

# Status of RTML design in TDR configuration

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Fermilab



- 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





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## Latest changes in central region (ERTL/PRTL) **Fermilab**

#### • Beam lines geometry in global coordinate defined in document EDMS D\*0969765

Tunnel         Description         Parameter         Value         Description         Parameter         Value           Positon DR Exit (Center of Septum)         x(m)         100.000 (center of Septum)         Electron DR Entrance (center of Septum)         x(m)         10           Positon Extraction Line Bend (Center of Bend)         x(m)         97.114         Electron DR Entrance (center of Septum)         x(m)         65.192           Positon Extraction Treaty Point (Center of Bend)         x(m)         94.410         Electron Injection Treaty Point x(m)         x(m)         65.192           Positon Extraction Treaty Point End of DR Extraction Treaty Point X(m)         y(m)         0.350         Start of DR lectron Source Line y(m)         x(m)         61.11           Start of Positon RTML Line and of Section B Straight         x(m)         63.851         Start of Section B Straight         x(m)         61.11           Line Angle         q(rod)         1.81.50         Ine Angle         q(rod)         1.81.50           Q         Start of Arc         x(m)         63.851         Start of Section B Straight         x(m)         62.92           V(m)         1.850         z(m)         2.31.862         End of Arc         x(m)         62.92           Q         Start of Arc         x(m)         63.831	
Positron DR Exit (Center of Septum)         x(m)         100.000 y(m)         Electron DR Entrance z(m)         x(m)         100 y(m)           Positron Extraction Line Bend (Center of Bend)         x(m)         97.114 (Center of Septum)         Electron DR Entrance x(m)         x(m)         100.000 z(m)         Z(m)         200 y(m)           Positron Extraction Line Bend (Center of Bend)         y(m)         0.350 z(m)         Center of Septum)         y(m)         100.000 y(m)         Z(m)         100.000 y(m)         100.000 y(m)         100.000 y(m)         Z(m)         100.000 y(m)         100.000	
Verticity         Vertical (Center of Septum)         Vertican (Center of Septum)         Vertical (Center	00.000
Z(m)         75:590         Z(m)         Z(m) <thz(m)< th="">         Z(m)         <thz(m)< th=""> <th< td=""><td>1.650</td></th<></thz(m)<></thz(m)<>	1.650
Open         Positron Extraction Line Bend (Center of Bend)         x(m)         97.114 (Positron Extraction Treaty Point x(m)         Electron IDR Entrance y(m)         x(m)         100 (Positron Extraction Treaty Point x(m)         x(m)         100 (Positron Extraction Treaty Point x(m)         x(m)         100 (Positron Extraction Treaty Point x(m)         x(m)         96.192 (Positron Extraction Treaty Point x(m)         x(m)         92.100 (Positron Extraction Treaty Point X(m)         111 (Positron Extraction Treaty Point X(m)         112 (Positron Extreaty Extraction Extraction Ex	80.700
Up         Up         0.350 Z(m)         Center of Septum) Z(m)         y(m)         Z(m)         Z	97.113
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	1.650
O         Positron Extraction Treaty Point x(m)         94.410         Electron Injection Treaty Point x(m)         x	01.307
End of DR Extraction Line z(m)         y(m) 106.988         Start of DR Injection Line z(m)         y(m) 11           Positron Extraction Treaty Point Start of Positron RTML Line the Length Line Length Line Length Line Angle         y(m) 106.988         End of Electron Source Line z(m)         x(m) 11           CO         End of Section B Straight V(m)         y(m) 128.559         Line Length Line Angle (red)         L(m) 128.559         Line Length Line Angle (red)         L(m) 128.559         X(m) 128.559         X(m)	94.410
Image: Second	1.650
Positron Extraction Treaty Point x(m)         94.410 y(m)         Electron Injection Treaty Point End of Electron Source Line z(m)         x(m)         5           Start of Positron RTML Line Line Length         L(m)         106.988         End of Electron Source Line z(m)         z(m)         111           Line Length         L(m)         128.558         Line Length         L(m)         112           End of Section B Straight         x(m)         63.851         Start of Section B Straight         x(m)         62           Y(m)         1.650         y(m)         231.862         z(m)         232           Arc Angle         (frad)         0.168         Arc Angle         (frad)         231.862           Arc Angle         (frad)         0.168         Arc Angle         (frad)         233           Arc Angle         (frad)         0.168         Arc Angle         (frad)         233           Arc Angle         (frad)         0.168         Arc Angle         (frad)         233           Arc Length         S(m)         14.053         Arc Length         S(m)         14         14           Ine Length         (frad)         0.168         Arc Angle         (frad)         17         24           Y(m)         1.650<	12.103
