The Future of PHENIX: Upgrading to sPHENIX and Beyond

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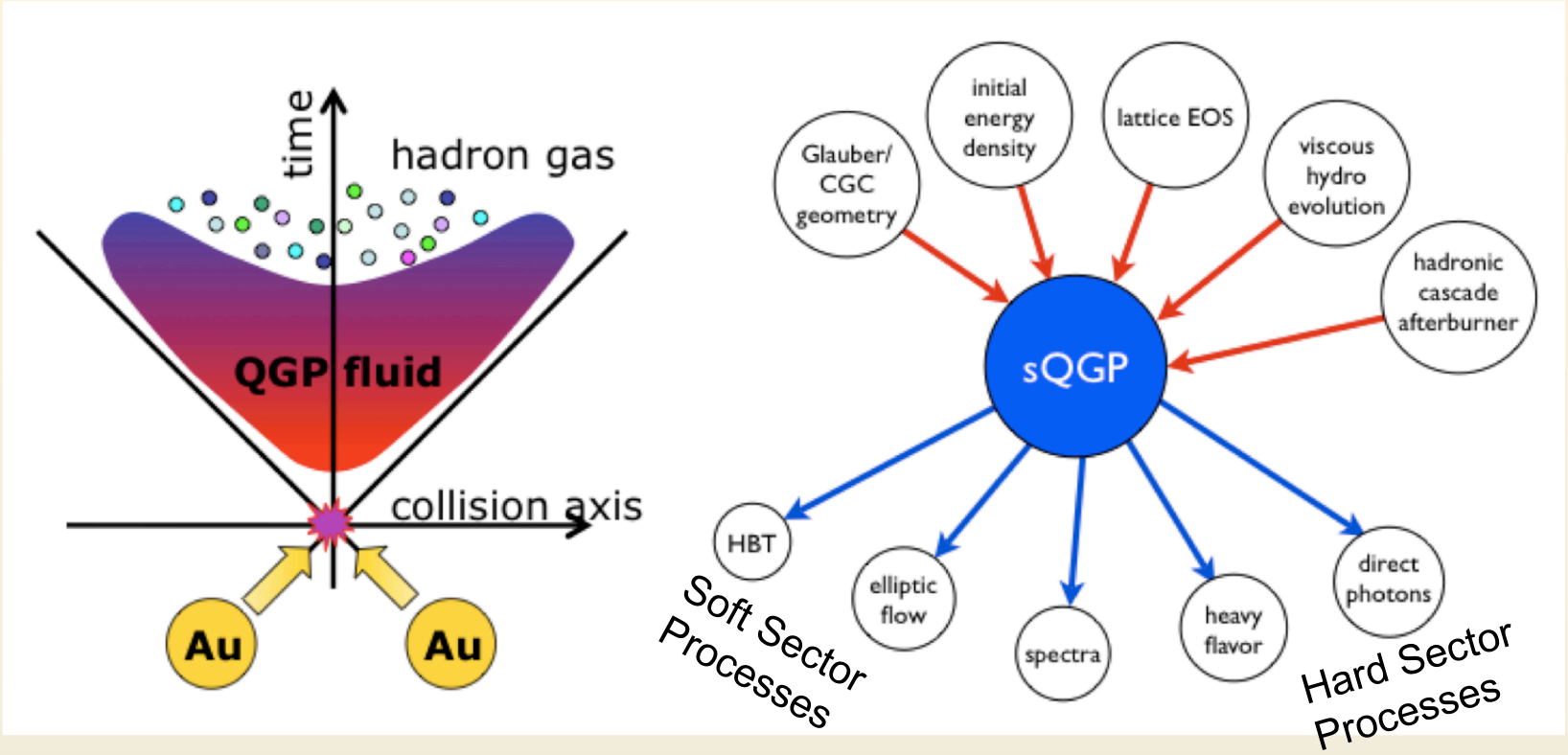
For the PHENIX Collaboration

Todays Goals

- Present a physics case for sPHENIX: A jet detector at RHIC
  - Can Jets be measured at RHIC?
  - Are they interesting?
- Present an overview of sPHENIX detector
  - Describe the baseline detector
  - Outline the capabilities of the sPHENIX detector
- Looking towards the future
  - What is the timeline for sPHENIX?
  - Beyond sPHENIX; the EIC era

