



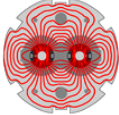
LARP



QXF Plans and Preparation for Project

G. Ambrosio

2/17/14

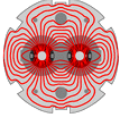


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Outline

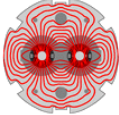
- Overview
- Short models plan
- Long models plan
- Schedule and budget
- Preparation for Project



LARP-CERN Integrated Plan

LARP and CERN are working closely together for developing and demonstrating the MQXF design:

- Requirements from Hi-Lumi LHC WP3
 - With strong LARP participation
- Shared work for the design (single design)
 - Working groups with representatives from 4 labs
- Shared effort for the 1st short model (SQXF1)
- Work in parallel for subsequent short models (SQXF)
- LARP/CERN full-length (4m/6m) prototypes (LQXF)



Plan Overview

- **Short model program: 2014-2016**
 - Fabrication of practice coils is starting this month
 - According to schedule presented at CM20 (4/13)
 - First SQXF coil test (Mirror structure) in Dec. 2014
 - First magnet test (SQXF1) in May 2015
 - 2 (LARP) + 3 (CERN) short models + reassembly (~4)
- **Long model program: 2015-2017**
 - Coil winding starts in 2015: Jan. (LARP), Sept. (CERN)
 - First LQXF coil test (Mirror structure) in Dec. 2015
 - First model test in Oct. 2016 (LARP) and July 2017 (CERN)
 - 3 (LARP) + 2 (CERN) models in total
- **Series production: 2018-2022**



SQXF plan and schedule:

Coil fabrication



- LARP

- Number of coils

- First set
 - 2 practice coils
 - 1 mirror coil
 - 5 RRP coils
- Second set
 - 5 RRP coils

- Fabrication steps

- First set
 - FNAL: winding + curing
 - BNL, FNAL, LBNL : reaction + impregnation
- Second set
 - FNAL: winding + curing
 - LBNL: reaction + impregnation

- Fabrication time

- ~100 days (5 months) per coil
- 1 coil produced every month
 - Budget limited

- CERN

- Number of coils

- First set
 - 2 practice coils
 - 1 mirror coil
 - 5 RRP coils
- Second set
 - 6 PIT coils
 - 5 RRP coils

- Fabrication steps

- Winding + curing + reaction + impregnation

- Fabrication time

- ~100 days (5 months) per coil
- 1 coil produced
 - every 2 months in the 1st year
 - every 1.5 months in the 2st year
 - every 1 months in the 3st year

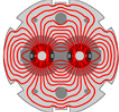


SQXF plan and schedule: Tests



*From assembly to test and disassembly: ~5 months; Test by **LARP** or **CERN***

- 1st generation coils
 - First **LARP coil test** in 12/2014 (mirror structure)
 - First **CERN coil test** in 04/2015 (SQXF structure with practice coils or LARP mirror structure)
 - First magnet test (**SQXF1**) in 05/2015
 - Assembled and tested by LARP with 3 LARP coils and 1 CERN coil
 - Then **SQXF1b** (prestress optimization)
 - First magnet test by CERN (**SQXF2**), then **SQXF2b** (test of LHe containment)
- 2nd generation coils
 - LARP RRP: **SQXF3** (04/2016) and **SQXF3b** (11/2016)
 - CERN PIT: **SQXF4** (2016-2017)
 - CERN RRP: **SQXF5** (2017)
- Test of 2-magnets in 1-cold-mass: **SQXF5+SQXF3b** (2017)

