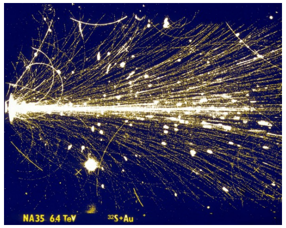
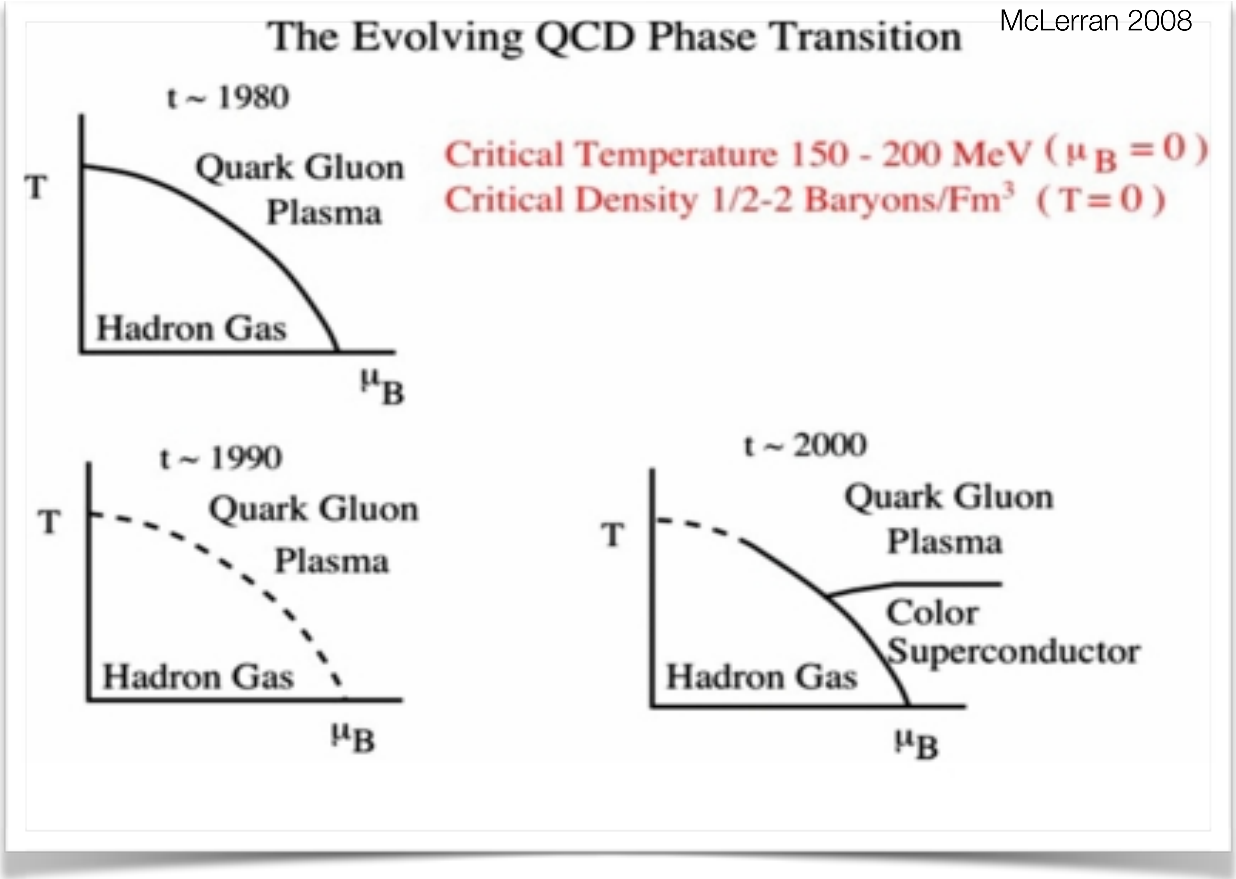
Future plans at RHIC: sPHENIX

Gunther Roland (MIT) Mexico City Oct 30, 2017

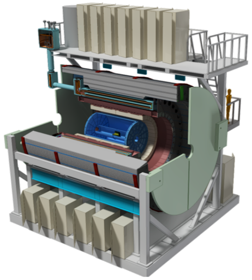


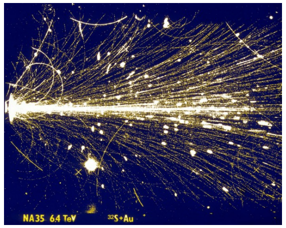


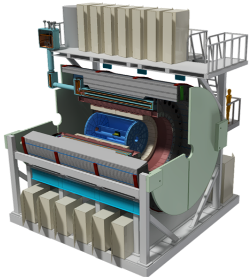
McLerran 2008

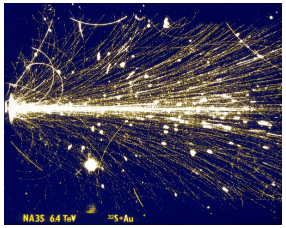
The Evolving QCD Phase Transition

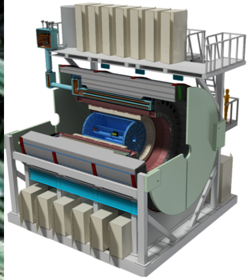
Critical Temperature 150 - 200 MeV ($\mu_B = 0$)
Critical Density 1/2-2 Baryons/Fm^3 (T=0)




NA35 64 TeV
^{32}S+Au







Intersections

30 years ago

NA35 collaboration

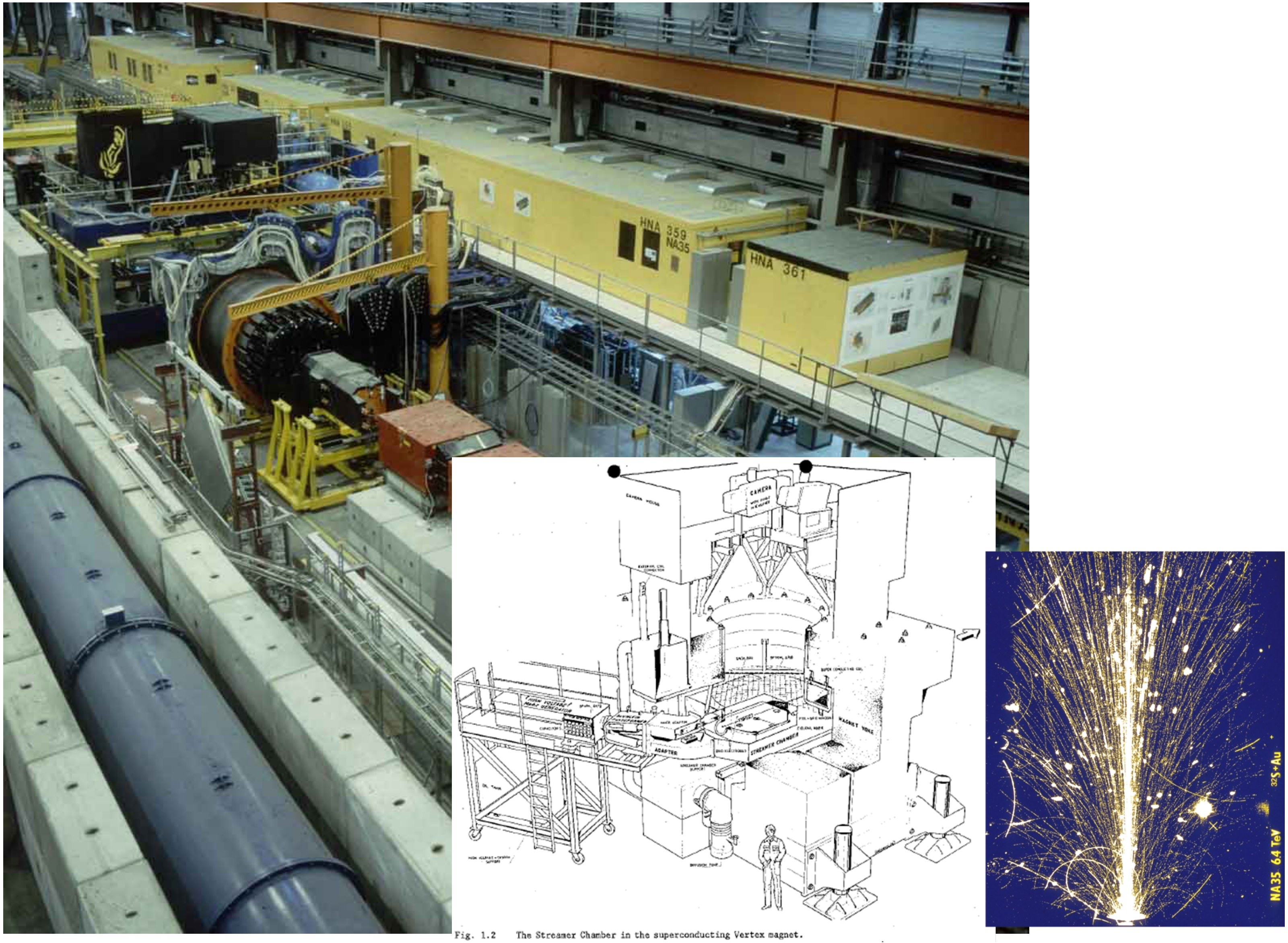
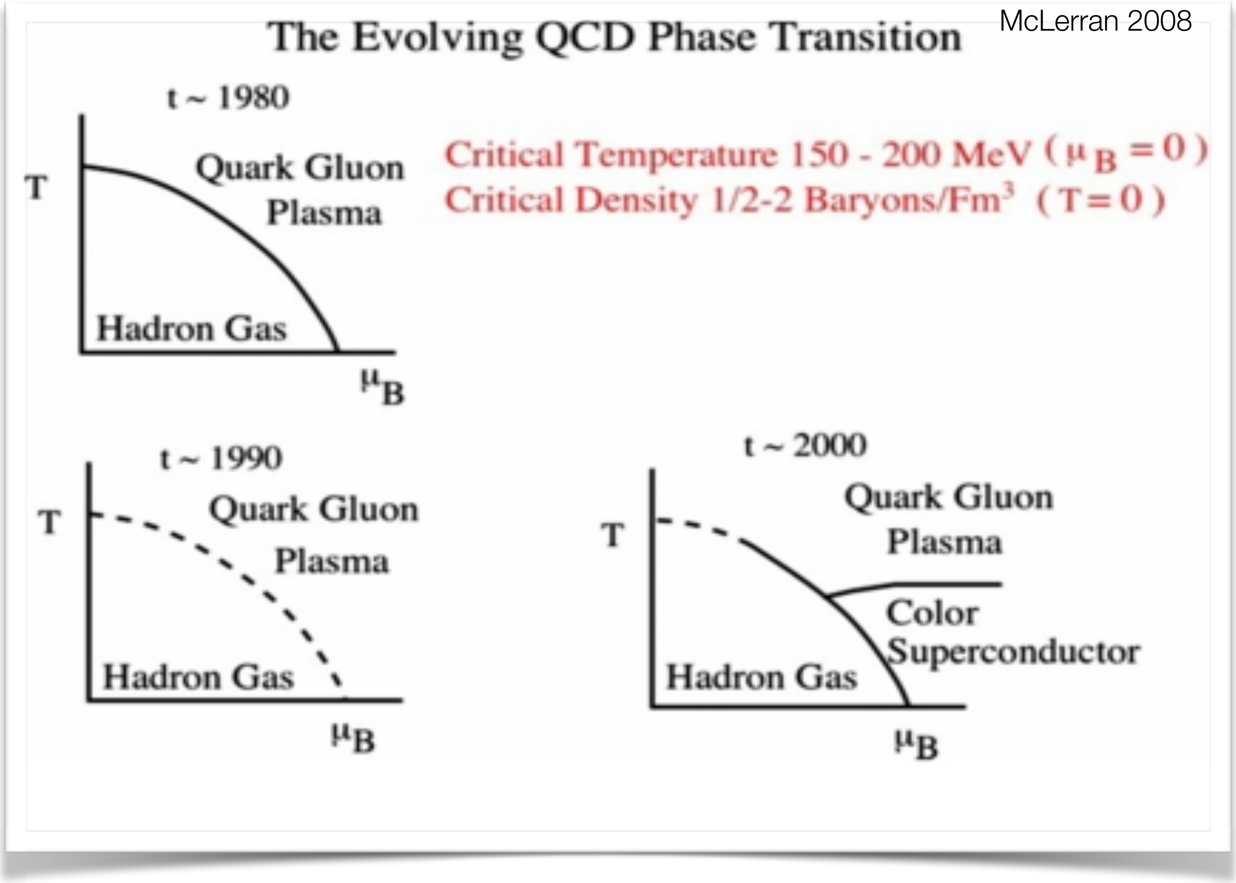


Fig. 1.2 The Streamer Chamber in the superconducting Vertex magnet.

**Observe the QGP/HG phase transition
Critical phenomena!**



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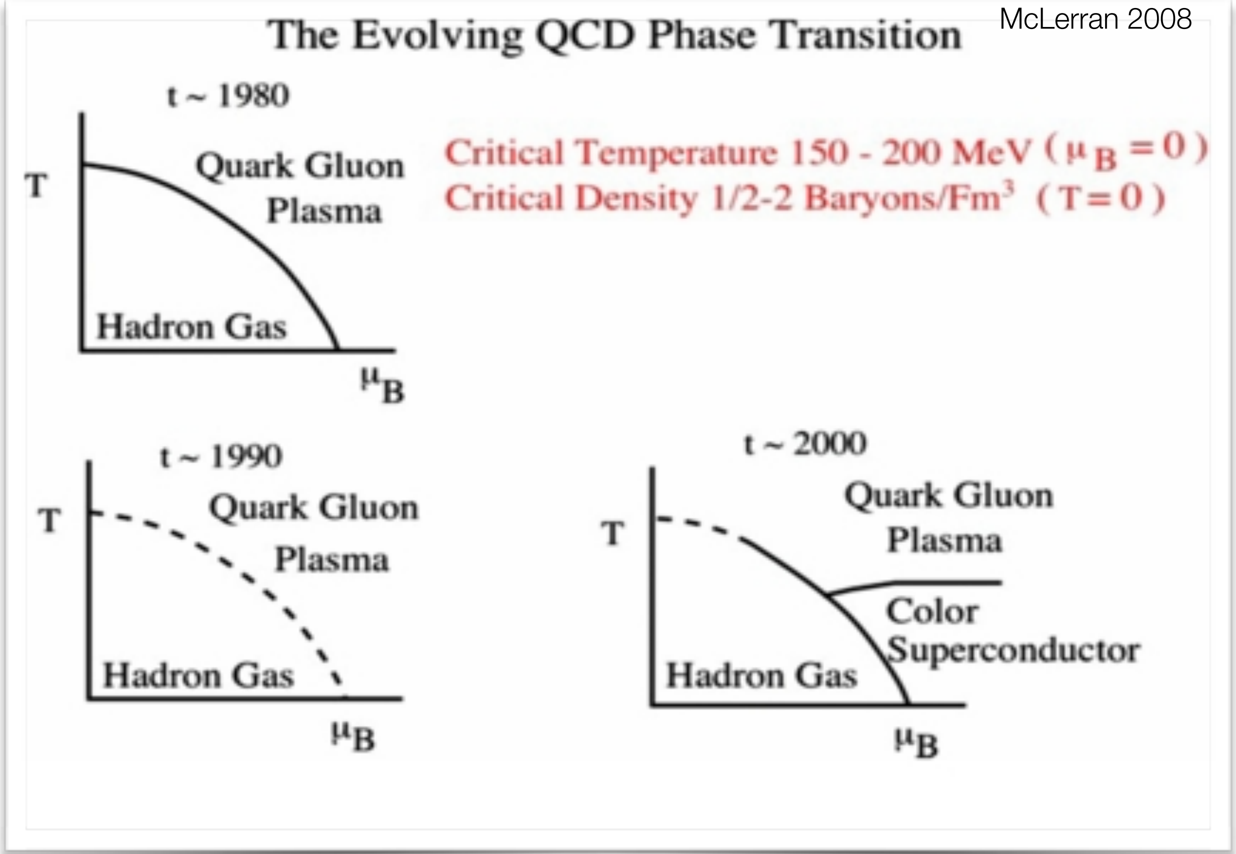

McLerran 2008

The Evolving QCD Phase Transition

Critical Temperature 150 - 200 MeV $(\mu_B = 0)$
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Discover the QGP
Onset of Deconfinement

New Scientist 19 February 1987

29

SCIENCE

On the trail of the quark-gluon plasma

Christine Sutton

PHYSICISTS seem to be tantalisingly close to observing the exotic state of matter known as a quark-gluon plasma, or "quagma". Theory implies that such a plasma should exist in matter where the energy density is much higher than usual. Recent experiments at CERN, the European centre for nuclear research in Geneva, suggest that high-energy collisions of oxygen nuclei with targets of large nuclei, such as lead, are approaching the appropriate energy density. High-energy cosmic-ray nuclei show similar effects.

