US LHC Accelerator Project and Research Program

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Outline

US LHC Accelerator (Construction) Project

Project Technical Status

Cost and Schedule Performance

US LHC Accelerator Research Program

Goals

Planned Research Program Activities

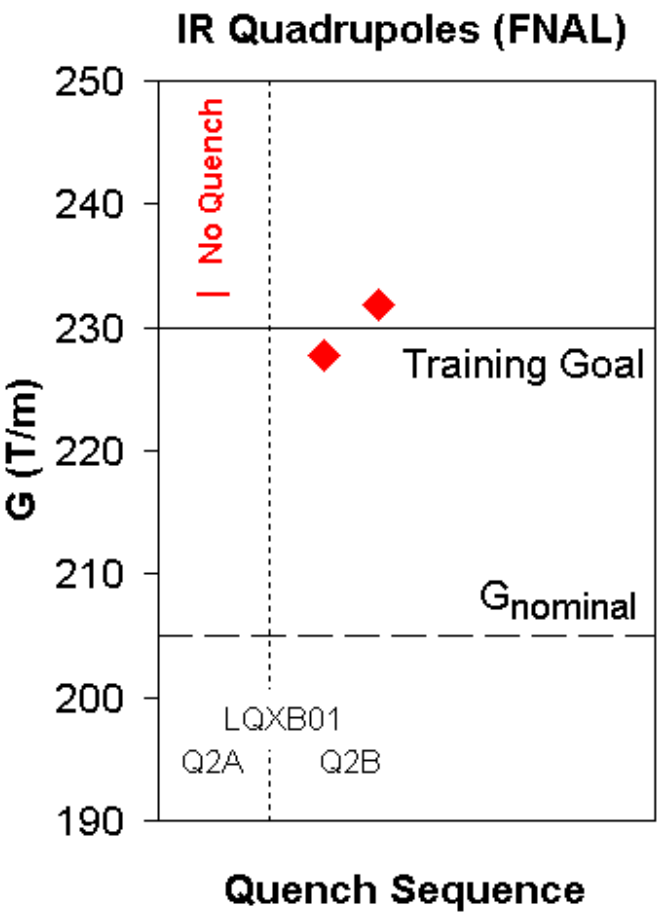
Program Planning and Next Steps

US LHC Accelerator Project Status

IR Quadrupoles

IR Quadrupoles are well into production.

- First complete Q2 (2 MQXB magnets) is a great success.
- Second Q2 is complete.
- 5 more MQXB complete
  . . . half the production.
- 5 MQXA delivered from KEK.



US LHC Accelerator Project Status

Beam Separation Dipoles

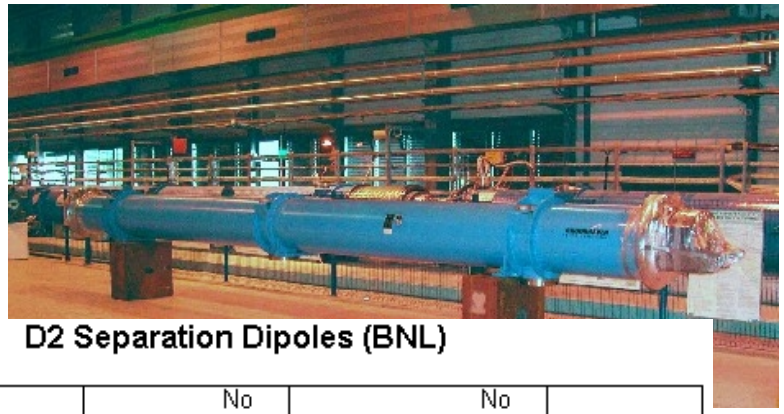
Beam separation dipoles far into production.

D1 - Construction and testing of all 5 D1's is complete.
- 1 is at CERN, 1 is in transit, and 3 are being prepared to ship.

