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# HEP LHC Operations Program and Upgrades

**HEPAP Meeting  
June 4, 2010**

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# HEP LHC Operations Program



- The LHC Detector Operations Program is a joint effort of DOE and NSF to:
  - Manage the common fund contributions for US physicists working on CMS and ATLAS.
  - Maintain detector systems and subsystems that are US responsibility.
    - Carry out directed R&D needed to maintain and eventually upgrade the detectors.
    - Provide computing and data storage needed for physics analysis.
- With the goal of enabling US physicists to fully and successfully participate in LHC physics.
- The program overseen by the LHC Joint Oversight Group.
- The Ops program does not support physics research.
  - Research is supported through peer reviewed funding.



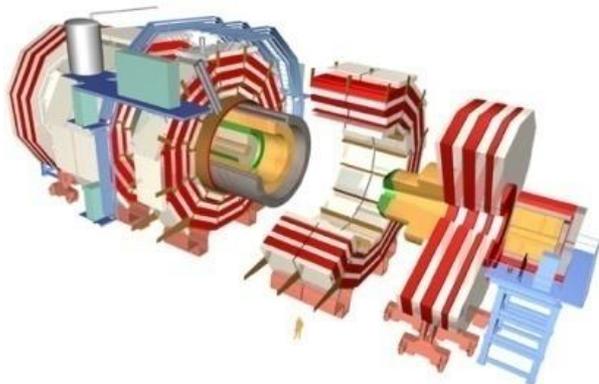
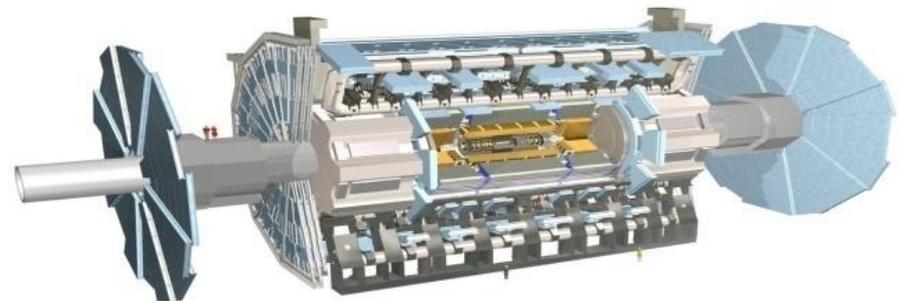
# LHC Detectors



- The U.S. contributed to the construction of ATLAS and CMS over a fifteen year period
  - The U.S. ATLAS and U.S. CMS construction projects were formally closed out in June 2008, with a total of \$331M spent

ATLAS: 2734 scientists from 174 institutions in 37 countries

- U.S.: 581 scientists from 40 universities, 4 labs. 22% of collaboration.
- 40% long term residence at CERN
- ~172 graduate students



CMS: 1940 scientists in 181 institutions in 39 countries

- U.S. 677 scientists from 48 universities and 1 lab. 34.5% of collaboration
- 33% long term residence at CERN
- ~220 graduate students



# LHC Maintenance & Operations (M&O)



- The U.S. LHC construction projects built detector sub-systems or sub-system components which have been installed and commissioned in the respective detectors.
- Scope of U.S. LHC M&O: activities targeted toward performance of U.S. supplied detectors.
  - Detector Operations
  - Maintenance and Spares
  - Detector R&D for M&O
    - For example, CMS work on forward hadron calorimeter phototubes and the outer hadron calorimeter hybrid photodiodes.
  - Generic R&D has been a component for an expected luminosity upgrade of the LHC



# U.S. CMS Responsibilities



US CMS's view of its responsibilities



## 1. U.S. Responsibilities

•The U.S. has major responsibility in many CMS Detector Systems originating from the Construction Project and extending to operations, alignment, calibration, reconstruction, maintenance and upgrades

- U.S. led subsystems

- Hadron Calorimeter
- Endcap Muons
- Forward pixels

For description of CMS detector see link "Overview of the CMS Detector" and "Web based CMS detector description" on agenda page.

