Brookhaven National Laboratory

2023 Gertrude Scharff-Goldhaber Prize presented to

Xiaofeng Wang

by Brookhaven Women in Science

August 15, 2023

for Equal Advancement BWIS

Agenda

12:00 PM → 12:10 PM **Welcome** 10m

Speakers: Jessica Gasparik (Brookhaven National Lab), Dr Marc-André Pleier (BNL)

12:10 PM → 12:20 PM **Equity, Diversity and Inclusion at BNL** 10m

Speaker: Dmitri Denisov (Brookhaven National Laboratory)

12:20 PM → 12:30 PM **Memories of Gertrude Scharff-Goldhaber** 10m

Speakers: Prof. Alfred Scharff Goldhaber (SBU), Dr Michael H. Goldhaber

12:35 PM → 12:55 PM **Energy Dependence of Breit-Wheeler Process in Heavy-Ion Collisions and its Application to Nuclear Charge Radius Measurements** 20m

The Breit-Wheeler process is the simplest process for creating matter and antimatter from the collision of two photons. This conversion of light into matter is a direct corollary of Einstein's mass-energy equivalence, E = mc^2. The process was theorized in 1934, but went nearly a century without experimental confirmation until it was discovered by the STAR Collaboration at RHIC in 2021. This discovery was made at top RHIC energy in gold-gold collisions. While the process is now well established at high energies, there is a peculiar feature predicted by Quantum Electrodynamics (QED) that the interaction cross section will diverge (infrared divergence) at low photon energy. The flexibility of RHIC, allowing heavy-ion collisions at lower energies, allows this prediction to be tested and other characteristics of the newfound process to be uncovered.
In this presentation, we will present measurements of the energy dependence of Breit-Wheeler process in gold-gold collisions at STAR. The corresponding results computed by QED are consistent with STAR measurements and found to be sensitive to the nuclear charge distribution. Following this approach we demonstrate that the experimental measurements of the Breit-Wheeler process in heavy-ion collisions can be used to quantitatively constrain the nuclear charge radius of high energy atomic nuclei.

Speaker: Xiaofeng Wang (Shandong Univeristy)

About BWIS

- Brookhaven Women in Science (BWIS) is a diverse and inclusive community that promotes equal opportunity and advancement for all women in support of world-class science.
- We sponsor workshops, speaker series, scholarship and award ceremonies, and networking events.
- We contribute to the community by working with schools, community groups, and organizations to support education in science, technology, engineering, and math (STEM), and professional development.

Gertrude Scharff-Goldhaber

- first woman PhD to be hired by BNL in 1950.
- started the Brookhaven Lecture series in 1960
- founding member of BWIS in 1979
- “The vicious cycle which was originally created by the overt exclusion of women from mathematics and science must be broken… [I]t is of the utmost importance to give a girl at a very early age the conviction that girls are capable of becoming scientists.”

Gertrude Scharff-Goldhaber

- first woman PhD to be hired by BNL in 1950.
- started the Brookhaven Lecture series in 1960
- founding member of BWIS in 1979
- Robert Park (APS): “One of the great women pioneers in what was an almost exclusively male profession. … An inspiration to generations of women in physics, she was only the third female physicist elected to the National Academy of Sciences.”

Gertrude Scharff-Goldhaber

- first woman PhD to be hired by BNL in 1950.
- started the Brookhaven Lecture series in 1960
- founding member of BWIS in 1979
- Peter Bond: “Trudy Goldhaber made important contributions to science, but she also made strong contributions to the Lab as a whole, to women in science and to education. She made the Lab a better place.”

Commemorative Plaque

- Gertrude Scharff-Goldhaber plaque installed in B510 next to her old office (1-200):

- Thanks for the support by Brookhaven Women in Science, the Nuclear & Particle Physics Directorate & the Physics Department!

March 27, 1992

BROOKHAVEN BULLETIN
Vol. 46 - No. 13 March 27, 1992
BROOKHAVEN NATIONAL LABORATORY

Mary White Heads Labwide Training Effort

To ensure that all employees are appropriately trained in accordance with a new Lab training policy, the BNL Training Office has been established — headed by Mary White, Personnel Division.

As explained by BNL Director Nicholas Samios, the office was created "as part of our commitment to the Tiger Team to establish standards for the Laboratory's training program."

The U.S. Department of Energy's (DOE) Tiger Team visited BNL in 1990 during DOE's assessments of the national laboratories' compliance with applicable environmental, safety and health regulations. It recommended a more consistent Labwide approach to training. Thus, the new office will put a new BNL training policy into effect.

This policy, together with standards and guidelines for training, was the recommendation of an 18-person task force, which reported to BNL Deputy Director Martin Blume and included representatives of management, existing training functions, and environmental safety and health coordinators. The task force's proposals, the result of several months of work, were tried out on a small scale in the Alternating Gradient Synchrotron Department (AGS), which was chosen for this purpose because it had already developed a training plan.

Following a successful pilot program in the AGS, the BNL Training Office was established. Its responsibilities, as announced in Samios' January memo to department and division managers, include: establishing training standards and seeing that they are carried out; coordinating preparation of department and division training plans; setting up and maintaining a Labwide training database; assisting department training coordinators in the design and development of training courses; and evaluating and reporting on the Lab's progress toward achieving a documented, performance-based training program.

"To establish the training program on these lines is an tremendous undertaking," said White, "but once it is in place, there will be many advantages. Labwide coordination will avoid duplication of effort and provide consistency of documentation. Many departments and divisions are already delivering excellent training to employees, but without consistent documentation, the Lab does not always get credit for these efforts.

"I feel strongly, however," continued White, "that it is very important to recognize the diversity of the Lab. Within our policy there is flexibility to accommodate differences in how departments accomplish the common goal. For example, as training procedures are proposed, we will ask for input as to how they might work in practical application. Of course, there must be a minimum level of consistency in order to have an effective database."

As White sees it, one of her first tasks is to establish strong links with each department and division through the designated training coordinator who will be the liaison with the Training Office.

"I think the key to a good Labwide program is participation at the working level," said White. "I am soliciting ideas from training coordinators so that they may develop workable departmental training plans. The Training Office will provide hands-on assistance, especially in the beginning stages, to help training cordinators get started."

(continued on page 2)

Roger Stoutenburgh

Mary White, Training Office Manager, meets with Management Oversight Committee members: (standing, from left) Gerald Kinne, Associate Director for Reactor, Safety & Security; Robert D'Angio, Personnel Division Manager; Richard Spellman, Central Shops Division Manager; (seated, from left) Chemistry Department Chairman Norman Sutin and BNL Deputy Director Martin Blume. Not present is Mark Sakitt, Assistant Director for Planning & Policy.

Women's History Month Salute

Mary White is only one of the 832 women who today make up nearly one-quarter of BNL's work force of 3,400. She is also representative of approximately 500 Brookhaven women in management, administrative, clerical or supervisory positions.

Said Women's Program Coordinator Virginia Brown, "The business of the Laboratory is science, but our scientists, engineers and others on the research and development staff need administrative support to accomplish research objectives. Because, at BNL, there is a relatively large proportion of women performing many aspects of administrative support, it is appropriate for BNL to salute their accomplishments as part of the 1992 observance of Women's History Month."

At the Laboratory, administrative support specialists range from administrative division managers, accountants and budget analysts to secretaries, office services assistants and administrative assistants.

Feldberg Honored for Research

Senior Chemist Stephen Feldberg, who heads the Chemical Sciences Division (CSD) in the Department of Applied Science (DAS), was awarded this year's Charles N. Reilley Memorial Award for Electroanalytical Chemistry.

The award was presented to Feldberg in the form of a plaque and a $1,500 honorarium by the Society of Electroanalytical Chemistry on March 11, at an award symposium during its annual Pittsburgh Conference and Exposition on Analytical Chemistry and Applied Spectroscopy in New Orleans. Recognizing an active researcher who has made a major contribution to the theory, instrumentation or applications of electroanalysis, the Reilley Award award is supported by BAS, Inc.

Stephen Feldberg

Electrochemistry deals with the physical chemical changes accompanying the passage of an electric current through a solution. In electroanalytical chemistry, electrochemical measurements are used to analyze and describe the behavior of various chemical systems.

Feldberg was cited for "persistently novel insights [in]to electrochemical processes [that] have benefited [his] many colleagues around the world." In addition, it was noted, his "nomination was supported by an unusually wide spectrum of [his] colleagues and was indicative of their appreciation of [his] pioneering role and the influence of [his] outstanding collaborations over the breadth of electrochemistry."

As his major contribution to electroanalytical chemistry, Feldberg was recognized for using what are called finite-difference equations to solve previously intractable problems evolving from complex interaction of electron transfer, mass transport and chemical reactions.

Prior to his work, "Many problems of interest were being oversimplified to make them mathematically tractable," explains Feldberg. "Now, because these numerical methods are reasonably user-friendly, people

(continued on page 2)

New Women's Physics Prize Honors Gertrude Goldhaber

As Women's History Month draws to a close, Brookhaven Women in Science (BWIS) announces that applications are now being accepted for a new physics prize to be awarded to a woman graduate student in physics at the State University of New York at Stony Brook, in recognition of her substantial promise and accomplishment.

The Gertrude S. Goldhaber Prize has been established to honor Gertrude Scharff-Goldhaber for her outstanding contributions in the field of nuclear physics and for her support of women in science.

Now a collaborator in the Physics Department, Scharff-Goldhaber in 1950 became the first woman Ph.D. physicist appointed to the BNL staff. In her research, she has specialized in studying the systematics and characteristics of nuclear excitations in a wide range of nuclei, and has synthesized her understanding of these static and dynamic nuclear properties into far-ranging models. She has also left her mark at the Lab as the founder of the Brookhaven Lecture series, in 1960, and a founding member of BWIS, in 1979.

Gertrude Goldhaber

The winner of the Goldhaber Prize will receive $500 from a fund administered by BWIS and will be expected to give a seminar on her work at the award ceremony to be held this fall. To be eligible for the award, a nominee must be a candidate for a doctoral degree, must still be active as a physics graduate student and must not be receiving her degree before October 1 of this year.

Any member of the BNL staff or the faculty in Stony Brook's Physics Department may nominate candidates for this prize. The nomination deadline is May 8, 1992, and the award recipient will be announced by mid-June.

For more information on nominations or to make a contribution to the prize fund, contact BWIS Goldhaber Prize, P.O. Box 183, Upton NY 11973, or call Vicki McLane, Ext. 5205.

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1992 First Prize Recipient

July 17 1992

First Goldhaber Prize Awarded

Xiaodong Zhang, a BNL guest junior research associate who has just completed her third year as a physics graduate student at the State University of New York at Stony Brook, has been selected by Brookhaven Women in Science (BWIS) as the first winner of the new Gertrude S. Goldhaber Prize in physics.

Zhang was nominated for the $500 prize by Janos Kirz, a professor of physics at Stony Brook who conducts research at BNL's National Synchrotron Light Source (NSLS) on x-ray microscopy, a technique for producing images of biological specimens. Zhang began working with Kirz's NSLS group after completing her first year of graduate school. As Kirz wrote, "It took her very little time to learn enough to become an important contributor."

Among Zhang's accomplishments, Kirz cited the deconvolution of the

Roger Stoutenburgh

Xiaodong Zhang at x-ray microscopy beam line X1A, at the NSLS.

Oct. 1st 1992

First Gertrude S. Goldhaber Prize Presented

Roger Stoutenburgh

Xiaodong Zhang (left), a graduate student in physics at the State University of New York at Stony Brook and a guest junior research associate at BNL, was awarded the first $500 Gertrude S. Goldhaber Prize in Physics on October 1.

Presented by Brookhaven Women in Science (BWIS), the award honors Gertrude Scharff-Goldhaber (second from right). Now a collaborator in the Physics Department, the noted nuclear physicist was a founding member of BWIS and has long been a champion of education and opportunities for women in science. She was also the first woman Ph.D. to be hired at Brookhaven, when she and her husband, former BNL Director Maurice Goldhaber (right), AUI Distinguished Scientist emeritus, came to the Lab in 1950.

Their son, Alfred Goldhaber (second from left), is with Stony Brook's Physics Department. He presented the award to Zhang just before she gave a seminar on her research in scanning soft x-ray microscopy.

1992 First Prize Recipient

Imperial College London

HOME | HONOURS AND MEMBERSHIPS | RESEARCH | PUBLICATIONS | TEACHING | EXTRA

PROFESSOR XIAODONG ZHANG

Faculty of Medicine, Department of Medicine

Professor of Macromolecular Structure and Function

- SUMMARY
- MINI CV

- 1988 - B.Sc. in Physics, Peking University, China
- 1995 - Ph.D. in Physics, SUNY @ Stony Brook, USA
- 1995 - 1997 postdoctoral fellow, Harvard University

AFFILIATIONS

> Centre for Structural Biology
> Electron Microscopy Centre
> Structural Biology

CONTACT

+44 (0)20 7594 3151

LINKS

for Equal Advancement BWIS

Recipients Thus Far

year	name	affiliation	year	name	affiliation
2022	Jiayi Chen	Brandeis	2005	Anne Sickles	SBU
2021	Yanzhu Chen	SBU	2004	Mirna Lerotic	SBU
2020	Rebekah Pestes	Virginia Tech	2003	Lilia Anguelova	SBU
2019	Brooke Russell	Yale	2003	Carola Berger	SBU
2018	Minjung Kim	Seoul NU	2002	Yiing-Rei Chen	SBU
2017	Anna Gura	SBU	2001	Jane Burward-Hoy	SBU
2016	Kathryn Meehan	UC Davis	2001	Irina Mocioiu	SBU
2015	Fen Guan	SBU	2001	Rebecca Christianson	MIT
2014	Li Yi	Purdue	2000	Diana Vaman	SBU
2013	Sara Callori	SBU	1999	Angelika Osanna	SBU
2012	Marija Kotur	SBU	1998	Shan-Ho Tsai	SBU
2011	Megan Connors	SBU	1998	Mary Josephine Bellanca	SBU
2010	Johanna Nelson	SBU	1997	*N.N.*	*N.N.*
2009	Na Li	CCNU	1996	Q. Joan Harris	MIT
2008	Christine Nattrass	Yale	1995	*N.N.*	*N.N.*
2007	Manuela Kulaxizi	SBU	1994	Fang Shu	SBU
2006	Enju Lima	SBU	1992	Xiaodong Zhang	SBU

Thanks to Linda Bowerman, Will Safer & his team for archaeological support!

Recipients Thus Far

year	name	affiliation	year	name	affiliation
2022	Jiayi Chen	Brandeis	2005	Anne Sickles	SBU
2021	Yanzhu Chen	SBU	2004	Mirna Lerotic	
2020	Rebekah Pestes	Virginia Tech	2003	Lilia Anguelova	SBU
2019	Brooke Russell	Yale	2003	Carola Ber	SBU
2018	Minjung Kim	Seoul NU	2002	Yiing	SBU
2017	Anna Gura	SBU	2001	ward-Hoy	SBU
2016	Kathryn Meehan	UC Davis	20	Mocioiu	SBU
2015	Fen Guan	SBU		Rebecca Christianson	MIT
2014	Li Yi	Purd	000	Diana Vaman	SBU
2013	Sara Callori		1999	Angelika Osanna	SBU
2012	Marija Kotur		1998	Shan-Ho Tsai	SBU
2011	Megan Connor	SBU	1998	Mary Josephine Bellanca	SBU
2010	Johanna	SBU	1997	*N.N.*	*N.N.*
2009	Na	CCNU	1996	Q. Joan Harris	MIT
2008	Nattrass	Yale	1995	*N.N.*	*N.N.*
2007	anuela Kulaxizi	SBU	1994	Fang Shu	SBU
2006	Enju Lima	SBU	1992	Xiaodong Zhang	SBU

Still in academia: ≥63%; in tenure (track) position: ≥ 56%

Thanks to Linda Bowerman, Will Safer & his team for archaeological support!

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Recipients Thus Far

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Acknowledgements

- Review Committee: Björn Schenke, Aihong Tang, and Elizabeth Worcester
- This year's $4,000 prize is made possible by funding from Brookhaven Science Associates as well as generous support from the Brookhaven National Laboratory Nuclear & Particle Physics Directorate, the Physics Department, Energy & Photon Sciences Directorate, the Diversity, Equity & Inclusion Office, and the Long Island Section of the American Nuclear Society

Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

Gertrude Scharff-Goldhaber Prize 2023 Ceremony

Diversity, Equity and Inclusion at BNL

Dmitri Denisov with thanks to Noel Blackburn

August 14, 2023

@BrookhavenLab

BNL DEI Vision

Support the Lab's mission by fostering a psychologically safe environment for everyone to be authentic and productive in a respectful and diverse workplace thereby BNL recognizes its fullest potential and remains relevant in the future

Develop the behaviors to produce the habits that result in the desired workplace

Moving Forward

Brookhaven continues to view culture change—altering behaviors and perspectives—as the primary challenge in advancing its DEI vision. To accelerate the DEI effort at the Lab, multi-year strategic plan is based on:

- Developing a psychologically safe and respectful workplace where everyone is valued for their perspective
- Fostering a sense of belonging
- Creating a welcoming environment for a diverse workforce
- Increasing access for communities unfamiliar with the U.S.