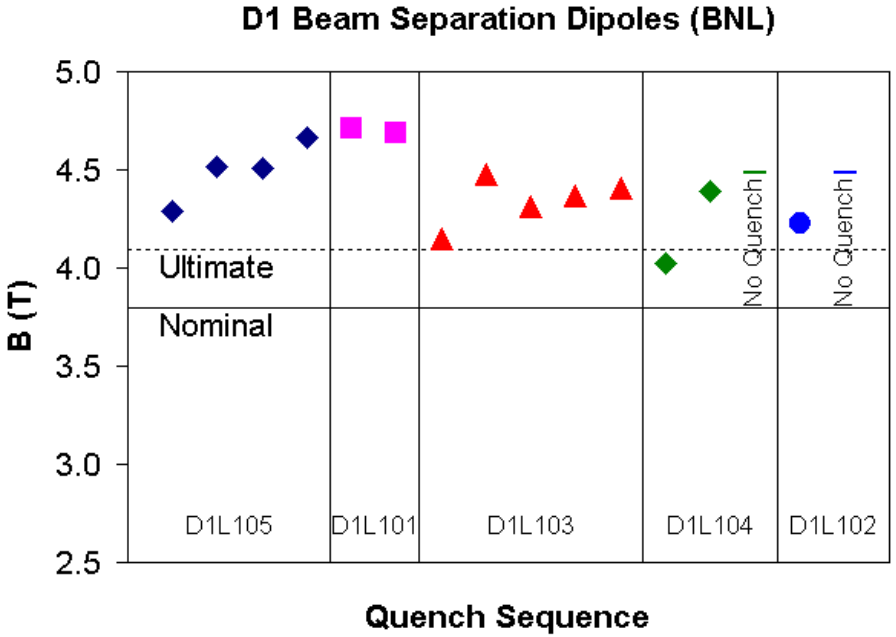
D2 - Construction of all 9 D2's is complete.
- First 4 have been tested.

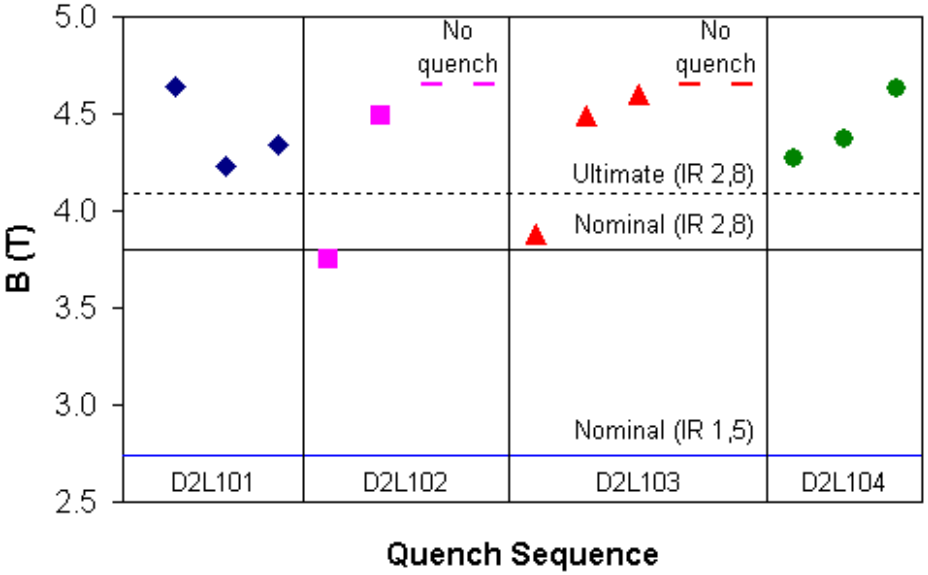
D4 - One of 3 cold masses complete.

D3 - All coils wound.



D2 Separation Dipoles (BNL)



