

25 Years of PHENIX

W.A. Zajc
Physics Department
Columbia University, New York, NY

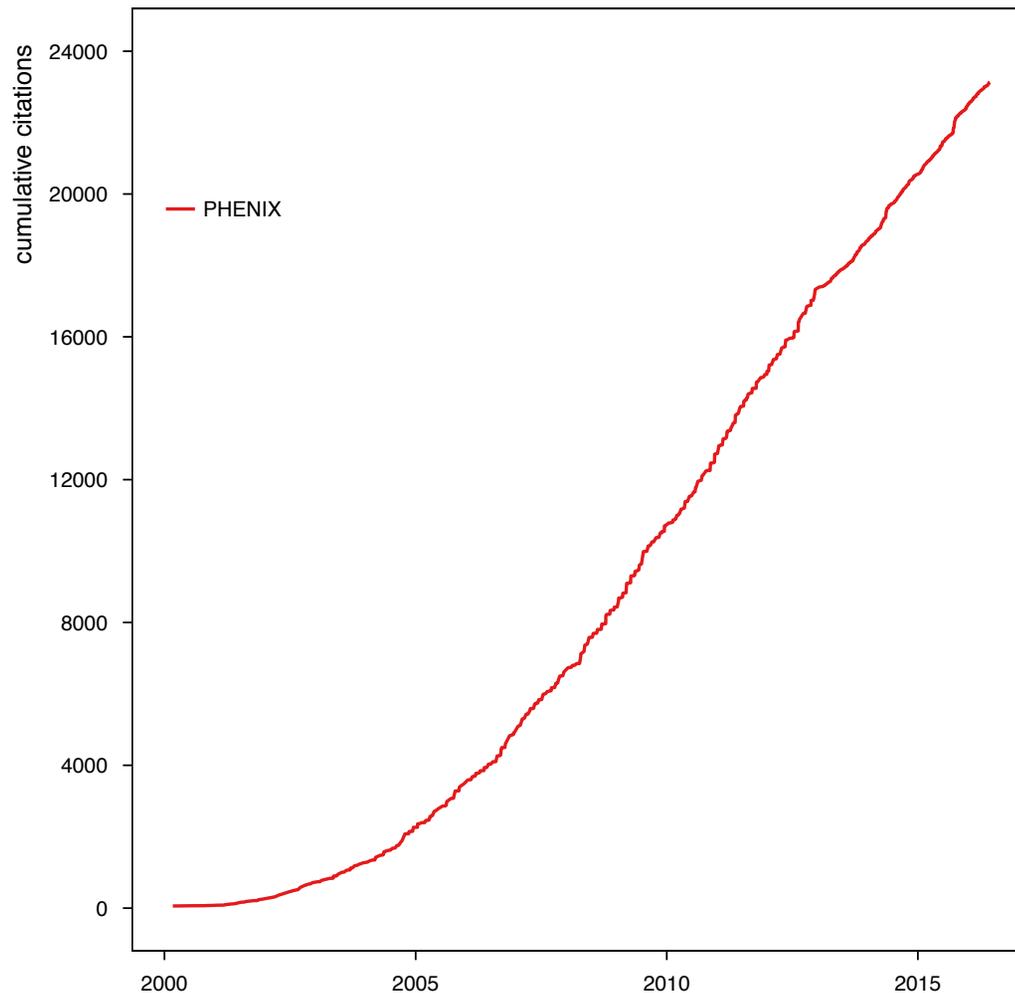
Thanks to
John Haggerty, Hubert van Hecke, Dave Morrison, Jamie Nagle, Ilya Ravinovich,
Baldo Sahlmueller, Walter Sondheim, Ralf Seidl



An Important Number

- 525,948.766

- **525,948.766** = $\frac{25 \text{ Years}}{25 \text{ Minutes}}$





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ASSOCIATED UNIVERSITIES, INC.

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Office of the Director

September 9, 1991

Prof. P. Braun-Munzinger Department of Physics SUNY-Stony Brook Stony Brook, NY 11794-3800	Prof. S. Nagamiya Department of Physics Columbia University 538 West 120th Street New York, NY 10027	Dr. G. Young MS 373 Oak Ridge National Laboratory P.O. Box X, Bldg. 6003 Oak Ridge, TN 37830
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Dear Peter, Shoji and Glenn:

This is to confirm the discussion we had on Tuesday, September 3, 1991 regarding the decisions made by the Program Advisory Committee with respect to your RHIC Letters of Intent.

1. The Committee decided to reject all three of the Letters of Intent because of what were felt to be major deficiencies in each of them.
2. The Committee decided to place the emphasis on a detector designed to study electrons and photons emerging from the QGP. In this regard, it will address some of the basic physics interests of each of your groups.
3. The Laboratory has appointed Sam Aronson as Spokesman and Project Director with the charge of developing a new collaboration to design and build such a detector. We strongly urge each of you and your current respective collaborators to join in this effort. Those of you who are primarily interested in hadron physics will be welcomed by the STAR collaboration which has been empowered to build a large TPC detector.
4. The Laboratory is prepared to contribute at most \$50 million to the design and construction of this detector. Hopefully, you can find resources outside of the Laboratory to augment this sum.
5. It is hoped that the new collaboration can present a conceptual design to the Technical Advisory Committee in mid December. Sam Aronson will have final authority as to the technical and scientific content of the proposal. He is in the process of forming an advisory committee composed primarily of the leadership of the three former collaborations to assist in the conceptual design.

Although I realize that each of you is very disappointed, I hope that you will find it possible to become a part of this effort. We need all of you in order to maximize our probability of success.

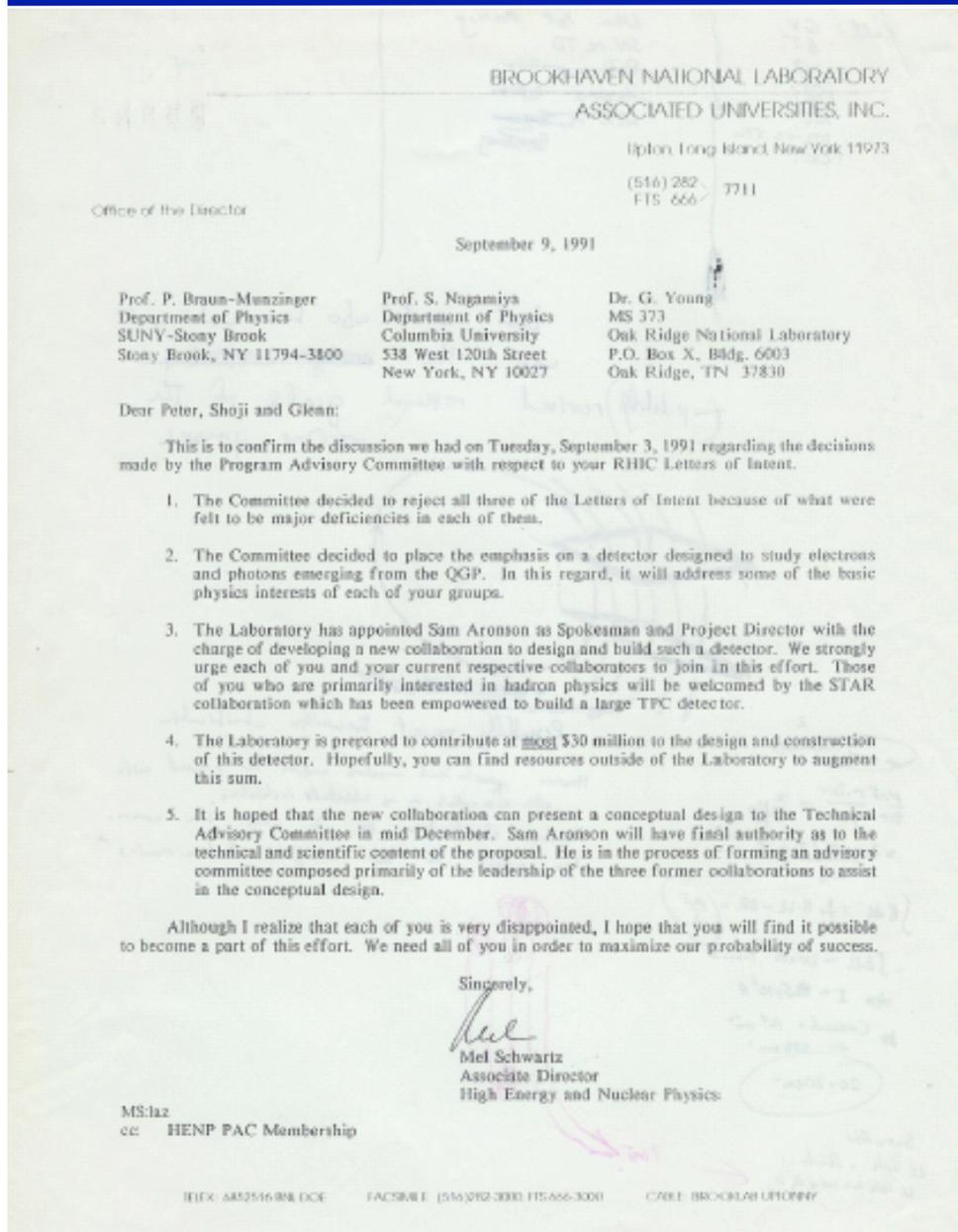
Sincerely,

Mel Schwartz
Associate Director
High Energy and Nuclear Physics

MS:laz
cc: HENP PAC Membership

TELEX: 4852516 BNL DCE FACSIMILE: (516) 282-3000 (516) 282-3000 CABLE: BROOKLAB UPTON NY





- RIP:

- Dimuon
- TALES/SPARC
- OASIS

- Née

- RE2
- “RHIC Experiment 2”

