PHENIX Status

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RHIC S and T review
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BROOKHAVEN NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY

Publication Status

PHENIX

PHENIX papers since May 2018 (QM18)

PRL123,022301	(2019)	Scaling of low p_T direct photon yield
PRD99,092003	(2019)	$b \to e$ and $c \to e$ in pp at 200 GeV
PRC99,054903	(2019)	Two particle correlation with respect to event plane
PRC99,044912	(2019)	π^0 -hadron correlation in pp and pA
PRD99,072003	(2019)	dimuons from Drell Yan and bb decays in $p+p$ 200 GeV
PRC99,204903	(2019)	Event-by-event elliptic flow in AuAu 200 GeV
Nature P 15,214	(2019)	Evidence for Small QGP droplet
PRL121,022301	(2018)	$dN_{ch}/d\eta$ and v_2 in small systems
PRC98,054903	(2018)	π^0 and η in Cu+Au 200 GeV
PRC98,054902	(2018)	Low p_T direct photons in Cu+Cu
PRD98,092006	(2018)	$\phi \to \mu\mu$ in $p+p$ 510 GeV
PRD98 072004	(2018)	Direct photon and hadron correlation in $p+p$ 200 GeV
PRD98,032007	(2018)	A_L of $W \to \mu$
PRD98,012006	(2018)	A_N of forward J/ψ in p+A
PRC98,014912	(2018)	Long range correlation of high p_T hadrons in pp and d+Au
PRC97,064911	(2018)	HBT Levy fit analysis
PRC97,064904	(2018)	Identified hadron v_2 in pAu and ^{3}HeAu
arXiv:1903 07422		Forward hadron A_N in pAu (PRL proof)
arXiv:1906.09928		Forward hadron R_{pA}
arXiv:1805.04066		$\mu\mu, e\mu, ee$ correlations in $p+p$ 200 GeV

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Publication since May 2018

- 17 papers published + 1 in proof
  - Nature Physics: small QGP droplets
    - First PHENIX paper accepted by Nature Physics
  - PRL: v_2 and $\frac{dN_{ch}}{d\eta}$ in p+A, d+Au, and ^{3}He+Au
  - PRL : scaling of low p_T direct photon yield
  - PRL proof:Suppression of A_N of hadrons in $p + A$
  - PRD: $b \to e$ and $c \to e$ in $p + p$
- 2 papers in journal review. Expect that they will be accepted soon
  - PRD(review) $ee, \mu\mu, e\mu$ correlations in pp 200 GeV
  - PRC(review) R_{pA} of forward hadrons at 200 GeV

