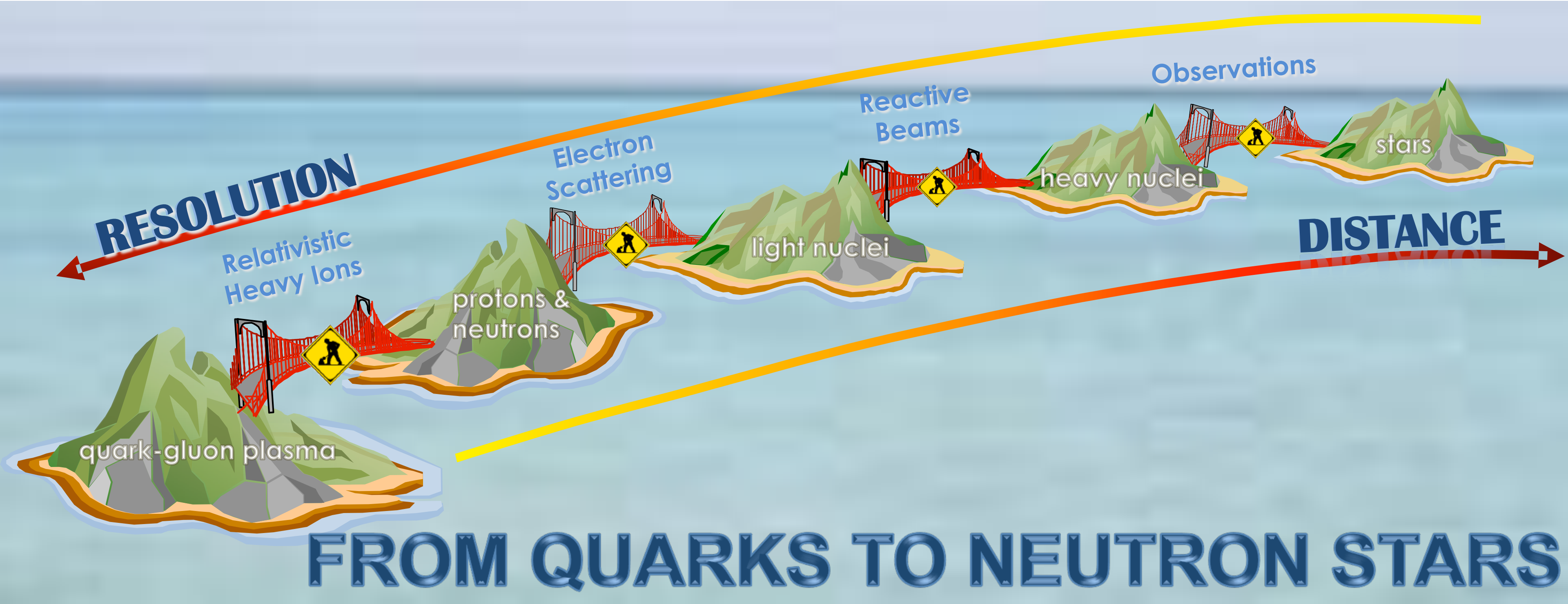
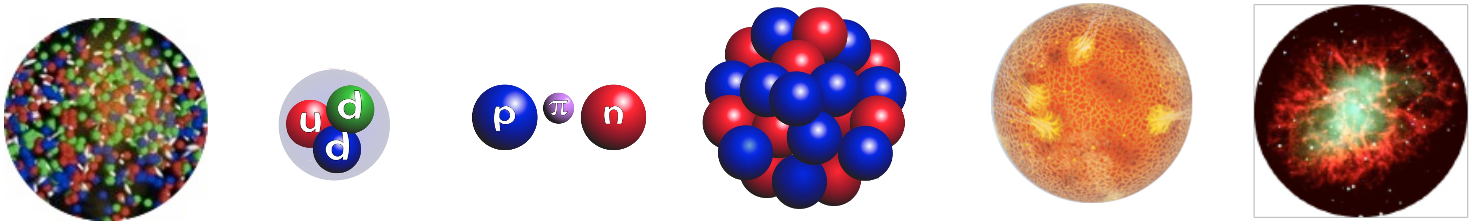
Subfields of nuclear physics

