

High Energy and Nuclear Physics at the Dept. of Energy

Dr. Kathleen Turner

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

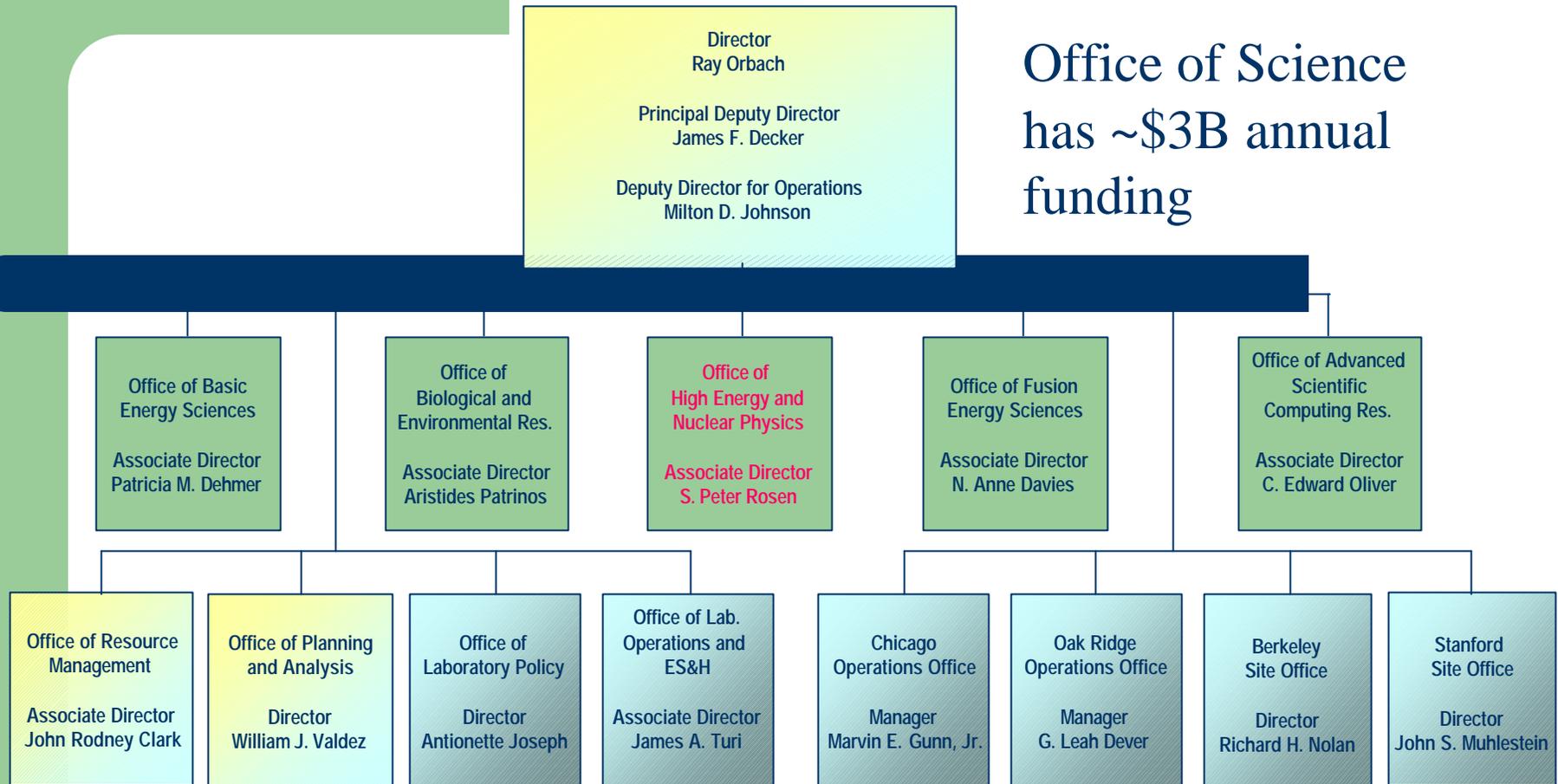
Talk at National Academy of Science,
Committee on Astronomy & Astrophysics
May 2, 2002

