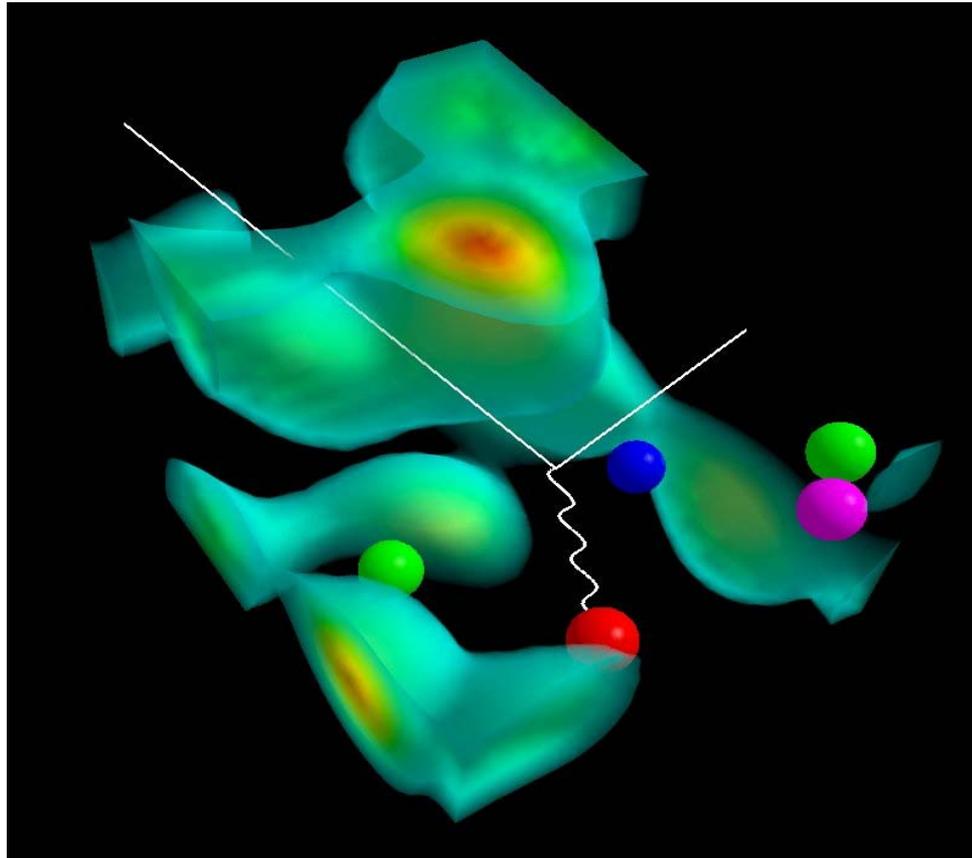


# An Electron-Ion Collider at JLab



**Anthony W. Thomas**

**DIS09 Madrid : April 30<sup>th</sup> 2009**



Thomas Jefferson National Accelerator Facility



# Long-term Landscape : ELIC

30-225 GeV p

30-100 GeV/A ions

Electron  
Cooling

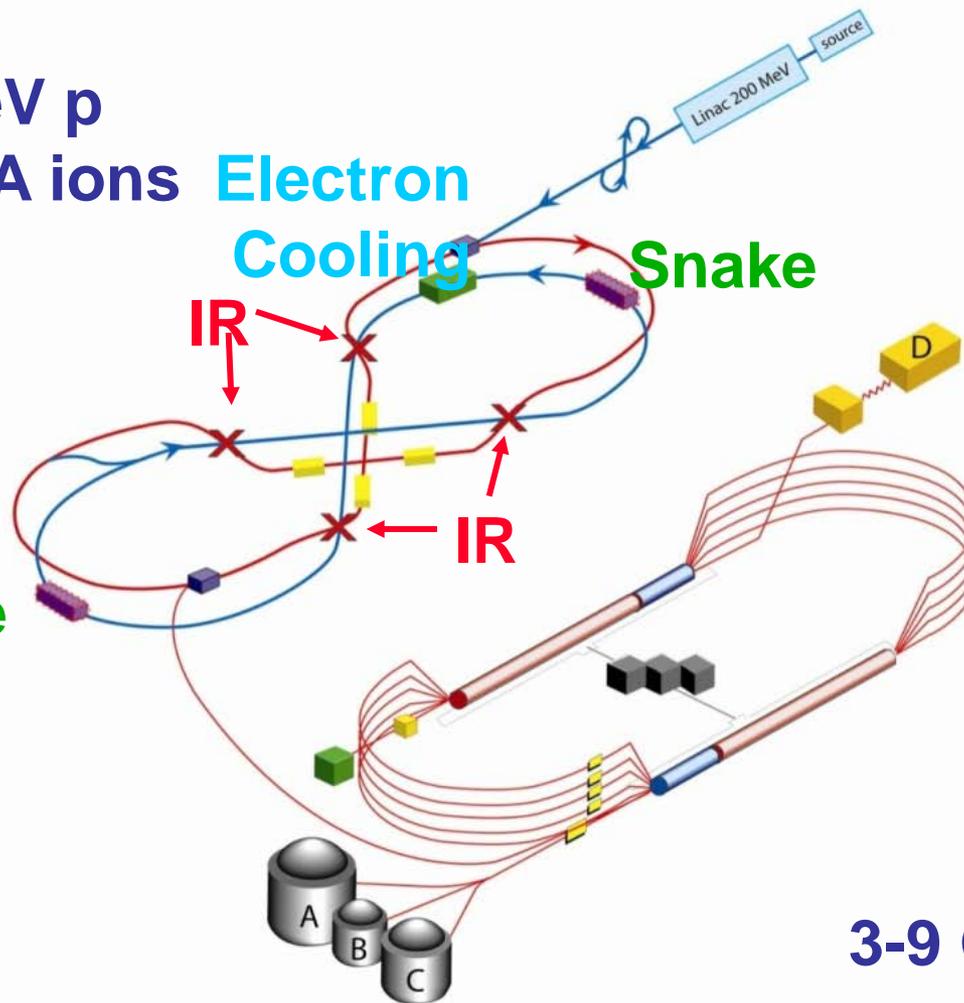
Snake

Snake

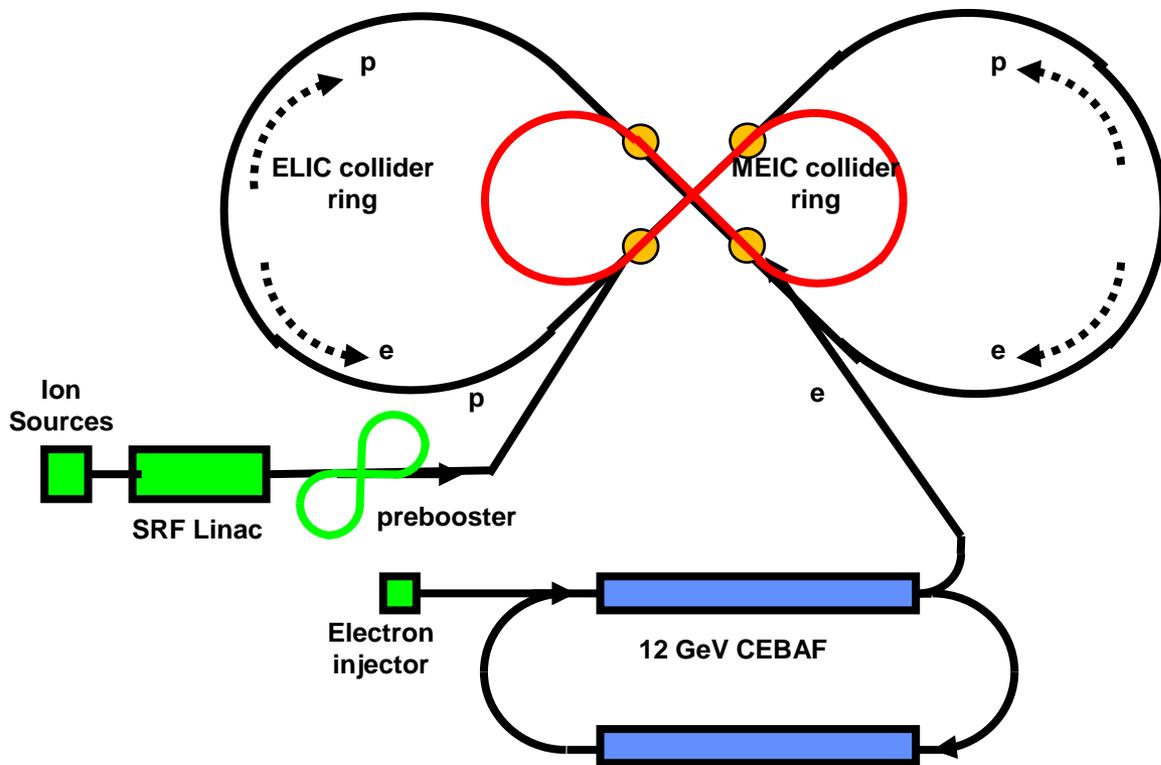
IR

IR

3-9 GeV e<sup>+</sup> and e<sup>-</sup>



