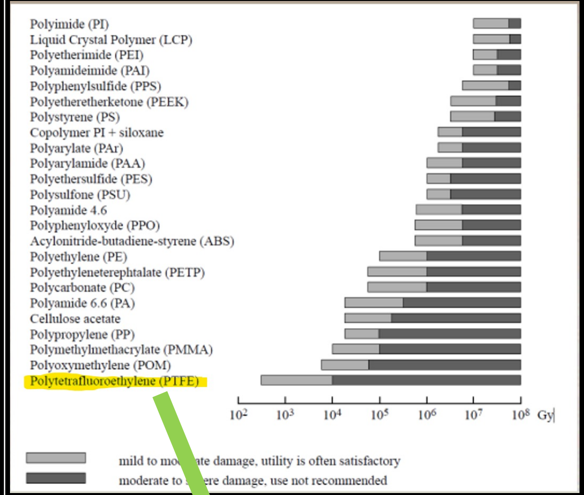
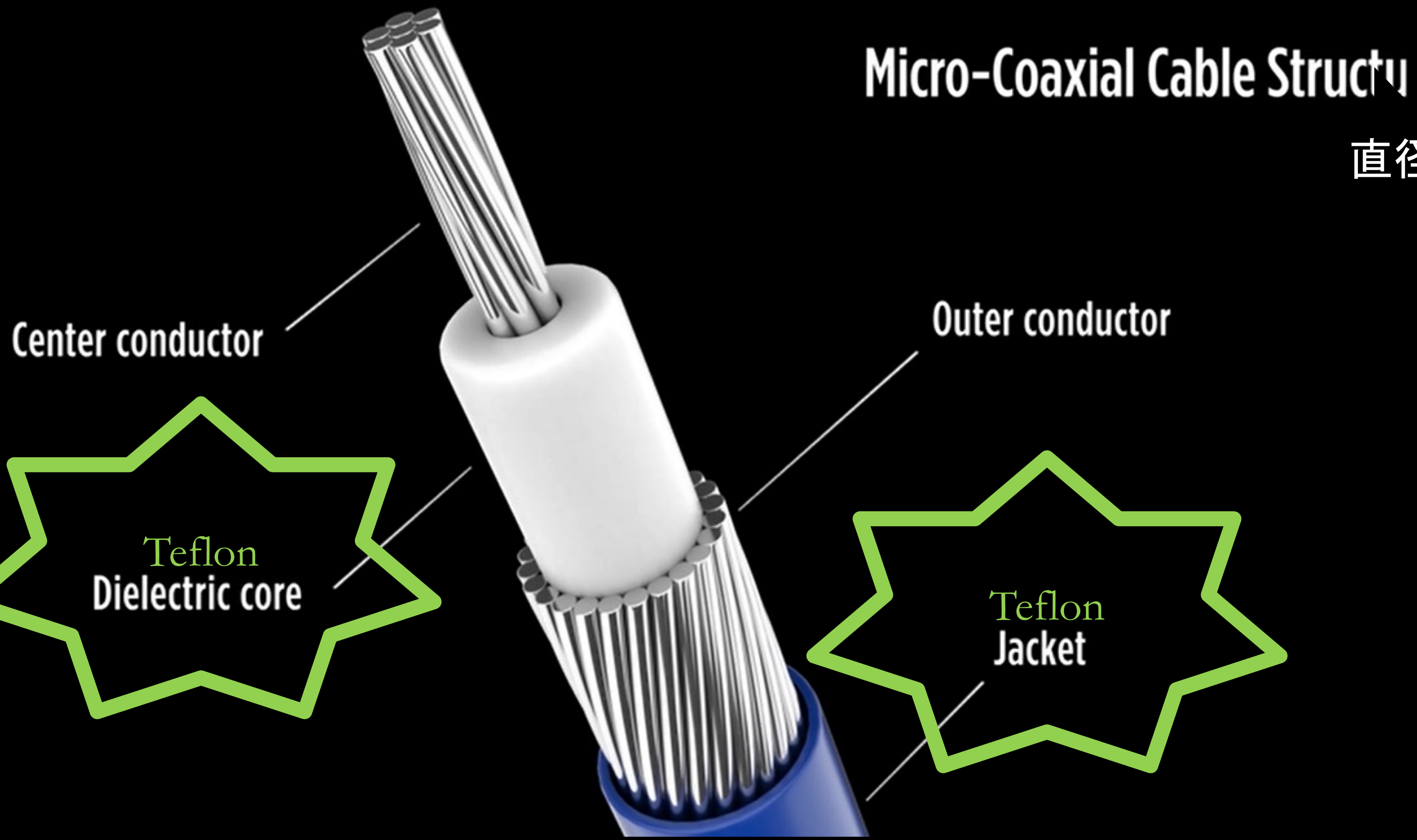
Radiation Hardness of micro-coaxial cable

Structure of μ-Coax



https://www.osti.gov/servlets/purl/1467983

Weak against Radiation



直径0.24mm

Teflon Dielectric core

Teflon Jacket

引用:https://www.i-pex.com/ja-jp/library/video/micro-coaxial-capabilities

Method : How to examine the radiation hardness

- non-irradiated μ-coax
- neutron- irradiated μ-coax

⇒ **Compare** the signal transmission performances with/without irradiation

How to examined radiation hardness of the μ-coax-cables

◦non-irradiated μ-coax

◦neutron- irradiated μ-coax

Compare the signal transmission performances with/without irradiation

TDR
(Time Domain Reflectometry)