Strategy Behind BNL Vision

DEI Strategy Pillars

Pillar I: Leadership Accountability

- Appointment of new CDO reporting to the Lab Director
- Strong Leadership support of Directorate DEI Councils
- Leadership increased support and communication with ERGs
- Directorate Leaders establishing/strengthening external partnerships through signed MoUs with MSIs

Pillar II: Structural Barriers

- New Performance Appraisal guidance for Lab staff Annual DEI goals based on impact to the Lab
- Appointed an Equity Officer
- Developed and conducted training workshops for ERGs and DEI Councils
- Developed workshop to encourage leaders to cultivate appropriate habits to address a more diverse workplace

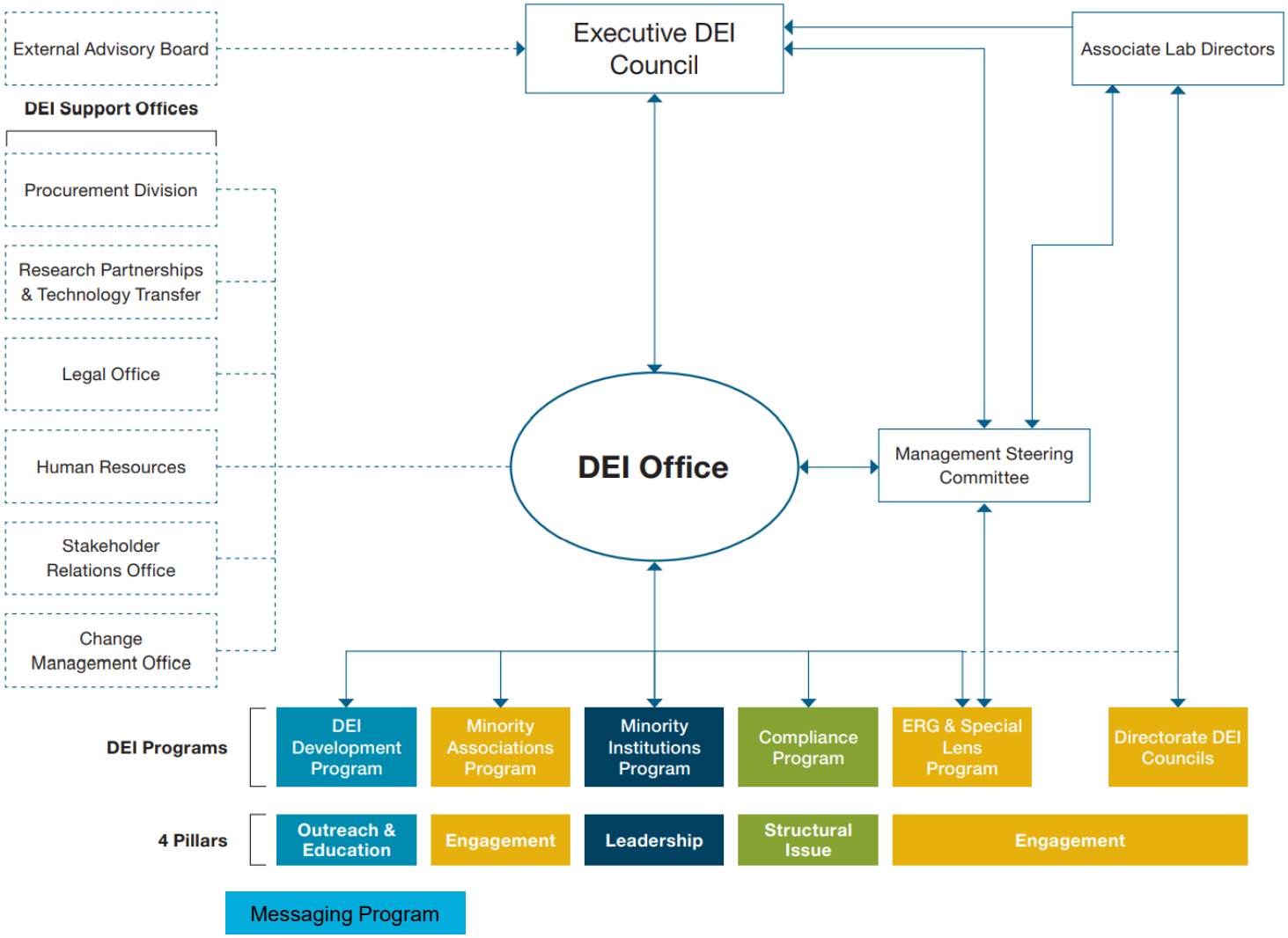
Pillar III: Engagement

- Management Steering Committee-DEI Executive Council-Employee Resource Group (ERG) leaders, Directorate DEI Councils and Special Lens Groups
- DEI Office promoting more directorate/departmental social activities
- DEI Office and SRO hosting a Recognition event for the Lab's 75th Anniversary
- Developing lab wide DEIA messaging to promote a respectful workplace

Pillar IV: Outreach & Education

- Partnership between Human Resources, DEI Office, Office of Educational Programs (OEP), Scientific Directorates targeted outreach programs
- Co-hosted energy course for NYC 11th and 12th grade URMs with AABE in FY22 & FY23
- Re-established the Professional Associates Program introducing two recent graduated undergrads to the support side of the Lab
- Collaborating with InCREASE to co-host a President Forum& Facility workshops introducing DOE-BNL to MSIs

Diversity, Equity and Inclusion Functional Chart



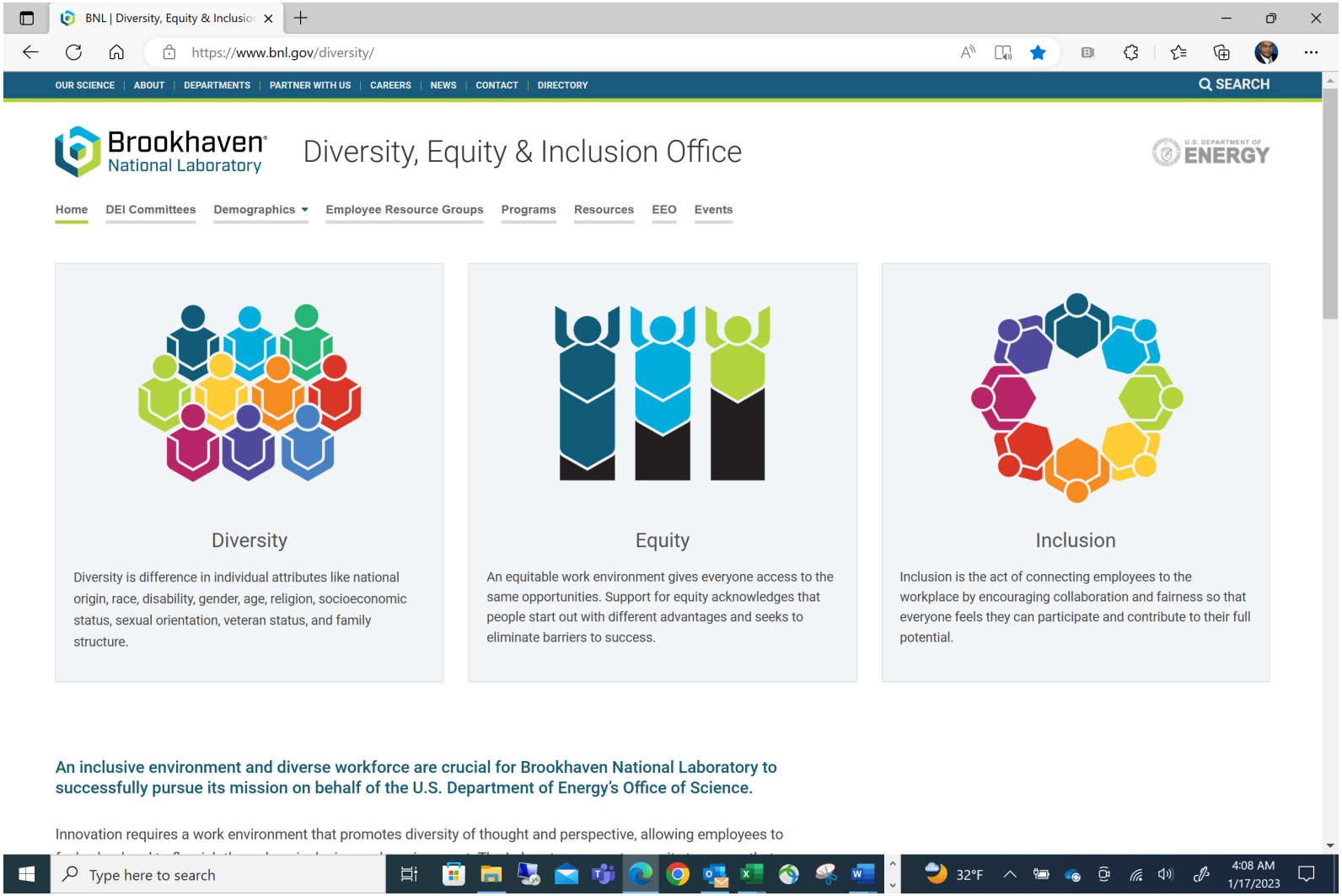
Driving the DEI Vision:
Lab-wide oversite, policy setting, communication, coordination, & integration

Stewardship:
Lab-wide activities in support of DEI policies

Implementation:
(Directorate level) DEI Councils, ERGs and other Groups assist in the DEI strategy

Brookhaven National Laboratory

DEI Office Website



DEI Office Website

Resources

DEI Performance Appraisal Guidance

Assistance for departments and staff in developing DEI goals for Performance Appraisals. DEI goals should aim to provide impact and value to the organization by first providing impact and value directly to employees – this includes the individual, others within the organization, and/or external to the organization in the spirit of and in representation of the Lab.

DEI Appraisal Guidance

Quarterly Themes

Each quarter, the Lab focuses on a key DEIA theme or topic. Resources for each Theme include videos, discussion prompts, and suggested actions plans. Curated resources are provided that allow everyone to choose their own learning path.

See DEI Quarterly Themes

Lab Diversity & Inclusion Plan (LDIP)

To achieve our DEIA vision and address the major DEIA challenges, a multi-year, strategic approach has been established.The Laboratory Diversity & Inclusion Plan lays out our DEIA strategy, documenting how we will cultivate an inclusive environment, recruit and retain a diverse workforce, develop partnerships with minority serving institutions, and more.

FY23 Diversity & Inclusion Plan

PIER Plan

The DOE Office of Science requires that all project proposals include an appendix containing a Promoting Inclusive and Equitable Research (PIER) Plan that describes how applicants will promote DEIA in their project. Use the BNL PIER Plan Template (.docx) and the PIER Guidance document (.docx) to assist you in addressing PIER

MoU Program

Part of the Lab's 4-pillar DEIA strategy, the 'Expanding the Circle of Peers' pillar increases the trusted relationships managers, scientists, and engineers rely on when seeking qualified talent. Memorandums of Understanding (MoUs) between the Lab and Minority Serving Institutions establish a formal relationship that benefit both partners.

Many Activities are in Progress

- Workshop on Exploring Collaboration with Minority Serving Institutions in Nuclear and Particle Physics, July 18-19, 2023
  - 17 MSIs participated, including students
- Proposals submitted responding to DOE-SC FOAs on FAIR and RENEW programs in collaborations with MSIs have been successful
- Workforce development and pipeline: outreach, BNL summer Sundays, SULI, SCGSR and more
- And many other initiatives
- Brookhaven makes the Top 20 Government Employer List for 2023 Annual issue of Equal Opportunity Magazine

Top 20 Government Employers

1. National Aeronautics and Space Administration (NASA)
2. Federal Aviation Administration (FAA)
3. National Security Agency (NSA)
4. U.S. Environmental Protection Agency (EPA)
5. U.S. Nuclear Regulatory Commission (NRC)
6. Air Force Civilian Service (AFCS)
7. U.S. Naval Research Lab (NRL)
8. U.S. Department of State (DOS)
9. Central Intelligence Agency (CIA)
10. Transportation Security Administration (TSA)
11. U.S. Secret Service (USSS)
12. Brookhaven National Laboratory

READERS' CHOICE 2022 TOP 20 GOVERNMENT EMPLOYERS STEM WORKFORCE DIVERSITY

Readers were asked to list the top STEM-focused government agencies for which they'd most like to work or which they believe would provide a positive working environment for members of minority groups and diverse cultures. Here are the results.

13. The Air Force Research Lab (AFRL)
14. U.S. Department of Commerce (DOC)
15. Oak Ridge National Laboratory (ORNL)
16. Military Sealift Command (MSC)
17. Los Alamos National Laboratory (LANL)
18. U.S. Army Corps of Engineers (USACE)
19. National Geospatial-Intelligence Agency (NGA)
20. Sandia National Laboratories

Workshop on Exploring Collaboration with Minority Serving Institutions

Brookhaven National Laboratory

BNL DEI Vision

Support the Lab's mission by fostering a psychologically safe environment for everyone to be authentic and productive in a respectful and diverse workplace thereby BNL recognizes its fullest potential and remains relevant in the future

Gertrude Scharff-Goldhaber Prize 2023 presented to Xiaofeng Wang

- "I have been fascinated by physics since I was a young student, I wanted to understand the fundamental nature of matter and energy and the origin and evolution of the universe."

- Wang's study of the Breit-Wheeler process began in the autumn of 2019, under the supervision of Zhangbu Xu (BNL), Chi Yang (Shandong University), and James Daniel Brandenburg (Ohio State University).

Brookhaven National Laboratory

STAR

SHANDONG UNIVERSITY 1901

Energy Dependence of Breit-Wheeler Process in Heavy-Ion Collisions and Its Application to Nuclear Charge Radius Measurements

Xiaofeng Wang （王晓凤）

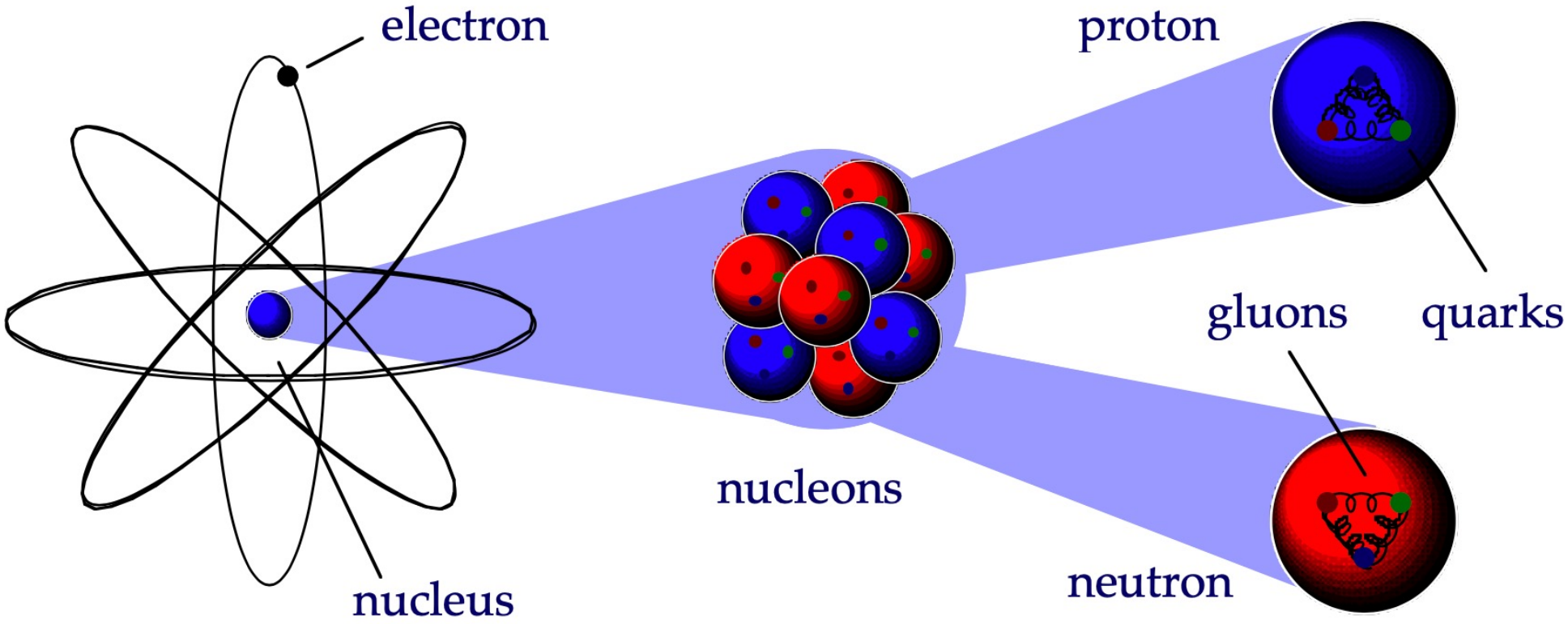
Scharff-Goldhaber Prize Ceremony

August 15, 2023

Outline

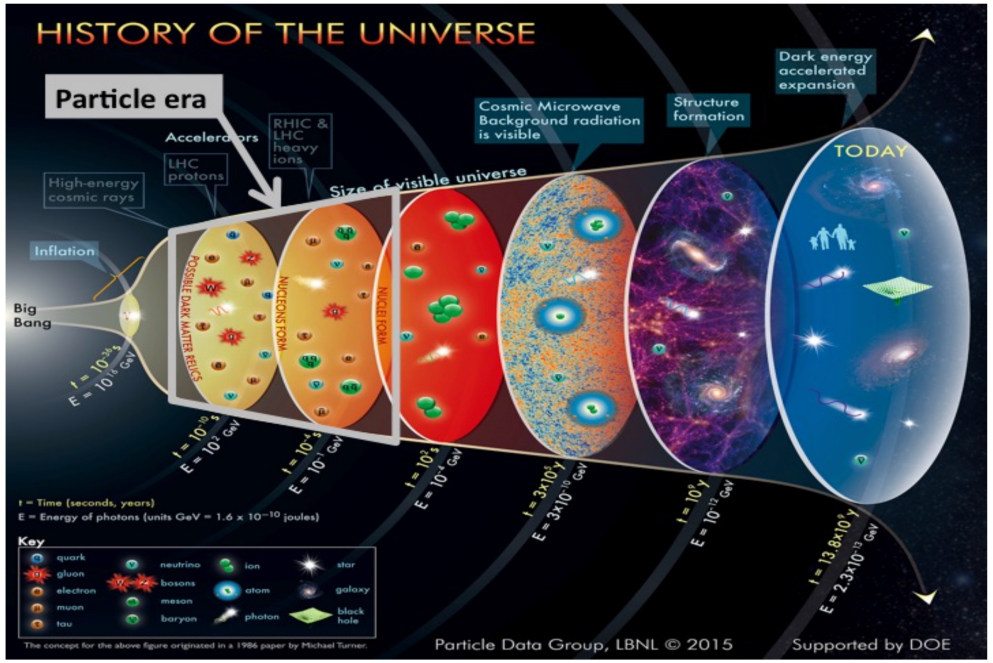
- Quark Gluon Plasma in Heavy Ion Collisions
- Breit-Wheeler Process in Heavy Ion Collisions
- Application of Breit-Wheeler Process
  - ✓Study the properties of quark gluon plasma
  - ✓Map the magnetic field
  - ✓Constrain nuclear charge radii
- Summary and Perspective

