eRHIC Overview

- Why is it important and timely to study the fundamental origin of observable matter?
- Why a high luminosity lepton-ion collider?
- Why now?
- Why eRHIC?
- eRHIC conceptual design
- Cost
- Schedule

Why study the fundamental structure of matter?

- QCD is the gauge theory which provides the basis for understanding the nucleon and atomic nuclei
- The valence quark region is well explored experimentally and reasonably well understood theoretically
- Frontier research in QCD demands a concerted experimental effort directed at the role of the gluons and sea quarks
- A new accelerator which directly probes the quarks and gluons is required

  Lepton probe
  High center of mass energy
  High luminosity $\Rightarrow$ precision vs. *ab initio* QCD
  Polarized lepton, nucleon
  Optimized detectors
- This accelerator is urgently needed to make progress in this field of research and has substantial discovery potential

Crucial, open questions to be addressed by eRHIC

- **Spin structure of the nucleon** *See talk by Abhay*
  - $g^p_1(x)$ at low x **dramatic QCD prediction**
  - gluon and sea quark polarization
  - new (GPD, transversity) parton distributions
- **Partonic understanding of nuclei** **hot QCD**
  - gluon momentum distribution in nuclei
  - fundamental explanation of nuclear binding
  - saturation, color glass condensate *See talk by Raju*
- **Test QCD**
  - Precision: Bjorken Sum Rule
  - Novel physics: Hard diffraction

Significant discovery potential

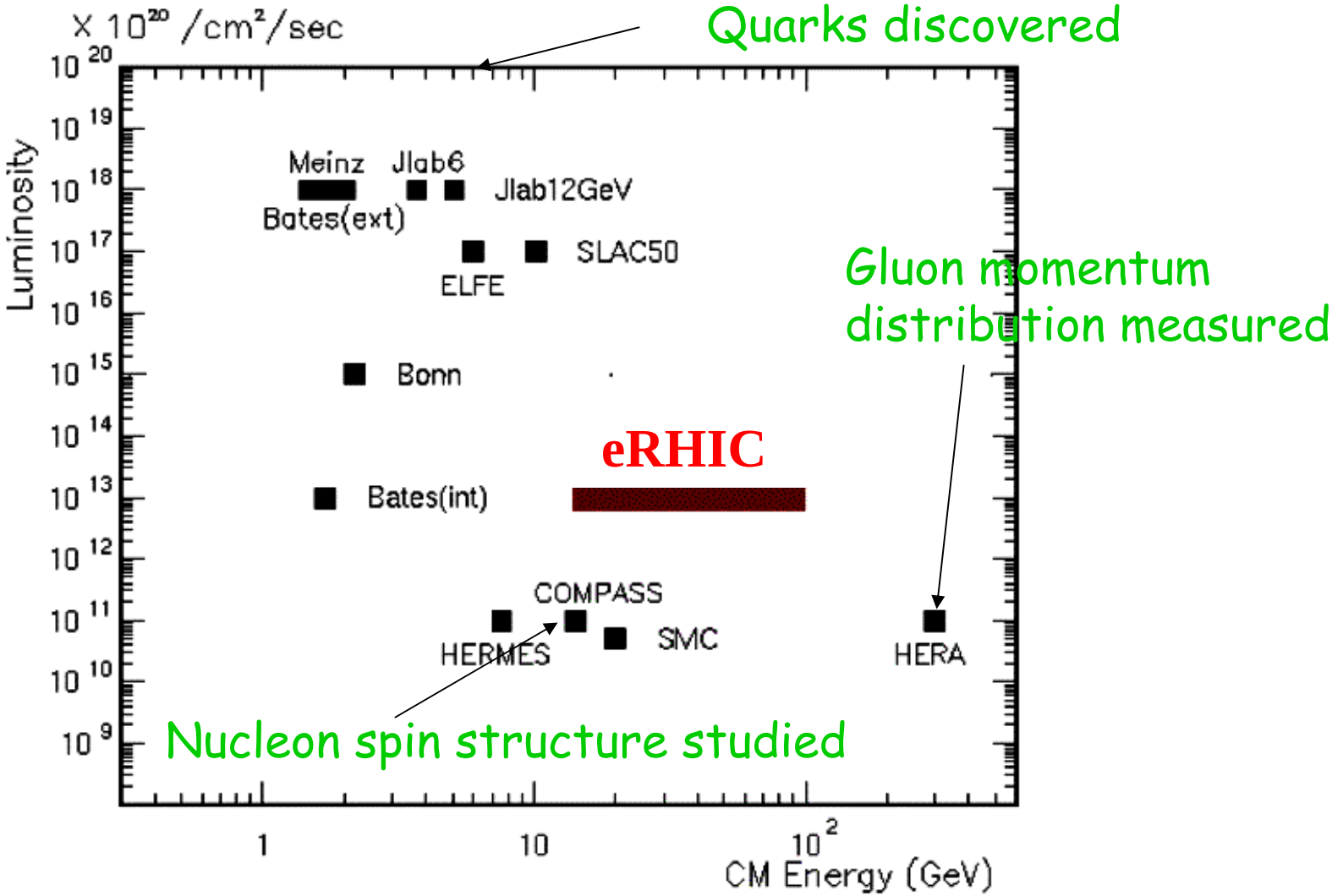
Why a high luminosity lepton-ion collider ?