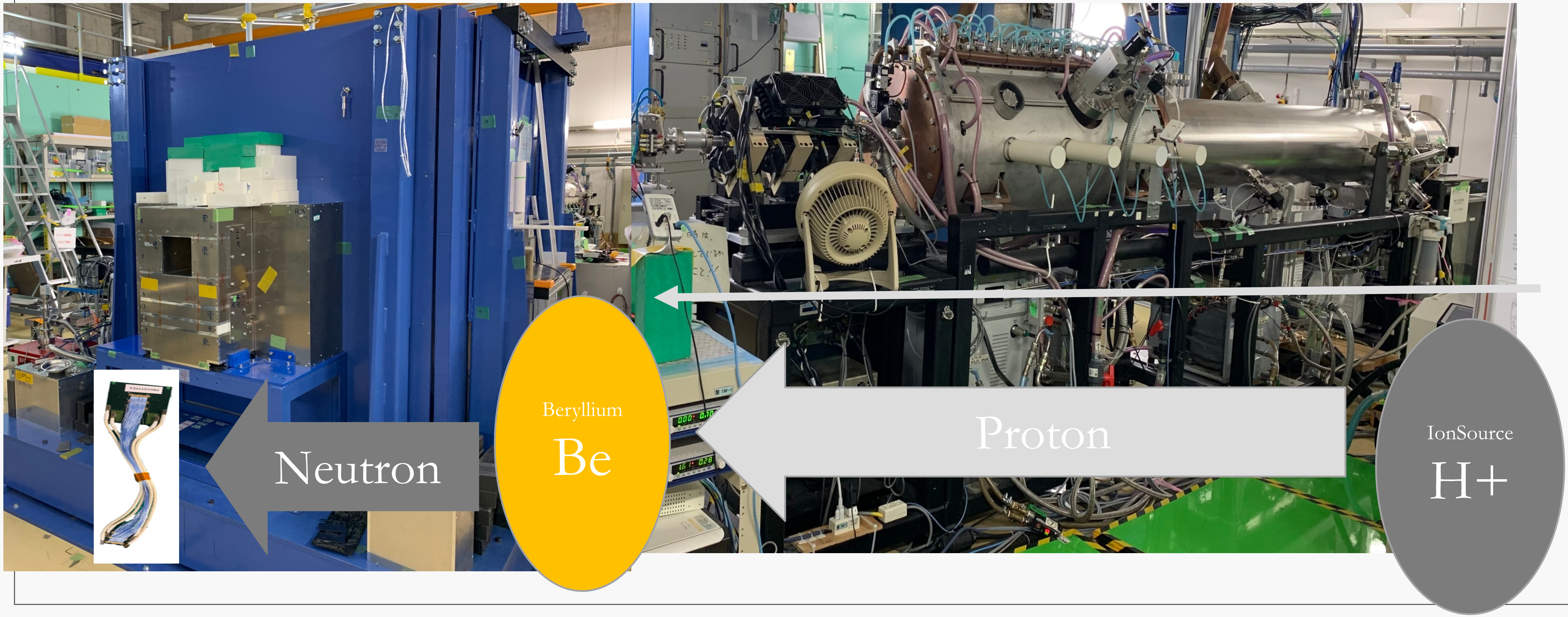
S-parameters
①transmission loss
②return loss

Eye Pattern

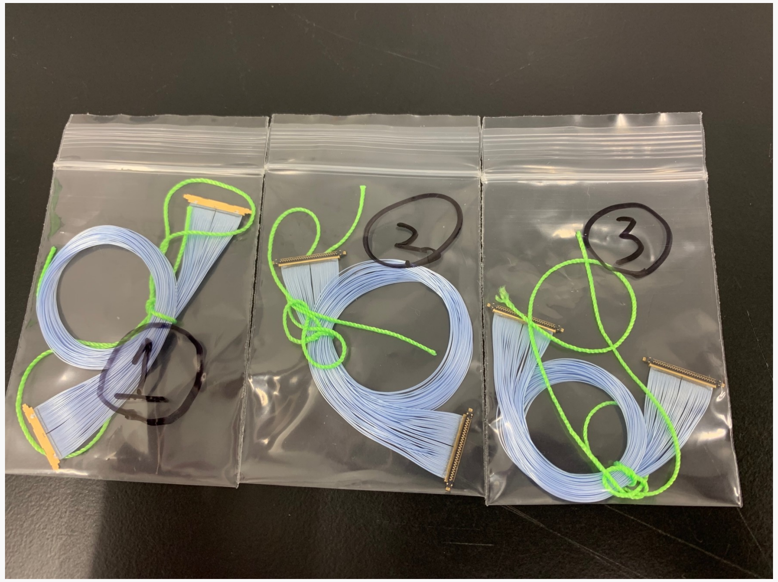
Neutron irradiation in RANS

What is RANS?

- RANS is Neutron irradiation system in Riken.

