



US LHC Accelerator Research Program
brookhaven - fermilab - berkeley

The U.S. LHC Accelerator Research Program:
A Proposal

R. Kephart, M.J. Lamm, P. Limon, J. Marriner, T. Sen, J. Strait, A.V. Zlobin
Fermi National Accelerator Laboratory
Batavia, IL 60510

P. Cameron, A. Drees, W. Fischer, R. Gupta, M. Harrison, F. Pilat, S. Peggs
Brookhaven National Laboratory
Upton, NY 11973

W. Barletta, J. Byrd, P. Denes, M. Furman, S. Gourlay, A. Ratti, W. Turner
Lawrence Berkeley National Laboratory
Berkeley, CA 94720

May 2003



Outline

Program Goals

Overview of the Technical Program and Schedule

Organization and Management

Cost and Budget Development

Conclusions



Goals of the US LARP

Advance High Energy Physics

- Help bring the LHC on and up to design performance quickly.
- Improve LHC performance by advances in understanding and instrumentation.
- Use LHC as a tool to gain deeper knowledge of accelerator science and technology.
- Extend LHC as a frontier HEP instrument with a timely luminosity upgrade.

Advance U.S. Accelerator Science and Technology

- Keep skills sharp by helping commission the LHC.
- Conduct forefront AP research and development.
- Advance U.S. capabilities to improve the performance of our own machines.
- Prepare U.S. scientists to design the next generation hadron collider.
- Develop technologies necessary for the next generation of hadron colliders.

Advance International Cooperation in the High Energy Accelerators



Overview of the Technical Program

- Help commission the hardware delivered by the US LHC Accelerator Project and later by the LARP
- Help commission the LHC with initial beam.
- Develop and build new instruments that will improve the operation of the LHC and help us perform accelerator physics experiments.
- Use the LHC to perform experiments and test calculations and theories of fundamental accelerator science.
- Perform accelerator physics studies and advanced magnet R&D that will result in the IR designs and prototype IR magnets for a timely LHC luminosity upgrade.



Schedule – Commissioning and Instrumentation

The LARP schedule is driven by the LHC schedule:

- August 2004 – Installation of US-provided equipment begins.
- April 2005 – Hardware commissioning of 1st US-provided IR.
- April 2006 – Sector test with beam.
- April 2007 – First beam in LHC.
- July 2007 – First LHC collisions.
- 2007 - 2010 – LHC luminosity rises towards design value.

⇒ Hardware commissioning activity peaks 2005-2007.

⇒ Beam commissioning peaks 2007-2009.

Preparations must start in 2004 to allow us to be fully integrated with CERN so we can have maximum impact.

⇒ Beam instrumentation R&D must start *now* so that the instruments we develop contribute to the efficient commissioning the LHC.



Schedule – Accelerator Physics and Upgrades

- 2007 - 2010 – LHC luminosity rises towards design value.
- 2011 - ... – LHC runs at asymptotic performance parameters.

⇒ LHC will be the **forefront vehicle** for high energy hadron accelerator physics **as soon as it is operational**.

Fundamental accelerator physics research based on the LHC must start well before this so that we are **ready to exploit this opportunity**.

