

Forging a Vision for the Future of Nuclear and Particle Physics at BNL

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“Get to Know the Lab” Forum

November 15, 2012

Continuing BNL's long tradition of international leadership in NPP...

RHIC has been enormously successful and is crucial to the DOE mission in NP...

But our efforts in NPP are jeopardized by federal budget deficit and shifting national priorities...

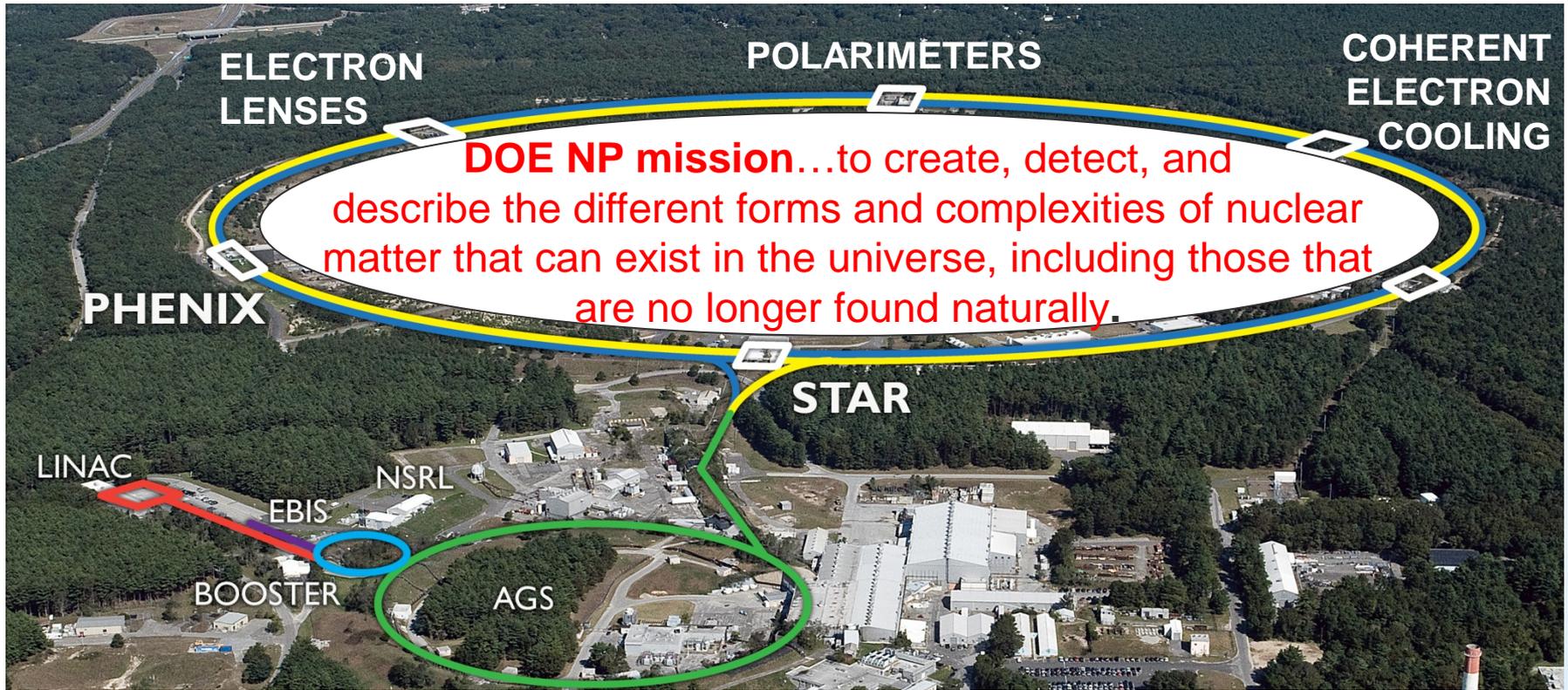
My aim is to leave legacy of 20-year vision for NPP

BROOKHAVEN
NATIONAL LABORATORY

a passion for discovery



RHIC is Crucial to DOE's NP Science Mission



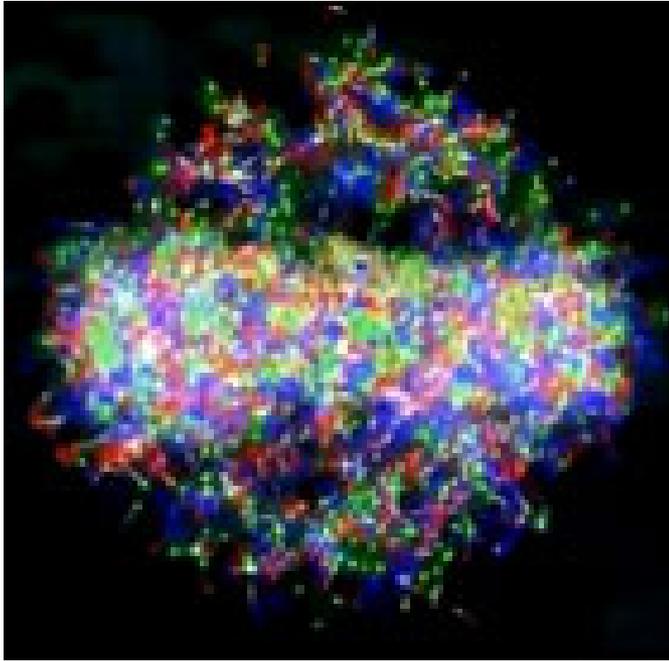
RHIC hallmarks:

