



Physics Department

Retreat for Postdoctoral Research Associates

Hong Ma
Chair, Physics Department, BNL
Aug 25, 2023



BNL Physics Department

- The Department has ~ 250 staff members
 - including ~40 postdocs, ~100 research staff, plus IT, technical, engineering and administrative support staff
- Leading roles in large international collaborations for nuclear and particle physics experiments
- Theoretical physics programs that guide and support the experimental programs
- Hosting large user communities for our program
- **Nuclear Physics Program**
 - RHIC experiments: PHENIX, STAR, sPHENIX
 - Future EIC Experiments: ePIC, EIC physics and detector R&D
 - BNL has a strong research effort on heavy ion, spin physics and theory, and is responsible for the detector operation and upgrades.
- **High Energy Physics Program**
 - Host lab for US ATLAS Operations Program and Upgrade Project
 - Host lab for US Belle II Operations Program
 - BNL is a leading contributor to Fermilab neutrino programs
 - Astrophysics and Cosmology at the Rubin Observatory (LSST), and LuSEE-Night operation and science
 - Strong research programs in energy, intensity, cosmic frontiers and theory
- **Software and Computing**
 - RHIC Computing Facility, US ATLAS Tier-1 and US Belle II Tier-1 are part of Scientific Data and Computing Center
 - A common software group that supports all experimental programs

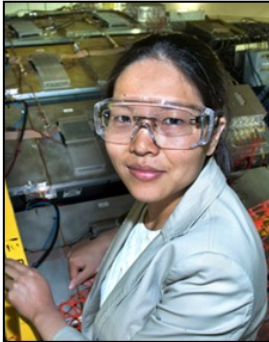
DOE Early Career Awards in Physics Department

FY 2011



Anže Slosar
Cosmic Frontier

FY 2013



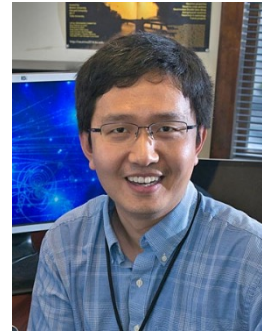
Lijuan Ruan
STAR

FY 2014



Bjoern Schenke
Nuclear Theory

FY 2014



Xin Qian
Intensity Frontier

FY 2016



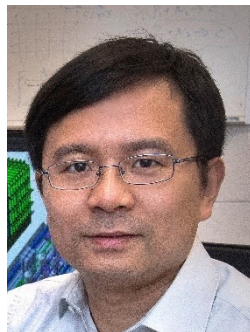
Christoph Lehner
High Energy Theory

FY 2017



Alessandro Tricoli
Energy Frontier

FY 2017



Chao Zhang
Intensity Frontier

FY 2019



Viviana Cavaliere
Energy Frontier

FY 2023

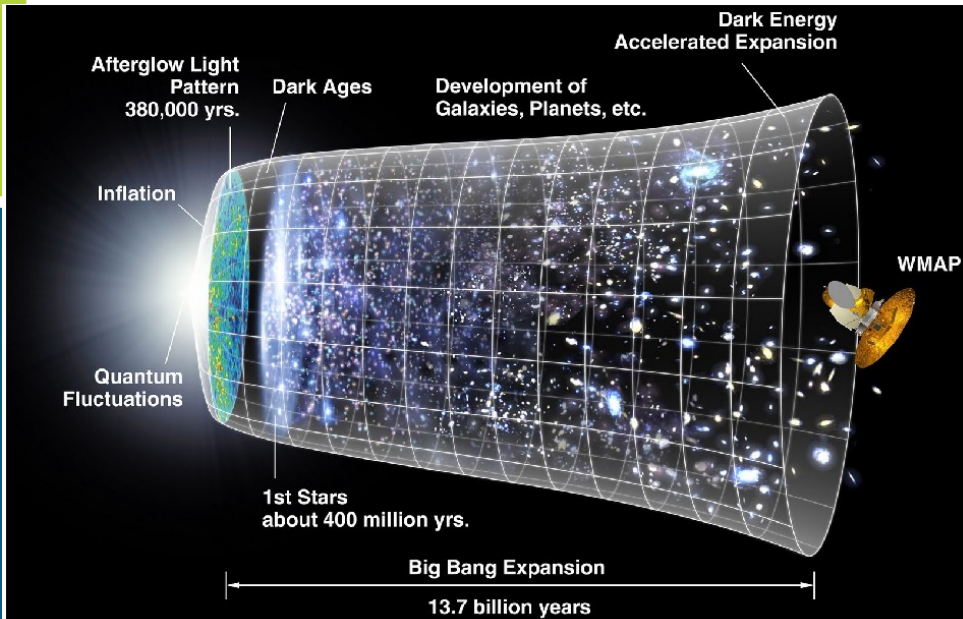


Elizabeth Brost
Energy Frontier

Former Physics Department Postdocs with ECAs after BNL

Name	Group	Institute	Year
Lisa Whitehead	EDG	Univ of Houston	2012
Stephanie Majewski	Omega	Univ of Oregon	2014
Dennis Perepelitsa	PHENIX	Univ of Colorado	2017
Michael Mooney	EDG	Colorado State	2020
Luchang Jin	Nuclear Theory	UConn	2020
Chun Shen	Nuclear Theory	Wayne State	2021
Daniel Brandenburg	STAR	Ohio State	2023

Current nuclear physics program: RHIC

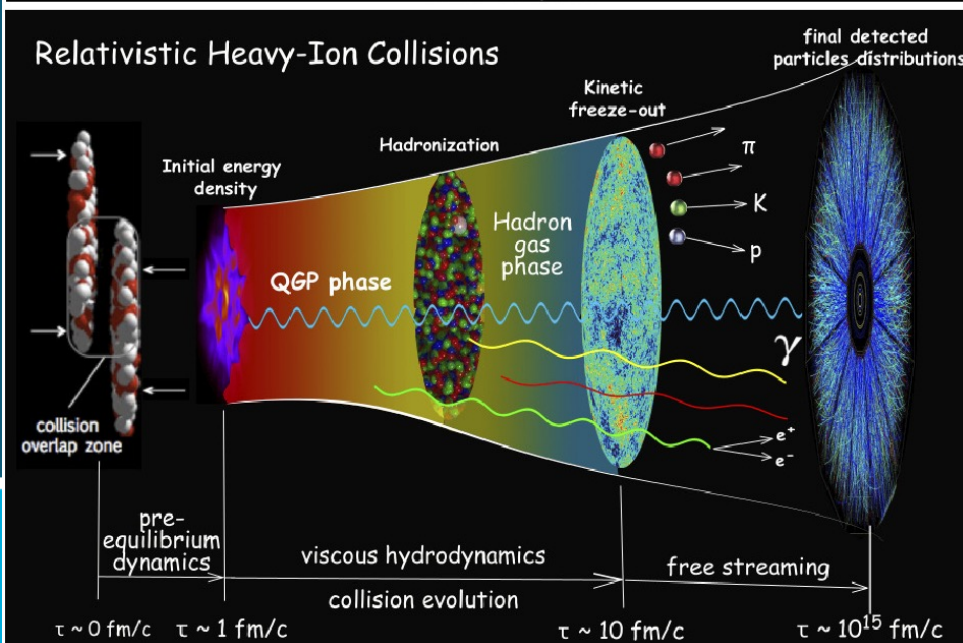


Relativistic Heavy Ion Collider:
Recreates the universe as it existed a few microseconds after the big bang

