



US LHC Accelerator Program

bnl – fnal – lbnl – slac

US LHC Accelerator Project US LHC Accelerator Research Program

Phil Pfund
Fermilab

DOE Annual Program Review
24 March 2004



US LHC ACCELERATOR PROJECT

brookhaven - fermilab - berkeley

IR Final Focus Systems: Points 1, 2, 5, 8

- US-built quadrupoles (FNAL)
- Japanese-built quadrupoles (KEK)
- CERN-provided correctors
- Cryostats for all quadrupole assemblies (FNAL)
- US-built beam separation dipoles (BNL)
- US-built IR feed boxes (LBNL+FNAL)
- US-built specialized absorbers (LBNL)

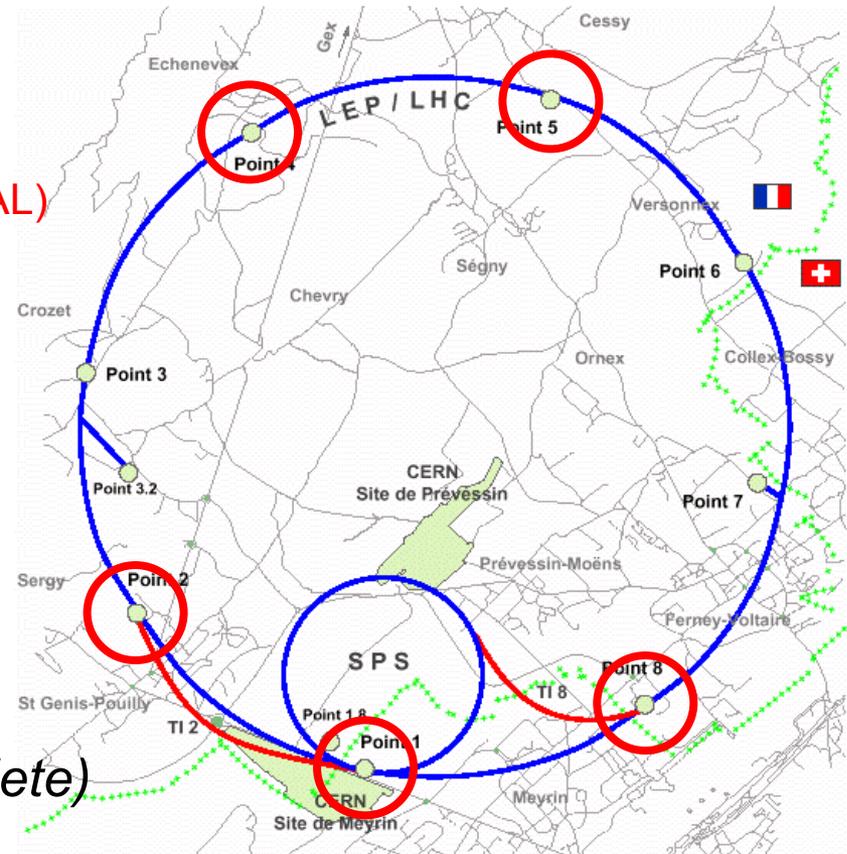
RF Region: Point 4

- Beam separation dipoles (BNL)

Wire and Cable for Main Magnets:

- Measurement of SC wire & cable (BNL)
- Cable production support (LBNL - complete)

Accelerator physics (all 3 labs - complete)



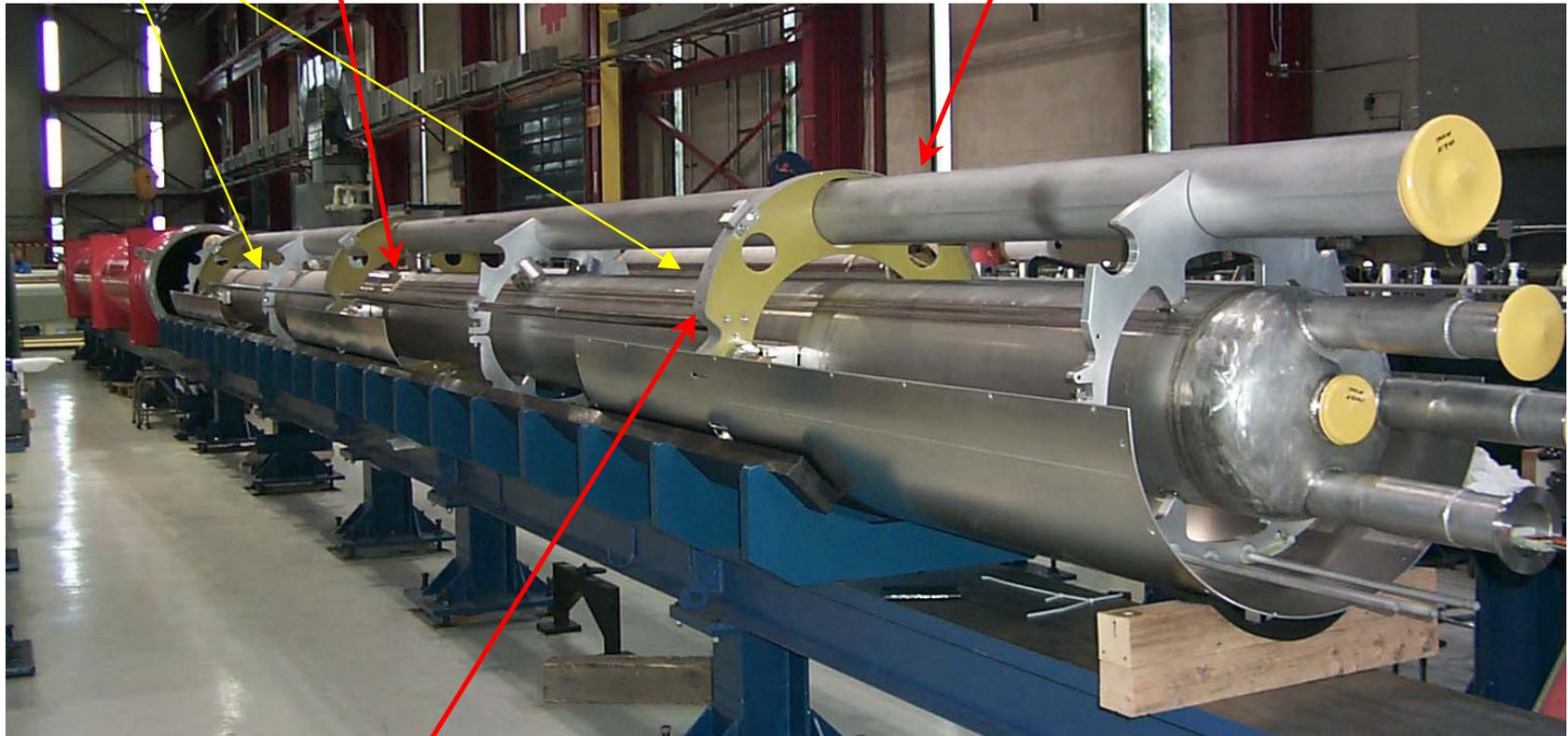
Project management and oversight (FNAL)



