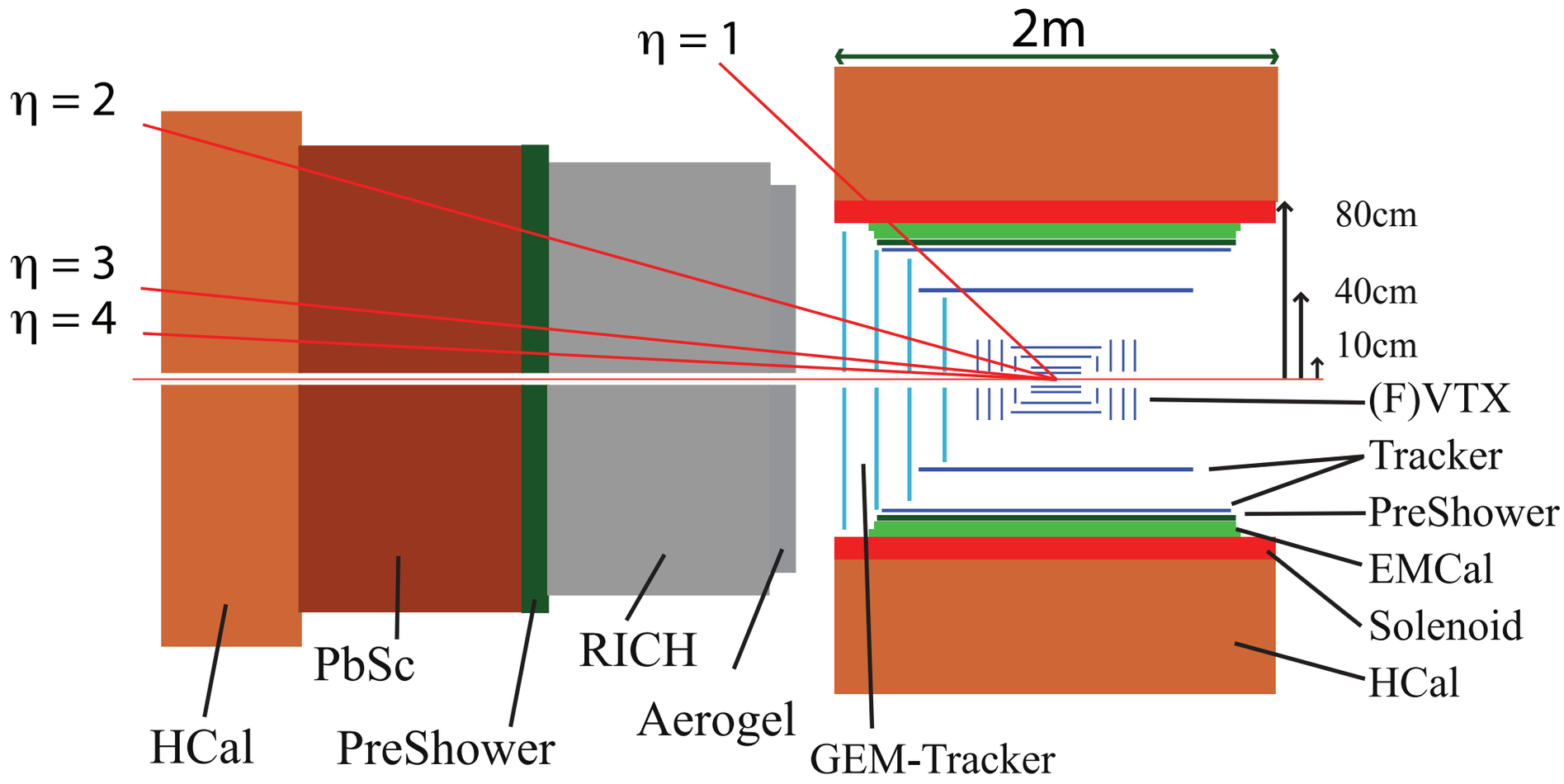
Overview of the PHENIX Decadal Plan



PHENIX R&D Workshop

November 2003

PHENIX Experiment at RHIC:
Decadal Plan 2004-2013

Brookhaven National Laboratory

Relativistic Heavy Ion Collidier

November, 2003

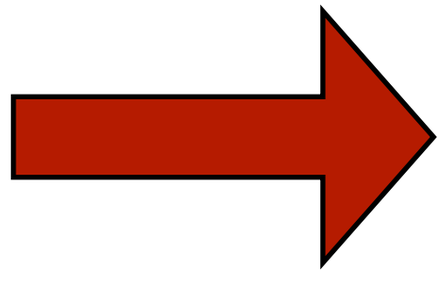
PHENIX

Spokesperson: William A. Zajc, *Columbia University*

Deputy Spokesperson: Glenn R. Young, *Oak Ridge National Laboratory*

Operations Manager: Edward O'Brien, *Brookhaven National Laboratory*

Upgrades Manager: Axel Drees, *Stony Brook University*



HBD
VTX
FVTX

October 2010

The PHENIX Experiment at RHIC

Decadal Plan 2011–2020

Brookhaven National Laboratory

Relativistic Heavy Ion Collider

October, 2010

PHENIX

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*

next 5 years

5++ years

PHENIX Collaboration Meeting (August 5th 2009)

bnl.gov https://www.phenix.bnl.gov/cdsagenda//fullAgend

MacRumors : Mac ... Phoronix JLC-Online Forum... arXiv xn

CDS Agendas - Browse | PHENIX Collaboration Meetin...

[CDS Agenda System v4.2.9] [Tools] [Change View] [Modify] [User] [Go To] Style: Standard Meeting (multi sessions) | full display | all days | [Help]

PHENIX Collaboration Meeting

Date/Time: from Wednesday 05 August 2009 (09:00) to Friday 07 August 2009 (18:00)

Location: BNL

Room: Large Seminar Room

Chair: B.Jacak,Y.Akiba,M.GrossePerdekamp,R.Seto,B.Johnson

Description: *NOTE: This is a draft and very preliminary agenda with only a few speaker names assigned. Everything here now is subject to change.*

[last update: Friday 21 August 2009]

Wednesday 05 August 2009 09:00->12:30	A. Exciting Physics for the Next Decade of PHENIX (Large Seminar Room)	Barbara Jacak
Wednesday 05 August 2009 11:30->12:30	B. Exciting Physics for the Next Decade in PHENIX (Large Seminar Room)	Rich Seto
Wednesday 05 August 2009 14:30->16:45	C. Exciting Physics for the Next Decade in PHENIX (Large Seminar Room)	John Haggerty
Wednesday 05 August 2009 16:45->18:00	D. New Idea Flash Talks (Large Seminar Room)	Barbara Jacak (SBU Physics)
Thursday 06 August 2009 09:00->12:30	E. Upgrades I: Operating and Under Construction (Large Seminar Room)	Ed O'Brien
Thursday 06 August 2009 13:30->17:30	F. Upgrades II: Under Development and New Ideas (Large Seminar Room)	Yasuyuki Akiba (RIKEN)
Friday 07 August 2009 09:00->10:30	G. Preliminary Data Presentation and Flash Talks (Large Seminar Room)	Barbara Jacak
Friday 07 August 2009 10:30->12:00	H. PHENIX Institutional Board Meeting (90 min.) (Large Seminar Room)	Barbara Jacak
Friday 07 August 2009 13:30->18:00	I. Analysis Outlook and Student Talks (Large Seminar Room)	Brant Johnson

August 2009

Done

Now: 41°F Tue: 34°F Wed: 35°F

From: Vigdor, Steven <vigdor@bnl.gov>
Date: Wed, Dec 16, 2009 at 6:44 PM
Subject: Charge for new decadal plans for STAR and PHENIX
To: Barbara Jacak <jacak@skipper.physics.sunysb.edu>, Nu Xu <nxu@lbl.gov>

Dear Barbara and Nu,

As we have discussed in Spokesperson's Meetings, I am herein charging the PHENIX and STAR Collaborations with generating new decadal plans that lay out your proposed science goals and detector upgrade paths for the period 2011-2020. The decadal plans generated in 2003 have been extremely useful for RHIC and both experiments. Now that we have received (or are on the verge of receiving) funding to carry out most of the upgrades described in those earlier reports, it is timely to develop a clear roadmap for what comes next. With current funding profile guidance from DOE, it appears that the STAR Heavy Flavor Tracker may be completed in FY2015, and the suite of significant PHENIX upgrades are likely to be completed sooner. We also anticipate that the various RHIC machine luminosity upgrades under way (six planes of stochastic cooling, 56 MHz SRF rebunching, electron lenses) or contemplated (low-energy electron cooling) will be completed by 2015. Not unexpectedly, then, we are being asked by DOE what plans we have for RHIC beyond 2015.

• • •

1. What science will the current upgrades do?

2. Compelling science (beyond #1) to be done at RHIC?

3. Upgrades and R&D required for #2?

4. Can your future detector do EIC physics?

5. How will the Collaboration evolve?

Are quarks strongly coupled to the QGP at all distance scales?

What are the detailed mechanisms for parton-QGP interactions and responses?

Are there quasiparticles at any scale?

Is there a relevant screening length in the QGP?

How is rapid equilibration achieved?

What is the nature of the spin of the proton?
How can we describe the multidimensional landscape of nucleons?
How do quarks and gluons hadronize into final-state particles?

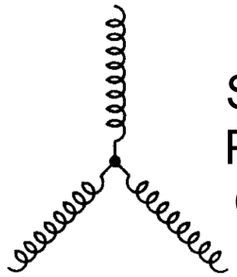
Constrain the flavor-separated sea quark helicity distributions via W measurements in longitudinally polarized p+p collisions at $\sqrt{s}$ = 500 GeV.
Probe $\Delta g(x)$ down to lower momentum fractions in longitudinally polarized p+p collisions at $\sqrt{s}$ = 500 GeV.
Explore several transverse spin measurements in transversely polarized p+p collisions at $\sqrt{s}$ = 200 GeV and at lower energies.

Dynamical Origins of Spin-Dependent Interactions
New Probes of Longitudinal Spin Effects
Measurements with Polarized ^{3}He and Increased Energies

Probe Integrates Over a Range of Q^2

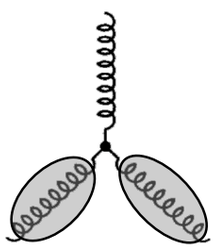
Q^2

P_T Initial Parton



pQCD Scattering from Point-Like Bare Color Charges

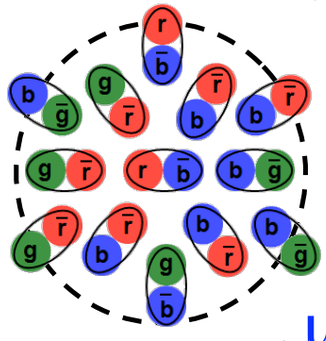
What scale sets this transition?



Scattering from Thermal Mass Gluons?

What scale sets this transition?

pQCD Scattering From Quasiparticles with size ~ μ_{Debye}

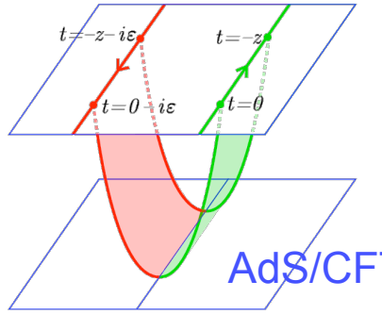


?→

← ?

Strong Coupling No Quasiparticles

$\mu_{Debye} \rightarrow 0$



T_c

W. Horowitz

complementarity of RHIC and LHC

A number of strengths of the RHIC physics program and the complementary role of the LHC are itemized here and then a detailed discussion of each follows.

