

RDR Magnet Systems Group Vancouver GDE Meeting - 060719

Overview

J. Tompkins, FNAL

Overview - People

- **Magnet System Group Leaders**
 - **Asia - Ryuhei Sugahara, KEK, Japan**
 - **Americas - John Tompkins, Fermilab, USA**
 - **Europe - Eduard Bondarchuk, Efremov Inst., Russia**
- **Magnets and Associated Systems**
 - **Conventional Magnets**
 - Cherrill Spencer, SLAC
 - Vladimir Kashikhin, Fermilab
 - Eduard Bondarchuk, Efremov
 - Jin-Young Jung, LBNL
 - Ross Schlueter, LBNL
 - **Superconducting Magnets**
 - Vladimir Kashikhin, Fermilab
 - Brett Parker, BNL
 - Gianluca Sabbi, LBNL

People, cont.

- **Magnet folks, cont.**
 - **Kicker, Septum, and Pulsed Magnets**
 - Tom Mattison, UBC/SLAC
 - **Undulators**
 - Jim Clarke, Daresbury Lab
 - **Wigglers**
 - Mark Palmer, Cornell
 - **Power Supply Systems**
 - Paul Bellomo, SLAC
 - **Conventional Facilities**
 - Ryuhei Sugahara, KEK
 - **Controls Interface**
 - Mike Tartaglia, FNAL
 - **Magnet Movers**
 - David Warner, Colorado State Univ.

Approach

- **Work Plan - Stage 0**
 - **Discussions with Area Systems Leaders**
 - overview of lattice magnet requirements
 - identify issues, areas of uncertainty
 - **Define 'standard' set of magnet requirements for use in developing magnet designs and distribute to Area Systems Leaders**
- **Stage 1**
 - **Collect the basic requirements data from Area Systems groups**
- **Stage 2 - Review input data from Area Systems**
 - **Identify items/areas in need of clarification**
 - **Identify (if possible) missing or incomplete data**
 - **Iterate with Area Leaders on magnet parameters, 'stringing' rules, etc.**
- **Stage 3 -Reduce magnet lists to a manageable number of magnet styles**
 - **Iterate with Area Leaders on magnet styles decision**
- **Stage 4 -Develop conceptual designs for magnet styles**
 - **Focus on cost drivers - either large quantity or high complexity**

Approach, cont.

- Stage 5 - Develop associated requirements from conceptual design parameters developed in Stage 4
 - power supply systems
 - controls
 - Infrastructure - wall power, LCW, alcove space, cable trays, etc.
- Stage 6 - Estimate cost based on designs for styles
 - Use scaling for variants of a style
 - Use existing costs where available
 - e.g., LCLS magnets, FNAL magnets, Cornell wigglers, etc.
 - Estimates from specific designs
 - BNL direct wind SC magnets; Daresbury undulator
 - Estimates from industry, other labs

Approach vs. Reality

- That was the plan, and it was followed at the beginning of the effort (Feb/Mar...)
- However, given the actual (i.e., short) time scale and limited resources to develop conceptual designs
 - Most costs are not from detailed estimates
 - Conceptual designs developed for a portion of the styles
 - Engineers' estimates used along with scaling from similar but not necessarily identical magnets
 - Detailed estimates only in instances where designs and magnets exist (e.g., wigglers), or are based on an ongoing R&D program (undulators)
 - Estimates are being sought from industry for a small number of high quantity magnets (e.g., e+ source transfer line quadrupoles >1600 magnets; Damping Ring quadrupoles, dipoles)
 - Efforts begun in Japan, through KEK, and the US, through Fermilab
 - Require detailed specifications and a drawing package
- Not all system estimates have been completed