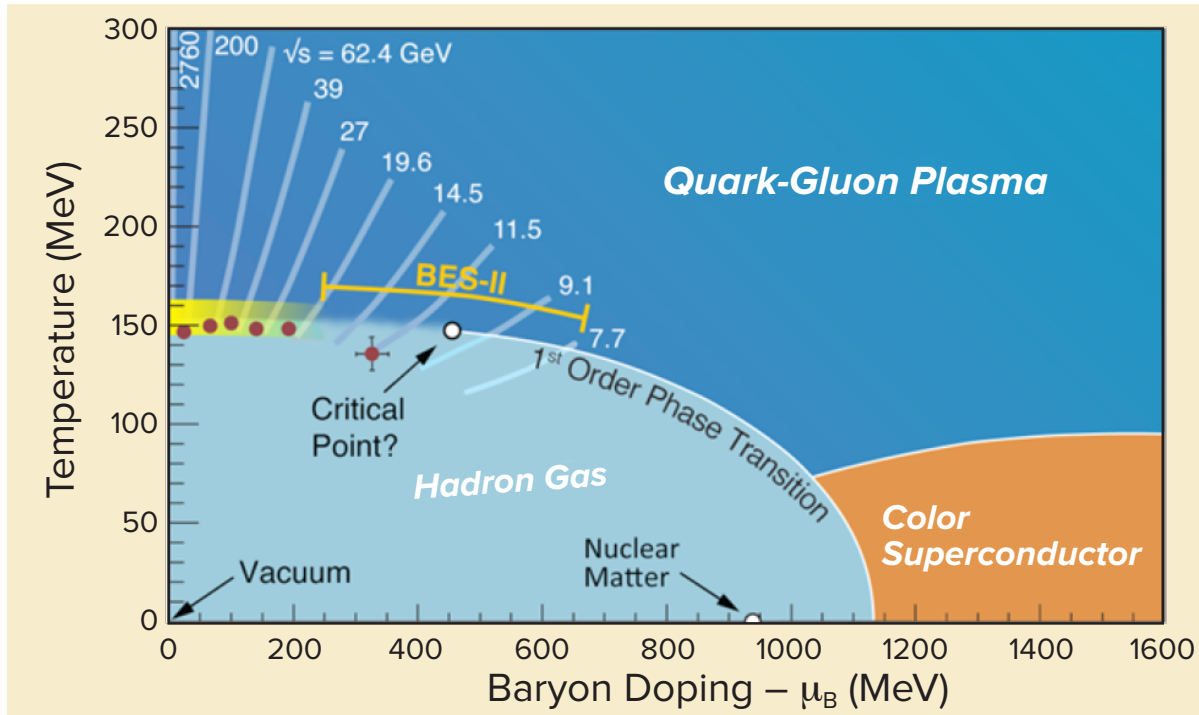
Discovered that matter at a few Trillion degrees behaves as a nearly perfect fluid

Also the only Polarized Proton collider

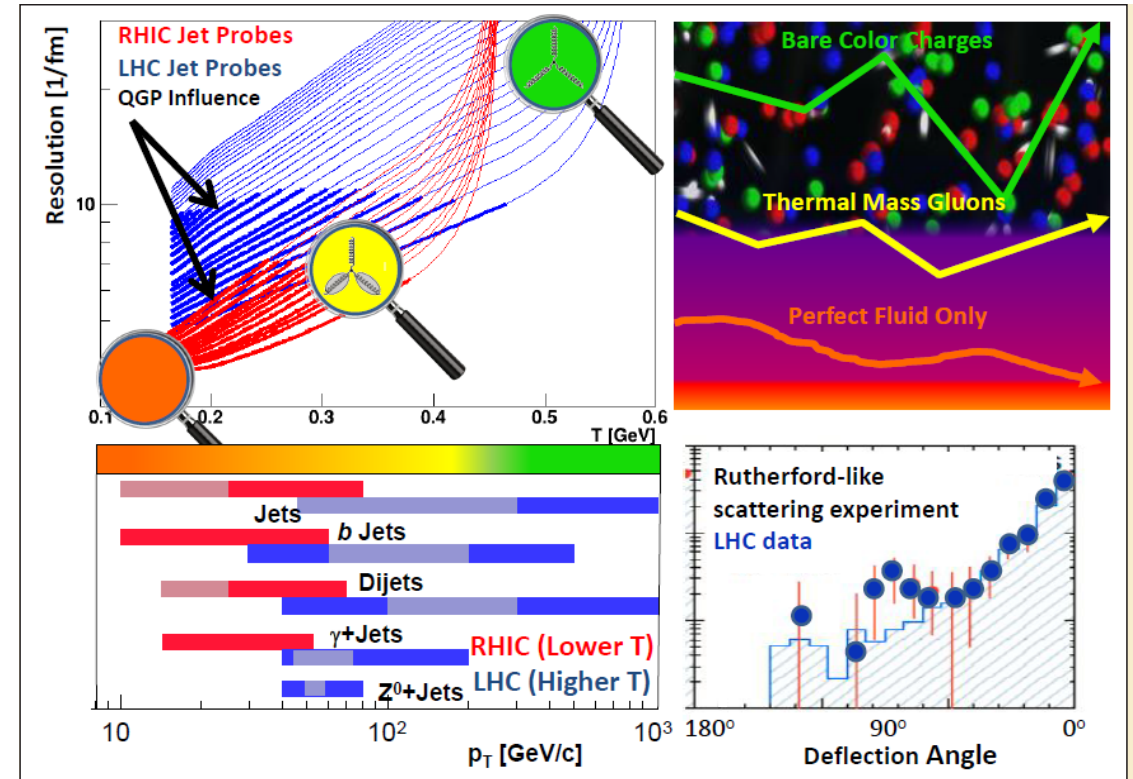
Discovered that gluons carry a substantial fraction of the proton spin



