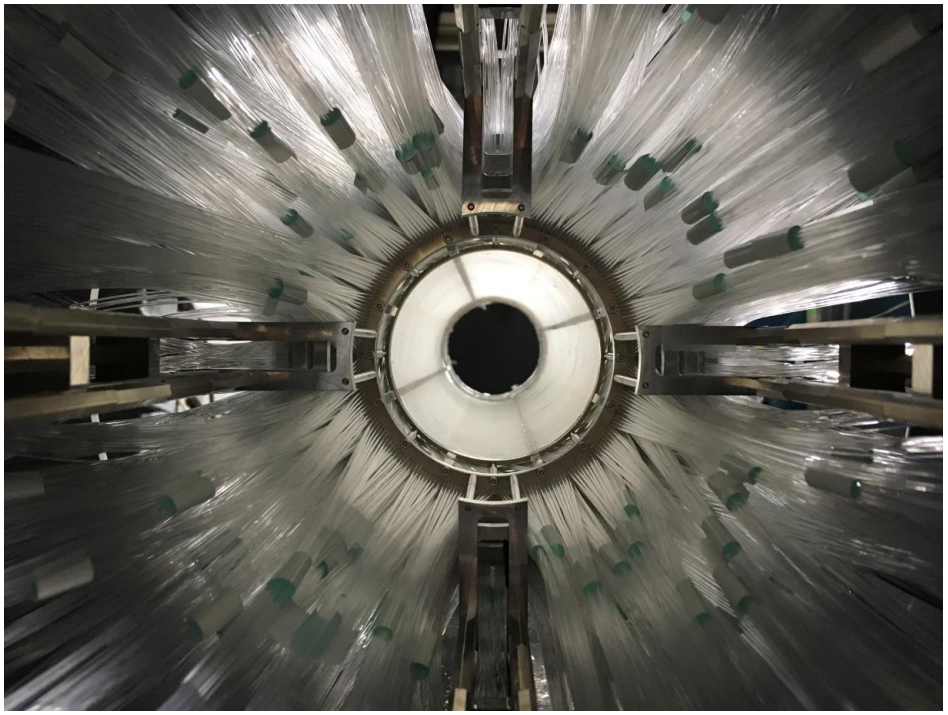
5th International Workshop on New Photon-Detectors PD18

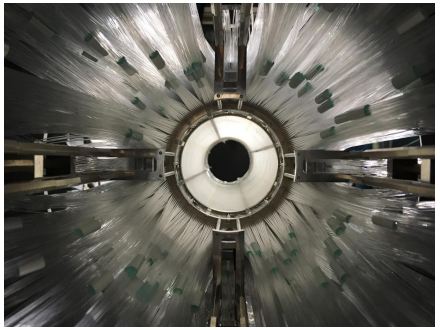


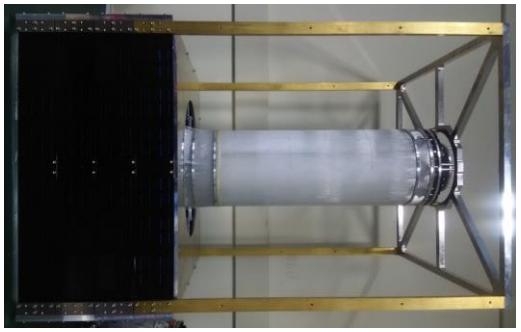
“Operation of multi-MPPC system for cylindrical scintillation fiber tracker”

Yuya Akazawa (KEK)
for the J-PARC E40 collaboration

Contents

Cylindrical Fiber Tracker





- Introduction
  - Motivation and requirements
  - Specifications
- Fabrication
  - Fiber placement
  - PPD Read-out
- Performances for pion and proton
  - Tracking resolution
  - Particle ID via ***ΔE-E*** correlation

Σp scattering experiment (J-PARC E40)

Purpose

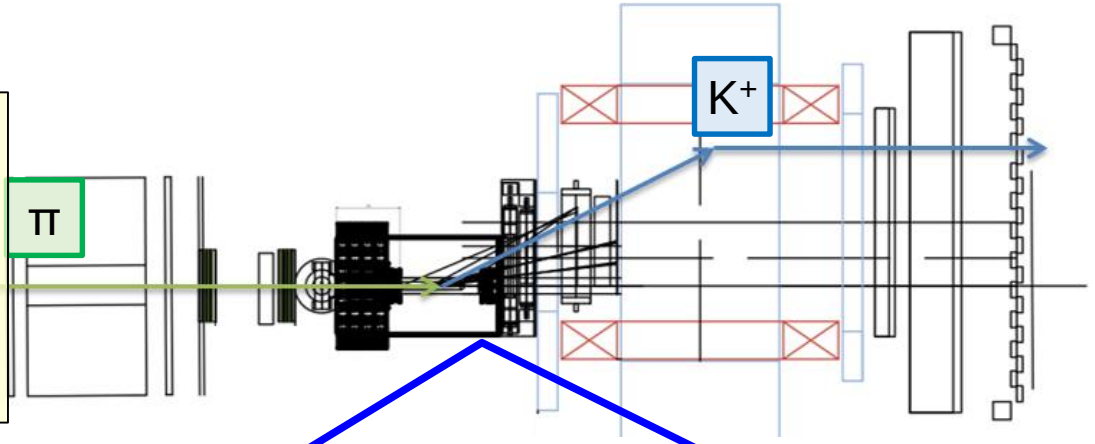
- Σp scattering experiment in J-PARC, Japan ⇒ Study of ΣN interaction

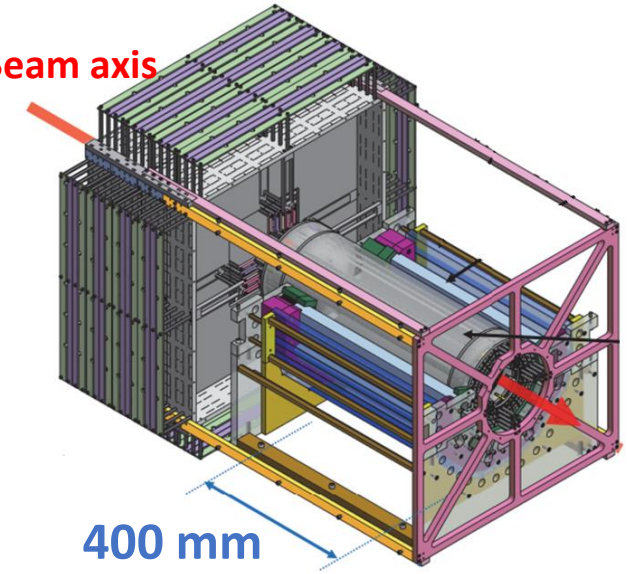
Measurement of **dσ/dΩ of Σp scattering** with **high statistics**

Setup

J-PARC K1.8 beam line

- Target : Liquid H_2(300mm thick)
- π beam 20M[/spill] (spill≅2s)
  - π^-:1.32[GeV/c], π^+:1.4[GeV/c]
- Scattered K^+
  - 0.6~0.9[GeV/c]





CATCH

(**C**ylindrical **A**ctive **Tracker** and **Calorimeter** system for **H**yperon-proton scattering)

- Cylindrical Fiber Tracker(CFT)
- BGO Calorimeter

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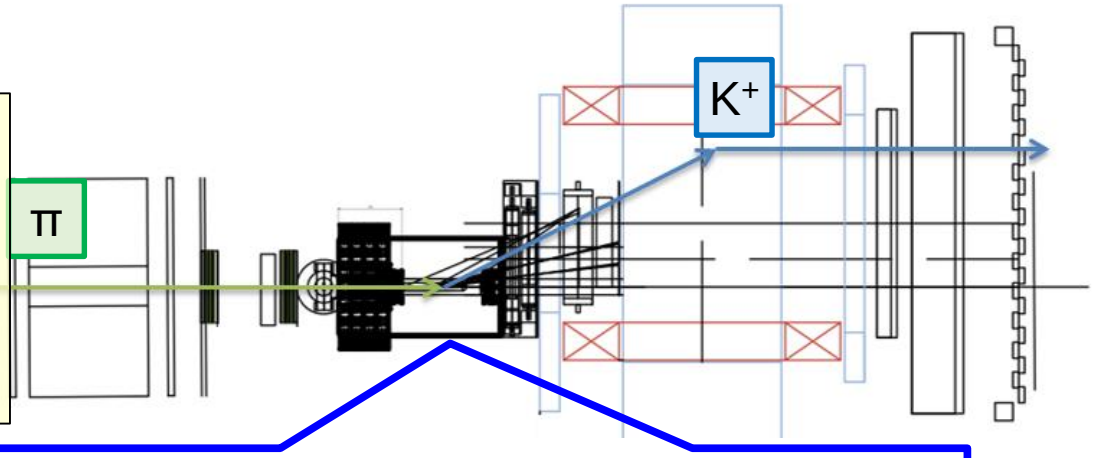

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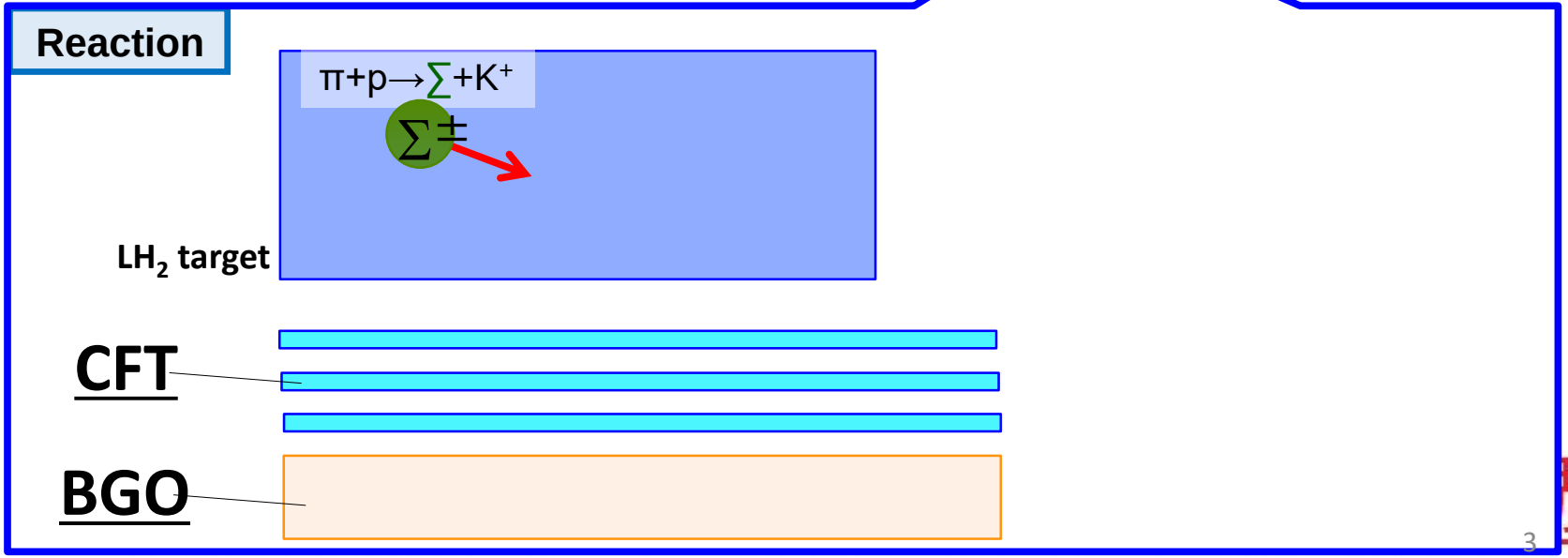