According to current theories of particle physics, the protons and neutrons within atomic nuclei are themselves composite. They consist of quarks, which are bound together by the strong nuclear force. The force is transmitted by gluons—"messenger" particles that flit from quark to quark, and which can also interact between themselves.

At low energies, in the nuclei of the everyday world, the quarks and gluons are confined within the protons and neutrons. Moreover, even in high-energy experiments at particle accelerators, the quarks and gluons generally seem to exist only within the particles classified as hadrons. However, theories of the strong force indicate that when the energy density of matter becomes high enough, the quarks and gluons are no longer confined within hadrons, but instead form a plasma, in analogy to the way that at high energies a gas of atoms becomes a plasma of electrons and ions.

Matter in normal nuclei has an energy density of about 150 million electronvolts per cubic femtometre (MeV/fm^3), where a femtometre is 10^{-15}m. Theorists predict that at energy densities several times greater than this—a few GeV/fm^3—the quark-gluon plasma will form. One place to search for them is in the collisions of heavy nuclei, each containing many protons and neutrons. The hope is that a nucleus in a suitable "target" might impede a nucleus flying towards it and create a region of high-energy density for a fraction of a second.

Evidence that nuclei do stop high-energy projectiles in this way would come from the debris of the collisions. If most of the debris moves away in the direction in which the projectile nucleus was heading, then the projectile has to a large extent passed through the target nucleus. But if the debris is scattered sideways, it indicates that the target had tended to stop the projectile.

For several years, a team of physicists from Japan and the US, known as JACEE for Japanese-American Cosmic-ray Emulsion Experiment, has been studying the collisions of high-energy cosmic rays in detectors flown on balloons at high altitudes. The researchers can identify the incoming nuclei and measure the energy and momentum of the hundreds of particles produced in the collisions. In some instances, the detectors reveal more than 400 charged particles accompanied by many photons, most of which probably come from the decays of neutral forms of the particles known as pions.

The JACEE team measure the average momentum of the photons in a direction transverse (sideways) to the general motion of the initial nucleus and the subsequent debris. The momentum taken sideways in these collisions is greater than might be expected by extrapolating data from lower energy experiments at accelerators (*Physical Review Letters*, vol 57, p 3249). The researchers estimate that energy densities of 1-2 GeV/fm^3 or more existed in the collisions with the highest average values of transverse momentum.

Tracks of 220 charged particles spill out from the collisions of a high-energy oxygen nucleus in a lead target to the left of this picture from the NA35 experiment at CERN

Experiments with cosmic rays are notoriously difficult, not least because the number of large nuclei at very high energies is very low. The results from the JACEE experiment are not conclusive evidence for the formation of a quark-gluon plasma; indeed, various other effects could explain the increased transverse momentum. However, the data do underline the need for detailed experiments in the controlled conditions of particle accelerators, of the kind that have taken place at CERN.

Last September, CERN produced particle beams of a record high energy when the Super Proton Sychotron (SPS) accelerated oxygen nuclei to 3200 GeV—an energy of 200 GeV for each of the 16 nucleons (protons and neutrons) in an oxygen nucleus. Then in November, the machine delivered an oxygen beam for 17 days to experiments waiting to catch the first glimpse of a quark-gluon plasma (*New Scientist*, 13 November, p 40).

While it is still too early for the various teams to make detailed conclusions, some very encouraging features are already emerging from the data. First, the oxygen collisions have tended to produce large numbers of particles, sometimes carrying very large amounts of energy transverse to the beam direction. The image shown here is from the experiment code-named NA35, which is run by a team of 59 physicists from 8 nations. The apparatus includes a device called a streamer chamber, which makes visible the tracks of charged particles produced when the oxygen beam strikes a target 13 cm in front of the chamber. Beyond the chamber, banks of detectors intercept the continuing paths of the particles and yield valuable information on their energies.

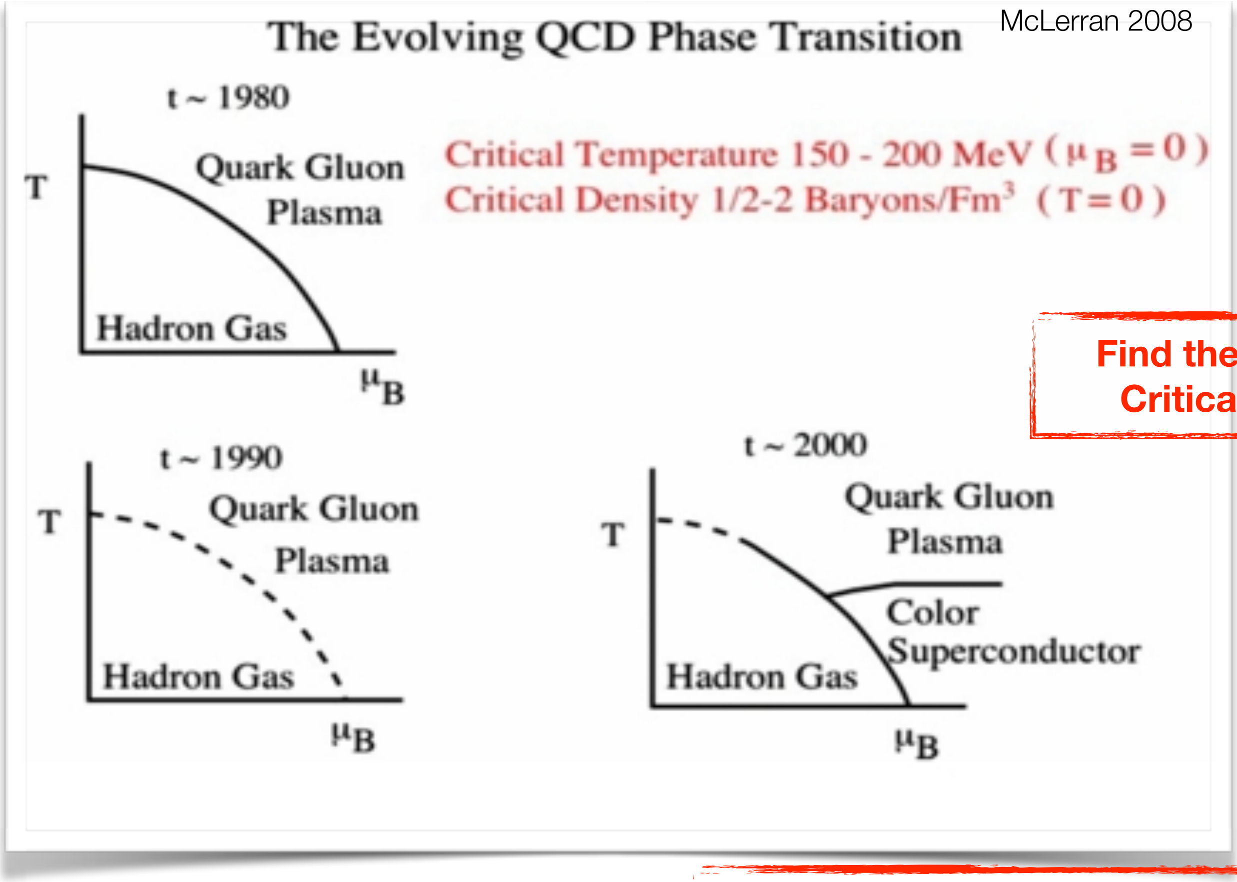
In this example, the streamer chamber reveals the tracks of 220 charged particles and, from other information, the researchers can estimate that some 80 or so neutral particles also emerged from the collision. From the amount of energy measured at certain angles, the team can also estimate how much of the original oxygen ion's energy has been redistributed in all directions. In this case, about 50 per cent of the incoming energy has been "thermalised".

From measurements of this kind, the teams running NA35 and the experiment known as Helios can conclude that up to 70 per cent of the oxygen's energy is deposited in the collisions with a target of lead. In other words, the nuclei in the targets can almost stop the incoming oxygen nuclei. Using this information, the researchers can estimate the energy density at the point of collision to be 3 to 5 GeV/fm^3.

A second interesting observation is that the 16 nucleons in the oxygen nucleus appear to behave as 16 independent objects; there is little tendency for one nucleon to act in the shadow of another and therefore have a reduced effect, as might be expected. This is very encouraging in terms of further runs planned for later this year with beams of sulphur (16 protons and 16 neutrons) and calcium (20 protons and 20 neutrons). If the nucleons in these ions also behave independently, then they should produce energy densities 20 to 30 per cent higher than oxygen ions.

This week, NA35 is publishing some of its first results, from the test run in September, in *Physics Letters B*. They report an estimated transverse energy density of about 3 GeV/fm^3—sufficient, they conclude, "for a comprehensive quark matter search". Meanwhile, quagma enthusiasts will also await detailed results from experiments such as Helios, which can identify some particles and thereby search for precise "signatures" of the quark-gluon plasma. ☐

Observe the QGP/HG phase transition
Critical phenomena!



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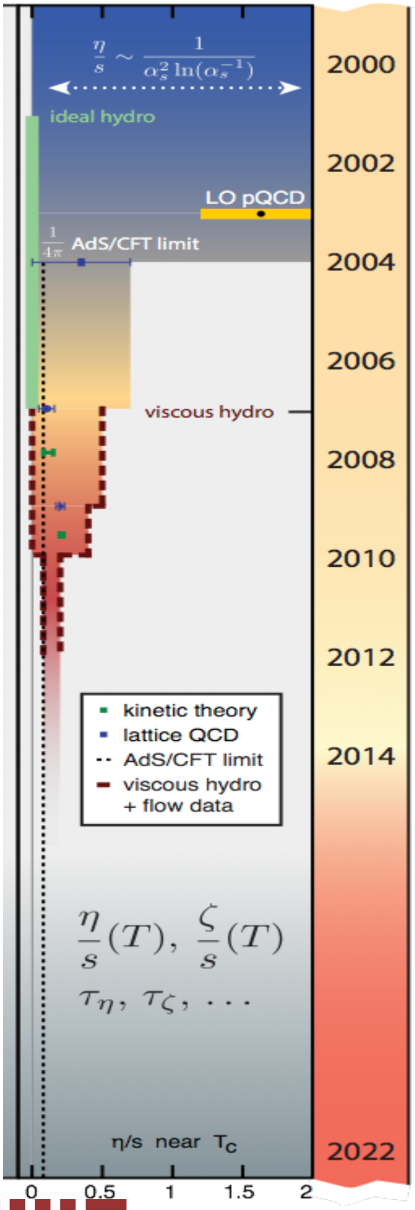
Find the Critical Point!
Critical phenomena

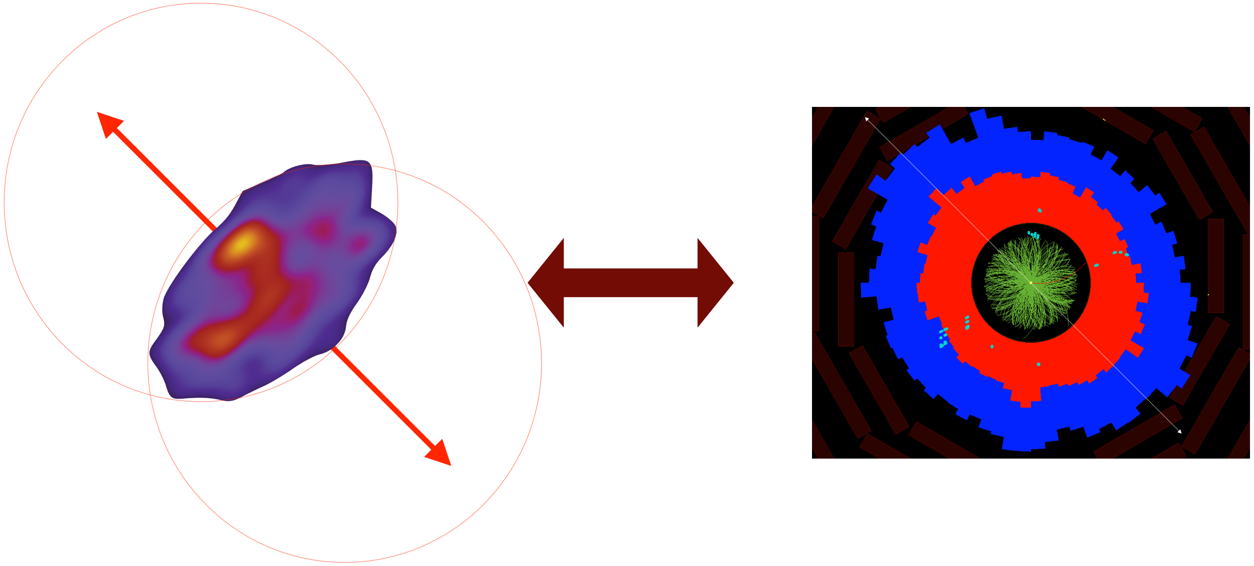
Discover the QGP
Onset of Deconfinement

What are the properties of QGP?
Initial structure, Transport coefficients,…

QGP properties: η/s

Gale, Jeon, Schenke
Int.J.Mod.Phys. A28 (2013) 1340011





Established viscous hydrodynamics as successful effective theory of long-wavelength dynamics of QGP (at few x Tc)

Explained structure and fine-structure of final state correlations based on understanding of initial geometry at (thermal) O(1fm) scale and transport coefficient η/s ~ 1/(4π)

Demonstrated unique place of sQGP among known states of matter; broad connection with other strongly coupled materials (from string theory to cold atoms)

Speakers:

Néstor Armesto (Universidad de Santiago de Compostela, Spain)
Alejandro Ayala (ICN-UNAM, Mexico)
Octavio Castaños (ICN-UNAM, Mexico)
Arturo Fernández (FCFM-BUAP, Mexico)
Paolo Giubellino (University of Torino, Italy & ALICE-LHC)
Gerardo Herrera (CINVESTAV, Mexico)
Arturo Menchaca (IF-UNAM, Mexico)
Antonio Ortiz (Lund University, Sweden)
Gunther Roland (Massachusetts Institute of Tecnology, USA)
Daniel Tapia (University of Paris, France)
Thomas Trainor (University of Washington, USA)

Open Issues in
Heavy-Ion Physics

Symposium in Honor of
Guy Paić

December 1-2, 2012
Hotel Camino Real, PUEBLA

More information: www.nucleares.unam.mx

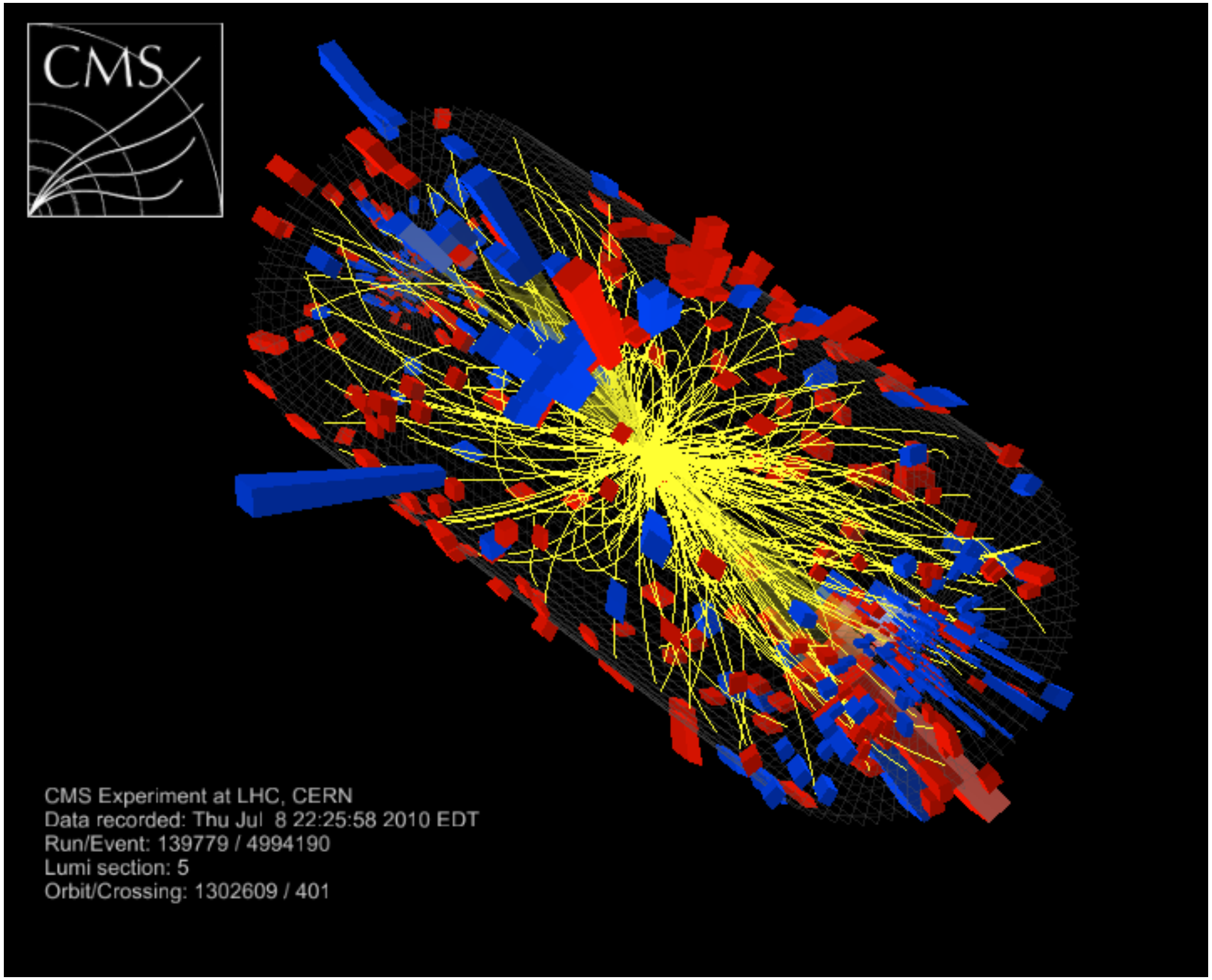
Organizing Committee:

