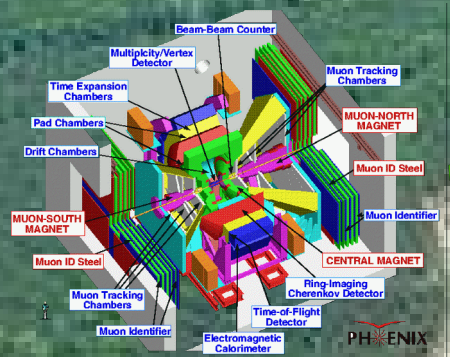
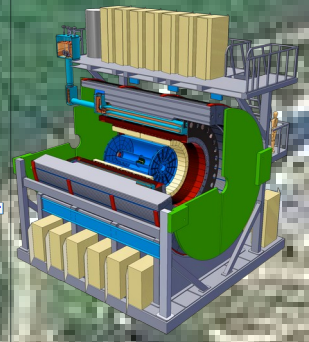

Relativistic Heavy Ion Collider/
Alternating Gradient Synchrotron
Users' Executive Committee

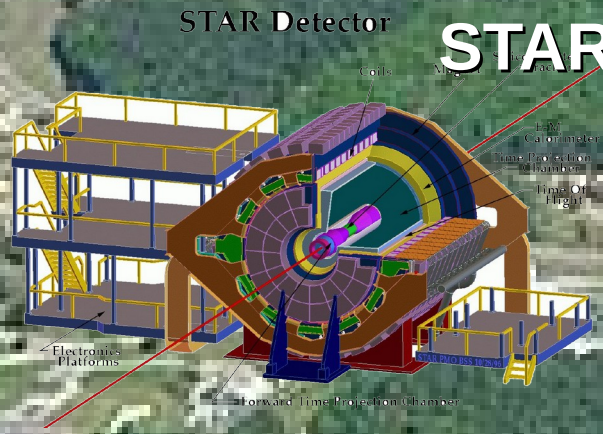
Opportunities



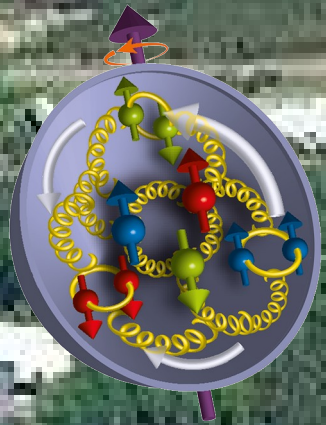
PHENIX



sPHENIX



STAR

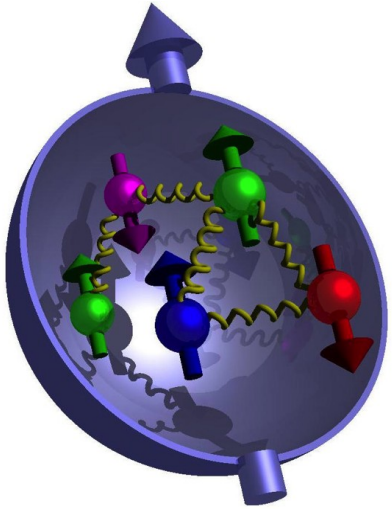


Theory

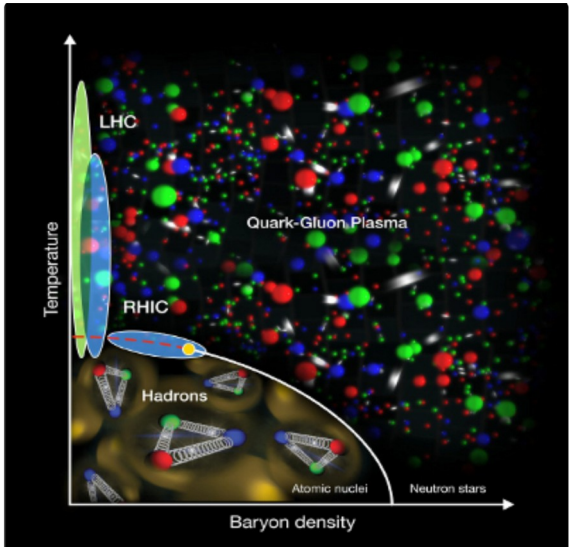
AGS

Subjects

- **Proton structure with polarized proton beams**

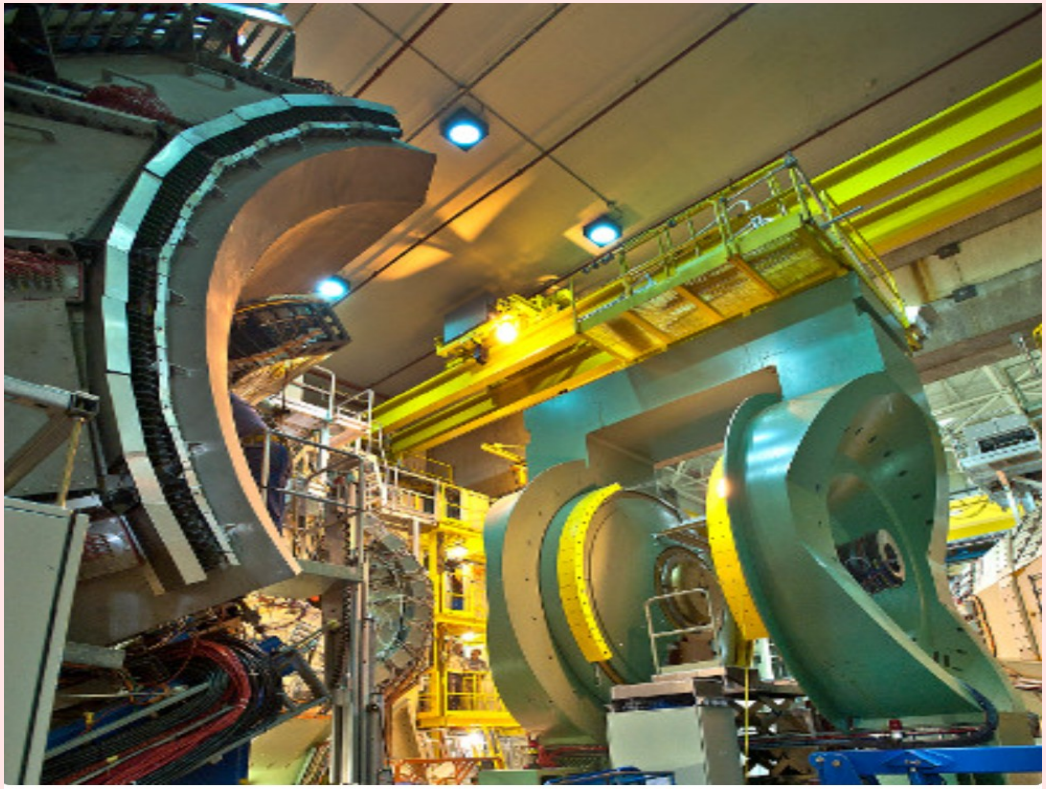


- **Quark Gluon Plasma created in high energy nuclear collisions**



- **Dark matter searches**
- **Accelerator physics**
- **Impact of radiation on cells**

PHENIX



Data Taking complete 2016

Published >200 papers

PHENIX data sets

year	Beam, E(GeV)	Recorded data (pp equiv)	upgrade	Physics
2016	AuAu 200 dAu 200 dAu 62,39,20	2.3/nb (90/pb) **15B events** 1G & 73/nb (29/pb) 0.6G 0.1G, 8M	VTX,FVTX MPC-EX	Heavy Flavor Gluon nPDF Small QGP
2015	pp 200 pAu 200 pAl 200	23/pb 80/nb (16/pb) 275/nb (7.4/pb)	VTX, FVTX	Heavy Flavor Transverse spin CNM, small QGP
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2011	pp 510 AuAu 200 AuAu 19, 27	28/pb 0.8/nb (32/pb)	W-trigger VTX	Anti-quark spin Heavy flavor BES-I
2010	AuAu 200 AuAu 62,39,7	1.1/nb (44/pb)	HBD	Low mass ee BES-I

Many physics topics with variety of high statistics datasets

Remaining PHENIX Key Physics Analyses

RUN14 and RUN16 Au+Au collisions at 200 GeV data set of about 30 billion events remains to be fully analyzed

Unique high impact analysis topics to be addressed with PHENIX data from RUN14+16 in next 2-3 years

- Measure initial temperature of QGP at RHIC
  - Thermal e^+e^- pairs in mass range 1 to 3 GeV/c^2
- Separate charm and bottom energy loss and flow
  - midrapidity measurement with electrons
  - forward/backward rapidity measurements with muons

For more information contact:

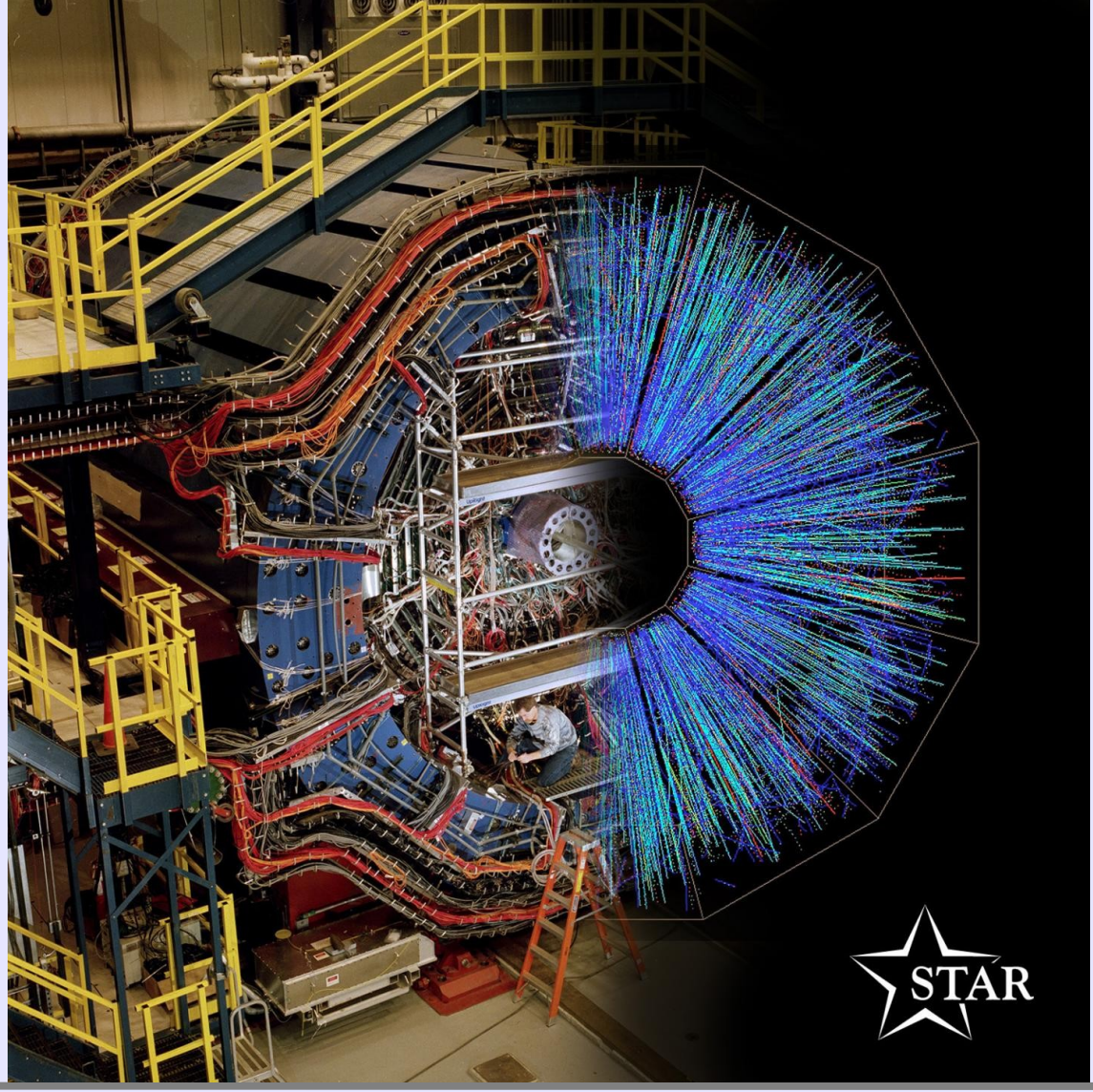
Spokesperson: Y. Akiba akiba@bnl.gov

Deputy Spokespersons: Axel Drees axel.drees@stonybrook.edu

Sasha Bailevsky shura@bnl.gov

STAR

STAR is composed of 72 institutions from 15 countries, with a total of 695 collaborators. A variety of personnel participate in the collaboration, including students, university faculty and staff, national laboratory staff, and engineers.



STAR's Future Run Plan

Table 1: Proposed Run-22 assuming 20 cryo-weeks, including an initial one week of cool-down and a two weeks set-up time.

$\sqrt{s}$ (GeV)	Species	Polarization	Run Time	Sampled Luminosity	Priority
510	pp	Transverse	16 weeks	400 pb^{-1}	1

p+p 510 GeV: probe down to x~2×10-3 (gluons) and up to x~0.5 (valence quarks) regions

Table 2: Proposed Run-23 - Run-25 assuming 28 cryo-weeks of running every year, and 6 weeks set-up time to switch species in 2024. Sampled luminosities assume a "take all" triggers.

Data Taking
24 weeks Au+Au
11 weeks pp
11 weeks p+Au
24 weeks Au+Au

$\sqrt{s_{NN}}$ (GeV)	Species	Number Events/ Sampled Luminosity	Year
200	Au+Au	10B / 31 nb^{-1}	2023
200	pp	235 pb^{-1}	2024
200	p+Au	1.3 pb^{-1}	2024
200	Au+Au	10B / 31 nb^{-1}	2025

Transversely polarized pp and p+Au with equal nucleon-nucleon luminosities essential to optimize several critical measurements

p+p: enable detailed evolution studies, critical for precise factorization and universality tests, essential baseline for p+Au
