



Presentation to the Board on Physics and Astronomy

**Office of Nuclear Physics
Office of Science
Department of Energy
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U.S. Department of Energy**



U.S Nuclear Physics Program Provides World Leadership Capabilities Today



DOE SC NP has lead Federal responsibility for nuclear physics research

- Provides over 90% of Federal support
- Primary Builder/Operator of Facilities: National User & University Facilities
- Primary supporter of research community (60% of university researchers)
- Works closely with NSF to develop a coordinated US program

Today U.S. NP program is a leader and is defining the field

- World leaders in two major subfields (hot, dense nuclear matter/quark structure of matter)
- Among the leaders in other subfields (nuclear structure/astrophysics & neutrino science)
- Has identified the opportunities to address the forefront questions

Scientific opportunities for nuclear physics today are compelling

- Fundamental questions are still not answered
- Advances in accelerator/detector/computing technologies have put the answers within reach
- These discoveries and advancements will have significant impact on other scientific fields

Foreign investments made and planned challenge this U.S. leadership in the future

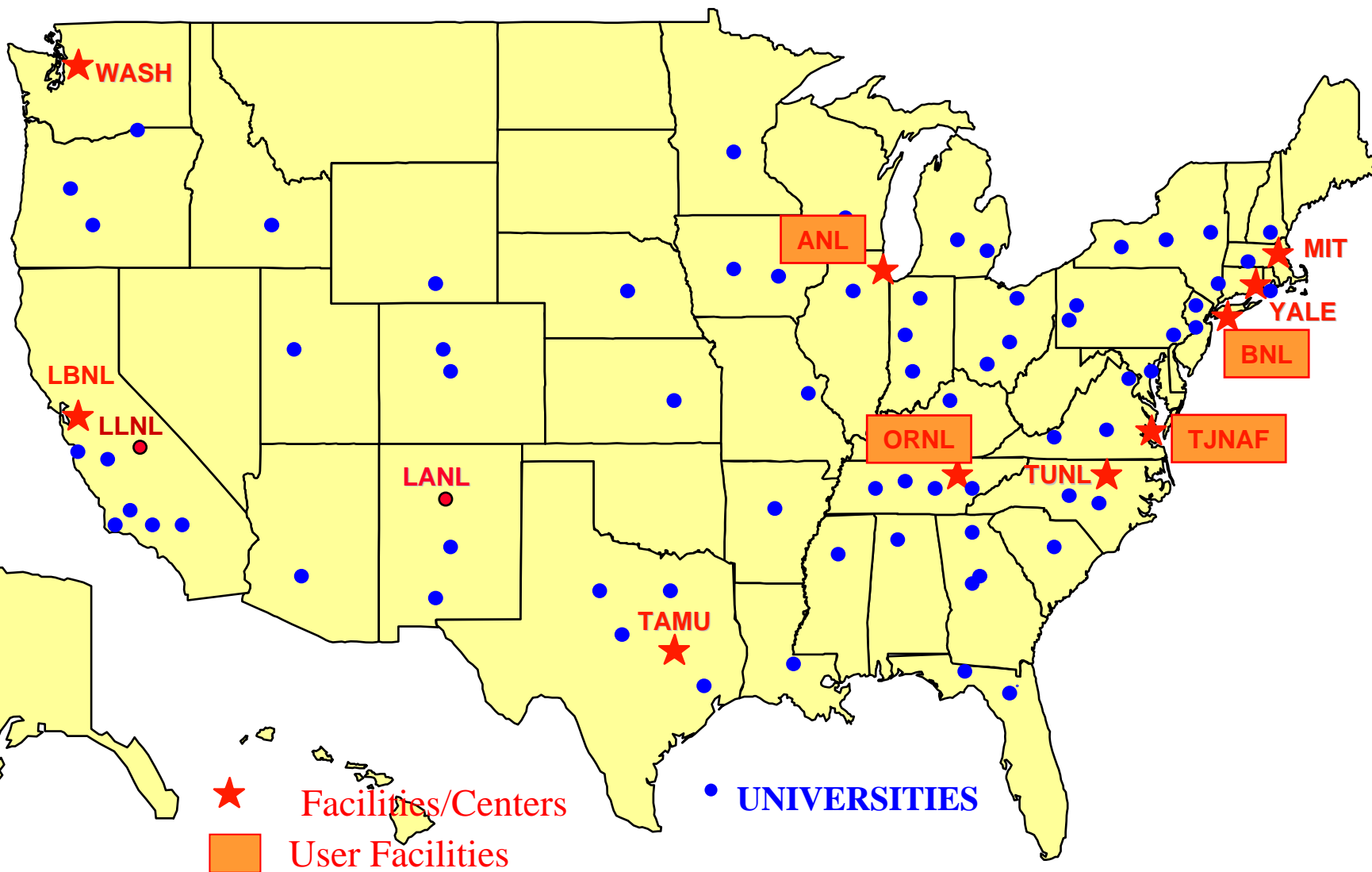
- Heavy ion LHC (CERN)/FAIR (Germany) → RHIC (heavy ions) Hot, dense nuclear matter
- FAIR (Germany)/J-PARC (Japan) → CEBAF/RHIC (protons) Quark Structure of Matter
- FAIR (Germany)/RIKEN (Japan) → ATLAS/HRIBF/(MSU) Nuclear Structure/Astrophysics
ISAC (Canada)/SPIRAL II (France)



