

# Physics at the Dept. of Energy - Interagency Projects

**Dr. Kathleen Turner**

**Division of High Energy Physics,  
Office of Science, DOE**

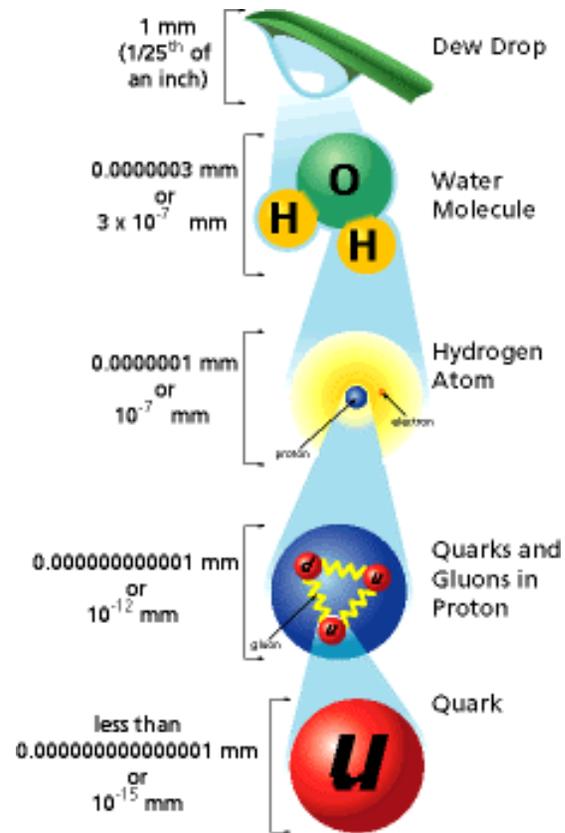
Talk at Goddard Memorial Symposium,  
Greenbelt, MD -- March 20, 2002

# Division of High Energy Physics Mission

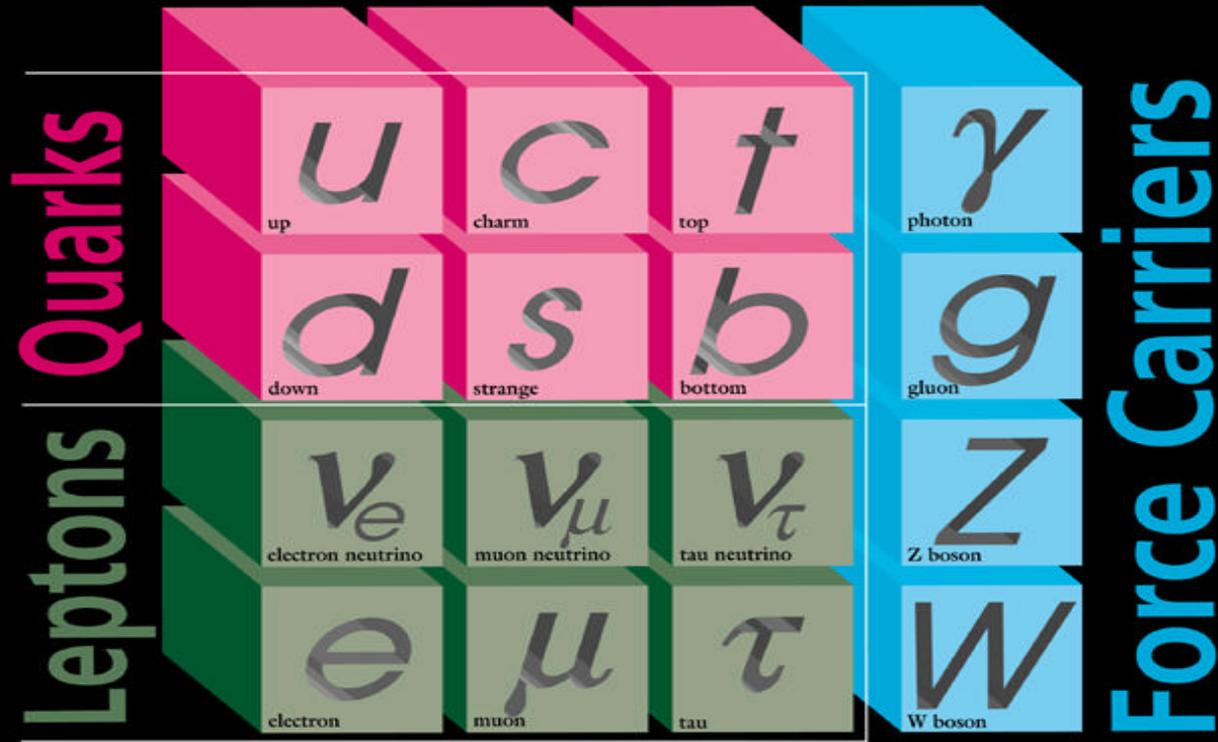
What is High Energy (or Particle) physics?

