DOE Viewpoint
Snowmass Computing Frontier

CSS2013 • Snowmass on the Mississippi
Minneapolis, Minnesota
July 29 – August 6, 2013

Lali Chatterjee and Larry Price
Office of High Energy Physics
Office of Science, U.S. Department of Energy

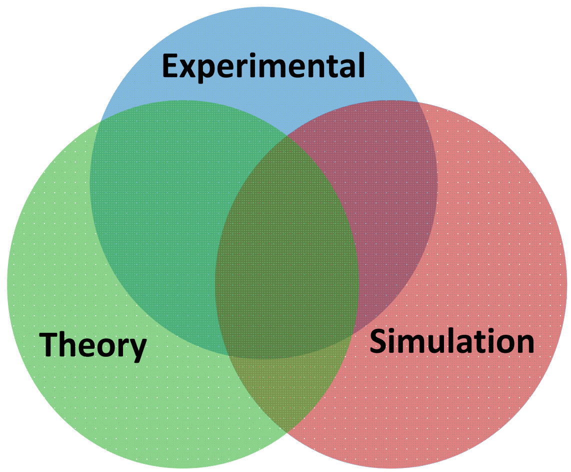
DOE Office of High Energy Physics (HEP)

HEP Mission is to understand

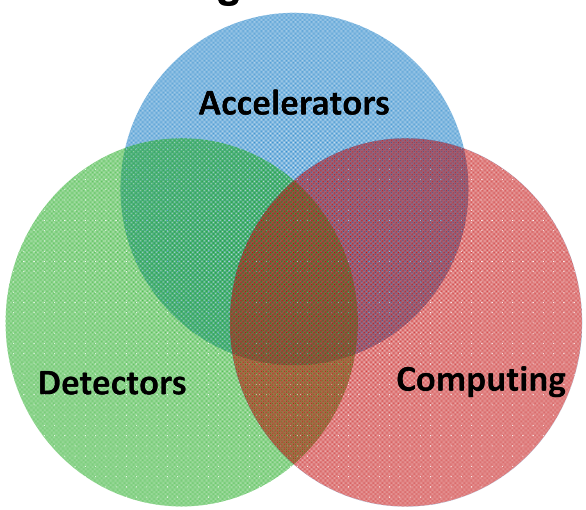
- **How the universe works at its most fundamental level,**
- **By discovering the elementary constituents of matter & energy,**
- **Probing the interactions between them, and**
- **exploring the basic nature of space and time.**

The DOE Office of High Energy Physics sponsors research in elementary particle physics – largely characterized by multi-institutional, multi–agency–funded, international collaborations and proceeding via three experimental frontiers along with Theory, Computing and Technology.