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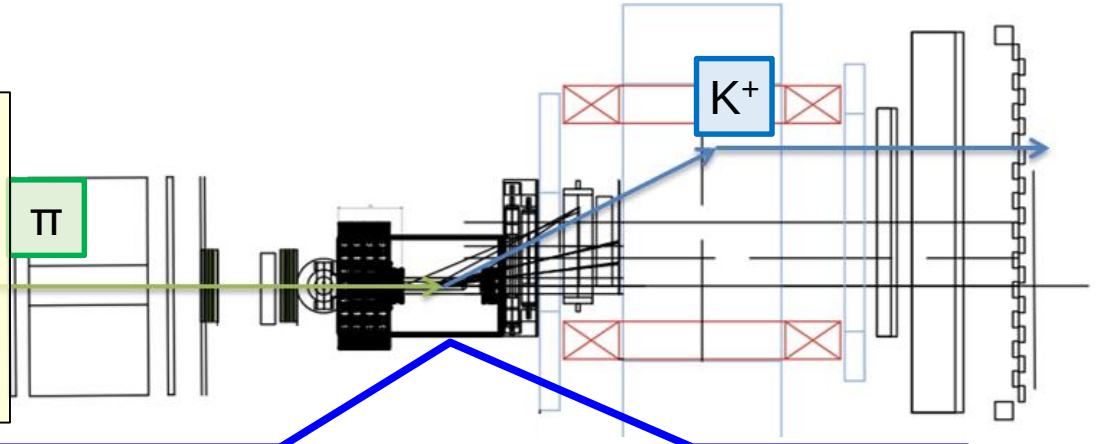

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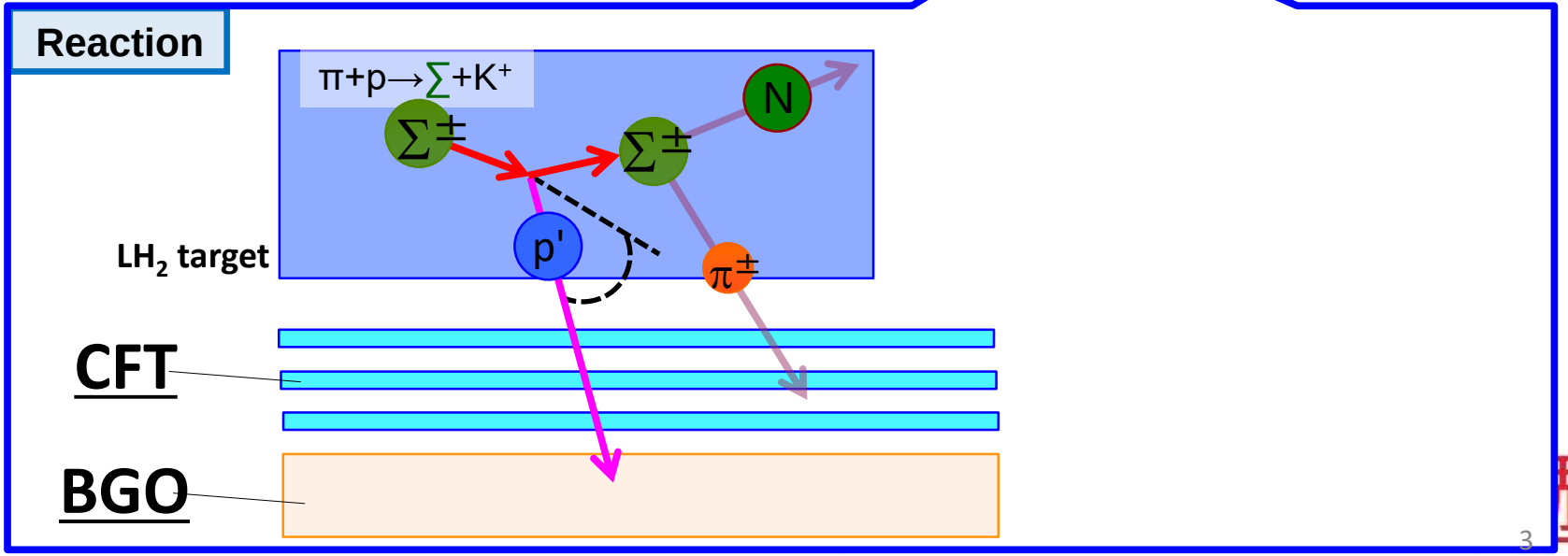

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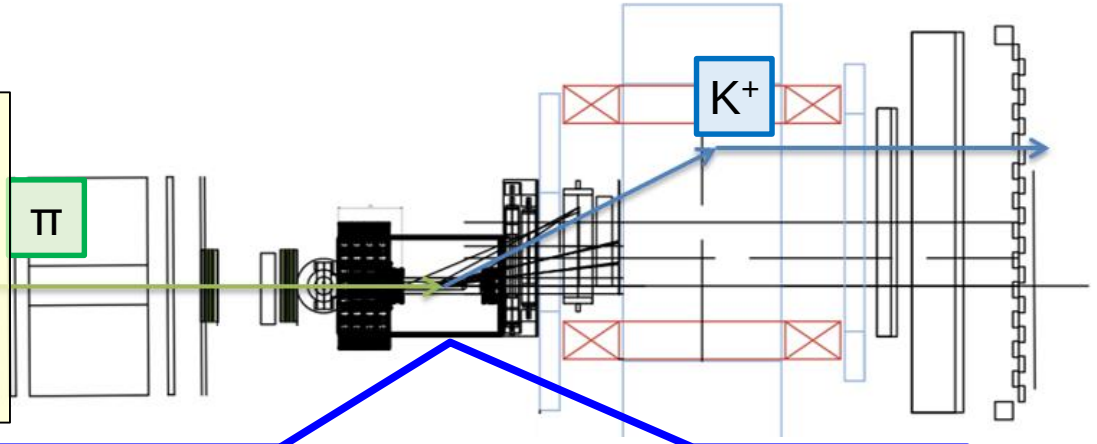

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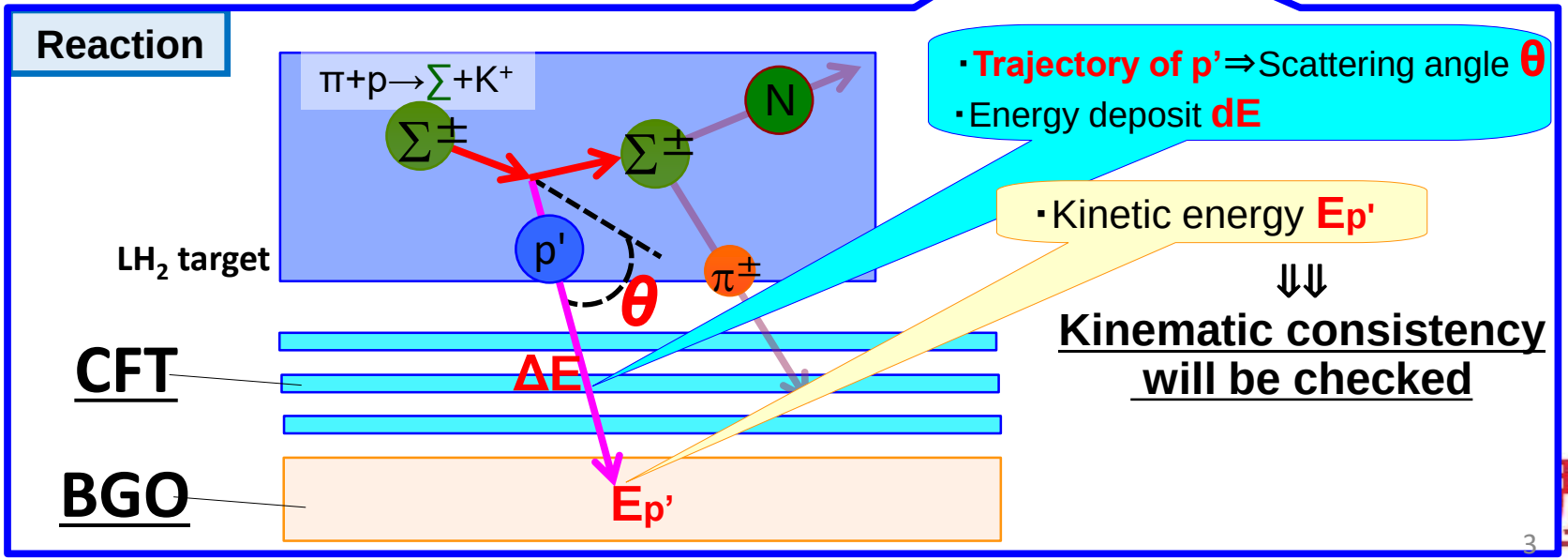
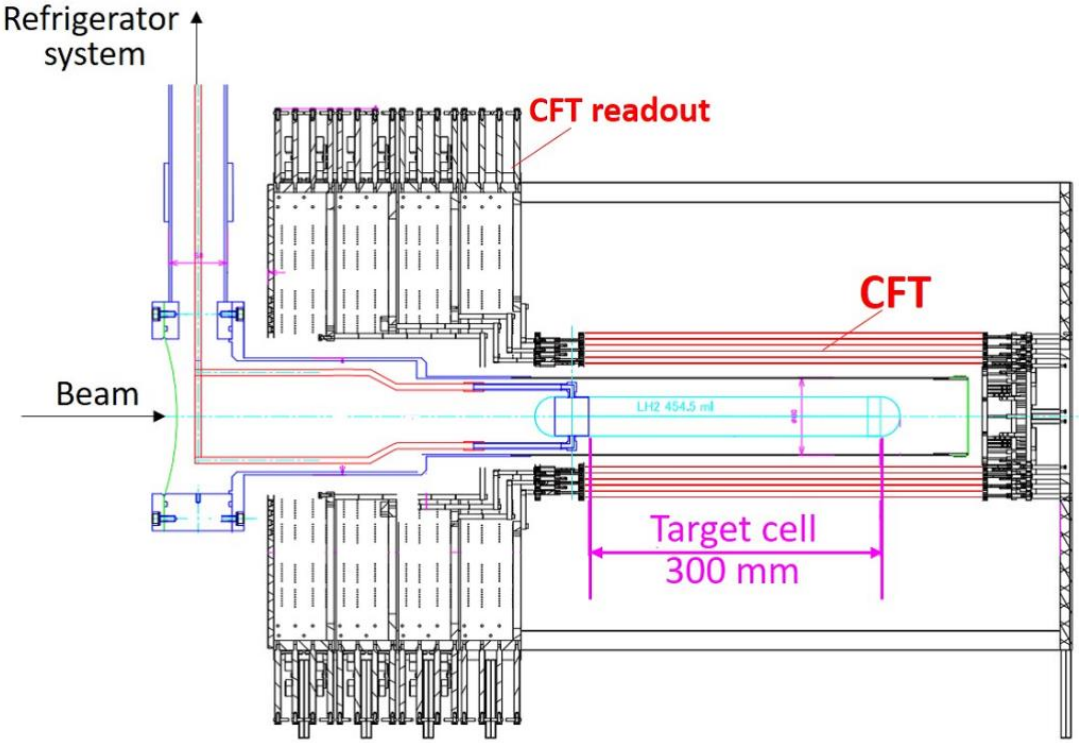
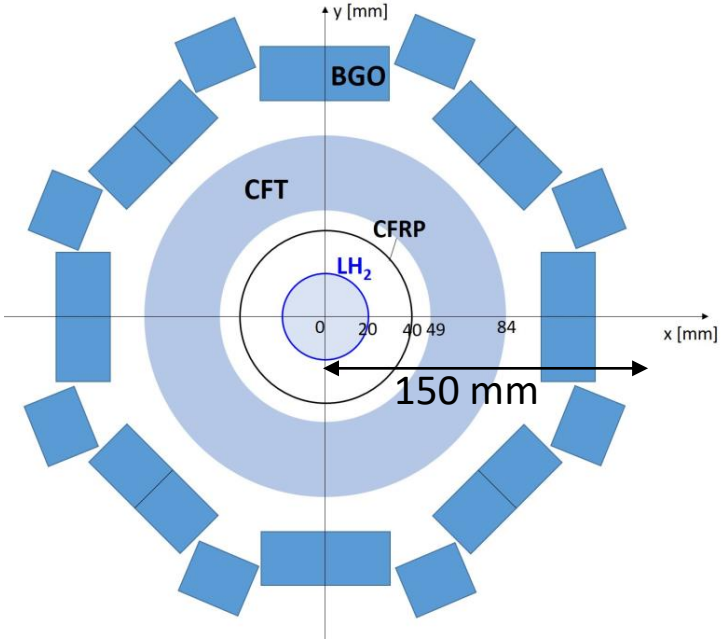


