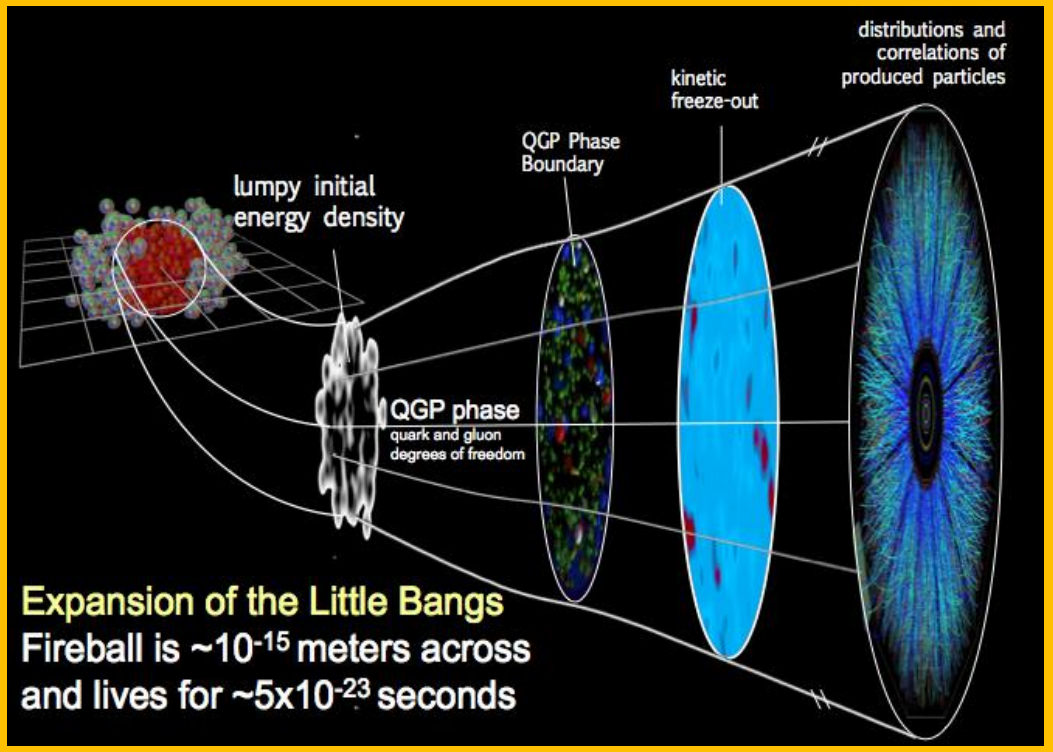
Česká účast v BNL: RHIC 2016-2022 Electron-Ion Collider

Jaroslav Bielcik FJFI ČVUT Praha



Obsah

- Informácia o VVI BNL-CZ
- RHIC plán do 2020+
- US Nuclear Physics Long Range Plan – Electron Ion Collider

Cestovní mapa ČR velkých infrastruktur pro výzkum, vývoj a inovace

- V ostatných 10 rokoch účasť ČR v BNL výrazne vzrástla
- RHIC: Tvoríme 4% uživateľov (15 PHENIX, 22 STAR)
- FJFI ČVUT, MFF UK Praha, ÚJF AV ČR
- Výzkumná infrastruktura BNL-CZ sa stala súčasťou cestovnej mapy 2016-2022
- Cieľom je hlavne podporiť provoz a inovaci detektorov (STAR, PHENIX/sPHENIX)

Berndt Mueller (Associate Laboratory Director for Nuclear & Particle Physics , BNL)

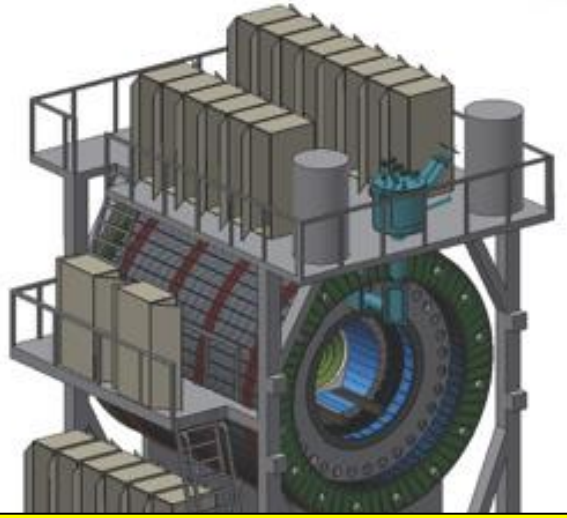
Completing the RHIC science mission

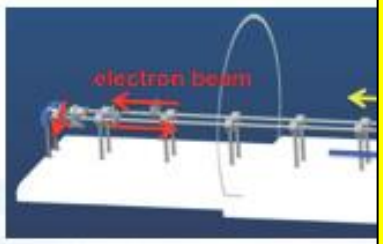
Status: RHIC-II configuration is complete