Pioneering - 1st facility to clearly see transition to quark-gluon matter; world's only polarized collider; 1st use bunched-beam stochastic cooling to enhance collider luminosity

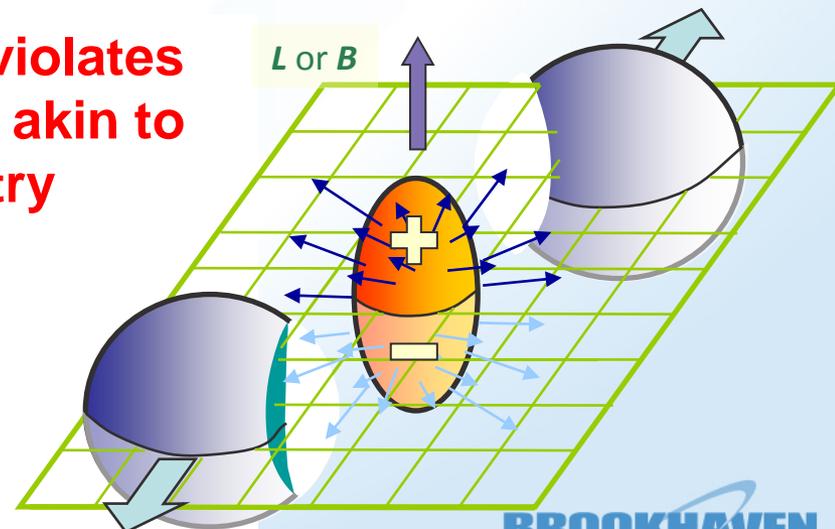
Productive - > 350 refereed papers, > 35K citations, > 350 Ph. D. 's in 1st 12 years, many more in pipeline, no rate falloff in sight

Versatile - wide range of beam energies and ion species (enhanced by EBIS) ⇒ definitive discoveries in important regime

Compelling Discoveries from RHIC's 1st 12 Years



- A new state of matter (QGP), comprising quarks & gluons under conditions last existing ~ 1 microsec after Big Bang
 - **“Nearly perfect”** (i.e., friction close to minimum possible) liquid behavior, very different from anticipated ideal gas
 - Temperatures reaching ~ 4 trillion °C, well above predicted “melting” temp. for neutrons & protons -- **250,000 times hotter than the center of the Sun**
-
- **Hints of “bubbles”** in which matter violates fundamental symmetries – possibly akin to origin of matter-antimatter asymmetry
 - Heaviest antimatter nucleus ever detected, record likely to stand for foreseeable future
 - **1st indication of gluon saturation**
 - Gluon spin preferences contribute comparably to quarks to overall proton spin