“CATCH”





Main topics : operation of CFT

Measurement of **trajectories** & **energy deposit** by CFT
with combination of **scintillation fibers** & **MPPCs**

Cylindrical Fiber Tracker (CFT)

- Three dimensional tracking

⇒ Two types of fiber arrangement

- 4 Straight layers (Parallel to the beam axis)
- 4 Spiral layers (Along the side of cylindrical shape)

Fibers	1st	2nd	3rd	4th
Straight layer	584	692	800	910
Spiral layer	426	472	510	538

Each fiber signal is
read by MPPC fiber by fiber.

Fiber : 0.75 mmΦ (Kuraray SCSF-78M)
MPPC : 1 × 1 mm^2, 400 pixels
(HPK S10362-11-050P)

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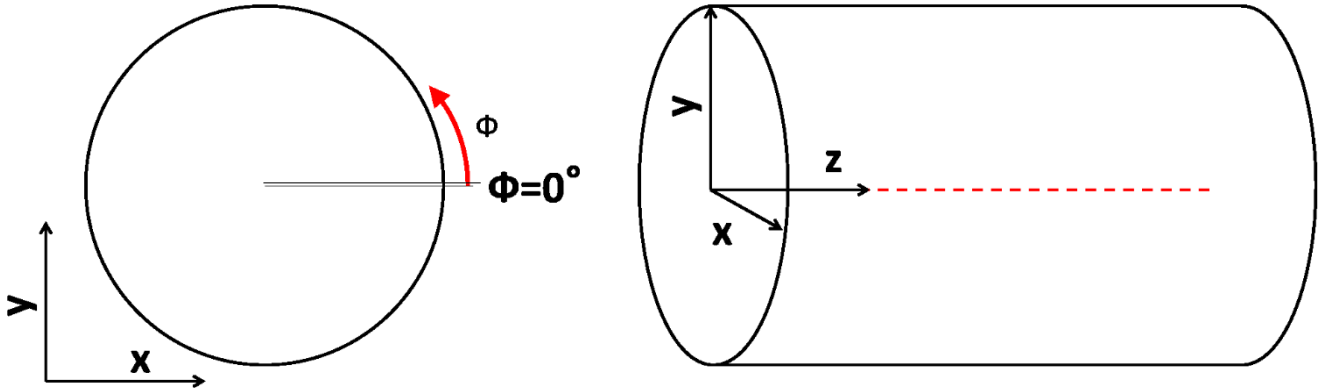

Straight layer Hit segment measured "Φ" position

Spiral layer *z* position is obtained by hit segment and Φ

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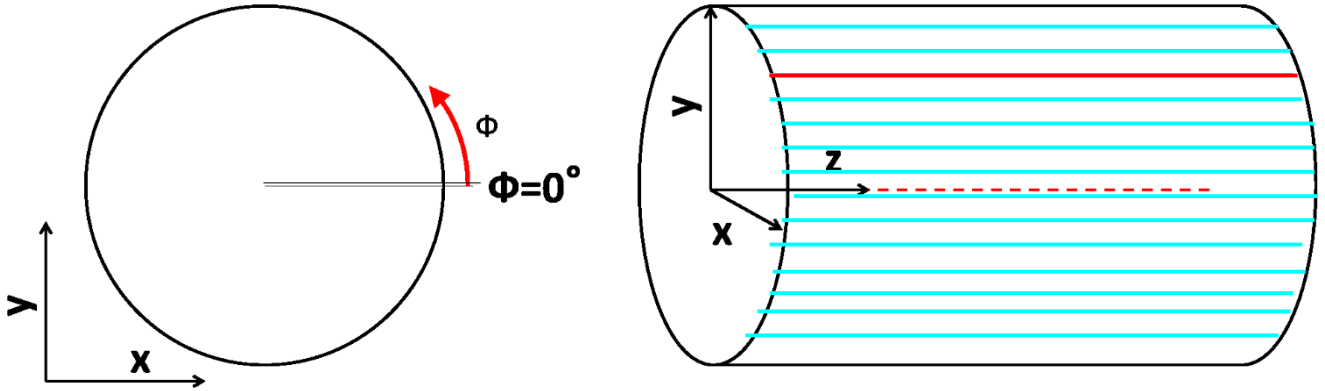

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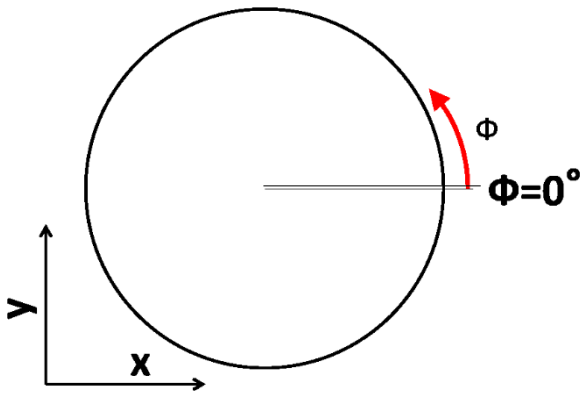
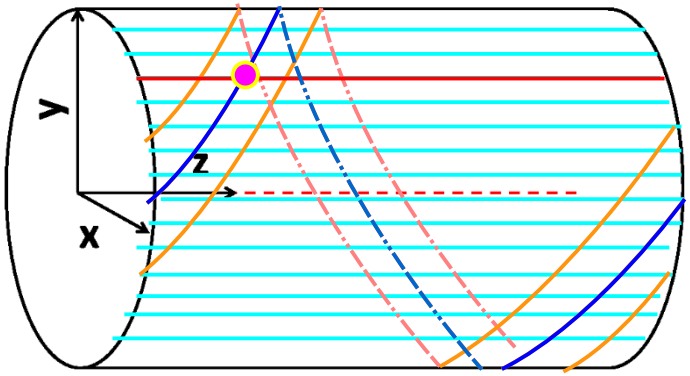


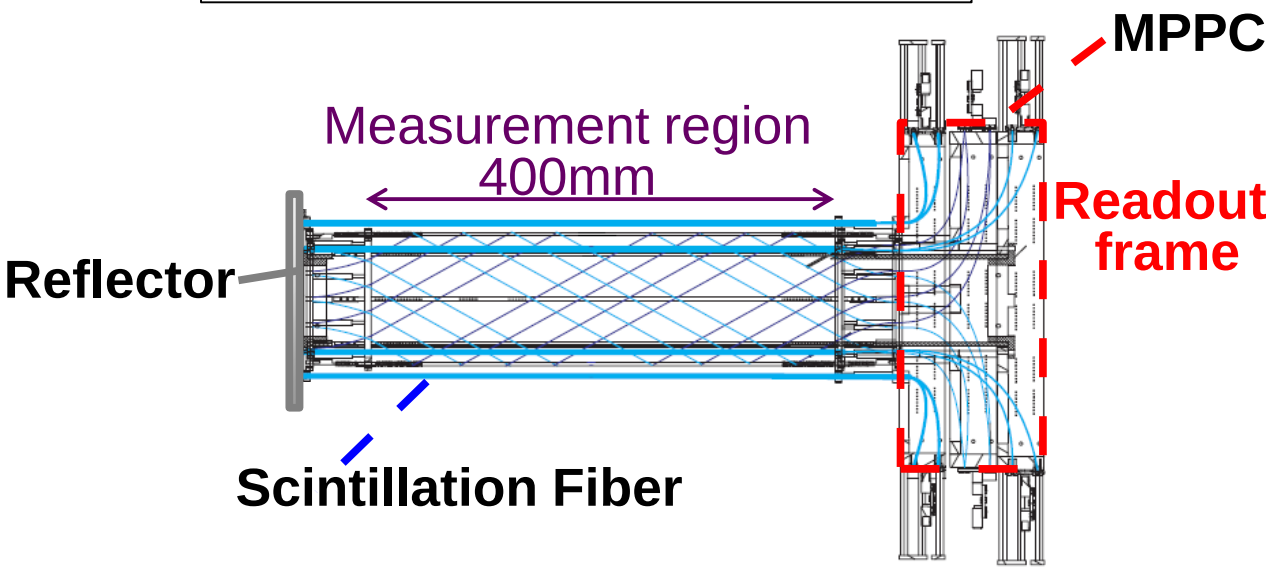


Straight layer Hit segment measured "Φ" position

Spiral layer z position is obtained by hit segment and Φ

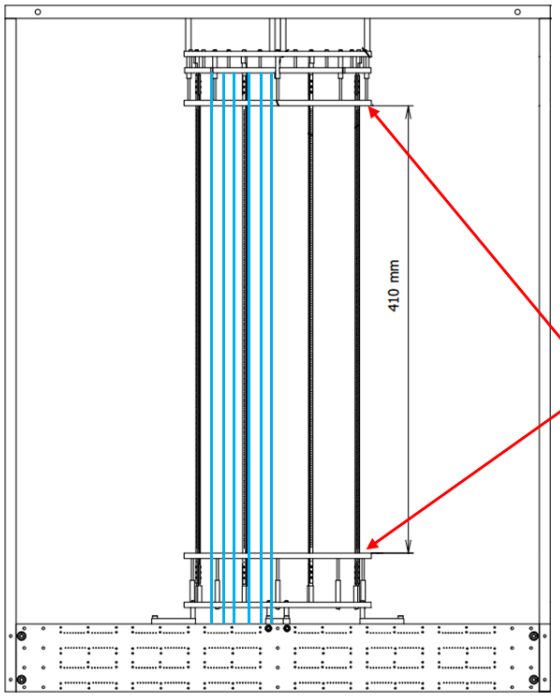
Fabrication of CFT

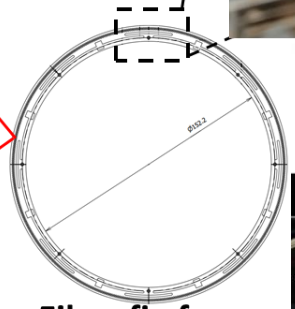
- Fiber placement
  - Straight layer
  - Spiral layer
- MPPC Readout

