# CMS iRPC Backend and Trigger status
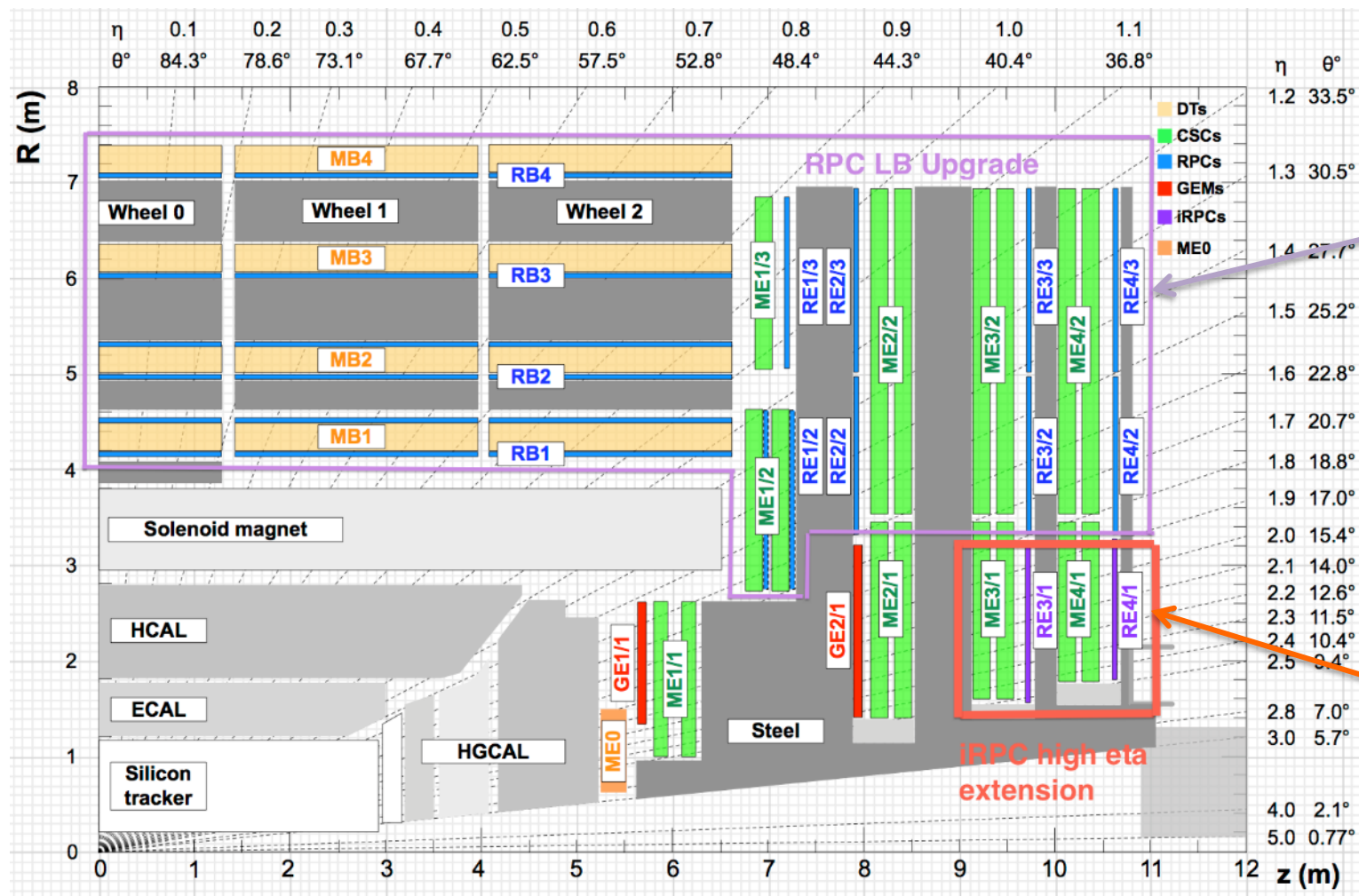
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Trigger Lab/IHEP Beijing

CLHCP2023

# Outline

- Overview

- iRPC BE/TRG demonstrator development

- Preliminary results of data analyses for beam test

- BE development for iRPC QC3

- P5 demonstrator backend integration preparation

- Summary

CLHCP2023

Upgrade of Link System to improve timing resolution for existing RPC ($|\eta| < 1.9$)

Extend the RPC coverage up to $|\eta| = 2.4$ to increase redundancy in high eta region in stations 3 and 4

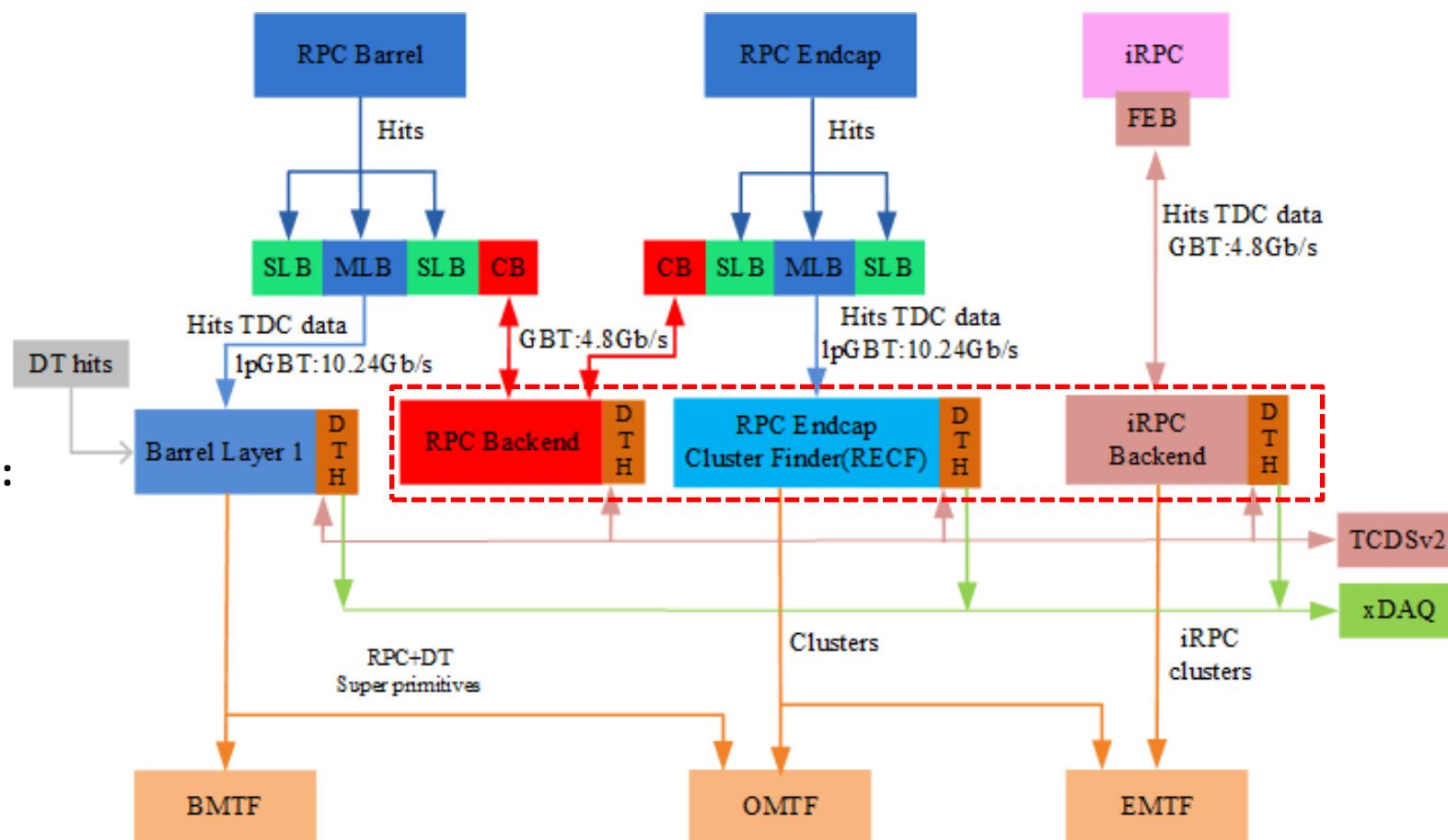◆ **iRPC BackEnd and Trigger (iRPC BE):**

