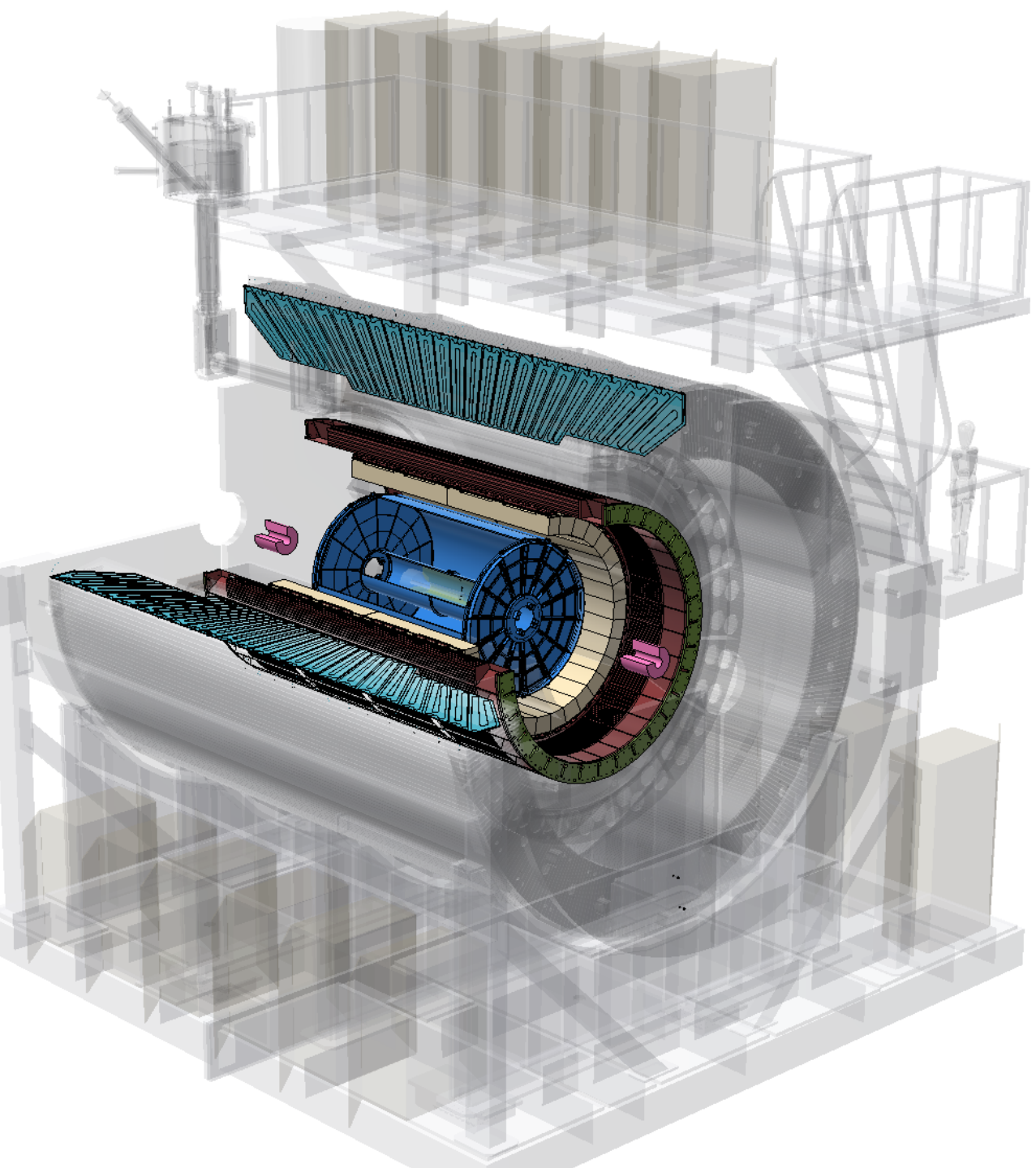


sPHENIX software and computing “workfest”

Dave Morrison (BNL)
Gunther Roland (MIT)

co-spokespersons

BROOKHAVEN NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY | Office of Science

So, what's a workfest?

- A bit of overview and then splitting up into groups to tackle specific projects
- Very productive to get the right people in one place to work together
- Not very formal – be sure to introduce yourself to all
- Reconvene regularly to share progress, air problems
- sPHENIX has had successful workfests on a number of topics

“an army marches on its stomach”

– various (including Galen of Rome, Fredrick the Great, Napoleon Bonaparte)

logistics!

