LARP DOE Review – Q&A

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February 18th 2014

Show ramp up of LAP and ramp down of LARP

- Show ramp up of LAP (LHC Accelerator Project) and ramp down of LARP

Based on "Preliminary Deliverables" (June '13)
CD-4 by FY23

	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	LARP TOTAL	PROJECT TOTAL
"R&D" LARP Funding	$ 5M	$ 5M	$ 5M	$ 6M	$ 7M	…	…	…	…		
LARP funding	$16M	$16M	$16M							$48M	
LLI (pre-Project funding)		$10M	$23M								$33M
Project funding				$34M	$51M	$43M	$31M	$17M	$6M		$182M
TOTAL	$16M	$26M	$39M	$34M	$51M	$43M	$31M	$17M	$6M	$48M	$215M

↑ CD-0/CD-1/CD-2

LARP

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(?) Consistency in funding profile over a number of presentations

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What is included ?

From M. Kaducak Presentation

- 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.

Funding Profile Tables

- You saw 2 "overall cost tables"

Based on "Preliminary Deliverables" (June '13)
CD-4 by FY22

LARP and US-HL-LHC Needs: June '13 Review

- In Jun '13, the LARP/US-HL-LHC Project underwent a LARP Internal Review that presented the following profile request for LARP continuation until 2017 and for US-HL-LHC Project
- CD-4 planned by end-FY22

LARP Funding Total ~ 62 M$

Project Funding Total ~205 M$

Totals w/Distributed Contingency	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	Total
Existing LARP Management	$900,000	$900,000	$900,000	$900,000	$900,000	$0	$0	$0	$0	$0	$4,500,000
IR Quad Prototypes	$5,428,000	$6,674,495	$10,787,491	$6,128,707	$2,092,806	$432,039	$0	$0	$0	$0	$31,543,537
Crab Cavity Prototype	$797,492	$1,200,000	$2,298,266	$187,697	$0	$0	$0	$0	$0	$0	$4,483,455
Feedback System Des/Dev	$1,317,124	$1,409,219	$1,772,012	$1,711,097	$0	$0	$0	$0	$0	$0	$6,209,452
Add'l Mgmt for Construction	$0	$302,287	$991,260	$1,300,231	$1,678,290	$2,075,913	$2,132,028	$2,189,578	$2,248,830	$2,152,449	$15,070,867
IR Quad Construction	$0	$0	$9,445,813	$18,642,867	$25,211,021	$29,682,904	$26,944,355	$19,340,937	$10,411,064	$1,043,069	$140,722,029
Crab Cavity Construction	$0	$0	$195,681	$3,386,538	$3,831,668	$15,353,475	$11,615,261	$8,190,661	$3,800,762	$2,342,882	$48,716,928
Feedback System Construction	$0	$0	$0	$0	$2,330,342	$2,536,272	$1,199,412	$0	$0	$0	$6,066,027
Totals	**$8,442,617**	**$10,486,001**	**$26,390,523**	**$32,257,136**	**$36,044,127**	**$50,080,604**	**$41,891,056**	**$29,721,175**	**$16,460,656**	**$5,538,400**	**$257,312,295**
US-LARP Budget											
LARP Budget for Projects	$9,400,000	$9,400,000	$9,400,000	$9,400,000	$9,400,000						$47,000,000
Other LARP Budget: **-General Accelerator R&D** **-Toohig and Long Term Visitors** **-Programmatic Travel**	$3,000,000	$3,000,000	$3,000,000	$3,000,000	$3,000,000						[illegible]
Total LARP Budget (Exist Program	$12,400,000	$12,400,000	$12,400,000	$12,400,000	$12,400,000						$62,000,000
Pre-Project Funding Required	$0	$1,086,001	$16,990,523	$22,857,136	$0						[illegible]
Project Funding Required	$0	$0	$0	$0	$26,644,127						[illegible]
Total Funding Required	$12,400,000	$13,486,001	$29,390,523	$35,257,136	$39,044,127						[illegible]

- LARP request in FY14:
  - 13.5 M$ + 2 M$ (GARD) = 15.5 M$
- LARP/+ Pre-Project Request in FY15:
  - 29.4 M$ + 4 M$(GARD) = 33.4 M$

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Based on "Preliminary Deliverables" (June '13)
CD-4 by FY23

