



# U.S. LHC Program



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**HEPAP July 11, 2005**



# U.S. LHC Program – History-1

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- **SSC terminated** in October 1993, and U.S. physicists turn to LHC
- U.S. involvement in **LHC placed before HEPAP in 1994**, with a subpanel recommending that the U.S. declare its intention to join other nations in constructing the LHC, and initiate negotiations...
- DOE and NSF negotiate **U.S.–CERN International Agreement** for U.S. participation, with **DOE** agreeing to provide **\$450M** and **NSF \$81M** to build components for ATLAS, CMS, and the LHC machine (formally signed in **December 1997**)
- This makes U.S. Official **Observer** at CERN Council, **member of** LHC Machine Board and Resource Review Boards for ATLAS & CMS and establishes U.S.–CERN Cooperation Committee (**CUCOM**)



# U.S. LHC Program – History-2



- **MOU** between DOE and NSF **signed in June 1998**, establishing Joint Oversight Group (**JOG**) for agency **oversight** of U.S. LHC.
- U.S. becomes major contributor to **ATLAS (BNL host lab)** and **CMS (with Fermilab as host lab)**, providing ~25% of personnel
- FNAL, BNL, and LBNL form **U.S. LHC Machine Collaboration (with Fermilab as host lab)**
- **U.S. LHC Construction Project** established under guidelines set by the **International Agreement**, **DOE–NSF MOU**, and a Congressionally mandated **cap of \$531M for fabrication** of all deliverables (\$200M for accelerator and rest for detectors)
- **U.S.** ATLAS, CMS, and LHC Machine collaborations agree via **MOUs** on deliverables with ATLAS, CMS and **CERN**, establish good working relationships with their international counterparts, and **provide U.S. deliverables on schedule and within budget**

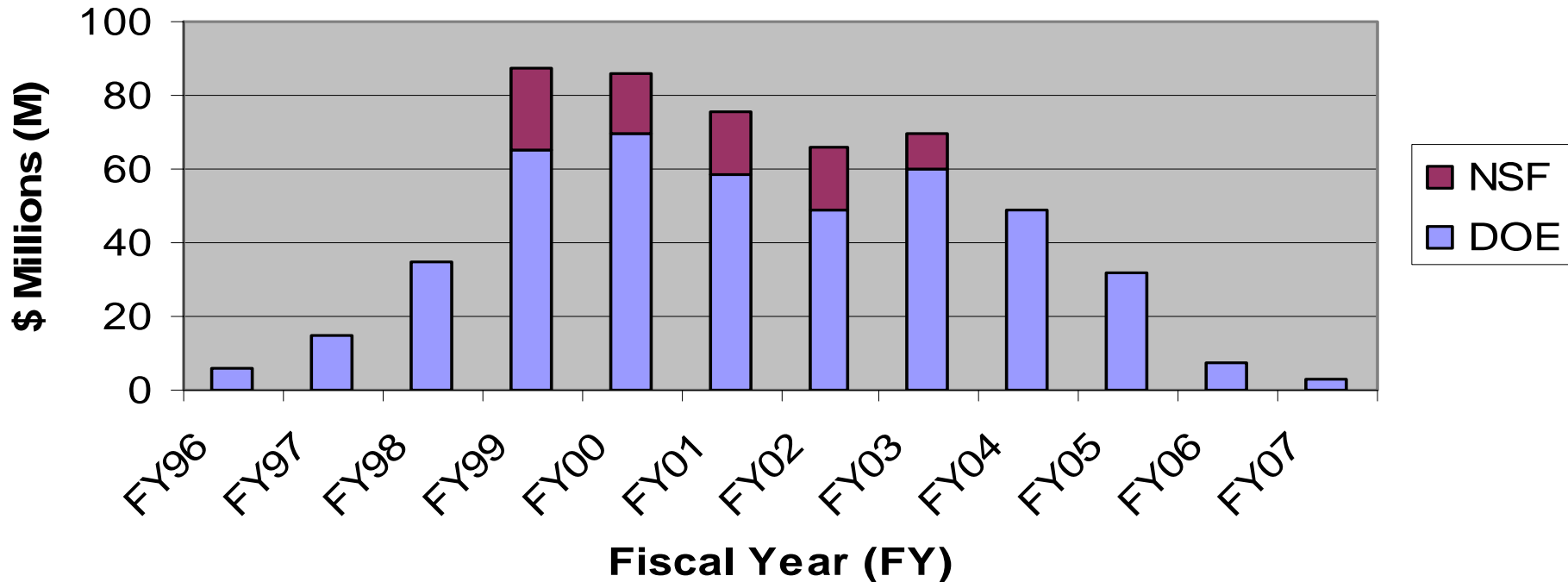


# DOE & NSF Funding for the U.S. LHC Construction Project



## U.S. Large Hadron Collider Construction Project Funding Profile

(Total Funds = \$531 M; DOE: \$450M, NSF: \$81M)





