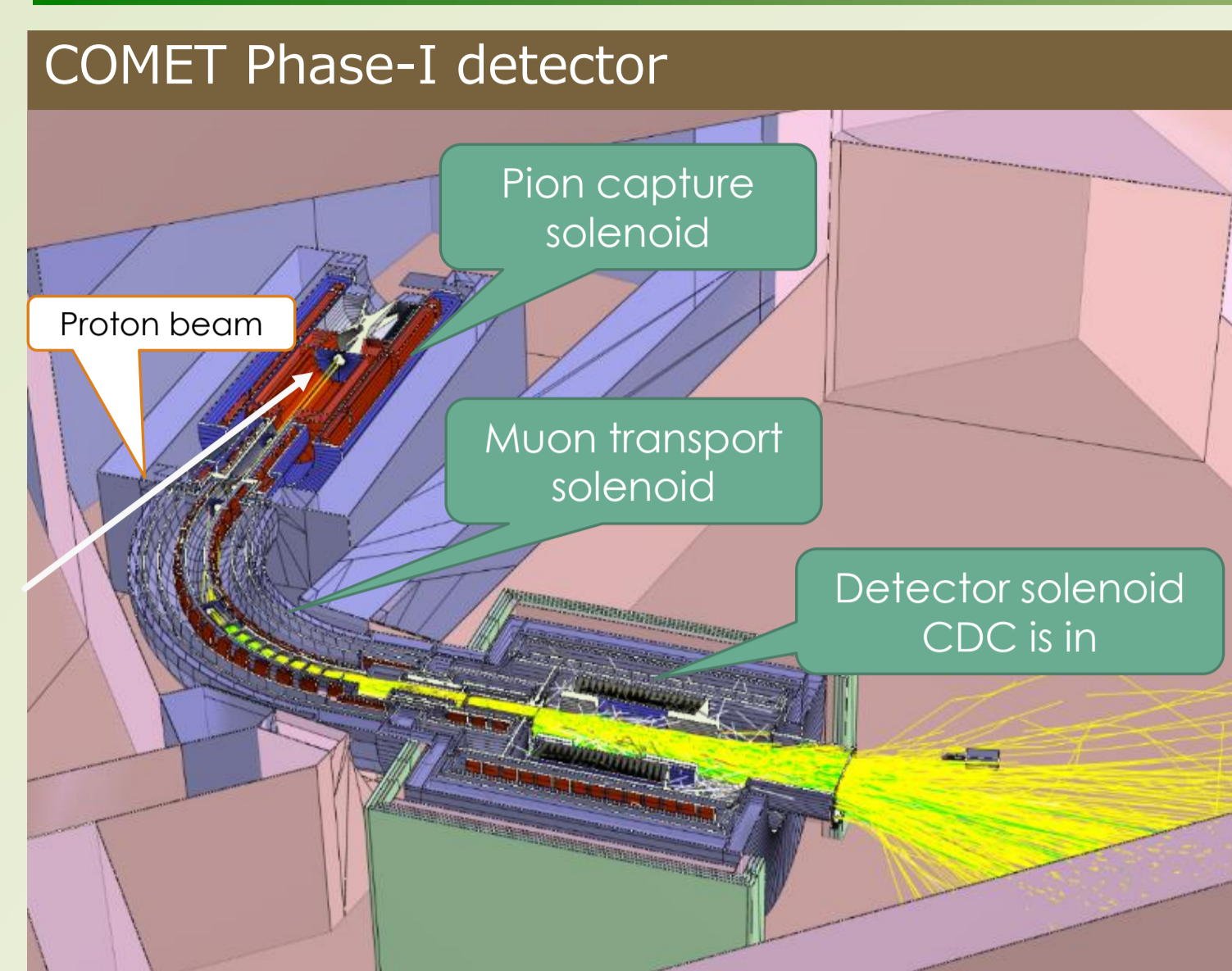


# A local event builder for the COMET CDC with ZeroMQ

IGARASHI Youichi, KEK, Japan

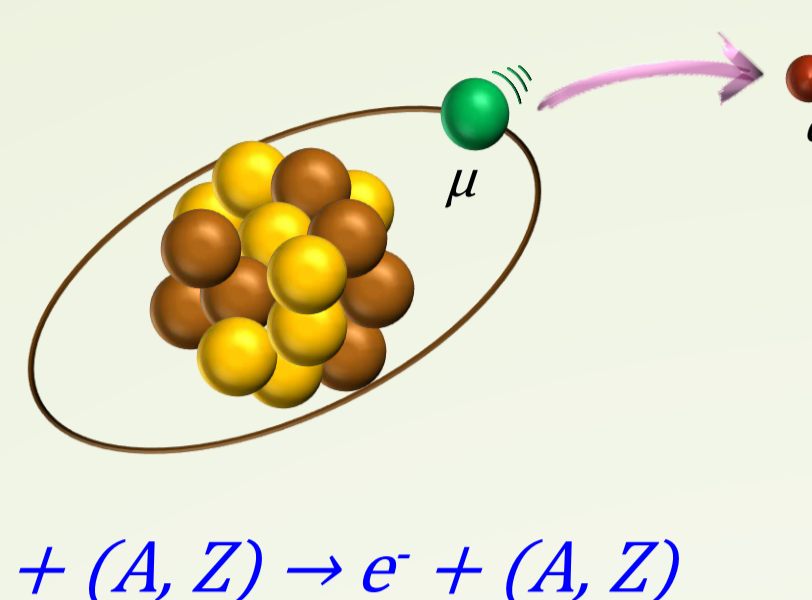


## J-PARC COMET Phase-I : A new muon-to-electron conversion search

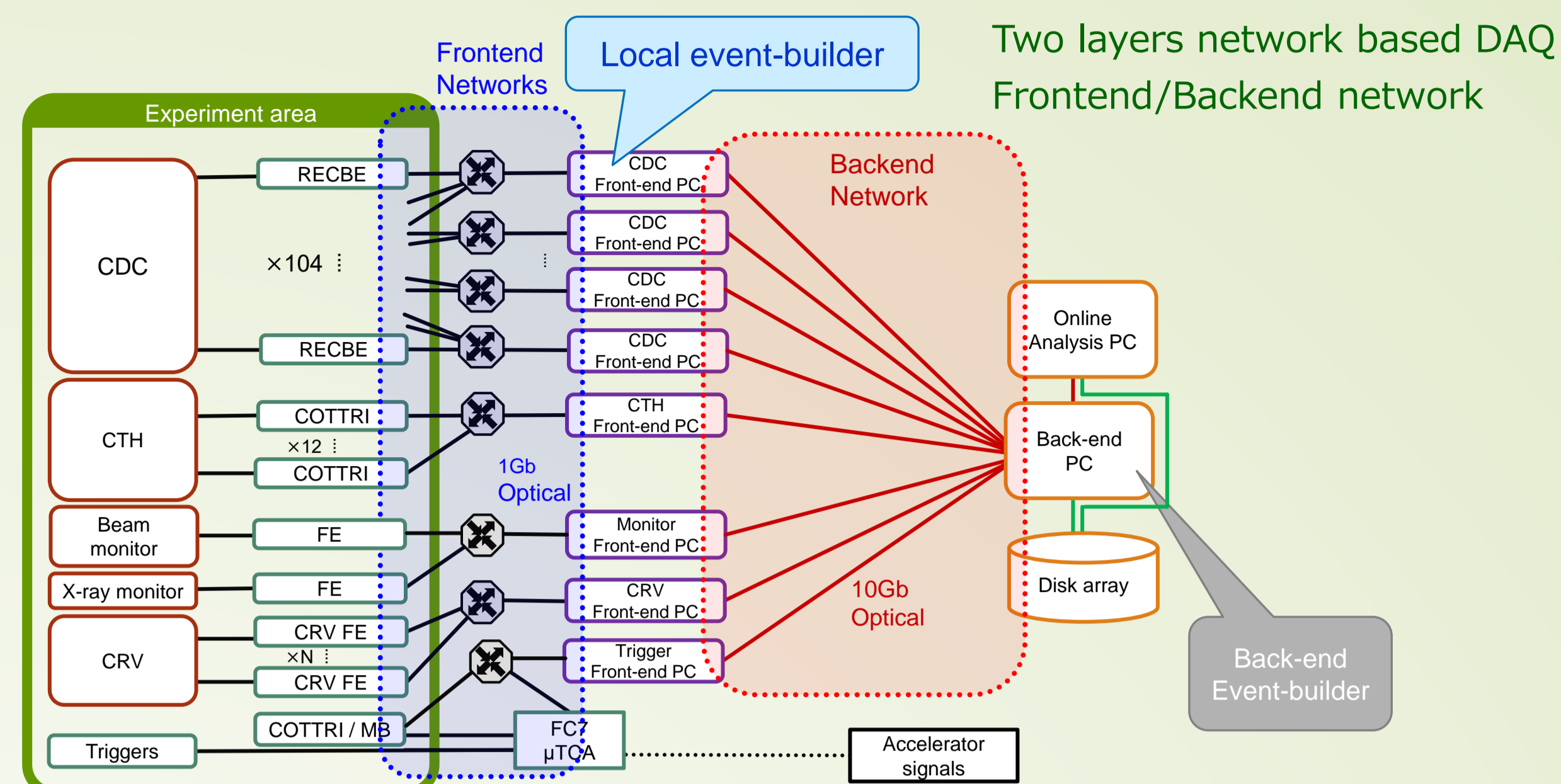


An experiment to discover the charged lepton flavor violation in  $\mu N \rightarrow eN$  will start at J-PARC Hadron facility.

The experiment aims to search with the sensitivity of  $O(10^{-15})$ .