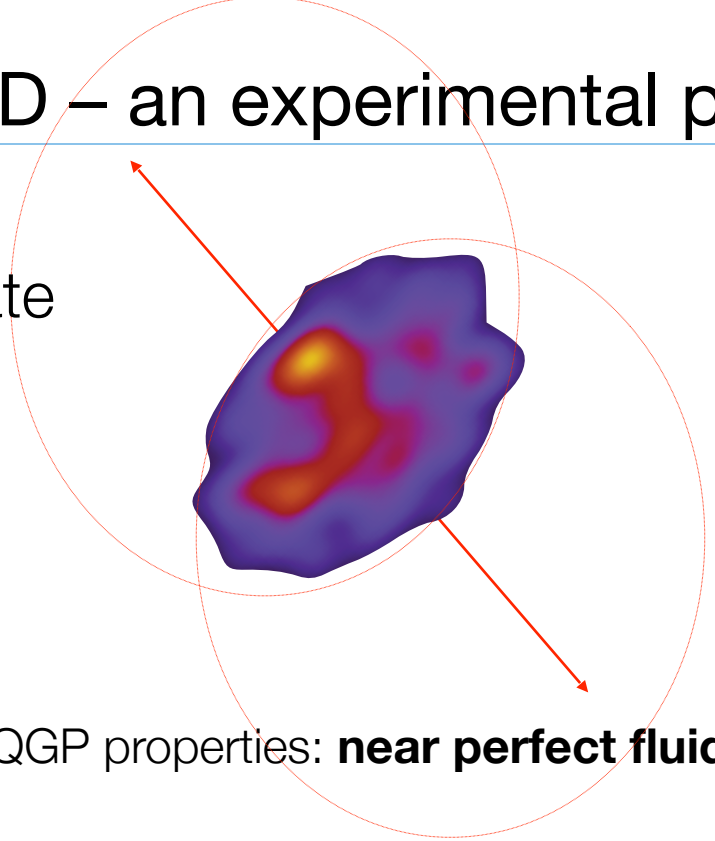
- The army: thanks to Berndt Mueller (NPP Assoc. Lab Director) for support to enable bringing in experts from overseas!
- The stomach: thanks to Hong Ma (Physics Dept. Chair) and BNL for support for morning/afternoon coffee breaks!
- Big thanks to Mariette Faulkner and Erica Lamar (sPHENIX admins) for a huge effort for lunch logistics as BNL food service is on … hiatus
  - $75 to Mariette this morning: a prix fixe Long Island lunch menu for the week. Bon appétit!
- Workfest photo this morning at 10:30am

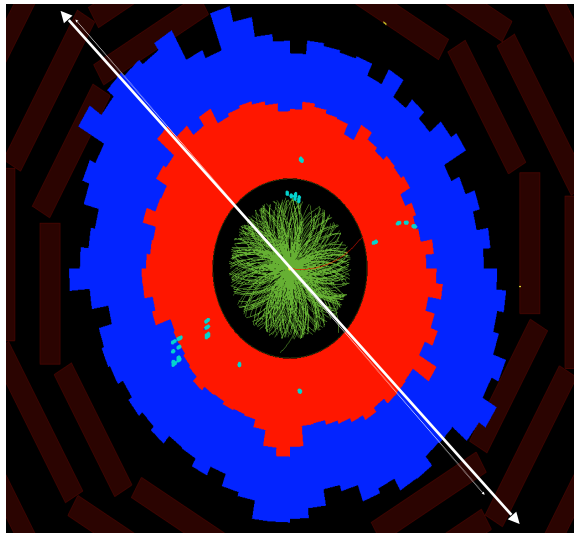
the most important logistical info – wifi!

- eduroam works just fine
- “corus” is SSID for BNL’s guest network
  - quick online registration
  - registration needs handshake via mobile to complete
    - international phone numbers seem to be tricky, just enlist a friendly holder of a U.S. phone to help

Hot QCD – an experimental path forward

Initial state

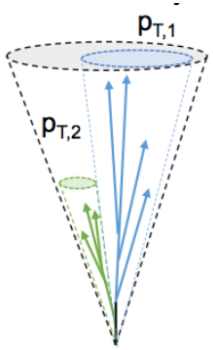




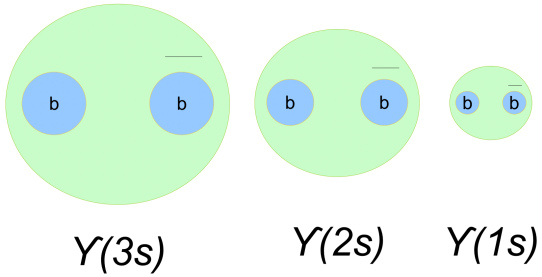
experiment

- Surprising QGP properties: **near perfect fluidity** and **extreme opacity**
- Precision studies at RHIC and LHC $\Longrightarrow$ much final state structure via relativistic viscous hydrodynamics applied to QGP evolution
- Success of LHC experiments in HI physics $\Longrightarrow$ large acceptance, high resolution tracking, high collision rates and full EM+Hadronic calorimetry
- **Improved instrumentation at RHIC and LHC to understand emergence of QGP properties from underlying asymptotically weakly coupled interactions**