Alejandro Ayala
Gerardo Herrera
Eleazar Cuautle
Arturo Fernández
Mario Rodríguez
Mario Iván Martínez

2010

$N_{ch} = 258$ $dNch/d\eta \approx 65$

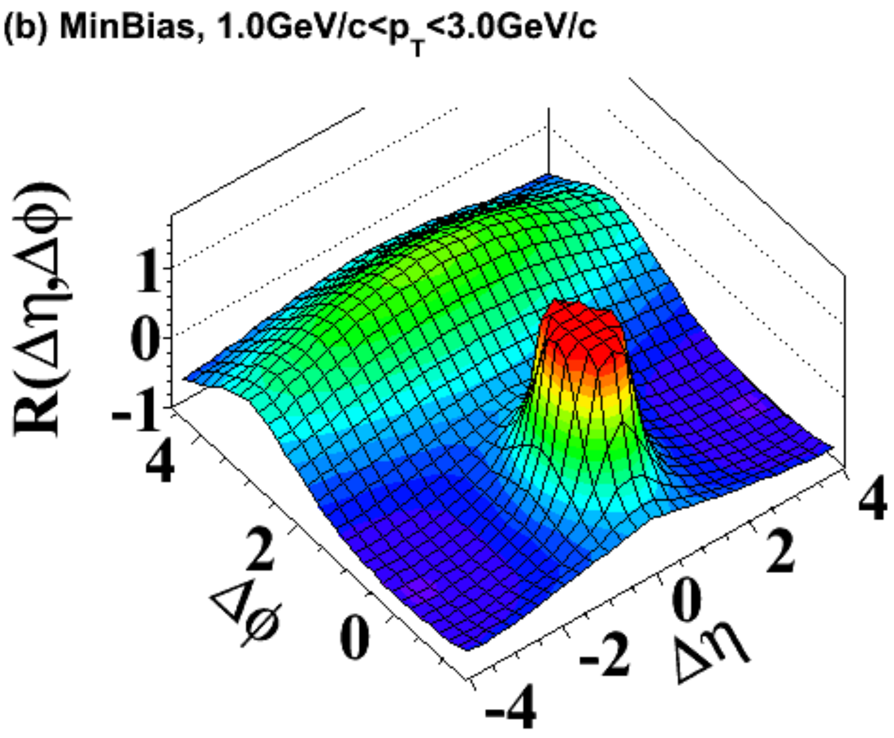
CMS arXiv:1009.4122



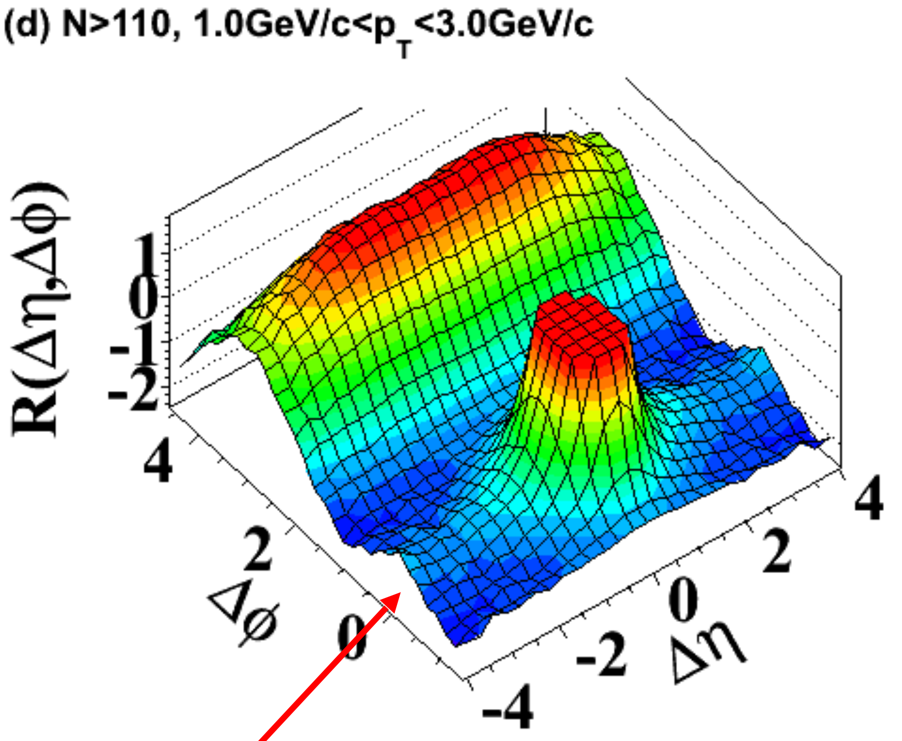
High multiplicity events selected with online track reconstruction. Used unprescaled trigger on 1pb^{-1} (5x10^{10} events)

Long-range near-side correlations seen in 7TeV pp

MinBias



High multiplicity (N>110)



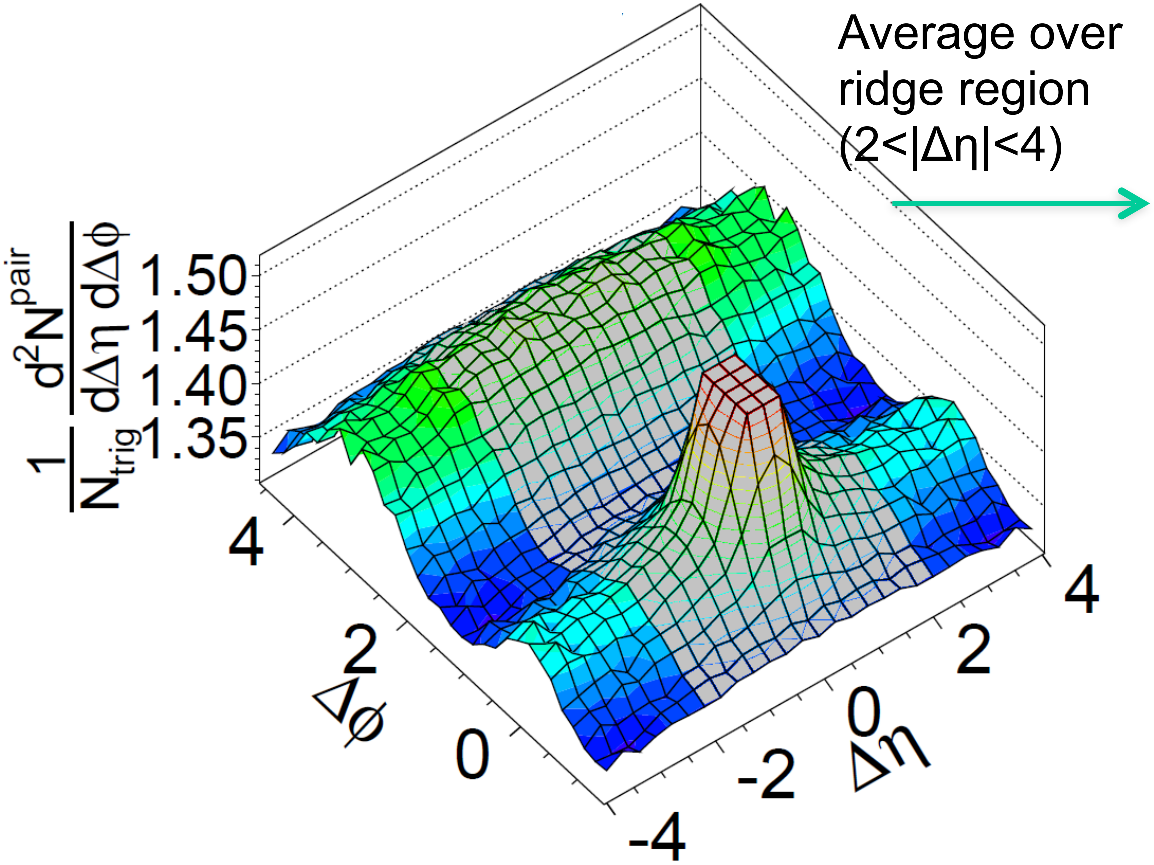
Charged hadron correlations in CMS tracker ($|\eta| < 2.4$)

Pronounced structure at large $\Delta\eta$ around $\Delta\phi \approx 0$!

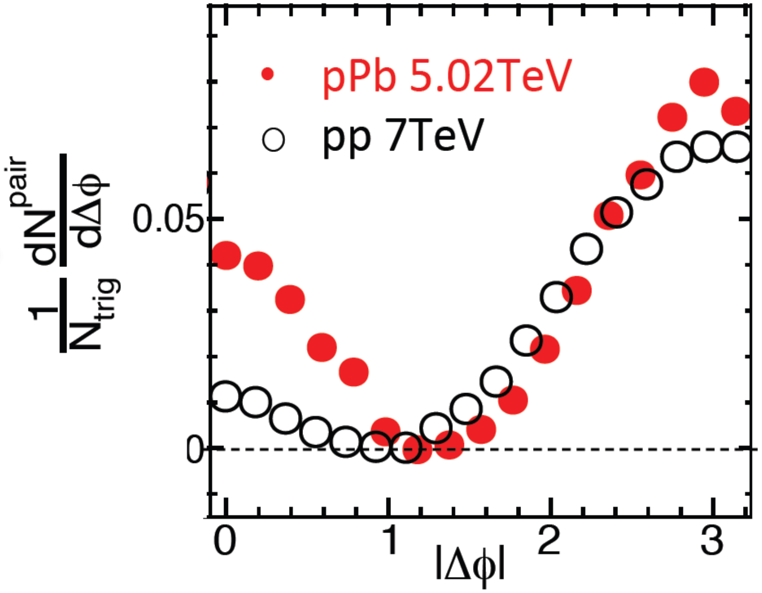
Much stronger effect seen in pPb at 5TeV

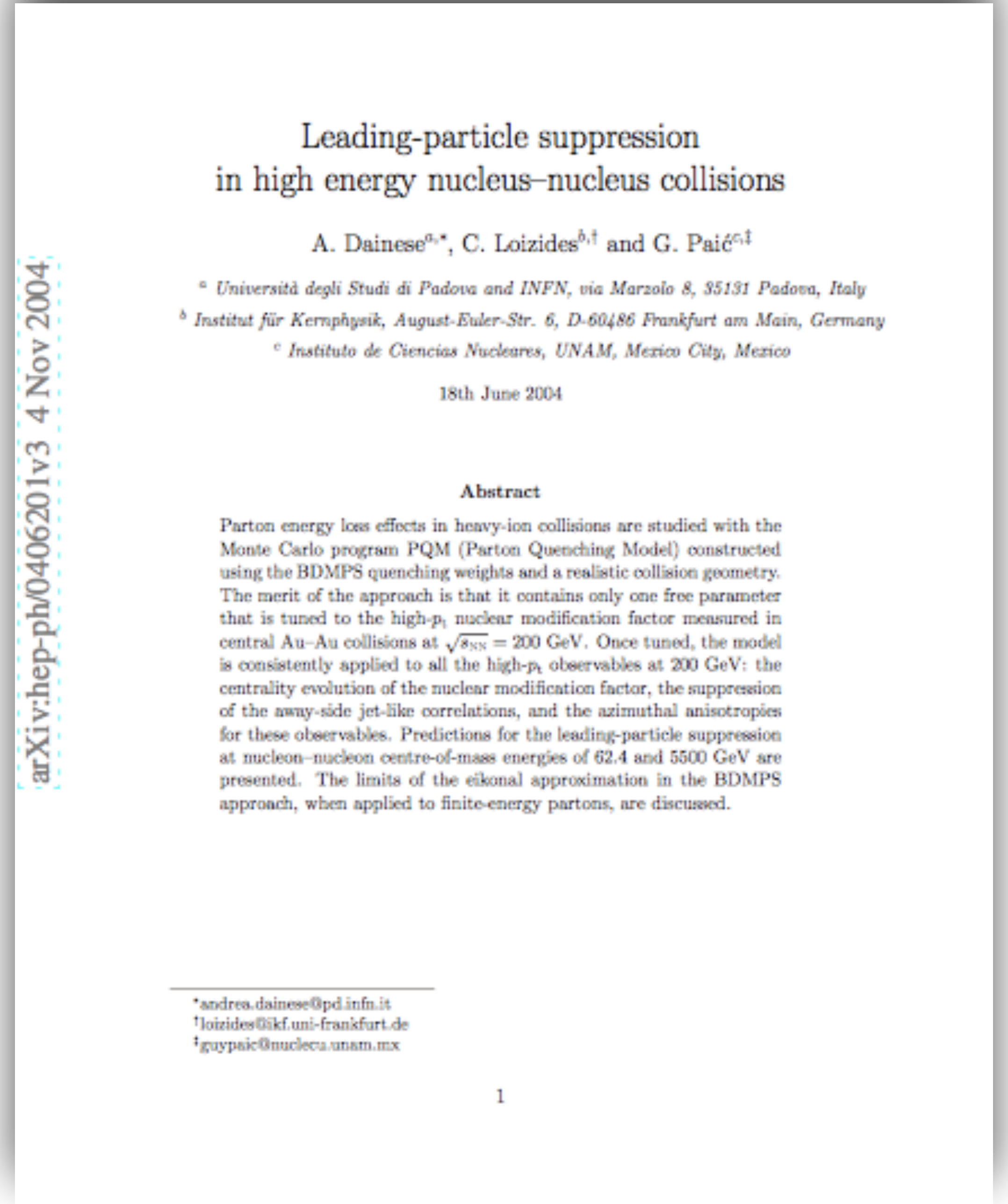
Study the “long-range” region

“ZYAM”: Normalize associated yield to be zero at minimum



Average over ridge region (2<|Δη|<4)





Leading-particle suppression in high energy nucleus–nucleus collisions

A. Dainese[a,*], C. Loizides[b,†] and G. Paić[c,‡]

[a] *Università degli Studi di Padova and INFN, via Marzolo 8, 35131 Padova, Italy*
[b] *Institut für Kernphysik, August-Euler-Str. 6, D-60486 Frankfurt am Main, Germany*
[c] *Instituto de Ciencias Nucleares, UNAM, Mexico City, Mexico*

18th June 2004

Abstract

Parton energy loss effects in heavy-ion collisions are studied with the Monte Carlo program PQM (Parton Quenching Model) constructed using the BDMPS quenching weights and a realistic collision geometry. The merit of the approach is that it contains only one free parameter that is tuned to the high-p_t nuclear modification factor measured in central Au–Au collisions at $\sqrt{s_{NN}} = 200$ GeV. Once tuned, the model is consistently applied to all the high-p_t observables at 200 GeV: the centrality evolution of the nuclear modification factor, the suppression of the away-side jet-like correlations, and the azimuthal anisotropies for these observables. Predictions for the leading-particle suppression at nucleon–nucleon centre-of-mass energies of 62.4 and 5500 GeV are presented. The limits of the eikonal approximation in the BDMPS approach, when applied to finite-energy partons, are discussed.

