

Measurement of the quenching factor for BGO crystals for the BISCOTTEE experiment

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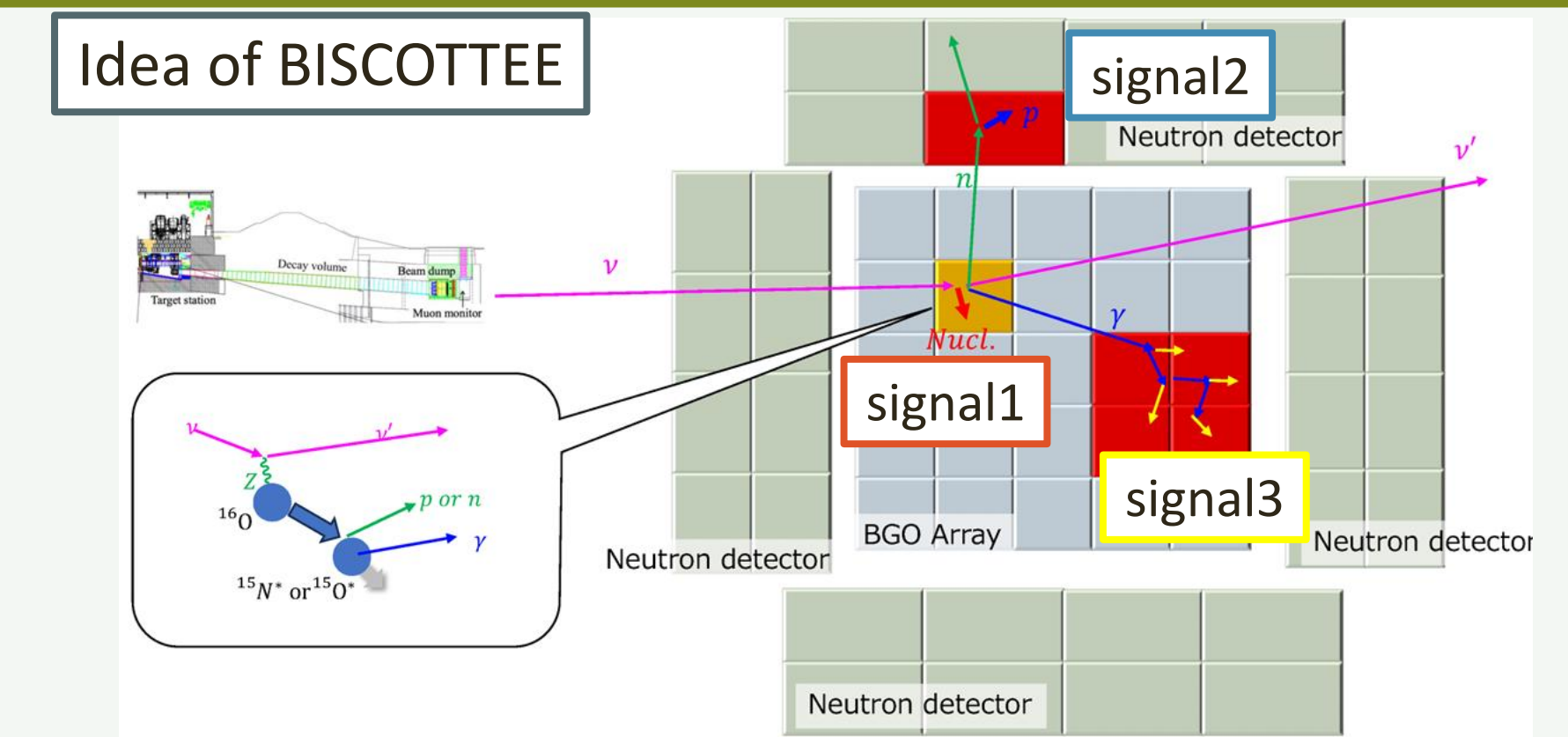
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BISCOTTEE

BISmuth-germanate Crystal base neutrino(neutrino)-nucleus scattering Experiment

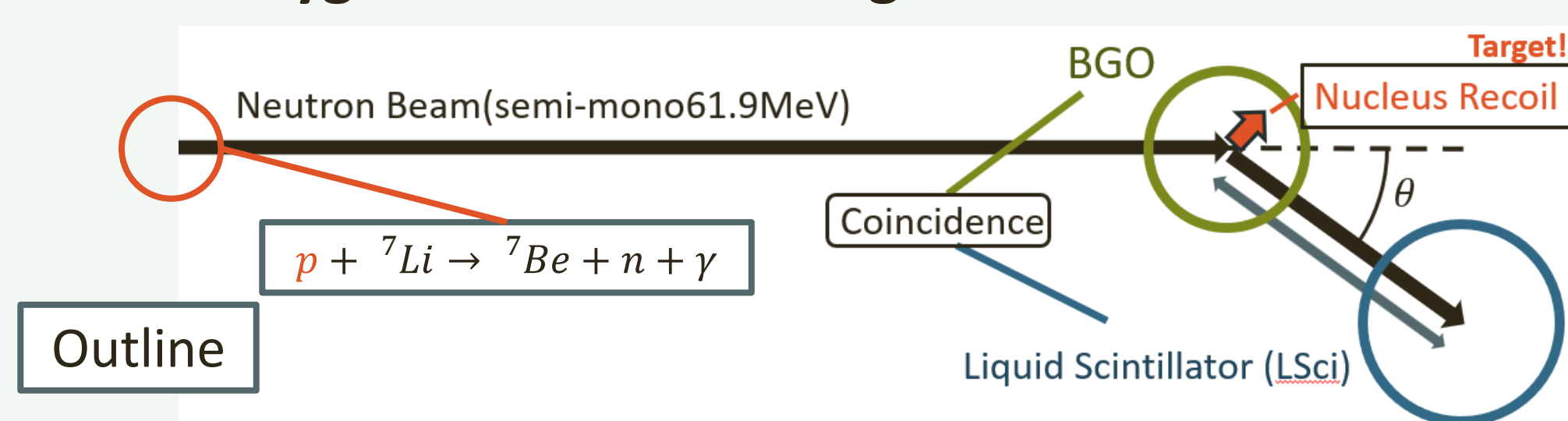
A new experiment, **BISCOTTEE**, has been proposed to **measure neutrino–oxygen Neutral-Current Quasi-Elastic (NCQE) interactions**. A short-baseline **neutrino beam** is directed onto a **BGO detector**.

