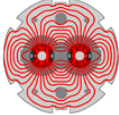




# Cost Estimates for LARP to Project Transition

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17-Feb-2014



# Outline

- Background
- LARP->HL-LHC Scope in June 2013
- Cost Estimating and Scheduling Methodology
- Magnet schedule assumptions and overview
- Project Management Ramp Up
- Cost Summaries

The subject of this talk is construction project related costs. Current LARP funding and scope are discussed in each subsystem.



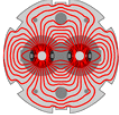
# History



The first effort to converge on a scope, cost, and schedule for a HL-LHC related construction project borne out of LARP was conducted in late 2012. The result was a down-selection from several candidate deliverables.

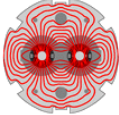
Following the down-selection, cost and schedule estimates for the construction project were refined and presented at an internal LARP review with external reviewers in June 2013.

<https://indico.fnal.gov/conferenceOtherViews.py?view=standard&confId=6836>



# LARP->HL-LHC Project Scope as of June 2013

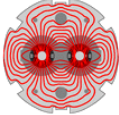
- **Magnets**
  - Assemble, test, and deliver 20 (16 + 4 spares) Q1/Q3 quadrupole structures, where “structure” = coils clamped radially in aluminum shells, axially with stainless steel rods and end plates
- **Crab Cavities**
  - Assemble, test, deliver 10 cryomodules of 3 cavities each
    - Contain cavities, He vessels, tuners, HOM mode dampers
    - Cryogenics, RF power, local installation provided by CERN
    - 8 CM needed in pts 1 and 5, 2 spares (one per IP)
- **Wideband Feedback System**
  - Fully functioning wideband feedback system for SPS and commissioning support.



# June 2013 Review Charge

1. Can the proposed project scope fit within the schedule and budget guidance given?
2. Are the proposed cost, cost profiles and schedules reasonable?
3. Is the plan to integrate external contributions within the constraint of a fixed budget adequate?
4. Is the technical plan proposed by each sub-project optimally developed? Are there additional technical risks that should be considered?
5. Is the proposed management structure appropriate for the scope and scale of the project?
6. Are there additional comments the Committee feels are relevant, regarding either individual tasks or the project as a whole?

June 2013 review charge was construction related.



# June 2013 Review Outcome

- Magnets

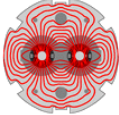
- The technical feasibility of the quad program seems reasonable.
- The cost have a decent basis in the LARP R&D program
- The scope is reasonable for a \$200M US contribution.
- The major uncertainties and risk appear to be programmatic in nature.

- Crab Cavities

- Costs & cost profiles: these are not unreasonable at this point in the project.
- Schedule: Can the proposed project scope fit within the schedule and budget guidance given?
  - Yes, but only if the required budgets are forthcoming. It will be challenging to meet the 2015 schedule for the prototype cryomodule, and it's likely the schedule contingency of up to one year will be needed.

- Wideband Feedback System

- We feel that proposed manpower allocations may be underestimated. To appropriately amortize the engineering work done in the research phase of the project (through 2016), there has to be continuity in engineering manpower.
- Presented schedule estimates are optimistic and have minimal headroom to react to additional budget pressures.



# Updates since June 2013

- The construction project cost estimates have not been updated to account for the following changes:
  - Change of Crab Cavity deliverable from assembled and tested cryomodules to dressed cavities (4 cavities x 2 sides of the IP x 2 beams x 2 IPs = 32 cavities). Will likely lead to a net savings and a reduced pre-construction engineering effort.
  - Change of test stand upgrade sequence. June plan was to upgrade FNAL test stand first using GARD funds, with BNL test stand being upgraded with construction funds. Latest plan is to upgrade BNL stand first using APUL funds in conjunction with LARP funds.

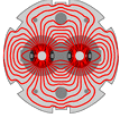


# Construction Cost Estimate Methodology



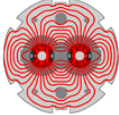
- Guidelines issued for estimating each deliverable with respect to project accounting (overheads, escalation, contingency).
- Formats were time phased estimates on spreadsheets. These are ok for now, but do not lend themselves to straightforward updates based on status.
- Preliminary discussions with CERN regarding interfaces and handoff points.
- Attempted to reconcile with near term budget realities, but there are still challenges.





