2022/11/11

NEUTRON IRRADIATION ON MICRO COAXIAL CABLES

背景

SPHENIX実験は放射線がたくさん出る。

衝突点の近くに装置がある

簡単には取り出せない

よってマイクロ同軸ケーブルの放射線耐性を調べる必要がある。

topic

Last November, Neutron irradiation on micro coaxial cables.

purpose

Investigating radiation damage on cable

process

① Neutron irradiation on micro coaxial cables ← NOW

②take out

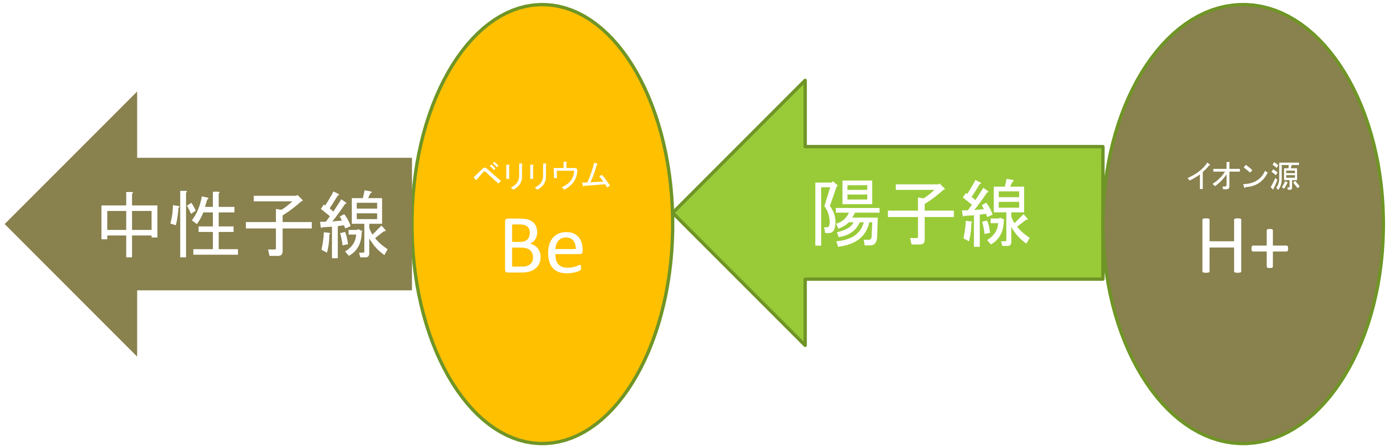
③check performance of m-coax

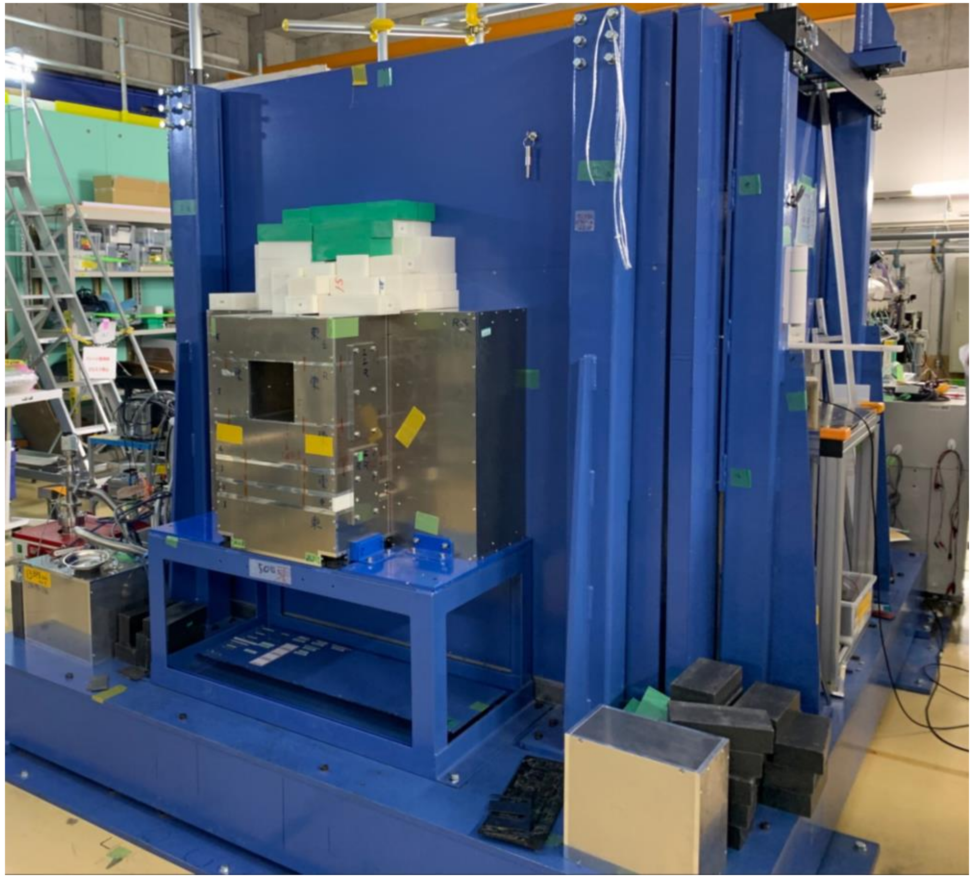
（Example: sPara,TDR,eye Diagram)

NEUTRON IRRADIATION

What is RANS?

RANS is Neutron irradiation system in Riken.