- Vertex detectors in STAR (HFT) and PHENIX
- Luminosity reaches 25x design luminosity

Plan: Complete the RHIC mission in 3 campaigns:

- **2014–17: Heavy flavor probes of the QGP using the micro-vertex detectors; Transverse spin physics**
- *2018: Install low energy e-cooling* (LEReC)
- **2019/20: High precision scan of the QCD phase diagram & search for critical point**
- *2021: Install sPHENIX*
- **2022–23: Probe QGP with precision measurements of jet quenching and Upsilon suppr**
- *Transition to eRHIC ?*





2016 Au+Au 200 GeV 10 weeks
Au+p at 62 and 39 GeV 5 weeks

2017 p+p 510 GeV transversely polarized

2018 No run

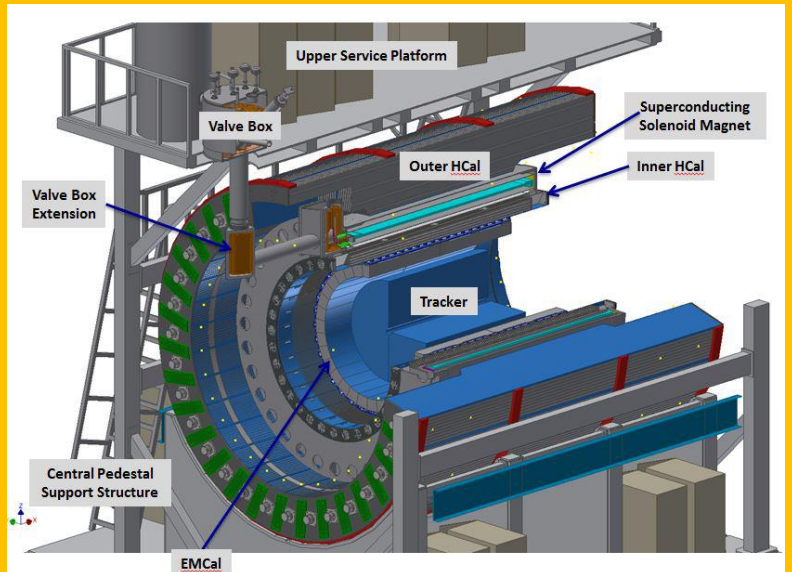
2019-2020 BES II high statistics

Brookhaven Science Associates

New RHIC Detector/SPhenix

- (2004 J.Harris Comprehensive New Detector at RHIC)
- 2012: Prvý návrh sPHENIX
- June 16, 2015: BNL sPHENIX/ New RHIC Detector Workshop
- 57 Institutions joined (inc. Joint Czech Group)
- 10.-12. Dec. 2015: Rutgers University Inaugurácia novej **New RHIC detector** kolaborácie

- Potential future application as a foundation for an EIC detector
- Ready for Beam Jan 2022



US New Long Range Plan for Nuclear Science 2015

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 was due by **October 2015**

2015 Long Range Plan for Nuclear Science

From: APS DNP [mailto:dnp=aps.org@mail222.suw14.mcdlv.net] On Behalf Of APS DNP
Sent: Monday, October 19, 2015 9:25 AM
To: Xu, Zhangbu
Subject: DOE/NSF Long Range Plan

DOE Office of Science for Nuclear Physics
DOE/NSF NSAC Long Range Plan

Member of the Nuclear Science Community:

In 2014 the DOE/NSF Nuclear Science Advisory (NSAC) was charged with conducting a new study of the opportunities and priorities for United States nuclear physics research and with recommending a long range plan that would provide a framework for coordinated advancement of the Nation's nuclear science research programs over the next decade. In response, NSAC formed a sub-committee chaired by Dr. Donald Geesaman of Argonne National Laboratory to prepare a response.

At the October 15, 2015, NSAC Meeting the 2015 Long Range Plan for Nuclear Science Report was accepted. Below is a link to the report, "Reaching For The Horizon", which can be found on the Nuclear Physics website.

http://science.energy.gov/~/media/np/nsac/pdf/2015LRP/2015_LRPNS_091815.pdf

Sincerely,

Timothy J. Hallman
Associate Director of the DOE Office of Science for Nuclear Physics

REACHING FOR THE HORIZON

The Site of the Wright Brothers' First Airplane Flight

The 2015 LONG RANGE PLAN for NUCLEAR SCIENCE

2015 Long Range Plan for Nuclear Science

RECOMMENDATION I

The progress achieved under the guidance of the 2007 Long Range Plan has reinforced U.S. world leadership in nuclear science. The highest priority in this 2015 Plan is to capitalize on the investments made.