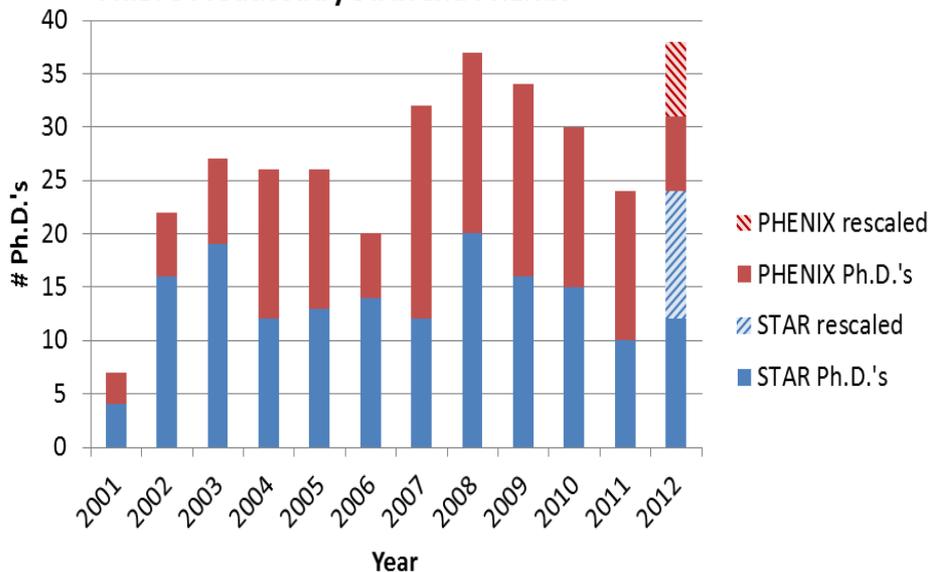


RHIC's Most Important Products

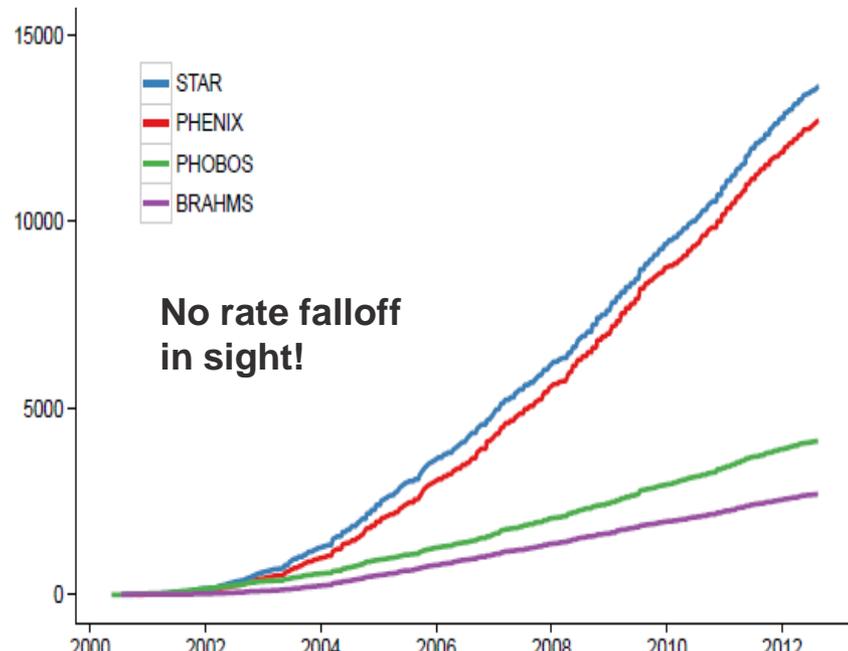
| Collaboration | Total # Refereed Papers | Total # Citations for Refereed Papers | # PRL's | # Citations for 2005 White Paper | Position of 2005 White Paper Among Most Cited NP Papers 2001-12 | # Papers with >250 Citations |
|----------------------|-------------------------|---------------------------------------|------------|----------------------------------|---|------------------------------|
| PHENIX | 126 | 13,292 | 57 | 1358 | 5 | 12 |
| STAR | 160 | 14,434 | 54 | 1382 | 4 | 15 |
| PHOBOS ^{a)} | 39 | 4057 | 15 | 1049 | 7 | 1 |
| BRAHMS ^{b)} | 22 | 2649 | 10 | 1040 | 8 | 3 |
| Total = | 347 | 34,432 | 136 | 4829 | | 31 |

Also, >40% of all-time top-cited Nuclear Theory arXiv papers are RHIC-related!

