

PHENIX and Japan Korea collaboraiton

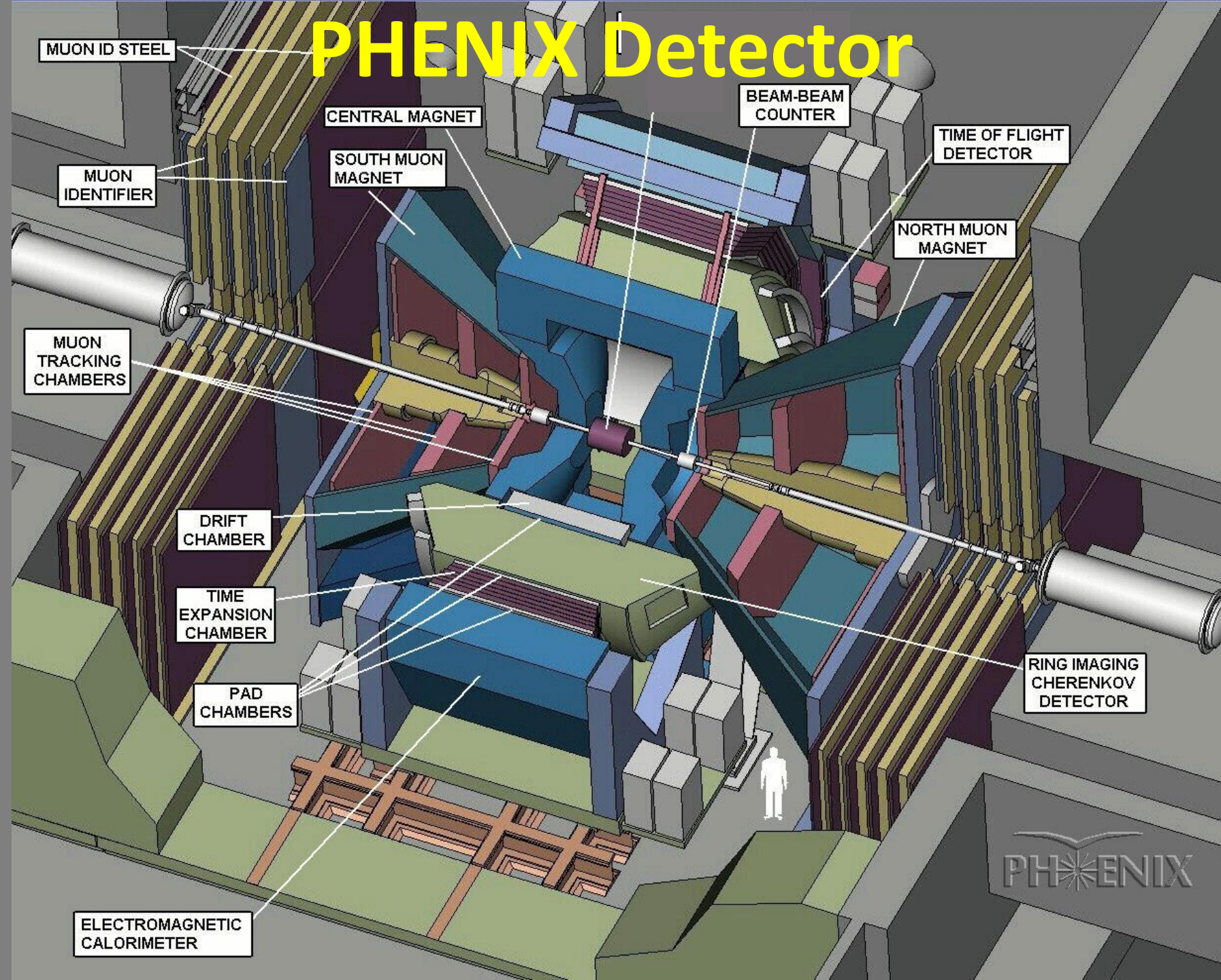
Y. Akiba (RIKEN/RBRC)

ANPhA Symposium
Academia Sinica, Taiwan
2025/11/29

Outline

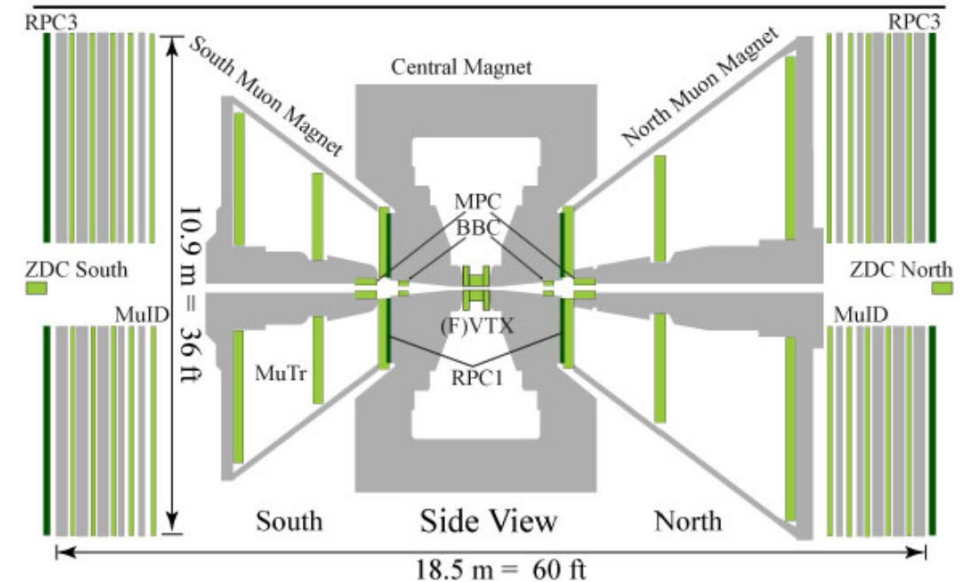
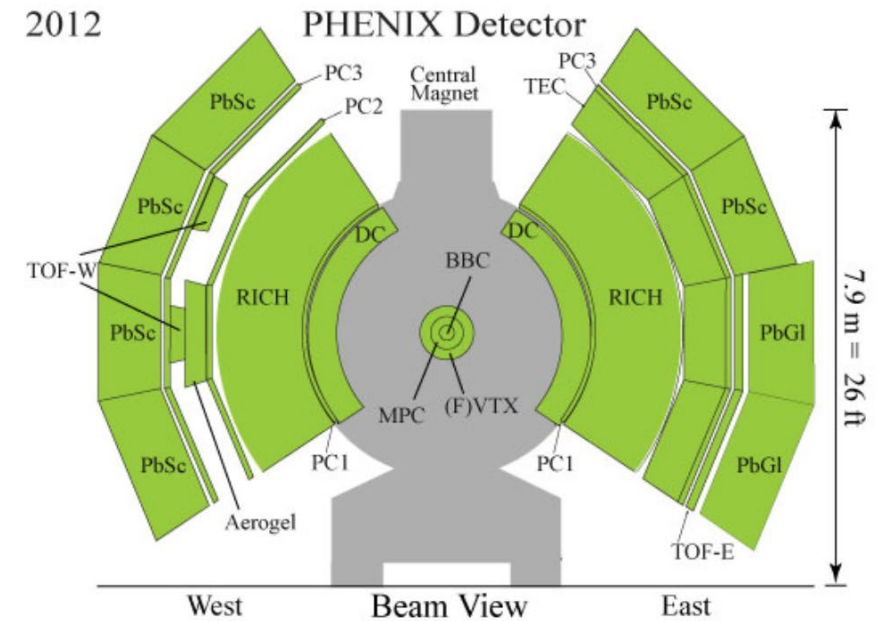
- PHENIX Experiment at RHIC
- Japan-Korea collaboration in RIKEN
- Recent highlights from PHENIX

