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 tranfer 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	1	2	0	0	0	0	1	8	0	0	0	0
Normal cond Corrector	15	6170	11	0	3968	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; Vl. 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 (Vl. Kashikhin)
- Main Linac
  - Quadrupole & corrector designs
    - FNAL – Vl. 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 (Vl. 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 ⇔ number of rings
  - e+ source
    - Undulator
    - Long transfer line ⇒ >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 ~1μT (warm) and ~10μT (cold)
- *Reliability*
  - MTBF for magnets ≥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