Past Reviews, Future Plans, Budget and Schedule

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Overview

- Addressing recommendations from past reviews
- Scope of planned work
- LARP Plans
- Schedule
- Cost estimate
- Risk Reduction
- Conclusions

From 2011 DOE Review of LARP

1. Work with the CERN-RF group to develop clear specifications and a realistic R&D plan with goals.

The goals are now clearly focused on delivering fully dressed cavities for the SPS test. CERN has released the functional specification for the systems required in the SPS tests.

2. Prepare and submit a limited scope plan to DOE requesting potential funds to fabricate a prototype "bare" cavity conforming to specifications from CERN.

DOE has awarded in 2013 a phase II SBIR to Niowave in support of the crab cavity program.

From 2012 DOE review of LARP

1. Focus efforts in completing three prototype crab cavities and testing by the end of CY13.

The two LARP bare cavities have been completed and tested successfully in 2013. The third cavity is beyond LARP's responsibility and under development in the UK and CERN.

2. The plan for testing at CERN in SM18, the main cryogenic test station, may not be doable. Review the current plan and modify test schedules to be more realistic.

All vertical testing of LARP cavities is planned at US labs. CERN is enhancing its SRF capabilities in SM18 and a one year delay in LS2 make us believe we complete the planned tests in time for installation in the SPS.

Scope of US Contribution

- LARP proposes to fund R&D until the SPS test
  - Deliver two fully dressed cavities of each design (DQW and RFD) for testing in the SPS
    - 2 cavities, He vessels, tuners, HOM mode dampers
    - RF couplers provided by CERN
    - Cryogenics, RF power, local installation provided by CERN

- US Construction Project proposes to fund production
  - Deliver all fully dressed cavities
    - Cavities include He vessels, tuners, HOM mode dampers
    - Cryogenics, RF power, local installation provided by CERN
    - 32 cavities needed in pts 1 and 5, plus spares

Feedback from DOE reminds that the effort on crab cavities should be carried through construction and not be limited to the SPS test

Collaboration Plans Overview

- SPS Validation Tests before LS2
  - 2 cavities, one plane only (H or V), no LHC test
  - Prove crab concept with proton beams – First time!
  - Study machine protection aspects
  - Beam studies (noise, heat loads, LLRF..) during dedicated machine studies (MD)

- Essential to finalize HL-LHC design
  - CERN will make a final decision on the adoption of crab cavity system only after a successful SPS test

- Build a prototype cryomodule for HL-LHC next
  - same/similar cavities, new dimensions and interfaces

SPS vs. LHC Needs

- SPS
  - 3-4 year focus
  - Down-selected many objectives
    - Streamlined goals to simplify systems and provide more fundamental answers
      - Ie. Does crabbing work with proton beams?
      - Can we control the beam and with what precision
      - We don't need active alignment to verify this
      - No testing in the LHC

- LHC implementation will need SPS results and much more

Open questions towards the LHC

- Include active alignment
- Cryomodule configuration
  - N of cavities per CM?
    - 2x4 vs 1x8 vs….
- Cavity design (H vs V)
  - is the ability to kick in both planes a requirement for any cavity?
- What is the *final* operating gradient/kick per cavity? Final aperture?
- Impedance budget
  --> what is the acceptable n of cavities, HOM damping requirements…
- Field quality requirement?
- Final optics
  - Crab in both planes at both IPs? (ie. kissing)
- Magnetic shielding?
- ….and more….

We will need to finalize all of the above (and more) before deriving a baseline design of the cryomodule for the HL-LHC….in TDR in 2016?

Mismatch with timing of SPS test results

What will go in the SPS?

- Proposing a ***selection criteria*** at the May Technical review
  - Define what is required and what is important
  - From technical performance to cost, schedule, ease of integration
    - Preparation led by CERN

- Provocative comment for cavity selection

Any cryomodule to meet requirements and pass SM18 Horizontal test in 2016 has a great chance to be installed in the SPS

