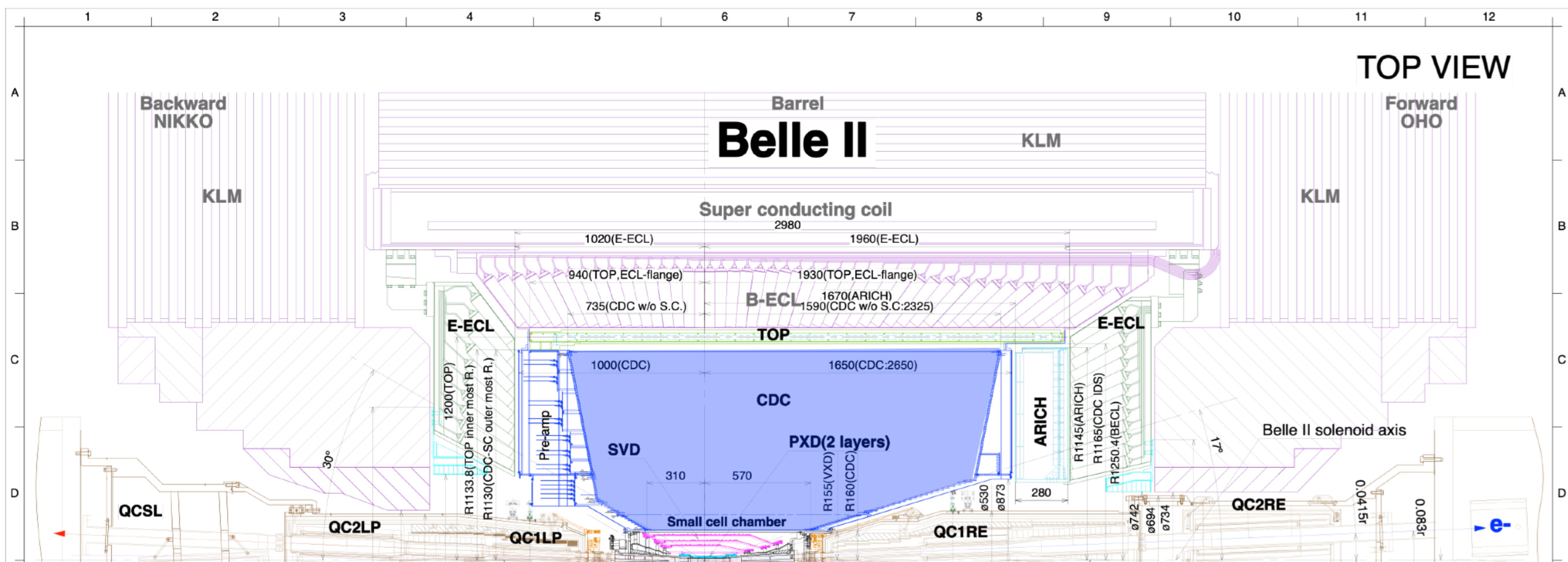
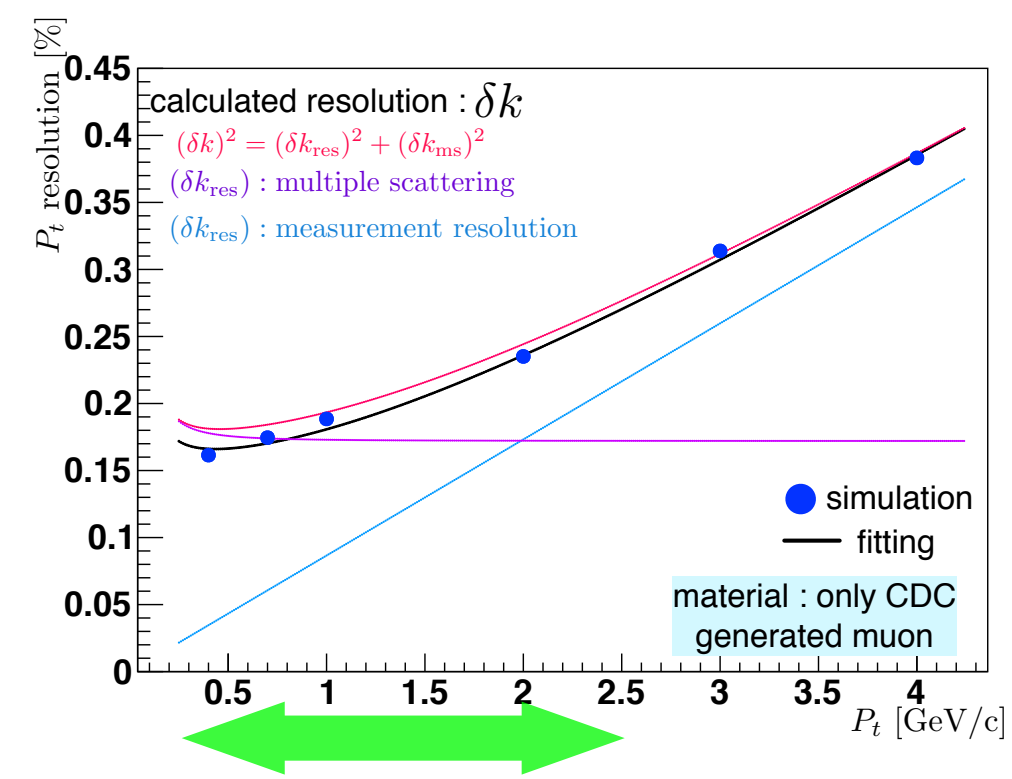


Belle II CDC design

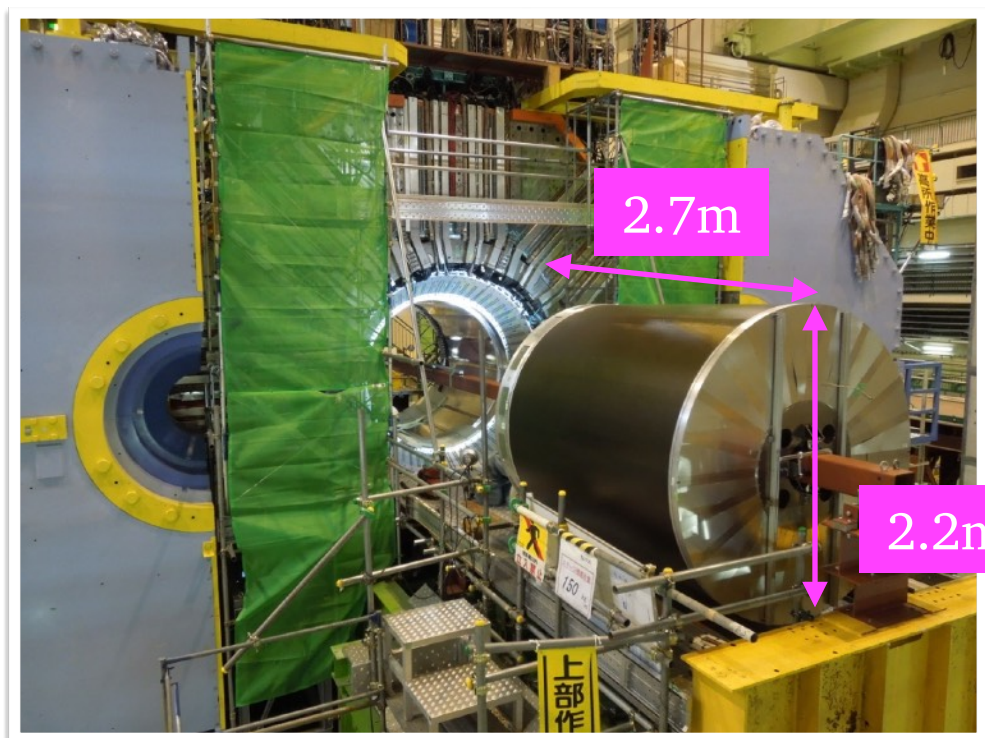
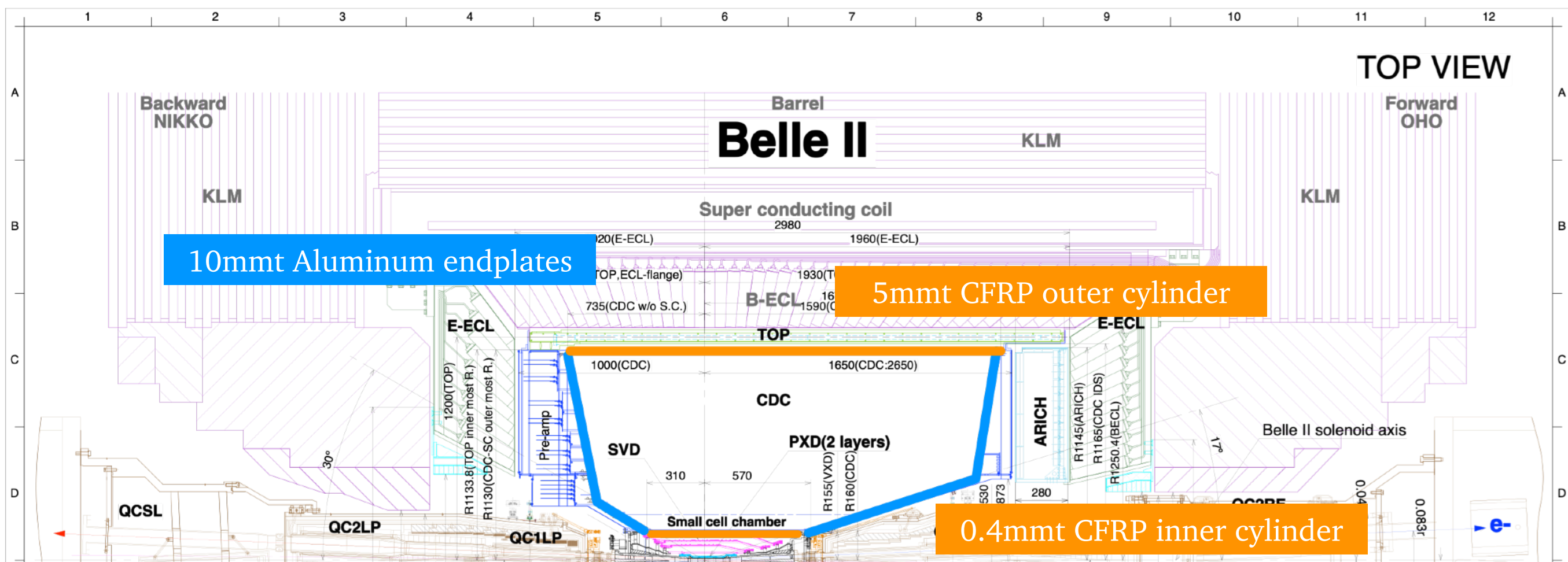
Nanae Taniguchi (KEK)



- SuperKEKB/Belle II
 - e+(4 GeV) e-(7 GeV) collider
 - design luminosity : $6 \times 10^{35} / \text{cm}^2/\text{s}$
- Role of charged particle tracker of Belle II
 - momentum measurement
 - magnetic field = 1.5T
 - dEdx measurement for particle identification
 - track trigger
- CDC = Central Drift Chamber