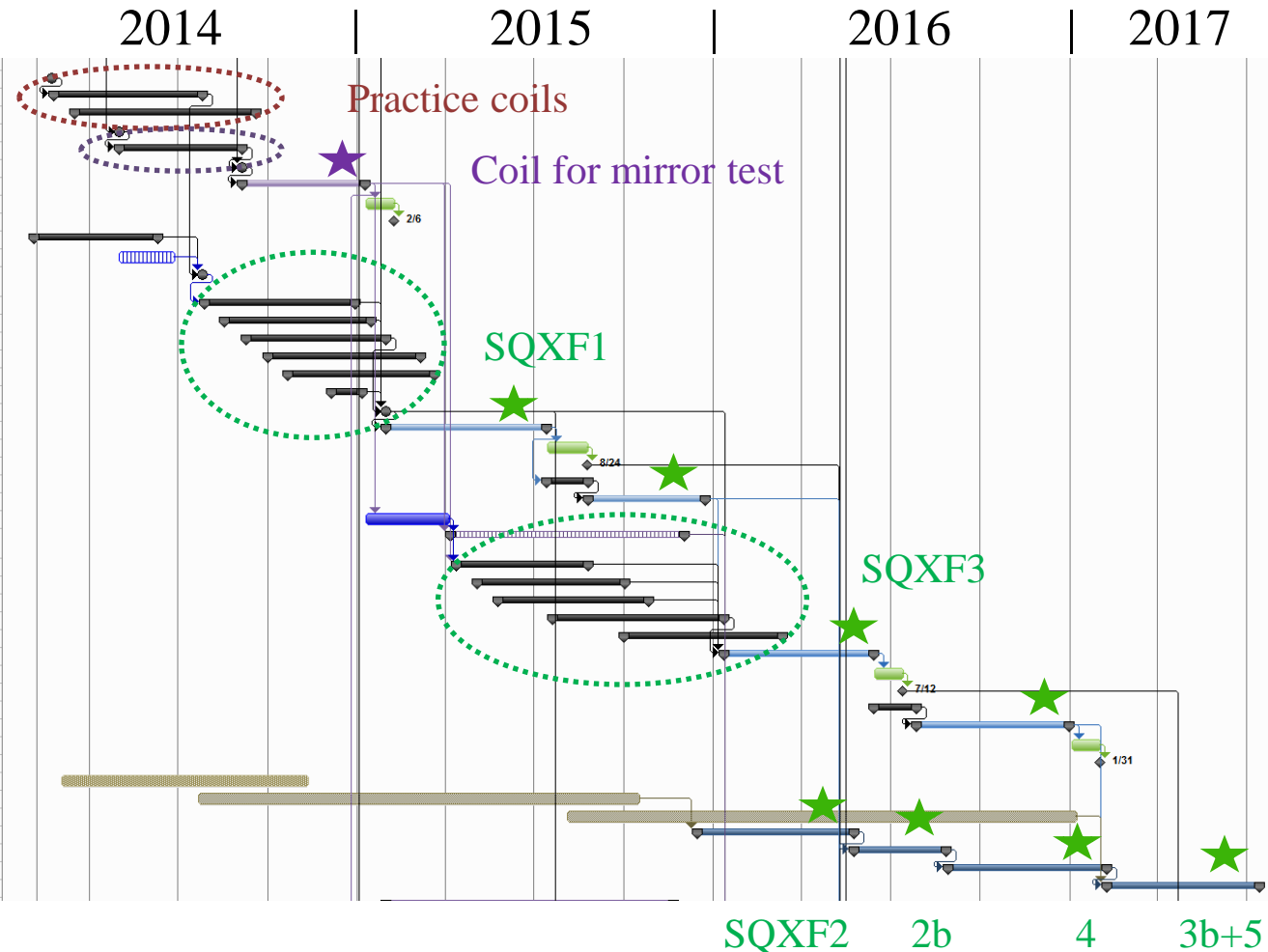


LARP



SQXF Schedule

| | | | | |
|---------|--|----------|--------------|----------------------------------|
| 132/169 | | | | |
| 150 | Start Practice Coils - RM | 0 days | Fri 2/21/14 | Fri 2/21/14,23,38,89,115,121 |
| 151 | Practice Coil #L1 | 108 days | Mon 2/24/14 | Fri 7/25/14,150 |
| 156 | Practice Coil #L2 | 131 days | Mon 3/17/14 | Thu 9/18/14,90 |
| 163 | Start Practice Coils #3 - RM | 0 days | Thu 5/1/14 | Thu 5/1/14,21,91,125,153 |
| 164 | Coil #L3 (for mirror test) | 87 days | Fri 5/2/14 | Thu 9/4/14,163 |
| 169 | Mirror assembly Readiness Rev | 0 days | Thu 9/4/14 | Thu 9/4/14,164,53 |
| 170 | SQXFM mirror assembly & test | 85 days | Fri 9/5/14 | Thu 1/8/15,169 |
| 175 | SQXFM Test Analysis | 4 wks | Fri 1/9/15 | Fri 2/6/15,170 |
| 176 | SQXFM Test Review | 0 days | Fri 2/6/15 | Fri 2/6/15,175 |
| 177 | HQ feedback | 90 days | Mon 2/3/14 | Mon 6/9/14 |
| 182 | end spacer adjustments | 8 wks | Thu 5/1/14 | Thu 6/26/14,153 |
| 183 | SQXF1 Coils Readiness Review - RM | 0 days | Fri 7/25/14 | Fri 7/25/14,182,151,177 |
| 184 | Coil #L4 | 107 days | Mon 7/28/14 | Mon 12/29/14,92,183 |
| 191 | Coil #L5 | 102 days | Mon 8/18/14 | Wed 1/14/15,92 |
| 197 | Coil #L6 | 97 days | Tue 9/9/14 | Thu 1/29/15,93 |
| 203 | Coil #L7 | 107 days | Wed 10/1/14 | Fri 3/6/15,94 |
| 210 | Coil #L8 | 102 days | Wed 10/22/14 | Fri 3/20/15,94 |
| 216 | Coil C3 (CERN) | 20 days | Fri 12/5/14 | Mon 1/5/15 |
| 219 | SQXF1 Assembly Read. Rev - RM | 0 days | Thu 1/29/15 | Thu 1/29/15,184,191,197,71,5,216 |
| 220 | SQXF1 Assembly & Test | 115 days | Fri 1/30/15 | Mon 7/13/15,219 |
| 226 | SQXF1 Test analysis | 6 wks | Tue 7/14/15 | Mon 8/24/15,220 |