Configuration of Atom



Quarks/gluons: confined in protons and neutrons through strong force

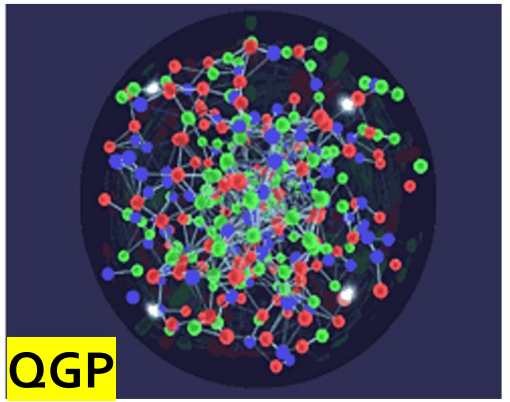
Quark Deconfinement



Quark-Gluon Plasma (QGP):

A new state of quark and gluon degrees of freedom

Is it possible to observe QGP in the laboratory?



Relativistic Heavy Ion Collisions: Heated to 10^{12} K !!

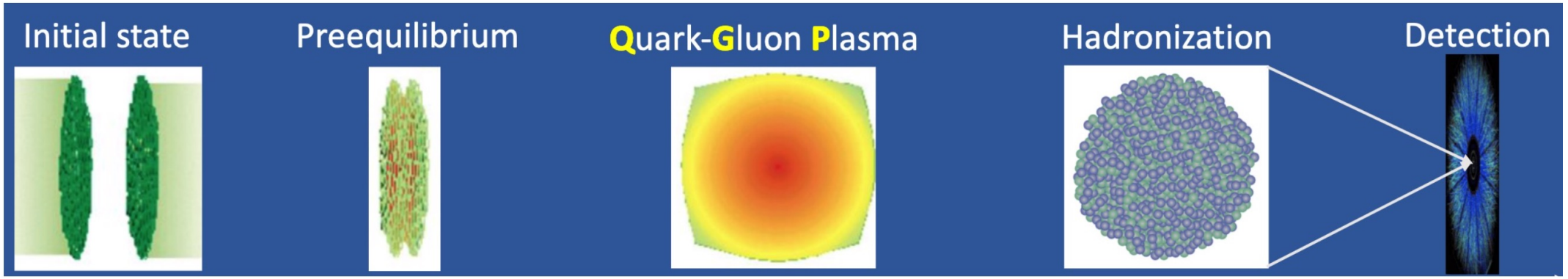
The core temperature of the sun: $2*10^7$K
(quarks are still confined in hadrons)

T. D. Lee (1926-)

the Nobel Prize in Physics in 1957

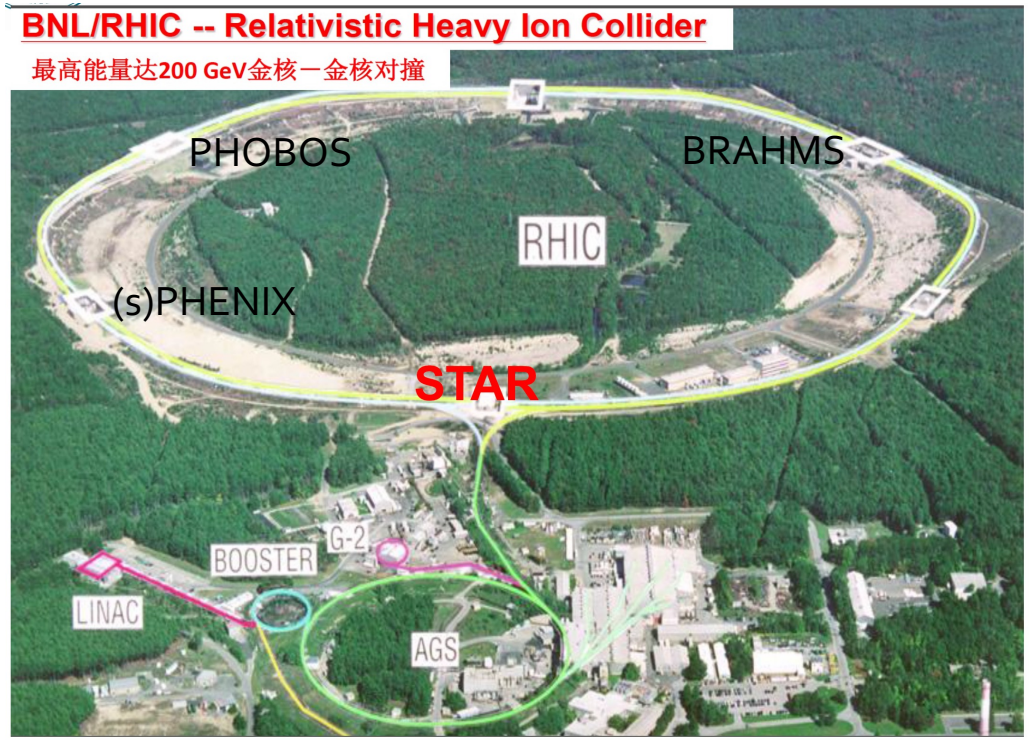
T. D. Lee and G. C. Wick, Phys. Rev. D 9, 2291 (1974).
Vacuum stability and vacuum excitation in a spin-0 field theory.

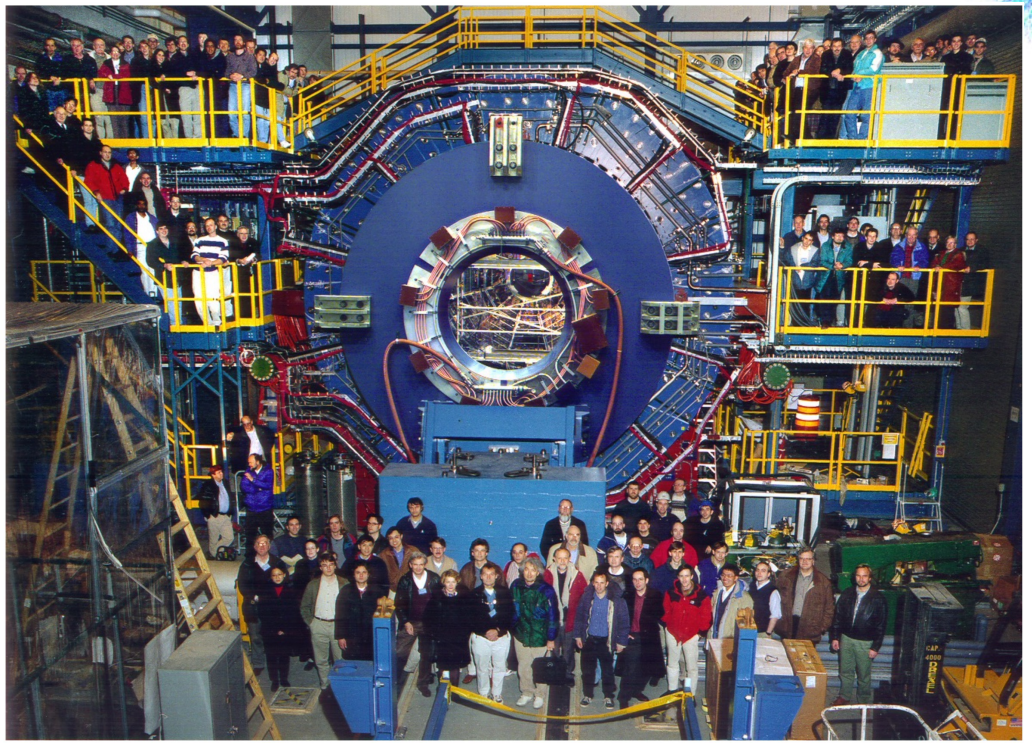
Hottest Temperature in the Lab: About 10^5 times hotter than the center of the Sun



QGP can be created in relativistic heavy ion collisions

Relativistic Heavy Ion Collider (RHIC) and STAR



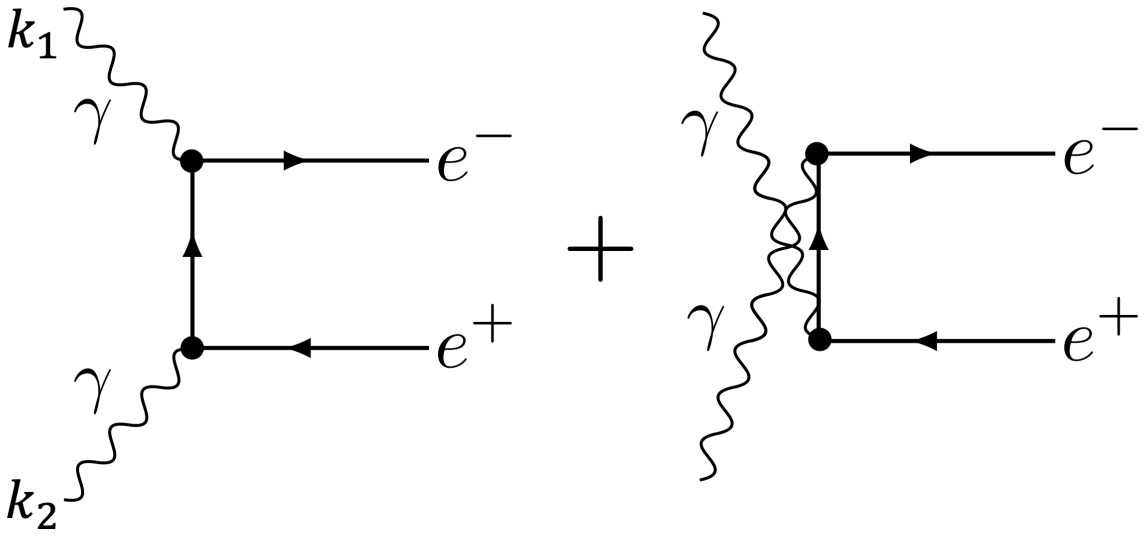


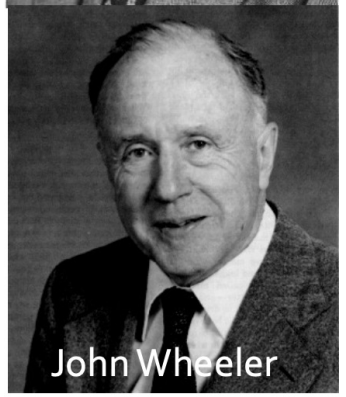
RHIC can create QGP

Solenoidal Tracker At RHIC (STAR) can measure the properties of QGP

Dielectron: No strong interaction → Ideal electromagnetic probe for probing QGP properties

The Breit-Wheeler Process : $\gamma\gamma \rightarrow e^+e^-$





◆**Breit-Wheeler process:**

converting **real** photon into e^+e^-

Breit & Wheeler, Phys. Rev. 46 (1934) 1087

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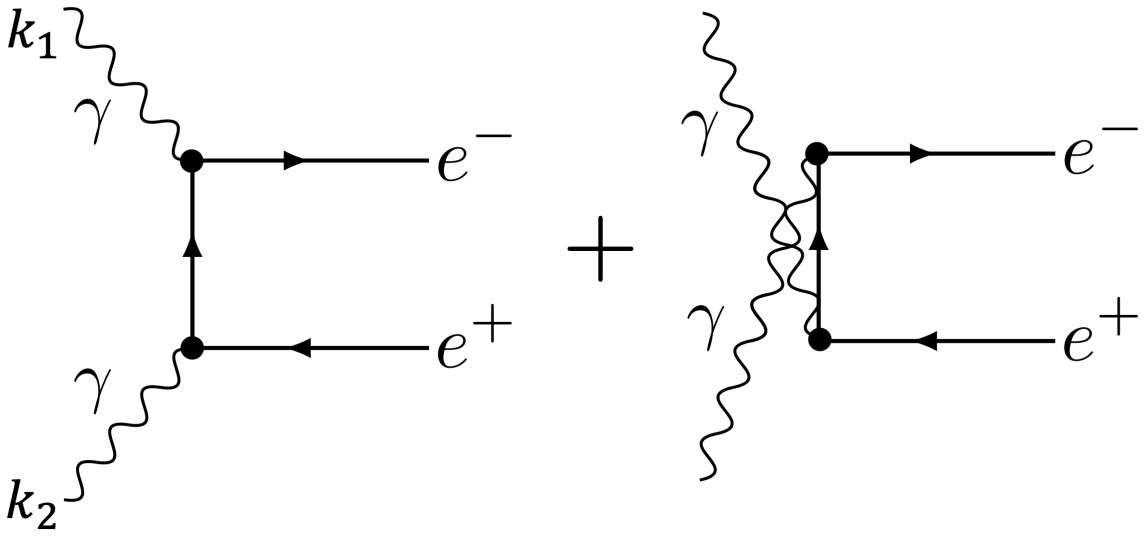
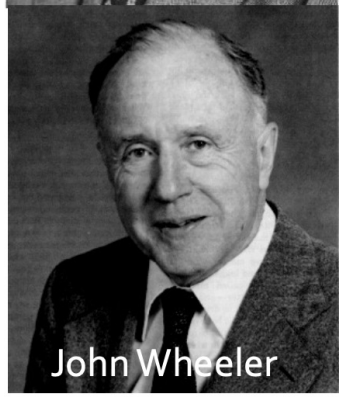


Hard to observe

- The cross section is small
- The insufficiently large available densities of photon


Gregory Breit


John Wheeler

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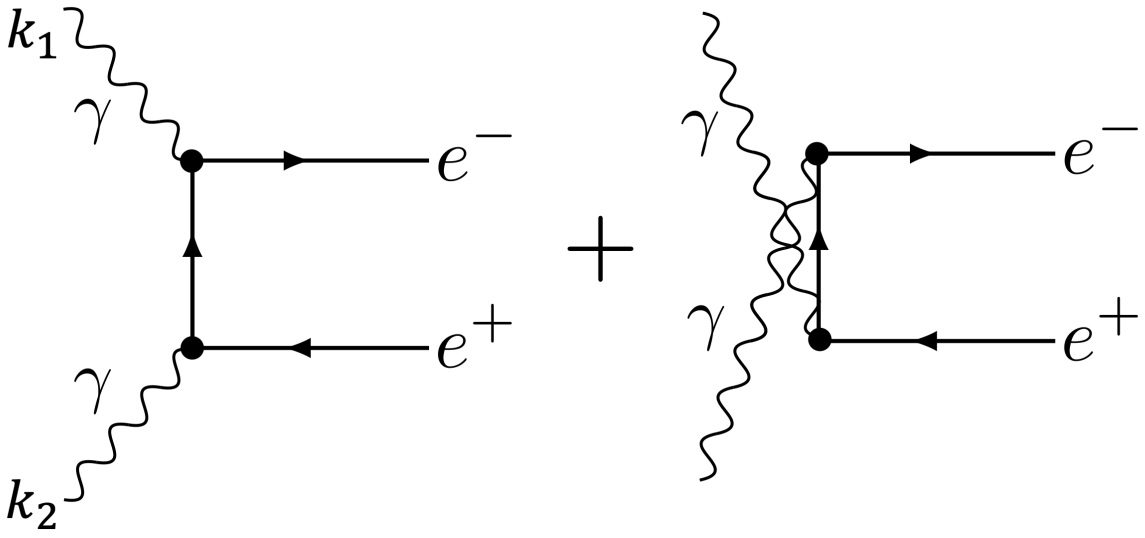