- Fast/Slow control(TTC),
- Monitor
- Data readout,
- Trigger Primitive(Cluster) Generation

◆ **RPC Endcap Cluster Finder(RECF):**

- Data readout
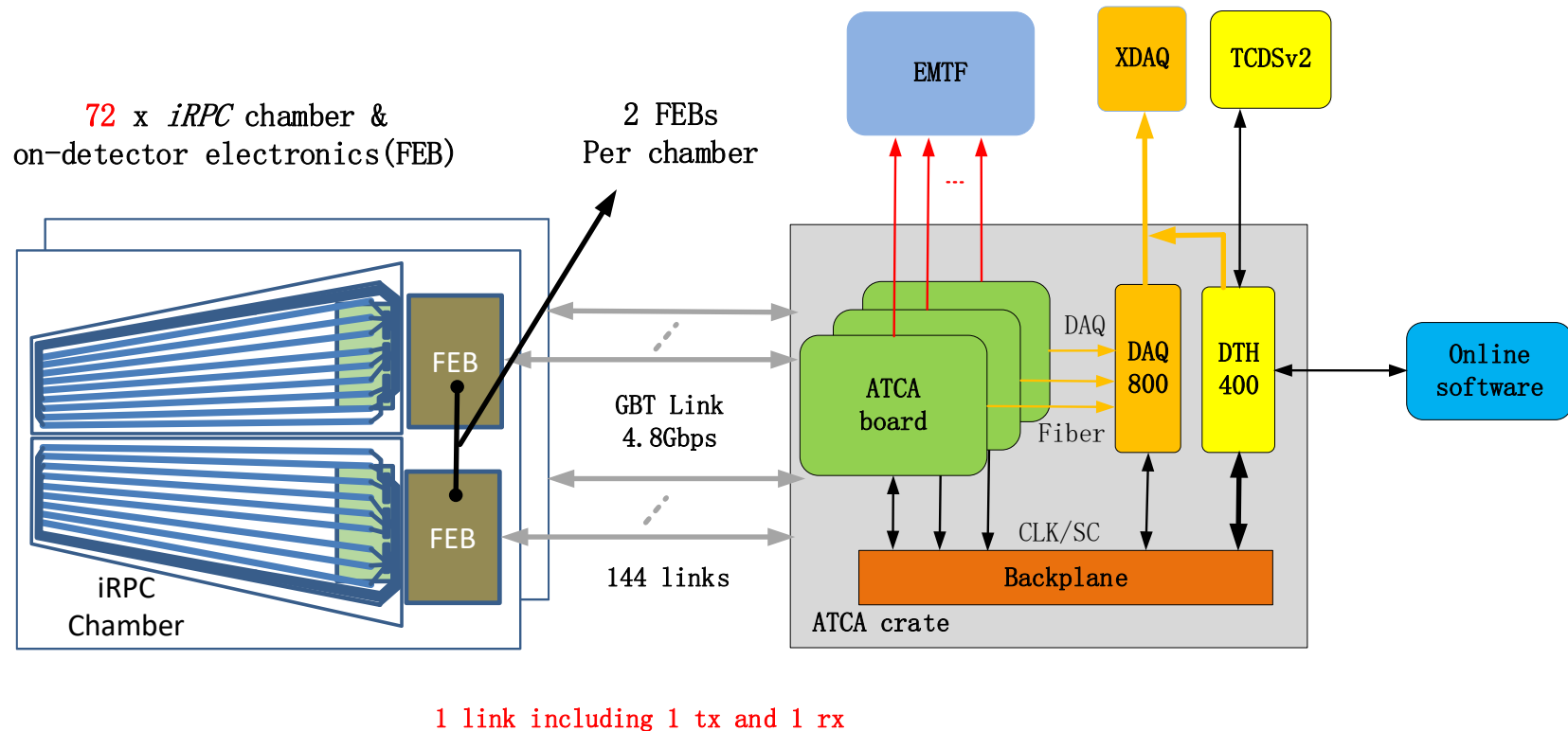- Trigger Primitive(Cluster) Generation
- TP data Fanout

◆ **RPC backend:**

- Fast control(TTC)
- Slow control
- monitor

# iRPC BE/TRG system

◆ iRPC BE/TRG system
  ➢ 1  ATCA Crate
  ➢ 1  DTH400
  ➢ 1  DAQ800
  ➢ 8  ATCA serenity
    boards



72 x *iRPC* chamber &
on-detector electronics(FEB)

2 FEBs
Per chamber

GBT Link
4.8Gbps

144 links

iRPC Chamber

FEB

FEB

EMTF

XDAQ        TCDSv2

ATCA board

DAQ
800

DTH
400

Online software

DAQ

Fiber

CLK/SC

Backplane

ATCA crate

1 link including 1 tx and 1 rx

# iRPC Backend and Trigger schedule

◆ 2023-2024

- ➢ MTCA BE/TRG integration in P5 on iRPC demonstrators with FEB V2_2

- ➢ Data taking in P5 use MTCA BE/TRG board for iRPC demonstrator chamber test

- ➢ work in Serenity steering committee and technical group for key technology design and test

◆ 2025 -2026

- ➢ Start BE/TRG firmware merge to serenity ATCA

- ➢ ATCA BE/TRG integration in P5 on iRPC demonstrators with FEB V2_3

◆ 2027-2028

- ➢ Full ATCA BE/TRG for iRPC integration in P5

- ➢ Taking Data with iRPC chamber installed in P5 in local

# iRPC Backend and Trigger progress

◆ Present progress is based on MTCA BE board.

