Brookhaven National Laboratory

2024 Gertrude Scharff-Goldhaber Prize presented to

Zhiwan Xu

by Brookhaven Women in Science

July 26, 2024

for Equal Advancement BWIS

Agenda

11:00 AM → 11:10 AM **Welcome** 10m

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

11:10 AM → 11:20 AM **Equity, Diversity and Inclusion at BNL** 10m

Speaker: Dr John Hill (Brookhaven National Laboratory)

11:20 AM → 11:30 AM **Memories of Gertrude Scharff-Goldhaber** 10m

Speakers: Prof. David Goldhaber (Stanford University), Dr Michael H. Goldhaber

Michael H. Goldhab...

11:35 AM → 11:55 AM **Search for the Chiral Magnetic Effect from RHIC Beam Energy Scan-II data with STAR** 20m

Parity (left-right) symmetry violation in the weak interaction was discovered in 1956, winning the Nobel Prize in 1957. However, parity violation in strong interactions remains undiscovered. The strong interaction describes how quarks, fundamental constituents of matter, are bound together by gluons. Gluons, carrying color charges, can also interact with each other, causing an imbalance in the chirality (handedness) of quarks, known as chirogenesis. This phenomenon is analogous to baryogenesis (production of matter (baryons)) in the early universe, to which we owe our own existence. At the Relativistic Heavy-ion Collider (RHIC) at Brookhaven National Laboratory, a new state of matter is created known as Quark-Gluon-Plasma, where quarks and gluons are unbound. The collisions at RHIC also generate the most powerful magnetic fields on earth, providing an opportunity to study chirogenesis through the Chiral Magnetic Effect (CME). The Beam Energy Scan (BES) program at RHIC explores a variety of magnetic field conditions in terms of strength and decay time length. Scientists aim to detect CME-induced electric charge separation using the STAR detector, employing innovative methods to minimize background. We will present the findings of charge separation at BES-II in search for this local parity and charge-parity violation in strong interactions.

Speaker: Dr Zhiwan Xu (University of California, Los Angeles)

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.

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)

Stephen Feldberg

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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for Equal Advancement BWIS

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

CONTACT

+44 (0)20 7594 3151

AFFILIATIONS

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

LINKS

for Equal Advancement BWIS

Recipients Thus Far

year	name	affiliation	year	name	affiliation
			2006	Enju Lima	SBU
2023	Xiaofeng Wang	Shandong	2005	Anne Sickles	SBU
2022	Jiayi Chen	Brandeis	2004	Mirna Lerotic	SBU
2021	Yanzhu Chen	SBU	2003	Lilia Anguelova	SBU
2020	Rebekah Pestes	Virginia Tech	2003	Carola Berger	SBU
2019	Brooke Russell	Yale	2002	Yiing-Rei Chen	SBU
2018	Minjung Kim	Seoul NU	2001	Jane Burward-Hoy	SBU
2017	Anna Gura	SBU	2001	Irina Mocioiu	SBU
2016	Kathryn Meehan	UC Davis	2001	Rebecca Christianson	MIT
2015	Fen Guan	SBU	2000	Diana Vaman	SBU
2014	Li Yi	Purdue	1999	Angelika Osanna	SBU
2013	Sara Callori	SBU	1998	Shan-Ho Tsai	SBU
2012	Marija Kotur	SBU	1998	Mary Josephine Bellanca	SBU
2011	Megan Connors	SBU	1997	*N.N.*	*N.N.*
2010	Johanna Nelson	SBU	1996	Q. Joan Harris	MIT
2009	Na Li	CCNU	1995	*N.N.*	*N.N.*
2008	Christine Nattrass	Yale	1994	Fang Shu	SBU
2007	Manuela Kulaxizi	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
			2006	Enju Lima	SBU
2023	Xiaofeng Wang	Shandong	2005	Anne Sickles	SB
2022	Jiayi Chen	Brandeis	2004	Mirna Lerotic	
2021	Yanzhu Chen	SBU	2003	Lilia Anguelova	SBU
2020	Rebekah Pestes	Virginia Tech	2003	Carola Ber	SBU
2019	Brooke Russell	Yale	2002	Yiing	SBU
2018	Minjung Kim	Seoul NU	2001	ward-Hoy	SBU
2017	Anna Gura	SBU	20	a Mocioiu	SBU
2016	Kathryn Meehan	UC Davis		Rebecca Christianson	MIT
2015	Fen Guan	SBU	2000	Diana Vaman	SBU
2014	Li Yi		1999	Angelika Osanna	SBU
2013	Sara Callori	U	1998	Shan-Ho Tsai	SBU
2012	Marija Kotur	SBU	1998	Mary Josephine Bellanca	SBU
2011	Megar	SBU	1997	*N.N.*	*N.N.*
2010		SBU	1996	Q. Joan Harris	MIT
2009		CCNU	1995	*N.N.*	*N.N.*
2008	Christine Nattrass	Yale	1994	Fang Shu	SBU
2007	Manuela Kulaxizi	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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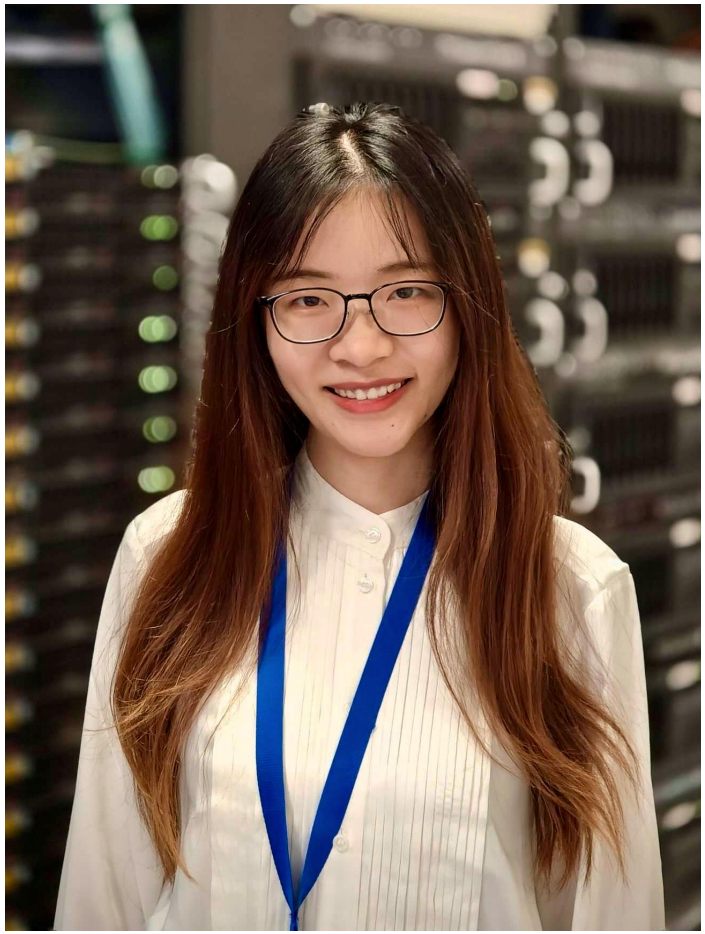
Acknowledgements

- Review Committee: Mary Bishai, Björn Schenke, 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 Energy & Photon Sciences Directorate, the Diversity, Equity & Inclusion Office, Human Resources, and the Long Island Section of the American Nuclear Society.

Zhiwan Xu



2014-2018 *B.S. Fudan University*
2018-2024 *Ph.D. in Physics, UCLA*
2024-now *Postdoc, Los Alamos National Lab*

“My curiosity of about the basic entities of matter and the origin of our universe led me on a journey to the cutting-edge research at the Brookhaven National Lab, where we focus on studying the fascinating world of particles and fundamental forces that shape everything around us.”

“Stay hungry. Stay foolish.”
— Steve Jobs 2005

Brookhaven National Laboratory

Supported in part by
U.S. DEPARTMENT OF ENERGY

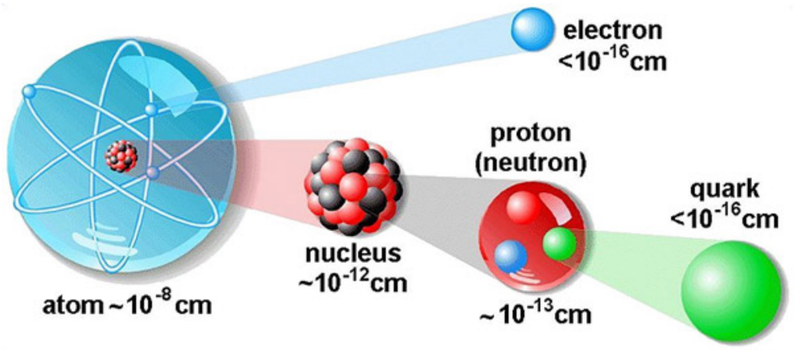
Search for the Chiral Magnetic Effect from RHIC Beam Energy Scan-II data

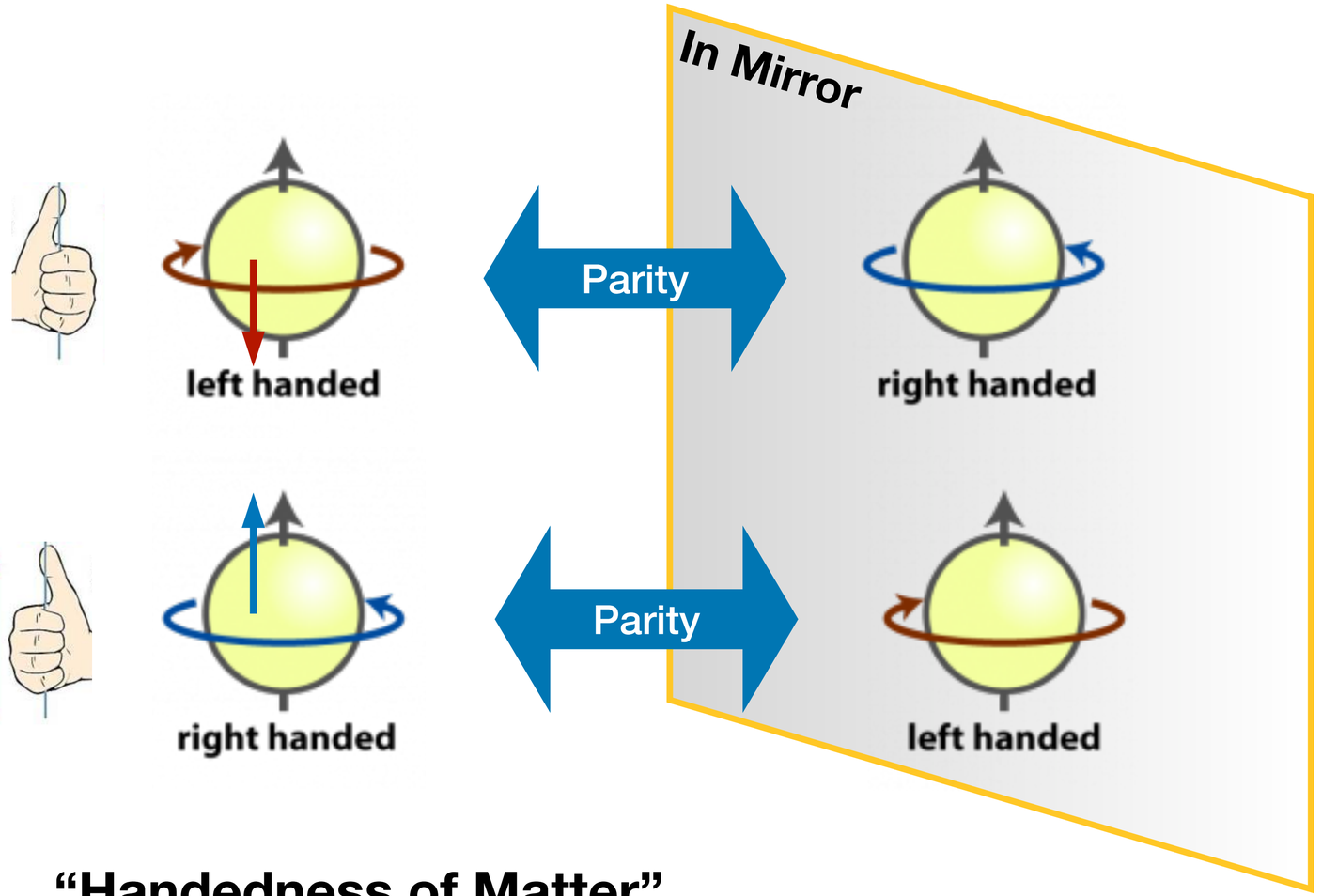
Zhiwan Xu
Physics & Astronomy Department
University of California, Los Angeles
July 26, 2024

