Opportunities at LHC, RHIC, FAIR, and CSR

(Heavy ion collisions at $\sqrt{s_{NN}}$ = 5.5 - 0.0005 TeV)

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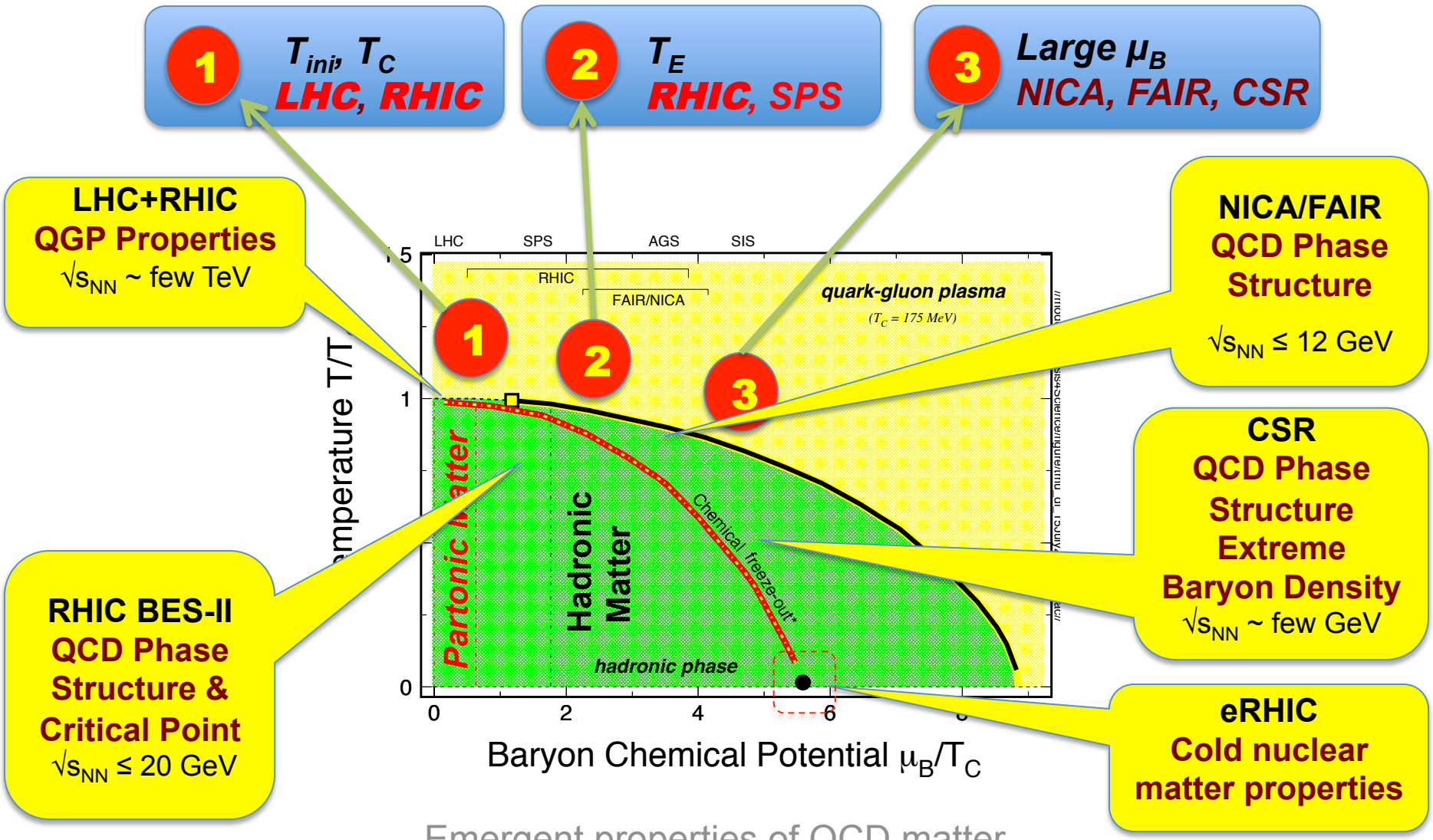
Exploring the QCD Phase Structure

