Signal intensity measurement of hydrophone to position change of Bragg-peak using iono-acoustic wave in hospital-based cyclotron

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The proton beam features an iono-acoustic signal at the Bragg-peak. The study of measuring the signal intensity of the hydrophone for the position change of the Bragg-peak using an iono-acoustic signal is performed in a hospital-based proton source.

Introduction

◆ *Proton range verification*

- Unlike X-ray therapy, treatment with protons transfers a high amount of energy to the end of the beam (Bragg-peak).
- In flash therapy that irradiates high doses in a short time, it is more important to find the correct position of the proton beam.
- Experimental cyclotron proton sources have been studied to measure proton range. Few studies have been done on hospital-based cyclotron proton sources.
- We confirmed the possibility of measurement through the last simulation study, and based on this, we intend to measure the intensity of hydrophone to position change of Bragg-peak using the iono-acoustic wave in the cyclotron proton beam of Samsung Medical Center (SMC).

Methods

◆ *Hospital-based proton source*

- The proton source of the experimental cyclotron has high currents at short pulse widths, and the proton source of hospital-based cyclotron has low current at long pulse widths.
- When the pulse width increases, the range of the iono-acoustic wave increases and a reflected wave is generated.
- When the beam current is low, the intensity of the iono-acoustic wave decreases.
- To address the low intensity and long pulse width, we used a signal amplifier and measured the position of the proton beam by comparing the intensity of the iono-acoustic wave over distance.

◆ *Experiment environment*

- The proton beam energy is 230 MeV and beam current was is 11 nA.
- The phantom size is 420.0 × 220.0 × 250.0 mm^3.
- The irradiation time was set at a 200 msec cycle and 20 msec irradiation, 180 msec rest.
- The position of the Bragg-peak was set at 32 cm from the entrance and 24 cm using a water equivalent phantom.
- The position of the hydrophone was set from 5 cm to the right of the entrance of the beam to 32 cm (A point), 28 cm (B point), and 24 cm (C point) in the direction of the beam. (Fig 1)

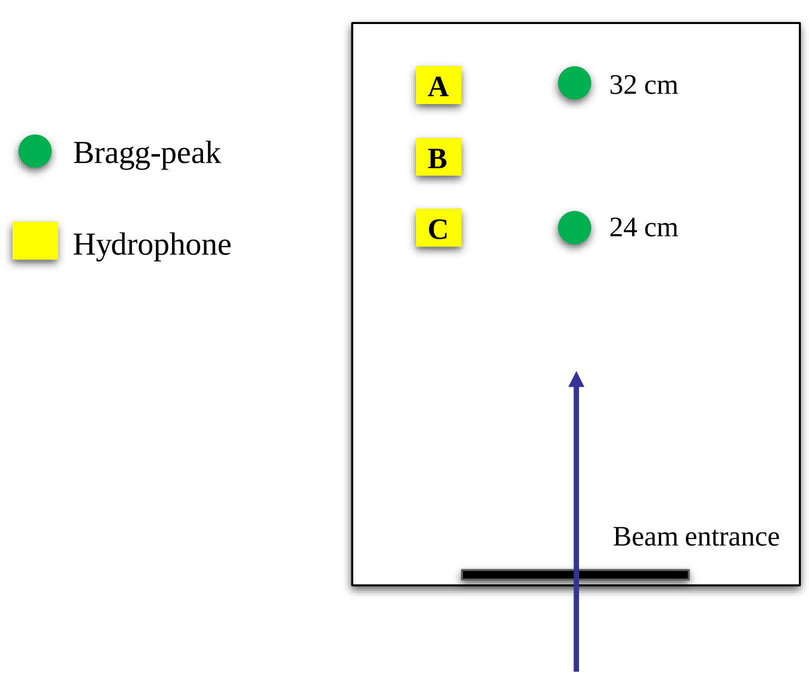

Figure 1. Phantom 2D image used in experiment.

- The signal intensity of A point at 32 cm and the C point at 24 cm, the C point at 32 cm and the A point at 24 cm, and the B point at two Bragg-peak positions were compared.
- To reduce noise, a high-resolution mode was used in the oscilloscope and 2000 signals were summed and compared.

