Scientific motivation for the request by the AIACE experiment of beam time at the Frascati Beam Test Facility

The AIACE experiment is in the process of designing and building a new Cherenkov detector to be installed as part of the existing CLAS (Cebaf Large Acceptance Spectrometer) equipment in Hall B at the Thomas Jefferson National Accelerator Facility (Jefferson Lab) in Newport News, Virginia, USA. The new Cherenkov will be used by experiment E-03-006, "The GDH Sum Rule with nearly real photons and the proton g_1 structure function at low momentum transfer".

The experiment was approved by the Program Advisory Committee in January 2003 and has been given high priority in the scheduling process. Goal of the experiment is to measure inelastic electron scattering from a polarized electron beam off a polarized hydrogen (ammonia) target at very low scattering angles, down to 5 degrees. This is not currently possible in CLAS because of limitations in the downstream beamline and most important because the current Cherenkov detector optics is not optimized for the small angle scattering configuration where electrons are bent away from the beamline by the toroidal magnetic field ("outbending" field).

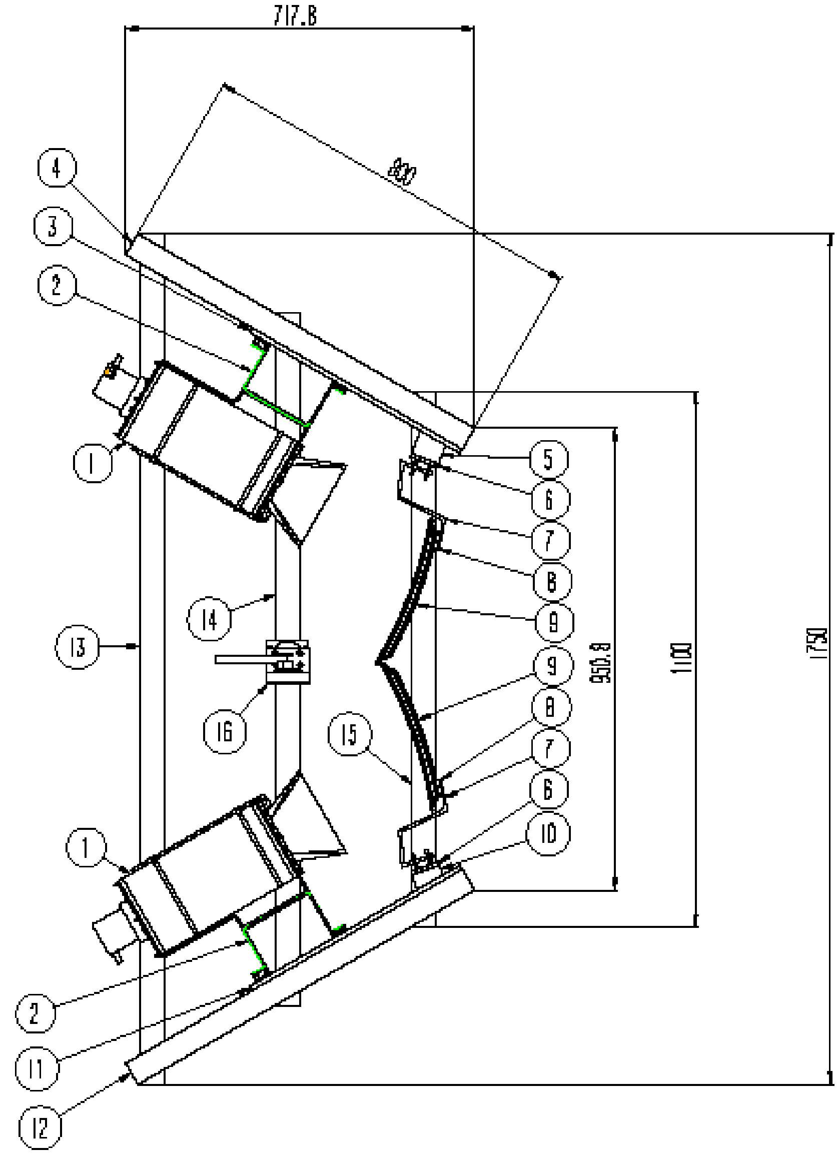
We therefore designed a new type of threshold Cherenkov counter where the optics is specifically optimized for electron scattering with outbending field. This Cherenkov counter is based on 11 pairs of spherical mirrors of varying radius and size (the two members of a pair being identical) and each mirror focuses the light onto a photomultiplier placed at the side of a submodule. Cherenkov light will be generated by electrons passing through perfluorobutane gas (C_4F_{10}), a non-flammable gas about 10 times heavier than air and with good UV transparency, kept at a few mbar above atmospheric pressure. Another feature of experiment E-03-006 is that instead of using polarization asymmetries to derived the physics of interest, we want to measure directly polarized absolute cross section differences, as the latter method would allow to reduce or eliminate some types of systematic errors. It is therefore very important to be able to measure the absolute scatterered electron yield, a task that with the previous detector was made difficult in some kinematic regions due to the complicated optics and consequent non-uniformities, leading to a limited fiducial region for absolute measurements.

Simulations indicate that the optics devised for the new Cherenkov counter should allow to obtain a very high number of photoelectrons, with an event distribution practically always above about 10 photoelectrons when various kinematics are considered, which would allow very good and uniform detection efficiency, a necessary requirement for measuring absolute cross sections.

Based on the initial design, we built a prototype that reproduces the smallest detector submodule covering the portion of smallest scattering angles. The prototype has therefore two mirrors and two photomultipliers as illustrated in the pictures below. We would like to characterize the detector performance in terms of photoelectrons given the optical properties of the prototype mirrors that were measured elsewhere. In particular, we would like to shoot the beam on several points at the entrance window and at a few angles with respect to the entrance window plane, corresponding to different reflection points on each of the two mirrors and different reflection paths onto the photomultipliers.

A liquefied perfluorobutane gas supply is available and will be used to the fill the detector during the test after cleaning up with nitrogen. We also developed a mass spectrometer system based on a vacuum chamber and a filament, where a small amount of gas from the detector can be analyzed on-line to check its purity.

The measurement at the Beam Test Facility in Frascati would allow us to assess the Cherenkov performance and check the results from the optical Monte Carlo, and it would provide some insight for future alignment procedures.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