

PHENIX data analysis and data preservation

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for PHENIX Collaboration

PAC 2022/06/2

Recent highlights and publication status

PHENIX papers since June 2021

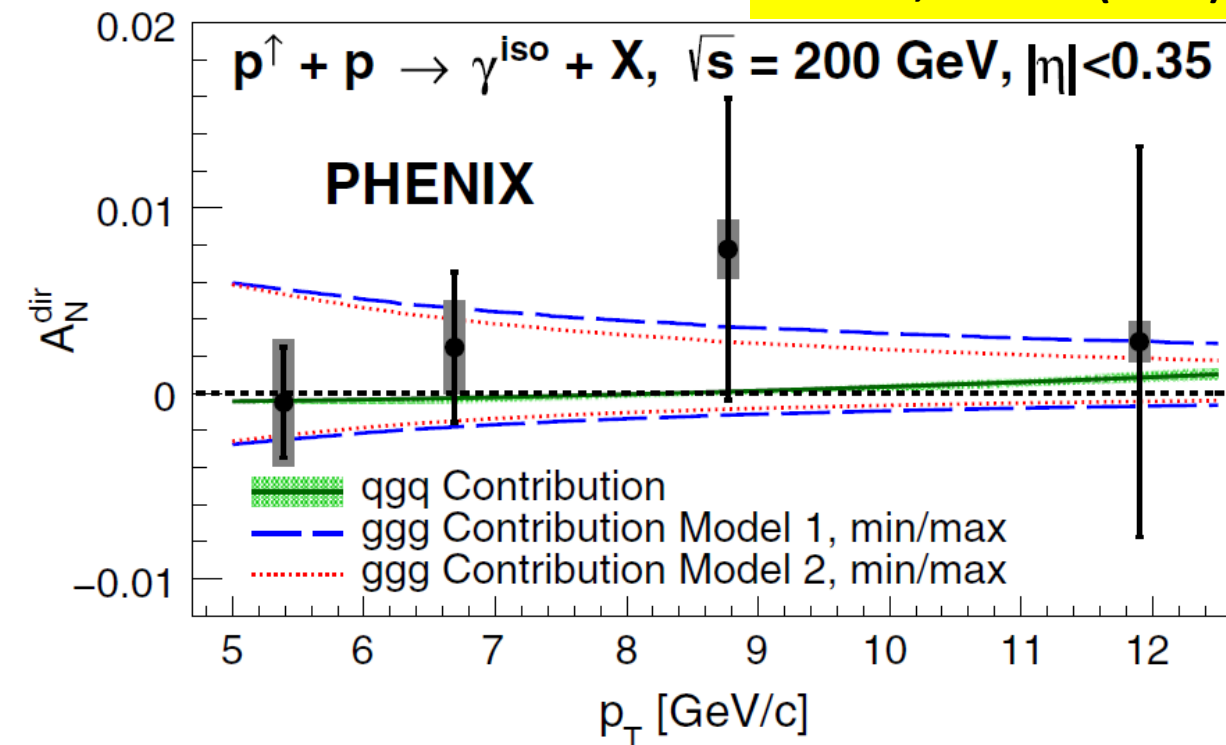
PRD105,302004 (2022)	Very forward A_N of neutrons in $p + p, p + \text{Al}, p + \text{Au}$
PRD105,302003 (2022)	Charged pion A_N at 200 GeV
PRD105,024901 (2022)	Kinematic dependence of flow in $p + \text{Au}, d + \text{Au}, {}^3\text{He} + \text{Au}$
PRL127,162001 (2021)	A_N of direct photons in $p + p$ at 200 GeV
arXiv:2202.03863	Forward and Backward $\psi(2S)$ in $p + p, p + \text{Al}, p + \text{Au}$
arXiv:2111.05756	π^0 in $p + \text{Al}, p + \text{Au}, d + \text{Au}, {}^3\text{He} + \text{Au}$
arXiv:2204.12899	A_N of heavy flavor decay electrons
arXiv:2203.17187	non-prompt direct photons in Au+Au 200 GeV
arXiv:2203.17058	R_{AA} of $b \rightarrow e$ and $c \rightarrow e$
arXiv:2203.12354	low p_T direct photons in Au+Au at 39 and 62.4 GeV
arXiv:2203.09894	flow in $p + \text{Au}, d + \text{Au}, {}^3\text{He} + \text{Au}$
arXiv:2203.06087	ϕ in $p + \text{Al}, p + \text{Au}, {}^3\text{He} + \text{Au}$
arXiv:2202.08158	cross section and A_{LL} of direct photons in $p + p$ at 510 GeV
arXiv:1805.04066	$\mu\mu, e\mu, ee$ correlations in $p + p$ 200 GeV

3 published + 2 accepted + 8 journal review

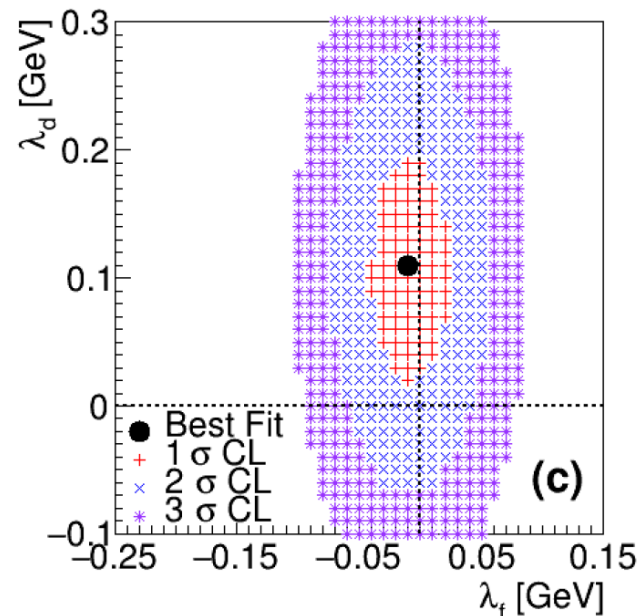
12 papers submitted in the last 1 year

Spin Physics highlights

PRL127, 162001 (2021)



arXiv:2204.12899 (2022)



