Decadal Planning in PHENIX

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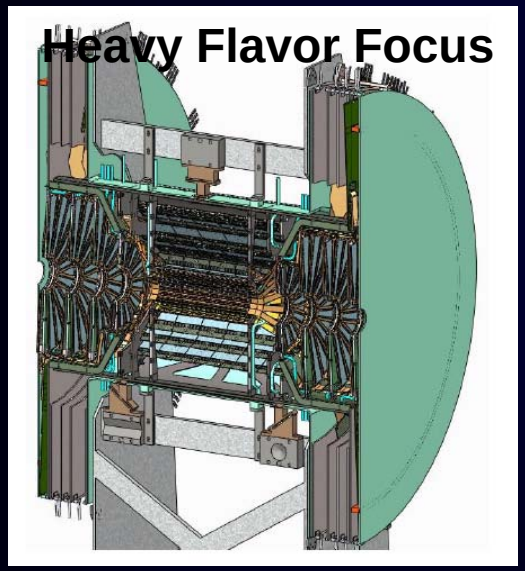
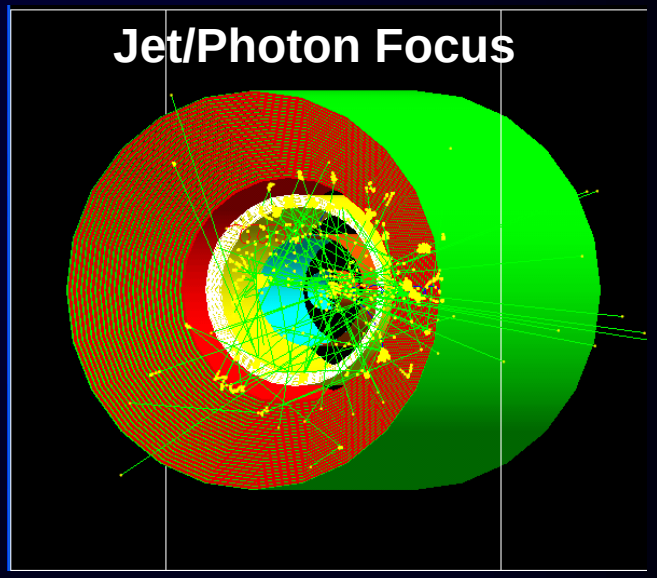
for the PHENIX Collaboration

What You Might Know (0-5 Years)



What You Don't Know (6-10 Years)



Saturation, the Color Glass Condensate and Glasma:
What Have we Learned from RHIC?
RIKEN BNL Research Center Workshop
May 10-12, 2010 at Brookhaven National Laboratory

What is the Decadal Plan Charge?

ALD Steve Vigdor has charged PHENIX and STAR to write decadal plans due August 1, 2010.

1. Summarize detector upgrades underway and to be utilized in the next 5 years.

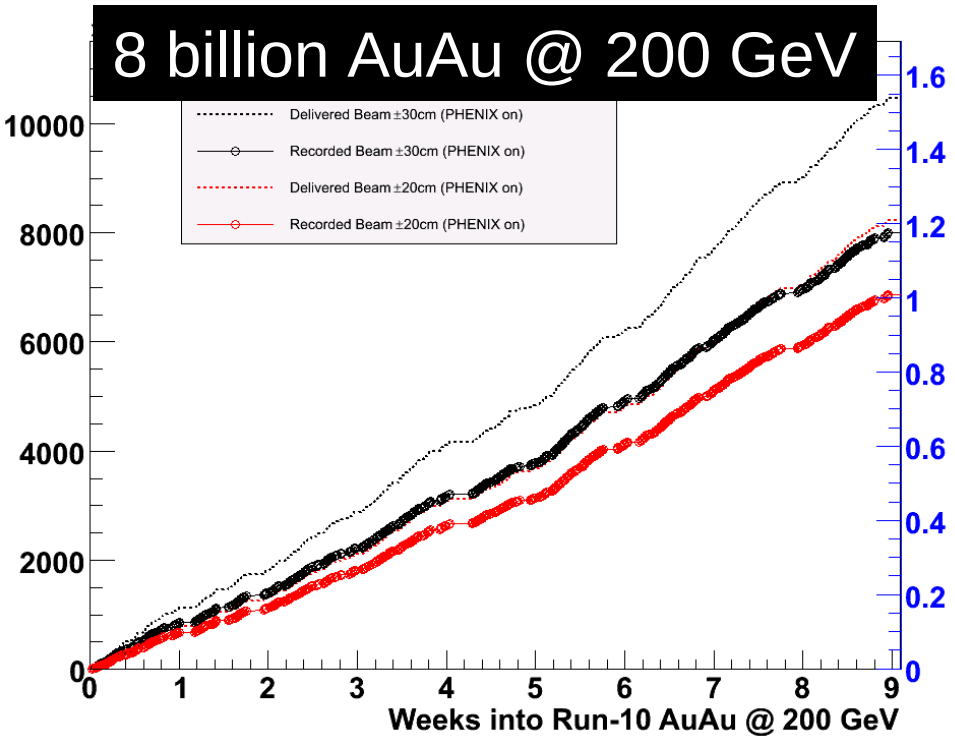
2. Compelling science beyond 5++ years that require additional detector upgrades and machine capabilities.

3. Prioritize the physics and the upgrades above.

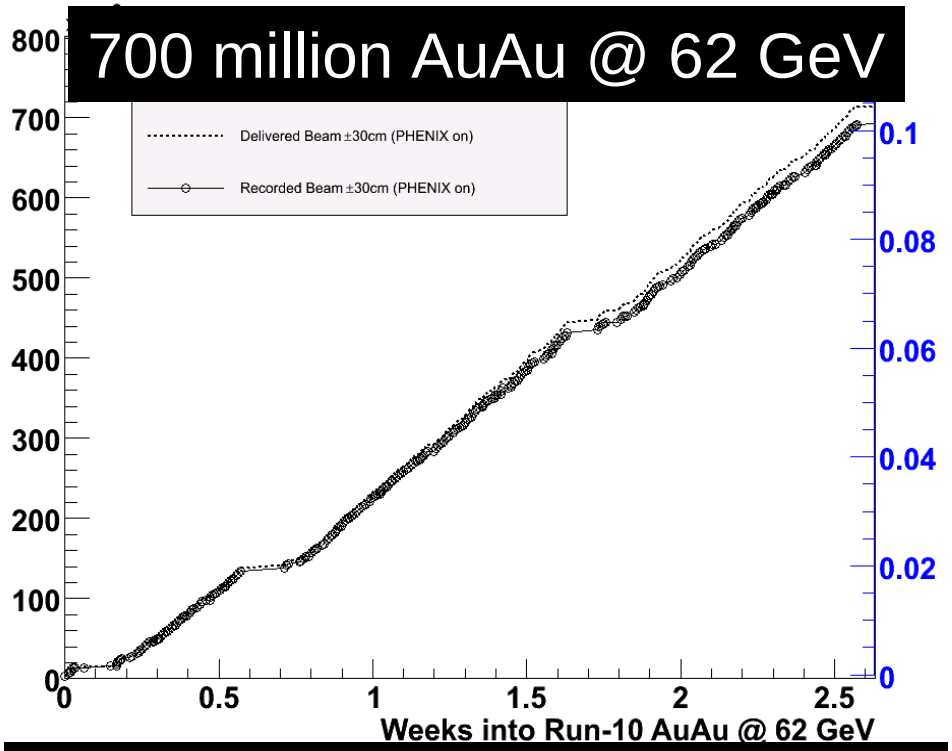
4. Discuss the option of an electron beam in the tunnel and thus an ePHENIX and eSTAR in the MeRHIC and EIC era.

5. Discuss the evolution of the collaboration and experimental effort.

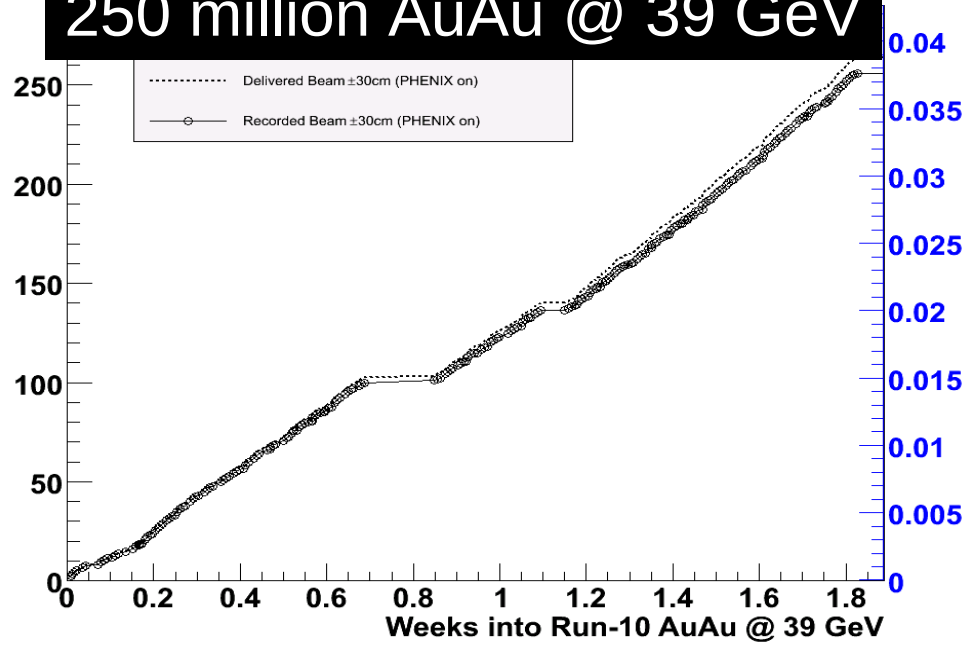
8 billion AuAu @ 200 GeV



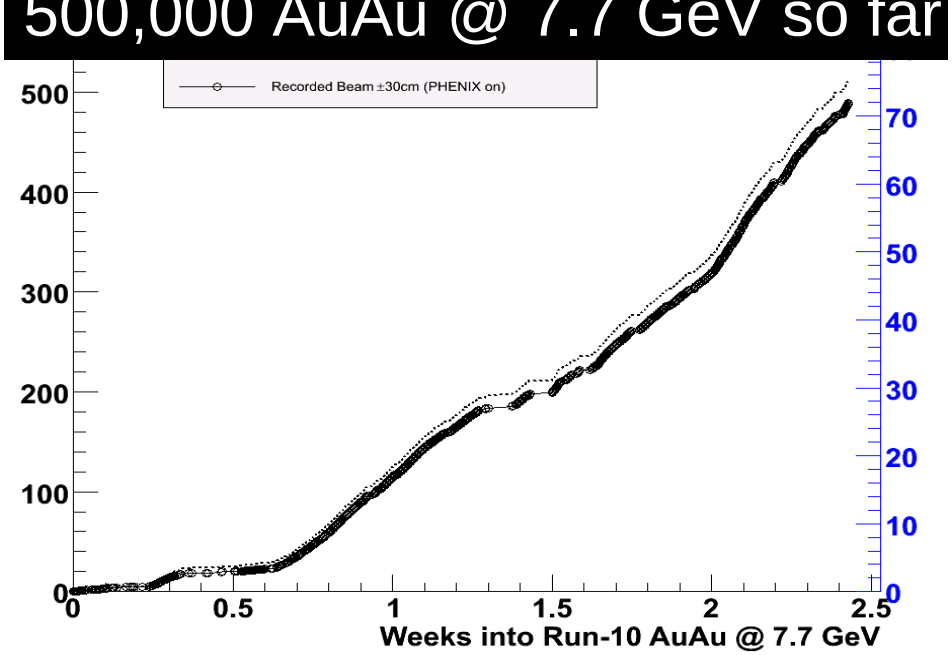
700 million AuAu @ 62 GeV



250 million AuAu @ 39 GeV



500,000 AuAu @ 7.7 GeV so far



Great Run-10 Data Set!