SC NP Program supports

Research (85 universities and 6 National Laboratories)

Facility operations (4 User Facilities and 8 Centers)





NP National User Facilities serve an international community

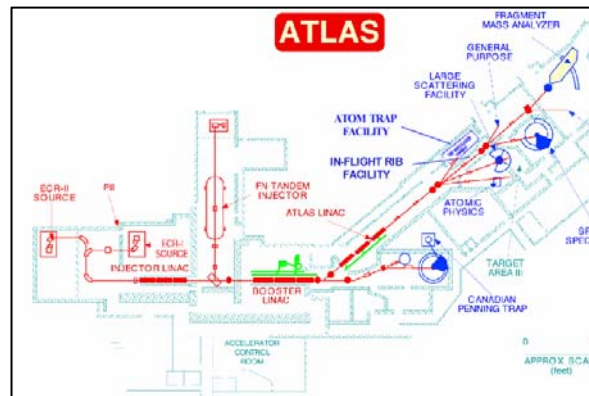


RHIC Brookhaven National Laboratory

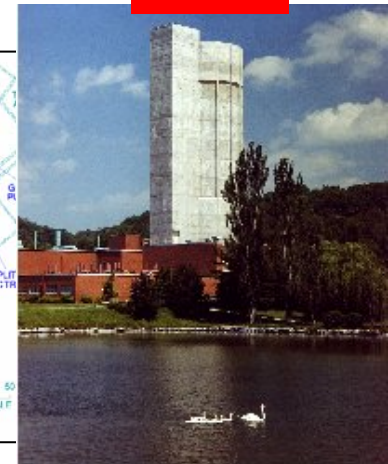


<u>Facility</u>	<u>Number of Users</u>		
	<u>U.S.</u>	<u>Foreign</u>	<u>Total</u>
RHIC	~ 500	~ 500	~1000
CEBAF	~ 670	~ 330	~1000
ATLAS	~ 200	~ 180	~ 380
HRIBF	~ 85	~ 15	~ 100
	~ 1455	~1025	~2480

CEBAF Jefferson Laboratory



HRIBF





The Science

Scientific thrusts and opportunities identified by the scientific community

Major Scientific Thrusts of the Field

Quark Structure of Matter

Structure of nucleons & nuclei in terms of their quark substructure

Phases of Nuclear Matter

Properties of hot, dense nuclear matter
 Search for evidence of a quark-gluon plasma

Nuclear Structure & Dynamics

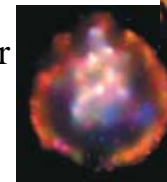
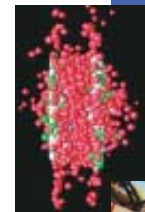
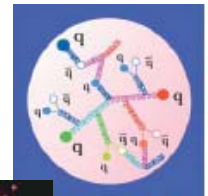
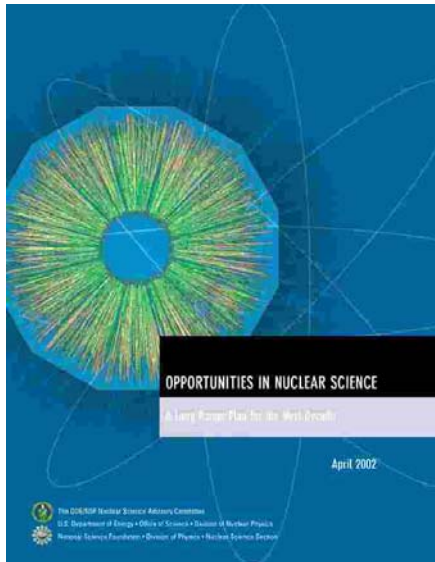
Nuclear structure at extreme excitation, angular momentum, and proton/neutron ratios

Nuclear Astrophysics

Reaction rates and simulations relevant to stellar burning and supernovae phenomena

Fundamental Symmetries

The nucleon/nucleus as a laboratory to test the Standard Model and fundamental theories





Fundamental questions CEBAF (electron) and RHIC (proton) Programs



- No free quarks ?

"Confinement"?

- Mass of hadrons ?

"Mass without mass"?

- Changes in medium?

