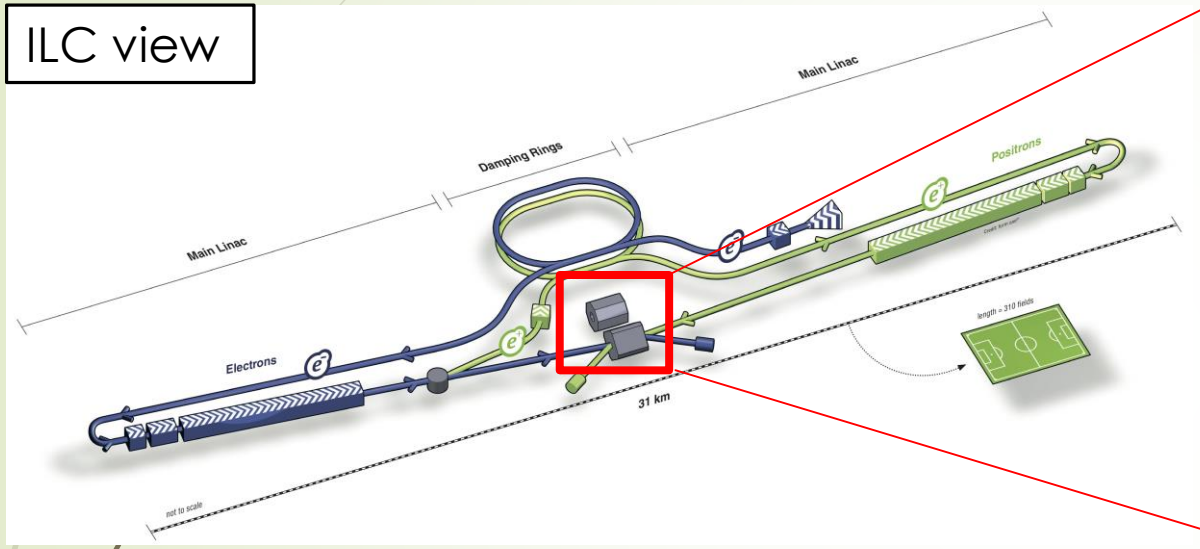
Performance evaluation of read out board (EBU) for scintillator electromagnetic calorimeter

