

A decorative diagonal line of small, semi-transparent colored dots (pink, blue, and green) runs from the top-left to the bottom-right of the slide, passing through the text.

# Central Drift Chamber for Belle-II

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НАНАЭ ТАНИГУТИ

Belle-II collaboration

# Belle-II tracker

- SuperKEKB/Belle-II

- $e^+(4.0\text{GeV}) e^-(7.0\text{GeV})$  collider
- target luminosity :  $8 \times 10^{35} \text{ cm}^{-2}\text{s}^{-1}$ 
  - challenges for high luminosity (KEKB X40)

Detector/readout is fully upgraded

- Role of charged particle tracker of Belle-II

- momentum measurement
  - momentum of charged particles : 1-2 GeV/c
- tracking
- trigger signal
- particle identification

multiple scattering effect is dominant  
to momentum resolution  
→ low material detector

gas/wire chamber

fast readout electronics

# low material

10mm Aluminum endplates

5mm CFRP outer cylinder

0.4mm CFRP inner cylinder

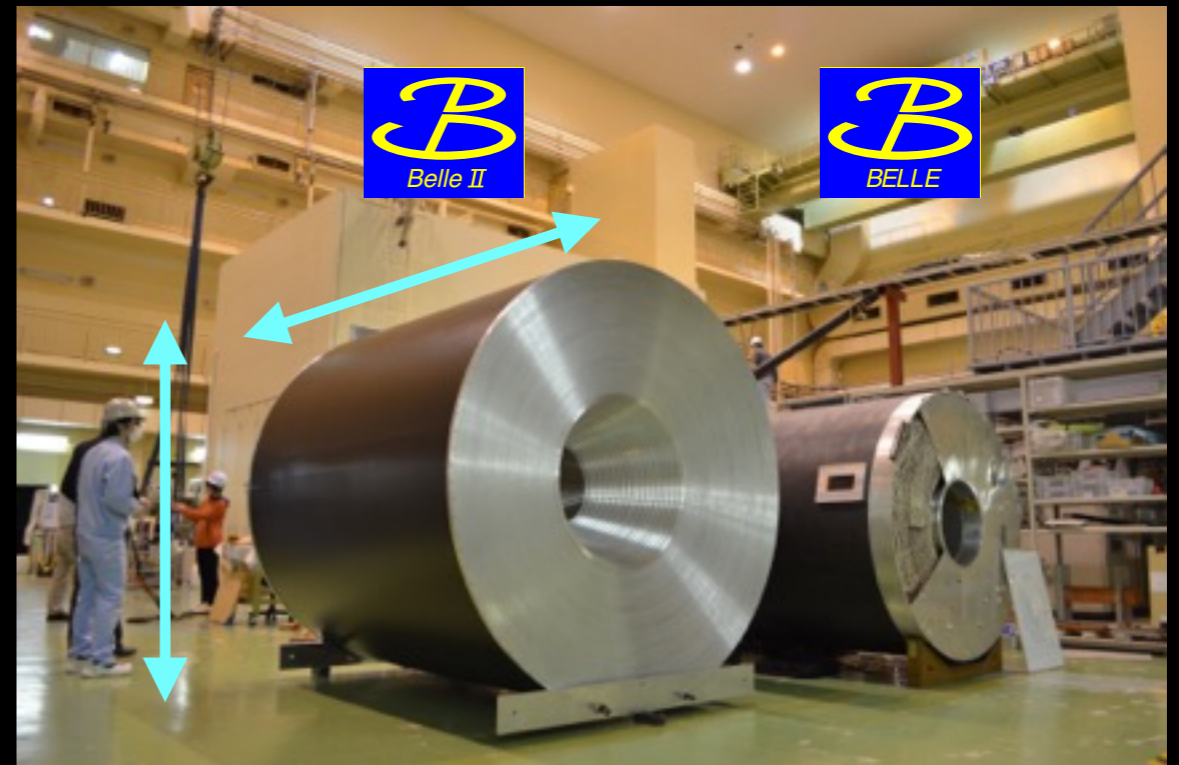
30 $\mu$ m  $\Phi$  Au-W sense wire (14336)

126 $\mu$ m  $\Phi$  (no-plated) Al field wire (42240)

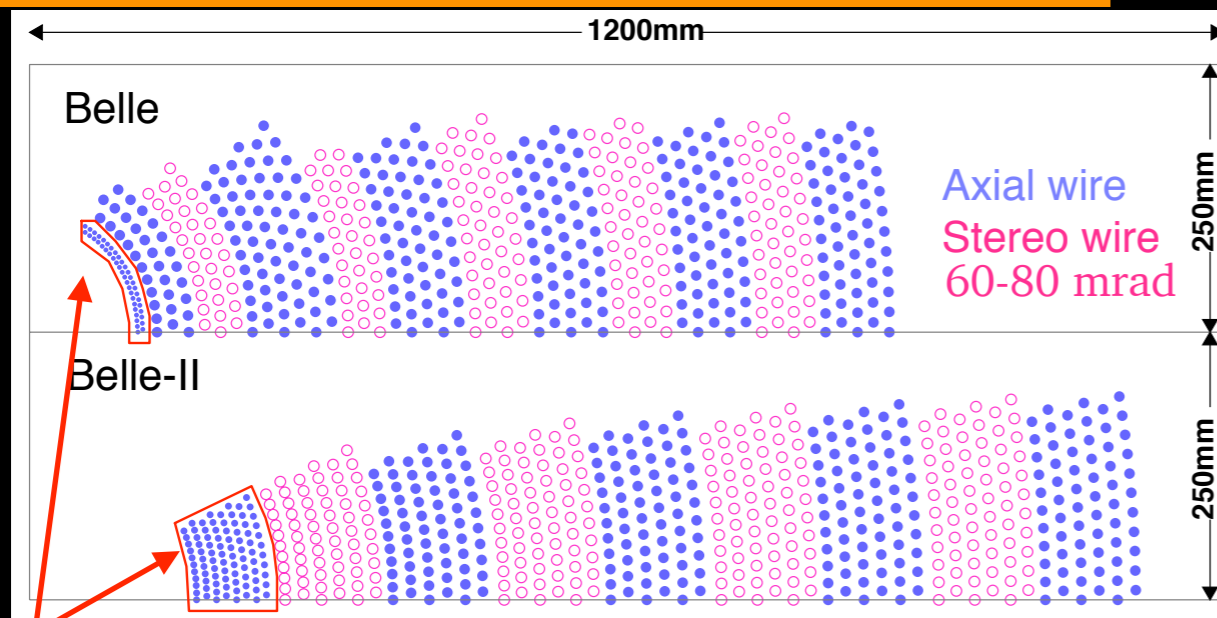
He : ethane (50:50) mixture gas

5 X axial layers  $\rightarrow$  2D tracking

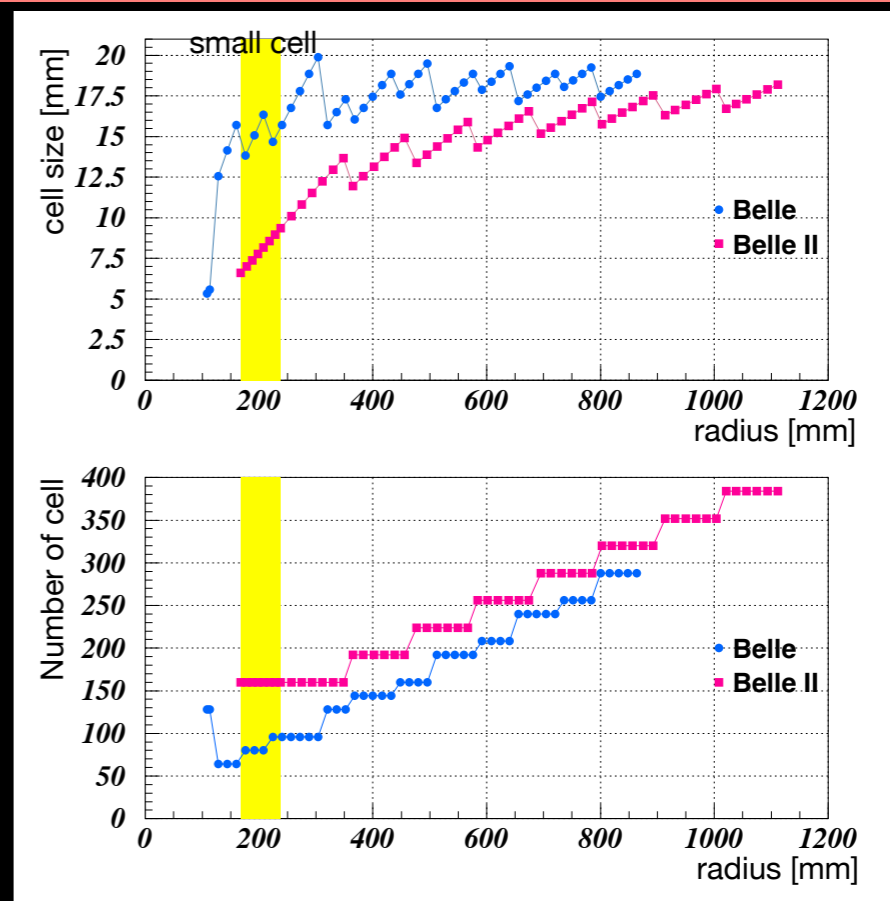
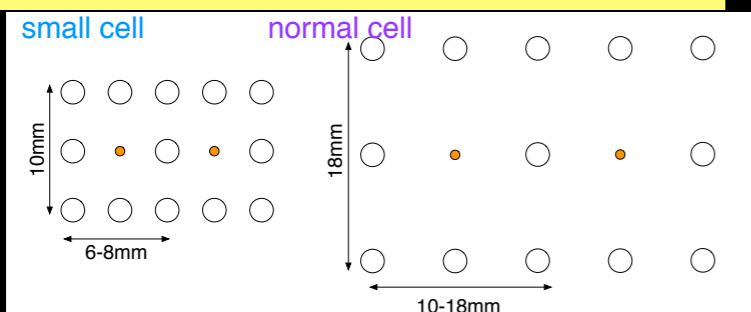
4 X stereo layers  $\rightarrow$  z information



finer  $\Phi$ -division  $\rightarrow$  reduce occupancy  
smaller cell size in  $\Phi$