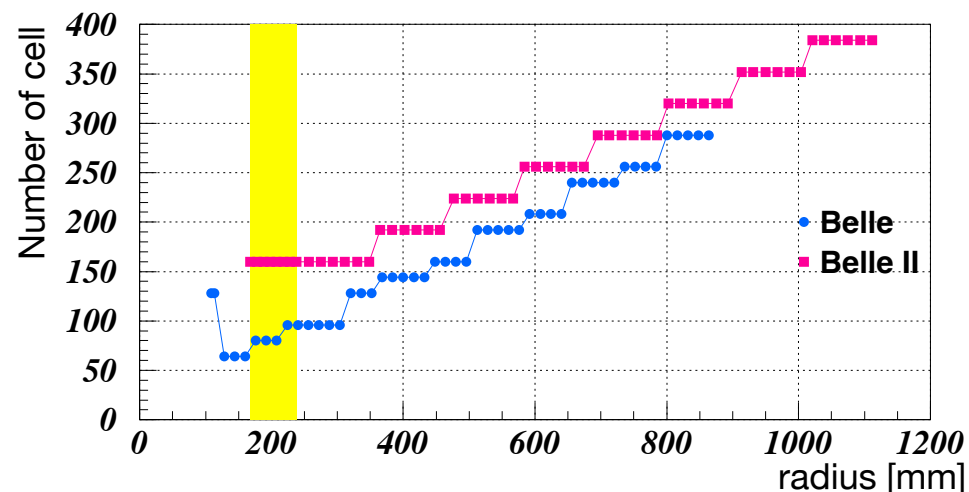
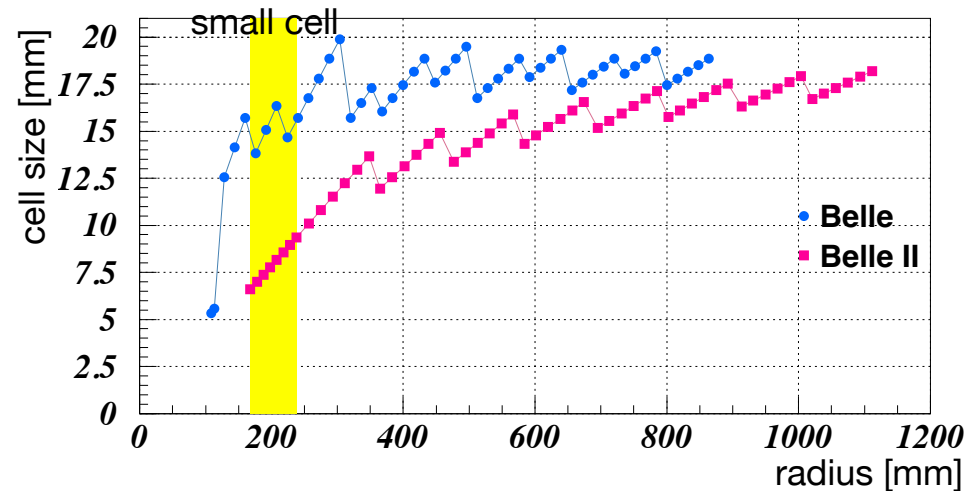
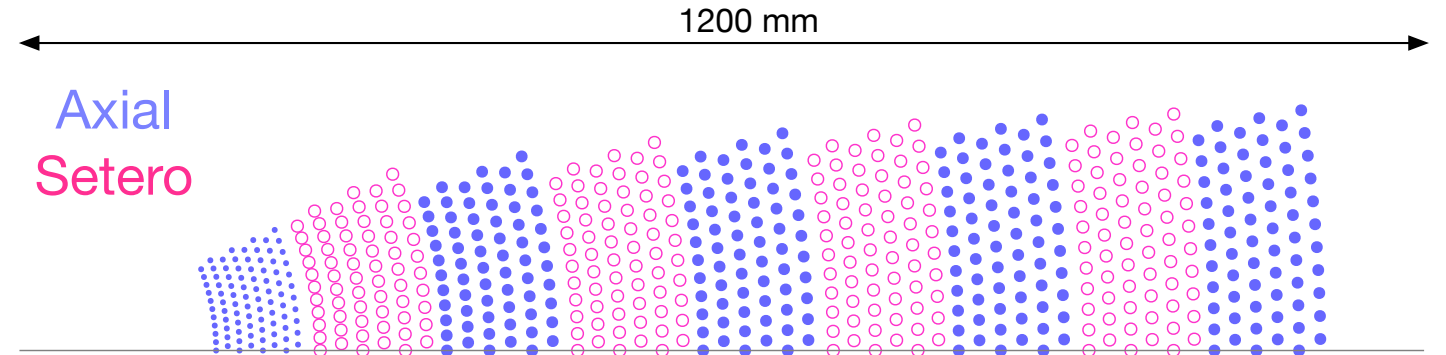
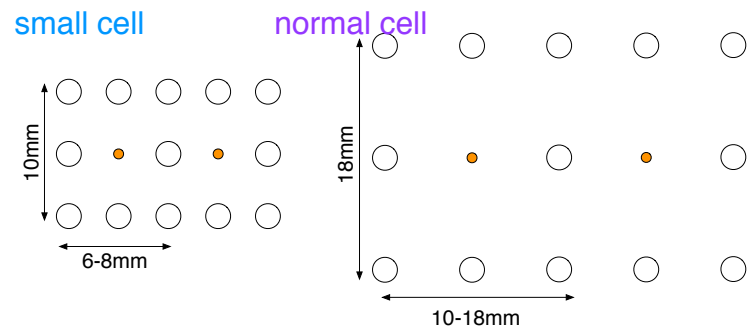
multiple scattering is dominant



CDC installation (2016)

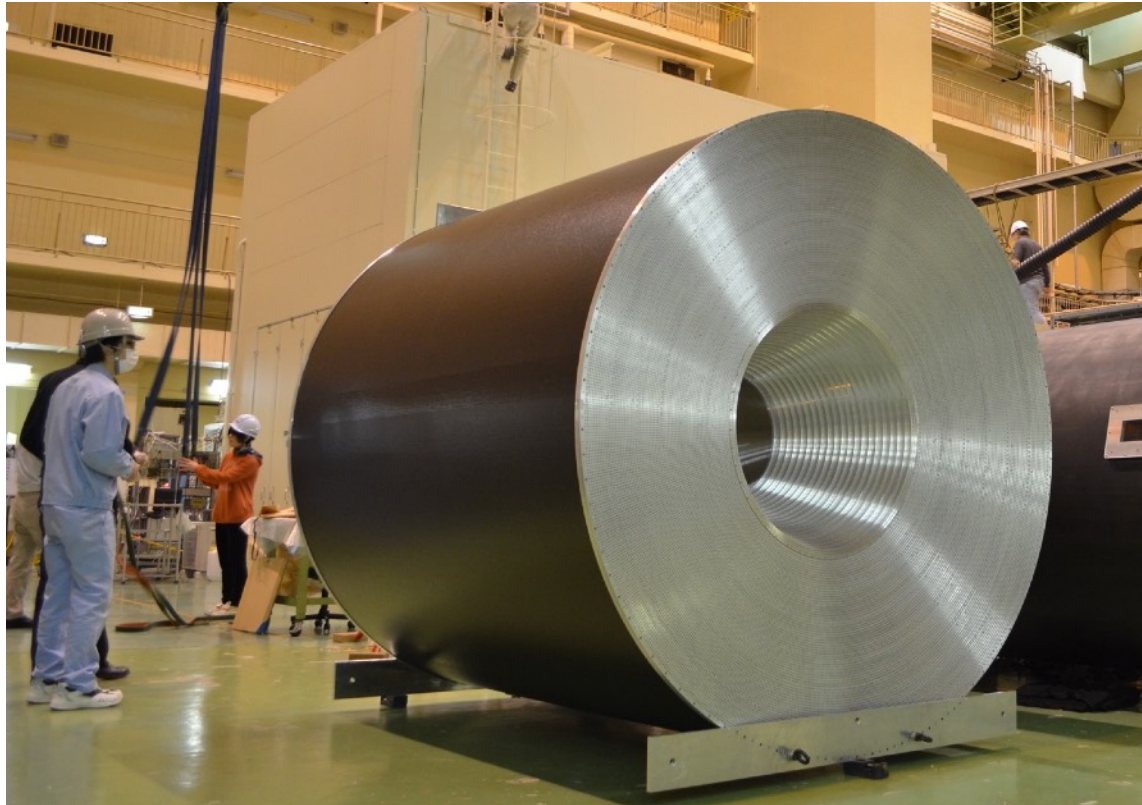
- wire
 - sense x 14336; Au-W ($\phi 30\mu\text{m}$). 50gw
 - field x 42240; Al ($\phi 126\mu\text{m}$). 80gw
- gas
 - He:ethane = 50:50
 - typical gas gain $\sim 2 \times 10^4$
 - operation voltage; 1.99 - 2.39kV

cell configuration



- 56 layers in total
 - radius of innermost/outermost = sense wire
168/1111.4 mm
- ‘super layer’ structure
 - 5-axial super layers and 4-stereo super layers
 - stereo (+/-)45 ~ 74
 - innermost super layer = small cell (2+6 layers)