- ? The “science of matter, energy, space and time”
- ? Physics of the fundamental laws of nature - study fundamental forces and matter in the universe
- ? Strong overlaps with astrophysics and cosmology

# Getting down to basics....



# ELEMENTARY PARTICLES



I II III  
Three Generations of Matter

# Where We Do Our Experiments

## Particle Accelerators

“Atom Smashers” ? create particles and interactions

## The Universe

? Detectors underground, on the ground, and in space to measure fundamental particles and their interactions

# Particle Accelerator

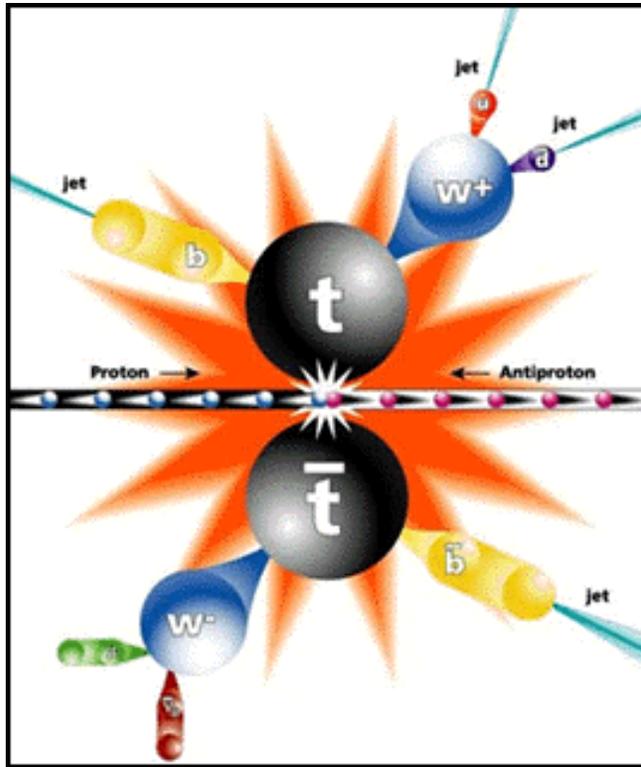
Fermilab – Tevatron Collider



Inside the tunnel



# Proton Anti-Proton Collision



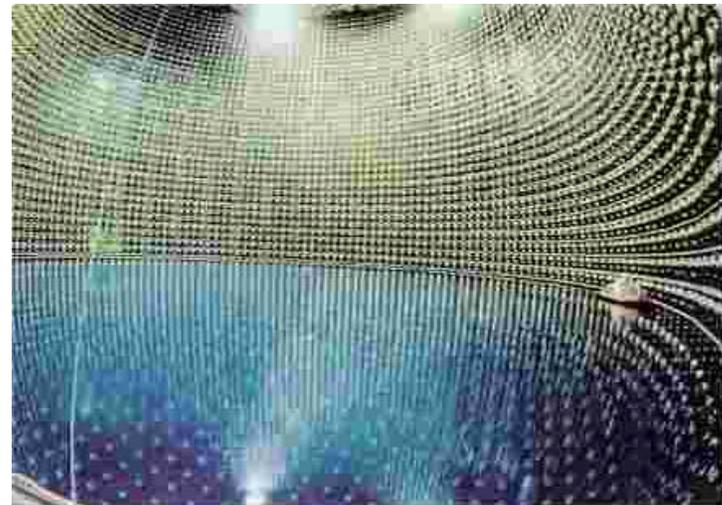
? up and down quarks inside protons collide and create higher mass (~ 180 times mass of proton!) top quarks

