

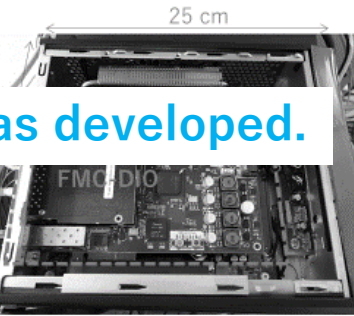
# Application of the White Rabbit System at SuperKEK

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 Y. Iitsuka, East Japan Institute of Technology (EJIT), Ibaraki, Japan

## Slave node we use at KEK

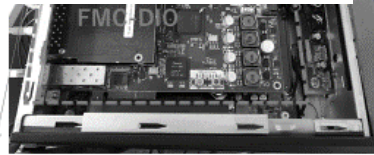
We develop the slave node with SPEC+FMC-DIO.  
 The firmware and software are from the starting kit v3.1.  
<https://ohwr.org/project/wr-starting-kit/wikis/home>

Packed with homebuilt PC  
 2.9GHz 6core CPU, 8GB of RAM, SSD 500GB  
 Ubuntu 18.04 LTS OS



## SuperKEKB-type slave node was developed.

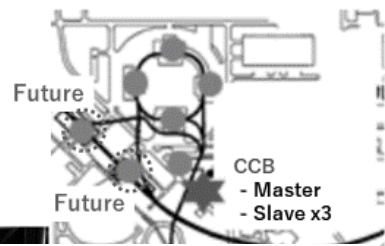
Everything is controlled via EPICS.



When input signal comes this way, ...

## Beam Gate delivery

Beam Gate is a kind of Beam Permission Signal.  
 It prohibits and inhibits the beam injection from LINAC.  
 The SuperKEKB operator dynamically switches the status of signal to control the operation beam current.



The beam permission signal is delivered from CCB to LINAC.

## Beam Permission Signal is transferred via the WR network.

In positron injection, we store the beam into the damping ring at least 40ms. Its larger than LINAC operation period, 20ms. The control signals to components in downstream from damping ring must be delivered 40ms later than that to electric gun. WR can manage such kind of delay.



## WR at SuperKEKB

WR grand-master is synchronized with GPS

- Slave node-1: reference signal from master abort module (LER/HER)
- Slave node-2: reference signal from master abort module (LER/HER)
- Slave node-3: reference signal from master abort module (LER/HER)
- Slave node-4: reference signal from master abort module (LER/HER)

Operation has been started since the 2021 autumn run.

LINAC boundary provides the PPS signal to Event Timing System for synchronization.  
 - Slave node-4:

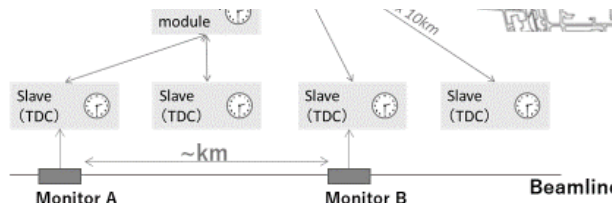


## Distributed TDC

Distributed TDC is a part of distributed DAQ.  
 It can compare the input timing among separated nodes with GPS timestamp.

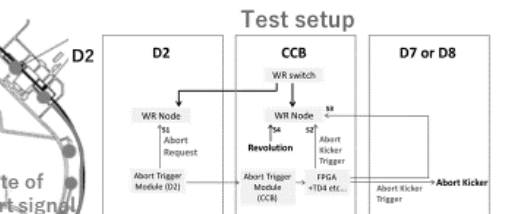


## Distributed TDC was configured.

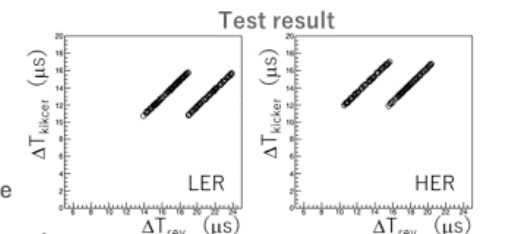


Distributed TDC is a strong tool to diagnose the source of the problem in the beam operation.

More modules will be installed next year to help machine operation.