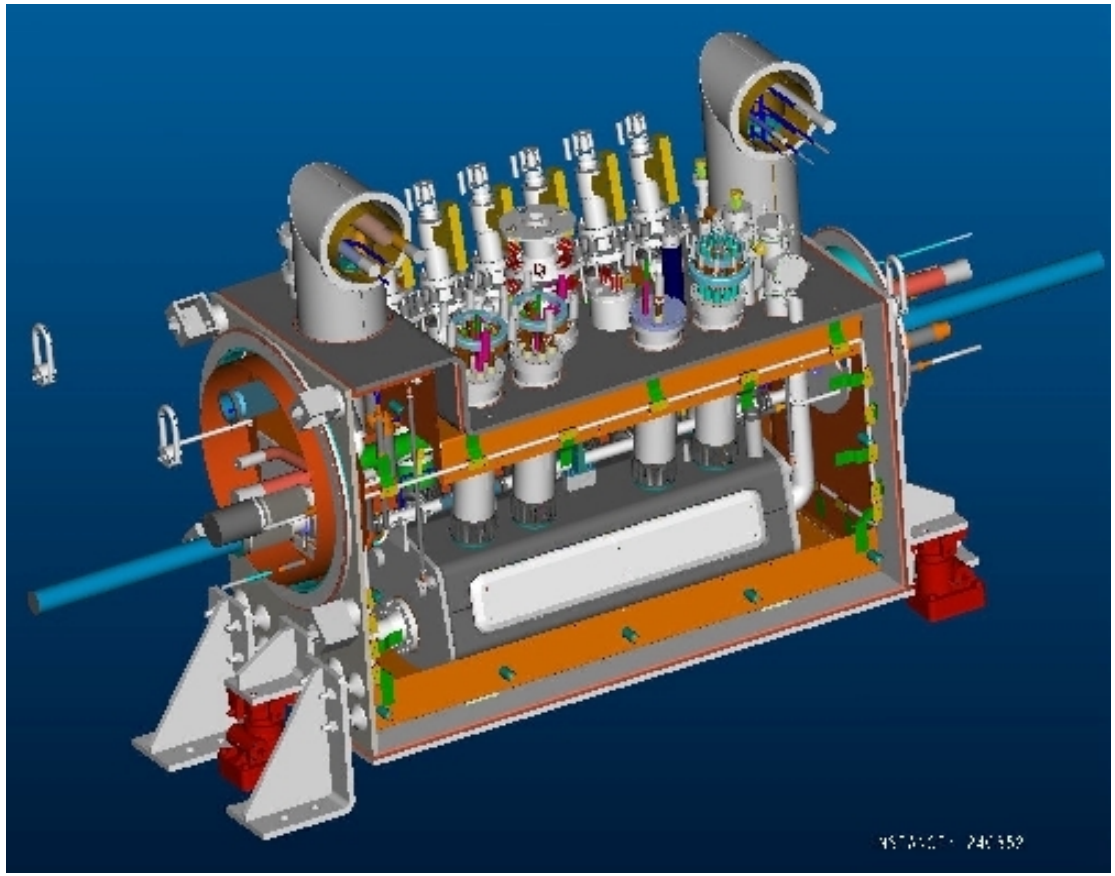


US LHC Accelerator Project Status

IR Feed Boxes

Within weeks of signing big contract for feedbox assembly.

- Design is complete.
- Good proposals received from 2 qualified vendors . . . Now in BAFO stage.
- HTS leads arriving at Fermilab for testing.
- Vapor cooled lead contract signed.
- Fabrication of lab-provided components has started.



US LHC Accelerator Project Status

IR Absorbers

IR Absorbers production assembly nearing completion.

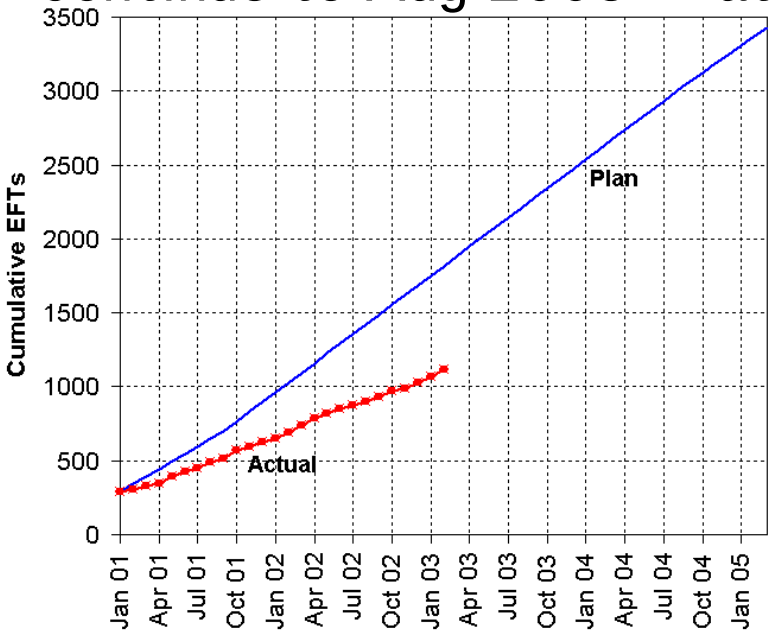
- Last major component – TAN beam tube – being e-beam welded.
- Final assembly and test of TAS is under way.
- Plan to ship all absorbers this spring.