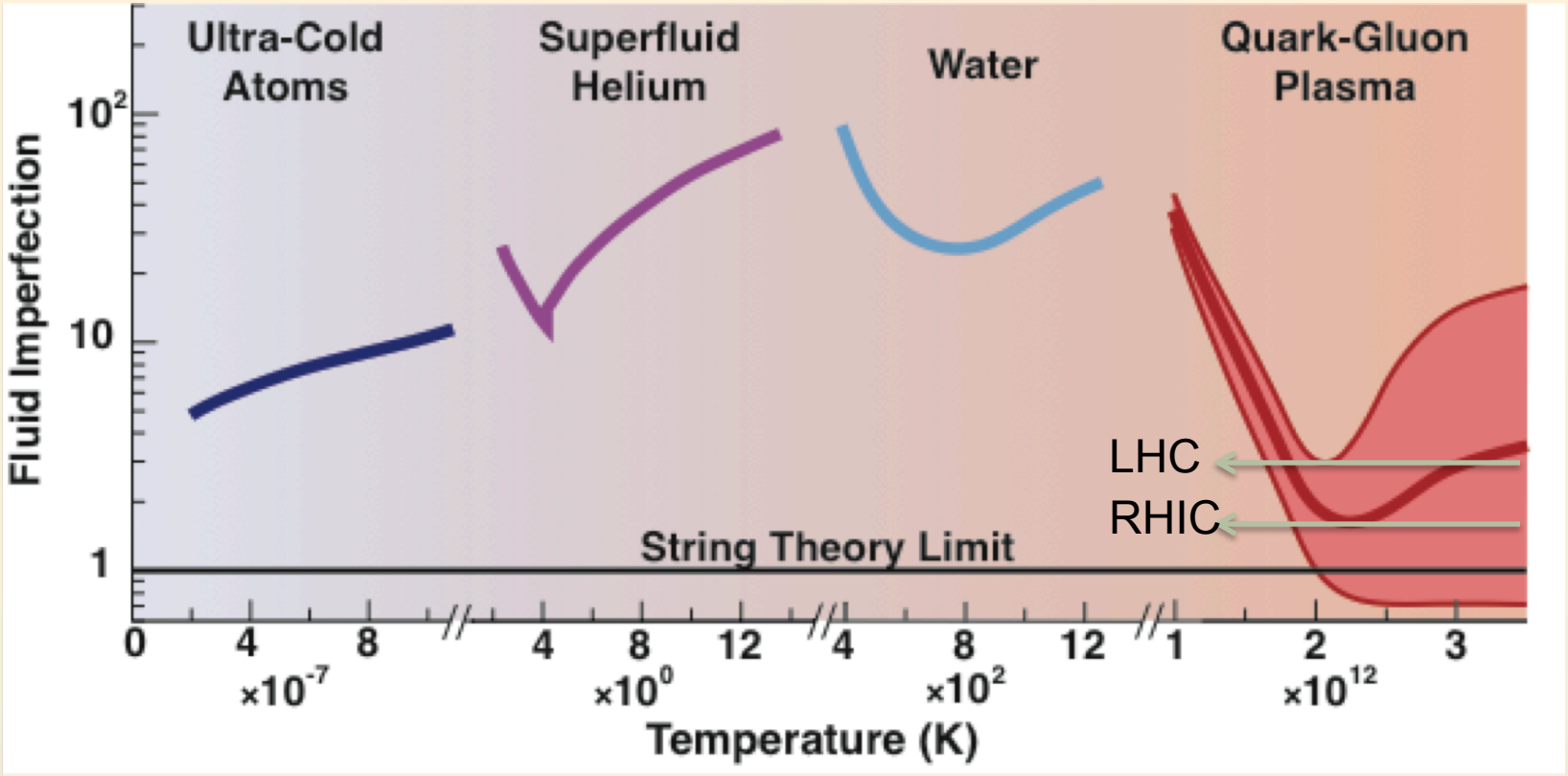
Strongly Coupled (s)QGP



The small-viscosity hydrodynamic evolution of the QGP suggests a strong coupling. This is a key aspect of the "standard model" for heavy ion collisions.

Missing is a detailed examination of the hard sector, parton energy loss, and a detailed program in the heavy quark sector

Viscosity Near the Phase Transition



Many systems have a minimum shear viscosity to entropy density ratio, η/s, at the phase transition point

This quantity is not yet well constrained for the Quark-Gluon Plasma

PHENIX

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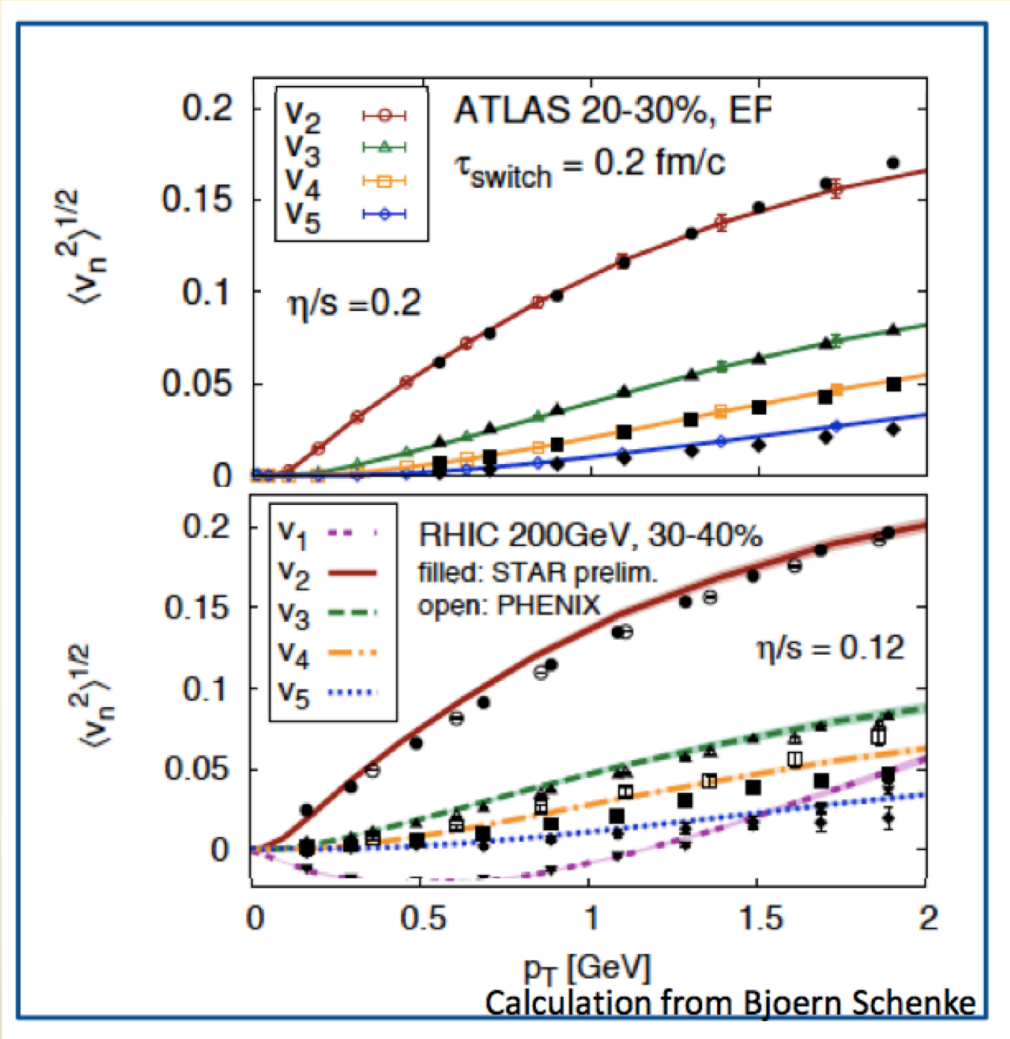
Viscosity Differences?