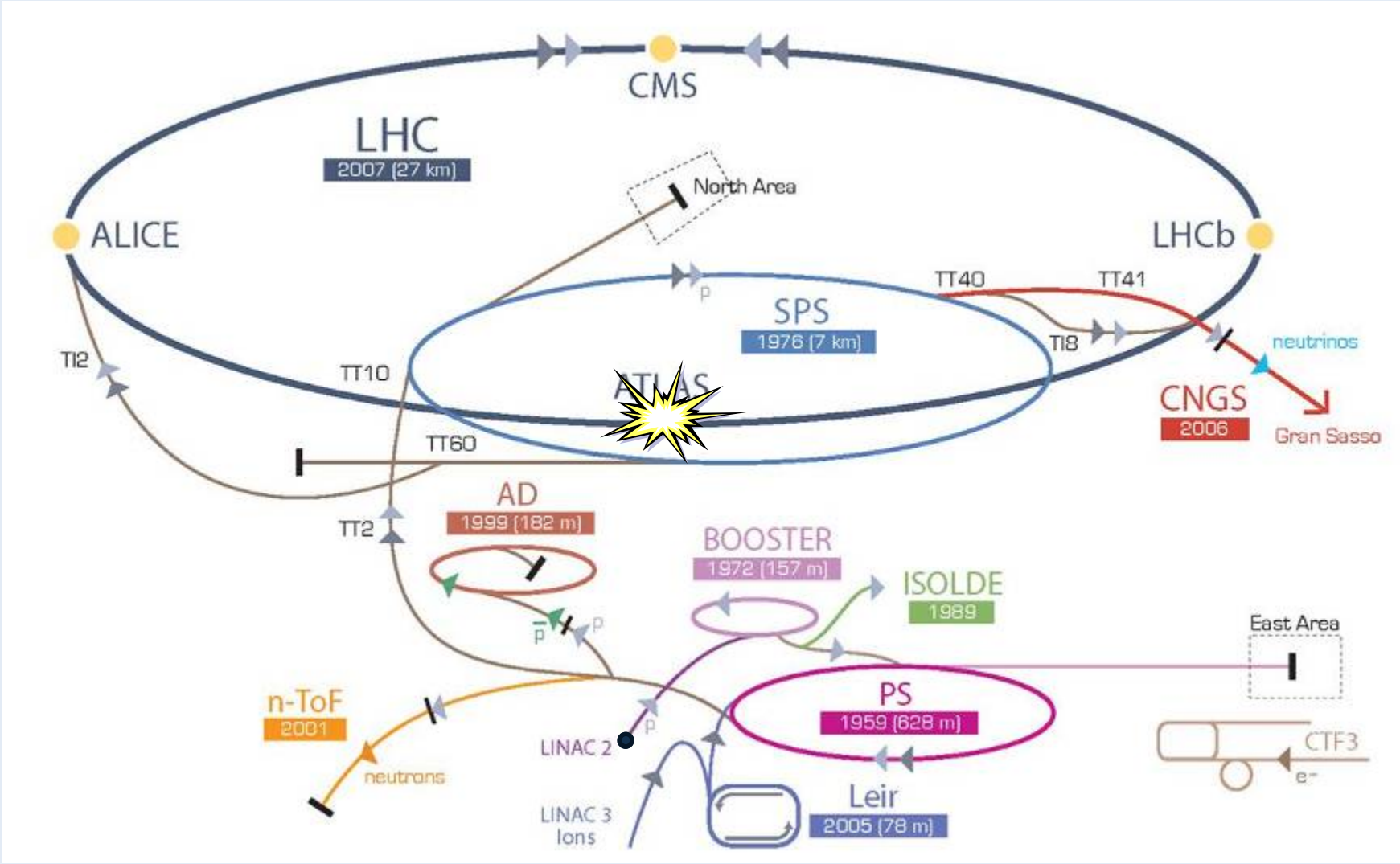


Emergent properties of QCD matter

LHC

($\sqrt{s_{NN}}$ ~ 0.9 – 5.5 TeV)

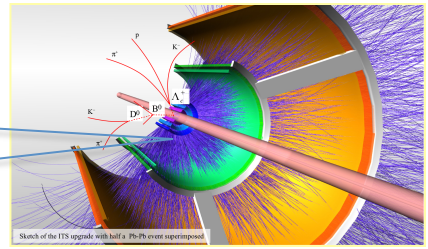
Large Hadron Collider



ALICE at LHC

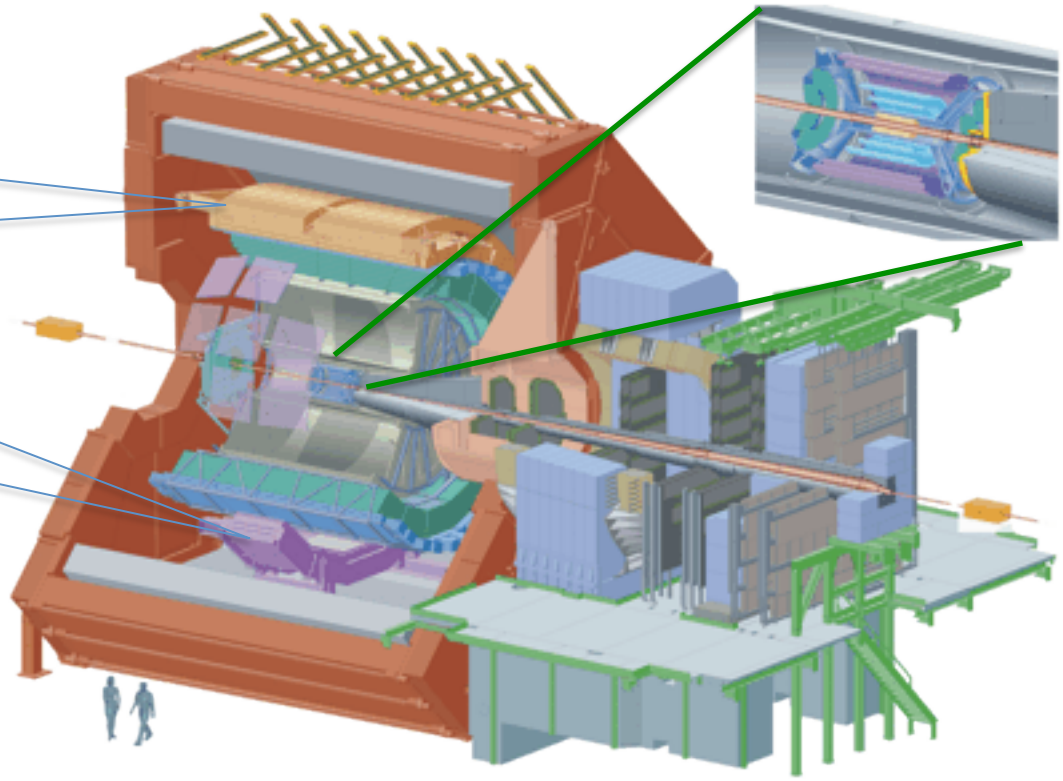
Chinese Contributions*
(Central China Normal University, China Institute Atomic Agency)

