Status of the J-PARC E16 experiment in 2024

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Experiment E16[1,2] commenced in 2020 at the J-PARC Hadron Experimental Facility, to investigate the chiral symmetry restoration in dense nuclear matter by measuring the vector meson decays in nuclei. This experiment aims to systematically study the spectral modification of vector mesons in nuclei, particularly the ϕ meson, using the e^+e^- decay channel, with statistics that are two orders larger in magnitude than those of the precedent E325[3] experiment performed at KEK-PS. In other words, it aims to accumulate 1×10^5 to 2×10^5 events for each nuclear target (H, C, Cu, and Pb) to deduce the dependence of the spectral modification on the size of nucleus and the meson momentum.

The proposed spectrometer comprises 26 modules. A module comprising Lead-glass calorimeter (LG) and Hadron-blind detector (HBD) for electron identification, as well as three-layers of GEM Trackers (GTR) and a single layer of silicon strip detector (SSD) as the tracking devices. As a first step, eight modules were installed and operated.

Commissioning runs, totaling 403 hours, as summarized in Table 1, were performed in 2020–2021. In these runs, detector performance was almost confirmed. The major issue detected in the commissioning runs was the micro beam structures, which deteriorated the DAQ performance due to the time-localized high beam intensity.[4] To solve this, Hadron beamline (BL) group and slow extraction (SX) group in MR[a] proposed some countermeasures. Additionally, we upgraded our DAQ system to reduce the dead time. In June 2023, a test run was performed, but interrupted soon due to an accident in the facility; however, the upgraded DAQ and countermeasures for the micro beam structure were applied and worked well within the limited beam time.[1]

In 2024, finally 237 hours of beam time were available for the beam and trigger study. The beam time included about 15% down time due to MR or beamline malfunction less than one hour per incident.

With the improved beam structure owing to BL and SX groups, a trigger study was performed with the upgraded DAQ.[5] In addition, a high-multiplicity veto was newly introduced to reduce the event overlap due to the remaining micro structure. The GTR trigger-hit multiplicity was used as an index: the events over 15 hits were vetoed. The veto effectively reduces the beam protons, and also the trigger request, extending the DAQ live time. To maximize the recorded beam, optimization was performed, which required the product of the not-vetoed duration and the DAQ live time. As a result, averaged recorded beam proton per spill was 0.61×10^{10} protons for a beam intensity of 0.89×10^{10} protons. The live ratio was 68%, which could be improved in the future by further beam improvement.

Table 1. Run-time summary.

	Run-0a 2020	Run-0b 2021	Run-0c 2021	Run-0d 2023	Run-0e 2024	Total
Period	6/4–20	2/11–28	5/28–6/9	6/19–21	4/19–6/3	
Days	17	18	12	3	23	73
Beamtime (H)	159	110	134	11	237	651
Raw data (TB)	33	28	46	5.7	350	463

A main trigger of E16 is designed to collect the vector meson decays in the e^+e^- decay channel. In the trigger logic, the electron candidate is defined by a triple coincidence of LG, HBD, and outermost GTR. We required two electron candidates, separated by a certain angle, to suppress the background e^+e^- pairs from the Dalitz decay of π^0 and from the γ conversion in the target and detector materials. In the trigger study, following parameters were tuned; coincidence time window, threshold of LG, angle distance of the pair. As a result of the study, about 4 k/spill of the trigger request (with 90% DAQ live time) was realized with a reasonable trigger inefficiency, mainly due to the tighter geometrical coincidence map. The map was designed to accept the e^+ and e^- from the ϕ meson decay, using a detector simulation with a kinematical distribution of the ϕ meson generated by the cascade code JAM.[6] The 'tight' matching window on the map was used to reduce accidental coincidence.

It should be noted that the high-momentum beam line that we used was shutdown during day time, typically 9:00–18:00, in this beam time. This was to avoid the overrun of the maximum electric power in the J-PARC campus, and also to keep the power-supply building cool against the shortage of the cooling capacity encountered in the year. Such interruptions are inefficient for the operation of the GEM detectors (HBD and GTR), because approximately an hour of waiting time is required to obtain a stable gain, once the beam is turned off for several hours.

Based on the data in 2024, we requested the beam time for the physics run, with an updated technical design report. That was discussed in FIFC (Facility Impact and Funding Committee) held in Nov. 2024, and also in PAC held in Jan. 2025.

References
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