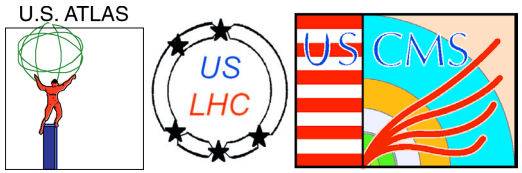


US LHC Consortium

US CMS Collaboration Meeting

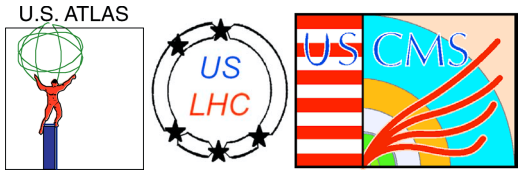
Wesley H. Smith, *U. Wisconsin*

April 25, 2003

This talk is available on:

http://hep.wisc.edu/wsmith/cms/USCMS_USLHC_0403.pdf

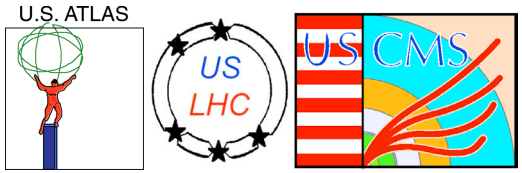
More info: http://www.hep.wisc.edu/USLHC/



U.S. LHC Consortium

Steering Committee Appointed by US CMS, US ATLAS, and US LHC Accelerator Groups:

Steve Gourlay
Dan Green
Homer Neal, Sr.
Harvey Newman
Steve Peggs
James Siegrist
Wesley Smith
James Strait
George Trilling
Bill Willis



U.S. LHC Consortium Activities

Talk by D. Green to P5 on Jan. 29

Visit to NSF, Feb. 21

- Talks on Universities & Physics (S. Eno), M&O (S. Seidel), Computing (L. Bauerdick) Outreach (K. Baker)

