Prospettive in fisica adronica: il progetto EIC

Cédric Mezrag

INFN Roma1

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In collaboration with
Evaristo Cisbani
Giovanni Salmè

Hadron physics

Studying strong interaction bound-states

- Fundamental law of the strong interaction: QCD.

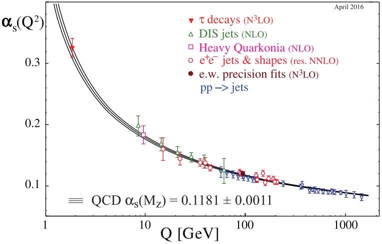
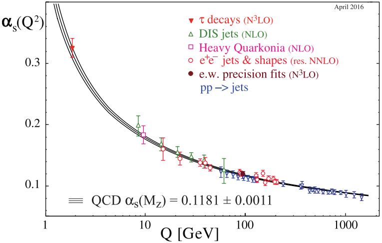


figure from PDG 2016

- Fundamental law of the strong interaction: QCD.
- Fundamental degrees of freedom: quarks and gluons



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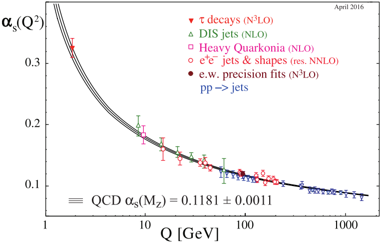
- Fundamental law of the strong interaction: QCD.
- Fundamental degrees of freedom: quarks and gluons
- Interesting phenomenon:
  - Asymptotic freedom
  - Confinement



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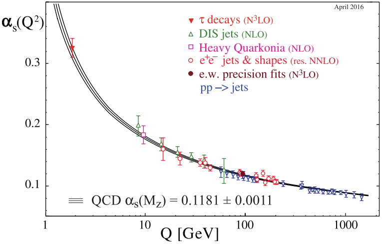

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Features of QCD

- No access to fundamental degrees of freedom
- Bound-states whose properties **emerge** from the dynamic of the strong interaction

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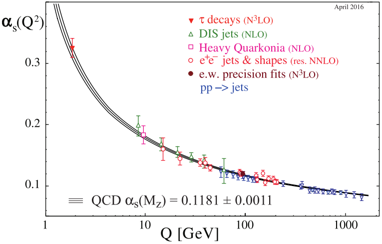
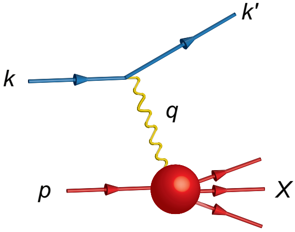


figure from PDG 2016

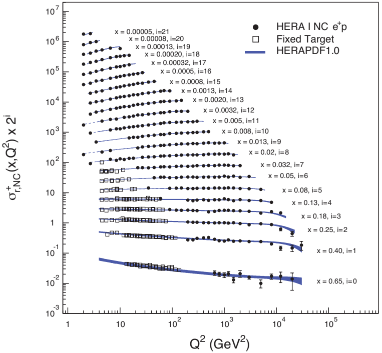
Probing QCD dynamic

- Electroweak and strong probes can be used to extract partonic information from data
- Scheme and scale dependence

