Development of Bonner Sphere Spectrometer for Neutron Source with 30 MeV Proton Cyclotron

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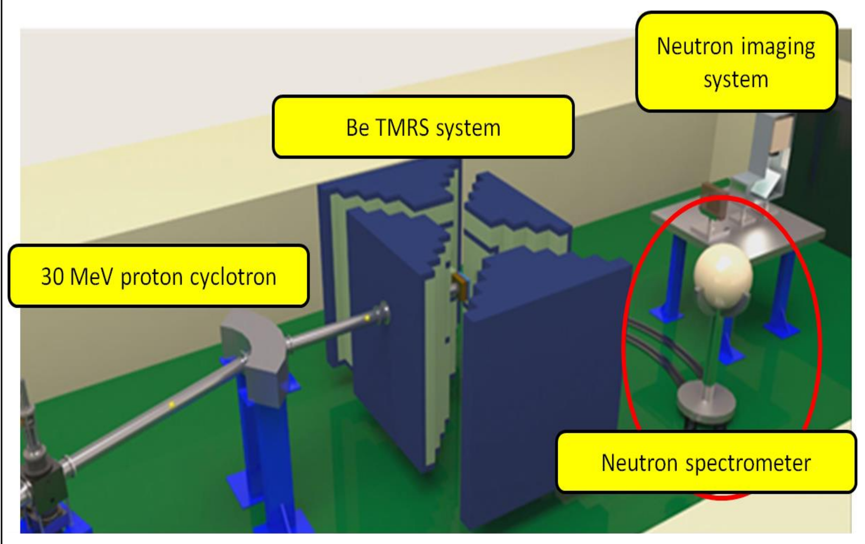
Introduction

❖ **At Advanced Radiation Technology Institutes (ARTI), Jeongeup**

➔ **Accelerator-based neutron source in development**

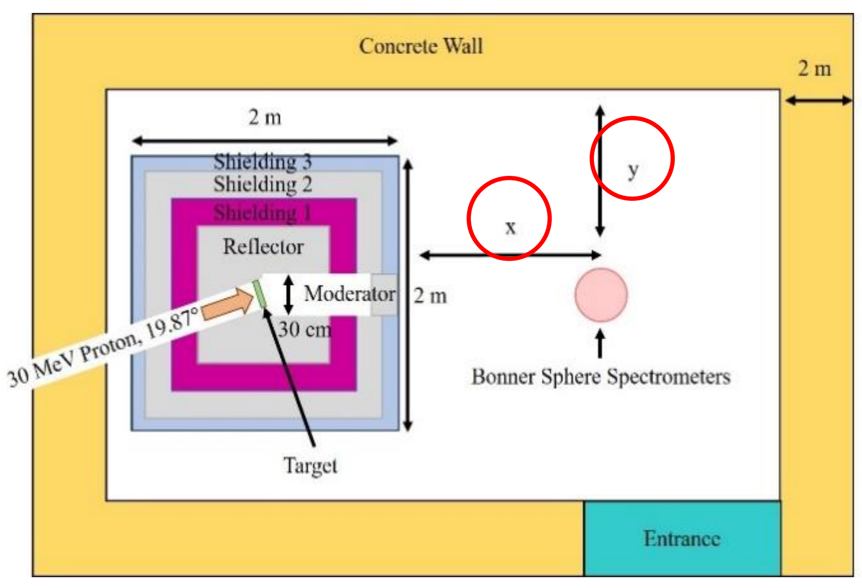
- **Neutron generation by TMRS (target-moderator-reflector-shield)** at RFT-30 cyclotron (30 MeV proton cyclotron) [1]
  - Target : Generating neutrons
  - Moderator : Cooling down neutrons
  - Reflector : Reducing neutron loss by collision
  - Shield : Removing unintended radiations
- **Neutron spectrum acquisition by BSS and spectrum unfolding [2,3]**
  - BSS (Bonner sphere spectrometer) : Set of neutron detectors with different moderation medium such as HDPE (high density polyethylene)



