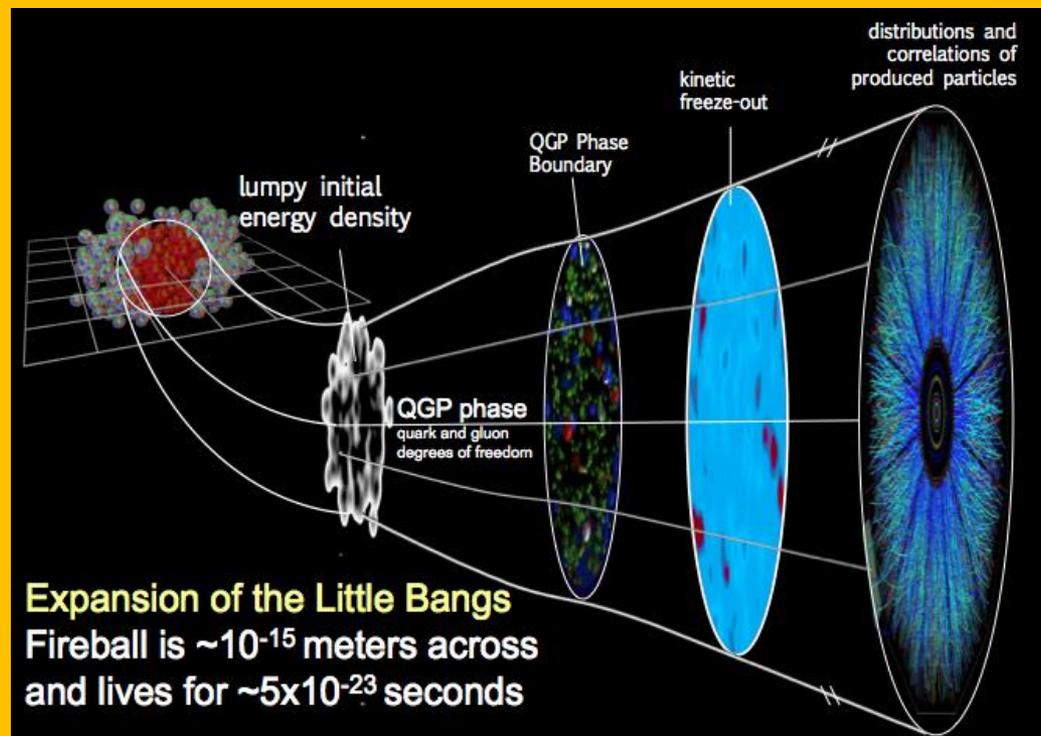


# Česká účast v BNL: RHIC 2015-2022 Electron-Ion Collider

Jaroslav Bielcik FJFI ČVUT Praha



# Aktualizacia plánu VVI

- V ostatných 10 rokoch účasť ČR v BNL výrazne vzrástla
- RHIC: Tvoríme 4% užívateľov (15 PHENIX, 22 STAR)
- FJFI ČVUT, MFF UK Praha, ÚJF AV ČR
- 2014 vznik Výboru pre spoluprácu ČR s BNL
- Návrh BNL-CZ Výskumná infraštruktúra v BNL

# RHIC/eRHIC Schedule

BNL document on transition to eRHIC, submitted to DOE in 10/2013

Years	Beam Species and Energies	Science Goals	New Systems Commissioned
2014	15 GeV Au+Au 200 GeV Au+Au	Heavy flavor flow, energy loss, thermalization, etc. Quarkonium studies QCD critical point search	Electron lenses 56 MHz SRF STAR HFT STAR MTD
2015-16	2015 p+p 200 GeV p+Au 200GeV p+Si 200GeV 2016 Au+Au 200 GeV p+p 500 GeV (or Au+Au and p+p 62 GeV)	main initial ies cs	PHENIX MPC-EX Coherent e-cooling test
2017	No Run		Low energy e-cooling upgrade
2018-19	5-20 GeV Au+Au (BES-2)	Search for QCD critical point and onset of deconfinement	STAR ITPC upgrade Partial commissioning of sPHENIX (in 2019)
2020	No Run		Complete sPHENIX installation STAR forward upgrades
2021-22	Long 200 GeV Au+Au with upgraded detectors p+p, p/d+Au at 200 GeV	Jet, di-jet, $\gamma$ -jet probes of parton transport and energy loss mechanism Color screening for different quarkonia	sPHENIX
2023-24	No Runs		Transition to eRHIC