?  $E=mc^2$

# On the Ground & Below Ground



Pierre Auger: High Energy Cosmic Ray Detector in Argentina - 1600 stations being built over 3000 km<sup>2</sup> site



SuperKamiokande – Underground neutrino detector in Japan  
~13,000 phototubes  
50,000 metric tons of pure water

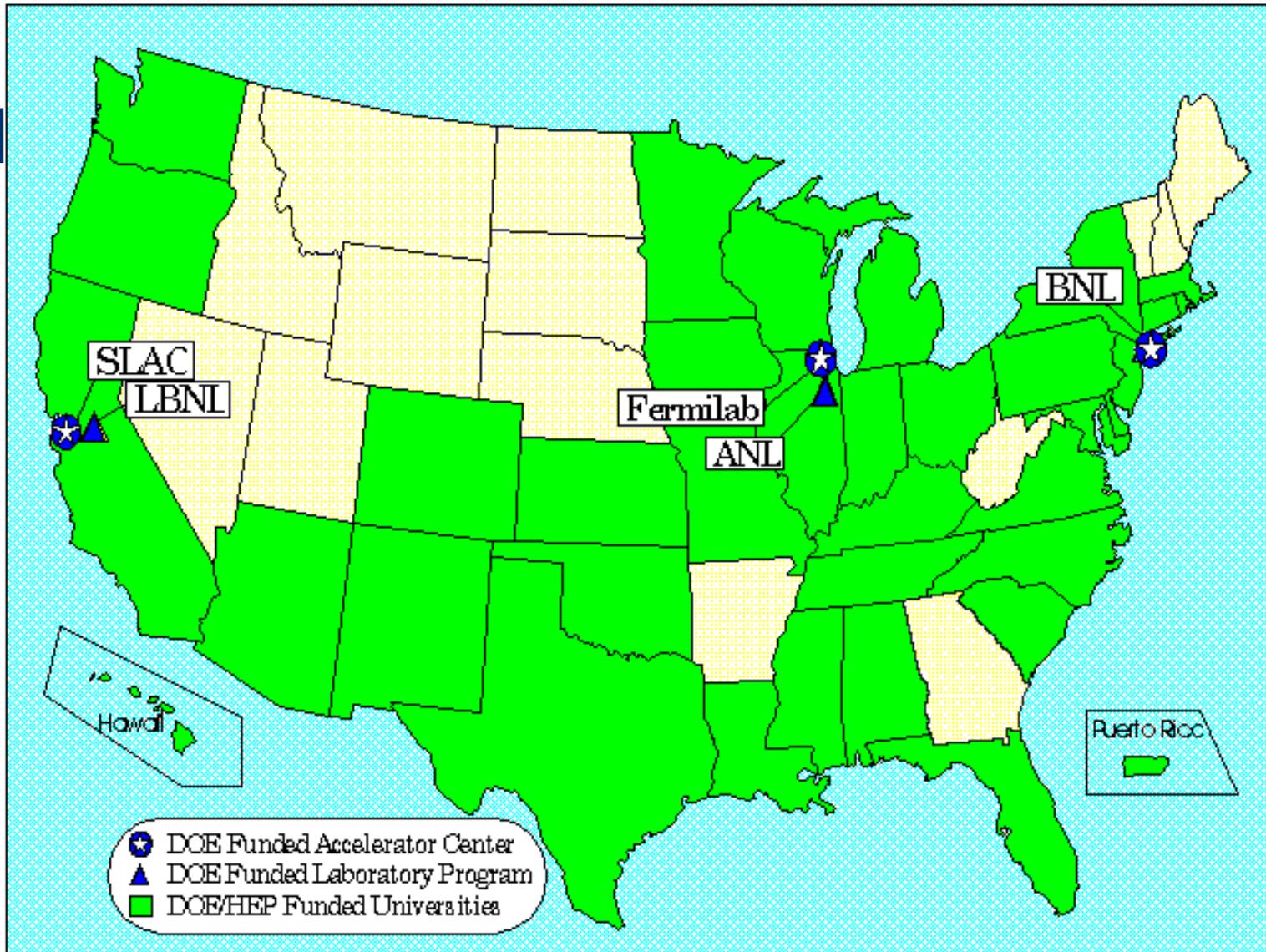
# Our Scientific Community

We provide on-going support for high energy physicists at our (contractor operated) **labs (5)** & **universities (~110)** with HEP programs