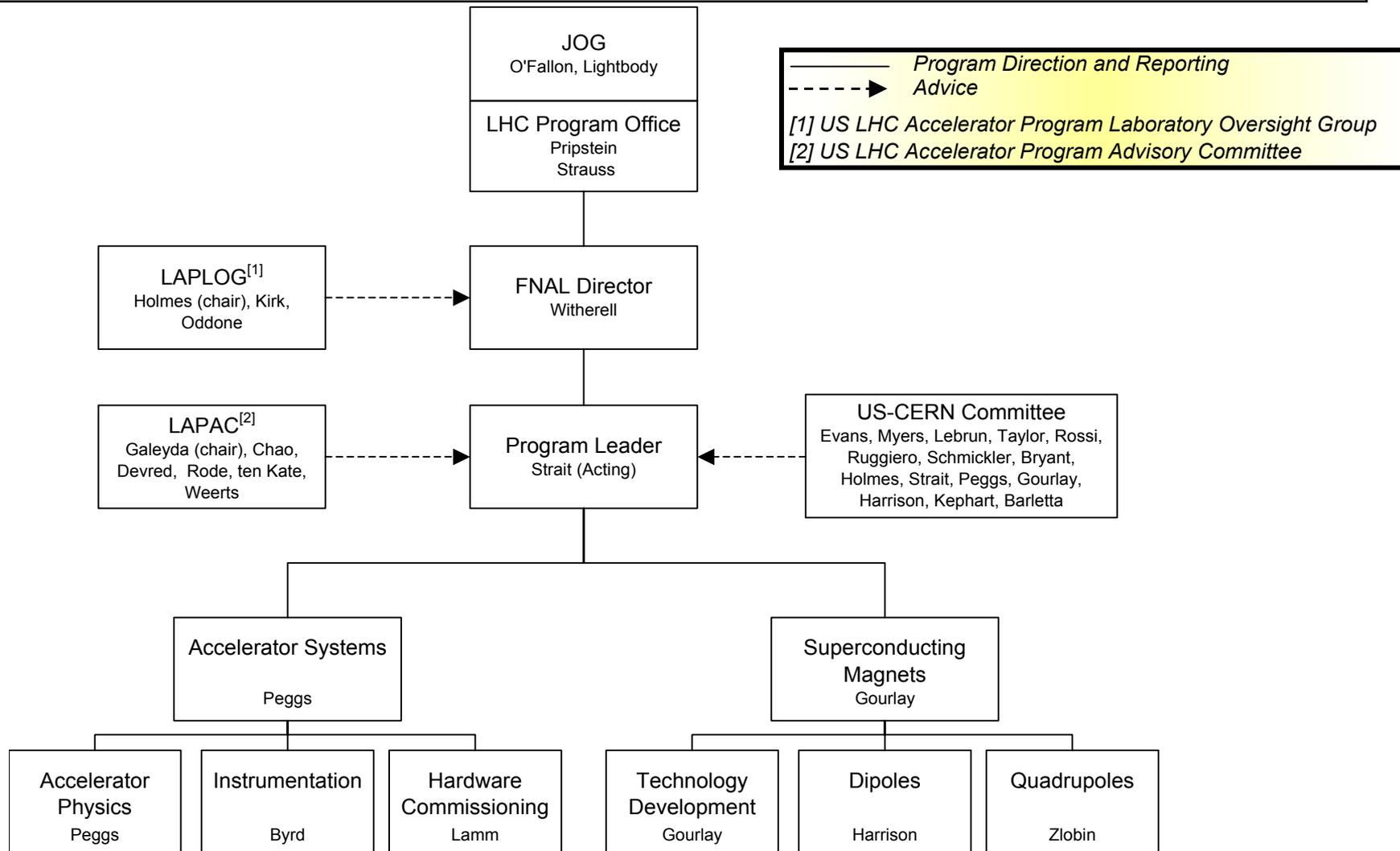
⇒ **Significant upgrades** to the LHC and its experiments will be required **by the middle of the next decade** to extend its physics reach and keep its physics program productive.

Extensive R&D will be required to develop the **accelerator physics understanding** and the **beyond-the-state-of-the-art technologies** required to push the LHC beyond its already demanding parameters.

... **This R&D must start now** to ensure we are ready for the upgrades.



Organization and Management





Leadership and Management Structure

Fermilab Director

- DOE has assigned Fermilab to serve as Host Lab. (See Appendix B.)
- Provides management oversight for LARP.
- Has ultimate responsibility, in consultation with BNL and LBNL Directors, for effective operation of LARP.
- Advised by LAPLOG.

Program Leader

- Sets overall program direction.
- Responsible for successful execution of the LARP.
- Reports to the Fermilab Director and the JOG.
- Advised by LAPAC, US-CERN Committee, Executive Committee.



Leadership and Management Structure

Work is organized according to technical deliverables:

Accelerator Systems (Steve Peggs)

- Hardware Commissioning (Mike Lamm)
- Accelerator Physics (Steve Peggs)
- Instrumentation and Diagnostics (John Byrd)

Superconducting Magnet R&D (Steve Gourlay)

- Technology Development (Steve Gourlay)
- IR Dipoles (Mike Harrison)
- IR Quadrupoles (Alexander Zlobin)

Each division or group leader

- Represents the *national* program... all labs are involved in all areas.
- Develops annual program plan and budget, under direction of Program Leader.