$$A_N(p^{\uparrow} + p \rightarrow \text{HF}(e^{+/-}) + X)$$

$$\sqrt{s} = 200 \text{ GeV}$$

$$|\eta| < 0.35$$

PHENIX

Theory: PRD78, 114013

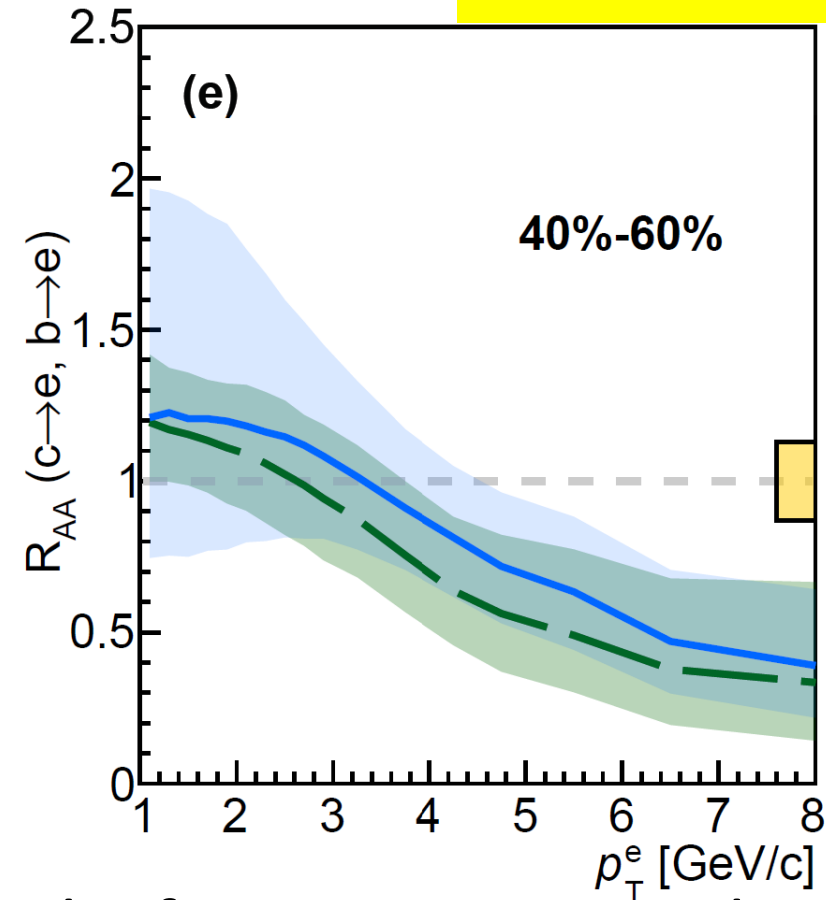
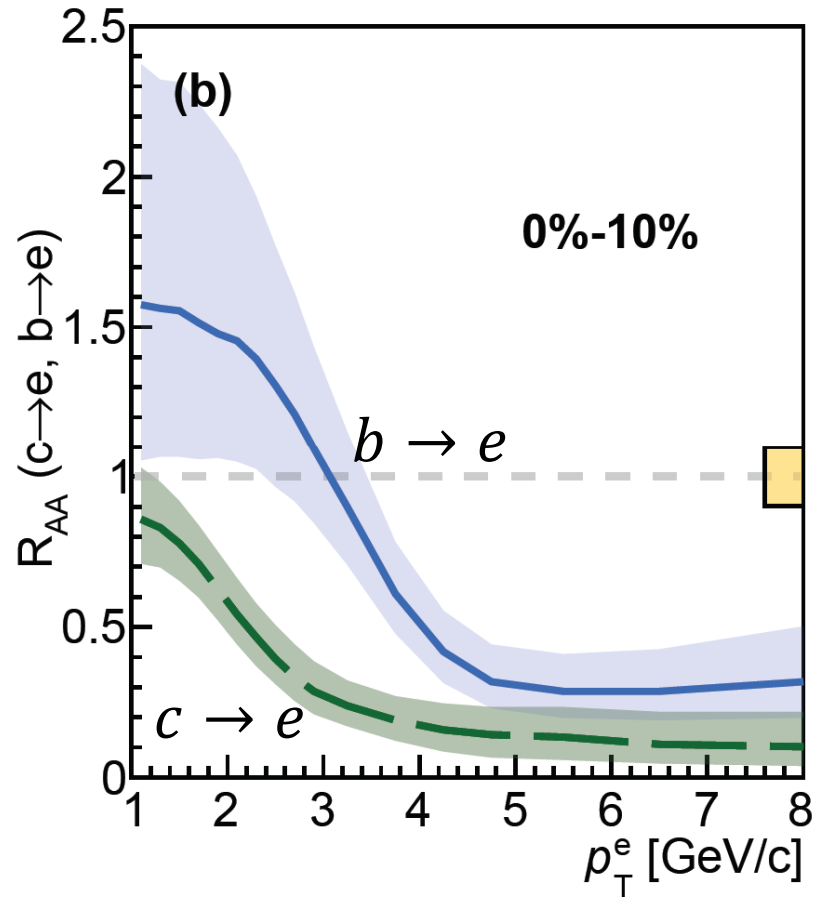
$$A_N^{D^0/\bar{D}^0 \rightarrow e^{+/-}}(\lambda_f, \lambda_d)$$

- Measurement of Direct photon A_N
- Constraint on gluon's dynamic motion in the proton
- News release at BNL and RIKEN

- Measurement of A_N of heavy-flavor decay electrons
- Constraint on parameters of Tri-Gluon model
- Submitted to PRL

