

# BNL-CZ research infrastructure

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Czech Technical University in Prague

on behalf of CTU, NPI and CU groups

October 17, 2022

Day with particle and astroparticle research infrastructures

# BNL-CZ mission

Provide access and support of participation of Czech research and education institutions to one of the world's most prominent research facility, Brookhaven National Laboratory.

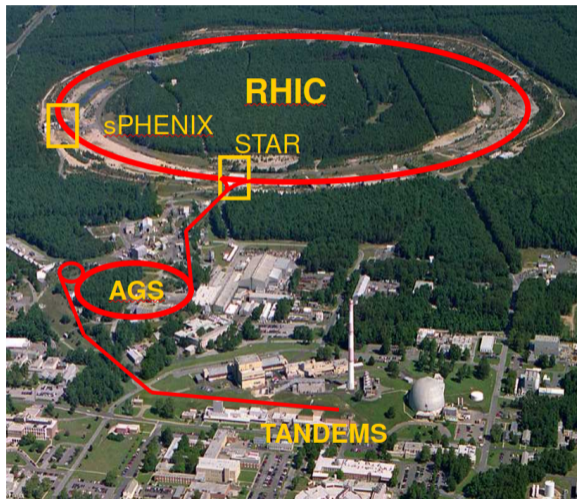
- Active areas of contribution from CTU, NPI and CU:
- STAR
  - ▶ Jana Bielčíková: STAR Council Chair 2021 – 2024
  - ▶ Continuous leadership in physics working groups (heavy flavor, jets, UPC)
  - ▶ Physics topics studied: open heavy flavor, quarkonia, jet properties, electromagnetic processes
  - ▶ Expertise in slow controls
  - ▶ Operation of the experiment, ZDC on-site experts
- PHENIX / sPHENIX
  - ▶ Development of tracking detectors
  - ▶ Proton spin physics
- EIC project
  - ▶ Silicon trackers, calorimetry
  - ▶ Low- $Q^2$  electron tagging
  - ▶ Luminosity monitor

# BNL-CZ team

- Team from CTU and NPI:
- Staff: J. Adam, J. Bielčíková, J. Bielčík, P. Chaloupka, M. Šumbera, B. Trzeciak
- Postdocs: L. Kosarzewski, O. Mezhenska
- Ph.D. students: J. Češka, A. Das, L. Holub, L. Kramárik, R. Líčeník, O. Lomický, S. Pal, V. Prozorova, M. Robotková, T. Truhlář
- 9 undergraduate students
- In addition, most of the above people are in EIC team + K. Augsten, Z. Janoška, F. Křížek, M. Marčišovský, M. Myška, G. Neue, L. Tomášek
- Team from Charles University: Mir. Finger, Mich. Finger, A. Květoň, M. Slunečka

Names in red: leaders of STAR, sPHENIX and EIC group

# RHIC collider



RHIC is a versatile collider:

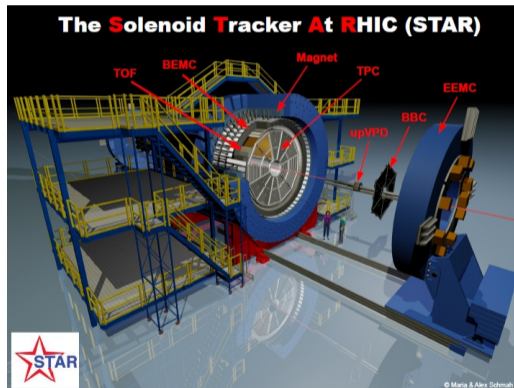
- Collision species: pp, p+A, A+A up to U+U
- Collision energy:  $\sqrt{s_{NN}} = 7\text{-}200$  GeV (p+p 500 GeV)
  - ▶ QCD phase diagram exploration
- Polarized p+p collisions
  - ▶ Proton spin physics
- RHIC operational since 2000
- 2023-25: last data taking with upgraded detectors and unprecedented statistics
- Experiment data preservation and availability afterwards