ITS Upgrade:
1) ~$20M (1M*)
2) Complete 2018



DCal:
1) $5M (0.78M*)
2) Complete 2013

PHOS FEE:
1) $17M (1.5M*)
2) Completed 2013



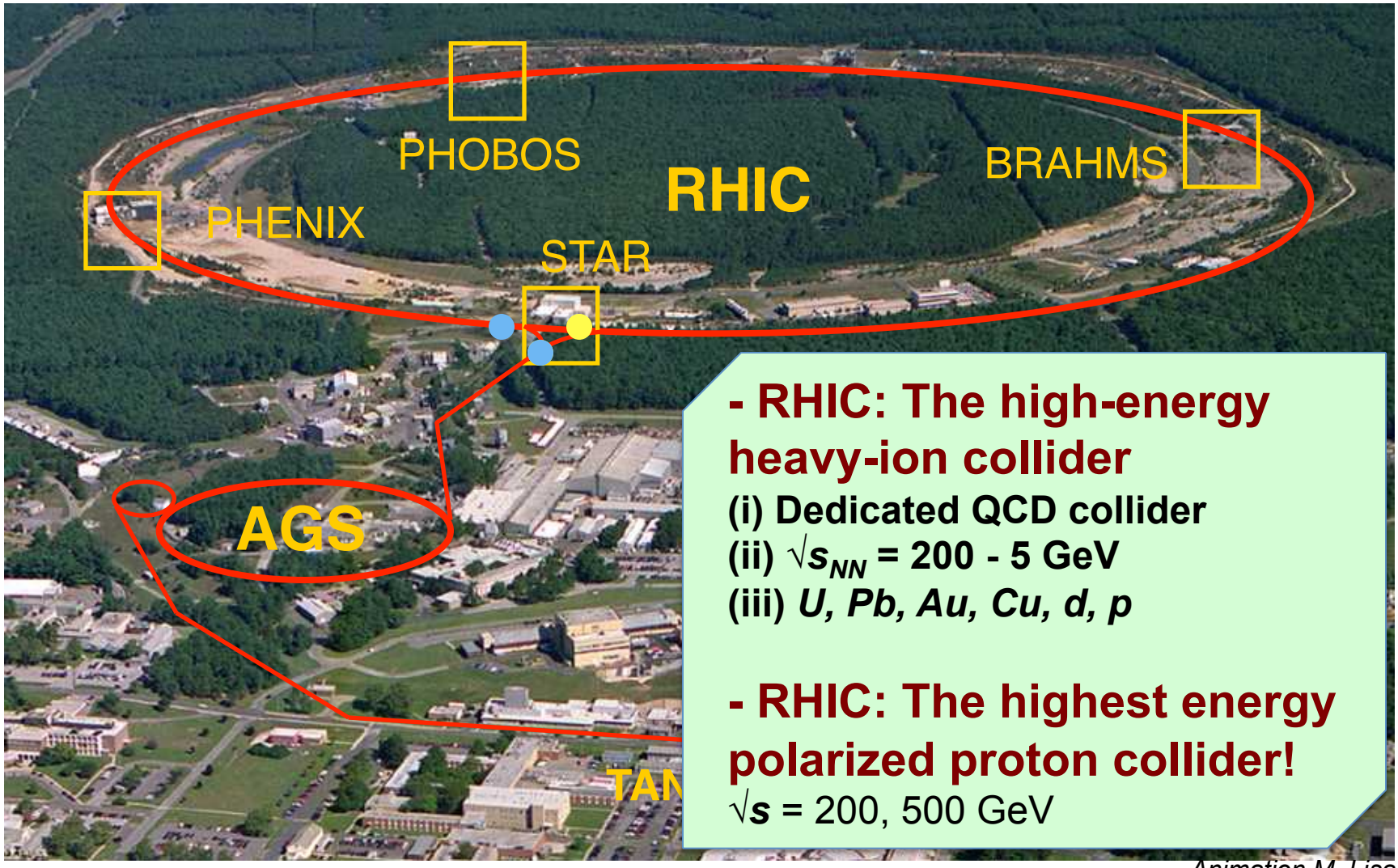
Key Physics:
QGP properties at
$\mu_B \sim 0$ region.

RHIC

($\sqrt{s_{NN}}$ ~ 5 - 200 GeV)

Relativistic Heavy Ion Collider

Brookhaven National Laboratory (BNL), Upton, NY



- RHIC: The high-energy heavy-ion collider

(i) Dedicated QCD collider

(ii) $\sqrt{s_{NN}}$ = 200 - 5 GeV

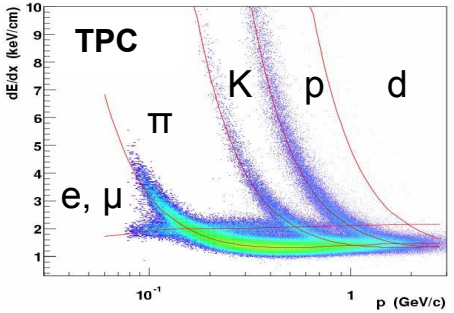
(iii) *U, Pb, Au, Cu, d, p*

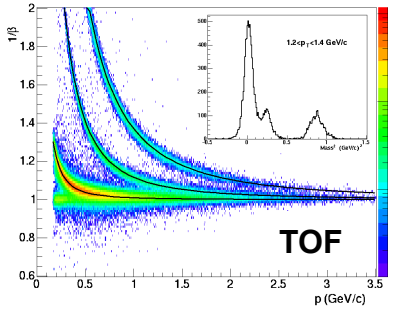
- RHIC: The highest energy polarized proton collider!

