Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

Welcome remarks

Haiyan Gao
ALD, Nuclear and Particle Physics, BNL

RHIC & AGS Users' Meeting

June 10, 2021

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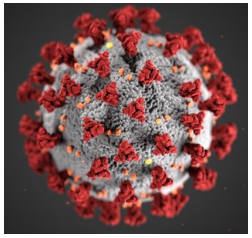
BNL anti-harassment policy

At Brookhaven National Laboratory (BNL) or BNL-sponsored events,

“Discriminatory behavior or harassment of conference participants or presenters will not be tolerated.”

Please refer to the poster on the Annual Users’ Meeting website under Participant Information.

COVID-19



COVID-19 pandemic affected our lives and activities in major ways

- ~3 months laboratory shut-down in March-June 2020
- ~30% of staff on site daily since June 2020, new guidelines became effective on June 7th

Minimized impact by following federal, State and DOE rules and regulations

- Safety of our staff and their families is our highest priority
- We developed ways to progress in the challenging new environment
  - Exemplary progress with sPHENIX upgrade
  - RHIC performing extremely well, STAR 2021 data taking exceedingly well, good progress with STAR forward upgrade
  - Strong performance/record with data analysis and publications

BNL provided strong support in fighting the virus

- Including performing calculations for medical purposes and experiments at NSLS-II
- NNP computing contributes to COVID work

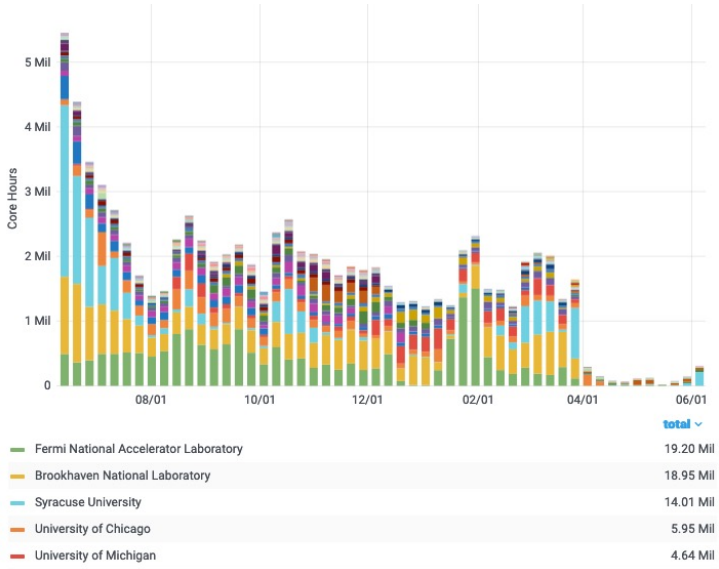
COVID is affecting operations and projects costs

- We continue to learn and adjust as the situation develops

NPP computing contribution to covid-19 computing research effort through Open Science Grid (OSG) a member of COVID-19 High Performance Computing (HPC) Consortium

https://opensciencegrid.org/

https://covid19-hpc-consortium.org



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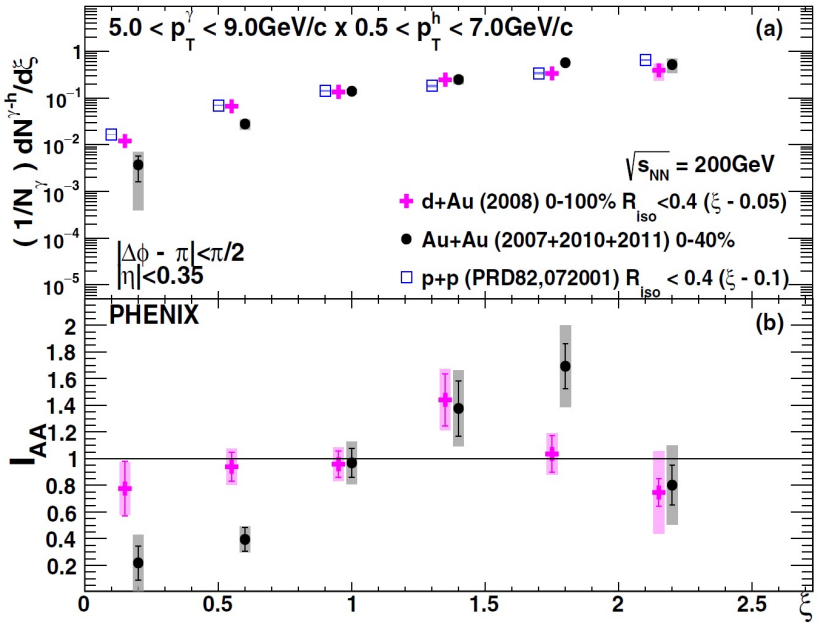
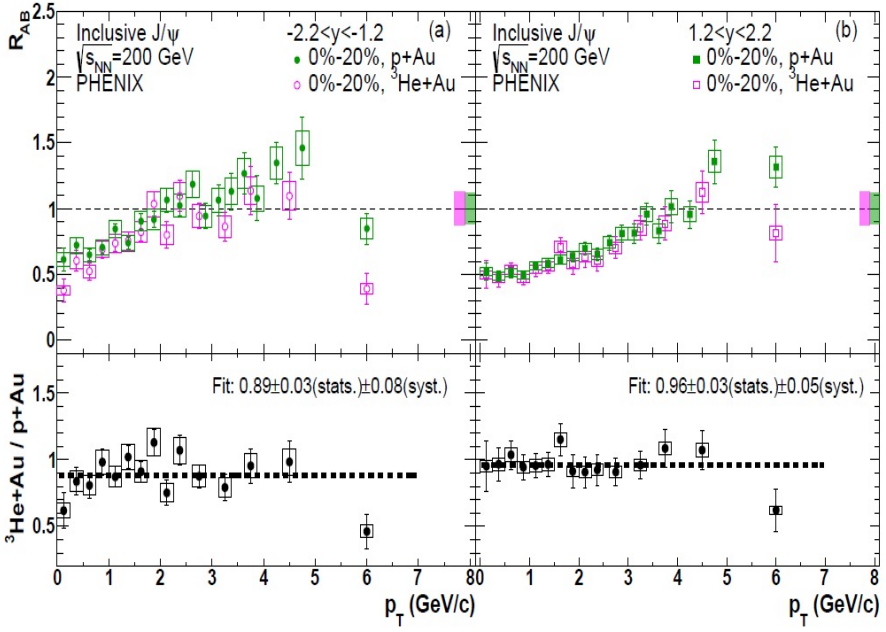
Highlights of PHENIX publication in 2020