Ph.D.'s Produced by STAR and PHENIX



Cumulative Citations of RHIC Exp'ts

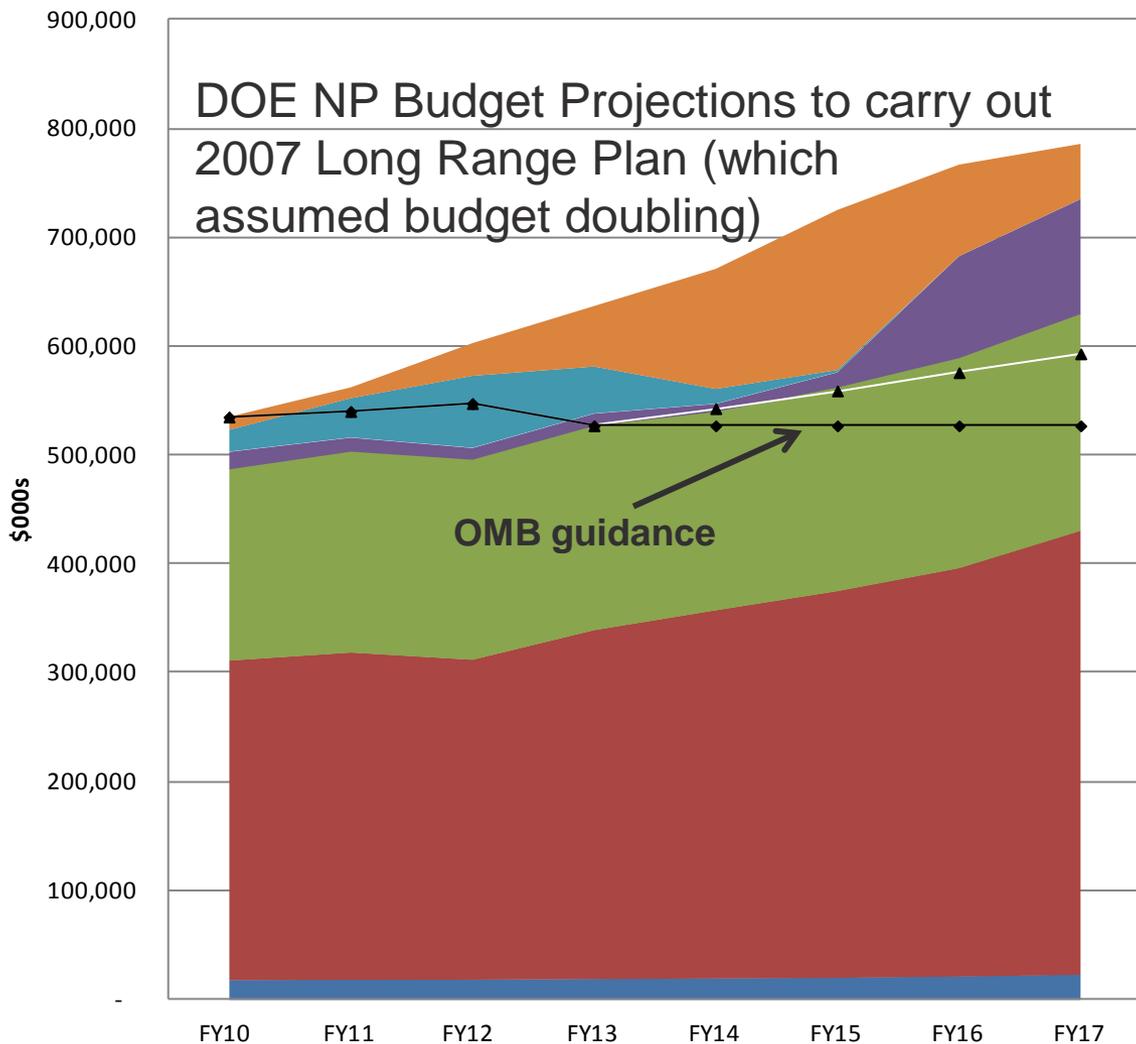


Plus >190 tenured faculty positions worldwide + 6 cover story articles +...

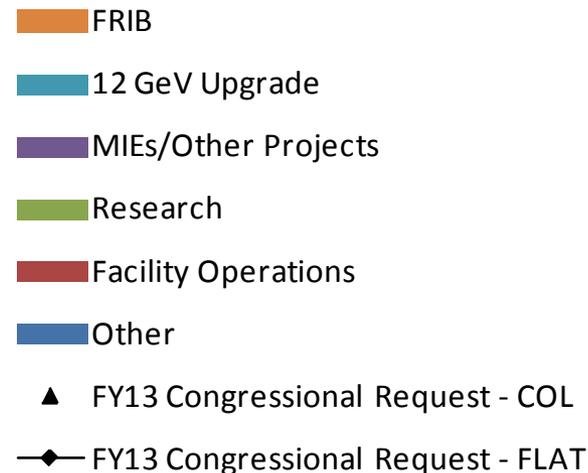
Thanks in part to vigorous foreign investment, e.g., \$130M from RIKEN...

Why is RHIC Vulnerable, in Light of Impressive Track Record?

- This chart reflects the estimated funding needed to implement the majority of elements of the NSAC 2007 Long Range Plan (LRP) – not including EIC.
- The FY 2013 Congressional Request is reflected as two lines, one assuming 3% cost-of-living into the outyears and the other assuming flat funding into the outyears.



- **FY13 shortfall ~\$100M → ~\$250M by FY17**
- **Requires serious re-prioritization by NSAC**
- **NSAC process will complete by Jan. 2013**
- **RHIC accounts for major fraction of ongoing facility operations**



4 Major White Papers Prepared for Tribble Panel in 2012

The Ca



Hot and D
Unraveling the Mys
A Community White Paper

Elke-Car
Carl Gagliard
Itaru Nakaga

Electron Ion Collider:
The Next QCD Frontier

Executive Summary

Understanding the glue that binds us all

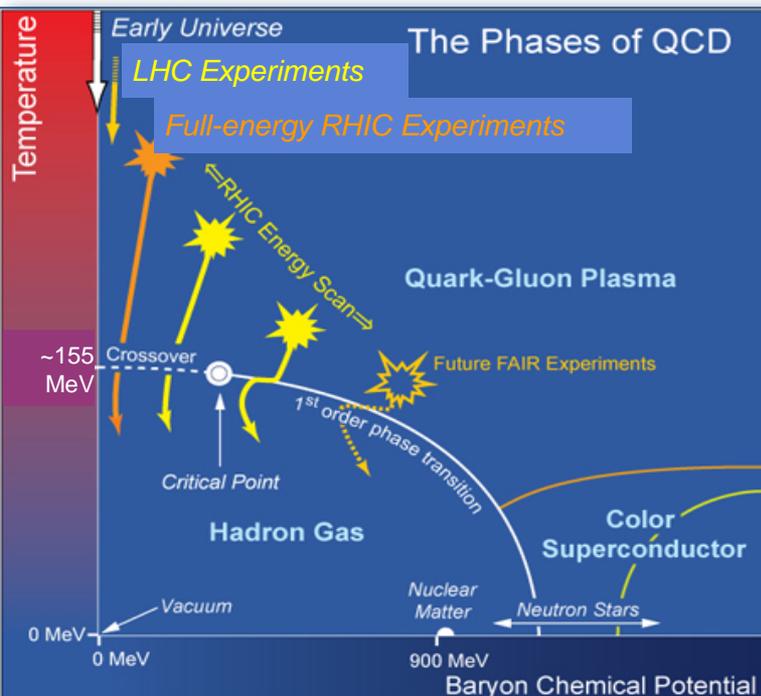
All four are posted, as are Tribble Panel presentations on RHIC,
on www.bnl.gov/npp website.

Broad Science Goals for the Next Decade

Quantify properties of the QGP and features of the QCD phase diagram, as functions of temperature and net quark density from the onset of deconfinement toward even earlier universe conditions.

Exploit new discovery potential in searches for a QCD critical point and for the nature and influence of quantum fluctuations in initial densities and the excited QCD vacuum.