PHENIX Detector



PHENIX experiment at RHIC

- PHENIX was the largest RHIC experiment
- It completed data taking in 2016, to be upgraded to sPHENIX
- Large amount of data were collected by PHENIX during its 16 years of operation
- Collaboration continues working on the data analysis and physics publication



$\sqrt{s_{NN}}$ [GeV]										
510	✓									
200	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
130									✓	
62.4	✓			✓		✓			✓	
39				✓					✓	
27									✓	
20				✓		✓			✓	
14.5									✓	
7.7									✓	

PHENIX publications

- **228 physics papers published**

– Phys. Rev. Lett.	77
– Phys. Rev. C	97
– Phys. Rev. D	48
– Nature Physics	1
– Phys. Letter B	4
– Nucl. Phys. A	1

- **Total citation: ~38000**

• Topcite 1000+	3
– 500-1000	7
– 250-500	25
– 100-250	68
– 50-100	43

PHENIX White Paper: 3934 cites

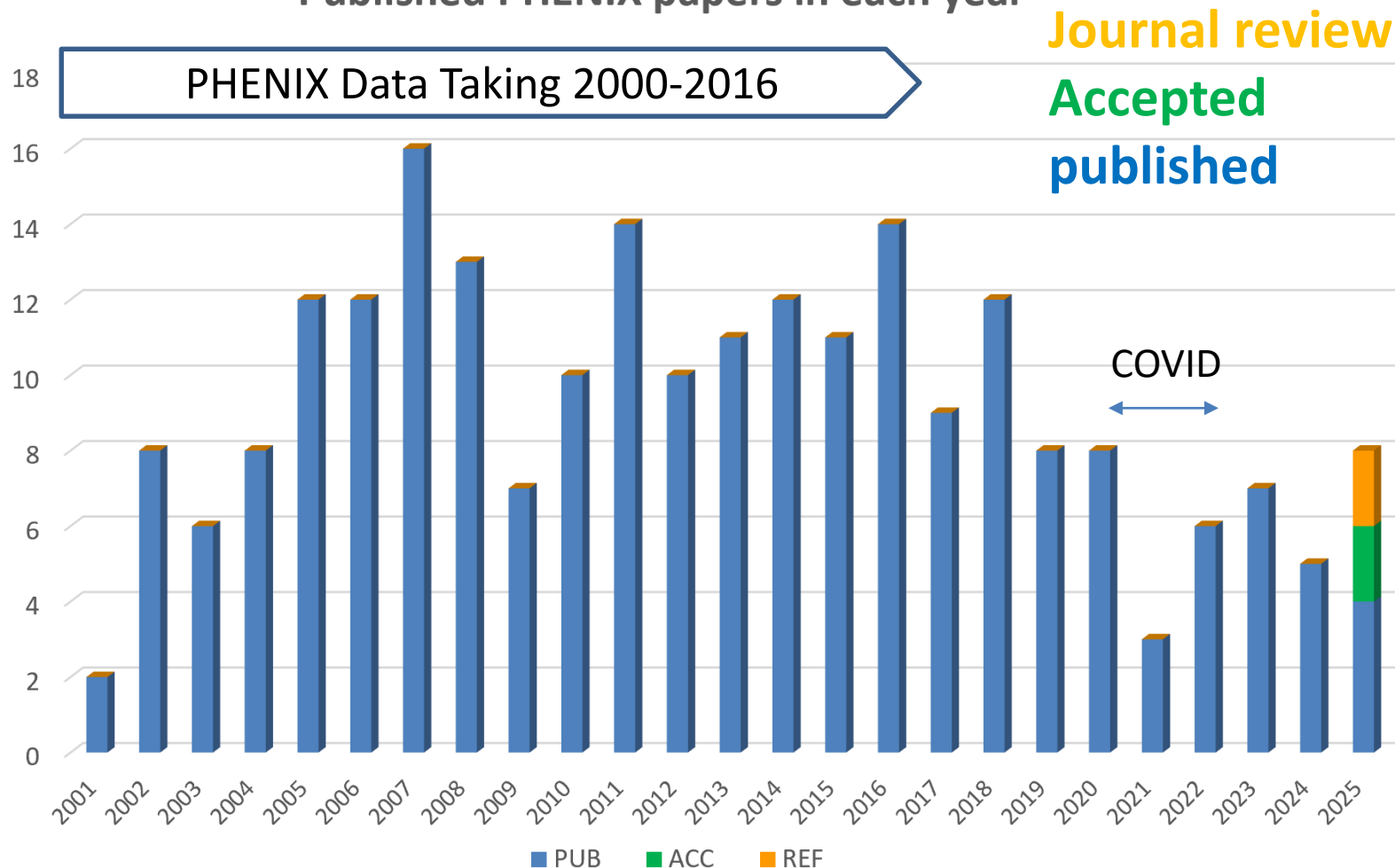
Jet quenching discovery: 1279 cites

PID hadron in AuAu: 1055 cites

Nature P paper: 383 citations

**146 physics papers in topcite 50+
(165 if proceedings and detector
papers are included)**

Published PHENIX papers in each year



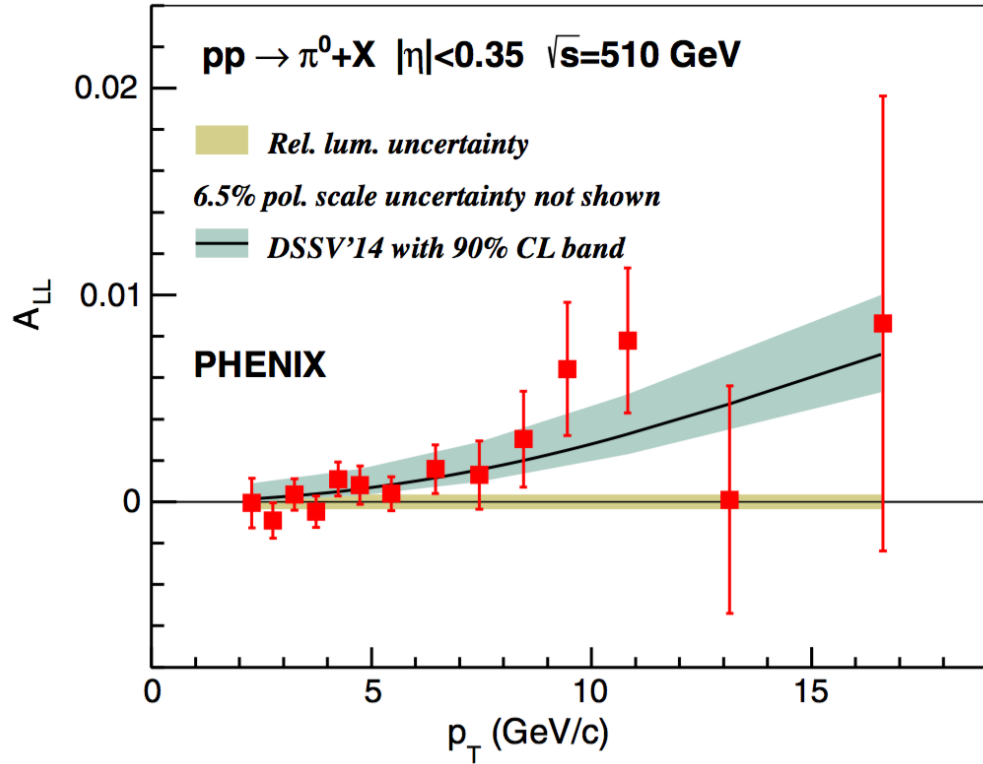
Japan – Korea collaboration in PHENIX at RIKEN