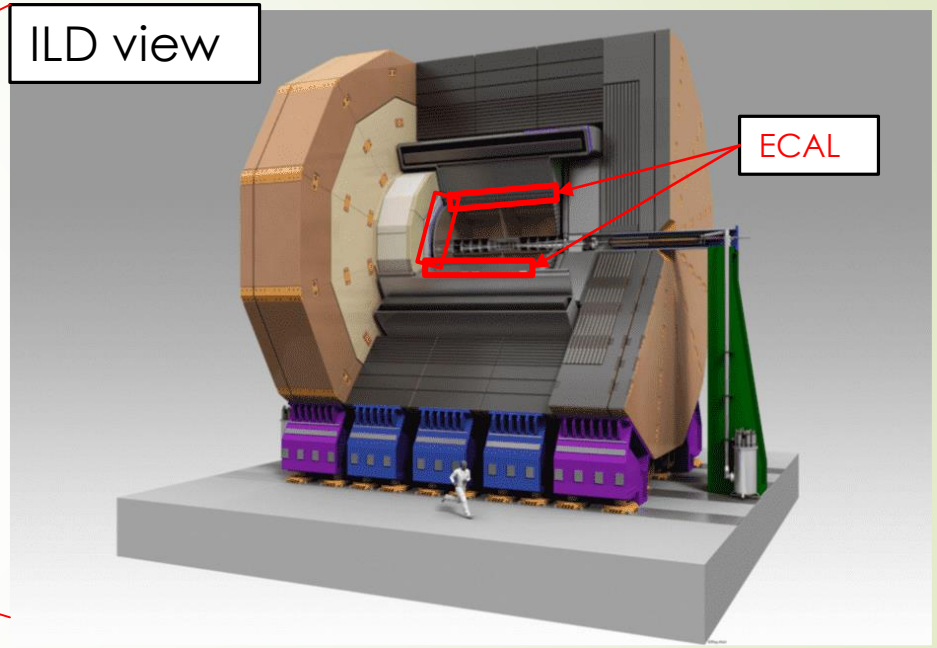
Shinshu-University Yukinaru Tamaya

International linear Collider (ILC)plan and ILD

ILC view

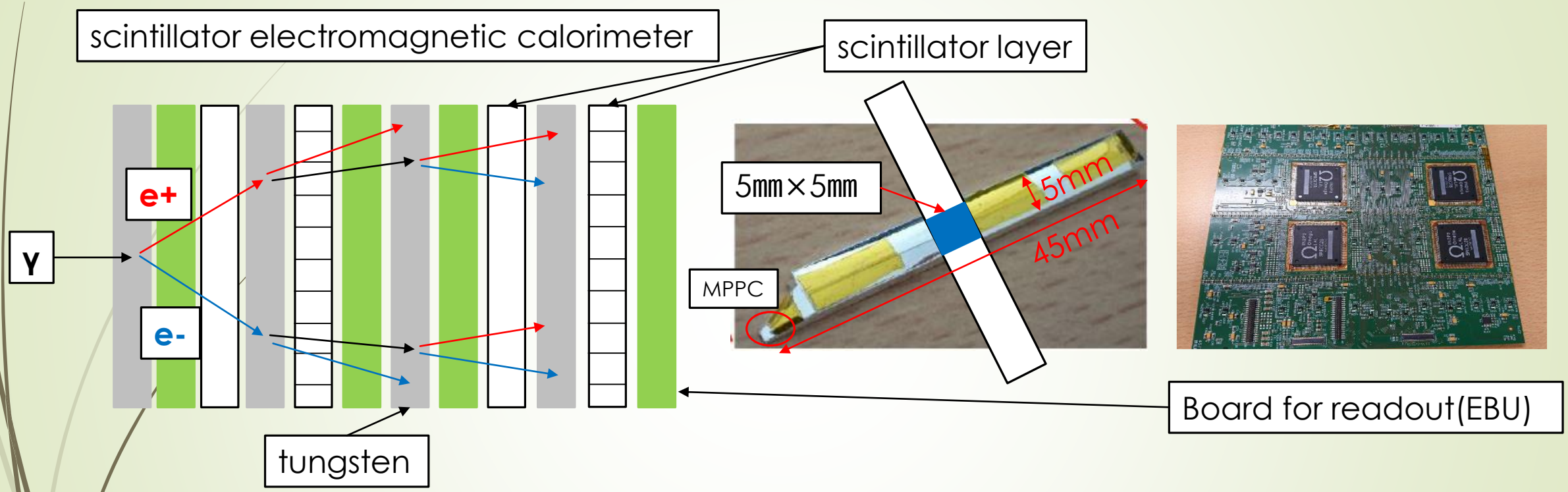


ILD view



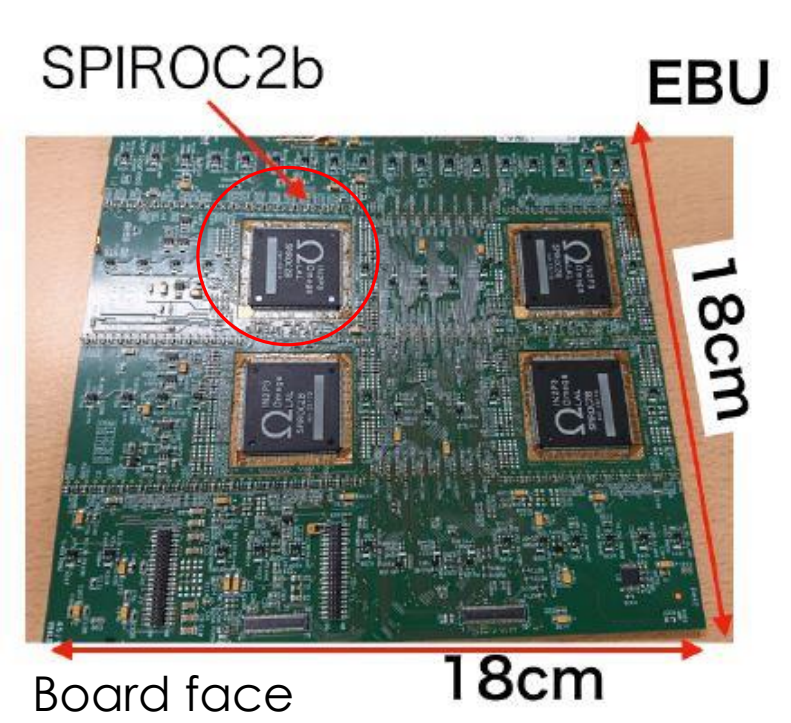
- ILC has 250 GeV energy of the center of mass system, and measures Higgs particle precisely.
- ILD is planned as one of the measuring instruments of ILC, and uses a method called Particle Flow Algorithm (PFA).
- The electromagnetic calorimeter (ECAL) used in PFA mainly measures the energy of photons and achieves particle separation in the jet.