- With the imminent completion of the CEBAF 12-GeV Upgrade, its forefront program of using electrons to unfold the quark and gluon structure of hadrons and nuclei and to probe the Standard Model must be realized.
- Expeditiously completing the Facility for Rare Isotope Beams (FRIB) construction is essential. Initiating its scientific program will revolutionize our understanding of nuclei and their role in the cosmos.
- The targeted program of fundamental symmetries and neutrino research that opens new doors to physics beyond the Standard Model must be sustained.
- The upgraded RHIC facility provides unique capabilities that must be utilized to explore the properties and phases of quark and gluon matter in the high temperatures of the early universe and to explore the spin structure of the proton.

RECOMMENDATION II

The excess of matter over antimatter in the universe is one of the most compelling mysteries in all of science. The observation of neutrinoless double beta decay in nuclei would immediately demonstrate that neutrinos are their own antiparticles and would have profound implications for our understanding of the matterantimatter mystery.

We recommend the timely development and deployment of a U.S.-led ton-scale neutrinoless double beta decay experiment.

A ton-scale instrument designed to search for this as-yet unseen nuclear decay will provide the most powerful test of the particle-antiparticle nature of neutrinos ever performed. With recent experimental breakthroughs pioneered by U.S. physicists and the availability of deep underground laboratories, we are poised to make a major discovery.

This recommendation flows out of the targeted investments of the third bullet in Recommendation I. It must be part of a broader program that includes U.S. participation in complementary experimental efforts leveraging international investments together with enhanced theoretical efforts to enable full realization of this opportunity.

2015 Long Range Plan for Nuclear Science

RECOMMENDATION III

Gluons, the carriers of the strong force, bind the quarks together inside nucleons and nuclei and generate nearly all of the visible mass in the universe. Despite their importance, fundamental questions remain about the role of gluons in nucleons and nuclei. These questions can only be answered with a powerful new electron ion collider (EIC), providing unprecedented precision and versatility. The realization of this instrument is enabled by recent advances in accelerator technology.

We recommend a high-energy high-luminosity polarized EIC as the highest priority for new facility construction following the completion of FRIB.

The EIC will, for the first time, precisely image gluons in nucleons and nuclei. It will definitively reveal the origin of the nucleon spin and will explore a new quantum chromodynamics (QCD) frontier of ultra-dense gluon 5 The 2015 Long Range Plan for Nuclear Science Reaching for the Horizon fields, with the potential to discover a new form of gluon matter predicted to be common to all nuclei. This science will be made possible by the EIC's unique capabilities for collisions of polarized electrons with polarized protons, polarized light ions, and heavy nuclei at high luminosity.

RECOMMENDATION IV

We recommend increasing investment in small-scale and mid-scale projects and initiatives that enable forefront research at universities and laboratories.

Innovative research and initiatives in instrumentation, computation, and theory play a major role in U.S. leadership in nuclear science and are crucial to capitalize on recent investments. The NSF competitive instrumentation funding mechanisms, such as the Major Research Instrumentation (MRI) program and the Mathematical & Physical Sciences mid-scale research initiative, are essential to enable university researchers to respond nimbly to opportunities for scientific discovery. Similarly, DOE-supported research and development (R&D) and Major Items of Equipment (MIE) at universities and national laboratories are vital to maximize the potential for discovery as opportunities emerge

Future starts now

In the 2015 long range planning (LRP) activity of the US Nuclear Science Community the joint Town Meetings on QCD unanimously and enthusiastically endorsed the **Electron-Ion Collider (EIC)** as **the highest priority for new facility** construction in the US. The view of the broader US nuclear science community, to be expressed in the NSAC Long Range Plan, will be released in October of this year. We hence think it is timely for the US and the international users of a future US-based EIC to organize more formally with the goal of giving the future users community a stronger and more visible role in the process leading to the creation of an EIC.

We are writing to invite you and colleagues at your Institution to join in the international Electron-Ion Collider Users Group (EICUG) with the aim of realizing the EIC in the United States. Currently there are two designs of the US EIC under consideration, one at Brookhaven National Laboratory based on RHIC and the other at Jefferson Laboratory based on the 12-GeV CEBAF facility.