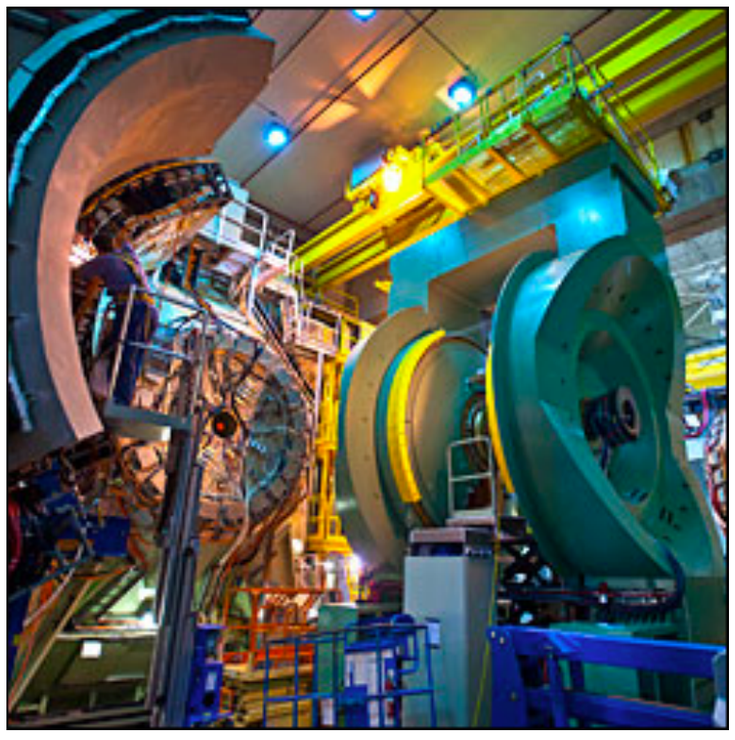
- sQGP created at RHIC is optimal for *strongly coupled* studies. Whether the medium at the LHC is strongly or weakly coupled remains to be determined experimentally.
- RHIC is a powerful and flexible facility that will allow us to *dial* the medium properties via colliding different nuclear species, colliding at different energies, and comparison with critical baseline p+p and proton(deuteron)-nucleus collisions at the same $\sqrt{s_{NN}}$.
- RHIC experiments will measure jets with energies $15 < E_T < 60$ GeV thus spanning a large range of scales in the medium as shown in Figure 3.3.
- RHIC collisions are dominated by quark jets over a wide E_T range. In a complementary way, LHC has a majority contribution from gluon jets.
- RHIC experiments have shown that cold nuclear matter initial state effects are modest at midrapidity for $p_T > 2\,\mathrm{GeV}/c$ and can be separated from jet quenching effects.
- PHENIX and an upgraded PHENIX can sample a very large Au+Au luminosity with minimum bias triggers, which is crucial for lower energy jet studies and understanding calorimeter trigger biases for higher energy jet studies.

Brookhaven Lab Ranked No. 1 for Hadron Collider Research

Atom-smashing experiments at Relativistic Heavy Ion Collider yield 4 of top-5 most-cited scientific papers

Friday, December 10, 2010

UPTON, NY — The U.S. Department of Energy's (DOE) Brookhaven National Laboratory has been named the number one institution in the world for hadron collider research — research that explores the very earliest moments of the universe, the most fundamental particles of matter, and the forces through which they interact by colliding particles such as protons and heavy ions at very high energies.



PHENIX Detector

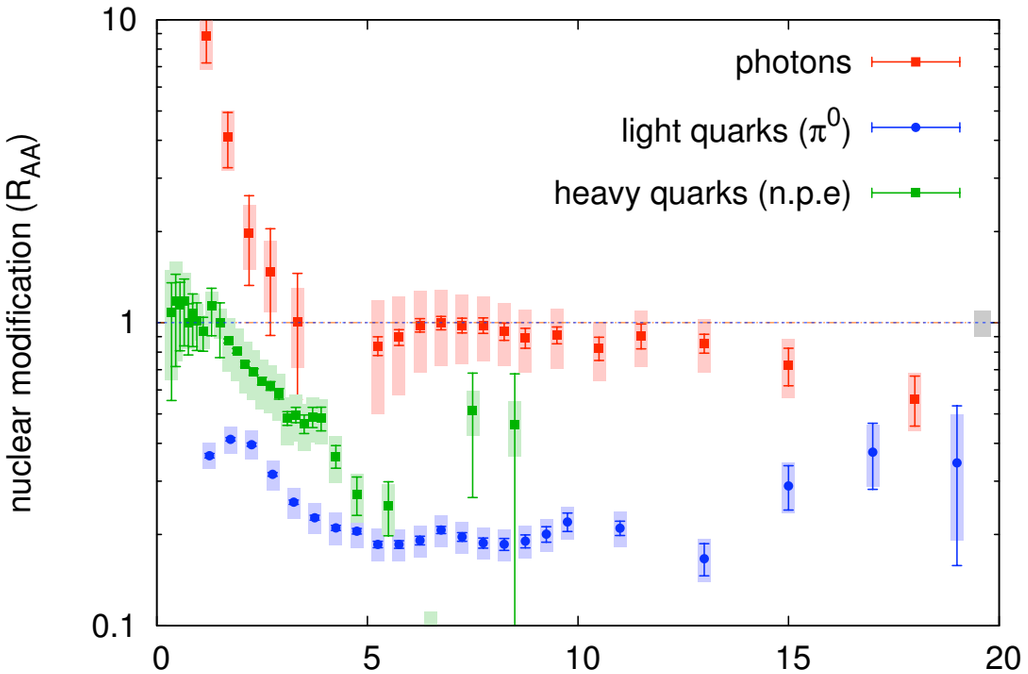
+ENLARGE

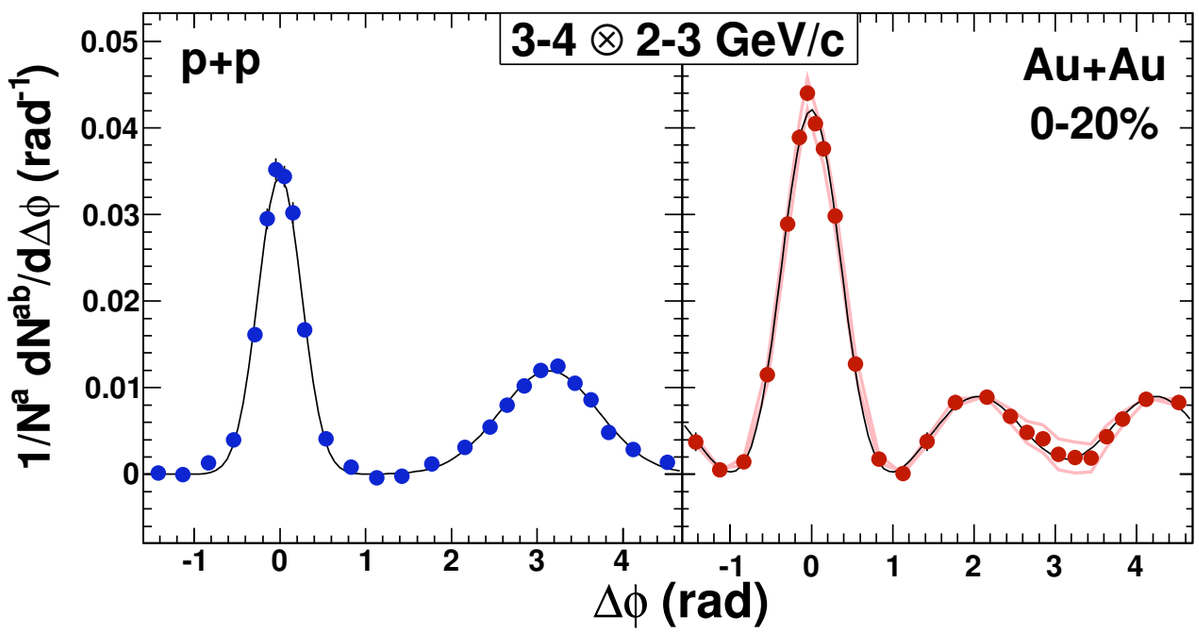
The ranking, compiled by ScienceWatch.com based on number of citations of scientific papers, notes that the list of top "hadron collider" papers over the past decade "is dominated by the physics from RHIC" — Brookhaven's Relativistic Heavy Ion Collider, where collisions of gold ions have produced a seething quark-gluon plasma 250,000 times hotter than the center of the sun. Four of the top-five papers describe research at RHIC that revealed the surprising liquid nature of the early universe.

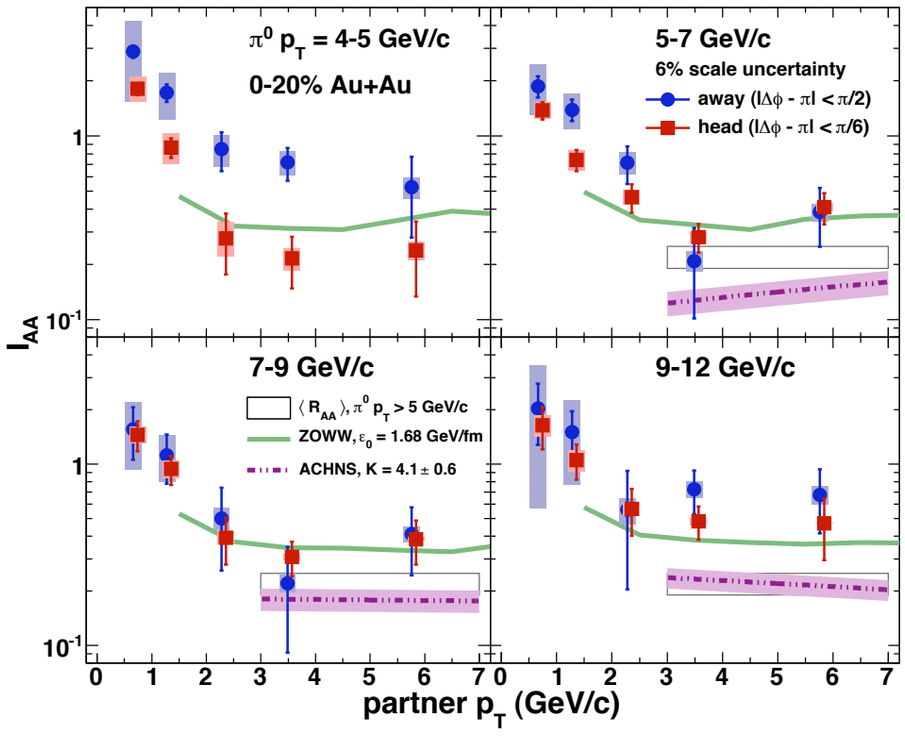
"RHIC has been an incredibly productive facility since it began colliding ions in 2000, with more than 300 scientific publications to date," said Steven Vigdor, Brookhaven's Associate Laboratory Director for Nuclear and Particle Physics. "As a dedicated facility for nuclear physics research with the ability to collide a wide range of ions — as well as a unique ability to collide polarized protons — RHIC will continue to be a leader in this field for many years to come."

