THE CSRe INTERNAL TARGET SYSTEM

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Abstract

An internal target is to be equipped in the experimental ring CSRe. The internal target is designed to operate both in the polarized mode and in the unpolarized mode. The polarized internal target uses the state selection in multiple magnets to get the polarized atomic beams. The unpolarized target is a cluster-jet target. A large pumping system is used to minimize the gas load to the ring to an acceptable level. In this paper the main parameters, the design philosophy and the structure of CSRe internal target is described.

1 INTRODUCTION

Experiments with polarized internal gas targets in storage ring are of great importance in nuclear physics. Important additional information on the nuclear interactions may be obtained in experiments using polarized target. It permits the study of the spin structure of hadrons and allows measurements of nuclear form factor. The polarized atomic beam targets may be obtained either by state selection in multiple magnets [1] or by optical pumping induced by laser light [2], either directly or through spin exchange. The polarized internal target techniques using a storage cell was first demonstrated at the VEPP-3 electron storage ring at Novosibirsk [3]. Since then, the polarized internal target experiments have been performed at the electron storage ring at Heidelberg [4], the IUCF cooler storage ring at Indiana [5] and at AmPS ring at NIKHEF [6]. To meet the requirements of the nuclear and atomic physics experiments the CSRe internal target is designed to provide both polarized and unpolarized atomic beams. The CSRe polarized internal target uses rf-transition and the state selection in multiple magnets to get the polarized atomic beams. The unpolarized target is a cluster target.

The structure, the design philosophy and the main parameters of the CSRe internal target is presented in this paper.

2 TECHNICAL DESCRIPTION

The internal target is located in one of the straight section of the CSRe [7]. It can operate in the polarized mode with H_2 and D_2 gases, and in the unpolarized mode with noble gases and molecular gases such as nitrogen, hydrogen, CH_4 and so on. The structures of the polarized and unpolarized targets are shown in Fig. 1 and Fig. 2, respectively. Two kinds of the targets use different source part and the same beam dump system

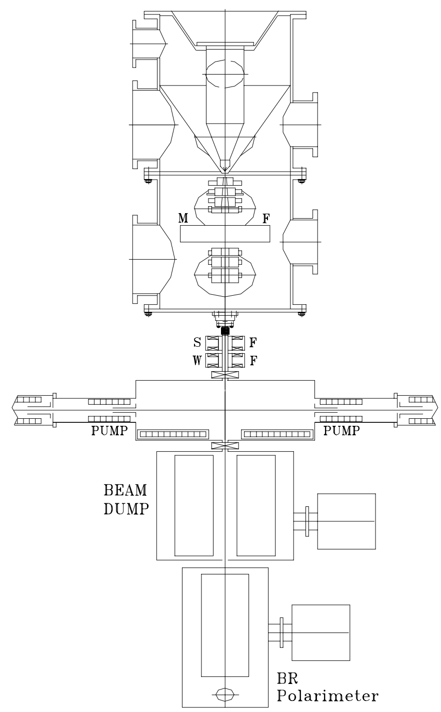

Figure 1. The structure of the polarized target.

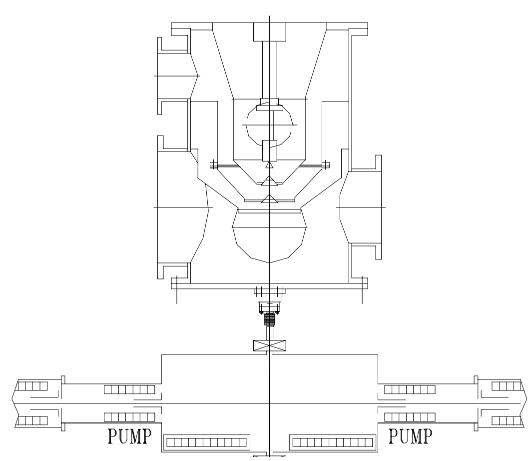

Figure 2. The structure of the cluster target

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including the conventional dump which is necessary for unpolarized cluster target and the polarimeter which is necessary for the control of the polarized atomic beams. The source part of polarized target and unpolarized target can be easily changed from one to another.