STAR

THE UNIVERSITY OF CALIFORNIA · LET THERE BE LIGHT · UCLA

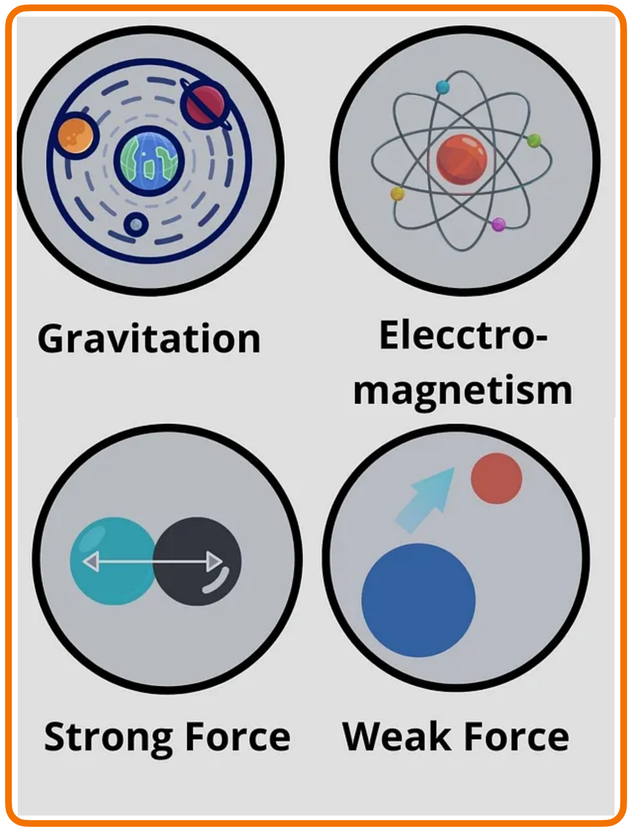
The Parity of Elementary Particles

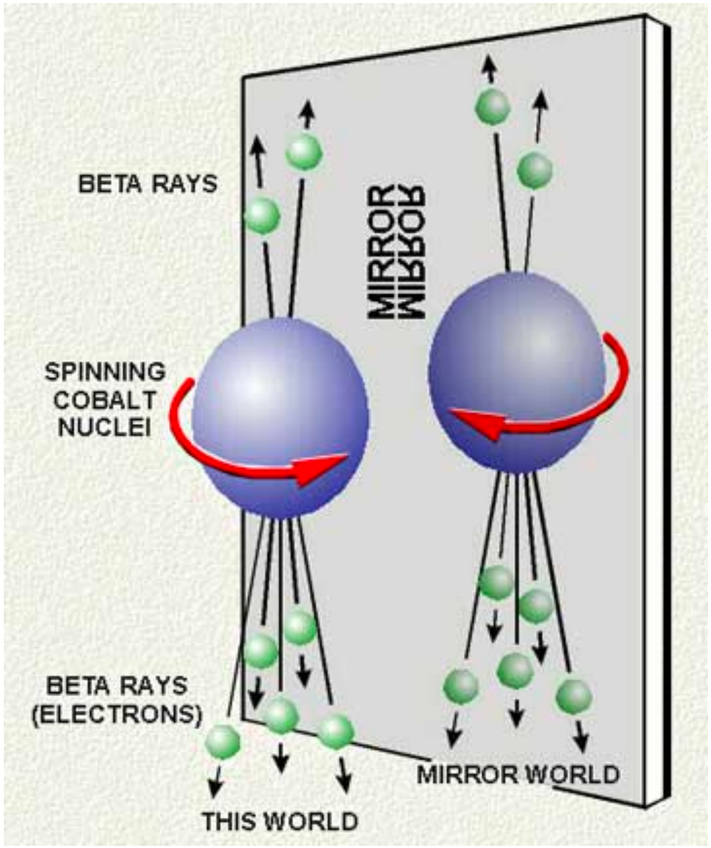




“Handedness of Matter”
~ Chirality

Discovery of Parity Violation in Weak Interaction





Chien-Shiung Wu

Photo from the Nobel Foundation archive.

Chen Ning Yang

Prize share: 1/2

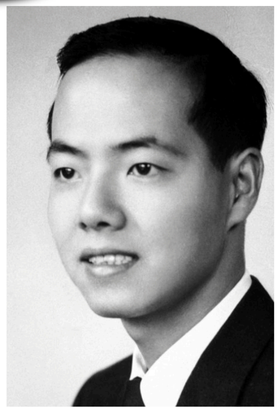


Photo from the Nobel Foundation archive.

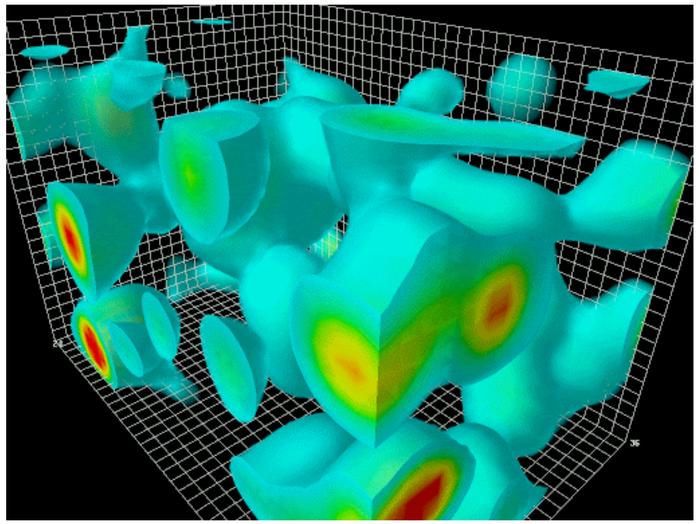
Tsung-Dao (T.D.) Lee

Prize share: 1/2

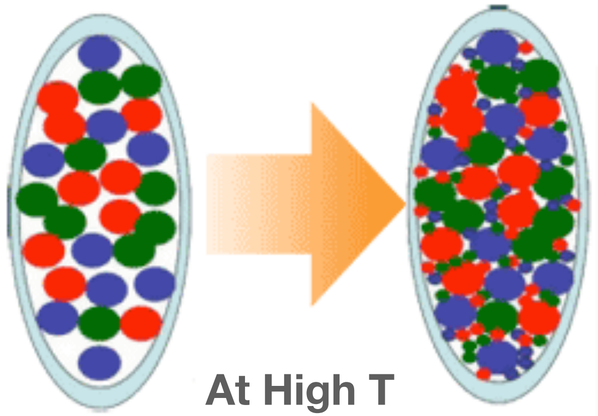
1956: **Co60 experiment (by Chien-Shiung Wu et al) discovered Parity symmetry breaking in the weak interaction.**

1957: **Nobel Prize for Yang and Lee**

Parity Violation in Strong Interaction?



A vacuum still has stuff in it



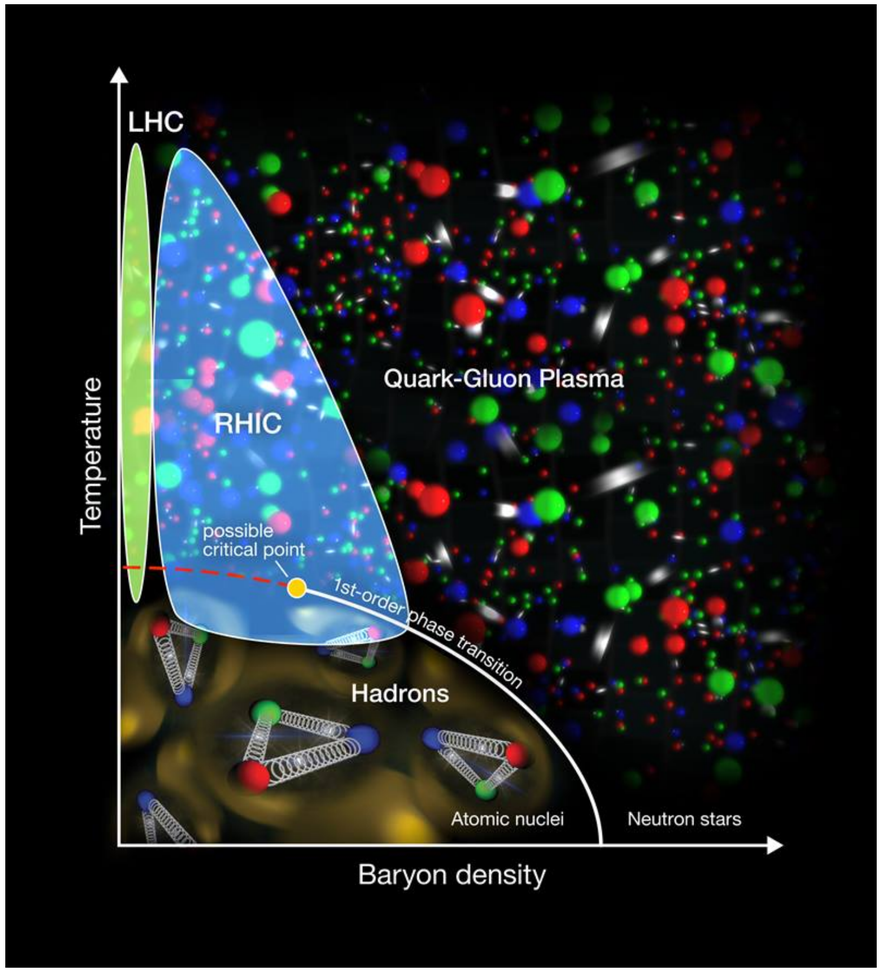
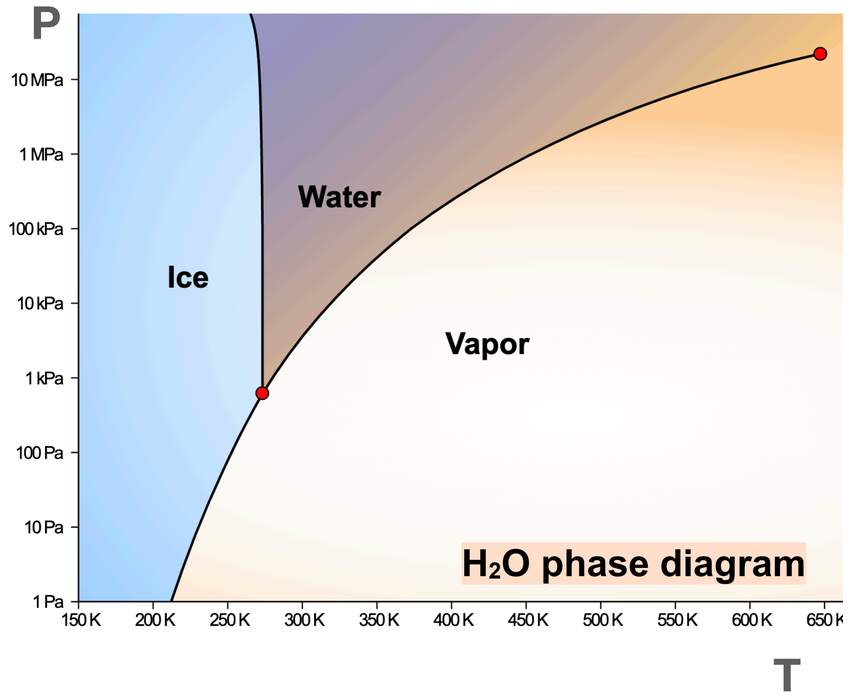