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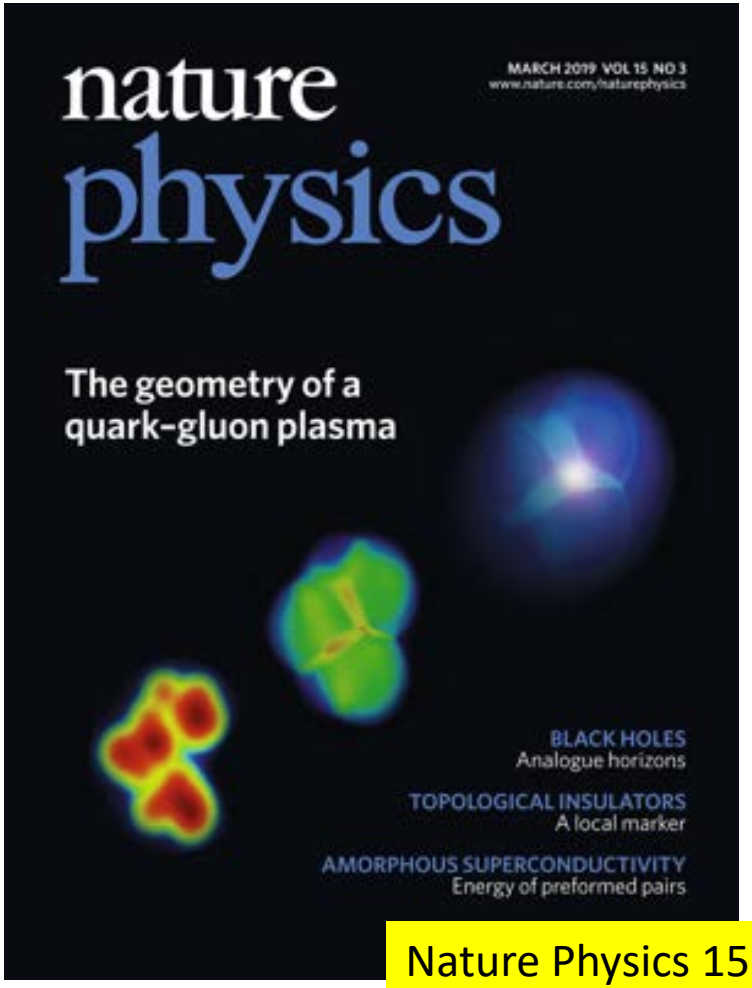
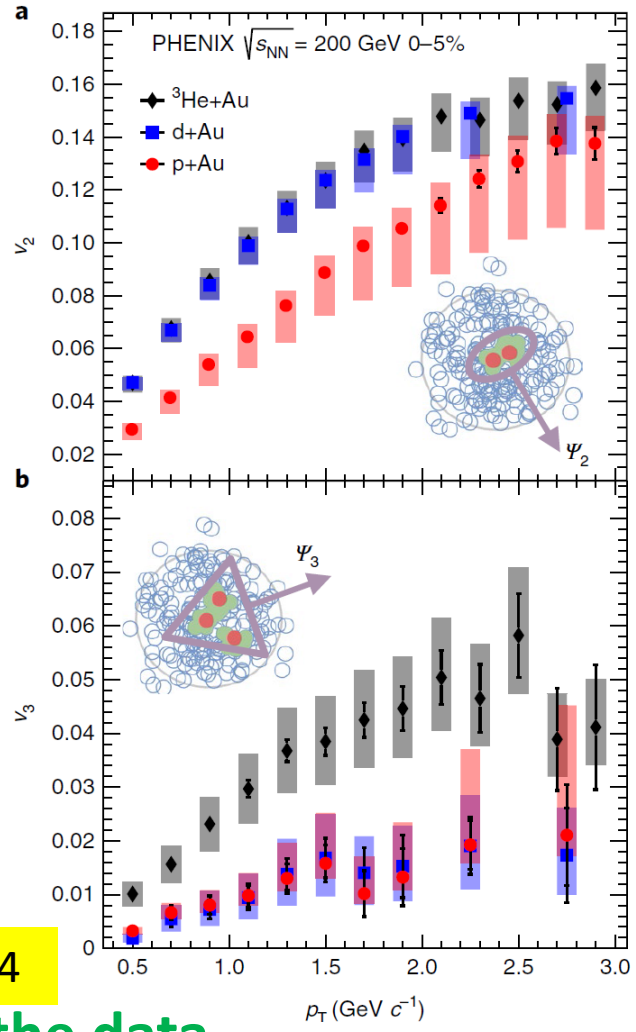
Evidence for small QGP droplets