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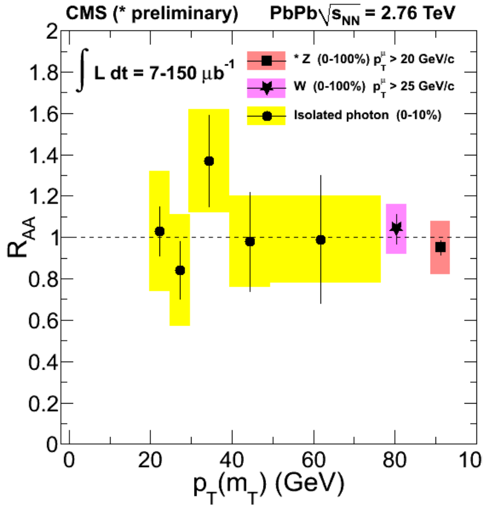
[*] andrea.dainese@pd.infn.it
[†] loizides@ikf.uni-frankfurt.de
[‡] guypaic@nuclecu.unam.mx

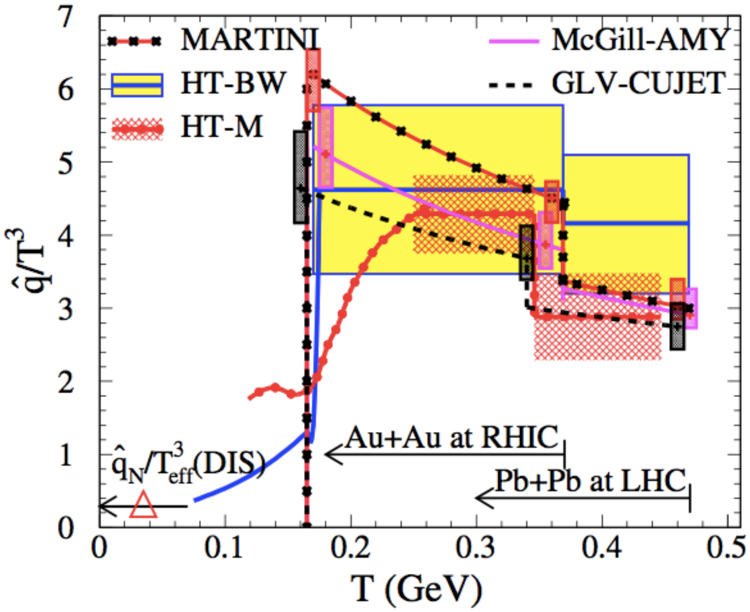
1

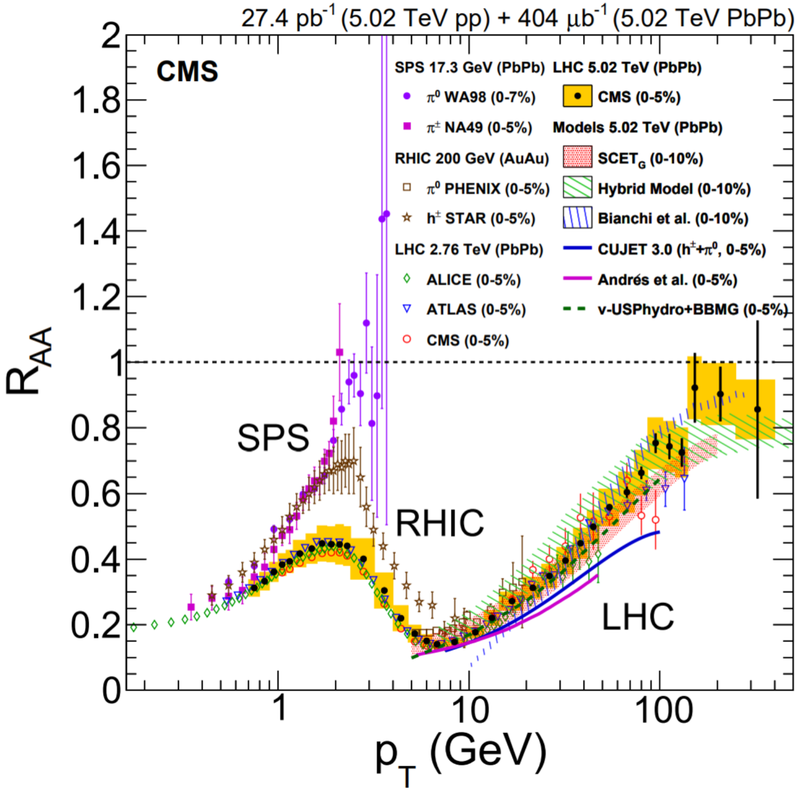
QGP properties: $\hat{q}$, $\hat{e}$



High p_T/high mass vectorbosons unmodified

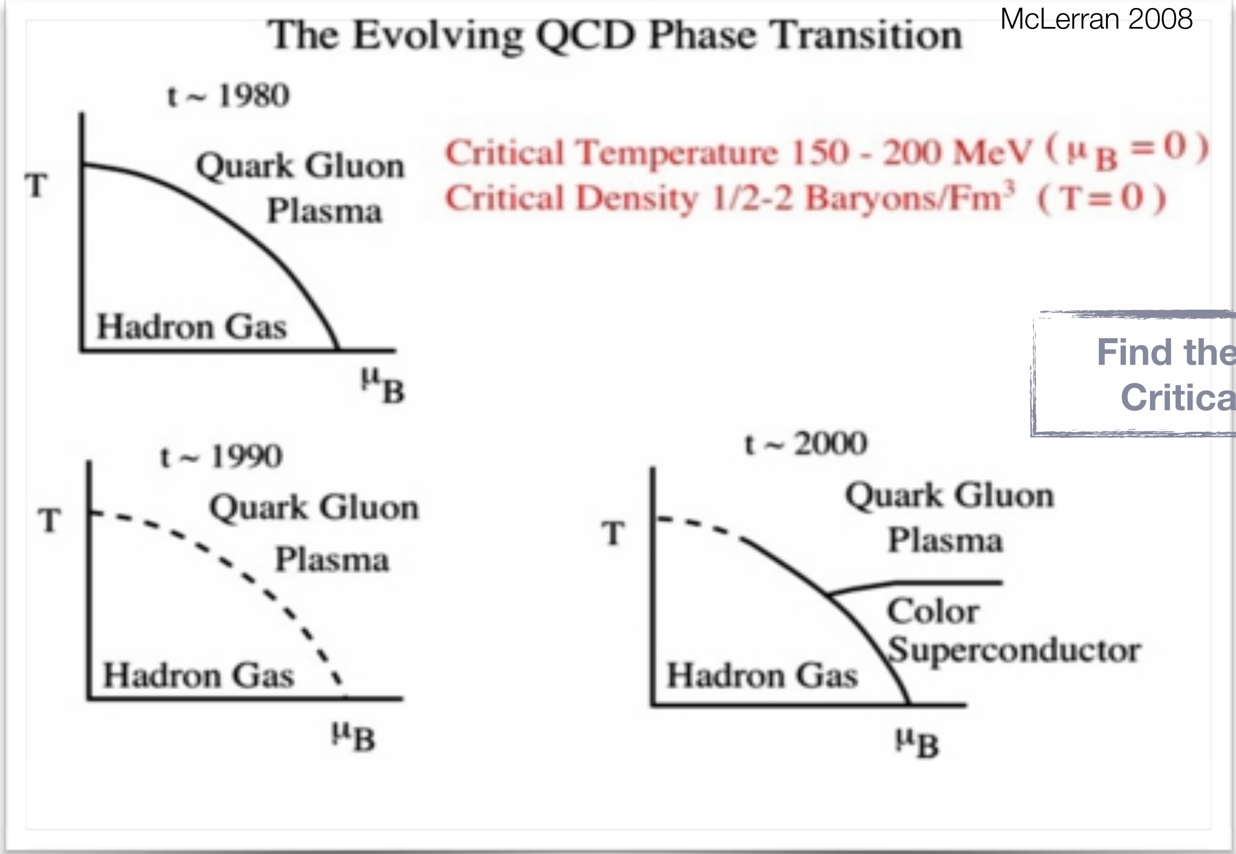
JET collaboration, 2013





Charged hadrons suppressed

Observe the QGP/HG phase transition
Critical phenomena!



McLerran 2008

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Find the Critical Point!
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Discover the QGP
Onset of Deconfinement

What are the properties of QGP?
Initial structure, Transport coefficients,…

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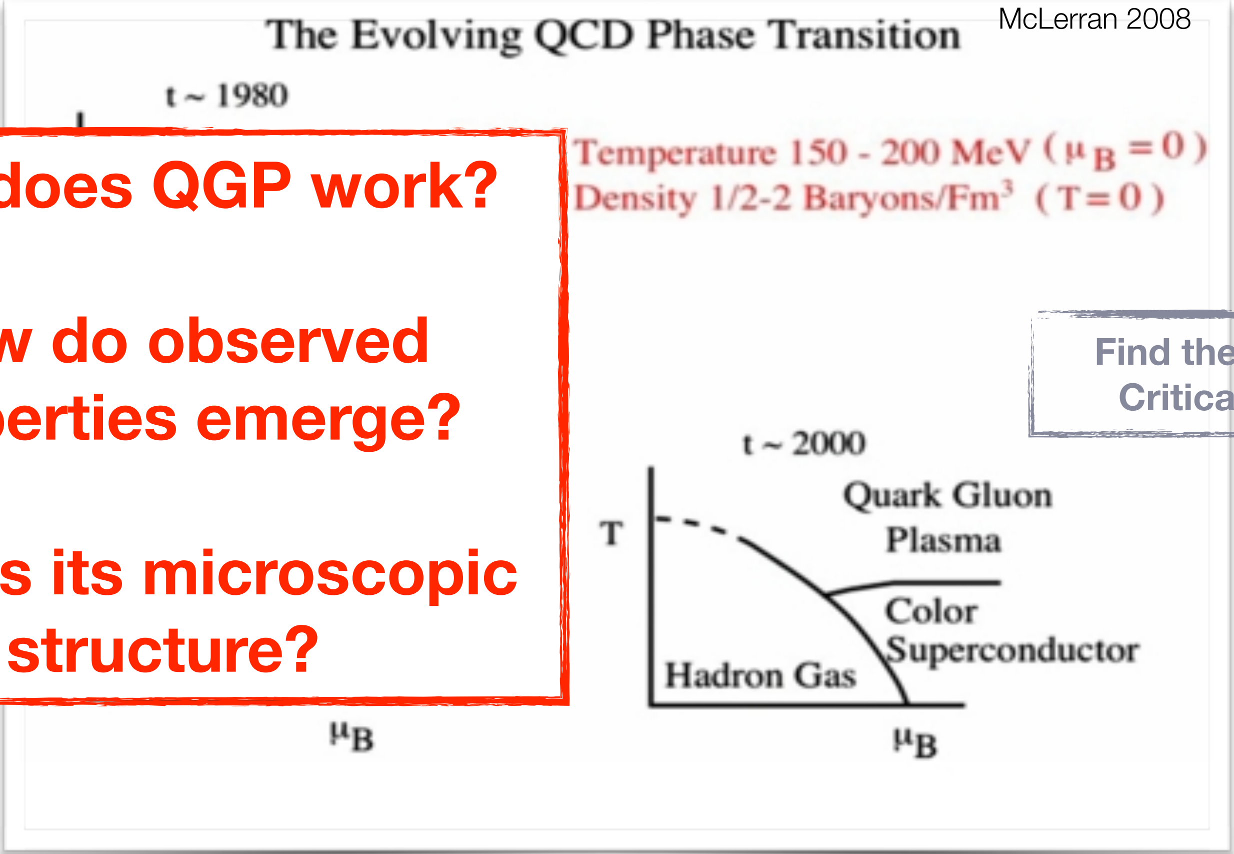
Critical phenomena!



McLerran 2008

The Evolving QCD Phase Transition

t ~ 1980

Temperature 150 - 200 MeV ($\mu_B = 0$)
Density 1/2-2 Baryons/Fm^3 (T = 0)

t ~ 2000

How does QGP work?

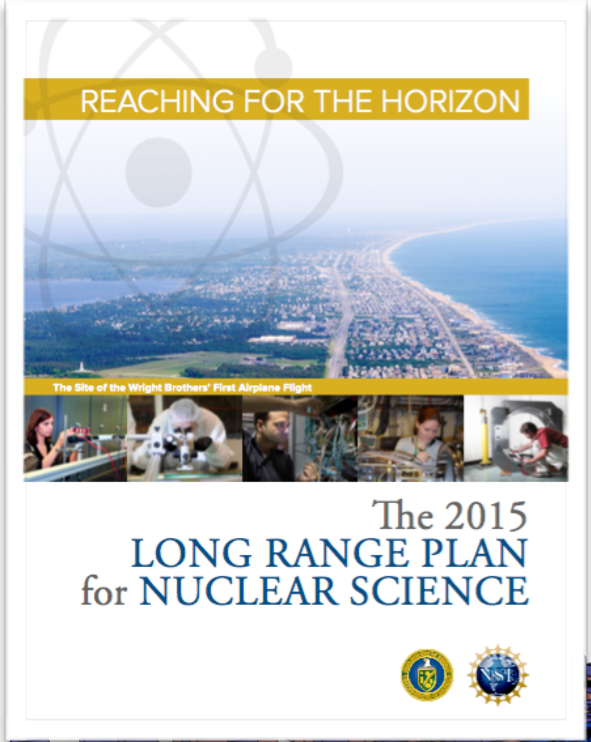
How do observed properties emerge?

What is its microscopic structure?

Find the Critical Point!
Critical phenomena

Discover the QGP
Onset of Deconfinement

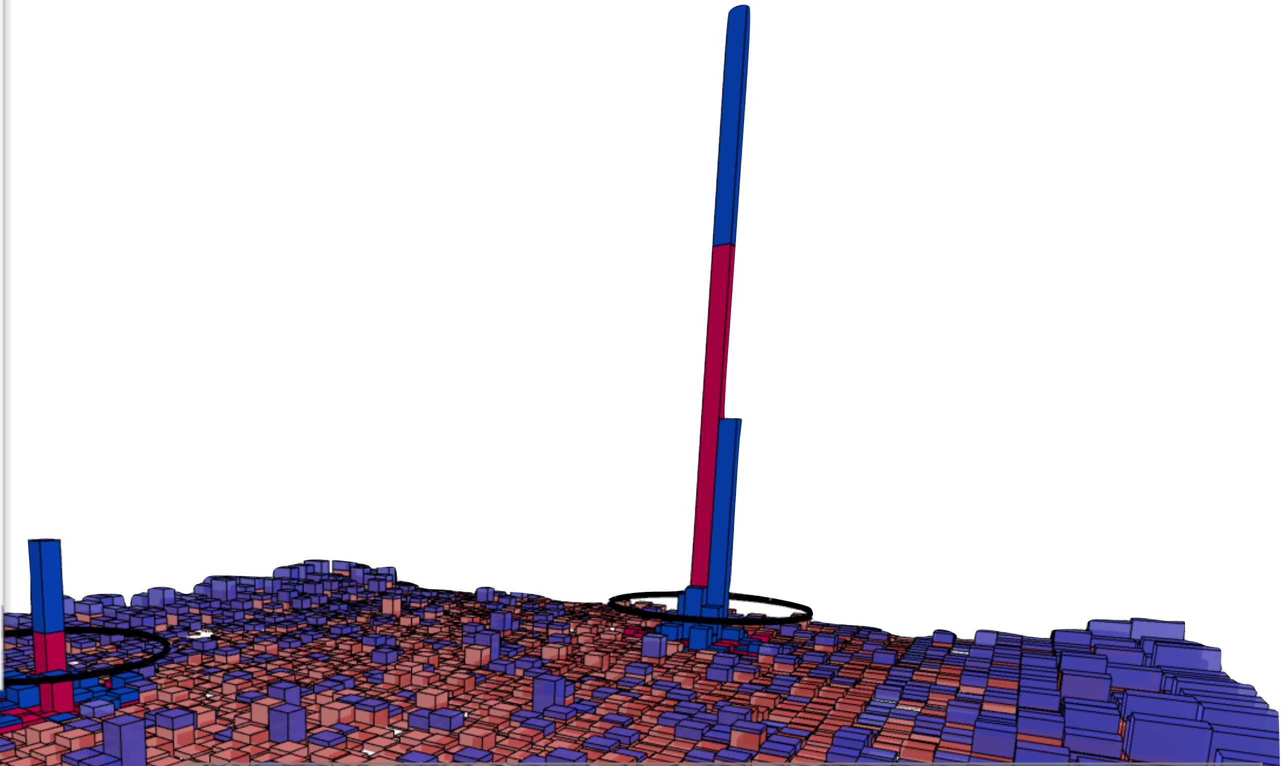
What are the properties of QGP?
Initial structure, Transport coefficients,…