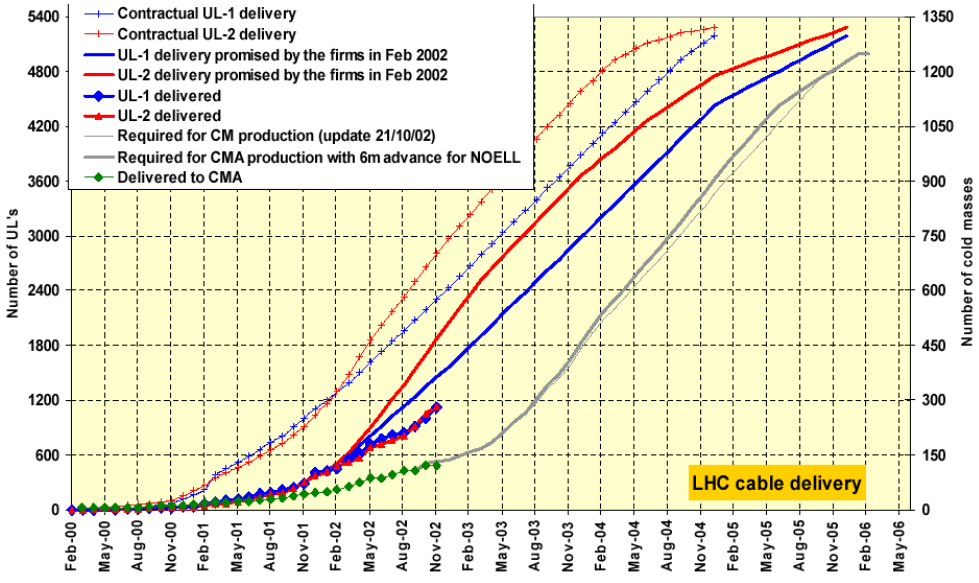
US LHC Accelerator Project Status

Superconductor Testing

Production SC cable testing continues.

- Sample rate from CERN during FY 2002 was 53% of baseline established in 2001 (=53% of BNL's capacity.)
- Rate has increased to ~75% over past several months.
- more efficient test procedure established, lowering maximum test rate from 66 -> 60 tests/month. Feb test rate = 56.
- Continue to Aug 2005 => at most 2922 tests (baseline = 3430).