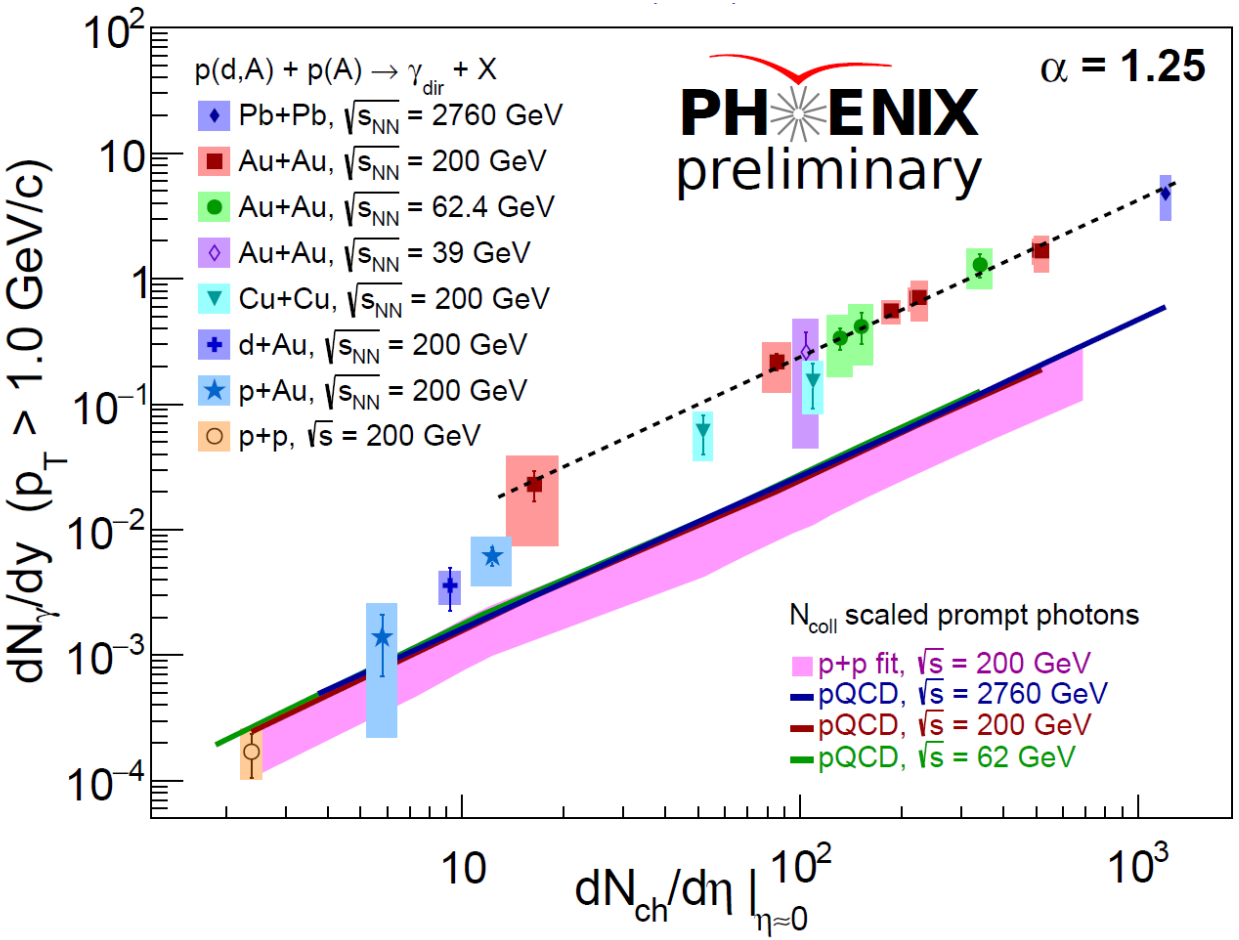


Nature Physics 15(2019) 3,214



- **Formation of QGP droplets describes the data**
  - **There is *no viable alternative*-theoretical explanation of the data**
- **Featured in the cover of March 2019 issue of Nature Physics**

Low p_T direct photons



AuAu
PRL123 022301(2019)

Cu+Cu
PRC98 054902(2018)

