2021 GHP Topical Group Meeting

News from BNL

Dmitri Denisov (BNL)

April 15, 2021

BROOKHAVEN NATIONAL LABORATORY

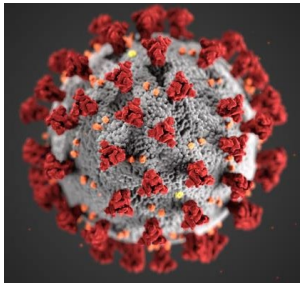
U.S. DEPARTMENT OF ENERGY

Agenda

- RHIC Beam Energy Scan II
- Highlights of RHIC New Results
- Next steps: RHIC detector upgrades
- Progress on the EIC

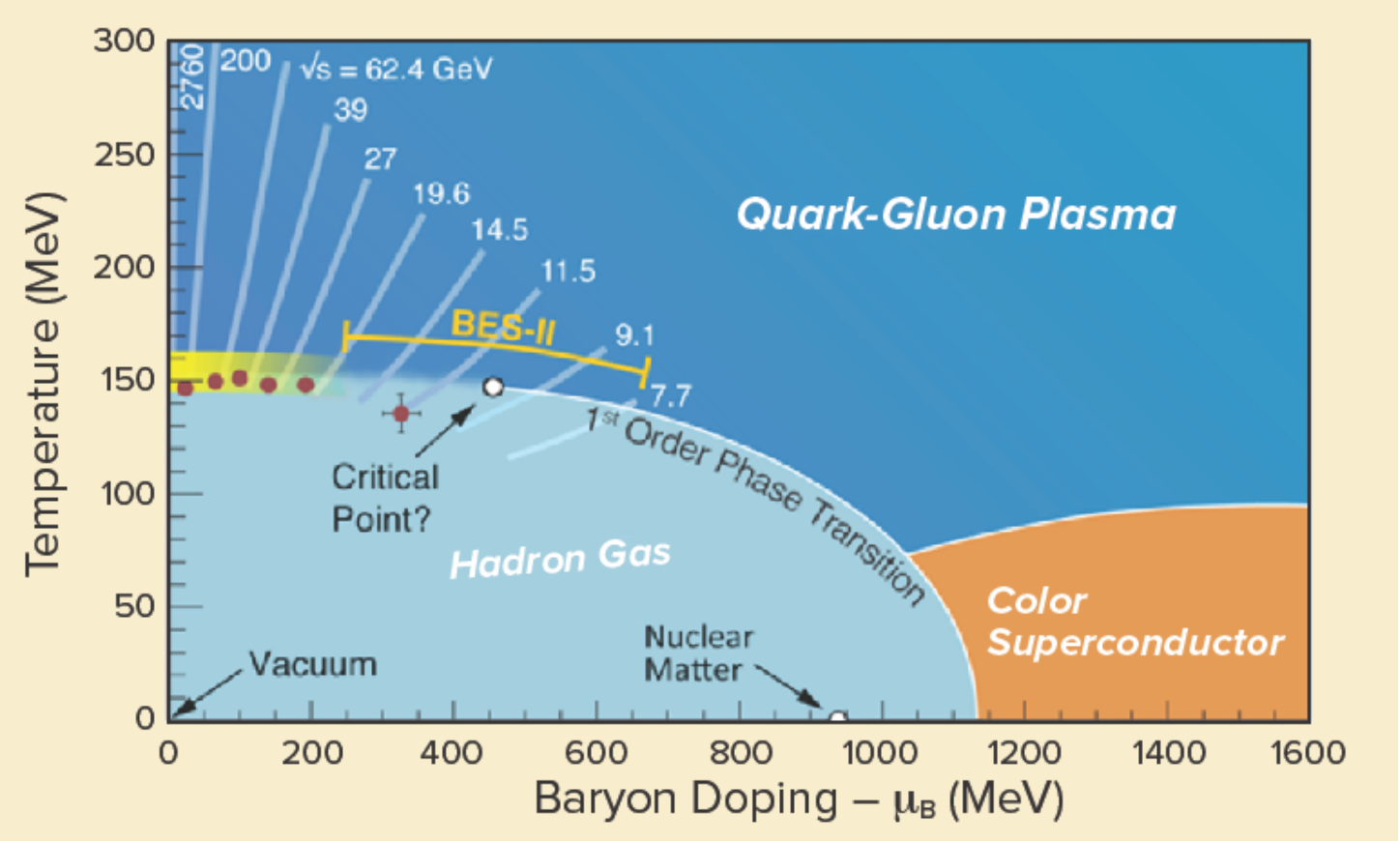
COVID-19

- COVID-19 pandemic affected our lives and activities in major ways
  - ~3 months laboratory min-safe mode in March-June 2020
  - ~30% of staff on site daily since June 2020
- We minimize 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
    - Full success of RHIC 2020 run
    - Exemplary progress with sPHENIX upgrade
    - Strong science analysis and publications



- BNL provided strong support in fighting the virus
- The pandemic is not over yet