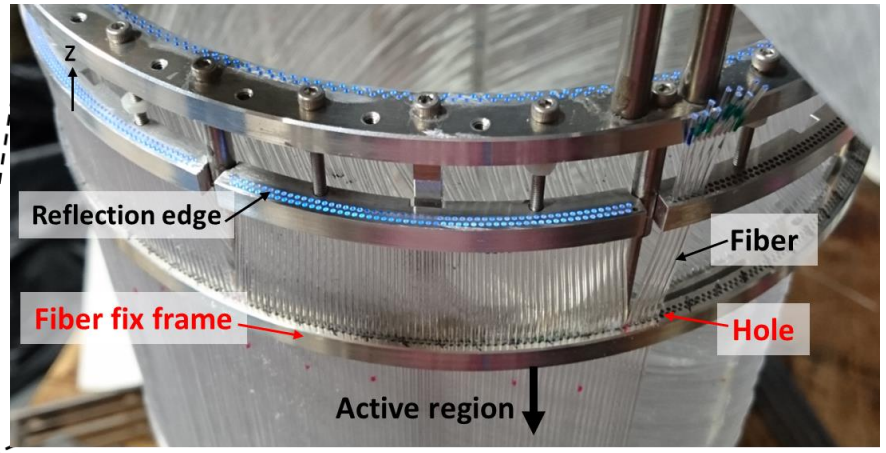


Fiber Placement : “Straight layer”

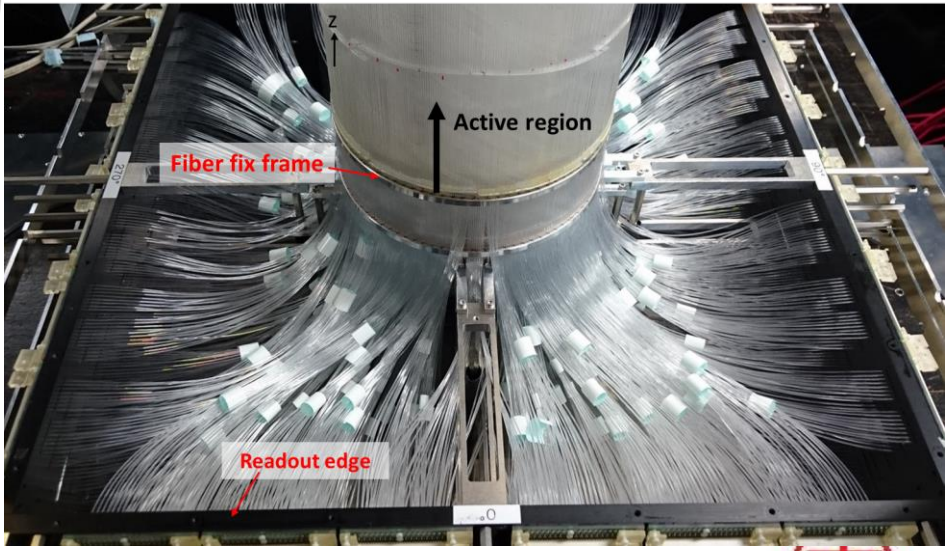
Each fiber passes through
a hole on the “Fiber fix frame”







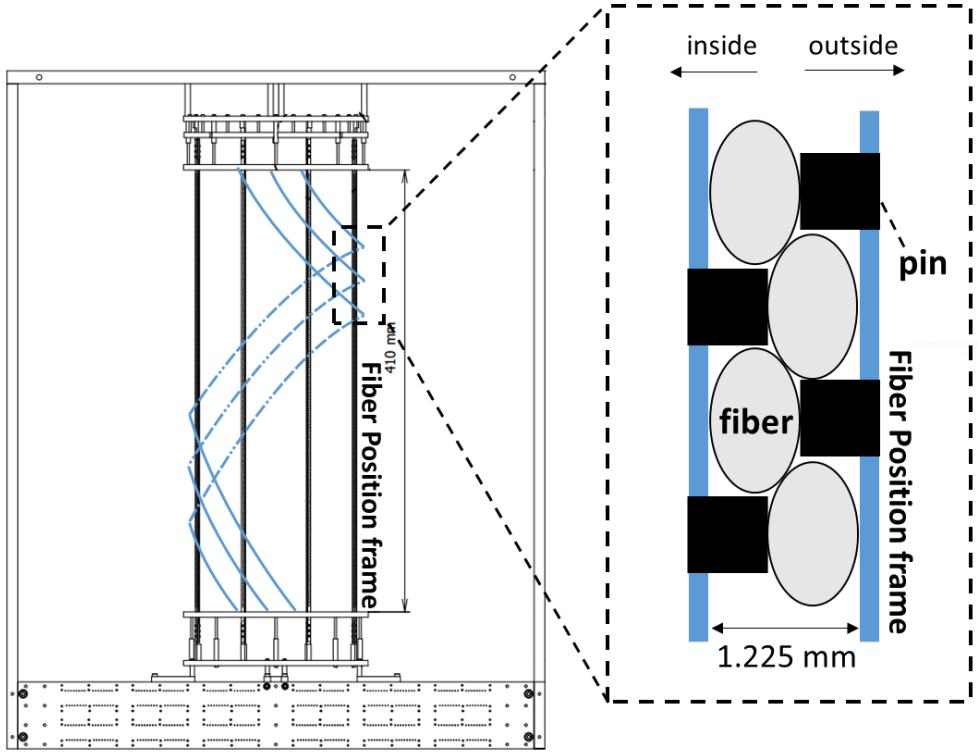
Kuraray SCSF-78M
Diameter : 0.75mm

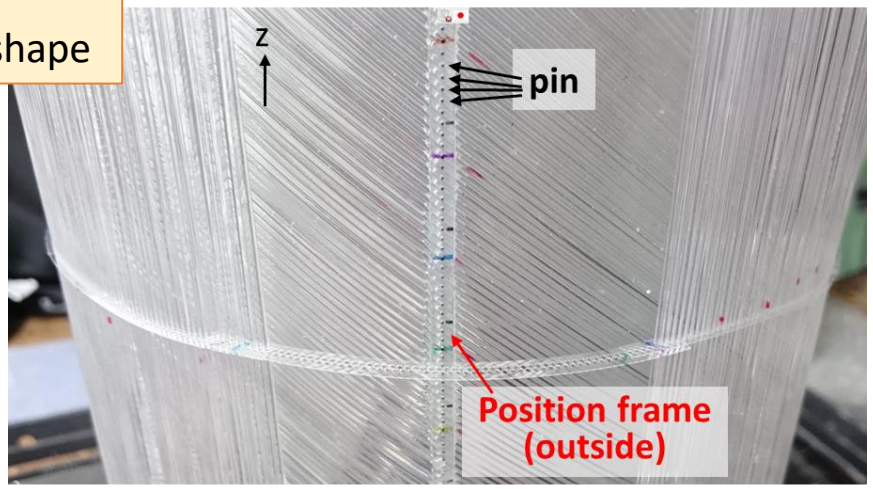


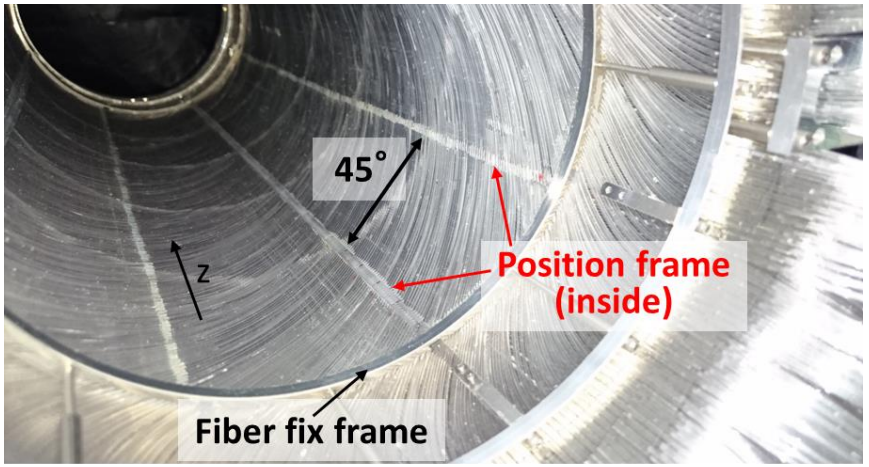
Two fiber fixing frames are installed
at both ends of the measurement region.

Fiber Placement : “Spiral layer”

Fibers are fixed to the “Fiber position frames”
at eight circular points with 45° interval in a cylindrical shape





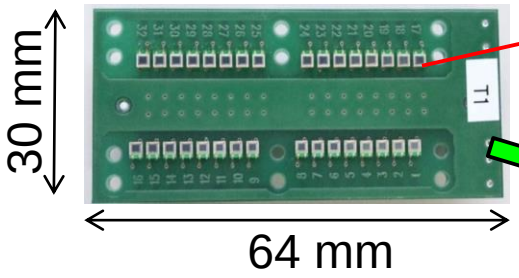


Fiber position is decided at each 45°
for realizing the spiral shape.

After fabrication of all layers,
they were combined to one detector.