p+A QM2018 prelim

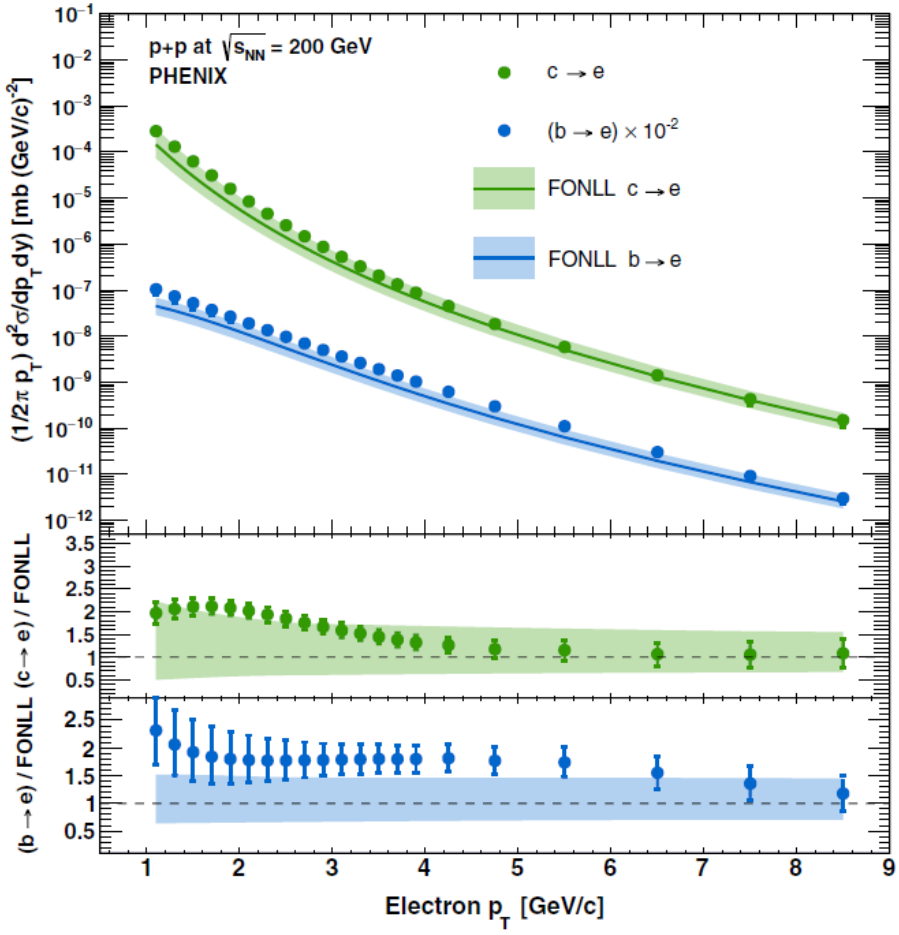
- Scaling means similar photon source across beam energies

→ Most photons are emitted at the phase transition
Au+Au paper is accepted by PRL (in proof). Cu+Cu paper published

- Evidence for Photon enhancement in $p + A$ and d+Au

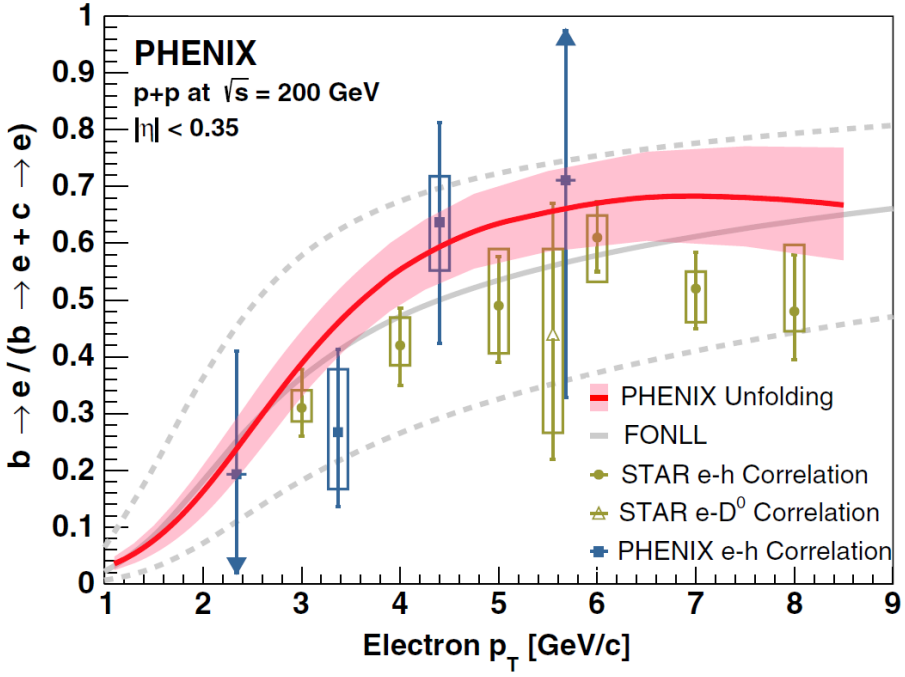
→ Support QGP formation in small systems