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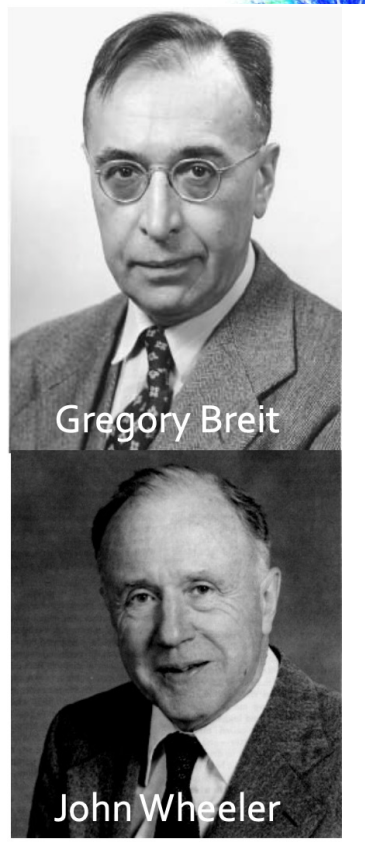

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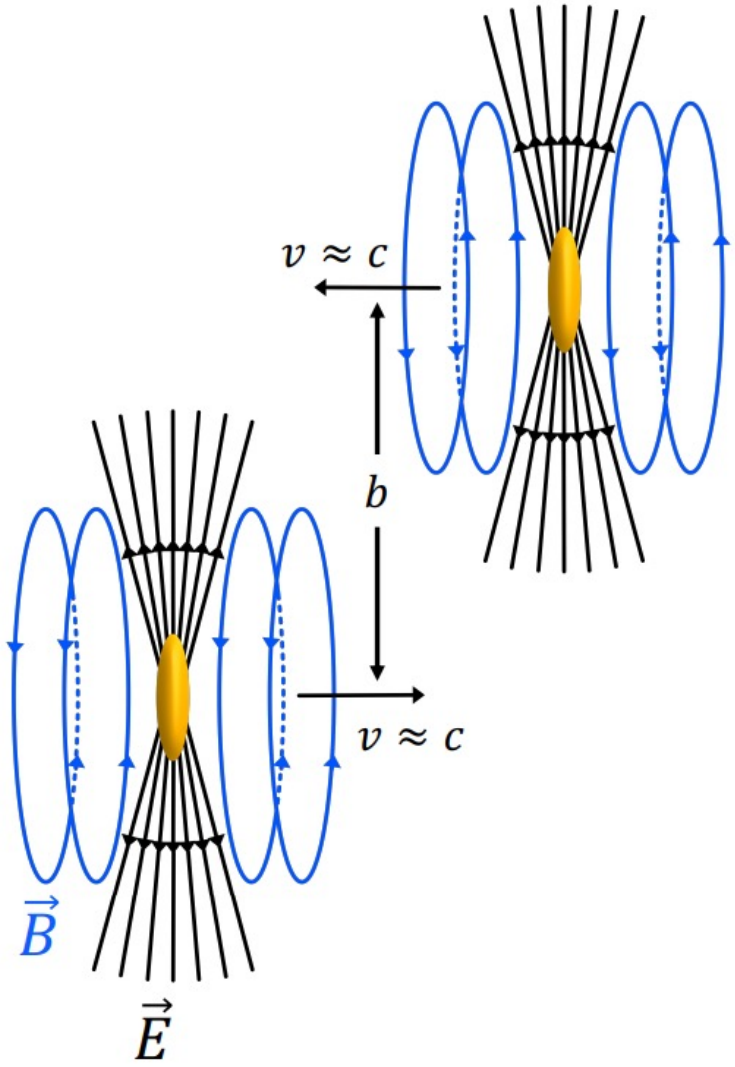
Breit & Wheeler, Phys. Rev. 46 (1934) 1087

of quanta. In the considerations of Williams, however, the large nuclear electric fields lead to large densities of quanta in moving frames of reference. This, together with the large number

Ultra-Peripheral Heavy Ion Collisions (UPCs)



- Highly Lorentz-contracted charged nuclei produce electromagnetic fields (EM)
- Equivalent Photon Approximation (EPA): EM fields → a flux of **quasi-real photons**

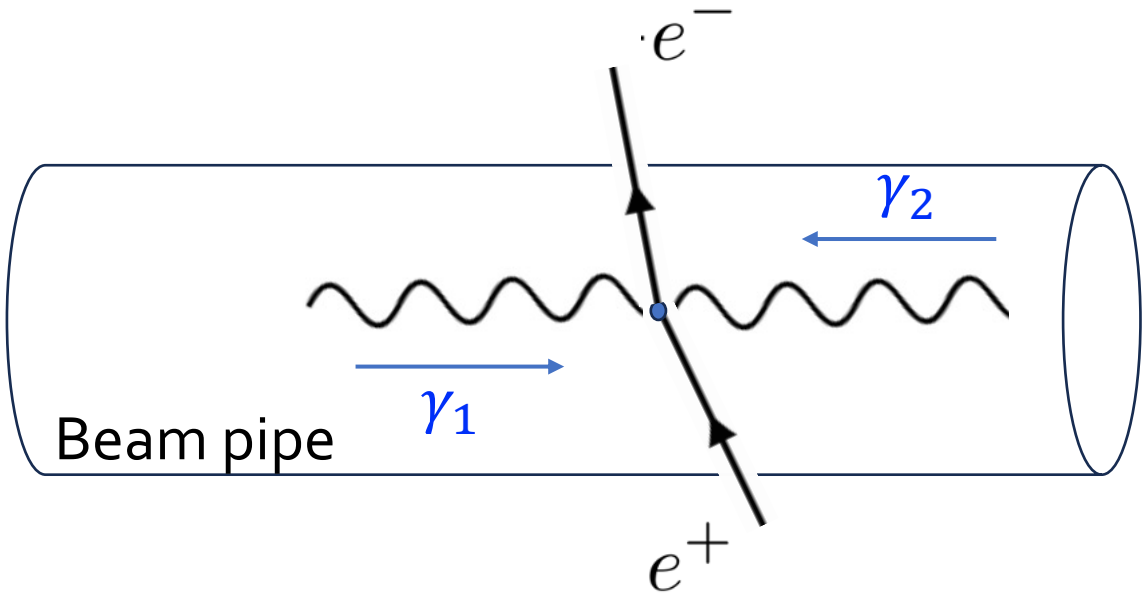
  Weizsäcker, C. F. v. Zeitschrift für Physik 88 (1934): 612
- High photon density from highly charged nuclei ($\propto Z^2$)
- Virtuality $Q^2 \lesssim (\hbar/R_A)^2$ in UPCs $\Longrightarrow$ **almost real**

  Ann.Rev.Nucl.Part.Sci. 55 (2005) 271-310
- Virtuality cancels at low photon transverse momentum

  Vidovic, M. and Greiner, M. and Best, C. Phys.Rev.C 47 (1993) 2308-2319

Breit-Wheeler Process Was Observed in UPCs at STAR

STAR, PRL 127 (2021) 052302



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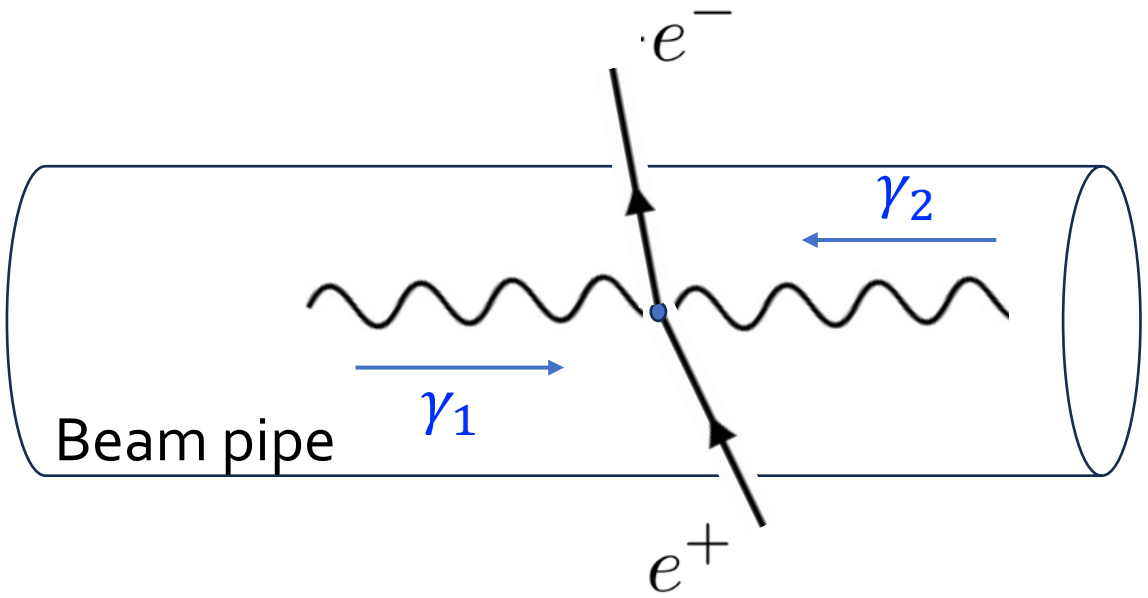

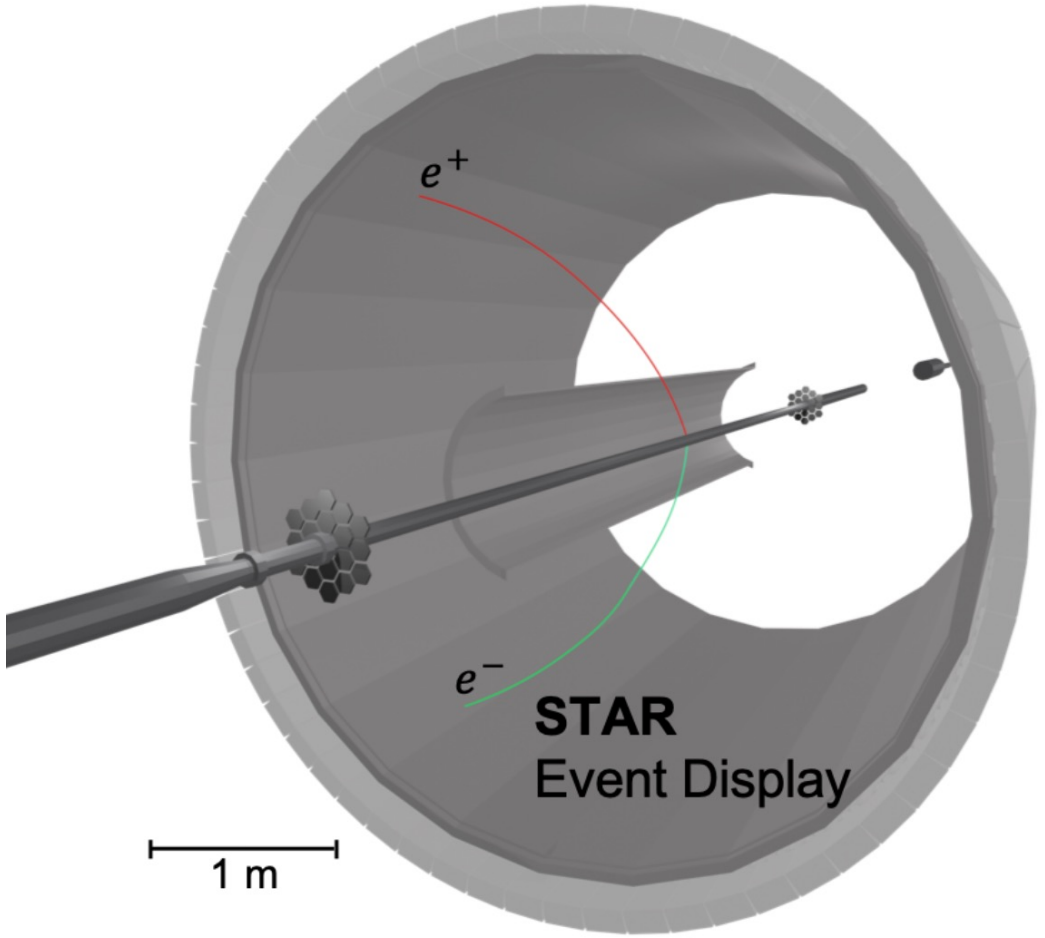

Distinctive features of BW process

- Exclusive production of e^+e^- pair

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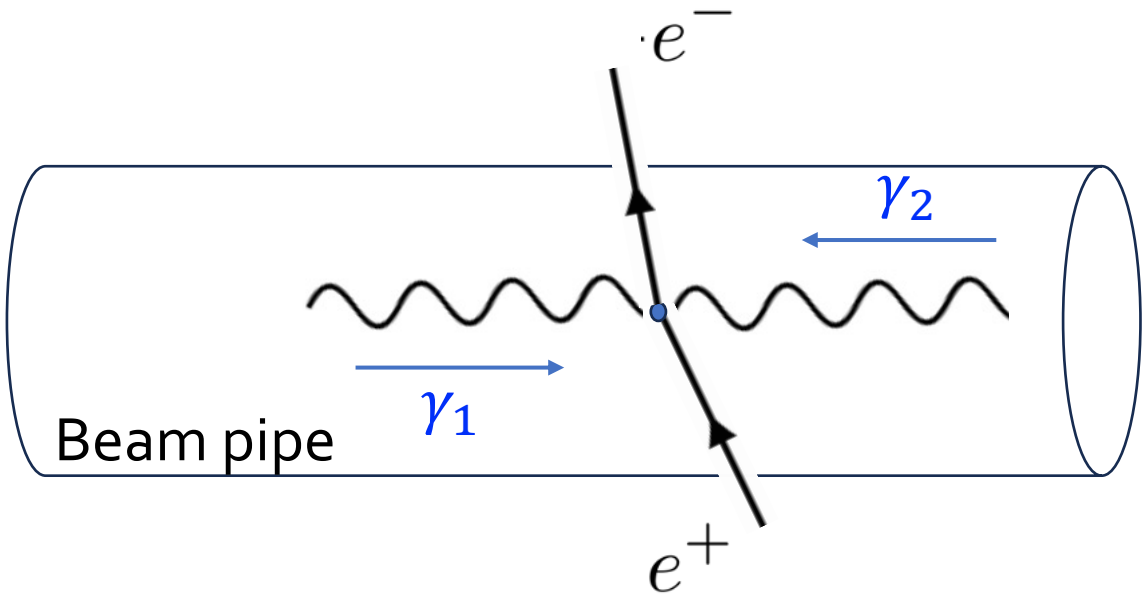
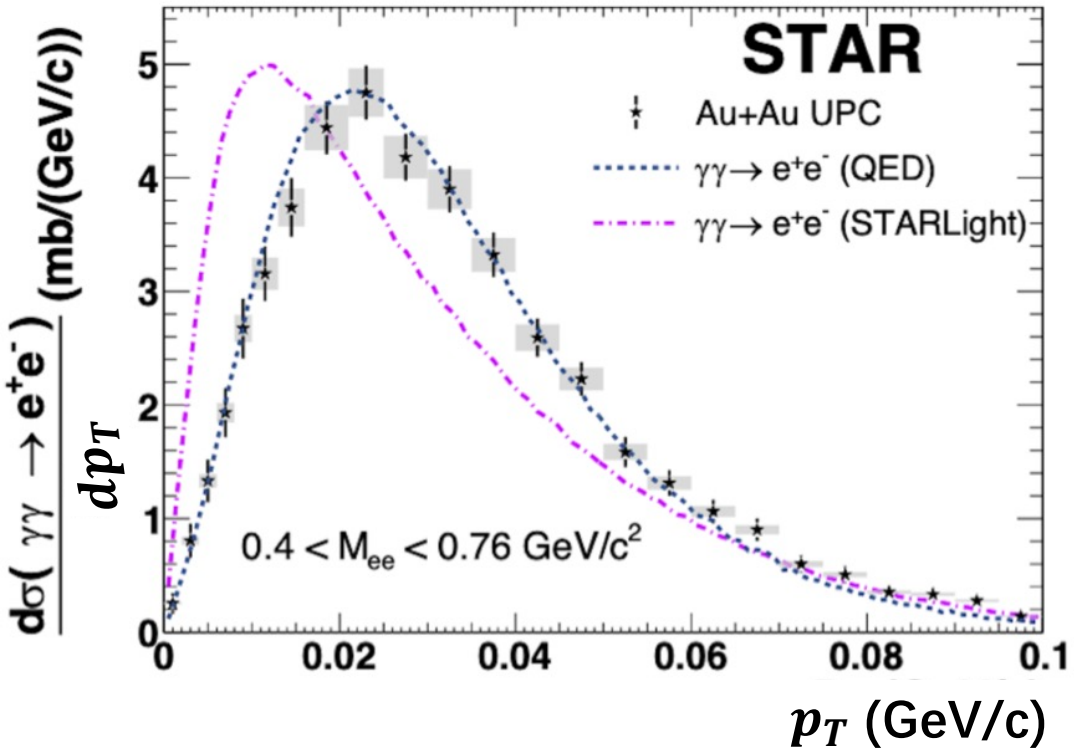