# Consideration of Staging – Medium Energy



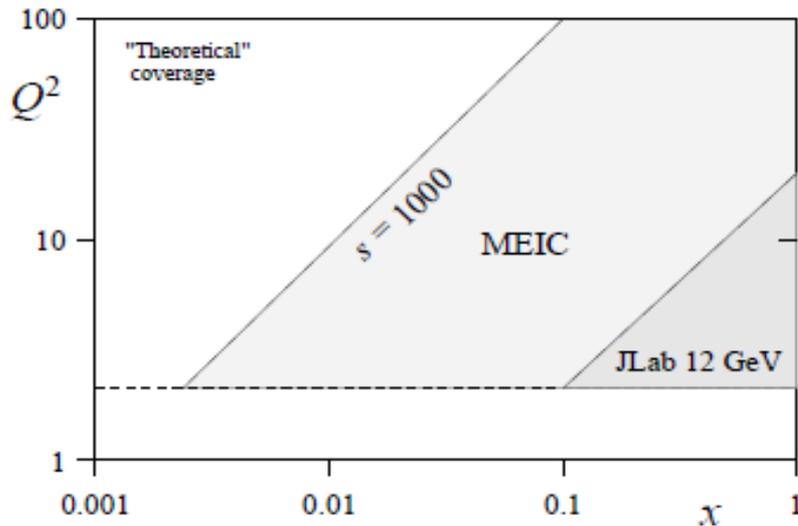
MEIC parameters	Length (m)
Arc	157
Straight section	150
Insertion section	10
Circumference	634

# A High-Luminosity Medium-Energy Collider (MEIC) for Nuclear Physics at JLab

- Ring-ring collider with
  - electron energies ranging from **3 to 11 GeV**
  - proton energies ranging from **12 to 60 GeV**