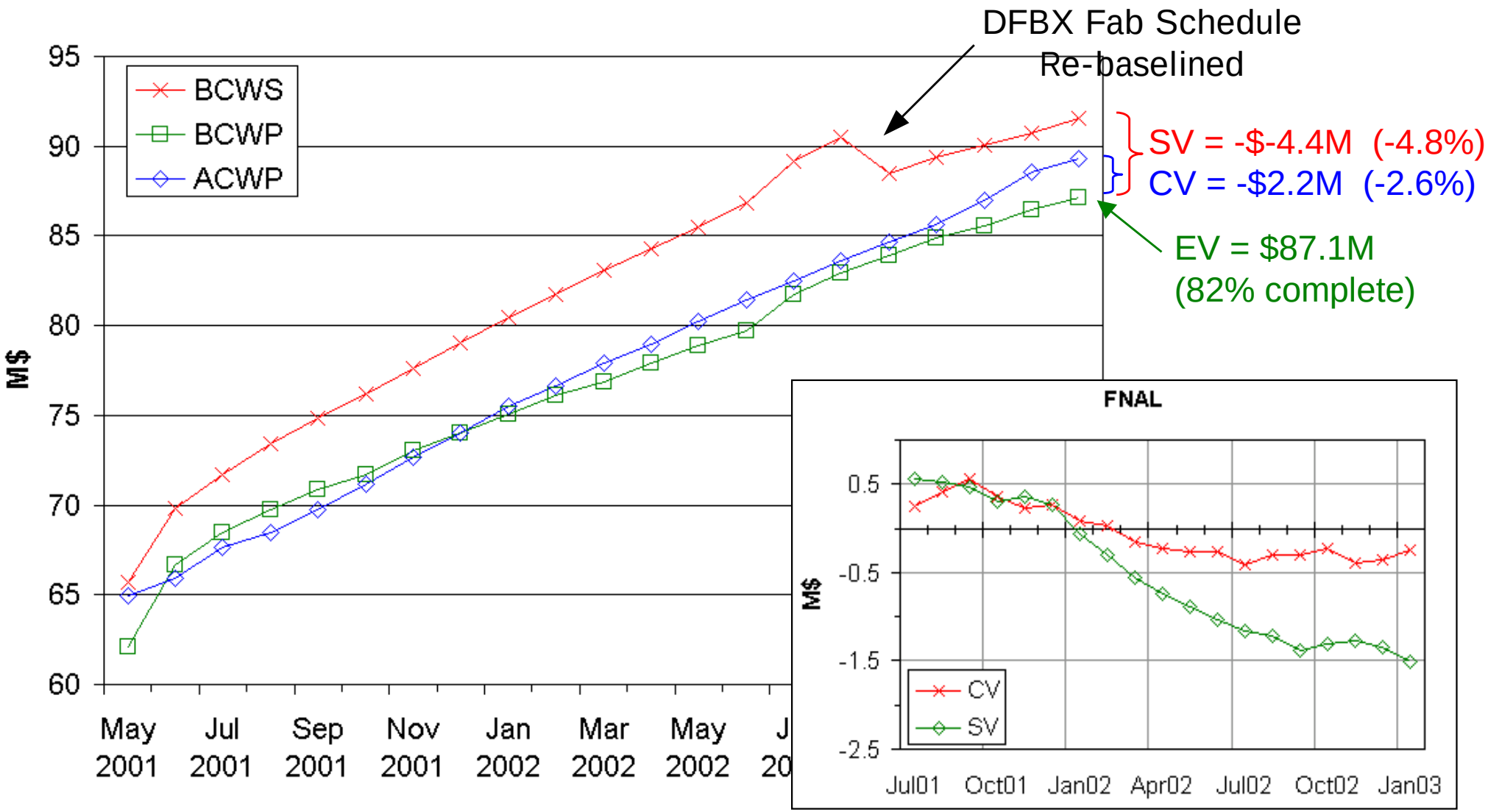


Project Status
Schedule Summary

Schedule situation remains satisfactory:

- Overall the project ramains ~5 months behind *our* schedule.
- Delivery of CERN-provided correctors to Fermilab is slowing quadrupole production.
  - Fermilab adjusting production plan to minimize impact.
  - Expect corrector deliveries to start in April.
- New baseline set of milestones for delivery to CERN has been established, consistent with the current installation schedule.
- We remain ahead of schedule for delivery of our equipment to CERN by the required installation dates.

Cost and Schedule Performance



Cost and Schedule Performance

Principal causes of unfavorable cost trends:

- Magnet testing difficulties at BNL and FNAL.
- Magnet acceptance effort at BNL.
- Major push to complete DFBX design at LBNL
  + VC lead purchase price well above baseline.
- Low efficiency of cable testing at very low rate.

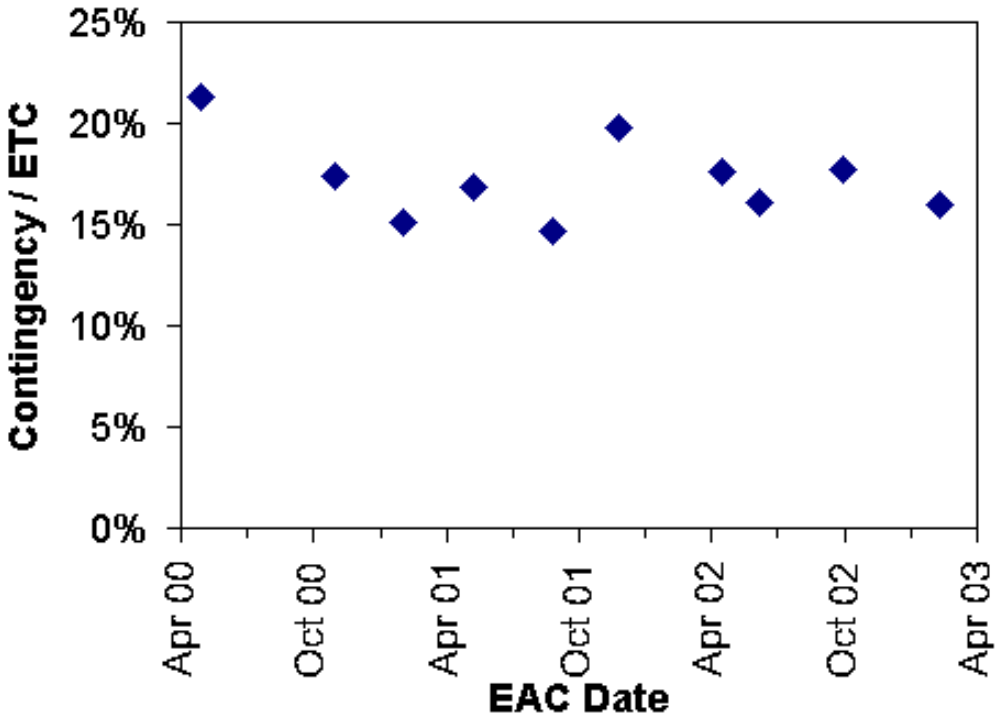
•Principal causes of schedule trends:

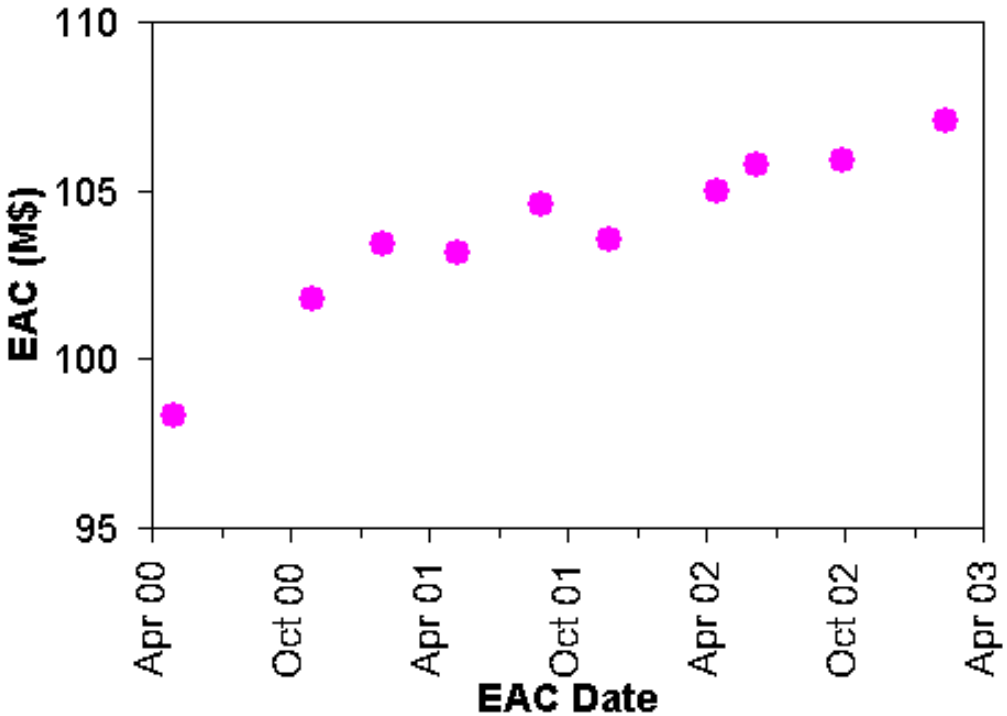
- All of the above, plus…
- Slow delivery of correction coils to Fermilab.
- Slow delivery of D4 dipole laminations from vendor.

Future cost pressures:

- Rearrangement of inner triplet correctors under consideration.
- CERN requesting additional magnetic measurements on dipoles.
  CERN agrees to cost offsets, if these are implemented.
- Need to keep internal costs tightly controlled.

EAC and Contingency History





Contingency computed from EAC continues to be in the 15-20% range.

- Accomplished through active management, plus some scope adjustment
- Constant vigilance on costs is required.
- CERN agrees that changes generated by them must be offset by cost reductions elsewhere, so that EAC is not changed.

US LHC Accelerator Project
Summary

- Technical progress is excellent.
- There are no major schedule issues.
- Cost and contingency situation requires continued vigilance.

> <u>From the February Lehman Review Closeout Report:</u>
> The major challenge for PMO is to successfully complete the U.S. LHC project within budget. … Since potential significant calls on contingency still exist, this will continue to require extremely careful management and control.

- Excellent and constructive working relations continue with CERN (and KEK).
- We remain fully committed to deliver on our commitments to CERN

  Full technical performance,

  On time,

  Within our budget,

  and every action is and will be taken to ensure success.

US LHC Accelerator Research Program

brookhaven - fermilab - berkeley

The US National Labs have made a significant investment in and are making a significant contribution to the construction of LHC.

- We are major players in IR design and construction.
- LHC has provided an important boost to accelerator technology development in the US Labs, especially SC magnets at FNAL.

We should exploit and extend this investment by continuing the collaboration with CERN into the commissioning, operational, and upgrade phases of the LHC accelerator program.

- FNAL, BNL, and LBNL are currently working with CERN to develop a proposal to DOE to fund the US LHC Accelerator Research Program (LARP).
- "Start-up" funding has been received last year and this year to support program planning.