Thanks to CAD and
PHENIX Run Coordinator Stefan Bathe

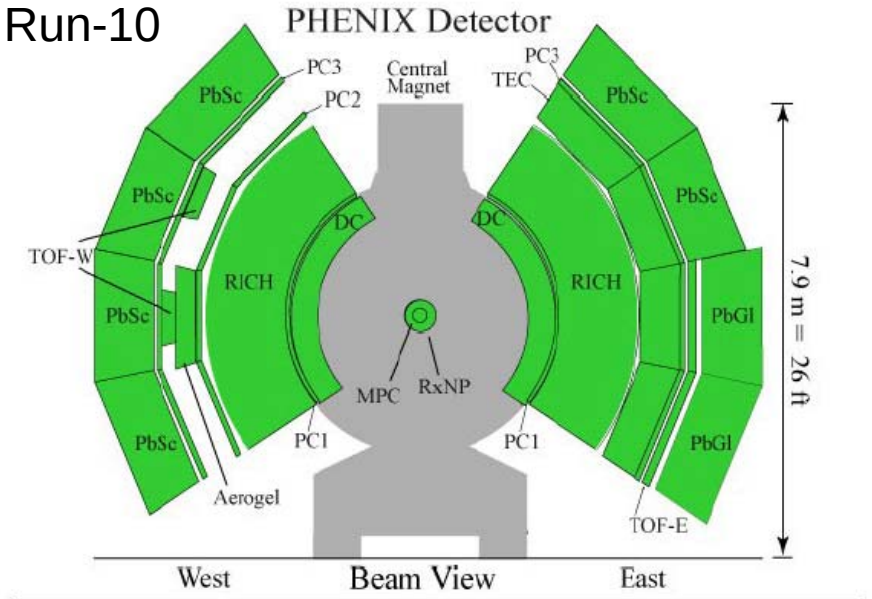
(HBD Detector for Low Mass Dileptons Working!)

Upgrade Philosophy

Go after the physics you really want and that gets people excited.

Build upon existing strengths!

Next 5 Years



Run-11:

Silicon VTX on schedule.
Precision heavy flavor era!

Muon Trigger Upgrade on schedule! Forward W→μ

DAQ Upgrade on schedule!

Run-12:

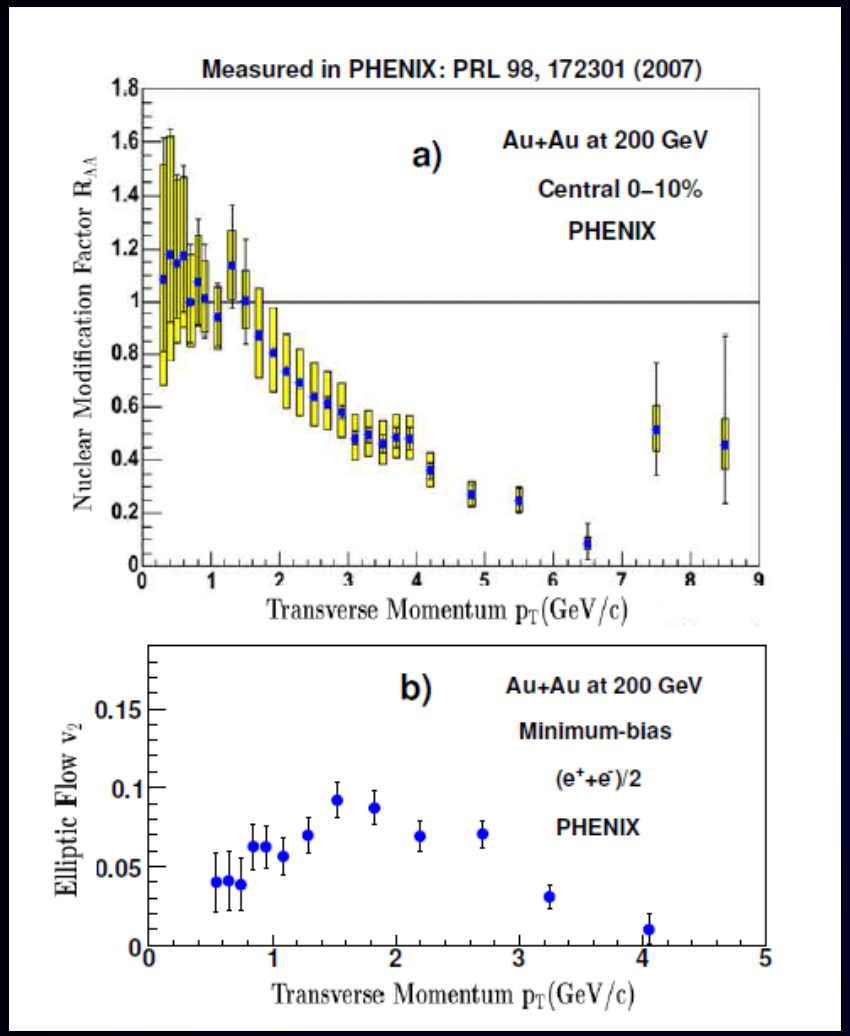
Forward silicon VTX available.

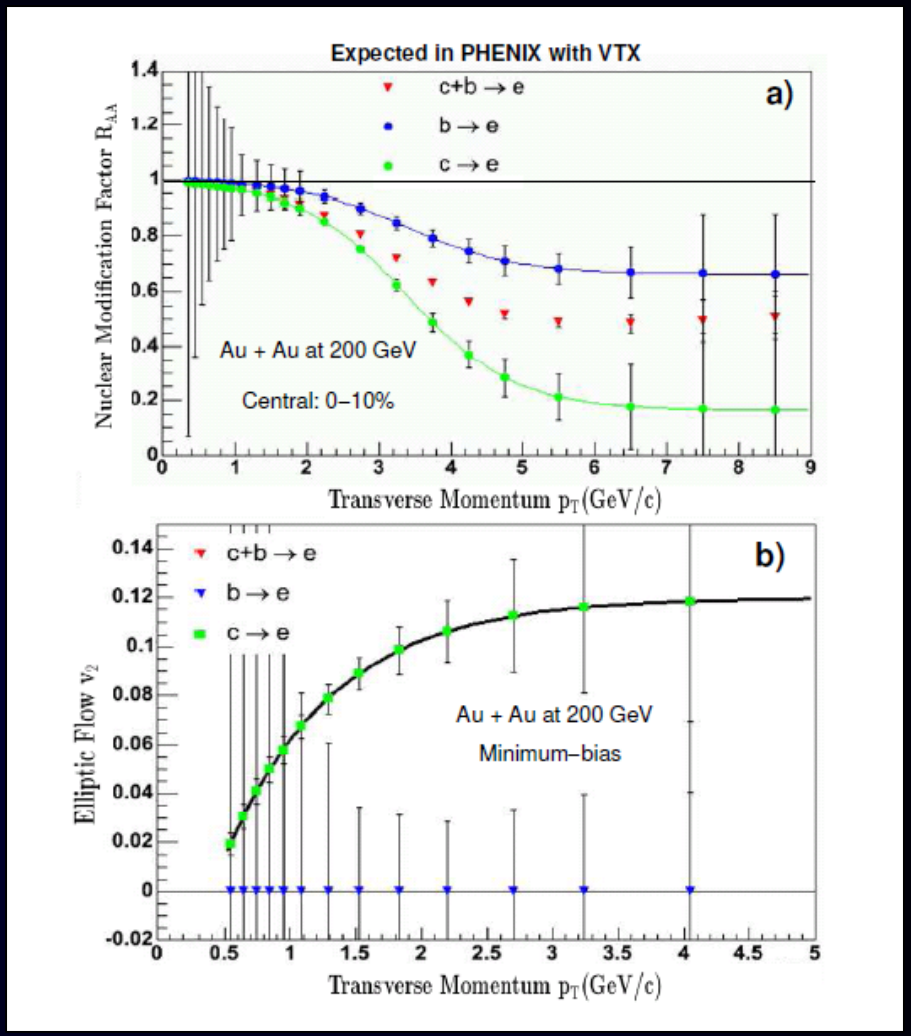
Run-14:

Forward Calorimetry
(FOCAL proposal – see R. Seto's talk)

Critical to exploit the detectors to do the physics they were designed for.

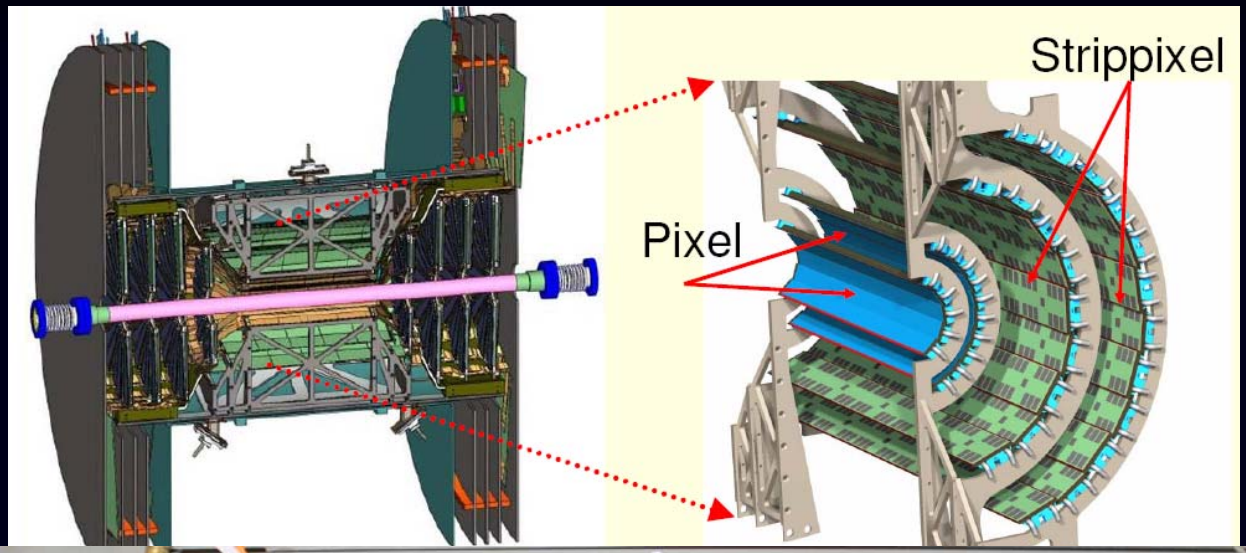
(One Example) PHENIX Knows Electrons!

