

1ST EUROPEAN SCHOOL ON THE PHYSICS OF THE ELECTRON-ION COLLIDER

18–22 Jun 2023
Corigliano-Rossano, Italy

Welcome!

[a mix of context, introduction(s), and information to set the stage]

P. Antonioli
INFN Bologna



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TOPICS

- Deep Inelastic Scattering
- Physics at the EIC
- EIC detectors
- PDFs in a free proton and in nuclei
- Transverse-momentum distributions
- Hadron spectroscopy
- Machine learning applications for DIS
- Hands-on sessions

INTERNATIONAL ADVISORY COMMITTEE

- P. Antonelli (INFN-Bologna)
- E. Aschenauer (Brookhaven National Laboratory - USA)
- S. Datta-Varma (INFN-Trieste)
- A. Dechamps (Stony Brook University & CEFS - USA)
- B. Erasmov (IMT Atlantique, CHRS-ICP3 - France)
- I. Galis (DESY - Germany)
- A. Mukherjee (Indian Institutes of Technology - India)
- P. Newman (Birmingham University - UK)
- B. Pasquini (Pavia University)
- P. Rossi (Jefferson Lab - USA & INFN-LNF)
- D. Sokhan (JRFU-CEA, Paris-Saclay University - France)
- J. Wagner (NCBI - Poland)

ORGANIZING COMMITTEE

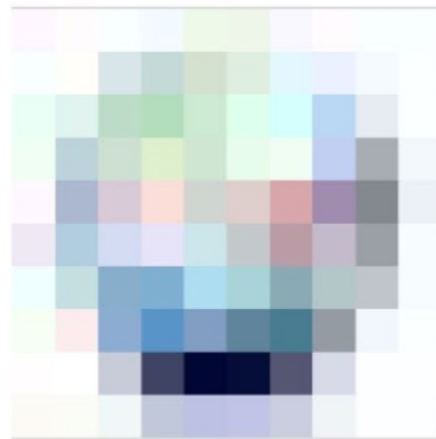
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- A. Mastroianni (Foggia University)
- M. Radici (INFN-Pavia)
- E. Tassi (University of Calabria - Chair)
- C. Tosi (Catania University - Vice Chair)

<https://agenda.infn.it/eic2023>
email: eic2023@infn.it



A new pair of glasses to look inside the nucleon

If Deep Inelastic Scattering is a pair of glasses to look inside the nucleon, EIC is definitely a **new pair of glasses!**



Resolution is a few times smaller than target



Resolution **10's** of times smaller than target



Resolution **100's** of times smaller than target

Credit: Yulia Furletova

Almost 60 years later do we understand the hadrons?

Volume 8, number 3

PHYSICS LETTERS

1 February 1964

A simpler and more elegant scheme can be constructed if we allow non-integral values for the charges. We can dispense entirely with the basic baryon b if we assign to the triplet t the following properties: spin $\frac{1}{2}$, $z = -\frac{1}{3}$, and baryon number $\frac{1}{3}$. We then refer to the members $u^{\frac{2}{3}}$, $d^{-\frac{1}{3}}$, and $s^{-\frac{1}{3}}$ of the triplet as "quarks" q and the members of the

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look for some fundamental explanation of the situation. A highly promised approach is the purely dynamical "bootstrap" model for all the strongly interacting particles within which one may try to derive isotopic spin and strangeness conservation and broken eightfold symmetry from self-consistency alone ⁴). Of course, with only strong interactions, the orientation of the asymmetry in the unitary space cannot be specified; one hopes that in some way the selection of specific components of the F-

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$z = -1$, so that the four particles d^- , s^- , u^0 and b^0 exhibit a parallel with the leptons.

