



Ring to Main Linac Magnets

V. Kashikhin for ILC ALCPG 2007, FNAL Meeting
October 23, 2007



1	RTML Magnets May 3, 2007														
2	V.S.Kashikhin														
3															
4	NC - normal conductor														
5	SC - Superconductor														
6	Q20L200 - Quadrupole 20 mm aperture diameter and 200 mm magnet effective length														
7	D25L900V1 - Dipole 25 mm gap, 900 mm effective length in most cases equal yoke length, variant 1 (different gap width)														
8	Lefm, m - modified effective length														
9	Gm, Bm - modified quadrupole gradient and dipole field														
10															
11															
12															
13	Name	Count	2 RTM Type	Int.Str.	MaxG,B	Lefm,m	NC Quads	SC Quads	Bends	Solenoids	Kickers	Bumps	Septums	NC Correctors	SC Correctors
14	QRTML1	16	Q20L100	0.400	4.000	0.1	1562								
15	QRTML2	1422	Q20L200	17.520	87.600	0.2									
16	QRTML3	8	Q20L400	6.650	16.625	0.4									
17	QRTML4	44	Q20L800	13.300	16.625	0.8									
18	QRTML5	36	Q60L200	3.714	18.570	0.2									
19															
20	QRTML6	36	QSC75L200	2.430	12.150	0.2		36							
21															
22	DRTML1	32	D25L400	0.028	0.071	0.4									704
23	DRTML2	128	D25L900V1	1.060	1.178	0.9									
24	DRTML3	144	D25L900V2	0.904	1.004	0.9 b=40cm									
25	DRTML4	144	D25L900V3	0.650	0.722	0.9 b=10cm									
26	DRTML5	8	D25L1600	0.625	1.299	1.6									
27	DRTML6	12	D25L1800	1.400	1.299	1.8									
28	DRTML7	56	D25L1900	1.794		1.9									
29	DRTML8	180	D25L2300	1.823		2.3									
30															
31	SLRTML1	8	SL20L2600	13.099	4.999	2.62					8				
32															
33	DCRTML1	2248	D20L50	0.053	0.757	0.07								2004	
34	DCRTML2	54	DSC75L200	0.007	0.073	0.1									84
35															
36	Total	4576													