PRC102, 054910 (2020)



- Direct-photon and hadron correlation in AuAu and dAu are compared
- Medium modification of jet fragmentation in AuAu

PRC102, 014902 (2020)



- Comprehensive study of J/ψ production in small systems (pAu, dAu, ^{3}HeAu) in forward and backward directions
- Cold Nuclear Matter effects on J/ψ

Acknowledgement: the PHENIX Collaboration

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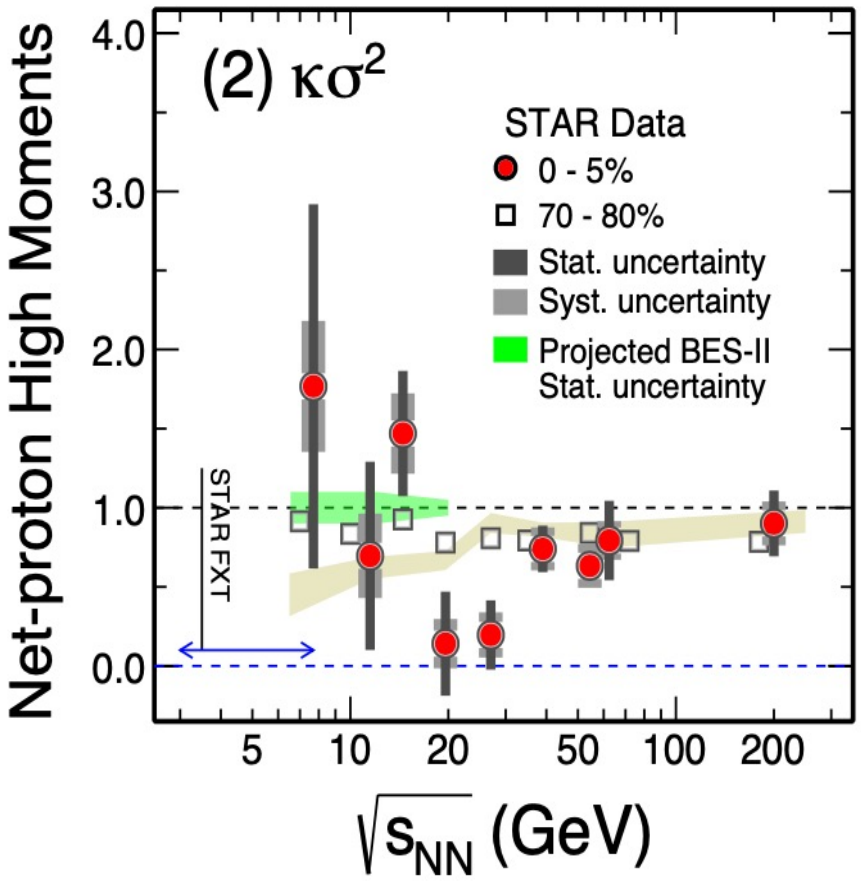
STAR: Critical Point Search

Phys. Rev. Lett. **126** (2021) 92301



- Non-monotonic variation of moments of net-baryon number distribution
  - Related to correlation length and susceptibilities of the system, suggested as a signature of a critical point
- Final BES-I based result

kurtosis × variance of the net-proton number: non-monotonic variation as a function of collision energy observed (3.1σ)

Acknowledgement: the STAR Collaboration

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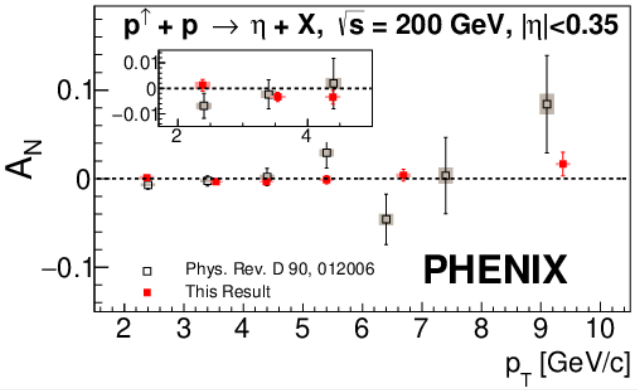
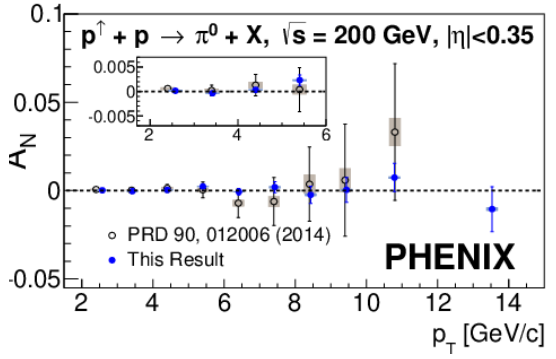
Central arm A_Ns

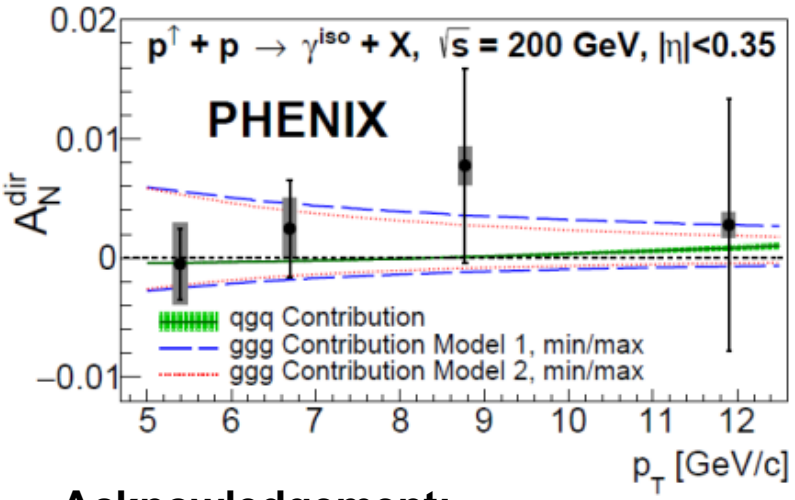
PRD 103 (2021), 052009

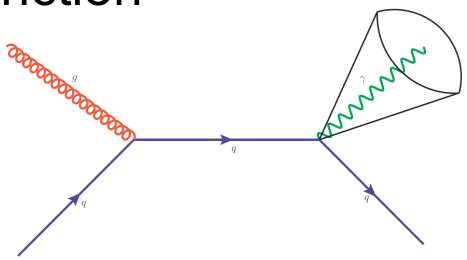
- Substantial updates for π^0 and η single spin asymmetries at central rapidity
- First direct photon A_N extracted at RHIC
- Mostly sensitive to initial state effects (no fragmentation) → quark-gluon and gluon-gluon correlation functions
- Power to constrain gluon-gluon correlation function as well