From the soft sector:

There are indications that the shear velocity to entropy is smaller at RHIC.

Shown are first 5 azimuthal moments reproduced with a hydro-based evolution at both LHC and RHIC

The question is how these changes appear in the hard sector?

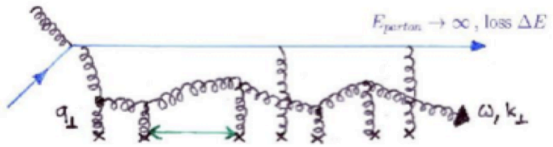


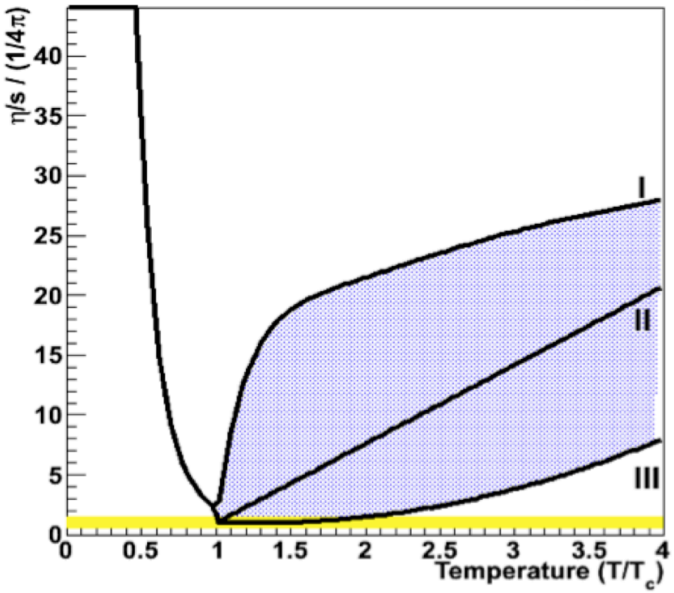
Relationship to Hard Sector Physics

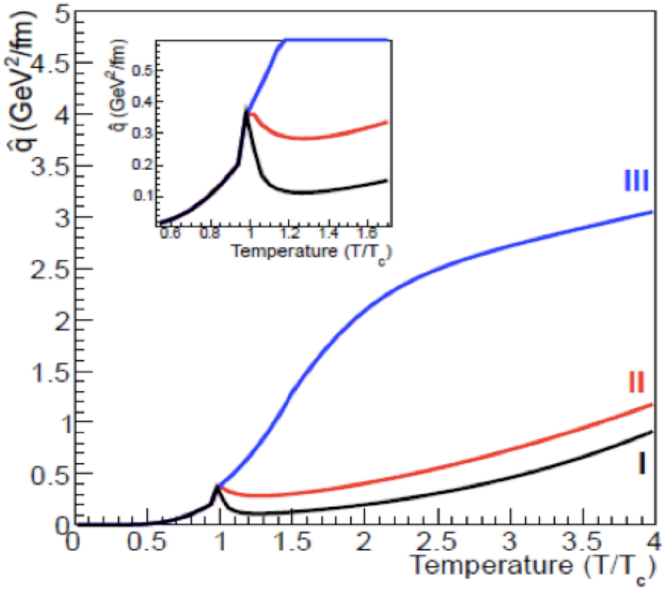
"Small Shear Viscosity Implies Strong Jet Quenching"

A. Majumder, B. Muller, X.N. Wang, PRL (2007).

$$\hat{q} \stackrel{?}{=} \frac{1.25T^3}{\eta / s}$$







Key is independently measuring both sides of this equation!

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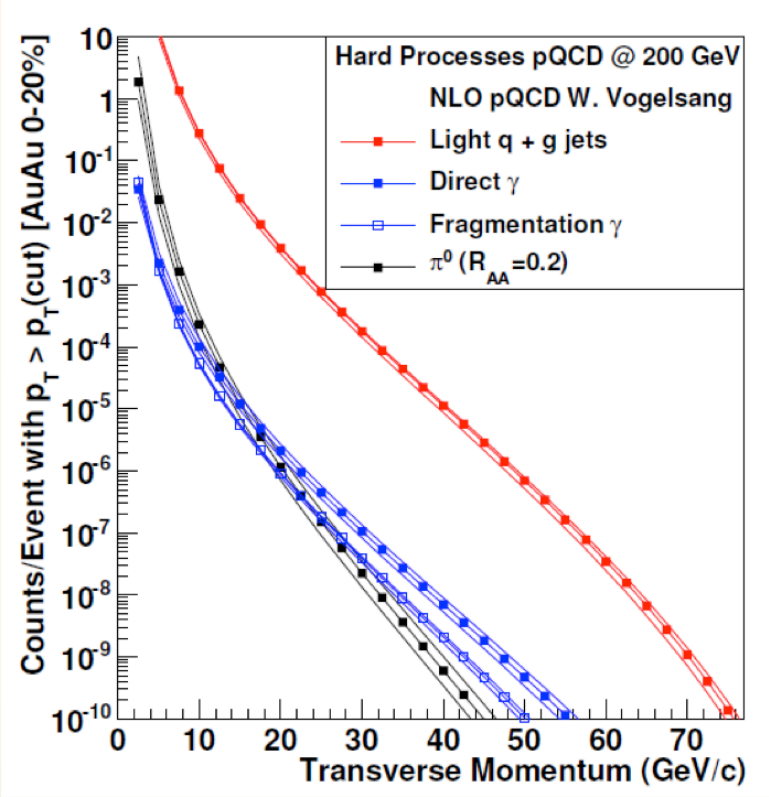
Observables in sPHENIX

