

PHENIX Collaboration

- **Successes**
- **Opportunities**
- **Challenges**

Barbara Jacak
for the PHENIX Collaboration

slides can be found at:

http://www.phenix.bnl.gov/WWW/publish/jacak/sp/presentations/DOErev_jul08/

PHENIX

Central Arm Tracking

Drift Chamber

Pad Chambers

Time Expansion Chamber

Muon Arm Tracking

Muon Tracker

Calorimetry

PbGl

PbSc

MPC

Particle Id

Muon Identifier

RICH, HBD

TOF E & W

Aerogel

TEC

Global Detectors

BBC

ZDC/SMD Local Polarimeter

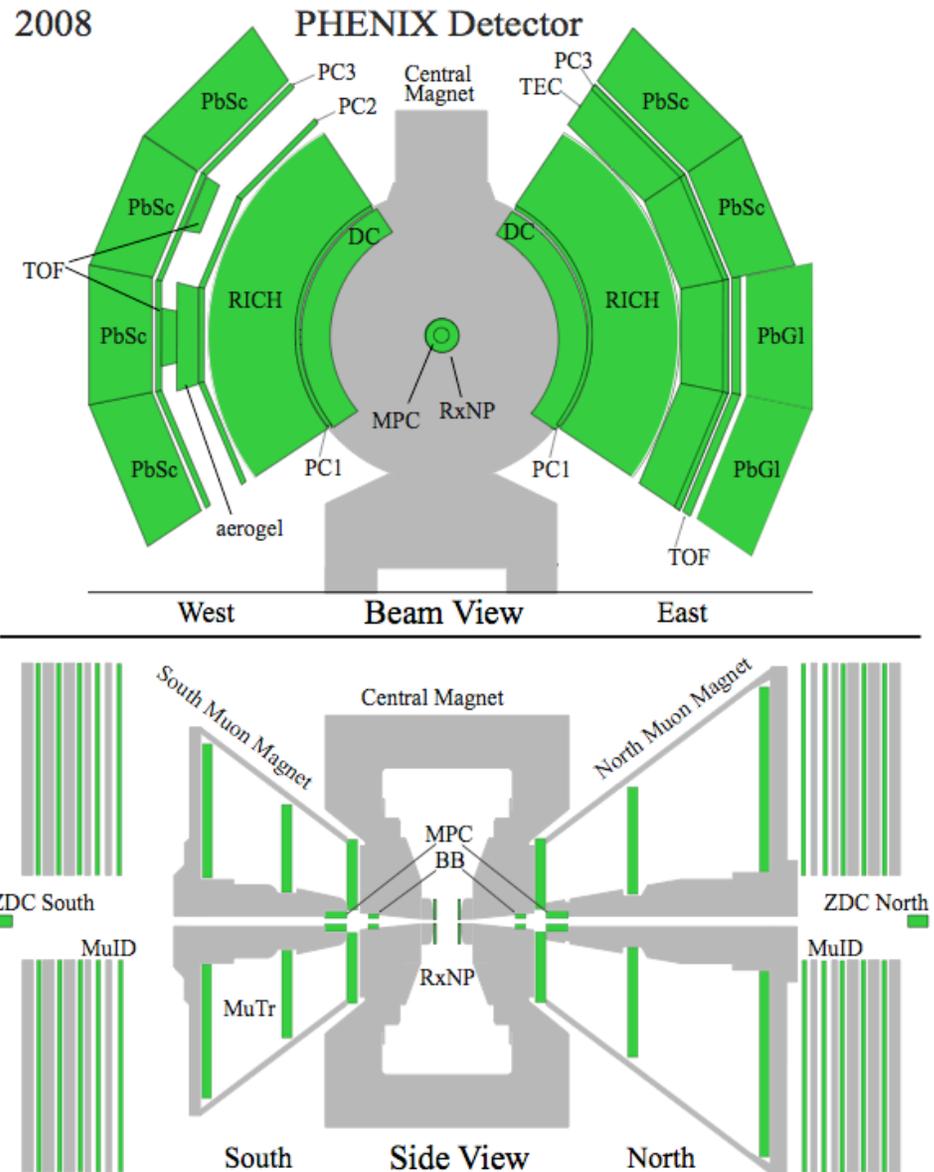
Forward Hadron Calorimeters

RXNP

DAQ and Trigger System

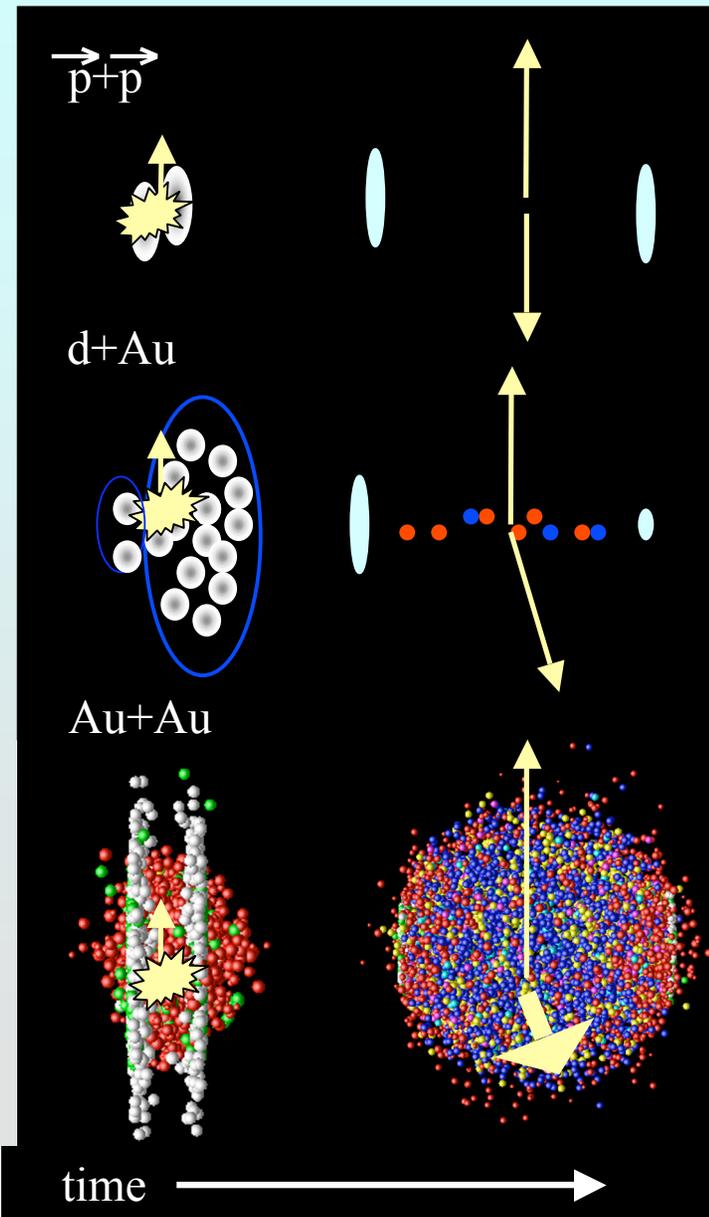
Online Calibration and Production

2008



PHENIX

Physics Thrusts



- **Spin structure of the nucleon**
Do gluons carry proton's spin?
How about sea q , $qbar$?
p+p: baseline/benchmark pQCD
- **Hot QCD**
d+Au: initial state nuclear effects
A+A: QGP properties
Why such a perfect fluid?
Screening?
Thermal radiation?

PHENIX is optimized to use hard probes of the soft medium!

● **successes**

PHENIX is a superb training ground

76 Ph.D. degrees earned on PHENIX

18 in 2007

8 in 2008, so far

15 since last S&T review

~ 13 Masters/Diploma theses

+ 72 *Ph.D. students working*

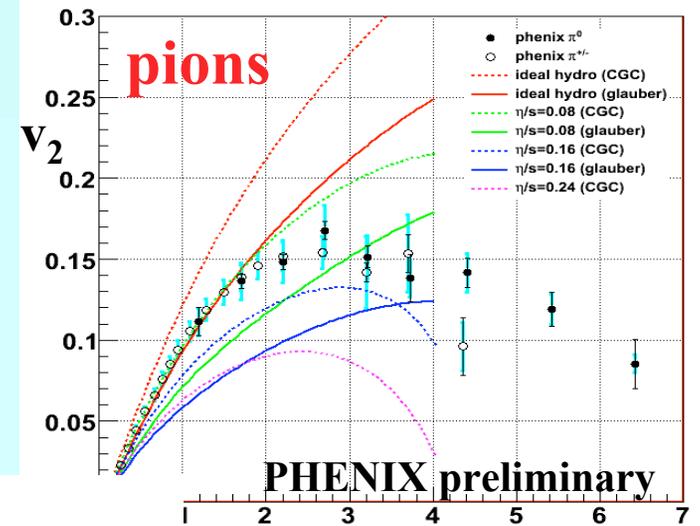
awards in the past year

Aidala	Christine	2008	Sambamurti Memorial Lectureship
Dahms	Torsten	2008	NPA Young Scientist award: best talk at QM08
Dion	Alan	2008	RHIC/AGS Thesis Award
Morreale	Astrid	2008	UC Dissertation Year Fellowship, Ben Shen Memorial Scholarship, User' Meeting Recognition
Chvala	Ondrej	2008	President, Association of Students & Postdocs
Johnson	Brant	2008	Co-Chair, National User Facility Organization
Boyle	Kieran	2008	SBU President's Award to Distinguished Ph.D. Student
Deshpande	Abhay	2008	Chair, RHIC/AGS Users Executive Committee
Jacak	Barbara	2008	Distinguished Professor
Woody	Craig	2007	President of IEEE Nuclear and Plasma Sciences
O'Brien	Edward	2007	APS Fellow
Toldo	Frank	2007	BNL staff Spotlight Award
Ogilvie	Craig	2007	Master Teacher Award
Hemmick	Thomas	2007	Distinguished Teaching Professor
Lenz	Mike	2007	BNL staff Spotlight Award
Sakai	Shingo	2007	Kakudan Nuclear Physics Forum Thesis Award
Lenz	Bill	2007	BNL staff Spotlight Award

Major discoveries

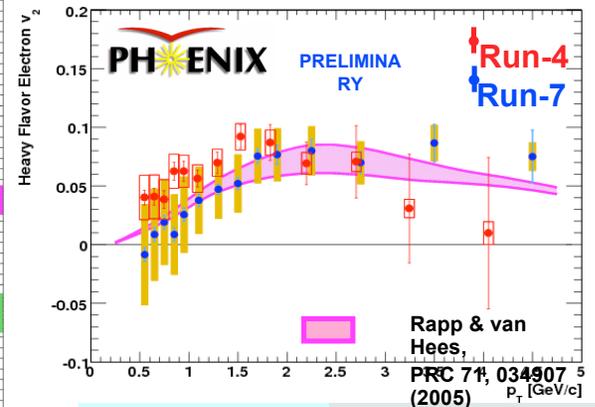
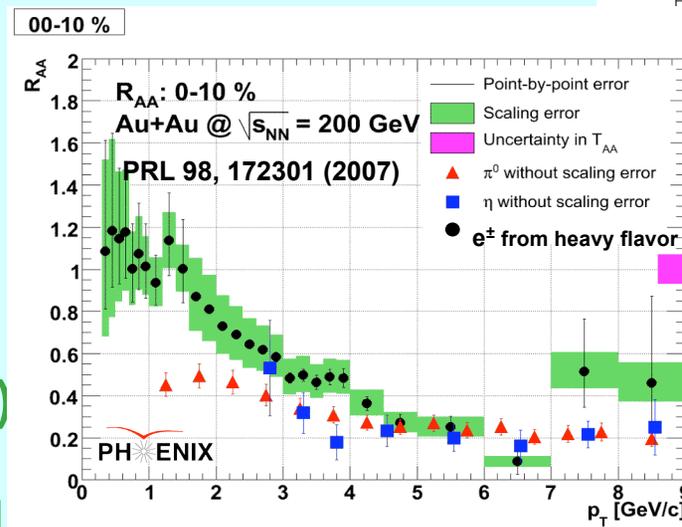
- **Viscosity/entropy ratio is very low a “perfect” liquid**

PRL98, 172301 (2007); 97 SPIRES citations
 Web of Science (WOS): in top 100 cited among all PRL's published in 2007