# Započala príprava US New Long Range Plan for Nuclear Science

## **NSAC Meeting 24.4.2014**

Dr. T. J. Hallman (Associate Director for Nuclear Physics , DOE Office of Science) charge to NSAC to produce LRP (2015-2025), report is expected to be submitted October 2015 to DOE and NSF.

## **26.5. 2014**

Haiyan Gao (Duke) and Craig Roberts (Argon) were nominated by the DNP Executive Committee to be the conveners for the Hadron QCD town meeting.

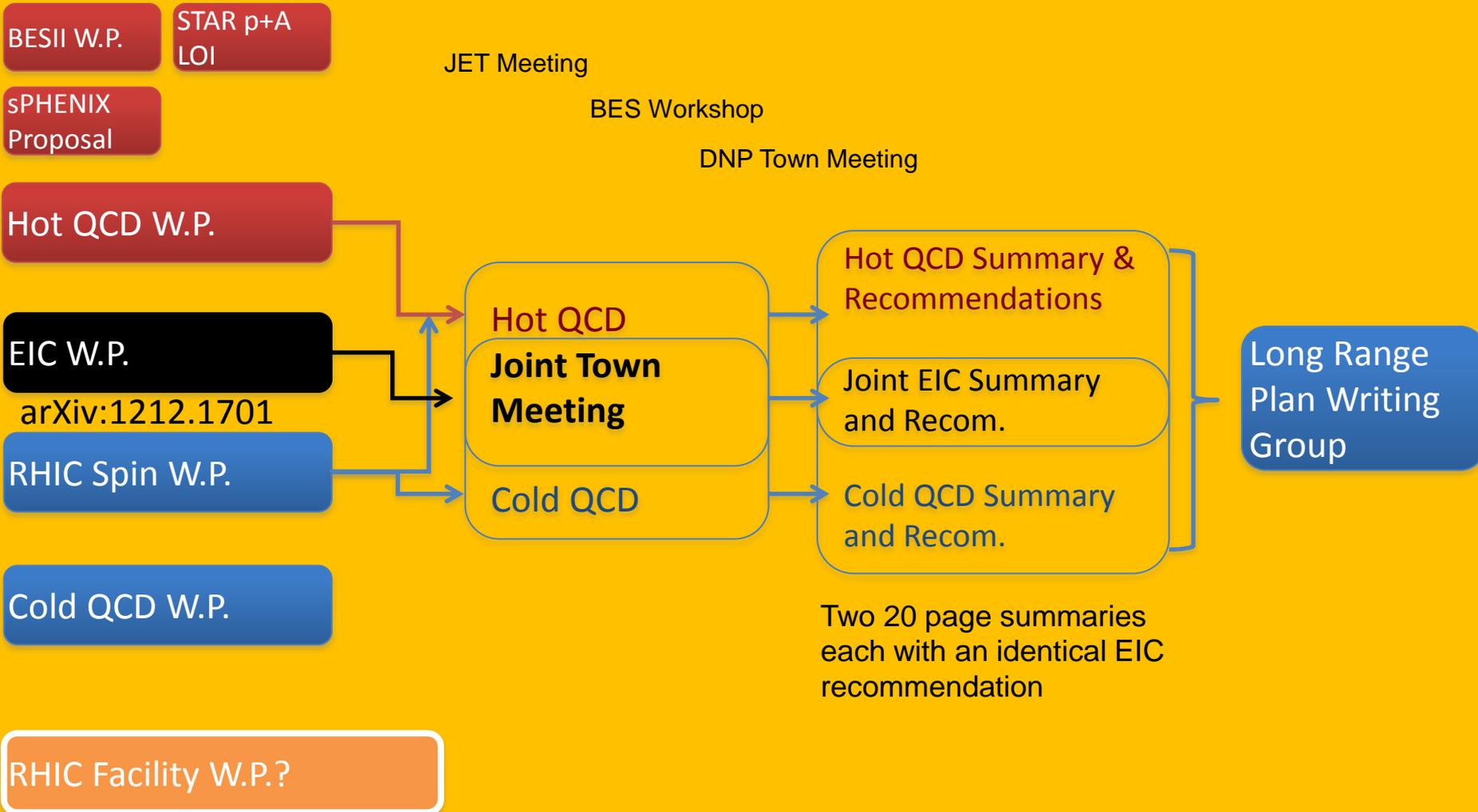
**June 2014** LRP Working group formed <http://www.phy.anl.gov/nsac-lrp/>

