Status of the J-PARC E16 experiment in 2023

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We proposed the experiment E16[1)] to measure the vector meson decays in nuclei in order to investigate the chiral symmetry restoration in dense nuclear matter. The experiment started at the J-PARC Hadron Experimental Facility.

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 prior E325[2)] 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) and deduce the dependence of the spectral modification on the size of nucleus and meson momentum.

The proposed spectrometer comprises 26 modules. As shown in Fig. 1, 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.

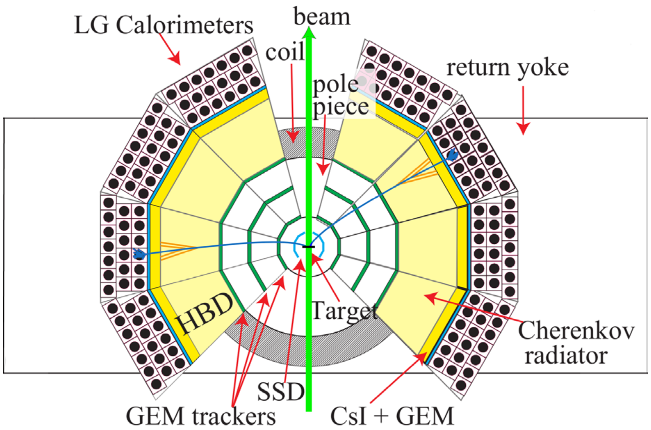

Fig. 1. Cross-sectional plan view of the E16 spectrometer in the eight-module configuration for Run-1, and operated in June 2023 for the first time.

Commissioning runs, in total 403 hours as summarized in Table 1, were performed in 2020-21 at the newly constructed 'High-momentum beam line (High-p line).' Owing to budget limitations, a limited number of modules were installed in the commissioning runs. In these runs, detector performance was almost confirmed.

Table 1. Run-time summary.

	Run-0a 2020	Run-0b 2021	Run-0c 2021	Run-0d 2023	Total
Period	6/4-20	2/11-28	5/28-6/9	6/19-21	
Days	17	18	12	3	50
Beam time (h)	159	110	134	11	414
Raw data (TB)	33	28	46	5.7	113

The major issue detected in the commissioning runs is the micro beam structures, which deteriorate the DAQ performance due to the time-localized high beam intensity.[3)] We observed two types of structures, approximately 5 ms cycle and 5.2 μs cycle. The former was known in other J-PARC secondary beam line, but the latter was unknown, namely, first observed at High-p line. The origin of former is thought to be a current ripple in the magnet power supply of MR,[a)] and the latter is a beam optics which is dispersive at the branching point from the main primary beam line to High-p line. As countermeasures, new optics were applied for the latter. For the former, the power supply was already replaced for the power upgrade of MR, and the ripple was reduced in the test magnet.

Additionally, we upgraded our DAQ system to reduce the dead time. Data buffering using a RAM module on the GEM readout board was implemented to use the off-spill time for the data transfer.

In June 2023, a commissioning run was performed, but it was interrupted by the facility accidents. Only 10.5-hours of beam time was executed out of 180 hours approved for the trigger and beam study, just after the 10.5 hours of beam tuning in High-p line out of the approved 53 hours. Even with the limited beam time, we confirmed following two. 1) New beam optics reduces the 5.2-μs structure. Unfortunately, a fine tuning of the MR power supply was not performed yet in the beam time, thus 5-ms structure was not reduced. 2) The new DAQ worked well to reduce the dead time as designed. For the minimum bias trigger (4k/spill), the DAQ live time was improved from $\sim$30% to $\sim$80%. It should be noted that the performance should be checked for the ee-trigger to collect vector mesons, which was not tested due to the beam time shortage.

In the beam time, eight new modules of SSD were commenced, which is developed in collaboration with the CBM group at GSI. Thus, full-eight modules were operated for the first time.

Next beam time (222 hours) will be scheduled in or after April 2024. With these results, the updated TDR will be submitted for an approval of Run-1.

References

1) S. Yokkaichi *et al.*, J-PARC proposal No. 16 (`http://j-parc.jp/researcher/Hadron/en/pac_0606/pdf/p16-Yokkaichi_2.pdf`): K. Aoki *et al.*, Few-Body Syst. **64**, 63 (2023).
2) R. Muto *et al.*, Phys. Rev. Lett. **98**, 042501 (2007).
3) S. Yokkaichi, RIKEN Accel. Prog. Rep. **56**, 111 (2023).

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a) J-PARC Main Ring Accelerator

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