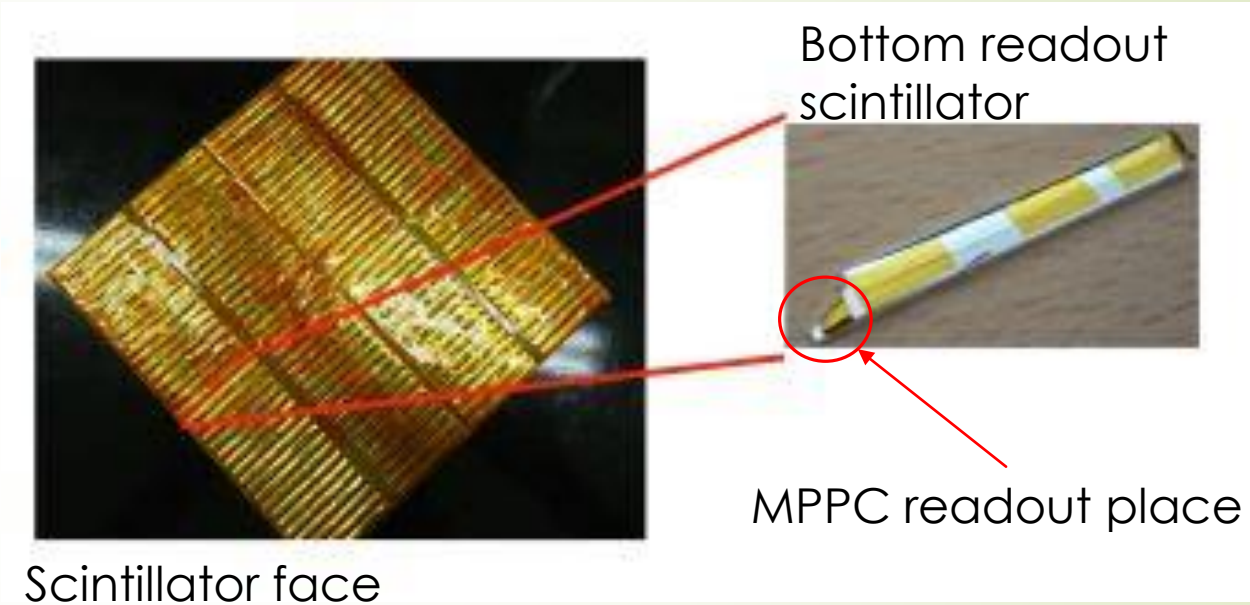
Scintillator electromagnetic calorimeter



- Scintillator electromagnetic calorimeter has tungsten in absorption layer and scintillator layer in detection layer and board for readout.
- The size of scintillator is 45mm×5mm×2mm.
- Scintillator layer have 5mm×5mm spatial resolution.
- Each scintillator equips a MPPC, which detects scintillation light of scintillator.