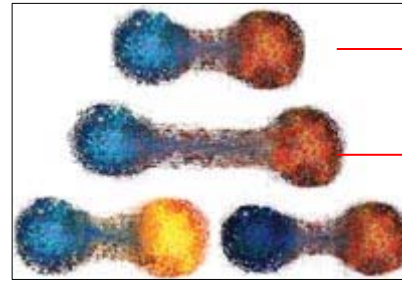
"Restoration of Chiral Symmetry"?

- Hadronic states?

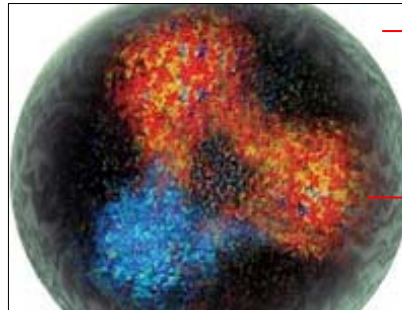
Spectroscopy of new bound systems?

- Hadronic interaction ?

Remnant of quark-quark interaction?



Force independent of distance



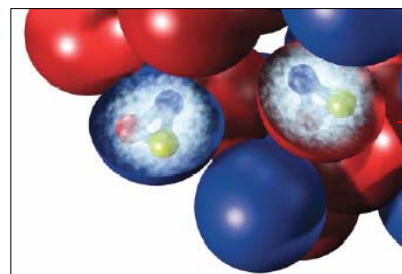
QCD vacuum

Valence quark



Meson

Baryon



Nucleus

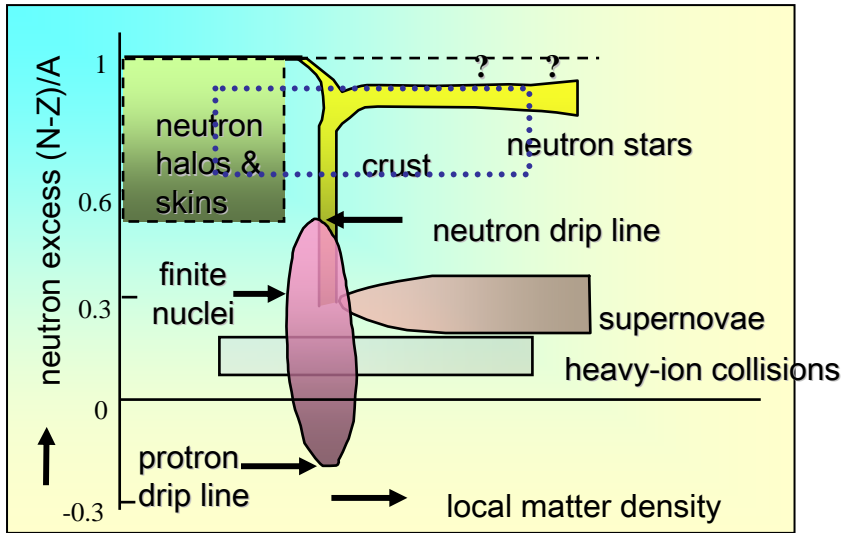
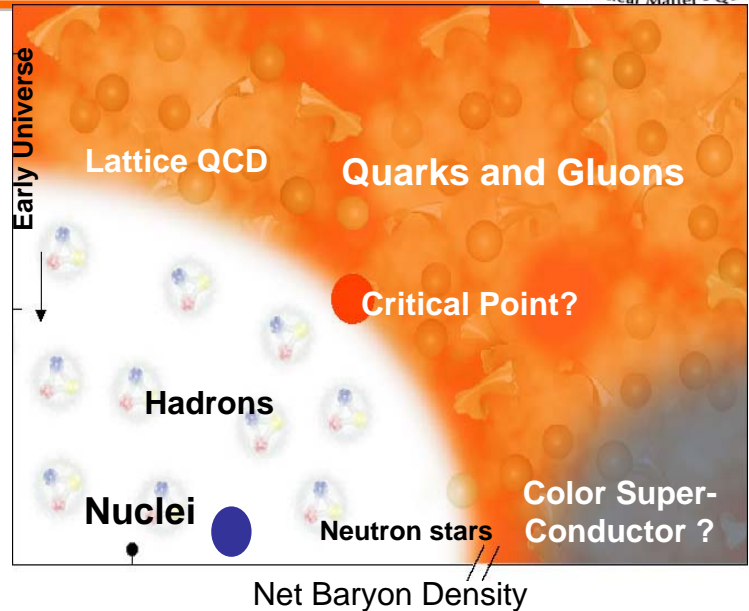