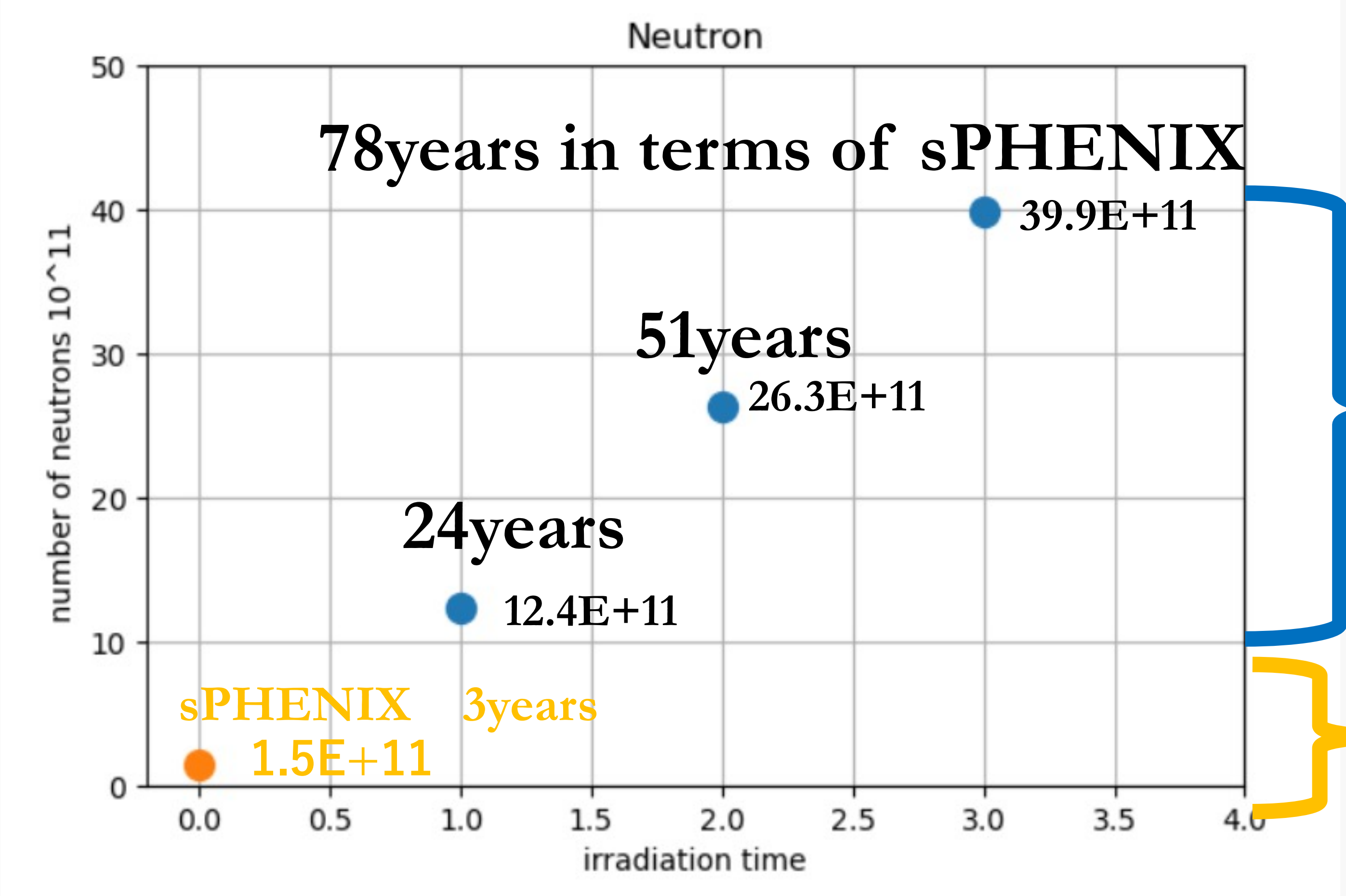


- Prepare three types of micro coaxial cables For 1-hour, 2-hour, and 3-hour exposure



Result

irradiated the number of neutrons
> sPHENIX's the number of neutrons

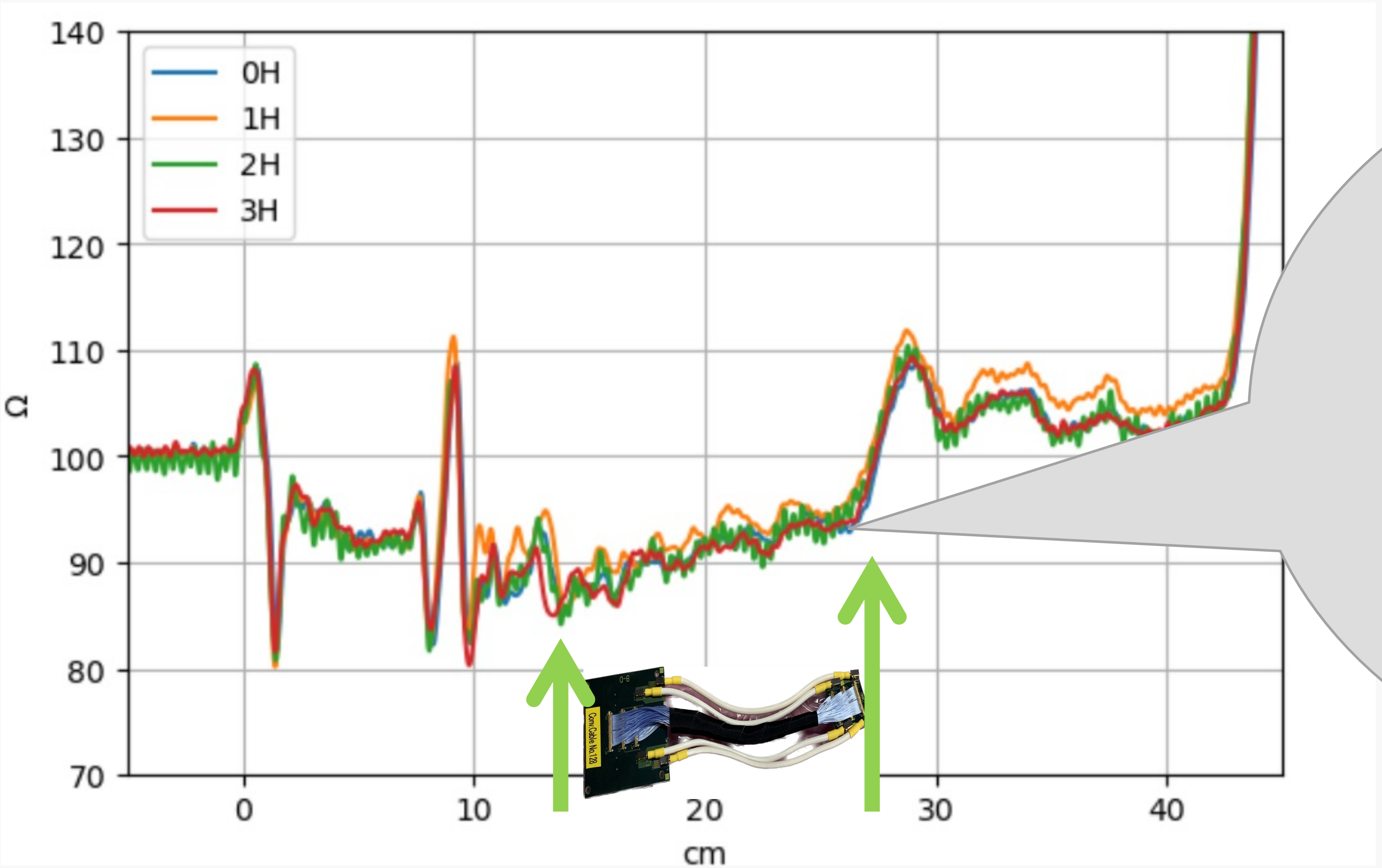


Amount of neutrons irradiated using RANS

the amount of radiation μ-coax will be exposed to at sPHENIXat around the conversion cables are installe

