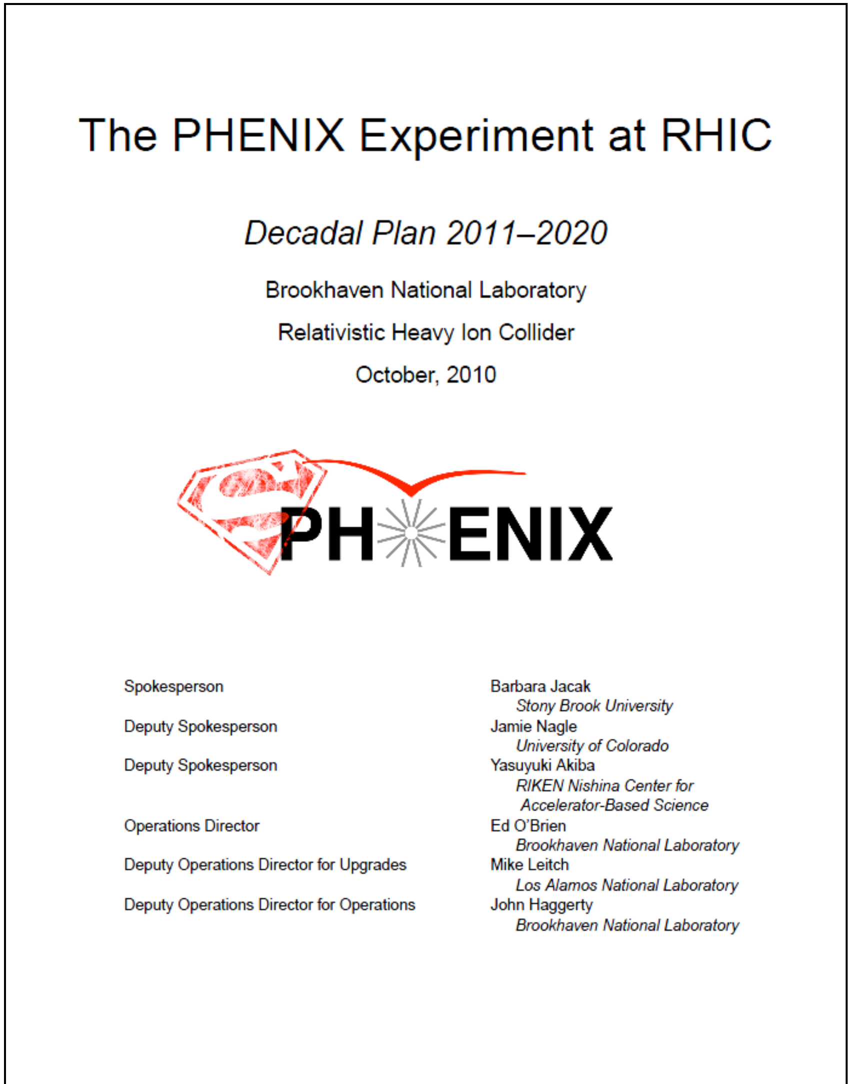
PHENIX Decadal Plan

Y. Akiba (RIKEN) for PHENIX Collaboration

NPP PAC

June 7, 2011

PHENIX Decadal Plan (Oct 2010)



The PHENIX Experiment at RHIC

Decadal Plan 2011–2020

Brookhaven National Laboratory

Relativistic Heavy Ion Collider

October, 2010

Spokesperson	Barbara Jacak *Stony Brook University*
Deputy Spokesperson	Jamie Nagle *University of Colorado*
Deputy Spokesperson	Yasuyuki Akiba *RIKEN Nishina Center for Accelerator-Based Science*
Operations Director	Ed O'Brien *Brookhaven National Laboratory*
Deputy Operations Director for Upgrades	Mike Leitch *Los Alamos National Laboratory*
Deputy Operations Director for Operations	John Haggerty *Brookhaven National Laboratory*

- Submitted on Sept 30, 2010
- Available at http://www.phenix.bnl.gov/phenix/WWW/docs/decadal/2010/phenix_decadal10_full_refs.pdf
- Two parts:

2010-2015 (mid term)

Physics with (F)VTX, μTrig

2015+ (longer term)

Larger Upgrade (sPHENIX)

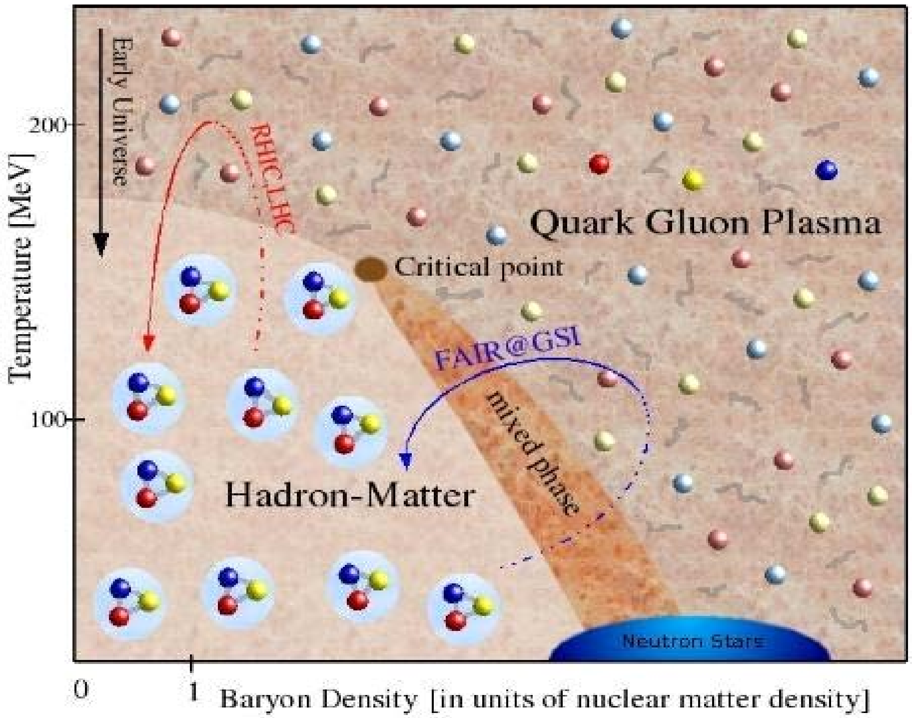
eRHIC connection (ePHENIX)

Outline

- Current Understanding
- Mid-term Plan (~2015+)
- Physics beyond 2015+
  - sPHENIX
  - ePHENIX and eRHIC

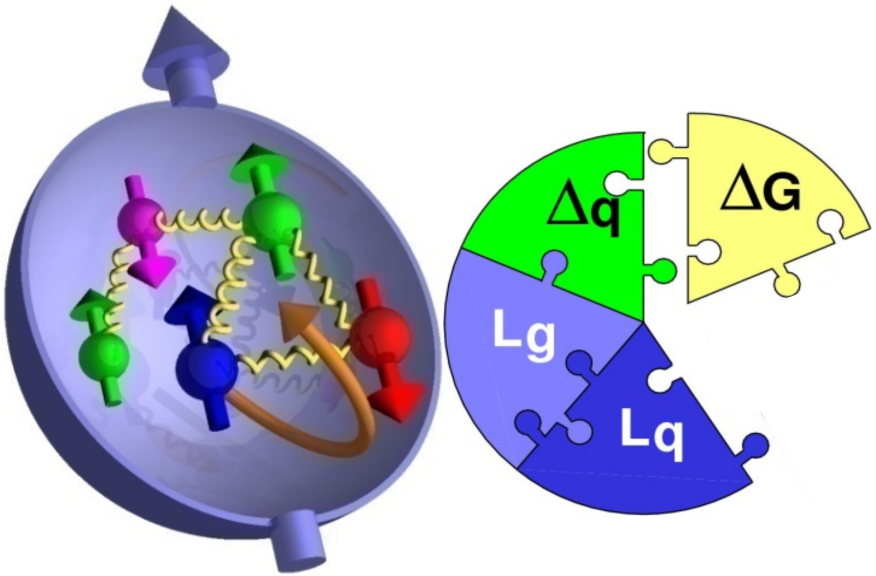
Study of QCD

Heavy Ion Physics



Phase structure of QCD matter
Properties of sQGP

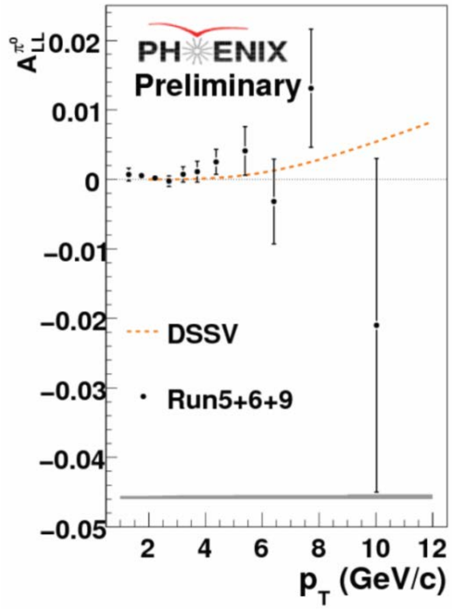
Spin Physics

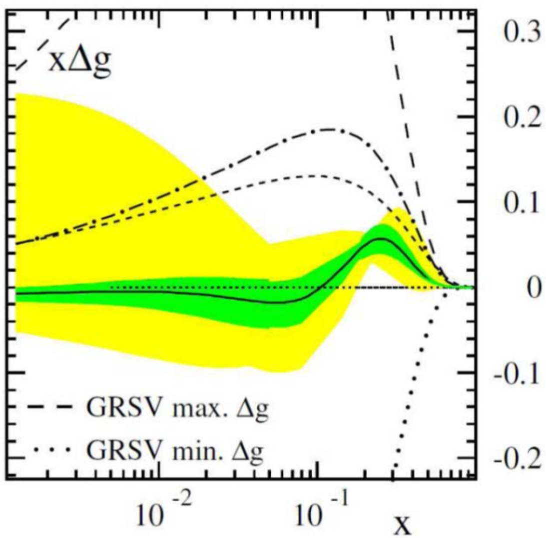


Proton and its spin contents

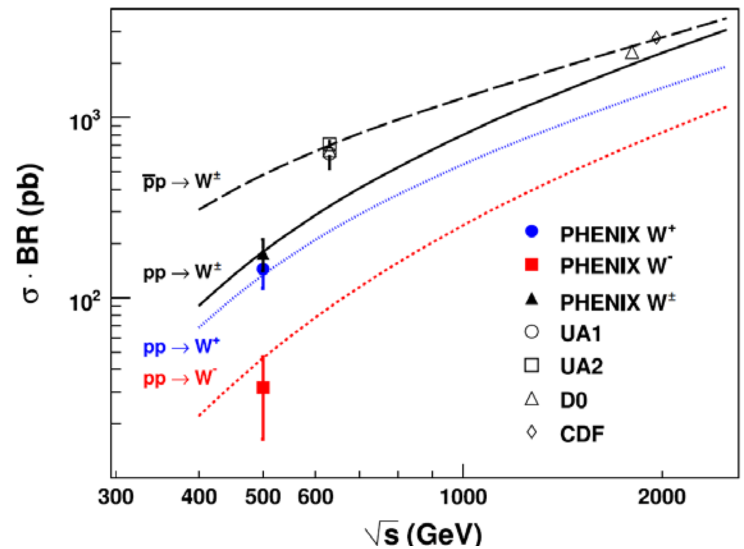
Current Understanding: Spin

Gluon contribution to the proton spin is not large

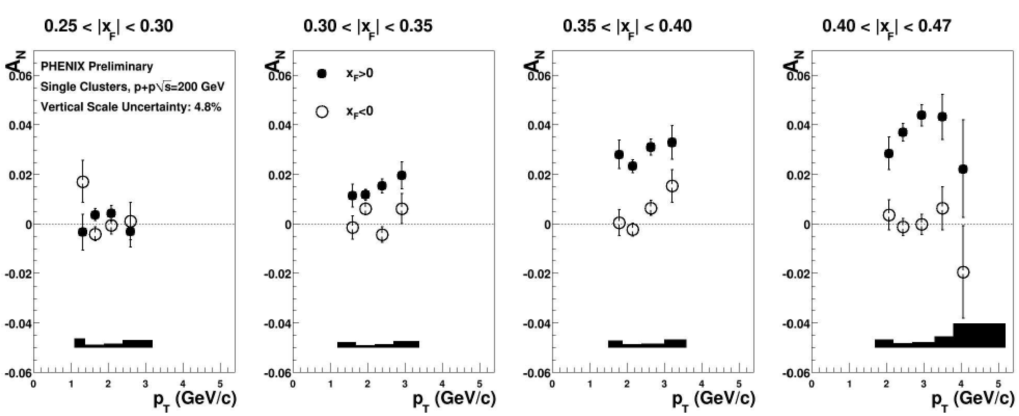


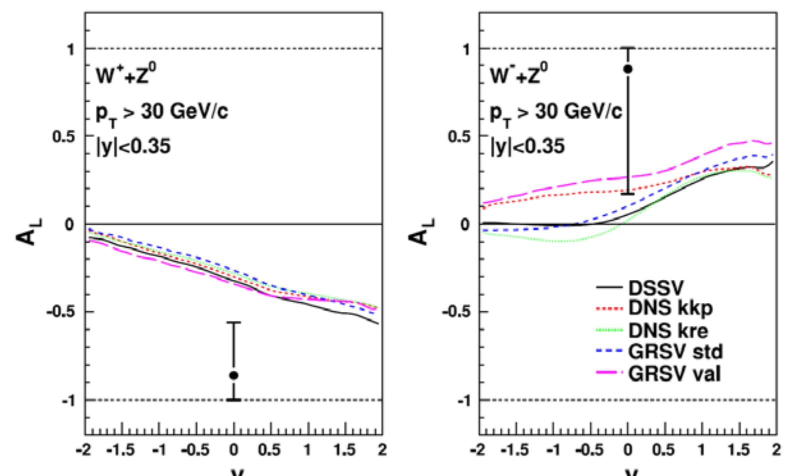


Measurement of anti-quark spin with the W boson started



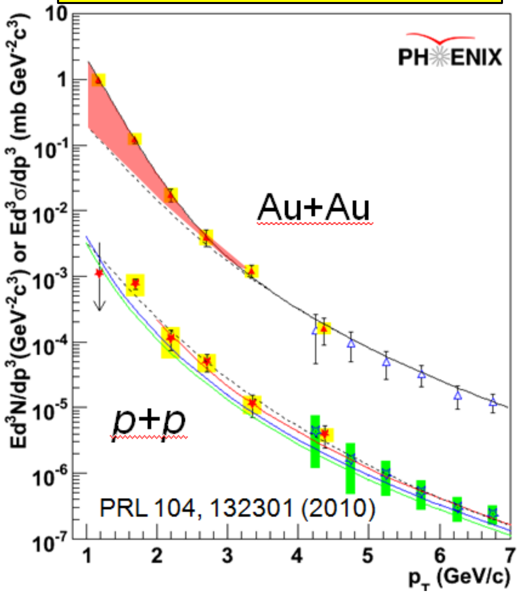
Transverse spin physics: A_N at large xF

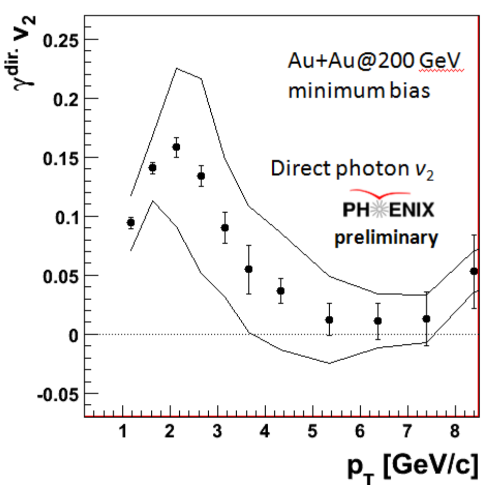




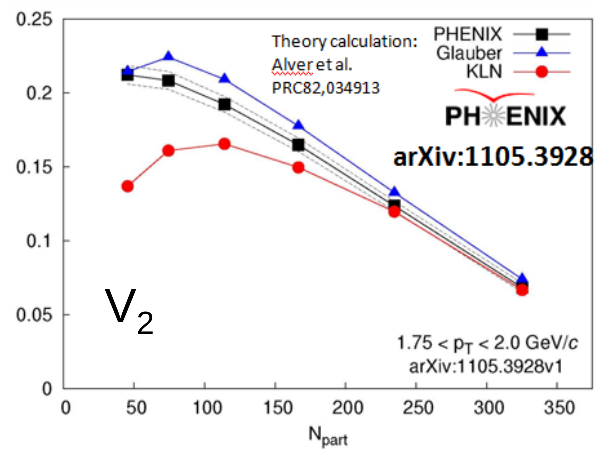
Current understanding: QGP

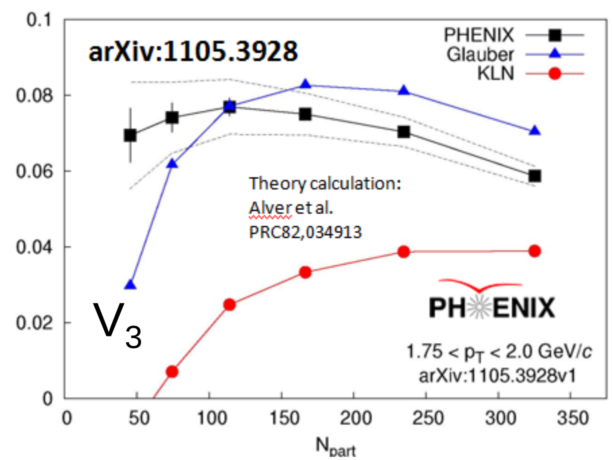
Thermal photons
T_i =300-600 MeV



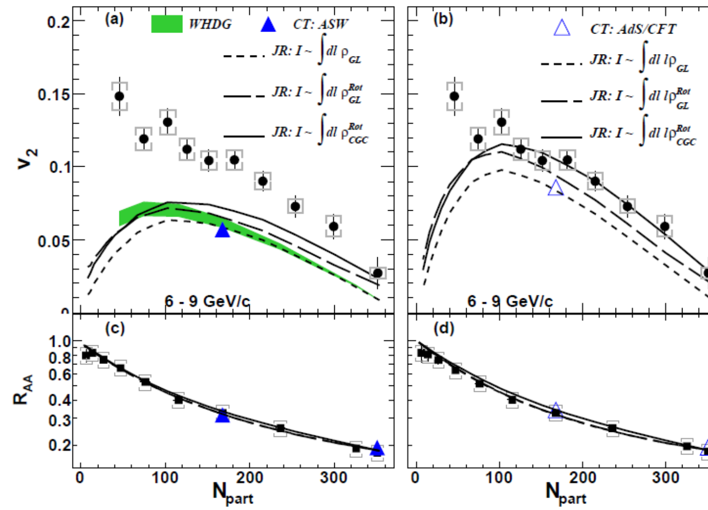


v_2 and v_3 (and v_n)
Glauber initial state
and $\eta/s\sim1/4\pi$ favored

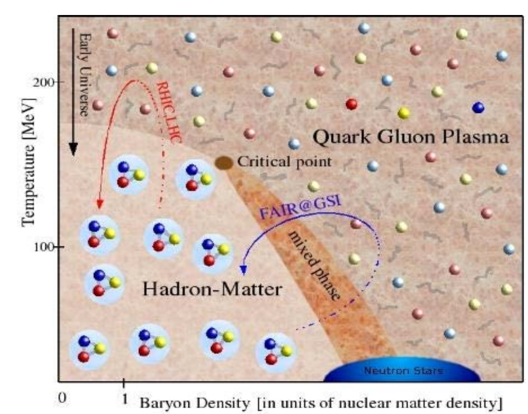




R_{AA} and v_2 at high p_T
ΔE ~ (path length)^3
favored

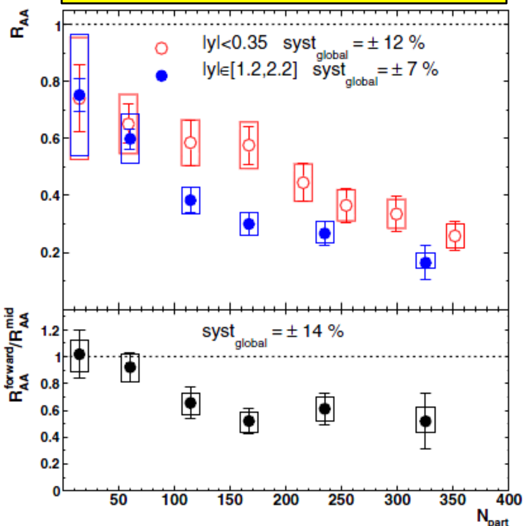


PRL105,142301

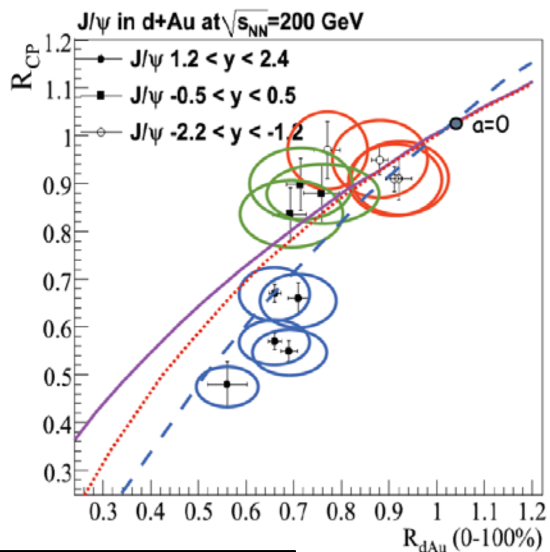


Current Understanding: QGP (2)

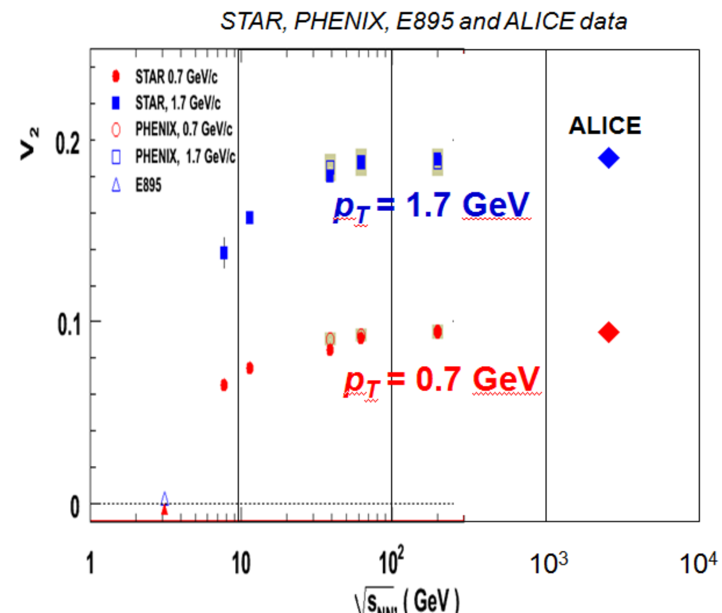
J/ψ suppression
Debye screening?
Puzzle remains



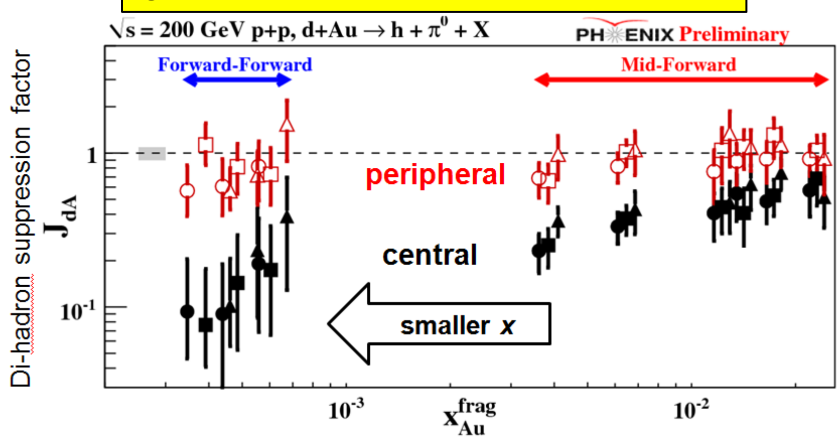
Detailed study of
CNM effect on J/ψ



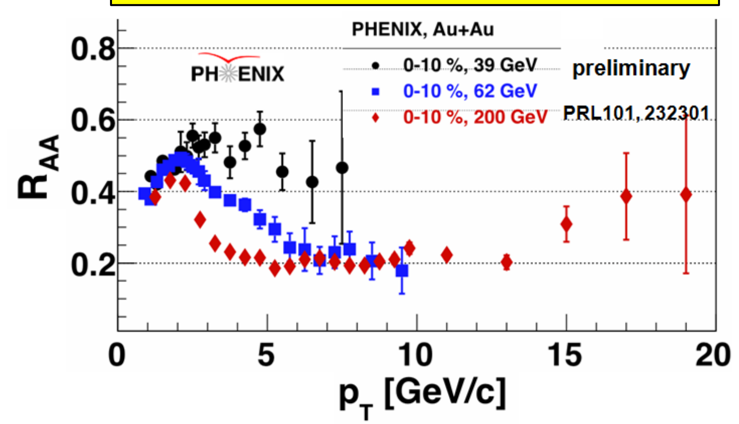
V_2 saturates for $s^{1/2}$ >39 GeV



Di-hadron suppression at small x
gluon saturation?