- Single jets, direct photons: R_{AA}, v_n
- Intra-jet hadron correlations: Longitudinal and radial modifications
- Jet-jet, photon-jet correlations: I_{AA}, A_j
- Jet-hadron correlations: global response
- Heavy flavour jets
- Separated Upsilon states

Anticipated Jet Rates at RHIC



200 billion sampled, 50 billion collected
In 20 weeks of Au+Au running

-1 < η < 1	Au+Au (central 20%)	p+p	d+Au
> 20GeV	10^7 jets 10^4 photons	10^6 jets 10^3 photons	10^7 jets 10^4 photons
> 30GeV	10^5 jets 10^3 photons	10^5 jets 10^2 photons	10^4 jets 10^3 photons
> 40GeV	10^5 jets	10^4 jets	10^5 jets
> 50GeV	10^4 jets	10^3 jets	10^4 jets

Rates based on stochastic cooling, but no additional upgrades to RHIC

Large rates allow differential measurements with geometry (v_2, v_3, A+B, U+U, …) and
Precise control measurements (p(d)+Au, and p+p)
80% of events are dijets

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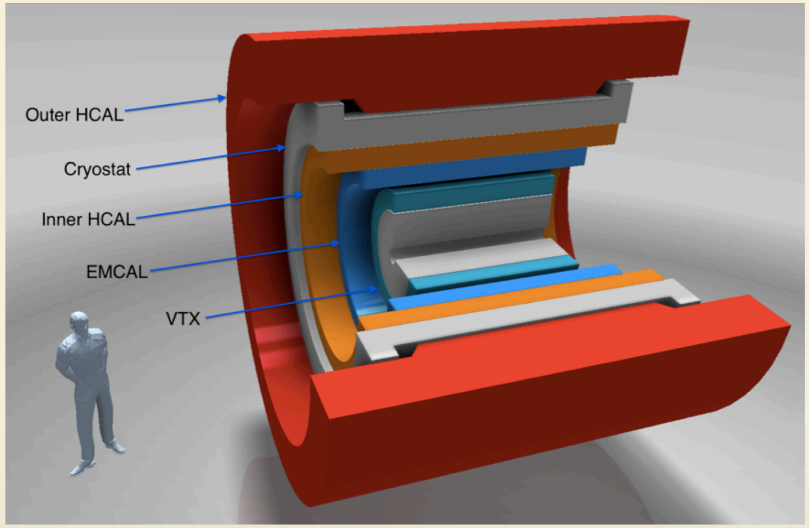
sPHENIX Detector

- Coverage:
  - $|\eta| < 1.1$
  - 2π in ϕ
- Superconducting Solenoid
- Hermetic calorimetry
- Full tracking
- Options for future forward detectors



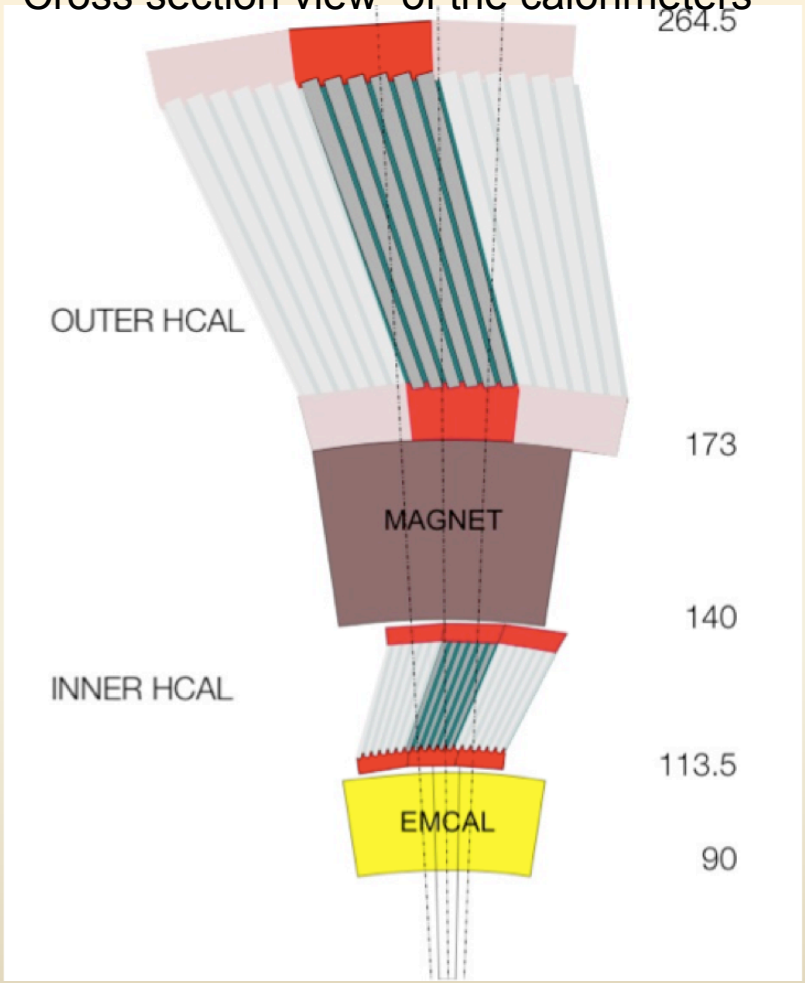
BaBar Solenoid

- Superconducting solenoid
- 1.5T Field
- Homogeneous in center
- Dimensions:
  - R_{inner} = 140 cm
  - R_{outer} = 170 cm
  - Length = 385 cm
- Preparations are being made to transport to BNL this year.