2102.13585, Submitted to PRL





Acknowledgement:
the PHENIX Collaboration

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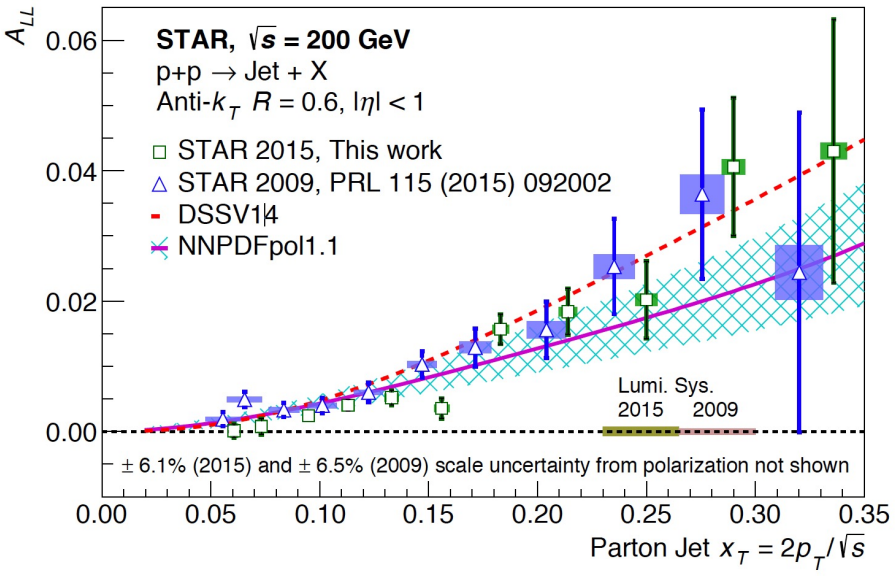
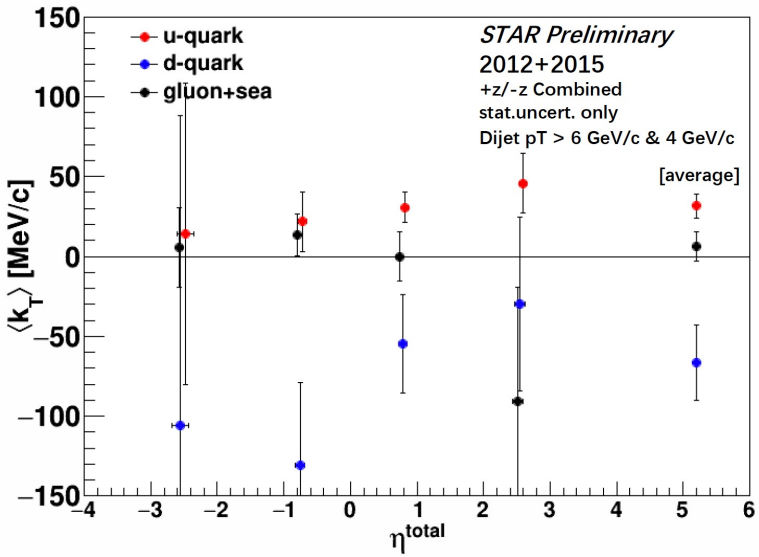
STAR Highlights : Gluon spin from inclusive/dijets A_{LL}

- Phys. Rev. D 103, 091103 (2021) (Editor's suggestion)
- 2015 200 GeV data
- Inclusive jets (shown) and dijets
- Sensitive to Delta G
- Excellent agreement with DSSV and NNPDF.
- Reduced error for data will allow for reduction of errors in theoretical curves.



Flavor separated k_T dependent Sivers in Dijet Production



- $Q^2 > 160\ \mathrm{GeV}^2$
- $\langle k_T^u \rangle > 0, \langle k_T^d \rangle < 0, \langle k_T^{g+sea} \rangle \sim 0$
- $\left|\frac{\langle k_T^d \rangle}{\langle k_T^u \rangle}\right| \sim 2$
- No clear dependency on η^{total} at given statistics

