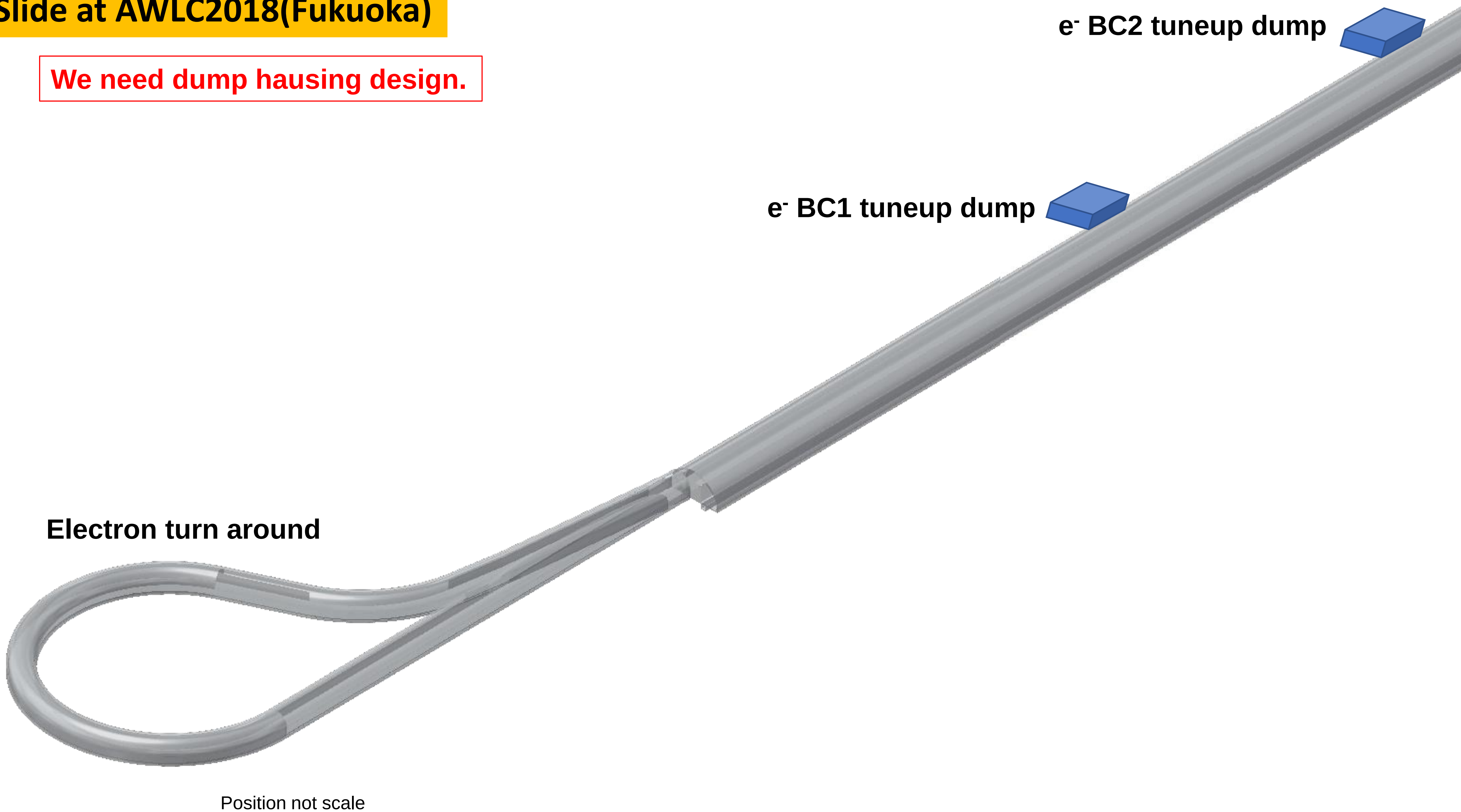
We need dump hausing design.