  ➢ iRPC BE/TRG firmware development，online control function integrated

  ➢ Suggestion to FEB for firmware upgrade based on beam test

  ➢ Timing reference study

  ➢ Backend system setup and development for QC3 in Gent, Mexico and 904

  ➢ iRPC P5 demonstrator backend integration preparation

◆ Details of progress see following slides.

# iRPC BE/TRG Demonstrator

➢ Before Last version of ATCA serenity board availability, we are working on present BE/TRG board for system study.

➢ BE/TRG board-designed by IHEP trigger group

  Virtex-7 FPGA：Core FPGA( GBT Communication with Feb + data processing);
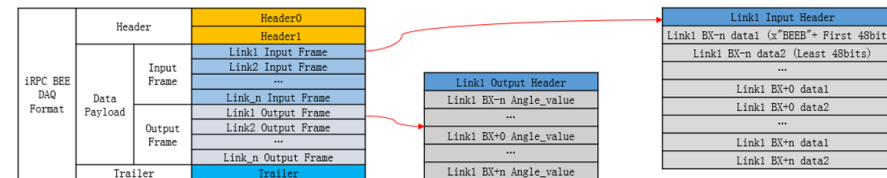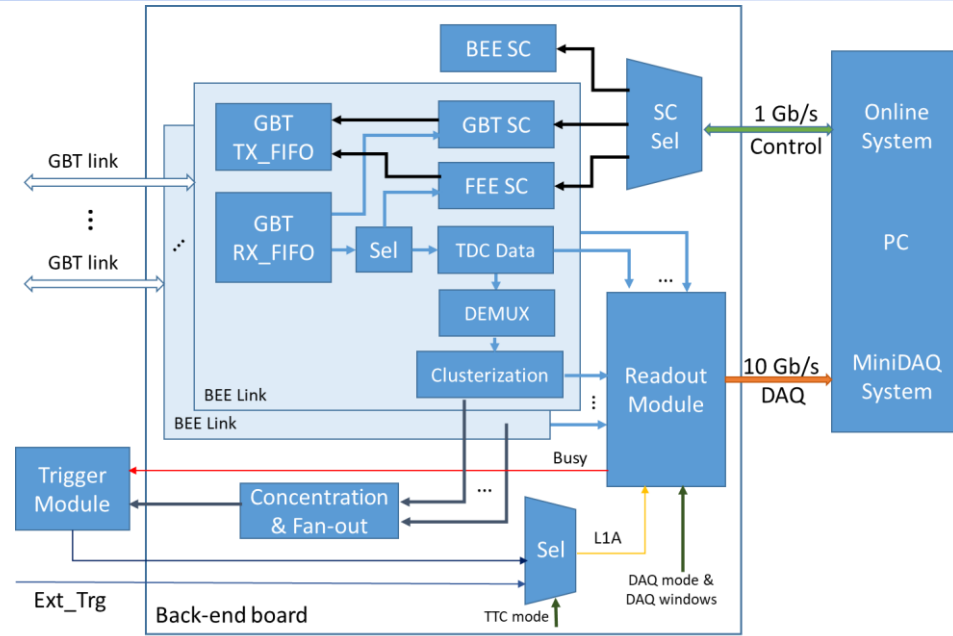  Kintex-7 FPGA：Control FPGA(clock configuration , SC)

