Status of RTML design in TDR configuration

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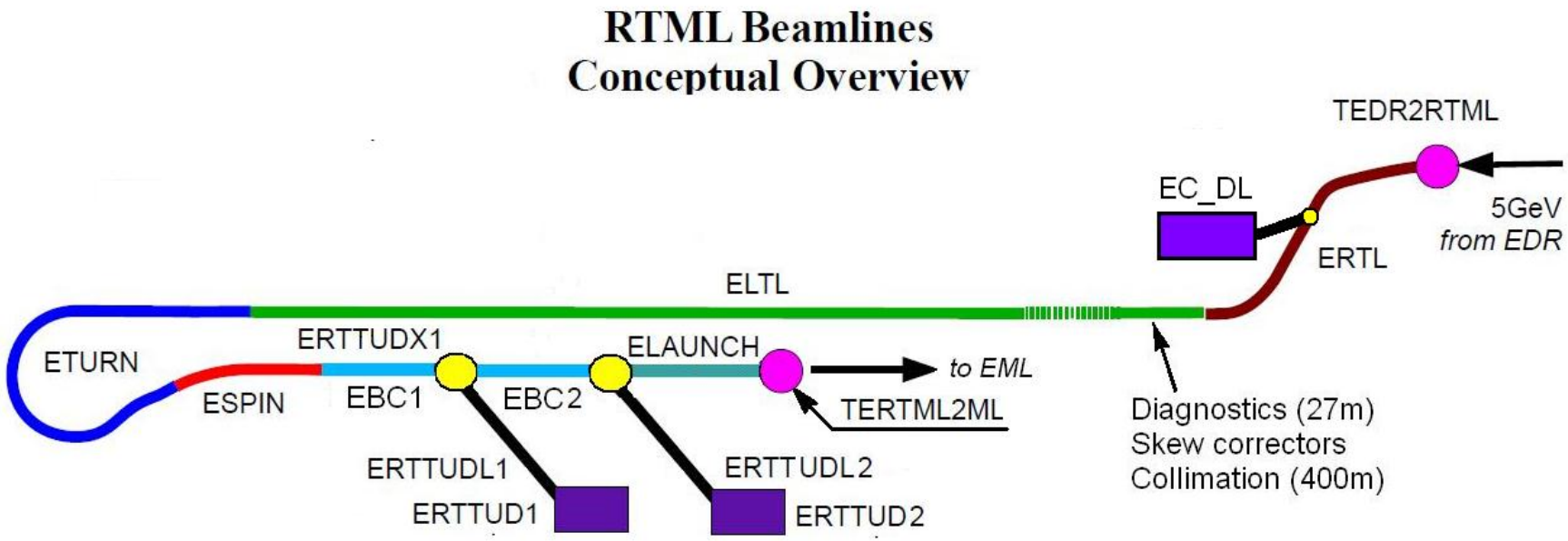
Fermilab

OUTLINE:

- Latest changes in central region (ERTL/PRTL)
- Return Line Dog-Legs design (ELTL/PLTL)
- ML Treaty point definition and matching
- Earth curvature in Return Lines (ELTL/PLTL)
- Latest changes in 2 stage Bunch Compressor
- Magnet count and Heat Load/Cost estimation
- Summary

RTML Beamlines



TEDR2RTML	Treaty Point Electron Damping Ring to RTML
ERTL	Electron Ring to Line (Damping Ring to Main Tunnel)
ELTL	Electron Long Transfer Line
ETURN	Electron Turnaround
ESPIN	Electron Spin Rotation and Emittane Diagnosis
EBC1 EBC2	Electron Bunch Compressor (stage 1 and 2)
ELAUNCH	Electron Launch to Main Linac
EC_DL	Electron Central Dump Line
ERTTUDX(1/2)	Electron RTML Tuneup Dump Extraction
ERTTUDL(1/2)	Electron RTML Tuneup Dump Line
ERTTUD(1/2)	Electron RTML Tuneup Dump
TERTML2ML	Treaty Point Electron RTML to Main Linac

Courtesy of B. List (updated by V. Kapin & N. Solyak)

Latest changes in central region (ERTL/PRTL)

- Beam lines geometry in global coordinate defined in document EDMS D*0969765

ELTR Tunnel	Positron Extraction from DR			Electron Injection to DR		
	Description	Parameter	Value	Description	Parameter	Value
Section A	Positron DR Exit	x(m)	100.000	Electron DR Entrance	x(m)	100.000
	(Center of Septum)	y(m)	0.350	(Center of Septum)	y(m)	1.650
		z(m)	75.590		z(m)	80.700
	Positron Extraction Line Bend	x(m)	97.114	Electron DR Entrance	x(m)	97.113
	(Center of Bend)	y(m)	0.350	(Center of Septum)	y(m)	1.650
		z(m)	96.192		z(m)	101.307
	Positron Extraction Treaty Point	x(m)	94.410	Electron Injection Treaty Point	x(m)	94.410
	End of DR Extraction Line	y(m)	0.350	Start of DR Injection Line	y(m)	1.650
		z(m)	106.988		z(m)	112.103
Section B	Positron Extraction Treaty Point	x(m)	94.410	Electron Injection Treaty Point	x(m)	94.410
	Start of Positron RTML Line	y(m)	0.350	End of Electron Source Line	y(m)	1.650
		z(m)	106.988		z(m)	112.103
	Line Length	*L(m)*	*128.558*	*Line Length*	*L(m)*	*123.590*
	Line Angle	*q(rad)*	*1.811*	*Line Angle*	*q(rad)*	*1.811*
	End of Section B Straight	x(m)	63.851	Start of Section B Straight	x(m)	65.032
		y(m)	1.650		y(m)	0.000
		z(m)	231.862		z(m)	232.151
Section C	Start of Arc	x(m)	63.851	End of Arc	x(m)	65.032
		y(m)	1.650		y(m)	0.000
		z(m)	231.862		z(m)	232.151
	Arc Angle	*q(rad)*	*0.168*	*Arc Angle*	*q(rad)*	*0.168*
	Arc Radius	*R(m)*	*83.500*	*Arc Radius*	*R(m)*	*84.716*
	Arc Length	*S(m)*	*14.053*	*Arc Length*	*S(m)*	*14.258*
	End of Arc	x(m)	59.381	Start of Arc	x(m)	60.497
		y(m)	1.650		y(m)	0.000
		z(m)	245.167		z(m)	245.650
Section D	Start of Section D Straight	x(m)	59.381	End of Section D Straight	x(m)	60.497
		y(m)	1.650		y(m)	0.000
		z(m)	245.167		z(m)	245.650
	Line Length	*L(m)*	*123.595*	*Line Length*	*L(m)*	*123.595*
	Line Angle	*q(rad)*	*1.979*	*Line Angle*	*q(rad)*	*1.979*
	End of Section D Straight	x(m)	10.307	Start of Section D Straight	x(m)	11.423
		y(m)	1.650		y(m)	0.000
		z(m)	358.602		z(m)	359.085
Section E	Start of Arc	x(m)	10.307	End of Arc	x(m)	11.423
		y(m)	1.650		y(m)	0.000
		z(m)	358.602		z(m)	359.085
	Arc Angle	*q(rad)*	*0.415*	*Arc Angle*	*q(rad)*	*0.415*
	Arc Radius	*R(m)*	*72.130*	*Arc Radius*	*R(m)*	*66.930*
	Arc Length	*S(m)*	*29.956*	*Arc Length*	*S(m)*	*27.796*
	End of Arc	x(m)	4.380	Start of Arc	x(m)	5.923
		y(m)	1.650		y(m)	0.000
		z(m)	387.746		z(m)	386.128