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

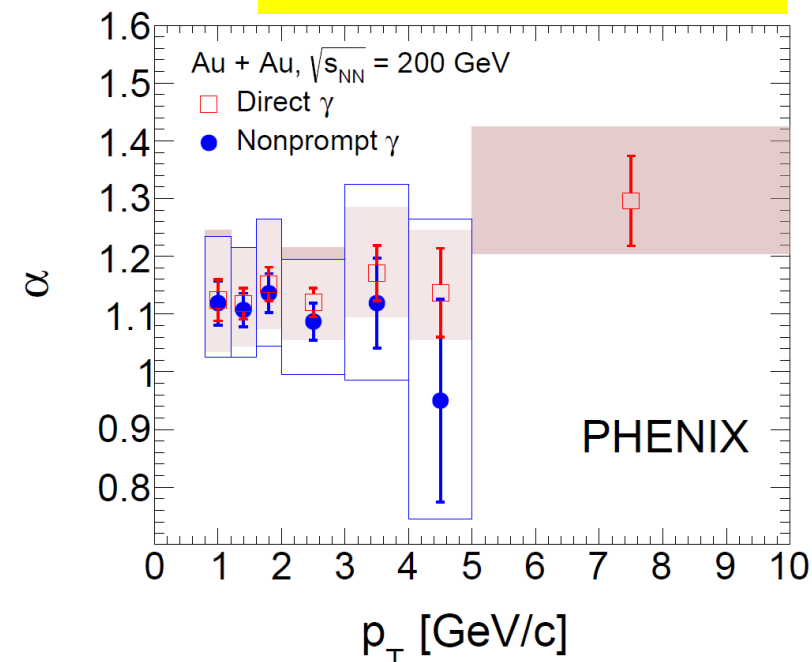
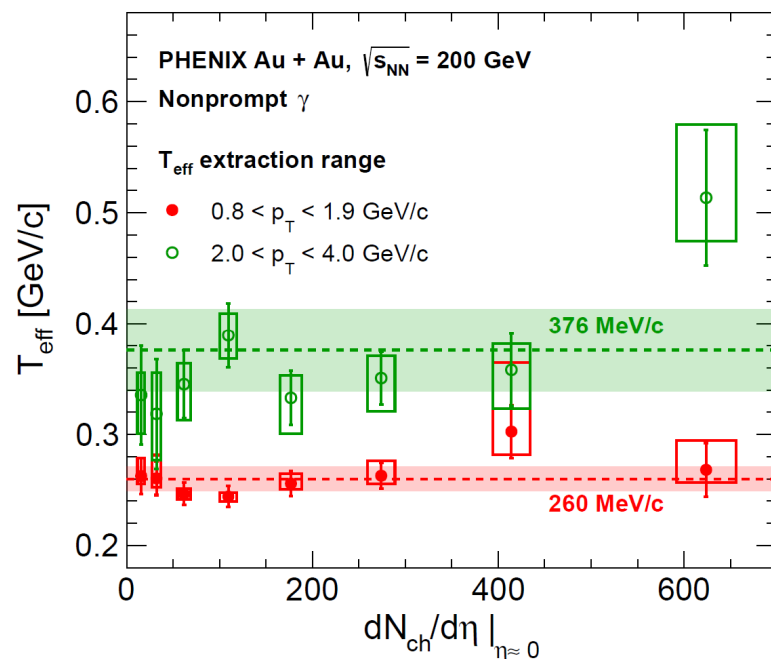
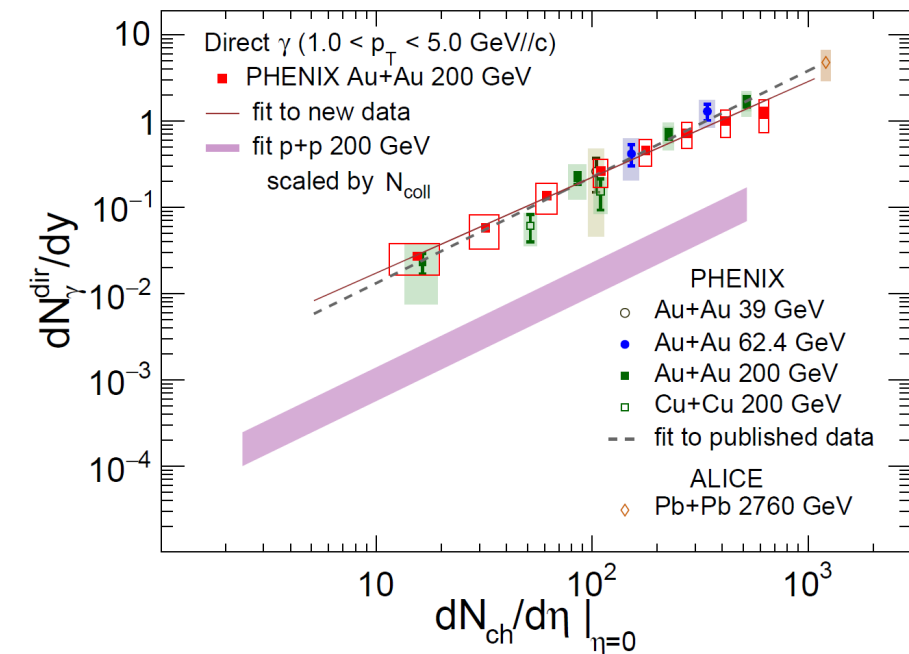
arXiv:2203.17058



- 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
- Next: 2014+2016 Au+Au data analysis