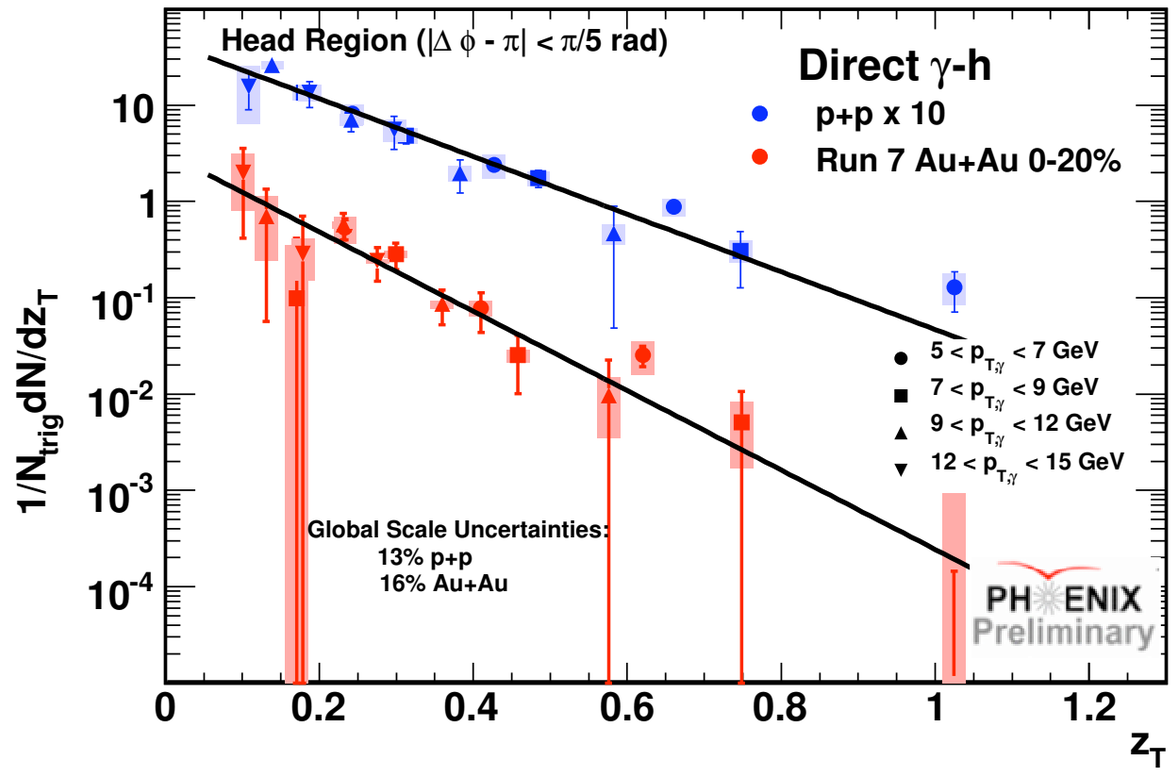
http://sciencewatch.com/ana/st/hadron/

We have learned many things from leading hadrons ...

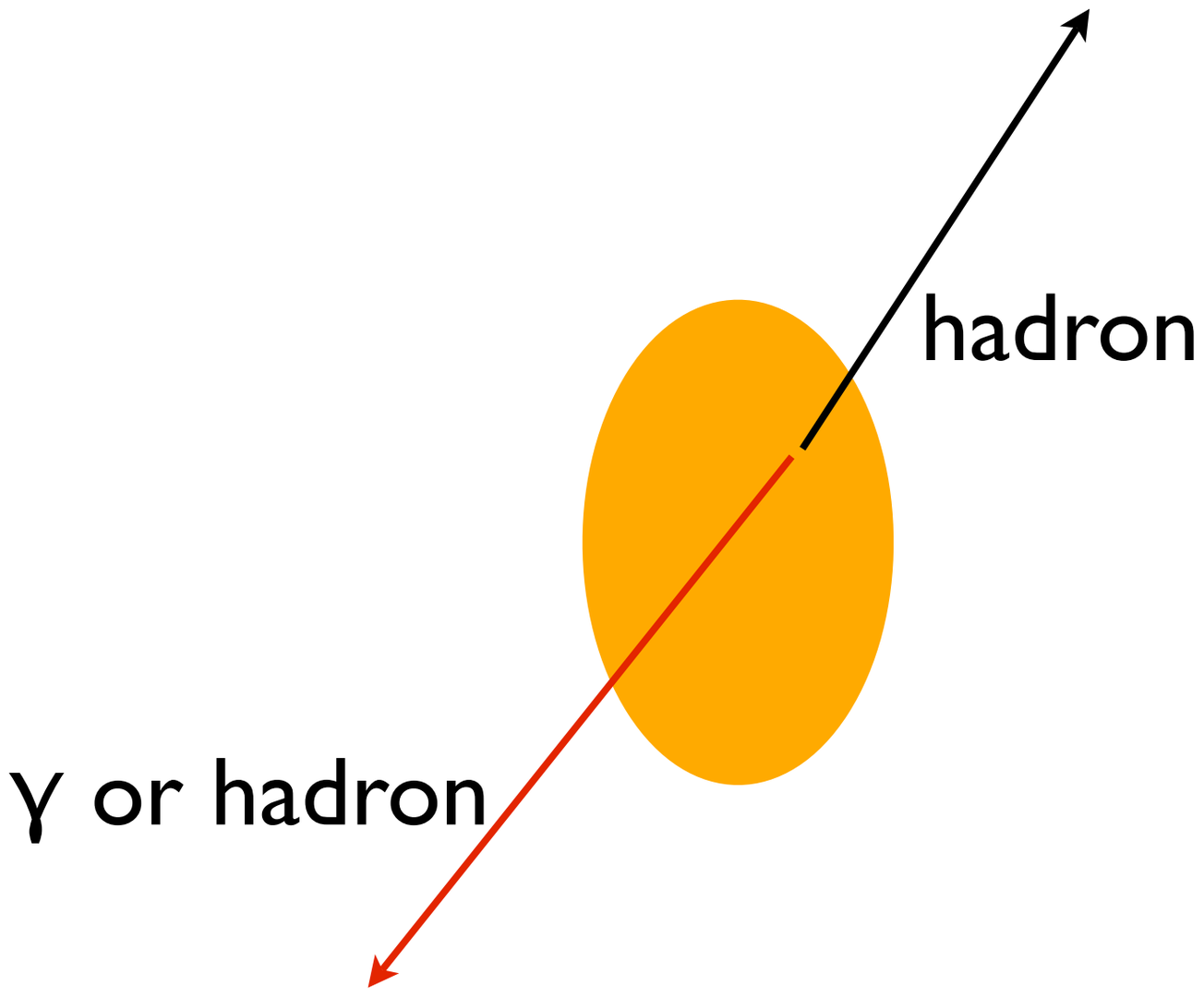








... but leading hadron studies do have their limits



surface bias, fluctuations from (modified?) fragmentation, bias toward high z fragmentation, increasing backgrounds for high p_T tracks, etc

What's needed?

- Establish length dependence of energy loss.
- Establish energy dependence of energy loss.
- Measure medium modification of angular and momentum distribution of radiated energy.
- Measure quark mass dependence of energy loss.

- Many opportunities at RHIC and LHC:
  - Tagged jets (energy, flavor)
  - Angle dependence
  - System size dependence
  - Fully reconstructed jets
- A world-class jet detector at RHIC is needed