Fermilab LHC IR Quadrupole

2 MQXB (FNAL quad) welded end-to-end with central sleeve; CERN corrector inside

External Heat Exchanger for IP1/5 dynamic heat load



“Spider” support for alignment rigidity



LHC IR Quadrupole Production at Fermilab





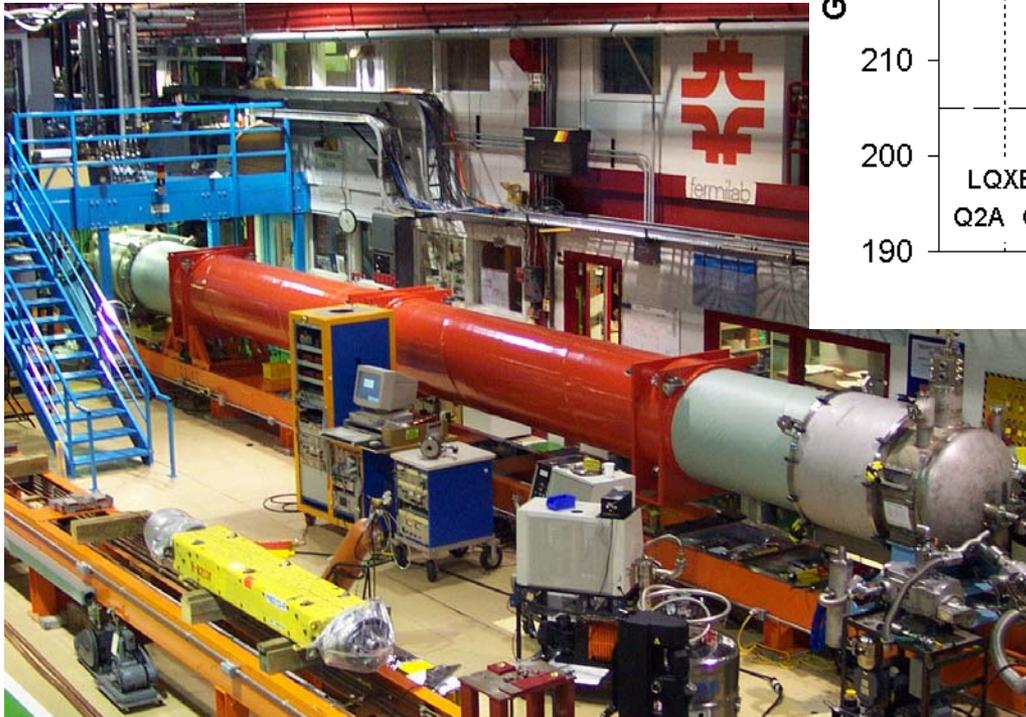
IR Quadrupole Production Status

IR Quadrupoles are well into production.

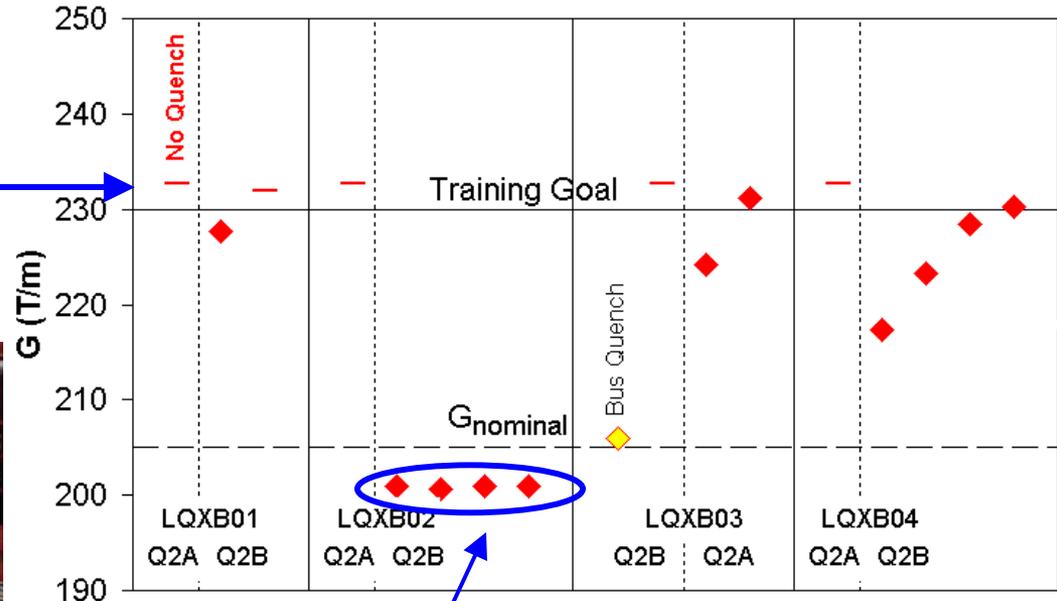
- 4 of 9 Q2 (2 MQXB + CERN corrector) have been built.
 - Two (#1 and #3) are ready to ship, pending acceptance formalities.
 - But one MQXB in Q2#2 failed to reach operating gradient. Magnet has been disassembled to diagnose the problem.
 - Testing of Q2#4 is complete.
 - Q2#5 is in cryostat assembly.
- 13 of 18 KEK quads are at FNAL; 1st Q1 assembly is complete.
- Correctors now arriving from CERN - no longer the critical path.