Construct RTML Line         y(m)         0.350         End of Electron Source Line         y(m)         111           Line Length         L(m)         128.558         Line Length         L(m)         112           Line Angle         q(rad)         1.811         Line Angle         q(rad)         112           End of Section B Straight         x(m)         63.851         Start of Section B Straight         x(m)         6           y(m)         1.650         z(m)         231.862         z(m)         233           Arc Angle         q(rad)         0.168         Arc Angle         q(rad)         2(m)         233           Arc Angle         q(rad)         0.688         Arc Angle         q(rad)         0.68         Arc Angle         q(rad)         0.68           Arc Angle         q(rad)         0.688         Arc Angle         q(rad)         0.68         Arc Angle         q(rad)         0.68           Arc Angle         q(rad)         0.688         Arc Angle         q(rad)         0.68         Arc Angle         q(rad)         0.69           Q(m)         14.053         Arc Length         y(m)         1.650         z(m)         245           End of Arc         x(m)         59.381	94.410
Vinite         Z(m)         106.988         Z(m)         111           Line Length         L(m)         128.558         Line Length         L(m)         12           End of Section B Straight         X(m)         63.851         Start of Section B Straight         X(m)         6           Y(m)         1.650         Y(m)         1.650         Y(m)         23           Start of Arc         X(m)         63.851         End of Arc         X(m)         6           Y(m)         1.650         Y(m)         23         2         7         23           Arc Angle         q(rad)         0.168         Arc Angle         q(rad)         2         3           Arc Radius         R(m)         83.500         Arc Radius         R(m)         6           Arc Length         S(m)         14.053         Arc Length         S(m)         7           End of Arc         X(m)         59.381         Start of Arc         X(m)         6           Y(m)         1.650         Y(m)         2         2         2         2         2         2         2         2         2         2         2         2         2         2         2         2         2	1.650
Open         Line Length Line Angle         L(m)         128.558 (rad)         Line Length Line Angle         L(m)         12           End of Section B Straight         x(m)         63.851 (y(m)         Start of Section B Straight         x(m)         66           Y(m)         1.650 (z(m)         231.862         Z(m)         225           Start of Arc         x(m)         63.851 (z(m)         End of Arc         x(m)         66           Y(m)         1.650 (z(m)         231.862         Z(m)         233         Z(m)         233           Arc Angle         q(rad)         0.168 (rad)         Arc Angle         q(rad)         231.862         Z(m)         233           Arc Angle         q(rad)         0.168 (rad)         Arc Angle         q(rad)         233           Arc Length         X(m)         14.053 (rad)         Arc Radius         R(m)         233           Arc Length         X(m)         14.050 (rad)         Arc Length         X(m)         243           End of Arc         X(m)         59.381 (rad of Section D Straight         X(m)         243           Y(m)         1.650 (rad)         Z(m)         245.167         Z(m)         244           Line Length         L(m)         1.1650 (rad)<	12.103
Line Angle         q(rad)         1.811         Line Angle         q(rad)           End of Section B Straight         x(m)         63.851         Start of Section B Straight         x(m)         6           y(m)         1.650         z(m)         231.862         z(m)         23           Start of Arc         x(m)         6.63.851         End of Arc         x(m)         6           y(m)         1.650         y(m)         231.862         z(m)         23           Arc Angle         q(rad)         0.168         Arc Angle         q(rad)         24           Arc Angle         q(rad)         0.168         Arc Angle         q(rad)         26           Arc Length         S(m)         14.063         Arc Length         S(m)         7           End of Arc         x(m)         59.381         Start of Arc         x(m)         6           y(m)         1.650         y(m)         2(m)         24         x(m)         6           y(m)         1.650         y(m)         2(m)         24         x(m)         6           y(m)         1.650         y(m)         2(m)         24         y(m)         2(m)         24           Q(m)         2(m)<	23.590
Ope         End of Section B Straight         x(m)         63.861 (y(m)         Start of Section B Straight (y(m))         x(m)         (e           V(m)         1.650 (z(m))         231.862         Z(m)         22           Start of Arc         x(m)         63.861         End of Arc         x(m)         26           V(m)         1.650 (z(m))         231.862         Z(m)         22         2(m)         22           Arc Angle         q(rad)         0.168         Arc Angle         q(rad)         2(m)         22           Arc Radius         R(m)         83.500         Arc Radius         R(m)         83         2(m)         2(m)           Arc Length         S(m)         14.053         Arc Length         S(m)         1           End of Arc         x(m)         59.381         Start of Arc         x(m)         2(m)           Z(m)         245.167         Z(m)         24         2(m)         24           Y(m)         1.650         Y(m)         12         2(m)         24           Y(m)         1.650         Z(m)         24         24         24           Y(m)         1.650         Z(m)         24         24         2(m)         24 <td>1.811</td>	1.811
O         y(m)         1.650 z(m)         y(m)         z(m)         231.862 z(m)         z(m)         241.862 z(m)         z(m)         242.867 z(m)         z(m)         242.867 z(m)         z(m)         242.867 z(m)         z(m)         242.867 z(m)         z(m)         242.867 z(m)         z(m)         242.867 z(m)         261.866	65.032