Image courtesy of Brookhaven National Laboratory

Phase change to Plasma

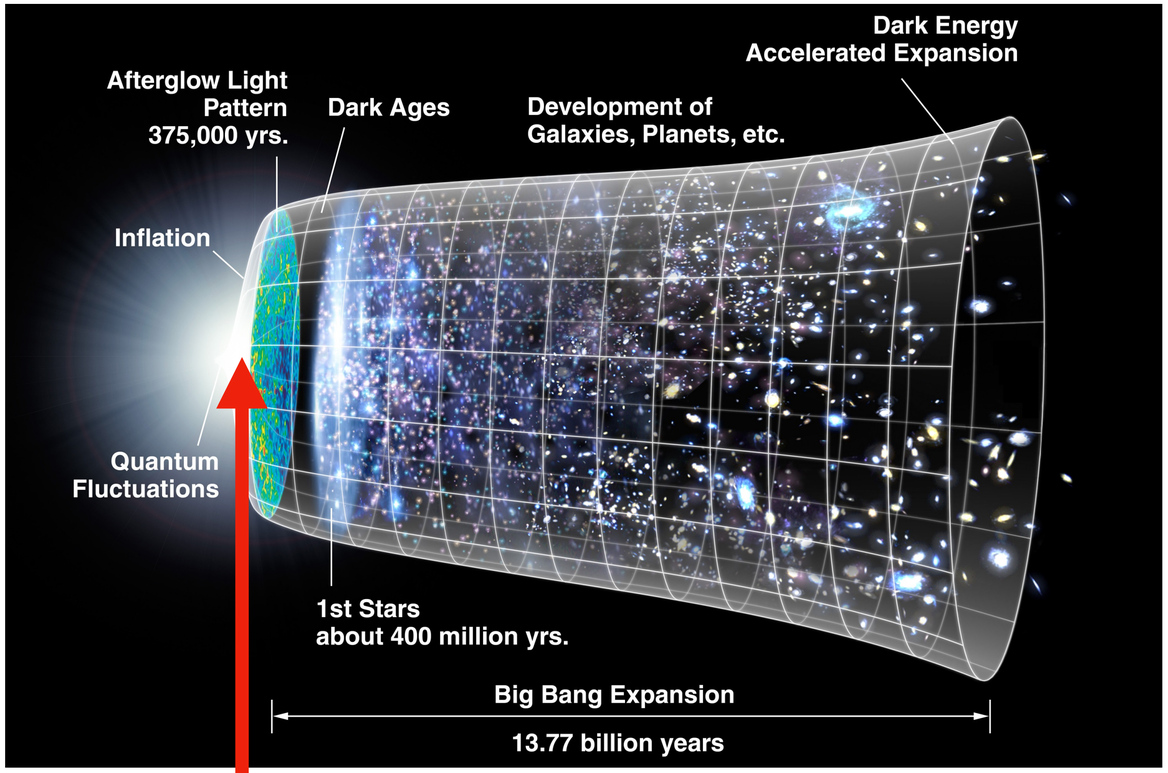


http://www.physics.adelaide.edu.au/theory/staff/leinweber/VisualQCD/Nobel/

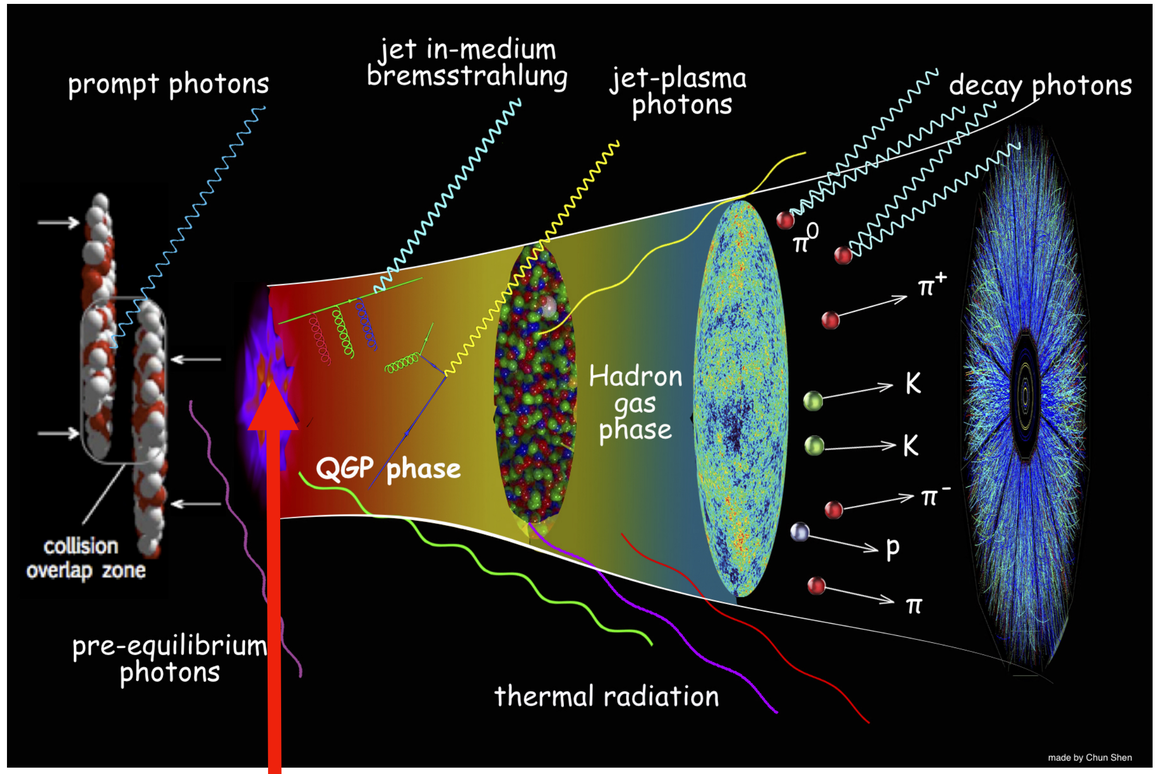
https://www.science.smith.edu/~jbrady/petrology/igrocks-diagrams/unary/H2O.php

Quark Gluon Plasma: the Small Bang

The Big Bang Theory



the "Small Bang" at RHIC



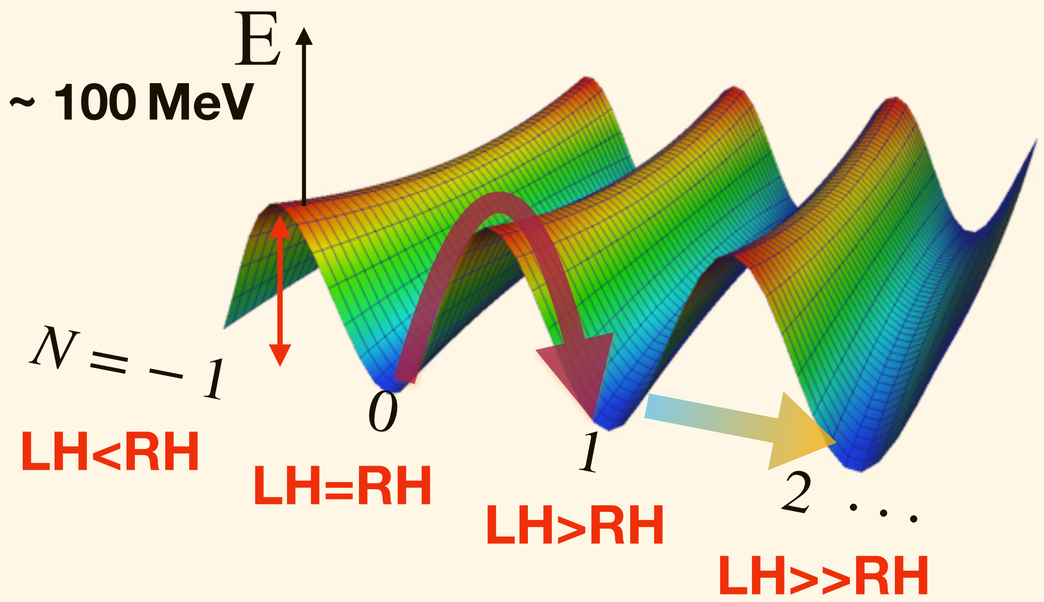
"Baryogengesis" **Matter > Anti-matter**

"Chirogenesis" **More LH>RH (RH>LH) in local domain**

https://www.bnl.gov/newsroom/news.php?a=11795

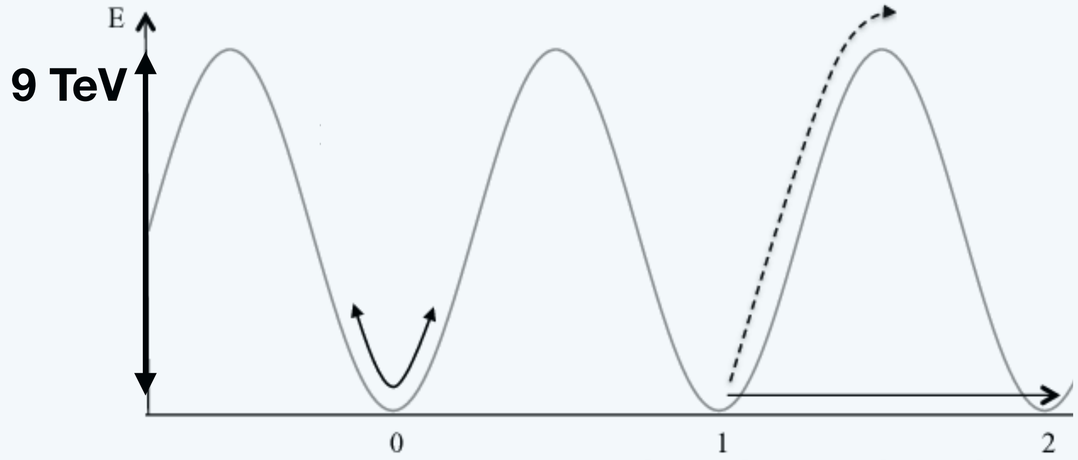
The Role of Vacuum Topology

- Valleys represent a different universe (domain) with different proportions of hardness



"Chirogenesis"

- Analogy: Electro-Weak vacuum



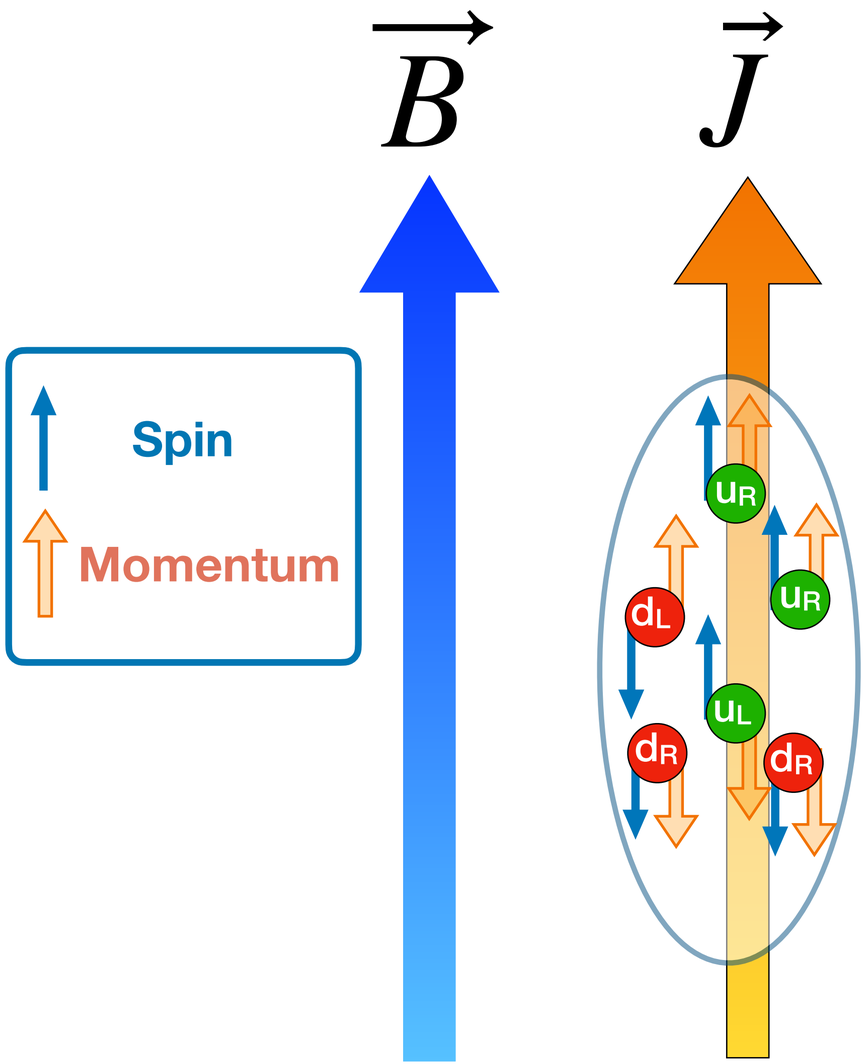
(L+B)=anti(L+B) (L+B)>anti(L+B)

Matter= Antimatter > Antimatter

Baryogengesis

Amoroso, Simone & Kar, Deepak & Schott, Matthias. (2020). How to discover QCD Instantons at the LHC.