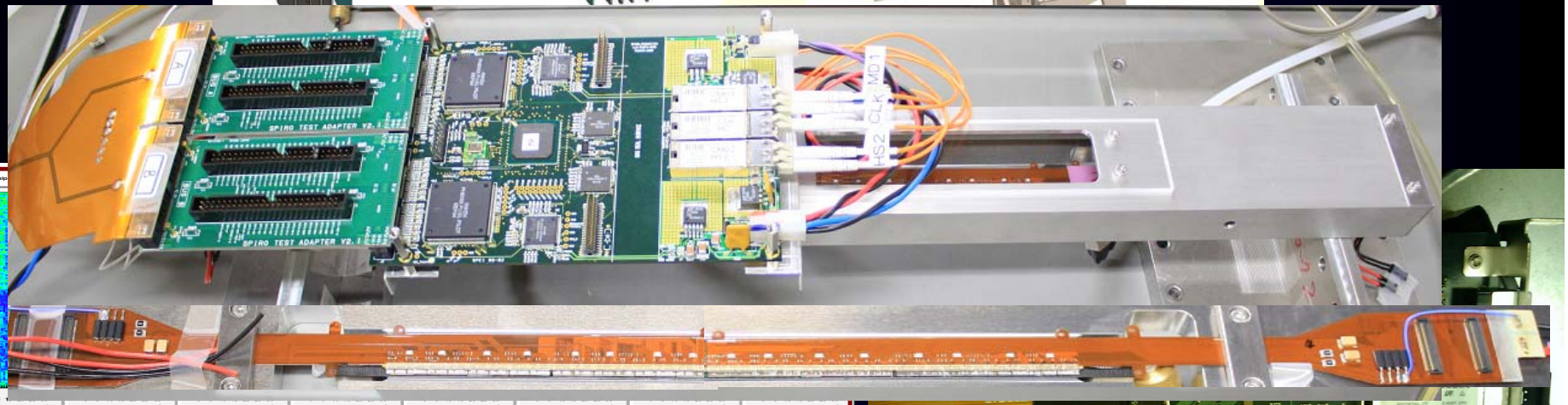


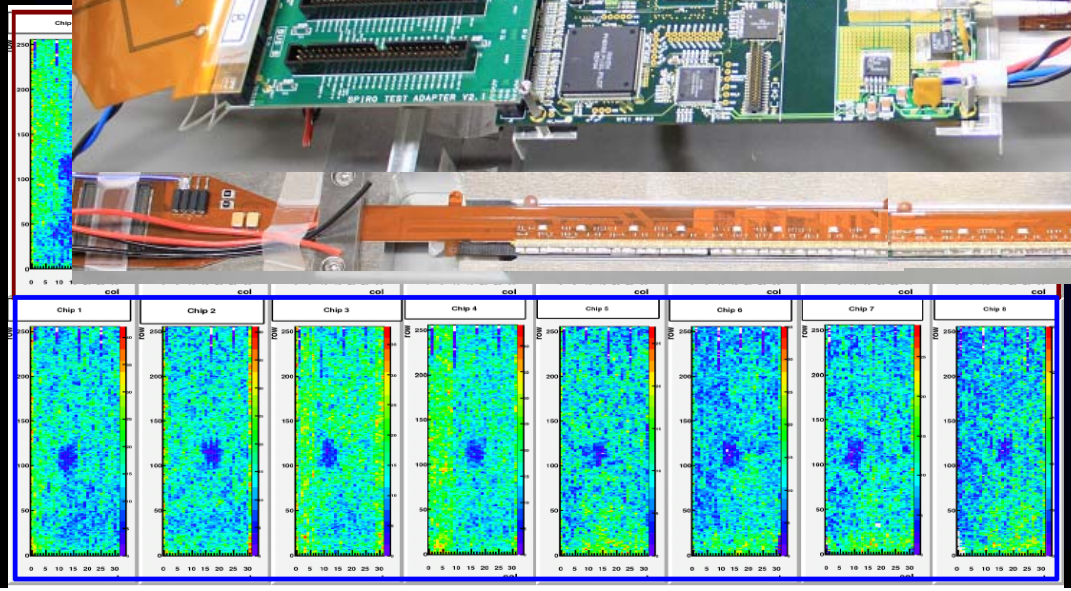


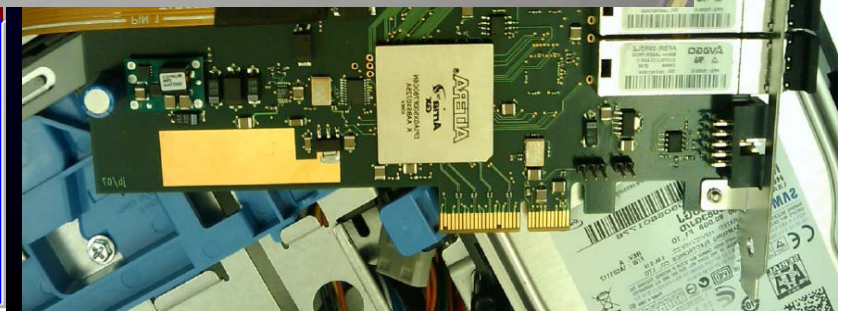
Run-11 AuAu @ 200 GeV will start to deliver this great physics!

Vaporware → Real Hardware → Physics (2011)

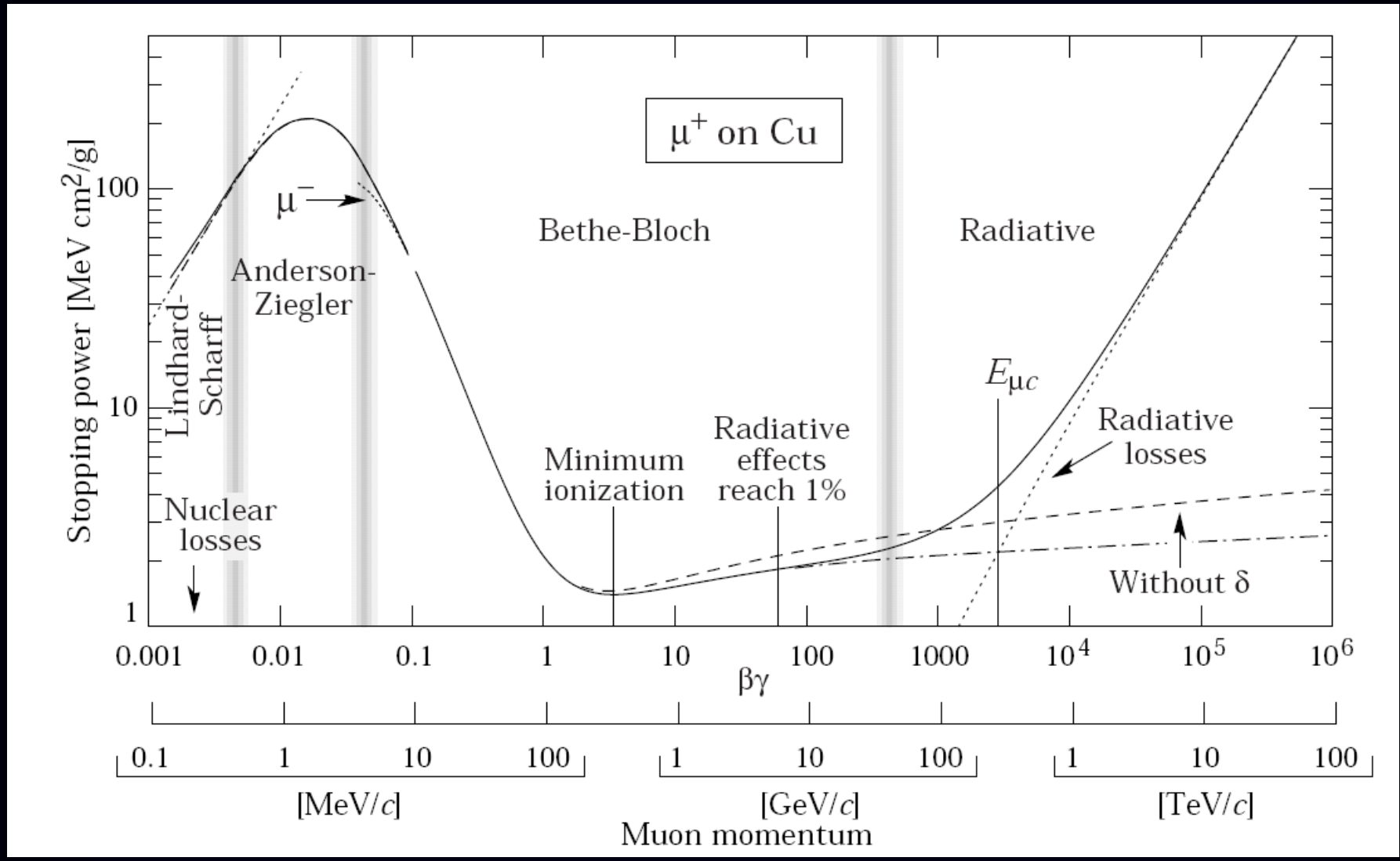








QED Mastered



QCD Mastered?