➢ iRPC BE/TRG Demonstrator
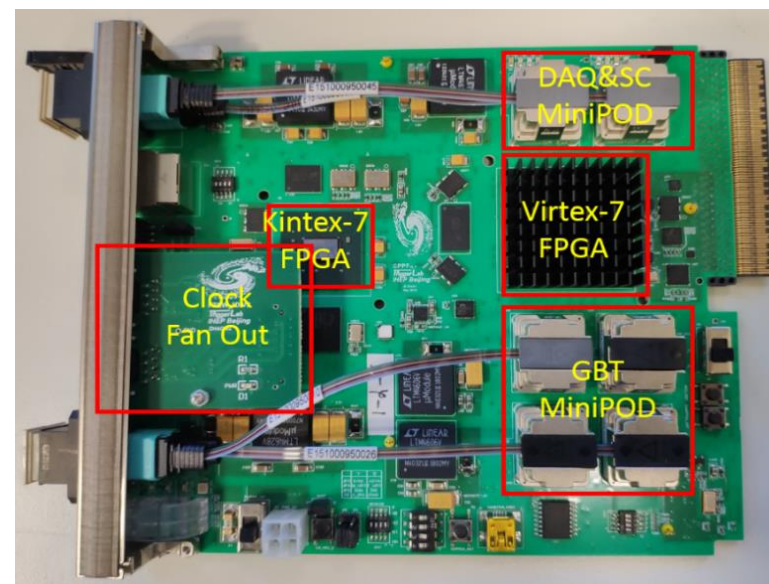




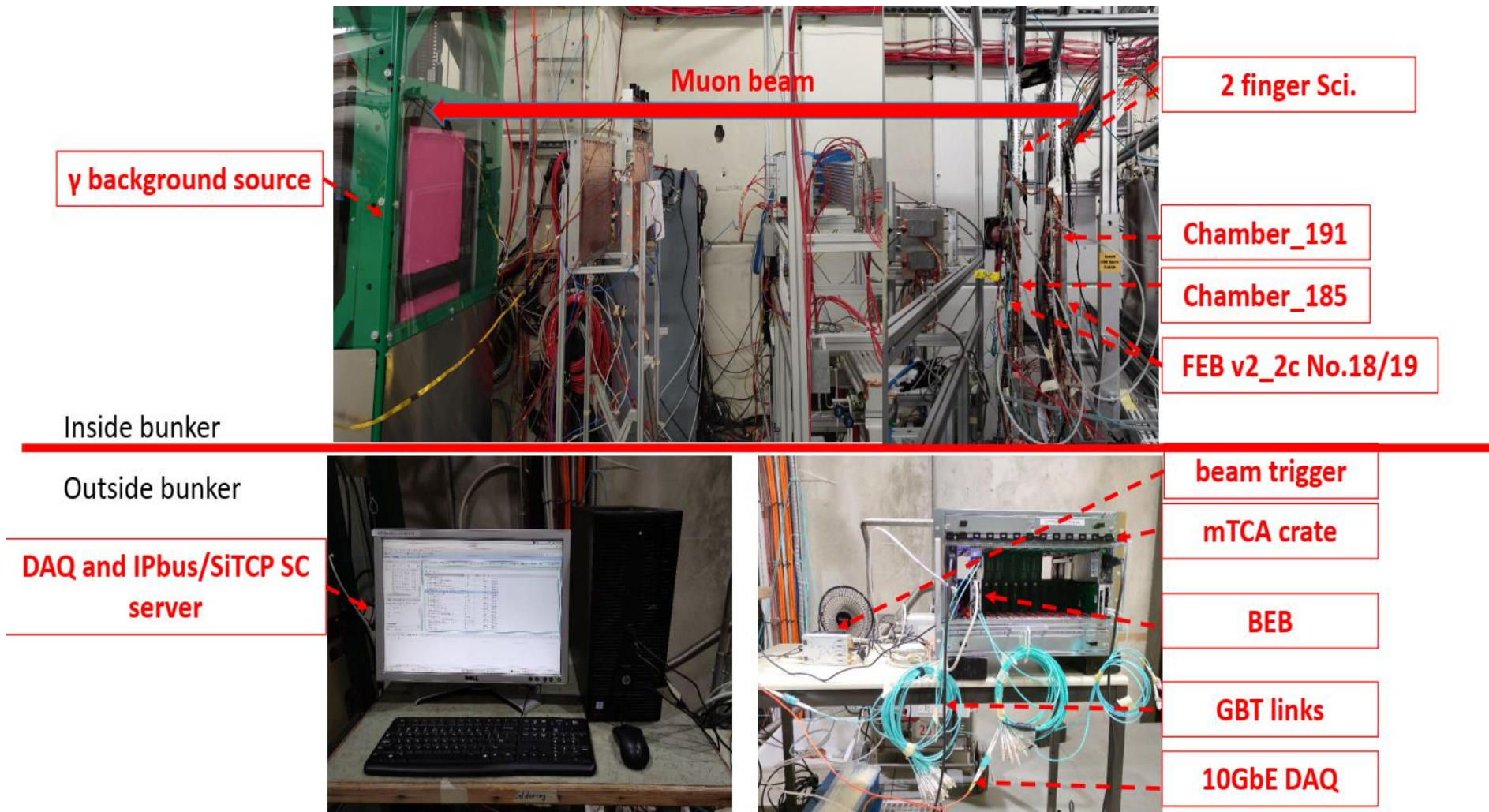System in Beijing similar to the one in P5
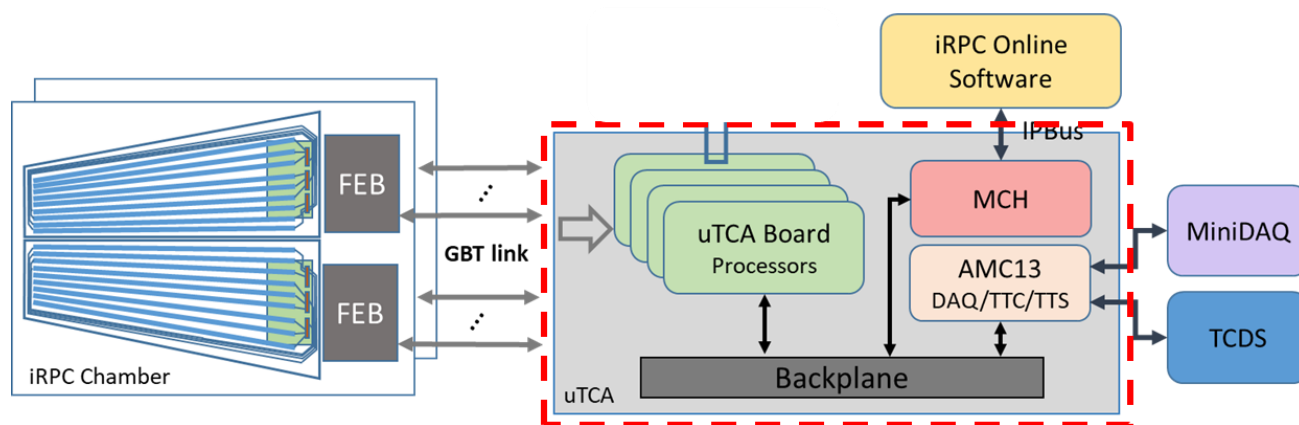
- **BE firmware function**
  - Transmission link:   Done
    - Bidirectional, 4.8Gb/s
  - Fast control: Done
    - BC0/resync
    - Timing reference distribution
  - Slow control: Done
    - BEE-SC/FEE-SC/GBT-SCA
    - PC to BEB control link
    - 1Gb/s, Sitcp protocol/Ipbus
  - Cluster finding algorithm:  July 2024
    - DEMUX/Cluster finding/Angle conversion
  - DAQ package: May 2024
  - BEB to PC DAQ link : Done
    - 10Gb/s, TCP/IP







DAQ data format

2023/11/19          CLHCP2023

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◆ Data taking with beam for BE/TRG function development and verification .

