MEG II実験陽電子タイミングカウンターのコミッショニング
– エンジニアリングラン最初の結果 –

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東北学院大学（泉キャンパス）

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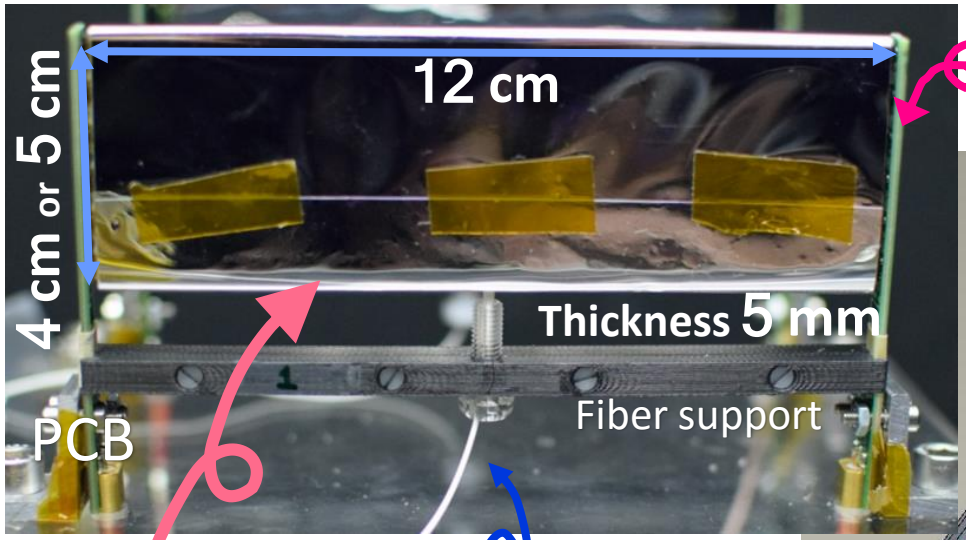
Overview of Timing Counter



6 SiPMs in series at the both ends
AdvanSiD (Italy) 3x3 mm², 50x50 um² pixels

256 x 2
(up and down stream) counters

Fast Plastic Scintillator
BC422, rise time 0.35 ns
attenuation length 8 cm
With reflector (3M film)

Optical Fiber for laser light
Inter-counter time offset is calibrated by laser.

Calibration→ Next talk
M. Nakao

Cable (RG178)
Non-magnetic

Back plane
Long PCB ~80 cm
Multi layer, coaxial like

σ~30 ps (with 9 counters) was demonstrated.


¼ TC installation is
Completed

TC Pilot Run

¼ counters are installed and tested in MEG II site, πE5 beam line at PSI in Switzerland.

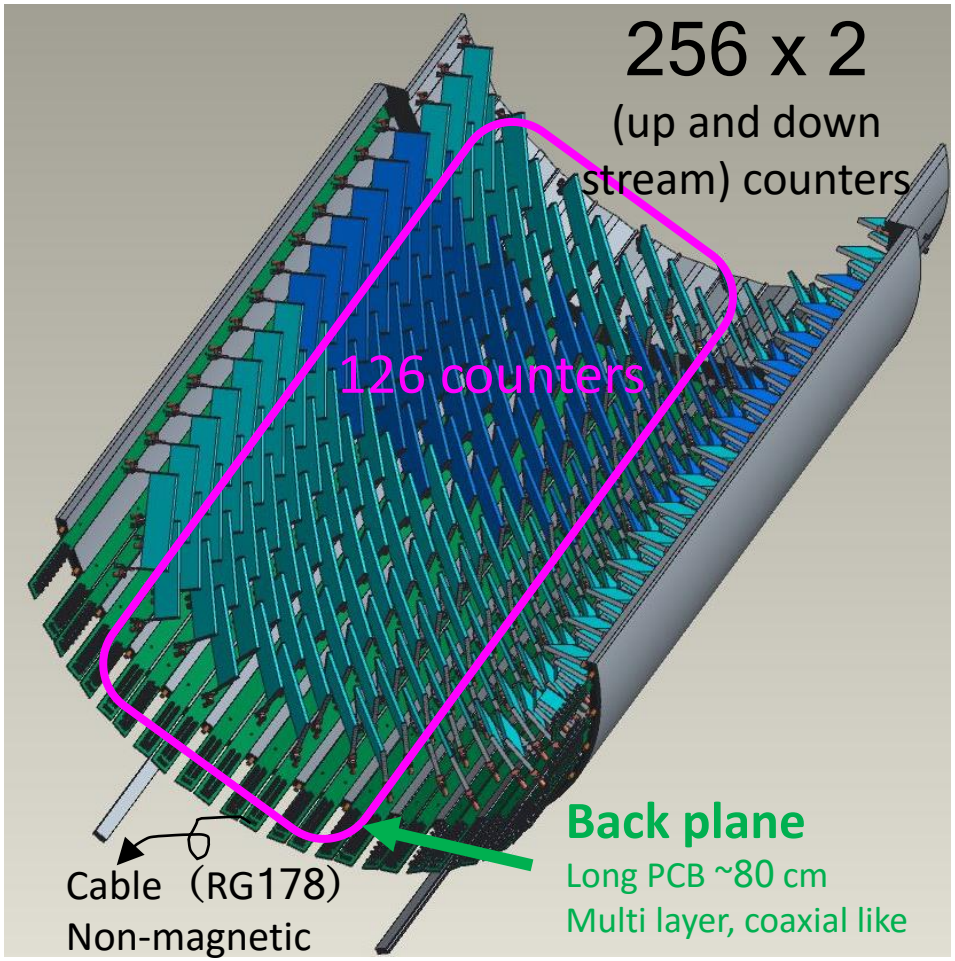
- Beam: DC muon beam. Muons are stopped at target (~7×10^7 μ/s)
- Installed: ¼ TC, magnet, target, frame of drift chamber, DAQ full system

Goal

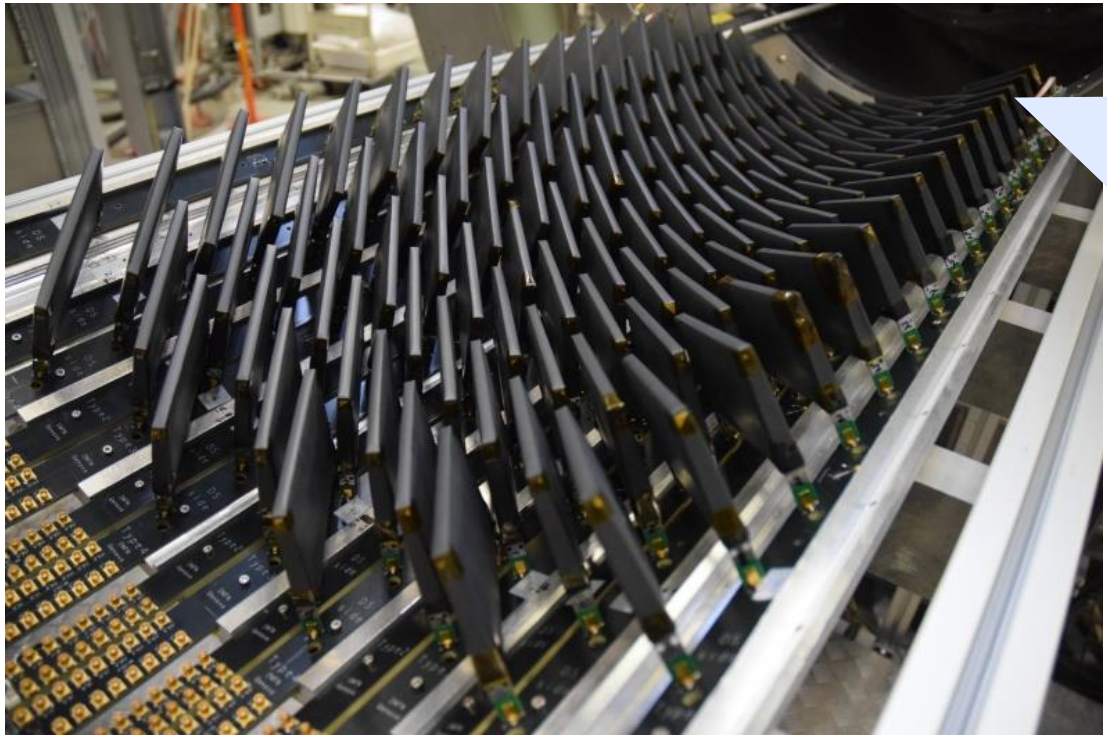
- Check mechanical integrity
- Operate TC all systems
  - counters, laser calibration systems, DAQ, trigger, slow control such as temperature and HV
- Apply full analysis
  - Measure positrons time
  - Calibrate inter counter jitter

