

Probing Nucleons and Nuclei in High Energy Collisions

INT 18-3 Program on EIC Physics

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Motivation/Recent History

EIC Program at the INT in 2010

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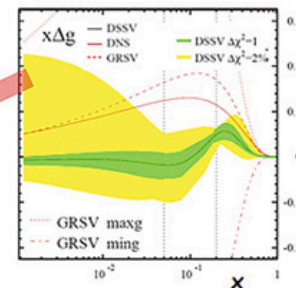
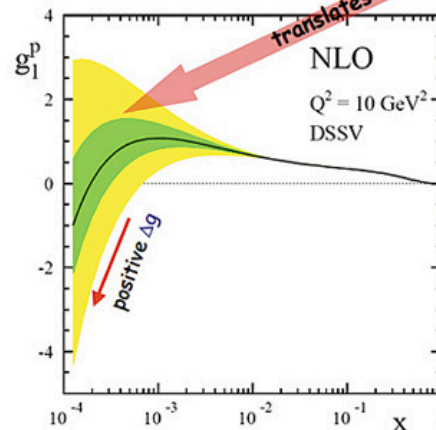
Gluons and the quark sea at high energies: distributions, polarization, tomography

September 13 to November 19, 2010

Report from the INT program "Gluons and the quark sea at high
energies:
distributions, polarization, tomography"

o small x uncertainty from DSSV

$$\frac{dg_1}{d \log(Q^2)} \propto -\Delta g(x, Q^2)$$



QCD theory progress:
NNLO kernels on the horizon
Vogt, Moch, Ragal, Vermaseren

important exercise to be done:
global QCD fit with projected
EIC data to quantify their impact

studies already under way

This INT program will address open questions about the dynamics of gluons and sea quarks in the nucleon and in nuclei. Answers to these questions are crucial for a deeper understanding of hadron and nuclear structure in QCD at high energies. Many of them are relevant for understanding QCD final states at the LHC, which often provide a background for physics beyond the standard model. The topics addressed in this program have important ramifications for understanding the matter produced in heavy-ion collisions at RHIC and the LHC.

Topics covered in 2010:

week	dates	topics
1	13–17 Sept	Workshop on "Perturbative and Non-Perturbative Aspects of QCD at Collider Energies" Agenda
2	20–24 Sept	open conceptual issues: factorization and universality, spin and flavor structure, distributions and correlations Agenda
3–5	27 Sept –15 Oct	small x, saturation, diffraction, nuclear effects; connections to p+A and A+A physics; fragmentation/hadronization in vacuum and in medium Agenda for week 3 Agenda for week 4 Agenda for week 5
6–7	18–29 Oct	parton densities (unpolarized and polarized), fragmentation functions, electroweak physics Agenda for week 6 Agenda for week 7
8–9	1–12 Nov	longitudinal and transverse nucleon structure; spin and orbital effects (GPDs, TMDs, and all that) Agenda for week 8 Agenda for week 9
10	16–19 Nov	Workshop on "The Science Case for an EIC" Agenda for week 10

Organization: Conveners and Wiki Pages

To facilitate the organization of the program there are convenors for the following subtopics:


- **The Origin of Nucleon Spin** [Wiki pages](#)
 - Longitudinal spin structure: polarization of sea quarks and gluons
 - Transverse spin structure: spin-dependent correlations, the quest to access orbital angular momentum[D. Hasch, M. Stratmann, F. Yuan](#)
- **The Spatial Structure of QCD Matter** [Wiki pages](#)
 - Tomography of the nucleon
 - Initial state for experiments which study hot QCD
 - Are gluons clumped or uniformly distributed in the nucleus?[M. Burkardt, V. Guzey, F. Sabatie](#)
- **QCD Matter under Extreme Conditions** [Wiki pages](#)
 - Investigate strong color fields in nuclei
 - Search for the color glass condensate[A. Accardi, M. Lamont, C. Marquet](#)
- **Beyond the Standard Model**
 - Test of the BjorkenSum Rule
 - Electroweak tests[K. Kumar, Y. Li, W. Marciano](#)

Outcomes

- The 2010 EIC program was very helpful in building the EIC community


- Proceedings were published (rare for the INT):

- 2010 program laid the groundwork for the EIC White Paper

 Cornell University Library

We gratefully acknowledge support from the Simons Foundation and member institutions

arXiv.org > nucl-th > arXiv:1108.1713

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Nuclear Theory

Gluons and the quark sea at high energies: distributions, polarization, tomography