Most Recent Magnet Count

Magnet Type	Grand Totals		Sources			Damping Rings			2 RTML		2 Linacs		2 BeamDel	
	Styles	Quantity	Style	e- Qty	e+ Qty	Style	e-DR Qty	2e+DR Qty	Style	Qty	Style	Qty	Style	Qty
Dipole	31	1834	11	12	156	2	130	260	6	676	0	0	12	600
Normal Cond Quad	50	5440	17	87	1984	3	783	1566	6	600	0	0	24	420
Supercond Quad	12	758	2	13	45	0	0	0	1	64	3	624	6	12
Sextupole	6	1614	2	0	30	2	520	1040	0	0	0	0	2	24
Supercond Sextupole	4	8	0	0	0	0	0	0	0	0	0	0	4	8
Normal cond Solenoid	6	54	6	15	39	0	0	0	0	0	0	0	0	0
Supercond Solenoid	2	10	2	2	0	0	0	0	8	0	0	0	0	0
Normal cond Corrector	15	6120	11	0	3068	3	350	700	1	1152	0	0	0	0
Supercond Corrector	16	1490	1	0	90	0	0	0	1	128	2	1248	12	24
Pulsed/Kickers/Septa	14	539	2	0	21	4	68	136	3	60	0	0	5	254
Supercond Wiggler	1	240	0	0	0	1	80	160	0	0	0	0	0	0
NC Octupole/Muon Spoilers	3	16	0	0	0	0	0	0	0	0	0	0	3	16
Supercon Oct/Undulator	5	58	1	0	50	0	0	0	0	0	0	0	4	8
Overall Totals	165	18231	54	129	6383	15	1931	3862	19	2688	5	1872	72	1366
Totals w/o correctors	134	10571	ILC Magnet count for 250Gev on 250Gev beams with baseline configuration											
Total Normal cond	125	15667												
Total Superconducting	40	2564	~14% of all magnets are superconducting											
28June06 version		Compiled by Cherrill Spencer, ILC Magnet Systems Group, Inaugural Publication: 1May06												

Status

- Received formal magnet data input from all area systems in roughly the following order:
 - RTML, BDS, Main Linac, e⁺ Source, e⁻ Source, Damping rings
 - Differing degrees of completeness, finality
- Break down of work areas:
 - Area Systems magnets (more detail to come)
 - Specialty Magnets: Kickers, Septum, and Pulsed Magnets - Tom Mattison (UBC/SLAC)
 - Developing requirements and specifications with the Area Leaders
 - Developing "ROM" costs
 - Significant issue: which technology FIDs, thyratrons, etc.
 - Magnet Movers (only used in BDS) - David Warner (CSU)
 - 3 axis R&D system developed
 - Cost estimate developed for 5 axis system

Status, cont.

- Break down of work areas, cont.
 - **Power Systems - Paul Bellomo (SLAC)**
 - Closely coupled to magnet design sequence
 - Individual or 'strings' powering layouts
 - Has power supply, cabling, conduits/trays, etc., and wall power requirements for all magnets which have design parameters
 - **Controls - Mike Tartaglia (FNAL)**
 - Works closely with Power Systems
 - Specifications for magnet powering permissions, ground fault detection, and superconducting magnet and lead protection, and associated instrumentation and data
 - **Infrastructure, Conventional Magnets- Ryuhei Sugahara (KEK)**
 - Facilities for test and measurement of conventional magnets
 - Storage facilities for magnets during production & installation period
 - Installation requirements coordination with CFS
 - **Infrastructure, Superconducting Magnets- J. Tompkins (FNAL)**
 - Cold test facilities coordination with Cryogenics Group (T. Peterson)
 - Planning for Main Linac quadrupole & corrector assemblies, wigglers, undulators, and IR superconducting magnets

Status of Design and Cost Input to Area Systems

- **Beam Delivery System**
 - Conversion to styles and cost estimate for nearly all conventional magnets delivered (C. Spencer)
 - Difficult magnets in 2 mrad line, where incoming and disrupted beams are very close, are still being examined
 - Very preliminary solutions have been generated very recently - feasibility studies still in progress
 - Cost estimates not yet developed
 - Superconducting magnets in 20 mrad line have been designed and estimated by B. Parker & M. Anerella (BNL)
 - Superconducting magnets in 2 mrad line have been scaled from FNAL LHC designs; VI. Kashikhin & A. Zlobin
 - Costs for 5 axis movers delivered by D. Warner (CSU)

Area System Magnet Status, cont.

- **RTML**
 - Conversion to styles and cost estimate for nearly all conventional magnets delivered (VI. Kashikhin)
- **Main Linac**
 - **Quadrupole & corrector designs**
 - FNAL - VI. Kashikhin et al. - early conceptual designs exist
 - Includes quadrupole plus horizontal and vertical steering dipoles, and a skew quadrupole corrector
 - Cost estimate submitted based on costs of similar sized superconducting correctors
- **e⁺ source**
 - Conversion to styles and cost estimate for nearly all conventional magnets delivered (VI. Kashikhin)
 - Looking in detail at xfer line quadrupoles (>1650 total) and associated x & y trim correctors
 - Large solenoids need further study

Status of Input to Area Systems

- **Damping Rings**
 - Ring dipoles, quads, and sextupoles have conceptual designs and cost estimates - Jin-Young Jung (LBNL), E. Bondarchuk (Efremov), N. Morozov (Dubna)
 - Wigglers are Cornell design and cost estimate
 - LBNL is providing DR mechanical integration, stands design and cost
 - Injection and extraction lines yet to be specified and have not been worked on
- **e- source**
 - Not much accomplished here due to lack of resources: ran out of time and people
 - Similarities in many magnets to e- source
 - Work to continue after Vancouver

Preliminary Look at Cost Drivers

- **Magnet Cost Drivers**
 - **BDS**
 - μ spoiler - dominated by large amount of steel; impact on installation to be discussed in break-out session
 - SC magnet systems in IR region of both 20 mrad and 2 mrad lines
 - "Difficult" magnets in 2 mrad line are potentially expensive - large size, significant power requirements
 - **Main Linac**
 - None identified at this point
 - **RTML**
 - None identified at this point

Preliminary Cost Drivers, cont.