CMS End-Cap Muon Station with U.S. Cathode Strip Chambers positioned on Disk, at CERN Bldg SX-5. Successful “slice-test” of CSCs with Hadron Calorimeter modules and other muon chambers executed past fall, with 25 ns (LHC) beam structure





# Section of U.S. CMS Hadron End Calorimeter for which U.S. is doing cabling, testing and integration





CMS Underground Experimental Hall. Civil construction now complete, and lowering of first detector components expected in early 2006.





View of ATLAS Cavern, when fifth Aircore Toroid was about to be installed. Completed Barrel Tile Calorimeter surrounds Liquid Argon Cryostat, which was a U.S. deliverable (in back behind scaffolding).



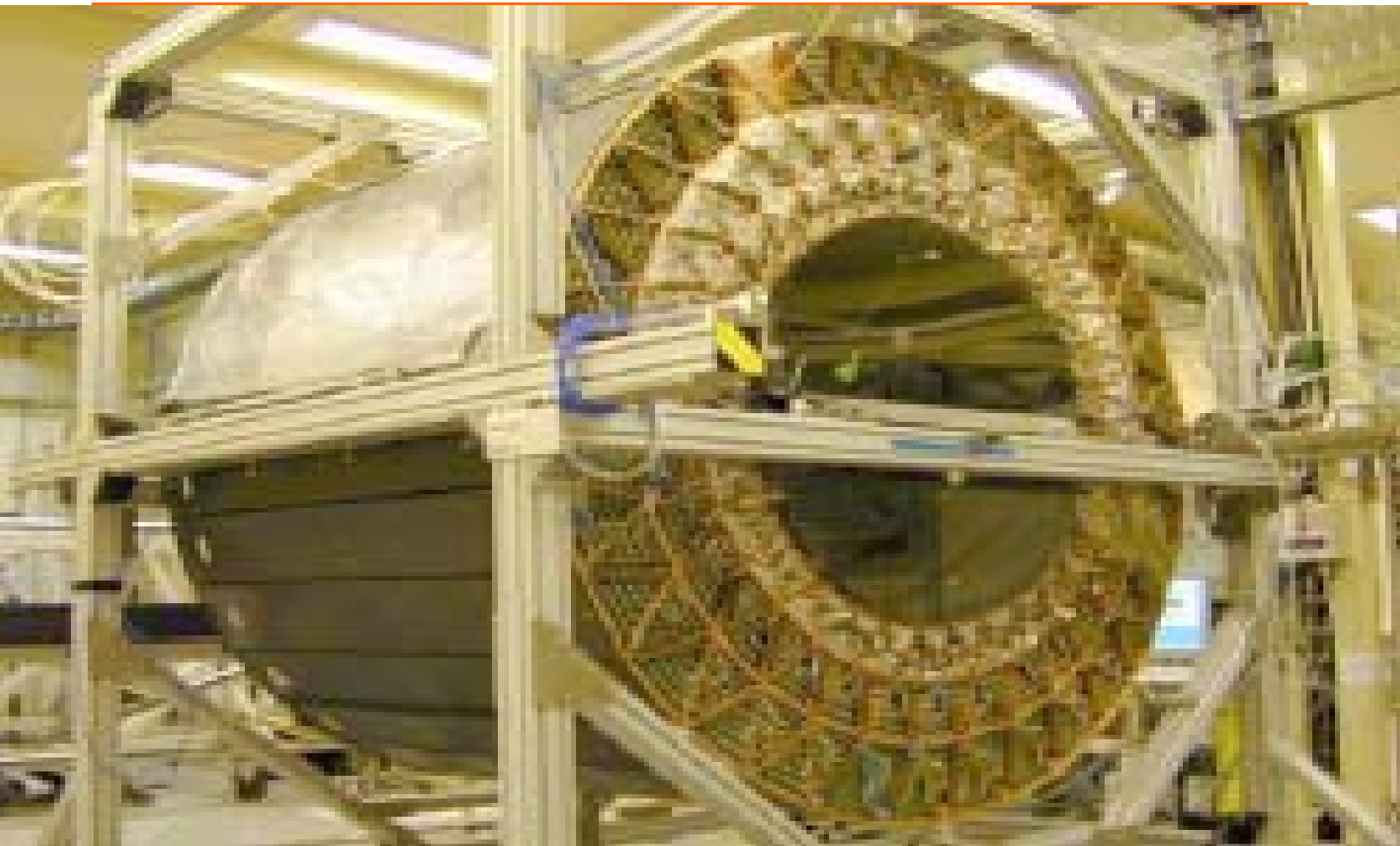
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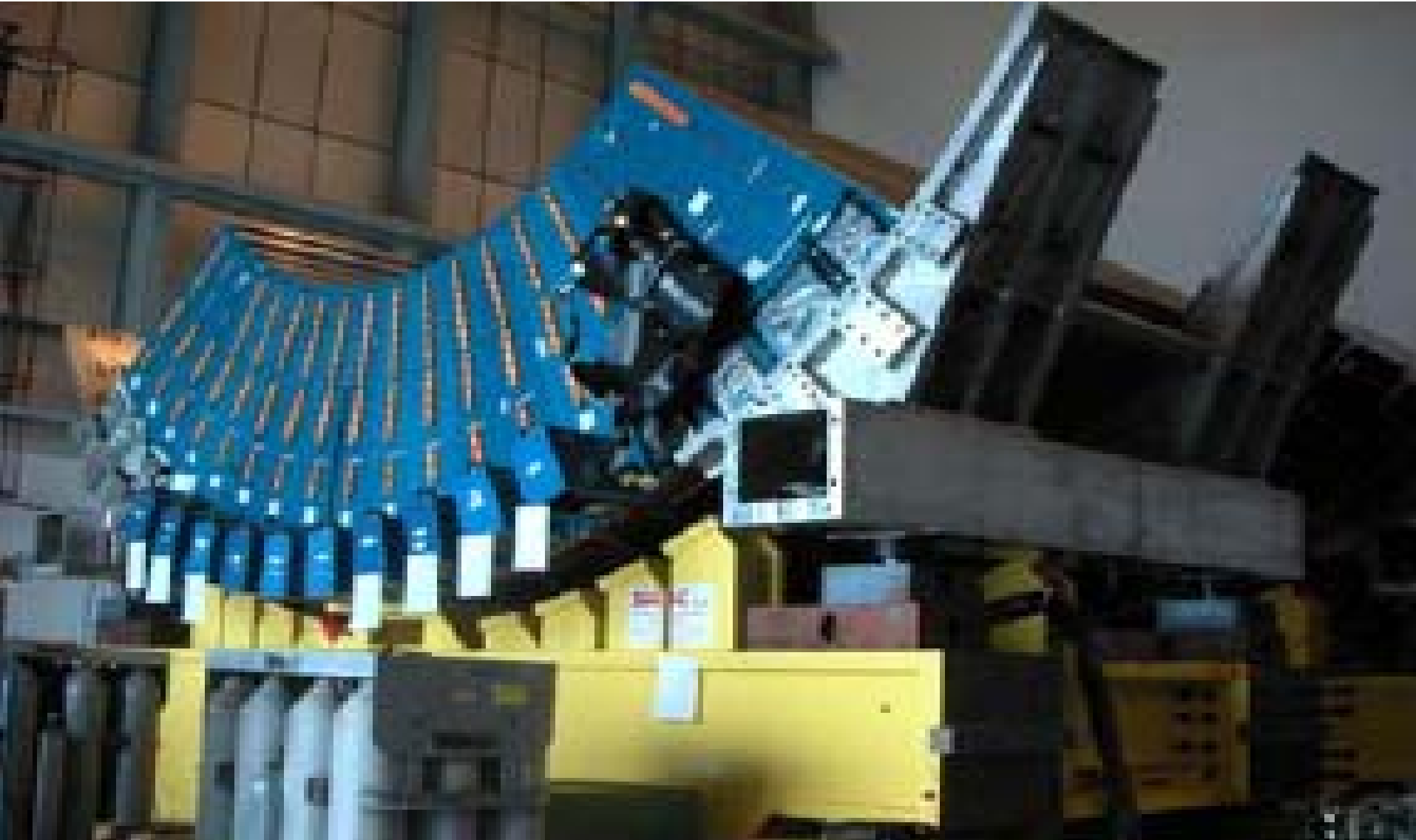
ATLAS Barrel Transition Radiation Tracker, a U.S. deliverable, with all modules installed at CERN.





ATLAS extended barrel modules, a U.S. deliverable, being outfitted with electronics and services, tested and commissioned in preparation for integration into the detector.

