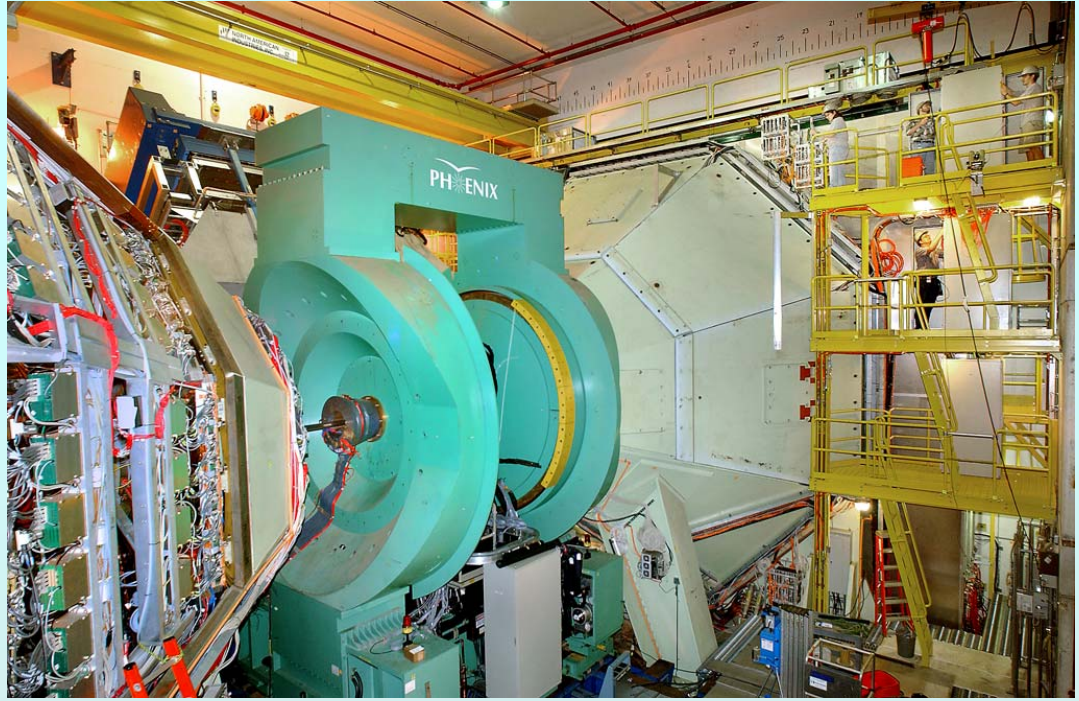
PHENIX

- Accomplishments
- Status
- Plans
- Issues



Barbara Jacak

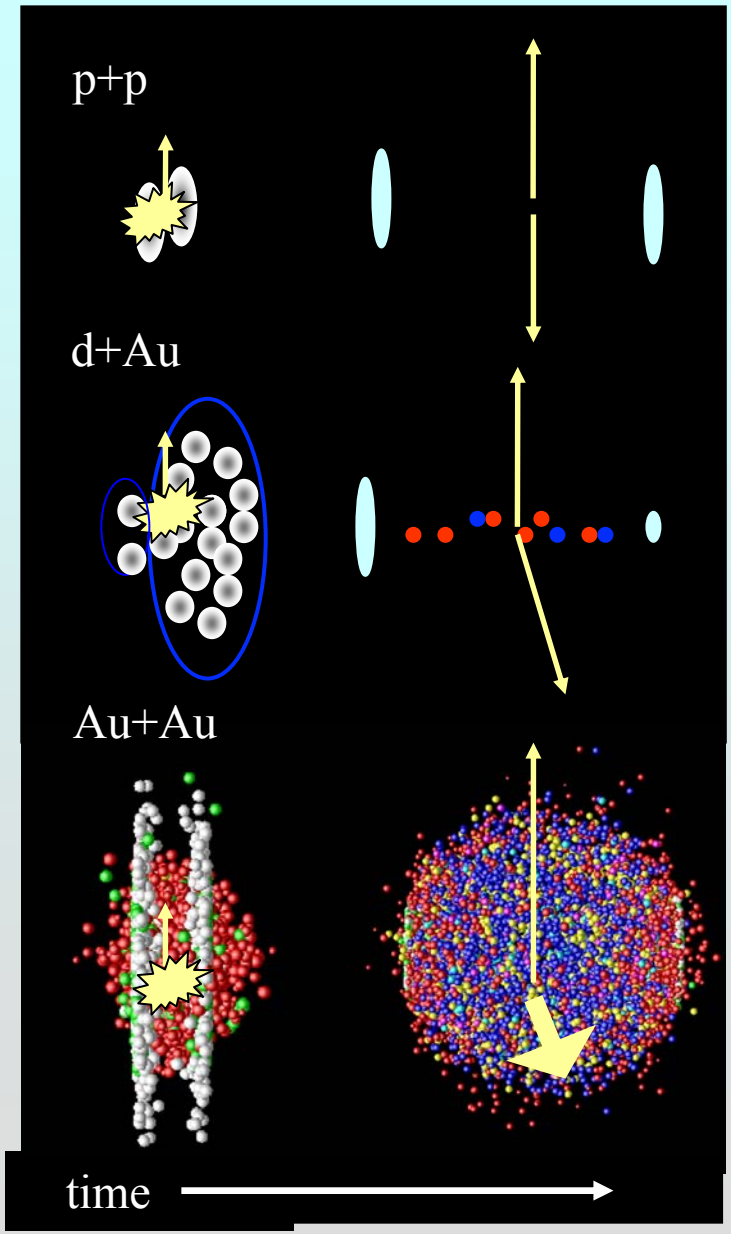
for the PHENIX Collaboration*

slides can be found at:

http://www.phenix.bnl.gov/WWW/publish/jacak/sp/presentations/DOErev_jul07/

* thanks for material: E. O'Brien (Operations Manager), A. Drees (Upgrade Manager) , B. Zajc, M. Grosse-Perdekamp, M. Leitch (2007 Run Coord.) and J. Nagle (Trigger Coord.)

Two Broad Physics Thrusts of PHENIX



- **nuclear matter under extreme conditions**
  - **p+p: baseline/benchmark pQCD**
  - **d+Au: control for initial state nuclear effects**
  - **A+A: hot, dense ~perfect fluid**
    - **strong flow, jet quenching, quarks recombine→ hadrons, medium response to jets**
  - ***hard probes of soft medium!***
- **spin structure of the nucleon**
  - **first measurement of A_{LL} → gluon polarization**
- ***→ detector, trigger, high rate DAQ for e, μ, γ, high p_T***

- accomplishments

Baseline PHENIX Configuration

Central Arm Tracking
- Drift Chamber
- Pad Chambers
- Time Expansion Chamber

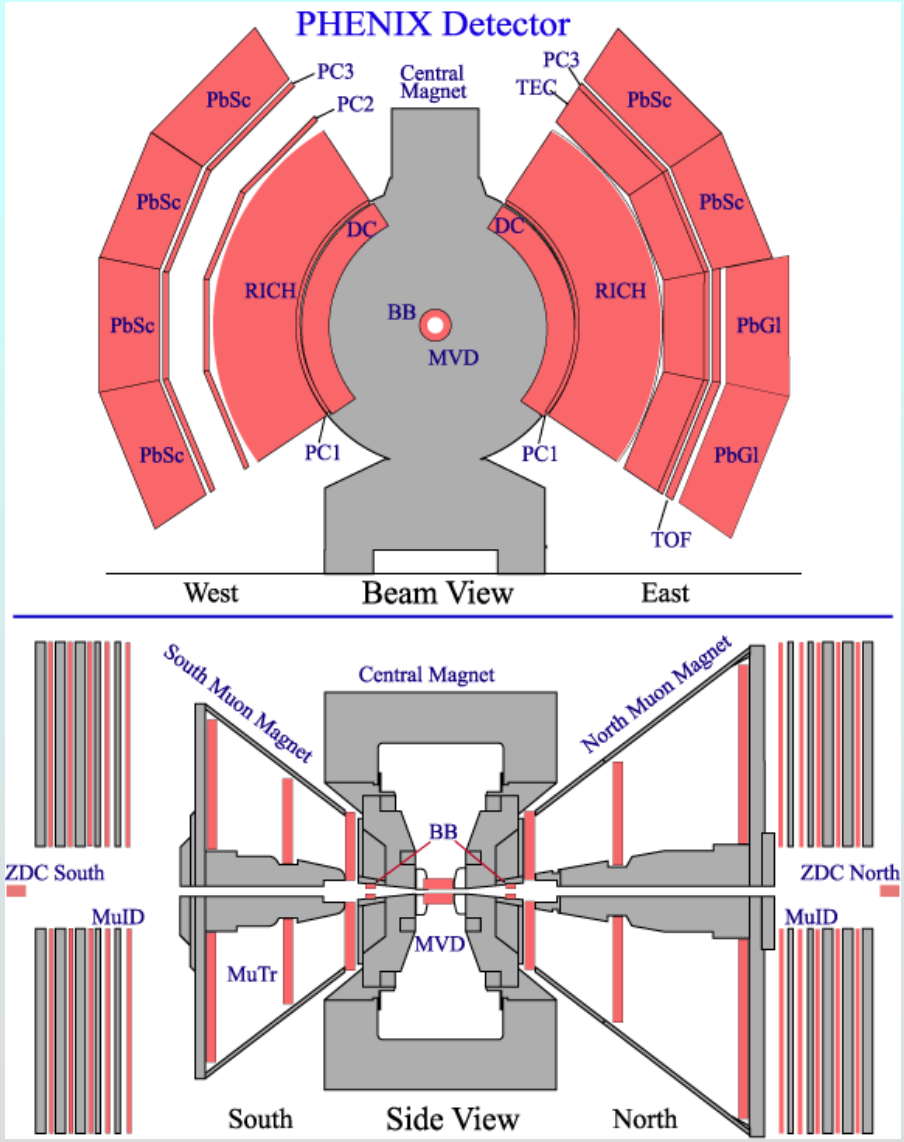
Muon Arm Tracking
- Muon Tracker

Calorimetry
- PbGl
- PbSc

Particle Id
- Muon Identifier
- RICH
- TOF
- TEC

Global Detectors
- BBC
- ZDC/SMD Local Polarimeter
- Forward Hadron Calorimeters
- NTC
- MVD

Online Calibration and Production



have since added aerogel, TOF-W, MPC, RXNP, HBD

The PHENIX Run History

The RHIC machine performance has been very impressive:

- **Collided 4 different species in 7 years**
  - **AuAu, dAu, pp, CuCu**
- **6 energies run**
  - **9.2 GeV, 19 GeV, 22.5 GeV, 62.4 GeV, 130 GeV, 200 GeV**

Most machine design luminosity specs have been surpassed !

PHENIX	Year	Species	$s^{1/2}$ [GeV]	∫Ldt	N_{tot} (sampled)	Data Size
Run1	2000	Au-Au	130	1 μb^{-1}	10 M	3 TB
Run2	2001/02	Au-Au	200	24 μb^{-1}	170 M	10 TB
		Au-Au	19	------	<1 M	
		p-p	200	0.15 pb^{-1}	3.7 G	20 TB
Run3	2002/03	d-Au	200	2.74 nb^{-1}	5.5 G	46 TB
		p-p	200	0.35 pb^{-1}	6.6 G	35 TB
Run4	2003/04	Au-Au	200	241 μb^{-1}	1.5 G	270 TB
		Au-Au	62.4	9 μb^{-1}	58 M	10 TB
Run5	2005	Cu-Cu	200	3 nb^{-1}	8.6 G	173 TB
		Cu-Cu	62.4	0.19 nb^{-1}	0.4 G	48 TB
		Cu-Cu	22.4	2.7 μb^{-1}	9 M	1 TB
		p-p	200	3.8 pb^{-1}	85 G	262 TB
Run-6	2006	p-p	200	10.7 pb^{-1}	233 G	310 TB
		p-p	62.4	0.1 pb-1	10 G	25 TB
Run-7	2007	Au-Au	200	813 μb^{-1}	5.1 G	650 TB

Transferred 0.6 PB of data to Japan via Grid for Analysis in 2005/06

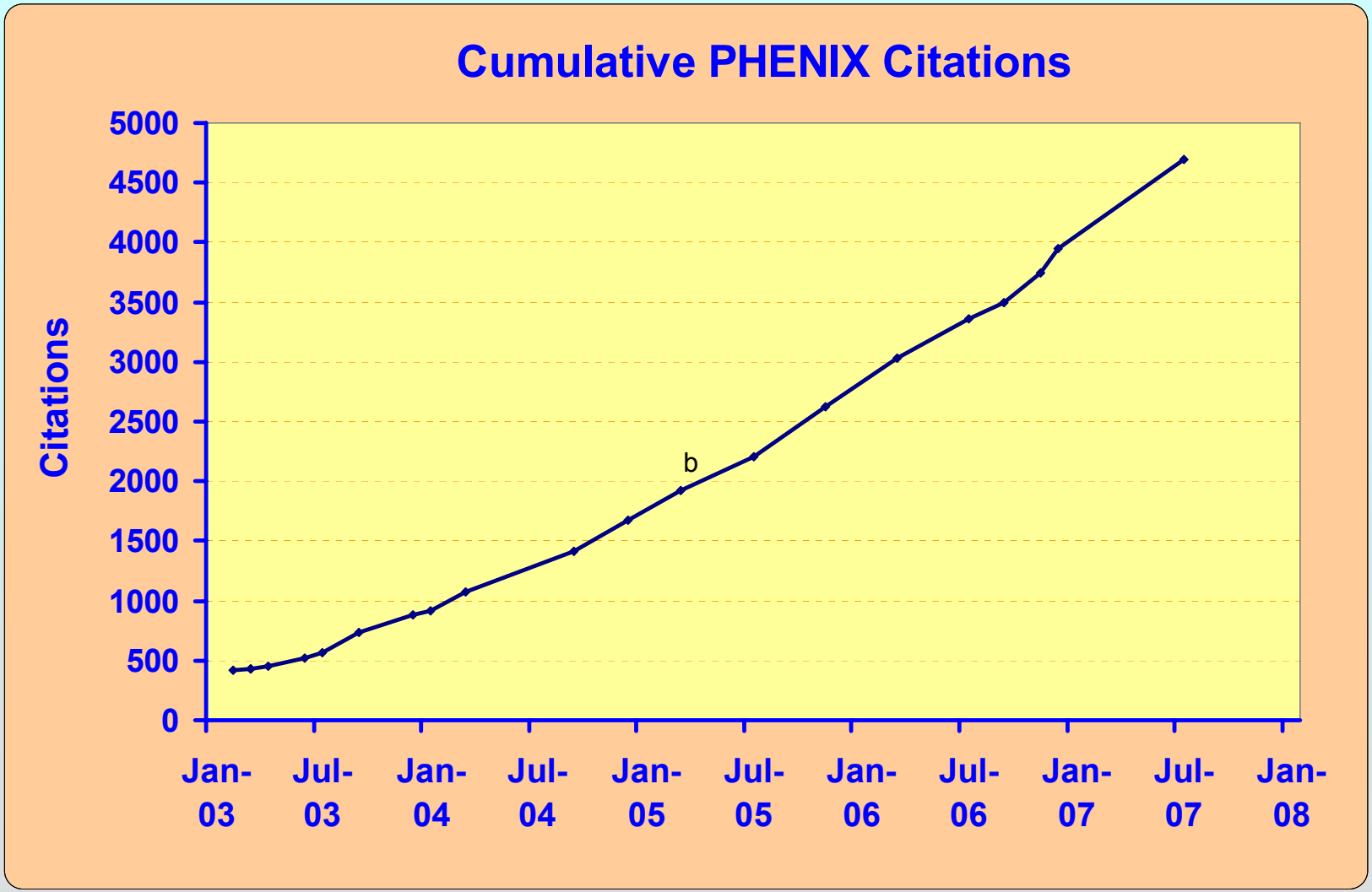
High scientific productivity *WHILE RUNNING!*

- 60 physics papers published: 41 PRL, 10 archival
  submitted 19 papers in 2006
- highly cited – PHENIX has produced
  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. A757,184, 2005)
  2nd most cited nucl-ex paper in 2006
  50th most cited of "all HEP" in 2006
  (355 citations)
- Most RHIC cited paper, with 388 citations is

"Suppression of hadrons with large transverse momentum in central Au+Au collisions at s(NN)**(1/2) = 130-GeV"

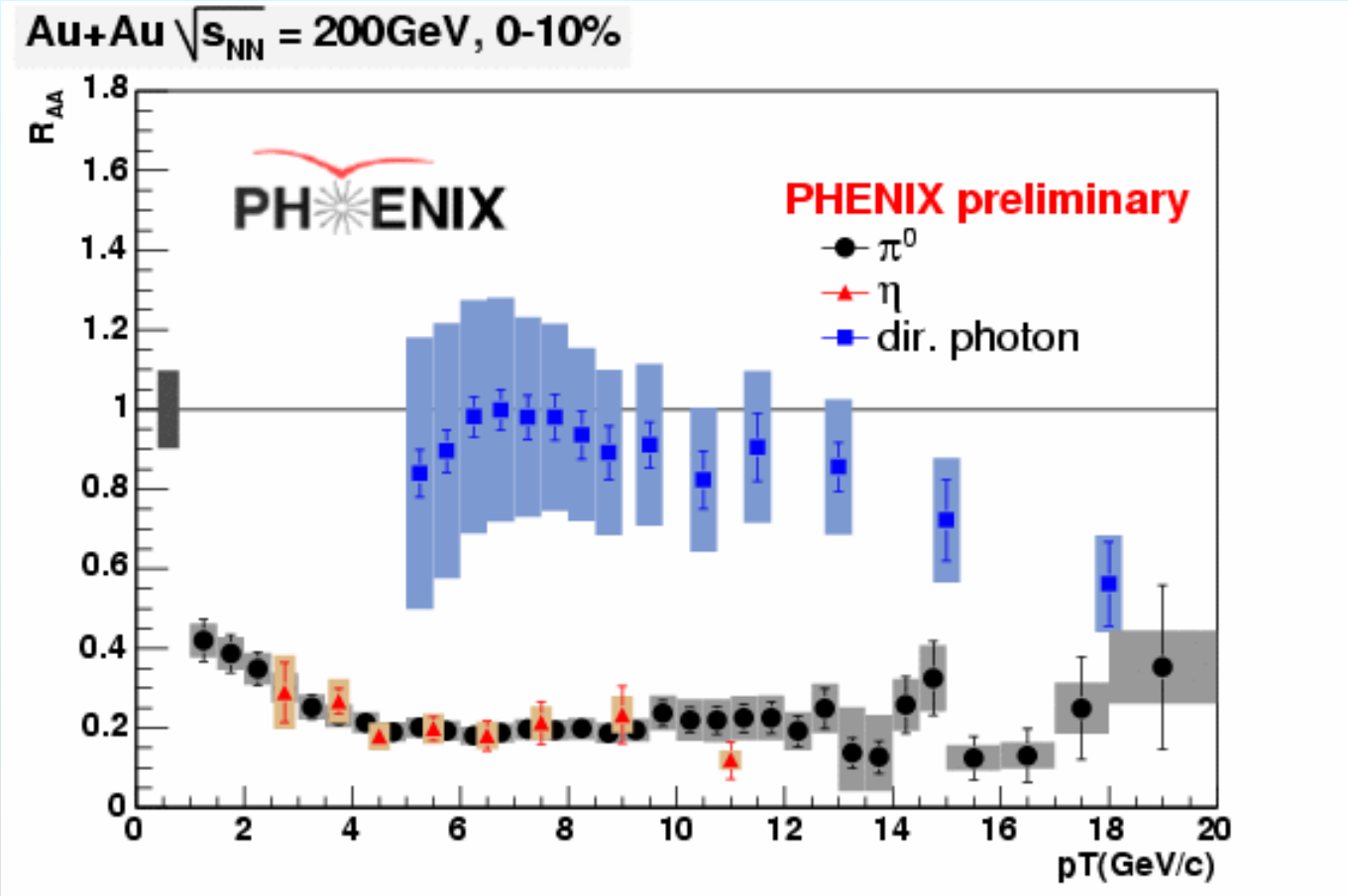
Adcox, et al., PRL 88, 022301 (2002)

over 1000 citations per year!

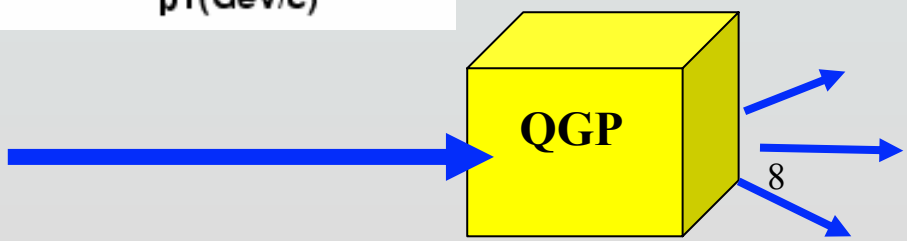


recent results: icons of physics at RHIC!

