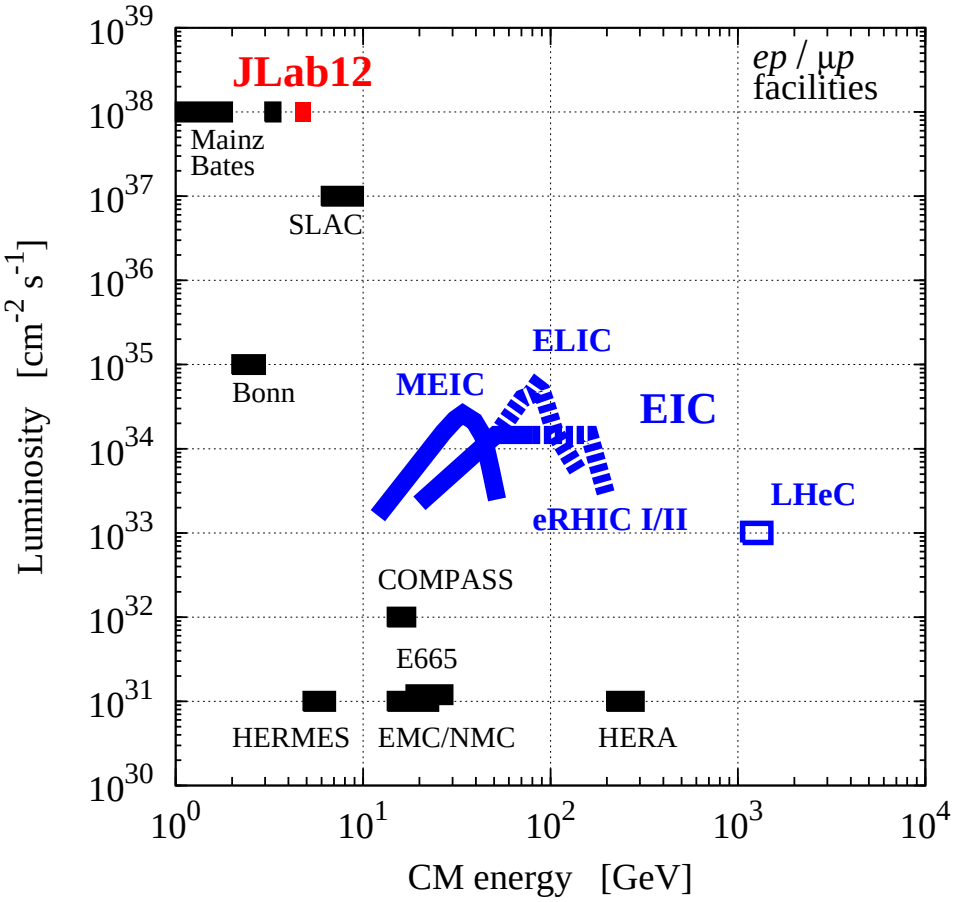
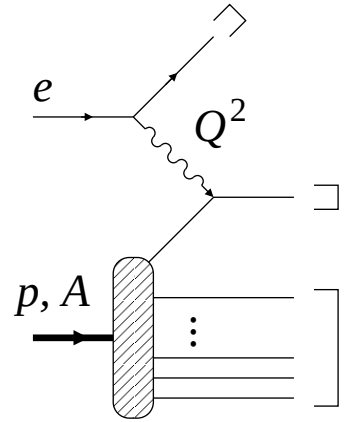
Nuclear physics at the energy-luminosity frontier: From JLab 12 GeV to an Electron-Ion Collider

L. Elouadrhiri, C. Weiss (Organizers), APS DNP Session 1WA, 23–Oct–13





- Scattering energy

  Resolution scale $1/Q$

  Target configurations, types of constituents

- Luminosity

  Rare processes, exceptional configurations

  Multi-variable final states

  Polarization effects

This workshop
Physics at "energy–luminosity frontier"
Complementarity JLab 12 GeV – EIC
Status and prospects of EIC

Physics topics

I) Three–dimensional structure of nucleon in QCD — Xiangdong Ji

Quark/gluon number densities
Spin and orbital motion
Spatial distributions
Multiparticle correlations

II) QCD in nuclei – short distances, high energies — M. Sargsian

Short–range structure and NN interaction in QCD
Modification of nucleon's quark/gluon structure
Collective effects: Shadowing, diffraction
High gluon densities and saturation

