New experiment, BISCOTTEE, to measure NCQE interactions based on BGO detector

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UCI Department of Physics & Astronomy
Poster #105

● BISCOTTEE

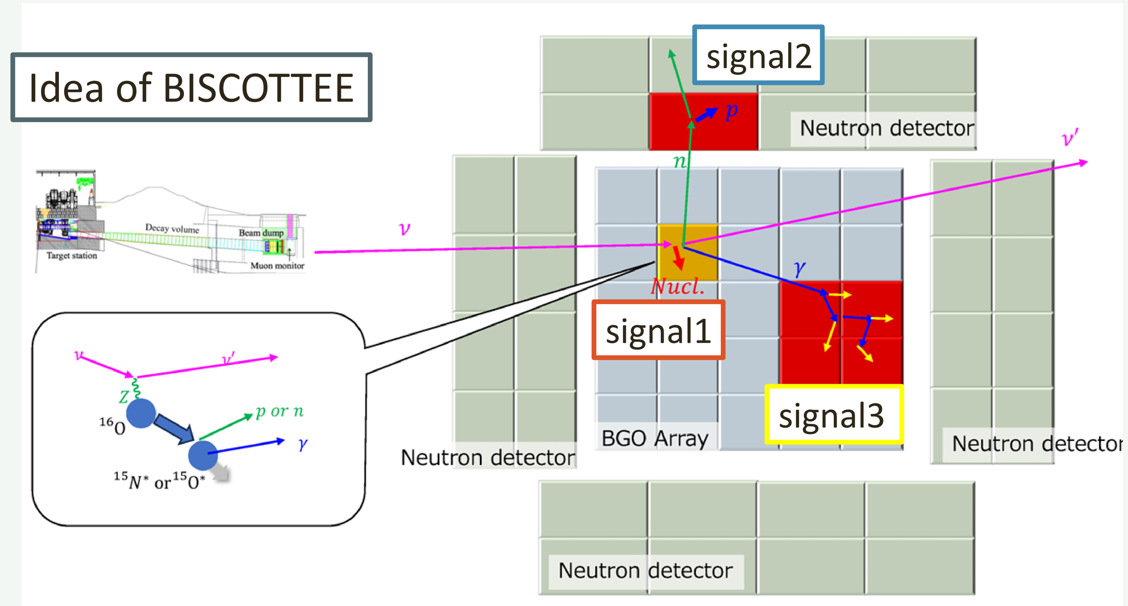
BISmuth-germanate **C**rystal base neutrin**O**(neutr**O**n)-nucleus sca**TTE**ring Experiment

A new experiment, **BISCOTTEE**, has been proposed to **measure neutrino–oxygen Neutral-Current Quasi-Elastic (NCQE)** interactions. A short-baseline **neutrino beam** is directed onto a **BGO detector.**

$$\nu(\bar{\nu}) + {}^{16}\mathrm{O} \rightarrow {}^{15}\mathrm{O} + \mathrm{n} + \gamma$$

signal1 (^{15}O), signal2 (n), signal3 (γ)

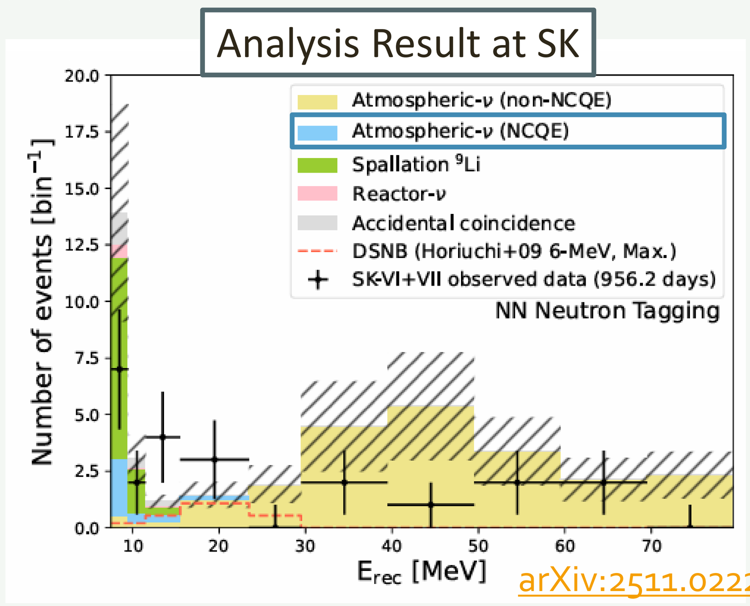
In this poster, preliminary experiment is presented.