Results

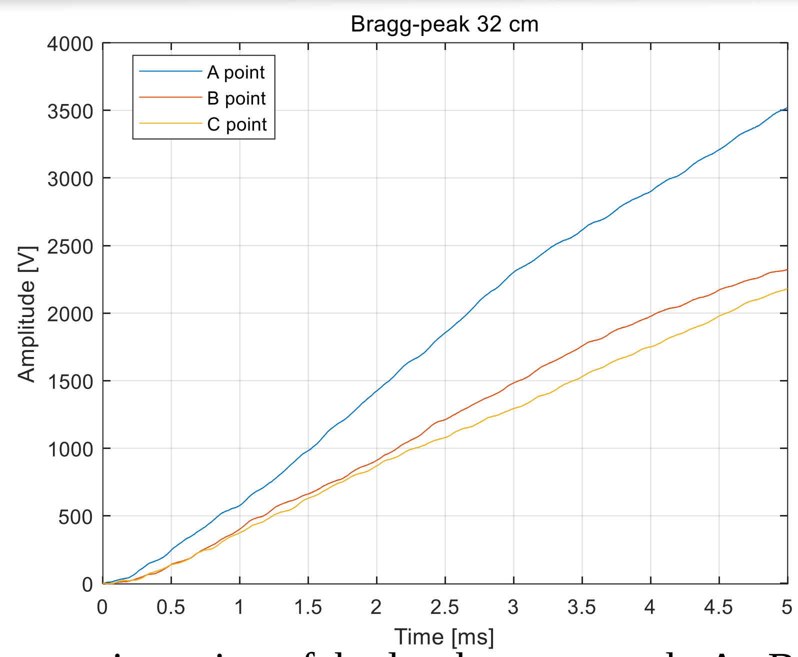

Figure 2. Average intensity of hydrophone at each A, B, C position at Bragg-peak 32 cm.

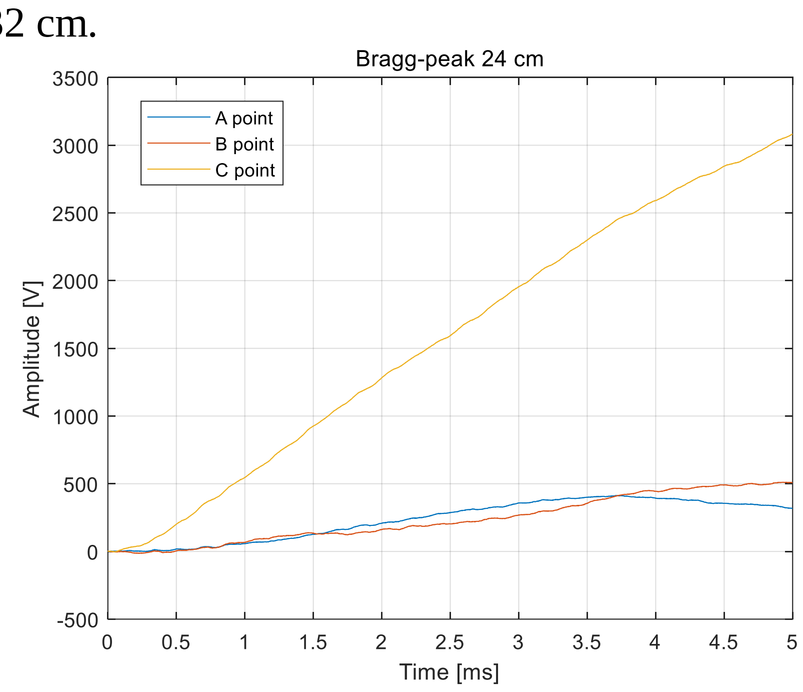

Figure 3. Average intensity of hydrophone at each A, B, C position at Bragg-peak 24 cm.

Table 1. The results of iono-acoustic wave intensity. [V]

Bragg-peak	A point	B point	C point
32 cm	3521	2324	2181
24 cm	318	508	3083

Table 2. The results of comparing signals at the same distance from different locations. [V]

	32 cm A : 24 cm C	32 cm B : 24 cm B	32 cm C : 24 cm A
Difference	438	1816	1863

Conclusion

- The intensity of the beams was compared with the hydrophone located at the same distance from the two Bragg-peak positions.
- In this study, the correlation of the signal intensity could not be found at the same distance between the proton Bragg-peak position and the hydrophone.
- If the influences of the reflected signal and noise are evaluated and corrected, it is thought that good results will be obtained..

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