| 227 | SQXF1 Test Review | 0 days | Mon 8/24/15 | Mon 8/24/15,226 |
| 228 | SQXF1 disassembly | 31 days | Tue 7/14/15 | Tue 8/25/15,220 |
| 232 | SQXF1b (prestress adj) | 82 days | Tue 8/25/15 | Wed 12/23/15,228 |
| 240 | modifications for SQXF2 coils | 60 days | Fri 1/9/15 | Fri 4/3/15,170 |
| 241 | 2nd SQXF mirror for issue in 1st mirror test | 168 days | Mon 4/6/15 | Wed 12/2/15,170,240 |
| 244 | Coil #L9 | 95 days | Mon 4/13/15 | Tue 8/25/15,170,240,95 |
| 250 | Coil #L10 | 107 days | Mon 5/4/15 | Fri 10/2/15,96 |
| 257 | Coil #L11 | 108 days | Mon 5/25/15 | Mon 10/26/15,97 |
| 263 | Coil #L12 | 120 days | Mon 7/20/15 | Mon 1/11/16,98 |
| 269 | Coil #L13 (spare) | 111 days | Thu 10/1/15 | Fri 3/11/16,99 |
| 275 | SQXF3 | 108 days | Tue 1/12/16 | Mon 6/13/16,244,250,257,263,232 |
| 281 | SQXF3 Test Analysis | 4 wks | Tue 6/14/16 | Tue 7/12/16,275 |
| 282 | SQXF3 Test Review | 0 days | Tue 7/12/16 | Tue 7/12/16,281 |
| 283 | SQXF3 disassembly | 31 days | Tue 6/14/16 | Wed 7/27/16,280 |
| 287 | SQXF3b | 108 days | Thu 7/28/16 | Fri 12/30/16,283 |
| 293 | SQXF3b Test Analysis | 4 wks | Mon 1/2/17 | Tue 1/31/17,287 |
| 294 | SQXF3b Test Review | 0 days | Tue 1/31/17 | Tue 1/31/17,293 |
| 295 | CERN Practice coil | 178 days | Mon 3/3/14 | Mon 11/10/14 |
| 296 | CERN RRP coils (6) | 315 days | Mon 7/21/14 | Fri 10/16/15 |
| 297 | CERN coils PIT (6) + RRP (5) | 361 days | Mon 8/3/15 | Fri 1/6/17 |
| 298 | SQXF2-CERN | 111 days | Wed 12/16/15 | Tue 5/24/16,296 |
| 300 | SQXF2b-CERN w LHe containm. | 66 days | Wed 5/25/16 | Fri 8/26/16,298 |
| 302 | SQXF4-CERN w PIT | 111 days | Mon 8/29/16 | Tue 2/7/17,300 |
| 304 | SQXF5&SQXF03b CERN | 111 days | Wed 2/8/17 | Fri 7/14/17,302,287,297 |