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	0.000
Start of Arc         x(m)         63.851 (y(m)         End of Arc         x(m)         6 (x(m)           Arc Angle         (frad)         0.168 (rad)         Arc Angle         (frad)         231.862           Arc Angle         (frad)         0.168 (rad)         Arc Angle         (frad)         231.862           Arc Radius         R(m)         83.500 (rad)         Arc Radius         R(m)         26           Arc Length         S(m)         14.053 (rad)         Arc Length         S(m)         1           End of Arc         x(m)         59.381 (rad)         Start of Arc         x(m)         6           y(m)         1.650 (rm)         2(m)         245.167         z(m)         24           Line Length         L(m)         123.595 (rad)         Line Length         L(m)         12           Line Length         L(m)         123.595 (rad)         Line Length         L(m)         12           Line Angle         (frad)         1.979 (rad)         1.979         Line Angle         (frad)         1.979           Um         5         2(m)         358.602         z(m)         35         2(m)         35           Um         10.307         Start of Arc         x(m)         10.30	32.151
Vini         1.650 z(m)         y(m)         231.862 z(m)         y(m)         225 z(m)           Arc Angle         (frad)         0.168 Arc Radius         Arc Angle         (frad)         231.862           Arc Radius         R(m)         83.500 Arc Radius         Arc Radius         R(m)         26           Arc Length         S(m)         14.053 Arc Length         S(m)         14.053 Arc Length         S(m)         16           End of Arc         x(m)         59.381 y(m)         Start of Arc         x(m)         24           V(m)         1.650 z(m)         245.167         z(m)         24           Line Length         x(m)         59.381 y(m)         End of Section D Straight         x(m)         6           V(m)         1.650 z(m)         245.167         z(m)         24           Line Length         Lime Angle         q(rad)         1.979         Line Angle         q(rad)         12           Line Angle         Q(rad)         1.979         Line Angle         Q(rad)         12           Vm)         1.650 z(m)         358         Line Angle         Q(rad)         11           Vm)         1.650 z(m)         358         Z(m)         358         2 <td< td=""><td>65.032</td></td<>	65.032
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	0.000
Arc Angle         q(rad)         0.168         Arc Angle         q(rad)           Arc Radius         R(m)         83.500         Arc Radius         R(m)         8           Arc Radius         R(m)         14.053         Arc Radius         R(m)         8           Arc Length         S(m)         14.053         Arc Length         S(m)         1           End of Arc         x(m)         59.381         Start of Arc         x(m)         6           y(m)         1.650         z(m)         245.167         z(m)         24           Q         Start of Section D Straight         x(m)         1.650         y(m)         2           z(m)         245.167         z(m)         24         2         2         2         2         2         2         3	32.151
Oto         Arc Radius         R(m)         83.500         Arc Radius         R(m)         6           Arc Length         S(m)         14.053         Arc Length         S(m)         14.053         Arc Length         S(m)         17           End of Arc         x(m)         59.381         Start of Arc         x(m)         6         y(m)         24           Y(m)         1.650         z(m)         245.167         z(m)         24           X(m)         59.381         End of Section D Straight         x(m)         6           y(m)         1.650         z(m)         245.167         z(m)         24           Line Length         L(m)         123.595         Line Length         L(m)         12           Line Length         L(m)         123.595         Line Length         L(m)         12           Line Angle         q(rad)         1.979         Line Angle         q(rad)         12           End of Section D Straight         x(m)         10.307         Start of Arc         x(m)         16           y(m)         1.650         z(m)         358.602         z(m)         358         2           Arc Angle         q(rad)         0.415         Arc Angle	0.168
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	84,716
O         End of Arc         x(m)         59.381 y(m)         Start of Arc         x(m)         6 y(m)           V(m)         1.650 z(m)         245.167         z(m)         24           V(m)         1.650 z(m)         245.167         z(m)         24           V(m)         1.650 z(m)         245.167         z(m)         24           Line Length         L(m)         123.595 (r)         Line Length         L(m)         12           Line Length         L(m)         12.355 (r)         Line Length         L(m)         12           Line Angle         q(rad)         1.979         Start of Section D Straight         x(m)         12           Y(m)         1.650 z(m)         358.602         z(m)         35           Start of Arc         x(m)         10.307 y(m)         End of Arc         x(m)         1           Y(m)         1.650 z(m)         358.602         z(m)         35         35           Arc Angle         q(rad)         0.415         Arc Angle         q(rad)         35           Arc Angle         q(rad)         0.415         Arc Angle         q(rad)         35           Arc Angle         q(rad)         0.415         Arc Angle         q(rad)	14.258