Physics Motivation (Search for DSNB at SK)

In Diffuse Supernova Neutrino Background (DSNB) search at Super Kamiokande (SK), neutrino-oxygen **NCQE events** are one of the **main backgrounds.**
A large systematic error of 71% is assigned to the estimated number of **NCQE events.**

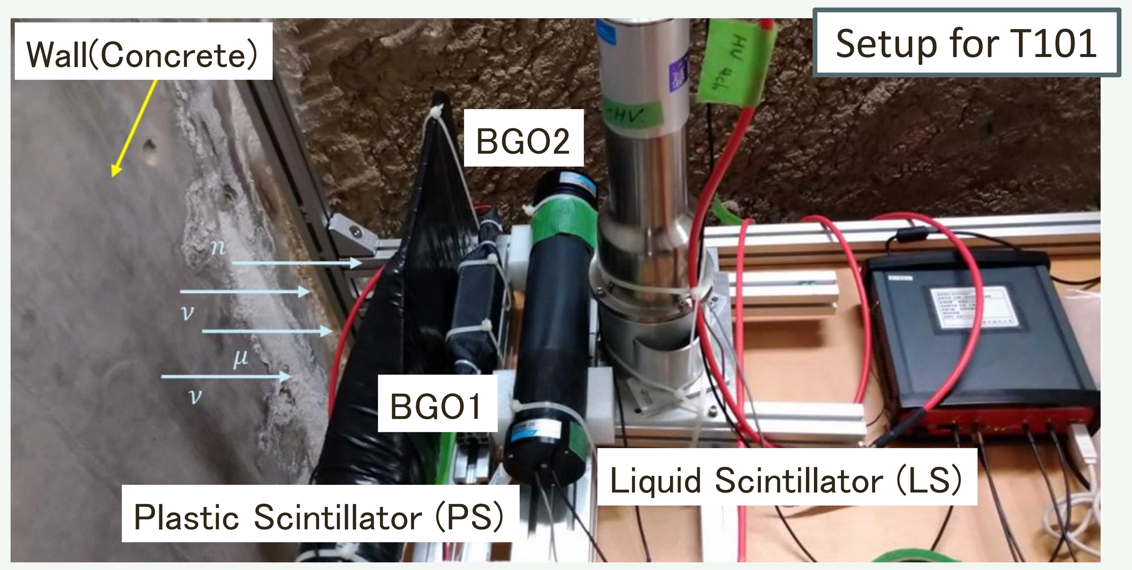
⇨ **Reducing this uncertainly is motivation** for a Measurement of NCQE Interactions.