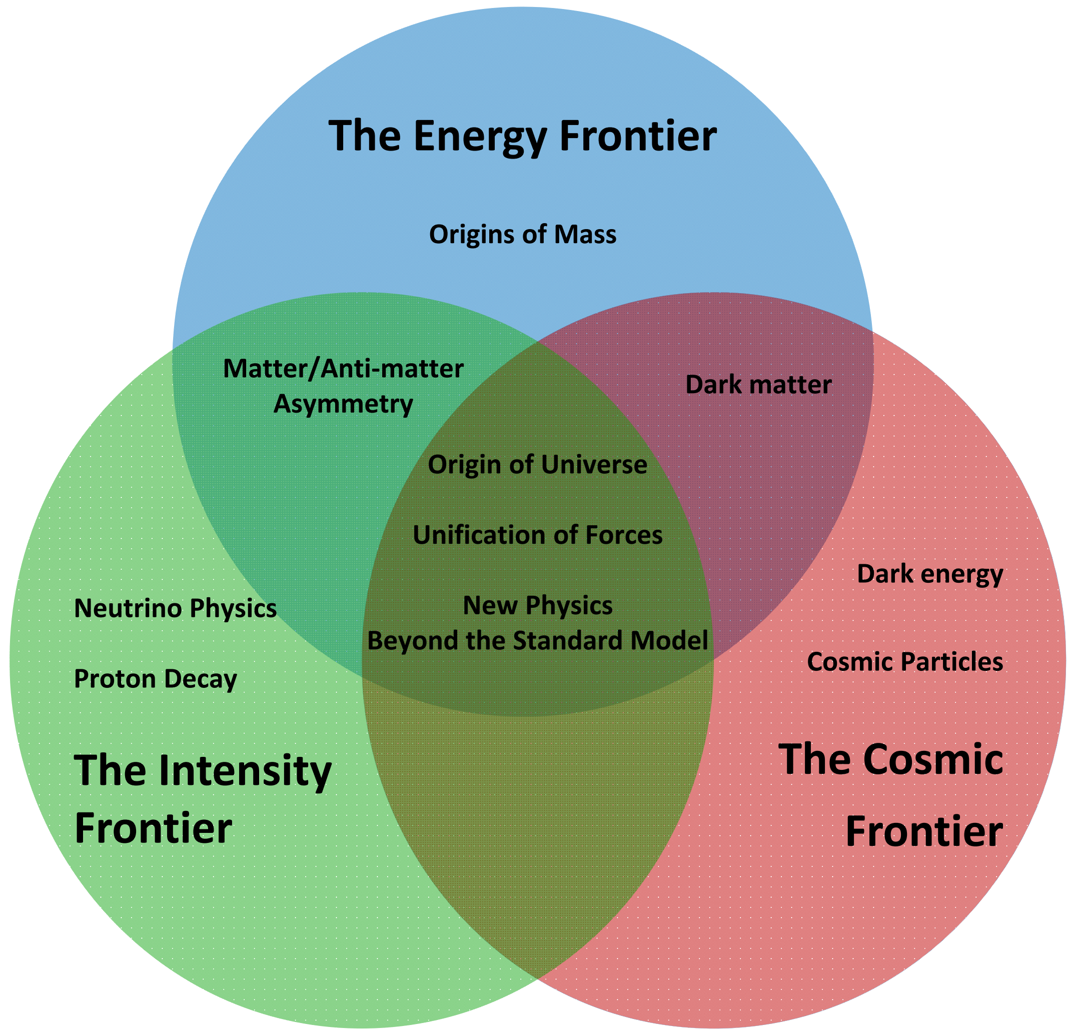
HEP Physics and Technology



Along Three Paths

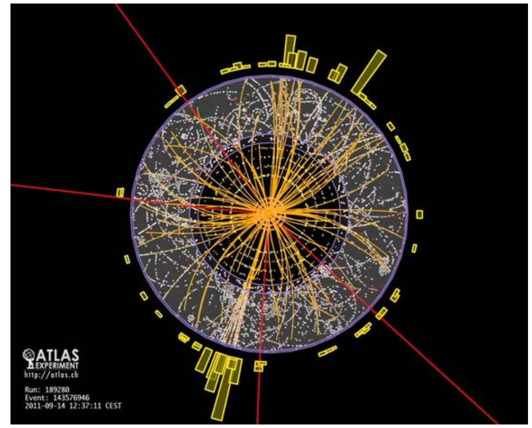


Enabled by
Advanced Technologies



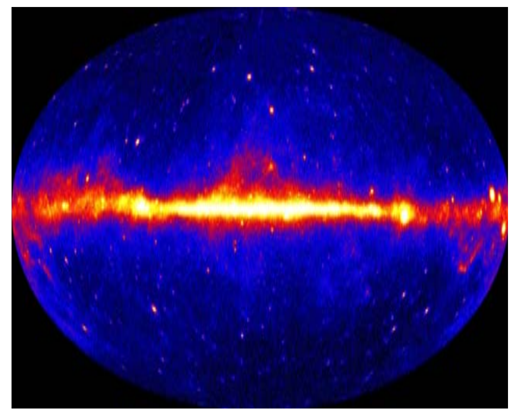
Physics Frontiers

From Deep Underground to the Tops of Mountains, HEP pushes the Frontiers of Research



RESEARCH AT THE ENERGY FRONTIER — HEP supports research where powerful accelerators such as the LHC are used to create new particles, reveal their interactions, and investigate fundamental forces, and where experiments such as ATLAS and CMS explore these phenomena.

RESEARCH AT INTENSITY FRONTIER — Reactor and beam-based neutrino physics experiments such as Daya Bay, NOvA and LBNE may ultimately answer some of the fundamental questions of our time: why does the Universe seem to be composed of matter and not anti-matter?



