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BRAGG CURVE COUNTER FOR PRIMARY BEAM MONITOR

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Abstract

The prototype Bragg Curve Counter(BCC) has been tested by α-source(^{241}Am) with a continuous gas flow system (P-10 :90% Ar+10% CH_4, at 300Torr). Two types of the Frisch grid were prepared for the BCC. One was made of expanded metal meshes, which consist of 175 meshes/inch^2 with a 100μm^t nickel sheet. The other was made of a 1mm pitch wire with ϕ 50μm of the tungsten. The shape of Bragg peak signal was compared each other. It was found that the energy spectrum obtained by the wire grid is a little sharper than that obtained by the meshes grid. However the meshes grid is superior than the wire grid so far as handling and durability are concerned.

Introduction

We concentrate on the Bragg Curve Counter (BCC) in order to measure the primary extracted beam of both high-intensity proton beam and low-intensity heavy ion beam. The Bragg Curve Counter is the ionization chamber with a Frisch grid. It is well known that the maximum ionization that we call Bragg Peak is occurred, just before the charged particle stops. This peak height is proportional to the atomic number of the incident particles. Therefore by measuring the maximum peak height from the anode of the BCC, we can define the atomic number of the charged particle coming into the BCC. Furthermore we measure the total ionization charge of incident particles by the BCC, we can define the kinetic energy of the incident particle. The differential cross section of the target fragment from the thin gold target is well known and reaches to a few mb/sr per each fragment atomic number. Therefore if we measure the thin target fragment yields by the BCC which has 10msr in solid angle, we can define the beam intensity under a highly accurate statistics. If we use the 1mg/cm^2 gold foil target, the total matter in the primary beam line becomes one thousandth of the present beam monitor system (e.g. SEC, Ion Chamber, etc.). The energy loss of the primary beam will be therefore minimized in the present methods.

Design of the Bragg Curve Counter

The BCC detector consists of an anode, eleven field-shaping rings and a Frisch grid in the same vacuum chamber. Figure 1 shows the cross section of the prototype BCC. The detector assembly is enclosed by the SUS pipe of 210mm inner diameter. Though the outer size of all electrodes is the same diameter of 180mm, the inner hole shape is like a cone, i.e. the inner hole of the first ring is diameter of ϕ 50mm and the end hole is diameter of ϕ 160mm. The eleven field-shaping rings are set 25mm apart each other. Each ring is chained by the 1 MΩ resistor, the uniform electric field is established by a series of the field shaping rings. The solid angle is 4π/200. This BCC can keep an α-source away from the first field shaping ring. The gas region between the source and the first shaping ring functioned as the energy degrader. Therefore this BCC can measure Bragg peaks of α-particles with various energy. The anode was connected to a charge sensitive amplifier, in order to observe the Bragg peak signal and the energy range. The role of the Frisch grid is to reduce the effect that the pulse height depends on the particle incident angle respect to the anode plane. We have made two types of the Frisch grid. One is made of the expanded metal meshes with the 100μm thick nickel sheet, and the other is made of the ϕ 50μm tungsten wire with a pitch of 1mm. The geometrical transparency of the each grid is 90% and 95%.

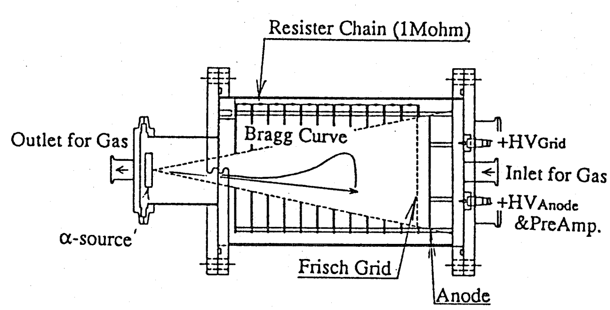

Fig.1 the cross section of a prototype BCC.

The screening inefficiency of the wire grid is estimated to be ~0.85%. This detector has 3 gas inlets on the bottom flange, through that the fresh gas is introduced and flowed to the first field-shaping ring from the anode. The parameters of the detector we made are listed in table 1.

Cathode to grid distance	25mm
Gird to anode distance	15mm
Cathodes and anode plate	2mm^t
Grid wire diameter	160mm
Frisch Grid wire pitching	1mm
Tungsten wire thickness	50 μm
Gas	P-10 (90% Ar+10% CH_4)

Table 1 Design parameters of the BCC detector

Tests of the prototype BCC

The gas was used P-10 (90% Ar+10% CH_4) at a pressure of 300 Torr. At the beginning, the gas was sealed in the counter. However the pulse height of the output signals became lower gradually due to a lot of out-gas from an inside wall of the counter. We have employed a gas flow system. This system supplies a fresh P-10 gas to the BCC at lower pressure than 760torr. The gas is poured into near the anode and is poured out the first field-shaping ring. Therefore even after a long term operated, the output signal level was stable. The electric field between the field shaping rings and the ground potential was +990V. The anode was fixed at a potential of +1100V, corresponding to the reduced field (E/P) in the active region of ~0.11 Volts/(cm Torr).