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# U.S. Feedbox and IR magnets at assembly area at CERN





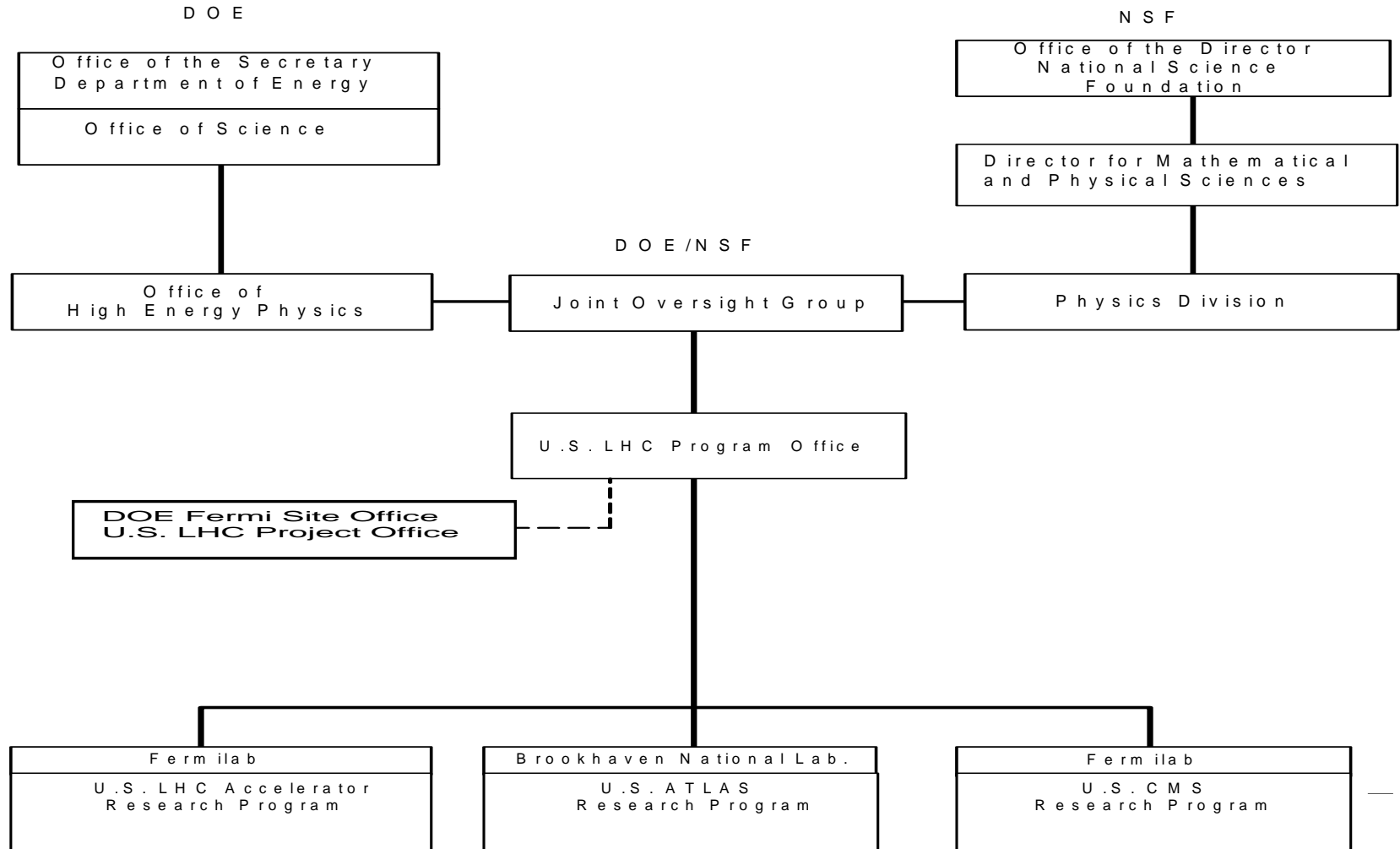
# U.S. LHC Program – History-3



- The **U.S. LHC Research Program** envisioned to provide technical support for executing research after construction. As the Construction Project started to take root, Research Program **started to trickle-on in ~FY 2000**, with inflection point in funding profile in FY '05, and steady state essentially beyond FY '07 (at level of funding guidance yet to be fully reviewed). Research Program also concerns upgrade of **detectors and accelerator** for eventual LHC luminosity of  $10^{35}/\text{cm}^2\text{-s}$ . Large part of **Core Program in HEP/EPP** is expected to contribute to all aspects of U.S. LHC Program activities.
- **First “running” likely in mid 2007, with decent data in 2008. This will be one of the major U.S. HEP/EPP programs for 15–20 years!**
- The remarkable achievements and **success of all components of the U.S. LHC Program attributable to the U.S. experimenters** managing and executing the construction and research activities: **Lothar Bauerdick, Bob Cousins, Howard Gordon, Dan Green, John Huth, Jim Kerby, Steve Peggs, Steve Reucroft, Jim Shank, Jim Strait, Michael Tuts, Bill Willis** and their legions.