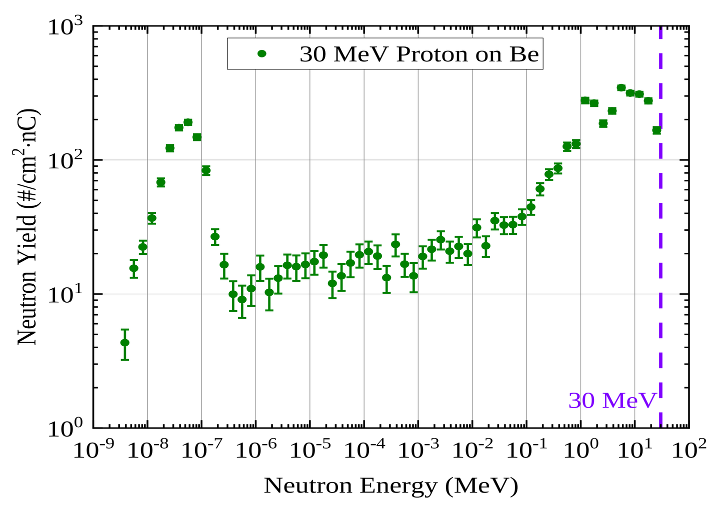
❖ **In this paper are included :**

- **Monte Carlo simulation result** by MCNP 6.2 [4]
  ➔ Neutron spectrum prediction for TMRS
- **$^{252}_{98}$Cf-emitted neutron measurement**
  ➔ Optimization and characteristics confirmation of BSS

Monte Carlo Simulation for TMRS



※ **For (x, y) = (0.35, 2)**



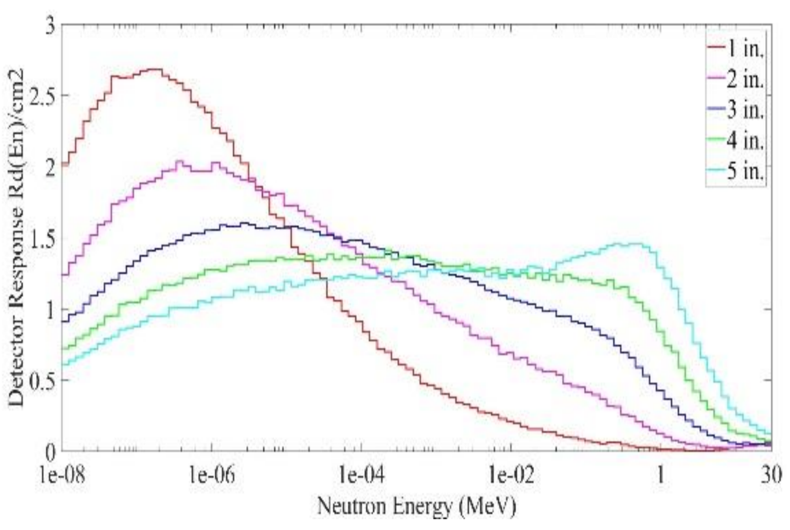
❖ **Setup for TMRS measurement on plan**

- Target : 5.5 mm Be
- BSS : Total 4 spheres ➔ 0 (bare), 2, 3 & 5 in.
  - Measurement spots : x ➔ 0.35 (Limit), 2, 3 & 4 m
    y ➔ 1, 2 (Along the neutron beam line) & 3 m

❖ **Neutron spectrum by TMRS simulation**

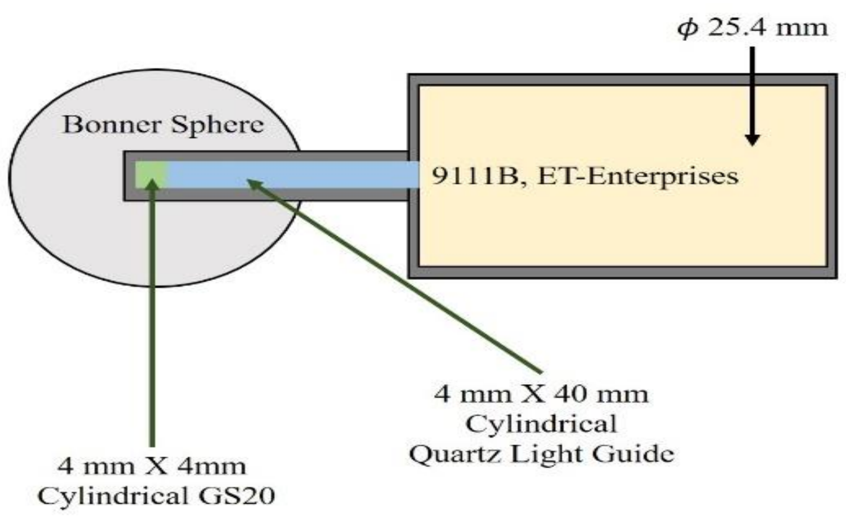
- Fast (above 1 MeV) : No or negligible moderation
- Thermal (below 1 eV) : Fully thermalized by moderation
- Others : Not gone through full thermalization