PLTR Tunnel	Positron Injection to DR			Electron Extraction from DR		
	Description	Parameter	Value	Description	Parameter	Value
Section A	Positron DR Entrance	x(m)	100.000	Electron DR Exit	x(m)	100.000
	(Center of Septum)	y(m)	0.350	(Center of Septum)	y(m)	1.650
		z(m)	-80.700		z(m)	-75.590
	Positron Injection Line Bend	x(m)	97.113	Electron Extraction Line Bend	x(m)	97.114
	(Center of Bend)	y(m)	0.350	(Center of Bend)	y(m)	1.650
		z(m)	-101.307		z(m)	-96.192
	Positron Injection Treaty Point	x(m)	94.410	Electron Extraction Treaty Point	x(m)	94.410
	Start of DR Injection Line	y(m)	0.350	End of DR Extraction Line	y(m)	1.650
		z(m)	-112.103		z(m)	-106.988
Section B	Positron Injection Treaty Point	x(m)	94.410	Electron Extraction Treaty Point	x(m)	94.410
	End of Positron Source Line	y(m)	0.350	Start of Electron RTML Line	y(m)	1.650
		z(m)	-112.103		z(m)	-106.988
	Line Length	*L(m)*	*123.590*	*Line Length*	*L(m)*	*128.558*
	Line Angle	*q(rad)*	*-1.811*	*Line Angle*	*q(rad)*	*-1.811*
	Start of Section B Straight	x(m)	65.032	End of Section B Straight	x(m)	63.851
		y(m)	0.000		y(m)	1.650
		z(m)	-232.151		z(m)	-231.862
Section C	End of Arc	x(m)	65.032	Start of Arc	x(m)	63.851
		y(m)	0.000		y(m)	1.650
		z(m)	-232.151		z(m)	-231.862
	Arc Angle	*q(rad)*	*0.168*	*Arc Angle*	*q(rad)*	*0.168*
	Arc Radius	*R(m)*	*84.716*	*Arc Radius*	*R(m)*	*83.500*
	Arc Length	*S(m)*	*14.258*	*Arc Length*	*S(m)*	*14.053*
	Start of Arc	x(m)	60.497	End of Arc	x(m)	59.381
		y(m)	0.000		y(m)	1.650
		z(m)	-245.650		z(m)	-245.167
Section D	End of Section D Straight	x(m)	60.497	Start of Section D Straight	x(m)	59.381
		y(m)	0.000		y(m)	1.650
		z(m)	-245.650		z(m)	-245.167
	Line Length	*L(m)*	*123.595*	*Line Length*	*L(m)*	*123.595*
	Line Angle	*q(rad)*	*-1.979*	*Line Angle*	*q(rad)*	*-1.979*
	Start of Section D Straight	x(m)	11.423	End of Section D Straight	x(m)	10.307
		y(m)	0.000		y(m)	1.650
		z(m)	-359.085		z(m)	-358.602
Section E	End of Arc	x(m)	11.423	Start of Arc	x(m)	10.307
		y(m)	0.000		y(m)	1.650
		z(m)	-359.085		z(m)	-358.602
	Arc Angle	*q(rad)*	*0.415*	*Arc Angle*	*q(rad)*	*0.415*
	Arc Radius	*R(m)*	*66.930*	*Arc Radius*	*R(m)*	*72.130*
	Arc Length	*S(m)*	*27.796*	*Arc Length*	*S(m)*	*29.956*
	Start of Arc	x(m)	5.923	End of Arc	x(m)	4.380
		y(m)	0.000		y(m)	1.650
		z(m)	-386.128		z(m)	-387.746

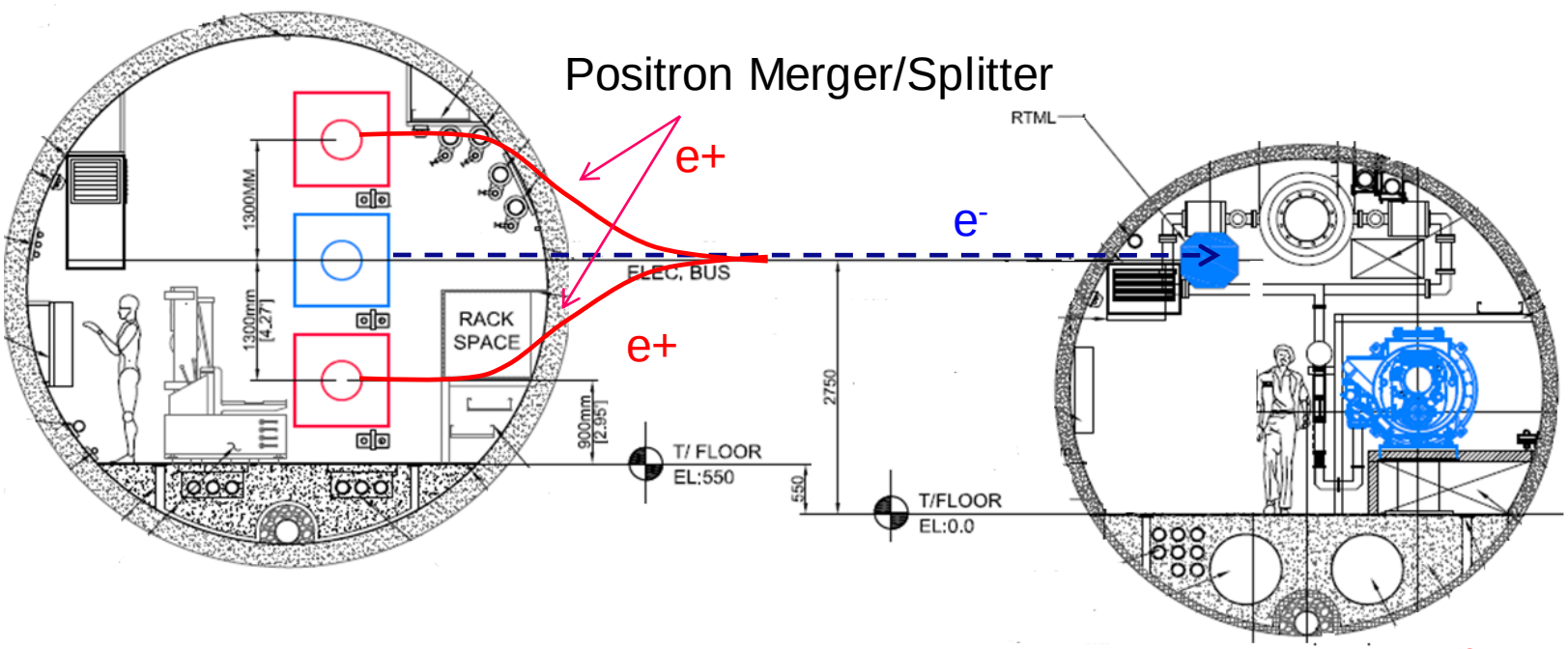
Latest changes in central region (ERTL/PRTL)

Twiss parameters defined in document EDMS D*0966225

Parameter	x-value (target)	y-value (target)	z-value (height)
	Positron Extraction Lines:		Ring1 / Ring2
Treaty point position	108.42m a 107.49m	4.72m a 5.59m	-1.3m / +1.3m
Treaty point angle	(p - 0.240) rad	0.0mrad	0.0mrad / 0.0mrad
Ext septum position*	75.59m	0.0m	-1.3m / +1.3m
h and h'	0.0	0.0	---
a	-0.7989	1.5752	---
b	45.0m	29.96m	---
	Electron Extraction Line:		Ring1
Treaty point position	-107.49m	5.59m	0.0m
Treaty point angle	(p - 0.240) rad	0.0mrad	0.0mrad
Ext septum position*	-75.59m	0.0m	0.0m
h and h'	0.0	0.0	---
a	-0.7989	1.5752	---
b	45.0m	29.96m	---

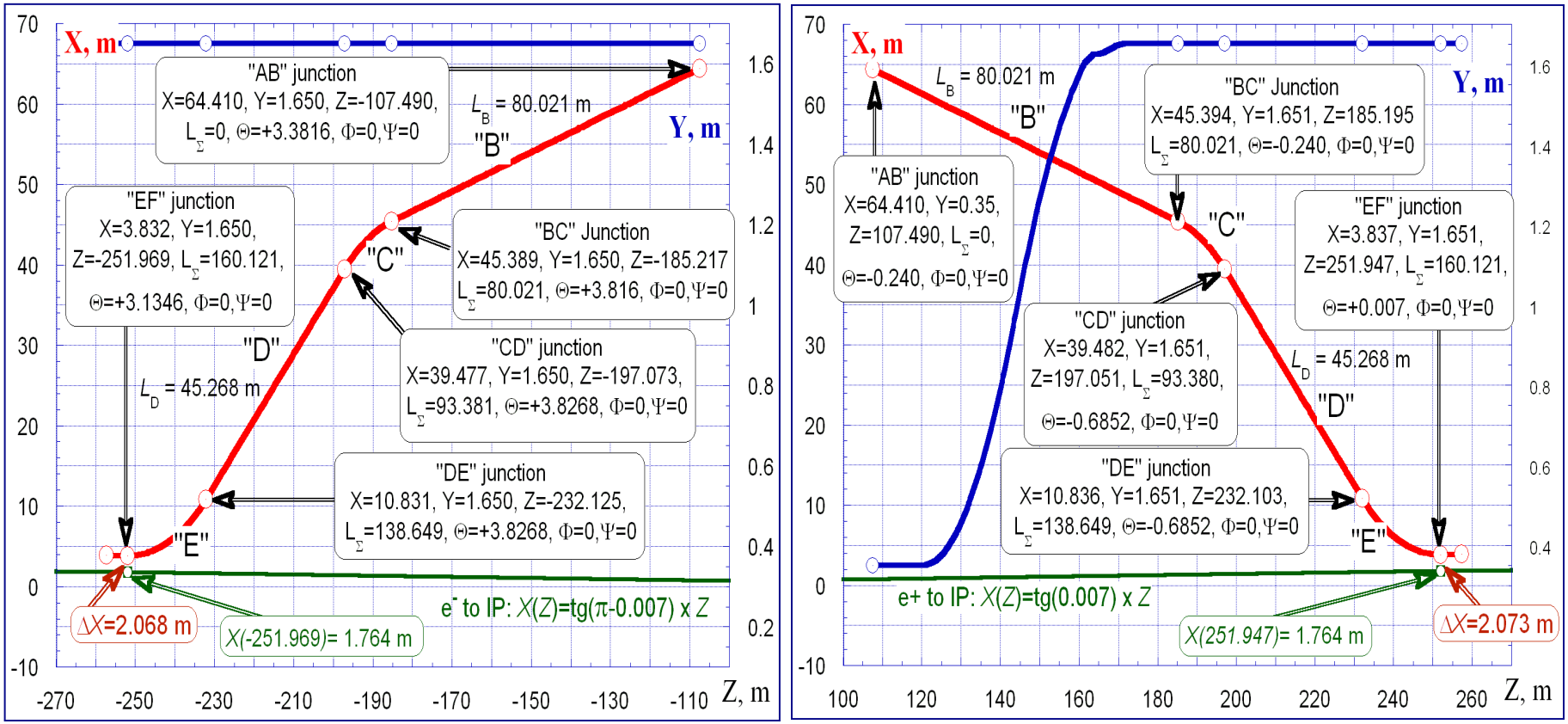
ERTL/PRTL (Electron-Ring-to-Linac) lines