# Organization Chart for U.S. LHC Research Program



———— Program Direction and Reporting  
----- Communication and Coordination



# U.S. LHC Program



- Flushed with success from the construction effort, **U.S.** is positioning itself to be an **effective** player in **running** of the **experiments and uncovering the physics** once the LHC starts. Much physics-directed **analysis** is **in full swing** on Monte Carlo events, with great **interest and input from U.S. phenomenologists**
- Fabrication of U.S. **deliverables** is **nearly complete**. Construction effort in various stages of testing, installation, and commissioning.
- For more documentation on the original U.S. LHC **Project Execution Plan**, see:  
<http://www.ch.doe.gov/offices/FAO/projects/uslhc/pep/index.html>
- U.S. LHC Research **Program Execution Plan** and **Management Plans** about to be unveiled.



# Perspective on U.S. LHC Research Program



- **STRUCTURE** (two major components, aside from Construction Project that will be ~97% finished by September 30, 2005):
  - **U.S. ATLAS and U.S. CMS Experiments**
    - Software and Computing (**S&C**), including facilities, core software, grid software, and support of analysis.
    - Maintenance and Operations (**M&O**), including pre-operations
    - **Detector R&D** for eventual luminosity upgrade of LHC
  - **U.S. LHC Accelerator R&D Program (LARP)**
    - Fundamental **accelerator physics**
    - **Commissioning** of accelerator
    - **Beam instrumentation, tune feedback and collimation**
    - **Superconducting Nb<sub>3</sub>Sn magnet R&D** for upgrade, and demonstration of viability of large-aperture, high-field, long **IR quadrupoles**



# Perspective on U.S. LHC Research Program (cont'd)



## • FEATURES

- **Extensive** planning and regular **oversight** – external and internal DOE/NSF reviews and discussions.
- Main costs involve human resources. Experts are not off-shelf commodities. Long-term planning and budget **stability** is key.
- Bulk (~80%) of DOE funding is **for experiments**, with NSF providing another ~35% of DOE part. LARP purely DOE.
- U.S. **success rests on** expected **shift** of interest and scientists from current activities funded in **Core Program** to LHC! Eventually, perhaps >50% of U.S. experimenters may join
- **Networking** resources for effective data transfer (sufficient **bandwidth**) comprise an essential ingredient for success of U.S. participation in the LHC. DOE and NSF **working on this**.





# DOE & NSF Funding for LHC

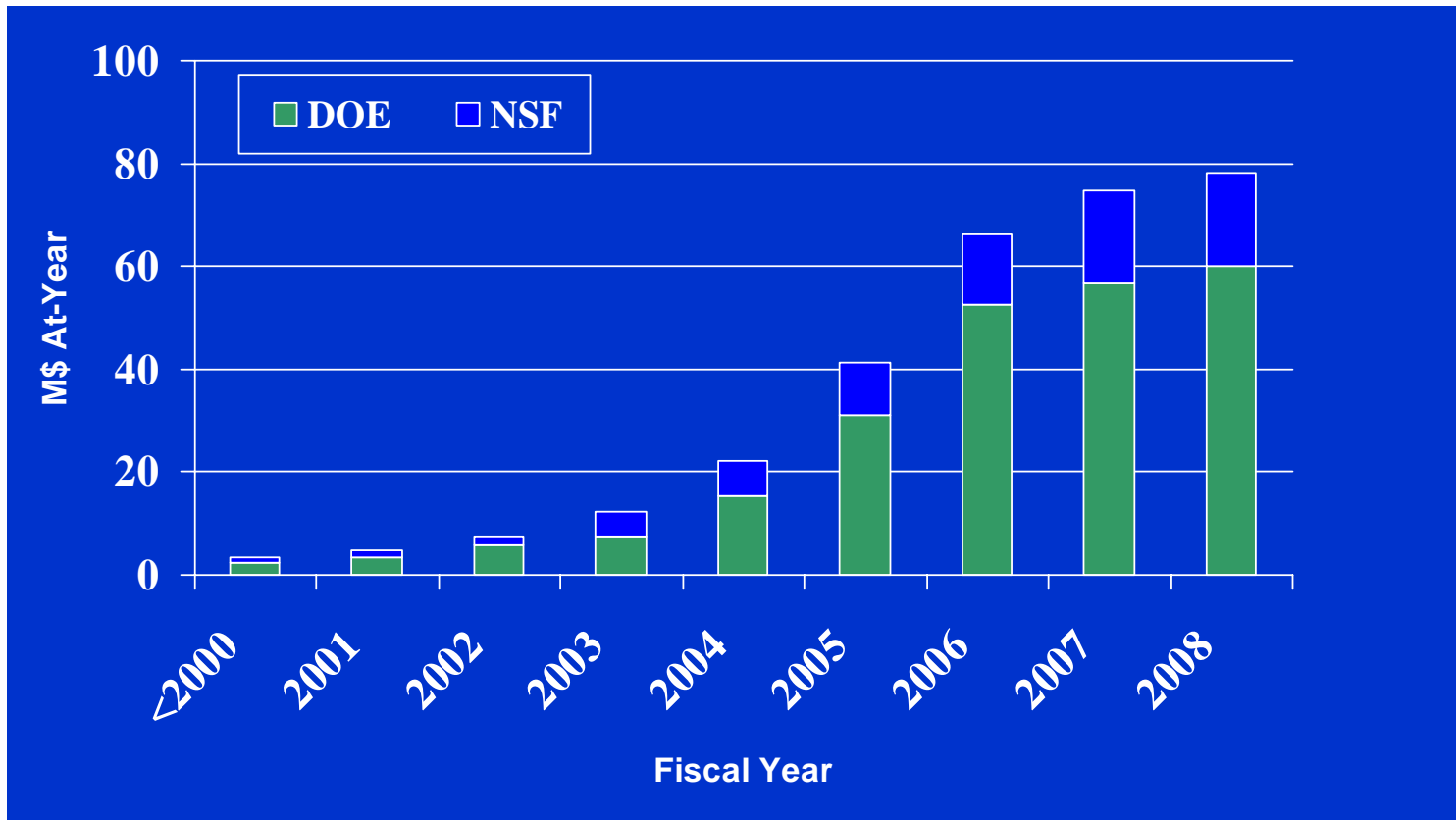
## U.S. LHC Research Program Funding Profile (Suggested Guidance per June 04) B/A in \$M

