

EIC Experimental Program

- Center for Frontiers in Nuclear Science (CFNS)
- The EIC Working Group at BNL
- The EIC Users Group, the International Landscape

The background & motivation

Success of the EIC, and its full exploitation depends on *strong collaboration between theory and experimental communities*, not only from other subfields of nuclear science (QCD community) but also beyond → Need to continually explore avenues to **deepen and broaden** the science scope beyond the EIC White Paper.

EIC with ~10 years of time scales → creates a special type of need to *attract, engage and support young scientists, who will be leaders of the programs at the EIC.*

An opportunity arose to attract **non-DOE/NSF funding** for supporting such an activities to help the EIC Users Community → try to create a Center dedicated to the science of EIC to achieve the above two broad goals.



**Center for Frontiers
in Nuclear Science**

<https://www.stonybrook.edu/cfns/>

Founded in September 2017

9/17/2019

Vision:

A Center for all scientists interested in the US Electron Ion Collider

A “home” for

- scientific discourse and
- help seed future collaborations
- attract & support young scientists

Work with the EIC Users Group & the two Labs, optimally to help realize the US EIC

The Center for Frontiers in Nuclear Science

Support (Thanks!)

- The Simons Foundation (\$5M) over 10 years & Stony Brook University/NY State (\$3M)
- With strong backing from Stony Brook University & Brookhaven National Laboratory and their managements

Two footprints:

- Stony Brook, Physics Building C-floor (Peter Paul Seminar Room, CFNS lounge, Visitor offices) + the labs (for detector R&D if necessary) in the basement: renovation funded by NY State funds
- BNL, Physics Building: "Library" now converted in to Seminar Room & 6 visitor cubicles : renovation funded by BNL

CFNS Governance

- **International Advisory Committee: *A formal annual review & advise***

R. Milner (MIT, Chair), A. Caldwell (MPI, Munich), L. Elouadrhiri (Jlab), B. Jacak (UCB/LBNL), X. Ji (Shanghai/Maryland), Y. Kovchegov (OSU), Z.-E. Meziani (ANL), W. Nazarewicz (MSU), P. Newman (Birmingham, UK), B. Pasquini (Pavia), F. Pilat (ORNL), J. Qiu (Jlab), G. Sterman (SBU), W. Vogelsang (Teubingen)

Ex. Officio: B. Mueller (BNL), B. Surrow (Chair, EICUG-SC), and Rolf Ent (TBC)

- **Program Advisory Committee: *Review of Workshop proposals***

M. Diehl (DESY, Chair), C. Keppel (Jlab), K. Kumar (U. Mass), P. Shanahan (MIT), F. Yuan (LBNL)

- **Local Steering Committee: *Help implement IAC and PAC recommendations***

T. Hemmick (SBU), D. Kharzeev (SBU/BNL), J. Kiryluk (SBU), T. Ullrich (BNL/Yale), R. Venugopalan (BNL, Co-Chair) & A. Deshpande (SBU, Chair)

- **Scientific Coordinators: *Logistical implementation with scientific outlook***

C. Gal (SBU), J. H. Lee (BNL),

- **Administrative support:**

S. Delquaglio (SBU), M. Veri-Viteri (SBU) and R. Nieves (BNL) [All working for CFNS partially]

- **Director: *Smooth running of all activities and scientific initiatives***

A. Deshpande (SBU/BNL)

CFNS Activities & Initiatives: An Overview

SBU-BNL [Joint CFNS Seminars](#) : 2/month alternate between BNL and SBU

CFNS [Workshops and Adhoc Meetings](#)

CFNS Post doctoral fellows program:

- Post doctoral fellows coordinated and funded through BNL LDRDs at BNL
- Post doctoral fellows at SBU funded through Simons Funds
- Joint post doctoral fellows with remote institutions

Supervised by CFNS associated scientists/faculty (BNL, SBU and some remote university faculty)

Topics associated with the Electron Ion Collider, but also current research activities at RHIC and Jefferson Lab, CERN