In this poster, **preliminary experiment** is presented.



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.

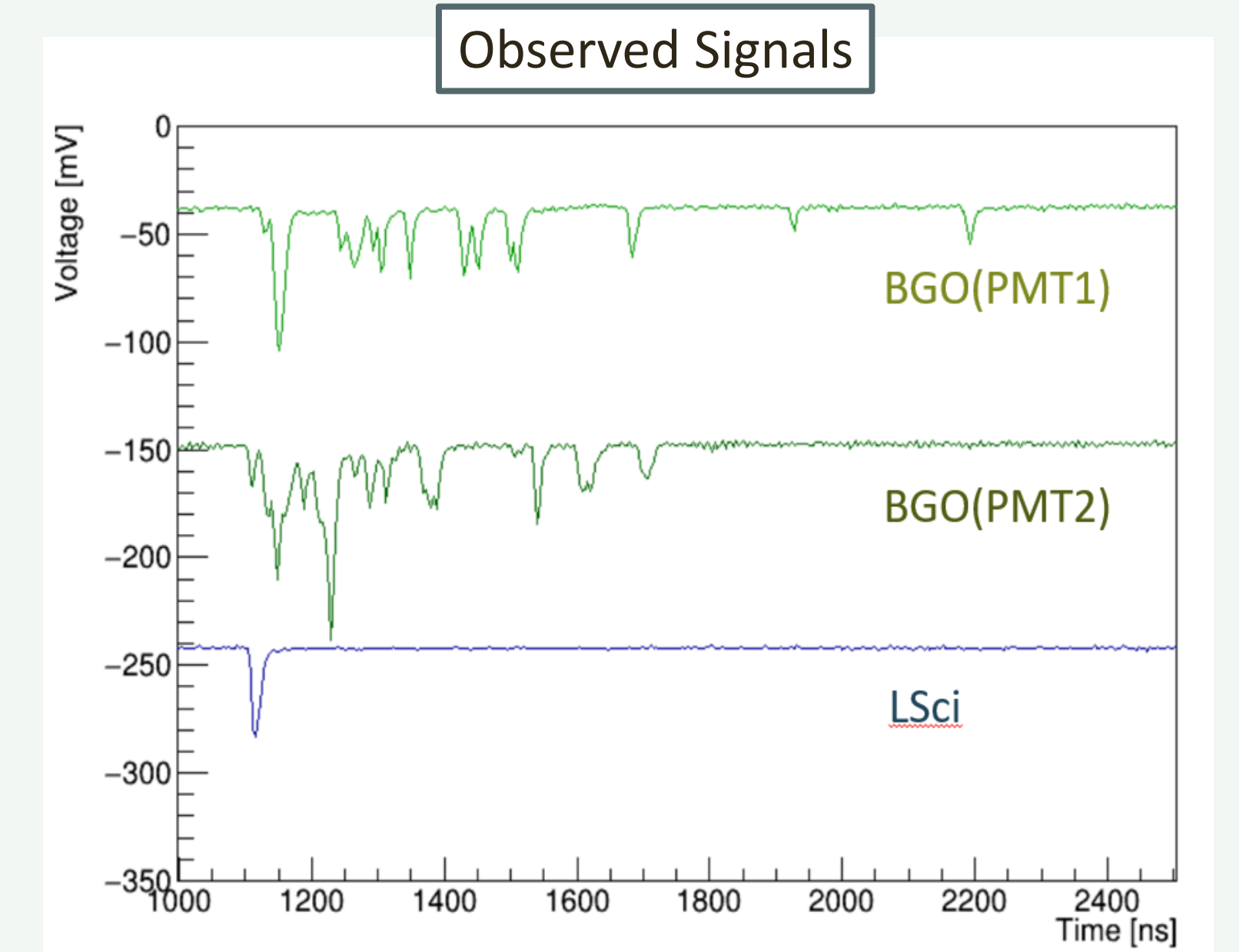
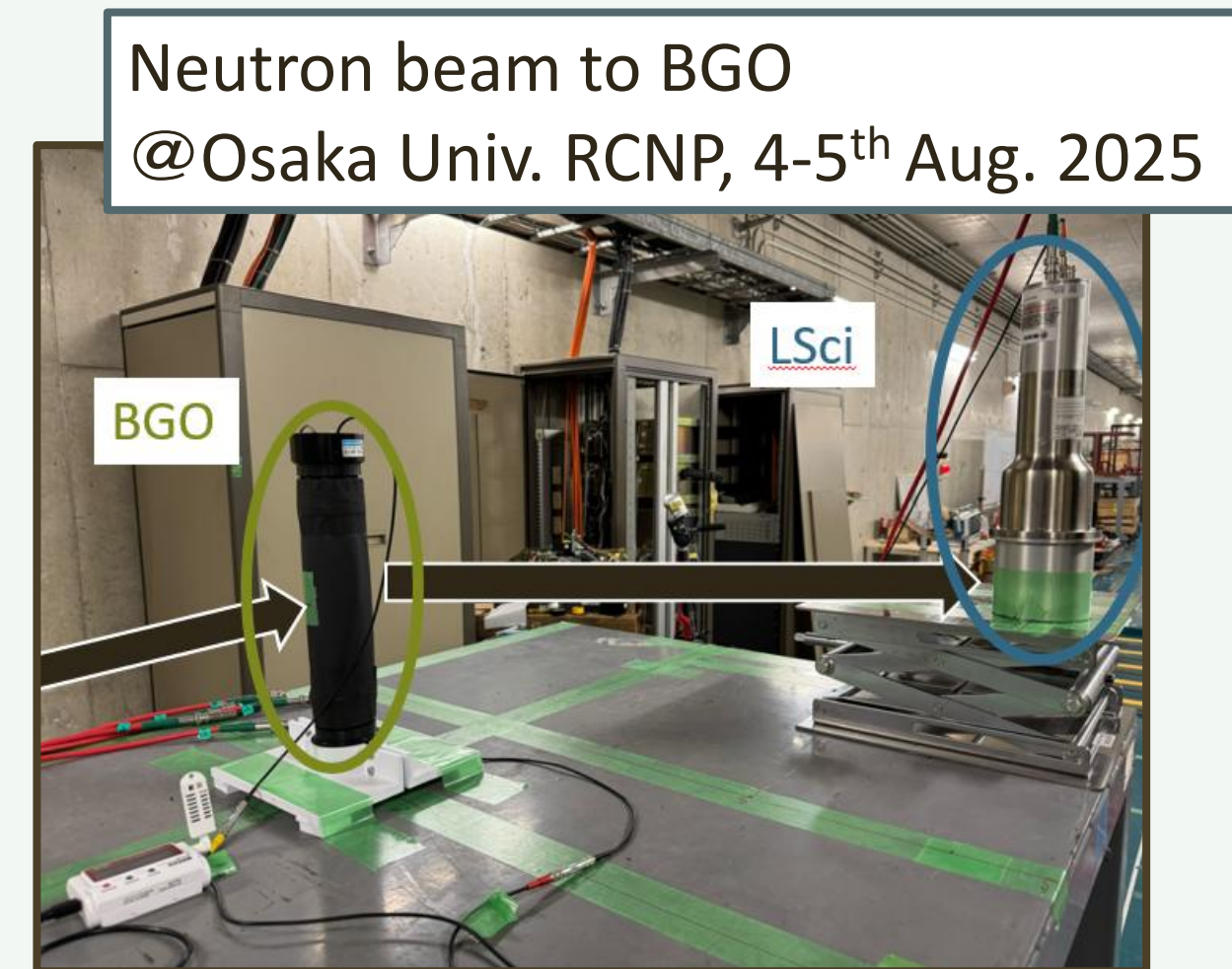