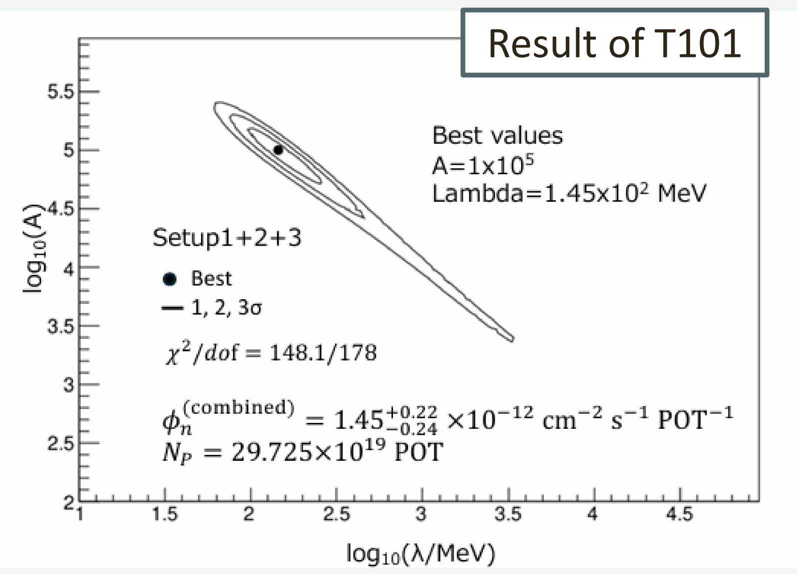


arXiv:2511.02222v1

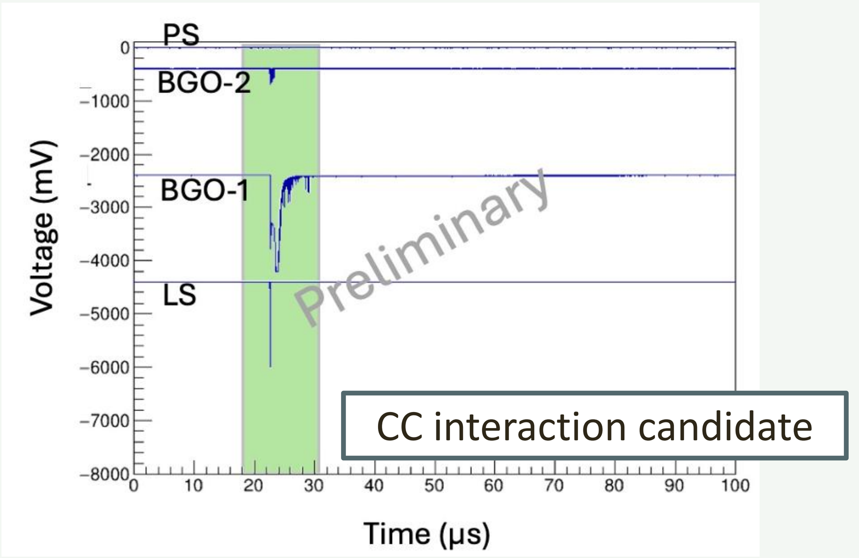
● J-PARC T101 experiment

BISCOTTEE will be performed at the **J-PARC** neutrino beamline, located 280 m downstream of the beam target.
Beam-induced neutrons, a dominant source of **background for the NCQE measurement**, were measured (**T101 experiment**) .





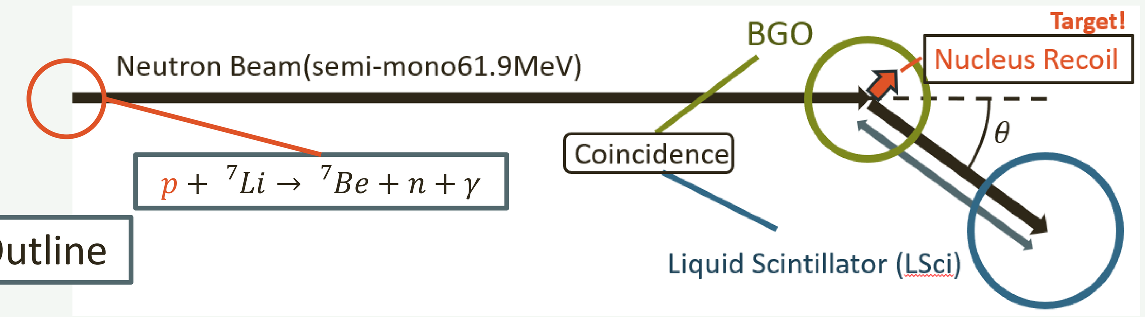
We assumed $\Gamma_n(E_n) = A\exp(E_n/\lambda)$ as the **neutron flux.**



One event of the neutrino-BGO **CC candidate** is observed, at the experiment.

● Preliminary experiment for measuring BGO quenching factor

It is important to observe recoil nuclei in the BISCOTTEE. signal1
We have measured the **QF (quenching factor) of BGO scintillation light yield for oxygen nuclear recoil** by observing **neutron–oxygen elastic scattering** events.