Abort response time is measured



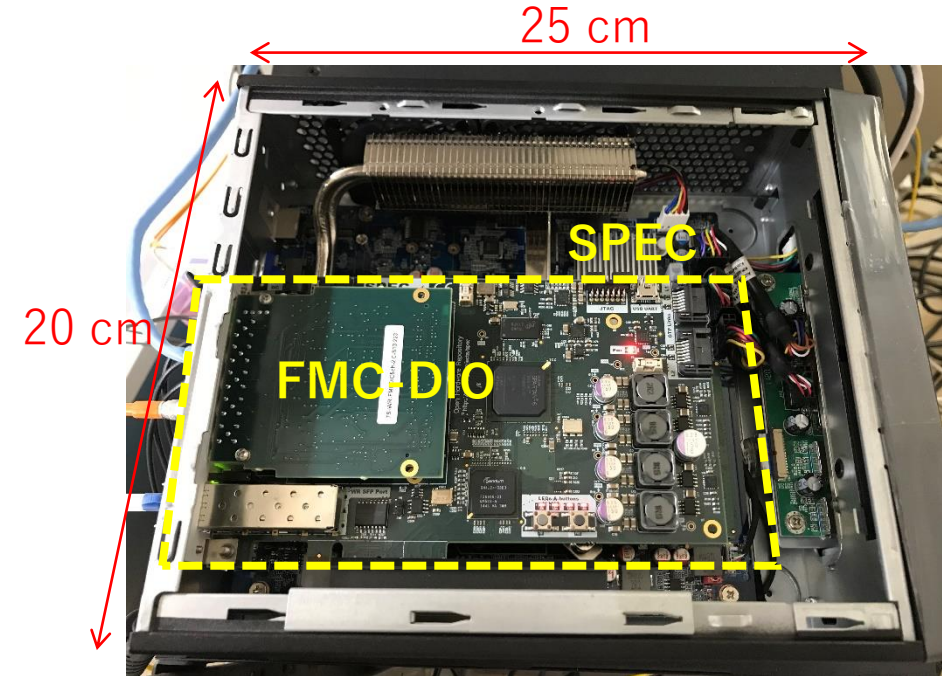
# Slave node we use at KEK

We develop the slave node with SPEC+FMC-DIO.  
The firmware and software are from the starting kit v3.1.  
<https://ohwr.org/project/wr-starting-kit/wikis/home>  
That means “*You can easily try what we did*”.

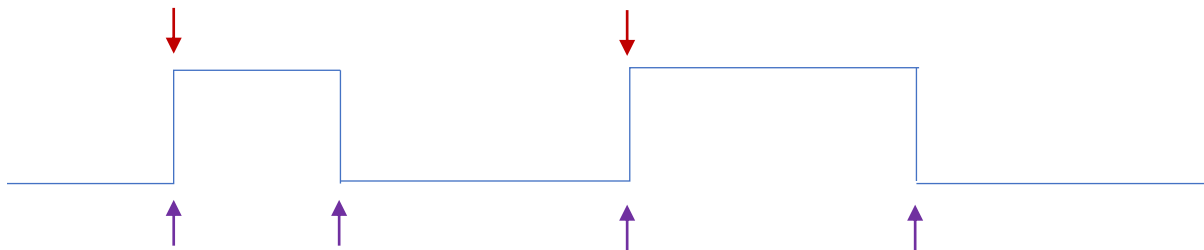
- Only two customizations. **I believe they are large innovations.**
- Inform timestamp when both the HIGH/LOW transition of signals.
  - Everything is controlled via EPICS.



**Packed with homebuilt PC**  
2.9GHz 6core CPU, 8GB of RAM, SSD 500GB  
Ubuntu 18.04 LTS OS



When input signal comes this way, ...



Our firmware informs the timestamp at **both higher and lower transitions** of the signal while the original firmware informs only **higher transition**.

```
kaji@abcob13:~$ camonitor ET_WR4:DIO:CH3:STA
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:47.429220 0
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:48.415682 1
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:48.427068 0
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:49.413764 1
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:49.424909 0
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:50.411602 1
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:50.422968 0
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:51.409291 1
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:51.420828 0
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:52.407124 1
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:52.418668 0
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:53.404925 1
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:53.416241 0
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:54.402805 1
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:54.414349 0
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:55.400572 1
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:55.412050 0
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:56.398703 1
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:56.409842 0
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:57.396396 1
ET_WR4:DIO:CH3:STA 2021-10-17 18:30:57.407609 0
^C
[kaji@abcob13 ~]$
```

Timestamp is informed via EPICS PV.

