Workshop to Explore Physics Opportunities with Intense, Polarized Electron Beams up to 300 MeV

Le Meridien Hotel
Cambridge, MA

March 14-16, 2013

Book of Abstracts

Sponsored by

Thomas Jefferson Laboratory
Johannes-Gutenberg Universität Mainz
MIT

Thursday March 14th
Plenary Session
Hunsaker Ballroom, Le Meridien Hotel

9:00-9:45
Light and Dark - a survey of new physics ideas in the 1-100 MeV window
Maxim Pospelov
University of Victoria/Perimeter Institute

I review the set of theoretical ideas motivating experimental searches of light and not-so-massive particles using the high-intensity electron beams. While "dark photon" is the chief example of such physics, the other interesting "light and dark" states (e.g. "Dark Higgses") are also of interest. I will discuss particle physics, cosmology and astrophysics applications.

9:45-10:30
Overview: Parity Violation Physics
Yury Kolomensky
University of California, Berkeley

Parity violation (PV) electron scattering experiments have played pivotal role in the development and tests of the Standard Model. I will review the history of the PV program, the present status of the field, and describe exciting new opportunities which can address open questions in nuclear and nucleon structure, and probe new electroweak physics phenomena with mass scales of order TeV.

10:30-11:00 Coffee break

11:00-11:45
Precision Nucleon Structure
Carl Carlson
College of William and Mary

We will discuss theory relevant to nucleon measurements at the precision frontier. Topics to be considered will include the proton radius puzzle, parity violating scattering experiments, and the symbiosis between nuclear and atomic physics in precision atomic experiments.

11:45-12:30
Nuclear astrophysics and electron beams
Achim Schwenk
Technical University, Darmstadt

Electron beams provide important probes and constraints for astrophysics. This is especially exciting at energies within the regime of chiral effective field theory, which provides a systematic expansion for nuclear forces and electroweak operators based on quantum chromodynamics. This talk will discuss recent highlights and future directions, including nuclear reactions and structure for astrophysics, the neutron skin and constraints for the properties of neutron-rich matter in neutron stars and core-collapse supernovae, and the possibility of simulating the dark matter response of nuclei with electrons.

12:30-14:00 Lunch break

14:00-14-30
The Jefferson Lab FEL Driver ERL
David Douglas
Jefferson Laboratory

Jefferson Lab has for over a decade been operating high power IR and UV FELs using CW energy recovering linacs based on DC photocathode electron sources and CEBAF SRF technology. This machine has a unique combination of beam quality, power, and operational flexibility, and thus offers significant opportunity for experiments that use low and medium energy (several tens to few hundreds of MeV) electron beams. We will describe the system and detail its present and near-term (potential) performance. Recent internal-target analysis and validation testing will be discussed, and schemes for single- and two-pass fixed target operation described. An introduction to subsequent discussions of beam quality [1] and upgrade paths to polarized operation/higher energy [2] will be given. [1] P. Evtushenko, this workshop; [2] C. Tennant, *Upgrade Capabilities of the Jefferson Lab FEL Driver*, this workshop.

14:30-15:00
The MESA accelerator
Kurt Aulenbacher
University of Mainz

The Mainz Energy recovering Superconducting Accelerator (MESA) may allow for new particle physics experiments at the 100 MeV scale. The Energy Recovery Linac (ERL) principle allows the introduction of windowless internal targets, while still achieving stationary beam conditions. Such a mode is difficult to maintain with conventional storage rings at low energies. In ERL mode, a beam power of 1 MW at the target will compensate for the low areal density of an internal target in order to maintain a sufficient luminosity. On the other hand, MESA will also be able to operate as a conventional accelerator with external beam (EB-mode). An important experiment in EB mode will be a precision measurement of the electro-weak mixing angle that will require a high intensity, highly polarized external beam.

15:00-15:30
Energy Recovery Linac Development at BNL
Ilan Ben-Zvi
Collider-Accelerator Department, Brookhaven National Laboratory

Energy Recovery Linacs (ERL) are important for a variety of applications, from high-power Free-Electron Lasers (FEL) to polarized-electron polarized-proton colliders. The ERL current is arguably the most important characteristic of ERLs for such applications. With that in mind, the Collider-Accelerator Department at Brookhaven National Laboratory embarked on the development of a 300 mA ERL to serve as an R&D test-bed for high-current ERL technologies. These include high-current, extremely well damped superconducting accelerating cavities, high-current superconducting laser-photocathode electron guns and high quantum-efficiency photocathodes. In this presentation I will cover these ERL related developments.

15:30-16:00 Coffee break

16:00-16:30
Polarized Electron Beams at milliAmpere Average Current
Matt Poelker
Jefferson Laboratory

This contribution describes the challenges associated with developing a polarized electron source capable of uninterrupted week-long operation at milliAmpere average beam current and with 80% polarization. Challenges will be presented in the context of assessing the required level of extrapolation beyond the performance of today s CEBAF polarized source, specifically related to average beam current and bunch charge. Particular attention will be paid to lifetime-limiting mechanisms, and strategies to construct a photogun that operates reliably at bias voltage > 350kV.

16:30-17:00
Precision electron polarimetry
Eugene Chudakov
Jefferson Laboratory

A new generation of precise Parity-Violating experiments will require a sub-percent accuracy of electron beam polarimetry. Compton polarimetry can be accurate enough at high energies, but at a few hundred MeV the analyzing power becomes too small. Moller polarimetry provides a high analyzing power independent on the beam energy, but is limited by the properties of the polarized targets commonly used. Options for precision polarimetry at ~300 MeV will be discussed, in particular a proposal to use ultra-cold atomic hydrogen traps to provide a 100%-polarized electron target for Moller polarimetry.

17:00-17:30
Results of the High-Power FEL Beam Transmission Tests at the Jefferson Laboratory

Christoph Tschalär
MIT

Tests were performed to pass a 100-MeV, 430-kWatt cw electron beam from the energy-recovery linac at the Jefferson Laboratory's FEL facility through a set of small apertures in a 127-mm long aluminum block. Beam transmission losses of 3 p.p.m. through a 2-mm diameter aperture were maintained during a 7-hour continuous run.