→ Next talk: M. Nakao

Half of DS counters are installed.

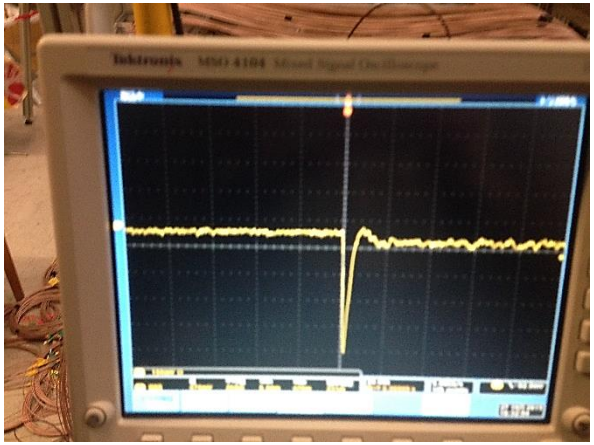


Installation and Assembly



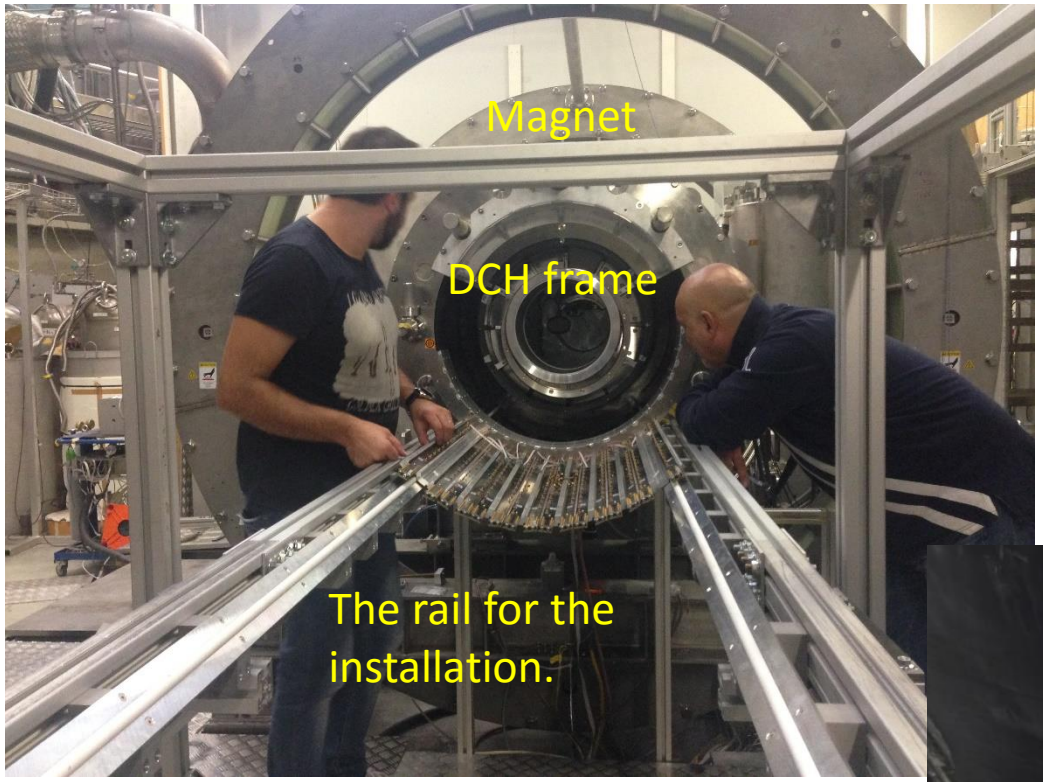
Inner step

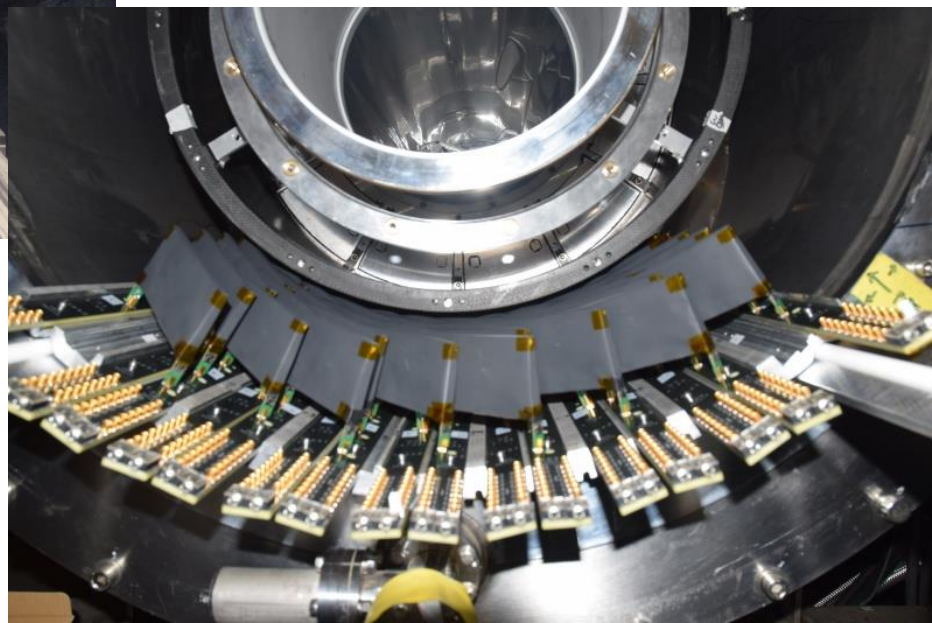
- Mount the counters one by one and check the signals after cabling
  - To Check the signal from cosmic ray.
    - We did not check waveform detail behavior at that moment.



Signals from ALL counters!