IR Quadrupole Test Results



9 T →



Quench Sequence

Appears to be flawed or damaged superconductor ... under investigation.



Beam Separation Dipole Production at BNL

Beam separation dipoles far into production.

D1 - 4 of 5 D1's are at CERN.

- 5th is ready to ship, pending acceptance formalities.

D2 - 9 of 9 D2's are complete and tested.

- 3 D2's are at CERN.

D4 - 3 of 3 D4's are complete.

- 1st is on the test stand.

D3 - 6 of 6 cold masses (2 per cryostat) are complete.

- 1st D3 is complete.

Dipole testing will be complete by June 2004.

Last dipole to be shipped by early 2005.



Cryostat assembly of
the 1st D3 at BNL.



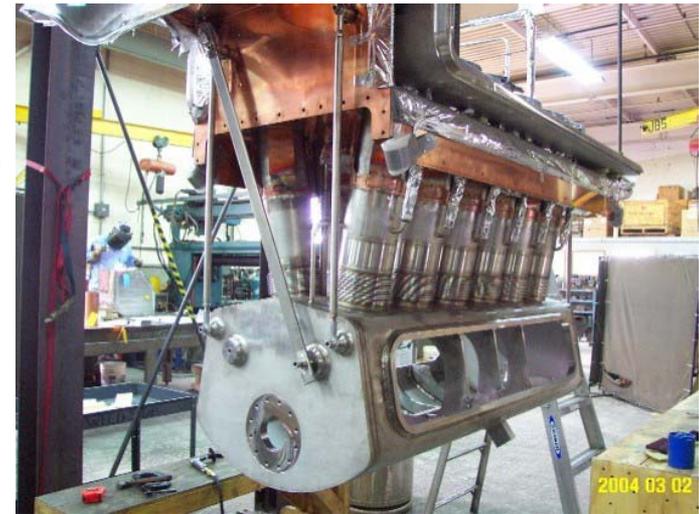
Arrival of 1st D2 at CERN.



IR Feed Boxes (LBNL & FNAL) and Absorbers (LBNL)

DFBX Production moving forward well.

- Production proceeding well at Meyer Tool.
- 15 of 20 HTS lead pairs have been tested at FNAL.
- All lab-provided equipment has been delivered.
 - Bus ducts and beam tubes (LBNL).
 - Instrumentation ducts (FNAL).



IR Absorbers production assembly is complete.

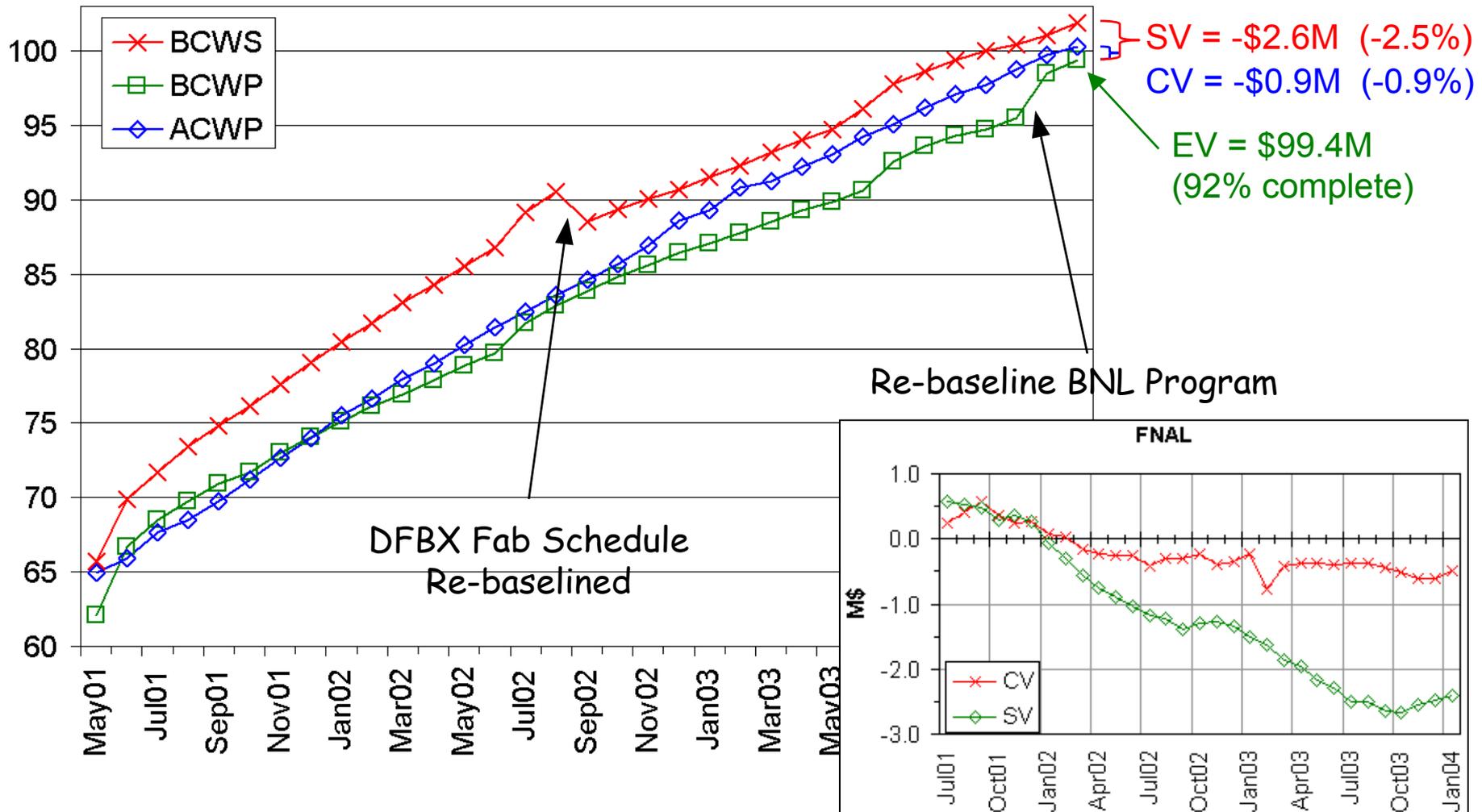
- 4 of 4 TAS are at CERN.
- 4 of 4 TAN are complete and in transit to CERN.