III) Emergence of hadrons from color charge — W. Brooks

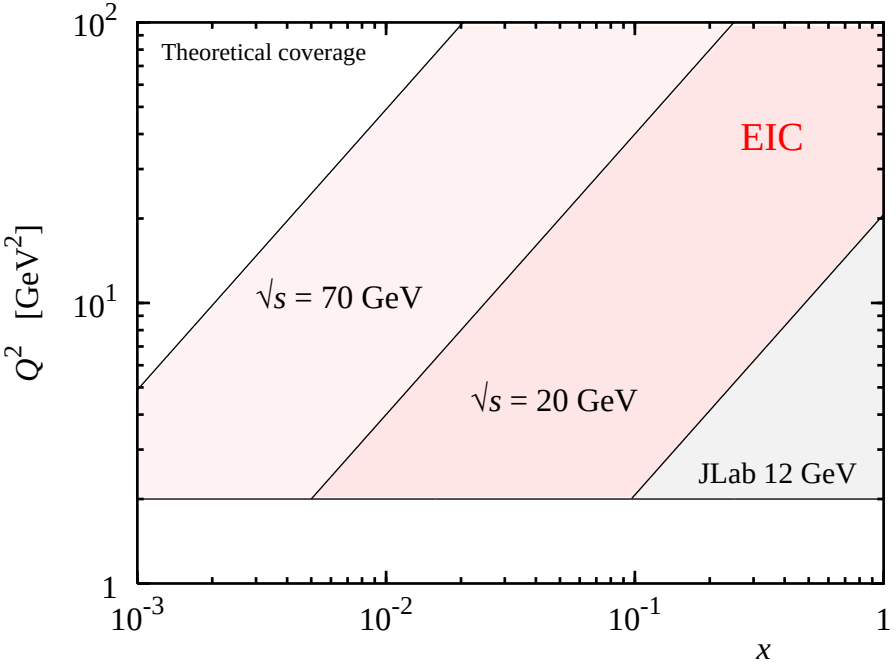
Parton fragmentation, color neutralization, hadron formation
Interaction of color charge with matter

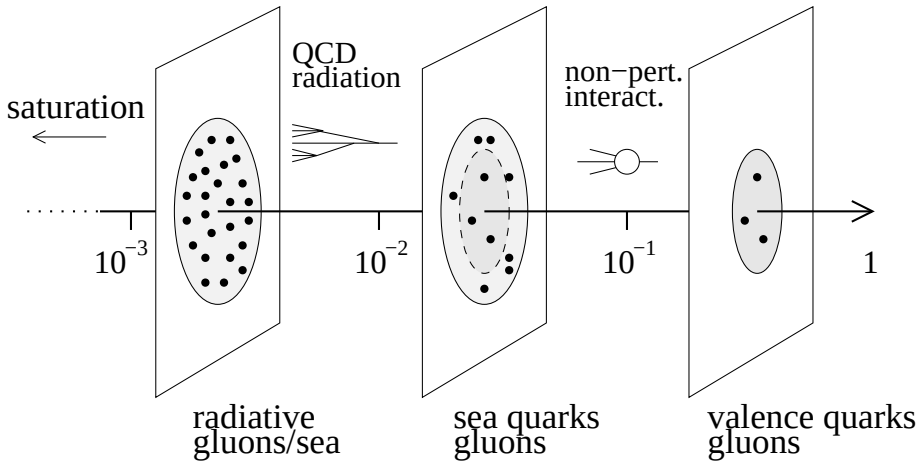
Natural complementarity/evolution JLab 12 GeV $\rightarrow$ EIC

Other topics: Electroweak physics, hadron spectroscopy, in DNP sessions!

Other contexts for EIC physics: RHIC Spin, HERA ep, RHIC/LHC heavy–ion, not excluded!

Physics: 3D nucleon structure in QCD





- Relativistic many–body system

  Particle number changes with energy and resolution scale!