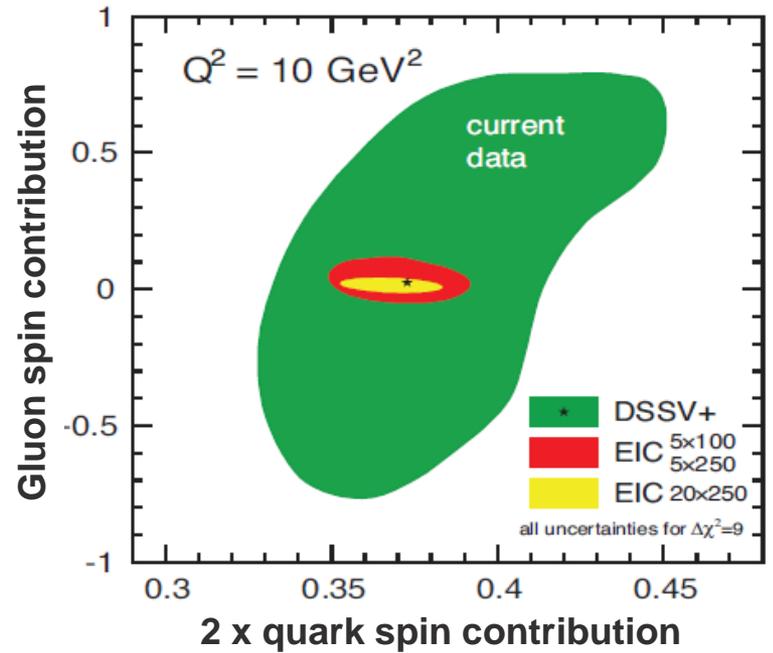
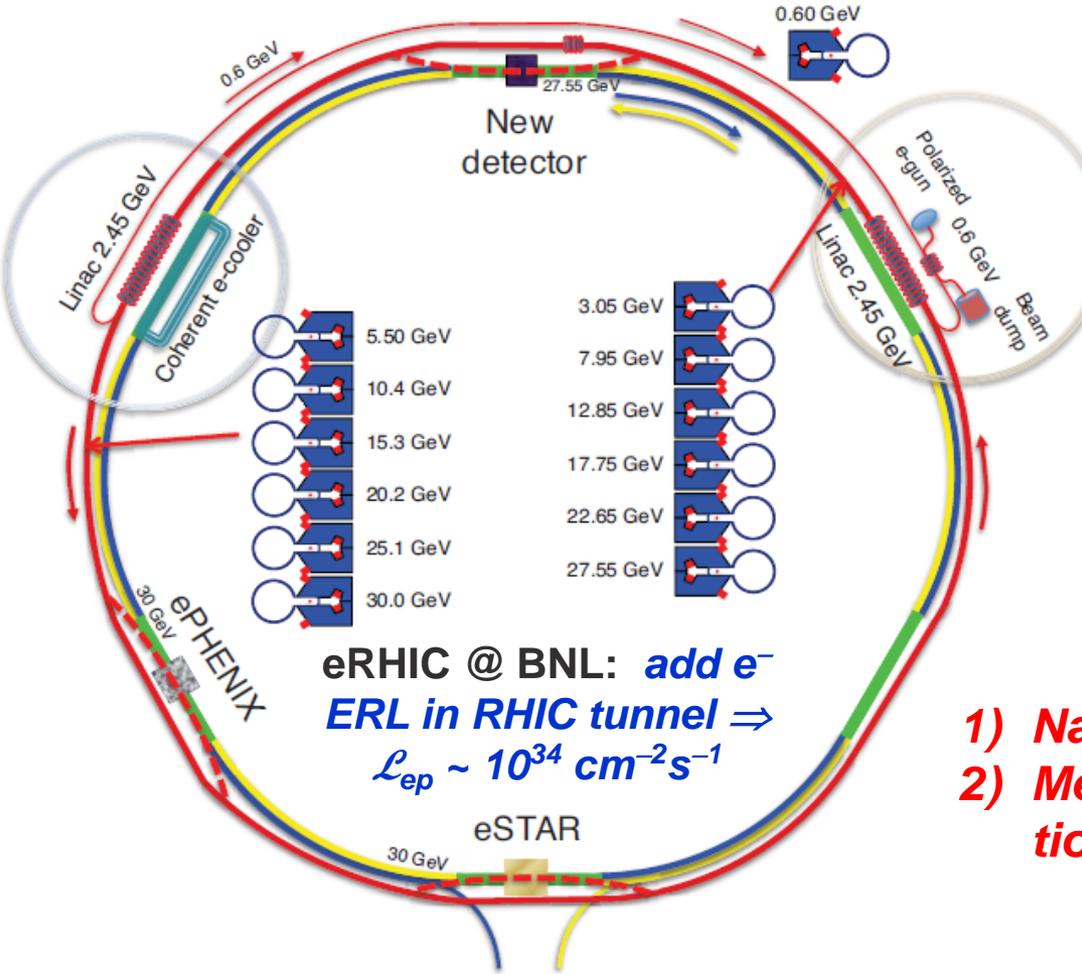
Continue explorations of the role of soft gluons in cold nuclear matter (gluon saturation, contributions to proton spin).



