お知らせ

KEKの売店で 「ミニ超伝導加速空洞」の販売をスタート!

2017/7/11 | お知らせ

7/6からKEKの売店で「ミニ超伝導加速空洞」の販売が開始されました。

「ミニ超伝導加速空洞」は、9セル空洞、3セル空洞、シングルセル空洞の３種類です。

ILCに使われる加速空洞と同じ素材 Nb (ニオブ)でつくられてます。

9セル、3セルが売れ行き好調です！

皆様もKEKにいらっしゃった時は、ぜひ、売店にゴー !!!

ステージングの検討は最終段階。TCMBのレビュー中。８月にLCBに報告する予定

Summary of Staging Consideration

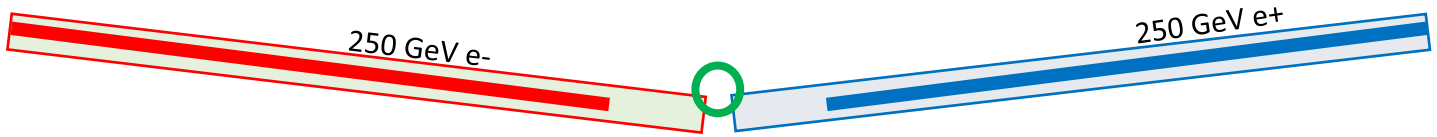
CFS Conditions & cryomodule distribution

H. Hayano, 07212017

staging option name （given by S. Michizono, 02052017）

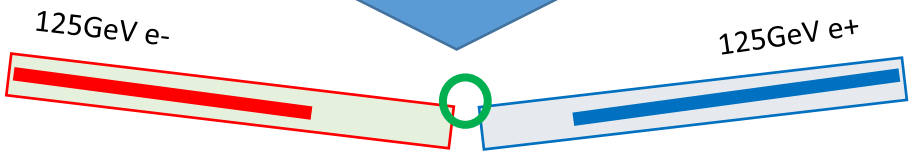
350GeV option were added

500GeV **TDR:**



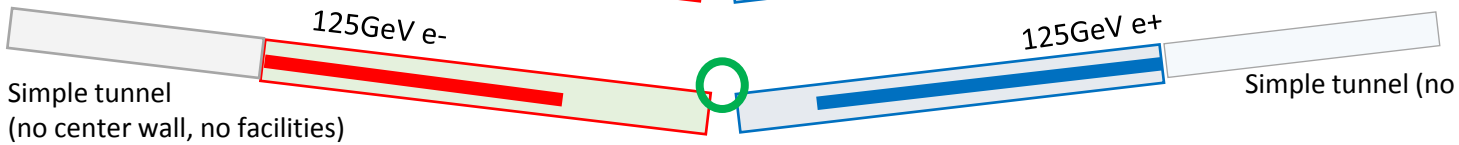
33.5km tunnel
collision timing considered

250 GeV **Option C:**



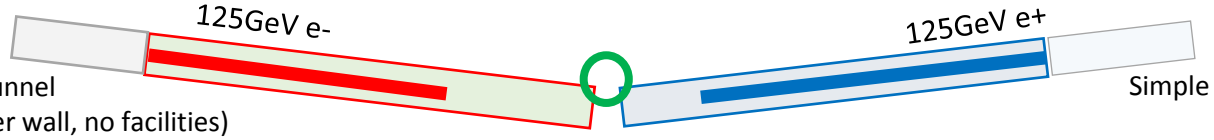
20.5km tunnel

Option D:



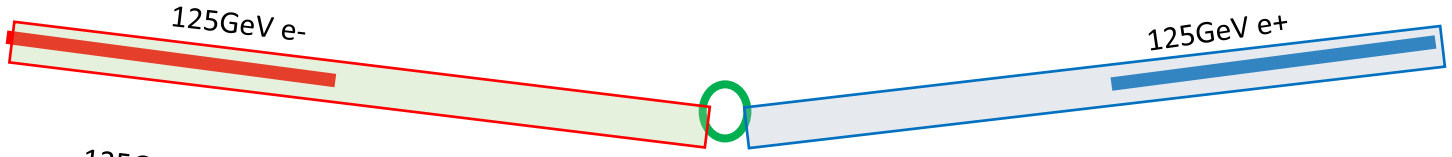
33.5km tunnel

350GeV Option D':

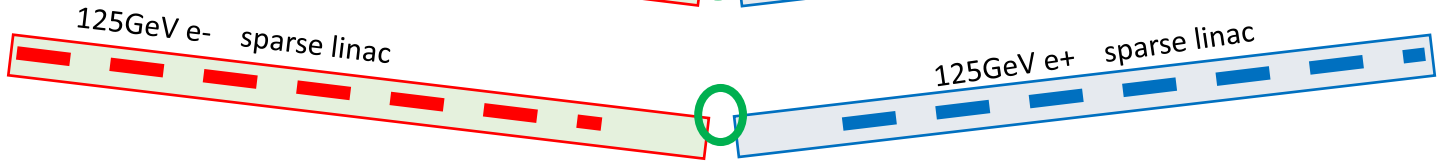


27.0km tunnel

Option E:
350GeV Option E':



Option F:
350GeV Option F':



less important for staging, cost reduction effect are less.

How to estimate the cost of each option

TDR cost

↓

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

TDR-updated cost

↓

WG2

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

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);

