Beam Use Proposal for Runs 7 and Beyond

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for the PHENIX Collaboration

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Outline

- Collaboration Status
- PHENIX Achievements & Discoveries
- PHENIX Physics goals for Run 7-10
  - 200 GeV/A Au+Au (x10 integrated luminosity)
  - d+Au (58 pb^{-1} → reference for Au+Au)
  - 200 GeV p+p (≥ 71 pb^{-1} → measure ΔG)
  - 500 GeV p+p
  - (W production → quark, antiquark polarization)
  - Au+Au energy scan (search for critical point)
  - additional heavy ion system(s)
- Beam Use Proposal

  Boundary conditions & issues

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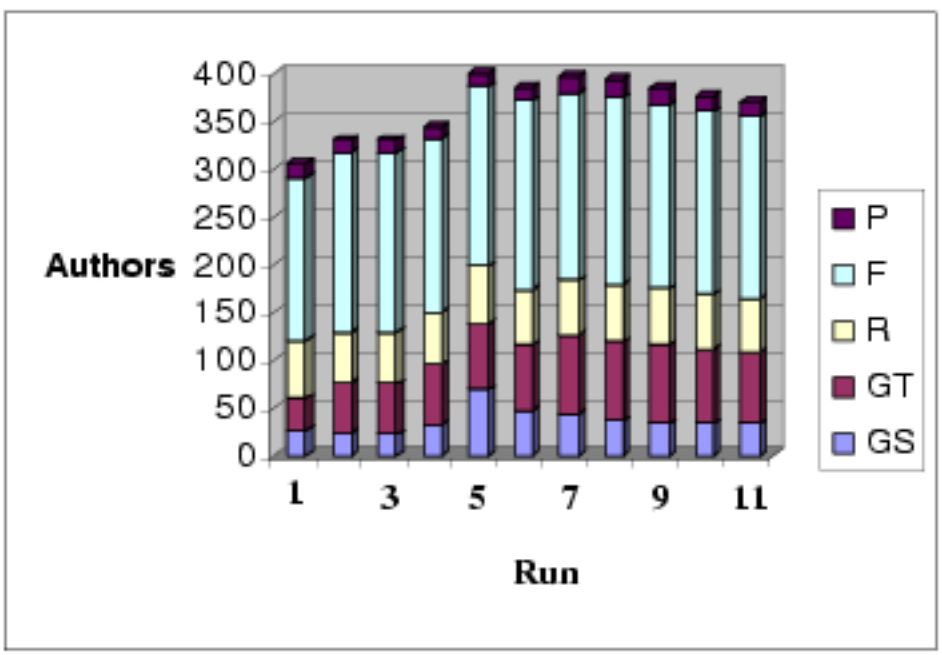
PHENIX is, and will remain, strong



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PHENIX is fantastically productive

- 51 Papers published to date + 4 others accepted
  + 7 in review process
  impact of our papers is enormous!
- PHENIX has
  20% of the 50 most cited nucl-ex papers *of all time!*
  22% of the 50 most cited nucl-ex papers in 2006
- PHENIX White paper (Nucl.Phys. A757, p. 184, 2005)
  2nd most cited nucl-ex paper in 2006
  50th most cited of "all HEP" in 2006
  (316 citations)
- Most cited paper, with 374 citations is

"Suppression of hadrons with large transverse momentum in central Au+Au collisions at s(NN)**(1/2) = 130-GeV"
Adcox, et al., PRL 88, 022301 (2002)

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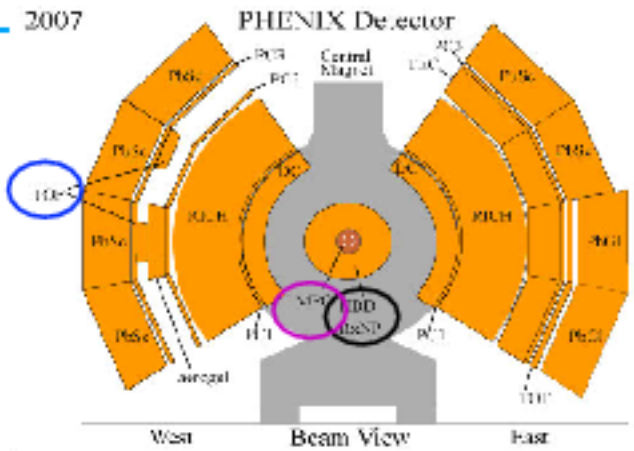
4 upgrades in place for Run-7 *

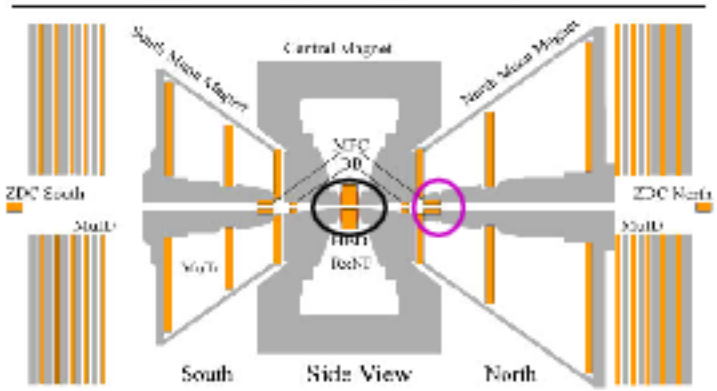
TOF-W (PID)

2007 PHENIX Detector



Hadron Blind, Reaction Plane detectors

Muon Piston Calorimeter (N)



* Thanks to the ever-impressive 1008 staff!

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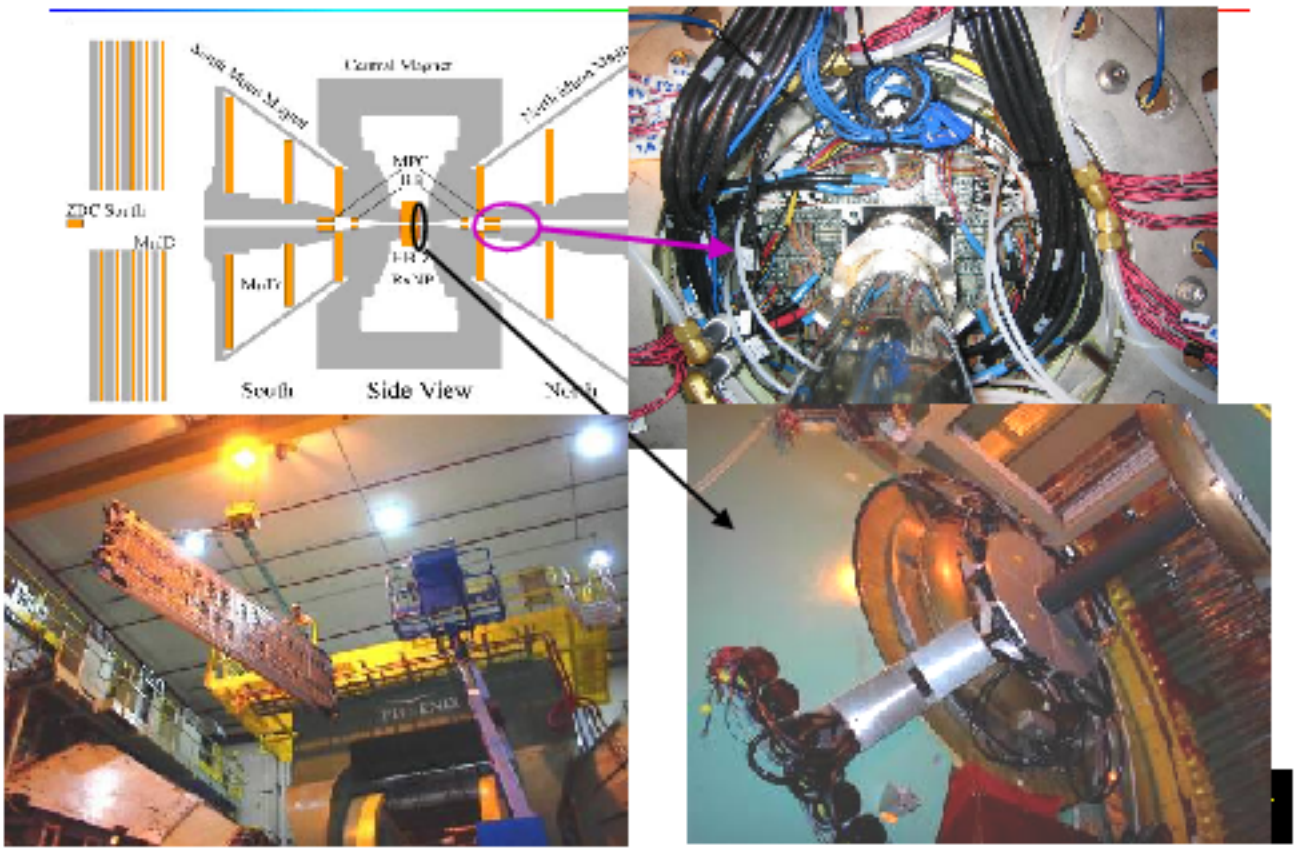
a closer look