Advisory Groups and Peer Review

LHC Accelerator Program Laboratory Oversight Group (LAPLOG).

- Relevant Deputy/Associate Directors of the participating labs.
- Advises FNAL Director in his oversight duties with respect to LARP.
- Addresses high-level inter-laboratory issues.
- Reviewed and approved the LARP proposal on May 14, 2003.

US-CERN Committee for the LARP.

- Combines leaders of US LARP with relevant CERN leaders.
- Jointly chaired by CERN LHC Project Leader and LARP Leader.
- Reviews proposed topics for US-CERN collaboration on LHC.
 - Reviewed and approved the LARP proposal on April 10, 2003.
(See Appendix D.)
 - Reviews changes to the program as it develops.
- Provides top-level coordination of on-going collaborative work.



Advisory Groups and Peer Review

Executive Committee.

- Made up of the US members of the US-CERN Committee.
- Advises Program Leader on programmatic issues within the US Labs:
 - Division of LARP technical work.
 - Resource allocation.
 - Proposed program changes prior to submission to US-CERN Committee.

US LHC Accelerator Program Advisory Committee (LAPAC).

- Distinguished accelerator scientists and technologists, and high energy physicists who are not involved in LARP.
- Provides independent advice on scientific, technical and management performance of LARP.
- Conducts reviews of the program as a whole and of individual elements as needed, but at least once per year.
- Reviewed early version of LARP program June 17-18, 2002.



Management Oversight and Performance Evaluation

This is an R&D program

=> earned value management and program tracking is not appropriate.

Oversight and performance evaluation will be provided by:

- Periodic (quarterly or semi-annual) **written progress reports** from sub-program leaders.
- **Annual work plan submitted** by each sub-program leader, which
 - outlines plans, goals and budgets, and
 - compares progress made relative to the previous year's plan.
- **Periodic technical reviews** of each major program element.
 - Conducted by experts not directly involved with the work under review.
 - Review committees report to the Program Leader
 - LAPAC independently reviews the program as a whole, and may organize additional focused reviews.



Changes to the LARP Work Scope

Proposals for new program elements or major changes to existing ones may be submitted from **within** or **outside** the current LARP collaboration. **Written proposal** must be submitted to Program Leader, who will **decide** if it is to be accepted based on **advisory committee reviews**.

- Program Leader will **consult with CERN** about match to overall LHC program, **and with DOE**, if additional funding is needed.
- **LAPAC** will provide independent advice on the **scientific and technical merit, and the proposed budget and schedule**.
- **Executive Committee** review will include:
 - Match of proposed work to LARP goals.
 - Feasibility of fitting proposed work within available funding.
- **US-CERN Committee** will provide final review, including
 - Technical and scientific merit.
 - Match to the needs of the overall LHC program.



Toohig Fellowships

Individuals from outside the LARP collaborating institutions may be supported by the LARP as **Toohig Fellows**.

The work done by a Toohig Fellow will

- Be done in **cooperation with the LARP**.
- Be done **at a LARP institution or at CERN**.
- Be part of an **existing LARP sub-program**,

or

- Be an **original idea** of the individual investigator, subject to the procedure for adding new programs to the work scope.

These Fellowships are named **in honor of the late Rev. Dr. Timothy Toohig, SJ**, who spent his life working to foster international cooperation in HEP, and **who inspired us to start the U.S. LHC Accelerator Research Program**.



Cost Estimate and Budget Development

Cost and schedule estimates have been developed for each major sub-program.

- **This is an R&D program** => It is neither necessary nor sensible to perform detailed “bottoms-up” cost estimates.
- **Differing degree of detail** involved in cost estimates **for different program elements**.
 - Moderately detailed estimates for some instrumentation.
 - Level-of-effort estimates for commissioning and accelerator physics.
 - Cost models for magnet R&D that indicate the types and level of R&D that can be supported by the budget ... but which are *not* (cannot be) comprehensive, multi-year program plans.
- **Cost estimates presented here do not represent a rigid plan**.
 - Program budgets and cost estimates will be updated as part of the annual budget and planning cycle.
 - Program plan will evolve as the R&D progresses.