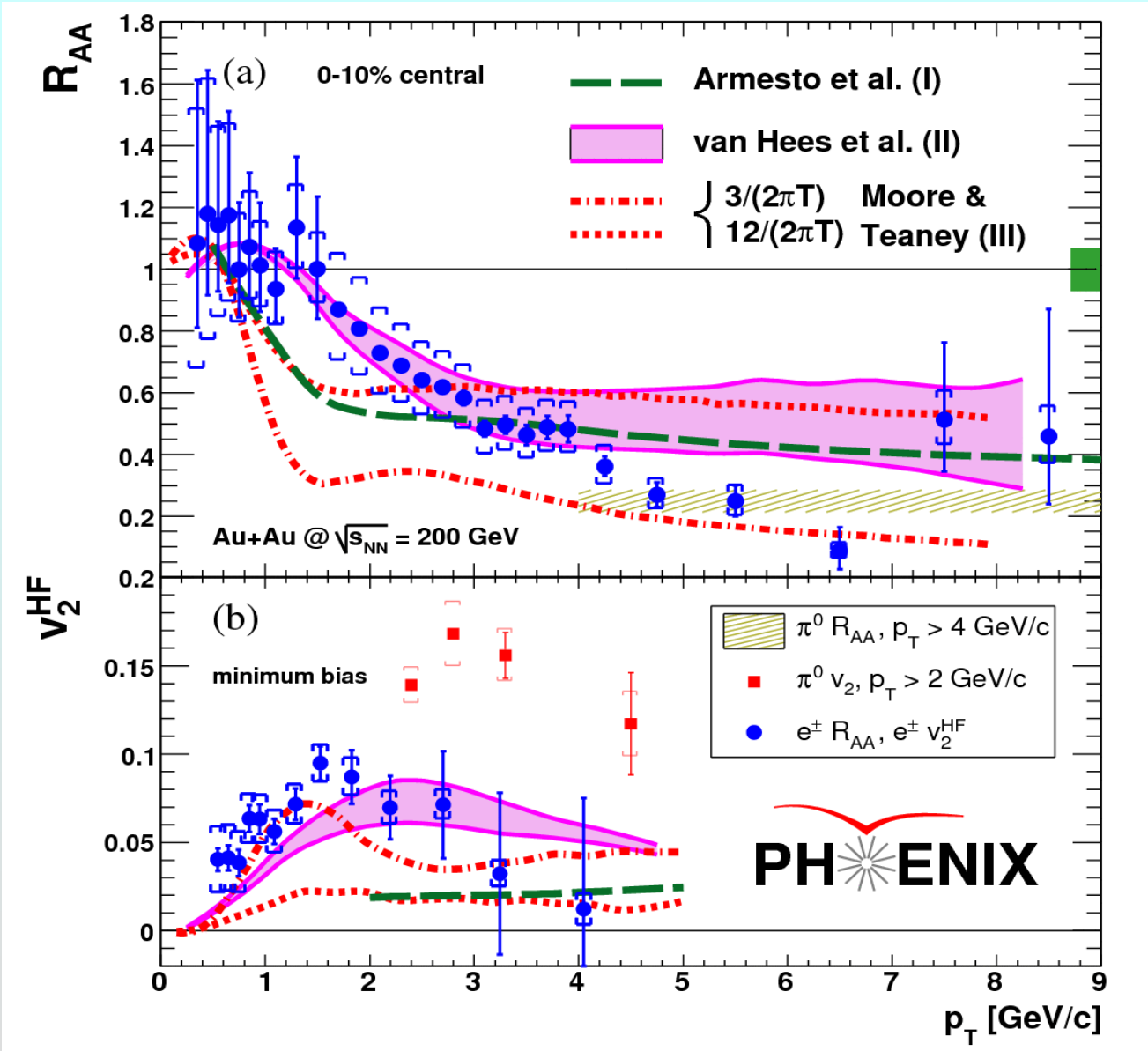
π^0 suppressed to high p_T, direct γ at very high p_T?



colored probes interact, γ do not…



heavy quarks lose energy & flow along too



relaxation time short → small viscosity

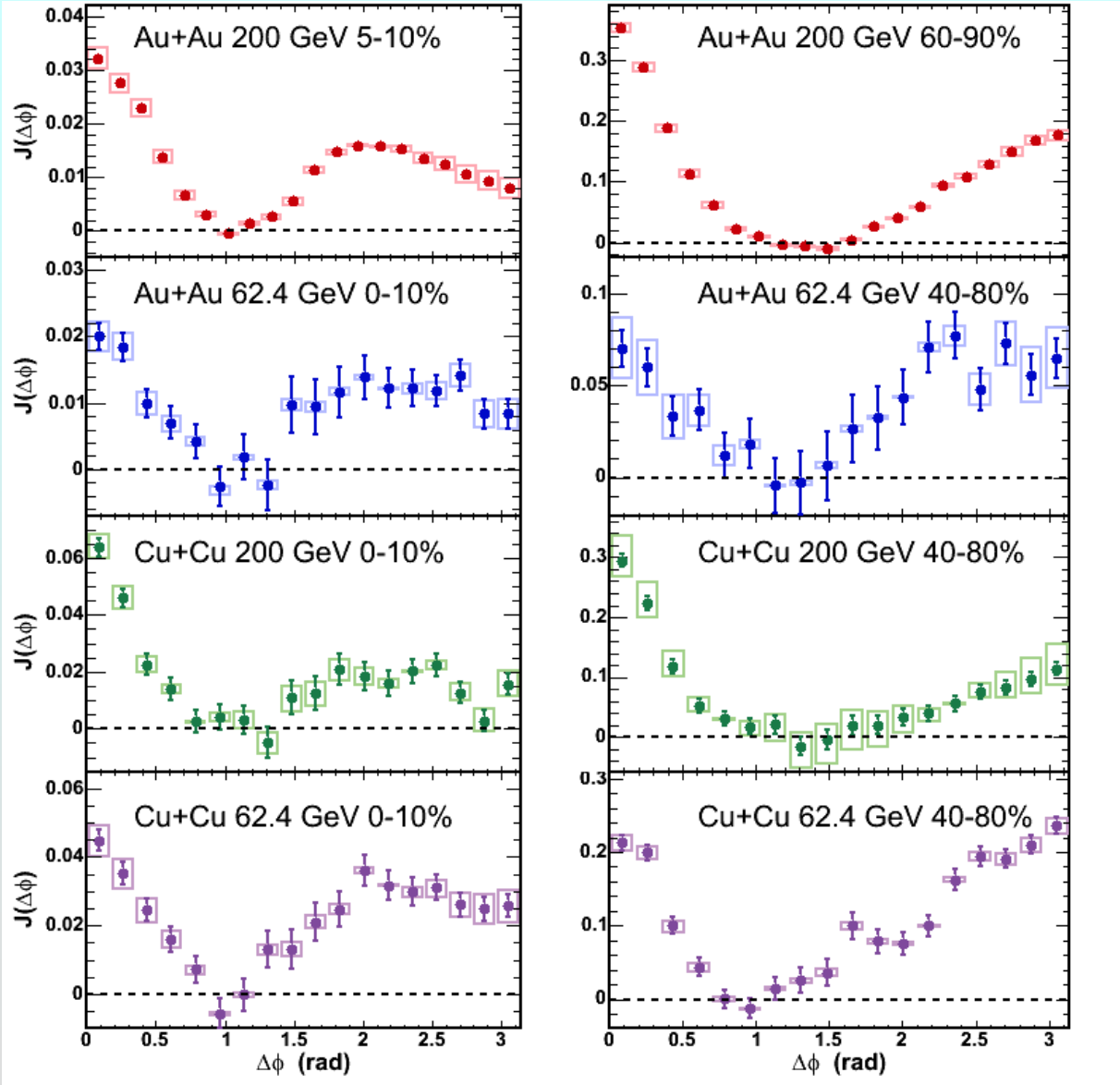
PHENIX

Phys. Rev. Lett. 98, 172301 (2007)

the medium responds to deposited energy

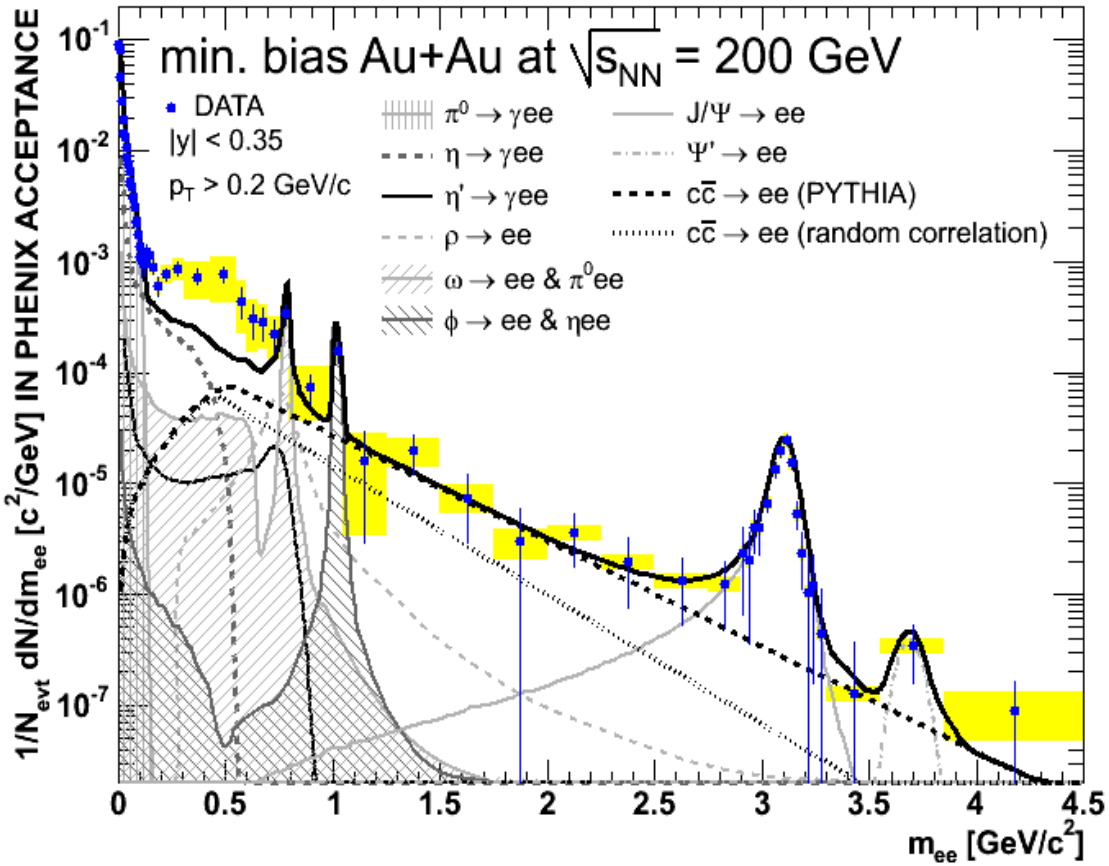
di-hadron data show:

strong modification of away-side jet shape



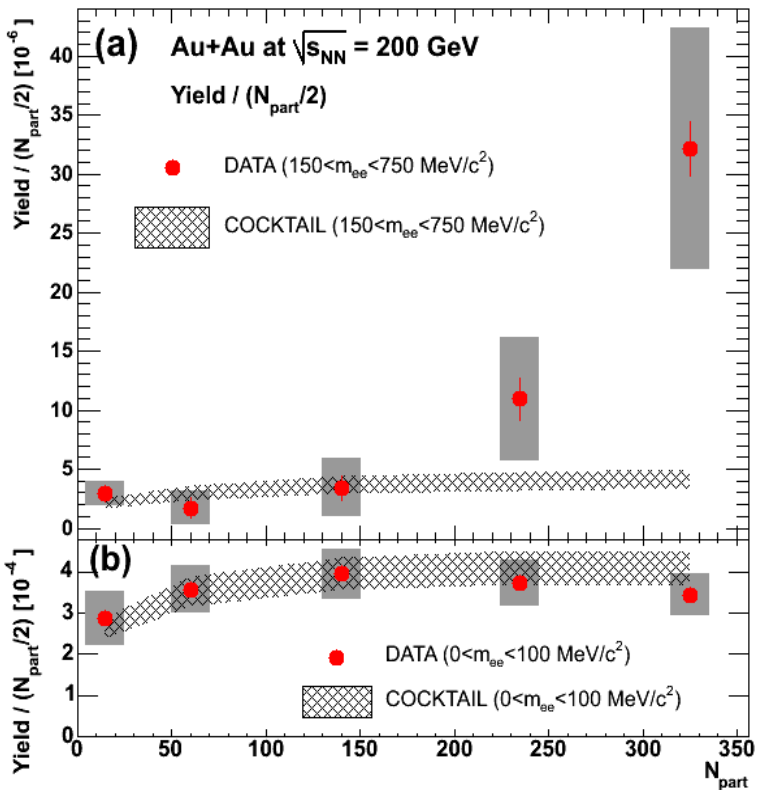
Phys. Rev. Lett. 98, 232302 (2007)

low mass dilepton excess seen at RHIC!



PHENIX
submitted to Phys. Rev. Lett
arXiv:0706.3034

yield excess grows faster than N_{part}
excess > ρ modification

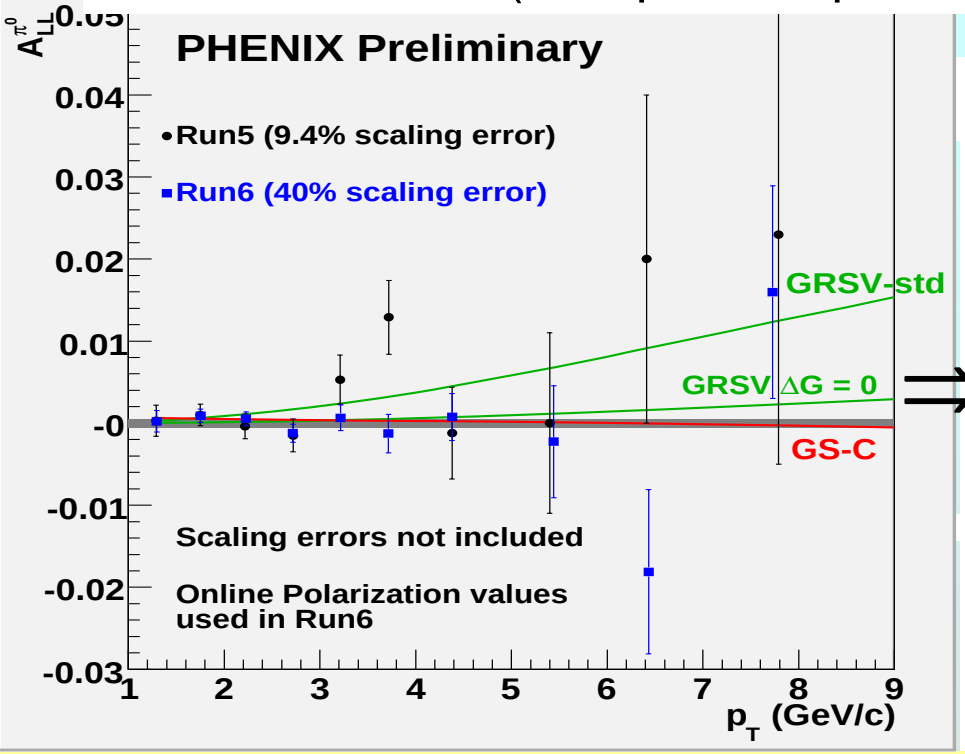


NSAC milestone: 2010

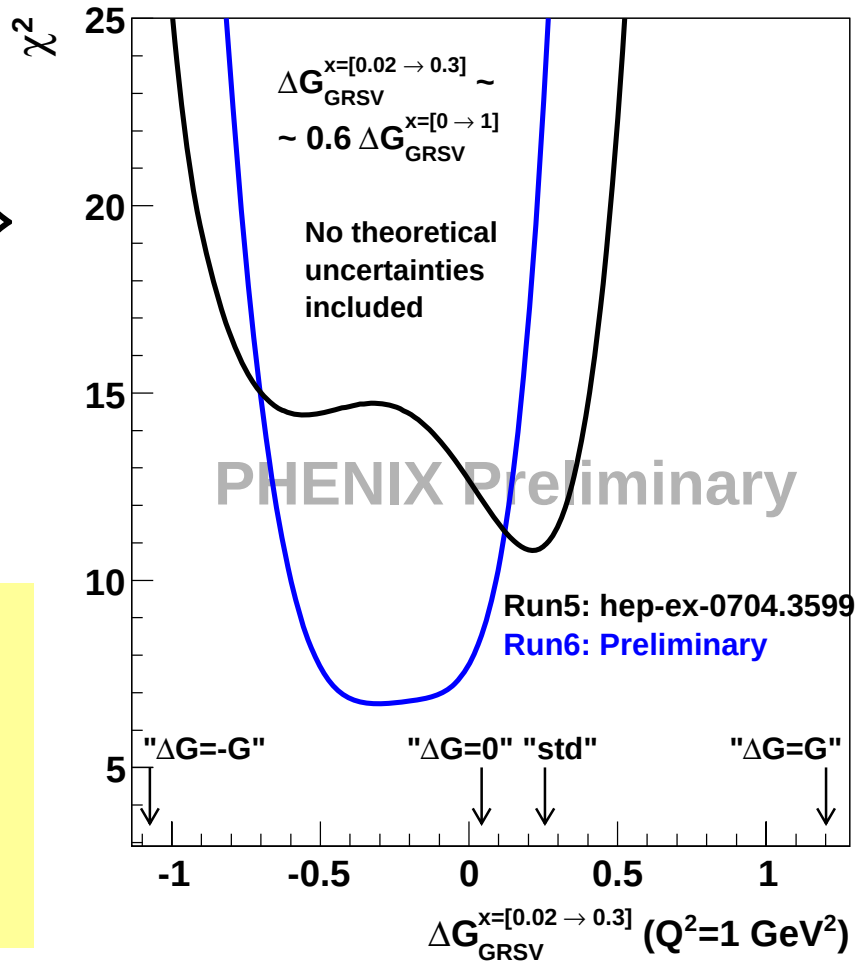
PHENIX

Spin: the surprises continue!

arXiv 0704.3599 (accepted for publication)



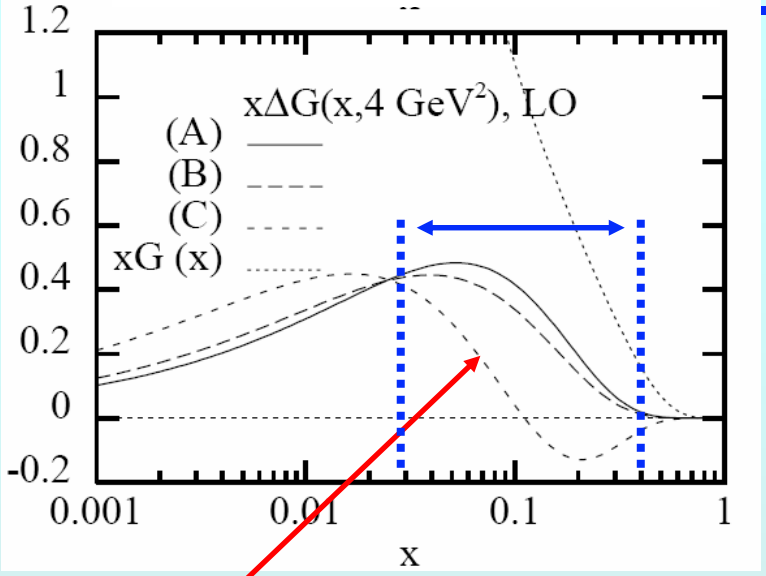
Calc. by W.Vogelsang and M.Stratmann



"std" scenario, $\Delta G(Q^2=1GeV^2)=0.4$, is excluded by data on >3 sigma level:
$\chi^2(std)-\chi^2_{min}>9$

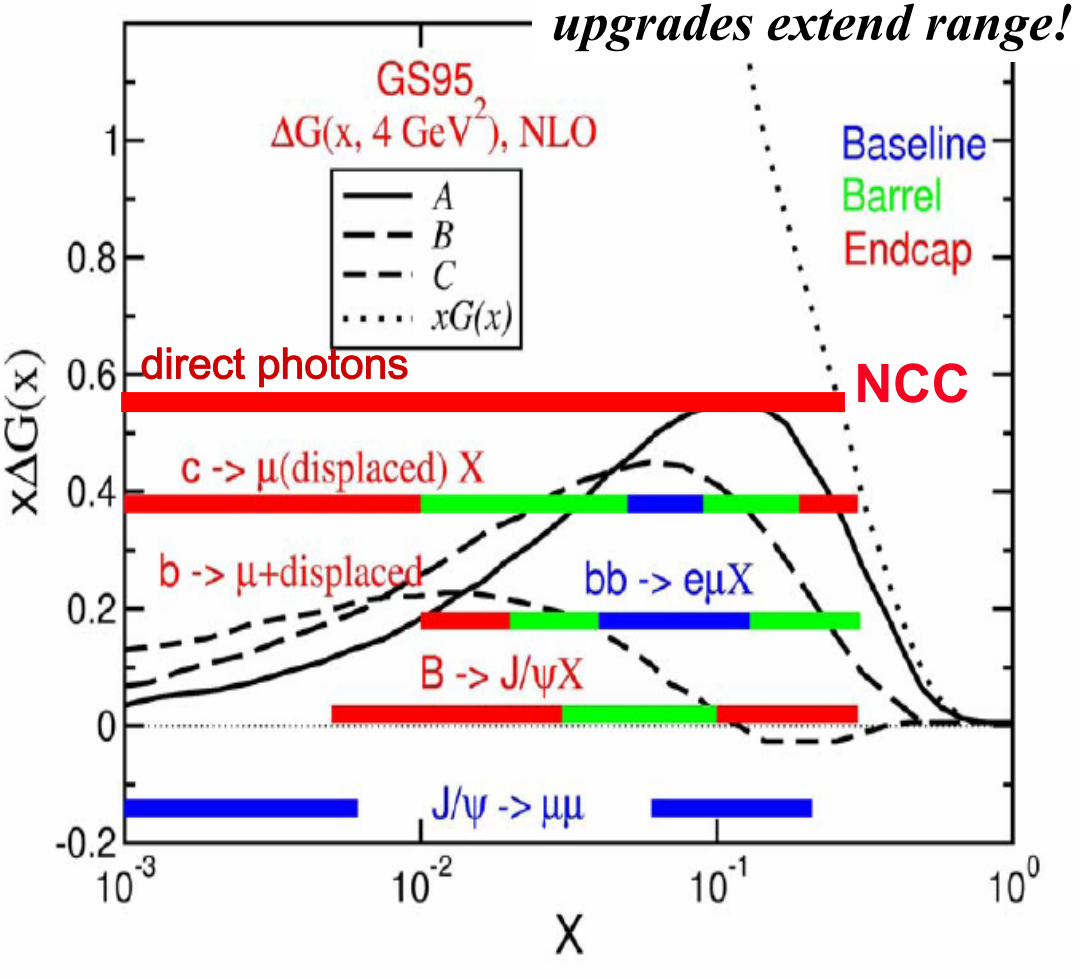
- ✓ **Uncertainties from functional from ΔG(x) are not included. Reducing these requires measurement at lower x.**

Gehrmann-Stirling models



must examine lower x

upgrades extend range!



