Nuclear Physics

and (Nuclear Science Advisory Committee's role in)

Strategic Planning of the Isotope Program

Robert Tribble

Workshop on the Nation's Needs for Isotopes: Present and Future

August, 2008

DOE and NSF formed the **Nuclear Science Advisory Committee** in October, 1977

Early History

Herman Feshbach
Massachusetts Institute of Technology,
Chairman

Fay Ajzenberg-Selove
University of Pennsylvania

Peter D. Barnes
Carnegie-Mellon University

Gerald E. Brown
State University of New York at Stony Brook

William A. Fowler
California Institute of Technology,

Gerald T. Garvey
Argonne National Laboratory

Willy Haeberli
University of Wisconsin

Isaac Halpern
University of Washington

Bernard G. Harvey
Lawrence Berkeley Laboratory

John R. Huizenga
University of Rochester

Edward A. Knapp
Los Alamos Scientific Laboratory

Robert E. Pollock
Indiana University

Donald Robson
Florida State University

Thomas T. Sugihara
Texas A&M University

Major role of **NSAC**
in past three decades:
provide guidance to DOE and NSF for
strategic planning
in the Nuclear Physics program

$\Rightarrow$ **Long Range Plans**

A LONG RANGE PLAN FOR NUCLEAR SCIENCE
DECEMBER 1979
The DOE/NSF Nuclear Science Advisory Committee

Herman Feshbach
Massachusetts Institute of Technology,
Chairman

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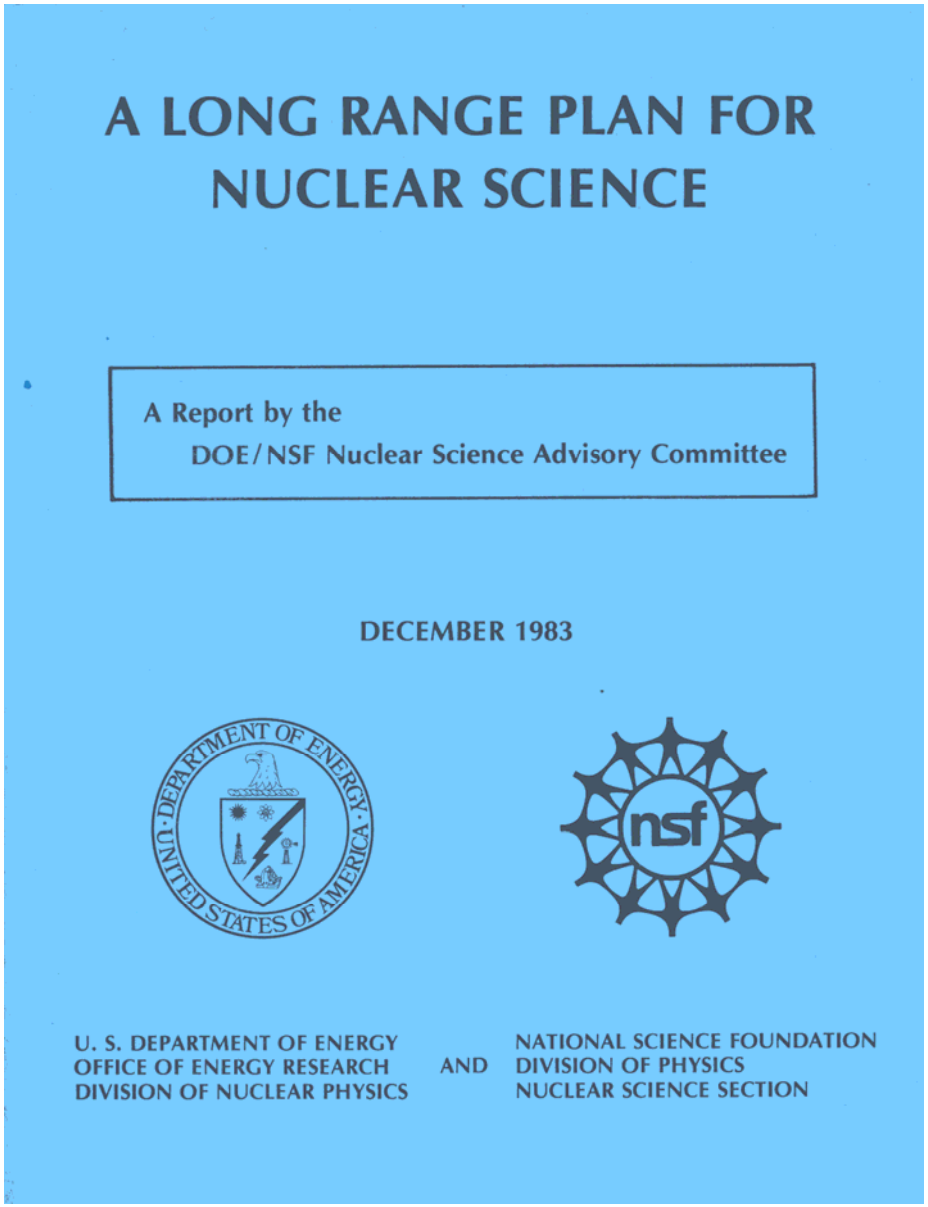
Recommended construction of a high-energy electron beam facility to study nucleon and nuclear structure.

