Beam Polarization and Polarimetry at EIC

Report of Contributions

https://indico.bnl.gov/e/7583

Contribution ID: **2** Type: **Talk**

Polarization Upgrade and Polarimetry at the SuperKEKB Facility

Friday, 26 June 2020 11:05 (30 minutes)

SuperKEKB is an unpolarized electron-positron collider designed for a luminosity of 8 × 10³⁵ cm^{−2}s^{−1} with a 4 GeV positron beam (Low Energy Ring - LER) and 7 GeV electron beam (High Energy Ring - HER). To enable precision measurements of the weak neutral couplings in the Belle II experiment, an upgrade is under consideration to polarize the HER to 70% by injecting polarized electrons (due to the short beam lifetime, Sokolov-Ternov self-polarization is impractical). In most areas of the HER the spin will be oriented transversely, but around the interaction region spin rotators will align the spin longitudinally. In addition to Mott polarimetry in the injector, we will measure the stored beam polarization to a precision of 0.5% with a combination of Compton polarimetry and measurements of the forward-backward asymmetries in e⁺e[−] rightarrow; τ⁺τ[−] events at the interaction point. This will allow measurements of sin² theta;_W^{eff} with a combined uncertainty comparable to the Z⁰ world average measured uncertainty of pm;0.00016 from LEP and SLD, but made at a significantly lower energy scale of 10.58 GeV.

Primary author: DECONINCK, Wouter

Presenter: DECONINCK, Wouter

Contribution ID: **3** Type: **Talk**

Development of absolute polarimeter for the low energy $^3\mathrm{He}^{++}$ ion beam

Monday, 29 June 2020 11:00 (30 minutes)

For the Electron-Ion Collider, a polarized $^3\mathrm{He}^{++}$ ion source is being constructed at the Electron Beam Ionization Source (EBIS) of the Brookhaven National Laboratory. For precision determination of the $^3\mathrm{He}$ polarization, the $^3\mathrm{He}$ beam, after acceleration to 6 MeV at EBIS, will be elastically scattered off a gas $^4\mathrm{He}$ target. For such a scattering, the analyzing power $A_\mathrm{N}(E_\mathrm{beam}, \theta_\mathrm{CM})$ can reach absolute, 100%, maximum at some points in the beam energy / center of mass scattering angle plane [1]. Several such points were found in Refs. [2, 3] including $(E_\mathrm{beam} = 5.3\,\mathrm{MeV}, \theta_\mathrm{CM} = 91^\circ)$.

The vertically polarized $6\,\mathrm{MeV}$ $^3\mathrm{He}^{++}$ ion beam will enter, through a thin window (to minimize the energy loss of the beam), to the scattering chamber filled with $^4\mathrm{He}$ gas at a pressure of $\sim 5\,\mathrm{Torr}$. Two left-right symmetric Si strip detectors (with vertically oriented strips) will be used to detect both scattered $^3\mathrm{He}$ and recoil $^4\mathrm{He}$ particles in every event. Good energy and time resolution of the detectors will allow us to recognize $^3\mathrm{He}$ and $^4\mathrm{He}$ signals and to eliminate background events. A spin rotator will provide the beam spin-flip to suppress the acceptance and intensity related systematic errors.

For the polarimeter calibration, we plan to scan the $^3\mathrm{He}$ energy (by variation the entrance window thickness) and to measure the spin-correlated asymmetry dependence on scattering angle θ_CM. Analyzing power $A_\mathrm{N} = 100\%$ can be attributed to the absolute maximum found in these measurements.

[1] G. Plattner et al., "Absolute calibration of spin – 1/2 polarization", Phys. Lett. B **36**, 211 (1971)
[2] D.M. Hardy et al., "Polarization in $^3\mathrm{He}$ + $^4\mathrm{He}$ elastic scattering", Phys. Lett. B **31**, 355 (1970)
[3] W.R. Boykin, S.D. Baker, D.M. Hardy, "Scattering of $^3\mathrm{He}$ and $^4\mathrm{He}$ from polarized $^3\mathrm{He}$ between 4 and 10 MeV", Nucl. Phys. A **195**, 241 (1972)

Primary author: Mr ATOIAN, Grigor (Brookhaven National Lab)

Co-authors: ZELENSKI, Anatoli (Brookhaven national Lab); POBLAGUEV, Andrei (BNL)

Presenter: Mr ATOIAN, Grigor (Brookhaven National Lab)

Contribution ID: **4** Type: **Talk**

Absolute polarization measurement of the 200 MeV proton beam at Linac.