- Systems with strong US participation

- Trigger
- Data Acquisition
- Silicon Strip Tracker
- Electromagnetic Calorimeter
- CMS so far uses a "you built it, you maintain it" philosophy
  - This may be changing as new groups not involved in original construction join

• In addition to detectors, the U.S. has major responsibilities in Software and Computing activities

- Tier-1
- 7 Tier-2s
- Fair share of development of computing and analysis framework and infrastructure

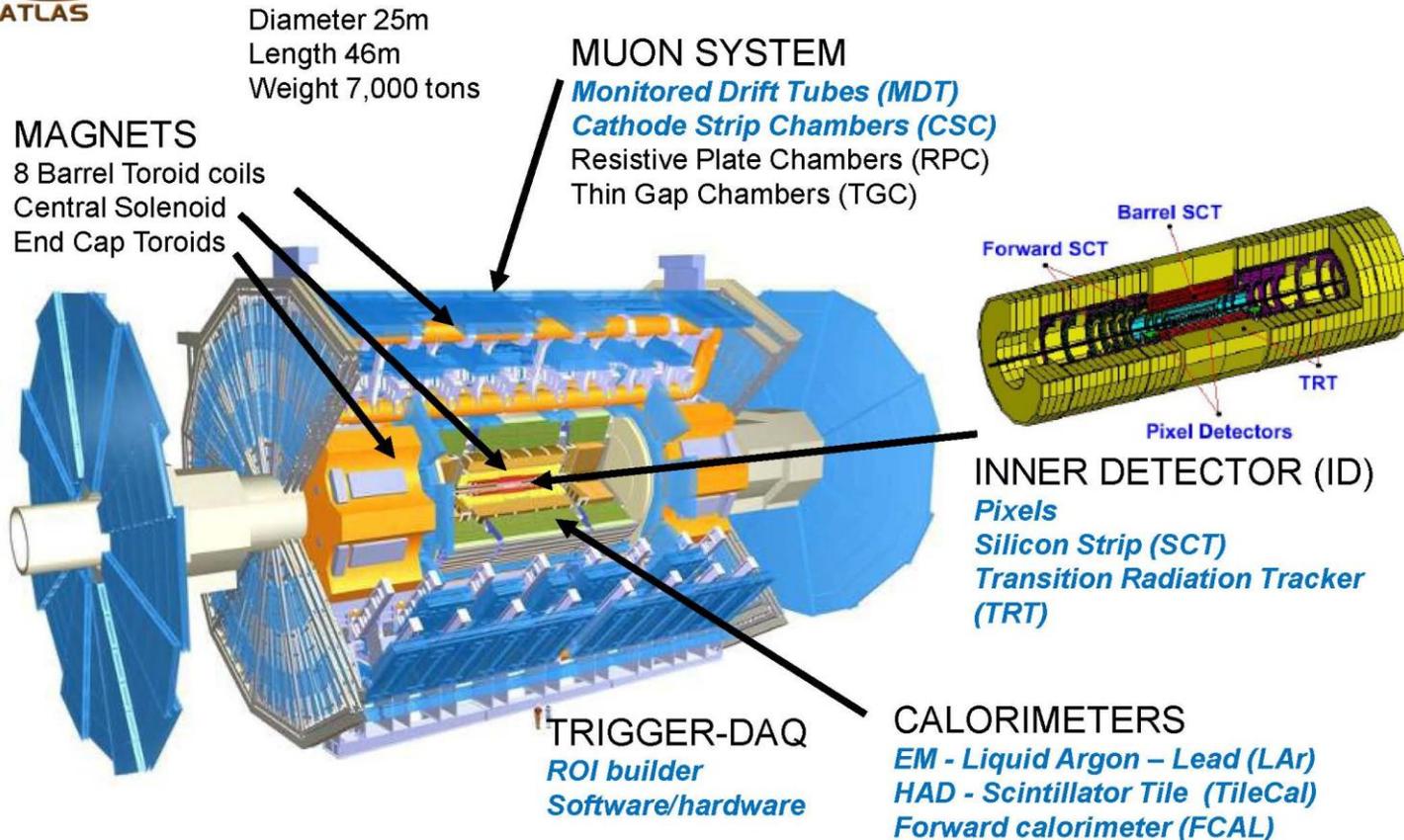
see "USCMS Computing" on agenda page.