Goals of the US LHC Accelerator Research Program

- Apply our unique expertise to machine development in support of HEP.
  - Rapid commissioning of LHC hardware systems.
  - Rapid commissioning of LHC beams.
  - Understanding machine behavior and limitations, and overcoming the limitations to increase delivered luminosity.
  - Developing upgrades to extend the performance and physics reach of LHC.
- Seize a unique opportunity to work at the forefront of accelerator physics and technology.
  - Forefront research opportunities for US accelerator physicists.
  - LHC upgrades present unique opportunities to extend US leadership in state-of-the-art accelerator technology, especially SC magnets.
  - Expertise gained from LHC can be applied to development of US machine.

LHC Schedule & Upgrade Options

- ***LHC Schedule***
  - ***First Beams*** ***April 2007***
  - ***Physics Run*** ***July 2007***

- ***LHC Upgrade Options***
  - Luminosity upgrade – SLHC : L = 10^{35} cm^{-2} s^{-1}

    --extends LHC mass reach by ~ 20-30%
    --modest changes to machine
    --very challenging for experiment
    --time scale ~ 2015

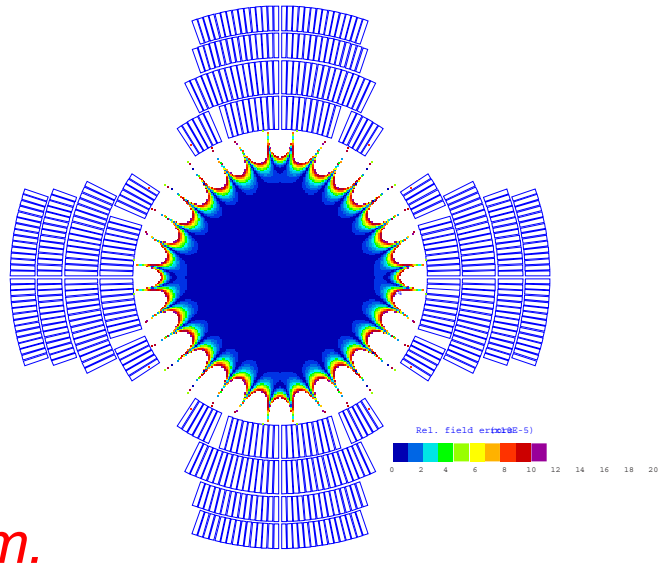
  - Energy Doubled LHC - EDLHC: $\sqrt{s}$ ~ 25 TeV L = 10^{34}-10^{35} cm^{-2} s^{-1}

    --extends LHC mass reach by ~ 1.5-2 for L=10^{34}-10^{35}
    --requires new machine (e.g. 15 T magnets …)
    --very expensive option
    --time scale > 2020

U.S. Role in Machine R&D

LHC R&D by the U.S. Labs will focus on increasing the luminosity.

- *Understand the limitations of the current machine configuration, particularly the IRs, and develop modifications.*
- *Low β^* insertion sections: (separation dipoles, triplet quads)*
- *Develop high-field Nb_3Sn magnets for new low β^* insertion, for example: quad aperture 70 -> 110 mm => β^* 50 -> ~17 cm.*