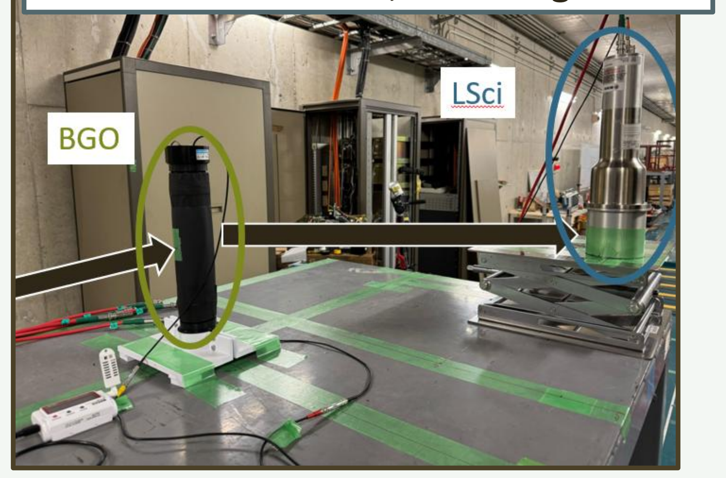


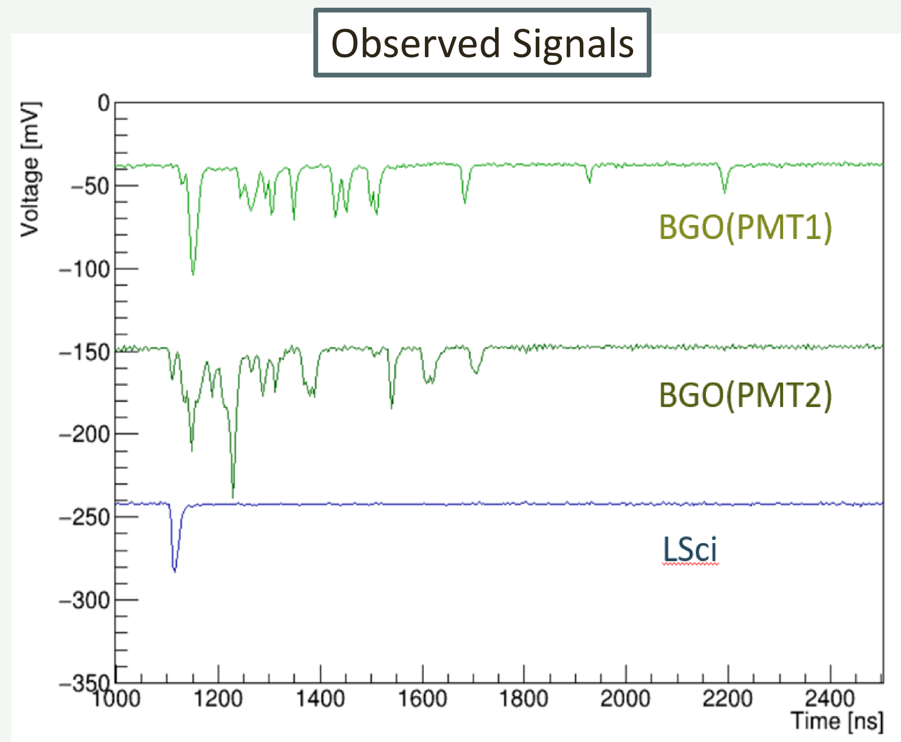
We have two experimental setups for measurements

$$\theta = 30°, E_R(\theta) = 1028\ keV$$
$$\theta = 45°, E_R(\theta) = 2226\ keV$$

We can observe visible energy as function of $E_{BGO}^{obs} = QF \times E_R(\theta)$