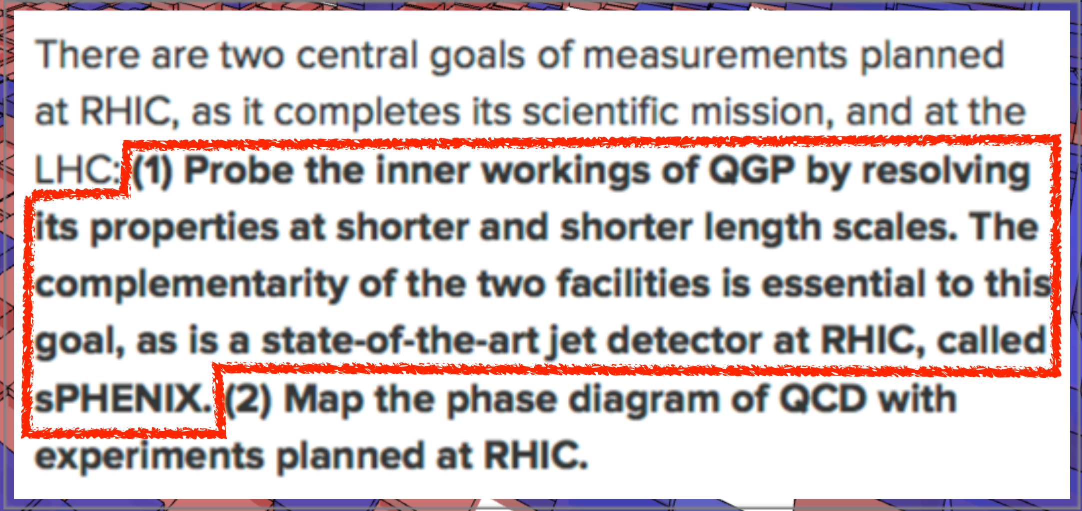


REACHING FOR THE HORIZON

The Site of the Wright Brothers' First Airplane Flight

The 2015
LONG RANGE PLAN
for NUCLEAR SCIENCE

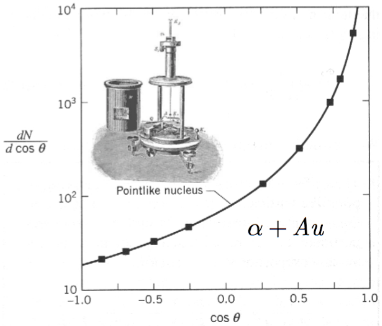




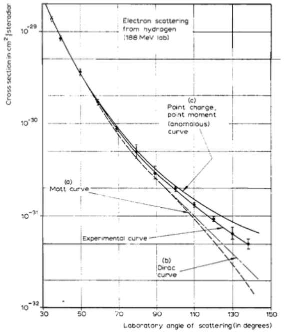
There are two central goals of measurements planned at RHIC, as it completes its scientific mission, and at the LHC: **(1) Probe the inner workings of QGP by resolving its properties at shorter and shorter length scales. The complementarity of the two facilities is essential to this goal, as is a state-of-the-art jet detector at RHIC, called sPHENIX. (2) Map the phase diagram of QCD with experiments planned at RHIC.**

Probing the inner workings of QGP

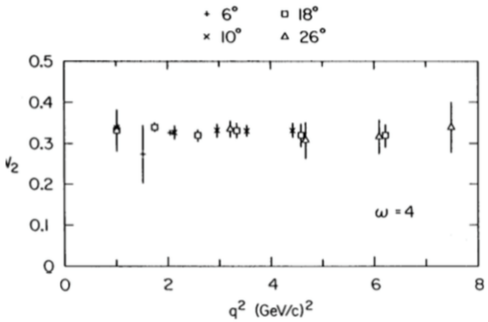
Atoms➔Nuclei



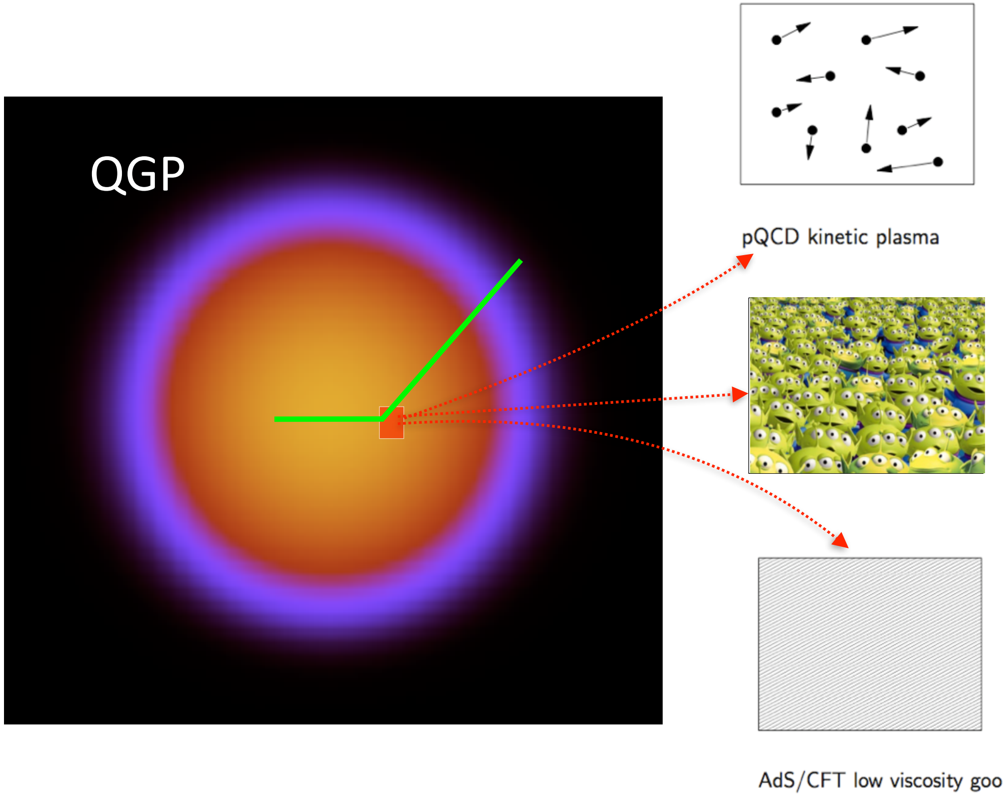
Nuclei➔Nucleons



Nucleons➔Quarks

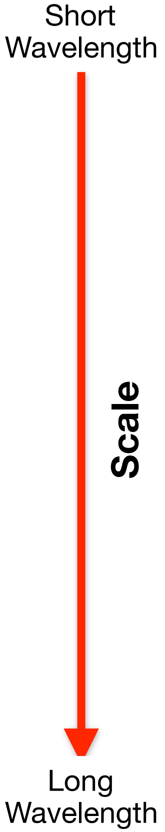


What is the microscopic structure of QGP?



pQCD kinetic plasma

AdS/CFT low viscosity goo



Short Wavelength

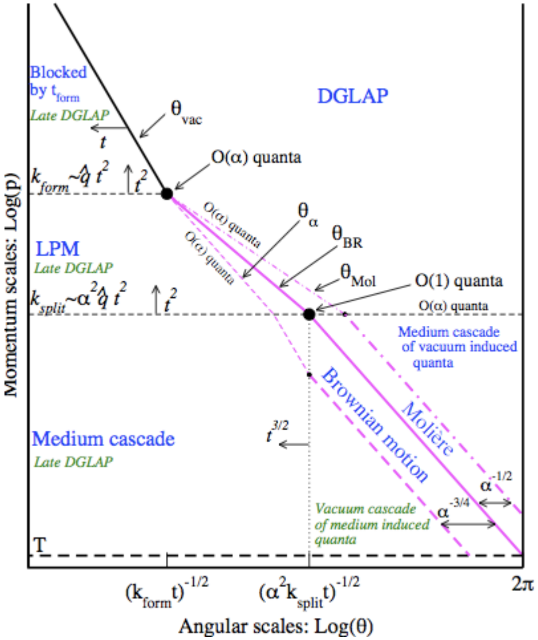
Scale

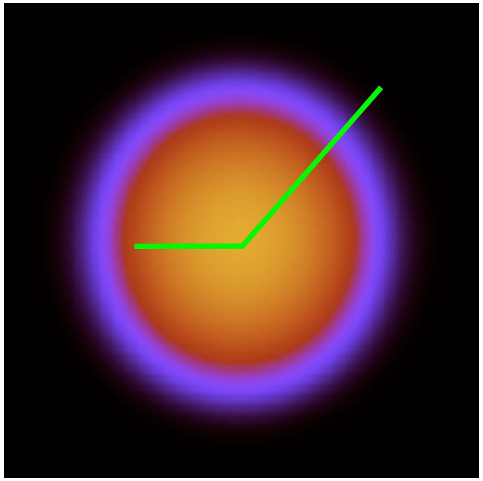
Long Wavelength

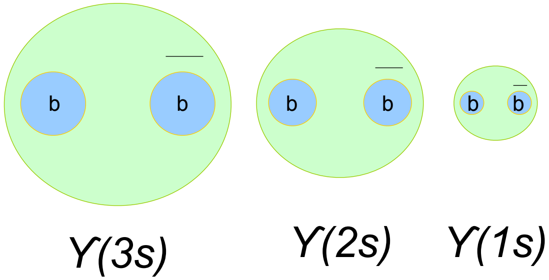
Probing the inner workings of QGP

Three key approaches to study QGP structure at multiple scales

Jets and jet structure

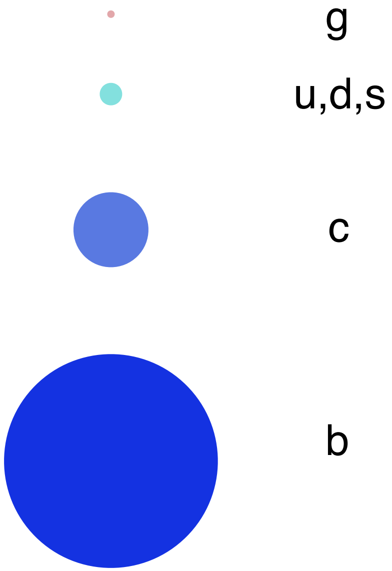






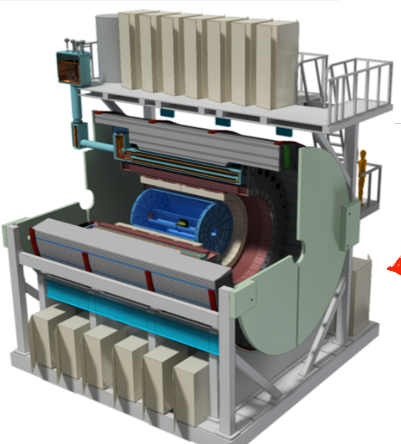
Upsilon spectroscopy

Parton mass/flavor



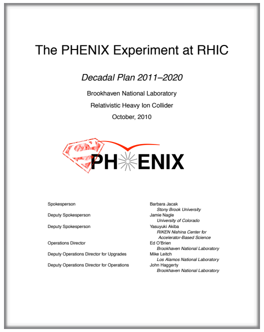
Physics drives detector requirements

Physics goal	Detector requirement
High statistics for rare probes	**Accept/sample full delivered luminosity** Full azimuthal and large rapidity acceptance
Precision Upsilon spectroscopy	Hadron rejection > 99% with good $e^{+/-}$ acceptance Mass resolution 1% @ m_{Υ}
High jet efficiency and resolution	Full hadron and EM calorimetry Tracking from low to high pT
Control over parton mass	Precision vertexing for heavy flavor ID
Control over initial parton p_T	Large acceptance, high resolution photon ID
Full characteri s	High efficiency tracking for $0.2 < p_T < 40$GeV



Seven years of development

- **sPHENIX Concept in the PHENIX Decadal Plan (charged by ALD Steve Vigdor): October 2010**
- Original proposal http://arxiv.org/abs/1207.6378: July 2012
  (new superconducting solenoid & optional additional tracking)
- BNL Review (chaired by Tom Ludlam) of sPHENIX proposal: October 2012
- Updated sPHENIX proposal: October 2013
- BNL Review (chaired by Sam Aronson) of "ePHENIX" LOI: January 2014
- "ePHENIX" White Paper (http://arxiv.org/abs/1402.1209): February 2014
- Future Opportunities in p+p and p+A with the Forward sPHENIX Detector (http://www.phenix.bnl.gov/phenix/WWW/publish/dave/sPHENIX/ pp_pA_whitepaper.pdf): April 2014
- Updated proposal, submitted to DOE: June 2014 (incorporation of Babar magnet and tracking)
- DOE Science Review: July 2014
- Updated Proposal http://arxiv.org/abs/1501.06197 : November 2014
- DOE Science Review (chaired by Tim Hallman): April 2015 – successful science review
- **Science collaboration formed: December 2015**
- **sPHENIX CD-0: October 2016 (DOE Mission need")**
- MVTX pre-proposal: March 2017; Director's review July 2017
- Modest forward upgrade LOI: June 2017
- **DOE CD-1 review expected in first half of CY 2018** (Director's review August 2017)



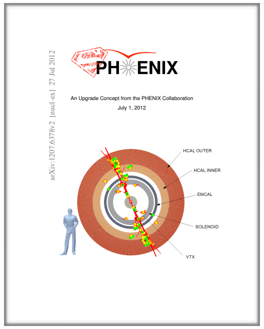
The PHENIX Experiment at RHIC

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*



arXiv:1207.6378v2 [nucl-ex] 27 Jul 2012

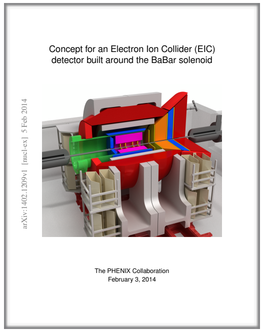
PHENIX

An Upgrade Concept from the PHENIX Collaboration
July 1, 2012

HCAL OUTER
HCAL INNER
EMCAL
SOLENOID
VTX

Future Opportunities in $p+p$ and $p+$A Collisions at RHIC with the Forward sPHENIX Detector

The PHENIX Collaboration
April 29, 2014



Concept for an Electron Ion Collider (EIC) detector built around the BaBar solenoid

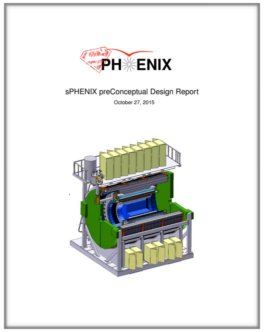
arXiv:1402.1209v1 [nucl-ex] 5 Feb 2014

The PHENIX Collaboration
February 3, 2014

PHENIX

An Upgrade Proposal from the PHENIX Collaboration

Original: July 1, 2012
Updated: October 1, 2013
Updated: June 19, 2014
Updated: November 19, 2014



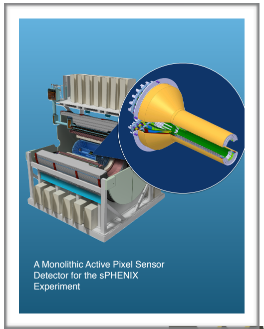
PHENIX

sPHENIX preConceptual Design Report
October 27, 2015

sPHENIX-note sPH-cQCD-2017-001

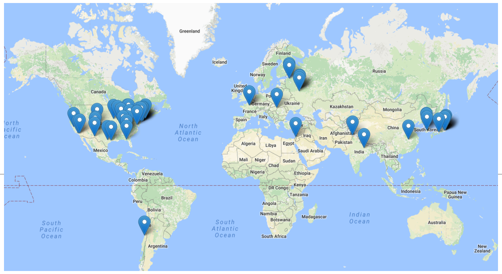
sPHENIX Forward Instrumentation
A Letter of Intent