Stronger suppression with $s^{1/2}$



Measuring the Properties of the QGP

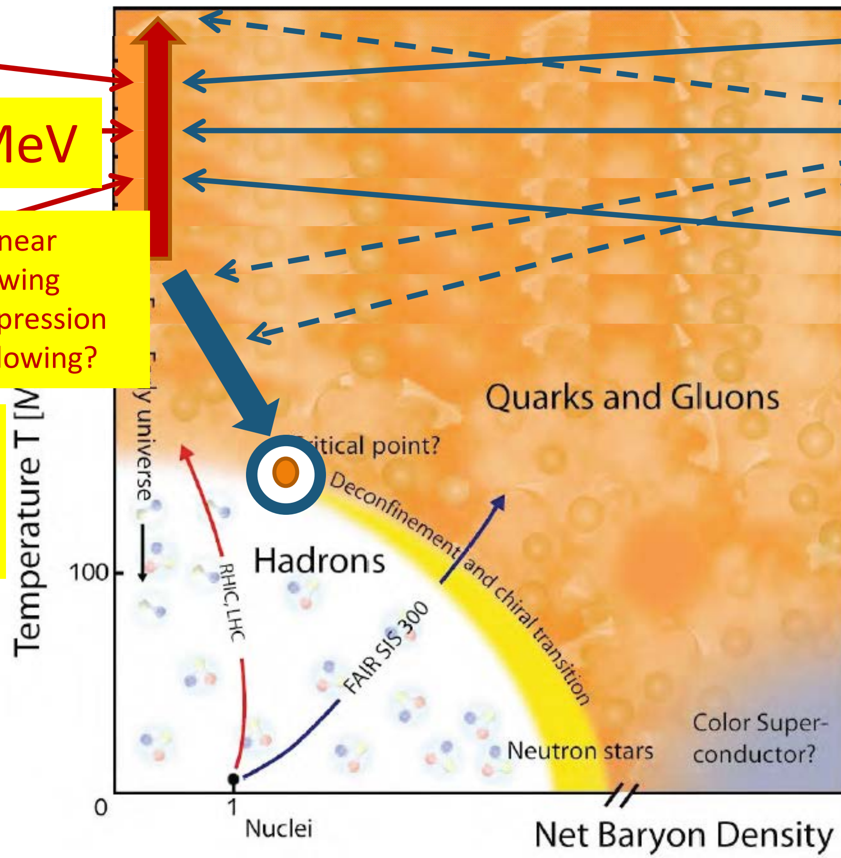
Conditions ⟹ Properties

$\mu \sim 0$

T_i =300-600 MeV

CNM effects
non-linear shadowing
low-*x* suppression
anti-shadowing?

Initial State
$\xrightarrow{?}$Glauber



Screening length

$\eta/s \xrightarrow{?} 1/4\pi$

$\Delta E \rightarrow l^3$

Question:
How can we measure QGP properties at RHIC better in the next decade

Stefan Bathe for PHENIX, QM2011

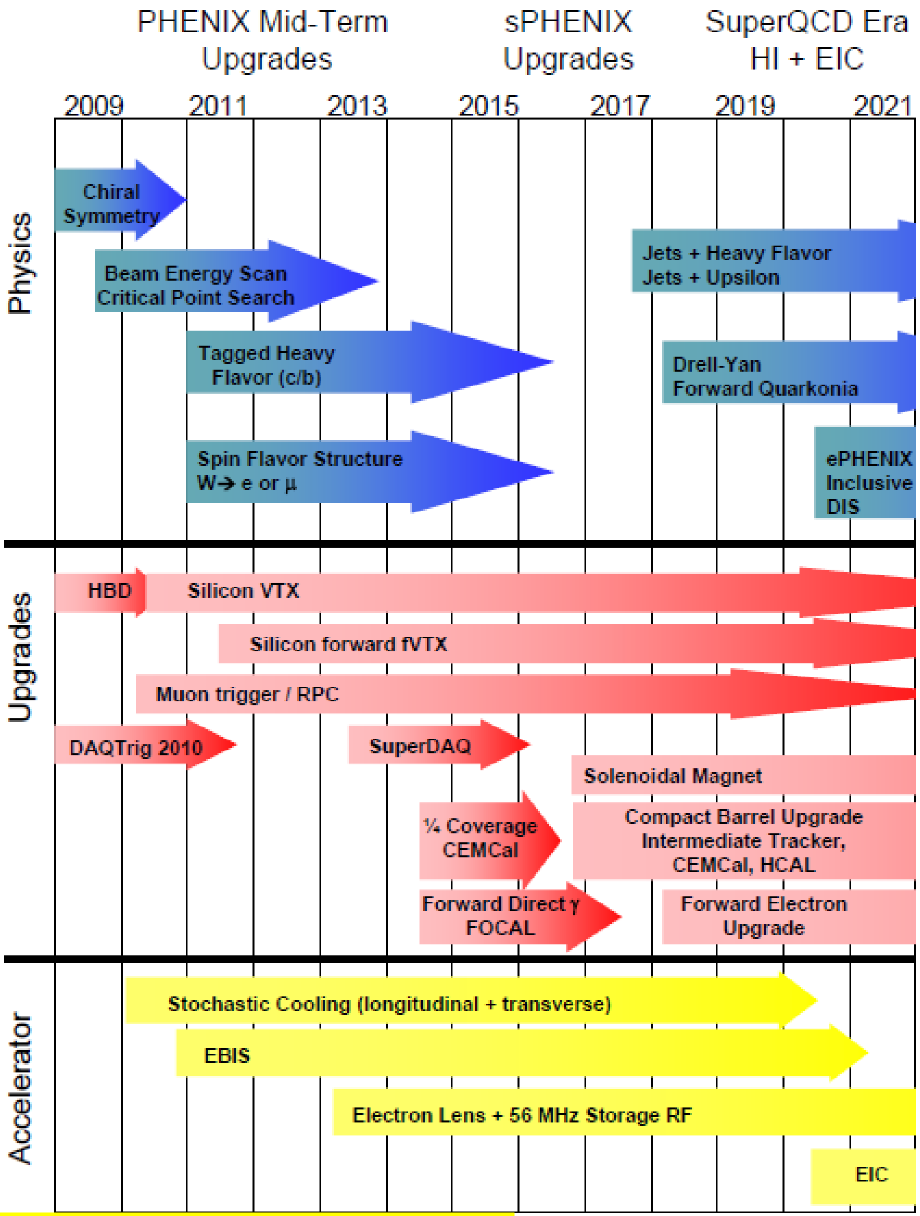
Stefan Bathe's PHENIX highlight talk at QM2011

Mysteries in heavy ion physics

- **Energy loss mechanism**
  - @ LHC 40 GeV jets opposing 100 GeV jets look "normal"
    - no broadening or decorrelation
    - no evidence for collinear radiation from the parton
  - @ RHIC low energy jets appear to show medium effects
    - but, "jet" is defined differently *First answer in next 5 years*
  - → c&b to probe role of collisional energy loss ***VTX, FVTX***
  - → quantify path length dependence ***U+U, Cu+Au***
- **J/ψ suppression and color screening**
  - amazingly similar from $\sqrt{s}$=17-200 GeV; but initial states differ
  - not SO different at LHC
  - → Other states y& $\sqrt{s}$ dependence (e.g. ψ')***FVTX, statistics***
  - → d+Au for initial state; 130 GeVAu+Au eventually?

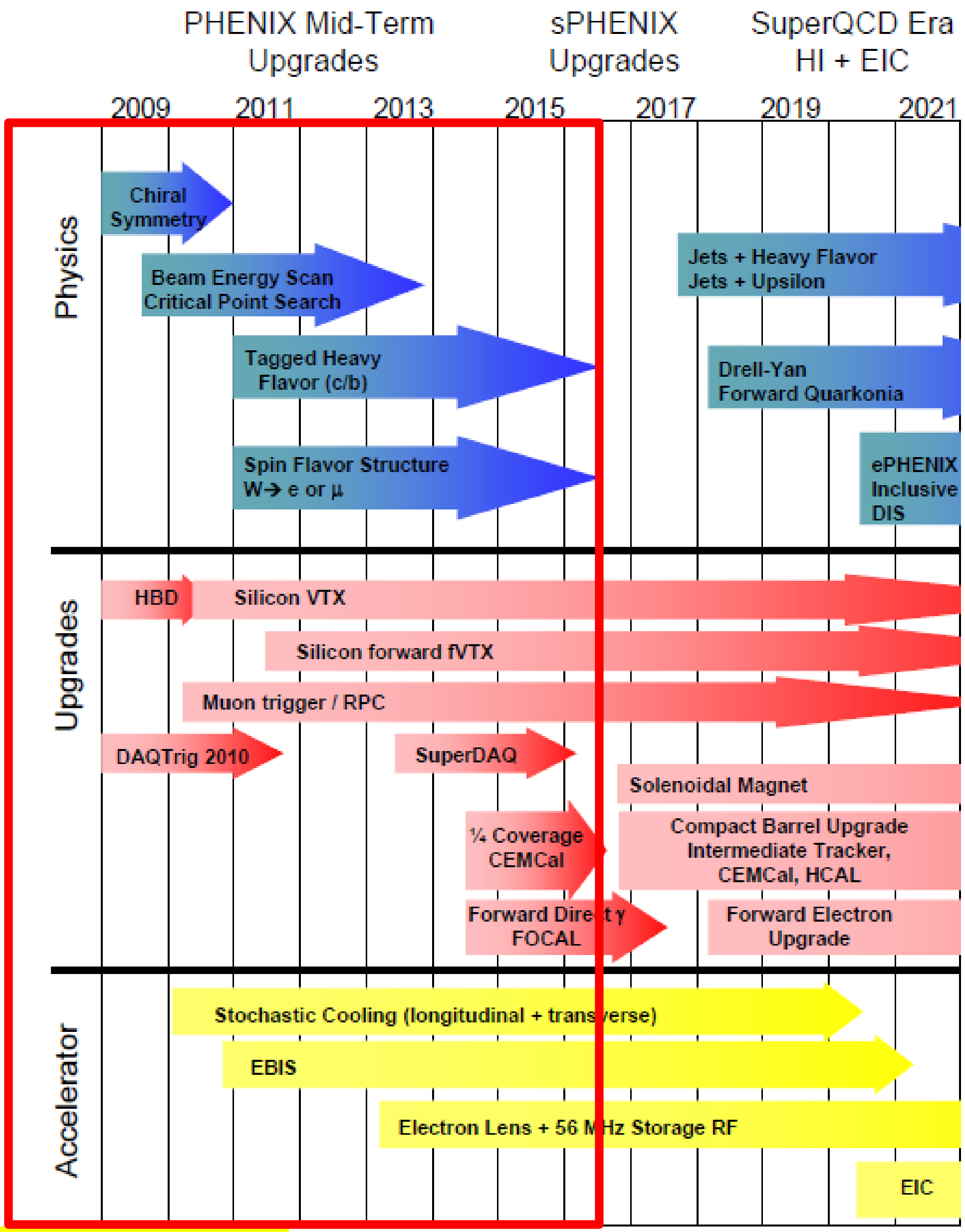
Those compelling questions require new upgrade

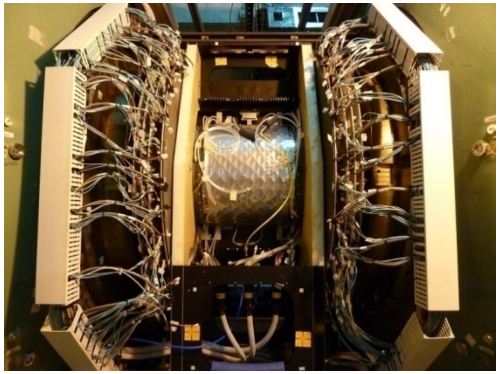
RHIC/PHENIX Upgrade and Physics



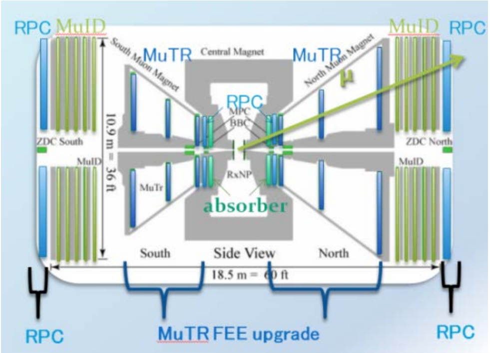
PHENIX Decadal Plan

Mid-term plan (to ~2015+)

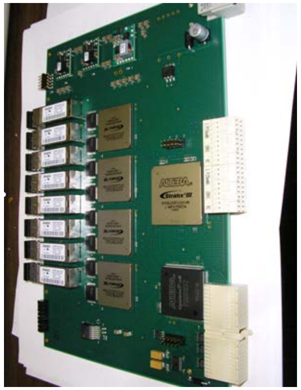




VTX
FVTX



μTrig



DAQ2010
5kHz→9kHz

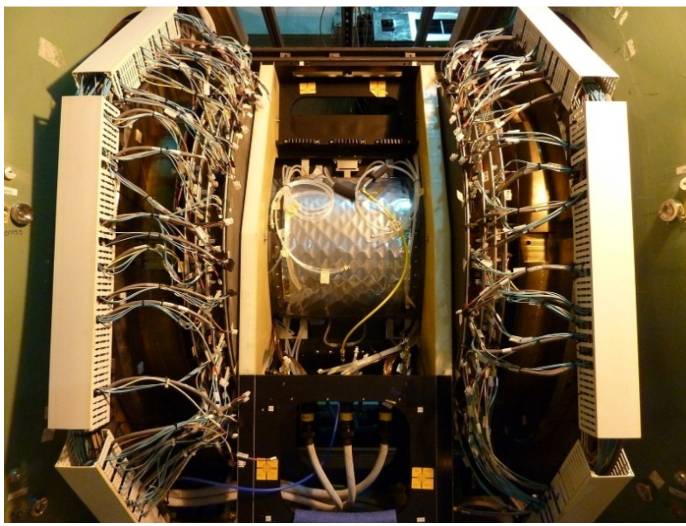
PHENIX Decadal Plan

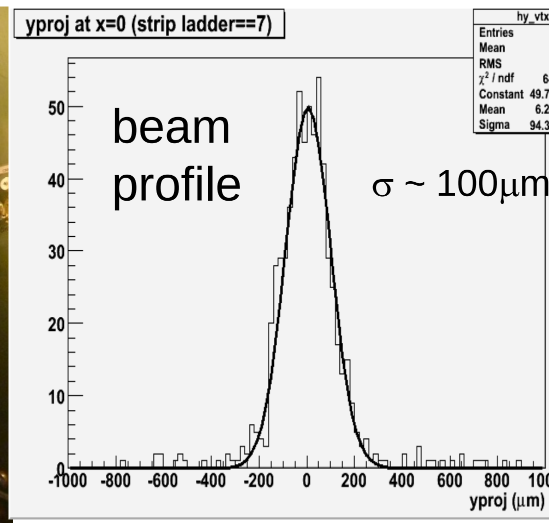
VTX is completed!

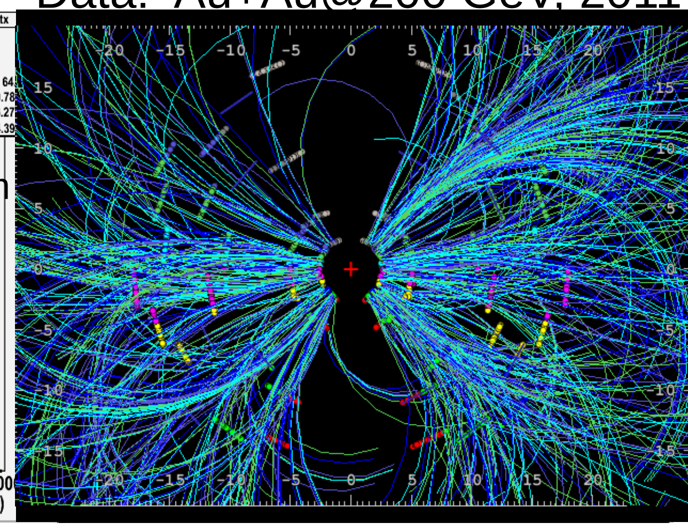
- Installation in PHENIX completed on Dec 1, 2010
- Commissioned during 500 GeV p+p run (complete)
- Taking 200 GeV Au+Au data now.
  Already recorded ~2 billion events of Au+Au data
  Will record a few times more by the end of RUN11.

status

Data: Au+Au@200 GeV, 2011



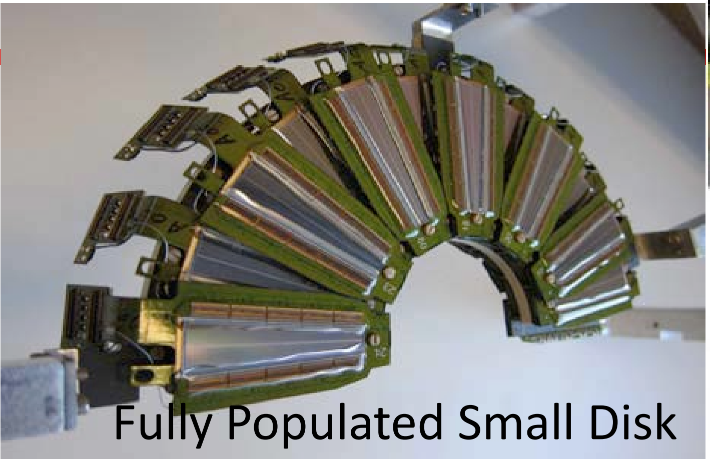




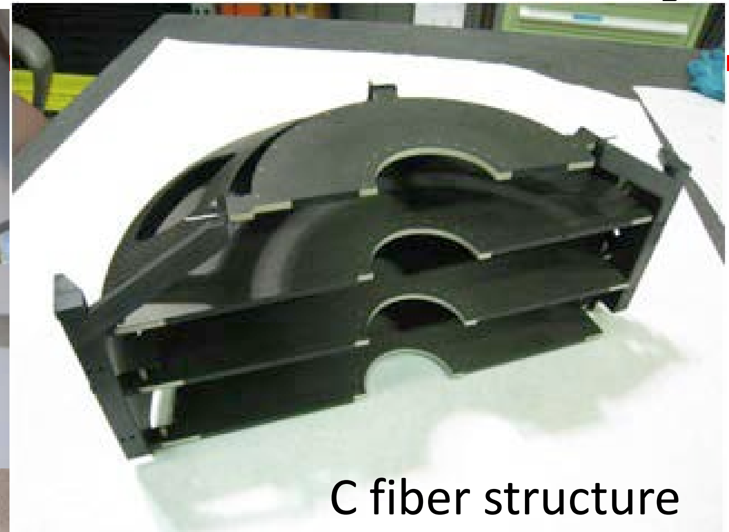
physics

- *R_{AA} of c, b quarks separately*
- *v_2 of c, b quarks separately*
- *Jet tomography (di-hadron, g-h, c-h, c-c)*