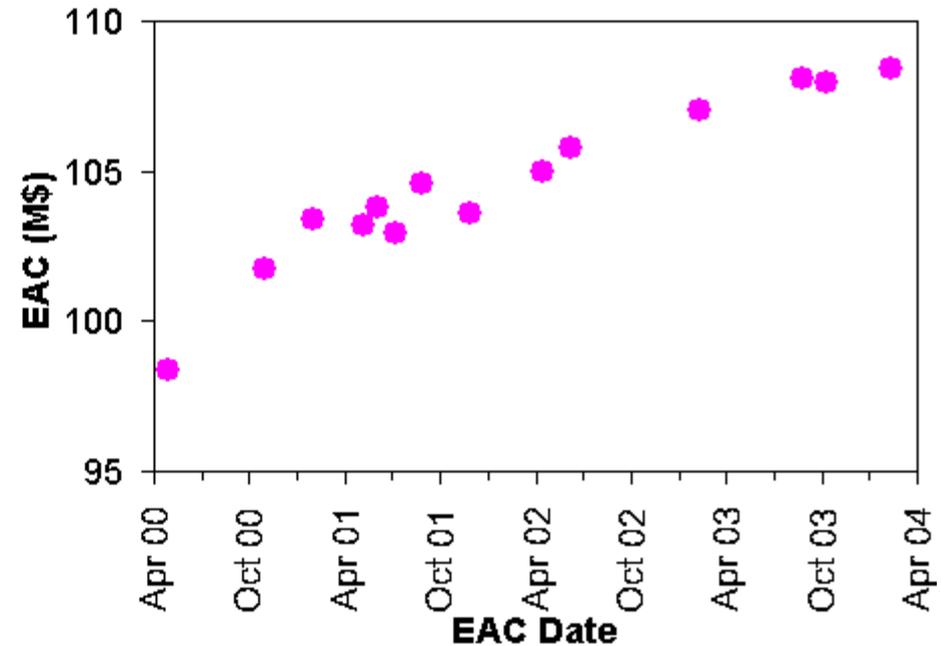
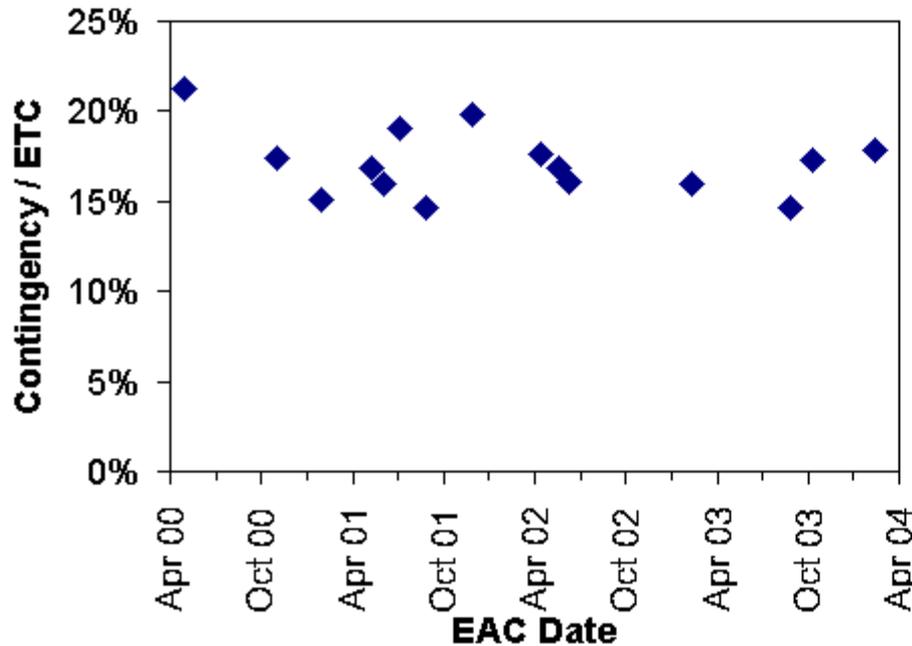
Cost and Schedule Performance

through January 2004





EAC and Contingency History



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

- Accomplished through active management, with support of top management of all 3 U.S. Labs.
- Cost of rebuilding Q2 is included, but further evaluation is on-going.



Project Completion Schedule Summary

- **Large float** relative to Project Completion milestone (30 Sep 05) exists **for dipoles and absorbers**.
- **Cable testing** will continue at maximum possible rate **through March 2005**.
- **Minimal float for shipping of last quadrupole** relative to Project Completion milestone.
=> aggressive monitoring of CERN corrector testing, and high priority to FNAL quad production and testing will be required.
- **Minimal float for shipping of last DFBX** with respect to Project Completion milestone.
=> aggressive monitoring and timely support of vendor will be required.



