

AFRICAN COUNTRIES JOINING LARGE INTERNATIONAL COLLABORATIONS – PHENIX AND EIC



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<https://www.unza.zm/people/school-of-natural-sciences/department-of-physics/dr-benard-mulilo>



NELSON MANDELA
UNIVERSITY

**The 3rd African Conference on
Fundamental and Applied Physics**

25 – 29 September 2023

Venue: Protea by Marriot Hotel King George, George, South Africa



9/28/23

B. Mulilo

ACP2023, September 25-29, 2023, Protea Hotel, George, South Africa

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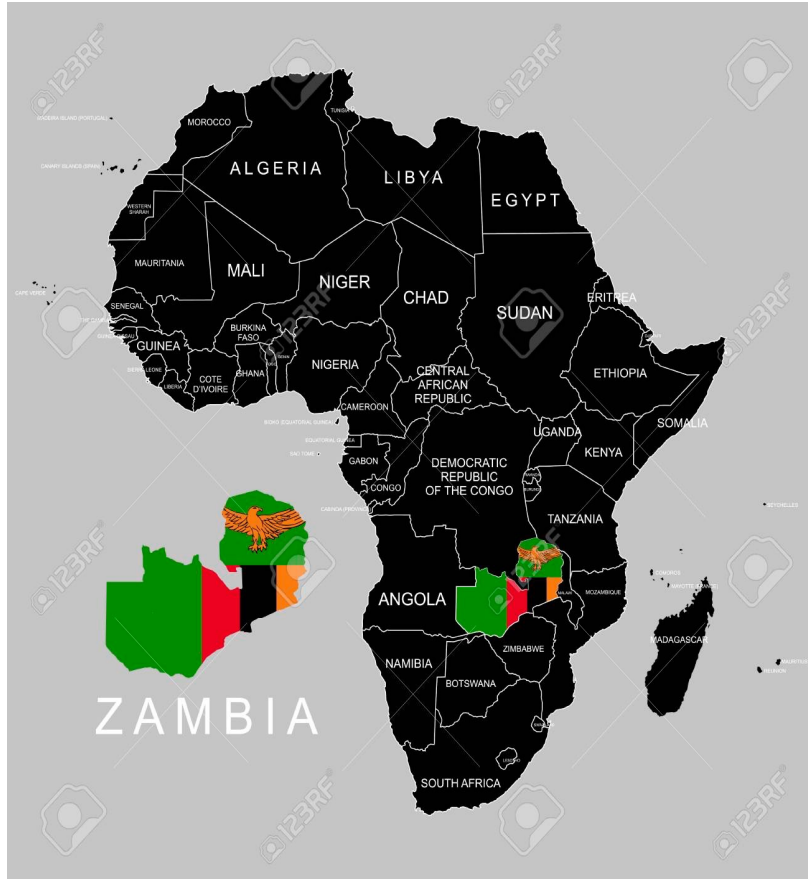
OUTLINE

- University of Zambia Overview
- Building Capacity in Nuclear Science & Technology (NST)
- PHENIX Collaboration
- Electron Ion Collider (EIC) Research Opportunity
- Summary



UNIVERSITY OF ZAMBIA (UNZA) OVERVIEW

UNZA is geographically situated in Southern Africa, Lusaka, Zambia.



Zambia derives its name from the Zambezi river.



The river hosts the Victoria falls (UNESCO Site ID: 509) on the border between Zambia and Zimbabwe. The falls is one of largest waterfalls in the world with a width of about 1, 708 m.

Zambia is 752,617 Km² subdivided into 10 provinces with an estimated population of 20 million in 2023.



UNIVERSITY OF ZAMBIA (UNZA) OVERVIEW

- UNZA is a public university. Zambia's largest and oldest learning institution.
- Established in 1965 & opened to the public on July 12, 1966.
- **Students:** 30, 000 (undergraduate + postgraduate)
- Language of instruction - **English**.
- **UNZA has 13 Schools:** Agr. Sciences, Education, Engineering, Business Studies, Health Sciences, Humanities & Social Sciences, Law, Medicine, Mines, Nursing Sciences, Public Health, Veterinary Medicine, & **School of Natural Sciences (NS)**.



Website: <https://www.unza.zm>.



UNIVERSITY OF ZAMBIA OVERVIEW - SCHOOL OF NATURAL SCIENCES

The School of Natural Sciences comprises six (6) Departments:

- Physics
- Chemistry
- Biological Sciences
- Mathematics and Statistics
- Computer Science
- Geography and Environmental Studies

Bachelors degrees in NS are four-year programs.

Master's programs are 2 years (1 year taught + 1 year research + thesis).

Doctoral degrees are three-year minimum offered as PhD by research only.



BUILDING CAPACITY IN NUCLEAR SCIENCE AND TECHNOLOGY (NST) – DEPARTMENT OF PHYSICS

Taken following steps:

- Formation of Nuclear, High Energy, & Medical Physics (NHEMP) research group.
- Three MSc curricula being finalized with the financial support of GRZ and IAEA besides an already running MSc in Physics:
 1. Master of Science (MSc) in [Nuclear Engineering](#)
 2. Master of Science (MSc) in [Medical Physics](#).
 3. Master of Science (MSc) in [Health Physics and Radiation Protection](#).



BUILDING CAPACITY IN NUCLEAR SCIENCE AND TECHNOLOGY (NST) – DEPARTMENT OF PHYSICS...