Chiral Magnetic Effect



Magnetic field (B) can induce charge separation (current J) for quarks at chirality imbalance (μ_5): CME.

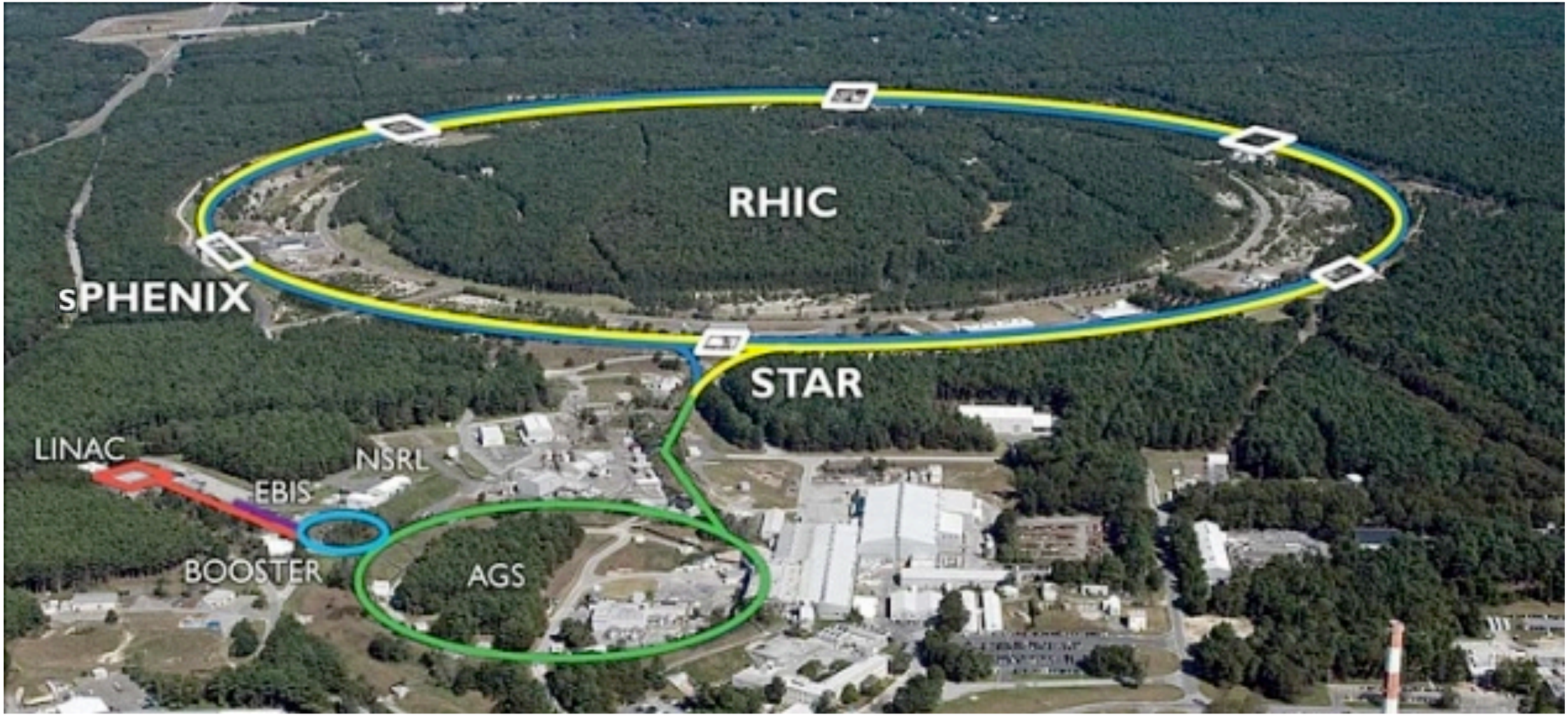
$$\vec{J} \propto \mu_5 \vec{B}$$

odd parity *even parity*

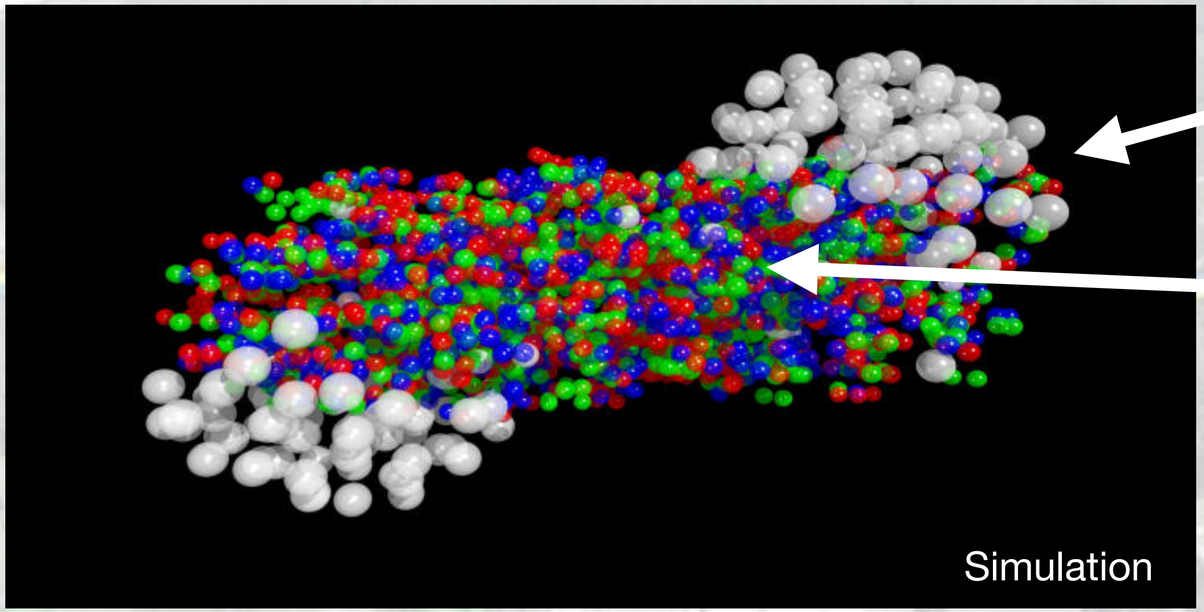
- **Manifestly violate local Parity symmetry.**

- **A strong B field** **The key condition**

Gold-Gold Collisions at RHIC



Heavy-Ion Collisions at RHIC

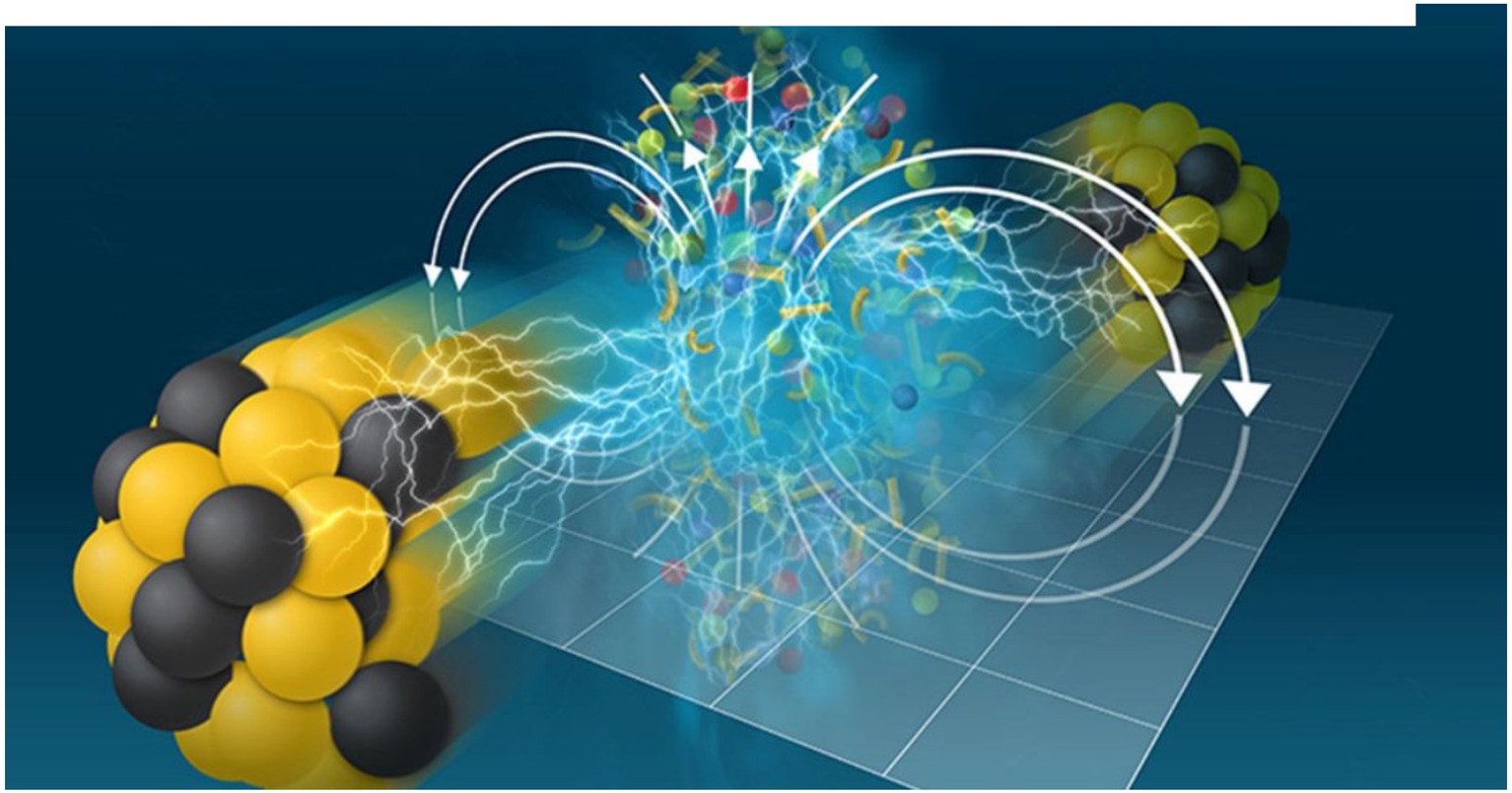


- Spectator protons carry “+” charges
  - Create B field
- Participants:
  - At high T: Quarks are liberated
  - Gluons create chirogenesis