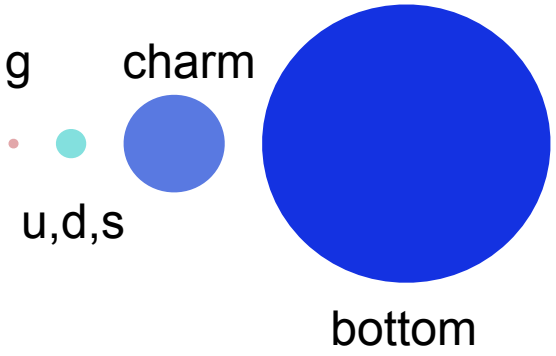
Hard Probes: sPHENIX ⊕ LHC



Jet structure
vary momentum/
angular scale of probe



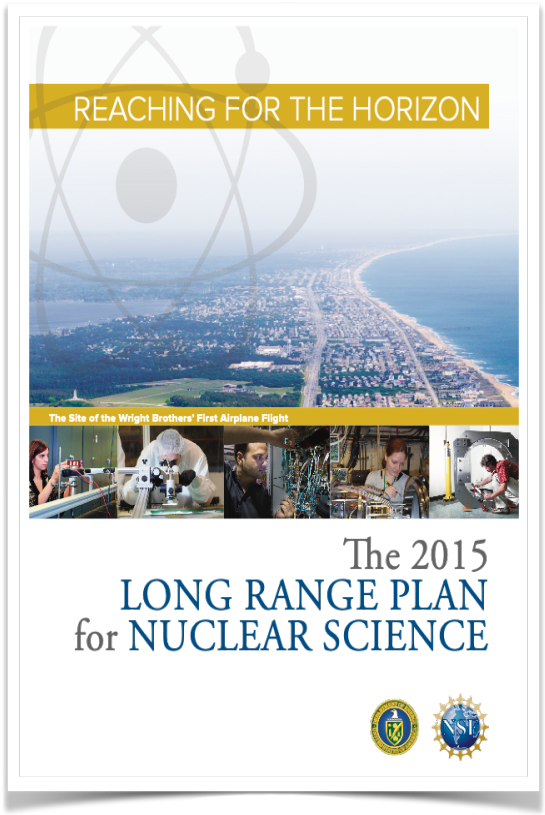
Quarkonium spectroscopy
vary size of probe



Parton energy loss
vary mass/momentum of probe

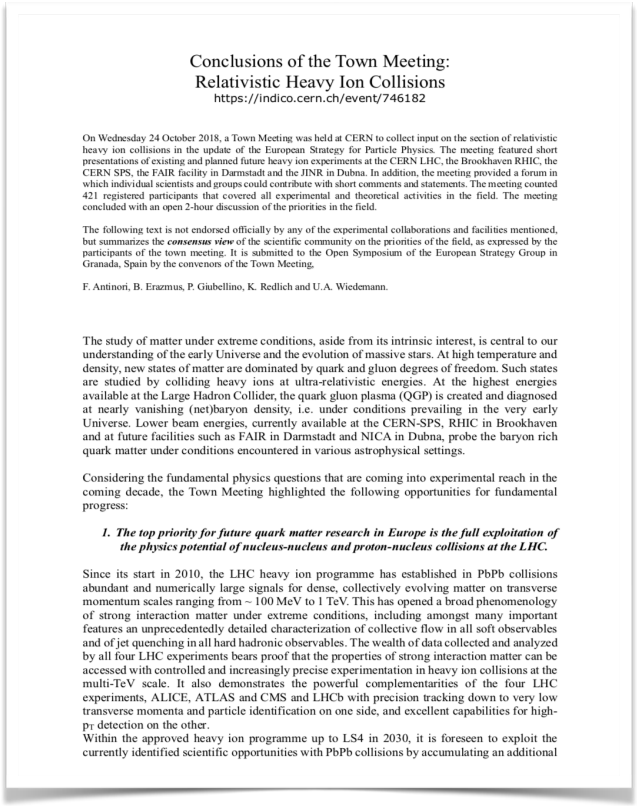
sPHENIX science mission

2015 US NP LRP



Reaffirmed in ECFA heavy-ion (WG5) discussion

WG5 for 2019 ECFA process



Conclusions of the Town Meeting:
Relativistic Heavy Ion Collisions
https://indico.cern.ch/event/746182

On Wednesday 24 October 2018, a Town Meeting was held at CERN to collect input on the section of relativistic heavy ion collisions in the update of the European Strategy for Particle Physics. The meeting featured short presentations of existing and planned future heavy ion experiments at the CERN LHC, the Brookhaven RHIC, the CERN SPS, the FAIR facility in Darmstadt and the JINR in Dubna. In addition, the meeting provided a forum in which individual scientists and groups could contribute with short comments and statements. The meeting counted 421 registered participants that covered all experimental and theoretical activities in the field. The meeting concluded with an open 2-hour discussion of the priorities in the field.