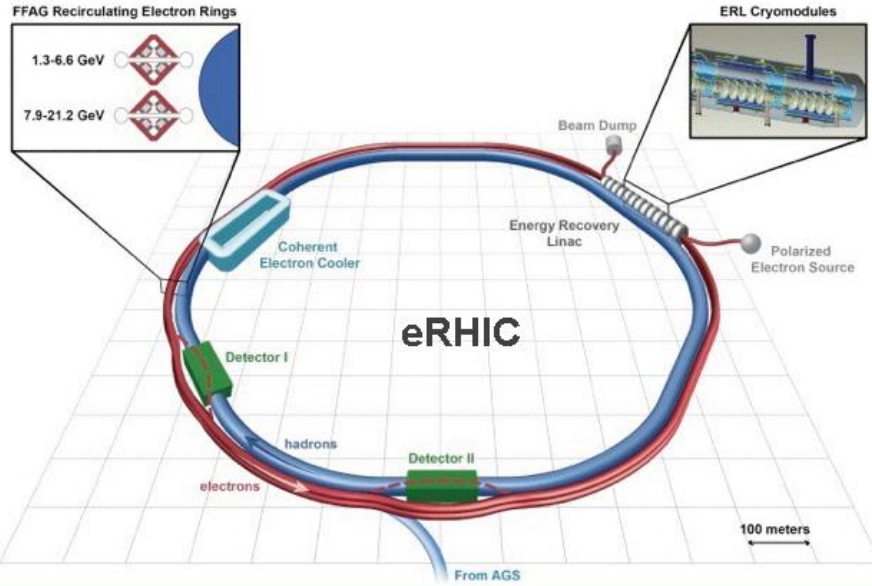
ELECTRON ION COLLIDER USER GROUP MEETING 2016, UC BERKELEY, JANUARY 6-9, 2016

EIC@BNL

EIC Design

eRHIC ERL + FFAG ring design @ $10^{33}/cm^2s$

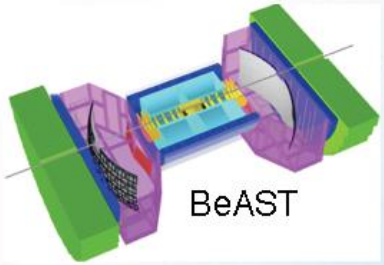
15.9 GeV e^- + 255 GeV p or 100 GeV/u Au.