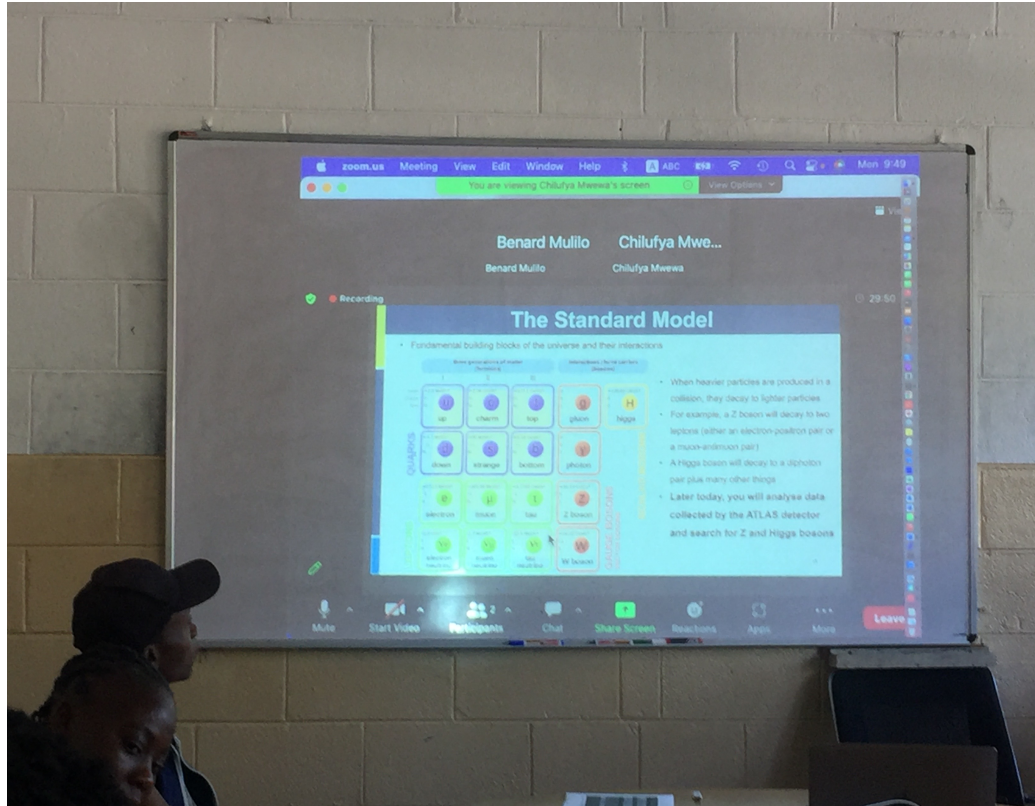
Further, since last year, UNZA Department of Physics -

- Started participating in **IPPOG's International Particle Physics Masterclasses** organized by **TU Dresden & QuarkNet Notre Dame**.
- **UNZA particle physics masterclass** is coordinated by **Dr. Chilufya Mwewa** (Postdoc., BNL, USA) & **Benard Mulilo** (Lecturer & Coordinator of NHEMP at University of Zambia).



BUILDING CAPACITY IN NUCLEAR SCIENCE AND TECHNOLOGY (NST) – DEPARTMENT OF PHYSICS...

22 students participated in the masterclass. ATLAS and PHENIX lectures were delivered by Dr. Chilufya Mwewa and myself.



Acknowledgements to [Kenneth](#), [Uta](#), [Pedro](#),..., & [CERN](#) to bring on board the UNZA masterclass.



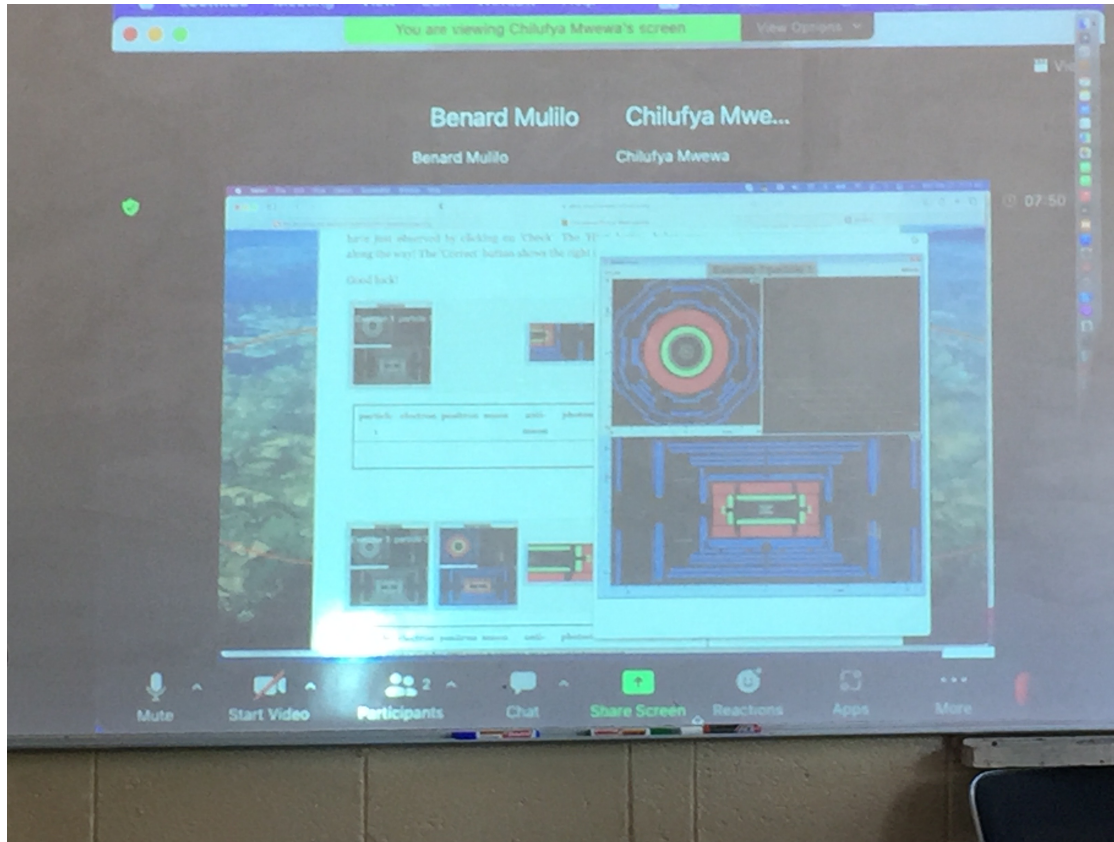
BUILDING CAPACITY IN NUCLEAR SCIENCE AND TECHNOLOGY (NST) – DEPARTMENT OF PHYSICS...

