

Physics Consequences of Various eRHIC Designs



Abhay Deshpande
Stony Brook University & RBRC
June 13, 2005

Designs

- ◆ Ring Ring (ZDR)
- ◆ Linac-Ring (Are we separating these in this review?)
 - Linac-Ring (MIN) 1 IR
 - Linac-Ring (MAX) 4 IRs



Physics Frontiers of eRHIC

- ◆ Nucleon structure
 - Quark and gluon distributions & correlations
 - Understanding the nucleon spin structure
- ◆ Study of hard scattering in nuclear environment
- ◆ Study of extreme nuclear environment!
 - Precision study of physics of saturation or color glass condensate

Tools needed for physics goals

◆ Nucleon structure including its *spin*

- Polarized lepton
- Polarized nucleon beams
- High enough beam energy
- Beam energy variability

◆ QCD in nuclear environment

- Nuclear targets from p to heavy nuclei Pb U with few intermediate steps
- Energy variation of the beam

◆ At least one state-of-the-art e-p/A detector

Advantages of a collider

- ◆ Geometry: inclusive, semi-inclusive, exclusive measurement
- ◆ High Center of Mass energy
- ◆ For spin experiments in addition: lowest dilution factor
- ◆ A cartoon of geometry



Deep Inelastic Scattering & Types of Scattering

- ◆ Feynman diagram
- ◆ Inclusive, semi-inclusive and exclusive measurements
- ◆ Comments on luminosity requirements
- ◆ Comments on detector acceptance and its close correlation with the IR design
 - Reference to talks by B. Surrow & C. Montag et al.

Nucleon structure (I)

◆ Physics topics of interest

- High statistics measurement of c,b physics
- Low x , low Q^2 measurements related to physics of confinement
- Transition from QCD to perturbative QCD
- F_L

◆ Comment on equipment requirement if unique (accelerator parameter or detector issues)

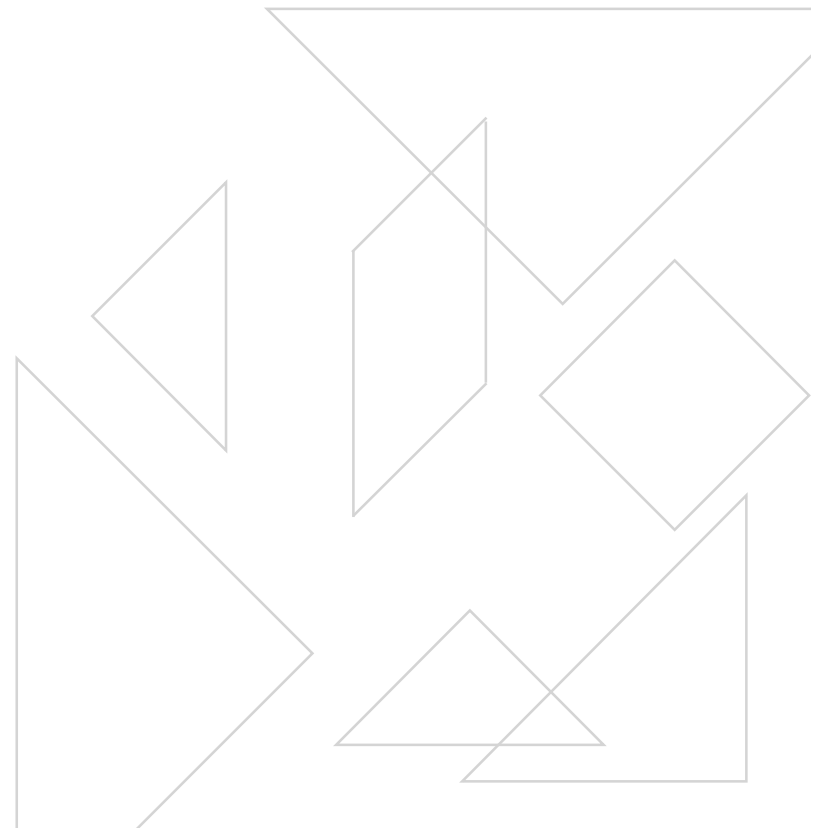
Nucleon Structure (II)

- ◆ High η physics or forward physics with dedicated detector
 - Acceptance requirement details in Surrow's talk?
 - Comment on the IR design requirements and refer to C. Montag's talk
 - Possible connection to linac or ring design