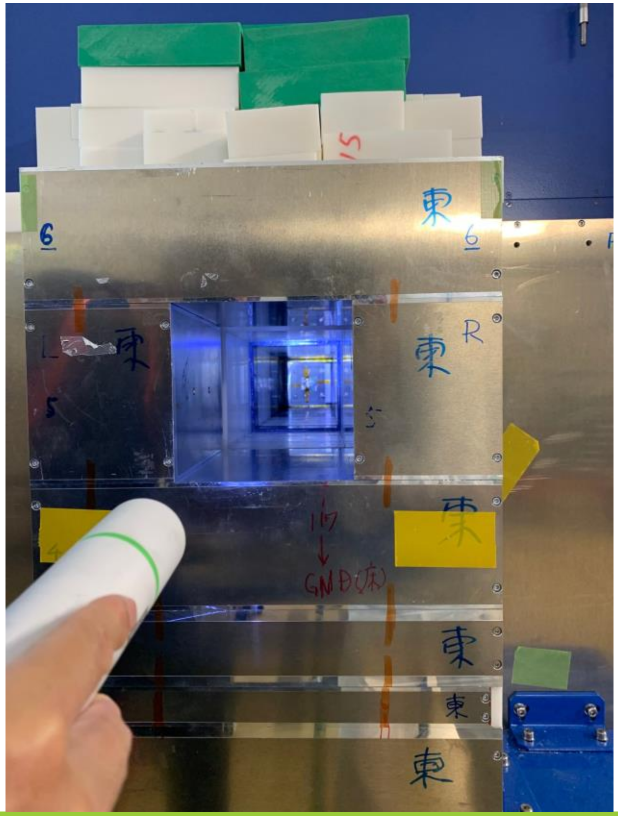
Process

① Prepare three types of micro coaxial cables

For 1-hour, 2-hour, and 3-hour

②put in the box

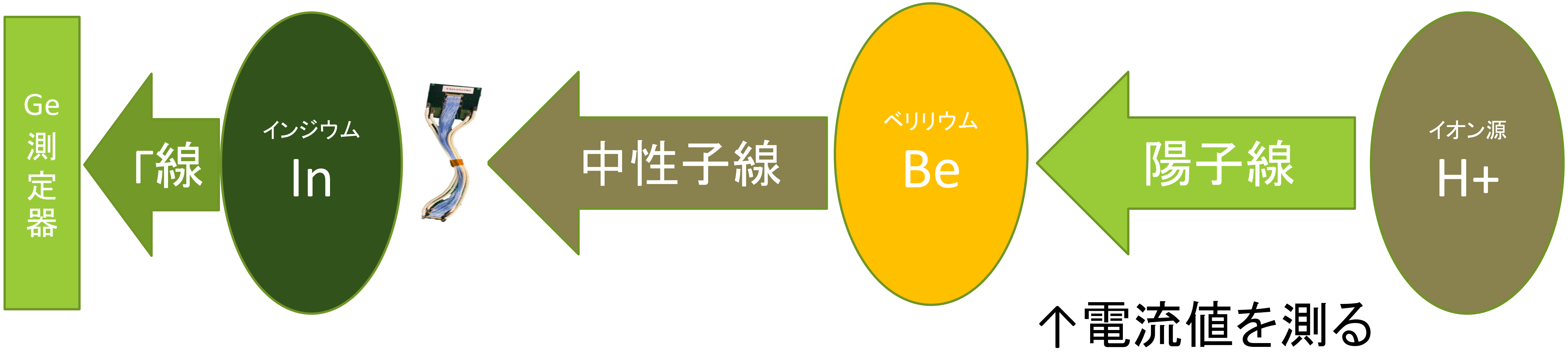
③install box ④ start Neutron irradiation



ESTIMATE THE NUMBER OF NEUTRON

情報提供:順天堂大の初田さん

Estimate the number of neutron To use indium



how it works

①インジウム箔は照射した中性子数によって出るγ線量が分かっている。

The amount of γ rays produced by the indium foil is known according to the number of neutrons irradiated to the foil.

②γ線を測定することで、インジウム箔に照射した中性子数が分かる

The number of neutrons irradiated to the indium foil is known by measuring the γ rays.

③ターゲットに照射した中性子数が分かる。

The number of neutrons irradiated to the target is known.

	Number of protons	Number of γ rays	number of neutrons
INTT	know		goal
Hatuta	know ratio	know	Know 5.4E+11 ratio

Number of protons = time × (average I) /e

e =1.62E-19

Number of γ rays that measured by Ge detector

The number of protons in m-coax