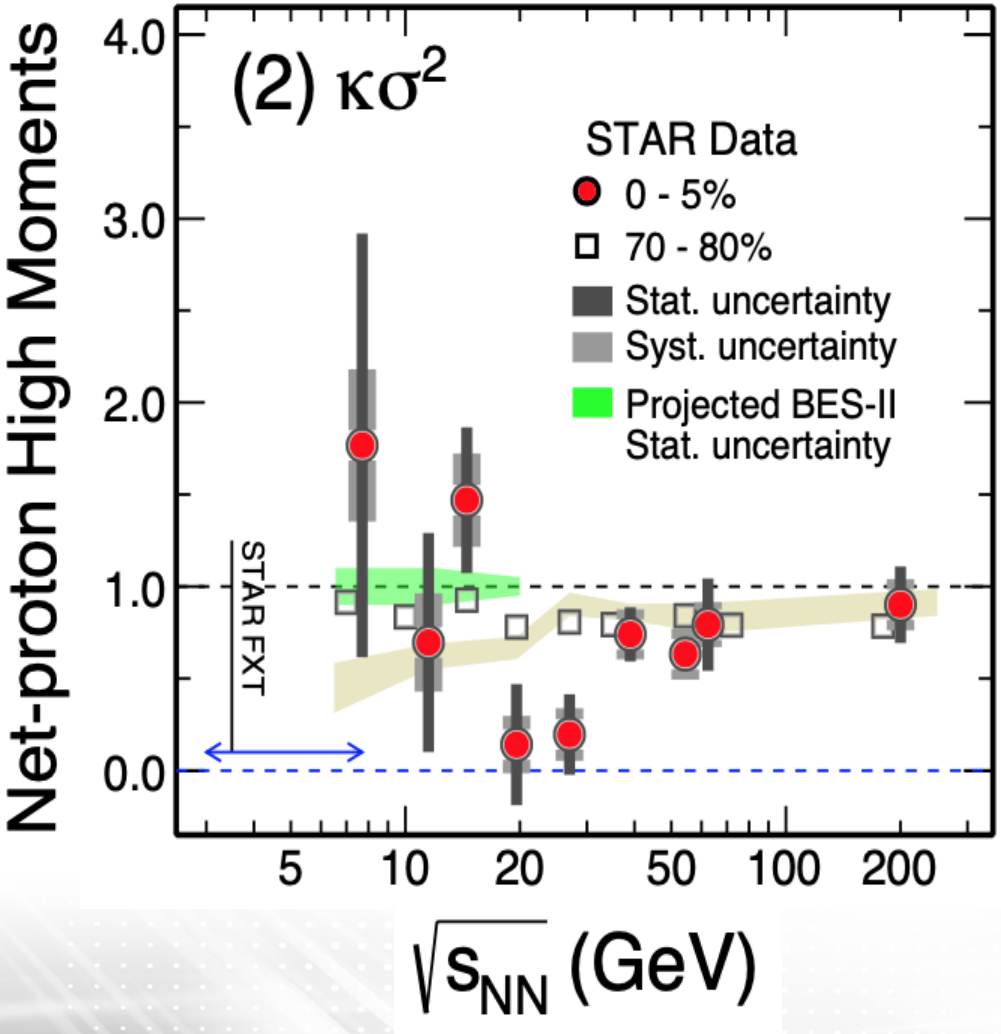
RHIC Beam Energy Scan Phase 2



- High sensitivity search for structure in phase diagram as a function of baryon doping
  - Enabled by upgrades to accelerator and detector

Status from BES I: Critical Point Search

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



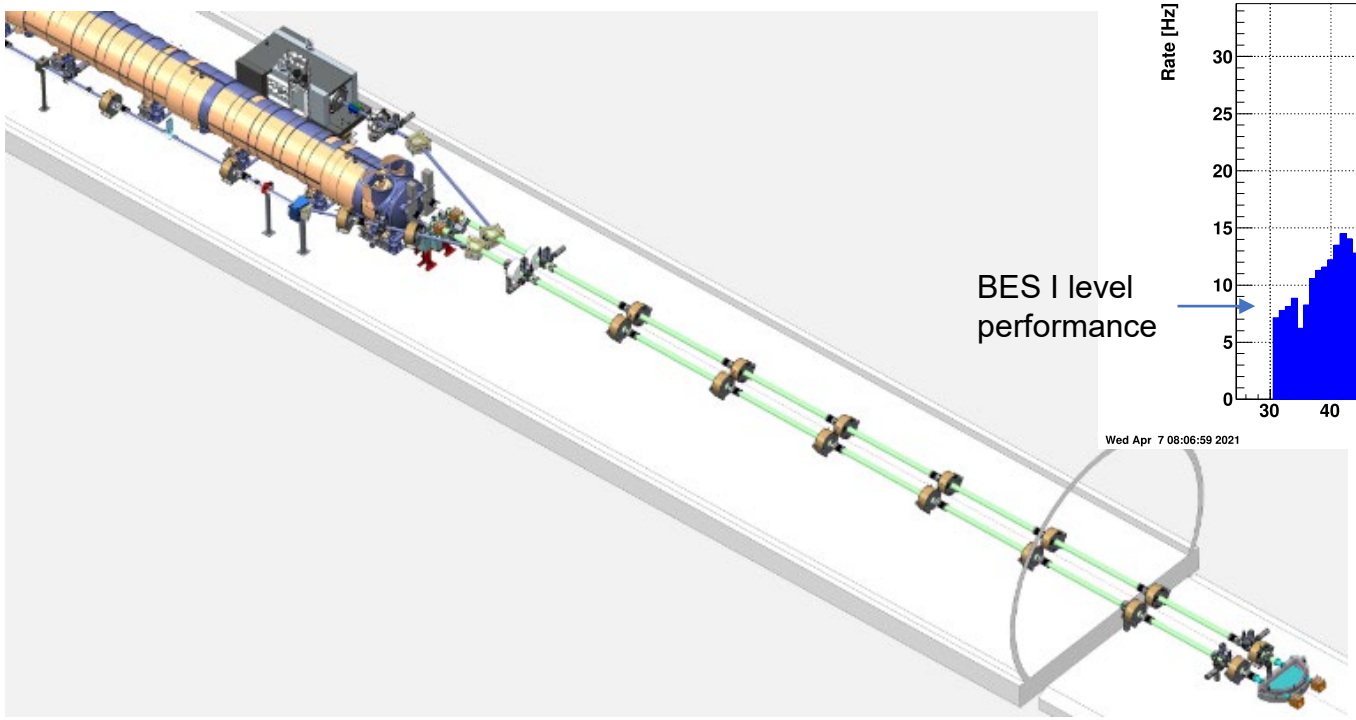
- Final BES I based result
- Non-monotonic variation of moments of net-baryon number distribution
  - Related to correlation length, suggested as a signature of a critical point