Past Korean student of PHENIX in RIKEN

Student	Research Topic	Ph.D Year	Mentor @ RIKEN
Sagnhwa Park (SNU)	Sea Quark Polarization thru Run13 W->mu Longitudinal Single Spin Asymmetry	2015	Itaru Nakagawa
Inseok Yoon (SNU)	Gluon Polarization thru Run13/12/11 Central Arm π^0 Longitudinal Double Spin Asymmetry	2016	Yuji Goto
Taebong Moon (Yonsei Univ.)	Gluon Polarization through Run13 Central $\pi^{+/-}$ Longitudinal Double Spin Asymmetry	2016	Yasuyuki Akiba
Chong Kim (Korea Univ.)	Sea Quark Polarization thru Run13 W->mu Longitudinal Single Spin Asymmetry	2015	Ralf Seidl
Minjung Kim (SNU)	Forward Neutron Asymmetry A_N for Run15 pA	2018	Itaru Nakagawa
SeYoung Han (Ewha Univ.)	Search for mini-QGP in Small Colliding System using Run15 High Multiplicity Events	2018	Itaru Nakagawa
JaeHee Yoo (Korea Univ.)	Gluon Polarization through Run15 pA Central $\pi^{+/-}$ Longitudinal Double Spin Asymmetry	2019	Itaru Nakagawa/Ralf Seidl
Junsang Park	Very forward Transverse Single Spin Asymmetry of Neutron Using RHICf Detector at STAR	-	Yuji Goto
Minho Kim (Korea Univ.)	Very forward Transverse Single Spin Asymmetry of π^0 Using RHICf Detector at STAR	2019	Yuji Goto
Benard Mulilo (Korea Univ.)	p_T dependence of Forward Neutron Asymmetry A_N for Run15 pA	2021	Itaru Nakagawa/Ralf Seidl

$\Delta G \neq 0$ from π^0 A_{LL} and A_L of $W^\pm \rightarrow \mu^\pm$

PRD93 011501 (2013)



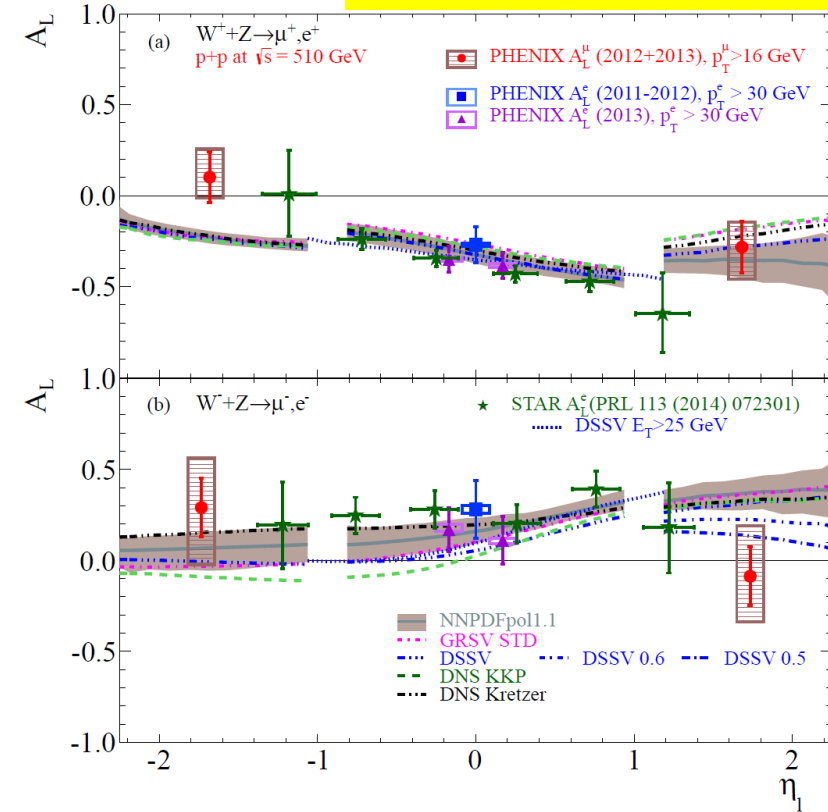
First observation of Non-vanishing A_{LL} of π^0

Evidence of $\Delta G \neq 0$

News release by BNL and RIKEN in 2016

Thesis Work by Inseok Yoon (SNU)

PRD98 032007 (2018)

