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THE CELSIUS/WASA FACILITY*

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The WASA (Wide Angle Shower Apparatus) is a new detector system with very high acceptance presently being commisioned at the CELSIUS storage ring located at The Svedberg Laboratory in Uppsala. It has been designed to study rare decays of light mesons with sensitivity down to 10^{-9} in the branching ratio. It will also allow for unprecedented quality measurements of differential cross sections of different reactions induced by protons and light nuclei.

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1. Introduction

The WASA detector located at the pellet target station is now being completed and commissioned. It has been built by laboratories and universities in Dubna, Jülich, Łódź, Moscow, Novosibirsk, Osaka, Tsukuba, Tübingen, Uppsala and Warsaw. We present here the potential of the apparatus.

2. The CELSIUS accelerator and target system

The CELSIUS accelerator and storage ring gives maximum energy 1360 MeV for protons and 470 MeV/nucleon for ions with charge to mass ratio of one half. The precision study of rare processes requires high luminosity and the thin, windowless target to avoid the conversion and secondary interaction in the target material. The newly developed target system provides a stream of hydrogen pellets of about 30μm in diameter. A jet of liquid hydrogen is broken-up into droplets by piezo-electrically induced vibration of the injection nozzle. The droplets are freezing by its own evaporation in the vacuum and form the solid pellets. After a collimation the pellets are directed through a thin tube into scattering chamber. The pellet target thickness up to 5×10^{15} atoms/cm^2 gives acceptable half-lives of the circulating ion beam as well as acceptable vacuum conditions.

3. The detector

The detector has the capability of measuring photons, electrons and hadrons. The cross section of the detector are presented in the Fig.1.

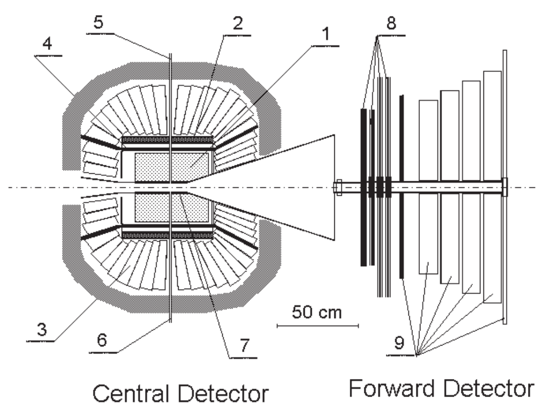

Fig. 1. The detector cross section. 1 denotes the central wire chamber, 2 — superconducting selenoid, 3 — CsI crystal scintillators, 4 — plastic scintillator barrel, 5 — pellet tube, 6 — cryogenic pump tube, 7 — beryllium tube, 8 — wire chamber planes and 9 — plastic scintillator planes.

The central part of the detector (Central Detector), optimized for electrons and photons, consists of a cylindrical drift chamber sitting inside a superconducting solenoid that is surrounded by a CsI(Na) calorimeter. The fast signal for trigger is provided by the plastic scintillator barrel situated in between the drift chamber and the solenoid. The calorimeter consists of 1012 CsI(Na) scintillating crystals shaped as truncated pyramids. The length of the crystals varies from 30 cm (16.2 radiation lengths) in the central part to 20 cm in the backward and 25 cm in the forward part. To obtain good energy resolution of the calorimeter the crystal surfaces were treated to assure uniform light output along the crystal axis. Each crystal is optically coupled by light guides to the photomultiplier placed outside of the iron yoke and supplied with light fiber providing light pulser calibration signals.

The forward part of WASA (Forward Detector) covers scattering angles in the range of $3°$ to $18°$ and is designed to measure the projectiles and target recoil particles. It consists of several drift-chamber planes and 8 planes of plastic scintillators of the total thickness 50 cm. The mesons can be tagged via missing mass to two protons, deuteron or helium ions identified and measured in the Forward Detector. Deuterons and He nuclei at scattering angles below $1°$ are measured accurately in a spectrometer system using the accelerator magnets.

The disturbances in the measurement of particles by secondary interactions are minimized by using windowless target, beryllium scattering chamber and the thin walls solenoid (0.18 radiation lengths). The high intensity internal proton beam of the CELSIUS storage ring interacting with the windowless hydrogen pellet target can provide up to 10^9 η's per year.

4. Physics program

The forward part of the WASA detector and two matrices of CsI(Na) scintillators proceeded by the plastic hodoscopes were already in use with the cluster-jet target [1]. The collaboration has studied π^0 and η meson production in nucleon-nucleon collisions near threshold as well as $\pi^+\pi^-$ pair production. Some of the reaction channels were measured for the first time. The results are presented in [2–7]. Other items of interest were bremsstrahlung, deuteron break-up mechanism, and searches for dibaryon states.

The Collaboration will continue studies of π^0 and η production from pp and pd interactions in the high acceptance conditions. The new detector is particularly well suited for the measurement of lepton pair production. This will permit clear distinction between different sources of leptonic pairs in light nuclei interactions. The precise study of the lepton pair invariant mass distribution from the single and double Dalitz decays of η will permit to get new information on the transition meson form-factor at small Q^2.

However the most challenging goal is the study of both charged and neutral rare η decays. It will permit to test Chiral Perturbation Theory with better precision and to search for the effects of fundamental symmetries violation.

An increase of maximum energy of protons to 1.95 GeV and of heavy ions to 720 MeV/nucleon is under consideration. It will open up new physics possibilities, such as the η' and Φ meson production and decay studies. By this presentation we also want to stimulate new ideas and we encourage interested people to join the group for exploatation of the CELSIUS/WASA facility.

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