spatial layers of small cell



## low material

10mmt Aluminum endplates

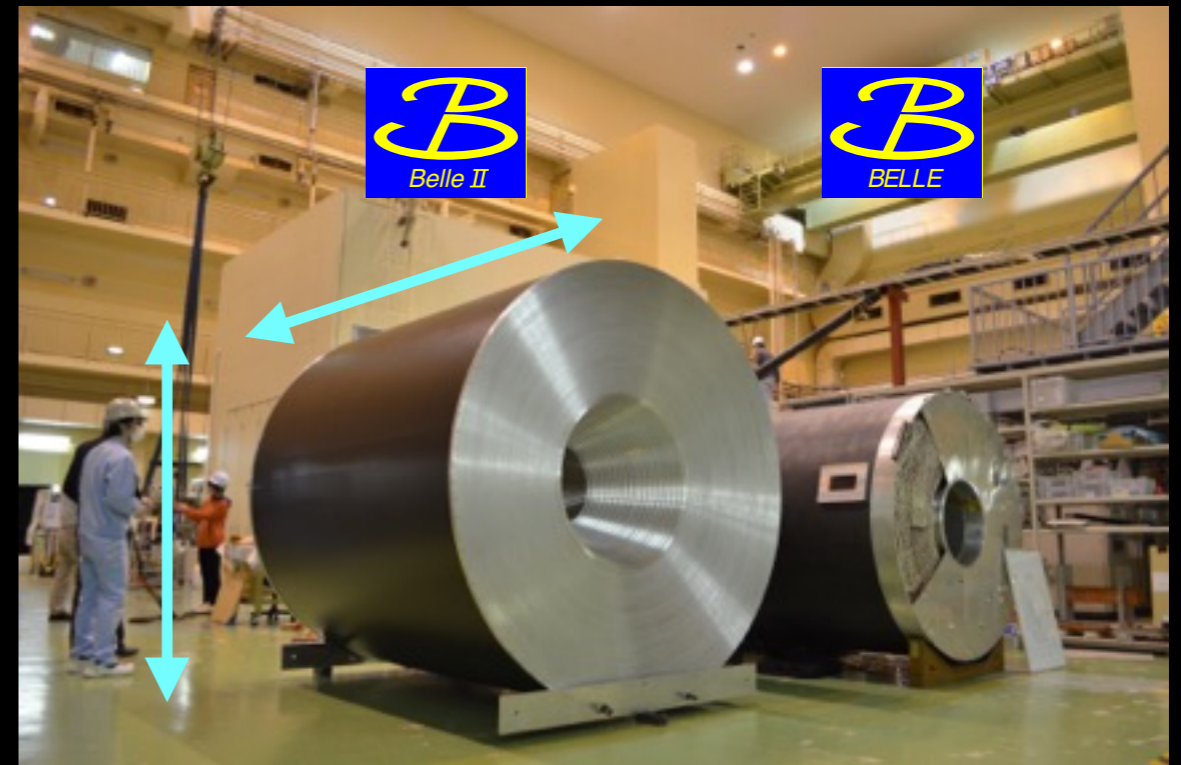
5mmt CFRP outer cylinder

0.4mmt CFRP inner cylinder

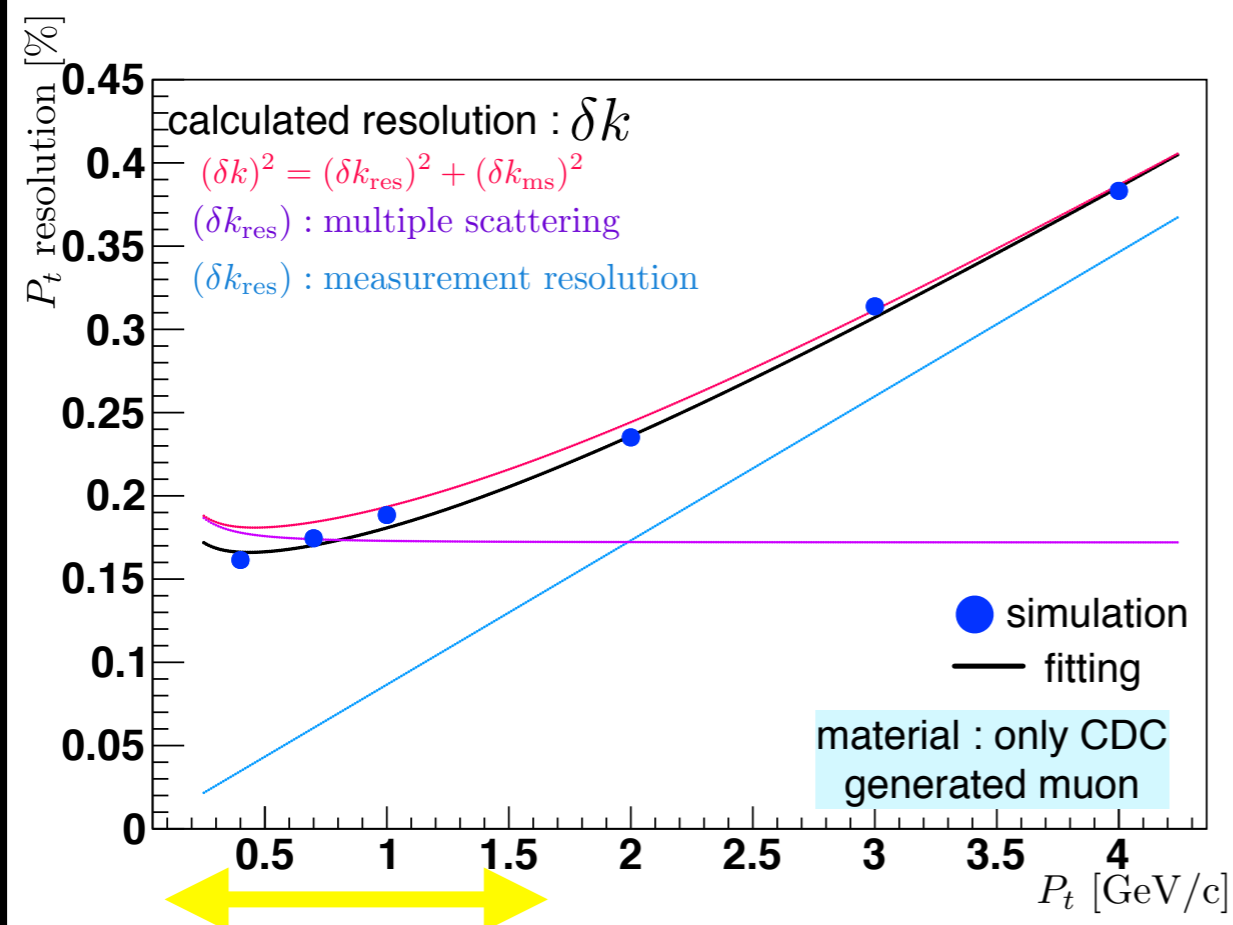
30 $\mu\text{m}$   $\Phi$  Au-W sense wire (14336)

126 $\mu\text{m}$   $\Phi$  (no-plated) Al field wire (42240)

He : ethane (50:50) mixture gas



## calculation and simulation



$$\sigma_{r\phi} = 100\mu\text{m}$$

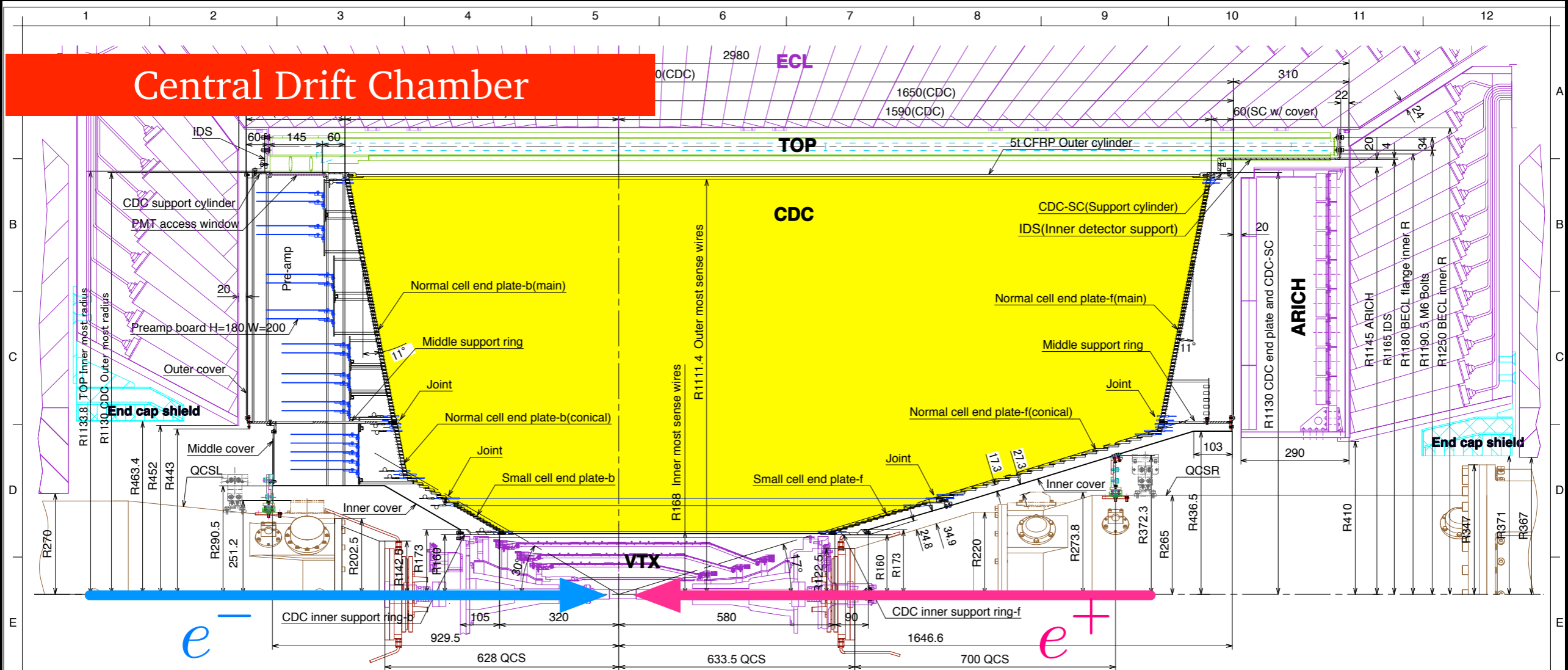
$$B = 1.5\text{T}$$

$$\text{Number of layers} = 56$$

$$X_0 = 269.471\text{m}$$

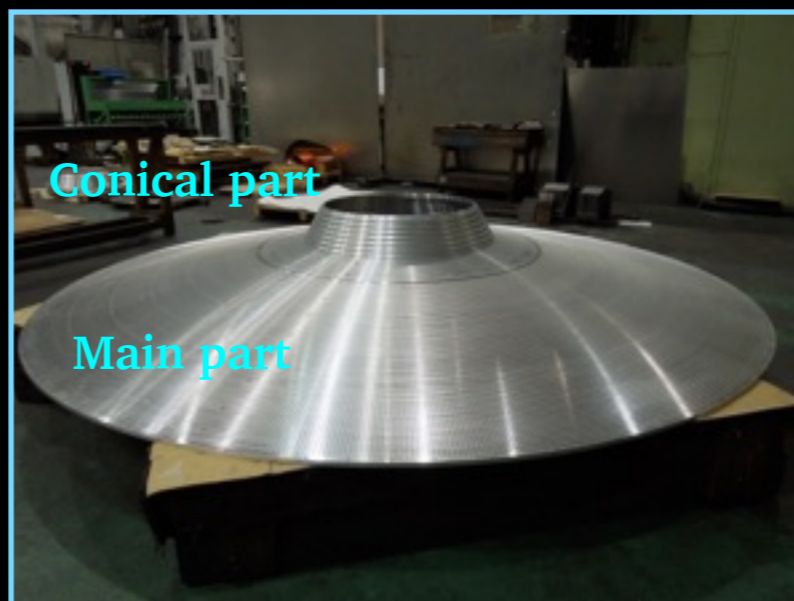
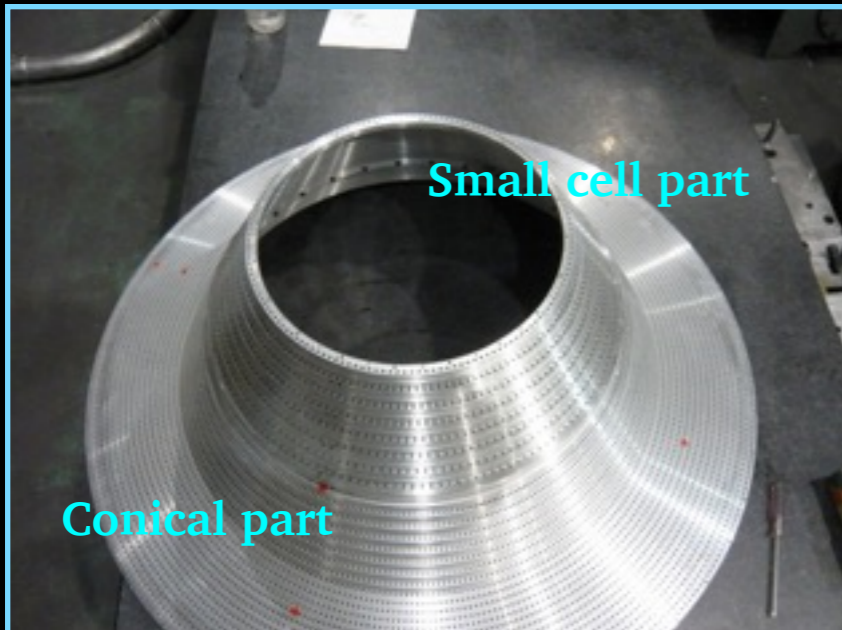
multiple scattering effect is dominant to momentum resolution