Exploring the Extremes RHIC (heavy ion) and Exotic Beam studies

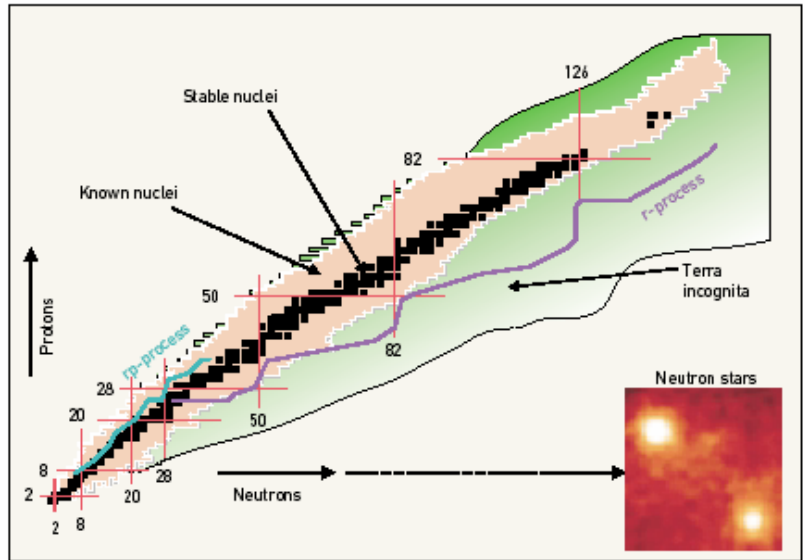


RHIC and LHC

$T_c \sim 0,2 \text{ GeV}$



Exotic Beam Facilities

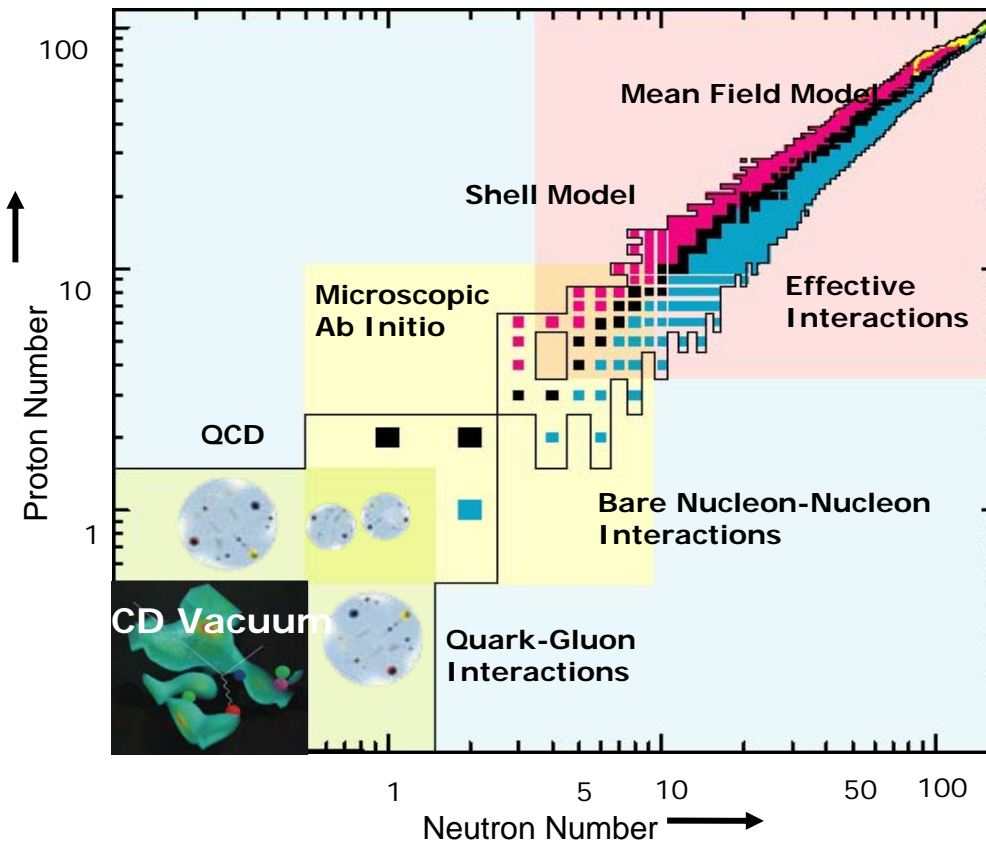
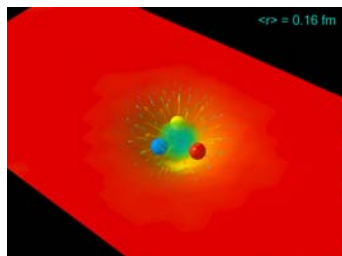




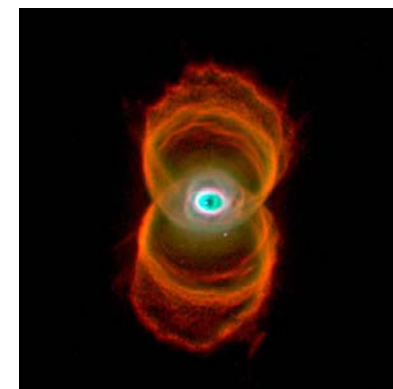
Nuclear Physics outcomes are relevant to other scientific fields