The sPHENIX Collaboration
June 2017



A Monolithic Active Pixel Sensor Detector for the sPHENIX Experiment

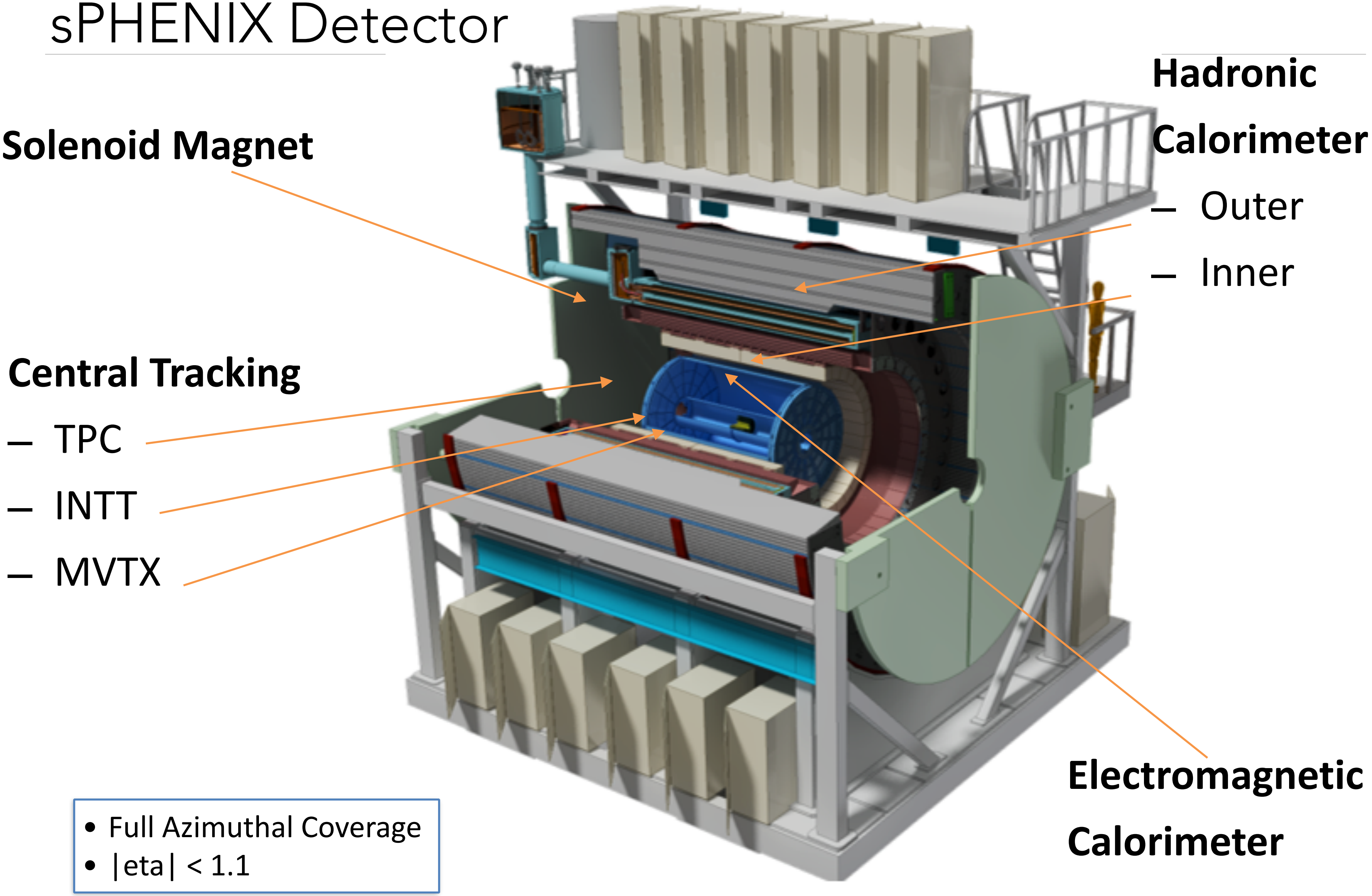
64 institutions and counting



Augustana University
Banaras Hindu University
Baruch College, CUNY
Brookhaven National Laboratory
CEA Saclay
Central China Normal University
Chonbuk National University
Columbia University
Eötvös University
Florida State University
Georgia State University
Howard University
Hungarian sPHENIX Consortium
Insititut de physique nucléaire d'Orsay
Institute for High Energy Physics, Protvino
Institute of Nuclear Research, Russian Academy of Sciences, Moscow
Institute of Physics, University of Tsukuba
Iowa State University
Japan Atomic Energy Agency
Joint Czech Group
Korea University
Lawrence Berkeley National Laboratory
Lawrence Livermore National Laboratory
Lehigh University
Los Alamos National Laboratory
Massachusetts Institute of Technology
Muhlenberg College
Nara Women's University
National Research Centre "Kurchatov Institute"
National Research Nuclear University "MEPhI"
New Mexico State University
Oak Ridge National Laboratory
Ohio University
Petersburg Nuclear Physics Institute
Purdue University
RIKEN
RIKEN BNL Research Center
Rikkyo University
Rutgers University
Saint-Petersburg Polytechnic University
Stony Brook University
Temple University
Tokyo Institute of Technology
Universidad Técnica Federico Santa María
University of California, Berkeley
University of California, Los Angeles
University of California, Riverside
University of Colorado, Boulder
University of Debrecen
University of Houston
University of Illinois, Urbana-Champaign
University of Jammu
University of Maryland
University of Michigan
University of New Mexico
University of Tennessee, Knoxville
University of Texas, Austin
University of Tokyo
Vanderbilt University
Wayne State University
Weizmann Institute
Yale University
Yonsei University

4th sPHENIX Collaboration Meeting (June 2017)

sPHENIX Detector



Solenoid Magnet

Hadronic Calorimeter

- Outer
- Inner

Central Tracking

- TPC
- INTT
- MVTX

Electromagnetic Calorimeter

- Full Azimuthal Coverage
- |eta| < 1.1

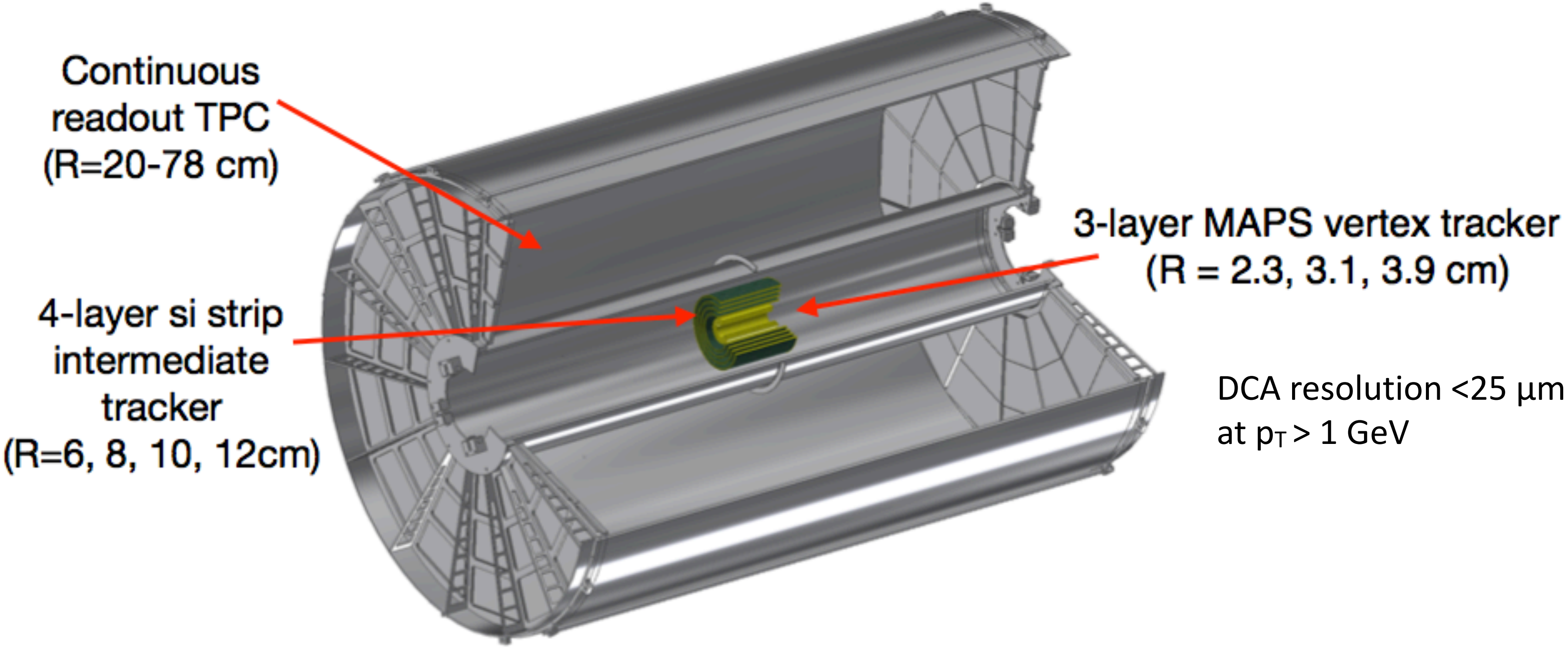
sPHENIX Magnet

- Former BaBar Experiment's SC-Solenoid - B ~ 1.4T
- Inner Radius of 140 cm and 33 cm thick
- 3.8 m long

2016 Successful low field test
2017 Full field test soon


2015

Central Tracking System



Continuous readout TPC (R=20-78 cm)

4-layer si strip intermediate tracker (R=6, 8, 10, 12cm)

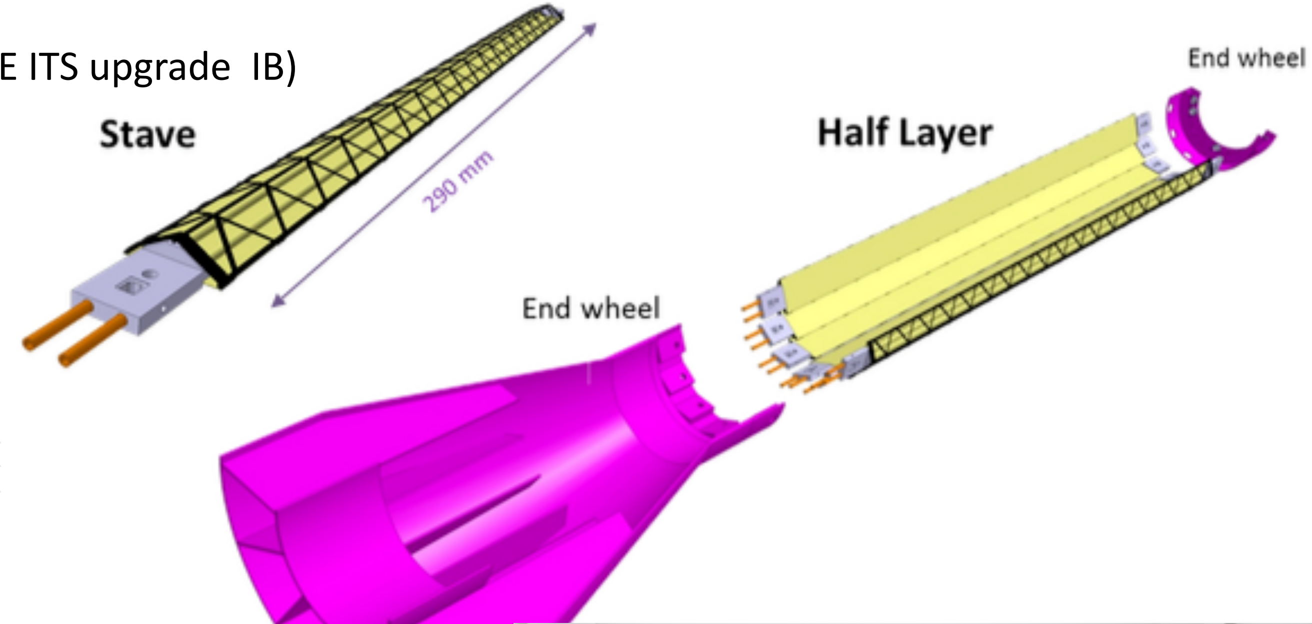
3-layer MAPS vertex tracker (R = 2.3, 3.1, 3.9 cm)

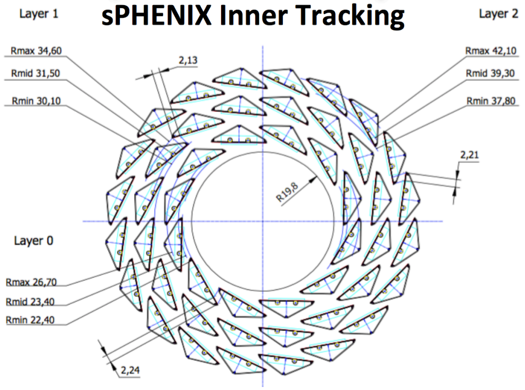
DCA resolution <25 µm at p_T > 1 GeV

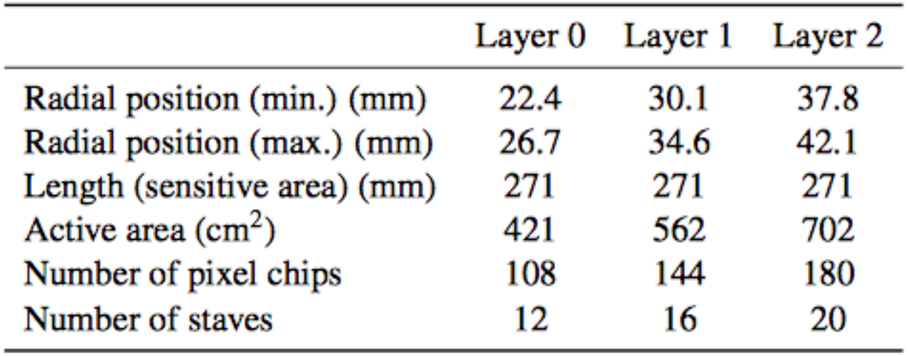
Good momentum resolution from p_T=0.2 to 40GeV

MVTX (micro vertex tracker)

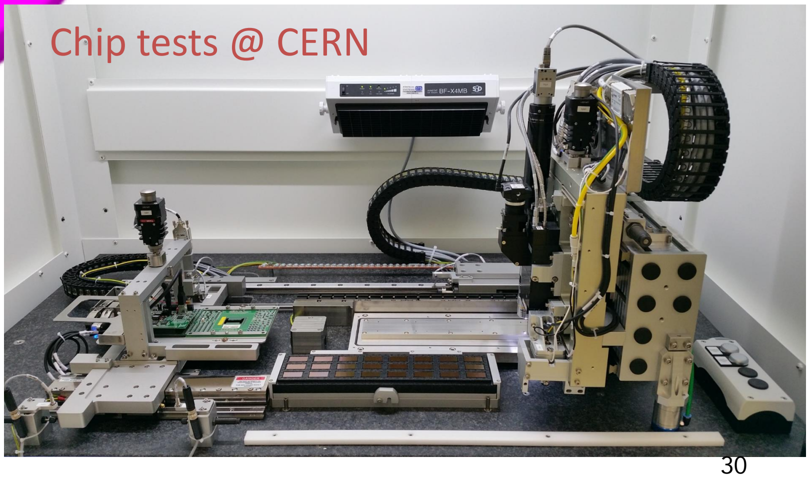
- MAPS technology (copy of ALICE ITS upgrade IB)
- Fine pitch 28 x 28 um^2
- Good time resolution 5 us
- High efficiency > 99%
- Low noise < 10^{-6}




sPHENIX Inner Tracking

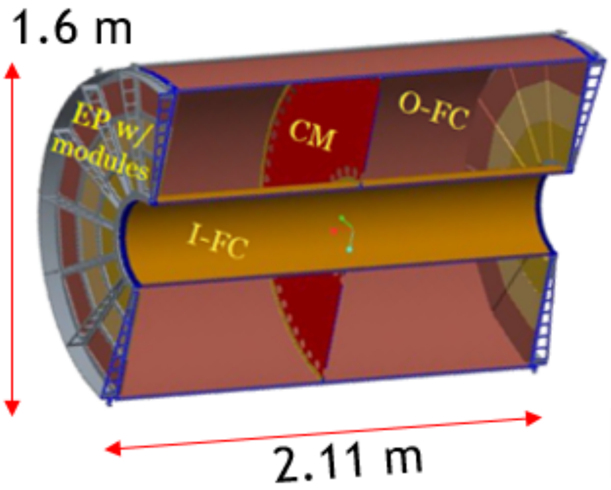


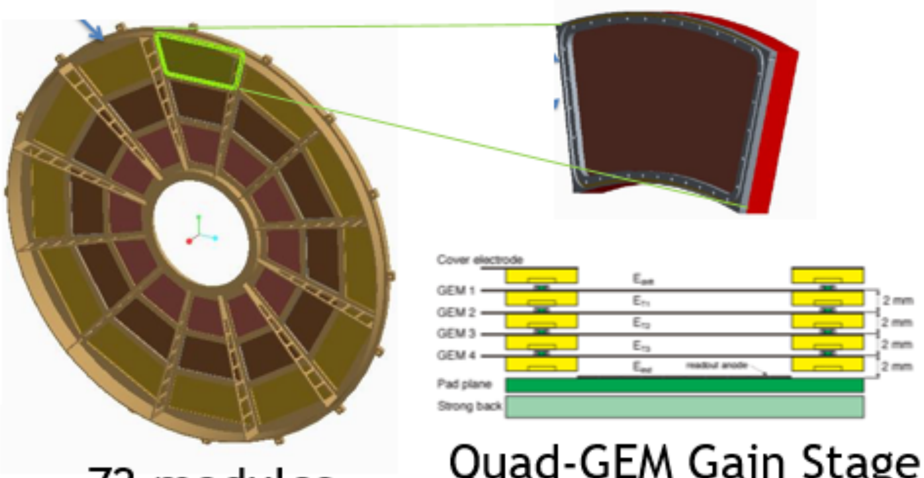
	Layer 0	Layer 1	Layer 2
Radial position (min.) (mm)	22.4	30.1	37.8
Radial position (max.) (mm)	26.7	34.6	42.1
Length (sensitive area) (mm)	271	271	271
Active area (cm^2)	421	562	702
Number of pixel chips	108	144	180
Number of staves	12	16	20