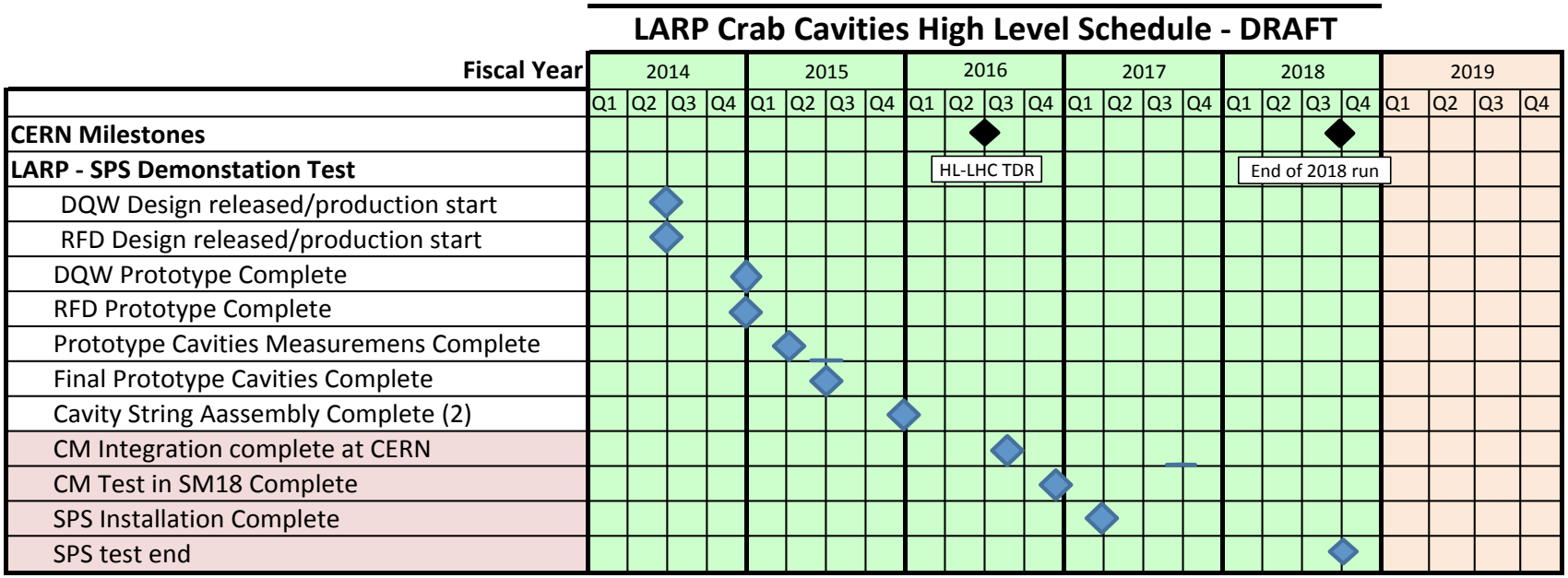
- Ultimately what goes in the SPS is a CERN decision

Schedule for SPS Test

- CERN has prepared a fully integrated schedule
  - Draft distributed separately
  - Broadly inclusive
    - All aspects of the planning for the SPS test
  - Synchronized with LARP