D. Boer, M. Diehl, R. Milner, R. Venugopalan, W. Vogelsang, A. Accardi, E. Aschenauer, M. Burkardt, R. Ent, V. Guzey, D. Hasch, K. Kumar, M. A. C. Lamont, Y. Li, W. J. Marciano, C. Marquet, F. Sabatie, M. Stratmann, F. Yuan, S. Abeyratne, S. Ahmed, C. Aidala, S. Alekhin, M. Anselmino, H. Avakian, A. Bacchetta, J. Bartels, H. BC, J. Beebe-Wang, S. Belomestnykh, I. Ben-Zvi, G. Beuf, J. Blumlein, M. Blaskiewicz, A. Bogacz, S. J. Brodsky, T. Burton, R. Calaga, X. Chang, I. O. Cherednikov, P. Chevtsov, G. A. Chirilli, C. Ciofi degli Atti, I. C. Cloet, A. Cooper-Sarkar, R. Debbe, Ya. Derbenev, A. Deshpande, F. Dominguez, A. Dumitru, R. Dupre, B. Erdelyi, C. Faroughy, S. Fazio, A. Fedotov, J. R. Forshaw, R. Geraud, K. Gallmeister, L. Gamberg, J.-H. Gao, D. Gassner, F. Gelis, G. P. Gilfoyle, G. Goldstein, et al. (125 additional authors not shown)

(Submitted on 5 Aug 2011 (v1), last revised 28 Nov 2011 (this version, v2))

This report is based on a ten-week program on "Gluons and the quark sea at high-energies", which took place at the Institute for Nuclear Theory in Seattle in Fall 2010. The principal aim of the program was to develop and sharpen the science case for an Electron-Ion Collider (EIC), a facility that will be able to collide electrons and positrons with polarized protons and with light to heavy nuclei at high energies, offering unprecedented possibilities for in-depth studies of quantum chromodynamics. This report is organized around four major themes: i) the spin and flavor structure of the proton, ii) three-dimensional structure of nucleons and nuclei in momentum and configuration space, iii) QCD matter in nuclei, and iv) Electroweak physics and the search for physics beyond the Standard Model. Beginning with an executive summary, the report contains tables of key measurements, chapter overviews for each of the major scientific themes, and detailed individual contributions on various aspects of the scientific opportunities presented by an EIC.

Comments: 547 pages, A report on the joint BNL/INT/Jlab program on the science case for an Electron-Ion Collider, September 13 to November 19, 2010, Institute for Nuclear Theory, Seattle; v2 with minor changes, matches printed version

Subjects: Nuclear Theory (nucl-th); High Energy Physics - Phenomenology (hep-ph); Nuclear Experiment (nucl-ex)

Report number: INT-PUB-11-034, BNL-96164-2011, JLAB-THY-11-1373

Cite as: arXiv:1108.1713 [nucl-th]
(or arXiv:1108.1713v2 [nucl-th] for this version)