Presentation to HEPAP on Mar. 6

- Presented by H. Neal & collaboratively assembled

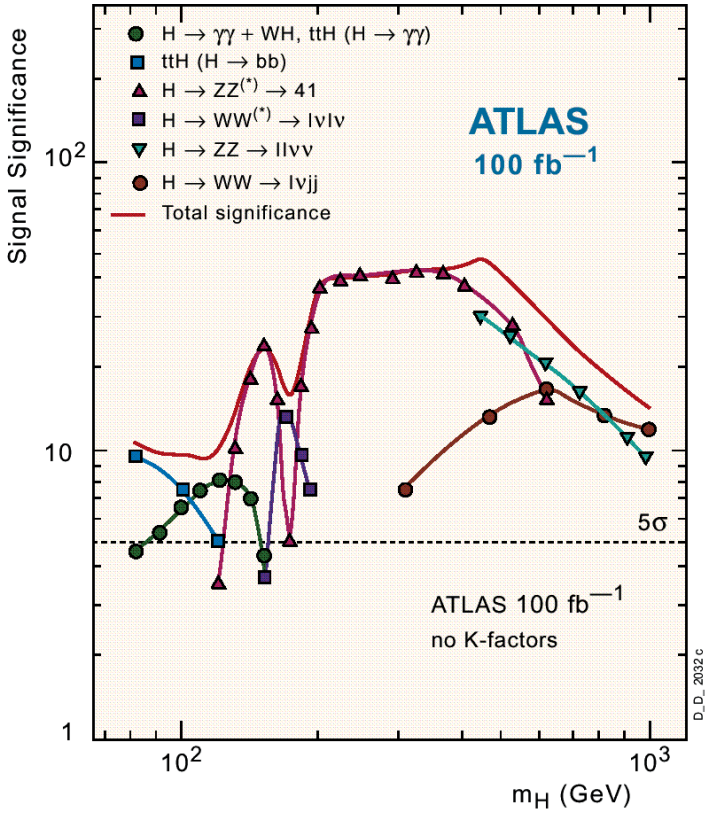
Visit to DOE, Apr. 17

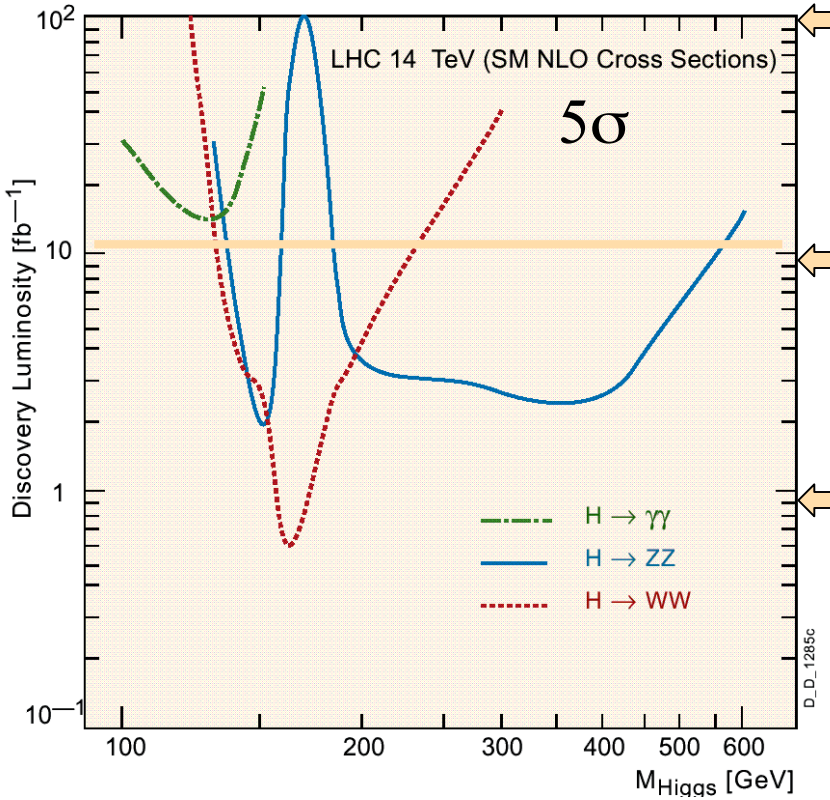
- Talks on Universities & Physics (S. Eno), M&O + Upgrades (S. Seidel), Computing (L. Bauerdick) LHC Machine (J. Strait)

All well received & group was encouraged to continue visits & presentations

- Flavor of message from consortium in next slides
- You are encouraged to also carry this message to funding agencies, etc.