- LARP Schedule Consistent with CERN's plan
  - Distributed separately

LARP CC Schedule Highlights

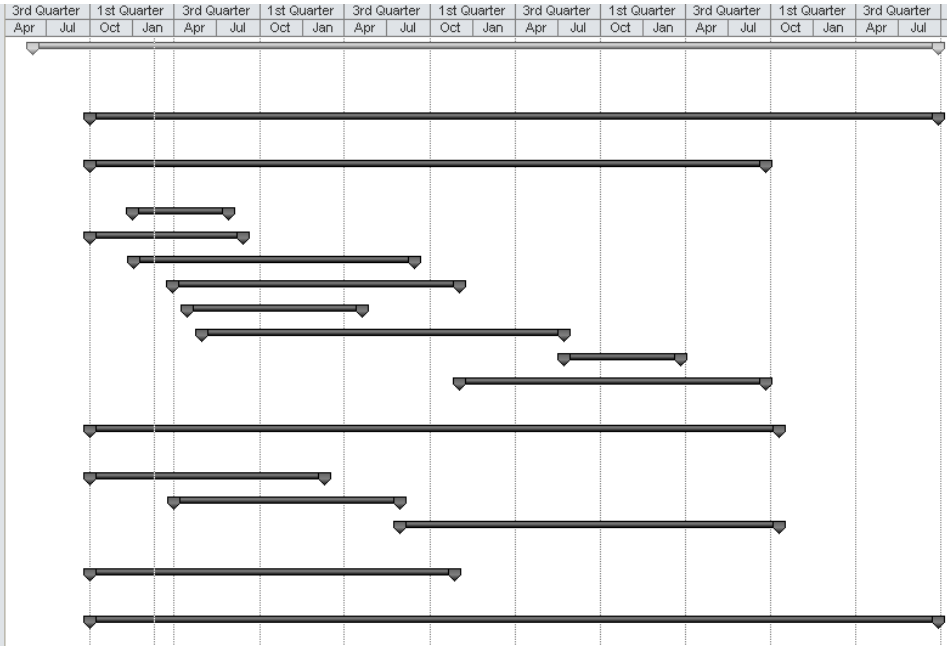


FY14 major deadlines

- Cavity model design freeze in April 2014
  - And start of cavity construction
- Technical review of HL-LHC Crab Cavity Program on May 5-6 at BNL
  - LARP is part of this
- Bare cavities measured at Niowave by October

LARP Resource Loaded Schedule

Task Name	Total Cost $	Start	Finish	Cost	Cont $
US Contribuiton to Crab Cavities	5,829,323.12	Sat 6/1/13	Mon 9/24/18	4,618,789.12	1,210,534.00
Larp R&D	5,829,323.12	Tue 10/1/13	Mon 9/24/18	4,618,789.12	1,210,534.00
DOW Crab Cavity (LARP)	2,019,296.52	Tue 10/1/13	Wed 9/20/17	1,556,078.52	463,218.00
DOW PoP Cavity Final Study	99,297.44	Thu 1/2/14	Fri 7/25/14	76,384.44	22,913.00
DOW Prototype for SPS Design and Fab	197,895.60	Tue 10/1/13	Tue 8/26/14	152,227.60	45,668.00
Higher Order Mode (HOM) Coupler assembly	391,335.67	Thu 1/2/14	Fri 8/28/15	301,029.67	90,306.00
Fabrication and Testing dressed cavity #1-2	588,893.27	Thu 3/27/14	Wed 12/2/15	455,761.27	133,132.00
Prototype Fabrication at Niowave	0.00	Mon 4/28/14	Fri 5/8/15	0.00	0.00
Cryomodule Design Support (DOW)	295,896.94	Thu 5/29/14	Wed 7/13/16	227,613.94	68,283.00
SPS test support (DOW)	77,337.11	Thu 7/14/16	Wed 3/22/17	59,490.11	17,847.00
Design LHC Dressed Cavities (DOW)	368,640.50	Thu 12/3/15	Wed 9/20/17	283,571.50	85,069.00
RFD Crab Cavity (LARP)	1,723,408.30	Tue 10/1/13	Wed 10/18/17	1,293,383.30	430,025.00
RFD Final Design and Fab Support	436,967.40	Tue 10/1/13	Mon 2/16/15	342,198.40	94,769.00
RFD Prototype Cavity for SPS	932,003.20	Tue 4/1/14	Mon 7/27/15	678,538.20	253,465.00
Design LHC Dressed Cavities (RFD)	354,437.70	Tue 7/28/15	Wed 10/18/17	272,646.70	81,791.00
Cavity String Prep + Ship	656,417.28	Tue 10/1/13	Mon 11/23/15	525,673.28	130,744.00
LARP Oversight and Technical Support	1,430,201.00	Tue 10/1/13	Mon 9/24/18	1,243,654.00	186,547.00



Long Term Plan

- Complete prototype design, fab and testing
- Prepare for SPS test
  - A cavity selection criteria document is under development
- Contribute to CC experimental program in the SPS
- Design and test a prototype cryomodule for LHC
  - Assuming cavities are ok, no new development
  - Design studies must start while SPS tests are underway
- Build production run for HL-LHC
  - Possibly use prototypes as deliverables or spares

LARP Cost Estimate

- Bottom-up - Resource loaded schedule using average rates for broad categories at each lab
  - Scientist/Engineer, Designer, Technician, PostDoc
- Fully burdened, including materials and travel
- Base costs escalated each year
- Schedule details are still high level for HL-LHC proposal
  - But already integrated with CERN schedule for SPS test
  - Plan to refine towards CD-1