Hadron Blind Detector

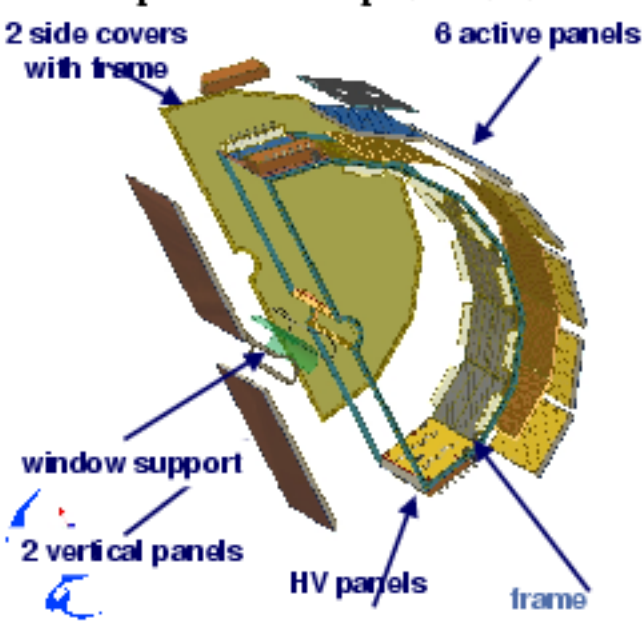
novel concept for e ID → Dalitz rejection

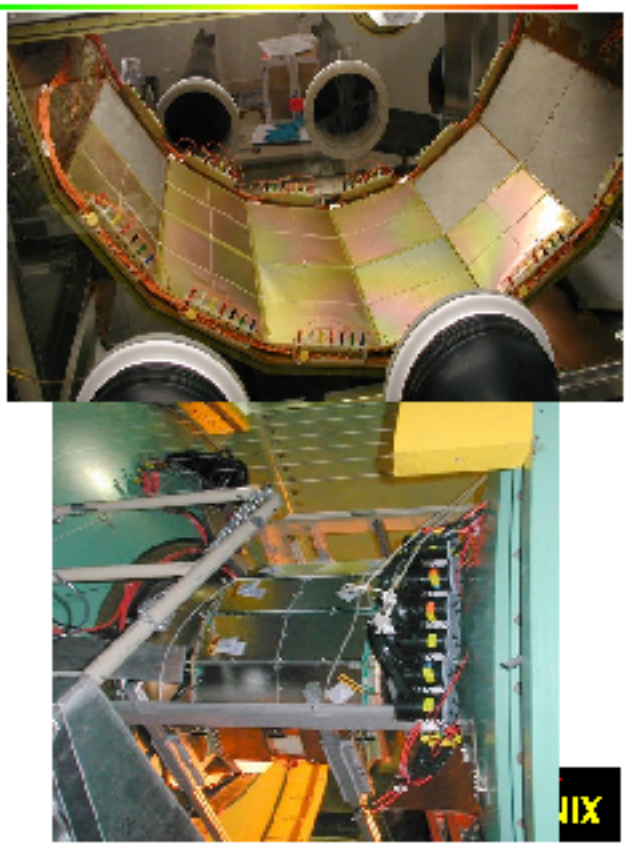
windowless CF_4 Cherenkov detector

50 cm radiator length

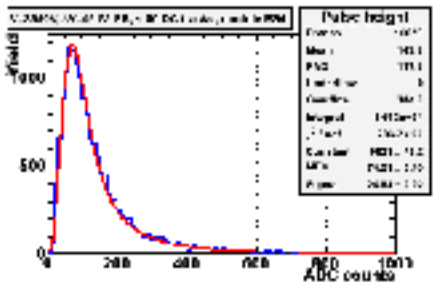
CsI reflective photocathode

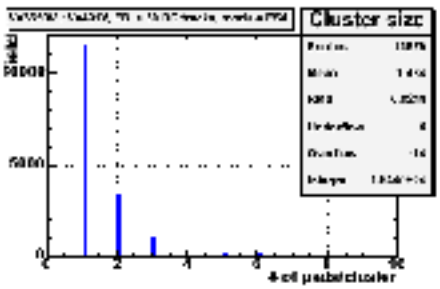
Triple GEM with pad readout





HBD Commissioning Underway

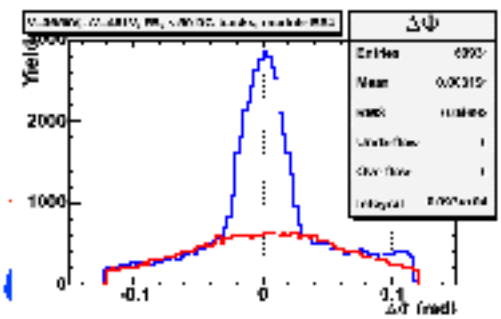


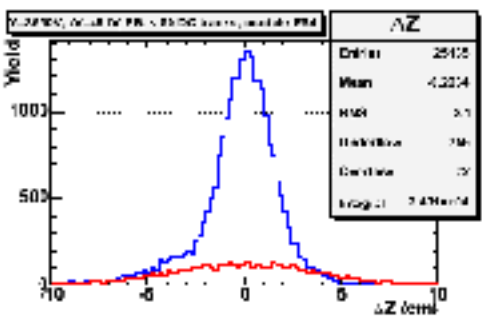


Gas gain:
(assuming a primary charge of 19e in the 1.5mm drift gap and a conversion of 10 ADC counts/fC)

G = 2900

Hadrons selected in central arm projected onto HBD





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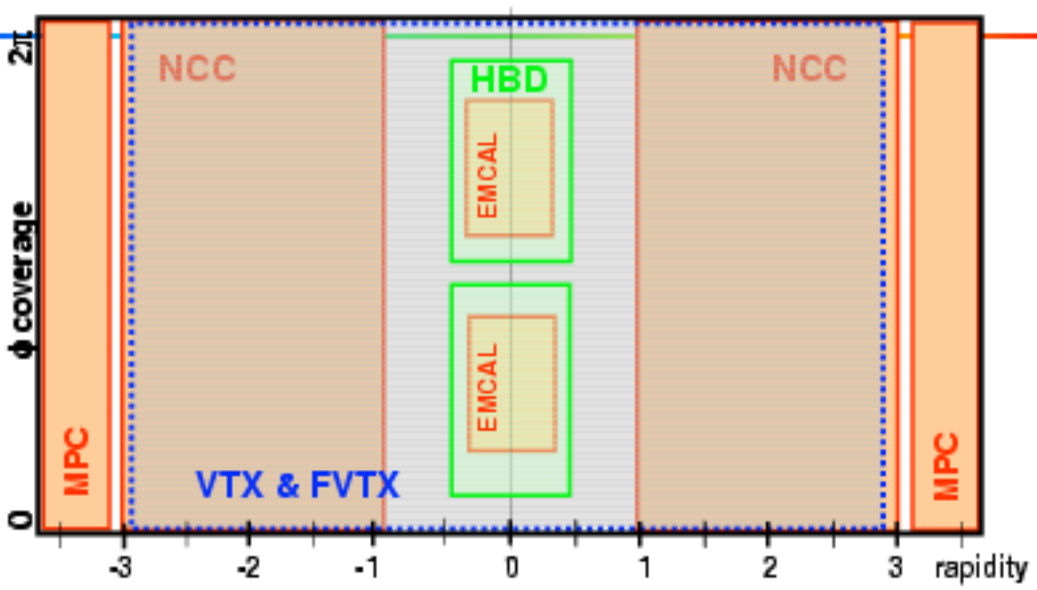
Upgrade path increases PHENIX acceptance