# Experiments at RHIC

## STAR

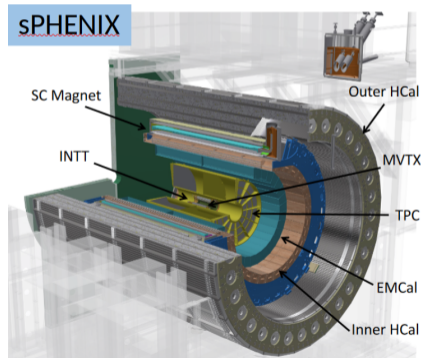
- Comprehensive midrapidity detector
- Recently upgraded with forward detectors



735 collaborators from 72 institutes and 15 countries

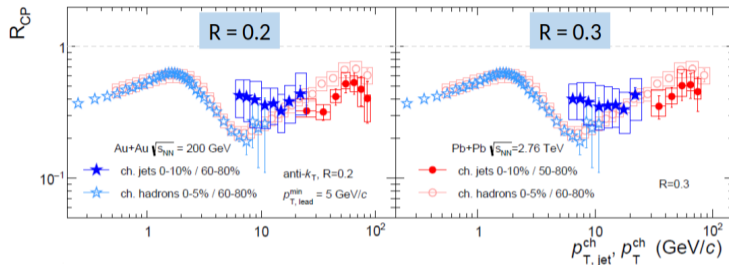
## sPHENIX

- New detector to become operational in 2023
- Full jet reconstruction, b-jet tagging, quarkonia



357 members from 82 institutions and 14 countries

# Contributions to key STAR results



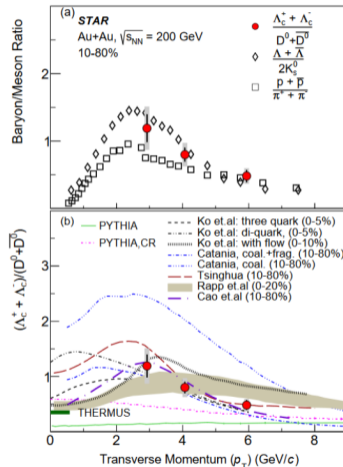
- Strong suppression of jet production in central Au+Au collisions at RHIC similar to that at the CERN LHC

STAR: PRC 102 (2020) 054913

- First measurement of  $\Lambda_c/D^0$  ratio in heavy-ion collisions
  - ▶ Parton recombination at play for heavy quarks observed as well

STAR: PRL 108 (2012) 072301

STAR: PRL 124 (2020) 17, 172301

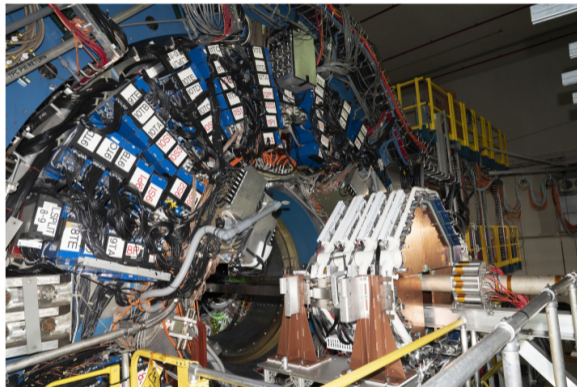


# Contribution to slow controls for STAR

- Forward upgrade, FST (silicon) and sTGC (gaseous) trackers + electromagnetic and hadron calorimeters
- Monitoring of sTGC HV
- Controls for FST power and cooling
- Pressure readout for sTGC gas system
- Development of inherently safe TOF HV shutdown