Monday, 29 June 2020 10:30 (30 minutes)

The $200\,\mathrm{MeV}$ polarimeter at Linac is based on the elastic proton-carbon scattering at $16.2°$ angle, where the analyzing power reaches almost absolute maximum which was experimentally established with high accuracy of $99.35 \pm 0.15\,\%$. The elastically and inelastically scattered protons are clearly separated by the difference in the propagation through adjustable thickness copper absorber and energy deposition of the stopped protons in the detectors. The elastic scattering polarimeter used for calibration of a high rate inclusive $12°$ polarimer for the on-line polarization tuning and monitoring. In Run 2017 a new WFD based DAQ was developed for better elastic scattering isolation. Preliminary results showed, that experimental uncertainties in the absolute polarization measurements are expected to be $\frac{\mathrm{syst}}{P} < 0.6\,\%$ and $\frac{\mathrm{stat}}{P} \sim 0.4\,\%/\mathrm{hour}$. We plan further DAQ and detectors improvements in the next polarized proton Run.

Primary author: POBLAGUEV, Andrei (BNL)

Co-authors: ZELENSKI, Anatoli (BNL); ATOIAN, Grigor (BNL)

Presenter: POBLAGUEV, Andrei (BNL)

Contribution ID: **6** Type: **Talk**

Can absolute polarization of the ^{3}He beams at EIC be precisely measured by HJET?

Monday, 29 June 2020 11:30 (30 minutes)

A possibility to precisely measure absolute vertical polarization of the EIC ^{3}He beams using the polarized hydrogen gas jet target (HJET) is discussed. By concurrent measurement of a_h and a_p, the beam $h^\uparrow p$ and jet $p^\uparrow h$ spin asymmetries for the detected recoil protons, the He3 beam polarization can be approximated by $P_{\rm beam} = P_{\rm jet} \times a_h\kappa_p/a_p\kappa_h$, where $\kappa_p = 1.793$ and $\kappa_h = -1.398$ are derived from the magnetic moments μ_p and μ_h, and $P_{\rm jet} \approx 0.957$ is the jet polarization determined by a conventional Breit-Rabi polarimeter. The result does not depend on the actual parameters of hp scattering: total cross-section $\sigma_{\rm tot}$, forward real-to-imaginary ratio ρ, or Coulomb phase δ_C.

Corrections of a few percent to the value of $P_{\rm beam}$ due to the term $\sim m^2/s$ in the electromagnetic spin-flip amplitude and due to hadronic spin-flip amplitudes r_5^{hp} and r_5^{ph} are well determined. Since the ^{3}He ground state is mostly fully space-symmetric S state, the hp spin-flip amplitudes can be readily related with sufficient accuracy, $r_p^{hp} = r_5^{pp}/3$ and $r_5^{ph} = r_5^{pp}$, to the amplitude measured in elastic pp scattering. Considering the experimental uncertainty in the value of r_5^{pp} as well as the uncertainties in the measurement of a_h/a_p, we can expect $\sigma_P^{\rm syst} \leq 0.9\,\%$ accuracy for the absolute ^{3}He beam polarization at EIC.

Since only the recoil proton is detected in HJET measurements, the acquired data may be contaminated by inelastic (^{3}He break-up) events. However, since only low energy protons in the small solid angle at 90 degree are counted, the inelastic component is strongly suppressed. Analyzing Run 16 data with a deuteron beam, we found that data contamination by the break-up events should not exceed a few percent. In addition, the inelastic corrections are significantly canceled in the a_h/a_p ratio. Thus, the anticipated alteration of the measured $P_{\rm beam}$ due to ^{3}He break-up can be neglected.

Primary author: POBLAGUEV, Andrei (BNL)

Co-authors: BUTTIMORE, Nigel (Trinity College Dublin); ZELENSKI, Anatoli (BNL)

Presenter: POBLAGUEV, Andrei (BNL)

Contribution ID: **7** Type: **Talk**

Light ion polarimetry at high energy

Monday, 29 June 2020 13:15 (30 minutes)

Peripheral scattering of polarized proton, deuteron, and Helium-3 ions on light nuclei, and other nuclei, provides a method of evaluating the level of polarization of high energy beams. The asymmetry of recoils resulting from elastic collision can indicate the analyzing power required for polarimetry provided a number of quantities are known with sufficient accuracy.