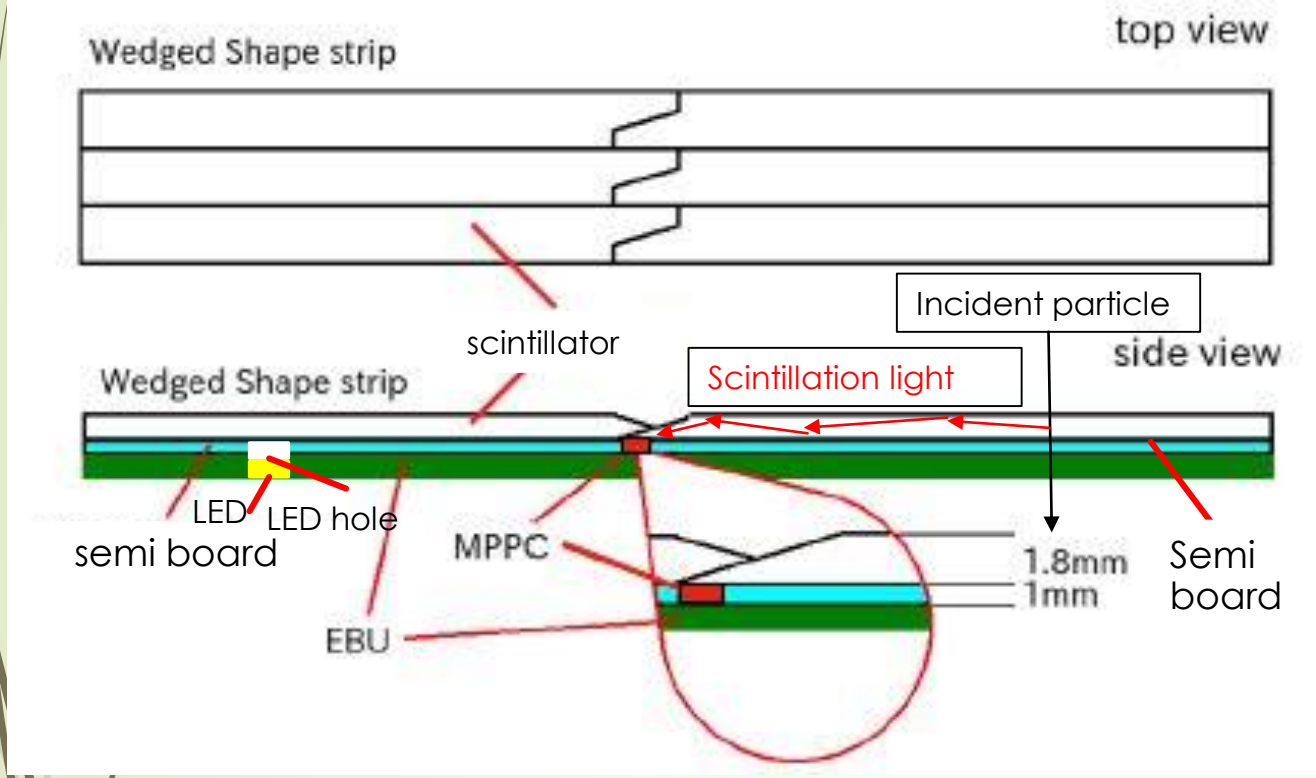
ECAL Base Unit(EBU)





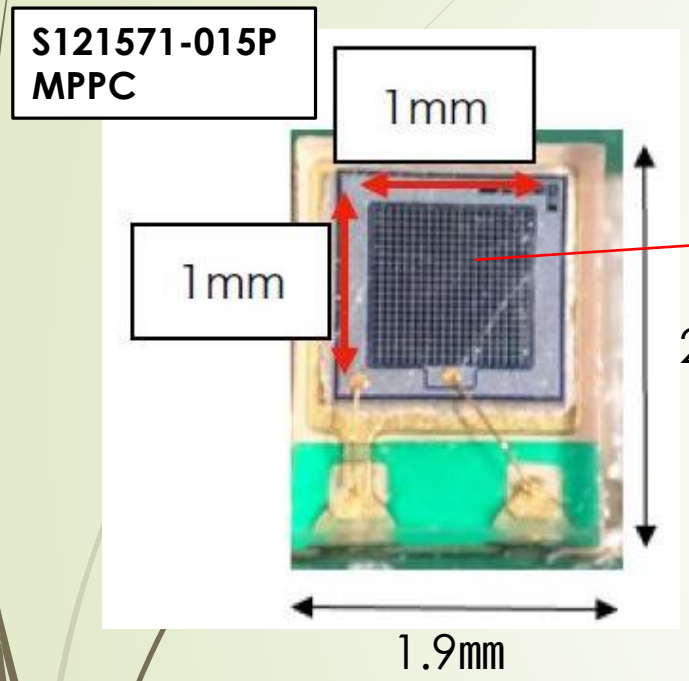
- EBU is fabricated by DESY.
- EBU is a PC board which connects MPPC's to the scintillator.
- One EBU is equipped with four ASIC's called SPIROC2b which is developed by OMEGA group.
- One SPIROC2b can control 36ch of MPPC's and can adjust each applied voltage for a channel.