We have two experimental setups for measurements

$$\theta = 29.97^\circ, E_R(\theta) = 994 \text{ keV}$$

$$\theta = 45.00^\circ, E_R(\theta) = 2307 \text{ keV}$$

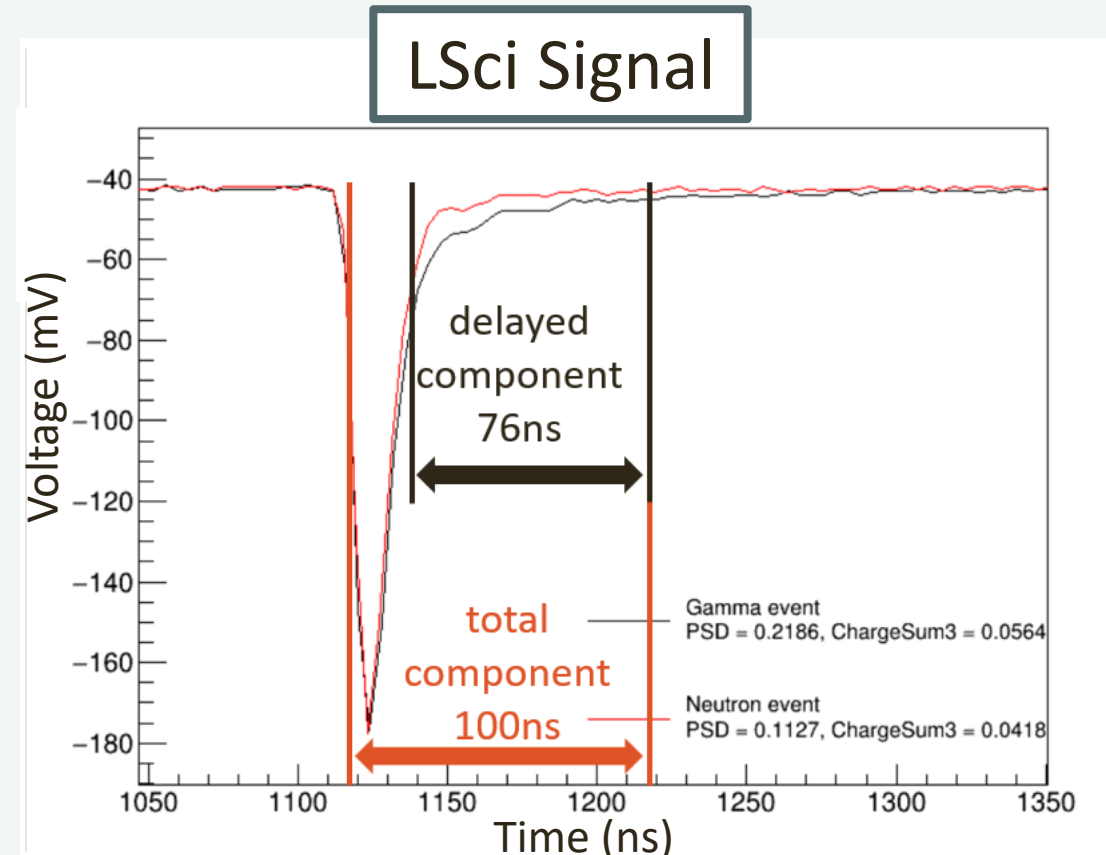
We can observe visible energy as function of $E_{BGO}^{obs} = QF \times E_R(\theta)$