A simpler and more elegant scheme can be constructed if we allow non-integral values for the charges. We can dispense entirely with the basic baryon b if we assign to the triplet t the following properties: spin $\frac{1}{2}$, $z = -\frac{1}{3}$, and baryon number $\frac{1}{3}$. We then refer to the members $u^{\frac{2}{3}}$, $d^{-\frac{1}{3}}$, and $s^{-\frac{1}{3}}$ of the triplet as "quarks" q and the members of the anti-triplet as anti-quarks \bar{q} . Baryons can now be



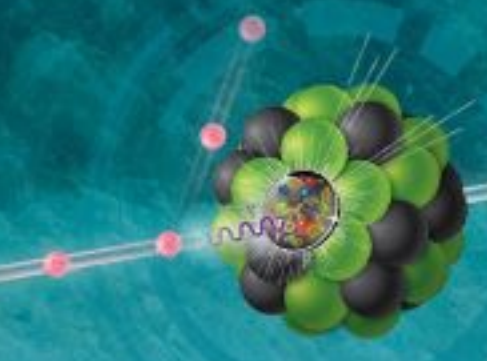
Department of Energy

U.S. Department of Energy Selects Brookhaven National Laboratory to Host Major New Nuclear Physics Facility

JANUARY 9, 2020

[Energy.gov](#) » U.S. Department of Energy Selects Brookhaven National Laboratory to Host Major New Nuclear Physics Facility

WASHINGTON, D.C. – Today, the **U.S. Department of Energy (DOE)** announced the selection of Brookhaven National Laboratory in Upton, NY, as the site for a planned major new nuclear physics research facility.





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A school

- to grow and nurture the EIC-generation of scientists who will be the leaders at the Electron Ion Collider
- to create a European counterpart of the CFNS EIC School already operating at Stony Brook University (with easier access also outside US)
- to strengthen INFN growing EIC community
- to factorize the big asset of a strong theoretical community working on hadron structure physics in Italy

When the idea of the school was born....

From Salvatore Fazio <salvatore.fazio@unical.it>  Reply Reply All Forward Archive Junk Delete More 

To Me <pietro.antonio@bo.infn.it>  11/11/21, 18:00

Cc Enrico Tassi <enrico.tassi@fis.unical.it> , Marcella Capua <marcella.capua@fis.unical.it> 

Subject **Chiacchierata EIC/ATHENA col gruppo di Cosenza**

Caro Pietro,

in preparazione alla giornata nazionale di Torino, come gruppetto di Cosenza ci farebbe piacere scambiare quattro chiacchiere con te.

In particolare per esplorare insieme l'opportunità o meno di un nostro possibile contributo alla causa, che vada oltre lo sviluppo di nuovi generatori e del caso di fisica.

Così cogliamo pure l'occasione per presentarci. Che ne pensi?

Se va bene, proponi pure quando sei più libero. Per quanto mi riguarda la prossima settimana siamo in pausa didattica, quindi è un buon momento. Probabilmente lo stesso è vero anche per Marcella ed Enrico.

Cari saluti,

Salvatore

The "chat" then happened on **16th November 2021**. This is when we first considered the idea of a school. We start it today, 18 months later: a little miracle!

Without Cosenza group simply it wouldn't ever happened.

A super thanks to **Enrico, Marcella and Salvatore!**



School's "rules"

- informal and relaxing atmosphere: privilege the interaction among students, lecturers. LOC, ...
- the school is an opportunity to expand your scientific network. We have our badges but by tomorrow evening at the latest we have to know the name of all other participants by heart
- LOC and lecturers are at your disposal!
- the program doesn't cover all (on purpose) but we do hope it will be a good start and a good compass for all of you



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<https://agenda.infn.it/e/EICschool2023>
email: eicschool2023@lists.infn.it



Today:
how we arrived to 9 January 2020 announcement?
what is the physics of the DIS?

16:00	Welcome, overview of the school program	<i>Pietro Antonioli</i> 16:00 - 16:15
	The Electron-Ion Collider: from an idea to reality	<i>Abhay Deshpande</i> 16:15 - 17:00
17:00	Introduction to Deep Inelastic Scattering	<i>Enrico Tassi</i> 17:00 - 19:00
18:00		

Monday

09:00	Collinear proton PDFs from past, present and future data <i>Enrico Tassi</i>	08:30 - 10:30
10:00	Coffee break	
11:00	Theory of Transverse-momentum dependent distributions (TMD) <i>Alessandro Bacchetta</i>	11:00 - 13:00
12:00		
13:00	Lunch break	
14:00		
15:00	Theory of Transverse-momentum dependent distributions (TMD) <i>Alessandro Bacchetta</i>	14:30 - 15:30
16:00	Gluon TMDs <i>Francesco Giovanni Celiberto</i>	15:30 - 16:30
17:00	The case for ions: the physics of nuclear PDF and hadronization studies <i>Dr Pia Zurita</i>	16:30 - 17:30