1991 Labor Day Massacre

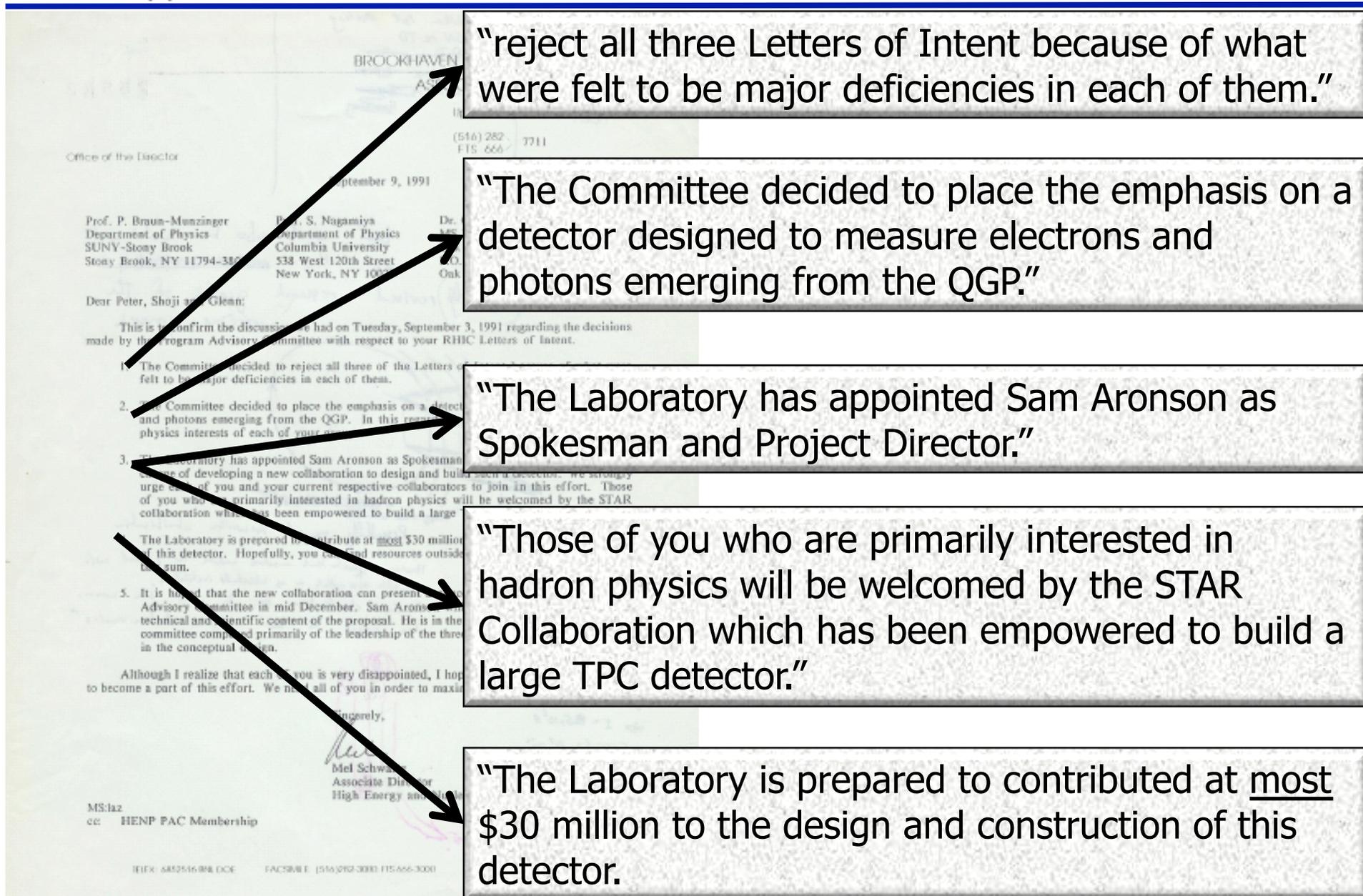
"reject all three Letters of Intent because of what were felt to be major deficiencies in each of them."

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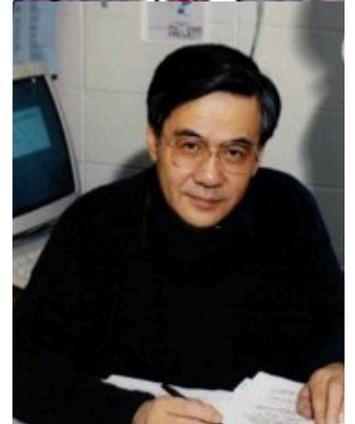
"Those of you who are primarily interested in hadron physics will be welcomed by the STAR Collaboration which has been empowered to build a large TPC detector."

"The Laboratory is prepared to contribute at most \$30 million to the design and construction of this detector."



- Dominated by the struggles you can easily imagine that follow from forced marriage of three major experiments...

- Most significant event: Profoundly wise decision by Sam Aronson to separate Project Director and Spokesperson → *Shoji Nagamiya*



BROOKHAVEN

PHENIX: 10-Mar-94 (STAR: Jan-93)

The PHENIX Has Risen: Second Major RHIC Experiment Approved

Following a successful two-day review of the cost and schedule proposed for the Pioneering High Energy Nuclear Interaction Experiment, the detector known for short as PHENIX was approved on March 10 as the second major experiment for BNL's Relativistic Heavy Ion Collider (RHIC).

In the search for quark-gluon plasma at RHIC, PHENIX will be competing with STAR, which is short for the Solenoidal Tracker at RHIC and which was approved in January 1993.

Despite nearly a year's lead time for STAR, both detectors are expected to be ready to "do RHIC physics on the day the machine turns on in 1999," says Thomas Ludlam, RHIC Associate Head for Detectors & Experiments.

"By the nature of the physics we will be investigating, our detector is very complex, but we now understand how to build it within budget and on time," comments Shoji Nagamiya, PHENIX Spokesman and a professor of physics at Columbia University.

In giving its approval to PHENIX, "The Technical Advisory Committee [TAC] was quite satisfied that all the budget, scheduling and management questions that were raised last November have been answered," continues Ludlam, who convenes this committee. "This review has allowed us to get the most physics for our dollar, and, in the process, the physics has been strengthened."

After PHENIX's conceptual design report was approved last February by the RHIC Program Advisory Committee,



estimate to Ludlam's TAC last November. At that time, however, the committee gave the experimenters five more months to reduce the cost of their detector by \$4.5 million.

"Instead of turning off any of the major subsystems, we tightened everything, especially the electronics and data-acquisition system," comments Sam Aronson, PHENIX Project Director, Physics Department. "While we won't be able to install as much of the detector as we had initially hoped, we will still be able to handle all the

physics that RHIC day one until the design intensity. This is expected, we will need additional funds to cover the components."

While some \$36.7 million is now available from RHIC construction funds to build PHENIX, the actual cost of the detector is approximately \$70 million. To cover the other half of the bill, PHENIX management enlisted collaborators from Japan, Russia, Germany and elsewhere in the U.S.,

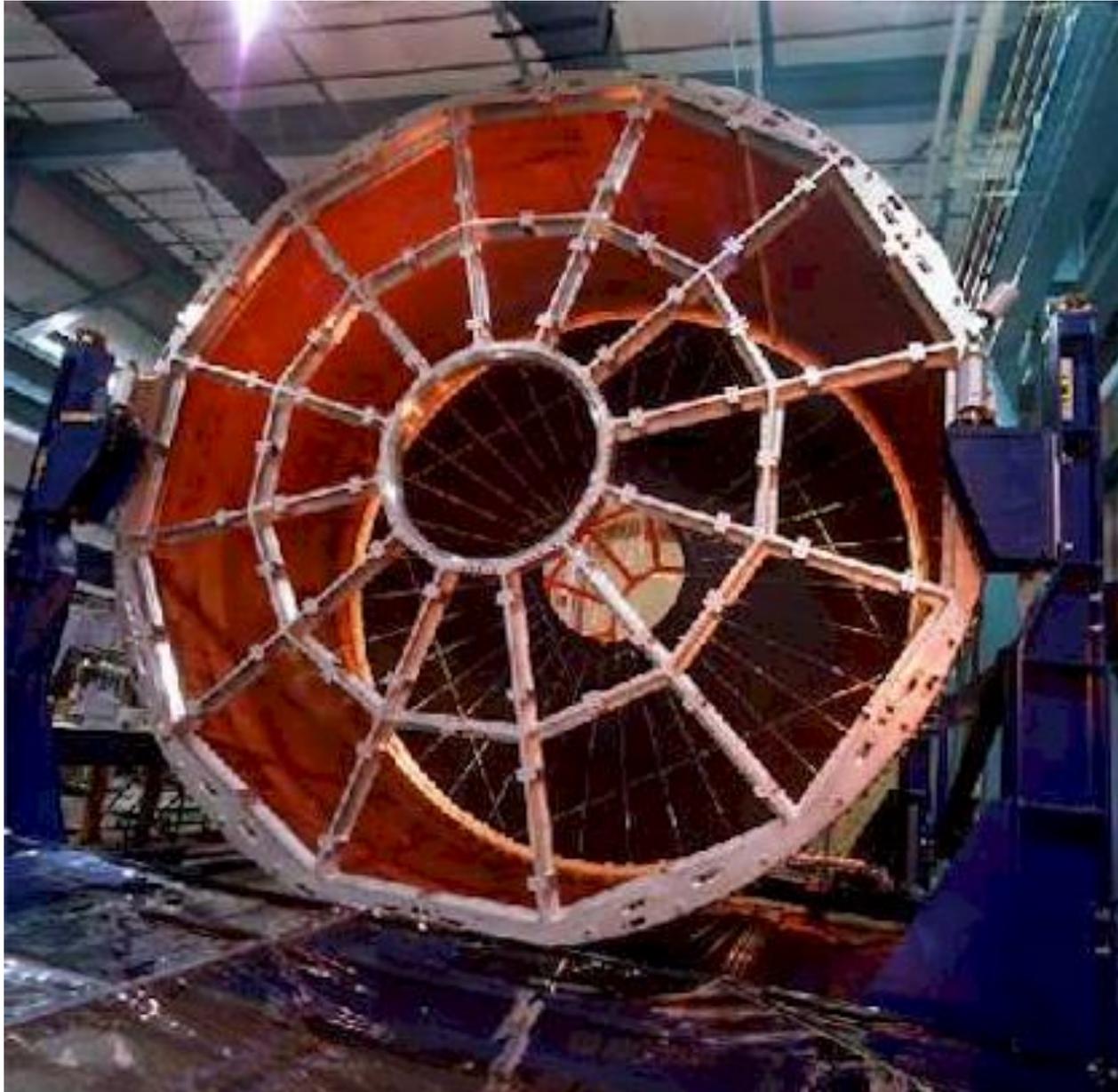
Despite nearly (sic) a year's lead time for STAR, both detectors are expected to be ready to "do RHIC physics on the day the machine turns on in 1999".

up of 12 heads of the detector's major subsystems, which is chaired by Aronson and meets every month or two. In addition, the entire collaboration gathers twice a year to review its progress, with the next meeting scheduled for this August at BNL.

(To reduce costs) "Instead of turning off any of the major subsystems, we tightened everything, especially the electronics and data acquisition system".

Chemist F. Sherwood Rowland, of the University of California, Irvine, will give an AUI Distinguished Lecture on Tuesday, March 29. His talk on "The Depletion of Stratospheric Ozone by Chlorofluorocarbons" will be held at 4:30 p.m. in Berkner Hall.

Tenure for Three Brookhaven Researchers





- Mar-97, Costa Mesa workshop: Abandon all tracking, just measure neutral mesons in calorimeter??
 - No !
- Jul-98: Ames meeting – too much experiment left at the end of the money...

Guidance

PH^{*}ENIX

“That which does not kill us, makes us stronger.”

(Friedrich Nietzsche)

“A man's got to know his limitations.”



You can't always get what you want

But if you try sometime

Yeah, you just might find

You get what you need

(Jagger/Richard)



Well, less is more, Lucrezia...

Ah, but a man's reach should exceed his grasp,

Or what's a heaven for? ...

(Robert Browning, 1855)

- Mar-97, Costa Mesa workshop: Abandon all tracking, just measure neutral mesons in calorimeter??
 - No !
- Jul-98: Ames meeting – too much experiment left at the end of the money...