STAR, PRL 127 (2021) 052302

QED: Quantum ElectroDynamics

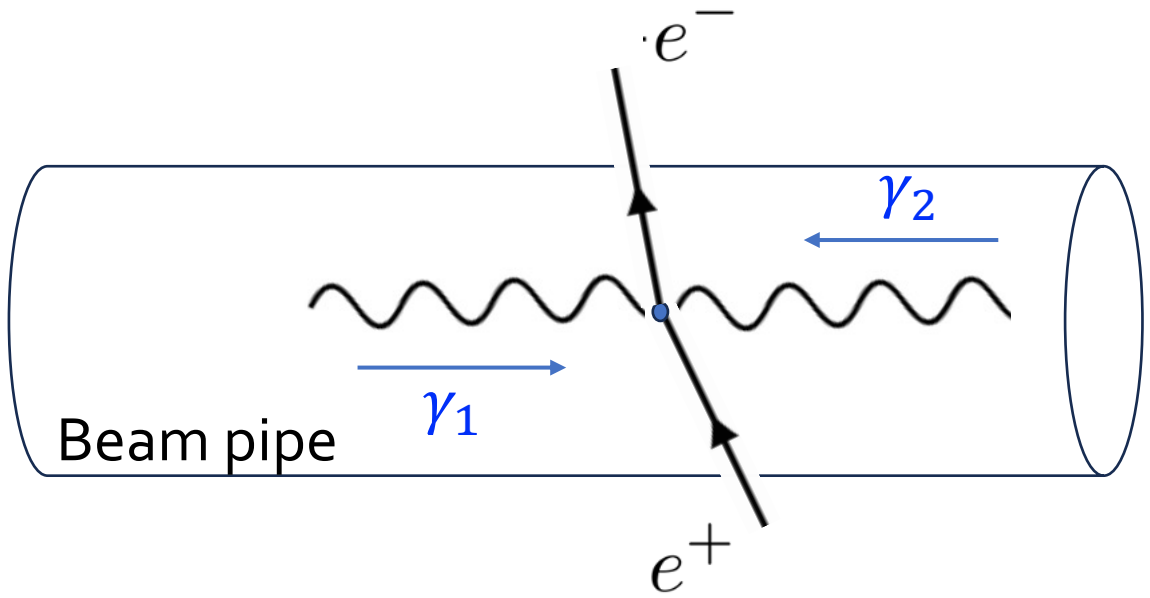


Distinctive features of BW process

- Exclusive production of e^+e^- pair
- **Concentrated at low transverse momentum(p_T)**
  - **Back to back in transverse plane**

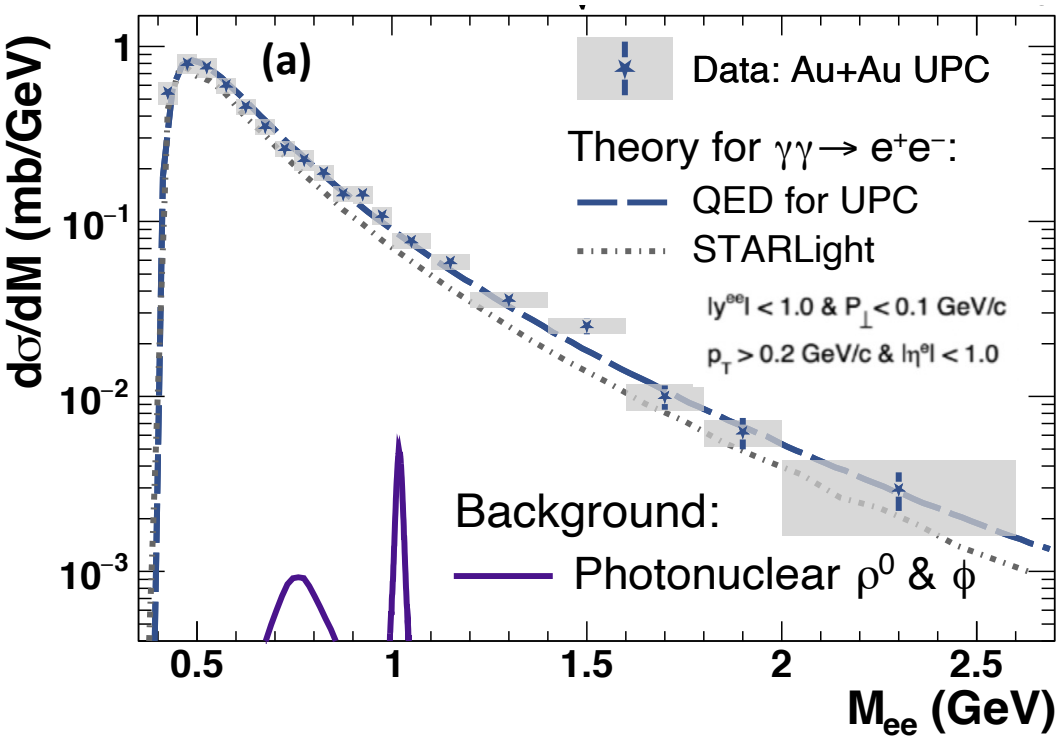
Breit-Wheeler Process Was Observed in UPCs at STAR

STAR, PRL 127 (2021) 052302



Einstein's mass-energy equation

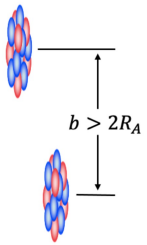
$$E^2 - p^2 = M^2, p \sim 0 \Longrightarrow E^2 = M^2$$



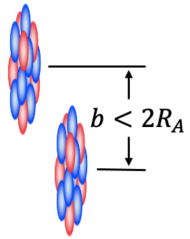
Distinctive features of BW process

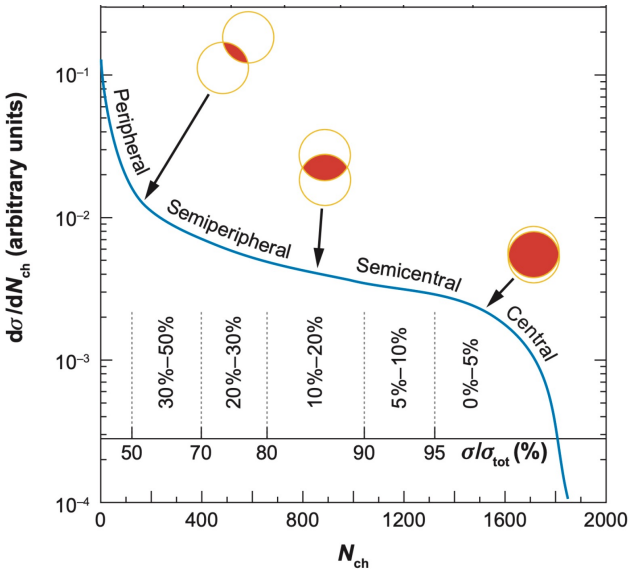
- Exclusive production of e^+e^- pair
- **Concentrated at low transverse momentum(p_T)**
  - **Back to back in transverse plane**
- Smooth invariant mass spectra
  - Quantum number conservation

Breit-Wheeler Process in Hadronic Heavy Ion Collisions (HHIC)



UPC ⟹ HHIC





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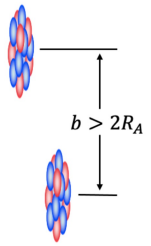

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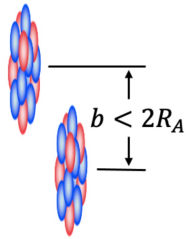
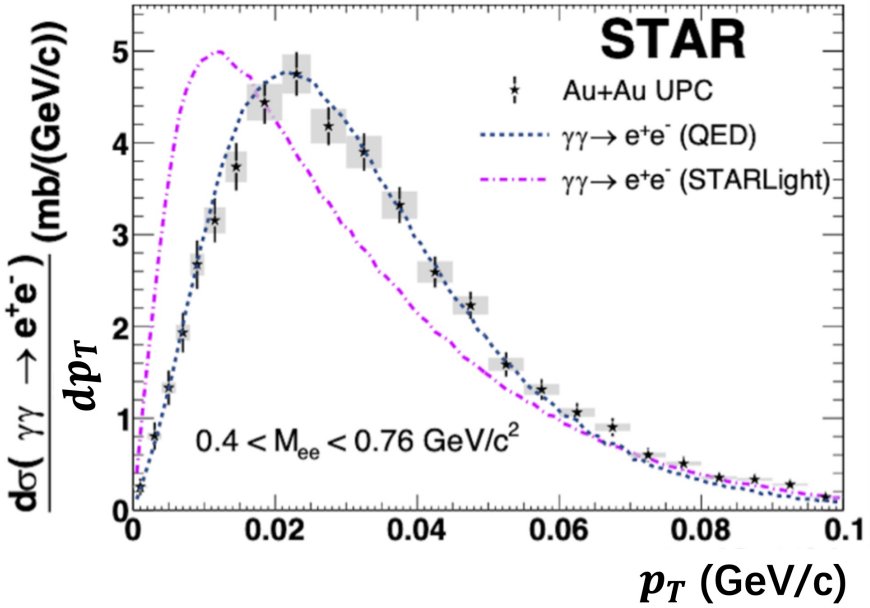
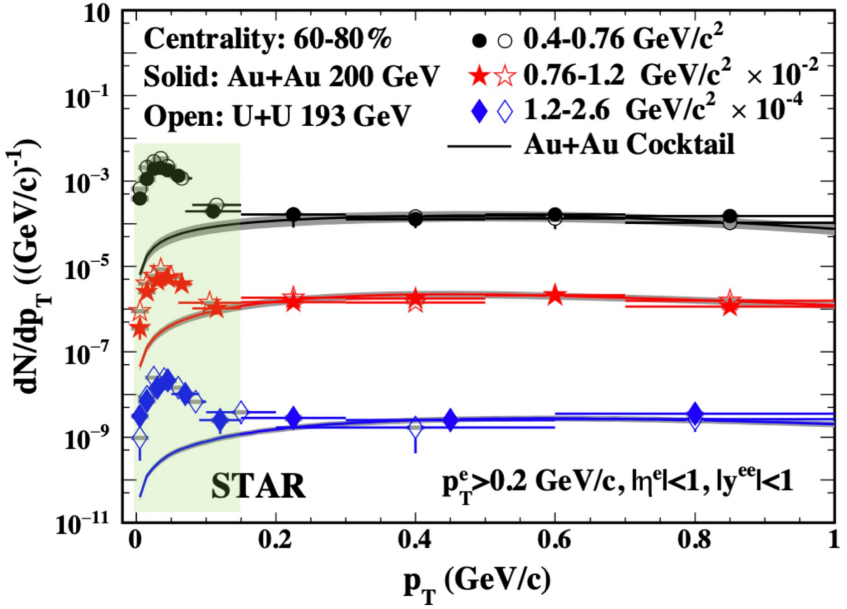
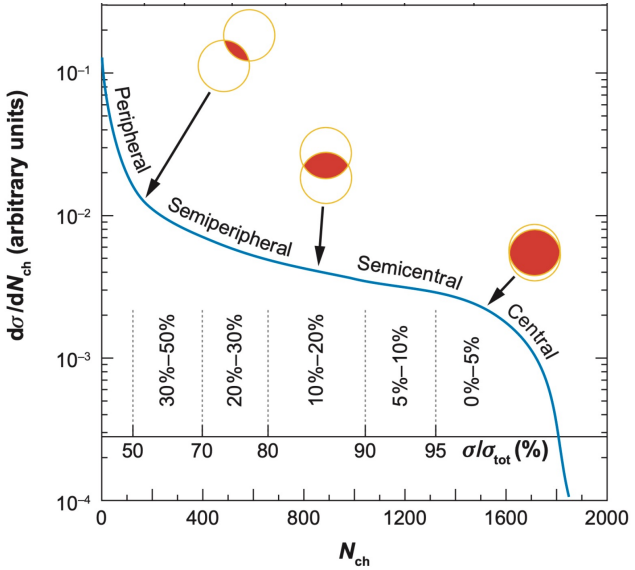




STAR: Phys.Rev.Lett. 127, 052302 (2021)

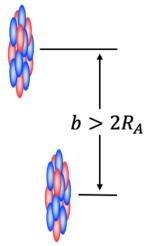


STAR: Phys.Rev.Lett. 121, 132301 (2018)



Photon-induced dielectrons as probes to study the properties of QGP in HHIC

Breit-Wheeler Process in Hadronic Heavy Ion Collisions (HHIC)



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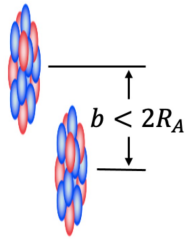

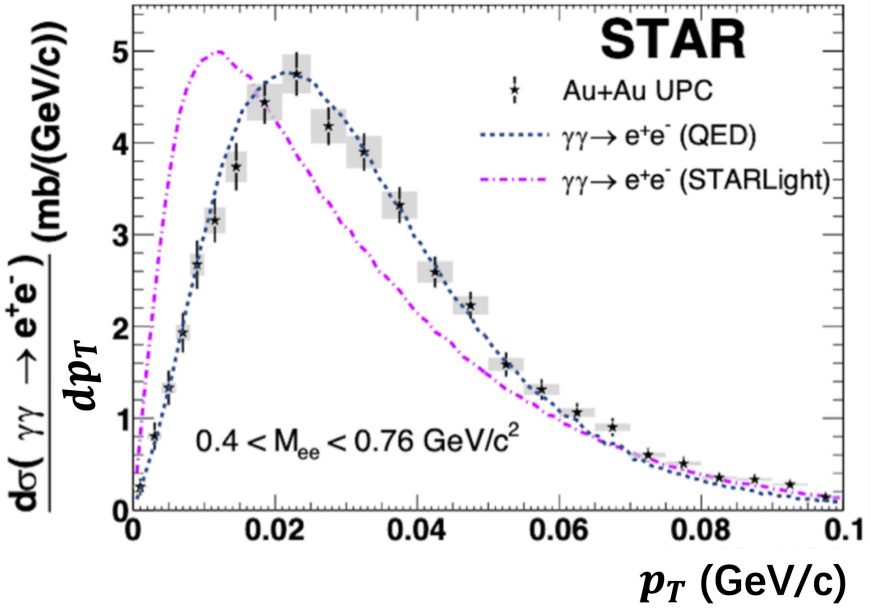

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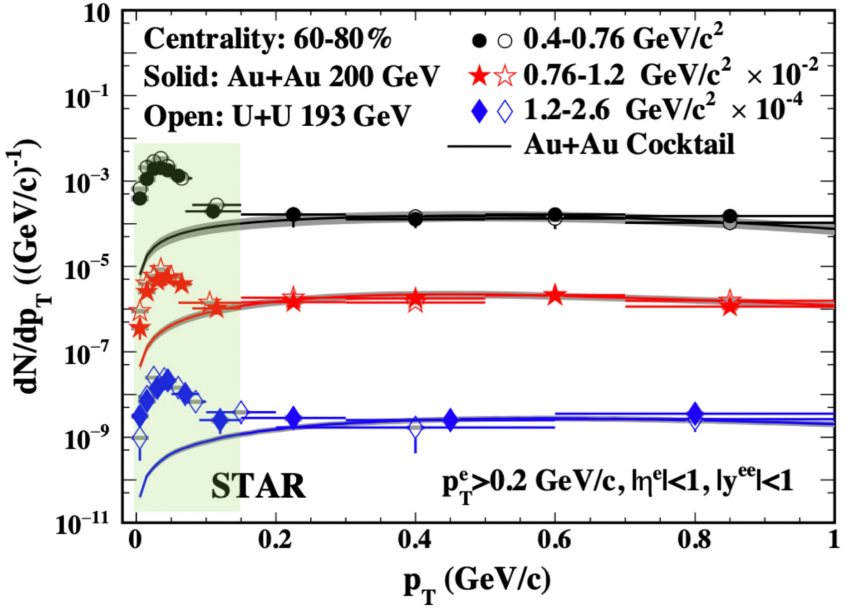

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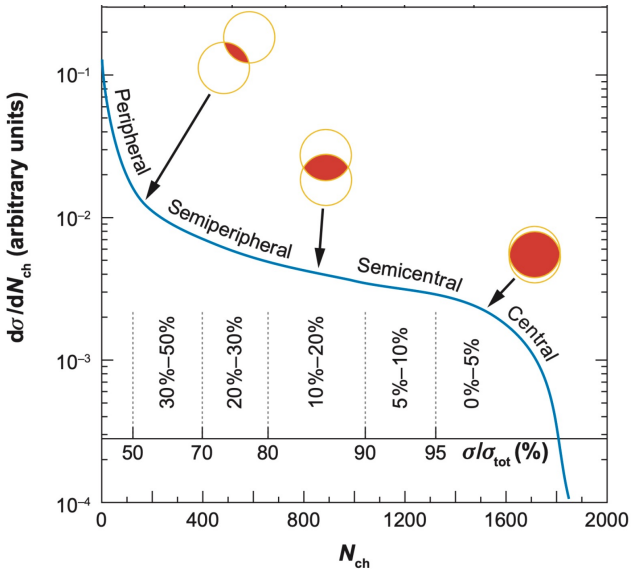

Data samples of 54 GeV and BES-I program

Energy	27 GeV	39 GeV	54 GeV	62 GeV
Used MB events	68M	132M	875M	62M

Photon-induced dielectrons as probes to study the properties of QGP in HHIC

Signal Extraction

Extracting the signal in signal/background is only 1%!