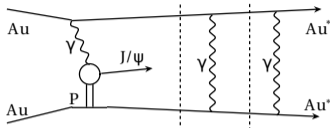


NIM A1013 (2021) 165644



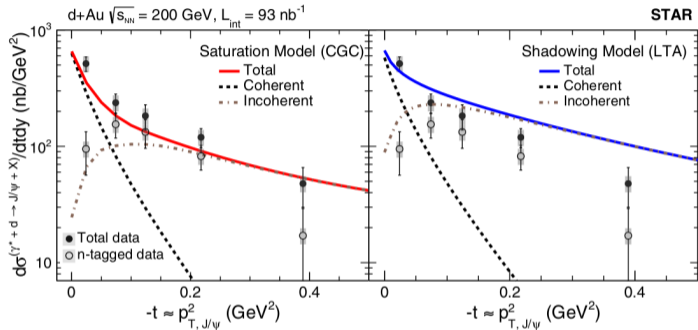
Forward tracking in STAR upgrade

# Contribution to electromagnetic physics at STAR



## Photonuclear interaction in AuAu beams

- Studies of photoproduction reactions on nuclei
- Proton-proton photoproduction interactions with use of Roman Pots
- Feasibility of dijet photoproduction
- Development and maintenance of a common analysis framework (upcDst)



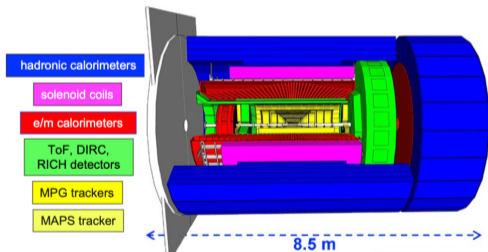
Coherent and incoherent  $J/\psi$  cross section in d+Au UPC



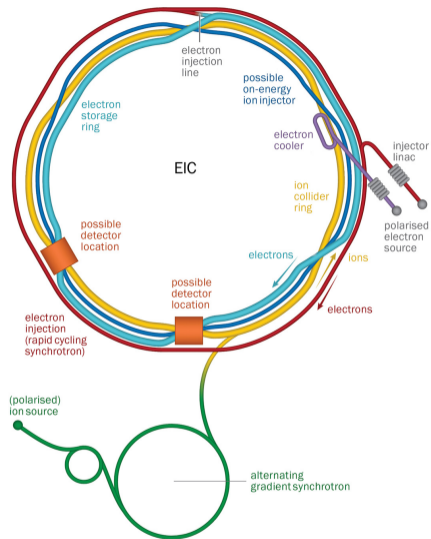
STAR: PRL 128 (2022) 12, 122303

# Electron Ion Collider (EIC)

- Polarized  $ep$  and  $e$ -ions up to  $18 \times 275$  GeV
- One of RHIC beams is re-used as hadron beam
- Physics of parton distributions, origin of proton spin and mass and jets in cold nuclear matter
- First data early 2030s



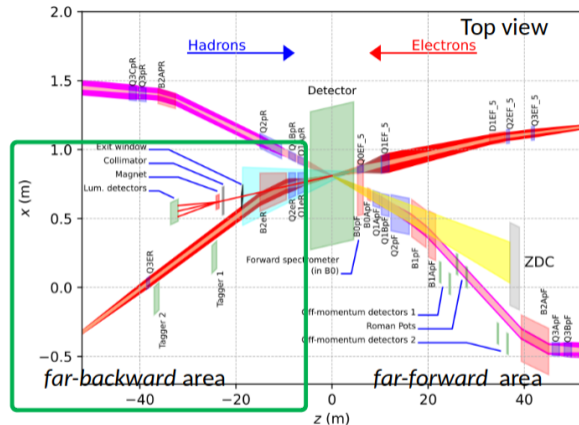
EPIC detector (at the location of STAR)



EIC users group: 1362 members  
from 267 institutions and 36 countries

# Active participation in EIC design

- Silicon CMOS vertex detectors, test for electronics radiation hardness
- Tests for MAPS + ASICs tracker sensors
- Testing and properties of the  $\text{PbWO}_4$  crystals (Crytur Turnov)
- Simulations for hadron calorimetry, geometry implementation, reconstruction
- Leadership in working group for far-backward instrumentation (luminosity monitor and low- $Q^2$  tagging)