Vin         1.650 z(m)         y(m)         245.167 z(m)         y(m)         244           Start of Section D Straight         x(m)         59.381 y(m)         End of Section D Straight y(m)         x(m)         69.381 y(m)           Line Length         L(m)         123.595 (rod)         Line Length         L(m)         123.595 (rod)           Line Length         L(m)         123.595 (rod)         Line Length         L(m)         12           Line Angle         q(rod)         1.979 (rod)         Start of Section D Straight         x(m)         12           Start of Section D Straight         x(m)         10.307 y(m)         Start of Arc         x(m)         16           Z(m)         358.602 z(m)         2         Z(m)         358         2         Z(m)         35           Arc Angle         q(rad)         0.415 z(m)         Arc Angle         q(rod)         2         35           Arc Angle         q(rad)         0.415 z(m)         Arc Angle         q(rod)         35           Arc Angle         q(rad)         0.415 z(m)         Arc Angle         q(rod)         35           Arc Angle         q(rod)         0.415 z(m)         Arc Angle         q(rod)         35           Arc Angle         q	60.497
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	0.000
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	45.650
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	60.497
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	0.000
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	45.650
Line Angle         (frad)         1.979         Line Angle         (frad)           End of Section D Straight         x(m)         10.307         Start of Section D Straight         x(m)         y(m)           y(m)         1.650         z(m)         358.602         z(m)         35           Start of Arc         x(m)         10.307         End of Arc         x(m)         1           y(m)         1.650         z(m)         358.602         z(m)         35           X(m)         10.307         End of Arc         x(m)         1         1           y(m)         1.650         y(m)         1         1         1         1           Z(m)         358.602         z(m)         358         3         1         1         1           Z(m)         358.602         z(m)         358         3         2         1         3	23.595
U         End of Section D Straight         x(m)         10.307         Start of Section D Straight         x(m)         y(m)         x(m)         x(m)         y(m)         x(m)	1.979
Vinite         1.650         y(m)           y(m)         1.650         z(m)         358.602           z(m)         358.602         z(m)         35           y(m)         1.650         z(m)         35           y(m)         1.650         z(m)         35           z(m)         358.602         z(m)         35           Arc Angle         q(rad)         0.415         Arc Angle         q(rad)           Arc Radius         R(m)         72.130         Arc Radius         R(m)         6           Arc Length         S(m)         29.956         Arc Length         S(m)         2           End of Arc         x(m)         4.380         Start of Arc         x(m)         y(m)	11.423
Z(m)         358.602         Z(m)         35           U         Z(m)         358.602         Z(m)         35           V         Y(m)         10.307         End of Arc         X(m)         Y(m)           Z(m)         358.602         Z(m)         355         Z(m)         355           Arc Angle         Q(rad)         0.415         Arc Angle         Q(rad)         Q(rad)           Arc Radius         R(m)         72.130         Arc Radius         R(m)         26           Arc Length         S(m)         29.956         Arc Length         S(m)         Z           End of Arc         X(m)         4.380         Start of Arc         X(m)         Y(m)	0.000
Start of Arc         x(m)         10.307         End of Arc         x(m)         y(m)           U         2(m)         358.602         z(m)         358.602         z(m)         358.602           Arc Angle         q(rad)         0.415         Arc Angle         q(rad)         4rc Radius         q(rad)         4rc Radius         R(m)         6           Arc Length         S(m)         29.956         Arc Length         S(m)         29.956           End of Arc         x(m)         4.380         Start of Arc         x(m)         y(m)	59.085
U         y(m)         1.650         y(m)           z(m)         358.602         z(m)         35           Arc Angle         q(rad)         0.415         Arc Angle         q(rad)           Arc Radius         R(m)         72.130         Arc Radius         R(m)         6           Arc Length         S(m)         29.956         Arc Length         S(m)         2           End of Arc         x(m)         4.380         Start of Arc         x(m)         y(m)	11.423
Image: Constraint of Arc Angle         Z(m)         358.602         Z(m)         358.602           Arc Angle         q(rad)         0.415         Arc Angle         q(rad)         4rc	0.000
Arc Angle         q(rad)         0.415         Arc Angle         q(rad)           Arc Radius         R(m)         72.130         Arc Radius         R(m)         6           Arc Length         S(m)         29.956         Arc Length         S(m)         2           End of Arc         x(m)         4.380         Start of Arc         x(m)         y(m)	59 085
Open Section         Arc Radius         R(m)         72.130         Arc Radius         R(m)         6000000000000000000000000000000000000	0.415
Composition         Composition <thcomposition< th=""> <thcomposition< th=""></thcomposition<></thcomposition<>	66,930
O         End of Arc         x(m)         4.380         Start of Arc         x(m)           v(m)         1.650         v(m)         1.650         v(m)	27 796
	5 923
	0.000
	0.000