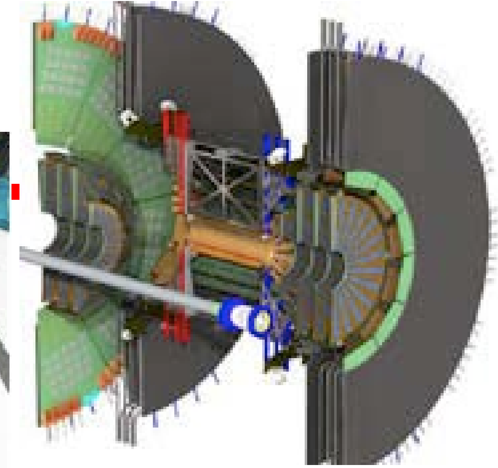
FVTX construction underway



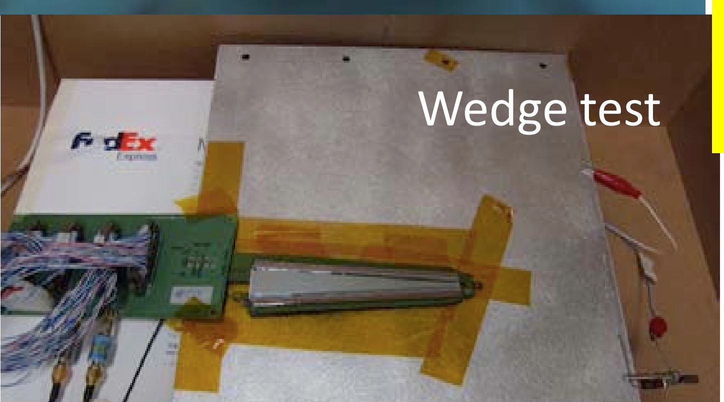
Fully Populated Small Disk



C fiber structure

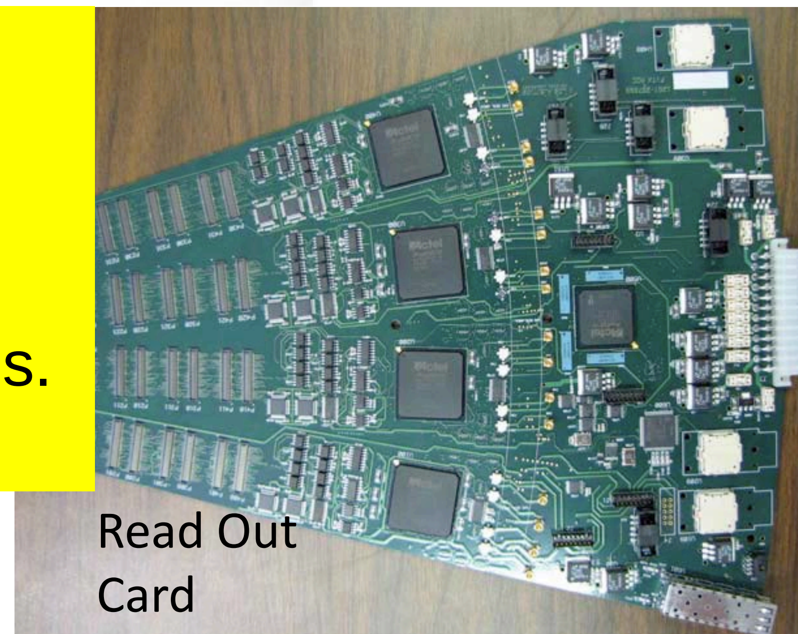


Fully Populated Large Disk



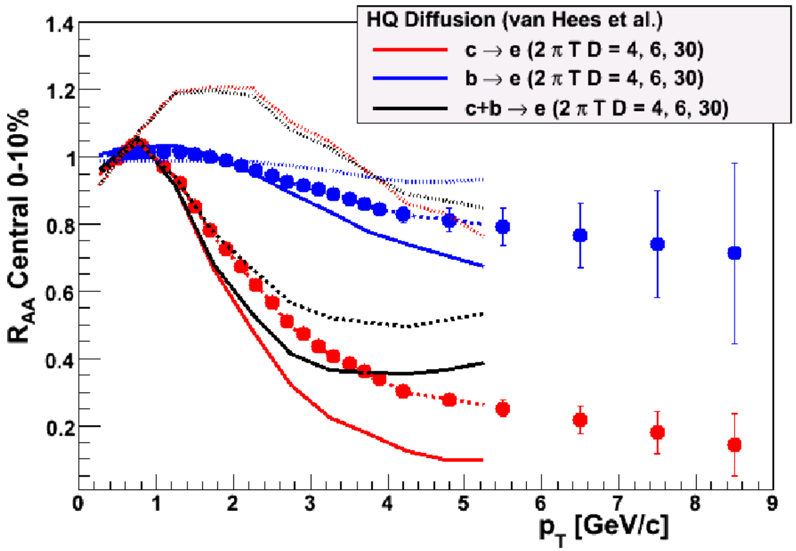
Wedge test

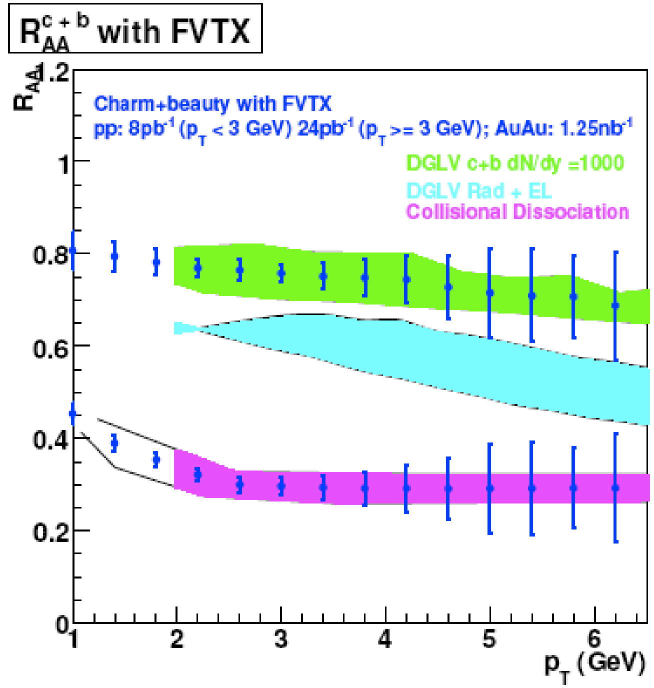
➔Forward rapidity open heavy flavor physics & Y(2S) suppres. AuAu&dAu

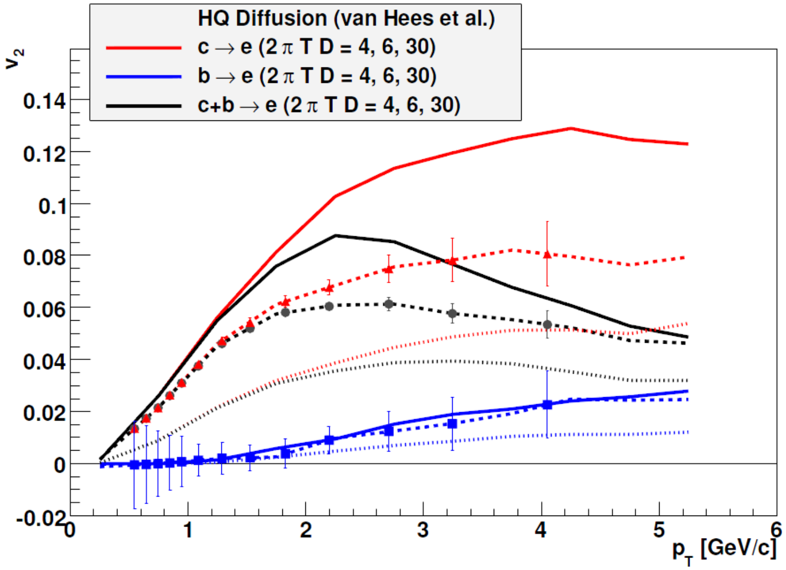


Read Out Card

Heavy quark R_{AA} and v_2 with VTX & FVTX



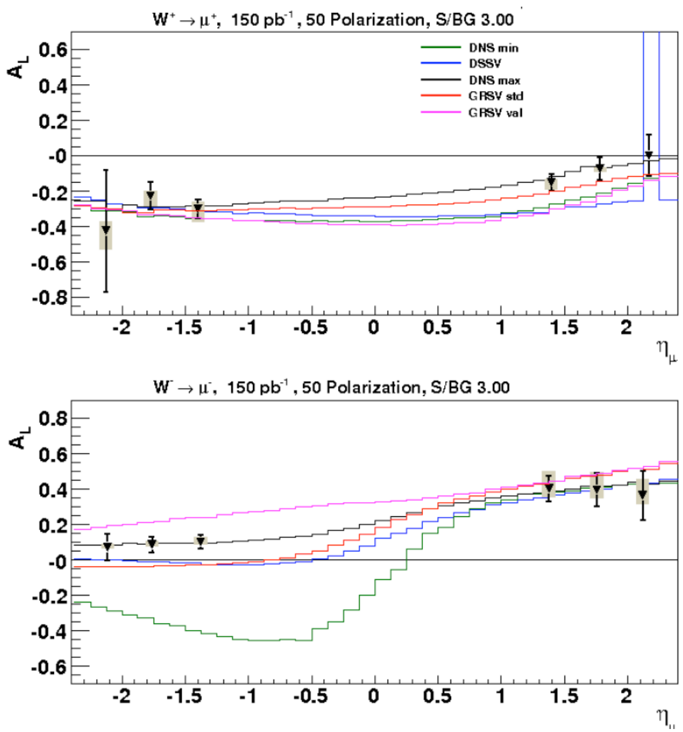


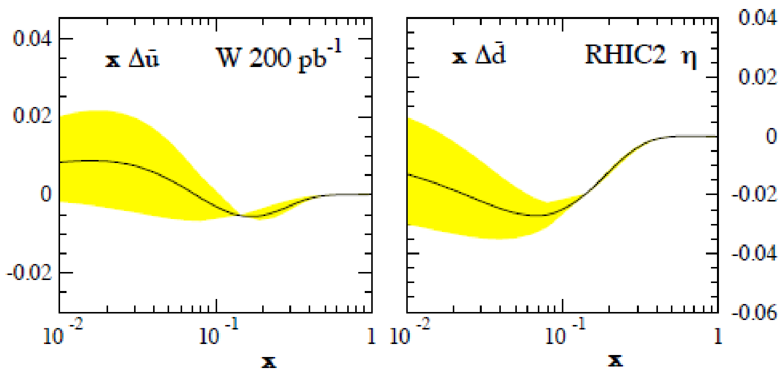


- Probe sQGP at RHIC with heavy quark
- High statistics and wide kinematic coverage
- Competitive with LHC

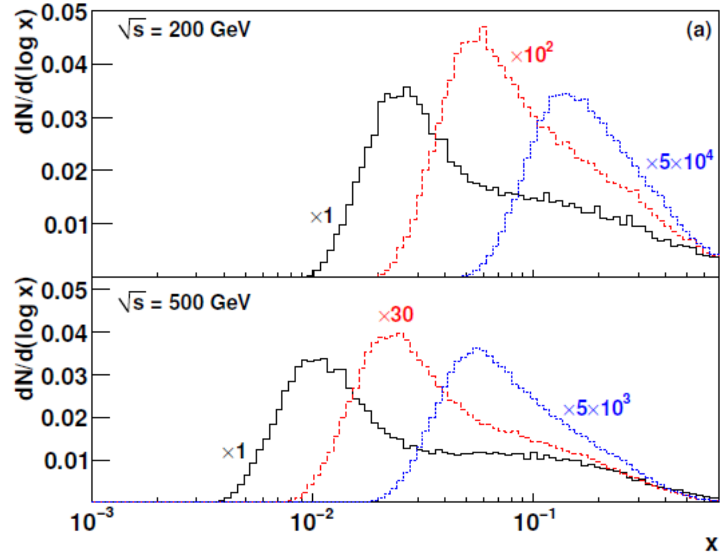
Spin Physics in Mid-term

$\Delta\bar{q}$ through the A_L of the W

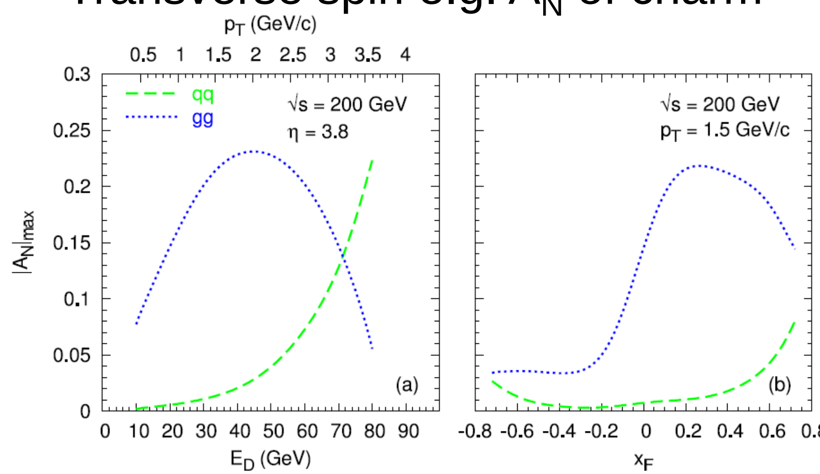




ΔG(x) at small x



Transverse spin e.g. A_N of charm



PHENIX RUN PLAN (2011-2015)

Table B.1: PHENIX run plan for the years 2010–2015. by (L), transverse by (T).

PHENIX Decadal Plan

run	Species	$\sqrt{s_{NN}}$	Wks	$\int L\,dt$ $\lvert z\rvert < 30$ cm	$\lvert z\rvert < 10$ cm	Pol.	Comments
11	$p+p$	500	10	50 pb^{-1}	20 pb^{-1}	50% (L)	W program + ΔG
	Au+Au	200	8		0.7 nb^{-1}		heavy flavor (VTX)
	Au+Au	18	1.5	5.5 μb^{-1}			energy scan
	U+U	192	1.5		0.03 nb^{-1}		explore geometry
12	$p+p$	500	8	100 pb^{-1}	35 pb^{-1}	50% (L)	W program + ΔG
	$p+p$	200	5	13.1 pb^{-1}	4.7 pb^{-1}	60% (T)	HI comparison
	Au+Au	200	7		0.8 nb^{-1}		heavy flavor (F/VTX)
	Au+Au	27	1	5.2 μb^{-1}			energy scan
13	$p+p$	500	10	200 pb^{-1}	74 pb^{-1}	60% (L)	W program
	U+U	200	5		0.57 nb^{-1}		geometry
	Cu+Au	200	5		2.4 nb^{-1}		
14	$p+p$	200	10	34 pb^{-1}	12 pb^{-1}	65% (T)	HI comp., transv.
	$p+p$	62	3	0.6 pb^{-1}	0.2 pb^{-1}	60% (T/L)	
	d+Au	200	8	260 nb^{-1}	150 nb^{-1}		CNM/FOCAL
	d+Au	62	2	6.5 nb^{-1}	3.8 nb^{-1}		
15	Au+Au	200	10		2.8 nb^{-1}		High Bandwidth
	Au+Au	62	4		0.13 nb^{-1}		HF vs $\sqrt{s_{NN}}$
	$p+{}^3$He	132	5			(T)	Test Run

Longitudinal spin@ 500 GeV
- W program
  350/pb for W→μ
  130/pb for W→e
- ΔG at small x

Transverse spin@200 GeV
  50/pb for muon arms
  17/pb with VTX
- A_N of various processes
- Exploratory of Drell Yan
  A_N : Sivers sign change

Spin @ 62 GeV
- ΔG at high x
- Transverse spin

PHENIX RUN PLAN (2011-2015)

Table B.1: PHENIX run plan for the years 2010–2015. Longitudinal polarization is indicated by (L), transverse by (T).

run	Species	$\sqrt{s_{NN}}$	Wks	$\int L\,dt$ $\lvert z\rvert < 30$ cm	$\lvert z\rvert < 10$ cm	Pol.	Comments
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12	$p+p$	500	8	100 pb^{-1}	35 pb^{-1}	50% (L)	W program + ΔG
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13	$p+p$	500	10	200 pb^{-1}	74 pb^{-1}	60% (L)	W program
	U+U	200	5		0.57 nb^{-1}		} geometry
	Cu+Au	200	5		2.4 nb^{-1}		
14	$p+p$	200	10	34 pb^{-1}	12 pb^{-1}	65% (T)	} HI comp., transv.
	$p+p$	62	3	0.6 pb^{-1}	0.2 pb^{-1}	60% (T/L)	
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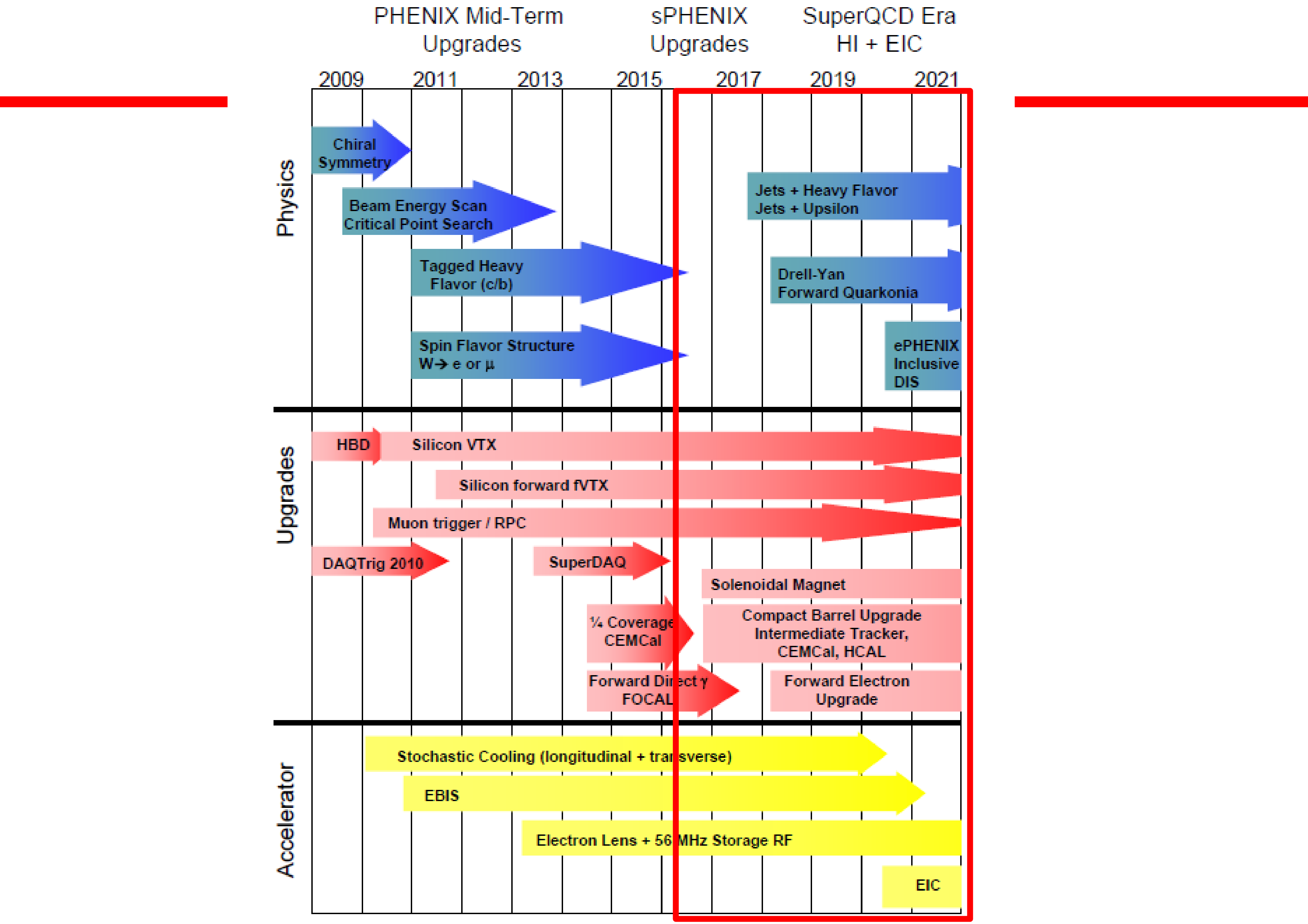
	Au+Au	62	4		0.13 nb^{-1}		HF vs $\sqrt{s_{NN}}$
	$p+{}^3$He	132	5			(T)	Test Run

Heavy quark physics with VTX is the main thrust of PHENIX Heavy Ion physics plan in 2011 - 2015
- Heavy quark energy loss
- Heavy quark flow

CNM on Heavy Quark

Plus

Spin Physics with VTX in p+p collisions
- Charm A_N, A_{LL}
- Bottom A_N A_{LL}
- photon jet A_N, A_{LL}
- di-jet A_N, A_{LL}


PHENIX Mid-Term Upgrades
sPHENIX Upgrades
SuperQCD Era HI + EIC
2009
2011
2013
2015
2017
2019
2021
Physics
Chiral Symmetry
Beam Energy Scan Critical Point Search
Tagged Heavy Flavor (c/b)
Spin Flavor Structure W→ e or μ
Jets + Heavy Flavor Jets + Upsilon
Drell-Yan Forward Quarkonia
ePHENIX Inclusive DIS
Upgrades
HBD
Silicon VTX
Silicon forward fVTX
Muon trigger / RPC
DAQTrig 2010
SuperDAQ
Solenoidal Magnet
¼ Coverage CEMCal
Compact Barrel Upgrade Intermediate Tracker, CEMCal, HCAL
Forward Direct γ FOCAL
Forward Electron Upgrade
Accelerator
Stochastic Cooling (longitudinal + transverse)
EBIS
Electron Lens + 56 MHz Storage RF
EIC

NEW questions due to RHIC discoveries

- Compelling goals for 2015+ - 2020
- Address with ion collisions

  Are quarks strongly coupled to the QGP at all scales?
  Are there quasiparticles at any scale?
  Mechanisms for parton-QGP interaction?
  and QGP response?
  Is there a relevant screening length in the QGP?
  How is rapid equilibration achieved?
  What is the structure of cold nuclei at small-x?