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	Magnet Parameters, May 3, 2007																			
2																				
3	Name	Count	RTML Type	Int.Str.	MaxG,B	Lefm,l	Xgap	YGap	Bpole,	lw/pole,A	I,A	Wc	Lcu,n	qcu,mr	Vcu,m3	mcu/mag,t	Mcu,tons	Rw,Ohm	U,V	P,W
4	DC Quadrupoles																			
5	QRTML1	16	Q20L100	0.400	4.000	0.1	0.02	0.02	0.040	1.67E+02	2	84	96	1	0.0001	0.0009	0.01	1.93	3.9	8
6	QRTML2	1422	Q20L200	17.520	87.600	0.2	0.02	0.02	0.876	3.66E+03	20	183	387	10	0.0039	0.0344	48.94	0.77	15.5	309
7	QRTML3	8	Q20L400	6.650	16.625	0.4	0.02	0.02	0.166	6.95E+02	20	35	140	10	0.0014	0.0125	0.10	0.28	5.6	112
8	QRTML4	44	Q20L800	13.300	16.625	0.8	0.02	0.02	0.166	6.95E+02	20	35	276	10	0.0028	0.0245	1.08	0.55	11.0	220
9	QRTML5	36	Q60L200	3.714	18.570	0.2	0.06	0.06	0.557	6.99E+03	200	35	87	50	0.0044	0.0388	1.40	0.03	7.0	1395
10	SC Quadrupoles																			
11	QRTML6	36	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
12	DC Dipoles																			
13	DRTML1	32	D25L400	0.028	0.070	0.4	0.03	0.03	0.070	7.31E+02	50	15	16	12.5	0.0002	0.0018	0.06	0.03	1.3	63
14	DRTML2	128	D25L900V1	1.060	1.178	0.9	0.03	0.03	1.178	1.23E+04	50	246	561	12.5	0.0070	0.0624	7.99	0.90	44.9	2245
15	DRTML3	144	D25L900V2	0.904	1.004	0.9	0.4	0.03	1.004	1.05E+04	50	210	668	12.5	0.0083	0.0743	10.69	1.07	53.4	2670
16	DRTML4	144	D25L900V3	0.650	0.722	0.9	0.1	0.03	0.722	7.55E+03	50	151	371	12.5	0.0046	0.0413	5.95	0.59	29.7	1485
17	DRTML5	8	D25L1600	0.625	0.391	1.6	0.03	0.03	0.391	4.08E+03	50	82	323	12.5	0.0040	0.0360	0.29	0.52	25.9	1293
18	DRTML6	12	D25L1800	1.400	0.778	1.8	0.03	0.03	0.778	8.13E+03	50	163	722	12.5	0.0090	0.0803	0.96	1.15	57.7	2887
19	DRTML7	56	D25L1900	1.795	0.945	1.9	0.03	0.03	0.945	9.87E+03	50	271	1528	12.5	0.0191	0.1699	9.52	2.44	122.2	6110
20	DRTML8	180	D25L2300	1.823	0.793	2.3	0.03	0.03	0.793	8.28E+03	50	271	1267	12.5	0.0158	0.1410	25.38	2.03	101.4	5069
21																				
22	DC RT Correctors																			
23	DCRTML1	2248	D20L50	0.053	1.050	0.05	0.02	0.02	1.050	8.78E+03	5	1756	379	2.5	0.0009	0.0084	18.97	3.03	15.2	76
24																				
25	DC SC Correctors																			
26	DCRTML2	54	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
27																				
28	SC Solenoids																			
29	SLRTML1	8	SLSC20L260	13.099	4.999	2.62	0.02	0.02	4.999	4.02E+06	####	1005	221	SC	SC	SC	SC	SC	SC	SC
30																				
31	Total	4576														Total Cu,to	131.3			
32																				