The CSRe polarized target uses superconducting sextupole magnets and classical Stern Gerlach separation scheme to obtain a high degree of polarization and purity of the beam. The intensity of the beam depends upon many factors: the degree of dissociation in the discharge tube, the efficiency of the beam formation system, the temperature of the nozzle, the velocity distribution of the beam, the attenuation of the beam in the source and the properties of the focusing magnet. The nozzle may be cooled down to 70K using LN_2 cooling. The superconducting magnet may be cooled down to about 4K using liquid helium. By optimizing the velocity distribution the polarized target is desired to achieve a density of $>5\times10^{11}$atoms/cm^2 and a diameter of < 8 mm at the interacting point. To coordinate the polarized atomic beam a magnet field around the interacting area is arranged. A set of compensation magnet is used to compensate the perturbation to the movement of the ring ion beams. The arrangement of the magnet will not affect the arrangement of the detectors and other necessary devices.

The unpolarized target is a cluster-jet target. By using the cluster-jet target it is possible to have a long distance between the nozzle and the interaction region, allowing for wide-angle detection. The beam formation part of the cluster target consists of four stages: the nozzle stage and three skimmer stages. The gas is pressed by a few atmospheres through the nozzle. The cluster beam is formed which is made to pass the skimmer and a set of the collimators, giving an intense beam with a well bounded intensity profile. An effective pumping system is used to reduce the pressure in the scattering chamber and keep the background vacuum of 10^{-11}mbar of the ring to be nearly unaffected. We calculated the pressure distribution in the present structure. The calculated results are listed in Table 1. According to the calculation the pressure in the scattering chamber could be decreased to the magnitude of 10^{-11} mbar (neglecting the gas load produced by the cluster evaporation) by using three stages of collimating and a pumping speed of 1500 l/s at each stage. To get a high compression ratio for hydrogen the turbo pumps will be backed with additional turbo pumps. A set of conductance limiter (Fig. 3) and a pumping system with enough pumping speed are used along the ring to decrease the gas load produced by cluster evaporation during the ion-cluster collisions to an acceptable level. In the calculation of the pumping speed requirement we suppose that each cluster encountered by the heavy ions will be fully evaporated and contributes additional gas load. The arrangement and the operation of the conductance limiter will not decrease the acceptance of the ring and operates with good reliability. The limiter is well designed upon the requirements of the UHV system. A three-stage beam dump with high efficiency is designed to ensure that the jet is pumped away without significant back-streaming. To achieve good density the nozzle should be cooled down to 20K with a two-stage cryostat. During the operation of the cluster target it is important to control the formation of the cluster since the large cluster will destroy the vacuum of the ring due to the cluster evaporation induced by the collision of the heavy ions. It means one should carefully choose different nozzle temperatures for different kinds of working gases. The cluster target is desired to have a density of $>1\times10^{12}$atoms/cm^2 and a diameter of < 3 mm at the interacting point.

Table 1. The pressure in each stage.

	Pumping speed (l/s)	Pressure (Pa)
Gas in chamber	1500	1×10^{6}
1st pumping stage	1500	2.3
2nd pumping stage	1500	5.3×10^{-4}
3rd pumping stage	1500	1.6×10^{-7}
Ring		2.4×10^{-9}

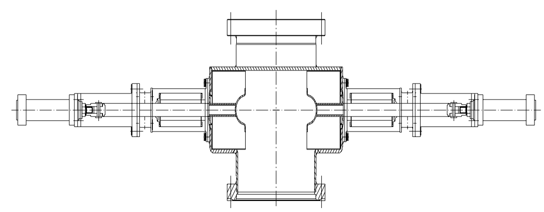

Figure 3. Conductance limiter

All the flanges and feed-through are metal-sealed flanges. The chamber of the source part, the beam dump and the polarimeter will not be baked during the operation and these chambers and flanges use stainless steel 304. The scattering chamber will be baked to 300°C and use 304L stainless steel. All flanges of the target chamber use 316LN stainless steel.

Two control systems for the target are designed. One will be located nearly to the target and another one will located in the central control room.

Now the general design of the CSRe internal target has been finished. The detailed technical design is in progress and can be finished soon. According to the time schedule of the project the CSRe internal target will be ready for the physics experiments at the end of 2003. Before the deadline the manufacturing, the assembling, testing and test-running should be finished.

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