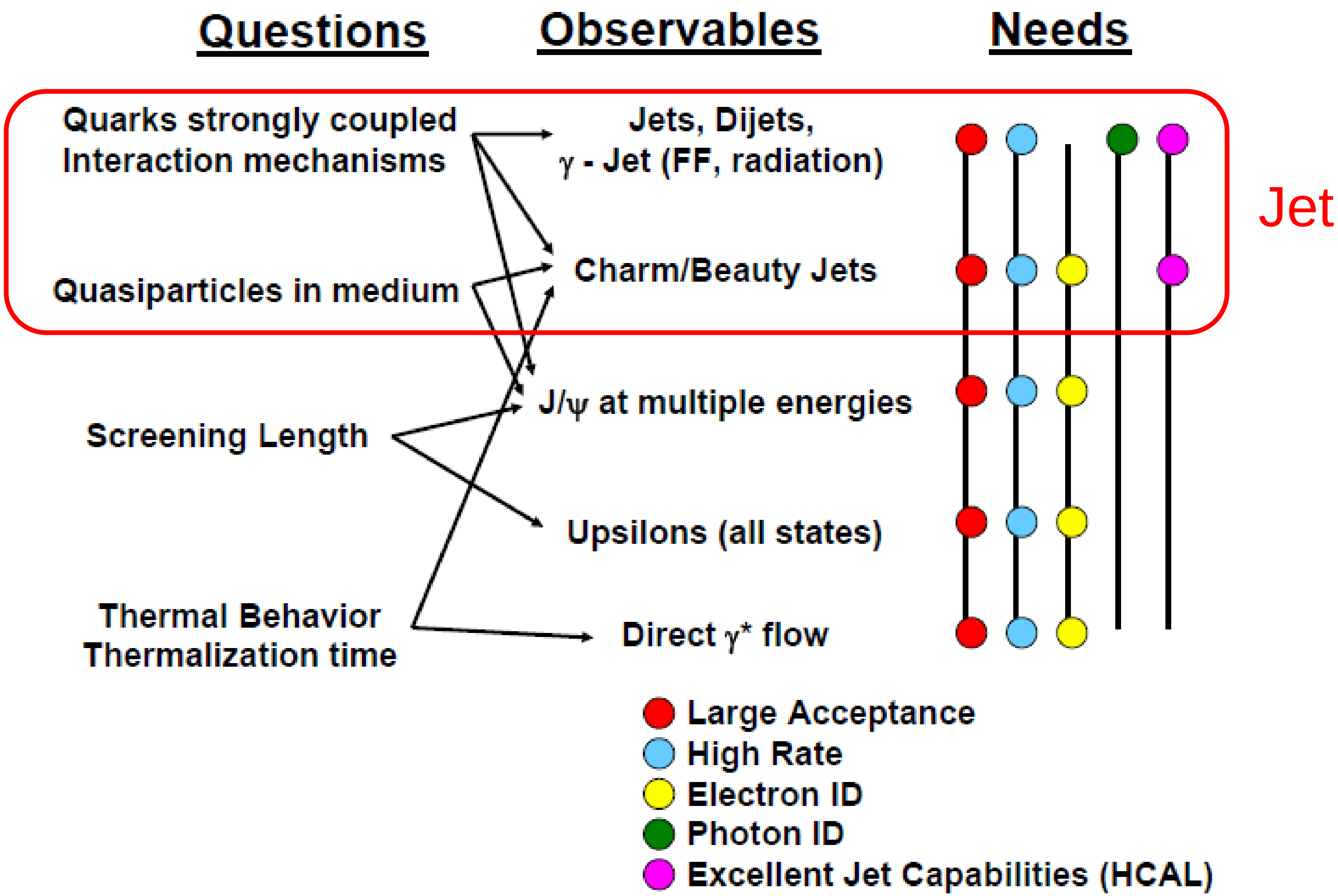
- Polarized proton running to answer

  Internal landscape of nucleons: Spin? parton correlations
  Color Interactions in QCD Drell Yan, jets A_N
  What governs hadronization?

Physics menu for 2015+

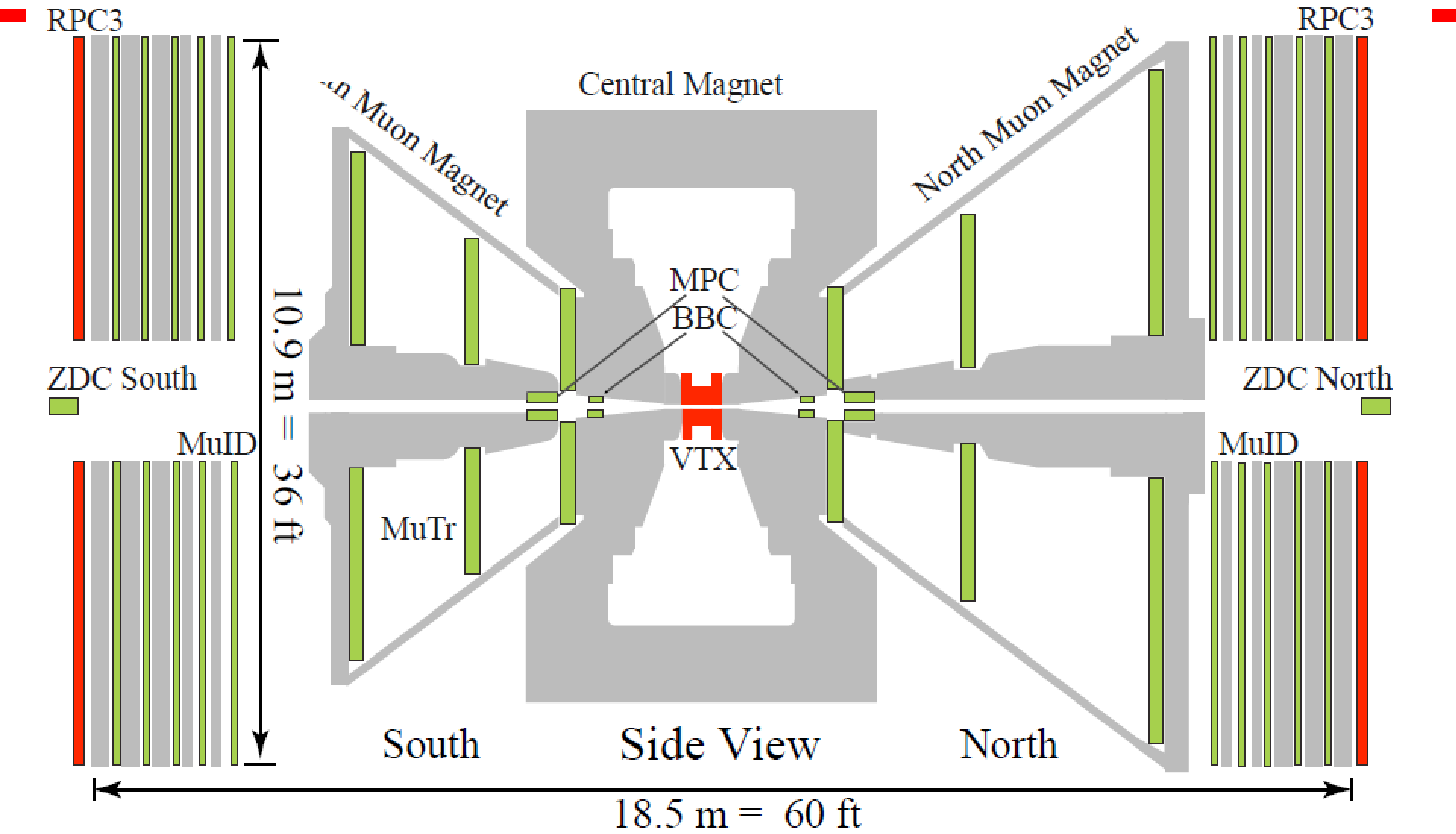
- Study of interaction between parton and sQGP medium
  - Direct measurement of Jets and their modification
- Study of mass dependence of medium-parton interaction
  - High statistic measurement of charm and bottom in Au+Au
  - Measurement of c and b jets
- Study of color screening in the medium
  - High Pt J/ψ >10 GeV/c)
  - Upsilon
- Probe of initial condition
  - Direct photon v2
- High density QCD at small x
  - Forward Physics
- ePHENIX
  - eA and ep when eRHIC beam come to PHENIX IR

Physics and observables in 2015+

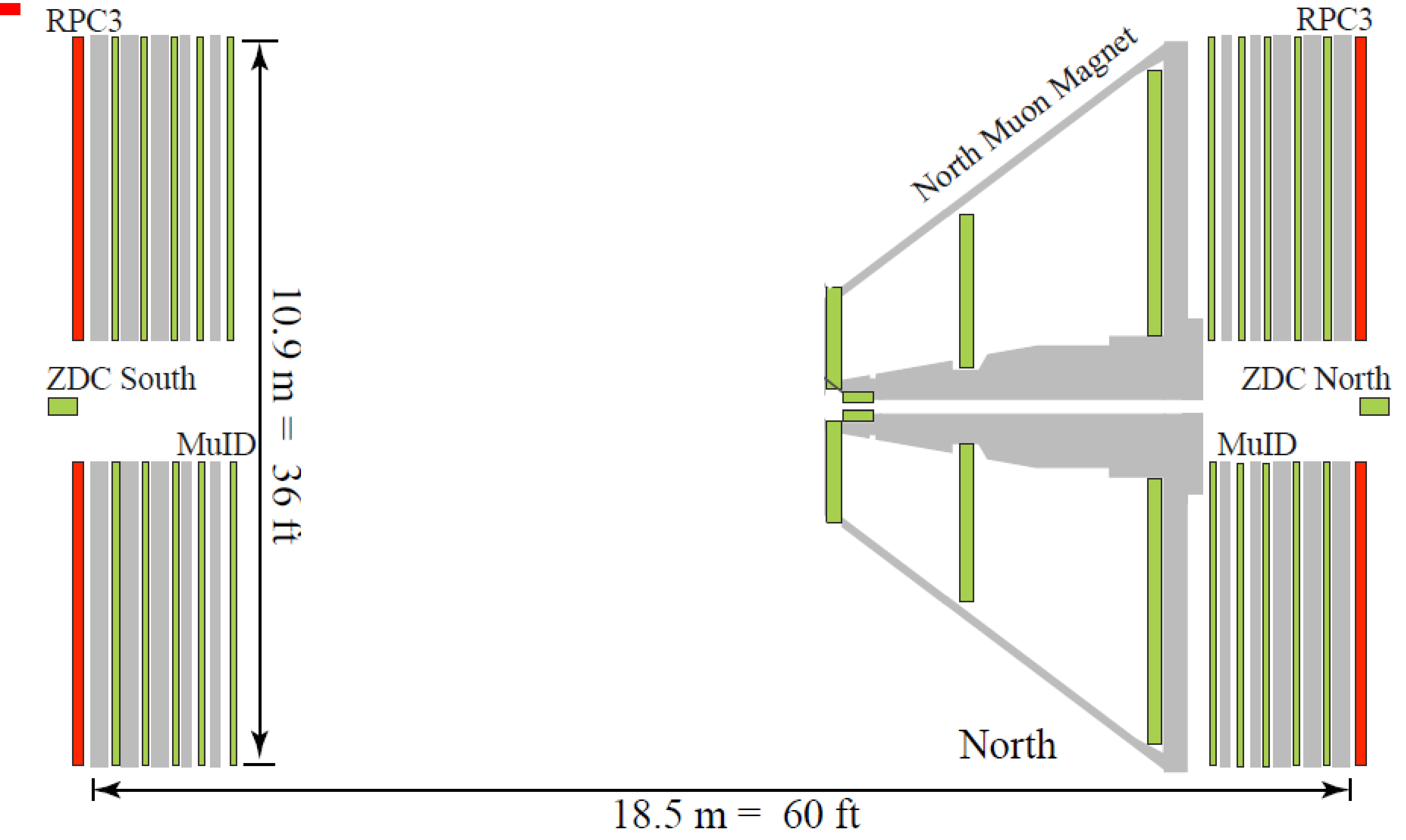


Those compelling questions require substantial upgrade

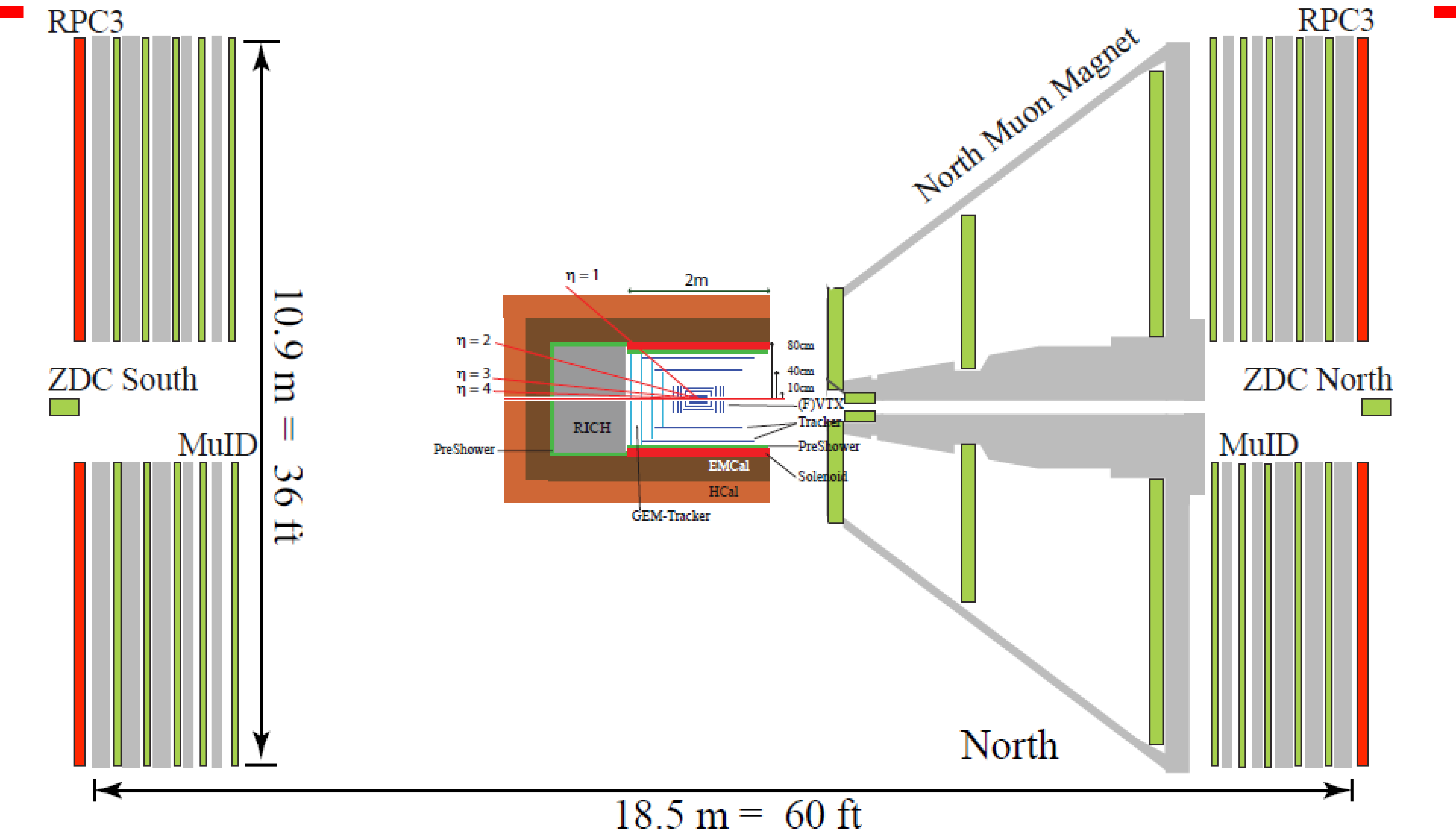
PHENIX → sPHENIX



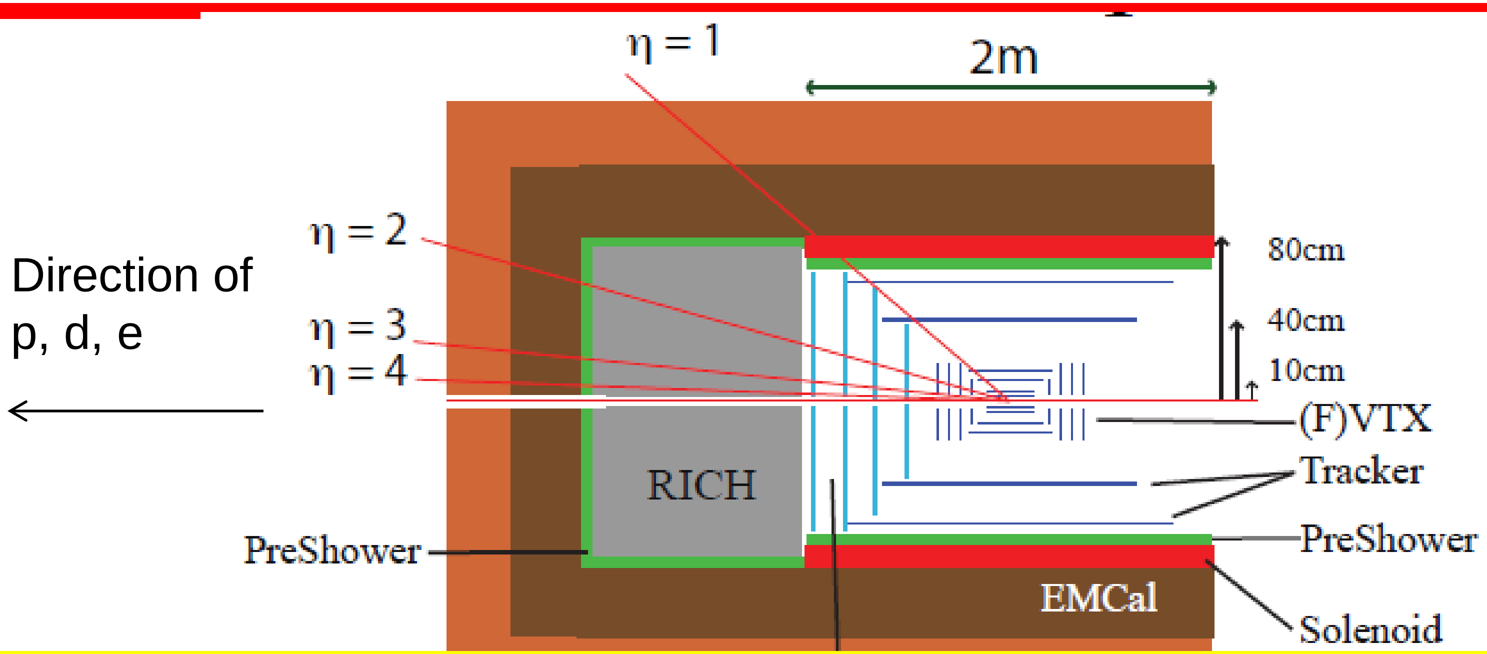
PHENIX → sPHENIX



PHENIX → sPHENIX



Large scale upgrade of PHENIX beyond 2015



Focused on capabilities to answer compelling questions
Don't try to do everything

- Compact detector covering -1 < η < 4
- Measure jets, electrons and photons in mid-rapidity → Measure QGP properties
- Gluon saturation physics at forward region (η > 1)
- First eRHIC detector (not yet optimized)

The PHENIX Decadal Upgrade Detector

Carry over from existing PHENIX:

- **VTX and FVTX**
- **EMCal in Forward Arm and perhaps barrel**
- **DAQ**
- **Infrastructure (LV, HV, Safety systems…)**

What is new:

- **2-3T solenoid (R = 60-100 cm)**
- **Preshower detector**
- **Barrel EMCal (maybe new)**

} $20M

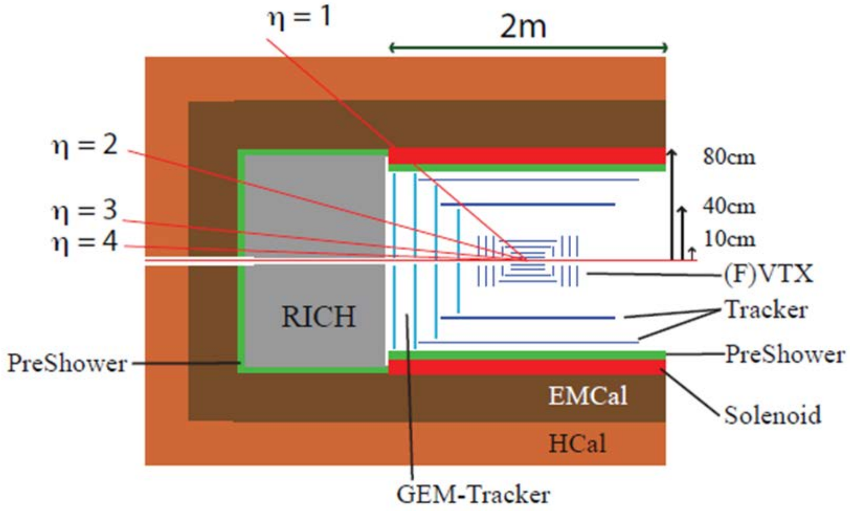
- **Hadronic Calorimetry** } $8-10M
- **Additional tracking layers of Si at ~ 40cm** } $5-7M
- **Forward Arm with RICH and GEM tracker** } $10M