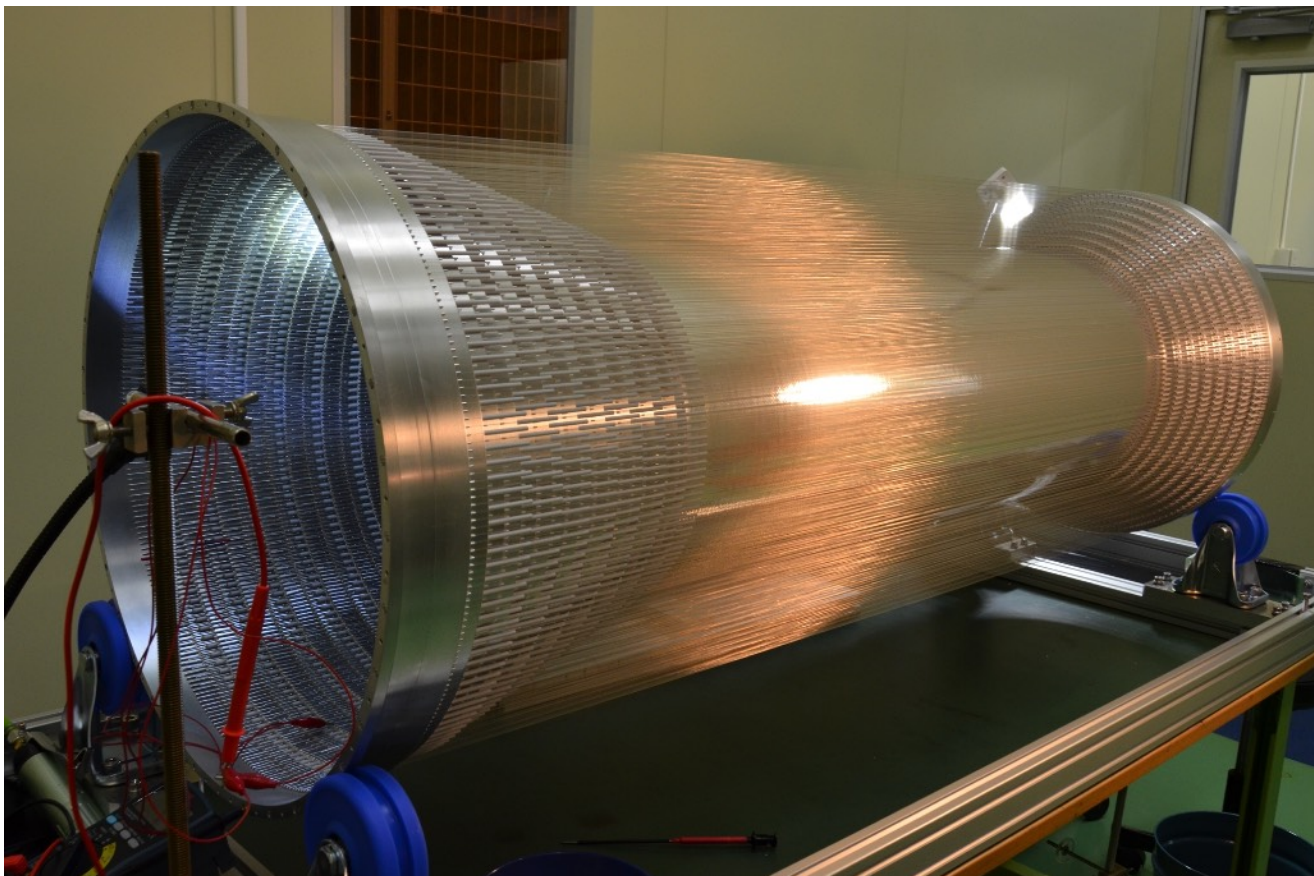
~ 550kg



gas seal

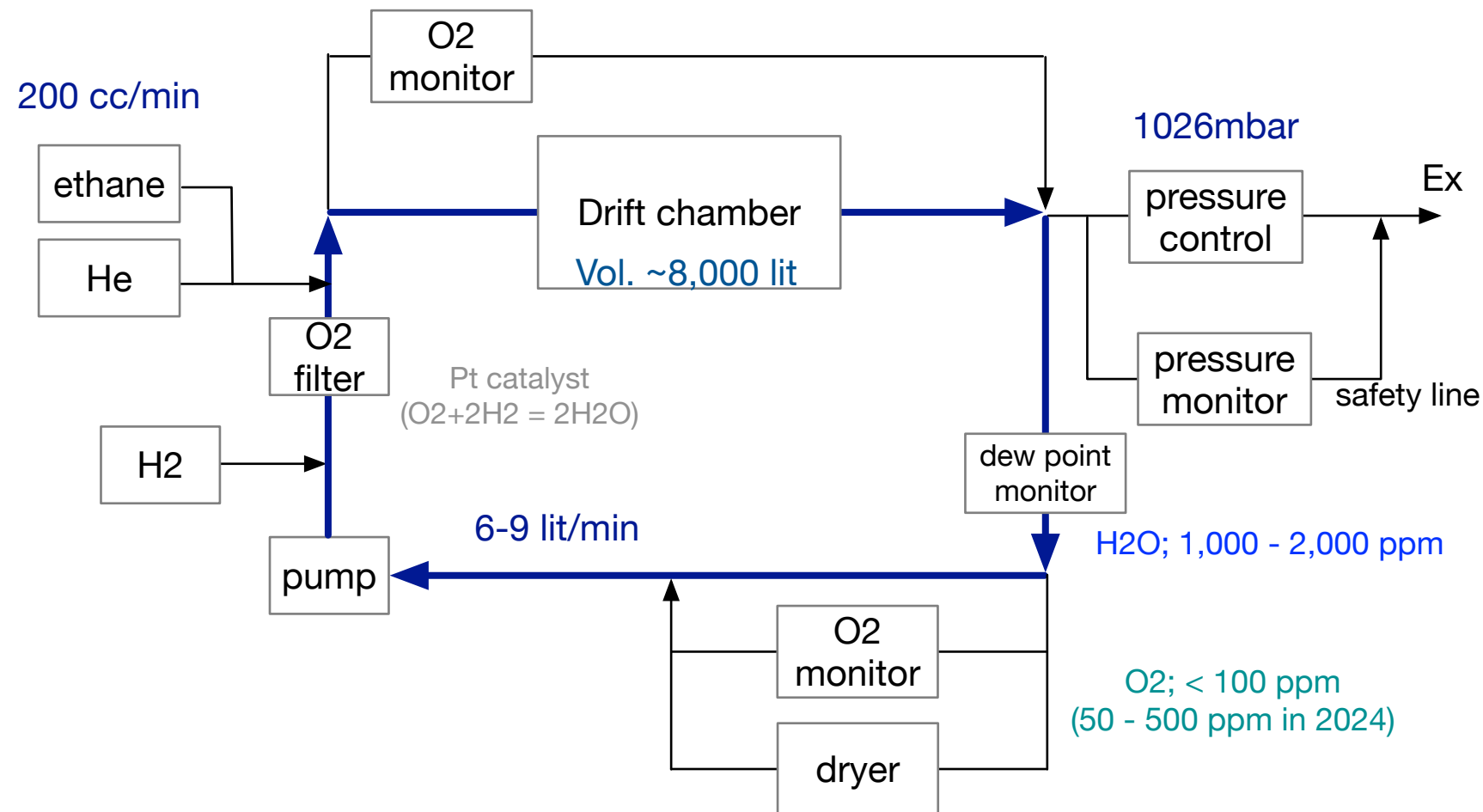


crimping



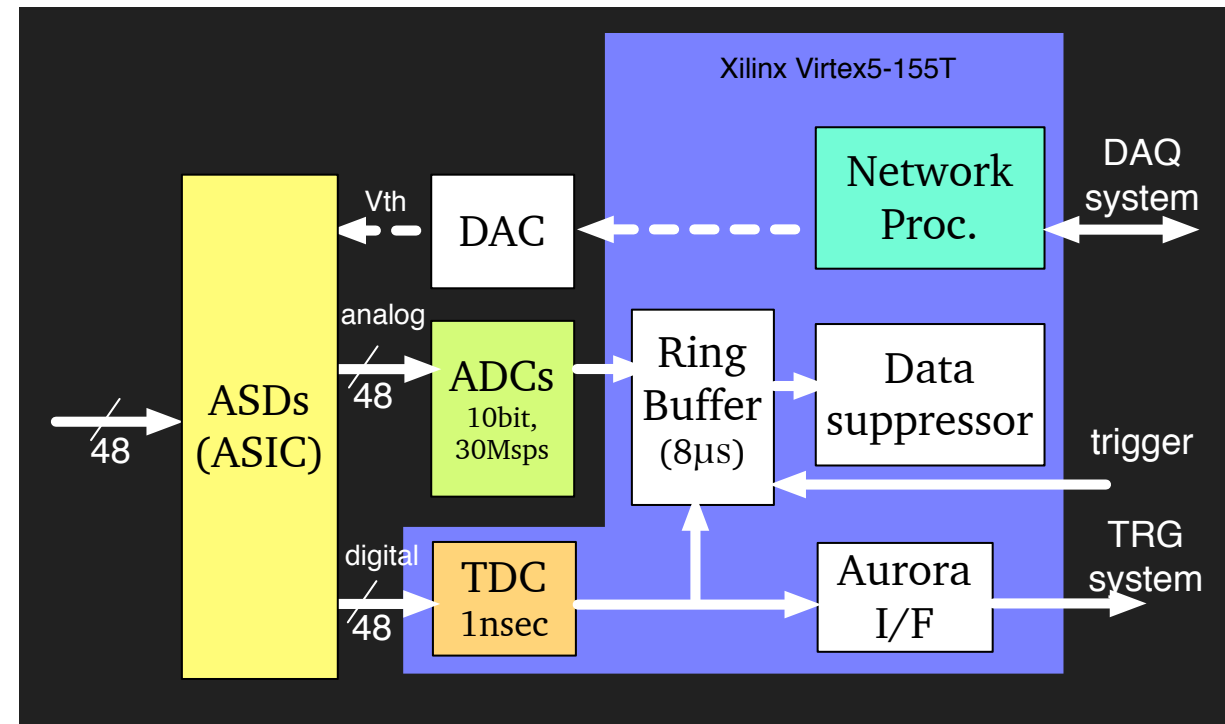
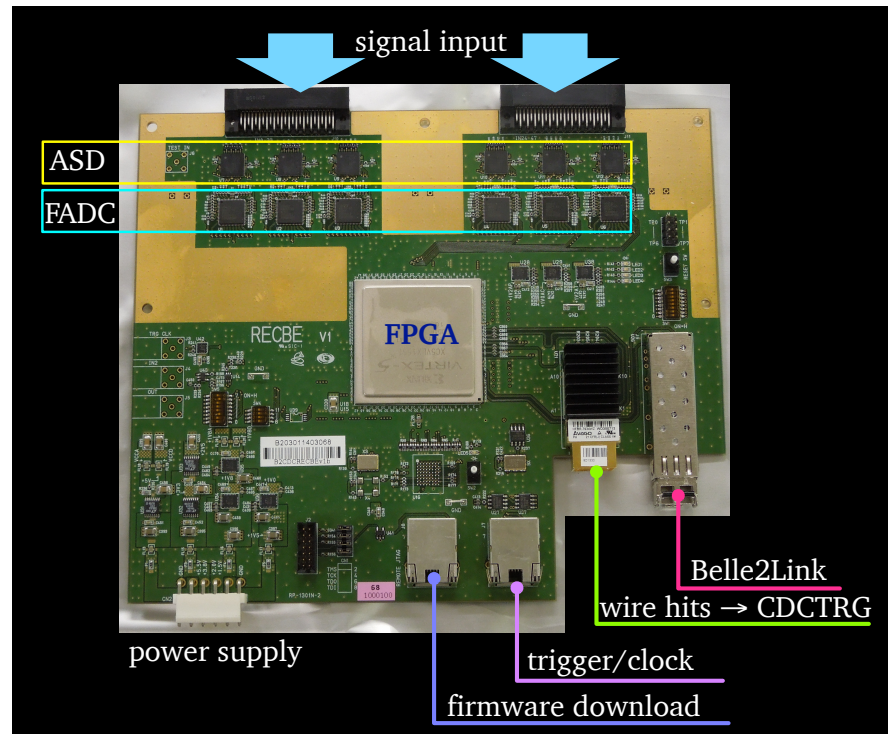
feedthrough

gas system



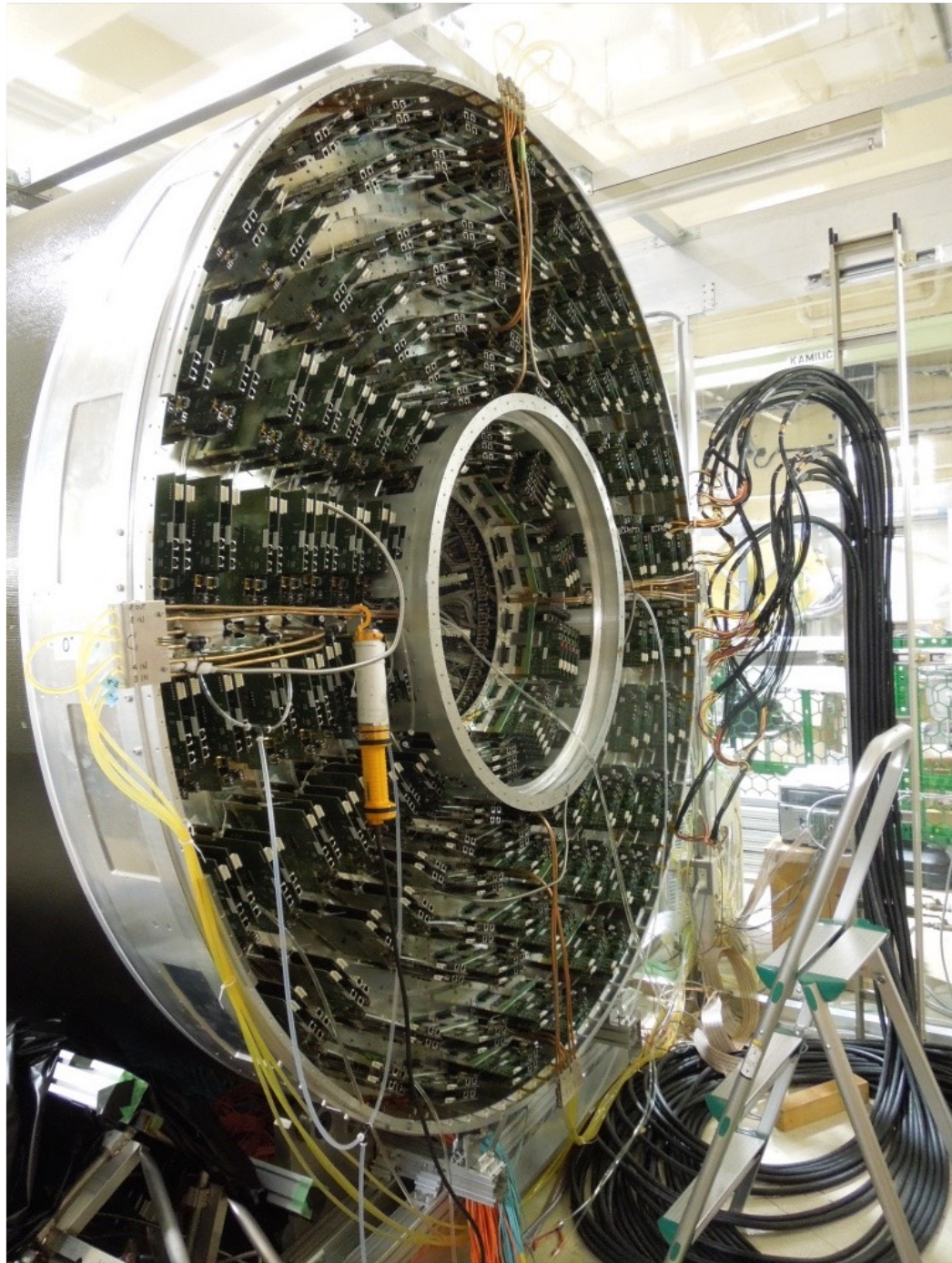
- keep absolute pressure constant ~1026 mbar to keep gas gain stable
- gas circulating (6-9 lit/min)
 - O₂/H₂O are removed and monitored in the circulation line
-

signal readout electronics



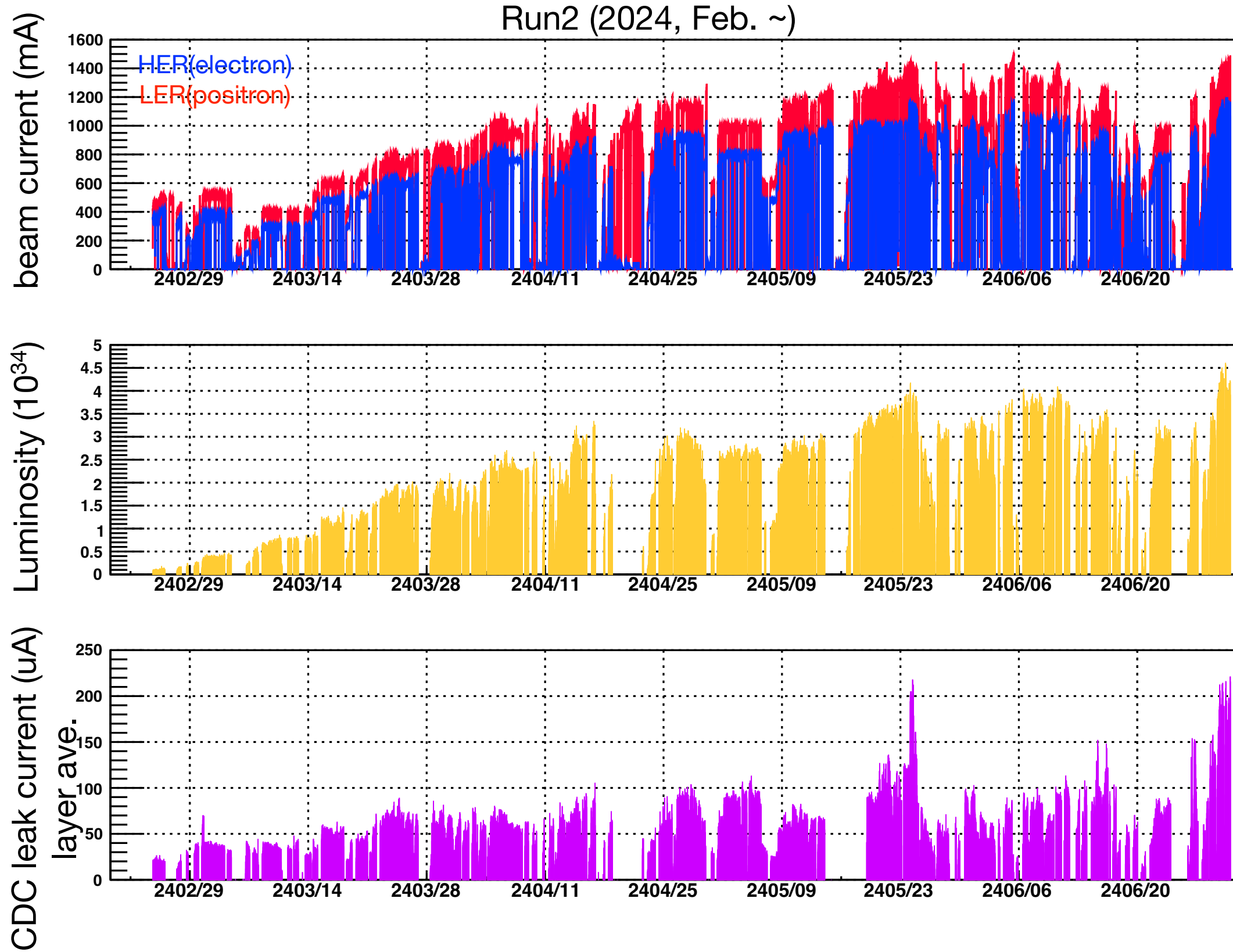
- FPGA-based front-end electronics
 - TDC 1 nsec resolution for drift time measurement
 - ADC 32MHz sampling for dEdx (charge) measurement
 - 48ch/board
- upgrade of readout board is ongoing
 - will install in long shutdown 2 (~2026)