Joint Town Meetings on QCD Temple University, **September 13-15, 2014**

**End-January 2015:** White papers, summarizing the Town Meetings  
Late March – early April 2015, resolution meeting of Long Range Plan Working Group

LRP: Final report is anticipate by **October 2015**

# Summary of the Process



# Recommendation 1

Over the past decade, through a panoply of measurements made in **heavy-ion collisions** at the **Relativistic Heavy Ion Collider** (RHIC) and the **Large Hadron Collider** (LHC), in concert with theoretical advances coming from calculations done using many different frameworks, we have obtained a broad and deep knowledge of what **hot QCD matter** does, but we still know little about how it works. These collisions create exploding little droplets of the hottest matter seen anywhere in the universe since it was a few microseconds old. We have increasingly quantitative empirical descriptions of the phenomena manifest in these explosions, and of some key material properties of the matter created in these “Little Bangs” which turns out to be a strongly coupled liquid. However, we still do not know the precise nature of the initial state from which this liquid forms, and know very little about how the properties of this liquid vary across its phase diagram or how, at a microscopic level, the collective properties of this liquid emerge from the interactions among the individual quarks and gluons that we know must be visible if the liquid is probed with sufficiently high resolution.

## **Recommendation 1:**

The discoveries of the past decade have posed or sharpened questions that are central to understanding the nature, structure, and origin of the hottest liquid form of matter that the universe has ever seen. As our highest priority we recommend a program **to complete the search for the critical point in the QCD phase diagram and to exploit the newly realized potential of exploring the QGP’s structure at multiple length scales with jets at RHIC and LHC energies.** This requires implementation of new capabilities of the RHIC facility (a state-of-the-art jet detector such as sPHENIX and luminosity upgrades for running at low energies) needed to complete its scientific mission, continued strong U.S. participation in the LHC heavy-ion program, and strong investment in a broad range of theoretical efforts employing various analytical and computational methods.

# Recommendation 2

**A high luminosity, high-energy polarized Electron Ion Collider (EIC) is the U.S. QCD Community's highest priority for future construction.**

The EIC will, for the first time, **precisely image the gluons and sea quarks in the proton and nuclei**, resolve the **proton's internal structure** including the origin of its spin, and explore a new QCD frontier of ultra-dense gluon fields in nuclei at high energy. These advances are made possible by the EIC's unique capability to collide polarized electrons with polarized protons and light ions at unprecedented luminosity and with heavy nuclei at high energy. EIC will be absolutely essential to maintain U.S. leadership in fundamental nuclear physics research in the coming decades.