1983 LRP

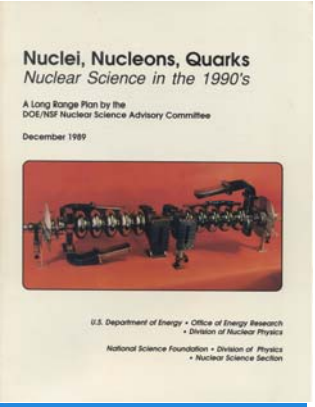


Community input at the spring 1983 American Physical Society meeting

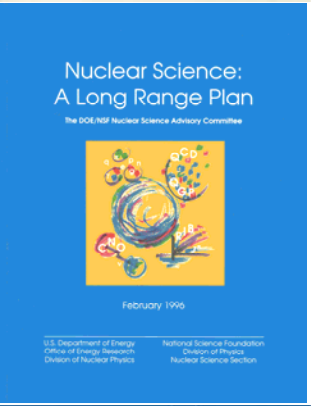
Working Group (56 members) met at Wells College in July, 1983 to formulate recommendations

3 Recommendations:
(1) Immediate $20 M increase in ops. and equipment; (2) **Construct** the **Relativistic Heavy-Ion Collider**; and (3) Increase in budgets for research and operations over longer term

Subsequent LRP's



1989 (complete Jefferson Lab Facility (JLab); build Relativistic Heavy Ion Collider (RHIC))



1996 (utilize new facilities (JLab and RHIC); upgrade National Superconducting Cyclotron Laboratory and plan for new rare isotope beam facility)

2002 (effective use of facilities; construct the Rare Isotope Accelerator; build deep underground laboratory ('DUSEL'); upgrade Jefferson Lab facility)

U.S. Nuclear Science

General goal:
Explain the origin, evolution, and structure of the visible matter of the universe—the matter that makes up stars, planets, and human life itself.

Frontiers:

- Quantum Chromodynamics (QCD)
- Physics of Nuclei and Astrophysics
- Fundamental Symmetries and Neutrinos

Fourteen key questions that guide the program

Advances in Nuclear Physics require interplay

Theory ↔ Experiment

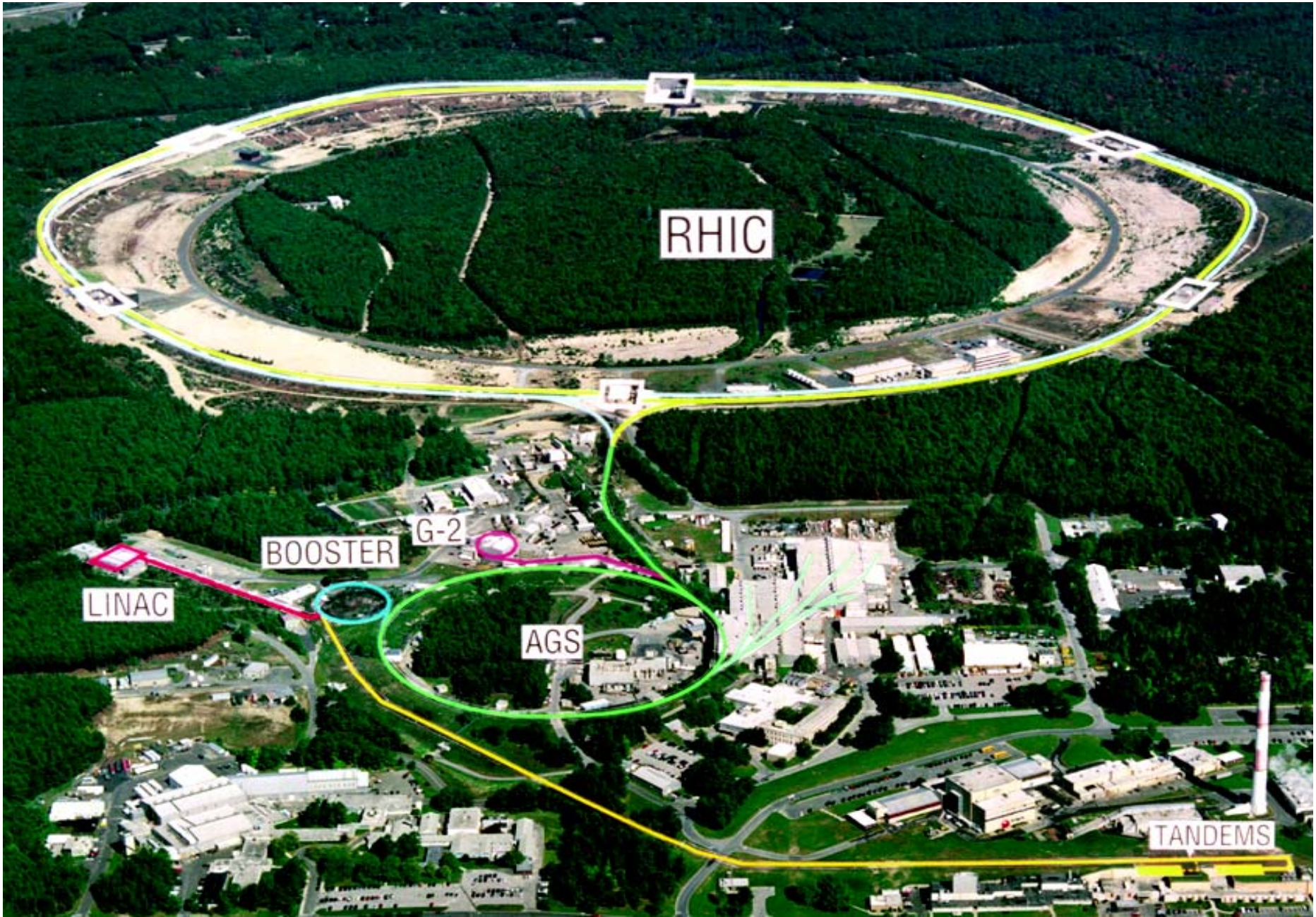
Experimental Program ⇒ Facilities

U.S. Facilities:

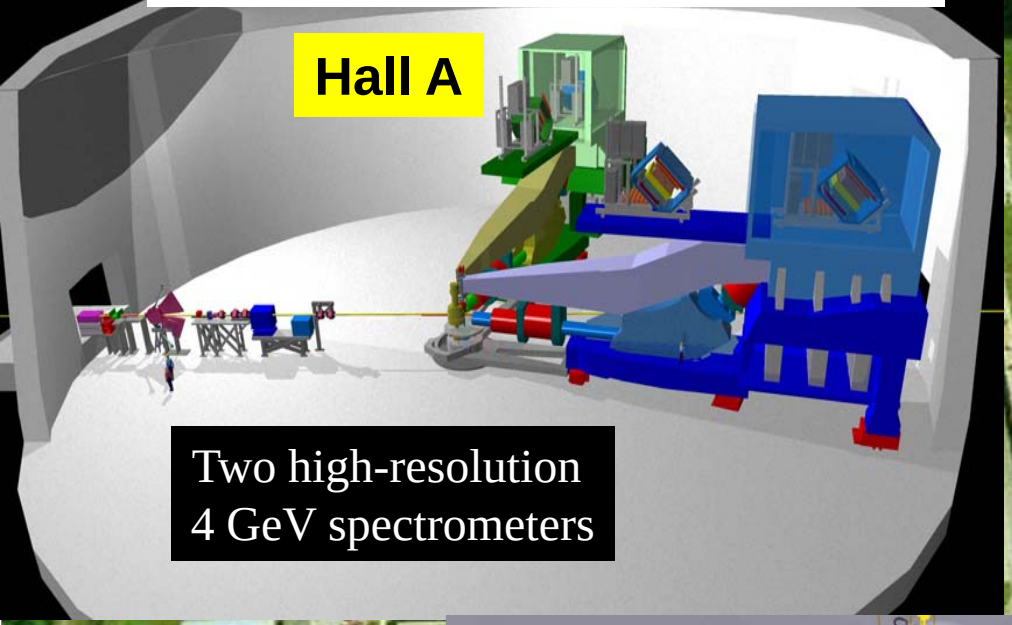
Quantum Chromodynamics

(and hadron structure)

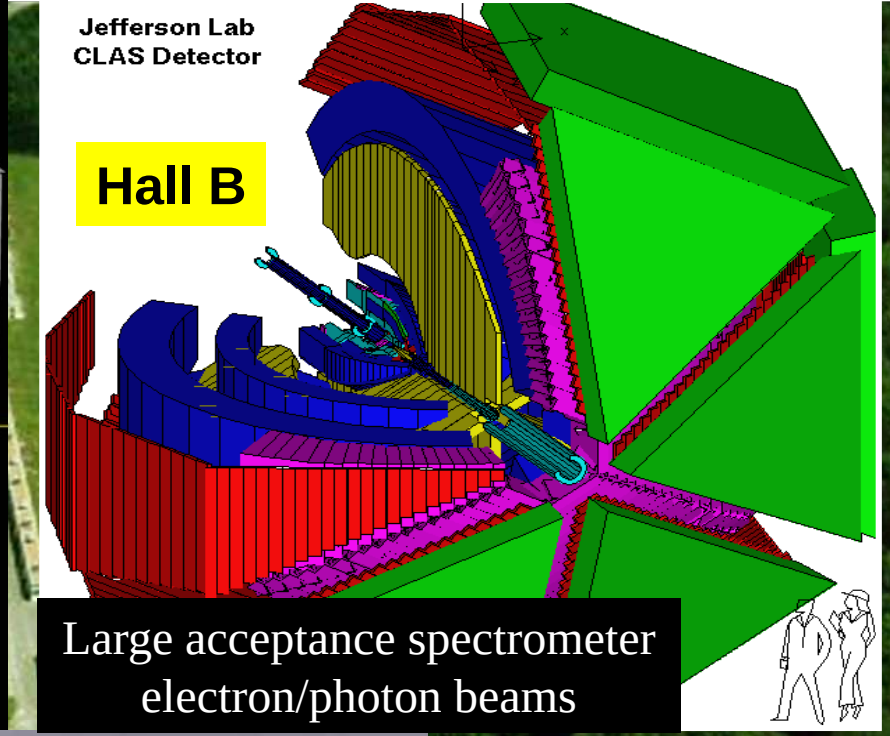
RHIC: the Relativistic Heavy Ion Collider