Will be talking mainly about the High Energy Physics Program

- The Science we do
- Where we do it
- How our community/culture/decisions/program direction works
- Current Partnerships in our program
- Our Astrophysics/Cosmology Projects
- Future projects

Office of Science

Office of Science
has ~\$3B annual
funding



NOTE: Director of Science equivalent to Assistant Secretary position and filled by Presidential Appointment (Senate confirmed); Principal Deputy Director equivalent to Principal Deputy Assistant Secretary; Associate Directors equivalent to Deputy Assistant Secretaries.



Approved: _____
James F. Decker
Principal Deputy Director
Office of Science

November 2001

Office of High Energy and Nuclear Physics (HENP)

HENP Associate Director: Peter Rosen

-- has ~\$1.1B annual funding

- Director for Nuclear Physics Division:

Dennis Kovar

- Director for High Energy Physics Division:

John O'Fallon

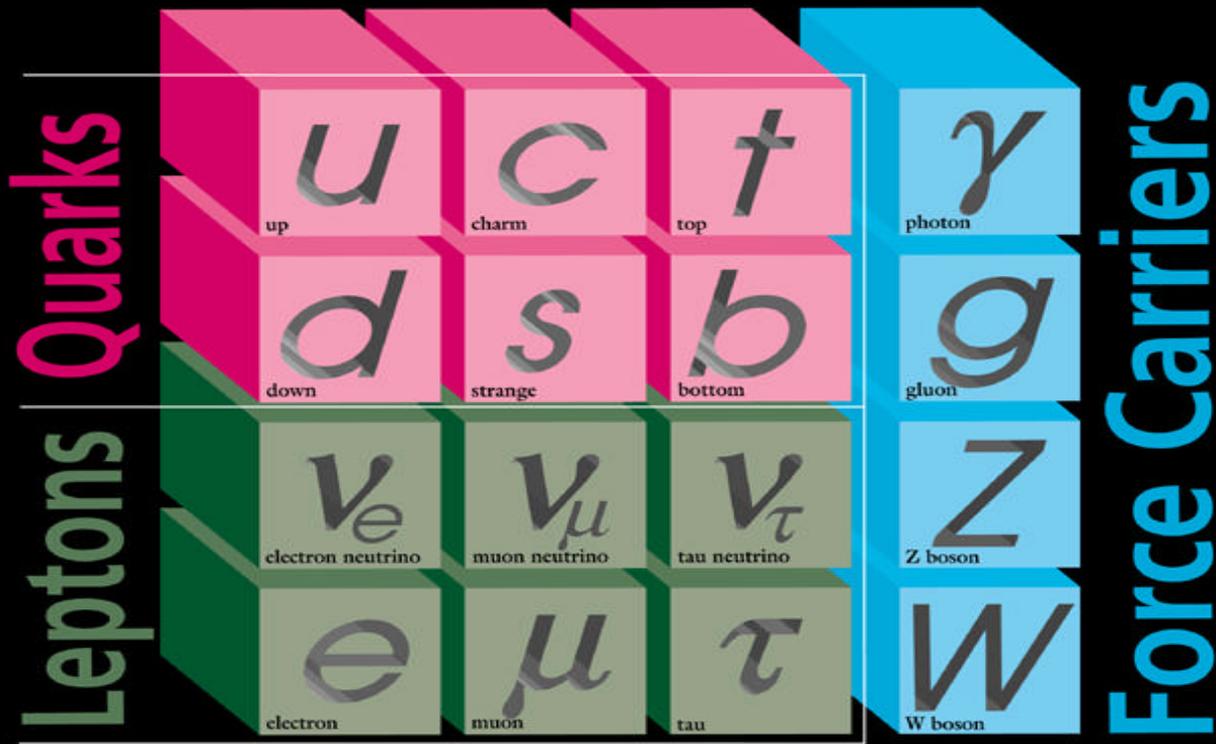
Division of High Energy Physics (HEP) Mission