q: fast color triplet

Jets and Leading Hadrons

q: fast color octet

C: slow color octet

B: slower color octet

Heavy Flavor

QQ: slow color singlet/octet

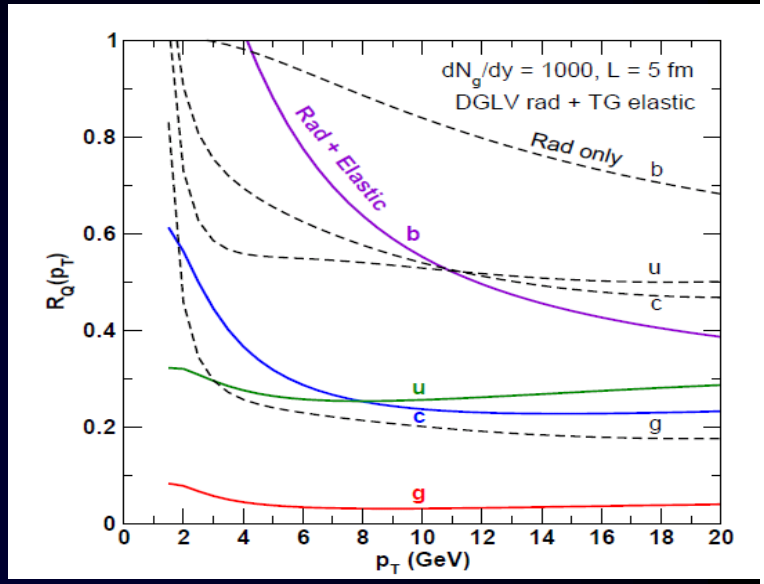
J/ψ and Upsilons

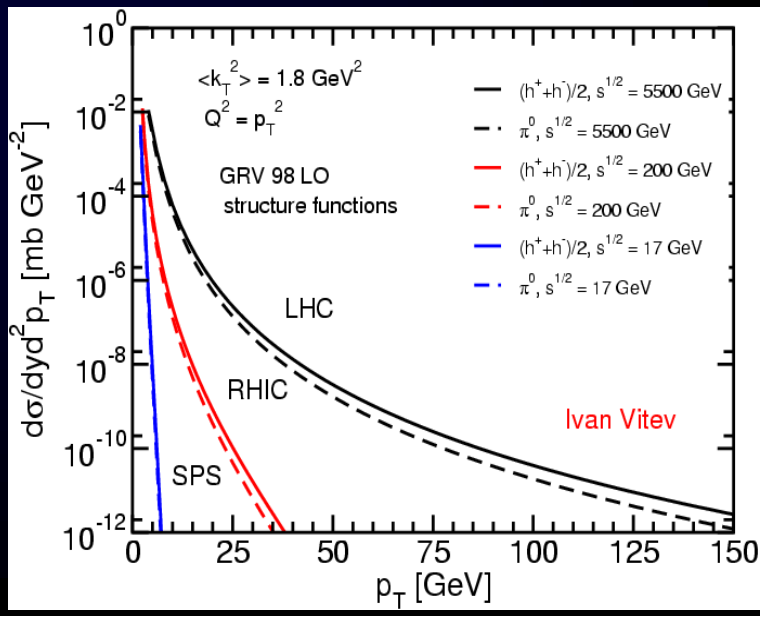
QQ: fast color singlet/octet

High pT J/ψ

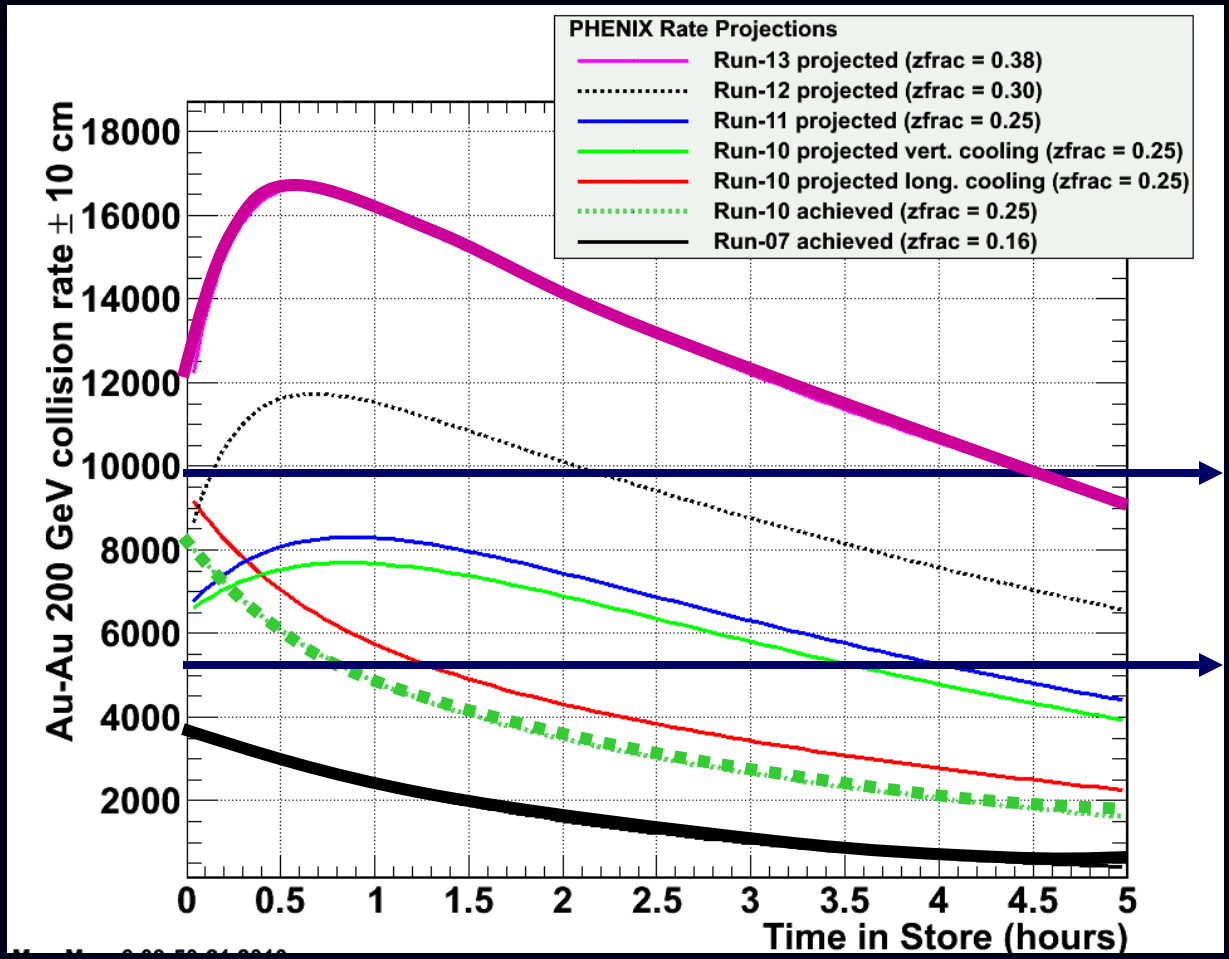
Photon: colorless

Hot QCD Medium



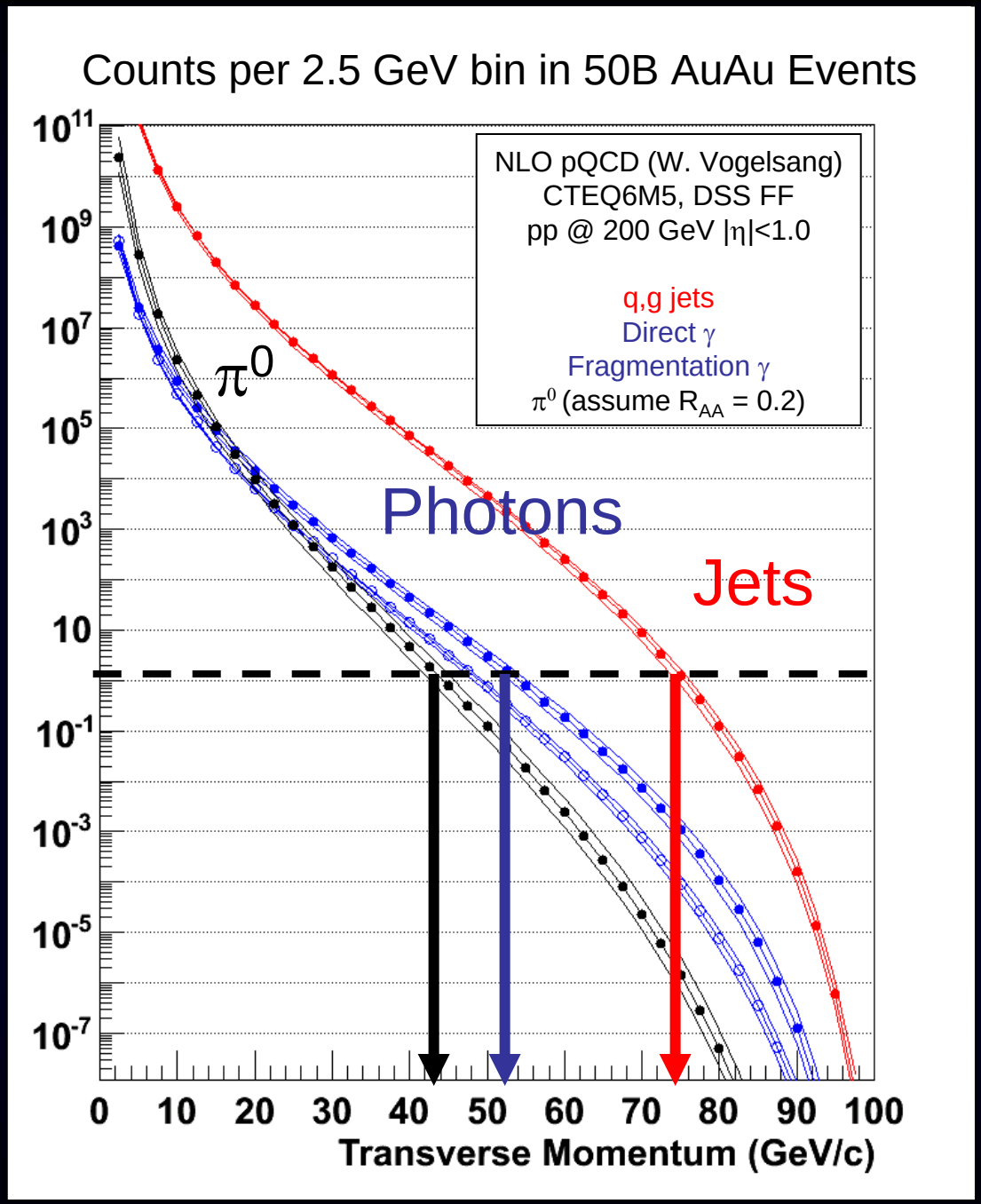


RHIC II Luminosity Projections



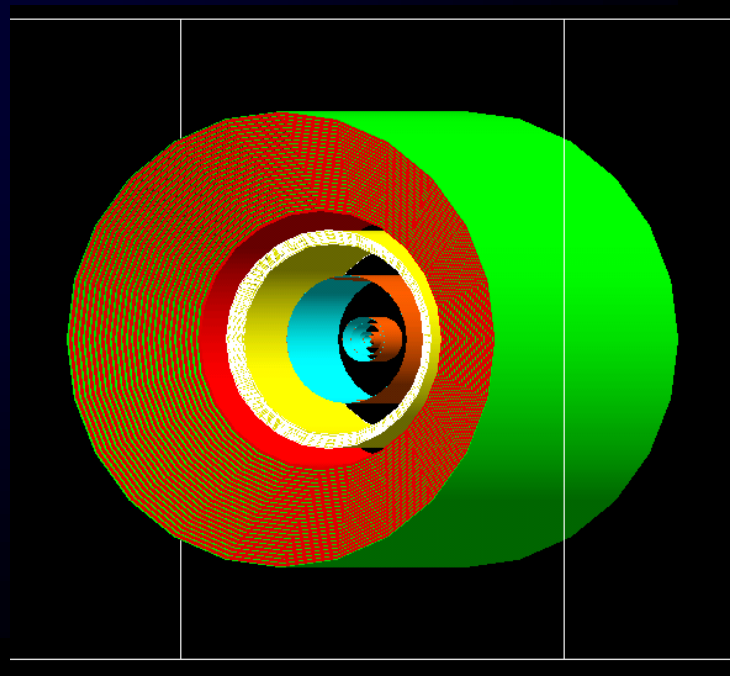
RHIC II luminosity and new proposed DAQ upgrades can yield 50 billion AuAu event samples (and with great new detector capabilities).

Thanks to Wolfram Fischer and CAD for input.


Counts per 2.5 GeV bin in 50B AuAu Events
NLO pQCD (W. Vogelsang)
CTEQ6M5, DSS FF
pp @ 200 GeV |η|<1.0
q,g jets
Direct γ
Fragmentation γ
π0 (assume RAA = 0.2)
π0
Photons
Jets
10^11
10^9
10^7
10^5
10^3
10
10^-1
10^-3
10^-5
10^-7
0 10 20 30 40 50 60 70 80 90 100
Transverse Momentum (GeV/c)

Step #1: Remove the outer PHENIX Central Arms
Step #2: Replace Axial Field Magnet with Solenoid
(2 Tesla with inner radius = 70 cm).
Step #3: New silicon tracking layers at 40 and 60 cm
Step #4: Compact EmCal (Silicon/Tungsten) $|\eta|<1.0$
8 cm total depth and preshower layer
Step #5: Hadronic Calorimeter Outside Magnet
Step #6: Maintain high DAQ bandwidth and triggers