Masterclass is a full-day event, so students had lunch, tea-breaks & a light moment to interact among themselves, tutors, and academic staff.



BUILDING CAPACITY IN NUCLEAR SCIENCE AND TECHNOLOGY (NST) – DEPARTMENT OF PHYSICS...

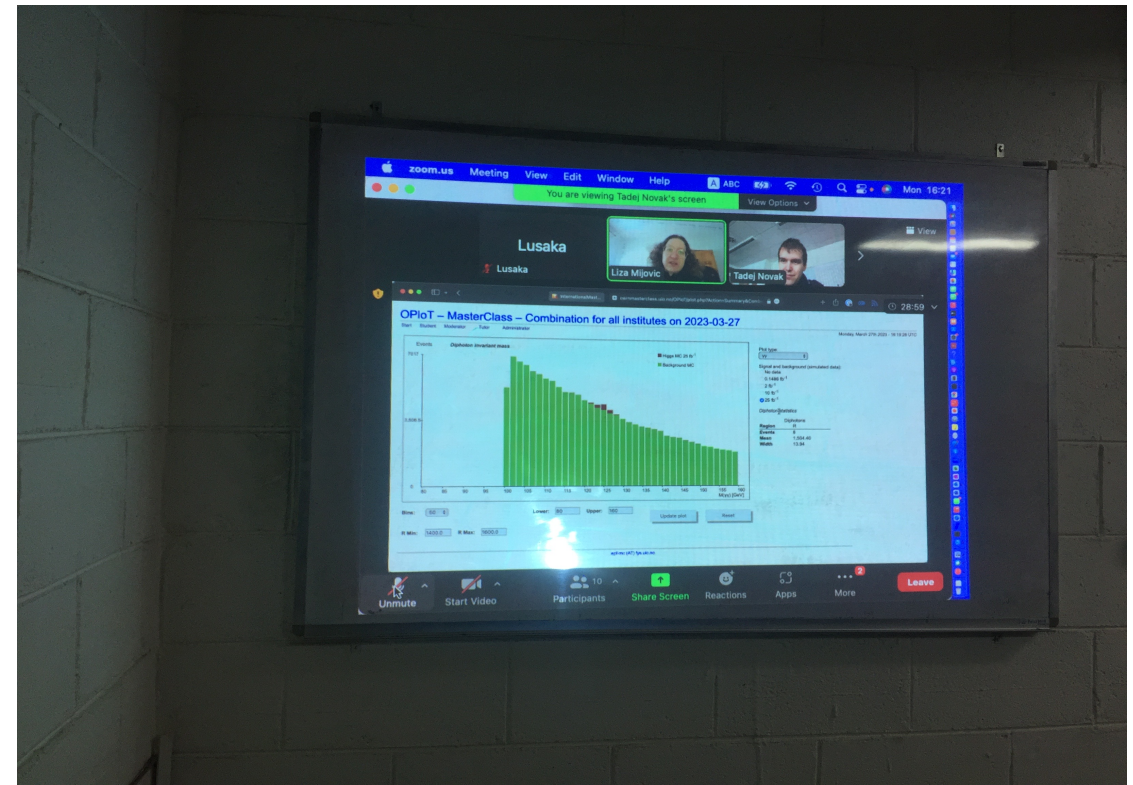
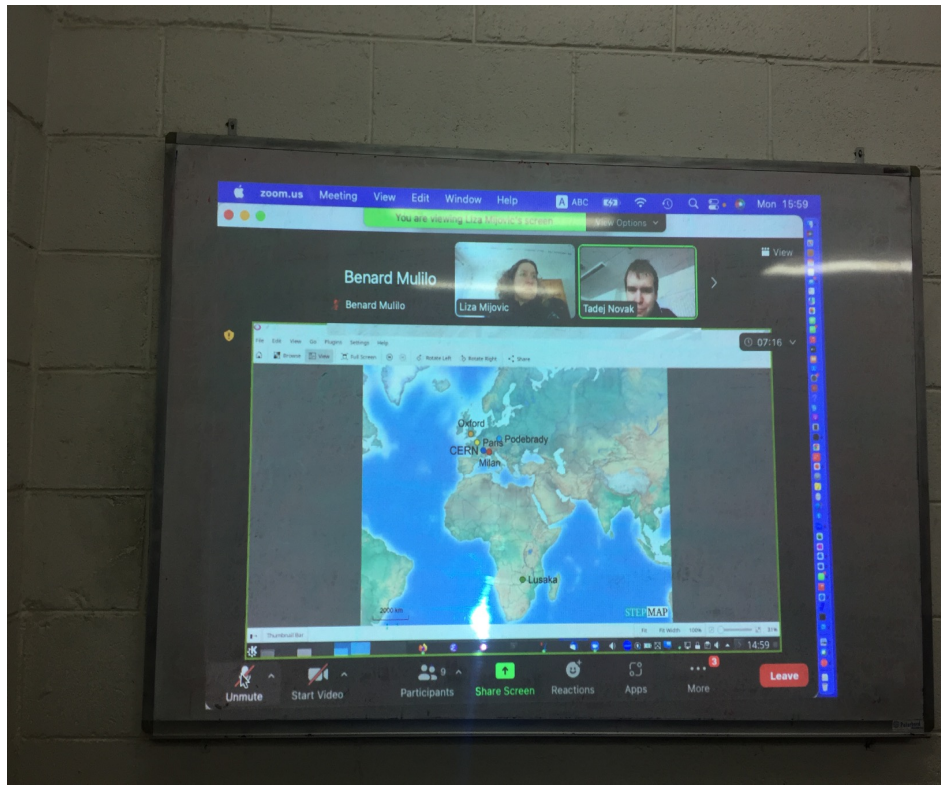
After lunch, students were oriented on the use of HYPATIA to analyze data, & later students participated **hands-on ATLAS' Z-Path experimental data**.