Our Science:

“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

ELEMENTARY PARTICLES



I II III
Three Generations of Matter

Where We Do Our Experiments

Particle Accelerators (Facilities)

“Atom Smashers” ? create particles and interactions

The Universe

Detectors underground, on the ground, and in space to study fundamental particles and forces

Particle Accelerator

Fermilab – Tevatron Collider



Inside the tunnel



HEP – our support

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

- University grants go through our office
 - funded based on peer review
 - experiments, theory, accelerator and advanced detector research
 - support ~ 500 each faculty, postdocs, grad students at Univ.
- Our office provides base operating support to the labs to run the facility, accelerators, build and run experiments and to support scientific, technical and managerial staff
- Our office provides oversight for the labs (annual reviews) and experiments (bi-annual during construction)

DOE-HEP funding (\$M)

	FY02	FY03 President's Request
Research & Technology	244.2	258.5
Facility Ops (incl. Capital equip)	457.5	446.4
Construction	11.4	20.1
Total (after SBIR & STTR deducted)	697.7	709.4

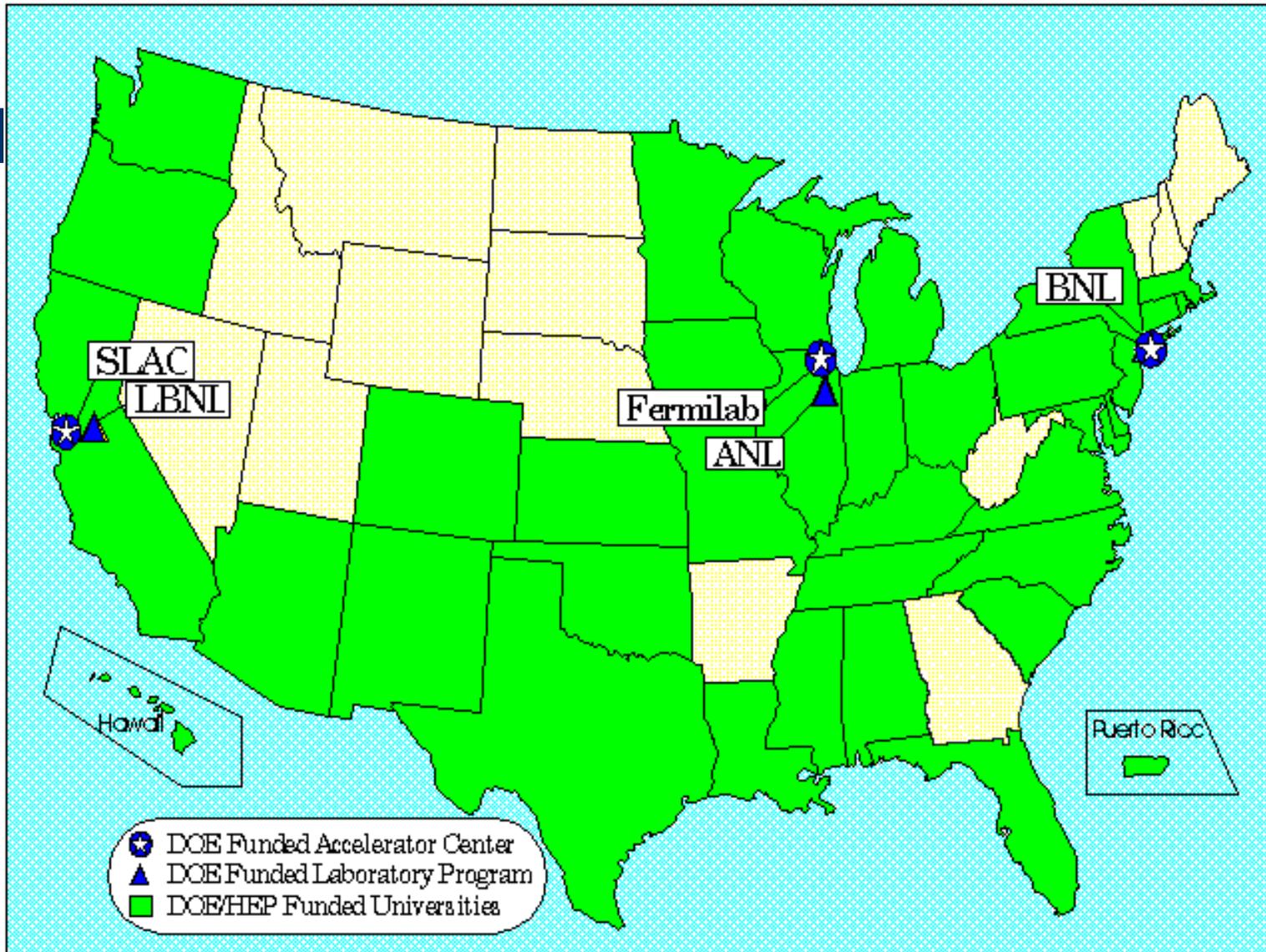
In the HEP Field:

✍ University & Lab physicists decide the science, design, build, operate and analyse data from the accelerators and experiments

? (can take 10-15 years or longer!)

✍ Theorists at Universities & labs are base funded too. They don't directly join experiments but work closely with experimenters in planning program, experiments and interpreting data.

DOE-HEP Funded Labs & Universities



Decision Process for Starting Experiments/Accelerators

This is a community-led field!

- ? Agencies receive proposals from physicists, then run peer reviews
- ? The field consists of DOE-High Energy Physics or NSF-Elementary Particle Physics (NSF-EPP) funded physicists.
- ✍ Scientists in the field come up with an idea & build support in community
- ✍ Usually hold summer meeting at Snowmass ~ every 3 years
- ✍ 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 (joint DOE/NSF) 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-HEP & NSF-EPP!
- ✍ Makes recommendations on new projects.

- ✍ We have extensive Technical, Cost, Schedule, Management “Lehman” reviews at each phase through construction of an approved project

How DOE runs Projects:

We **BASELINE** our projects before construction. At this point the technical/cost/schedule/management for whole project needs to be laid out.

The baselined project has set costs/schedule. To change it is a BIG DEAL/Headache.

The projects carry large enough **contingencies** to keep the cost/schedule within the baseline range.

Project Phases:

Preconceptual Planning Phase (at end of this have:)

Critical Decision 0 to Approve Mission Need

Conceptual Design Phase

CD-1 to Approve Preliminary Baseline

Preliminary Design Phase

CD-2 to Approve Performance Baseline

Final Design Phase

CD-3 to Approve Start of Construction

Construction Phase

CD-4 to Approve Start of Operations

Mission Operations Phase

“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
- ✍ We are 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
- ✍ Most of the major experiments have International Finance Committees for agency-level people to agree on funding.

Astrophysics/Cosmology Projects We're Involved In:

Ongoing

Milagro (w/NSF)
GRANITE/Whipple
SNO (mostly DOE-NP w/NSF)
SDSS (through Fermilab)
SuperK/K2K (w/Japan)
Axion-I (LLNL)

Underway

Pierre Auger (w/NSF)
KamLAND (w/DOE-NP)
CDMS-II (w/NSF)
AMS (w/NASA & foreign)
GLAST/LAT (w/NASA)