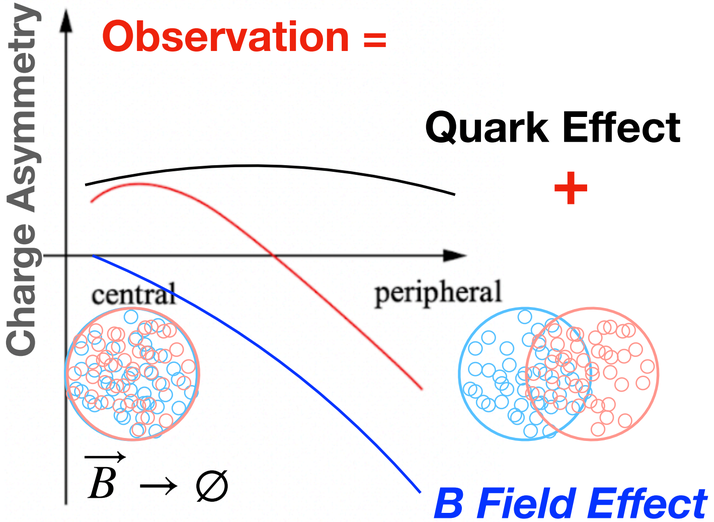
Strongest Magnetic Field on Earth

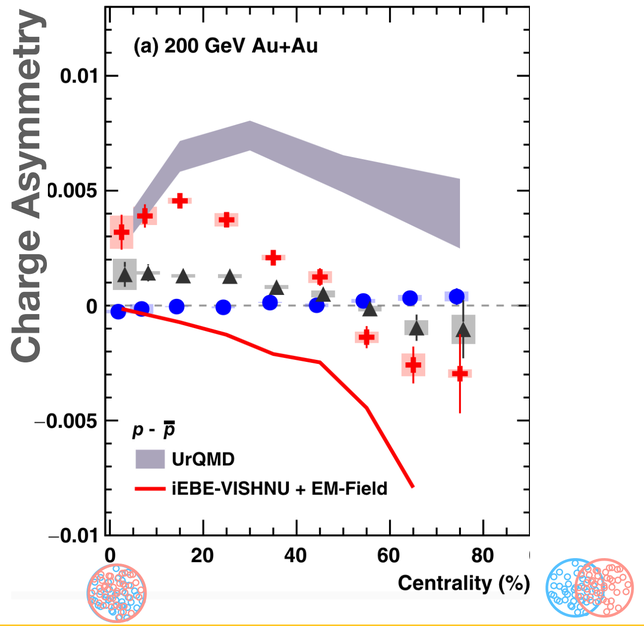
Brookhaven National Laboratory

Newsroom Media & Communications Office

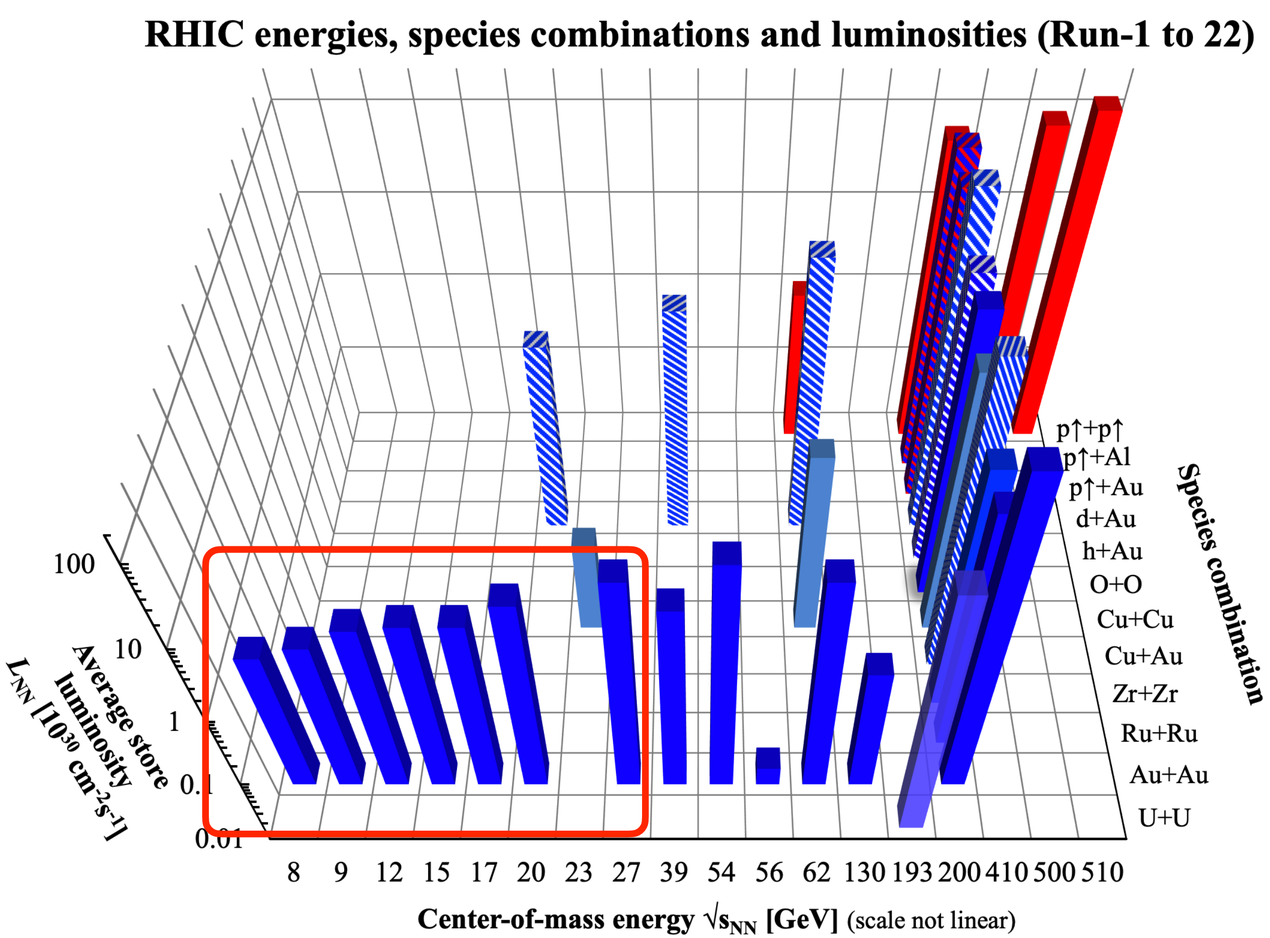


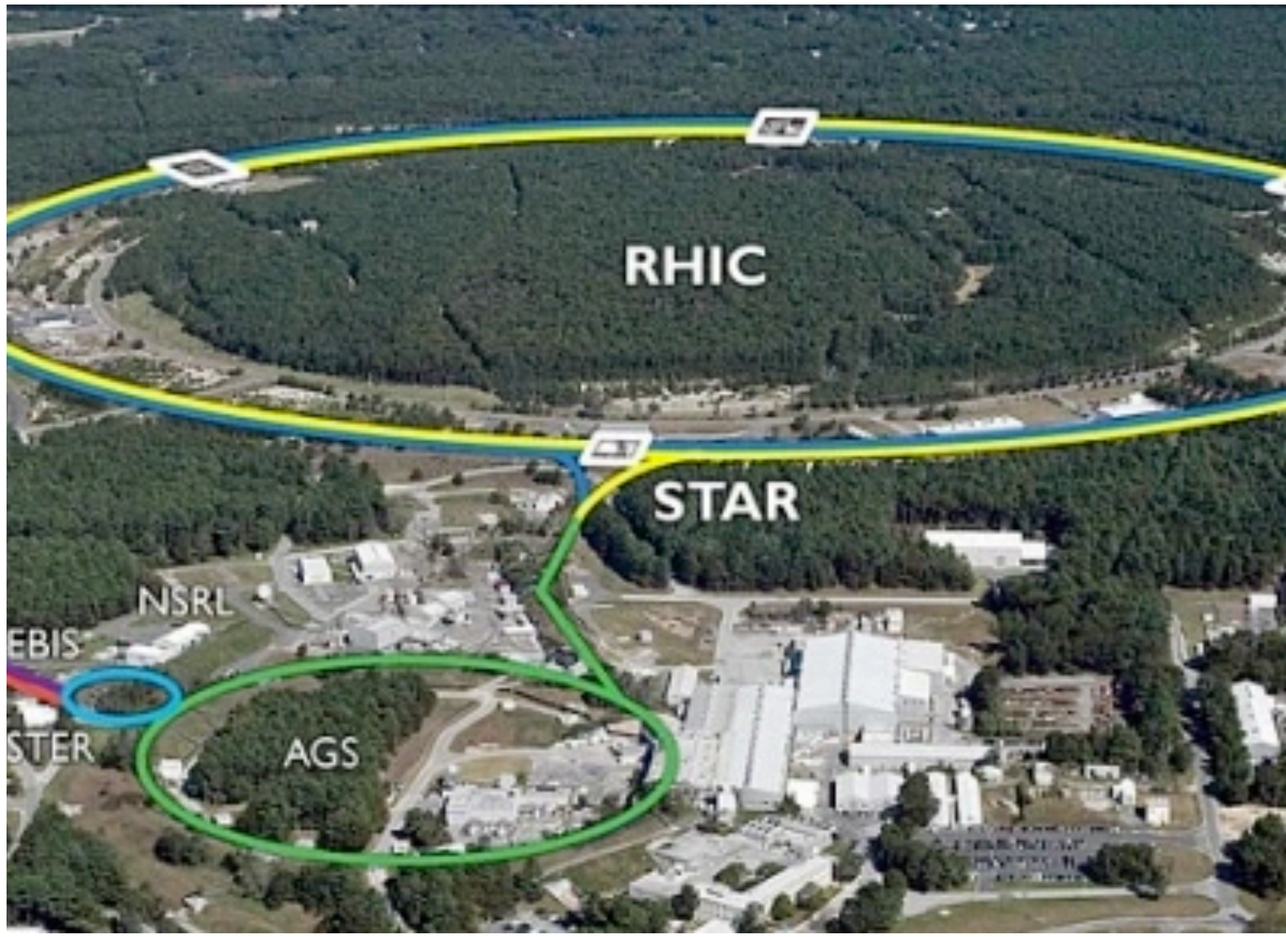
Phys. Rev. X 14, 011028





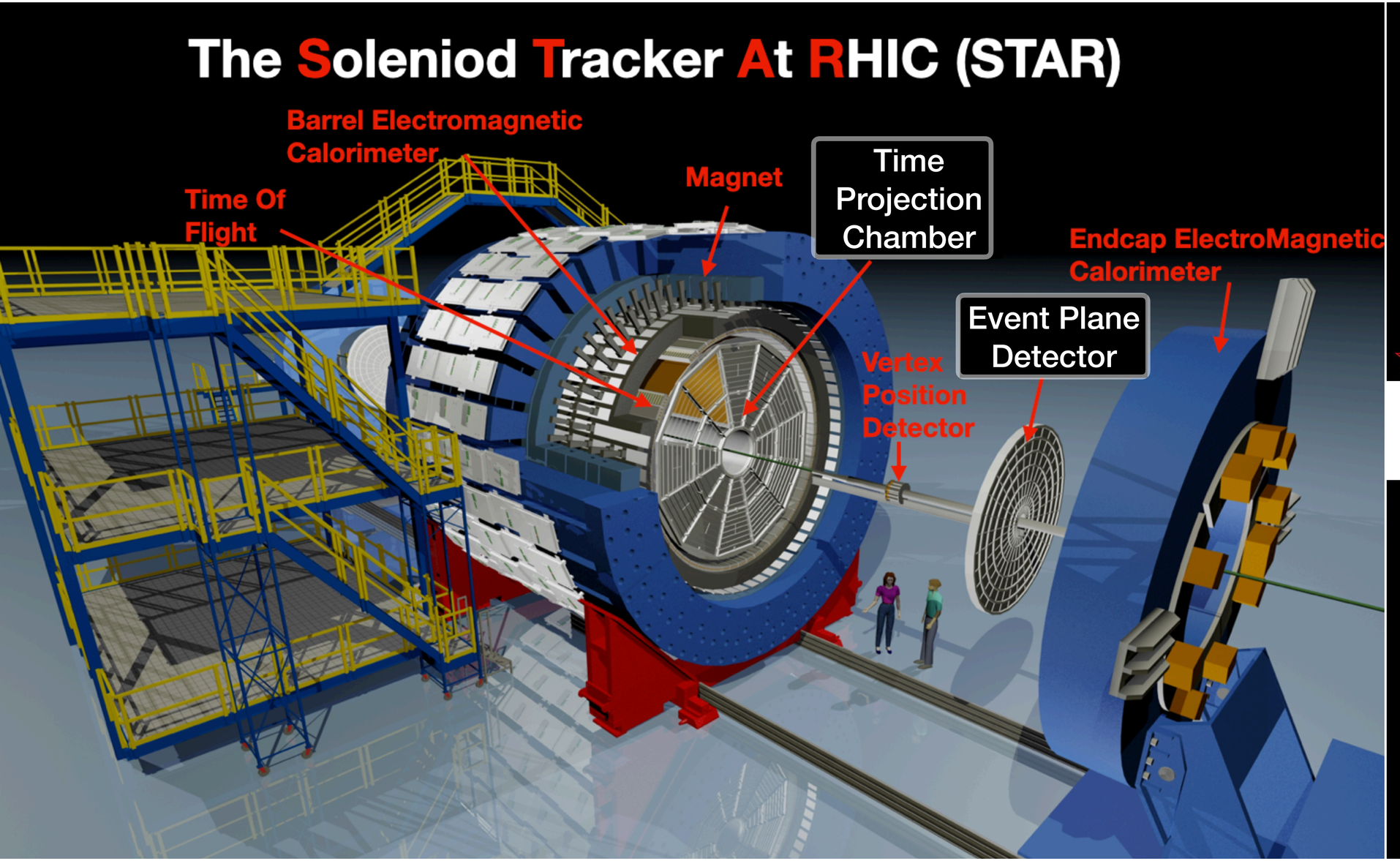
Beam Energy Scan at RHIC

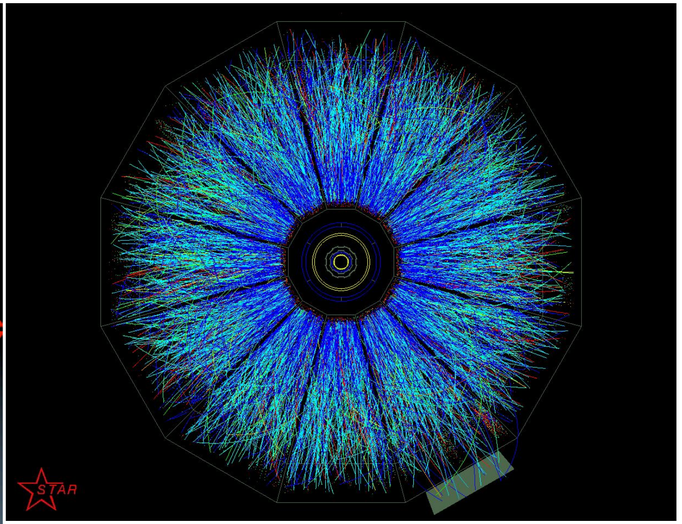




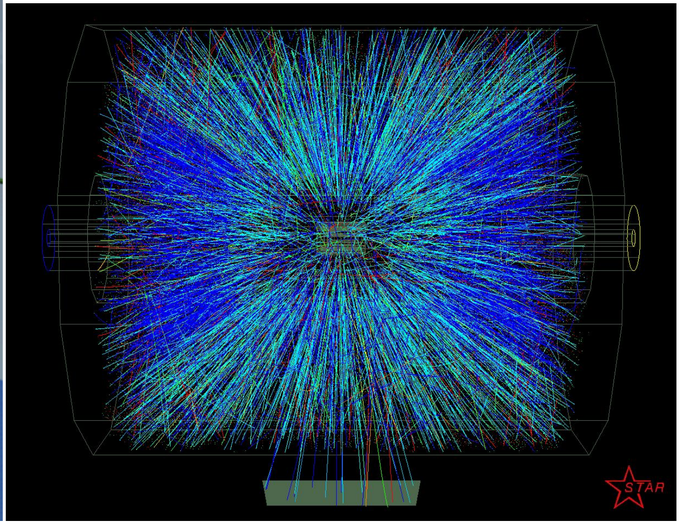
Beam Energy Scan-II

The STAR detector

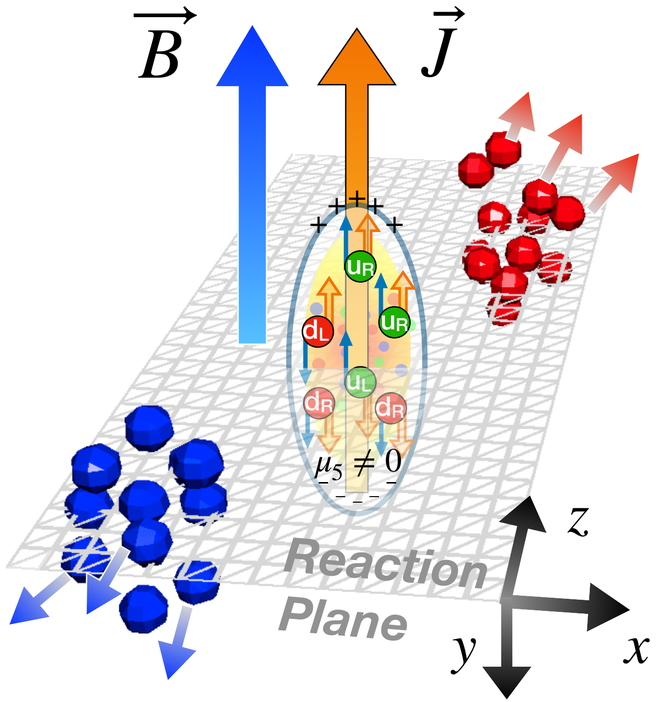


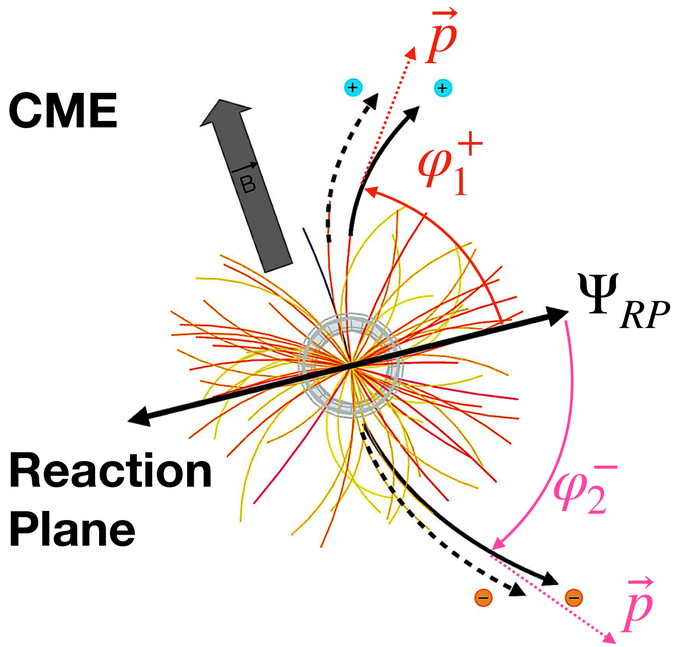


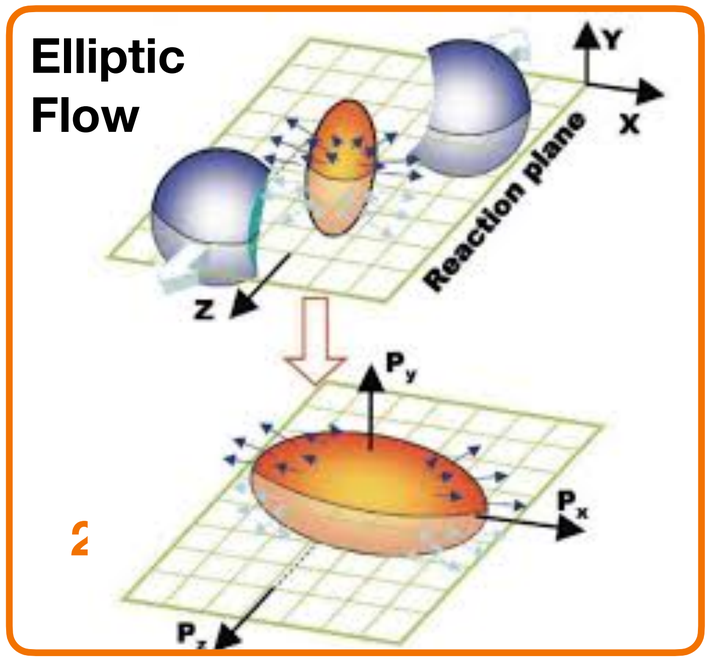
Front and Side View



How to measure the Chiral Magnetic Effect?







– **Expansion:**

$$\frac{dN_\pm}{d\varphi} \propto 1 + 2v_1\cos(\varphi - \Psi_{\rm RP}) + 2a_1^\pm\sin(\varphi - \Psi_{\rm RP}) + 2v_2\cos(2\varphi - 2\Psi_{\rm RP}) + \ldots$$