$\sqrt{s}$ = 200, 500 GeV

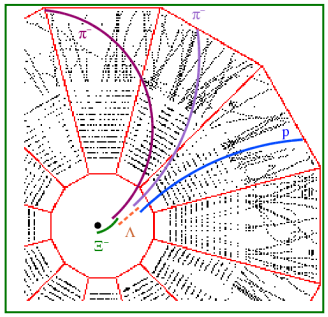
Animation M. Lisa

Particle Identification at STAR

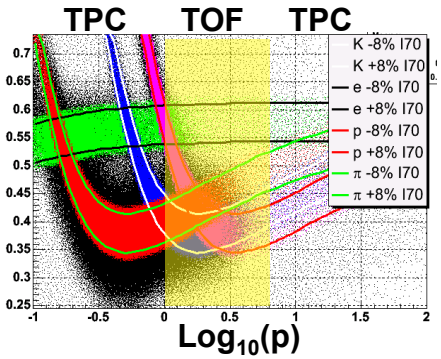


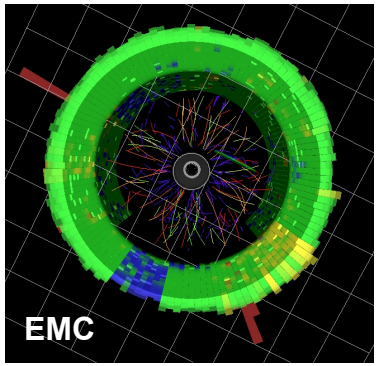


Charged hadrons

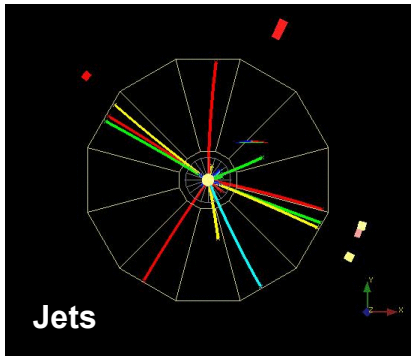


Hyperons & Hyper-nuclei

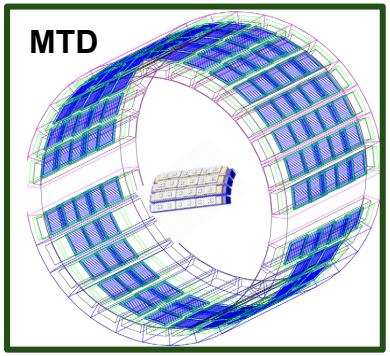




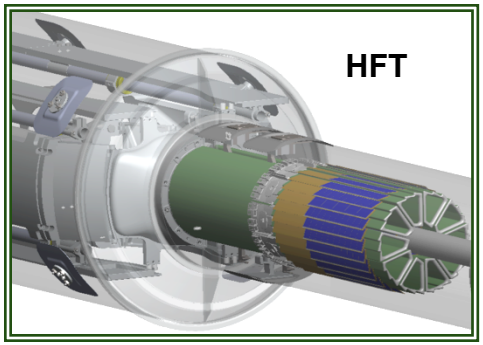
Neutral particles



Jets & Correlations



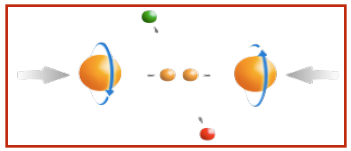
High p_T muons

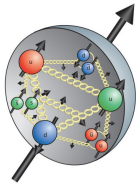


Heavy-flavor hadrons

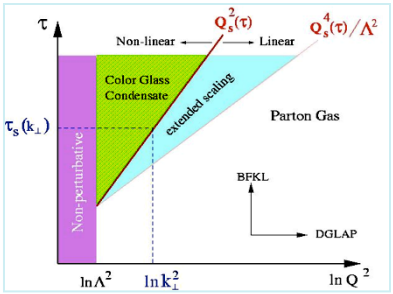
Key Physics:
- HFT & MTD completion in 2014.
- Heavy flavor, Quarkonium, and di-lepton measurements.

STAR Physics Focus



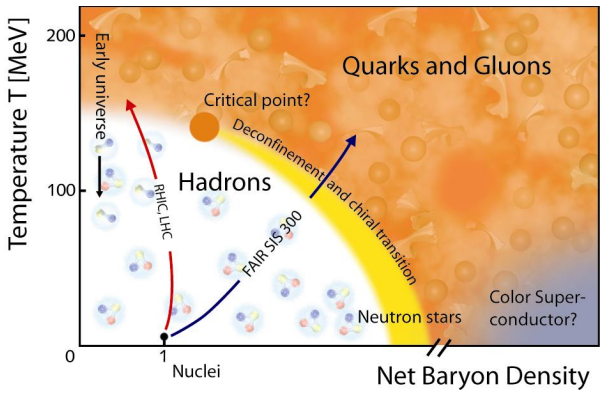


Polarized *p+p* Program
- ***proton intrinsic properties***



Small-x Physics Program
- Low-x properties, initial condition, ***CGC***
- Elastic and inelastic processes in pp2pp

STAR ***Decadal Plan*** *+ 2020 -* **eRHIC** (eSTAR)



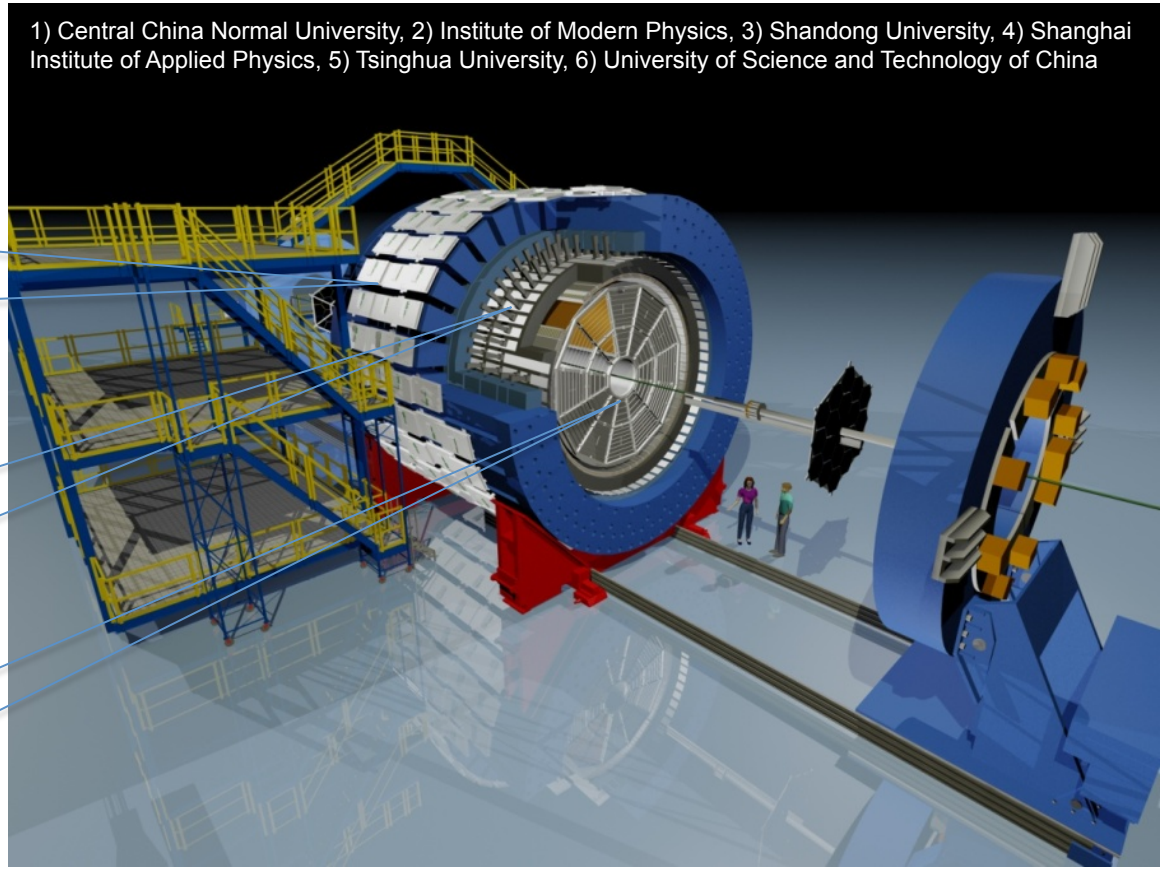
1) At 200 GeV at RHIC
- ***Deconfinement**** & *medium properties, EoS*
- pQCD in hot and dense medium