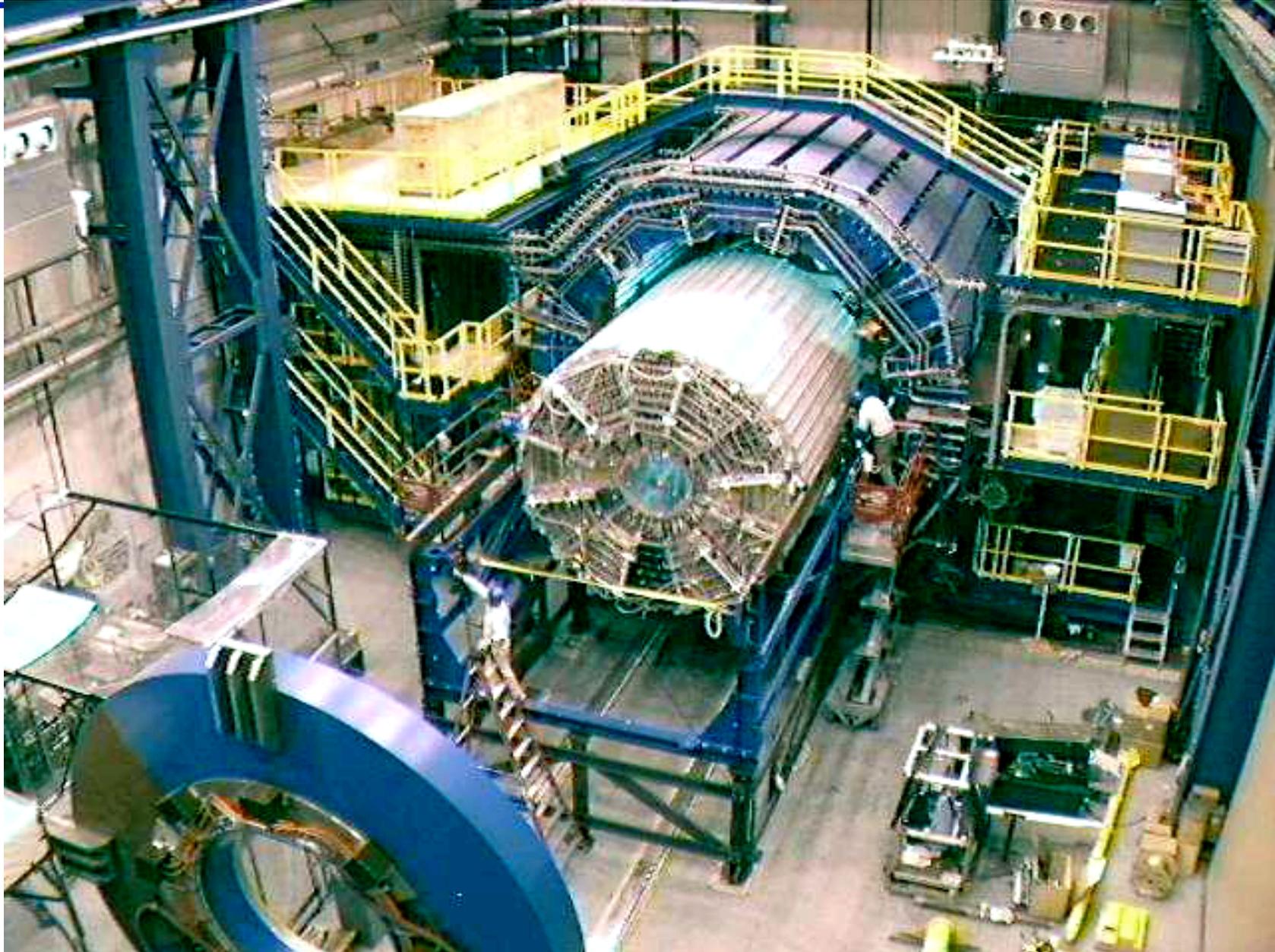
The PHENIX logo, identical to the one on the main slide, is positioned at the top left of the box.

Real Guidance

- Our reach has exceeded our grasp
- We can count on funds only up to our grasp
- We must have a clear set of principles from which to prioritize:
 - We must have a Year-1 physics capability
 - That physics must be matched to (expected) machine ramp-up
 - That physics should (ideally) be
 - ◆ of maximal impact
 - ◆ unique
 - We must not make decisions now that later cripple completion of PHENIX

PH  **ENIX**

STAR Circa Nov-98



- Some assembly required



- Several month RHIC schedule delay
 - (Mechanically unstable vacuum pipe support inside cryostat for short corrector magnet...)
- 18-Oct-99: (Public) **“The recently announced delay of the RHIC schedule provides us with an opportunity to make ready a significant fraction of the Baseline detector for the very start of RHIC operations.”**
- (Private): **“should be a call to arms to come and help in this last ditch effort to even the playing field with the other experiments!”**

PH  **ENIX**

First Event 15-Jun-00 !



PHENIX

Just a Few Months Later





Data Debut at QM01



PHENIX OVERVIEW

W.A. Zajc

Columbia University
for the PHENIX Collaboration

PHENIX QM01: 1st Jet Quenching Result



Central vs. Peripheral Yields

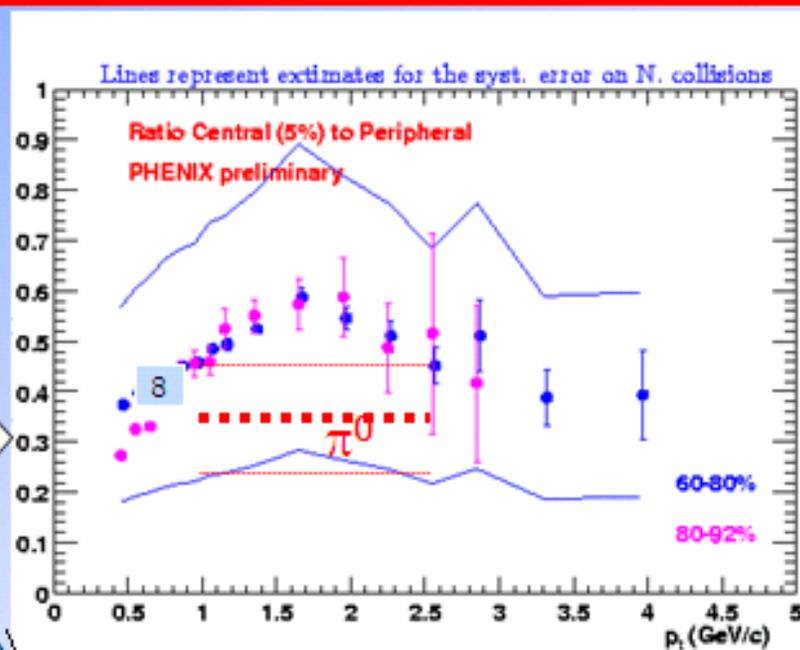
- Can study relative yields within the data set:

- Compare central to peripheral spectra vs. p_T
- Scale by the average number of collisions

$$\text{Ratio} = \frac{\text{Yield(Central)} / \langle N_{\text{COLL}}(\text{Central}) \rangle}{\text{Yield(Peripheral)} / \langle N_{\text{COLL}}(\text{Peripheral}) \rangle}$$

- Ratio unity if yields scale as number of collisions
- Ratio found to be less than 1, decreasing for $p_T > 2$ GeV/c
- Same is observed in π^0 analysis (very different systematics)

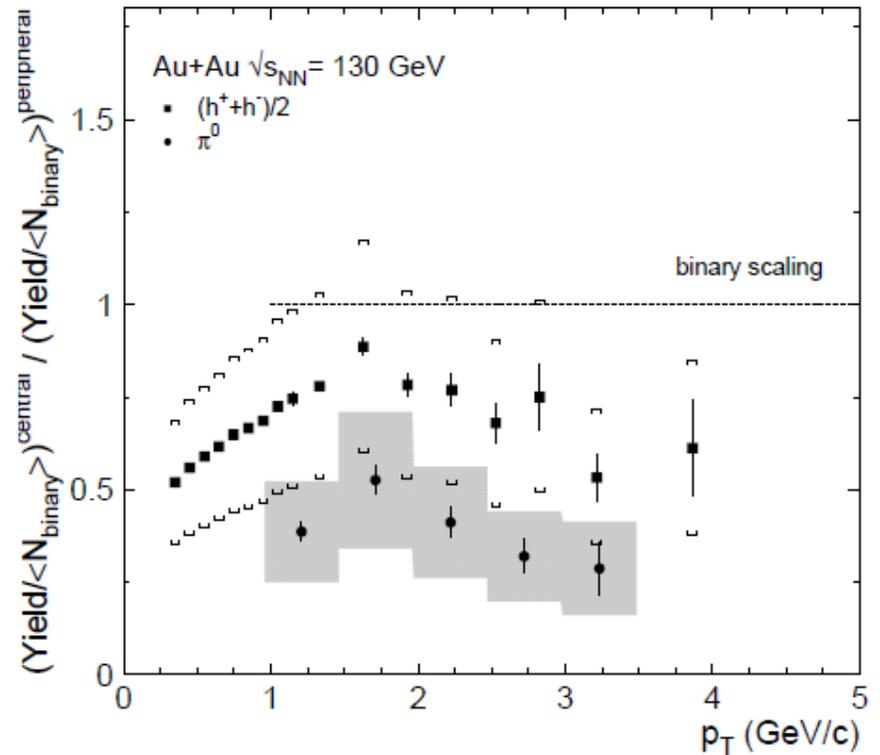
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3

2

- Suppression of hadrons with large transverse momentum in central Au+Au collisions at $\sqrt{s_{NN}} = 130$ GeV. (K. Adcox et al.). Phys.Rev.Lett. 88:022301,2002. e-Print: [nucl-ex/0109003](https://arxiv.org/abs/nucl-ex/0109003)



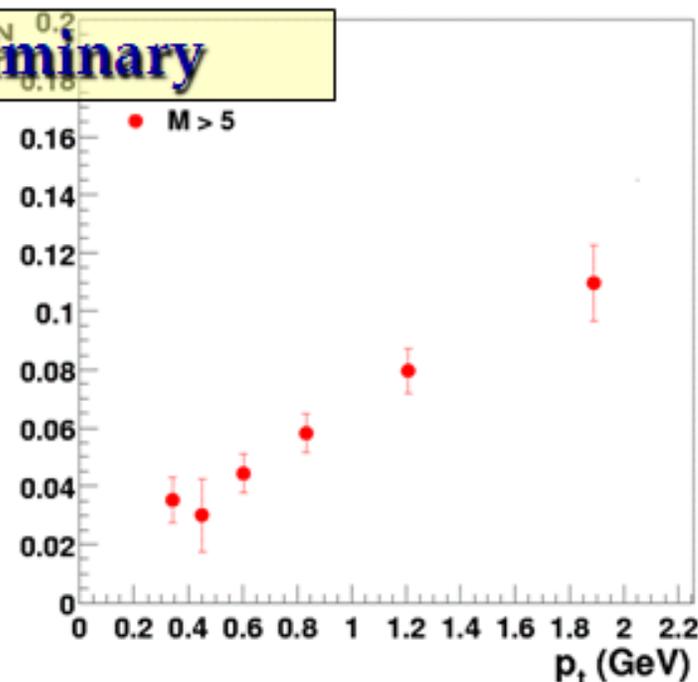
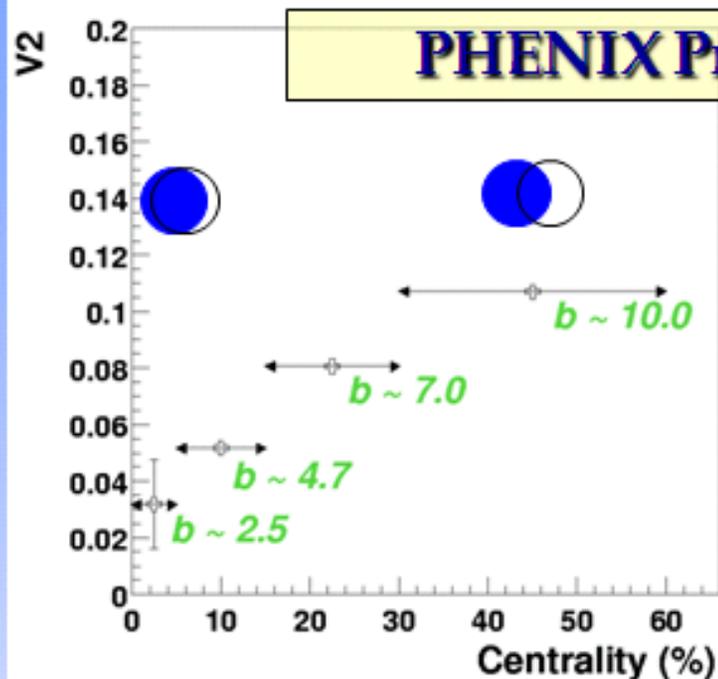
- 922 citations