Summary of Construction Cost Estimates

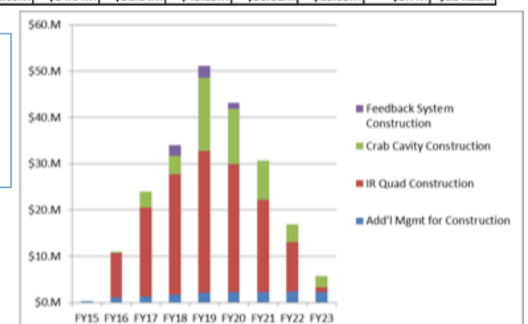
Assumed to be absorbed by LARP and not included in totals

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
Totals		**$9.93M**	**$22.69M**	**$34.04M**	**$51.14M**	**$43.15M**	**$30.61M**	**$16.95M**	**$5.7M**	**$214.22M**

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.**



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- LAP(MIE) estimate: 205$ -> 215 M$
  - Escalation effect + 1 extra year of Management
- LARP: From 62M$ in FY14-17 to 48 M$ in FY15-FY17
  - Accounts for funds received in FY14

LLI (Pre-Project) Funding

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- "LLI-like/Preproject Funding" presented by Mark do include more than just SC strand contract to insure immediate production start inFY18

	FY16	FY17
SC Wire	$2,432,810	$4,877,812
Test Facility Modifications	$1,371,190	
Winding and Curing Tooling		$731,003
Coil Handling/Storage		$1,019,503
Portable CMM Machine		$225,305
Reaction/Impregnation Tooling		$1,655,336
Cold Mass Assembly Tooling		$183,782
Coil Parts for first 10 coils		$834,418
Total M&S w/o contingency	$3,804,000	$9,527,158
Labor (eng, design, QC, L2 mgmt)	$3,341,563	$4,674,128
Total w/o contingency	$7,145,563	$14,201,286
Total including 35% contingency	**$9,646,510**	**$19,171,737**

Examples of Pre-MIE LLI funding needs

- Assuming MIE funding is available in FY18:
  - Strand Procurement
    - Need to start in Q4FY16 to be ready for first coil fabrication in Q2FY18
      - ~ $6.3M in Pre-MIE funding (preliminary)
  - Magnet Fabrication Tooling
    - Procurement in FY17
      - ~ $3.7M in Pre-MIE funding (preliminary)
  - Preparations for MQXF Test Facility
    - Test Stand Upgrade needs to start in FY17 , first MQXF test expected January 2019
      - Pre-MIE funding needs being identified

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B
Benefit of spending 15-18% of budget on HQ testing. In worst case, need to reduce magnet development by 5%. Justify the quench protection from HQ testing versus the 5% reduction.

- Benefits of spending 15-18% of budget on HQ testing. In worst case needs to reduce magnet development by 5%. Justify the quench protection from the HQ testing vs. the 5% reduction.

HQ = Risk Reduction for QXF

- Quench Protection
- Field Quality
- Personal note: although HQ activities in FY14 represent ~15% of the magnet budget, the HQ03 test is a small fraction of such budget. The amount of knowledge gained vs. the *rather* limited savings is for me the outstanding argument to continue the effort.

Quench Protection

- Test of Maximum acceptable temperature
  - Present understanding based on single TQ test (TQS01c), which did not have stainless steel core
- First test of CLIQ on a Nb_3Sn magnet
  - Very promising, but tested only on a short NbTi magnet
- Test of quench heaters optimized for QXF
- If we do not do perform these tests on HQ we will have to perform them on SQXF1 or SQXF1b
  - But we need a magnet that can approach SSL, and this is a destructive test (not likely on the 1st SQXF model)

➔ ~Two year min. delay on a critical part of the design

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Field Quality

- HQ03 test will either confirm that HQ02 low order harmonics are out of tolerance, or will show that we fixed them with more uniform coils
- It should also show the effectiveness of the planned correction scheme
- If we do not test HQ03 we will have to wait for SQXF1 and SQXF2 in order to have two similar magnets for checking field quality reproducibility

➔ <u>~Two year delay for feedback to beam dynamic simulations and setting of Field Quality requirements</u>

