Information Technology Tasks to Support the Future Program

Cosmic Frontier

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Outline

- What is the Cosmic Frontier?

- What is the timeline for Cosmic Frontier projects?

- What are the computing needs and technical challenges for Cosmic Frontier projects ?

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Cosmic Frontier
Fermilab Center for Particle Astrophysics

Scientific Mission:

To unify the astrophysics program at Fermilab, thereby enhancing the overall intellectual environment and the talent available to individual projects;

To provide a framework for initiating new ideas and developing new techniques;

To become an international center where scientists from Fermilab and the world user community can come to learn about and participate in the interface of particle physics and cosmology.

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Cosmic Frontier Science Questions

Dark Matter

What is the nature of the particles that make up most of the matter in the universe?

Dark Energy

What is the nature of the energy that is causing an accelerated expansion of the universe?

High Energy Cosmic Particles

What are the highest energy cosmic particles and how are they produced?

Quantum Spacetime

Can we determine the properties of spacetime at the Planck scale?

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Cosmic Frontier Projects at Fermilab

Dark Matter

Deep-underground, low-background experiments aimed at directly detecting Weakly Interacting Massive Particles (WIMPS) that may constitute dark matter (CDMS, COUPP, DarkSide, DAMIC)

Dark Energy

Imaging and spectroscopic surveys that measure the geometry and dynamics of the universe using multiple methods to understand dark energy (SDSS, DES, LSST)
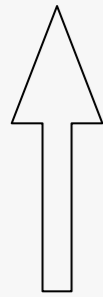
High Energy Cosmic Particles

Very large ground-based arrays to detect the highest energy cosmic rays (Pierre Auger South)

Quantum Spacetime

Laser interferometry to measure the 'jitter' in spacetime at the Planck scale (Holometer)

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Timeline for Cosmic Frontier Projects

Total project cost indicated by width of band

Legend

■ R&D	**Small:**	**Medium:**	**Large:**
■ Construction	Less than	$50-$750	Greater than
■ Operation	$50 million	million	$750 million

'11　　　　　　　　　　**'20**　　　　　　　　　　**'30**

Cosmic Frontier

Dark Matter: CDMS, COUPP, DarkSide
10-kg-scale operating 2012; 100-kg-scale operating 2015

Dark Matter: One-ton-scale experiments
one-ton-scale experiments

Dark Energy DES

Dark Energy: LSST

Cosmic Particles: Pierre Auger

Quantum Spacetime: Holometer

From draft of Fermilab's "Plan for Discovery" (2011 - 2030)

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Computing Needs & Challenges for Projects

High

DOE Priority for Cosmic Frontier Science at FNAL

	DAQ	Data Processing & Analysis	Grid/Cloud Computing	DBs	Storage	Simulation	HPC, GPUs
DM							
CDMS	Waveform sampling	Root	~150K cpu-hrs/year		maximum 100 TB/year	GEANT4	
COUPP		MatLab	~150K cpu-hrs/year		maximum 10 TB/year	GEANT4	
DarkSide	Waveform sampling	Root	~150K cpu-hrs/year		maximum 100 TB	GEANT4	
DE							
DES		Web portal	~30M cpu-hrs/year	Oracle	500 TB/year	Image simulation	
LSST	ATCA	L3 Science analysis toolkit	TeraGrid & OSG?	SciDB?	@NCSA & DE Center	Instrument model, Image simulation & Comp. cosmology	x
QS							
Holometer			~50K cpu-hrs/year		maximum 150 TB		
HECP							
Auger					maximum 2 TB/year	Air-shower Monte Carlo	x

Low

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Typical Dark Matter Experiment Computing Requirements (CDMS)

- Collecting data
  - Mainly home-grown data acquisition systems
  - Need serious data throughput to accommodate waveform sampling of pulse shapes
    - 20 MB/s is the current spec; may have to increase to 100 MB/s. Pipeline must extend from remote sites to Fermilab.
  - Real-time analysis of fraction of the data to assess quality
  - Recorded data volume ~ 30 TB/year; may grow to 100.

- Analyzing the data
  - Home-grown analysis but migrating towards standard HEP tools (Root, GEANT4).
  - Data processing requires significant CPU resources; currently 150K cpu-hours/year, may grow to 1000.
  - Use combination of Fermi-Grid and local clusters

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Large Synoptic Survey Telescope (LSST) Computing Challenges

- One 6-Gigabyte image every 17 seconds

- 30 Terabytes of data collected every night for 10 years

- 200-Petabyte final image data archive

- 20-Petabyte final database catalog

- 20 Trillion photometric measurements of 20 billion objects

- Repeat images of the entire night sky every 3 nights

- ~1000 images of each of 10 billion galaxies

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Summary

- The Cosmic Frontier includes projects for Dark Matter, Dark Energy, Quantum Spacetime, and High Energy Cosmic Particles.

- Dark Matter projects are similar in scale and there are usually multiple generations for each project as they get larger in size (for example, COUPP 4, COUPP 60, COUPP 500).

- LSST dominates Cosmic Frontier computing needs, and as a new institutional member we are looking for opportunities for Fermilab involvement. We are focusing on simulations for LSST, and on playing a significant role in a Dark Energy Science Center.

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