- Luminosity  $L \sim \text{few} \times 10^{34}$ , approaching  $10^{35} \text{ cm}^{-2} \text{ s}^{-1}$
- Requires **less R&D**, parameters within reach
- Physics: **Nucleon/nuclear structure in QCD**  
(*Gluon and sea quark imaging of the nucleon, nucleon spin, nuclei in QCD, QCD vacuum and hadronic structure*)
  - Natural extension of 12 GeV
  - Consistent with NSAC Long-Range Plan



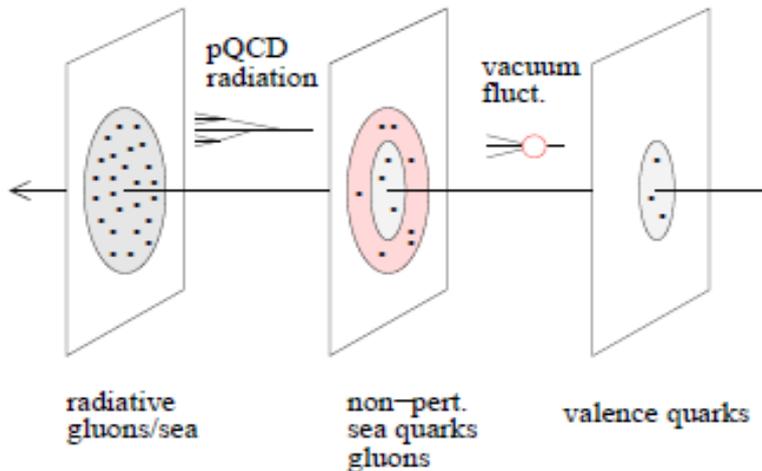
# Scientific Opportunities with Medium Energy EIC