B. Mueller, Hard Probes 2010

RPC3

South Muon Magnet

Central Magnet

North Muon Magnet

RPC3

MPC

BBC

ZDC South

ZDC North

MuID

VTX

MuID

10.9 m = 36 ft

MuTr

South

Side View

North

RPC3

RPC3

North Muon Magnet

RICH

PbSc

η = 1

η = 2

η = 3

η = 4

2m

80cm

40cm

10cm

(F)VTX

Tracker

PreShower

EMCal

Solenoid

HCal

ZDC South

ZDC North

MuID

MuID

PreShower

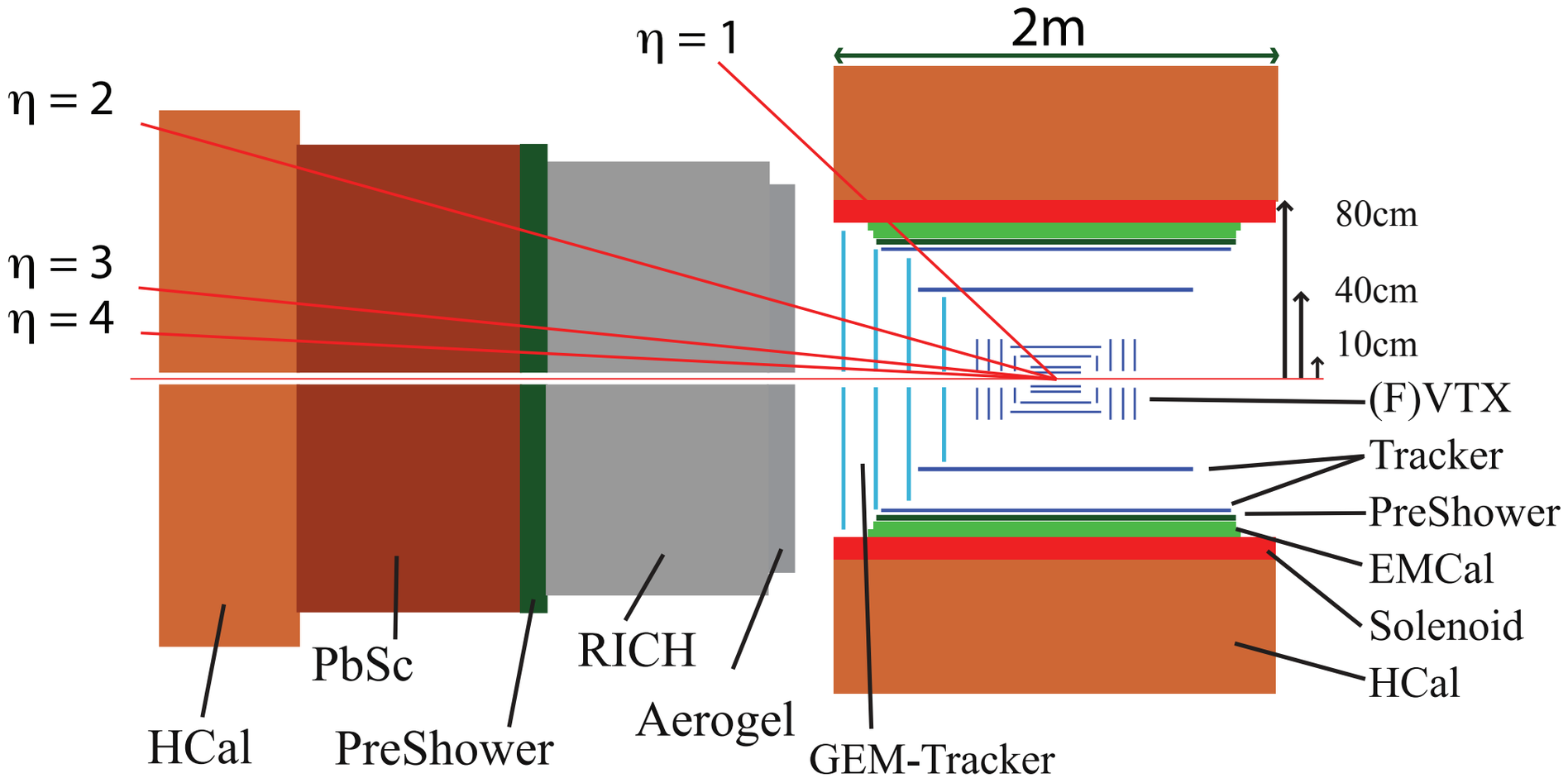
HCal

Aerogel

Side View

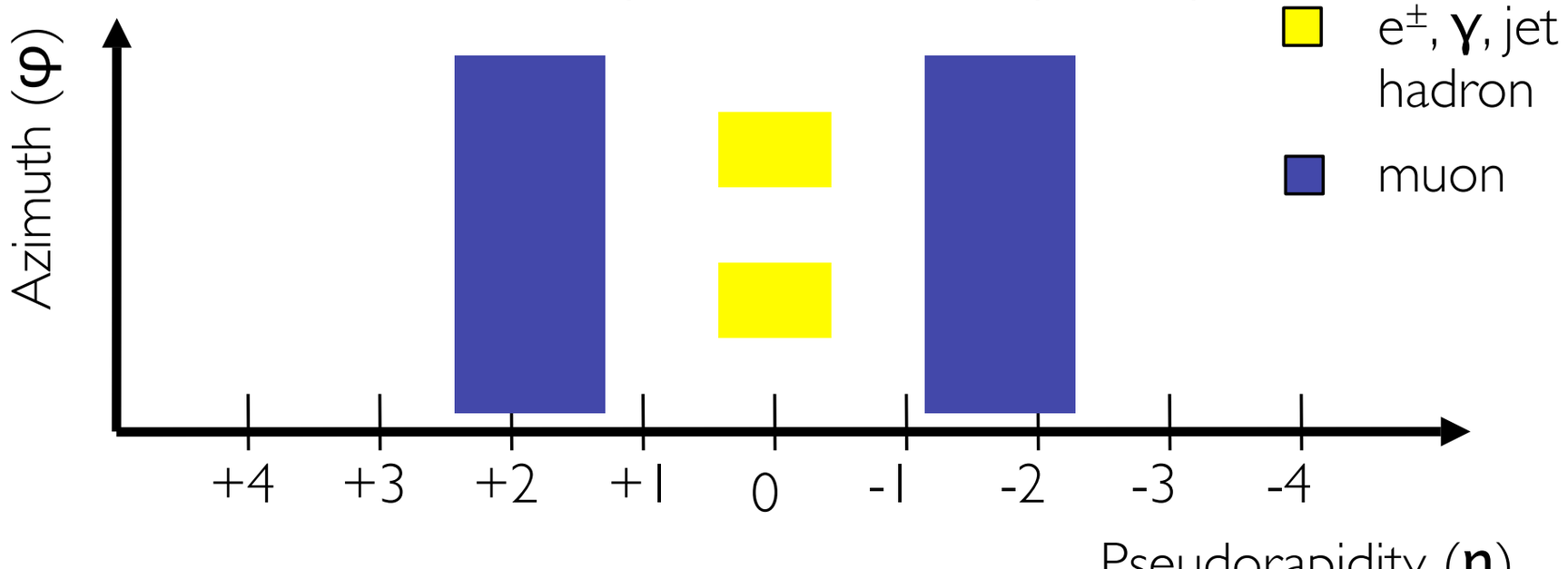
North

sPHENIX strawman

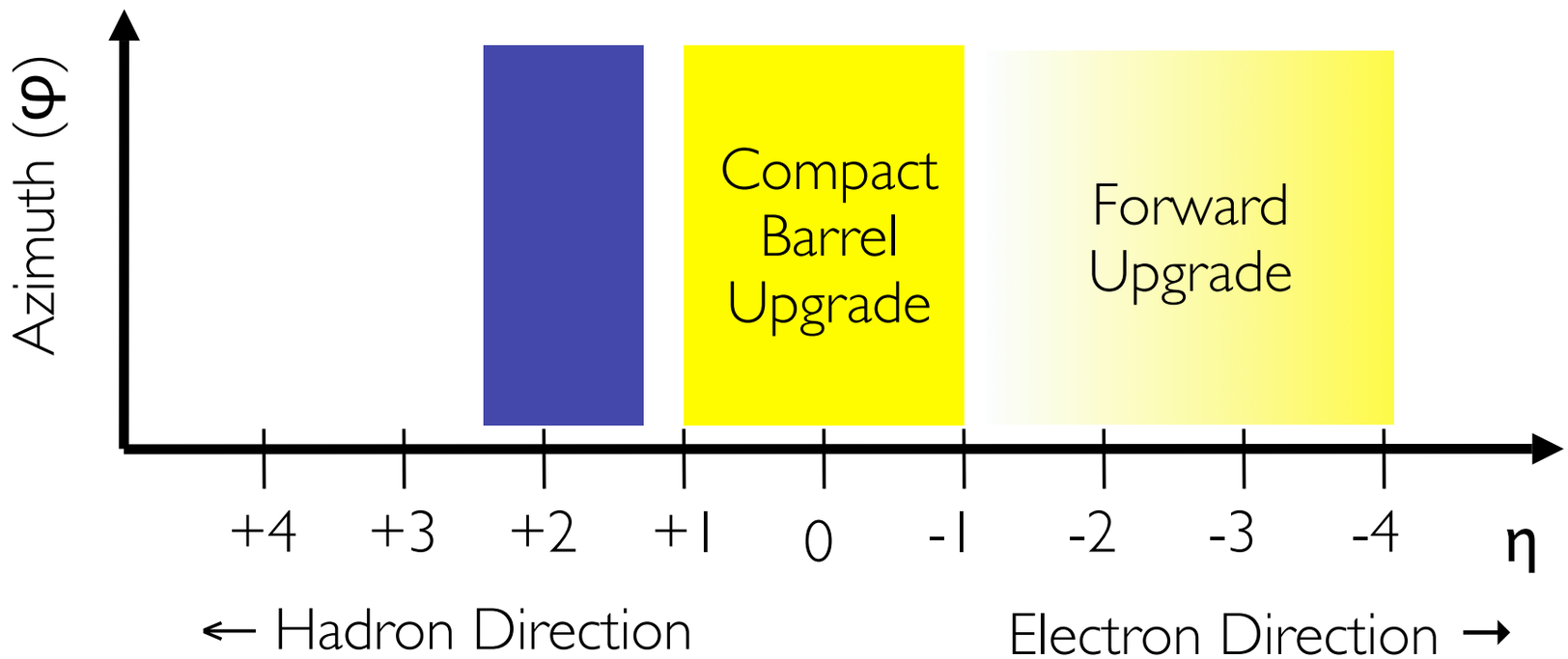


dimensions, technology, additional capabilities still under investigation

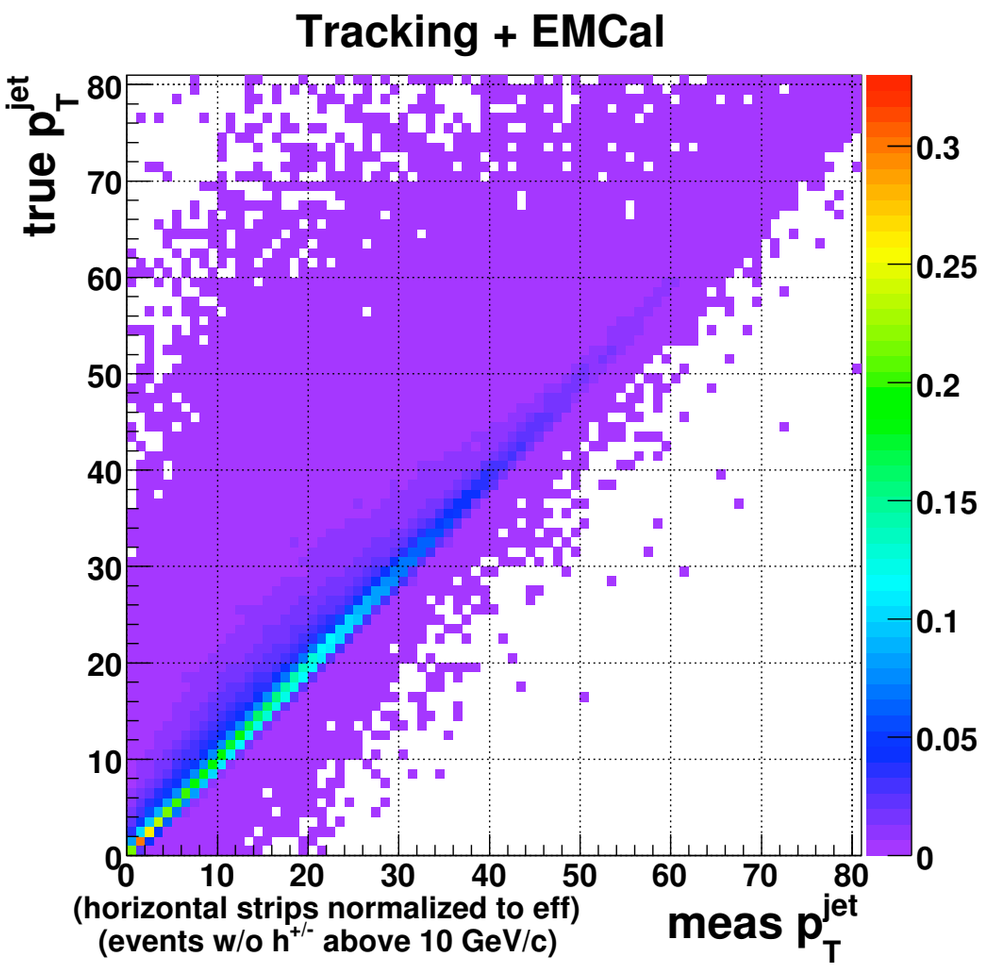
PHENIX Spectrometer (2010)

