Target fragmentation physics with EIC

Online Workshop, Center for Frontiers in Nuclear Science CFNS, Stony Brook University, Sep 28-30, 2020

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

Jefferson Lab

Center for Frontiers in Nuclear Science

Nuclear physics with high-energy electromagnetic probes

JLab 12 GeV

- Operating since 2018, first physics results, program for ~10 years
- Extensive data on hadronic final states from large-acceptance detectors CLAS12, GlueX, high-resolution spectrometers, recoil/breakup detectors
- Proposed detector upgrades SOLID, Moller, …

COMPASS muon beam at CERN

- Hadron structure program continuing

Electron-Ion Collider at BNL

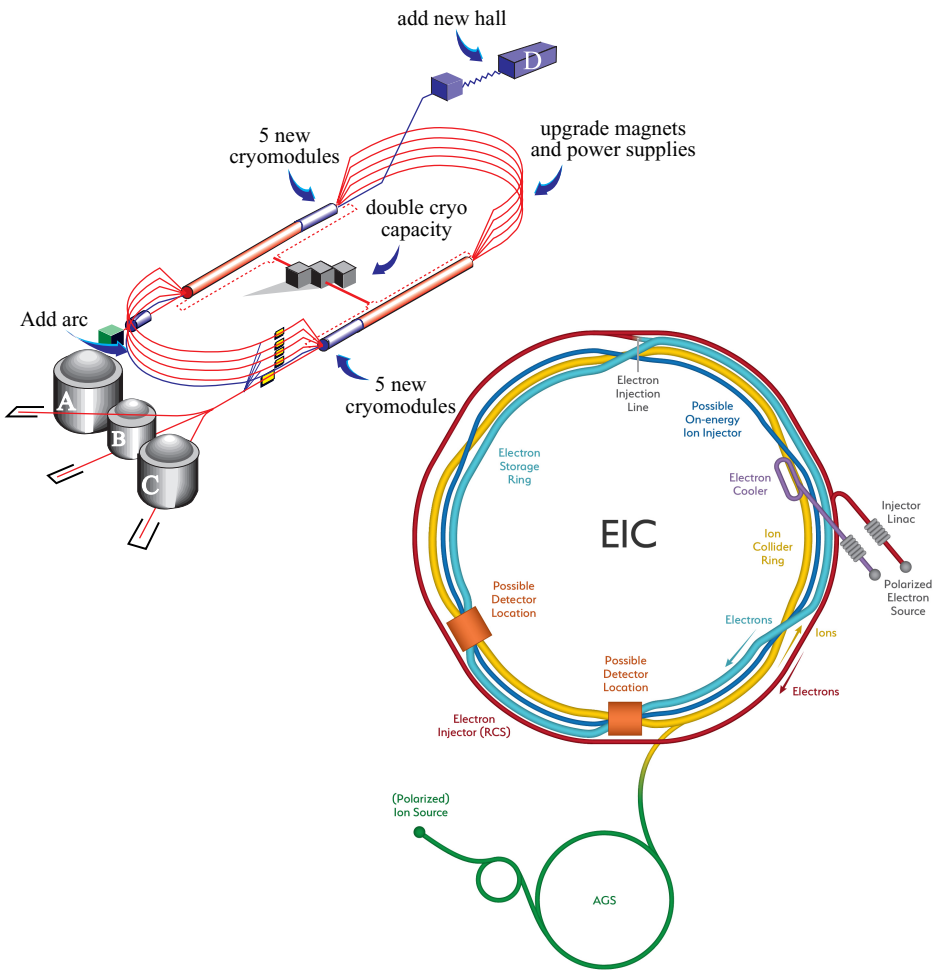
- DOE Project: CD0 2019, CD1 planned 2021-Q2; CD4 expected 2030
- Accelerator and IR/detector development advancing rapidly
- Vigorous community effort in physics and detector development: Yellow Reports
- Open to new physics ideas beyond approved program
- Forward detection of nucleons/ions/nuclear breakup

(HERA ep collider at DESY)