## The data taking network for COMET Phase-I

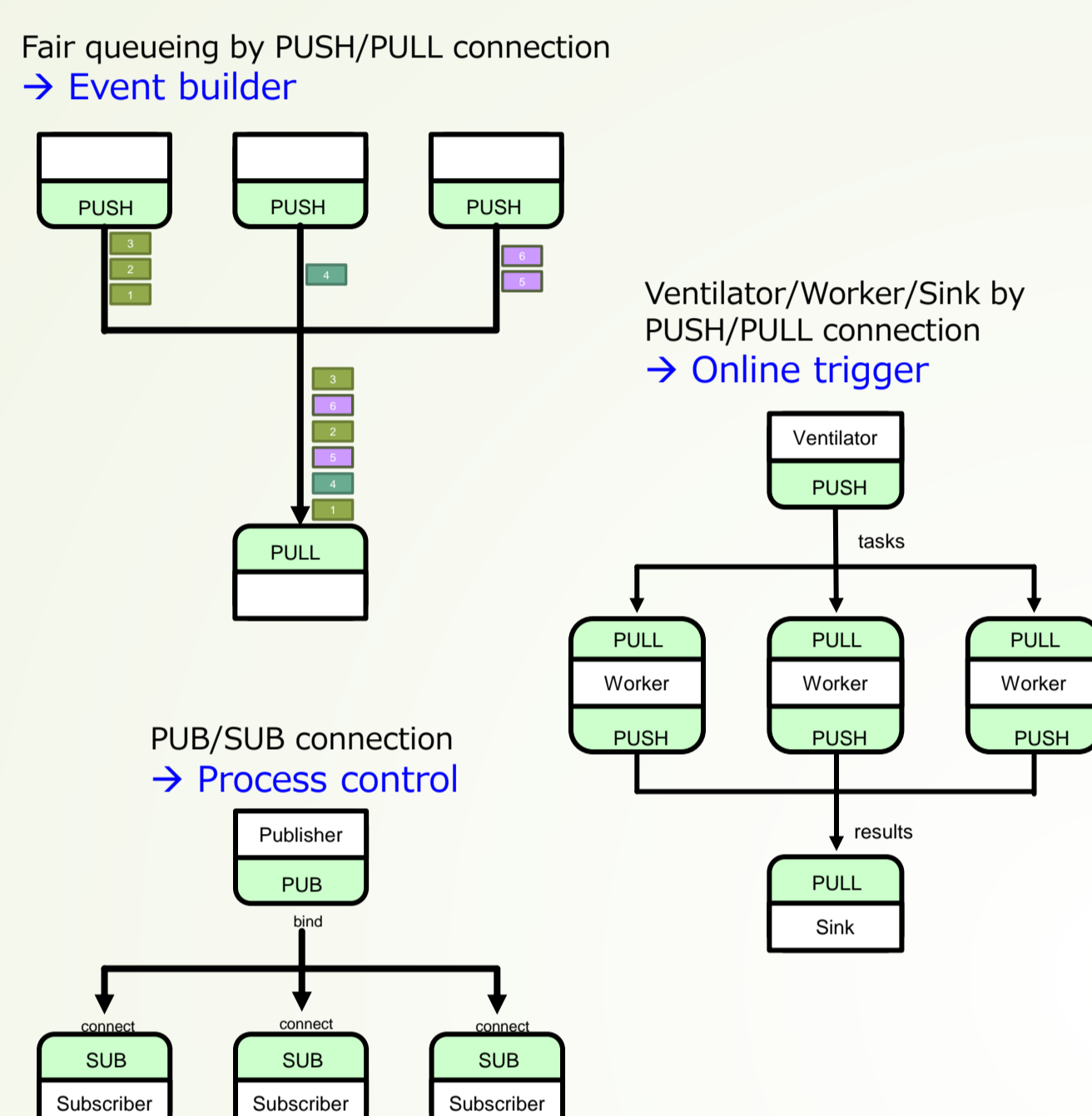


## Why do we use ZeroMQ for DAQ software?

ZeroMQ[2] provides desirable functions for a network-based DAQ.

ZeroMQ is an asynchronous message layer

- Non-blocking interface
  - It blocks when the queue is full.
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- Simple data frame with only length and payload
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  - The message queue works as a data buffer.
- Good portability, It works on many popular operating systems.
- It has useful and reliable communication models.
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## Local Event Builder (LEB)

### Motivation

- The detector system has over 100 front-end devices, It is effective to bind the readout in the intermediate.
- DAQ doesn't expect that COMET FEs work with the continuous normal operation, because of the radiation effects.
  - We employed "On detector readout electronics" concept. It has many merits such as S/N ratio, however radiation brings the malfunctions to the readout electronics.

### The requirements of the LEB

- The LEB should handle incomplete event-building.
- Some FE occasionally doesn't send any data cause of troubles.

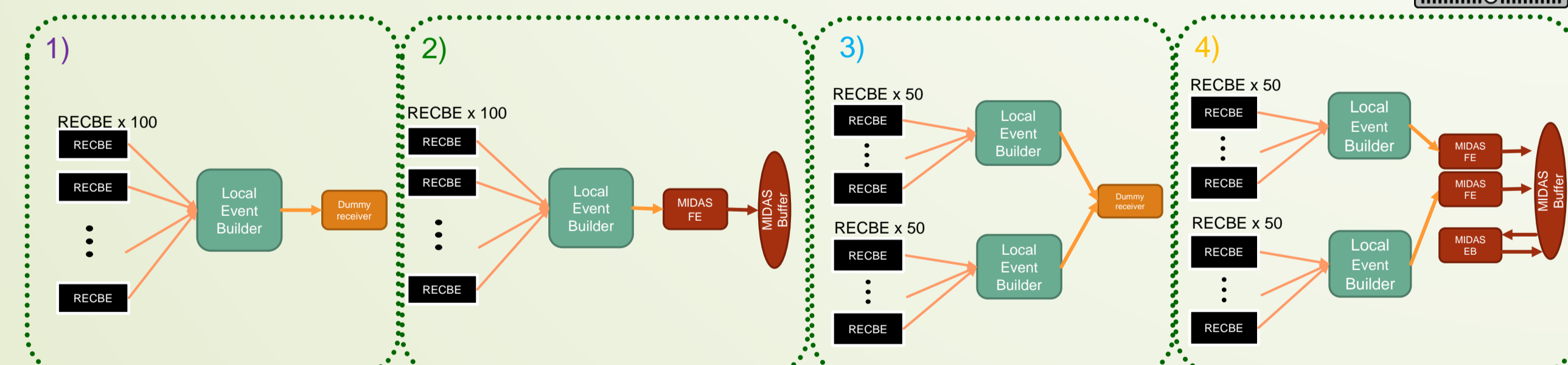
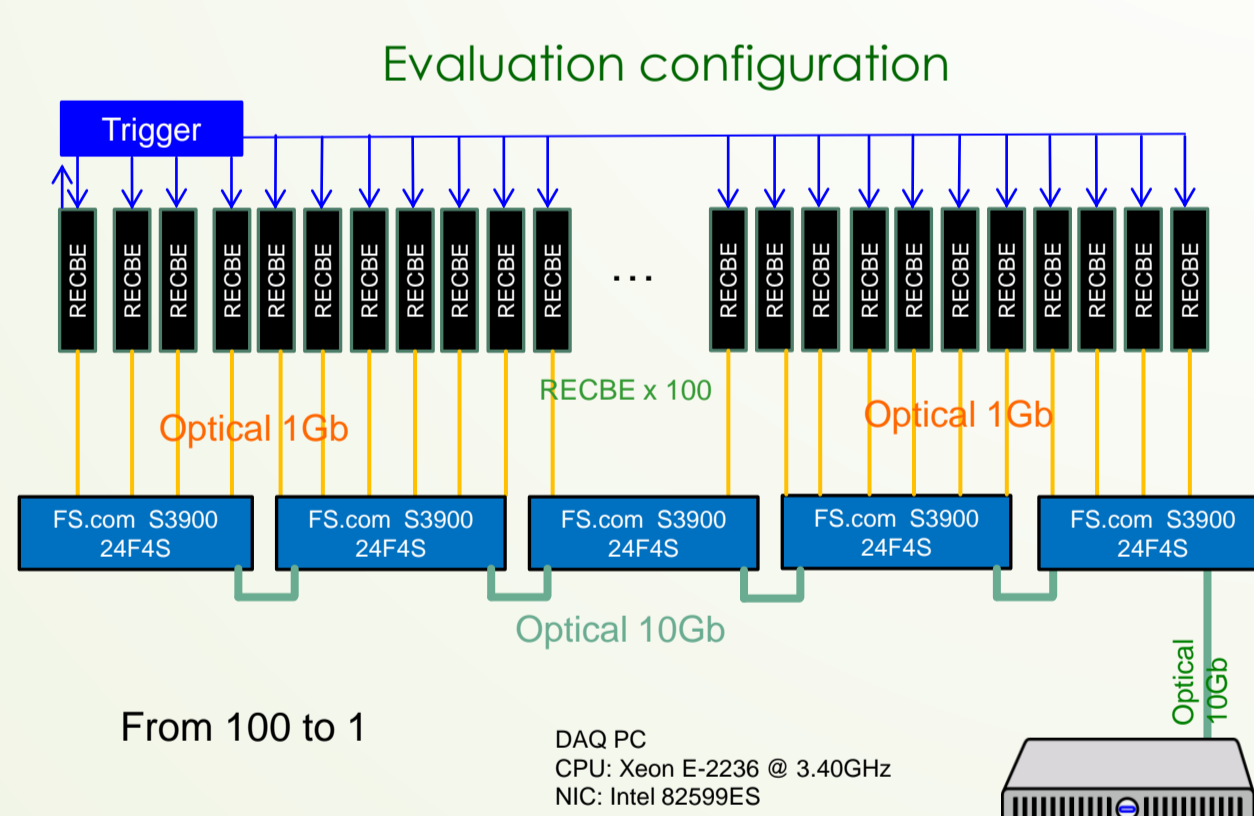
### Behavior of the LEB

- The LEB builds the event using the trigger number enclosed in the event fragment as a key.
- When the LEB succeeds to build a complete event, the LEB sends stacked incomplete events.
- The LEB sends the incomplete event fragments when their buffers are full.