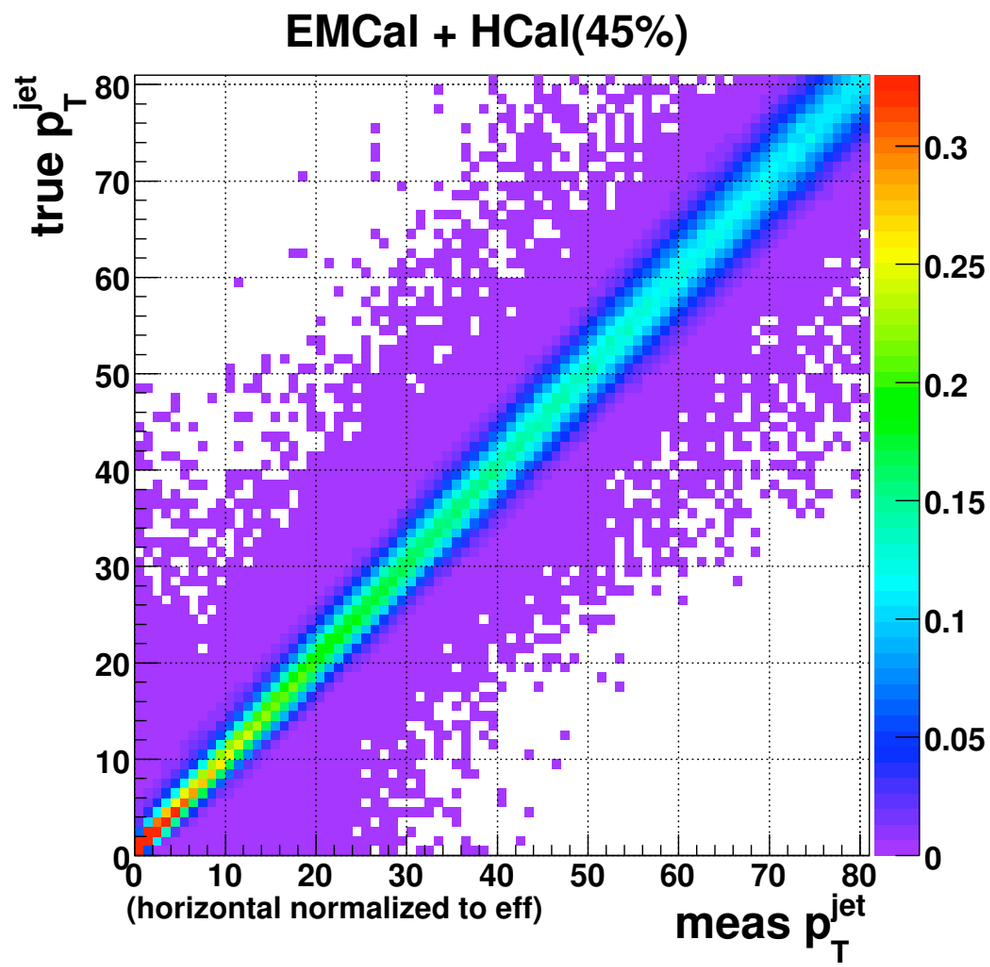


sPHENIX Upgrade



hadronic calorimetry tightens correlation between measured and true jet energy

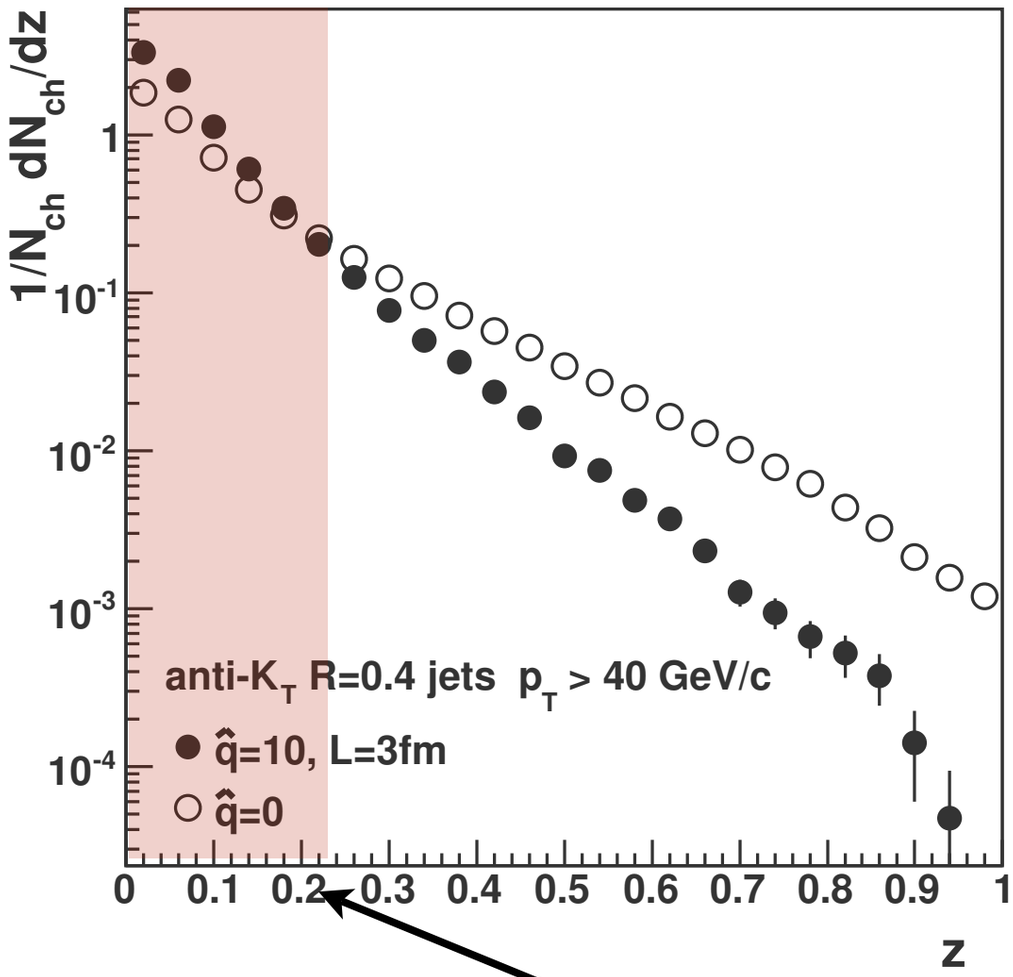


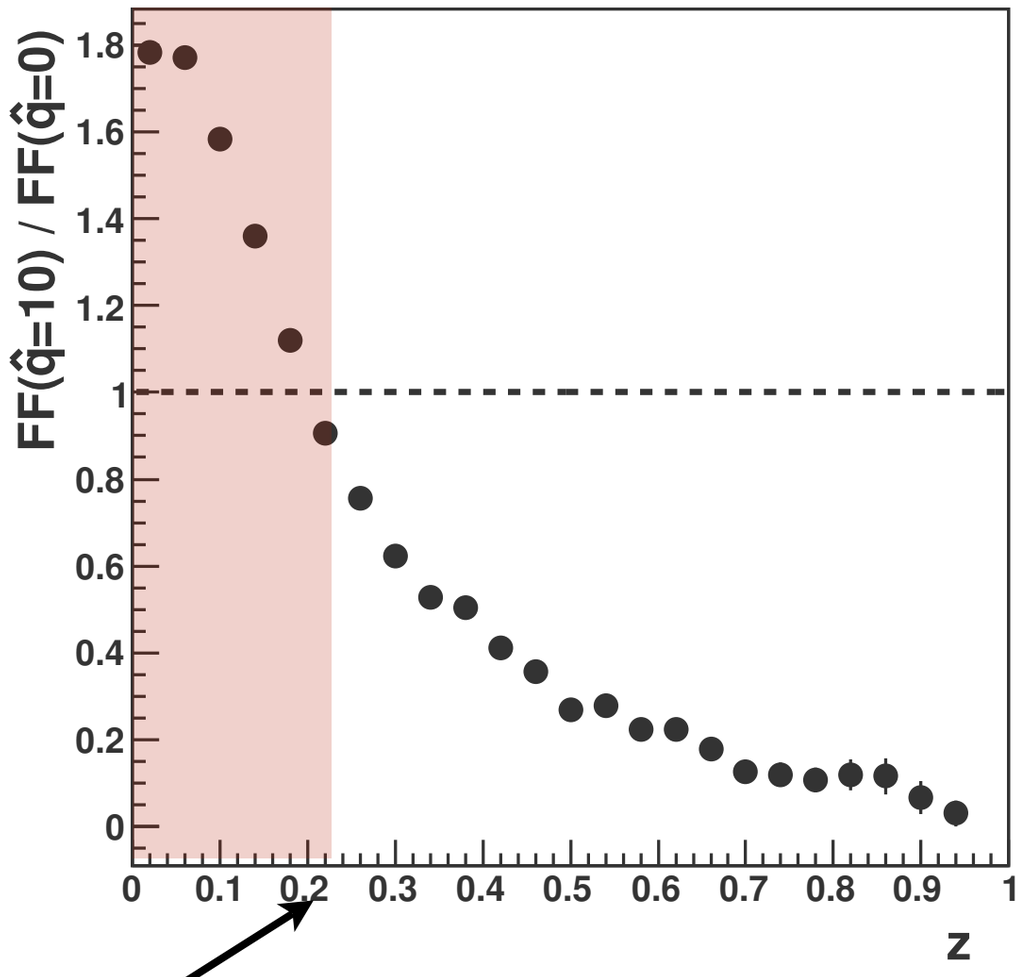


– reduced high p_T background

– catch neutral energy

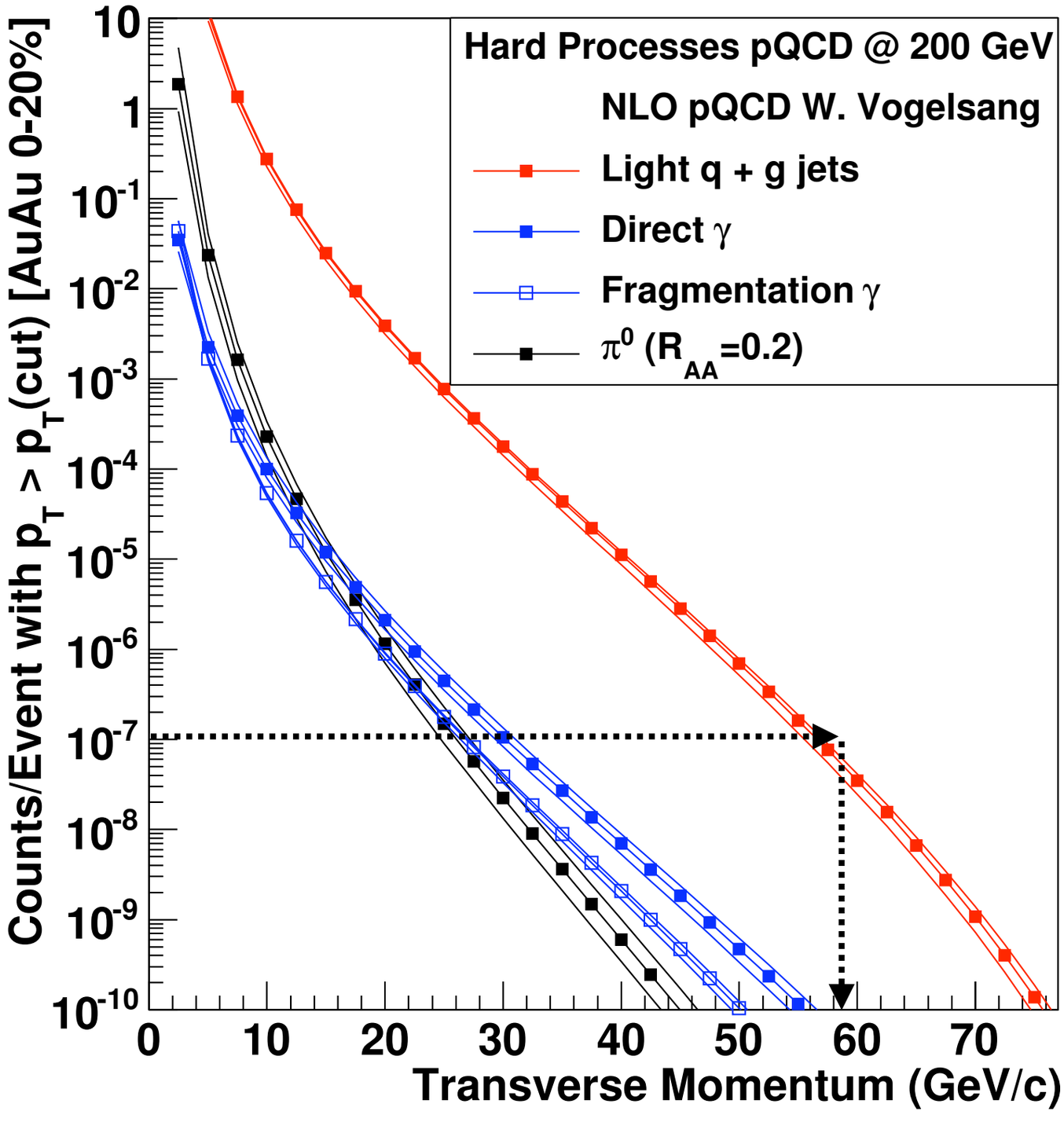
hadronic calorimetry ⇒ ability to study modifications of fragmentation functions to high *z*