Chip tests @ CERN

TPC

- From 20 cm to 78 cm in radius and 2.11 m in Z
- Continuous (high rate) readout achieved with MicroPattern gas detectors (Quad-GEM)
- 72 modules: 2(z) x 12 (phi) x 3 (r) with mix pads geometries: rectangular and zigzag
- Ne-based gas for high ion mobility and low transverse diffusion





72 modules
2(z), 12(ϕ), 3(r)

Quad-GEM Gain Stage
Operated @ low IBF

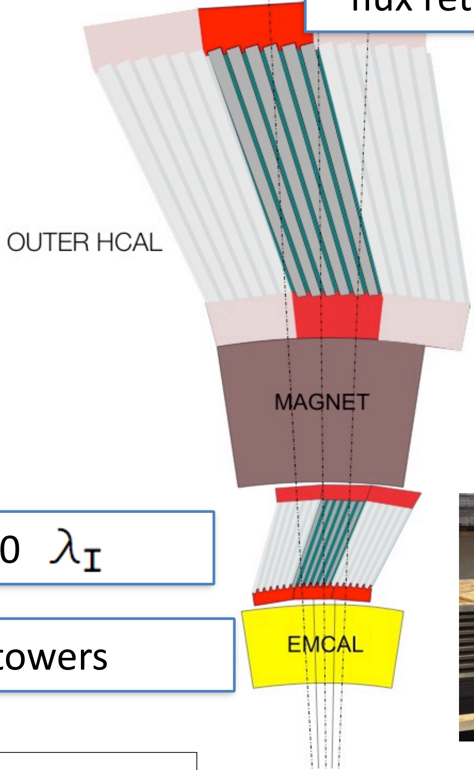
153.6k channels

Res < 250 um

Calorimeter stack

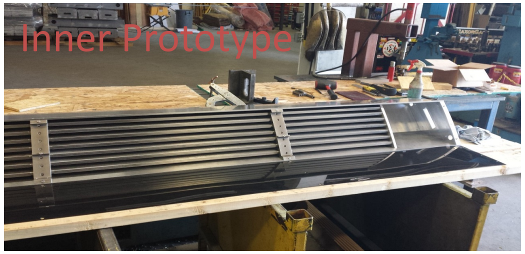
- EMCAL: Tungsten w/ embedded SciFi
- HCAL: Steel and scintillating tiles + WLS
- SiPM's (B field resistant)

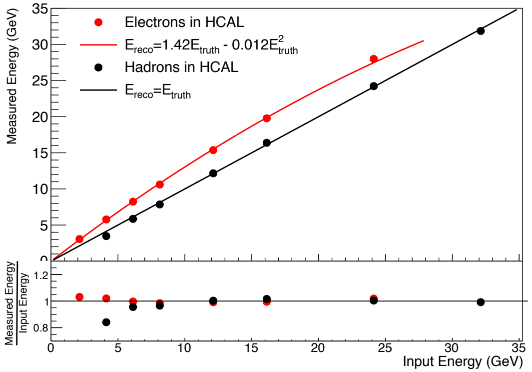
Outer
- 3.5 λ_I
- Steel also used as flux return



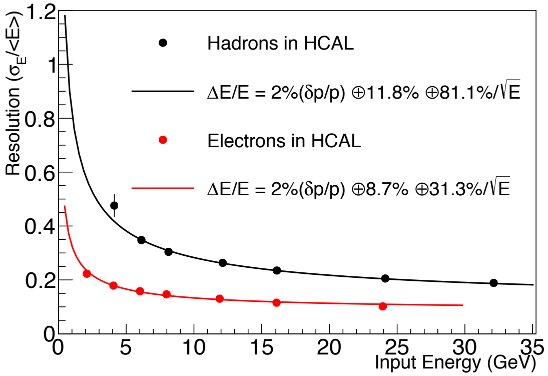
Inner: 1.0 λ_I

24576 towers

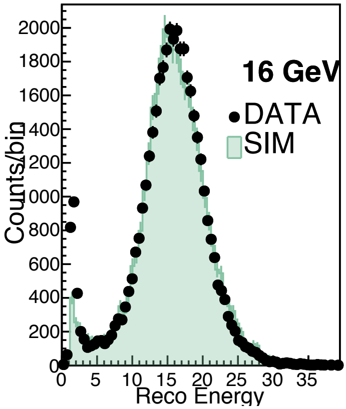


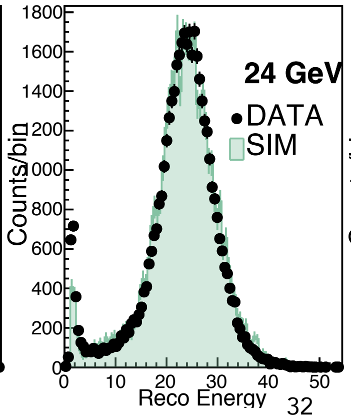


Linear response

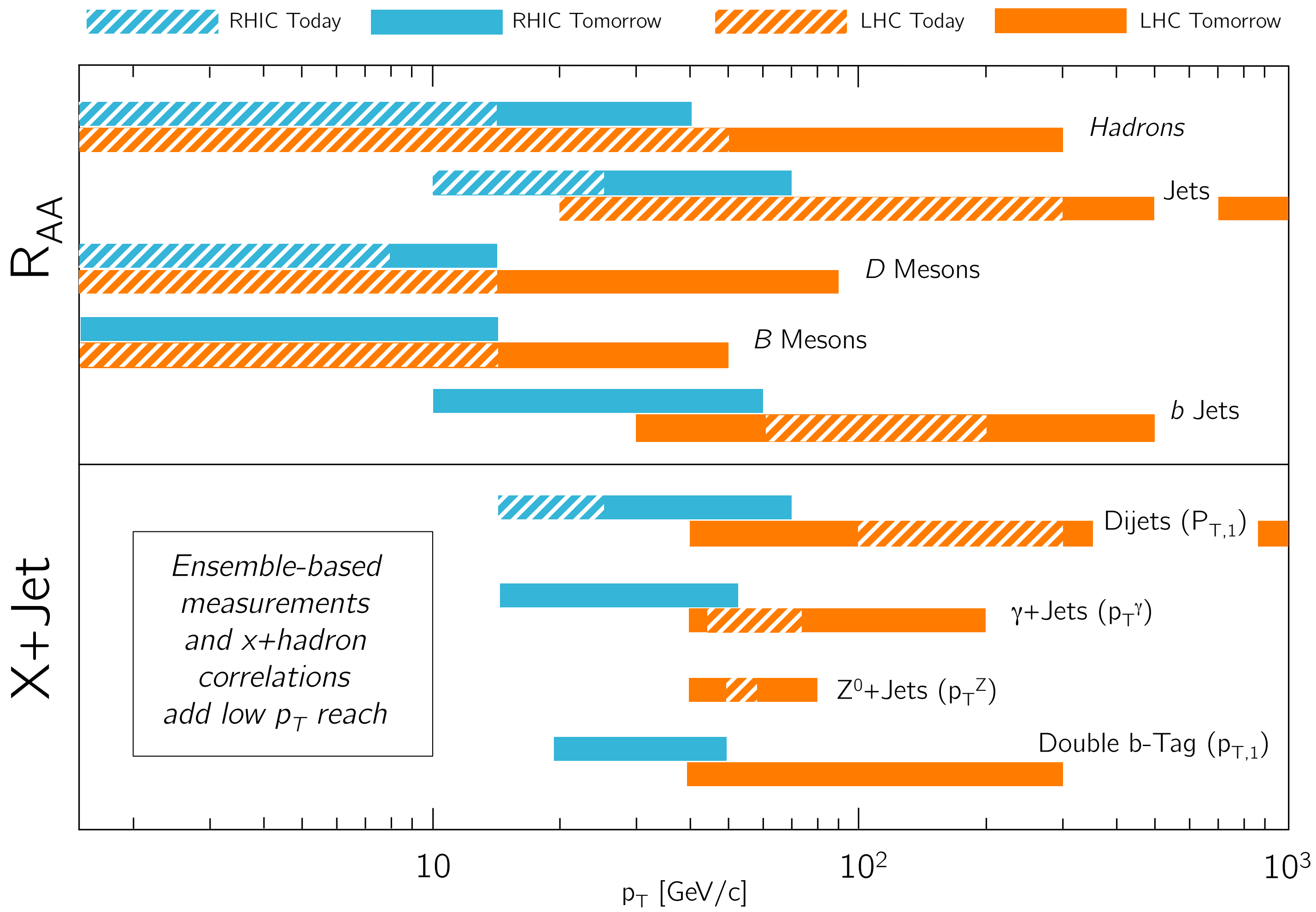


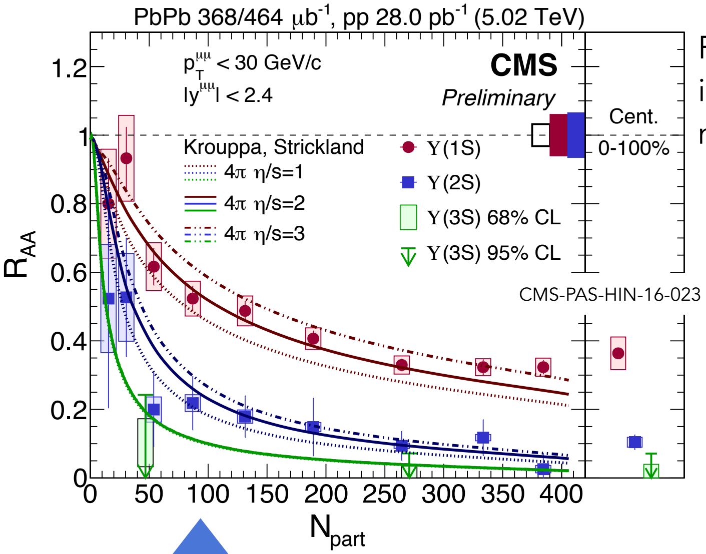
11.8%+81.1%/sqrt(E)





Unified approach to jet physics at RHIC and LHC

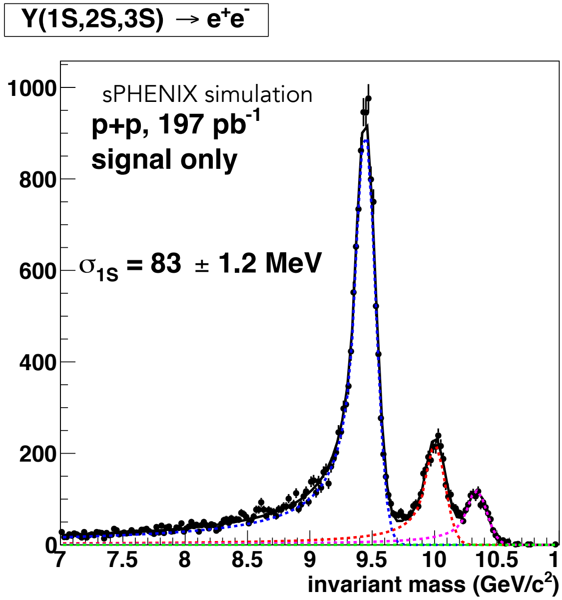




R_{AA}: modification of Upsilon yields in Au+Au relative to suitably normalized yields in p+p

Count every Υ delivered:

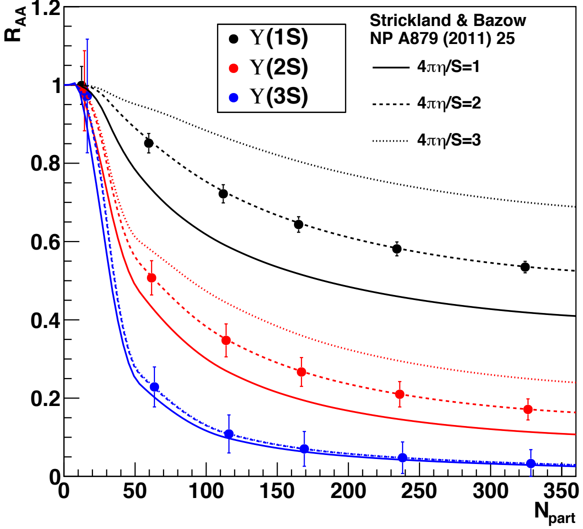
- large acceptance (2π × |η| < 1)
- high rate capability (15 KHz – commensurate with RHIC projections)
- triggering in p+p and p+A



Identify delivered Υ's:

- high track reconstruction efficiency (> 90% @ 3 GeV/c)
- good electron ID (90:1 rejection in Au+Au)

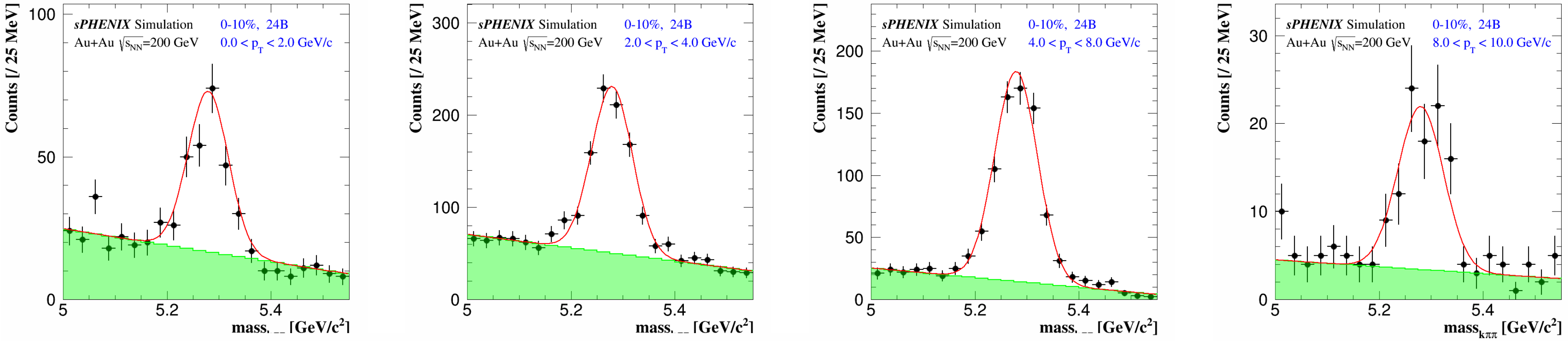
sPHENIX simulation
100B Au+Au

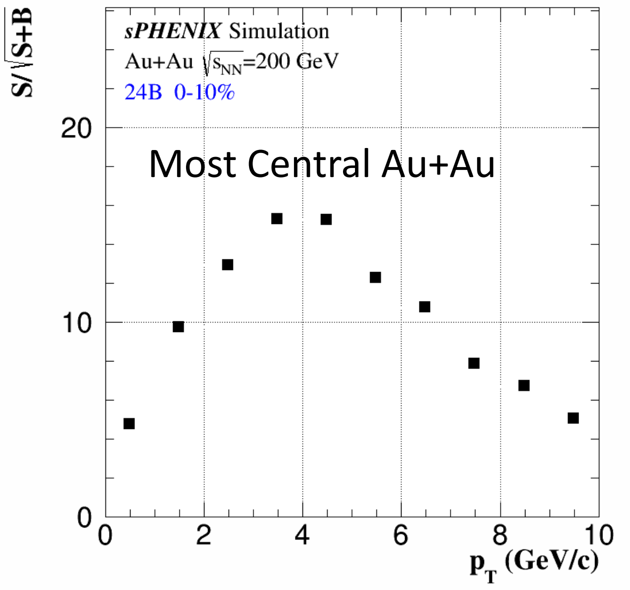


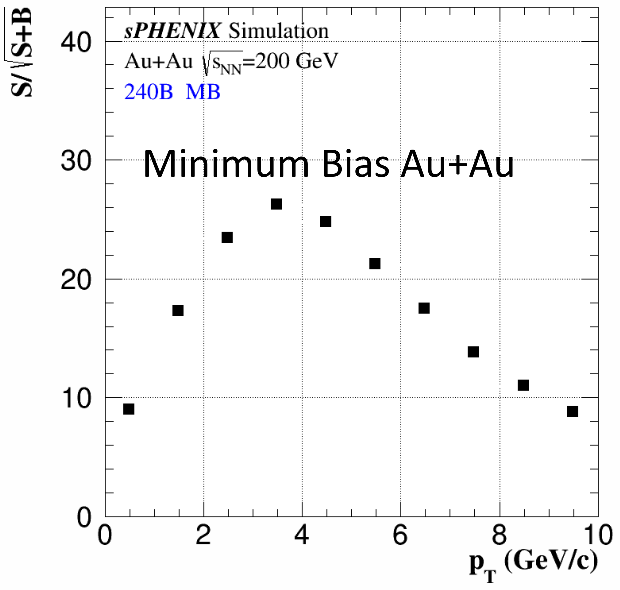
Distinguish separate mass states

- excellent momentum resolution in p_T ~ 4-10 GeV/c (σ_M < 100 MeV/c^2)