The following text is not endorsed officially by any of the experimental collaborations and facilities mentioned, but summarizes the ***consensus view*** of the scientific community on the priorities of the field, as expressed by the participants of the town meeting. It is submitted to the Open Symposium of the European Strategy Group in Granada, Spain by the convenors of the Town Meeting,

F. Antinori, B. Erazmus, P. Giubellino, K. Redlich and U.A. Wiedemann.

The study of matter under extreme conditions, aside from its intrinsic interest, is central to our understanding of the early Universe and the evolution of massive stars. At high temperature and density, new states of matter are dominated by quark and gluon degrees of freedom. Such states are studied by colliding heavy ions at ultra-relativistic energies. At the highest energies available at the Large Hadron Collider, the quark gluon plasma (QGP) is created and diagnosed at nearly vanishing (net)baryon density, i.e. under conditions prevailing in the very early Universe. Lower beam energies, currently available at the CERN-SPS, RHIC in Brookhaven and at future facilities such as FAIR in Darmstadt and NICA in Dubna, probe the baryon rich quark matter under conditions encountered in various astrophysical settings.

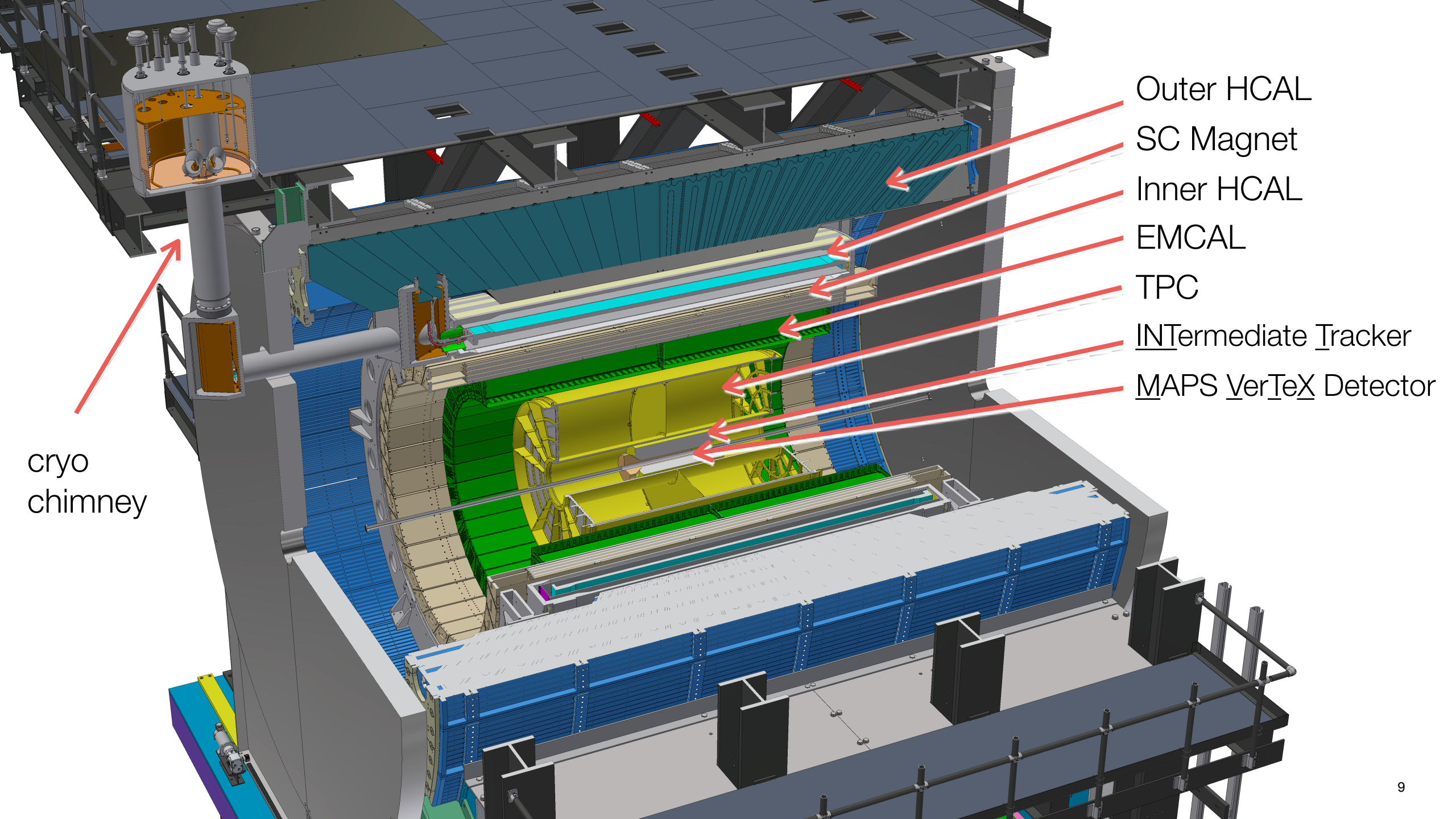
Considering the fundamental physics questions that are coming into experimental reach in the coming decade, the Town Meeting highlighted the following opportunities for fundamental progress:

1. ***The top priority for future quark matter research in Europe is the full exploitation of the physics potential of nucleus-nucleus and proton-nucleus collisions at the LHC.***

Since its start in 2010, the LHC heavy ion programme has established in PbPb collisions abundant and numerically large signals for dense, collectively evolving matter on transverse momentum scales ranging from ~ 100 MeV to 1 TeV. This has opened a broad phenomenology of strong interaction matter under extreme conditions, including amongst many important features an unprecedentedly detailed characterization of collective flow in all soft observables and of jet quenching in all hard hadronic observables. The wealth of data collected and analyzed by all four LHC experiments bears proof that the properties of strong interaction matter can be accessed with controlled and increasingly precise experimentation in heavy ion collisions at the multi-TeV scale. It also demonstrates the powerful complementarities of the four LHC experiments, ALICE, ATLAS and CMS and LHCb with precision tracking down to very low transverse momenta and particle identification on one side, and excellent capabilities for high-p_T detection on the other.
Within the approved heavy ion programme up to LS4 in 2030, it is foreseen to exploit the currently identified scientific opportunities with PbPb collisions by accumulating an additional

"Probe the inner workings of QGP by resolving its properties at shorter and shorter length scales. The complementarity of [RHIC and the LHC] is essential to this goal, as is a state-of-the-art jet detector at RHIC, called sPHENIX."

"The Town Meeting observes that the recently approved sPHENIX proposal targets these opportunities by bringing greatly extended capabilities to RHIC …"


Outer HCAL
SC Magnet
Inner HCAL
EMCAL
TPC
INTermediate Tracker
MAPS VerTeX Detector
cryo
chimney

sPHENIX collaboration

- Steady growth after CD-0
  - 18 new institutions (77 total)
  - about 25% non-US institutions
- CERN recognized experiment (April ’19)
- Steady evolution of collaboration organization

2016 2017 2018 2019

Berkeley, Purdue, Fudan University, UNC Greensboro, TEMPLE UNIVERSITY, cea, U. Sao Paulo, BERKELEY LAB, NCU, Taiwan, SEJONG UNIVERSITY, SINAP, PEKING UNIVERSITY, Florida AMU

List of Recognized Experiments

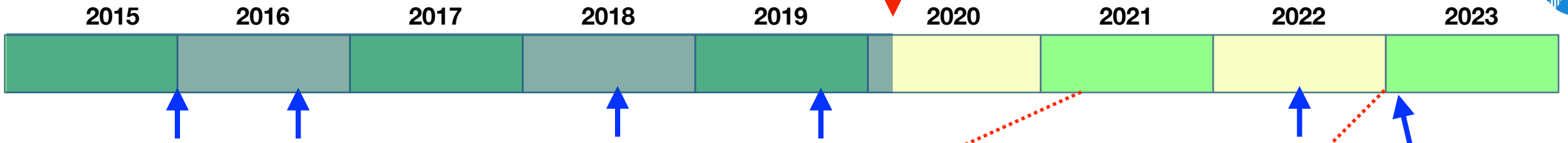
CERN

RE status at CERN

Ref.	Experiment	since	until
RE 33	LIGO	2016	31-MAR-2022
RE 34	JUNO	2017	31-MAR-2020
RE 35	SNO+	2017	31-MAR-2020
RE 36	Mu3e	2018	31-MAR-2021
RE 37	DarkSide 20k	2018	31-MAR-2021
RE 38	DAMIC-M	2019	31-MAR-2022
RE 39	sPHENIX	2019	31-MAR-2022

sPHENIX Timeline

You are here!



