

Exploring QCD with light nuclei at EIC

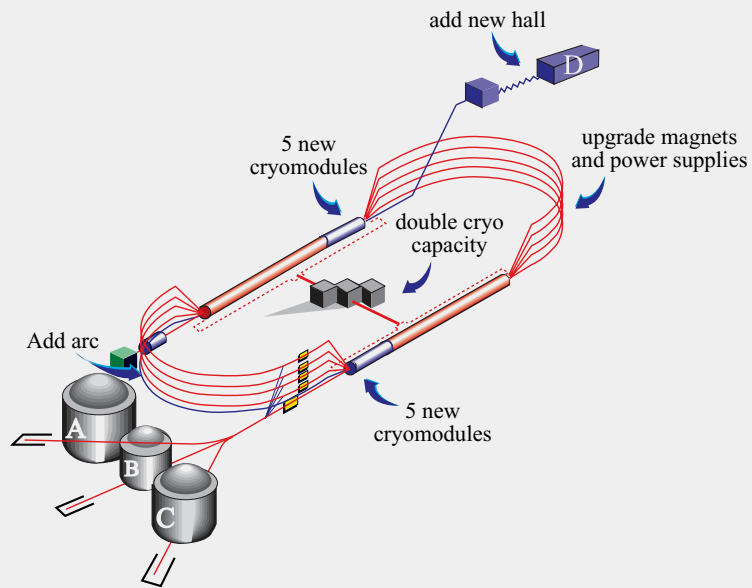
Topical Workshop, Center for Frontiers in Nuclear Science, Stony Brook University, Jan 21-24, 2020

A. Deshpande, R. Dupre, M. Patsyuk, M. Sargsian, M. Strikman, C. Weiss (Organizers)



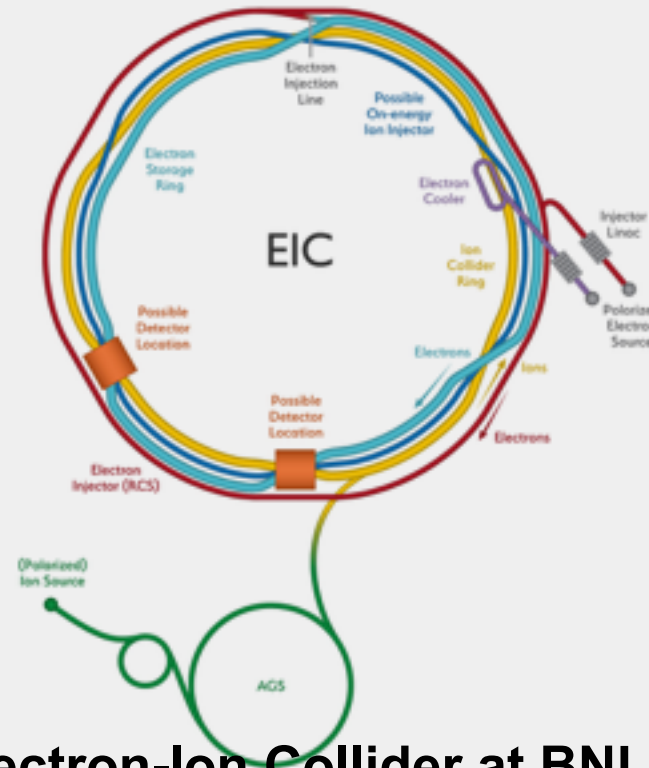
- **Welcome**
- **Context and objectives**
- **Plan of meeting**





JLab 12 GeV

- Operation since 2018
- First physics results
- Physics program ~10 years
- Proposed detector upgrades: Solid, Moller