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

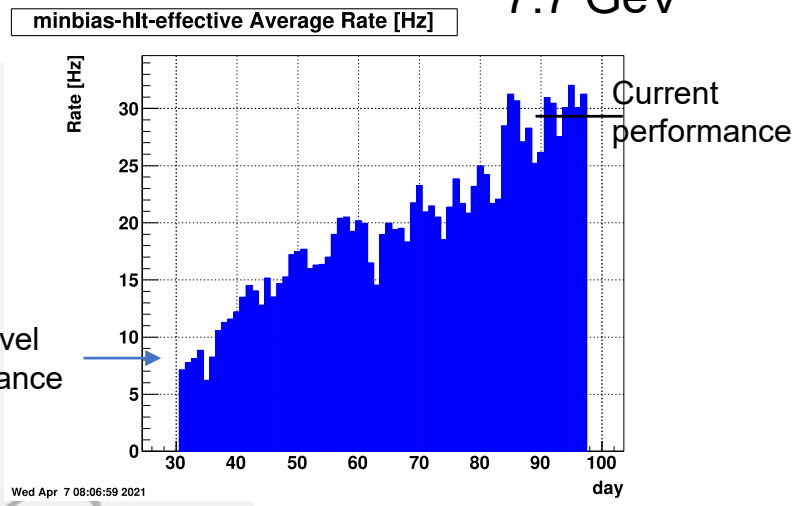
Beam Energy Scan II Data Collection

Beam Energy (GeV/nucleon)	$\sqrt{s_{NN}}$ (GeV)	μ_B (MeV)	Run Time	Number Events Requested (Recorded)	Date Collected
13.5	27	156	24 days	(560 M)	Run-18
9.8	19.6	206	36 days	400 M (582 M)	Run-19
7.3	14.6	262	60 days	300 M (324 M)	Run-19
5.75	11.5	316	54 days	230 M (235 M)	Run-20
4.59	9.2	373	102 days	160 M (162 M)[1]	Run-20+20b
31.2	7.7 (FXT)	420	0.5+1.1 days	100 M (50 M+112 M)	Run-19+20
19.5	6.2 (FXT)	487	1.4 days	100 M (118 M)	Run-20
13.5	5.2 (FXT)	541	1.0 day	100 M (103 M)	Run-20
9.8	4.5 (FXT)	589	0.9 days	100 M (108 M)	Run-20
7.3	3.9 (FXT)	633	1.1 days	100 M (117 M)	Run-20
5.75	3.5 (FXT)	666	0.9 days	100 M (116 M)	Run-20
4.59	3.2 (FXT)	699	2.0 days	100 M (200 M)	Run-19
3.85	3.0 (FXT)	721	4.6 days	100 M (259 M)	Run-18
3.85	7.7	420	11-20 weeks	100 M	Run-21[2]