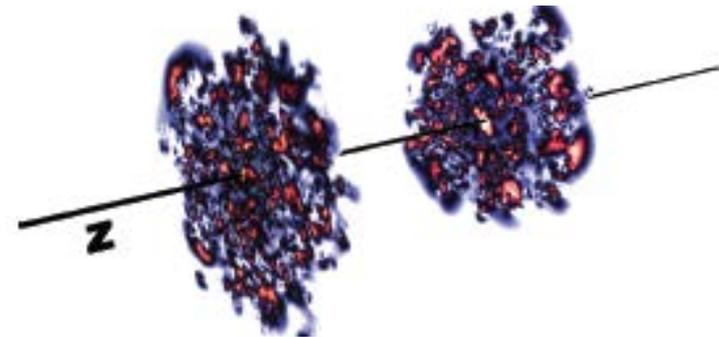
Search for a QCD Critical endpoint via low-energy scan in RHIC-II era

RHIC and LHC are complementary. Both are needed to explore the temperature-dependence of QGP properties (span factor ~ 1000 in \sqrt{s}). RHIC has unique reach to search for the QGP onset, unique ion species versatility and unique polarized proton capability, until EIC is realized. And QCD matter is RHIC's primary focus.

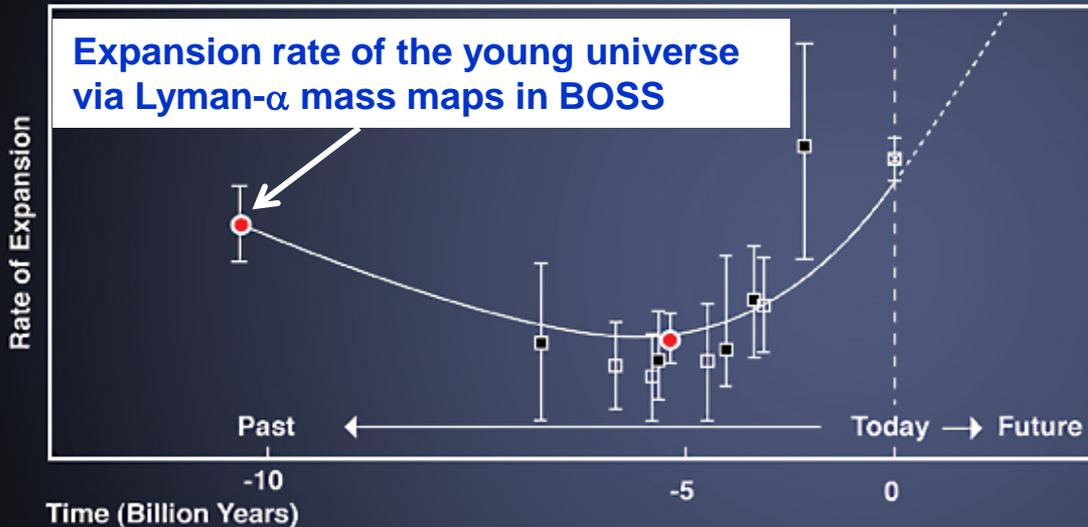
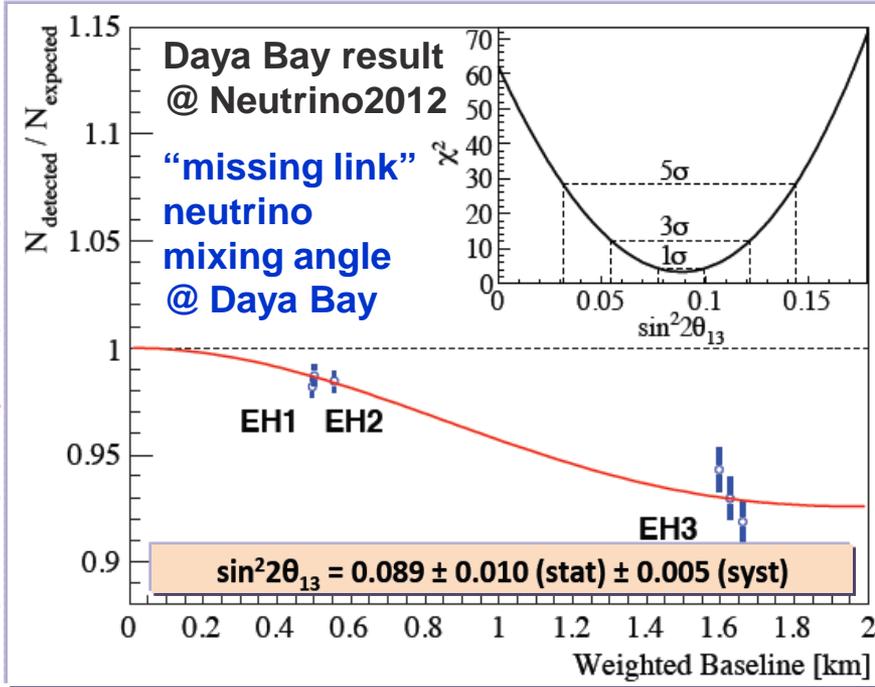
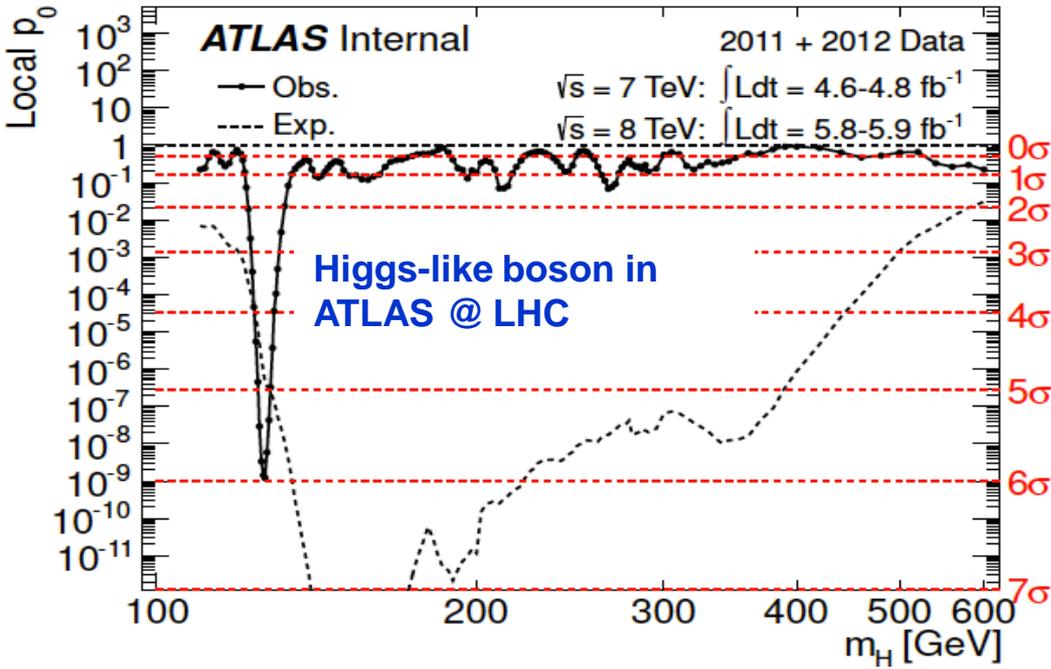
RHIC's 3rd Decade: Reinvention as eRHIC \Rightarrow Path Forward for Cold QCD Matter