	protons	neutrons
Hatuta	3.59E+17	5.47E+11
M-Coax 1hour	8.39E+17	12.4E+11
2hours	17.2E+17	26.3E+11
3hours	26.1E+17	39.9E+11

Luminosity of sPHENIX

Table 1.1: Summary of the sPHENIX Beam Use Proposal for years 2023–2025, as requested in the charge. The values correspond to 24 cryo-week scenarios, while those in parentheses correspond to 28 cryo-week scenarios. The 10%-*str* values correspond to the modest streaming readout upgrade of the tracking detectors. Full details are provided in Chapter 4.

Year	Species	$\sqrt{s_{NN}}$ [GeV]	Cryo Weeks	Physics Weeks	Rec. Lum. $\|z\| < 10$ cm	Samp. Lum. $\|z\| < 10$ cm
2023	Au+Au	200	24 (28)	9 (13)	3.7 (5.7) nb^{-1}	4.5 (6.9) nb^{-1}
2024	$p^{\uparrow}p^{\uparrow}$	200	24 (28)	12 (16)	0.3 (0.4) pb^{-1} [5 kHz 4.5 (6.2) pb^{-1} [10%-*st*	45 (62) pb^{-1}
2024	$p^{\uparrow}$+Au	200	–	5	0.003 pb^{-1} [5 kHz] 0.01 pb^{-1} [10%-*str*	0.11 pb^{-1}
2025	Au+Au	200	24 (28)	20.5 (24.5)	13 (15) nb^{-1}	21 (25) nb^{-1}