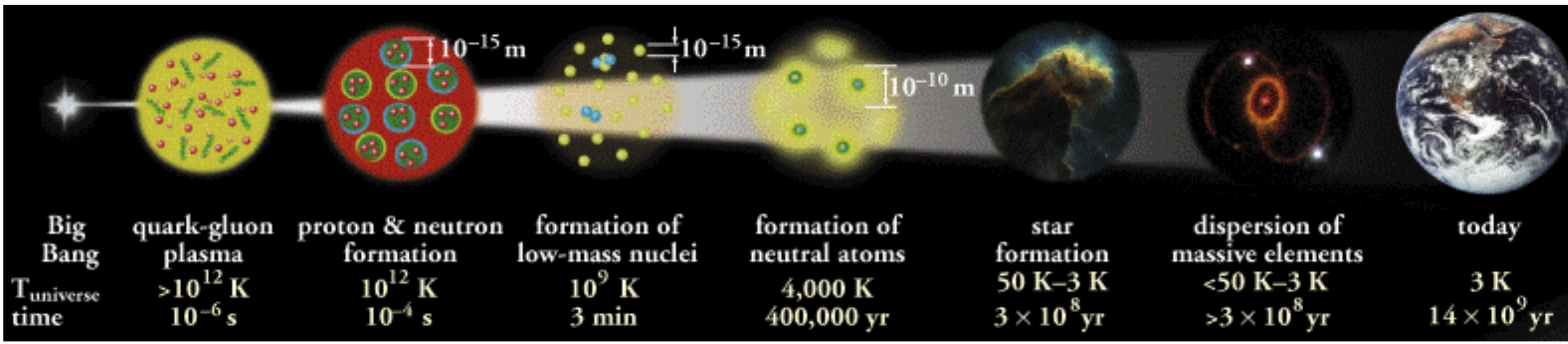
- Nuclear structure, whose goal is to build a coherent framework for explaining all properties of nuclei and nuclear matter and how they interact;
- Nuclear astrophysics, which explores those events and objects in the universe shaped by nuclei and nuclear reactions;
- Hot QCD, or relativistic heavy ions, which examines the state of melted nuclei and with that knowledge seeks to shed light on the nature of those quarks and gluons that are the constituent particles of nuclei;
- Cold QCD, or hadron structure, which explores the characteristics of the strong force and the various mechanisms by which the quarks and gluons interact and result in the properties of the protons and neutrons that make up nuclei;
- Fundamental symmetries, those areas on the edge of nuclear physics where the understandings and tools of nuclear physicists are being used to unravel limitations of the Standard Model and to provide some of the understandings upon which a new, more comprehensive Standard Model will be built.



Nuclear Physics in the Universe:

The Big Bang timeline, from inflation to quark soup to the birth of the light nuclei to the formation of atoms and gravitationally bound structures.