- Extensive results from 1992-2007 operations
- Archived data available for further physics analysis

Ultraperipheral pA/AA at LHC and RHIC

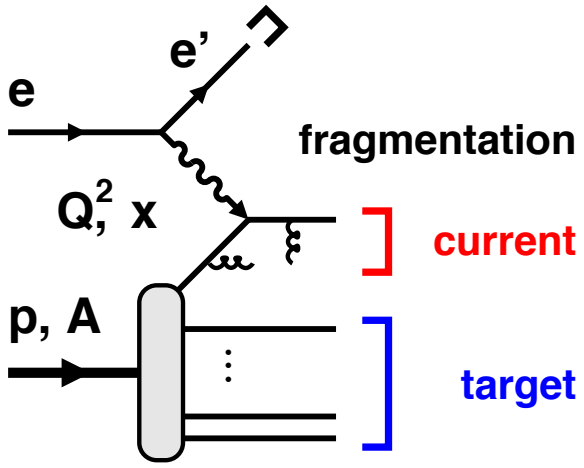
- Energy frontier in electromagnetic probes
- Synergies with ep/eA at EIC



Hadronic probes

LHC pp/pA/AA, RHIC pp/pA
GSI FAIR, J-PARC

Target fragmentation in high-energy processes



Target fragmentation

Fixed-target: Slow hadrons in target rest frame E << nu
Collider: Fragments close to beam rapidity

ep: Nucleon fragmentation
eA: Nuclear final-state interactions and breakup

Main characteristic: Interplay of high-energy process with low-energy structure of nucleon/nucleus

Physics largely unexplored, great potential!

Physics interest

- Dynamics of hadronization: Quantum number transport, diffraction, radiation, nonperturbative dynamics
- Structure of nucleon: Spin/flavor structure, parton correlations, transverse momentum
- Theory: QCD factorization of target fragmentation, conditional PDFs, evolution, connection with current fragmentation/TMDs
- Nuclei: Final-state interactions of fragments, nuclear breakup pattern, cascade models

Workshop: Objectives

- Review target fragmentation physics at fixed-target and collider energies
- Develop plan for target fragmentation measurements at EIC:
  Possibly input to Yellow Reports
- Initiate analysis of archived HERA data for pre-EIC studies
- Explore opportunities for target fragmentation studies with JLab12 data
- Stimulate theoretical research in target fragmentation and nuclear FSI

Workshop: Program

Monday 28 Sep: Target fragmentation in ep/γp colliders, HERA, UPCs, EIC

HERA final states, HERA database, forward protons/neutrons, QCD analysis, connection with diffraction, quantum number transport, target fragmentation in UPCs

W. Schmidke, A. Geiser, F. Ceccopieri, V. Guzey, M. Strikman, D. Tapia Takaki + Discussion

Tuesday 29 Sep: Target fragmentation in fixed-target eN, spin/flavor, correlations, theory, JLab12, EIC

QCD factorization, conditional PDFs, spin/flavor, transverse momentum, parton correlations, intrinsic strangeness, future EIC program

T. Rogers, A. Prokudin, C. Weiss, H. Avakian, P. Schweitzer, J-C. Peng + Discussion

Wednesday 30 Sep: Nuclear final-state interactions, nuclear breakup, fixed-target, EIC

Hadronization in nuclei, nuclear final-state interactions, nuclear breakup, cascade models, FLUKA, BeAGLE, EIC forward detectors

W. Chang, A. Jentsch, A. Ferrari, B. Guiot, U. Mosel, A. Larionov + Discussion

- We will have extensive discussions — after the presentations and in the discussion sessions. Everyone should participate. Speakers of the day should be available for questions. Please suggest topics/questions for discussion!
- We are coming together as researchers from different communities. Do not hesitate to ask basic questions or request explanations. Almost no one is an expert in “target fragmentation”…