- Lepton probe provides precision but requires high luminosity to be effective
- High $E_{cm} \Rightarrow$ large range of x, Q^2 $\quad Q_{max}^2 = E_{CM}^2 \cdot x$

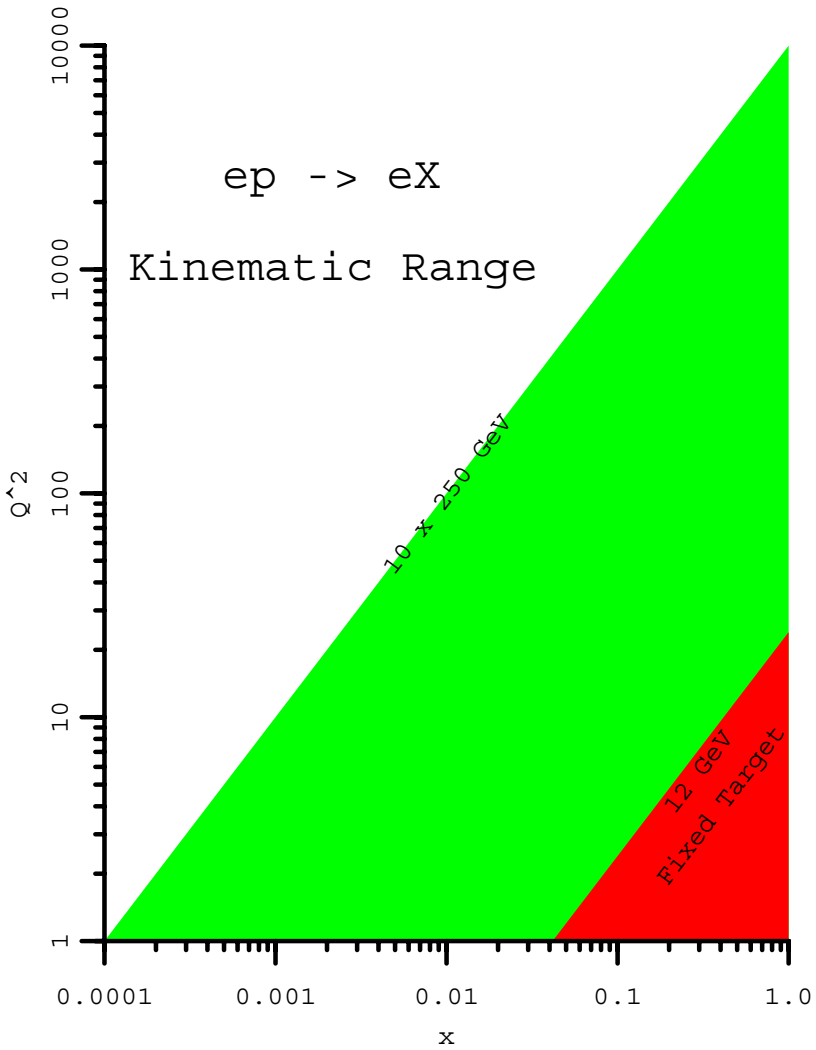
  x range: valence, sea quarks, glue

  Q^2 range: utilize evolution equations of QCD
- High polarization of lepton, nucleon achievable
- Complete range of nuclear targets
- Collider geometry allows complete reconstruction of final state