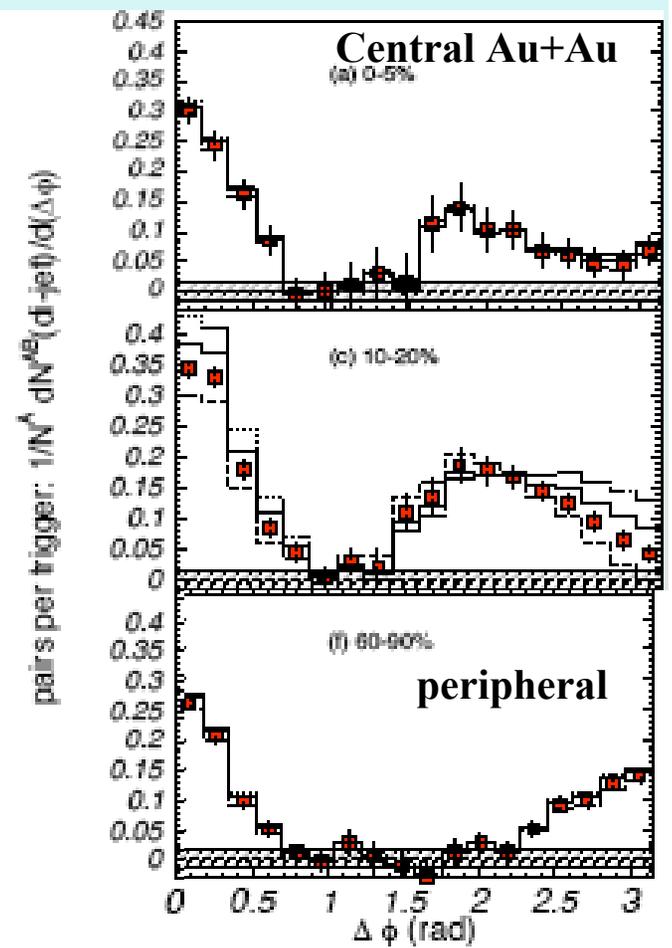
- **Opacity is huge stops q & g - charm stops and flows!**

PRL96,032301(2006)
 112 SPIRES cites
 WOS 6th most cited PRL in 2006



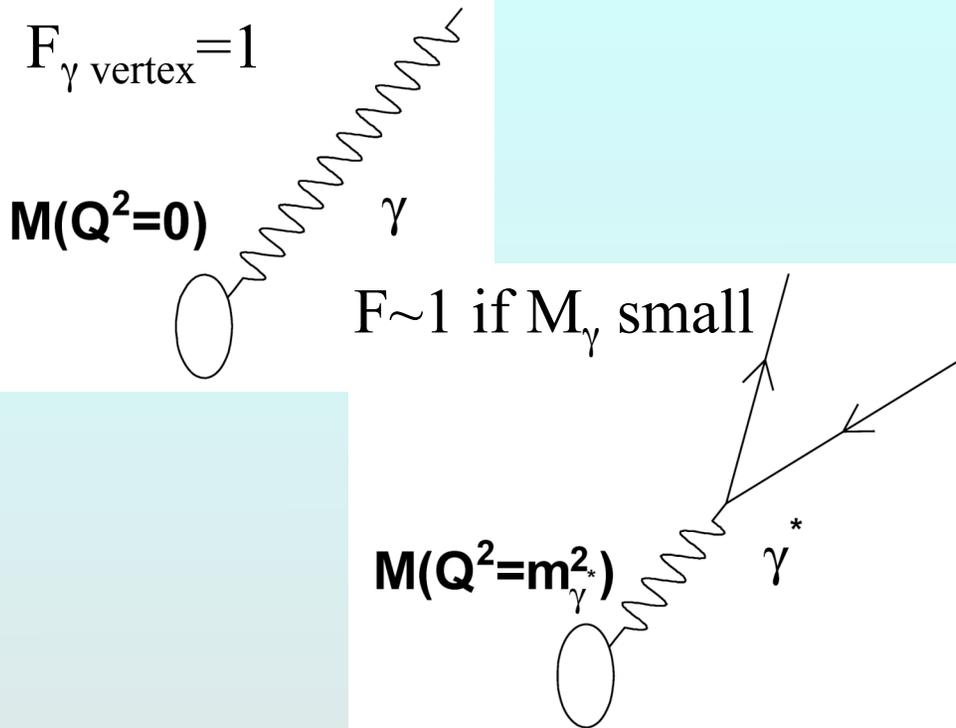
- **Matter may support shock waves**

PRL97, 152301 (2006); 173 SPIRES citations
 WOS 2nd most cited among all PRL
published in 2006



T_{init} via low mass, high p_T dileptons

arXiv: 0804.4168

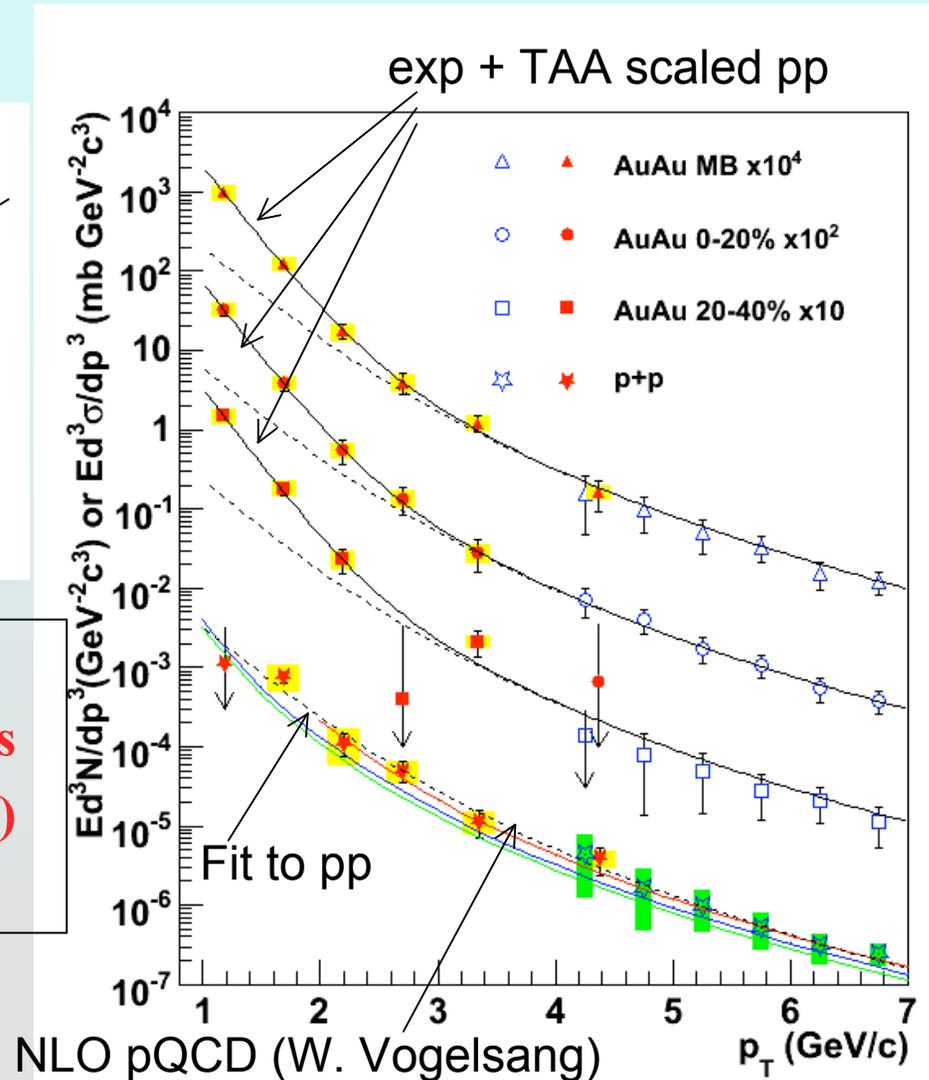


Agree with pQCD in p+p

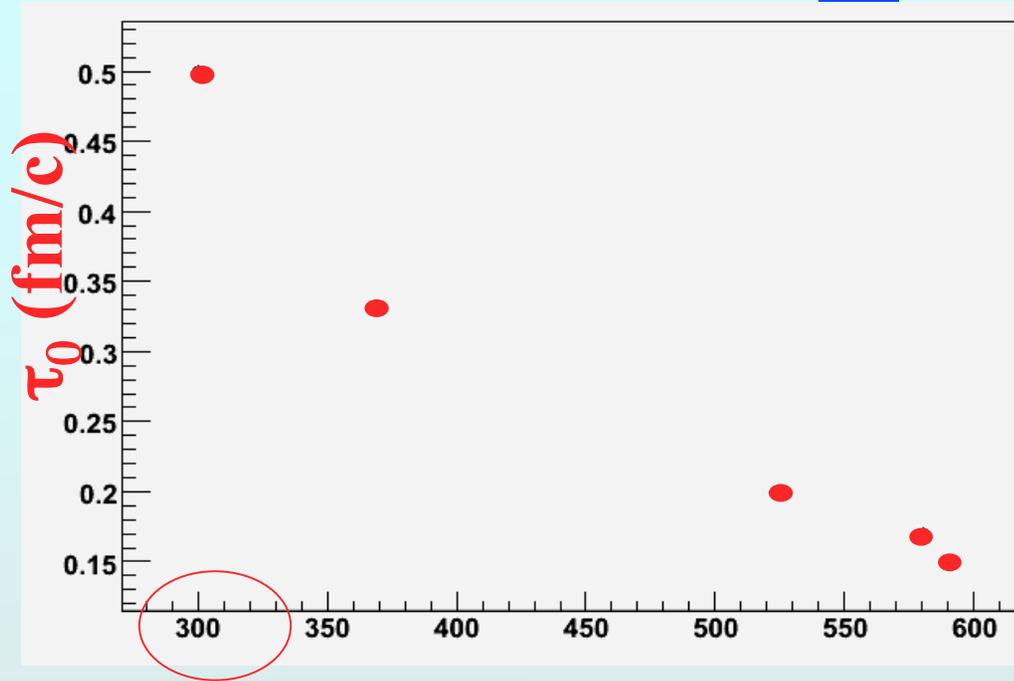
In Au+Au: soft (thermal) excess

$T = 221 \pm 23 \pm 18$ MeV (central)

$T = 224 \pm 16 \pm 19$ MeV (MB)



$$T_{\text{init}} > T_c$$



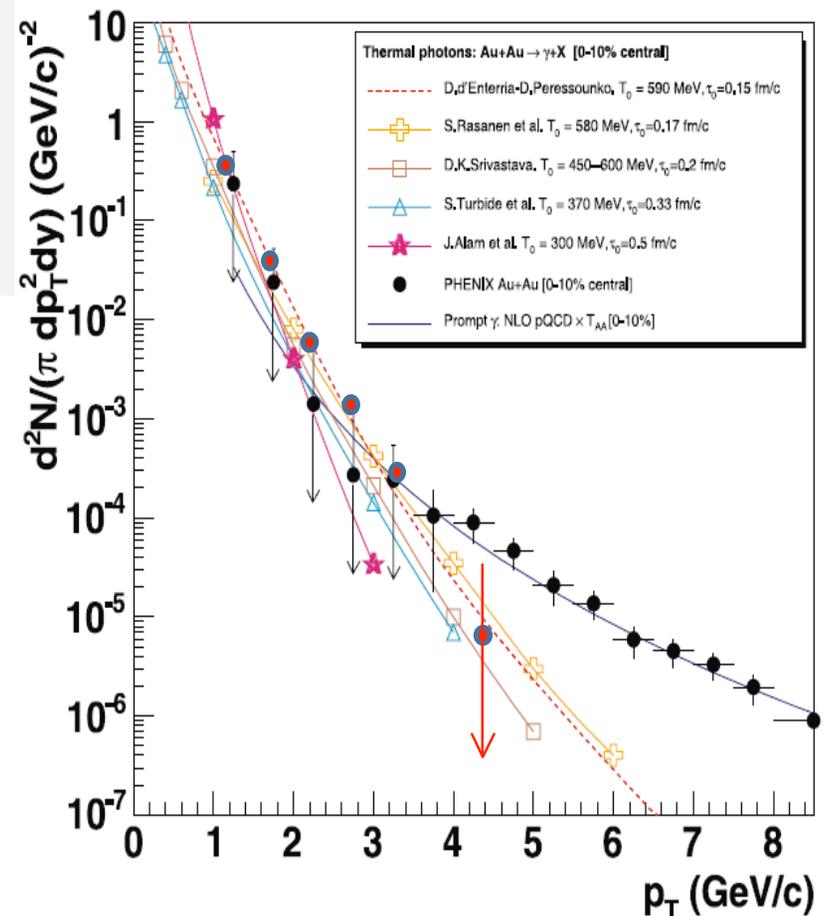
compare direct photon p_T spectrum to multiple models of hydrodynamic expansion

T_{init} (MeV)

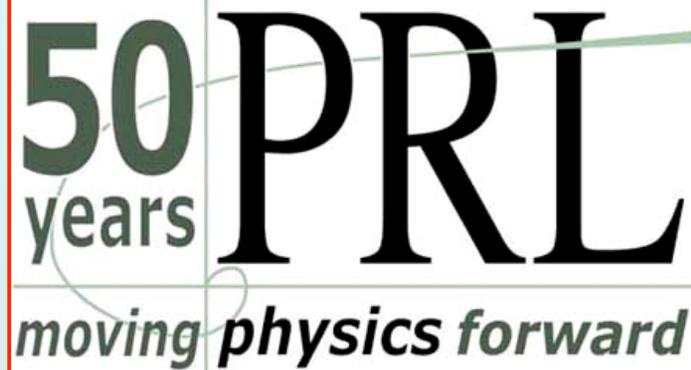
$T \propto \tau$ (as expected)

$T_{\text{init}} \sim 220$ MeV from simple exponential fit !!