Completing the RHIC Mission

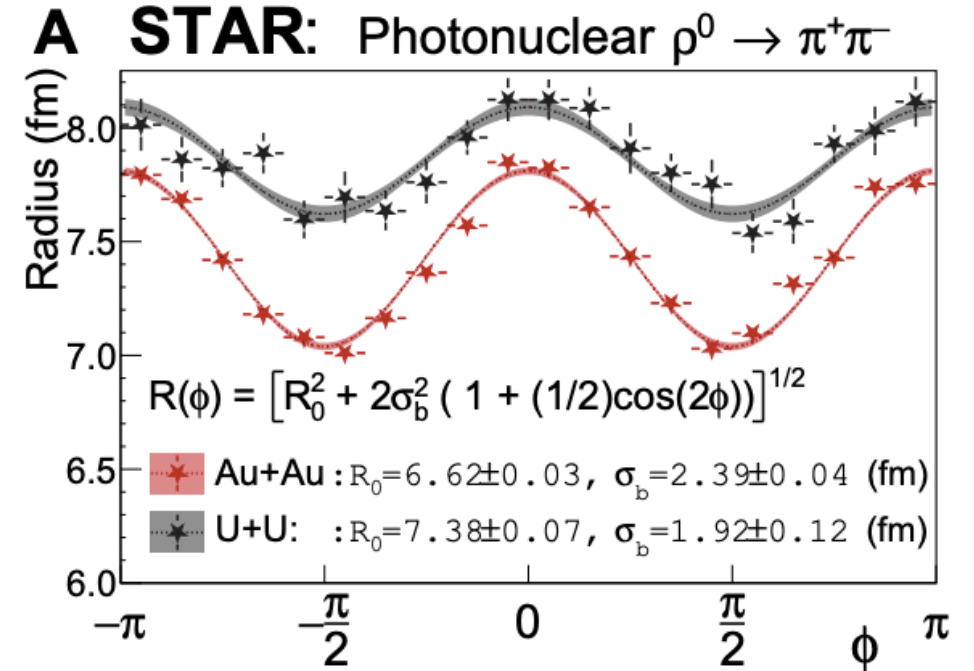
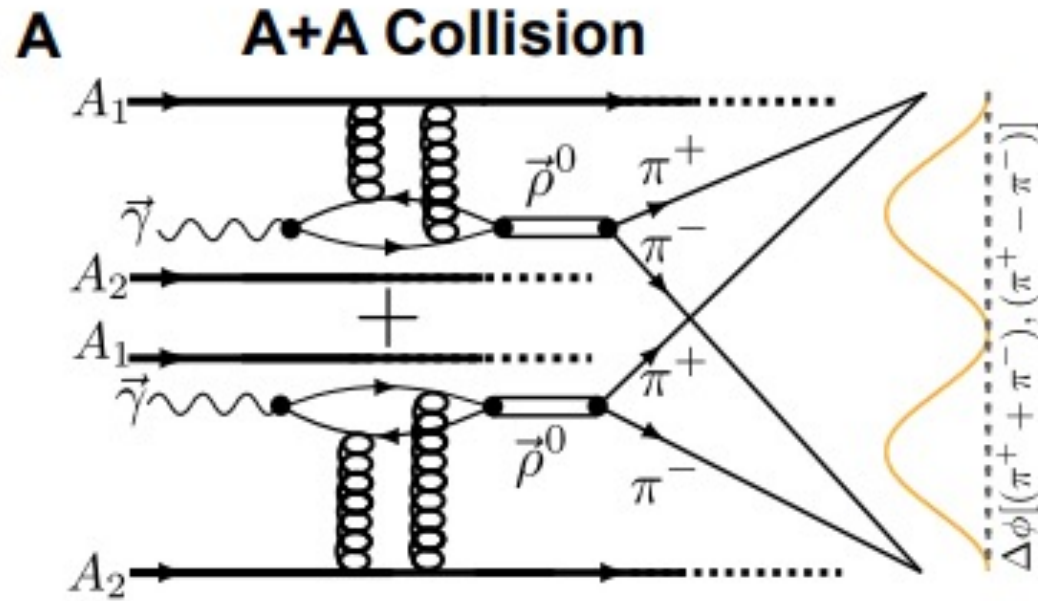


Analysis of Runs 2019-2021 from STAR
Exploring the phase diagram of QCD matter



Runs 2023-2025 with sPHENIX:
how does the perfect fluid emerge from quarks and gluons?

Tomography of Ultra-relativistic Nuclei with Gamma + A Collisions



Quantum interference enabled nuclear tomography:

- A novel approach to extract the strong-interaction nuclear radii, which were found to be larger than the nuclear charge radii

2204.01625,
Science Advances 9
 (2023) 3903

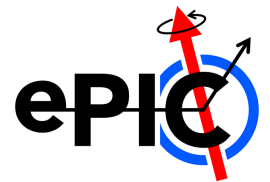
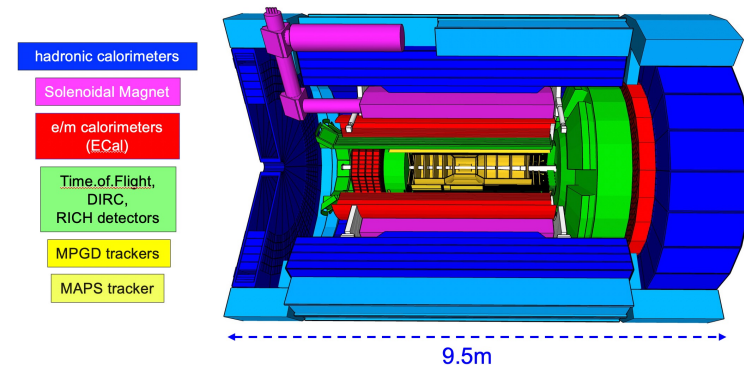
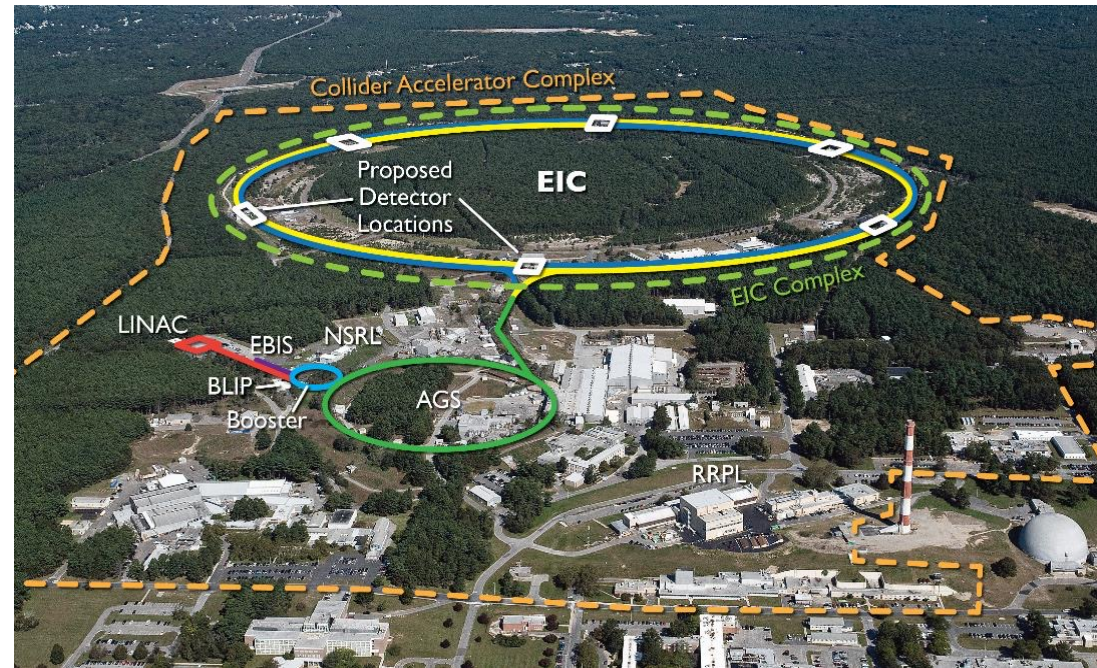
The Electron-Ion Collider

An EIC can uniquely address three profound questions about nucleons—neutrons and protons—and how they are assembled to form the nuclei of atoms:

- How does the **mass** of the nucleon arise?
- How does the **spin** of the nucleon arise?
- What are the emergent properties of dense systems of gluons?