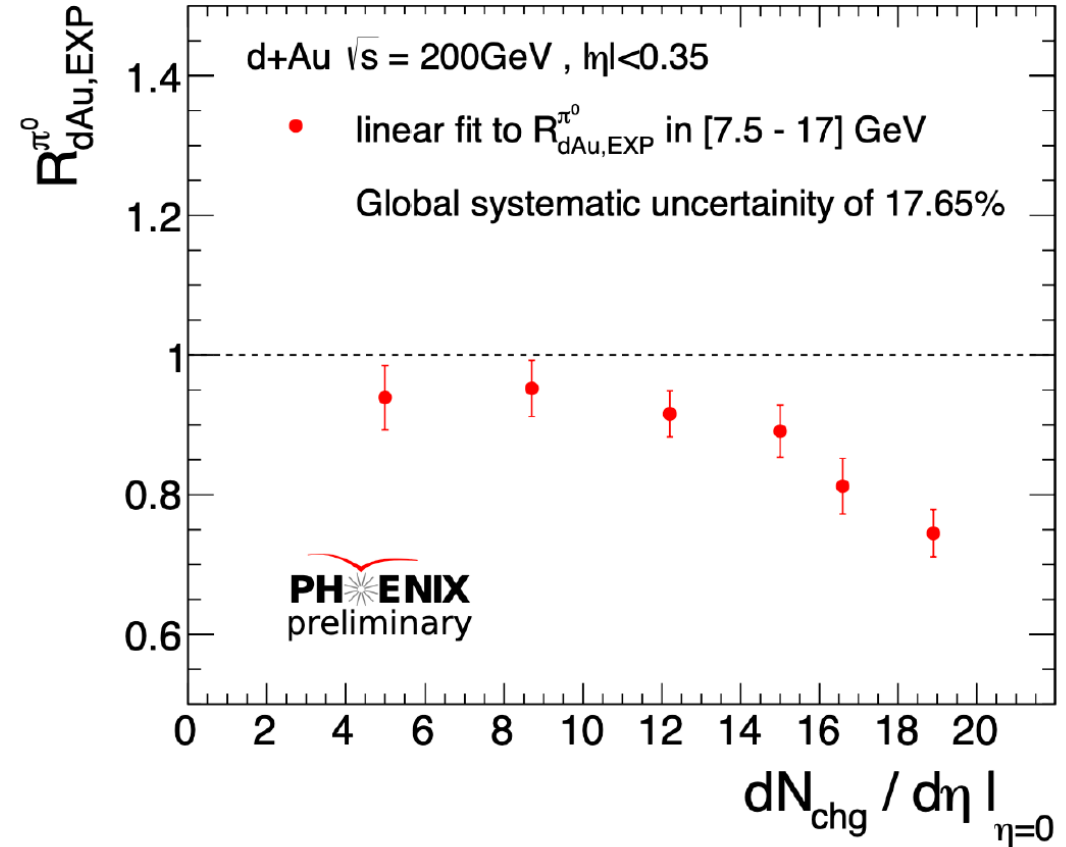
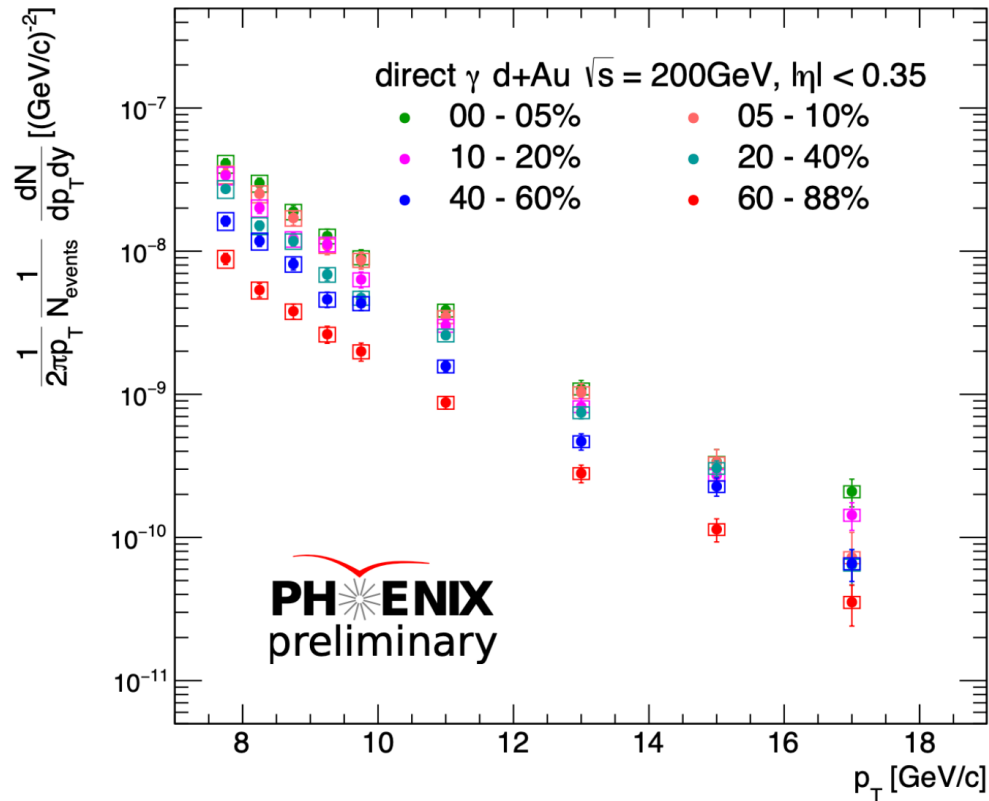
Non-prompt direct photons in Au+Au

arXiv:2203.17187 (2022)



- 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 $\alpha = 1.12 \pm 0.06 \pm 0.12$ (no p_T dependence)

π^0 and direct photon in d+Au



- π^0 and direct photon yield in d+Au is compared
 - π^0 is suppressed relative to direct photon in most central d+Au
- Evidence for π^0 suppression in most central d+Au

PHENIX publications

- **209 physics papers published**

– Phys. Rev. Lett.	75
– Phys. Rev. C	84
– Phys. Rev. D	44
– Nature Physics	1
– Phys. Letter B	4
– Nucl. Phys. A	1