LARP



Long model program

Plan and schedule

LARP

- **Number of coils**
 - 2 practice (1 FNAL & 1 BNL)
 - 1 coil for mirror test
 - 15 RRP coils
 - Coil winding starts **01/2015**
- **Models/tests**
 - 3 models, 3 tests + mirror
 - 2 structures
 - Vertical tests (BNL)
 - Mirror test in **12/2015**
 - First model test in **10/2016**
 - Last test **04/2018**

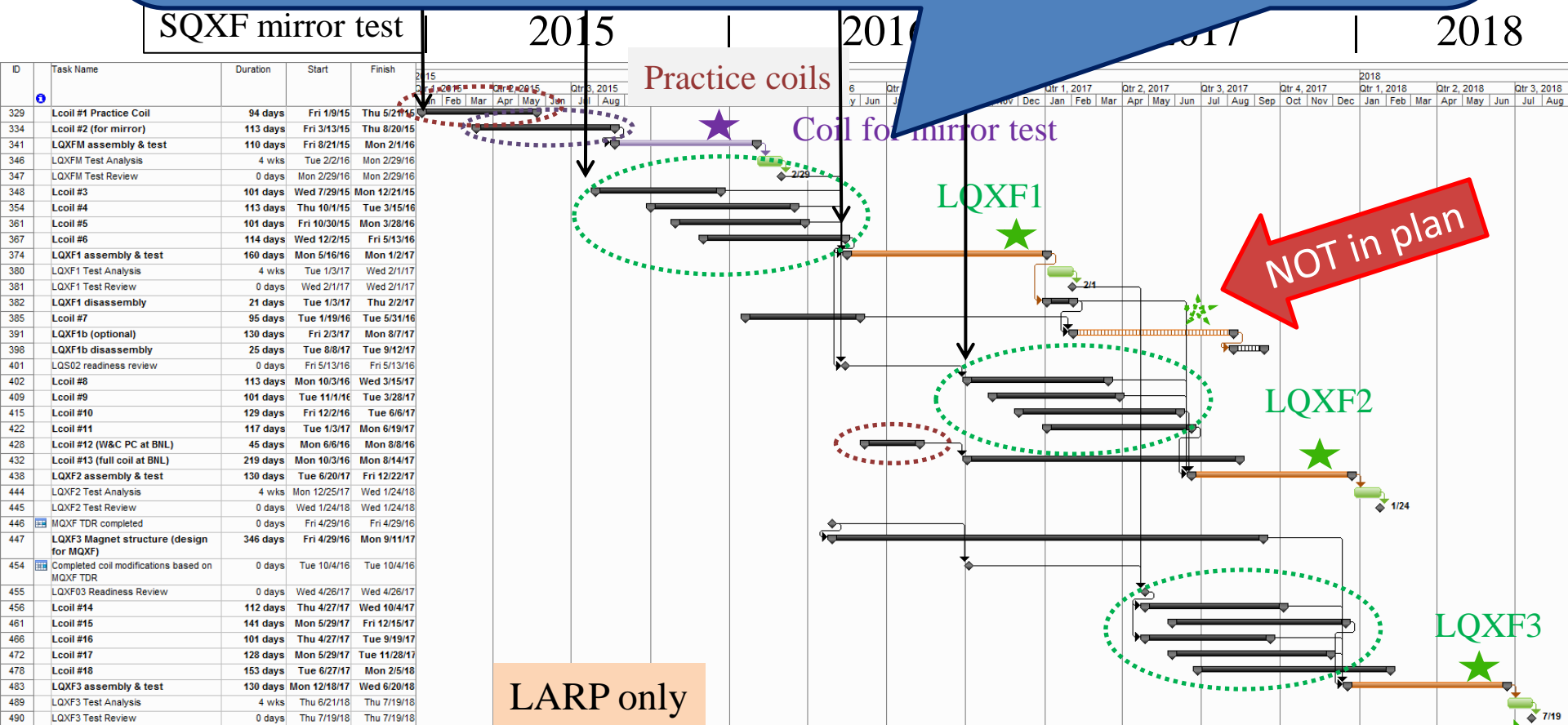
CERN

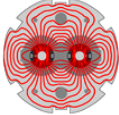
- **Number of coils**
 - 3 practice
 - 1 coil for mirror test
 - 11 coils (5 RRP + 6 PIT)
 - Coil winding starts **09/2015**
- **Models/tests**
 - 2 models, 3 tests
 - Horiz. “simplified” tests
 - Mirror test in **11/2016**
 - First model test in **07/2017**
 - Last test **10/2018**



"In preparing for battle, I have always found that plans are useless but planning is indispensable."

DWIGHT D. EISENHOWER

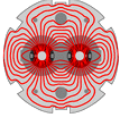




Planning

- Nb₃Sn magnets have never been used in a particle accelerator yet!