Elliptic Flow

- Extract v_2 's from $C(\Delta\phi)$
- Qualitative trends consistent with STAR results

Wednesday, Parallel Session II

R. Lacey: *Elliptic Flow Measurements with the PHENIX Detector System*



- PHENIX detector has provided outstanding data in first year of RHIC operations
 - Measured
 - ◆ Charged multiplicity
 - ◆ Transverse energy
 - ◆ Elliptic flow
 - ◆ Identified particle spectra
 - ◆ HBT parameters
 - ◆ High p_T spectra
 - ◆ Inclusive electron spectrum
 - ◆ (more)
 - Observed
 - ◆ Role of hard scattering
 - ◆ Intriguing systematics in high p_T particle yield
- *Ideally positioned to dramatically extend these results in second year of RHIC running*

PHENIX “Hadrons in RE2” 10 year later

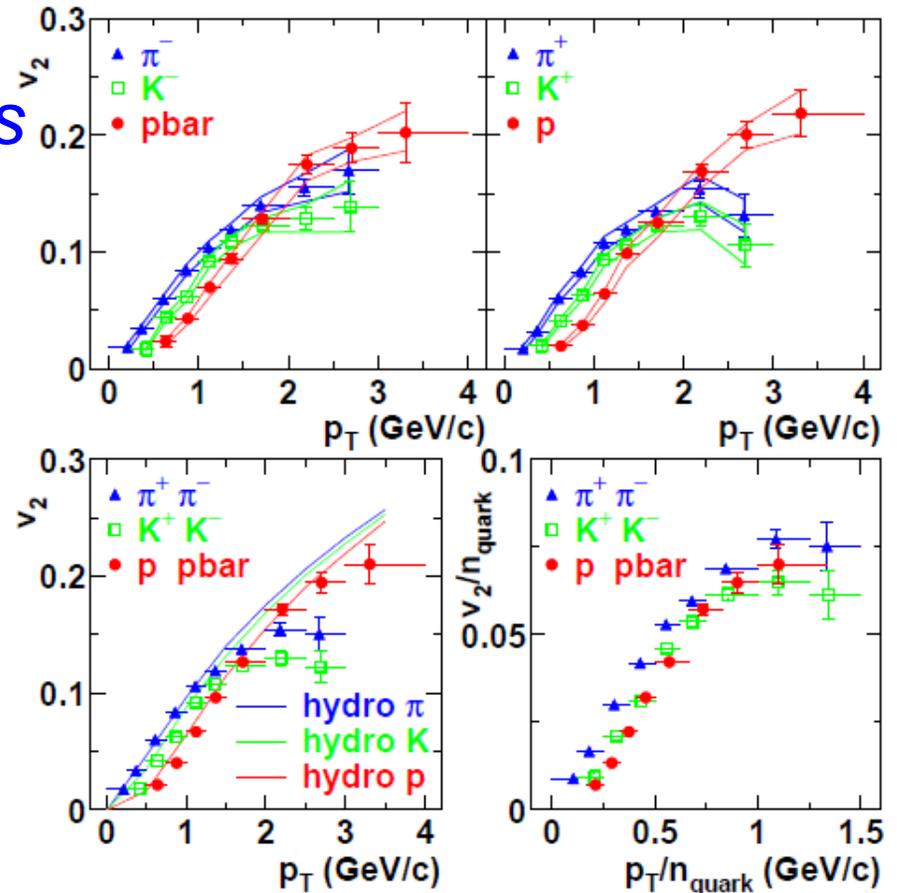
- *Elliptic flow of identified hadrons in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV.*

(Stephen Scott Adler et al.)

Phys.Rev.Lett.**91**:182301,2003.

[nucl-ex/0305013](https://arxiv.org/abs/nucl-ex/0305013)

- 685 citations



“Those of you who are primarily interested in hadron physics will be welcomed by the STAR Collaboration which has been empowered to build a large TPC detector.”

Hunting the Quark Gluon Plasma

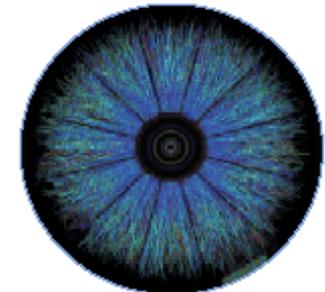
RESULTS FROM THE FIRST 3 YEARS AT RHIC

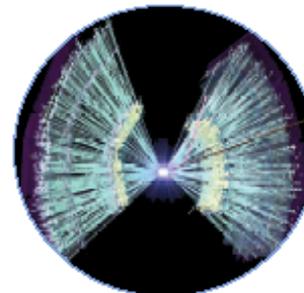
ASSESSMENTS BY THE EXPERIMENTAL COLLABORATIONS

April 18, 2005

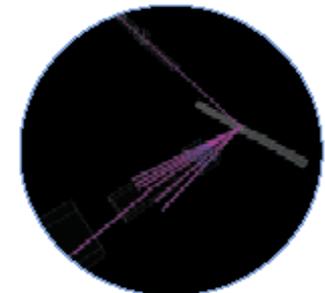


PHOBOS

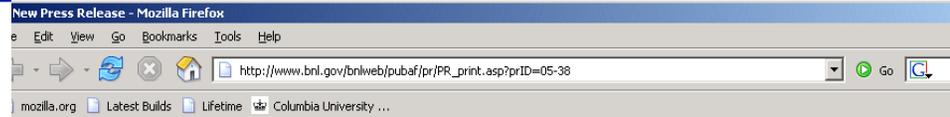




PHENIX




Relativistic Heavy Ion Collider (RHIC) • Brookhaven National Laboratory, Upton, NY 11974-5000



Close Window



Contact: Karen McNulty Walsh, (631) 344-8350 or Mona S. Rowe, (631) 344-5056

RHIC Scientists Serve Up "Perfect" Liquid

New state of matter more remarkable than predicted -- raising many new questions

April 18, 2005

TAMPA, FL -- The four detector groups conducting research at the [Relativistic Heavy Ion Collider](#) (RHIC) -- a giant atom "smasher" located at the U.S. Department of Energy's Brookhaven National Laboratory -- say they've created a new state of hot, dense matter out of the quarks and gluons that are the basic particles of atomic nuclei, but it is a state quite different and even more remarkable than had been predicted. In [peer-reviewed papers](#) summarizing the first three years of RHIC findings, the scientists say that instead of behaving like a gas of free quarks and gluons, as was expected, the matter created in RHIC's heavy ion collisions appears to be more like a *liquid*.

"Once again, the physics research sponsored by the Department of Energy is producing historic results," said Secretary of Energy Samuel Bodman, a trained chemical engineer. "The DOE is the principal federal funder of basic research in the physical sciences, including nuclear and high-energy physics. With today's announcement we see that investment paying off."



Secretary of Energy Samuel Bodman

"The truly stunning finding at RHIC that the new state of matter created in the collisions of gold ions is more like a liquid than a gas gives us a profound insight into the earliest moments of the universe," said Dr. Raymond L. Orbach, Director of the DOE Office of Science.

Also of great interest to many following progress at RHIC is the emerging connection between the collider's results and calculations using the methods of string theory, an approach that attempts to explain fundamental properties of the universe using 10 dimensions instead of the usual three spatial dimensions plus time.

"The possibility of a connection between string theory and RHIC collisions is unexpected and exhilarating," Dr. Orbach said. "String theory seeks to unify the two great intellectual achievements of twentieth-century physics, general relativity and quantum mechanics, and it may well have a profound impact on the physics of the twenty-first century."



The papers, which the four RHIC collaborations ([BRAHMS](#), [PHENIX](#), [PHOBOS](#), and [STAR](#)) have been working on for nearly a year, will be published simultaneously by the journal *Nuclear Physics A*, and will also be compiled in a [special Brookhaven report](#). The Lab announced at the April 2005 meeting

blog.inspirebeta.net/2011/06/topcited-hep-paper-of-all-time.html

INSPIRE

News and updates from INSPIRE - the information management system for High Energy Physics

WEDNESDAY, JULY 13, 2011

The topcited HEP paper of all time.

For as long as the annual [topcited papers](#) lists have been around, the all-time champion has been Weinberg's "A model of leptons", the 1967 paper that laid the foundation stone for the Standard Model. 30 years later, in November of 1997, the paper [The Large N limit of superconformal field theories and supergravity](#) by Maldacena appeared that established a connection between string theory and quantum field theory. It immediately set of a revolution in HEP and was the most highly cited paper ever since. Remarkably, its [highest citation count](#) was in 2010, where it received over 1,000 citations in a single year! One reason for this is [the heavy ion results](#) from Brookhaven that drew people to conclude that, based on Maldacena's work, the quark-gluon plasma can be modeled using string theory techniques.

Posted by Heath O'Connell at 12:50 AM

2 people +1'd this

0 comments:

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BLOG ARCHIVE

- 2011 (10)
 - November (1)
 - October (2)
 - September (1)
 - August (1)
 - July (3)



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Energy Loss and Flow of Heavy Quarks in Au+Au Collisions at $\sqrt{s(NN)^{1/2}} = 200\text{-GeV}$.

PHENIX Collaboration (A. Adare (Colorado U.) *et al.*) [Show all 421 authors](#).

Nov 2006
6 pp.