Position not scale

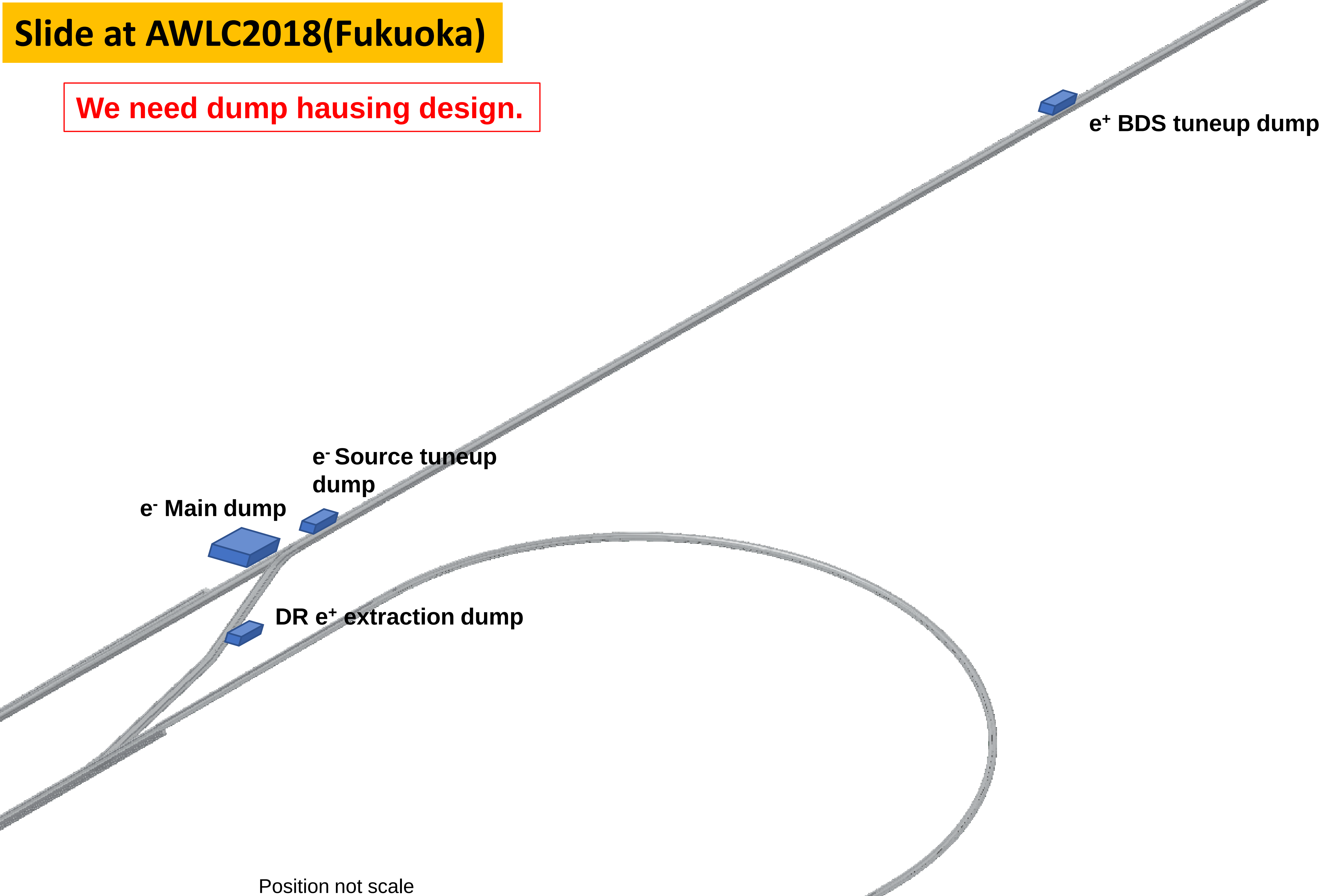
Slide at AWLC2018(Fukuoka)

We need dump hausing design.



