U.S. DEPARTMENT OF ENERGY

SciDAC PI Meeting 2015 High Energy Physics Overview

Lali Chatterjee
Program Manager
High Energy Physics (HEP)

HEP Science Drivers (P5) and Computing

Higgs

Neutrinos

Dark Matter

Dark Energy / CMB

New particles

Science Pursued Via Frontiers, Experiments, Projects & Technology

Computing - Simulations, Software, Tools, Data Solutions, Hardware, Systems, and Networks, mostly funded vertically within Experiments, Projects, and Lab Operations

Cross Cut & Global Solutions Increasingly Important:

Address the Facts of Technology Changes
Optimize Resources, Share innovation, Avoid Duplication,
Maximize External Resources and Partnerships
Strengthen Computing Within The Vertical Towers

HEP-ASCR Connections

- **SciDAC**

(SciDAC I, SciDAC II, SciDAC III, SciDAC III-2)

- *Off cycle SciDAC*: **Geant -4 Pilot Project**
  (Cross cut toolkit critical for HEP….and also used in medicine etc)

- **Software-Data- Networks Eco System**
  (near term & far term)

*** HEP Forum for Computational Excellence (FCE)**

*** ASCR Facilities * Data Demos for SC14**

*** Exascale Requirements Review (June 2015)**

SciDAC III - 2

- Re-competed soon after the HEP P5 report
- Focused on P5 Science Drivers
- FOA closed Jan 2015
- Two year projects to bring us in Phase
- Four Proposals Recommended for funding
- Three of these are same areas as current projects and same PI
- New project on data movement simulation

SciDAC III-2 2015-2017

Collaboration Title (abbreviated)	Lead Lab	PI (lead)	
Computing the Sky: Simulation and Analysis for Cosmological Surveys	ANL	Habib, Salman	
Community Project for Accelerator Science and Simulation-3	FNAL	Spentzouris, Panagiotis	
Optimizing HEP Data Management and Analysis Capabilities	FNAL	Lyon, Adam	
Exascale algorithms and software for lattice field theory	FNAL	Mackenzie, Paul	

Computation-Driven Discovery for the Dark Universe (SciDAC3)

Project Director: S. Habib (ANL) Institutional PIs: K. Heitmann (ANL), A. Slozar (BNL), N. Gnedin (FNAL), P. Nugent (LBNL), J. Ahrens (LANL), R. Wechsler (SLAC)

- **Science Targets: "Dark Universe" physics as probed by cosmological surveys — nature of dark energy and dark matter, neutrino sector, nature of primordial fluctuations**
- **Computational Program:**

*** Develop new cosmic probes and discovery channels**

*** Extraction and optimization of cosmological survey science**

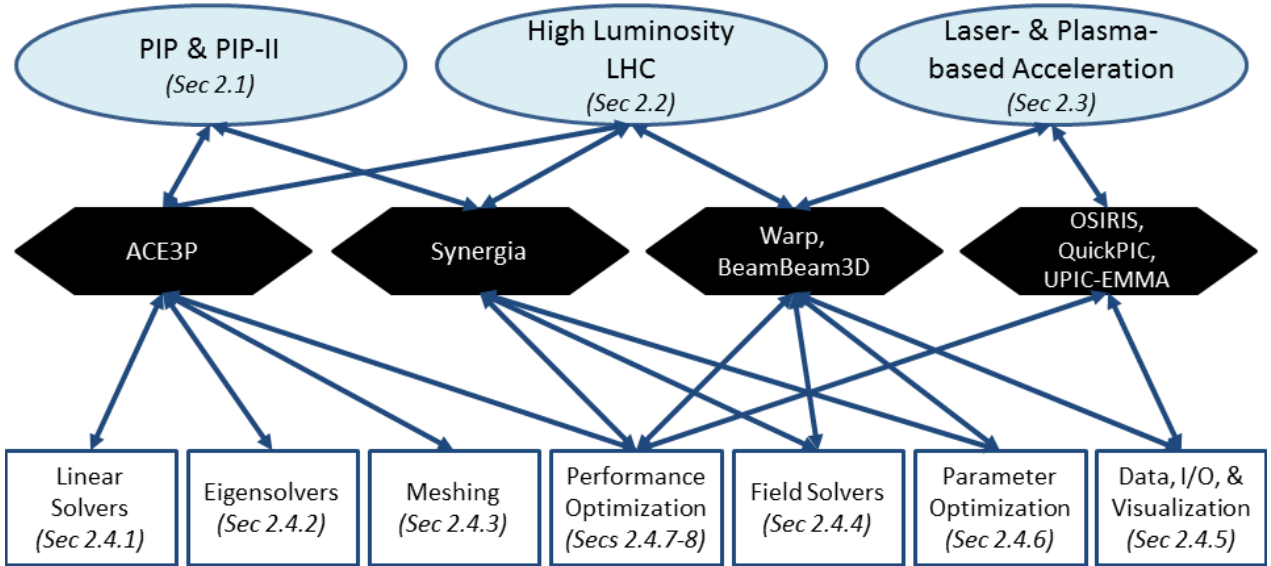
- **SciDAC Institutes: FastMATH, QUEST, SDAV**