Bonner Sphere Spectrometer Design

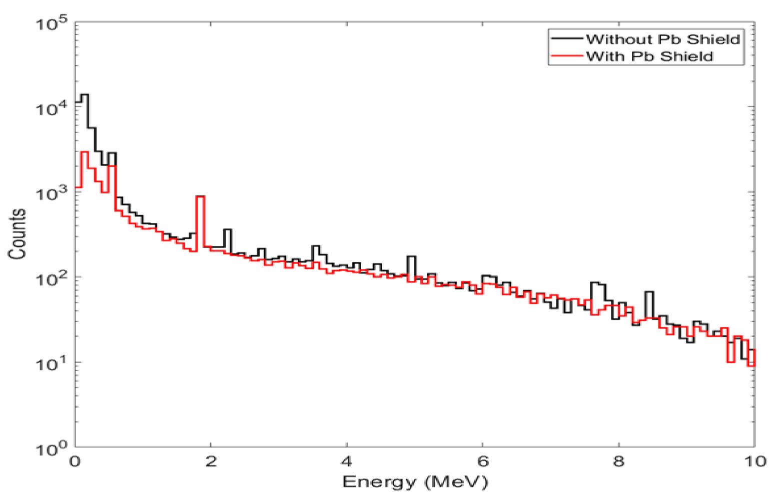


※ **Characteristics of BSS**

❖ **BSS with diverse sphere sizes has characteristics to detect widely-ranging neutrons via elastic collision with hydrogen nuclei at HDPE.**



※ **Gamma ray simulation results**



➔ About 13 times greater counts than neutrons

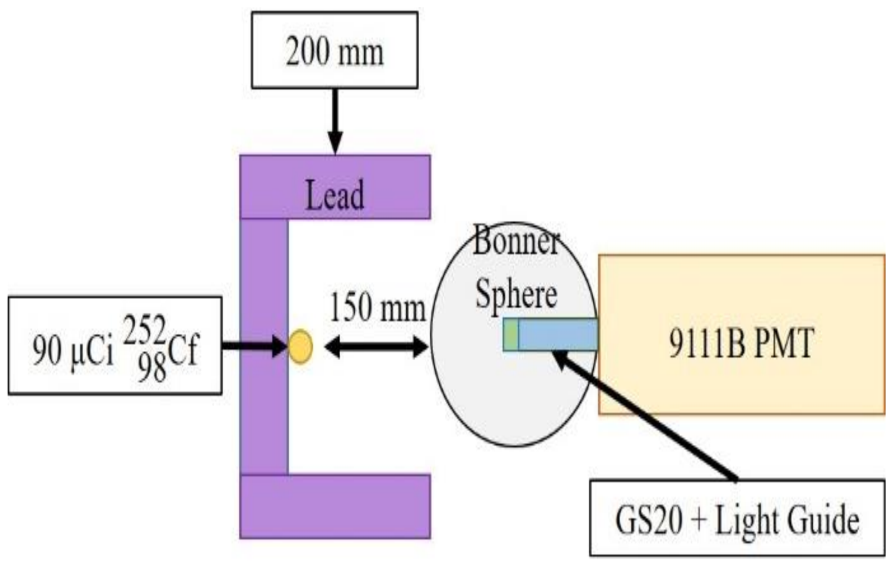
❖ **BSS design**

- ϕ 4 mm × 4 mm 95 % $^{6}_{3}$Li-enriched GS20
  - Advantages of GS20 : Fast decay constant (~ 18 ns)
    ➔ suitable for high radiation environment & capability of neutron-gamma discrimination [5]
- ϕ 4 mm × 40 mm quartz light guide coupled to PMT (photomultiplier tube)