Pending Starts

Veritas (w/NSF,SAO)
AXION-II

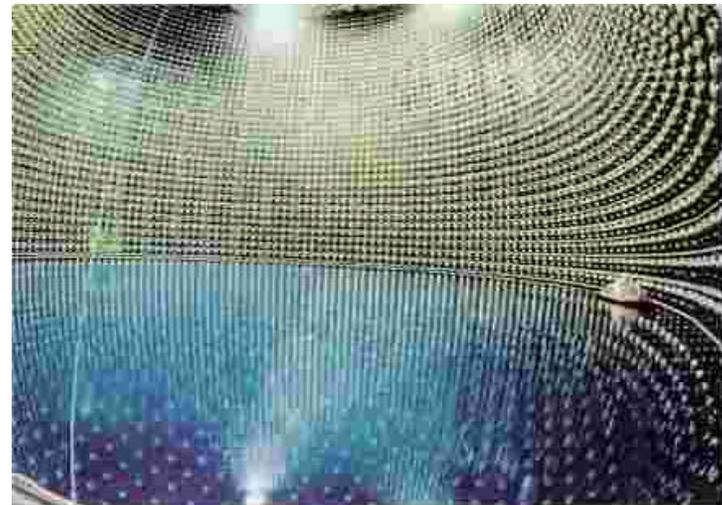
R&D

EXO (SLAC, Stanford)
SNAP (LBNL)

On the Ground & Below Ground



Pierre Auger: High Energy Cosmic Ray Detector in Argentina - 1600 stations being built over 3000 km² site



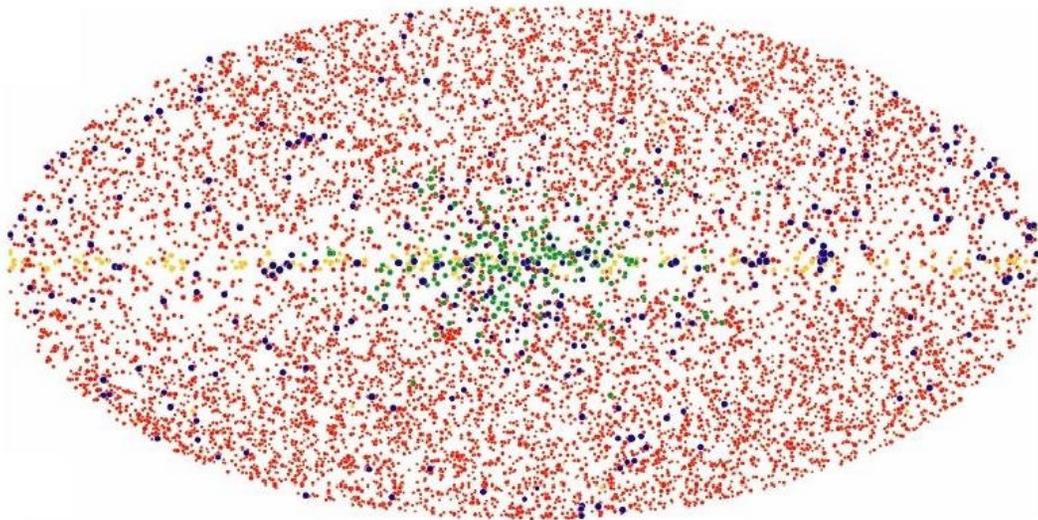
SuperKamiokande – Underground neutrino detector in Japan
~13,000 phototubes
50,000 metric tons of pure water

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 σ 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