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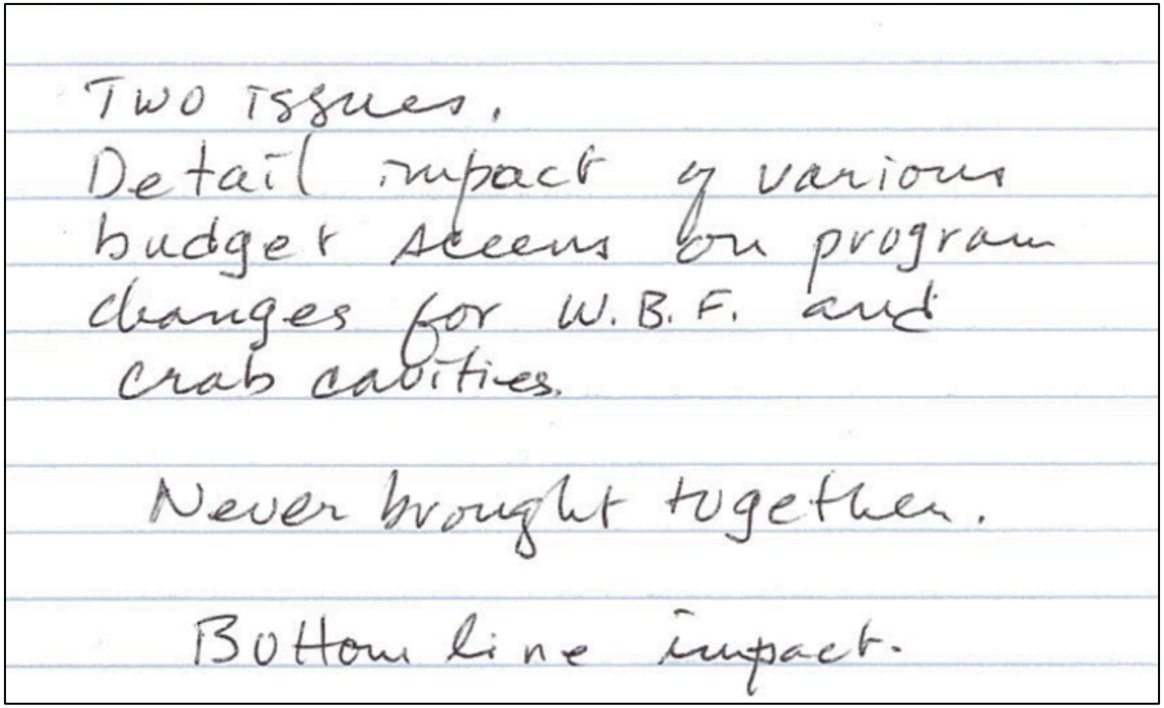
- NOTE: a ~2 year delay in these critical parts of the design (Quench Protection and Field Quality) is an extremely high risk
  - We will have to make decisions without this feedback
- Even if we cancel HQ we will have to do the scientific and engineering work associated with addressing these points, so the potential saving is limited.



Two Issues.
Detail impact of various budget [illegible] on program changes for W.B.F. and crab cavities.

Never brought together.

Bottom line impact.

- Two issues: detail impact of various budget … on program changes for WBF and Crab Cavities. Never brought together. Bottom line impact.

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CC - Funding Scenario 1

- Full funding
  - Still has a problem managing the difficult spending profile with peak in FY15
- FY15
  - Request FY14 contingency to restore most of the scope delayed from FY14 into FY15
    - Design and build tooling and structures for VT
    - Materials and service procurements for final processing (at JLAB/ANL) and VT
    - Expedite HOM dampers and tuners development
  - Staged delivery of 2 cavities into FY16
    - Still compatible with global schedule