Among the items needed is the Coulomb phase, $\delta_C \propto ZZ'\alpha$, encoding second order electromagnetic corrections to the scattering of charge Z ions on nuclei of charge Z'. This phase varies from about 7% to 12% as ZZ' ranges from 4 (3He-3He) to 12 (3He-12C) in the interference region. The behavior of the analyzing power as a function of momentum transfer is discussed, avoiding the assumption that δ_C is small as is common for the case of polarized proton proton scattering.

An expression for the momentum transfer at which the size of the analyzing power reaches a maximum is presented that involves electromagnetic form factors, the hadronic slope of the near forward differential cross section, and to first order, a contribution from the single helicity-flip hadronic amplitude normalized to the imaginary non-flip hadronic amplitude. The extreme value of the analyzing power is also noted, a value that depends upon the total cross section of the reaction and ρ, the real to imaginary ratio of the spin-averaged hadronic amplitude.

Primary author: BUTTIMORE, Nigel (Trinity College Dublin)

Presenter: BUTTIMORE, Nigel (Trinity College Dublin)

Contribution ID: **8** Type: **Talk**

Polarimetry based on forward neutrons in pA scattering

Monday, 29 June 2020 13:45 (15 minutes)

The PHENIX collaboration has observed a large azimuthal asymmetry of forward neutrons produced in polarized pA collisions. The data are well described by a model incorporating photons from the high Z nucleus photoproducing low mass baryonic states from the polarized proton. The model is based on well known electromagnetic effects and well measured photoproduction processes.

We will discuss possible application of this process to polarimetry of high energy polarized proton beams. A simple target/detector system will be described, based on standard detector technology. Rate estimates will be presented, based on feasible targets and realized RHIC and planned EIC polarized proton beams. Possible tests at RHIC runs in the next few years will be outlined.

Primary author: SCHMIDKE, William (BNL)

Presenter: SCHMIDKE, William (BNL)

Contribution ID: **9** Type: **Talk**

Transparent Spin Mode for Polarized Beams in the EIC

Friday, 26 June 2020 11:35 (30 minutes)

The transparent spin (TS) technique has been proposed as an efficient high-flexible method to control the beam polarization, from acceleration to long-term maintenance and real-time spin manipulation during an experimental run of a collider. Attractiveness of the TS method is that it allows for manipulation of the polarization using small insertions of weak magnetic fields (stationary or quasi-static) not affecting the orbital dynamics. The TS mode allows one to do frequent coherent spin flips of the beam to reduce experiment's systematic errors, and carry out ultrahigh precision experiments. The TS mode may allow one to significantly expand the capabilities of polarized beam experiments at the RHIC-based EIC at BNL in the US. It makes it possible to manipulate the polarizations of proton and 3He beams during experiments in the collider's entire energy range. The TS mode is also considered for spin control of polarized deuterons near the energies corresponding to integer spin resonances. The talk presents schemes for proton and deuteron polarization control using the TS mode in RHIC.

Primary authors: FILATOV, Yuri (MIPT); KONDRATENKO, Anatoliy (MIPT); KONDRATENKO, Mikhail (MIPT); DERBENEV, Yaroslav (Jefferson Lab); MOROZOV, Vasiliy (Thomas Jefferson National Accelerator Facility)

Presenter: FILATOV, Yuri (MIPT)

Contribution ID: **10** Type: **Talk**

Light Ion Polarimetry at the EIC

Monday, 29 June 2020 13:00 (15 minutes)

Polarization of high energy proton beams has successfully been measured at RHIC with elastic proton-proton and proton-Carbon scattering. The analyzing power is not known from first principles and has to be measured.

The observed background to the elastic scattering events needs to be much better understood because of the much shorter bunch spacing at EIC. This background can cause a simple dilution of the elastic scattering events or it can bias the polarization.

It will therefore be very informative to use the existing RHIC facilities in the next few years to assess as much information as possible for light ion polarimetry, namely event rates, both for elastic scattering and for backgrounds (including breakup), and analyzing powers.

A programme of simulations was initiated to prepare the mentioned measurements and to understand the EIC conditions. A first step is to simulate the proton-proton interactions at RHIC, for which the event generator Pythia6 is being used. Dpmjet3 is the event generator of choice to, first, reproduce Pythia6 results and, afterwards, to simulate interactions with light ions, as it is prepared to describe the interactions at low momentum transfer relevant for the polarimeters. The energy loss of the particles in the silicon sensors is to be described by Geant4. Simulation results will be presented and discussed.