Major milestones: CD-0 December 2019; DOE EIC site (BNL) selection Jan 2020; CD-1 June 2021; EIC project detector selected in March 2022; ePIC collaboration formed in July 2022; Start of EIC project construction after RHIC operation ends in summer 2025.

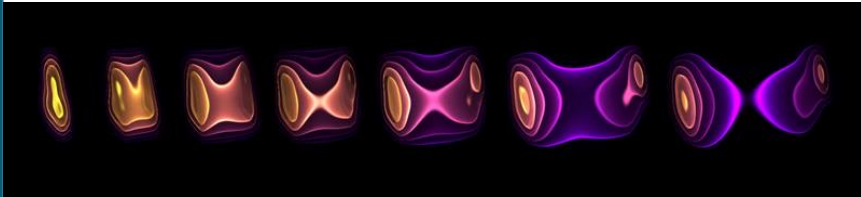
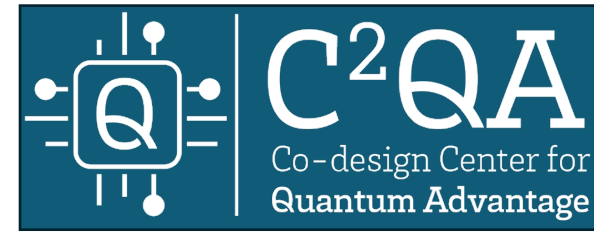
Physics Department focuses on EIC physics and participation in ePIC collab, and carries out R&D for the 2nd detector.



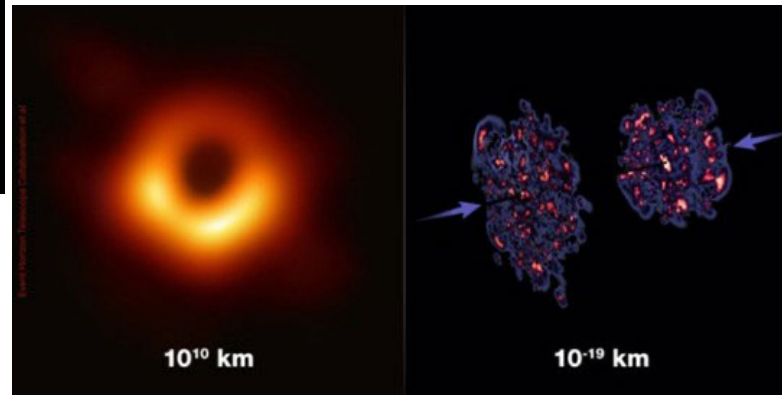
Nuclear Theory

Center of expertise in the theory of
Quantum Chromodynamics

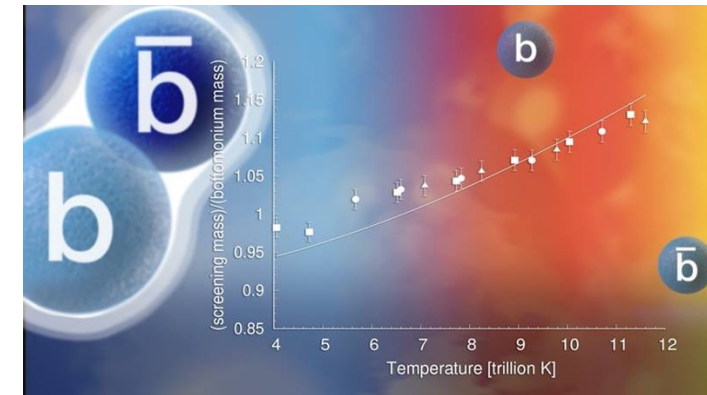
Including computational methods (Quantum, Lattice QCD)



Hitting Nuclei with Light May Create Fluid Primordial Matter



Scientists Find a Common Thread Linking Subatomic Color Glass Condensate and Massive Black Holes



Getting to the Bottom of When the Smallest Meson Melts

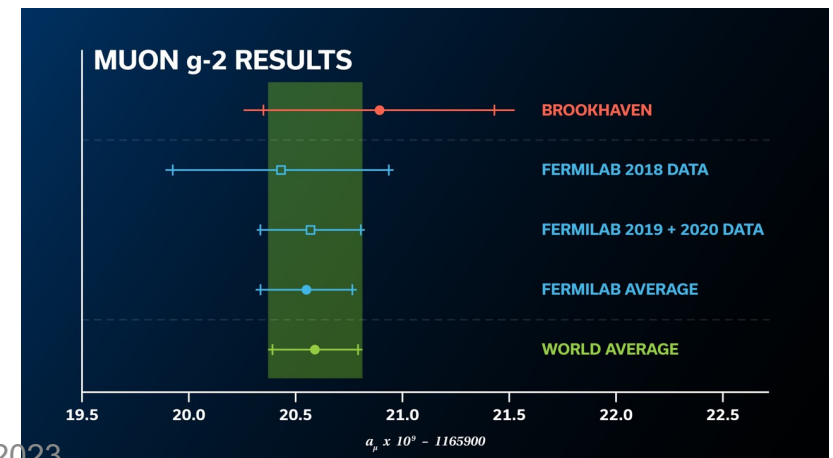
High Energy Physics Program in Physics Department

- **ATLAS experiment at CERN**
 - Lead laboratory for US ATLAS
- **Neutrino Program at Fermilab**
 - Proto-DUNE detector with BNL-developed components
 - Studying properties of neutrinos at short-baseline
- **Belle II experiment at KEK**
 - Lead laboratory for US Belle II
- **Rubin Observatory**
 - Commissioning the experiment in Chile
- **Theory, Detectors and Accelerators R&D**
 - Major contributions to the field

Upgraded ATLAS muon system at CERN



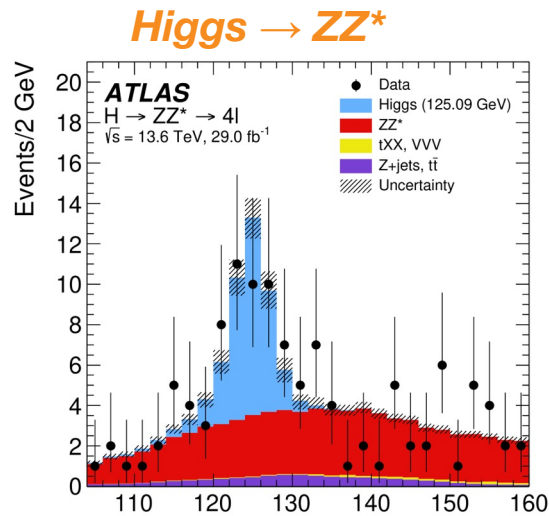
New g-2 Result



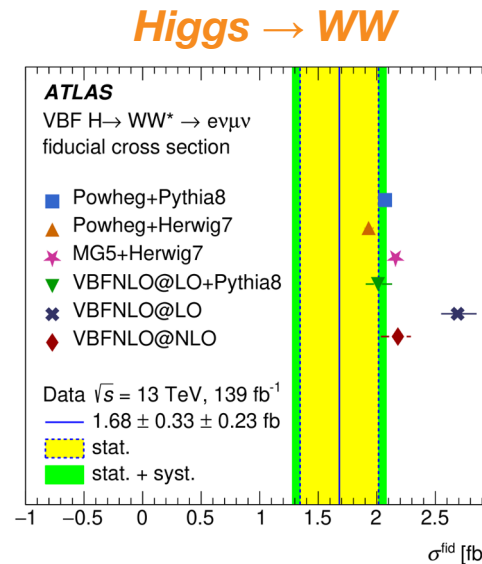
Science Highlights from BNL ATLAS effort