BUILDING CAPACITY IN NUCLEAR SCIENCE AND TECHNOLOGY (NST) – DEPARTMENT OF PHYSICS...

CERN's staff then collected and combined all students' analyzed ATLAS Z-Path results from all five institutions that took the masterclass on the day:

Lusaka, Oxford, Milan, Paris, & Podebrady.



NUCLEAR AND PARTICLE PHYSICS RESEARCH AND LARGE INTERNATIONAL COLLABORATIONS

Department is currently in collaboration with:

- **PHENIX** at Brookhaven National Laboratory (BNL), New York, USA.

UNZA signed Memorandum of understanding (MoU) with BNL in first-quarter of 2022.

UNZA currently contributing to PHENIX collaborative research work.

- The **Electron ion collider (EIC)** is another potential research opportunity.



PHENIX – RELATIVISTIC HEAVY ION COLLIDER (RHIC)

- **PHENIX – Pioneering High Energy Nuclear Interaction eXperiment**
- Heavy ion and proton collision exploratory experiment.
- Measures collision probes: photons, muons, neutrons, etc.,
- Study of new state of matter called quark-gluon plasma (QGP).

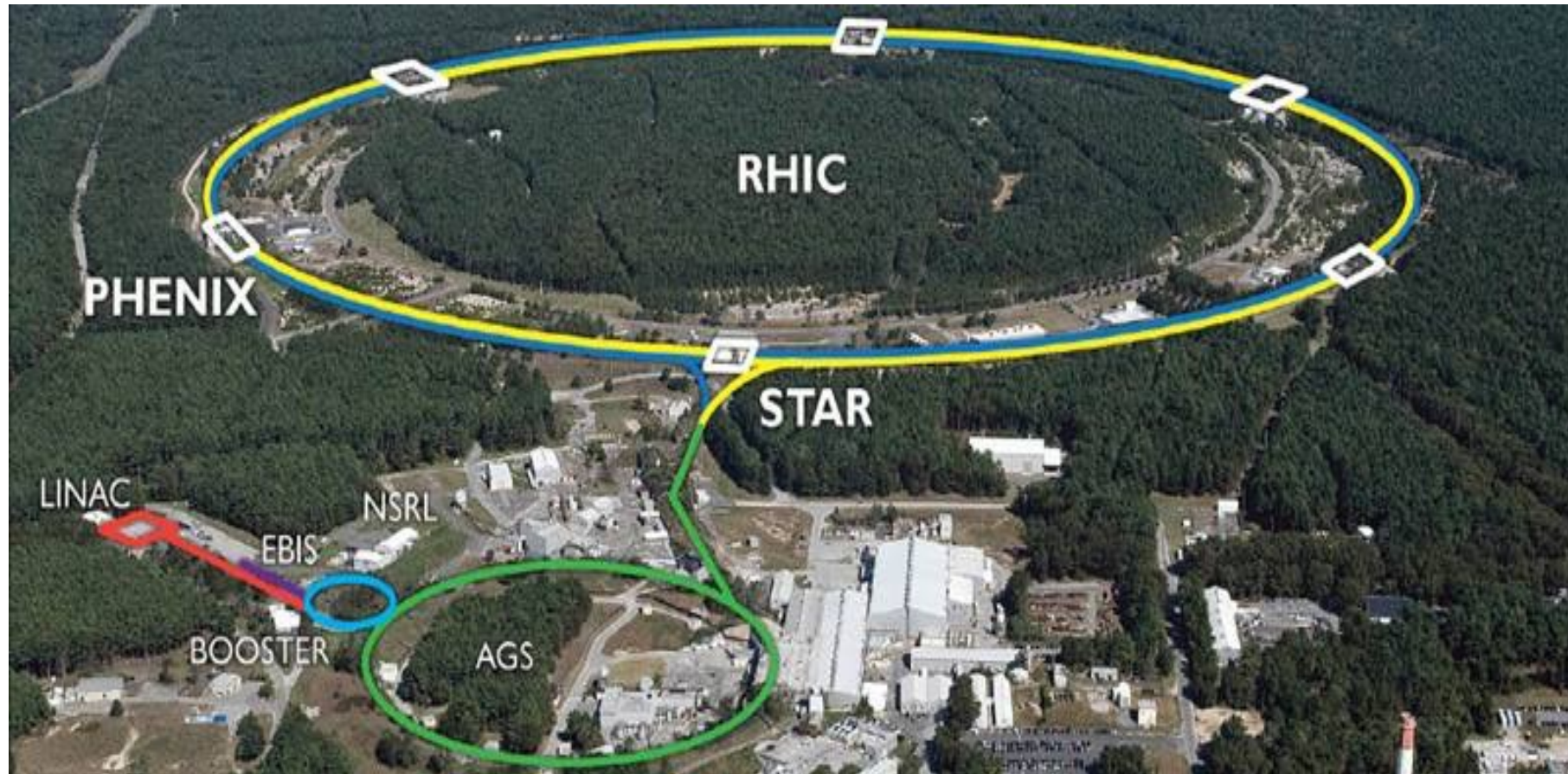
QGP allows us to better understand our universe.