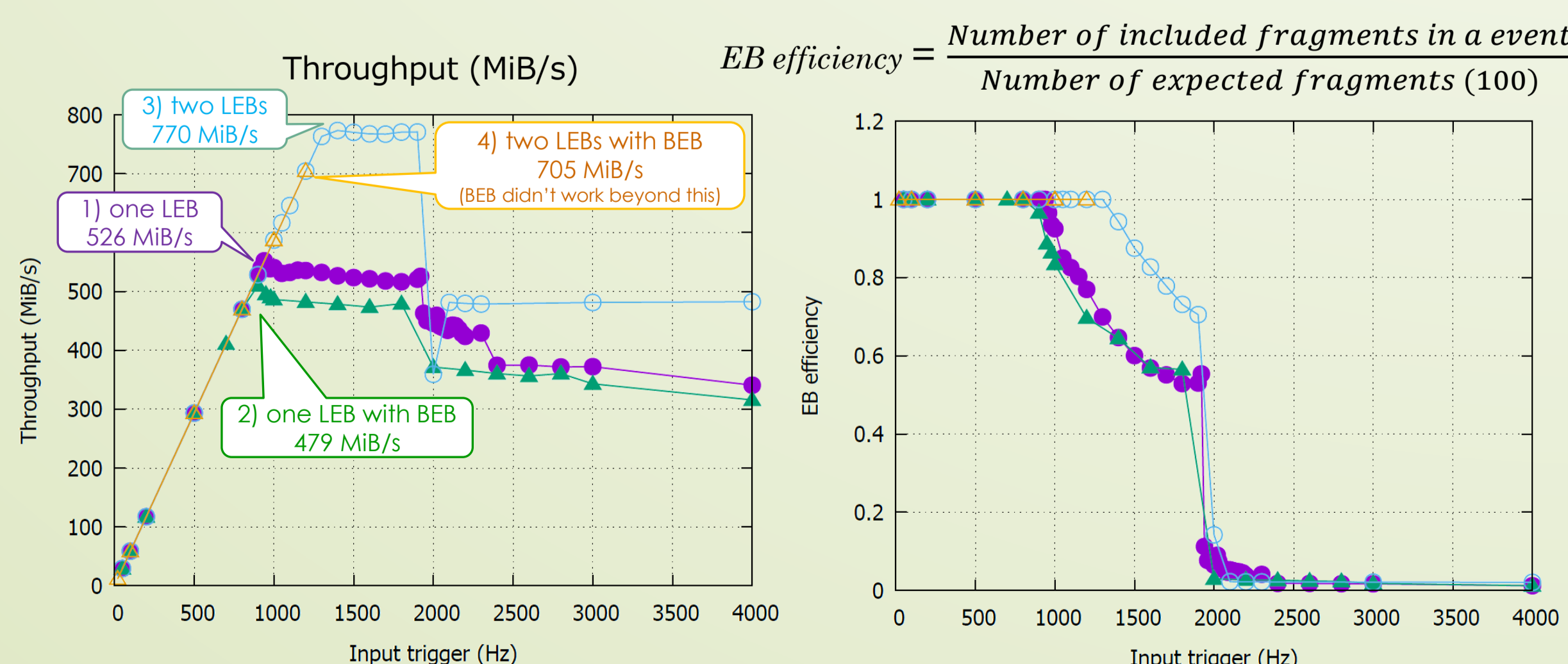
## Evaluation of the local event builder

We tested the LEB using the cosmic ray setup of the actual CDC readout electronics.

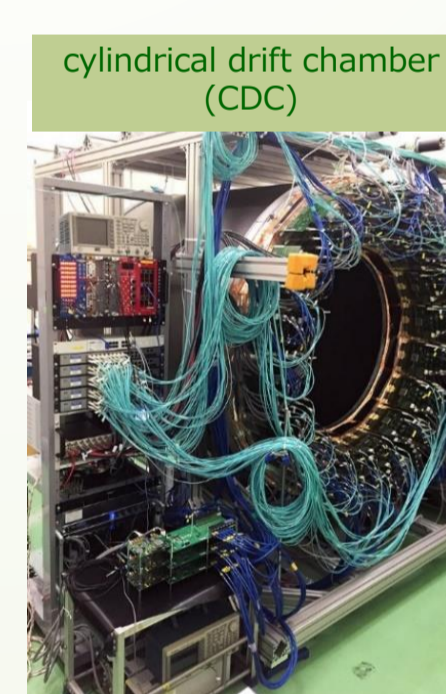
- One DAQ PC
  - Intel(R) Xeon(R) E-2236 CPU @ 3.40GHz
  - Five FS.com 1G-10G network switches
- Event fragment size: RECBE RAW mode (6144 B data)
- No trigger veto, No data recording
- MIDAS[4]-based DAQ software was used as a back-end DAQ.



## LEB performance

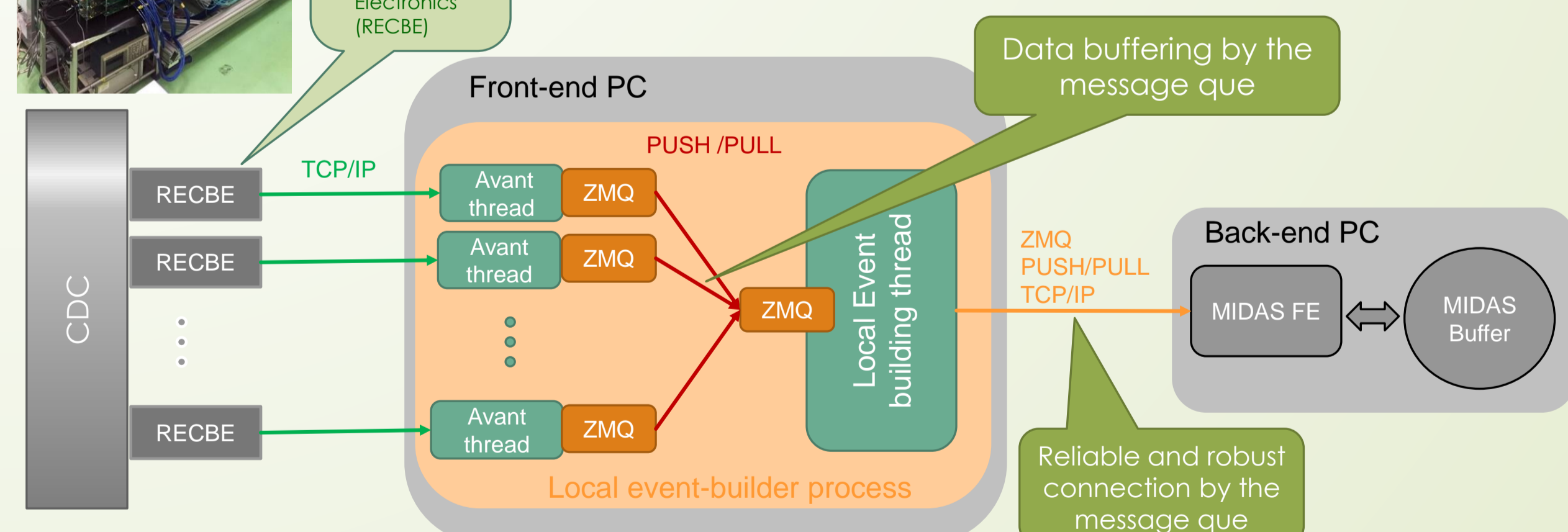


## Structure of the local event-builder with ZeroMQ



We try to develop a local event builder with ZeroMQ to read the COMET CDC[3].

- Avant thread: read data from the front-end cards
- Rear thread: build the event from the ZeroMQ buffer.



## Summary

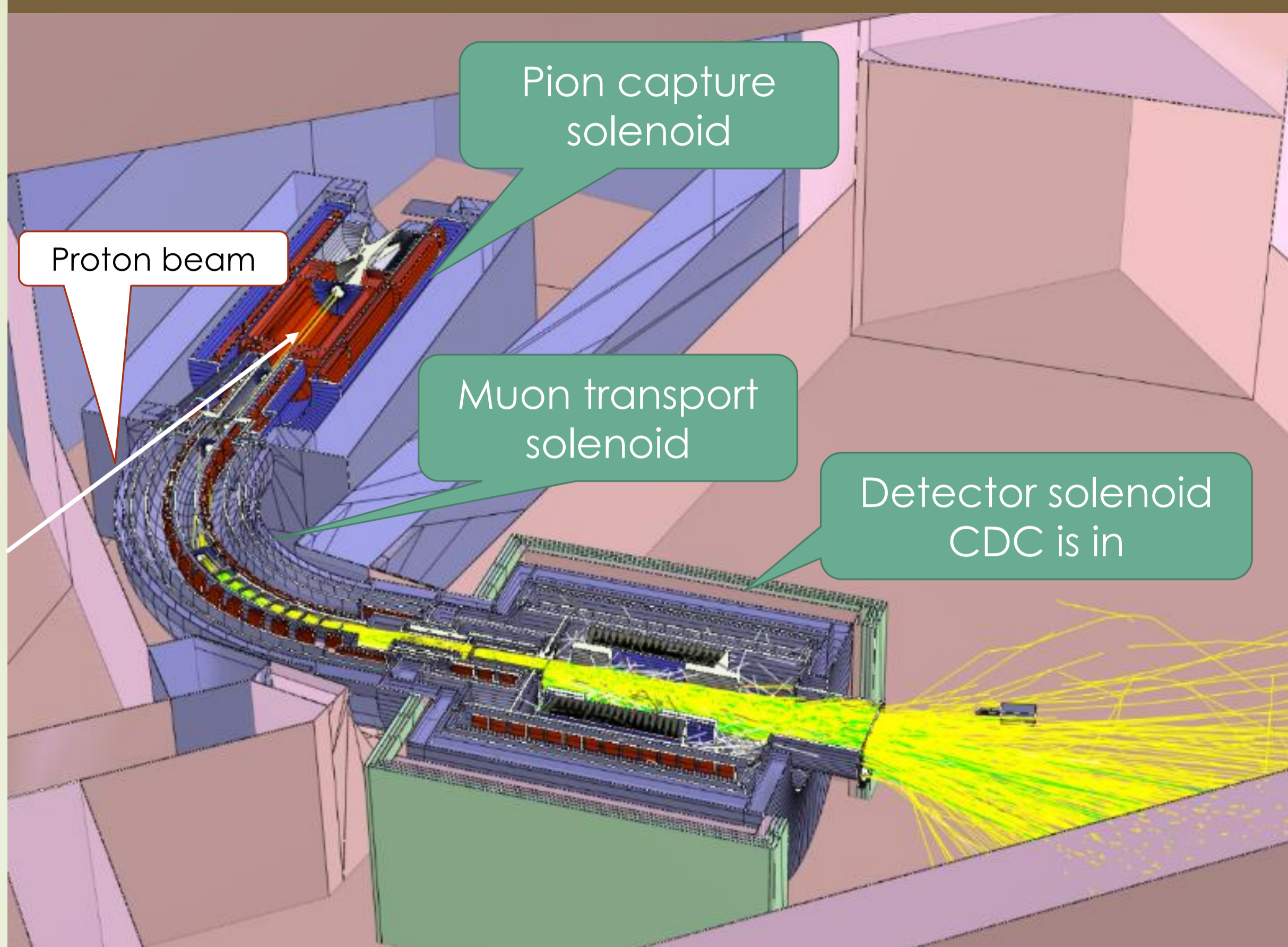
- ZeroMQ provides useful and robust functions beyond the communication link, and they fit a network-based DAQ well.
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- The throughput of the front-end PC is over 700 MiB/s using 10G ethernet with two LEBs, on the Xeon(R) E-2236 3.40GHz server PC.