	FY96-00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	TOTAL
<b>ATLAS</b>	<b>2.7</b>	<b>2.1</b>	<b>3.6</b>	<b>5.9</b>	<b>10.8</b>	<b>18.0</b>	<b>28.0</b>	<b>31.6</b>	<b>33.0</b>	<b>135.7</b>
DOE	1.4	1.8	2.8	3.4	7.3	12.8	21.3	22.6	24.0	97.3
NSF	1.3	0.3	0.8	2.5	3.5	5.25	6.75	9.0	9.0	38.4
<b>CMS</b>	<b>2.3</b>	<b>1.9</b>	<b>3.6</b>	<b>5.9</b>	<b>10.6</b>	<b>18.6</b>	<b>27.1</b>	<b>32.2</b>	<b>33.0</b>	<b>135.1</b>
DOE	1.4	1.8	2.8	3.4	7.1	13.4	20.3	23.2	24.0	97.3
NSF	0.8	0.2	0.8	2.5	3.5	5.25	6.75	9.0	9.0	37.8
<b>LARP DOE</b>			<b>0.3</b>	<b>0.8</b>	<b>1.3</b>	<b>3.3</b>	<b>11.0</b>	<b>11.0</b>	<b>12.0</b>	<b>39.6</b>
<b>Total</b>	<b>5.0</b>	<b>4.1</b>	<b>7.4</b>	<b>12.5</b>	<b>22.6</b>	<b>39.9</b>	<b>66.1</b>	<b>74.8</b>	<b>78.0</b>	<b>310.3</b>
DOE	2.9	3.6	5.8	7.5	15.6	29.4	52.6	56.8	60.0	234.1
NSF	2.1	0.5	1.6	5.0	7.0*	10.5*	13.5*	18.0*	18.0	76.2

\* As of FY 04, the starting dates for the projected NSF funding correspond to accelerated schedules to begin on 8/1/04, 5/1/05, 2/1/06 (each for a nine-month period) and 11/1/06. Thereafter, normal twelve-month funding will begin on November 1 of each year.



# Current Funding and Tentative Guidance for Total U.S. LHC Research Program





# Regular Reviews of Ongoing Activities of U.S. LHC Research Program



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**Review by M&O Evaluation Group (MEG) at Fermilab Jan 27-29, 2005**

- U.S. ATLAS and U.S. CMS M&O are being **managed effectively** - managers alert to problems and doing well!
- **M&O scope** and cost estimates proposed by collaborations are **reasonable**
- U.S. CMS and U.S. ATLAS have demonstrated **significant progress in their M&O** plans despite tight budgets. **FY05-08 are considered critical years** for commissioning of ATLAS and CMS detectors, their preparation for start of operations, and an important period to assure sufficient detector integration and readiness for data in 2007. Concern expressed about low contingency for unforeseen needs.
- U.S. CMS and U.S. ATLAS M&O programs **rely strongly on** support from the **Core** Program, including support for physicists working at CERN, and might require additional support to maintain **successful M&O effort**.
- Preliminary **plans for detector R&D** for upgrade of LHC are **reasonable**. The level and focus of the R&D effort appears **commensurate with current LHC upgrade plans**.