Result → PHENIX Reborn



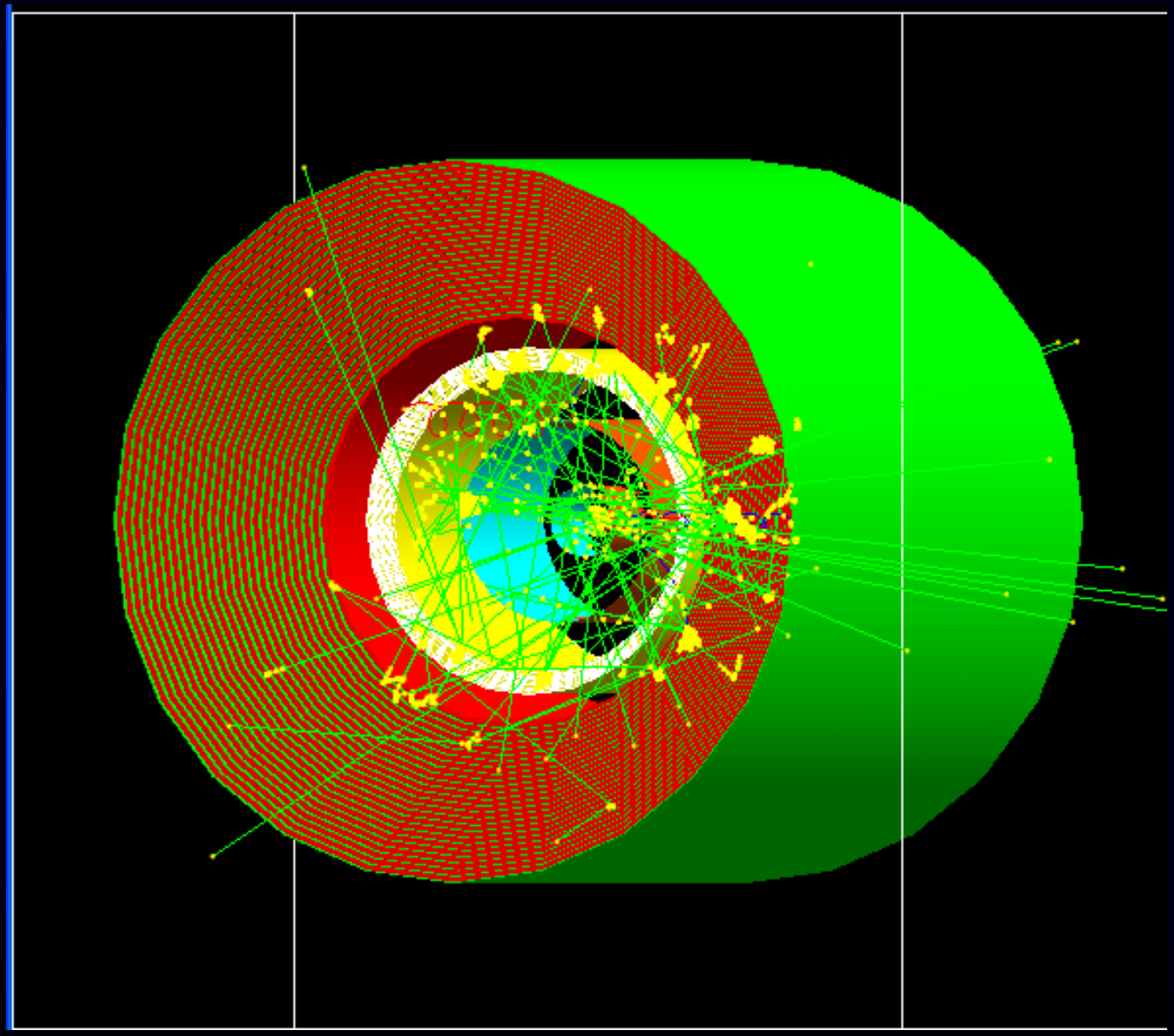
Some steps can be done incrementally, and some would require a longer shutdown (~ 1 – 1 ½ years).

Series of work-fest meetings to discuss physics goals and implement simulations.

Lots of fun!

Do we need contingency and overhead costing on pizza and beer?

GEANT-4 Simulation for Super-PHENIX
Q-PYTHIA Dijet Event

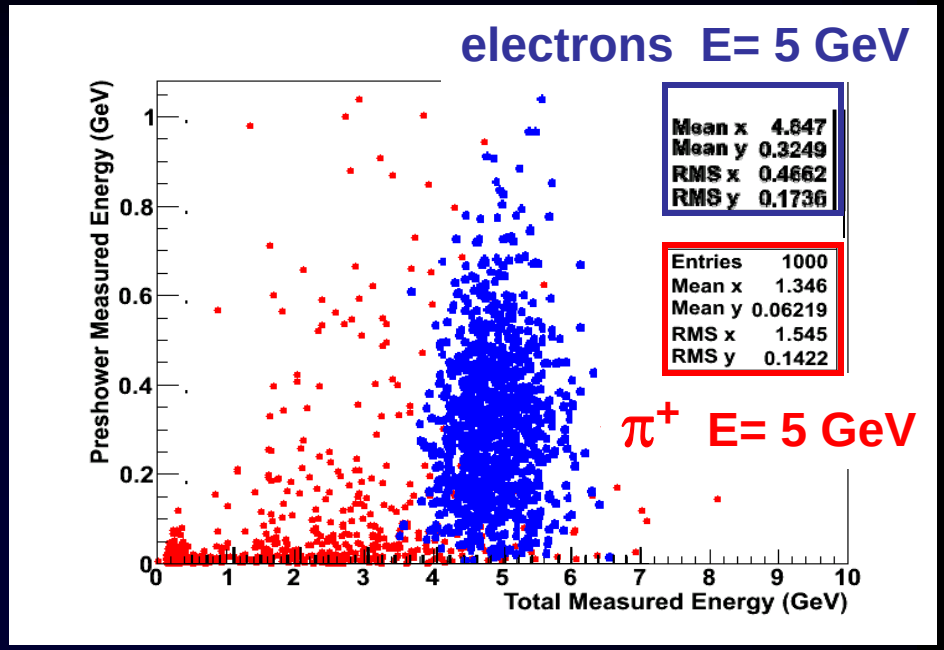


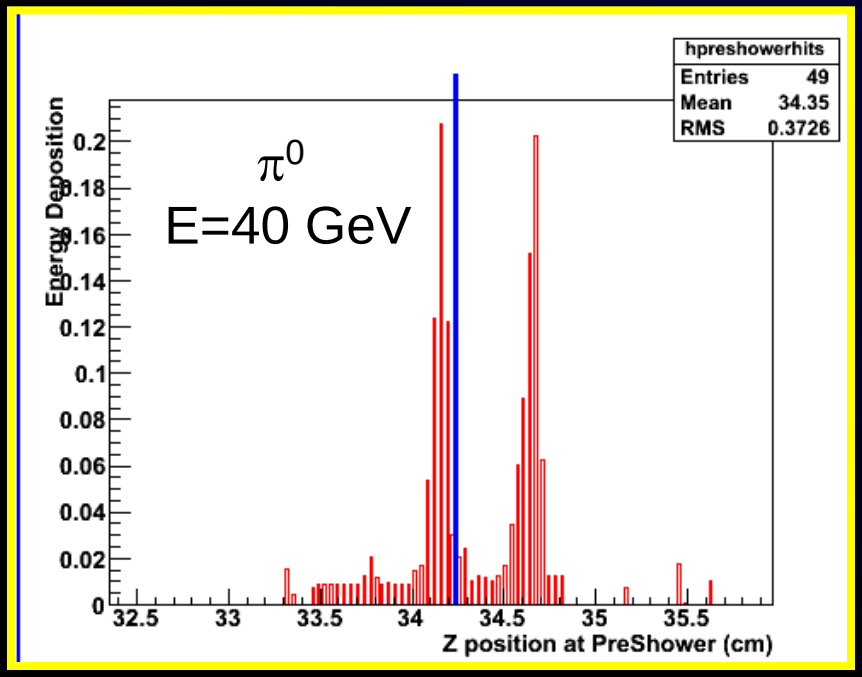
GEANT-4 Performance Evaluation Underway

Excellent electron-ID for pT > 2 GeV

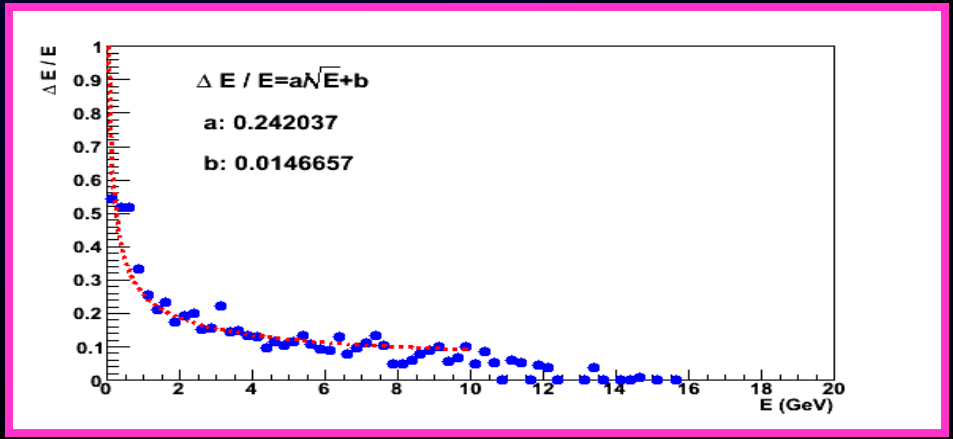
Need detailed study at lower pT as well.

γ/π^0 separation over full kinematics > 50 GeV





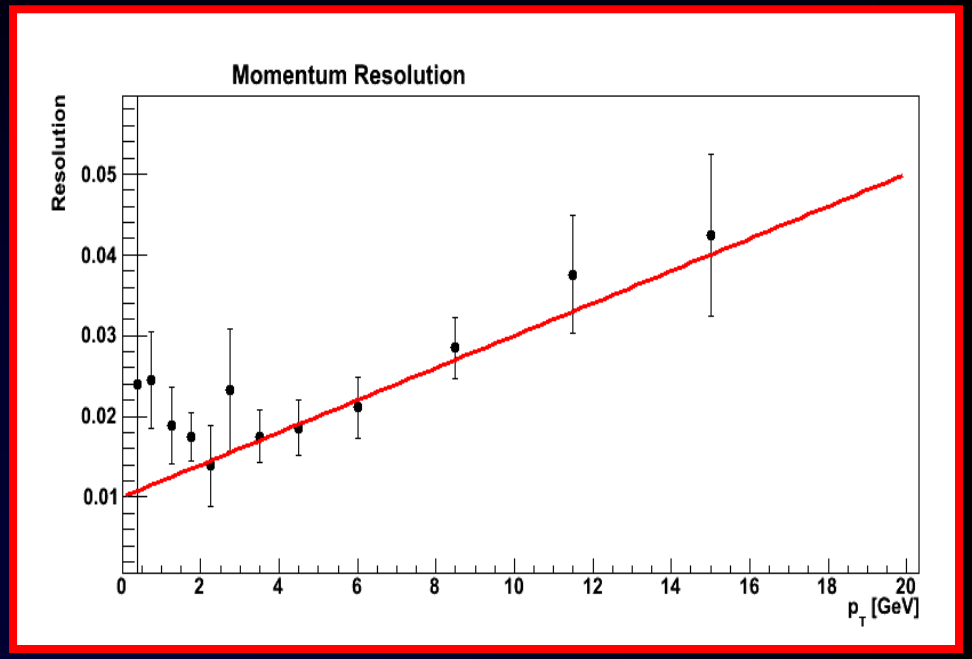
Energy Resolution

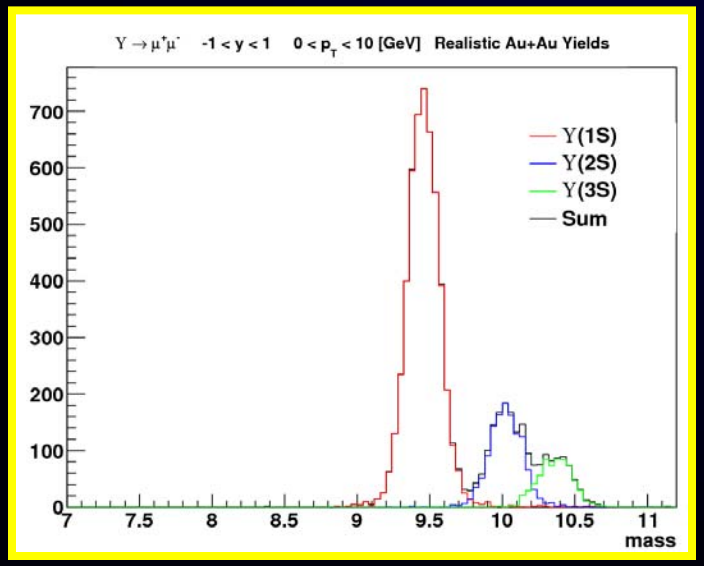


GEANT-4 Performance Evaluation Underway

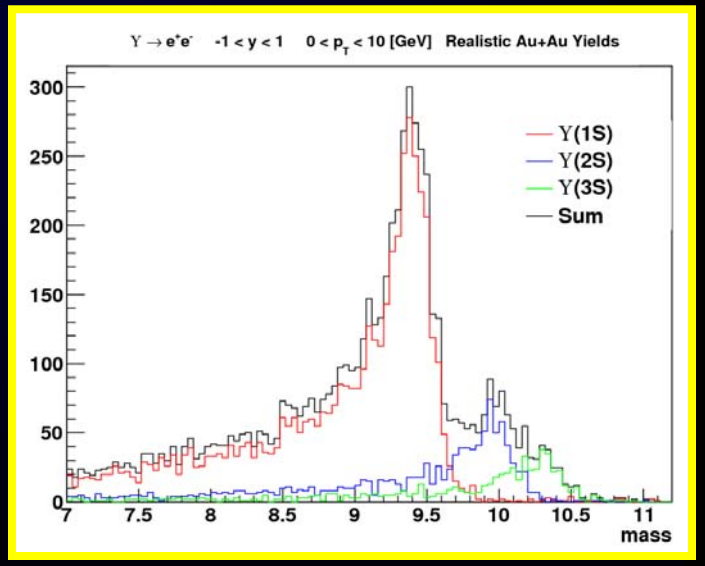
Very good momentum resolution.