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

Brookhaven Science Associates

Detector Options

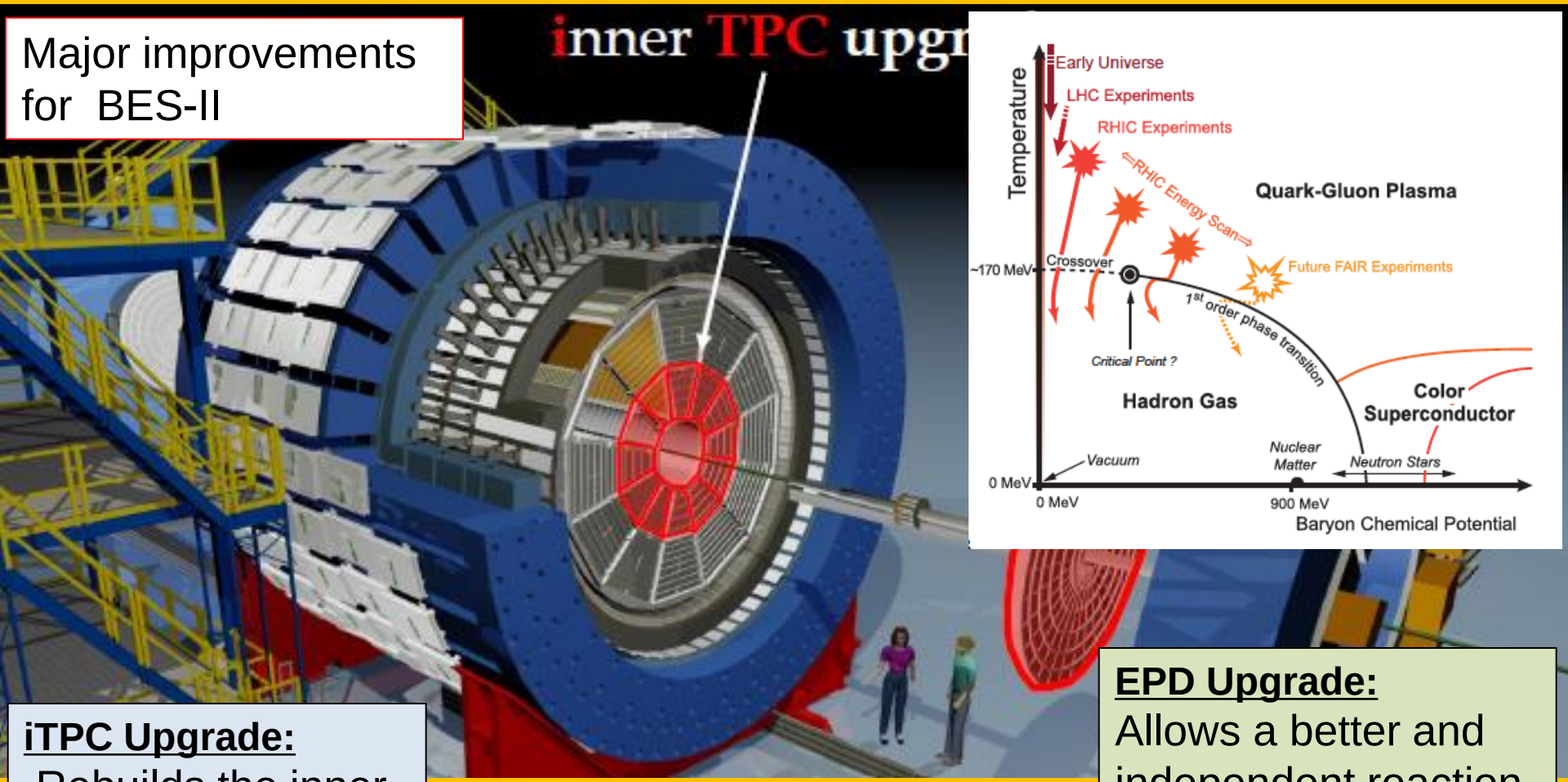


BROOKHAVEN NATIONAL LABORATORY

Ďakujem za pozornosť

Upgrades for Beam Energy Scan II

Major improvements for BES-II



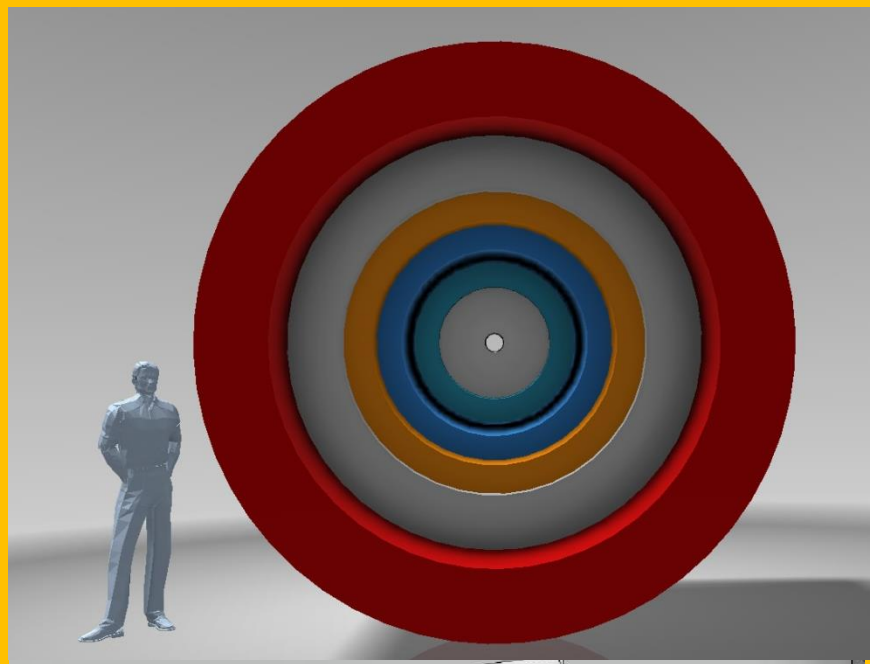
iTPC Upgrade:
Rebuilds the inner sectors of the TPC

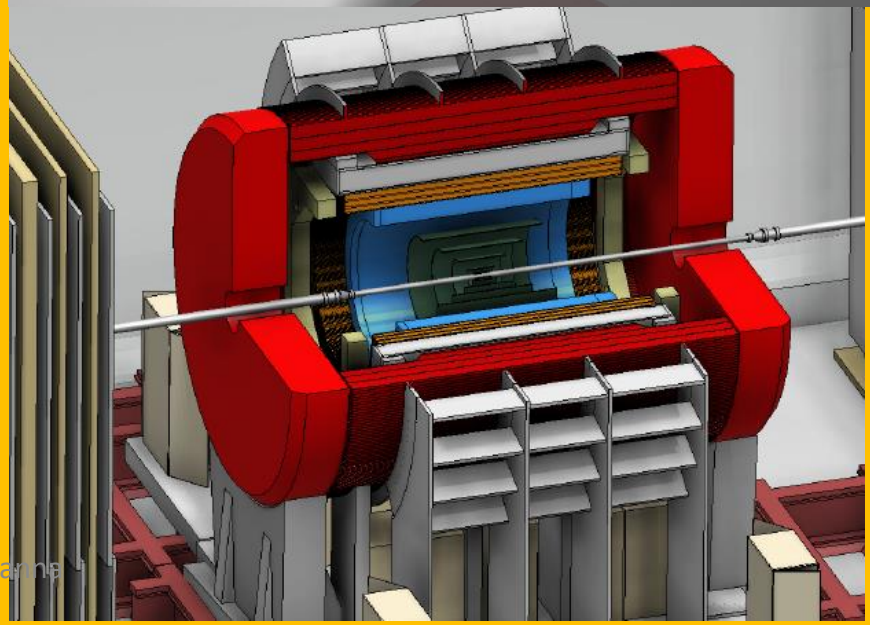
EndCap TOF Upgrade:
Rapidity coverage is critical for several proposed BES Phase II measurements