Day 1: Target fragmentation at HERA, UPCs, EIC

	Introduction and plan of workshop	*Organizers*	09:30 - 09:50
10:00	HERA target fragmentation data review	*William Schmidke*	09:50 - 10:20
	HERA database introduction	*Achim Geiser*	10:20 - 10:40
	Discussion		10:40 - 11:00
11:00	Fracture function analysis of HERA data	*Federico Ceccopieri*	11:00 - 11:30
	Diffraction as a special case of target fragmentation	*Vadim Guzey*	11:30 - 12:00
12:00	Discussion: Simulation tools, collaboration, next steps		12:00 - 12:20
	Break		12:20 - 13:00
13:00	Open questions in nucleon fragmentation	*Mark Strikman*	13:00 - 13:30
	Nucleon fragmentation studies in ultraperipheral pA collisions	*Daniel Tapia Takaki*	13:30 - 14:00
14:00	Discussion: Simulation tools, collaboration, next steps		14:00 - 15:30
15:00			

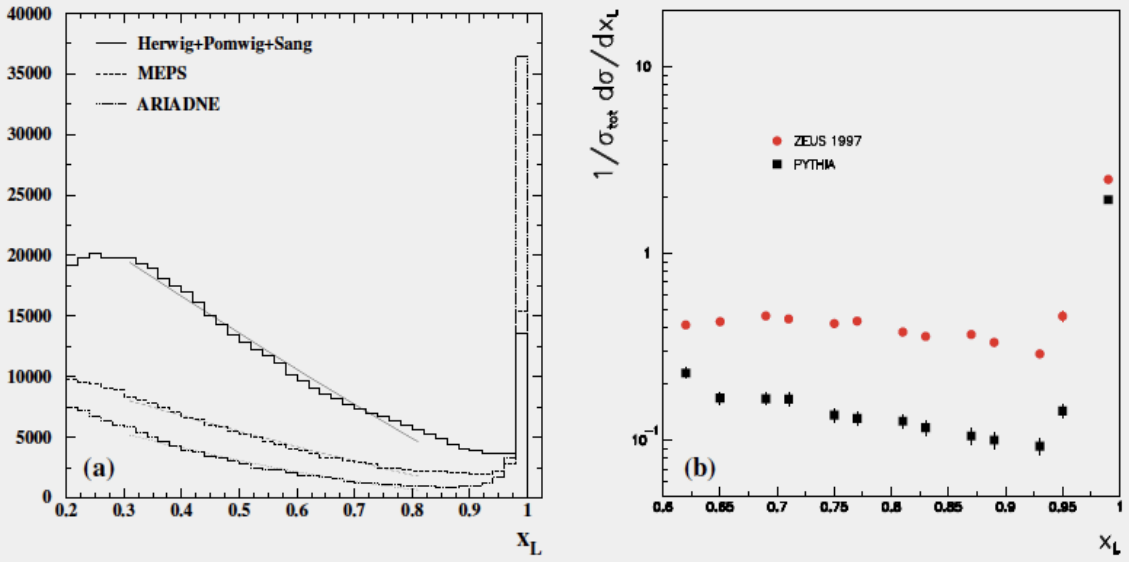


Fig. 2: (a) Differential cross section $d\sigma_{ep\to eX_p}/dx_L$ generated with LEPTO, with MEPS or ARIADNE, and with HERWIG+POMWIG+SANG Monte Carlos; (b) Comparison between the normalised differential cross section $1/\sigma_{tot}\ d\sigma_{pp\to X_p}/dx_L$ simulated with PYTHIA and $1/\sigma_{tot}\ d\sigma_{ep\to eX_p}/dx_L$ measured by the ZEUS Collaboration [9].

Old memories! "Leading proton production in ep and pp experiments: how well do high energy physics Monte Carlo generators reproduce the data," M. Ruspa et al., proceedings contribution to the HERA-LHC workshop 2004/2005

Day 1: Discussion

- Questions directly related to the presentations?
- Questions related to the concepts - fracture functions, factorization, ….
- What open questions in target fragmentation could/should be studied by analysis of archived HERA data
- What open questions in target fragmentation emerging from today's talks could/should be studied specifically with EIC

Tomorrow: Fixed-target, large-x, polarization, correlations