Tuesday

09:00	Facilities and Experiments for TMD studies <i>Silvia Dalla Torre</i>	08:30 - 09:30
10:00	The next nucleon microscope: the ePIC detector at EIC <i>Silvia Dalla Torre</i>	09:30 - 10:30
11:00	Coffee break	
12:00	Overview of the physics case for the EIC <i>Abhay Deshpande</i>	11:00 - 13:00
13:00	Lunch break	
14:00		
15:00	Cooking show: how to extract a TMD from a global fit <i>Matteo Cerutti</i>	13:00 - 14:30
16:00		
17:00	The case for ions: the physics of nuclear PDF and hadronization studies <i>Pia Zurita</i>	14:30 - 16:30

Wednesday

09:00	Introduction to Machine Learning techniques <i>Giorgia Miniello</i>	08:30 - 10:30
10:00	Coffee break	
11:00	Overview on spectroscopy <i>Annalisa D'Angelo</i>	11:00 - 13:00
12:00		
13:00	Lunch break	
14:00	Hands-on session on QCD DGLAP analyses for PDFs determination <i>Enrico Tassi</i>	13:00 - 14:00
15:00		
16:00		
17:00		

21:00	Poster by night: poster presentation under the stars	
22:00		21:15 - 22:15

Be respectful of timetable
(and of free time)

Thursday

09:00	Experimental results on TMD <i>Andrea Bressan</i>	08:30 - 09:30
10:00	The Italian contribution to the EIC <i>Pietro Antonioli</i>	09:30 - 10:30
	Coffee break	
11:00	Monte Carlo Event Generators for EIC <i>Andrea Bressan</i>	11:00 - 13:00
13:00	Lunch break	13:00 - 14:30
15:00	Combined session with the Summer meeting of the INFN's "EIC_NET".	14:30 - 16:30
	Coffee break	
17:00	Departures	

13:00	Lunch	
14:00	<i>Corigliano-Rossano</i>	13:00 - 14:30
	Welcome and introduction from INFN Cosenza <i>Corigliano-Rossano</i>	<i>Enrico Tassi et al.</i> 14:30 - 14:40
	EIC in 2023: from here to operations start in 2031 <i>Corigliano-Rossano</i>	<i>Abhay Deshpande</i> 14:40 - 15:20
15:00	Status EIC/ePIC and INFN involvement: at a turning point <i>Corigliano-Rossano</i>	<i>Pietro Antonioli</i> 15:20 - 15:55
16:00	ePIC: engage the Italian community with physics <i>Corigliano-Rossano</i>	<i>Salvatore Fazio</i> 15:55 - 16:35
17:00	Coffe break (and departure of students of EIC School) <i>Corigliano-Rossano</i>	17:00 - 17:30
	Status of ePIC tracker and overview of INFN R&D <i>Corigliano-Rossano</i>	<i>Domenico Colella</i> 17:30 - 18:00
18:00	Bending, test and characterization <i>Corigliano-Rossano</i>	<i>Rosario Turrisi et al.</i> 18:00 - 18:30

Thursday afternoon 21 and Friday 23 we will have NFN EIC_NET Annual Meeting 2023

Friday

	Status of ePIC forward dual RICH and overview of INFN R&D <i>Marco Contalbrigo</i>
09:00	dRICH simulation: towards definition of dRICH geometry <i>Chandradoy Chatterjee</i>
	Towards ALCOR64 <i>Fabio Cossio</i>
10:00	Photosensors <i>Roberto Preghenella</i>
	Wrap-up discussion toward dRICH review (July 2023)
	Coffee break
11:00	Interest on uRWELL in ePIC <i>Alessia Fantini</i>
	Planning INFN contribution to computing <i>Andrea Bressan</i>
12:00	The big planning picture <i>Pietro Antonioli</i>
	Discussion
13:00	Lunch
14:00	<i>Corigliano-Rossano</i>
	Discussion
15:00	<i>Corigliano-Rossano</i>
16:00	Coffee break and departure from the resort <i>Corigliano-Rossano</i>
17:00	<i>Corigliano-Rossano</i>

Don't forget to put your poster ON! → (and we will post them on Indico)

Please put your name and poster title here:

<https://docs.google.com/spreadsheets/d/192Svw50AhrYNVNpUSrJ9GHslpIAnDHzTyrscrLvnbM/edit?usp=sharing>

Official presentation under the stars: Tuesday evening

Don't forget to install software for hands-on session. Do it before the session!