# WR at SuperKEKB

**WR grand-master** is synchronized with GPS

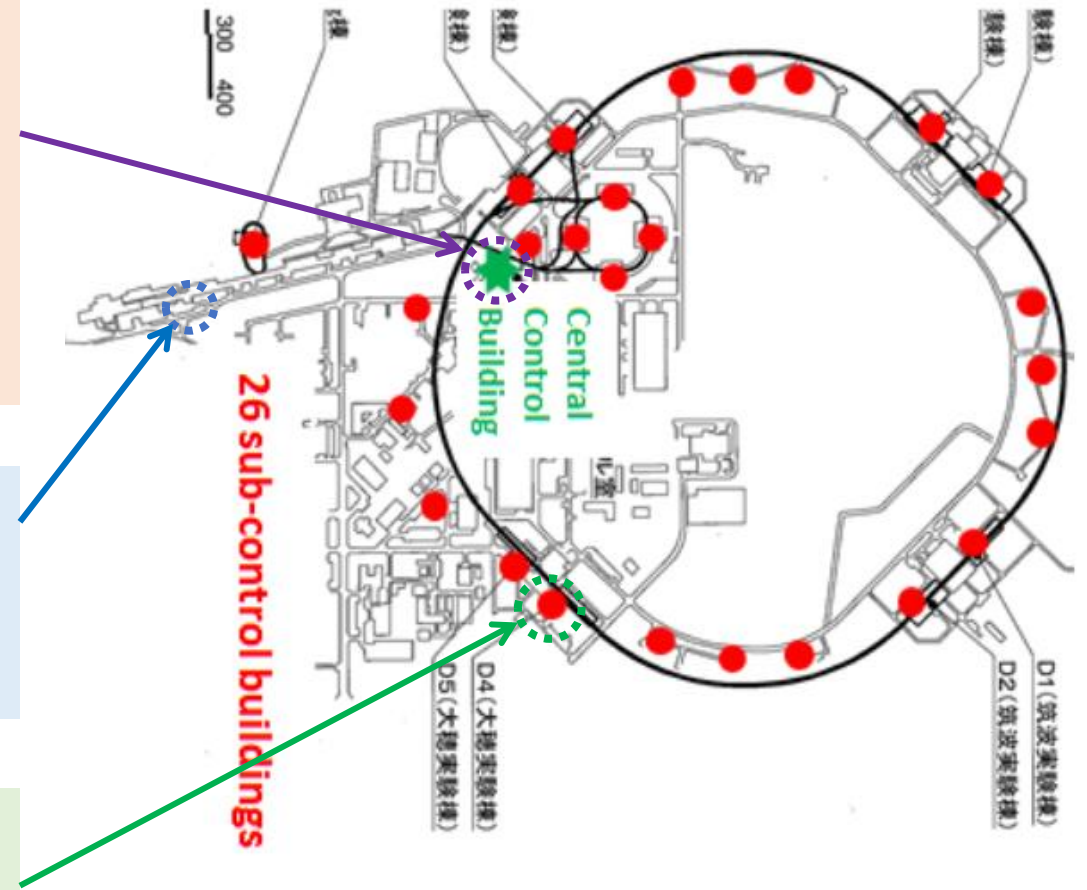
- Slave node-1:  
reference signal from master abort module (LER/HER)
- Slave node-2:  
abort kicker magnet trigger (LER/HER)  
Beam Gate input (LER/HER)
- Slave node-3:  
generation of rev/99176

**LINAC boundary** provides the PPS signal to Event Timing System for synchronization.

- Slave node-4:  
Beam Gate output (LER/HER)

**D4 slave** is directly connected with the WR master.

- Slave node-5:  
Beam Size monitor (X-ray monitor)





