Performance improvement of DAQ for the J-PARC E16 experiment

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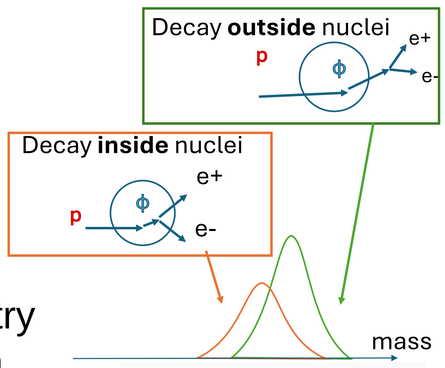
Summary

- ✓ J-PARC E16 experiment is investigating hadron mass origin by the vector meson mass spectra.
- ✓ DAQ update was performed as a countermeasure to the DAQ rate deterioration due to the beam structure.
  - ✓ DAQ bottleneck was removed by DDR3 RAM data buffering.
- ✓ DAQ rate was improved to ~82%@2.5 kHz request from ~15%@1 kHz request. DAQ requirement is satisfied!

Physics Motivation

Spontaneous chiral symmetry breaking is considered to be an origin of hadron mass.
the most part of the mass is made by interaction with condensed quark pair.
Under finite density conditions, the symmetry is expected to be restored, and the hadron mass is reduced.
the mass modification is partially shown in the previous experiment, KEK-PS E325.
However, the modification is observed in limited data, such as low momentum mesons and large nuclei. More statistics is needed to confirm the physics.
→ **J-PARC E16 experiment** is undergoing



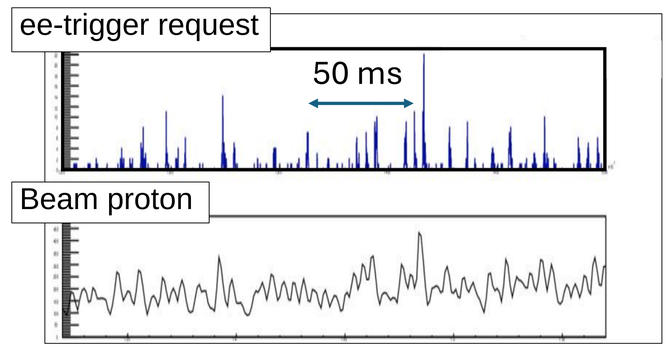
R. Muto *et al.*, PRL98 (2007) 042501

A modified ϕ mass spectrum measured in the KEK-PS E325.

Problem for physics data taking in 2021: DAQ efficiency deterioration

The proton beam in the high-p beamline used in this experiment has a time-dependent structure.
The DAQ rate deteriorated due to this structure, typically reaching ~15% at 1 kHz trigger request, compared to the design value of 76% at 1 kHz trigger request.

2021 commissioning run



J-PARC E16 experiment

Objective

Systematic study of the hadron mass modification

Approaches

Dilepton measurements to reconstruct the meson mass

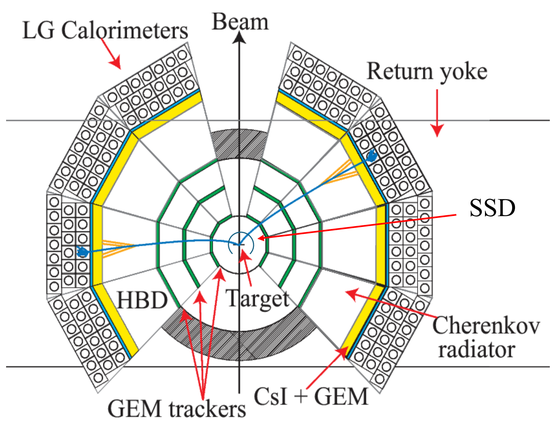
p+A→ρ/ω/φ + X, ρ/ω/φ →e+e-

30 GeV primary proton beam
- 10^{10} proton/spill(2 sec)
- ~10^{7} interaction/spill(2 sec)

Large acceptance
- Horizontal : ±15° ~ ±135°
- Vertical : ±45°

1/3 of the total has been installed

various targets
- C, Cu, Pb, etc.