CC - Funding Scenario 2

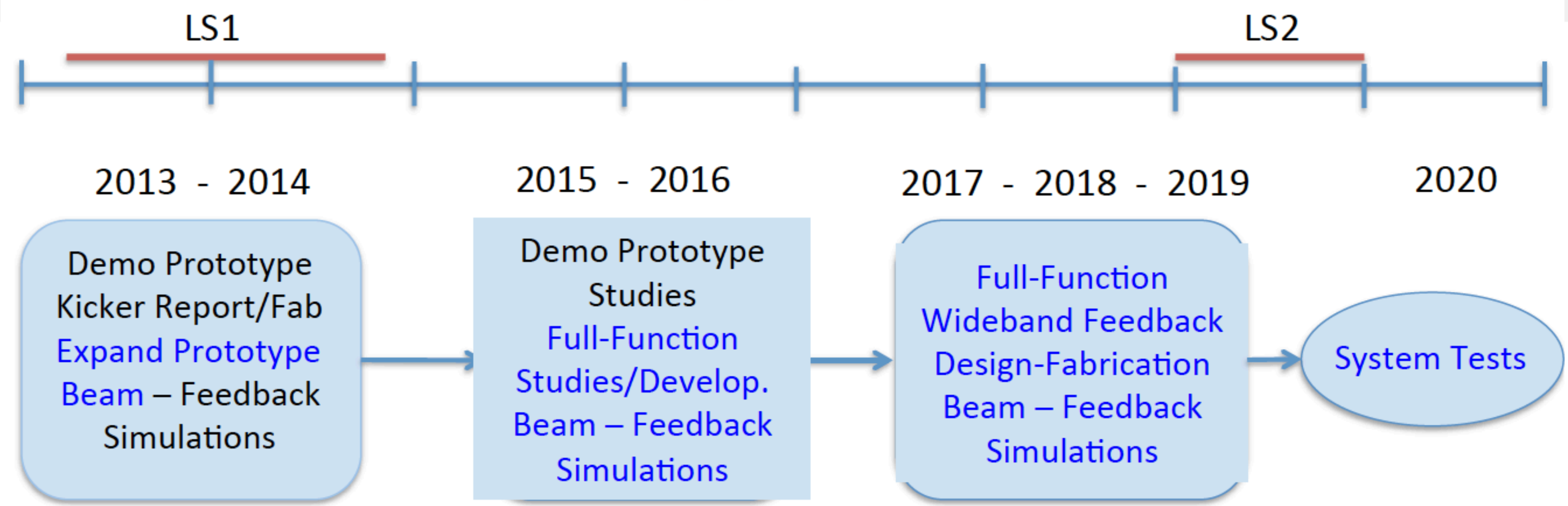
- Reduced LARP Funding ~ 10%
  - Reduce CC ~5-15% or ~$200k/year
- Options to trade scope to CERN (to be discussed)
  - Reduce engineering effort + ask for more CERN engineering help
  - CERN procures all materials and fabs all peripherals (tuners, HOM dampers…)
  - Reduce participation to SPS testing and beam studies
- Continue leading cavity production, testing for SPS and preparation for LHC

CC - Funding Scenario 3

- AKA - Nightmare
  - Reduce LARP ~20%
    - Reduce CC by ~25-35% or ~$500k/year
- Major scope reduction
  - To be discussed with CERN
  - Options:
    - Eliminate cavity string assembly and test + ship separate cavities
    - Move final testing of dressed cavities to SM18
    - CERN procures all materials and fabs all peripherals (tuners, HOM dampers…)
    - Reduction in participation in SPS testing and beam studies
- Still keep a core staff together to monitor production, advise CERN and participate in MDs
  - Cavity production and bare cavity testing
  - Peripherals design and fab support
  - Cryomodule integration + LHC implementation studies
  - Some participation to SPS testing

- *Such reduction would make LARP's contribution less and less relevant*

Research and Technology Timeline



- Demo Commissioned
- MDs Jan.-Feb. 2013
- Kicker Design, Fabrication and Installation
- Data Analysis, Models and Simulation Tools
- Expand Hardware Capability
- MDs with new Hardware