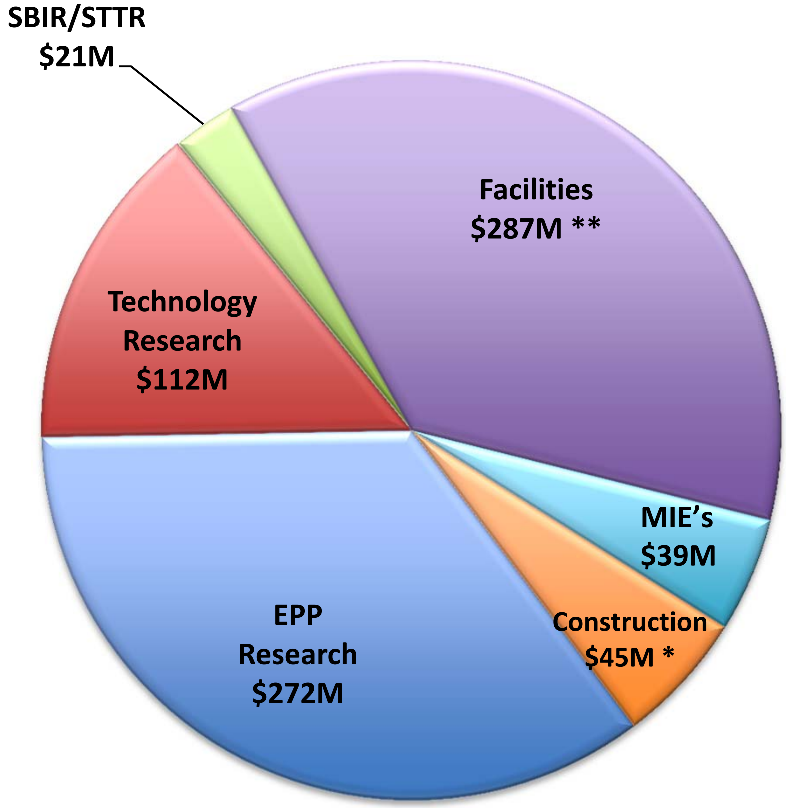
RESEARCH AT THE COSMIC FRONTIER — Through ground-based telescopes, space missions, and deep underground detectors, research at the cosmic frontier aims to explore dark energy and dark matter, which together comprise approximately 95% of the universe.

THEORY AND COMPUTATION — The interplay between theory, computation, and experiment is essential to the lifeblood of High Energy Physics. Computational sciences and resources enhance theory and enable data analysis, detector and accelerator development.

ACCELERATOR SCIENCE — Supports R&D at national labs and universities in beam physics, novel acceleration concepts, beam instrumentation and control, high gradient research, particle and RF sources, superconducting magnets and materials, and superconducting RF technology.

FY 2014 Request Crosscuts

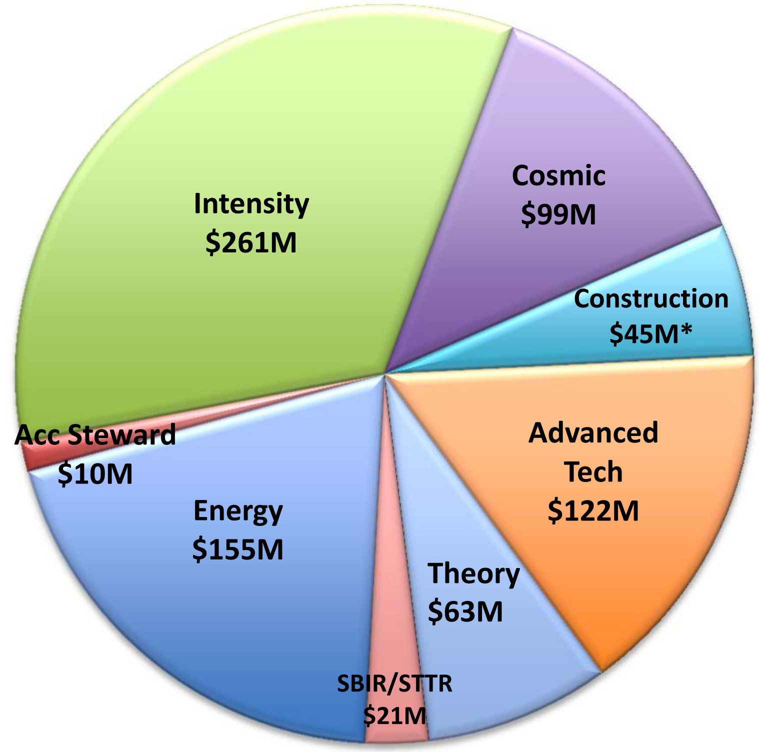
By Function



*Includes Other Project Costs (R&D) for LBNE

**Includes $15.9M Other Facility Support

By Frontier



*Includes Other Project Costs (R&D) for LBNE

DOE OHEP Organization

Office of High Energy Physics
James Siegrist (IPA)
Sherry Pepper-Roby

Eric Colby (IPA)

HEP Budget and Planning
- Donna Gilbert
- Dean Oyler
- John Boger
- Larry Price (Detailee)

HEP Operations
- Kathy Yarmas

Research & Technology Division
Glen Crawford
- Janice Hannan
- Christie Ashton
- Kristi Naehr
- Wanda Morris

Physics Research
- Energy Frontier: **Abid Patwa**, **David Boehnlein (IPA)**, **James Stone (IPA)**
- Intensity Frontier: **Alan Stone**, **Tim Bolton (IPA)**
- Cosmic Frontier: **Kathy Turner**, **Michael Salamon**
- Theoretical Physics: **Simona Rolli**

