# Ring to Main Linac Magnets

V. Kashikhin for ILC ALCPG 2007,  FNAL Meeting
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# RTML Magnet Styles

RTML Magnets May 3, 2007

V.S.Kashikhin

NC - normal conductor

SC - Superconductor

Q20L200 - Quadrupole 20 mm aperture diameter and 200 mm magnet effective length

D25L900V1 - Dipole 25 mm gap, 900 mm effective length in most cases equal yoke length, variant 1 (different gap width)

Lefm, m - modified effective length

Gm, Bm - modified quadrupole gradient and dipole field

| Row | 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 | QSC75L20 | 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 | | | | | | | | | | | | | |

# RTML Magnet Parameters

| | 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 2 RTML | Type | Int.Str. ' | MaxG,B | Lefm,ı | Xgap | YGap | Bpole, ' | Iw/pole,A | I,A | Wc | Lcu,n | qcu,mı | 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 | | | | | | | | | | | | | | | | | | | | |

# EDR Magnet Deliverables

## 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:

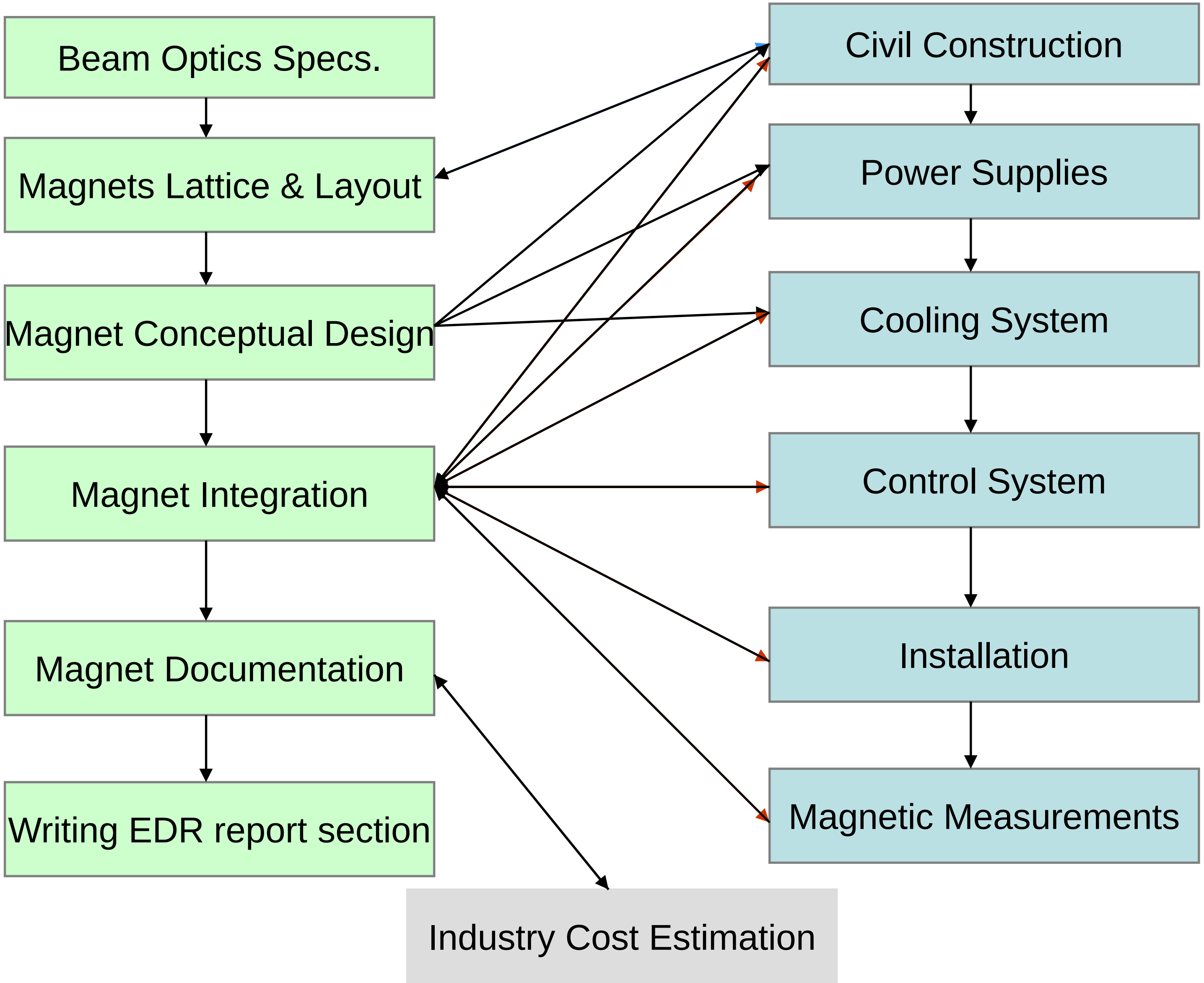
- Magnet specification with all needed parameters;
- Results of magnetic field analysis and also mechanical and thermal calculations.
- Magnet drawings with at least cross-sections and views transverse and longitudinal with all connections to the power, water, instrumentation and corresponding schematics;
- 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.

# EDR Magnet Design and Integration Process

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.

# EDR Magnet Design Information Flow

ILC International Linear Collider



# Magnet Design Issues

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.

# RTML Magnet WP

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

# Major Tasks and Objectives

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

# Deliverables from WP

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

# WP Major Milestones

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

# Required Resources, Facilities and Groups

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

# Minimum of Required Resources

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

# Summary

- 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.