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

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

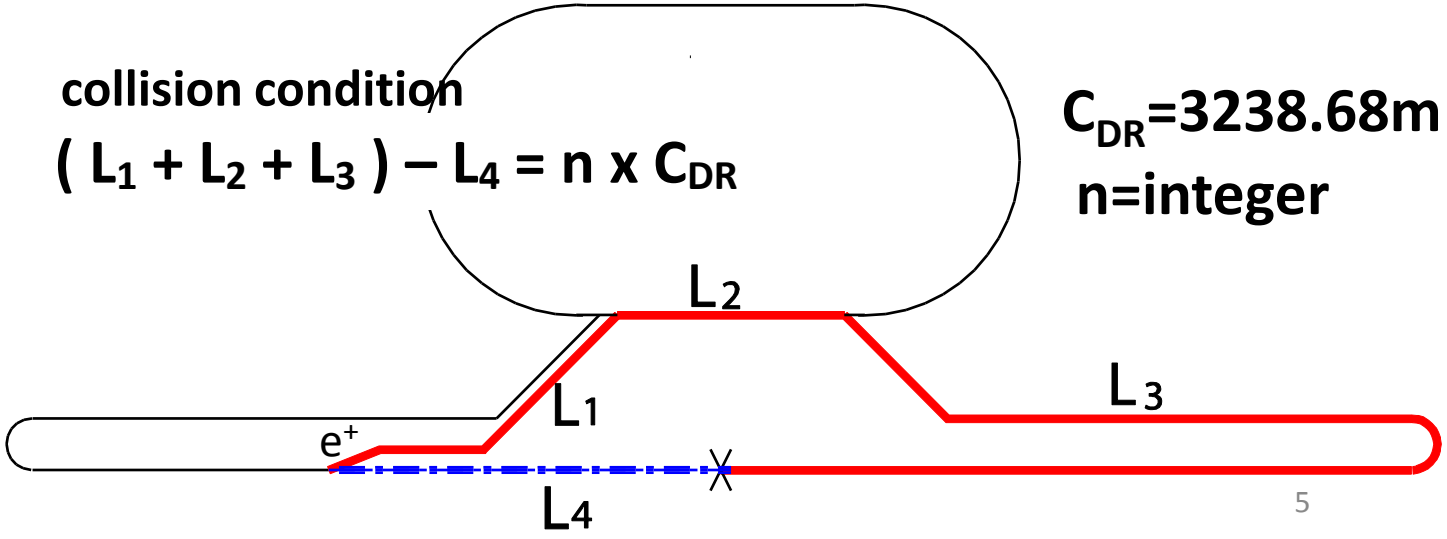
$$(L_1 + L_2 + L_3') - L_4 = 10 \times C_{DR}$$

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

collision condition

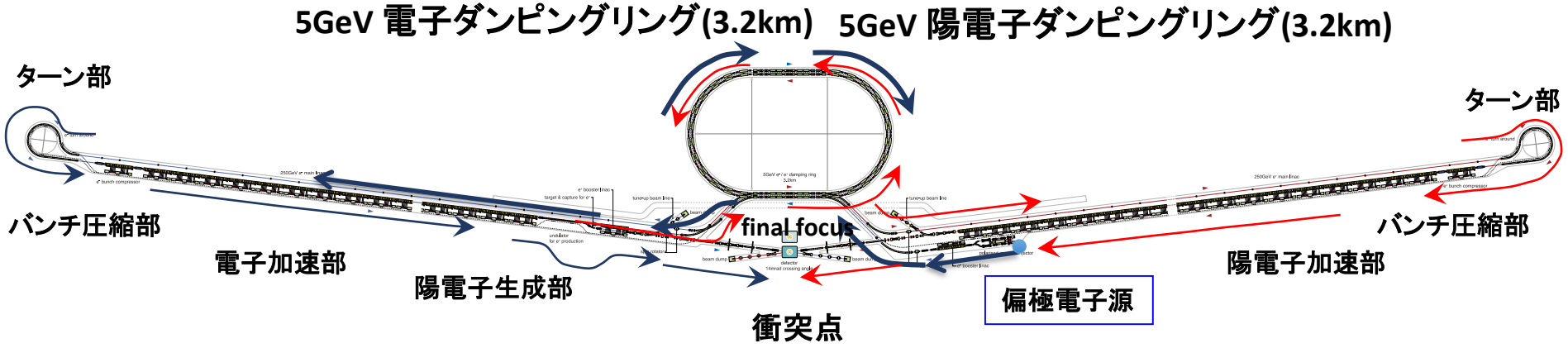
$$(L_1 + L_2 + L_3) - L_4 = n \times C_{DR}$$

C_{DR}=3238.68m
n=integer



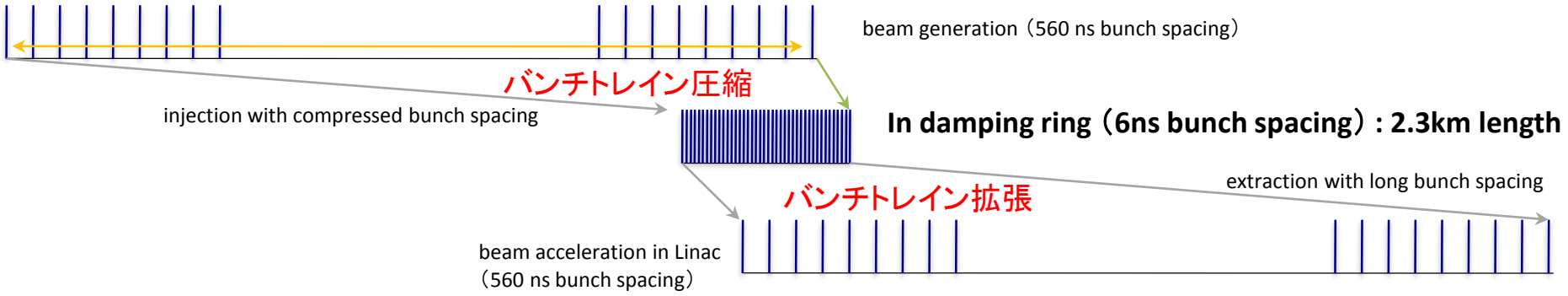
ダンピングリングへのビーム入射・出射

ILCのビーム加速のシーケンス



1msのビームトレインの中は

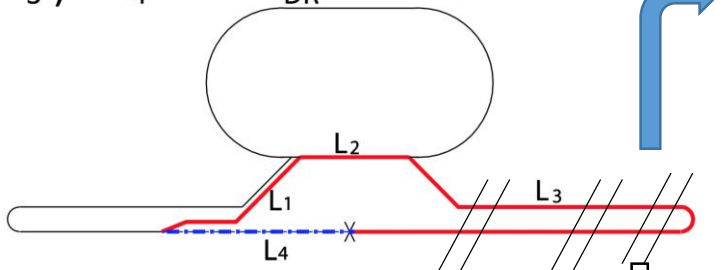
1312 bunch (220km length) ー＞実に長いバンチトレイン！



1312 bunch (220km length)

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.