GSC: $\Delta G(x_{gluon} = 0 \rightarrow 1) = 1$

$\Delta G(x_{gluon} = 0.02 \rightarrow 0.3) \sim 0$

GRSV-0: $\Delta G(x_{gluon} = 0 \rightarrow 1) = 0$

$\Delta G(x_{gluon} = 0.02 \rightarrow 0.3) \sim 0$

GRSV-std: $\Delta G(x_{gluon} = 0 \rightarrow 1) = 0.4$

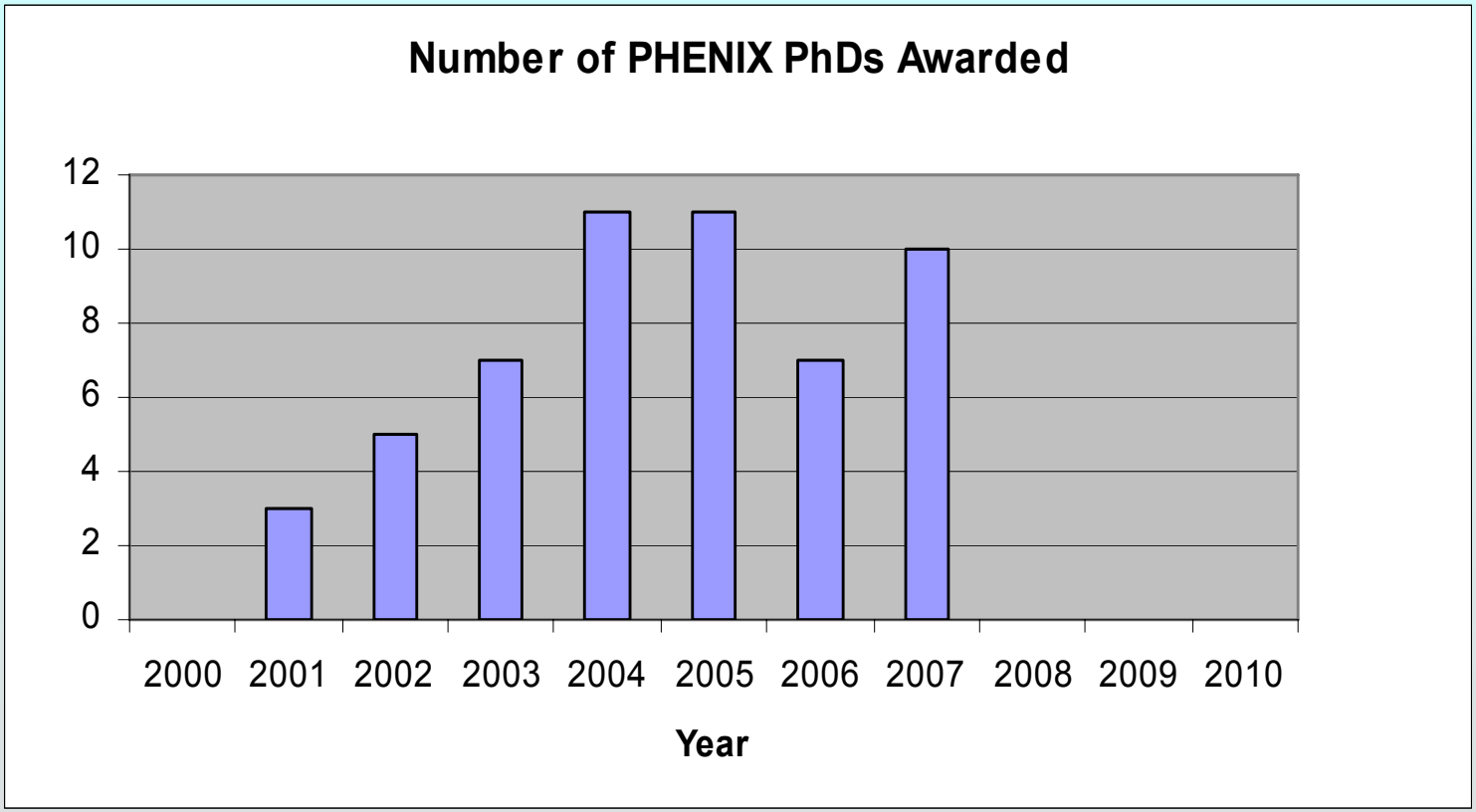
$\Delta G(x_{gluon} = 0.02 \rightarrow 0.3) \sim 0.25$

- charm and bottom identification by displaced vertices
- π^0, γ, Jet identification with larger acceptance

PHENIX

PHENIX is a superb training ground

54 Ph.D. theses + 12 Masters/Diploma theses



+ 83 Ph.D. students working

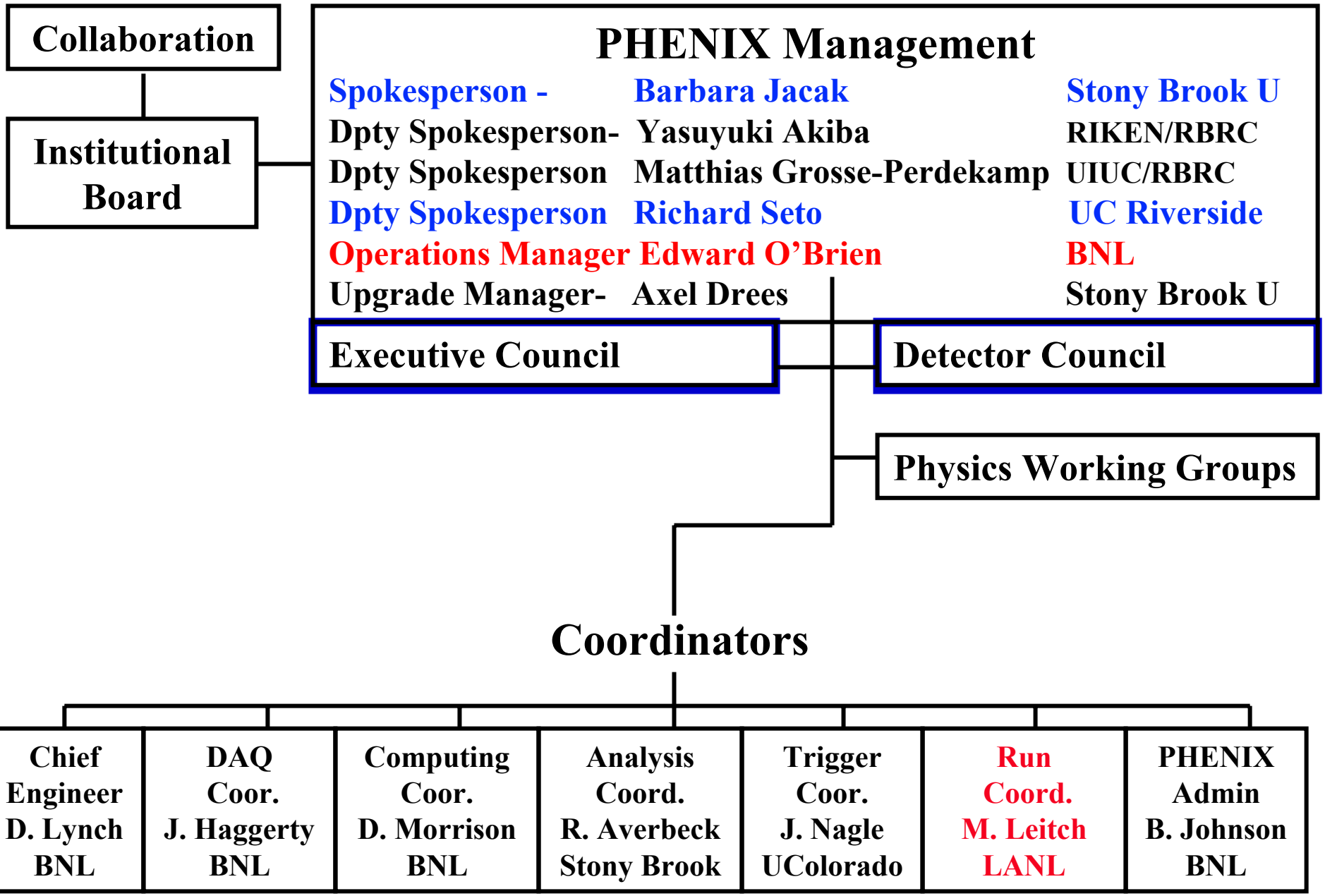
awards in past ~1 year

Sakaguchi	Takao	2007	NPA Young Scientist award for best poster
Okada	Hiromi	2007	RHIC/AGS Thesis Award
Grau	Nathan	2007	RHIC/AGS Thesis Hon. Mention
Gunji	Taku	2007	RHIC/AGS Thesis Hon. Mention
Boyle	Kieran	2007	RHIC/AGS Poster Award
Bayse	Austin	2007	SPS Outstanding Student Award
Riabov	Victor	2007	Russian Federation President's Competition
Desmond	Ed	2006	BNL Engineering Award
Velkovska	Julia	2007	Alfred P. Sloan Fellowship
Biggs	Carter	2006	BNL staff Spotlight Award
Csanad	Mate	2006	PAM Dirac Diploma at Erice School
Csorgo	Tamas	2006	Prize of Hungarian Academy of Sciences
Faulkner	Mariette	2006	BNL staff Spotlight Award
Isenhower	Donald	2006	Career Achievement Award from Abilene Chritian University
Kurita	Kazu	2006	Faraday Cup Award for RHIC polarimetry
Vertesi	Robert	2006	Fulbright Student Award
Labounty	Jimmy	2006	BNL staff Spotlight Award

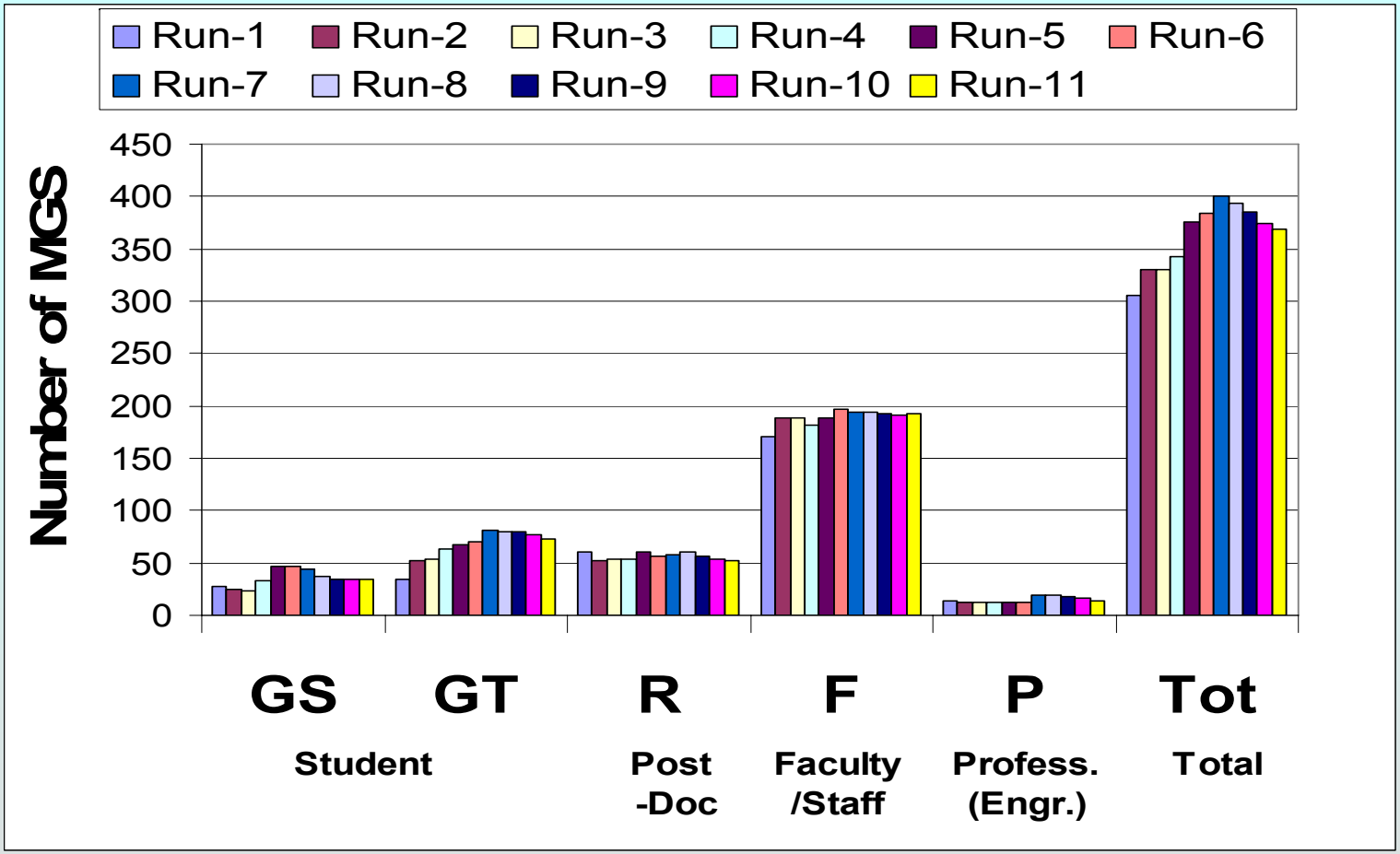
PHENIX

- **status**

Some Management Changes



Collaboration strength



some people leaving & others joining PHENIX must work to maintain student/postdoc strength

PHENIX IN 2007

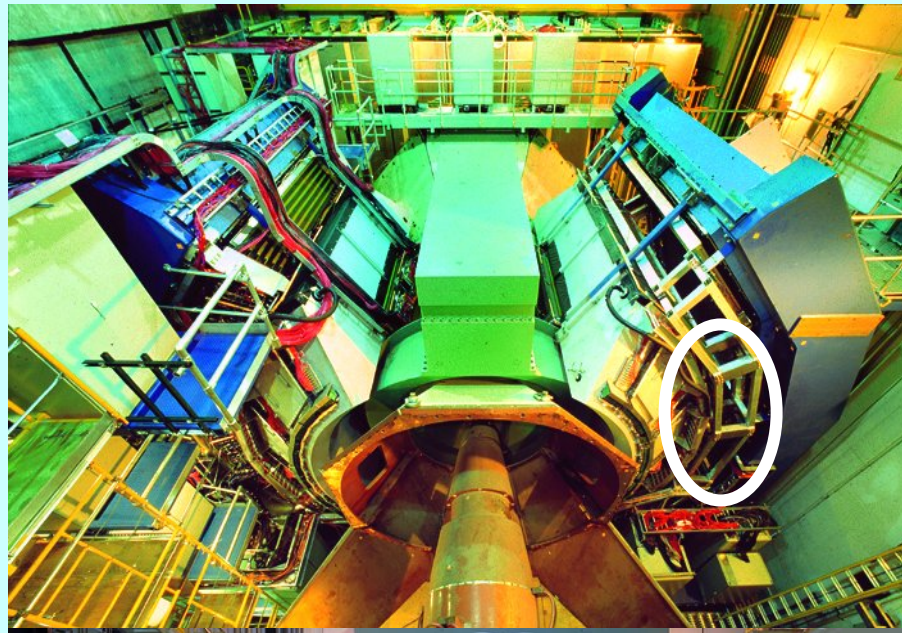
PHENIX (successful) philosophy:
Detector Redundancy,
Fine Granularity, Good Mass Resolution,
Superb Particle ID, High Data Rate
Limited Acceptance

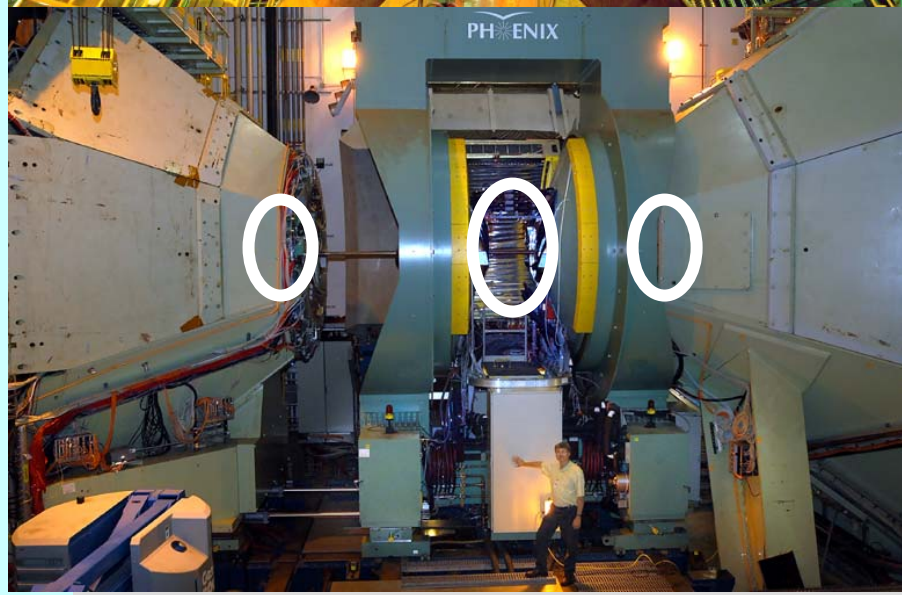
Charged Particle Tracking:
- Drift Chamber
- Pad Chamber
- Time Expansion Chamber/TRD
- Cathode Strip Chambers(Mu Tracking)

Particle ID:
- **Time of Flight** (East and **West**)
- Ring Imaging Cerenkov Counter
- TEC/TRD
- Muon ID (PDT's)
- Aerogel Cerenkov Counter
- **Hadron Blind Detector**

Calorimetry:
- Pb Scintillator
- Pb Glass
- **Muon Piston Calorimeter**

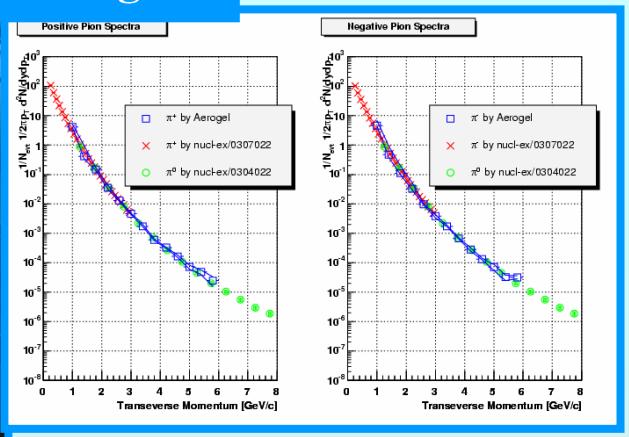
Event Characterization:
- **Reaction Plane Detector**
- Beam-Beam Counter
- Zero Degree Calorimeter/Shower Max Detector
- Forward Calorimeter