U.S. Groups need to be ready to search for Higgs on Day 1





1 year, design lum

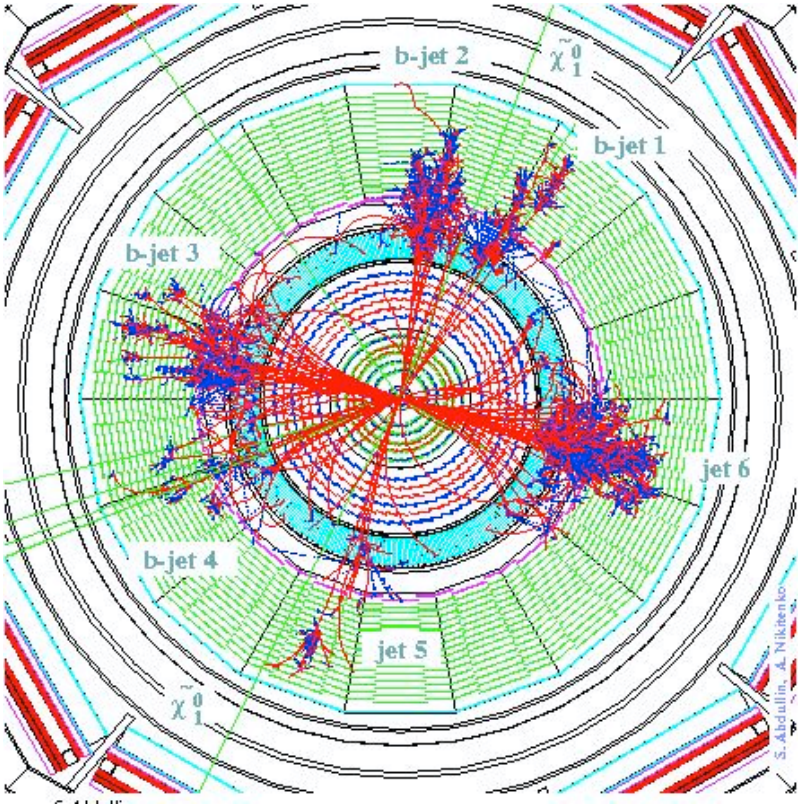
1 year, 1/10th design lum

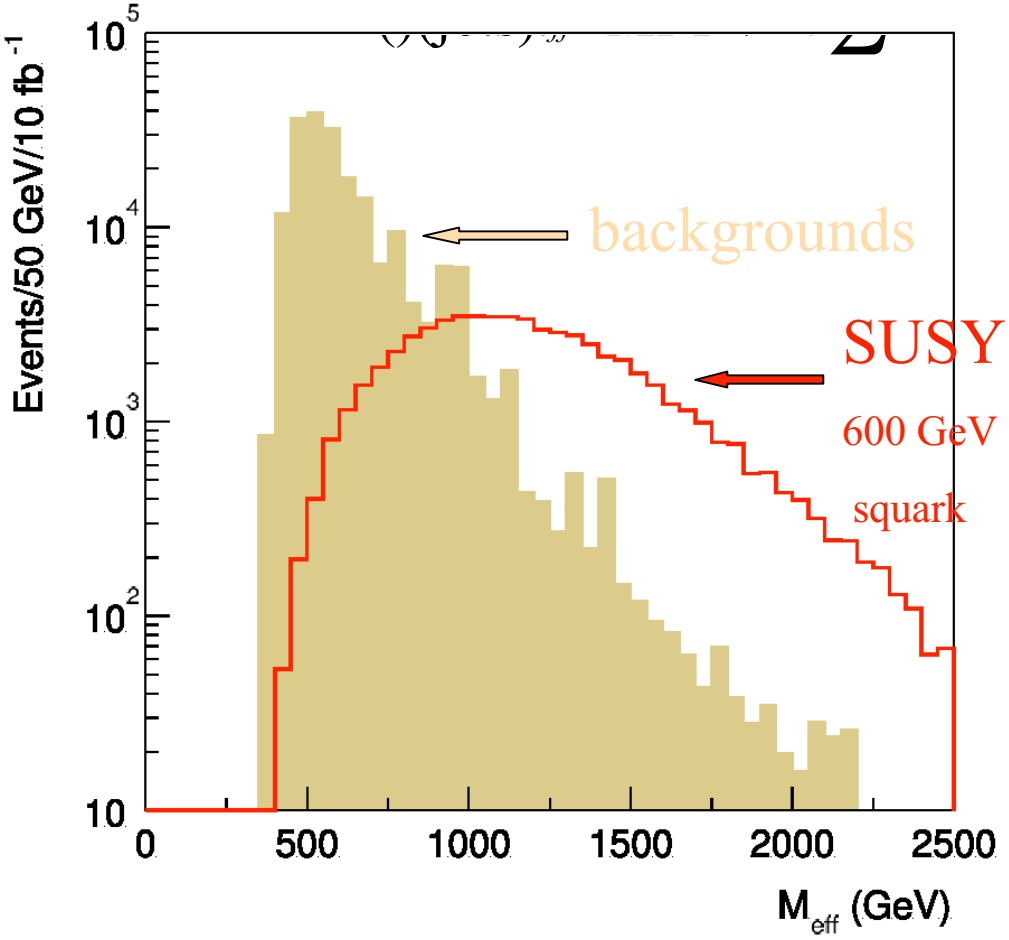
1 month, 1/10th design lum

If we can start up at 1/10th design luminosity, we'll discover a Higgs with mass greater than 130 GeV within 1 year. Will cover entire theoretically allowed range with 1 year of design luminosity.

Supersymmetry

We will discover supersymmetry if it is what stabilizes the Higgs mass.
Dramatic event signatures mean we will discover it quickly.