Deep Inelastic Scattering



$$Q^2 = -q^2 \qquad x_B = Q^2/(2p \cdot q)$$

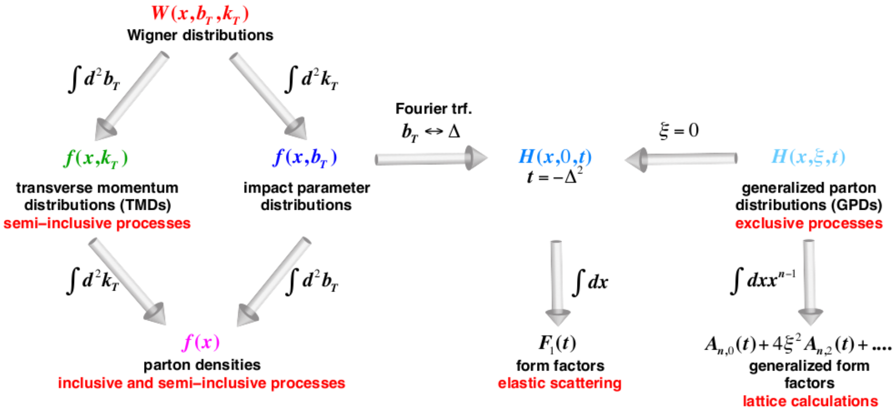


EM probe of hadron properties

- Several decades of measurements
- Scaling violation was an important QCD success
- 1D probability density of finding partons into hadrons

Multidimensional Structure of Nucleon

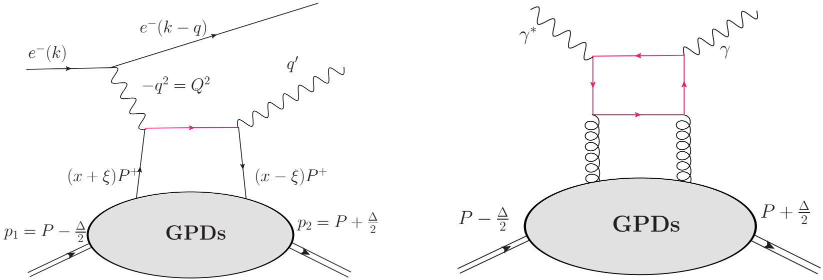
- **3D picture of nucleon in coordinate and momentum space**
- Gluon tomography & gluon momentum dependent distributions
- Spin & mass decompositions, gluon radius, pressure & shear forces within the nucleon



How can we extract the 3D structure from experimental data?

Tomography and exclusive processes

Deep Virtual Compton Scattering (DVCS)



- Exclusive processes give access to Generalized Parton Distributions encoding 3D structure in coordinate space
- EM probe and outcome make the access "clean"
- Difficulty: the proton has to remain intact despite high Q^2.

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Modern Challenges in Hadron physics

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A new state of matter

- Unambiguous signal of gluon saturation in eA collisions
- Study of property of Color Glass Condensate

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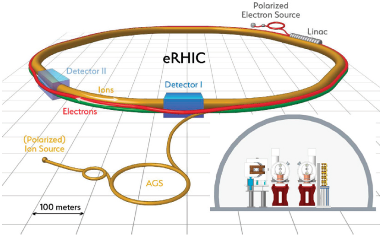
Impact of Nuclear Medium

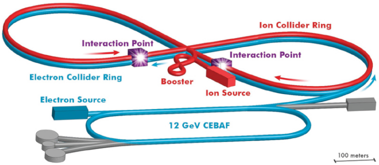
- **Study of the EMC effect on a wide kinematical range**
- 3D tomography of nuclei
- Hadronization mechanisms

EIC Project in a nutshell

An answer to modern hadron physics challenges

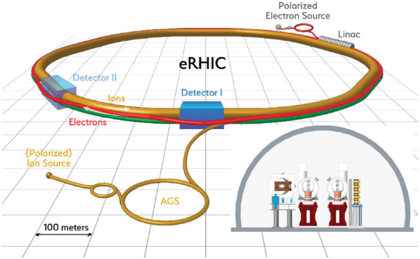
- US-based project of collider at “high-luminosity” ($\approx 10^3$ HERA)
  $\rightarrow$ important for 3D tomography
- CoM energy : 20-100 GeV (upgrade possible to 140 GeV)
  $\rightarrow$ key for studying gluonic effects and saturation
- Polarized beams
- Two different projects:





eRHIC project

Update November 2018

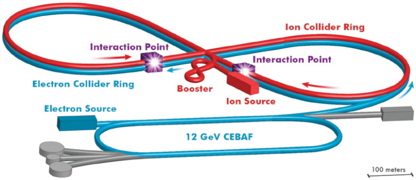


	e	p
Max. beam E (GeV/n)	15.9	275
Polarization	80%	70%
P. luminosity $10^{33}\text{cm}^{-2}\text{s}^{-1}$		10