### Reference

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- COMET collaboration, "Experimental Proposal for Phase-I of the COMET Experiment at J-PARC," 2012, [Online]. Available: [http://j-parc.jp/researcher/Hadron/en/pac.1207/pdf/E21\\_2012-10.pdf](http://j-parc.jp/researcher/Hadron/en/pac.1207/pdf/E21_2012-10.pdf)
- COMET collaboration, "COMET Phase-I Technical Design Report," Prog. Theor. Exp. Phys. 2020, 033C01, DOI: 10.1093/ptep/ptz125
- "MIDAS," [Online]. Available: [https://daq00.triumf.ca/MidasWiki/index.php/Main\\_Page](https://daq00.triumf.ca/MidasWiki/index.php/Main_Page)

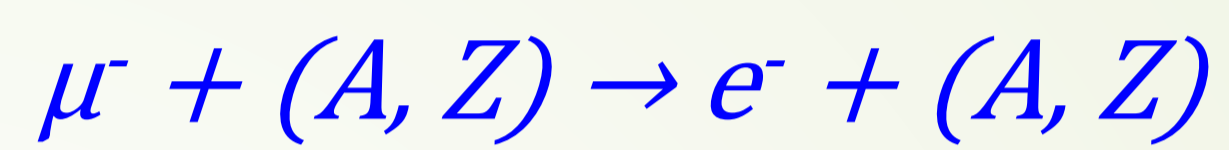
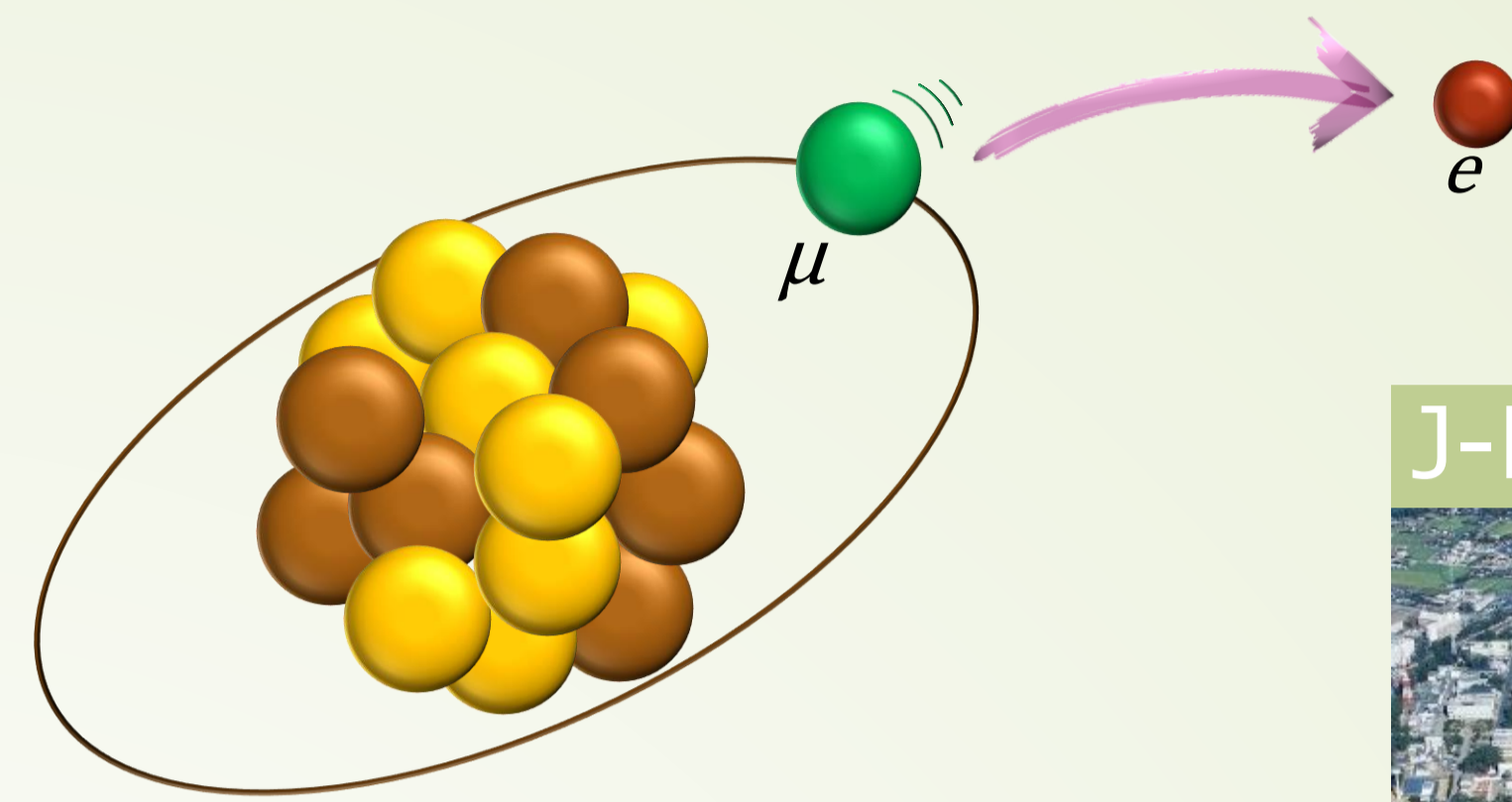
# J-PARC COMET Phase-I : A new muon-to-electron conversion search

COMET Phase-I detector

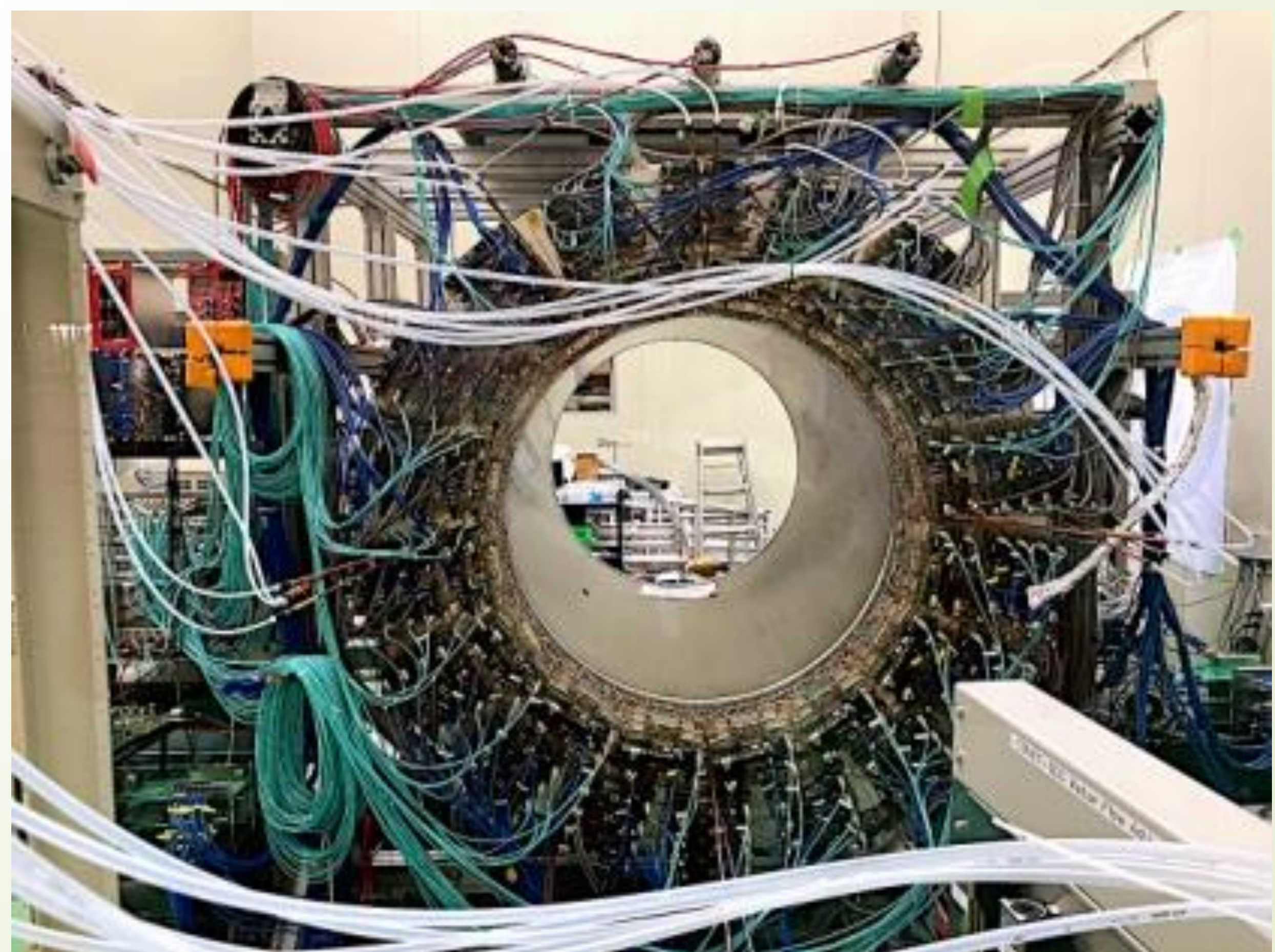
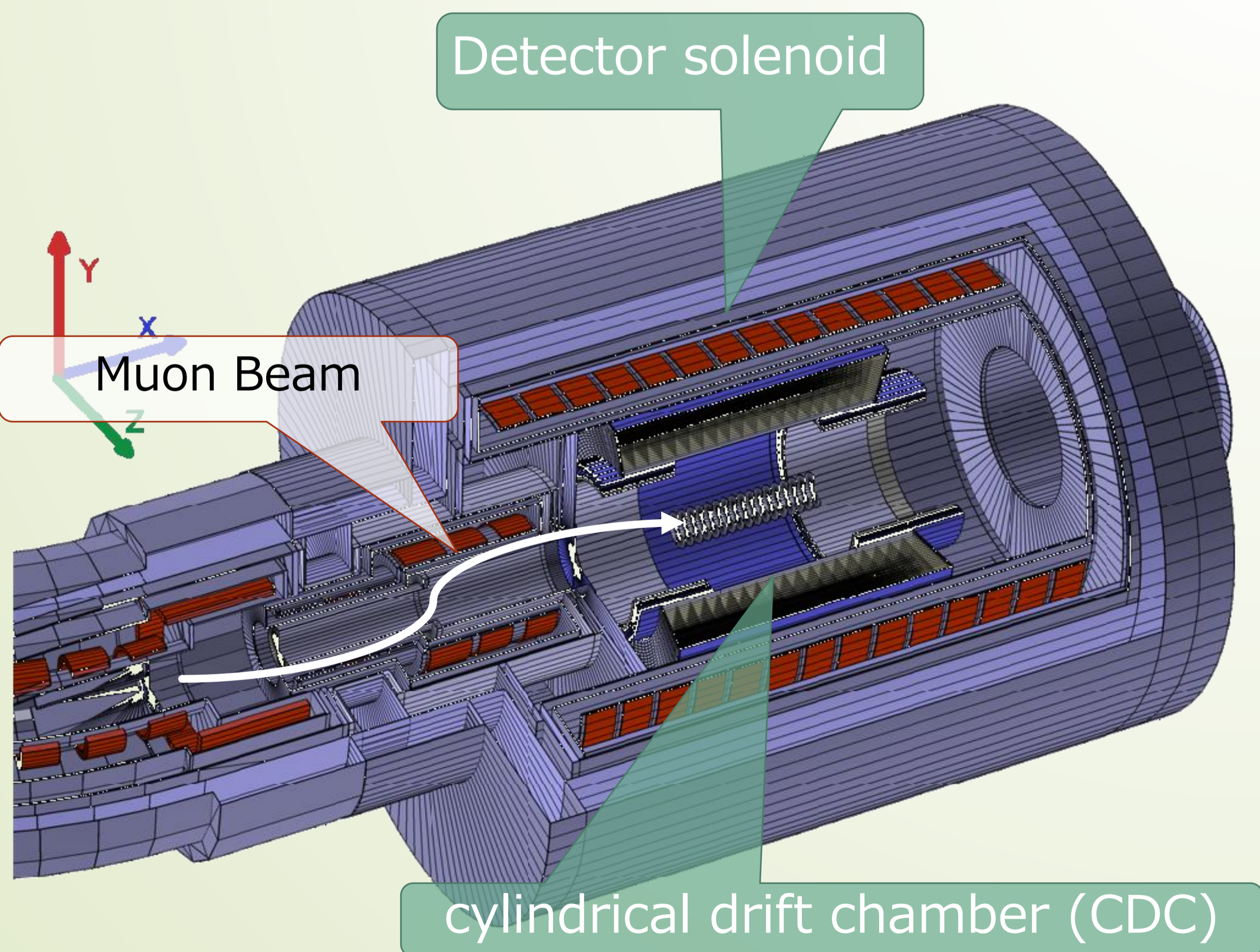