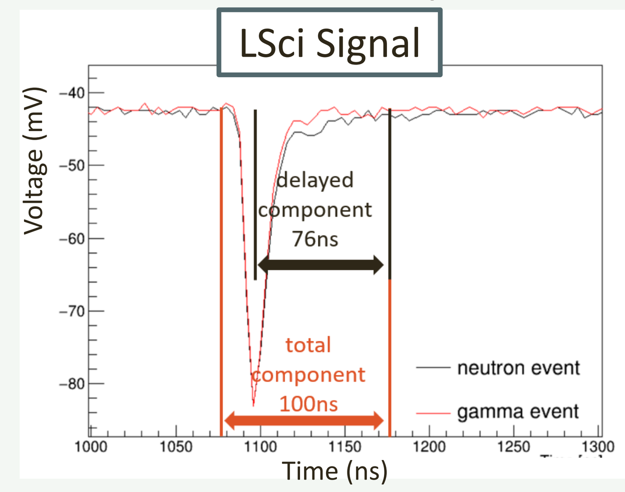
Neutron beam to BGO
@Osaka Univ. RCNP, 4-5th Aug. 2024

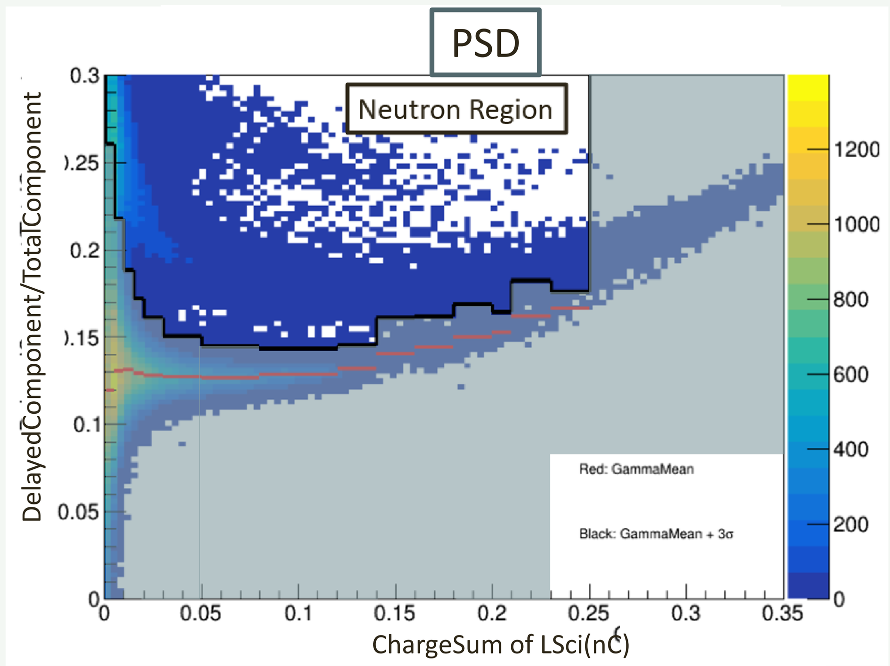




Analysis

Pulse Shape Discrimination (PSD)
Particle identification is possible in a liquid scintillator using **PSD.**