Research Technology
- General Accelerator R&D: **L.K. Len**, **John Boger**, **Eric Colby (IPA)**, **Ken Marken**, **Michael Zisman (Detailee)**
- Detector R&D: **Glen Crawford (Acting)**, **Peter Kim (Detailee)**
- Computational HEP: **Lali Chatterjee**, **Larry Price (Detailee)**
- SBIR/STTR: **Ken Marken**

Facilities Division
Mike Procario
Vera Bibbs

Facility Operations
- Fermilab Complex: **John Kogut**
- LHC Operations: **Simona Rolli**, **James Stone (IPA)**
- Other Operations (SLAC/Other Labs): **John Kogut**

Facilities Development
- LARP: **Bruce Strauss**
- SRF R&D: **Mike Procario (Acting)**
- Muon Accelerator (MAP): **Bruce Strauss**

Instrumentation & Major Systems
- NOvA – **Ted Lavine**
- MicroBooNE – **Ted Lavine**
- Mu2e – **Ted Lavine**
- LSST – **Helmut Marsiske**
- APUL – **Bruce Strauss**
- LBNE – **Mike Procario**
- Belle-II – **Helmut Marsiske**
- CMS Upgrade – **Simona Rolli**
- Atlas Upgrade – **Simona Rolli**
- MS-DESI – **Kathy Turner**
- Muon g-2 – **Ted Lavine**

FY 2014 High Energy Physics Budget

(Data in new structure, dollars in thousands)

Description	FY 2012 Actual	FY 2013 CR Actual	FY 2014 Request	Explanation of Change
Energy Frontier Exp. Physics	159,997	148,164	154,687	Ramp-down of Tevatron Research
Intensity Frontier Exp. Physics	283,675	287,220	271,043	Completion of NOνA (MIE), partially offset by Fermi Ops
Cosmic Frontier Exp. Physics	71,940	78,943	99,080	Ramp-up of LSST
Theoretical and Computational Physics	66,965	66,398	62,870	Continuing reductions in Research
Advanced Technology R&D	157,106	131,885	122,453	Completion of ILC R&D
Accelerator Stewardship	2,850	3,132	9,931	FY14 includes Stewardship-related Research
SBIR/STTR	0	0	21,457	
Construction (Line Item)	28,000	11,781	35,000	Mostly Mu2e; no LBNE ramp-up
Total, High Energy Physics:	**770,533**[a]	**727,523**[b,c]	**776,521**	**wrt FY12: Down -2% after SBIR correction** **wrt FY13: Up +3.6% after SBIR correction**
***Ref:* Office of Science (SC):**	**4,873,634**	**4,621,075**[c]	**5,152,752**	

SBIR = Small Business Innovation Research
STTR = Small Business Technology Transfer

[a] The FY 2012 Actual is reduced by $20,327,000 for SBIR/STTR.

[b] The FY 2013 CR Actual is reduced by $20,791,000 for SBIR/STTR.

[c] Reflects sequestration.

HEP Theory and Computation

Funding (in $K)	FY 2012 Actual	FY 2013 CR Actual	FY 2014 Request	Comment
Research	**64,465**	**63,198**	**59,670**	
HEP Theory	55,929	54,621	51,196	Follows programmatic reductions in Research
Computational HEP	8,536	8,577	8,474	
Projects	**2,500**	**3,200**	**3,200**	Lattice QCD hardware
TOTAL, Theory and Comp.	**66,965**	**66,398**	**62,870**	

Computing is an Integral part of HEP Science and is predominantly funded via the operations budgets for the major experiments and projects. The separate Computational HEP program funds computational science research via partnership initiatives, such as SciDAC, and a selection of community tools and pilot projects that cut across HEP programs. It optimizes a nominal budget by leveraging external and internal partnerships.

Computational HEP Program

HEP SciDAC focuses on partnership projects:

- **SciDAC 3 Projects –** (part of the Office of Science SciDAC Program)
  - In partnership with Office of Advanced Scientific & Computing Research (ASCR), DOE
- **Transforming GEANT 4 to multicore systems –**
  - A pilot project in partnership with ASCR Research Division
- **Open Science Grid (OSG)**
  - In partnership with National Science Foundation and Office of Nuclear Physics
- **Other Pilot Projects** with various partnerships including ASCR Facilities

Scientific Computing: Community Data Tools, codes, Frameworks, Distributed Computing, Networks, Software, data workflow and analytics portals... Includes pilot projects to help kick off specific activities like transitioning LHC software to HPC machines and data initiatives

SciDAC 3 Projects

Three SciDAC 3 Projects were funded in three topical areas in 2012 by HEP and ASCR via a joint Funding Opportunity Announcement