2) RHIC Beam Energy Scan (BES-I)
- ***QCD phase structure**:* phase boundary & critical point
- ***Chiral symmetry restoration****

* Holy Grail for the physics of high-energy nuclear collisions

Chinese Contributions to RHIC

1) Central China Normal University, 2) Institute of Modern Physics, 3) Shandong University, 4) Shanghai Institute of Applied Physics, 5) Tsinghua University, 6) University of Science and Technology of China



Barrel MRPC MTD:
1) $2.8M (0.8*)
2) 2014

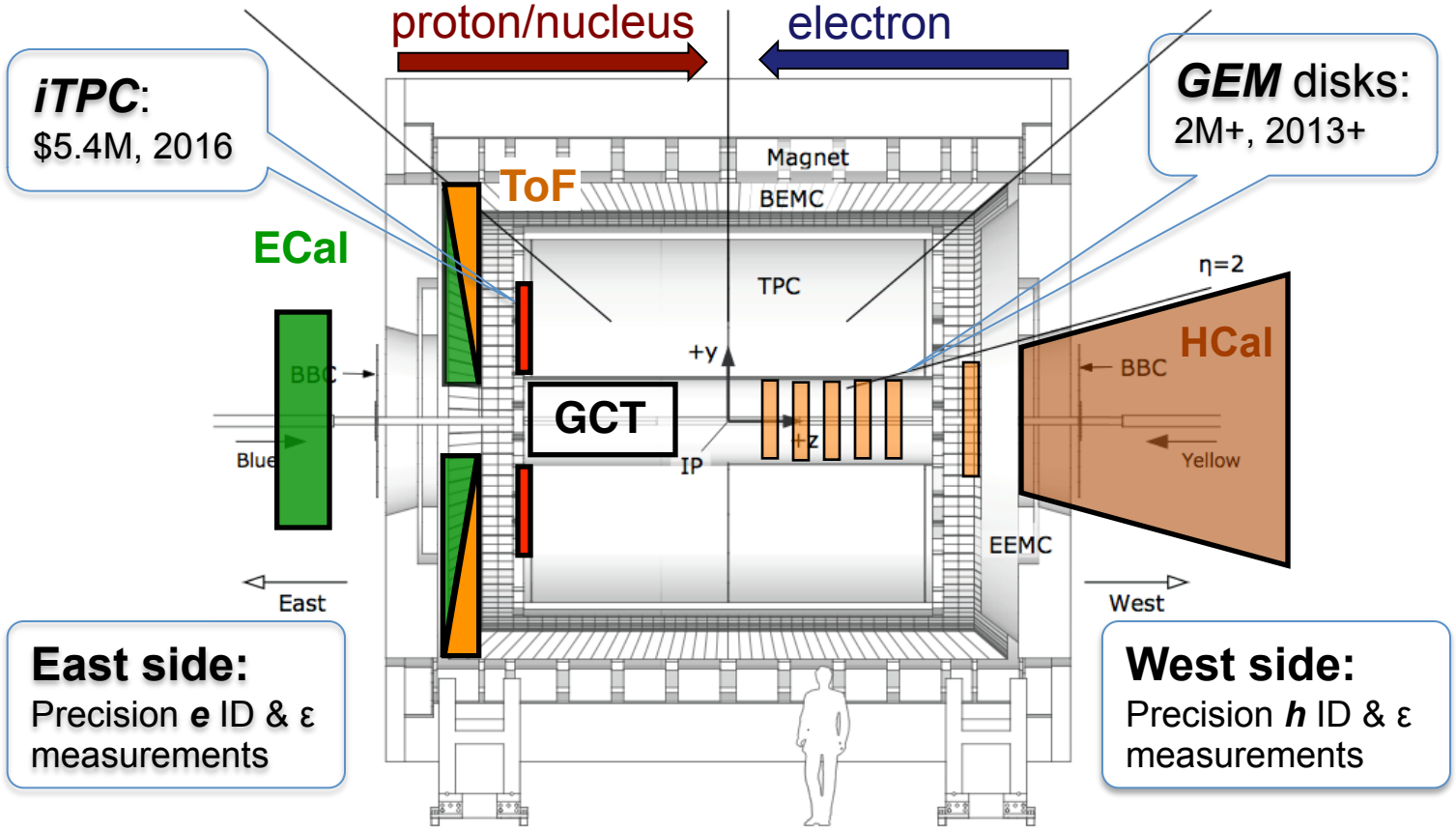
Barrel MRPC TOF:
1) $4.3M (2.3*)
2) Completed 2010

Si-Pixel HFT:
1) $16.5M (1.5*)
2) 2014

HLT: ~ $4M (0.5*)

1) Detector operation
2) Data calibration, analysis, publications
3) PWG co-conveners
4) Future upgrades and eRHIC