## In the HEP field:

- ✍ University & Lab physicists decide the science, design, build, operate and analyse data from the accelerators and experiments
  - ? (can take 10-15 years or longer!)
- ✍ experiment and theory are intertwined

## DOE-HEP Funded Labs & Universities



# Decision Process for Starting Experiments/Accelerators

This is a community-led field!

- ? Agencies receive proposals from the physicists and then run peer reviews
- ✍ Scientists in the field (DOE-High Energy or NSF-Elementary Particle Physics) come up with an idea & build support in community
- ✍ They develop the idea into an experiment or accelerator concept through laboratory (with funds available to develop new concepts) or their university
- ✍ The lab reviews it internally and then through external committees and then decides to make this a high priority project.
- ✍ SAGENAP panel looks at all non-accelerator facility proposals and decides scientific merit

# Program Direction and Reviews

- ✍ High Energy Physics Advisory Panel (**HEPAP**) & its subpanels are our community based advisory committees that provide recommendations on the direction of the field
- ✍ It reports jointly to DOE & NSF!
- ✍ Makes recommendations on new projects.
- ✍ We have extensive Technical, Cost, Schedule, Management “Lehman” reviews at each phase through construction of an approved project

# “DZero” Experiment at Fermilab

- ✍ Takes data from proton anti-proton collider: “Tevatron”
- ✍ First run 1992-1996, “Run 2” started March 2001
- ✍ 111 physics papers published so far – 100 students received PhD
- ✍ 600 physicists from 18 nations (~1/3 resident at lab)
  
- ✍ Radiation dosage in center of detector: ~ 200 Krad/ year  
(will be ~0.5 Mrad/yr in Run 2)
- ✍ 1M detector readout channels
- ✍ Event size: 250 kbytes
- ✍ Detector looks at ~ 2 Tbytes/sec, writes 12 Mbytes/sec to tape!

# DZero Detector



Size: 65x40x40 ft., 5500 tons



~ 600 physicists, 18 nations

# Current Experimental Program

(Major Experiments – all large, international collaborations)

- ✍ **DZero** and **CDF** at the Tevatron proton-antiproton collider (Fermilab)
  - ✍ search for Higgs, measurements of top quark, Super-symmetry, extra dimensions...
  - ✍ Currently running
- ✍ **BaBar** at PEP-II collider at SLAC
  - ✍ measurement of CP-violation, anti-matter vs. matter
  - ✍ currently running
- ✍ **Atlas** and **CMS** being built for Large Hadron Collider (LHC) at CERN (Geneva, Switzerland)
  - ✍ search for Higgs, data taking starts in 2007
- ✍ **MINOS** using Neutrinos at the Main Injector (NUMI) at Fermilab
  - ✍ Neutrino measurements, data taking starts in 2005

# Current Experimental Program, cont.

+ many other experiments going on at U.S. (Fermilab, SLAC, Brookhaven, Cornell, and foreign labs in Germany, Japan, Switzerland)

✍ also have involvement in many “non-accelerator” experiments studying:

- ✍ Ultra high energy cosmic rays
- ✍ High energy gamma rays
- ✍ Solar and atmospheric neutrinos
- ✍ Dark matter
- ✍ Dark energy