Nucleon spin structure (I)

- ◆ Spin program measurement list
- ◆ Comments on uniqueness of some measurements and unique requirements
- ◆ Emphasis on electron and positron requirements for $W^{+/-}$ requirements
- ◆ Emphasis on GPDs (beam charge/spin asymmetries) and emphasize that this is an evolving physics field, the terrain in 2013-15 might be very different than today

Nucleon Spin Structure (II)



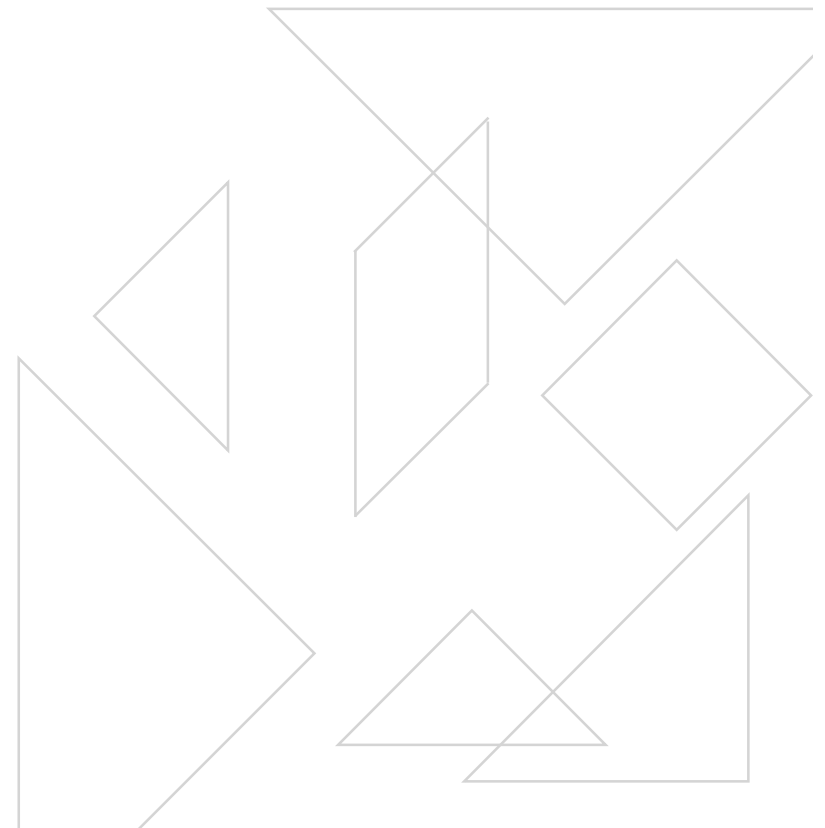
6/13/2005

1 BNL C-AD Machine Advisory
0 Committee on eRHIC

QCD in nuclear environment

- ◆ Intermediate and low x physics
- ◆ Intermediate x physics first time in collider mode, ability to study target as well as current fragments
- ◆ Low x physics believed to be gluon related, thus precision measurement of gluon distribution, main goal:
 - Description of how this will be accomplished
 - ◆ Scaling violations of F_2
 - ◆ F_L measurements: beam energy variation
 - ◆ Semi-inclusive: di-jet physics