Low Energy RHIC Electron Cooling

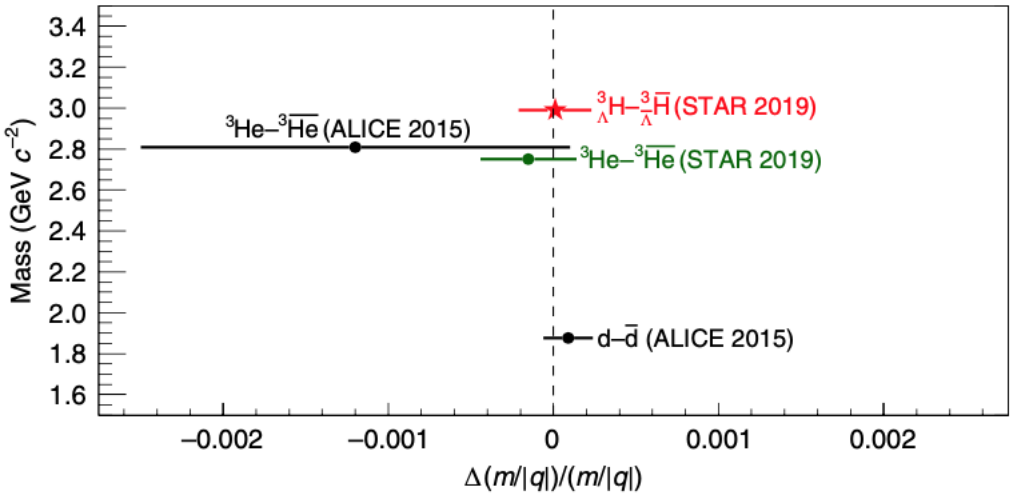


2021 Run
7.7 GeV



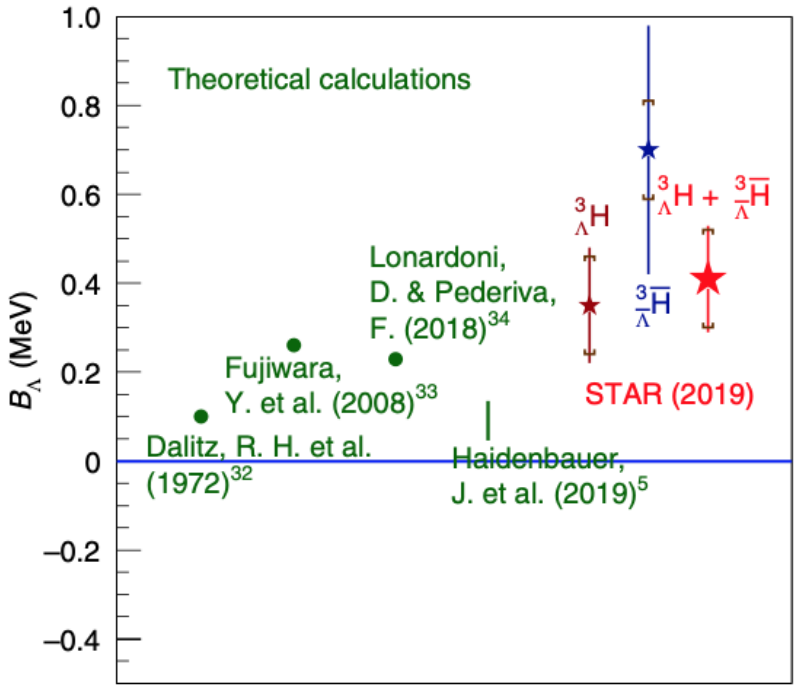
- First bunched beam electron cooling
  - Targeted at two lowest energies of BES II
  - Enabling upgrade to complete in reasonable beamtime

STAR: First Quantitative s-sbar Symmetry Test



Nature Physics **16** (2020) 409

No deviation from expected exact matter-antimatter binding energy symmetry observed



B_Λ differs from widely used predictions assuming hypertriton a weekly bound d-**Λ** system

Stringent constraints on hyperon-nucleon interactions

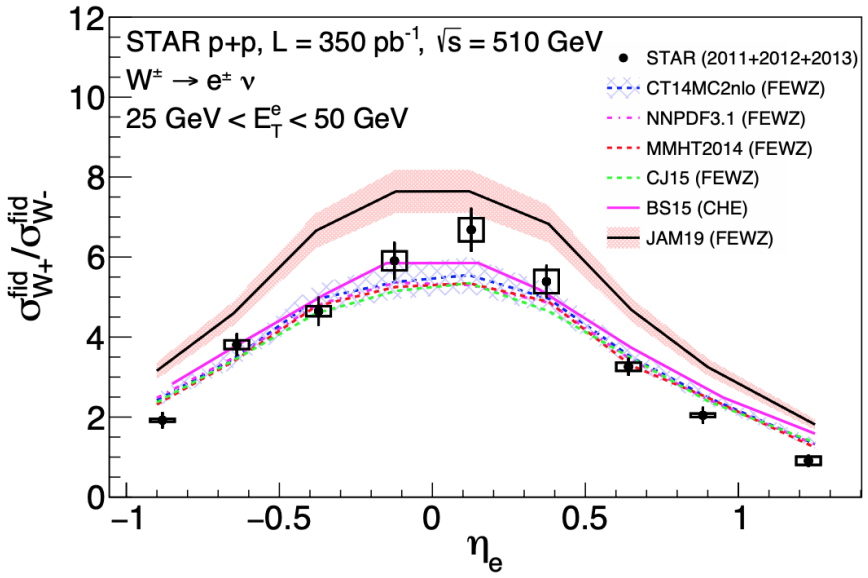
- Implications for neutron star interior studies where strange matter might exist

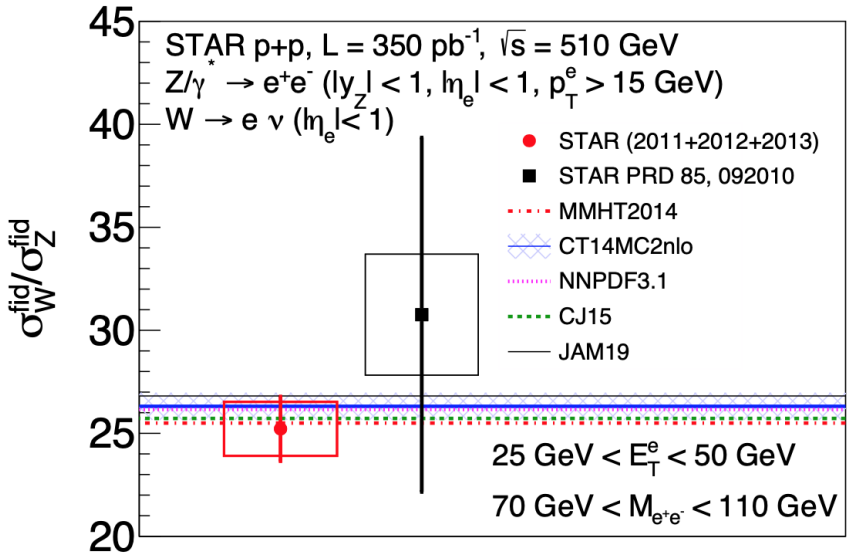
Continues string of hypernuclei results

Future: Fixed target adds further opportunities at high baryon density

W and Z Cross Sections

Phys. Rev. D **103** (2021) 012001





W^+/W^- cross section ratio:

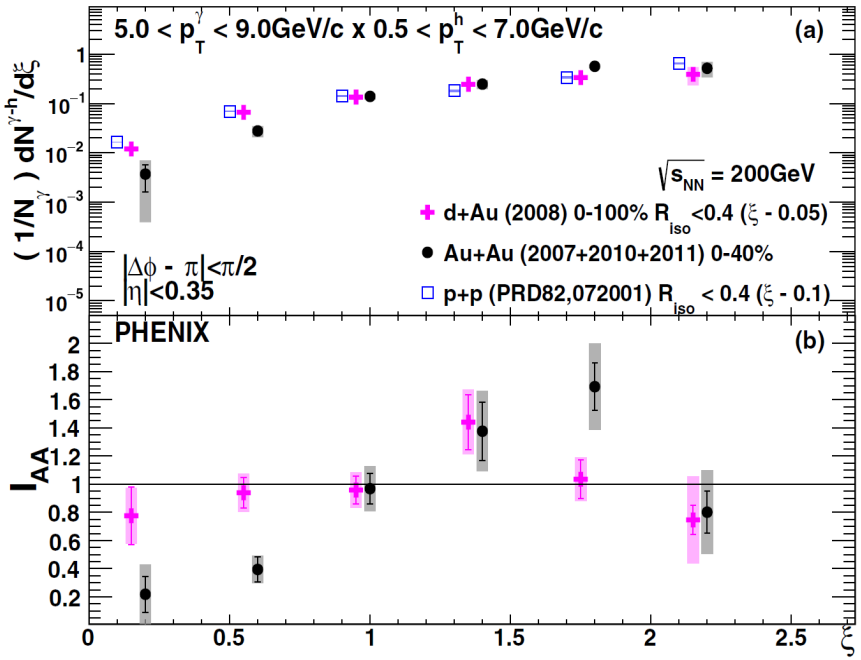
- Sensitive to unpolarized $\bar{d}/\bar{u}$ quark distribution
- Complementary to the Drell-Yan data with high $Q^2 \sim M_W^2$
- Insights into $\bar{d}$ and $\bar{u}$ at x > 0.05

W/Z cross section ratio:
sensitive to strange quark content of the proton

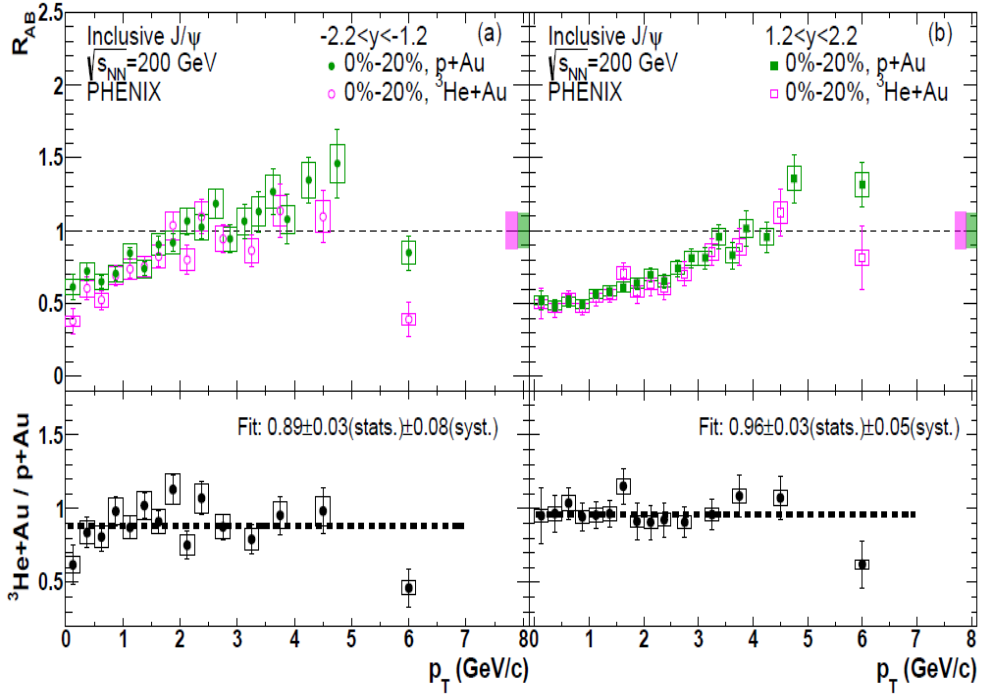
Serve as input into global analyses to provide constraints on the sea quark distributions

Highlights of PHENIX publication in 2020

PRC102, 054910 (2020)



PRC102, 014902 (2020)



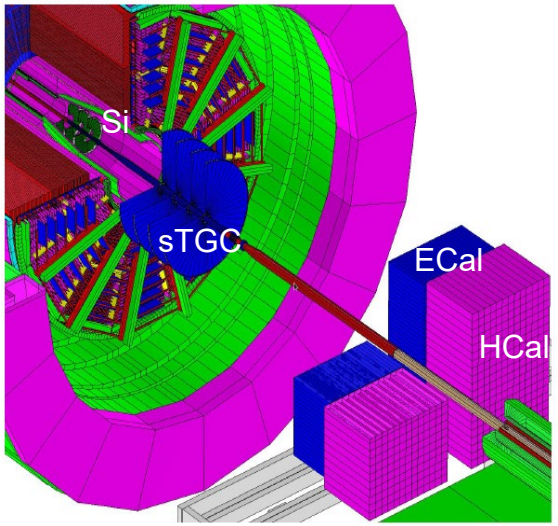
- Direct-photon and hadron correlation in AuAu and dAu are compared
- Medium modification of jet fragmentation in AuAu

- 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

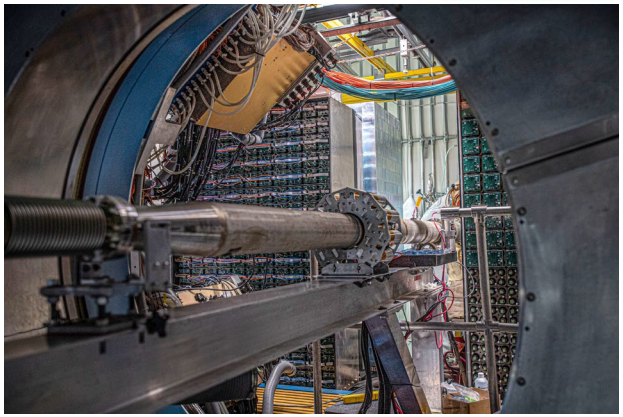
STAR Forward Upgrade

Physics target: measurements in ↑p+↑p and ↑p+A complementary to future measurements at EIC