*** Adaptive mesh refinement methods * Advanced statistical techniques * Large-scale analytics and visualization**

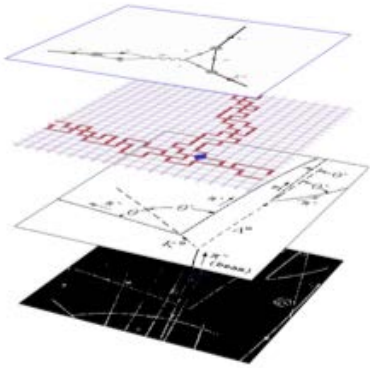
- **Major Results:**
  - **World's largest high-resolution N-body simulations with HACC**
  - **World's largest hydro simulations for Ly-α forest studies with Nyx**

ComPASS3: Community Project for Accelerator Science and Simulation

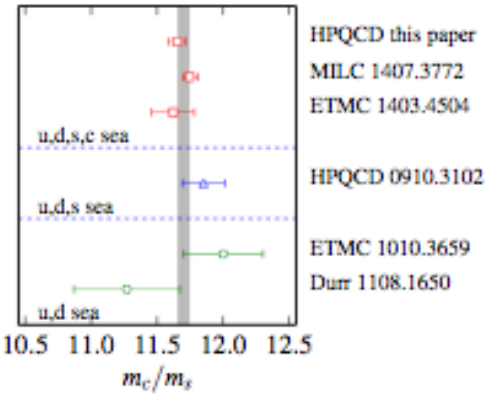
- Collaborating Institutions: Fermilab, Argonne, LBNL, RPI, SLAC, UCLA, U Oregon
- Accelerator applications: FNAL PIP-II, et al, LHC upgrades, laser- and plasma-based acceleration
- Computing topics: PIC on new architectures, performance and parameter optimization, scalable meshes and solvers
- HEP partnership with SciDAC Institutes:
- FASTMath, SDAV, and SUPER