18:30-20:00 Reception for workshop attendees at Le Meridien Hotel

Friday March 15th
Parallel Session PS1: Parity Violation
Kolker Room A

PS1A: Parity violation proton I (11:30 to 13:00)

11:30-12:00
Qweak Report and Technology Application at Lower Energies
Mark Pitt
Virginia Tech

The Qweak experiment has recently completed data-taking at Jefferson Lab. The primary focus of the experiment is to perform a precision measurement of the proton's neutral weak charge. The Standard Model gives a firm prediction for the weak charge; any deviation from that can be interpreted as evidence for new physics beyond the Standard Model. This precision, low energy measurement is sensitive to new physics signatures at energy scales up to 2 TeV. The experiment measures the parity-violating asymmetry in the scattering of 1.1 GeV longitudinally polarized electrons on the proton at low momentum transfer ($Q^2 \sim .026\ (GeV/c)^2$). A brief status report on the experiment will be given with a focus on existing instrumentation and demonstrated methodology for application to lower beam energy realizations of PV measurements.

12:00-12:30
Constrained γZ corrections to parity-violating electron scattering
Wally Melnitchouk
Jefferson Laboratory

We present the latest analysis of γ-Z interference corrections to the weak charge of the proton measured in parity-violating electron scattering, including a survey of existing models and a critical analysis of their uncertainties. Constraints from parton distributions in the deep-inelastic region, together with new data on parity-violating electron scattering in the resonance region, result in significantly smaller uncertainties on the corrections compared to previous estimates. The new constraints also allow precise predictions to be made for parity-violating deep-inelastic asymmetries on the deuteron.

12:30-12:50
Comparison of γZ Structure Function Models
Benjamin Rislow
College of William and Mary

The γZ-box is an important contribution to the proton's weak charge at low momentum transfer. The box is calculated dispersively and depends on off-diagonal structure functions, $F_{1,2,3}^{\gamma Z}(x,Q^2)$. At present, there are no data for these structure functions and they must be modeled by modifying existing fits to electromagnetic data. Each group that has studied the γZ-box used different modifications. The results of the PVDIS experiment at Jefferson Lab may provide a first test of the validity of each group's models. I present details of the different models and their predictions for the PVDIS result.

12:50-13:00 Discussion

13:00-14:00 Lunch break

PS1B: Parity violation proton II (14:00-15:00)

14:00-14:20
Precision Electroweak Studies with Parity-Violation in Electron Scattering
Kent Paschke
University of Virginia

Many models for new physics beyond the Standard Model imply the occurance of new neutral current interactions. The nature of such new physics can be revealed at the low-energy precision frontier, where electroweak studies of parity-violation in electron scattering will complement the energy-frontier studies at the LHC. In these low-energy measurements, the effects of new high-energy phenomena can be characterized as new four-fermion contact interaction amplitudes that would contribute to changes in the overall parity-violating interaction of electrons. Measurements of the parity-violating observable A_{PV} - a polarization-dependent cross-section asymmetry in the scattering of longitudinally polarized electrons from an unpolarized target - are sensitive to possible new physics contributions to multi-TeV mass scales. The 12 GeV upgrade at JLab provides a unique opportunity to measure A_{PV} in Moller scattering with a precision approaching 2%, a factor of 5 improvement over previous results. Such a measurement would be the most sensitive probe of new flavor and CP-conserving neutral current interactions in the leptonic sector until the advent of a linear collider or neutrino factory. Similarly, the planned fixed-target capability of the MESA upgrade at Mainz provides an opportunity to measure the weak charge of the proton to a precision of 2% to study possible new contributions to electron-proton couplings. The motivation for these experiments and the plans to meet the technical challenges for the MOLLER experiments will be reviewed.

14:20-14:40
Role of Charge Symmetry Breaking in Nucleon Structure and Parity Violating Electron Scattering
Gerald Miller
University of Washington, Seattle

I plan to review and update my paper Phys. Rev. C**57** (1998) 1492-1505, considering the availability of intense, polarized linac beams in the energy range up to 300 MeV. The aim is to see if charge symmetry breaking effects in the nucleon could be accessible in elastic electron scattering.

14:40-15:05
P2 - The weak charge of the proton
Dominik Becker
University of Mainz

At the new electron accelerator MESA in Mainz, we plan to determine the electroweak mixing angle to a relative precision of 1.5 per mille, in accuracy comparable to the present accuracy stemming from measurements at the Z-pole. This can be achieved through a measurement of the parity violating asymmetry in elastic e-p-scattering. It will take place at beam energies around 200 MeV ($Q^2 \sim 0.05\ (GeV/c)^2$). The expected accuracy as well as the experimental strategy will be presented. Monte Carlo results with respect to suitable detector setups will be shown and discussed.

15:05-15:20
Back angle measurements using P2
Sebastian Baunack
University of Mainz

The P2 experiment at MESA in Mainz aims to measure the PV asymmetry in ep-scattering at forward angle in order to determine the weak mixing angle with high precision. Here, considerations are presented to measure in parallel or in addition the PV asymmetry at backward angle. Such a measurement could help to decrease the existing uncertainties in the knowledge of the strange magnetic form factor G_M^s and/or the axial form factor G_A at low momentum transfer $Q^2 \leq 0.1\ (GeV/c)^2$. These uncertainties are a main contribution of the hadronic uncertainties in the main measurement P2.

15:20-15:30 Discussion

15:30-16:00 Coffee at Stata R&D Pub

PS1C: PC Carbon-12 (16:00-18:30)

16:00-16:30
Parity Violating Polarized eC Scattering Asymmetry and New Physics

William J. Marciano
Brookhaven National Laboratory

Theoretical motivation for a ±0.3% measurement of the weak charge of Carbon via polarized electron scattering as a means of uncovering New Physics will be presented. Comparison with Atomic Parity Violation, ep and ee scattering asymmetries will be given. The possibility and potential importance of carrying out such an experiment at very low momentum transfer, $\langle Q \rangle \sim 40$ MeV/c as a search for light "dark boson" effects will be discussed.

16:30-17:00

Nuclear physics aspects involved in studies of low-q PV electron scattering from carbon

T. William Donnelly
MIT

Several aspects where nuclear structure issues can have an impact on PV electron scattering from carbon will be discussed. These include the following: (1) isospin or proton/neutron distribution differences in the ground state of carbon, (2) the degree of uncertainty in the Coulomb distortion of the electron wave functions arising from uncertainties in the Coulomb potential provided by the carbon ground state, (3) the nucleonic strangeness content and attendant nuclear structure uncertainies, and (4) the impact of nuclear excitations in potential low resolution measurements where elastic scattering cannot be isolated. While all of these issues are secondary for low momentum transfer, reasonably forward-angle PV asymmetry measurements, the desired much higher precision PV asymmetry measurements being contemplated may have to confront them. The study on which this is based is a new analysis being undertaken by the speaker together with Oscar Moreno at MIT.