US LHC Accelerator Research Program *bnl – fnal – lbnl – slac*

Goals of the US LARP

Advance High Energy Physics

- Help bring the LHC on and up to design performance quickly.
- Improve LHC performance by advances in understanding and instrumentation.
- Use LHC to gain deeper knowledge of accelerator science and technology.
- Extend LHC as a frontier HEP instrument with a timely luminosity upgrade.

Advance U.S. Accelerator Science and Technology

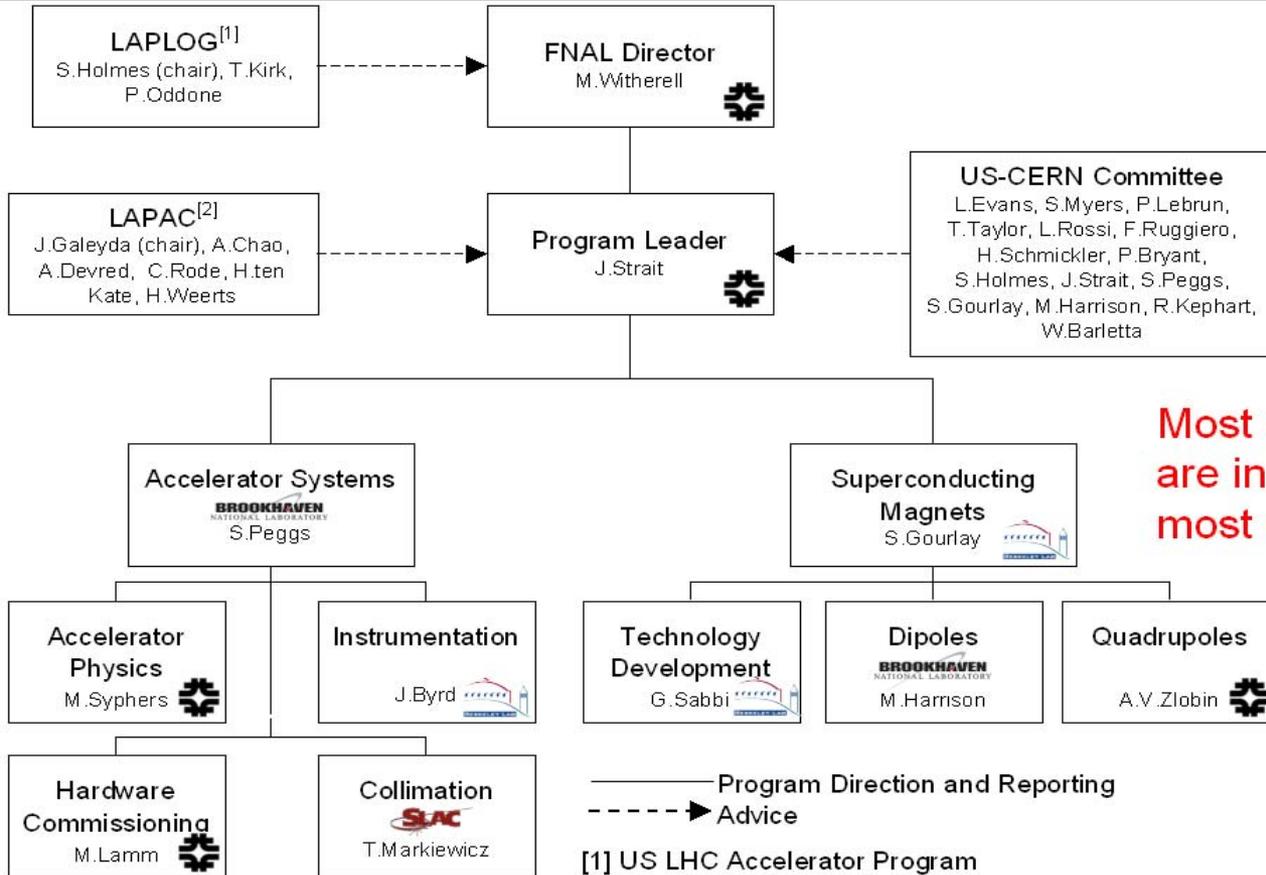
- Keep skills sharp by helping commission the LHC.
- Conduct forefront AP research and development.
- Advance U.S. capabilities to improve the performance of our own machines.
- Prepare U.S. scientists to design the next generation hadron collider.
- Develop technologies necessary for the next generation of hadron colliders.

Advance International Cooperation in the High Energy Accelerators

<http://www-td.fnal.gov/LHC/USLARP.html>



National Organization



Most of the labs are involved in most of the tasks!