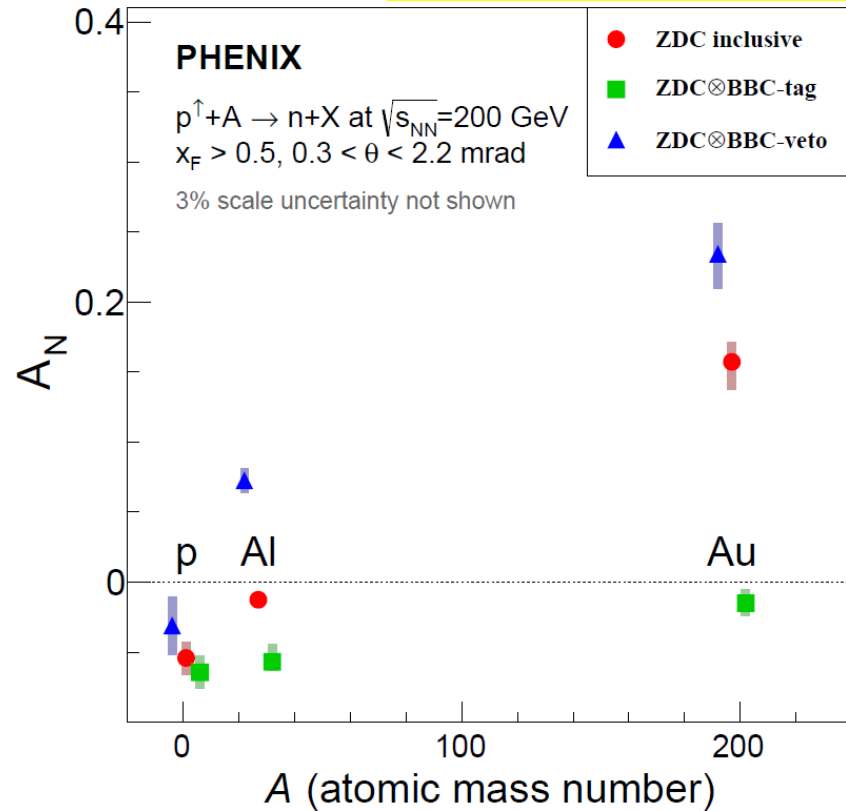


Concluded W A_L program with PHENIX

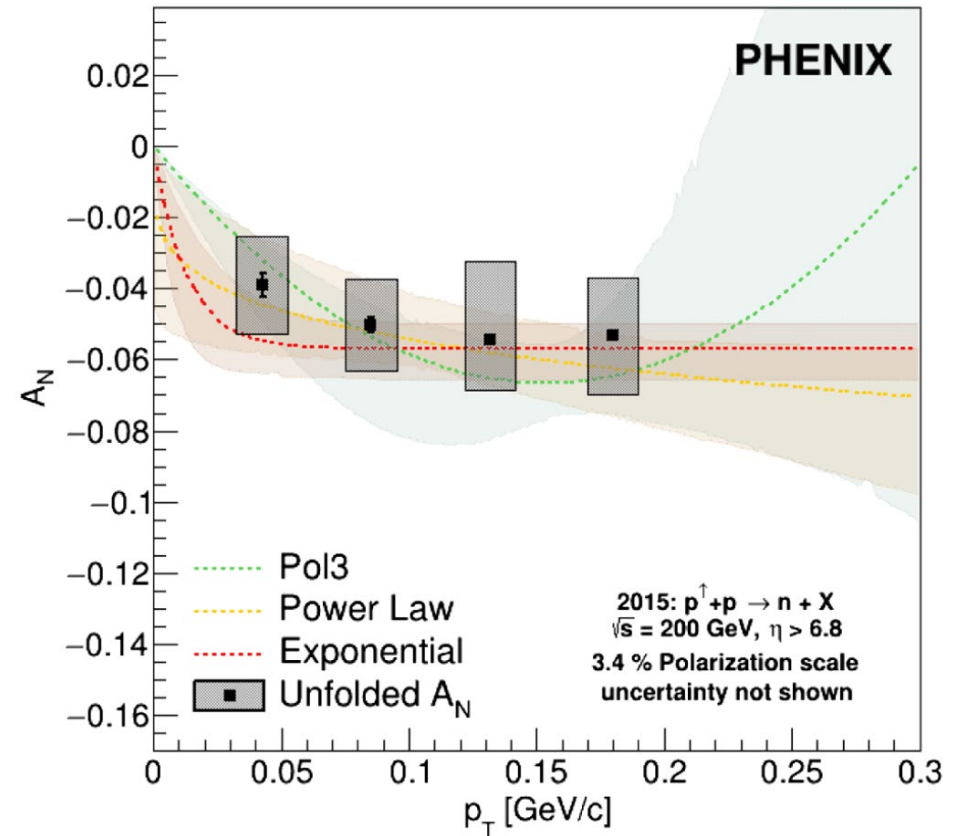
Thesis Work by Sanghwa Park (SNU)

A_N of very forward neutron

PRL120, 022001 (2018)



PRC103, 032007 (2021)

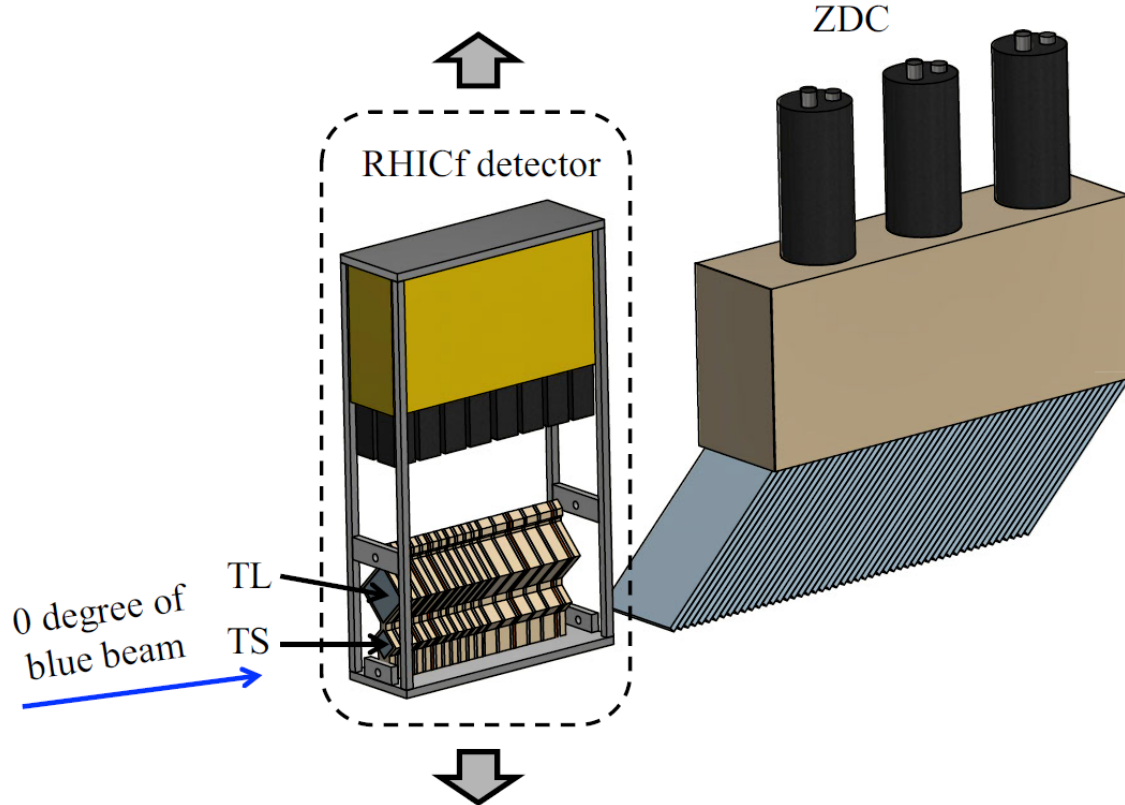


Large A_N of very forward neutrons in p+A
 News release by BNL and RIKEN in 2018
 Thesis work by Minjung Kim (SNU)

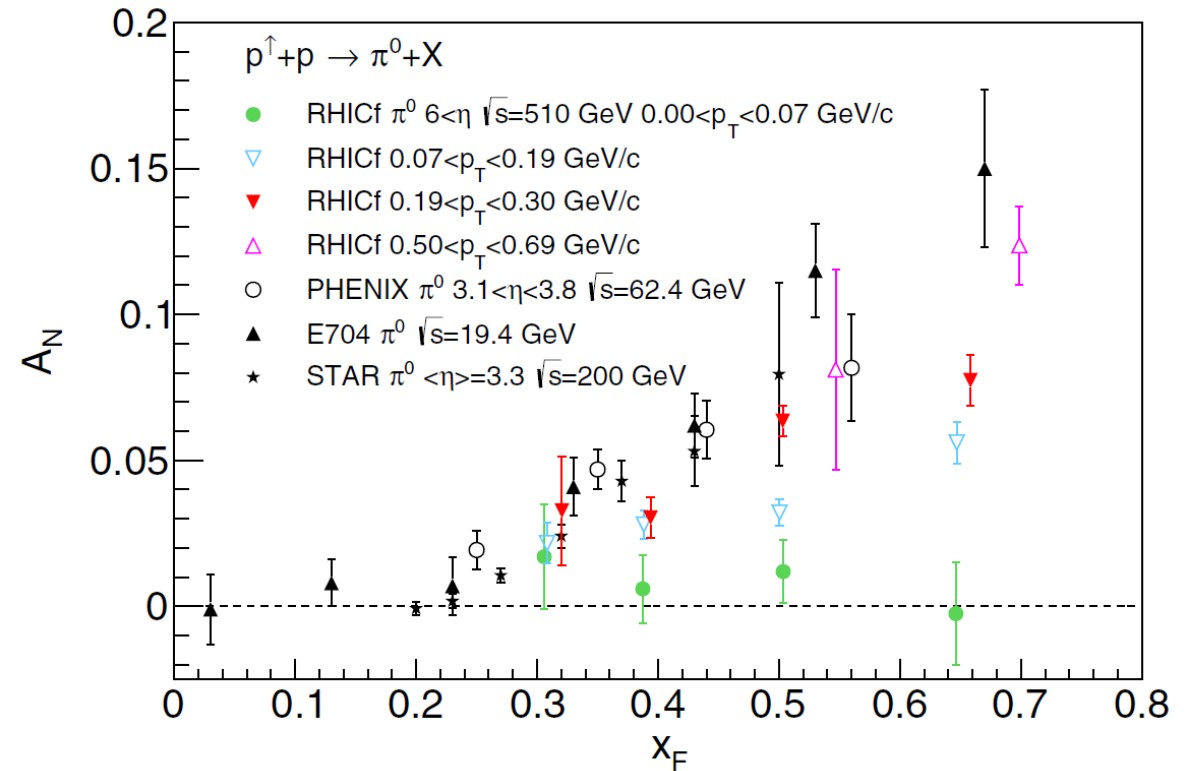
p_T dependence of A_N in pp
 Thesis work by Benard Mulilo (Korea)