Primary author: NUNES, Ana Sofia (Brookhaven National Laboratory)

Presenter: NUNES, Ana Sofia (Brookhaven National Laboratory)

Contribution ID: **11** Type: **not specified**

Welcome

Friday, 26 June 2020 08:00 (15 minutes)

Presenter: DESHPANDE, Abhay (Stony Brook University)

Contribution ID: **12** Type: **not specified**

Physics drivers for polarized beam

Friday, 26 June 2020 08:15 (30 minutes)

Presenter: BRESSAN, Andrea

Contribution ID: **13** Type: **not specified**

EIC accelerator design

Friday, 26 June 2020 08:45 (30 minutes)

Presenters: MONTAG, Christoph (BNL); MONTAG, Christoph (BNL)

Contribution ID: **14** Type: **not specified**

Polarised beams in particle colliders

Friday, 26 June 2020 14:00 (30 minutes)

Presenters: BAI, Mei; BAI, Mei (BNL)

Contribution ID: **15** Type: **not specified**

Physics with polarized positrons

Friday, 26 June 2020 09:15 (30 minutes)

Presenter: Dr VOUTIER, Eric

Contribution ID: **16** Type: **not specified**

Physics with polarized Deuterons

Friday, 26 June 2020 13:00 (30 minutes)

Presenter: LONG, Ellie (University of New Hempshire)

Contribution ID: **17** Type: **not specified**

Spin transparent configuration

Presenter: FILATOV, Yuri (MIPT)

Contribution ID: **18** Type: **not specified**

What is planned at ILC

Friday, 26 June 2020 10:35 (30 minutes)

Presenter: LIST, Jenny (DESY)

Contribution ID: **19** Type: **not specified**

Feasibility of Polarized Deuteron Beam

Friday, 26 June 2020 13:30 (30 minutes)

Presenter: HUANG, Haixin (Brookhaven National Lab)

Contribution ID: **20** Type: **not specified**

Possibilities of polarized positrons

Friday, 26 June 2020 09:45 (30 minutes)

Presenter: GRAMES, Joe (Jefferson Lab)

Contribution ID: **21** Type: **not specified**

Discussion

Friday, 26 June 2020 14:30 (1 hour)

Contribution ID: **22** Type: **not specified**

Experience from RHIC leading the way to EIC

Monday, 29 June 2020 08:00 (30 minutes)

Presenter: SCHMIDKE, William (BNL)

Contribution ID: **23** Type: **not specified**

Experience from COSY

Monday, 29 June 2020 08:30 (30 minutes)

Presenter: RATHMANN, Frank (Forschungszentrum Jülich)

Contribution ID: **24** Type: **not specified**

Elastic e-D scattering for deuteron polarimetry

Monday, 29 June 2020 09:00 (30 minutes)

Presenter: SCHMOOKLER, Barak (Stony Brook University)

Contribution ID: **25** Type: **not specified**

He-3 polarimetry / polarised targets

Monday, 29 June 2020 09:30 (30 minutes)

Presenter: CATES, Gordon (University of Virginia)

Contribution ID: **26** Type: **not specified**

Improvement of proton polarization for EIC

Monday, 29 June 2020 14:00 (30 minutes)

Presenter: SCHOEFER, Vincent (CAD)

Contribution ID: **27** Type: **not specified**

Polarized He3 in EIC

Monday, 29 June 2020 14:30 (30 minutes)

Presenter: MEOT, francois (bnl)

Contribution ID: **28** Type: **not specified**

Discussion

Monday, 29 June 2020 15:30 (1 hour)

Contribution ID: **29** Type: **not specified**

HERA Polarimetry (FP cavity in collider)

Wednesday, 1 July 2020 08:00 (30 minutes)

Presenter: SCHMITT, Stefan (DESY)

Contribution ID: **30** Type: **not specified**

Lepton polarimetry at JLab

Wednesday, 1 July 2020 08:30 (30 minutes)

Presenter: PASCHKE, Kent (University of Virginia)

Contribution ID: **31** Type: **not specified**

Compton Polarimeter laser options

Wednesday, 1 July 2020 09:00 (30 minutes)

Presenter: GAL, Ciprian (Stony Brook University)