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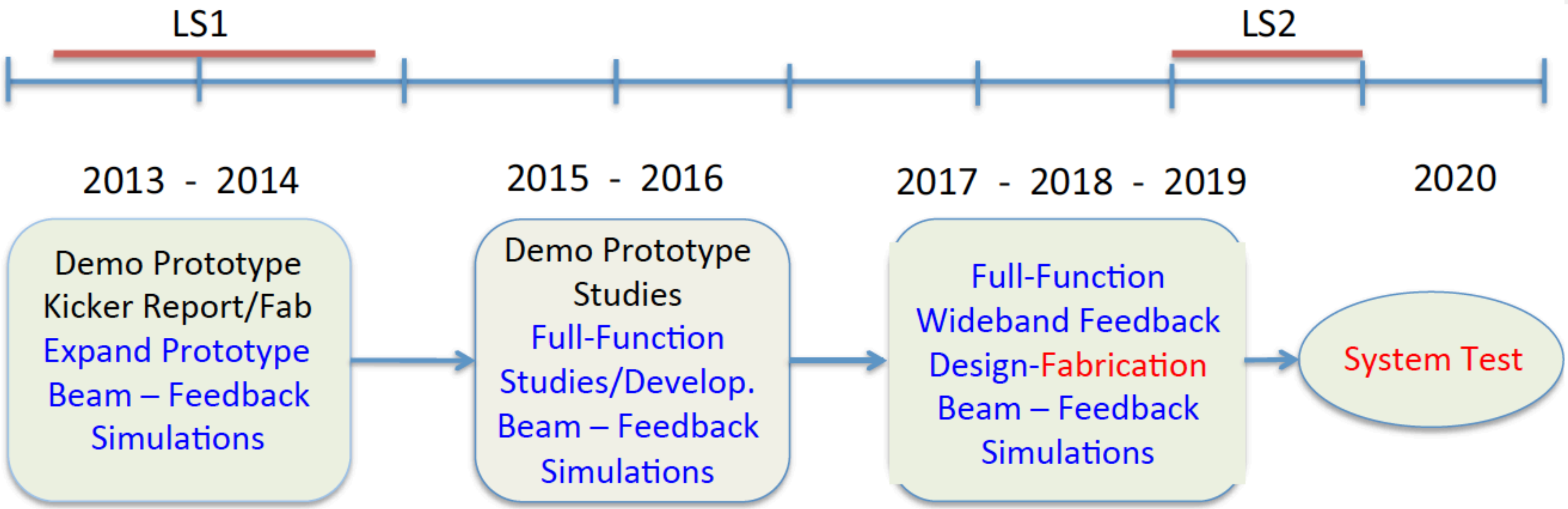
- Multi-bunch operation
- Data analysis, models and simulation tools
- System specifications and capabilities
- Full-function Wideband Feedback Technology Development.

- Full-Function Wideband Feedback Design-Fabrication
- Continue MD studies
- Validate Energy Ramp
- Analysis, models and simulation tools

- System Integration
- Full interface with CERN Control Room
- Estimation of System Limits and Performance
- LHC? PS? SPS?

- Essential goal - be ready at end of LS2 with full-function system ready for SPS Tests
- SPS upgrade after LS2 (new injector, higher currents, new operational modes)
- We must use the demo system, MD time post LS1 to validate control ideas, validate kicker and technical approach. Full Function is only 1 design iteration away from Demo System

Research and Technology Timeline 35% cuts



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- SPS upgrade after LS2 (new injector, higher currents, new operational modes)
- Impact - There is simply no functioning prototype in place post-LS2 to control HL upgraded currents. Many additional years needed to complete system

FY15, FY16 goals - with 12 - 16% cuts

- First priority - items dropped in FY14 cuts (Timing/Synch for energy ramp, Orbit offset compensation, matlab tools)
- Second - augment FY15 MD measurements with wideband DEMO system (SPS beam time and analysis)
  - Travel funds necessary to do SPS measurements
  - Diagnostic and beam instrumentation techniques to optimize feedback parameters and understand system effectiveness, interaction with existing feedback
  - Evaluate Kicker performance, options (wideband? dual band?) Estimate useful required power for full-function
- Third - FY16 High-speed DSP Platform consistent with 4 -8 GS/sec sampling rates for full SPS implementation
  - Partial lab evaluation and de-scoped firmware development
  - Estimation of possible bandwidths, architecture options for deliverable
- Assume Transfer to CERN funding- All aspects for kicker systems
  - Wideband 20 - 1000 MHz RF power amplifiers, with acceptable phase response
  - RF monitoring, control for SPS tests
- Impact - still not ready to develop full-function system in 2018, delays full-function system by 2 - 3 years, misses LS2 SPS startup

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Niowave
DOE/LAB not supplying
engineering plans/resources

~~Relying~~ what is PLAN B.

- NIOWAVE, DOE/LAB no supplying engineering plans/resources. What is plan B.