RHICf

News release by BNL and RIKEN in 2020



PHYSICAL REVIEW LETTERS **124**, 252501 (2020)



RHICf is a small experiment to measure very forward π^0 and neutrons

The results show x_F scaling of single spin asymmetry A_N of π^0

News release by BNL and RIKEN in 2020

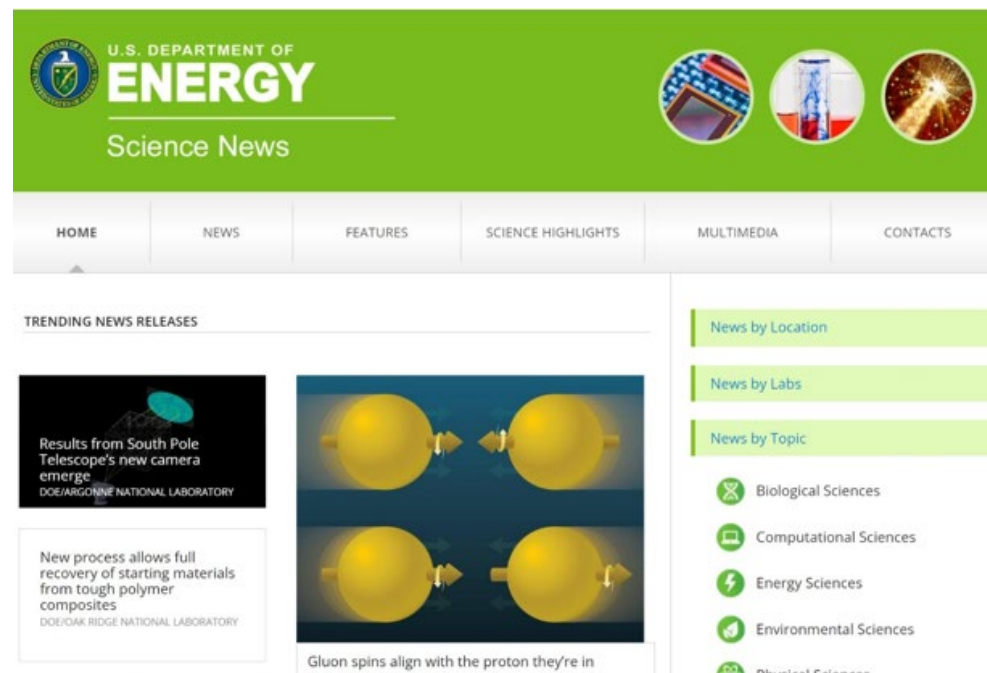
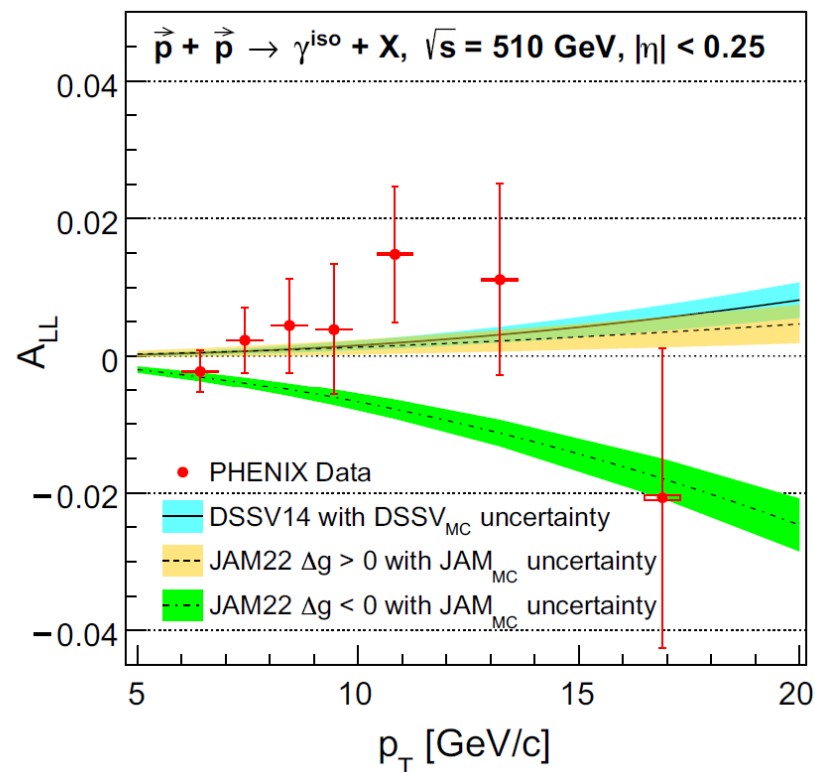
Thesis work by Minho Kim (Korea)

Recent highlights from PHENIX

Direct photon A_{LL}

PHYSICAL REVIEW LETTERS **130**, 251901 (2023)

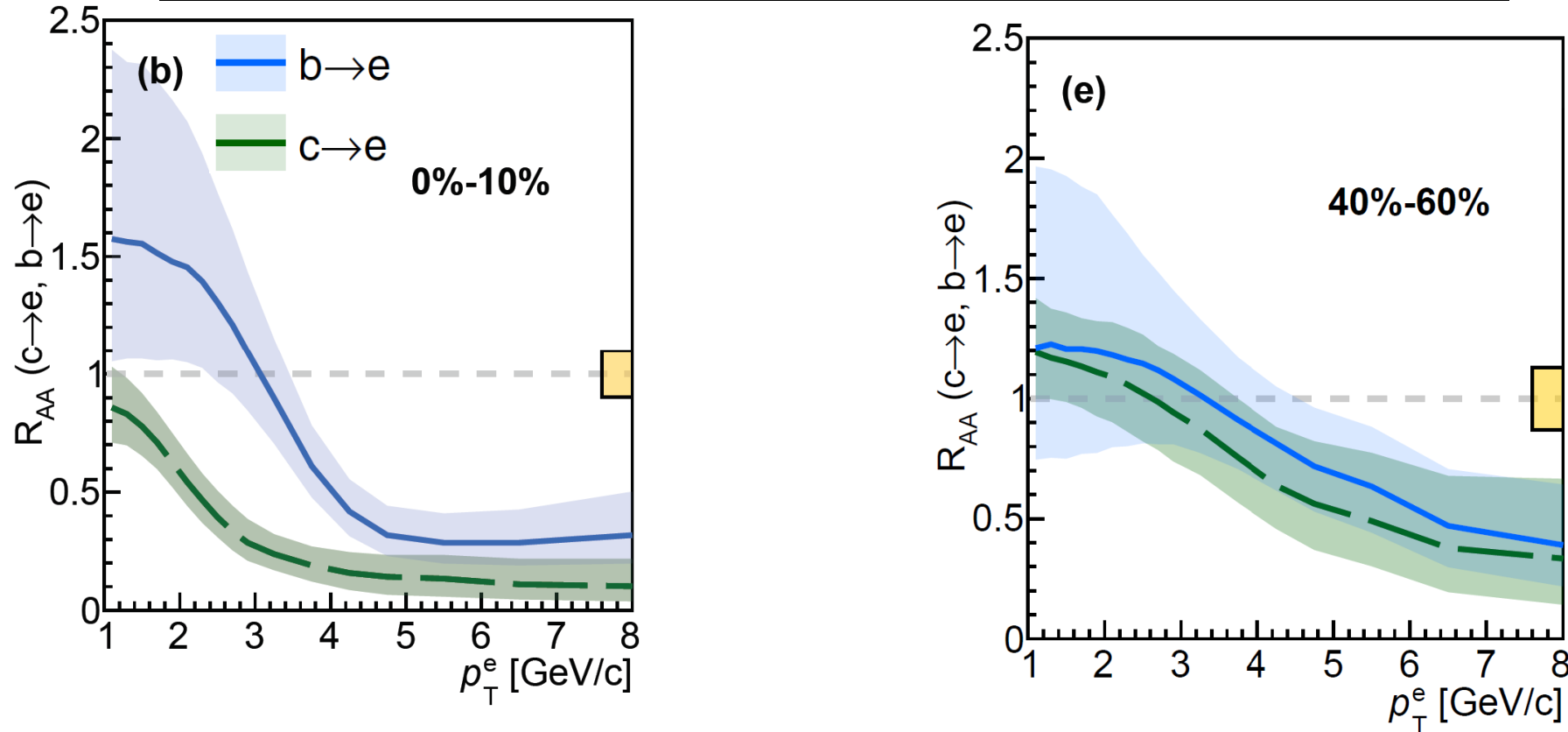
Measurement of Direct-Photon Cross Section and Double-Helicity Asymmetry at $\sqrt{s} = 510$ GeV in $\vec{p} + \vec{p}$ Collisions