- Particle collisions possible using relativistic heavy ion collider (RHIC).



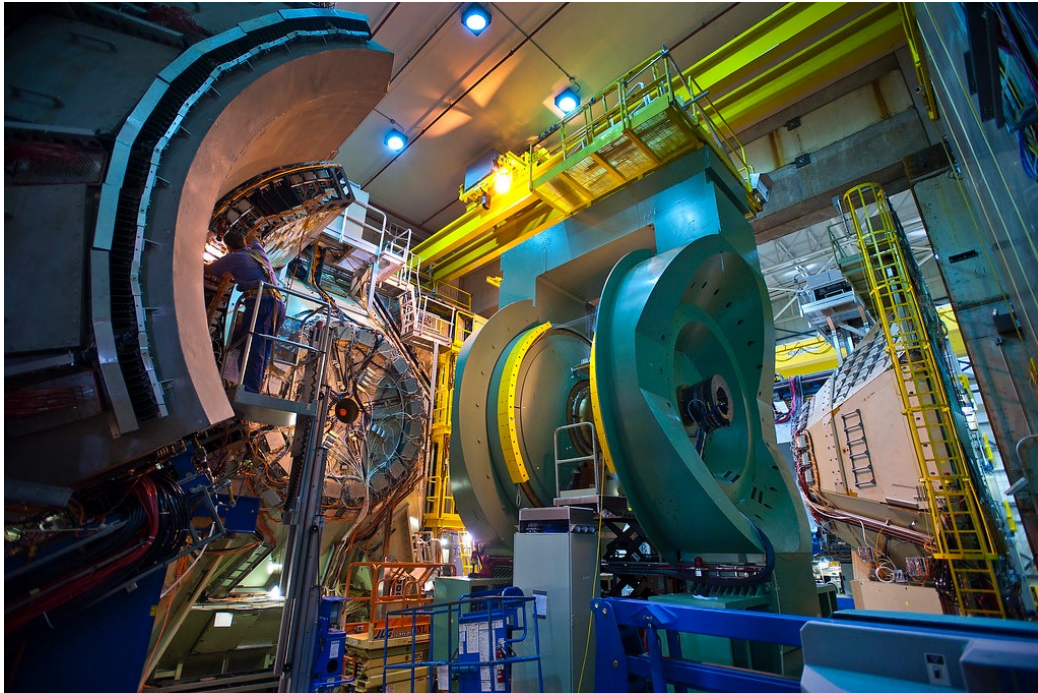
RHIC – BROOKHAVEN NATIONAL LABORATORY (BNL), USA

RHIC is world-class scientific research facility, physicists use to study what the universe may have looked like in the first few moments after its creation.

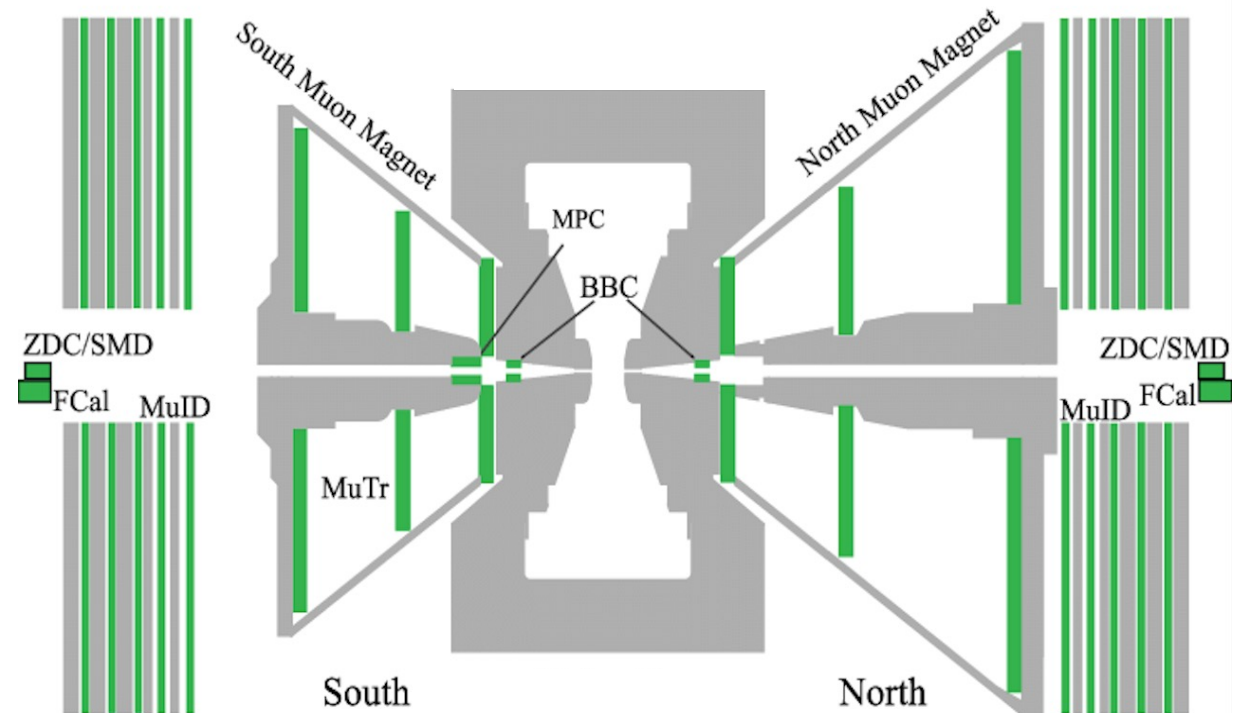


Layout of the Relativistic Heavy Ion Collider at Brookhaven National Laboratory (BNL), USA.