limit of *z*-reach if rejecting tracks over 10 GeV/c

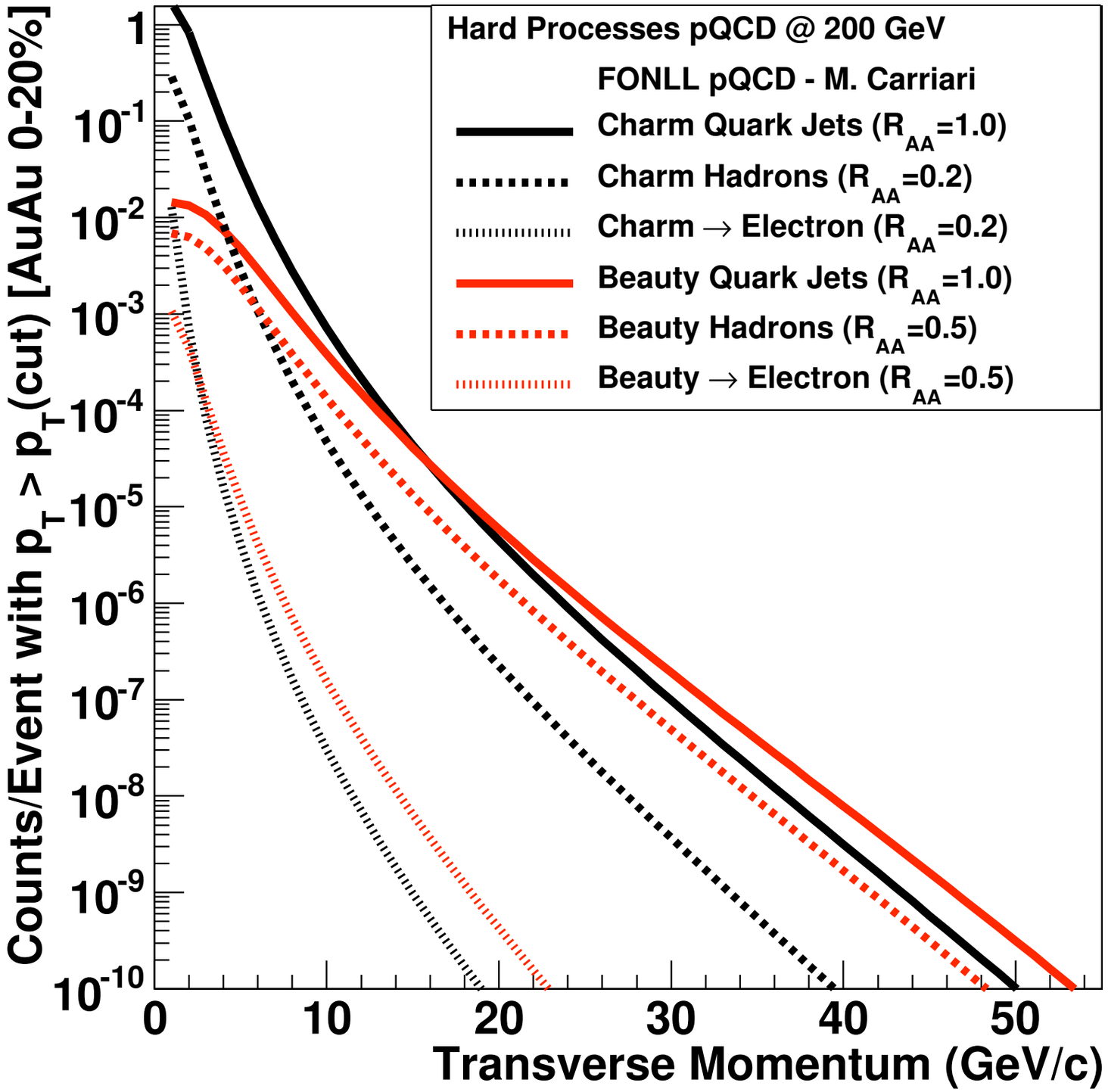
jet, photon, and π^0 rates in $|\eta| < 1$



(50x10^9 events $\Rightarrow$ 10^{10} central events)

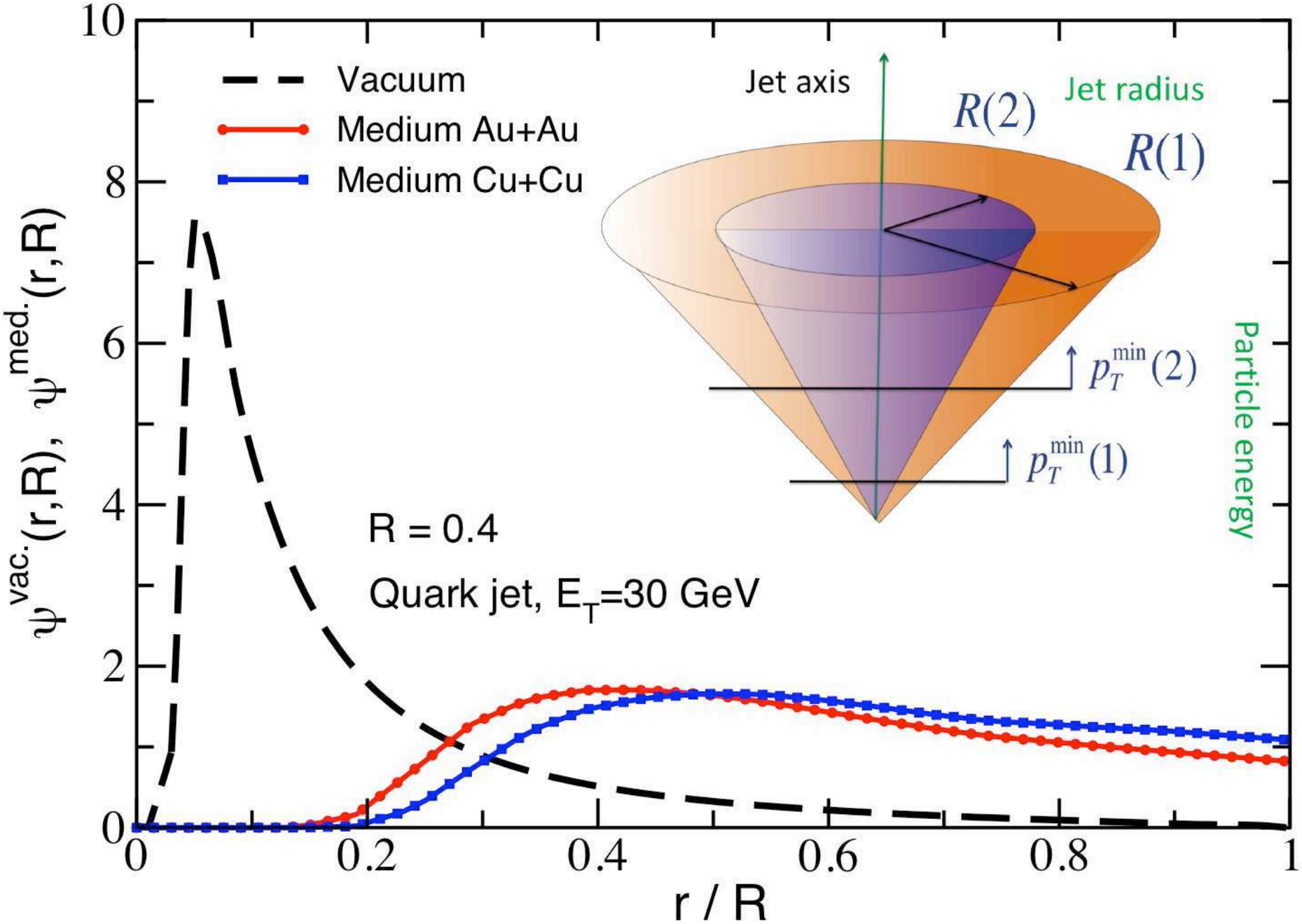
W. Vogelsang, private comm.

significant rates for heavy flavor tagged jets



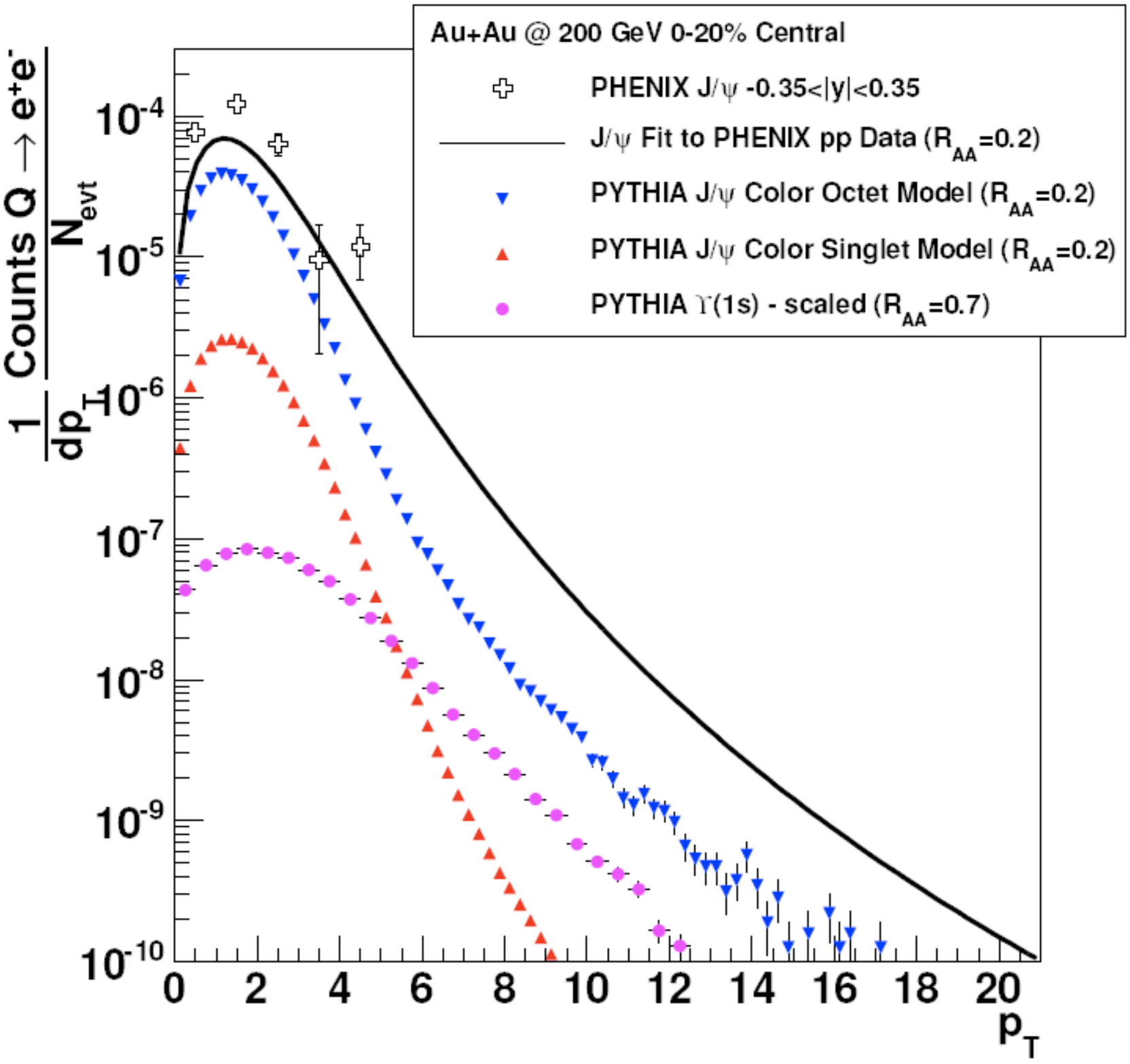
M. Cacciari, private comm.