STAR Future Upgrades



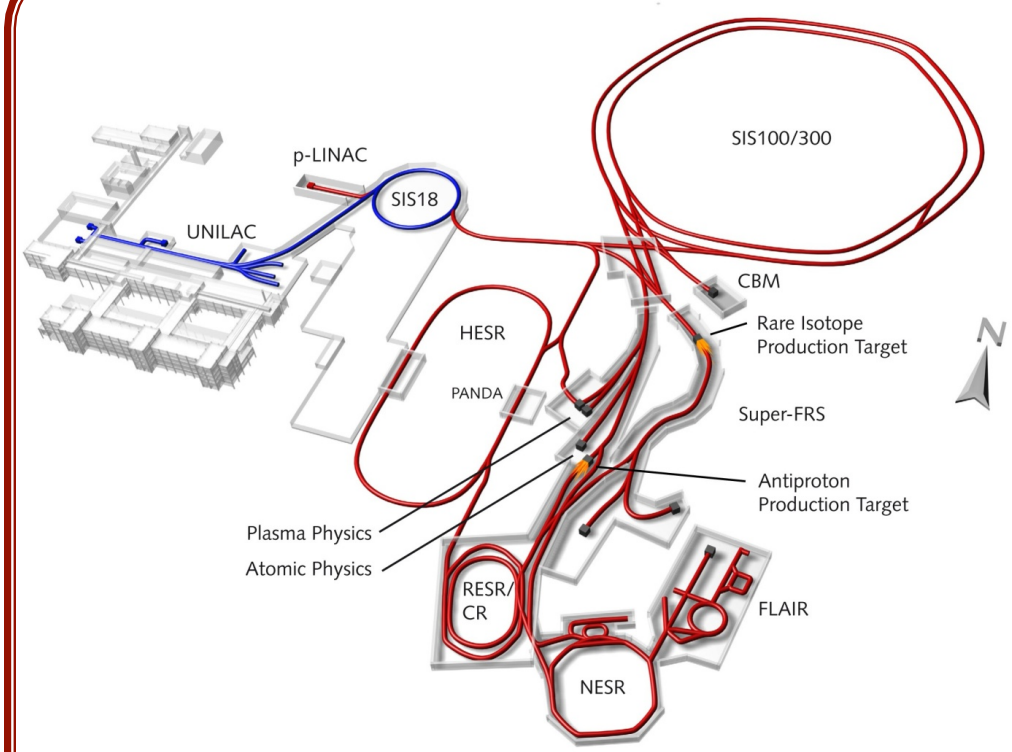
Key Physics (2015-2020):

1) Small-x cold nuclear matter properties in ep, eA, pA collisionsat eSTAR
2) Beam Energy Scan phase II measurements

FAIR

($\sqrt{s_{NN}}$ ~ 2.5 - 12 GeV)

Facility for Antiproton and Ion Research (FAIR)



Primary Beams

- 5x10^{11}/s; 1.5-2 GeV/u; $^{238}U^{28+}$
- factor of 10^{2-4} increased intensity
- 4x10^{13}/s 90 GeV protons
- 10^{10}/s ^{238}U 35 GeV/u (Ni 45 GeV/u)

Secondary Beams

- rare isotopes 1.5 - 2 GeV/u
- factor of 10^4 increased intensity
- antiprotons 3 - 30 GeV

Storage and Cooler Rings

- beams of rare isotopes
- e – A Collider
- 10^{11} stored and cooled antiprotons
  0.8 - 14.5 GeV

Advanced Accelerator Technology

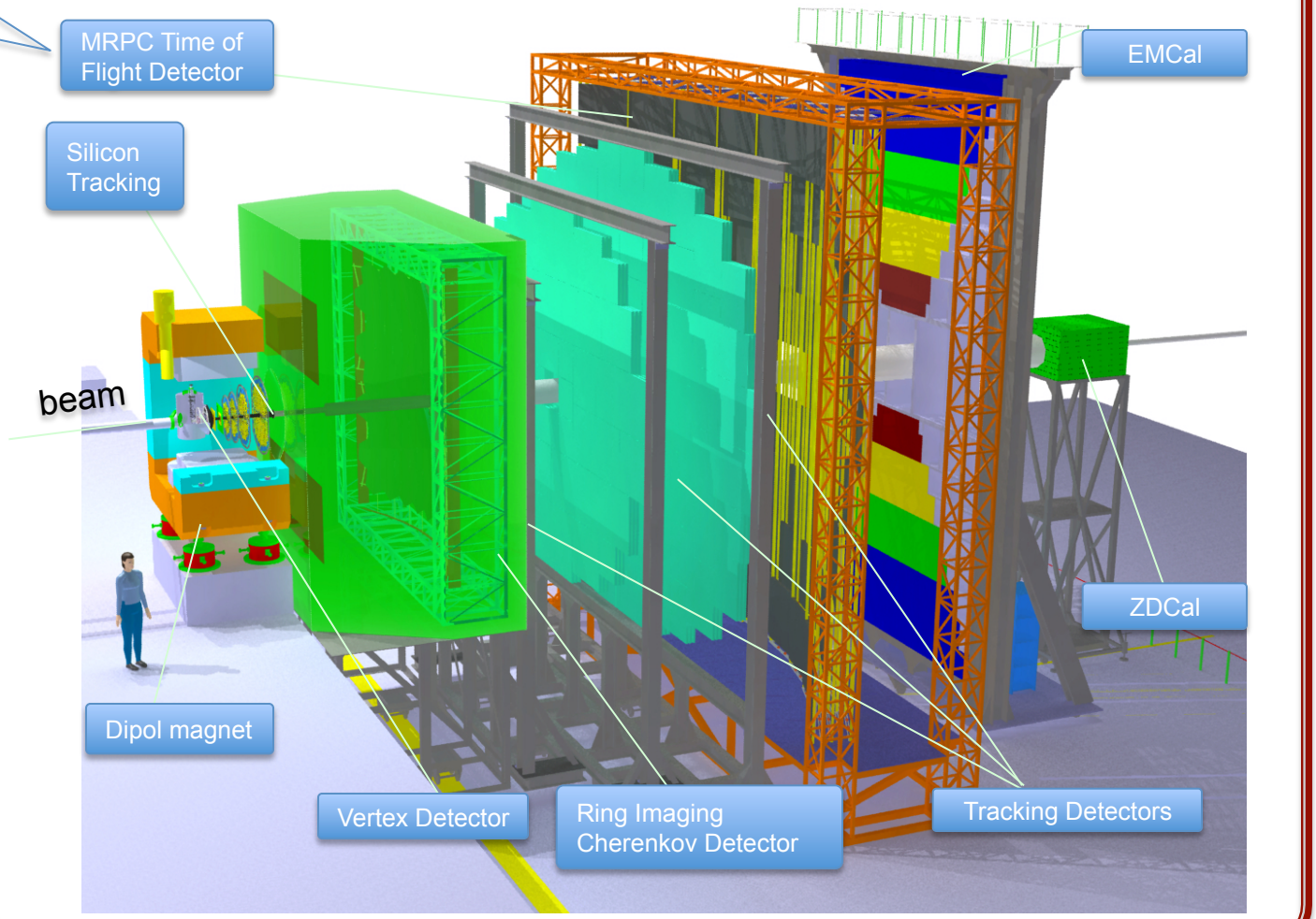
- Rapidly cycling superconducting magnets
- High energy electron cooling
- Dynamical vacuum, beam losses