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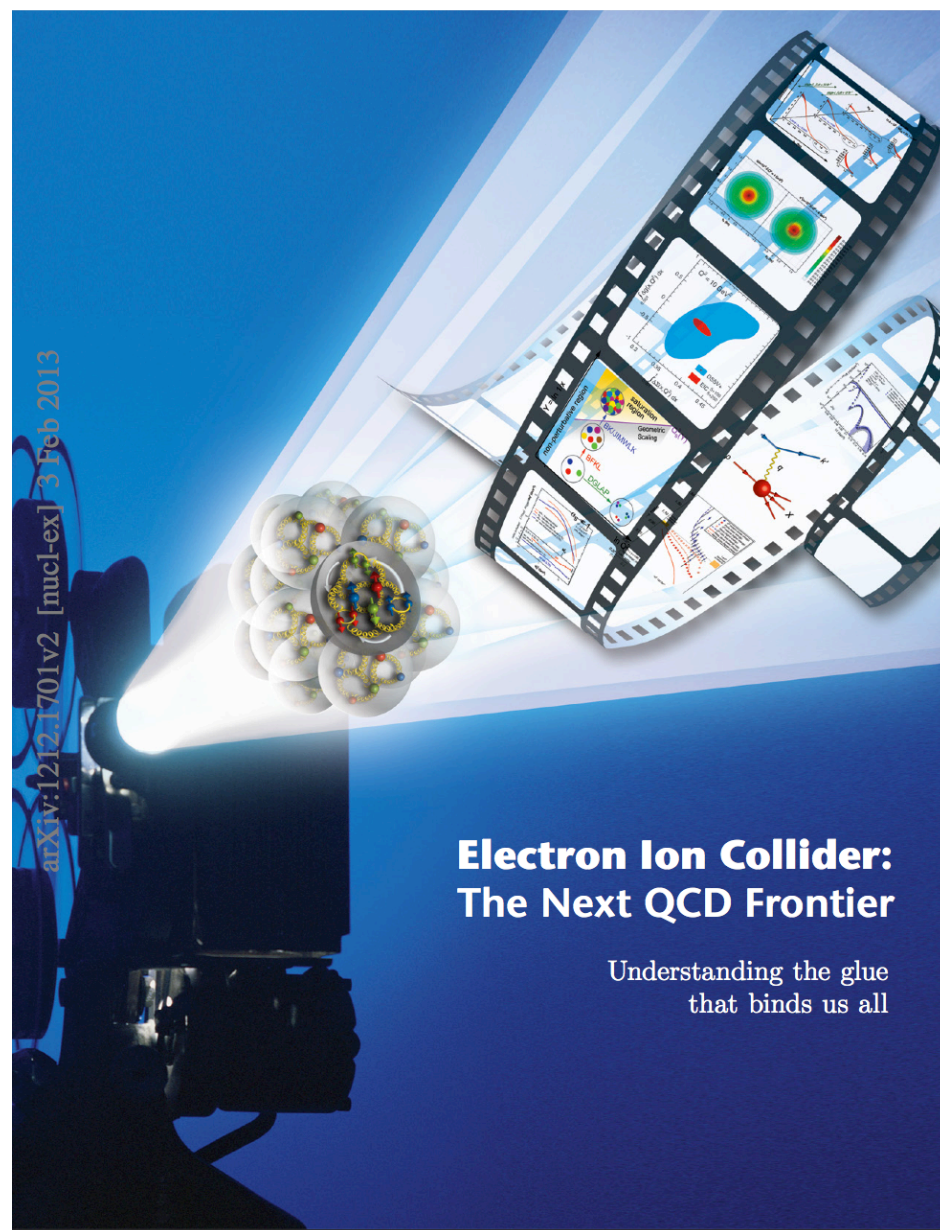
References & Citations

- INSPIRE HEP (refers to | cited by)
- NASA ADS

Bookmark (what is this?)

Electron-Ion Collider (EIC) White Paper

- EIC WP was finished in late 2012 + 2nd edition in 2014
- A several-year effort by a 19-member committee + 58 co-authors
- arXiv:1212.1701 [nucl-ex]

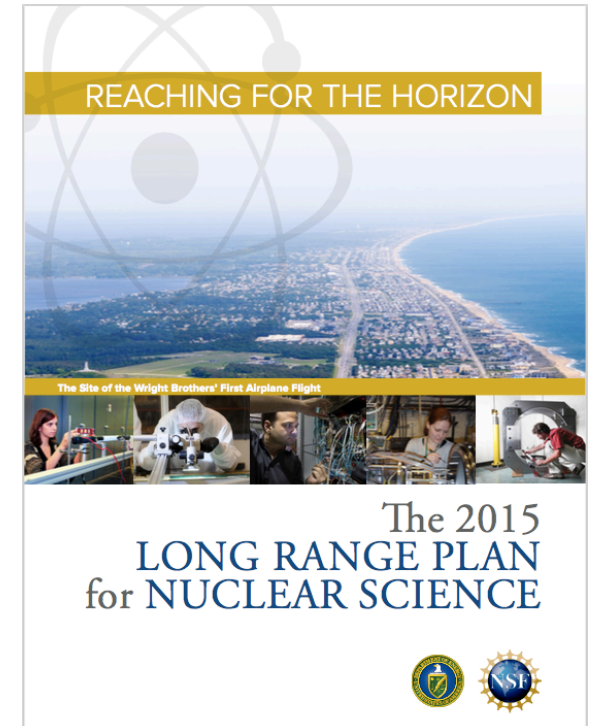


2015 Long Range Plan

RECOMMENDATION III

Gluons, the carriers of the strong force, bind the quarks together inside nucleons and nuclei and generate nearly all of the visible mass in the universe. Despite their importance, fundamental questions remain about the role of gluons in nucleons and nuclei. These questions can only be answered with a powerful new electron ion collider (EIC), providing unprecedented precision and versatility. The realization of this instrument is enabled by recent advances in accelerator technology.

We recommend a high-energy high-luminosity polarized EIC as the highest priority for new facility construction following the completion of FRIB.