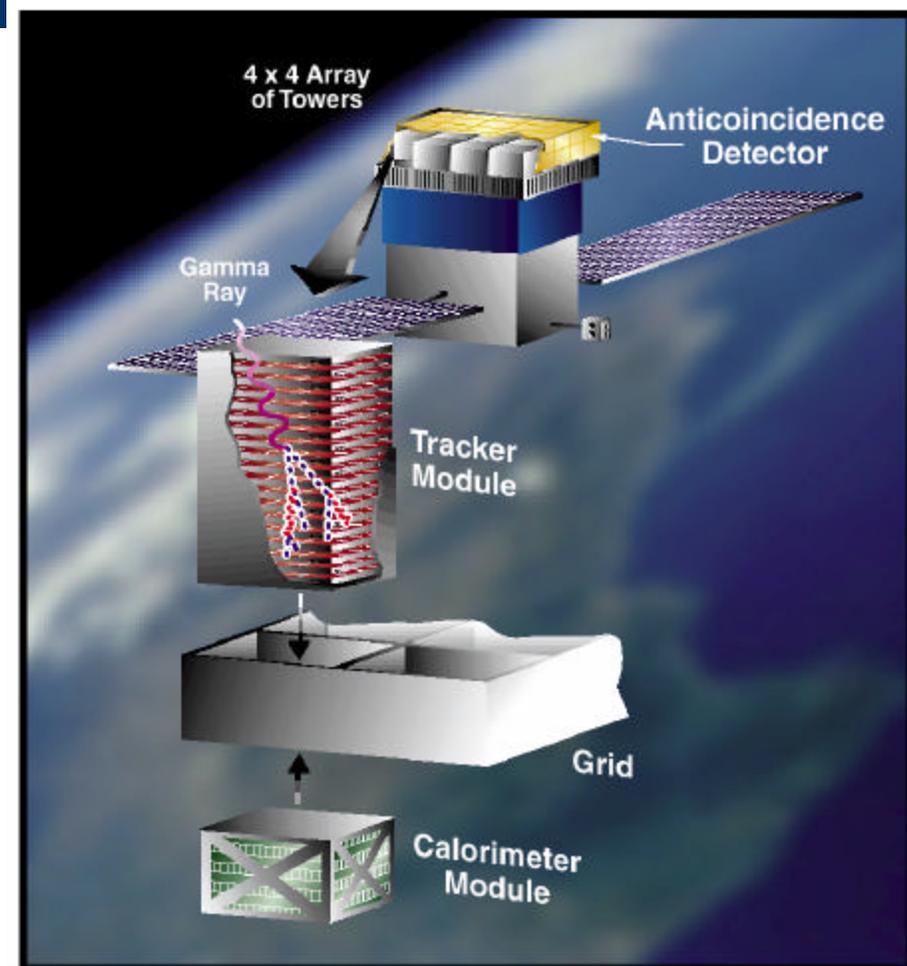
2000:

- ✍ 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

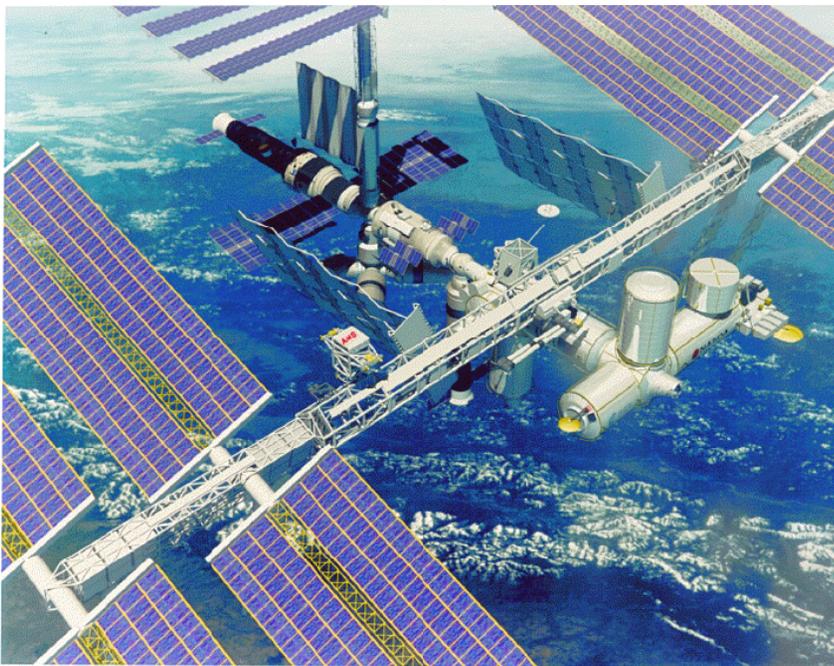
? Continue Partnerships at all Levels!