Luminosityのzの範囲が
z<10cmなので、全範囲
Luminosityを考えるには
3~4倍が必要

Investigate Neutron in sPHENIX from Luminosity

	Integrated Luminosity [/pb]	N_{eq}/cm^2 @ z=40cm	N_{eq}/cm^2 @ z=150cm
PHENIX	12	1.7×10^{10}	10^{11}
sPHENIX	66~264	$(9.4\sim37.6) \times 10^{10}$	$(5.5\sim22) \times 10^{11}$

There were two kinds of test diodes with different volumes which were 0.01 cm^3 and 0.004 cm^3. The increase of the leakage current of the diodes and the relevant fluences are summarized in Table 5. Only fifteen diodes are listed since the other diode was found to be defective during the leakage current measurement. The average fluence of the diodes was 1.0×10^{10} N_{eq}/cm^2. The estimated z dependence of the diode fluence is shown in Fig. 17 which is in agreement with the TLDs.

The sensor was irradiated at Z=25.2 cm for about 50 days and the integrated luminosity during this time was 12 pb^{-1}. The current related damage rate α was estimated to be 3.2×10^{-17} A/cm using the temperature history of the temperature loggers in the PHENIX IR. The increase of leakage current of a single strip was 2.2×10^{-10} A/strip as seen in Table 5. Figure 18 shows the IV and CV measurements, where the leakage current and capacitance were measured before and after irradiation. The fluence of irradiated stripixel sensor was estimated to be 9.4×10^9 N_{eq}/cm^2 which is consistent with the average fluence of the reference diodes.

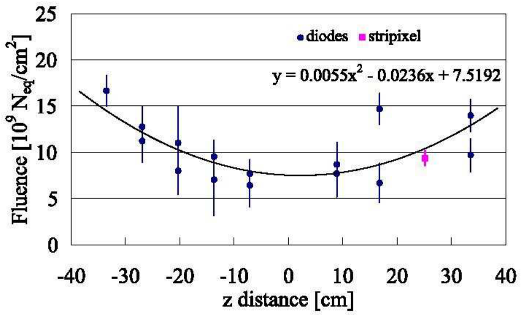


Fig. 17. Fluence of irradiated stripixel sensor and diodes at R=10 cm in PHENIX IR.

Conclusion

irradiated the number of neutrons

> sPHENIXs the number of neutrons

Therefore, if no anomalies are found in the performance evaluation, the radiation resistance of the micro coaxial cable is sufficient.

Next step is Take out

フラックスの求め方

The Cu foil which was irradiated behind the test stripixel sensor was taken out from the chamber and the γ ray intensity was measured with a germanium (Ge) detector. The γ ray spectrum of activated foil had three main energy peaks at 669 keV, 962 keV and 1412 keV. The fluence was calculated by the following equation.

$$\Phi = \frac{N_\gamma \lambda T_r}{\epsilon \mathrm{B} \sigma N_{Cu} d\Omega A} \tag{9}$$

$$A = (1 - \exp(-\lambda T_r))(\exp(-\lambda t_1) - \exp(-\lambda(t_1 + t_2))) \tag{10}$$

where N_γ is the number of γ rays at one of the energy peaks, λ is the decay constant, T_r is irradiation time, ϵ is the detection efficiency, B is the branching ratio of the γ ray, σ is the activation cross-section, N_{Cu} is the number of ^{63}Cu atoms, $d\Omega$ is the solid angle of a gamma ray detector, t_1 is start time of measurement of γ rays and t_2 is the measurement time. The Ge energy calibration and the detection efficiency determination were done using standard checking sources. The solid angle was calculated from the source distance and the size of the detector sensitive area. The fluence determined at each energy peak is shown in Fig. 11. The values are all consistent with the fluence determined by the reference diode when both statistical and systematic errors are considered.

マイクロ同軸ケーブルとは

sPHENIX実験に使用するシリコンセンサーからデータ読み出し回路ROCを繋ぐ、データ伝送ケーブル （伝送ケーブルbuxの変換ケーブル）