transmission performance measurement results

Result of TDR

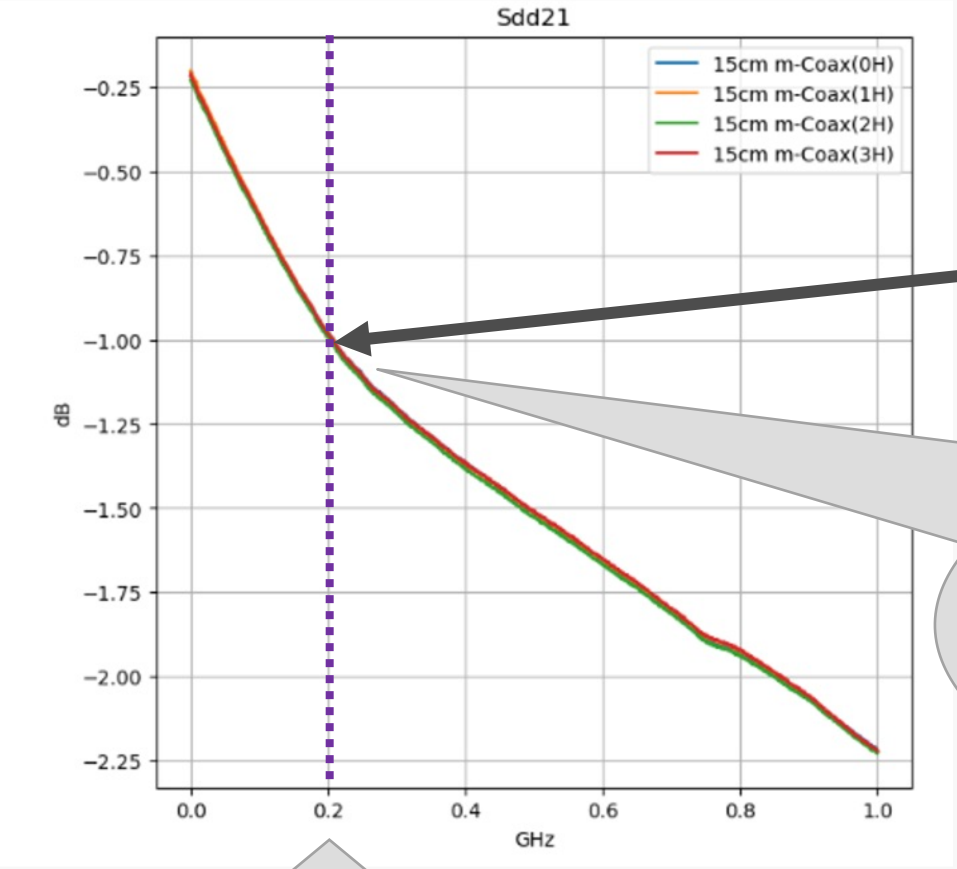


Results are consistent within 5%. May be induced by individual difference of the harnesses.

Result of transmission loss

Good

Bad



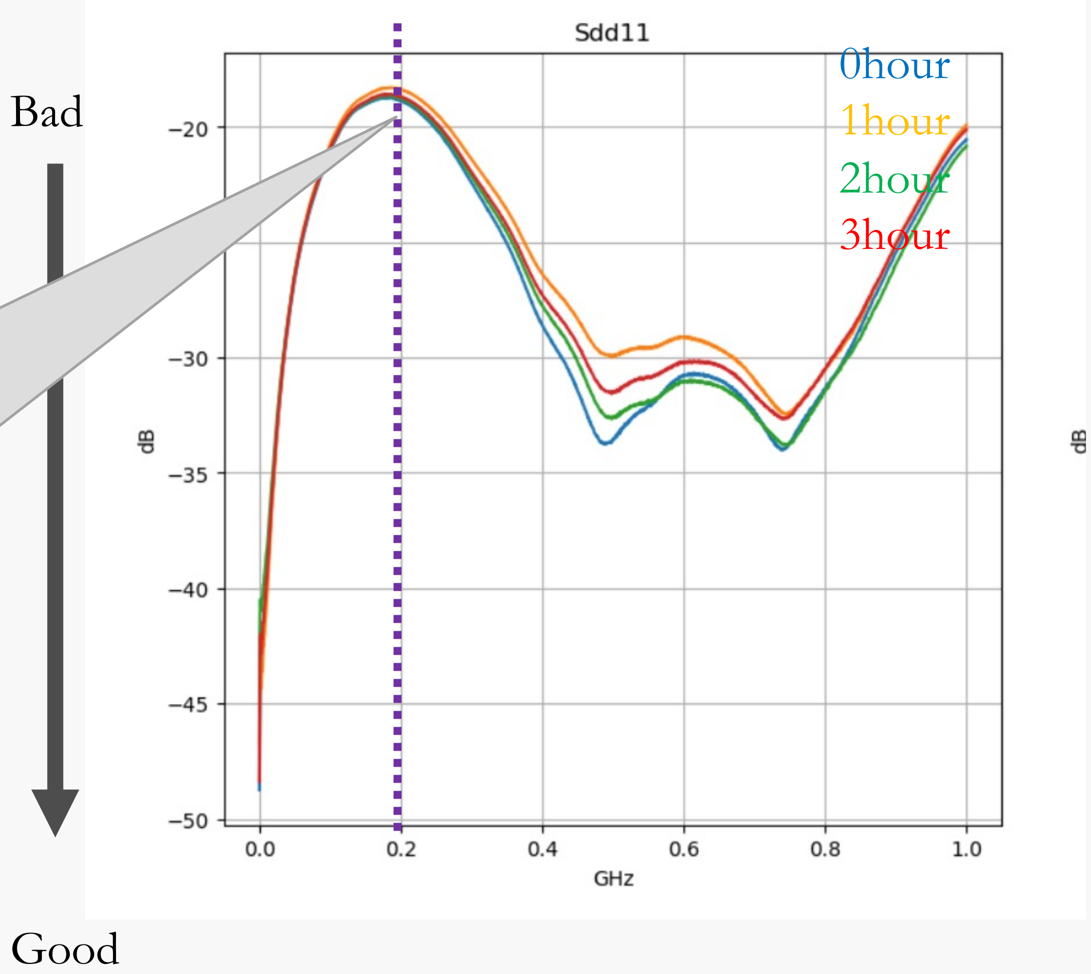
In actual use

- Vertical axis: dB = 20LOG10(S) / Horizontal axis: Frequency of input signal

Micro coaxial cable has S = -0.99±0.02dB at 0.2GHzThat is, signal attenuation is (89±2)% of the original

Results are consistent within 2%. May be induced by individual difference of the harnesses.