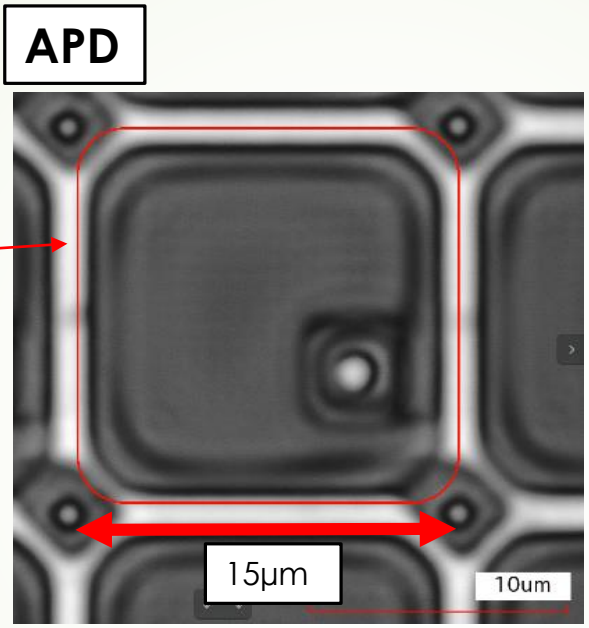
Bottom readout scintillator

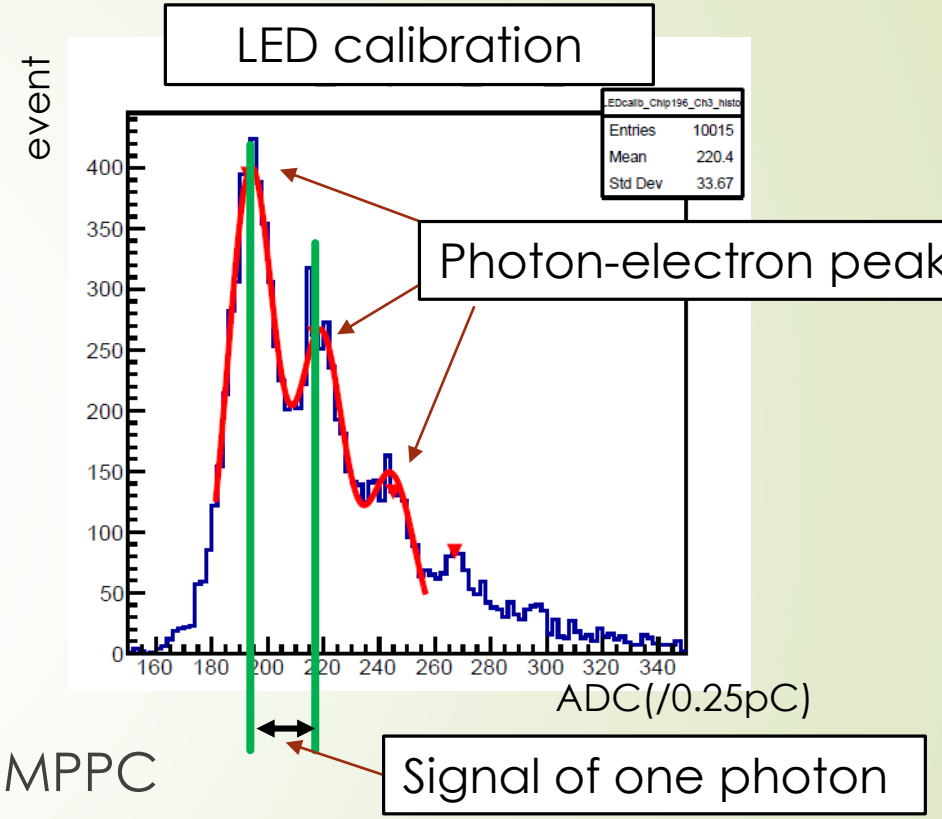


- Uses a plastic scintillator (EJ204 made by ELEJN) .
- The insensitive area is eliminated by alternately reading scintillators with a wedge-shaped tip at the bottom by a ppc.