$T_c \sim 170$ MeV



Reflections on 50 years of “April Physics”



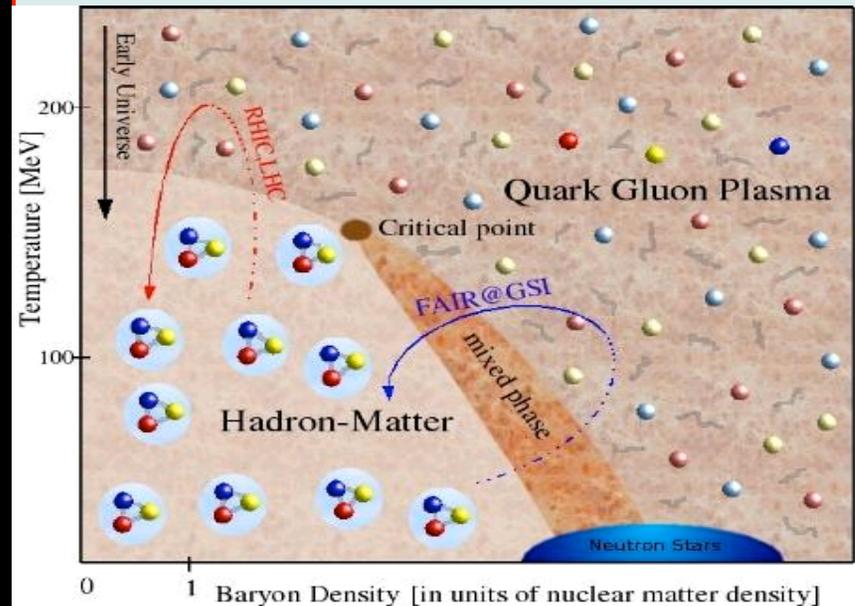
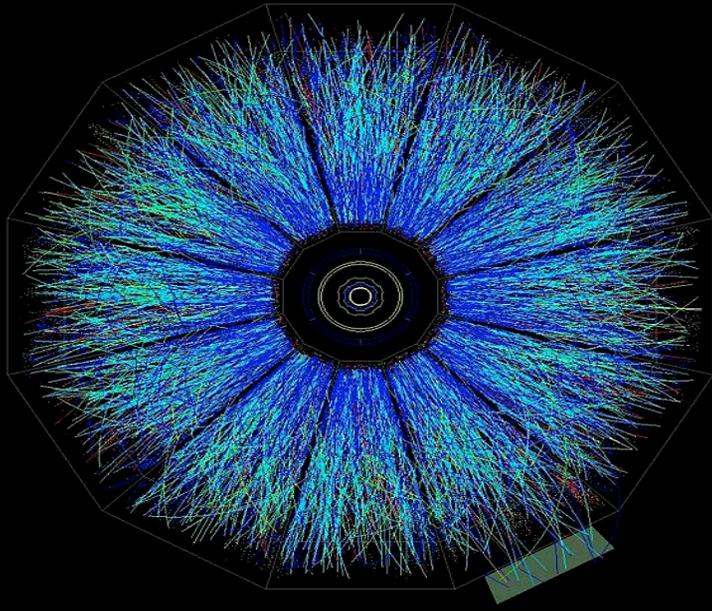
Michael S. Turner

Kavli Institute for Cosmological Physics

The University of Chicago

Re-alignment of Nuclear Physics

- Hot QCD: Heavy Ions (quark/hadron transition and phase diagram)
- Cold QCD: Nuclear Structure and full extent of chart of nuclides (effective theory of nucleons from QCD) – both nucleonic and shape dof interesting
- Nuclear Astrophysics: Burbidge, Burbidge, Fowler and Hoyle, RMP 29, 547 (1957) – origin of the chemical elements



Recent scientific accomplishments

- **First measurement of initial temperature at RHIC**

0804.4168

- **Discovery of low mass dilepton excess in central**

Au+Au 0706.3034

- **Quantitative analysis of energy loss**

- *PRC77,064907(2008); 0801.4020*

- **Opacity emergence between 22.4 and 62.4 GeV $\sqrt{s_{NN}}$**

0801.4555

- **Mapping the medium response to jets**

PRC78,014901(2008);0712.3033; PRC77, 011901(2007)

+ 8 additional papers: high p_T hadron suppression, J/Ψ suppression, source imaging, dielectrons (p+p), d+Au/p+Au/n+Au, fluctuations, phi flow, A_{LL} .

11 papers published since last S&T; 8 with referees

RHIC 'White Papers' Reach 'Renowned' Status

RHIC News, Wednesday, June 11, 2008

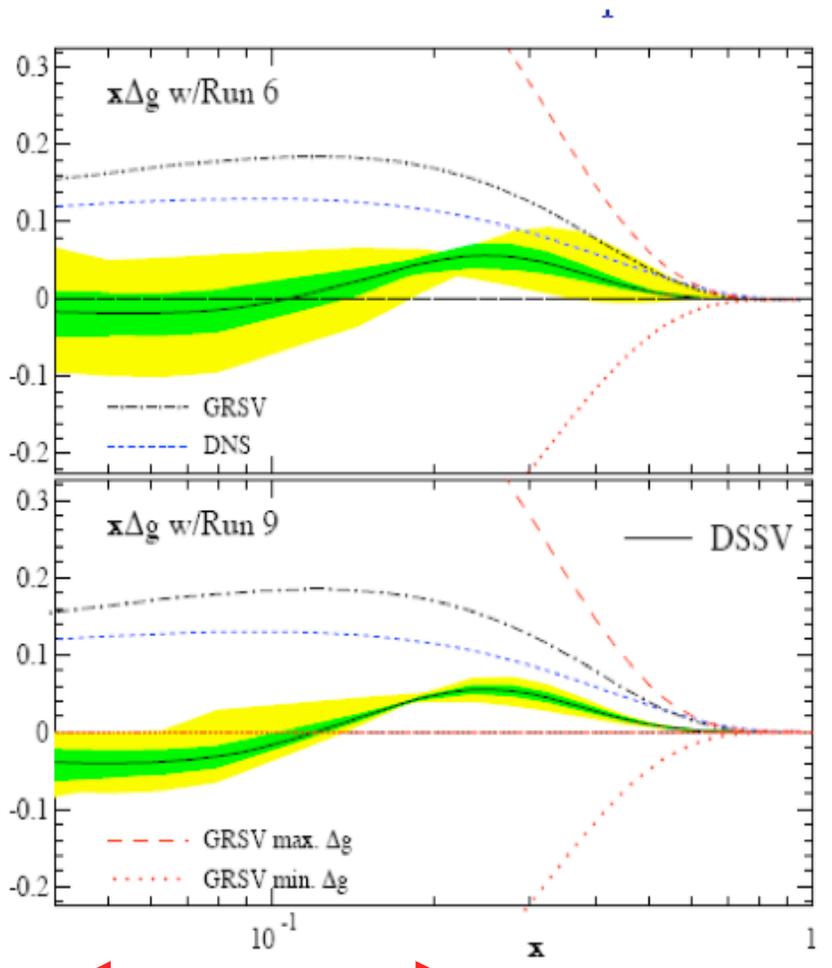
Fresh evidence of the impact of RHIC physics: The "white papers" published by the STAR and PHENIX collaborations in 2005 have each reached "renowned" status on the SPIRES electronic database of particle physics publications. That means these papers - which together with papers from BRAHMS and PHOBOS described the "perfect" liquid discovered at RHIC - have each received more than 500 citations in other published papers listed on the site.

525 citations!

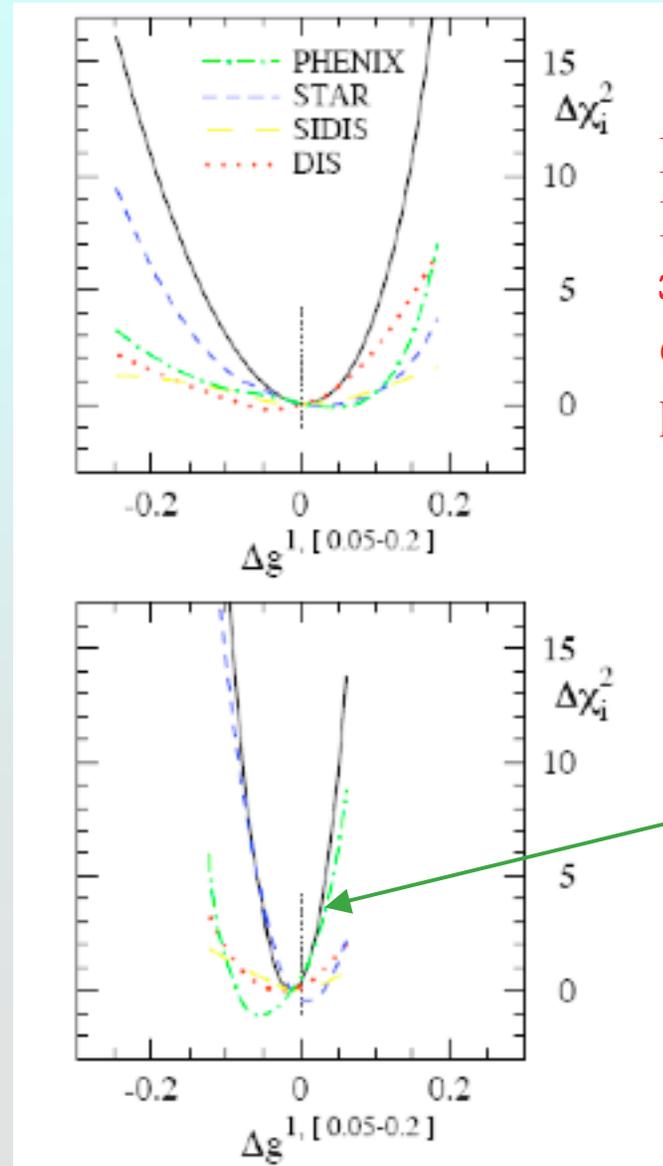
The PHENIX and STAR white papers now have the 7th and 8th largest number of citations of all nuclear physics experimental papers tracked on the SPIRES site. The PHOBOS and BRAHMS white papers are at 12th and 13th place, respectively. In fact, 15 of the 29 most-cited papers are from RHIC.

200 GeV polarized protons - the elusive ΔG

Global fits, DSSV arXiv:0804.0422



RHIC Constraint

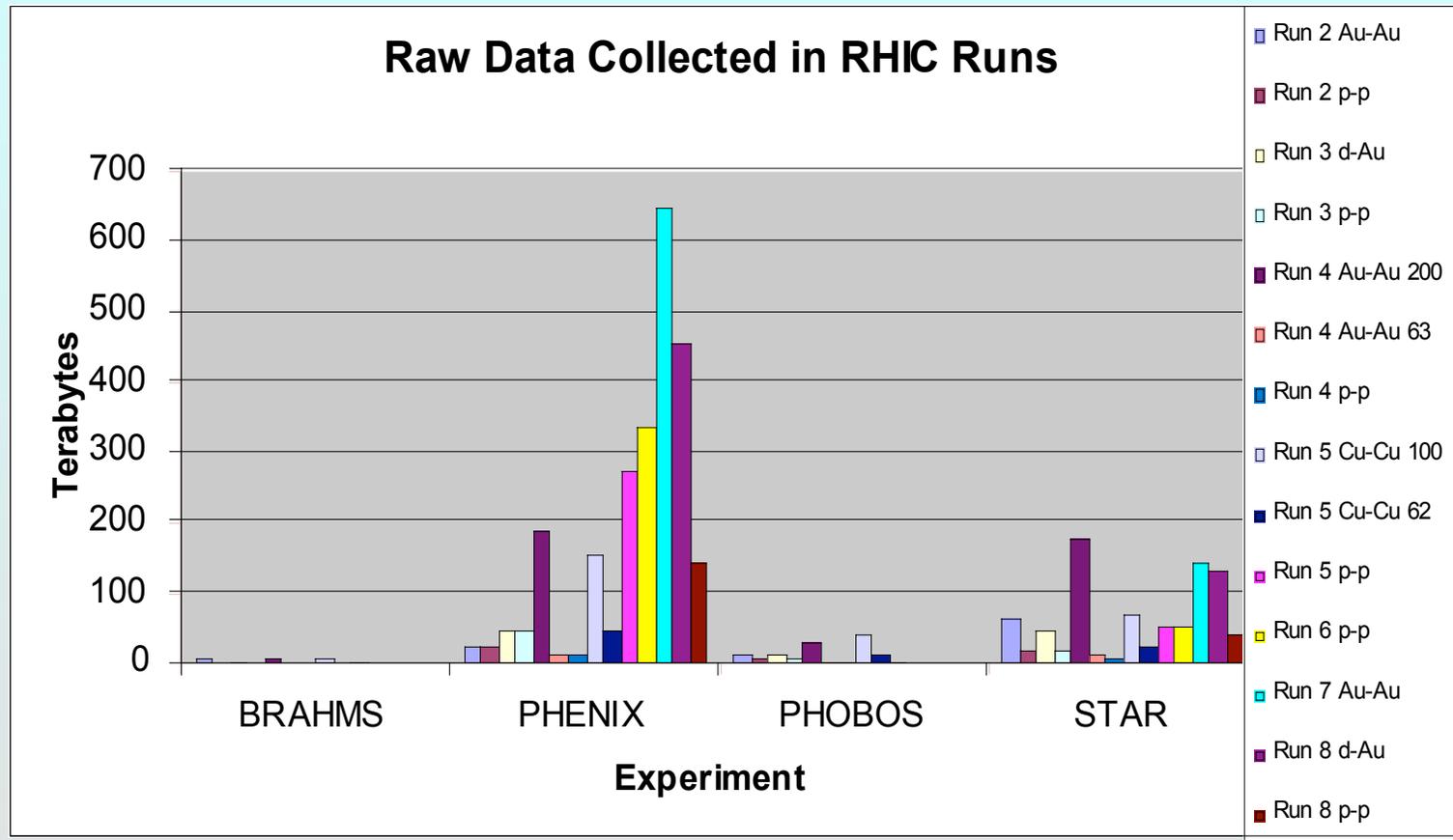


Run-6:
PHENIX
 $\pi^0 A_{LL}$
constrains
positive ΔG

Run-9: best
sensitivity in
0.05 < x < 0.2
via g-g; high
rate - low p_T

50 pb⁻¹
15

Data sets at ~PB level



Analyze data within 1 year!