———— Program Direction and Reporting
-----> Advice

[1] US LHC Accelerator Program Laboratory Oversight Group

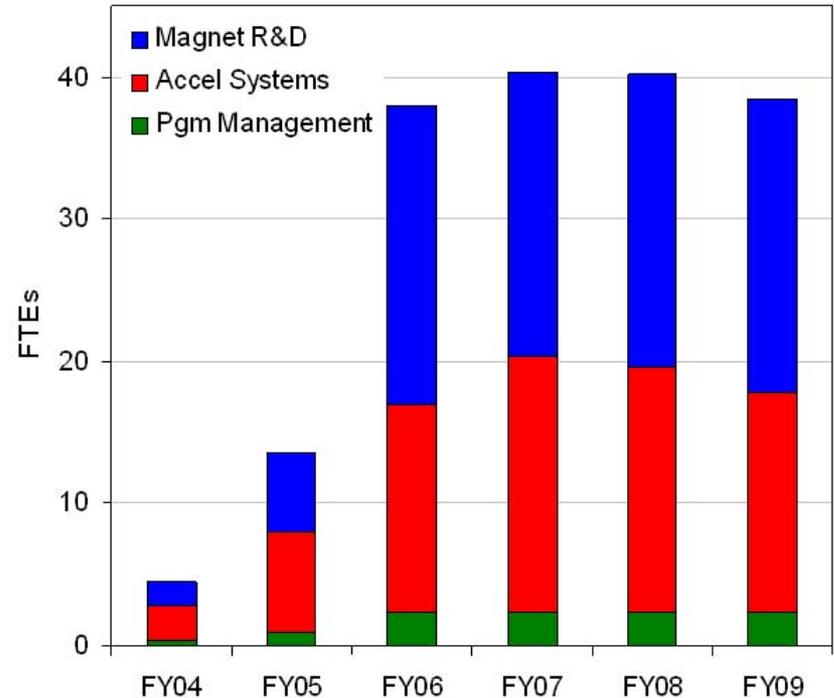
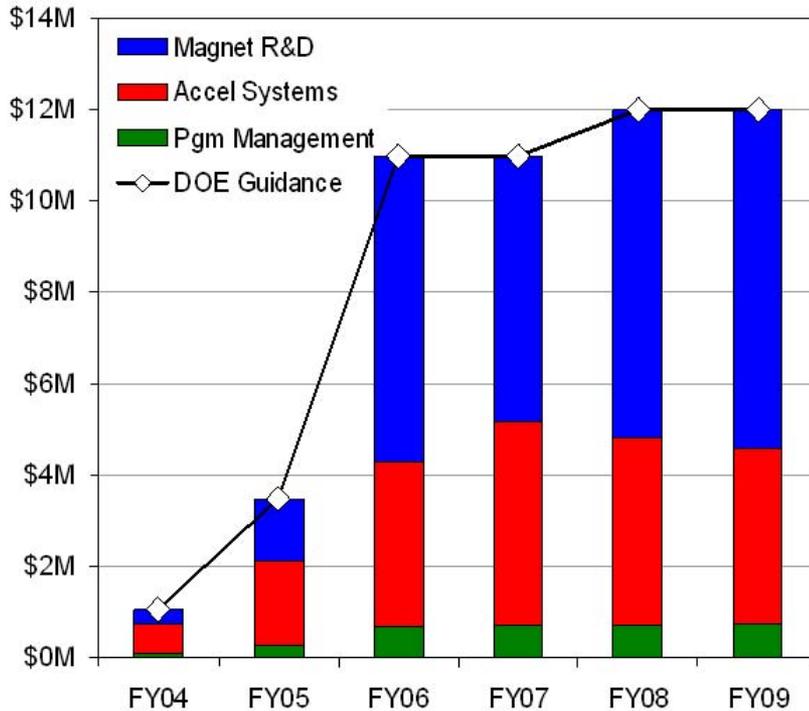
[2] US LHC Accelerator Program Advisory Committee

URA Visiting Comm – 12 Mar 2004

J. Strait – US LHC Accelerator Program



Funding and Budget



Funding is allocated on programmatic basis.
 . . . No predetermined split among the labs.



Schedule – Commissioning and Instrumentation

The LARP schedule is driven by the LHC schedule:

- August 2004 – Installation of US-provided equipment begins.
- April 2005 – Hardware commissioning of 1st US-provided IR.
- April 2006 – Sector test with beam.
- April 2007 – First beam in LHC.
- July 2007 – First LHC collisions.
- 2007 - 2010 – LHC luminosity rises towards design value.

⇒ Hardware commissioning activity peaks 2005-2007.

⇒ Beam commissioning peaks 2007-2009.

Preparations must start in 2004 to allow us to be fully integrated with CERN so we can have maximum impact.

⇒ Beam instrumentation R&D must start *now* so that the instruments we develop contribute to the efficient commissioning the LHC.



Schedule – Accelerator Physics and Upgrades

- 2007 - 2010 – LHC luminosity rises towards design value.
- 2011 - ... – LHC runs at asymptotic performance parameters.

⇒ LHC will be the **forefront vehicle** for high energy hadron accelerator physics **as soon as it is operational**.

Fundamental accelerator physics research based on the LHC must start well before this so that we are **ready to exploit this opportunity**.

⇒ **Significant upgrades** to the LHC and its experiments will be required **by the middle of the next decade** to extend its physics reach and keep its physics program productive.

Extensive R&D will be required to develop the **accelerator physics understanding** and the **beyond-the-state-of-the-art technologies** required to push the LHC beyond its already demanding parameters.
... **This R&D must start now** to ensure we are ready for the upgrades.



Hardware Commissioning

FY	Installation	Commissioning	Beam	Activity
2004	IR 8L			Planning
2005	IR 1L, 2R, 4R, 5L, 5R, 8R	IR2R, 8L		Hdw. Commissioning without beam.
2006	IR 1R, 2L, 4L	IR 1L, 4L, 4R, 5L, 5R, 8R	Injection Test (IR 8L and 8R)	Hdw. Commissioning + injection test.
2007		IR 1R, 2L	First Beam	System performance with Lum.
2008			$L > 10^{33}$	

- **Modest effort** by U.S. experts (~2 FTEs) will **ensure that our equipment is integrated efficiently** and that **we learn about system performance**.
- This will include a small on-site contingent to provide continuity and oversight, overlapping with shorter term assignments.
- A **modest M&S budget** will be provided **to allow hardware issues uncovered during commissioning to be addressed**.



Beam Commissioning & Accelerator Physics

Beam Commissioning

Original intention is to put **one US Accelerator Physicist on every commissioning shift**. How to organize this?

Activities in Beam and Instrumentation Commissioning will mainly be **organized through the AB-LHC operations team**.

The LARP commitment to BC must be made real with long term **individual commitments of up to 12 months**.

There is a **need for potential participants to visit CERN for short periods – 1 to 6 weeks**.

There is **no beam after 2004** until the sector test in 2006 (2007?)