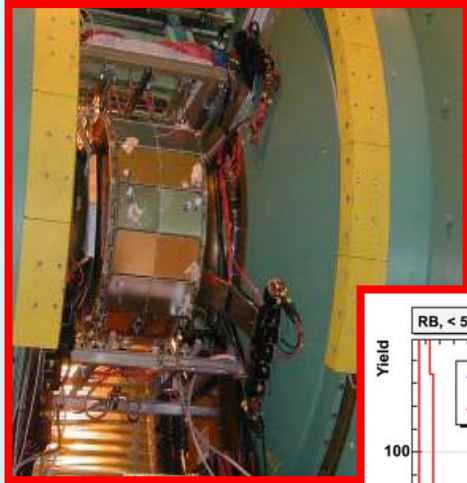


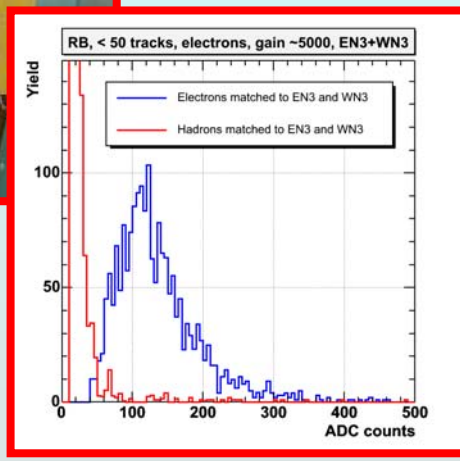
Upgrades in Run 6 & 7

Aerogel

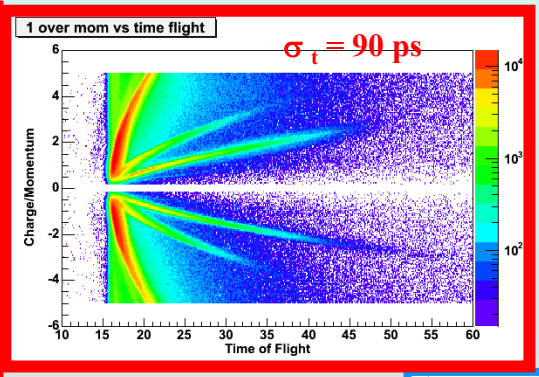


Hadron Blind Detector

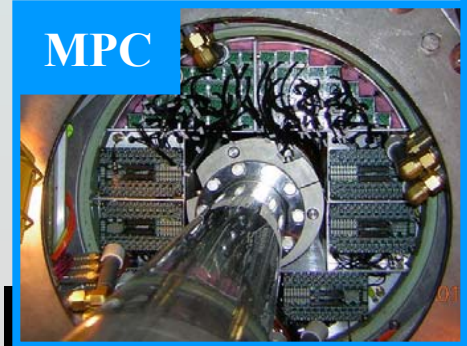


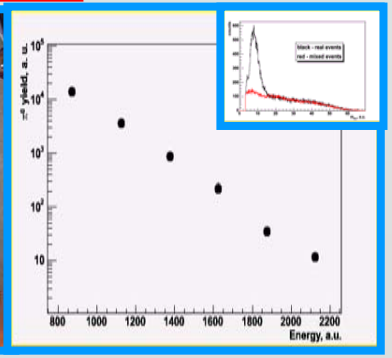


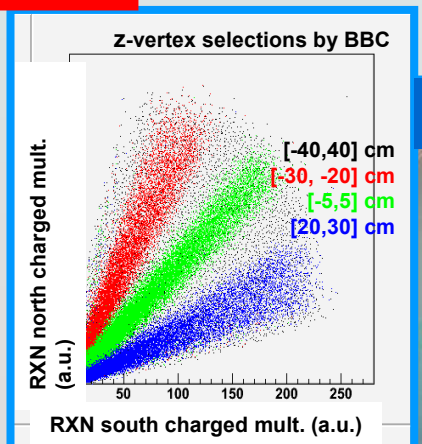
Time of Flight-West



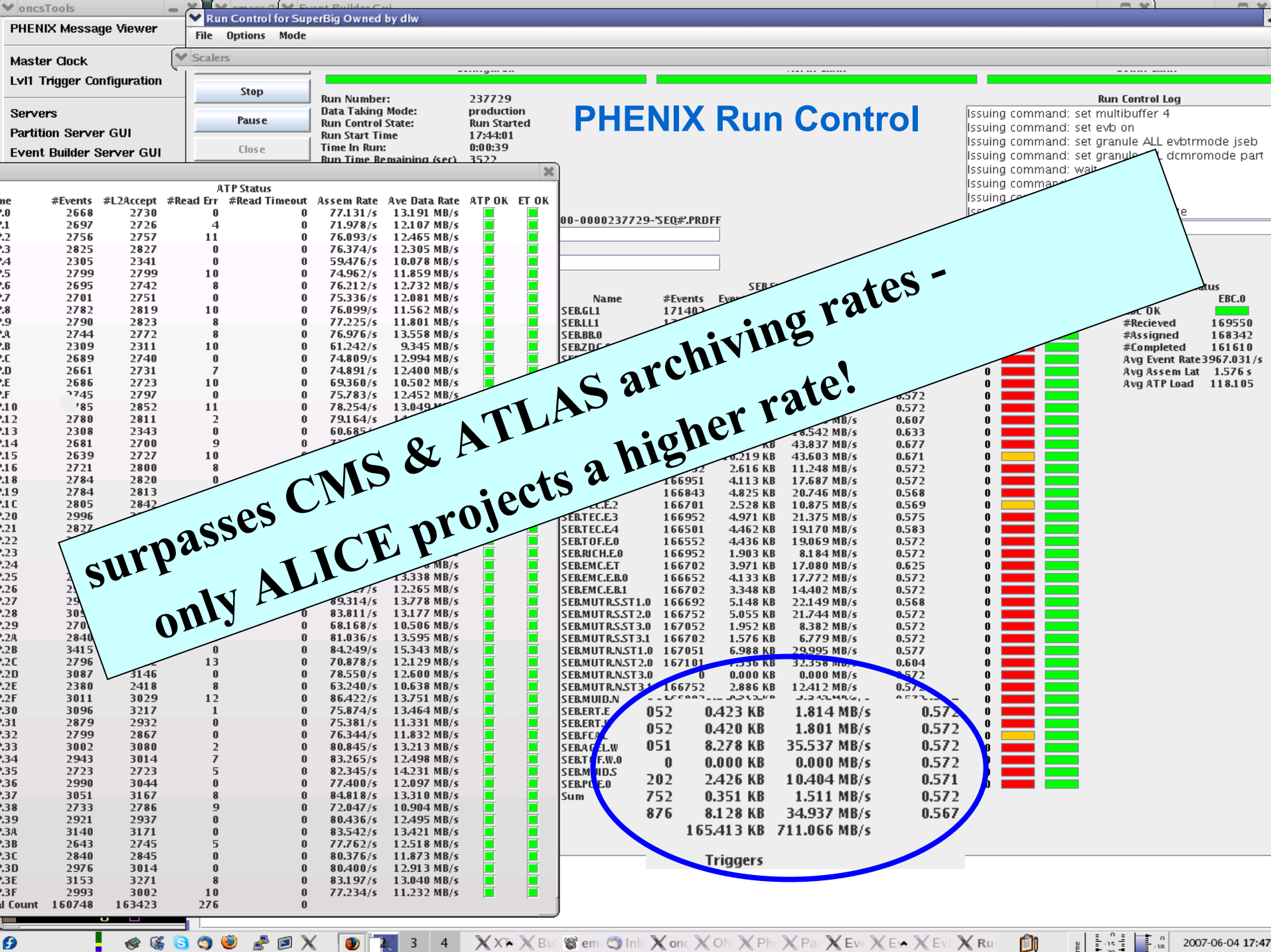
MPC







Reaction Plane Detector


PHENIX Message Viewer
Master Clock
Lvl1 Trigger Configuration
Servers
Partition Server GUI
Event Builder Server GUI
Run Control for SuperBig Owned by dlw
File Options Mode
Scalers
Stop
Pause
Close
Run Number: 237729
Data Taking Mode: production
Run Control State: Run Started
Run Start Time 17:44:01
Time In Run: 0:00:39
PHENIX Run Control
Run Control Log
Issuing command: set multibuffer 4
Issuing command: set evb on
Issuing command: set granule ALL evbtrmode jseb
Issuing command: wait
ATP Status
#Events #L2Accept #Read Err #Read Timeout Assem Rate Ave Data Rate ATP OK ET OK
Name #Events
SEB.GL1 171403
SEB.LL1
SEB.BB.0
SEB.EMC.E.2 166701 2.528 KB 10.875 MB/s 0.569
SEB.TEC.E.3 166952 4.971 KB 21.375 MB/s 0.575
SEB.TEC.E.4 166501 4.462 KB 19.170 MB/s 0.583
SEB.TOF.E.0 166552 4.436 KB 19.069 MB/s 0.572
SEB.RICH.E.0 166952 1.903 KB 8.184 MB/s 0.572
SEB.EMC.E.T 166702 3.971 KB 17.080 MB/s 0.625
SEB.EMC.E.B.0 166652 4.133 KB 17.772 MB/s 0.572
SEB.EMC.E.B.1 166702 3.348 KB 14.402 MB/s 0.572
SEB.MUTR.S.ST1.0 166692 5.148 KB 22.149 MB/s 0.568
SEB.MUTR.S.ST2.0 166752 5.055 KB 21.744 MB/s 0.572
SEB.MUTR.S.ST3.0 167052 1.952 KB 8.382 MB/s 0.572
SEB.MUTR.S.ST3.1 166702 1.576 KB 6.779 MB/s 0.572
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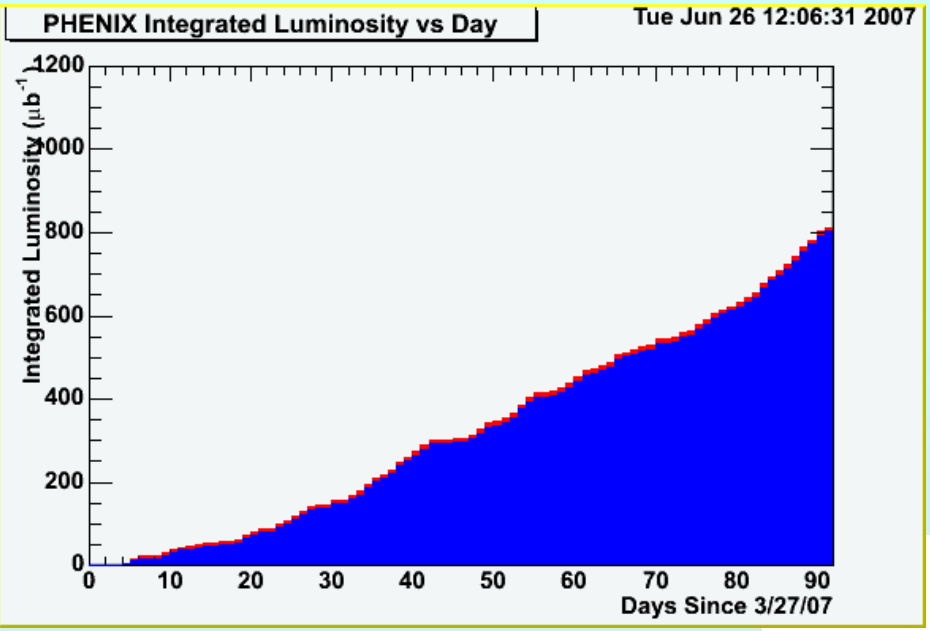
SEB.MUTR.N.ST2.0 167101 7.536 KB 32.358 MB/s 0.604
SEB.MUTR.N.ST3.0 0 0.000 KB 0.000 MB/s 0.572
SEB.MUTR.N.ST3.1 166752 2.886 KB 12.412 MB/s 0.572
SEB.MUID.N
SEB.ERT.E
SEB.ERT.J
SEB.FCAL
SEB.AGEL.W
SEB.TOF.W.0
SEB.MUIDS
SEB.PCAL.E.0
Sum
052 0.423 KB 1.814 MB/s 0.572
052 0.420 KB 1.801 MB/s 0.572
051 8.278 KB 35.537 MB/s 0.572
0 0.000 KB 0.000 MB/s 0.572
202 2.426 KB 10.404 MB/s 0.571
752 0.351 KB 1.511 MB/s 0.572
876 8.128 KB 34.937 MB/s 0.567
165.413 KB 711.066 MB/s
Triggers
EBC.0
#Recieved 169550
#Assigned 168342
#Completed 161610
Avg Event Rate 3967.031/s
Avg Assem Lat 1.576 s
Avg ATP Load 118.105
surpasses CMS & ATLAS archiving rates -
only ALICE projects a higher rate!

Run-7 a major success!

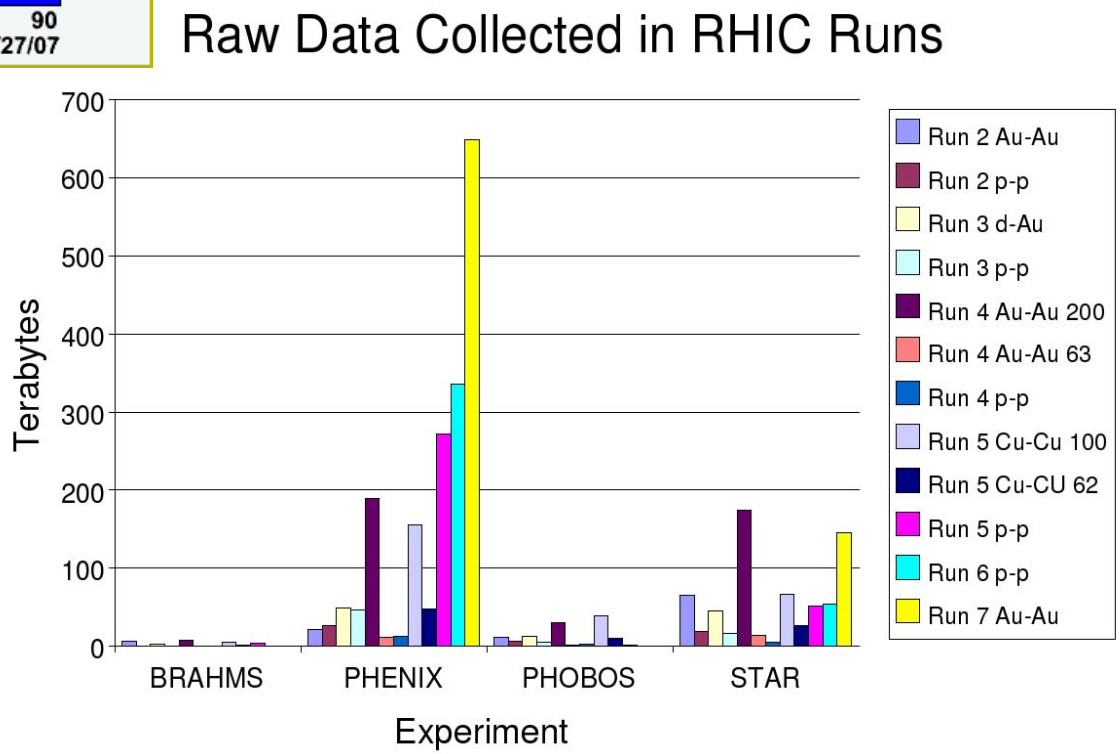


- 813 μb^{-1} data recorded
- *4 new subsystems:*

RXNP, TOF-W, MPC, HBD

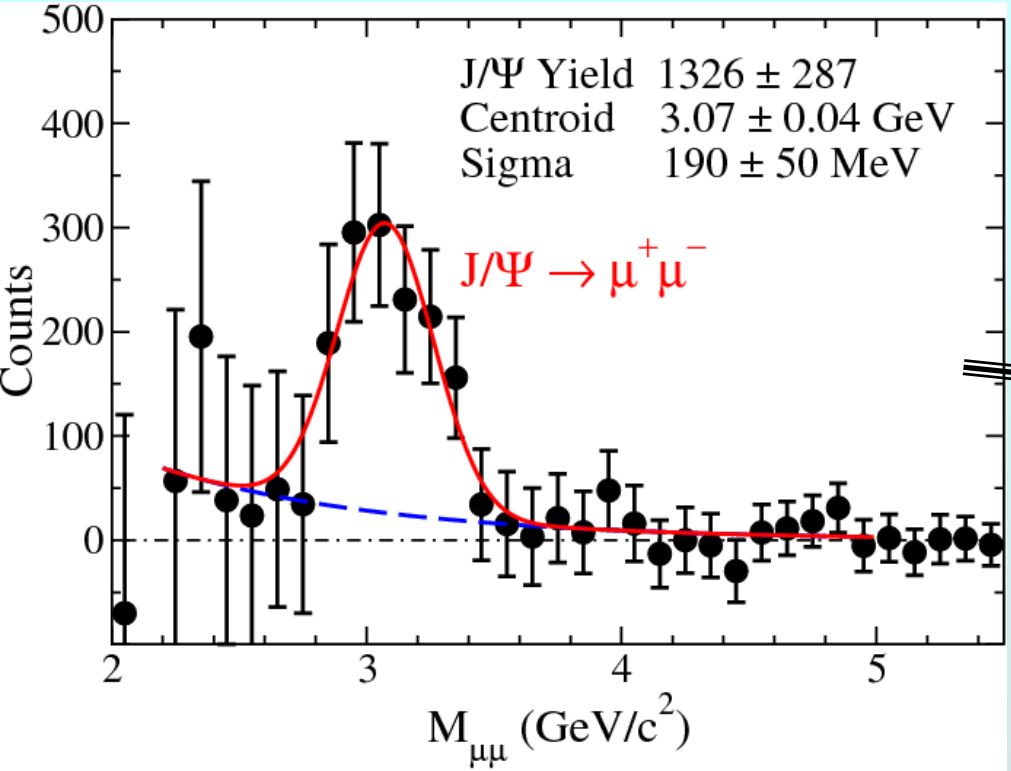
from T. Throwe, RCF

- **> 5.1 G events written**
- **Reached new DAQ performance levels ~ 5kHz**

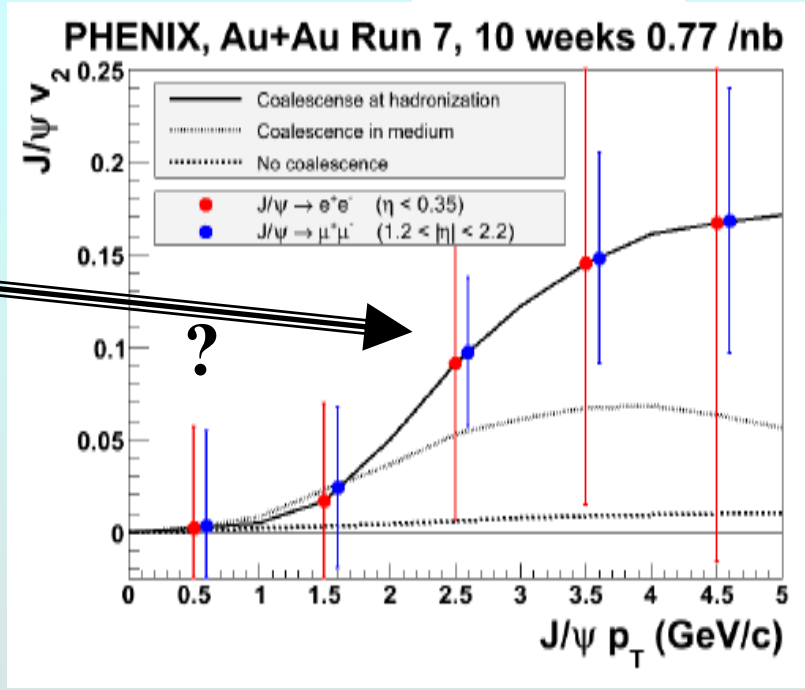


PHENIX

initial analysis: data quality very high



simulation



from initial analysis at CC-F (IN2P3 Computing Center)

~8% of the data, implies ~16,000 J/ψ → μμ

- plans

PHENIX mid-term plan:

- **Run-8: d+Au and 200 GeV p+p**

  cold nuclear matter comparison for J/ψ, jets, e+e-

  complete A_{LL} and A_N at 200 GeV

- **Run-9: 200 GeV Au+Au & p+p at 200 and/or 500 GeV**

  complete high statistics Au+Au

  begin 500 GeV spin runs

- **Run-10: Au+Au energy scan & 500 GeV p+p**

  search for QCD critical point

- **Run-11+ with new upgrades**

  VTX fully installed *c,b separation in Au+Au*

  Muon Trigger **W in 500 GeV p+p**

  FVTX and NCC

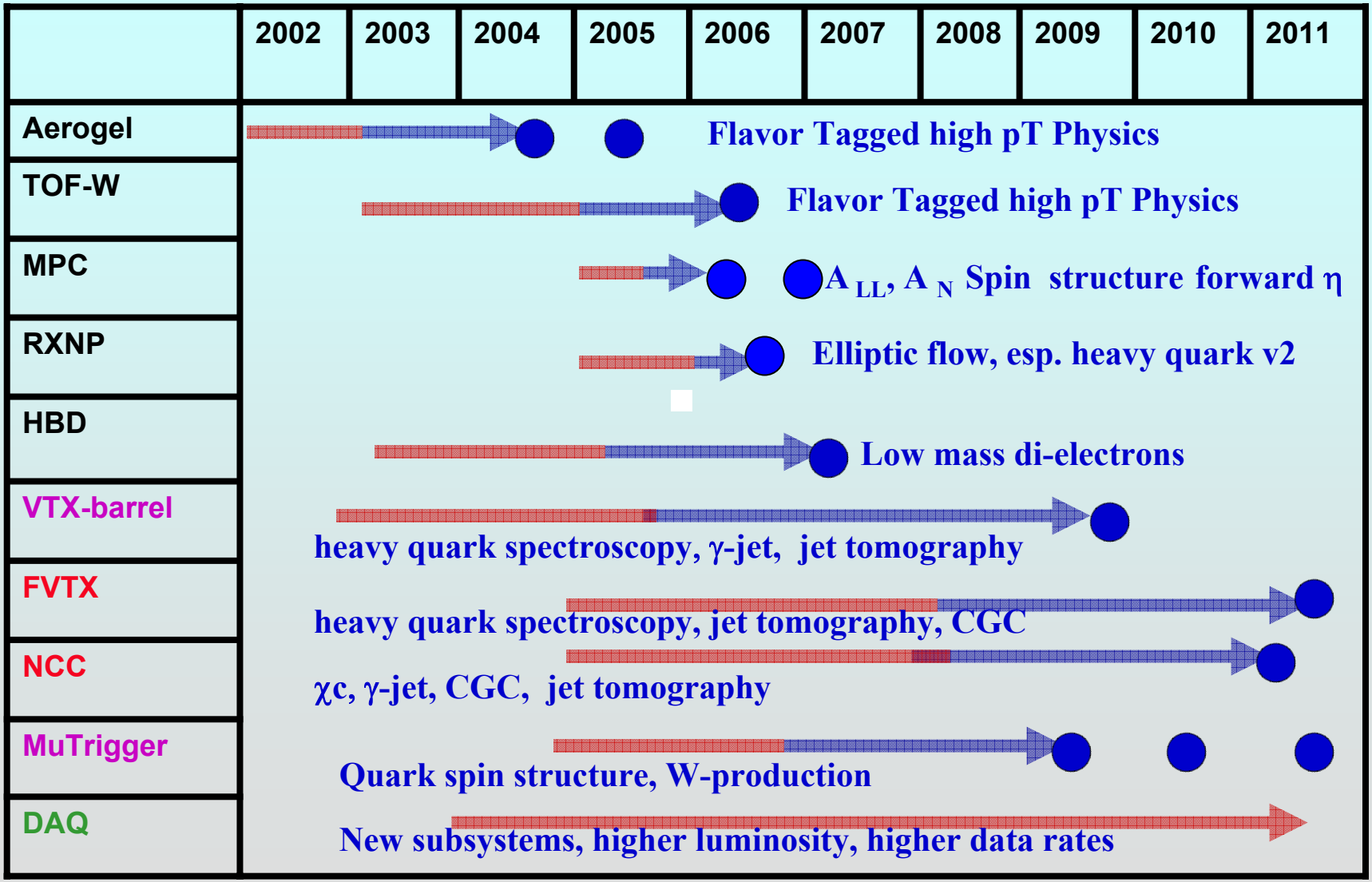
  collect integrated luminosity p+p for low x π^0,γ, W

  c/b, jet, γ-jet, χ_c in heavy ion collisions

PHENIX

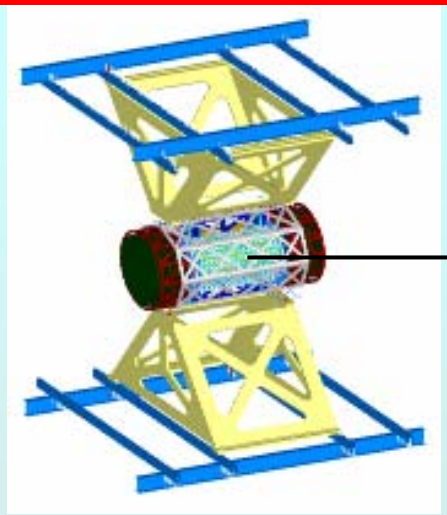
Spin structure, external medium probes & radiation

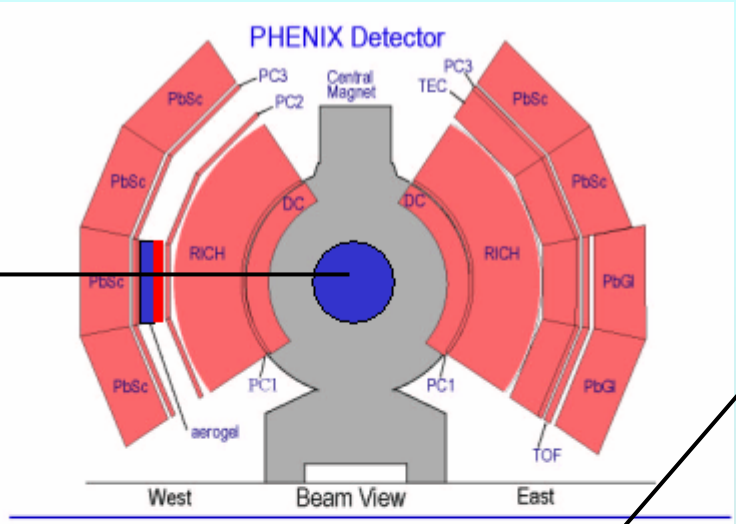
Enhance Physics Capabilities



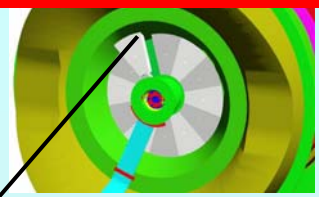
upgrades at a glance

Silicon VTX and FVTX





MuTrig Station 1



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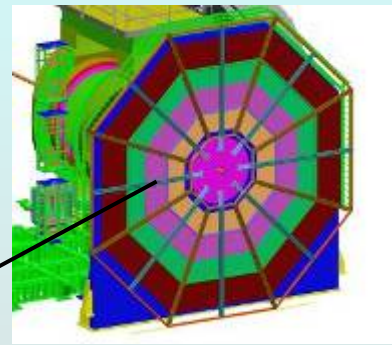
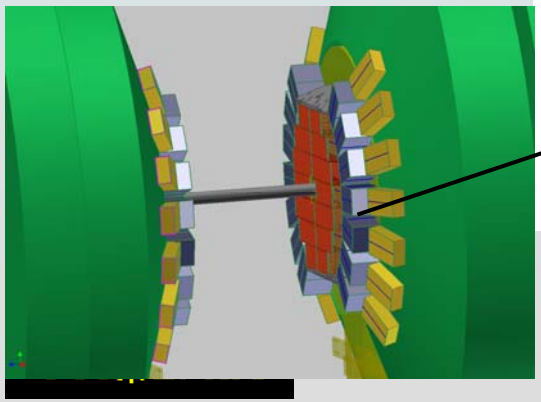
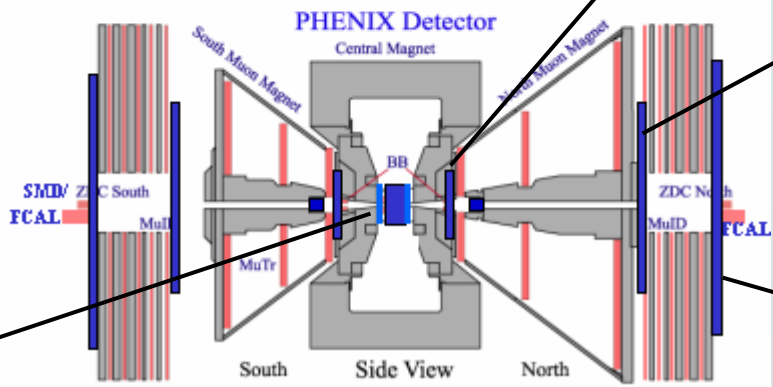
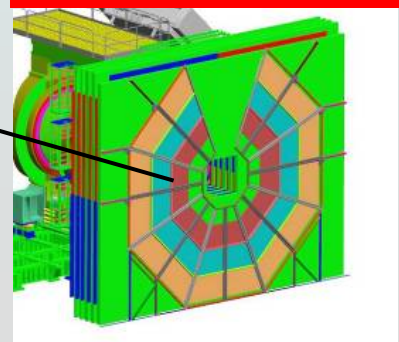