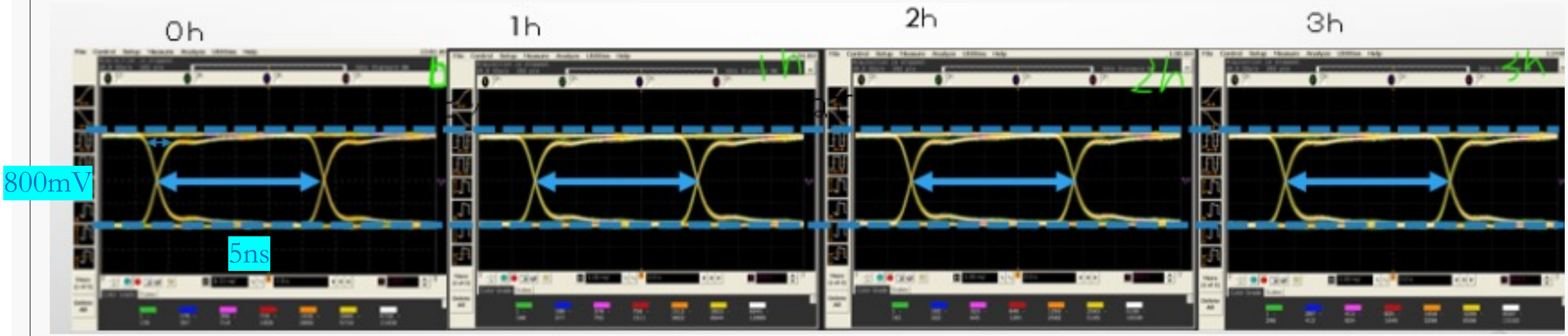
Result of Return loss



Results are consistent within 4%.
May be induced by individual difference of the harnesses.

Result of Eye Pattern

Eye pattern is created by cutting various transmission signals bit by bit and overlapping them



→No abnormality (change) in waveform

Conclusion

- TDR　No effect of irradiation
- s parameter　No effect of irradiation
- Eye pattern　No effect of irradiation

- **Based on above results, we conclude the radiation hardness of m-coax is sufficient for 3 years of operation in sPHENIX**

SUB

ESTIMATE THE NUMBER OF NEUTRON

How to examined radiation hardness of the μ-coax-cables

- ① Measure high speed signal transmission performance of the micro-coax cable.
- ②Calculate the amount of radiation μ-coax will be exposed to at sPHENIX
- ③ Irradiate neutrons to the micro-coax cable at RANS facility.
- ④ Redo the measurement of 1 and see if there is any degradation in the performance

The number of protons in μ-coax

	protons	neutrons
Existing	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

ratio

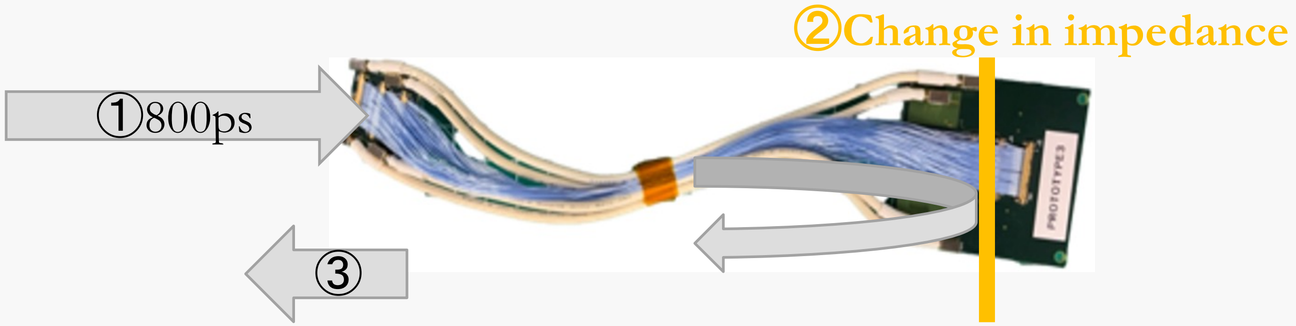
ratio

Expected sPHENIX-neutrons =1.5E+11

s parameter

$$\text{s para} = \frac{\textit{output signal}}{\textit{input signal}} = \text{transmission loss}$$