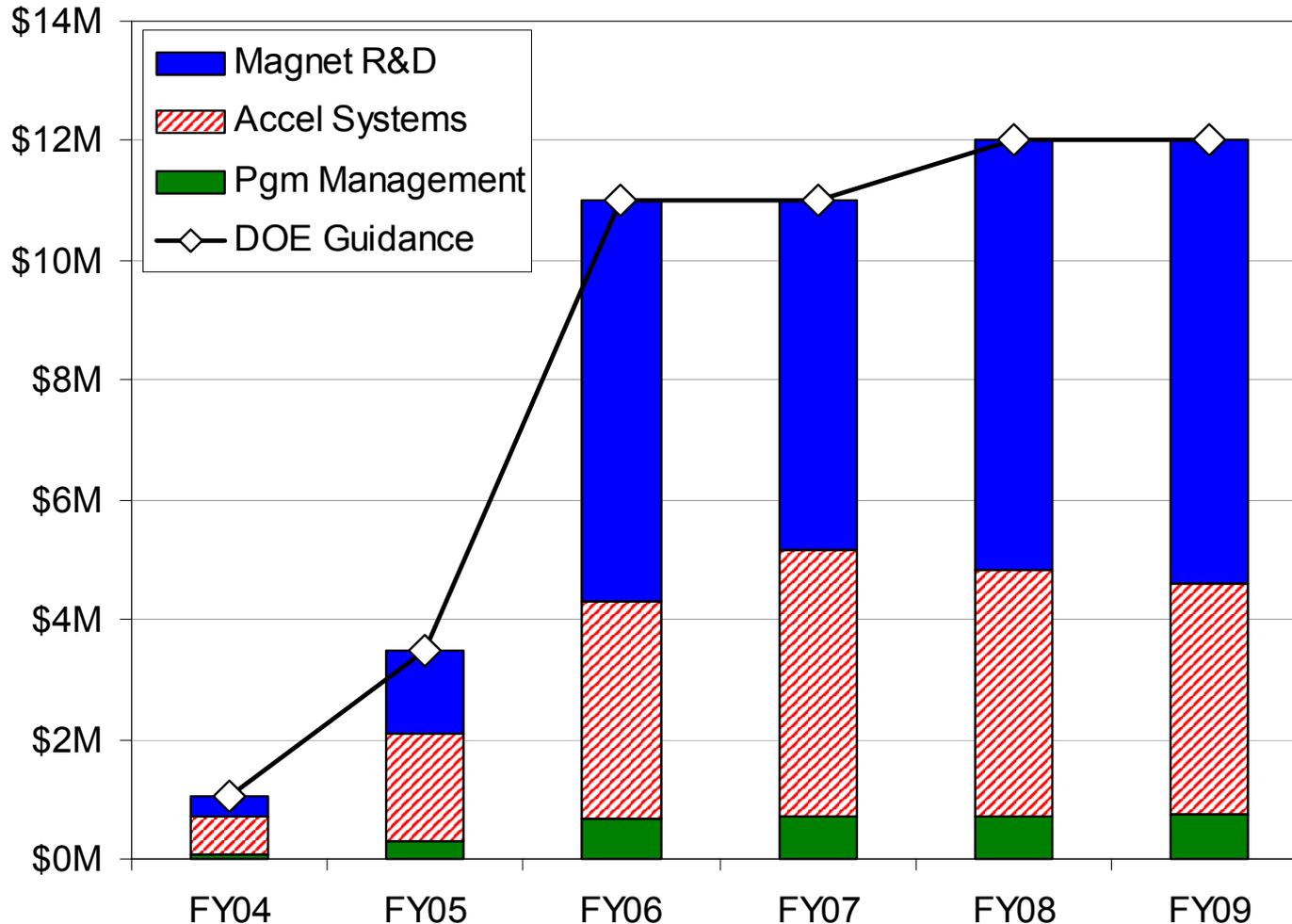


Cost Estimating Methodology

- Labor estimates developed for each program element in FTEs in broad categories:
 - Scientists, Engineers, Post-Docs, Students, Designers, Technicians, and Administrators.
- Effort converted to cost using 3-lab average rates, based on US LHC Accelerator (construction) Project baseline rates in FY2003 \$, with R&D program overheads applied:
 - Scientists and Engineers \$200k/year
 - Designers, Technicians and Administrators \$120k/year
 - Post-Docs and Students \$100k/year
- Three-lab average overhead rate applied to M&S direct cost.
- Travel estimated as proportional to FTE scientists and engineers.
- 3%/year escalation assumed.