# Partnerships

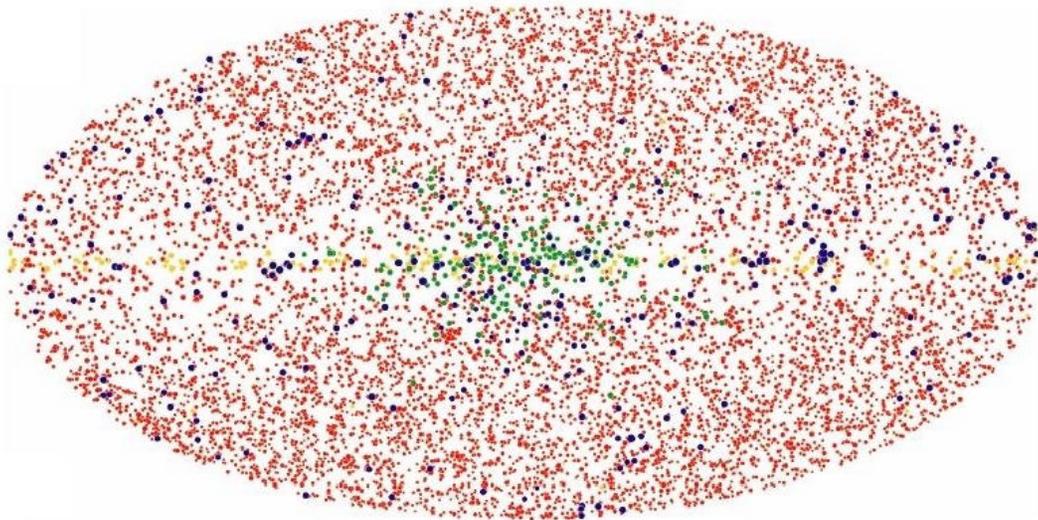
- ✍ DOE's major experiments are collaborations with contributions from National Science Foundation (NSF) and foreign agencies
- ✍ Almost all DOE-led U.S. experiments have NSF contributors (NSF-funded particle physicists and with equipment contributions)
- ✍ Atlas and CMS – led by CERN, we are U.S. partners with NSF
- ✍ Minor partners in many foreign experiments: Japan, Auger in Argentina, DESY lab in Germany, etc.
- ✍ We run joint reviews of projects with NSF and with foreign labs and agencies as needed

# Large Area Telescope (LAT) on the Gamma-ray Large Area Space Telescope (GLAST) Mission

- ✍ NASA's GLAST Mission has 2 instruments: LAT (principal) & GLAST Burst Monitor (GBM)
- ✍ DOE & NASA are partners in building LAT + 5 foreign partners
- ✍ Instrument: Measures with good resolution and wide field of view, energy and direction of high energy (20 MeV to > 300 GeV) Gamma-rays incident from space
- ✍ Physics:
  - understanding the mechanisms and behavior of particle acceleration in astrophysical environments (active galactic nuclei, supermassive black holes, etc)
  - determine the high energy behavior of gamma-ray bursts
  - Information on extragalactic background light and dark matter in the early universe

# GLAST – The Satellite & Sky Survey

## 5 $\sigma$ Sources from Simulated One Year All-sky Survey



Results of one-year  
all-sky survey.  
(Total: 9900 sources)

- AGN
- 3EG Catalog
- Galactic Halo
- Galactic Plane



# GLAST History

1992-1996: Collaboration (includes SLAC, Stanford, NRL, GSFC, France, Germany, Italy, Japan, Sweden) funded for instrument concept and design

1997:

- ✍ Mission endorsed by NASA Space Science Advisory Committee & highest priority of SEU subcommittee
- ✍ Presented to HEPAP

1998:

- ✍ NASA research announcement issued 1/98 for instrument technology development – 2 teams selected
- ✍ submitted proposal to DOE
- ✍ reviewed by SAGENAP(DOE)

1999:

- ✍ NASA A.O. released in August

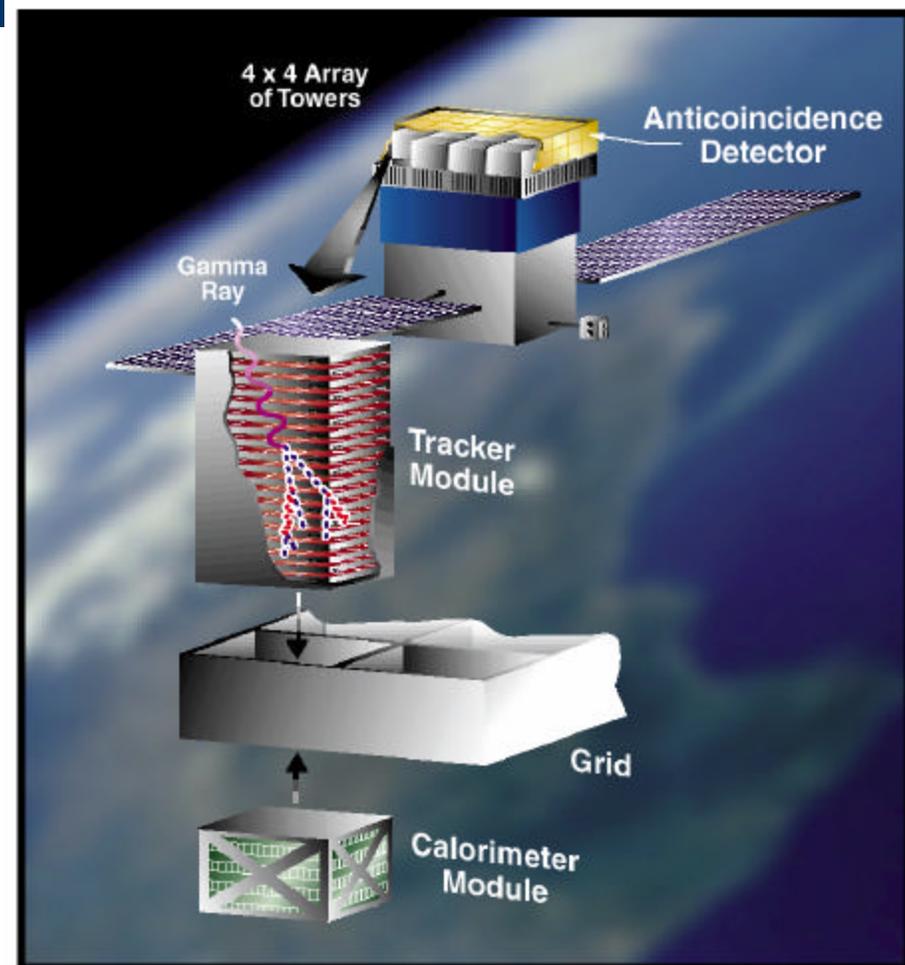
2000:

- ✍ LAT collaboration selected for GLAST mission, February
- ✍ NRC Decadal Astronomy & Astrophysics review ranks GLAST highest Mid-size mission for the decade - September

# GLAST LAT Instrument

LAT instrument:

- Tracker - silicon strip
- Calorimeter
  - Cesium Iodide
- Anti-coincidence detector
  - surrounds tracker



# Steps to getting here – GLAST/LAT

## 2001:

- ✍ Start joint DOE/NASA reviews of LAT
- ✍ Ballon flight of prototype module successful

## 2002:

- ✍ Joint reviews continue – passed PDR, in process of “baselining” (DOE)
- ✍ NASA/DOE Implementing Arrangement signed, January
- ✍ NASA/foreign agreements under review
- ✍ NASA/DOE having regular agency, project and instrument-level meetings
- ✍ Working well together at all levels
- ✍ **There are difference in schedules/methods/culture but we get together and we work it out!**