Apply the input signal



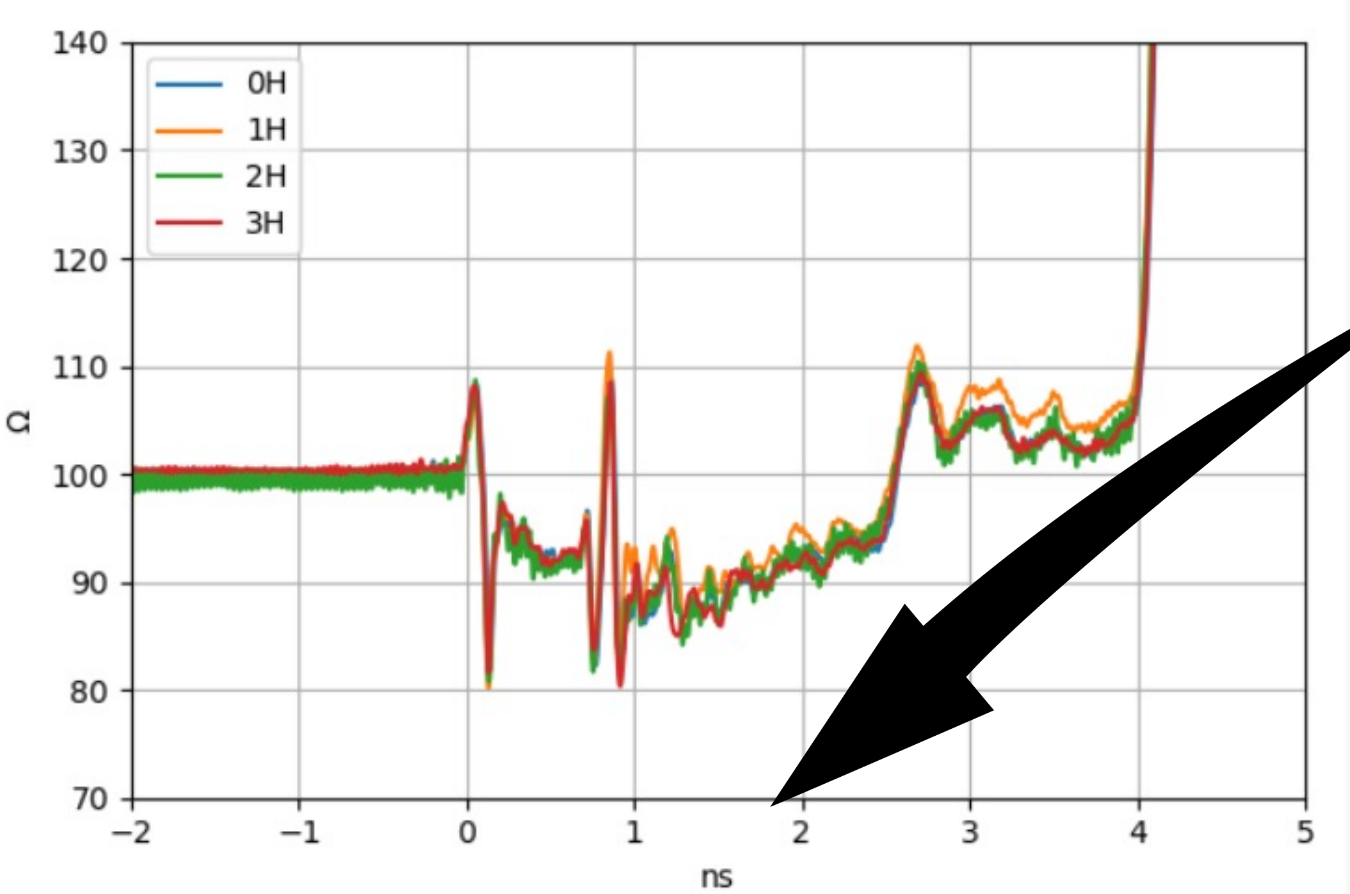
③observe the reflection and time delay

the time delay between the transmitted and reflected signals is used to **determine the distance** to the impedance change.

$$Z_L = Z_0 \frac{1+p}{1-p}$$

ZL: impedance of the sample
Z0: known impedance
p =reflected voltage/input voltage

Result of TDR



time delay (ns)

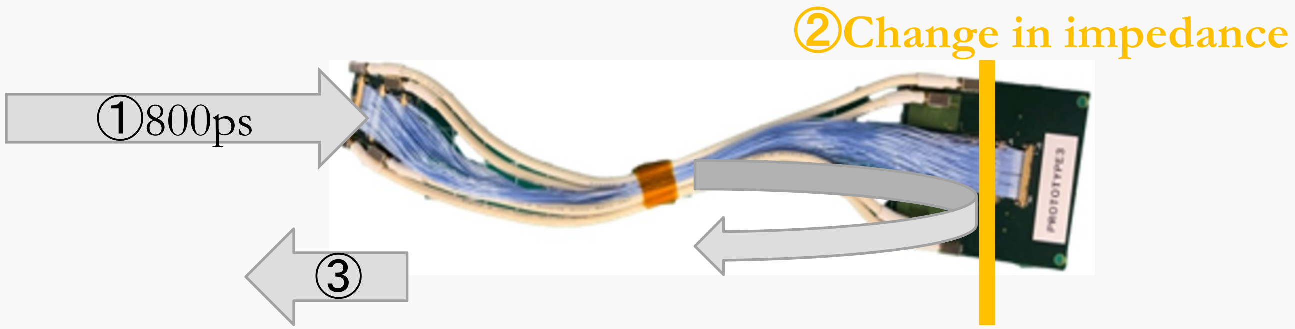
Distance (cm)

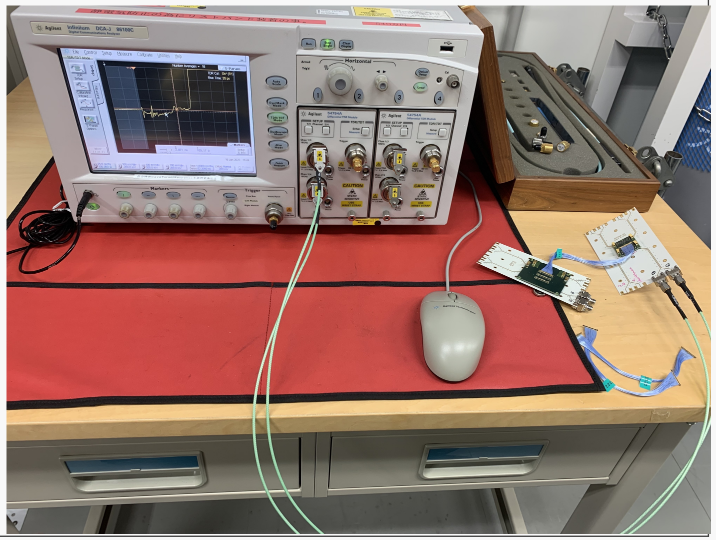
$$Distance = time \times 3/2 \times 10^{10} cm \div \sqrt{2.1}$$

TDR (Time Domain Reflectometry)