- Magnet Cost Drivers, cont,
 - **Damping Rings**
 - Wigglers
 - Number of magnets \Leftrightarrow number of rings
 - **e+ source**
 - Undulator
 - Long transfer line \Rightarrow >1600 quads & >3200 correction coils
 - **Kicker, septum, and pulsed magnets**
 - Fast pulse systems costly
- System Cost Drivers
 - **Individual power supplies**
 - Additional cabling cost
 - Reliability/redundancy cost

What is incomplete - still in progress

- e- source magnets
 - Work to continue (during/and) after Vancouver
 - Large solenoids
- e+ source magnets
 - Large solenoids
- BDS
 - 2 mrad line 'difficult' magnets need further study
 - Efficient design with lower power usage
 - Cost estimate
- Damping Rings
 - Injection and extraction lines
- Kickers & all that
 - Initial effort is to establish 'ROM' - next step is to develop cost estimate

Still in Progress

- Magnet support stands
 - LBNL working on integrated system for damping rings (conceptual design)
 - Fermilab ME has begun cost estimate work on stands looking for existing stand data
- Beam tube requirements
 - Vacuum and beam issues
 - In-situ bake out of the beam tube
 - Additional space for heaters and insulation
 - Direct impact on magnet inner diameter (increase) and thus cost
 - Install in-situ
 - "Break apart" magnet after installation and insert beam pipe
 - Impact on magnet alignment, reliability?

Still in Progress

- **Controls**
 - **Power supply specifications are being developed**
 - Ramp requirements for magnets
 - **Sensor definitions and protection**
 - Conventional magnets - temp, press., flow, etc.
 - SC magnets - quench protection coils & leads, etc.
 - **General provisions exist in Power Supply Systems effort**
- **BPM's**
 - **Interface issue - not a specific magnet task**
 - **Mounting to quadrupoles and sextupoles**
 - **Mechanical alignment tolerances**

What's Next - Plans and Goals

- **Complete remaining design/cost estimate work**
 - **e^- source**
 - **BDS 2 mrad IR problematic magnets**
 - **Damping Rings injection and extraction line magnets**
 - **Large solenoids in both e^+ & e^- sources**
 - **Kickers, septum and pulsed magnets**
 - Designs for each area
 - More detailed cost estimates
 - **Magnet stands**
 - Finish survey of existing stand costs
 - Get estimates for a few cases

Plans and Goals, cont.

- Merge designs and styles
 - Reduce number of styles across systems
 - Review for consistency
- 'Normalize' cost estimates from various sources
 - Consistent EDI based on level of complexity
 - Materials specifications, costs
 - Production labor rates
- Pursue estimates from industry for a subset of magnets
 - Get industrial input on cost drivers & savers for large quantity procurements
 - Get feedback on impact of specifications/requirements on cost

Plans and Goals, cont.

- **Begin active focus on reliability**
 - **FMEA exercise for a few magnet designs**
 - **Data from existing accelerators**
 - DESY - superconducting magnet in HERA
 - FNAL - Main Injector magnets
 - Information available, some additional effort needed to understand and quantify
- **And begin task of writing magnet section of the RDR...**

Critical Magnet Issues

- **Alignment with respect to beam path**
 - Focusing elements must preserve beam size
 - Offset of quadrupoles from beam axis must be adjusted by correction (steering)
 - Sub- μ accuracy achieved w/ mechanical movers in BDS
- **Stability**
 - Geometry - if magnet core is not mechanically stable its magnetic center will wander
 - Field stability/reproducibility
 - Over time (& thermal cycles for sc magnets)
 - With respect to changes in current
- **Stray Field**
 - Magnetic elements near SCRF cavities must meet stray field limits at cavity of $\sim 1\mu\text{T}$ (warm) and $\sim 10\mu\text{T}$ (cold)
- **Reliability**
 - MTBF for magnets $\geq 10^7$ hrs!
 - Meeting reliability requirements must be a key component of design approach
 - R&D program/'lifetime' studies required
- **Cost**
 - Design must be cost efficient while meeting lattice and reliability requirements