# 2023 BE beam test result

◆ Purpose:
  ➢ Check new functions implemented in FEB firmware v3.6 and v3.15
    • the Check-Sort-Push(CSP) mechanism
      • Data send priority based on timing, not channel
    • HR and LR data pair function
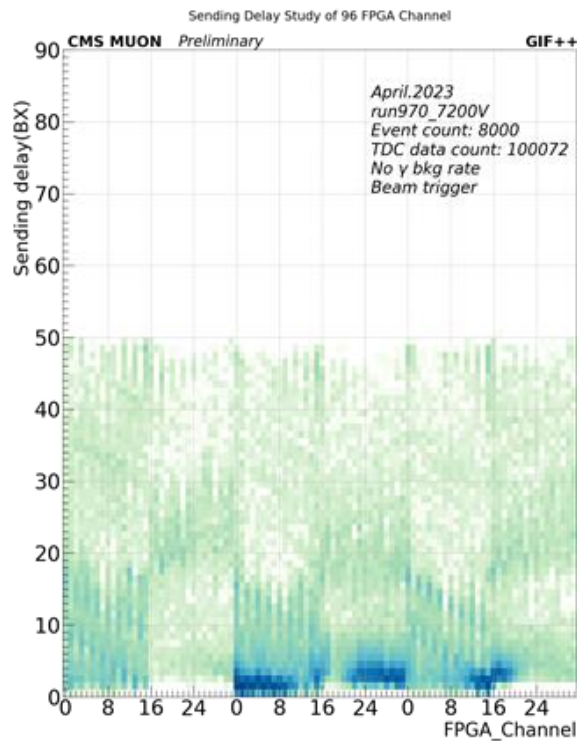      • (one strip tdc data from HR and LR concentrate in one GBT frame, and throw away only have HR or LR tdc data )
◆ Two kinds of Data took,
  ➢ pair function disabled
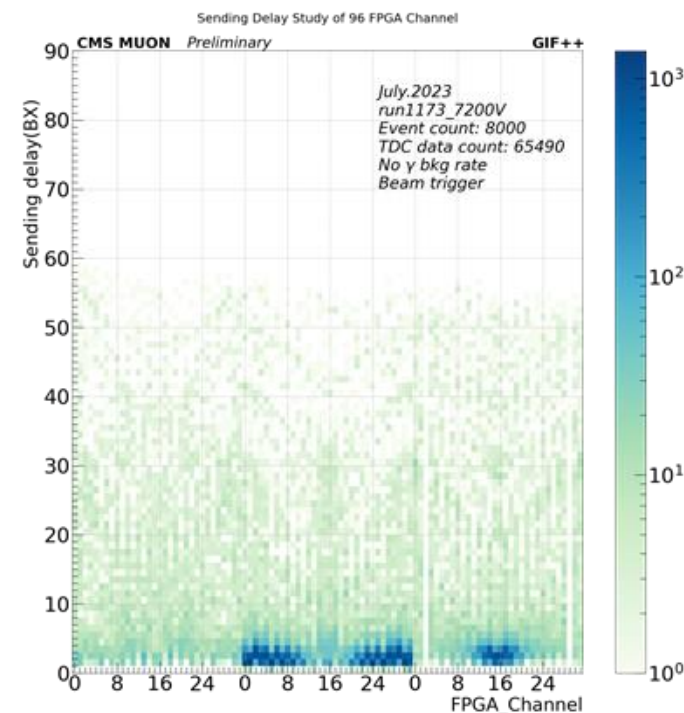  ➢ pair function enabled
◆ Results:
  ➢ Data sending delay distribution meet expectation. More details under study.
  ➢ Give upgrade suggestion to FEB team on v3.6.
  ➢ Pair function enabled data as expected in v3.15.
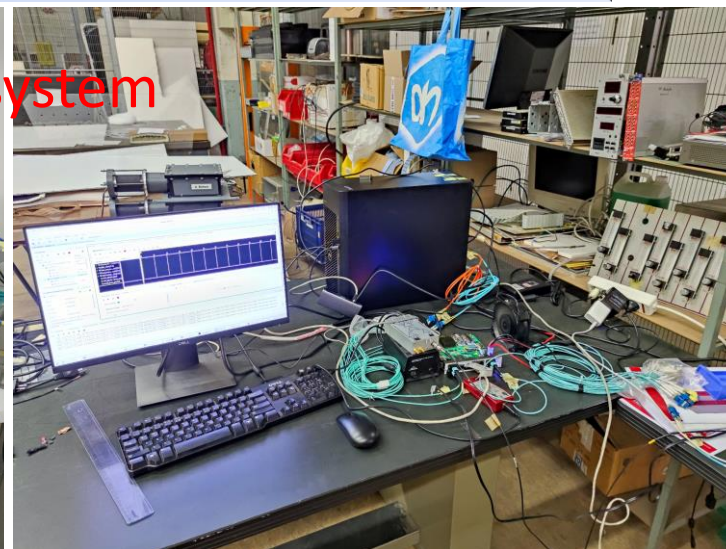
pair function disabled, no gamma background

pair function enabled, no gamma background

# iRPC QC3 BE development

- ◆ QC3 - iRPC Chambers Quality Control
  Chamber during construction and with cosmics **@ assembly sites**: Gas leak, dark current, cosmic (noise, eff, cluster size, HV).

- ◆ iRPC QC3 backend system.
  - ➢ Based on BE/TRG demonstrator
  - ➢ Single board system
  - ➢ One board readout one FEB for half chamber.

- ◆ Developed and set up two systems
  - ➢ Gent system: Jianing helped set up this system in July.2023
  - ➢ 904 system: Qingfeng set up 904 backend system
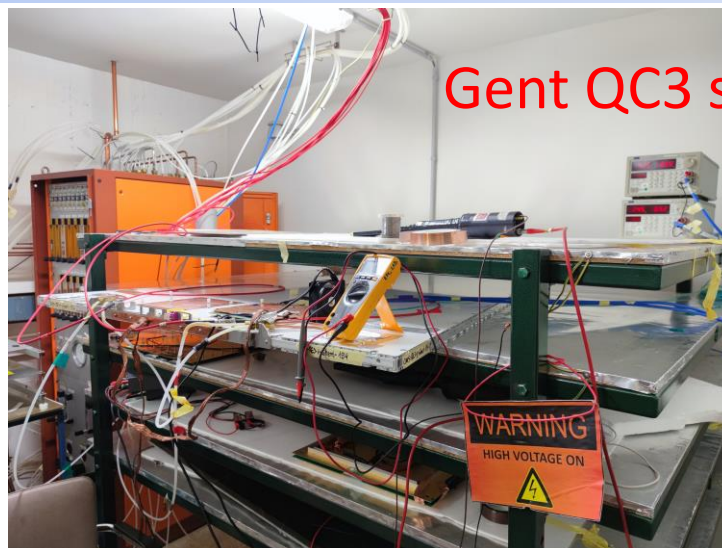


Gent QC3 system

904 QC3 system

◆ Qingfeng is working on QC3 data analysis module for quick test, 3 kinds of profile will generate after each QC data taking.

➢ TDC channel distribution: used to check is there any dead strip channel.
➢ Strip Hit distribution: used to roughly check FEB/BE working status and SCI area correct or not.
➢ Hit position distribution: roughly check SCI area is correct or not.
➢ How to provide the s-curve line is still under discussion.