- **Lattice Gauge Theory Research area:**
  - Searching for Physics Beyond the Standard Model: Strongly Coupled Field Theories at the Intensity and Energy Frontiers
- **Cosmic Frontier Scientific Simulations area:**
  - Computation-driven Discovery for the Dark Universe
- **Accelerator Science Modeling & Simulation category:**
  - Community Project for Accelerator Science and Simulation (ComPASS-2)

All are multi-institutional projects in the SciDAC model. More details are available at http://www.scidac.gov/hep/hep.html

SciDAC 3 and other Simulation Examples

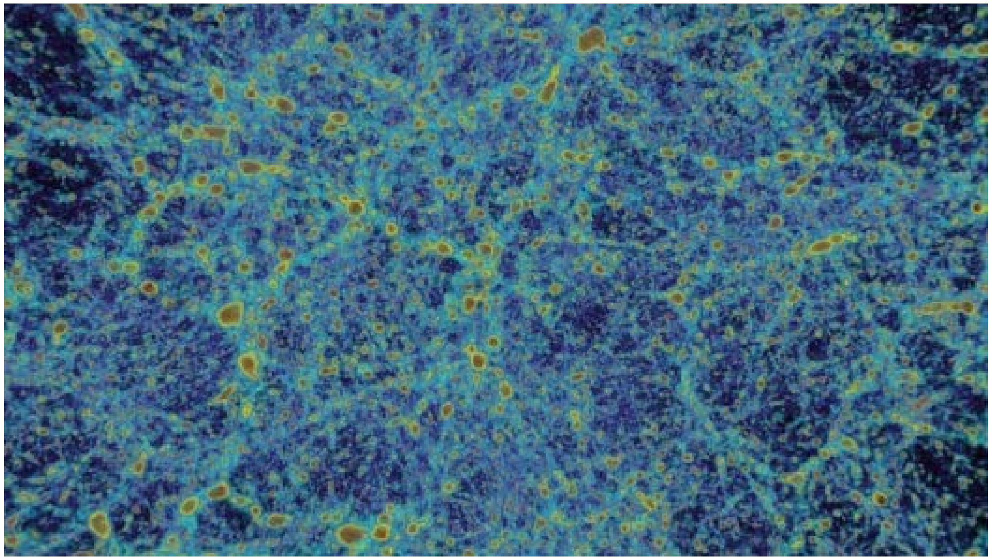
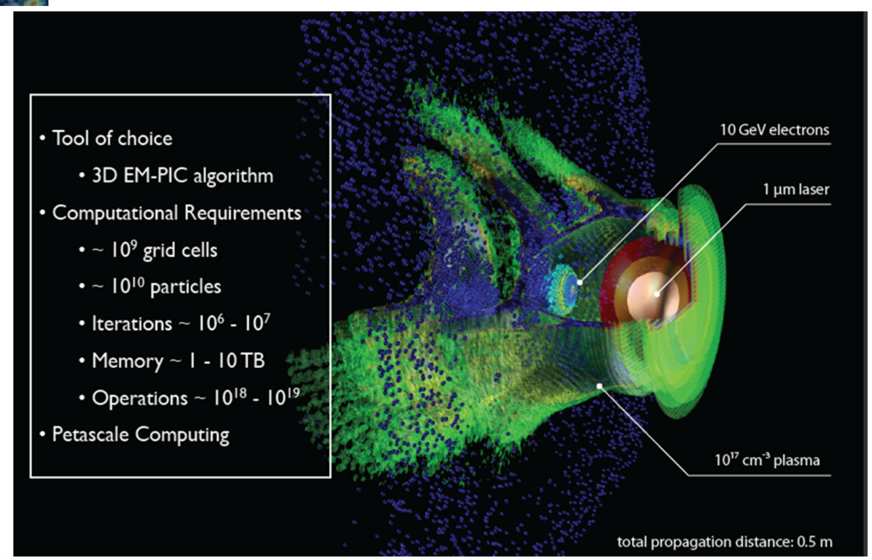