U.S. ATLAS

U.S. LHC Institutions

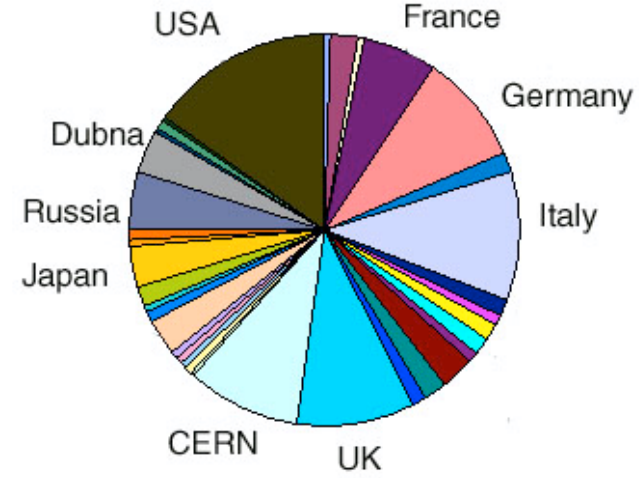
US CMS

Accelerator

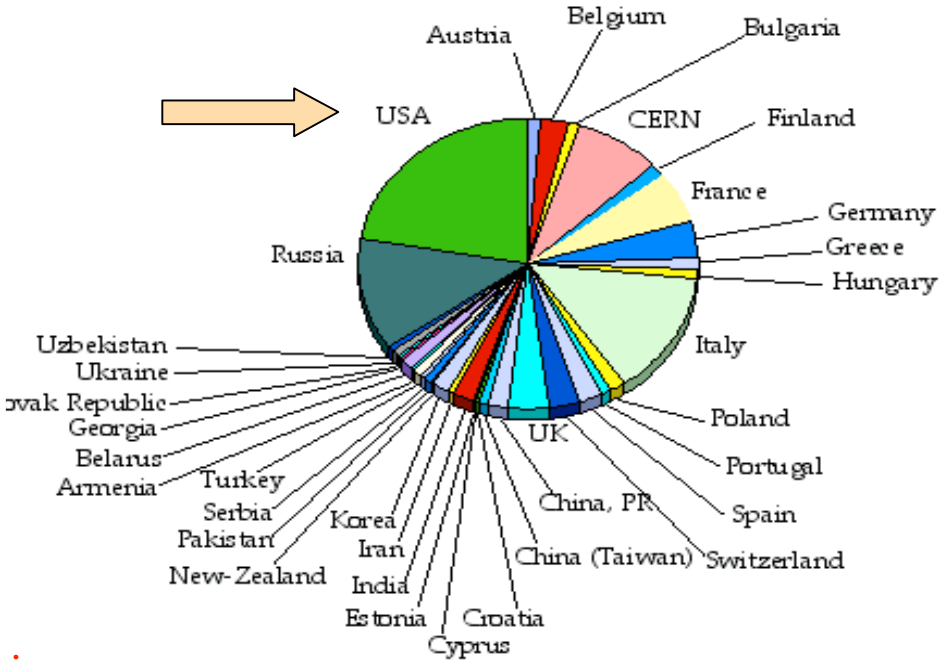
US ATLAS

LHC Collaborations

US ATLAS



CMS

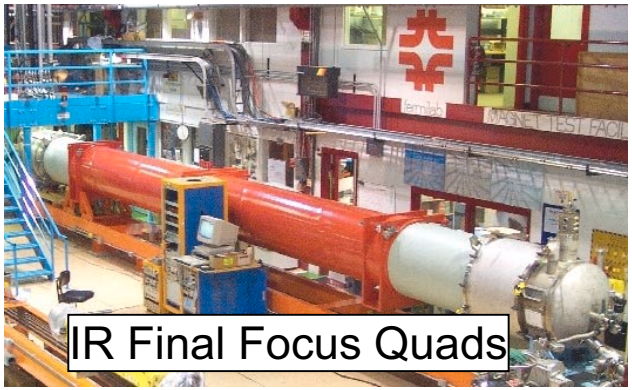


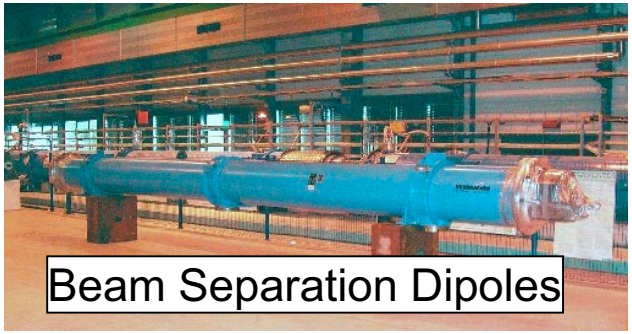
1849 Physicists and Engineers
34 Countries
147 Institutions