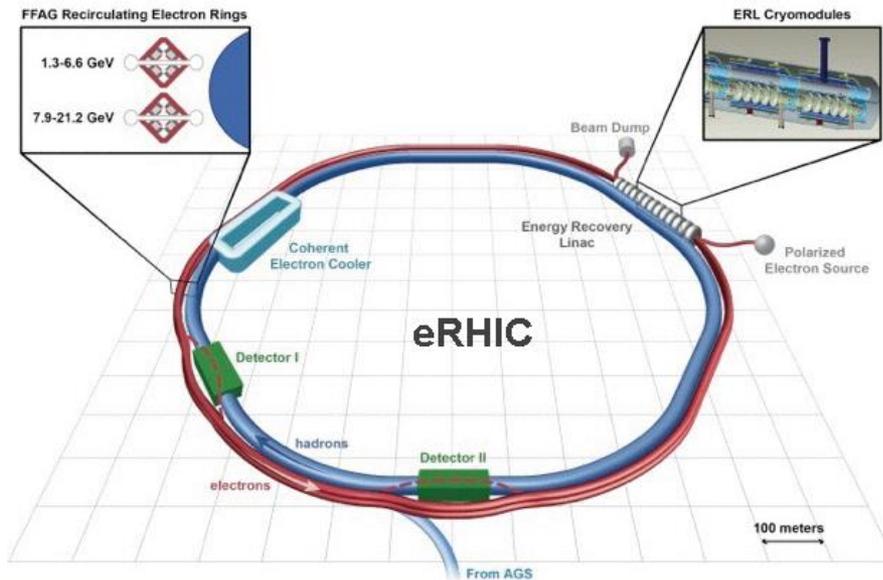
# Recommendation 3

We endorse the new initiatives and investments proposed in the Recommendation and Request received from the Computational Nuclear Physics Town Meeting, at a level to be determined by the requested NSAC subcommittee. In addition, we recommend new funding to expand the successful “Topical Collaborations in Nuclear Theory” program initiated in the last Long Range Plan of 2007, to a level of at least one new Topical Collaboration per year.

# EIC@BNL

## EIC Design

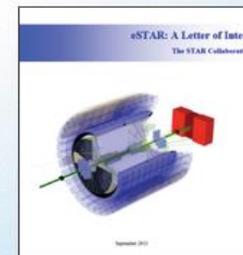
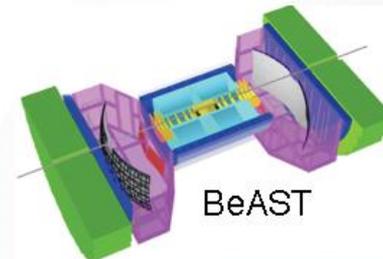
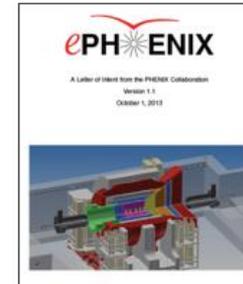
eRHIC ERL + FFAG ring design @  $10^{33}/\text{cm}^2\text{s}$   
15.9 GeV  $e^-$  + 255 GeV p or 100 GeV/u Au.



When completed, eRHIC will be the most advanced and energy efficient accelerator in the world