Nose Cone Calorimeter

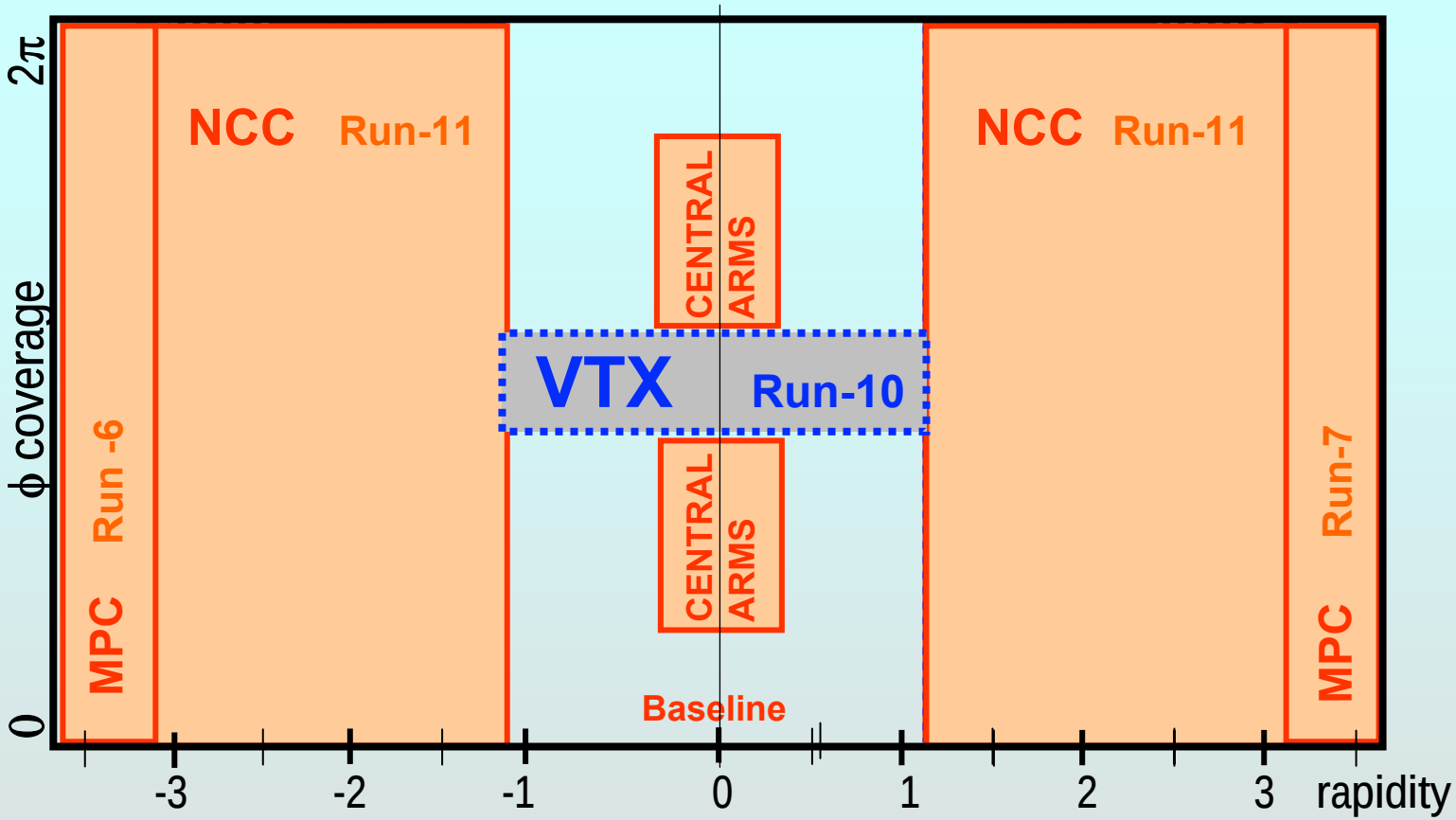




MuTrig Station 3



Enhanced Acceptance for Hard Probes



a) Heavy flavor with precision vertex tracking with silicon detectors
b) Direct γ and π^0 with combination of all electromagnetic calorimeters
c) Combine a) & b) for jet tomography with γ-jet

PHENIX

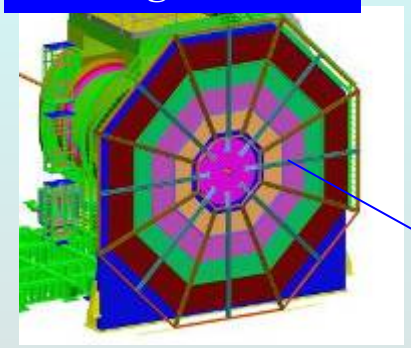
Muon Trigger

The Muon Trigger Upgrade consists of:

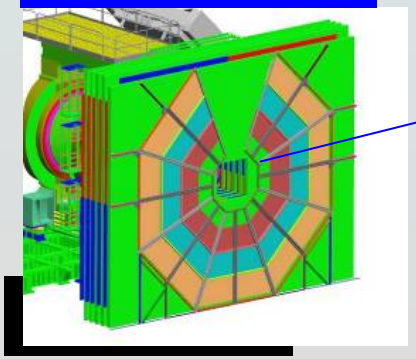
- **6 Stations of Resistive Plate Chambers**
  3 North, 3 South
- **Addition of LVL1 electronics to MuTracker**
  St1, St2 North and St1, St2 South
- **Increases LVL1 rejection by 2 orders of magnitude**

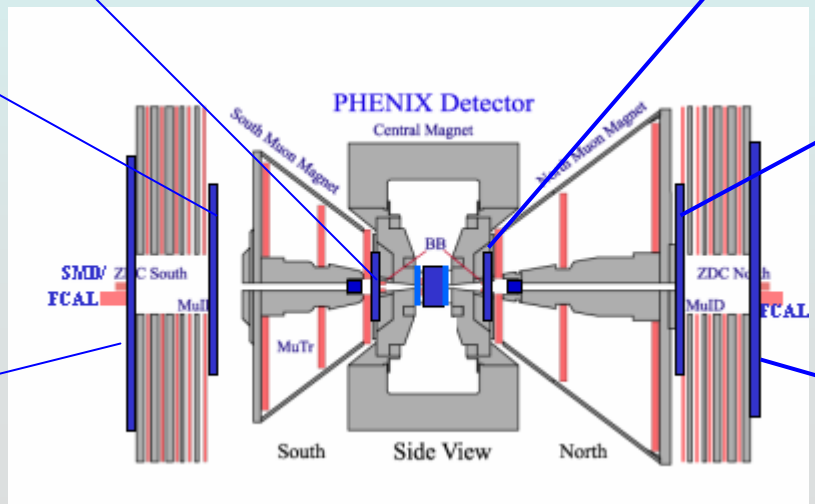
MuTrig Station 1

MuTrig Station 2



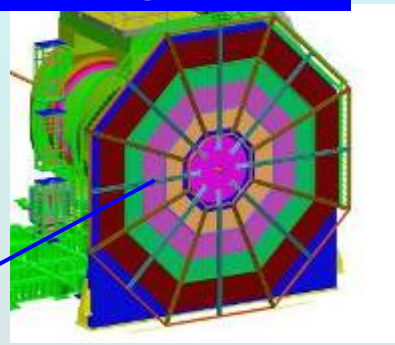
MuTrig Station 3



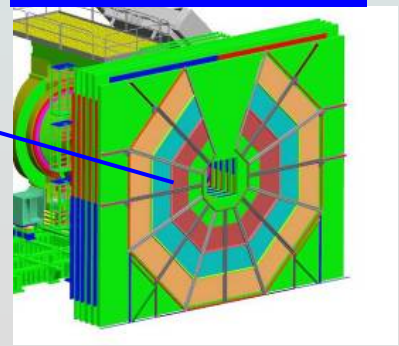


MuTrig Station 1

MuTrig Station 2

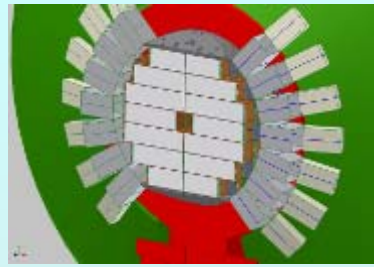


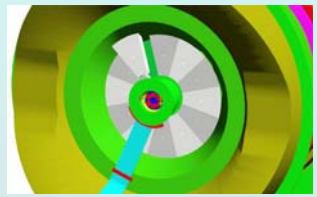
MuTrig Station 3

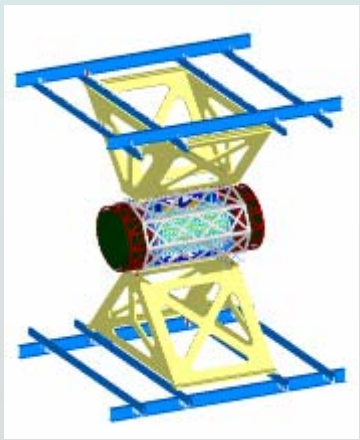


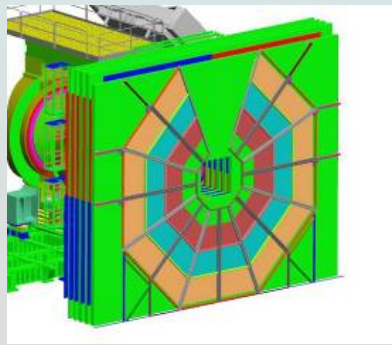
Installation in 2009 +

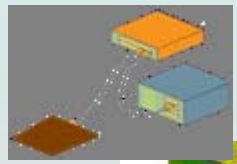
• TBD detector maintenance and repair	TBD months, each year
• Install new beampipe	1 month
• Install VTX	4 months
• Install RPC 3 North	3 months
• Install RPC 2 South and North	6 months
• Install FEE Upgrade MuTR 1, 2 North (all octants)	6 months
• Install LL1 North	3 months
• Install Full Cu absorber + NCC tungsten	2 months
• Install FVTX	2 months
• Install NCC N & S	2 months
• Remove Cu Shielding	1 month
• Install RPC 1AB North and South	3 months
• Install FEE Upgrade MuTR 3, South and North	6 months

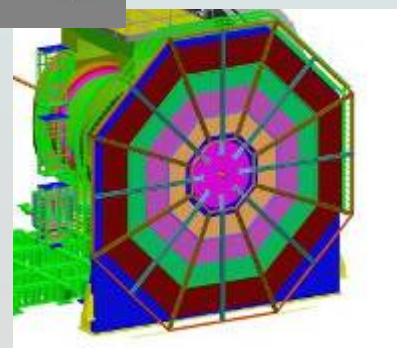


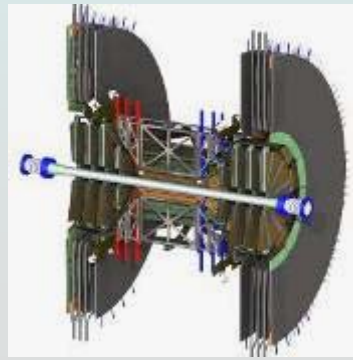








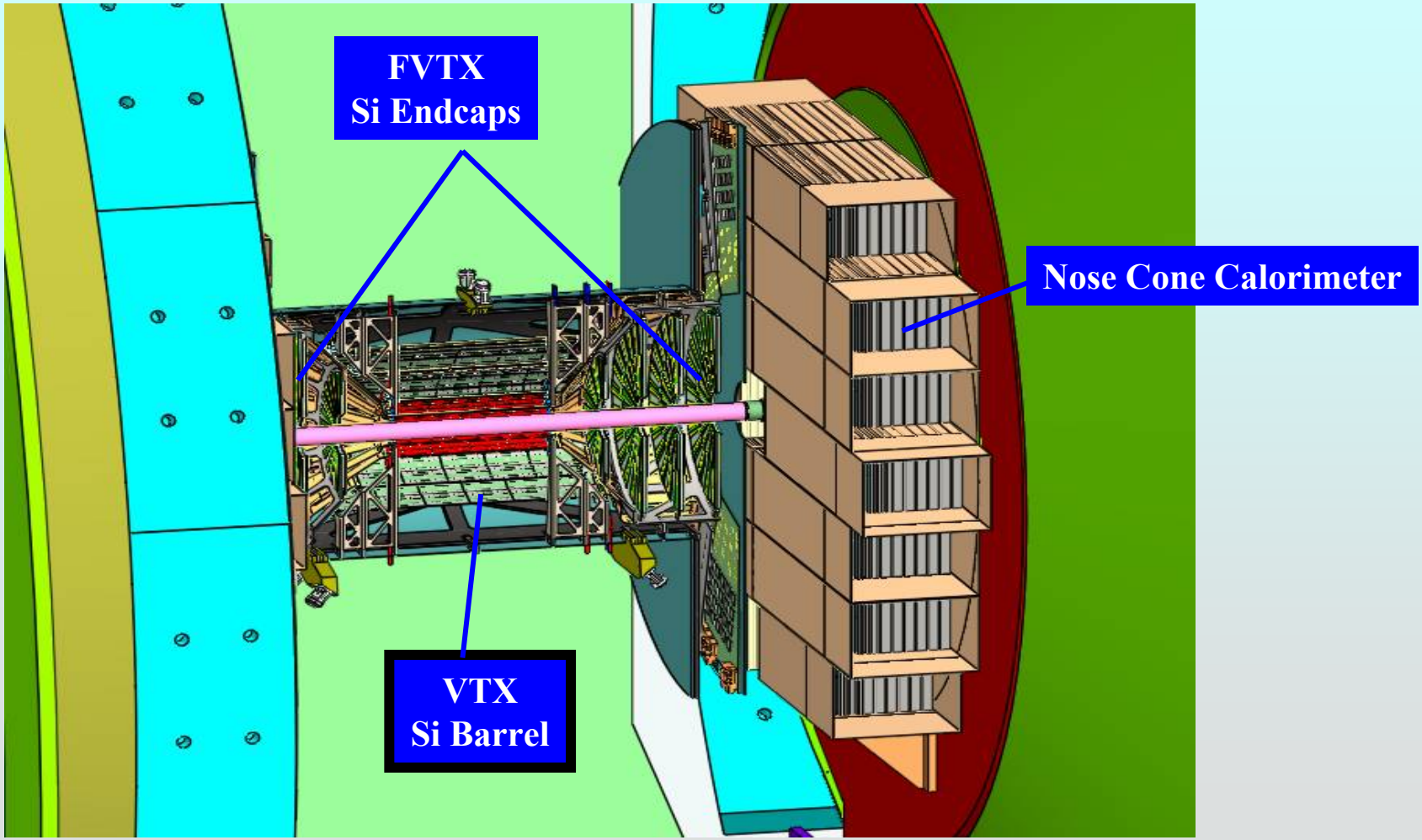




installation planning is underway

- some longer shutdowns will be desirable/necessary
- logical timescale is around 2010-2012
- LRP calls for RHIC II luminosity upgrade
  - some trade-off between construction & running
  - timescale may, in fact, match reasonably well with PHENIX upgrades installation needs
    - details still to be worked out
    - discussions with C-A D initiated

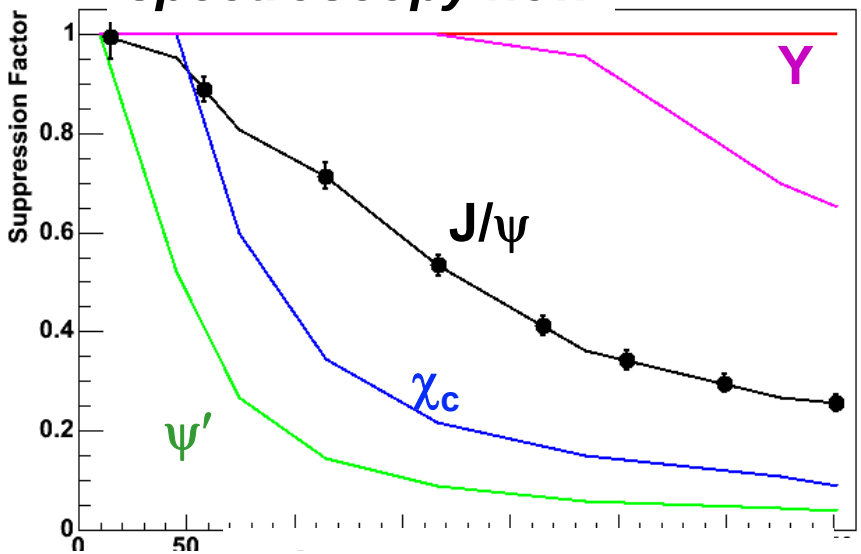
Tracking & Calorimetry Upgrades



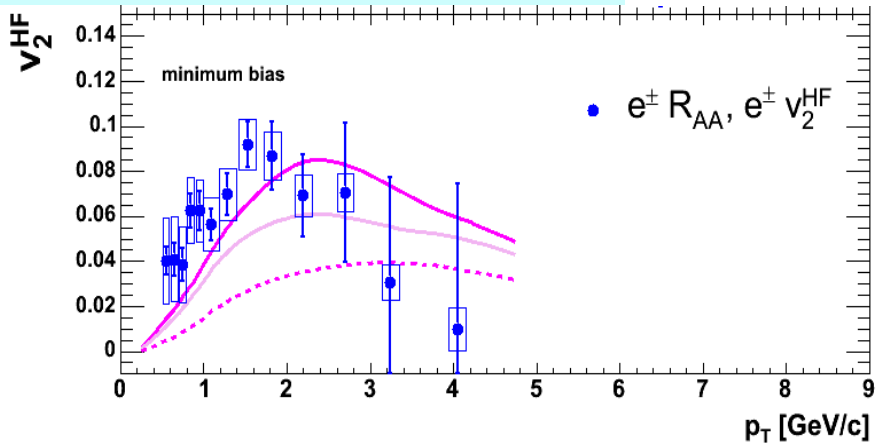
please see backup slides for details

heavy quark measurements

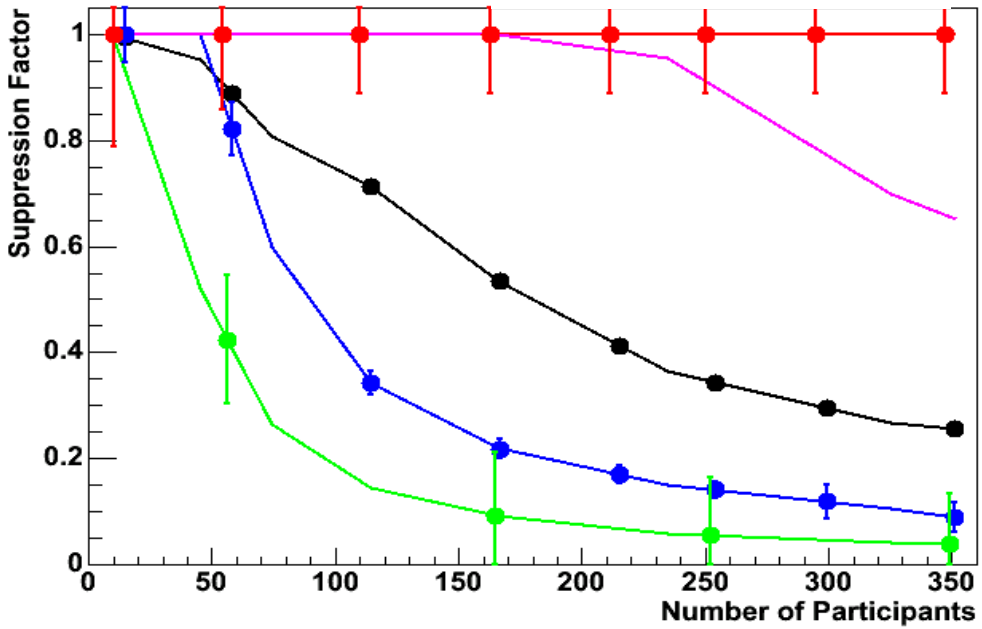
spectroscopy now



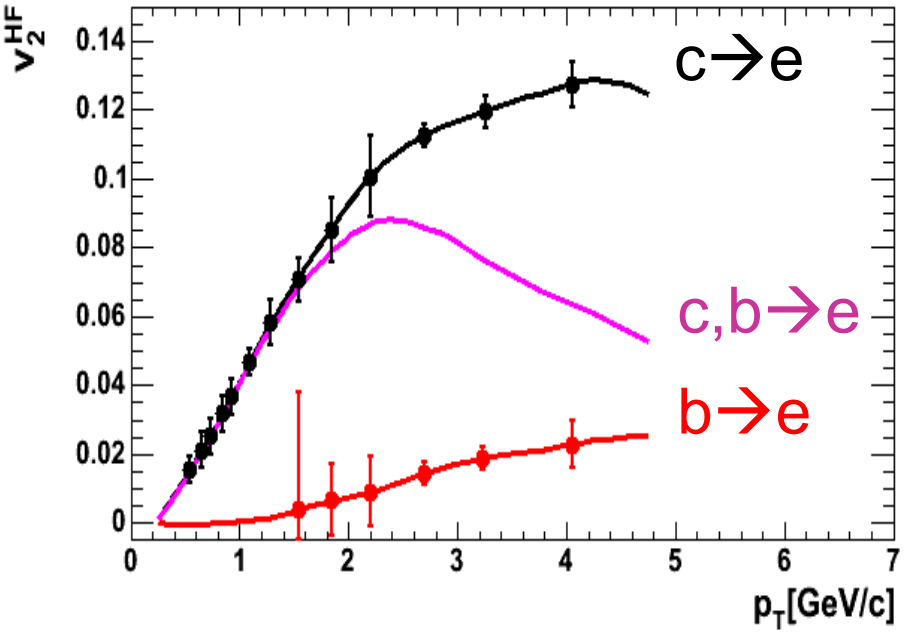
flow now



w/ NCC – RHIC II



w/ FVTX RHIC II



- issues

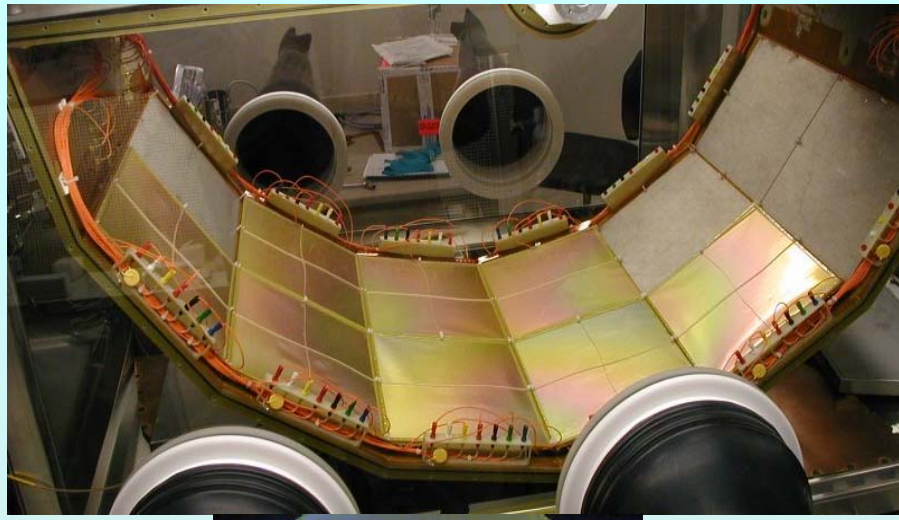
First run with novel Hadron Blind Detector

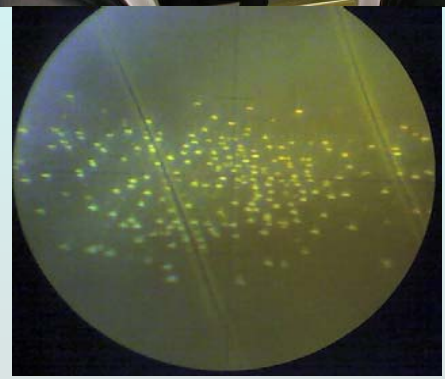
Windowless CF_4 Cherenkov detector

50 cm radiator length

CsI reflective photocathode

Triple GEM with pad readout





- LeCroy HV supply trip action under fault condition damaged GEM surfaces. Remove mesh bypass cap & replace damaged GEMs.
  - Enhanced photoelectron production at CsI coating of GEM surface increased gain. Operate at lower voltage.
  - Significant scintillation light from charged particles in CF4. Considering blinders between GEMs.