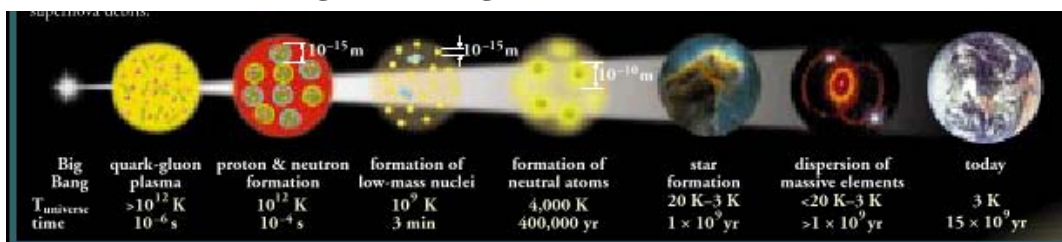
Understanding matter in the QCD Vacuum



Understanding astrophysics phenomena



Understanding matter origin and evolution of the universe





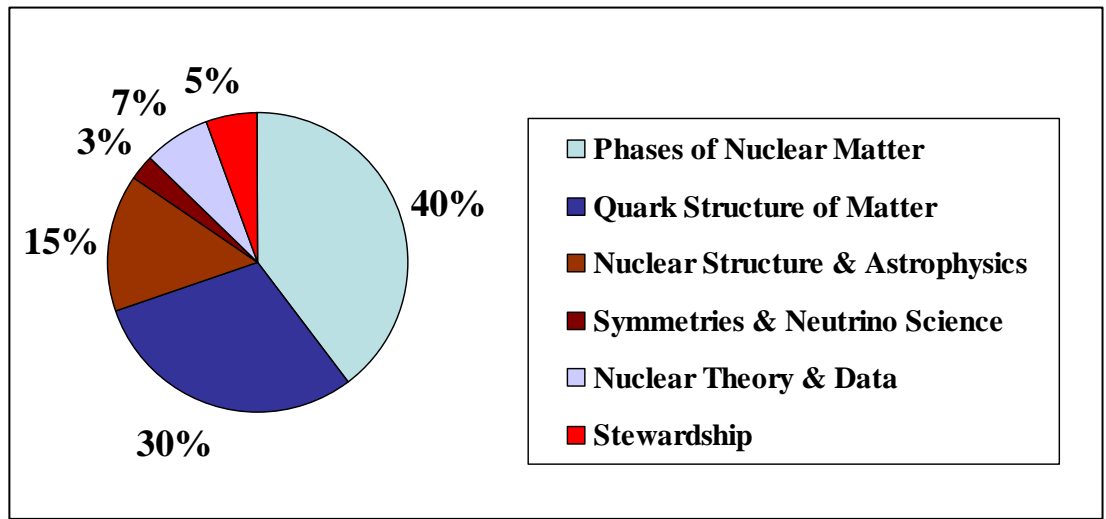
Program structured to address the scientific thrusts



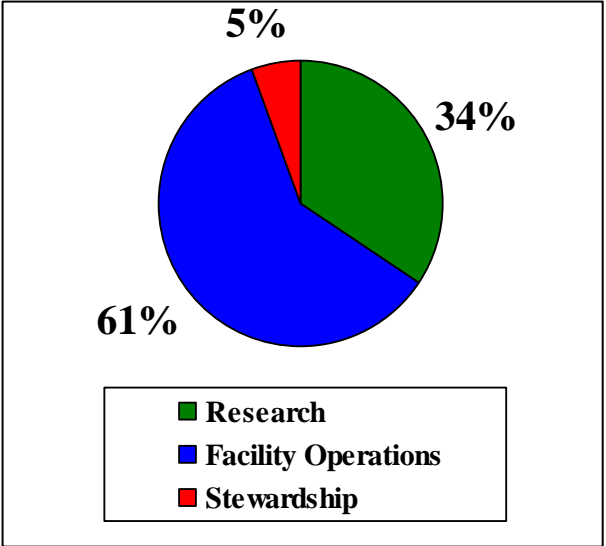
Subprograms are aligned with Scientific Thrusts

<u>Subprograms</u>	<u>FY2005</u> <u>(million \$)</u>	
Medium Energy	124.8	Quark Structure of Matter
Heavy Ions	174.7	Phases of Nuclear Matter
Low Energy	75.8	Structure/Astrophysics/Symmetries
Nuclear Theory	29.4	All NP areas plus Nuclear Data
	404.7	

Two of the Scientific Thrusts Dominate the Budget



Facility Operations Dominate Budget





Budget Context and Outlook



Funding for physical sciences, Office of Science and Nuclear Physics has been basically constant (eroded by inflation) over last number of years.