Evaluation of fake high p_T track rate underway.

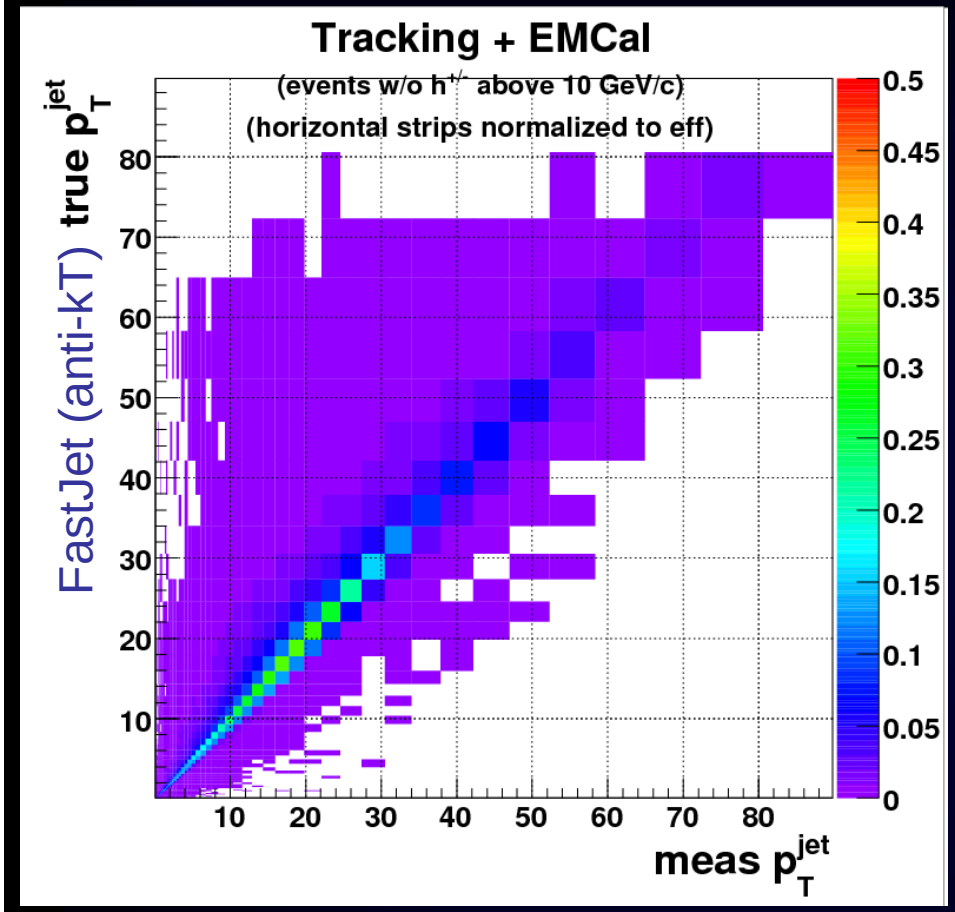


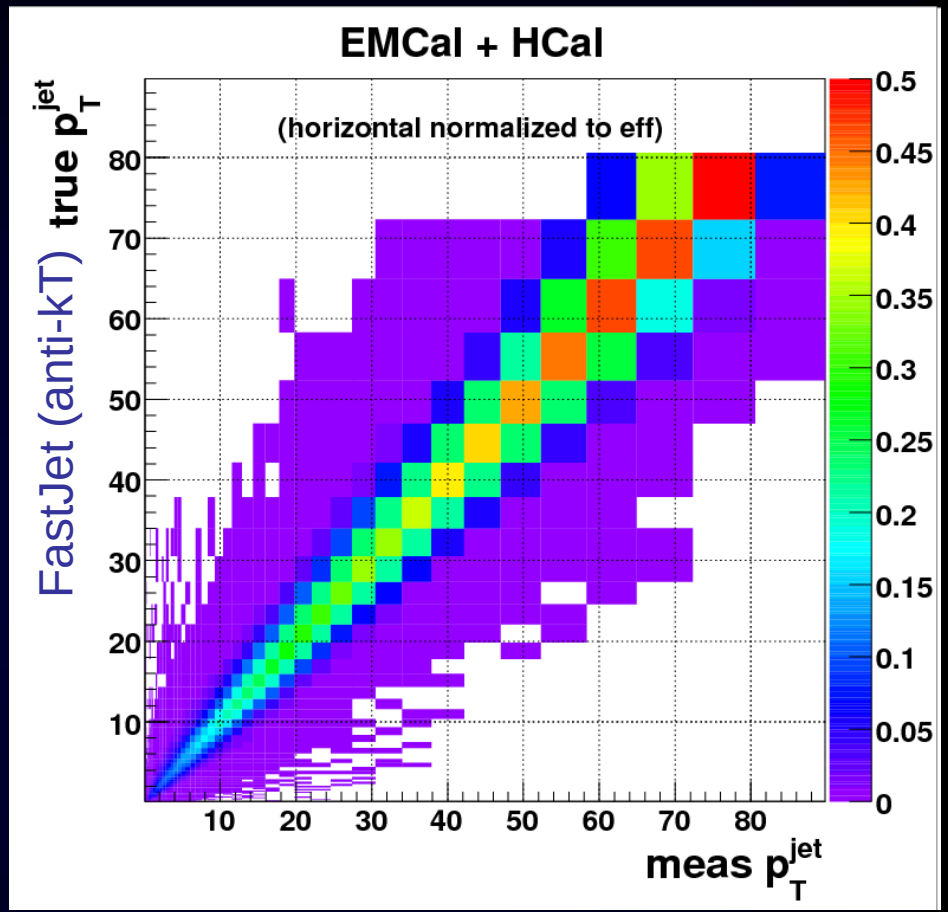


Upsilon Separation of States (with very different binding energies).



Fast Monte Carlo Jet Performance



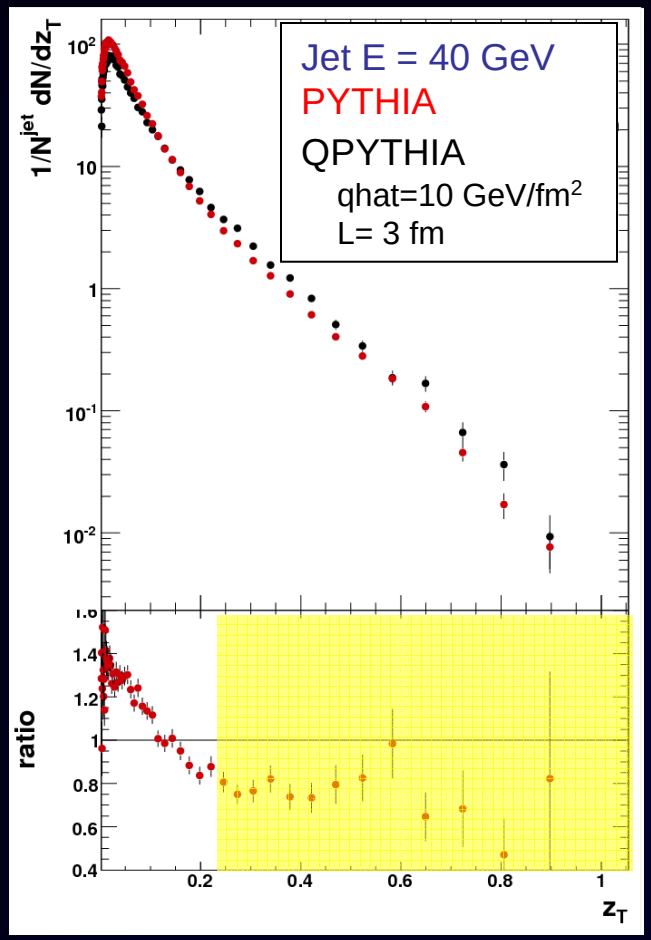


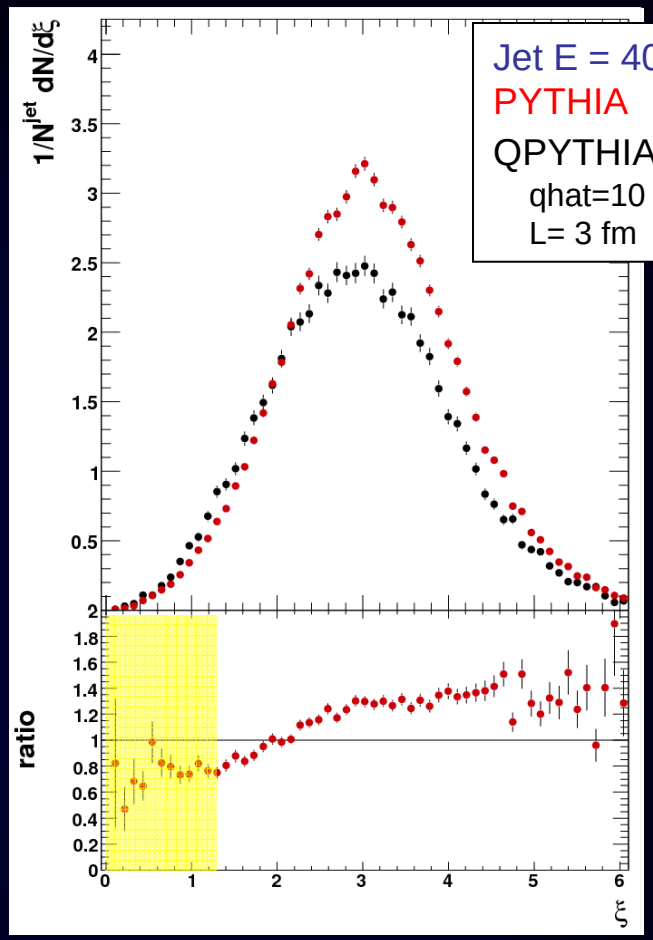
Mike McCumber (Colorado)

With tracking, dominated by "fakes" above some p_T (e.g. p_T > 10 GeV).
Thus, low overall efficiency for true high energy jets.
Bias in spectra reconstruction when FF is uncertain.

Issue largely solved with EMCal + HCal for jet energy!