signal readout electronics

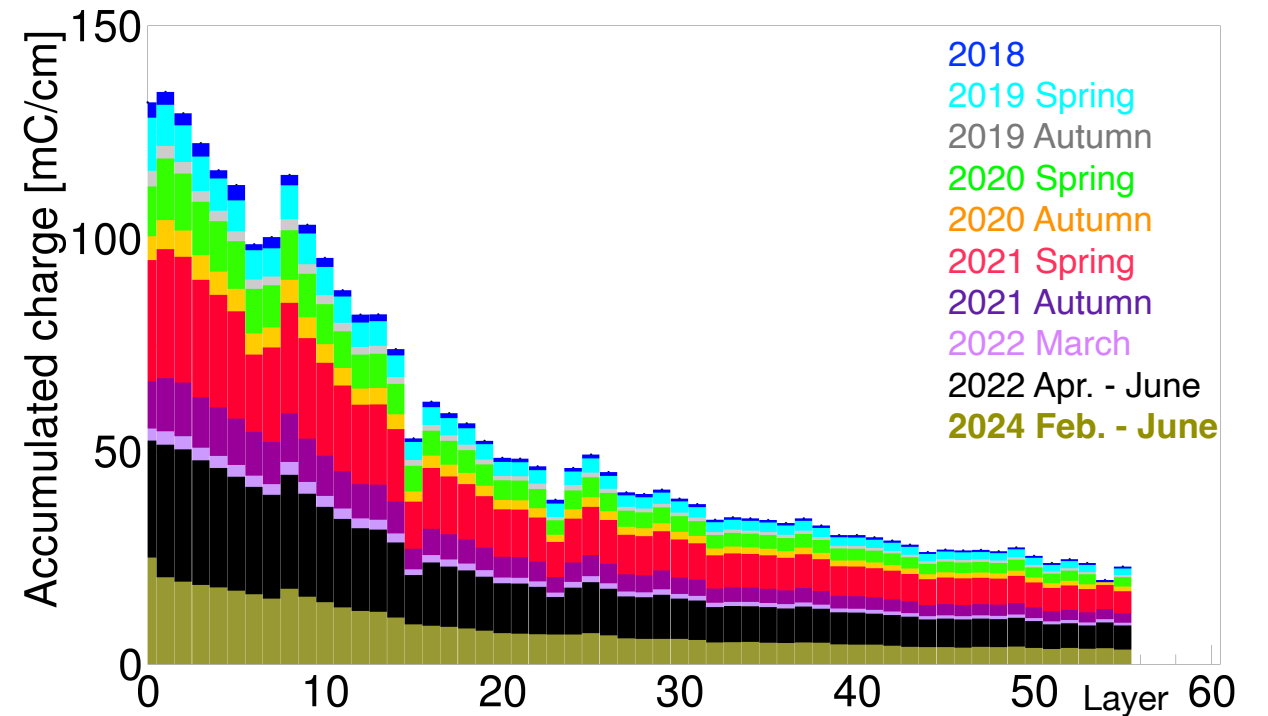
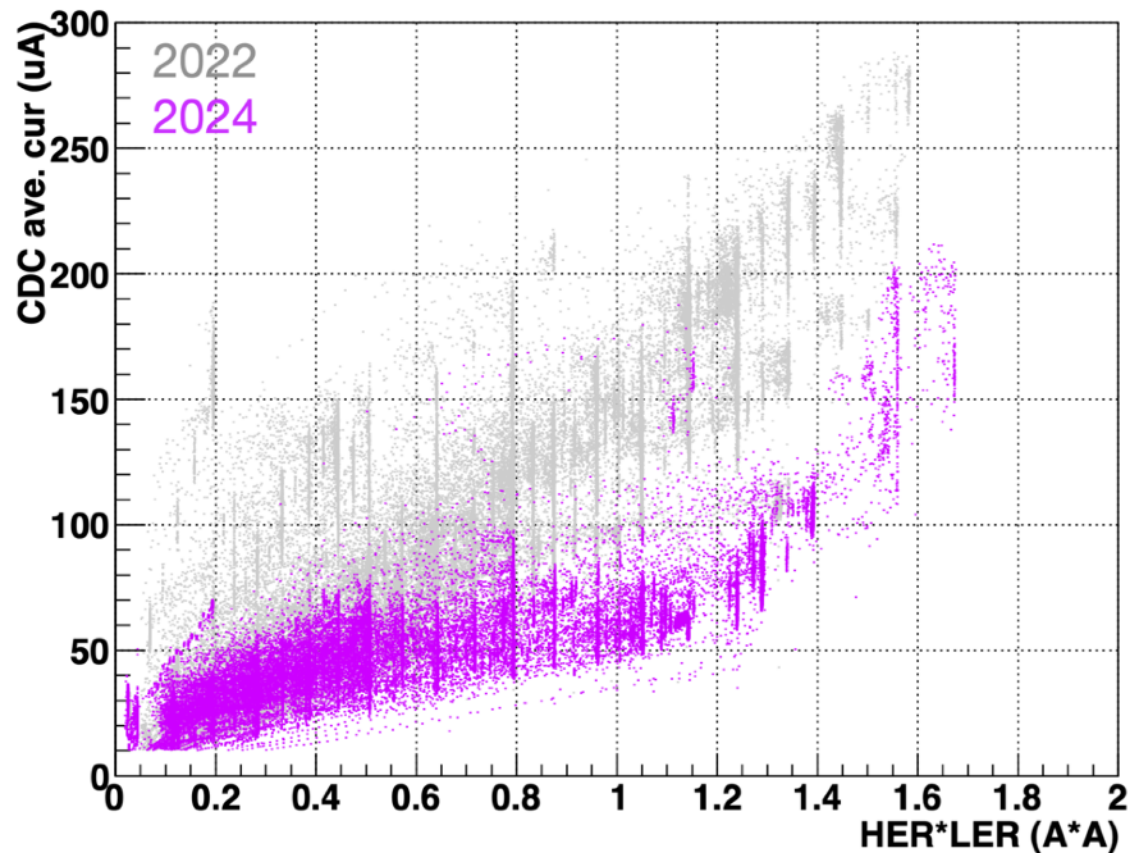


- readout board is located in detector
 - BWD side. direction of lower energy beam (positron)
- power consumption $14\text{W} \times 299 \sim 4.5\text{kW}$
 - water cooling

operation in beam (2024)



operation in beam



- beam background in 2024 has been suppressed at the same beam condition compared with 2022
- accumulated charge is 30-130mC/cm
 - no indication of aging effect (gain drop) so far
-