sPHENIX science collaboration

DOE CD-0
"Mission need" approval

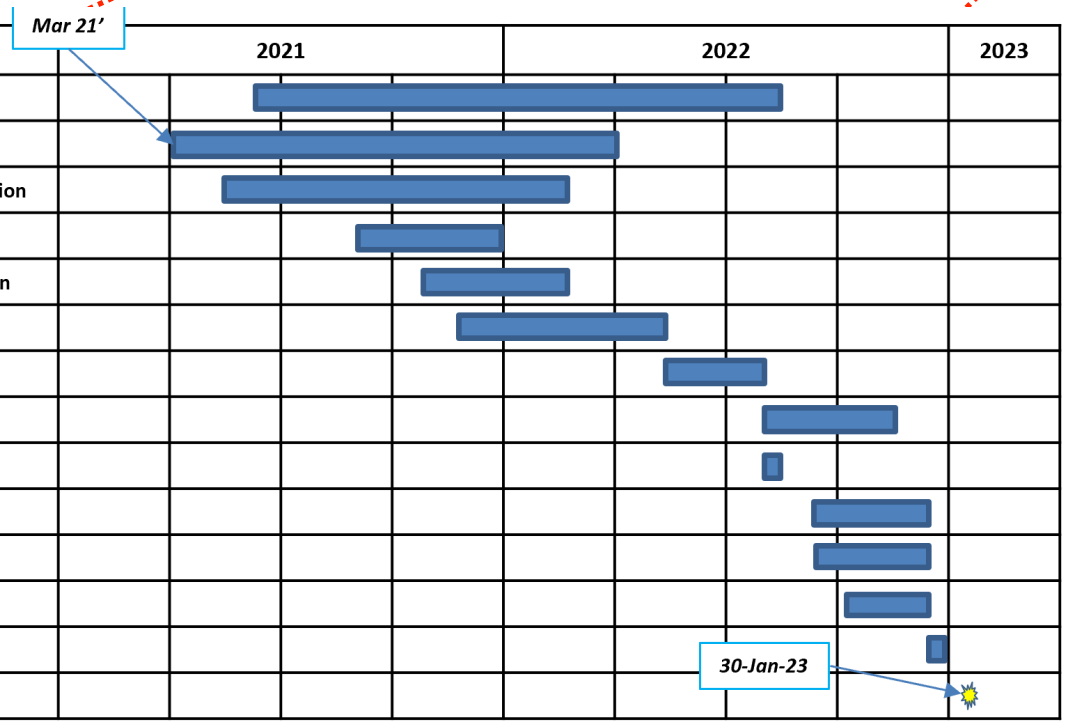
DOE CD-1/3A
Cost, schedule, advance purchase approval

BNL PD-2/3
Final project design approval, authorization to execute

Installation and commissioning

Start physics data taking

Installed Component	Scope of installation
Infrastructure	Safety, Cryo, Line Electric, Gas and cooling, other services
Cradle-Carriage	Base → OHCAL and Magnet → Structure → Pole Tips
Outer HCAL	13 Sectors → Magnet → 19 Sectors → Cables → Commission
Magnet	Install and align → prep cryo and electric
Inner HCAL	Assemble barrel → Insert and align → cable → Commission
EMCAL	Assemble in iHCAL bore → services → Commission
sPHENIX move to IR	Move into IR → connect magnet → field mapping
TPC	Install → Align → Services → Commission
Beam Pipe	Install, Support, Bake
INTT	Install → Align → Services → Commission
MVTX	Install → Align → Services → Commission
MBD	Install → Align → Services → Commission
Full System Commission	
Start of RHIC Run	



https://indico.bnl.gov/event/4788/attachments/19066/24594/sph-trg-000_06142018.pdf

sPHENIX run plan

https://indico.bnl.gov/event/4788/attachments/19066/24594/sph-trg-000_06142018.pdf

Year	Species	Energy [GeV]	Phys. Wks	Rec. Lum.	Samp. Lum.	Samp. Lum. All-Z
Year-1	Au+Au	200	16.0	7 nb^{-1}	8.7 nb^{-1}	34 nb^{-1}
Year-2	p+p	200	11.5	—	48 pb^{-1}	267 pb^{-1}
Year-2	p+Au	200	11.5	—	0.33 pb^{-1}	1.46 pb^{-1}
Year-3	Au+Au	200	23.5	14 nb^{-1}	26 nb^{-1}	88 nb^{-1}

Main Au+Au running mode: 15kHz min bias for $|z_{vtx}| < 10$cm

Ongoing discussions with BNL's Collider-Accelerator Dept. to optimize running conditions.