Analysis

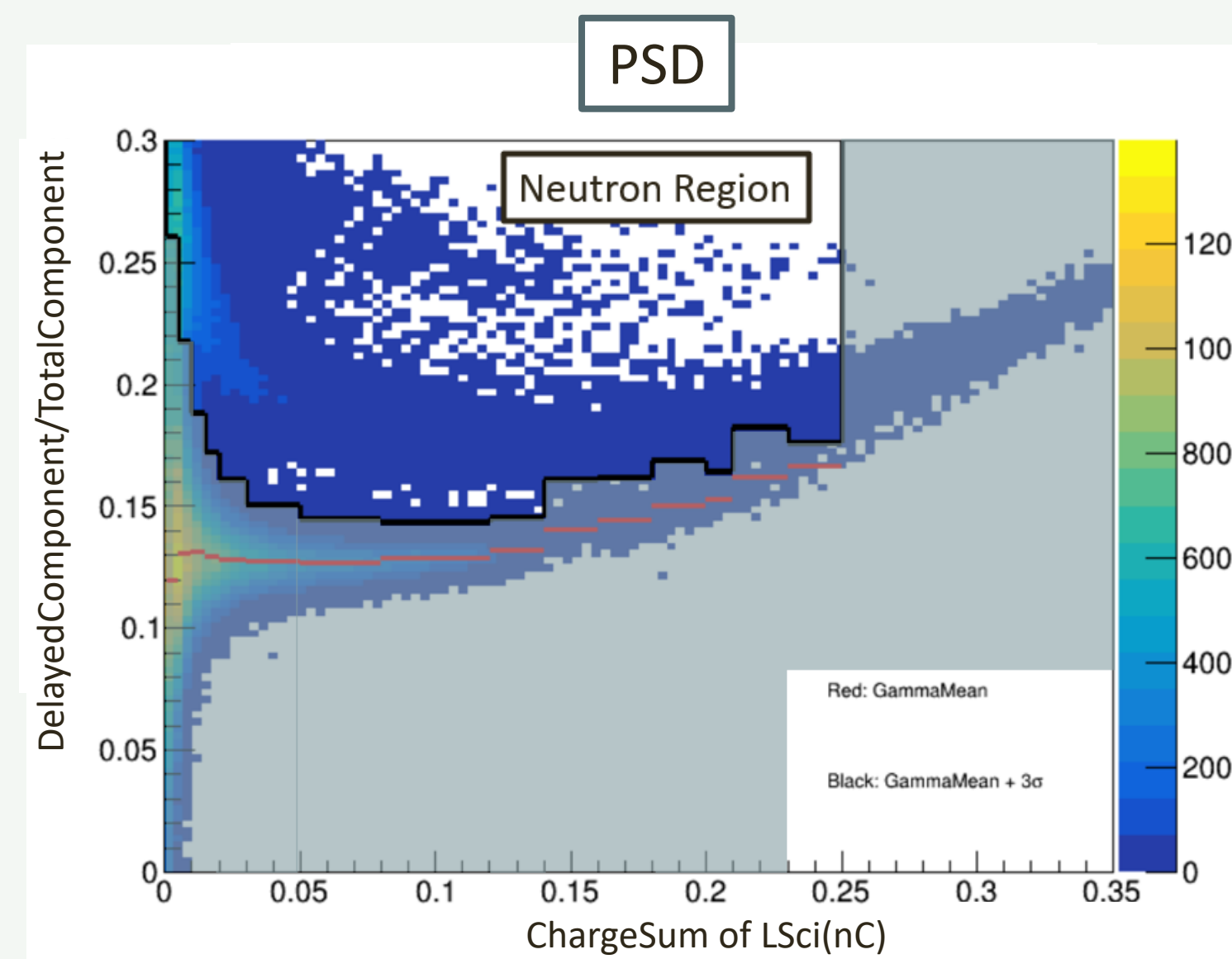
Pulse Shape Discrimination (PSD)

Particle identification is possible in a liquid scintillator using PSD.