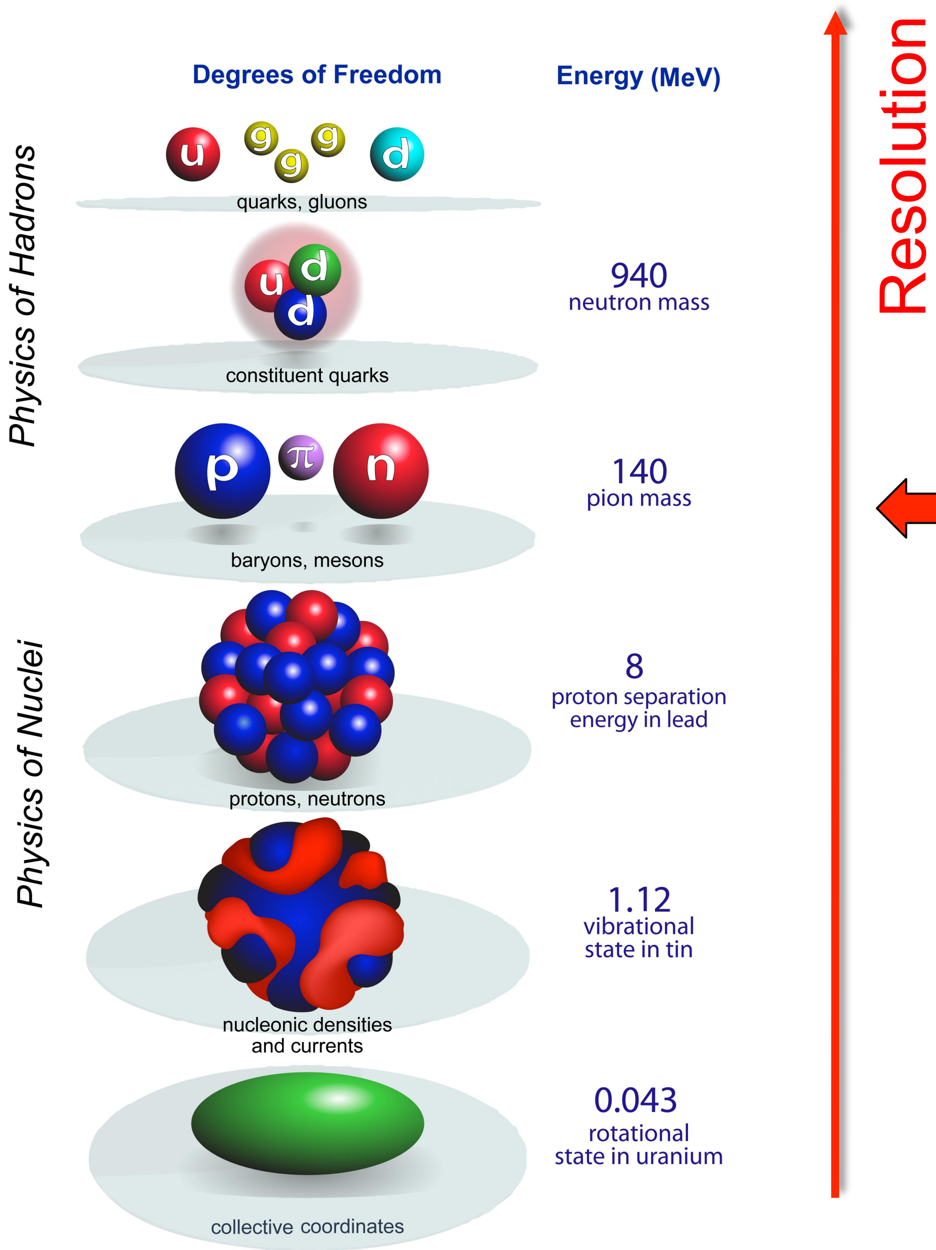




http://www.lbl.gov/abc/wallchart/

Image: Particle Data Group/Lawrence Berkeley National Laboratory

Nuclear degrees of freedom



Hot and dense quark-gluon matter

Hadron structure

Hadron-Nuclear
interface

Nuclear structure
Nuclear reactions

Nuclear astrophysics
New standard model

Applications of nuclear science

The scientific agenda (questions that drive the field)

PERSPECTIVES ON THE STRUCTURE OF ATOMIC NUCLEI

- What are the limits of nuclear existence and how do nuclei at those limits live and die?
- What do regular patterns in the behavior of nuclei divulge about the nature of nuclear forces and the mechanism of nuclear binding?
- What is the nature of extended nucleonic matter? What are its phases?
- How can nuclear structure and reactions be described in a unified way?
- How can the symbiosis of nuclear physics and other subfields be exploited to advance understanding of all many-body systems?

NUCLEAR ASTROPHYSICS

- How old is the universe?
- How did the elements come into existence?
- What makes stars explode as supernovae, novae, or X-ray bursts?
- What is the nature of neutron stars?
- What can neutrinos tell us about stars?

EXPLORING QUARK-GLUON PLASMA

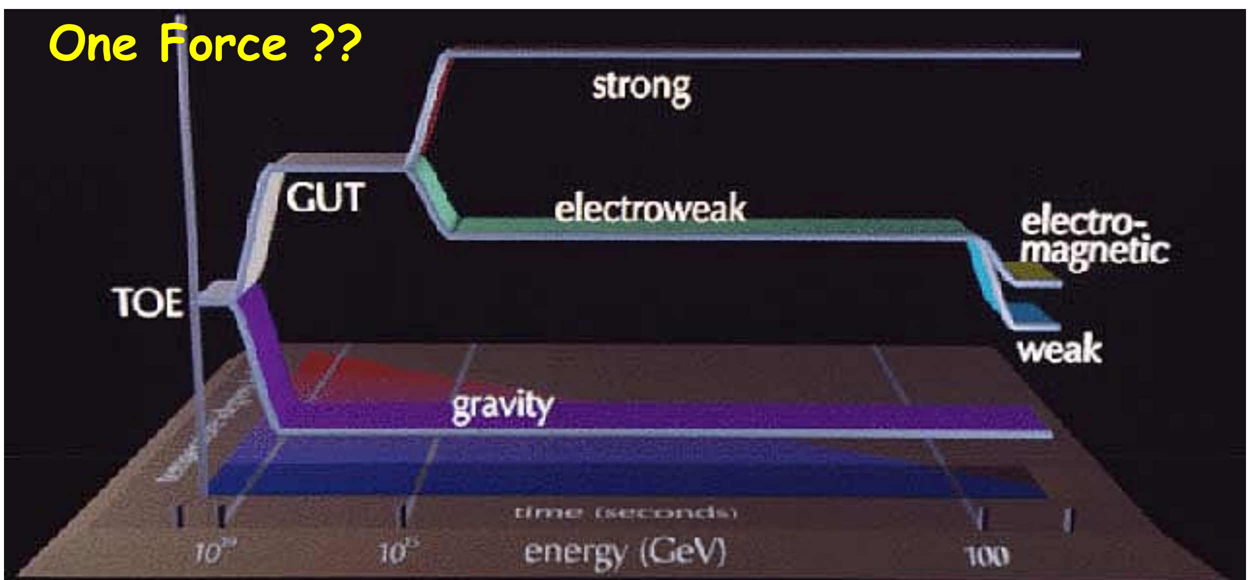
- What are properties of near-perfect liquid QGP
- What is the origin of confinement?
- What are the properties of the QCD vacuum? What is the origin of chiral symmetry breaking?
- What are the experimental signatures for a transition to new phases in relativistic heavy-ion collisions?
- What are the implications for the analogous epoch in the Big Bang?