- Determined that the gluon polarization is positive
- This is one of the original goals of RHIC spin physics program
- BNL and RIKEN news release and DOE science highlight in 2023

R_{AA} of $b \rightarrow e$ and $c \rightarrow e$

PHYSICAL REVIEW C **109**, 044907 (2024)

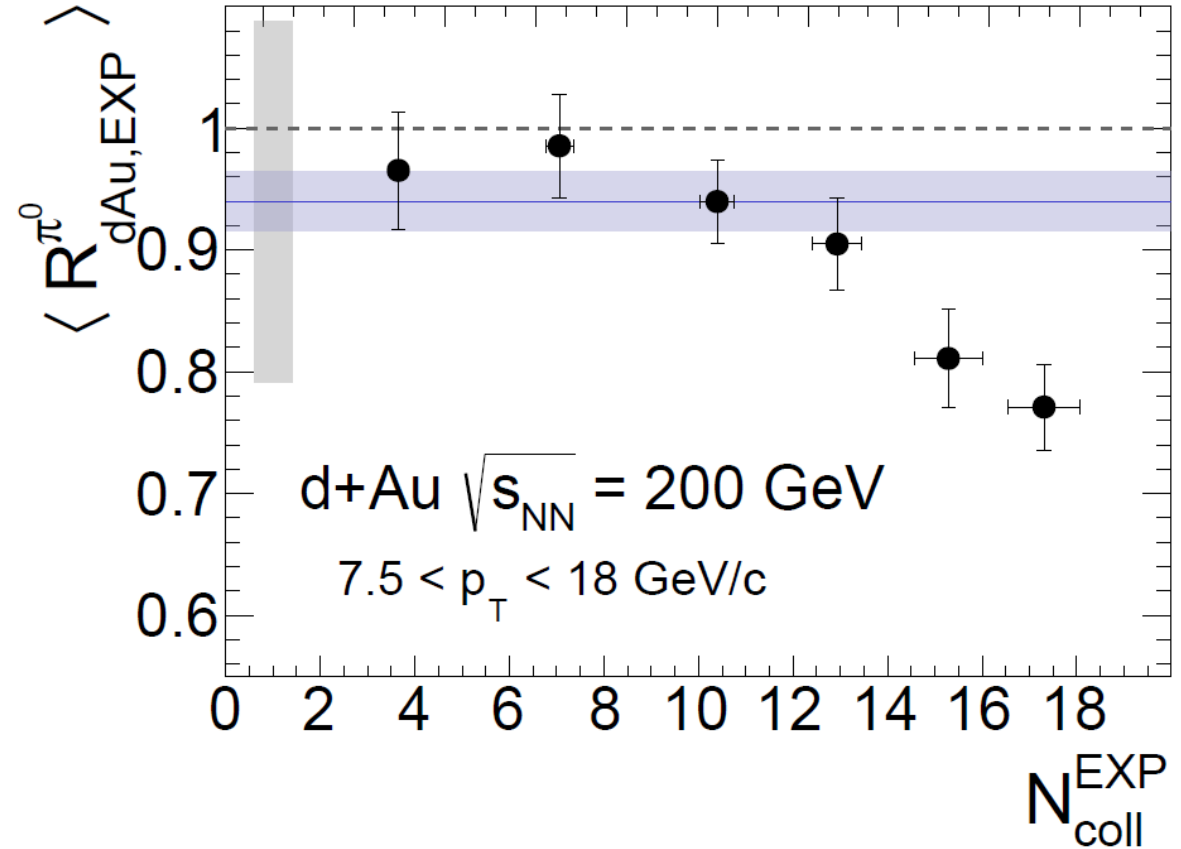
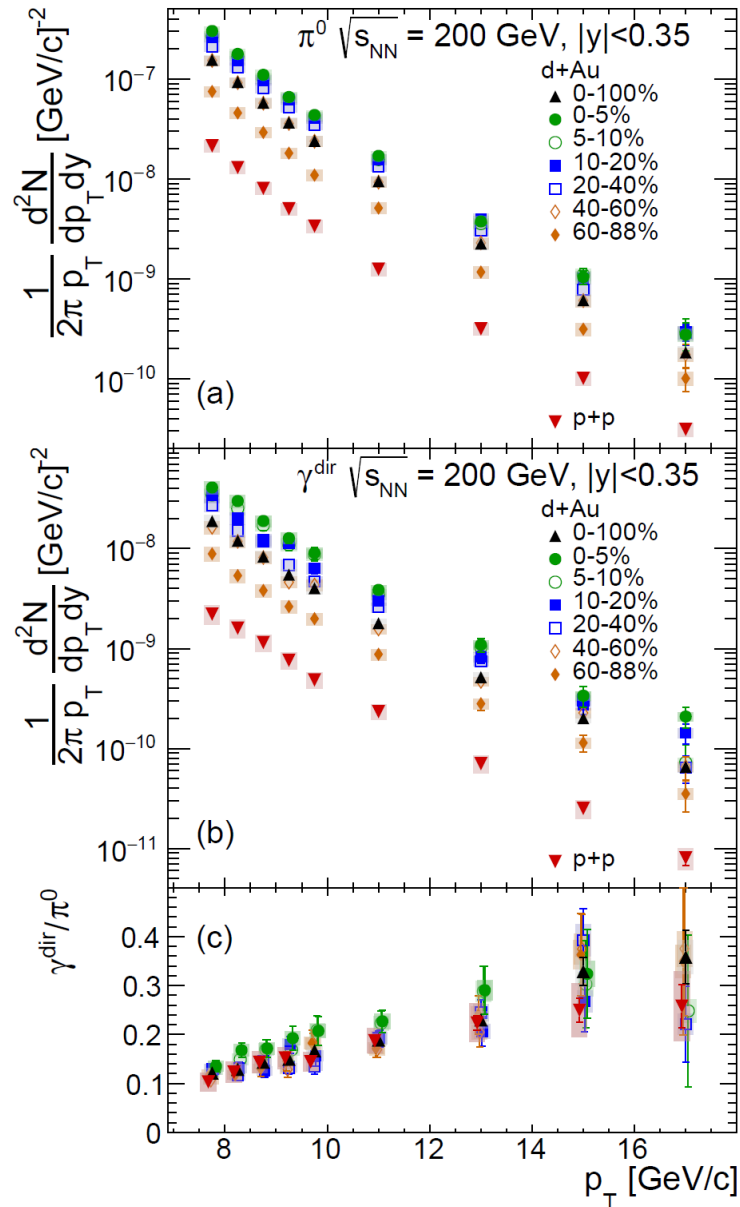


R_{AA} of $b \rightarrow e$ and $c \rightarrow e$ at midrapidity from 20B Au+Au data