The US provides about 20% of the author list in both experiments

…and about 5% of the machine construction

US LHC Accelerator Groups





Fermilab

Technical Division
Beams Division

IR quads, accelerator physics, project management

Brookhaven

Superconducting Magnet Division
Collider-Accelerator Department

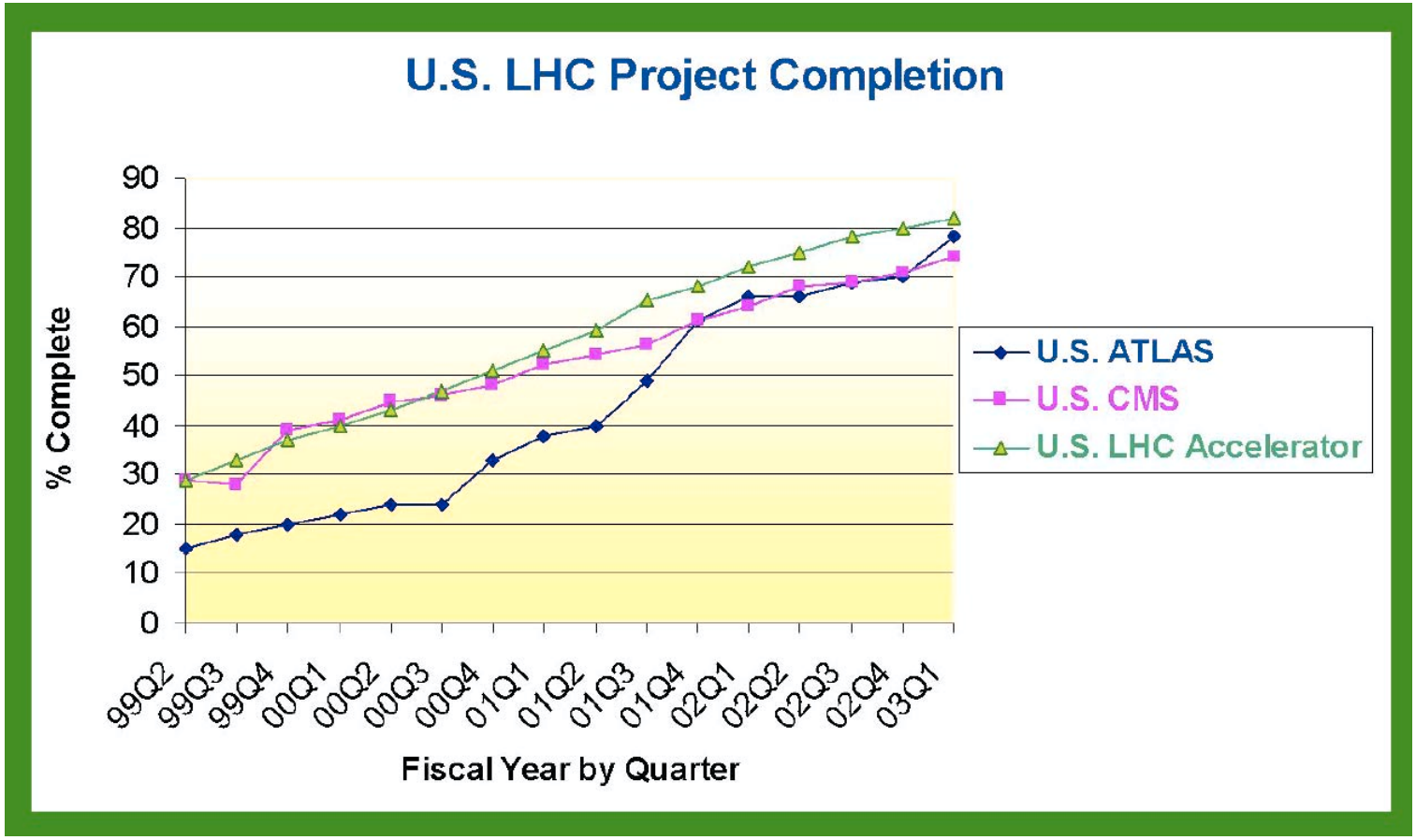
IR dipoles, SC cable testing, accelerator physics

Berkeley Lab

Accelerator and Fusion Research Division

IR feedboxes and absorbers, accelerator physics, SC cable production support

US LHC Construction Projects



The 531 M$ investment has been wisely used. The Projects are on schedule (for 2005 ~ completion) and on budget. The US LHC Projects are progressing steadily toward completion.