- Partonic kinematics similar



- 4 new detector systems $2.5 < \eta < 4$
  - ECal, HCal, Silicon and sTGC tracker
  - First data taking during Run 22



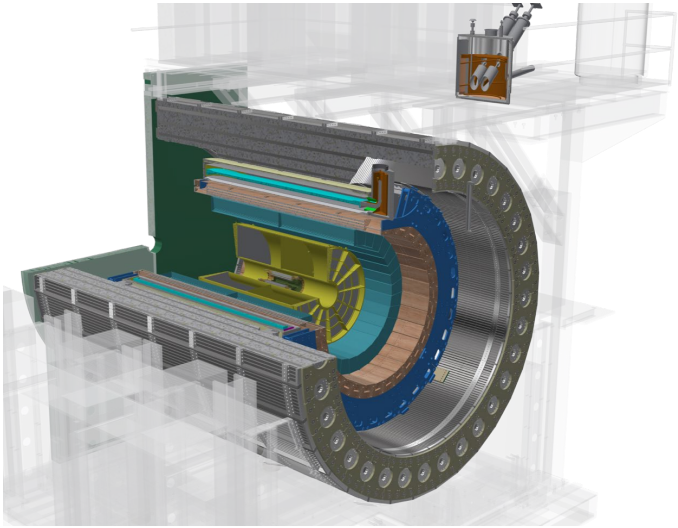
- Calorimeter systems installed in January 2021
  - Commissioning with beam in full swing

- Trackers
  - Full system prototype tests in Run 2020 and 2021
  - Production started

On track for Run 2022

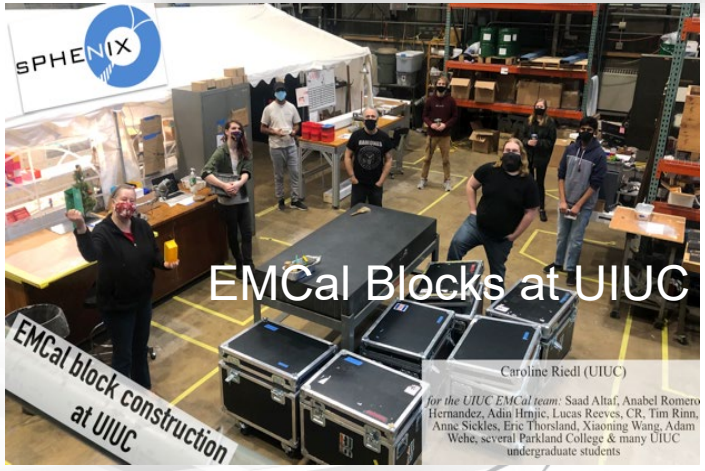
sPHENIX

Physics target: multiscale probe of QGP structure using jets, quarkonia, and heavy flavor



Construction continuing on track for first physics run in 2023

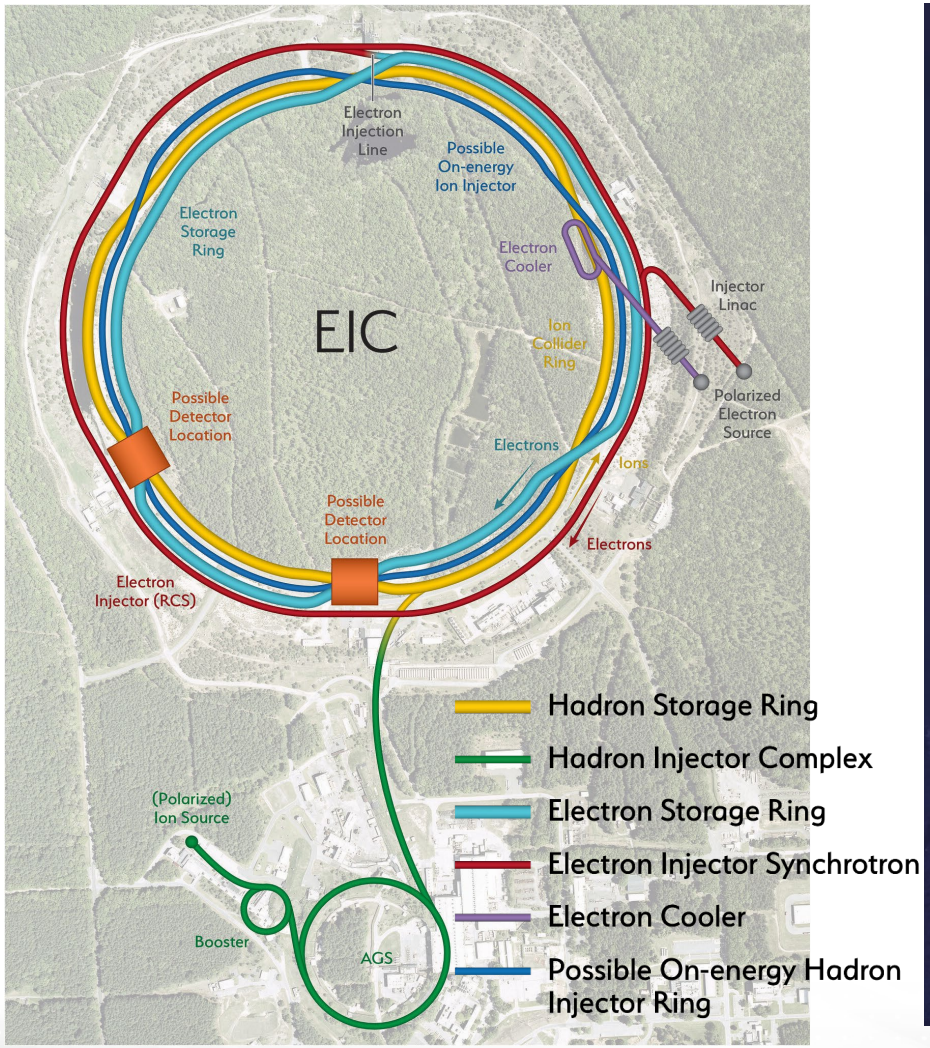
Collaboration has grown to 83 institutions across 4 continents