PLTR	Positron Inje	ction to	DR	Electron Extraction from DR						
Tunnel	Description	Parameter	Value	Description	Parameter	Value				
	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				
4		z(m)	-80.700		z(m)	-75.590				
2	Positron Injection Line Bend	x(m)	97.113	Electron Extraction Line Bend	x(m)	97.114				
Ę	(Center of Bend)	y(m)	0.350	(Center of Bend)	y(m)	1.650				
ů.		z(m)	-101.307		z(m)	-96.192				
Š	Positron Injection Treaty Point	x(m)	94.410	Electron Extraction Treaty Point	x(m)	94.410				
0)	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				
	Positron Injection Treaty Point	x(m)	94.410	Electron Extraction Treaty Point	x(m)	94.410				
Ш	End of Positron Source Line	y(m)	0.350	Start of Electron RTML Line	y(m)	1.650				
C		z(m)	-112.103		z(m)	-106.988				
.0	Line Length	L(m)	123.590	Line Length	L(m)	128.558				
<u></u>	Line Angle	q(rad)	-1.811	Line Angle	q(rad)	-1.811				
ĕ	Start of Section B Straight	x(m)	65.032	End of Section B Straight	x(m)	63.851				
S		y(m)	0.000		y(m)	1.650				
		z(m)	-232.151		z(m)	-231.862				
	End of Arc	x(m)	65.032	Start of Arc	x(m)	63.851				
()		y(m)	0.000		y(m)	1.650				
ç		z(m)	-232.151		z(m)	-231.862				
2	Arc Angle	q(rad)	0.168	Arc Angle	q(rad)	0.168				
Ę	Arc Radius	R(m)	84.716	Arc Radius	R(m)	83.500				
S S	Arc Length	S(m)	14.258	Arc Length	S(m)	14.053				
ő	Start of Arc	x(m)	60.497	End of Arc	x(m)	59.381				
0)		y(m)	0.000		y(m)	1.650				
		z(m)	-245.650		z(m)	-245.167				
~	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				
.0	Line Length	L(m)	123.595	Line Length	L(m)	123.595				
t	Line Angle	q(rad)	-1.979	Line Angle	q(rad)	-1.979				
ē	Start of Section D Straight	x(m)	11.423	End of Section D Straight	x(m)	10.307				
S		y(m)	0.000		y(m)	1.650				
		z(m)	-359.085		z(m)	-358.602				
	End of Arc	x(m)	11.423	Start of Arc	x(m)	10.307				
ш		y(m)	0.000		y(m)	1.650				
_		z(m)	-359.085		z(m)	-358.602				
2	Arc Angle	q(rad)	0.415	Arc Angle	q(rad)	0.415				
Ę	Arc Radius	R(m)	66.930	Arc Radius	R(m)	72.130				
S S	Arc Length	S(m)	27.796	Arc Length	S(m)	29.956				
ő	Start of Arc	<b>x(m)</b>	5.923	End of Arc	x(m)	4.380				
0)		y(m)	0.000		y(m)	1.650				
12112	50 NGC 162 2000	z(m)	-386.128		z(m)	-387.746				