PHENIX DETECTOR AT RHIC – BNL, UNITED STATES



PHENIX detector image

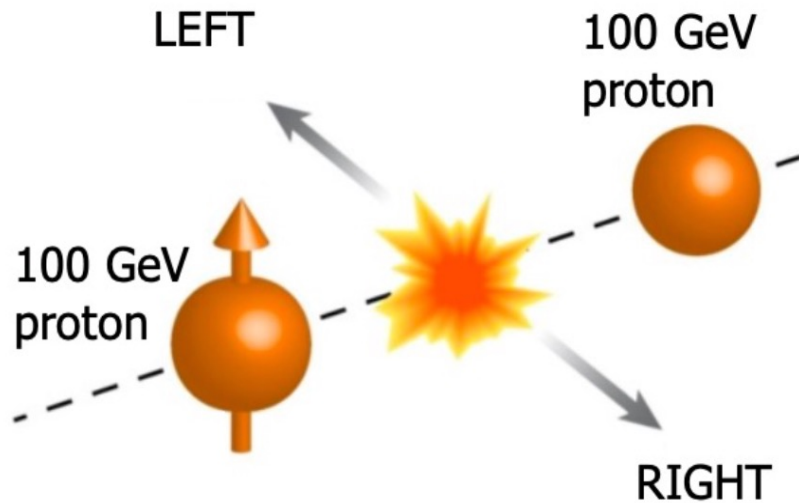


PHENIX detector side view

PHENIX detector is decommissioned, replaced by **sPHENIX**

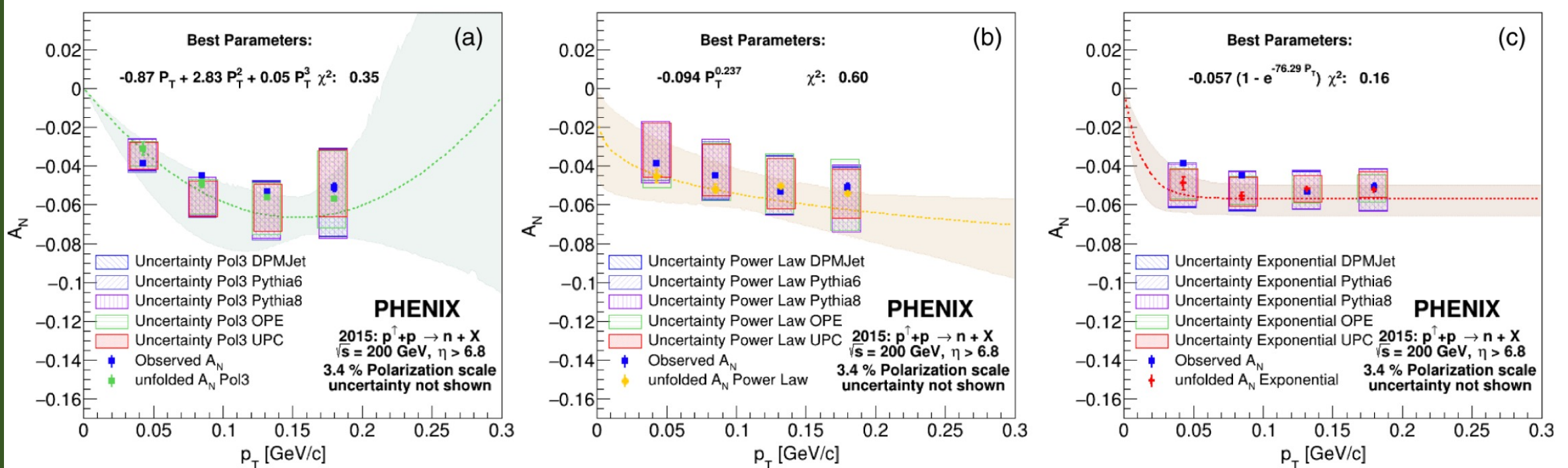
FORWARD NEUTRON TSSA IN P+P COLLISIONS AT 200 GeV – PHENIX 2015 DATA

Collision of 100 GeV proton with another 100 GeV proton at $\sqrt{s} = 200$ GeV



- Initial state: $p\uparrow + p$ collisions at $\sqrt{s} = 200$ GeV.
- Measure final state on either side of $p\uparrow$ - going direction – azimuthally.
- Perturbative quantum chromodynamics (pQCD) known to contribute negligibly to TSSA ($< 1\%$).
- Large TSSA imply nonperturbative spin-momentum & spin-spin correlations with proton.
- TSSA (A_N) = $\frac{\sigma^{\uparrow} - \sigma^{\downarrow}}{\sigma^{\uparrow} + \sigma^{\downarrow}}$ of final state particles.

FORWARD NEUTRON TSSA IN P+P COLLISION AT 200 GeV-PRD PUBLISHED RESULTS (PHD –THESIS WORK)



TSSA parametrizations as a function of p_T for (a) 3rd order polynomial dependence "Pol3," (b) power-law dependence "Power Law," and (c) an exponential dependence "Exponential."

Physical Review D 103 (3), 032007

MY PHD THESIS WORK WITH KOREA UNIVERSITY (SEOUL, SOUTH KOREA) IN COLLABORATION WITH RIKEN RESEARCH INSTITUTE IN JAPAN.



THE PHENIX COLLABORATIVE EFFORT WITH UNZA

PHENIX recognizes all contributing institutions to the experiment thus, since joining the collaboration in 2021, UNZA is one of the institutions on PHENIX publications in APR journals.