17:00-17:30

Measurement of the Weinberg Angle via electron scattering from ^{12}C-nuclei within the P2 experiment

Kathrin Gerz
University of Mainz

We introduce first feasibility considerations for the determination of the Weinberg Angle via scattering of electrons from Carbon nuclei in a graphite target at low Q^2. In order to make an assumption of the achievable precision we present analytic calculations as well as Monte-Carlo simulations. Furthermore the talk contains Geant4 simulations and a proposed experimental setup.

17:30-18:00 Discussion

Friday March 15th
Parallel Session PS2: Dark Photons
Cosman Room CTP 6C-442

PS2A: Dark photon searches (11:30-13:00)

11:30-11:55
Search for Dark Photons at MAMI
Harald Merkel
University of Mainz

The spectrometer setup of the A1 collaboration at MAMI provides high resolution spectrometers operated at very high luminosities, which are well suited for the search for dark photons in the mass range between 50 MeV and 300 MeV. In this talk, the current program will be presented and future possible extensions in mass range and sensitivity will be discussed.

11:55-12:20
Heavy Photon Search experiment at JLAB
Stepan Stepanyan
Jefferson Laboratory

The Heavy Photon Search (HPS) experiment in Hall-B at Jefferson Lab will search for new heavy vector boson(s), aka heavy photons, in the mass range of 20 MeV/c^2 to 1000 MeV/c^2 using the scattering of high energy, high intensity electron beams off a high Z target. The heavy photons are predicted in many BSM theories and are motivated by recent astrophysical observations of the possible annihilation of primordial dark matter into heavy photons, resulting an excess of high energy positrons and electrons in cosmic rays. The proposed measurements will cover the region of parameter space favored by the muon (g-2) anomaly, and will explore a significant region of parameter space, not only at large couplings ($\alpha'/\alpha > 10^{-7}$), but also in the regions of small couplings, down to $\alpha'/\alpha \approx 10^{-10}$. This small coupling region is not accessible to any other proposed experiment. The excellent vertexing capability of the Si-tracker uniquely enables HPS to cover the small coupling region. Also, HPS will be the only fixed target experiment proposed to date to search for heavy photons in an alternative to the e+e- decay mode, in the heavy photon's decay to $\mu+\mu-$. The HPS experiment has been approved by Jefferson Lab PAC with the highest rating. The HPS collaboration built and tested the main components of the HPS setup in 2012 (just before the end of CEBAF 6 GeV running). With anticipation of the early running in 2014-2015, the collaboration currently works towards construction of the main HPS setup. In this talk, the goals of the HSP experiment, a brief description of the apparatus, the test run results, and future plans will be presented.

12:20-12:45

Searching for new gauge bosons in the A' Experiment (APEX) at Jefferson Laboratory

Philip Schuster
Perimeter Institute

The A' EXperiment (APEX) at Jefferson Laboratory is designed to search for new vector bosons that have small couplings to charged particles. Such vectors can arise naturally from a small kinetic mixing of a new ``dark photon'' (A') with the photon --- one of the very few ways in which new forces can couple to the Standard Model --- and have received considerable attention as an explanation of various dark matter related anomalies. A' bosons are produced by radiation off an electron beam, and could appear as narrow resonances with small production cross-section in the trident e^+e^- spectrum. We plan to search for an A' using the CEBAF electron beam at energies of about 1 to 4 GeV incident on 0.5-10% radiation length multi-foil Tungsten targets, and measure the resulting e^+e- pairs using the High Resolution Spectrometers and a septum magnet in Hall A at Jefferson Lab. With a 33-day run, APEX will explore the region 50 MeV/c^2 < $m_{A'}$ < 550 MeV/c^2 with couplings α'/α down to 10^{-7}. This talk will present the experiment, test run results, and comment on future plans.

12:45 Discussion

Lunch: 13:00-14:00

PS2B: Dark photon searches (14:00-15:30)

14:00-14:25

Experimental concept and design of DarkLight, a search for a heavy photon

Ray Cowan
MIT

This talk gives an overview of the DarkLight experimental concept: a search for a heavy photon A' in the 10-100 MeV/c^2 mass range. After briefly describing the theoretical motivation, the talk focuses on the experimental concept and design. Topics include operation using the 500 kW, 100 MeV electron beam of the Jefferson Lab FEL, detector design and performance, and expected backgrounds estimated from beam tests and Monte Carlo simulations.

14:25-14:50

Background beam background measurements

Narbe Kalantarians
Hampton University

In July 2012 running with the test target at the JLab FEL, measurements of background rates of photons, neutrons, and charged leptons under different operating conditions were made. These background processes were simulated using assumptions for production mechanisms. The measured rates are compared with the simulations.

14:50-15:15
Detectors for dark photon search with MESA
Matthias Molitor
University of Mainz

The predictions of the standard model for the anomalous magnetic momentum of the muon, deviates from the direct measurements by 3.6σ. A gauge boson of a new U(1)-Interaction, the so called dark photon, is predicted in many expansions of the standard model and could explain those deviations. In order to search for such a dark photon, a dedicated experiment is scheduled at the planned low energy accelerator MESA in Mainz. The different detector concepts and their abilities in finding the dark Photon in the MESA experiment will be discussed.

15:15 Discussion

15:30-16:00 Coffee at Stata R&D Pub

PS2C: Theory (16:00 – 18:30)

16:00-16:30
Theoretical Description of Light Dark Gauge Boson Searches in Electron Scattering Fixed Target Experiments
Tobias Beranek
University of Mainz

Electron scattering fixed target experiments are a versatile tool to probe various kinds of physics phenomena. Recently fixed target experiments in which an electron beam is scattered off a heavy nucleus and a lepton anti-lepton pair is created, i.e. e(A,Z)->e(A,Z)l^+l^- were utilized to search for physics beyond the standard model at modest energies. In these experiments by detecting the l^+l^- pair, a search for a small, narrow resonance in the invariant mass spectrum of the lepton anti-lepton pair appearing over the smooth QED background, arising from the exchange of a new light gauge boson A' coupling to the dark sector as well as very weakly to standard model particles, is performed. Hence a precise understanding of the background is crucial. We present our work on the theoretical analysis of the phenomenology of the process e(A,Z)➔e(A,Z)l^+l^-. Therefore, we have performed an analysis of the cross sections, which are necessary to extract exclusion limits on the parameter space of the A', describing the existing experimental data taken at MAMI.