# Basis of Estimate

- **Magnets**
  - Detailed study of coil fabrication rates, capacities, and labor. Joint effort of BNL and FNAL.
  - Bottom up estimate of structure by LBNL.
  - Magnet testing estimate by FNAL T&I department
  - M&S costs based primarily on quotes and past procurements (LQ, LHQ).
- **Crab Cavities**
  - Bottom up engineering estimates
  - Prototype cavity procurements
- **Wideband Feedback**
  - experience designing/constructing/commissioning wideband coupled-bunch systems for PEP-II, ALS, PLS, BESSY-II, DAFNE and KEKB.



# Magnet Cost and Schedule



## Assumptions

June 2013 Review

Adjusted to latest LHC  
Shutdown Schedule

1. CD-3 in ~~FY2017~~ → FY2018. Guidance given is that CD-0,1,2 could occur simultaneously in FY17. This requires preparation.
2. Magnet Cold Mass Production window is ~~FY2017-2021~~ → FY2018-2022
  - a) Goal is >1 year schedule contingency relative to CERN schedule. Deliver production cold masses by end of FY21 ~~FY22~~ → for 10/22-3/23 10/23-3/24 installation in LHC.
3. Funds for SC wire purchase available in ~~FY2015~~ → FY2016. Up front payment of 13% required, with another 27% less than one year later.
4. CERN Hi-Lumi TDR is complete in ~~2015~~ → 2016.
5. FNAL and BNL each produce coils → cold masses. LBNL performs cabling and structure sub-assembly.
6. Coil yield is 8/9.
7. Test facility upgrades complete in time for production.



# High Level Magnet Production Schedule

		LARP Magnet High Level Schedule 12-Feb-2014																																										
Fiscal Year	FY2015				FY2016				FY2017				FY2018				FY2019				FY2020				FY2021				FY2022				FY2023				FY2024							
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4								
<b>Assumed Critical Decisions (or equivalent readiness)</b>			CD-0				CD-1				CD-2				CD-3										LS3 Start																			CD-4
<b>CERN Milestones (to be confirmed)</b>																																												
	PDR				Prelim. TDR				Final TDR				Final Executive Design												Last magnet in tunnel																			
<b>LARP Cable</b>																																												
Production Wire Order Payment #1																																												
Production Wire Order Payment #2																																												
Production Wire deliveries																																												
Production Cabling and Insulating																																												
<b>LARP Production (Q1+Q3)</b>																																												
Tooling, Equipment Procurement																																												
Coil Production																																												
Pre-Series Cold Mass Assembly (#1,2)																																												
Cold Mass Assembly and Test (#3-6)																																												
String Test at CERN																																												
Cold Mass #7-20 Assembly and Test																																												
All Cold Masses at CERN																																												

Identical schedule presented in June but delayed by one year here



LARP

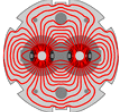


# Construction Project Management Functions

Level of effort and functions based on other ~\$200M projects, e.g. NOvA and Mu2e

Readiness	CD-0	CD-1	CD-2	CD-3					CD-4
	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
	FTE	FTE	FTE	FTE	FTE	FTE	FTE	FTE	FTE
1 FTE = 1768 Hours									
Project Mgr					1	1	1	1	1
Deputy Project Mgr				1	1	1	1	1	1
Project Engineer	0.5	1	1	1	1	1	1	1	1
Project Controls	0.5	2	2	2	2	2	2	2	2
Financial			1.0	1.0	1.0	1.0	1.0	1.0	1.0
QA Manager		0.1	0.1	0.1	0.1	0.1	0.1	0.1	
Risk Manager		0.1	0.1	0.1	0.1	0.1	0.1	0.1	
Admin		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
<b>TOTAL</b>	<b>1.00</b>	<b>3.30</b>	<b>4.30</b>	<b>5.30</b>	<b>6.30</b>	<b>6.30</b>	<b>6.30</b>	<b>6.30</b>	<b>6.10</b>

Readiness	CD-0	CD-1	CD-2	CD-3					CD-4			
Additional Management for Construction	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	Total w/o Cont	Cont%	Total incl. Cont
Materials	\$0.01M	\$0.07M	\$0.07M	\$0.07M	\$0.07M	\$0.07M	\$0.07M	\$0.08M	\$0.08M	\$0.58M	30%	\$0.76M
Labor	\$0.27M	\$0.85M	\$1.14M	\$1.49M	\$1.85M	\$1.90M	\$1.96M	\$2.01M	\$2.00M	\$13.48M	10%	\$14.82M
<b>Total Add'l Mgmt</b>	<b>\$0.28M</b>	<b>\$0.92M</b>	<b>\$1.21M</b>	<b>\$1.56M</b>	<b>\$1.93M</b>	<b>\$1.98M</b>	<b>\$2.03M</b>	<b>\$2.09M</b>	<b>\$2.08M</b>	<b>\$14.06M</b>	<b>11%</b>	<b>\$15.58M</b>