Cost Estimate Summary





Cost Estimate Summary

Table 4.1-1 LARP Cost Estimate Summary.

		FY04	FY05	FY06	FY07	FY08	FY09
Sub-program Costs							
Program Management	\$k	89	282	675	695	716	737
Accelerator Systems	\$k	638	1,823	3,623	4,457	4,098	3,850
Magnet R&D	\$k	323	1,395	6,697	5,849	7,193	7,415
Total Program Cost	\$k	1,049	3,500	10,995	11,001	12,007	12,002
DOE Funding Guidance	k\$	1,050	3,500	11,000	11,000	12,000	12,000



Cost Estimate Summary

Table 4.1-2 LARP M&S and Labor Cost Estimate Summary

		FY04	FY05	FY06	FY07	FY08	FY09
Labor count							
Scientist/Engineer	FTE	4.1	10.4	19.8	21.7	20.3	19.1
Post-doc/Student	FTE	0.0	0.5	4.3	6.5	7.0	7.0
Technician/Designer	FTE	0.5	2.7	13.9	12.2	12.9	12.4
Administrator	FTE	0.0	0.4	0.8	0.8	0.8	0.8
TOTAL LABOR	FTE	4.6	14.0	38.8	41.2	41.0	39.3
Labor cost	\$k03	870	2,502	6,154	6,550	6,404	6,104
Travel	\$k03	37	102	212	252	237	221
Materials & Services	\$k03	112	695	3,696	2,972	3,716	3,727
TOTAL COST							
Constant dollars	\$k03	1,019	3,299	10,062	9,774	10,357	10,052
With 3.0%/year escalation	\$k	1,049	3,500	10,995	11,001	12,007	12,002

~Flat level of effort in constant dollars



Program Management Cost Estimate

		FY04	FY05	FY06	FY07	FY08	FY09
Labor count							
Program Office							
Scientist/Engineer	FTE	0.2	0.5	1.0	1.0	1.0	1.0
Administrator	FTE		0.2	0.5	0.5	0.5	0.5
SUB-TOTAL	FTE	0.2	0.7	1.5	1.5	1.5	1.5
Accelerator Systems							
Scientist/Engineer	FTE	0.1	0.3	0.7	0.7	0.7	0.7
Administrator	FTE		0.1	0.2	0.2	0.2	0.2
SUB-TOTAL	FTE	0.1	0.4	0.9	0.9	0.9	0.9
Magnet R&D							
Scientist/Engineer	FTE	0.1	0.2	0.7	0.7	0.7	0.7
Administrator	FTE		0.1	0.2	0.2	0.2	0.2
SUB-TOTAL	FTE	0.1	0.3	0.9	0.9	0.9	0.9
Materials & Services							
Misc. Supplies (\$5k/FTE)	\$k03	2	7	16	16	16	16
SUB-TOTALS							
Labor count							
Scientist/Engineer	FTE	0.4	1.0	2.4	2.4	2.4	2.4
Administrator	FTE	0.0	0.4	0.8	0.8	0.8	0.8
TOTAL LABOR	FTE	0.4	1.4	3.2	3.2	3.2	3.2
Labor cost	\$k03	80	248	576	576	576	576
Travel	\$k03	4	11	26	26	26	26
Materials & Services	\$k03	2	7	16	16	16	16
TOTAL COST							
Constant dollars	\$k03	86	266	618	618	618	618
With 3.0%/year escalation	\$k	89	282	675	695	716	737