Year-1 (commissioning) + Year-2,3 (high statistics production): **145 billion** Au+Au collisions

cf. more than 20x STAR 2016 data set of 6.5 billion events (PAC 2017 presentation)

Consistent with BNL technically-driven timeline to an EIC

Year-4	p+p	200	23.5	—	149 pb^{-1}	783 pb^{-1}
Year-5	Au+Au	200	23.5	14 nb^{-1}	48 nb^{-1}	92 nb^{-1}

Collaboration sees strong science case for additional running

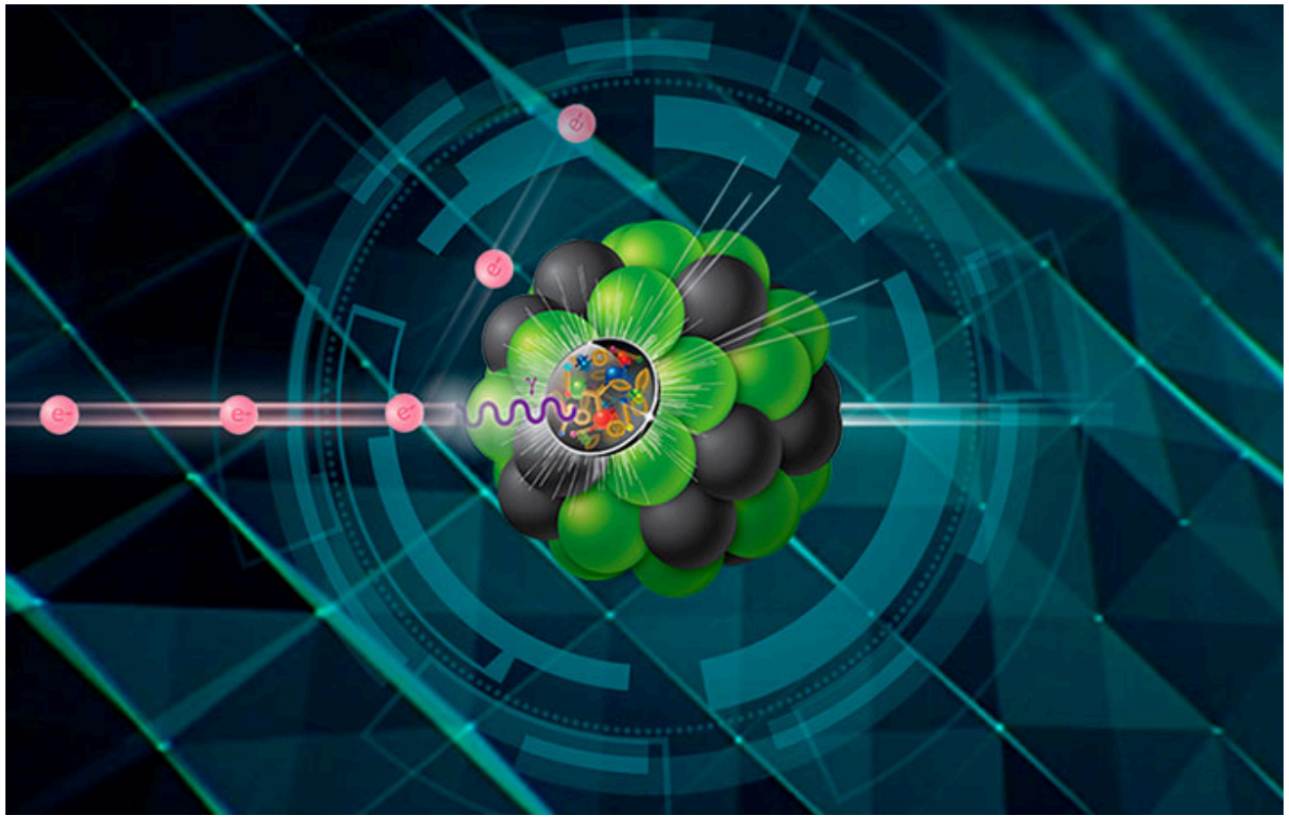
Improve uncertainties and respond to discoveries in first years