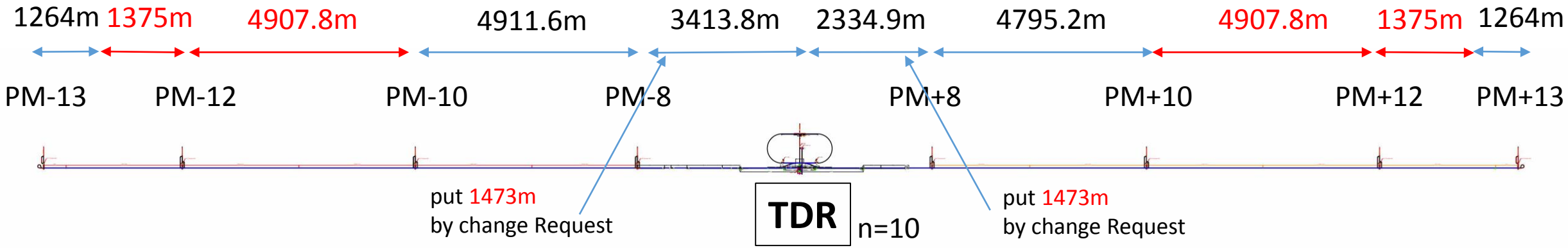
remove 1367.74m at BDS entrance (timing adjustment)

remove 202.02m at end of Linac area.

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

(-1367.74m - 4907.8m - 202.02m) x 2 = -12955.12m = - 4 x C_{DR}

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



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.

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.

Working assumption (4)

(11) TDR-undulator-based positron is kept in this study.
The length of undulator is streched to 231m 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.

TDR Cryomodule configuration

TDR

Ecm = 500GeV

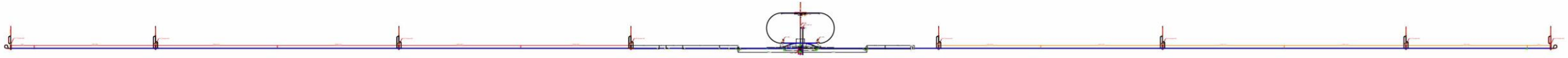
SRF 31.5MV/m

put 1473m by change Request

put 1473m by change Request

129.3m 2509.7m 4907.8m 4911.6m 3413.8m 2334.9m 4795.2m 4907.8m 2509.7m 129.3m

PM-13 PM-12 PM-10 PM-8 PM+8 PM+10 PM+12 PM+13



1264m 1375m

1375m 1264m

IR

BC						e+inj	Ecm=500GeV	e-inj					BC
51	99	189	189	189	189	24	cryomodules	24	180	189	189	189	99	51
17	22	42	42	42	42	8	RF unit	8	40	42	42	42	22	17
10.0	28.1	53.6	53.6	53.6	53.6	5.0	E gain (GeV)	5.0	51.0	53.6	53.6	53.6	28.1	10.0

Total length of tunnel = 15872.2m+14676.9m+1473m+1473m=33495m

Cavity active length = 1.0385m
Energy gain by 1 cavity = 31.5*1.0385 = 32.7 MeV
Energy gain by 1 RF unit = 32.7 MeV * 39 =1.2753 GeV
length of 1 RF unit = 58.3m

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.

BDS beamline will be longer, when we put the vertical bend.

BDS tunnel is laser straight.

3.2km

2.3km

PM-8

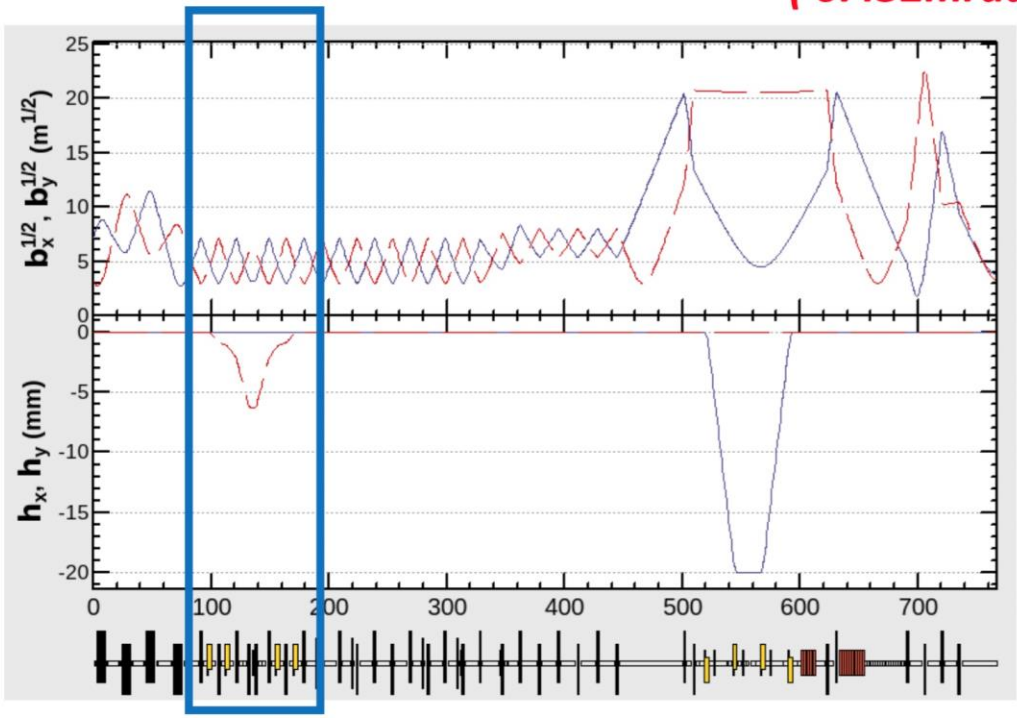
IP

PM+8

Simple vertical bend (+87.5m)