- Short models (SQXF):
 - 2_{new} + 2_{re} (LARP)
 - Minimum for quench performance and prestress range
 - 2_{new} + 2_{re} (LARP, RRP) + 2_{new} + 1_{re} (CERN, RRP)
 - OK for understanding He-shell impact and 2-in-1 He-vessel
 - Minimum for field quality
 - 1_{mirror} (LARP)
 - Very minimum (HQ had 3)
 - Provides test bed in case of issues

Minimal program.
Having LARP & CERN
in parallel provides
risk mitigation



Planning -

- Long models (LQXF):

- 3_{new} (LARP)

- Almost minimum for demonstration of reproducibility

- 0_{re} (LARP)

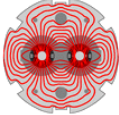
- This is a risk, LQS01b was very useful for LQ development

- 1_{mirror} (LARP)

- Minimum: if we have limited performance in LQXF1 the mirror test will help understanding cause btw coil/structure
- Provides test bed in case of issues

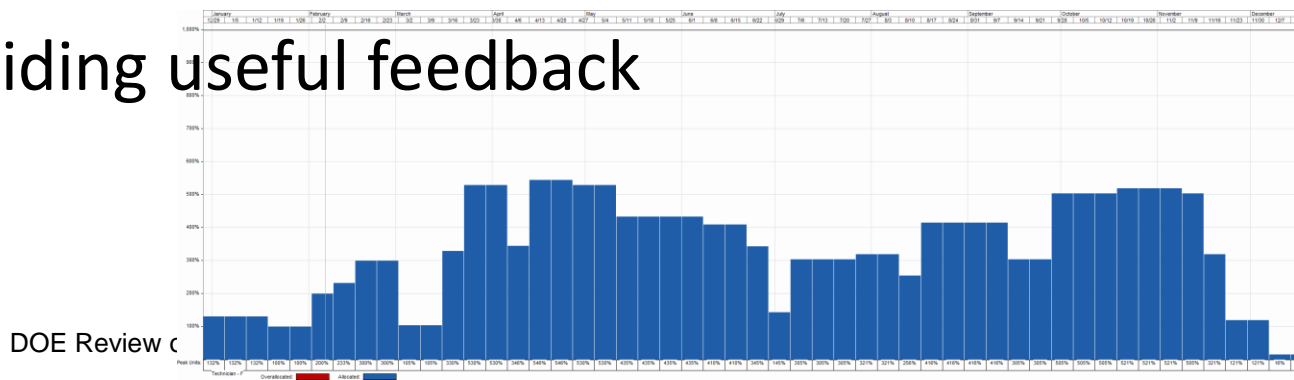
CERN will start after LARP and will develop 6.8m long magnets.

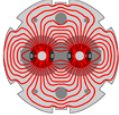
→ We count only on LARP for this.