Multi-Pixel Photon Counter(MPPC)







- MPPC developed by Hamamatsu Photonics, Shinshu University and other universities.
- Gain of one photon can be calibrated by LED.

- Feature of MPPC

1. magnetic field resistance
2. low voltage operation
3. high multiplication factor of $\times 10^5$
4. operable at normal temperature

SPIROC2b

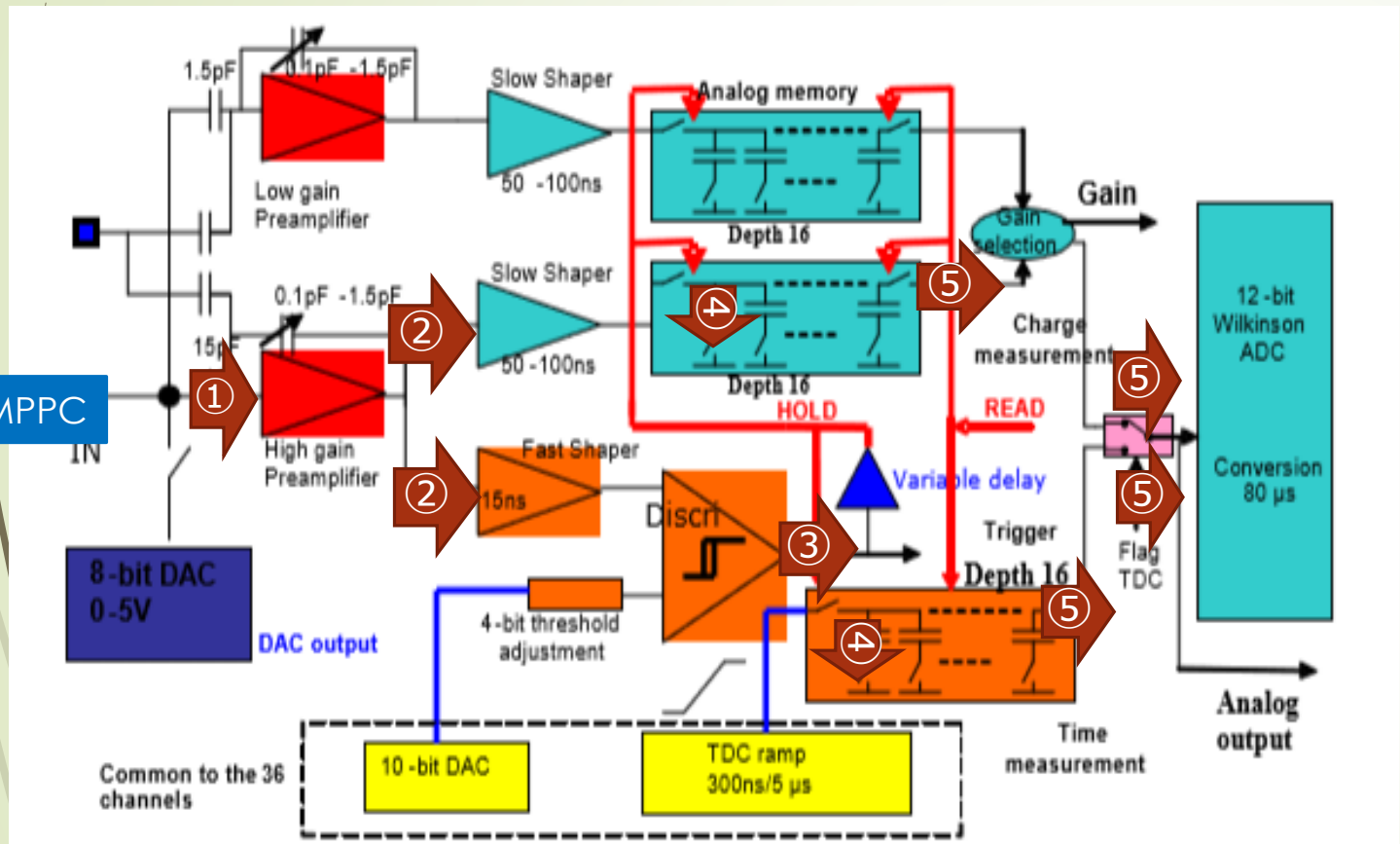


Figure 8: SPIROC one channel diagram

① The signal flows from the MPPC, and the signal is amplified by the preamplifier of the charge multiplier type.