p+Au: probe gluon saturation, quark-gluon structure of heavy nuclei, propagation and hadronization of colored partons
Au+Au: probe the inner workings of the QGP

Physics program

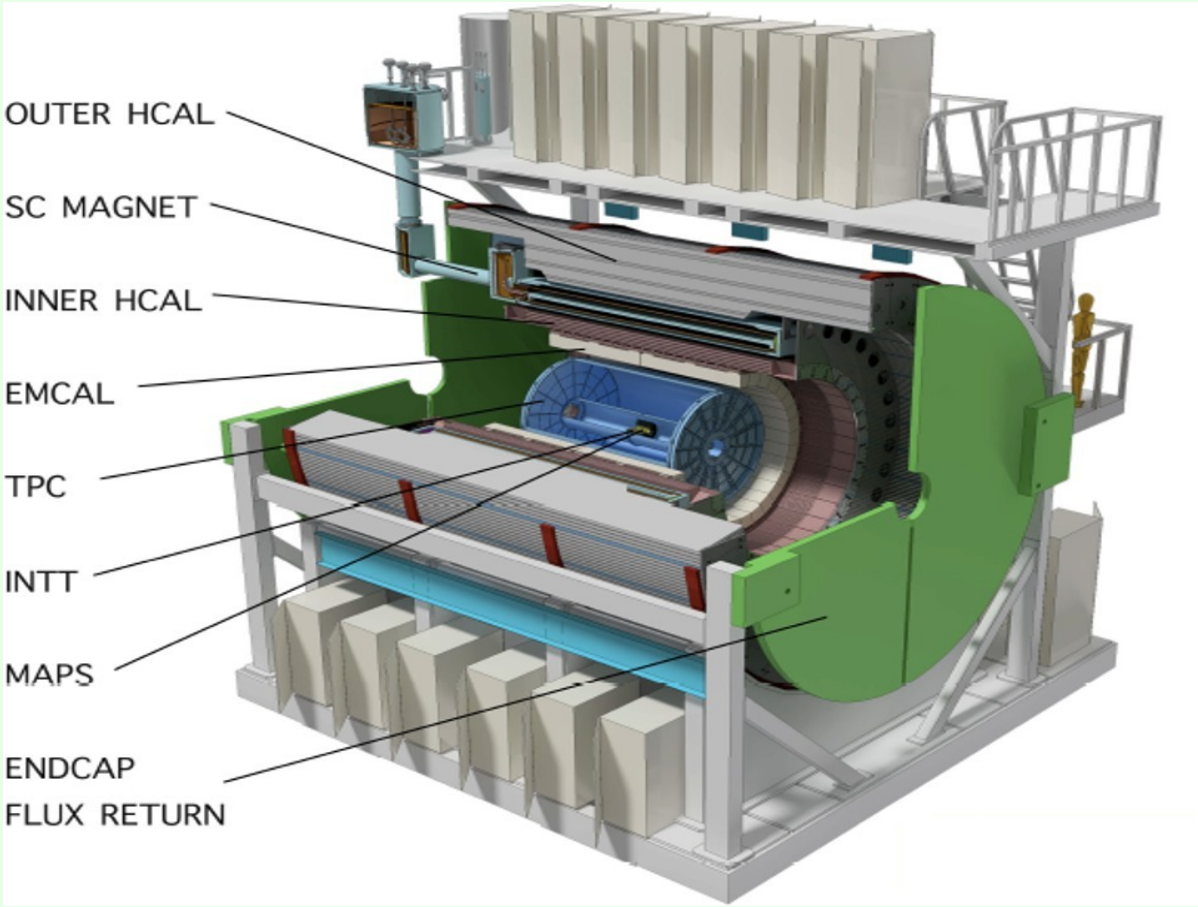
- **quantitative comparisons of the validity and the limits of factorization and universality in lepton-proton and proton-proton collisions for initial and final state TMDs.** Test of Sivers non-universality
  - Requirement:
    - large data sets √s = 200 and 500 GeV p↑p
      - low to high x, highest and lowest x with fSTAR
    - A_{UT} for W+/- Z0, A_{UT} for hadrons in jet
- First look Gluon GPD → E_g
  - Requirement:
    - data sets √s = 500 GeV p↑p and √s = 200 GeV p↑A
    - A_{UT} for J/ψ in UPC
- Physics driving the large A_N at forward rapidities and high x_F
  - Requirement:
    - large data sets √s = 200 and 500 GeV p↑p
      - low to highest x_F → fSTAR
    - charge hadron A_N at forward rapidities
- Nuclear dependence of PDFs, FF, and TMDs
  - Requirement:
    - large equal data set of √s = 200 p↑p and p↑Au
      - low to high x, highest and lowest x with fSTAR
    - R_{pA} direct photons and DY, hadrons in jet A_{UT}
- non-linear effects in QCD
  - Requirement:
    - large equal data set of √s = 200 p↑p and p↑Au
      - lowest-x through fSTAR
    - dihadron correlations for h+/-, γ-jet, di-jets