- **Total citation: ~31000**

• Topcite 1000+	2
– 500-1000	8
– 250-500	20
– 100-250	57
– 50-100	43

PHENIX White Paper: 3236 cites

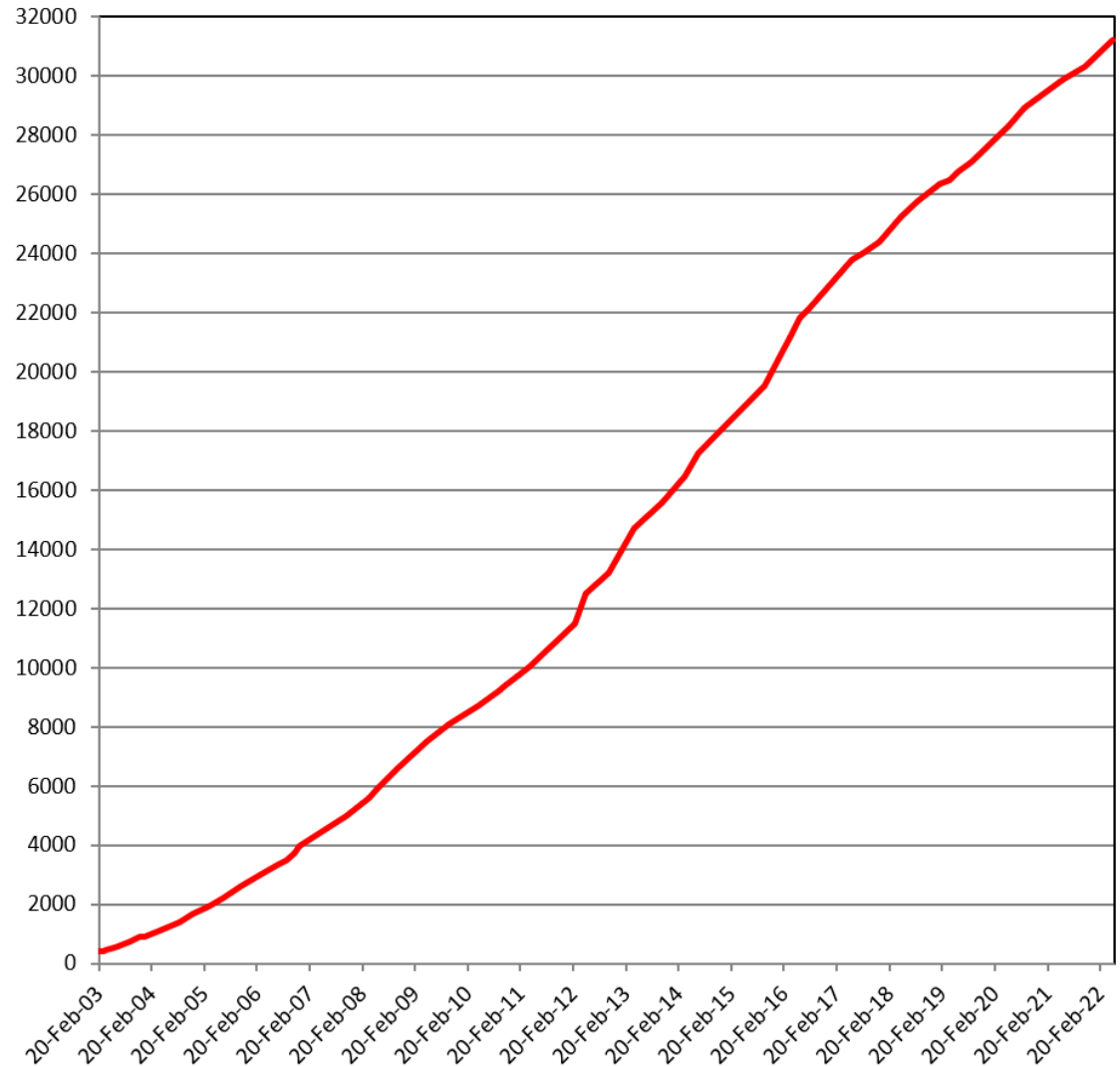
Jet quenching discovery: 1143 cites

Nature P paper: 203 citations

130 physics papers in topcite 50+

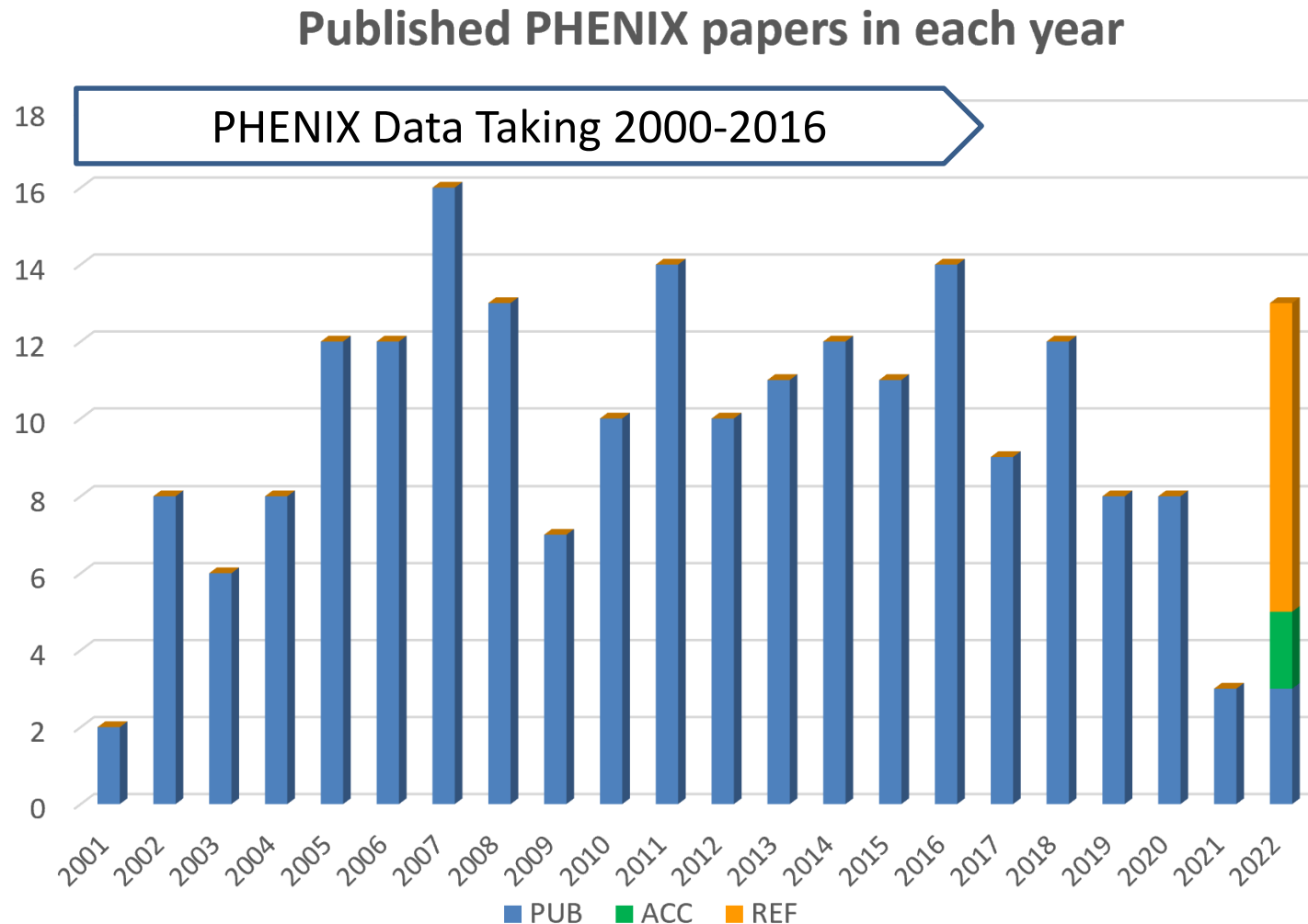
(155 if proceedings and detector papers are included)

Cumulative Citations of PHENIX papers



PHENIX publications

- 3 + 2 papers published/accepted and 8 submitted in 2022 so far
- Keep the scientific productivity with reduced collaboration



Analysis status

Golden datasets of PHENIX

year	Beam, E(GeV)	Recorded data (pp equiv)	upgrade	Physics
2016	AuAu 200 dAu 200 dAu 62,39,20	2.3/nb (90/pb) 15B events 1G & 73/nb (29/pb) 0.6G 0.1G, 8M	VTX,FVTX MPC-EX	Heavy Flavor Gluon nPDF Small QGP
2015	pp 200 pAu 200 pAl 200	23/pb 80/nb (16/pb) 275/nb (7.4/pb)	VTX, FVTX	Heavy Flavor Transverse spin CNM, small QGP
2014	AuAu 200, 15 ³ HeAu 200	2.3/nb (90/pb) 15 B events 25/nb (15/pb)	VTX, FVTX	Heavy Flavor Small QGP
2013	pp 510	240/pb	W-trigger	Anti-quark spin Gluon spin
2012	pp 510 pp 200 CuAu 200 UU 193	50/pb 4/pb 5/nb (60/pb) 0.17/nb (10/pb)	W-trigger VTX, FVTX	Anti-quark spin Transverse spin Heavy flavor Geometry
2011	pp 510 AuAu 200 AuAu 19, 27	28/pb 0.8/nb (32/pb)	W-trigger VTX	Anti-quark spin Heavy flavor BES-I
2010	AuAu 200 AuAu 62,39,7	1.1/nb (44/pb)	HBD	Low mass ee BES-I