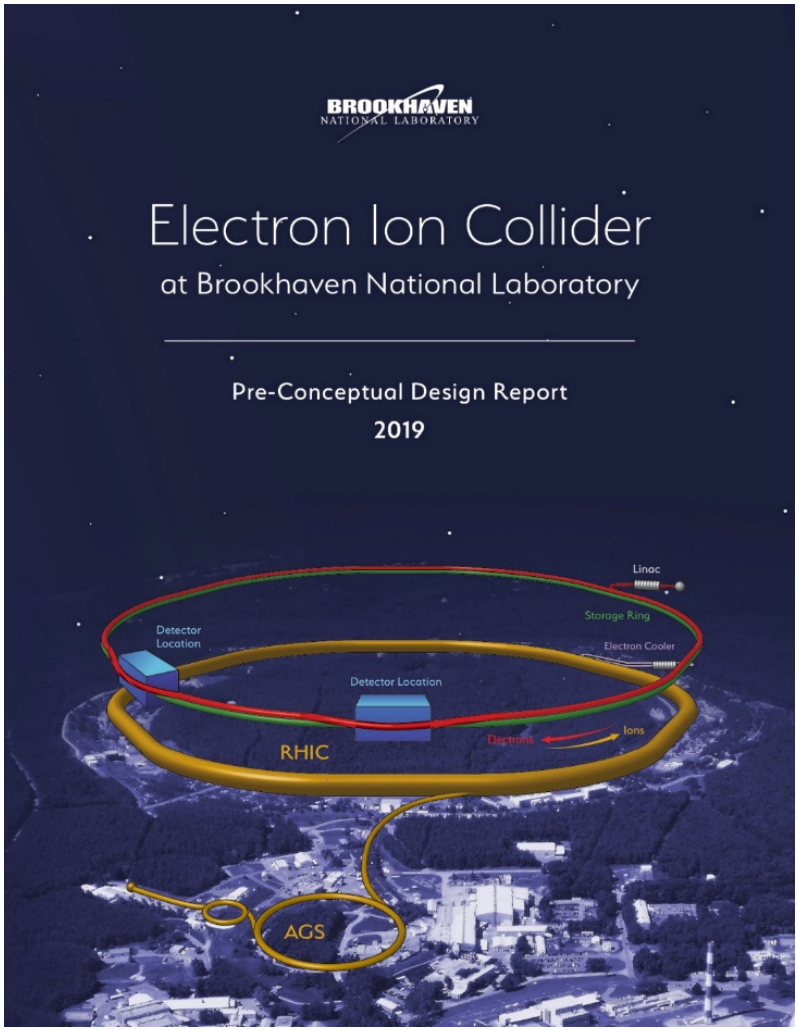


RHIC Runs 2021-25

Year		
2021	Completion of Beam Energy Scan II Precision investigation of structure of QCD phase diagram	
2022	↑p+↑p 500 GeV First run with STAR Forward Upgrade Transverse spin measurements complementary to EIC	
2023	Au+Au 200 GeV First physics run with sPHENIX First high energy heavy ion run with extended range from STAR BES II and Forward Upgrades	
2024	↑p+↑p and ↑p+Au runs at 200 GeV Reference data for 2023 run Further spin and cold QCD measurements complementary to EIC	
2025	High statistics Au+Au 200 GeV Realize sPHENIX capabilities	