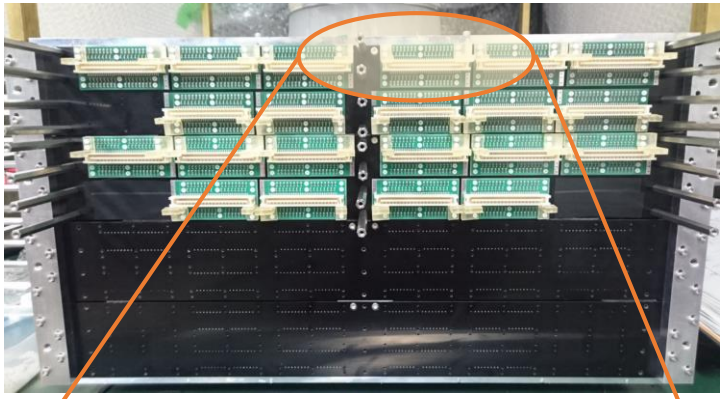
CFT Readout

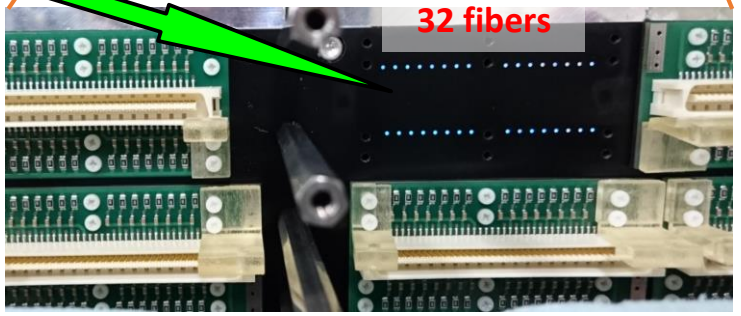
A circuit mounting 32 MPPCs



attach

Readout frame

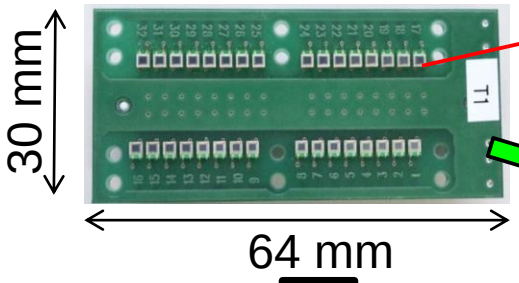




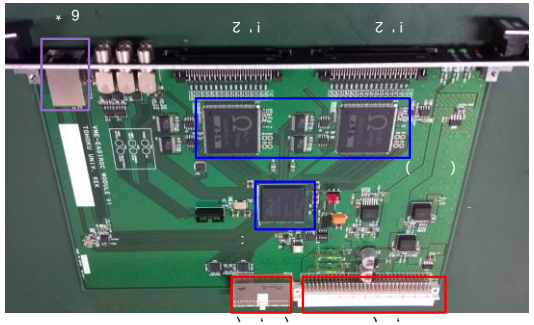
Number of Readout : ~5,000 channel

CFT Readout

A circuit mounting 32 MPPCs



VME EASIROC board



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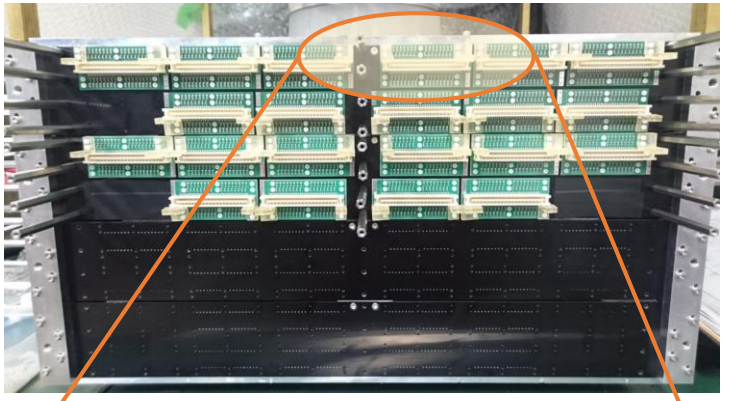

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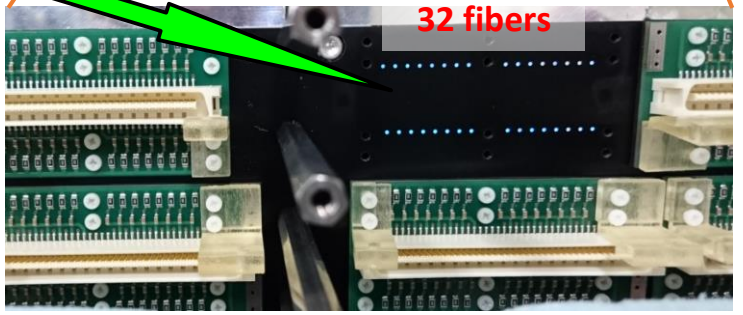


ADC , TDC , bias adjustment etc...
64 ch / board (2 EASIROC chip)

EASIROC chip : proceedings of NDIP 2011 Omega/IN2P3
EASIROC board : R. Honda PD12

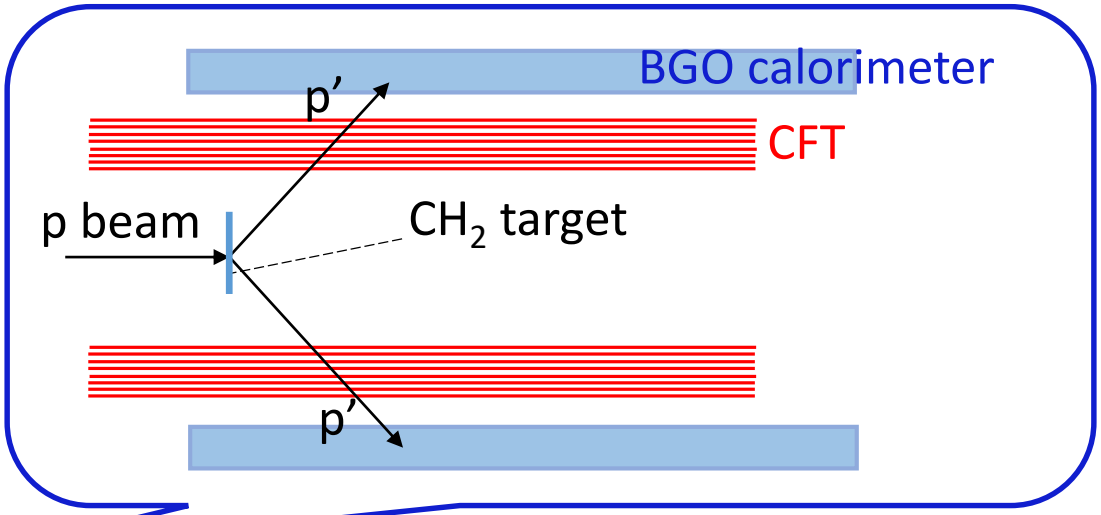
Number of Readout : ~5,000 channel
⇓⇓
32 MPPC circuits × 157
+
VME-EASIROC board × 79

Operation of CFT

- Reconstruction of trajectories
- Measurement of Energy deposit
  ⇒Particle separation of π/proton

Operation of CFT

~2014 **Prototype test**
2015~2016 **Fabrication of Actual type**
2017 **pp, pC scattering experiment @CYRIC** **with 80 MeV proton beam** first performance evaluation
2018 **Σp scattering experiment @ J-PARC** **with 1.32 GeV/c π beam** A part of it was performed.



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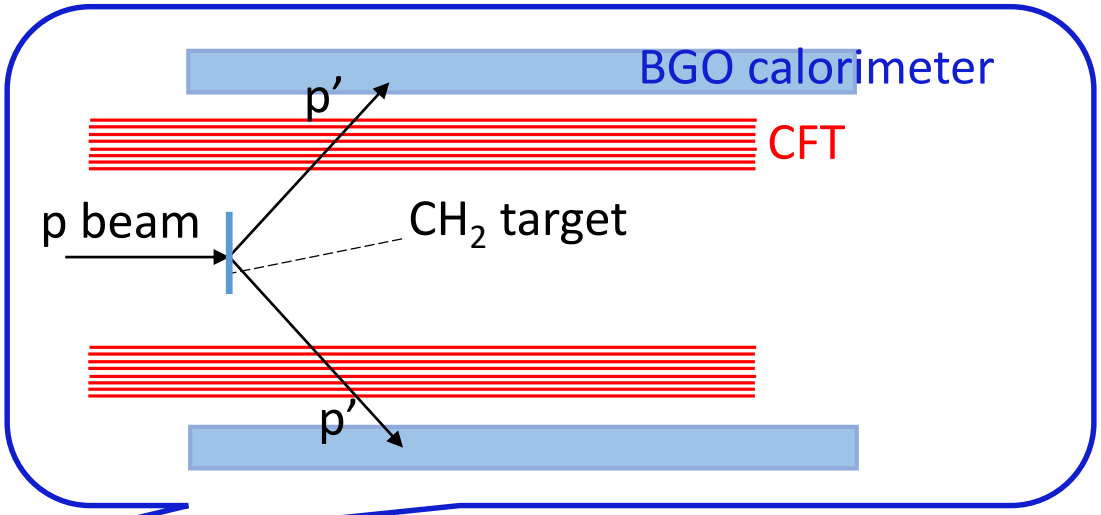

Results of performance evaluation

Angular resolution・・・ σ_θ = 1.6° (5~80 MeV proton)
- Fiber position was calibrated with cosmic ray

Energy resolution
- CFT・・・**20%(σ)** for 8~20 MeV proton
- BGO・・・**1.5%(σ)** for 80 MeV proton

Time resolution ・・・ Better than **2 ns(σ)**

Cross section accuracy (pp, pC scatt.)
- dσ/dΩ was derived by measuring p'
- Measured with **±10%** accuracy

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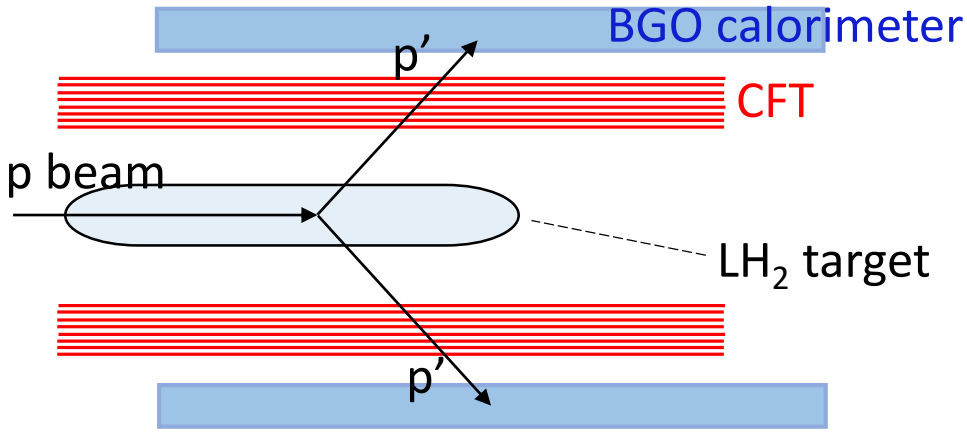

CFT measured the scattering angle θ.
BGO energy was calibrated with
the correlation between θ and Ep'.