LARP Annual, FNAL, Feb 27, 2004

S.Peggs

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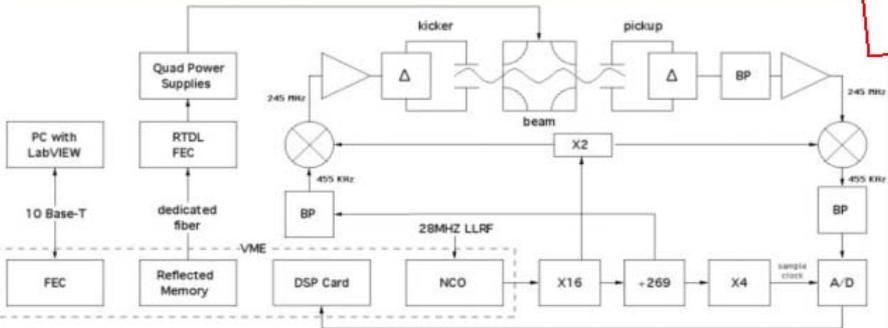


Beam Instrumentation

PLL Block Diagram



Tune Feedback (BNL+FNAL)

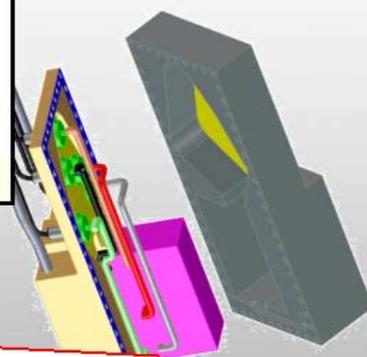


FNAL LARP meeting

26 Feb 04

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Detector



Fast Luminosity Monitor (LBNL)

- Metalized MACOR
- Component attach
- Strain relief



URA Visiting Comm – 12 Mar 2004

J. Strait – US LHC Accelerator Program



Beam Instrumentation

Abort Gap Monitor

Goal: detect presence of charge in gap for abort kicker rise time
LHC Spec

Possible solution: detect synch light with gated MCP/PMT.

Effort not funded by LARP in FY04. Increase to 140k\$ in FY05.

HAMAMATSU

GATEABLE MICROCHANNEL
PHOTOMULTIPLIER TUBE
R5916U-50 SE

Featuring Fast Gating Function with Improved Time Resolution and Switching Ratio

- FEATURES**
- High Speed Gating by Low Supply Voltage (+10V)
 - Gate Rise Time : 1 ns
 - Gate Width : 5 ns
 - Fast Rise Time : 100 ps
 - Narrow TTS : 90 ps
 - High Switching Ratio : 10⁴ at 500 nm
 - Low Switching Noise
 - Low Dark Noise
 - Variety of Microchannel Available
- APPLICATIONS**
- Experiment on entering
 - Satellite laser ranging
 - Fluorescence decay analysis

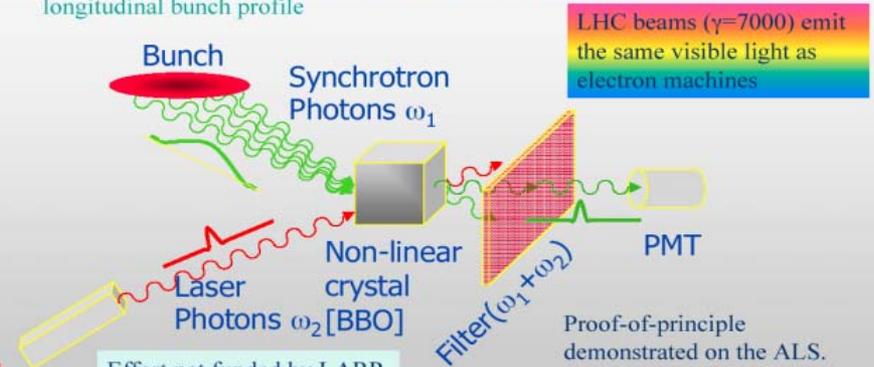


Abort Gap Monitor (LBNL)

Similar approach used in light sources to measure parasite bunches.

Optical Sampling Technology

- Use mixing of synchrotron radiation with a short laser pulse to sample the longitudinal bunch profile



Effort not funded by LARP in FY04. Increase to 140k\$ in FY05

Proof-of-principle demonstrated on the ALS. Developed in collaboration with femtoslicing program.

Longitudinal Density Monitor (LBNL)

LARP Mtg, 26-27 Feb 2004 page 11

John Byrd

LARP Mtg, 26-27 Feb 2004 page 10

John Byrd





R&D for Phase II Collimation System

NLC - The Next Linear Collider Project



LHC Collimator R&D Plan

Eric Doyle, Josef Frisch, Tom Markiewicz, Tor Raubenheimer
SLAC

LARP
Fermilab
27 February 2004

Propose to develop rotating metal collimators for a Phase II system to allow LHC to come to design luminosity.

URA Visiting Comm – 12 Mar 2004

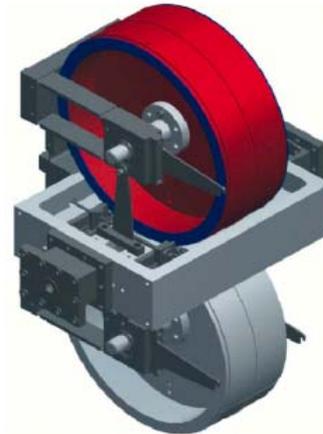
J. Strait – US LHC Accelerator Program

Baseline LHC collimation system (carbon primary absorbers) will limit bunch intensity to $<30\sim40\%$ of nominal
 $\Rightarrow L < 10\sim15\%$ of nominal.