eRHIC design \Rightarrow polarized e-p and e-A collisions up to energies >140 GeV; straightforward staging of electron energy; exploit ~\$2B RHIC replacement cost; facilitates...



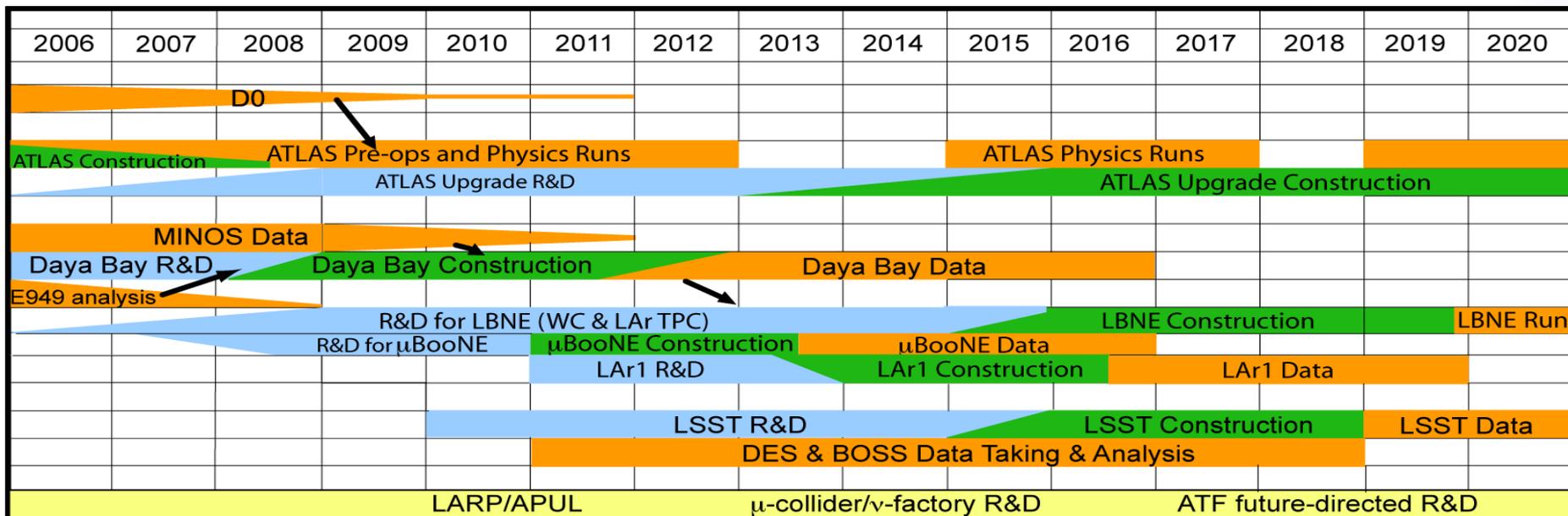
BNL'ers Have Lead Roles in Major 2012 HEP Discoveries



These results span the three frontiers of high-energy physics:
Energy (ATLAS)
Intensity (Daya Bay)
Cosmology (BOSS)