Installation and Assembly

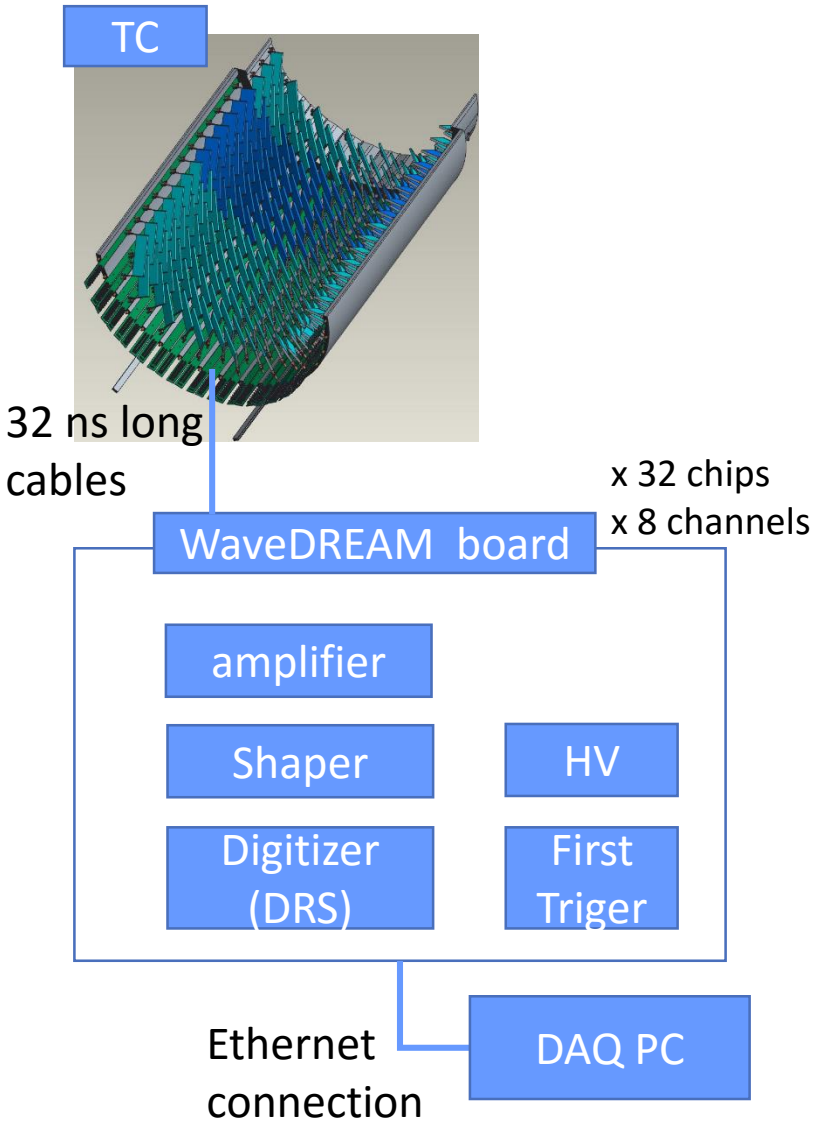




- Installation system are confirmed.
- We did not see any conflict b/w DCH and TC

DAQ

- Amplifier
  - Factor 1, 10, **100**
- Shaper
  - Pole zero cancellation (**on**/off)
- Digitizer (DRS)
  - Sampling speed **2GHz**
  - Calibration of intra channels, and inter chips are not implemented in the system for the moment. **External calibration** were used for time.
- Trigger
  - Pedestal, Single hit, coincidence, Track-like, and Laser trigger are prepared.
- Problems due to delay of preparation (to be fixed)
  - Noise (> 10 mV RMS)
  - Half of ADC readout are not reliable; many dead channels and digital noise
  - Dynamic range is not optimized.
  - …