performance

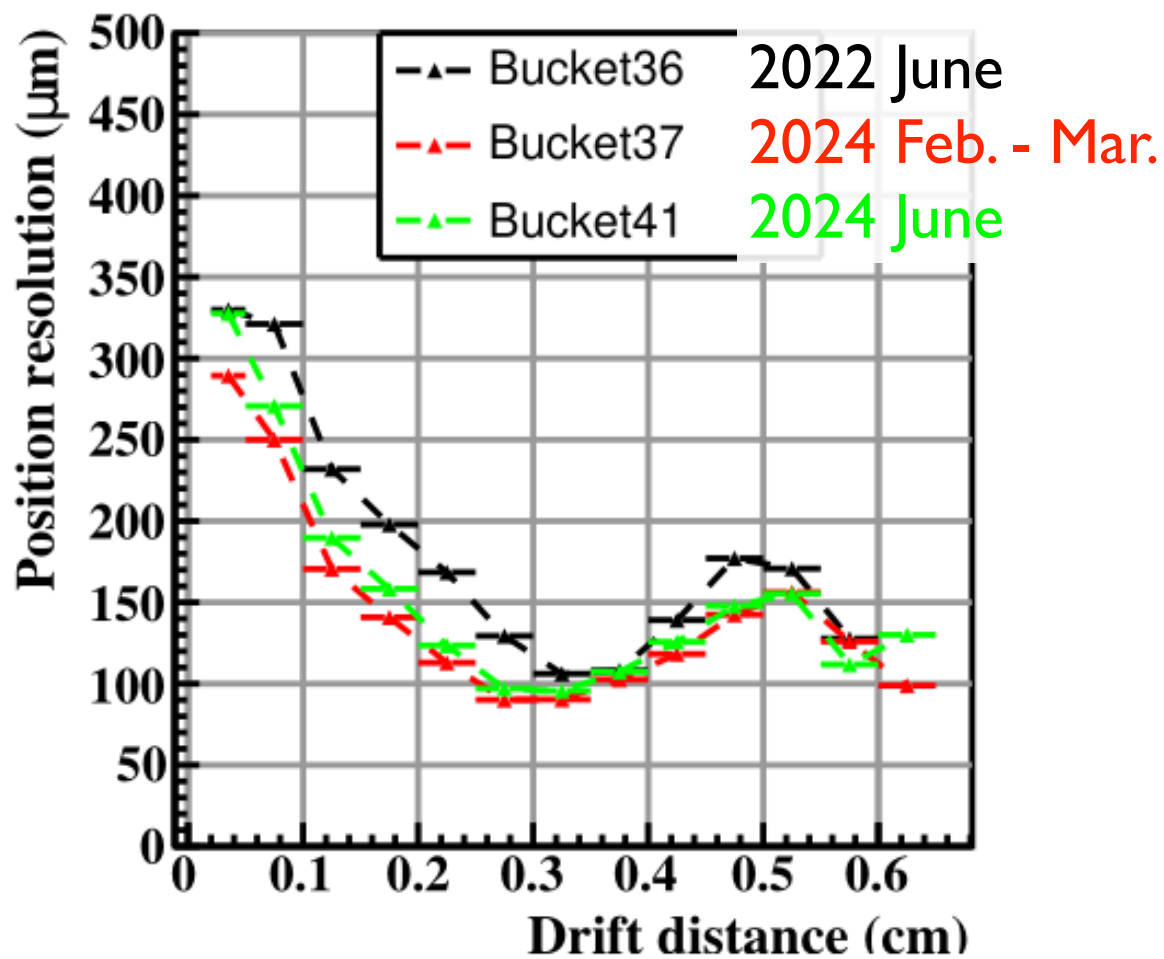
2

by Thanh Dong

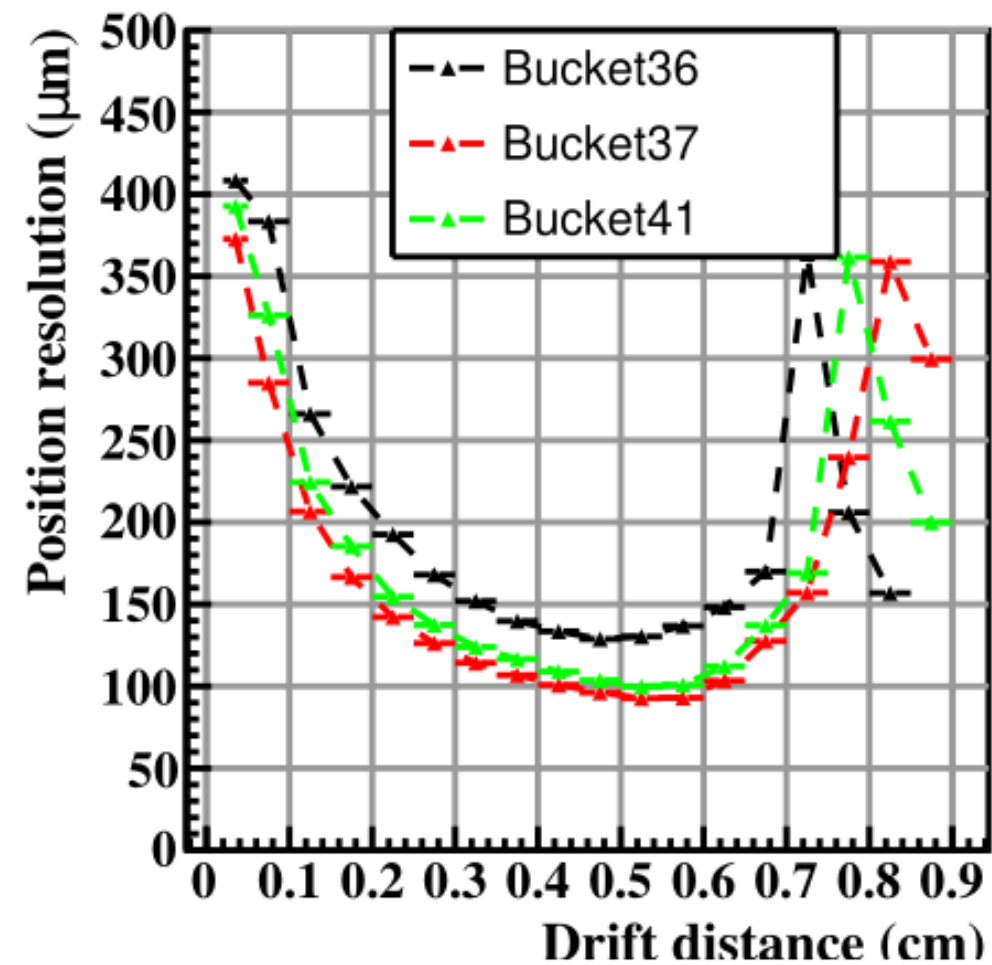
Position resolution

physics data

layer_3 $\theta=90$ $\alpha=-25$ $lr=1$ |



layer_54 $\theta=90$ $\alpha=-5$ $lr=1$ |

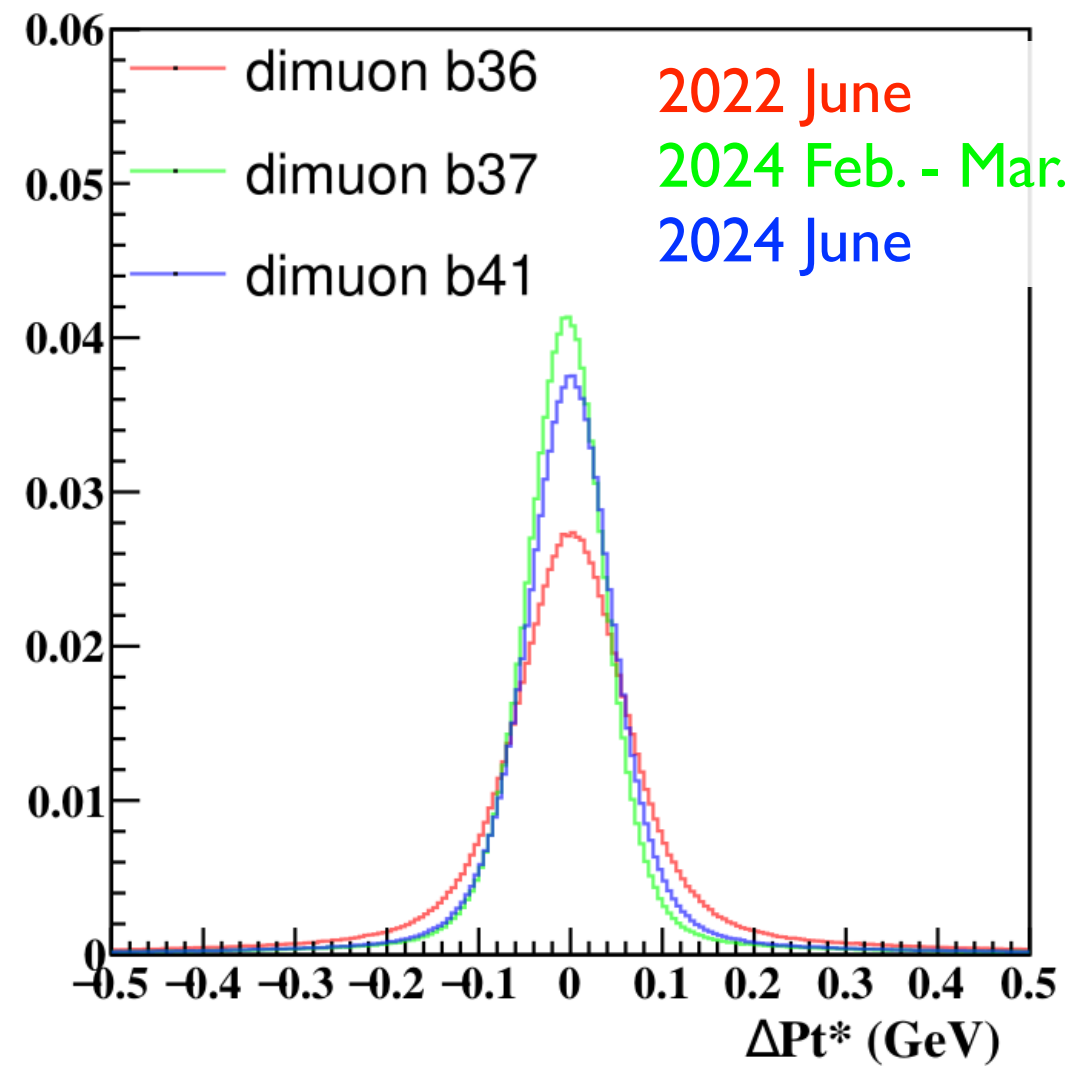
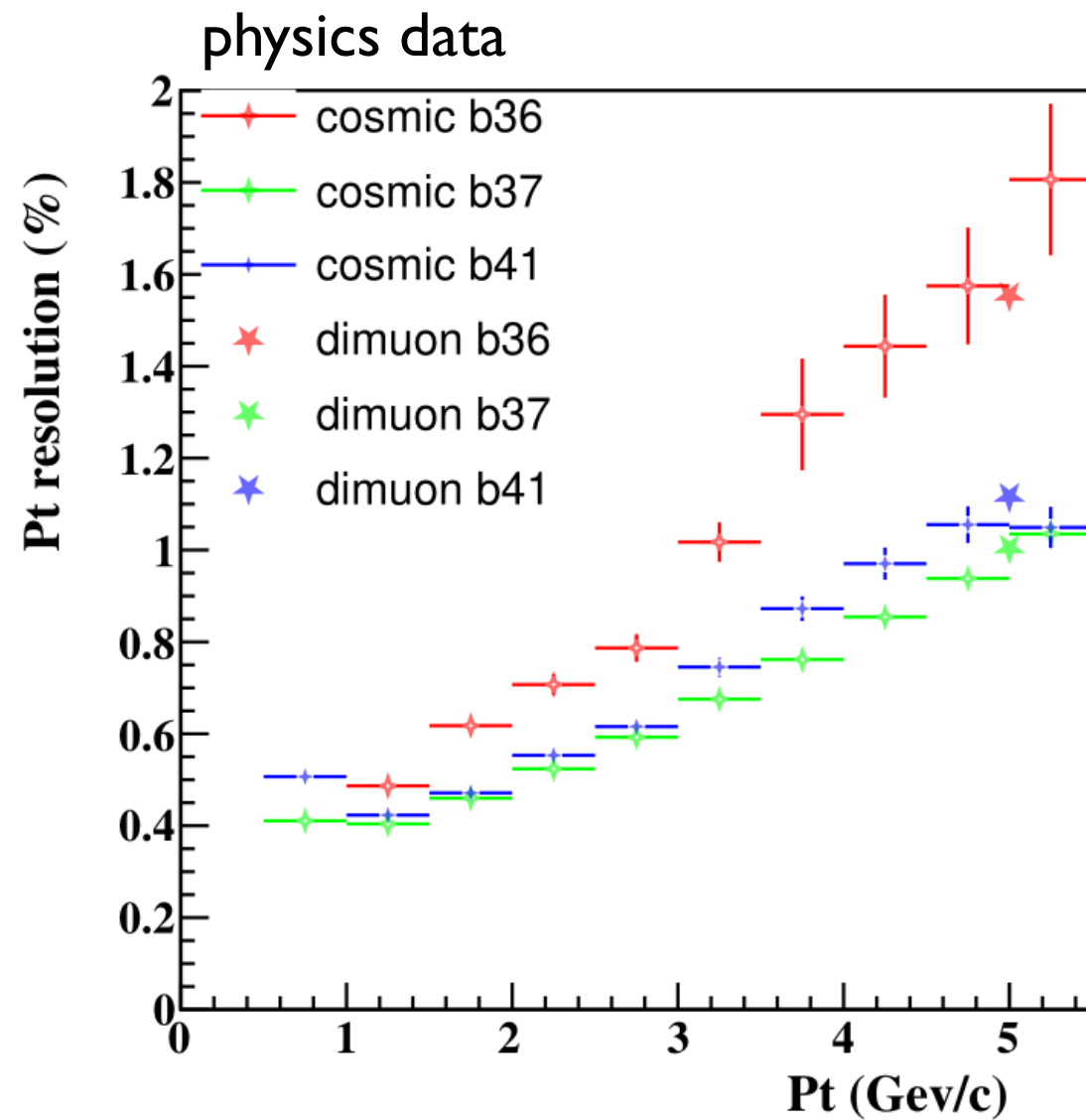


performance

3

by Thanh Dong

Pt resolution (reconstructed by CDC only)



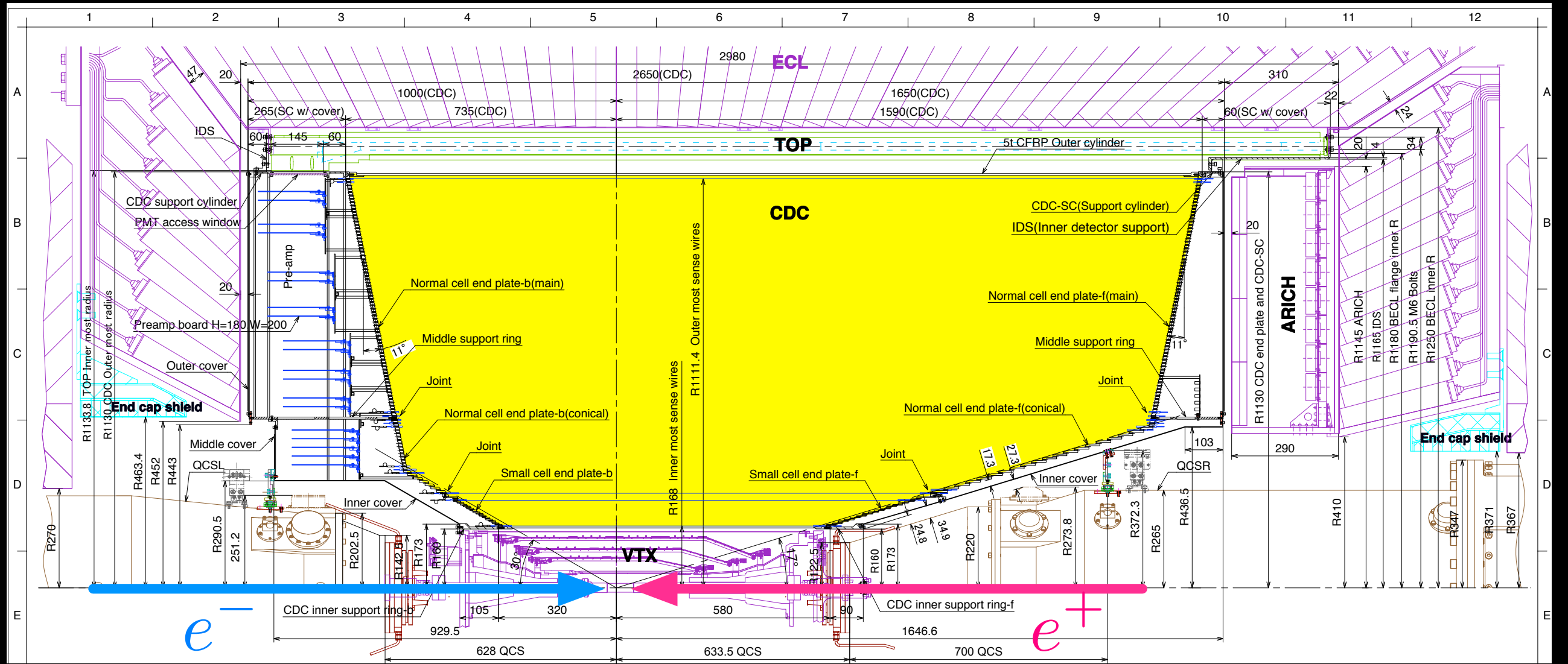
BACKUP

Type of super layer	No. of layers	No. of signal cells per layer	radius (mm)	Stereo angle (mrad)
Axial 0	8	160	168. - 238.0	0.
Stereo (U1)	6	160	257.0 - 438.0	45.4 - 45.8
Axial 2	6	192	365.2 - 455.7	0.
Stereo (V3)	6	224	476.9 – 566.9	-55.3 – -64.3
Axial 4	6	256	584.1 – 674.1	0.
Stereo (U5)	6	288	695.3 – 785.3	63.1 – 70.0
Axial 6	6	320	802.5 – 892.5	0.
Stereo (V7)	6	352	913.7 – 1003.7	-68.5 – -74.0
Axial 8	6	384	1020.9 – 1111.4	0.0