Jet Fragmentation Functions



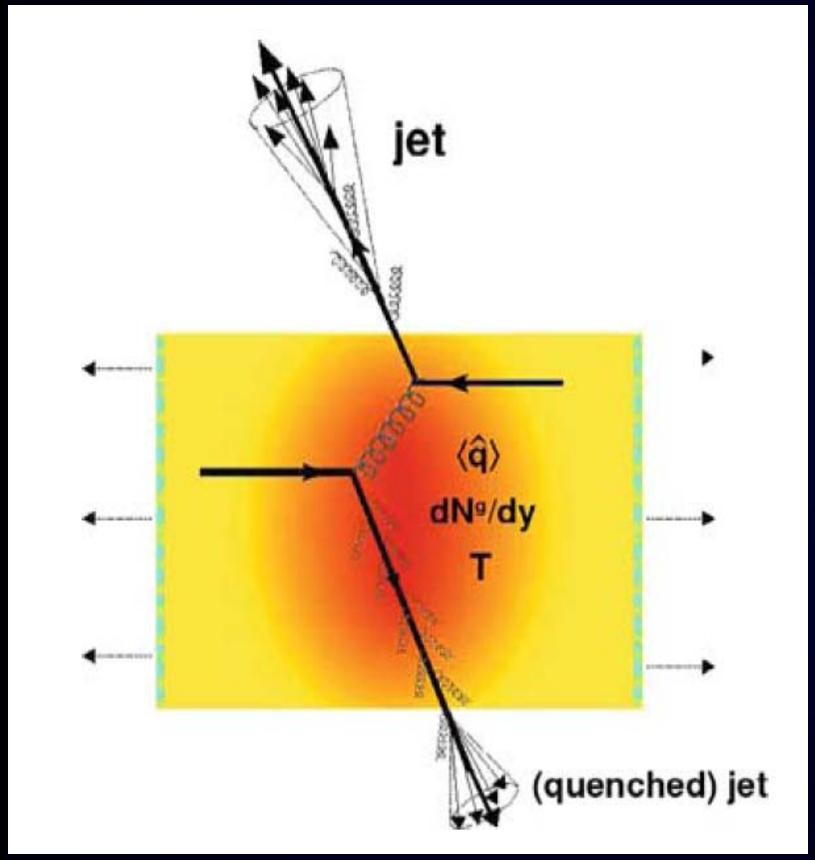


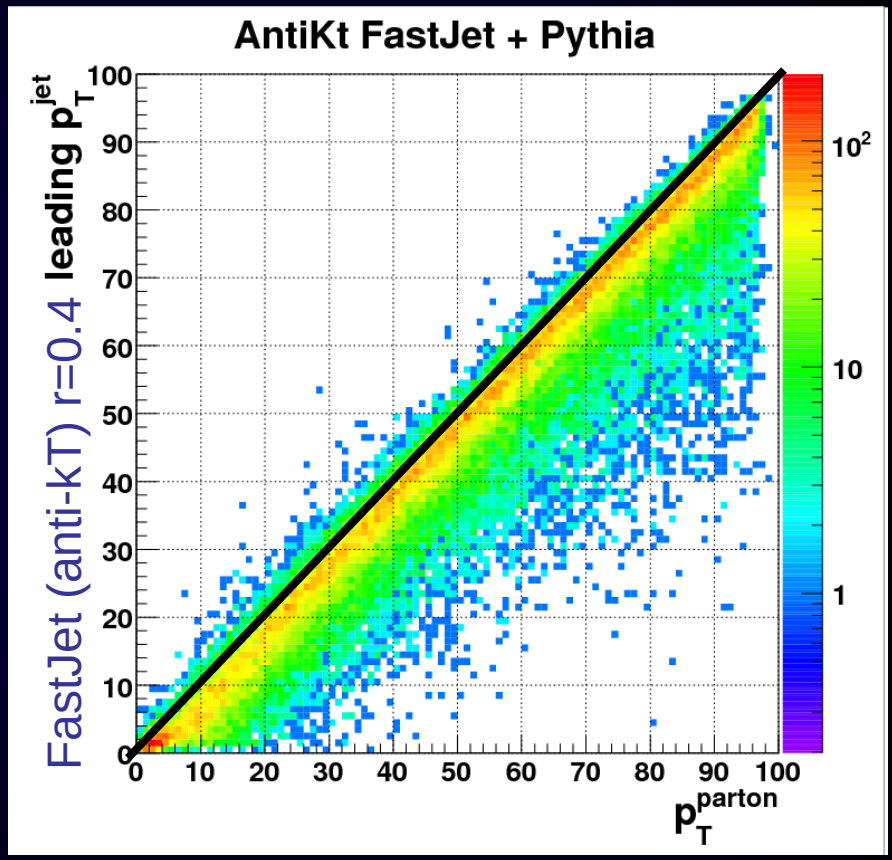
$=\log(1/z_T)$

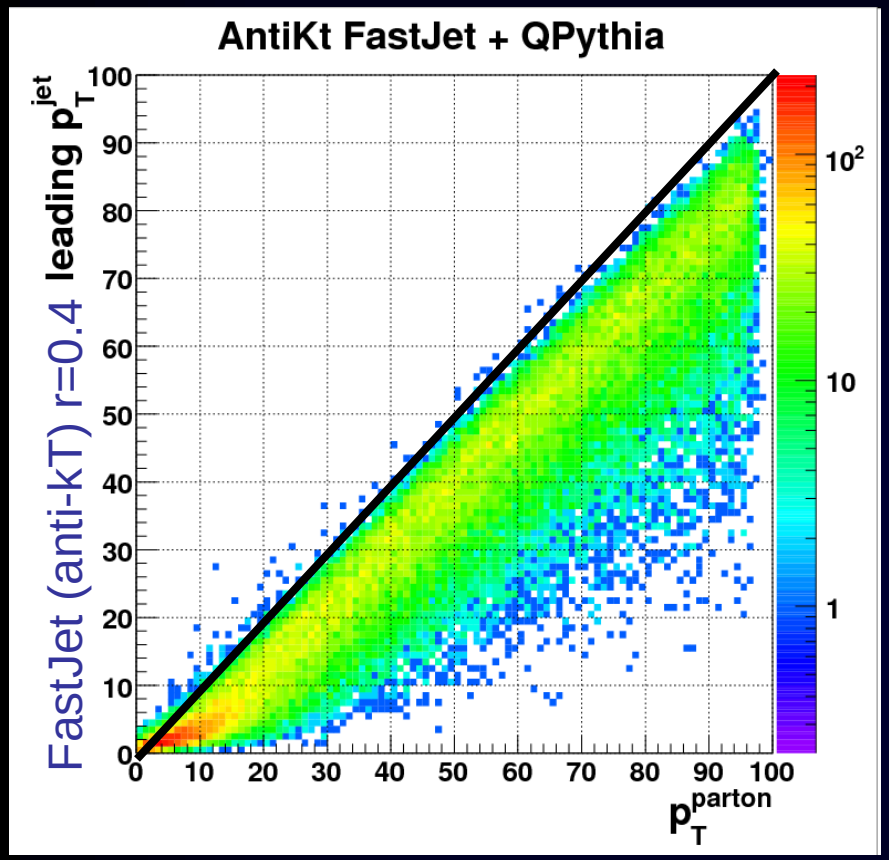
Without HCAL, if fakes dominate above p_T > 10 GeV, then yellow region is not possible without HCAL.

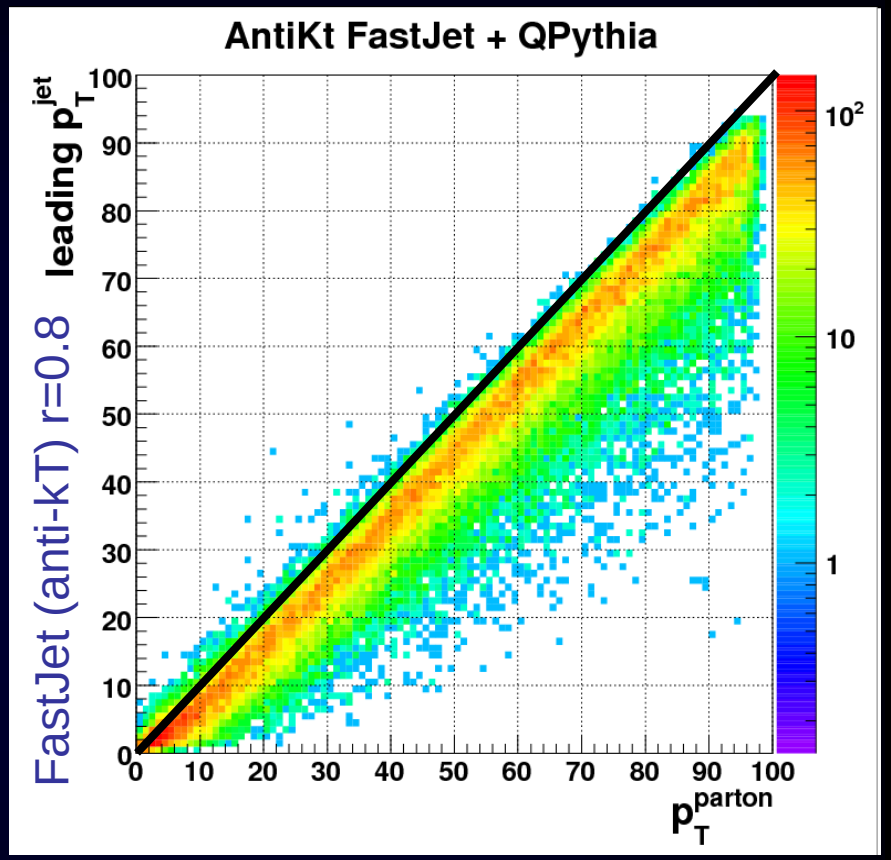
Key for understanding full evolution of high energy parton (far out of equilibrium) rapidly interacting in medium.

Is the reconstructed jet a proxy for the LO parton?
Is that critical to the extraction of the physics? Or just an easier way to think about it rather than NLO?