(i) π^0 *and direct* γ with additional EM calorimeters (NCC, MPC)
(ii) *heavy flavor* with silicon vertex tracker (VTX, FVTX)
(i)+(ii) for large acceptance γ-*jet*
(iii) *low mass dileptons* (HBD)

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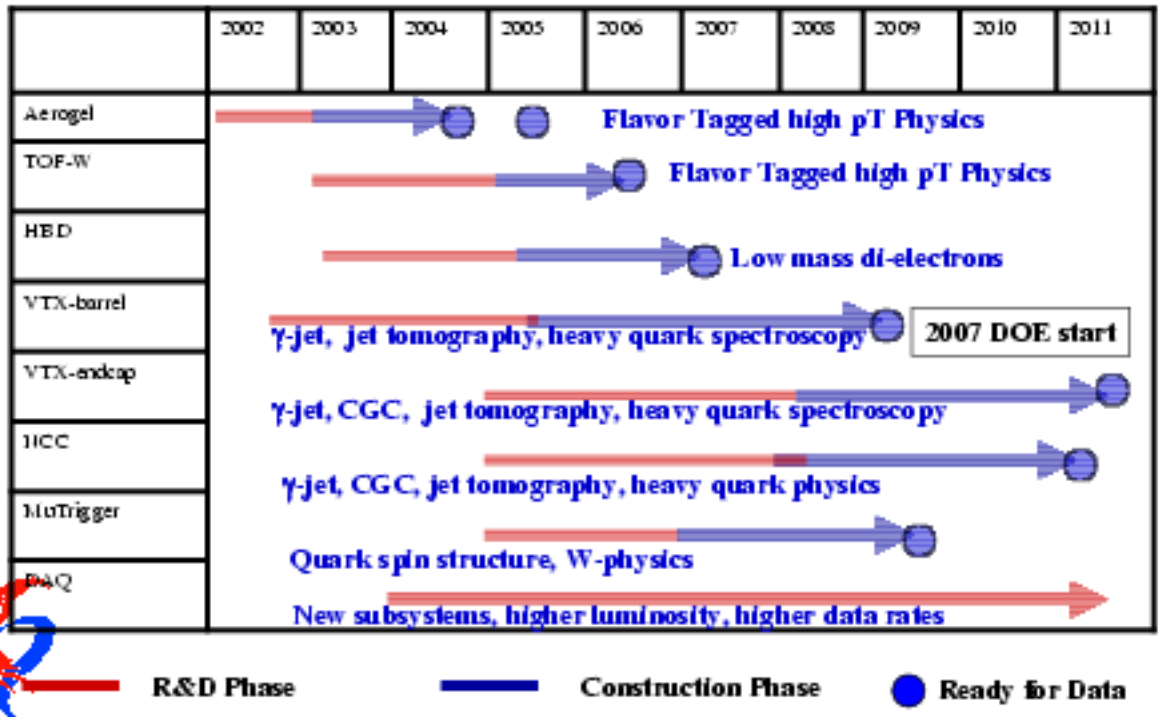
Upgrade Schedule



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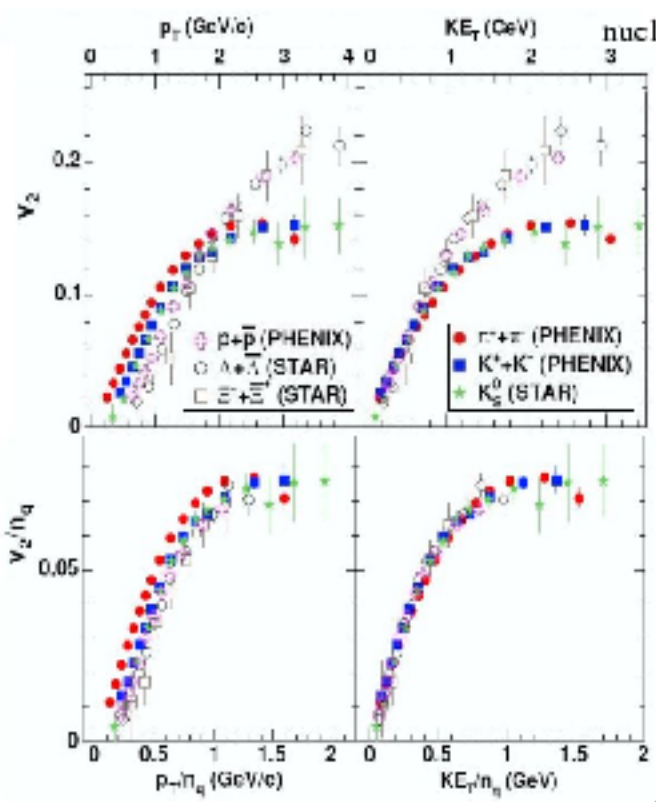
Heavy Ion Physics: Recent Achievements

Run 4 + 5 show:

Hadronization → final state coalescence of constituent quarks from a flowing medium



nucl-ex/0608033

accepted in PRL

19 citations already !

submitted to PRL:

ϕ scales as a_1 meson

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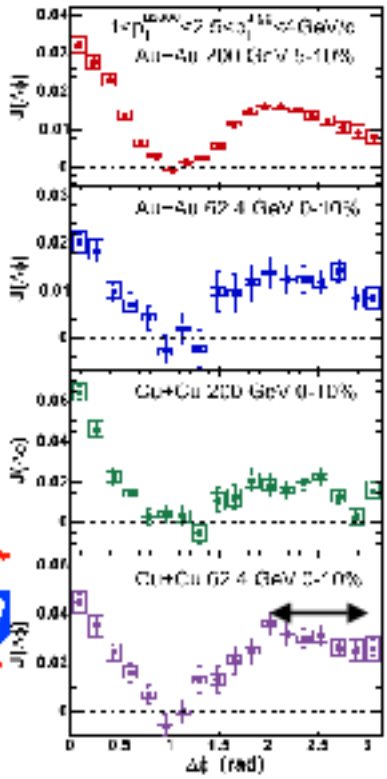
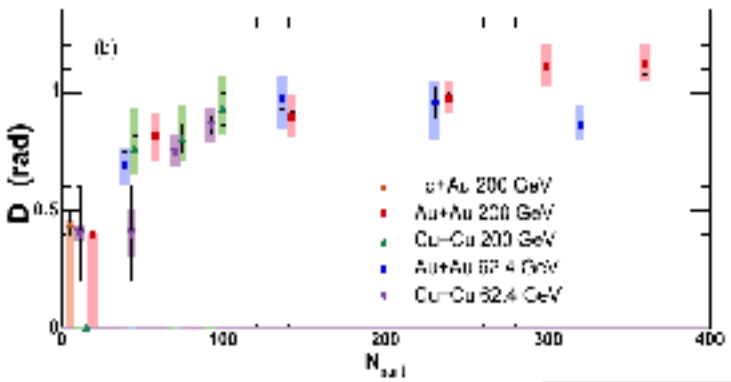
PHENIX achievements & discoveries (2)

1 Medium response to deposited energy - shock front? *



D

PRL 97, 052301 (2006) (105 citations)
and nucl-ex/0611019 (5 cites already)
accepted in PRL
many calculations of medium response, including by string theorists