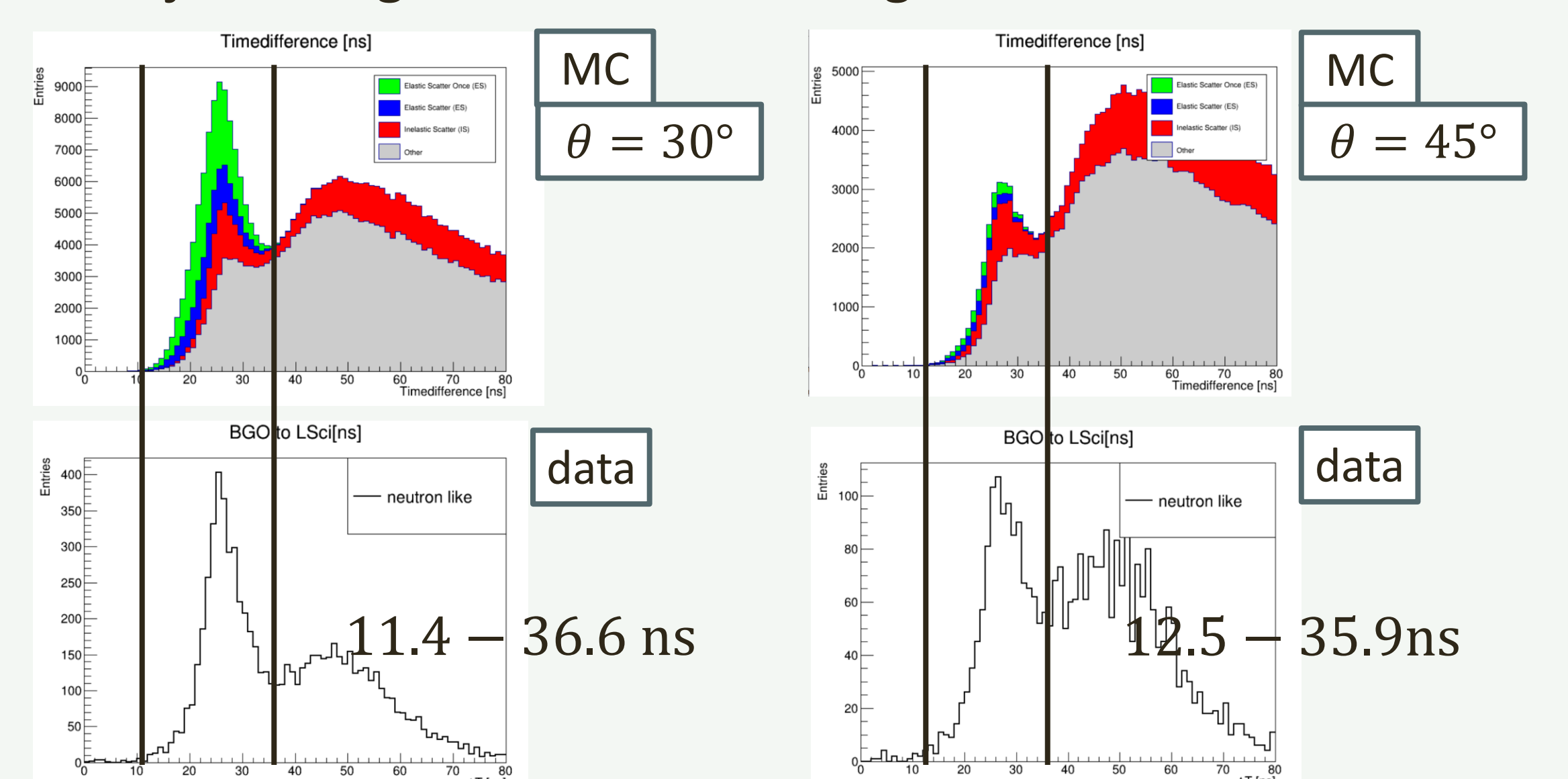
Neutron-induced signals exhibit a **larger delayed-component** than gamma induced signals.

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



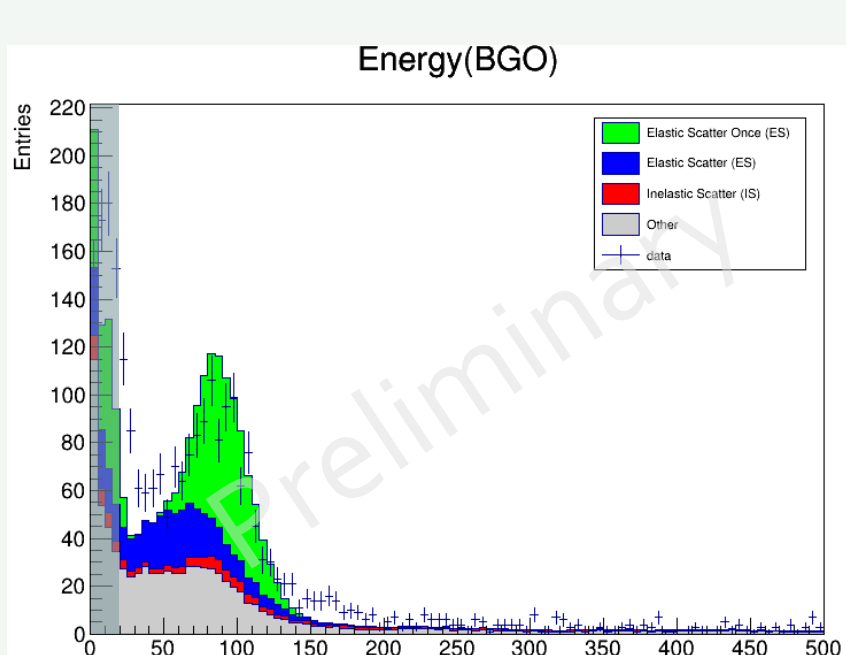
Time difference between LSci and BGO

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



Results

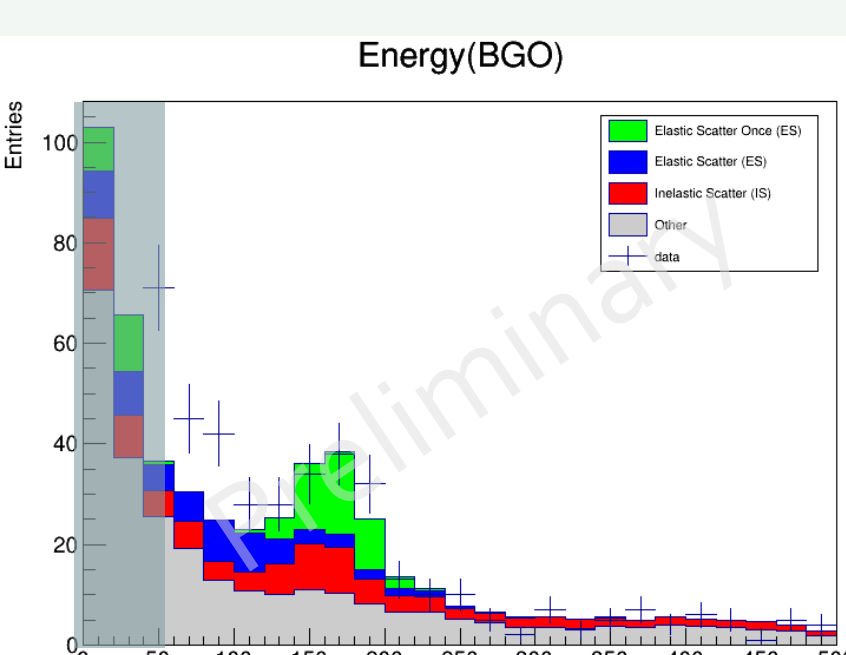
The **difference** between the energy spectra of the **simulation** and **experimental data** was evaluated using a χ^2 statistic, and the parameters were determined **by minimizing χ^2** .
We confirm the **oxygen nuclear recoil QF** as a result.