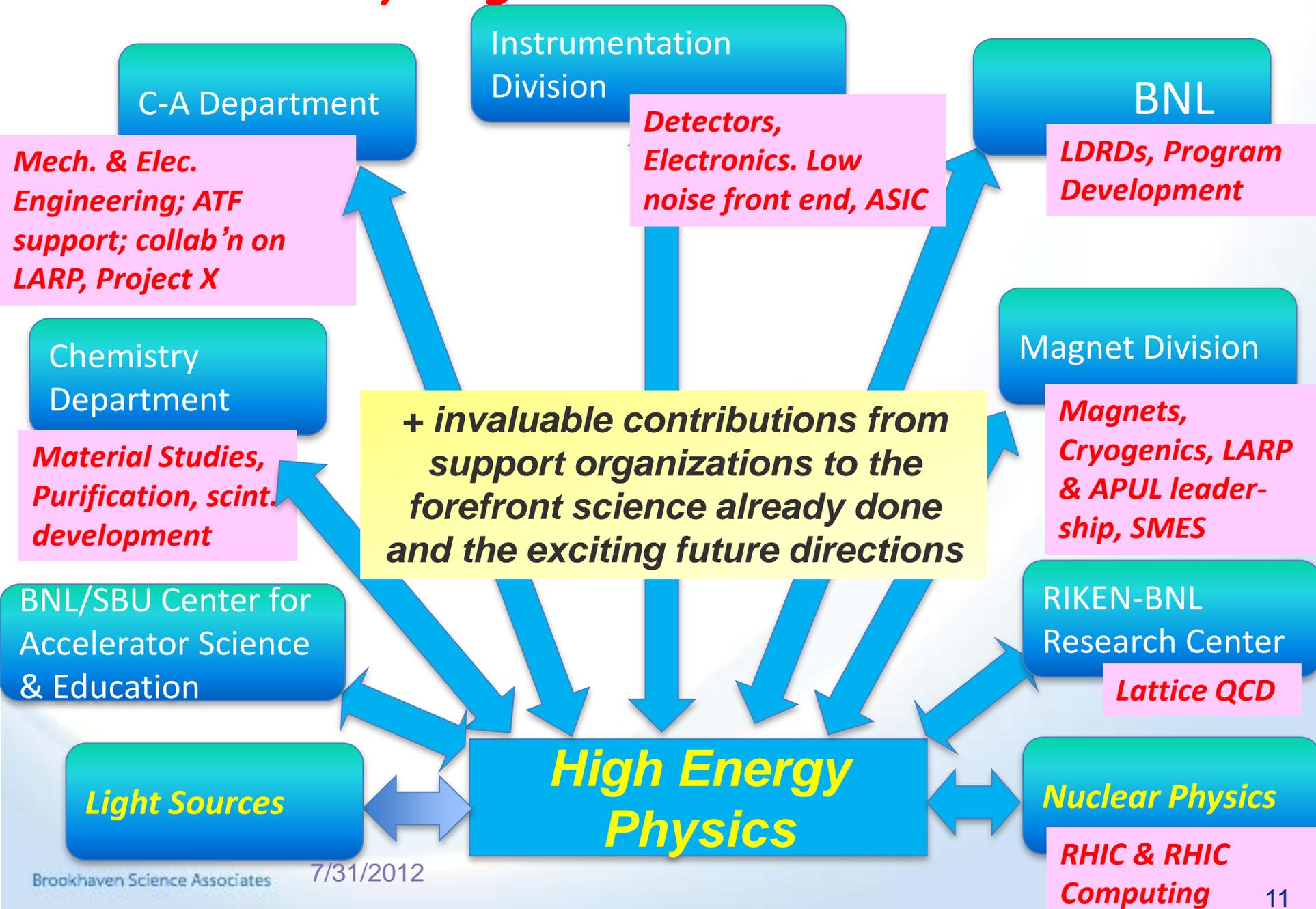
Long-Term Vision for BNL HEP

Goal: *technical & intellectual leadership in key experiments at the three frontiers (energy, intensity, cosmology), supported by theory and by critical advanced accelerator and detector R&D.*



- **ATLAS, neutrinos-LBNE, LSST are our physics priorities in the three frontiers for the coming decade – data-taking will continue to ~2030**
- **BNL program well aligned with, helps to determine, national HEP priorities**
- **It will be challenging to fit all of these projects, along with Fermilab Project X upgrade and contributions to LHC machine upgrade, into HEP budgets! Anticipate reduction in research budgets over next few years.**

Critical Synergies at a Multi-Mission Lab



Backup Slides

RHIC's Broader Value to Nation

RHIC's accelerators also provide beams for:

- **BLIP:** Brookhaven Linear Isotope Producer is used to supply *medical radioisotopes* for which there are not commercial suppliers, and to do advanced R&D on production of new isotopes (funded by ONP and cost recovery isotope sales)
- **NSRL:** NASA Space Radiation Laboratory is used to investigate *radiation hazards of space travel* (incremental costs funded by NASA, National Reconnaissance Office also interested in funding research)

RHIC's accelerator and detector research and patents are fueling work with industry, ARPA-E and DOD on:

- Next-generation *hadron radiotherapy* facilities for cancer treatment
- Superconducting magnet *energy storage* systems
- High-current energy recovery linacs for potential *defense applications*
- Next-generation *medical imaging* techniques and detectors

RHIC contributes to the national and local economy by:

- Training the next generation of highly skilled scientists (>20 Ph.D./year)
- Stimulating local industries in advanced accelerator technology (AES)
- Bringing ~50 person-years/year of users to spend time and money on Long Island