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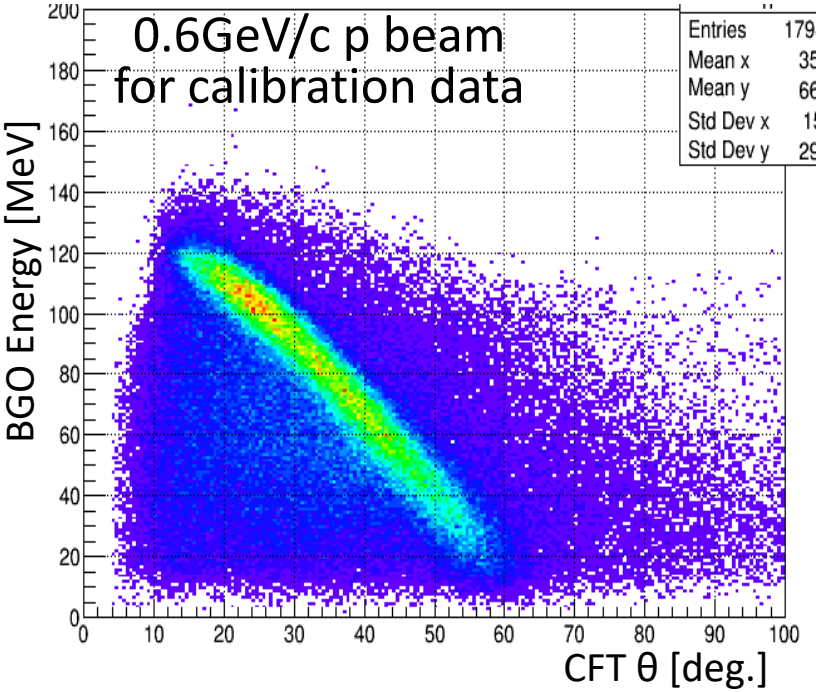

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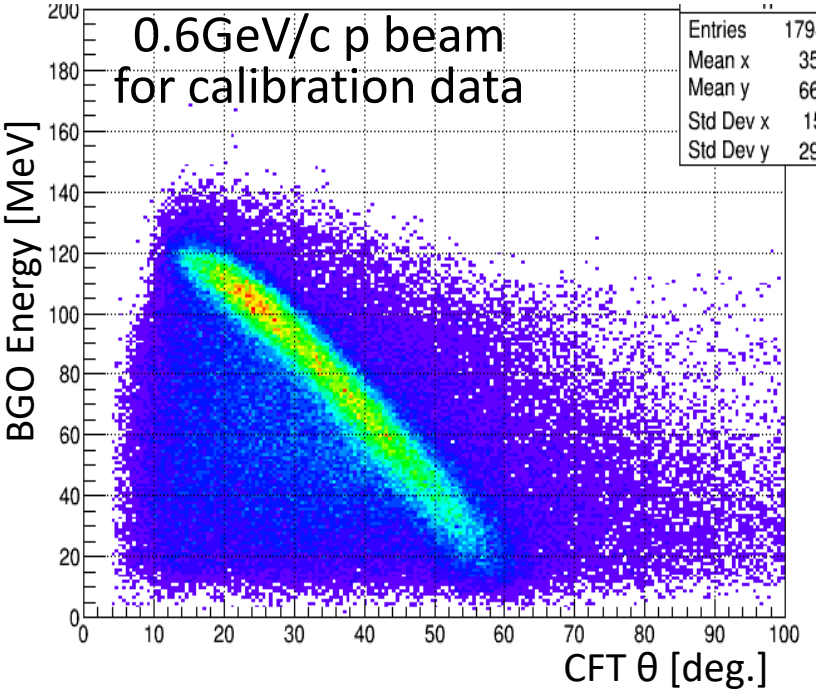

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Operation in the Σp scattering experiment

Operation of CFT

A part of the Σp scattering experiment was performed in June 2018.
10 MHz π beam was used and 2 MHz singles rate was estimated for CFT.

akazawa akazawa akazawa akazawa akazawa akazawa akazawa akazawa akazawa akazawa akazawa akawaza akazawa akazawa akazawa akazawa

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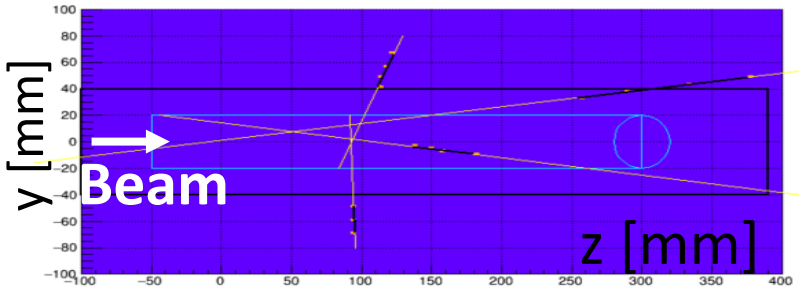
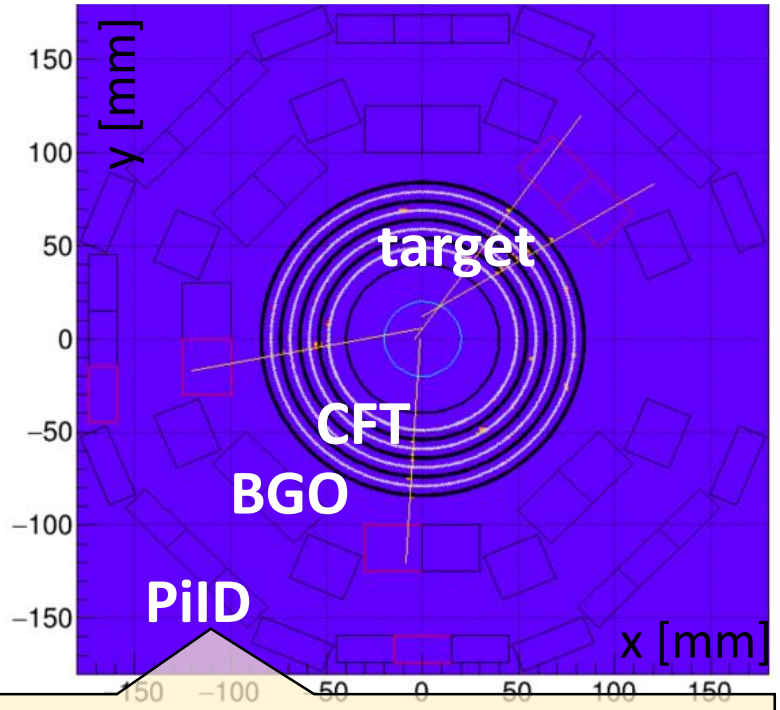


CFT measured trajectories
even in the high rate environment.



PiID Counter :
Almost π penetrates the BGO calorimeter
⇒ hit information of the PiID counter helps **the separation of π / proton.**

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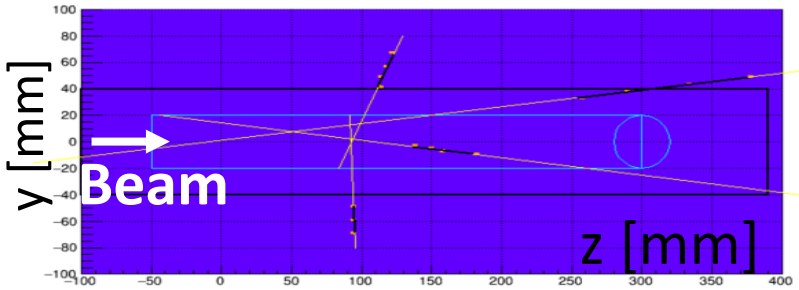

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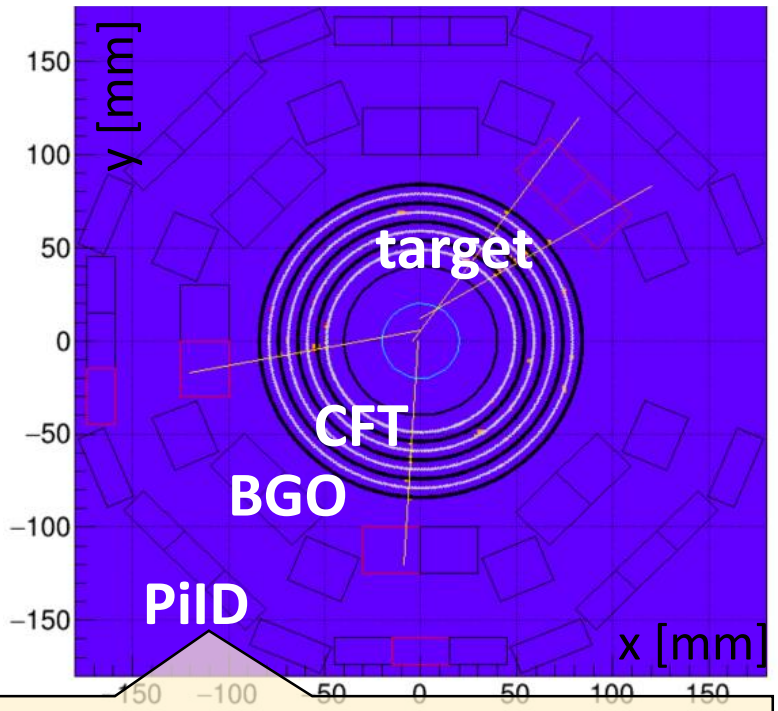
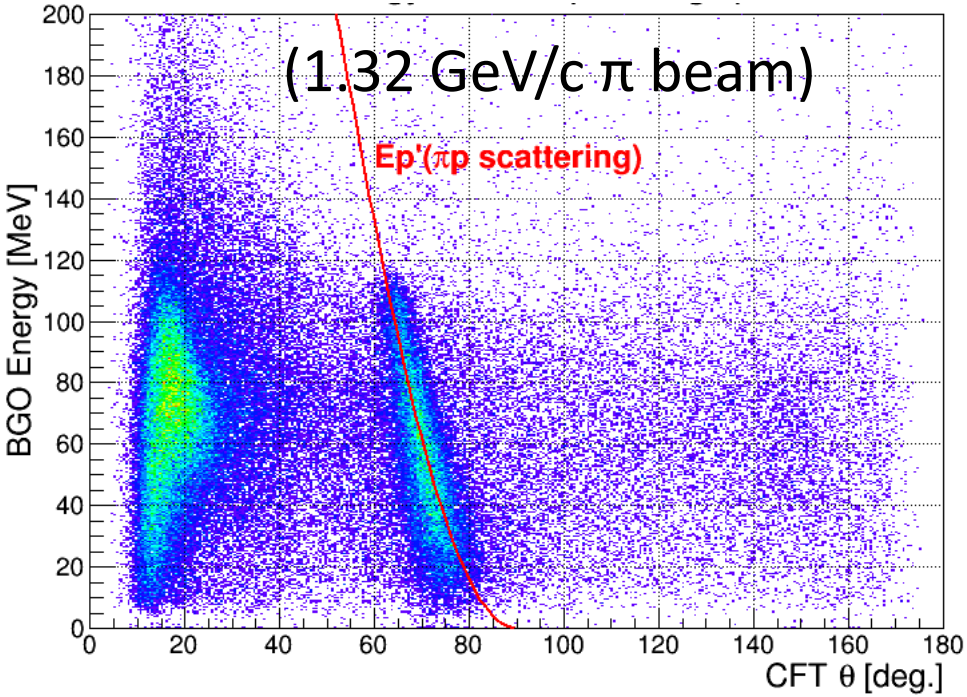


