THE WASA FACILITY AT THE CELSIUS STORAGE RING

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Abstract

The WASA facility, intended for production and rare-decay studies of light mesons, is currently being installed at the CELSIUS storage ring. The system will provide wide-angle detection of reaction and decay products from high-luminosity experiments using pellet targets of frozen hydrogen and deuterium micro-spheres.

1 INTRODUCTION

The WASA facility, shown in Fig. 1, will exploit the exciting possibilities to study rare reactions at CELSIUS. Inelastic reactions between beam particles and light targets can be measured over a large solid angle. WASA includes a pellet-target system, a central detector for particles scattered isotropically, a forward detector for particles scattered at angles between 3 and 18 degrees and a tagging spectrometer for He and deuteron recoils emitted at 0 degree. The scattered beam and target particles are emitted preferentially in the forward direction whereas the meson decay particles are emitted more isotropically.

The detector setup is designed to be capable of:

- handling luminosities of about 10^{32} $cm^{-2}s^{-1}$ using pellet targets of hydrogen and deuterium in a coasting beam of about 10^{10} protons.
- measuring charged particles and photons over a solid angle close to 4π with high accuracy in energy, charge and track coordinates.
- minimizing the photon conversion in the target, in the beam tube and in the vertex detector.
- providing a fast trigger for selection of rare events.

2 THE WASA FACILITY

The WASA facility is currently being installed at the CELSIUS storage ring. The commissioning period is scheduled to start early in 1999. Below we will give some details on the different main components of the WASA facility.

2.1 The pellet-target system

The heart of the WASA facility is the pellet-target system which was installed at CELSIUS in 1995 and has been operated in a configuration similar to the one of the final setup. From tests of the pellet target at CELSIUS it has been verified that all major conditions for use in WASA are satisfied [1].

The pellet production is made by breaking up a liquid jet into equally sized and spaced droplets, which are frozen by the injection into vacuum. The pellets have a diameter of 30 μm, a speed of about 60 m/s, and are produced at a rate of about $7x10^4$ s^{-1}.

Much efforts have been put into the diagnostics systems for alignment and tracking of individual pellets. The alignment is made by two computer controlled coordinate tables directing the droplet and pellet streams. The tracking of individual pellets, i.e. the on-line reconstruction of the interaction point between the pellets and the stored beam using an optical system, is still under development.

Hydrogen and deuterium pellets have been produced and tested in a long-term stability program. Also, in a test program at CELSIUS, the influence of the pellet stream on the stored beam and the ring vacuum has been measured and optimized for the WASA conditions. An optimal target thickness of $5x10^{15}$ $atoms/cm^2$ will give acceptable half-lives of the stored beam, about 5 min of a 1 GeV proton beam, as well as acceptable vacuum conditions, about 10^{-6} mbar, in the scattering chamber.

2.2 The superconducting solenoid

The central part of the WASA detector includes a magnetic field for an accurate measurement of charged particle momenta in the mini-drift-chamber, and to protect the central detector against low-energy delta electrons produced abundantly when the pellets pass the CELSIUS beam. The light superconducting solenoid with a NbTi/Cu matrix-wire embedded in an aluminum stabilizer to provide an axial magnetic field of 1.3 T in the volume of the mini-drift-chamber has been developed at KEK [2].

The solenoid is made extremely thin (0.18 radiation length) in order not to disturb the measurements in the surrounding CsI calorimeter. The photomultipliers of the calorimeter are mounted well shielded outside the iron yoke used for the return field. The yoke also serves as mechanical support for the crystals of the CsI calorimeter. The test setup in the CELSIUS hall with the iron yoke surrounding the superconducting solenoid is shown in Fig. 2.

2.3 The mini-drift-chamber

The mini-drift-chamber was developed and built by the Dubna/Moscow group. It will be used for measurement of the coordinates of particle tracks with polar angles between 25 and 155 degrees. The beryllium beam pipe is surrounded by the cylindrical chamber of the straw type with 1738 straws organized in stereolayers. Nine layers are parallel to the beam axis and eight layers have small skew angles that cause the stereolayers to form a hyperboloidal shape. The position resolution in the mini-drift-chamber is 100 μm radially and 1.5 mm along the beam axis.

2.4 The plastic scintillator barrel

The plastic scintillator barrel, prepared by the Warsaw group, will provide fast logic signals for the first level trigger and analogue signals for particle identification by the ΔE-E technique. It is placed just inside the super-conducting solenoid and surrounds the mini-drift-chamber. The plastic scintillator barrel consists of a cylindrical part and two end caps with a total of 144 scintillator strips of 8 mm thickness. In the cylindrical part there are 48 elements of 550 mm length forming a layer with small overlap between neighbouring elements.

2.5 The CsI calorimeter

The calorimeter, provided by the Novosibirsk group, will be used to measure energy and scattering angle of photons and charged particles. The modular electro-magnetic calorimeter consists of 1012 sodium-doped CsI scintillator crystals placed outside the superconducting solenoid and inside the iron yoke. It covers scattering angles from 20 to 169 degrees. The calorimeter with a total weight of 3.8 tons is together with the 5 tons heavy iron return yoke the heaviest component in WASA. The scintillator crystals are fixed individually into the iron yoke and the readout of the light signals are made via light guides with photomultiplier tubes placed in the field-free region outside the iron yoke.