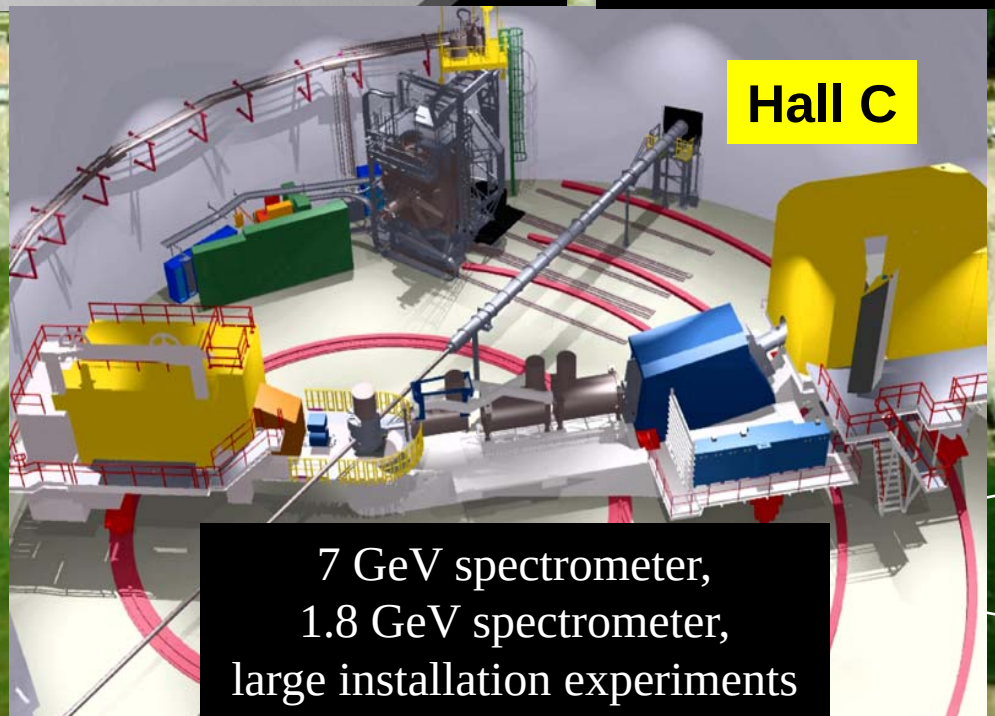
Jefferson Lab Today



Two high-resolution
4 GeV spectrometers



Large acceptance spectrometer
electron/photon beams



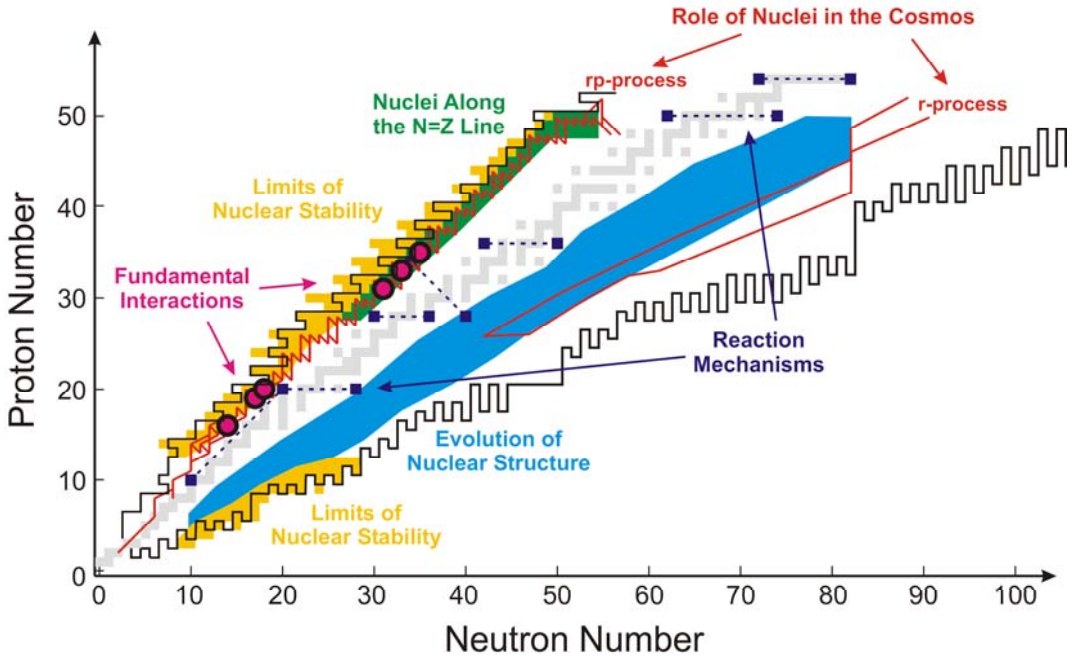
7 GeV spectrometer,
1.8 GeV spectrometer,
large installation experiments

C

U.S. Facilities: Physics of Nuclei and Nuclear Astrophysics

[Posters available for many of these!]

National Superconducting Cyclotron Laboratory
Coupled Cyclotron Facility



Primary beams (He–U): E/A ≤ 200 MeV
Fast and stopped rare isotopes beams
Reaccelerated beams in 2010

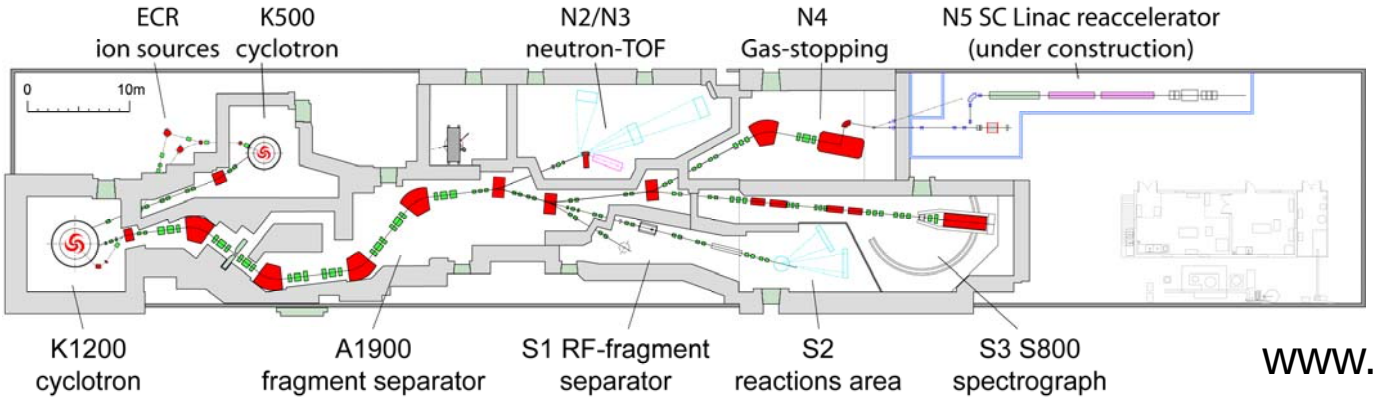
Research themes:

Properties of nuclei very far from stability

Nuclear processes responsible for the chemical evolution of the universe

Equation of state (EOS) of neutron-rich nuclear matter

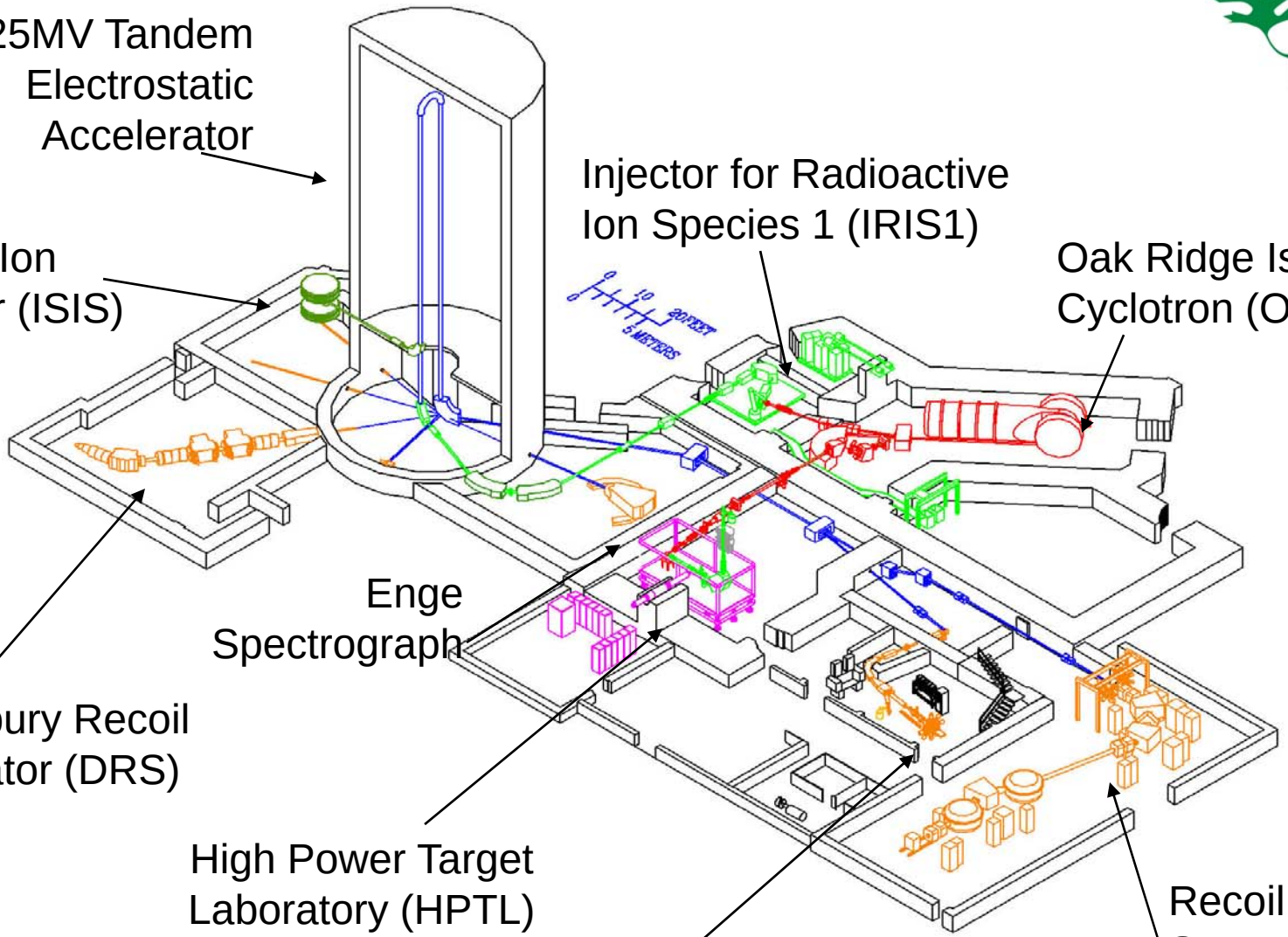
Beam dynamics and accelerator physics: superconducting cyclotrons, linacs, and magnets



Main funding comes from the U.S. National Science Foundation (NSF) and Michigan State University

www.nscl.msu.edu

Holifield Rare Isotope Beam Facility



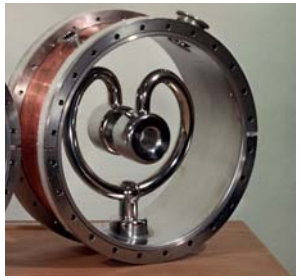
The Argonne Tandem Linear Accelerator System Facility

8.5-MV Tandem Injector

Important for:

Beams of A<58

Long-lived RIB's



ATLAS

FRAGMENT MASS ANALYZER
GAMMASPHERE
TARGET AREA IV
GENERAL PURPOSE BEAM LINE
LARGE SCATTERING FACILITY
ATOM TRAP
GENERAL PURPOSE BEAM LINE
ECR I ION SOURCE
ECR I ION SOURCE
FN-TANDEM INJECTOR
ATLAS LINAC
ATOMIC PHYSICS
SPLIT-POLE SPECTROMETER
INJECTOR LINAC
TARGET AREA III
BOOSTER LINAC
CANADIAN PENNING TRAP
& Advanced Penning Trap
PII
ACCELERATOR CONTROL ROOM
GENERAL PURPOSE BEAM LINE
0
50
APPROX. SCALE (feet)

2 ECR Ion Sources on HV platform

12-MV Positive Ion Injector (PII)

Required for:

Beams with A>58

Noble gases

High current

18 Quarter-wave SC resonators

24-Resonator Booster

19-Resonator ATLAS

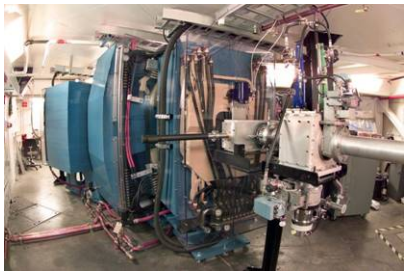
World-Class Equipment

88-Inch Cyclotron- Facilities

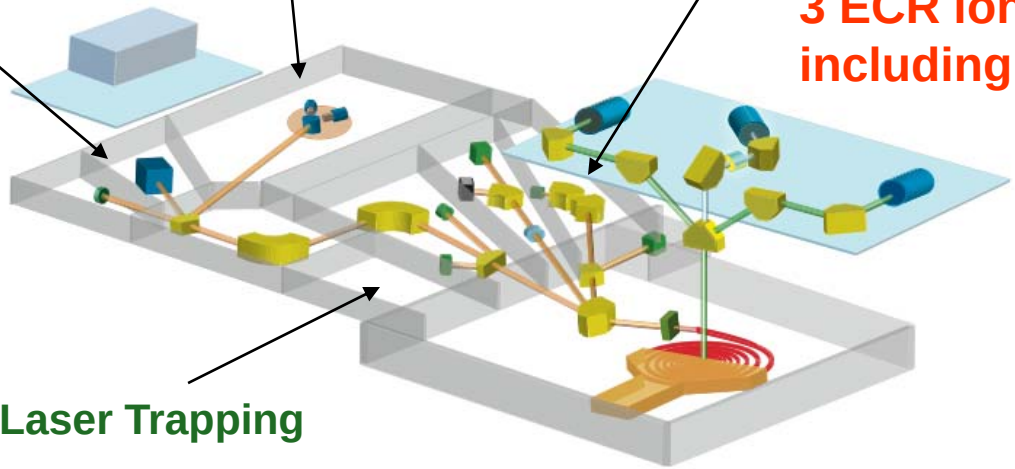
BASE Facility
Space radiation effects

LIBERACE

Berkeley Gas-filled Separator



3 ECR ion sources including VENUS

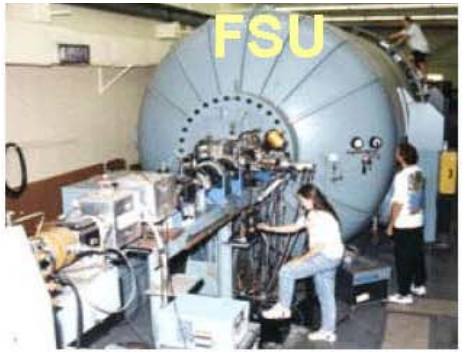


Laser Trapping

Proton	55 MeV
Alpha	130 MeV
Li to S	32 MeV/A
Kr	20 MeV/A
Xe	14 MeV/A
U	5 MeV/A

K-140 separated sector cyclotron
High intensity light and heavy ions

National Science Foundation mid-sized Facilities



FN Tandem with LINAC post-acceleration radioactive beam facility RESOLUT

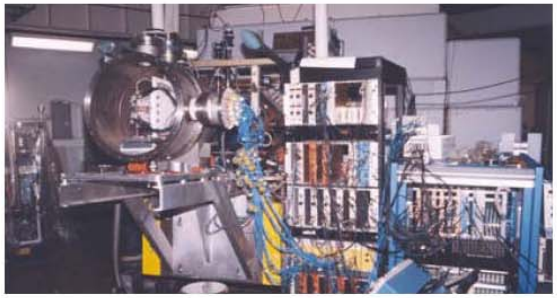
FN Tandem, KN & JN single ended accelerators radioactive beam facility TWINSOL AMS facility with gas filled spectrometer

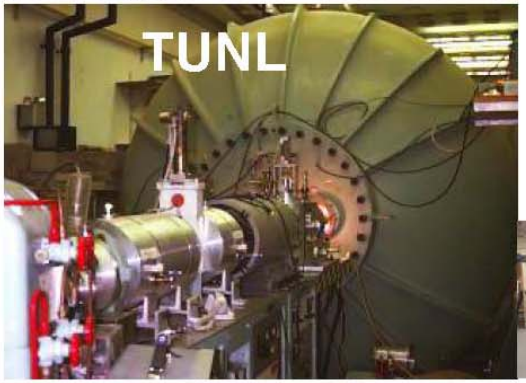
Department Of Energy University Facilities

University of Washington Tandem Van de Graaf and center for Nuclear and Particle Astrophysics

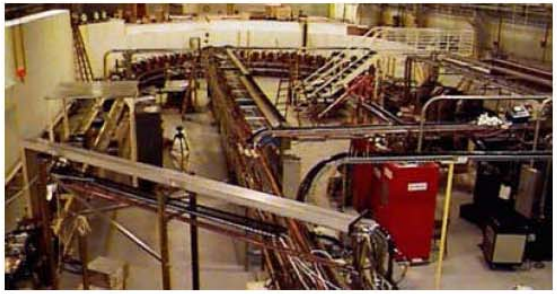
K-500 cyclotron
radioactive beam facility MARS

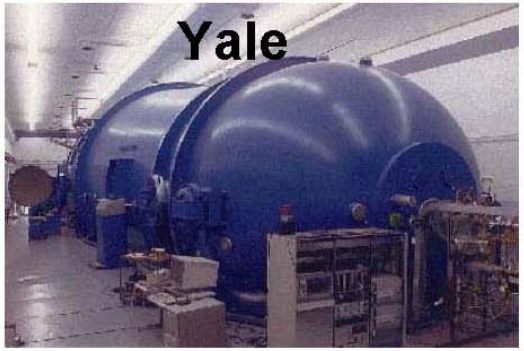
[**K150 (88”) cyclotron**]





FN Tandem, neutron beam facility
LENA laboratory, JN single ended machine
HIGS photon beam facility





MP Tandem
Sassyer Separator
Yrast Ball,

Fundamental Symmetries and Neutrinos

Uses wide range of facilities

(No specific Nuclear Physics facilities)

Partial list (alphabetical order):
Fermilab, Los Alamos Neutron Science Center, National Institute of Standards and Technology Reactor,
Power reactors, Spallation Neutron Source, Sun, . . .

NSAC today

NSAC Membership for 2008

Douglas Bryman
Univ. British Columbia

Richard Casten (DNP)
Yale University

Vince Cianciolo
ORNL

Charlotte Elster
Ohio University

Rolf Ent
JLab

Ulrich Heinz
Ohio State Univ.

Xiangdong Ji
Univ. of Maryland

Roy Lacey (ACS)
SUNY-Stony Brook

I.-Yang Lee
LBNL

Christopher Lister
ANL

Naomi Makins
Univ. of Illinois

Gail McLaughlin
NC State Univ.