Acknowledgement: the STAR Collaboration

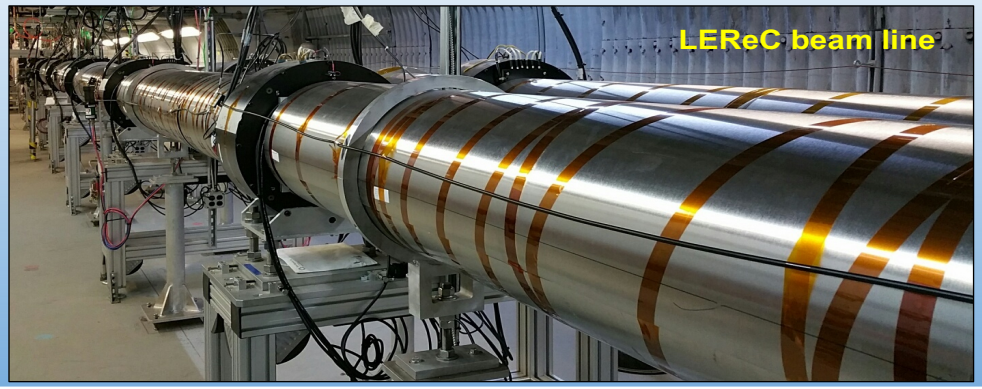
Budget

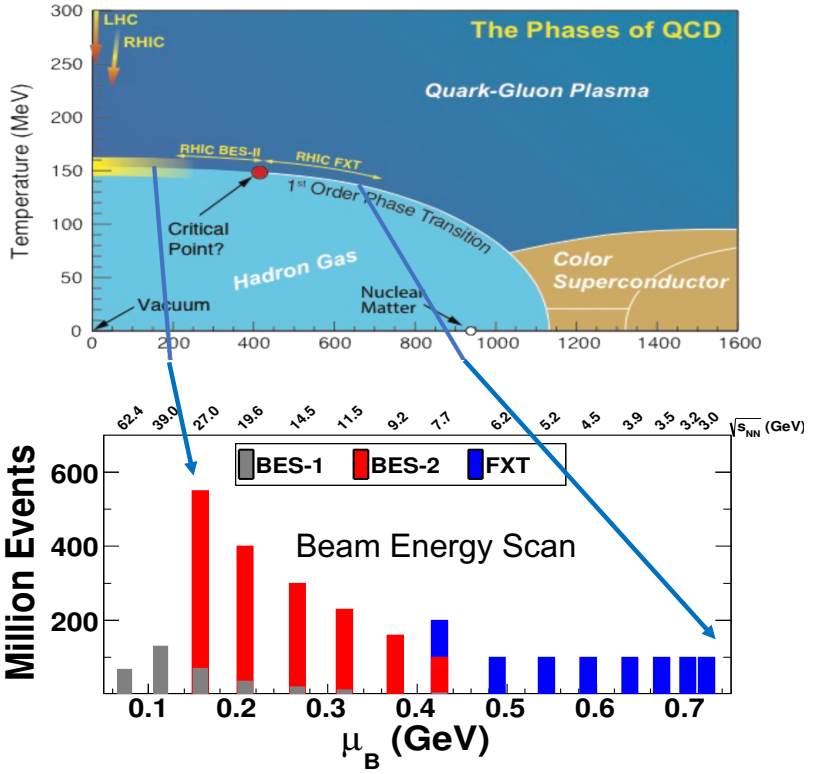
- FY22 President's budget request was announced on Friday, May 28th. The DOE Office of Science proposed budget is available here at https://www.energy.gov/science/office-science-budget.
- Reports from the NSF and the DOE (next two presentations)

After over a decade of discovery science – RHIC in the 2015 NSAC Long Range Plan

"There are two central goals of measurements planned at RHIC, as it completes its scientific mission, and at the LHC: **(1) Probe the inner workings of QGP by resolving its properties at shorter and shorter length scales. The complementarity of the two facilities is essential to this goal, as is a state-of-the-art jet detector at RHIC, called sPHENIX. (2) Map the phase diagram of QCD with experiments planned at RHIC.**"

LEReC = Low Energy RHIC electron Cooling
First-ever electron cooling with bunched beams
Test case for electron cooling at EIC





Beam Energy Scan

- What is the phase boundary of ordinary nuclear matter?
- Is there a critical point in the QCD phase diagram? If so, where?
  - 3-years run program, 13 energies
  - 7 energies new (fixed target)
  - >10-fold statistics for all energies

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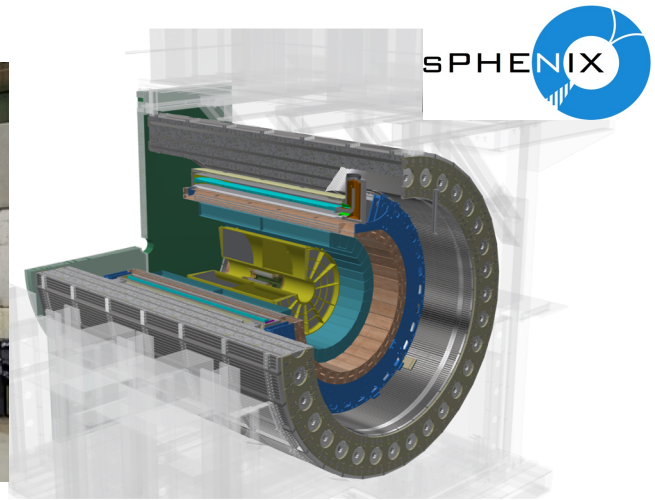
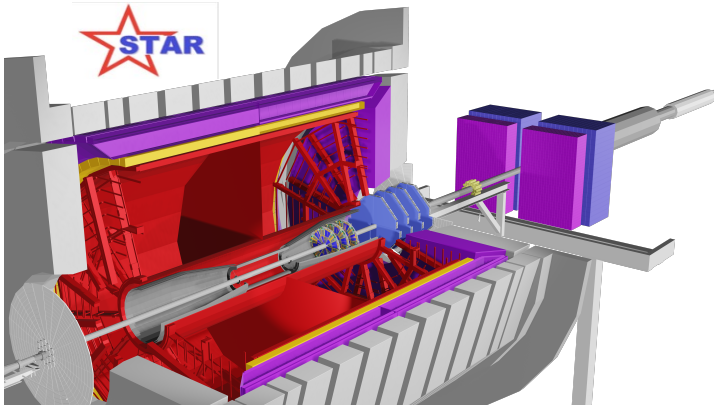
Completing the RHIC Mission: sPHENIX and STAR Upgrades

- sPHENIX will use energetic probes (jets, heavy quarks) to study quark-gluon plasma on different length scales
  - Where and how does plasma transitions from (quasi)particles to structureless "perfect" fluid?
- State-of-the-art collider detector using technology developed for LHC by ONP and OHEP

- New STAR forward detector upgrade probes universality of 3-D parton dynamics
- Important for EIC physics program





RHIC data taking scheduled for 2022–2025

sPHENIX upgrade will fully utilize the enhanced (50 times design) luminosity of RHIC, Forward spin run 2022 with STAR

NSF MRI Award Abstract # 1920077, MRI Consortium: Development of a Forward Calorimetry Upgrade for the STAR Detector

RHIC Run Plan 2021-2025

- **Beam Energy Scan II 2019-2021 with STAR**
  - Low energy ($\sqrt{s_{NN}}$ = 7.7, 9.2, 11.5, 14.5, 19.6 GeV) Au+Au runs using electron cooling to increase luminosity
  - Fixed target runs at (3.0), 3.5, 3.9, 4.5, 5.2, 6.2, 7.7 GeV
  - Search for signs of critical phenomena in event-by-event fluctuations

- **Forward spin run 2022 with STAR**
  - 500 GeV p+p enhanced by forward upgrades of STAR
  - Spin physics measurements complementary to EIC