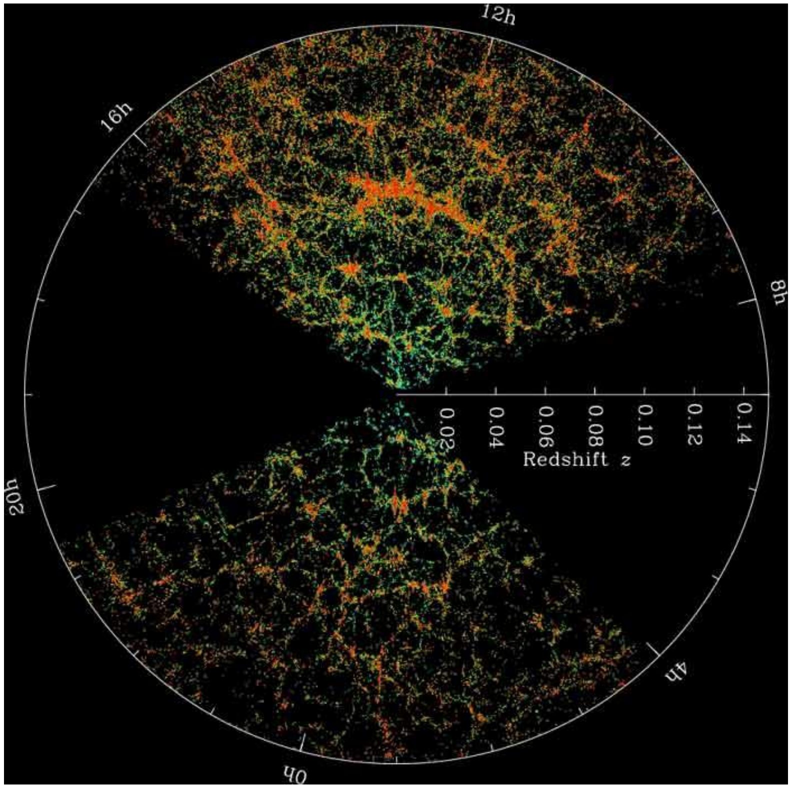
Image for Simulation of the universe taken from article in popular science e-zine: http://www.popsci.com/technology/article/2012-11/video-largest-most-hi-res-cosmological-simulations-known-universe These codes are also for SciDAC 3 project and a Data Workflow Portal (PDACS)

Modeling and Simulation for accelerator modeling – for energy and intensity frontiers via SciDAC 3 project and also stewardship.