And in local news …

Department of Energy Selects Site for Electron-Ion Collider

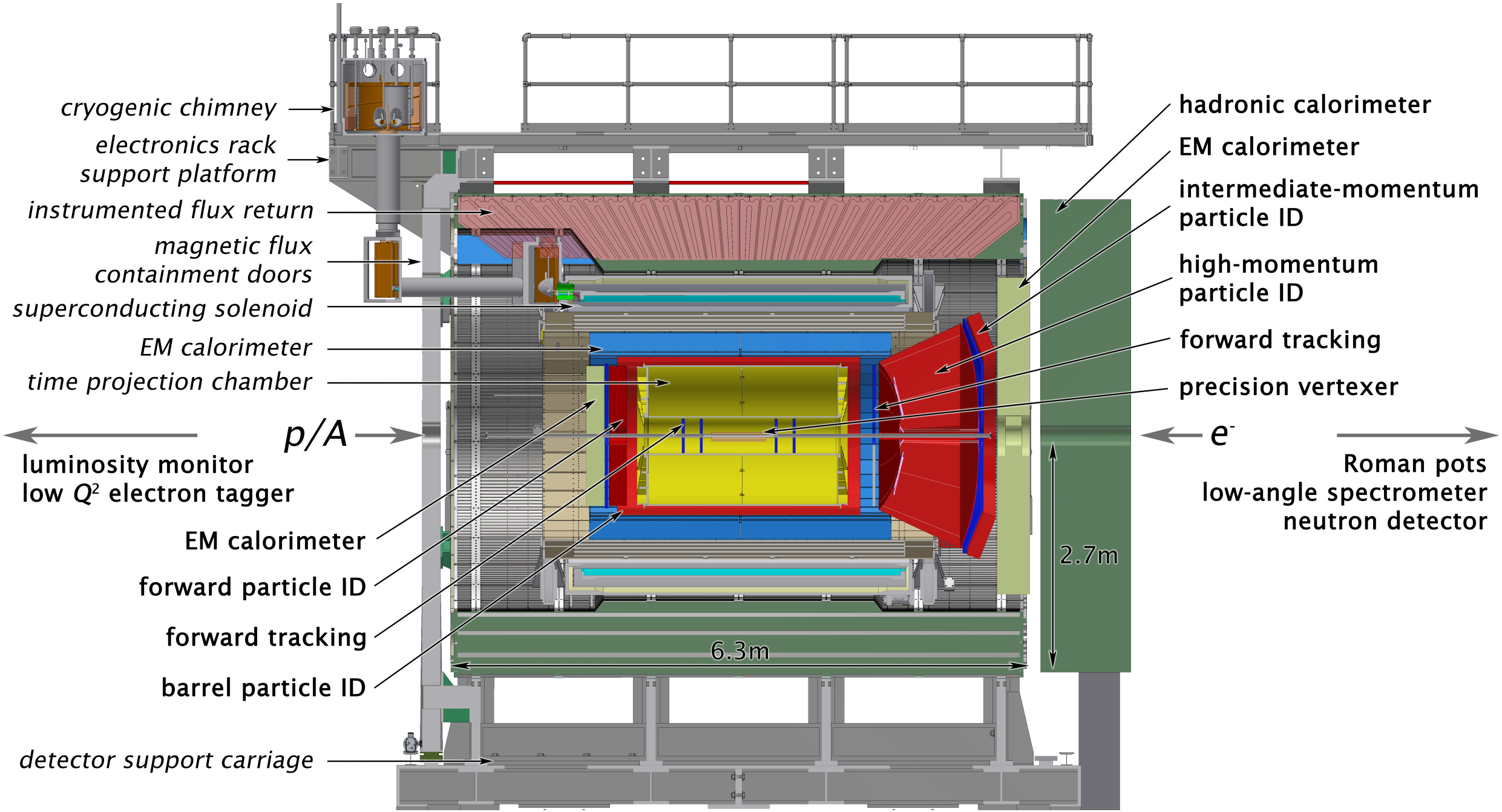
New facility to be located at Brookhaven Lab will allow scientists from across the nation and around the globe to peer inside protons and atomic nuclei to reveal secrets of the strongest force in nature

January 10, 2020



Electrons will collide with protons or larger atomic nuclei at the Electron-Ion Collider to produce dynamic 3-D snapshots of the building blocks of all visible matter.

- Last Thursday DOE announced CD-0 approval for EIC and selection of BNL as site
- Elements of plan presented by BNL to DOE
  - sPHENIX runs 2023–2025
  - sPHENIX as basis for an EIC detector
  - Start of physics program 2029/2030
- DOE determined cost range for accelerator and one detector: $1.6–2.6 billion


cryogenic chimney
electronics rack support platform
instrumented flux return
magnetic flux containment doors
superconducting solenoid
EM calorimeter
time projection chamber
p/A
luminosity monitor
low Q² electron tagger
EM calorimeter
forward particle ID
forward tracking
barrel particle ID
detector support carriage
hadronic calorimeter
EM calorimeter
intermediate-momentum particle ID
high-momentum particle ID
forward tracking
precision vertexer
e⁻
Roman pots
low-angle spectrometer
neutron detector
6.3m
2.7m

So … welcome!

Enjoy the week – I look forward to seeing the progress!

Friday morning will have a block of internal sPHENIX collaboration business, followed by a summary/wrap-up for the workfest for all.