For FY 2006 the Nuclear Physics program experienced a -9.4% reduction (Office of Science had a -4.4% reduction) compared to FY 2005.

Impact of FY 2006 funding on the DOE SC Nuclear Physics program has been significant.

- Significant reduction in running time at facilities (without a significant contribution from the private sector there would have been no running at RHIC)
- Reduction in support for researchers and graduate/undergraduate students.

NSAC guidance was sought and obtained on scientific opportunities, options and priorities for an optimum U.S. nuclear physics program under constrained budgets.

The FY 2007 Congressional Budget Request provides a significant increase for Nuclear Physics.

In the context of the Administration's plan to double the funding in ten years for the physical sciences (DOE SC, NSF and NIST), there is the opportunity for Nuclear Physics to implement a world-class program.



FY 2007 Congressional Budget Request



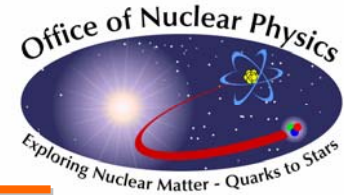
- **SC Budget Request is +\$505M (+14.4%) above FY 2006 Appropriations**
- **NP Budget Request is + \$87M (+23.7%) above FY 2006 Appropriations**

(dollars in thousands)

	FY 2005 Approp.	FY 2006 Approp.	FY 2007 President's Request	FY 2007 vs. FY 2006
Basic Energy Sciences.....	1,083,616	1,134,557	1,420,980	+286,423
Advanced Scientific Computing Research.....	226,180	234,684	318,654	+83,970
Biological and Environmental Research				
Base program.....	487,474	451,131	510,263	+59,132
Congressional-directed projects.....	79,123	128,700	—	-128,700
Total, Biological and Environmental Research.....	566,597	579,831	510,263	-69,568
High Energy Physics.....	722,906	716,694	775,099	+58,405
Nuclear Physics.....	394,549	367,034	454,060	+87,026
Fusion Energy Sciences.....	266,947	287,644	318,950	+31,306
Science Laboratories Infrastructure.....	37,498	41,684	50,888	+9,204
Science Program Direction.....	154,031	159,118	170,877	+11,759
Workforce Development for Teachers and Scientists.....	7,599	7,120	10,952	+3,832
Small Business Innovation Research/Technology Transfer.....	113,621	—	—	—
Safeguards and Security.....	67,168	68,025	70,987	+2,962
Subtotal, Science.....	3,640,712	3,596,391	4,101,710	+505,319
Use of prior year balances.....	-5,062	—	—	—
Total, Science.....	3,635,650	3,596,391	4,101,710	+505,319



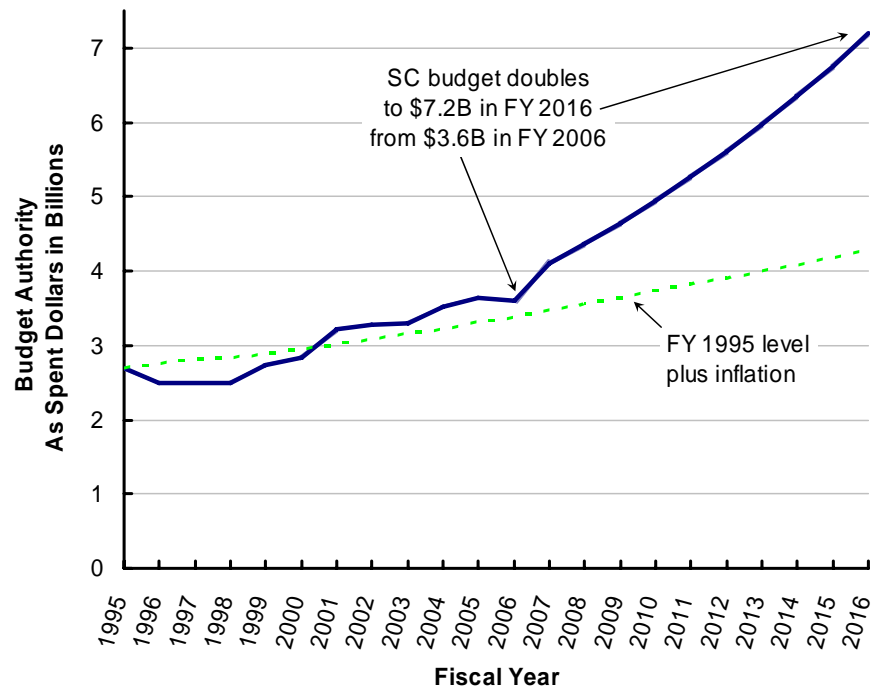
President's American Competitiveness Initiative



“We must continue to lead the world in human talent and creativity. Our greatest advantage in the world has always been our educated, hardworking, ambitious people -- and we're going to keep that edge. Tonight I announce an American Competitiveness Initiative, to encourage innovation throughout our economy, and to give our nation's children a firm grounding in math and science.”