Detector Schematic Backup slide #24



## ATLAS Layout & US M&O Participation

The similar slide from US ATLAS





# Common Contributions I



- Category A funds are used to cover the general operating costs of the experiments
  - The operation and maintenance of essential infrastructure components such as cooling systems,
  - Consumable items
  - Critical personnel
  - Critical computing systems required to support central services needed by the entire collaboration
  - Online data collection
- CERN runs a scrutiny group to scrub the costs.
- Cash payments in CHF are made yearly based on the number of Ph.D. authors.



# Common Contributions II



- Category B consists of costs borne to maintain specific detectors
  - The mechanisms for Category B differ between ATLAS and CMS
  - Category B expenses have an informal scrutiny process.
  - A mix of cash and in-kind contributions are used.
- Worldwide LHC Computing Grid pledges for computing
  - The experiments calculate computing resource needs on a yearly basis approximately eighteen months in advance.
  - The pledges are loosely based on the number of authors.
  - Contributions are in-kind.
- Agencies discuss and agree to these contributions at the Resource Review Board.



# Common Fund Example



## Meeting International Obligations – Common Costs

- Share is calculated each Oct 1; we want to complete payments before the Oct Resource Review Board (RRB) meeting
- Category A – ATLAS estimates are evaluated by Scrutiny group of RRB
  - General ATLAS operating costs, assessed by fraction of “PhD authors” (2009:  $409/1835 = 22.3\%$ )
- Category B – also scrutinized (although less formally)
  - Subsystem specific obligations, assessed roughly by PhD authors (actual formula a bit more complicated)
- Total obligation in out years is ~ \$5.5M/year, or roughly \$15k/PhD
  - Important to critically evaluate author list particularly for those supported by the OP; engaging Executive Committee in this task



# LHC Computing Pledge Example



## Meeting International Obligations – Computing Pledges

- 2010: New T1/T2 CPU (40.9/49.7 kHS06), Disk (5.1/5.3 TB) & Tape (4.1/0 TB) share will be met or exceeded
- ATLAS computing obligations are determined by ATLAS then scrutinized as part of the RRB process
- Substantial reduction in overall ATLAS computing resource needs in 2011-2012 – especially the cost-driving disk
  - US pledge currently based on 23% share

The cost per Ph.D. author to meet the computing pledges is ~\$30K for ATLAS. The contributions are in-kind.



# LHC Software



- Scope of U.S. LHC Software
  - Sub-system reconstruction – natural involvement deriving from US detector responsibilities
  - Core software – framework with interfaces to services, data, algorithms
  - Services – geometry, calibration, alignment
  - General reconstruction and analysis algorithms
  - Interfaces to grid-enabling software
- In addition to the Operations Program
  - Open Science Grid- support for common Grid middleware and grid operations (NSF and DOE supported)
  - USLHCNET-provides dedicated transatlantic networking for LHC data between the T0 at CERN and the T1s.
  - DISUN-NSF initiative for campus computing aligned with CMS T2 Computing