- Use the current BNL Ion accelerator and build new electron one
- Higher CoM energy design $\rightarrow$ better access to saturation regime
- Luminosity gained almost 1 order of magnitude compare to the original design (white paper)

JLEIC project

Update April 2019

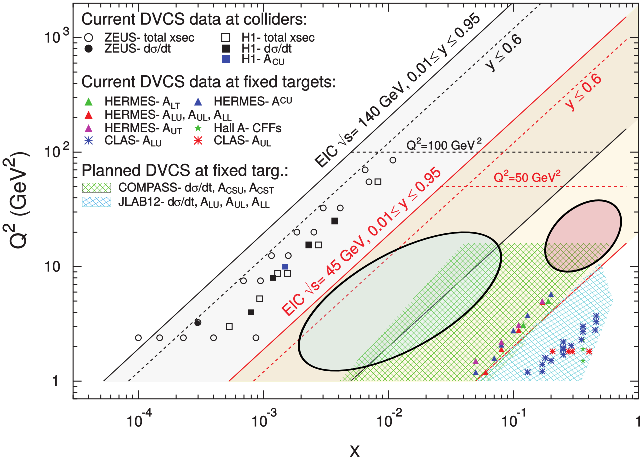


	e	p
Max. beam E (GeV/n)	12	200
Polarization	85%	80%
P. luminosity $10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$		15.5

- Use the current JLab electron accelerator and building a new 8-shape tunnel and ion accelerator
- Shape: better control of the polarization and polarized D beam
- Higher luminosity $\rightarrow$ better access to 3D tomography
- Proton beam energy gained a factor 2 since original MEIC design

DVCS at EIC

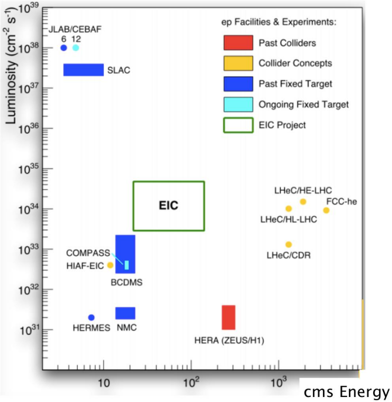
Kinematic coverage



The EIC will tremendously expand the kinematical coverage of DVCS

EIC requirements for physics

- High collision Luminosity ($>10^{33}/cm^2/s$)
- Variable center of mass energy for wide kinematics
- High electron (>80%) and light ion (>70%) polarization
- Wide range of nuclear beams (from p to U/Pb)
- Room in interaction point(s) for large acceptance spectrometer, tagging detectors
- Spectrometers with good PID



Beam Technologies

Colliding Beams

- Colliding Beam Dynamics and Technology
- High-Gradient Crab Cavities
- Computational Accelerator Techniques