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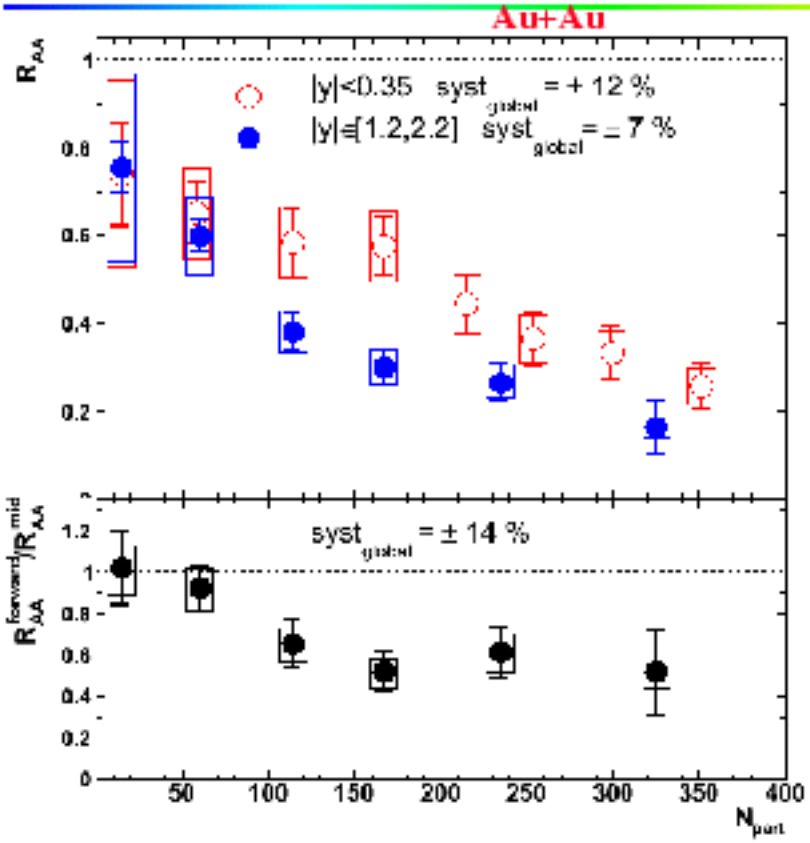
Heavy Quarks do interesting things, too

nucl-ex/0611020 (14 cites)



J/Ψ suppressed
i.e. color screening

(but only somewhat)

$c\bar{c}$ coalescence?
sequential melting of charmonia?

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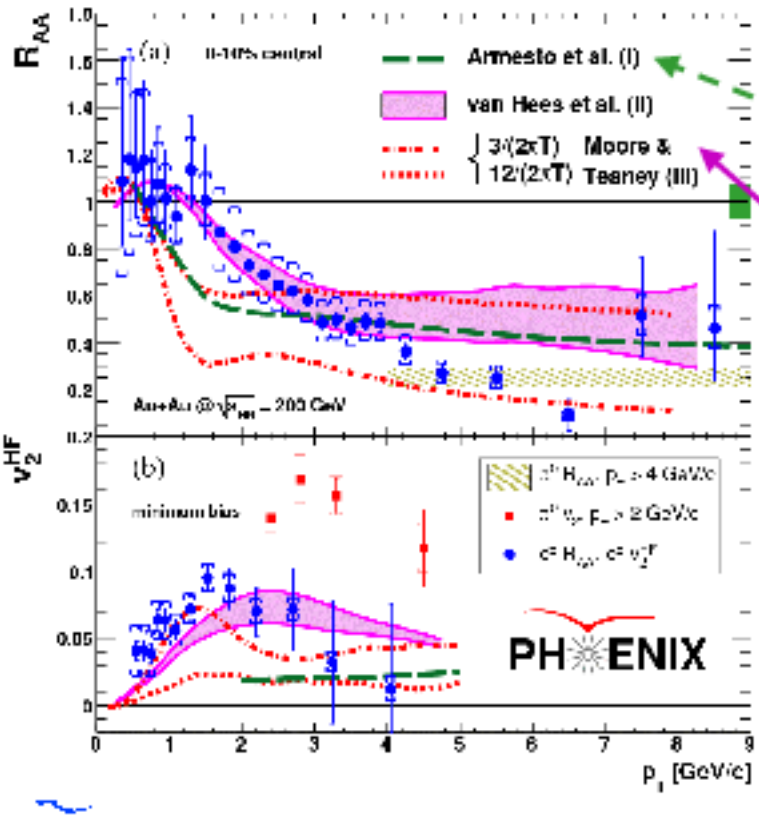
furthermore, open charm loses energy & flows!

nucl-ex/0611018, accepted in PRL

pp result: PRL97 *(13 & 17 cites)*



Radiative energy loss only fails to reproduce v_2^{HF}.

Heavy quark transport model has better agreement with both R_{AA} and v_2^{HF}.

Small relaxation time τ or diffusion coefficient D_{HQ} inferred for charm.

$D = 1/3 \langle v \rangle \lambda_{mfp}$

$= \langle v \rangle / 3\rho\sigma$

$D = \eta/\rho \sim \eta/S$

small D → small η/S

independent measure!

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Compelling questions

- **Does J/ψ flow (final state coalescence says yes…)!**
  J/ψ v_2, fate of direct γ
- **How efficient is transport in the medium?**
  π^0 at high p_T, di-jets, *γ-jet correlations*
- **Is hadronization really so simple?**
  extend light hadron measurements: π/K/p to 10 GeV/c
- **Is there evidence for chiral symmetry restoration and/or thermal radiation in low mass dileptons?**

→ **Extend sensitivity for new and rare channels via upgrades + increased integrated luminosity!**

Order of magnitude $\int \mathcal{L}$ over existing Run-4!

Collect in Run-7 + Run-9

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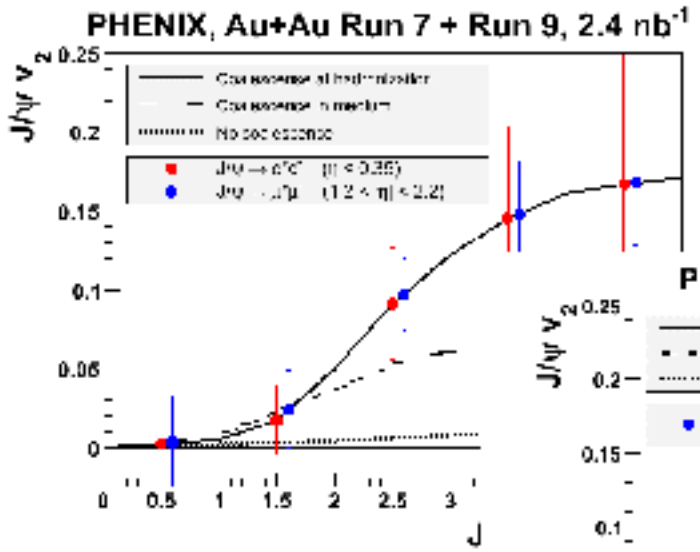
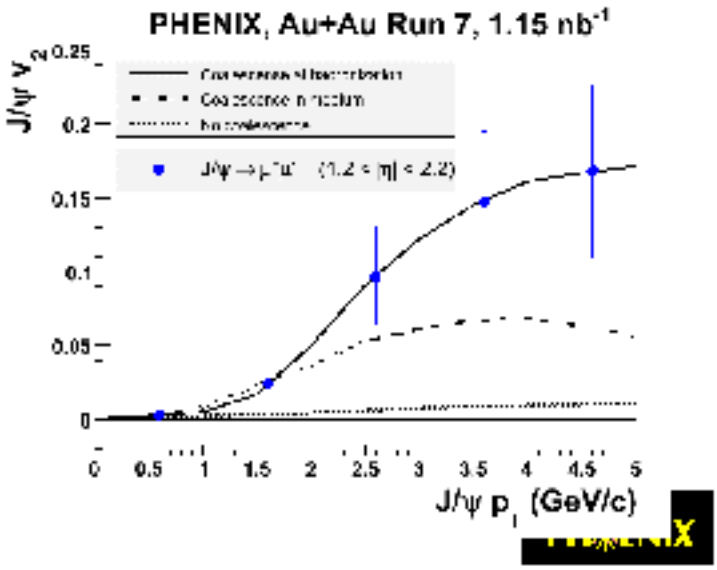
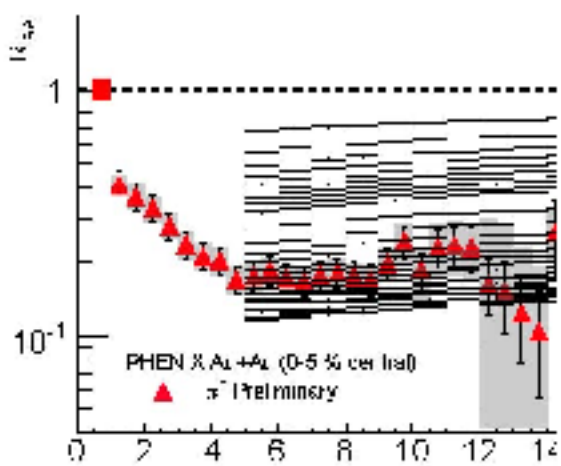
Precision of J/ψ v_2 measurement