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## Latest changes in central region (ERTL/PRTL) **Fermilab**

#### 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	
а	-0.7989	1.5752	
b	45.0m	29.96m	
	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	
а	-0.7989	1.5752	
b	45.0m	29.96m	

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

- 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)



# Latest changes in central region (ERTL/PRTL)



Geometrical configuration of central region Beam lines

Courtesy of V. Kapin

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## Latest changes in central region (ERTL/PRTL)







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## Return Line Doglegs design

## (ELTL/PLTL)

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



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



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



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ML Treaty points definition and matching

Treaty Point	TERTML2ML	TEML2PS	<b>TPS2EBDS</b>	FPRTML2ML	TPML2BDS			
	Electron	Electron Main	Positron	Positron	Positron Main			
	RTML to Main	Linac to	Source	RTML to Main	Linac to BDS			
	Linac	Positron	(Undulator	Linac		Main Li		
		Source (Undulator	Electron BDS			ما مؤنيه م ما		
		Section)	Election BBG			aennea		
<i>x</i> [m]	104,5245011	26,540	17,440	94,62043163	17,433			
<i>y</i> [m]	0	0	0	0	0	Geome		
z [m]	-14471,78005	-3331,319	-2253,464	13279,10984	2252,514			
ϑ [rad]	-0,0070	-0,0070	-0,0070	-3,1346	-3,1346	RIML		
φ [rad]	0	0	0	0	0	tuning		
ψ [rad]	0	0	0	0	0	tunng		
<i>d</i> [m]	3,220	3,220	1,665	1,665	1,665	Return		
		Optics F	unctions					
α <sub>x</sub> [1]	-0,3137	-2,402	-2,402	-0,3137	-2,402	the be		
β <sub>x</sub> [m]	100,94	51,33	51,33	100,94	51,33	horizoi		
η <sub>x</sub> [m]	0	0	0	0	0	unstra		
η' <sub>x</sub> [1]	0	0	0	0	0	upstie		
α <sub>y</sub> [1]	0,6451	0,4888	0,4888	0,6451	0,4888			
β <sub>y</sub> [m]	51,47	9,395	9,395	51,47	9,395			
η <sub>γ</sub> [m]	0	0	0	0	0			
η' <sub>y</sub> [1]	0	0	0	0	0			
Hor. 8	Ver. Dogleg	s		$\square$	$\supset$			
ELTL FODO system PLTL FODO system								
					<u> </u>			

e- Main Linac

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

**Fermilab** 

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

Hor. & Ver. Doglegs

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A. Vivoli, N.Solyak, V.Kapin, "Status of RTML design"

e+ Main Linac



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.



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.

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#### MAD8\_51 results for curved PLTL beam line:



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## Latest changes in 2 stage Bunch Compressor 🛟 Fermilab





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#### MAD8 results for 2 stage BC optics:



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Initi	al bea	am	BC1 param	eters	Beam	after B	C1	BC2 paramete	rs	Fi	Final beam			
dp/p, % (@5 MeV)	σ <sub>z</sub> , mm	E, MeV	A/-φ, MeV/ deg	R <sub>56</sub> , mm	dp/p, %	σ <sub>z</sub> , mm	E, Me V	A/-φ, MeV/ deg	R <sub>56</sub> , mm	dp/p, % (@15 MeV)	σ <sub>z</sub> , 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:

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ilc

### Lucretia Simulations of ILC 2-stage BC



Parameters:

2 × 10<sup>-5</sup>

1.5

1

0.5

-0.5

-1

-1.5

-2` -6

X' (rad) 0

İİL

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

-2

0

X (m)

2



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-0.8

-3

-2

-1

0

Y (m)

3

2



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%

0.13

0.14

σ<sub>En</sub>/E<sub>0</sub> (%)

0.15

0.16

0.17

0.18

0.19

0.12

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 %

6

σ<sub>z0</sub> (m)