“First, I propose to double the federal commitment to the most critical basic research programs in the physical sciences over the next 10 years. This funding will support the work of America's most creative minds as they explore promising areas such as nanotechnology, supercomputing, and alternative energy sources.”

**Office of Science Budget
Doubling from FY 2006 to FY 2016**





Goals of the Program



For U.S. to be a world leader in nuclear physics and achieve significant outcomes:

- Identify the most compelling scientific opportunities using the scientific community
- Design and build the facilities and tools that will address these opportunities
- Develop the research community and operate the facilities/tools to deliver significant outcomes

This leads to specific priorities for the U.S. NP program at this time:

- Operate and proceed with upgrades of RHIC and CEBAF to achieve their scientific goals
- Implement a plan to remain among the leaders in nuclear structure/astrophysics studies
- Implement capabilities to address high priority, high-impact scientific opportunities



Funding in the SC 10-year exercise supports these goals



Operate and proceed with upgrades of RHIC and CEBAF

- Operate the facilities and support the research community
- Proceed with CEBAF and RHIC upgrades
- Participate in the heavy ion program at LHC/CERN

Implement a plan to remain among the leaders in nuclear structure/astrophysics

- Operate the facilities and support the research community
- Allow U.S. researchers to do forefront science
 - (ATLAS and HRIBF accelerator/detector upgrades)
 - (Complete GRETINA detector)
 - (Experimental equipment at facilities with forefront exotic beam capabilities)
- Start construction of a U.S. exotic beam facility at end of this 5-year period

Implement the capabilities to address high priority scientific opportunities

- Fundamental neutron properties (tests of Standard Model) at the FNPB at SNS
- Neutrinoless Double Beta Decay experiment (mass/character of neutrino)
- Quantum ChromoDynamics (QCD) with lattice gauge calculations
- Next-generation nuclear physics research capabilities with accelerator R&D
- Nuclear data measurements and code development for next generation nuclear reactors



Opportunity to develop the tools for significant discoveries/major advancements



	Major Tools Today	Major Future Tool
<p>Nucleon-Degrees of Freedom (Nuclear Structure/Astrophysics)</p> <ul style="list-style-type: none"> What binds protons and neutrons into stable & unstable nuclei What is the origin of simple patterns in complex nuclei? When/how did the elements from iron to uranium originate? What causes stars to explode? 	<p>ATLAS, HRIBF (NCL/MSU)</p> <p>University accelerators</p> <p>Gammasphere</p> <p>SciDAC</p>	<p>Exotic Beam Accelerator</p> <p>Exotic Beam Investments</p> <p>GRETINA</p> <p>SciDAC</p>
<p>Quark-Degrees of Freedom (Quantum ChromoDynamics (QCD))</p> <ul style="list-style-type: none"> What is the nature of the quark-gluon matter of the early universe and what transitions led to protons and neutrons? Where is the glue that binds quarks into strongly interacting particles, and what are its properties? What is the internal structure of the proton? What does QCD predict for the properties of nuclear matter? 	<p>RHIC (STAR/PHENIX)</p> <p>SciDAC</p> <p>CEBAF</p>	<p>RHIC II (Detector Upgrades)</p> <p>HI LHC</p> <p>LQCD & SciDAC</p> <p>12 GeV CEBAF Upgrade</p>
<p>Fundamental Symmetries/Neutrinos (Test of "Standard Model")</p> <ul style="list-style-type: none"> What are the masses of neutrinos and how have they shaped the evolution of the universe? Why is there more matter than antimatter? 	<p><u>Neutrinos</u></p> <p>SNO, KamLAND, MiniBooNE</p> <p><u>Neutron Properties</u></p> <p>LANSCE expts</p>	<p>Double Beta Decay</p> <p>SNS expts (nEDM)</p>