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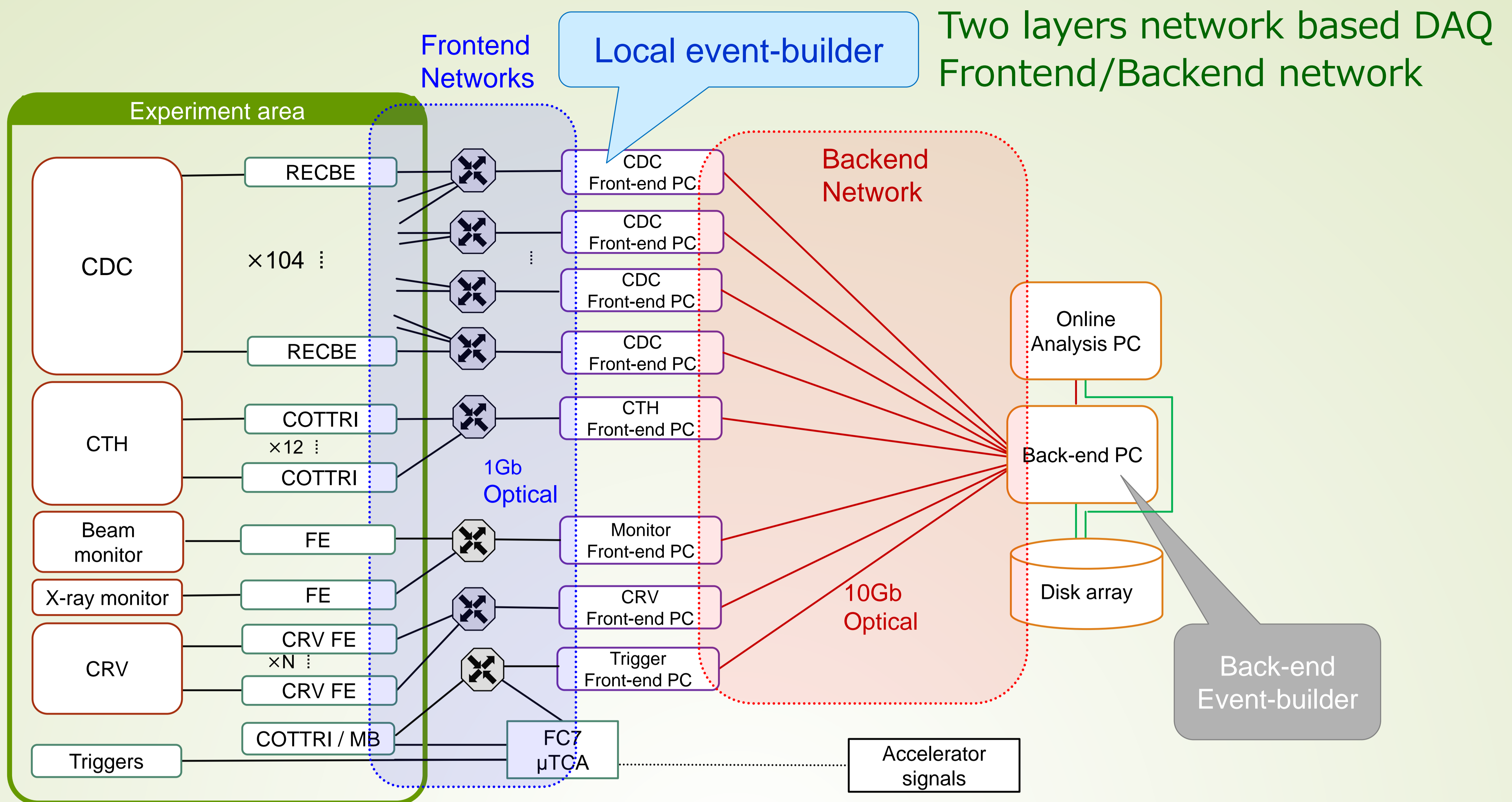
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J-PARC