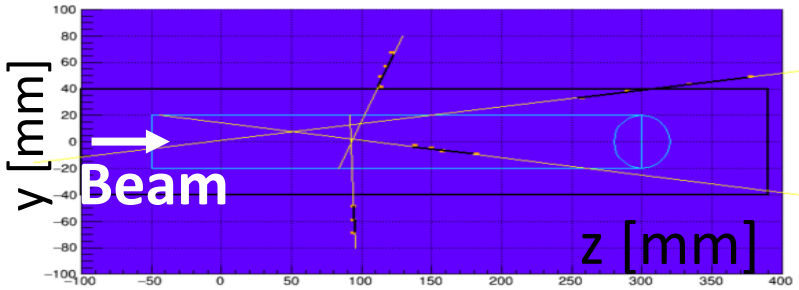


Energy calibration of BGO calorimeter
was performed by the pp scattering data.

PiID Counter :
Almost π penetrates the BGO calorimeter
⇒ hit information of the PiID counter helps
the separation of π / proton.

Operation of CFT

A part of the Σp scattering experiment was performed in June 2018.
10 MHz π beam was used and 2 MHz singles rate was estimated for CFT.



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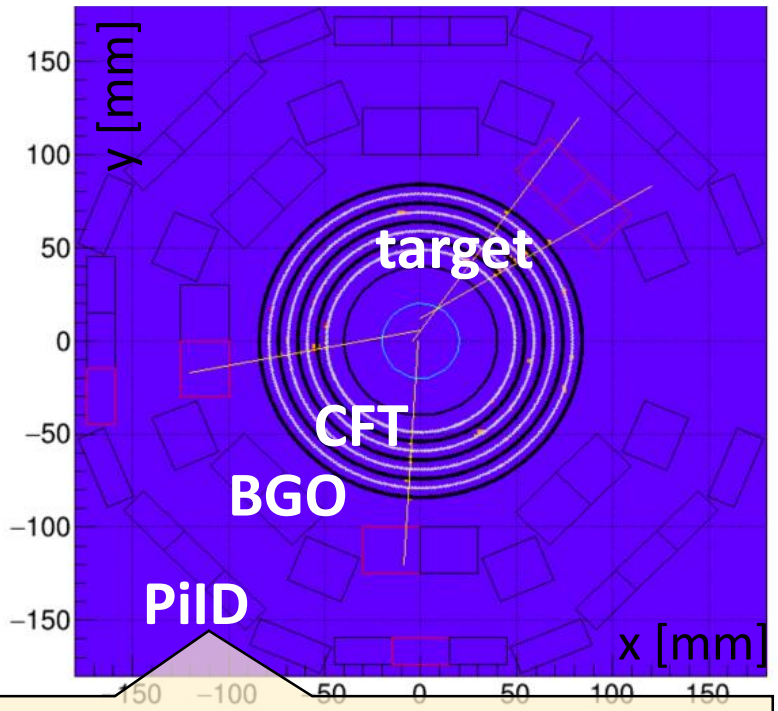

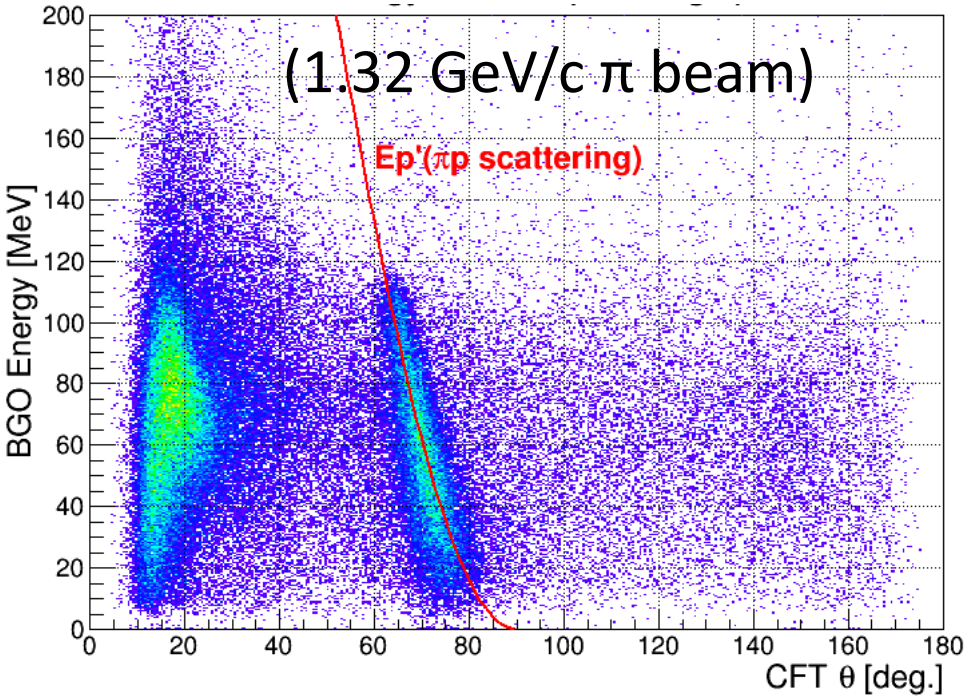

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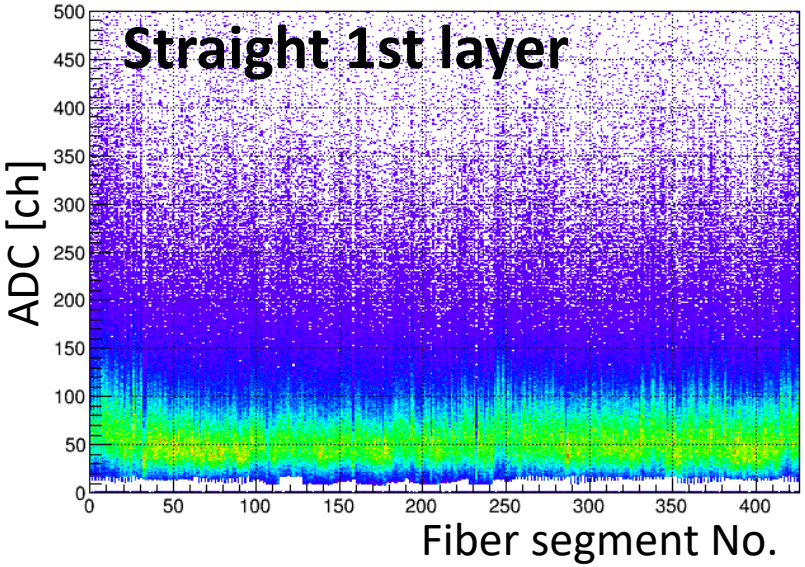
- Energy calibration
- Particle identification

Operation of CFT

TDC and **ADC** for all fiber channel was taken.

Energy calibration



× 8 layers

Fibers	1st	2nd	3rd	4th
Straight layer	584	692	800	910
Spiral layer	426	472	510	538

MPPC bias voltage is modified with the EASIROC board.

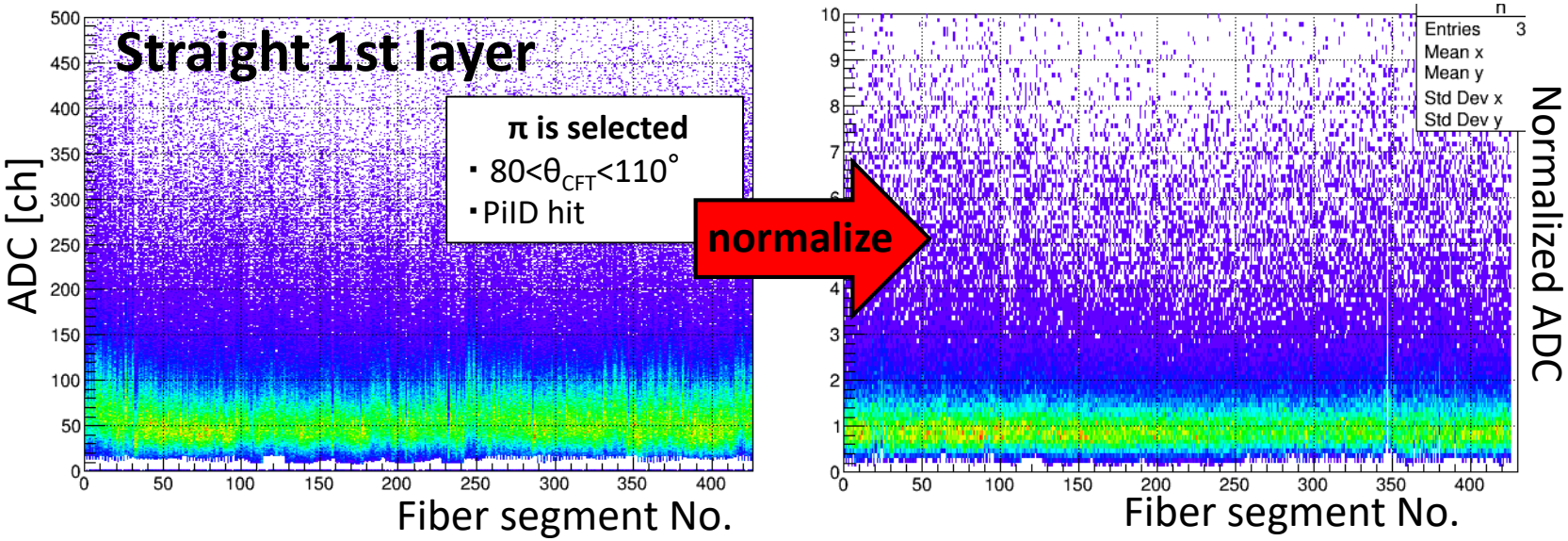
⇒ Gains could not be unified completely.

Due to noise and so on

Operation of CFT

TDC and **ADC** for all fiber channel was taken.

Energy calibration



We calibrated the energy for each layer as a first step.