Phys.Rev.Lett. 98 (2007) 172301
e-Print: [nucl-ex/0611018](#)

Abstract: The PHENIX experiment at the Relativistic Heavy Ion Collider (RHIC) has measured electrons from heavy flavor (charm and bottom) decays for $0.3 < p_T < 9$ GeV/c at midrapidity ($|\eta| < 0.35$) in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. The nuclear modification factor R_{AA} relative to p+p collisions shows a strong suppression in central Au+Au collisions, indicating substantial energy loss of heavy quarks in the medium produced at RHIC. A large azimuthal anisotropy, v_2 , with respect to the reaction plane is observed for $0.5 < p_T < 5$ GeV/c indicating non-zero heavy flavor elliptic flow. Both R_{AA} and v_2 show a p_T dependence different from those of neutral pions. A comparison to transport models which simultaneously describe $R_{AA}(p_T)$ and $v_2(p_T)$ suggests that the viscosity to entropy density ratio is close to the conjectured quantum lower bound, i.e., near a perfect fluid.

Keyword(s): [INSPIRE: nucleus nucleus: colliding beams](#) | [scattering: heavy ion](#) | [gold](#) | [charm](#) | [bottom](#) | [quark: hadroproduction](#) | [quark: decay](#) | [electron: yield](#) | [elliptic flow](#) | [multiple scattering](#) | [quark: energy loss](#) | [nuclear matter: effect](#) | [viscosity](#) | [entropy](#) | [model: fluid](#) | [PHENIX](#) | [experimental results](#) | [Brookhaven RHIC Coll](#) | [200 GeV-cms/nucleon](#)

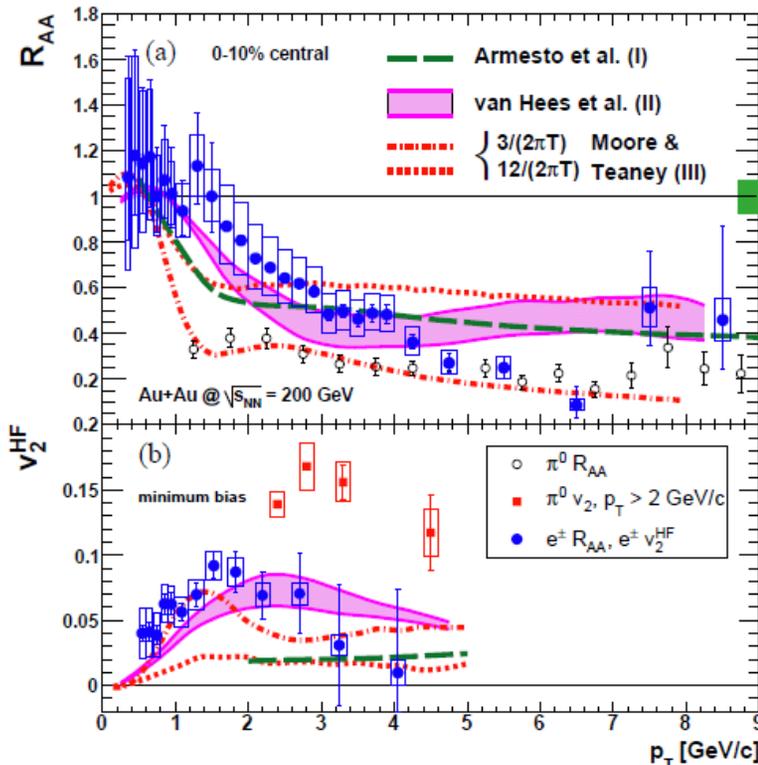
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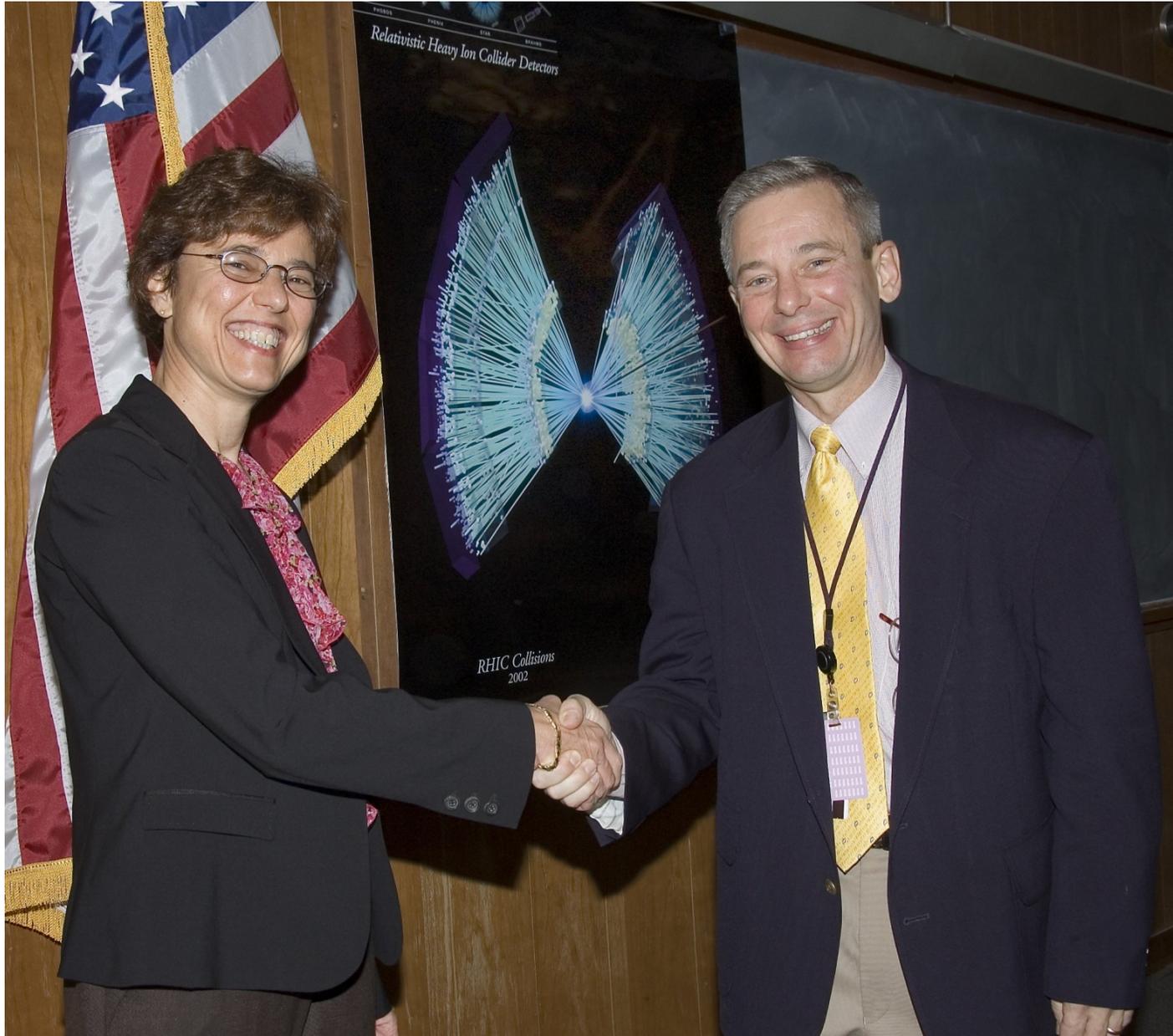


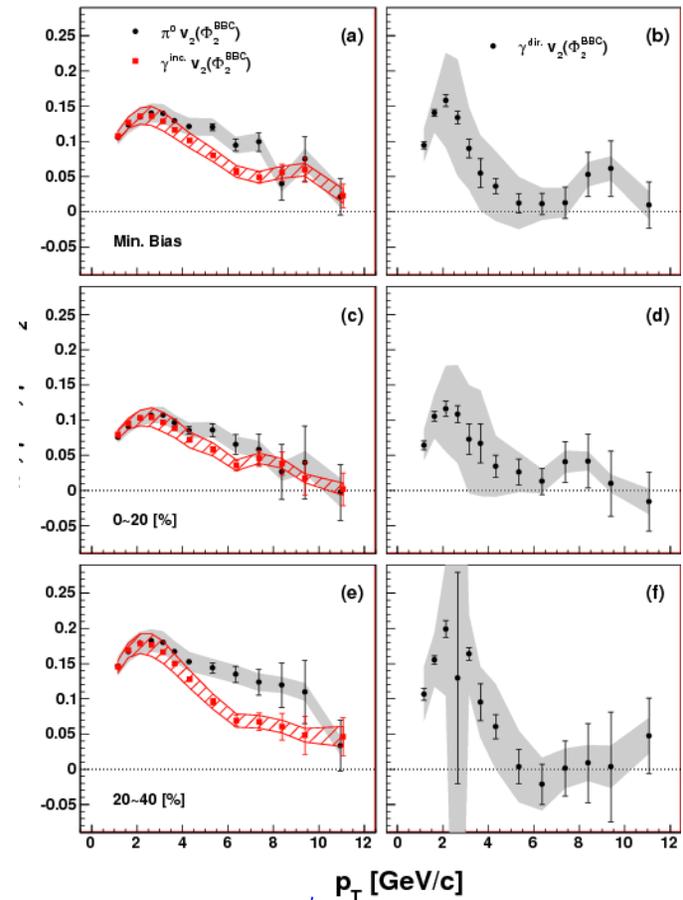
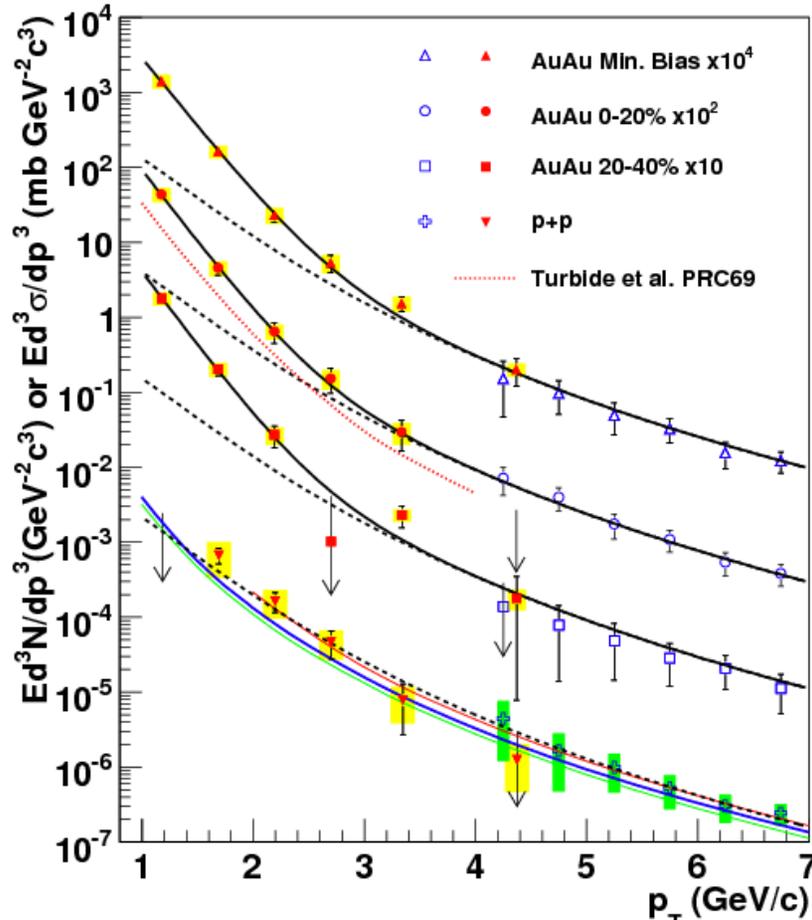