The screenshot shows a web page with a sidebar on the left and a main content area on the right. The sidebar contains a list of menu items: Overview, Important dates, Committees, Timetable, Contribution List, Call for Abstracts, My Conference, My Contributions, Registration, and Instructions for the hands-on session. The 'Instructions for the hands-on session' item is highlighted in grey, and a blue arrow points from the yellow warning box above to this item. The main content area has a title 'Instructions for the hands-on session' and a sub-header '1. xFitter'. Below this, there is a paragraph of text about the xFitter project, followed by three lines of text providing links to the project web page, the gitlab repository, and the documentation. A second sub-header '2. Docker Desktop installation' is visible at the bottom of the page. The browser's address bar at the bottom shows the URL 'https://www.docker.com/products/docker-desktop/'.

Overview

Important dates

Committees

Timetable

Contribution List

Call for Abstracts

My Conference

My Contributions

Registration

Instructions for the hands-on session

Instructions for the hands-on session

1. xFitter

The xFitter project is an open source QCD fit framework used to determine PDFs and to assess the impact of new data. The framework includes modules allowing for various theoretical and methodological options and is capable to fit a large number of relevant data sets from HERA, Tevatron and LHC. This framework is already used in many analyses at the LHC.

Here is the project web page: <https://www.xfitter.org/xFitter/>

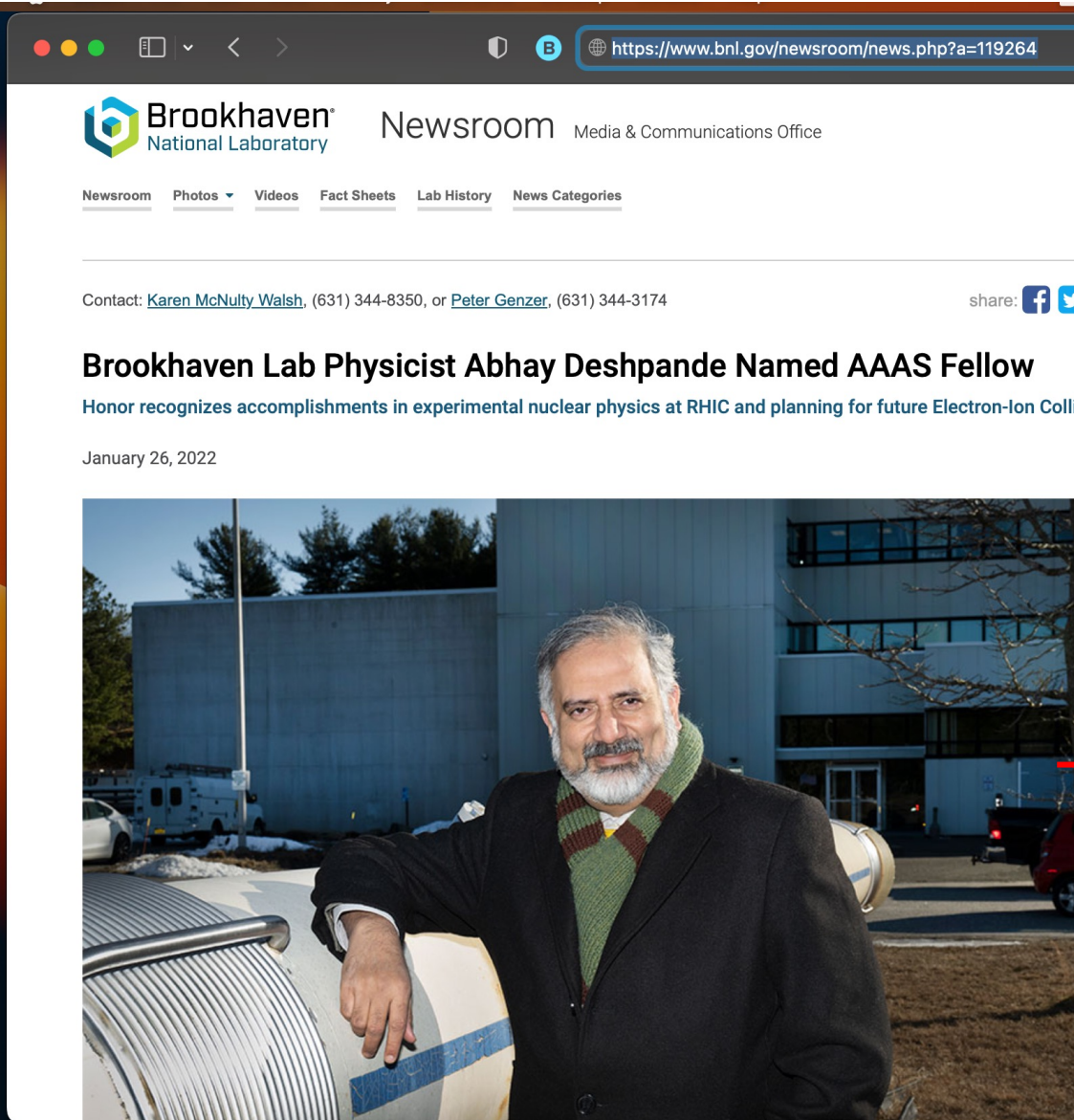
Here is the gitlab repository (master branch): <https://gitlab.cern.ch/fitters/xfitter>