Electron-Ion Collider at BNL

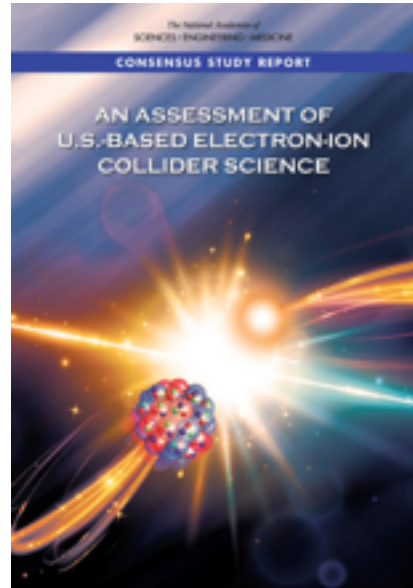
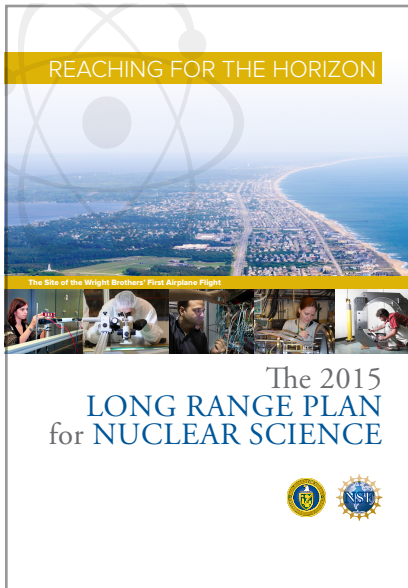
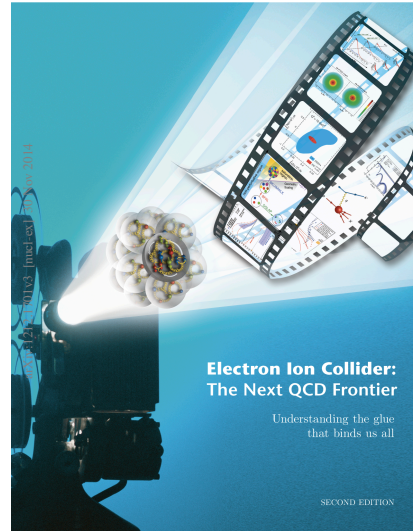
- Science and accelerator ideas developing since 1990s
- Recommended in 2015 NSAC Long-Range Plan
- CD0 and site selection announced Jan 2020

Other EM facilities

CERN COMPASS muon
MAMI, ELSA, SPRing-8
EIC in China

Hadronic probes

LHC pp/pA/AA/ γ A
RHIC pp/AA/ γ A
J-PARC
GSI FAIR
Dubna NIKA



• Three-dimensional hadron structure and spin

Sea quarks and gluon PDFs, nucleon spin decomposition;
 Spatial distributions GPDs, transverse motion TMDs, spin-orbit phenomena;
 chiral symmetry breaking and “origin of mass”; correlations and fluctuations

• QCD in nuclei

Nuclear modification of quark and gluon densities
 Short-range correlations, emergence of NN interactions from QCD
 Non-linear effects, gluon saturation at small x

• Emergence of hadrons from QCD

Quark/gluon fragmentation and hadronization; jet evolution and properties
 Interaction of color charge with matter

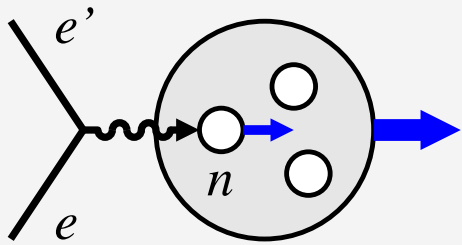
Science program still evolving!

EIC User Group conducting physics - detector studies

Measurements: ep — $eA(\text{light})$ — $eA(\text{heavy})$

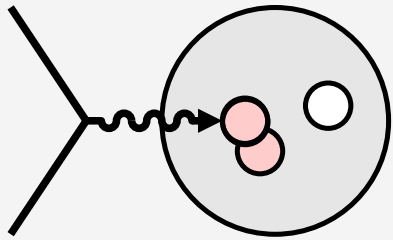
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This meeting!



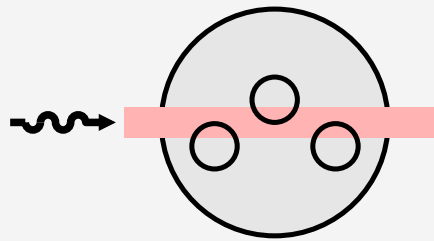
Neutron spin structure

- Flavor separation PDFs, GPDs, TMDs
- Singlet-nonsinglet QCD evolution, ΔG
- Energy-momentum tensor form factors
- Bjorken sum rule



Nucleon interactions

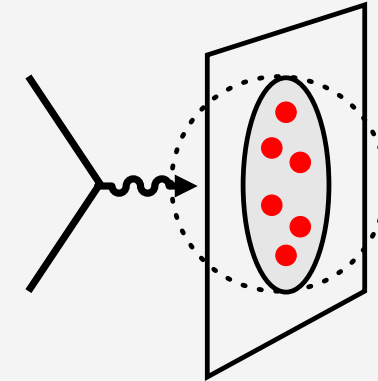
- Short-range NN correlations
- Origin of nuclear core
- Non-nucleonic DoF
- Connection with partonic structure, EMC