Data Production Status

RUN	beam	VTX/FVTX/Muon (heavy flavor)	Central Arm flow	Central Arm EM (γ , e)
16	Au+Au 200	VTX: DONE FVTX: DONE	DONE	DONE
	d+Au BES	DONE	DONE	DONE
15	p+p 200	DONE	DONE	DONE
	p+Au 200	DONE	DONE	DONE
	p+Al 200	N/A	DONE	DONE
14	Au+Au 200	DONE	DONE	DONE
	^3He +Au 200		DONE	DONE

- 2016 FVTX/muon nDST production completed in December 2021
- nDST production of PHENIX completed for all datasets

Status of key analysis

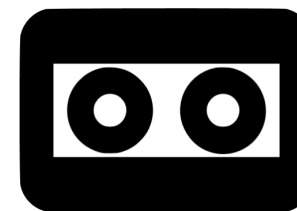
On-Going Key analysis		
Topic	Leading group	Time line
R_{AA} of $b \rightarrow e$ and $c \rightarrow e$	RIKEN; Nara Women	Submit by QM2022 ✓
v_2 of $b \rightarrow e$ and $c \rightarrow e$	RIKEN; Nara Women	Submit in 1 year
J/ψ and $\psi(2S)$ in small systems	Florida State U; LANL	Submit by QM2022 ✓
Flow of J/ψ	Vanderbilt	Preliminary in 1 year ✓
High p_T Direct photon in small systems	Stony Brook, Debrecen	Submit by 1 year
Direct photons in RUN14 Au+Au	Stony Brook	Submit by QM2022 ✓
Low p_T direct photons in Cu+Au	Stony Brook	Preliminary by QM2022
Low p_T direct photons in small systems	Stony Brook, St. Petersburg	Preliminary by QM2022
Direct γ -hadron correlations in Au+Au(RUN14)	Georgia State University	Submit in 1 year
Heavy Flavor electron A_N	U. Michigan	Submit in a half year ✓
Forward EM cluster A_{LL} at 510GeV	Stony Brook	Preliminary in 1 year

Key analysis needs additional funding

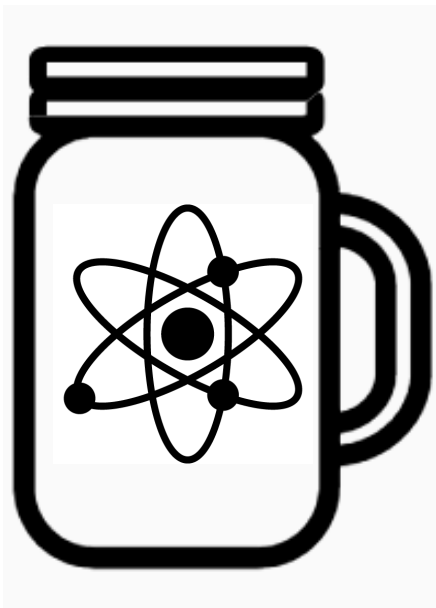
- $b \rightarrow e, c \rightarrow e$ with VTX (RUN14+16)
- $b \rightarrow \mu, c \rightarrow \mu$ with FVTX (RUN14+16)
- Intermediate mass dilepton (RUN14+16)
- Status of analysis is reported to DOE in January 2022
- Most of the key analysis is on schedule
- Request for funding for three key analyses that are not funded
 - PHENIX analysis review in 2019

Data and Analysis Preservation

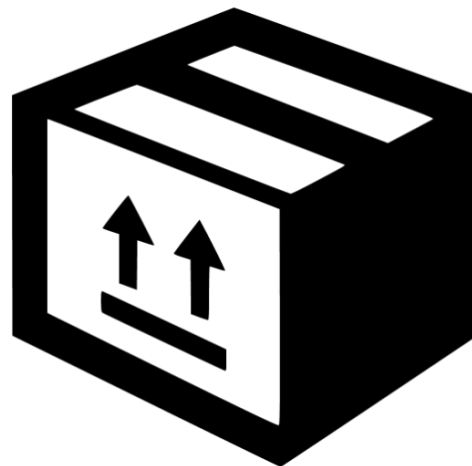
The DAP Strategy in PHENIX



Bit preservation
(BNL SDCC Storage)



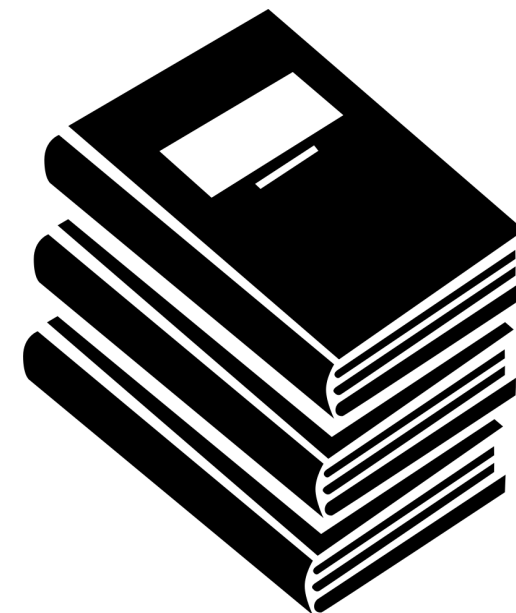
Analysis capture
(analysis notes, writeups,
scripts, flowcharts etc)



Software preservation:
Containers (Docker, Singularity)
CVMFS (network storage)