Higgs & Electroweak Symmetry Breaking is our flagship physics topic

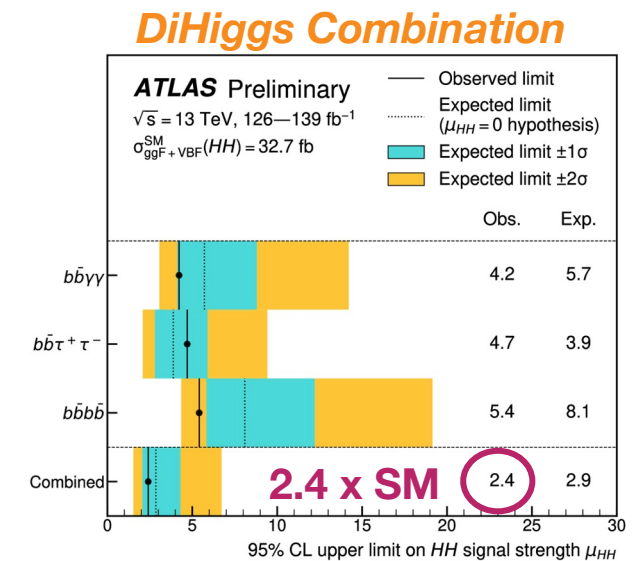
- crucial avenue to leverage in searches for new physical phenomena including Dark Matter
- aligned with P5 science drivers
- strong theory HET contributions and key analyses on ATLAS
- this physics drives our R&D in detector, trigger, performance, software, computing, theory, accelerator



First measurements of Higgs boson using Run 3 data at $\sqrt{s}=13.6$ TeV. Highlights commissioning ATLAS Phase-I upgrades, including NSW.



Tricoli ECA: first pure Higgs Vector Boson Fusion measurement of fiducial cross section in this channel



~50% better than expected from luminosity compared to previous result
 → driven by improved ML in object ID

2023Q4 (proj.)

SDCC



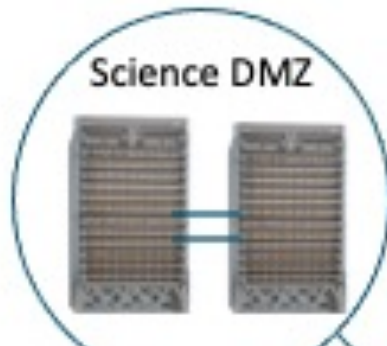
National Synchrotron Light Source II, CryoEM



Center for Functional Material



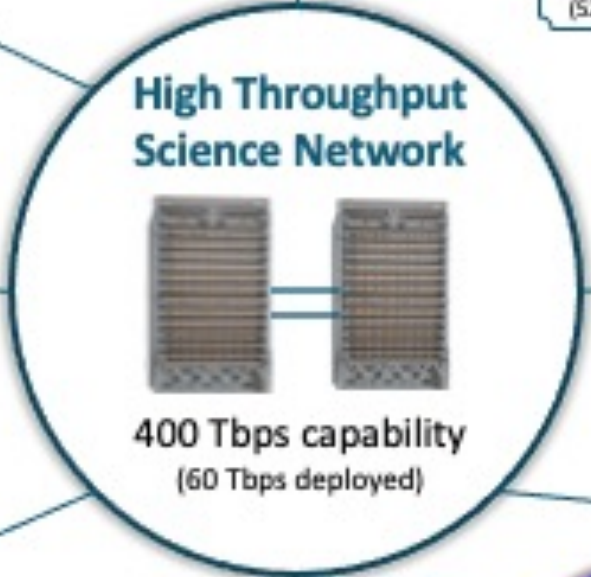
Relativistic Heavy Ion Collider - Facilities



0.2 Tbps

2x 400 Gbps

1.2 Tbps



0.8 Tbps

0.4 Tbps

0.7 Tbps

12 Tbps

1.2 Tbps

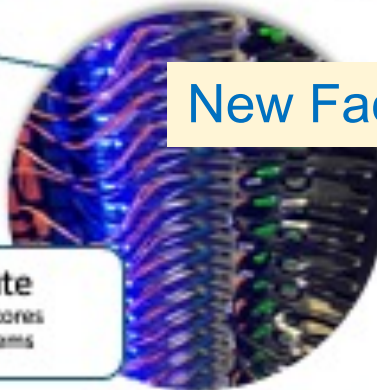
0.5 Tbps

18 Tbps

DTNs
(S2 systems)



Disk Storage
80 PB



Compute
110k CPU cores
5 HPC systems



Tape Storage
250 PB

New Facility in B725

Nuclear and Particle Physics Software Group (NPPS)

NPPS in Physics Department participates in a wide range of experiments across BNL's nuclear and particle physics programs. NPPS provides software and expertise across many technical areas, with a particular emphasis on common software solutions.

SW discussions are open to all. All involved in SW development are encouraged to participate.

Activities

NPPS members participate in many of BNL's nuclear and particle physics experiments and programs, working as members of experiment software teams. We also develop and participate in R&D projects, and community projects such as the HSF.

ATLAS at the LHC (CERN)

Belle II at SuperKEKB

Dark Energy Science Collaboration (DESC)

DUNE Long Baseline Neutrino Facility

Electron Ion Collider (EIC)

Google-ATLAS HL-LHC R&D Project

HEP Software Foundation (HSF)

Rubin Observatory (LSST)

LuSEE@Night

PHENIX at RHIC (BNL)

sPHENIX at RHIC (BNL)

STAR at RHIC (BNL)

Technical Areas

NPPS members and collaborators provide expertise and software in many technical areas.

AI/ML

Analysis tools

Collaborative tools, documentation and training

Core software & advanced algorithms

Databases

Data and analysis preservation

Distributed data management

Event data storage and I/O

High performance computing

Real-time analysis

Reconstruction

Simulation

Software infrastructure and support

User interfaces, monitoring and analytics

Workflow and workload management

Software

NPPS members and collaborators have developed and/or have expertise on many software products and projects, many of which are multi-experiment **common software**.

ACTS

Athena

ATLAS CI and nightly system

Conditions database

Data Carousel

DIRAC

dunetpc

e-A Simulation Toolkit (eAST)

eic-smear

ATLAS event service

Fun4All

funcX

geant4star

Harvester

Intelligent data delivery system (iDDS)

Invenio

Jekyll

LXR code browser

PanDA workload management system

PanDA monitoring system

PanDA Pilot

Parsl

ATLAS production system

ROOT

Rucio

Scikit-HEP

SHREK

Wire-Cell

Zenodo

Planning for the future

Snowmass / P5 Planning Process

To identify the most compelling scientific opportunities at the Energy, Intensity, and Cosmic Frontiers, and to identify those technologies required for frontier research.