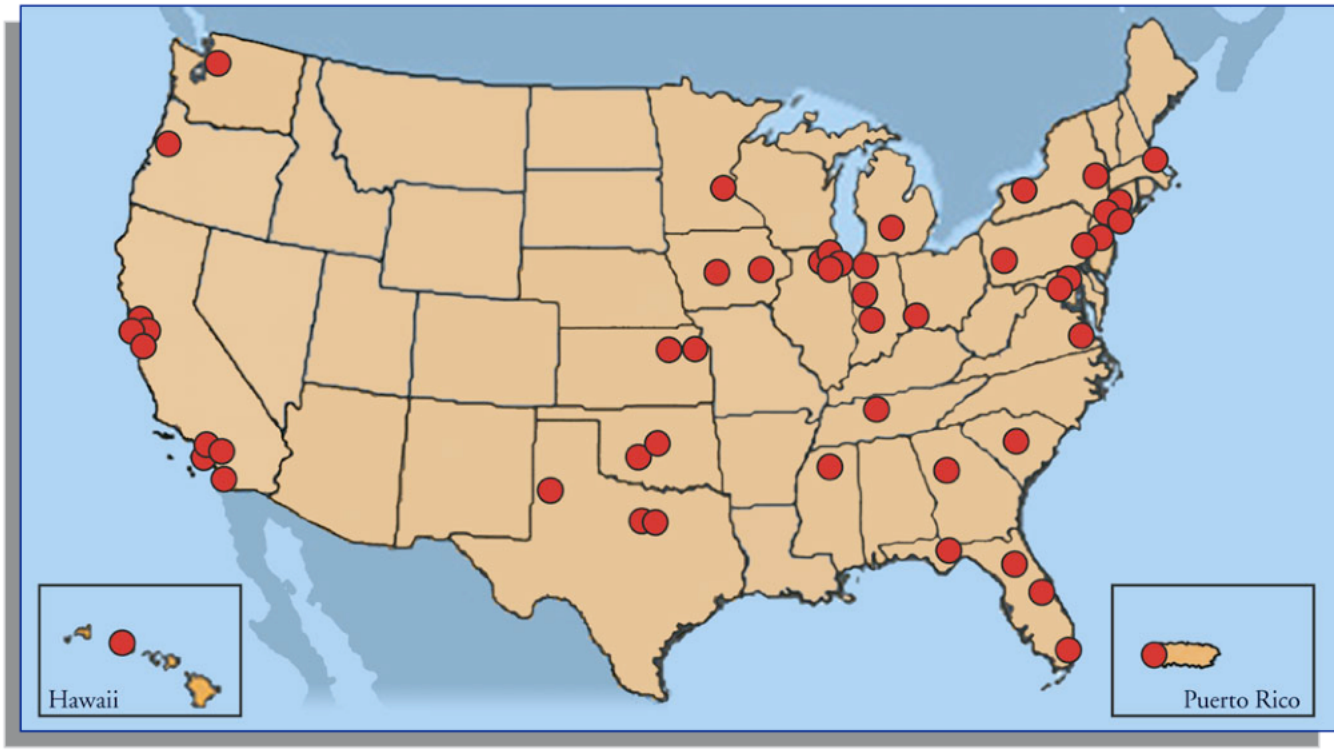
Education and Outreach

QuarkNet has 50 centers nationwide (60 planned).

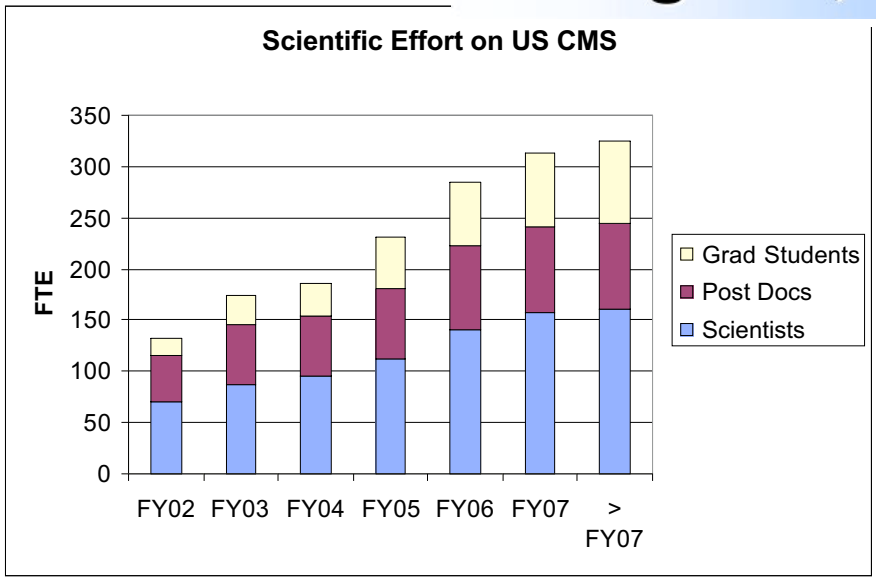
Each center has:
2-6 physicist mentors
2-12 teachers*

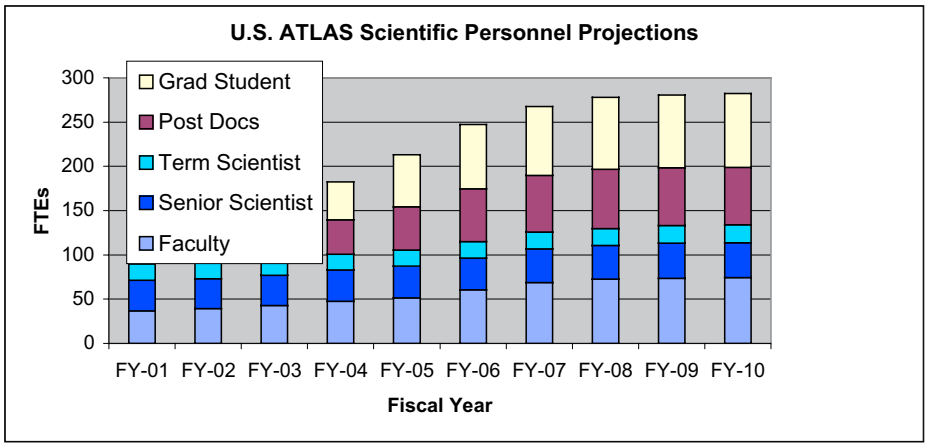
•Depending on year of the program and local variations.

•More in Randi Ruchti's talk tomorrow.