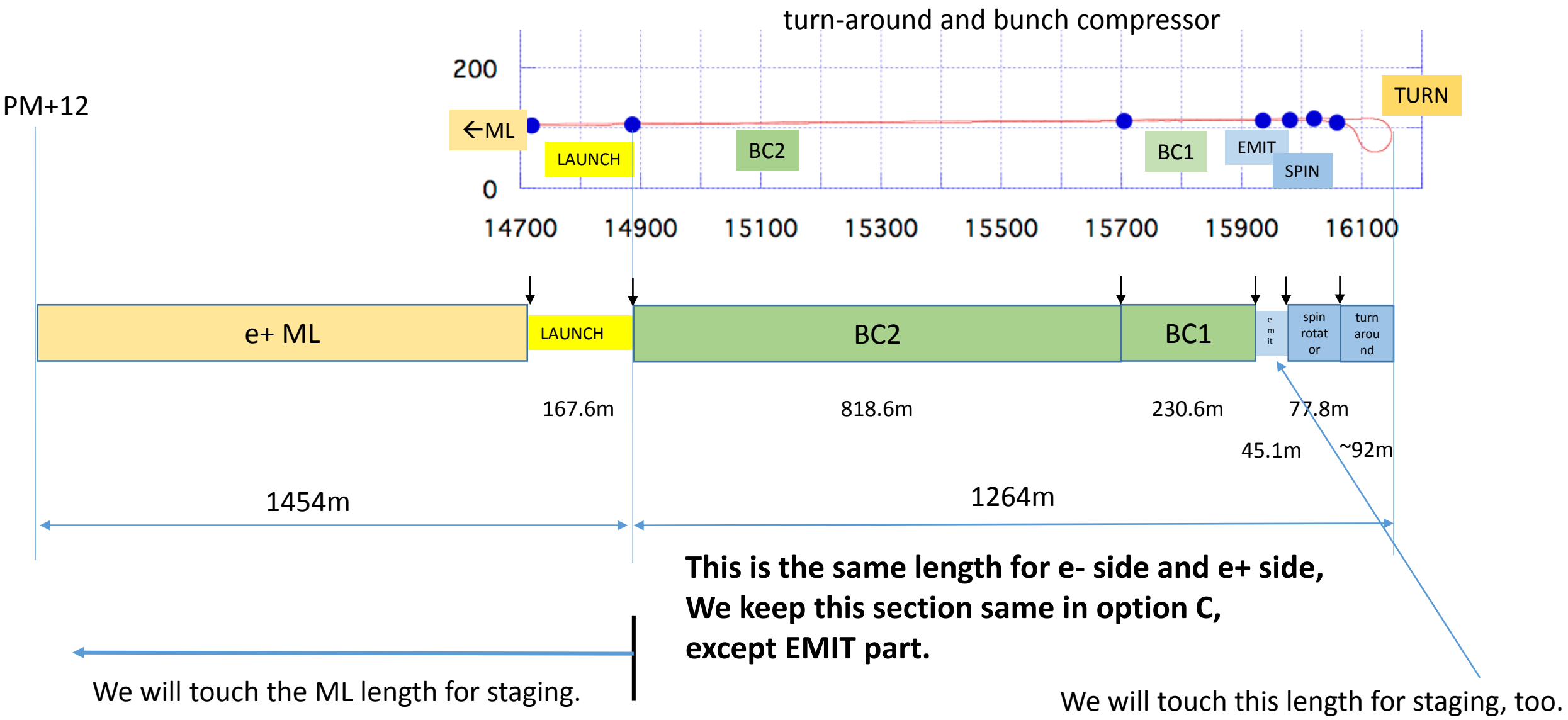
No vertical bend in optics deck (0.432mrad)

ML tunnel should be along geoid



ML tunnel should be along geoid

e+ Main Linac end region details



Parameters for staging RF unit count

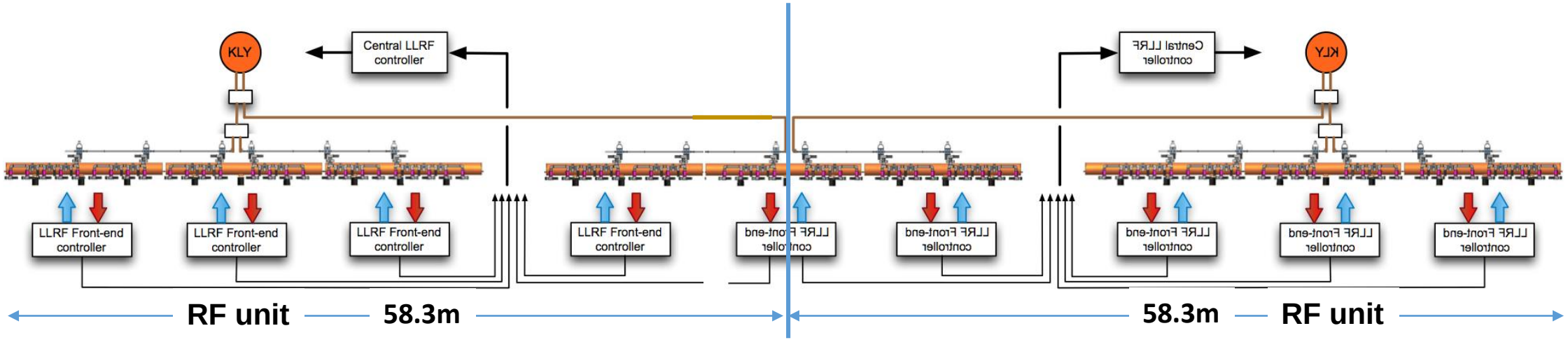
SRF 31.5MV/m

Cavity active length = 1.0385m
Energy gain by 1 cavity = 31.5*1.0385 = 32.7 MeV
Energy gain by 1 RF unit = 32.7 MeV * 39 =1.2753 GeV
length of 1 RF unit = 58.3m

SRF 35MV/m

Cavity active length = 1.0385m
Energy gain by 1 cavity = 35.0*1.0385 = 36.3 MeV
Energy gain by 1 RF unit = 36.3 MeV * 39 =1.418 GeV
length of 1 RF unit = 58.3m

"a Pair of RF units" is the fundamental unit of Main Linac Accelerator

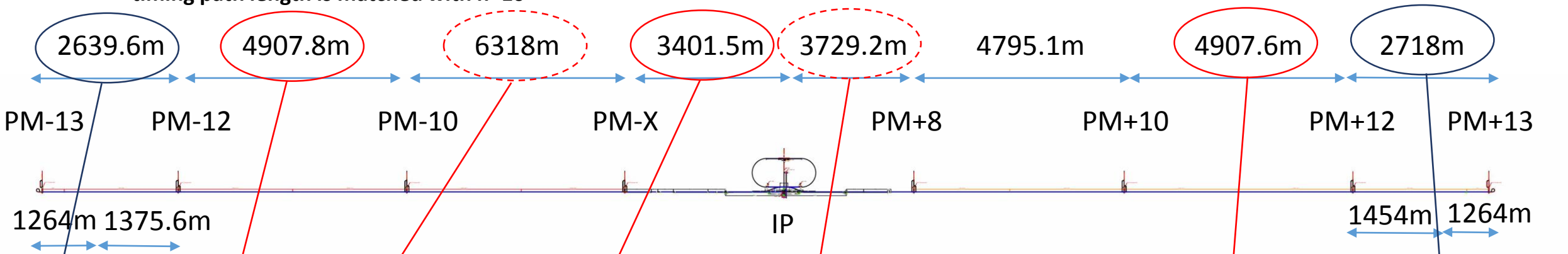


manipulation details for option C CFS configuration

TDR Recent Optics Deck (M. Woodley)