- **Runs with the addition of sPHENIX 2023-25**
  - Full energy ($\sqrt{s_{NN}}$ = 200 GeV) Au+Au, p+p, p+Au
  - Precision measurements of fully resolved jets and Upsilon states

Accelerator R&D with strong connection to EIC

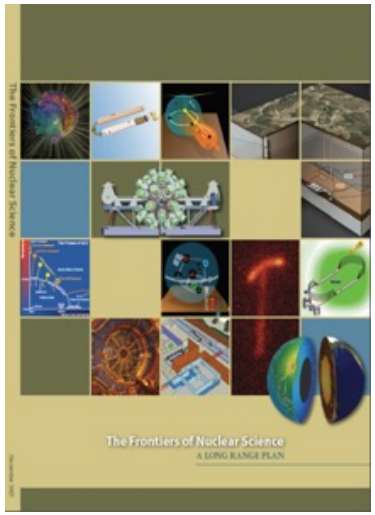
Upcoming Nuclear Physics PAC 2021

- Meeting dates: June 22-23, 2021 (virtual)
- Charge
  - BURs
    - STAR: Beam Use Requests for Runs 22-25
    - sPHENIX: Beam Use Requests for Runs 23-25
    - CeC: Beam Use Requests
  - Presentations
    - STAR: Update on BES, spin physics and isobar analyses
    - PHENIX: Update on ongoing analysis efforts and data archiving effort
    - sPHENIX: Installation status and schedule
    - Task force on the flow results from PHENIX and STAR experiments: status report presentation
- PAC written report expected within two weeks after the meeting

The Electron-Ion Collider – The Next QCD Frontier

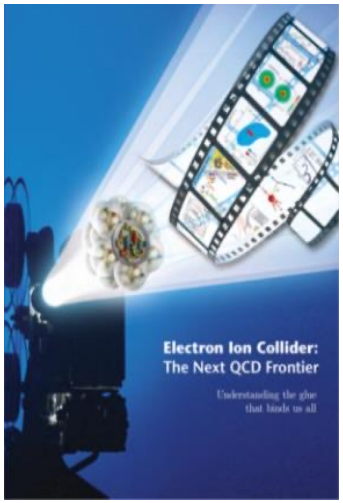
2018 NAS Report : An EIC can uniquely address three profound questions about nucleons—neutrons and protons—and how they are assembled to form the nuclei of atoms:

- 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?

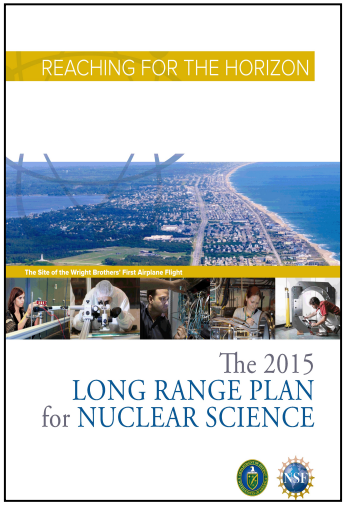


NSAC LRP 2007

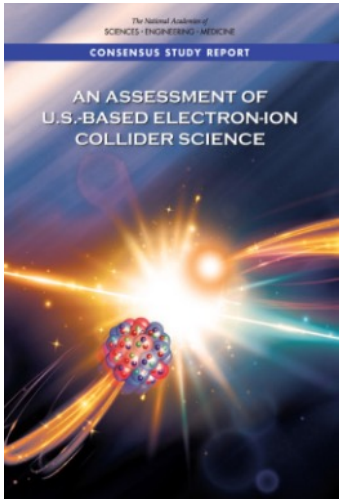
EIC INT Report 2011



EIC White Paper 2015



NSAC LRP 2015



NAS Report 2018

A long journey with years of community effort – the DOE announced the selection of BNL as the site for the EIC on Jan 9, 2020

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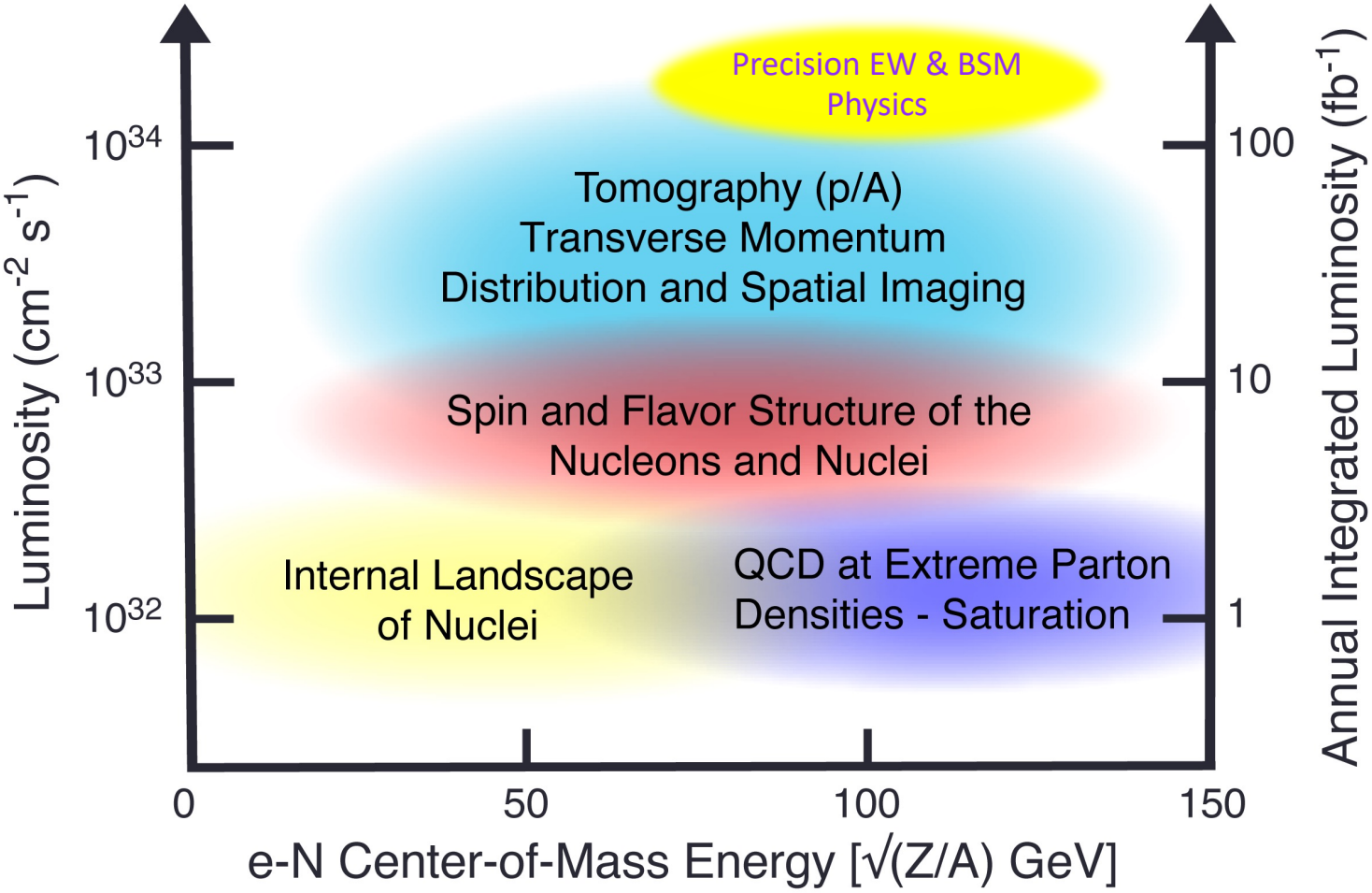
EIC Physics: CM vs. Luminosity vs. Integrated luminosity