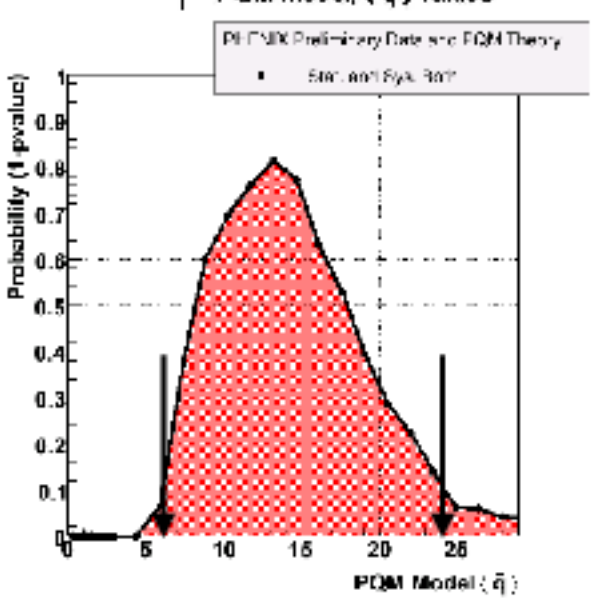


Run-7 will tell if J/ψ v_2 is zero or not

Need better statistics at high p_T



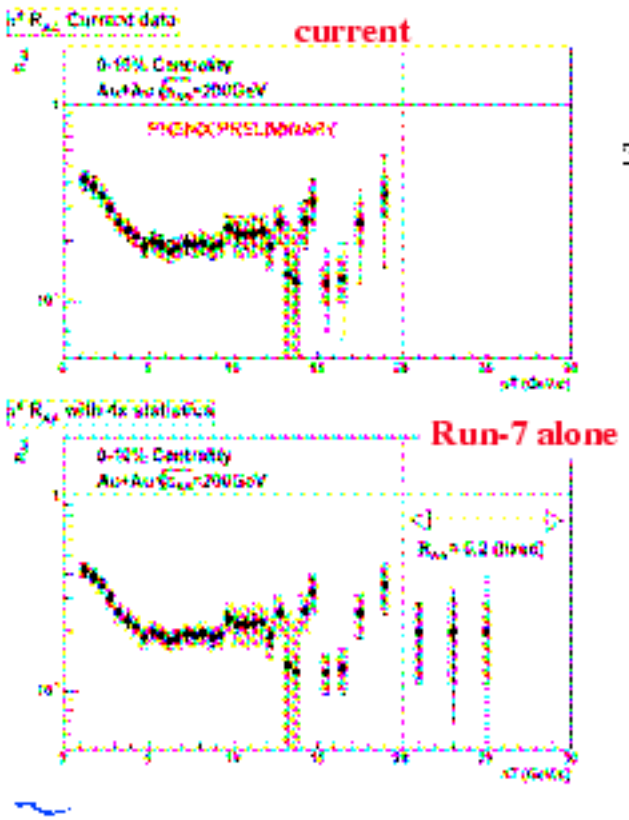
C. Loizides
hep-ph/0608133v2

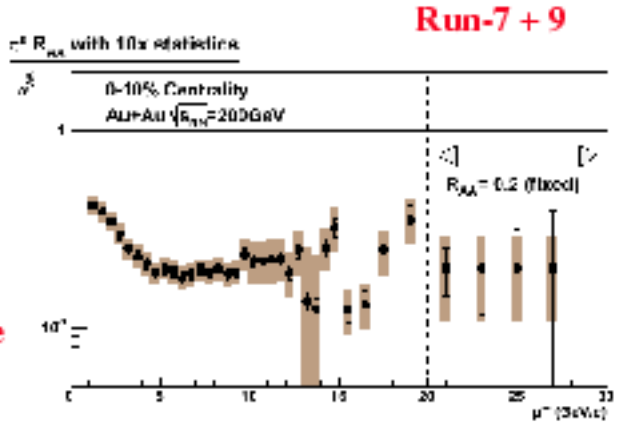


$6 \le \langle \hat{q} \rangle \le 24$ GeV^2/fm
(Probability > 10%)

$\hat{q} \sim \langle k_T \rangle^2 / \lambda$

Increase p_T range & errors





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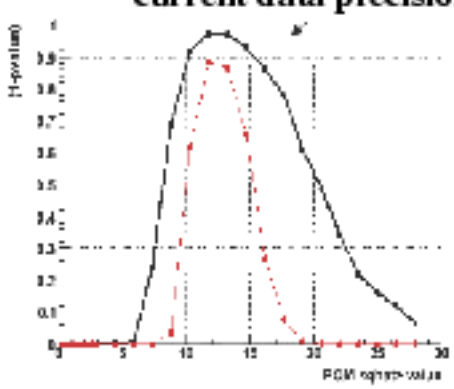
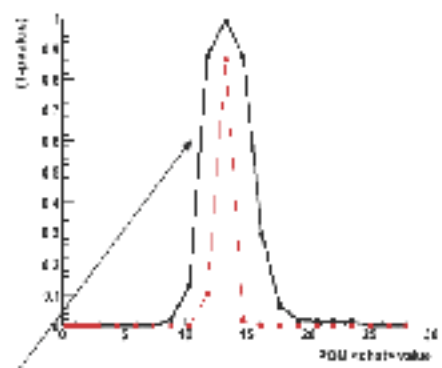
Runs 7+9: from limit to measurement of q-hat

simulation study, using qhat = 13.2

current data precision





x10 statistics

x10 statistics & no σ_{syst}

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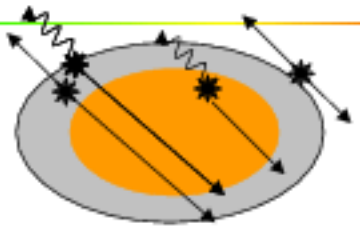
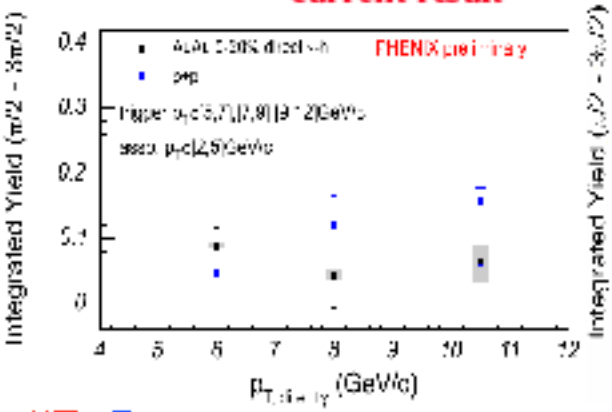
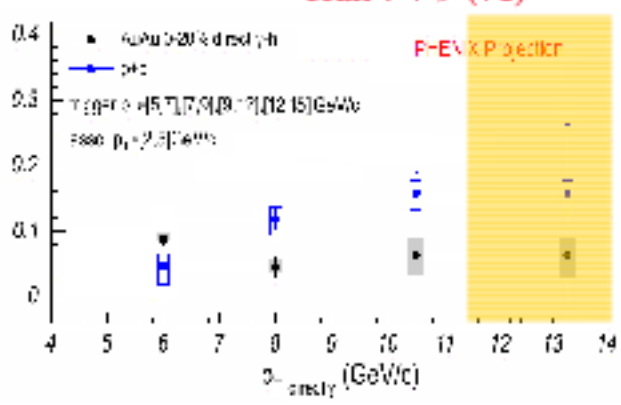
direct γ – jet coincidence: calibrated jet probe



current result



Run 7 + 9 (+8)