Other

- **Forward magnet**
- **Forward HCAL**
- **Barrel trking layer ~60cm**

} $10-15M

All cost estimate include overhead and contingency

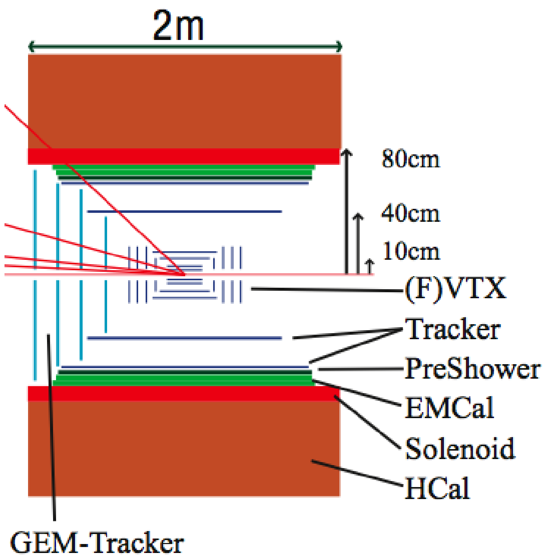


Can be built incrementally

Total Project Cost $53-62M

- **Approx ½ replacement cost of existing $130M PHENIX detector**
- **DOE contribution estimated to be 60% of total $32-44M**
- **Forward detector is key for eRHIC physics (part of eRHIC project?)**

staging



- Mid-rapidity detector

  Additional Si tracking

  Solenoid

  pre-shower

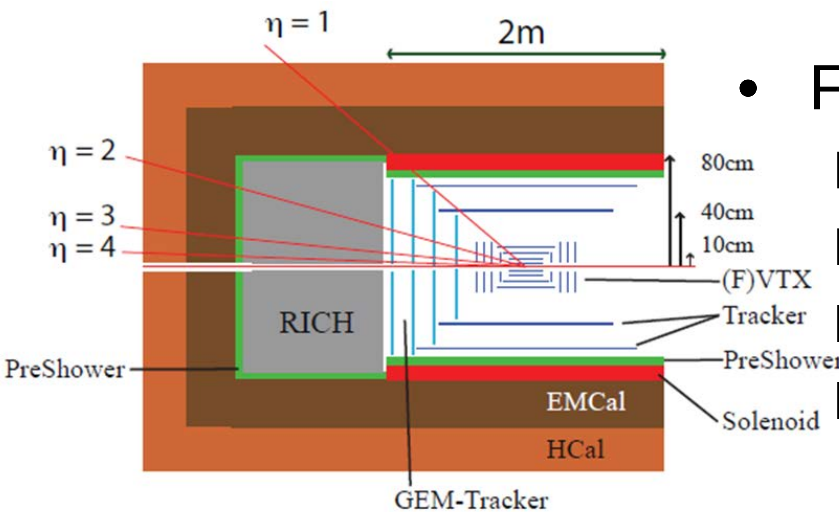
  EMCal

  Hcal

High stat. charm
5-7 M

Direct γ, π^0
Quarkonia
20 M

Jets
8-10M



- Forward Detector

  RICH and GEM tracker

  Forward magnet

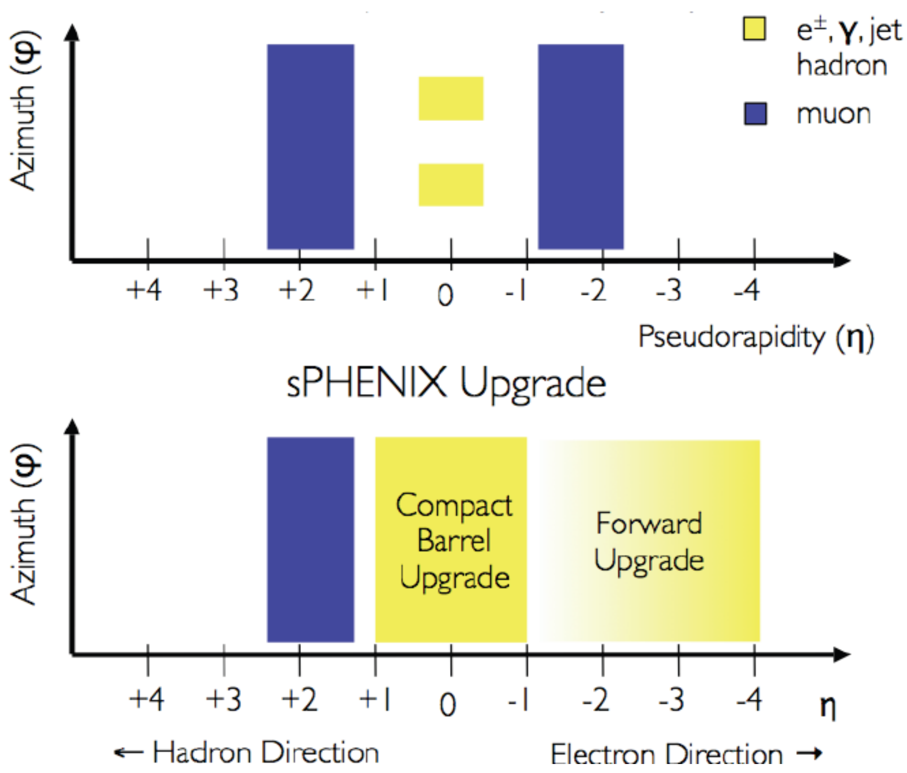
  Forward Hcal

  More barrel tracker

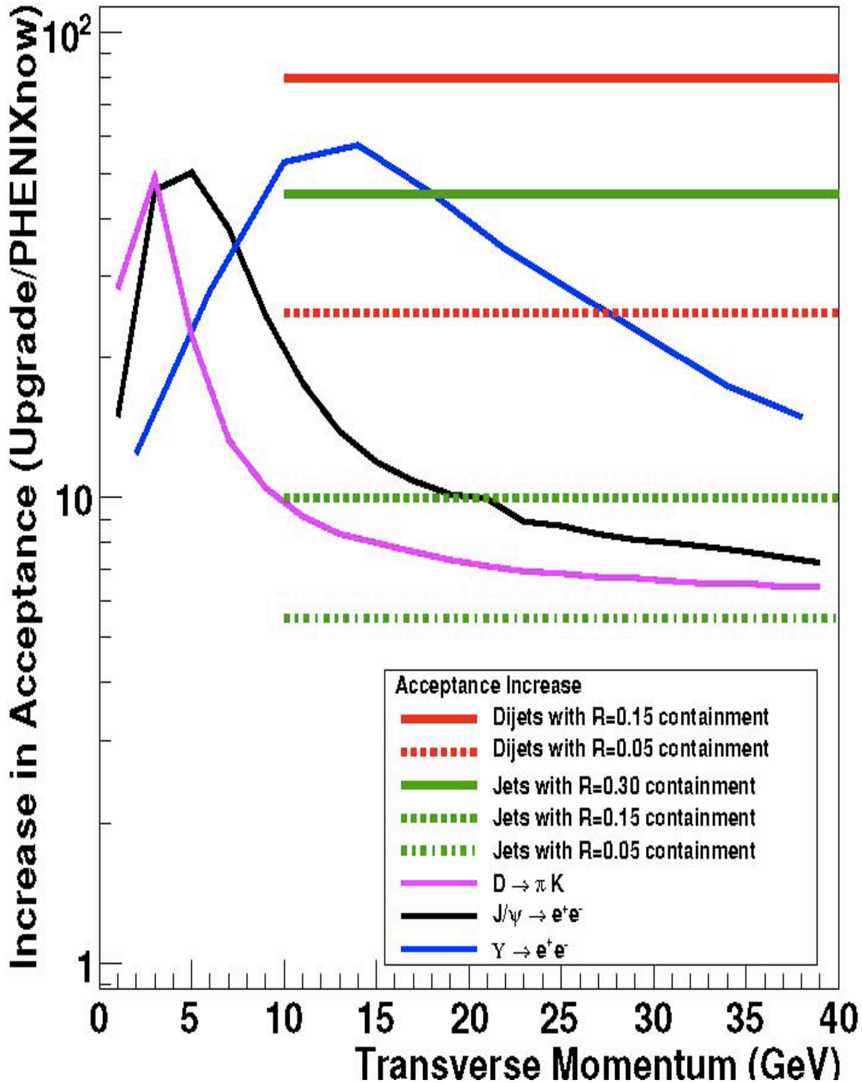
CNM,
eRHIC
10M

Saturation
QGP @ Fwd
eRHIC
10-15M

sPHENIX acceptance

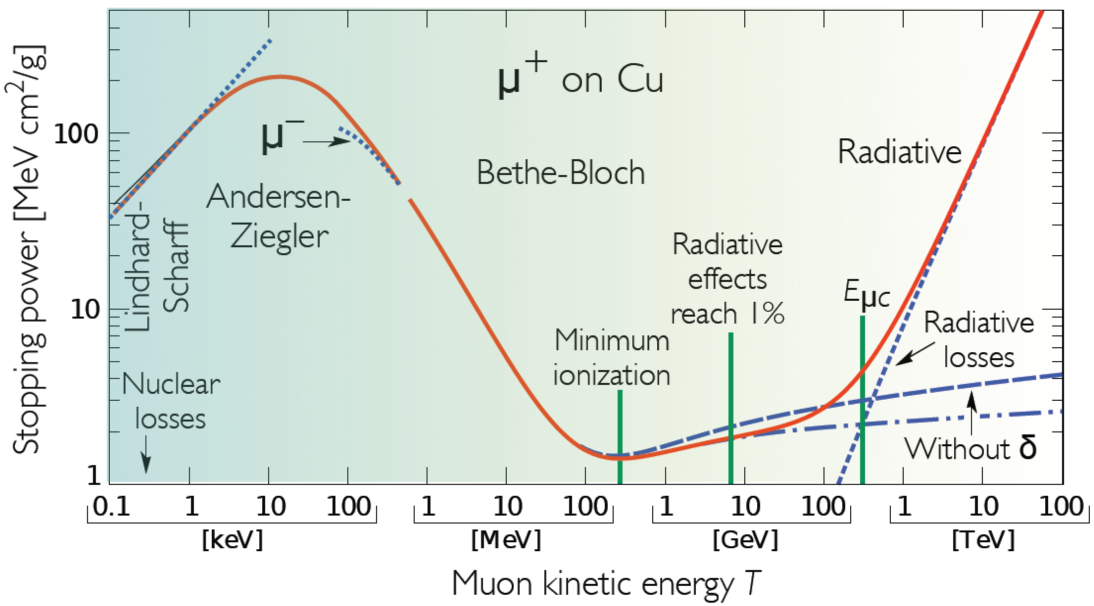


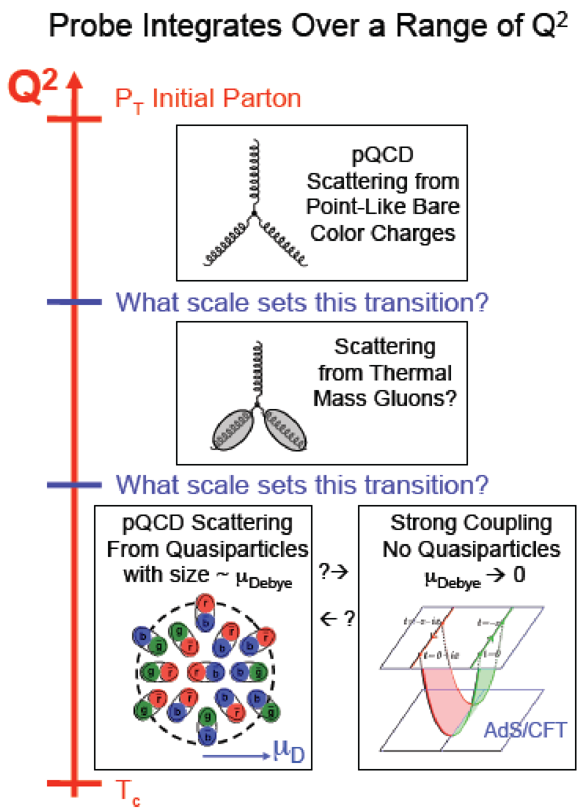
Much larger acceptance than PHENIX



+ DAQ/Trigger: 50B events / year!

Study of parton-medium interaction



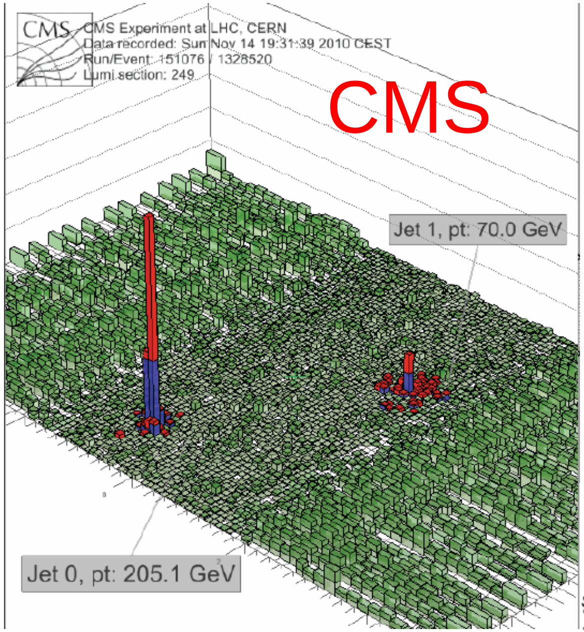


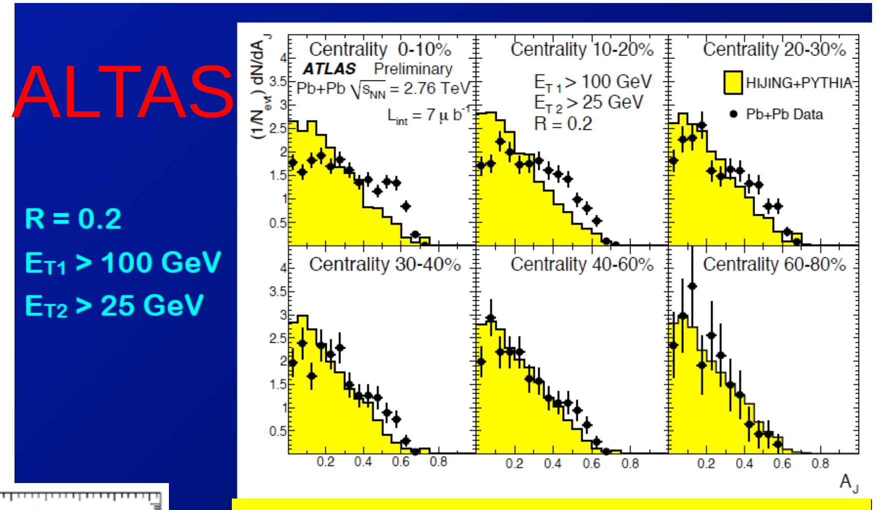
In QED, a rich structure of energy loss is well understood and quantitatively calculated.

Energy loss in QCD matter can have richer structure. How can we quantitatively study it?

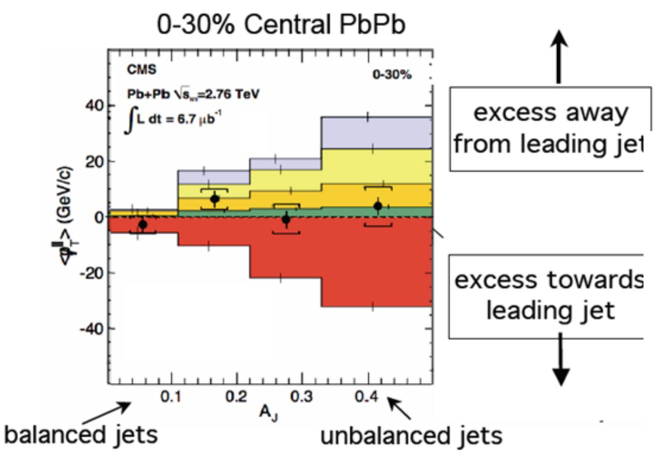
How parton-medium interaction depends on the scale

Jet measurements at LHC

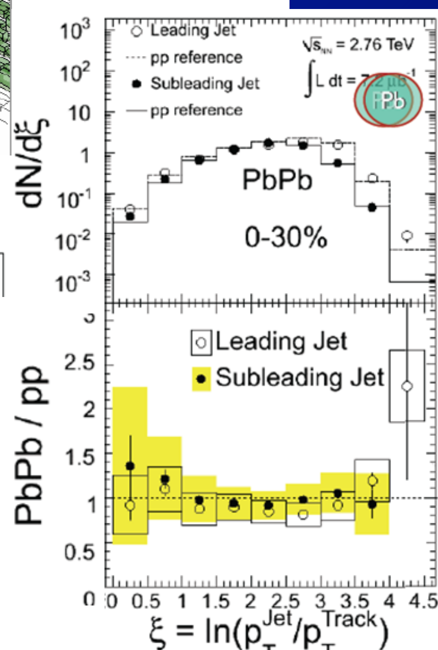




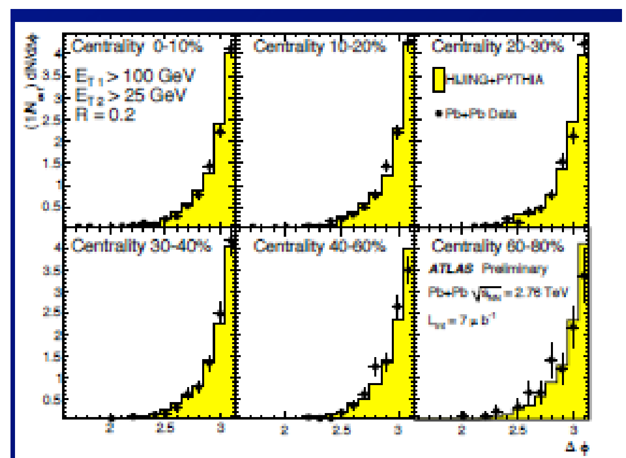
Large jet energy asymmetry



Lost energy goes to low pT particles



Jet shape is not modified



Little change in di-jet angle correlation $\Delta\phi$

LHC jets results from QM11

Very surprising results

- R_{AA} ~ 0.5 and independent of p_T (for p_T>50 GeV)
- Large jet asymmetry A_J is seen

→ Path length dependence of energy loss seems to be very steep
$\Delta E \sim l^3$ as AdS/CFT predicts? (and PHENIX derived in high pt v_2?)
Or it is even steeper? (No analysis yet)

- *Little modification* of jet fragmentation
- *Little modification* of di-jet angular correlation
- Lost energy goes to low p_T particles at large angle (i.e. bulk matter)

→ It is as if a parton only loses its energy in QGP and the lost energy is quickly dissipated in the medium. (heat up the medium)

→ Perturbative energy loss model is severely challenged (if not completely excluded)

What LHC data tells us at RHIC

- The answer depends on to whom you ask, but my lessons are

  Direct measurement of jets is very important at RHIC

  Hadronic calorimeter is the key at ATLAS/CMS

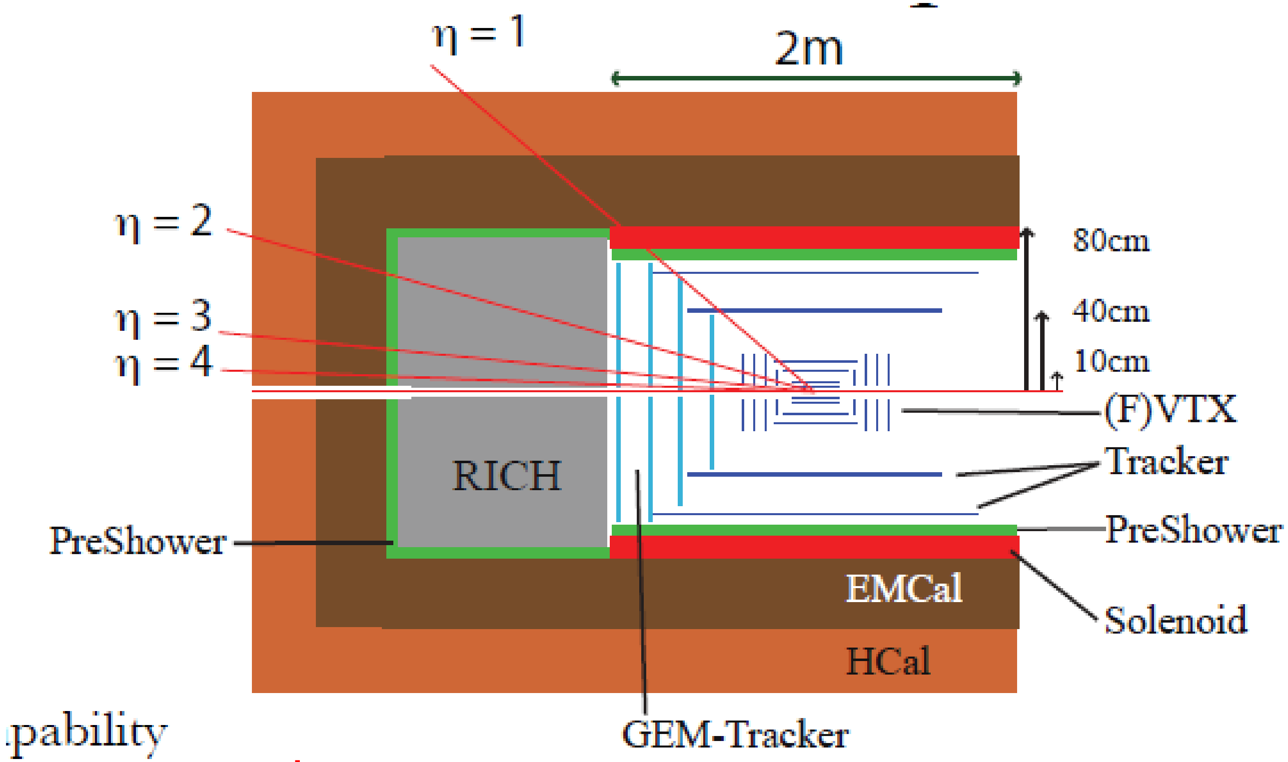
  → Need Hcal at RHIC to fully reconstruct jets

  Large coverage in y is essential

  - Jets can be measured in heavy ion collision with calorimeter
  - Jet is little modified

    → jet template in p+p can be used for reconstruction
  - Energy loss in the medium can be measured directly
    → strong constraint on the initial conditions and medium properties

sPHENIX: compact jet detector for RHIC



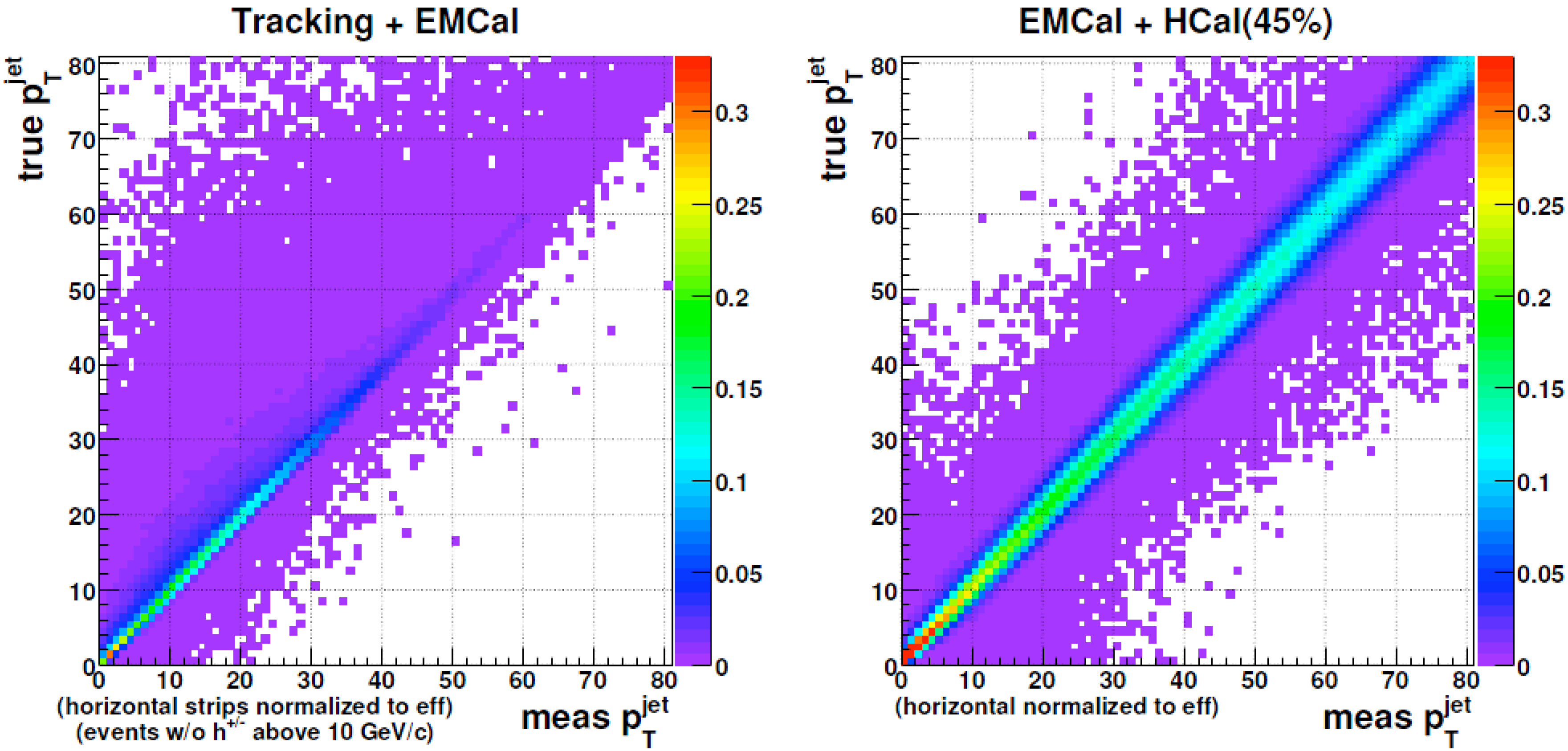
Focuses on p+p, d+A, ep, eA   Focuses on A+A