$$\propto \mu_5 B$$

but $\langle a_1 \rangle$ averaged out to be zero

Chiral Magnetic Effect observables:

$$\gamma^{112} = \left\langle \cos(\varphi_1 + \varphi_2 - 2\Psi_{\rm RP}) \right\rangle = \left\langle v_1 v_1 \right\rangle - \left\langle a_1 a_1 \right\rangle + {\rm BG}(v_2^{\rm cl})$$

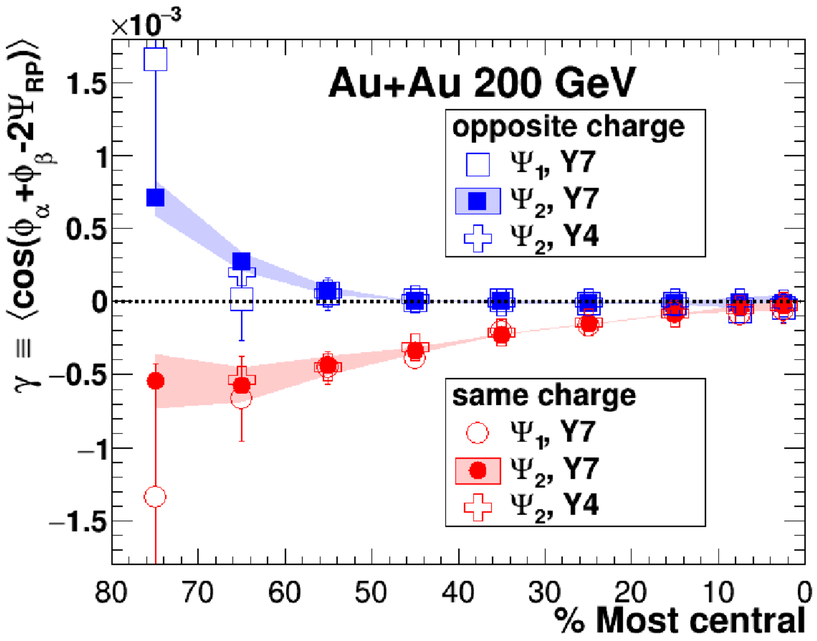
Signal BKG

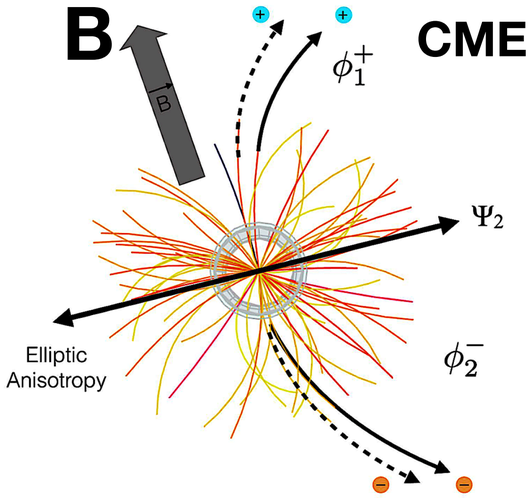
$$\Delta\gamma^{112} = \gamma^{OS} - \gamma^{SS}$$

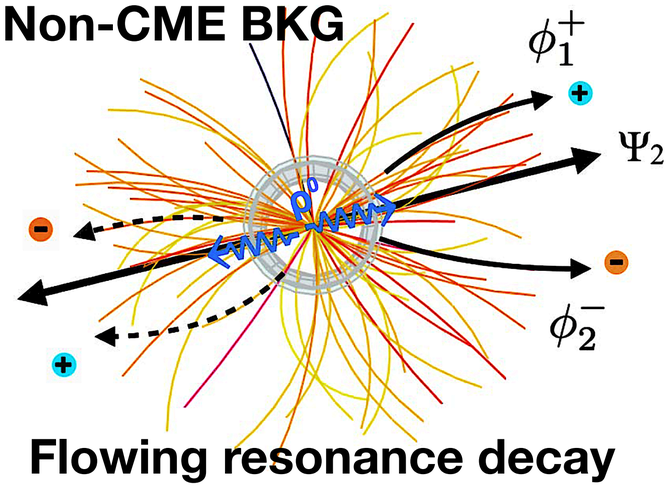
Cancels out

Measurement of Chiral Magnetic Effect

STAR, PRL 103(2009)251601;PRC 81(2010)54908;PRC 88 (2013) 64911







$$\Delta\gamma^{112} = \gamma^{OS} - \gamma^{SS} = \Delta\gamma^{\mathrm{CME}} + k\frac{v_2}{N} + \Delta\gamma^{\mathrm{nonflow}}$$