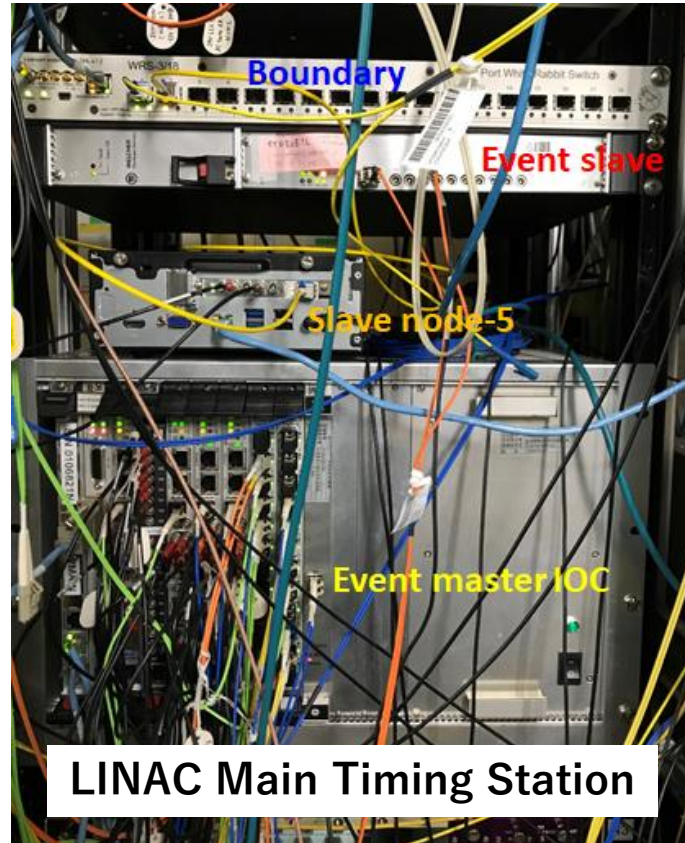
# Beam Gate delivery

Beam Gate is a kind of Beam Permission Signal. It prohibits and inhibits the beam injection from LINAC. The SuperKEKB operator dynamically switches the status of signal to control the operation beam current.

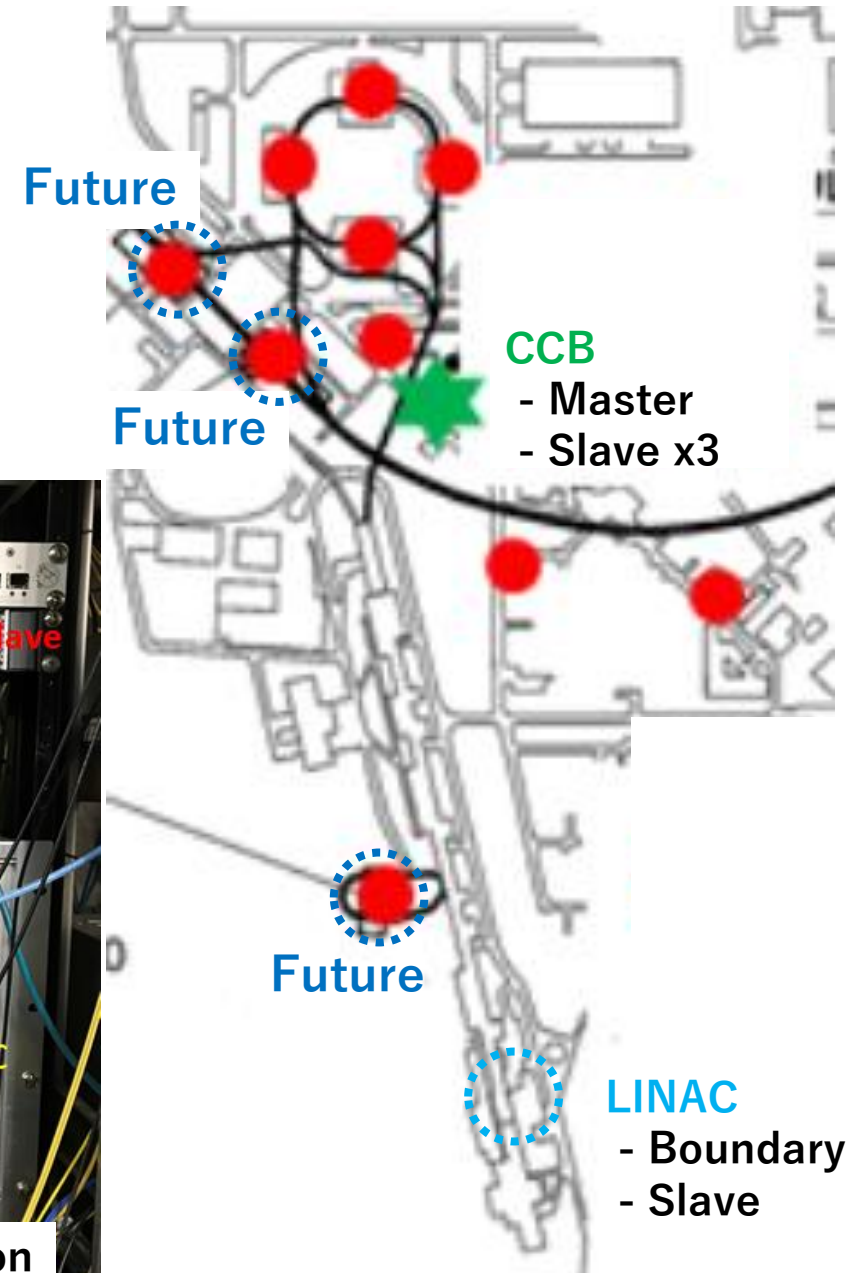
The beam permission signal is delivered from **CCB** to **LINAC**.