# GLAST/LAT - future

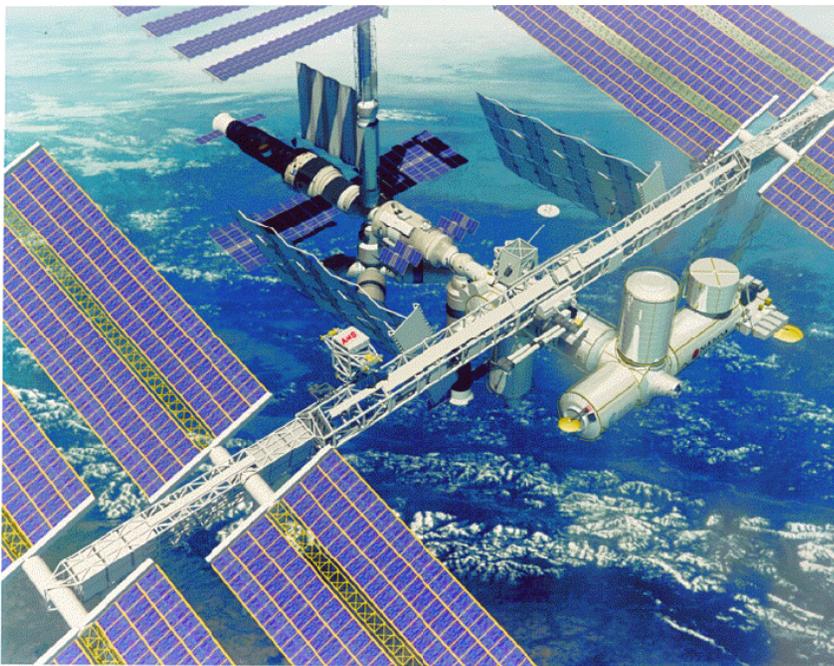
? Continue Partnerships at all Levels!

## Schedule:

- ✍ Now building and testing engineering models
- ✍ Implementation/Construction starts end of 2002
- ✍ Integration starts mid-2005
- ✍ Launch scheduled March 2006

# Other Projects with NASA

## ? AMS & BAF

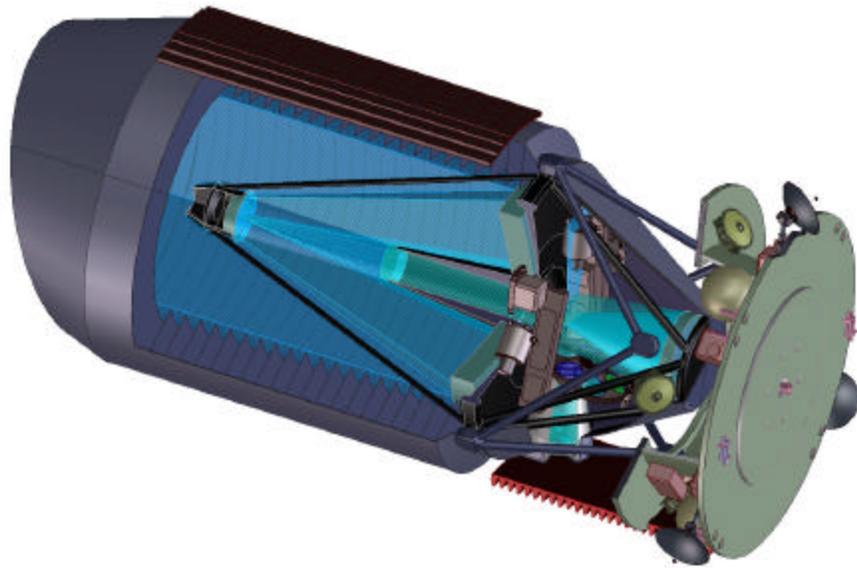


Alpha Magnetic Spectrometer  
-- An experiment to search in space for dark matter, missing matter & antimatter on the International Space Station (AMS-02 launch in 2004 for 3 yr Mission); AMS- 01 on STS-91

Booster Applications Facility (BAF) at Brookhaven Lab

- NASA funding, DOE (nuclear physics) construction and operations
- Purpose: radiation simulator for human exploration

# SNAP – SuperNova Acceleration Probe



The acceleration of the expansion of the universe due to unknown force (“Dark Energy”) was announced in 1998 by two groups of scientists (one group LBNL-based) using ground-based measurements of type Ia supernovae (used as “standard candles”)

DOE is funding R&D for the proposed SNAP telescope from LBNL; 3<sup>rd</sup> generation, dedicated experiment to discover and precisely measure properties of thousands of type Ia supernovae in redshift range  $z=0.1$  to 1.7 in order to measure acceleration/deceleration history of Universe.

- 2m wide field telescope launched into in high earth orbit
- billion-pixel optical and infrared cameras + spectroscopic measurements

# DOE/NASA partnerships

- ? There are new and exciting opportunities for fundamental physics research for DOE and NASA.
- ? We at DOE-HEP are looking forward to long and fruitful scientific partnerships.