THE STRONG FORCE AND THE INTERNAL STRUCTURE OF NEUTRONS AND PROTONS

- What are the internal structural properties of protons and neutrons and how do those properties arise from the motions and properties of their constituents?
- How do those properties change when protons and neutrons are combined into complex nuclei?
- Can QCD describe the full spectrum of hadrons in both their ground and excited states?
- How do the nucleonic models emerge from QCD?

FUNDAMENTAL SYMMETRIES

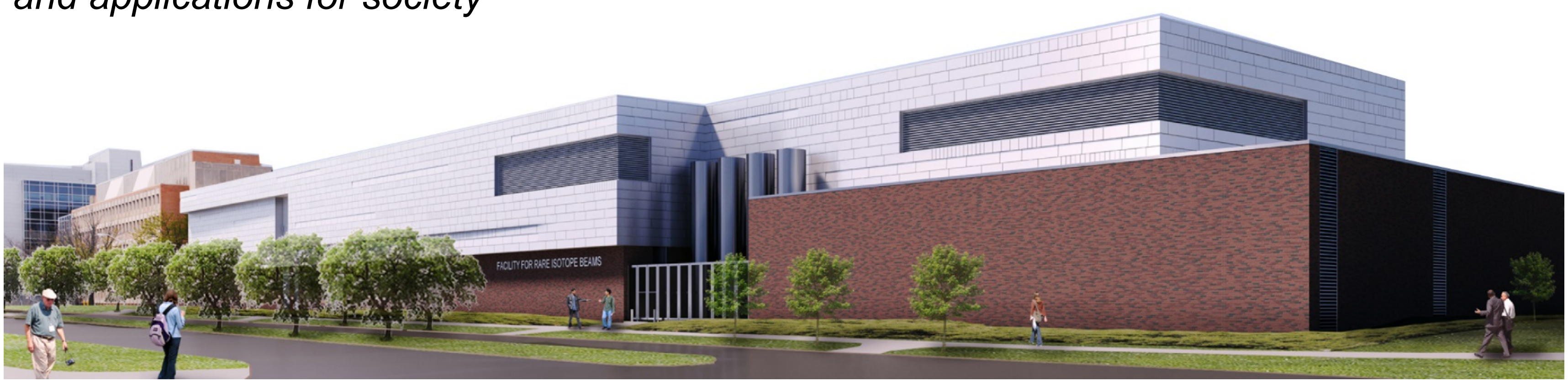
- What is the nature of the neutrinos, what are their masses, and how have they shaped the evolution of the cosmos?
- Why is there now more visible matter than antimatter in the universe?
- What are the unseen forces that were present in the dawn of the universe but disappeared from view as it evolved? Once very hot and very homogeneous, the universe now displays a preferred "handedness" and so the existence of lost forces.
- What are the low-energy manifestations of physics beyond the Standard Model? How can precision experiments in nuclear physics reveal them?