- Compact detector covering -1 < η < 4
- Measure jets, electrons and photons in mid-rapidity → Measure QGP properties
- Gluon saturation physics at forward region
- First eRHIC detector

Can be built incrementally

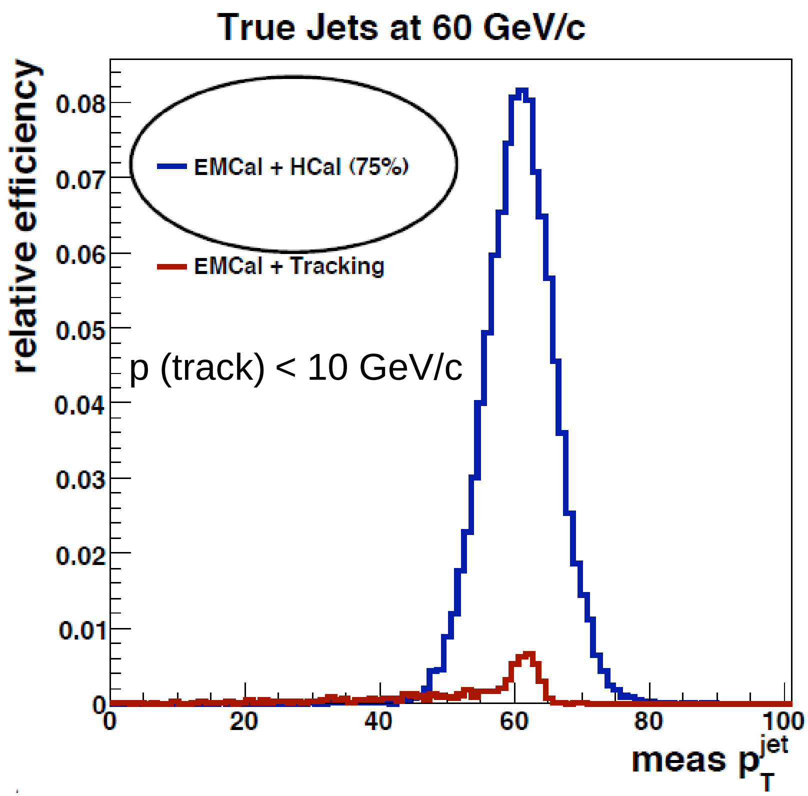
HCal improvement to Jet Energy Measurement

tracking p < 10 GeV/c required
to avoid fake jets

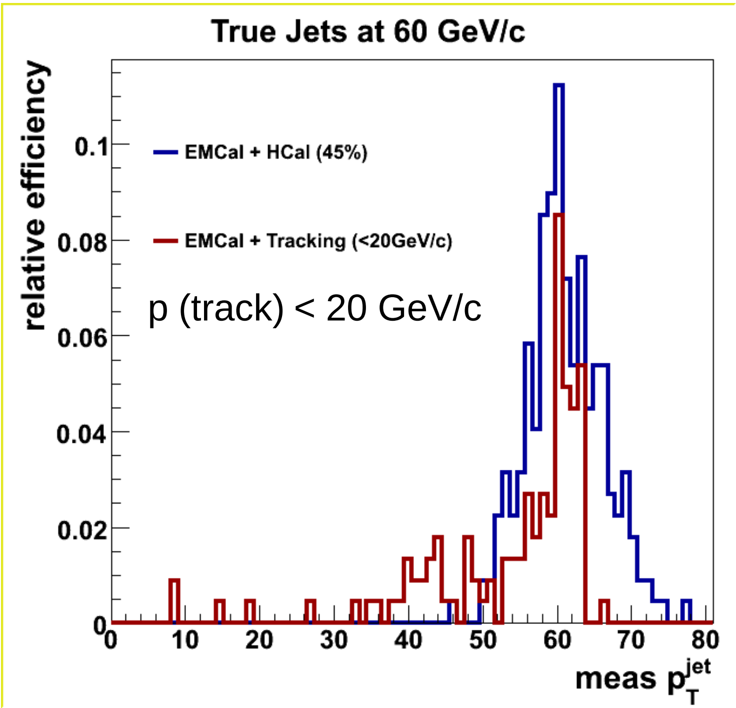


- No fake jet due to tracking background
- Catch neutral energy
- No asymmetric tail in measured energy → Essential for A_J measurement

HCal for jet measurement



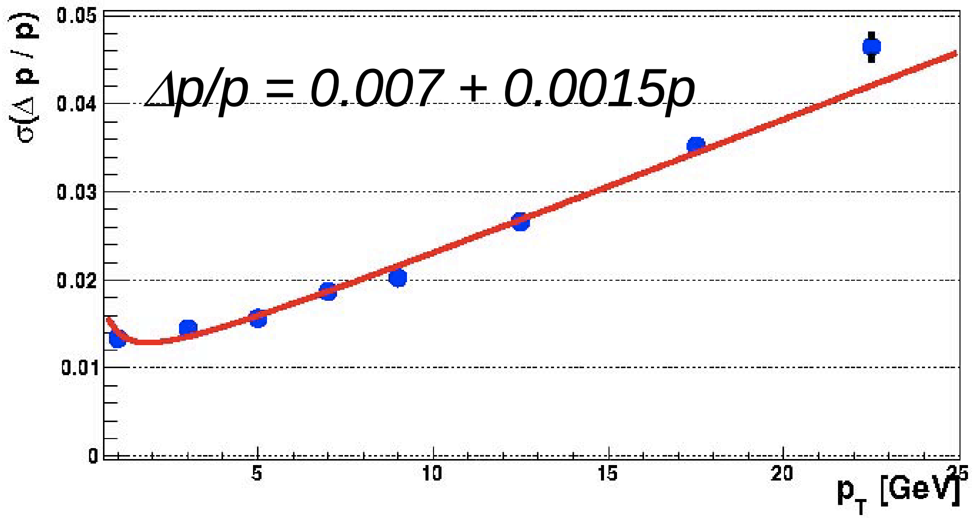
With 10 GeV tracking cut off, only tiny fraction of jet can be reconstructed

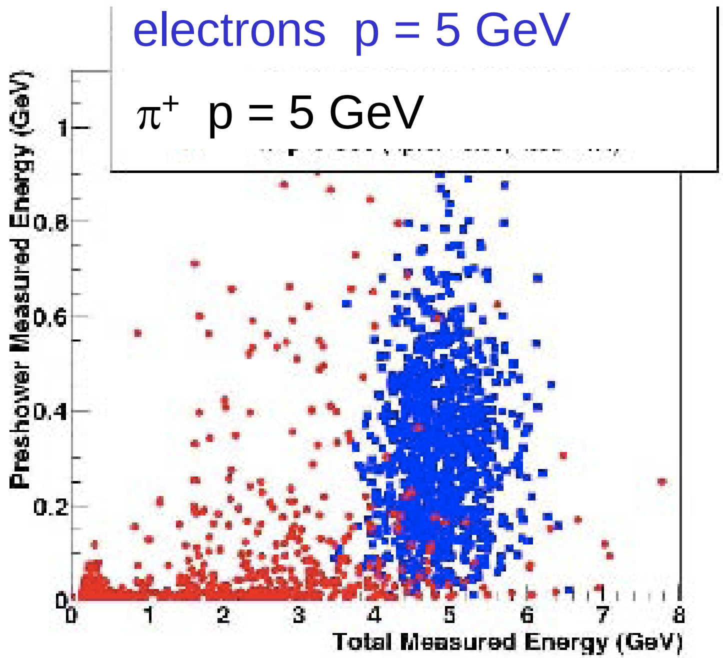


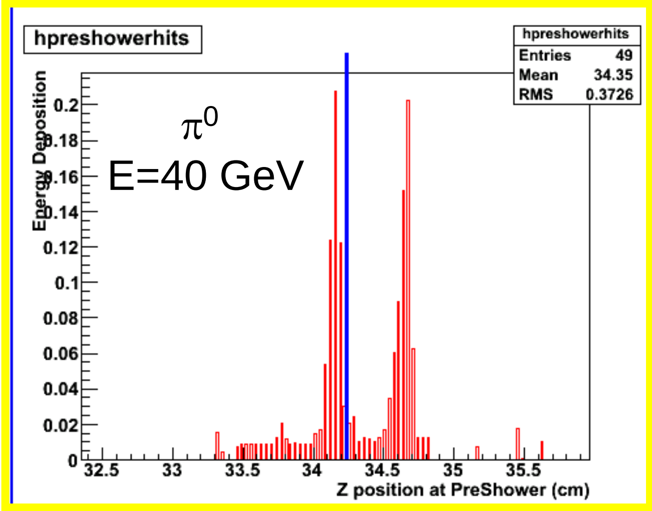
With 20 GeV tracking cut off, still less than 1/3 of jet is reconstructed at proper energy

- For di-jet asymmetry (A_J) measurement, the tail is the killer
- Hcal eliminates the tail.
- Hcal is not the cost driver of sPHENIX

Performance of sPHENIX







- Good mom. Resolution
- Good e/π separation by
  - Energy (EMCal)
  - Longitudinal Shower Profile
  - Pre-shower
- Single γ and π^0 separation by pre-shower

Barrel CEMC occupancy

Compact EMCal PS	Si-W	300 μm×6 cm	61	0.3
Compact EMCal	Si-W E1	0.75 cm×0.75 cm	61–64	0.110
	Si-W E2	1.50 cm×1.50 cm	64–68	0.03

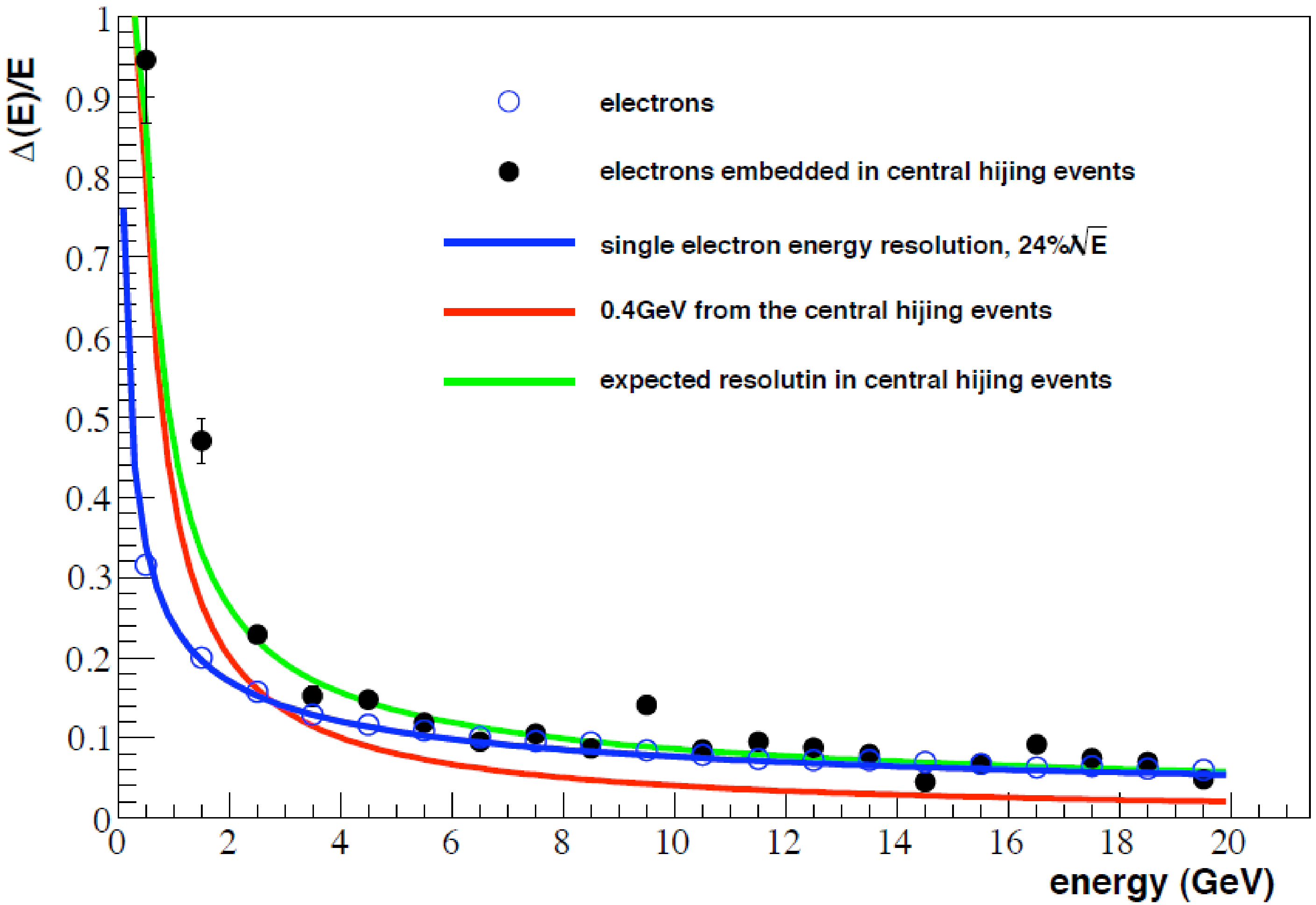
- tower granularity follows shower development
- Moliere radius ~ 2cm
- GEANT4 simulation of very central event

Energy Threshold (MeV)	Layer 1 Occupancy	Layer 2 Occupancy
0	26%	49%
5	15%	22%
10	12%	20%
20	10%	15%
30	7%	12%
40	6%	10%
50	5%	8%

Current PHENIX Thresholds
10MeV PbSc
14MeV PbGl
(S. Bazilevsky)

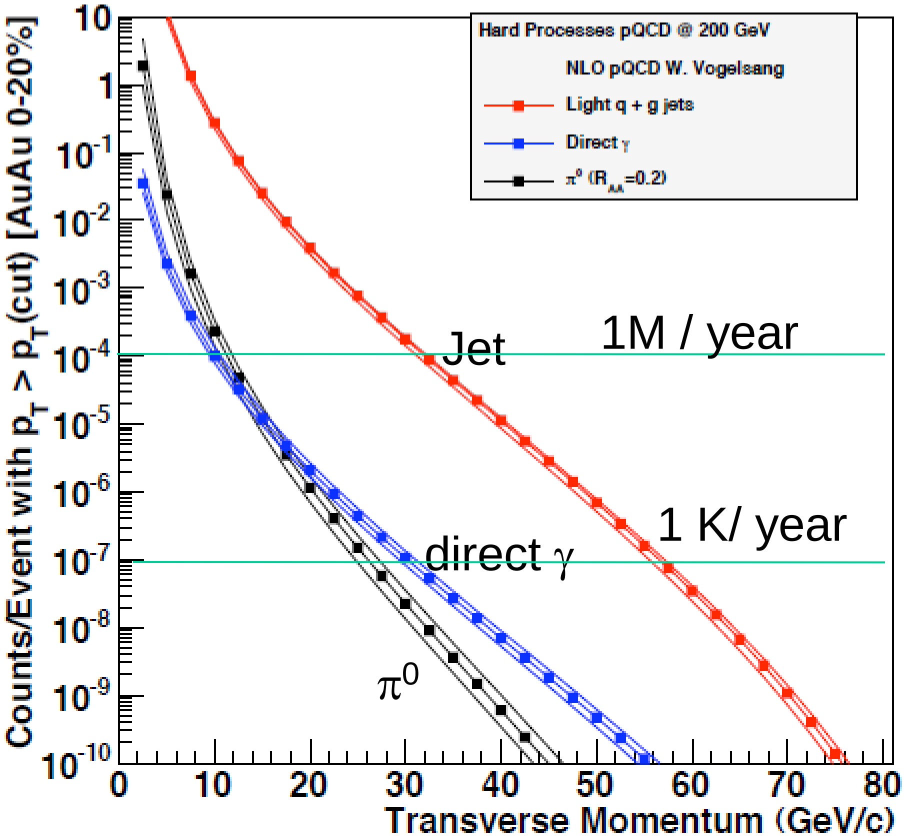
→ Reasonable threshold leads to moderate occupancy

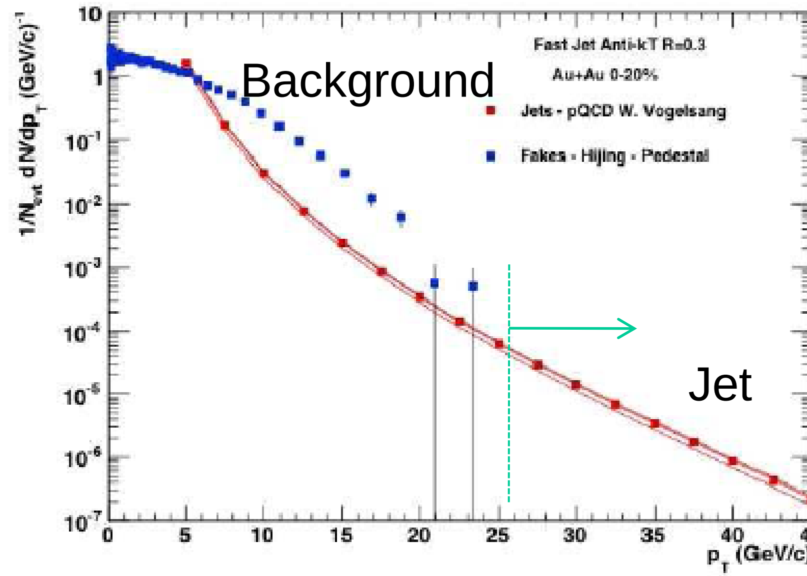
Impact on electron energy resoluiton



- Effects of underlying event is less important than energy resolution above a few GeV

Jet measurement with sPHENIX

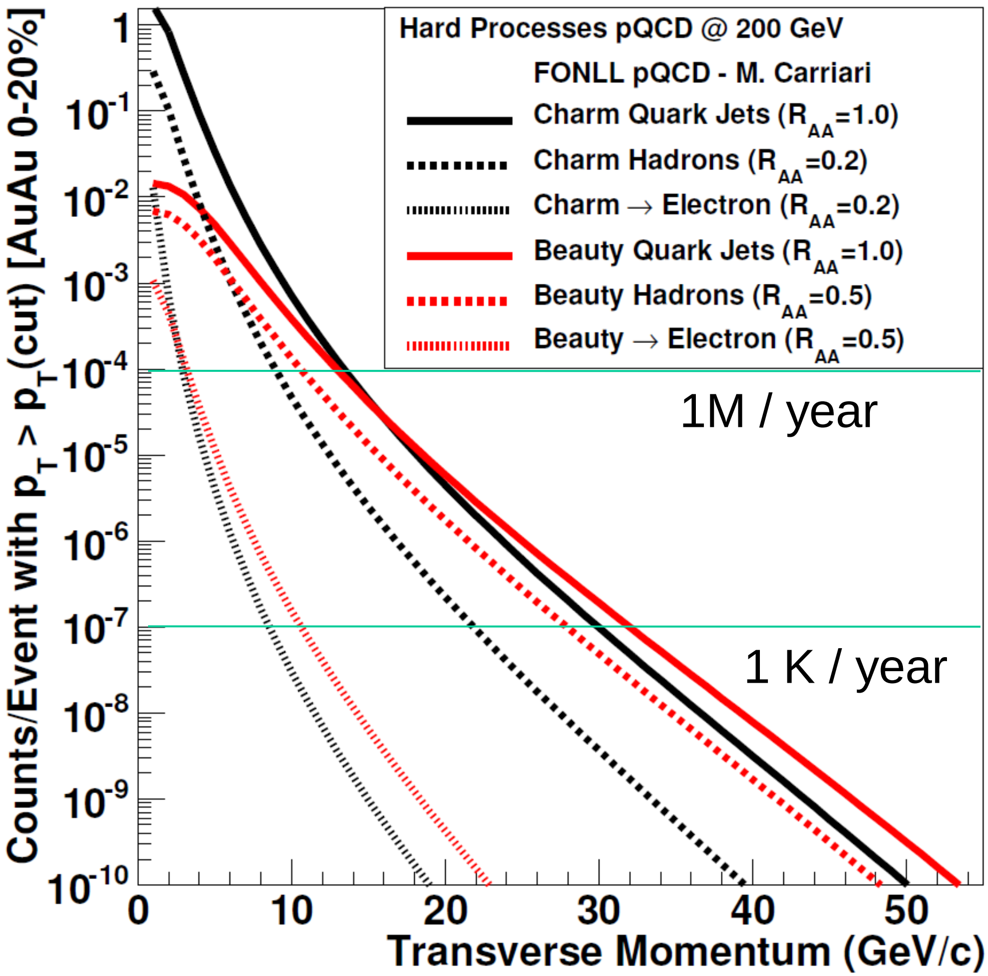


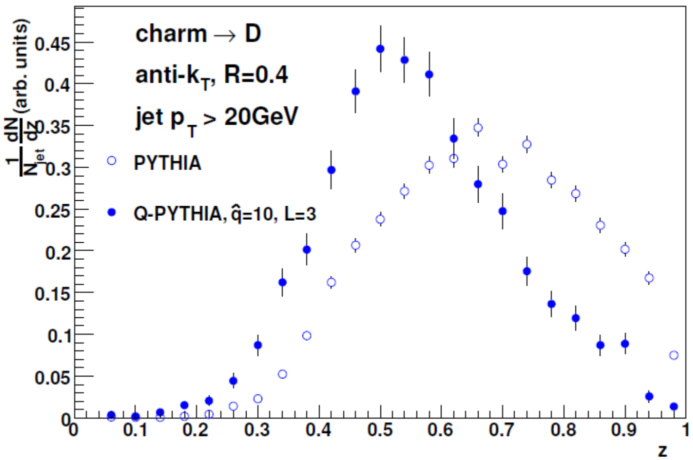


Jet signal is above fluctuation of background for pT>25 GeV for R=0.3
With smaller R, the BG can be even smaller. (ATLAS uses R=0.2)

- Measure jets for p_T>30 GeV
- Lower pT jets will be measured via direct γ-jet
- High statistics di-jet and γ-jet → Jet tomography of QGP at RHIC
- Complementary to LHC