PHENIX

concerns

- Run-6 and Run-7 preceded by terrible uncertainty
  - due to Congressional (non)action
  - devastating for morale
  - difficult for planning

- Detector operations & RCF capital
  - needed to operate & maintain detectors entering their 8th year
  - annual replacement of PHENIX RCF resources a must: Moore's law → keep up with datasets
  - squeezed in recent years, cannot continue

- Manpower levels within collaboration squeezed by flat-flat budgets (& '06 cuts to universities)

Increased ops tasks to BNL PHENIX group

- Natural burden to integrate new subsystems, BUT:
- Increasing work loads:
  - Software & calibrations infrastructure
  - Maintenance of legacy code
  - Increasing complexity of data production
  - Subsystem "small" ops tasks, DAQ interfaces
- Collaboration steps (to partially ameliorate):
  - negotiations with (also pinched) collaborators
  - new contributions/new PHENIX institutions
    - data management, simulations
    - data access an effective inducement
  - planned software reconfiguration – by subsystem
  - weigh service in speaker selections – increase size of PSB to aid in this
- *Need sufficient support to collaborating institutions*

Summary

- **PHENIX is extraordinarily successful and productive**
  unprecedented physics reach & flexibility
  discoveries & excitement continue
- **Simultaneously run/analyze our physics program & implement upgrades in detector & DAQ**
  unique photon, lepton, high pT capabilities
  + crucial overlap with other detectors
- **Operations shared by BNL & collaborating groups**
  but increasing burden on local group a concern
- **Robust plan for next phase of RHIC Physics**
  discovery → characterization of QGP
  upgrade program: new observables & reach, overlap
  maintain collaboration strength, *funding needed*

PHENIX

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PHENIX

14 Countries; 69 Institutions

~ 550 Collaborators

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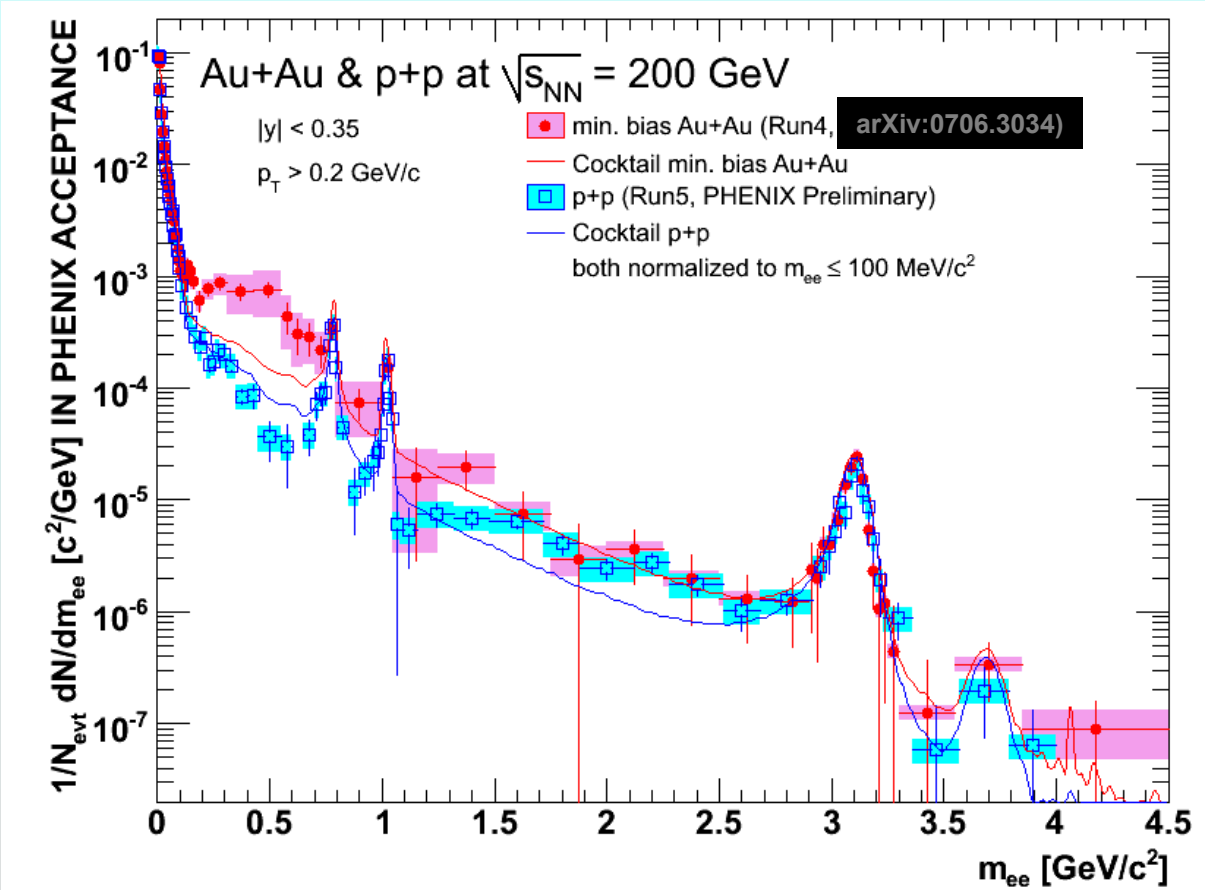
- backup slides

p+p – Au+Au comparison

A. Toia, S. Bathe

p+p normalized to m_{ee}<100 MeV/c^2

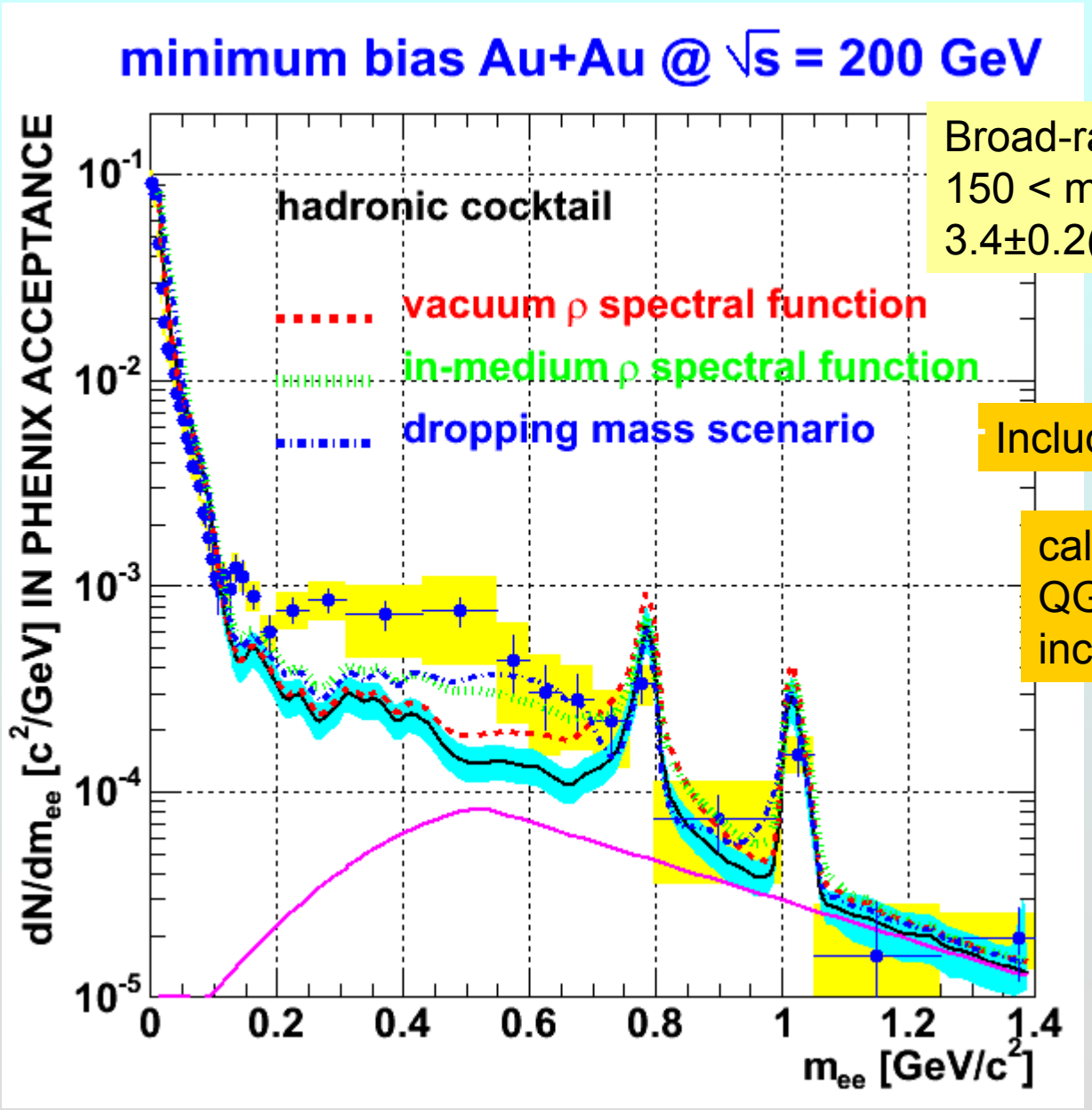


- p+p and Au+Au normalized to π^0 region
- Agreement at resonances (ω, ϕ)
- Au+Au enhancement for 0.2 < m_{ee} < 0.8 GeV

- Agreement in intermediate mass and J/Ψ just for 'coincidence' (J/Ψ happens to scale as π^0 due to scaling with N_{coll} + suppression)

Low-mass: Comparison with theory

A. Toia, S. Bathe



Broad-range enhancement:
$150 < m_{ee} < 750$ MeV
3.4±0.2(stat.) ±1.3(syst.)±0.7(model)

Includes chiral symmetry restoration

calculations for min bias, QGP thermal radiation included

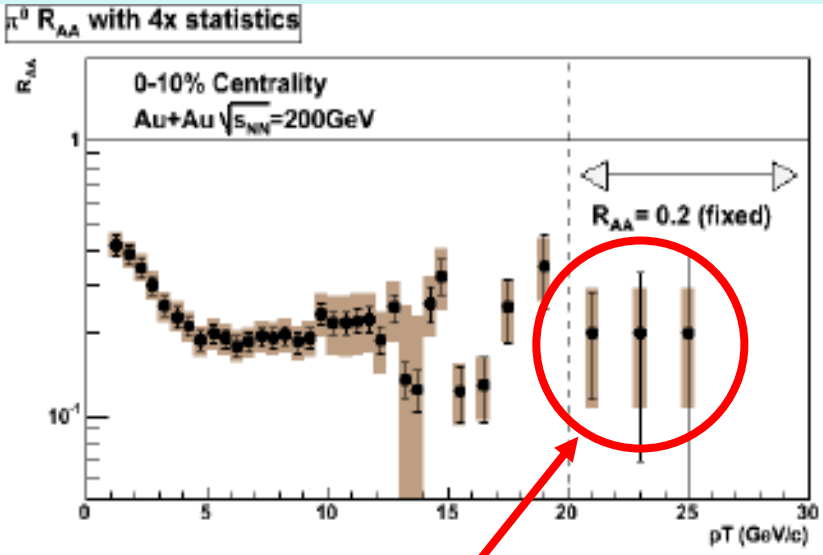
R.Rapp, Phys.Lett. B 473 (2000)
R.Rapp, Phys.Rev.C 63 (2001)
R.Rapp, nucl/th/0204003

PHENIX
submitted to Phys. Rev. Lett
arXiv:0706.3034

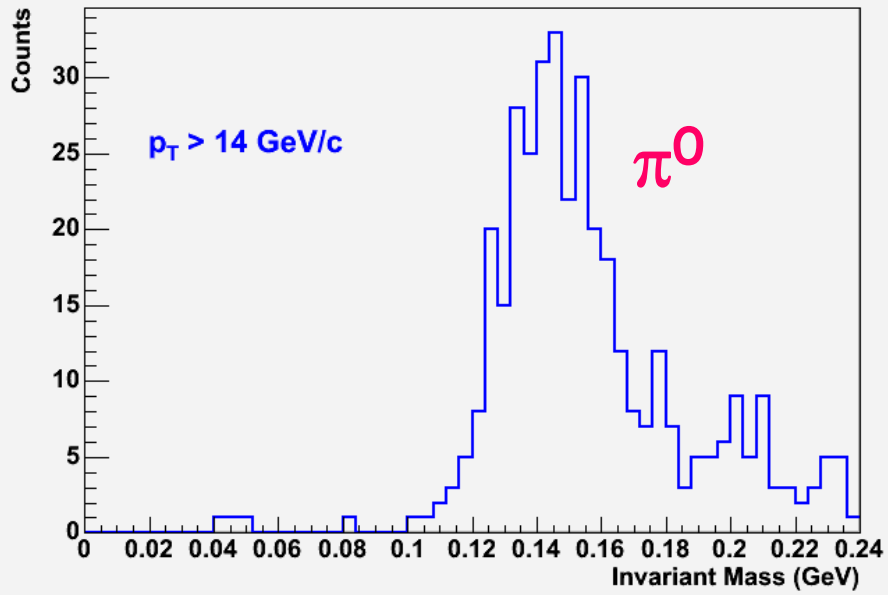
π^0's & η's

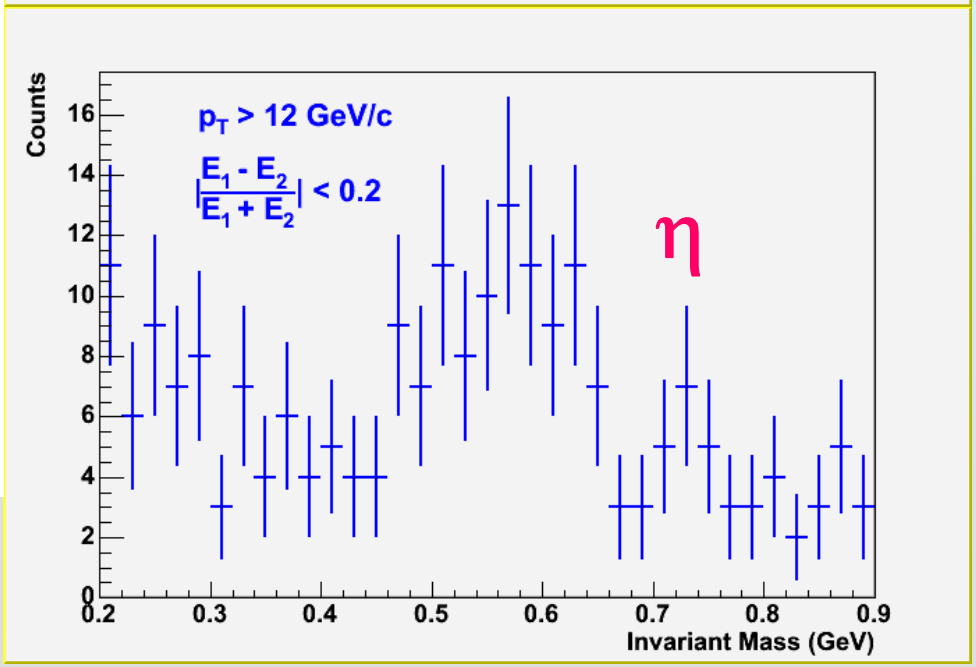
thanks to Justin Franz

from about 16% of present data



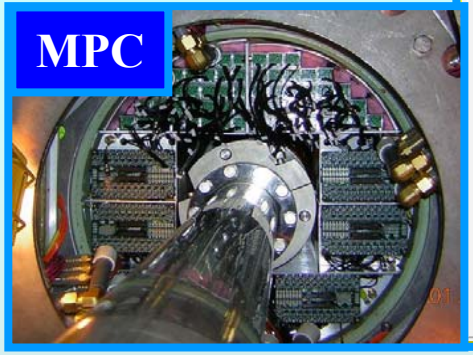
extended range in p_T

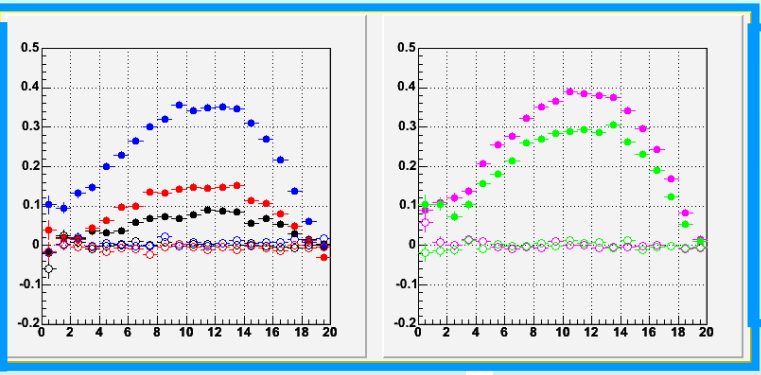




New subsystem performance

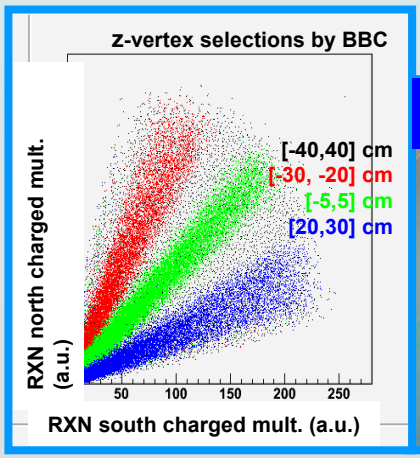
Reaction Plane with the MPC/BBC/RXNP



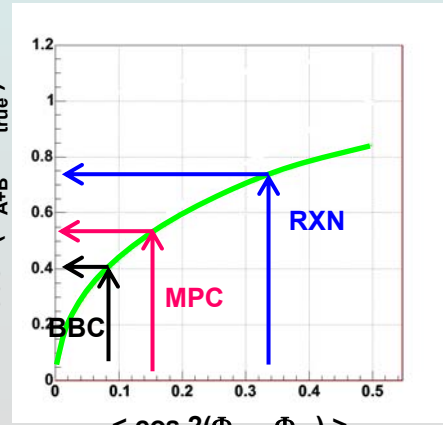


blue : rxn_S - rxn_N
red : mpc_S - mpc_N
black : bbc_S - bbc_N
pink : rxn - mpc
green : rxn - bbc
The solid symbols are average cos values.
The open symbols are average sin.

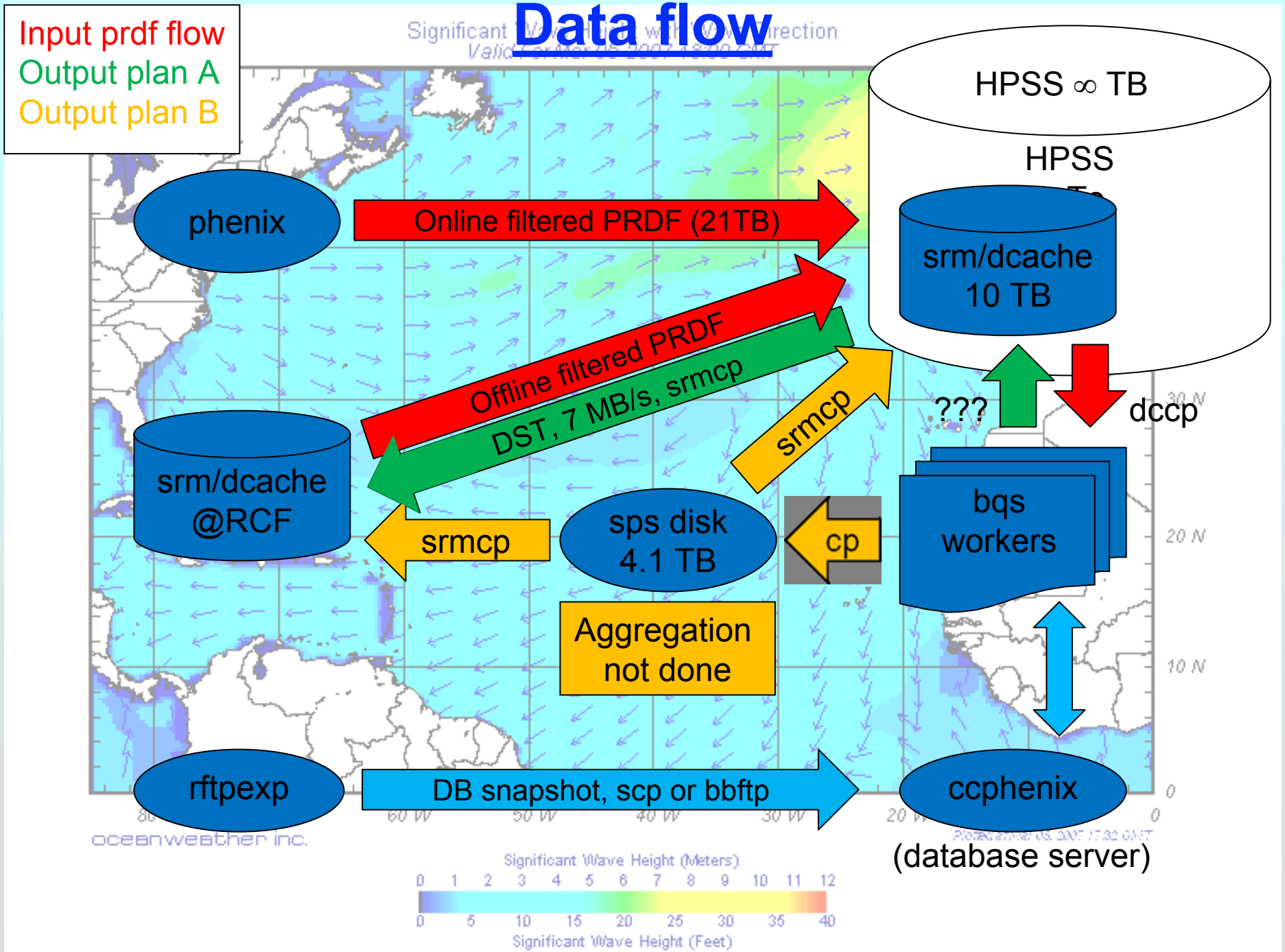
Triggering with the RXNP



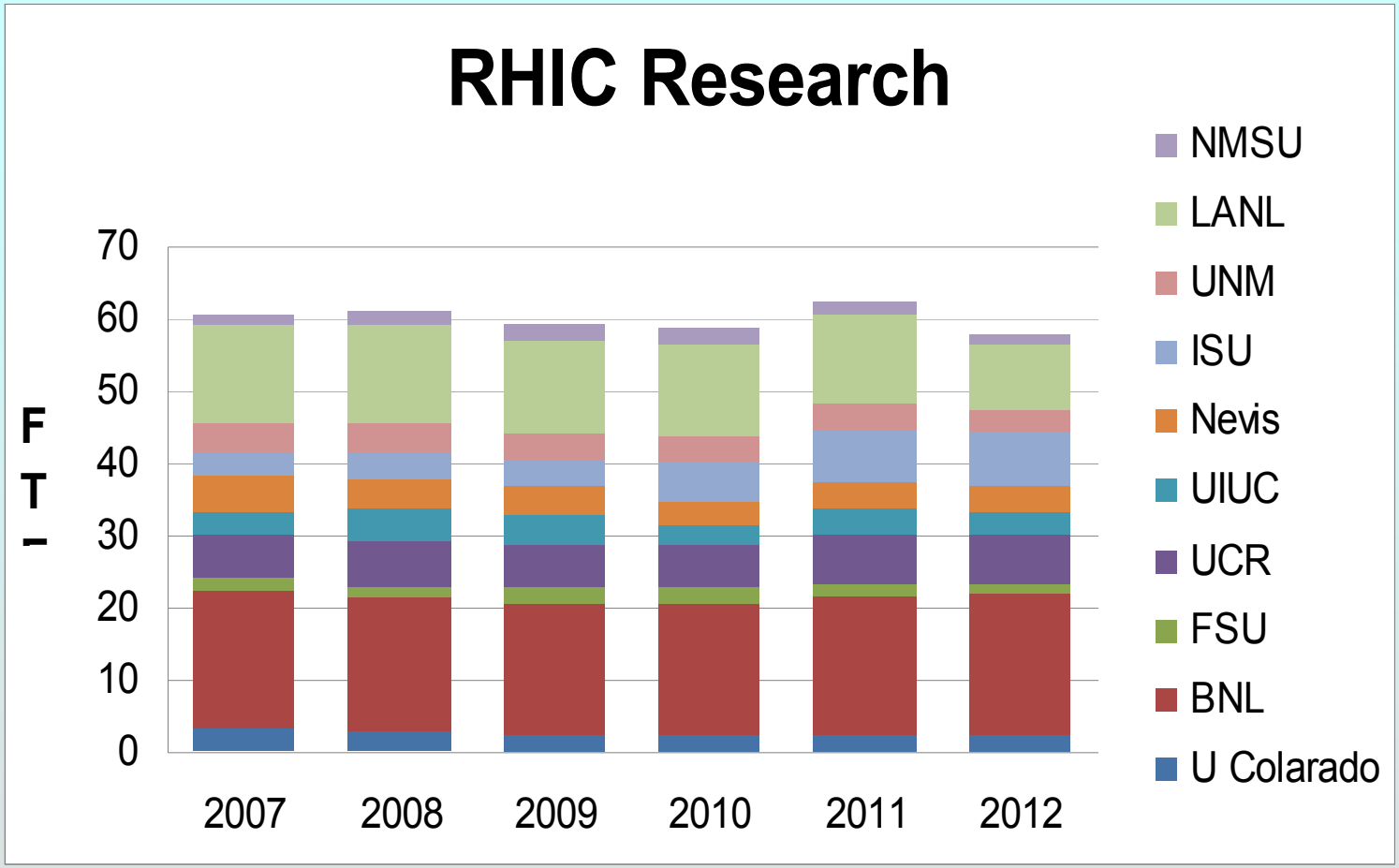
Reaction Plane Detector



Data flow


Input prdf flow
Output plan A
Output plan B
HPSS ∞ TB
HPSS
phenix
Online filtered PRDF (21TB)
srm/dcache
10 TB
Offline filtered PRDF
DST , 7 MB/s, srmcp
srmcp
???
dccp
srm/dcache
@RCF
srmcp
sps disk
4.1 TB
cp
bqs
workers
Aggregation
not done
rftpexp
DB snapshot, scp or bbftp
ccphenix
(database server)
oceanweather inc.
Significant Wave Height (Meters)
0 1 2 3 4 5 6 7 8 9 10 11 12
0 5 10 15 20 25 30 35 40
Significant Wave Height (Feet)