⁴⁶ *Physics and Astronomy Department, University of North Carolina at Greensboro, Greensboro, North Carolina 27412, USA*

⁴⁷ *Department of Physics and Astronomy, Ohio University, Athens, Ohio 45701, USA*

⁴⁸ *Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA*

⁴⁹ *IPN-Orsay, Univ. Paris-Sud, CNRS/IN2P3, Université Paris-Saclay, BP1, F-91406, Orsay, France*

⁵⁰ *Peking University, Beijing 100871, People's Republic of China*

⁵¹ *PNPI, Petersburg Nuclear Physics Institute, Gatchina, Leningrad region, 188300, Russia*

⁵² *Pusan National University, Pusan 46241, Korea*

⁵³ *RIKEN Nishina Center for Accelerator-Based Science, Wako, Saitama 351-0198, Japan*

⁵⁴ *RIKEN BNL Research Center, Brookhaven National Laboratory, Upton, New York 11973-5000, USA*

⁵⁵ *Physics Department, Rikkyo University, 3-34-1 Nishi-Ikebukuro, Toshima, Tokyo 171-8501, Japan*

⁵⁶ *Saint Petersburg State Polytechnic University, St. Petersburg, 195251 Russia*

⁵⁷ *Department of Physics and Astronomy, Seoul National University, Seoul 151-742, Korea*

⁵⁸ *Chemistry Department, Stony Brook University, SUNY, Stony Brook, New York 11794-3400, USA*

⁵⁹ *Department of Physics and Astronomy, Stony Brook University, SUNY, Stony Brook, New York 11794-3800, USA*

⁶⁰ *University of Tennessee, Knoxville, Tennessee 37996, USA*

⁶¹ *Texas Southern University, Houston, TX 77004, USA*

⁶² *Department of Physics, Tokyo Institute of Technology, Oh-okayama, Meguro, Tokyo 152-8551, Japan*

⁶³ *Tomonaga Center for the History of the Universe, University of Tsukuba, Tsukuba, Ibaraki 305, Japan*

⁶⁴ *Vanderbilt University, Nashville, Tennessee 37235, USA*

⁶⁵ *Weizmann Institute, Rehovot 76100, Israel*

⁶⁶ *Institute for Particle and Nuclear Physics, Wigner Research Centre for Physics, Hungarian Academy of Sciences (Wigner RCP, RMKI) H-1525 Budapest 114, POBox 49, Budapest, Hungary*

⁶⁷ *Yonsei University, IPAP, Seoul 120-749, Korea*

⁶⁸ *Department of Physics, Faculty of Science, University of Zagreb, Bijenička c. 32 HR-10002 Zagreb, Croatia*

⁶⁹ *Department of Physics, School of Natural Sciences, University of Zambia, Great East Road Campus, Box 32379, Lusaka, Zambia*

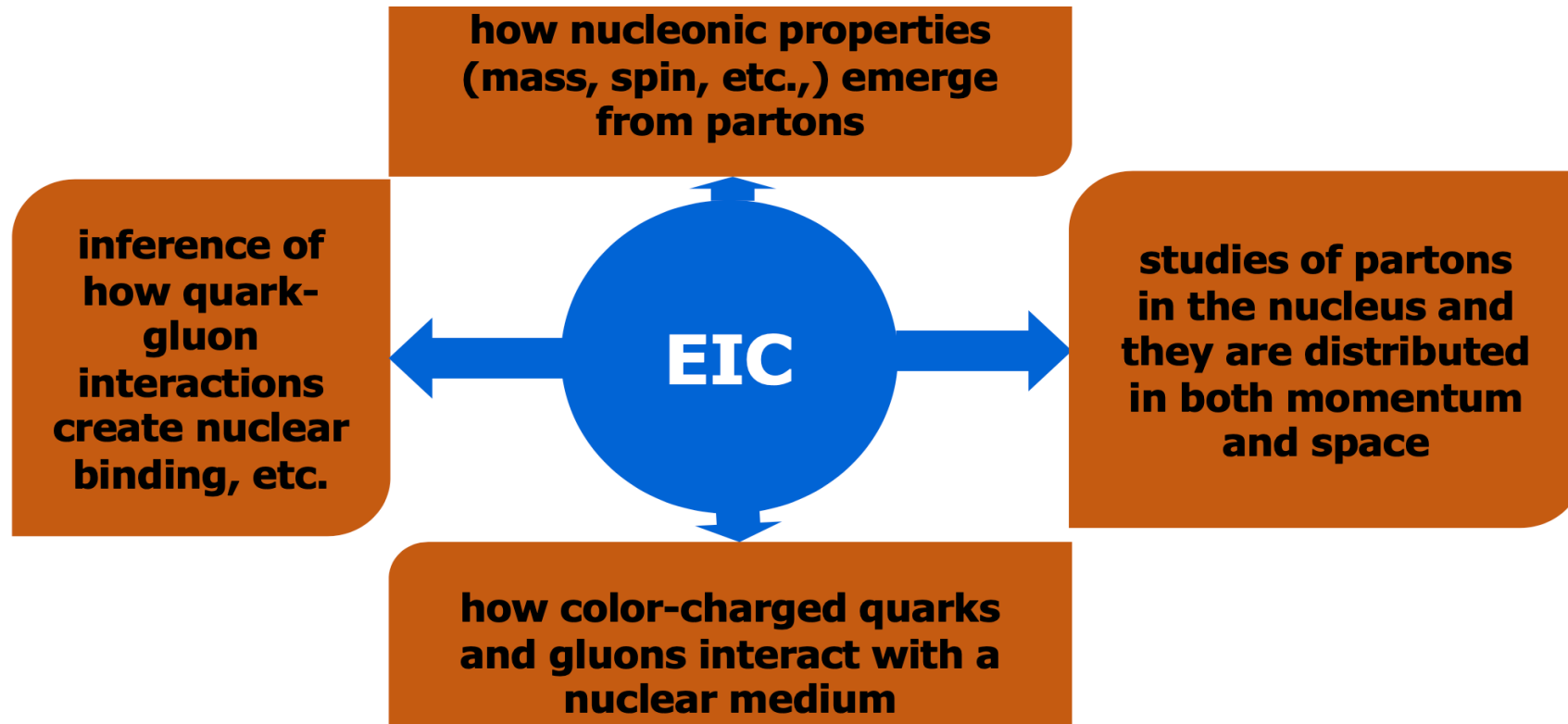


ELECTRON ION COLLIDER (EIC) RESEARCH

World's first polarized ep & eA in plan for construction at BNL
Discovery machine to unlock secrets of force binding matter.