# Regular Reviews of Ongoing of U.S. LHC Research Program (cont'd)



## Intensive S&C Review of U.S. ATLAS and CMS, March 1- 4, 2005 at BNL

- In general, **reviewers were pleased with leadership and work of U.S. teams**, but voiced some concern about U.S. CMS over-extension of responsibilities (e.g., in CMS core software)
- Following delay resulting from past funding uncertainties, experiments are now **ramping up deployment of Tier-1 and Tier-2 centers** (hear Jim W next).
- Recent completion of computing models and subsequent LHCC reviews led to **significant revisions** in required resources, which have been **incorporated** into the latest plans
- Committee expressed **concern about dependence of U.S. deliverables on funding from external grid projects** (some of limited duration). **DOE&NSF trying to help.**
- Considered **analysis at LPC** at Fermilab as particularly **advantageous for U.S. CMS physics program and involvement in LHC from afar**
- Asked **U.S. ATLAS to clarify its “Virtual Corridors” model** for support of physics analysis. (U.S. ATLAS will respond shortly.)



# Regular Reviews of Ongoing of U.S. LHC Research Program (cont'd)



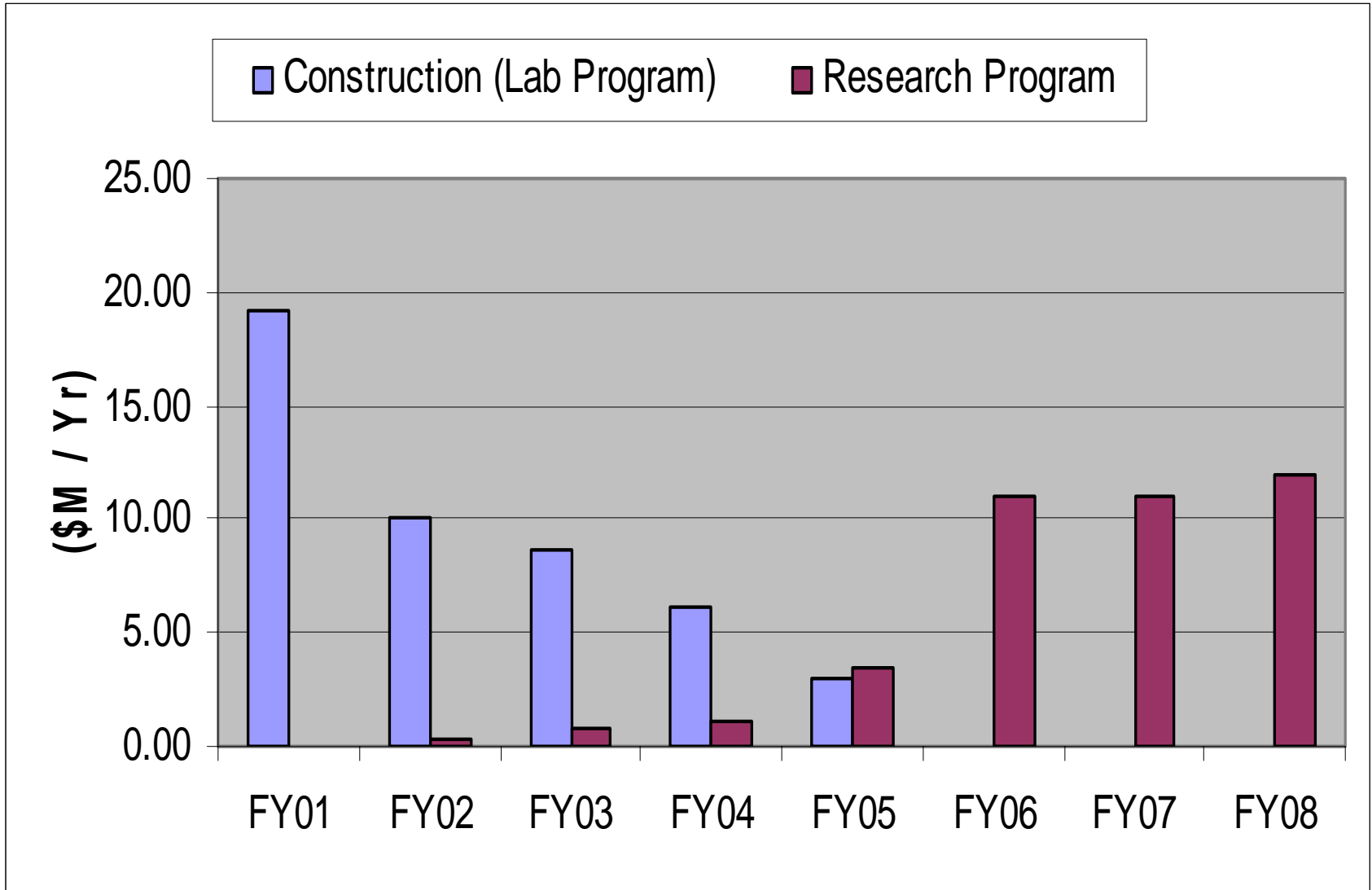
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## LARP reviewed on June 1-2, 2005 at Fermilab