manpower at U.S. institutions on FVTX, NCC



~ same number of non-US collaborators

we can build while taking & analyzing PHENIX data

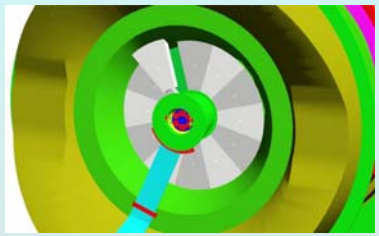
characterizing medium by rare probes

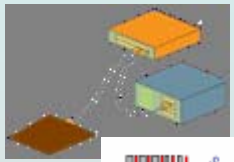
- High p_T direct γ, π^0, electrons : **medium opacity**
- $J/\psi \rightarrow \mu\mu$, $\chi_c \rightarrow J/\psi\ \gamma$, $\Upsilon \rightarrow \mu\mu$: **color screening**
- **Flavor tagged heavy quark medium interaction (single leptons w/ displaced vertex, D meson reconstruction) : drag forces on c, b quarks**
- **jet-jet (via h-h) and γ-jet coincidences: calibrated probes of medium opacity and response, tomographic studies**

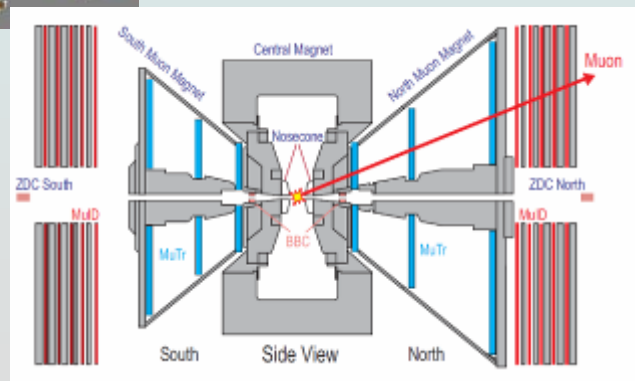
PHENIX

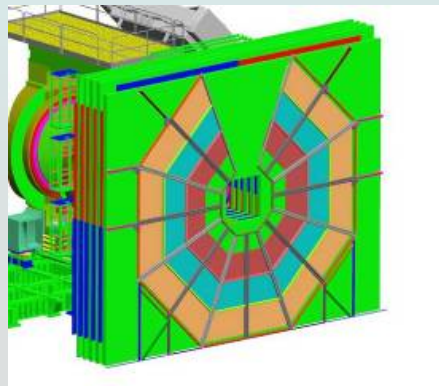
2008

- Run 8 Length (start of physics to run end) 7 months
- Shutdown Prep 2 weeks
- TBD detector maintenance and repair 0-3 months
- Install Cu absorber for 1 South octant, 1 week
- Install RPC 3 South 6 months
- Install FEE Repairs & Upgrade MuTR 1, 2 South all octs 4 months
- Install LL1 South 3 months
- Commissioning and run prep 1 month
- Shutdown length (End of run 8 to run 9 cooldown start) 6 months

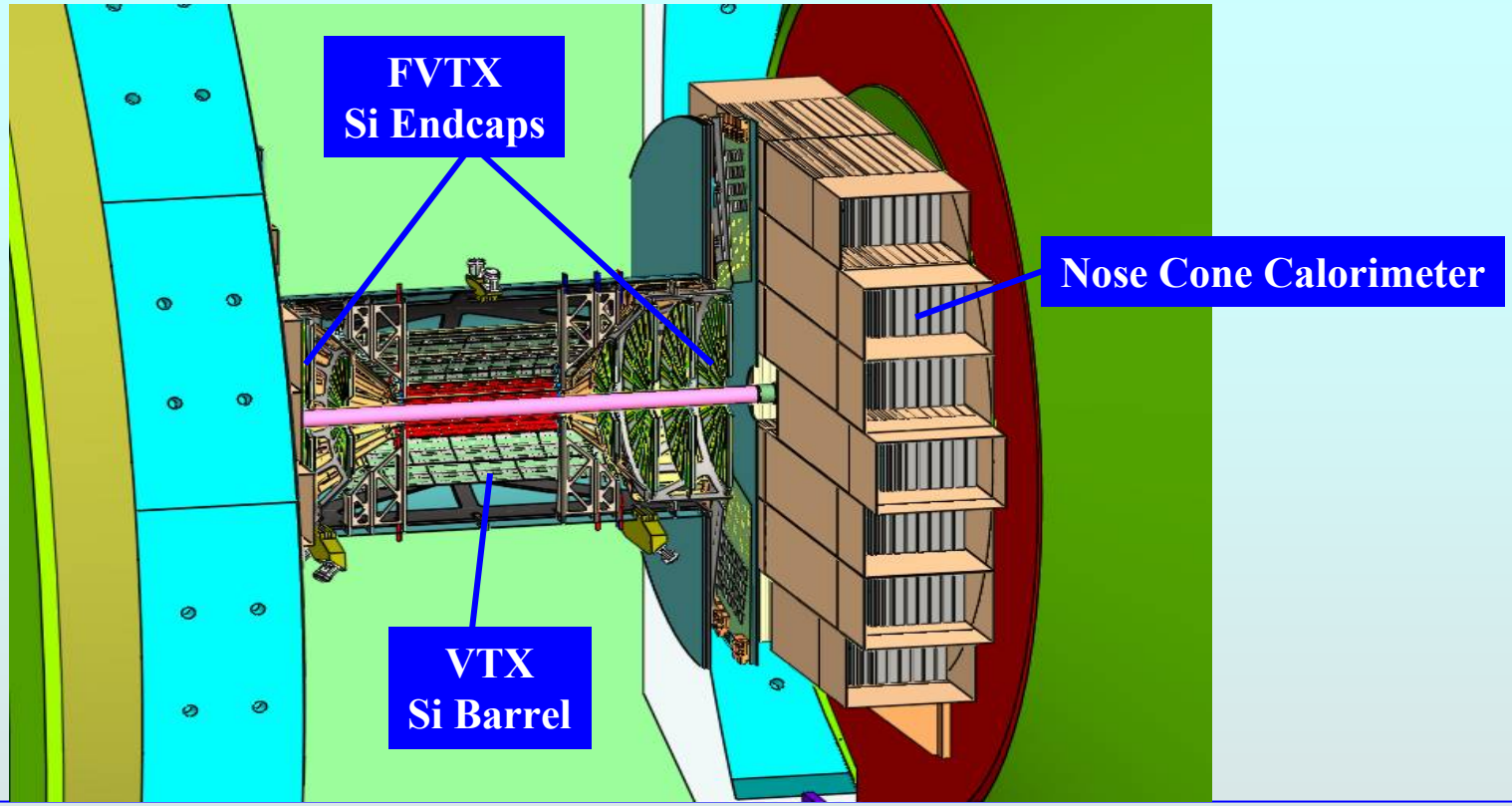








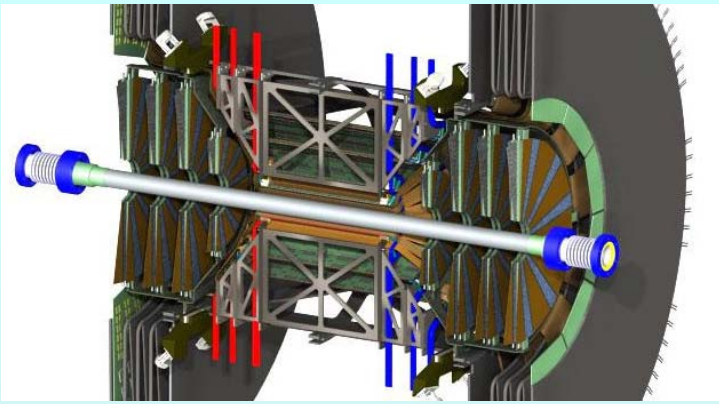
PHENIX Upgrades



The VTX, FVTX and NCC enhance AA, p(d)-A and p-p:

- c, b quark interaction in dense medium
- Charmonium spectroscopy (J/ψ, ψ' , χ_c and Υ)
- Gluon spin structure ($\Delta G/G$) through γ-jet correlations
- Transversity
- A-, p_T-, x-dependence of the parton structure of nuclei
- Gluon saturation and the color glass condensate at low x

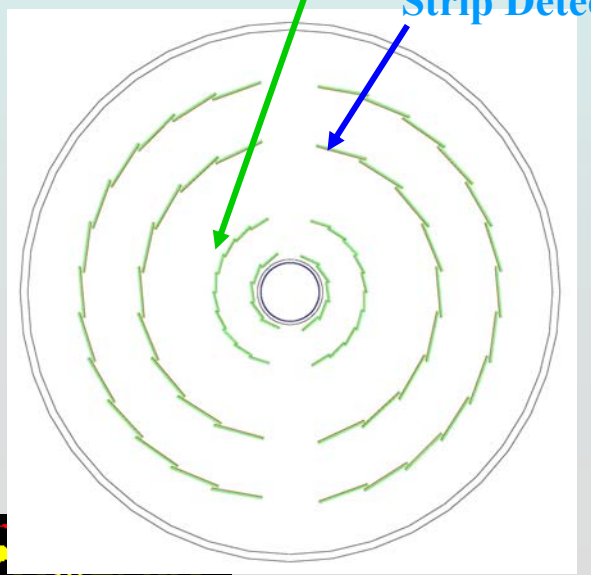
Barrel VTX Detector

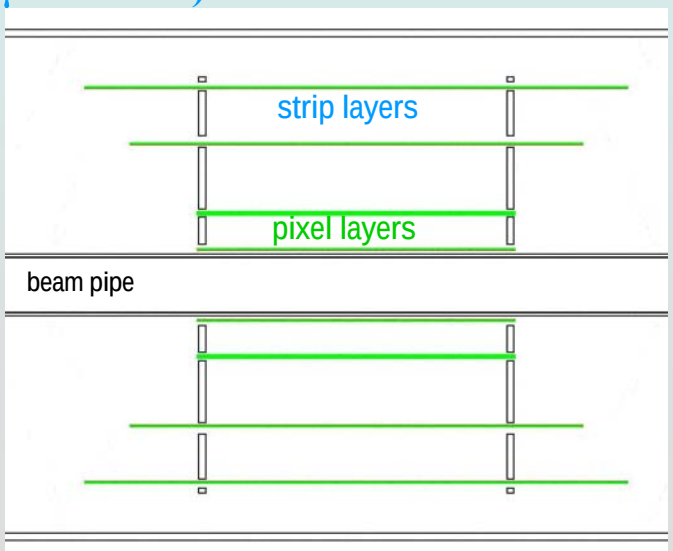


- **Specifications:**
  - **Large acceptance ($\Delta\phi \sim 2\pi$ and $|\eta| < 1.2$)**
  - **Displaced vertex measurement $\sigma < 40$ μm**
  - **Charged particle tracking $\sigma_p/p \sim 5\%$ p at high pT**
  - **Detector must work for both HI and pp collisions.**
- **Technology Choice**
  - **Hybrid pixel detectors developed at CERN for ALICE**
  - **Strip detectors, sensors developed at BNL with FNAL's SVX4 readout chip**

Hybrid Pixel Detectors (50 μm x 425 μm) at R ~ 2.5 & 5 cm

Strip Detectors (80 μm x 3 cm) at R ~ 10 & 14 cm



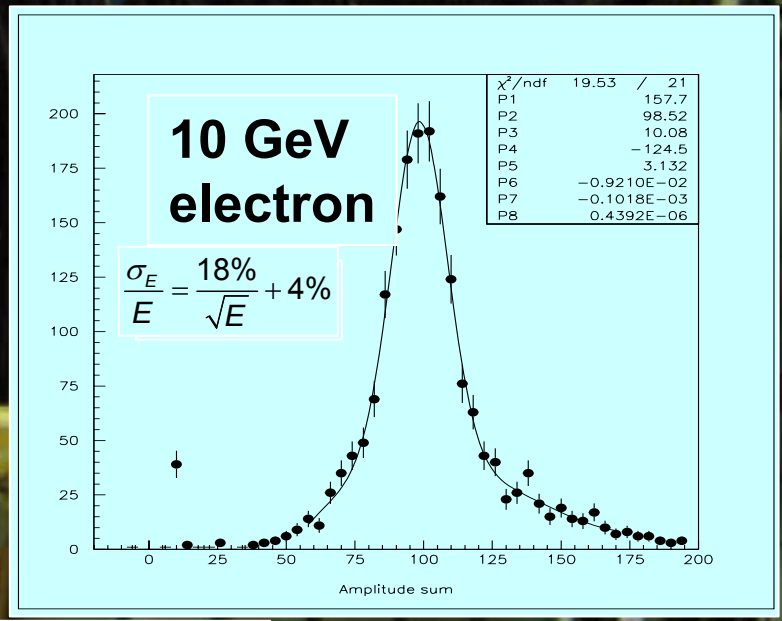


$|\eta|<1.2$
$\phi \sim 2\pi$
$z \sim \pm 10$ cm

Nose Cone Calorimeter

Tungsten-Silicon Calorimeter

- **Combination EM and Hadronic section**
- **Includes both preshower and shower max sections to optimize π^0 identification**
- **Smallest practical Moliere radius needed due to location 40 cm from PHENIX IP**
- **Covers 2π in azimuth and $1.0 < \eta < 3.0$**



500 um pitch Strips ("StriPixels")

PS "pre-shower"

SM "shower max"

Silicon pads 1.5x1.5 cm²

Readout in 3 longitudinal units

EM1 electromagnetic

EM2 electromagnetic

HAD hadron identifier

Depth: $42X_0$ ($1.6\ \lambda_{ABS}$)

$R_{Moliere}$ ~1.8 cm

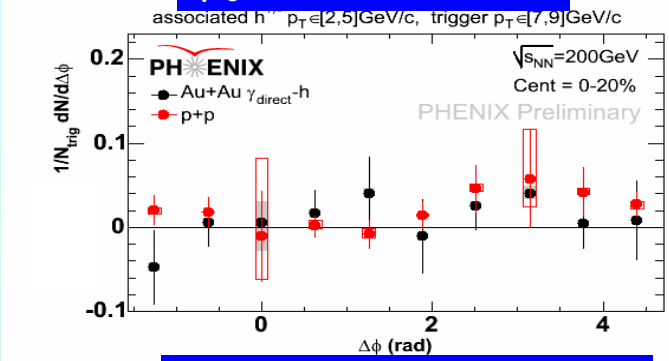
Tungsten 3 mm (EM) & 15mm (HAD)

Nose Cone Calorimeter

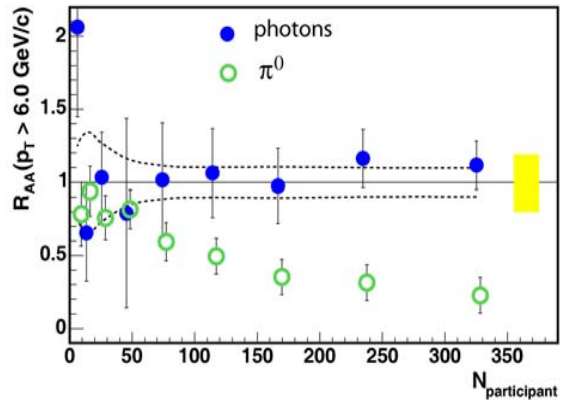
Physics Program of NCC includes:

- Factor of 5 increase in coverage for γ-jet measurements
- Energy loss at forward rapidiites
- Charm through electron channel at forward rapidities
- Suppression effects of χ_c in HI collisions
- Nuclear modification factor (CGC effects) in dAu using π^0, η, direct γ
- Measure ΔG at low x

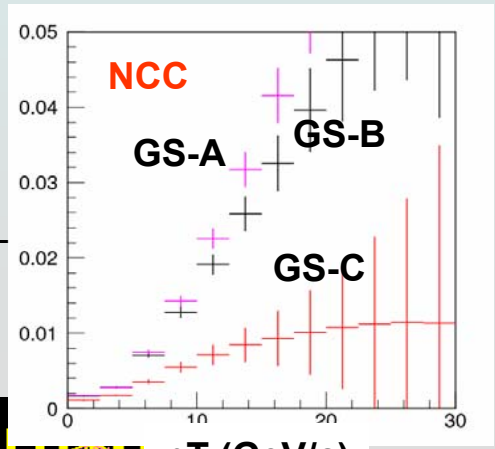
γ-jet measurements



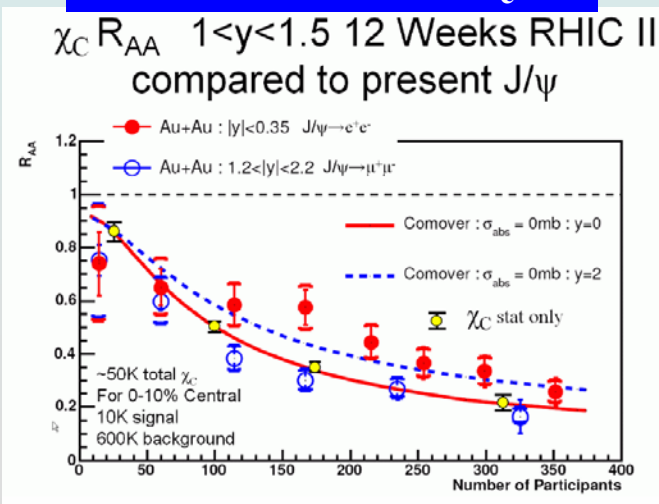
Energy loss at forward η

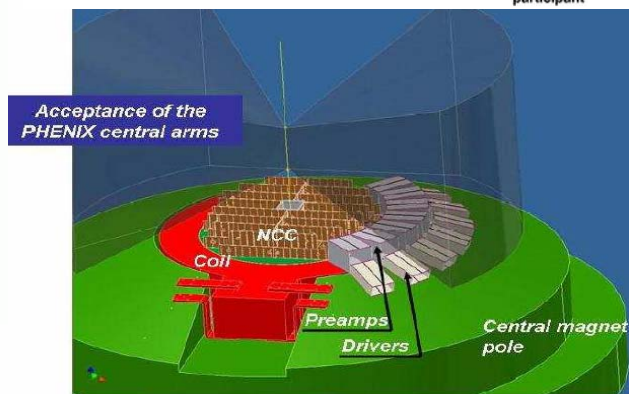


ΔG at low x



Measurement of the χ_c





PHENIX Nose Cone Calorimeter

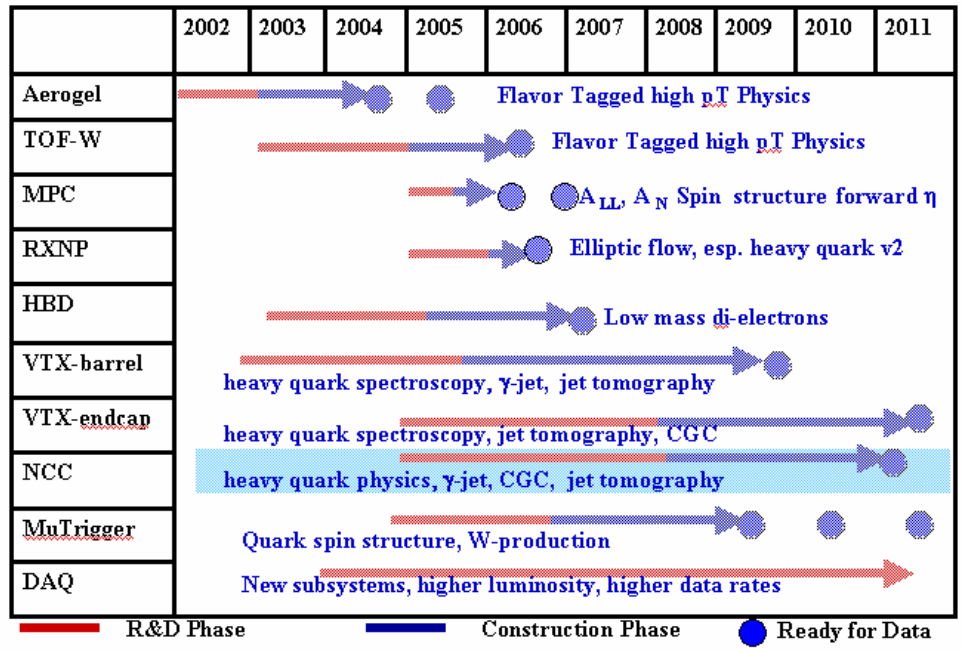
- The NCC extends our very successful program of using calorimetry to measure photons, jets and electrons into an important pseudo-rapidity region $1.0 < \eta < 3.0$ where we cover 2π in azimuth
- The DOE funded project costs $4.3M ($FY07) and involves physicists and engineers from 23 collaborating institutions in 6 countries.
- The DOE project covers the construction of one NCC. Non-US funds are actively being sought to fund the second NCC.