Visitor program for (mainly, but not exclusively) young scientists: short (< 7 days) and long (up to 3 months) term

CFNS [EIC QCD Summer Schools](#)

~250 Scientists have visited the Center per year for the last 2 years

CFNS Scientific Workshops 2018-2019-2020

Conferences, Workshops, and Ad-hoc Meetings in 2018

November 28-30 2018	CFNS Inaugural Meeting & International Advisory Committee Review Location: Stony Brook and Brookhaven National Lab*
October 17-19 2018	Forward Physics And Instrumentation From Colliders To Cosmic Rays Organizers: Abhay Deshpande (SBU), Nils Feege (SBU), Yuji Goto (RIKEN), Joanna Kiryuk (SBU), J.H. Lee (BNL), Christophe Royon (UKansas)
September 10-12 2018	Quantum Entanglement at Collider Energies Organizers: Keith Baker (Yale), Ian Cloet (Argonne), Abhay Deshpande (SBU/BNL), Dmitri Kharzeev (BNL/SBU), Yen-Jie Lee (MIT), Thomas Ullrich (BNL), Raju Venugopalan (BNL) Location: Stony Brook*
September 5-7 2018	Short-range nuclear correlations at an Electron-Ion Collider Organizers: Abhay Deshpande, Dmitri Kharzeev, Jianwei Qiu, Raju Venugopalan, Rik Yoshida, Thomas Ullrich, Witold Nazarewicz Location: Brookhaven National Lab*

Past Conferences, Workshops, and Ad-hoc Meetings

July 23-25 2018	Probing quark-gluon Organizers: Megan C Ringer, Konrad Tywc Location: Brookhave
June 4-6 2018	Next-generation GPI Organizers: Christiar Warsaw), Marie Boel Location: Stony Broc
February 5-9 2018	Polarized light ion ph Location: Ghent Univ
April 15 2018	Pre-DIS EIC Worksh Location: Kobe Univ
July 24-26 2019	<i>Ad-hoc</i> : Coherent Electron Cooling -- Theory, Simulation, and Experiment Location: Stony Brook University Organizers: Vladimir N Litvinenko, Gang Wang, Yichao Jing
July 9-10 2019	<i>Ad-hoc</i> : EIC PID Workshop Location: Stony Brook University Organizers: Greg Kalicy (CUA)
Jun 24-28 2019	Initial Stages 2019 Location: Columbia University Organizers: Peter Steinberg (BNL), Raju Venugopalan (BNL)
April 17-19 2019	CFNS Workshop on Lattice Parton Distribution Functions Location: Brookhaven National Lab Organizers: Taku Izubuchi (BNL/RIKEN-BNL), Xiandong Ji (University of Maryland, TD Lee Institute, Shanghai), Nikhil Karthik (BNL), Swagato Mukherjee (BNL), Peter Petreczky (BNL), Andreas Schaefer (Regensburg University), Sergey Syritsyn (SBU/RIKEN-BNL)
February 19-20 2019	<i>ad hoc</i> : sPHENIX DAQ Workfest Location: Stony Brook