Signal

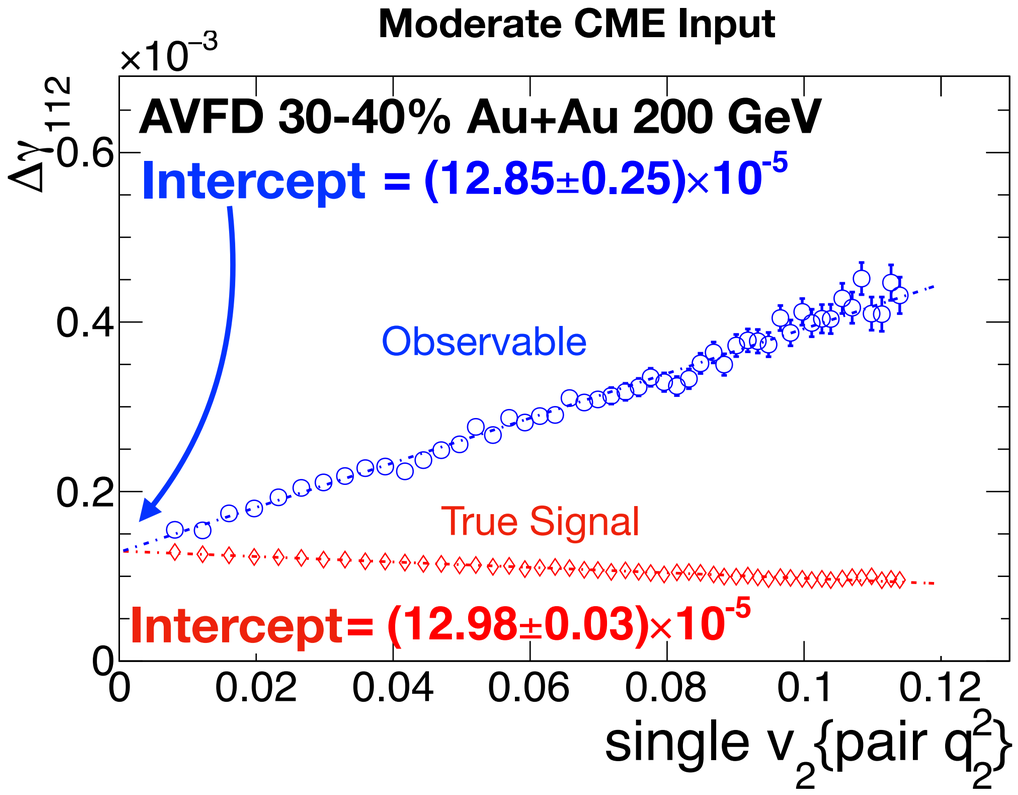
Background > 80%

γ_{os} > γ_{ss}, consistent with Chiral Magnetic Effect expectation

Measurement of CME is challenging because of the dominated background.

Suppress the major background

- We develop a new method to directly remove flow background in measurement.
- Project to spherical shape events ($v_2 = 0$), by utilizing the emission pattern.

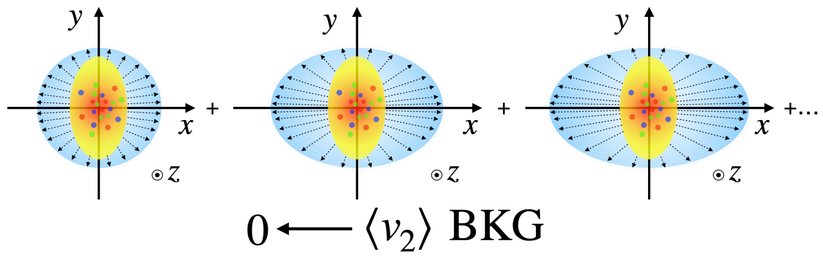


Z. Xu et al, PLB 848(2024)138367

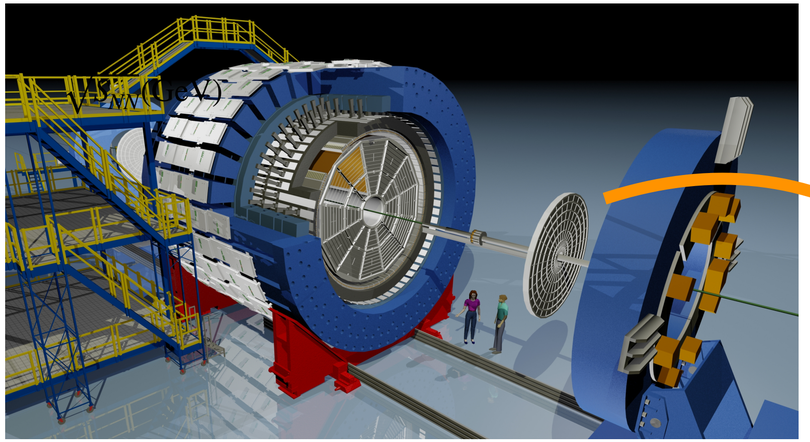
Event Shape Selection Spectator Detector

$$\Delta\gamma^{112} = \Delta\gamma^{\mathrm{CME}} + k\frac{v_2}{N} + \Delta\gamma^{\mathrm{non-flow}}$$

Measured Signal Backgrounds



Beam Energy Scan II data at RHIC

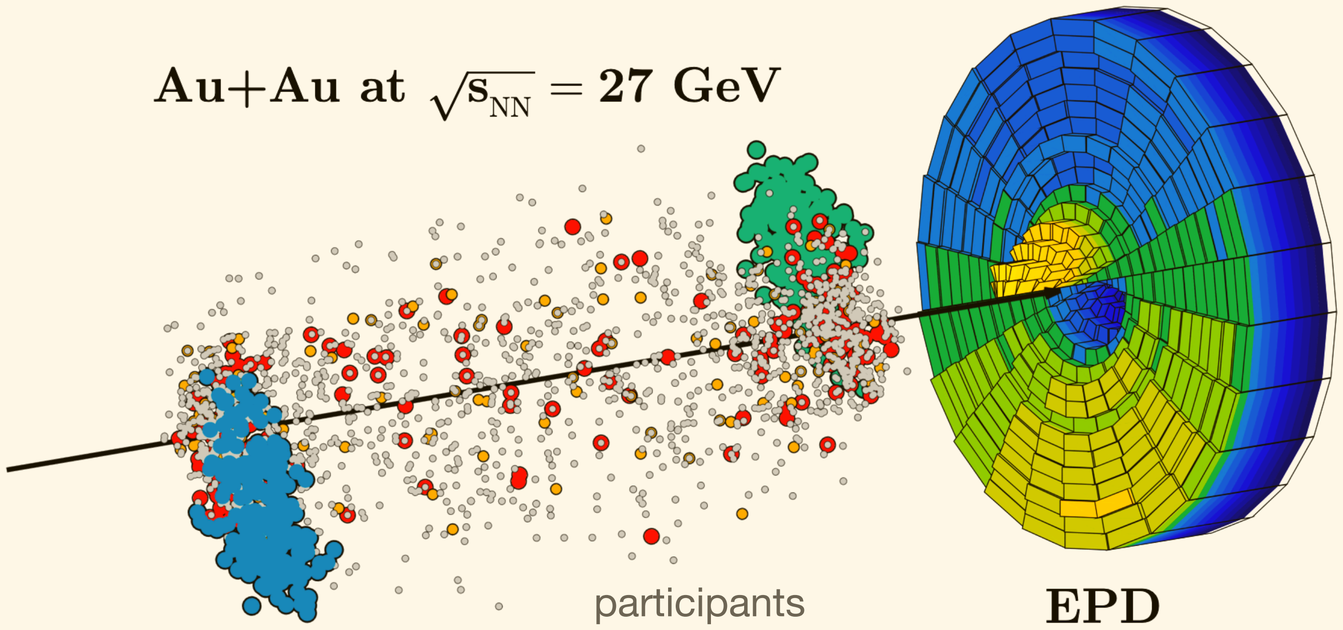


BES-II

Energy (GeV)	Events (10^6)	Year
27	555	2018
19.6	478	2019
17.3	220	2021
14.6	324	2019
11.5	230	2020
9.2	160	2020
7.7	101	2021

Forward spectators

STAR PLB 839 (2023) 137779

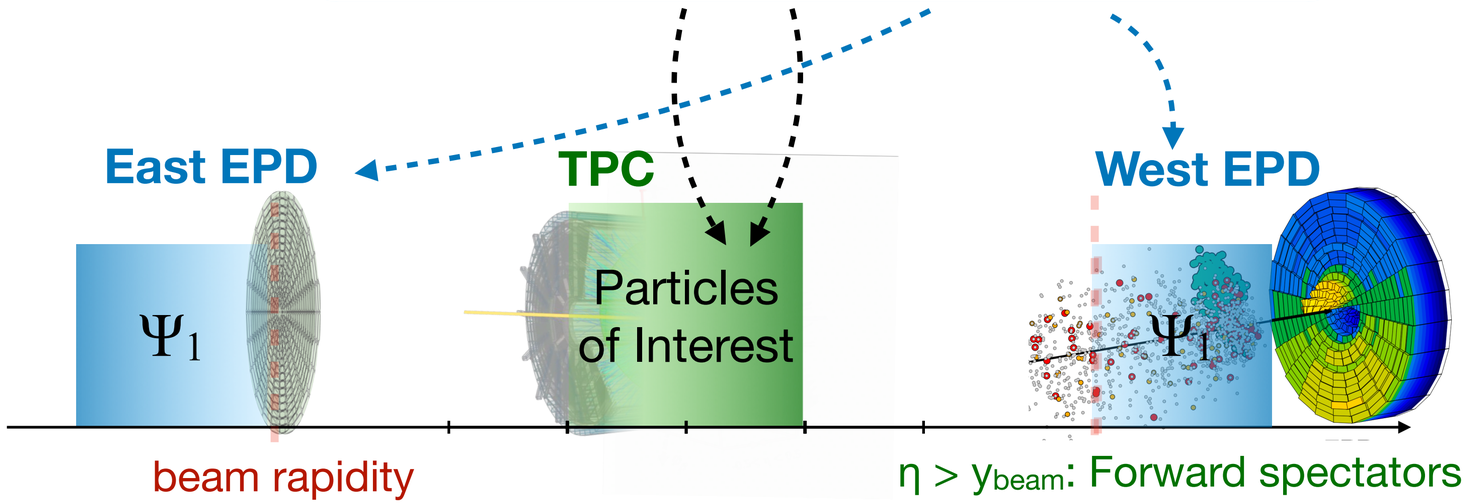


Event Plane Detector (EPD) Upgraded in 2018

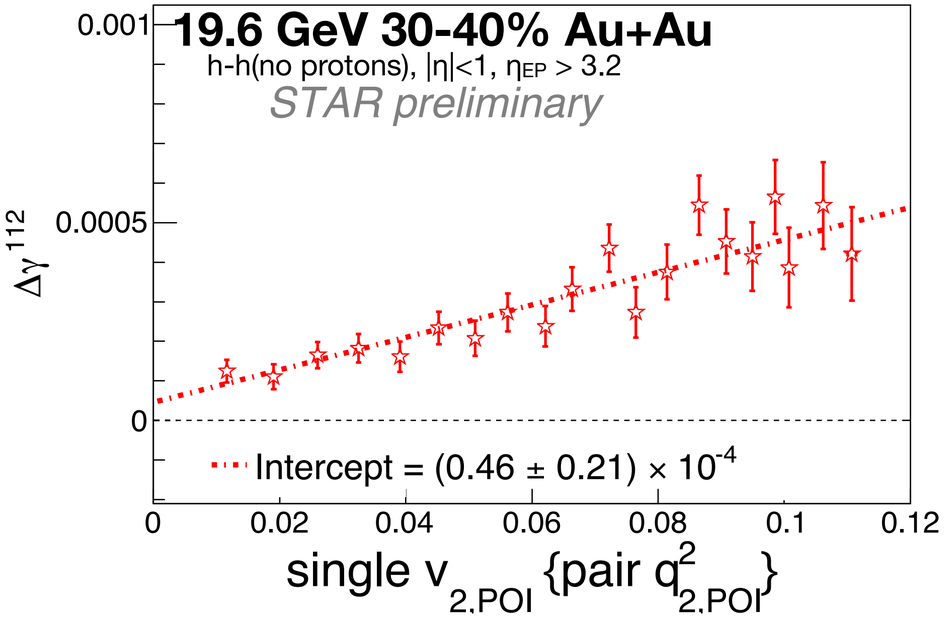
- **Targeting the spectator regions for B field**
- **Suppressing non- flow background**