# Some Successes of the Ops Program



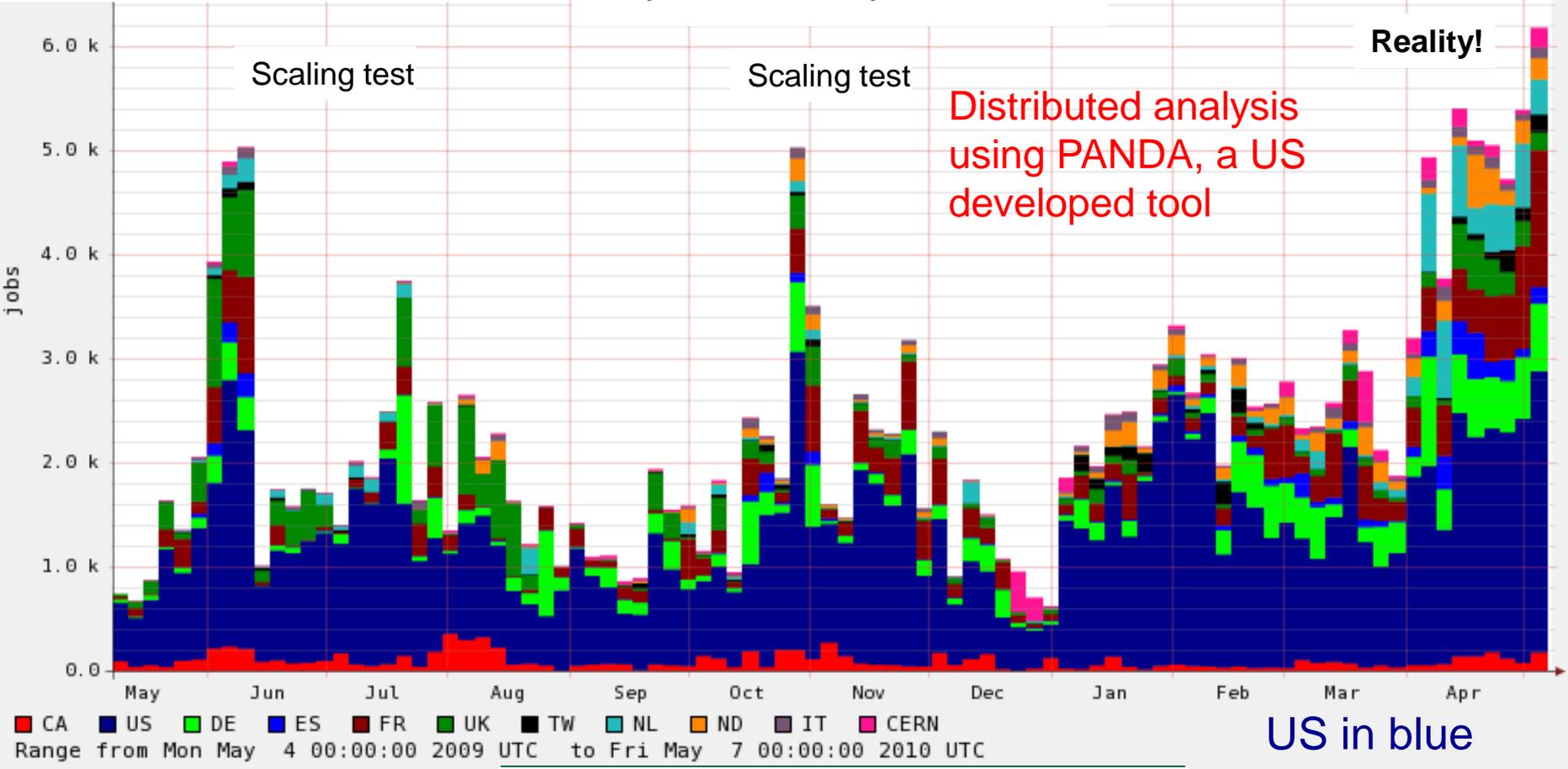
User counts	1mo	3mo	6mo
Feb-09	90	352	473
Mar-10	580	780	965

World Wide - analy\_running - year

May 2009 – May 2010



PROTOCOL / TOBI OETIKER

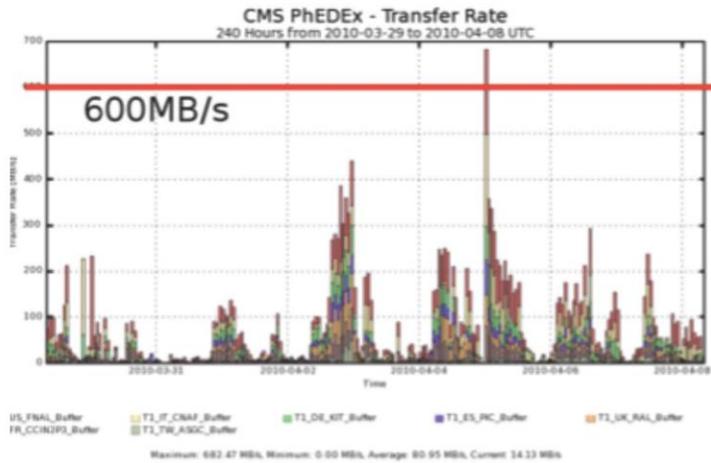
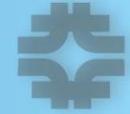