- **Run-7 reconstruction completed at RCF, France + PHENIX counting house**
- **Run-8**
 - muons ongoing, central arm & pp starting**
- **Have pushed 3.8 PB through the system since Jan.1**
 - 10-20 TB per day, with 60 TB peaks**
- **Production team drawn from collaboration**
 - Run-7: Carla Vale/BNL (now computing coordinator)**
 - asst: R. Belmont, Dillon Roach, M. Wysocki**
 - Run-8: Alex Linden-Levy/Colorado**
 - asst: R. Belmont, J. Seele, R. Yang**

Production Status

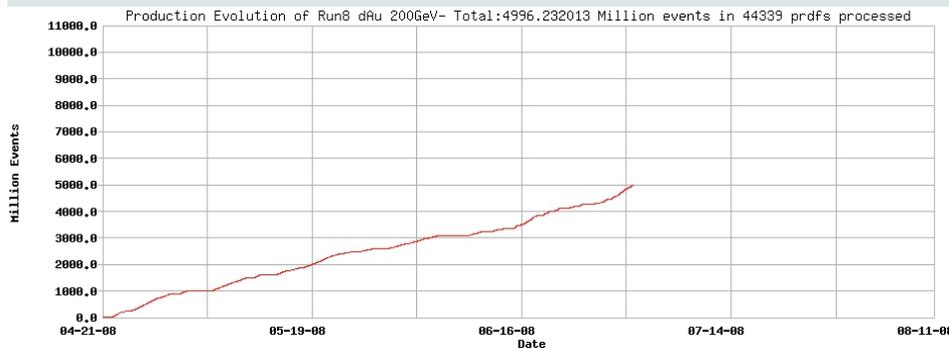
Run-7 Central Arm: 5.4B events, 7.5 months (with a pause for QM08 analysis)

Run-7 Muon Arms: 5.4B events, 3 months, finished in June



Run-8 d+Au Muon Arms: 5B (~ half) done, mostly at PHENIX, also RCF since Run-7 completed

Run-8 d+Au Central Arm: start in 1-2 weeks complete by Fall



Run-8 p+p @ RIKEN: testing, to start next week, ~ 4 months duration

PHENIX DAQ efficiency (see J.Nagle talk)

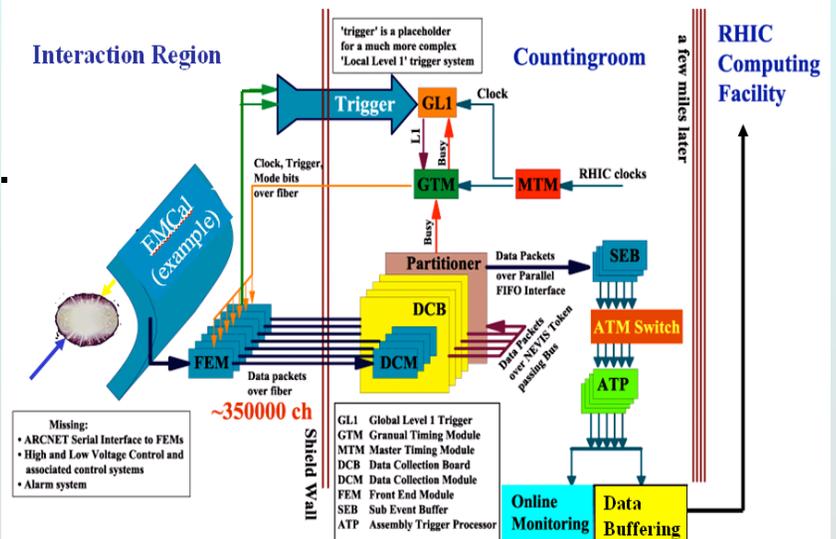
“Livetime”: fraction of delivered luminosity *within ± 30 cm* sampled by the PHENIX Level-1 triggers when the DAQ is running (uptime ~ 75 -80%).

Year	2007	2007 (last 2 wks)	2008	2008
Species	Au+Au	Au+Au	d+Au	p+p
Livetime	82%	90%	89%	89%

PHENIX has fully pipelined “deadtimeless” DAQ (+Front End Electronics and Triggers).

Similar to CDF,D0 (with slower clock) and ATLAS, CMS (with faster clock).

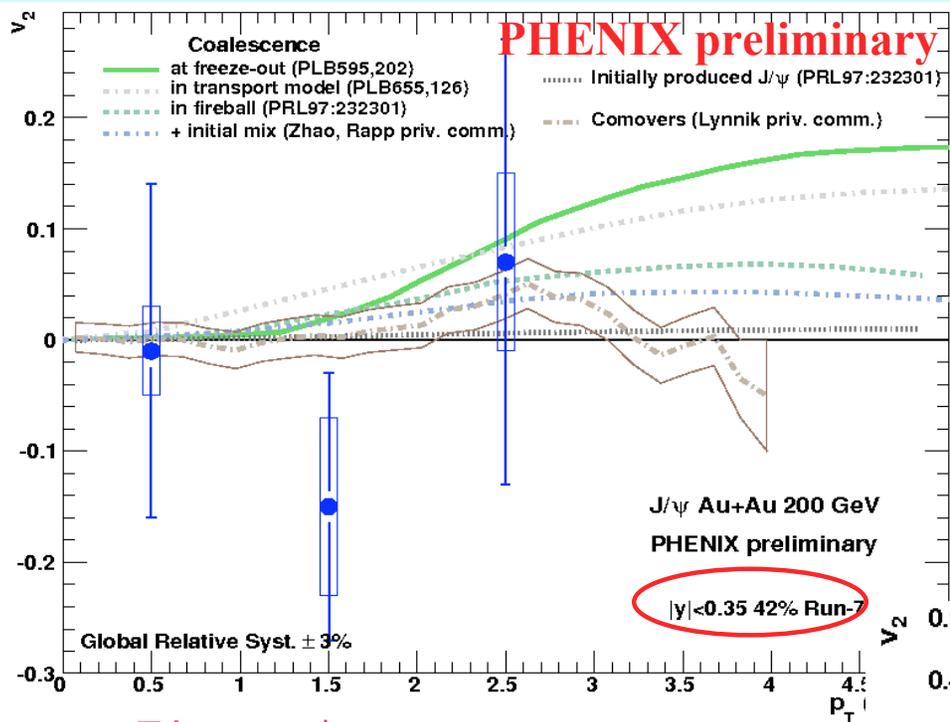
Thus, we can run at close to Level-1 trigger capacity at very high livetime.



Level-1 triggers: Interaction triggers (BBC, ZDC)
 Muon triggers (MuID)
 Photon triggers (EM Calorimeter)
 Electron triggers (EM Calorimeter + RICH)

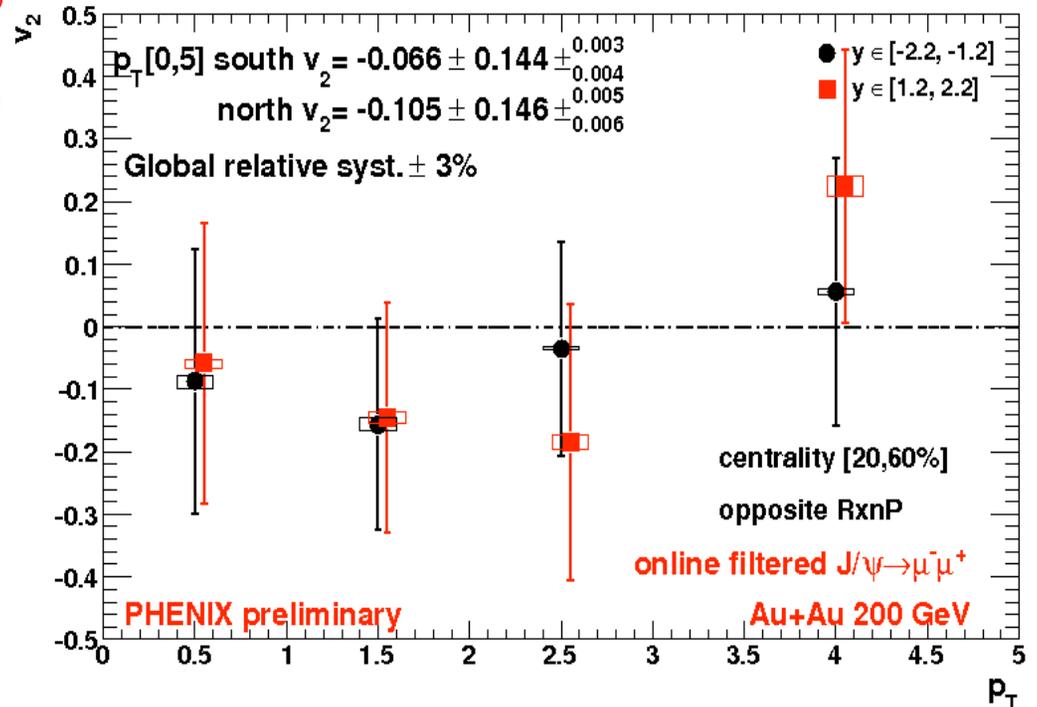
● opportunities

Open charm flows, does J/ψ ?

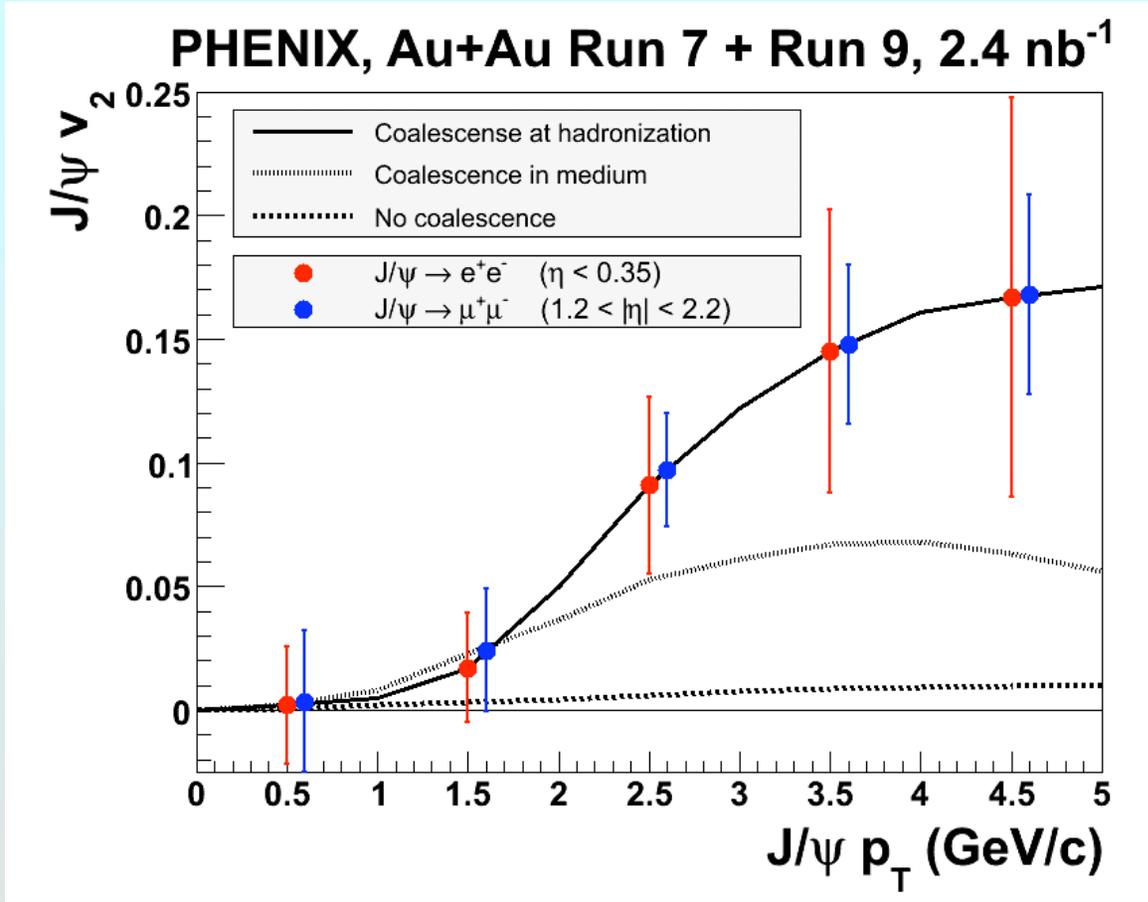


Run-7 with new reaction plane detector
 $J/\psi \rightarrow e^+e^-$ and $\mu^+\mu^-$ in central + muon arms

$J/\psi \rightarrow e^+e^-$



Need more 200 GeV Au+Au data



**Require 1.6 nb⁻¹
in Run-10***

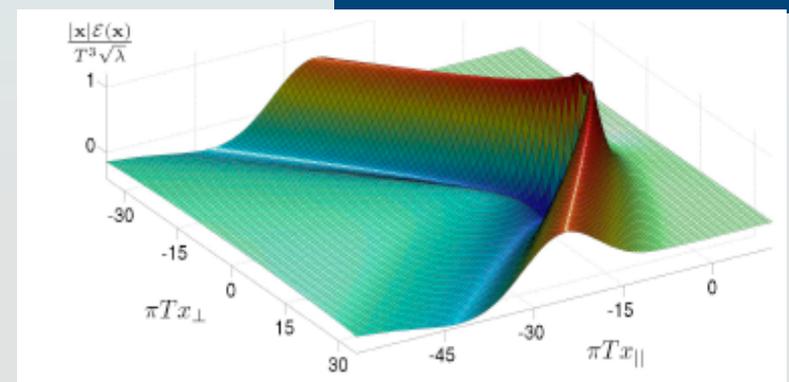
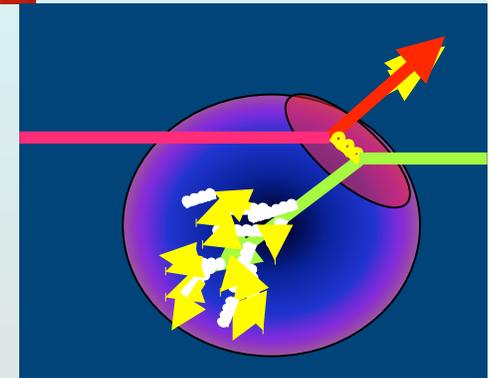
***according to current plan**

How does this exotic matter work? properties!