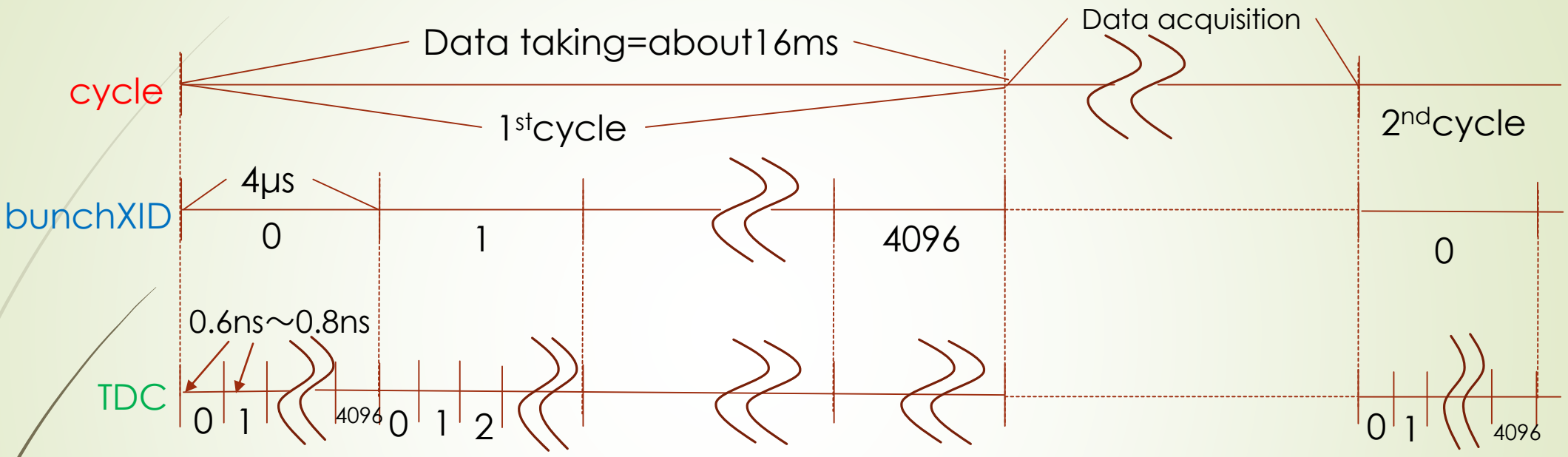
② Amplified signal is divided into a slow shaper (Tp50ns) and a fast shaper (Tp15ns).

③ Signal flowing through the fast shaper exceeds a predetermined threshold.

④ The signal flowing through the Slow shaper is temporarily stored in the memory cell up to 16 depth, and at the same time pulse high is also saved.

⑤ ①～④ if the operation occurs 16 times, or if it exceeds the predetermined time, the signal that has been temporarily stored flows to the ADC.

Time measurement of EBU



- Cycle : cycle consists of data taking time and data acquisition time. When memory cells are fully used until 16ms or they are not fully used till 16ms (named timeout), cycle goes to next cycle.
- bunchXID : BunchXID measure time that the data is stored in the memory cell with 4μs time interval.
- TDC : TDC measure time from the start time of bunchXID. One TDC digit is 0.6ns ~ 0.8ns.