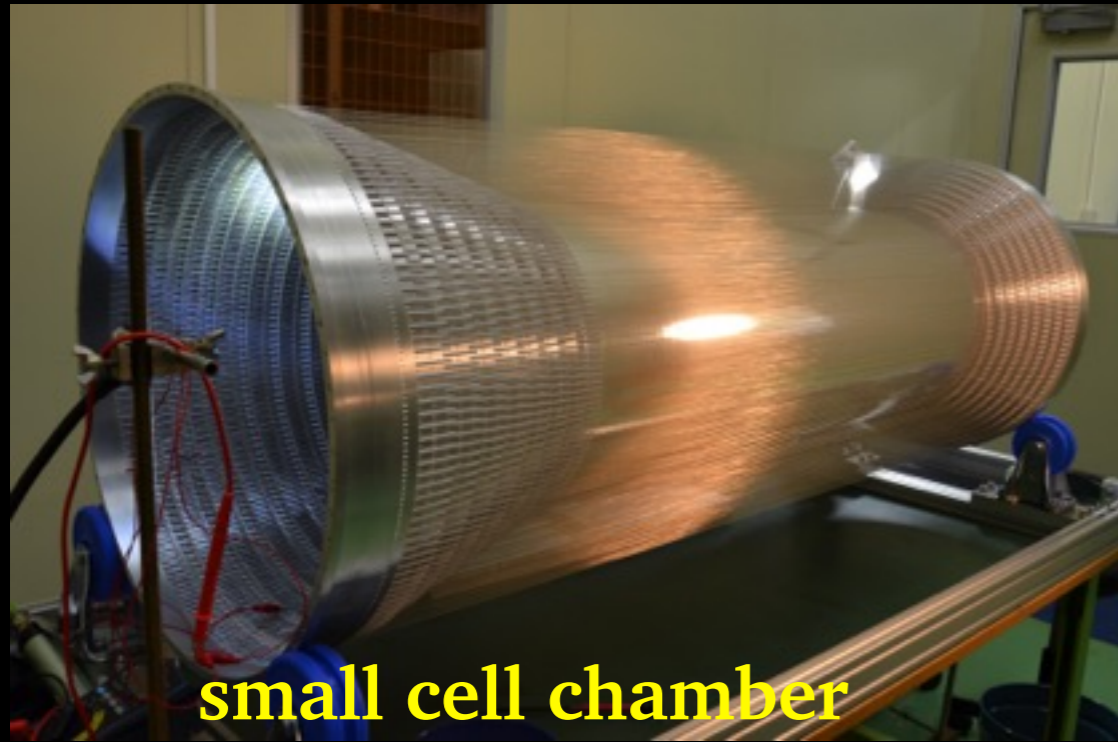
# Central Drift Chamber



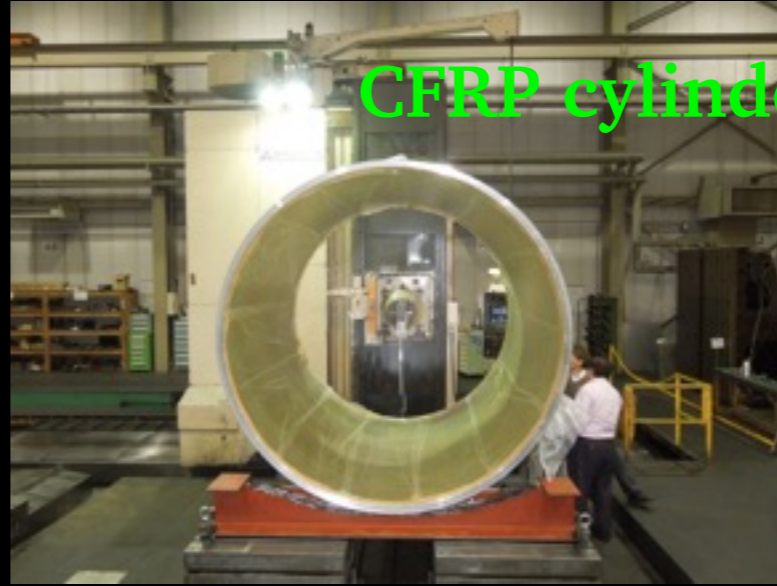
## Backward endplate

## Forward endplate

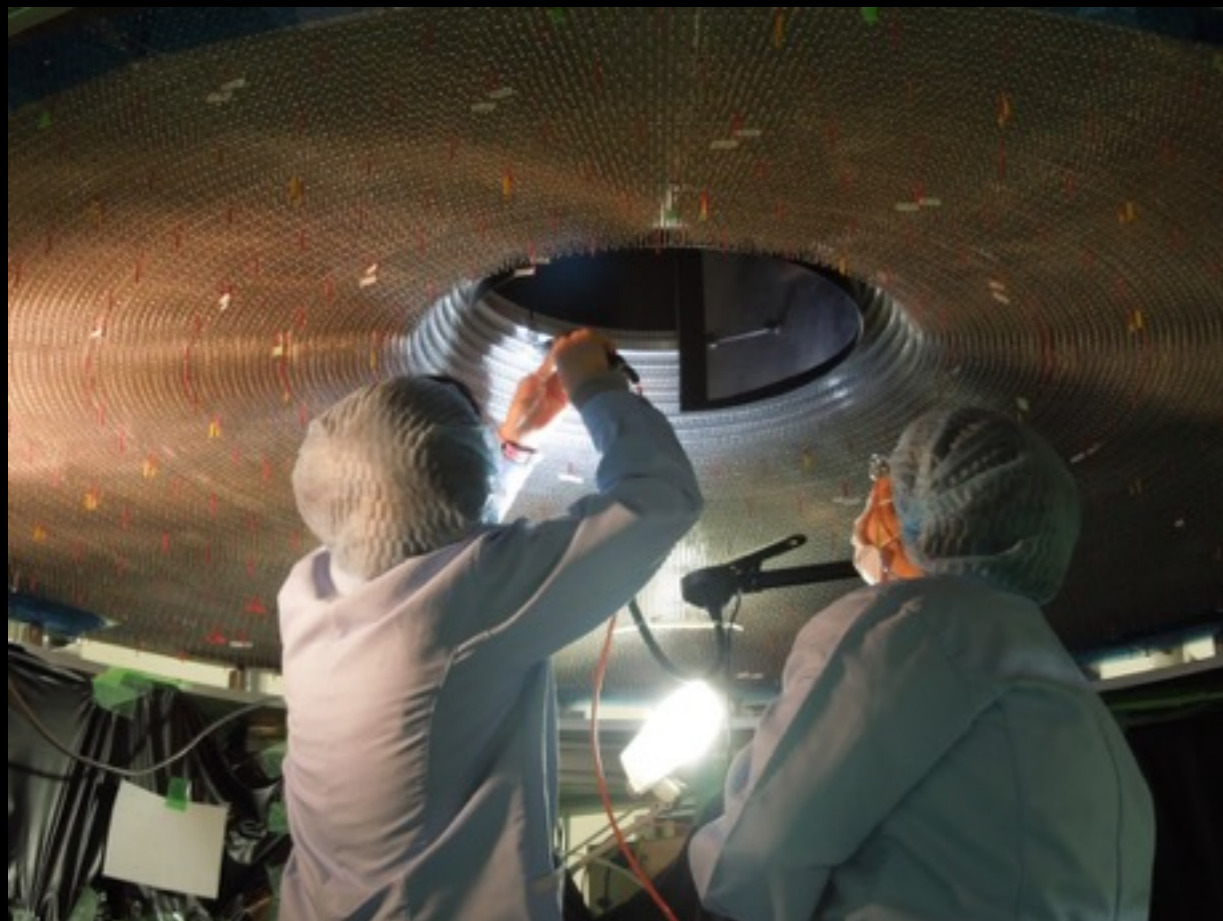




small cell chamber



CFRP cylinder



wire stringing 2012 Dec. - 2014 Jan.

# small cell chamber installation



# Readout electronics

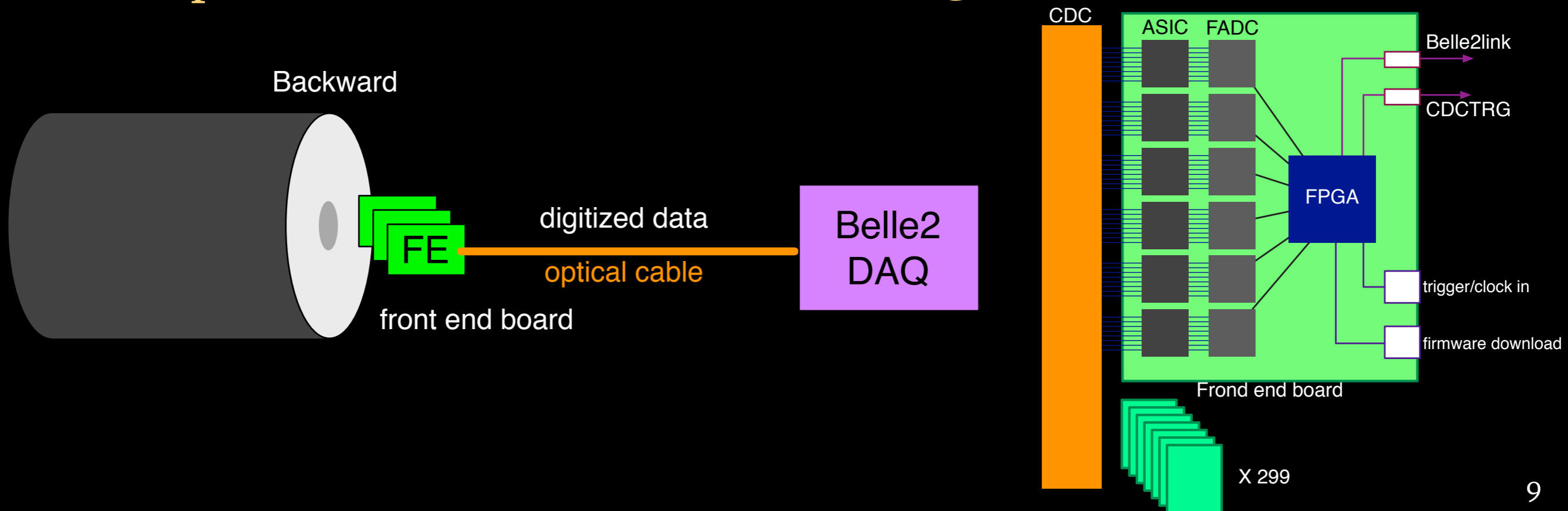


move to the next



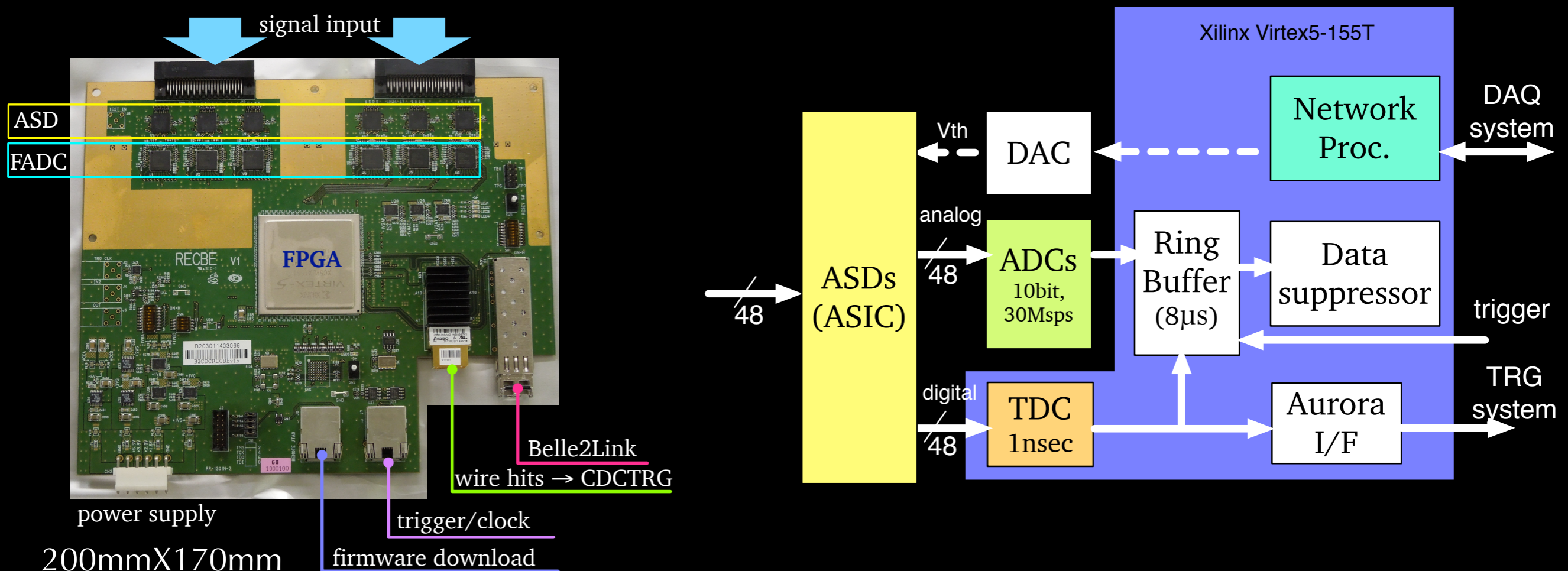
# Readout electronics

- readout electronics is in front of detector
  - signal channels : 14336
- digitized data is transferred to DAQ system
  - Amplifier, Shaper and Discriminator in ASIC
- optical link between FE and DAQ