NAS Report

Bottom Line

The committee unanimously finds that the science that can be addressed by an EIC is compelling, fundamental, and timely.

The unanimous conclusion of the Committee is that an EIC, as envisioned in this report, would be a unique facility in the world that would boost the U.S. STEM workforce and help maintain U.S. scientific leadership in nuclear physics.

The project is strongly supported by the nuclear physics community.

The technological benefits of meeting the accelerator challenges are enormous, both for basic science and for applied areas that use accelerators, including material science and medicine.

(E. Sichtermann's talk)

2018 INT Program on EIC

2018 INT Program on EIC

- Organizers: Y. Hatta (Kyoto-> BNL),
C. Marquet (Ecole Polytechnique),
A. Prokudin (Penn State Berks),
YK (Ohio State)
- Proposal submitted to the INT in the summer 2016
- Proposal was approved by the INT NAC in the summer 2016 and the program was scheduled for the fall of 2018
- Goal: assess the current status of the EIC-related physics (theory/phenomenology), with the aim of laying the groundwork for another EIC White Paper, to be presented in preparation to the next NSAC Long Range plan.



INT Program on EIC Physics, Fall 2018

- **Probing Nucleons and Nuclei in High Energy Collisions (INT-18-3)**
October 1 - November 16, 2018
Y. Hatta, Y. Kovchegov, C. Marquet, A. Prokudin
- Institute for Nuclear Theory, Seattle, WA
- Please mark
your calendars!

Advert example!



Poster and logo (thanks to Elke and BNL designers – very rare to have a poster at the INT, if it happened in the past at all):



OCTOBER 1 – NOVEMBER 16, 2018 • SEATTLE, WASHINGTON

PROBING NUCLEONS AND NUCLEI IN HIGH ENERGY COLLISIONS

Dedicated to the Physics of the Electron Ion Collider

Program held at the Institute for Nuclear Theory, supported by the US Department of Energy

<http://www.int.washington.edu/PROGRAMS/18-3>

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Yuri Kovchegov, *The Ohio State University*
Cyrille Marquet, *CPHT - Ecole Polytechnique*
Alexei Prokudin, *Penn State University Berks*

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PROGRAM STRUCTURE

Week 1 October 1-5	Week 2 October 8-12	Week 3 October 15-19	Week 4 October 22-26	Weeks 5 & 6 Oct. 29-Nov. 9	Week 7 November 12-16
Generalized parton distributions	Transverse spin and TMDs	Longitudinal spin	Symposium week	eA collisions	pA and AA collisions
Conveners: Tanja Horn Andreas Metz Christian Weiss	Conveners: Harut Avakian Alessandro Bacchetta Daniel Boer Zhongbo Kang	Conveners: Elke Aschenauer Keh-Fei Liu Cédric Lorcé Marco Stratmann	A five-day symposium will be held during the central week, covering all the major topics related to the EIC.	Conveners: Giovanni Chirilli Charles Hyde Anna Stasto Thomas Ullrich Bowen Xiao	Conveners: Adrian Dumitru François Gelis Tuomas Lappi Yacine Mehtar-Tani

Also thanks to Abhay and Rachel Nieves (BNL) for printing and mailing the posters.

Website:

<http://www.int.washington.edu/PROGRAMS/18-3/>

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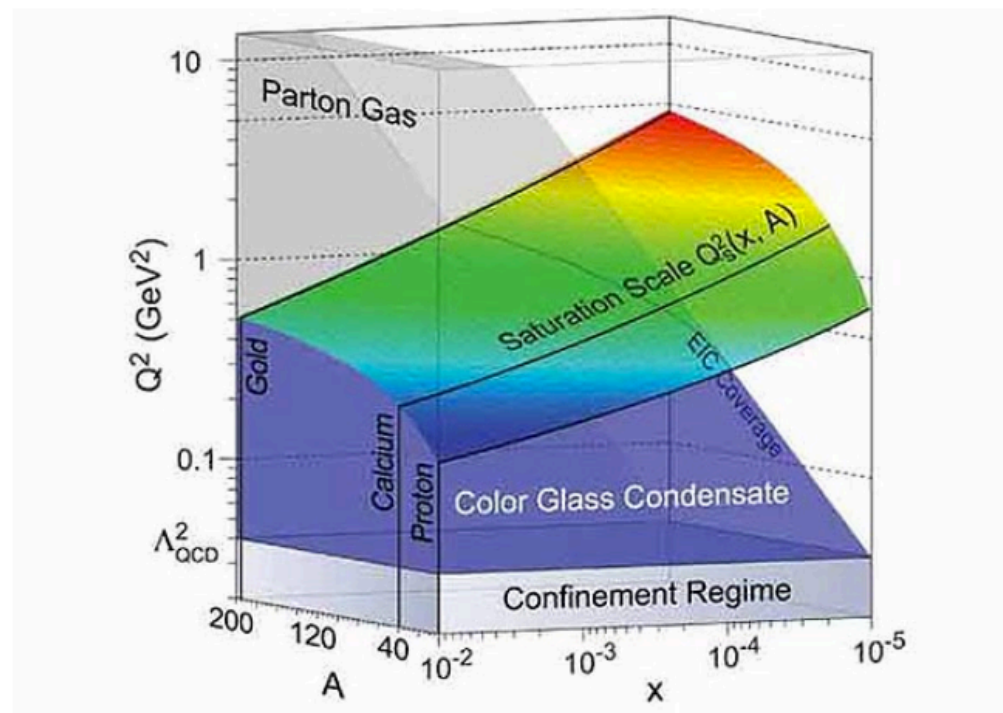
The application deadline has passed.