$$QF_o = (9.05_{-0.03}^{+0.03}(\text{stat.})_{-0.35}^{+0.22}(\text{syst.})) \times 10^{-2}$$

$$\chi^2/NDF = 165/55$$

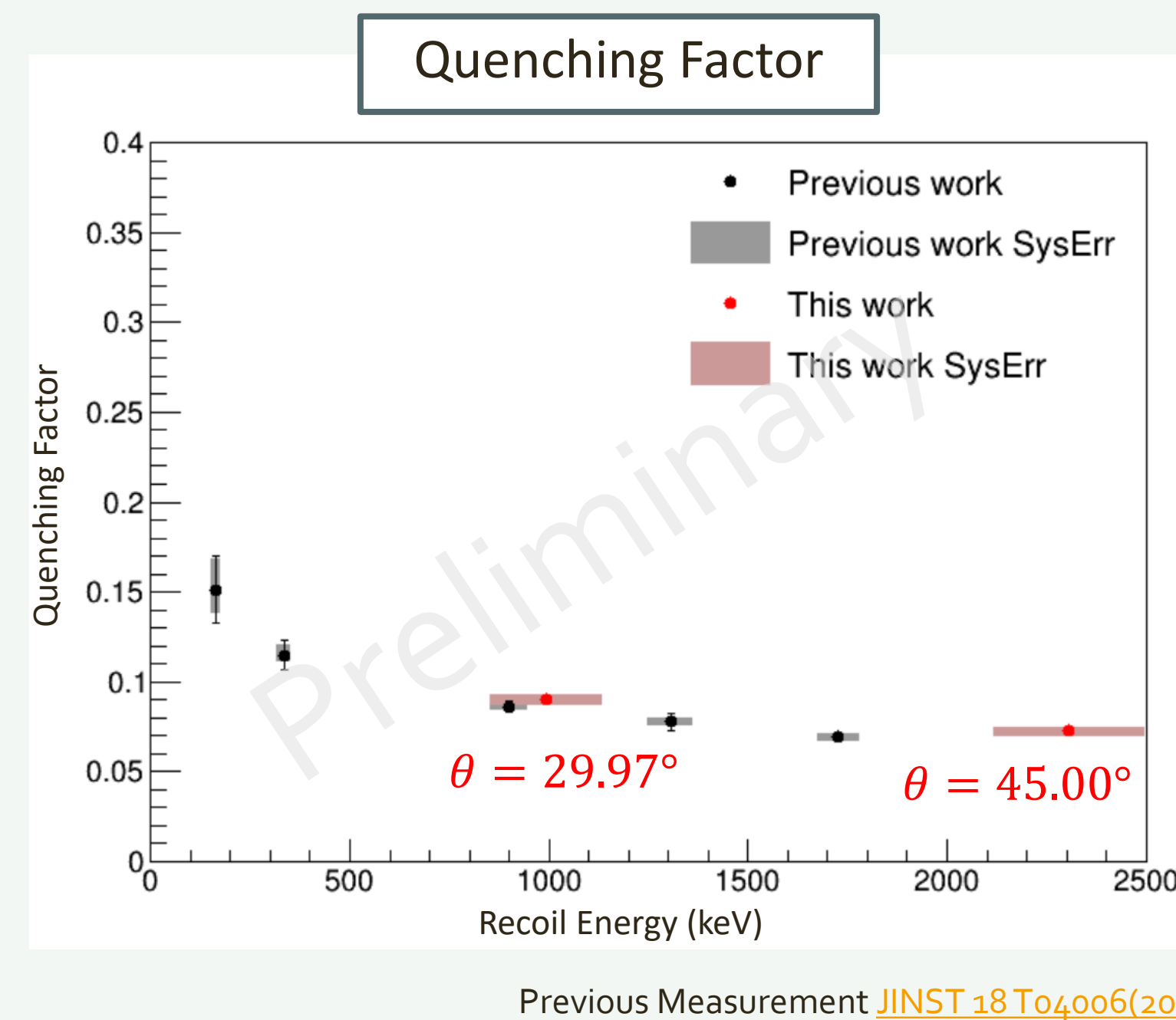
Observed energy in BGO($\theta = 29.97^\circ$)



$$QF_o = (7.24_{-0.03}^{+0.03}(\text{stat.})_{-0.29}^{+0.22}(\text{syst.})) \times 10^{-2}$$