Upcoming Conferences, Workshops, and Ad-hoc Meetings

May 2020	Workshop: Chirality, Vorticity and Magnetic Field in Heavy Ion Collisions Location: Stony Brook University Organizers: Dmitri Kharzeev
January 2020	Workshop: Exploring QCD with light nuclei at EIC Location: Stony Brook University Organizers: A. Deshpande, R. Dupre, M. Patsyuk, M. Sargsian, M. Strikman, C. Weiss
December 5-6, 2019	Review: CFNS Annual Review Location: Brookhaven National Laboratory Organizers: A. Deshpande, C. Gal
September 24-26 2019	Joint CFNS & RBRC Workshop on Physics and Detector Requirements at Zero-Degree of Colliders Location: Stony Brook University Organizers: Yuji Goto, J.H. Lee, Barak Schmookler, Chujo Tatsuya, Itaru Nakagawa, Joanna Kiryuk, and Yuji Yamazaki
Approved; Date TBD	Workshop: Beam Polarization and Polarimetry at EIC Location: CFNS (Stony Brook University or Brookhaven National Laboratory) Organizers: E. Aschenauer, D. Gaskell, V. Morozov, V. Ptitsyn, F. Willeke, C. Gal
Approved; Date TBD	Ad-hoc meeting: Electroweak Physics at the EIC Location: CFNS (Stony Brook University or Brookhaven National Laboratory) Organizers: W. Deconinck, Y. Furltova, C. Gal, M. Gericke
Approved; Date TBD	Ad-hoc meeting: Radiative Corrections Location: CFNS (Stony Brook University or Brookhaven National Laboratory) Organizers: J. Bernauer, J. Friedrich, H. Gao, R. Milner
Approval Pending Clarification	Ad-hoc meeting: Streaming Readout V Location: CFNS (Stony Brook University or Brookhaven National Laboratory) Organizers: J. Bernauer, M. Battaglieri, Y. Furltova, J. Huang, M. Purschke

CFNS Post Doctoral Fellow (& Students) Program

Activities supervised by CFNS associated faculty and scientists, reviewed by the IAC annually

- **Post doctoral fellows supported at BNL** on LDRDs ~ 9
 - Kolja Kauder, Alba Soto Ontoso, Abha Rajan, Kong Tu, Renaud Boussarie, James Daniel Brandenberg, Zhenyu Chen, Isaac Upsal
- **Post doctoral fellows supported at SBU** by Simons Foundation funds ~ 3
 - Barak Schmookler, Mriganka Mondal, Yuxiang Zhang, Esha Rolli
- **Joint positions with remote institutions** (Proposals come from remote PI's, CFNS pays 50% of the base salary of the post doc + 5k for travel support) ~ 5
 - With PI's: B. Jacak (UCB), Z. Kang (UCLA), Y. Kovchegov (OSU), Silvia Dalla Torre (INFN/Trieste), C. Hyde (ODU), G. Sterman (YITP/SBU), K. Paschke (Uva)
- **Graduate Student support** (partial, incidental) for local scientists (BNL and SBU) with SBU graduate students

Location: CFNS, Stony Brook

Organizers: Christine Aidala, Martha Constantinou, Abhay Deshpande, Ciprian Gal, Yacine Mehtar, Alexei Prokudin, Matt Sievert, Jinlong Zhang



1st CFNS Summer School for EIC Science

- August 1-9, 2019 at Stony Brook University
- **Teachers:** Z. Davoudi (Maryland), Y. Hatta (BNL), T. Horn (CUA), Z. Kang (UCLA), A. Kiselev (BNL), C. Lee (LANL), V. Morozov (Jlab), N. Sato (Jlab), M. Sievert (UIUC), A. Stasto (PSU), G. Sterman (SBU), J. Zhang (SBU)
- 25 selected students 5 countries (and 8 nationalities) + 5-7 local students and post docs attended
- Formal response from students recorded for future improvements. Over all Overwhelmingly positive.

Other initiatives under consideration:

- **CFNS Connections to International Institutions:** Exchange visitor programs for the EIC under various stages of discussion:
 - APCTP (South Korea), ICAS San Martin (Argentina), Institute of Physics, IIT's, NISER (India), exploring possibilities with Australia, Japan, open to other interests
- **“Edward Bouchet Initiative for QCD”** involving students and faculty from predominantly minority institutions in EIC related activities (~10 minority institutions + SBU, BNL, and MIT, Yale and U. Mass)
 - Seeking funds from a Traineeship opportunity at the NSF
 - Not aware of a similar opportunity at the DOE (input welcome)



EIC Working Group at BNL

Input from Thomas Ullrich

Will present the
current status of the
EIC WG.