By using the SuperKEKB-type node, both “Beam ON” and “Beam OFF” are noticed with the GPS timestamp. It is available on EPICS PV.

In positron injection, we store the beam into the damping ring at least 40ms. Its larger than LINAC operation period, 20ms. The control signals to components in downstream from damping ring must be delivered 40ms later than that to electric gun. **WR can manage such kind of delay.**

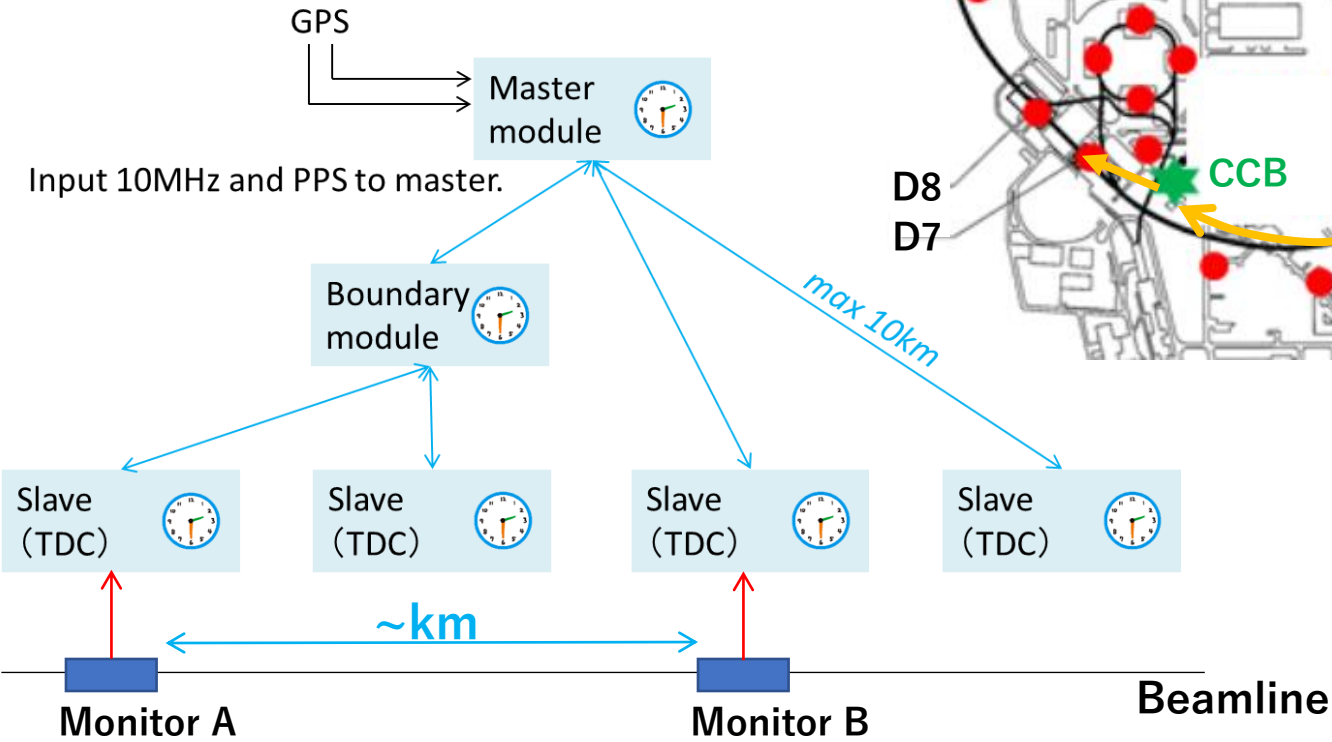


LINAC Main Timing Station

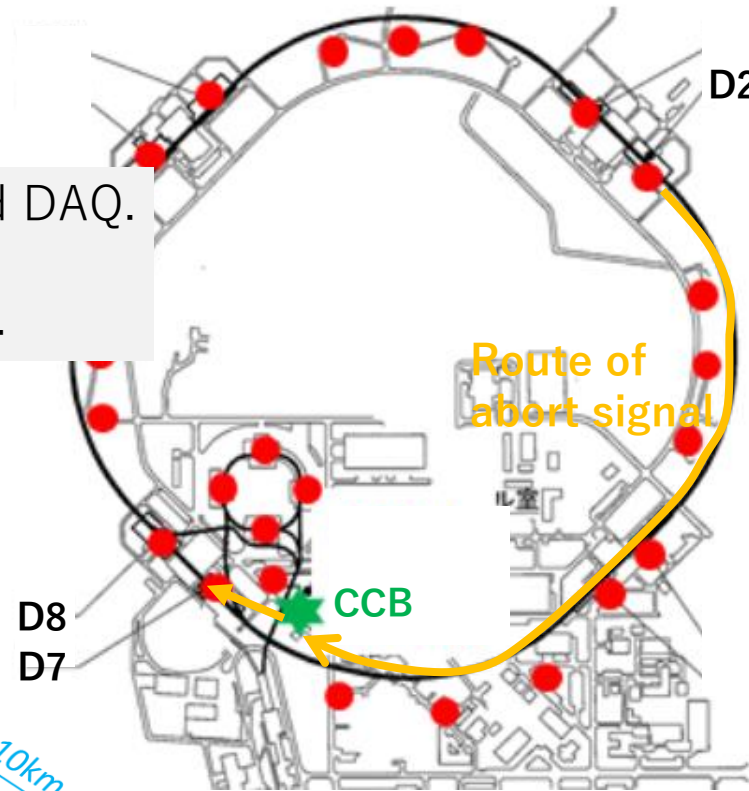