Luminosity

- Electron Cooling
- High-Current Energy Recovery Linear Accelerator

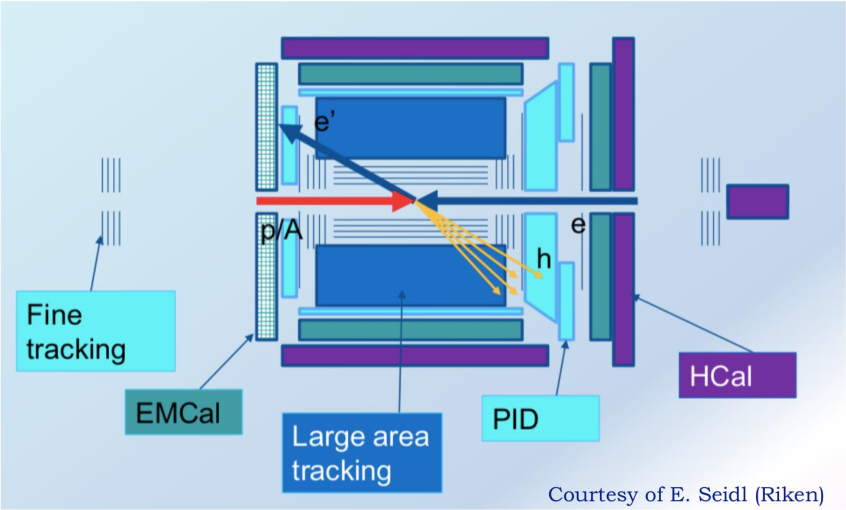
Polarization

- Intense Polarized Electron and Ion-Beam Sources
- Efficient Spin Manipulation in Polarized Beams

Accelerator

- Superconducting and Super-ferric Magnet Technology
- Advanced Accelerator Design and Modeling

Generic Detector Concept



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

Detectors R&D opportunities 1/2

- Tracking (Vertex, Main, Forward-Backward)
  - TPC (e.g. sPHENIX like)
  - Straw Tube (e.g. PANDA like)
  - Silicon Detectors (many options under evaluations: MAPS MIMOSA/STAR or ALPIDE/ALICE, Low Gain Avalance Detector from ATLAS ...)
  - Micromegas (e.g. CLAS12 like), GEM, uRWell
  - Retractable Roman Pot
- Calorimetry
  - EM (Barrel, Forward, Backward): homogeneous/sampling; APD - SiPM sensors; high res. crystal PWO_4 for ID
  - Hadron Calorimeter, Zero Degree
- Luminosity Monitor
- Polarimetry

Detectors R&D opportunities 2/2

- Particle ID
  - Hadrons:
    - ToF (down to few ps resolution),
    - RICHes: gas + MPGD sensors, compact and modular with aerogel + Fresnel lens + MCP-PMT, Dual aerogel&gas + MPC-PMT/SiPM
    - DIRC (focusing?)
  - Electrons:
    - High res CALO,
    - HBD (threshold Cherenkov) +TPC,
    - TRD + GEM
- Trigger and Data Acquisition
  - Streaming readout
- *Simulations/Optimization and Analysis software*

http://www.eicug.org/web/sites/default/files/EIC_HANDBOOK_v1.1.pdf

Italian activities to date

- Physics
  - **Theoretical developments***
  - **Experimental proposals***
- Software - Development of a global software structure for EIC including:
  - Physics simulations
  - Detectors simulations
  - Interface with theory and accelerator physics
- PID
  - modular RICH & **dual RICH***
  - gaseous RICHwith photocatodes of diamant powder
- EM-Calorimetry (GE)
- **Streaming Readout/Triggerless DAQ***

* Sezione's activities

Conclusion

Summary and conclusion

EIC : Shedding light key questions

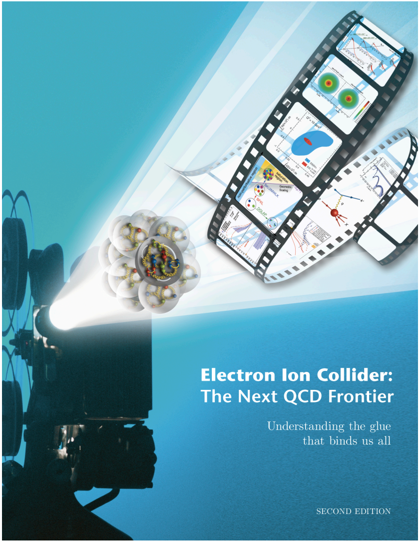
- Multidimensional structure of hadron
- Gluon saturation
- Nuclear medium modifications

A challenging machine

- Wide kinematical range and high luminosity
- R&D opportunities

Schedule

- DoE official kick start in autumn?
- Choice of site in 2020-21?
- First collision in 2030?



Thank you for your attention