Ecm = 500GeV Total length of tunnel = 17266.9m+16149.9m=33417m

timing path length is matched with n=10



Option C with n=6

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

2639.6m
– 404.04m/2
=2437.48m

remove timing adjust
6318m – 1367.74m = 4950.26m

3401.5m + 87.5m = 3489m

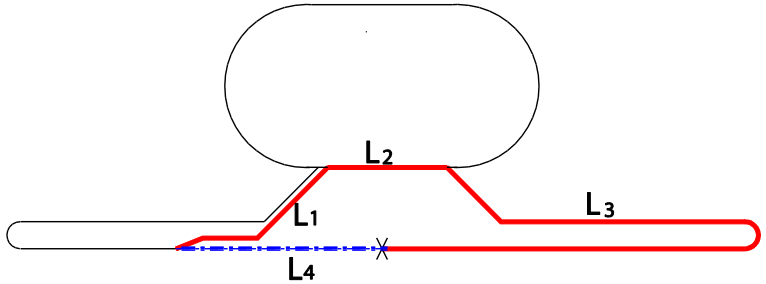
(2015 Okugi BDS) + 87.5m = 2361.46m
delta-L = -1367.74m

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

2718m – 404.04m/2
=2516m

collision condition

$(L_1 + L_2 + L_3) – L_4 = n \times C_{DR}$ C_{DR}=3238.68m



$(L_1 + L_2 + L_3) – L_4 =(L_1'+87.5)+L_2+(L_3'-1367.74x2-4907.6x2 -X) – (L_4'+87.5)$
$=(L_1'+L_2+L_3')-L_4' -(12550.68m +X)$
$=10 \times C_{DR} - 4 \times C_{DR}$
$= 6 \times C_{DR}$

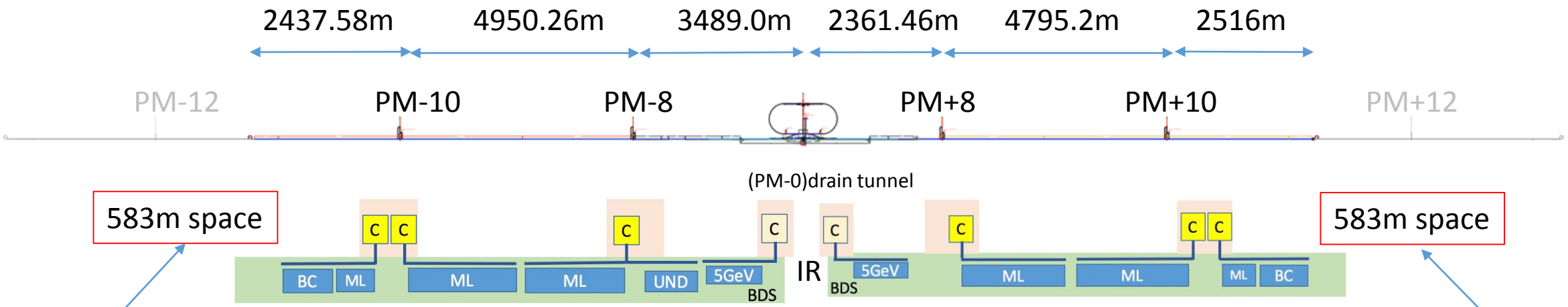
$4 \times C_{DR}$=4 x 3238.68m = 12550.68m + X
X = 404.04 m

LINAC configurations for each staging option

(number of RF unit, length of tunnel are considered for each option.)

Option C

Option C **ECM=250GeV** **SRF 31.5MV/m**



module space margin for option C, 31.5MV/m

module space margin for option C, 31.5MV/m

Ecm=250GeV

	BC				e+inj		e-inj				BC	
	51	90	189	189	24	module space	24	180	189	90	51	
	51	45	189	189	24	cryomodules	24	180	189	45	51	
	17	10	42	42	8	RF unit	8	40	42	10	17	
e^- 134.8GeV =	10.0	12.8	53.5	53.5	5.0	E gain (GeV)	5.0	51.0	53.5	12.8	10.0	= e^+ 132.3GeV

+5.8%margin

Total tunnel length = 20549.5m

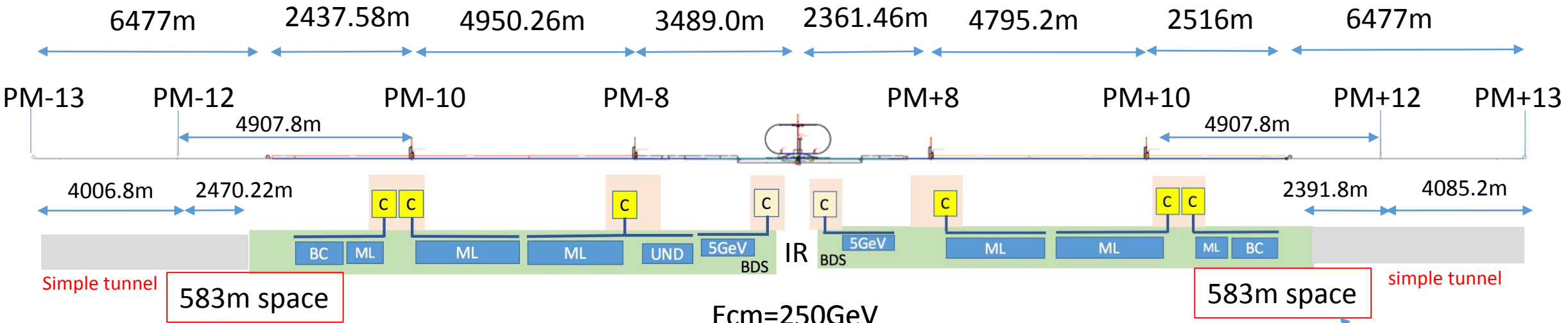
(20.5km)

Option D

SRF 31.5MV/m

Option D

Ecm = 250GeV tunnel=500GeV length, accelerator at downstream



583m space

583m space

Ecm=250GeV

	BC				e+inj		e-inj				BC
	51	90	189	189	24	module space	24	180	189	90	51
module space margin for option C, 31.5MV/m	51	45	189	189	24	cryomodules	24	180	189	45	51
	17	10	42	42	8	RF unit	8	40	42	10	17
e^- 134.8GeV =	10.0	12.8	53.5	53.5	5.0	E gain (GeV)	5.0	51.0	53.5	12.8	10.0

module space margin for option C, 31.5MV/m

= e^+ 132.3GeV +5.8%margin

tunnel total length = 17353.8m+16149.7m=33503.5m (33.5km)

simple tunnel length = 6477m+6477m=12954m (12.9km)