Brookhaven Science Associates

## Detector Options

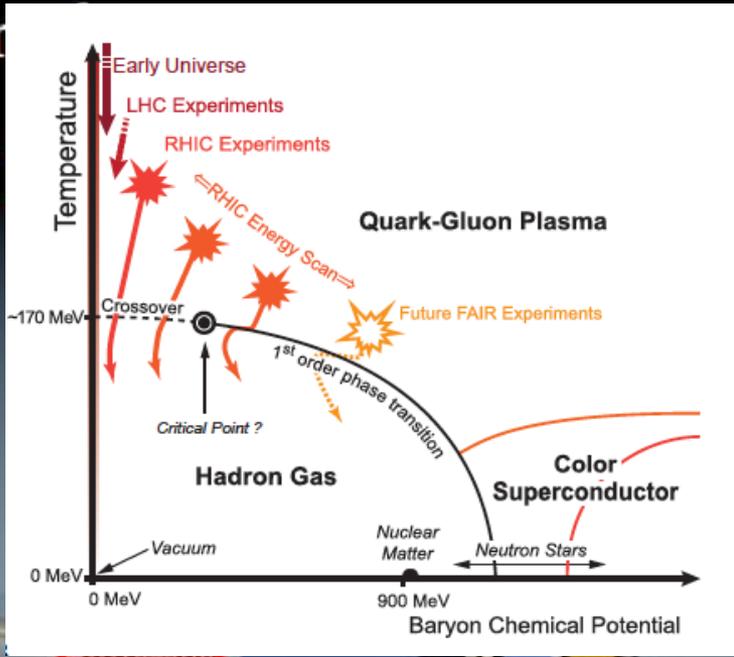
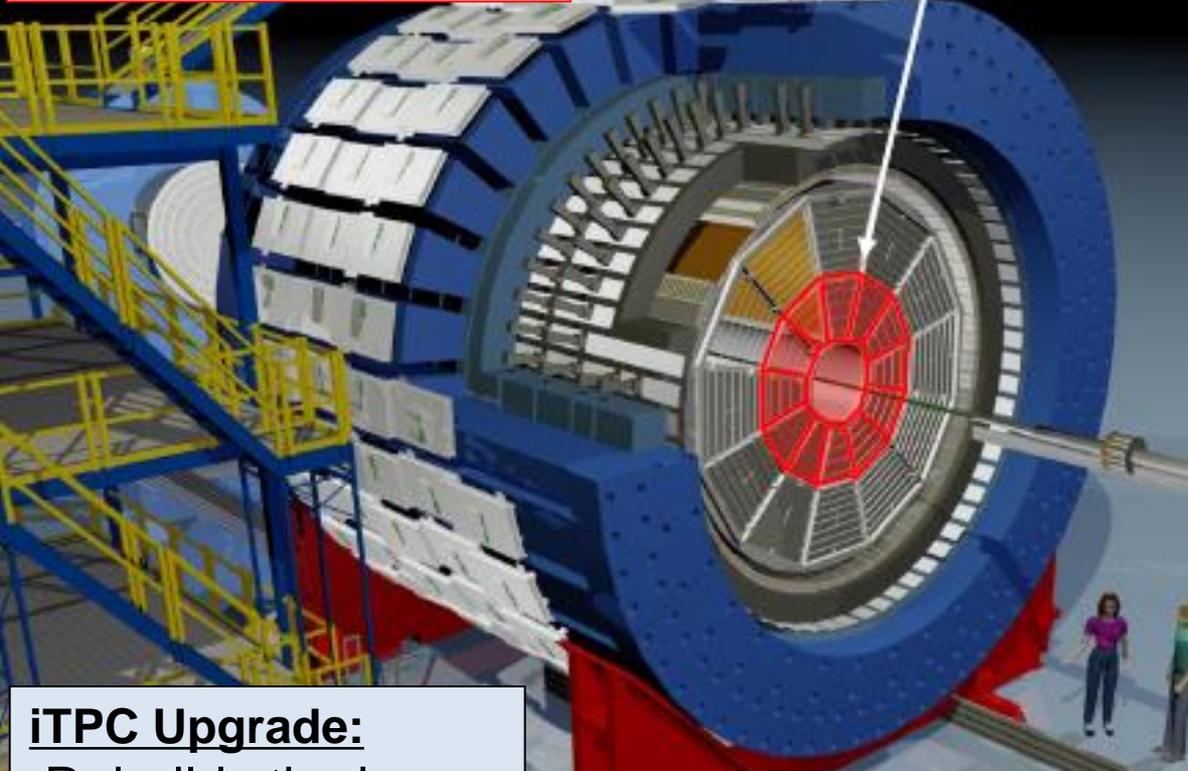