The **C**ompressed **B**aryonic **M**atter Experiment (**CBM**)

MRPC TOF:
1) €7.5M (3*)
2) 2018

Key Physics:
- QCD phase structure at high baryon density
- 1st order phase transition
- Quarkyonic matter

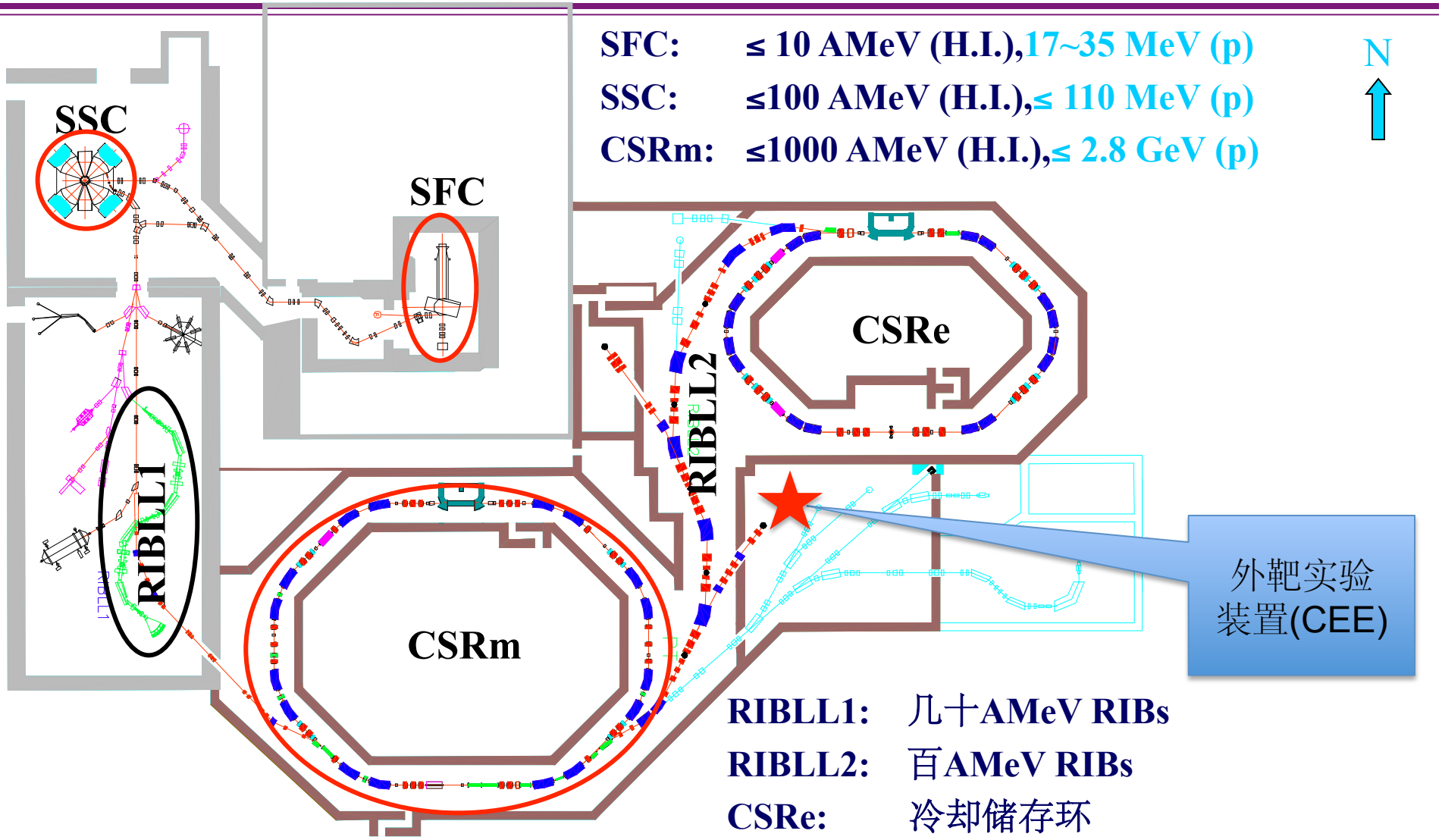
1) Central China Normal University, 2) Tsinghua University, 3) University of Science and Technology of China
* Planned Chinese contributions



CSR

($\sqrt{s_{NN}}$ ~ 0.5 - 1 GeV)

HIRFL-CSR 重离子束流



SFC: ≤ 10 AMeV (H.I.),17~35 MeV (p)

SSC: ≤100 AMeV (H.I.),≤ 110 MeV (p)

CSRm: ≤1000 AMeV (H.I.),≤ 2.8 GeV (p)