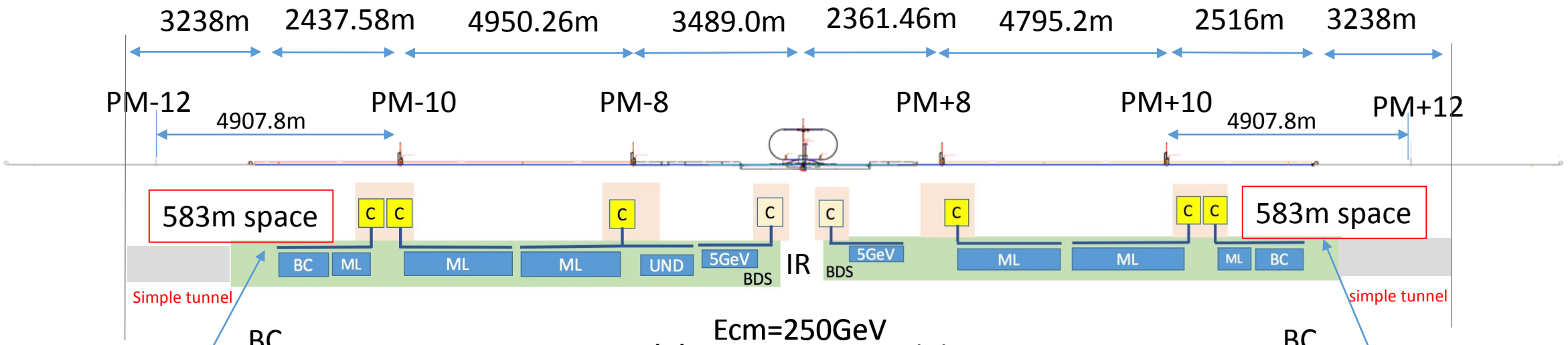
(n=4 extension on both end)

Option D’ 350GeV tunnel

SRF 31.5MV/m

Option D'

Ecm = 250GeV tunnel=350GeV length, accelerator at downstream



module space margin for option C, 31.5MV/m

module space margin for option C, 31.5MV/m

Ecm=250GeV

	BC				e+inj		e-inj				BC	
	51	90	189	189	24	module space	24	180	189	90	51	
	51	45	189	189	24	cryomodules	24	180	189	45	51	
	17	10	42	42	8	RF unit	8	40	42	10	17	
e^- 134.8GeV =	10.0	12.8	53.5	53.5	5.0	E gain (GeV)	5.0	51.0	53.5	12.8	10.0	= e^+ 132.3GeV

+5.8%margin

tunnel length = 14114.8m+12910.7m=27025.5m (27.0km)

simple tunnel length = 3238m+3238m=6476m (6.5km)
(n=2 extension on both end)

Option E

less important
for staging; cost reduction effect is small

TDR updated tunnel & place SC-ML accelerator upstream

Option E

SRF 31.5MV/m

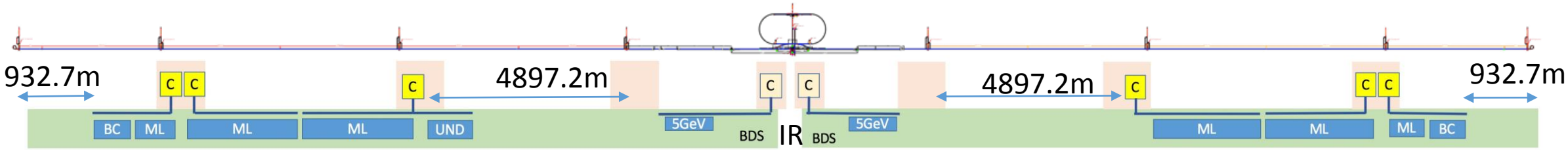
Ecm = 250GeV tunnel=500GeV length accelerator upstream

put 1473m
by change Request

put 1473m
by change Request

129.3m 2509.7m 4907.8m 4911.6m 3413.8m 2334.9m 4795.2m 4907.8m 2509.7m 129.3m

PM-12 PM-10 PM-8 PM+8 PM+10 PM+12



BC					Ecm=250GeV				BC
51	45	189	189	e+inj	cryomodules	e-inj	180	189	45	51
17	10	42	42	24	RF unit	24	40	42	10	17
10.0	12.8	53.6	53.6	8	E gain (GeV)	8	51.0	53.6	12.8	10.0
				5.0		5.0				

e^- 135.0GeV = = e^+ 132.4GeV

Total length of tunnel = 15872.2m+14676.9m+1473m+1473m=33495m

place SC-ML accelerator upstream

Option F

less important
for staging; cost reduction effect is small

TDR updated tunnel & place SC-ML accelerator sparse cut

Option F

put 1473m
by change Request

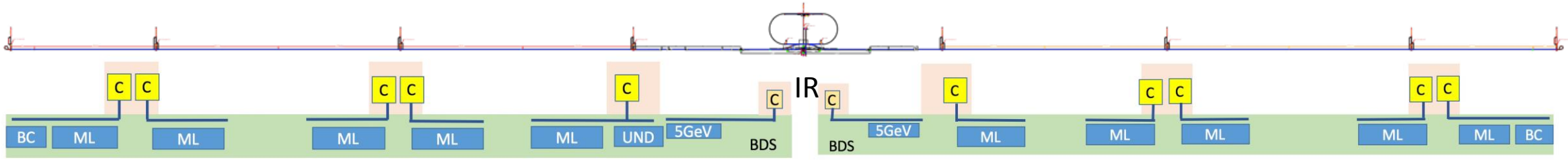
put 1473m
by change Request

SRF 31.5MV/m

Ecm = 250GeV tunnel=500GeV length accelerator sparse

129.3m 2509.7m 4907.8m 4911.6m 3413.8m 2334.9m 4795.2m 4907.8m 2509.7m 129.3m

PM-13 PM-12 PM-10 PM-8 PM+8 PM+10 PM+12 PM+13



BC						e+inj	Ecm=250GeV	e-inj						BC
51	45	99	90	99	90	24	cryomodules	24	90	90	90	99	45	51
17	10	22	20	22	20	8	RF unit	8	20	20	20	22	10	17
10.0	12.8	28.1	25.5	28.1	25.5	5.0	E gain (GeV)	5.0	25.5	25.5	25.5	28.1	12.8	10.0

e^- 135.0GeV = = e^+ 132.4GeV

Total length of tunnel = 15872.2m+14676.9m+1473m+1473m=33495m

Place SC-ML accelerator sparse cut, for 10Hz operation possible

ILC staging　Cost estimation Conditions

Conditions

(1) Estimate cost with ILCU unit for;

TDR-updated, staging option each with 31.5MV/m gradient

(2) Estimate cost for accelerator part;

using RF unit cost and other unit cost calculated from TDR,
decrease TDR cost by subtracting decreased number of units.
(ignor mass-production effect
which will be different for number of production.)