1. Design each magnet style:

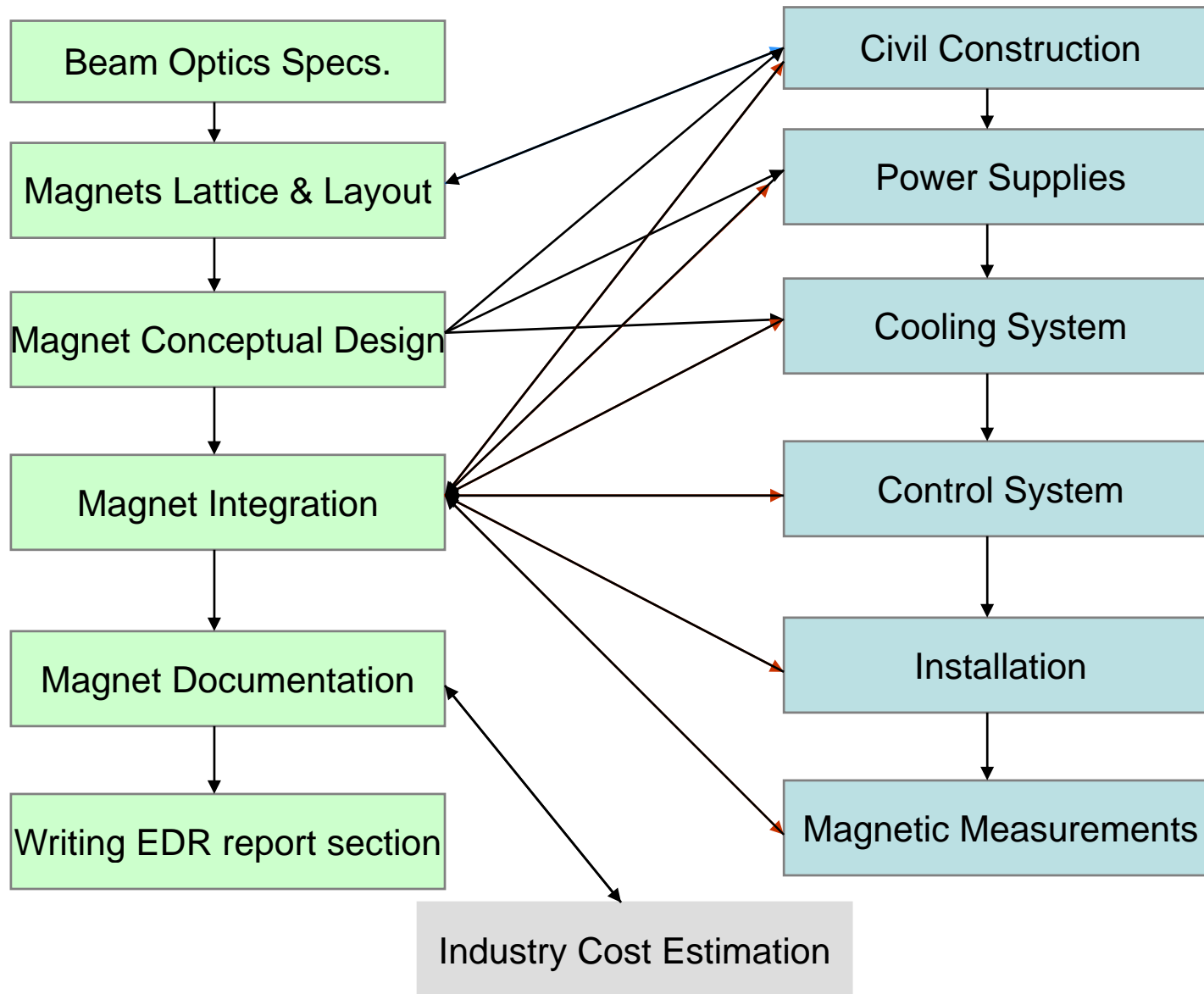
- Magnetic design (2D and if need 3D magnetic field simulations to confirm specified field quality and magnet performance;
- Pole profile and geometry optimization for better integrated field quality;
- Mechanical and thermal analysis;
- Magnet documentation.

2. Magnet documentation package should include at least:

- Magnet specification with all needed parameters;
- Results of magnetic field analysis and also mechanical and thermal calculations.
- Magnet drawings with at least cross-sections and views transverse and longitudinal with all connections to the power, water, instrumentation and corresponding schematics;
- Description of all used materials: iron, copper, insulation, probes, cables, etc...
- Description of magnet manufacturing technology: winding coil technique, epoxy impregnation, curing, stamping laminations, yoke and magnet assembly, etc...
- Magnet support structure general views with adjusting mechanisms
- Drawing of magnet mounting in the tunnel.



1. Magnet design should be made by professionals only.
2. The time depends on the experience of design engineer and supporting team. Only institutions with accelerator magnet design, building and testing experience should participate.
3. Designers should use the general magnet specification document as guidance for magnet design. This document should describe in general way the magnet technology which must be used.
4. The magnet design and integration should include several steps:
 1. Magnet conceptual design.
 2. Review magnet parameters and integration with power supply, cooling, vacuum, instrumentation, control systems and civil construction.
 3. Magnet optimization to optimize performance, cost, technology, mounting, installation, etc.
 4. Review of optimized system including matching to other sub-systems.
 5. Preparing pre-fabrication drawings and documentation.





1. The design process and information flow, data exchange between different areas, regions, institutions, teams, specialists. We should expect large fraction of time will be waiting additional information, technical decisions, changes in specs, etc...
2. Integration with other sub-systems and making technical decisions for all areas simultaneously on the same issue and problem.
3. Find professionals for magnet design and integration with needed experience.
4. Converting R&D projects into useful results for EDR.
5. Wasting large fraction of specialists time for meetings, reports, reviews, travels with corresponding low impact on EDR progress.
6. Any change in lattice or general magnet parameters will cause magnet redesign and corresponding design time increase.
7. The late start of EDR writing.
8. Industry cost estimation for different regions and firm ranks.



