Summary of Inaugural Meeting of the

EICUG Polarimetry Working Group

# Accelerator and Experimental Requirements

# 1. Summary:

Polarimetry will play a key role for demonstrating appropriate performance of the EIC electron and hadron beams. Locations of the electron and hadron polarimeters have been determined for both the JLEIC and eRHIC designs. Multiple polarimeters in multiple locations are desirable; for example, a transverse polarimeter in the JLEIC arcs would help check spin rotator setup, while a longitudinal polarimeter near the IP is desirable for the experiments. In addition, rapid polarization measurements are needed, especially at the highest electron energies where polarization lifetimes are not long.

Both the eRHIC and JLEIC designs have some challenges specific to each. At JLEIC, the hadron beam polarization will precess between the IP and the planned location of the polarimeter. This will require precise knowledge of the spin transport when determining the polarization at the IP. At eRHIC, the electrons are quickly accelerated from a few hundred MeV to several GeV in the rapid cycling synchrotron injector– measurement of the electron polarization during this acceleration cycle would be challenging.

The experiments at EIC will have unprecedented statistical precision, so systematic uncertainties should be controlled. Polarimetry impacts the uncertainties on measured asymmetries directly, and also have an impact on the measured luminosity due to the analyzing power associated with the Bethe-Heitler process. An additional complication for beam polarimetry at EIC is the potential variation of beam polarization on bunch history (as seen at HERA in the difference between non-colliding and colliding electron bunches) as well as possible dependence on beam profile (both transverse and longitudinal) as observed for the RHIC proton beams.

# 2. R&D Projects:

Suggested projects related to beam polarization propagation in EIC:

1. Understand the origins of the difference between colliding and non-colliding bunches at HERA. If this difference can be understood, determine if the same issues may be relevant for EIC and quantify.
2. Study the degree of the expected polarization profiles at EIC based on the mechanism described in [W. Fischer and A. Bazilevsky, Phys. Rev. ST Accel. Beams 15, 041001 (2012)].
3. Quantify the degree to which bunch-by-bunch and profile-dependent variations of the polarization of the electron/hadron beams impacts physics observables. Set limits on acceptable variation.

# Electron Polarimetry

# 1. Summary:

Compton polarimeters are planned for use in both the JLEIC and eRHIC electron rings. The JLEIC Compton will be downstream of the electron-hadron interaction region and will measure the longitudinal polarization of the electron beam with an emphasis on detection of the scattered electron. The eRHIC Compton polarimeter will measure transverse electron beam polarization at its own IP.

Backgrounds due to Bremsstrahlung radiation, beam halo, and synchrotron radiation can be significant. Simulations indicate that expected levels of Bremsstrahlung radiation should not be a problem, even for a simple 10 W CW laser system. Contributions due to halo can be significant in certain circumstances, but appropriate design choices can mitigate the potential risk. Synchrotron radiation will be significant. Special measures must be taken to minimize signal on the detectors.

While longitudinal polarimeters have demonstrated 1% level (or better) precision on several occasions, this is not true for transverse Compton polarimeters. The most recent (absolute) transverse Compton polarimeter (at HERA) achieved precision a precision of 2-3%. The largest systematic uncertainty came from understanding the detailed detector response.

# 2. R&D Projects:

Suggested projects for Electron Polarimetry:

1. Further studies of synchrotron backgrounds. This should include benchmarking of GEANT4-based simulations and studies of mitigation strategies.
2. Fast electron detectors. State-of-the-art suggests that fast electron detectors may have sufficient time resolution to be able to resolve the bunch structure of the electron beam and hence make measurements of the beam polarization bunch-by-bunch. A proof-of-principle demonstration would be interesting.
3. Development of high-precision transverse Compton polarimetry. The precision of transverse Compton polarimeters has been limited by knowledge of the detailed detector geometry and response. This can be mitigated with high resolution strip detectors – Monte Carlo studies should be carried out to determine what detector segmentation is required for high precision polarimetry.
4. Simultaneous measurement of longitudinal and transverse polarization. While the polarization direction of the electron beam can be determined via manipulation of the spin direction (Spin Dance measurements), simultaneous measurement of both longitudinal and transverse components would allow shorter beam setup times.
5. Alternate polarimetry techniques. While Compton polarimetry is well-suited for electron polarization measurements in collider rings, measurements with alternate techniques would allow greater confidence in the Compton results. Possible alternatives include Møller polarimetry with jet targets and spin-light polarimetry.

# Hadron Polarimetry

# Summary:

There have been two detailed talks describing the current situation measuring hadron polarization in RHIC. For the RHIC run in 2017 the best systematic uncertainty ever 1.1 % (blue) and 1.4 % (yellow) per beam, respectively. There have been several improvements described to guarantee stable operation at an EIC, with a hadron beam of high frequency and bunch current. But the most critical background to be suppressed are the “prompt” particles, which will overlap in a high frequency machine with the signal.

Prof. Buttimore reviewed the analyzing powers for different polarized hadron beam species:

* The 3He–C analyzing power is ≈ −78% of AN for p-C in the CNI region
  + The d–C CNI analyzing power is about one tenth of that for 3He–C
* Much more d–C data would be required to achieve good d polarimetry
  + Absolute polarized ion calibration needs the same polarized ion jet
* A study of recoiling ion kinematics may help avoid polarization dilution

The small analyzing power for polarized deuterium beams presents a significant challenge to have precise polarization measurements

Further alternative methods to measure polarization have been discussed, none of these methods would replace a absolute polarimeter, but some methods would be able to replace the pC polarimeters. There is significant more work needed to understand these alternative methods would provide all needed functionalities.

# R&D Projects:

# Simulation:

There are several topics which need to be better understood through simulations

* Develop a MC which allows to simulate the RHIC polarimeter setup
  + Can one reproduce the pC and pp ToF – ADC spectra and such understand the origin of the “prompts”
* Extend these simulations to polarized deuterium and He-3 beams

# Analysis of RHIC Data

Analyze the RHIC data to understand the bunch polarization as function of different beam parameters, i.e. emittance. After this we should verify these dependencies can be absolutely reproduced with beam simulations.

# Hardware

* In the upcoming polarized pp run in 2021 introduce a 2nd layer of Silicon to investigate the prompts can be vetoed by requiring no punch through
* Investigate an alternative option for the carbon fiber targets
* Develop silicon detectors with higher timing and energy resolution
* Is there an alternative detector technology to the Si?
* Investigate whether a technical solution for the alternative polarization methods is feasible
* Investigate a technical solution for the He-3 and deuterium polarimeters