Hadronic Calorimetry

- 2 Sections:
- Inner:
  - Copper absorber, $\approx 1\lambda$
  - Scintillating tiles with wave shifting fibers
- Outer:
  - Steel absorber, $\approx 4\lambda$
  - Scintillating tiles with wave shifting fibers
  - Acts as flux return
- Require only modest energy resolution

Cross section view of the calorimeters



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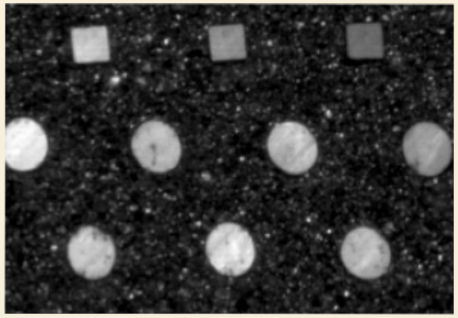
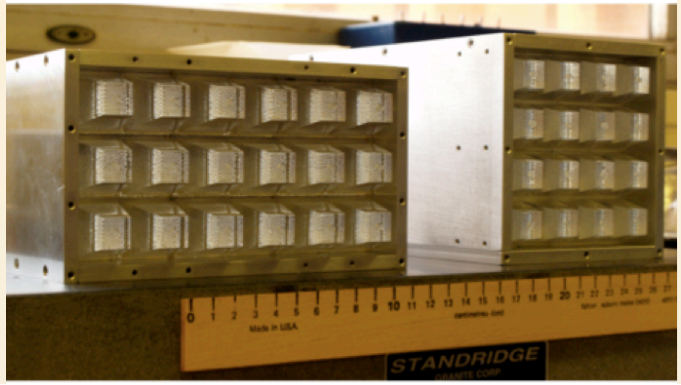
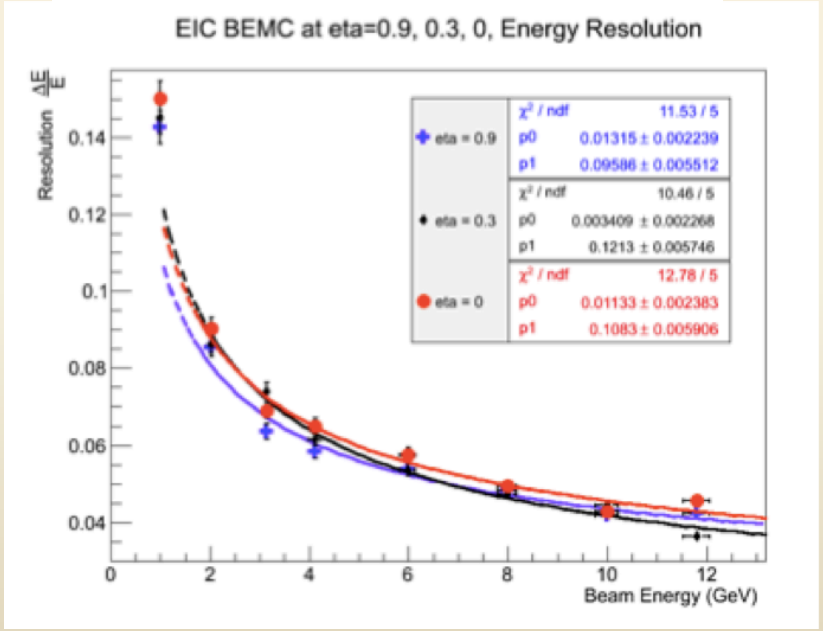
SPACAL Option

- Scintillating fiber embedded into tungsten powder epoxy

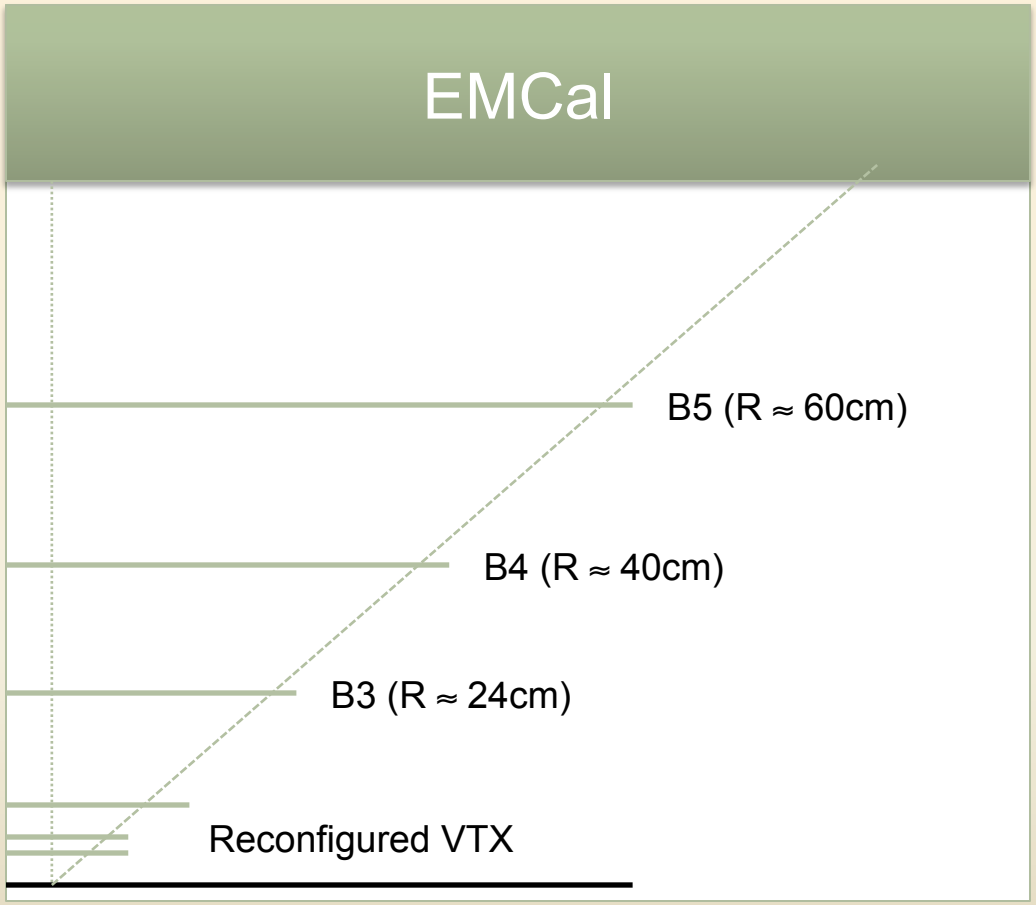






- 18 X_0 deep
- Sampling fraction ≈ 2%
- Resolution ≈ 12%/√E
- ≈ 500 pe/GEV
- SiPM based readout

