A4 Instrument

Created by: Johannes Gutenberg University Mainz, Petersburg Nuclear Physics Institute, Institut National de Physique Nucleaire et de Physique des Particules, Thomas Jefferson National Accelerator Facility, Massachusetts Institute of Technology

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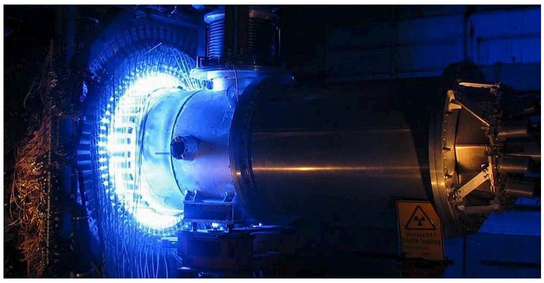
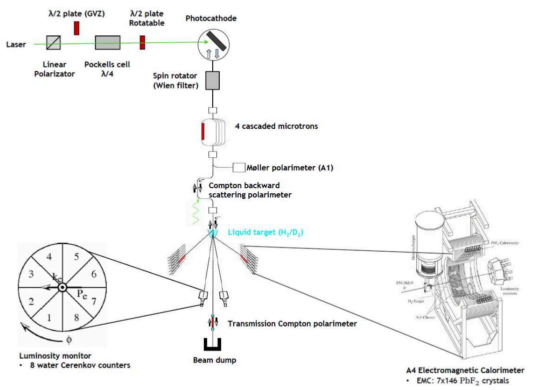
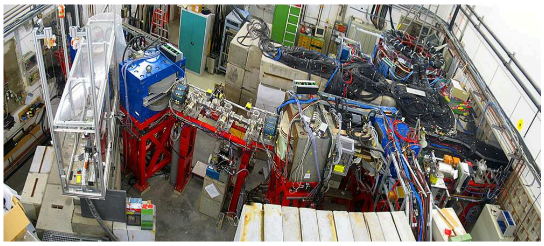
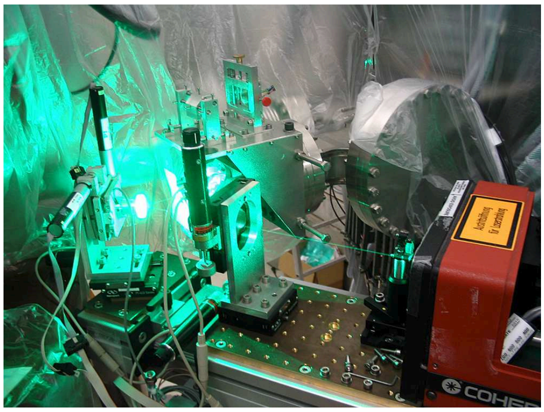
Description

The atomic nucleus is a bound state of protons and neutrons (so called nucleons). The A4 collaboration is investigating the structure of these nucleons. In a simple picture, nucleons are made up of three elementary constituents, two up- and one down-quark. Today's view of the nucleon is more complex: Beside the valence quarks also gluons, the force carrier of QCD, and quark-antiquark pairs known as sea quarks contribute to the properties of proton and neutron. In the quark sea also flavors occur which are not present in the valence quarks. The A4 collaboration is aiming to measure such flavor contribution, especially those of the strange quarks since they are the lightest non-valence quarks. In the experiment, polarized electrons are scattered off unpolarized nucleons and detected in a lead fluoride calorimeter. Depending on the polarization state there are tiny differences in the interaction strength due to the parity violation in the weak interaction. Consequently, the number of scattered electrons vary for the two polarization states. These numbers can be determined by the measurement of the parity violation asymmetry. This asymmetry reveals the distribution of strange quarks within the nucleon. The A4 collaboration measures small asymmetries in the cross section of elastic scattering of polarized electrons off an unpolarized target, basically hydrogen or deuterium. The momentum transfers achieved either in forward angle- or backward angle-configuration of the detector vary between 0.02 $(GeV/c)^{2}$ and 2.2 $(GeV/c)^{2}$. There are two main physics goals: (i) Parity violating electron scattering asymmetries are measured with a longitudinally polarized electron beam. Using input from the Standard Model the contribution of strange sea quarks to the vector form factors of the nucleon are determined. The combination of measurements on hydrogen and deuterium allow for an additional determination of the axial form factor of the proton referring to the nuclear anapole moment. (ii) Using a transversely polarized electron beam, the observed asymmetries arise at leading order from the interference of the one- and the two-photon-exchange amplitude. These asymmetries are sensitive to excited intermediate states of the nucleon. The imaginary part of the two-photon exchange amplitude can be determined. A high power liquid hydrogen target of 10 cm or 20 cm length and an electron beam of I = 20 muA lead to luminosities in the order of L = 10^{38} $cm^{-2}s^{-1}$. The scattered electrons are measured by a total absorbing, segmented lead fluoride calorimeter which deals with event rated of about 100 MHz. The degree of polarization of the electron beam is measured by a laser Compton backscatter polarimeter simultanously to the main experiment. With this apparatus, the internal cavity concept is realized for the first time.









References

- Concept and Realization of the A4 Compton Backscattering Polarimeter at MAMI
- Real-time calibration of the A4 electromagnetic lead fluoride (PbF2) calorimeter
- A high power liquid hydrogen target for the Mainz A4 parity violation experiment
- The analog trigger processor for the new parity violation experiment at MAMI
- A4 Compton polarimetry
- Background studies for the A4 experiment
- The Compton backscattering polarimeter of the A4 experiment
- Stabilization system of the laser system of the A4 Compton backscattering polarimeter
- Electron beam line design of A4 Compton backscattering polarimeter
- Rearrangement of the A4 calorimeter for the backward angle measurement