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methods

- Like sign (to remove combinational and correlated background)
- Mix event (to correct acceptance difference)
- Efficiency correction (for detector inefficiency and PID)
- Hadronic cocktail simulation to remove hadron contribution

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The first measurement of 80-100% centrality at STAR

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- No measurement of input (hadron p_T spectra, yield…)
- trigger bias in peripheral collisions

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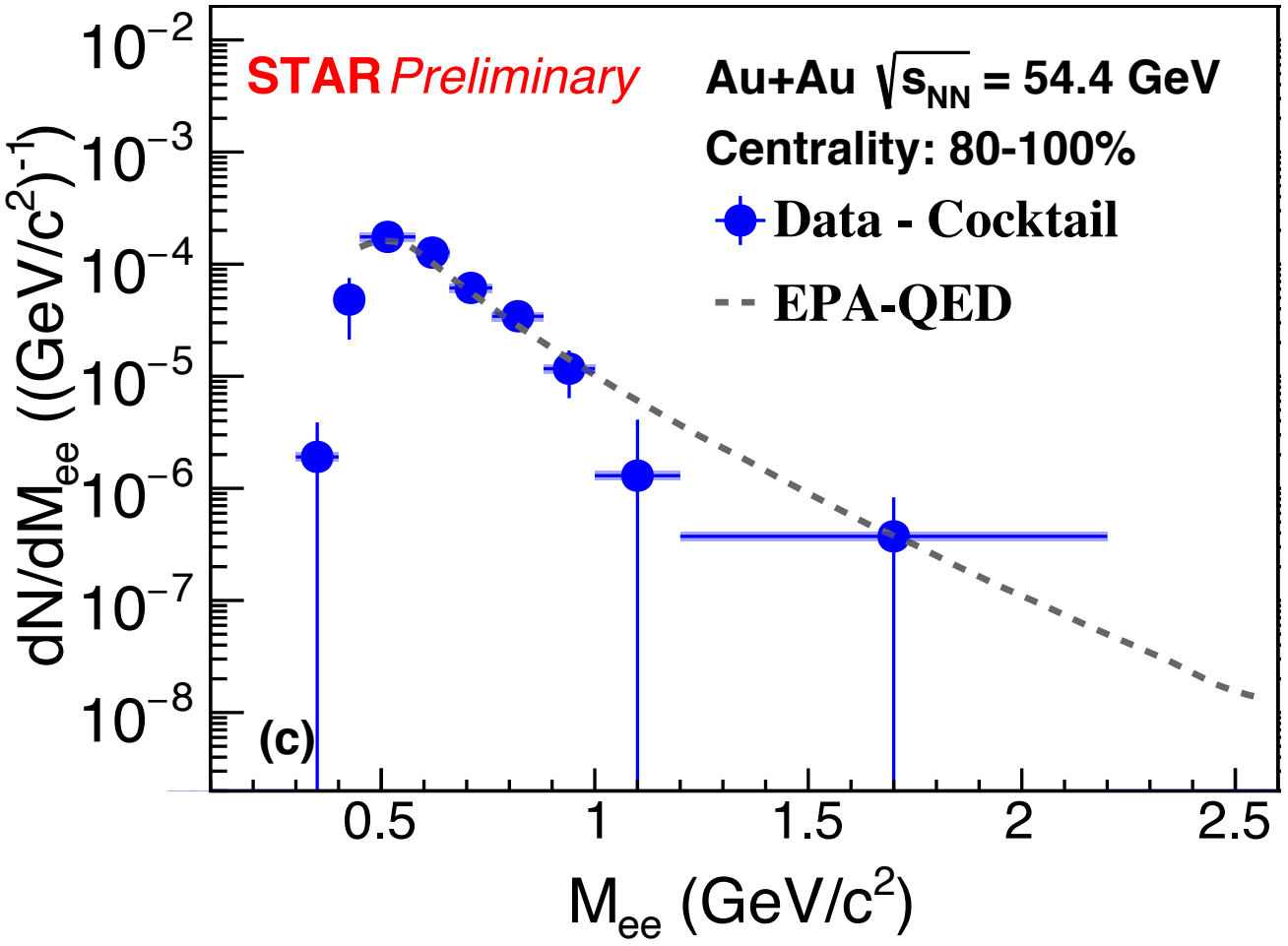
The first measurement of 80-100% centrality at STAR

- No measurement of input (hadron p_T spectra, yield…)
  - Tsallis Blast-Wave model
  - Two Component model and Glauber model
- trigger bias in peripheral collisions
  - Glauber model and QED prediction

methods

Invariant Mass Distribution at Low-p_T

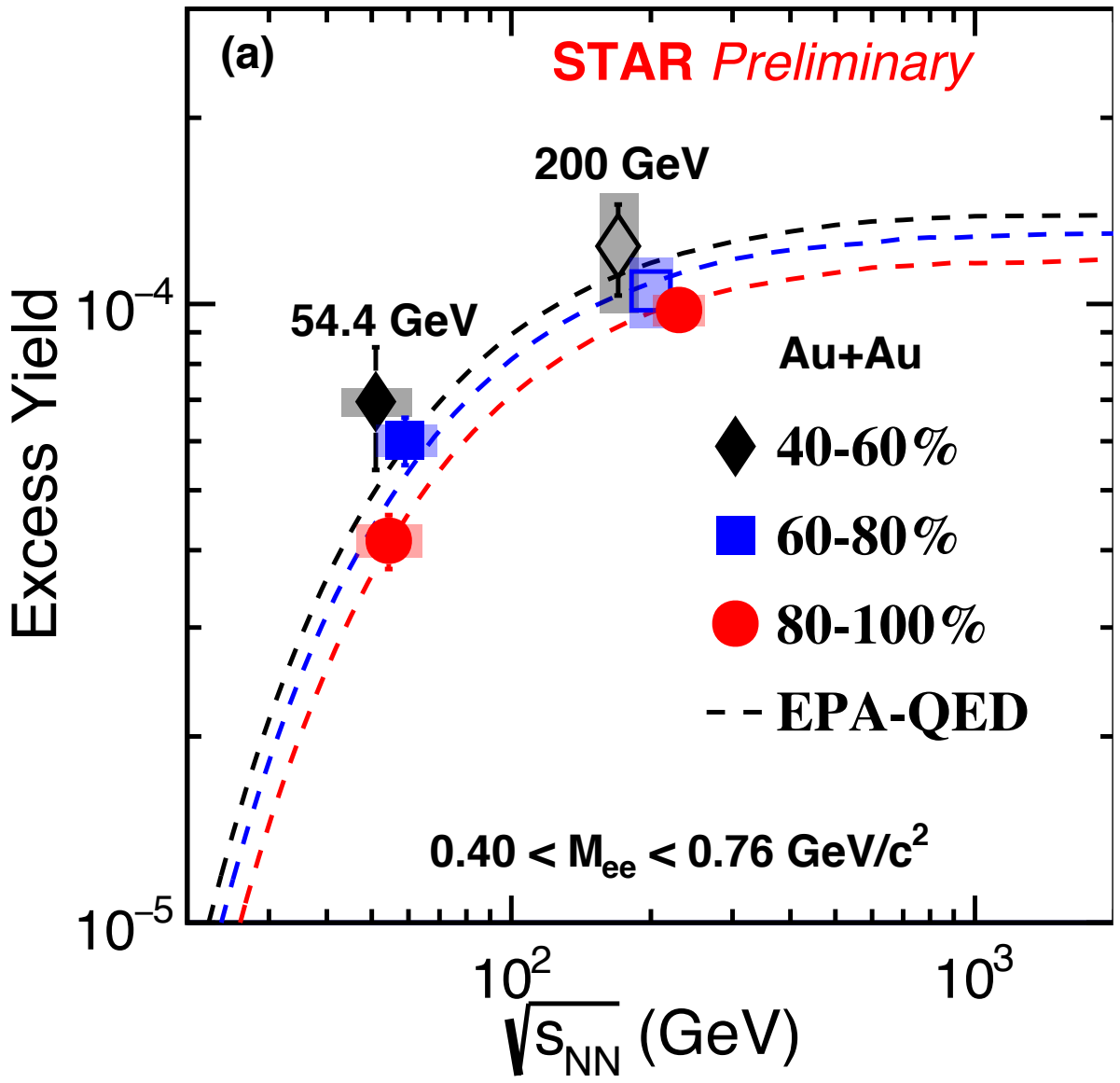


Excesses (Data - Cocktail) are extracted

No vector meson observed ($\gamma\gamma \not\rightarrow$ vector meson)

Excesses are well described by lowest order EPA-QED predictions

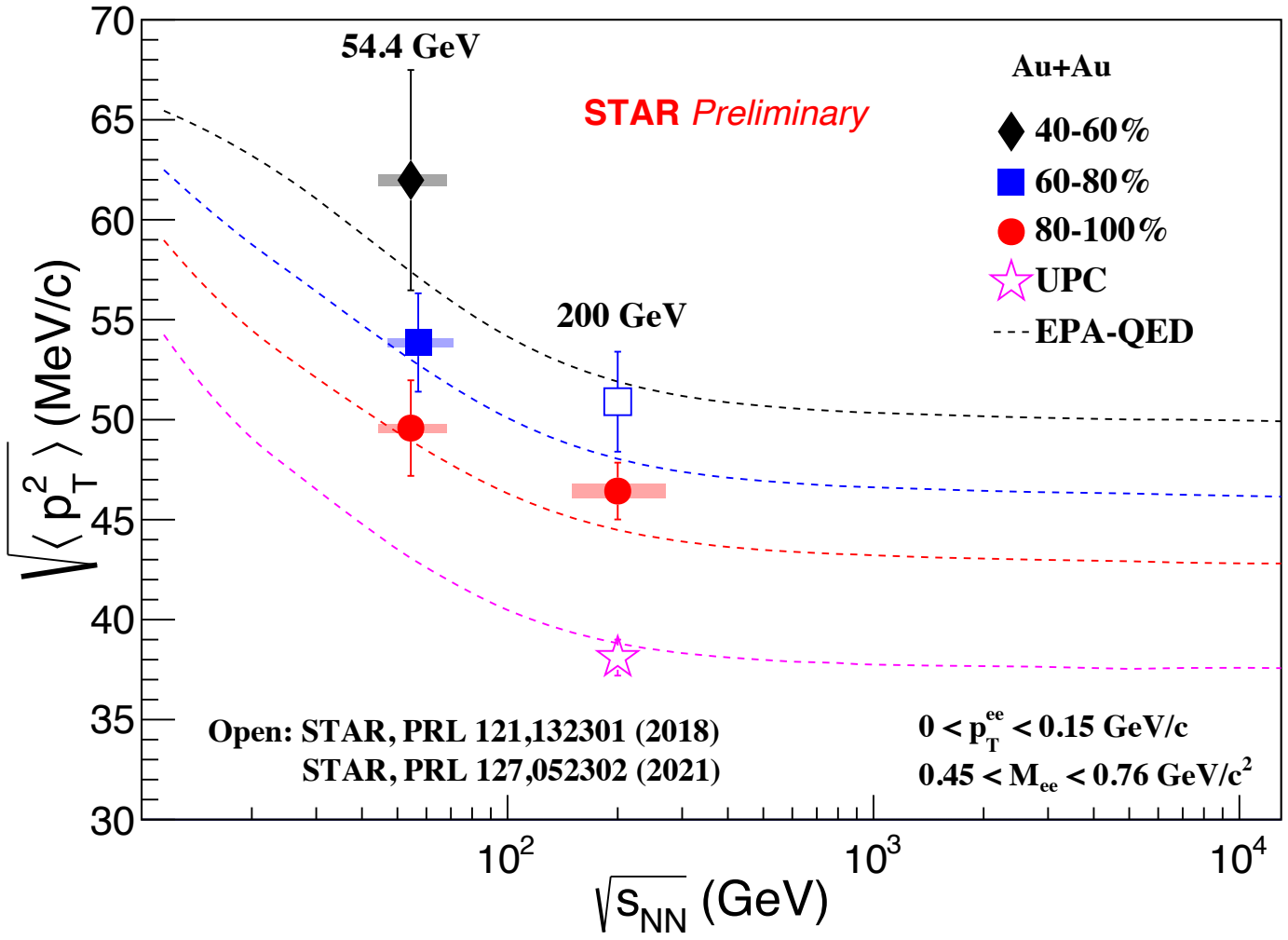
Energy Dependence of Excess Yield



Excess yield increase with beam energy

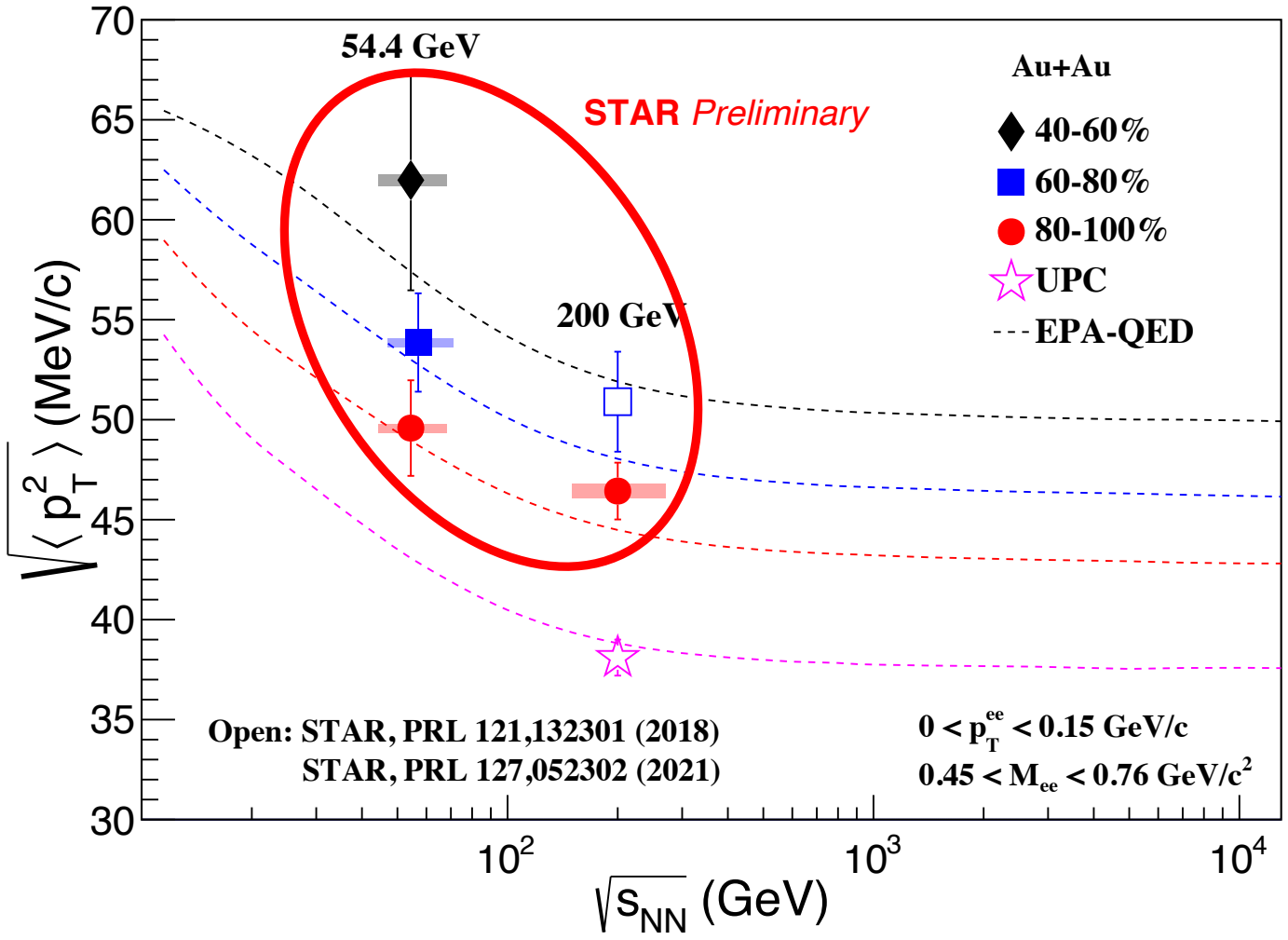
EPA-QED predicts similar energy dependence

Energy Dependence of $\sqrt{\langle p_T^2 \rangle}$



- The $\sqrt{\langle p_T^2 \rangle}$ of e^+e^- pairs decreases with increasing beam energy