**BROOKHAVEN**  
NATIONAL LABORATORY

# Upgrades for Beam Energy Scan II

inner TPC upgrade

Major improvements for BES-II



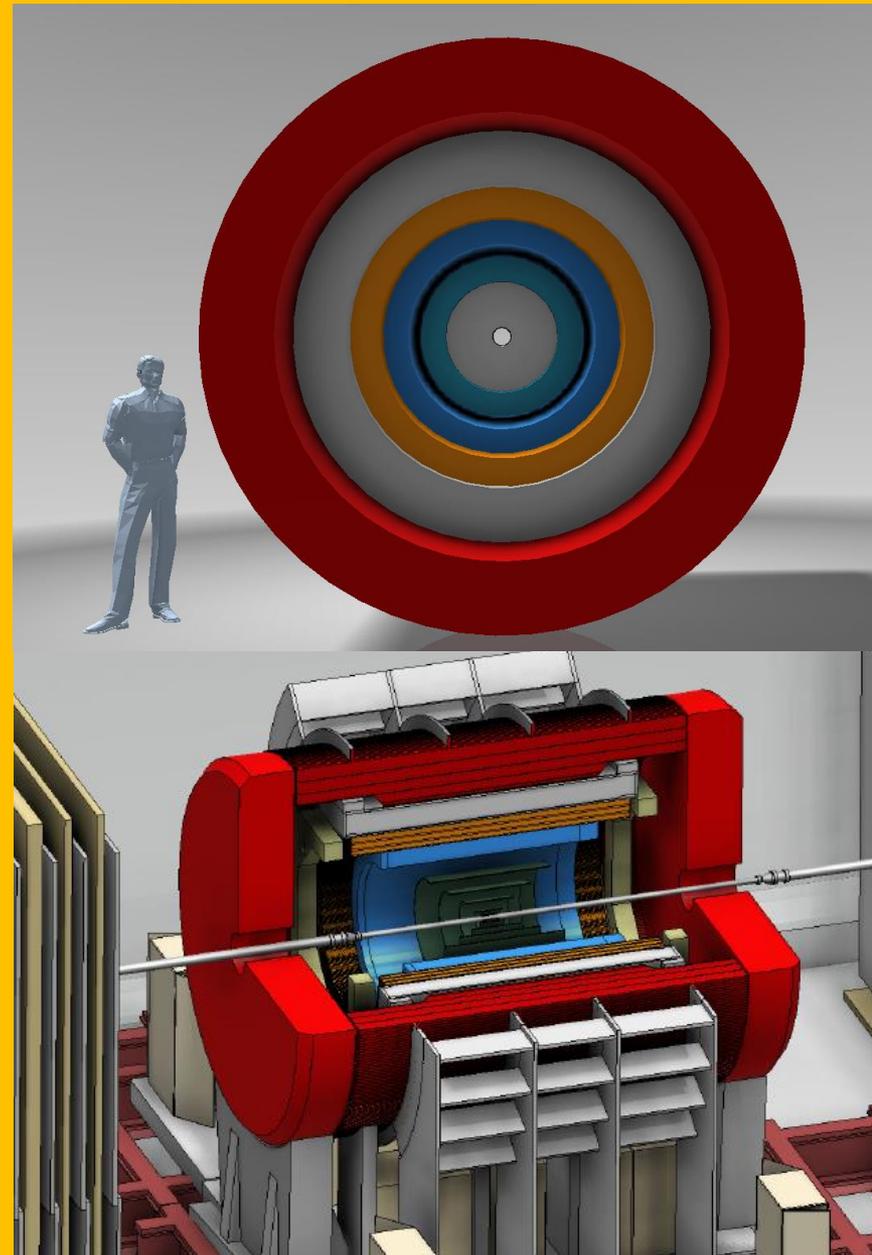
**iTPC Upgrade:**  
Rebuilds the inner sectors of the TPC

**EndCap TOF Upgrade:**  
Rapidity coverage is critical for several proposed BES Phase II measurements

**EPD Upgrade:**  
Allows a better and independent reaction plane measurement critical to BES physics

# sPHENIX Upgrade

- Proposed sPHENIX:
  - EM+hadronic calorimetry over  $|\eta| < 1.1$
  - Re-use existing BaBar 1.5T solenoid
  - Silicon tracking
  - DAQ rate  $\sim 10$  kHz
- Will provide full suite of jet and quarkonia data
- Maximal overlap with LHC measurements