# Readout electronics

- target trigger rate : 30kHz → pipeline
- position resolution ~ 100um → 1nsec resolution time counting
- dE/dx resolution ~ 6% → 32MHz FADC



2009

2010

2011

2012

2013

2014

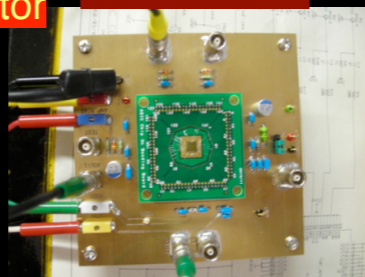
Amplifier



the first ASIC of Amp. Shaper and discriminator

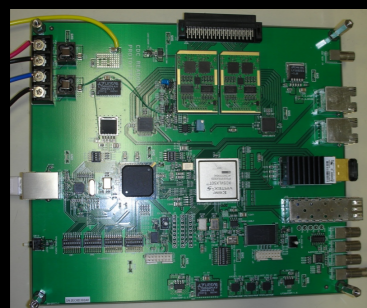


new ASIC



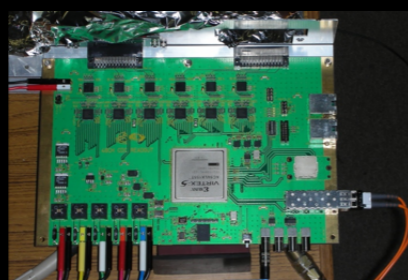
pre-mass production    mass production

16ch

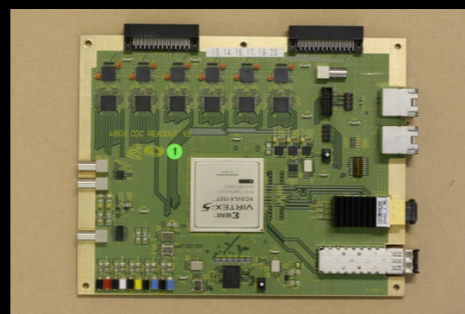


ver.0

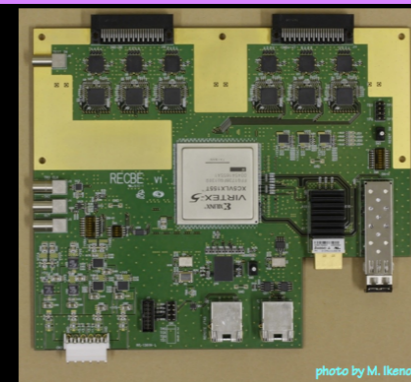
48ch



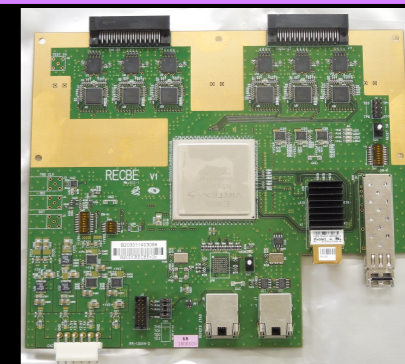
ver.1



ver.2/3



ver.4



ver.4

Beam test

Beam test

Beam test

ASIC mass production (~31k)

FE mass production (~330)



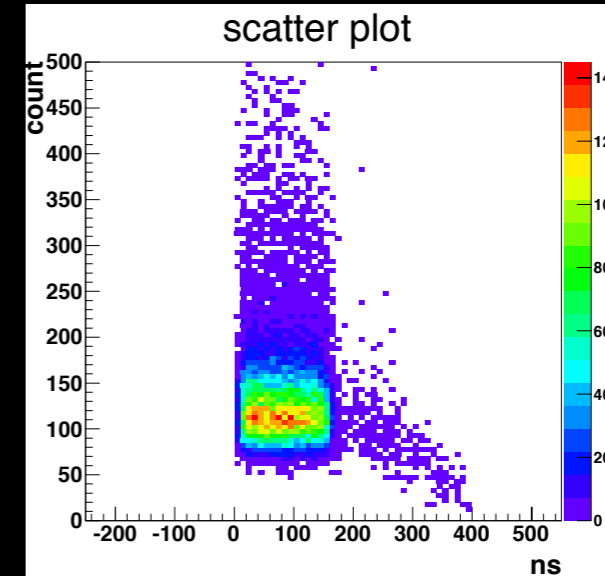
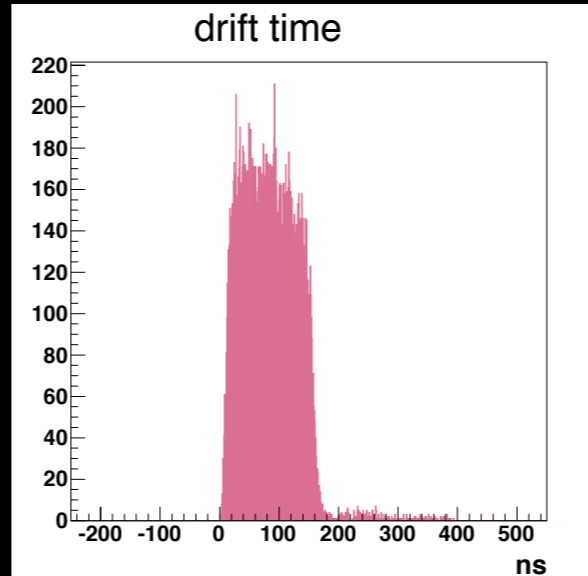
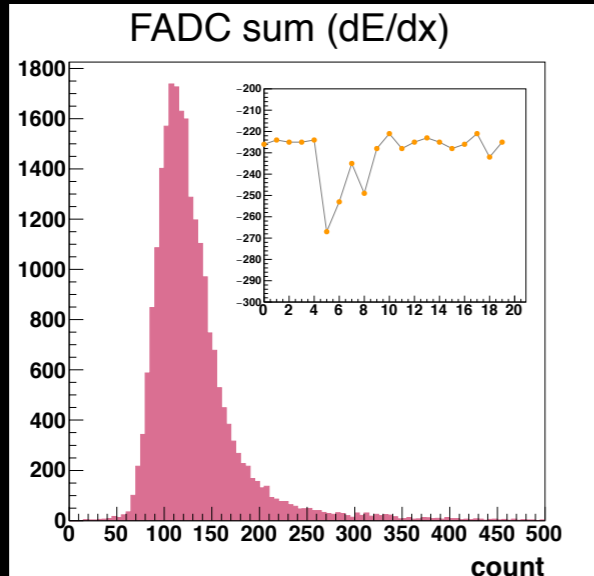
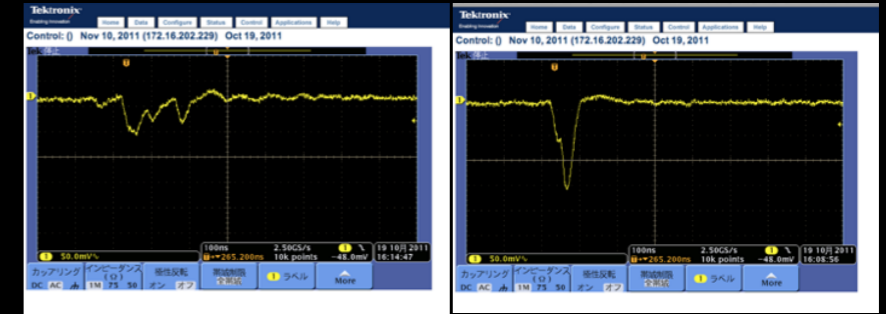
all parts are clear radiation test and test in magnetic field

1 GeV/c electron beam @ SPring-8, LEPS test beam line  
 5 layers test chamber

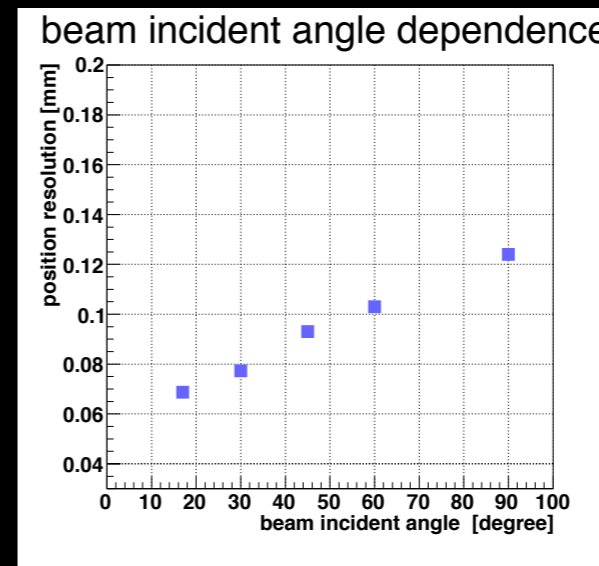
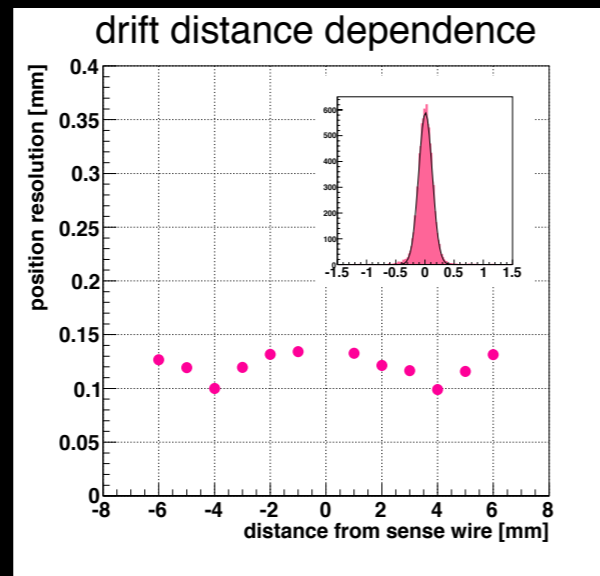
15x15 mm<sup>2</sup> square cell  
 $\phi=30\mu\text{m}$  Au-W sense wire  
 He-ethane(50:50) gas

study of readout board with well-understood detector

analog output using ASD test board



position resolution

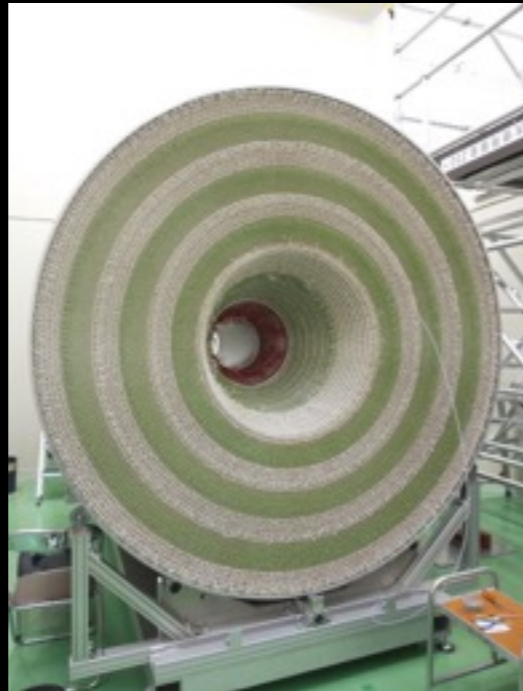


We confirm performance of readout satisfy requirements

HV side  
(Fwd.)



Apr. 2014



Oct. 2014



Dec. 2014



Jan. 2015

gas leak check

ground cable

HV cable

HV test

Readout  
(Bwd.)