To address important questions about the inner workings of the QGP

- **What is the precise temperature dependence of shear and bulk viscosity?** v_n as a function of η
- What is the nature of the 3-dimensional initial state at RHIC energies? r_n over a wide rapidity
- How is global vorticity transferred to the spin angular momentum of particles on such short time scales? How can the global polarization of hyperons be reconciled with the spin alignment of vector mesons? Λ, Ξ, Ω P_H and ρ_{00} of K*, φ, J/ψ
- What is the precise nature of the transition near μ_B=0? Net-proton C_6/C_2
- What is the electrical conductivity, and what are the chiral properties of the medium? Dielectron
- What can be learned about confinement and thermalization in a QGP from charmonium measurement? J/ψ v_2 and v_1, ψ(2S)
- What are the underlying mechanisms of jet quenching at RHIC energies? What do jet probes tell us about the microscopic structure of the QGP as a function of resolution scale? γ_{dir}+jet I_{AA}, γ_{dir}+jet acoplanarity, jet substructure

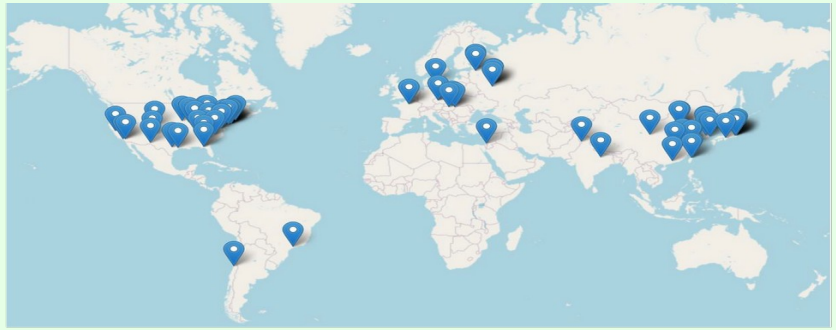
sPHENIX

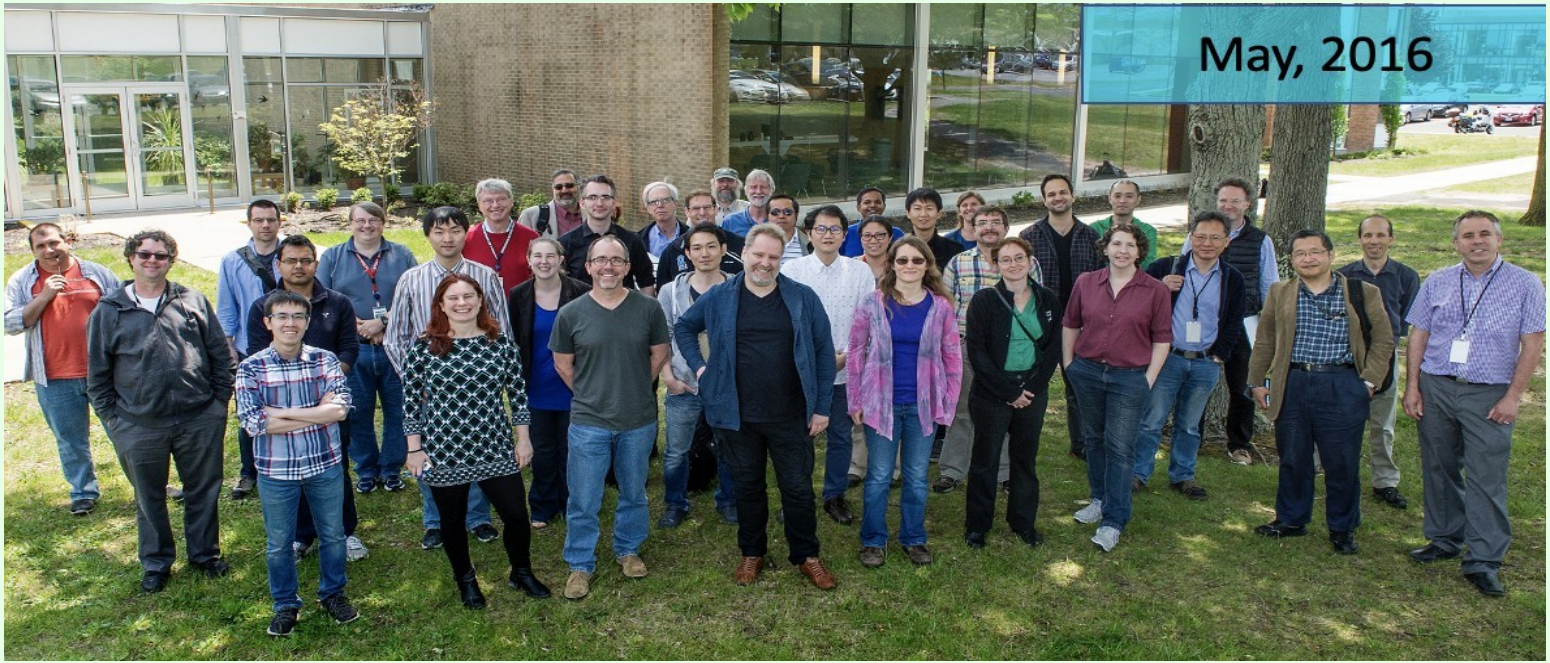
Calorimetry
Outer Hadronic Calorimeter (oHCAL) Inner Hadronic Calorimeter (iHCAL)
Electromagnetic Calorimeter (EMCAL)
Magnet
1.4T superconducting solenoid used by the BaBar experiment
Tracking
Time Projection Chamber (TPC) Intermediate Silicon Tracker (INTT) MAPS-based Vertex Tracker (MVTX)
Performance
High data rate : read out rate of 15 kHz for all subdetectors
Acceptance : hermetic coverage over full azimuth & pseudorapidity $|\eta| \leq 1.1$ for the tracking & calorimeter systems



sPHENIX Collaboration

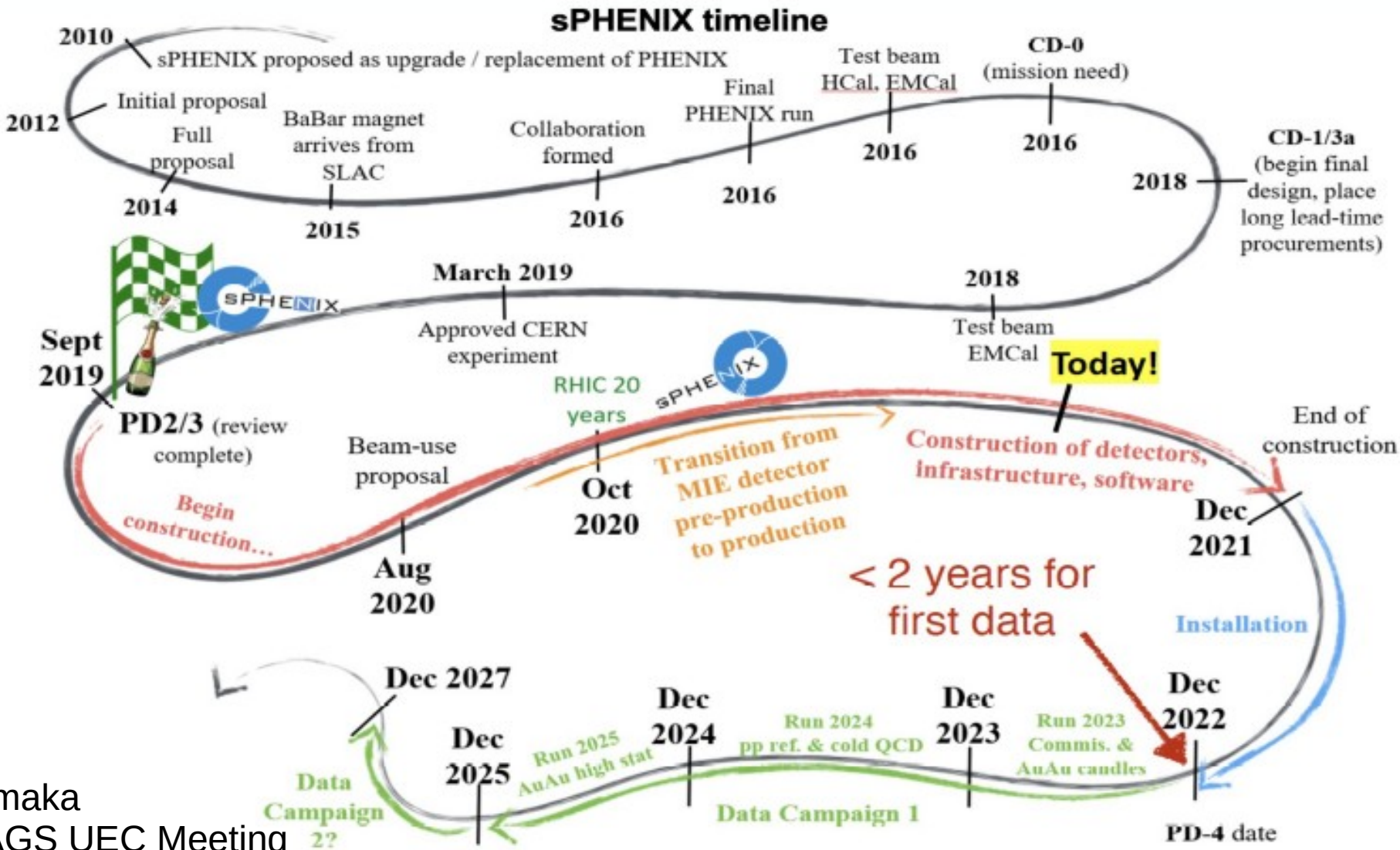
Officially formed in 2016
More than 320 members from 84 institutions in 14 countries as of 2021 Over 100 bi-weekly general meetings since inception