Central Tracking



Reconfigure the PHENIX VTX:

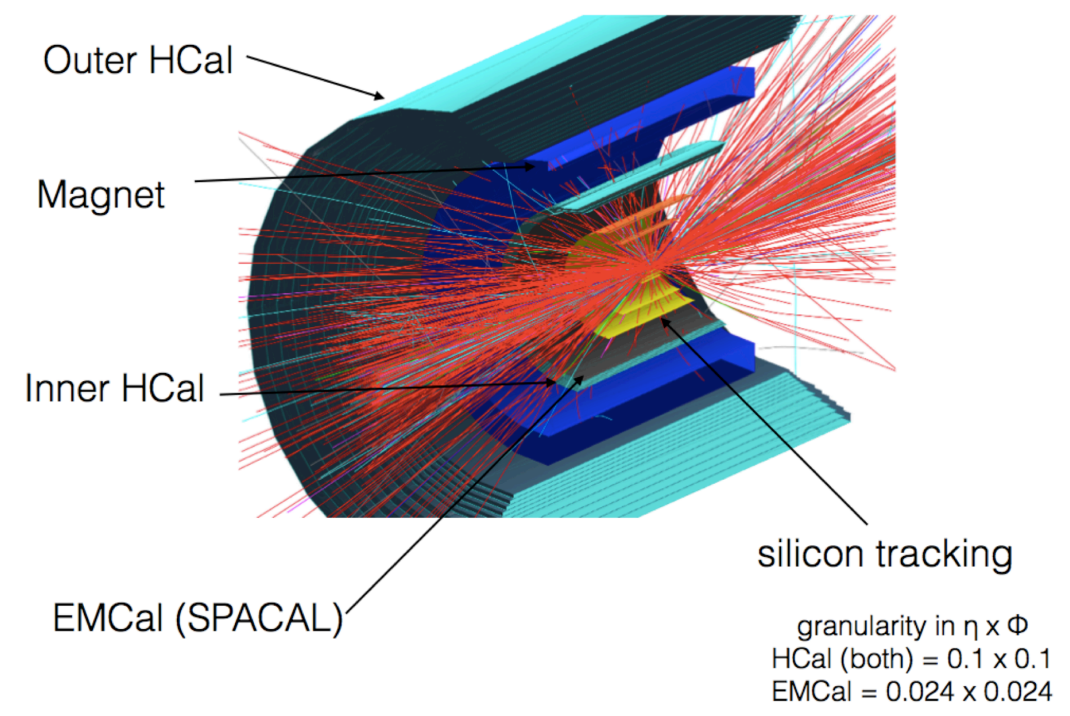
- 3 layers at R ≈2.7cm, ≈4.6cm, and ≈11.8cm.
- First 2 layers pixels, third layer stripixels
- Full 2π coverage

Add 3 additional outer layers of strip detectors

- Single sided
- 62.5 μm pitch
- 96mm strip length

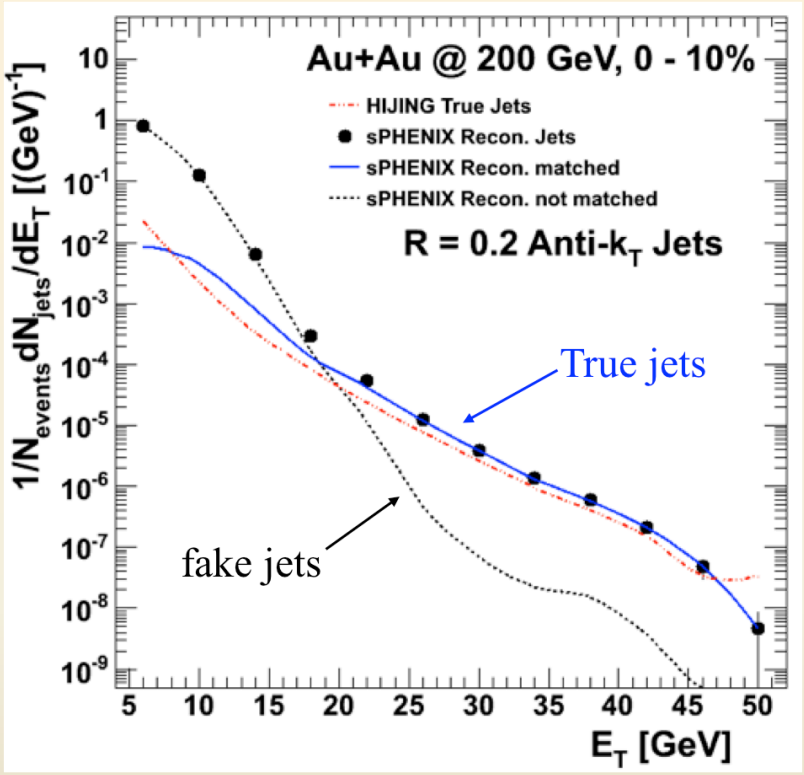
Working on optimizing the final design

sPHENIX in GEANT

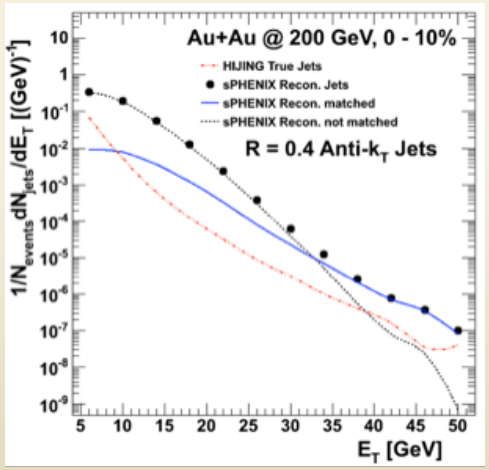


- Full GEANT4 simulation
- Study:
  - jet reconstruction
  - Tracking resolution
  - Detector optimization