(3) Consideration items for accelerator part;

Decrease number of RF unit (cavity&cryomodule, klystron, modulator,
waveguide,LLRF, installation)
Decrease number of cryogenics (cooling power is the same as TDR)
Add simple beam line for open space of cryomodules
Decrease of RTML-return line length
Increase number of positron undulator
Decrease of beam dump power for BDS tune-up

(4) Estimate cost for CFS part;

Because of TDR estimation method is not relevant to decomposition, calculate the CFS cost option by option.

ignore the cost difference depending on the length.

(5) Consideration items for CFS part;

Decrease of number of access-hall cavern

Decrease of number of access-tunnel

Decrease of number of surface access-station

Decrease of utility devices in the surface access-station and cavern

Decrease of Main Linac Tunnel length

Decrease of Utility device, AC power cable, water pipes of cut Main Linac Tunnel

Increase of simple tunnel

(6) Estimate cost for High-Q High-G R&D success;

If the R&D success, consider cost reduction effect on the change of RF unit cost and decrease number of RF unit.

No change for CFS part.

ILC staging Unit Cost

ILC staging Unit Cost

Details of calculations

“TDR_Value_Matrix-ay170119” = cost reference

geometry of RTML beam line = from “geom-pLET-tape.csv”
consider “eLET”, the same as “pLET”

pLET=positron :DR exit - RTML - turn around - BC - Main Linac - BDS

eLET=electron :DR exit - RTML - turn around - BC - Main Linac - BDS

RF Unit & Cryogenics

すみません。コスト情報は開示できません。

Main Linac SCRF and accelerator 31.5MV/m

L-band Cavities and Cryomodules w/o SC materials	[redacted]
L-band Cavities SC materials	[redacted]
L-band HLRF	[redacted]
Integrated controls and LLRF	[redacted]
Magnets and Power supplies	[redacted]
Installation	[redacted]
Cryogenics	[redacted]
Instrumentation	[redacted]

total = [redacted]

Main Linac RF unit= 378

RF Unit cost = [redacted]

(31.5MV/m)

Main Linac Cryogenics unit
= 4.5 + 4.5 =9

0.5 + 0.5 =1 are extracted from ML to RTML, they are for bunch compressor.

Cryogenics Unit cost
= [redacted] /9
= [redacted]

no change (did not touch)

すみません。コスト情報は開示できません。

RTML beam line

RTML

L-band Cavities and Cryomodules w/o SC materials	[redacted]	no change
L-band Cavities SC materials		no change
L-band HLRF		no change
Cryogenics		no change
Installation		no change
Integrated controls and LLRF		no change
Dumps and Collimator		no change

Magnets and Power supplies	[redacted]	total=[redacted], [redacted]/(2208x2) = [redacted]/(mag+PS+Inst set)
Instrumentation		
Vacuum	[redacted]	[redacted]/(16,286x2)m = [redacted]/m

below evaluation is estimated by positron RTML

return line : Quad+BPM+corrector interval = 36m, total length=15438m 428set

Ring-to-return : Quad+BPM interval = 2.4m, total length=450m 188 set

turn-to-BC1 : Quad+BPM+bend interval = 0.5m, total length=398m 796 set(Q)+796 set(B)

magnet+PS+instrumentation set =2208 Vacuum length = 16,286m

すみません。コスト情報は開示できません。

Main Linac simple beam line (no cryomodule part)

magnet+PS+Instr Unit cost = [redacted] /(mag+PS+Inst set)

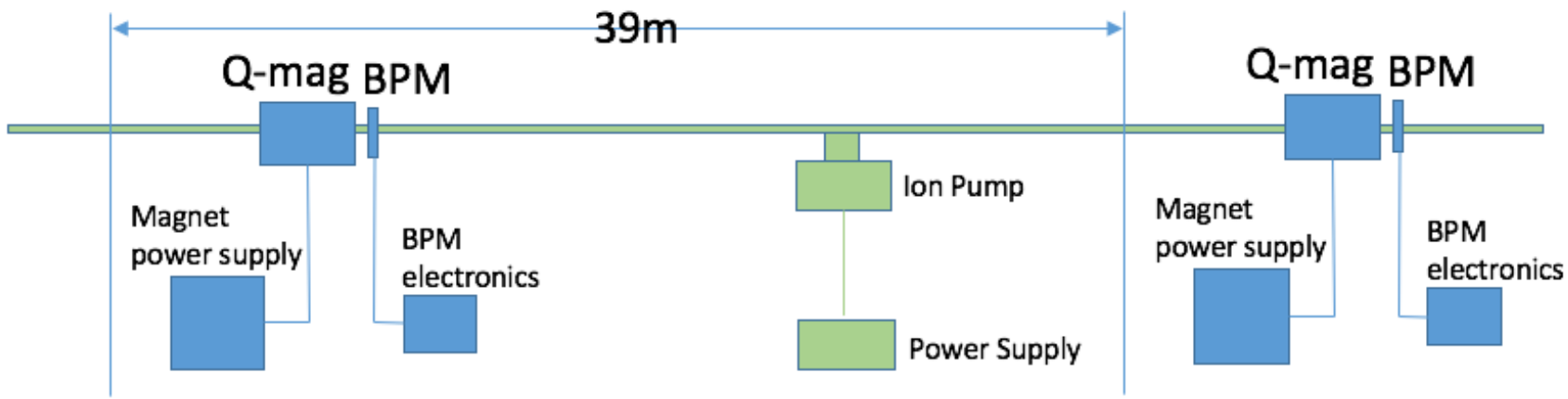
Vacuum Unit length cost = [redacted] /m

LINAC simle beam line Unit configulation

= (Quad+PS+Instr) + 39m vacuum

= [redacted] + 39m x [redacted]