  JLab 12 GeV: Valence quark component, incl. $x \to 1$

  EIC: Sea quarks, gluons, scale dependence

- Physical charateristics

  Quark/gluon number densities, incl. spin and flavor dependence — PDFs

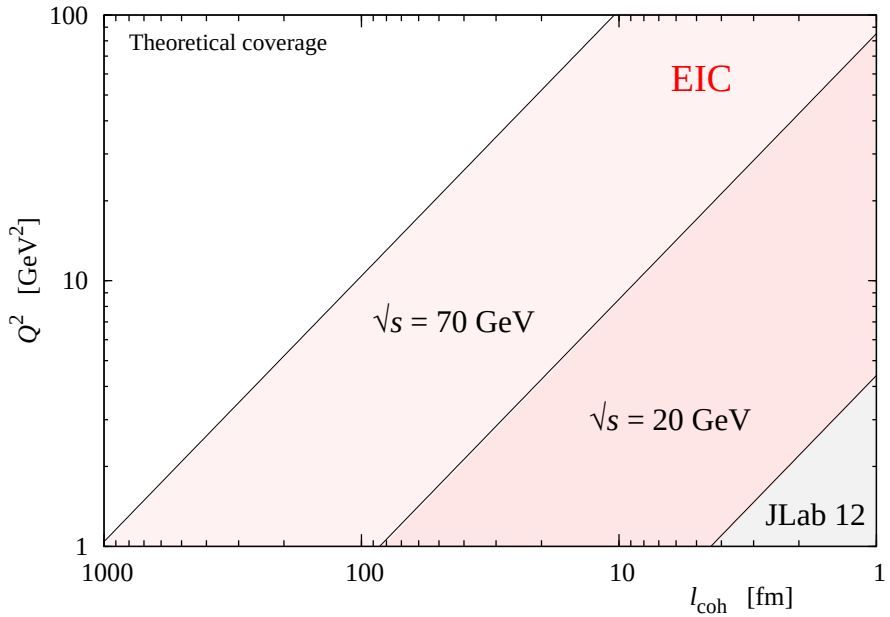
  Transverse spatial distributions — GPDs

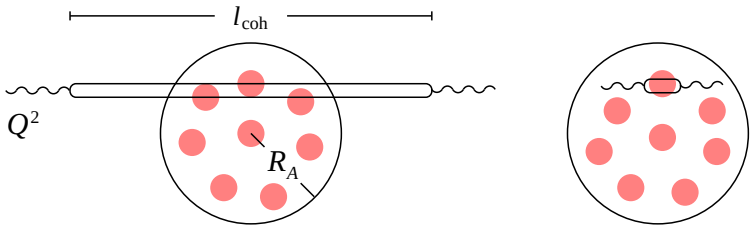
  Orbital motion — TMDs

  Multiparticle correlations — GPDs, higher twist

Reveal structure in unprecedented detail!

Physics: QCD in nuclei





- Small–size probe of color fields

  Color fields change with energy and probe size!

- JLab 12: Coherence length short

  Short–range correlations, QCD origin of NN interaction

  Quark structure of bound nucleon

- EIC: Wide range of probe size and coherence length

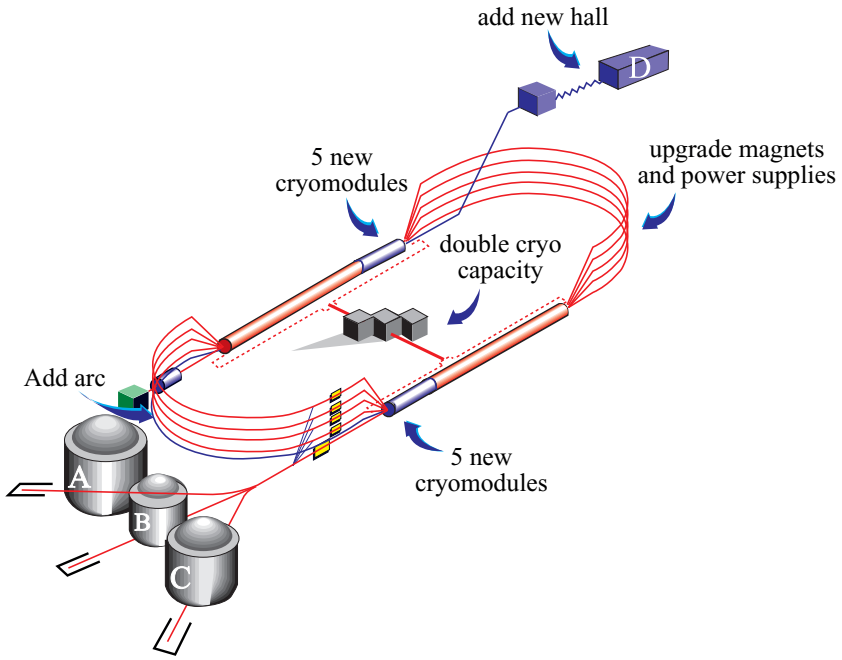
  Collective color fields in nuclei: Shadowing, diffraction, transparency

  Nuclear sea quarks and gluons

  High gluon densities, saturation

Explore region of new QCD phenomena!