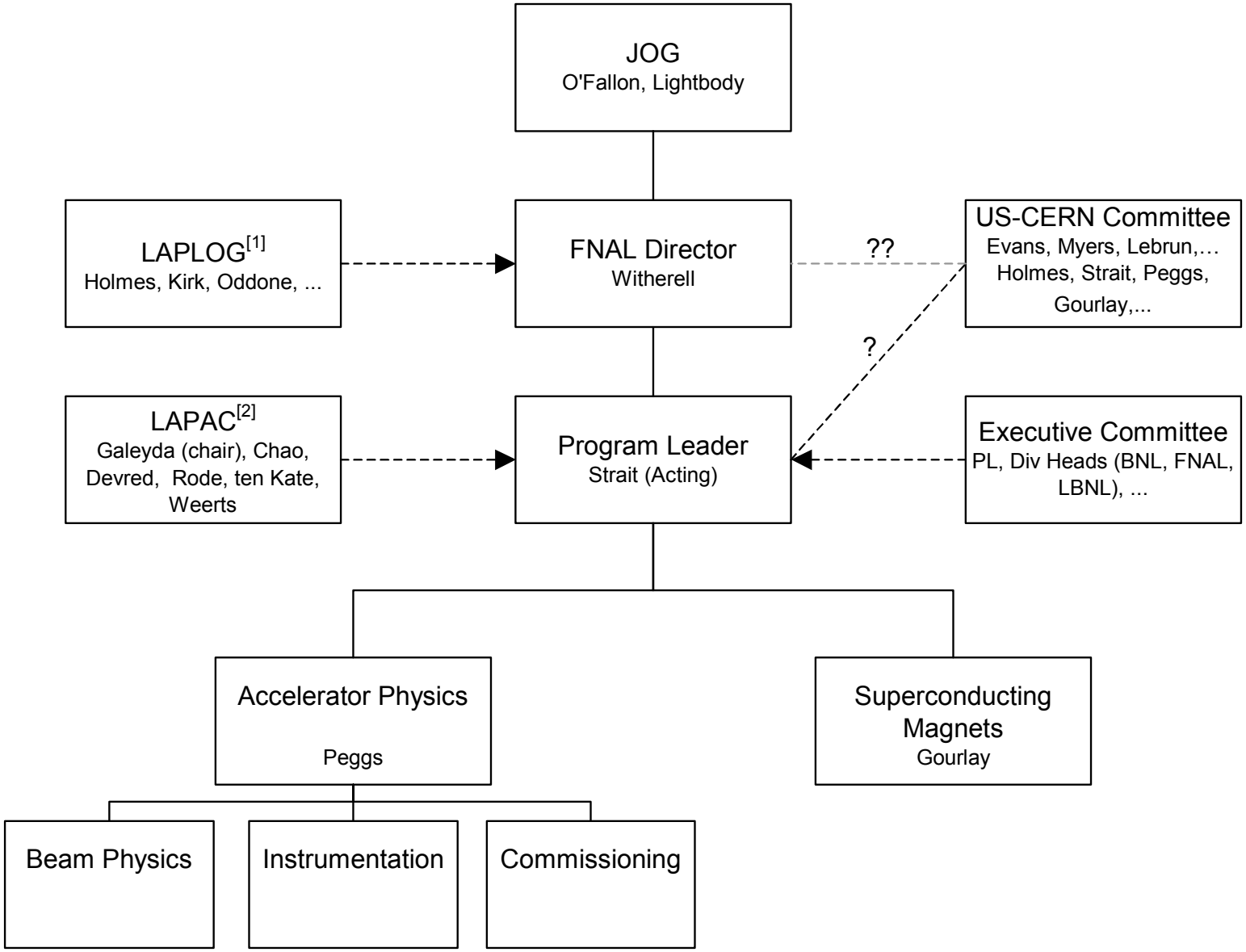
Other luminosity upgrade R&D to be addressed by CERN, e.g.

- *r.f. upgrades – for halving bunch length or handling superbunches*
- *collaborate with U.S. labs on R&D on luminosity upgrade magnets*

Program Planning Steps

- Collaboration Meeting on IR Upgrades held March 2002.
  - US labs, CERN, other European labs, KEK participated.
- US LHC Accelerator Program Advisory Committee.
  - Accelerator experts from outside the three collaborating US labs.
  - One meeting held so far (June 2002).
- US-CERN meeting on LHC Beam Instrumentation 28-30 January 2003.
  - Recommend technology for luminosity instrumentation.
  - Explore other opportunities for collaboration.
- Informal meetings on magnet collaboration 23-30 Jan 2003 at CERN.
- Chamonix Workshop on LHC Performance 3-8 March 2003.
  - 3 US accelerator physicists attended.
  - Opportunity to discuss US role in commissioning the LHC.
- US-CERN Steering Committee meeting, April 10, 2003.

Current *Draft* Organization



Interactions with DOE

We have received $100k/lab last year and this year. An asymptotic funding level of $10-12M is envisioned.

A “Guidance Letter” from John O’Fallon has been received, which corresponds well with our plans.

We are writing a proposal to DOE presenting our plans for this program.

- Will submit it to DOE after meeting of CERN-US “Steering Committee,” in April.

A Lehman Review will be held shortly after the proposal is submitted.

US LHC Accelerator Research Program Summary

- US collaboration on the LHC accelerator is an essential component of the US HEP program.
  - Supports CMS and ATLAS by improving LHC performance.
  - Advances our capabilities in accelerator physics and technology.
- The participants at all 3 labs have agreed on the scientific program
  - Accelerator Physics Research.
  - R&D to maximize baseline LHC performance for HEP.
  - R&D for LHC luminosity upgrade.

  and agreed on the management approach.
- Program is being planned in close collaboration with CERN.
- Written proposal will be submitted to DOE in April, followed by Lehman review.