- Committee **pleased with LARP progress**, and **convinced of the importance** of the tasks at hand. Seeing whether a **quadrupole of high field strength, large aperture and large length** (> 4m) can be built from **Nb<sub>3</sub>Sn** superconductor will be of **great value** to accelerator community (independent of ultimate success!).
- **Other components** of the LARP program (collimators, luminosity monitors, tune feedback...) **form major contributions** to the LHC program, and are **worthy of full support**.
- Building the prescribed **quadrupole magnet** as a proof of principle is **not an easy** matter, and requires use of all available U.S. magnet expertise.
- Committee had some concerns about technical goals of LARP, and requested a **detailed technical review of LARP R&D** (and contributions from the Core Program) in the first quarter of FY'06



# DOE Funding Profile for Accelerator





# A Word About Heavy Ions at LHC (LHC Heavy Ion Collider – **LHIC**)



- Three fantastic (bargain) opportunities for U.S. involvement in physics:  
(i) **ALICE Experiment on Heavy Ions**, (ii) **ATLAS Experiment**, and (iii) **CMS Experiment**. All three **want U.S. participation**. ALICE is keen to introduce **jet-trigger capability** (recent need resulting from discoveries at RHIC), and will go ahead with such goals with or without U.S., but faster with U.S. help. Both ATLAS and CMS want U.S. NP physicists to lead these efforts. They already have the important jet triggers, but need some calorimetry at zero degrees.
- **NSAC 2002**: “Wise to make **modest investment**”, especially for complementary issues in heavy-ion physics that cannot be addressed through program in the U.S.
- **NSAC/Barnes et al 2004**: “Participation at **LHC should become new component of U.S. HI program**,...comparable in investment priority with upgrades of each of the two large RHIC detectors”. This assumed **budgets at constant level of effort!**
- With current funding uncertainties, FY '06 and '07 budgets will determine the direction of involvement. Three separate **groups are eager to join ALICE, ATLAS and CMS**, with some implications for RHIC and rest of NP community.



# Current Status of US LHC Research Program



## ● PRESENT STATUS OF EXPERIMENTS

- The **U.S. LHC** fabrication project and research programs are **well managed**, making good progress, with **excellent international cooperation**
- Current **ramp-up** of support for Research Program is **crucial** for readiness for **first beam in 2007**, and for developing detectors and IR magnets for **upgrade**

## ● CHALLENGES

- Although budgets are tight, priorities in direction reviewed and supported by committees of experts. **We are keeping up well with other countries** (in LARP as well as in preparation for physics analysis).
- U.S. collaborations at LHC **cannot succeed without** the expected **migration from** ongoing commitments in the **U.S.-based research** program. This is starting (with cooperation from managers of Core and LHC programs).
- **Communication** (and some language problems ) between U.S. and CERN, but overall have good cooperation at all levels
- Funding for **support of U.S. personnel abroad** is a concern for all (including LARP). Resources for funding of LHC **hardware commissioning** still unclear.





# Some Afterthoughts

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- Assuming no major surprises, **finishing accelerator by July 2007** will be a magnificent **accomplishment** (some naysayers may think this unlikely, but nobody is betting against success!)
- Some **detector** components may not be completed, but detectors **will be functional** and capable of taking data by mid 2007. The CMS forward crystals will not be ready until 2007, and pixels will be installed in 2008 (delayed to protect from initial beam). ATLAS also has some trepidations about readiness, but, again, assuming no disasters, both **experiments expect to be in good shape for the first data run in spring 2008.**
- Initial luminosity may not be much higher than at Tevatron, but cross sections of interest will be far larger, and results expected to be very exciting. **Anything that can be measured will be interesting and publishable!**



"It ain't over 'til  
its over!"

Yogi Berra