Clear difference of charm and bottom suppression is seen

π^0 and direct photon in d+Au

PRL134,022302(2024)



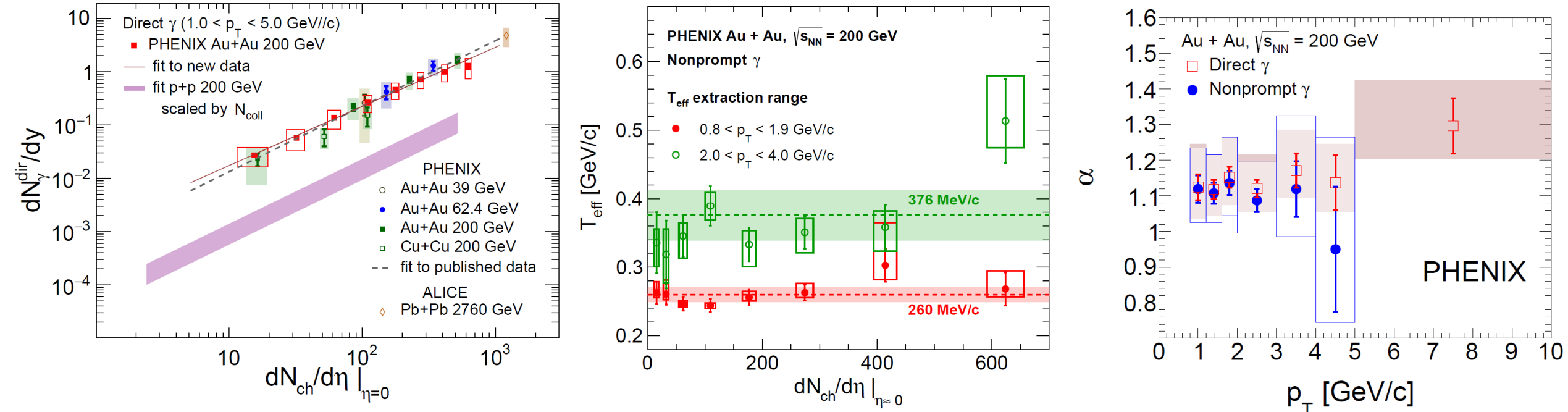
π^0 is suppressed relative to direct photon in central d+Au

→ Evidence of π^0 suppression in most central d+Au

BNL news release and DOE research highlight in 2025

Non-prompt direct photons in Au+Au

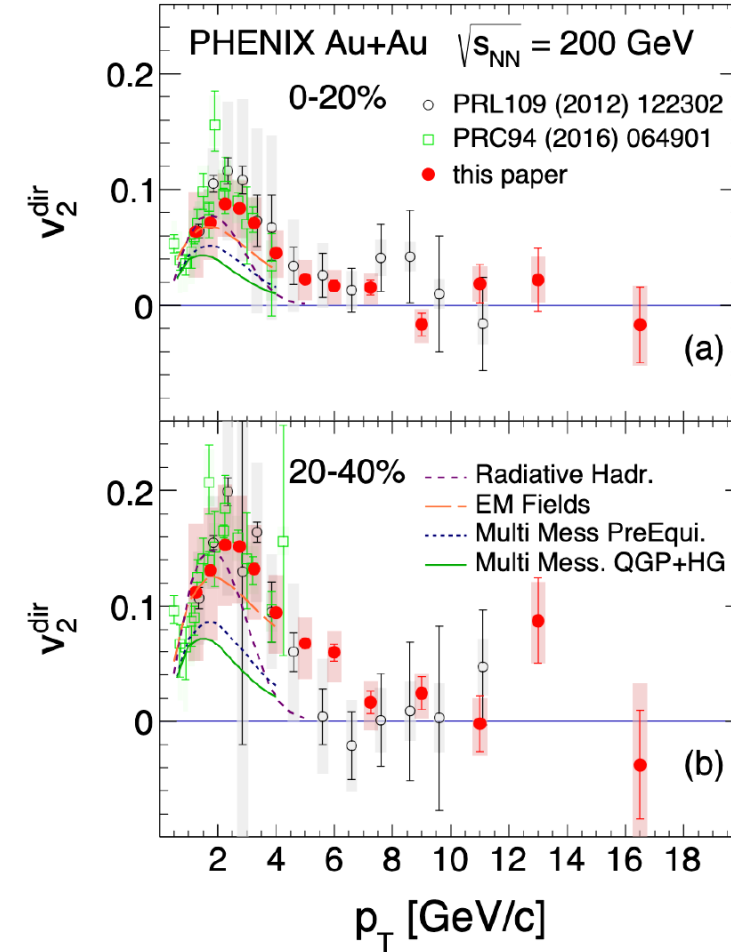
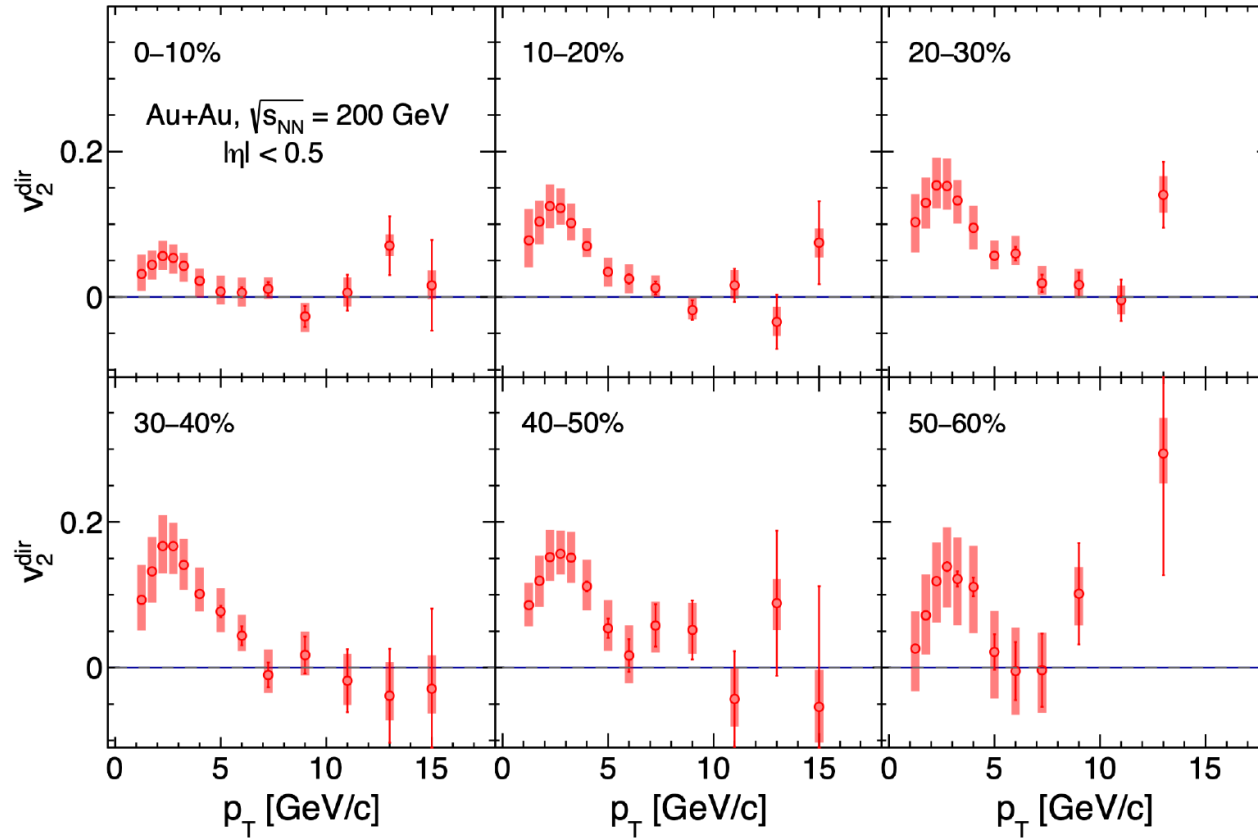
PHYSICAL REVIEW C **109**, 044912 (2024)