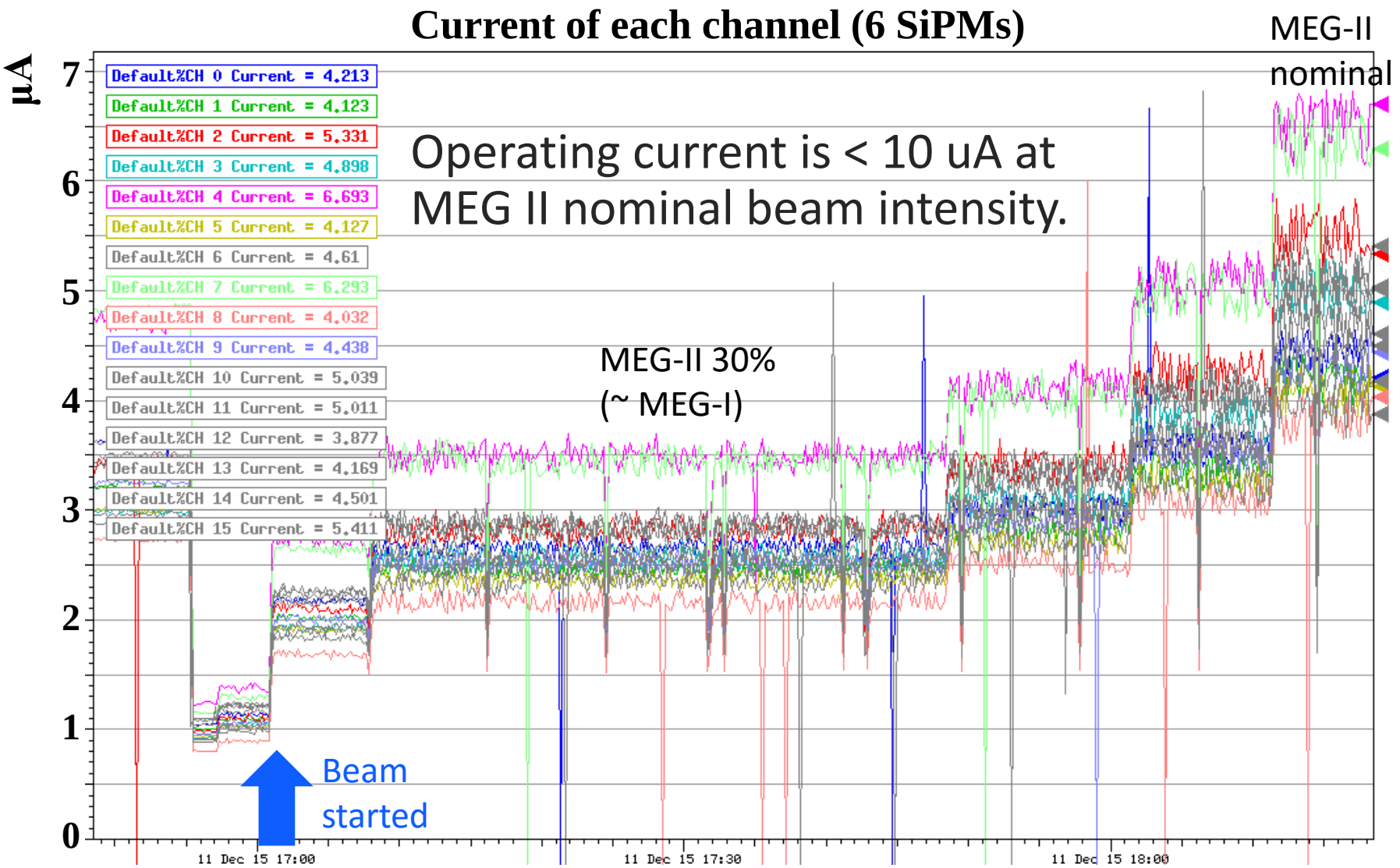


Data Taking

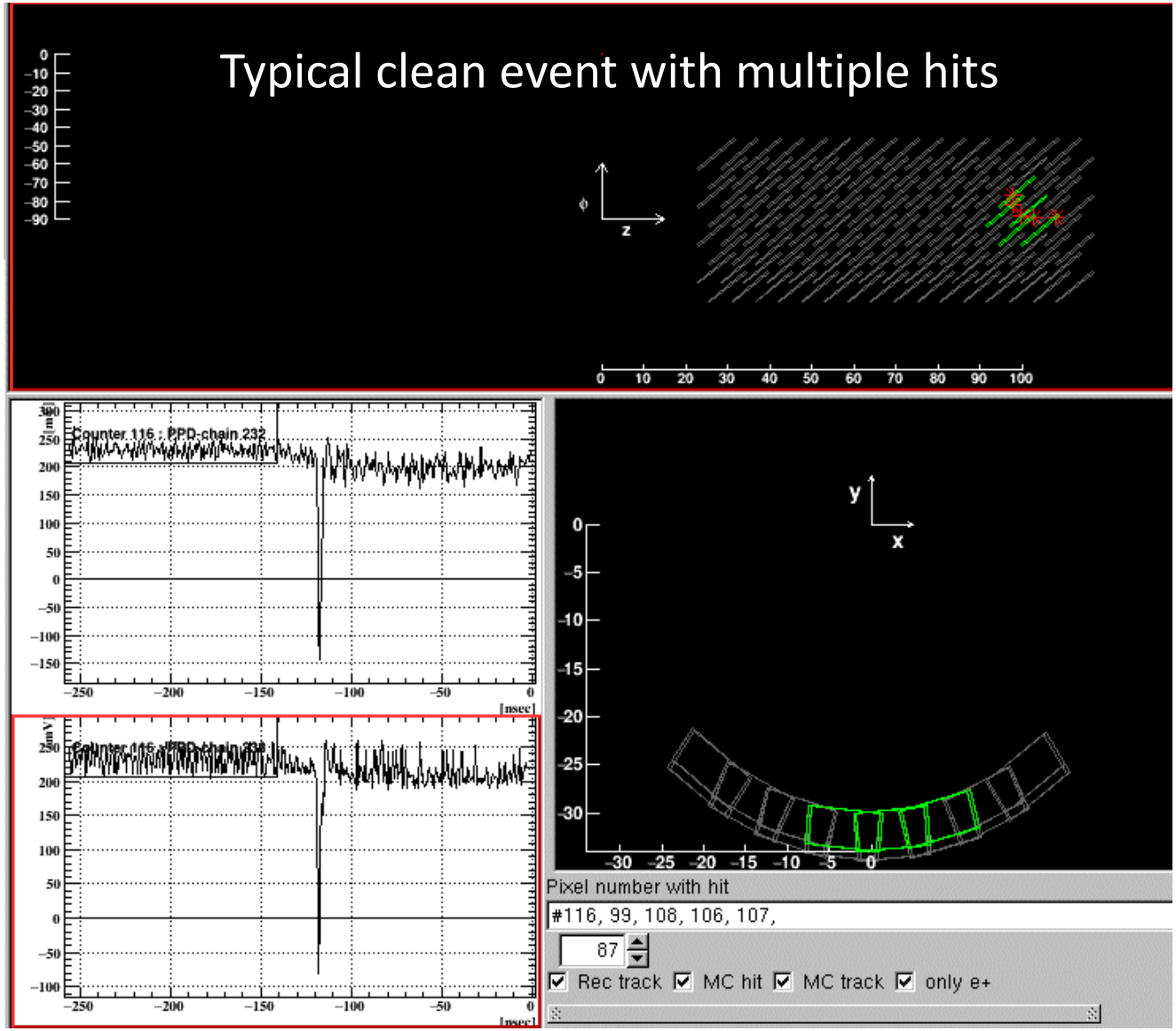
- Data taking started on 14th Dec.
- Preparation for DAQ system was delayed.
  - We performed pilot run with several problems in DAQ system. (It will be fixed.)
- Waveform readout started on 19th.
  - DAQ debugging took time.
  - Meaningful data (from timing view point) were taken last 10 hours.
  - Data quality of the run is not so good due to several DAQ problems.

- What we did
  - Current check
  - Test several trigger configurations
  - Threshold scan
  - Debugging of DAQ system
  - Calibration