Richard Milner
MIT

Michael Ramsey-Musolf
Univ. of Wisconsin

Hendrik Schatz
NSCL and MSU

Johanna Stachel
Univ. Heidelberg

Robert Tribble (chair)
TAMU

Thomas Ulrich
BNL

Ubirajara van Kolck
Univ. of Arizona

John Wilkerson
Univ. of Washington

Charter

On a continuing basis, NSAC will *provide advice upon request* to both the Department of Energy and the National Science Foundation on scientific priorities within the field of basic nuclear science research. Basic nuclear research is understood to encompass experimental and theoretical investigations of the fundamental interactions, properties, and structure of atomic nuclei.*

***May need modification in the near future!**

NSAC activities will include assessment of and recommendations concerning:

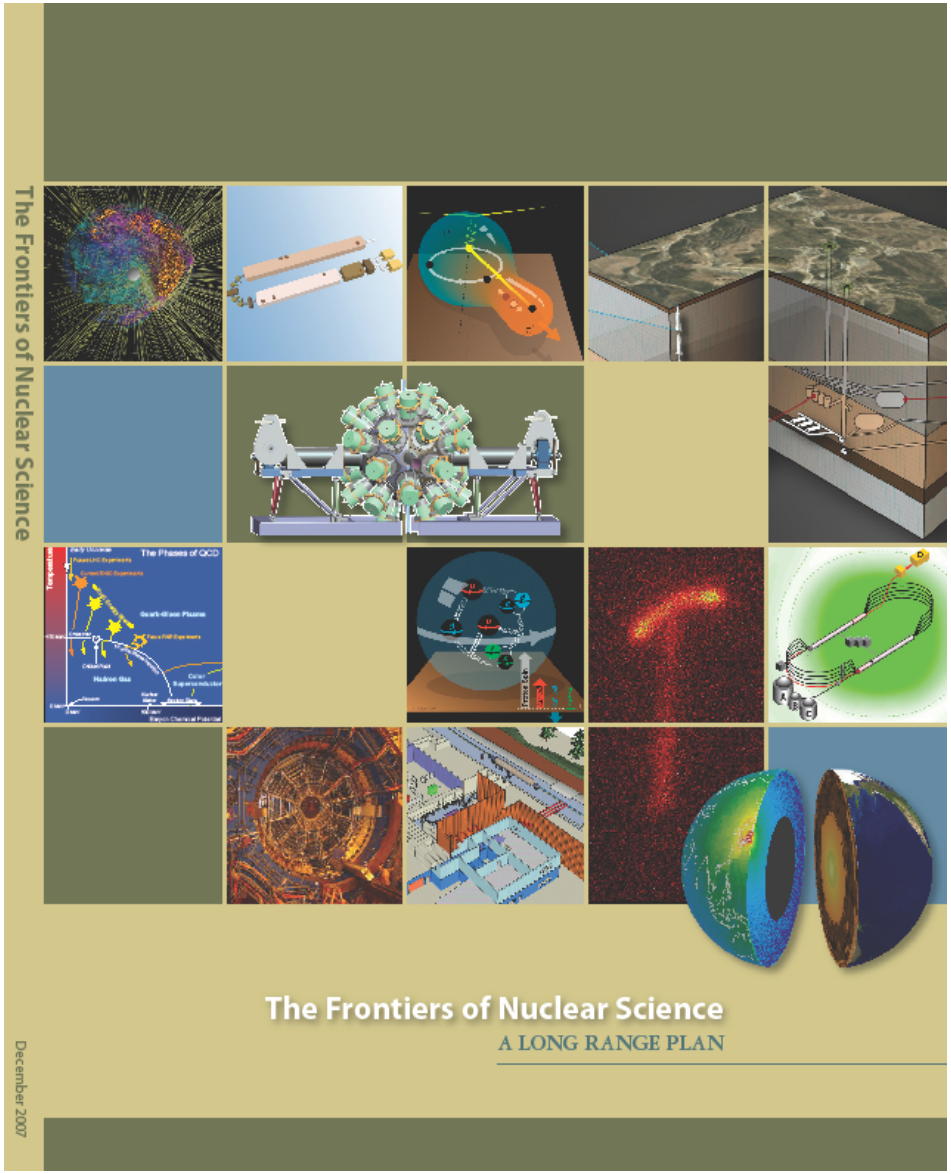
- **Objectives, directions and development, and future frontiers of the field of basic nuclear science research.**
- **Adequacy of present facilities, and the need and relative priority for new facilities.**
- **Facility and instrument development programs needed to advance the field.**
- **Institutional balance of support for optimized scientific productivity and training of nuclear scientists.**
- **Relationships of basic nuclear science with other fields of science.**
- **In addition, NSAC will conduct specialized studies when requested by the agencies. These studies will be published as reports, if appropriate.**

NSAC Activities 2003-2007

- 12 Subcommittee reports
- Formation of NuSAG (Neutrino Scientific Assessment Group)
  - Joint subcommittee with High Energy Physic setup for two years
  - Three separate charges given to NuSAG (three reports)
- Just completed new Long Range Plan (12/2007)

2007 LRP

Recent Activity



Town Meetings by APS/DNP:

-Nuclear Structure and Astrophsyics

-Neutrinos and Symmetries

-Phases of QCD Matter

-QCD and Hadron Structure

[White Papers produced]