Contribution ID: **32** Type: **not specified**

Low-energy polarimetry

Wednesday, 1 July 2020 10:15 (30 minutes)

Presenter: AULENBACHER, Kurt (Johannes Gutenberg Universitaet Mainz)

Contribution ID: **33** Type: **not specified**

Precision Mott Polarimetry

Wednesday, 1 July 2020 09:30 (15 minutes)

High-Precision 5 MeV Mott Polarimetry at CEBAF+
T.J.Gay*University of Nebraska - Lincoln*
*We report on the design and performance of a Mott polarimeter optimized for a nominal 5-MeV electron beam from the CEBAF injector. The rf time structure of this beam allows the use of time-of-flight in the electron detection, making it possible to isolate those detected electrons that originate from the scattering foil, and resulting in measured scattering asymmetries which are exceptionally stable over a broad range of beam conditions, beam currents, and target foil thicknesses. In two separate series of measurements from two different photocathode electron sources, we measured the Mott scattering asymmetries produced by an approximately 86% transversely polarized electron beam incident on ten Au foils with nominal thicknesses between 50 and 1000 nm. The statistical uncertainty of the measured asymmetry from each foil is below 0.25%. Within this statistical precision, the measured asymmetry was unaffected by ±1-mm shifts in the beam position on the target, and by beam current changes and dead-time effects over a wide range of beam currents. The overall uncertainty of our beam polarization measurement, arising from the uncertainty in the value of the scattering asymmetry at zero foil thickness as determined from our fits to the measured asymmetries versus scattering foil thicknesses, the estimated systematic effects, and the (dominant) uncertainty from the calculation of the theoretical Sherman function, is 0.61%. GEANT4 calculations give results for the asymmetry versus foil thickness in good agreement with our measurements. Future measurements at different beam energies and with target foils of different atomic numbers will seek to bound uncertainties from small effects such as radiative corrections to the calculation of the polarimeter analyzing power. A simultaneous high-precision measurement of the beam polarization with a different polarimeter, AESOP (Accurate Electron Spin Optical Polarimeter), under development at the University of Nebraska, is expected to allow a high-precision comparison of our measured asymmetries with theoretical calculations of the Mott analyzing power. Finally, the improved precision of the current Mott polarimeter along with similar improvements to other Jefferson Lab GeV-energy polarimeters warrants another "Spin Dance" precision comparison of all of these polarimeters.*This work was done in collaboration with J. M. Grames1, C. K. Sinclair1, M. Poelker1, X. Roca-Maza2, M. Stutzman1, R. Sulieman1, Md. A. Mamun1,3, M. McHugh4, D. Moser1, J. Hansknecht1, B. Moffit1, and Keith Foreman5.
1JLab
2UDS-Milano
3ODU
4GWU and
5UNL

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Presenter: GAY, Tim (University of Nebraska)

Contribution ID: **34** Type: **not specified**

Spin rotator design and spin matching

Wednesday, 1 July 2020 10:45 (30 minutes)

Presenter: PTITSYN, Vadim (C-AD, BNL)

Contribution ID: **35** Type: **not specified**

Compact spin rotator design

Wednesday, 1 July 2020 11:15 (30 minutes)

Presenter: LIN, Fanglei (Thomas Jefferson National Accelerator Facility)

Contribution ID: **36** Type: **not specified**

EIC electron polarization studies

Wednesday, 1 July 2020 11:45 (30 minutes)

Presenter: GIANFELICE, Eliana (FNAL)

Contribution ID: **37** Type: **not specified**

IR related effects

Wednesday, 1 July 2020 14:15 (30 minutes)

Presenter: MOROZOV, Vasiliy (Thomas Jefferson National Accelerator Facility)

Contribution ID: **38** Type: **not specified**

Fast spin tracking and spin matching with stochastic one turn maps

Wednesday, 1 July 2020 13:45 (30 minutes)

Presenter: BEZNOSOV, Oleksii (University of New Mexico)

Contribution ID: **39** Type: **not specified**

Acceleration of electrons in RCS

Wednesday, 1 July 2020 13:15 (30 minutes)

Presenter: RANJBAR, Vahid (BNL)

Contribution ID: **40** Type: **not specified**

Discussion

Wednesday, 1 July 2020 14:45 (1 hour)

Contribution ID: **41** Type: **not specified**

Bmad and PTC spin simulations

Monday, 29 June 2020 15:00 (30 minutes)

Presenter: SAGAN, David (Cornell)