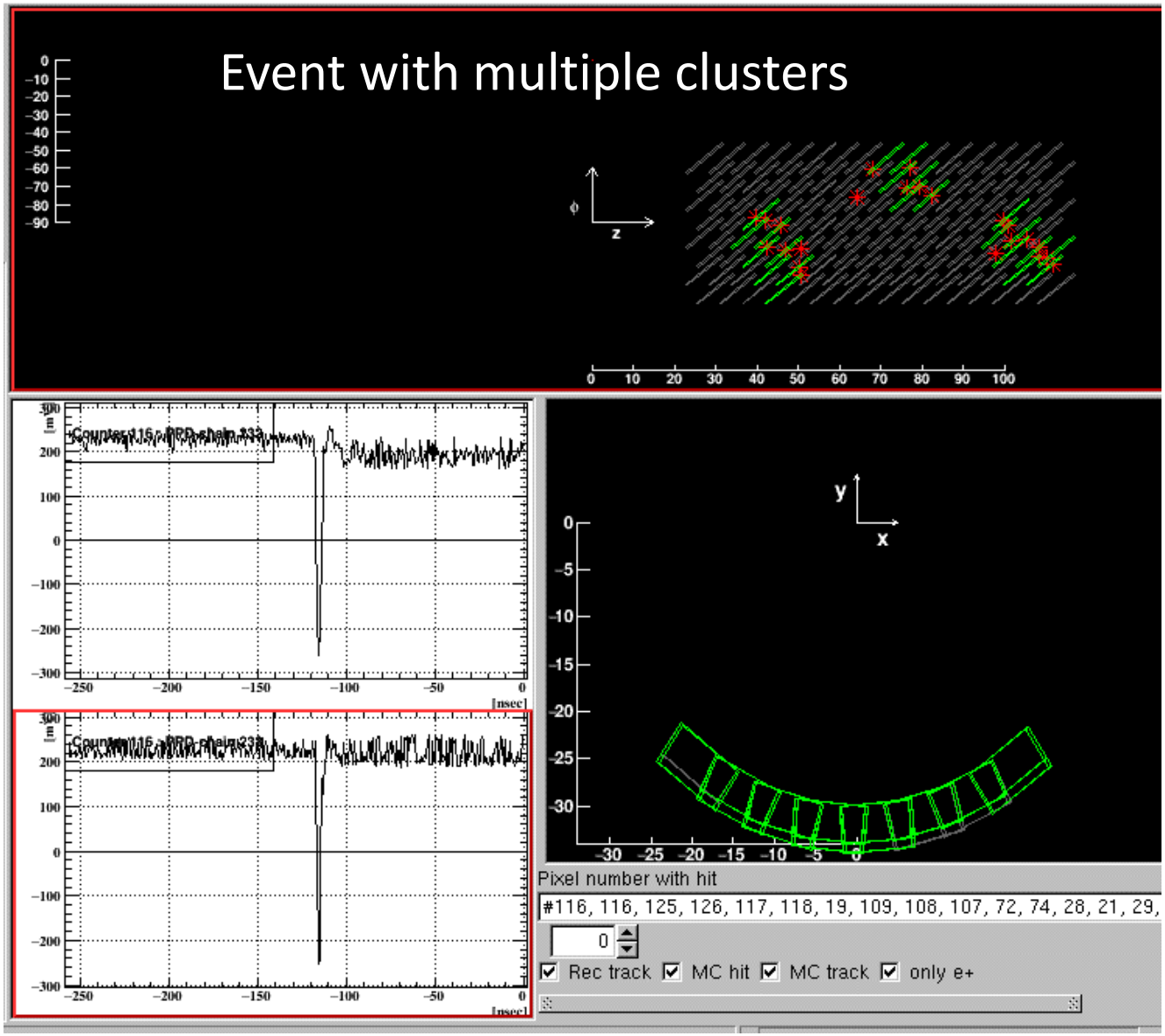
Current


Current of each channel (6 SiPMs)
µA
Default%CH 0 Current = 4.213
Default%CH 1 Current = 4.123
Default%CH 2 Current = 5.331
Default%CH 3 Current = 4.898
Default%CH 4 Current = 6.693
Default%CH 5 Current = 4.127
Default%CH 6 Current = 4.61
Default%CH 7 Current = 6.293
Default%CH 8 Current = 4.032
Default%CH 9 Current = 4.438
Default%CH 10 Current = 5.039
Default%CH 11 Current = 5.011
Default%CH 12 Current = 3.877
Default%CH 13 Current = 4.169
Default%CH 14 Current = 4.501
Default%CH 15 Current = 5.411
Operating current is < 10 uA at
MEG II nominal beam intensity.
MEG-II 30%
(~ MEG-I)
MEG-II
nominal
Beam
started
0
1
2
3
4
5
6
7
11 Dec 15 17:00
11 Dec 15 17:30
11 Dec 15 18:00

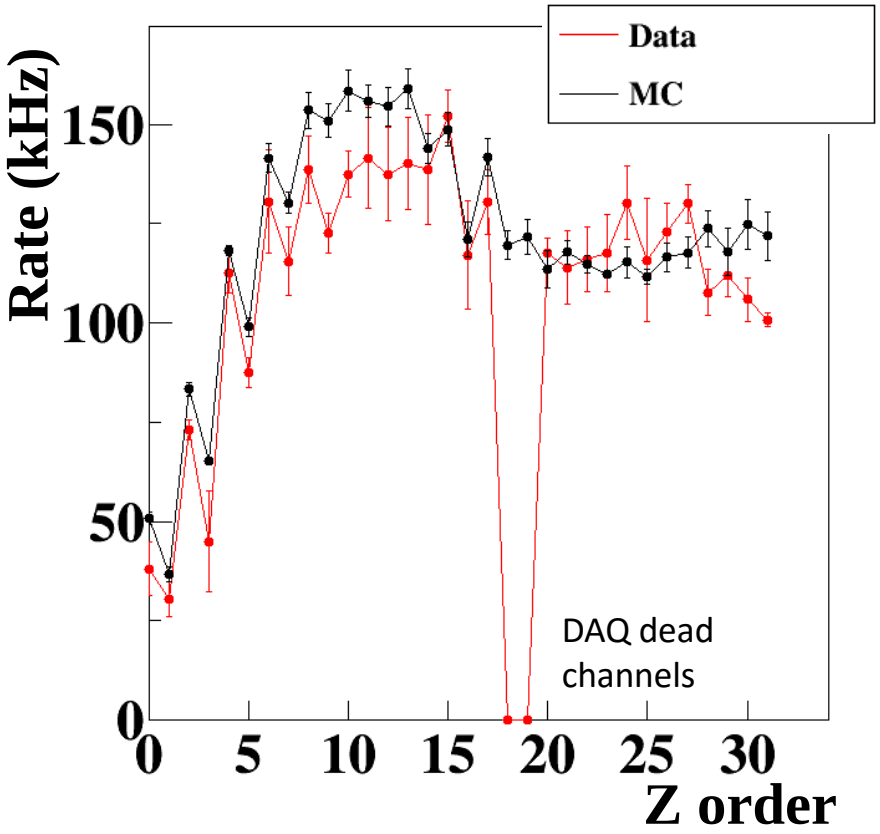
Event


Typical clean event with multiple hits
Counter 116 : PPD-chain 232
[nsec]
y
x
Pixel number with hit
#116, 99, 108, 106, 107,
87
Rec track
MC hit
MC track
only e+

Event


Event with multiple clusters
Pixel number with hit
#116, 116, 125, 126, 117, 118, 19, 109, 108, 107, 72, 74, 28, 21, 29,
Rec track
MC hit
MC track
only e+
[nsec]

Counter Hit Rate



MC set up

- No DCH frame
- Muon beam (Muons which penetrate the target are also simulated)

Data

- Pedestal trigger data
- Count no signal events.

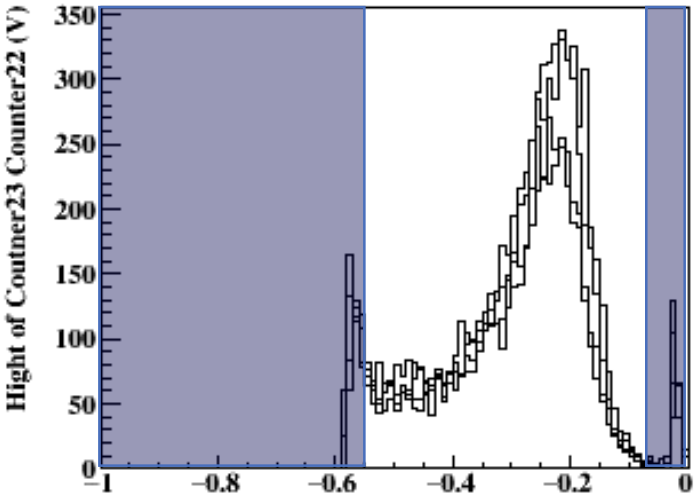
The hit rate is consistent with MC.

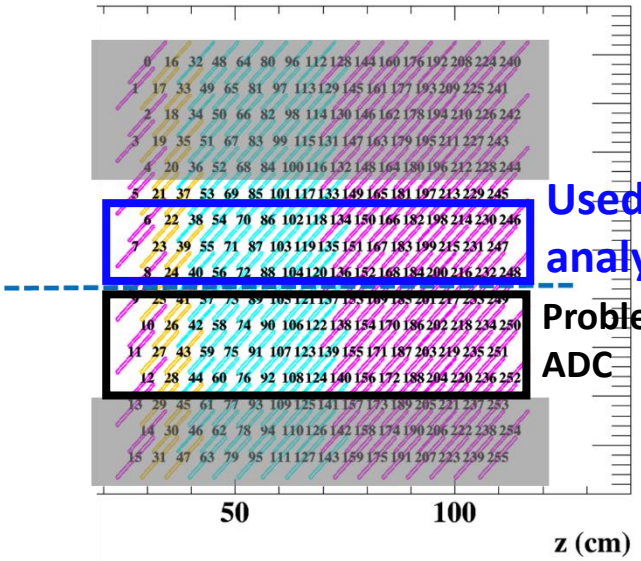
TC is operated at 50-150 kHz positron hits.