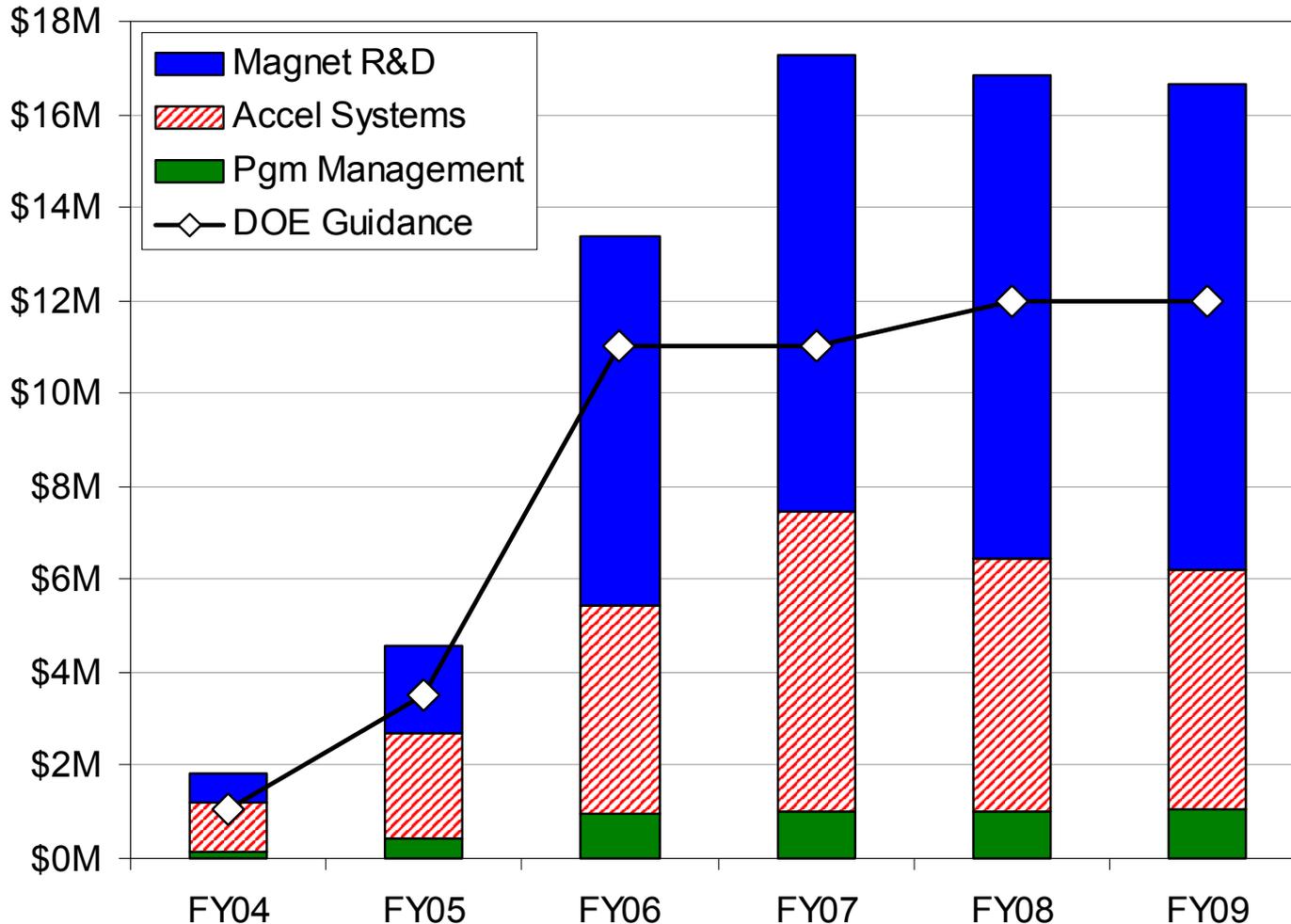


Compromises to Fit Program within Funding Guidance

- Instrumentation R&D starts more slowly than is desirable:
 - Some elements are supported at minimal level.
 - Operational systems may be delivered later than desirable.
- Level of effort on beam commissioning and accelerator physics has been reduced from original plan (12 -> 9.5 FTE).
- Magnet R&D starts slowly, and asymptotic program is not as strong as it should be.
 - May force early down-select to one magnet program (quadrupole or dipole).
- These compromises:
 - Increase technical risk.
 - Significantly limit our impact on LHC performance.
 - Significantly limit the benefit to the US accelerator programs.



“Unconstrained” Cost Estimate





Conclusions

- The U.S. labs can play an important role in speeding startup, bringing LHC up to design performance, and performing R&D for a luminosity upgrade, thereby maximizing the physics return on our large national investment.
- The LHC will be the frontier high energy accelerator, offering forefront opportunities for advanced accelerator physics and technology research and development.
- The US-CERN collaboration on LHC has been and will continue to be essential to advancing international cooperation in high energy accelerators, which will be crucial to the future of our field.
- The LARP provides the framework to extend the highly productive US-CERN collaboration on the LHC accelerator.