- DRs are is separated vertically by 1.3m: electron ring has the same elevation as RTML in ML tunnel
- Sources need cryomodules and SC solenoids, heavy objects sitting at floor (working agreement between sources, DR, RTML, CFS)



Courtesy of N. Solyak

Latest changes in central region (ERTL/PRTL)

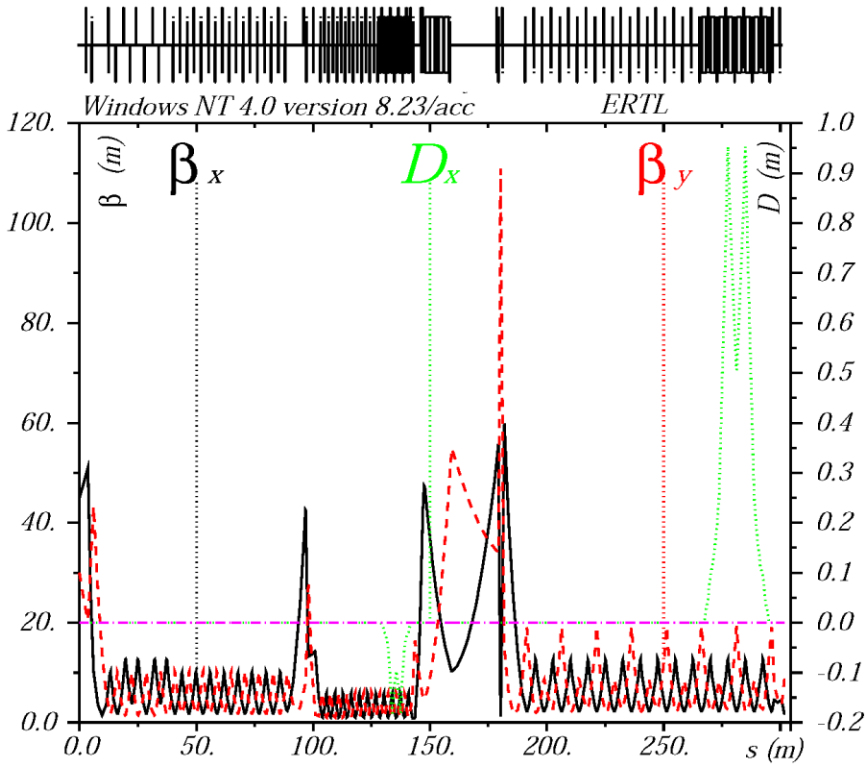


Geometrical configuration of central region Beam lines

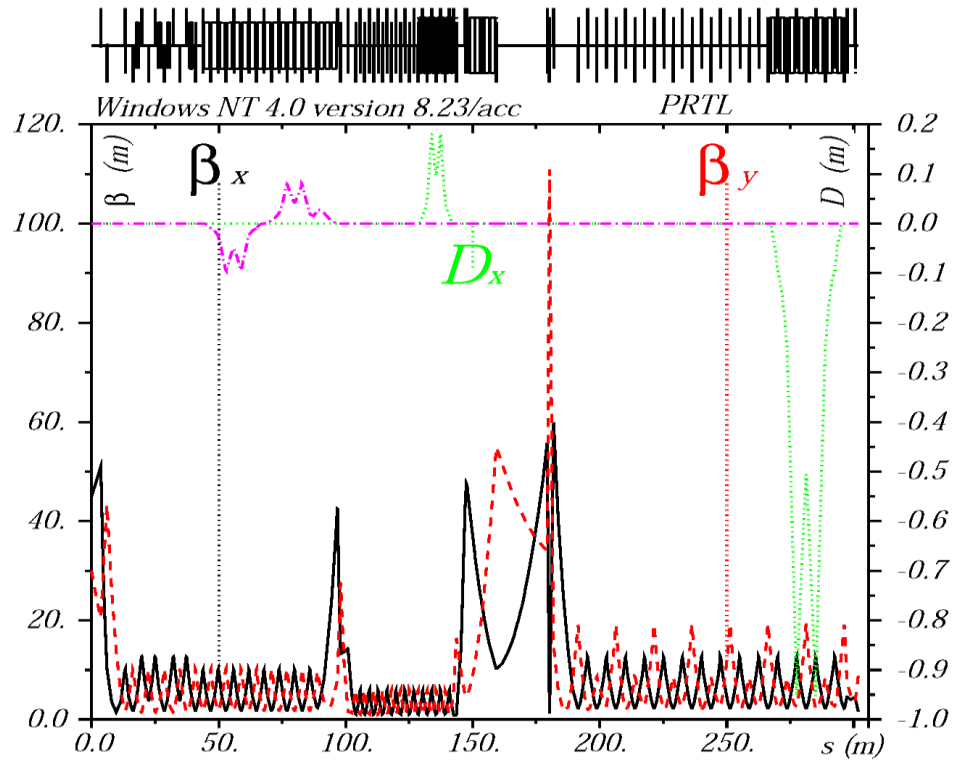
Courtesy of V. Kapin

Latest changes in central region (ERTL/PRTL)

Matching results with MAD8:



ERTL – electron line in central area

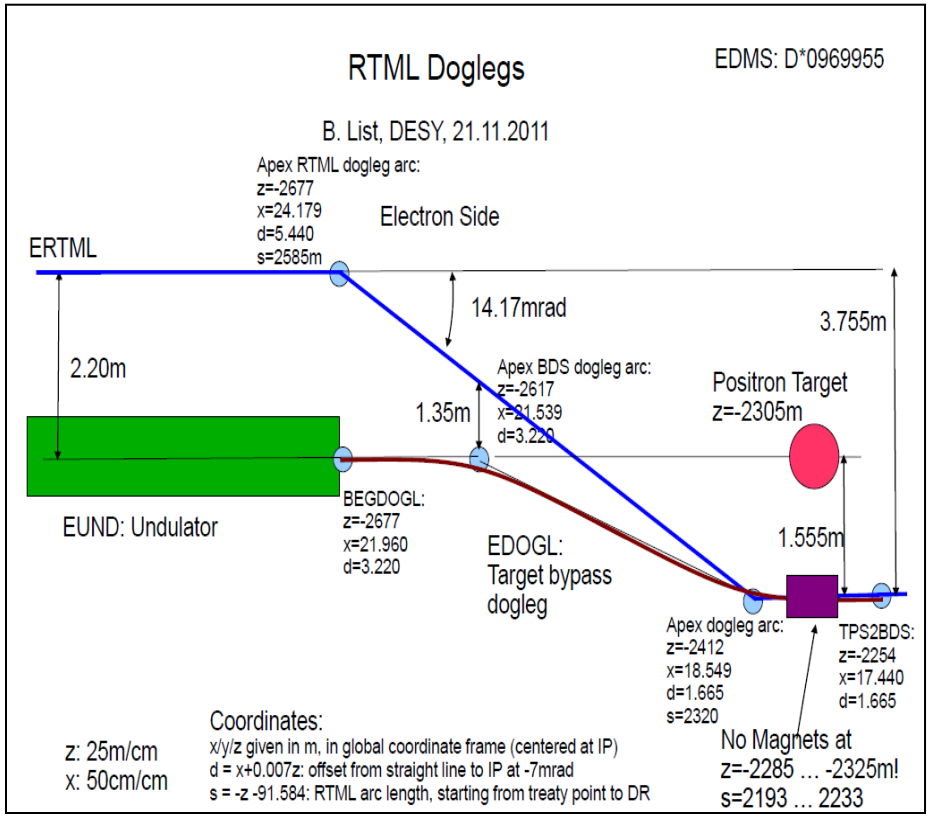


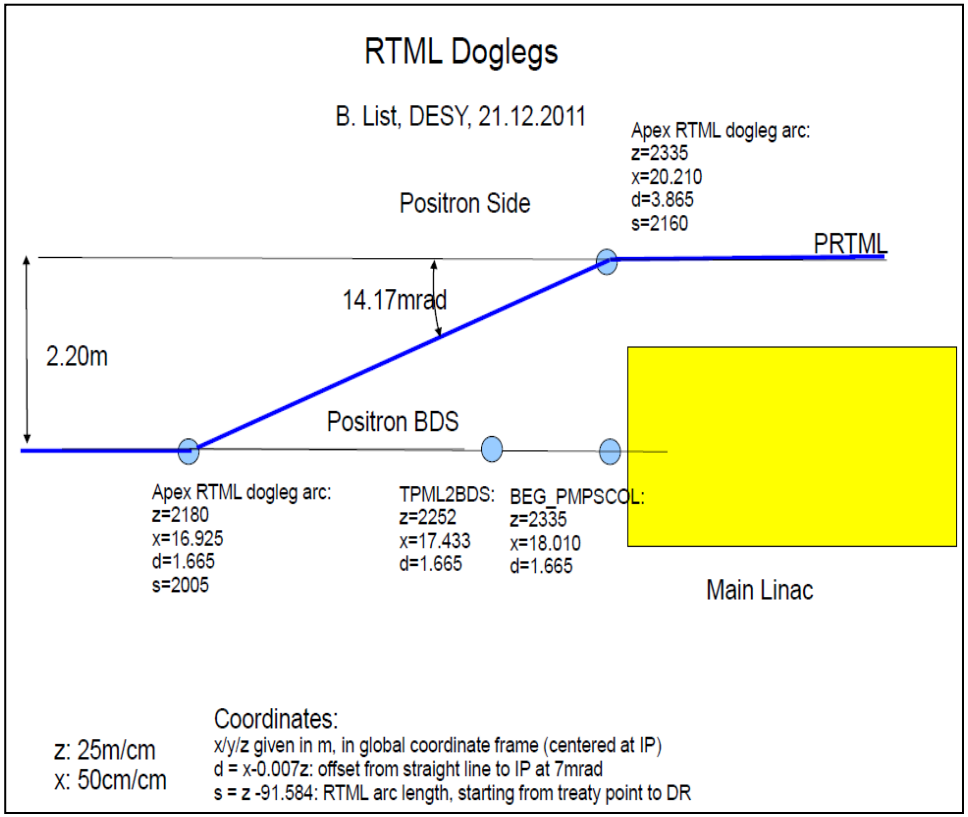
PRTL – positron line in central area

Courtesy of V. Kapin

Return Line Doglegs design (ELTL/PLTL)

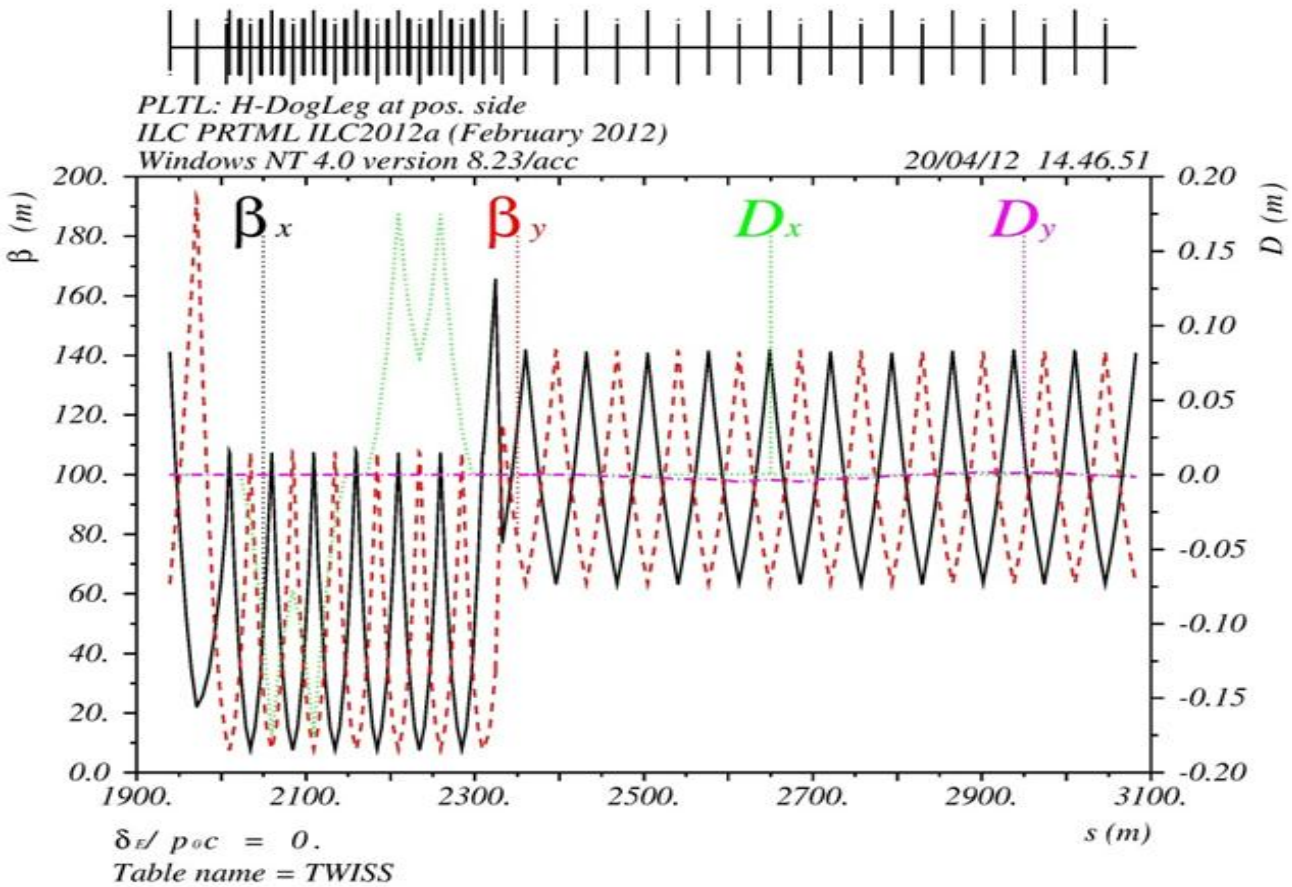
Geometry of the dog-leg defined in document EDMS: D*0969955





Return Line Doglegs design (2) (ELTL/PLTL)

Matching results with MAD8 for the ELTL/PLTL Dog-Legs:



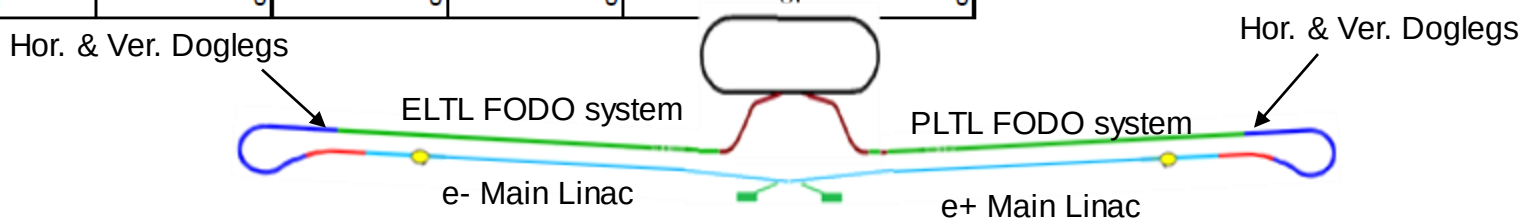
Courtesy of V. Kapin

ML Treaty points definition and matching

Treaty Point	TERTML2ML	TEML2PS	TPS2EBDS	TPRTML2ML	TPML2BDS
	Electron RTML to Main Linac	Electron Main Linac to Positron Source (Undulator Section)	Positron Source (Undulator Section) to Electron BDS	Positron RTML to Main Linac	Positron Main Linac to BDS
Geometry					
x [m]	104,5245011	26,540	17,440	94,62043163	17,433
y [m]	0	0	0	0	0
z [m]	-14471,78005	-3331,319	-2253,464	13279,10984	2252,514
ϑ [rad]	-0,0070	-0,0070	-0,0070	-3,1346	-3,1346
φ [rad]	0	0	0	0	0
ψ [rad]	0	0	0	0	0
d [m]	3,220	3,220	1,665	1,665	1,665
Optics Functions					
α_x [1]	-0,3137	-2,402	-2,402	-0,3137	-2,402
β_x [m]	100,94	51,33	51,33	100,94	51,33
η_x [m]	0	0	0	0	0
η'_x [1]	0	0	0	0	0
α_y [1]	0,6451	0,4888	0,4888	0,6451	0,4888
β_y [m]	51,47	9,395	9,395	51,47	9,395
η_y [m]	0	0	0	0	0
η'_y [1]	0	0	0	0	0