Timing Analysis

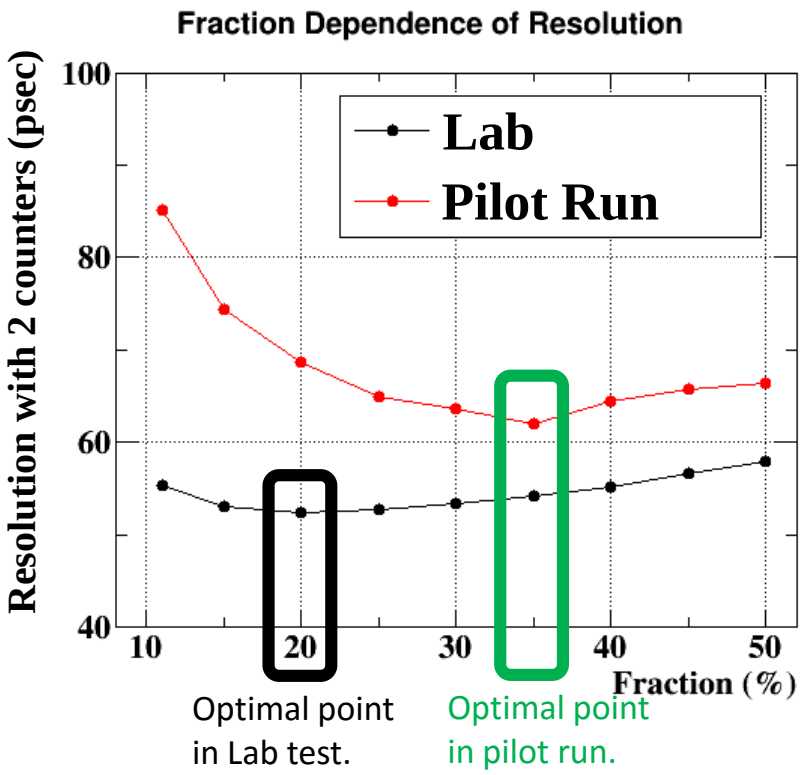
- Timing from the signal is calculated by constant fraction
- Cut
  - Energy and signal height cut are performed to remove saturated signal (due to problem of DAQ dynamic range) and too small signal.
- Use first hit, even if a counter has more than two hits.
- The difference b/w two adjacent counters. $(T_2\text{-}T_1)/2$.
  - We don't have enough data for analyze time with more than 3 hits.

Example of the signal height distribution





Resolutions Compare with ^{90}Sr data



*Mass production of the counters was reported in last JPS. Final counter resolutions are 70-80 ps.

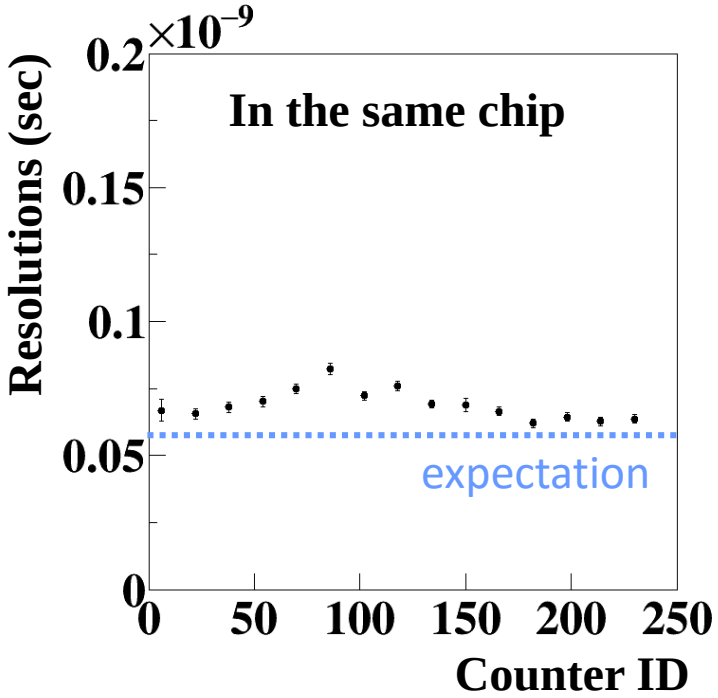
*Fraction is for constant fraction analysis

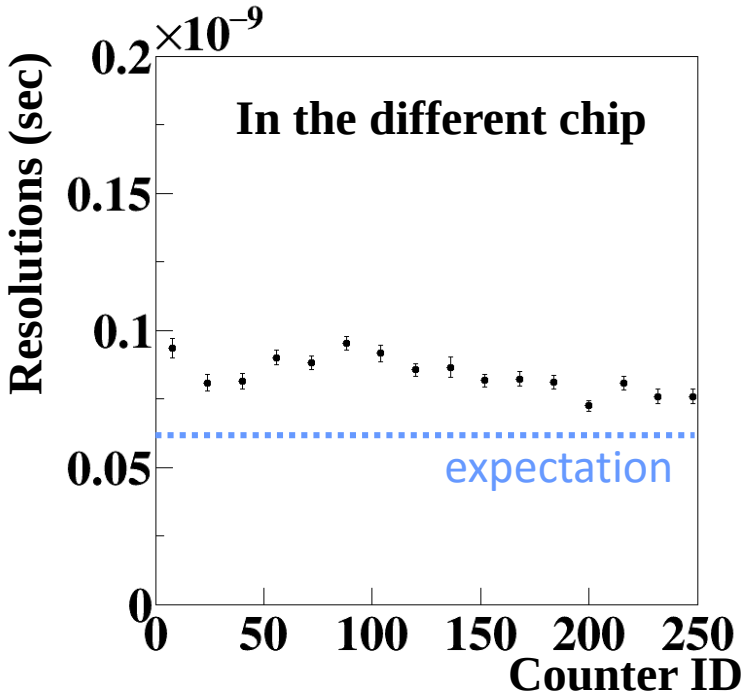
- Lab data with ^{90}Sr Calculated from single counter resolutions.
  - No energy correction, scattering effect, position dependence
- Optimal fraction is 35 % for the pilot run data, though it's 20 % in lab test because of noise.
- With optimal fraction, difference of the resolution is **~15%** while expected decreasing from difference of energy deposit is **5-10 %** from MC.
- Probably it comes from DAQ bad quality.
- We cannot conclude the reason because DAQ had problems.