# The data taking network for COMET Phase-I



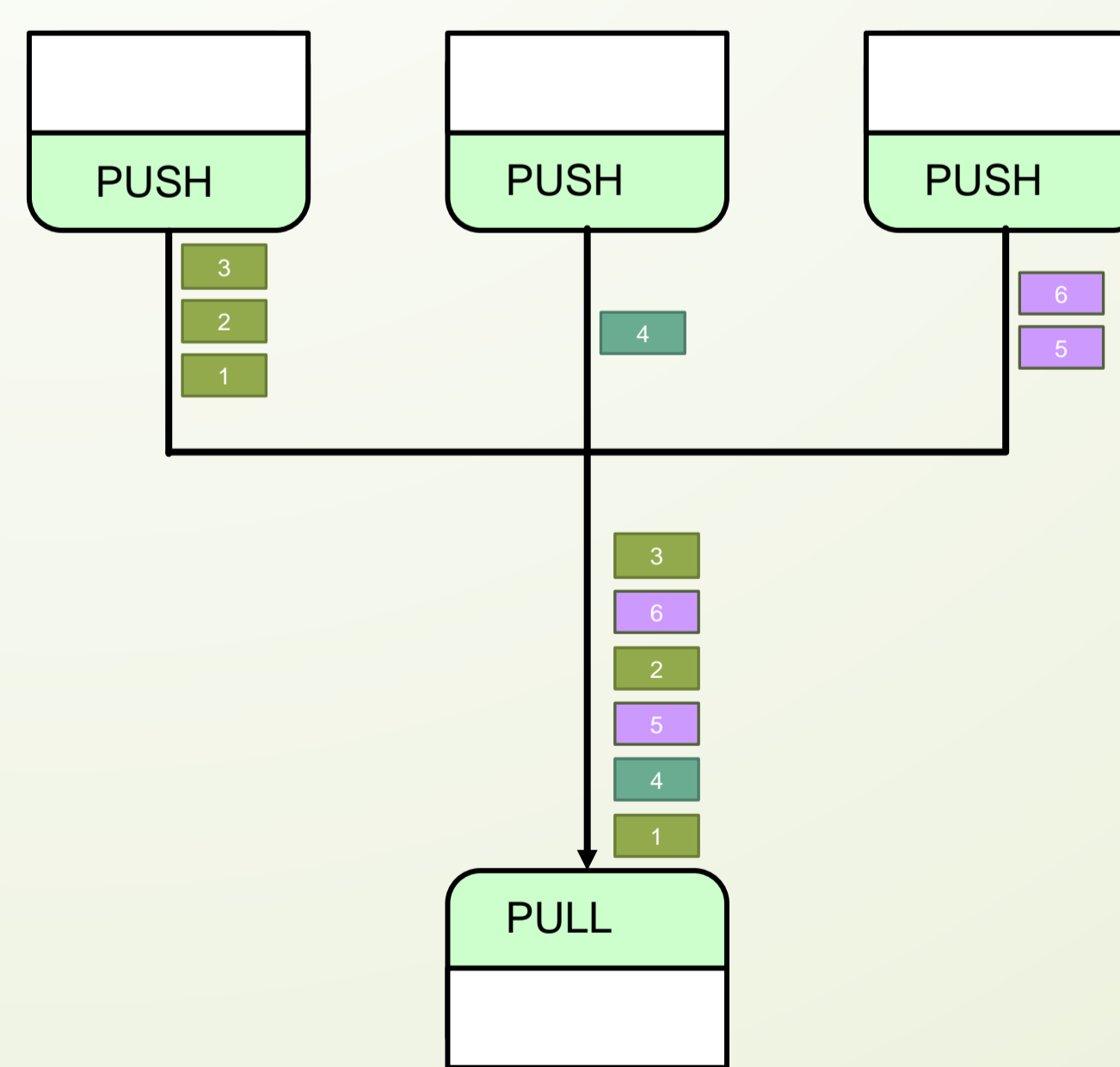
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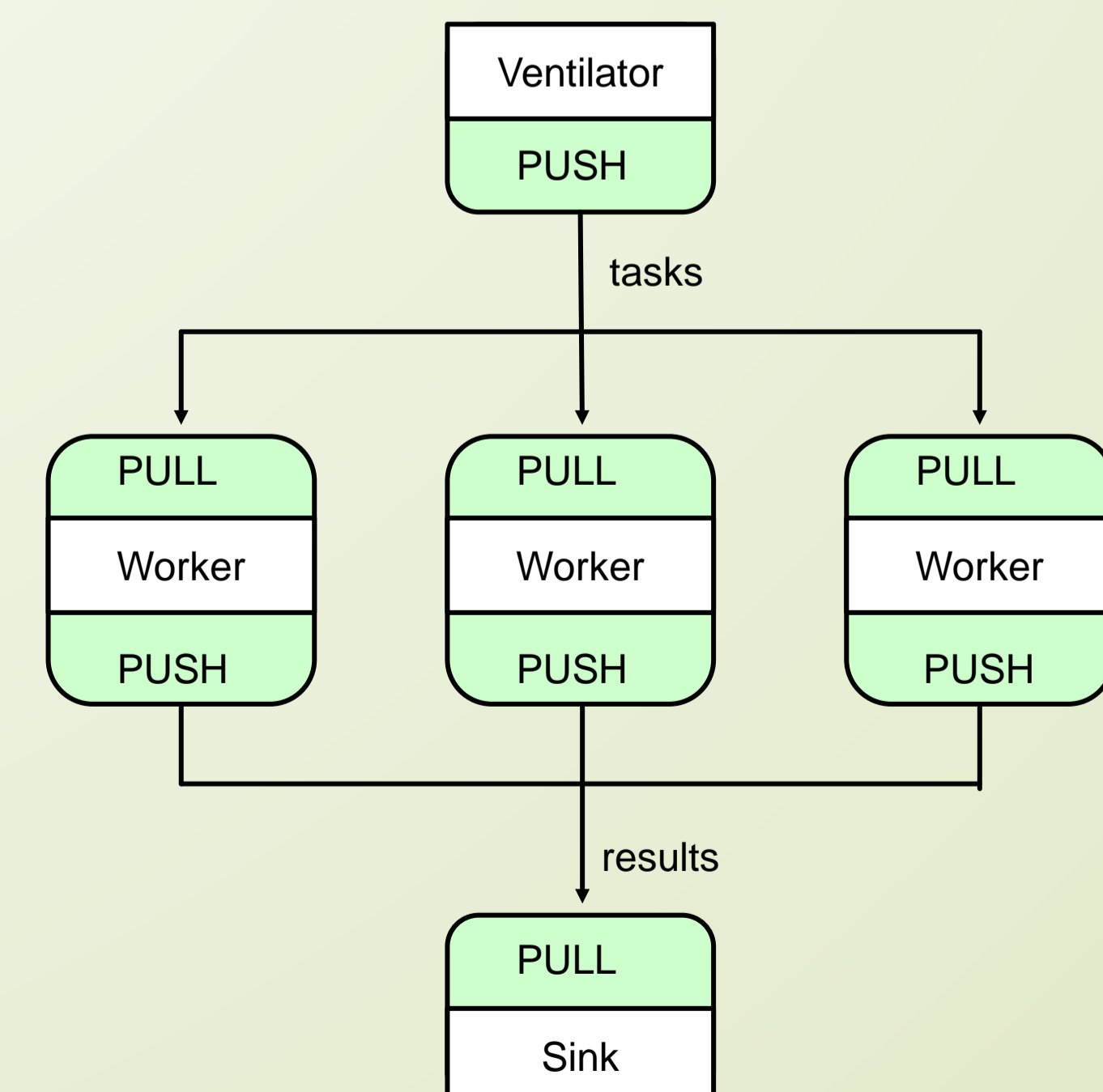
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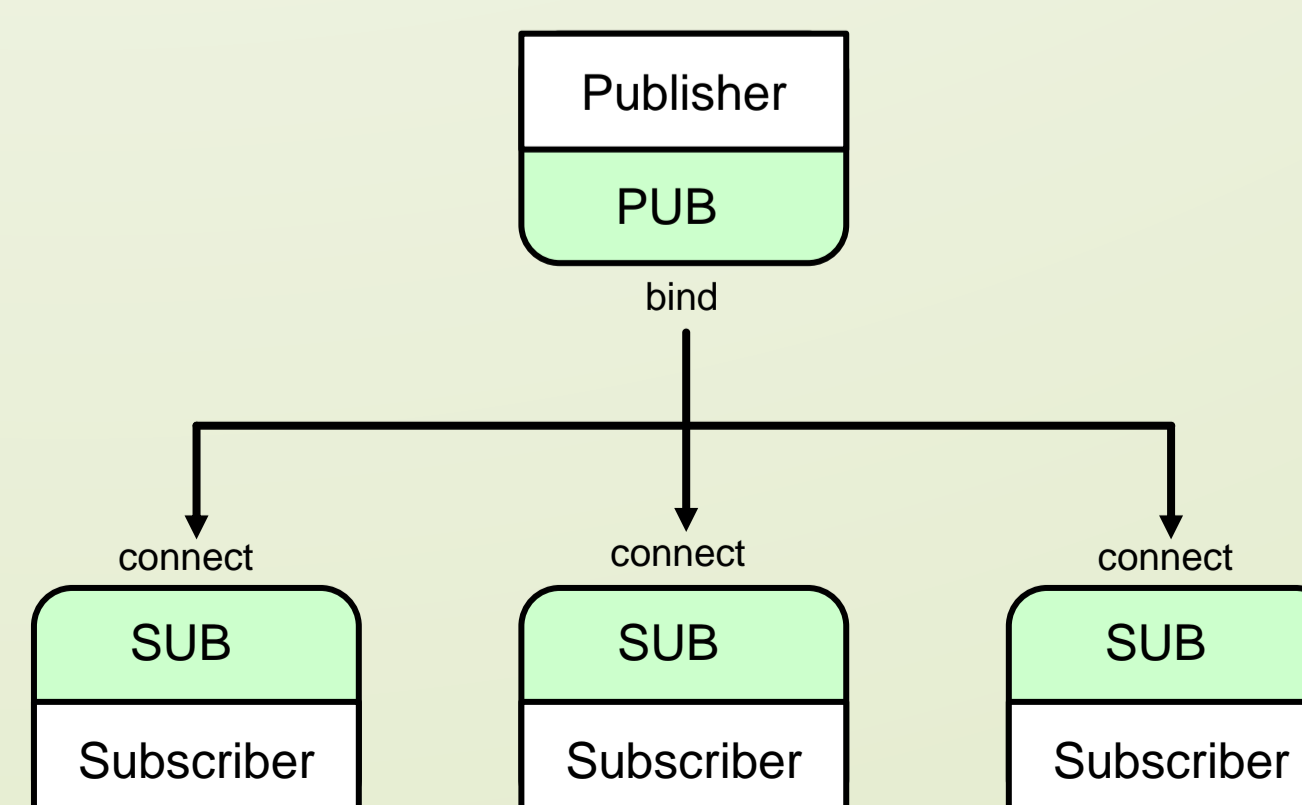
Fair queuing by PUSH/PULL connection  
→ **Event builder**