Charge to the BNL EIC Science Task Force Tom Ludlam 2009

The purpose of this task force is to consolidate and focus a well-defined effort at BNL to develop and advance the science program for an Electron Ion Collider, both for e-A and e-p collisions. Based in the BNL Physics Department, the Task Force will work closely with the accelerator scientists in the C-A Department, and with the working groups of the global EIC Collaboration.

Basic science questions and key measurements:

- Assemble a list of science questions that will drive the mission statement for an EIC, and a corresponding set of key measurements that will drive the machine requirements. A preliminary list should be completed in advance of the May EIC Collaboration meeting.
- Carry out simulations to demonstrate the feasibility and quality of the key measurements. An initial plan should be prepared for discussion at the May EIC Collaboration meeting. On a time scale of the fall of 2009 the Task Force should settle on a small set of key measurements to pursue in detail. Specific goals should be set for results that will be ready at the 2010 INT workshop.
- The above should include consideration of an initial “medium-energy” stage.

Machine requirements:

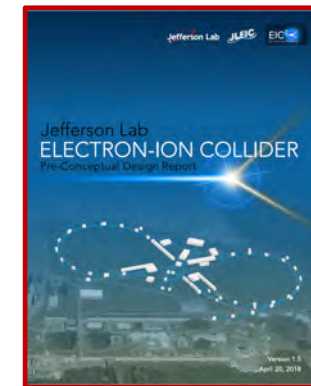
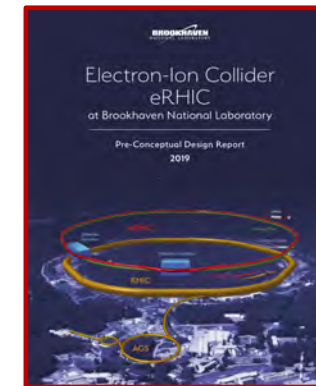
- Identify requirements for an EIC machine to accomplish the key measurements established above, including a “medium-energy” stage.

Detector design and development:

- Develop preliminary design concepts for possible EIC detectors based on the requirements related to the key measurements.
- Develop a common software framework for physics and detector simulations.
- Identify long-lead time (generic) R&D needs for an experimental detector.



EIC Task Force (now renamed a Working Group) has played a key role in developing the science case, defining the machine parameters & influencing the detector design ideas



Aim:

Provide scientific and technical guidance for realizing the EIC-at-BNL working with the CAD, the EIC Users Group (and recently in a coordinated way with the CFNS)

Approach:

Hired extremely talented scientists with experience in DIS to drive the physics at the EIC, established collaborations with the best theorists, conferences, workshops, visitors

Level of Support:

- Current level of support (B. Page, S. Fazio, A. Kiselev) + some IT support & travel, visitors, and funds to take on graduate students on selected topics

Physics & technical thrust:

- Broaden the physics scope of the EIC (Jets, GPDs, Imaging, Correlations)
- Actively support EIC IR design effort for the pre-CDR, Detector R&D and EIC software

Publications, conference & other talks:

- EIC Studies → in 6 peer-reviewed publications (2017 – [partial] 2019) → **~72 citations**
- Numerous workshop/conference presentations (many invited), proceedings and reports

The EIC Users Group and International Perspective

The EIC Users Group: EICUG.ORG

New:
[Center for Frontiers in Nuclear Science](#) (at Stony Brook/BNL)
[EIC²](#) at Jefferson Laboratory

Formally established in 2016
890+ Ph.D. Members from 30 countries, 189 institutions



EICUG Structures in place and active. (BNL scientists)

EIC UG Steering Committee (T. Ullrich)

EIC UG Institutional Board (R. Venugopalan, A. Deshpande)

EIC UG Speaker's Committee (L. Ruan)

Election & Nomination Committee (A. Deshpande)