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d+Au request for Run-8

- With recent p+p runs, d+Au data are the limiting factor for precision statements about the (small) nuclear modifications
- Run-3 d+Au provided 2.7 nb^{-1}
- Run-8: provide comparison for Run-7 Au+Au
  1.1 nb^{-1} Au+Au → 44 pb^{-1} equivalent p+p collisions
  J/ψ $<R_{AA}>$ ~ 0.5 → ~22 pb^{-1} equivalent p+p collisions
  → 58 nb^{-1} d+Au

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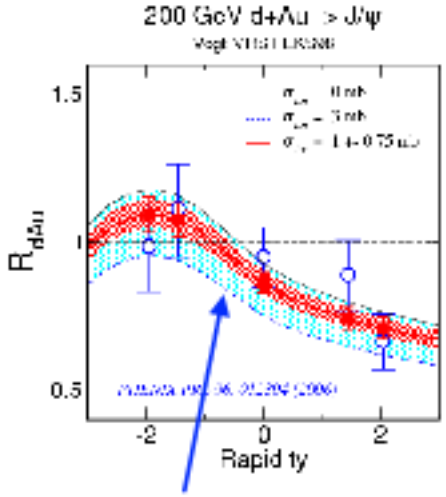
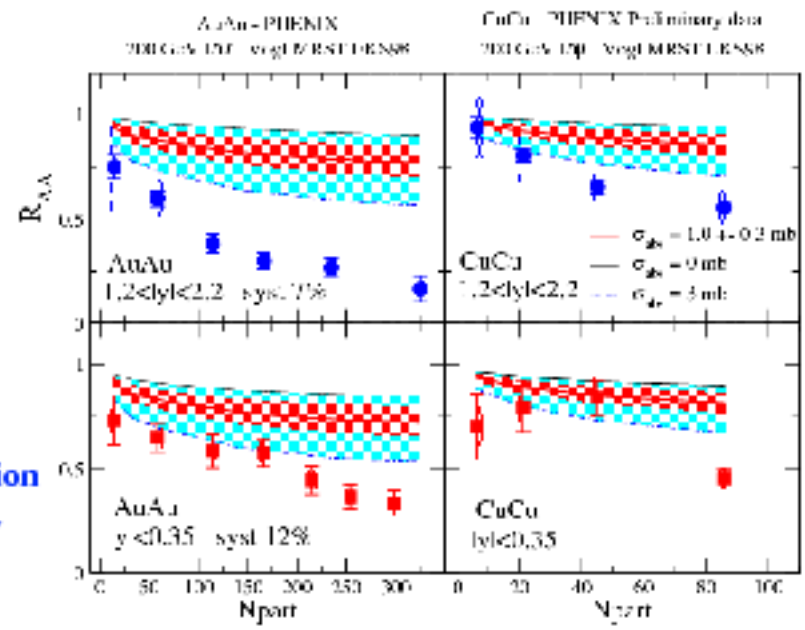
Run-8: major step for d+Au Physics



range of suppression factors allowed by σ_{abs} uncertainty

→ increased significance in A+A



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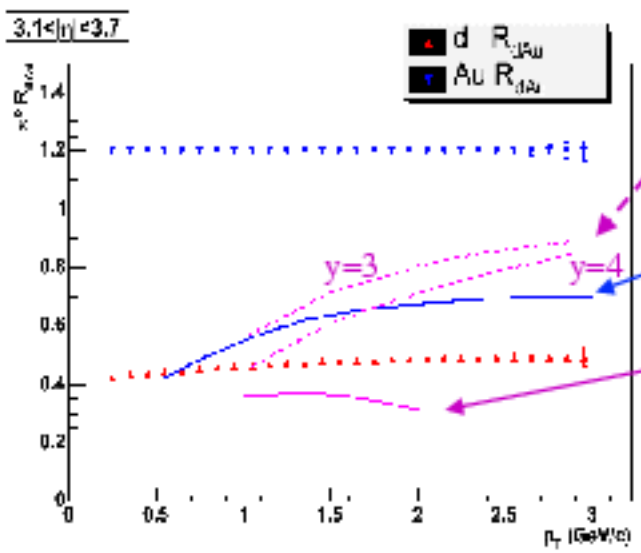
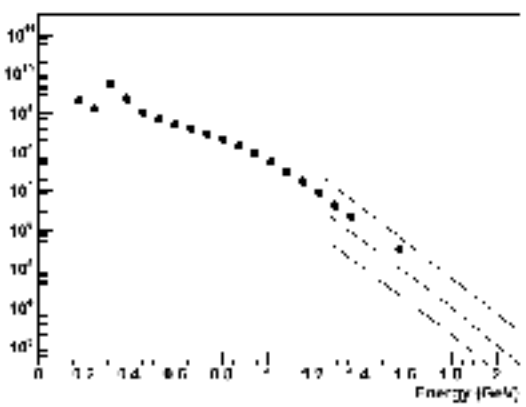
forward π^0 R_{dA} with the MPC



Qiu/Vitev, PLB 632, 507 (2006)
coherent multiple scattering

Kharzeev, et al, PLB599
CGC

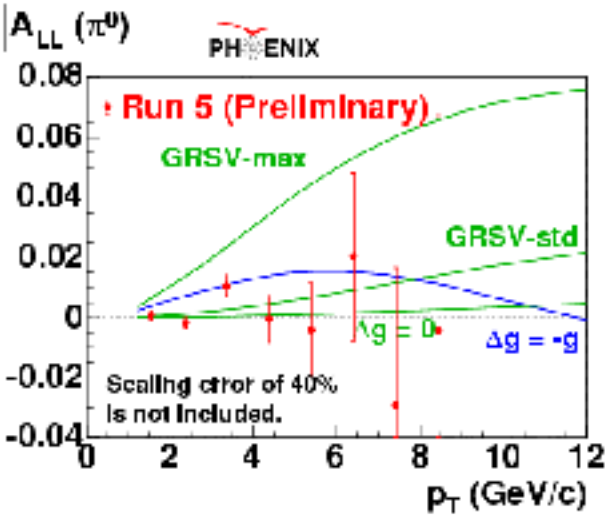
Vitev, hep-ph/0609156
+ initial state energy loss