◆ These modules will be integrated in webdcs.
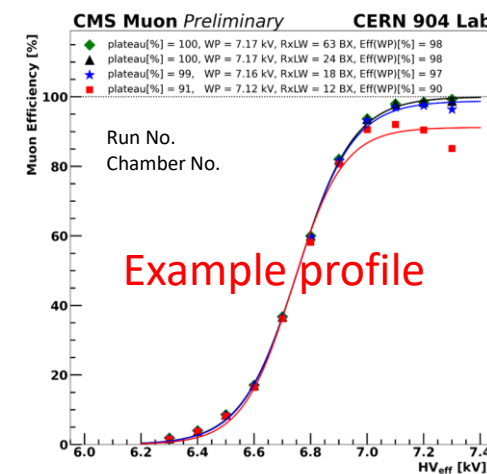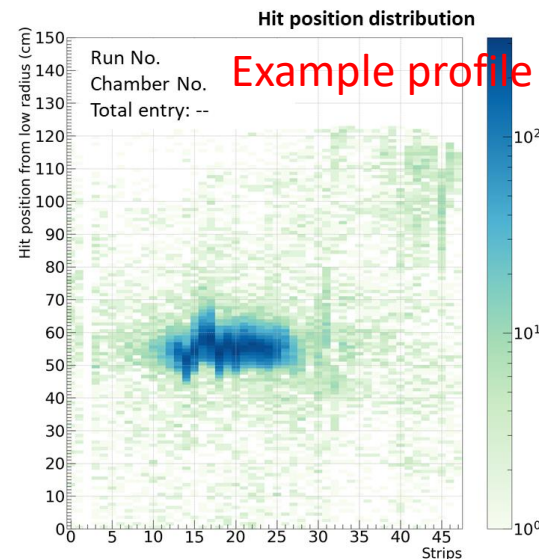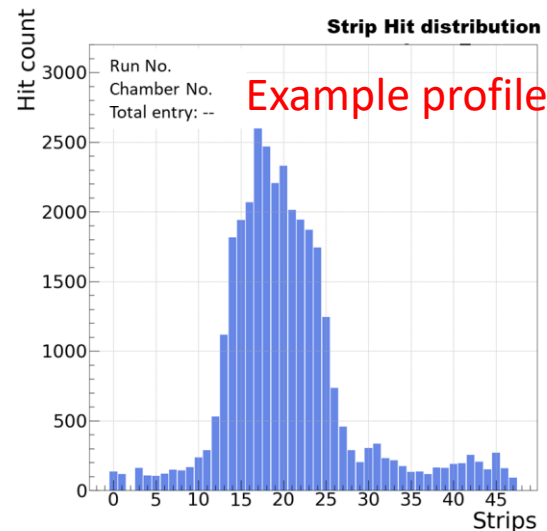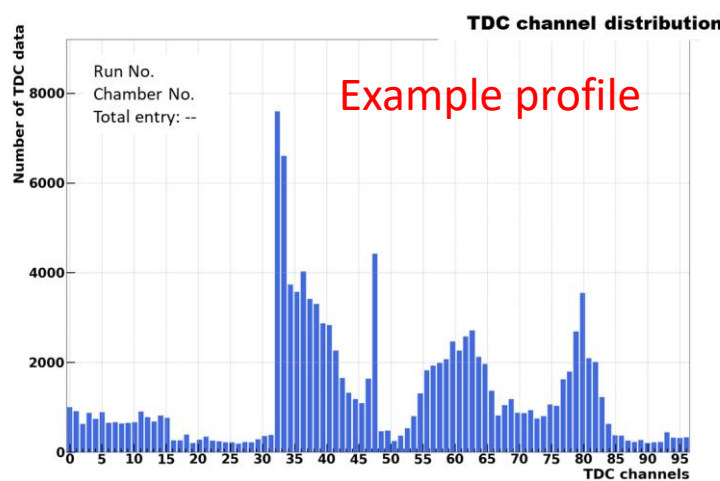
Chamber location and fiber cable routing

- Fiber Length (single direction):
  - Cable1 : varies from 7.7m to 35.5m
  - Cable 2: varies from 0.5m to 1.6m
- Maximum fiber length difference is 28.9m roughly.
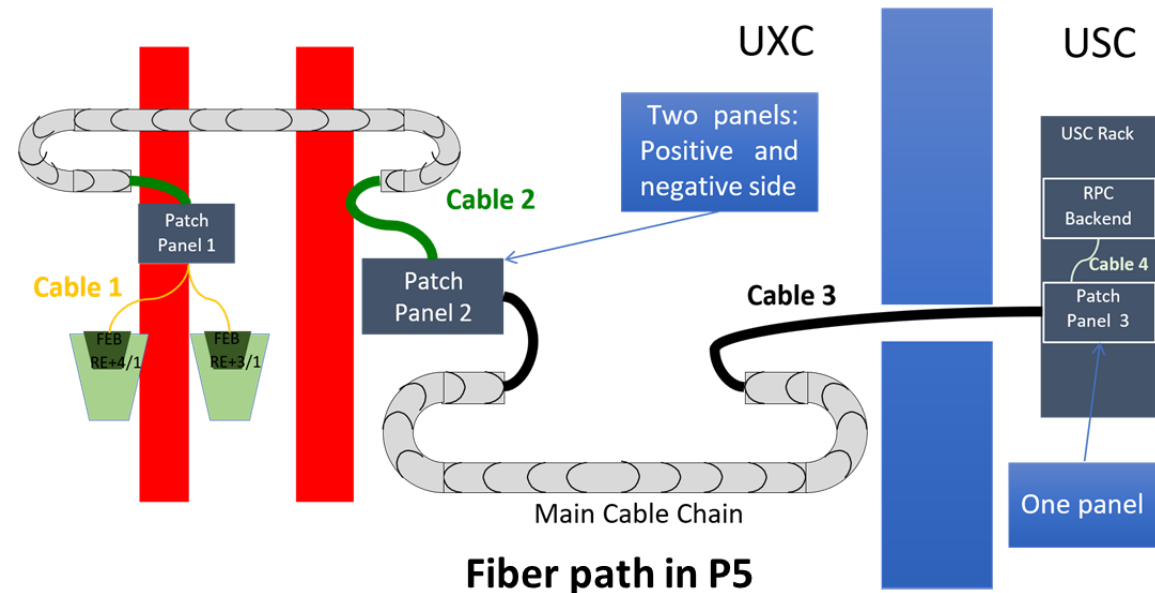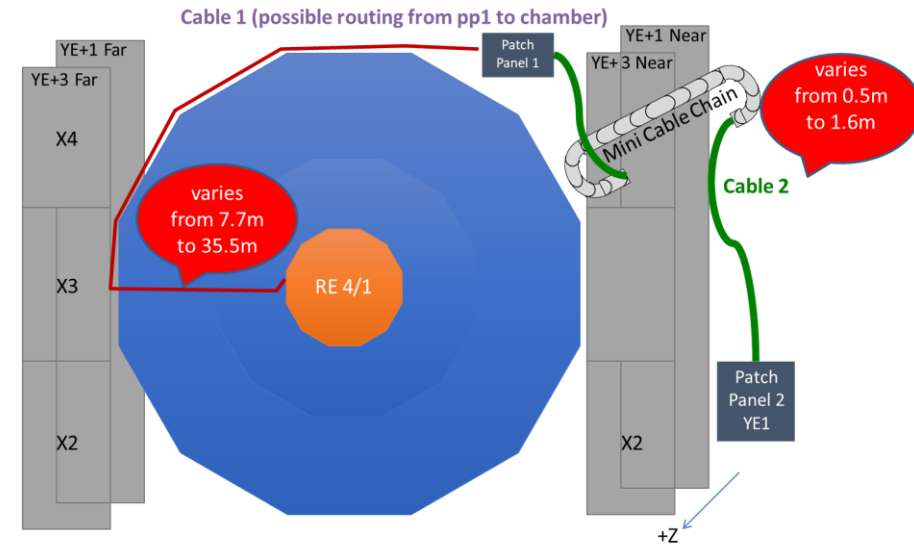
◆ iRPC chambers/FEBs receive fast control signal from backend via fiber cables,

➢ Clock, bunch info. BC0

◆ Different timing reference arrival time for each FEB because of chamber different locations in CMS.

➢ 28.9m roughly => leading to **144.5ns(≈6BX)** absolute timing difference (speed 20cm/ns).