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

sPHENIX Upgrade

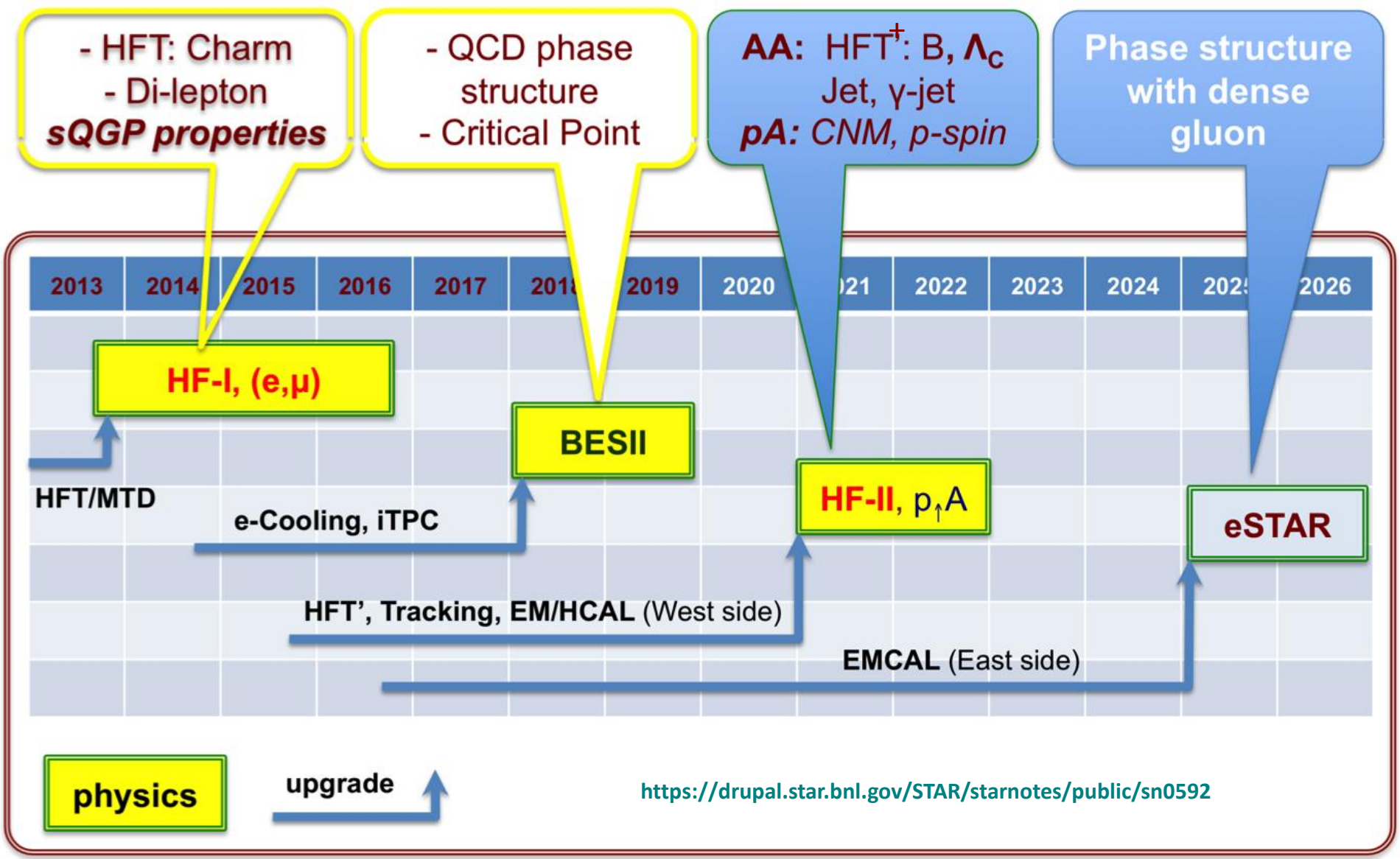
- Proposed sPHENIX:
  - EM+hadronic calorimetry over $|\eta| < 1.1$
  - Re-use existing BaBar 1.5T solenoid
  - Silicon tracking
  - DAQ rate ~ 10 kHz
- Will provide full suite of jet and quarkonia data
- Maximal overlap with LHC measurements