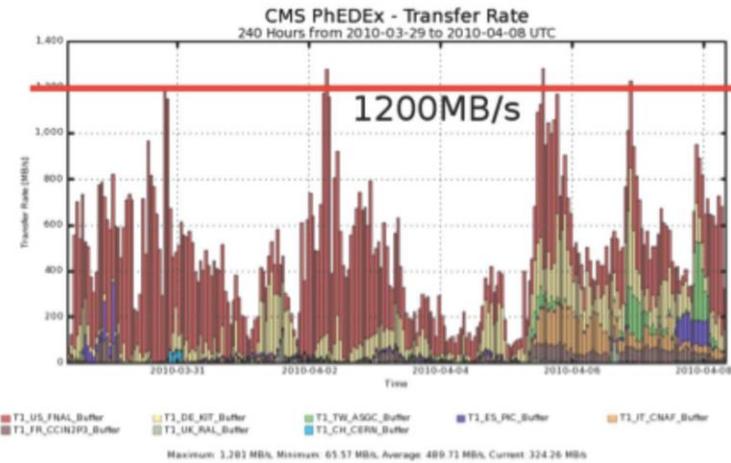
# Example of Network Performance



## Operations Performance: Data Transfers



(a) T0→T1



(b) T1→T2

- ◆ Transfers performed well and kept up with the data taking
- ◆ Overall data rate is still not that high on average, but peaks already hitting nominal rates



# Analysis Support



- Enable physics analysis by U.S. physicists on ATLAS and CMS
  - A mix of ops and physics research support.
  - Computing hardware for Analysis at Tier 2s,
  - Assistance for groups running local Tier 3 hardware
  - Providing direct technical support for analysis
- Effectiveness is tracked by metrics
- The LHC Physics Center at FNAL and the ATLAS analysis support centers are primarily research program activity staffed by physicists for physicists.



# U.S. ATLAS Support



## US ATLAS Analysis Support

Initial Organization, purpose (& acronyms)

Physics  
Research  
Funding

**Analysis Support Centers (ASCs)**

ANL, BNL, LBNL

Loci of support activity:  
Home to many ASG experts  
Site of tutorials/jamborees  
Regional gathering locations

May 11, 2010

Currently 3 components

**Analysis Support Group (ASGs)**

Software & performance experts based in US timezone

Most support provided by hypernews (little use of phone)

Many experts available during Jamborees & tutorials

US ATLAS DOE/NSF Review

Physics  
Research  
Funding

**Analysis Forums (AFs)**

Informal venue for physics/performance discussions

Regular meetings  
focus on nuts & bolts (often not possible in CERN-based meetings)

Complementary (not parallel) to CERN meetings

14

OPS funding



# Metrics: Speaker statistics



This data comes from ATLAS.

## Statistics on Speakers

1) # of internal talks (Working groups + collaboration meetings) in six month periods for the past two years for US and non-US.

See backup slides for earlier time periods

Talks (Oct09 – Mar10)

<u>meeting type</u>	<u># meetings</u>	<u># talks</u>	<u># US talks</u>	<u>fraction</u>
physics	286	963	248	0.26
performance	73	390	117	0.30
det/commiss	1744	4122	1106	0.27
software	330	1231	364	0.30
overview	15	188	36	0.19
governance	30	198	21	0.11
heavy ion	27	69	39	0.57
upgrade	93	140	18	0.13
US regional	101	378	223	0.59
nonUS regional	131	347	21	0.06
Total	2830	8026	2193	0.27

- above should be considered a lower bound (not all speakers without affiliation included)  
(some meetings list only a first name)

We are looking for evidence that US physicists are doing analyses.