Beam Energy Scan II at STAR

$$\gamma^{112} = \langle \cos(\varphi_1 + \varphi_2 - \Psi_{EPD,e} - \Psi_{EPD,w}) \rangle$$



CME observable



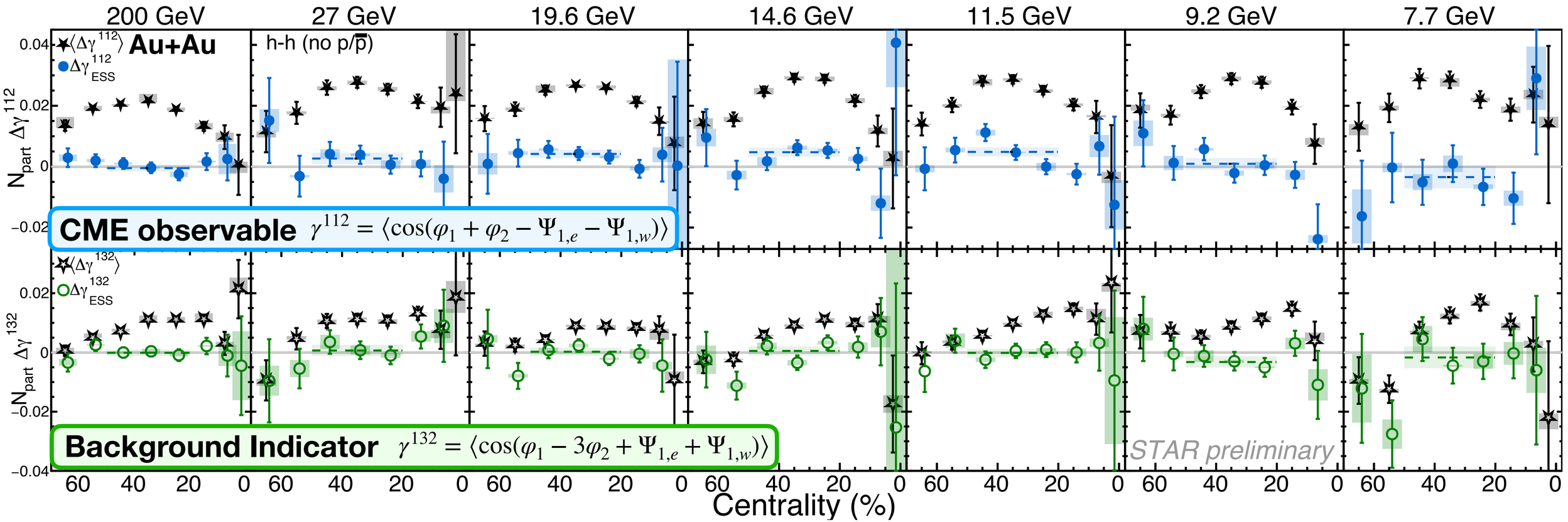
- **After Suppressing the flow BKG with ESS, and non-flow BKG with spectator plane from EPD:**
  - **The intercept of CME observable present a finite value.**

Event Shape Selection **Spectator Ψ_1**

$$\Delta\gamma^{112} = \Delta\gamma^{\mathrm{CME}} + k\frac{v_2}{N} + \Delta\gamma^{\mathrm{non-flow}}$$

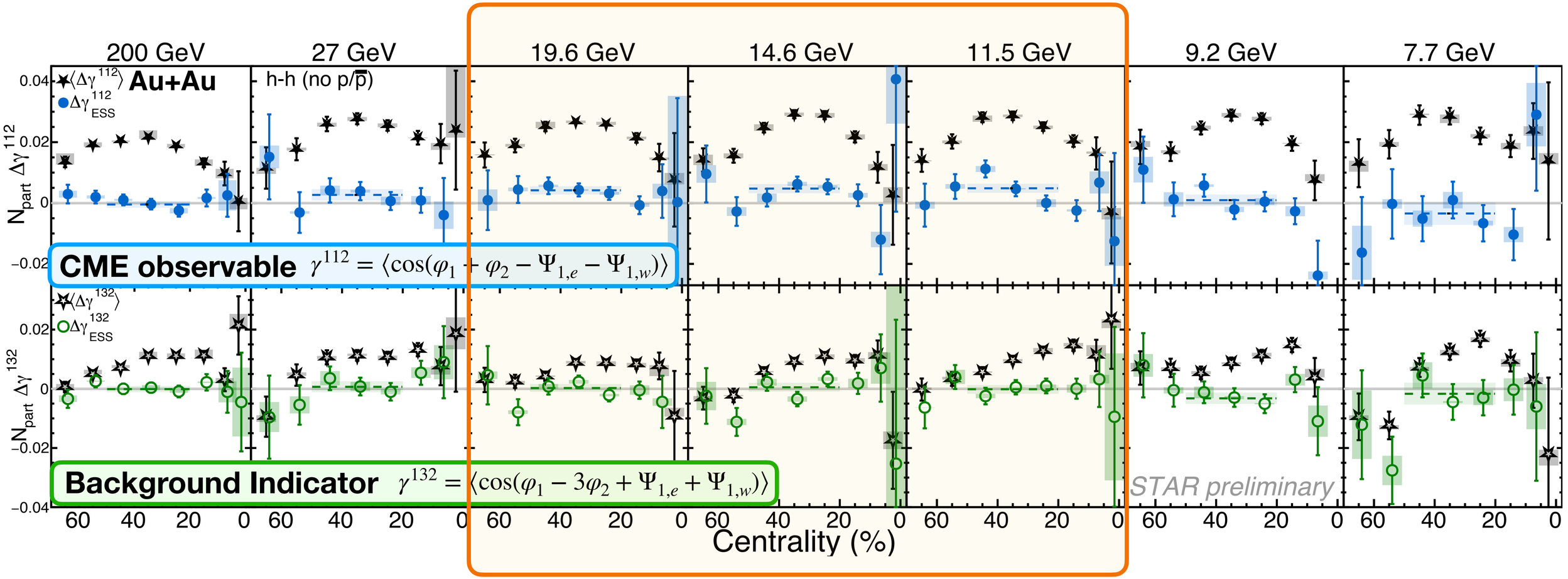
Measured **Signal** **Backgrounds**

The Beam Energy Scan II Results



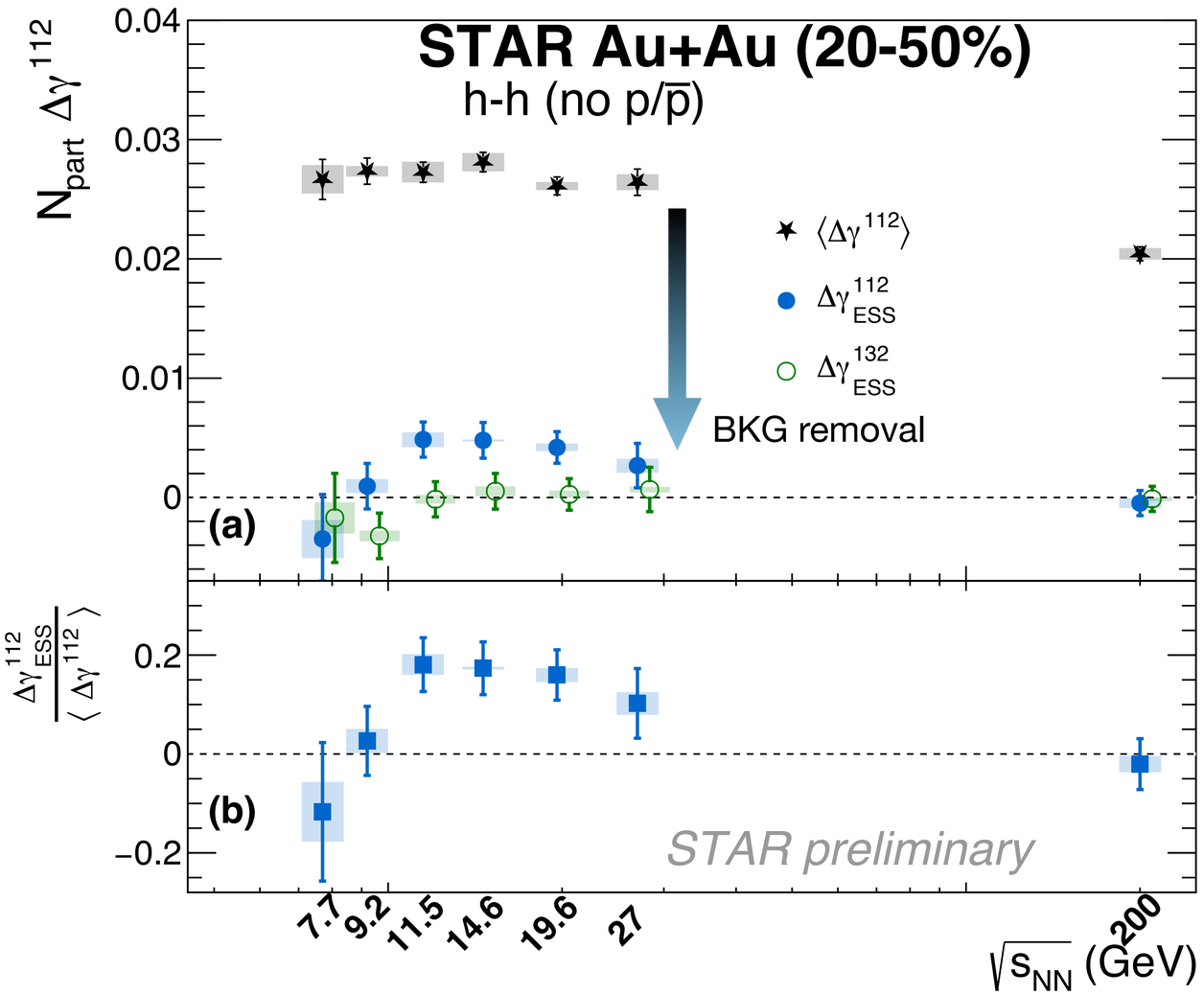
- The background indicator $\Delta\gamma^{132}_{ESS}$ is consistent with zero across the beam energy scan.
- Finite charge separation in $\Delta\gamma^{112}_{ESS}$ observed in mid-central 20-50% events between 10—20 GeV.
  - at 11.5, 14.6 and 19.6 GeV, each with above 3σ significance.

The Beam Energy Scan II Results



- The background indicator $\Delta\gamma^{132}_{ESS}$ is consistent with zero across the beam energy scan.
- Finite charge separation in $\Delta\gamma^{112}_{ESS}$ observed in mid-central 20-50% events between 10—20 GeV.
  - at 11.5, 14.6 and 19.6 GeV, each with above 3σ significance.

Beam Energy Dependence



- After removing the flow BKG with ESS, and nonflow BKG using Spectator Plane,
  - A finite residual charge separation (3σ above zero) at 11.5, 14.6 and 19.6 GeV
- The background indicator is consistent with zero.

- The residual charge separation may come from the Chiral Magnetic Effects?
- It can largely enhance our understanding of the local parity violation in the strong interaction.

Acknowledgement

*I would like to take this opportunity to express my special gratitude to my supervisor, **Prof. Huan Huang**, and my friends and colleagues, **Gang Wang, Oleg Tsai** from UCLA, and **Aihong Tang** from BNL.*

I also want to thank all the collaborators at STAR especially folks of the CME focus group.

Thank you for helping me build my academic career!