Schedule:

- ✍ Now building and testing engineering models
- ✍ LAT passed PDR review Jan.02
- ✍ LAT baseline review scheduled for July '02
- ✍ Implementation/Construction starts end of 2002
- ✍ Integration starts mid-2005
- ✍ Launch scheduled March 2006

Other Projects with NASA

? AMS & BAF

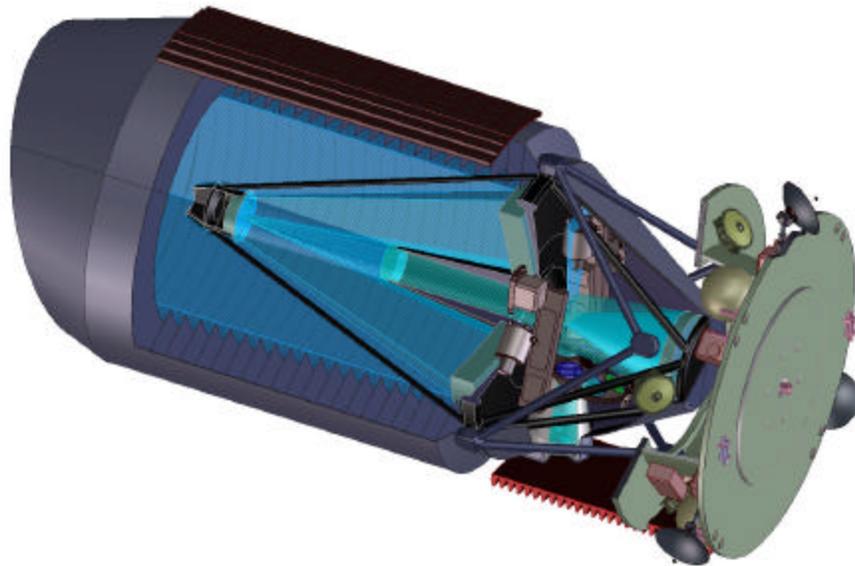


Alpha Magnetic Spectrometer
-- An experiment to search in space for dark matter, missing matter & antimatter on the International Space Station (AMS-02 launch in 2004 for 3 yr Mission); AMS- 01 on STS-91

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; 3rd 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

SNAP - recommendations

SAGENAP panel – Feb. '00

“The scientific goals of the experiment ... deemed extremely important”

DOE R&D review held Jan. '01

“SNAP’s science goals are excellent and address fundamental questions in particle physics and cosmology”

HEPAP Subpanel (Jan. '02) says:

“We endorse R&D funding for SNAP from the high-energy physics program. We recommend that the full SNAP project, if approved, include significant NASA participation in the construction & launch of the instrument, in partnership with DOE & NSF.

NAS CPU report (M. Turner) – April 2002

One of the 3 new non-prioritized initiatives recommended is for a Wide-field telescope in space to use supernovae to probe the expansion history and probe the nature of dark energy (partnership between NASA & DOE) – e.g. SNAP

DOE R&D review scheduled for July '02

NASA and DOE are talking to each other about how such a mission could happen.

National Advisory Panel for Astronomy & Astrophysics

Currently being put together for NASA & NSF

DOE is certainly interested in finding out how this panel will work – will discuss with other agencies

DOE partnerships

- ? There are many and exciting opportunities for fundamental physics research at intersection of fields for DOE, NSF & NASA.
- ? We are looking forward to long and fruitful scientific partnerships.