Jet Studies: Fake Jet Rates



- For R = 0.2 jets real jets dominate HIJING above 20 GeV
- Details in PRC86 (2012) 0204908
- For R = 0.4 real jets dominate > 30 GeV



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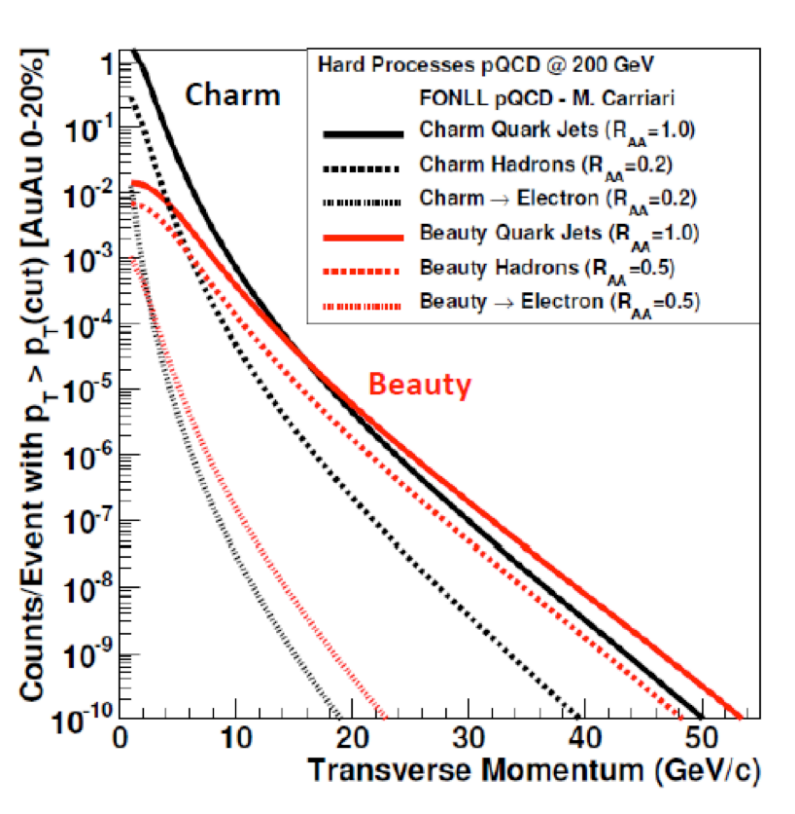
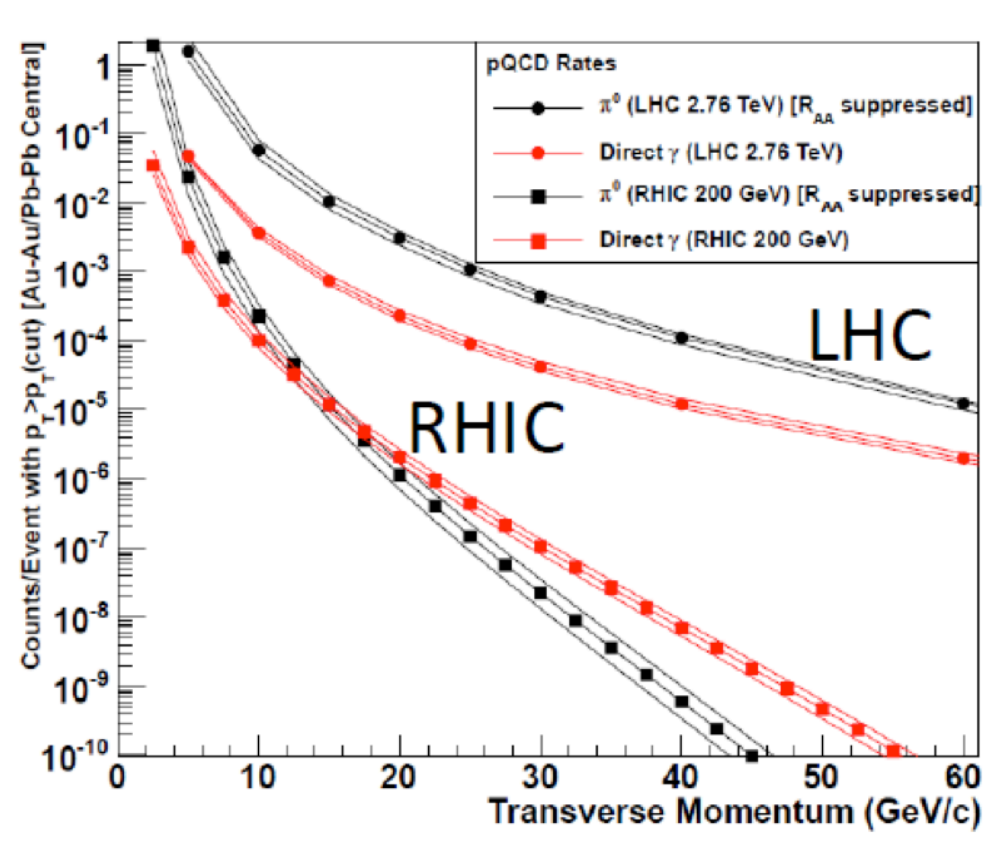
Charm/Beauty Tagged Events