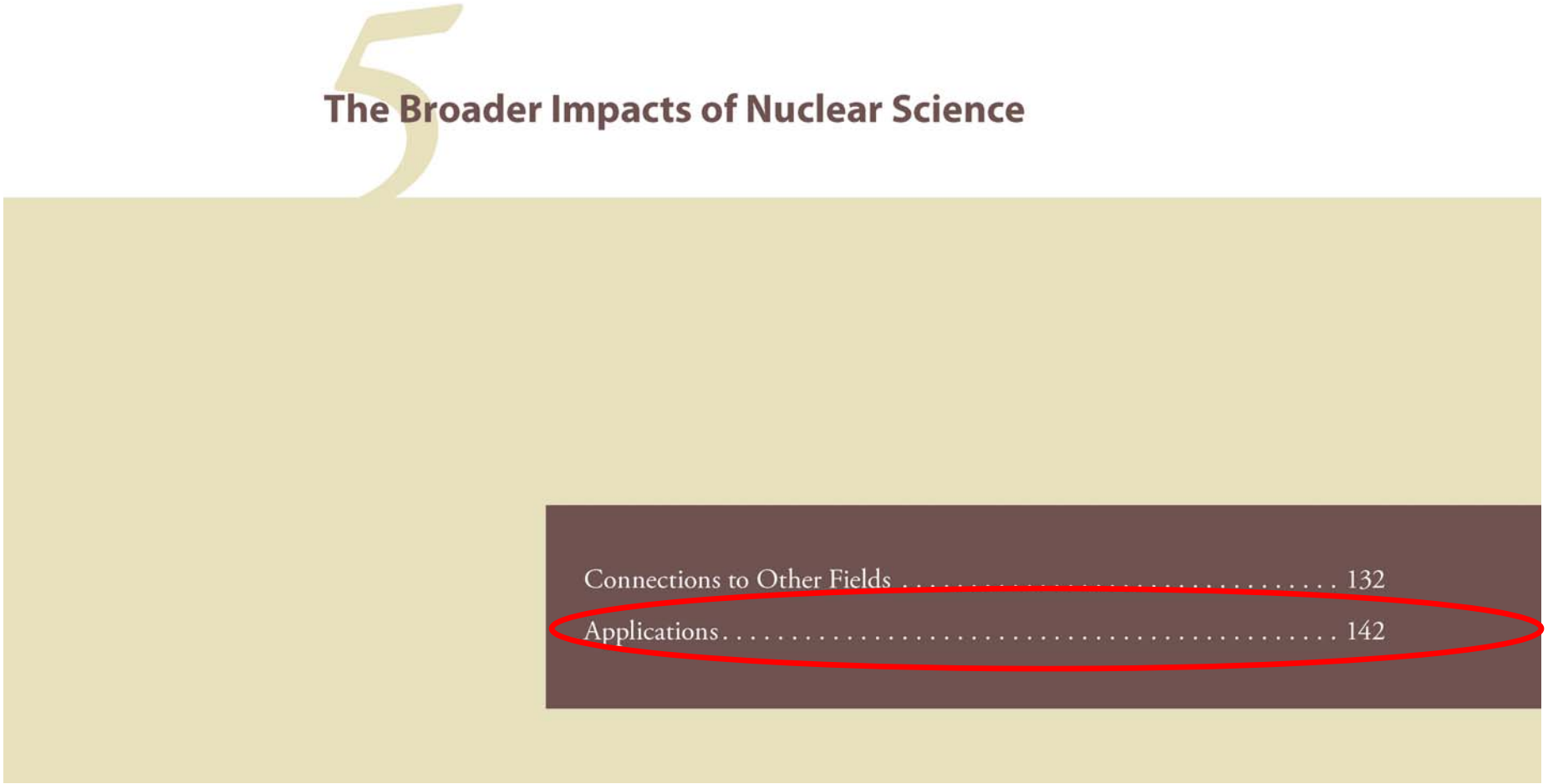
59 member Working Group met in Galveston in May, 2007 to determine priorities

4 Recommendations: (1) JLab Upgrade, (2) construct FRIB, (3) Standard Model initiative ('DUSEL'), (4) RHIC II.

[http://www.sc.doe.gov/np/nsac/nsac.html]

NSAC and Isotope Production

NP and applications – a long tradition



NSAC and Isotope Production

Table 5.1: Summary of current applications of nuclear science

Medical Diagnostics and Therapy
- Radiography
- Computerized tomography
- Positron emission tomography
- MRI (regular)
- MRI (with polarized noble gases)
- Photon therapy
- Particle-beam therapies
- Instrument sterilization with ^{60}Co gamma rays
- Linac irradiation treatments
- Radioisotope tagging

Safety and National Security
- Airport safety and security
- Large-scale X-ray scanners
- Nuclear materials detection
- Arms control and nonproliferation
- Stockpile stewardship
- Tritium production
- Space-radiation health effects
- Semiconductor performance in radiation environments
- Food sterilization
- Electronic single-event upset testing

Energy Production and Exploration
- Nuclear reactors
- Oil-well logging
- Research and development for next-generation nuclear reactors

Art and Archaeology
- Authentication
- Nuclear dating

Material Analysis
- Activation analysis
- Accelerator mass spectrometry
- Atom-trap trace analysis
- Forensic dosimetry
- Proton-induced X-ray emission
- Rutherfold backscattering
- Ion-induced secondary-ion emission
- Muon spin rotation

Environmental Applications
- Climate-change monitoring
- Pollution control
- Groundwater monitoring
- Ocean-current monitoring
- Radioactive-waste burning
- Radon detection
- Smoke-stack monitoring

Materials Testing and Modification
- Trace-isotope analysis
- Ion implantation
- Surface modifications
- Flux pinning in high-T_c superconductors
- Free-electron lasers
- Cold and ultra-cold neutrons
- Single-event efforts
- Microphone filters

NSAC and Isotope Production

From **2007 LRP Overview**:

tory, that there will be many.

Through applications, nuclear science provides a return on the federal investment made to support the program of basic research. Recognizing this, we welcome closer ties between basic research and the applications of our trade.

RESOURCES

NSAC was provided budget guidance by DOE and NSF

NSAC and Isotope Production

Upcoming Activities:

- Establish Standing Subcommittee on Isotopes?
- First charge(s)?

Possible tasks:
- identify needs and priorities for new isotopes for R&D
- develop long term strategy (i.e. an 'LRP') for the Isotope Program

Actual charge(s) to NSAC at next meeting – August 21, 2008!

NSAC and Isotope Production

Outcomes from this Workshop are very important as a first step for the upcoming NSAC subcommittee work on isotopes!