N

RIBLL1: 几十AMeV RIBs

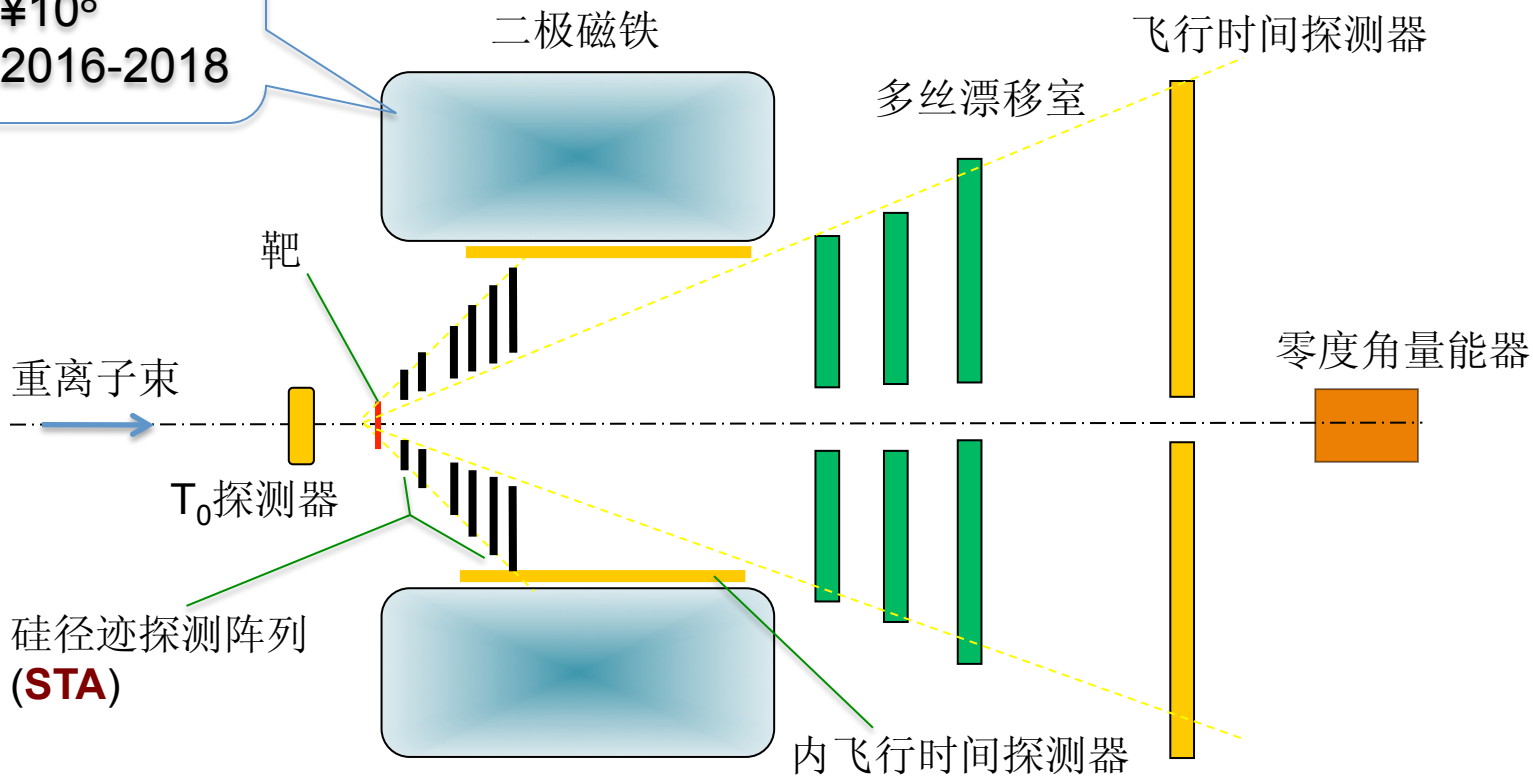
RIBLL2: 百AMeV RIBs

CSRe: 冷却储存环

CEE 概念性设计

低温高密核物质测量谱仪（CEE）

CEE:
1) ¥10^8
2) 2016-2018

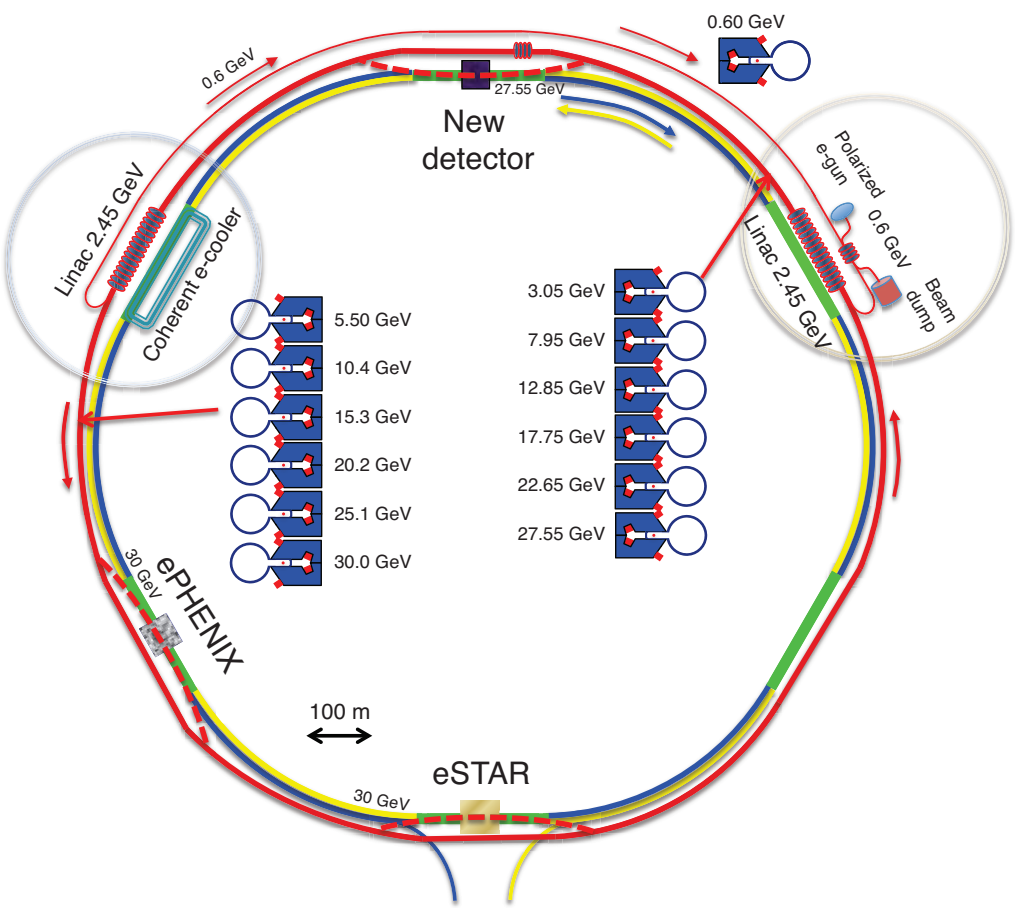


Key Physics (2016-2018):
1) Properties of baryonic matter at extremely high baryon density
2) Training next generation nuclear scientists

eRHIC

(2020 – 2025)

RHIC Version: eRHIC



1) Reuses RHIC tunnel & detector halls ⇒ minimal civil constructions
2) Reuses significant fractions of STAR/PHENIX detectors
3) Exploits existing HI beams for precocious access to very high gluon density regime
4) Polarized p and HI beam capabilities already exist (RHIC replacement cost ~$2B)
5) Design allows staging approach, start with 5-10 GeV and upgrade to ~20 GeV polarized e^- beam

➢ Add an electron ring, reuse RHIC ➔ eRHIC

Study emergent properties of matter with QCD degrees of freedom