Main Linacs/RTML treaty points defined in document: D*0975575

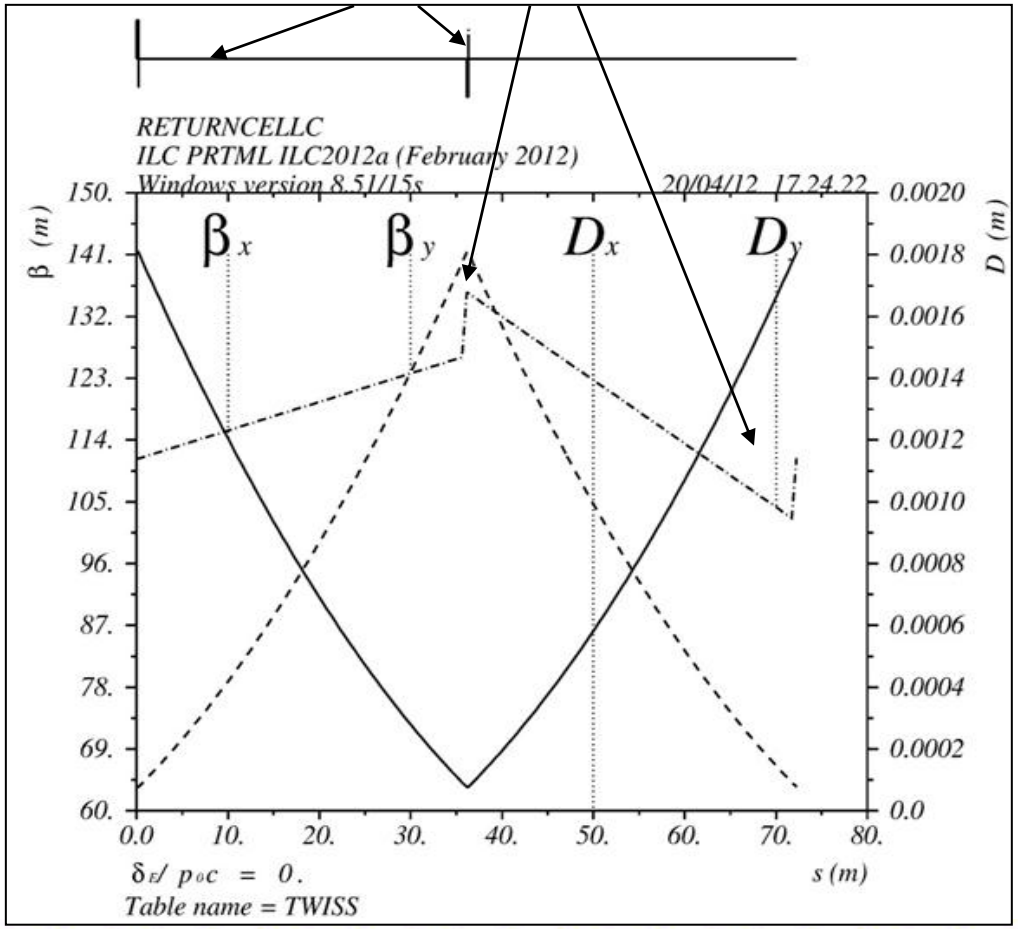
Geometrical matching of the 2 RTML beam lines is made by tuning the cell length of the Return Lines FODO system and the bending angles in the horizontal and vertical doglegs upstream the Turn Around



Earth curvature in Return Lines (ELTL/PLTL)

For Cryogenic requirements main linacs need to follow the curvature of the Earth.
Return lines are located in the same tunnel with ML's, then they need to be curved too.

Vertical correctors

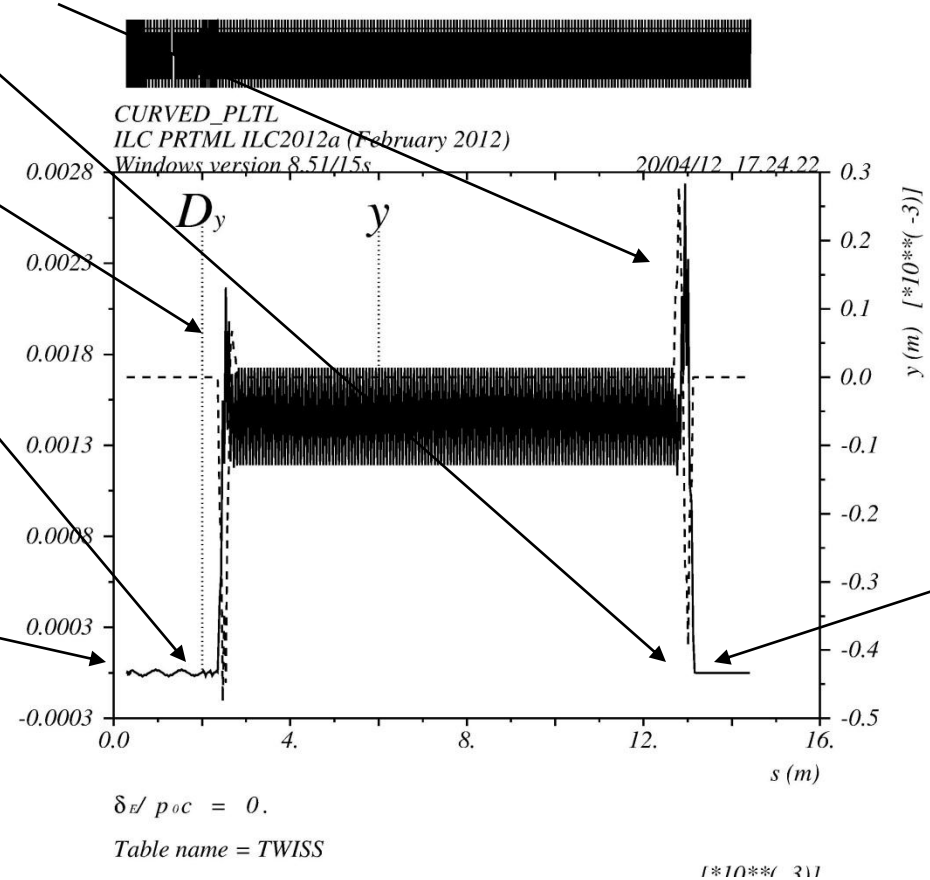


Geometric curvature of the beam lines are realized in MAD8 with combinations of VKICKERS and thin vertical BENDS. The beam orbit is curved by introducing vertical dipole correctors at each quadrupole of the FODO lattice, which create a small vertical dispersion. This is then matched to the straight lines by means of 4 vertical dipole correctors upstream and downstream the curved section.

Earth curvature in Return Lines (ELTL/PLTL)

MAD8_51 results for curved PLTL beam line:

Vertical correctors for dispersion matching

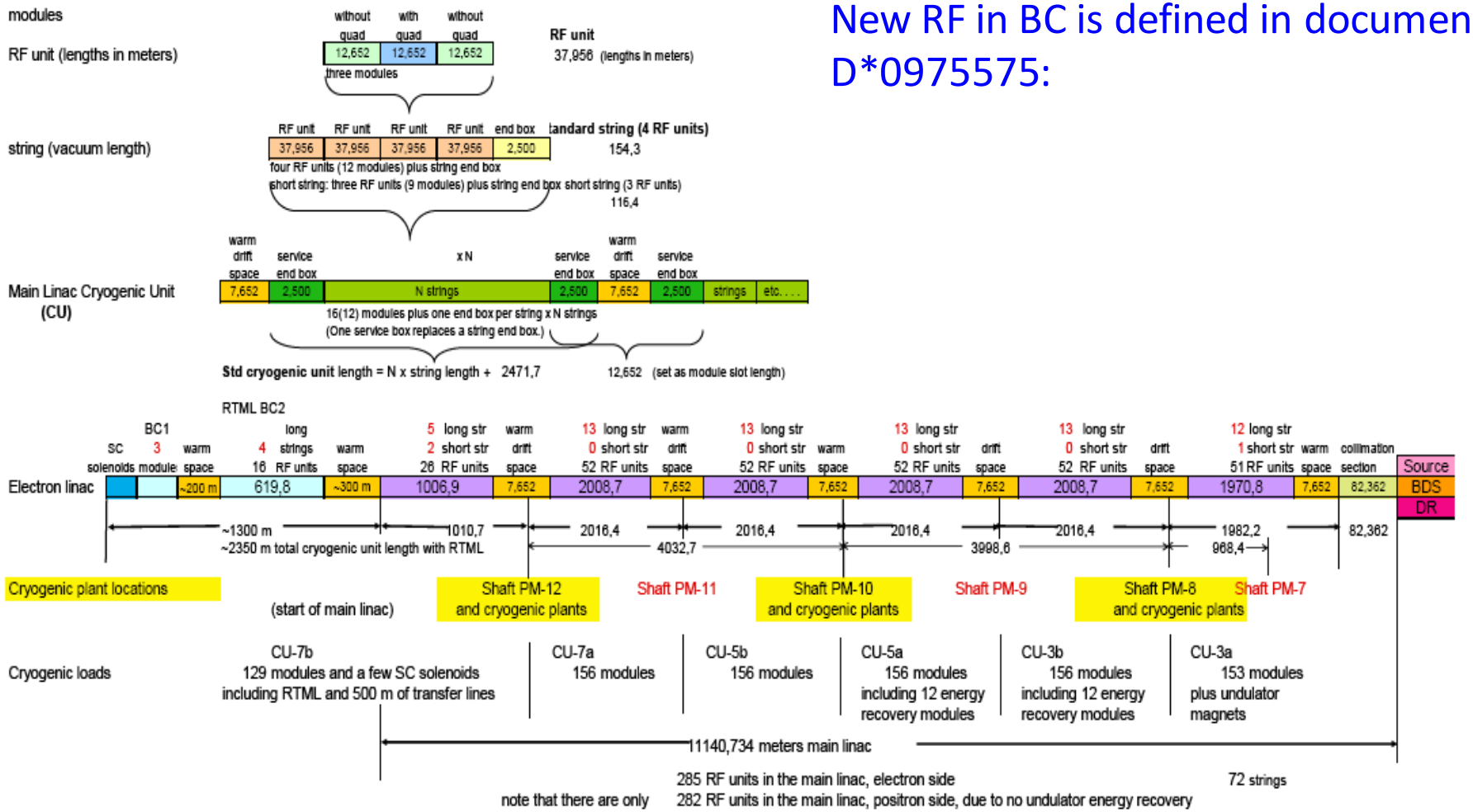


Straight line

Straight line

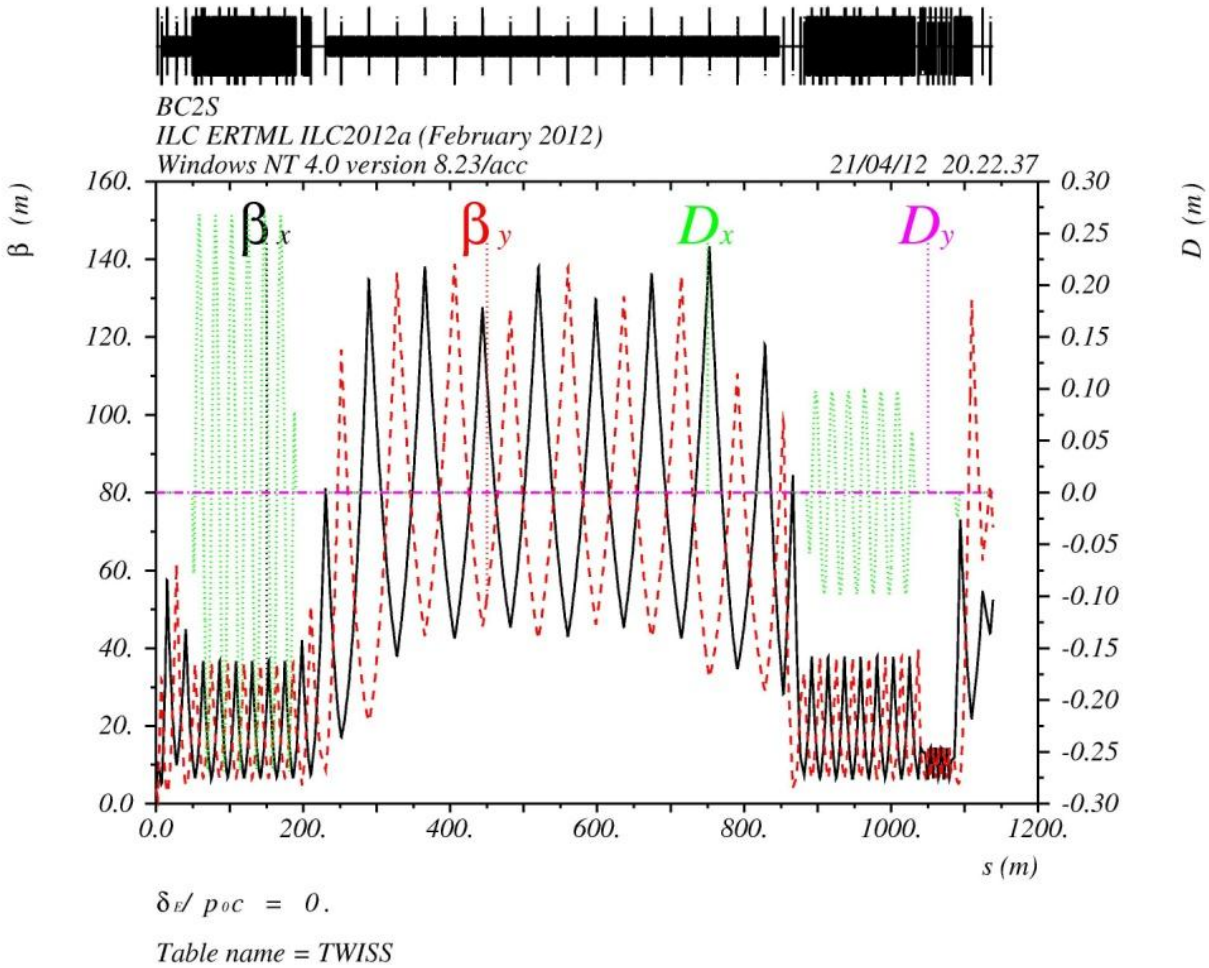
Latest changes in 2 stage Bunch Compressor

New RF in BC is defined in document D*0975575:



Latest changes in 2 stage Bunch Compressor

MAD8 results for 2 stage BC optics:



Simulations of 2 stage Bunch Compressor

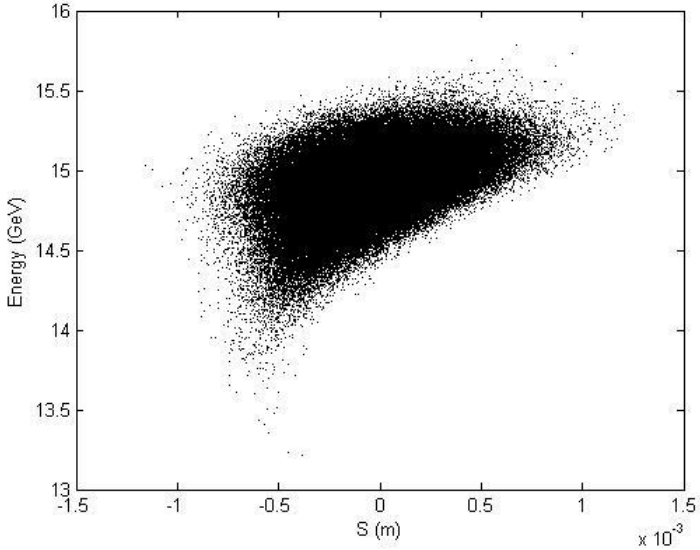
Initial beam			BC1 parameters		Beam after BC1			BC2 parameters		Final beam		
dp/p, % (@5 MeV)	σ_z, mm	E, MeV	A/-φ, MeV/ deg	R_{56}, mm	dp/p, %	σ_z, mm	E, MeV	A/-φ, MeV/ deg	R_{56}, mm	dp/p, % (@15 MeV)	σ_z, mm	E, MeV
0.109	6	5	465/ 115	372	1.42	0.878	4.8	11e3/ 24	55.1	1.126	0.299	14.85
0.122	6	5	465/ 115	372	1.42	0.902	4.8	11e3/ 25.3	55.1	1.17	0.3	14.75
0.134	6	5	465/ 115	372	1.42	0.92	4.8	11e3/ 27	55.1	1.23	0.296	14.6

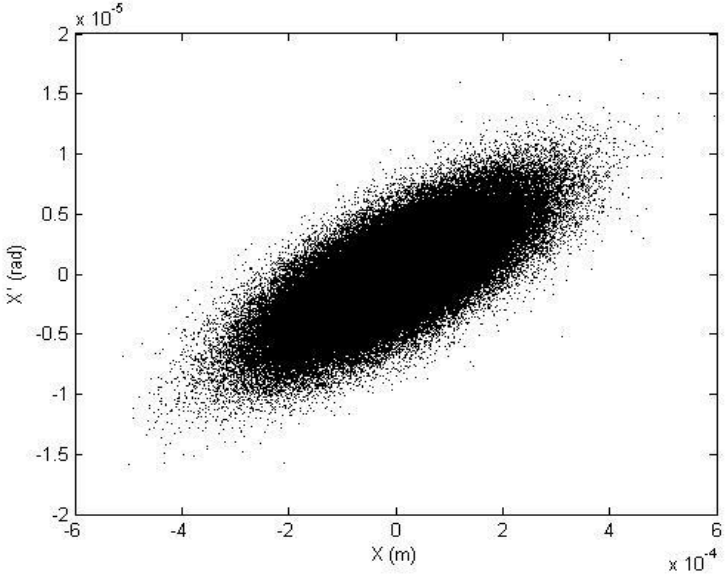
Simulation results by S. Seletskiy:

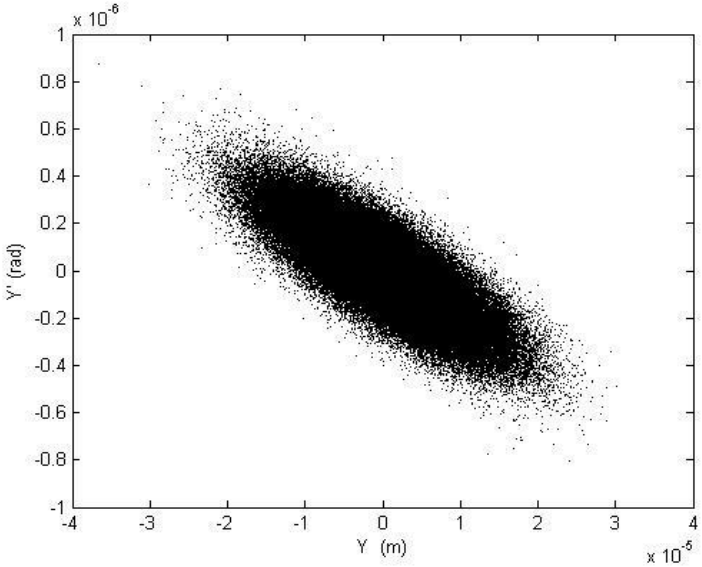
Lucretia Simulations of ILC 2-stage BC

Parameters:

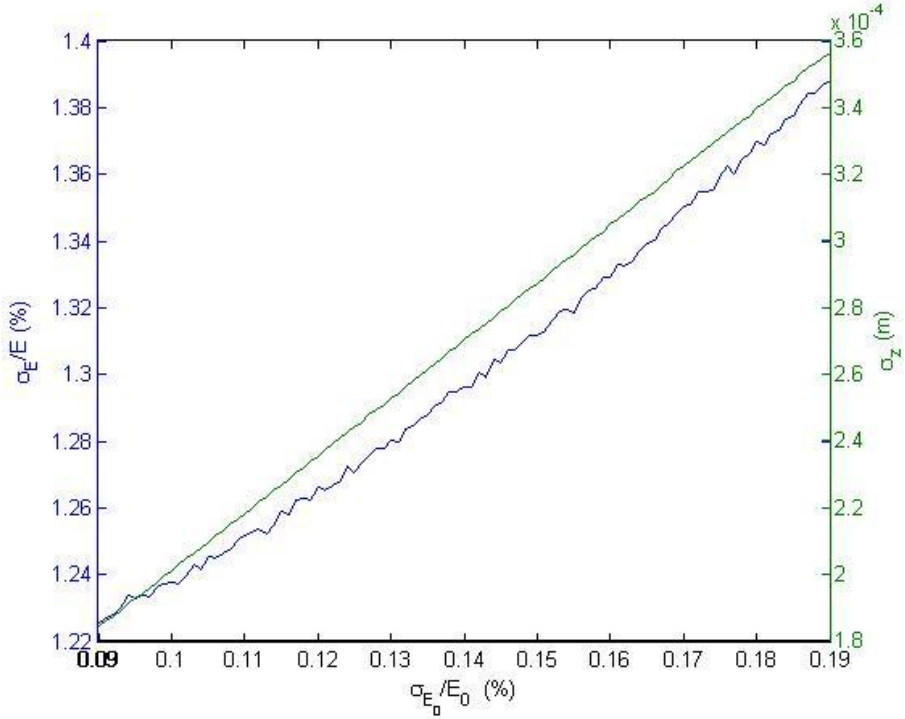
Initial Energy: 5 GeV
Initial Norm. Emittance (H/V): 8e-6/20e-9 m rad
Acc. Gradient (BC1/BC2): 18.7/27.1 MV/m
Total Voltage (BC1/BC2): 465/11700 MV
RF phase (BC1/BC2): -115/-30 deg
R_{56} (BC1/BC2): -375.8/-55.2 mm
Norm. Emittance Growth (H/V): <0.75/<2.0 %
Final Energy: 14.91 GeV

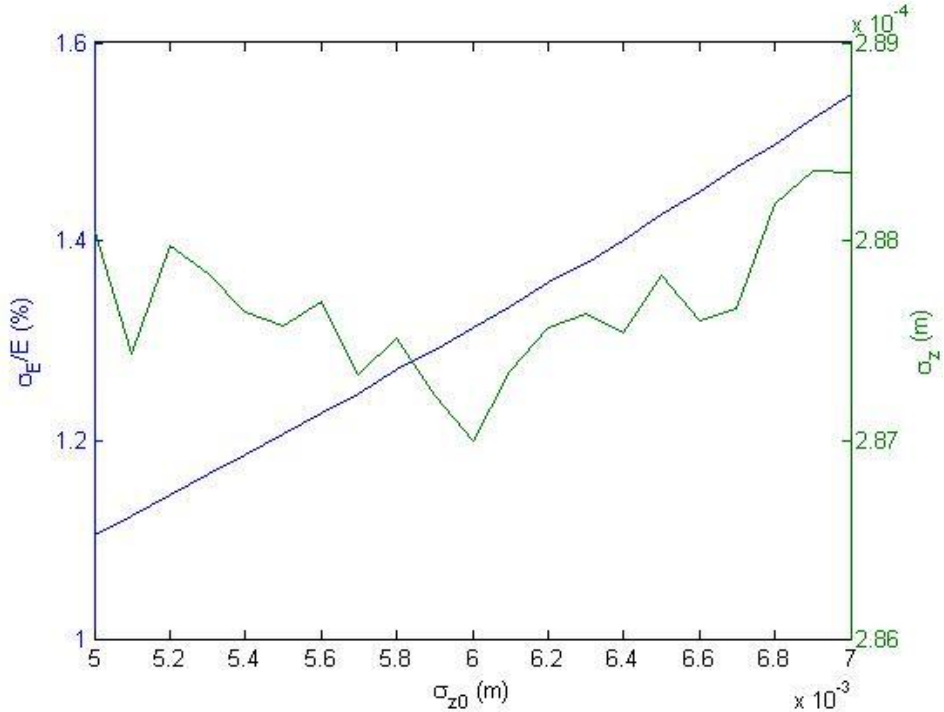






BC Performance for different initial energy spread and bunch length





Initial Bunch Length: 6.0 mm
Initial Energy Spread: 0.09 - 0.19 %
Final Bunch Length: 0.185 - 0.355 mm
Final Energy Spread: 1.22 - 1.39%

Initial Bunch Length: 5.0 – 7.0 mm
Initial Energy Spread: 0.15 %
Final Bunch Length: 0.287 - 0.2885 mm
Final Energy Spread: 1.11 - 1.54 %

Magnet count and Heat Load/Cost estimation

Magnet count and Heat & Power Load for RTML estimated with RDR parameters.

RTML (Ring-To-Main-Linac) DESIGN CRITERIA FOR CFS

MAR 14 2012

RTML Heat and Power Load (Totals RTML shown) 5HZ FULL POWER UPGRADE [CFS FACILITIES BASELINE]

HEAT LOAD to CFS	Total KW	rough location	Qty	Load to water-LCW				Load to Air	Beam tunnel Temperature	Notes
				KW heat load	LCW supply temperature (F)	Delta T (F)	or Flow (gpm)	KW heat load		
RTML components										
Magnets	** 931	beam	4651	838	90	20	286	93	104F (40C)	Qty and KW from P.Bellomo 5/9/2007. [SEP 3 2010, scale qty by ratio of 4000/4334). File/Email N. Solyak Aug 2011. [MAR 8 2012 meeting w Alessandro & Nikolay]
Cables	158	beam		106	90	N/A	N/A	52		P.Bellomo 5/9/2007. Aug 2011 CFS & NSolyak [MAR 8 2012 meeting w Alessandro & Nikolay]
Power supplies	168	caverns, Alcoves & Svc Tnl	TBD	156	90	N/A	N/A	12		P.Bellomo 5/9/2007. Aug 2011 CFS & NSolyak [MAR 8 2012 meeting w Alessandro & Nikolay]
RF for BC1	300	Alcove		270	90	45	41	30		Jul 14 2009 Nikolai & Marc (50% from RDR). Aug 2011 CFS&NSolyak + assume % to air + used RDR. [MAR 14 2012 Update from Alessandro]
RF for BC2 (32 RF)	3911	75% in svc tunl		3168	90	45	481	743.1		[MAR 8 2012 meeting w Alessandro & Nikolay]
Racks (32RF)	320	Servc Tunl		320	90	N/A	N/A	0		
Dumps *	0	beam		0	90	56	0	0		(RDR showed 250 KW each AL ball dump with 30 gpm] Jul 14 2009 Nikolai & Marc (50% from RDR)
	0	beam		0	90	56	0	0		from dump list 2009 - not used?
Total heat load for CFS	5788	4858						930		* (6) 220 KW dump are not used all the time

** =Magnet power calculated for nominal paramaters of lattice

POWER			LOAD DISTRIBUTION
Beam Power (from N.S.)	1427	KW	4% of rtml are located in LTR area (central region to DR)
Numbers from Table above	5788	KW	96% are in the rtml ends
TOTAL POWER operating	7.21	MW	

Yellow highlighted numbers are changes compared to the last version

RTML (Ring-To-Main-Linac) DESIGN CRITERIA FOR CFS

MAR 14 2012

RTML Heat and Power Load (Totals RTML shown) 5HZ LOW POWER [ILC BASELINE]

HEAT LOAD to CFS	Total KW	rough location	Qty	Load to water-LCW				Load to Air	Beam tunnel Temperature	Notes
				KW heat load	LCW supply temperature (F)	Delta T (F)	or Flow (gpm)	KW heat load		
RTML components										
Magnets	** 931	beam	4651	838	90	20	286	93	104F (40C)	Qty and KW from P.Bellomo 5/9/2007. [SEP 3 2010, scale qty by ratio of 4000/4334). File/Email N. Solyak Aug 2011. [MAR 8 2012 meeting w Alessandro & Nikolay]
Cables	158	beam		106	90	N/A	N/A	52		P.Bellomo 5/9/2007. Aug 2011 CFS & NSolyak [MAR 8 2012 meeting w Alessandro & Nikolay]
Power supplies	168	caverns, Alcoves & Svc Tnl	TBD	156	90	N/A	N/A	12		P.Bellomo 5/9/2007. Aug 2011 CFS & NSolyak [MAR 8 2012 meeting w Alessandro & Nikolay]
RF for BC1	250	Alcove		225	90	45	34	25		Jul 14 2009 Nikolai & Marc (50% from RDR). Aug 2011 CFS&NSolyak + assume % to air + used RDR. [MAR 14 2012 Update from Alessandro]
RF for BC2 (32 RF)	2585	75% in svc tunl		2094	90	45	318	491		[MAR 8 2012 meeting w Alessandro & Nikolay]
Racks (32RF)	320	Servc Tunl		320	90	N/A	N/A	0		
Dumps *	0	beam		0	90	56	0	0		(RDR showed 250 KW each AL ball dump with 30 gpm] Jul 14 2009 Nikolai & Marc (50% from RDR)
	0	beam		0	90	56	0	0		from dump list 2009 - not used?
Total heat load for CFS	4412			3739				673		* (6) 220 KW dump are not used all the time