2014 P5 Report

Building for Discovery

Strategic Plan for U.S. Particle Physics in the Global Context



P5 townhall meetings earlier this year.

2023 P5 report is expected to be released in the fall

NSAC Long Range Plan

To identify and prioritize the most compelling scientific opportunities for the U.S. nuclear physics program to pursue over the next decade (2023-2032) and articulate its potential scientific impact.

2015 Long Range Plan



The 2015
LONG RANGE PLAN
for **NUCLEAR SCIENCE**



LRP Resolution meeting took place July 10-14, 2023
(H.Gao, L. Ruan, B. Schenke)

Report is expected this October



Implementing 2014 P5 Vision

- **Energy Frontier**
 - Hosting project for \$300M HL-LHC ATLAS upgrade
 - Building magnets for the HL-LHC
 - Developing HL-LHC computing and software
- **Intensity Frontier**
 - Contributing to DUNE experiment
 - Leading DUNE far detector Module 2 activities
 - Preparing Belle II detector for Run II
- **Cosmic Frontier**
 - Getting ready to analyze Rubin Observatory data
 - Building LuSEE-Night mission to the far side of the moon
- **Leading Technologies Developments for Particle Physics**
 - Computing and software
 - Detectors and electronics
 - Accelerator R&D including superconducting magnets
- **Actively participating in developing long term future**
 - Snowmass and P5

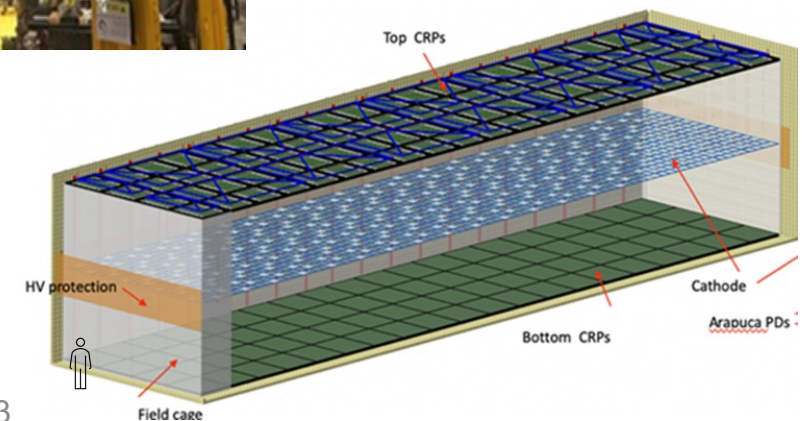
HL-LHC magnet testing at BNL



ATLAS silicon assembly at BNL



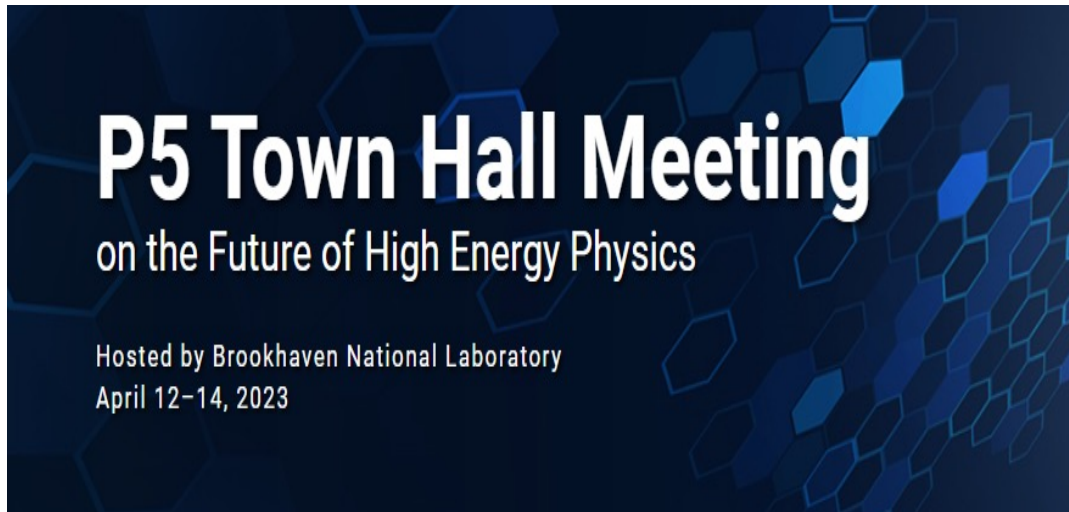
DUNE Module 2 design



Snowmass/P5 and BNL



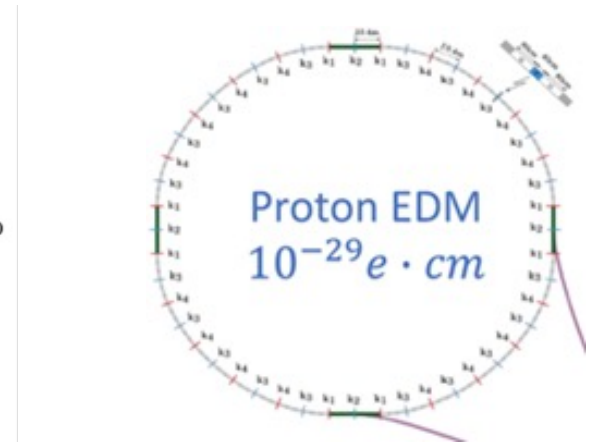
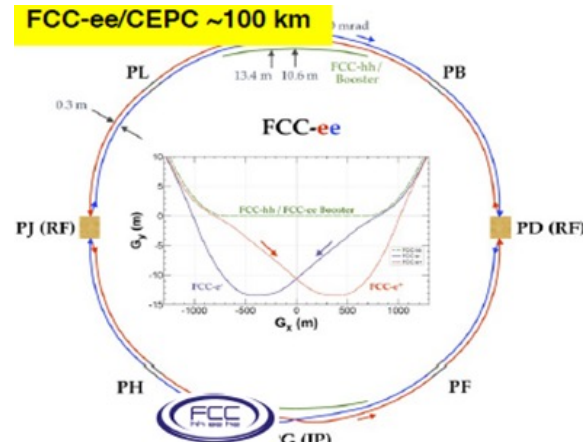
- The field needs new facilities and experiments which are exciting/competitive and affordable
 - Over 130 white papers submitted by BNL scientists to Snowmass
 - BNL is involved in all frontier's activities – supporting field's diversity
- Investing into proposals supported by Snowmass and presented to P5
- Organized P5 meeting at BNL with over 600 participants