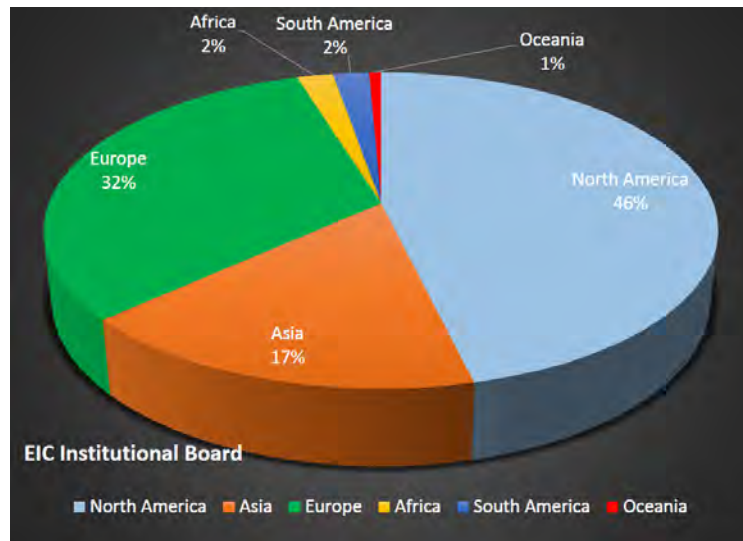
Task Forces setup by the EICUG:

-- Beam polarimetry (E. Aschenauer+..)

-- IR/Luminosity measurement (A. Kiselev, C.Montag+..)

-- Software (T. Wenaus+..)

Annual meetings: Stony Brook (2014), Berkeley (2015), ANL (2016), **Trieste (2017)**, CAU (2018), **Paris (2019)**, [FIU \(2020\)](#), **Warsaw (2021)**



EIC UG and **International** Perspective

Steering Committee: (has elected **European and Asian** representative)

- Bernd Surrow (Chair, Temple), Richard Milner (Vice-Chair, MIT), John Arrington (ANL), Ernst Sichterhmann (LBNL), **Marco Radici (INFN)**, **Daniel Boer (Groningen, Europe)**, **Yuji Goto (RIKEN, Asia)**, **Thomas Ullrich (BNL)** & Rolf Ent (JLab)

Institutional Board: (already has non-US member)

- C. Aidala (U. of Michigan, Chair), **A. Bressan (INFN, Vice-Chair)**

Conference and Talks committee: (already has non-US member)

- **R. Seidl (RIKEN)**, **C. M. Camacho (Orsay)**, **B. Pasquini (INFN Pavia)**, S. Salur (Rutgers), D. Romanov(Jlab)

Election & Nomination Committee: (already has non-US member)

- **A. Deshpande (SBU/BNL)**, C. Weiss (Jlab), **P. Newman (Birmingham)**, Yuri Kovchegov (OSU), **M. Ruspa (INFN, Torino)**

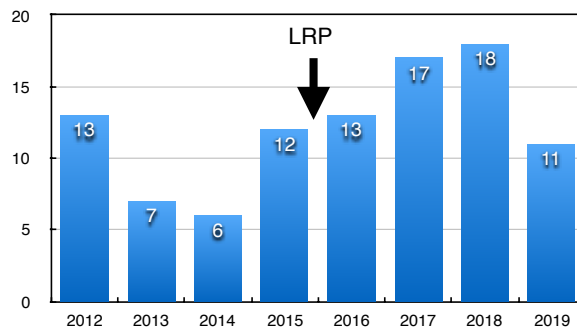
EIC detector R&D program

Thomas Ullrich

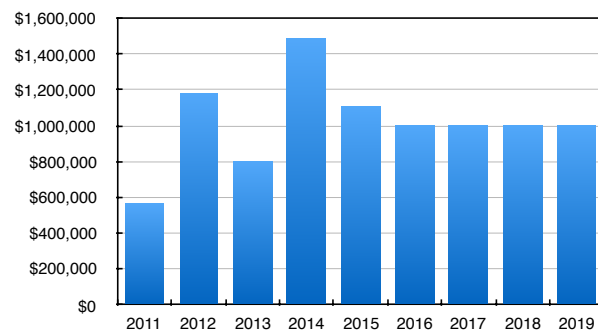
URL: https://wiki.bnl.gov/conferences/index.php/EIC_R%25D