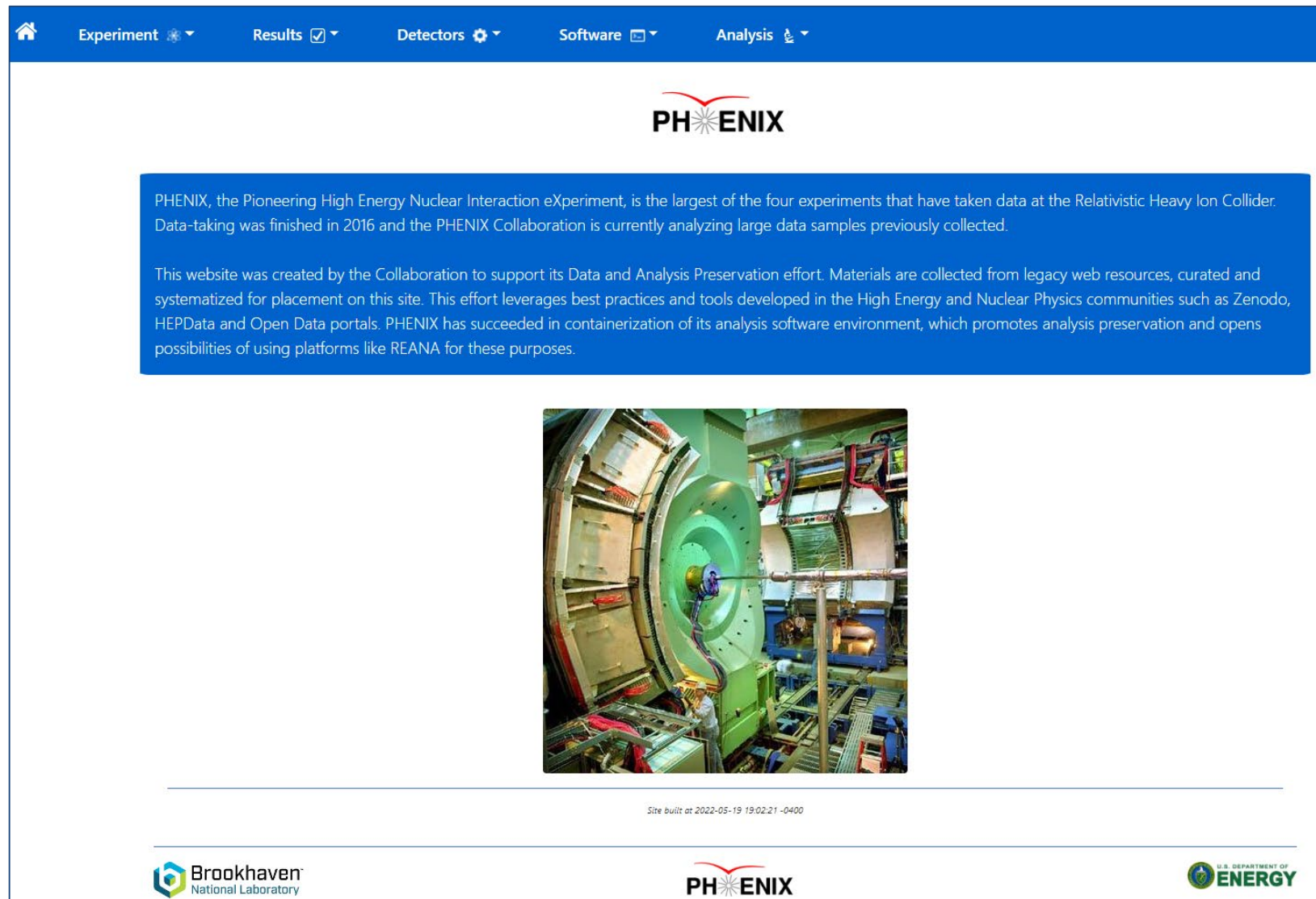


Web-based
Documentation
(new PHENIX website)



Modern repositories for
research materials
(Zenodo, HEPData)