- **Viscosity/entropy ratio is very low**
a “perfect” liquid
How low? Why? Consequences?
- **Opacity very high**
Effectively stops quarks & gluons
Do even b quarks screech to a halt?
How and why?
- **Matter may support shock waves**
What’s the speed of sound?
Damping?
Other transport properties?
- **Color screening magnitude?**



Example of the viscosity of milk. Liquids with higher viscosities will not make such a splash when poured at the same velocity.



To answer these compelling questions

- **J/ψ flow (coalescence vs. screening) and screening length?**
 J/ψ v_2 , spectroscopy of heavy quark bound states
 - **How is energy deposited to/transported in the medium?**
 γ - h correlations, h - h correlations, fate of direct γ
 - **Evidence for chiral symmetry restoration? Low mass e^+e^-**
 - **Are b quarks stopped by the medium? separate c & b**
 - **Can we see gluon saturation? x depend. of π^0 in $d, Au + Au$**
 - **How do highest energy densities differ?**
 - **Where is the QCD critical point?**
- **Extend sensitivity via increased integrated luminosity**
short term: order of magnitude $\int \mathcal{L}$ over existing Run-4!
combined Run-7 + Run-10
- **longer term: RHIC-II Au+Au with VTX, FVTX, NCC**
c/b separation, scan γ and π^0 vs. x
- **U+U in Run-11 (energy density \sim 60% higher than Au+Au)**

ΔG not large: sea quarks polarized? d vs. u?

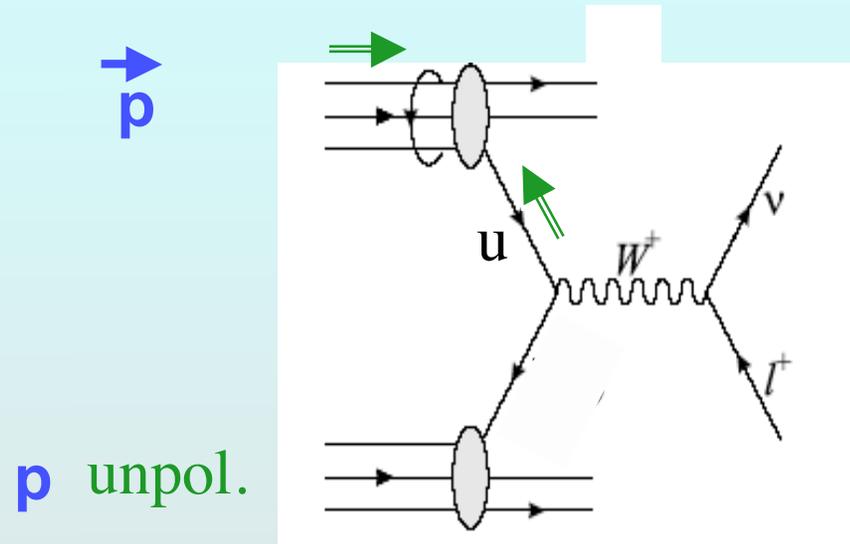
Probe $\Delta\bar{q}-\Delta q$ via W production

$$\Delta d + \bar{u} \rightarrow W^-$$

$$\Delta\bar{u} + d \rightarrow W^-$$

$$\Delta\bar{d} + u \rightarrow W^+$$

$$\Delta u + \bar{d} \rightarrow W^+$$



100% Parity-violating:
$$-A_L = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-}$$

Start: 2009(tests)/2010(trigger) with 500 GeV p+p

Future HI Milestones



Requires upgrade



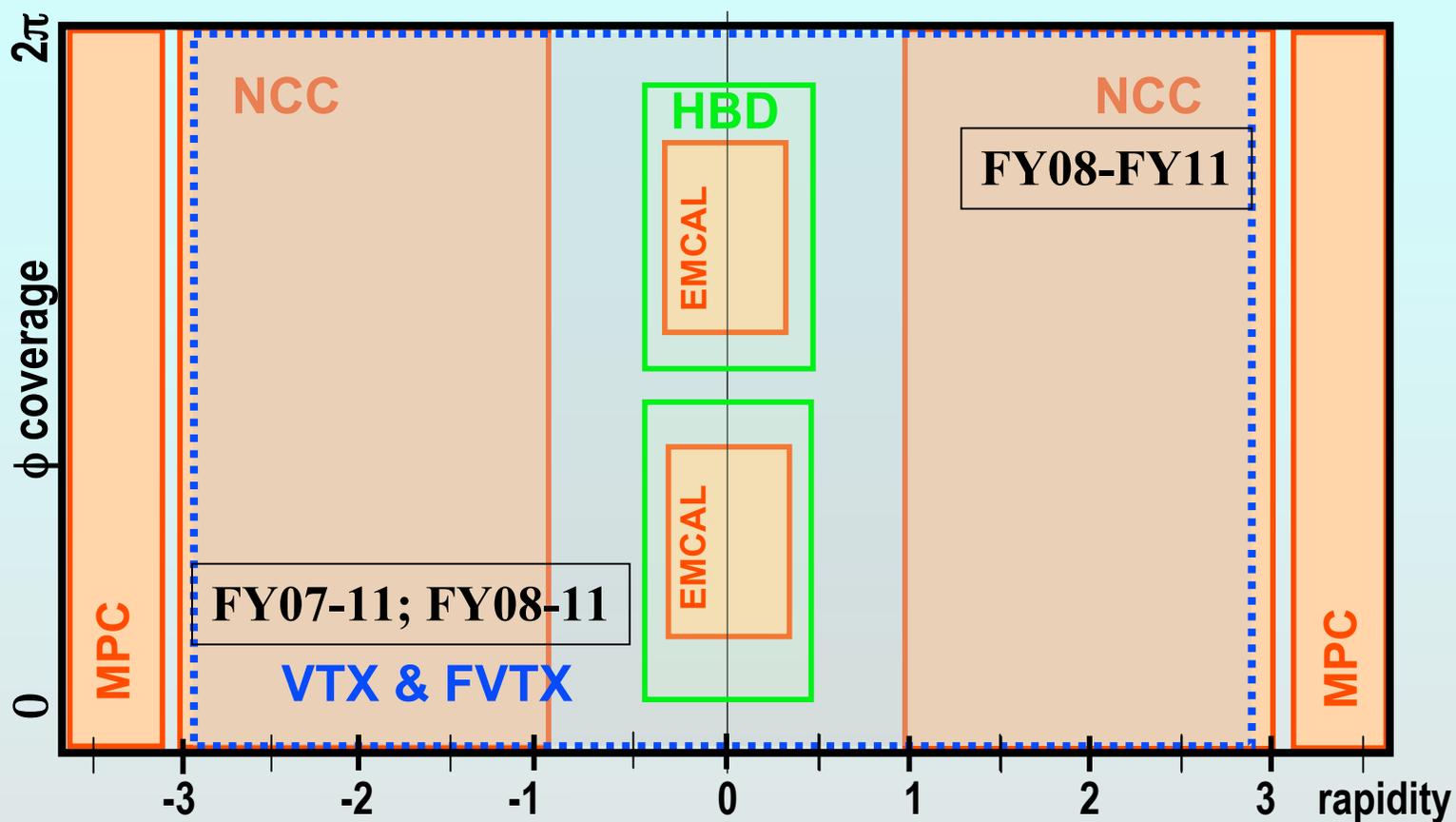
Year	#	Milestone
2009	DM4	Perform realistic three-dimensional numerical simulations to describe the medium and the conditions required by the collective flow measured at RHIC.
2010	DM5	Measure the energy and system size dependence of J/Ψ production over the range of ions and energies available at RHIC.
2010	DM6	Measure e^+e^- production in the mass range $500 \leq m_{e^+e^-} \leq 1000$ MeV/c ² in $\sqrt{s_{NN}} = 200$ GeV collisions.
2010	DM7	Complete realistic calculations of jet production in a high density medium for comparison with experiment.
2012	DM8	Determine gluon densities at low x in cold nuclei via p + Au or d + Au collisions.
2015	DM9 (new)	Measure bulk properties, particle spectra, correlations and fluctuations in Au + Au collisions at $\sqrt{s_{NN}}$ from 5 to 40 GeV to search for evidence of a critical point in the QCD matter phase diagram.
2014	DM10 (new)	Perform calculations including viscous hydrodynamics to quantify, or place an upper limit on, the viscosity of the nearly perfect fluid discovered at RHIC.
2014	DM11 (new)	Measure jet and photon production and their correlations in $A \approx 200$ ion+ion collisions at energies from $\sqrt{s_{NN}} = 30$ GeV up to 5.5 TeV.
2016	DM12 (new)	Measure production rates, high pT spectra, and correlations in heavy-ion collisions at $\sqrt{s_{NN}} = 200$ GeV for identified hadrons with heavy flavor valence quarks to constrain the mechanism for parton energy loss in the quark-gluon plasma.
2018	DM13 (new)	Measure real and virtual thermal photon production in p + p, d + Au and Au + Au collisions at energies up to $\sqrt{s_{NN}} = 200$ GeV.

Spin Physics Milestones

Year	#	Milestone
2013	HP8	Measure flavor-identified q and \bar{q} contributions to the spin of the proton via the longitudinal-spin asymmetry of W production.
2013	HP12	Determine if gluons have appreciable polarization over any range of momentum fraction between 1 and 30% of the momentum of a polarized proton.
2015	HP13	Test unique QCD predictions for relations between single-transverse spin phenomena in p - p scattering and those observed in deep-inelastic lepton scattering.

