Physics Consequences of Various eRHIC Designs

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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 a evolving physics field, the terrain in 2013-15 might be very different than today

Nucleon Spin Structure (II)

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)

eRHIC: xq2 domain

- Xq2 plot

eRHIC: CM vs luminosity domain

What physicists see in the two designs?

- Ring-Ring
  - *Polarized* electron & positron beams
  - ~15% effect on beam polarization vs. CM energy
  - L ~ 10^{33} cm^2/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 ~ 10^{34} cm^2/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 loose 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} cm^2/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)

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