$b \rightarrow e$ and $c \rightarrow e$ in $p + p$



PHYSICAL REVIEW D **99,** 092003 (2019)

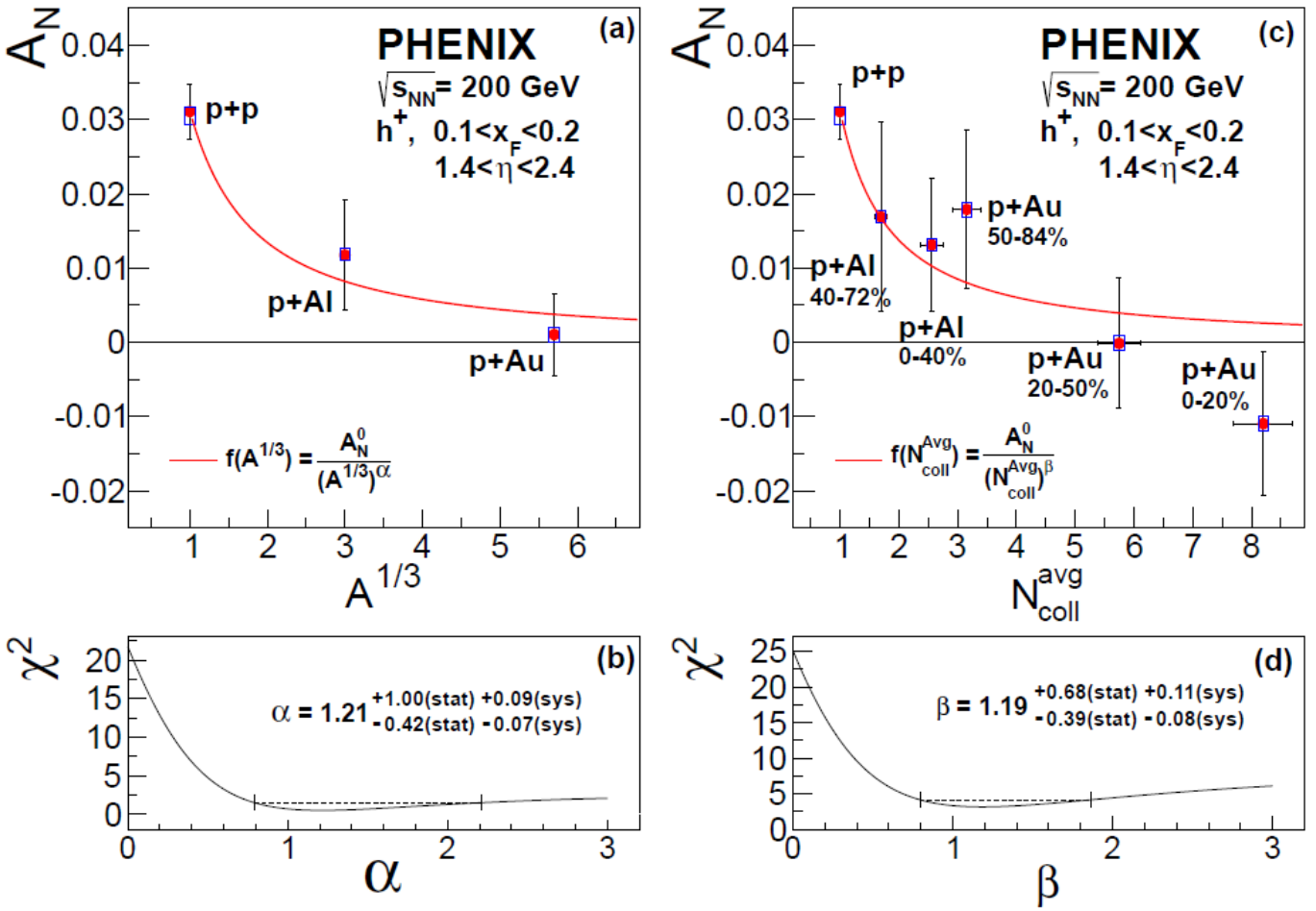
Measurement of charm and bottom production from semileptonic hadron decays in $p+p$ collisions at $\sqrt{s}=200$ GeV