Estimated budget highlights

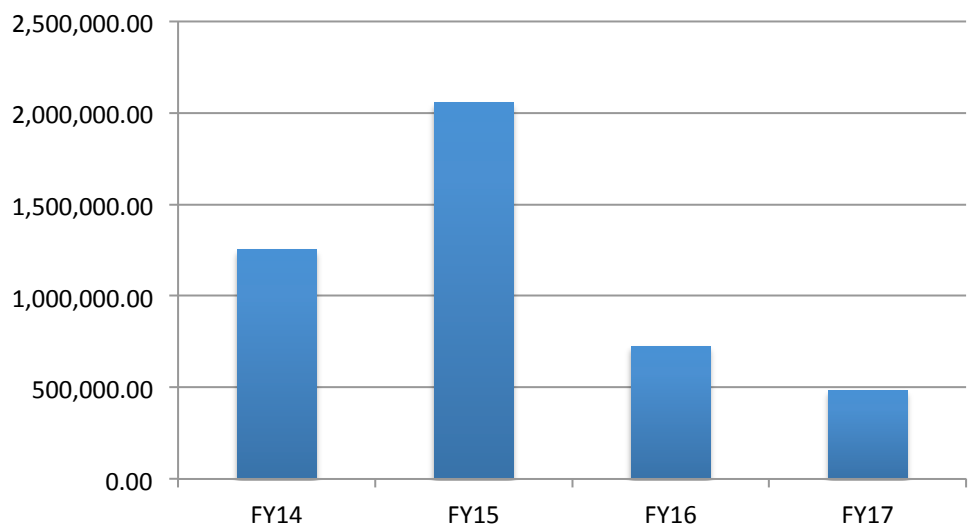
- LARP –> SPS demonstration
  - 4 years, $4.6M estimate, $6M with 30% contingency
  - Hard to implement in flat budget envelope of LARP

- External Resources:
  - CERN ME committed >0.5 FTE/yr in support of CM development and integration in SPS test
    - Engineering design
  - SBIR
    - Niowave received in April 2013 a Phase II SBIR in support LARP's deliverable
  - STFC
    - Requesting funding to contribute to the activity (mostly on CM design)

- CERN offering to pick up some difference in case of a shortfall
  - But there are restrictions and requires planning

Spending profile

- Meets LARP requested cost envelope
- Makes FY15 very challenging
  - Partly due to FY14 “nightmare” allocation
  - Partly due to deadlines to meet SPS schedule
- Assumes some additional funds in FY17 to start design for HL-LHC project



3 Funding Scenarios

- 1. Baseline
  - Spending profile higher in earlier years to support cavity production
    - Limited contingency when needed
    - Success still depends upon external contributions
- 2. Bad news
  - Serious limitation to our contributions
    - Limited participation in cavity testing and integration
    - …and in the SPS tests
- 3. Nightmare (= FY14)
  - No engineering, no testing, only postdocs
  - No testing or HW construction
    - Can LARP remain relevant in the CC program with such limitations?

Caution(s)

- LARP is funded year by year
  - Guidance to keep CC funding >$1M per year
  - As long as LARP is funded
    - Presently planned until FY17 included
  - Limited availability of LARP funds make our target of testing in the SPS a challenge
  - External (GARD, SBIR) contributions or funds greatly help
- Some possible scenarios are very dangerous for this program
  - "Nightmare" is right!

Risks and Concerns

- Scope
  - While the CC system is the only way to substantially increase luminosity, CERN's decision on implementing CCs depends upon a successful SPS test until 2018.
  - System requirements for LHC not yet finalized.
- Budget and Schedule
  - Spending profile does not match LARP's available funds
  - LARP R&D Schedule is still aggressive for a 2016 delivery
    - Even if we got all requested funding as of June 2013
- Resources
  - Many preferred resources already committed to several other projects.

Risk Mitigation

- Scope
  - delivering cold masses only reduces uncertainty risks on LHC CM requirements and implementation
- Schedule
  - While we are aiming at shipping at the end of 2016, LS2 is not scheduled until 2018
- Budget
  - CERN is committed to the project and could provide additional resources if needed
- Resources
  - This collaboration we leverage long established expertise at each lab, taking advantage of current and past similar projects and existing resources

Leveraging Existing Assets

- Cavity and CM development expertise
  - BNL, FNAL and ODU
- CAD and beam dynamics models
  - LBNL, SLAC
- Rapid quench and energy deposition studies
  - FNAL
- Processing and test facilities
  - ANL, BNL, JLAB

Final Comments

- Extremely talented team
  - Important to allocate funding AND securing availability of key resources
    - And to keep the team together through the completion of the project
- Challenge of managing contributions outside LARP's funding
    - But everyone is committed to the common goals
- Technical results are very encouraging
  - LARP played a key role in demonstrating the feasibility if these systems
  - Technical leadership can be sustained with proper funding
    - Could position LARP CC similarly to the Ni_3Sn in magnets
- On track for CD process

Questions?