Cross section of the spectrometer

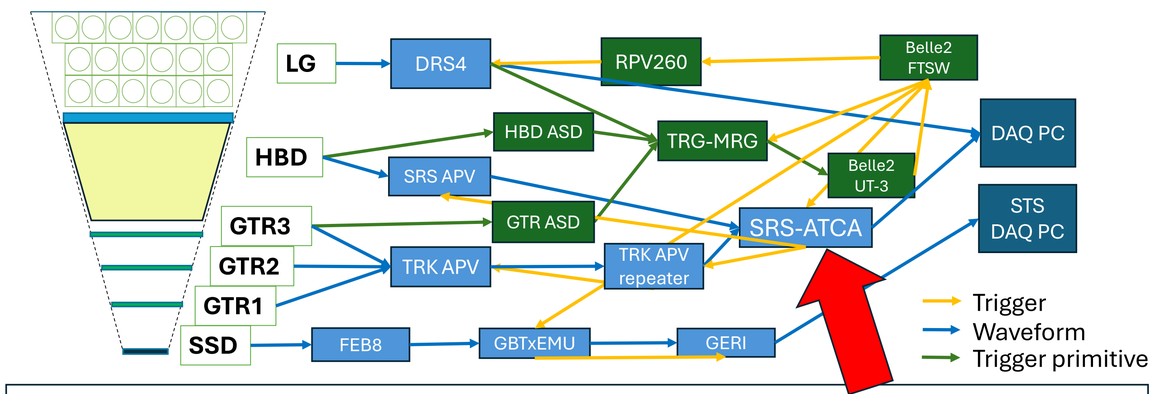
Total number of channels in full acceptance

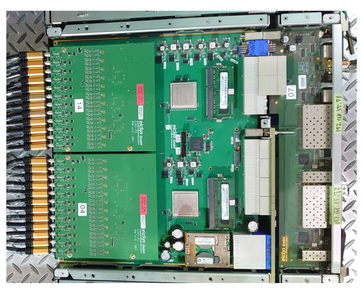
Waveform : 148,740 ch
- GTR : 58,032 ch
- HBD : 36,400 ch
- LG : 1,060 ch
- SSD : 53,248 ch