- $b \rightarrow e$ and $c \rightarrow e$ are separated by VTX
- Baseline for R_{AA} of $b \rightarrow e$ and $c \rightarrow e$

Suppression of A_N in p+A

arXiv:1903.07422



A_N of positive hadrons in pAu is suppressed compared with p+p

A-independence hypothesis of TSSA is clearly disfavored

PRL proof

PHENIX publications

- **195 physics papers published/accepted**
  - Phys. Rev. Lett. 73+1
  - Phys. Rev. C 79
  - Phys. Rev. D 36
  - Nature Physics 1
  - Phys. Letter B 4
  - Nucl. Phys. A 1
- **Total citation: ~27000**
- Topcite 1000+ 2
  - 500-1000 6
  - 250-500 19
  - 100-250 50
  - 50-100 43

PHENIX White Paper: 2718 cites

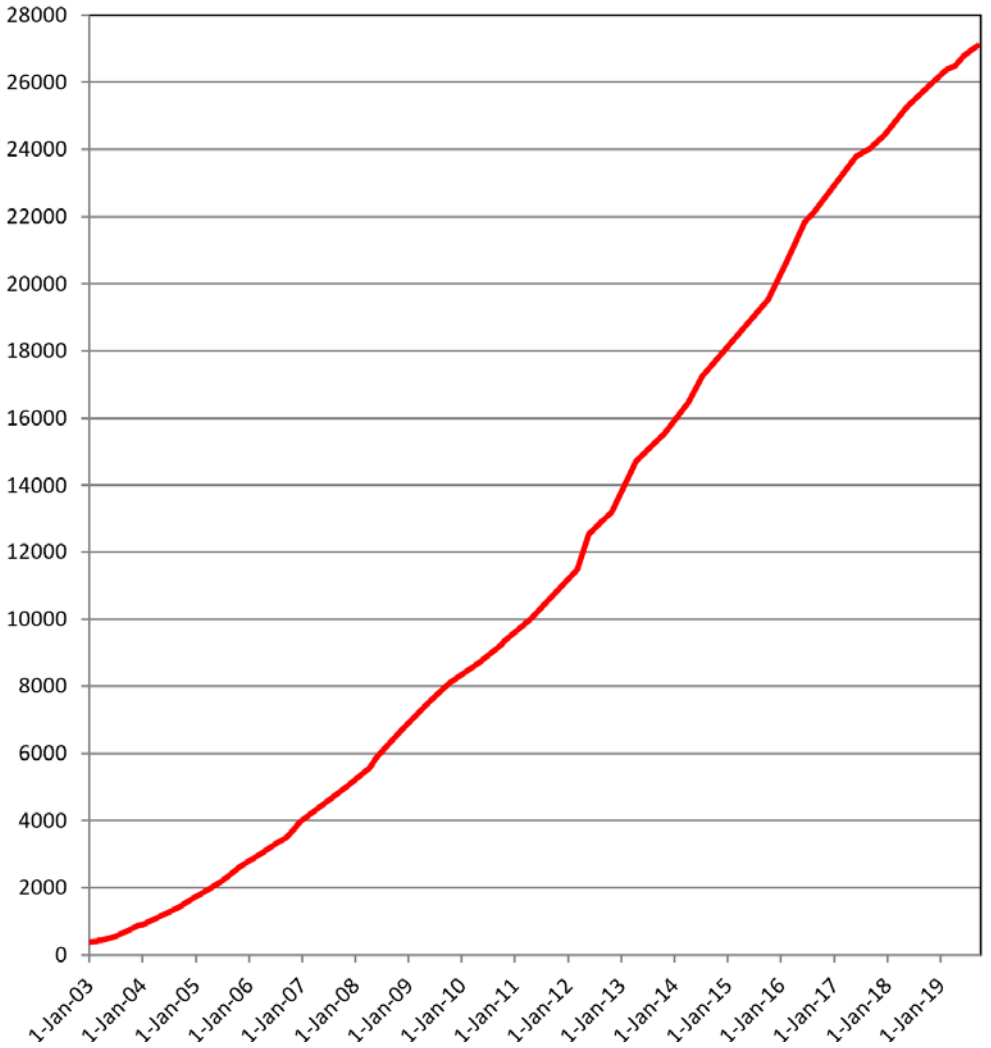
Jet quenching discovery: 1046 cites

Nature P paper: 53 citations

120 physics papers in topcite 50+

(141 if proceedings and NIM papers are included)

Cumulative Citations of PHENIX papers



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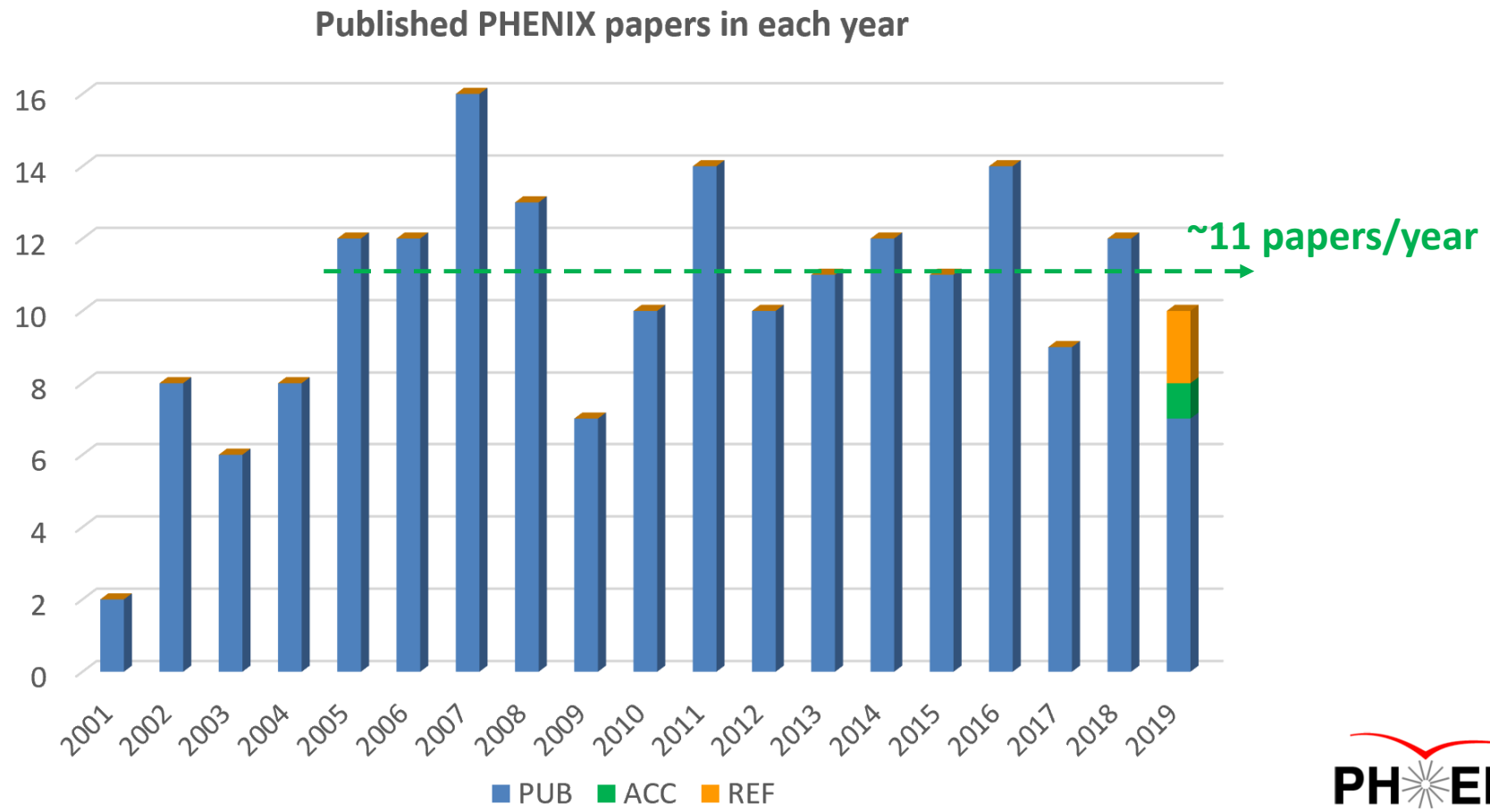
PHENIX publications