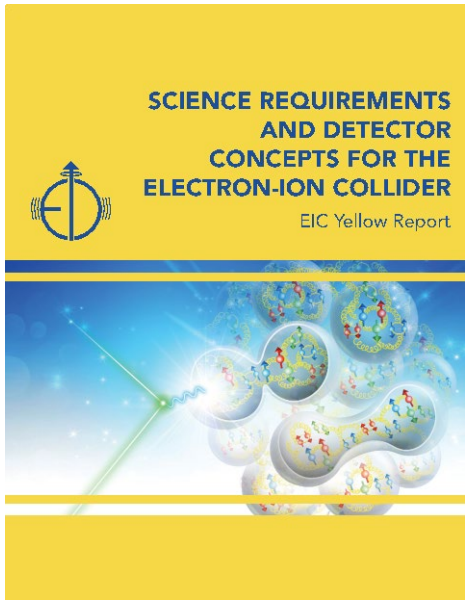
Electron Ion Collider Project

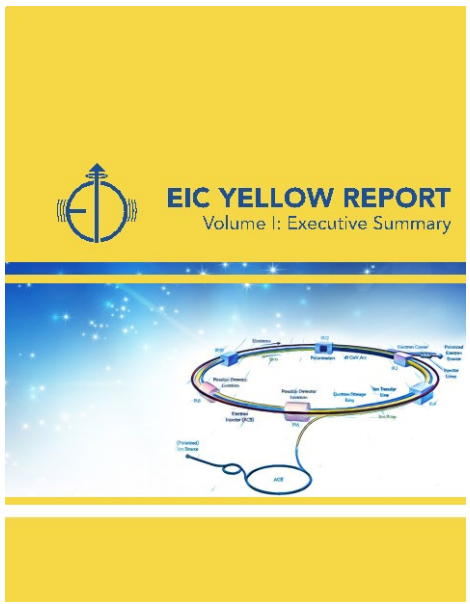


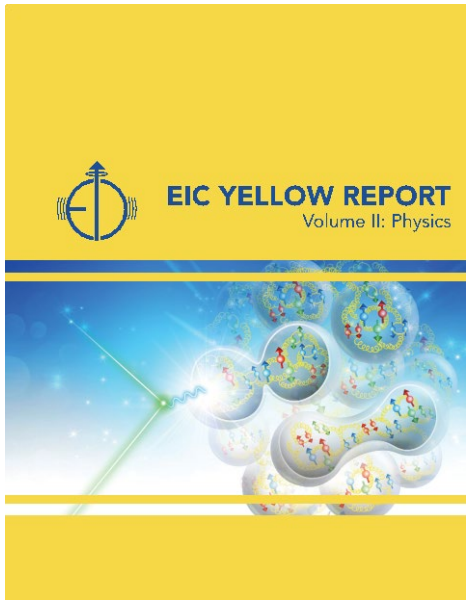


Joint project between BNL and TJNAF
DOE CD-1 Review in January 2021

EIC Physics and Detectors

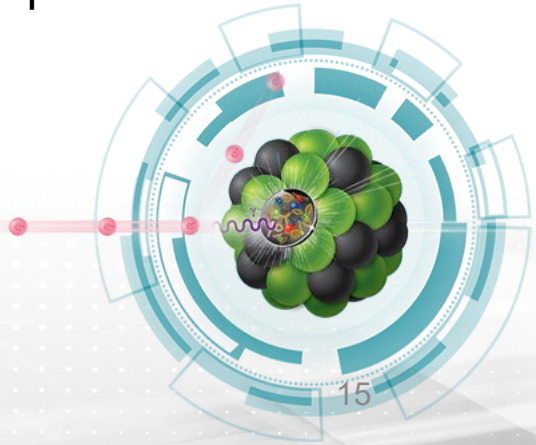






- Yellow Report: major effort guided by the EIC Users' Group
  - Released March 2021, http://www.eicug.org/web/sites/default/files/Yellow_Report_v1.1.pdf

- Call for Collaboration Proposals for Detectors at the Electron-Ion Collider



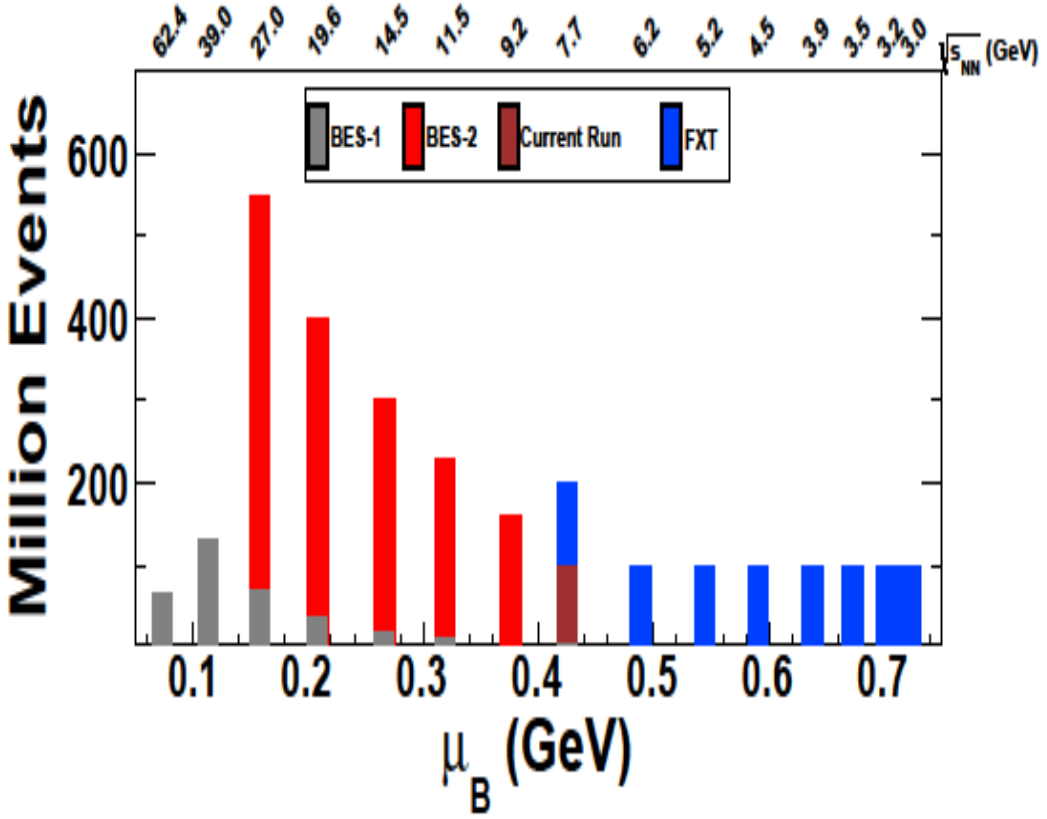
Deadline for submission:
December 1, 2021

https://www.bnl.gov/eic/CFC.php

News from BNL

- COVID affected many of our plans
  - Progressing safely
  - RHIC Run and detectors upgrades are on schedule
- Rate of RHIC publications is strong
  - Many new exciting results
- RHIC plans for 2022-2025 runs are developed
  - Based on sPHENIX and STAR upgrades
- Electron Ion Collider is rapidly progressing toward implementation
  - In close cooperation between BNL and TJNAF

Beam Energy Scan II Status



- Currently ~60% through last BES II energy
  - Orders of magnitude increase in statistical power
- Since LRP 2015 target of opportunity
  - Day-scale fixed target runs to extend to higher baryon density