- 12 GeV upgrade will map the spin and flavor dependence of pdfs in valence region

## Medium Energy Collider

- Precise exploration of spin and flavor dependence in sea



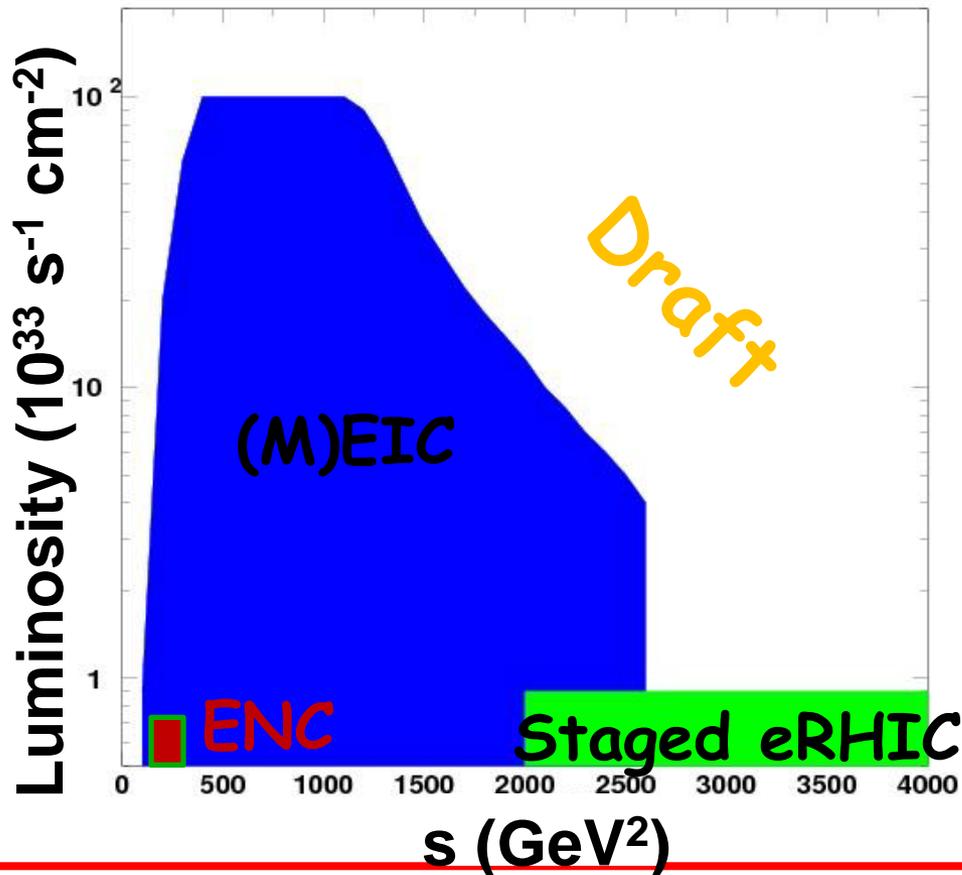
- GPDs & transverse spin to investigate orbital angular momentum of quarks and gluons & spatial distribution

- Quark and gluon structure of nuclei (flavor & spin too) through the shadowing region

- $J/\Psi$  production, fragmentation....

# (M)EIC@JLab: Present Status

MEIC Baseline Parameters



## Plot assumptions:

- 1) Detector/DAQ/electronics limits the luminosity to  $10^{35}$
- 2) Scale to higher electron beam energies (up to 11 GeV) at fixed synchrotron limit
- 3) Luminosity for staged eRHIC at 2 on 250 is similar as for 4 GeV on 250 GeV (from EICAC meeting)

- Design provides excellent luminosity for  $200 < s < 1200$  ( $x = 0.0008$  @  $Q^2 = 1$ )  
( $x = 0.01$  @  $Q^2 = 12$ )
- Good luminosity ( $10^{33}$  or more) down to  $s = 100$  and up to  $s = 2640$   
(can access gluons down to  $x = 0.001$  or so)