BNL, Charles Univ, Chonbuk Univ, Columbia Univ, Czech Tech Univ, Czech Inst of Phys, Ewha Womans Univ, Florida State, FNAL,Helsinki Inst of Physics, Iowa State Univ, JINR-Dubna, Jyvaskyla Univ, Korea Univ, Moscow State Univ, Myongji Univ, RIKEN, Stony Brook Univ, Tsukuba Univ, Univ Cal Riverside, Univ of Colorado, Univ of Illinois-UC, Yonsei Univ

•Approx. 1/3 of PHENIX institutions are involved in this project.
•Good balance between HI and Spin physicists
•Balance between personnel with expertise in hardware, software and physics analysis

PHENIX

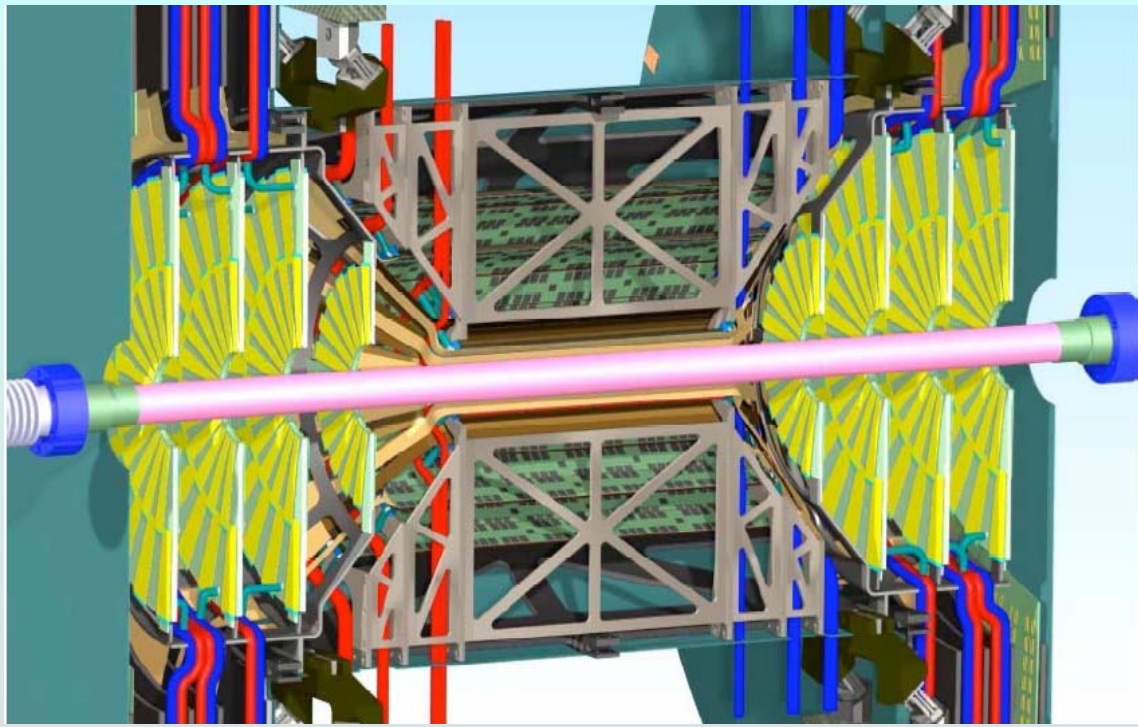
Upgrade Physics



Forward Silicon Vertex Detector - FVTX

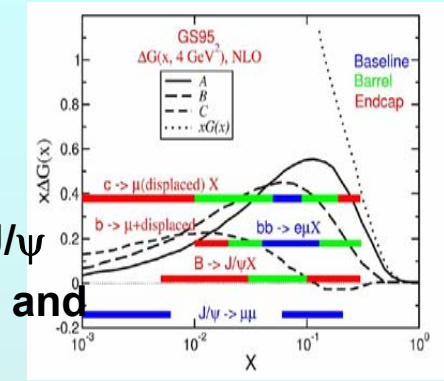
FVTX Specifications:

- 2 endcaps
- 4 pixelpad layers/endcap
- ~550k channels/endcap
- Electronics a mod of BTeV readout chip
- Fully integrated mech design w/ VTX
- 2π coverage in azimuth and $1.2 < |\eta| < 2.4$
- Better than 100 μm displaced vertex resolution



Forward Silicon Vertex Detector - FVTX

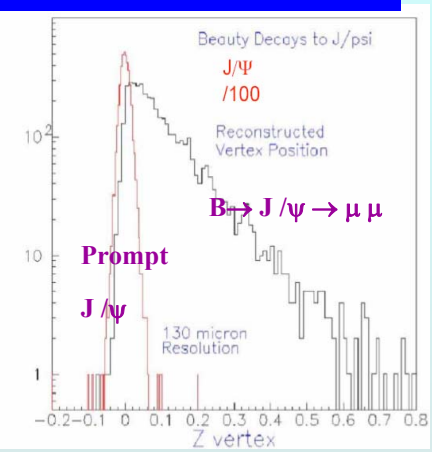
Enhanced x coverage



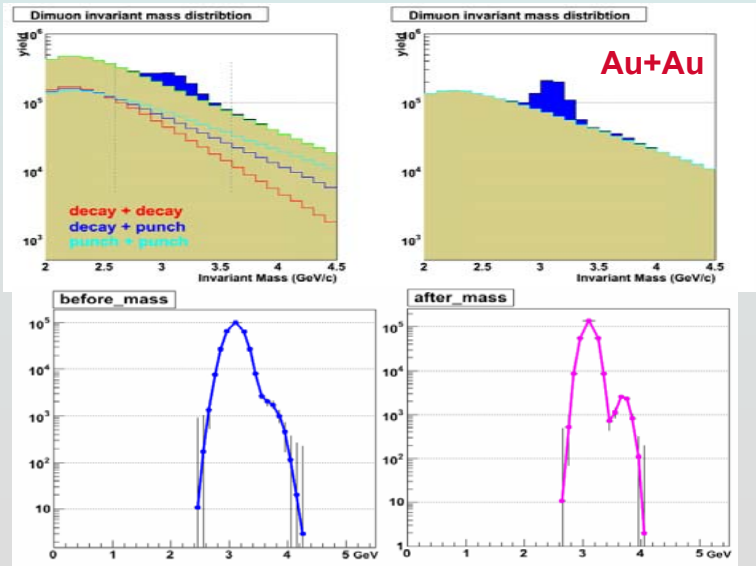
Physics Program of FVTX includes

- Resolving J/ψ and ψ' in Muon arms
- Resolving ϒ at y=0 using Muon arms
- Direct measure of B meson through displaced J/ψ
- Drell-Yan Measurements in dAu at both forward and midrapidities
- c, b ID for both HI physics & ΔG spin measurements
- Nuclear modification factor (CGC effects) in dAu using hadrons, c, b, and J/ψ

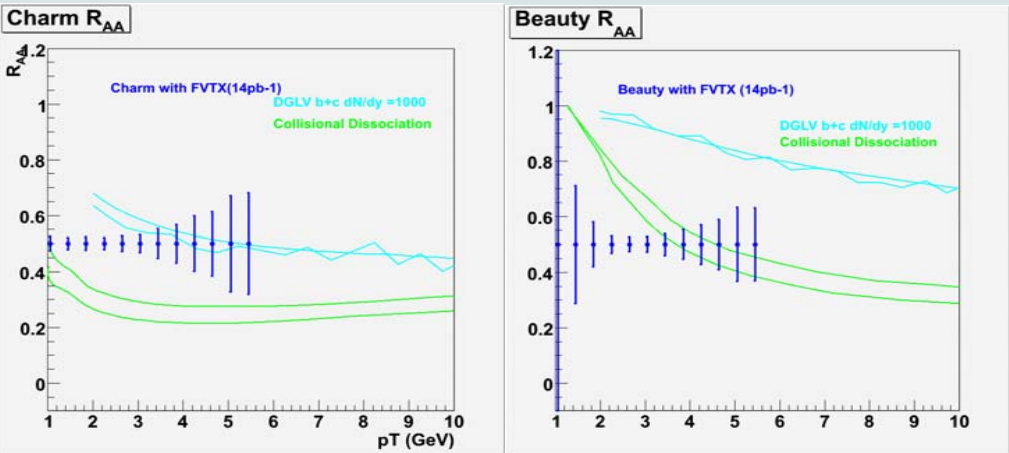
Direct measure of B



J/ψ, ψ' separation



c, b suppression at forward η

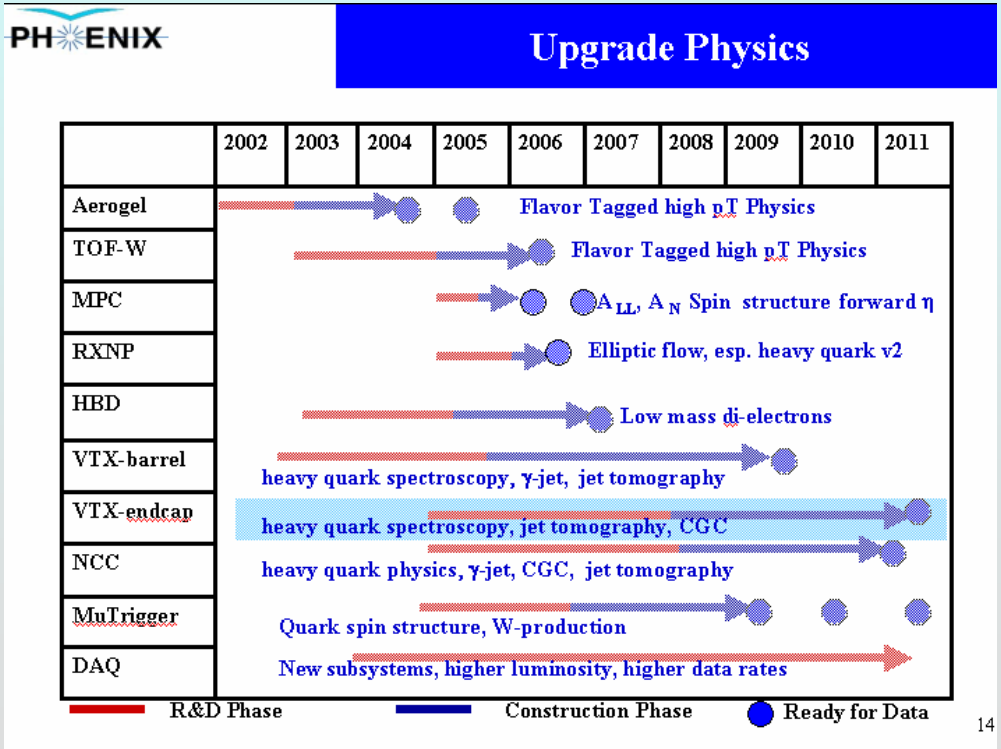


PHENIX Forward Silicon Vertex

- The two silicon endcaps of the FVTX project extends our ability to do physics studies using heavy quark probes into forward rapidities. It will enable the separation of c and b components in HI, spin and p-A physics processes as well as expand of our ability to do quarkonium spectroscopy.
- The DOE funded project costs $4.6M ($FY07) and involves physicists and engineers from 14 institutions in 6 countries

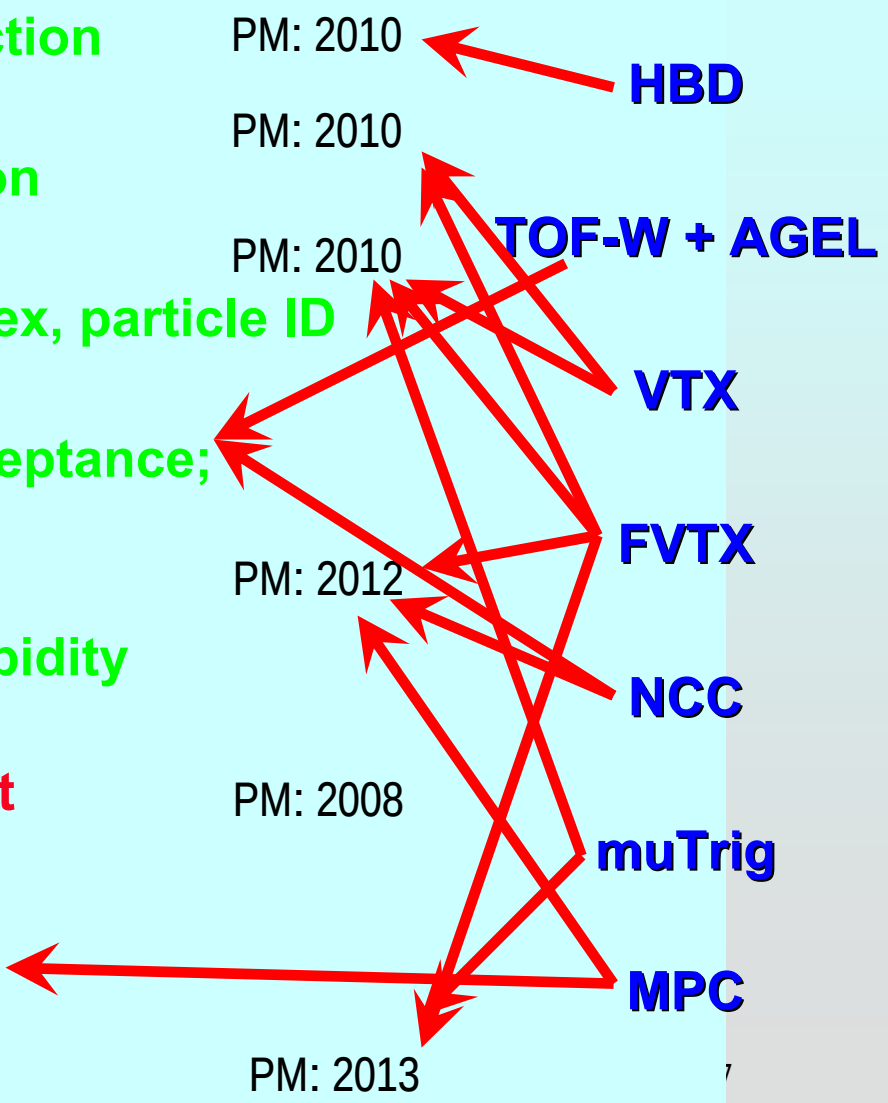
BNL, CEA- Saclay, Charles Univ, Columbia Univ, Czech Tech Univ, Czech Inst of Phys, Iowa State, Jyvaskyla Univ, KEK, Kyoto Univ, LANL, New Mexico State Univ, Univ of New Mexico, Yonsei Univ

- Approx. 20% of PHENIX institutions are involved in this project.
- Good balance between HI and Spin physicists
- Balance between personnel with expertise in hardware, software and physics analysis



NSAC Performance Measures

- **Heavy Ion:**
  - e-pair mass spectrum
    - "Hadron Blind" Dalitz pair rejection
  - Open charm measurements in AA
    - High Resolution vertex detection
  - Charmonium Spectroscopy
    - High luminosity; precision vertex, particle ID
  - Jet Tomography
    - High luminosity; increased acceptance; enhanced particle ID
  - Gluon shadowing; low-x in d-Au
    - particle detection at forward rapidity
- **Spin:**
  - Complete initial $\Delta G/G$ measurement
    - No upgrades needed
  - Transverse spin measurements
    - Forward particle measurement
  - W measurements at 500 GeV
    - Forward tracking/triggering



*DOE performance milestones set by NSAC

In simple quark model picture

QPM picture, eg.

$$A_L^{W^+} = \frac{\Delta u(x_1, M_W^2)}{u(x_1, M_W^2)}, \quad x_1 > x_2$$

Ws in polarized p-p:

high Q^2 → theoretically clean, ab initio

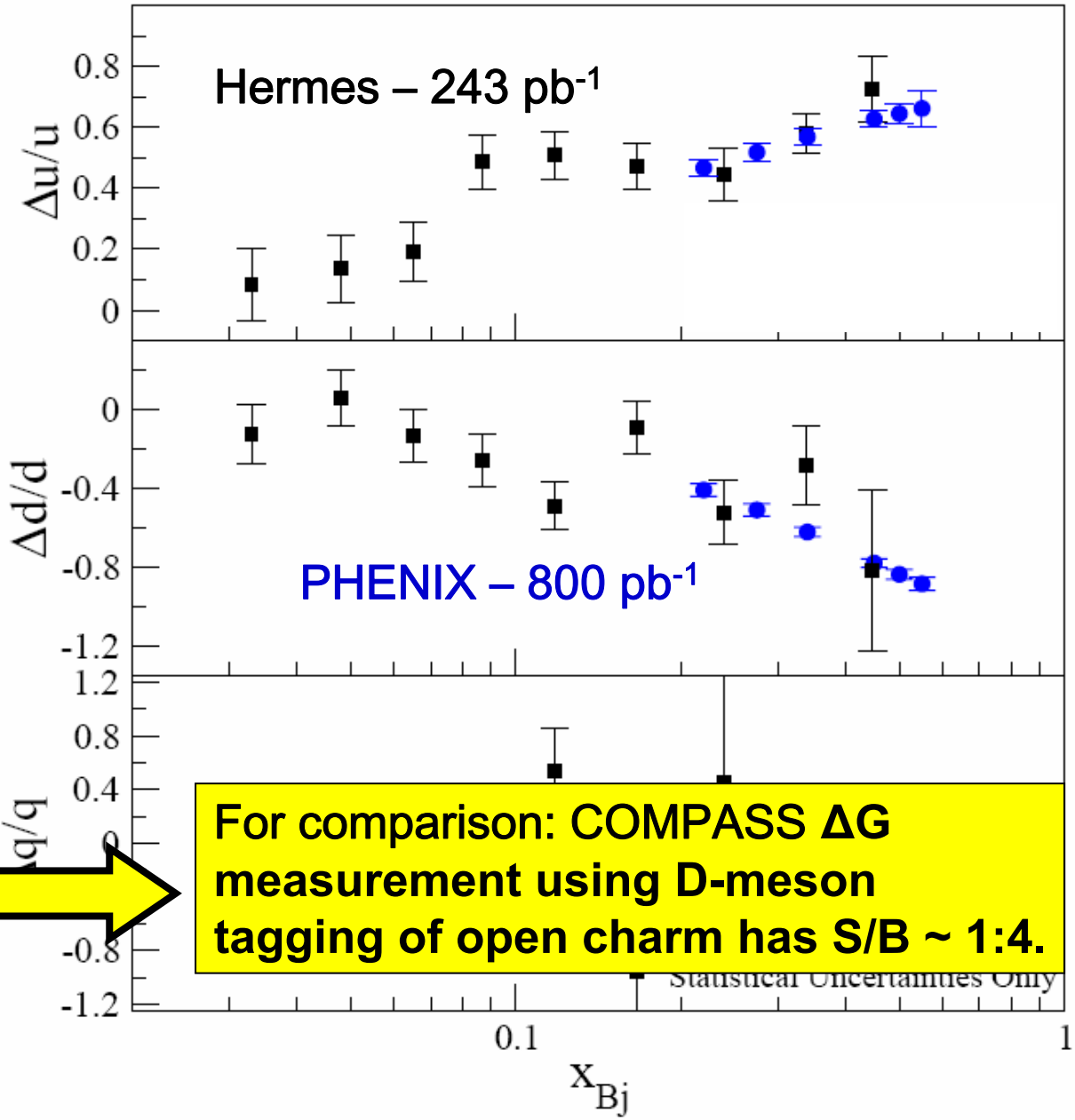
no FF-info needed

Background:

Absorber → S/B ~ 3:1

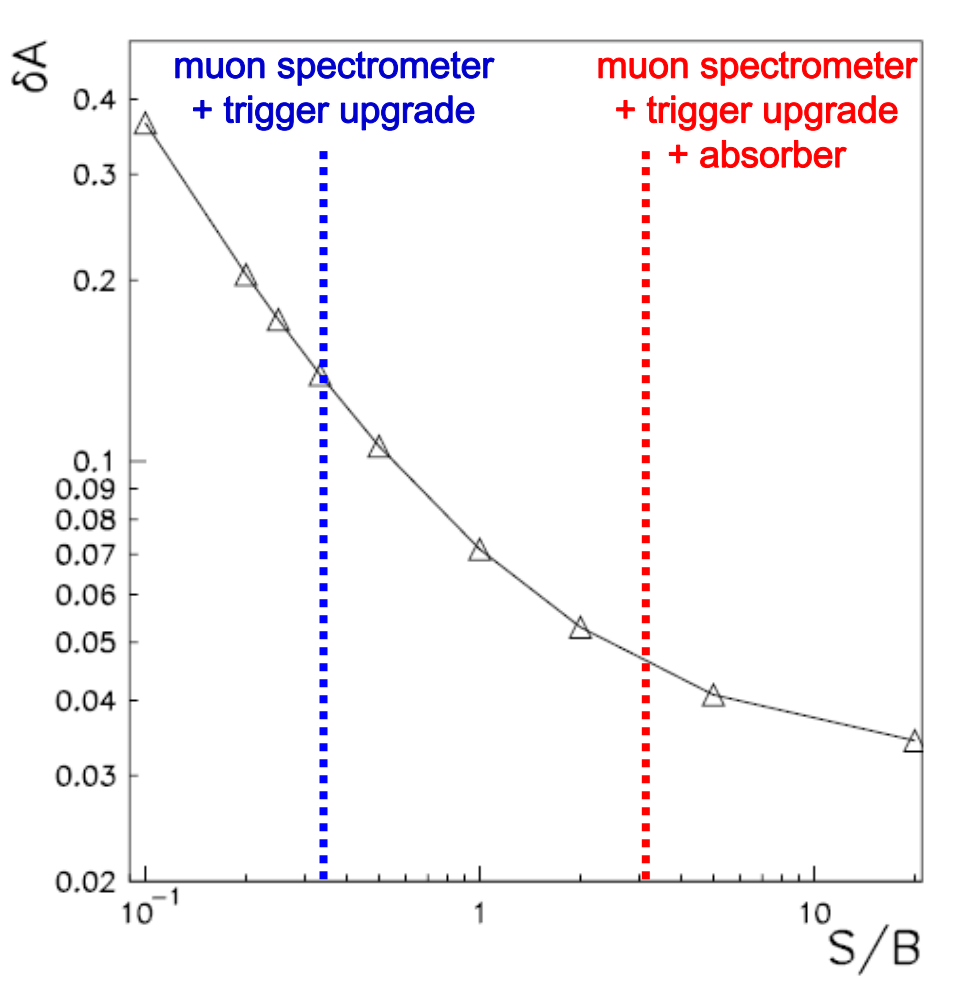
Isolation using FVTX/NCC additional rejection ~ x 5

Energy deposit NCC: x 50



For comparison: COMPASS **ΔG** measurement using D-meson tagging of open charm has S/B ~ 1:4.

W physics S/B


δA
0.4
0.3
0.2
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
muon spectrometer
+ trigger upgrade
muon spectrometer
+ trigger upgrade
+ absorber
10^{-1}
1
10
S/B