sPHENIX 3-Year Run Plan

Year	Species	$\sqrt{s_{NN}}$	Cryoweeks	Physics weeks	Rec. Luminosity	Samp. Luminosity
2023	Au+Au	200	24 (28)	9 (13)	3.7 (5.7) nb^{-1}	4.5 (6.9) nb^{-1}
2024	p↑p↑	200	24 (28)	12 (16)	0.3 (0.4) pb^{-1}	45 (62) pb^{-1}
2024	p↑+Au	200	-	5	0.003 pb^{-1}	0.11 pb^{-1}
2025	Au+Au	200	24 (28)	20.5 (24.5)	13 (15) nb^{-1}	21 (25) nb^{-1}



Ejiro Umaka
RHIC/AGS UEC Meeting

How to join an experiment? Example from STAR

1. Initiate a discussion with the Spokespeople

   Generally speaking we will ask:

   1. what are your science interests?
   2. how many people, and at what level (faculty,Postdocs, grad/undergrad students etc) are currently and do you expect eventually to be in your group?
   3. How long do you plan to work on STAR and what other commitments do you have?
   4. Do you expect to have funding to enable you to travel to cover your shift dues etc?

2. After initial discussion we ask you to submit a formal application – an “application form” is provided
3. Application is discussed in management team
4. If positive we send your application, endorsed by the management to the STAR Council
5. STAR Council has final decision. After reading the application and inviting you to present your case to the Council a vote will be taken
6. If positive you will be admitted as an associate institution for a period of one year. During that one year each new institution will be associated with a mentoring STAR institution that will assist the new institution to become integrated and
   productive in STAR. The new institution will be represented on the STAR Council by the mentor institution Council representative. At the conclusion of this one year the new institution may apply for full membership that will include a seat on the Council. Such an application must receive an affirmative vote from at least 75% of all eligible Council voters.

BNL Nuclear Theory group

- Excellence in scientific research aimed towards supporting and guiding the experimental programs at RHIC and the future EIC
- Training a new generation of scientists (most of the former group postdocs are now faculty members across the globe working in RHIC and EIC physics or work in high performance computing)
- Lay out for future directions in Nuclear Physics: gluon saturation in eA collisions, Chiral Magnetic Effect, synergy of QIS and physics of RHIC and EIC
- Scientific Staff: Y. Hatta (RBRC theory leader), D. Kharzeev (joint with Stony Brook U.), Y. Mehtar-Tani (RBRC Fellow), S. Mukherjee, (BEST Director, SciDAC, Co-PI), P. Petreczky (Group Leader), R. Pisarski (C^{2}QA, sub-thrust leader) , B. Schenke , R. Venugopalan, (C^{2}QA, sub-thrust leader)

BEST= Beam Energy Scan Topical Collaboration
C^{2}QA = Co-design Center for Quantum Advantage
RBRC = Riken-BNL Research Center

Support for RHIC and EIC science

- QCD phase diagram and physics of BES program, sPHENIX: quarkonia, jets, out of equilibrium dynamics and early states in HIC

- Nucleon spin, hadron structure, color glas condensate (was proposed by BNL Theorists)

- Leadership in lattice QCD (SciDAC, USQCD, also INCITE and ALCC computing awards), Quantum Information science (leadership in C^2QA)


https://i.ytimg.com/vi/mZnv6LXD9qs/maxresdefault.jpg
Relativistic Heavy Ion Collider
(s)PHENIX
STAR

Contacts and links

RHIC/AGS Users' Executive Committee
http://www.rhicuec.org/
Chair Elect: Zhenyu Ye (University of Illinois Chicago)
Chair: Christine Nattrass (University of Tennessee, Knoxville)
Past Chair: Ron Belmont (University of North Carolina at Greensboro)

STAR Collaboration
https://www.star.bnl.gov/
Co-spokespeople: Helen Caines (Yale University) and Lijuan Ruan (Brookhaven National Laboratory)

PHENIX Collaboration
https://www.phenix.bnl.gov/
Spokesperson: Yasuyuki Akiba (RIKEN Nishina Center for Accelerator-Based Science)

sPHENIX Collaboration
https://www.sphenix.bnl.gov/
Co-spokespeople: Dave Morrison (Brookhaven National Laboratory) and Gunther Roland(MIT)

BNL Nuclear Theory Group
https://www.bnl.gov/physics/ntg/
Group leader: Peter Petreczky (Brookhaven National Laboratory)

Collider and Accelerator Group
https://www.star.bnl.gov/
Group leader: Bill Christie (Brookhaven National Laboratory)

PHENIX: data analysis and publication

- Members can access to PHENIX data and all internal information of PHENIX
- Analysis are presented in Physics Working Group (PWG) and discussed in PWG. PHENIX has two PWGs (Heavy Ion PWG and Spin PWG)
- Analysis results can be presented in conferences outside of PHENIX after they are approved as “PHENIX Preliminary”.
  - Only 1 preliminary approval for the same measurement
- One analysis gets mature, a Paper Preparation Group (PPG) of the topics is formed. PPG finalize the analsyis and draft manuscripts of the paper.
  - 1st internal release (2weeks) : all collaboration can give commetns
  - Revision of the manuscript by PPG with Internal Review Committee
  - 2nd internal release (1 week)
  - submit to journal (PRL, PRC, PRD)