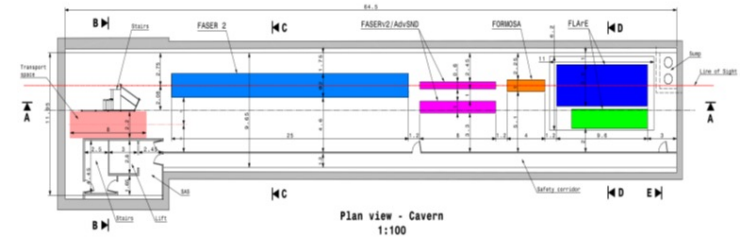
P5 Proposals BNL is Actively Engaged in

- DUNE Phase II
 - Modules 3 and 4
- Higgs factory
 - Physics, detectors, accelerators
- Muon collider
 - Unique expertise at BNL
- Proton EDM experiment at BNL
 - Unique way for exciting science using infrastructure built for HEP decades ago
- Forward Physics Facility at CERN
 - Neutrinos at the energy frontier, search for new physics
- PIONEER
 - Small scale experiment with deep science connection to fundamental principles
- LHCb upgrade
 - Have experts in both physics and detectors, upgrade starts after HL-LHC projects

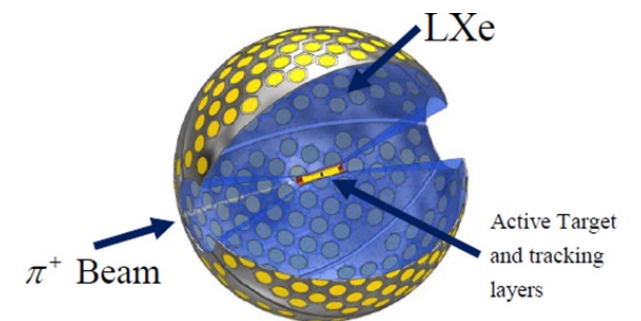
Various proposals for accelerator, detectors, computing and related R&D



Forward Physics Facility



PIONEER



Investment for the future

Laboratory Directed Research and Development (LDRD) & Program Development (PD)

Postdocs play critical roles in these programs

LDRD#	PI	TITLE	FY 2023	FY 2024	FY 2025
22-018	E. Brost, et al	Real-time image classification using machine learning.	200000		
22-022	A. Nomerotski	1 Picosecond timing to probe time-energy entanglement of Photons and to study longitudinal beam profiles at NSLS II and EIC	200000		
22-027	Z. Tu	Probing Nucleon Spin Structure with Quantum Entanglement	200000		
23-013	M. Diwan	Physics & Simulations very high energy neutrino fluxes & events-LHC	200000	200000	
23-019	V. Tishchenko	R&D for Pioneer: Next generation Rare Pion Decay Experiment	200000	200000	
23-014	Q. Huang	Data Popularity, Placement Optimization & Storage	200000	200000	
23-016	Y. Mehtar-Tani	3 D Structure of the Proton: from partons to strong fields	200000	200000	
23-049	M. Pleier	Capturing Leadership at future Higgs Factory for BNL	250000	500000	500000
23-050	T. Ullrich	Second EIC Detector: Physics case and Conceptual Design	350000	498000	496000
23-051	D Morrison	RBRC research from RHIC to EIC	437000	1175000	1325000
24-016	A. Slozar	Enabling Neutrino-triggered Rubin observations		200000	200000

PD #	PI	Title	FY 2023	FY 2024	FY 2025
21-006	Lancon	DUNE Computing	100000		
22-005	Deshpande	EIC Director of Science	288900		
22-008	Lauret	Data Store and Access	105500	107300	
23-002	DiCanto	Heavy Flavor Physics at LHCb upgrade II	50000	334000	344000
23-004	Dunlop	Leadership of EIC Group	385000	380000	390000
23-006	Ma	MSI Collaboration and workforce development	170000	334000	344000
23-007	Venugopalan	EIC Theory Institute	486000	494000	499000

Nuclear Physics: Transition from RHIC to EIC

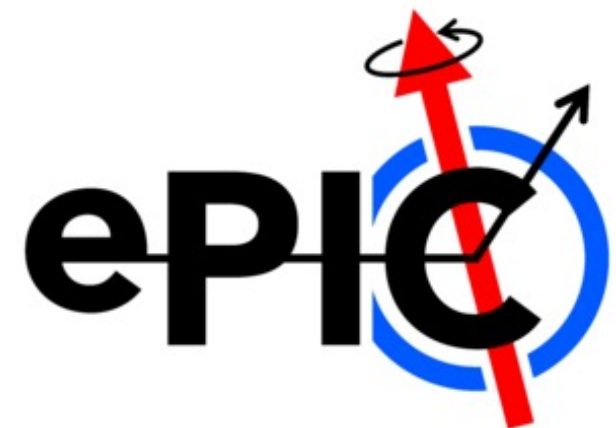
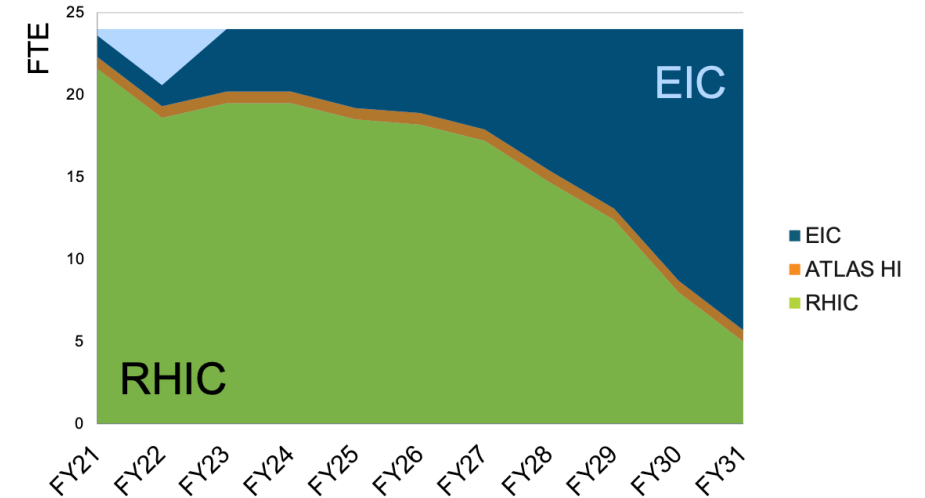
Preliminary plan developed in 2021 for transition from RHIC to EIC in Research

Substantial activities continue on RHIC analysis through the decade, but progressively larger effort on EIC

EIC group formed Oct 1, 2022 to focus effort with strong research and technical interest in ePIC, the detector funded under the EIC project

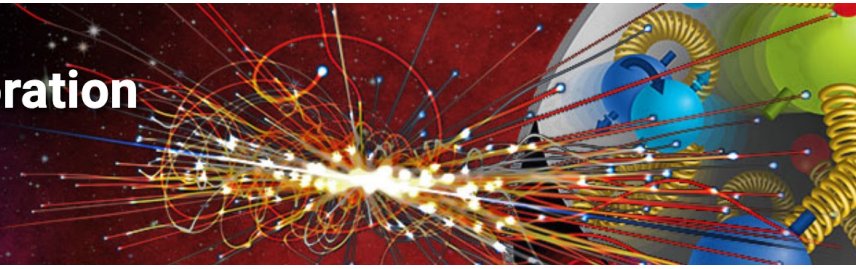
Strong LDRD support to investigate physics opportunities and complementarity of the second EIC detector.