one way to study the effect of the medium

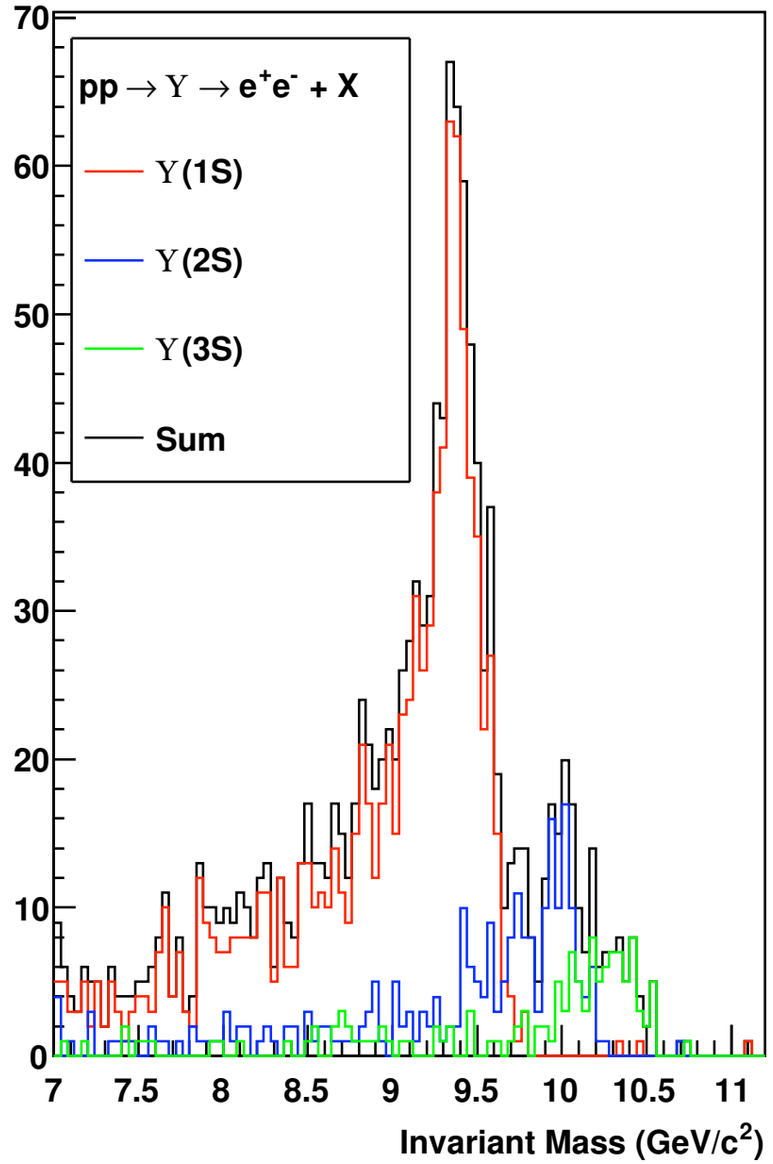


Vitev and Zhang, Phys. Rev. Lett., 104:132001, 2010

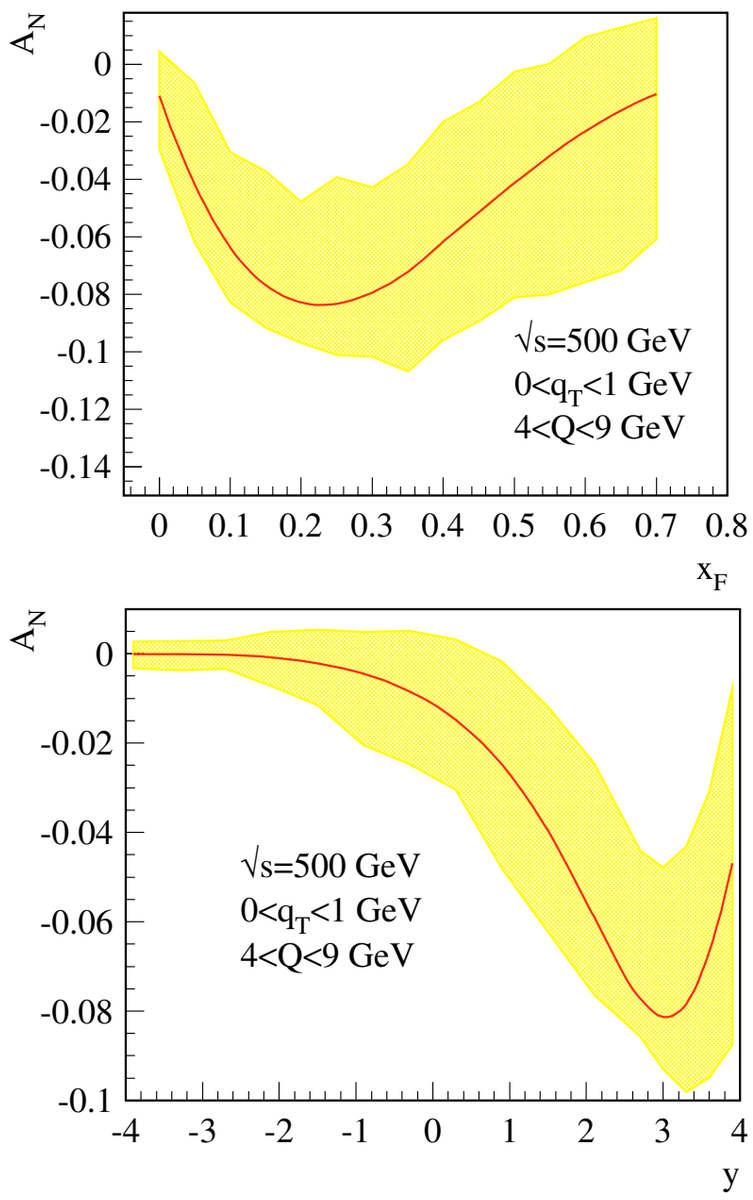
Quarkonia



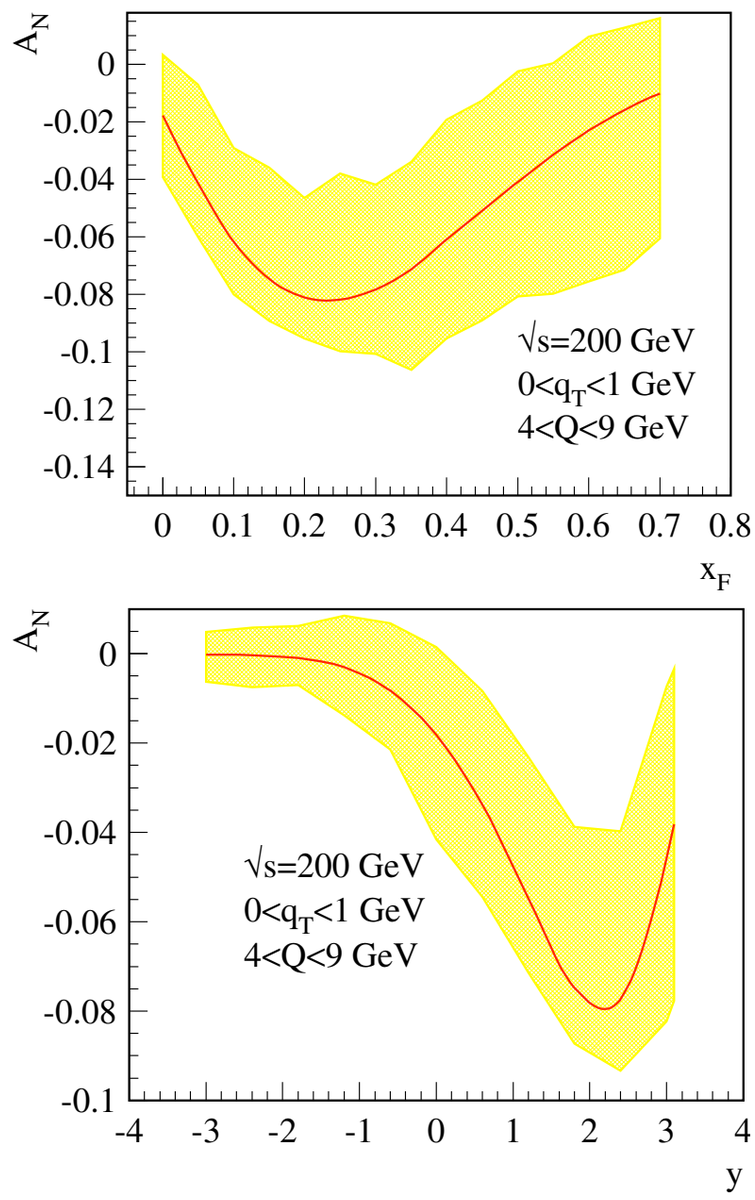
G4 studies of ϒ separation



500 GeV

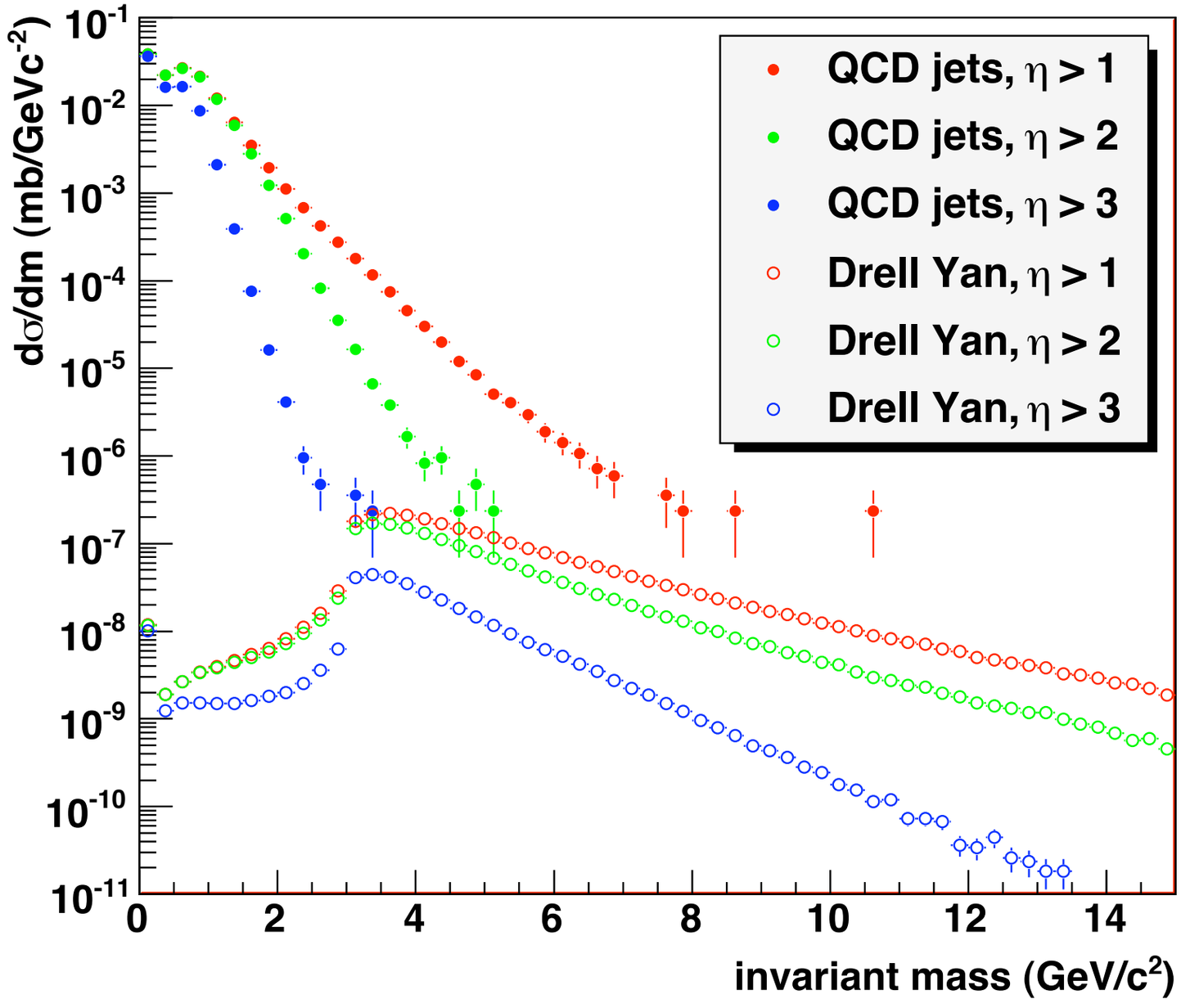


200 GeV

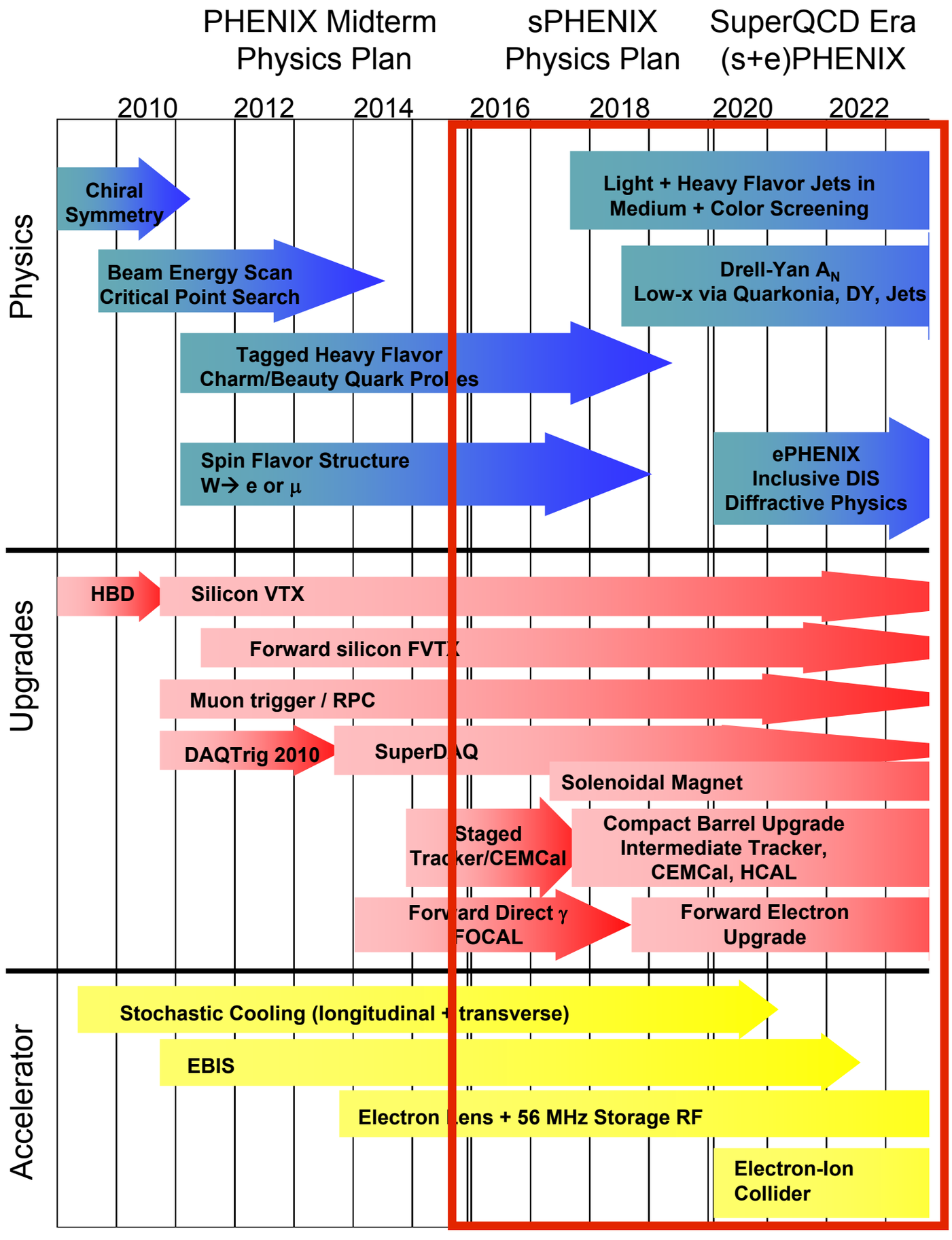


A_N via Drell-Yan

access to dynamical origin of spin



Drell-Yan begins to dominate for M_{ee} > 4 GeV


PHENIX Midterm Physics Plan
sPHENIX Physics Plan
SuperQCD Era (s+e)PHENIX
2010
2012
2014
2016
2018
2020
2022
Physics
Chiral Symmetry
Beam Energy Scan Critical Point Search
Tagged Heavy Flavor Charm/Beauty Quark Probes
Spin Flavor Structure W→ e or μ
Light + Heavy Flavor Jets in Medium + Color Screening
Drell-Yan A_N Low-x via Quarkonia, DY, Jets
ePHENIX Inclusive DIS Diffractive Physics
Upgrades
HBD
Silicon VTX
Forward silicon FVTX
Muon trigger / RPC
DAQTrig 2010
SuperDAQ
Solenoidal Magnet
Staged Tracker/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
Electron-Ion Collider

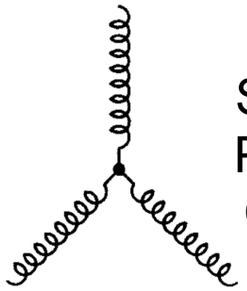
bring it all together

- Exciting near-term program driven by current upgrades: VTX, FVTX, MuTrig, DAQ2010