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PHENIX organization

- PHENIX is one of two large experiments at RHIC when RHIC started in 2000. It is an international collaboration of 14 countries/areas.
- PHENIX completed data taking in 2016. The successor experiment, sPHENIX experiment will start in 2023 to complete scientific mission of RHIC.
- PHENIX collaboration collaborates based on bylaws.
- Spokesperson (term: 3 years) Y. Akiba akiba@bnl.gov
- Deputy Spokespersons: Axel Drees axel.drees@stonybrook.edu
  Sasha Bailevsky shura@bnl.gov
- Executive Council (EC) advise the spokesperson
  14 members (4 exofficio, 6 elected, 2 juniors, 2 appointed)
- Institutional Board (IB)
  one member from each collaboration institutes
- One institute: at least one Member of Good Standing (MGS)
  A MGS is expected to devote >30% of research time for PHENIX
- Admission of new collaboration is discussed in an IB meeting and voted by IB
  – 4 new collaboration institutes after 2016
- PHENIX Speakers Bureau (PSB) distributes PHENIX talks among international conferences to PHENIX members

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Datasets of PHENIX

year	Beam, E(GeV)	Recorded data (pp equiv)	upgrade	Physics
2016	AuAu 200 dAu 200 dAu 62,39,20	2.3/nb (90/pb) **15B events** 1G & 73/nb (29/pb) 0.6G 0.1G, 8M	VTX,FVTX MPC-EX	Heavy Flavor Gluon nPDF Small QGP
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2013	pp 510	240/pb	W-trigger	Anti-quark spin Gluon spin
2012	pp 510 pp 200 CuAu 200 UU 193	50/pb 4/pb 5/nb (60/pb) 0.17/nb (10/pb)	W-trigger VTX, FVTX	Anti-quark spin Transverse spin Heavy flavor Geometry
2011	pp 510 AuAu 200 AuAu 19, 27	28/pb 0.8/nb (32/pb)	W-trigger VTX	Anti-quark spin Heavy flavor BES-I
2010	AuAu 200 AuAu 62,39,7	1.1/nb (44/pb)	HBD	Low mass ee BES-I

Many physics topics with variety of high statistics datasets

Diversity in Nuclear Theory

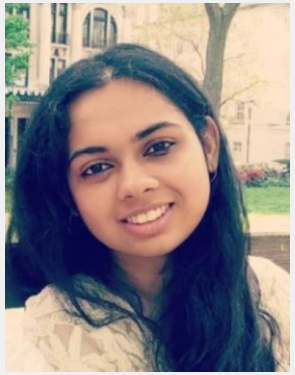
Training and education is key for a diverse workforce

Postdocs:

Abha Rajan, Now at ODU

Alba Otonso Soto, now in Saclay

Sohini Bhattacharya, Started 10/4/2021



Latino grad students:

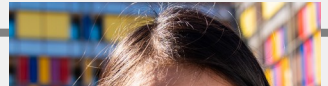
F. Salazar Wong, postdoc UCLA

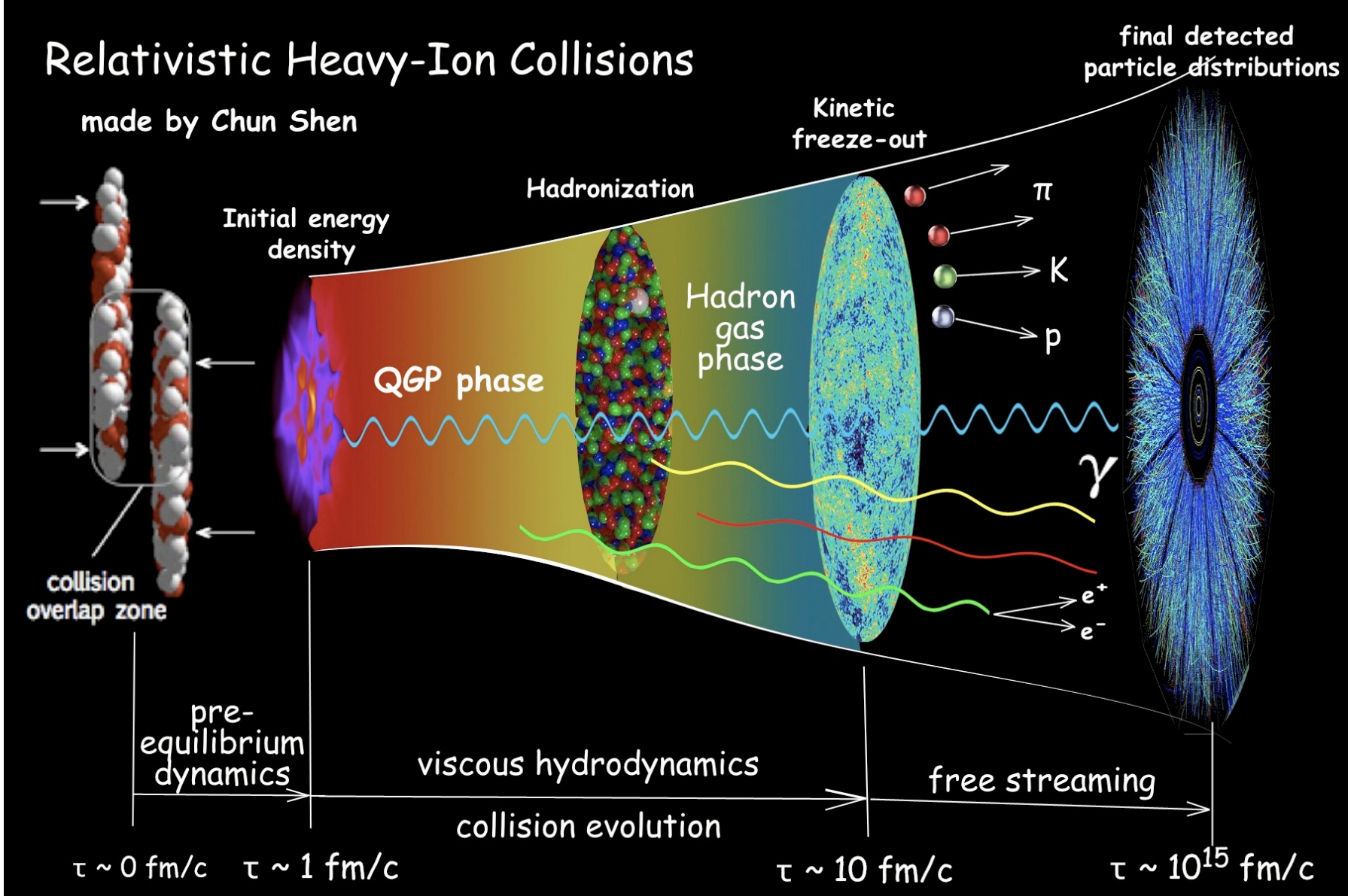
C. Shugert, Applied Physics Lab, John Hopkins U.