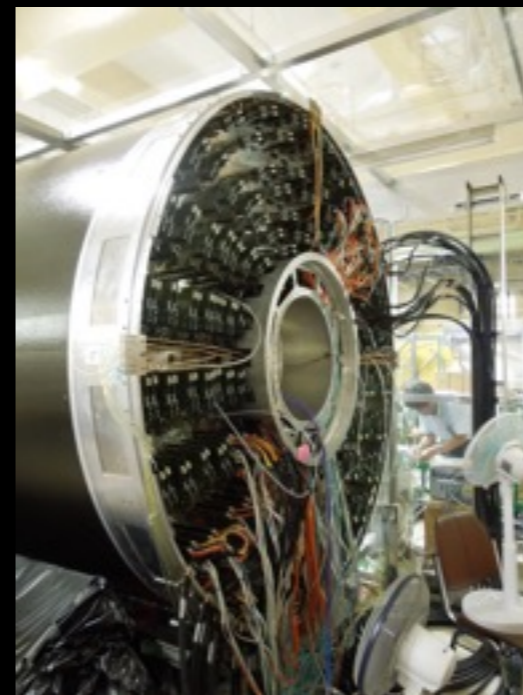
Dec. 2015

signal cable



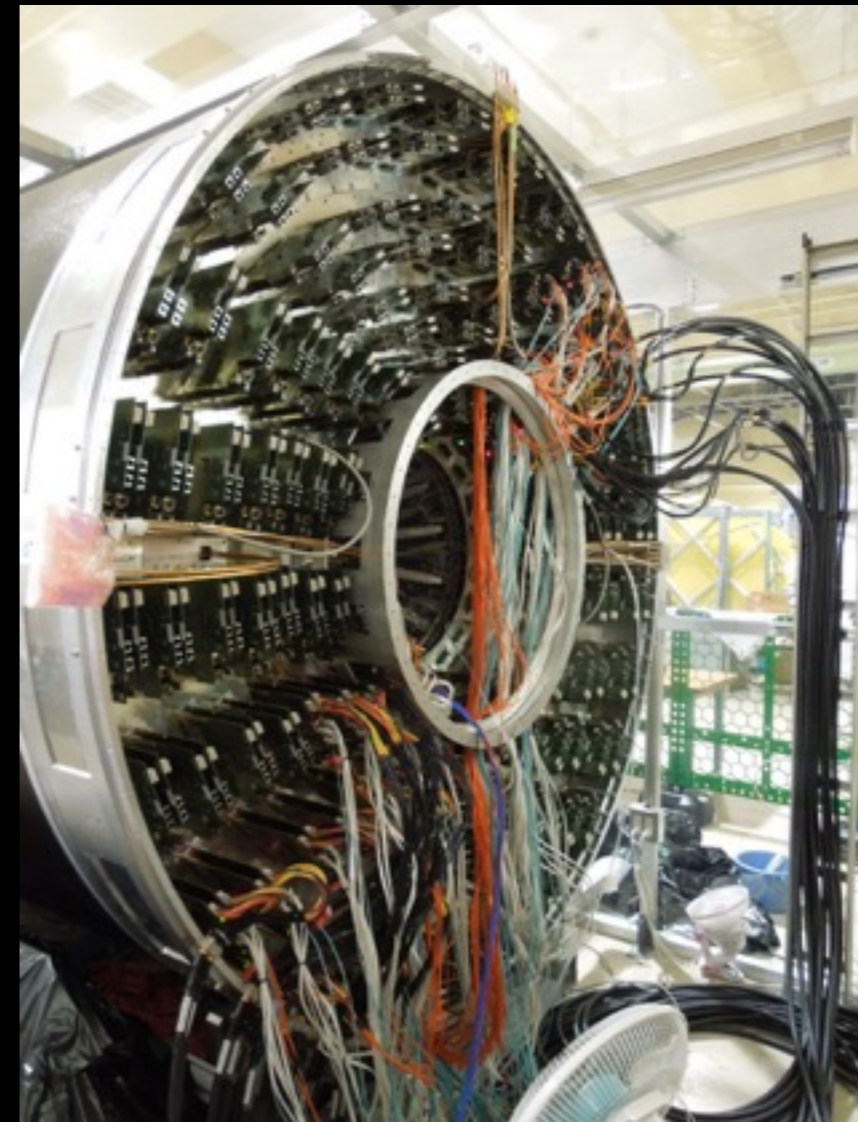
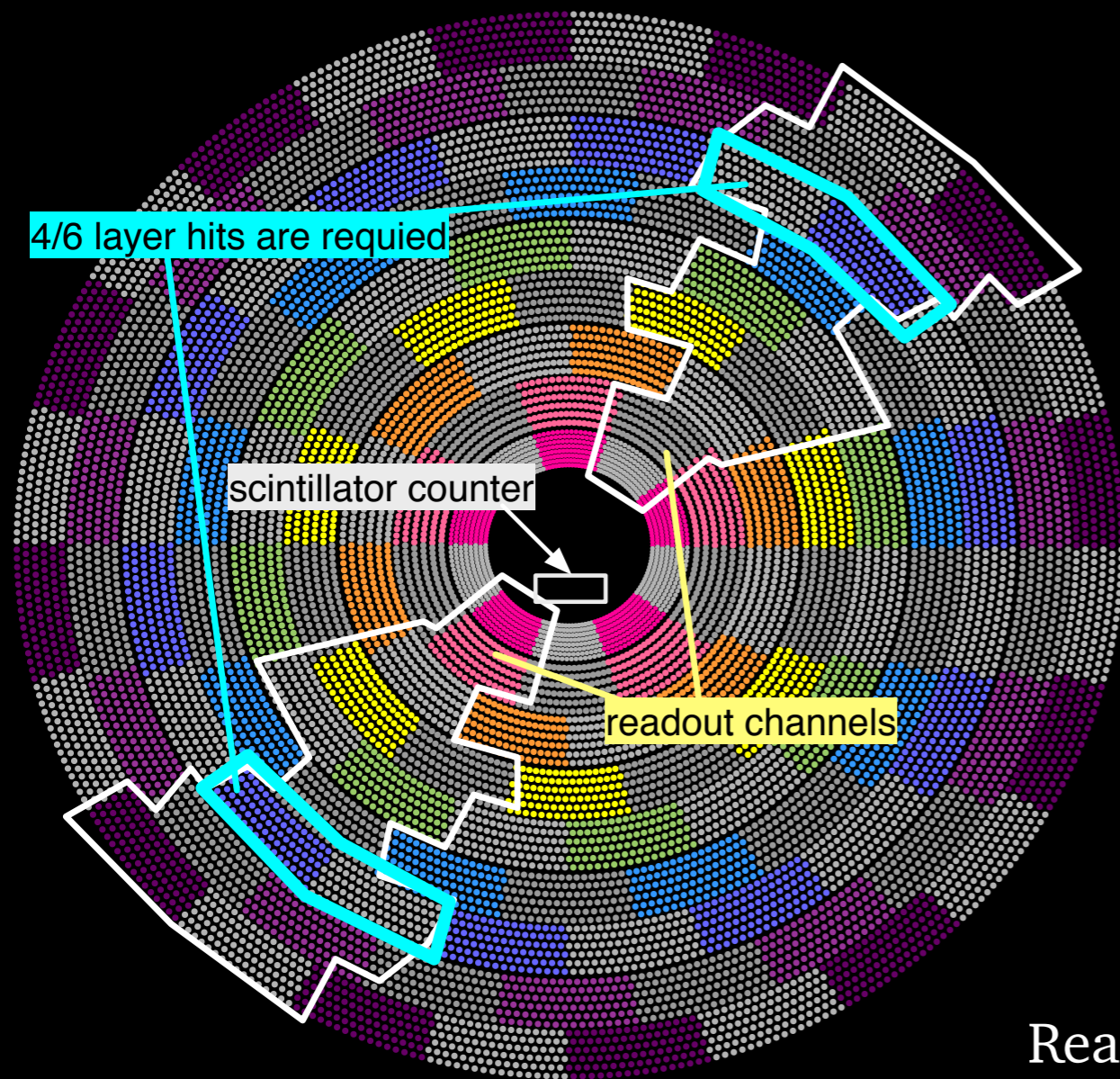
Jan. 2016

FE installation



Spring - Autumn. 2016

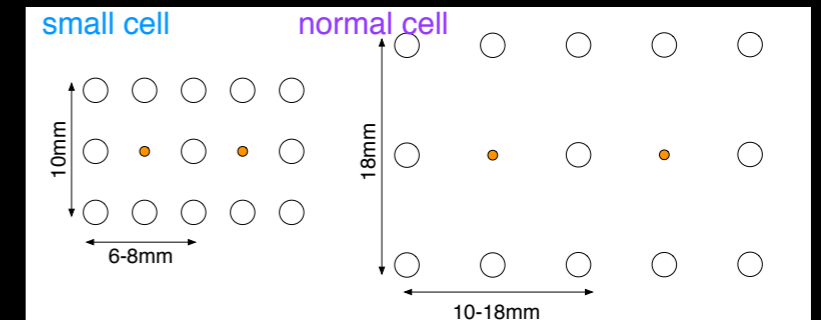
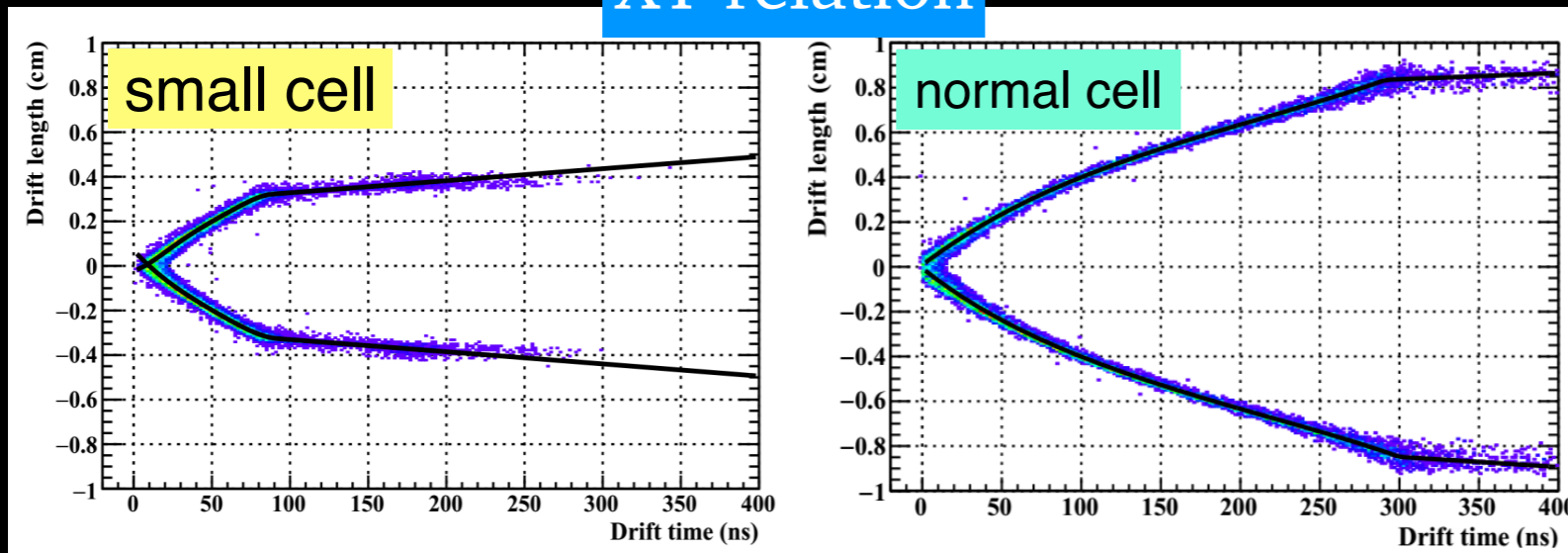
cosmic ray test