eRHIC will be a unique accelerator



Q^2 and x Range of eRHIC



- E_e=5-10 GeV
- E_p=30-250 GeV
- $s^{\frac{1}{2}}$=25-100 GeV
- x_{Bj}=10^{-4} to 0.7
- Q^2=0 to 10^4 $(GeV/c)^2$
- polarization of $e^{\pm}$, p, ^{3}He ~ 70%
- heavy ion beams of all elements
- high luminosity > 10^{33} cm^{-2} s^{-1}

Why now?

- Understanding the fundamental structure of matter of central importance in physics, e.g.
  - Spin structure of the nucleon
  - Partonic understanding of nuclei
- Over last 40 years increasing sophistication both in experimental techniques and theoretical understanding of DIS
- Lepton-nucleon capability disappearing at high energy lepton facilities (SLAC, Fermilab, CERN, and DESY)
- **Planning of next generation facility a matter of urgency**

Why eRHIC?

- Collider with both polarized nucleon and heavy ion beams exists at BNL
- Capitalize on ~ $ 1 billion investment in RHIC
- Strong scientific interest from RHIC community
- In March 2002, the leading lepton-collider option was identified as a ring-ring configuration using the existing RHIC collider: eRHIC
- Even with these advantages it will take a significant amount of time to realize eRHIC
- eRHIC complementary to other research efforts within the US and worldwide
- eRHIC is an opportunity for the United States to enhance leadership worldwide in an important field of science

eRHIC evolution

- Substantial international interest in high luminosity (~$10^{33}cm^{-2}s^{-1}$) polarized lepton-ion collider over decade
- Workshops

Seeheim, Germany	1997	MIT, USA	2000
IUCF, USA	1999	BNL, USA	2002
BNL, USA	1999	JLab, USA	2004
Yale, USA	2000		

- eRHIC received favorable review of science case in US 2001 Nuclear Physics Long Range Plan, with strong endorsement for R&D
- At BNL Workshop in March 2002, a plan was formulated to produce a conceptual design for ERHIC within three years
- NSAC in March 2003, declared eRHIC science `absolutely central' to future of Nuclear Physics
- eRHIC identified in November 2003 as future priority in DOE Office of Science 20 year planning

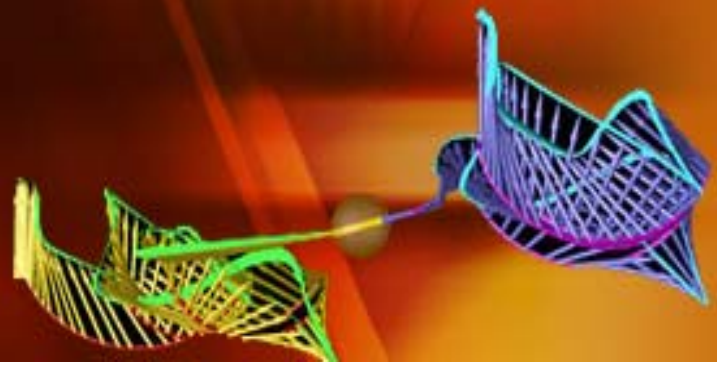
Steering Committee

- A. Caldwell (MPI Munich)
- A. Deshpande (StonyBrook)
- R. Ent (JLab)
- G. Garvey (LANL)
- R. Holt (ANL)
- E. Hughes (Caltech)
- K.-C. Imai (Kyoto Univ.)
- R. Milner (MIT)
- P. Paul (BNL)
- J.-C. Peng (Illinois)
- S. Vigdor (Indiana Univ.)