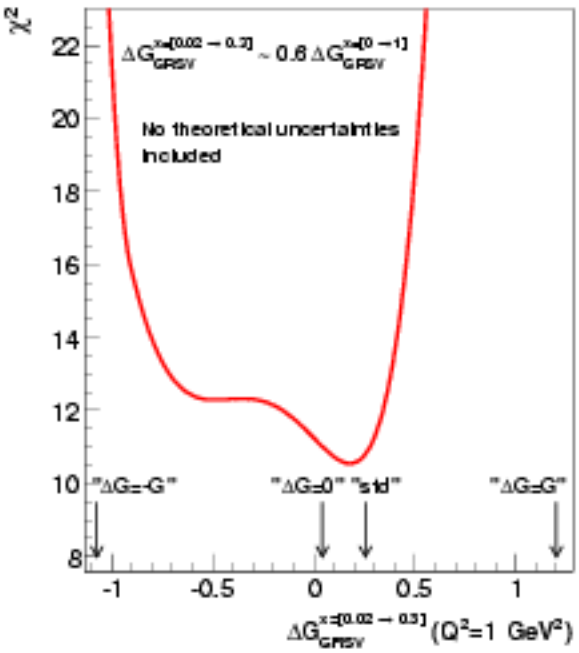


π^0 spectrum in MPC south

polarized p+p: on the road to determining ΔG

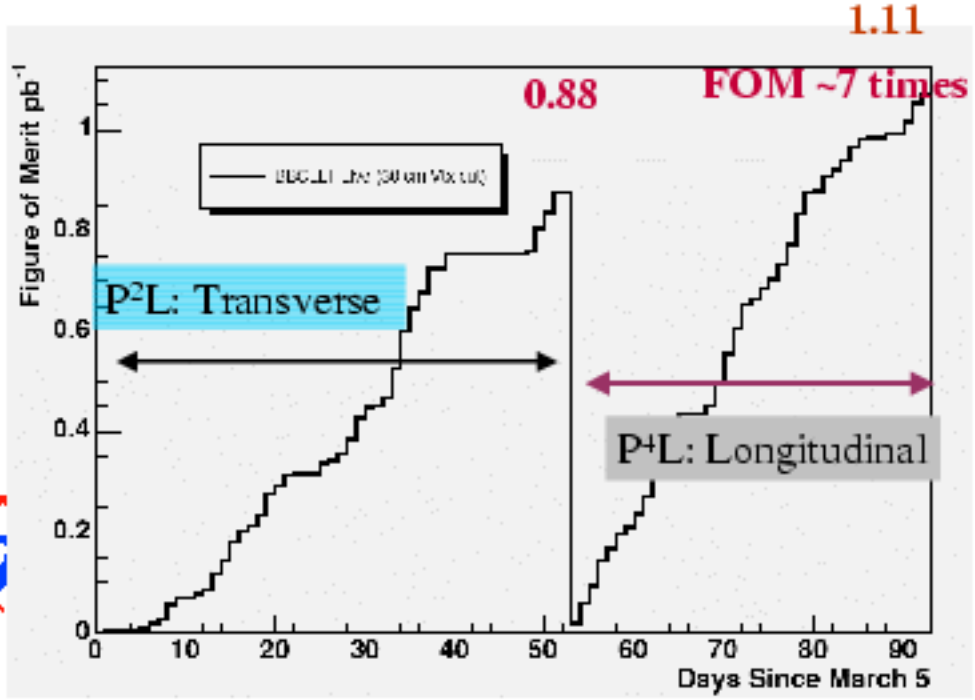
Run 5:



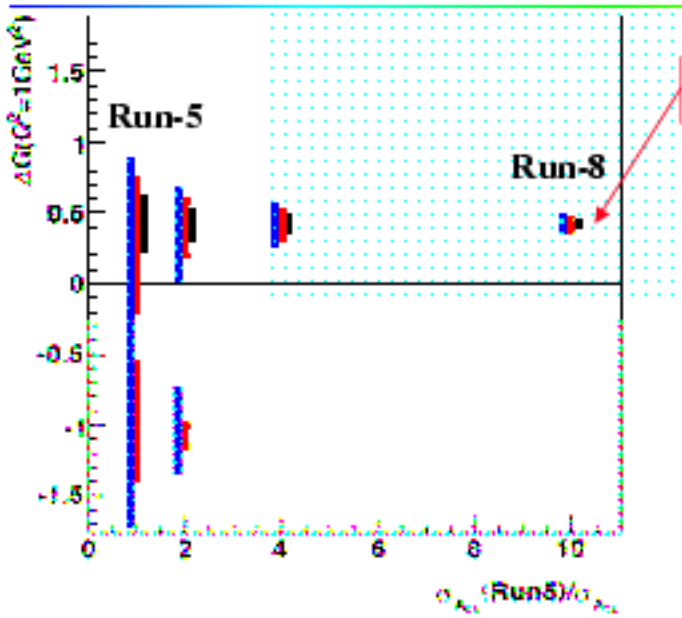


Run-6

- Reconstruction is essentially complete, analysis underway



with Run-8



3, 2, 1 σ errors

to achieve this, need
≥ 71 pb^{-1} recorded

DOE milestone for ΔG measurement: 2008

PHENIX remains committed to yearly p+p running, to develop required luminosity & polarization.
Next goal is 500 GeV p+p for W production

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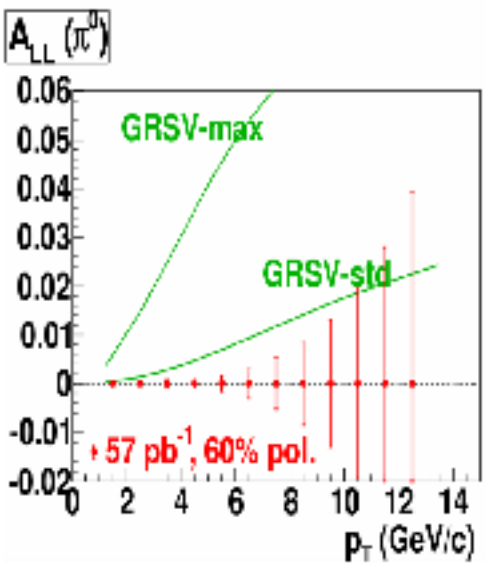
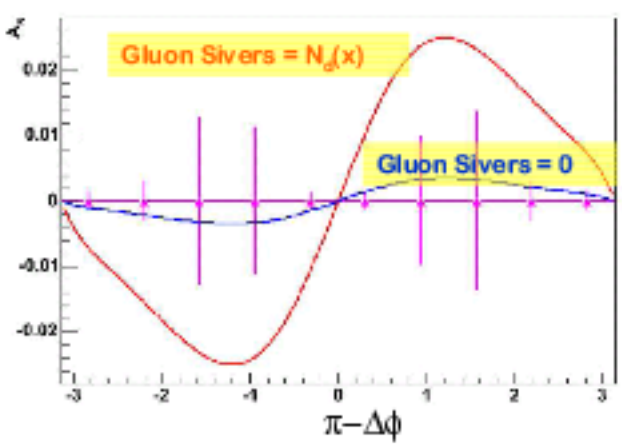
From our previous Run-7 request



approximately what's expected for Run-8

for 2.7 + 6.0 pb^{-1} transverse pol. recorded (<Run-8) di-hadron (+ singles) measurement

Boer and Vogelsang, hep-ph/0312320



Basis for time request

- RHIC Collider Projections for delivered luminosities
  - *from June 1, 2006
- 30 cryoweeks * was 32.5 in Sept. 06 plan
  - *2 weeks cool-down + warm-up*
  - *1.5 week per species set-up (+ 0.5-1 wk for pol. p+p)*
  - *1 week per species ramp-up*
  - 22.5 physics weeks for two species *was 25 weeks
- PHENIX efficiency of 42%
  - 60% live x 70% of collisions inside Z ± 30cm
  - * was 23% in Run-6
    - significant backgrounds at store start
    - extended vertex distribution (?)
    - we anticipate better tune & DAQ start in Run-8

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Boundary conditions

- *Funding constraints*
  - 30 cryo weeks rather than 32+
  - cascading effects of curtailed Run-6 and Run-7 lengths
    - *hopefully that era is over…*
- *Upgrades schedule*
  - Beam species, energies tailored to utilize upgrades
  - Current plan is to replace HBD by VTX for Run-10
- *Milestones*
  - Polarized gluon distribution in 2008
  - First W physics (u,d polarization) in 2011
- Realism in what RHIC can deliver

► solution: optimal + conservative plans

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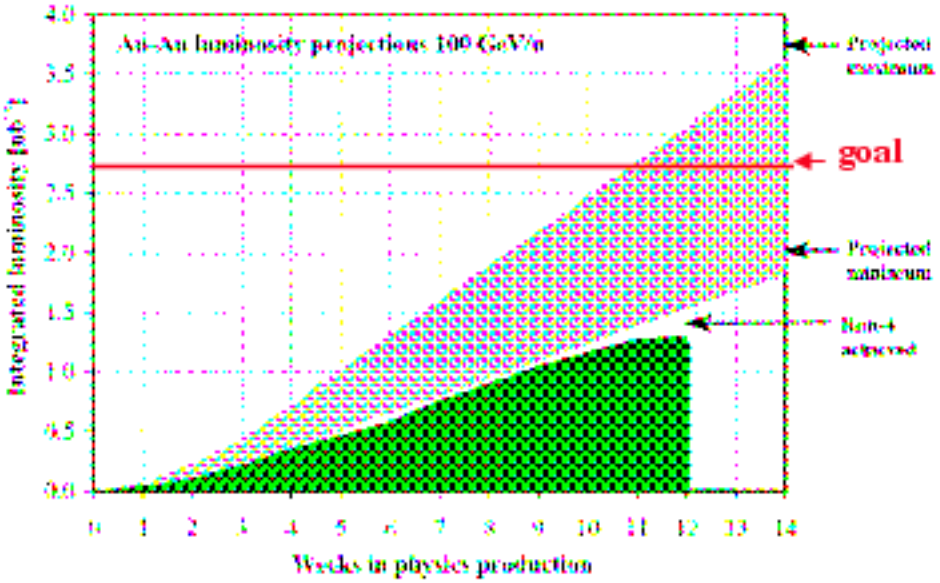
CAD projections for AuAu luminosity (Run-7)