◆ Data in same event will have different timestamp. This make problem in cluster finding. This studied and compensated in BE.
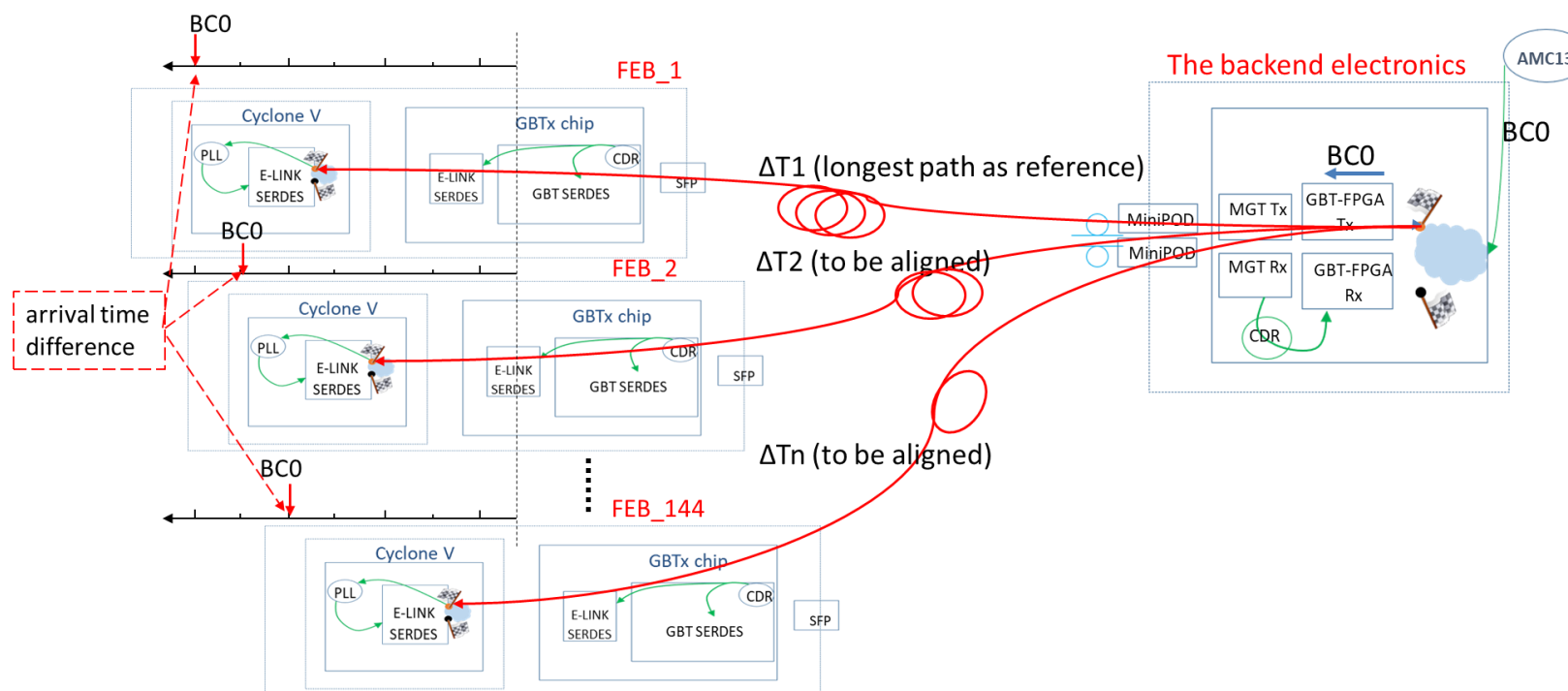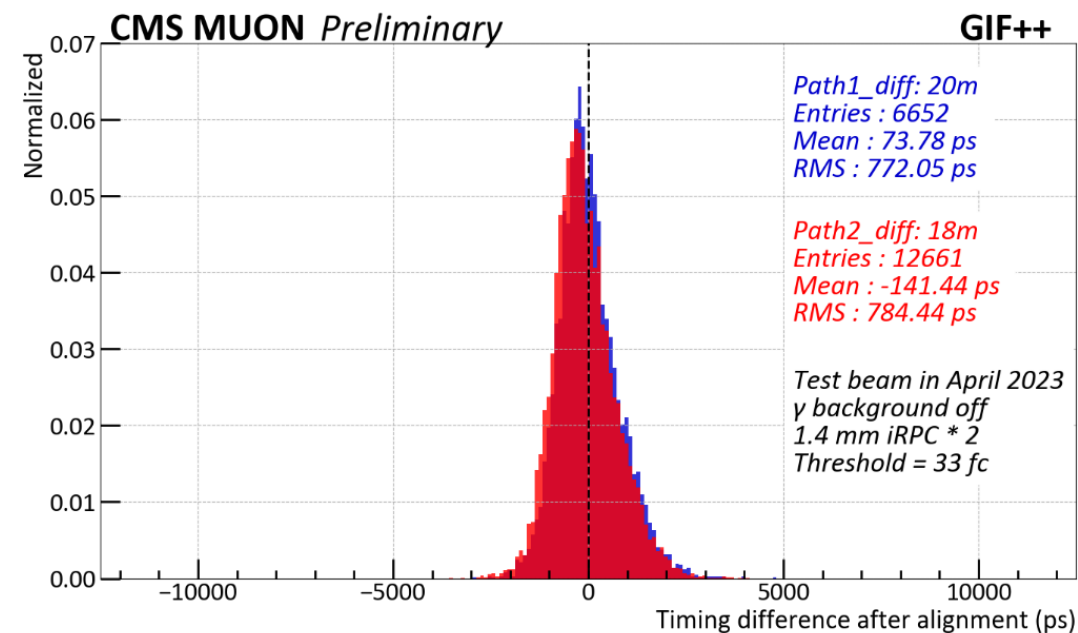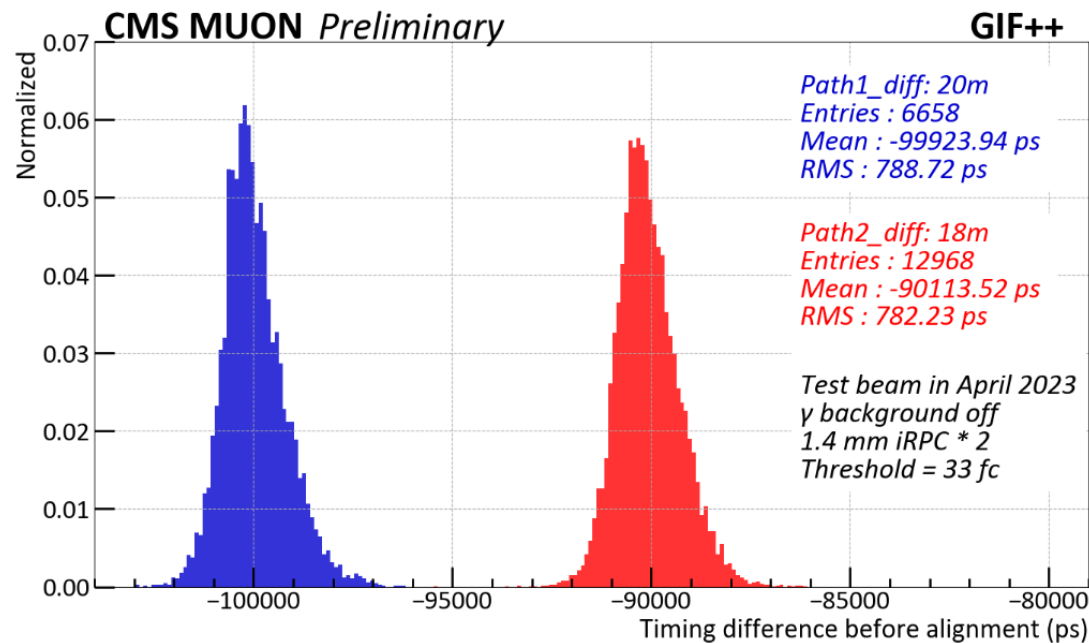
- 3 channels system used for study, with fiber length 20m, 22m, and 40m.
- After alignment, Timing reference difference changed from -99.923/-90.115 ns to within 1.25 ns.