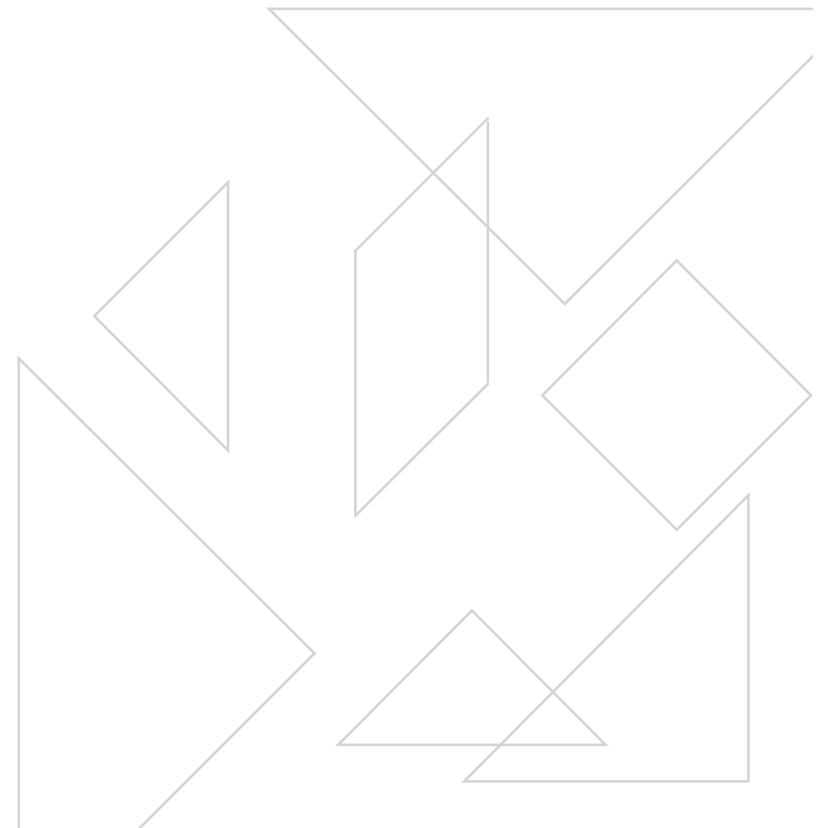
QCD in nuclear environment (II)



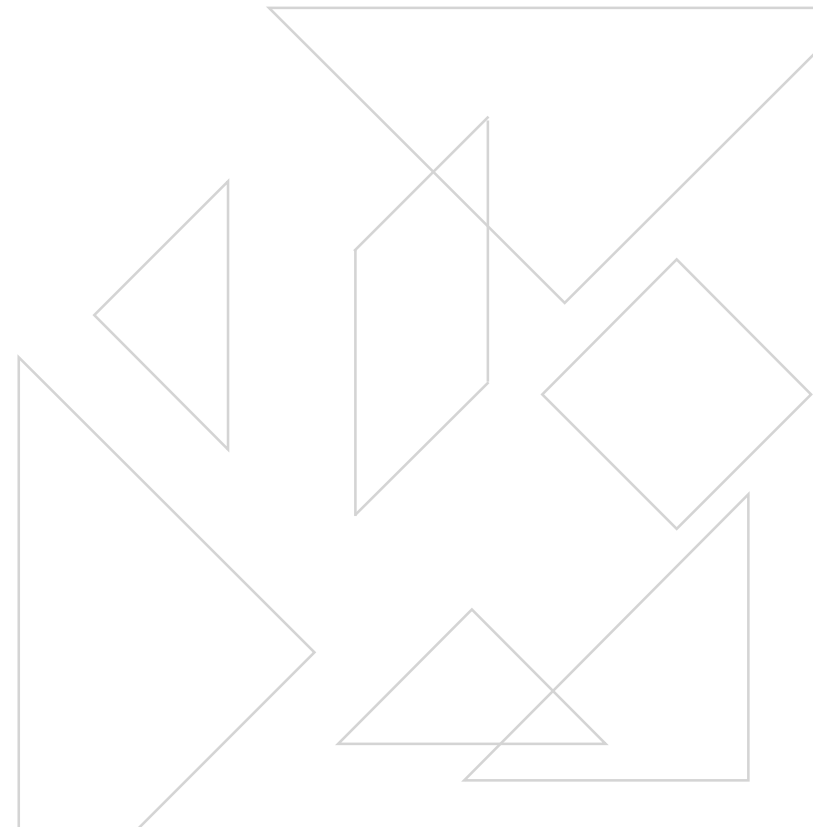
6/13/2005

- 1 BNL C-AD Machine Advisory
- 2 Committee on eRHIC

eRHIC: xq2 domain



eRHIC: CM vs luminosity domain



6/13/2005

1 BNL C-AD Machine Advisory
4 Committee on eRHIC

What physicists see in the two designs?