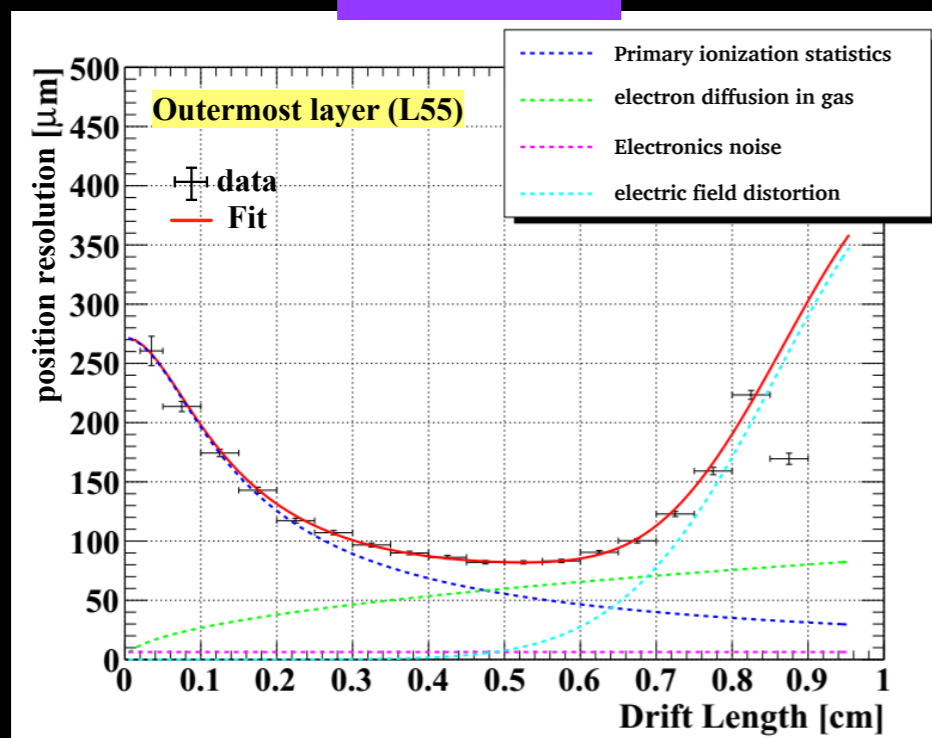
Readout 20% electronics with Belle2DAQ system  
- detector is isolated from Belle structure  
- 60/299 front-end boards readout

# cosmic ray test

## XT relation



## residual

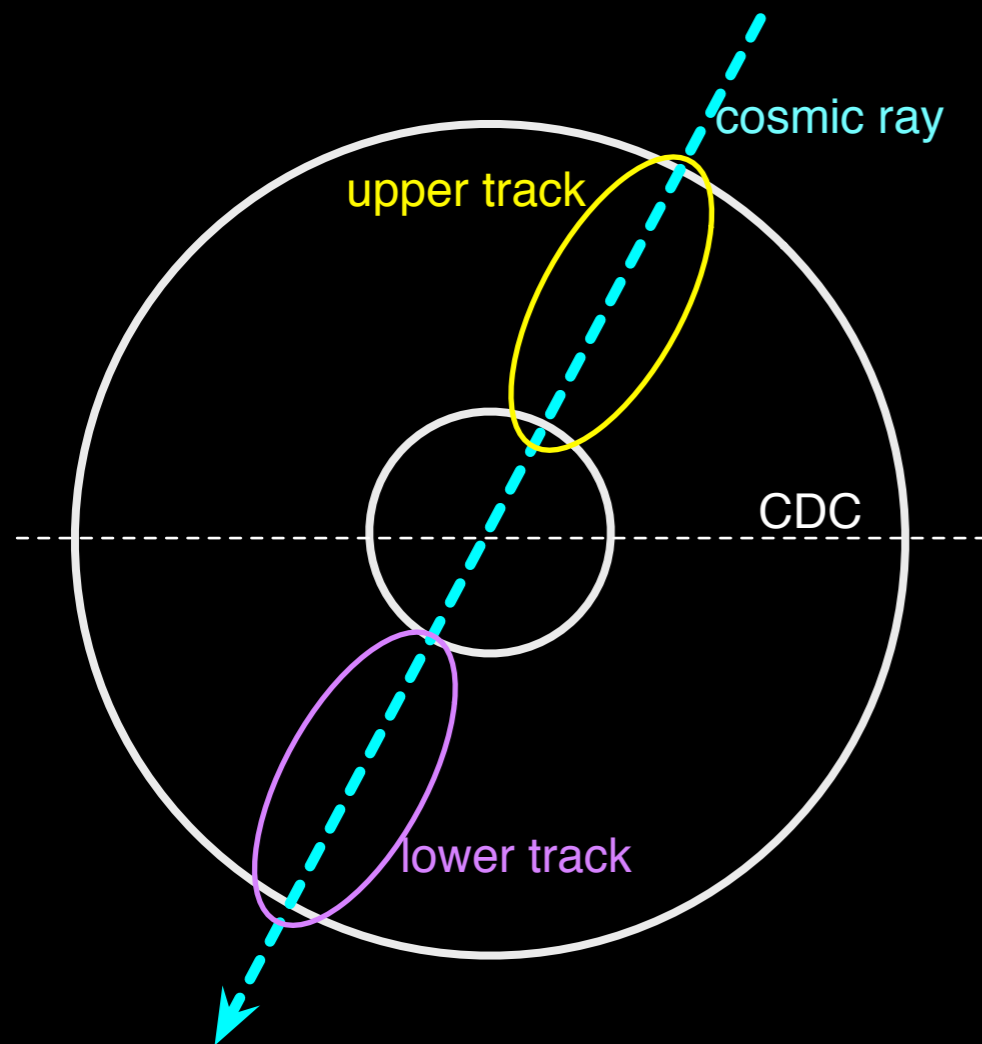


## Including

- $t_0$  correction
- iteration of XT function extraction
- time of flight
- propagation delay on wire

position resolution  $\sim 100\mu\text{m}$

# cosmic ray test

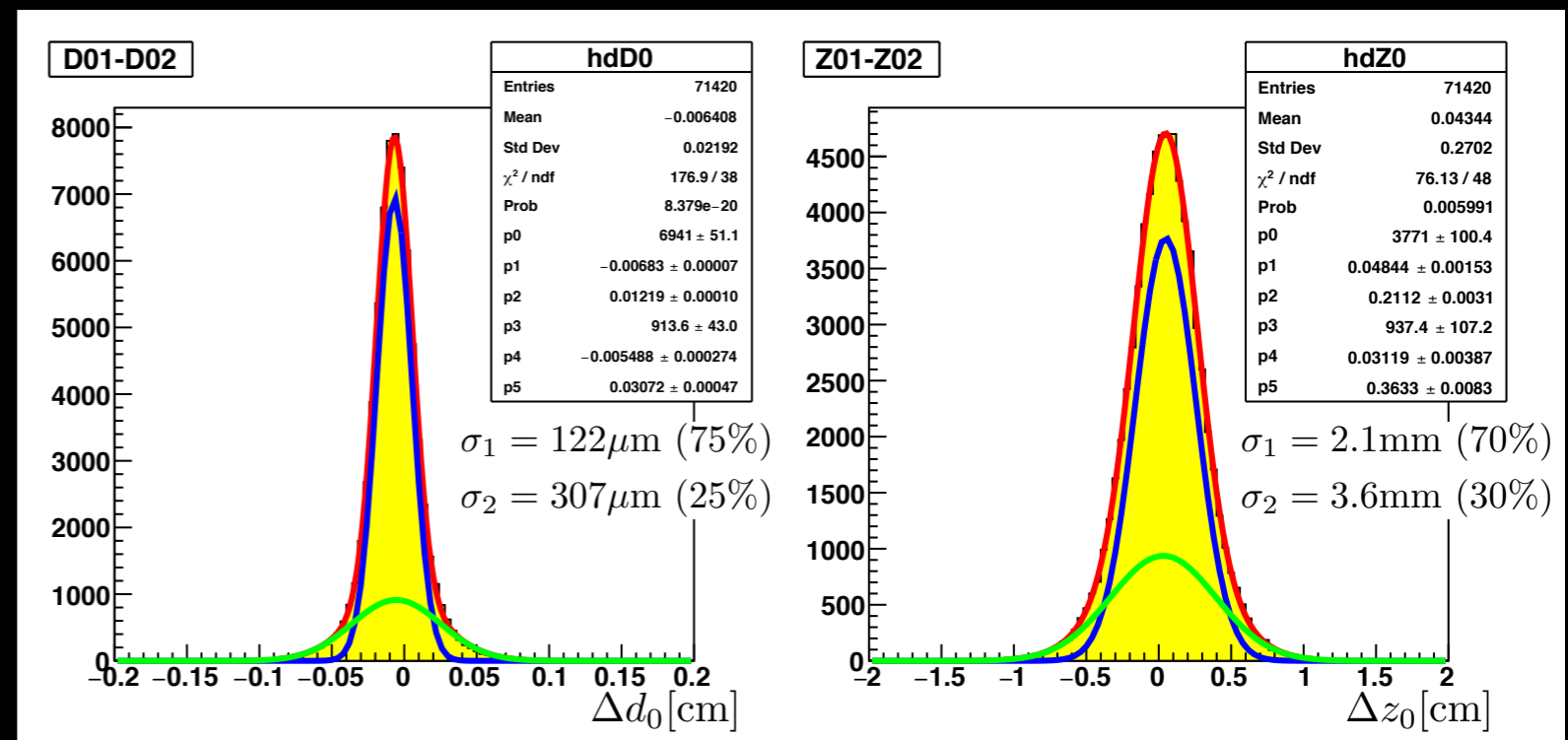


one cosmic ray track is track-fitted as separated tracks in upper and lower regions

$$\Delta d_0 = d_0^{\text{upper}} - d_0^{\text{lower}}$$

$$\Delta z_0 = z_0^{\text{upper}} - z_0^{\text{lower}}$$

$d_0$  : impact parameter( $r\phi$ )  
 $z_0$  : impact parameter( $z$ )