- Precision Tracking:
  - Allows identification of secondary vertices
  - Large displaced vertices tag events with charm and beauty
  - Key test of mass dependence on energy loss



Direct Photons



- Excellent direct photon capabilities.
- Direct photons dominate in central Au+Au collisions for p_T > 20GeV/c.
- Isolation cuts along with full calorimetry allow p+p and p+A comparison measurements

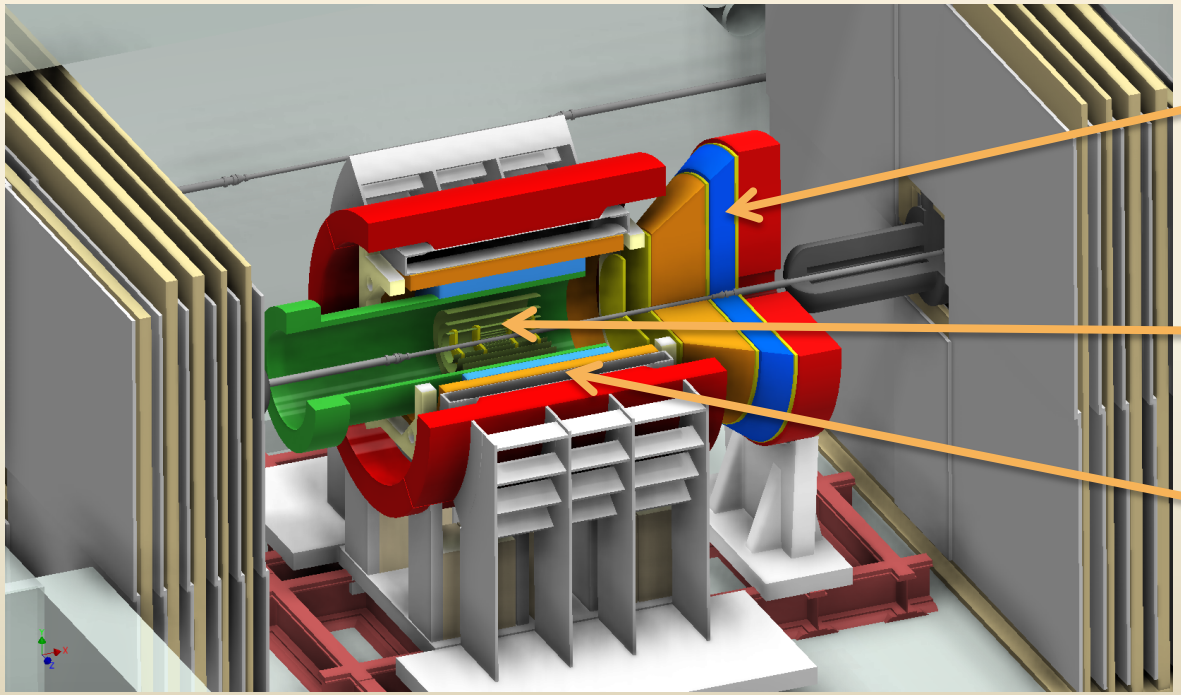
sPHENIX Timeline

- July 2014: DOE Science Review was held
  - Initial reports are favorable and encouraging!
- 2014-2016: RHIC running with PHENIX and STAR
  - Start sPHENIX detector construction
- 2017: No Run,
  - Low energy e-cooling ugrade
  - Decommision PHENIX and start installation of sPHENIX
- 2018-2019: Beam Energy Scan running of RHIC
  - partial sPHENIX comissioning
- 2020: No Run
  - Complete sPHENIX installation
- 2021-2022: Long 200 GeV Au-Au Run
  - sPHENIX is up and running

Beyond sPHENIX

BaBar solenoid is ideal for an EIC detector. Higher coil density at ends, coupled with proper flux return shape provides good analyzing power at forward angles.

sPHENIX calorimetry design meets with EIC physics requirements in terms of segmentation and energy resolution.



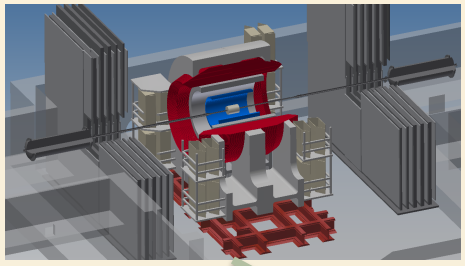
Forward tracking, particle ID and electromagnetic calorimetry

Upgraded central tracking: TPC, GEMS….

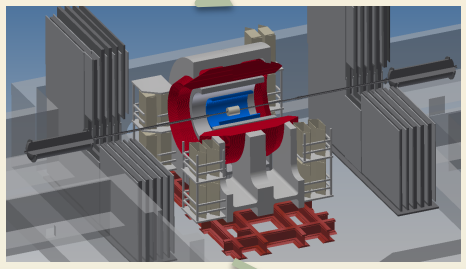
Preshower and PID upgrades

Summary

- RHIC can probe the QGP using jets
- sPHENIX will measure jets with full calorimetry, direct photons and upsilons
- sPHENIX will be taking data by 2021
- The detector will provide a strong base for a future eRHIC experiement

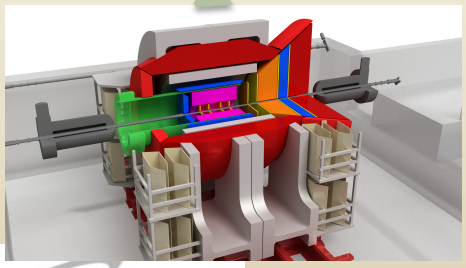


PHENIX
Today



sPHENIX
2021

eRHIC
2025



BACKUP SLIDES