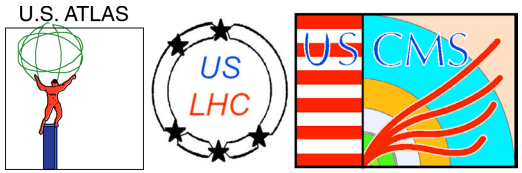
LHC a growing part of the U.S. HEP Program; More users on the way





Projections of Scientific Effort:

It is expected that the scientific effort will grow by a factor of two and will be a critical part of the overall U.S. experimental particle physics effort.

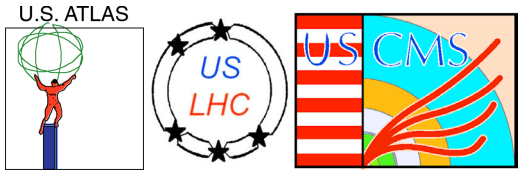


Computing Infrastructure

It won't be a matter of just turning on the beam and discovering a new particle. The high luminosity, large data samples, and theoretical uncertainties on the background will make understanding what we are seeing a tremendous challenge.

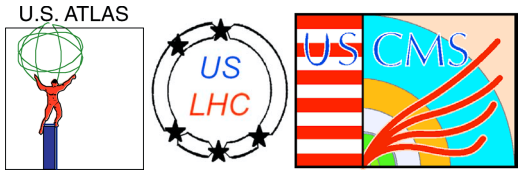
As part of meeting this challenge, we will achieve a cultural generation change at the leading edge of the transition to the Information Age:

- We will enable continual collaboration from home universities
- We will reach out to younger students and involve them in the process of search and discovery
- Make our field, and its advances in technology, as well as science, "closer" and more relevant to everyday university life



LHC Computing Challenge

- Tens of Petabytes/year of stored and processed data distributed worldwide in the early days of LHC running, rising to the Exabyte range in the following decade
- Processing power required will progress from the equivalent of hundreds of thousands to millions of today's PCs.
- Emergence of the first truly global systems for data-intensive processing and analysis



Needs of the US LHC Experimental Program

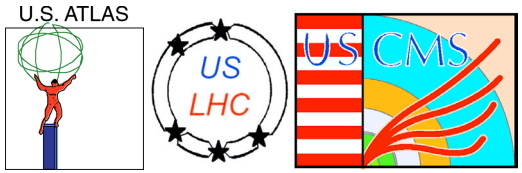
In order for the US to lead in LHC physics discoveries following the machine turn-on:

- Support of postdocs, students and travel
- Support of computing infrastructure

In order to operate & realize the full capability of the detector equipment built by the US:

- Support of maintenance and operations
- Support of technical personnel to maintain the detectors
- Support of US work on machine commissioning and studies

Needs to ramp up now to be ready for 2007



Accelerator Research with LHC

The LHC offers unique opportunities to work at the forefront of accelerator physics and technology.

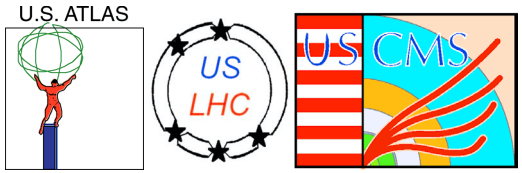
Beam Physics Research

- *LHC beam conditions will be the most extreme yet encountered.*
- *Forefront research at LHC can feed back to the US accelerator program.*

The LHC will be a hard machine to operate.

- *US work on machine commissioning will speed LHC turn on.*
- *US accelerator physicists' calculations and experiments to*
  - *understand performance limitations of current configuration*
  - *develop advanced instruments and controls*
  - *develop solutions to performance limitations*

will help maximize the delivered luminosity to ATLAS and CMS.



LHC Schedule & Upgrades

- ***Luminosity upgrade x10 – SLHC : $L = 10^{35}$ cm^{-2} s^{-1}***
  - ***--extends LHC mass reach by ~ 20-30%***
  - ***--modest changes to machine***
  - ***--detector upgrades needed***
  - ***--time scale ~ 2014***

- ***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 …)***
  - ***-- mostly uses detector upgrades for SLHC***
  - ***--time scale > 2020***

SLHC Detector R&D - I

Inner Tracker: rebuild

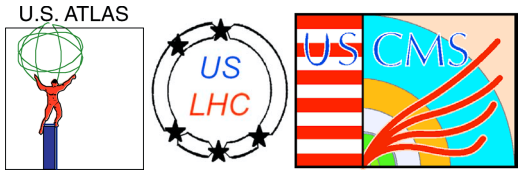
- **r < 20 cm: new approach, 20 < r < 60 cm: extend pixel technology, 60 cm < r: extend strip technology**
- **New approaches: defect-engineered Si, 3D detectors, new sensor materials, cryogenic Si, monolithic pixels**