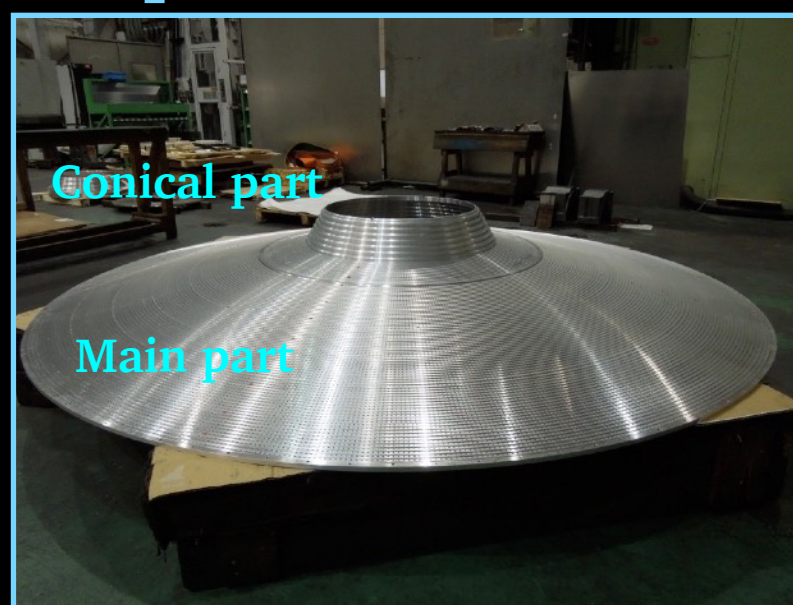
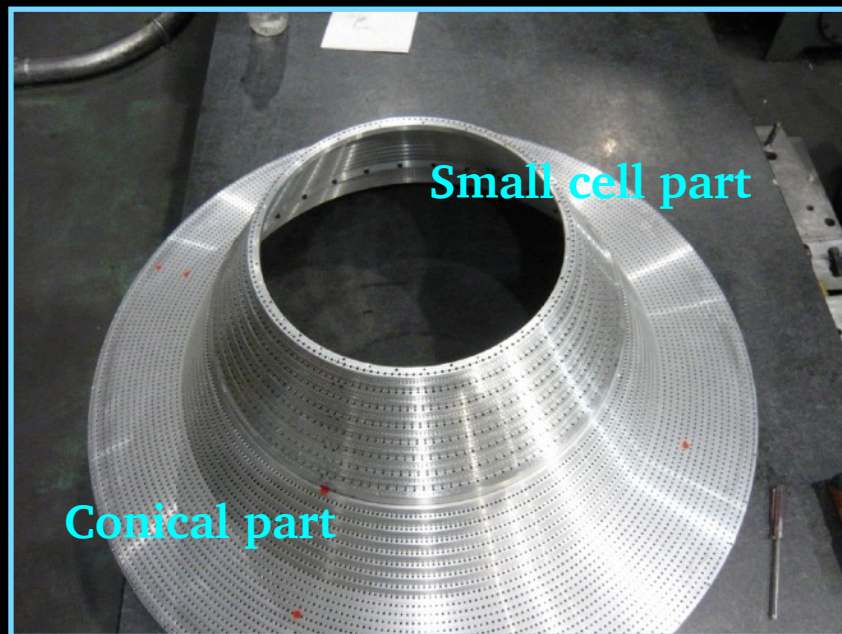


gas seal for Al-pin hole of feedthrough

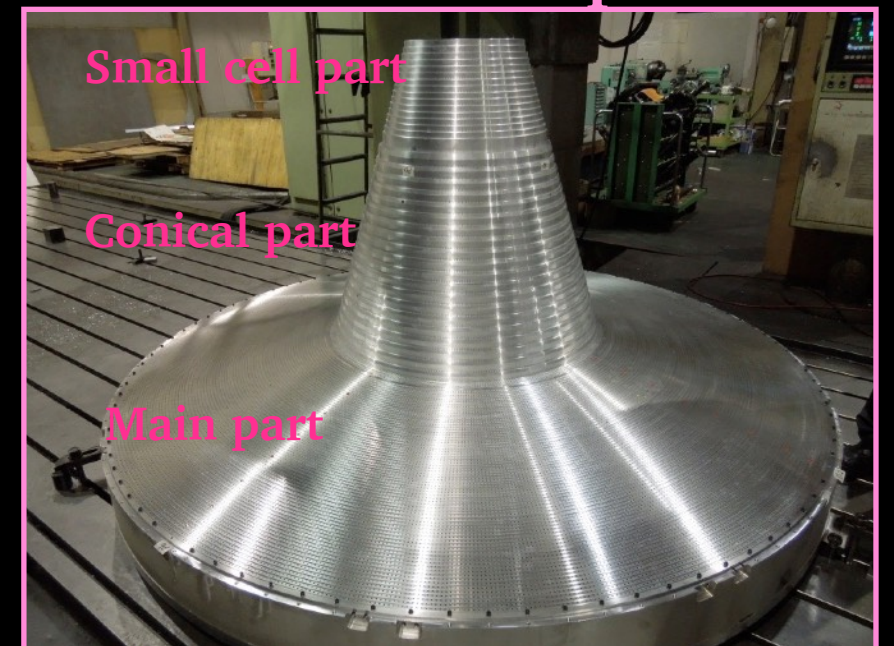
LOCTITE : liquid gasket (anaerobic seal)

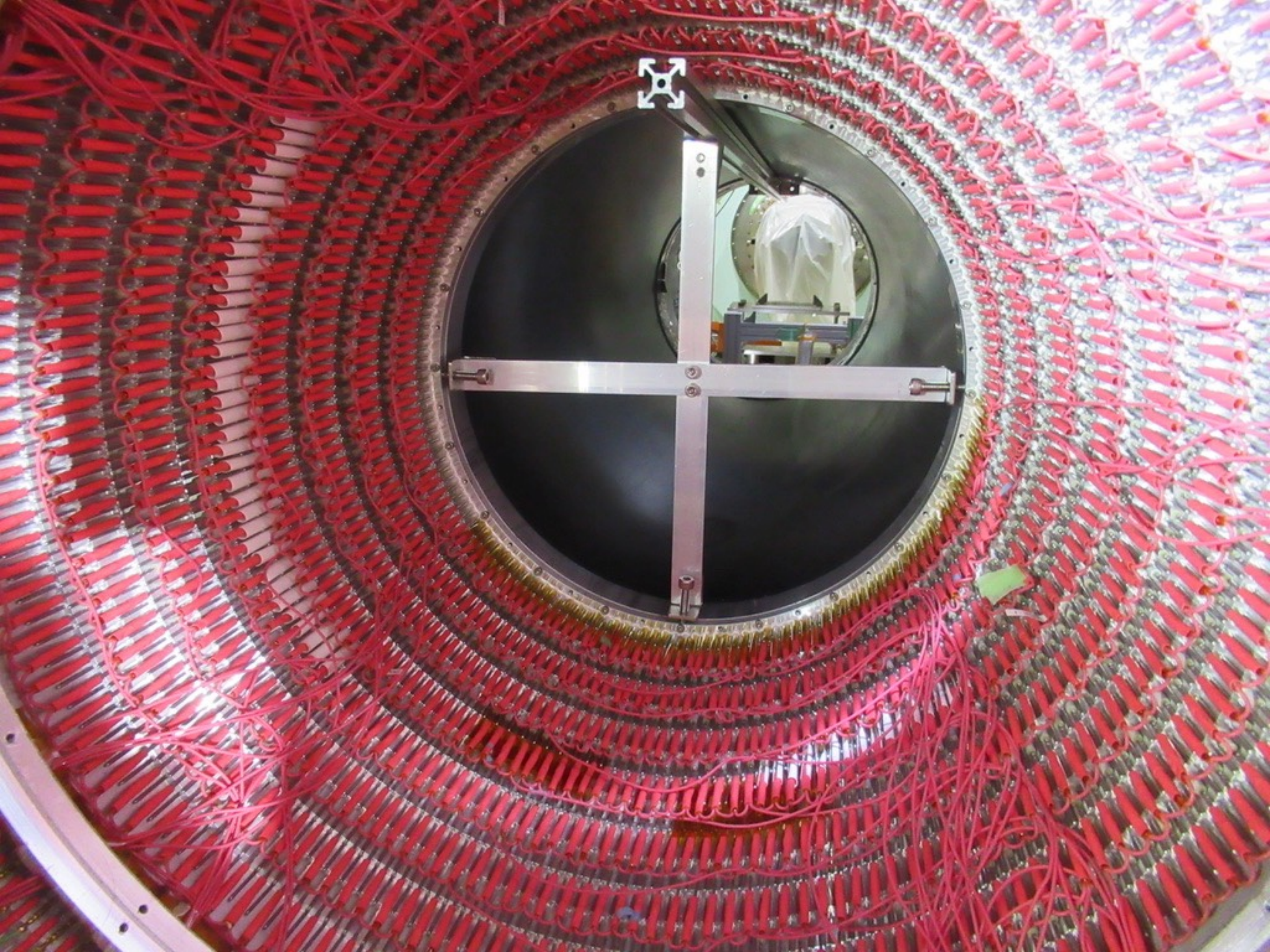


Backward endplate



Forward endplate



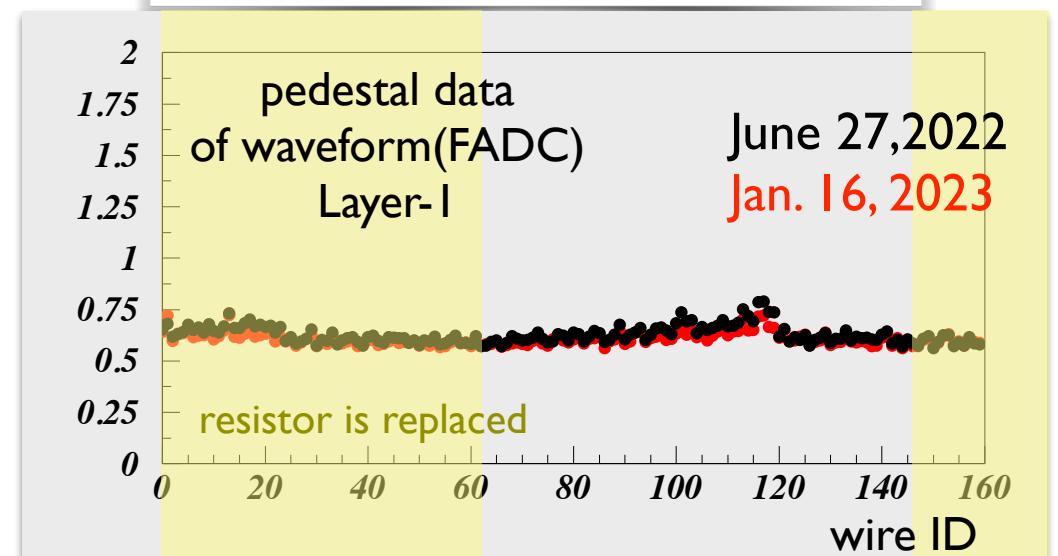
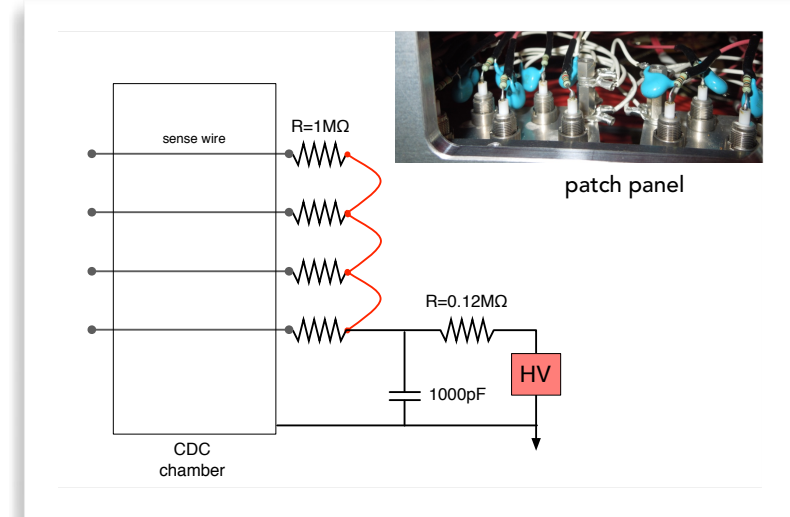
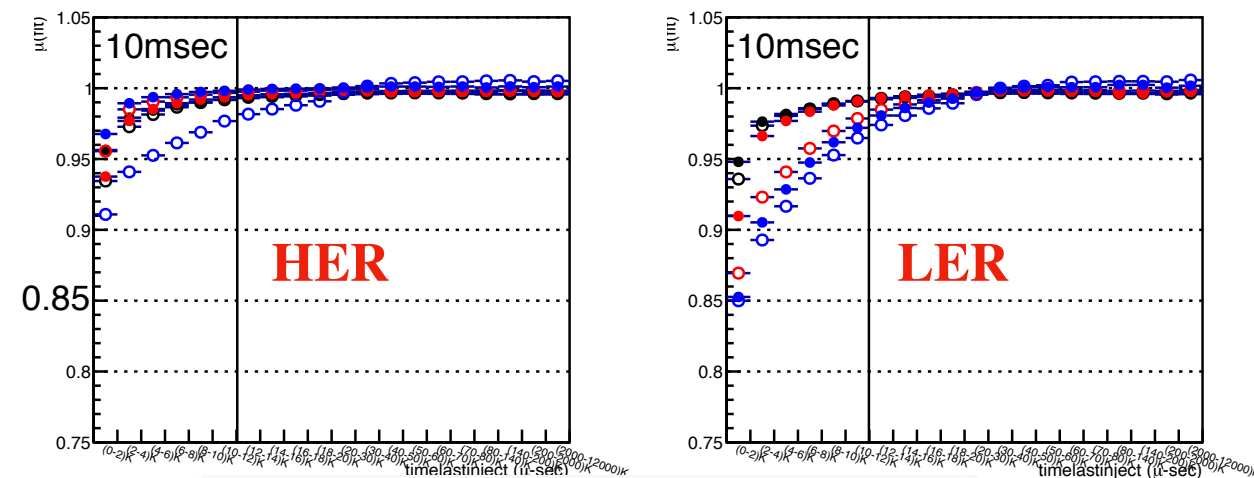


gain drop related to beam operation

- In Jan, replacement of resistor on HV divider was finished
 - to decrease gain drop due to voltage drop
 - $120\text{k}\Omega \rightarrow 1\text{k}\Omega$ determined by tests using test chamber
 - thanks to strong supports by NPC members
- performance confirmed after resistor replacement
 - pedestal data and cosmic data by turning ON HV