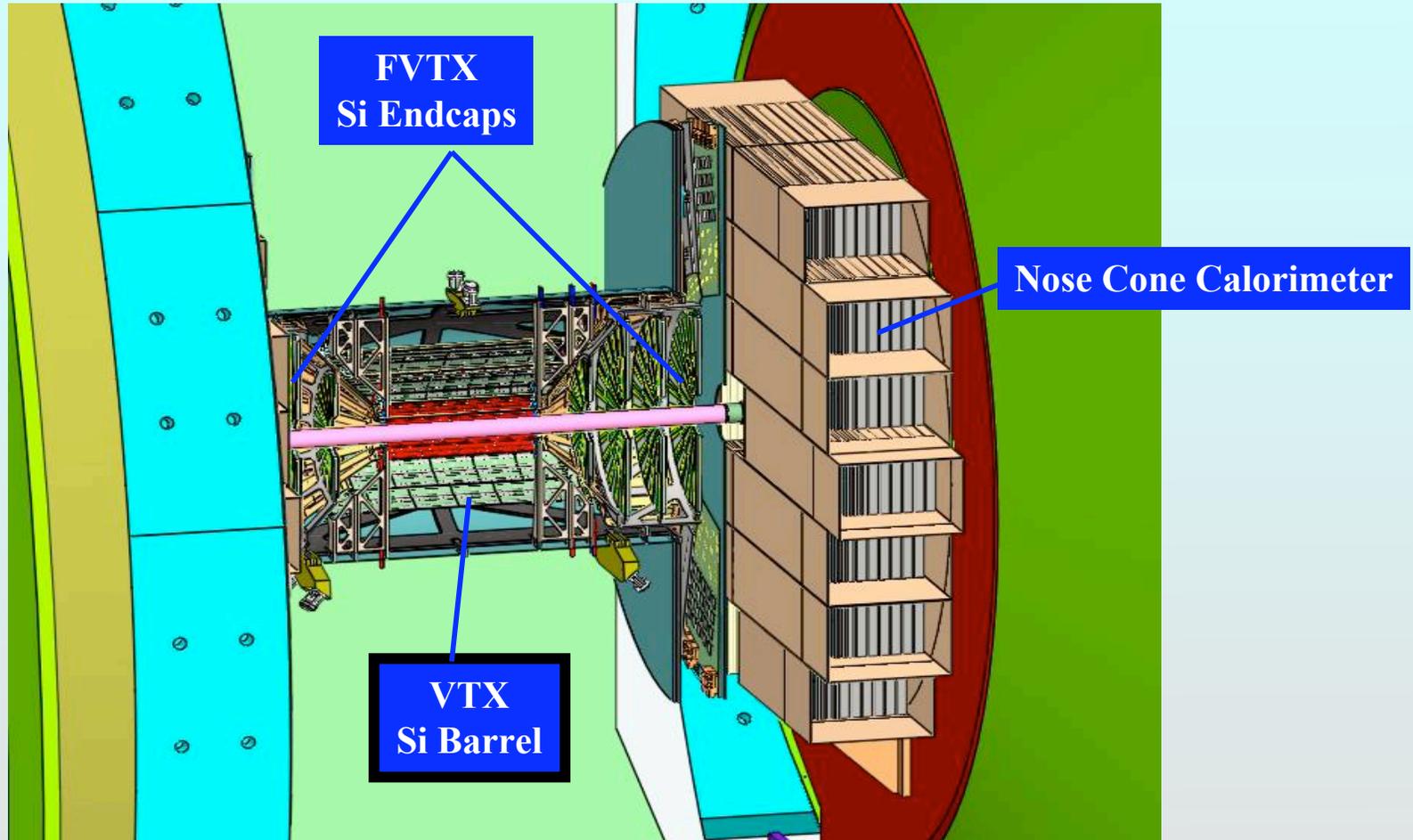


Detector Upgrades



- (i) π^0 and direct γ with additional forward EM calorimeters (NCC)
- (ii) heavy flavor with silicon vertex trackers (VTX, FVTX)
- (i)+(ii) for large acceptance γ -jet (γ -h at intermediate p_T)

Tracking & Calorimetry Upgrades



Charmonium spectroscopy & c,b interaction in dense medium
Gluon spin structure ($\Delta G/G$) via γ_{direct} , γ -jet; Transversity
Parton structure of nuclei, saturation at low x via $\pi^0(x, p_T)$ 29

Muon Trigger

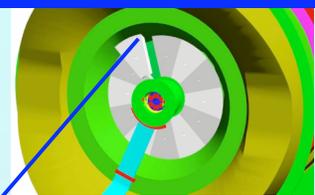
The Muon Trigger Upgrade consists of:

- 4-6 Stations of Resistive Plate Chambers
3 North, 3 South
- Addition of LVL1 electronics to MuTracker
St1, St2 North and St1, St2 South
possibly station 3, as well
- Increases LVL1 rejection by 2 orders of magnitude

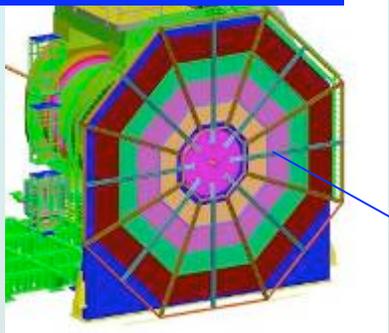
MuTrig Station 1



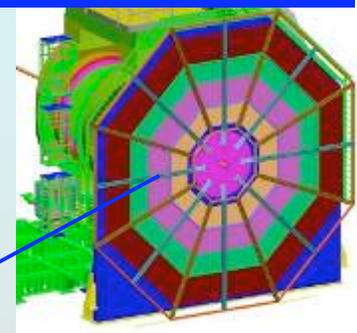
MuTrig Station 1



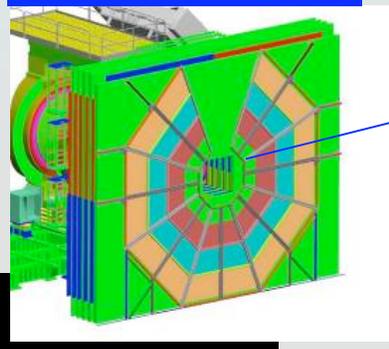
MuTrig Station 2



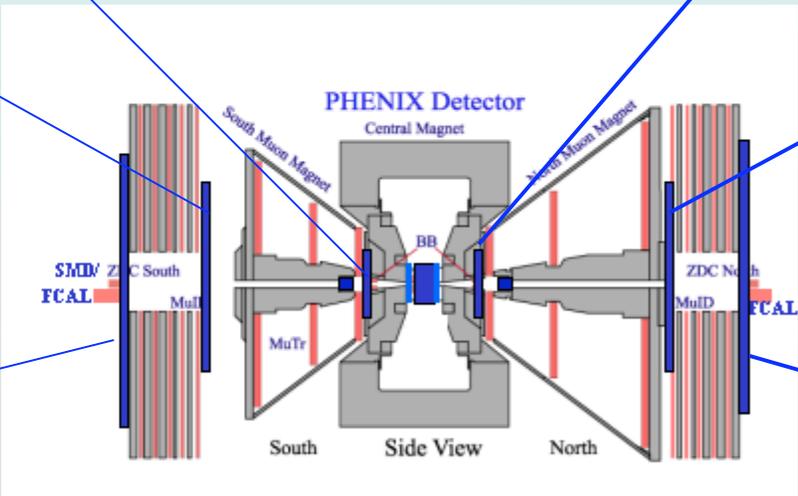
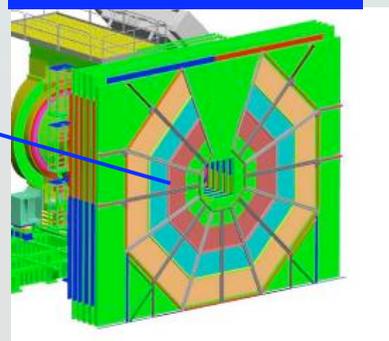
MuTrig Station 2



MuTrig Station 3



MuTrig Station 3



● Challenges

Exciting physics to do

- We need to construct big upgrades to do it
Build PHENIX VTX, FVTX, NCC MIE upgrades
Commission HBD and complete Muon Trigger
DAQTrig2010 upgrade (talk of J. Nagle)
- Increased luminosity to access rare probes
- Schedule upgrades and running time to get the physics
- Keep collaboration engaged in era of LHC, JPARC
- How to proceed in the meanwhile to make it all come together?!!

RHIC Run Plan

Fiscal Year	Colliding Beam Species/Energy	Comments
2009	500 GeV p+p	Assuming ~April 1 start, about 5-6 physics weeks to commission collisions, work on polarization & luminosity and obtain first W production signal to meet RIKEN milestone
2010	200 GeV p+p	~12 physics weeks to complete 200 GeV A_{LL} measurements – could be swapped with 500 GeV Run 9 if Run 9 can start by March 1, 2009; STAR DAQ1000 fully operational
	200 GeV Au+Au	9-10 physics weeks with PHENIX HBD, STAR DAQ1000 & TOF permits low-mass dilepton response map and 1 st collision test of transverse stochastic cooling (one ring)
2011	Au+Au at assorted low E	1 st energy scan for critical point search, using top-off mode for luminosity improvement – energies and focus signals to be decided, commission PHENIX VTX (at least prototype)
	200 GeV U+U	1 st U+U run with EBIS, to increase energy density coverage
2012	500 GeV p+p	1 st long 500 GeV p+p run, with PHENIX muon trigger and STAR FGT upgrades, to reach ~100 pb ⁻¹ for substantial statistics on W production and ΔG measurements
	200 GeV Au+Au	Long run with full stochastic cooling, PHENIX VTX and prototype STAR HFT installed; focus on RHIC-II goals: heavy flavor, γ -jet, quarkonium, multi-particle correlations
2013	500 GeV p+p	Reach ~300 pb ⁻¹ to address 2013 DOE performance milestone on W production
	200 GeV Au+Au or 2 nd low-E scan	To be determined from 1 st low-E scan and 1 st upgraded luminosity runs, progress on low-E e-cooling, and on installation of PHENIX FVTX and NCC and full STAR HFT
2014	200 GeV Au+Au or 2 nd low-E scan	Run option not chosen for 2013 run – low-E scan addresses 2015 DOE milestone on critical point, full-E run addresses 2014 (γ -jet) and 2016 (identified heavy flavor) milestones. Proof of principle test of coherent electron cooling.
	200 GeV p+p	Address 2015 DOE performance milestone on transverse SSA for γ -jet; reference data with new detector subsystems; test e-lenses for p+p beam-beam tune spread reduction

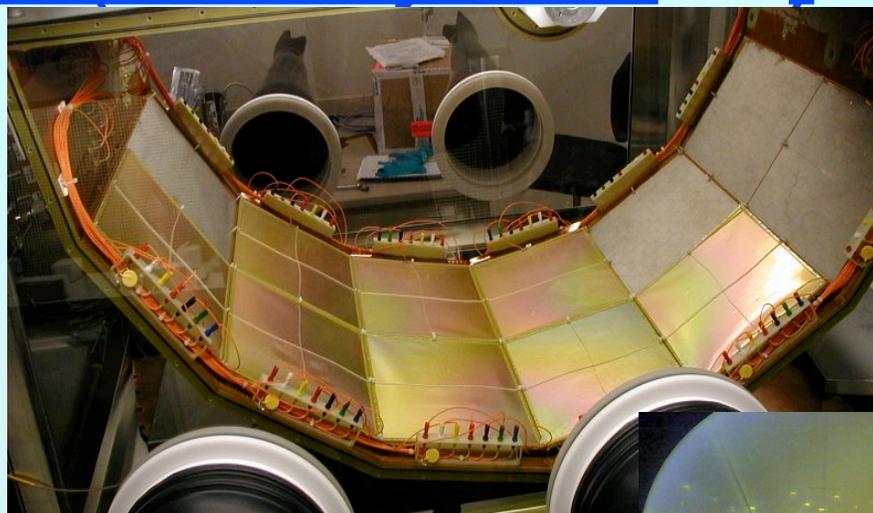
Hadron Blind Detector (Dalitz rejection e^+e^-)

Windowless CF_4 Cherenkov

50 cm radiator length

CsI reflective photocathode

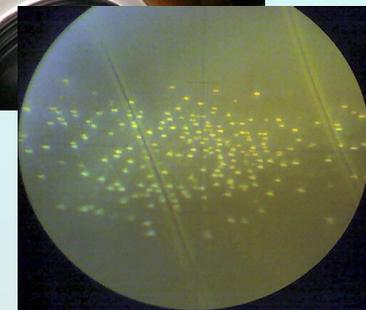
Triple GEM with pad readout



Multi-module trips (optical cross talk) damaged GEM surfaces.

New HV distribution & relay boards, GEMs

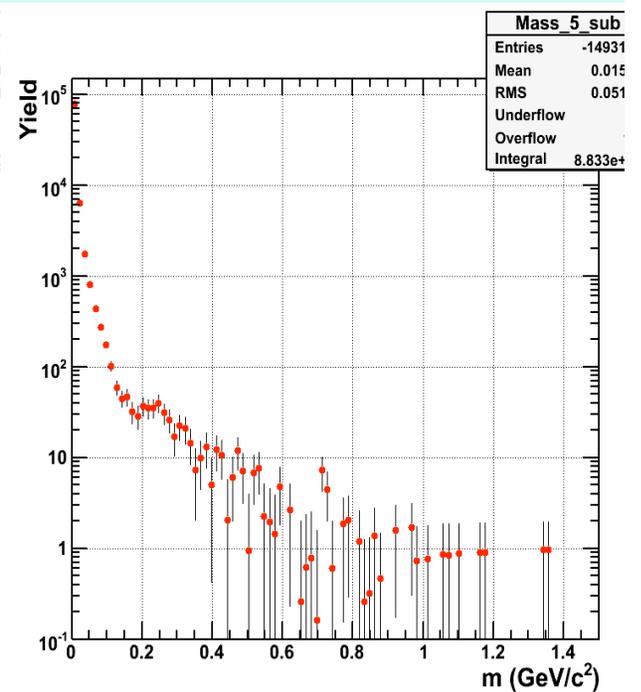
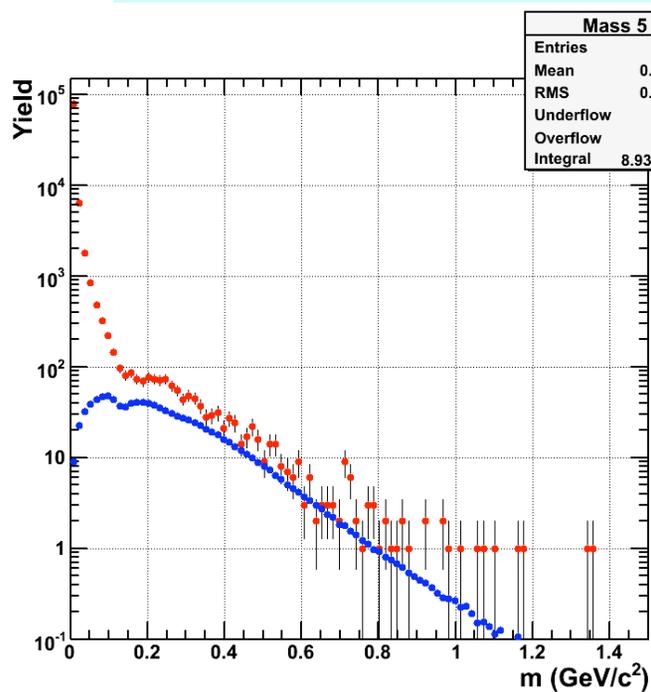
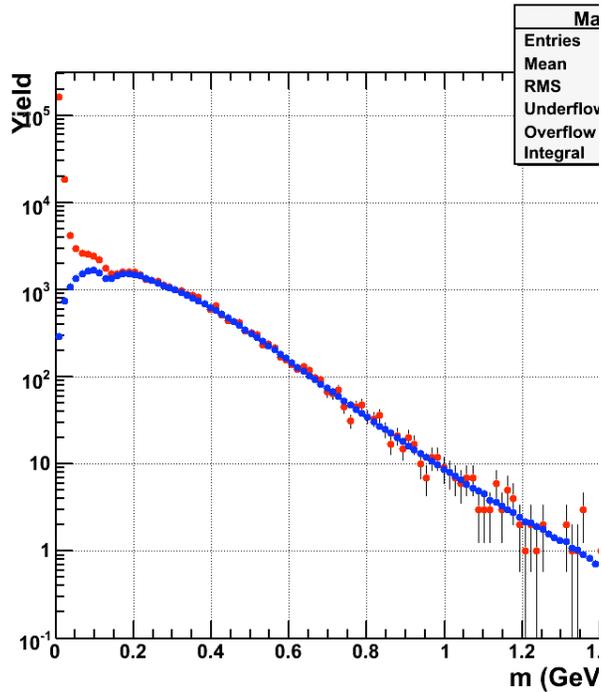
- Discharges related to dust in GEMs. *Powerwash GEMs, UPLA vacuum glove box, new assembly procedure. Improved charge extraction → lower operating voltage.*
- Water contamination found at 20-40 ppm, limiting UV transparency. *Vessel baked, new window, circulate more gas.*