Dakujem za pozornost

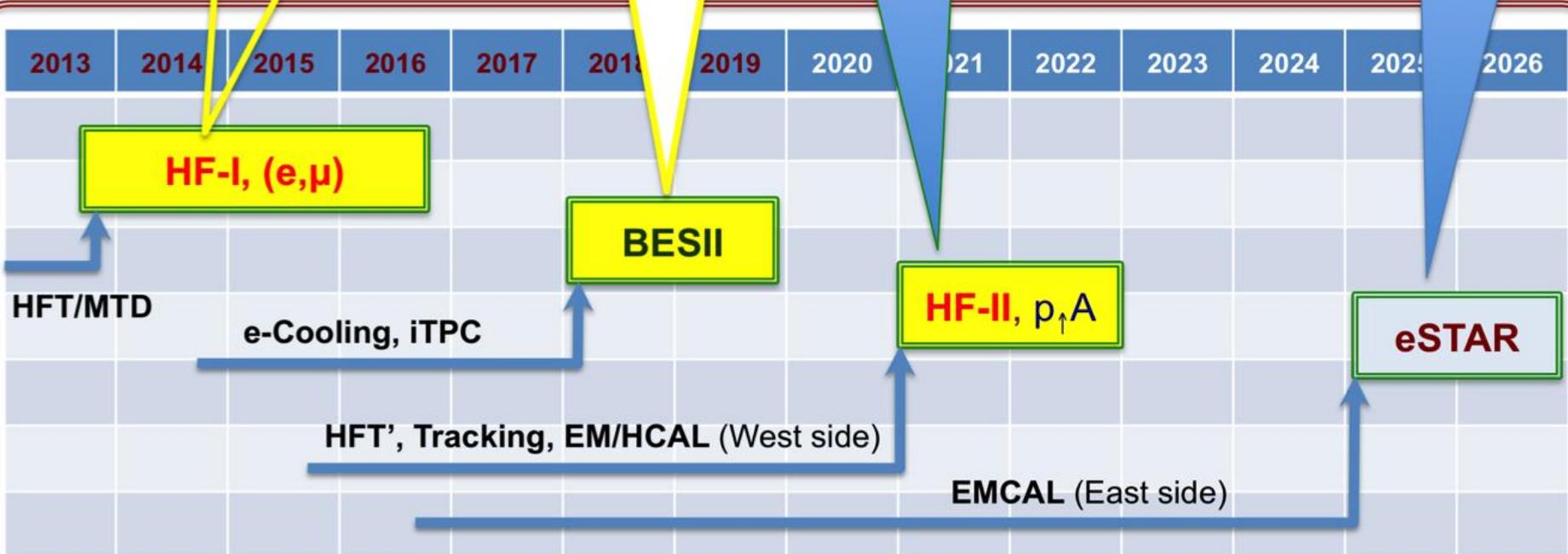
# STAR focus in next decade

- HFT: Charm  
- Di-lepton  
**sQGP properties**

- QCD phase structure  
- Critical Point

**AA:** HFT<sup>+</sup>: B,  $\Lambda_C$   
Jet,  $\gamma$ -jet  
**pA:** CNM, p-spin

Phase structure  
with dense gluon



physics

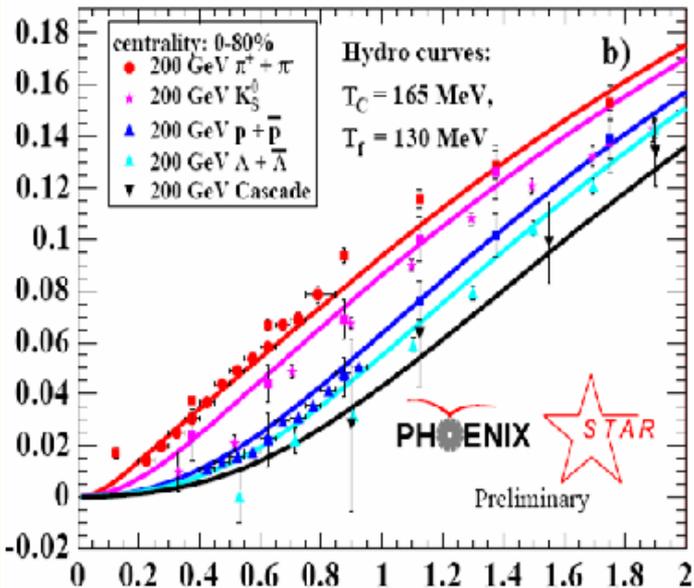
upgrade

<https://drupal.star.bnl.gov/STAR/starnotes/public/sn0592>

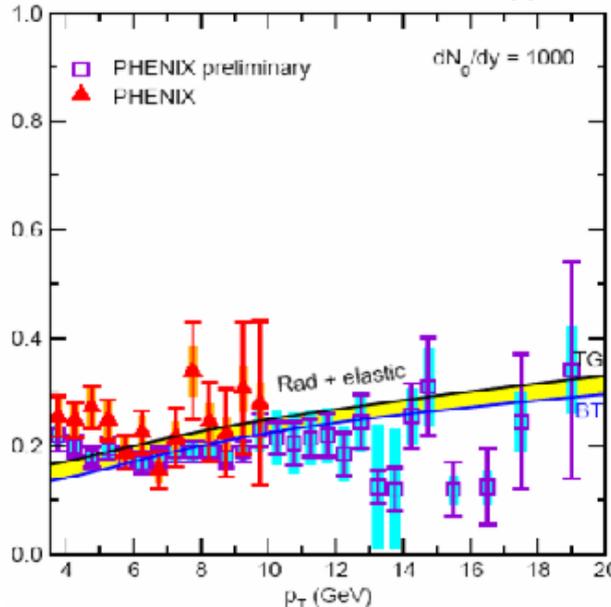
# RHIC Experiments: Discoveries

*RHIC experiments take advantage of RHIC data and make major discoveries:  