LARP

# Summary of Construction



## Cost Estimates

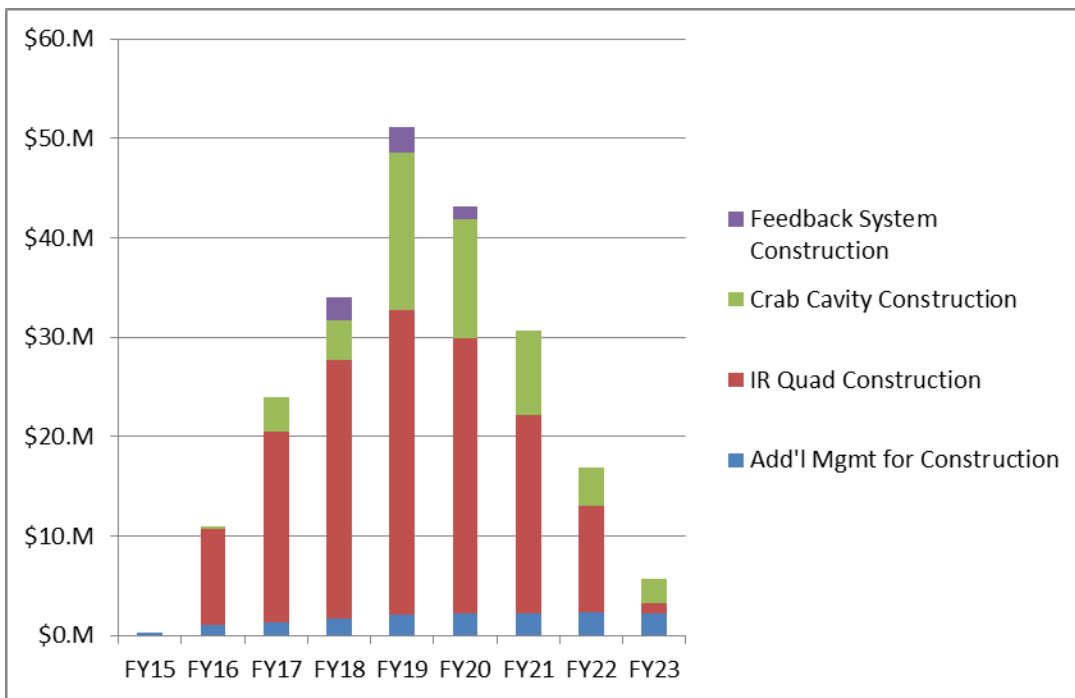
Assumed to be absorbed by LARP and not included in totals

Construction (for FY23 completion) w/Distributed Contingency	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	Total
Add'l Mgmt for Construction	\$0.31M	\$1.02M	\$1.34M	\$1.73M	\$2.14M	\$2.2M	\$2.26M	\$2.32M	\$2.22M	\$12.85M
IR Quad Construction		\$9.73M	\$19.2M	\$25.97M	\$30.57M	\$27.75M	\$19.92M	\$10.72M	\$1.07M	\$144.94M
Crab Cavity Construction		\$0.2M	\$3.49M	\$3.95M	\$15.81M	\$11.96M	\$8.44M	\$3.91M	\$2.41M	\$50.18M
Feedback System Construction				\$2.4M	\$2.61M	\$1.24M				\$6.25M
<b>Totals</b>		<b>\$9.93M</b>	<b>\$22.69M</b>	<b>\$34.04M</b>	<b>\$51.14M</b>	<b>\$43.15M</b>	<b>\$30.61M</b>	<b>\$16.95M</b>	<b>\$5.7M</b>	<b>\$214.22M</b>

SC Wire first payment, test facility upgrade, production engineering

SC Wire second payment, production tooling, coil and cold mass parts for first production year

Estimates based on June 2013 scope, but escalated by one additional year. **Table includes ~30% contingency evenly spread.**





# Summary



- Substantial work put into estimates for a project at this stage.
- Management model and staffing plan under development. Unknown parameter is level of rigor required for a “proceed as-if in CD process” scenario.
- Technical and management CD-X readiness and long lead procurements will require funding in advance of the assumed FY18 CD-3 to supplement the existing flat-flat LARP levels.

Thank you