Summary of Resolutions

With 2 counters the resolutions are

- 60-80 ps in the same chip, 70-100 ps in the different chip
- In Lab 55-65 ps is expected



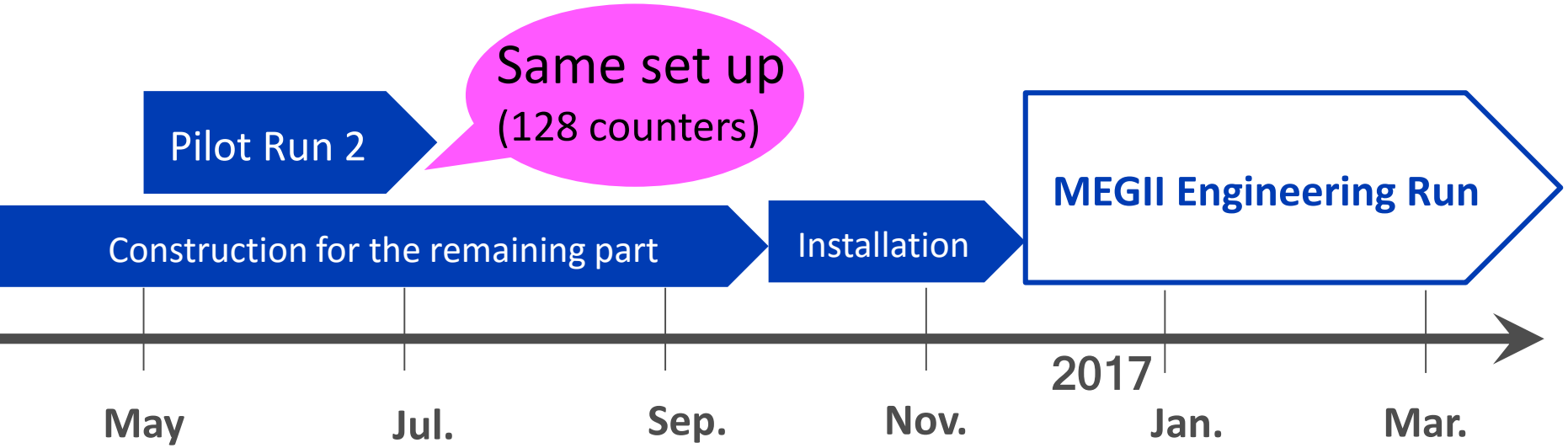


The differences of the resolutions in the same or different chips come from the synchronization among chips.

→ Final chips will have the clock for the synchronization, and the effect will be small.

Plan and Status

Since DAQ system had problems, we plan another run with the same set up of TC and modified DAQ.



We are preparing remaining part:

- Machining of new support structure is on going.
- Mass production of the last pixels is currently on going.

Every staff will be completed in few months.

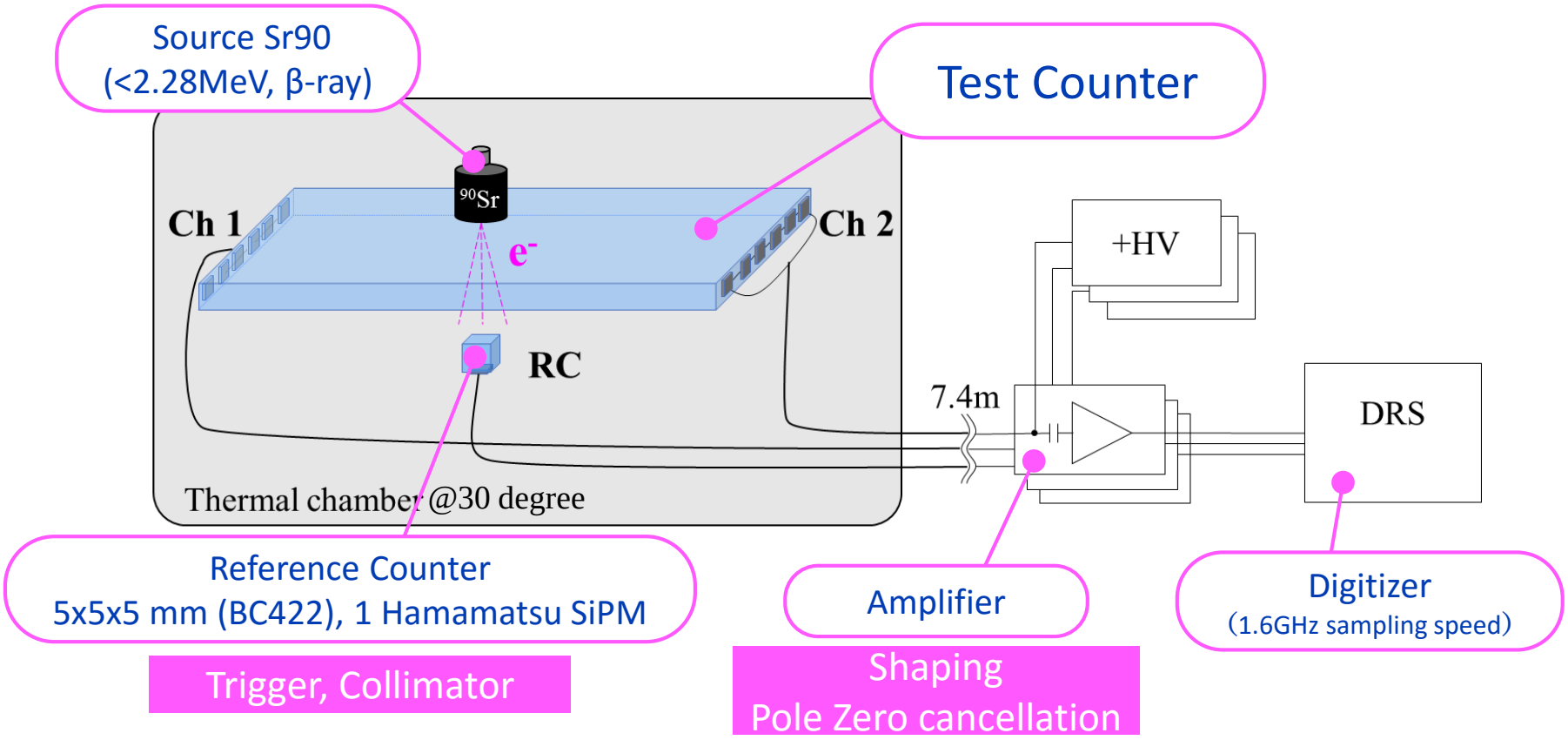
Summary

- Installation of ¼ TC was completed.
  - All counters worked properly.
  - Installation system is confirmed without any conflict with other detectors.
- Though we had DAQ problems, we succeeded to extract timing information.
  - With 2 counters the resolutions are 60-80 ps in the same chip, and 70-100 ps in the different chip.
  - They are worse than expected resolutions ~ 60 ps.
- In May we'll have 2nd pilot run with modified DAQ.

Back Up

Counter Mass Test

Check the resolution for every final counter. (measure at 3 points)