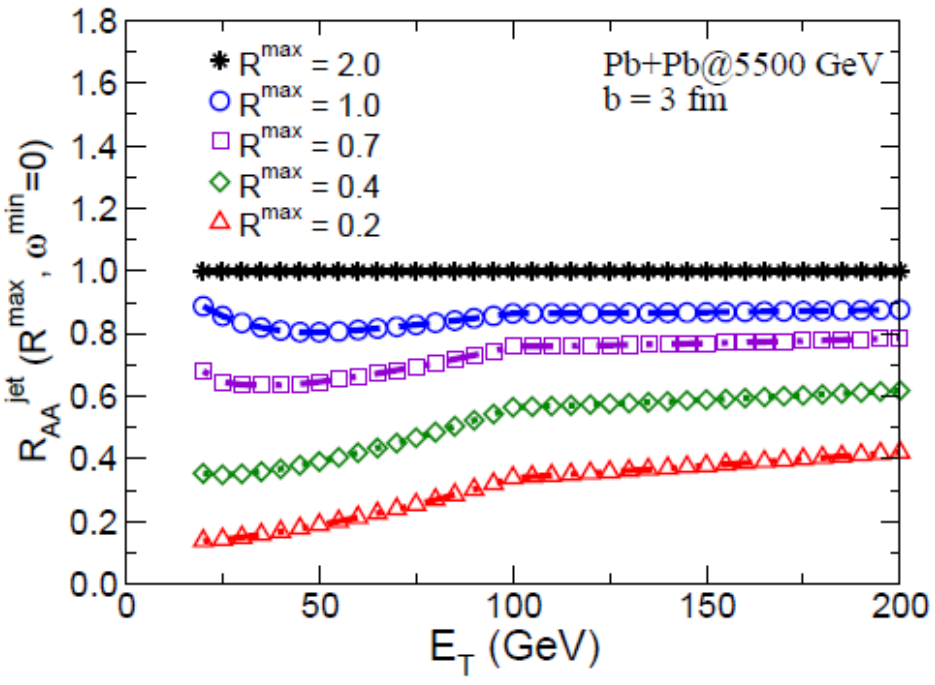


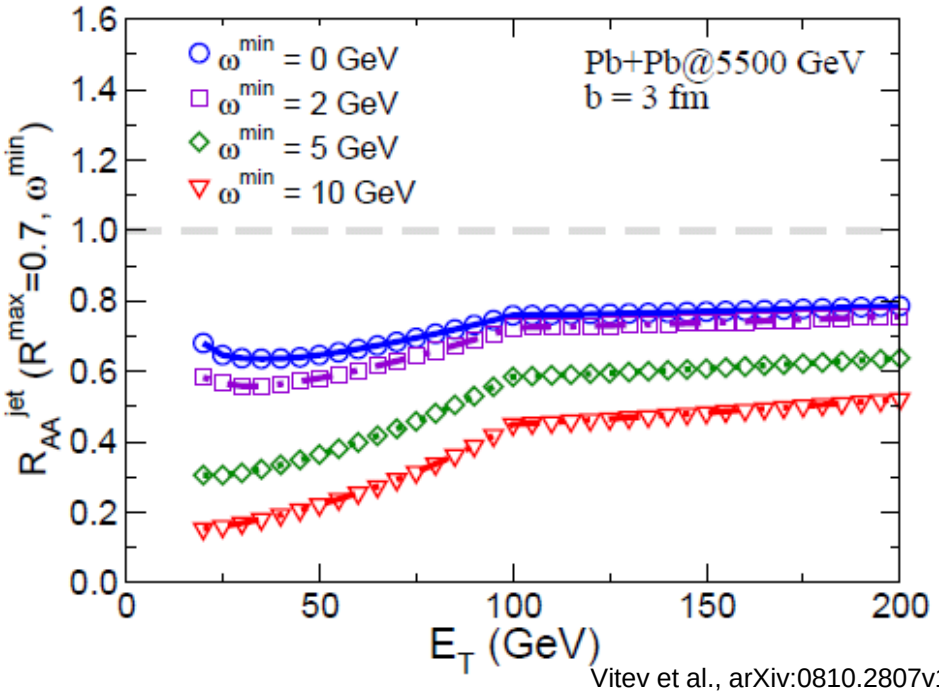



AntiKt FastJet + QPythia
FastJet (anti-kT) r=0.4 leading p_T^{jet}
p_T^{parton}
0 10 20 30 40 50 60 70 80 90 100
10^2
10
1


AntiKt FastJet + QPythia
FastJet (anti-kT) r=0.8 leading p_T^{jet}
p_T^{parton}
0 10 20 30 40 50 60 70 80 90 100
10^2
10
1

Jets and Direct Photon-Jet Correlations are very rich with information.





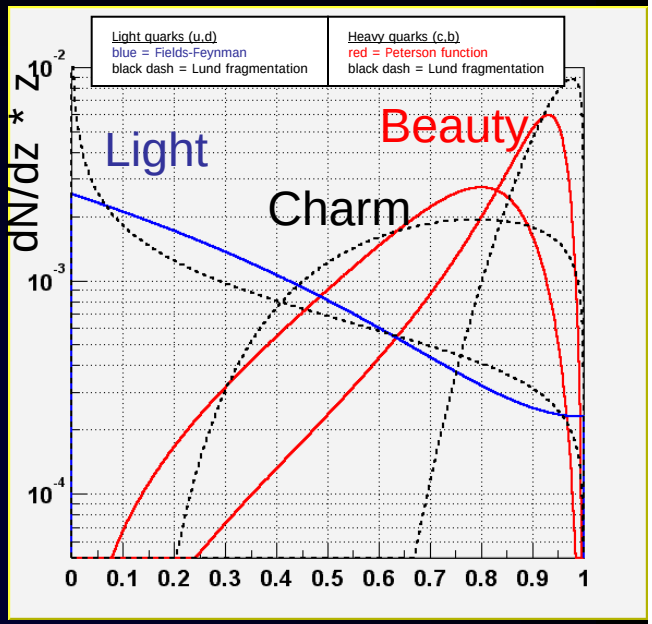
Vitev et al., arXiv:0810.2807v1

New Super-PHENIX (sPHENIX)

I) Modified FF for charm and beauty tagged jets

II) Direct photon – jet correlations (much lower jet background, jet shape analysis too).

III) Large acceptance and rate allows J/ψ suppression at AuAu @ 62 and 39 GeV.



IV) Upsilon states (three states span large range of binding energies) giving access to screening length information.

V) Internal conversion direct photons v2 (!)

e-ID at lower pT being checked.

VI) Much more than can be listed just here…

Centrality Dependence of EMC Effect ?

High-x nuclear PDF constraints from very high p_T direct photons

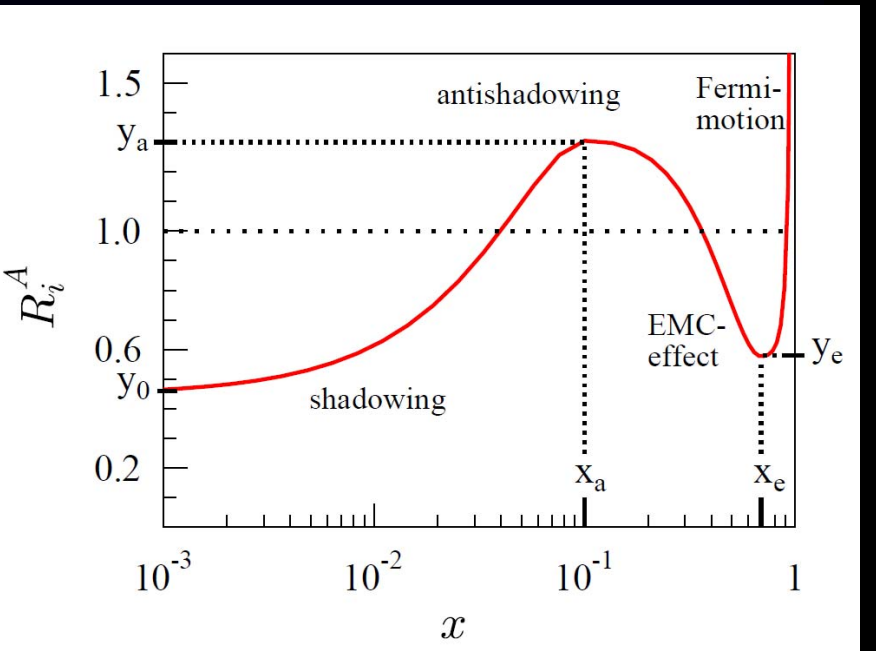
(reach is ~ 30-50 GeV → x~ 0.3-0.5)

Even W cross section at 200 GeV p+p is 32/pb makes measurement possible in d+Au and Au+Au !

(Idea of Yasuyuki Akiba)

e/π separation of pre-shower + EMCal is ~1000.
W→e can be identified in Au+Au

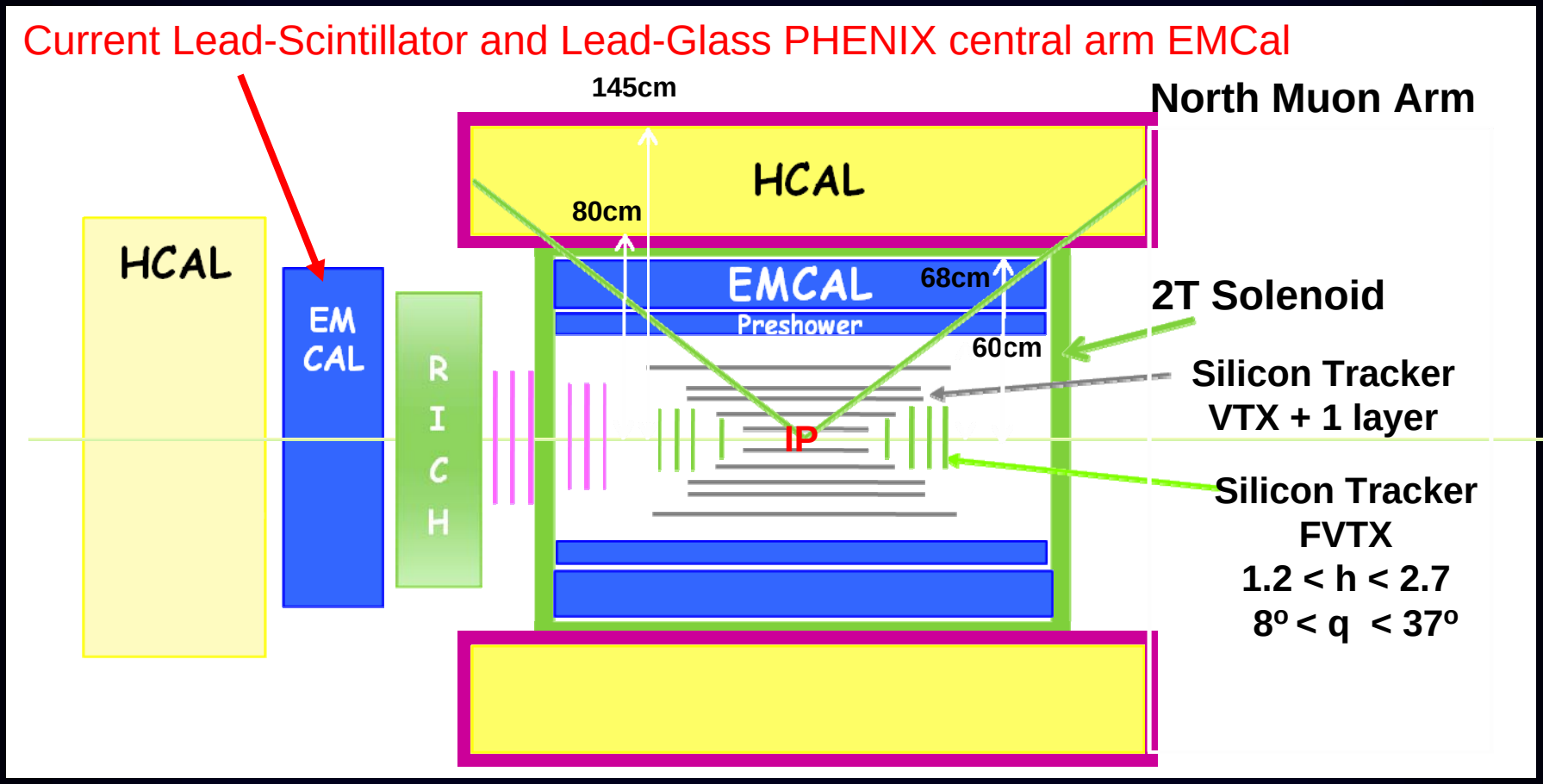
Rough rate estimate for AuAu 500 W→e (p^T>25 GeV/c) in |y|<1.0 in 50 billion Au+Au minimum bias events.



* Many new ideas - input from theorists welcome - may see the light of experimental data with this next detector!

Forward Direction Ideas

Discussing in 5++ years to remove the south muon spectrometer and build an electron/photon endcap spectrometer.



Transverse Drell-Yan measurement under study!
Collins/Sivers measurements beyond FOCAL under study
ePHENIX capabilities under study (led by Elke Aschenauer)

Summary

What are the big science questions we believe will be unanswered in 5 years at RHIC, and can only be answered with upgraded detectors and accelerator at RHIC (and not at the LHC)?

How and why does the system behave as it does? Not just characterizing single numbers (thermalization time, viscosity, qhat)…

Understanding the full coupling and evolution of these hard probes with the medium (Mastering QCD).

Also, theory input/suggestions is most welcome. Perhaps the idea of sampling 50 billion AuAu events with excellent jet, heavy flavor (including jets), photon capability will spark new ideas.