Talks Online

INT Program INT-18-3

Probing Nucleons and Nuclei in High Energy Collisions

October 1 - November 16, 2018



2018 INT Program on EIC

- Invitations sent out in late 2017 – early 2018.
- Currently have 114 people registered for the program (including 4 organizers and ~20 conveners). Mainly theorists (INT), but with a healthy number of experimentalists.
- The program is 7 weeks long – a bit shorter than the 2010 program which was 10 weeks long. Hence we will have a slightly faster pace.
- The INT budget for the program is completely committed. Most people did not receive full support at this point (not enough funds).
- The program received generous support from JLAB and BNL with each of the labs supporting most of their participants.

Program Structure

Except for week 2 and the symposium week, each day of the program will usually consist of about two seminars in the morning with free discussions and informal seminars in the afternoon. The participants are encouraged to stay for several weeks in order to facilitate cross-disciplinary discussions and research. The topics organized week-by-week are as follows:

Week 1 (October 1-5) : Generalized parton distributions

Conveners: Tanja Horn, Andreas Metz, Christian Weiss

The first week will focus on various aspects of GPDs: theory, phenomenology, lattice QCD computations, models. The recent progress and efforts towards the EIC will be discussed.

Week 2 (October 8-12) : Workshop on Transverse spin and TMDs

Conveners: Harut Avakian, Alessandro Bacchetta, Daniel Boer, Zhongbo Kang

The focus will be shifted to the physics of TMDs such as TMD factorization and evolution, phenomenological implementations, relation to jet physics, and lattice results. A workshop registration fee may apply.

Week 3 (October 15-19) : Longitudinal spin

Conveners: Elke Aschenauer, Keh-Fei Liu, Cedric Lorce, Marco Stratmann

A week devoted to the longitudinal spin structure of the proton including the unpolarized/ polarized PDFs, spin sum rules, the orbital angular momentum of the proton (OAM) and lattice results.

Week 4 (October 22-26) : Symposium week

A five-day symposium will be held during the central week, covering all the major topics related to the EIC. A workshop registration fee may apply.

Weeks 5 & 6 (October 29-November 9) : eA collisions

Conveners: Giovanni Chirilli, Charles Hyde, Anna Stasto, Thomas Ullrich, Bowen Xiao

These two weeks will focus on the physics of electron-ion collisions. Topics such as nuclear PDF/TMD/GPD, non-linear small- x evolution equations, diffraction, particle production and correlations will be discussed.

Week 7 (November 12-16) : pA and AA collisions

Conveners: Adrian Dimitru, Francois Gelis, Tuomas Lappi, Yacine Mehtar-Tani

The final week will be devoted to studying implications of what we would learn in eA collisions at EIC for our understanding of pA and heavy ion collisions at RHIC and LHC (and *vice versa*).

Plans

- Wiki pages or Google Docs for each week to document important developments, to be maintained by conveners; plenty of INT-style discussions; identify key new measurements one can do at the EIC; try to achieve deeper understanding of existing observables (NLO, NNLO, model-dependence/independence, etc.); compose and sing EIC-themed songs by bonfire...
- Ultimately will put together proceedings, post them on the arXiv and publish them too: any preferences? Journal (could be free) or labs printing (if they pay)?
- Does the EIC User community have any specific requests? Is there anything else that is needed? wanted? wished for?