- Answering fundamental questions beyond that calls for qualitatively new capabilities
- "sPHENIX": compact, uniform detector
  - jets, quarkonia, γ-jet correlations, tagged jets
  - forward physics, spin, "0^{th} order" EIC detector
  - DAQ to record 25 billion Au+Au events/20wks
  - utilize projected RHIC luminosity
- PHENIX decadal plan: www.bnl.gov/npp

Probe Integrates Over a Range of Q^2

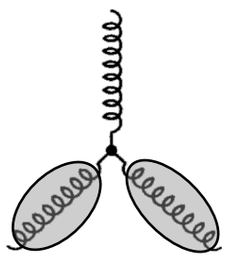
Q^2

P_T Initial Parton



pQCD Scattering from Point-Like Bare Color Charges

What scale sets this transition?



Scattering from Thermal Mass Gluons?

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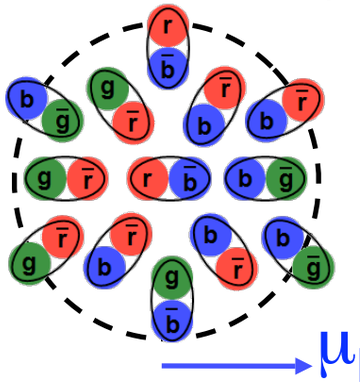
pQCD Scattering From Quasiparticles with size ~ μ_{Debye}



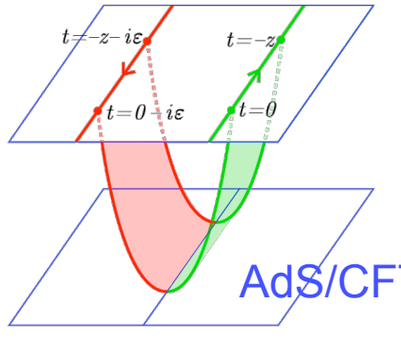
μ_D

?→

← ?

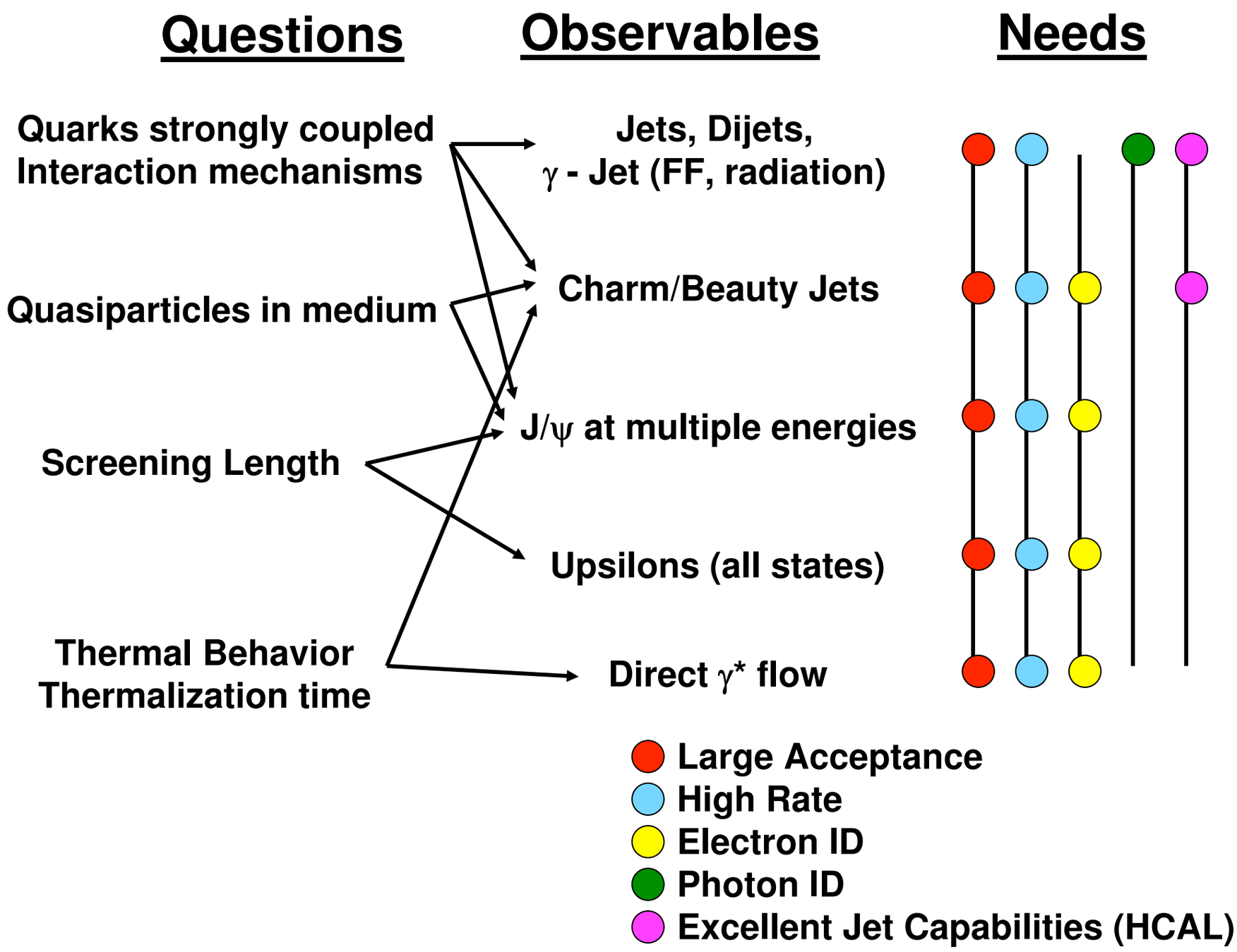
Strong Coupling No Quasiparticles

$\mu_{Debye} \rightarrow 0$



AdS/CFT

T_c


Questions
Observables
Needs
Quarks strongly coupled
Interaction mechanisms
Jets, Dijets,
γ - Jet (FF, radiation)
Quasiparticles in medium
Charm/Beauty Jets
Screening Length
J/ψ at multiple energies
Upsilons (all states)
Thermal Behavior
Thermalization time
Direct γ* flow
Large Acceptance
High Rate
Electron ID
Photon ID
Excellent Jet Capabilities (HCAL)