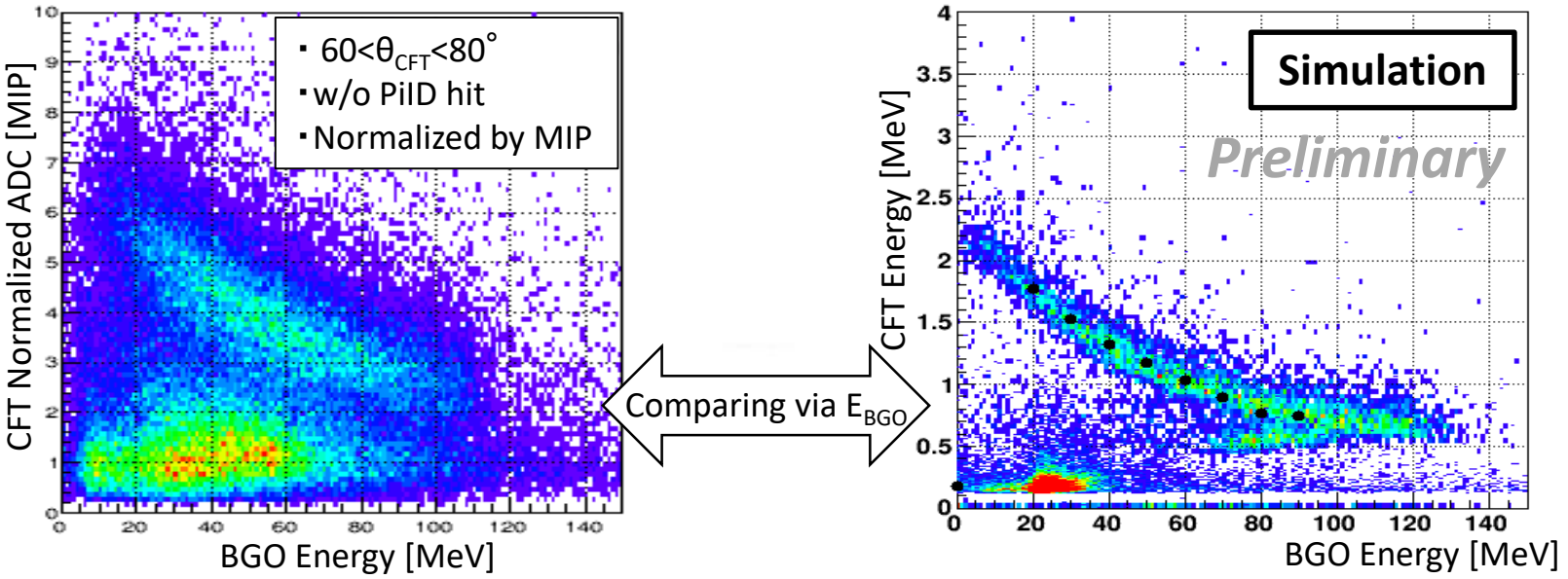
(⇒ It is better to do it for each channel.)

We normalized the each MPPC gain with the MIP peak for unified handling.

Operation of CFT

TDC and **ADC** for all fiber channel was taken.

Energy calibration



scattered π' & recoil p' from πp scatt.

Operation of CFT

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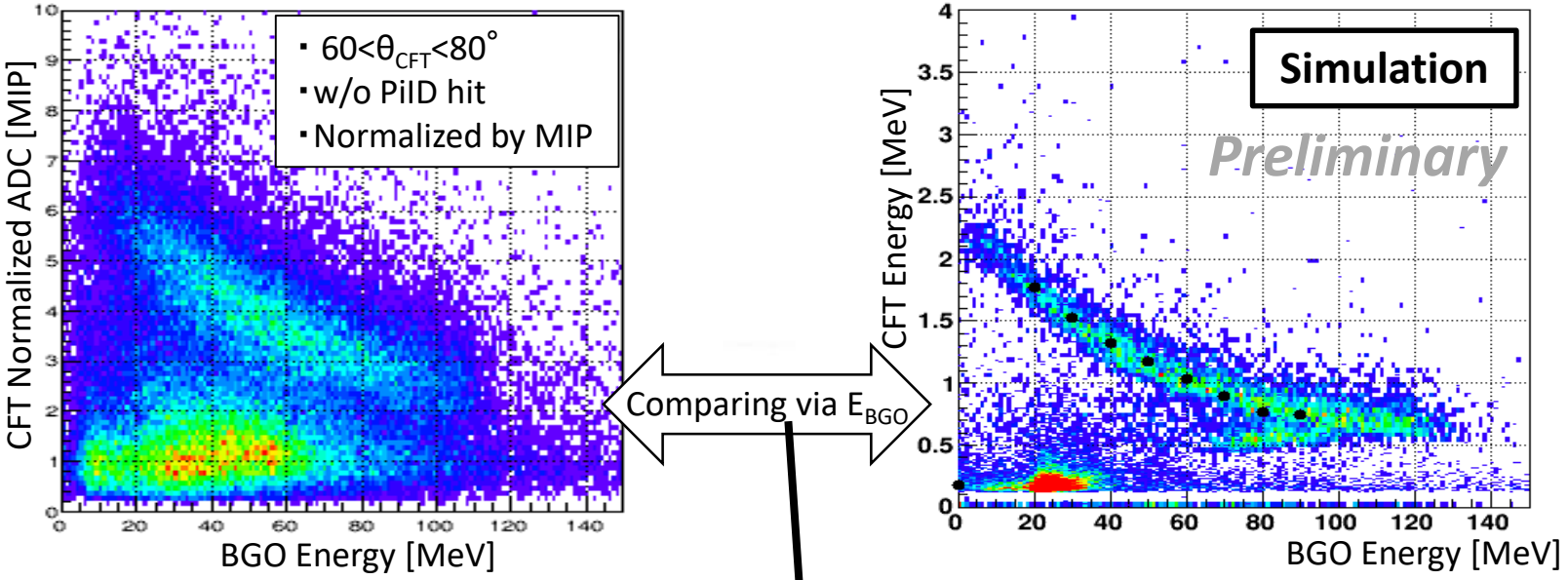
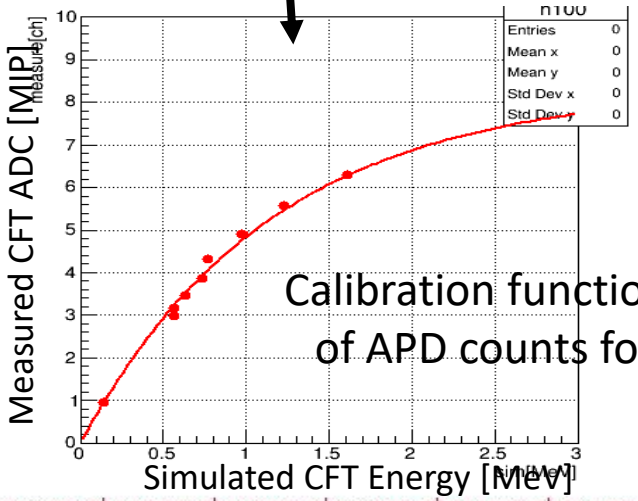
Energy calibration





Calibration function considering the saturation of APD counts for large number of photons

Particle identification

Since pions from Σ decay and π beam etc. are measured together with protons, particle discrimination is necessary.

⇒ ***ΔE-E*** correlation

Particles pass through **CFT** and stop in **BGO calorimeter**

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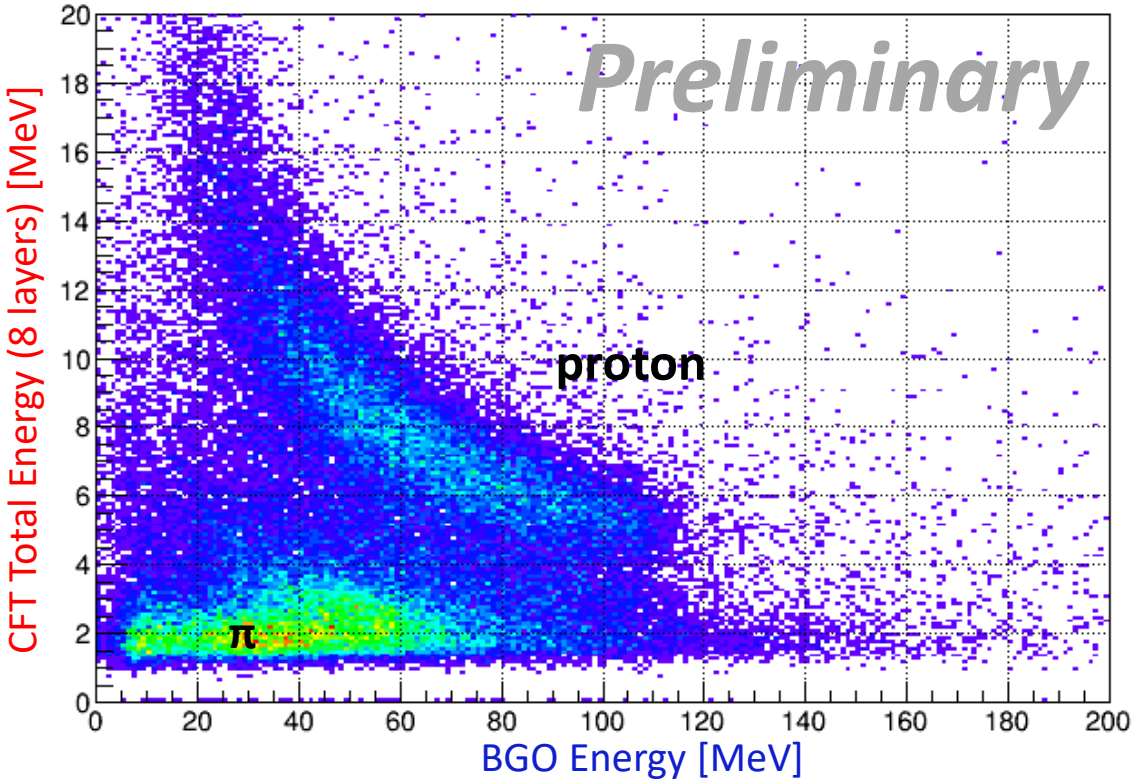

Although analysis is still on going,
the separation of proton and π was performed by CATCH system.

Summary

- A new Σp scattering experiment
  - For study of ΣN interaction
  - dσ/dΩ with high statistics is necessary
    ⇒ A new detector system “CATCH” which measures **Trajectories** and **Energies**
  - It is started from June in 2018.

- Development of Cylindrical Fiber Tracker
  - Two fiber arrangements : Straight and Spiral layers
  - About 5,000 fibers are read by MPPCs.
    MPPCs are read and operated by VME EASIROC boards. ⇒ ADC, TDC

- Performance of CFT
  - Angular resolution of CFT ・・・ $\sigma_\theta = 1.6^\circ$
  - Energy resolution ・・・20%(σ) @ 8~20 MeV proton
  - Time resolution ・・・ 2 ns(σ)

- Operation in the Σp scattering experiment
  - CFT works under 10 MHz π beam environment.
  - π and proton is separated with ΔE-E correlation

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