EIC Physics: CM vs. Luminosity vs. Integrated luminosity



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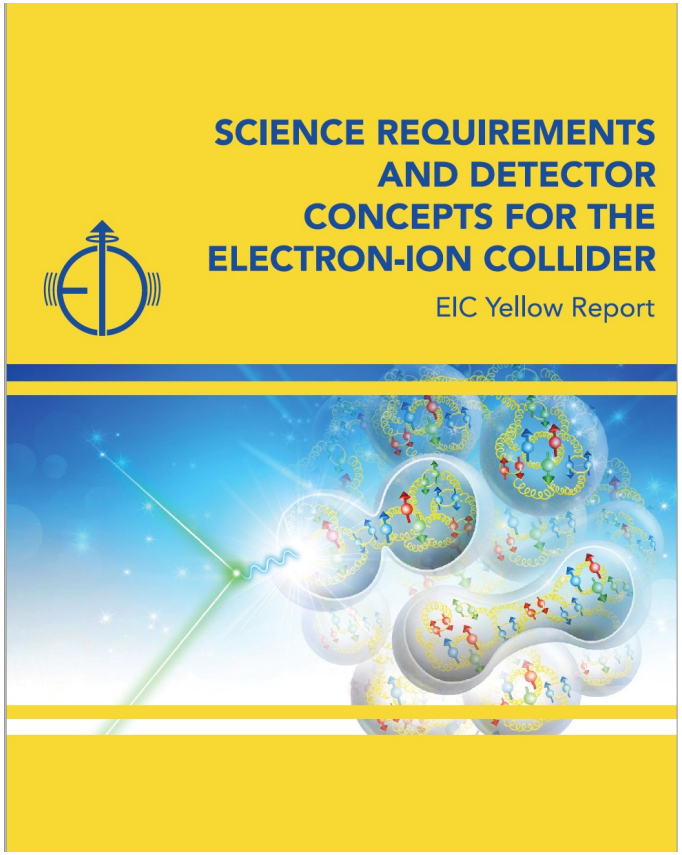
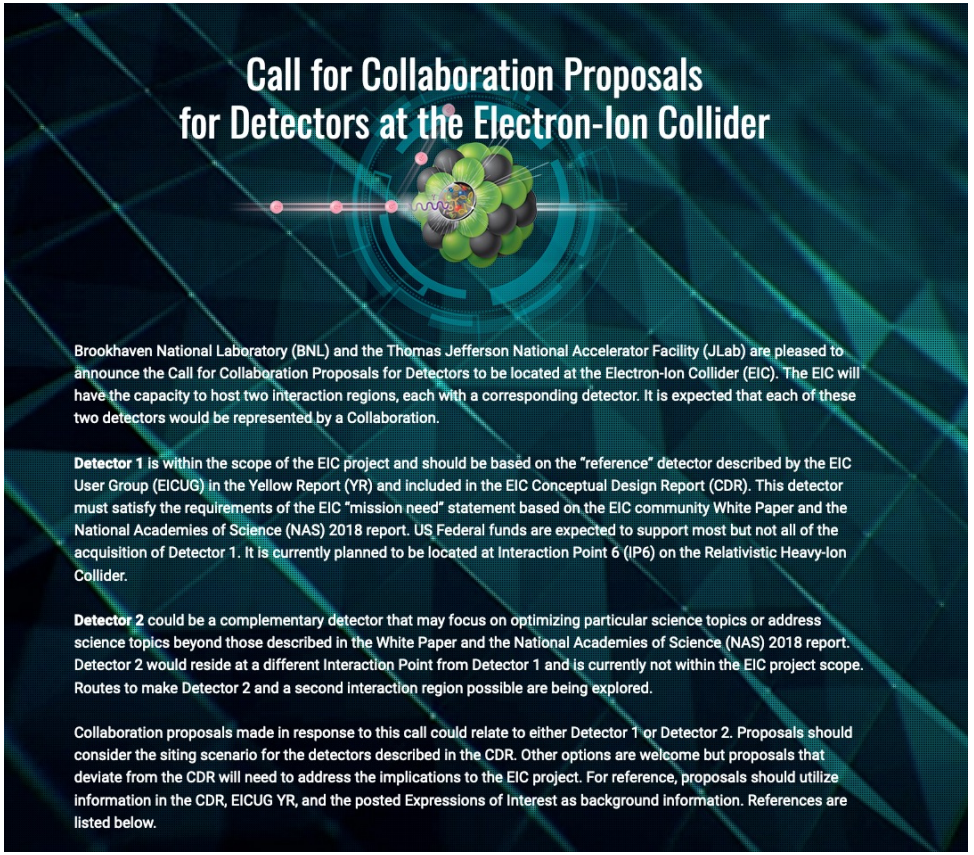
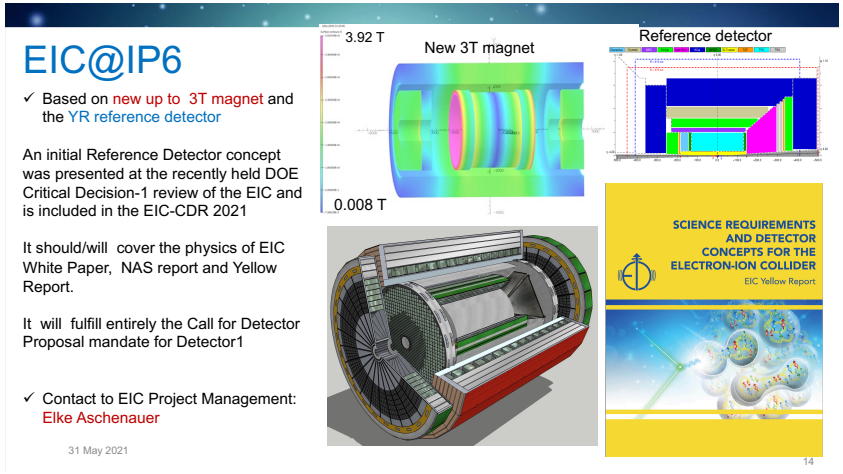
EIC Yellow Report and Call for Collaboration Proposals for Detectors