July 17-22, 2006

Workshop on QCD: Future Perspectives

Hosted By: Brookhaven National Laboratory



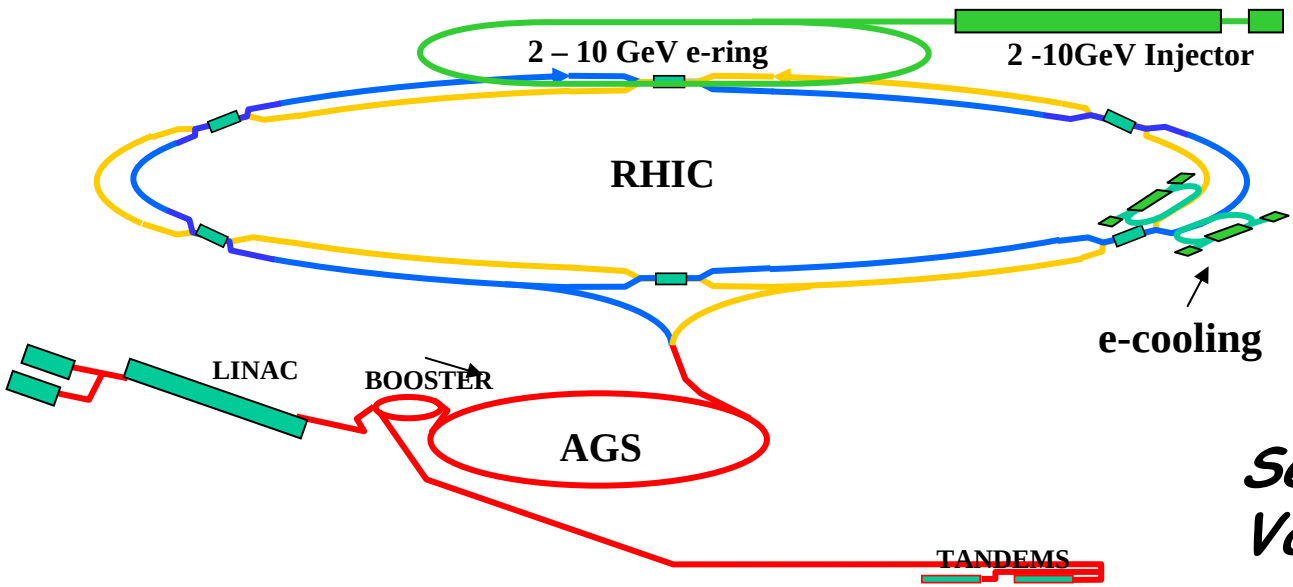
- Long Range Planning Exercise for Nuclear Physics planned to start Fall 2006
- Goal: identification of eRHIC as a major priority for new construction
- QCD: Future Perspectives Workshop at BNL in July
  RHIC+ RHIC/spin+RHIC II + eRHIC + JLab@12GeV+……
- APS study of QCD under consideration
- Detector R&D meeting
- Polarized electron source workshop
- Optical stochastic cooling workshop

eRHIC Machine Design

- A Zero-order Design Report (ZDR) has been completed in March 2004 and reviewed by the BNL MAC in June 2005
- Endorsement of basic design with many good technical criticisms and suggestions
- The leading eRHIC design concept is a ring-ring configuration and will reach ~10^{33} cm^{-2} s^{-1} luminosity
- The present design includes a full energy linac injecting polarized electrons (positrons) into a 10 GeV electron ring
- A more ambitious linac-ring concept is also under consideration to reach luminosity ~ 10^{34} $cm^{-2}s^{-1}$