- Heavy quark
 - Energy loss

- Flow
 - along with

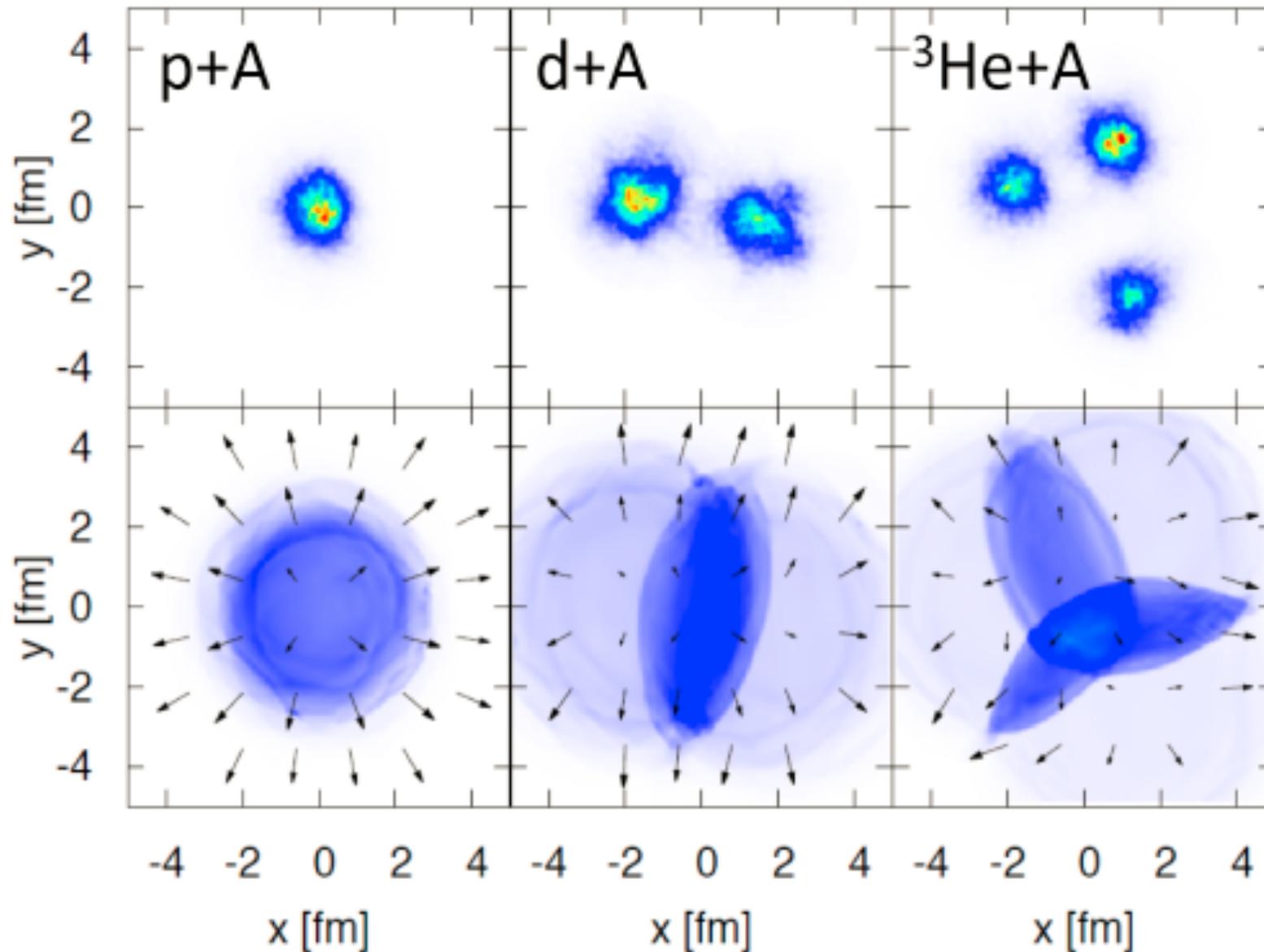
matter's diffusion coefficient D . Using the observation [32] that $D \approx 6 \times \eta / (\epsilon + p)$ with $\epsilon + p = Ts$ at $\mu_B = 0$ provides an estimate for the viscosity to entropy ratio $\eta/s \approx (\frac{4}{3} - 2)/4\pi$, intriguingly close to the conjectured quantum lower bound $1/4\pi$ [33]. This result is consistent with

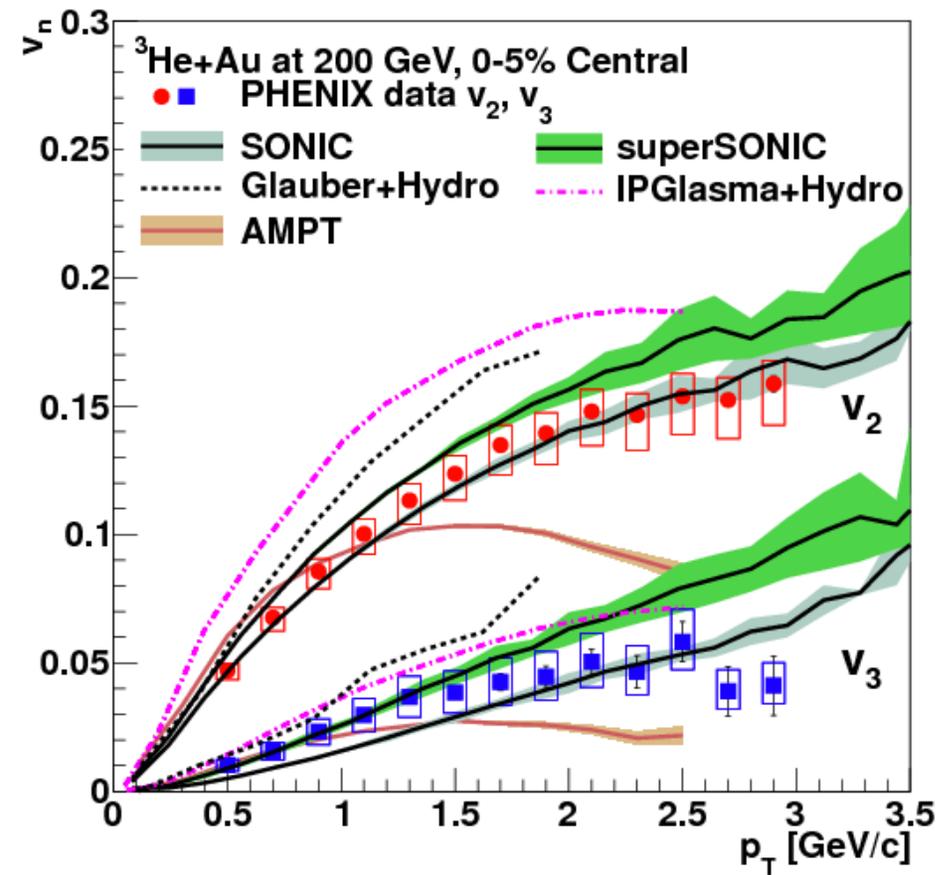
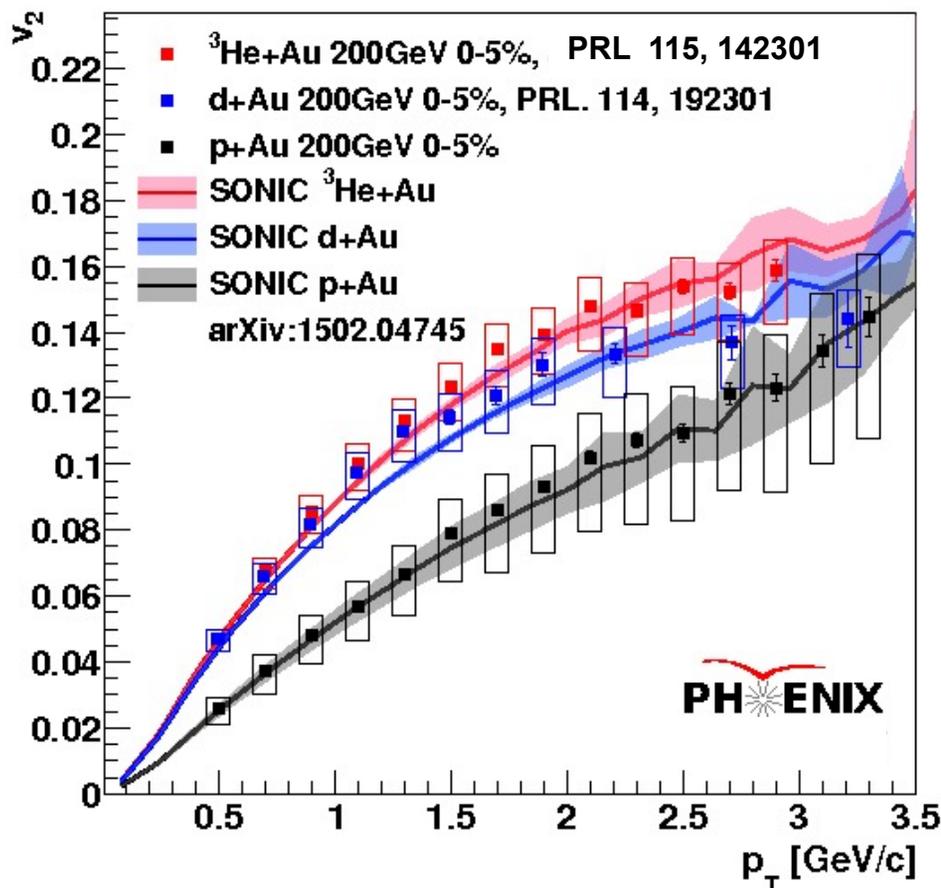