Facility for Rare Isotope Beams at MSU

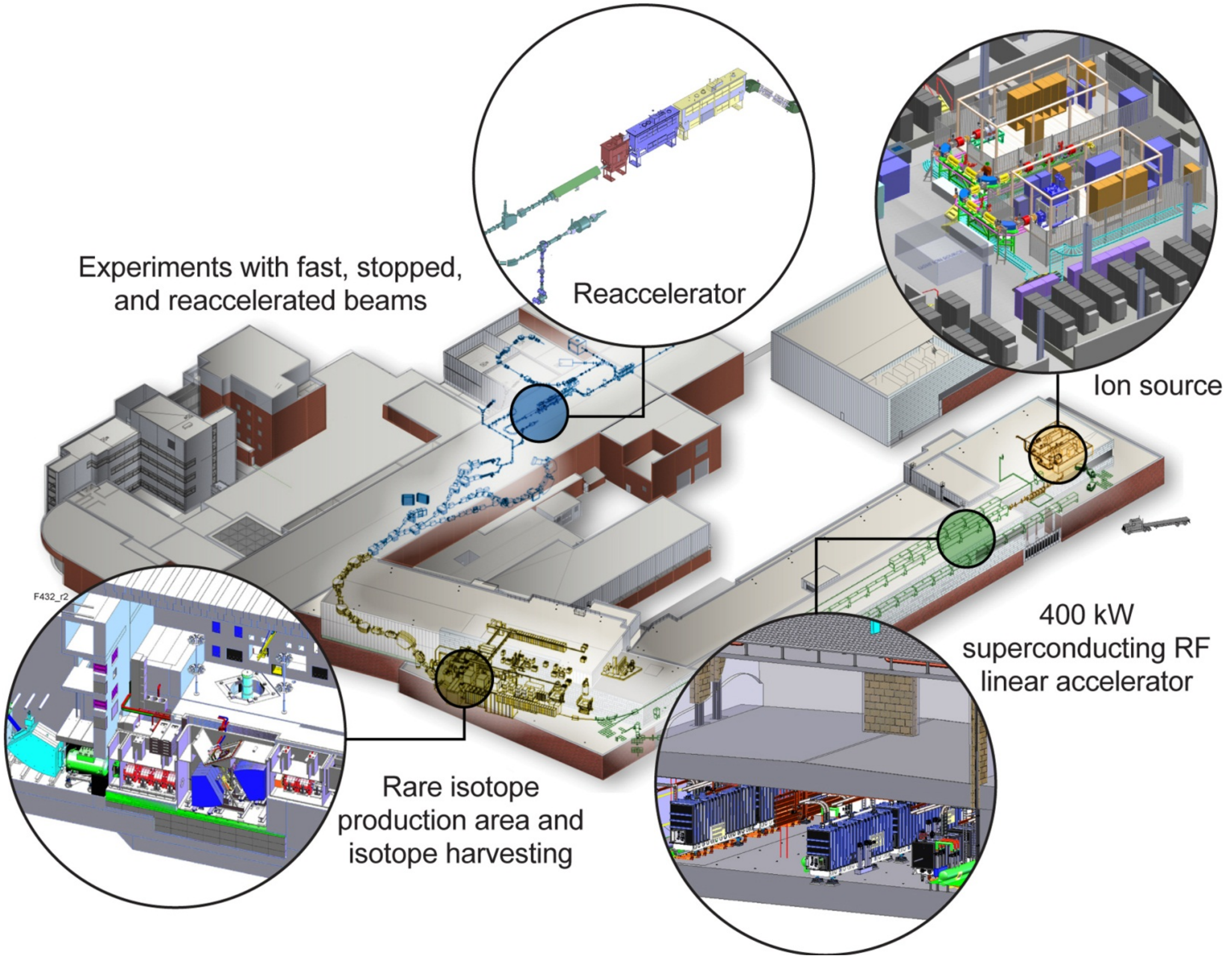
- FRIB will be a $730 million national user facility funded by the Department of Energy Office of Science (DOE-SC), Michigan State University, and the State of Michigan
- FRIB Project completion date is June 2022, managing to an early completion in fiscal year 2021
- FRIB will serve as a national user facility for world-class rare isotope research, and builds on more than 50 years of nuclear science expertise developed at MSU

FRIB will enable scientists to make discoveries about the properties of these rare isotopes in order to better understand the physics of nuclei, nuclear astrophysics, fundamental interactions, and applications for society



http://www.frib.msu.edu/news/photo-gallery/four-camera.html

World's Most Powerful Rare Isotope Research Facility



The Science is in the FRIB Logo

Properties of atomic nuclei

- Develop a predictive model of nuclei and their interactions

Astrophysics: Nuclear processes in the cosmos

- Origin of the elements, chemical history

Societal applications and benefits

- Medicine, energy, material sciences, national security

Tests of laws of nature

- Tiny effects amplified in certain nuclei; complementary information to LHC

MICHIGAN TERRITORY.
GEOGRAPHICAL, STATISTICAL, AND HISTORICAL MAP OF MICHIGAN TERRITORY.
MICHIGAN TERRITORY. No. 36.
SITUATION, BOUNDARIES, AND EXTENT.
FACE OF THE COUNTRY, SOIL, &c.
LAKES, BAYS, AND RIVERS.
ANIMALS, &c.
CLIMATE.
CIVIL DIVISIONS AND POPULATION.
TOWNS AND FORTS.
GOVERNMENT.
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