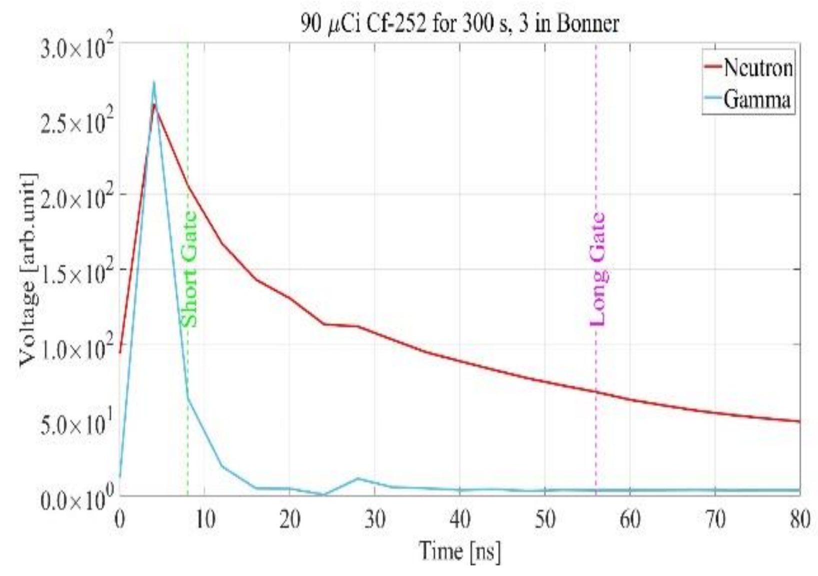
Acknowledgments

This research was supported by National R&D Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning (2020M2D1A1064206).

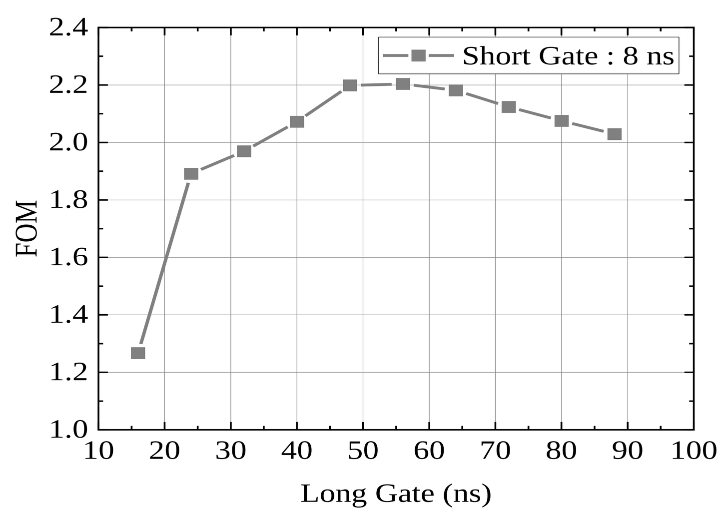
Measurement with $^{252}_{98}$Cf

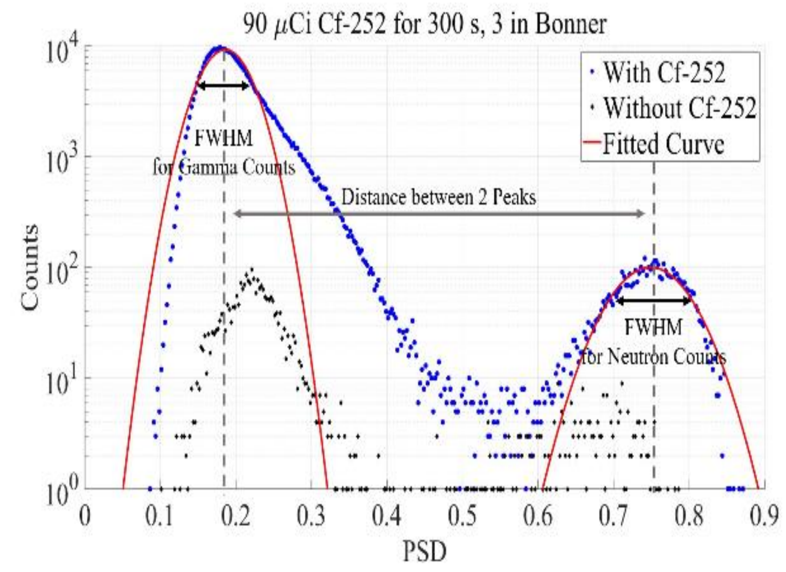


※ **Pulses from BSS**



※ **BSS Optimization**





❖ **Experiment setup**

- Used spheres : 0 & 3 in.
- 150 mm away from encapsulated 90 µCi $^{252}_{98}$Cf for 300 s
- Recorded by a 250 MHz digitizer, DT5725 from CAEN