Here the Documentation (Wiki): <https://gitlab.cern.ch/fitters/xfitter/-/wikis/home>

2. Docker Desktop installation

← → ↻ 🔒 🔑 🔍 https://www.docker.com/products/docker-desktop/ 📄 ☆ 🏠 📄 ☰

And finally few words and two links about our today's lecturers



Brookhaven National Laboratory Newsroom Media & Communications Office


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Contact: [Karen McNulty Walsh](#), (631) 344-8350, or [Peter Genzer](#), (631) 344-3174

Brookhaven Lab Physicist Abhay Deshpande Named AAAS Fellow

Honor recognizes accomplishments in experimental nuclear physics at RHIC and planning for future Electron-Ion Collider

January 26, 2022



Deshpande has been a long-time collaborator on nuclear physics research at Brookhaven Lab's [Relativistic Heavy Ion Collider](#) (RHIC), including using the unique capabilities of this DOE Office of Science user facility to unravel how particles called [quarks and gluons](#) contribute to the intrinsic angular momentum, or spin, of protons. (Protons and neutrons together are known as nucleons, the building blocks of atomic [nuclei](#).) Deshpande's research specifically helped determine the gluon contribution to proton spin from measurements taken using the PHENIX detector during collisions of polarized proton beams at RHIC.

Even while pursuing this ambitious research program, Deshpande has been a strong advocate for the future of nuclear physics research. He has been a central spokesperson for an effort to transform RHIC, at the completion of its scientific program, into an [Electron-Ion Collider](#) (EIC). The EIC, now in the planning stages at Brookhaven Lab, will solve remaining questions about proton spin and enable a deeper exploration of how nature's strongest force binds quarks and gluons to build up the structure of the protons, neutrons, and nuclei that make up everything we see in the universe today.

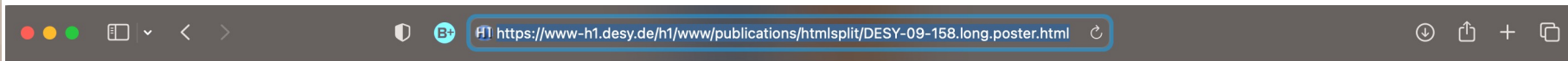
Brookhaven Lab will build the facility in close collaboration with partners from Thomas Jefferson National Accelerator Laboratory and Deshpande has worked hard to foster that spirit of cooperation. He has helped to lay the plans for the accelerator and detector components that will be essential for advancing EIC science and has led programs to gain support from throughout the worldwide nuclear physics research community.

As director of EIC science for Brookhaven Lab, he has planned and participated in workshops and conferences around the world. He also spearheaded the establishment of the [Center for Frontiers in Nuclear Science](#), a joint

<https://www.bnl.gov/newsroom/news.php?a=119264>



if Abhay is behind EIC, Enrico is behind many of nowadays DIS textbook figures from HERA!