NLC - The Next Linear Collider Project



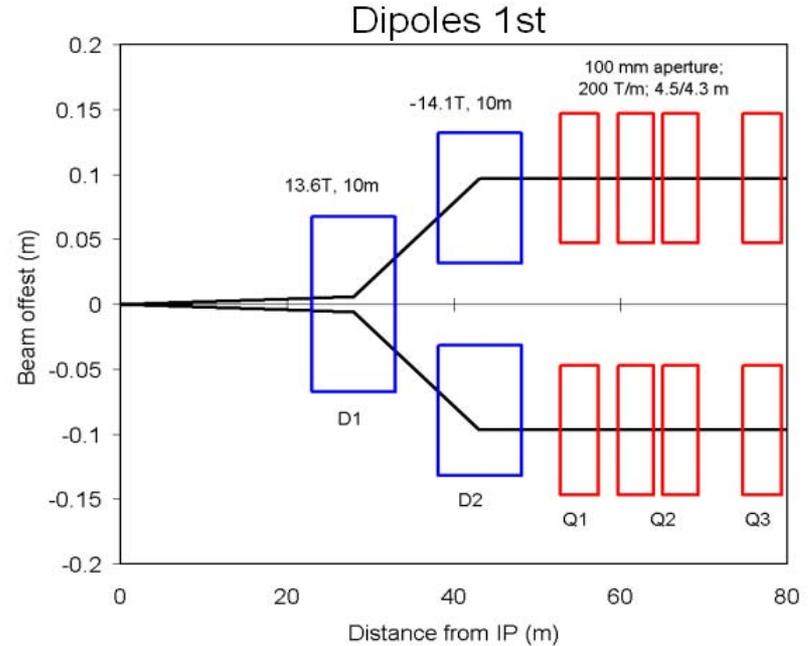
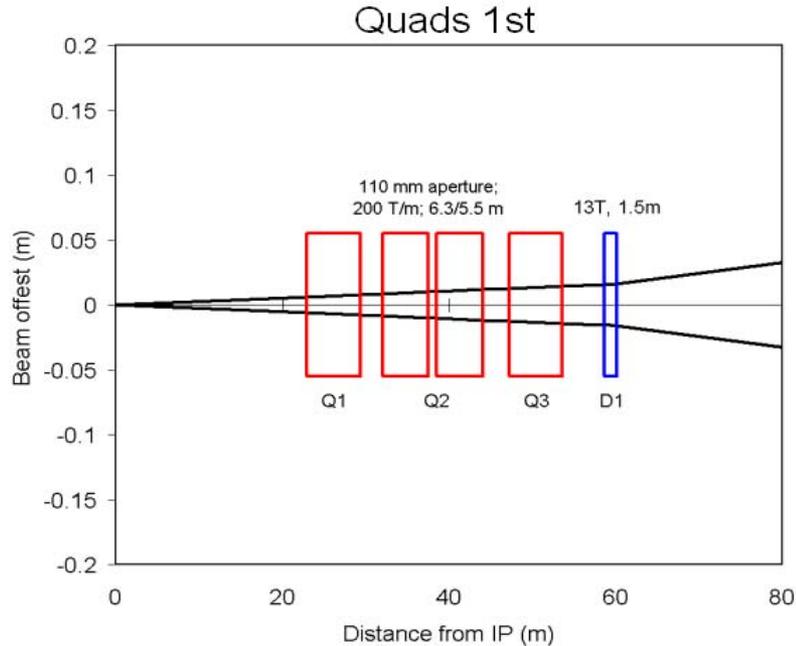
NLC Rotating Collimator



6
Tom Markiewicz



New IRs for Luminosity Upgrades: Accelerator Physics and Magnet R&D



J. Strait, et al., Towards a New LHC Interaction Region Design for a Luminosity Upgrade, PAC 2003.



FY05 Sums

- Quads and Technology development

- Design studies
- Build a quad ASAP
- Continued sub-scale quad studies (new geometries)
- Materials studies
- Cable R&D

FNAL + LBNL

\$1,562k

- Dipole Development

- Complete cold mass design
- Thermal analysis
- Build R&D coils (no cost cable)
- Build “simplified” cold mass

BNL + FNAL

\$500k

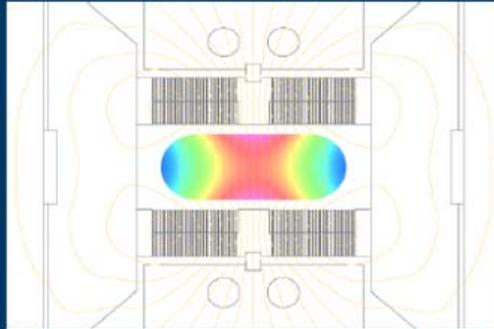
Not \$1,270

Not \$1,395

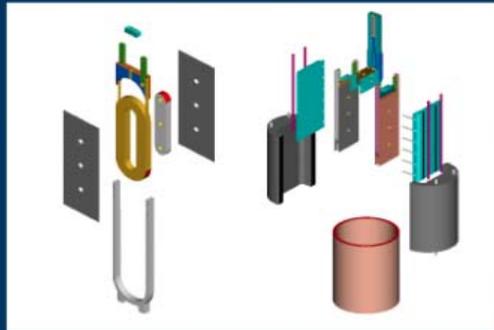
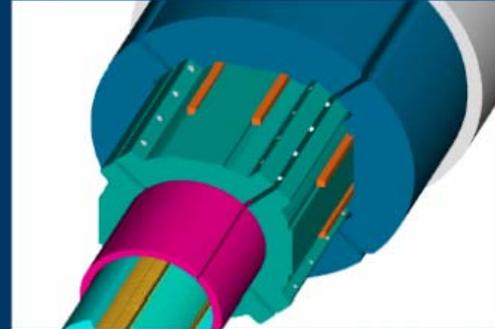


Technological Models

Split-coil/HD1 dipole



Quadrupole Structure



SM (common coil)



SM Quadrupole

LARP Collaboration Meeting February 26 - 27, 2004

S. Gourlay



Summary and Conclusions

US LHC Accelerator Project is moving towards completion:

- IR Quadrupoles and Feedboxes are well into production.
- IR Dipole production is nearing completion.
- IR Absorbers production is done.
- SC Cable testing proceeding well.

Cost and schedule (quads and feedboxes) are tight and are being managed closely.

US LHC Accelerator Research Program has been launched.

- Vigorous planning and first real work this year on Accelerator Physics, Machine Commissioning, Instrumentation, and Magnet R&D.
- SLAC has joined the collaboration to develop Phase II Collimators.

Funding is limited relative to the breadth and depth of interest in the LHC within the US Labs.