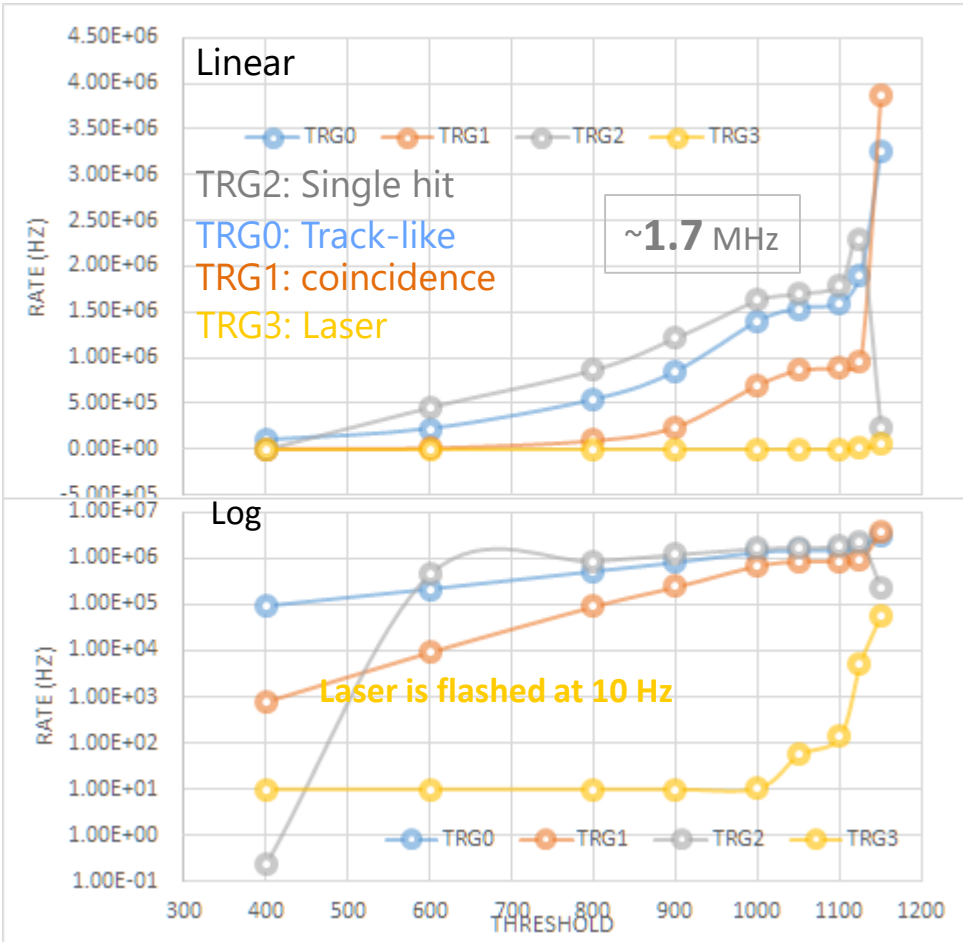
Trigger

Five trigger are prepared.

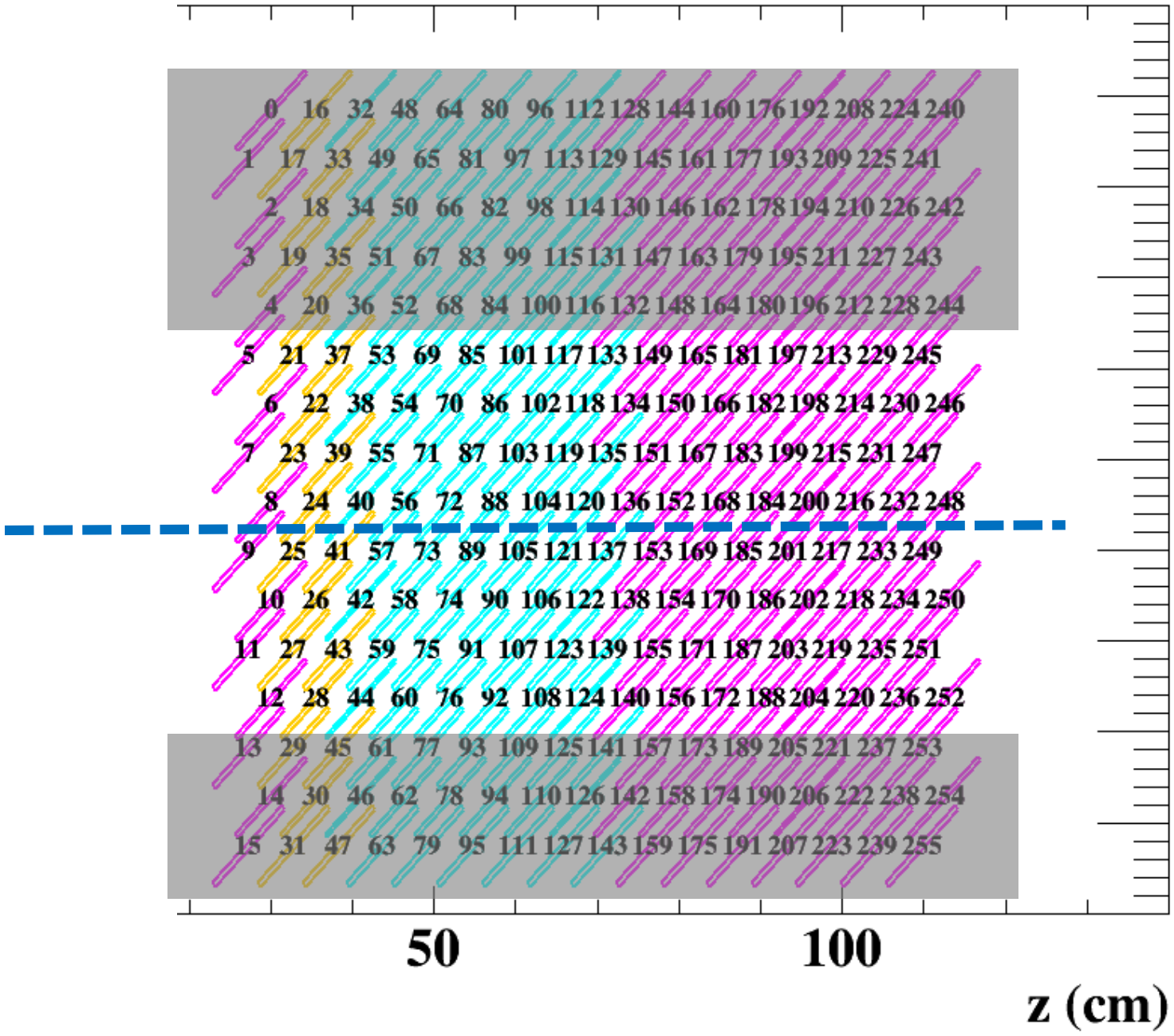
- Pedestal
- Single hit
- coincidence
- Track-like
- Laser

- Discriminator threshold scan
- Separation b/w signal and noise doesn't seem so good.
  - Signal size should be large enough.
  - Baseline fluctuation (different offset over channels, event-by-event fluctuation) & large noise

Trigger rates measured with the TCB scalers



Discriminator threshold scan


0 16 32 48 64 80 96 112 128 144 160 176 192 208 224 240
1 17 33 49 65 81 97 113 129 145 161 177 193 209 225 241
2 18 34 50 66 82 98 114 130 146 162 178 194 210 226 242
3 19 35 51 67 83 99 115 131 147 163 179 195 211 227 243
4 20 36 52 68 84 100 116 132 148 164 180 196 212 228 244
5 21 37 53 69 85 101 117 133 149 165 181 197 213 229 245
6 22 38 54 70 86 102 118 134 150 166 182 198 214 230 246
7 23 39 55 71 87 103 119 135 151 167 183 199 215 231 247
8 24 40 56 72 88 104 120 136 152 168 184 200 216 232 248
9 25 41 57 73 89 105 121 137 153 169 185 201 217 233 249
10 26 42 58 74 90 106 122 138 154 170 186 202 218 234 250
11 27 43 59 75 91 107 123 139 155 171 187 203 219 235 251
12 28 44 60 76 92 108 124 140 156 172 188 204 220 236 252
13 29 45 61 77 93 109 125 141 157 173 189 205 221 237 253
14 30 46 62 78 94 110 126 142 158 174 190 206 222 238 254
15 31 47 63 79 95 111 127 143 159 175 191 207 223 239 255
50
100
z (cm)