◆ Ring-Ring

- Polarized electron & positron beams
- ~15% effect on beam polarization vs. CM energy
- $L \sim 10^{33}$ cm²/sec (about 80 pb⁻¹/day)
- CM ~ 30 - 100 GeV
- Single IR

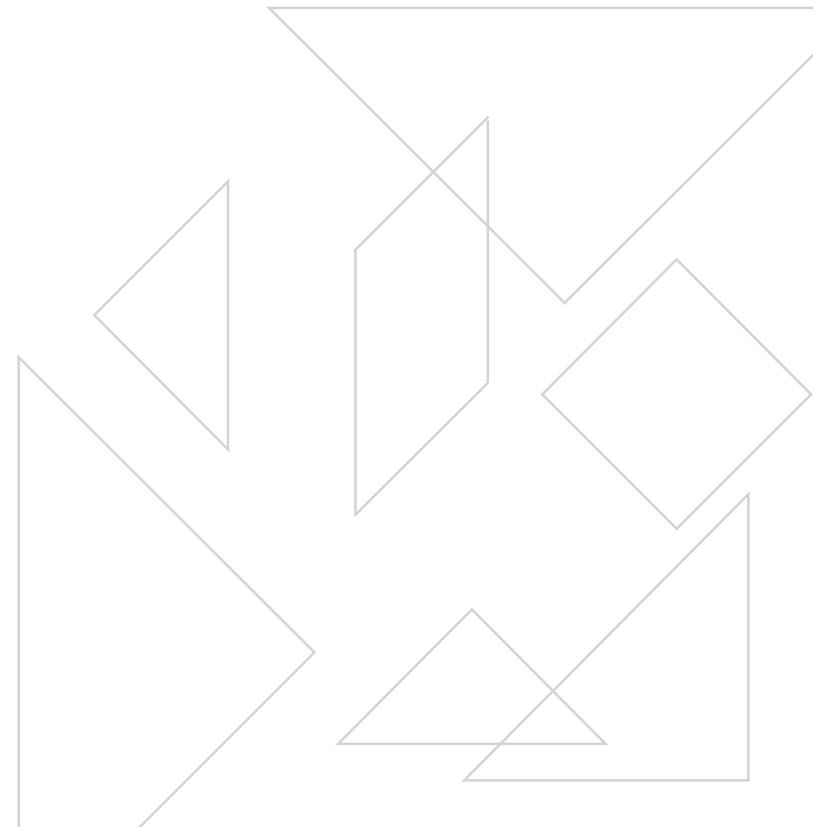
◆ Ring-Linac

- Polarized electron, un-polarized positron beams
- Beam polarization transparent to CM energy
- $L \sim 10^{34}$ cm²/sec
- CM ~ 30 - 140 GeV (add linac)
- Multiple IRs

◆ Detector/IR issues: Refer to B. Surrow, C. Montag et al.

What physics at what luminosity?

- ◆ Physics measurements and integrated luminosity (table? Bullets?) or any other way of conveying this.....



What will we lose if RR?

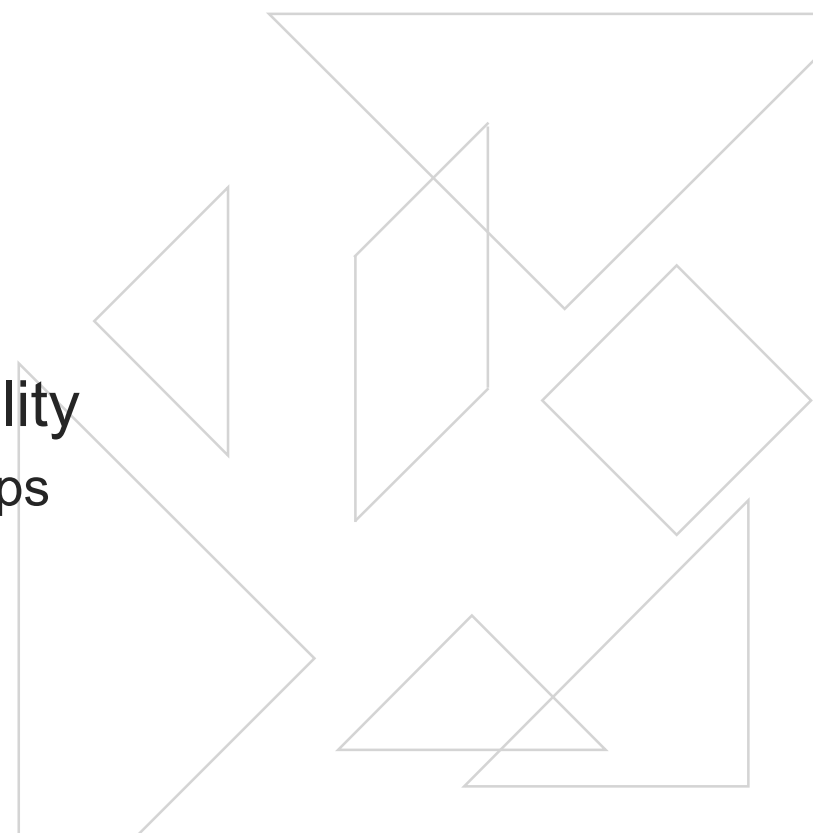
- ◆ Most physics goals presented could be achieved
 - Acceptance in IR good
 - Luminosity does not drop by more than factor 4-5 compared to original design request 10^{33} cm²/sec
- ◆ Exclusive physics program promises to lead to orbital angular momentum in future(?) *This could be challenging!*
 - DVCS
 - Vector meson production
 - Leading to Generalized Parton Distributions (GPDs)
- ◆ *Uniqueness of low x for this physics just being explored*