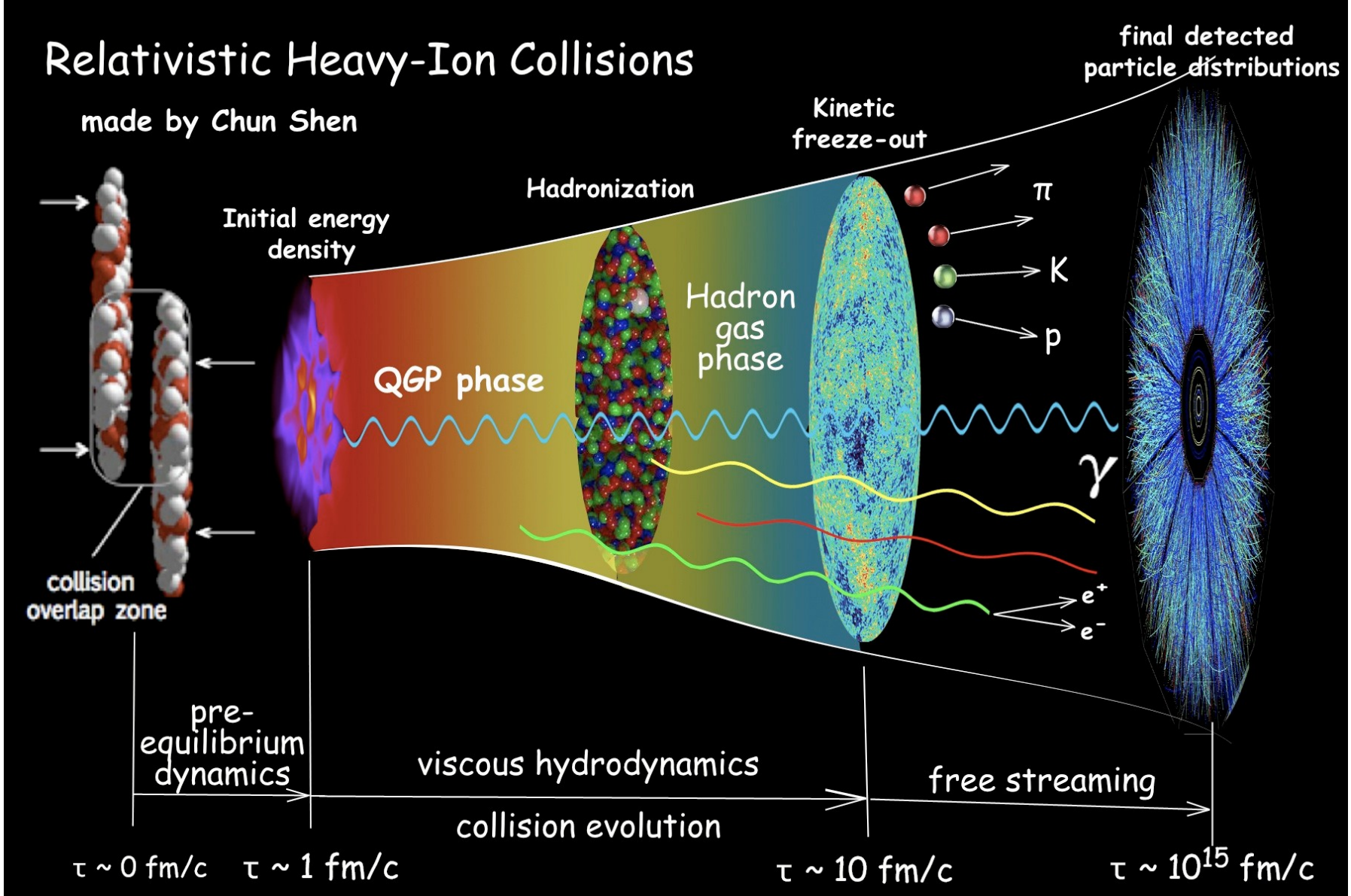
Advisors:
Petreczky, Schenke, Venugopalan

Schenke and Venugopalan participate in various lab educational programs:

Sixtus Kuudar (Florida A&M,URM), Viraj Jayam (HSRP, now undergrad at Stanford), Casey Cartwright (DOE's SCGSR program, U Alabama), Wenjie Gong (SULI, Harvard, Goldwater Fellowship), collaboration with Prof. N. Mitra, Gissi




Relativistic Heavy-Ion Collisions
made by Chun Shen
final detected particle distributions
Kinetic freeze-out
Hadronization
Initial energy density
π
K
p
Hadron gas phase
QGP phase
γ
e+
e-
collision overlap zone
pre-equilibrium dynamics
viscous hydrodynamics
free streaming
collision evolution
τ ~ 0 fm/c
τ ~ 1 fm/c
τ ~ 10 fm/c
τ ~ 10^15 fm/c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