Work closely with EIC Project to coordinate the transition from RHIC to EIC



Workshop on Exploring Collaboration with MSIs in Nuclear and Particle Physics

Hosted by Brookhaven National Laboratory
July 18–19, 2023



Workshop on Exploring Collaboration with Minority Serving Institutions (MSIs) in Nuclear and Particle Physics was a great success at BNL, July 18-19, 2023

- 17 MSIs participated, including deans and department chairs, professors and students
- DOE-NP, HEP and IP program managers participated in a panel discussion
- Many new ideas on research collaboration and workforce development with MSIs were discussed. A list of actions to follow.

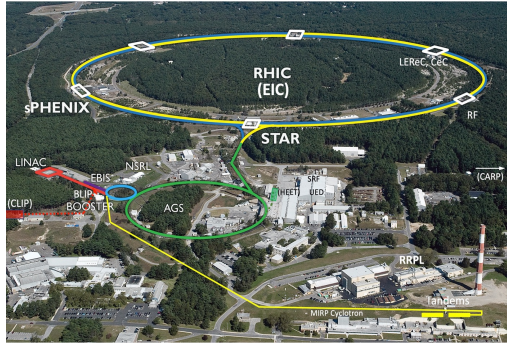


RENEW Programs

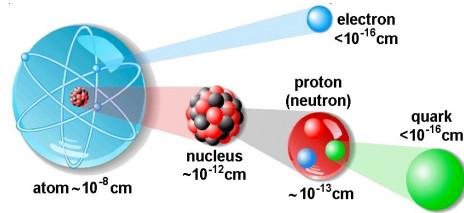
Reaching a New Energy Sciences Workforce

- 2022 RENEW Programs
 - Pathway Fermilab and Brookhaven Summer School
 - Neutrino Physics for Undergraduate Minority Advancement in Science(NuPUMAS)
 - 2021 (RENEW) PREP-NPT, a successful nuclear physics traineeship program at BNL
- Successful proposals with MSIs on 2023 RENEW calls
 - With Florida International University (HEP):
 - *Developing novel high-performance SPAD detectors for HEP - creating a training and research path for minority students*
 - With State University of New York at Old Westbury (OW) (HEP)
 - *Long Island High Energy and Astrophysics Undergraduate Pathway (LEAP-UP)*
 - Will support OW to start physics major this fall.
 - [Adjunct teaching positions at Old Westbury are available for postdocs to gain teaching experience](#)
 - PREP-NPT will be funded again by DOE Nuclear Physics (NP)
 - DOE Office of HEP supports BNL HEP to participate in PREP-NPT
 - Will identify URM students from collaborating MSIs with interest in HEP
 - Invited to be part of RENEW HBCU Collider Consortium
- We need all of you to participate in the program to build a more diverse workforce

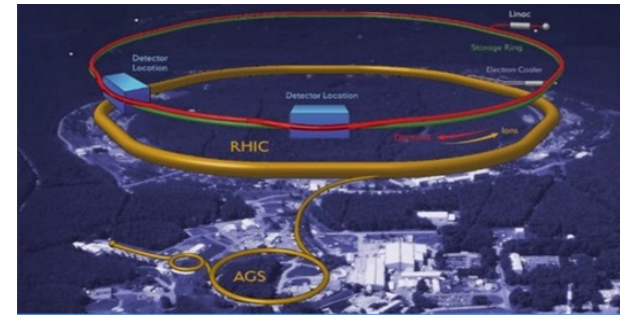
Postdocs are key part of the workforce for the science programs: THANK YOU! NPP programs provide great training ground for career in science and technology



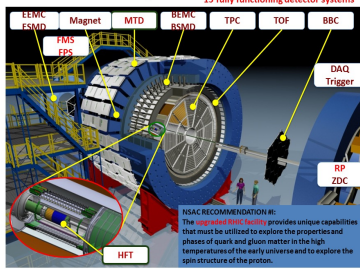
To understand sub-atomic world deeper



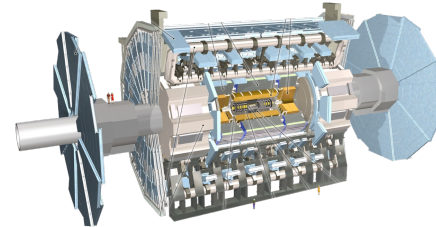
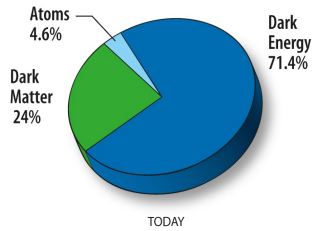
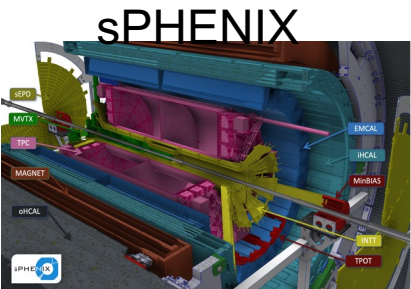
Electron-Ion Collider



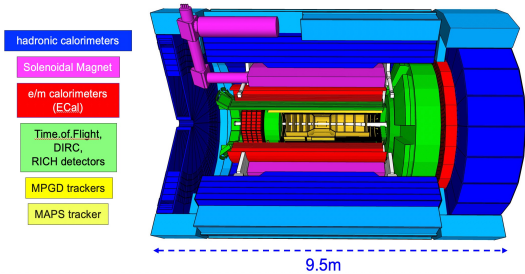
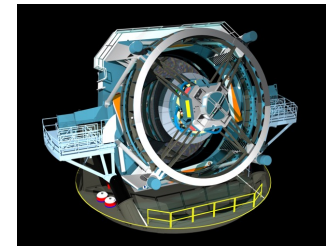
STAR Detector System



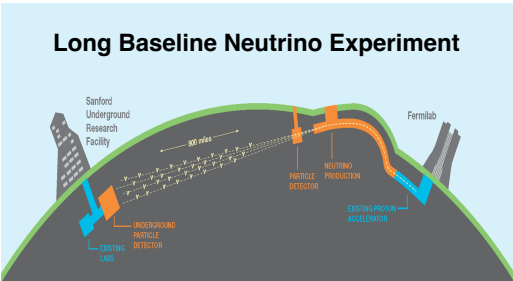
X10³ increases in DAQ rate since 2000, most precise Silicon Detector (HFT)



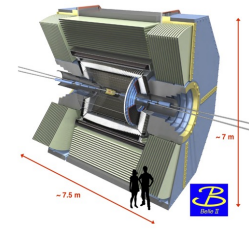
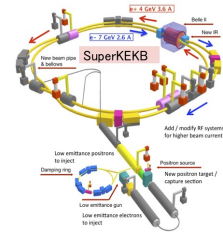
ATLAS @ LHC



ePIC Experiment at EIC

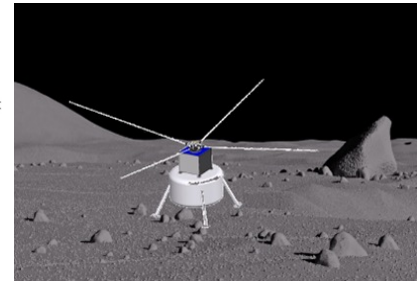


Long Baseline Neutrino Experiment



Belle II at SuperKEKB

Rubin Observatory



LuSEE-Night mission