The EIC user community (including many of you) actively developing proposals

ATHENA



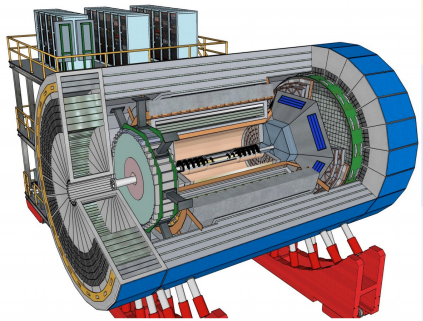
Yulia Furletova (JLAB)

Other proposal(s) might be in the making also

ECCE General Detector Concept

ECCE

The ECCE detector concept is undergoing rapid development



ECCE ELECTRON ENDCAP STRAWMAN

Tracking: MAPS, Micro Pattern Gaseous Detectors (MPGD)
Electron Detection: **PWO&SciGlass**
- Inner part: PWO crystals (reuse some)
- Outer part: SciGlass (backup PbGl)

h-PID: mRICH
- From yellow report

HCAL: Steel from magnet or Pb/Sc or Fe/Sc
- Not instrumented and only serve as flux return?
- Instrumented \w reduced thickness (lower energies)

ECCE CENTRAL BARREL STRAWMAN

Tracking: Silicon barrel tracker (optional Si/GEM hybrid)
Electron PID: SciGlass (backup: W/Sc (Pb/Sc) shashlik)
- SciGlass remains to be demonstrated
- Several backup options – lower resolution though

h-PID: hpDIRC & AC-LGAD
- Compact
- AC-LGAD never been shown for barrel configuration
- AC-LGAD backup: dE/dx (needs more space)

HCAL: magnet steel (reuse) - **Fe/Sc**

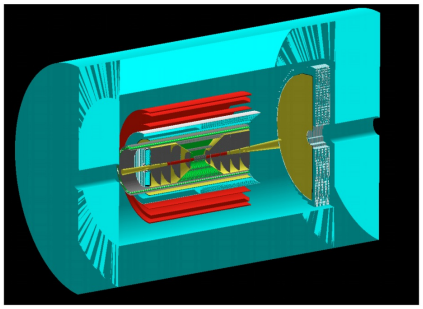
ECCE HADRON ENDCAP STRAWMAN

Tracking: MAPS, Micro Pattern Gaseous Detectors (MPGD)
h-PID: dRICH&TOF
e/h separation: TOF & aerogel
- TRD to separate electrons from high momentum hadrons?

Electron PID: W/ScFi, Pb/Sc or W/Sc shashlik
HCAL: Pb/Sc or Fe/Sc
- Alternative for improved resolution: dual readout, high-granularity

Or Hen, Tanja Horn, John Lajoie, the ECCE team

CORE: a COmpact detectoR for the EIC
- a Detector 2 (IP8) proposal



Pawel Nadel-Turonski
Stony Brook University

Charles Hyde
Old Dominion University

for the CORE pre-collaboration
(open to all users)

EIC UG meeting, May 20, 2021

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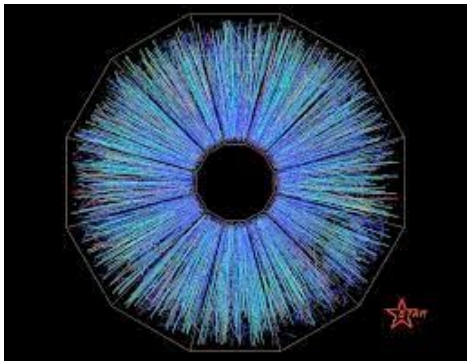
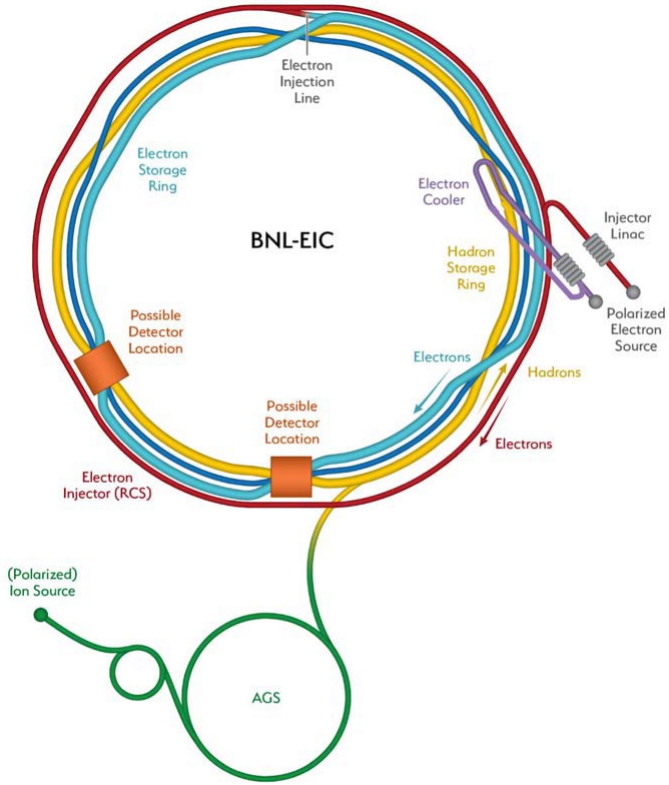
Nuclear and Particle Physics