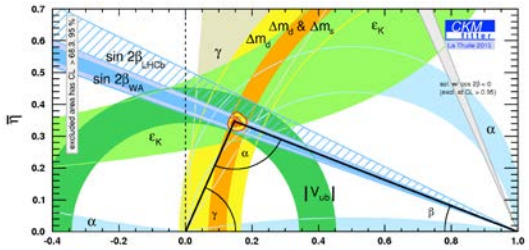


Lattice QCD - new techniques & precision



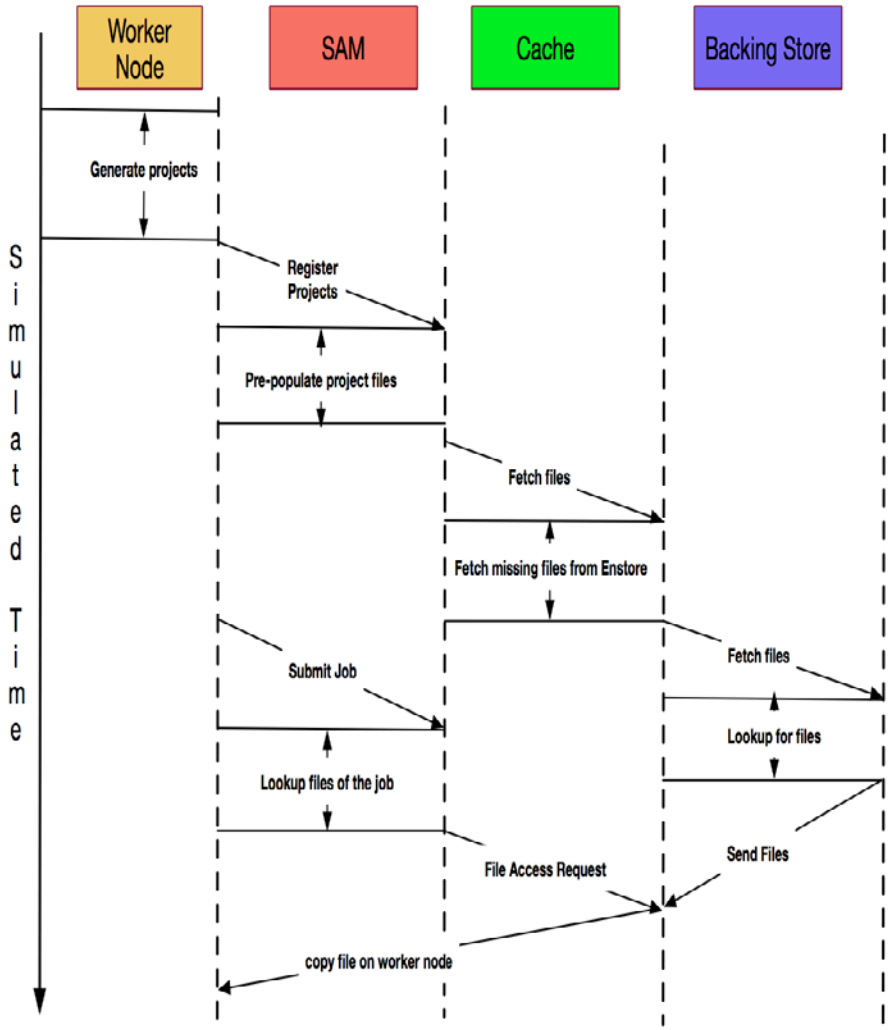
- Created new methods for calculating the decay of a kaon into two pions. (RBC)
  - This pioneered the still little-explored territory of calculating multi-particle decays with lattice QCD.
- Gauge configurations generated with SciDAC software were used to pioneer new methods for determining quark masses several times more precise than ever before. (HPQCD).
  - Quark masses this precise will be needed to analyze Higgs decays to ultra-high precision and for many other purposes.
- Calculated many corrections needed to obtain the CKM quark mixing matrix elements from the leptonic and semileptonic decays of mesons. (Fermilab/MILC, HPQCD, RBC).
  - These allowed much more stringent tests in the search for new physics in these decays.
- In software, a new library, QUDA ("*kyoo-da*"), was developed to allow convenient porting of QCD code to GPUs.





SciDAC III – 2 Data Simulation Project

- **Prototype an end-to-end simulation of data facilities that support extreme scale computing**
  - **Study and simulate Fermilab's HEP scientific data facility**
  - **Validate against actual data facility logging information**
- **Deliverables**
  - **Publish results of simulation under different HEP workflow scenarios**
  - **Publish simulation prototype code**
  - **Publish data facility logging information**
- **Validated simulation will be crucial for refinement of current HPC systems and design of future exascale facilities**
- **Joint HEP/ASCR, ANL/FNAL project**



PI's: Adam Lyon (lyon@fnal.gov) & Rob Ross (rross@mcs.anl.gov)

The Science Drivers of Particle Physics

- **Use the Higgs boson as a new tool for discovery**
- **Pursue the physics associated with neutrino mass**
- **Identify the new physics of dark matter**
- **Understand cosmic acceleration: dark energy and inflation**
- **Explore the unknown: new particles, interactions, and physical principles**

Closely LINKED to SciDAC and the computing-data eco system.