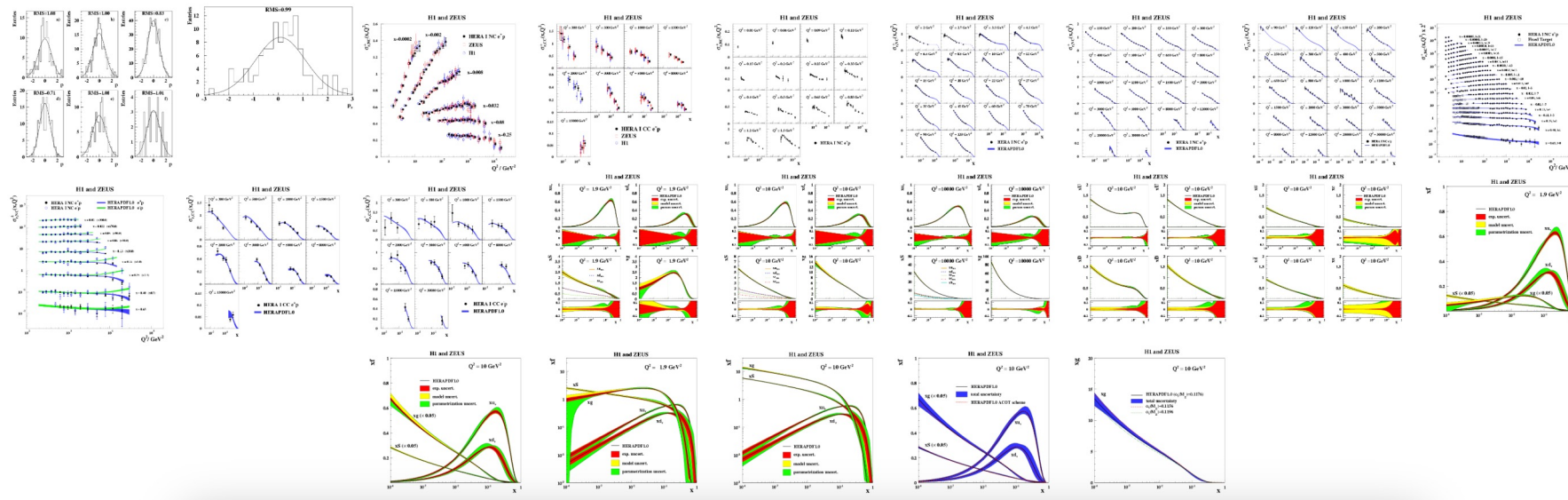
Publication of the H1 and ZEUS Collaborations

DESY-09-158 Combined Measurement and QCD Analysis of the Inclusive ep Scattering Cross Sections at HERA

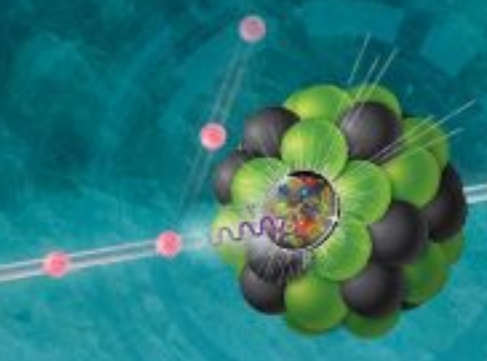
arxiv:0911.0884
H1-189

Reference	H1 and ZEUS Collab., F.D. Aaron et al., JHEP01 (2010) 109, 11/09
Figures	(1) (2) (3) (4) (5) (6) (7) (8) (9) (10) (11) (12) (13) (14) (15) (16) (17) (18a) (18b) (19a) (19b) (20) (21)
Tables	(readme) (nce+p) (nce-p) (cce+p) (cce-p)
Links	H1 and ZEUS combined results H1 publications ZEUS publications Abstract from hep-ex Spire's pdf version
Comments	The data in this paper are superseded by the new H1-ZEUS data combination Eur.Phys.J.C75 (2015) 12, 580 [arxiv:1506.06042]. A typo was found in formula (2): the expression $x\tilde{F}_3$ should be replaced by $-x\tilde{F}_3$.

Gallery



<https://www-h1.desy.de/h1/www/publications/htmlsplit/DESY-09-158.long.poster.html>



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Enjoy the school!