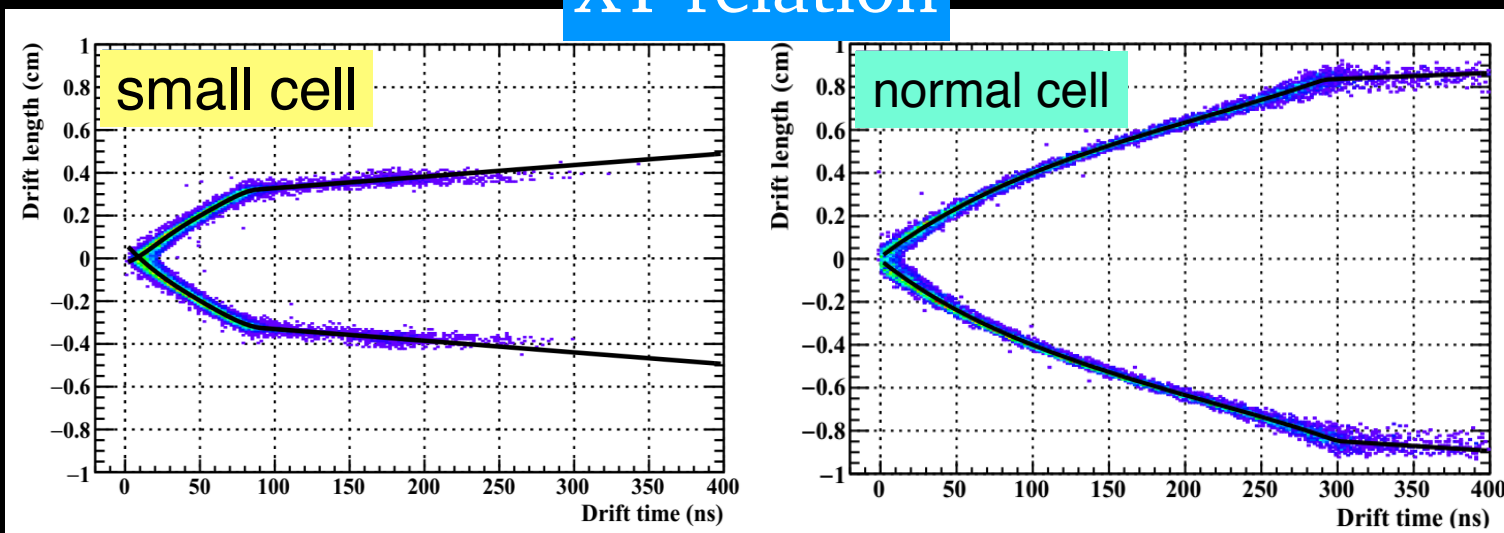
2022ab data

dEdx mean vs. TimeSinceLastInjection

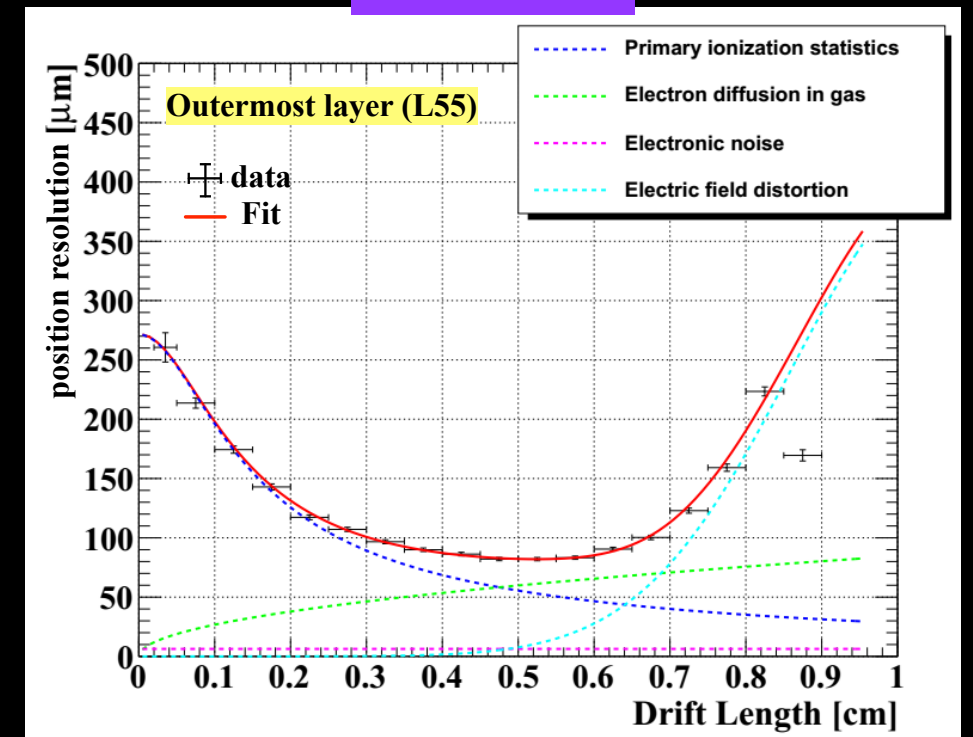


cosmic ray test

XT relation

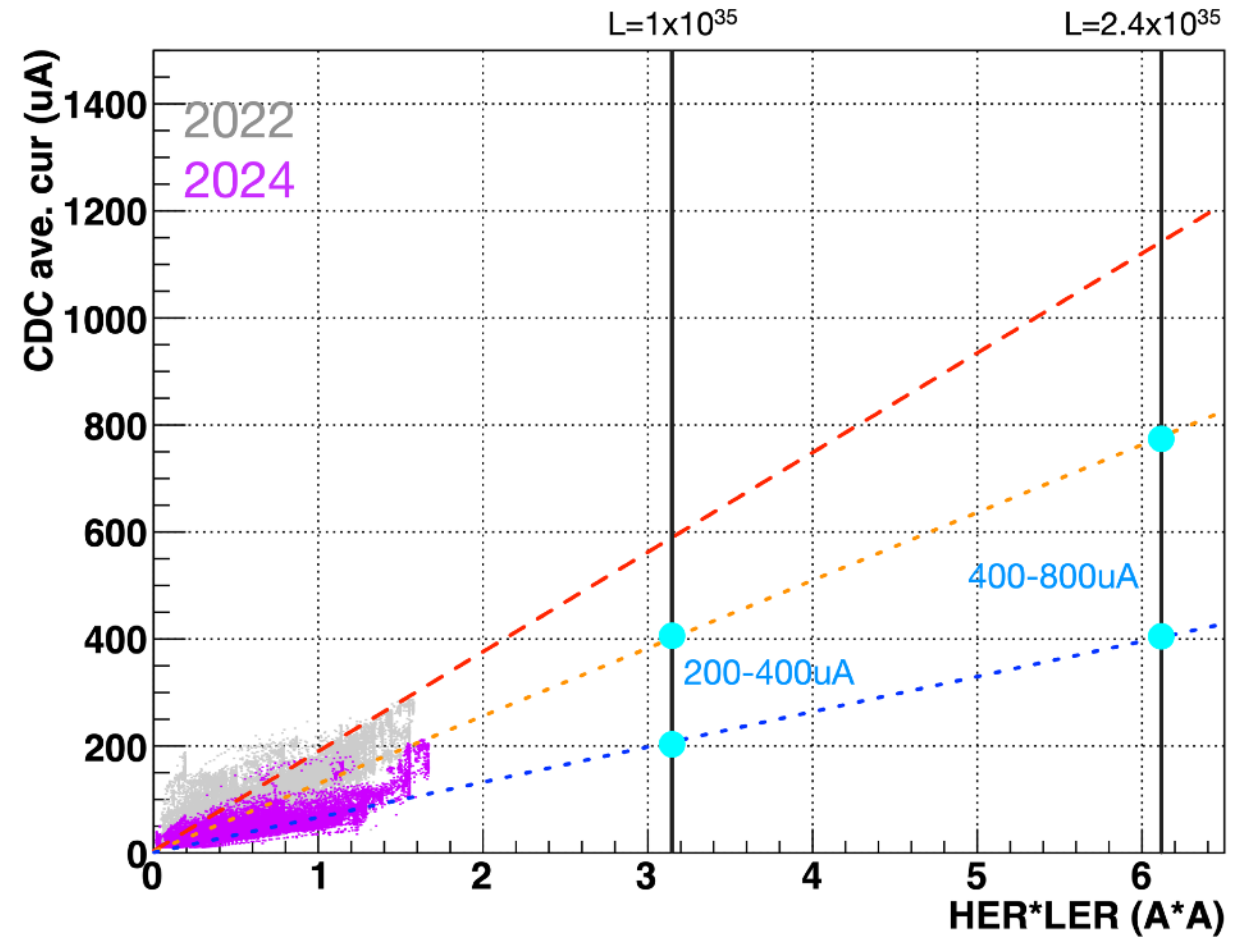
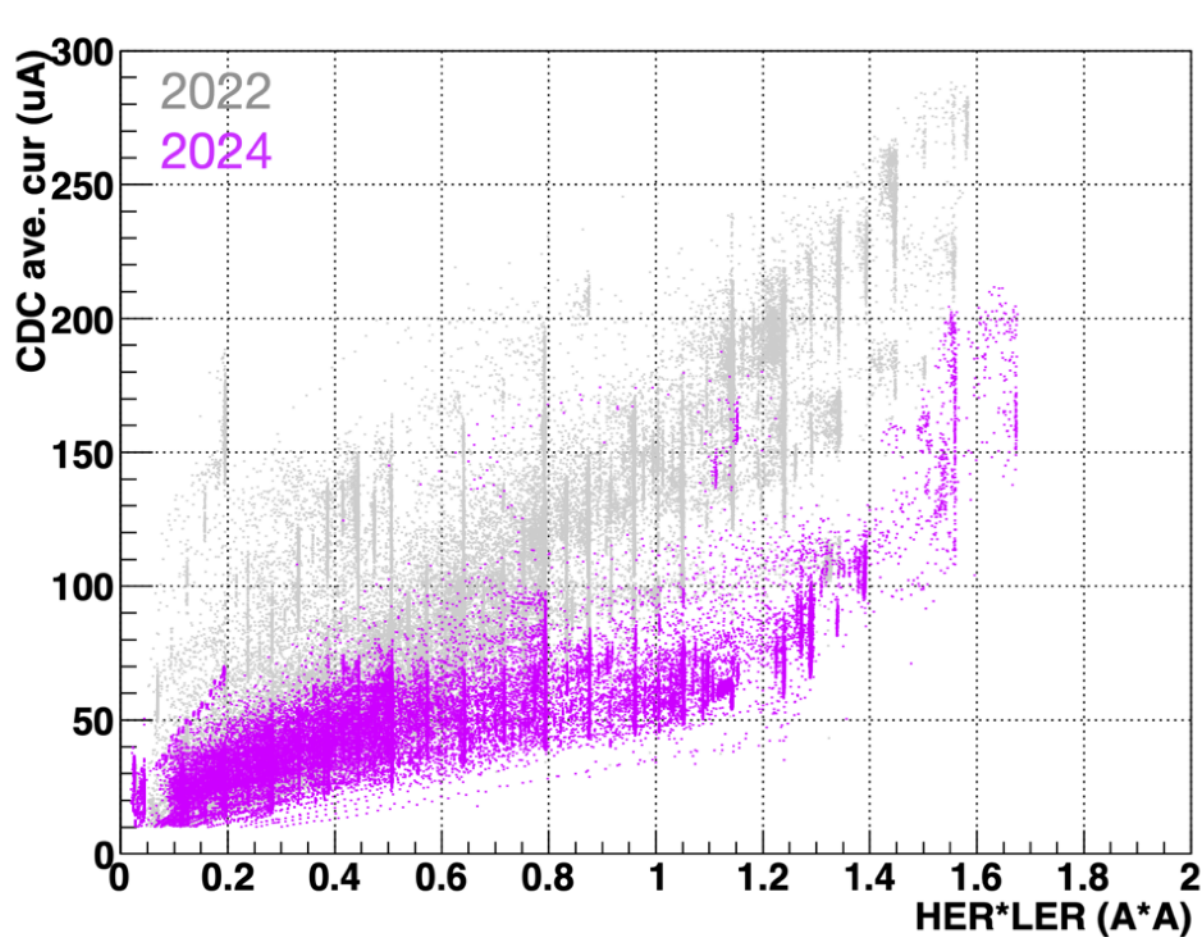