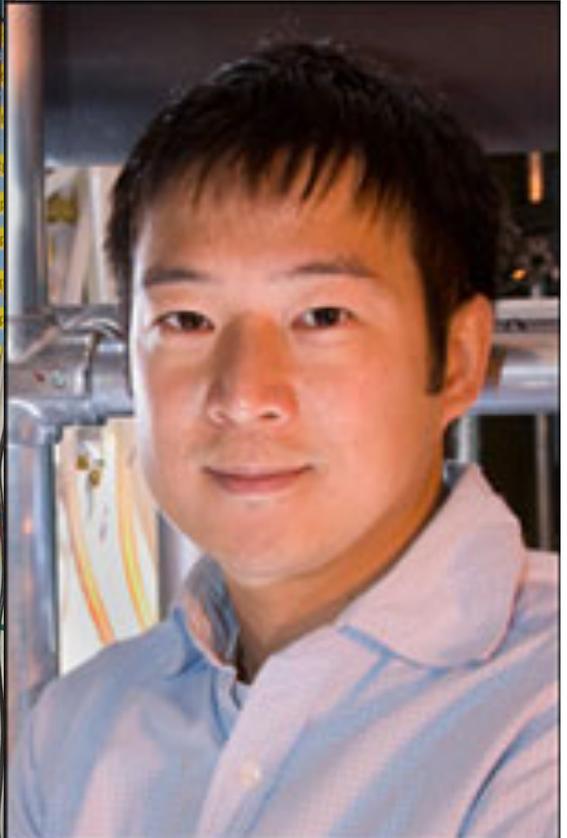
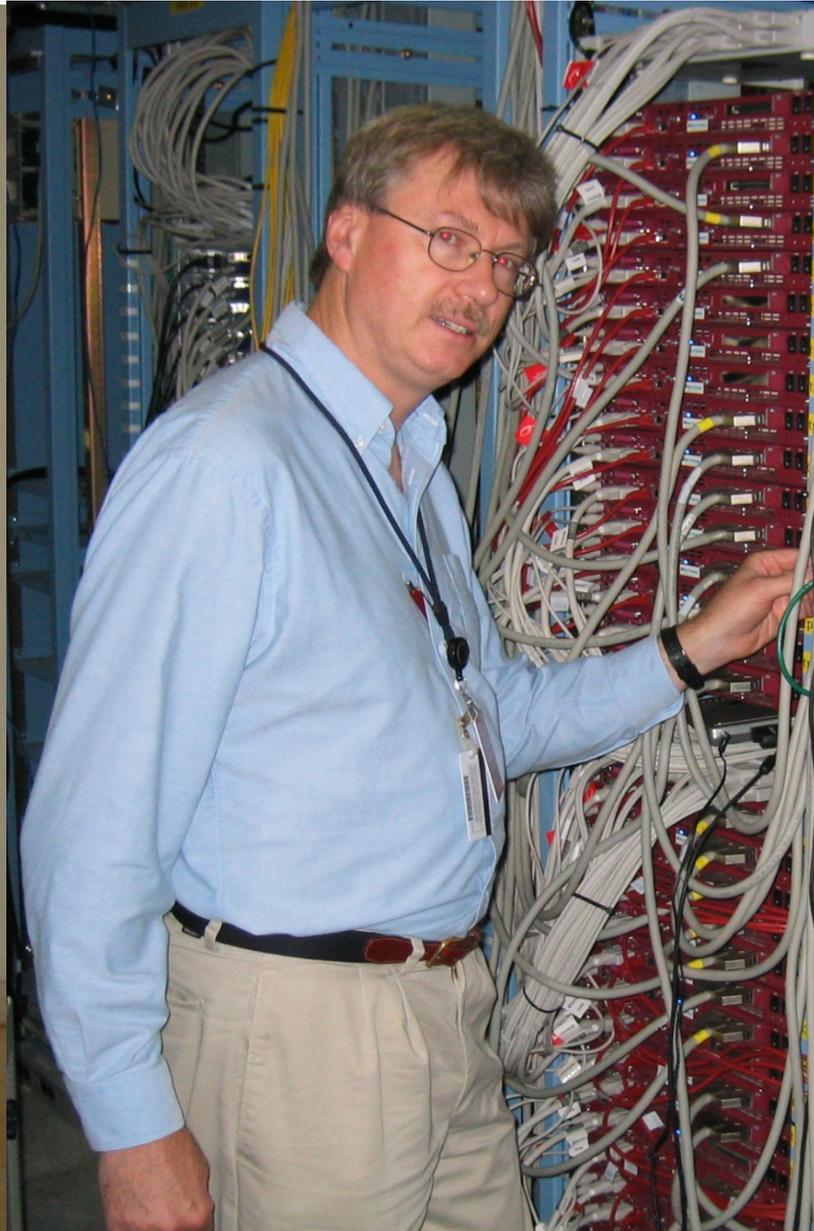
- Enhanced production of direct photons in Au+Au collisions at $\sqrt{s_{NN}}=200$ GeV and implications for the initial temperature, A. Adare et al., Phys.Rev.Lett. 104,132301, [arXiv:0804.4168](https://arxiv.org/abs/0804.4168)
- Observation of direct-photon collective flow in $\sqrt{s_{NN}}=200$ GeV Au+Au collisions, A. Adare et al. Phys.Rev.Lett. 109, 122302, [arXiv:1105.4126](https://arxiv.org/abs/1105.4126)







- Measurement of long-range angular correlation and quadrupole anisotropy of pions and (anti)protons in central d+Au collisions $\sqrt{s_{NN}}=200$ GeV, A. Adare et al., Phys.Rev.Lett. 114,192301, [arXiv:1404.7461](https://arxiv.org/abs/1404.7461)
- Measurements of elliptic and triangular flow in high-multiplicity $^3\text{He}+\text{Au}$ collisions at $\sqrt{s_{NN}}=200$ GeV, A. Adare et al., Phys.Rev.Lett. 115,142301, [arXiv:1507.06273](https://arxiv.org/abs/1507.06273)

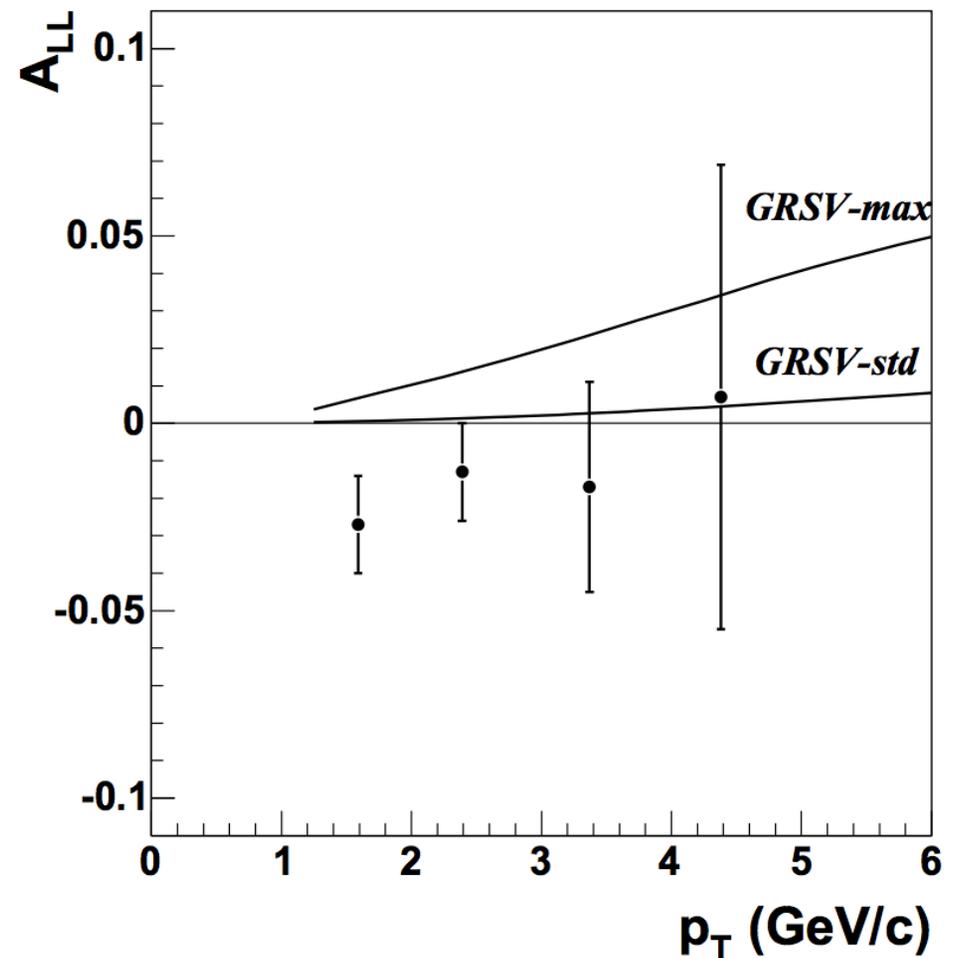






PHENIX Integral Spin Program

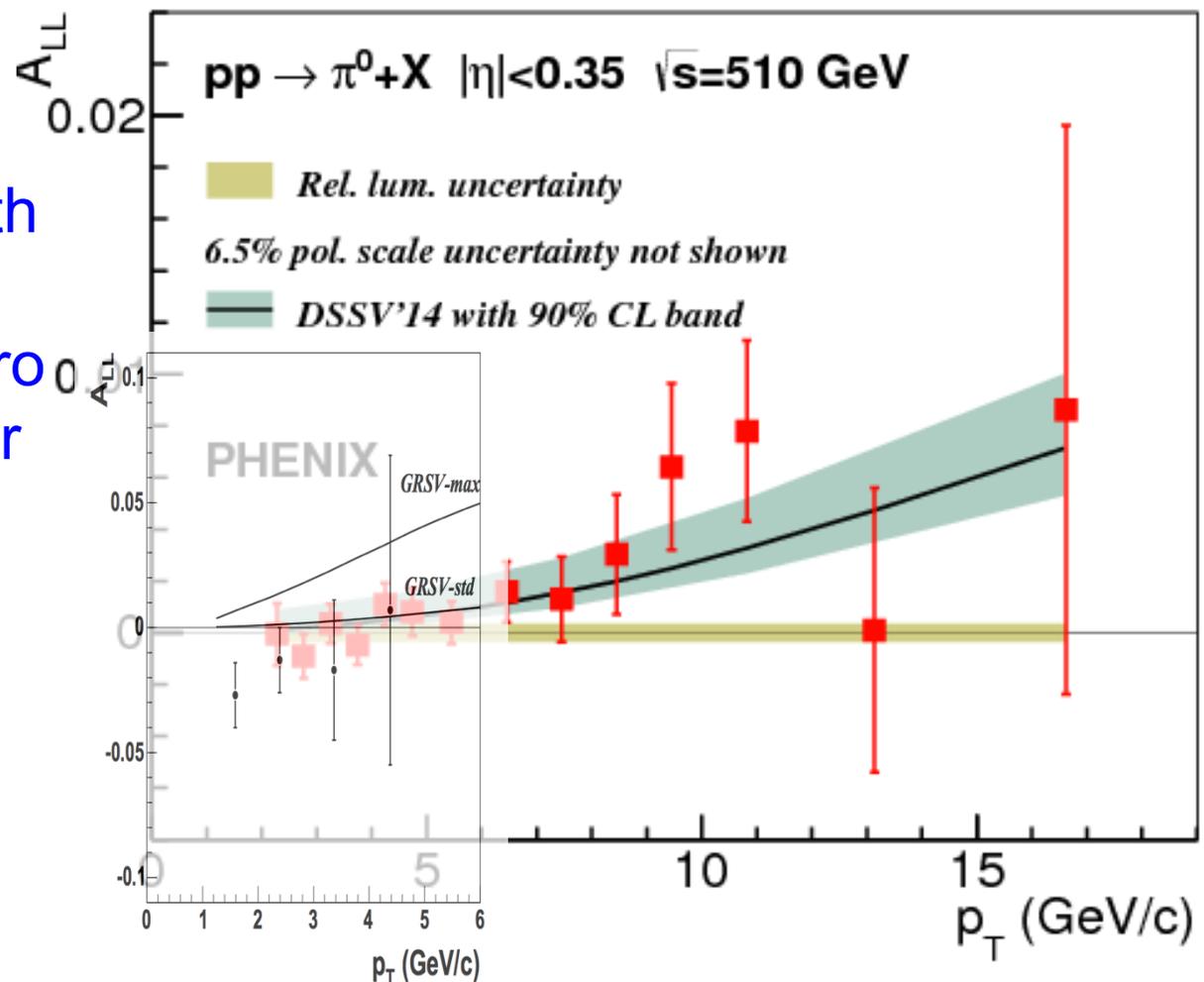
- Double helicity asymmetry in inclusive mid-rapidity π^0 production for polarized p+p collisions at $\sqrt{s} = 200$ GeV, S.S. Adler *et al.*, Phys.Rev.Lett. **93** (2004) 202002, hep-ex/0404027