Interaction with Niowave

- We are well aware that we don't even have a direct contract with the company.
- They're are under contract with DOE's SBIR Program. Beneficial aspect of interaction between Niowave and LARP are multiple:
  - Access to superb technical expertise at National Labs/Universities
  - Activity in conjunction with world-wide "science phenomenon"
  - In the interest of both Niowave, DOE and LARP to have proficient handshaking.


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SBIR

The SBIR Program

The Small Business Innovation Research (SBIR) program is a highly competitive program that encourages domestic small businesses to engage in Federal Research/Research and Development (R/R&D) that has the potential for commercialization. Through a competitive awards-based program, SBIR enables small businesses to explore their technological potential and provides the incentive to profit from its commercialization. By including qualified small businesses in the nation's R&D arena, high-tech innovation is stimulated and the United States gains entrepreneurial spirit as it meets its specific research and development needs.

- At this point we don't know for sure that they will make four cavities with the funds available in the SBIR. They did make that statement
- We are establishing strict processes with verification points and reviews to insure success on all sides of the equation.

Vendor Interaction (1)

This document outlines the interactions/joint contribution points recommended by the cavity design teams as pertains to the fabrication by vendors of crab cavities for the US LARP Hi-Lumi upgrade project. Each design team will appoint a lead to serve as the single point of contact for such design. This includes BNL and ODU for the cavity design, and FNAL for cryostat design and integration.

Initial discussion with the engineering team at the vendor.

The initial discussion on the fabrication process is a necessary step that would allow the cavity design teams to have a reference context for subsequent discussions. As part of the discussion, the cavity design teams would provide tolerances for fabrication as well as input in the production approach proposed by the vendors.

Review of mechanical production drawings.

From the cavity design perspective, this is the most important checkpoint, the inspection and cross-check of the mechanical drawings for the different dyes/parts to be fabricated, as any conflicting dimensions could be detected by the cavity design teams.

Pre-production material qualification.

The properties of all Nb material used in the systems need to be verified and documented before using such material in production. CERN supplied steel will be used in flanges and vacuum components where specified.

Vendor Interaction Document (2)

Advance notice of changes.

If during the fabrication process, the engineering team at the vendor encounters a problem that requires a deviation from the original plan/drawings, the cavity design teams should be given the opportunity to determine how any proposed changes in the original plan/design would impact the different parameters of interest, and whether the proposed changes to the original plan are acceptable from the cavity performance standpoint or new solutions need to be found. No change is authorized without written authorization from the design teams.

Regular progress updates.

In order to ensure a successful outcome, the cavity design and engineering teams should have frequent and regular communication, both during the fabrication process and the cavity testing. The vendor team should expect full collaboration from the cavity design teams in terms of simulations and parameters needed for different fabrication steps, such as for example information needed for fine-tuning trimming purposes.

Regular visits from a LARP representative are planned to monitor production and compliance with requirements and specified processes. All visits will be in a non-intrusive way and on a mutually agreed upon schedule.

Procedure for chemical/heat treatment and HP rinsing (if needed).

Conceptually new cavities might require different procedures for chemical/heat treatment and/or HP rinsing. The cleaning process for such complex structures might require bulk BCP treatment of parts prior to welding, for example. The cavity design teams will provide, with input from the vendor, the detailed process including all steps required for chemical/heat treatment and/or HP rinsing, and how those steps fit into the fabrication/testing procedures.

Vendor Interaction Document (3)

Cavity testing.

The cavity design teams will participate in any testing of the cavity performed by the vendor, at all key steps of the production process. The vendor should provide a schedule for checks and testing with as much advance notice as possible, to allow the cavity design teams to plan accordingly.

Documentation

All documentation will be delivered in the CERN EDMS system, including production drawings, test qualification results, measurements and procedures. LARP receives full rights to all drawings generated in the process.

Niowave has agreed to this plan and will add the internal production schedule so we can interact accordingly.

Cavity Fabrication Plan

- Presented by ODU
  - BNL preparing a very similar one
- Regular monitoring from FNAL
  - Dedicated visits from cavity designers at stated check points
- Preparing a material qualification document
- Requesting all documentation be prepared in CAD compatible format
  - Niovawe will generate the fabrication drawings
    - And has agreed to give them to the collaboration at the end of the SBIR for anyone to use

Cavity Fabrication Plan (ODU)