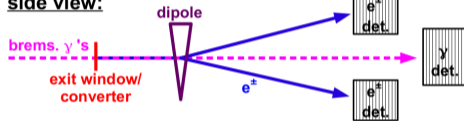


Interaction region for the EIC

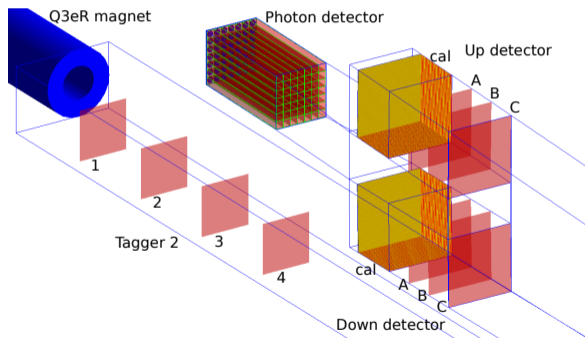
# Luminosity monitor for the EIC

Based on counting hard photons from elastic bremsstrahlung,  $ep \rightarrow e\gamma p$  or  $eAu \rightarrow e\gamma Au$ , because the cross section is precisely known from QED

**side view:**



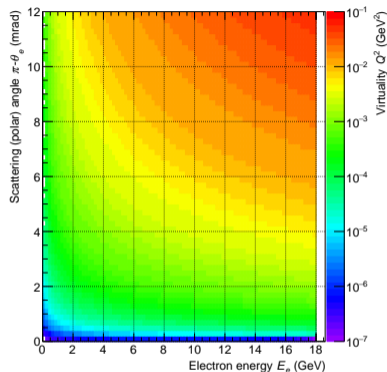
- Two methods for bremsstrahlung  $\gamma$  detection, direct  $\gamma$  det. and conversion  $e^\pm$  pairs
- Contribution to simulation geometry and light collection



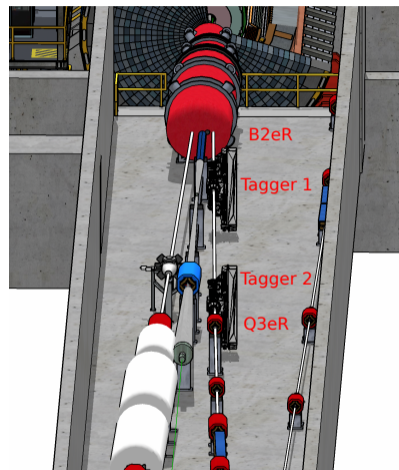
Detector section in Geant4

# Electron tagging at the EIC

- Tagger 1 and 2 detectors, 20 and 30 m from interaction point
- Complementary acceptance in virtuality  $Q^2$  (shown as color scale)
- Machine learning is applied to reconstruct original scattered electron
- Contribution in phenomenology, tracking and ML reconstruction



Virtuality (color scale) as a function of electron energy and scattering angle



Tagger detectors



# Outreach activities



- Big Bang Stage at Colors of Ostrava
- International MasterClasses
- Staň se na den vědkyní (related to the International day of women and girls in science)
- Částicová Praha (Week of particle physics at Prague)
- Dialogue art and science in the Archa theatre in Prague

# BACKUP

# Organization structure for BNL-CZ and its management

**Scientific Director**  
Jaroslav Bielik

**Administration assistant**  
Zdenka Cislerova

**Executive board**  
Petr Chaloupka CTU STAR  
Jana Bielikova NPI STAR  
Lukas Tomasik CTU sPhenix  
Miroslav Finger CU sPhenix

**Scientific board of BNL-CZ**  
Alberica Toia  
*(Goethe University in Frankfurt)*  
Pavel Cejnar  
*(Charles University)*  
Alexander Kupco  
*(Physics Institute of CAS)*  
Daniel Kikola  
*(WUT Warsaw)*  
Leticia Cunqueiro  
*(ORNL)*

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Miroslav Vrius

**sPhenix/EIC**  
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Miroslav Finger