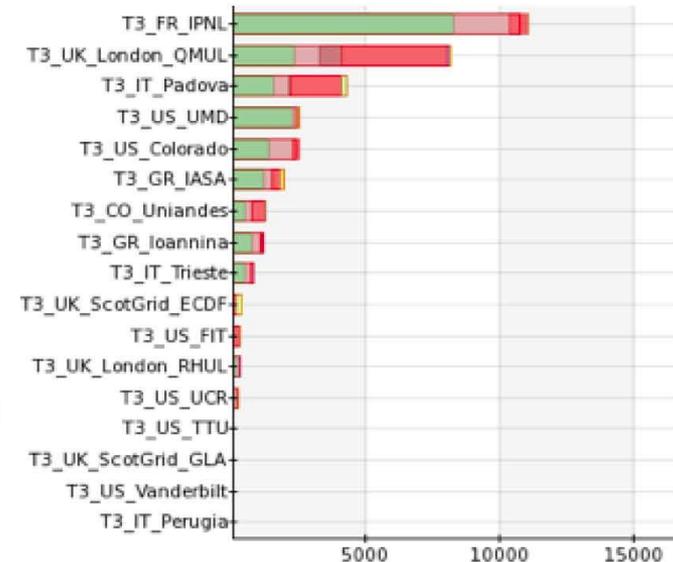


# Tier 3 Support



## US CMS Tier-3s have taken off

- Many US Universities have received (some) funding for Tier-3 centers
- S&C provides Tier-3 support through Nebraska and Colorado
  - with help from Fermilab
- Current CMS has **45** Tier-3 centers registered in PhEDEx
  - 15 US T3s have successfully received data during the last quarter
    - from all T1 sites around the world!



- ❑ I plan to ask S&C manager to help Universities with their Tier-3s
  - ❑ started discussing with Tier-3 support people how to address these issues
  - ❑ This will be the best way to ensure that Tier2's don't become overloaded



# A Laboratory-University Partnership



- Each experiment has a host laboratory responsible for managing the program.
  - Brookhaven is the host laboratory for US ATLAS.
  - Fermilab is the host laboratory for US CMS.
- The Tier 1 centers are at the host labs.
- The Tier 2 centers are at universities except for SLAC's.
- Try to match work to the expertise.
  - May find the right expertise at a lab or a university.
  - Universities funded by lab subcontracts
- Funding splits in FY 2010 after common costs
  - ATLAS
    - 4 Labs 21.4\$M, Universities 11\$M
  - CMS
    - Lab 19\$M, Universities 17\$M



# Spending Breakdown



Planned **spending** presented at LHC Ops review in May 2010  
on thousands of dollars

	CMS	ATLAS
Category A	4,384	6,203
M&O including Category B	11,113	12,322
Computing Facilities	12,815	14,762
Software Development	4,029	5,379
Analysis Support	826	366
Upgrade R&D	3,959	3,876
Outreach	150	50
Program Management	1,280	1,105
Total	38,556*	44,053*

\*includes carry-over



# Funding Guidance



- In 2010, each program received \$28M + \$9M DOE+NSF
- Additional LHC support grants
  - OSG ~\$6M/year (2010 final year)
    - DOE HEP, NP, & ASCR and NSF
  - DISUN \$1M/year (2010 final year)
    - NSF
  - USLHCNET \$2M/year (2011 final year)
    - DOE HEP
  - Looking for ways to continue this support.
- The level of funding for the LHC OPS program is likely to be constant
  - In the out-years assume 2.5% escalation for DOE component.
  - NSF cooperative agreements are up for renewal in 2011



# NSF SUPPORT FOR LHC OPERATIONS PROGRAM AND DETECTOR UPGRADES: A SUMMARY



**❑ Purpose:** *Support is for university groups operations activities in U.S. ATLAS and CMS Collaborations ( following detector construction for \$81M)*

[NSF also provides core program support for LHCb (Syracuse) and TOTEM initial phase (Penn State/Case Western)]

**❑ Ops support coordinated with that of DOE**

**❑ Operations Funding Profile (equally divided for ATLAS &CMS)**

FY	03	04	05	06	07	08	09	10	11
\$M	5.0	7.0	10.5	13.6	18.0	18.0	18.0	18.0	18.0

**Budgets for FY 12-16 depend on the development of new 5-year cooperative agreement proposals for approval by the National Science Board. The process is to begin shortly.**