# MEIC Parameter Table: Medium Energy

Beam energy	GeV	60/5	60/4	60/3	45/5	45/4	45/3	30/5	30/4	30/3
Circumference	m	560	560	560	560	560	560	560	560	560
Beam current	A	0.6/2	1.2/3.2	2.7/5	0.5/2	0.6/2.3	2.1/5	0.7/2	0.5/3.5	0.6/4
Repetition	GHz	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Particles/bunch	$10^{10}$	0.7/2.5	1.5/4	3.4/6.3	0.6/2.5	0.7/2.9	2.6/6.25	0.9/2.5	0.7/4.4	0.8/5
Bunch Length	mm	5	5	5	5	5	5	5	5	5/5
Norm. hori. emit.	$\mu\text{m}$	1/147	1/120	0.8/75	0.7/147	0.5/85	0.6/75	0.5/147	0.4/85	0.4/75
Norm. vert. emit.	$\mu\text{m}$	0.1/15	0.2/24	0.8/75	0.14/29	0.17/28	0.6/7.5	0.5/147	0.4/85	0.4/75
Horizontal $\theta^*$	mm	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5
Vertical $\theta^*$	mm	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5
Size at IP (x/y)	$\mu\text{m}$	8.7/2.7	8.8/3.9	8	8.7/3.9	7.4/4.3	8	8.7	7.4	8
Hori. Beam-beam		.005/.002	.007/.04	.009/.1	.006/.01	.009/.02	.012/.08	.006/.01	.015/.02	.015/.02
Vert. beam-beam		.015/.05	.015/.09	.009/.1	.013/.03	.015/.04	.012/.08	.006/.01	.015/.02	.015/.02
Laslett tune shift	proton	0.1	0.1	0.055	0.1	0.1	0.1	0.1	0.1	0.1
Luminosity ( $10^{34}$ )	$\text{cm}^{-2}\text{s}^{-1}$	3	6.8	13	1.8	2.7	10	1.2	2.1	3.1

- Luminosity is given as a peak value per IP, may be reduced by other beam dynamics effects. We assume maximum allowable synchrotron radiation (SR) power density is 20 kW/m.
- We can allow 60x11 GeV/c (CM energy up to 51 GeV) with a luminosity of  $1.3 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ .
- Case of 60x3 GeV/c provides highest luminosity (above  $10^{35}$ ) due to optimization of low electron energy (low SR power) and high proton energy (low space charge effect)
- Studies of new ideas/concepts for increasing luminosity for low proton energy are in progress

# MEIC Accelerator R&D

- Key R&D for MEIC are
  - electron cooling for delivering low emittance/ultra short ion bunches
  - Traveling focusing for suppressing space charge effect & boosting luminosity
  - Crab cavity required for colliding high repetition beams
  - Forming high intensity low energy ion beam
  - Beam-beam effect
- There are other less critical/challenging R&D topics but required by ZDR

Level of R&D	MEIC	ELIC
Nearly impossible		
Very challenging		Electron cooling
Challenging	Electron cooling Traveling focusing	Crab crossing/crab cavity
Likely	Crab crossing/crab cavity High intensity low energy <i>i</i> beam Beam-beam	High intensity low energy <i>i</i> beam Beam-beam
Know-how	Spin tracking IP design/chromaticity	Spin tracking IP design/chromaticity

# Back-up



# MEIC Design Features

- An ultra high luminosity collider, up to above  $10^{35} \text{ cm}^{-2}\text{s}^{-1}$  per detector
- CM energy from 8 GeV (4x4 GeV/c) up to 51 GeV (60x11 GEV/c)
- Up to 4 IPs (1 for low proton energy, 3 for medium proton energy)
- High polarization for both electron and light ion beams (due to Figure-8 ring)
- Natural staging path to high energy ELIC (250x10 GeV)
- Can also be staged (1<sup>st</sup> stage with warm ion ring, up to 12 GeV/c)
- Possibility of polarized positron-ion collider in the same low to medium energy region with same high luminosity.
- Significant lower cost comparing full ELIC