Ventilator/Worker/Sink by PUSH/PULL connection  
→ **Online trigger**



PUB/SUB connection  
→ **Process control**



# Local Event Builder (LEB)

## Motivation

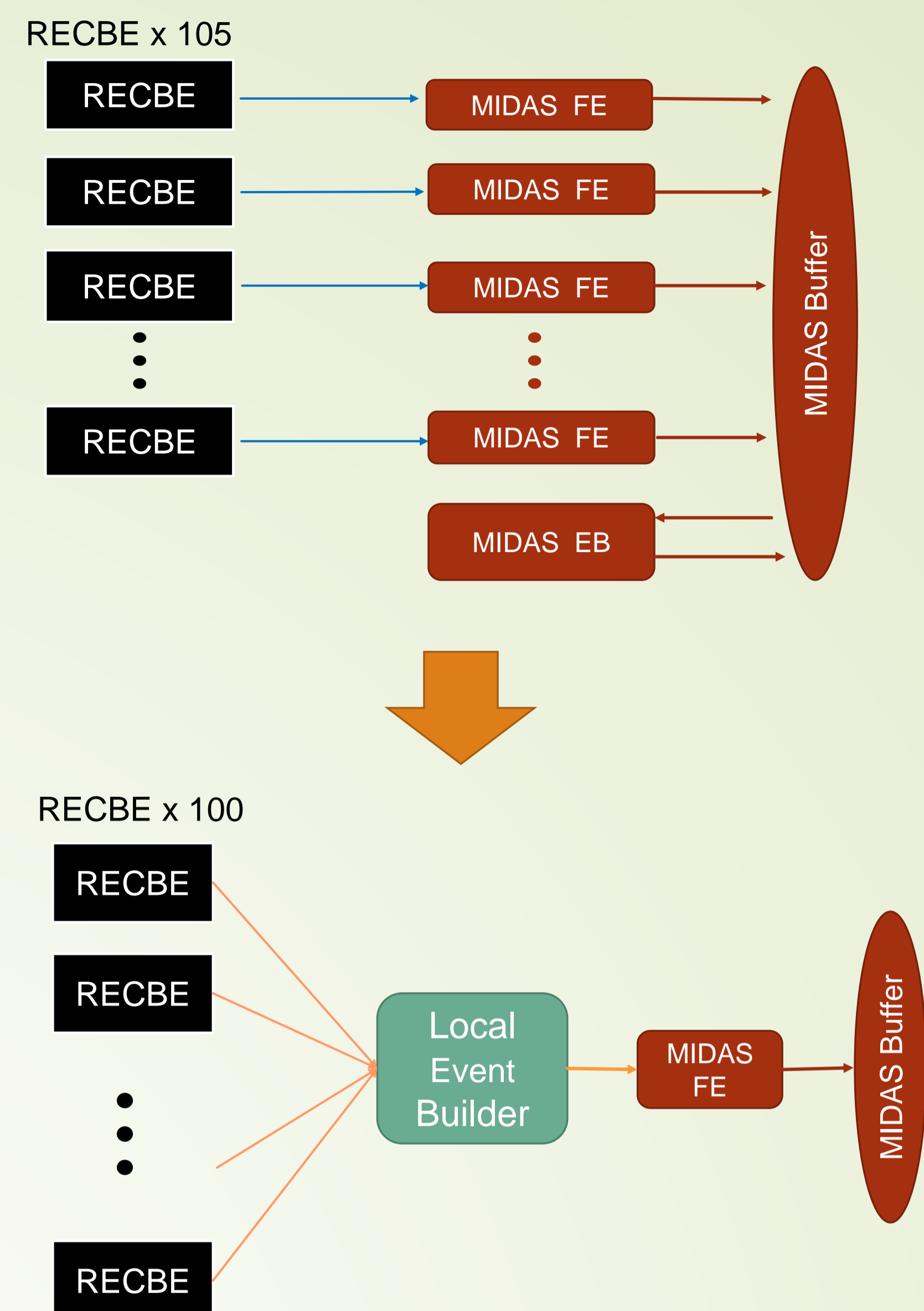
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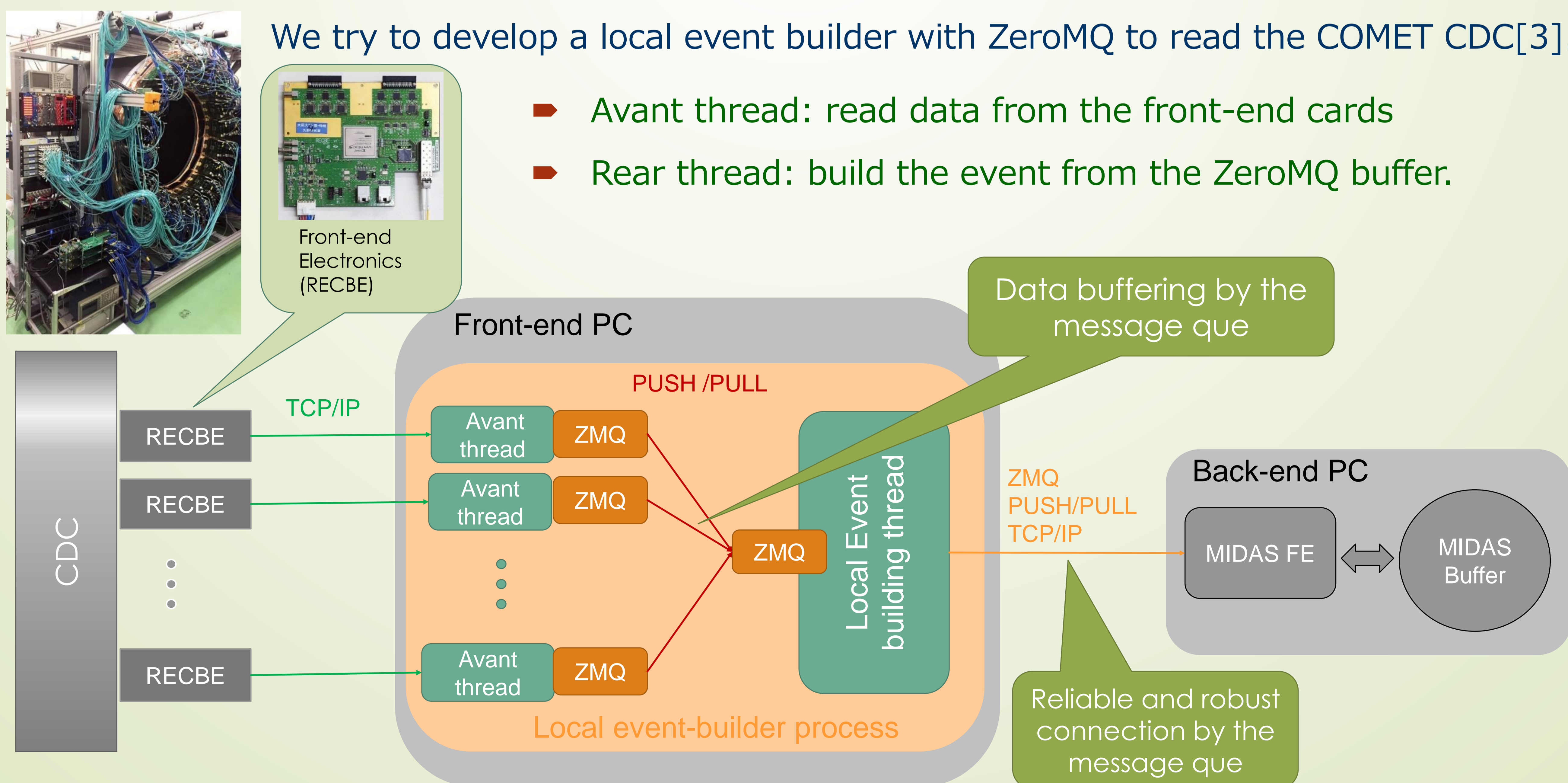
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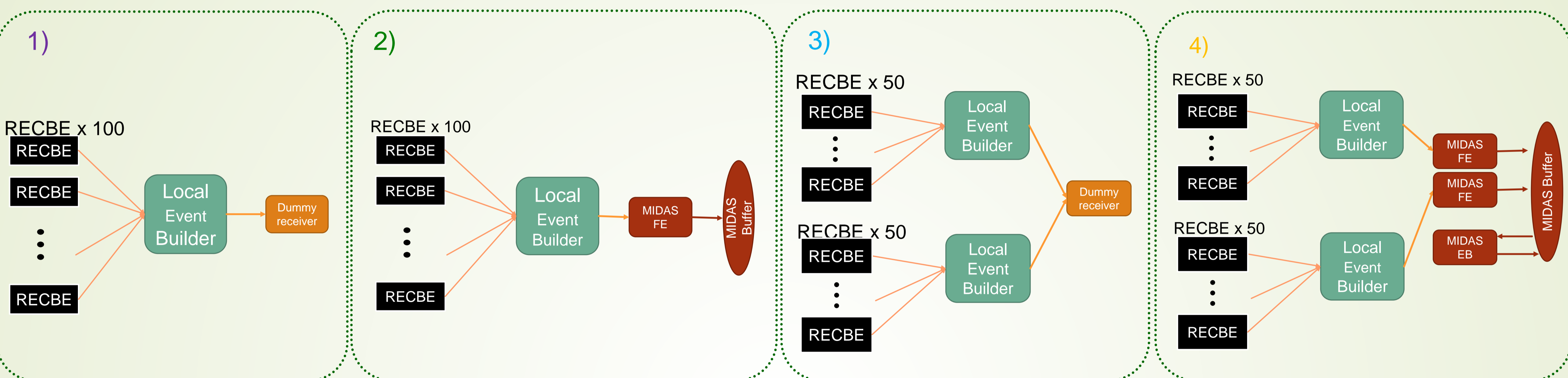
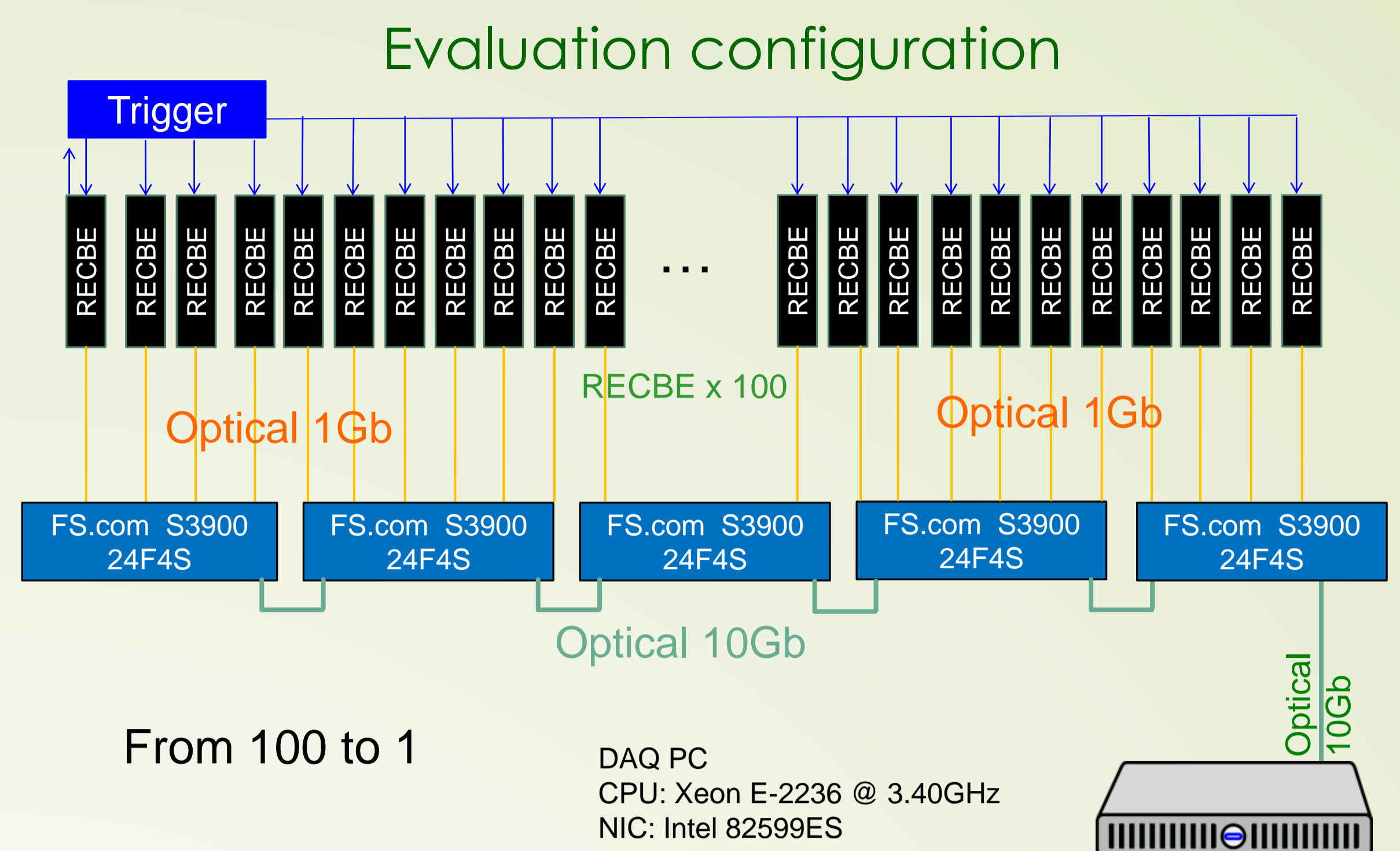