16:30-17:00
Searches at e+e- colliders
Fabio Bossi
INFN, Frascati

Searches for new, light, neutral vector particles are being pursued by several different experiments in the world using e+e- collision data at center-of-mass energies between about 1 and 10 GeV. I will review the most recent results from KLOE, BESIII, BABAR and BELLE and briefly discuss future perspectives.

17:00-17:30
The TREK/E36 Experiment at J-PARC
Michael Kohl
Hampton University

Experiment E36 is planned to run at the J-PARC K1.1BR kaon beamline in 2014-15 using a stopped kaon beam along with the TREK target and detector setup. The decay products of stopped positive kaons will be observed with a large-acceptance toroidal spectrometer capable of tracking charged particles with high resolution, combined with a photon calorimeter with large solid angle and redundant particle identification systems. With the aim to test lepton universality in the $K_{e2}/K_{\mu 2}$ ratio with high precision, the experiment is highly sensitive to new physics beyond the Standard Model. A further goal of E36 is to search for a heavy, sterile neutrino in two-body kaon decay, along with additional searches for exotic decay modes including the possibility to produce a dark photon from an outgoing muon. An overview of the planned experiment and the current project status will be presented.

17:30-18:00 Sarah Andreas
Hidden Photons in Beam Dump Experiments and in connection with Dark Matter
Sarah Andreas
DESY
Light extra U(1) gauge bosons, so called hidden photons, have attracted much attention since they are a well motivated feature of many beyond the Standard Model scenarios and could be the mediator of the interaction with hidden sector dark matter. I will present in this talk limits on hidden photons from past electron beam dump experiments including two new limits from such experiments at KEK and Orsay. In addition, the features of an extension to a simple supersymmetric hidden sector model with a viable dark matter candidate are shown.

18:00-18:30

Searching for an invisible dark photon with DarkLight

Yonatan Kahn
MIT

The DarkLight experiment at Jefferson Lab is designed to search for a new U(1) vector boson A' in the mass range 10-100 MeV through its decay A' ➔ e+ e-. We will show that DarkLight is also sensitive to an A' decaying to invisible final states, but because of QED backgrounds, such a search is only feasible with photon detection. Surprisingly, pileup can be mitigated with a cut on the sign of the missing invariant mass-squared. We give the DarkLight reach for the invisible search assuming a nominal two-month running time, and compare to constraints from anomalous magnetic moments and rare kaon decays.

Friday March 15th
Parallel Session PS3: Nucleon structure
LNS Conference Room 26-528

PS3A: Proton charge radius (11:30-13:00)

11:30-12:00
High precision measurement of the proton charge radius
Mehdi Meziane
Duke University

The recent high precision measurements of the proton charge radius performed at PSI from muonic hydrogen Lamb shift puzzled the hadronic physics community. A value of 0.8418 ± 0.0007 fm was extracted which is 7σ smaller than the previous determinations obtained from electron-proton scattering experiments and based on precision spectroscopy of electronic hydrogen. An additional extraction of the proton charge radius from electron scattering at Mainz is also in good agreement with these "electronic" determinations. An independent measurement of the proton charge radius from unpolarized elastic ep scattering using a spectrometer free method was proposed and fully approved at Jefferson Laboratory in June 2012. This novel technique uses the high precision calorimeter HyCal and a windowless hydrogen gas target which makes possible the extraction of the charge radius at very forward angle and thus very low Q^2 up to 10^{-4} $(GeV/c)^2$ with an unprecedented subpercent precision for this type of experiment. I will review the recent progress on the proton charge radius extraction and I will present the proposed high precision measurement.

12:00-12:30
The MUon proton Scattering Experiment (MUSE) and the Proton Radius Puzzle
Ronald Gilman
Rutgers University

The proton radius puzzle concerns the difference between the 0.88 fm radius extracted from atomic hydrogen and ep scattering measurements and the much more precise 0.84 fm radius extracted from muonic hydrogen measurements. While there is no generally accepted explanation of the puzzle, possible solutions include novel beyond standard model physics, novel hadronic physics, and issues and/or underestimated uncertainties in the ep measurements. The MUon proton Scattering Experiment (MUSE) at the Paul Scherrer Insitut pion M1 beamline investigates some possible solutions to the puzzle by scattering a mixed μ/e/π beam from a liquid hydrogen target, with a Q^2 range of about 0.002 - 0.08 GeV^2. Measurements of both μ+ and μ- at multiple beam momenta allow for checks of systematics, determination of two-photon exchange effects and magnetic contributions, and a radius determination at a similar level of precision to existing ep scattering experiments. Simultaneous electron scattering allows similar tests and a comparison of the two probes. The physics background, status, and plans for the experiment will be discussed.

12:30-13:00
The initial state radiation experiment at MAMI
Miha Mihovilovic
University of Mainz

The discrepancy between the proton charge radius extracted from the muonic hydrogen Lamb shift measurement and the best present value obtained from the elastic scattering experiments, is still unexplained and represents a burning problem of today's nuclear physics. Trying to solve the proton radius puzzle, a new experiment at MAMI is underway, aimed at measuring proton form-factors at very low momentum transfers by using a new technique based on initial state radiation. The emission of a real photon by an electron prior to the interaction with a proton reduces the four-momentum transferred to the proton, which allows us to probe its structure at smaller Q^2. In the first approximation the radiative tail of the elastic peak represents a coherent sum of the initial and final state radiation. Hence, precise measurements of the radiative tail at constant beam energy and scattering angle in combination with a sophisticated Monte-Carlo simulation to disentangle initial and final-state contributions, provide us with a unique possibility to determine the form-factors for Q^2 as low as $10^{-4}(\mathrm{GeV}/c)^2$, and with a sub-percent accuracy. In this presentation, the current status of the experiment will be presented. First the underlying idea will be explained, followed by a brief description of the Monte-Carlo simulation software Simul++, utilized for the comparison of the predicted form-factors to the measured data. First findings of the pilot measurements performed in 2010 will be presented. The main goal of this analysis has been to check the feasibility of the proposed experiment and to recognize and overcome any obstacles before running the full experiment, which is planned for 2013.