Purpose : to measure the impedance characteristics of a transmission line

①send a short electrical pulse(800ps) down the transmission line

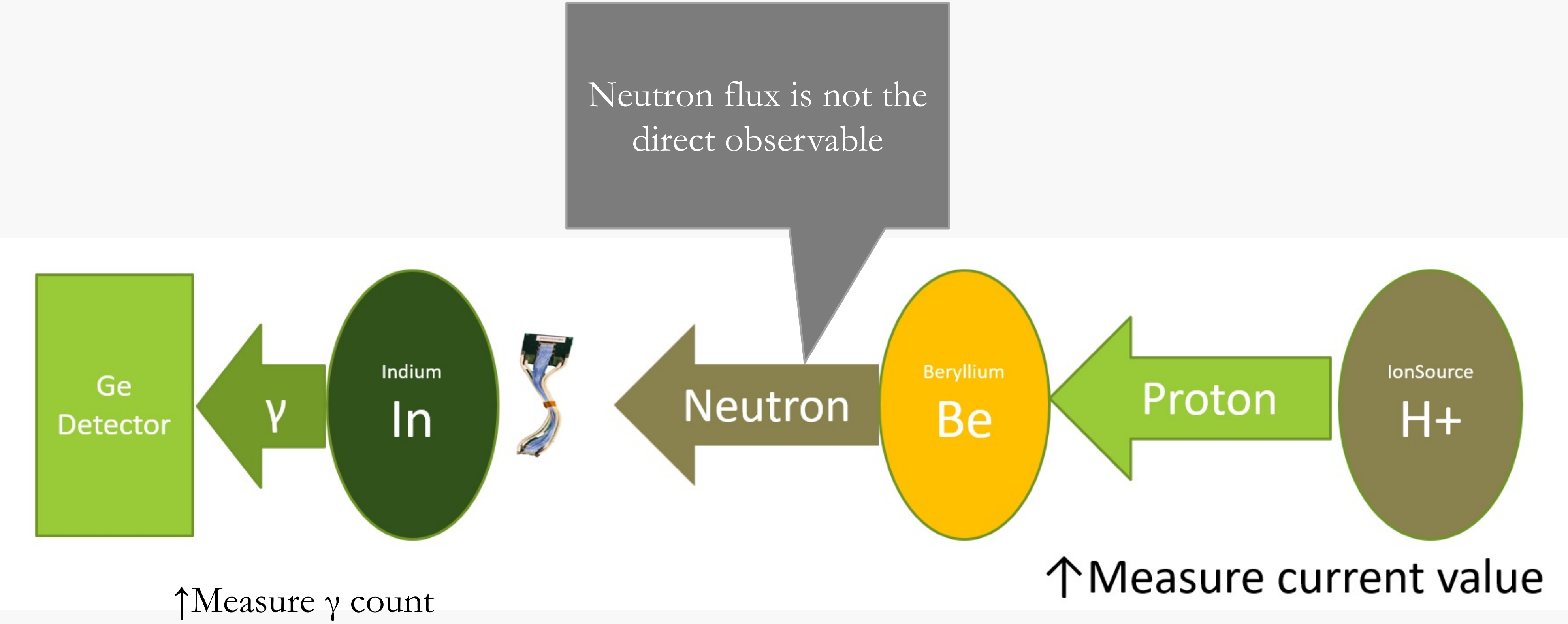




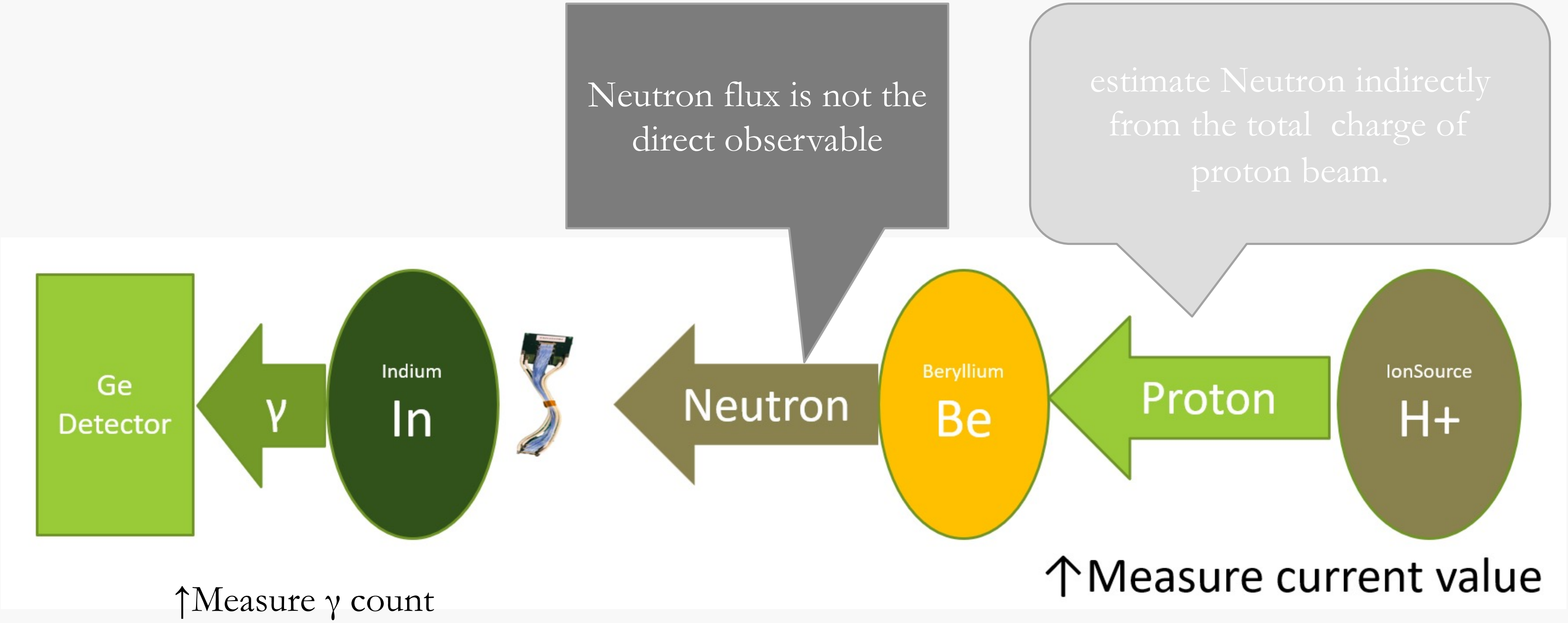
②the reflection that is created when the pulse encounters a change in impedance