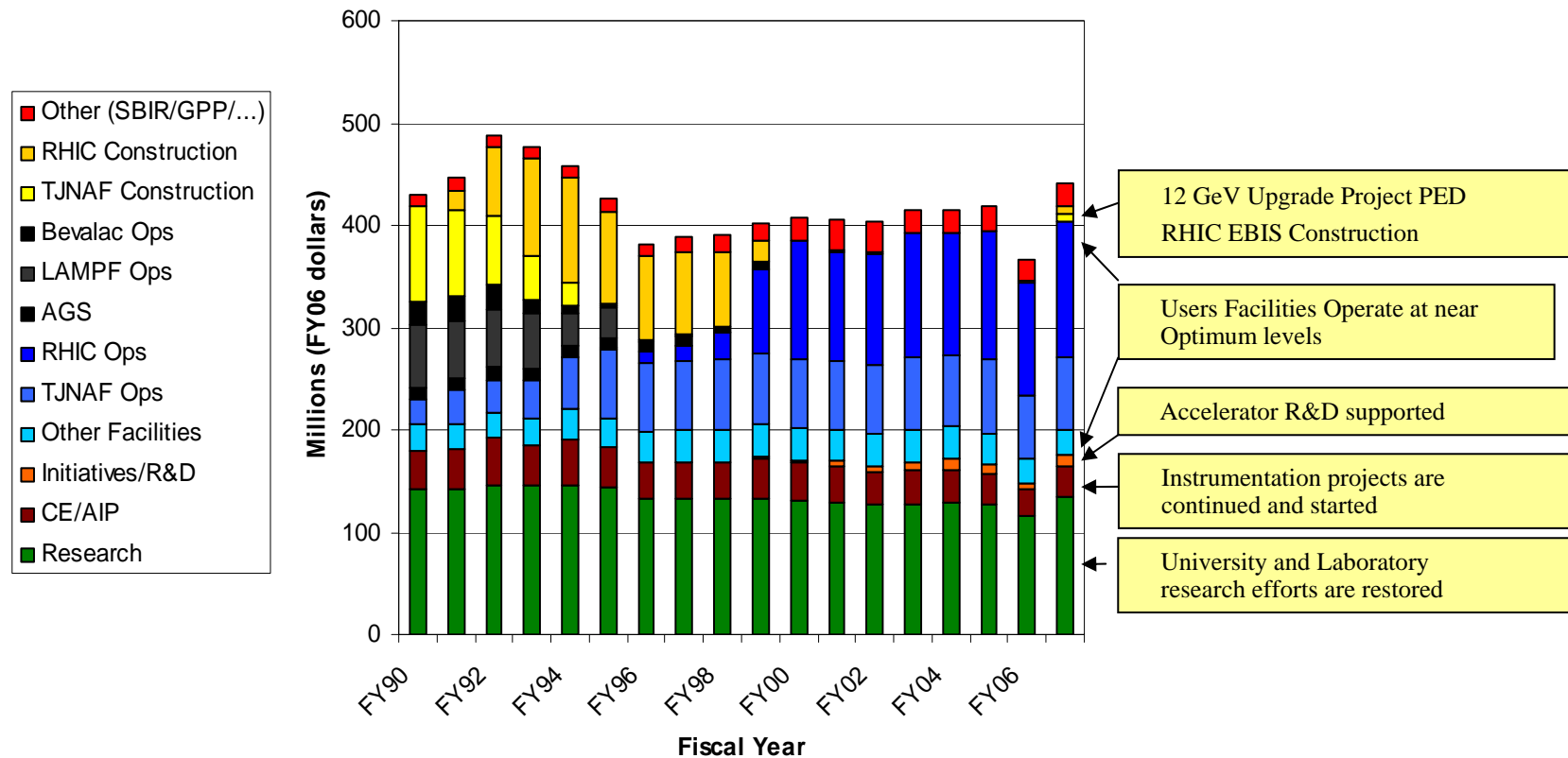


DOE SC NP Program in FY 2007



FY 2007 Budget Request supports a strong productive program that develops needed research capabilities

- Facility Operations continue to take lion's share of budget (~55%)
- Important investment for RHIC, CEBAF and high priority scientific opportunities
- Research efforts are restored & accelerator R&D (RHIC II and exotic beam facility) supported





Planning Processes



Guidance on scientific opportunities and priorities from scientific community

- DOE/NSF Nuclear Science Advisory Committee (NSAC): [[new Long Range Plan](#)]
- Other bodies (National Academy of Sciences, APS, etc.): [[RISAC & Decadal Survey](#)]
- Laboratory Facility Program Advisory Committees (PACs), etc.

Strategic Plan and Priorities developed within the Office of Science

- 5-year plans and priorities for new research capabilities

Administration Priorities and Interagency Planning

- Annual OMB/OSTP Research Priorities/President's Management Agenda
- OSTP Interagency Working Groups: [[POU & HEDP](#)]

International Coordination

- Extensive collaboration occurs through various international agreements
- 1999 MegaScience Nuclear Physics Working Group Report
- On-going Global Science Working Group on Nuclear Physics [[Report 2008](#)]



Summary



The U.S. nuclear physics program is a world-leader or among the leaders in all the major scientific thrusts of nuclear physics today because of past investments.

To realize the benefits of the past investments and achieve the planned goals one needs sustained funding to operate the facilities and support the research community.

To remain competitive and maintain a leadership role in the future investments in expanded research capabilities are needed.

In the context of the a doubled budget for the Office of Science over next ten years – there an opportunity for NP to implement a world-class program that will deliver new insight into the nature and structure of matter – that will have significantly impact outside of nuclear physics.