13:00-14:00 Lunch

PS3B: Nucleon polarizabilities (14:00-15:30)

14:00-14:30
Measuring the scalar and vector polarizabilities of the nucleon using polarized photons and targets
Rory Miskimen
University of Massachusetts, Amherst

The electric and magnetic polarizabilities of the proton are known with "reasonable" precision (reasonable for α, less so for β) from unpolarized Compton scattering. However, we know relatively little about the spin-polarizabilites of the proton, which parameterize how a polarized photon interacts with the proton spin. The most model independent way to measure spin-polarizabilities is in double-polarized Compton scattering experiments. This talk will present new results from the Mainz A2 collaboration on the proton spin-polarizabilities. A new program at Mainz to make precision measurements of alpha and beta for the proton using incident linearly polarized photons will also be discussed.

14:30-15:00
Proton polarizabilities -- status and relevance
Vladimir Pascalutsa
University of Mainz

Recent progress in understanding nucleon polarizabilities from the viewpoint of chiral perturbation theory provides a clear-cut motivation for the new round of polarised Compton scattering experiments commencing soon at MAMI and HIGS. The impact of proton polarizability studies on the "proton charge radius puzzle" will be discussed in detail.

15:00-15:30
High-Accuracy Analysis of Compton Scattering in Chiral EFT: Status and Future
Harald W. Griesshammer
George Washington University

Compton scattering from protons and neutrons provides important insight into the structure of the nucleon. For photon energies below about 300 MeV, the process is parameterised by six dynamical dipole polarisabilities which characterise the two-photon response to a monochromatic photon of fixed frequency and multipolarity. Their zero-energy limits are the static electric and magnetic scalar dipole polarisabilities α_{E1} and β_{M1}, and the four spin-polarisabilities. Differences between proton and neutron values stem from isospin-breaking pion-nucleon interactions and thus test chiral symmetry and the pattern of its breaking. Recently, a new extraction of the static electric and magnetic scalar dipole polarisabilities from all published elastic data below 300 MeV was performed in Chiral Effective Field Theory. The static electric and magnetic scalar polarisabilities of the proton and neutron turn out to be identical within the accuracy of available data. Since the most reliable neutron values come thus far from deuteron data, nuclear binding and meson-exchange effects must be subtracted with reliable theoretical uncertainties. ChiEFT is ideal for that purpose since it provides a model-independent estimate of higher-order corrections and encodes the correct low-energy dynamics of QCD, including, for few-nucleon systems, consistent nuclear currents, rescattering effects and wave functions.
After reviewing ingredients and results, this talk discusses the following topics: status of few-nucleon Compton theory; desirable improvements of the database; elastic and inelastic Compton scattering on deuterons and ^{3}He; predictions for high-intensity experiments with polarised targets and polarised beams. The goal is to extract not only scalar nucleon polarisabilities, but also the so-far poorly explored spin-polarisabilities, which parametrise the stiffness of the nucleon spin in external electro-magnetic fields.

15:30 Coffee at Stata R&D Pub

PS3C: QCD (16:00-18:30)

16:00-16:30
Lattice QCD for Nuclear Physics
William Detmold
MIT

Improved methods and computational resources are broadening the scope of lattice Quantum Chromodynamics (QCD) beyond the traditional domain of particle physics into the realm of light nuclei. I will present an overview of recent advances in lattice QCD studies of the spectroscopy and structure of nucleons and nuclei.

16:30-17:00
Nuclear structure corrections to Lamb shift in muonic deuterium
Mikhail Gorshteyn
University of Mainz

We calculate the nuclear structure-dependent correction to Lamb shift in muonic deuterium from the two-photon exchange diagram from forward dispersion relations. The input in forward dispersion integrals is directly related to experimental data on elastic deuteron form factors and inclusive virtual photo absorption. The formalism operates with one subtraction function that is related to the deuteron's nuclear magnetic polarizability $\beta_M(Q^2)$. The uncertainty in the calculation of Lamb shift is dominated by that in $\beta_M(Q^2)$, and we argue that new measurements of low-energy Compton scattering off deuteron and new theoretical calculations of $\beta_M(Q^2)$ are necessary to match the precision of atomic level measurements.

17:00-17:30
Chiral Symmetry Tests
Barry R. Holstein
University of Massachusetts, Amherst

Although one often associates tests of QCD with high energy accelerators, where the quark-gluon structure may be probed directly, it is also possible to utilize low energy reactions to test QCD via its chiral symmetry property. We shall discuss three different classes of such probes, each of which utilizes photons:

i) Chiral anomaly reactions
ii) Hadron polarizabilities
iii) Hadronic parity violation

Examples of each and future prospects will be examined.

17:30-18:00
Photo-pion Production: Tests of Chiral Symmetry
Aron Bernstein
MIT

The possibility of having intense electron beams with energies above the pion threshold opens up important experimental possibilities in confinement scale QCD. This will enable the use of thin, pure, polarized, targets combined with "virtual photon tagging", i.e. forward electron scattering (up to ~ 3 degrees). This produces a high flux of almost real photons with large transverse polarizations as well as circular polarization for longitudinally polarized electrons. Utilization of single and double polarization observables will enable us to perform accurate and sensitive, measurements for photo-pion production on the nucleon and few body systems. In addition, using thin and windowless targets will allow the observation of low energy recoils near threshold. This ability will greatly extend the possibility of observation of photo-pion production from the neutron in d and ^{3}He targets. The use of transverse polarized targets will enable measurements of low energy π-N final state interactions that have previously been impossible to access with pion beams. They have also not been possible for previous photo-pion reactions with conventional photon taggers and polarized targets such as butanol for which the background contributions from the constituent C and O nuclei are very large, particularly near threshold. Other fundamental studies such as Compton scattering will also be made possible with this facility. These low energy reactions are particularly fundamental to study the dynamics of chiral symmetry breaking in QCD and to test predictions that depend on the finite up and down quark masses including isospin breaking. Confronting these predictions is a timely and fundamental challenge that an intense beam of electrons can address.