Dakujem za pozornost

STAR focus in next decade



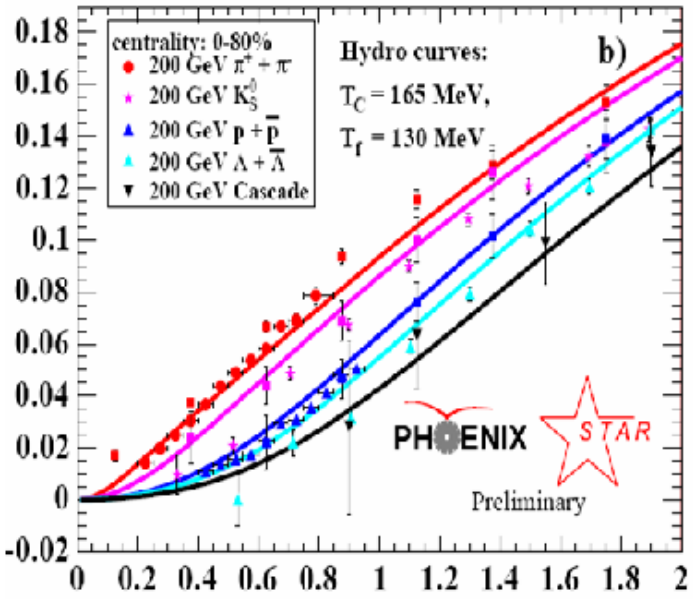
https://drupal.star.bnl.gov/STAR/starnotes/public/sn0592

RHIC Experiments: Discoveries

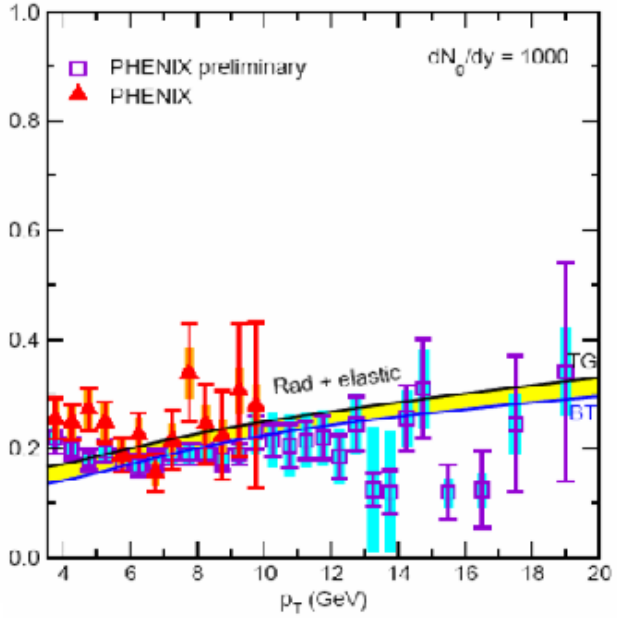
RHIC experiments take advantage of RHIC data and make major discoveries:

creation of strongly-coupled QCD matter at high temperature and energy density

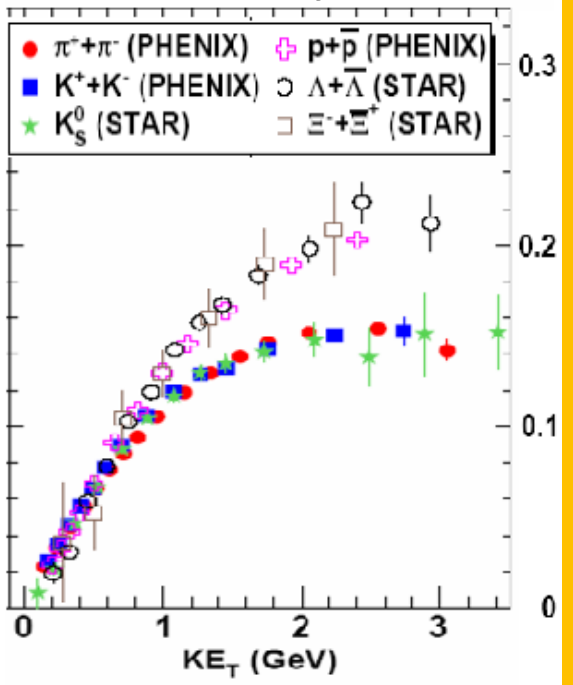
$v_2(p_T,m)$



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



$v_2(KE_T,n_q)$



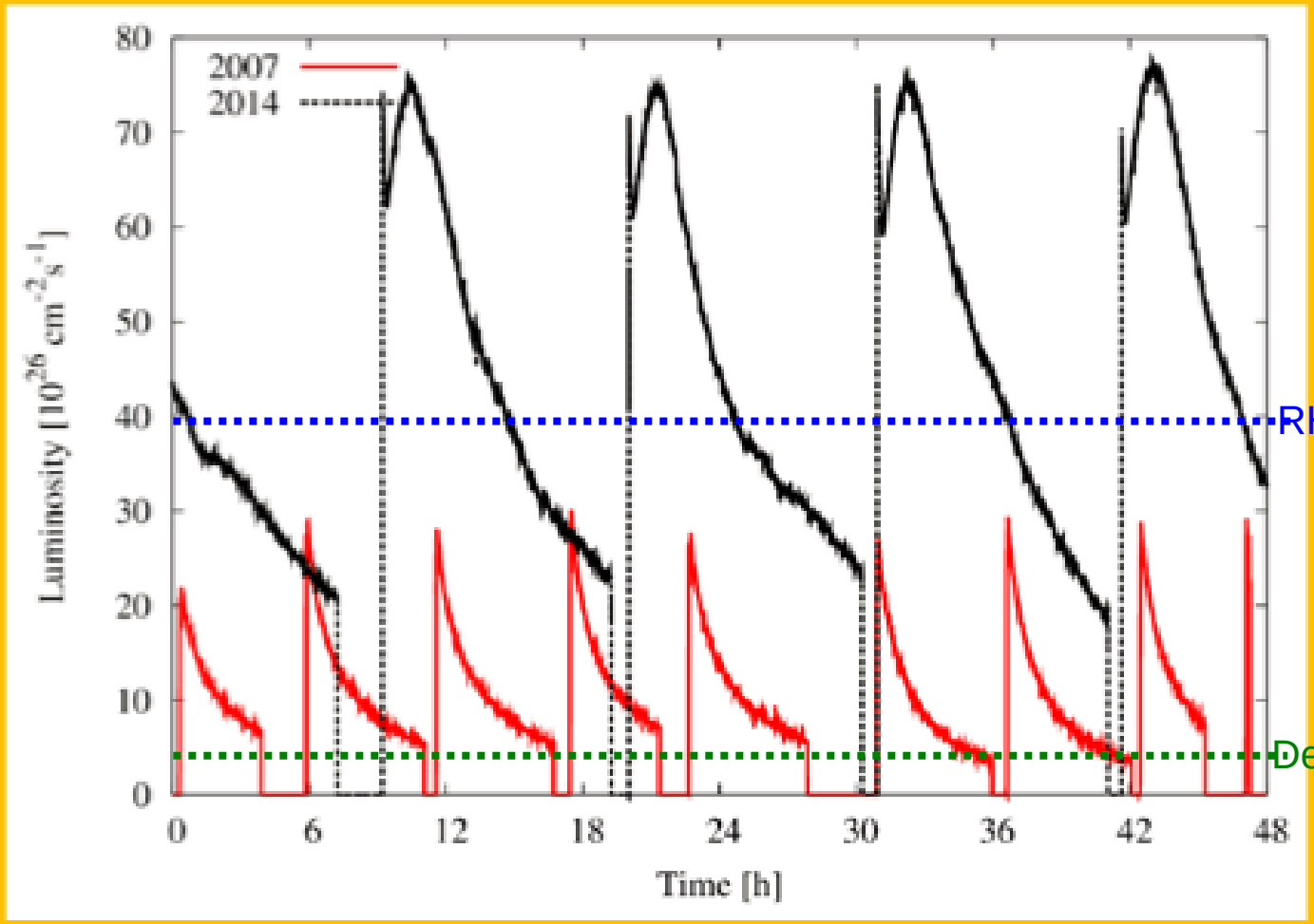
Collective Expansion:
ideal hydrodynamics
(QGP equation-of-state)

Quark Energy-Loss:
perturbative QCD
(gluon radiation)

Hadronization:
quark coalescence

rapid thermalization, "perfect liquid" ⇒ strongly-interacting QGP

RHICII Luminosities are Here



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		ain initial ies cs	PHENIX MPC-EX Coherent e-cooling test
2017			Low energy e-cooling upgrade
2018-19		point and onset	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, γ-jet probes of parton transport and energy loss mechanism Color screening for different quarkonia	sPHENIX
2023			

2016 Au+Au 200 GeV 10 weeks
Au+p at 62 and 39 GeV 5 weeks

2017 p+p 510 GeV transversely polarized

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2019-2020 BES II high statistics

In all the scenarios developed so far, RHIC will complete its mission latest in 2023.

Summary of the Process