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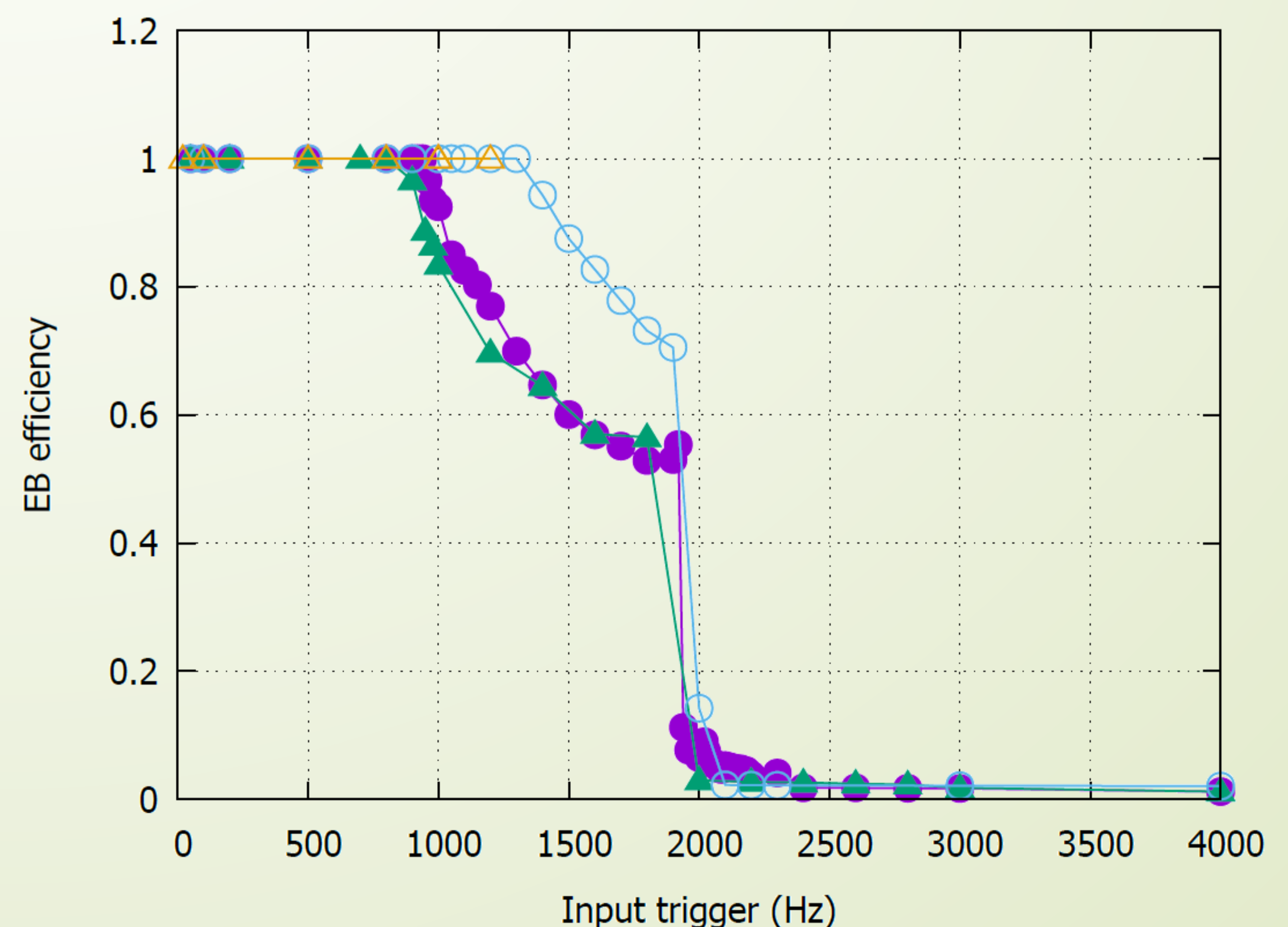
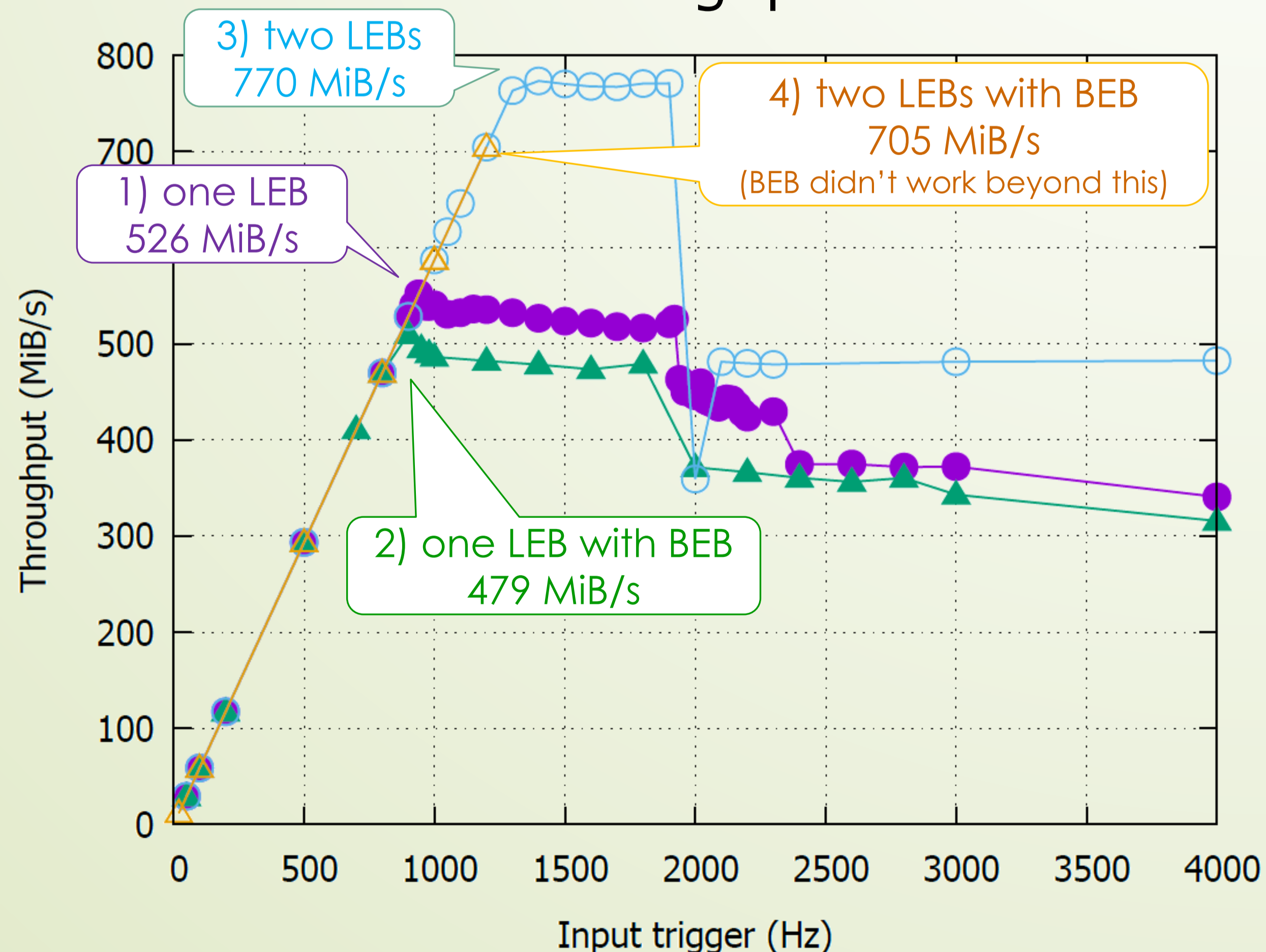
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## LEB performance

$$EB \text{ efficiency} = \frac{\text{Number of included fragments in a event}}{\text{Number of expected fragments (100)}}$$

### Throughput



The size of the event fragments is 6144 B

# Summary

- ZeroMQ provides useful and robust functions beyond the communication link, and they fit a network-based DAQ well.
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[3] COMET collaboration, “ COMET Phase-I Technical Design Report,” Prog. Theor. Exp. Phys. 2020, 033C01, DOI: 10.1093/ptep/ptz125

[4] “MIDAS,” [Online]. Available: [https://daq00.triumf.ca/MidasWiki/index.php/Main\\_Page](https://daq00.triumf.ca/MidasWiki/index.php/Main_Page)