Friday March 15th
Parallel Session PS4: Physics with nuclear targets
Kolker Room B

PS4A: Electroweak probes of nucleon structure and astrophysics I (11:30-13:00)

11:30-11:55
Determination of astrophysical thermonuclear rates with a bubble chamber: The $^{12}C(\alpha,\gamma)^{16}O$ reaction case
Claudio Ugalde
University of Chicago/Argonne National Laboratory

Hydrostatic helium burning in stars is dominated by the 3 $\alpha \rightarrow {}^{12}C$ and $\alpha + {}^{12}C \rightarrow \gamma + {}^{16}O$ nuclear processes. While the former is thought to be reasonably well understood, the latter has eluded even the most sensitive laboratory measurements. This reaction not only has a strong influence on the nucleosynthesis of most elements of the periodic table, but also determines the structure and evolution of subsequent stellar burning stages and explosive scenarios. We have devised a technique for measuring the $^{12}C(\alpha,\gamma)^{16}O$ reaction with a considerable improvement in sensitivity from previous experiments.
Adopting ideas from dark matter search experiments with bubble chambers, we have found that a superheated water vessel would be sensitive to α-particle and ^{12}C recoils produced from a gamma-ray beam impinging on ^{16}O nuclei. The main advantage of the new target-detector system is a density as high as a factor of several orders of magnitude over conventional gas targets. Also, the detector would be virtually insensitive to the gamma-ray beam itself, thus allowing us to detect only the products of the nuclear reaction of interest.

11:55-12:20
Measurements of the Astrophysical S-factor of the $^{12}C(\alpha,\gamma)^{16}O$ Reaction
Genya Tsentalovich
MIT

A measurement of the astrophysical S-factor of the $^{12}C(\alpha,\gamma)^{16}O$ reaction is proposed using the inverse $^{16}O(\gamma,\alpha)^{12}C$ reaction. The proposed experiment uses electron beam to produce Bremsstrahlung photons and allows an extension of the range of measurements down to E_{CM} = 0.6 - 0.7 MeV.

12:20-12:45
Clean measurements of the nucleon axial-vector and magnetic free-neutron form factors.
Alexandre Deur
Jefferson Laboratory

We will discuss the feasibility of a weak charged current experiment using a low energy electron beam. A first goal is to measure the Q^2 dependence of the axial-vector form factor $g_A(Q^2)$. It can be extracted model- independently and as robustly as for

electromagnetic form factors from typical electron scattering experiments, in contrast to the ways used so far to access $g_A(Q^2)$. If $g_A(Q^2)$ follows a dipole form, the axial mass can be extracted with a better accuracy than the world data altogether. The most important detection equipment would be a segmented neutron detector with good momentum and angular resolution that is symmetric about the beam direction, and covers a moderate angular range. A moderately high intensity beam (100 μA) is necessary. Beam polarization is highly desirable as it provides a free clean measurement of the backgrounds. Beam energies between 70 and 110 MeV are required. This range would provide a Q^2 mapping of g_A between $0.01 < Q^2 < 0.04$ $(GeV/c)^2$.
30 days of beam can yield 24 data points with a subpercent statistical and point-to-point uncorrelated uncertainties on each points. Such experiment may also allow to access the free-neutron magnetic form factor G^n_M as well as the ratio of the axial-vector and vector coupling constants, lambda = g_A/g_V. Free-neutron form factors have not been directly measured so far and are quantities of fundamental importance for hadronic and nuclear physics. lambda can be obtained from the electron spin-neutron momentum correlation parameter. This novel method for extracting lambda would have a completely different set of systematic uncertainties compared to polarized neutron beta decay, which is traditionally used to extract lambda. A different method for determining lambda is highly desirable because of the significant disagreement between the most precise measurement and the remaining world data all of which use neutron beta decay. The experiment employs the usual technics of electron-nucleon scattering and presents no special difficulty. Higher energy versions of this experiment are possible. They could yield measurements of g_A up to Q^2=3 $(GeV/c)^2$ and the possibility to access other form factors, such as the almost unknown pseudoscalar form factor g_P. However, such experiments become much more challenging as soon as beam energies pass the pion production thresholds.

12:45-13:00 Discussion

13:00-14:00 Lunch break

PS4B: Electroweak probes of nucleon structure and astrophysics II (14:00-15:30)

14:00-14:25
Weak Form-Factors of ^{3}He from e + ^{3}He --> ^{3}H + ν
Dipangkar Dutta
Mississippi State University

A low energy polarized electron beam could enable the extraction of the A=3 weak axial and pseudo-scalar form factors F_A and F_P using the reaction e + ^{3}He ➔ ^{3}H + ν. These form-factors could be use to obtain $g_A(Q^2)$, $g_P(Q^2)$ and the ratio g_A/g_V. We will discuss the feasibility of such an experiment using a small toroidal magnet and a radial time projection chamber to detect the recoil Triton. A moderately high intensity polarized electron beam (100 μA) with beam energies between 70 - 300 MeV is necessary for the cross section measurement and to provide a free clean measurement of the backgrounds. Moreover, in addition to the cross section one should also measure the electron spin and recoil Triton correlation coefficient to help extract the complete set of form-factors.

These measurements would be complementary to the e + p ➔ n + ν measurement also being discussed in this workshop. These novel electron scattering based measurements would have a completely different set of systematic uncertainties compared to polarized neutron beta-decay and muon capture experiments which are typically used to extract the weak form-factors, and could help resolve the significant disagreement between the most precise measurements and the remaining world data.

14:25-14:50

Ideas for fundamental polarized electron scattering at the S-DALINAC

Joachim Enders
Technical University, Darmstadt

To the superconducting Darmstadt electron linear accelerator S-DALINAC [1], providing electron beams of energies up to 130 MeV and currents up to 60 muA, a source of polarized electrons has been added recently [2]. In addition to an overview of the present status of the facility, the foreseen polarimeters [3] and further R&D work on the source [4], examples for possible future experiments will be given. Present ideas comprise, e.g., (i) the determination of the fifth structure function in (e,e'x) reactions, in particular for light nuclei, along the lines of Ref. [5], (ii) the measurement of the Mott scattering analyzing strength at several 10 MeV near 180 degrees [6,7], and (iii) the determination of bremsstrahlung polarization depending on electron spin polarization [8,9]. Another recent proposal on measuring spin-correlations in Moeller scattering by the QUEST collaboration will be discussed in a separate contribution [10].

Supported by DFG through CRC 634 and in part by the state of Hesse through the LOEWE centre HIC for FAIR.