Possible eRHIC layout

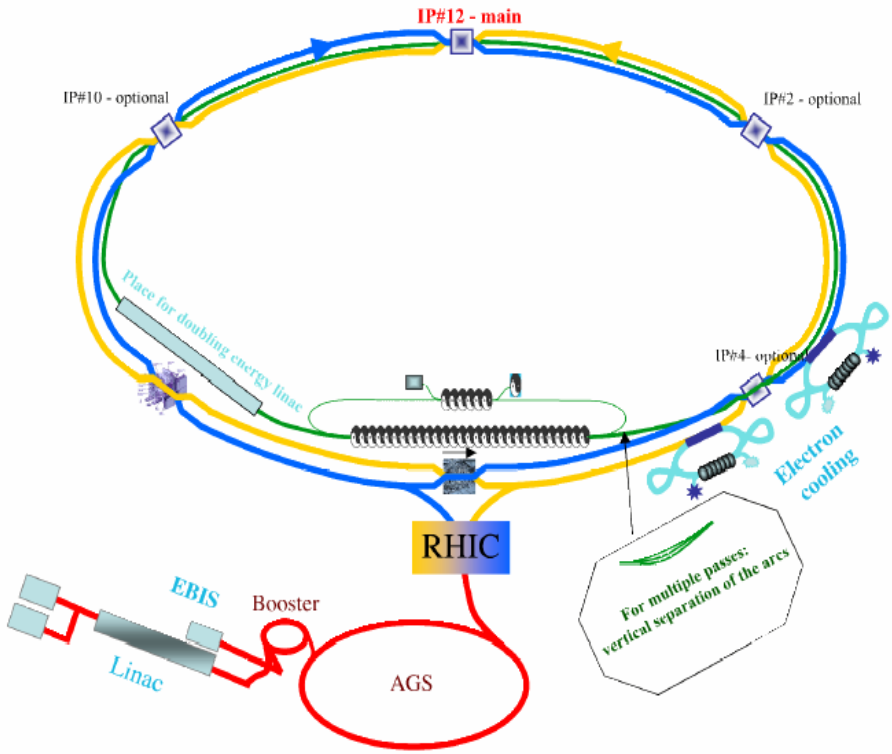
- Collisions at 12 o'clock interaction region
- 10 GeV, 0.5 A e-ring with 1/3 of RHIC circumference
- Inject at full energy 5 – 10 GeV
- Existing RHIC interaction region allows for typical asymmetric detector (similar to HERA or PEP II detectors)



See talk by Vadim

eRHIC: linac-ring concept

- Two possible designs are presented in the ZDR
- Electron beam is transported to collision point(s) directly from superconducting energy recovery linac (ERL)
- Features:
  - Higher luminosity (~ X 5) possible
  - Rapid reversal of electron polarization
  - Machine elements free region approx. ±5m
  - Simpler IR region design: Round beams possible
  - Multiple interaction regions
  - No positrons



eRHIC ring-ring design concept estimated cost (FY06$)

10 GeV Electron injector	$ 130M
10 GeV Storage ring	$ 170M
Detector	$ 120M
Interaction region	$ 10M

Total Estimated Direct Costs	$430M
EDIA; Conting@25%; ProjG&A	$220M
Total Estimated Costs (w/o escalation)	$650M

Cost framework well understood and stable

Present Schedule Estimate

- 2007 NSAC approval
- 2009 Q1 CD0
- 2008-10 R&D funding
- 2010 Q1 CD1
- 2011 Q1 CD2
- 2012 Q1 CD3 (begin construction)
- 2016 Q4 CD4 (commissioning begins)

Urgent Priorities

- Urge increased support for long term R&D
  Important examples include
  - development of polarized ^{3}He ion source for RHIC
  - demonstrate optical stochastic cooling
  - polarized electron source technology
- Urge support for resources for eRHIC detector and simulations group

See talk by Bernd

Summary

- eRHIC is required within a decade to maintain progress in the study of the fundamental structure of matter

  spin structure of nucleon

  partonic basis of atomic nuclei

- eRHIC is an outstanding scientific opportunity to realize the next generation QCD machine in a cost effective way
- An eRHIC accelerator design has been developed based on realistic considerations and which can deliver luminosity close to 10^{33} cm^{-2} s^{-1} - cost model is well understood
- The more ambitious linac-ring concept has the potential to yield higher luminosity and is under development
- Urgency to realize eRHIC driven by strength of scientific case and interest from worldwide community
- We request the resources and support to make a convincing case to broad nuclear physics community over next year for eRHIC