Data from working sectors analyzed.

Good e/h separation observed.

HBD Run-7 data



e+e- no HBD
info

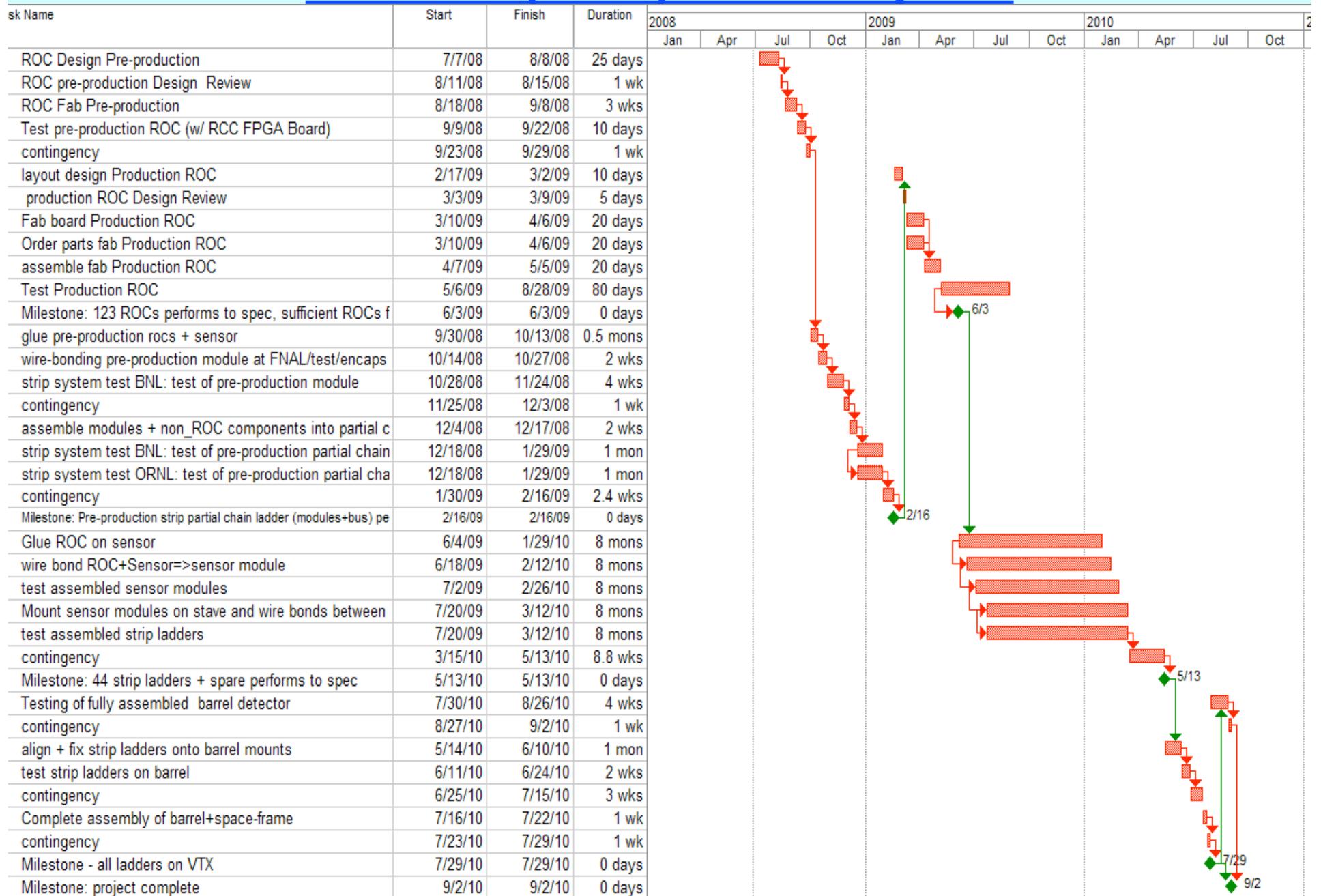
After HBD cuts

combinatorial
subtracted

14 photoelectrons in Run-7, ~20 next run

***HBD-West ready; better than 14 ppm water.
Holding voltage in CF4. HBD-East ready soon.***

VerTeX (VTX) critical path



VTX milestones

	<u>WBS</u>	<u>Milestone</u>	<u>baseline</u>	<u>new</u>	<u>delay</u>
pixel	1.2.3.4	pixel sensor modules performs to spec	9/17/07	8/20/08	338 days
	1.2.3.5	60 pixel buses + spares fabricated	11/1/07	11/4/08	369
	1.2.9.3	1st prototype pixel ladder performs to electrical spec	8/2/07	9/30/07	58
	1.5.2.15	30 + spare pixel staves delivered	8/28/08	8/2/08	-2
	1.2.9.5	30 pixel ladders assembled + spare	1/29/09	6/17/09	139
strip	1.1.3.5	pre-production det module perform to spec		12/3/08	
	1.1.3.4	Pre-production strip ladder performs to spec	8/22/08	4/17/09	238
	1.1.1.6	123 ROCs performs to spec; for half-VTX	1/7/09	6/3/09	147
	1.5.2.16	44 + spare strip staves delivered	7/20/09	7/1/09	-19
	1.1.4.5	22 strip ladders performs to spec, half-VTX	11/9/09	12/9/09	30
	1.1.4.6	44 strip ladders + spare performs to spec	5/14/10	5/13/10	-1
mech	1.5.2.17	12 barrel mounts delivered	4/24/09	10/27/08	-179
	1.5.2.18	space frame delivered	7/20/09	7/9/09	-11
	1.5.4.3	infrastructure ready for installation	8/19/09	5/18/09	-93
	1.5.3.4	all ladders on VTX	7/8/10	8/18/10	41
	1.6.5	Project complete	9/9/10	9/2/10	-7

VTX simulation (e^{\pm} impact , c/b, tracking)

- VTX detector material & response implemented into PHENIX simulation (PISA)

Includes charge sharing, noise and clustering

- VTX software manpower (simulations + analysis)

M. Kurosawa - PISA implementation

K. Nakano, M. Togawa - detector response

S. Whitacker, Togawa, Nakano - jets

A. Dion, S. Lebedev, R. Petti - standalone tracking

A. Bergstrom, S. Lebedev - DCA resolution

S. Bathe - global tracking with PHENIX arms

K. Ozawa

Beginning “blind” analysis test of VTX & FVTX performance on signals buried in fully simulated HIJING events → prepare software for calibration, alignment & data analysis of first data

ForwardVerTeX (ψ' , Y, B \rightarrow J/ ψ , c/b, D-Y)

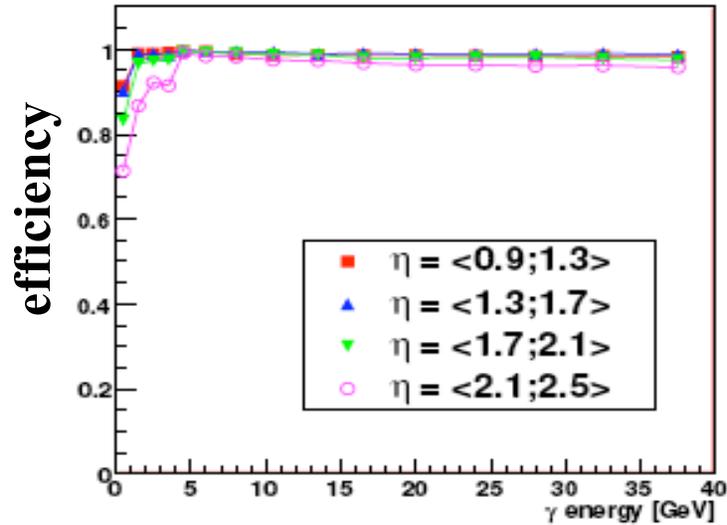
WBS Item Description	Project Completion Date	Critical Path	Issues
WBS 1.1 DOE construction funds received	Q3 FY08		
Accounts open	Q3 FY08		
WBS 1.6.2.2.2 Review and Approve wedge, disk, cage design	Q3 FY08		
WBS 1.4.3.2.5 HDI tested	Q3 FY08		2-3 month delay *
WBS 1.4.1.2.3 Sensor prototype tested	Q1 FY09		~1 month delay in procurement**
WBS 1.4.1.2.5 First prototype wedge assembly	Q1 FY09		
WBS 1.5.2.2.6 PHENIX system test complete	Q1 FY09		
WBS 1.5.2.2.8 Review and Approve FEM and ROC	Q2 FY09		ROC/FEM procurement delayed from FY08 to FY09 (funding not available)***
WBS 1.4.1.3.1 Sensor Procurement complete	Q3 FY09		
WBS 1.4.1.2.6 Wedge assembly test complete	Q4 FY09		
WBS 1.4.2.5.1 FPHX engineering run complete	Q1 FY10	yes	Increased cost, ~1 month delay in prototype delivery***
WBS 1.5.3 ROC and FEM production Complete	Q2 FY10		Some procurement delay to allow FPHX costs to be covered***
WBS 1.7.1.1 Disk Assembly begins	Q3 FY10		
WBS 1.5.5.6 Install ancillary Equipment	Q4 FY10		
WBS 1.7.1.1 Disk Assembly complete	Q1 FY11		
WBS 1.7.2.1 ½ Cage Assembly finished	Q2 FY11		
WBS 1.7.3 Install into VTX enclosure	Q2 FY11		
WBS 1.7.3 Project Complete	Q3 FY11		