2.6 The forward detector

The forward detector to be used at the WASA facility has been operated successfully for a number of years at the CELSIUS cluster-jet target. Details of the detector are given in Ref. [3]. In short it consists of four parts:

- a tracker made of proportional counter straw chambers in four layers for accurate determination of scattering angles.
- a three-layer hodoscope of thin plastic scintillators for fast position determination and trigger. The first two planes are made of 24 spiral segments each, whereas the third plane is divided into 48 straight sectors. This detector is provided by the Jülich group.
- a four-layer thick plastic scintillator array, built by the Warsaw group, for energy measurements of charged particles. Each layer is 110 mm thick.
- a veto hodoscope with plastic scintillator bars, prepared by the Tübingen group, to detect penetrating particles.

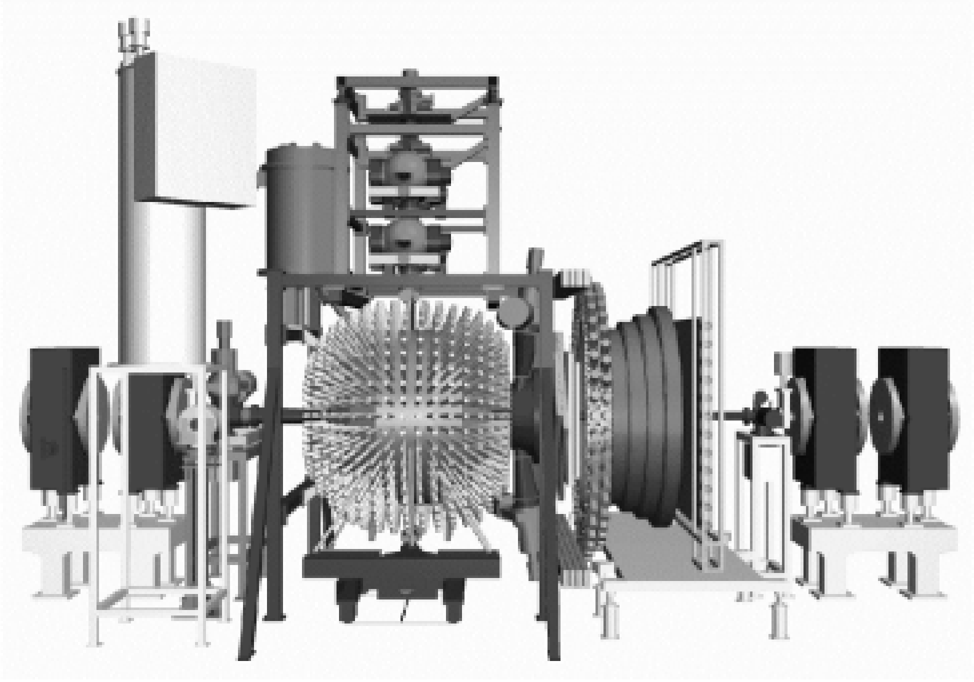

Figure 1: *CAD view of the WASA facility with the forward detector to the right, the pellet generator on top and the cryogenic system for the solenoid to the left. The iron yoke for magnetic field return with the CsI calorimeter PM tubes sticking out is seen in the center.*

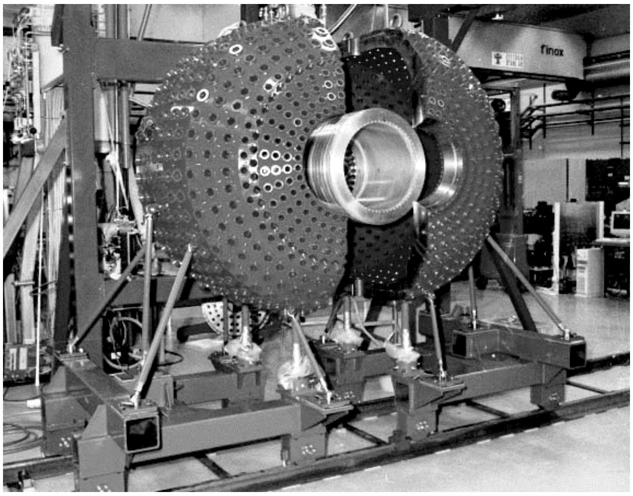

Figure 2: *Test setup in the CELSIUS hall with the iron yoke surrounding the superconducting solenoid.*

2.7 The tagging spectrometer

Because of the accelerator beam pipe, the smallest scattering angle that can be measured by the forward detector described above is 3 degrees, thus prohibiting very-near-threshold measurements of meson production using the forward-going recoils. A tagging spectrometer for nuclear recoils emitted at 0 degree has therefore been developed by the MEPI and Dubna groups. It is making use of the first bending magnet downstream the interaction point, in combination with a detector setup measuring direction, energy loss and total energy of the particles.

2.8 The trigger system

The anticipated high particle fluxes put very hard demands on both single detector elements, especially the straw chambers, and on the trigger and data acquisition system. WASA is designed for a maximal total event rate of 10^7 per second.

The trigger conditions for the 4π detector will be implemented in three different levels. The first level uses logic conditions based on the fast signals from the plastic scintillators which initiates the data acquisition. In the second level trigger, the pattern and energy information from the CsI crystals will be used. This level can give a reset of the frontend digitizing electronics. The third level will use the processors in the data acquisition system and will have full access to the digitized energy and position information from all detector elements.

2.9 The data acquisition system

To have sufficient capacity and a high level of reliability the WASA data acquisition system is based on an ATM switch for the transportation of data. The system will handle up to 3500 words per event of digitized data from the front-end electronics. It will also reduce the data flow from about 10 Megawords per second to about 2 Megawords per second that can be written to a number of tape stations simultaneously.

3 CONCLUSION

The WASA facility, being built up at the CELSIUS storage ring, will constitute a powerful experimental station for high-precision and high-sensitivity measurements of rare production and decay processes of light mesons. Wide-angle detection will be used to measure charged as well as neutral reaction products from the high-luminosity experiments.

4 REFERENCES

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