[1] A. Richter, Proc. EPAC 1996, p. 110; [2] C. Eckardt *et al*., Proc. PAC 2011, p. 853; [3] C. Eckardt *et al*., Proc. DIPAC 2011, p. 515; [4] M. Espig *et al*., Proc. IPAC 2012, p. 2642; [5] J. Mandeville *et al*., Phys. Rev. Lett. **72**, 3325 (1994);
[6] P. Ugincius, H. Uberall, G. H. Rawitscher, Nucl. Phys. A **158**, 418 (1970); [7] D. H. Jakubassa-Amundsen, R. Barday, J. Phys. G **39**, 025102 (2012); [8] S. Tashenov *et al.,* Phys. Rev. Lett. **107**, 173201 (2011); [9] R. Martin *et al*., Phys. Rev. Lett. **108**, 264801 (2012); [10] J. Ciborowski, this conference.

14:50-15:15

Study of quantum spin correlations of relativistic electron pairs -- testing nonlocality of relativistic quantum mechanics

Jacek Ciborowski
University of Warsaw, Poland

The Polish-German project QUEST (Darmstadt-Krakow-Lodz-Warsaw) aims at studying relativistic quantum spin correlations of the Einstein-Rosen-Podolsky-Bohm type, through measurement of the correlation function and the corresponding probabilities for relativistic electron pairs. The results will be compared to theoretical predictions obtained by us within the framework of relativistic quantum mechanics, based on assumptions regarding the form of the relativistic spin operator. Agreement or divergence will be interpreted in the context of non-uniqueness of the relativistic spin operator in quantum mechanics as well as dependence of the correlation function on the choice of observables representing the spin. Pairs of correlated electrons will originate from the Moller scattering of polarised 15 MeV electrons from S-DALINAC, Darmstadt, incident on a Be target. Spin projections will be determined using the Mott polarimetry technique. Measurements are planned for different beam polarisations (longitudinal, transverse and intermediate) and different orientations of the beam polarisation vector w.r.t the Moller scattering plane. Our project is the first to study the relativistic spin correlation function for particles with mass. In addition, our calculations have shown that a measurement below 2 MeV, requiring a refined experimental technique, would be of particular interest due to a strongly non-monotonic dependence of the correlation function on beam energy, in contrast to the case known so far entangled photons.

15:15-15:30 Discussion

15:30-16:00 Coffee break at Stata R&D Pub

PS4C: Studies of A_T and R_n with nuclear targets (16:00-18:30)

16:00-16:25
Single-Spin Asymmetries in Elastic Electron-Hadron Scattering
Andrei Afanasev
George Washington University

Single-spin asymmetries (SSA) for elastic electron-hadron scattering may be either parity-violating or parity conserving. While the former arise due to neutral weak currents, the latter are caused by the effects beyond plane-wave Born approximation. In this talk, I review theoretical approaches to calculations of the parity-conserving SSA for electron scattering on the nucleon and nuclei.

16:25-16:45
Measurement of the parity violating asymmetry on deuterium and the axial form factor
David Balaguer Rios
University of Mainz

The A4 collaboration at the MAMI facilities has measured the parity violating asymmetry on proton and deuteron at forward and backward angles at $Q^2 = 0.23\ (\mathrm{GeV}/c)^2$. The analysis of the data for the parity violating asymmetry on deuteron at $Q^2 = 0.23\ (\mathrm{GeV}/c)^2$ is presented in this talk. This asymmetry is more sensitive to a linear combination of the magnetic strange form factor and the isovector axial form factor. Combining the different measurements of the parity violating asymmetry at this transfer momentum an experimental value of the isovector axial form factor can be extracted.

16:45-17:10
Neutron Skins and Neutron Stars
Jorge Piekarewicz
Florida State University

A neutron star is a gold mine for the study of physical phenomena that cut across a variety of disciplines, from particle physics to general relativity. Indeed, the limits of nuclear existence, the collision of energetic heavy ions, the structure of neutron stars, and the dynamics of core-collapse supernova all depend critically on the equation of state of neutron-star matter. In this presentation I will concentrate on the enormous impact that a high-precision determination of the neutron-skin thickness of Lead could have on a host of neutron-star observables.

17:10-17:35
The neutron skin in neutron-rich nuclei at Jefferson Lab
Mark Dalton
Jefferson Laboratory

Jefferson Lab has an ongoing program to access the symmetry energy of neutron-rich nuclear matter by measuring the "neutron skin" in neutron-rich nuclei. This is achieved through measurement of the parity-violating asymmetry in electron scattering, which is sensitive primarily to the neutron component of the nuclear form-factor and is free from most strong-interaction uncertainties. The recent PREX experiment measured this asymmetry from ^{208}Pb at $Q^2 \sim 0.009$ (GeV/c)^2 and from this data, the neutron skin was determined to 2-sigma. Design work for a further, more-precise measurement on ^{208}Pb is underway and there is also an effort to do a complimentary experiment on ^{48}Ca. A surprising ancillary result of this program is that the beam-normal single-spin asymmetry for ^{208}Pb is consistent with zero, and strongly disagrees with calculations. This may provide an important benchmark for incorporating Coulomb distortions in dispersion calculations.

17:35-18:00
Status and prospect of R_n measurements at Mainz
Concettina Sfienti
University of Mainz

Parity-violating electron scattering is particularly sensitive to the neutron density. The recent PREX Experiment at JLab has demonstrated the feasibility of this method meanwhile outlining its major experimental challenges. On the other side, intermediate energy photons are an ideal probe for studying the properties of strongly interacting matter from the nuclear scale down to the sub-nuclear components of the nucleus. Among others coherent pion photoproduction from nuclei is an attractive technique to obtain information on the existence and nature of neutron skins in nuclei.
The simultaneous combination of different techniques allows a systematic determination of the neutron skin of nuclei across the periodic table thus benchmarking modern calculation.

Recently a systematic investigation of the latter method has been exploited at the MAMI accelerator. At MESA the same experimental setup as in the measurement of the weak mixing angle measurement allows for a measurement of the parity violating asymmetry for longitudinally polarized electron scattered heavy nuclei with a 1% resolution competitive with the future PREX measurements. Status and prospects of the projects will be presented.