residual

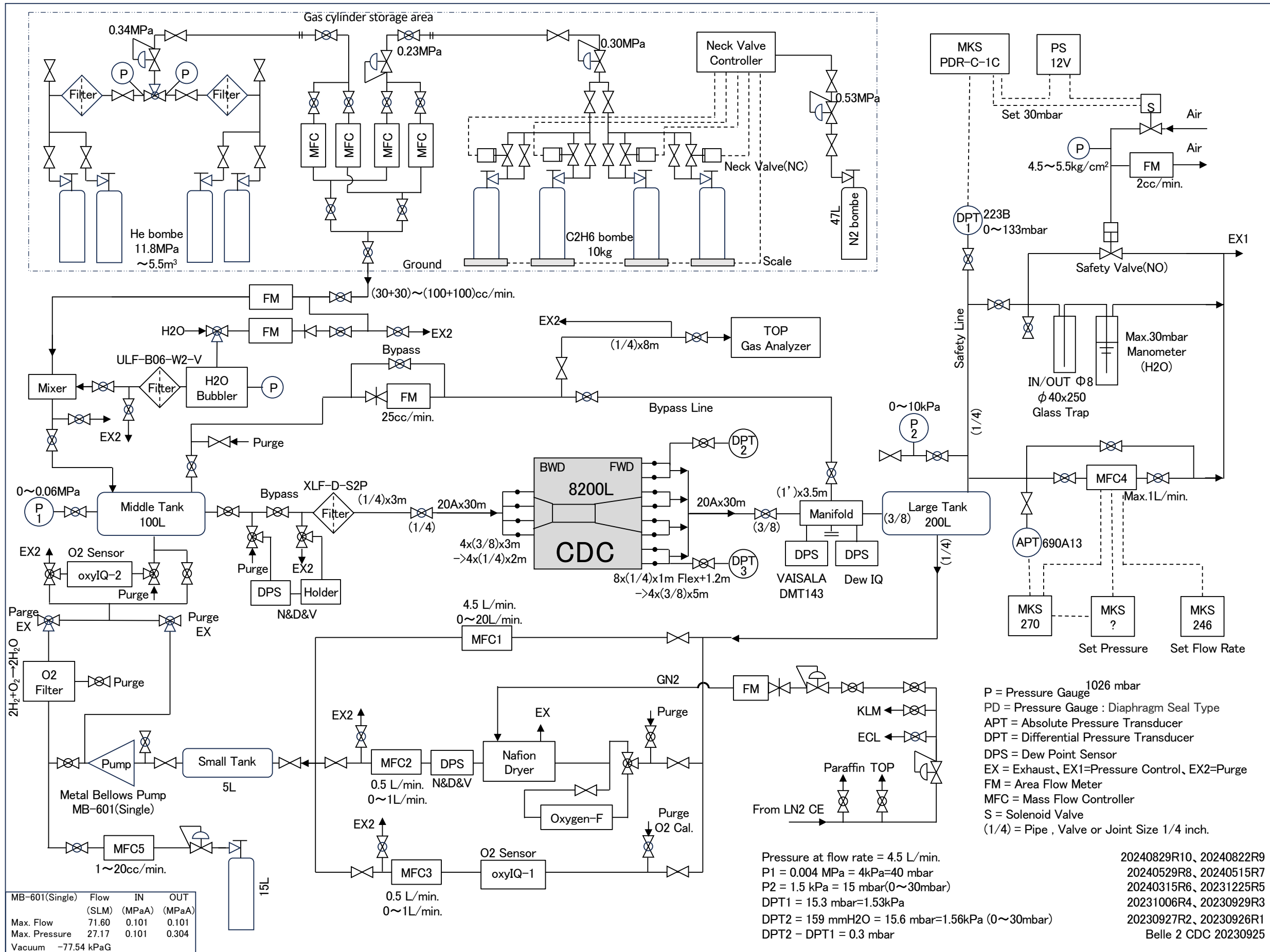


- t_0 correction
- iteration of XT function extraction
- time of flight
- propagation delay on wire

CDC leak current v.s beam current



- beam background is suppress in 2024 compared with 2022
- CDC leak current ; 200-400(400-800)uA/layer at $L=1 \times 10^{35}$ (2.4×10^{35})
 - luminosity expectation is based on the Masuzawa-san's slide at BPAC
- accumulated charge $\sim 0.39-0.78$ C/cm/year at $L=2.4 \times 10^{35}$ for innermost layer
 - assuming 6 months physics run/year
 - $\sim 6\%$ gain degradation at 1 C/cm (Belle-1 study with test chamber)

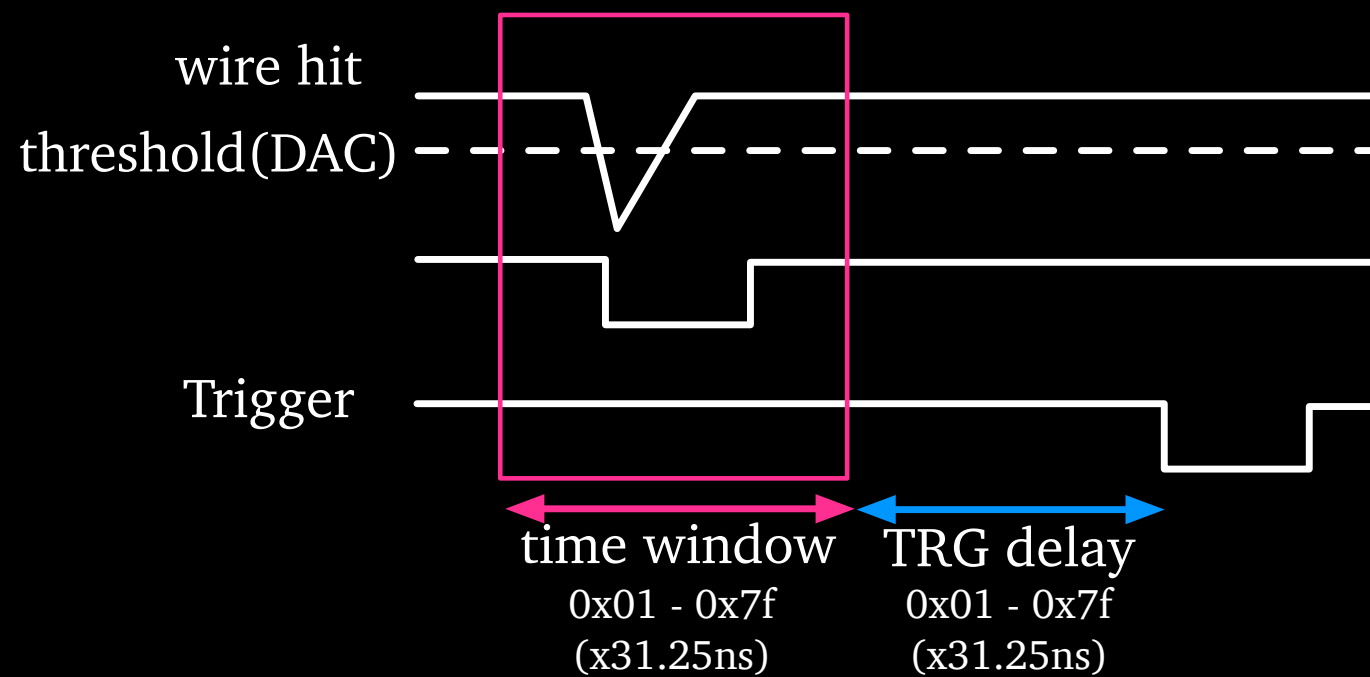


MB-601(Single)	Flow (SLM)	IN (MPaA)	OUT (MPaA)
Max. Flow	71.60	0.101	0.101
Max. Pressure	27.17	0.101	0.304
Vacuum	-77.54	kPaG	

Pressure at flow rate = 4.5 L/min.
P1 = 0.004 MPa = 4kPa=40 mbar
P2 = 1.5 kPa = 15 mbar(0~30mbar)
DPT1 = 15.3 mbar=1.53kPa
DPT2 = 159 mmH2O = 15.6 mbar=1.56kPa (0~30mbar)
DPT2 - DPT1 = 0.3 mbar

20240829R10, 20240822R9
20240529R8, 20240515R7
20240315R6, 20231225R5
20231006R4, 20230929R3
20230927R2, 20230926R1
Belle 2 CDC 20230925

- P = Pressure Gauge
- PD = Pressure Gauge : Diaphragm Seal Type
- APT = Absolute Pressure Transducer
- DPT = Differential Pressure Transducer
- DPS = Dew Point Sensor
- EX = Exhaust, EX1=Pressure Control, EX2=Purge
- FM = Area Flow Meter
- MFC = Mass Flow Controller
- S = Solenoid Valve
- (1/4) = Pipe, Valve or Joint Size 1/4 inch.



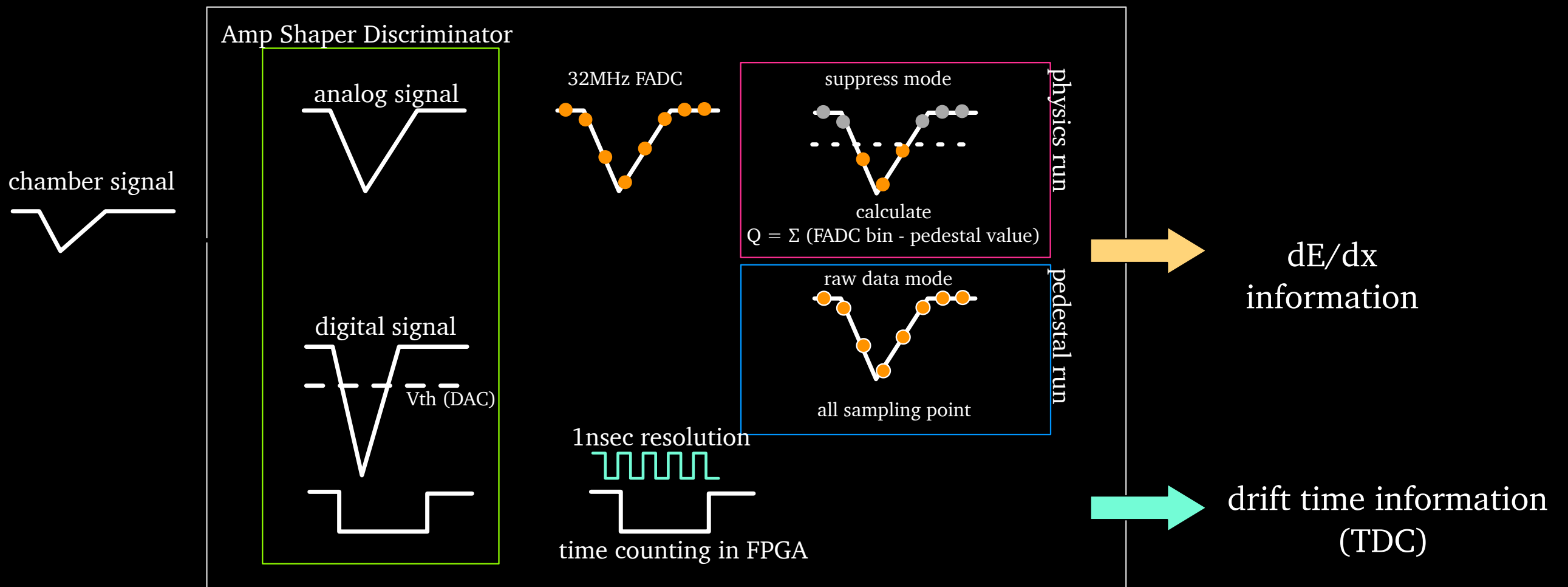
setting parameter (register write/read)

Board by board

- time window
- TRG delay
- Discriminator threshold
- threshold for summed FADC bin

Channel by channel

- pedestal value



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 : X299
- power consumption = $14\text{W}/\text{board} \times 299 \sim 4.2\text{kW}$
 - water cooling