See http://www.rhichome.bnl.gov/RHIC/Runs/RhicProjections.pdf (figure 2)
It is assumed that the peak performance is reached after 4 weeks of linear ramp-up, starting with 25% of the final value. Note that these are weeks of physics running



need 1.1 nb^{-1} recorded, 2.6 nb^{-1} delivered

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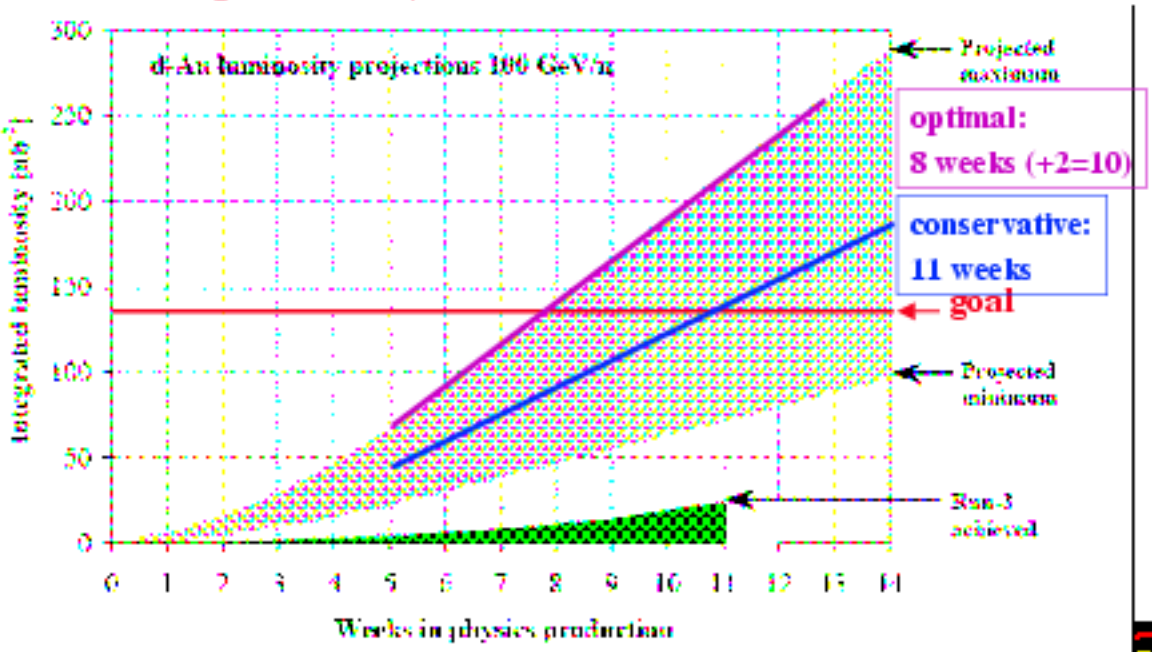
d+Au Run-8

- **58 nb^{-1} recorded (138 delivered) = x20 Run-3**
- **comparable J/ψ statistics to Run-7 Au+Au**



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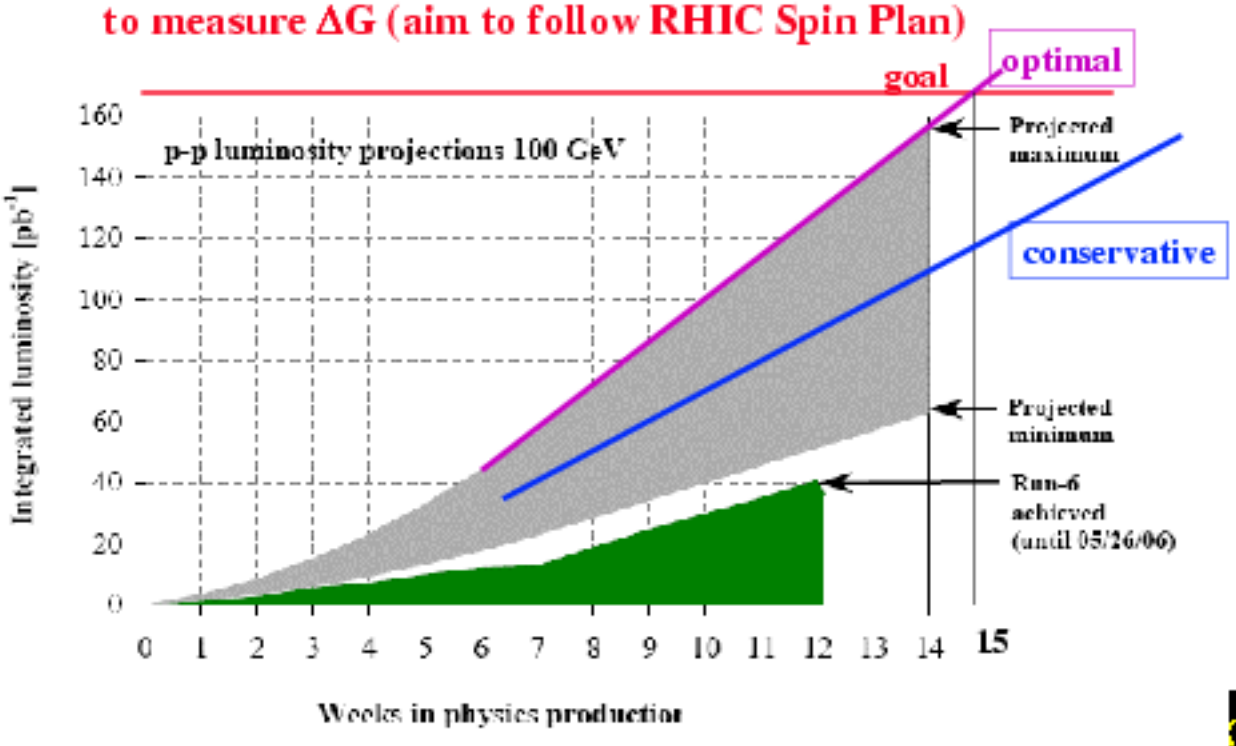
Run-8 polarized p+p

- 71 pb^{-1} recorded (167 delivered)

to measure ΔG (aim to follow RHIC Spin Plan)



Summary of proposal for Run 7-10

RUN	SPECIES	$\sqrt{s_{NN}}$ (GeV)	PHYSICS WEEKS	∫ L dt (recorded)	p+p Equivalent
7	Au+Au	200	12	1.1 nb^{-1}	44 pb^{-1}
8	d+Au	200	10	58 nb^{-1}	23 pb^{-1}
	p+p	200	15	71pb^{-1}	71 pb^{-1}
9	Au+Au	TBD	25-M		
	p+p	500	M		
10	U+U?	200	25-N		
	p+p	500	N		

Run 9 & 10 plan

Run-9

- complete large 200 GeV/A Au+Au data set
  → definitive measurements with rarest probes
- if needed, complete 200 GeV polarized p+p
- begin 500 GeV polarized p+p for W production
- aim to begin low energy scan & utilize HBD

Run-10

- begin commissioning VTX detector (HBD removed)
  → both p+p and heavy ion running
  ion species/energy depend on Runs-7,9 and EBIS
- significant 500 GeV polarized p+p for W production
  utilizing muon trigger

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Concluding Remarks

- PHENIX (and RHIC) have been extremely successful
  Runs 1-6 analyzed
  publications are done or on the way
  impact is extremely high
- Extend demonstrated spin physics capabilities to higher p_T and to new channels
- Careful planning and execution of upgrades
  open new physics channels, extend reach for rare processes
  help attract new collaborators to PHENIX
  closely coupled to accelerator capability development
  drive Beam Use Proposals for coming years
  will prepare PHENIX for data-taking with RHIC-II

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