QXF Schedule

- From strand procurement to test analysis
- Durations based on input from task leaders and L3s
- Schedule is budget limited (scenario #1)
- Resource loading is in progress
 - Started with this FY in order to compare RLS estimate with LARP-style estimate
 - Already providing useful feedback





LARP MS Budget Request

| Unit: M\$ | FY14 | FY15 | FY16 | FY17 | FY18 |
|--------------|-------------|------------|------------|------------|------------|
| Labor | 6.1 | 5.8 | 5.7 | 6.9 | 0.2 |
| M&S | 1.4 | 2.8 | 2.8 | 1.3 | 0.1 |
| TOTAL | 7.5* | 8.6 | 8.5 | 8.2 | 0.3 |

*Assuming \$0.3M from APUL contingency

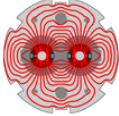
• M&S drivers:

- Conductor (S/LQXF coils): \$2.5 M
 - Assuming \$1.2 M CDP contribution
- QXF coil tooling: ~\$1.5 M
- LQXF structures (2): \$0.8 M
- BNL vert. test facility upgr.: \$0.7 M

Need some trimming to fit into Scenarios #1,2

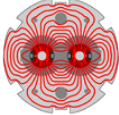
In order to fit into Scenario #3 we have to remove the LQXF mirror (\$1.5M):
 Strand, Cable, Coil fabrication, Structure procurement, Assembly, Test.

→ high risk in case of limited performance of LQXF1



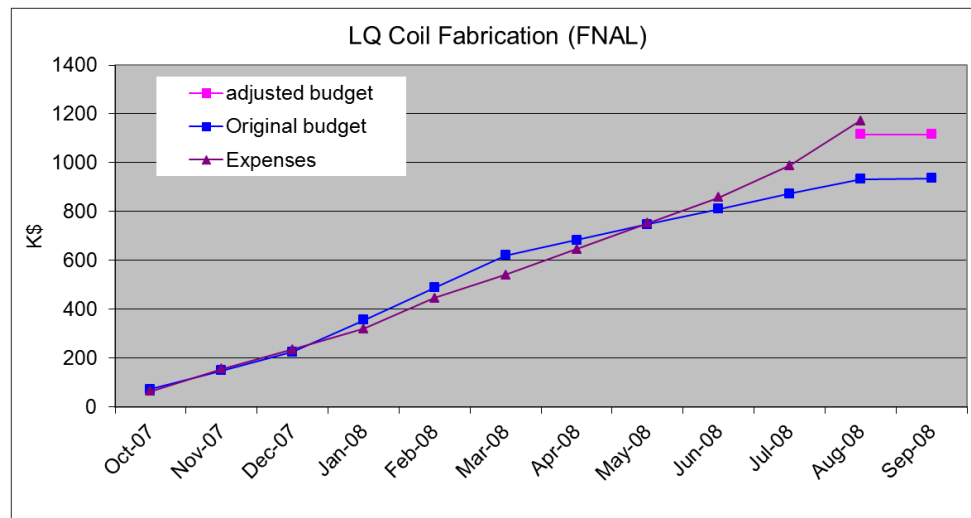
Preparation for Project

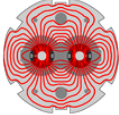
- Each lab is focusing and starting/strengthening its contributions to the Construction Project
 - Starting wind&cure line for LQXF coils at BNL
 - Strengthening QC and QA in all areas
 - Setting up a test facility for L/MQXF magnets
 - Building documentation and process
 - Conductor specs
 - Functional test requirements
 - SQXF1 design report



Monitoring Expenses

- For all major tasks we plan to monitor expenses vs. estimates on a monthly base
 - Both Labor and M&S
 - Work performed vs. work scheduled is already monitored separately
 - Previously done for some LQ tasks
 - First step toward EVMS





Conclusions

- In HiLumi, for the 1st time ever, Nb₃Sn magnets are a critical component of a particle accelerator
 - There is an intrinsic risk ... unknown unknowns
- LARP in collaboration with CERN has developed a plan adequate to this challenge
- We can make it successful with the best resources at all labs and sufficient support from the funding agency.