solved
sufficient float; prepare
& expedite testing

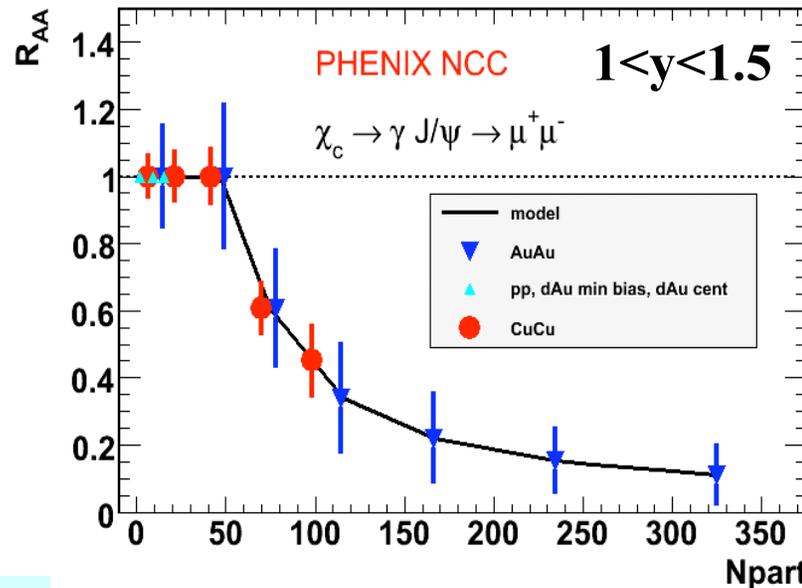
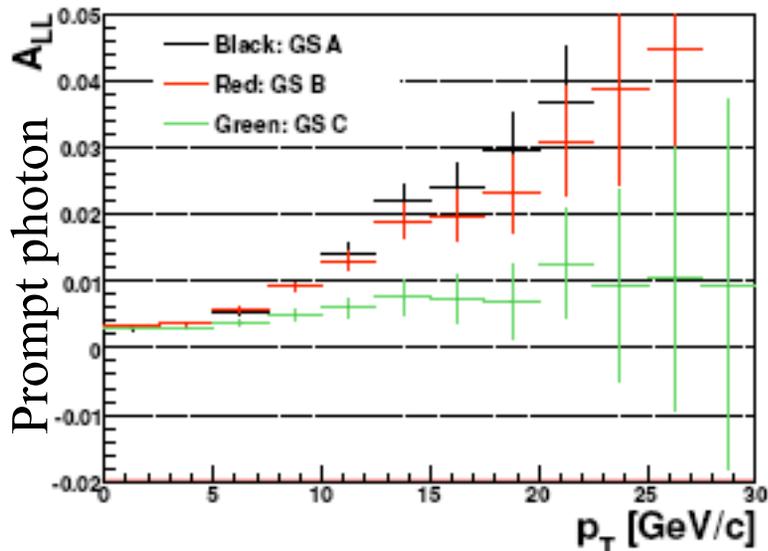
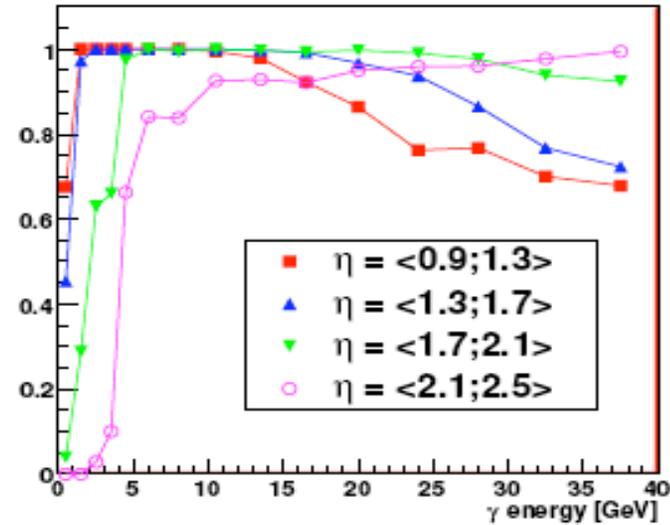
Collab provide
more testing

Nose Cone Calorimeter*

a) γ reconstruction eff., pp minbias



b) γ reconstruction eff., AuAu 0-10 %

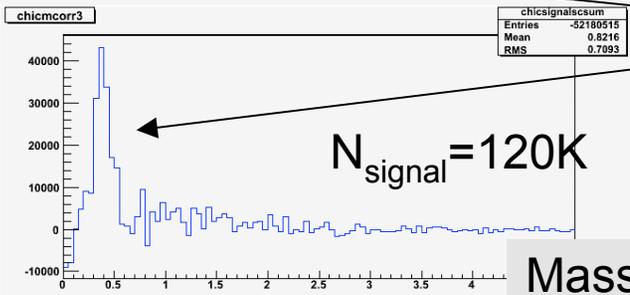
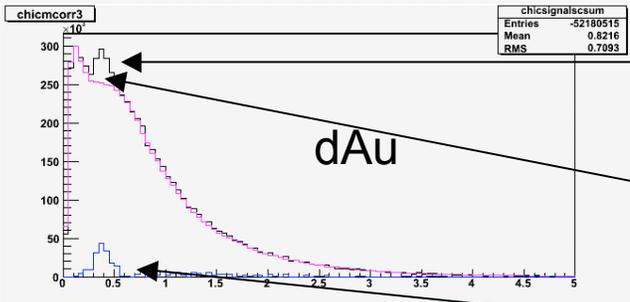
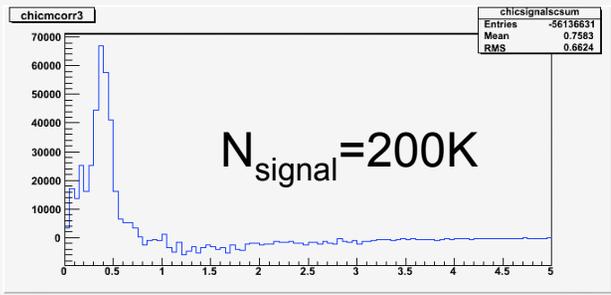
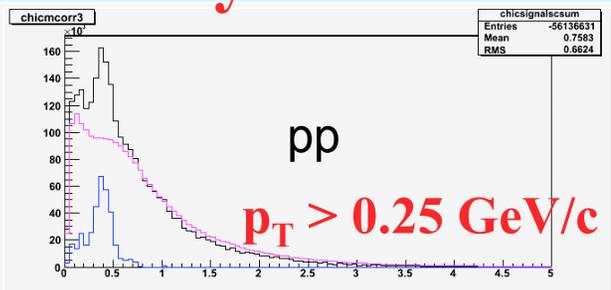


PID, isolation cuts still under development

Awaiting cost & schedule review, start

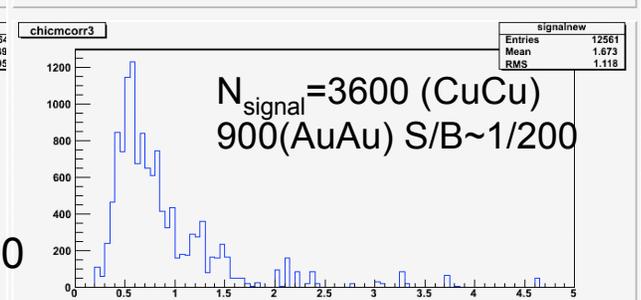
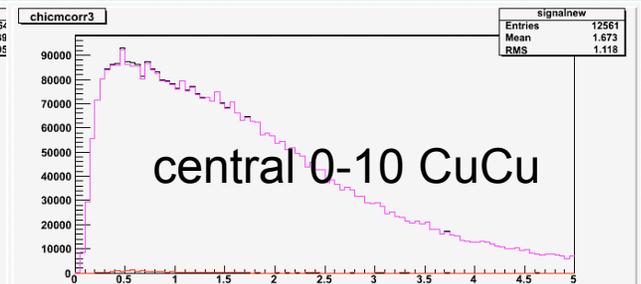
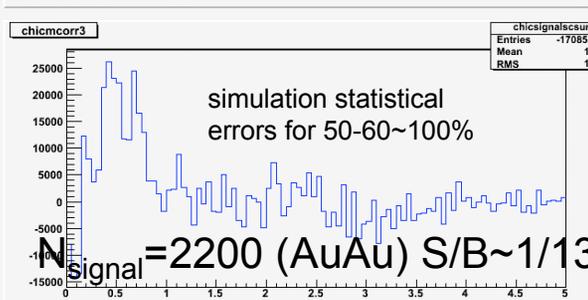
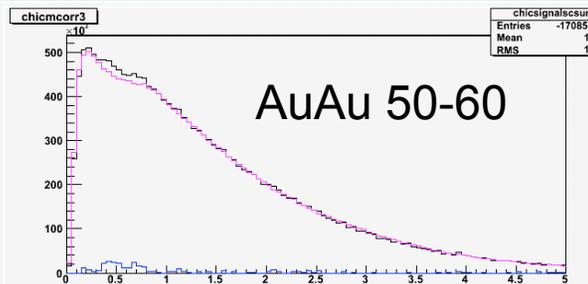
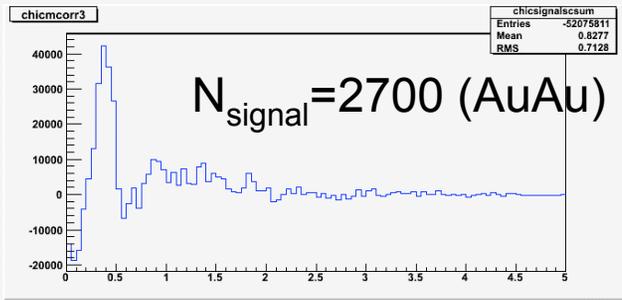
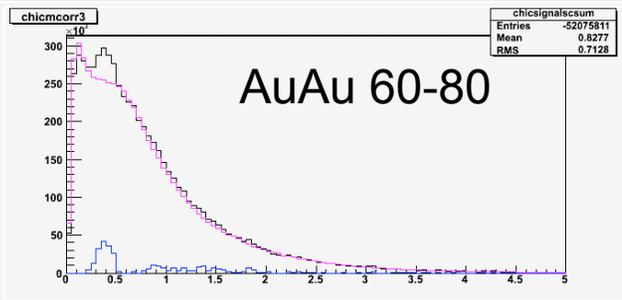
$1.0 < y < 1.5$

χ_c in NCC + muon arm



Beam test fall '08;
Russian and
Korean sensors
Goal: complete for
high luminosity
Au+Au in Run-12

Mass ($\chi_c - J/\psi$)



How to manage the aggressive schedule?

- Improve communication with MIE project managers
- Began weekly meetings of VTX + PHENIX management
 - ⇒ Improve intra-project communication
 - ⇒ Regularly track progress toward milestones
 - ⇒ Actions to ameliorate schedule/cost impacts
- Begin similar meetings with other upgrade teams
 - Collaboration management must determine how best to accomplish this
 - Rearrange some other responsibilities?
- *We will need some help from BNL*
 - Financial admin assistance for Ed O'Brien
 - Partial support for other management members?
 - Perhaps other kinds of help also needed

PHENIX Management

Spokesperson -	Barbara Jacak	Stony Brook U
Dpty Spokesperson-	Yasuyuki Akiba	RIKEN/RBRC
Dpty Spokesperson	Matthias Grosse-Perdekamp	UIUC/RBRC
Dpty Spokesperson	Richard Seto	UC Riverside
Operations Manager	Edward O'Brien	BNL
Upgrade Manager-	Axel Drees	Stony Brook U

Coordinators

Chief Engineer D. Lynch BNL	DAQ Coor. M.Purschke BNL	Computing Coor. C. Vale BNL	Analysis Coord. A. Frawley Florida St.	Trigger Coor. J. Nagle UColorado	Run-9 Coord. J. Haggerty BNL	PHENIX Admin B. Johnson BNL
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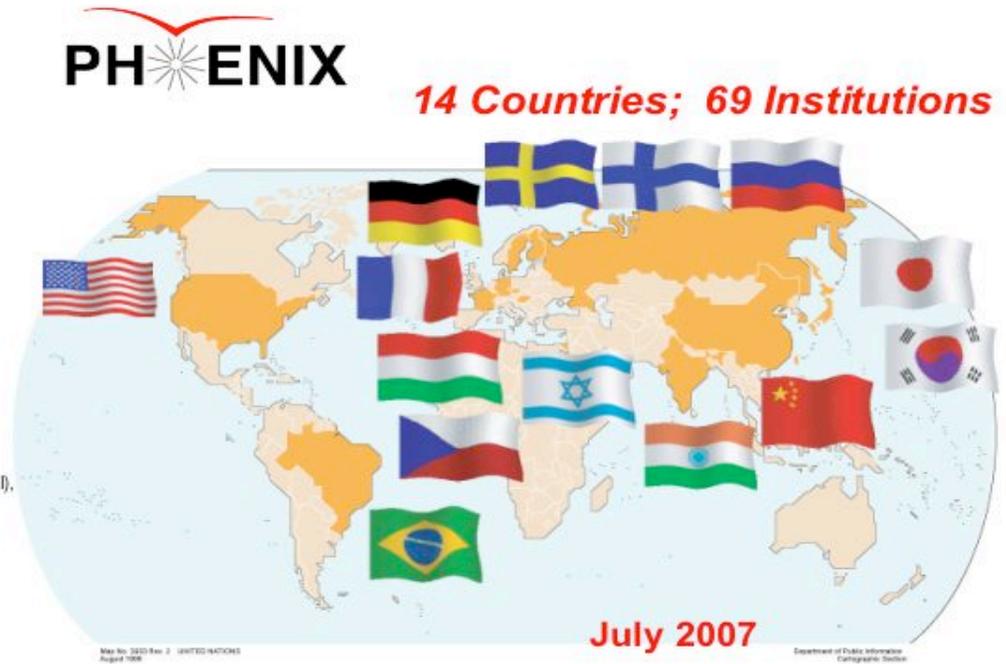
- **Upgrades: M. Grosse-Perdekamp (Mu Trigger), Y. Akiba (VTX), M. Brooks-LANL(FVTX), R. Seto (NCC)**
- **Educational value of university-based upgrade projects *extremely* high**
 - High level technical training for students**
 - Graduate (NB: >50% leave basic research)**
 - Undergraduates participate readily**
- **Develop new leaders in the field**
- **Strengthen technical infrastructure at educational institutions**

Summary

- PHENIX is extraordinarily successful and productive
unprecedented physics reach & flexibility
discoveries & excitement continue
- Robust plan for next phase of RHIC Physics
discovery → characterization of QGP
Upgrade program: new observables & reach
New physics to maintain collaboration momentum
LHC and J-PARC offer attractive options
- Simultaneously run/analyze our physics program +
implement detector & DAQ upgrades
A challenge for PHENIX manpower & management
Imperative to succeed for vitality of the program

PHENIX Collaboration

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~ 550 Collaborators

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