creation of strongly-coupled QCD matter at high temperature and energy density*

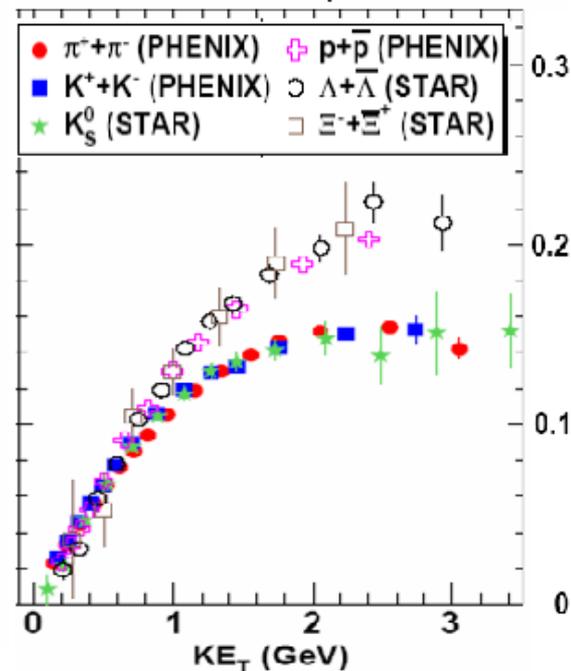
$v_2(p_T, m)$



$R_{AA}(p_T) = (\text{spec})_{AA} / (\text{spec})_{pp}$



$v_2(KE_T, n_q)$



Collective Expansion:

ideal hydrodynamics  
 (QGP equation-of-state)

Quark Energy-Loss:

perturbative QCD  
 (gluon radiation)

Hadronization:

quark coalescence

rapid thermalization, "perfect liquid"  $\Rightarrow$  strongly-interacting QGP

# RHICII Luminosities are Here