18:00-18:30 Discussion

Friday March 15th
Parallel Session PS5: Technology
Building 24 Conference Room

PS5A: Accelerator (11:30-13:00)

11:30-12:00
Upgrade Capabilities of the Jefferson Lab FEL Driver
Christopher Tennant
Jefferson Laboratory

The Free Electron Laser (FEL) driver at Jefferson Laboratory has proved to be a uniquely flexible machine whose world-class lasing performance enables cutting edge photon science, but which is also capable of providing beam conditions necessary for internal target experiments. Adding a polarized electron source to the FEL driver would further broaden the scope of experiments (e.g. fixed target) that could be performed at the facility. Various upgrade scenarios, such as replacing linac cryomodules and utilizing 2-pass operation to extend the energy reach, will be discussed. Additionally, preliminary start-to-end simulations will show current capabilities and provide guidance for anticipated performance with upgrades.

12:00-12:30
Large Dynamic Range Diagnostics For High Current LINACs
Pavel Evtushenko
Jefferson Laboratory

Jefferson Lab FEL driver accelerator Energy Recovery Linac has provided beam with average current of up to 9 mA and beam energy of 135 MeV. The high power beam operations have allowed developing and testing methods and approaches required to setup and tune such facility simultaneously for high beam power and high beam quality required for high performance FEL operations. In this contribution we briefly review this experience and outline problems that are specific to high current - high power non-equilibrium LINAC beams. While original strategy for beam diagnostics and tuning have shown to be quite successful, some shortcomings and unresolved issues were also observed. The most important issues are the non-equilibrium (non-Gaussian) nature of the LINAC beam and the presence of small intensity large amplitude fraction of the beam a.k.a. beam halo. Thus we also present a list of the possible beam halo sources and discuss possible mitigations means. We argue that for proper understanding and management of the beam halo large dynamic range ($>10^6$) transverse and longitudinal beam diagnostics can be used. We also present results of transverse beam profile measurements with the dynamic range approaching 10^5 and demonstrate the effect the increased dynamic range has on the beam characterization, *i.e.* emittance and Twiss parameters measurements. We also discuss near future work, which we will be doing in this field where the JLab FEL facility will be used for beam tests of the developed diagnostics.

12:30-13:00
Status of the MESA Injector
Robert Heine
University of Mainz

In this Talk we present several possible configurations of an injector linac for the upcoming Mainz Energy-recovering Superconducting Accelerator and dicuss their suitability for the project

13:00-14:00 Lunch break

PS5B: Precision Polarimetry (14:00-15:30)

14:00-14:20
Polarimeters at MAMI and MESA: Past and future
Valery Tyukin
University of Mainz

High accuracy polarimetry is mandatory for several experiments planned at MAMI and MESA, especially for the planned P2-experiment. We discuss a recently finalized polarimeter comparison at MAMI. Measurements of the relative analyzing powers of three different electron beam polarimeters have been performed using the MAMI beam. The same source of polarised electron was used for all measurements with the same magnitude of beam polarisation. Measurements with high statistical accuracy of the scattering asymmetry as a function of the spin orientation were made with each polarimeter. A critical analysis of systematic errors is presented. We conclude that in order to define absolute beam polarization with a relative accuracy better than 0.5 %, radically new approaches must be taken.

14:20-14:40
The polarimetry chain at MESA
Kurt Aulenbacher
University of Mainz

The P2-experiment tries to perform a precision measurement of the electro-weak mixing angle. In order not to limit the achievable accuracy of the result, the beam polarization must be known to better than half a percent. We propose to operate two polarimeters which individually achieve the desired accuracy. In order to circumvent the limitations of existing polarimeters, we intend to use a) a double polarization experiment with completely polarized target ("Hydro-M ller" polarimeter following a suggestion by Chudakov and Luppov) and b) a self calibrating low energy polarimeter ("Double scattering polarimeter"). Especially the latter device seems to have the potential for accuracies below 0.5%.

14:40-15:00
Electron Polarimetry at Low Energies in Hall C at Jefferson Lab
David Gaskell
Jefferson Laboratory

Although the bulk of Jefferson Lab experiments require multi-GeV electron beams, we have on a few occasions had the opportunity to make electron polarization measurements at rather low energies. In this talk I will discuss some of the practical difficulties encountered in performing electron polarimetry via Moller scattering at energies on the order of a few hundred MeV. I will also discuss commissioning and operation of the Hall C Compton polarimeter at 1.1 GeV. While Moller scattering is likely the preferred method of electron polarimetry at energies below 500 MeV, there are certain aspects of the polarimeter and experiment design that must be considered.

15:00-15:30
Moeller Polarimetry with Polarized Atomic Hydrogen at MESA
Patricia Aguar Bartolome
University of Mainz

A new generation of parity violation electron scattering experiments are planned to be carried out at the Institut fur Kernphysik in Mainz. These experiments will be performed at low energies of 100-200 MeV using the new accelerator MESA (Mainz Energy recovering Superconducting Accelerator). One of the main challenges of such experiments is to achieve an accuracy in beam polarization measurements that must be below 0.5%. This very high accuracy can be reached using polarized atomic hydrogen gas, stored in an ultra-cold magnetic trap, as the target for electron beam polarimetry based on Moeller scattering. Electron spin-polarized atomic hydrogen can be stored at high densities, over relatively long time periods, in a high magnetic field (8T) and at low temperatures (0.3K). The gradient force splits the ground state of the hydrogen into four states with different energies. Atoms in the low energy states are trapped in the strong magnetic field region whereas the high energy states are repelled and pumped away. The physics of ultra-cold atomic hydrogen in magnetic traps and the status of the Mainz Hydro-Moeller project will be presented.

15:30-16:00 Coffee break at Stata R&D Pub

PS5C: Experiment: Targets, spectrometers etc. (16:00-18:30)

16:00-16:30
Designing high power targets with computational fluid dynamics (CFD)
Silviu Covrig
Jefferson Laboratory

The 2500 W liquid hydrogen target for the Qweak experiment was the first target designed with CFD at Jefferson Lab. The target was successfully employed in two physics runs between 2010-2012. A CFD facility is being established at Jefferson Lab to design, build and test a new generation of liquid hydrogen targets. I will present the state of the CFD facility and future plans.

16:30-17:00
Report on Workshop on TPCs at high rate experiments
TBA

On February 28 and March 1 at Bonn University, Germany, a workshop to study TPCs at high rate experiments will take place. Issues such as readout concepts, ion back flow, aging, field homogeneity, and calibration systems will be discussed. A summary report on the workshop will be presented.

17:00 Discussion