# NSF support (cont'd) -- II



- ❑ **Ops funding** includes support for Tier- 2 computing facilities  
( 4 for ATLAS, 7 for CMS)
- ❑ **Funding from other NSF-wide sources** (ie , non-EPP core), examples :
  - Major Research Instrumentation (MRI):
    - FY09: \$500K for LHCb
    - FY 10: \$1.7M for US CMS, and \$620 K for US ATLAS
    - FY 11: 4 LHC proposals submitted requesting ~\$7.4M
  - Partnerships for International Research and Education (PIRE):
    - for US CMS, \$2.5 M over 5 years
- ❑ **Funding from other Physics Division sources and partnerships with other NSF Offices :**
  - Open Science Grid (OSG), with DOE, \$13.9 M over 5 years (NSF part)
  - DISUN initiative for campus computing for CMS (\$1M/yr for 5 years)
  - ATLAS/CMS graduate student awards at CERN (eg, \$365K in FY 10)
  - Education with research (eg Quarknet [with DOE], CHEPREO, I2U2,..)



# Program Oversight



- The Joint Oversight Group meets at least twice a year.
  - Hears about progress of the program
  - Discusses the international obligations before the RRB.
  - Agencies discuss their funding and plans.
  - An updated program management plan is being prepared.
    - Address the needs of the program during running.
- There is a yearly peer review of the Ops program charged by the JOG.
  - Most recent one was in May. The report is being prepared.
- There are biweekly working group phone calls between the agencies and the ops program managers.



# LHC Schedule



- A reconsideration of the LHC performance and schedule came out of the Chamonix meeting in February 2010.
- CERN Council will consider the new plan developed since then in June.
  - The 7 TeV LHC run began in March with a targeted delivery of  $1 \text{ fb}^{-1}$  by 2011 ( $100 \text{ pb}^{-1}$  in 2010).
  - A long shutdown in 2012 is required to fix the splices to enable safe operation at (near) design energy.
  - LHC run in 2013 and 2014 expected at 13-14 TeV with integrated luminosity between  $10\text{-}20 \text{ fb}^{-1}$ .
  - A shutdown around 2015 is needed to add collimators/tie in Linac4
    - CERN assessment: An extensive 'consolidation' program is required to run the accelerator complex for as long as needed—those resources compete with accelerator upgrades
  - The beam operating parameters continue to evolve.
- The CMS and ATLAS detectors were generally built to handle  $300 \text{ fb}^{-1}$  and  $1\text{-}3 \times 10^{34} \text{ cm}^{-2} \text{ sec}^{-1}$ .



# Accelerator Upgrade Plans



- CD-0 was approved for the Accelerator Project for the Upgrade of the LHC in October 2008.
- APUL presented a plan to construct new dipoles and cold powering for the upgrade of the ATLAS and CMS IRs.
  - A review for CD-1 was held in January 2010.
- After the Chamonix meeting the APUL deliverables did not fit the new plan.
  - Put APUL into hibernation while an alternative useful scope could be developed.
- FY 2010 appropriation saw one cut from the request.
  - \$7 M less for LHC. The APUL request was up \$6.5 M.

*“The Committee questions the increased investment in Large Hadron Collider [LHC] support when the timing of the restart of the LHC is in doubt.”*

*-- Senate Report of the Energy Water and Development Committee*



# LHC Detector Upgrade Plans



- At this time, the U.S. does not anticipate requesting upgrade funding in FY12.
  - Justifications are not currently compelling in light of the schedule and luminosity profile.
- Participation in the upgrades will be re-evaluated after data is collected and the CERN accelerator schedule is meeting milestones.
- DOE is planning a redirection of LHC Operations fund previously targeted for long term phase II LHC detector R&D to a generic detector R&D program.
  - R&D funds necessary for M&O support will remain in the budget.
  - Proposal driven process which will also include the ILC community.
  - Details are being planned to enable an orderly transition.



# NSF Upgrade Strategy



## ❑ Upgrade R&D Strategy:

- decision reaffirmed to keep the R&D funding support in the Ops program to stimulate a focused R&D effort by a closer coupling between actual operating experience and perceived upgrade goals ;
- possible other support from NSF-wide programs such as MRI.

- ## ❑ Upgrade Construction Strategy:
- totally changed because of the change and remaining uncertainty in the LHC run plan and upgrade schedule. Now focused only on the “initial” upgrades. ***Possible funding support no sooner than FY 2013.*** Meanwhile, possible earlier (but limited) support from other sources may be from the MRI program.