What will we loose with LR?

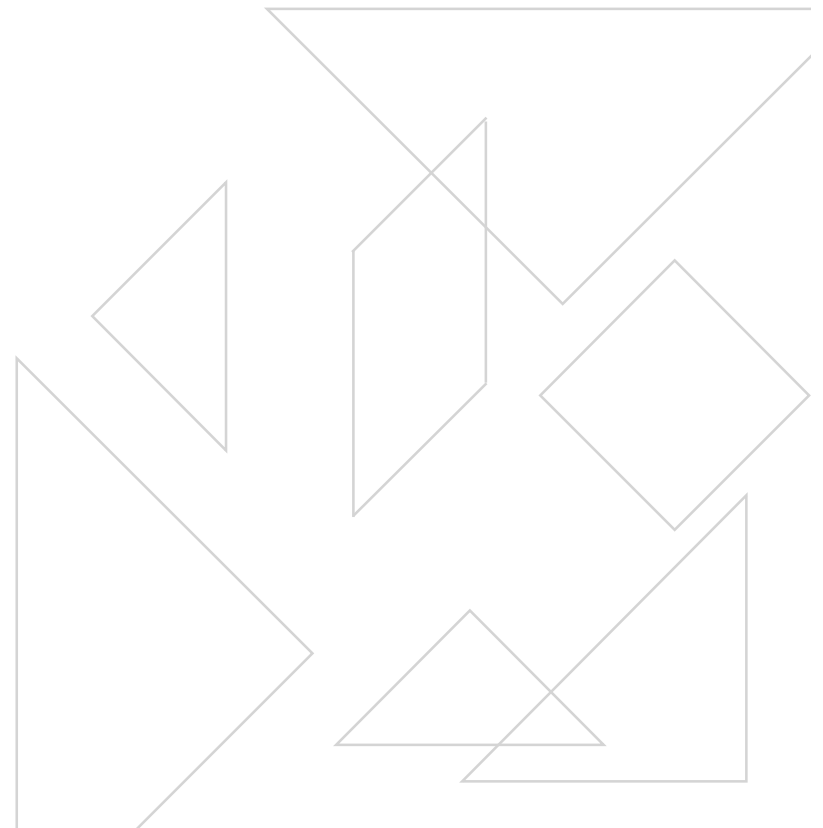
- ◆ High luminosity, upgrade possibility of future for energy and number of IRs, transparency in beam polarization through the CM energy: all very attractive features
- ◆ No polarized positron beams
 - No $W^{+/-}$, disentanglement of heavy quark distributions
 - ◆ Detailed slide of this physics with luminosity requirements and asymmetry
 - Do GPD studies of the future need polarized positron as well as electron beams? Opinion is divided... even amongst experts. Under discussion

RR vs. LR correlated issues

- ◆ Number of IRs
 - Consequences
 - LR only interesting if 4 IRs?
- ◆ Luminosity comparison
 - Consequences
 - Only one IR still worth going for?
- ◆ Future upgrade issues?
- ◆ Time scale for technical feasibility
 - Interests of different physics groups
- ◆ Cost comparison



RR vs. LR other Issues (II)



6/13/2005

2 BNL C-AD Machine Advisory
0 Committee on eRHIC

Concluding thoughts

- ◆ No matter which design realizes eRHIC will be a unique facility for QCD in the next decade
- ◆ Interest growing and expected to increase
 - May impose more stringent constraints on luminosity, polarization, detector requirement
- ◆ Far from any final decisions on the design
 - Work on both should continue until the decision needs to be made