# P5 Demonstrator BE/TRG integration plan

- ◆ P5 Demonstrator BE integration for iRPC schedule
  - ● Target 1, Nov. 2023: One BE/TRG board read two FEB boards without AMC13
    - ➢ Sitcp Slow control interface
    - ➢ Without MTCA crate and AMC13
    - ➢ Random trigger for noise data taking and self-trigger for data taking
    - ➢ Data taking and saving locally.

  - ● Target 2, Jan. 2024 : two BE/TRG board read four FEB boards with AMC13
    - ➢ Ipbus Slow control interface
    - ➢ With MTCA crate and AMC13, AMC13 working loopback mode
    - ➢ Random trigger for noise data taking and self-trigger for data taking
    - ➢ Data taking and saving locally.

  - ● Target 3, Spring 2024: Two BE/TRG boards read four FEB boards with AMC13 and CMS trigger (TBD)
    - ➢ Ipbus Slow control interface
    - ➢ With MTCA crate and AMC13, AMC13 connected with central TCDS
    - ➢ CMS trigger  for data taking
    - ➢ Data taking and saving locally.

# P5 Demonstrator BE integration preparation status

◆ Demonstrator integration preparation status
- ➢ One BE/TRG board is already in 904, so everything is ready for target 1 integration
- ➢ Another two BE/TRG boards are ready in Beijing lab, waiting for delivering.
- ➢ TTC module and DAQ readout module for two backend boards still under development.
- ➢ AMC13 configuration is being studied.

# Status of ATCA Serenity

- ◆ Zhen-An LIU in Serenity Steering committee.

- ◆ Jingzhou ZHAO in Technical and Layout Group.

  - ➢ Schematic design

  - ➢ PCB layout and review

  - ➢ Serenity test

- ◆ Serenity-S1 version main function list.

  - ➢ Single FPGA design(Serenity-S1), Supports VU13P-A2577 package,

  - ➢ 124 bi-dir links @25 Gbps

  - ➢ Soc for board management.

- ◆ Serenity short plan

  - ➢ Serenity in pilot production

  - ➢ First small batch expected finish at the end of 2023.
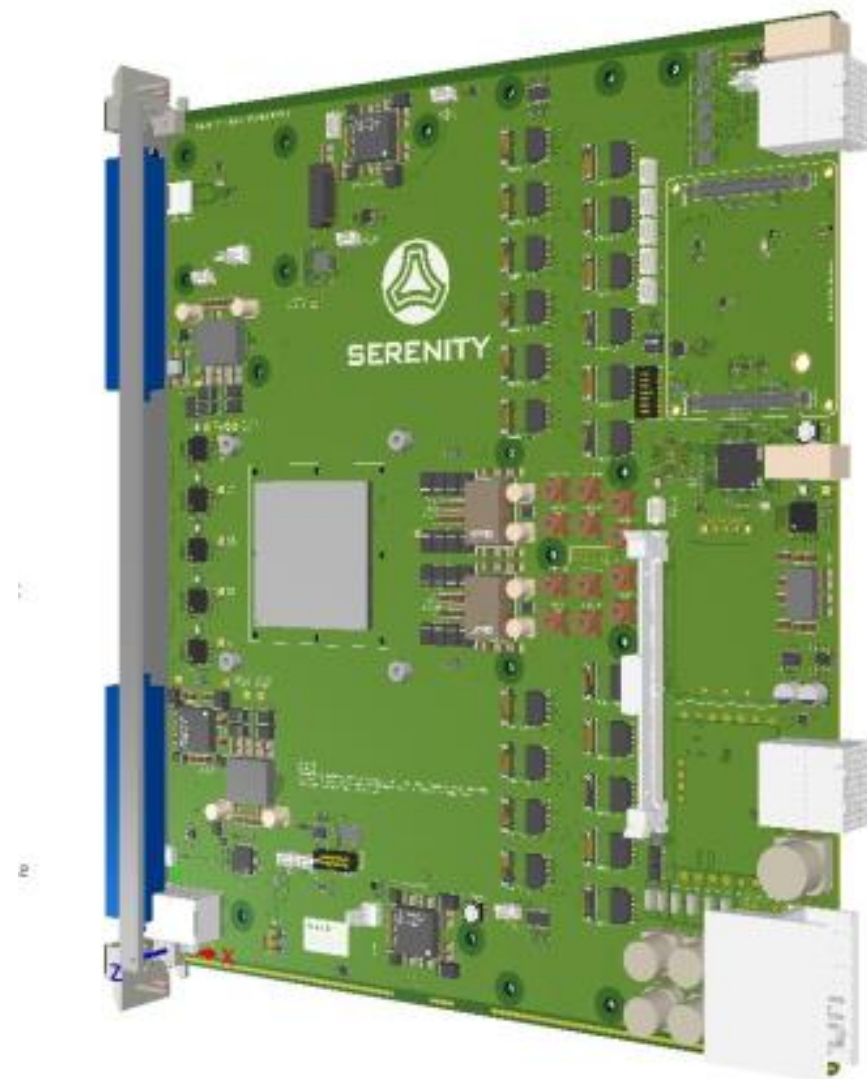
# Summary

◆ IHEP TRG group made good progress on iRPC/RPC BE/TRG this year.

◆ iRPC BE/TRG demonstrator developed for iRPC backend system study.

◆ iRPC data sending delay studied in beam test.

◆ Backend developed iRPC QC3 backend system and set up two system in Gent and 904.

◆ P5 backend Demonstrator installation is in preparation status.