Facilities: JLab 12 GeV



CW beam $\sim 100\,\mu A$
Energy before upgrade 6 GeV
Accelerator operating since 1994

- CEBAF "race track" accelerator with linacs + arcs

  Uses unique superconducting RF technology

  Extensible to max. 24 GeV

- Experimental halls

  A, C Magnetic spectrometers
  B Large–acceptance detector CLAS

- JLab 12 GeV Upgrade

  Double beam energy 6 $\rightarrow$ 12 GeV
  Largely complete, accelerator to be commissioned

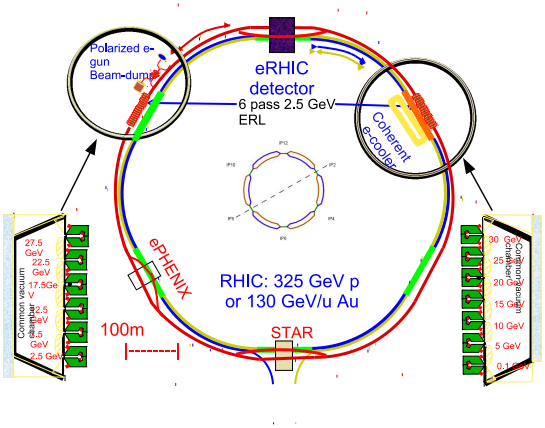
  Add Hall D: γ beam, GlueX detector
  Hall construction finished, detector assembly on-going

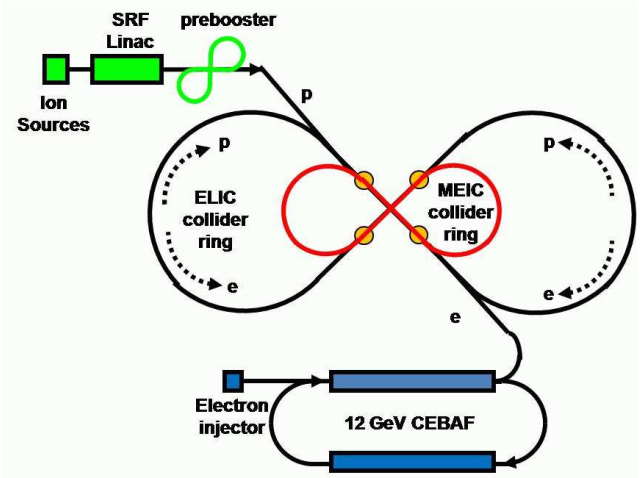
  New/upgraded detectors in exisiting halls:
  CLAS12 in Hall B, SHMS in Hall C
  Assembly on-going

  DOE project (CD0 2004, CD3 2008)
  Total cost $\sim$ 300M$

Facilities: Electron–Ion Collider

A. Deshpande





Convergence in design parameters, "staging."
Different technological challenges!

First eA collider, first polarized!

- BNL linac–ring design eRHIC

  RHIC proton/ion beam up to 325 GeV
  5–20 (30) GeV electrons from linac in tunnel staged
  Luminosity $\sim 10^{34}(10^{33})$ cm^{-2}s^{-1} over wide range
  Re-use RHIC detectors? PHENIX, STAR

- JLab ring–ring design MEIC/ELIC

  11 GeV CEBAF as injector continued fixed-target op
  Medium–energy: 1 km ring, 3–11 on 60/96 GeV
  High–energy: 2.5 km ring, 3–11 on 250 GeV
  Luminosity $\sim 10^{34}$ over wide range
  Figure–8 for polarization transport, up to four IP's
  Polarized deuteron beam possible

- Related proposals

  CERN LHeC: 20–150 GeV on 7 TeV ep unpol
  Ring–ring and linac–ring discussed, $L \sim 10^{33}$

  EIC@China project in Lanzhou
  Design targets similar to JLab MEIC

  GSI ENC: 3.3 GeV on 15 GeV ring–ring
  using FAIR HESR, $L \sim 10^{32}$ PANDA detector