Coherent phenomena

- Nuclear shadowing
- Approach to saturation
- Diffraction, quantum fluctuations

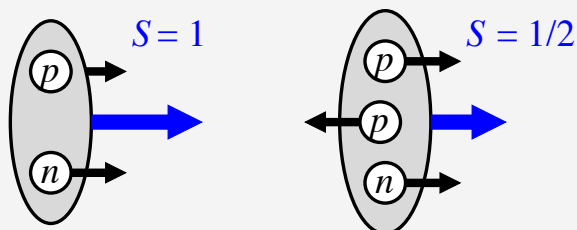
[Nuclear rest frame view]



Nuclear quark-gluon imaging

- Nuclear GPDs
- Spatial distributions of quarks/gluons
- Spin effects, deformation

- Many connections; same measurement can serve multiple purposes
- Complement information from ep, eA(heavy)

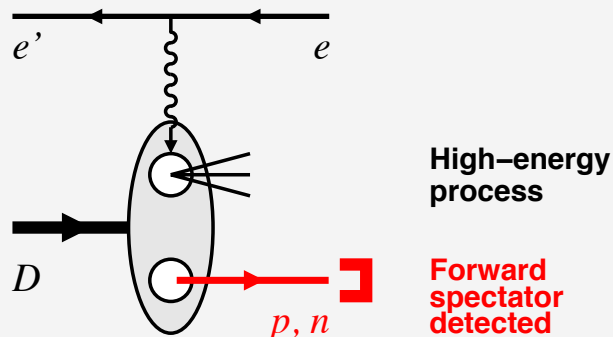


Polarized nuclear targets/beams

- Fixed-target: D, 3He
- EIC beams: D(?), 3He, $A>3$?
- Used for neutron spin structure, GPDs, spin-dependent EMC, tensor-polarized observables...

Nuclear structure from theory

- Nonrelativistic: EFT interactions with controlled accuracy and 3N forces, few-body bound states
- Light-front: Approximate methods
- Challenges: Non-nucleonic DoF, e.g. intrinsic Δ 's; final-state interactions in breakup



Nuclear breakup detection

- Fixed-target: Breakup detector near target: JLab BONuS, ALERT, TDIS
- EIC: Forward detectors integrated in beam optics and IR design
- Used for identifying active nucleon, controlling nuclear configuration in high-energy process

- Unique “set of tools”
- Methods specific to light nuclei: distinct field of research!
- Synergies with low-energy nuclear structure physics

Target fragmentation in DIS

QCD factorization and fracture functions, dynamics and spin dependence, nuclear breakup and FSI
Ceccopieri, Strikman, Keppel, Weiss

Neutron spin structure measurements

Polarized ^3He DIS/SIDIS, non-nucleonic DoF in nuclear spin structure, polarized deuteron and spectator tagging, neutron GPDs
Maxwell, Guzey, Cosyn, Scopetta, Biselli

Coherent processes with light nuclei

Heavy quarkonium production and DVCS on light nuclei, nuclear GPDs
Joosten, Scopetta

Small-x dynamics in light nuclei

Nuclear shadowing, diffraction, quantum fluctuations
Guzey, Schenke

Short-range correlations in light nuclei

Limit of nucleon degrees of freedom, nuclear core, contact formalism, universality, exclusive and inclusive measurements, 3N correlations
Sargsian, Boeglin, Piasetzky, Cruz Torres, Pybus, Denniston, Nguyen, Day

Nuclear interactions and partonic structure

EMC effect, SRC-EMC connection, QCD structure of SRCs, nuclear pions
Miller, Venugopalan, Arrington, Segarra

Tensor-polarized deuteron

Partonic structure, polarized target development, EIC studies
Kumano, Slifer, Long

Forward ion detection with EIC

Acceptance and resolution, IR and forward detector design
Nadel-Turonski, Hyde, Jentsch

Next steps in light-ion physics with EIC

Simulation tools, planning, collaboration
Schmookler, All

- The topics will be covered by presentations and group discussions
- We want to leave as much time as possible for discussion after the presentations:
 $40 = 30 + 10$ min, $30 = 23 + 7$ min
- Workshop dinner on Wednesday, Jan 22, 7-10 PM, at the Curry Club in East Setauket.
We thank the CFNS for hosting this event! [\[Announcement\]](#)
- On Thursday, Jan 23, 10-12 AM, the EIC User Group has its regular remote meeting.
We will provide a connection from the conference room, so that interested people can call in.