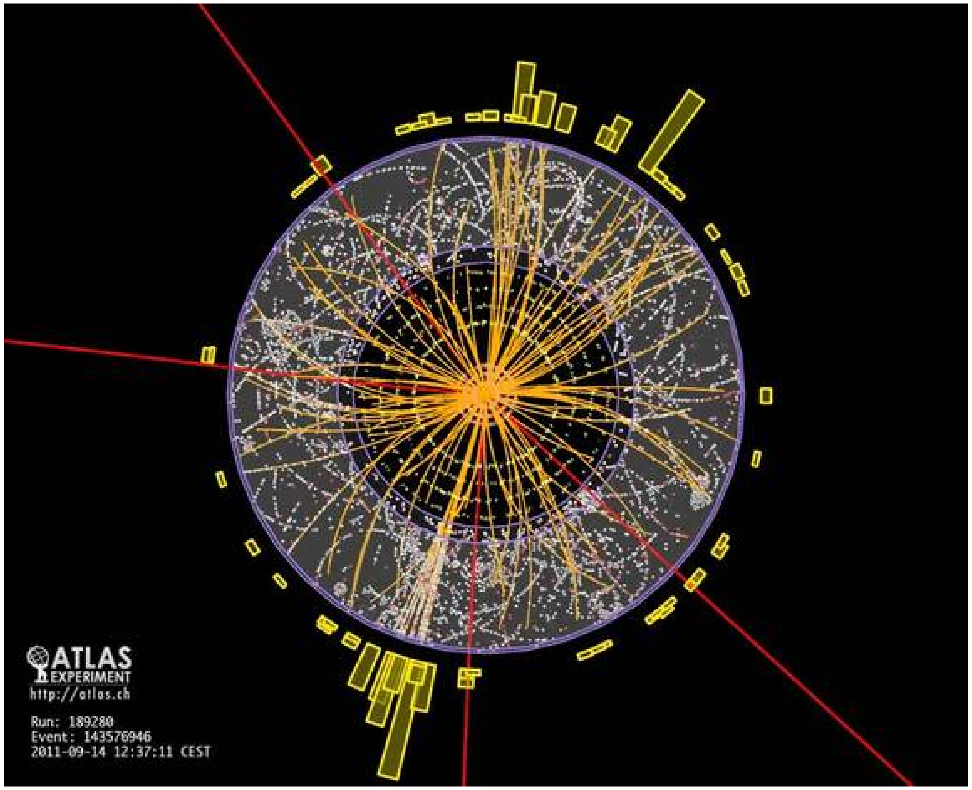


Computing – for HEP Science

Experimental and Observational HEP relies on Advanced Computing



Sloan Digital Sky Survey



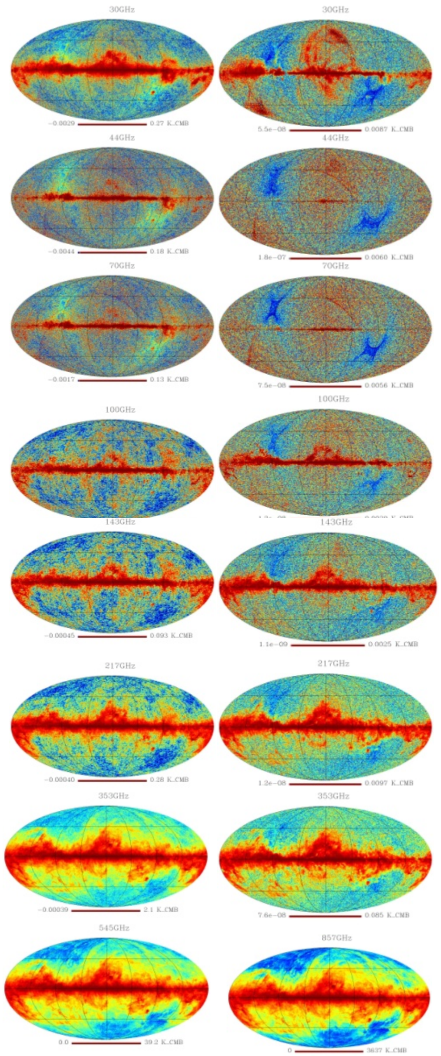
LHC Event

HEP Computing and Discovery

The 2011 Nobel Prize in Physics to
Saul Perlmutter, Adam Riess, Brian Schmidt,
" for the discovery of the accelerating expansion of the Universe through observations of distant supernovae"
used a robotic telescope equipped with a CCD detector instead of traditional camera and relied heavily on computing

The Cosmic Frontier, continues to provide massive computing and data challenges – both from simulations and experiments – likewise for the Energy Frontier - in particular after the projected LHC upgrades…

Simulations for Science



One simulated realization of the temperature and polarization of the sky as observed by Planck at each of its 9 observing frequencies (2 unpolarized).

- **The analysis of Cosmic Microwave Background data depends on computationally challenging simulations with up to 10,000 realizations of the entire experiment for Monte Carlo studies.**
- **Researchers generated the first comprehensive simulation of the ongoing ESA/NASA Planck mission, including 100 MC realizations.**
- **This ran on up to 100,000 cores of NERSC's *Hopper* supercomputer, taking 500,000 CPU-hrs and generating 35TB of data.**
- **This simulation is now being used to validate the ongoing analysis of the real Planck data in preparation for their release in January 2013.**

Julian Borrill – Computational Cosmology Center, Berkeley Lab (for the US Planck team)

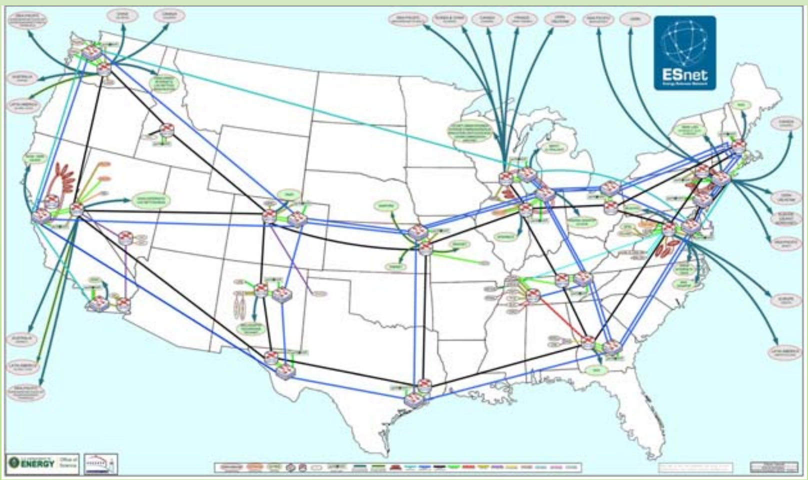
National High Performance Computing (HPC) Resources

DOE Office of Science (SC) Computing Facilities - managed by ASCR:

- **NERSC** (at LBNL), **ALCF** (at ANL), **OLCF** (at ORNL)
- Major allocations on ALCF and OLCF are awarded competitively with some Director's Reserves at each
- NERSC is specifically for use by SC Science Programs and HEP receives allocation for HEP users
  - HEP Allocation Manager- Dr. Lali Chatterjee, HEP
- Other DOE Supercomputers are at NNSA Labs
- HEP Researchers can also use NSF and NASA supercomputers
- ***Primary users for HPC:*** lattice gauge theory groups, cosmic frontier simulations & accelerator modeling
- ***New users:*** Energy Frontier theory and experiments, cosmic frontier experiments, accelerator stewardship