Test Results

The anode signal was fed to a charge sensitive pre-amplifier, and the Bragg peak signal was obtained using a shaping amplifier with a time constant of 0.25 μs. The energy signal was obtained using a shaping amplifier with a time constant of 10 μs that was longer compared to the signal pulse length(6 μs).

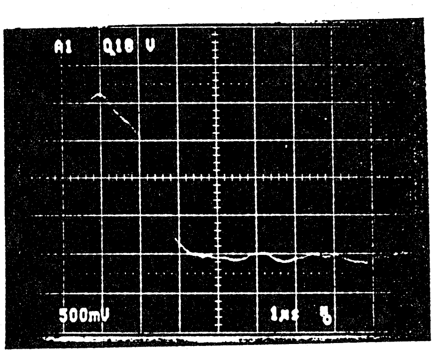

Fig.2 Pulse pattern at the short shaping time τ_s (0.25 μs)

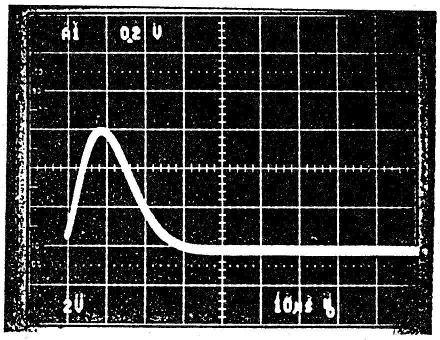

Fig.3 Pulse pattern at the long shaping time τ_s (10 μs)

Each signal at the wire grid viewed on oscilloscope is shown in Fig.2 and Fig.3, respectively. The output of shaping amplifier was connected to Multi Channel Analyzer and was analyzed to the atomic number and the energy range. The typical noise level was about 50mV. In this test the noise level did not broade than the Bragg peak signal. The counting rate was ~5 counts/s, we measured at 300sec to obtain about 1500 events. Figure 4 shows a two dimensional plot of correlations between the Bragg peak vs. the energy with the expanded meshes grid and the wire grid. At the same gain sets of the spectroscopy amplifier, the pulse height obtained by the wire grid was higher than that obtained by the expanded meshes grid. The energy resolution(FWHM) was about 5% for both grids.

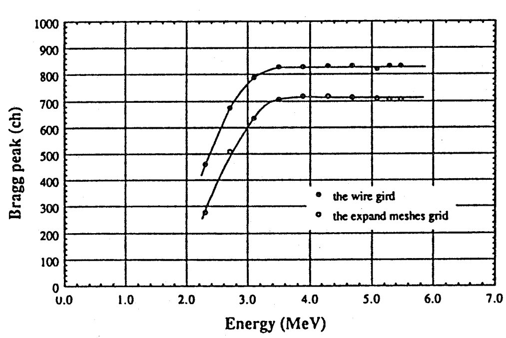

Fig.4 Two dimensional contour plot of correlations between Bragg peak signals vs energy

Figure 4 shows that the rise in respect to the energy is steeper for the wire grid than for the meshes grid. The wire grid can be used on the measurement of lower energy particles. The difference of the atomic number at low energy will be clear, because the height of the Bragg peak signal is higher. In Figure 5, the Bragg peak height at the long-run operation is shown. The Bragg peak signal is seemed to have a day cycle. In particular the peak height becomes low at daytime, it may be caused by the out-gas from an inside wall depending of the wall temperature. Thus we can measure the Bragg peak signals with excellent stability by keeping the detector in the thermostatic chamber.

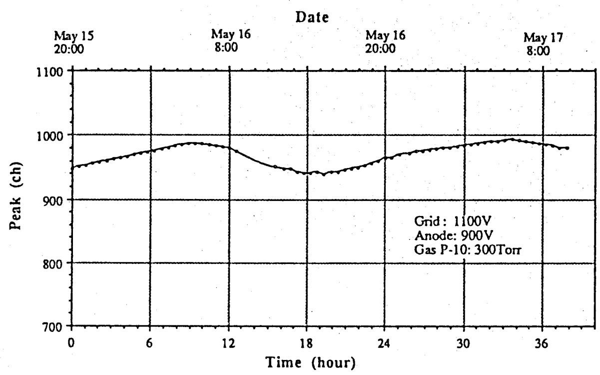

Fig.5 Behaviour of the Bragg peak height

Summary

We made a prototype Bragg curve counter, and the test of the BCC made evidences as follows:

(1) The frisch grid with a parallel wire is gainful compared with the expanded meshes grid.

(2) The Bragg peak signal can be measured with good stability in long term operation with a continuous gas flow system.

Acknowledgments

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