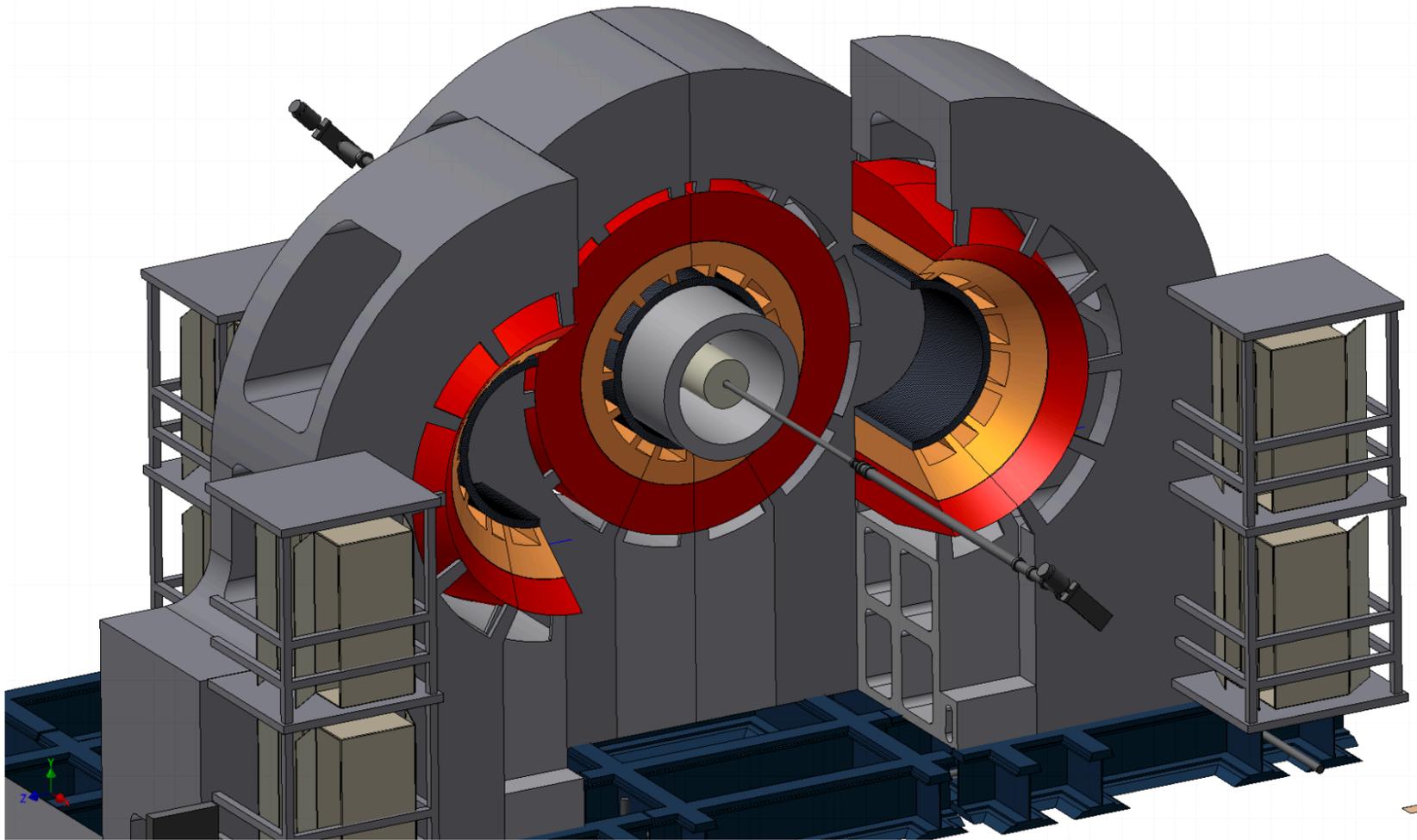


PHENIX Integral Spin Program+12y

- Inclusive cross section and double-helicity asymmetry for π^0 production at mid-rapidity in p+p collisions at $\sqrt{s} = 510$ GeV, A. Adare *et al.*, Phys.Rev. **D93** (2016) 011501, [arXiv:1510.02317](https://arxiv.org/abs/1510.02317)

- Good agreement with NLO pQCD fits incorporating nonzero gluon polarization for $x > 0.05$



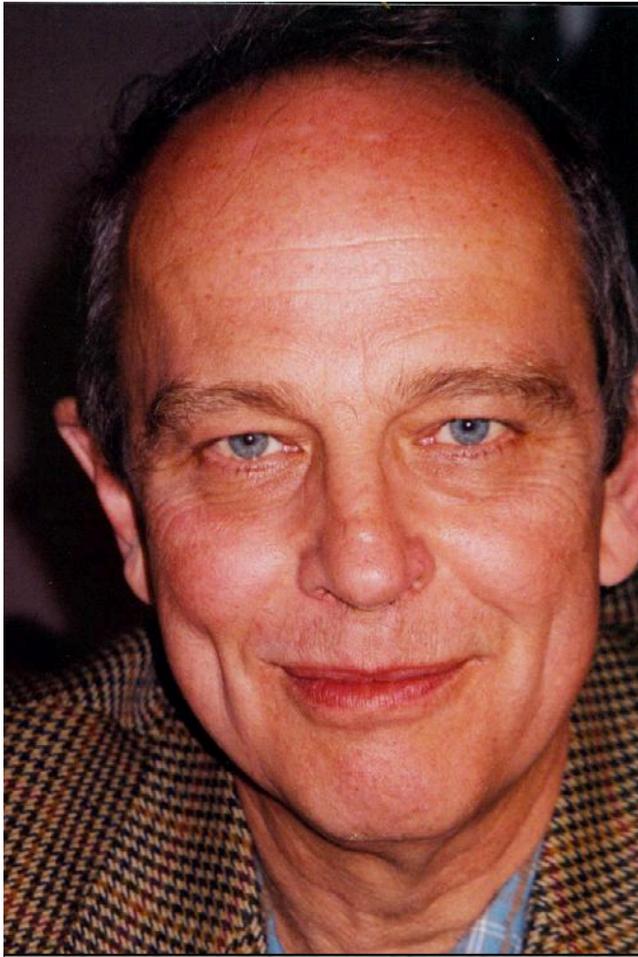


See sPHENIX talk by Megan Connors this afternoon



Secrets to Success

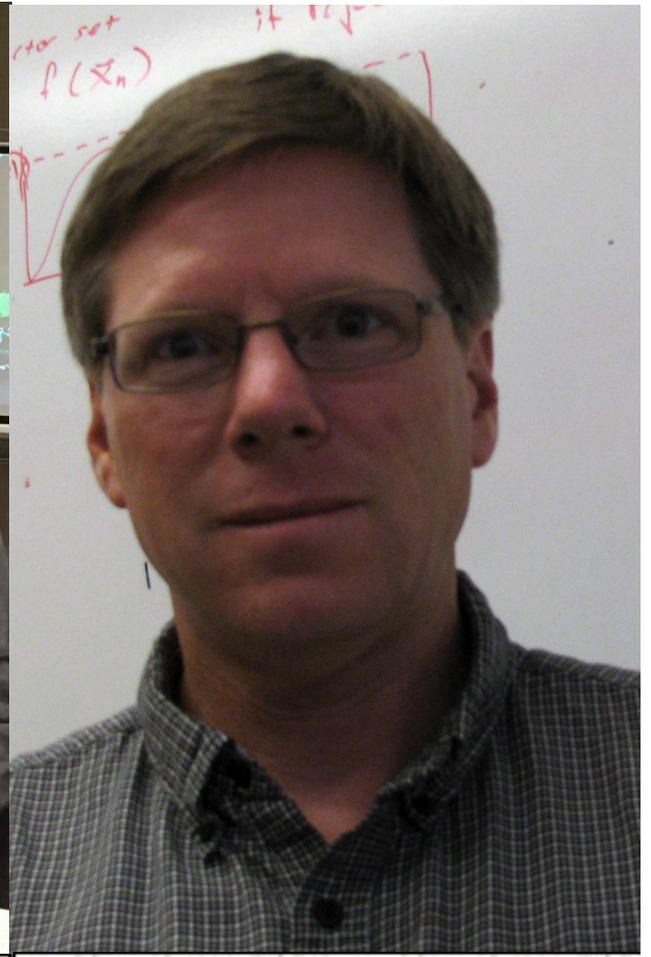




Gabor David

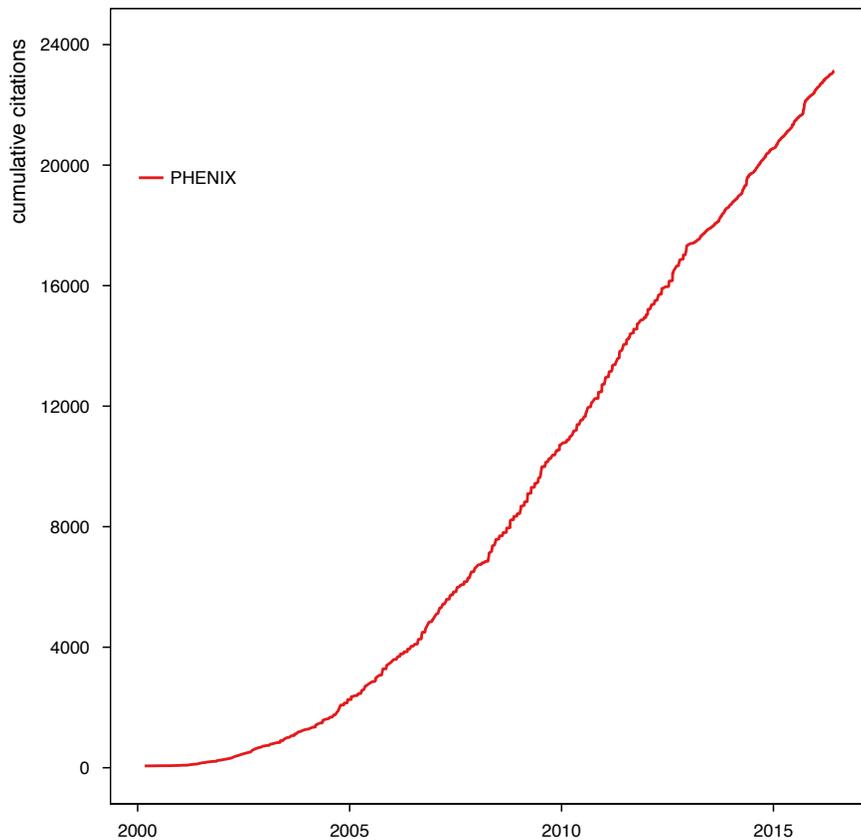


Achim Franz



Jeff Mitchell

- 175 articles
- 22,500 citations



Brant Johnson