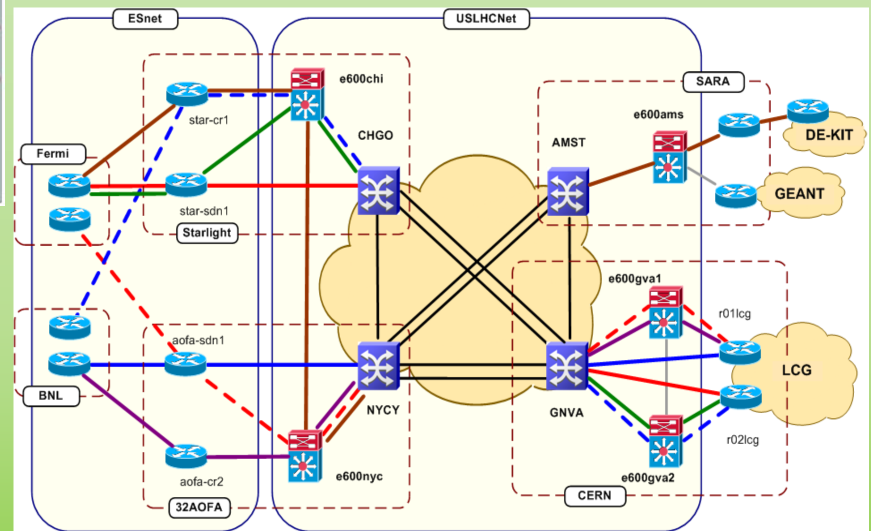
HEP Computing and Networking

- **Department of Energy Office of Science**
  - **Provides important national and international networks critical for HEP**



Esnet Science Data Network

US LHCNet



Thoughts and Questions from the DOE Perspective

- **Computing in the DOE program is organized and funded largely through large projects (ATLAS, CMS,…') and labs (FNAL, SLAC,….), with a modest "Computational" HEP program.**
  - Most of computing is not managed as a whole
  - Are "cross-cutting" solutions or efficiencies missed through this organization?
- **Would HEP benefit from a computing R&D program aimed at our specific needs? If so:**
  - What initial topics could be addressed?
  - Why would they not be addressed as well within individual projects?
- **Does HEP support and develop common tools (used across the field) appropriately?**
  - What are the common tools hat are most important to the field?
  - Are there tools that are needed but somehow not being developed?
- **Would some of these issues be addressed by establishing a Virtual Center for HEP Computing, consisting of distributed experts in different aspects of computing made available broadly to the HEP community?**

Thoughts and Questions (cont'd)

- **How long must data be preserved and what are the technical and intellectual challenges involved?**
- **How do we best make use of "new" technology (and what happens if we don't)?**
- Highly parallel supercomputers, Highly parallel processor chips (multicore), GPUs, Cloud computing
- **Is there a software strategy to handle any (likely) computing architecture of the next several years.**
  - Cannot rewrite software for each hardware change.

Lattice Gauge Theory teams have been at the forefront of evolving computing architectures for years and continue to work with industry and advanced prototypes

Community Input in 2 Ways This Year

- **1. This Snowmass process**
  - We are looking forward to the white papers and deliberations from Snowmass and hearing the community thoughts
  - The format of the Snowmass Computing Frontier as User Needs and Infrastructure Issues is apt as is its interfacing with the science and other frontiers.
- **2. Meeting on Scientific Computing & Simulations in High Energy Physics (building on results from Snowmass)**
  - Co Chairs: Dr. Salman Habib and Prof Paul Avery
  - Planned for Dec 9-11, 2013;
  - Goals: to identify opportunities and requirements for improving the effectiveness the fundamental reliance of HEP on computing and simulation
  - cross cutting aspects, computational R&D, leadership in the international context, solutions for software, including frameworks, codes and data tools widely used in HEP, partnerships needs and opportunities – including industry…
  - Attendance will be limited because of budget limitations
- **3. HEPAP could consider issues raised by 1. or 2., if significant enough**

HEP Data Management

The Office of Science Statement on Digital Data Management will require a Data Management Plan with all proposals submitted for Office of Science research funding.

See spring HEPAP presentation by Laura Biven:

http://science.energy.gov/~/media/hep/hepap/pdf/march-2013/2013_Spring_HEPAPBriefing_v3_NoBackup_LBiven.pdf

Requirements will be included in all solicitations and invitations for research funding posted on or after October 1, 2013.

Information will also be available via the DOE Office of Science Website and on the High Energy Physics webpage.

Note: Proposals submitted to the FY14 Comparative Review FOA [DE-FOA-0000948] or the Early Career Program 2013 FOA [DE-FOA-0000751] that have already been posted will not require Data Management Plans

Conclusions

- **HEP success has always been tied to advances in computing and other technology**
  - E.g., LHC Computing, enabled by networks and the Grid
- **The external world of computing is changing now as fast as it ever has and should be instrumental in enabling new knowledge in physics**
- **More commonality and community planning is needed for future computing systems in HEP**
- **DOE is actively considering the organization and priorities for Computing in the field and is looking forward to input from Snowmass and the follow-on Meeting.**