[Details in BNL's senior researcher – Dr. R. Venugopalan]

Key physics research questions EIC is to address include:



THE EIC CFNS-CTEQ 2023 SUMMER SCHOOL – STONY BROOK UNIVERSITY



June 5–16, 2023 — in-person event.

Hosted by [Stony Brook University](#).

Attracted participants from [Africa](#), [Asia](#), [Europe](#), & [North America](#).

Participants included [students](#), [postdocs](#), [faculty](#) with expertise in theory & expt'al particle physics.

School featured [lectures](#), [tutorials](#), and [discussion sessions](#).

Acknowledge CFNS & South African Institute of Physics (SAIP) support.



SUMMARY

- UNZA is participating in annual IPPOG's International Particle Physics Masterclasses.
- UNZA is a registered member of the PHENIX Collaboration.
- Electron ion collider (EIC) - another potential research opportunity for Africa.

More interesting EIC content will follow from talks by:

- BNL senior researcher, [Dr. R. Venugopalan](#) – Science of the EIC.
CFNS director (SBU) – [\(Prof. A. Deshpande\)](#) – Status and opportunities at the EIC.

Acknowledgements

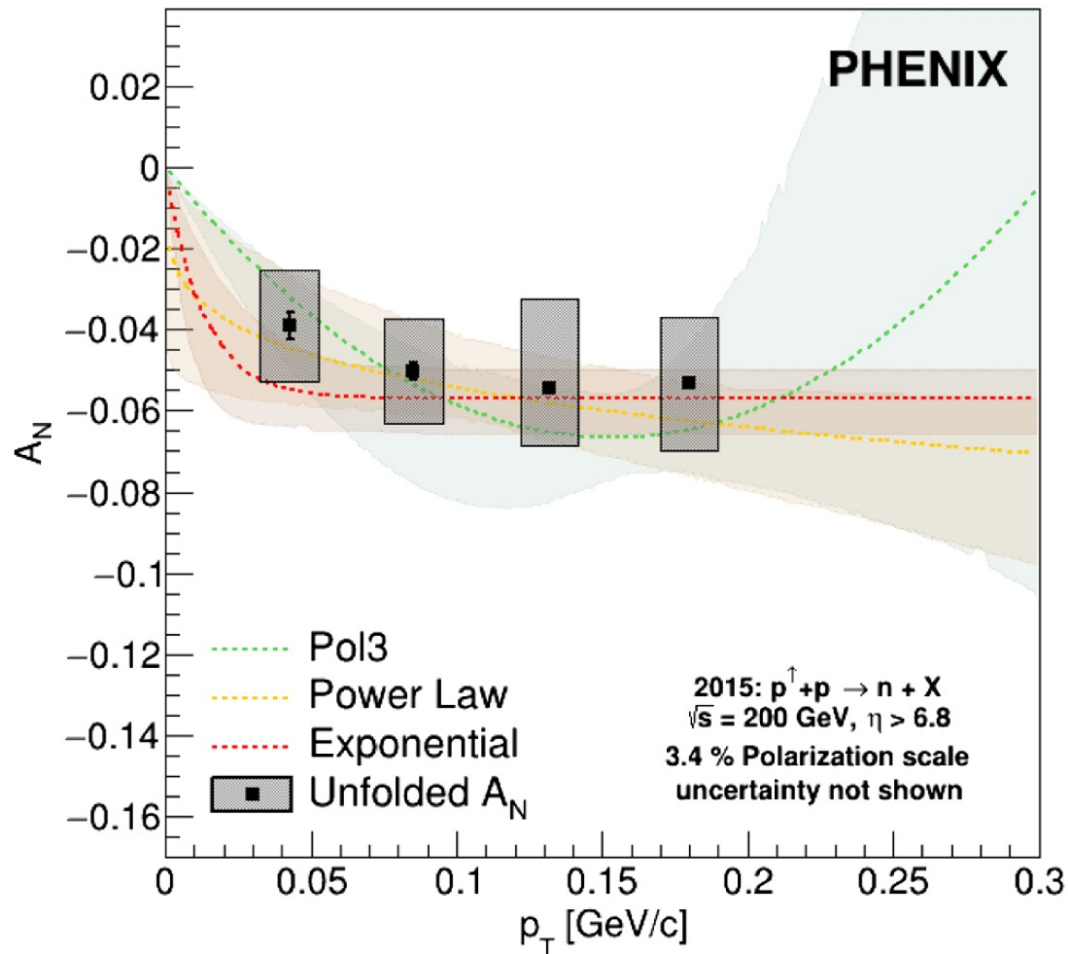
- Unceasing support from BNL's senior researcher - [Dr. Ketevi Assamagan](#).
- Support from the [LOC, IOC, ASP-Alumni program, SAIP, & the Nelson Mandela University](#)).



BACKUP



FORWARD NEUTRON TSSA IN P+P COLLISION AT 200 GeV-PRD PUBLISHED RESULTS



Neutron transverse single spin asymmetries as a function of the true transverse momentum.

Data points represent unfolded asymmetries obtained via average over all parametrizations and MC generators.

Uncertainty boxes represent systematic uncertainties due to parametrization, functional form, MC generator, and the unfolding procedure.