Trigger : 2,620 ch
- GTR : 624 ch
- HBD : 936 ch
- LG : 1,060 ch

E16 DAQ

- Waveform sampling
- Data size: 0.9 MB/event
- Trigger rate: a few kHz



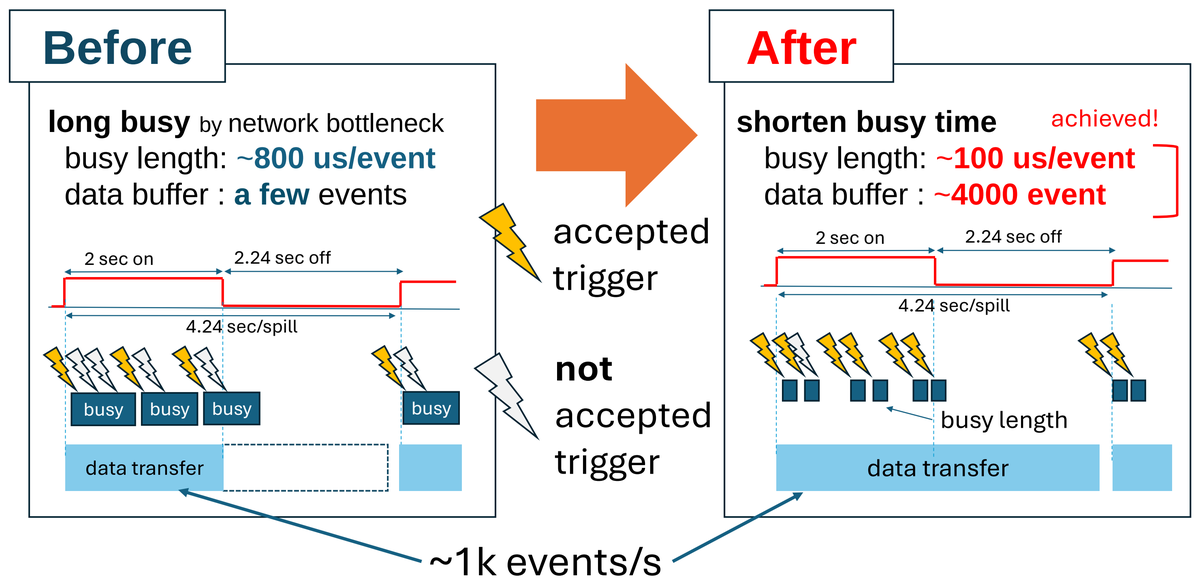


GEM waveform Digitizer: SRS-ATCA

- Waveform data processing by ADC and FPGA
- 2GB DDR3 RAM slots are implemented
- Data transfer rate: 1Gbps x 2/module

DAQ upgrade: data buffering

The E16DAQ bottleneck was SRS-ATCA.
J-PARC hadron beamline has 4.2 sec spill cycle, and 2.0 sec spill-on.
This spill-off time can be utilized, and bottleneck can be removed with RAM data buffering.



Commissioning run in 2024

In 2024, commissioning data was taken **with the new DAQ system.**
It was performed 237 hours in total.

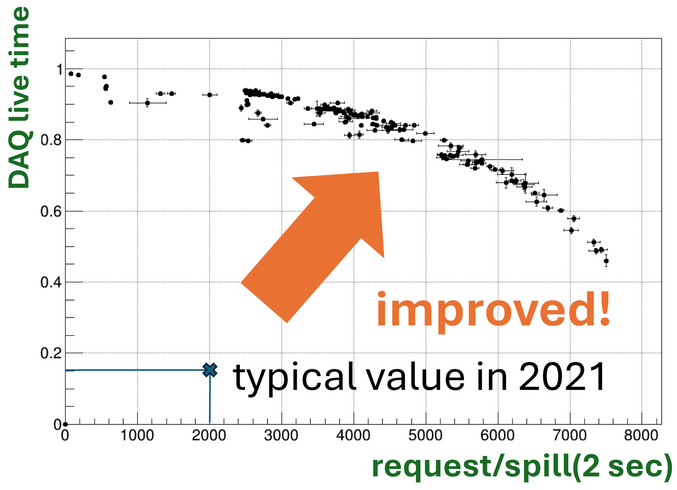
Objective

- DAQ test
- trigger parameter tuning

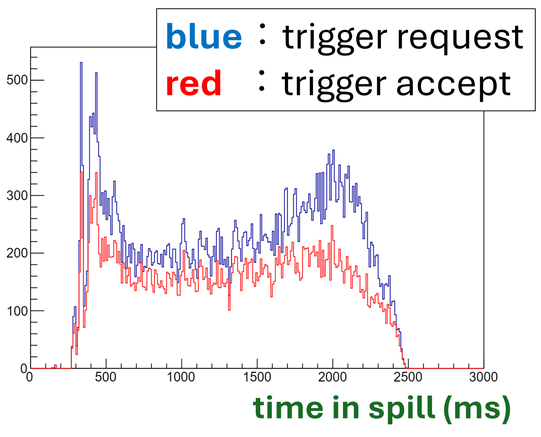
Results

previous value:
15%@1 kHz trigger request

updated value:
82%@2.5 kHz trigger request



DAQ efficiency (=trigger accept/request) plot of physics data taking runs



Trigger accept and trigger request in a typical run in 2024