Heavy flavor tagged jets



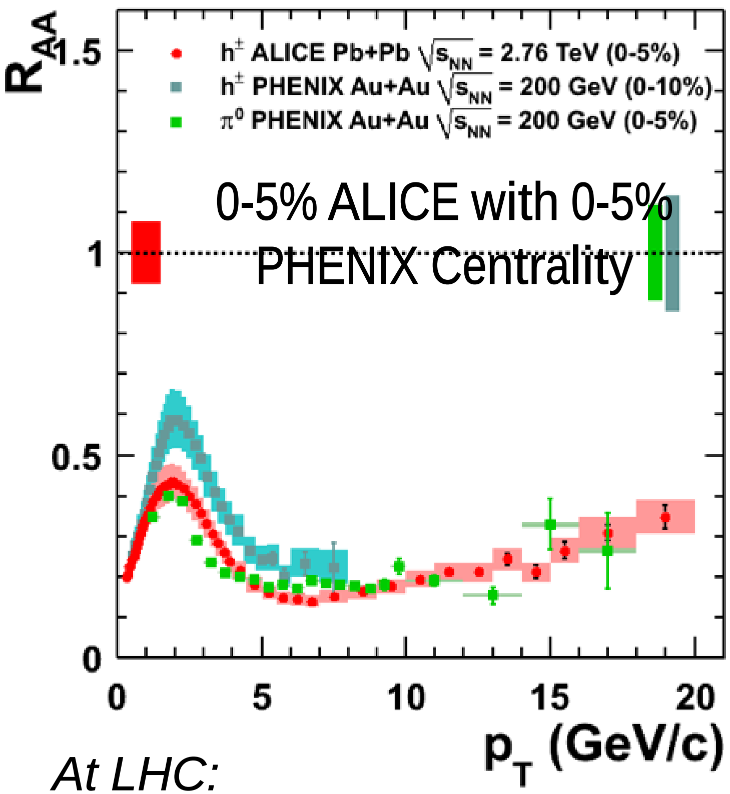


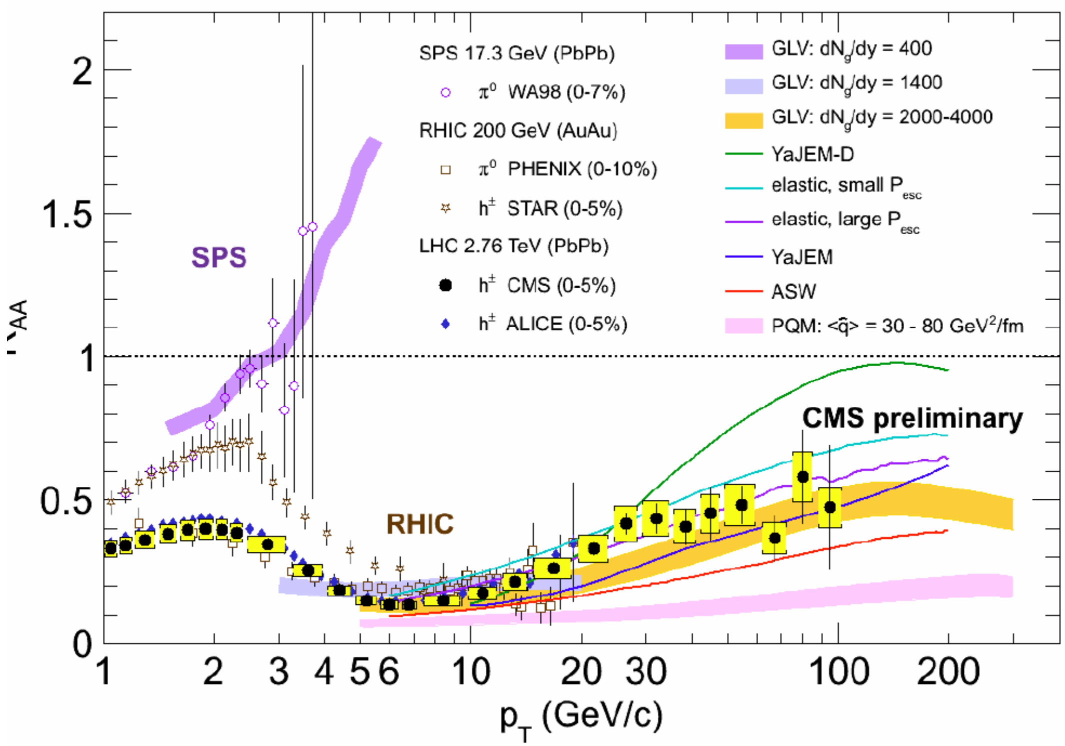
Charm/bottom are tagged by (F)VTX

- Charm and bottom FF is hard → sensitive to jet modificaiton
- Is HQ jet also little modified by QGP?
- Charm/bottom are rare at RHIC

→ Good probe for jets with large energy loss

R_{AA}: Rise for p_T>10 GeV/c





Strong constraint on the parton energy loss models

At LHC:

Minimum R_{AA} is ~0.1 at p_T~6 GeV/c; stronger suppression than RHIC (R_{AA}~0.2)

Rise to R_{AA} ~ 0.5 at p_T~30-40 GeV/c and seems to saturate

At RHIC

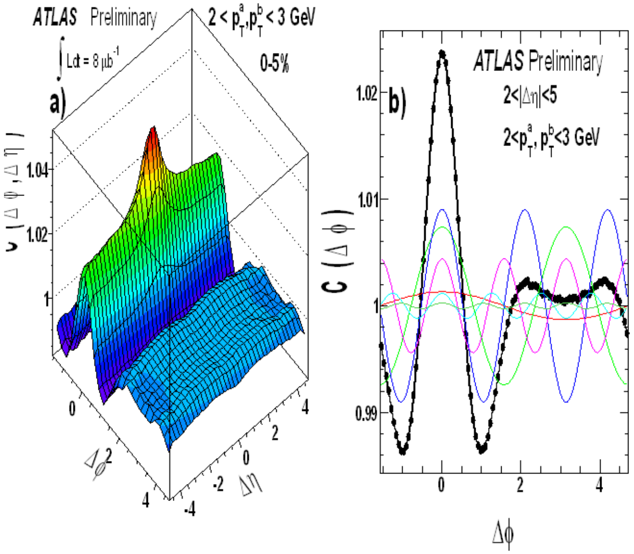
sPHENIX can measure π^0 up to 40 GeV where R_{AA} saturates at LHC

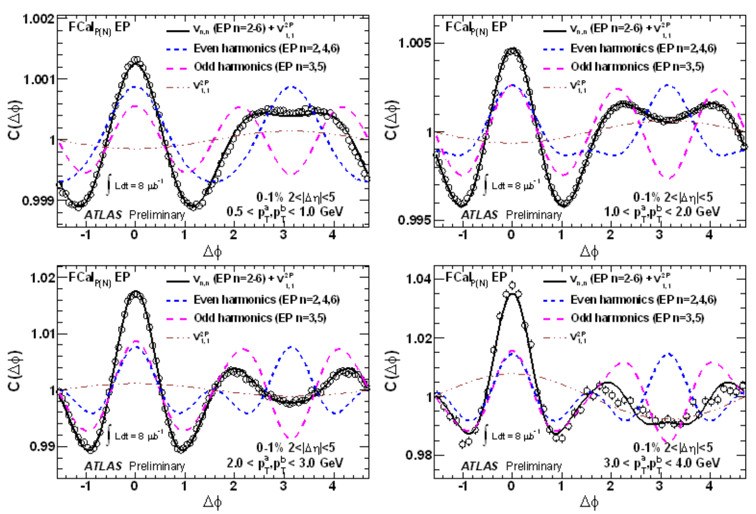
Comparison of RHIC / LHC is important to understand energy loss

Large y coverage

- Sensitive to early fluctuation

  v2, v3, v4….
- Calorimeter coverage with reasonable $\Delta\phi$ $\Delta\eta$ segmentation and wide y coverage alone should be very powerful.
- Flow v_n analysis of ATLAS demonstrates the power of wide y coverage.
- ATLAS has started v_n analysis using calorimeter alone.





What can be done with jet/di-jet

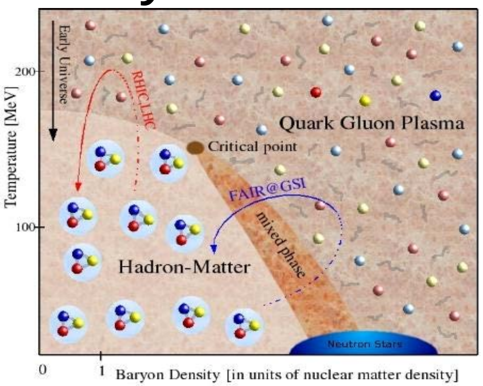
- High statistics jets/di-jets measurement w.r.t. reaction plane

➔ Determine path length dependence of energy loss

➔ CT scan of energy density of QGP in each centrality

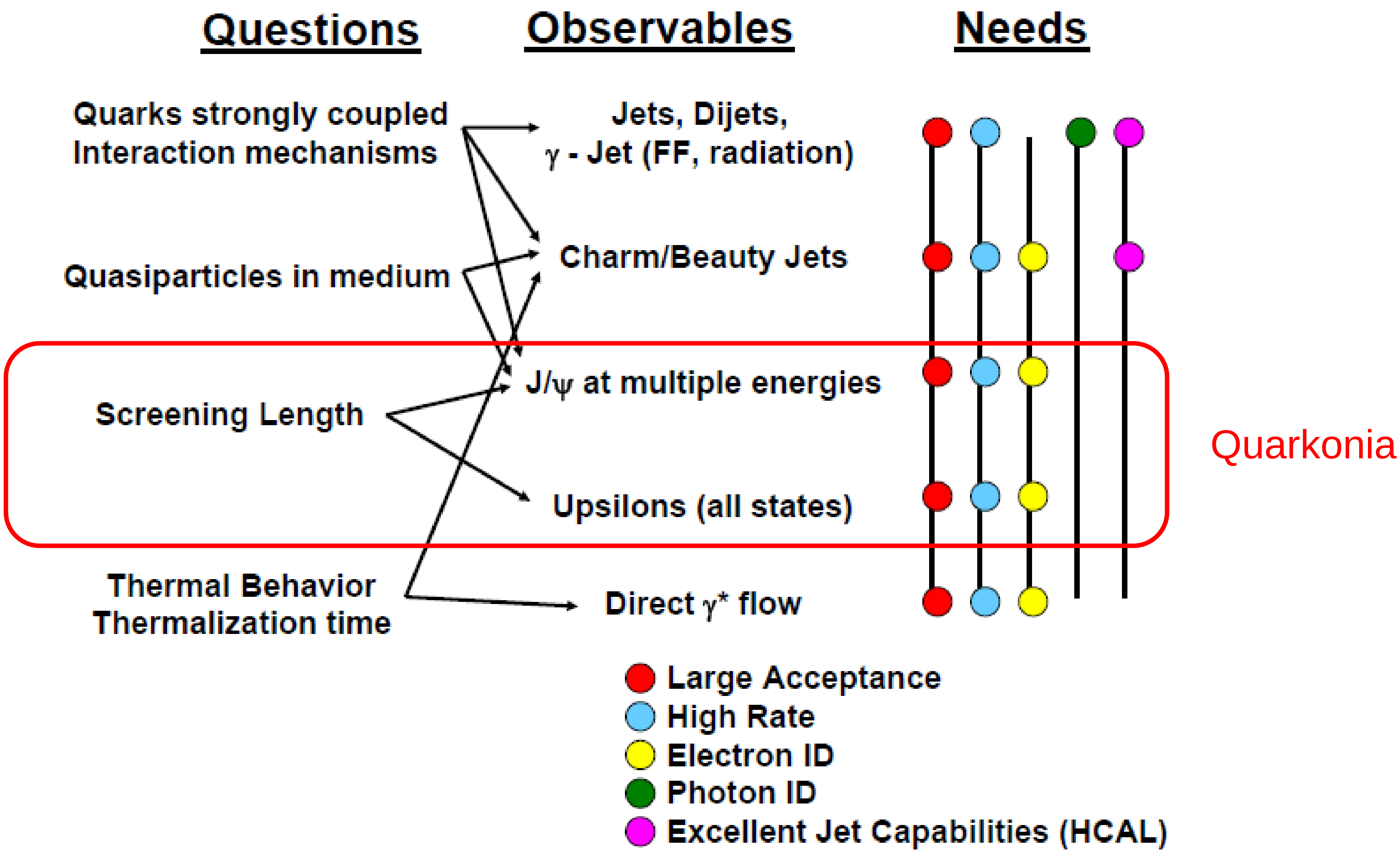
  ➔ Better constraint on initial state

  ➔ Better determination of QGP properties such as η/s

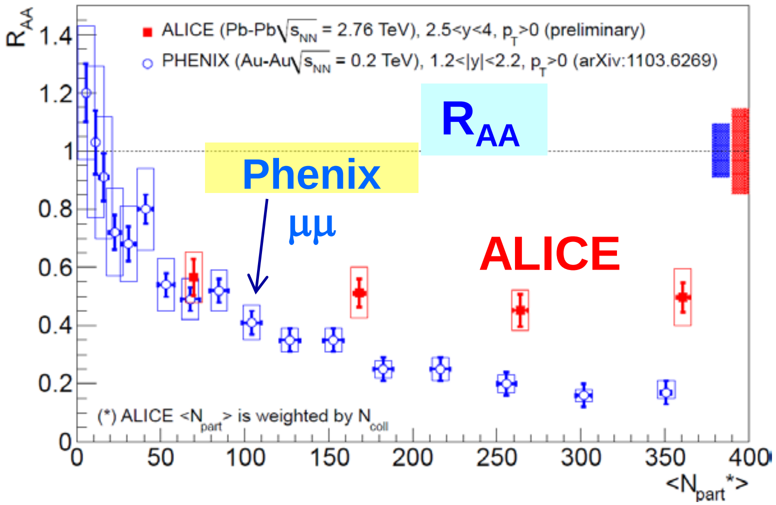


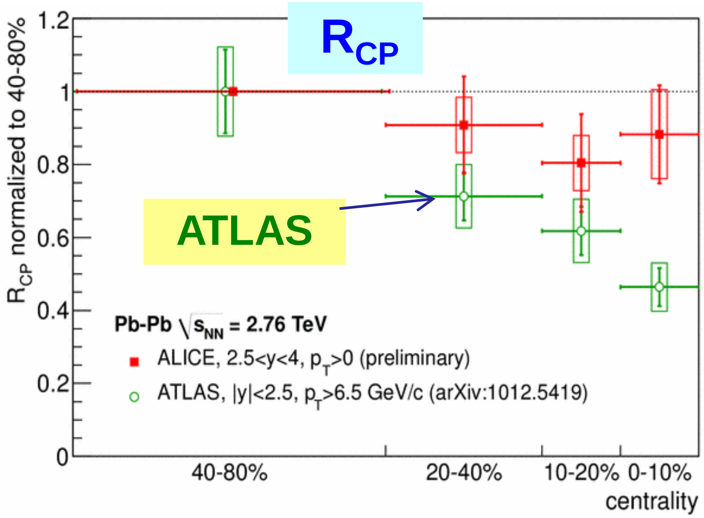
- Complementary to LHC
  - Lower p_T (30 (15) to 60 GeV) vs (p_T> 50 GeV)
  - Little multiple jet background
  - High p_T jets at RHIC are dominantly quark jets
  - Compare dE/dx (path_length, ε) at RHIC and LHC
    - Is energy loss scale with energy density ε of QGP?
    - Is path length dependence similar?
- Good Geometry control
  - From d+Au (Pb, U) to U+U to Cu+Au etc…

Physics and observables in 2015+



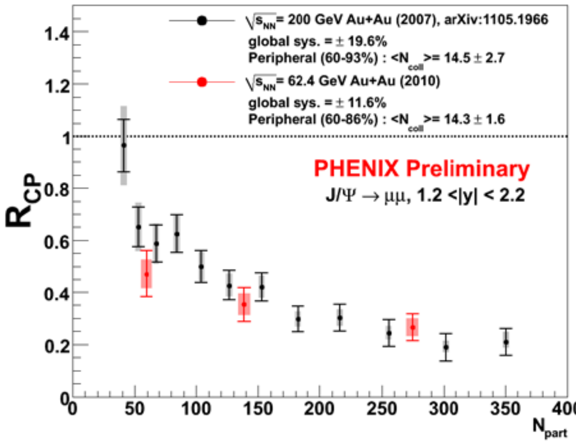
J/ψ suppression remains as puzzle

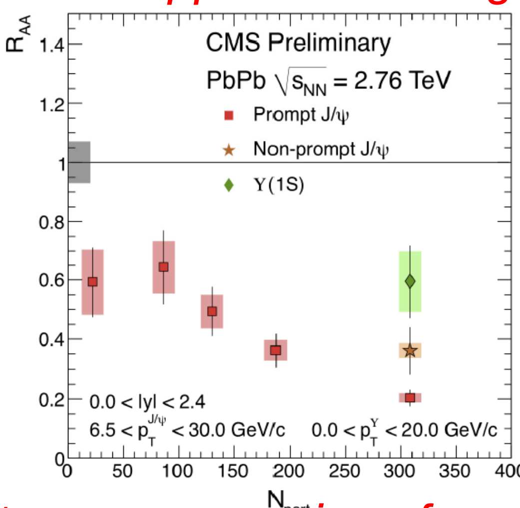




Less suppression @LHC than RHIC??

More suppression at High p_T?



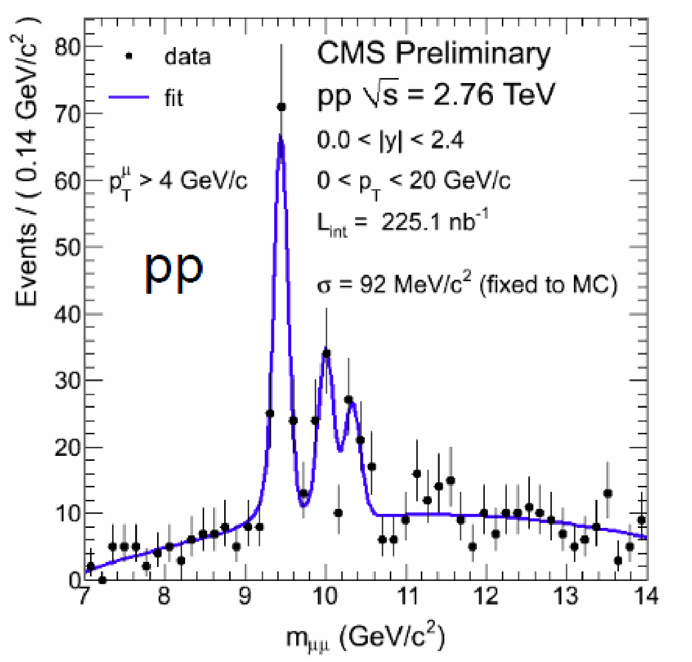


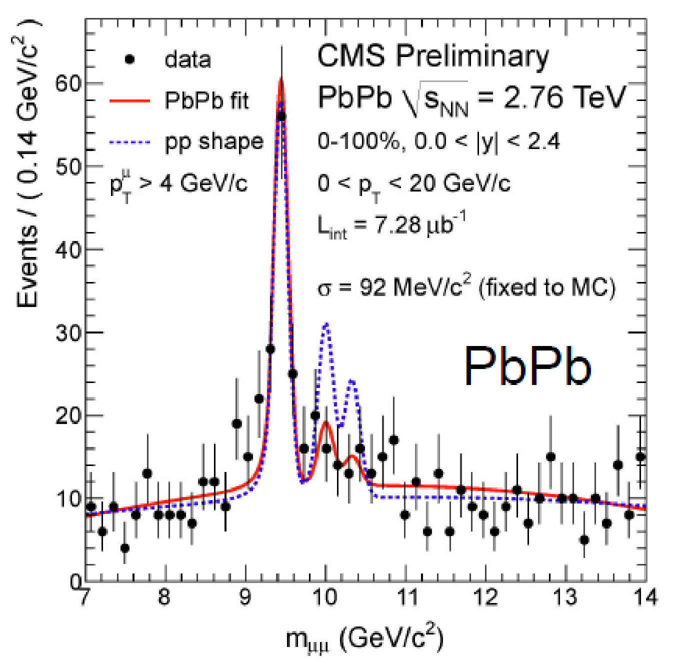
Strong suppression at 62 GeV

Strong suppression of prompt J/ψ?