# Distributed TDC

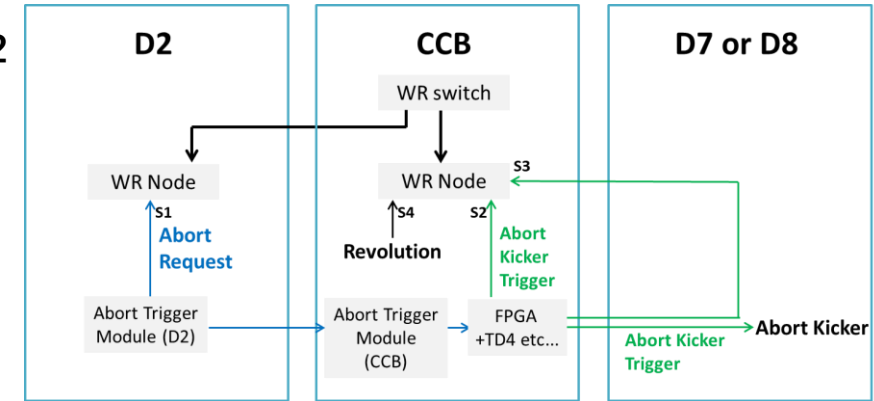
Distributed TDC is a part of distributed DAQ. It can compare the input timing among separated modes with GPS timestamp.



Distributed TDC is a strong tool to diagnose the source of the problem in the beam operation. More modules will be installed next year to help machine operation.



## Test setup



Abort response time is measured precisely for the first time. Its correlation with the revolution is observed.

## Test result