- To lead and support discovery-based, innovation-driven research at the frontiers of accelerator, high-energy and nuclear physics, and to apply scientific and technological breakthroughs for societal benefits
- To become the premier center for QCD physics in the world attracting diverse talents worldwide and educating STEM workforce for the nation



From one discovery

collider to another



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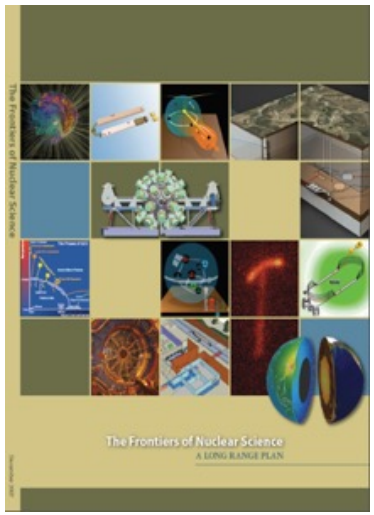
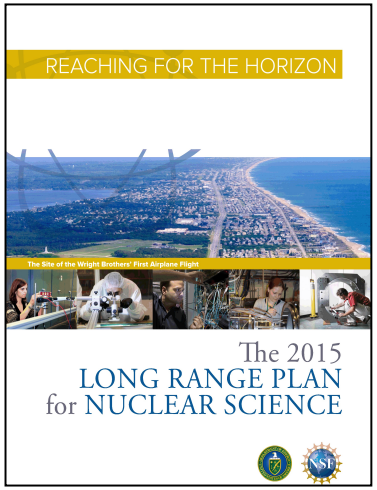
Upcoming NSAC Long Range Plan



NSAC LRP 2007



NSAC LRP 2015

Next LRP

NSAC LRP 2021-2023?

- With the EIC project underway, our community is at a good place
- Many challenges: technical, budgetary, competing needs, geopolitical, COVID, etc
- Engagement, stronger collaborations within the QCD community, and the broader nuclear physics community
- Long-term future of NP
- International Collaborations

Opportunities and Challenges

- To create a more diverse, inclusive and safe environment to conduct and support discovery-based science – collaboration and engagement with the Users communities
- Great opportunities for enhancing existing International collaborations and build new ones, but also have challenges (geopolitical, COVID,…..)
- The budgetary constraint and uncertainty
- The completion of the planned RHIC program in the scheduled time frame with limited cryo-weeks
- The transition from RHIC to EIC
- Diversity, equity and inclusion (DEI): culture, strategy, competition, pipeline (collaborations and engagement with Users communities) (some examples in the next a few slides)

Pipeline – Diversity, Equity and Inclusion – stronger partnerships with universities

Chasman Award 2021

Maria Stefaniak – RHIC (STAR)

- Study of the interdependencies between two collective flow effects: elliptic v2 and triangular flow v3 that characterize the shape and dynamics of expanding matter
- Increasing differences are observed between protons' and antiprotons' v3 with the decrease of the collision energy.
- She performs various experimental tests of the proposed theoretical scenarios to explain differences between the flow of particles and antiparticles.
- expecting to graduate with a double diploma from Warsaw University of Technology, Poland & Subatech-IMT Atlantique, France in summer 2021

Mikaela Dunkin – NSLS-II

- Study of the structure of various materials to understand how instability and disorder impact battery function
- Stony Brook University (SBU), expecting to graduate in May 2022

The award ceremony will take place virtually Tuesday, June 29, 2021, at 1 p.m.

Nuclear Physics Traineeship (NPT) Program

- Newly funded by the DOE HQ to support 10 URMs virtually summer 2021, 8 onsite summer 2022

  PI: Mickey Chiu

  Co-PIs: Abhay Deshpande, Stony Brook/BNL
  Carol Scarlett, Florida A&M University
  Marcus Alfred, Howard University
  Willie Rockward, Morgan State University
  Mark Harvey, Texas Southern University
  Ratnakar Palai, University of Puerto Rico

- Diverse research topics mentored by NPP scientists, National Nuclear Data Center (NNDC), and Computational Science Initiatives (CSI)

- Holistic approach: BNL research + Mentoring + Preparation (additional NP courses at SBU) → graduate school (MSI advisors and SBU)

A second NPT program at BNL

- NuSTEAM - Nuclear Science in Texas for the Enhancement and the Advancement of Minorities
- This is a new collaborative effort by four Texas-based minority serving universities University of Houston (UH), University of Texas - Rio Grande Valley (UTRGV), University of Texas – El Paso (UTEP) and Prairie View A&M University (PVAMU).
- 9 undergraduate students from the participating institutions will go through a six-week training program at UH, followed by a two-week program at BNL and two semesters of collaborative research at their home institutions.
- Program presently funded for two years: 2021/2022
- Research topics: Relativistic Heavy Ions (Experiment, Theory), Neutrino Physics, Medical Physics, Space Science, Machine Learning in NP, Career Building
- PI: Claudia Ratti (UH)
- Co-PIs: Rene Bellwied, Dan Cherdack, Larry Pinsky, Anthony Timmins (UH)

  Jorge Munoz (UTEP)

  Efrain Ferrer, Vivian Incera (UTRGV)

  Gary Erickson, Premkumar Saganti (PVAMU)
- BNL Collaborators: Lijuan Ruan, Steven Kettell, Mary Bishai

DOE's Office of Science Graduate Student Research (SCGSR) Program

"Through world-class training and access to state-of-the-art facilities and resources at DOE National Laboratories, SCGSR prepares graduate students to enter jobs of critical importance to the DOE mission and secures our national position at the forefront of discovery and innovation."

"Since 2014, the SCGSR program has provided more than 700 U.S. graduate awardees from 150 universities with supplemental funds to conduct part of their thesis research at a host DOE laboratory in collaboration with a DOE laboratory scientist." – 78 selected from cycle 2 of 2020 solicitation

Two solicitation cycles each year. The 2021 Solicitation 1 cycle is ended 5:00pm ET, May 5, 2021. **Look for 2021 Solicitation 2 cycle**

For more information on SCGSR: https://science.osti.gov/wdts/scgsr

BNL (NPP) supported and will continue to support the Users communities working on AGS, RHIC and in the future on the EIC

Thank you for your attention!

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