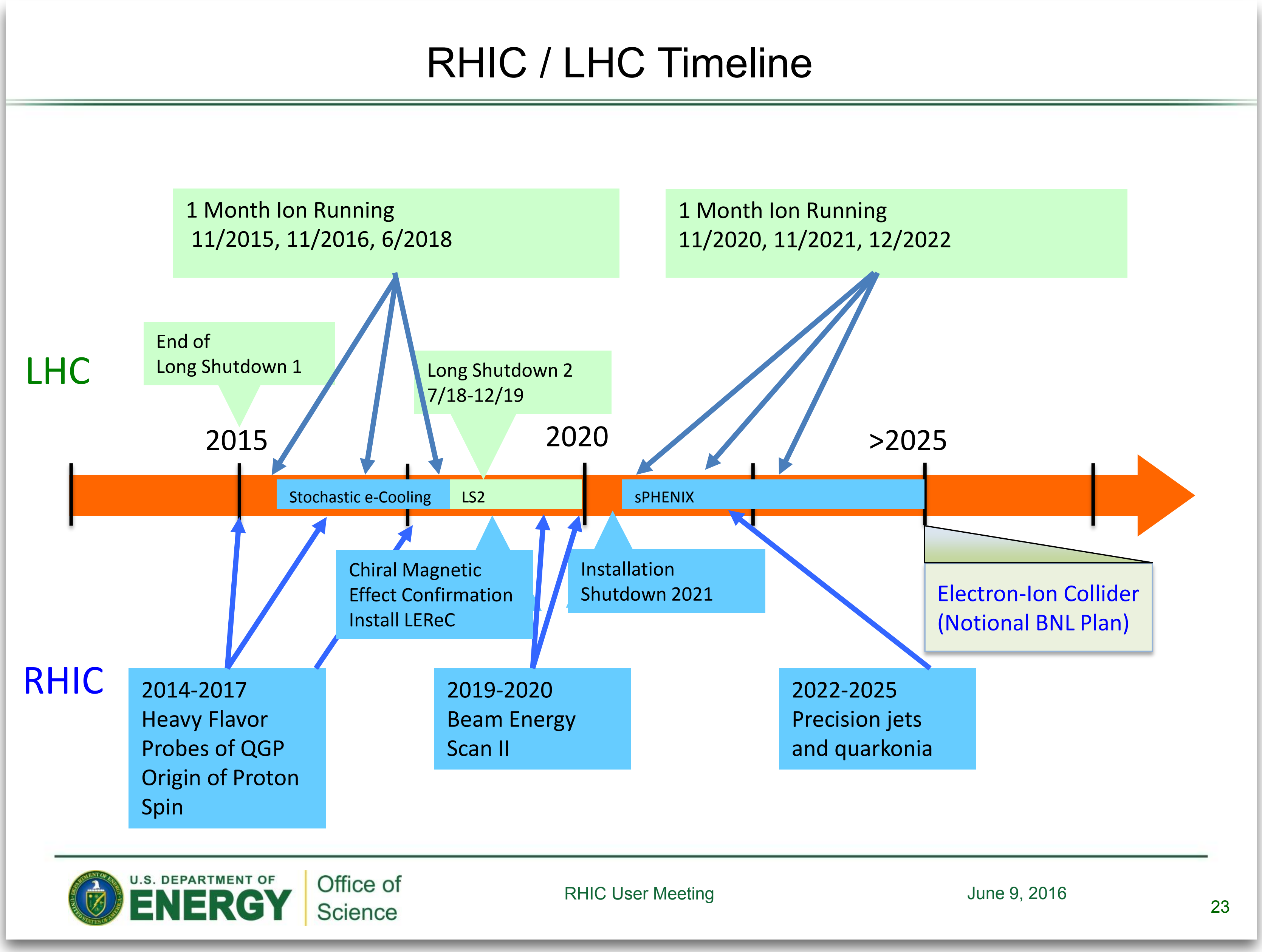
Fully Reconstructed B+ Mesons







CMS style: no PID, but very good DCA resolution combined with high statistics



RHIC / LHC Timeline

LHC

1 Month Ion Running
11/2015, 11/2016, 6/2018

1 Month Ion Running
11/2020, 11/2021, 12/2022

End of
Long Shutdown 1

Long Shutdown 2
7/18-12/19

2015

2020

>2025

Stochastic e-Cooling

LS2

sPHENIX

Chiral Magnetic
Effect Confirmation
Install LEReC

Installation
Shutdown 2021

Electron-Ion Collider
(Notional BNL Plan)

RHIC

2014-2017
Heavy Flavor
Probes of QGP
Origin of Proton
Spin

2019-2020
Beam Energy
Scan II

2022-2025
Precision jets
and quarkonia

U.S. DEPARTMENT OF ENERGY | Office of Science

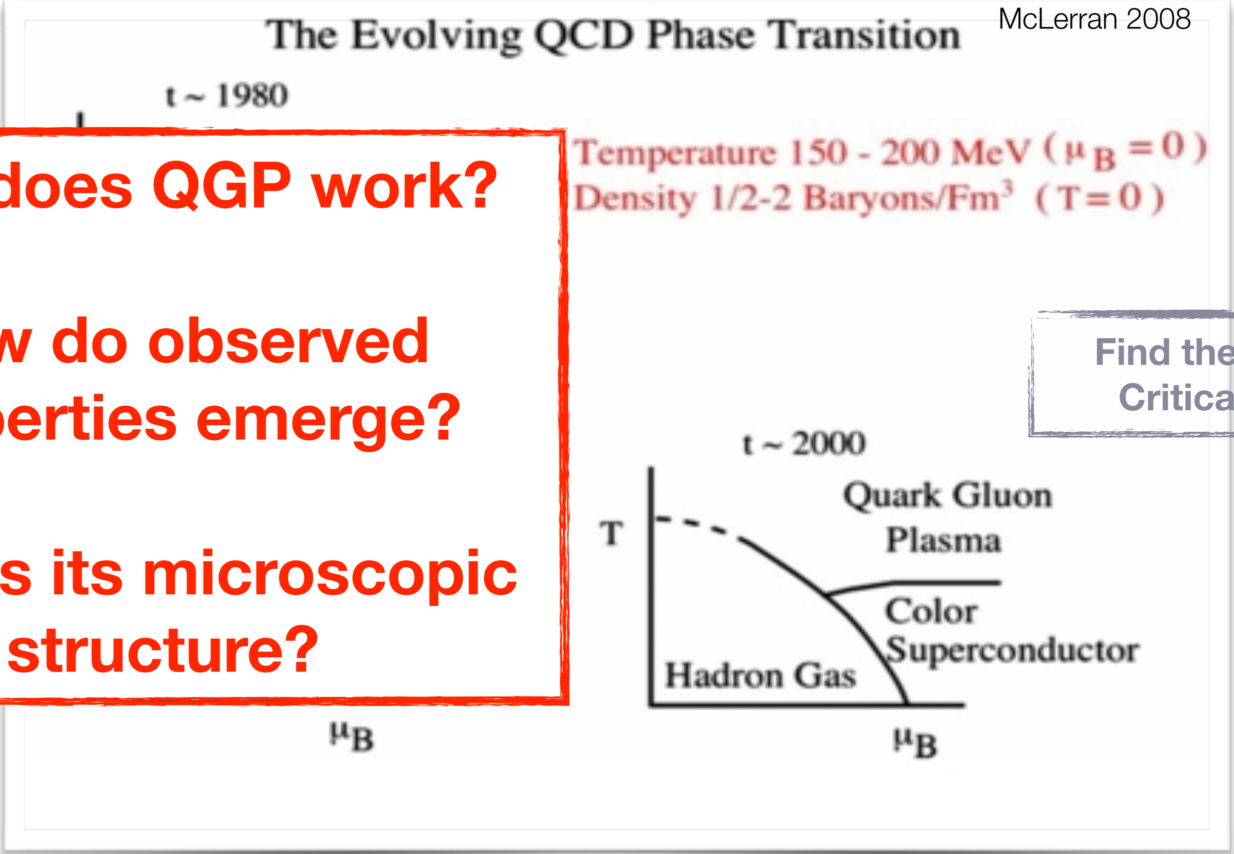
RHIC User Meeting

June 9, 2016

23

Slide from Tim Hallman's talk at RHIC Users' Meeting, June 2016

Observe the QGP/HG phase transition
Critical phenomena!



McLerran 2008

How does QGP work?

How do observed properties emerge?

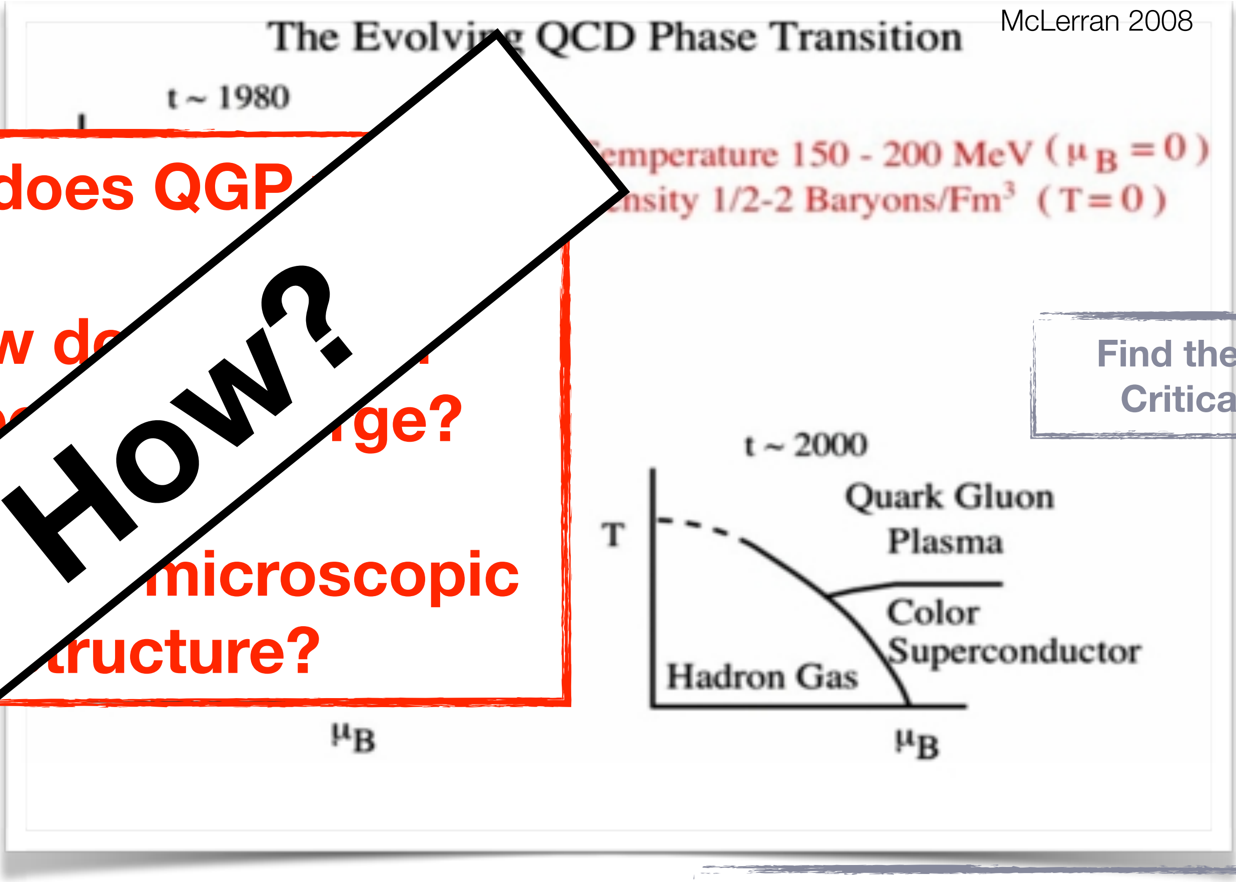
What is its microscopic structure?

Find the Critical Point!
Critical phenomena

Discover the QGP
Onset of Deconfinement

What are the properties of QGP?
Initial structure, Transport coefficients,…

Observe the QGP/HG phase transition
Critical phenomena!



McLerran 2008

How does QGP

How do
prop
rge?

W
microscopic
tructure?

How?

Find the Critical Point!
Critical phenomena

Discover the QGP
Onset of Deconfinement

What are the properties of QGP?
Initial structure, Transport coefficients,…

Billion dollar question (not rhetorical)

- Understanding the emergence (and inner workings) of a strongly coupled system from a asymptotically weakly coupled gauge theory is a billion dollar question (2015 NP LRP)

- Measuring the effective gluon density in heavy-ion collisions at some energy is not

  - specific numerical values of qhat / ehat don’t seem to have particular “meaning” (c.f., η/s)

Inner workings of QGP - “quasiparticles”

- Can RHIC/LHC measurements identify scale dependent properties of QGP, e.g., quasiparticles with a given mass etc?

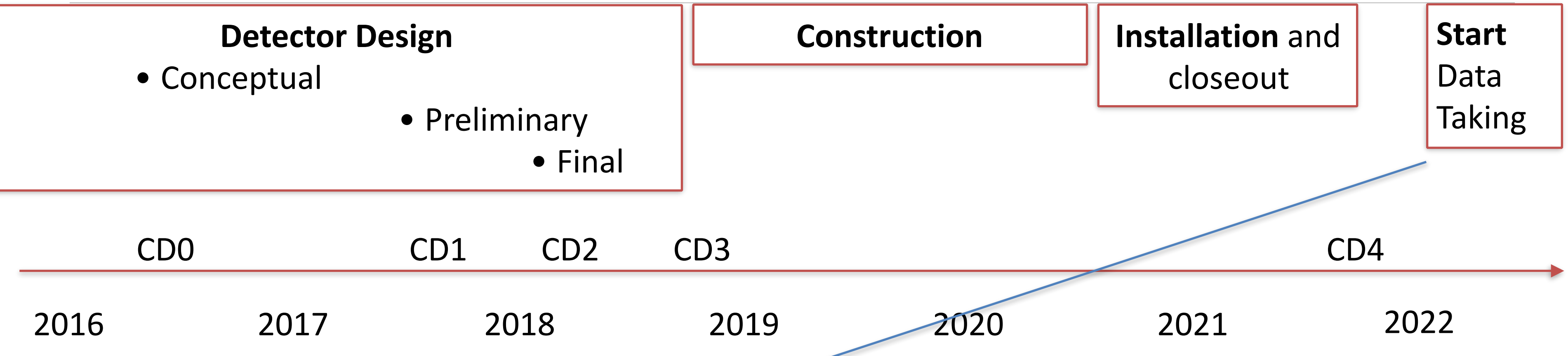
- Current emphasis on understanding parton shower modifications in trivial media - pre-requisite to achieve ultimate goal

- Develop toy models of **interesting** media to understand ultimate sensitivity

Outlook

- From NA35 to sPHENIX
  - Three decades of discoveries
  - Profound questions remain
- Look forward to presenting first sPHENIX results in at the next meeting in 2022!

sPHENIX TimeLine



Detector Design
- Conceptual
- Preliminary
- Final

Construction

Installation and closeout

Start Data Taking

Year	System	Weeks	Samp. Lum, A
2022	Au+Au	16	34 nb^{-1}
2023	p+p	11.5	267 pb^{-1}
2023	p+Au	11.5	1.46 pb^{-1}
2024	Au+Au	23.5	88 nb^{-1}
2025	p+p	23.5	783 pb^{-1}
2026	Au+Au	23.5	92 nb^{-1}

200 GeV/c

Au+Au @ 200 GeV, |Z|<10 cm

Minimum Bias @ 15kHz
47B (2022) + 96B (2024) + 96B (2026) =
239 Billion Events

Level-1 Trigger (e.g. high pT photons)
550 Billion Events

Au+Au @15kHz, All Z
1.5 Trillion Events