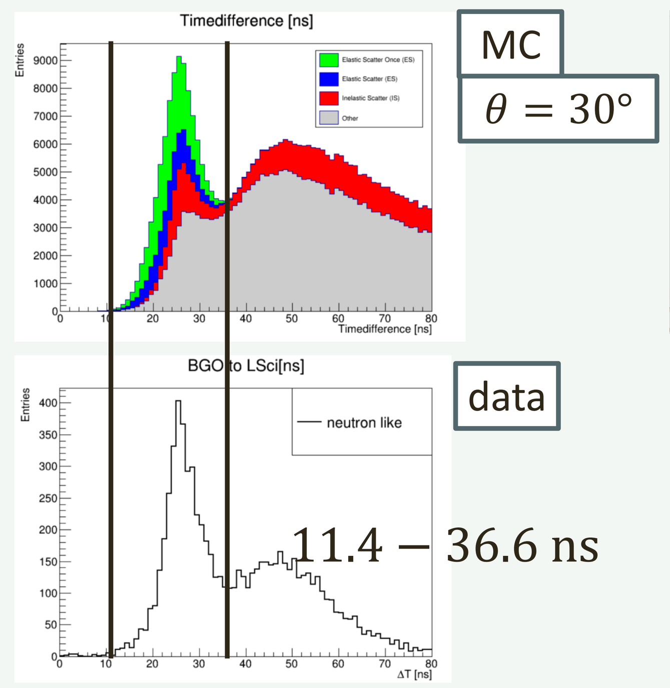


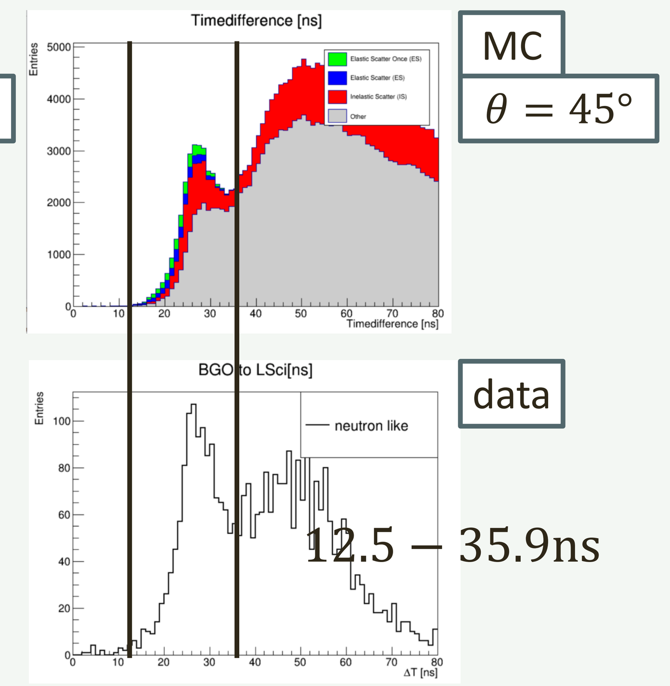


Neutron-induced signals exhibit **a larger delayed-component** than gamma-induced signals.

We use $\frac{\text{DelayedComponent}}{\text{TotalComponent}}$ as a factor for discrimination.

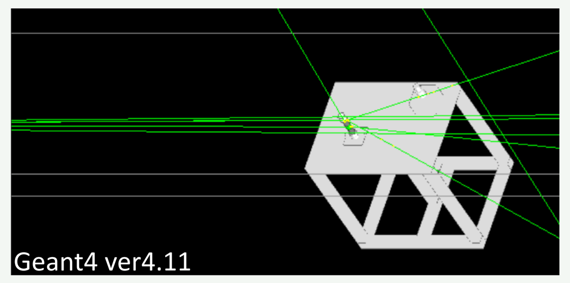
Time difference between LSci and BGO
Comparison between simulation and experimental data was used to **reject background-dominated regions.**

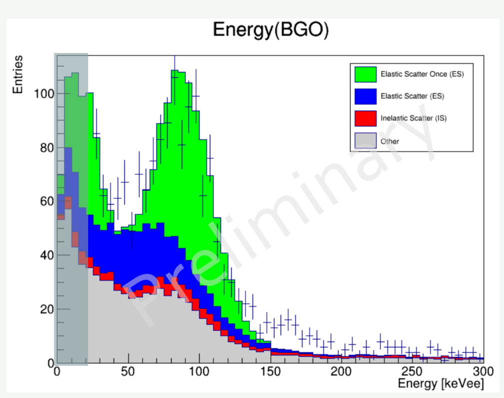




Results

The difference between the energy spectra of the **simulation and experimental data** was evaluated using a χ^2 statistic, and the parameters were determined **by minimizing χ^2.**
We confirm **the oxygen nuclear recoil QF** as a result.