③observe the reflection

how it works


Neutron flux is not the direct observable
Ge Detector
γ
Indium
In
Neutron
Beryllium
Be
Proton
IonSource
H+
↑Measure current value
↑Measure γ count

how it works

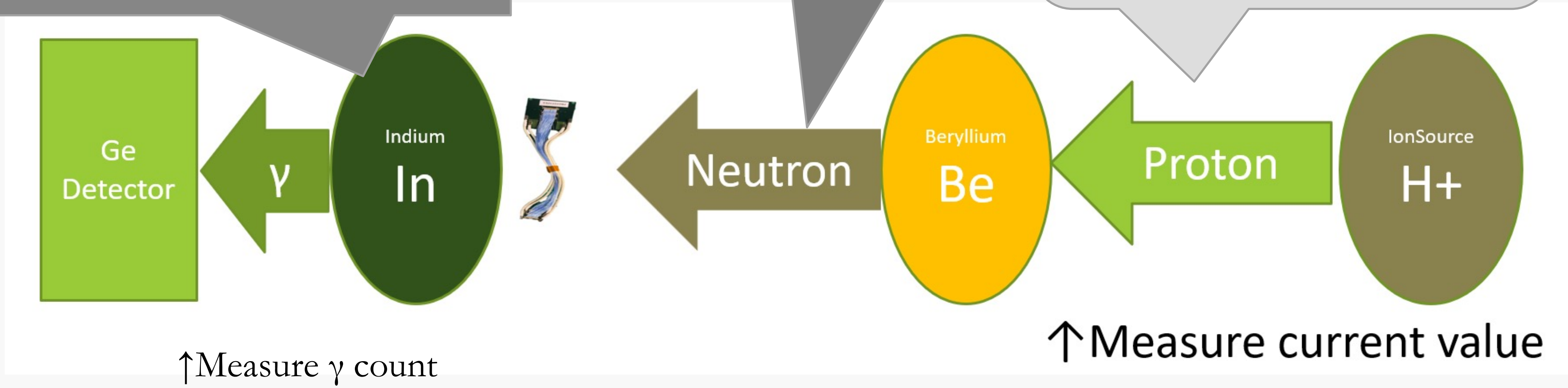

Neutron flux is not the direct observable
estimate Neutron indirectly from the total charge of proton beam.
Ge Detector
γ
Indium
In
Neutron
Beryllium
Be
Proton
IonSource
H+
↑Measure current value
↑Measure γ count

how it works

The neutron flux can be calculated by
1.cross calibrating proton charge
2.gamma ray emission from an indium foil

Neutron flux is not the direct observable

estimate Neutron indirectly from the total charge of proton beam.



	Number of protons	Number of γ rays	number of neutrons(Neq)
Existing Measurement	Known	known	Calculate 5.4E+11
INTT	Measured		Goal

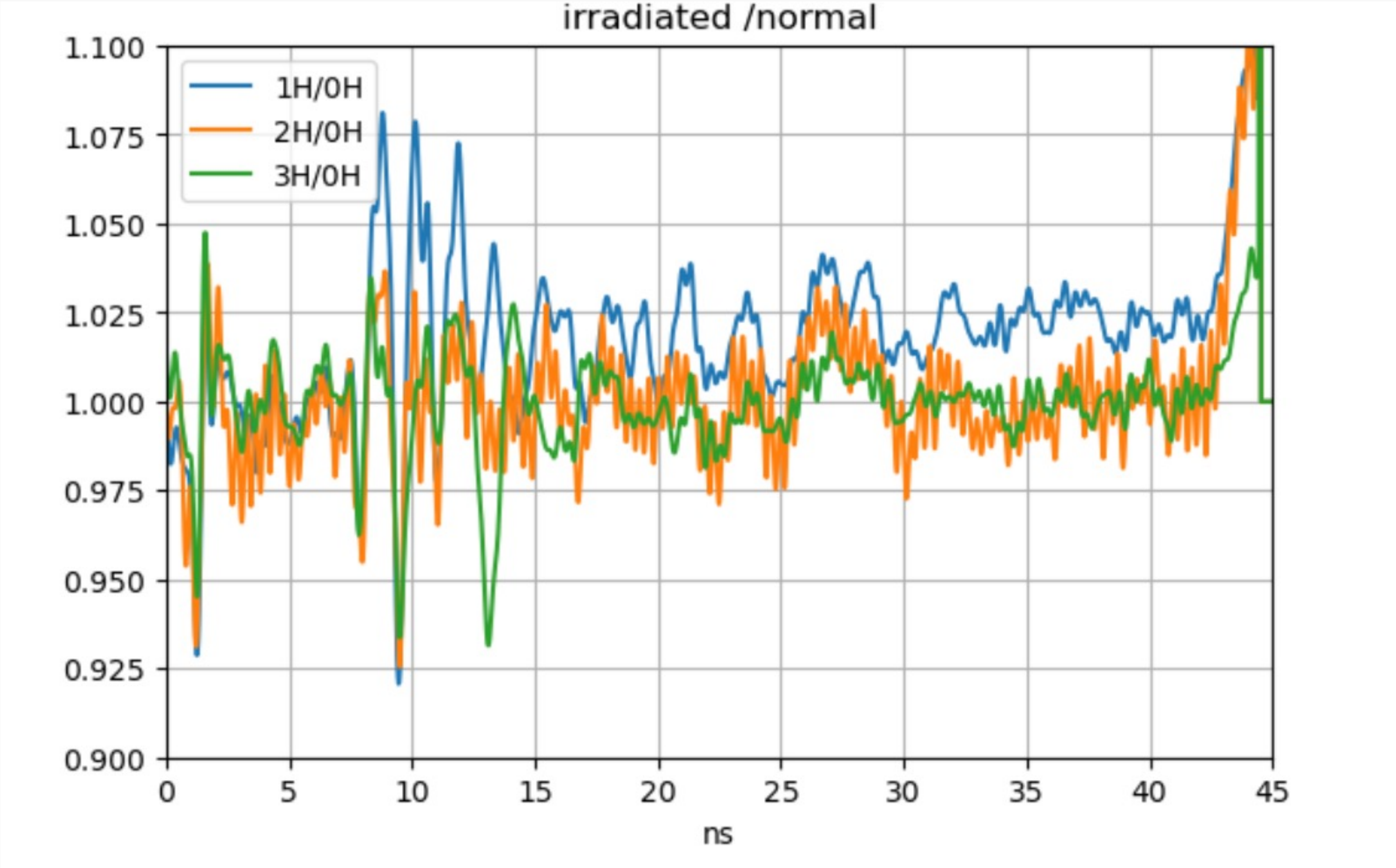
ratio

ratio

Number of protons is known from charge of proton beam
Number of protons = time ×(average I) /e
e =1.62E-19
Number of γ rays that measured by Ge detector

Neq is the equivalent flux of 1meV neutrons

Existing Measurement : Courtesy of Ms. Hatsuda, Juntendo University


irradiated /normal
1.100
1.075
1.050
1.025
1.000
0.975
0.950
0.925
0.900
1H/0H
2H/0H
3H/0H
0
5
10
15
20
25
30
35
40
45
ns