** =Magnet power calculated for nominal paramaters of lattice

POWER			LOAD DISTRIBUTION
Beam Power (from N.S.)	941	KW	4% of rtml are located in LTR area (central region to DR)
Numbers from Table above	4412	KW	96% are in the rtml ends
TOTAL POWER operating	5.4	MW	

Magnet count and Heat Load/Cost estimation

Cost for RTML magnets & PS estimated using RDR data.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1					Magnet Parameters, April 13, 2012																						
2																											
3	Name	Count 2 RTML	Type	Int.Str. T,Tr	MaxG,B	Lefm,m	Xgap	YGap	Bpole, T	Iw/pole,A	I,A	Wc	Lcu,m	qcu,mm^2	Vcu,m3	mcu/mag,tc	Mcu,tons	Rw,Ohm	U,V	P,W	Ctool,k$	Cmag, $	Cstand,$	Cmts,k$	Cmt,k$	Cn,k$	Comments
4	DC Quadrupoles																										
5	QRTML1	8	Q20L100	0,400	4,000	0,1	0,02	0,02	0,040	1,67E+02	2	84	96	1	9,631E-05	0,0008571	0,006857	1,93	3,9	8	25	3000	3000	31,0	28,0	73	The same dye
6	QRTML2	1526	Q20L200	17,520	87,600	0,2	0,02	0,02	0,876	3,66E+03	20	183	387	10	0,0038667	0,0344134	52,514862	0,77	15,5	309	40	5000	3000	48,0	45,0	12248	The same dye
7	QRTML3	0	Q20L400	6,650	16,625	0,4	0,02	0,02	0,166	6,95E+02	20	35	140	10	0,0014009	0,0124684	0	0,28	5,6	112	40	8000	3000	51,0	48,0	40	The same dye
8	QRTML4	0	Q20L800	13,300	16,625	0,8	0,02	0,02	0,166	6,95E+02	20	35	276	10	0,0027552	0,0245213	0	0,55	11,0	220	40	12000	3000	55,0	52,0	40	The same dye
9	QRTML5	36	Q60L200	3,714	18,570	0,2	0,06	0,06	0,557	6,99E+03	200	35	87	50	0,0043592	0,038797	1,3966937	0,03	7,0	1395	40	15000	3000	58,0	55,0	688	
10	SC Quadrupoles																										
11	QRTML6	38	QSC80L200	2,430	12,150	0,2	0,08	0,08	0,486	8,13E+03	50	163	SC	SC	SC	SC	SC	SC	SC	SC	200	50000	3000	253,0	250,0	2214	
12	DC Dipoles																										
13	DRTML1	0	D25L400	0,028	0,070	0,4	0,025	0,025	0,070	7,31E+02	50	15	16	12,5	0,0001975	0,0017578	0	0,03	1,3	63	40	5000	3000	48,0	45,0	40	
14	DRTML2	55	D25L900V1	1,060	1,178	0,9	0,025	0,025	1,178	1,23E+04	50	246	561	12,5	0,0070153	0,0624364	3,4340023	0,90	44,9	2245	40	10000	4000	54,0	50,0	810	FNAL Cost at 5(
15	DRTML3	192	D25L900V2	0,904	1,004	0,9	0,4	0,025	1,004	1,05E+04	50	210	668	12,5	0,0083445	0,0742665	14,259161	1,07	53,4	2670	40	40000	4000	84,0	80,0	8488	
16	DRTML4	192	D25L900V3	0,650	0,722	0,9	0,1	0,025	0,722	7,55E+03	50	151	371	12,5	0,0046415	0,0413091	7,9313455	0,59	29,7	1485	40	30000	4000	74,0	70,0	6568	
17	DRTML5	20	D25L1600	0,625	0,391	1,6	0,025	0,025	0,391	4,08E+03	50	82	323	12,5	0,0040411	0,0359662	0,7193246	0,52	25,9	1293	60	30000	4000	94,0	90,0	740	The same dye
18	DRTML6	0	D25L1800	1,400	0,778	1,8	0,025	0,025	0,778	8,13E+03	50	163	722	12,5	0,0090217	0,0802931	0	1,15	57,7	2887	60	40000	4000	104,0	100,0	60	The same dye
19	DRTML7	16	D25L1900	1,795	0,945	1,9	0,025	0,025	0,945	9,87E+03	50	271	1528	12,5	0,0190946	0,1699422	2,7190747	2,44	122,2	6110	60	45000	4000	109,0	105,0	844	The same dye
20	DRTML8	219	D25L2300	1,823	0,793	2,3	0,025	0,025	0,793	8,28E+03	50	271	1267	12,5	0,0158406	0,1409815	30,874946	2,03	101,4	5069	60	50000	4000	114,0	110,0	11886	The same dye
21																											
22	DC RT Correctors																										
23	DCRTML1	2283	D20L50	0,053	1,050	0,05	0,02	0,02	1,050	8,78E+03	5	1756	379	2,5	0,000948	0,0084373	19,262322	3,03	15,2	76	25	3000	3000	31,0	28,0	13723	
24																											
25	DC SC Correctors																										
26	DCRTML2	58	DSC80L200	0,0073	0,037	0,2	0,08	0,08	0,037	1,22E+03	100	12	11	SC	SC	SC	SC	SC	SC	SC	40	20000	3000	63,0	60,0	1374	
27																											
28	SC Solenoids																										
29	SLRTML1	8	SLSC20L2600	13,099	4,999	2,62	0,02	0,02	4,999	4,02E+06	4000	1005	221	SC	SC	SC	SC	SC	SC	SC	200	200000	5000	405,0	400,0	1840	
30																											
31	Total	4651														Total Cu,to	133,1				Total cost, k$					61676	
32																											

Summary and outlook

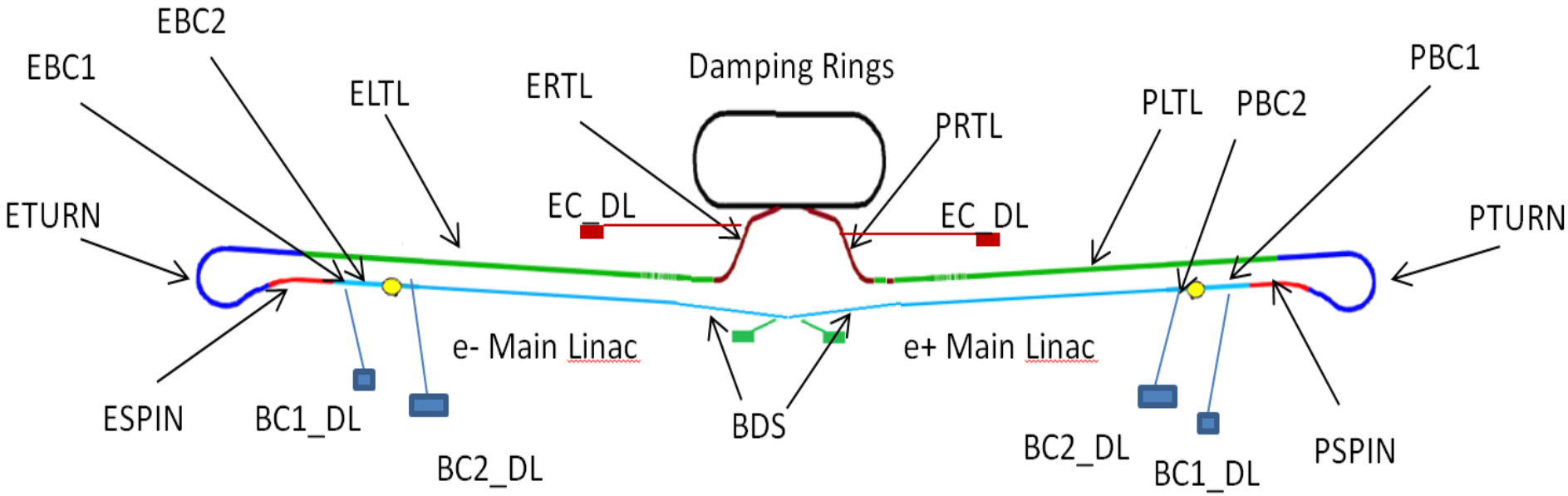
- Central region, return lines and Bunch Compressor have been designed according to specifications.
- Earth curvature in return lines have been designed.
- Geometrical matching of DR/ML Treaty points have been performed, optics matching almost done.
- Simulations of BC have been performed with good results.
- Magnet count and Heat Load/Cost estimations almost completed.

Thanks for your attention.

BACK UP SLIDES

Layout

RTML LAYOUT



	Length in TDR (m)	Length in RDR (m)	Δs (m)
ERTML	17 140.844	16 171.529	919.315
PRTML	15 948.136	14 791.983	1 156.153

- Lines EC_DL and BC1_DL have same lattice design.