- Started in 2011 at BNL (Tom Ludlam), with JLab and DOE office of NP, funded by DOE through RHIC operations funds.
- Non-site-specific and **open to international collaborators**

Number of Proposals per FY



Funding per FY



- 10-11 proposals supported at a time, 46 institutions (**13 non-US**), 6 national labs, 187 participants
- Funding requests typically ~3 times the available funding
- Current topics include: Calorimetry, Tracking/PID, Si Tracking, e+A simulations, software development, background studies, TRD, DAQ/Streaming Readout, and R&D for Roman Pots

Summary

- The Center for Frontiers in Nuclear Science is now an emerging as a strong center of QCD related to EIC; Ready and is already to working the EICUG, the Labs to seed collaborations, expand the EIC science, working with its young scientists and visitors.
- At BNL the EIC Working Group continues to be an extremely effective group to focus on details of the EIC science and its growth. Has strong influence on the EIC design parameters including machine, IR and detector.
- The Users Group is maturing fast, and will play a critical role working with the Labs (and the DOE) to attract national and international collaborators. BNL is playing a strong role in the UG.

Fast movement of the EIC towards the CD process is anticipated eagerly with excitement, enthusiasm and gratitude.

Thank you

EIC WG Publications FY17-FY19

~15 publications in FY17-FY19 led by the members of the EIC Task Force

- E.C. Aschenauer, S. Fazio, J.H. Lee, H. Mantysaari, B.S. Page, B. Schenke, T. Ullrich, R. Venugopalan, P. Zurita, “The Electron-Ion Collider: Assessing the Energy Dependence of Key Measurements”, Rept. Prog. Phys. 82 (2019) no.2, 024301
- Measuring the Weizsäcker-Williams distribution of linearly polarized gluons at an electron-ion collider through dijet azimuthal asymmetries, Adrian Dumitru, Vladimir Skokov, Thomas Ullrich, Phys. Rev. C99 (2019), 015204
- S. Fazio, “Nuclear Parton Distributions at the future Electron-Ion Collider”, PoS DIS2017 (2018) 084
- B.Azmoun et al, “Design Studies for a TPC Readout Plane using Zigzag Patterns with Multistage GEM Detectors”, IEEE Trans.Nucl.Sci. 65 (2018) no.7, 1416-1423.
- B.Azmoun et al, „Design Studies for a TPC Readout Plane using Zigzag Patterns with Multistage GEM Detectors“, arXiv:1801.03087
- H. Mäntysaari and P. Zurita, “In depth analysis of the combined HERA data in the dipole models with and without saturation,” arXiv:1804.05311 [hep-ph].
- E. C. Aschenauer, S. Fazio, M. A. C. Lamont, H. Paukkunen and P. Zurita, “Nuclear Structure Functions at a Future Electron-Ion Collider,” Phys. Rev. D 96, no. 11, 114005 (2017), arXiv:1708.05654 [nucl-ex].
- E. C. Aschenauer et al., “The Electron-Ion Collider: Assessing the Energy Dependence of Key Measurements”, arXiv:1708.01527 [nucl-ex].
- M. Zurita, Proceeding the workshop “Exposing Novel Quark and Gluon Effects in Nuclei”
- M. Zurita, Proceedings of CIPANP 2018
- E. C. Aschenauer et al., The Electron-Ion Collider: Assessing the Energy Dependence of Key Measurements , Aug 4, 2017. BNL-114111-2017, arXiv:1708.01527
- S. Fazio, "Nuclear Parton Distributions at the future Electron-Ion Collider", Published in: PoS DIS2017 (2018) 084
- S. Fazio, "Physics opportunities at the future eRHIC electron-ion collider", AIP Conf.Proc. 1819 (2017) no.1, 050002
- Studying the photon structure at an EIC, Underlying events at EIC.
- X. Chu et al., Photon structure studied at an Electron Ion Collider, Phys. Rev. D, 96, 074035, 2017