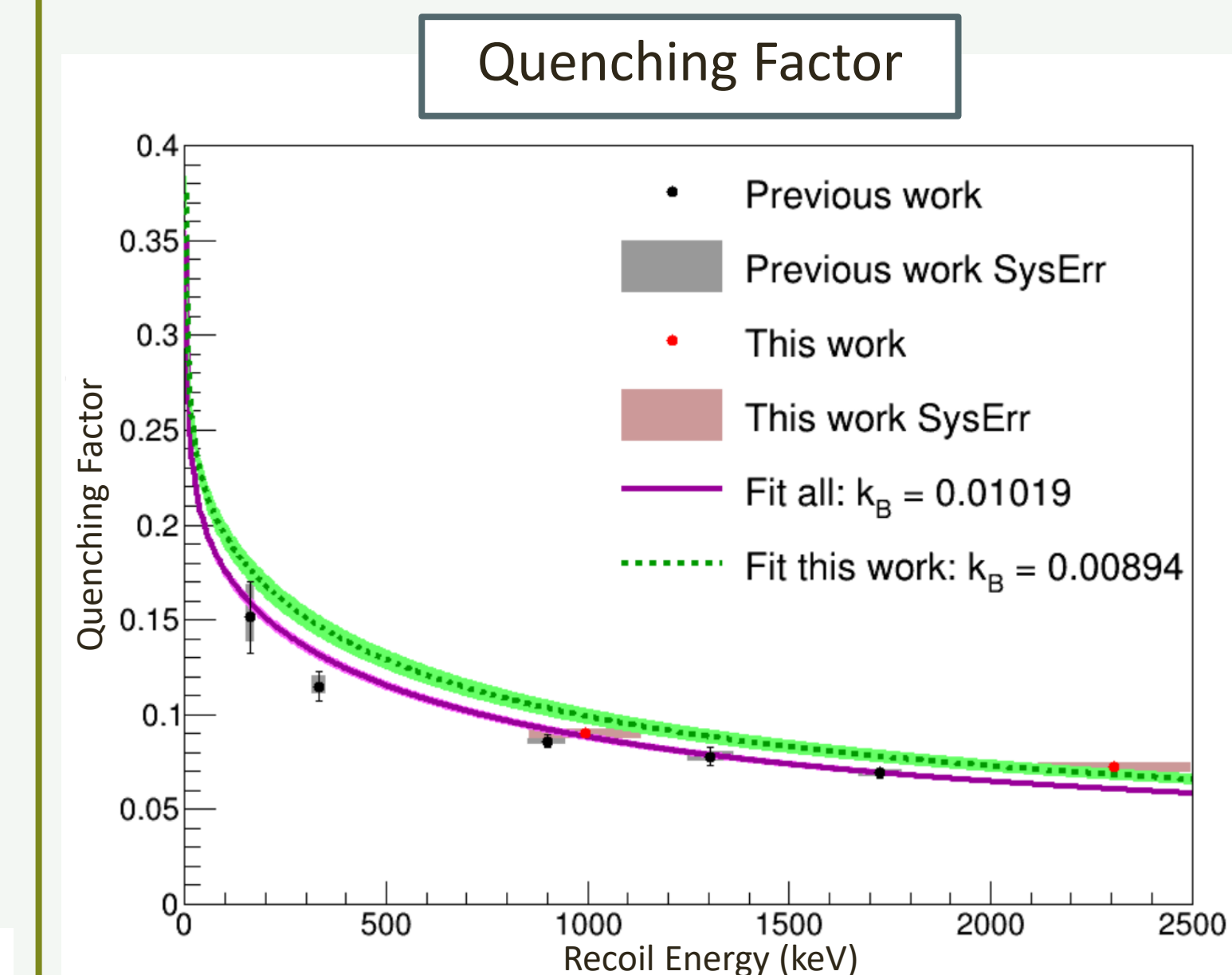
$$\chi^2/NDF = 38/20$$

Observed energy in BGO($\theta = 45.00^\circ$)



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

Discussion



Birks' law

$$QF_i(E) = \frac{L_i(E)}{L_e(E)} = \frac{\int_0^E \frac{dE}{1 + kB \left(\frac{dE}{dr} \right)_i}}{\int_0^E \frac{dE}{1 + kB \left(\frac{dE}{dr} \right)_e}}$$

$QF_i(E)$... Quenching factor of ion
 $L_i(E)$... Luminous amount of ion
 $L_e(E)$... Luminous amount of electron
 $\left(\frac{dE}{dr} \right)_i$... Stopping power of ion
 $\left(\frac{dE}{dr} \right)_e$... Stopping power of electron
 kB ... Birks factor

Quenching factor can be predicted using **Birks' law**.
The **Birks factor** was estimated from two separate fits:

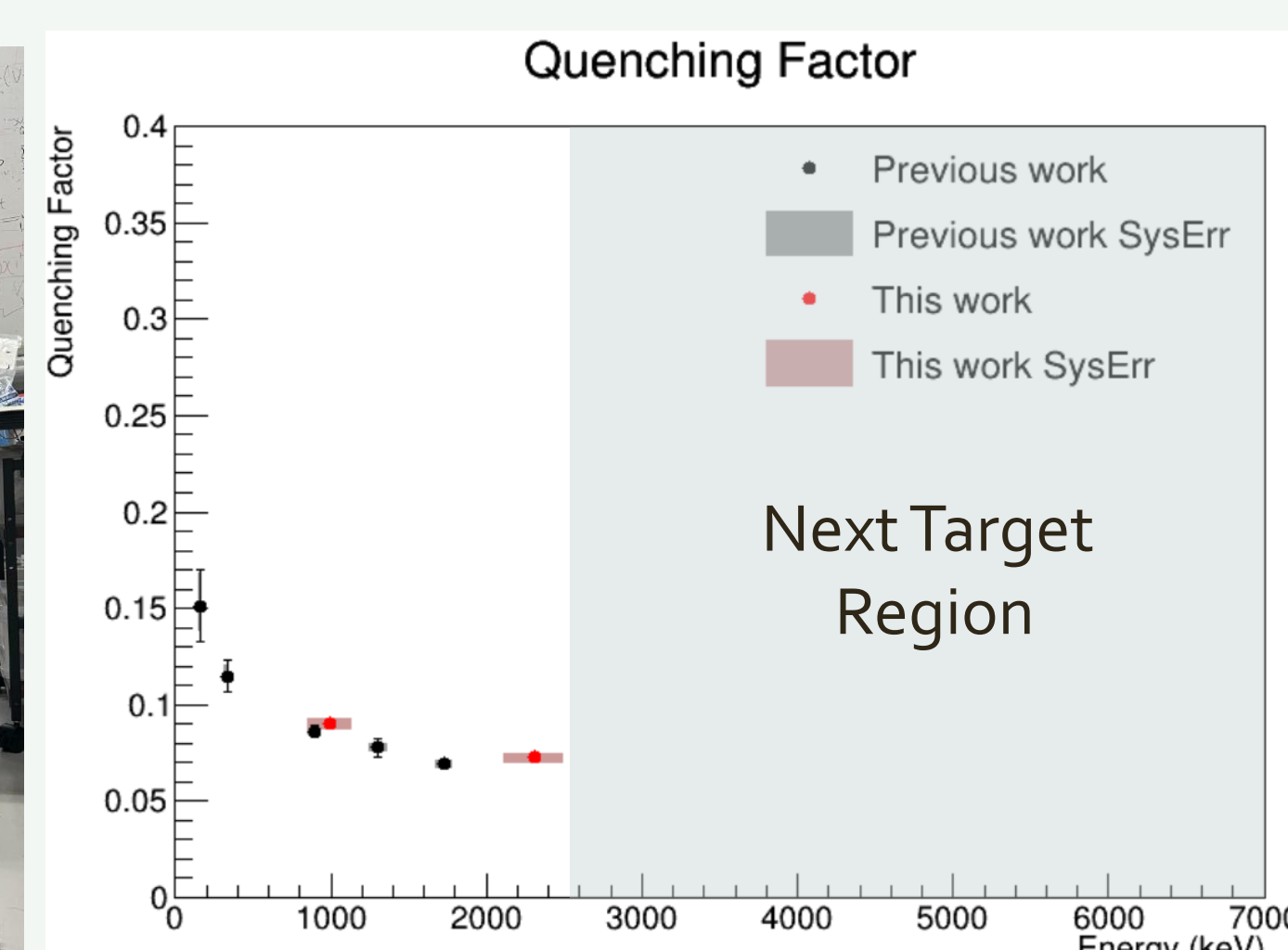
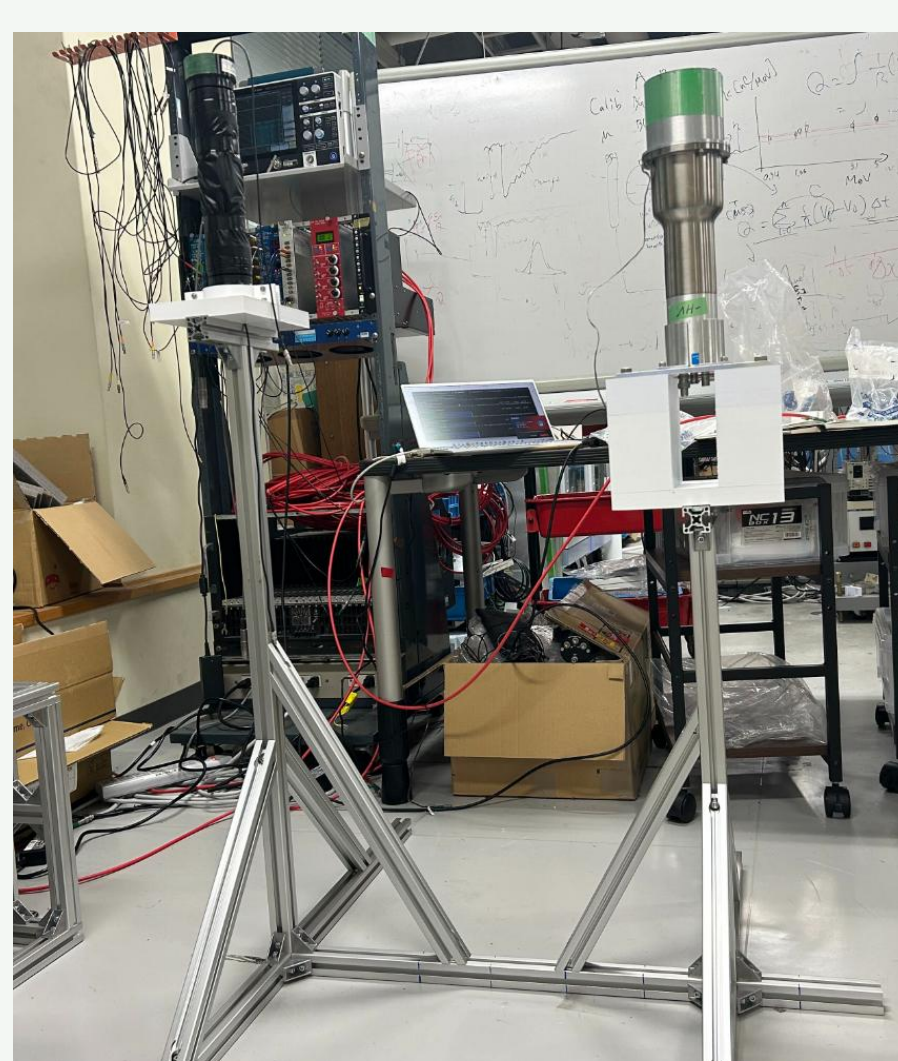
- using only the results of this experiment
 $kB = (8.94_{-0.43}^{+0.45}) \times 10^{-3} \text{ g/cm}^2/\text{MeV}$
- using both our results and previous measurements
 $kB = (10.19_{-0.26}^{+0.27}) \times 10^{-3} \text{ g/cm}^2/\text{MeV}$

Future

Beam experiment conducted on September 24–25, 2026

Data collected at higher recoil energy

Analysis in progress!



Conclusion

Beam experiment has been conducted on 4-5th Aug. 2025 at Osaka Univ. RCNP

Several selection criteria were applied to identify neutron–oxygen elastic scattering events.

QF (quenching factor) of BGO scintillation light yield was measured

$\theta(^{\circ})$	$E_R(\text{keV})$	QF_o
29.97 ± 0.07	993 ± 140	$(9.05_{-0.03}^{+0.03}(\text{stat.})_{-0.35}^{+0.22}(\text{syst.})) \times 10^{-2}$
45.00 ± 0.07	2307 ± 190	$(7.24_{-0.03}^{+0.03}(\text{stat.})_{-0.29}^{+0.22}(\text{syst.})) \times 10^{-2}$