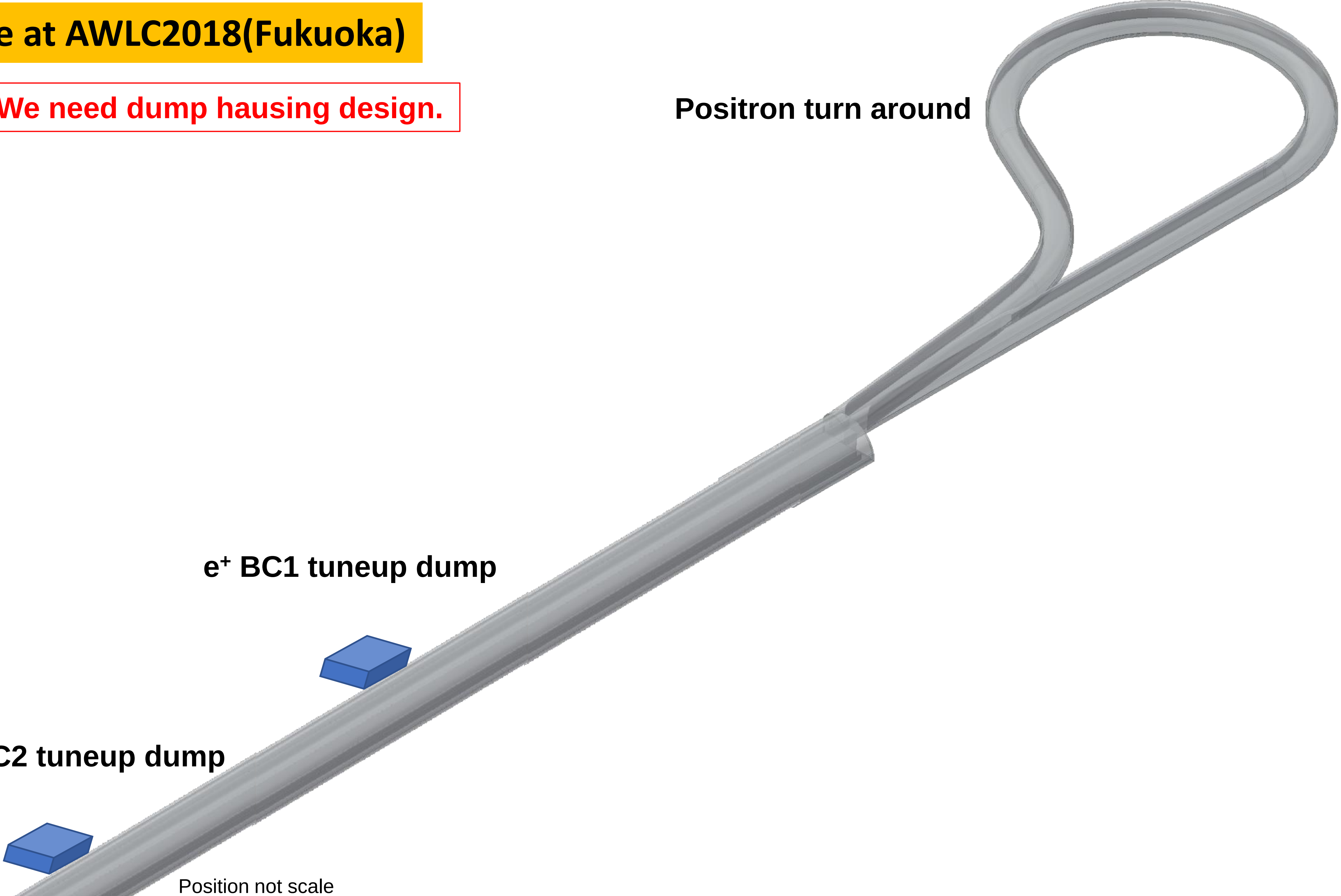
Slide at AWLC2018(Fukuoka)

We need dump hausing design.



Slide at AWLC2018(Fukuoka)

We need dump hausing design.



End of Slide