- High statistics direct photon measurement in Au+Au in 2014 run
- Non-prompt component of direct photons is extracted
- Effective temperature depends on p_T range
- Photon yield $\simeq (dN/d\eta)^\alpha$ with $\alpha = 1.12 \pm 0.06 \pm 0.12$

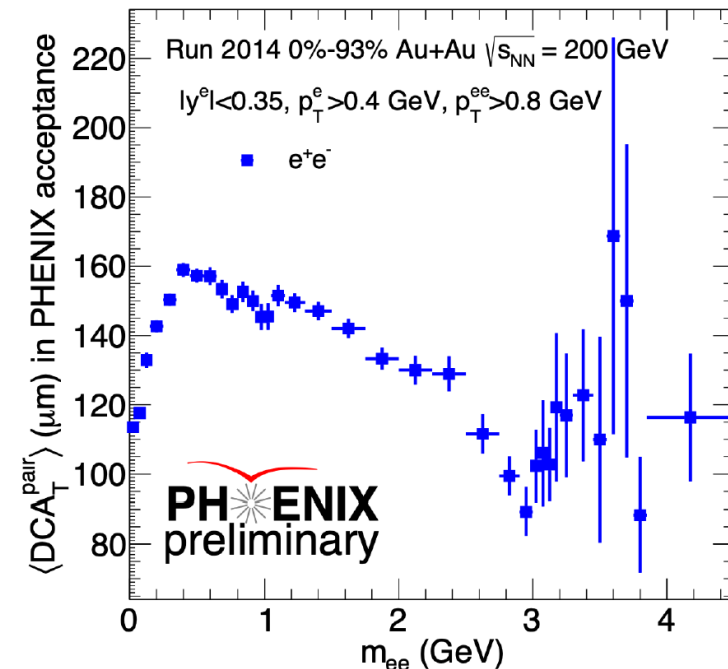
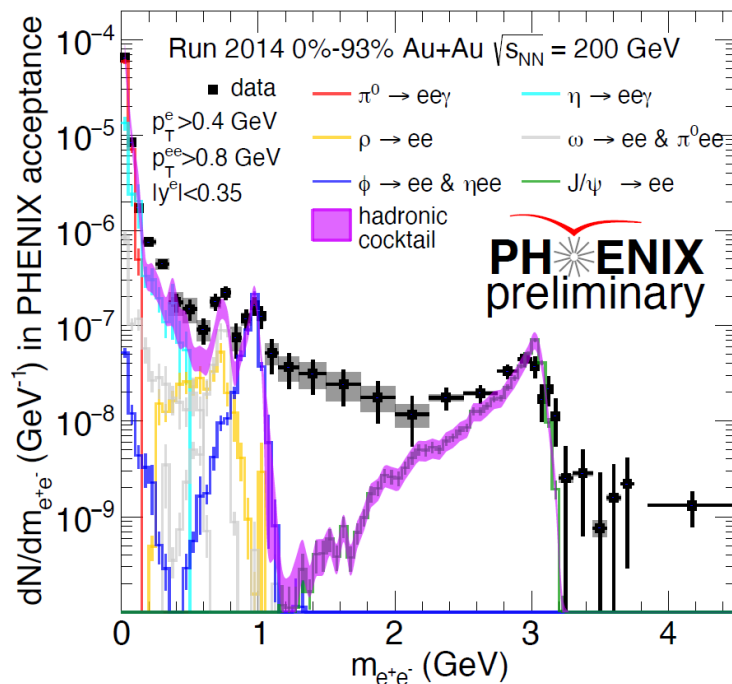
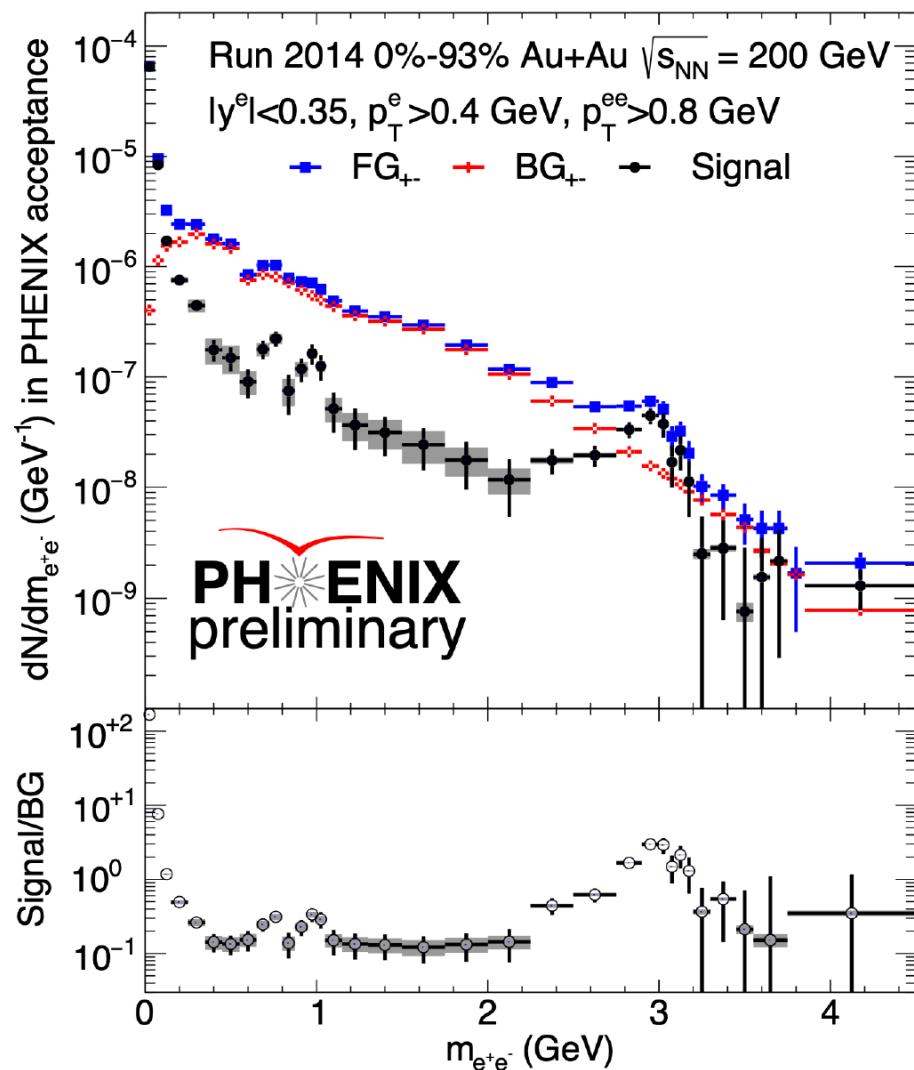
Direct photon v2

arXiv:2504.02955



Low p_T Large flow of direct photons
High p_T consistent with zero

Dielectrons in Au+Au



Measurement of e^+e^- in $1 < m_{ee} < 3$ GeV/c, where large thermal contribution is expected

Next Step: Separate the thermal component from background from b and c decays with DCA measurement by silicon vertex tracker

Summary

- PHENIX was the largest of RHIC experiments
 - Measurement of hadrons, photons, electrons, and muons with high speed DAQ
 - PHENIX completed its data taking in 2016
 - Collaboration continues working on data analysis and publication
- Very successful Japan-Korea collaboration in PHENIX and RHICf
- Recent highlights from PHENIX