Need high statistics and large y range of J/ψ measurement

CMS sees Suppression of Y(2S,3S)



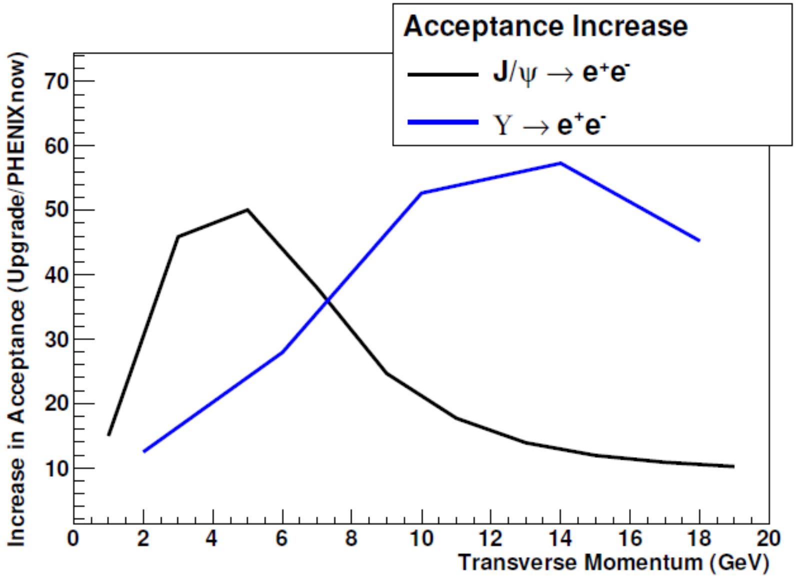


$$\Upsilon(2S+3S)/\Upsilon(1S)\big|_{pp} = 0.78^{+0.16}_{-0.14} \pm 0.02 \qquad \Upsilon(2S+3S)/\Upsilon(1S)\big|_{PbPb} = 0.24^{+0.13}_{-0.12} \pm 0.02$$

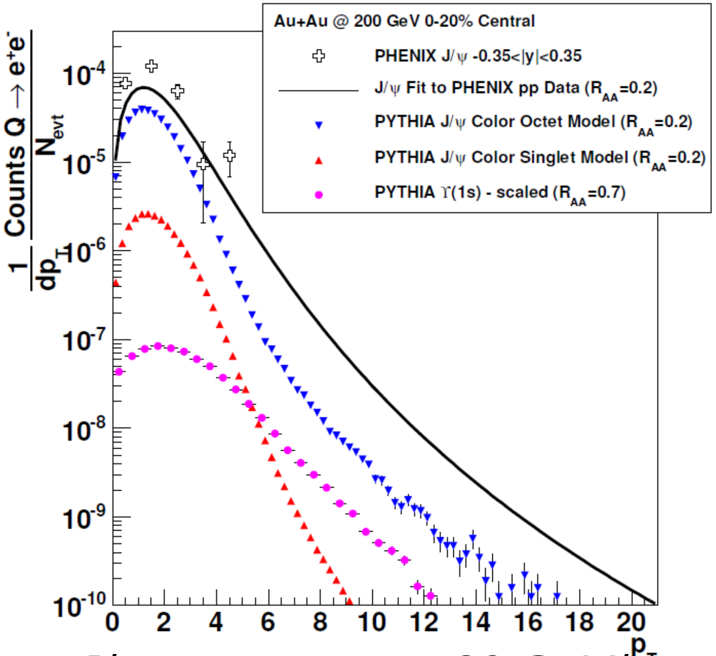
$$\frac{\Upsilon(2S+3S)/\Upsilon(1S)\big|_{PbPb}}{\Upsilon(2S+3S)/\Upsilon(1S)\big|_{pp}} = 0.31^{+0.19}_{-0.15} \pm 0.03$$

- The data show that the 2s/3s are reduced as compared to the 1S.
- Large acceptance Y measurement at RHIC is important
- Very important to separate 1S/2S/3S states: senstive to screening length

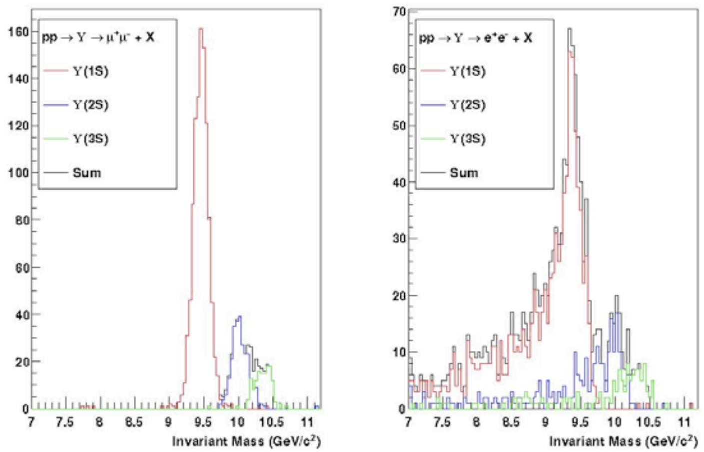
Quakonia in sPHENIX



Much larger acceptance for J/ψ and Y
Wide rapidity coverage -1< η < 4



J/ψ p_T range to ~20 GeV/c



- Can separate 3 Upsilon states
- Can measure relative suppression of 2S/3S vs 1S
- If 1S is not suppressed…
  measure of screening length

Beam Energy Scan

Large acceptance → Energy scan of rare probes at lower beam energy

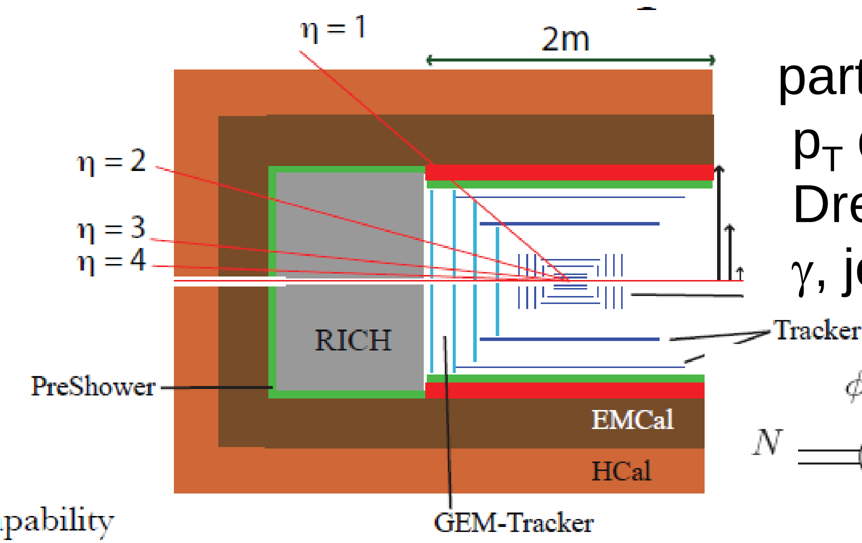
- Jets
- High p_T single hadrons
- Open heavy flavor
- Quarkonia

  repeat energy scan of 20 – 200 GeV with large acceptance detector to characterize the suppression as a function of sqrt(s)

- Photon-hadron, Photon-jets

  Probe Energy loss and QGP response in lower beam energy

Forward spectrometer & “ePHENIX”

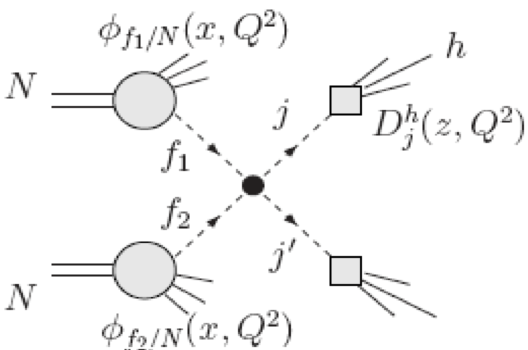


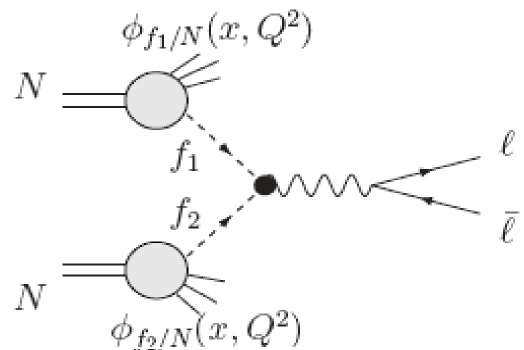
parton dynamics in polarized p+p

p_T dependent PDFs (TMD’s) & FF’s

Drell-Yan to probe q ⊥ polarization

γ, jets, hadrons:other subprocesses





- ePHENIX:

  Detect scattered lepton forward (DIS, SIDIS)

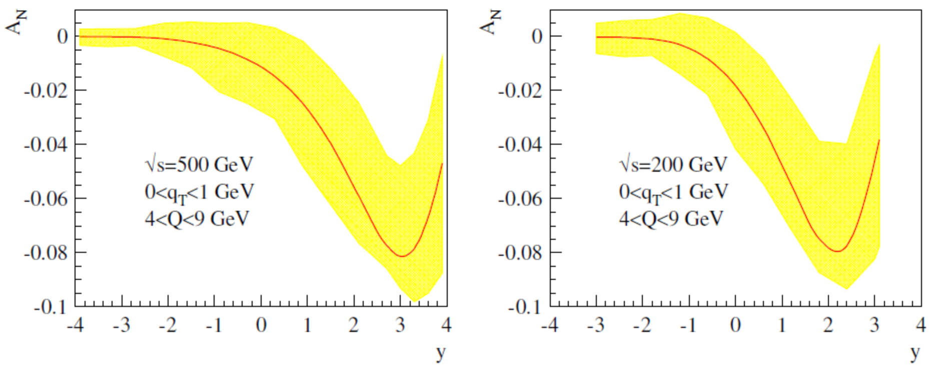
  Investigate nuclear pdf’s to low-x (down to 10^{-5})

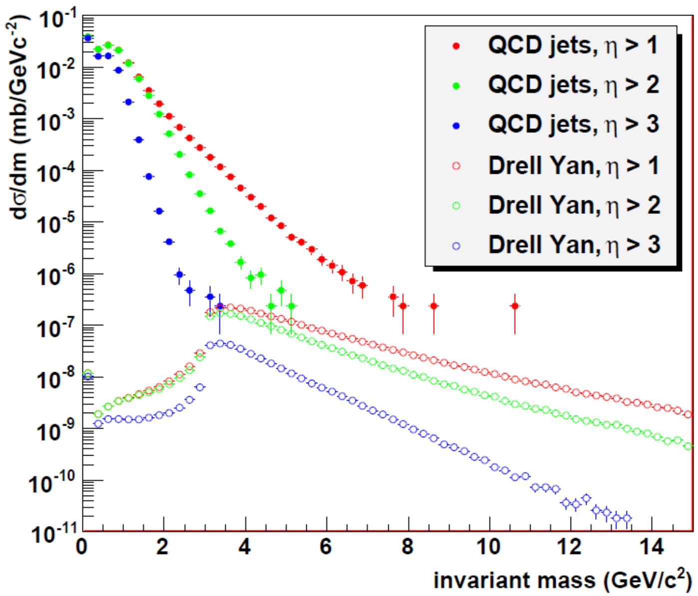
  Access DVCS by detection of forward nucleon and detection of produced vector meson

  Following the Decadal Plan charge we did not yet optimized for EIC

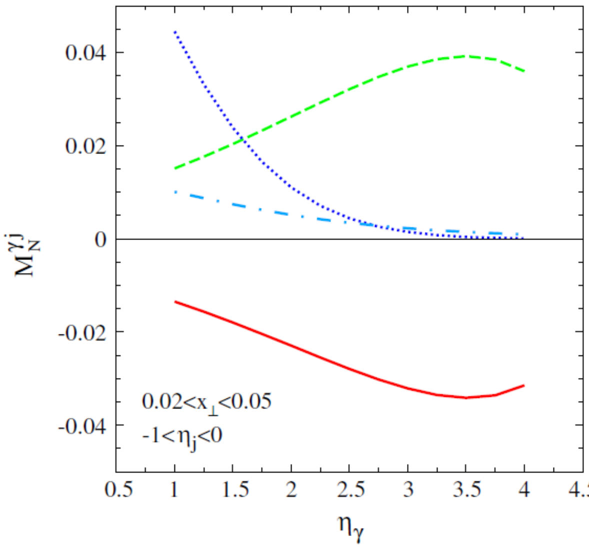
Spin Physics with sPHENIX

A_N of DY at forward rapdity

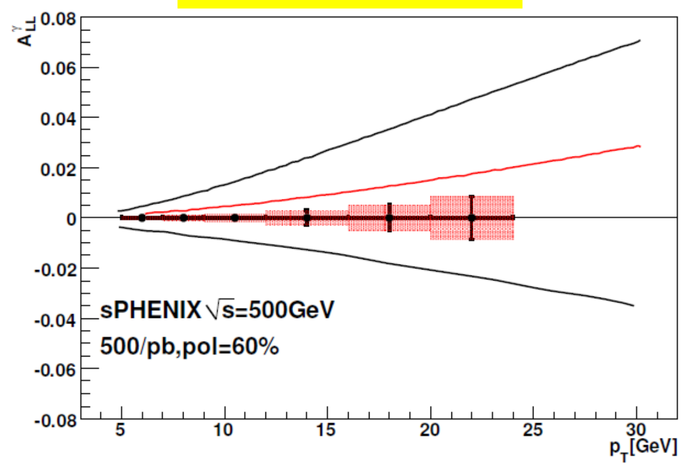




γ-jet transverse spin moment



A_{LL} of Direct γ



Forward Physics Objectives

- Transverse spin phenomena
  - Kinematics high x_f, high rapidity $|\eta| > 2$
  - Drell-Yan test QCD prediction for Sivers btwn SIDIS and DY
  - Separate Sivers and Collins and do a flavor separation for the PDFs
    - p^0-jet, γ – jet, IFF for identified hadrons,
    - jet A_N, direct photon
- Longitudinal spin phenomena
  - high rapidity $|\eta| > 2$ → extend x coverage for ΔG and Δq
- Drell-Yan in dAu
  - Measure quark distributions in nuclei
  - Possible access to quark saturation
- EIC physics
  - Measure polarized and unpolarized inclusive structure functions in ep / eA (F_2, F_L, F_3, g_1, g_2, g_5)
  - "Diffractive physics" (DVCS, etc.)

eRHIC Physics

eA (5 GeV e x 130A GeV HI to 30 GeV x 130AGeV)

- Saturation Physics, CGC

  eRHIC proved deep inside the saturation region
- Gluon density $G(x,Q^2,b)$ in nuclei

  b: impact parameter. 3D picture of PDF
- Parton fragmentation in nuclei

  hadron formation and energy loss in Cold Nuclear matter

ep (5 GeV e x 325 GeV p to 30 GeV e x 325 GeV p)

- Polarized PDF

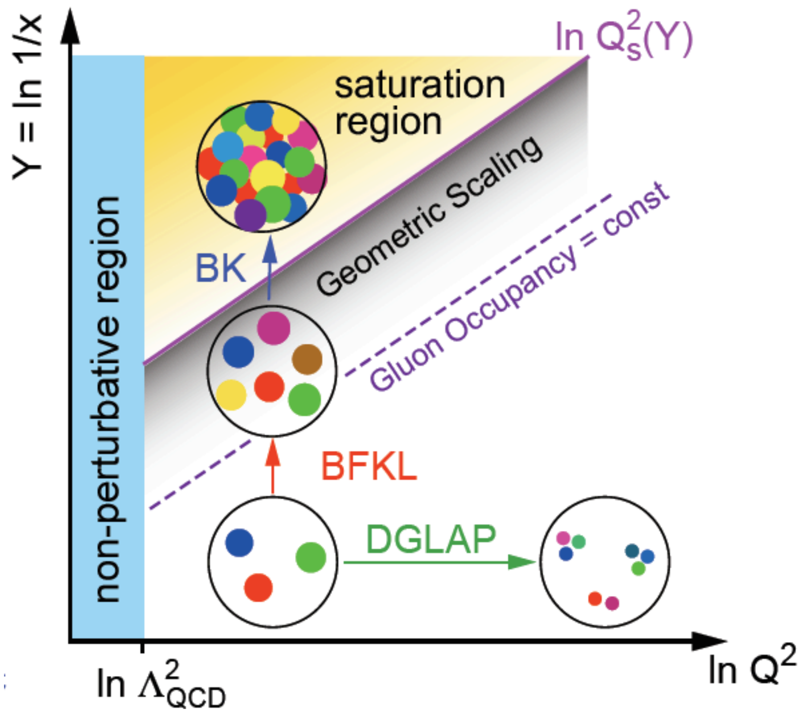
  $\Delta G(x)$, $\Delta u(x)$, $\Delta d(x)$ at small x
- Parton Angular Momentum distribution

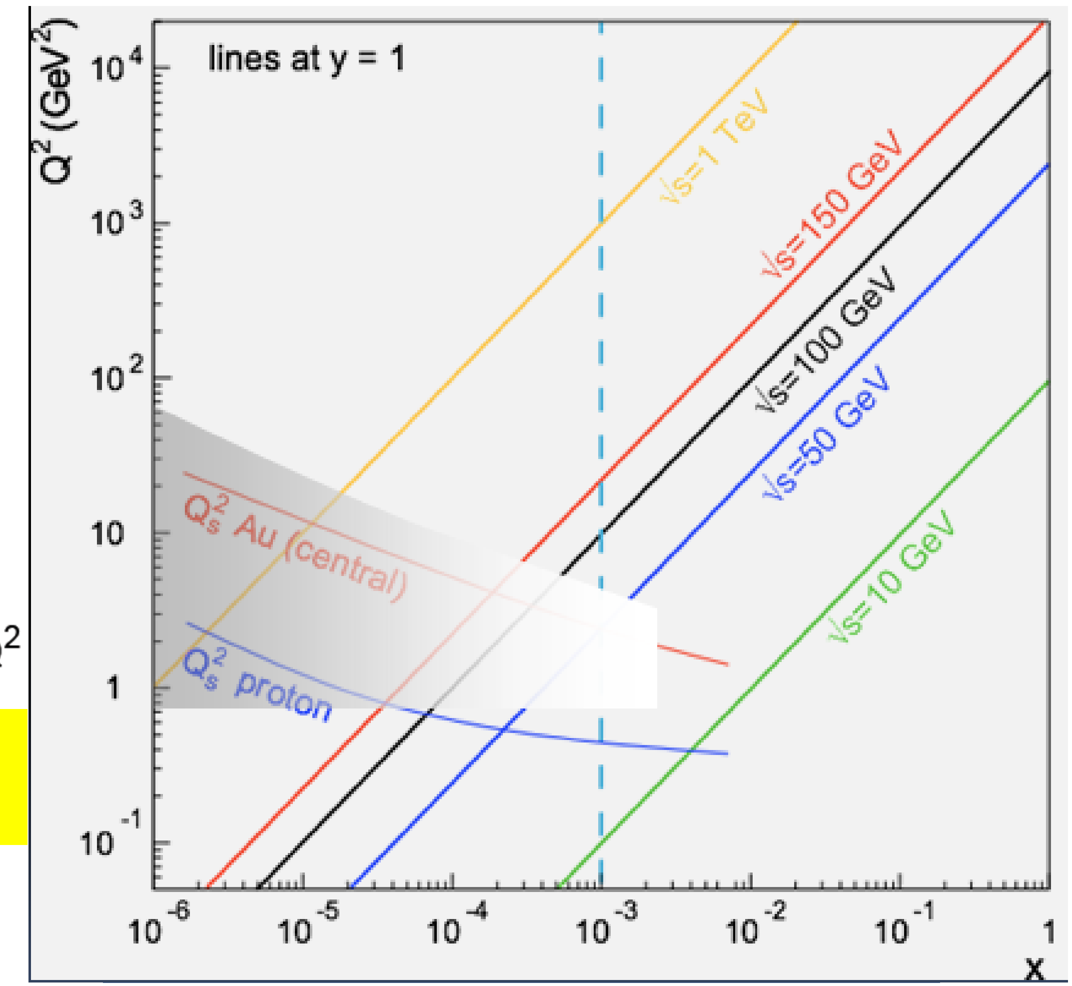
  GPD, DVCS
- TMD

  $q(x,kT,Q^2)$ from SIDIS and charm production

Parton Saturation

At eRHIC, saturation should be achieved
5 (30) x130 GeV → $s^{1/2}$ = 51 (125) GeV

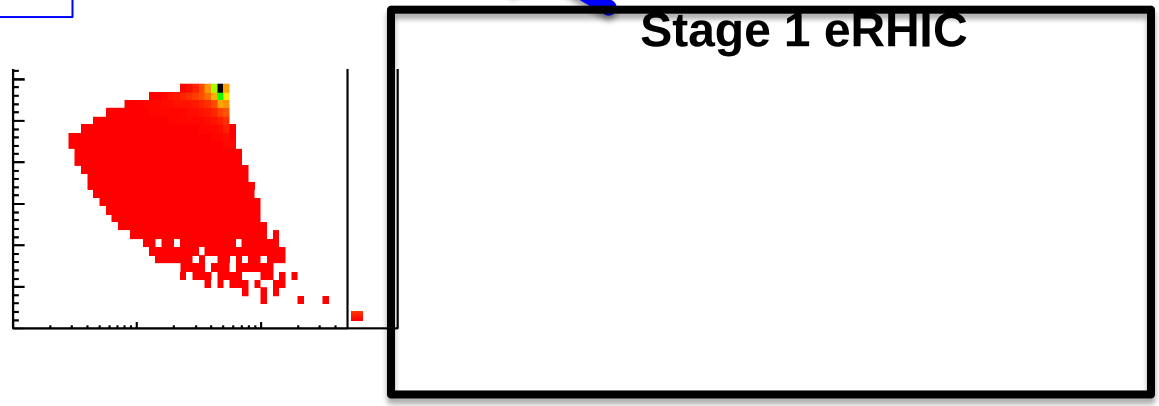


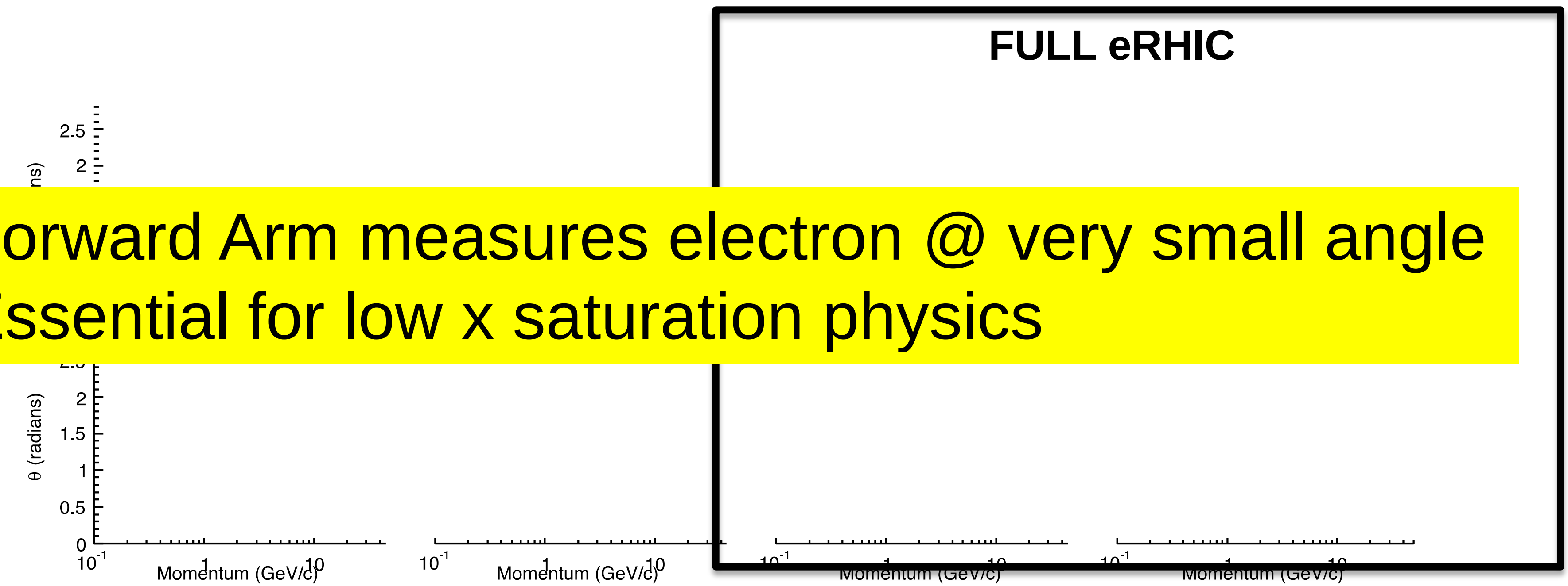


At Small x, saturation must set in when gluons start overlapping

Where does the electron go?

$Q^2 > 1$ GeV^2 & $0.01 < y < 0.9$





Forward Arm measures electron @ very small angle
Essential for low x saturation physics

Summary

Mid-term (2011 – 2015+)

Harvest physics from PHENIX upgrades and RHIC performance increase

- W measurements at 500 GeV
- VTX & FVTX → Heavy quark physics in Heavy ion and Spin

Beyond 2015+

- Address compelling new questions by a substantial upgrade

Compact Jet detector

characterize energy loss mechanism

characterize property of QGP

Large acceptance J/ψ and Y

study Debye screening of QGP

Forward detector

Large y coverage to study QGP

Cold Nuclear Matter effects

First eRHIC detector to study gluon saturation effects