Energy Dependence of $\sqrt{\langle p_T^2 \rangle}$

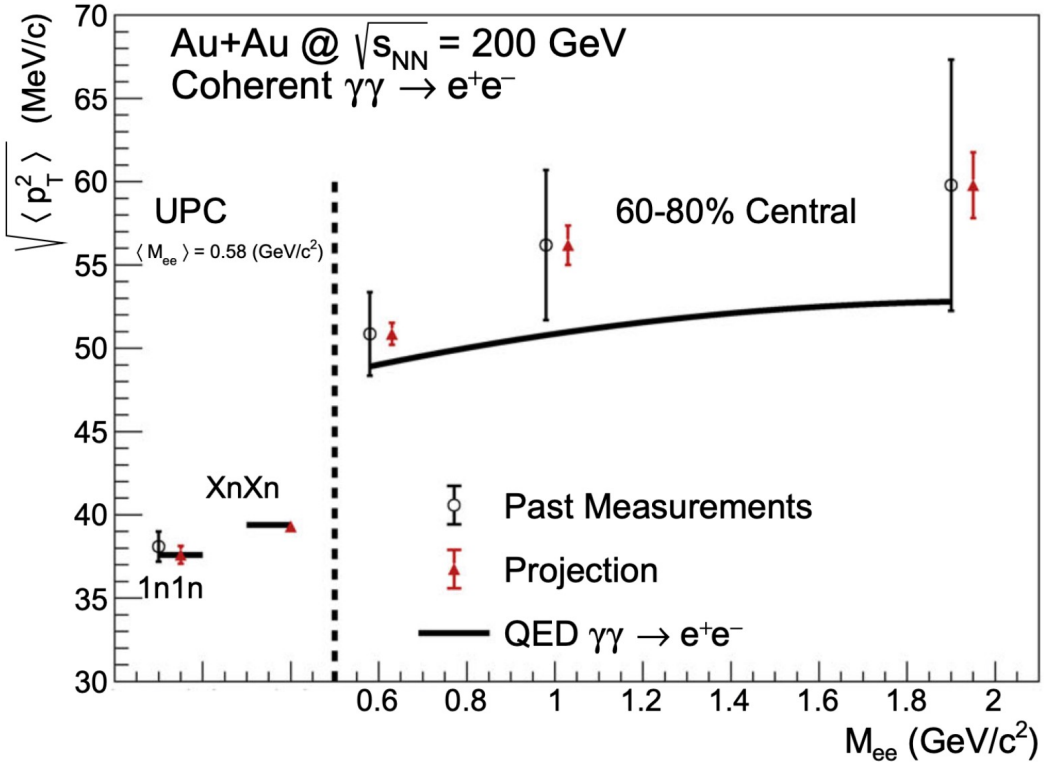


- The $\sqrt{\langle p_T^2 \rangle}$ of e^+e^- pairs decreases with increasing beam energy
- Indication of final state effect

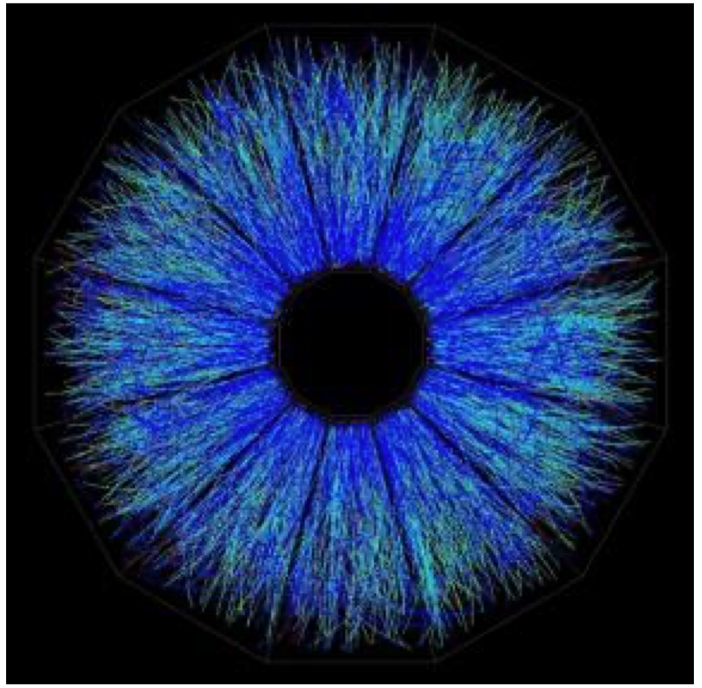
Are There Final-State QED Effect?

higher statistics

STAR collaboration Beam Use Requests for Run-23-25

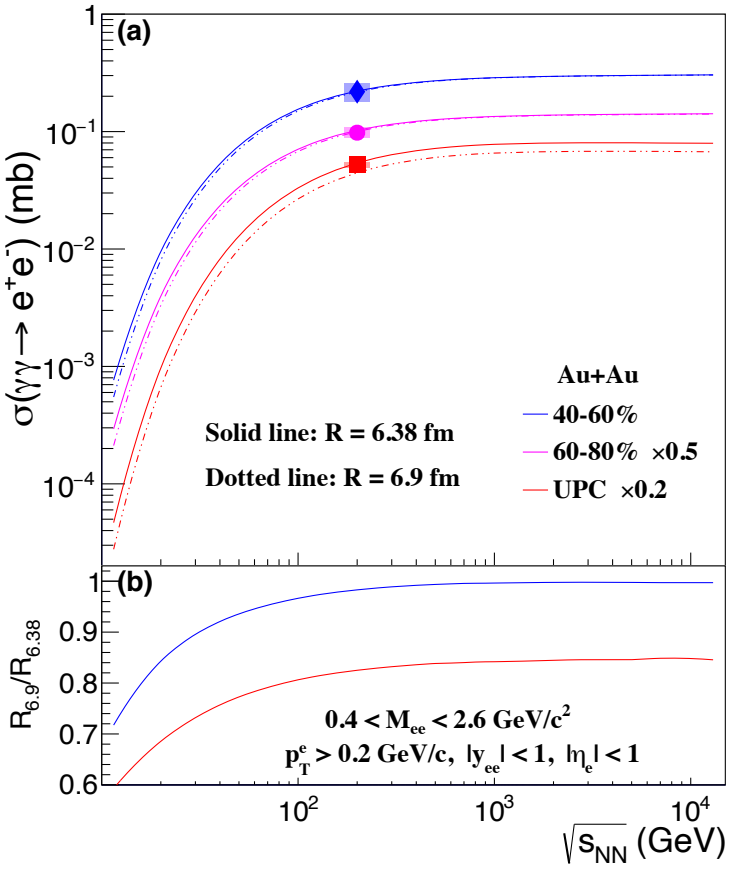


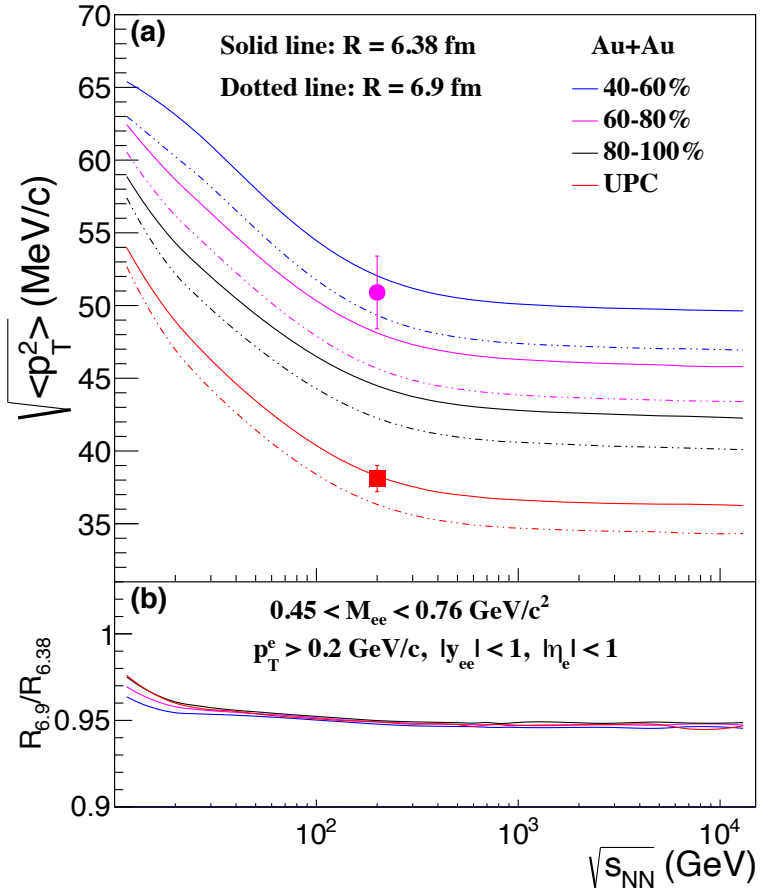
Upgrade of inner
Time Projection Chamber



lower p_T,
lower systematic uncertainty

Energy Dependence of Cross Section and $\sqrt{\langle p_T^2 \rangle}$





The kinematics of the Breit-Wheeler process are **sensitive** to the details of the **nuclear charge distribution**

X. W, J.D. Brandenburg, L. Ruan, F. Shao, Z. Xu, C. Yang, and W. Zha. Phys. Rev. C 107, 044906 (2023)

Application: Mapping the Magnetic Field

R. D. Woods and D. S. Saxon, Phys. Rev. 95, 577–578 (1954)

Woods-Saxon: $$\rho_A(r) = \frac{\rho^0}{1 + \exp[(r - R)/d]}$$

R: charge radius, d: skin depth

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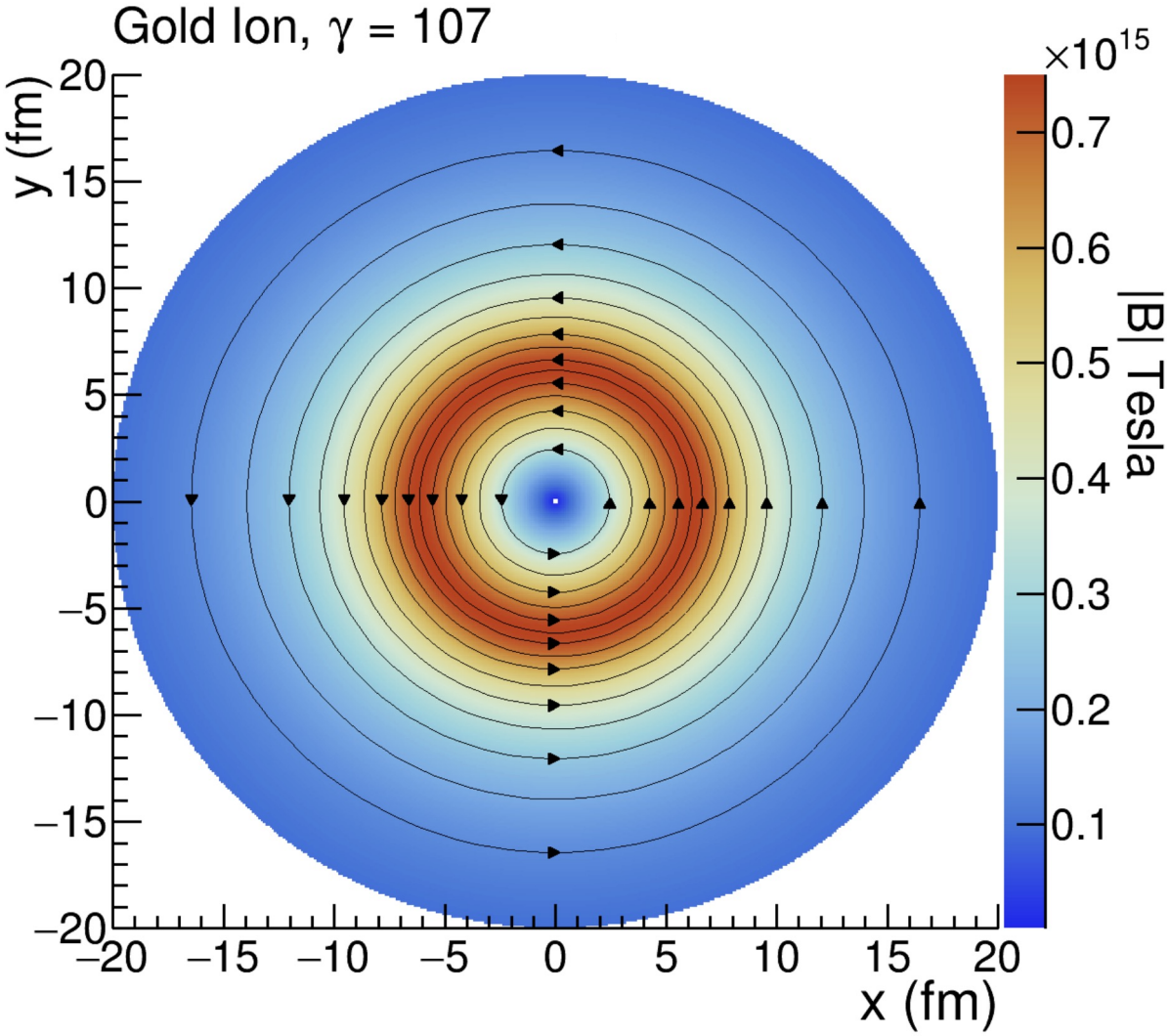
Nuclear charge distribution

↓ Biot-Savart Law

Magnetic field



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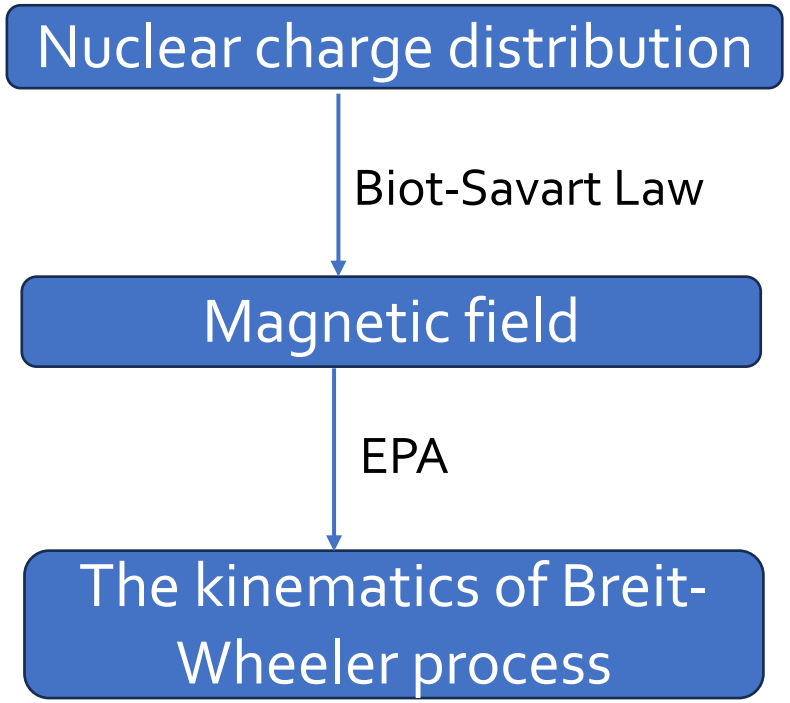
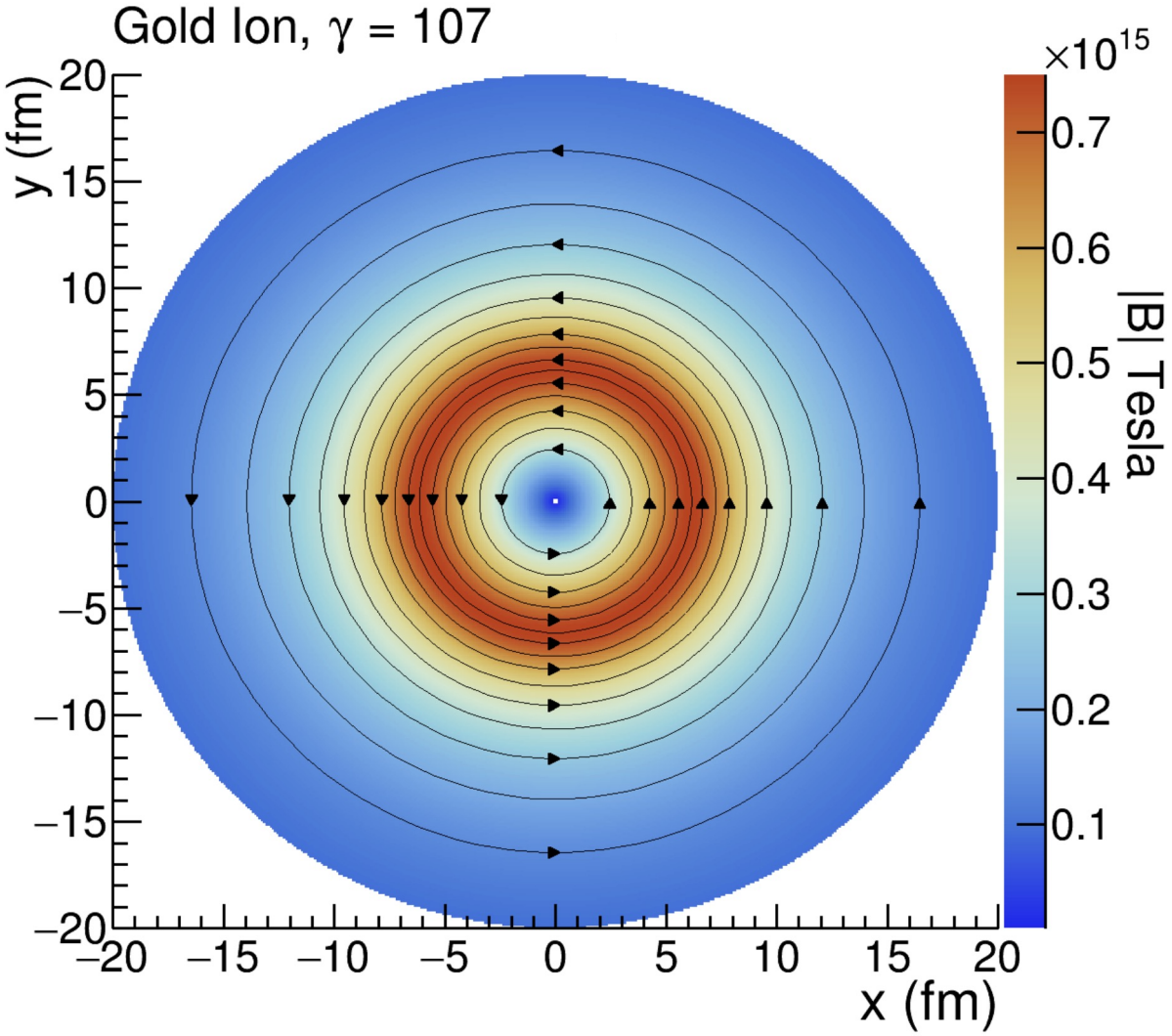