The new website – Docker/REANA content added



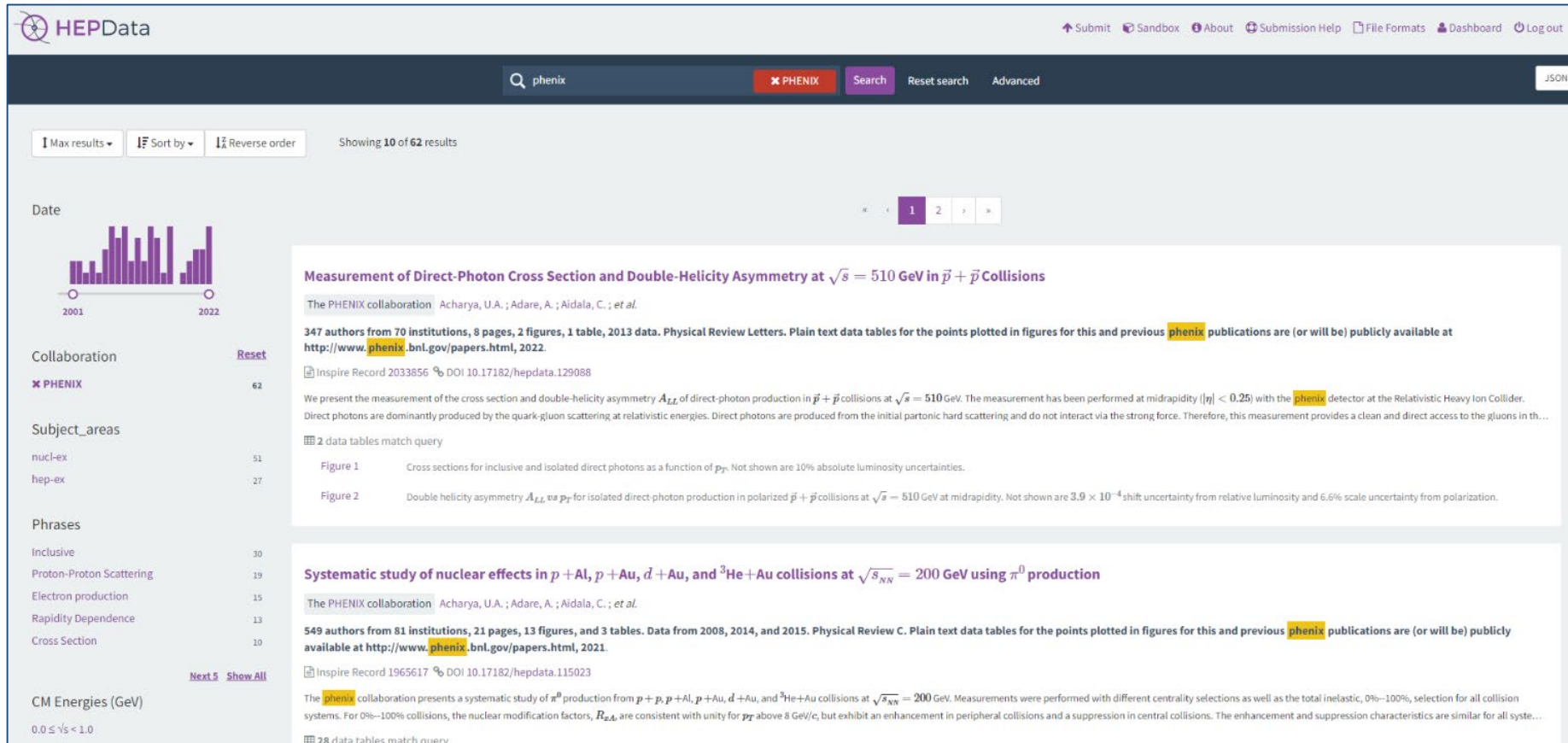
Progress with HEPData data preservation

HEPData
submissions
mandated for all
new publications

Revisiting older
publication materials
as time permits

In the past 2 years,
went from 23 to **62**
published items

Team effort, using
GitHub for material
development



Zenodo@CERN - the PHENIX community

<https://zenodo.org/communities/phenixcollaboration>

- >500 PHENIX items, uploads ongoing

The screenshot displays the Zenodo interface for the PHENIX Collaboration community. The top navigation bar includes the Zenodo logo, a search bar, and links for 'Upload' and 'Communities'. A user profile dropdown shows 'phenix-dap-l@lists.bnl.gov'. The main header reads 'PHENIX Collaboration'. Below this, a 'Recent uploads' section features a search bar and a list of three items, each with a 'View' button. The first item, 'π⁰-hadron correlations in 200GeV Au+Au collisions' by Wong, Cheuk-Ping, is a thesis from September 21, 2020. The second, 'PHENIX measurement of system size dependence of low momentum photon production' by Esha, Roli, is a presentation from September 20, 2020. The third, 'Study of jet modifications at PHENIX using two-particle azimuthal correlations and high-pT hadrons' by Wong, Cheuk-Ping, is also a presentation from September 20, 2020. A fourth item from September 17, 2020, is partially visible. On the right, a green 'New upload' button is present. Below it, the community logo 'PHENIX' is shown. The community description states its purpose is to promote long-term data preservation. It lists the curator as 'PhenixCollaboration', the policy as 'Not specified', the creation date as 'May 18, 2020', and the harvesting API as 'OAI-PMH interface'. At the bottom right, a section asks 'Want your upload to appear in this community?' with a link to click the upload button.

zenodo Search Upload Communities phenix-dap-l@lists.bnl.gov

PHENIX Collaboration

Recent uploads

Search PHENIX Collaboration

September 21, 2020 (v1) Thesis Open Access View

π⁰-hadron correlations in 200GeV Au+Au collisions

Wong, Cheuk-Ping;

The study of jet modifications helps to understand the properties of the QGP. In this research, jets are studied using π⁰-hadron azimuth correlations which use high momentum neutral pions as triggers to indicate the presence of a jet.

Uploaded on September 21, 2020

September 20, 2020 (v1) Presentation Open Access View

PHENIX measurement of system size dependence of low momentum photon production

Esha, Roli;

Direct photons provide information about the space-time evolution of matter produced in relativistic heavy-ion collisions. PHENIX results are presented.

Uploaded on September 20, 2020

September 20, 2020 (v1) Presentation Open Access View

Study of jet modifications at PHENIX using two-particle azimuthal correlations and high-pT hadrons

Wong, Cheuk-Ping;

Summary of observables in heavy-ion collisions and the nuclear modification factors.

Uploaded on September 20, 2020

September 17, 2020 (v1) Presentation Open Access View

Signature of collectivity and flow of light and heavy quarks in small systems observed

New upload

Community

PHENIX

PHENIX Collaboration

The purpose of this community is to promote the long-term Data and Analysis Preservation goals and mandate of the PHENIX Collaboration (RHIC).

Curated by:
PhenixCollaboration

Curation policy:
Not specified

Created:
May 18, 2020

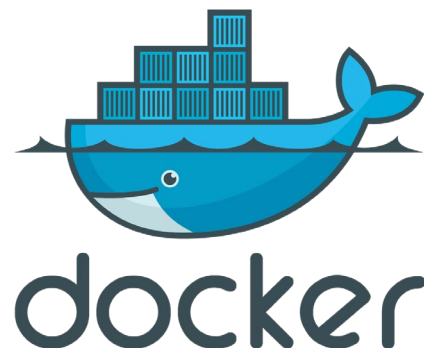
Harvesting API:
[OAI-PMH interface](#)


Want your upload to appear in this community?

- Click the button above to upload a record directly to this community.

Progress with REANA









- Complete PHENIX software stack captured in Docker and CVMFS (file system) – a major milestone
- Storage at BNL scaled up to 2.6TB which is sufficient for many final-stage analyses
- **Successfully captured the crucial part of a real PHENIX analysis (d+Au Direct Photon) in REANA**



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reana

Reproducible research data analysis platform

Flexible	Scalable	Reusable	Free
Run many computational workflow engines.	Support for remote compute clouds.	Containerise once, reuse elsewhere. Cloud-native.	Free Software. MIT licence. Made with ❤ at CERN.
 COMMON WORKFLOW LANGUAGE 	  	 	

PHENIX School 2022

Thursday 02 June 2022

Day 1 (08:00->12:00)		Chair: Roli Esha , Krista Smith
08:00	Opening welcome (15')	Yasuyuki Akiba (RIKEN)
08:15	Introduction : Physics (45')	William Zajc (Columbia)
09:00	Break (15')	
09:15	Introduction : Experiment (45')	Takao Sakaguchi (BNL)
10:00	Key PHENIX analyses (45')	Ron Belmont (UNC)
10:45	Break (15')	
11:00	PHENIX Software (30')	Dillon Fitzgerald (U Mich)
11:30	PISA (30')	Niveditha Ram (SBU)

- Since 2017, we organize a PHENIX school for new students and postdocs to teach RHIC physics and PHENIX data analysis.
- PHENIX School 2022 is from 6/2 to 6/3

Issues and Concerns

- After completion of data taking in 2016, the number of active members of PHENIX has decreased
 - Start of sPHENIX in 2023 could reinforce this trend
- Resources are needed for analysis and publication of key physics topics
 - Continuing support in BNL physics (both senior and postdoc)
 - Requesting DOE for additional resource for three key unfunded analysis
- More resources are needed for data preservation
 - Current level (0.5FTE NPPS expert FTE) is not sufficient
 - The collaboration is working with the lab on identifying additional help with data preservation

Summary

- PHENIX completed its data taking in RUN16
- Publication status
 - PHENIX continues to produce high impact results
 - We will complete publication of major results by 2023 (sPHENIX start)
- Towards completion of Data analysis and preservation
 - nDST production completed
 - DAP page to preserving the knowledge of PHENIX data analysis
 - REANA: successfully capture realistic analysis (d+Au direct photon)
 - PHENIX School