6. Magnets and PS

Design, specify & optimize DC conventional magnets

Optimize number of types and apertures

Design warm quads, bends and correctors

Design and prototype BC wiggler wide aperture magnet

Design, prototype quad/corrector for return line

Design tune-up Septa and PS

Design and Specify pulsed magnets

Design tune-up extraction kickers and pulsers

Design feed-back, feed-forward correctors and PS

Design/prototype SC quad/corrector for BC1/BC2

Design, specify SC solenoid

Optimize PS and cabling

Design, specify DC PS

Design stable supports for magnets



- 1. Magnets and PS specifications**
- 2. Magnets and PS conceptual design**
- 3. Design Magnets and PS fabrication, test, installation, and repair**
- 4. Magnets and PS optimization to reduce total cost**
- 5. Magnets and PS prototyping at the level of available funds**
- 6. Magnets and PS tests**
- 7. Writing EDR collaborative report**



1. All Magnets and PS conceptual drawings, schemes
2. Conceptual drawings of magnets mounting in the tunnel
3. Drawings of all prototypes
4. Prototypes test results
5. Results of optimization
6. RTML Magnets and Power Supplies section of EDR



1. Magnet and PS specifications

February 1, 2008

2. Room temperature magnets and DC PS conceptual design

October 1, 2008

3. Superconducting quadrupole package design

October 1, 2008

4. Superconducting and pulsed magnets and PS conceptual designs

February 1, 2009

5. Magnets and PS optimization and cost analysis

October 1, 2009

6. Magnets and PS prototypes fabrication and tests

February 1, 2010

7. Finish writing EDR RTML Magnets section

May 1, 2010



1. Experienced in Magnet Technology: Engineers, Designers, Drafters, Scientists

2. Design, Test, and Fabrication facilities

3. Who is interested and contact persons at the moment:

FNAL – N. Solyak (Area Leader), J. Tompkins, V. Kashikhin – Magnets Design, Prototyping, and Tests

KEK – K. Tsuchiya – Magnets Design

SLAC – P. Bellomo – Power Supplies

UBC – T. Mattison – Pulsed Magnets Design

Efremov Institute – E. Bondarchuk – Magnets Design and Prototyping

JINR – E. Syresin, N. Morozov – Magnets Design



1. Magnet specification – 1 week (Scientist, Engineer)
2. 2D Magnetic design – 2 weeks (Engineer)
3. Magnet engineering design – 2 week (Engineer)
4. Conceptual design drawings – 4 week (Designer)
5. Magnet support and installation in the tunnel - 2 week (Designer)
6. Magnet optimization and integration with other systems – 2 weeks (Engineer)
7. Magnet description including fabrication technology, test program, installation and repair – 2 weeks (Technology Engineer)

Total per magnet – 15 weeks or 0.3 FTE

14 DC RT Magnets: ~ 4.2 FTE

SC Quadrupole package : 0.8 FTE

SC Solenoid: 0.5 FTE

Septums: 0.5 FTE

Power supplies: 3 FTE

Pulsed magnets: 2 FTE

Total magnets and PS: 11 FTE or 5.5 FTE/year



- All RTML magnets are feasible for design and fabrication.
- Total number of magnets 4576.
- Number of magnet styles: Dipoles- 6, Quadrupoles – 4 plus 1 – superconducting, Correctors – 2 plus 1 superconducting, 1 superconducting solenoid, plus septums, bumps and kickers.
- Time frame for the magnet design depends on many factors (region, firm, institution, salary range, experience, supporting structure, etc.).
- Magnets for R&D and prototyping: 1- conventional dipole, 1- conventional quadrupole, 1- corrector, 1- superconducting quadrupole package including correctors, 1- superconducting solenoid 0.5 m model.
- Goals for R&D: prove chosen magnet technology, reliability, investigate magnetic center stability in quadrupoles at BBA, hysteresis effects in dipoles, prove the chosen magnetic measurement technique. Investigate coupling effects between main magnet and correctors. Investigate the magnets long term behavior.