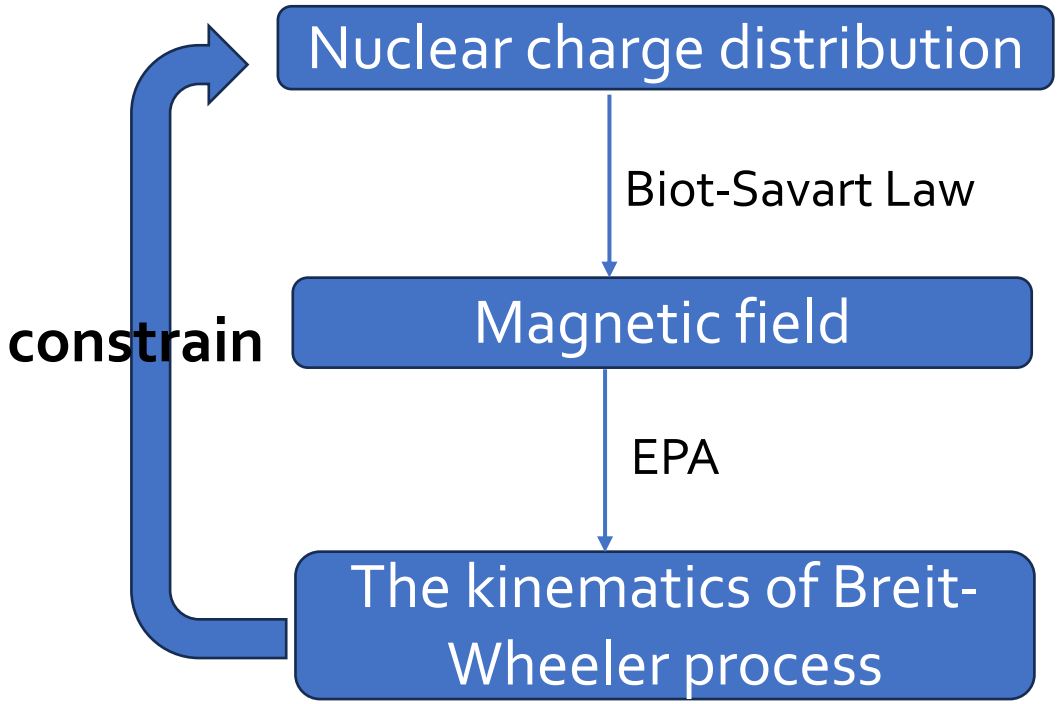


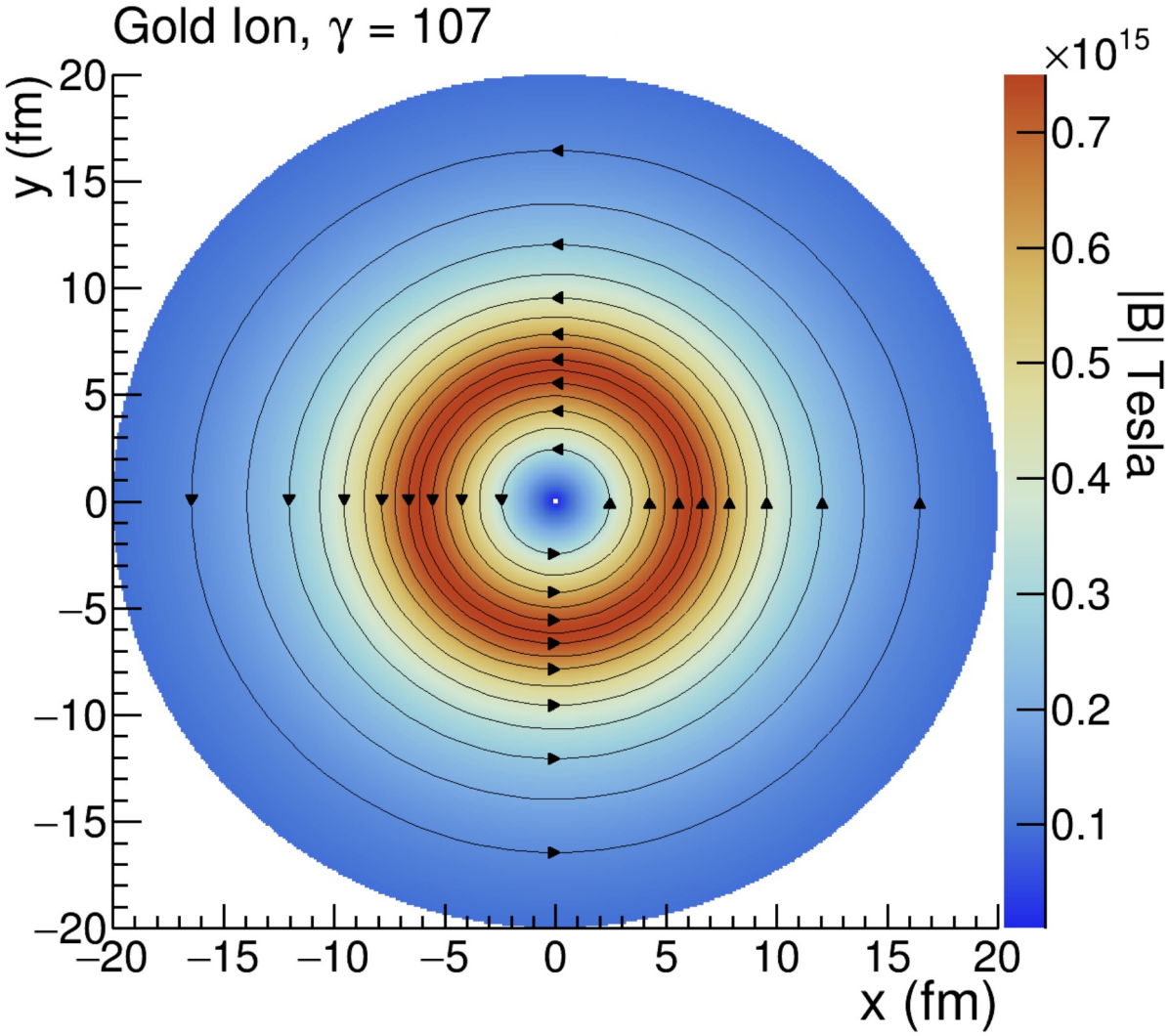
Application: Mapping the Magnetic Field

R. D. Woods and D. S. Saxon, Phys. Rev. 95, 577–578 (1954)

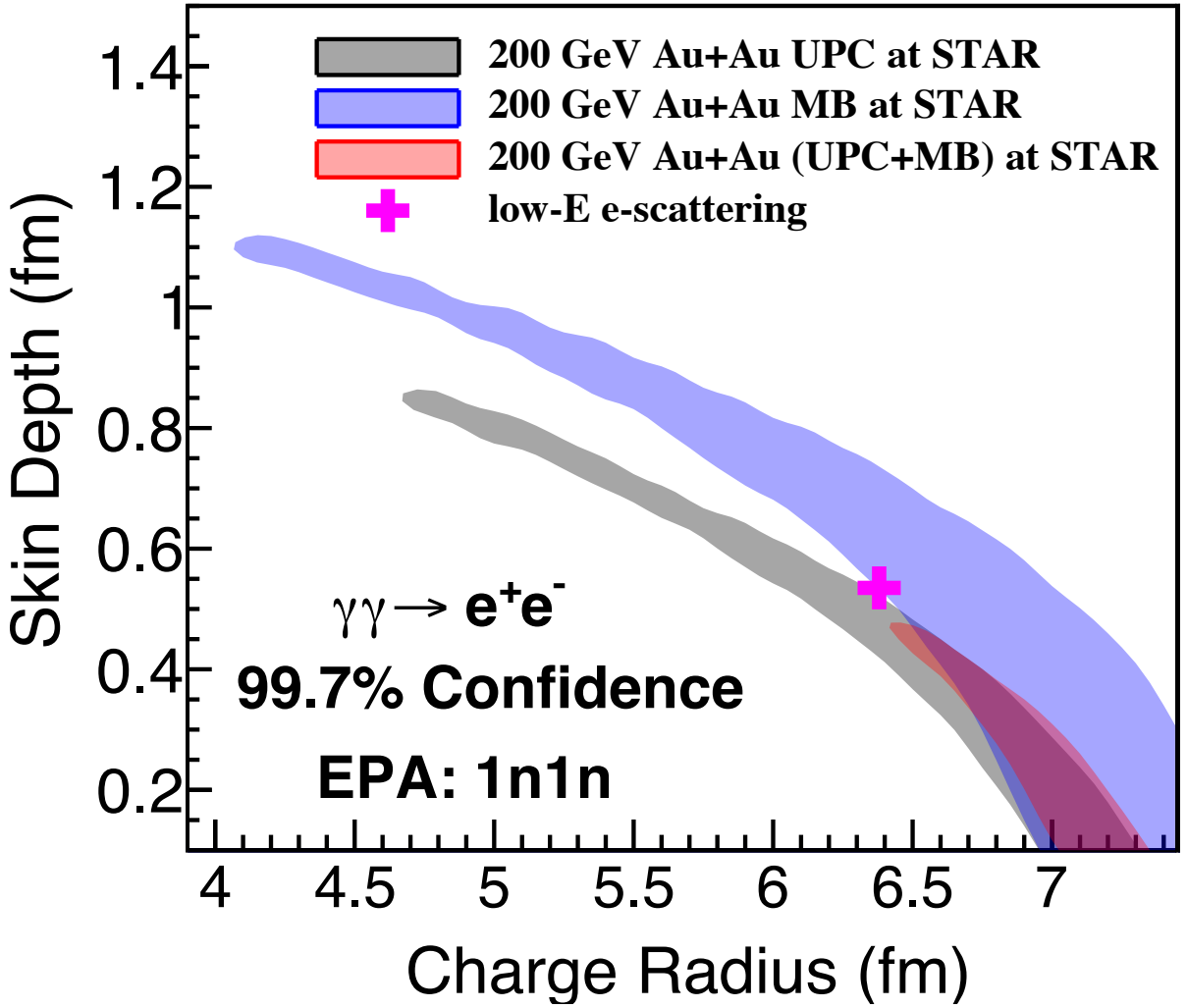
Woods-Saxon: $\rho_A(r) = \frac{\rho^0}{1 + \exp[(r - R)/d]}$

R: charge radius, d: skin depth





Application: Constrain Charge Distribution with Precision



RMS of radius, low-E e-scattering: 5.33 fm

	UPC	MB	UPC+MB
RMS	5.39+0.14-0.21	5.67+0.08-0.12	5.53+0.10-0.02

UPC consistent with nominal nuclear geometry

Peripheral collisions systematically larger

Indication of final state effect in HHIC

X. W, J.D. Brandenburg, L. Ruan, F. Shao, Z. Xu, C. Yang, and W. Zha. Phys. Rev. C 107, 044906 (2023)

Summary

- Breit-Wheeler process has been measured at STAR
  - ✓ **The kinematics** of the Breit-Wheeler process have beam energy dependences
  - ✓ $\sqrt{\langle p_T^2 \rangle}$ and nuclear charge radius: Indication of final state effect
- **Application:** Breit-Wheeler process can be used to **map the magnetic field** and **constrain nuclear charge distribution**

Summary

- Breit-Wheeler process has been measured at STAR
  - ✓ **The kinematics** of the Breit-Wheeler process have beam energy dependences
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- **Application:** Breit-Wheeler process can be used to **map the magnetic field** and **constrain nuclear charge distribution**

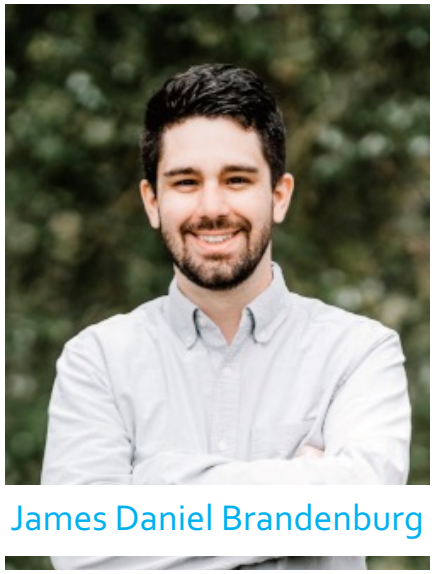
Perspective

- The high-statistics data produced by STAR from 2023 to 2025, can be used to search for the final state effect from QGP
- Recently, the LHC has also measured the dilepton production via photon fusion. We can use these results to measure the charge radius of the lead nucleus

Acknowledgement


Zhangbu Xu

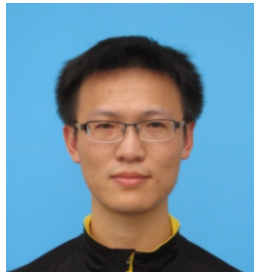

Chi Yang

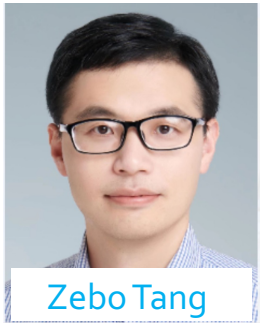

James Daniel Brandenburg


Fenglan Shao


Lijuan Ruan


Shuai Yang


Wangmei Zha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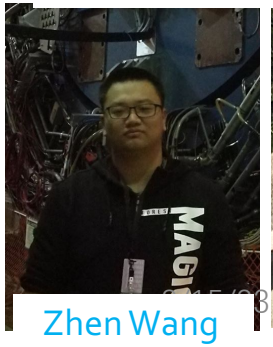
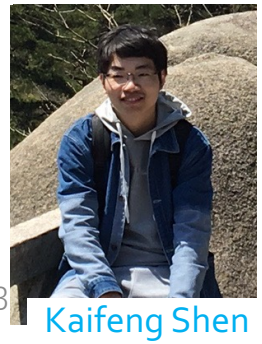

Zhen Wang


Kaifeng Shen


Jian Zhou


Xin Wu

SDU STAR Group

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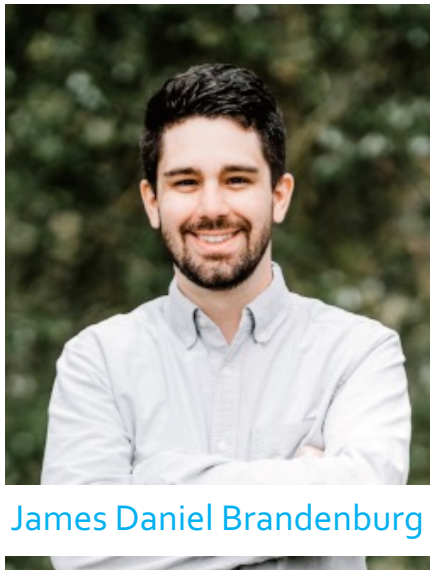
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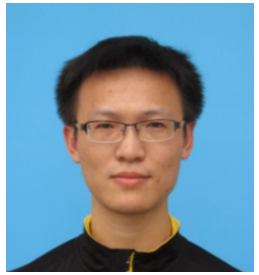
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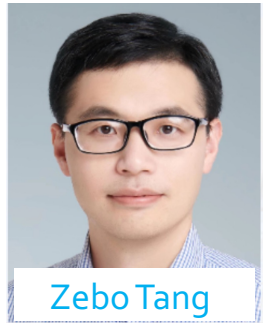
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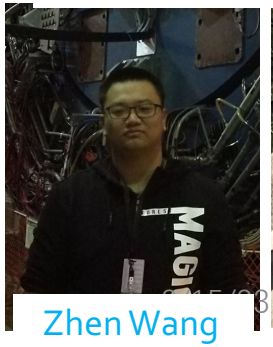
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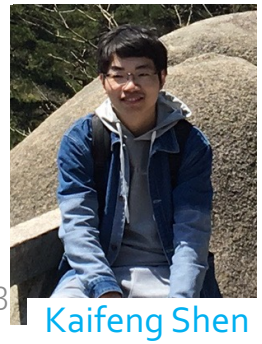
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Thanks for your attention!