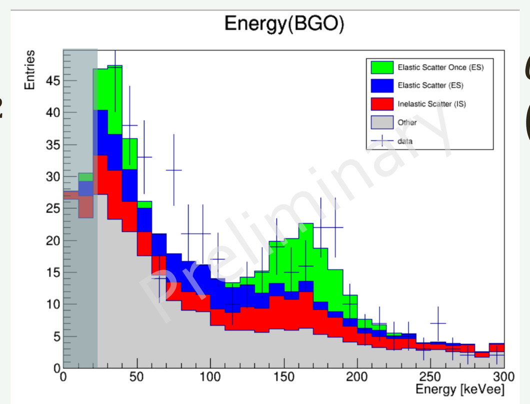




$QF_O = (9.20^{+0.17}_{-0.10}) \times 10^{-2}$

$\chi^2/NDF = 106/54$

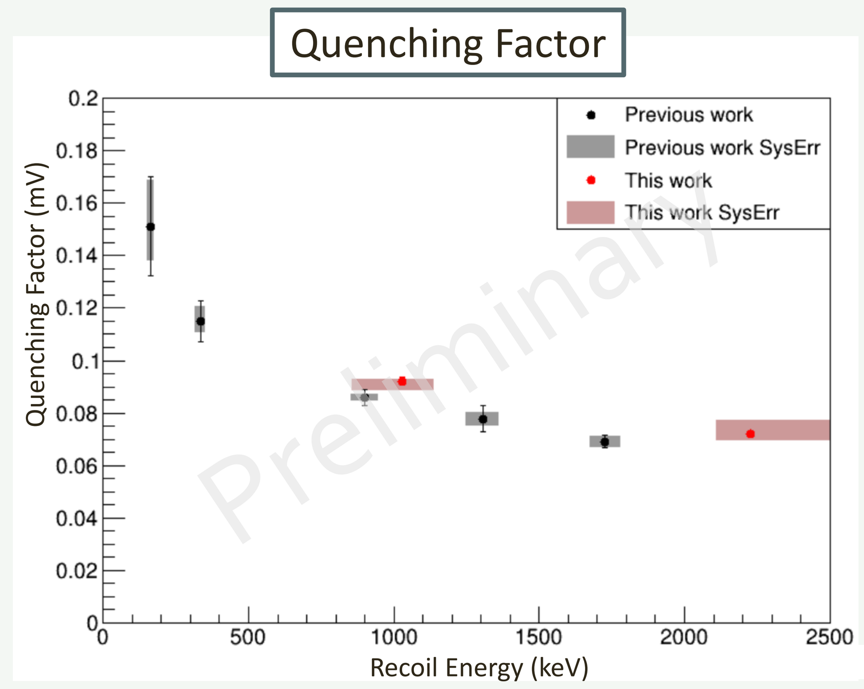
Observed energy in BGO($\theta = 30°$)



$QF_O = (7.21^{+0.08}_{-0.05}) \times 10^{-2}$

$\chi^2/NDF = 112/26$

Observed energy in BGO($\theta = 45°$)



The oxygen nuclear recoil QF was measured at **two recoil energies** and found to be **consistent with a previous measurements.**

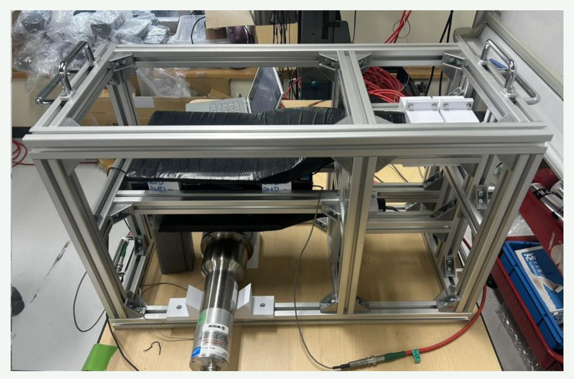
Previous Measurement JINST 18 T04006(2023)

Not all possible systematic uncertainties have been taken into account.

● Milestone of BISCOTTEE

BISCOTTE Phase-0 (J-PARC T116 experiment)

This is planned for the **next beam time at J-PARC.**
We will measure accelerated **anti-neutrino-induced neutron**, and we want to measure **the cross section of CC interactions in BGO.**
Preparation is in progress at Kobe Univ.



Phase-1
5 kg BGO detector: Observation of charged-current (CC) events and measurement of their cross sections.
Phase-2
10 kg BGO detector: Improved measurement of the CC cross section and first observation of neutrino–oxygen NCQE events (p-channel).
Phase-3
100kg BGO detector: Observation of NCQE events (n-channel) and measurement of the NCQE cross section.

the next decades