Calorimetry: usable with caveats

- **ATLAS (Liquid Argon):** Front end board should be redesigned either by making components more radiation resistant, and/or use analog optical links to bring the signals out.
- **CMS (xtal ECAL, scint. HCAL): Endcap scint. Damage**
  - Investigate more radiation tolerant scintillator
- **Modify readout & trigger electronics for crossing ID**

Muon Systems: usable up to high η

- **Replace front end readout & trigger electronics**
- **Additional Shielding needed**



SLHC Detector R&D - II

Trigger: rebuild for 12.5 ns

- **Double operational frequency from 40 MHz to 80 MHz**
  - Processing & data transfer
- **Design for much higher rejection power for pileup to retain output rate of 100 kHz**
  - Exploit newer generation programmable devices

DAQ: evolve to higher performance

- **Increase in bandwidth due to increase in event size.**
  - Use new commercial network technologies
  - Issue: Control & management of 10K CPU farms.

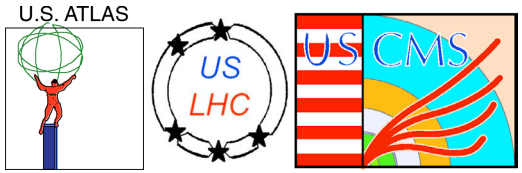
LHC Accelerator Upgrades

- ***SLHC Luminosity upgrade to 10^{35}:***
  - *-- increase bunch intensity to beam–beam limit → L ~ 2.5 x 10^{34}*
  - *-- halve bunch spacing to 12.5 ns (electron cloud limitation?)*
  - *-- Reduce β* by x2-3 (Nb_3Sn insertion magnets)*
  - *-- Increase crossing angle.*
  - *-- Reduce bunch length. (new RF)*
  - *-- Super Bunch option being investigated.*

moderate hardware changes time scale ≥ 2014

- ***EDLHC √s upgrade to 25 TeV :***
  - *-- ultimate LHC dipole field : B= 9 T → √s = 15 TeV*
    - *→ any energy upgrade requires new machine & Injector*
  - *-- present magnet technology up to B ~ 10.5 T*
    - *small prototype at LBL with B= 14.7 T*
  - *-- magnets with B~17 T may be reasonable target for operation in >2020 provided intense R& D on new superconductors (e.g. Nb_3Sn)*

major hardware changes time scale ≥ 2020



U.S. Role in Machine R&D

Nb_3Sn has never been used before in an accelerator.

- *Intensive R&D program required, starting soon.*
- *"Small-scale" application in luminosity upgrade is a stepping stone towards large scale use as main magnets of a future machine.*
- *Success of LHC program depends on continued vigorous base program R&D at all three labs.*

We will concentrate on the most challenging magnets for new IR.

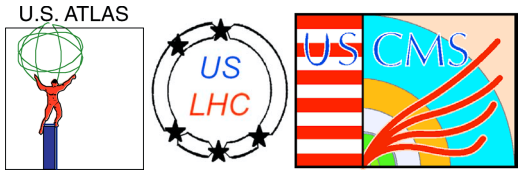
- *Could be either dipole or quadrupole.*
- *Greatest opportunity to advance our capabilities for the future.*
- *Best chance for earliest possible upgrade … we can start sooner than CERN.*

Collaboration with CERN and other non-U.S. labs.

- *We do not have the resources to develop all the required IR magnets.*
- *Expect Nb_3Sn R&D to start at CERN ~2006-2007.*

R&D relevant to a possible EDLHC is covered by the base R&D program.

- *Key questions of maximum field and cost minimization aren't LHC specific.*
- *High-field dipole programs at FNAL, LBNL, and BNL are addressing these now.*



Summary of US LHC Program Needs

In order for the US to lead in LHC physics discoveries following the machine turn-on:

- Support of postdocs, students and travel
- Support of computing infrastructure

In order to operate & realize the full capability of the detector equipment built by the US:

- Support of maintenance and operations
- Support of technical personnel to maintain the detectors
- Support of US work on machine commissioning and studies

In order to fully exploit the LHC and sustain U.S. leadership in HEP detectors and accelerators:

- Support of detector & accelerator upgrade R&D

Needs to ramp up now to be ready for 2007

LHC & Future of U.S. HEP

Large Investment Yields a Great Opportunity for Fundamental Discoveries

Steady Stream of Frontier Physics for 2 Decades, starts immediately at LHC turn-on

- Enormous energy leap

US must not just participate, must lead

- Highly competitive physics environment requires strongly supported postdocs and students with state-of-the-art tools

Physics Analysis Challenges will advance Computational & Networking Technology

- Bring the physics "home" to the U.S.
- Direct application to other areas of science

LHC Detector & Machine Upgrade R&D will drive US HEP & Accelerator Technology

- Preparations start soon

Demonstrates a Successful International Partnership

- Important precedent for other science projects

More info: http://www.hep.wisc.edu/USLHC/