= [redacted] ILCU/(39m)



Beam Dump

すみません。コスト情報は開示できません。

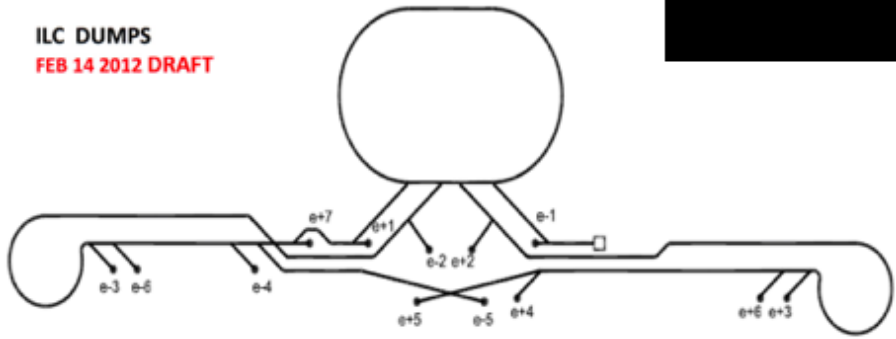
BDS

18MW x 4 [redacted] reduced to → 18MW x 2 + 220kW x2

[redacted] x 2 + [redacted] x 2

= [redacted] (BDS Dump)

Dumps and Collimator



MPD	e-1	SC TUNE UP DUMP	311 KW**	MPD	e+1	SC TUNE UP DUMP	311 KW**
MPD	e-2	EDRX TUNE UP DUMP	220 KW	MPD	e+2	PDRX TUNE UP DUMP	220 KW
MPD	e-3	RTML TUNE UP DUMP	220 KW	MPD	e+3	RTML TUNE UP DUMP	220 KW
HPD	e-4	BDS TUNE UP DUMP	18 MW	HPD	e+4	BDS TUNE UP DUMP	18 MW
HPD	e-5	PRIMARY e-DUMP	18 MW*	HPD	e+5	PRIMARY e+DUMP	18 MW*
MPD	e-6	RTML TUNE UP DUMP	220 KW	MPD	e+6	RTML TUNE UP DUMP	220 KW
				MPD	e+7	TARGET DUMP	200 KW*

MPD = HIGH POWER DUMPS (1e-; 2e+; 6 RTML)
HPD = MEDIUM POWER DUMPS (4 BDS)
* = indicate non-stop dump (always on)
**= indicate 45KW always on

RTML Dumps= 220kW x 6 = [redacted]

thus, 220kW dump unit cost = [redacted]

TABLE 3.11-1
Dump types and locations

Item	#	Locations		CFS DUMP Criteria Feb 14, 2012
Beam Dumps				
10 MW 10 atm water	4	Ends of linacs and BDS dumplines		e-4, e-5, e+4, e+5
300 kW undulator photon	1	Behind positron production target		e+7
250 kW aluminum ball	9	DR injectors (2)→ RTML (6) → positron production undulator chicane (1)		→e-1, e+1 →e-2, e-3, e-6, e+2, e+3, e+6 →Combined with e-4 with undulator relocation.
Fixed 10 kW solid metal, peripherally cooled	6	100 MeV points in e- sources (2), 114 and 400 MeV points in e+ sources (4)		
Insertable low power tuning dumps	2	Final focus		
Faraday cups	2	Electron guns		
Uncooled aluminum blocks	2	DR abort dumps		

← BDS

すみません。コスト情報は開示できません。

Positron Undulator

Undulator total (147m) cost is [redacted] (from Yokoya-san's information),
while magnet and power supplies portion is [redacted] in positron source.

For 250GeV machine, undulator length is increased to 231m.
The cost is scaled up by the increased length.

([redacted] / 147m) x 231m = [redacted]
delta-Cost = + [redacted] (+ [redacted] MILCU)

Summary of Unit cost (ILCU) for 31.5MV/m

すみません。コスト情報は開示できません。

Main-Linac-SRF

RF Unit cost = [redacted] (31.5MV/m)

Cryogenics Unit cost = [redacted]

RTML return line & Linac simple beam line

magnet+PS+Instr Unit cost = [redacted] /(mag+PS+Inst set)

Vacuum Unit length cost = [redacted] /m

return-line / LINAC simle beam line Unit configulation
= (Quad+PS+Instr) + 36m vacuum (for return line)
= (Quad+PS+Instr) + 39m vacuum (for ML simple beam line)

Beam Dump

Change only on BDS dump
(four big dump -> two big + two small)

[redacted] x 2 + [redacted] x 2 = [redacted] (BDS Dump)

Undulator

delta-Cost = +[redacted] (+[redacted] MILCU) (147m -> 230m)

すみません。コスト情報は開示できません。

ILC staging　Cost Estimation results

H. Hayano, M. Miyahara, N. Terunuma “Staging-Cost-20170614”

ILC-staging		total cost (MILC)	decreased fraction from TDR	
TDR		**7984.85**	**0.0%**	
TDR recent optics deck		**7951.51**	**-0.42%**	shield 3.5m ->1.5m, width11m->9.5m, add 3km for timing
Option-C	**(31.5MV/m)**	[redacted]	[redacted]	250GeV Ecm machine
	(35MV/m)	[redacted]	[redacted]	250GeV Ecm machine, decrease RF unit for 35MV/m
Option-D	**(31.5MV/m)**	[redacted]	[redacted]	250GeV Ecm machine, add simple tunnel for 500GeV
	(35MV/m)	[redacted]	[redacted]	250GeV Ecm machine, add simple tunnel for 500GeV decrease RF unit for 35MV/m
Option-D’	**(31.5MV/m)**	[redacted]	[redacted]	250GeV Ecm machine, add simple tunnel for 350GeV
	(35MV/m)	[redacted]	[redacted]	250GeV Ecm machine, add simple tunnel for 350GeV decrease RF unit for 35MV/m

Summary of WG2 : CFS staging

(1) We examined the conditions to be considered for the staging, such as, collision timing condition, energy margin, cryoline length, undulator length, access point intervals, RF unit arrangement, etc.

(2) CFS configurations for option C, option D and D' are proposed. option E and F configurations are also proposed.

(3) Cost estimation conditions are examined.

(4) Unit Cost estimation & cost reductions are examined. The calculation is under cross-checking. Reduction of common part is under discussion.

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