❖ **PSD (Pulse Shape Discrimination) to distinguish neutron and gamma pulse**

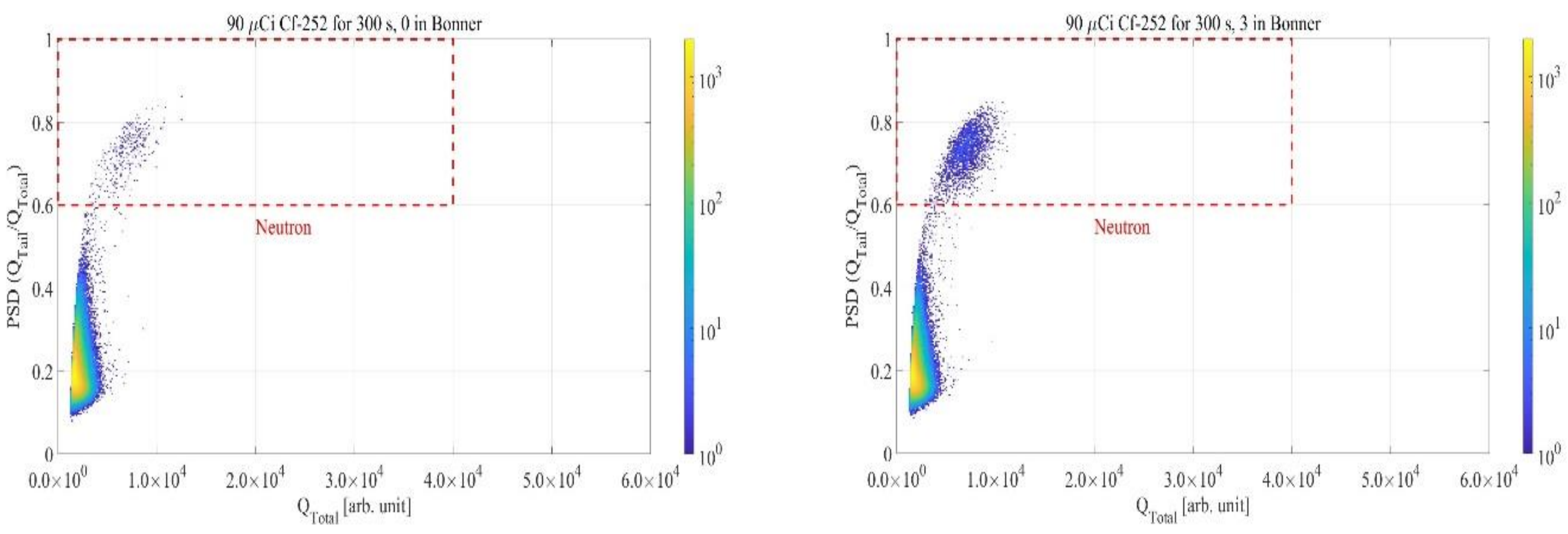
- Q_{total} : V-t integral from pulse rise to signal tail (Long Gate)
- Q_{tail} : V-t integral from signal head (Short Gate) to signal tail

➔ PSD Ratio : $\frac{Q_{tail}}{Q_{total}}$

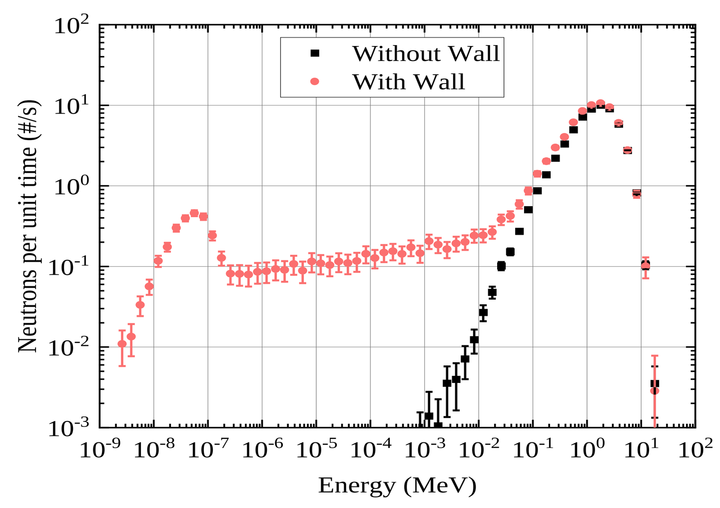
❖ **Maximum FOM (Figure of Merit) if BSS is optimized**

- FOM : $\frac{\text{(Distance between two peaks)}}{\text{(Sum of full width half maximum of two peaks)}}$ [6]
- Maximized when long gate is 56 ns

Results



※ **Spectrum Variation by Surrounding Wall**



	0 in.	3 in.
MCNP6.2	26±2	2258±12
Experiment	330±18	2487±50

➔ Discrepancies by excluding neutrons scattered from the surrounding during the simulation

Conclusions & Future Plan

❖ **Necessity of BSS due to wide neutron spectrum from the simulation**

➔ **Development of BSS & optimization through $^{252}_{98}$Cf-emitted neutron measurement**

❖ **On plan : Measurements after completion of TMRS & implementation of neutron spectrum unfolding**

Reference

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