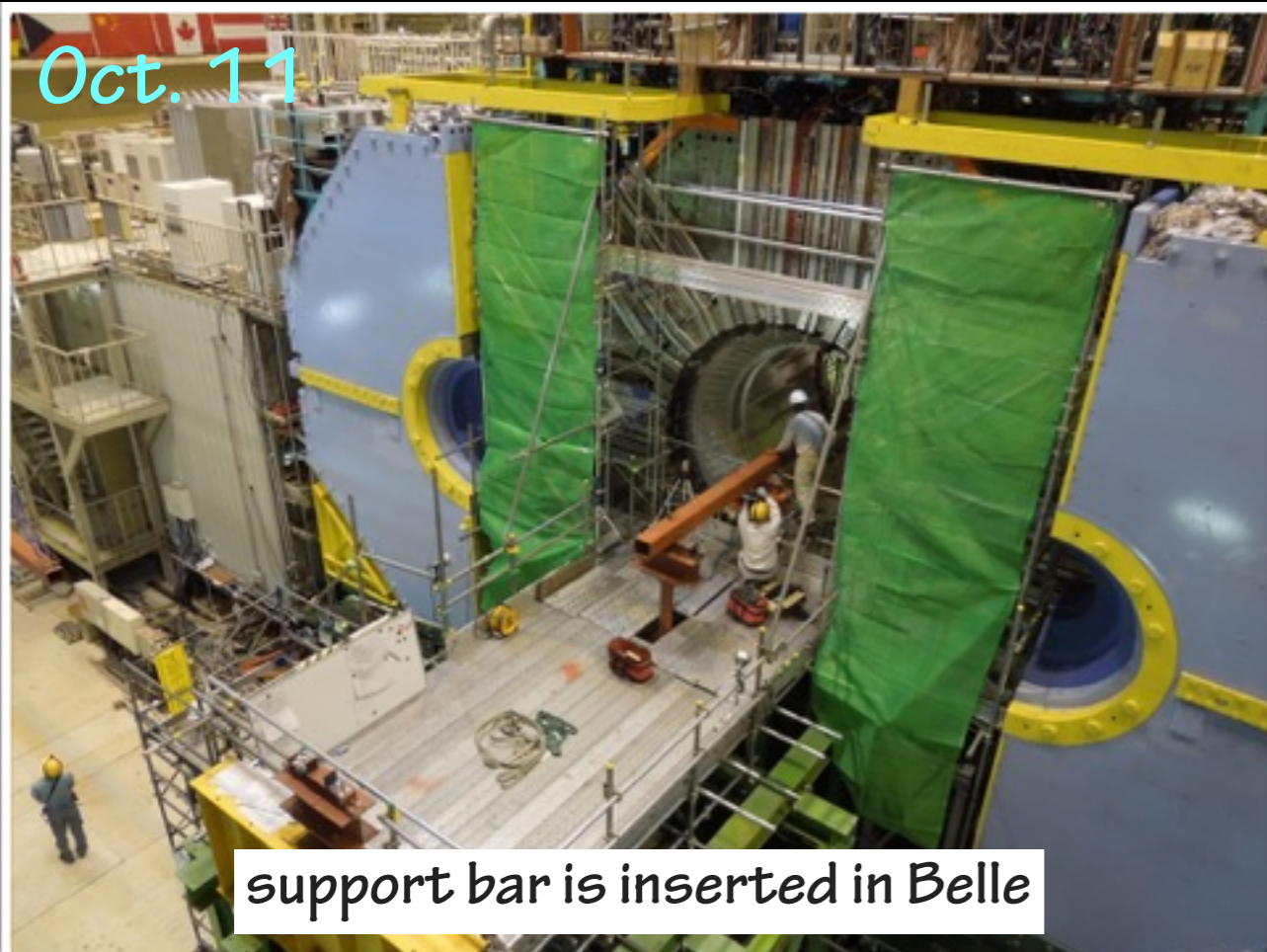


mean is shifted due to mis-alignment of wire position

good resolution is obtained



Oct. 11



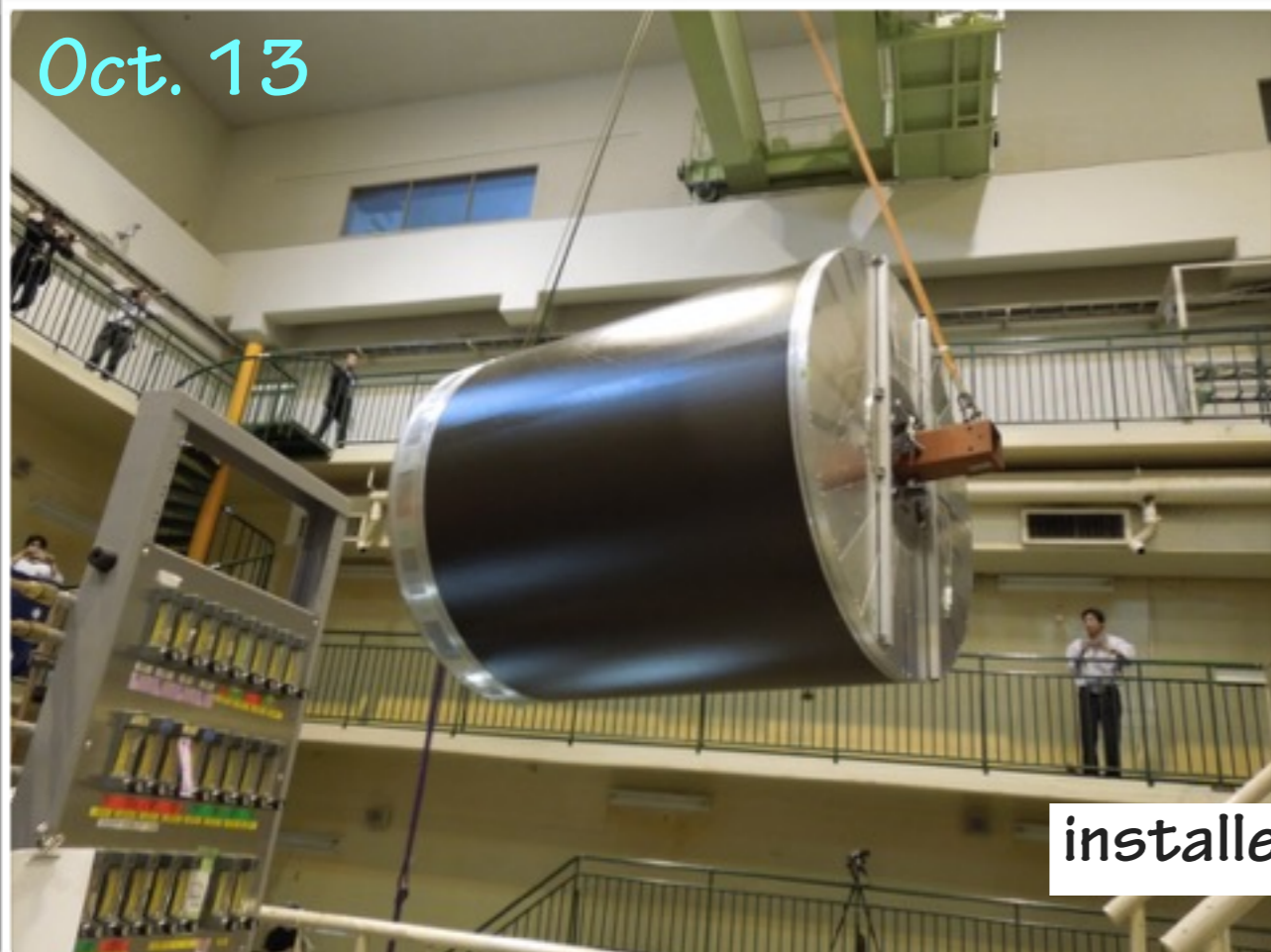
support bar is inserted in Belle

Oct. 12



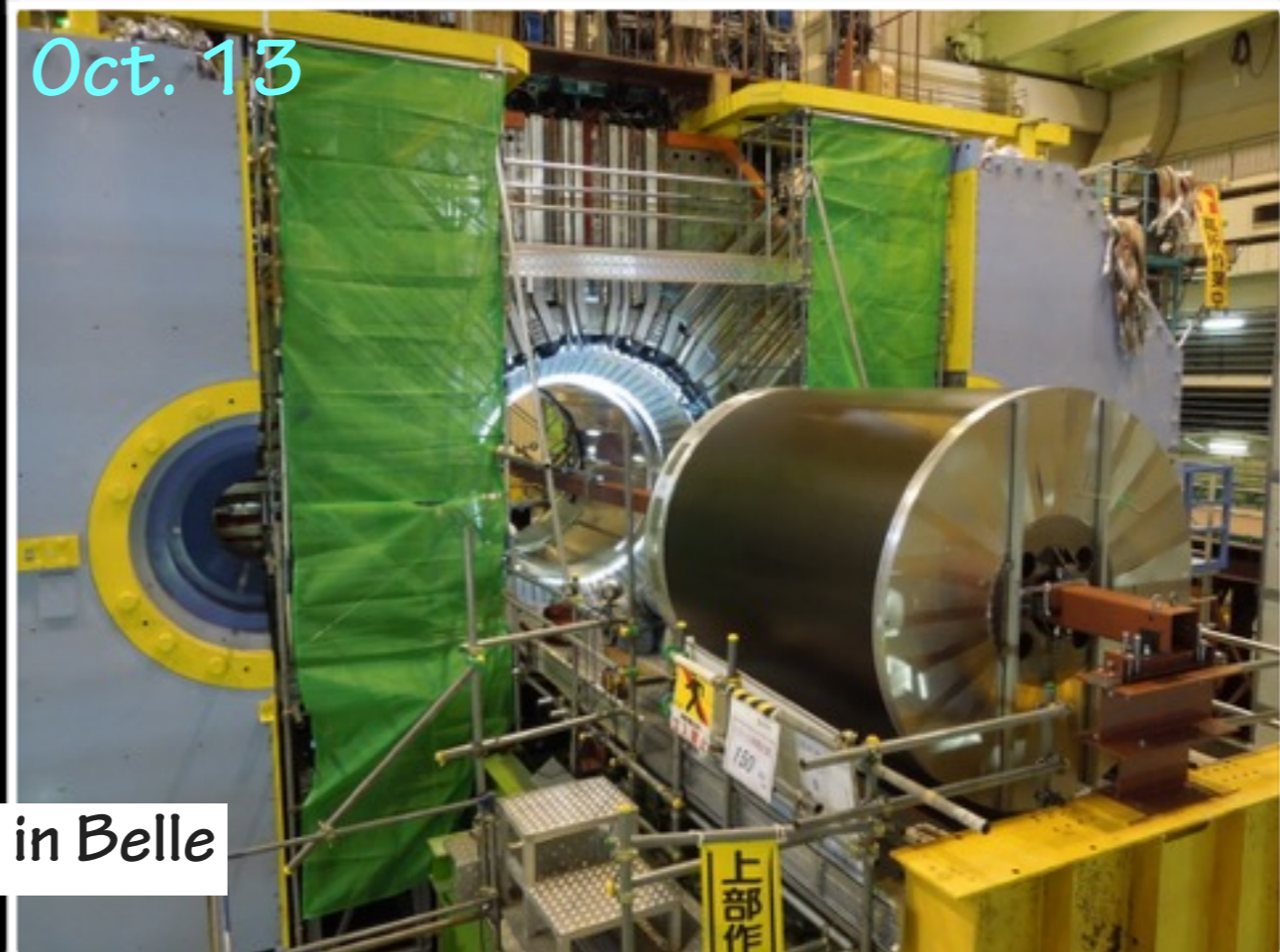
support bar is inserted in CDC

Oct. 13



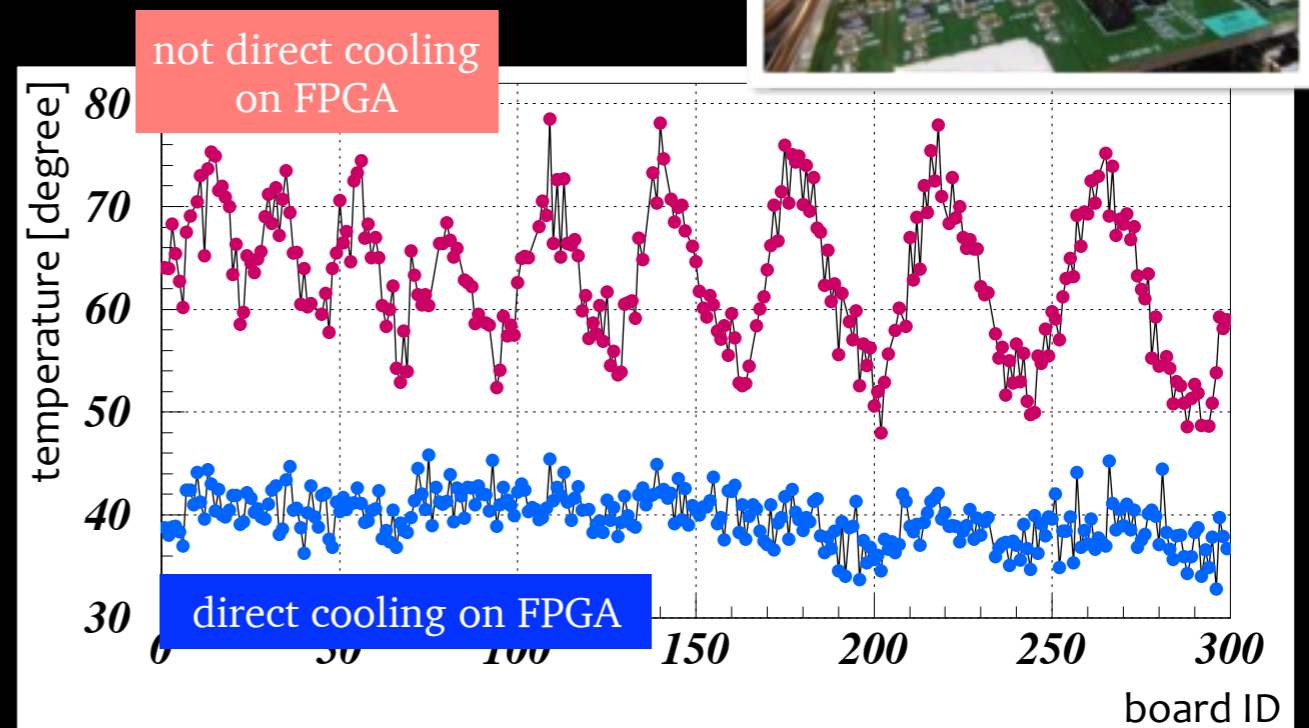
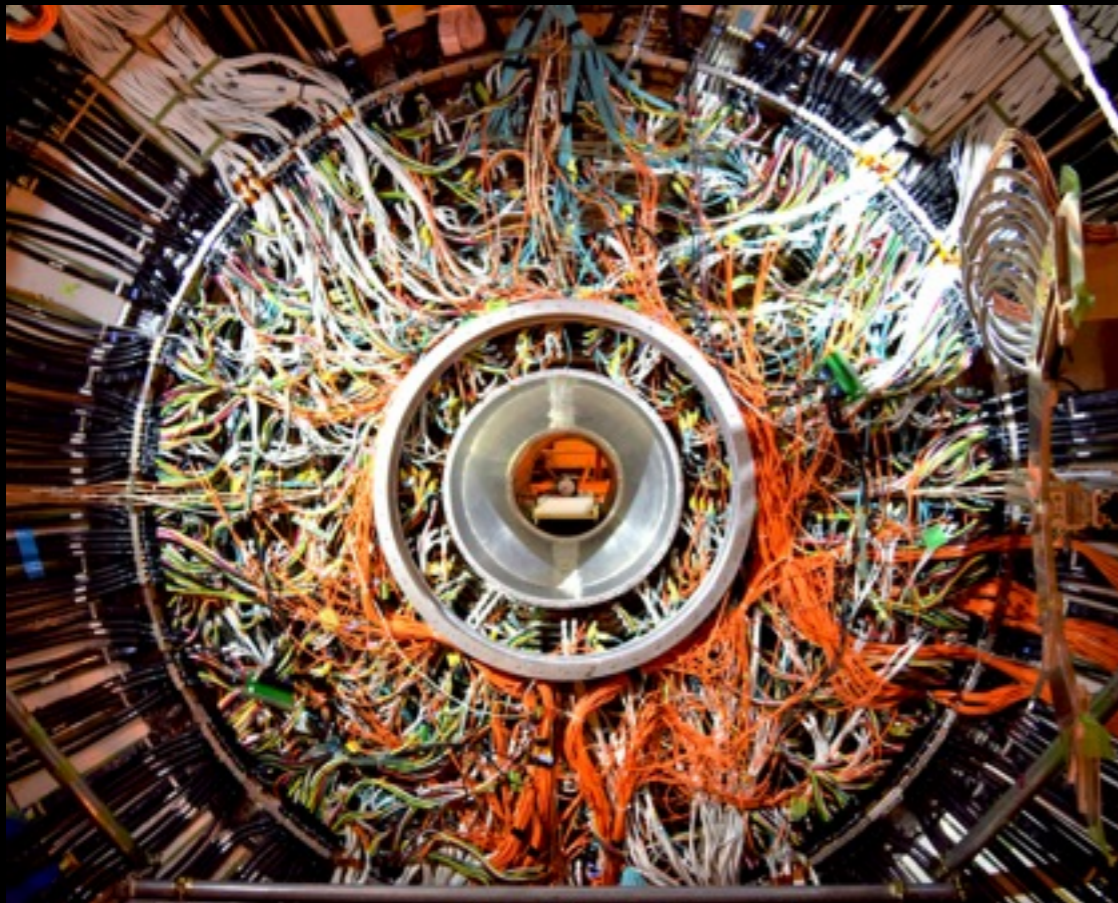
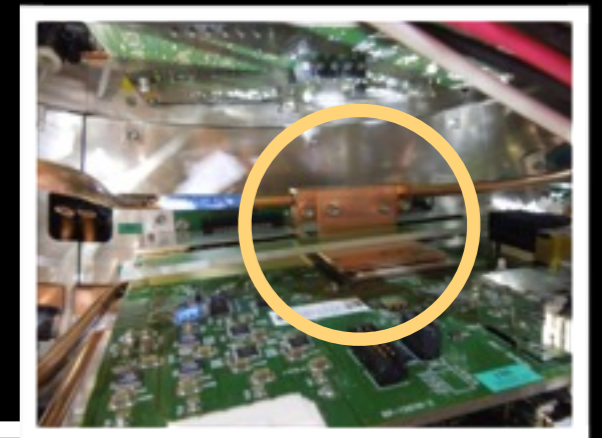
installed in Belle

Oct. 13

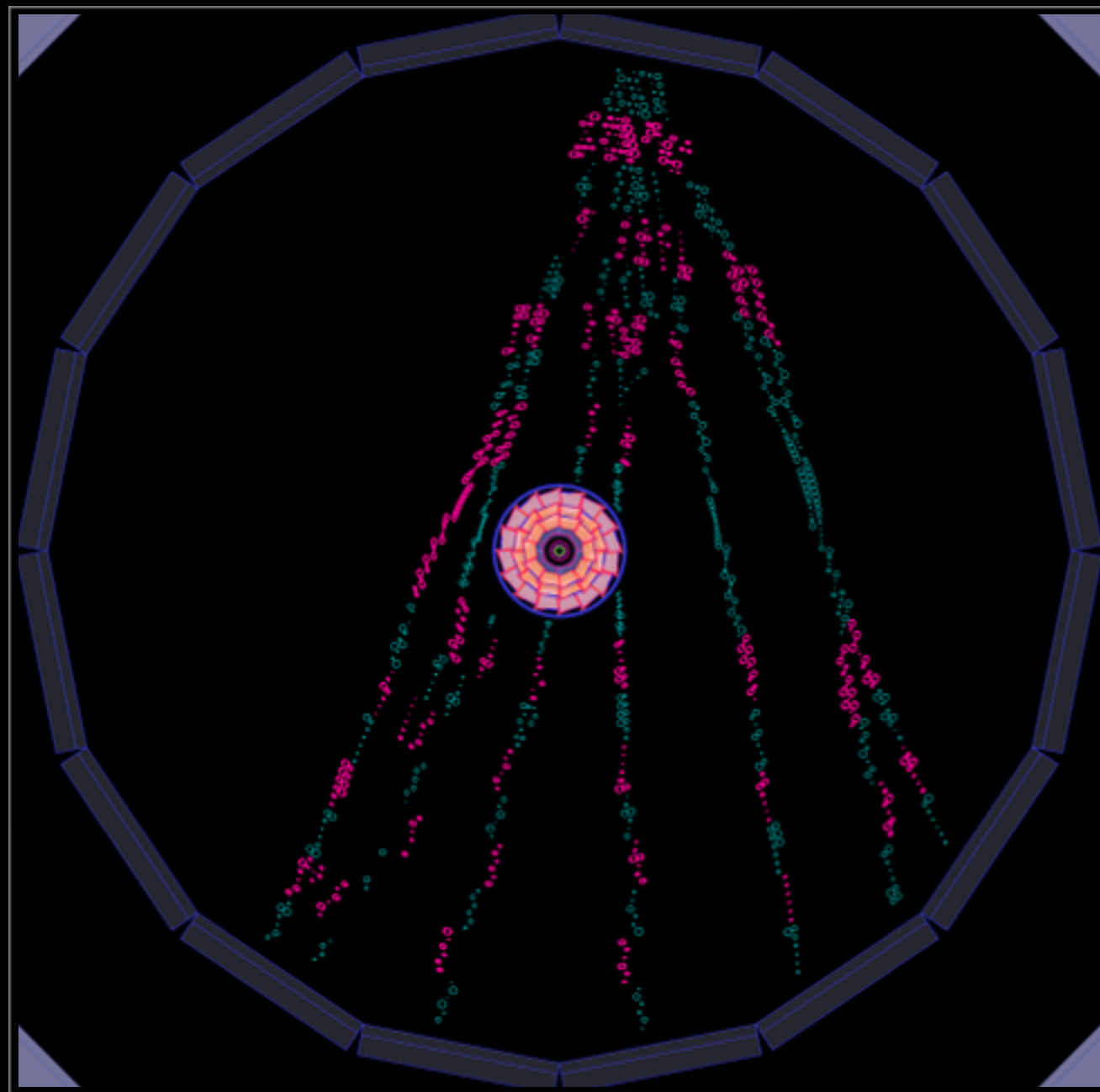


# cabling and cooling

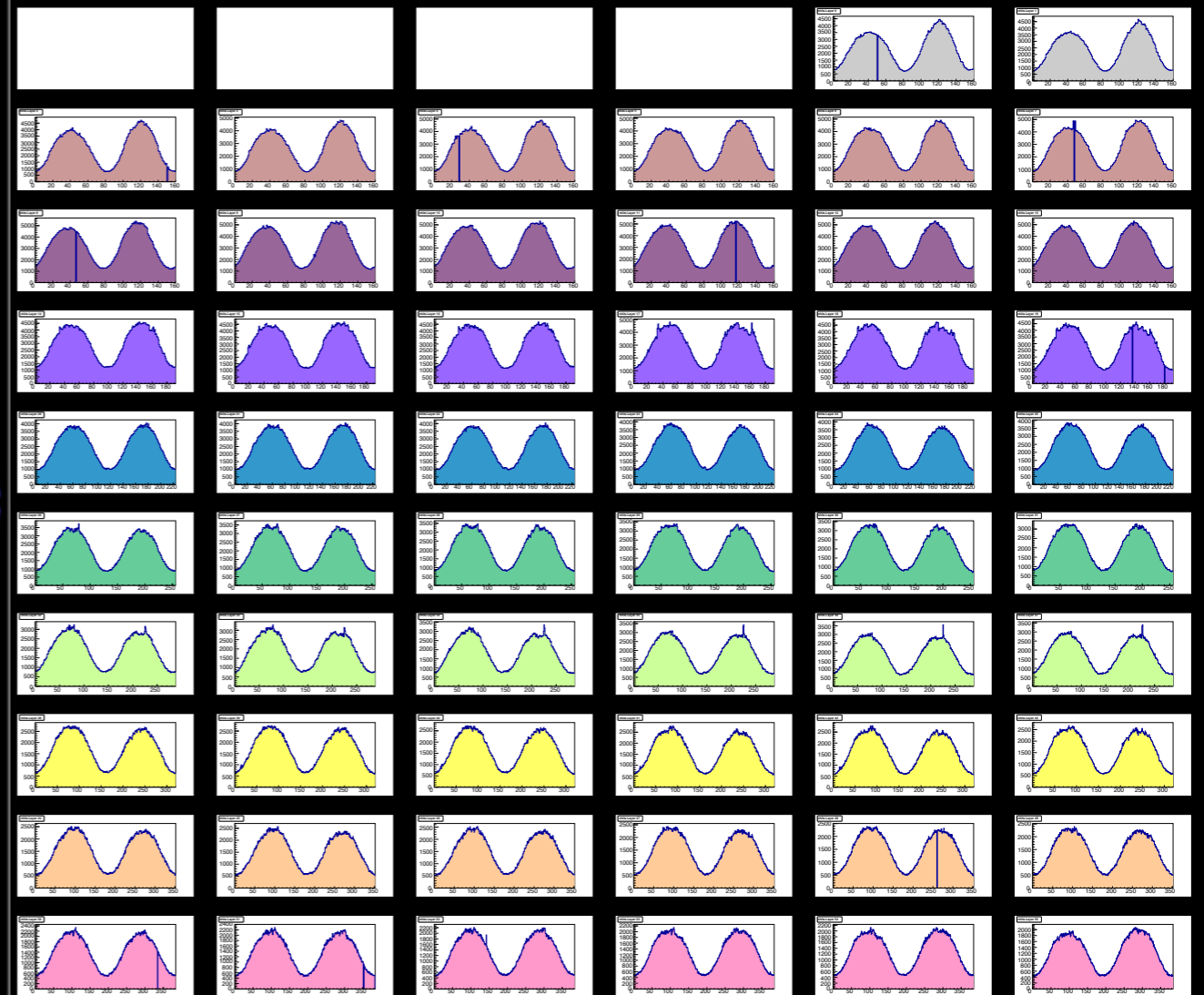
- **cables for readout electronics**
  - data link : X299 optical fiber pairs
  - TRG link : 12C optical fibers X299
  - trigger and timing distribution and configuration of FPGA: cat.7 cable X(299x2)
  - Low voltage power supply cable : X150 pairs
  - High voltage cable : X240
- **power consumption = 14W/board x299 ~ 4.2kW**
  - water cooling



# commissioning with cosmic ray



no magnetic field



dead channels (11/14336 < 0.1%)

# summary

- Belle2 charged particle tracking detector
  - Central Drift Chamber is main device
  - detector and readout have been fully upgraded
  - detector installation has been successfully done (2016)
  - commissioning using cosmic ray with entire readout is started (without magnetic field)
    - alignment and calibration is ongoing
- Roll-in is scheduled in the middle of April
  - data taking with magnetic field
  - integration data taking with PID detector and calorimeters
- First physics run in 2018



BINP (Sep. 2016 )