- ~11 papers per year since 2005
- 7 papers published in 2019 so far (+1 accept + 2 in review)
- Complete publication of major results by 2023



Data analysis Status and outlook

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

Many physics topics with variety of high statistics datasets

3 years to complete publication of key results

Data Production Status

RUN	beam	VTX/FVTX/Muon (heavy flavor)	Central Arm flow	Central Arm EM (γ, e)	MPC/EX (small-x)
16	Au+Au 200	**Starting**	**DONE**	**DONE**	N/A
	d+Au BES	Needs calibration, 2019	**DONE**	**DONE**	calibration
15	p+p 200	**DONE**	**DONE**	**DONE**	N/A
	p+Au 200	**DONE**	**DONE**	**DONE**	
	p+Al 200	N/A	**DONE**	**DONE**	
14	Au+Au 200	**DONE**	**DONE**	**DONE**	N/A
	3He+Au 200	2019	**DONE**	**DONE**	

- Run16AuAu ~ 6 months of CPU

Focus on key analysis topics

- PHENIX has variety of high statistics data from RUN10 to RUN16
- Physics output is limited by the analysis workforce, not the amount of the data.
- It is important to focus on important physics topics that PHENIX has strength
  - Flow in large and small system
  - Low p_T direct photons
  - High p_T direct photons
  - Open HF (VTX/FVTX)
  - Quarkonia
  - Direct photon – jets correlation
- Extract property parameters (η/s , $\hat{q}$, $\Delta E(L)$, …) of QGP and PDF from “global analysis”.

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Workforce for PHENIX analysis

- Current workforce (Survey spring 2019)

MA/MS student	3.0	FTE
PhD students	31.3	FTE
Postdocs	5.8	FTE
Senior Scientist	3.9	FTE
Total	44.0	FTE

- US University groups are committed in PHENIX analysis now. They are moving to sPHENIX
  - sPHENIX start taking data in CY2023
- Maintaining the current level of workforce for PHENIX analysis is essential to complete all Key analysis before the start of sPHENIX
- Additional resource to the US University groups of PHENIX would be very effective

Need for service work of analysis

- Service works for data analysis are essential to keep the physics analsys productivity
  - Recalibration
    - Many recalibrators not ready for recent runs
    - Vital for high statistics RUN14-16 data
  - Documentation
    - Good documentation is needed to keep the data analyzable in future
  - Simulation
    - Tuning of PHENIX Geant3 simulator for each runs
- Need additional resource in the US University groups of PHENIX

Summary

- PHENIX completed its data taking in RUN16
  - Removal and Repurposing is basically completed
- Publication status
  - PHENIX continues to produce high impact results
    - Publishing ~11 papers per year, ~2000 citations/year
  - highlights
    - Evidence for small QGP droplets in small systems
    - Scaling of low pT direct photon
    - b and c production in p+p
    - Suppression of AN in pA
- Status of Data analysis and outlook
  - DST production except for heavy flavor measurement in RUN16 are basically completed
  - Physics output is limited by workforce for the analysis
  - Many on-going physics analysis topics
  - Keeping the level workforce is essential to complete key analyses before the start of sPHENIX

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