6.2

6.4

6.6

6.8

x 10<sup>-3</sup>

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1.22

0.1

0.11

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5.2

5

5.4

5.6

5.8

Magnet count and Heat Load/Cost estimation Fermilab

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

RTML (Ring-To	)-Mair	1-Linac	) DE	SIGN (	RITE	RIA FO	)R CF	S		MAR 14 2012
RTML Heat and Pow	/er Load	(Totals F	RTML	shown) <u>5</u>	HZ FULI	POW	ER UPO	GRADE [CFS	FACILI	TIES BASELINE]
					Load to wat	ter-LCW		Load to Air	Beam	
<u>HEAT LOAD to CFS</u>	Total KW	rough location	Qty	KW heat load	LCW supply temperature (F)	Delta T (F)	or Flow (gpm)	w KW heat load		Notes
RTML components										
Magnets	** 931	beam	4651	838	90	20	286	93		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	104F (40C)	Jul 14 2009 Nikolai & Marc (50% from RDR). Aug 2011 CFS&NSolyak + assume % to air + used RDR. <b>[MAR 14 201</b> <b>Update from Alessandro]</b>
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 J	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)
Pumps *	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 p	ower calculate	ed for non	ninal paramat	ers of lattice					
POWER Beam Power (from N.S.)		1/127	ĸw	LOAD D	ISTRIBU	TION	arealco	ntral region to		

RTML (Ring-To	)-Mair	1-Linac	;) DE	SIGN (	RITE	RIA FO	)R CF	S		MAR 14 2012
<b>RTML Heat and Pov</b>	ver Load	(Totals F	RTML	shown) <u>5</u>	HZ LOW	/ POWI	E <mark>r [Ilc</mark>	BASELINE		
					Load to wat	ter-LCW		Load to Air	Beam	
HEAT LOAD to CFS	Total KW	rough location	Qty	KW heat load	LCW supply temperature (F)	Delta T (F)	or Flow (gpm)	KW heat load	tunnel Temperatur e	Notes
RTML components				•	1					
Magnets	** 931	beam	4651	838	90	20	286	93		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	104F (40C)	Jul 14 2009 Nikolai & Marc (50% from RDR). Aug 2011 CFS&NSolyak + assume % to air + used RDR. <b>[MAR 14 2012</b> 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 J Jul 14 2009 Nikolai & Marc (50% from RDR)
Bamps *	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 p	ower calculate	ed for nor	ninal paramat	ers of lattice					•
POWER				LOAD D	ISTRIBU	TION				
Beam Power (from N.S.)		941	KW	4% of rtm	are locate	ed in LTR	area (ce	entral region to	DR)	
Numbers from Table abov	/e	4412	KW	96% are in	the rtml e	ends				
TOTAL POWER operating		5.4	MW							

ellow highlighted numbers are changes compared to the last version

umbers from Table above

5788

7.21 MW

KW 96% are in the rtml ends

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#### Cost for RTML magnets & PS estimated using RDR data.

	Α	В	С	D	E	F	G	Н	- I	J	K	L	М	Ν	0	Р	Q	R	S	Т	U	V	W	Х	Y	Z	AA	
1				N	lagnet Pa	arameters	, April 13,	2012																				
2																												
3	Name	Count 2 RTML	Туре	Int.Str. T,Tr M	laxG,B	Lefm,m	Xgap	YGap	Bpole, T	lw/pole,A	I,A	Wc	Lcu,m	qcu,mm^2	Vcu,m3	mcu/mag,t	Mcu,tons	Rw,Ohm	U,V	P,W	Ctool,k\$	Cmag, \$	Cstand,\$	Cmts,k\$	Cmt,k\$	Cn,k\$	Comments	Maç
4	DC Quadrup	oles																										
5	QRTML1	8	Q20L100	0,400	4,000	0,1	0,02	2 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	2 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	C	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	C	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 Quadrup	oles																										
11	QRTML6	38	QSC80L200	2,430	12,150	0,2	80,08	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	6 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	j(
15	DRTML3	192	2 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	2 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	C	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 Corr	ectors																										
23	DCRTML1	2283	D20L50	0,053	1,050	0,05	0,02	2 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 Corr	ectors																										
26	DCRTML2	58	DSC80L200	0,0073	0,037	0,2	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 Solenoid	ls																										
29	SLRTML1	8	SLSC20L2600	13,099	4,999	2,62	0,02	2 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																												<u> </u>
31	Total	4651														Total Cu,to	133,1				Total cost,	k\$				61676		<u> </u>
32																												



- 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





### **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.

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