For each memory cell ,MIP and Pedestal measurement

SPIROC2b

SPIROC2b

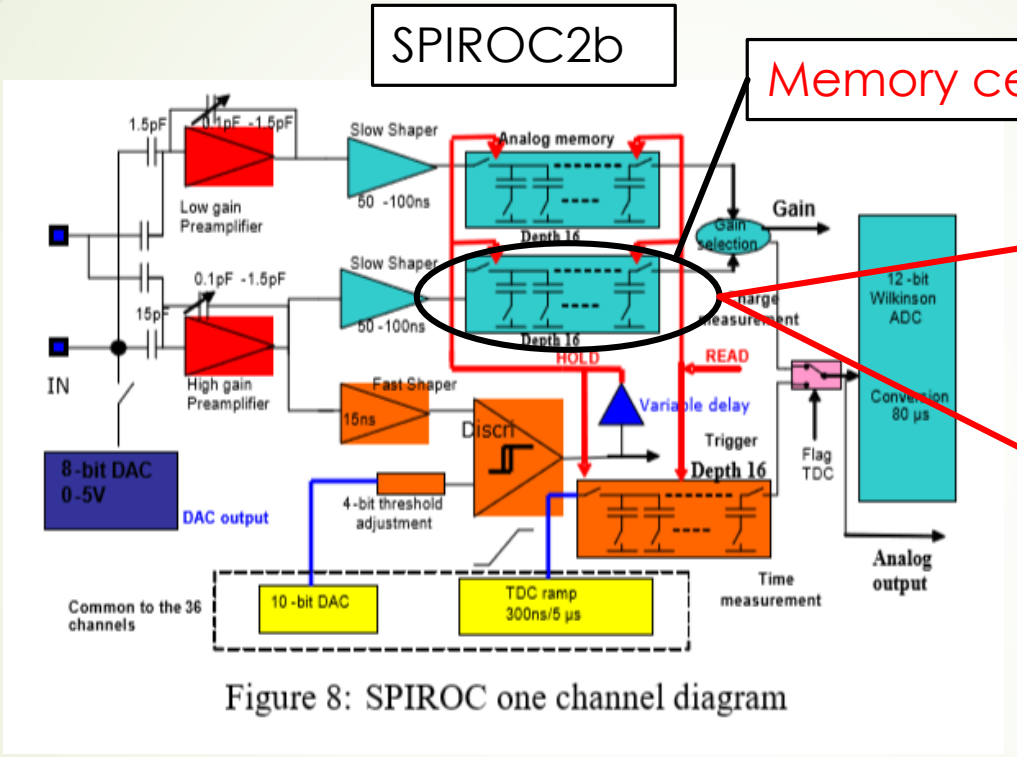
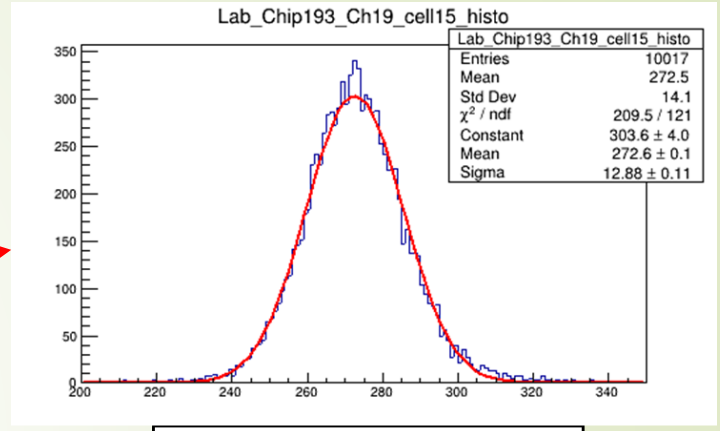
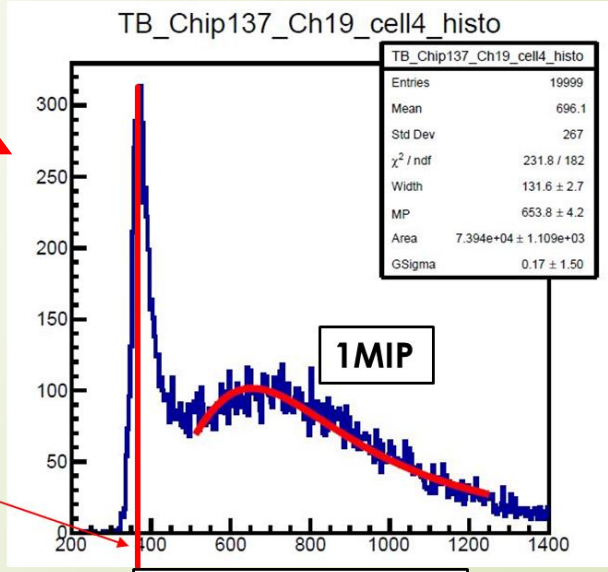


Figure 8: SPIROC one channel diagram

Memory cell(0~15)



Pedestal measurement



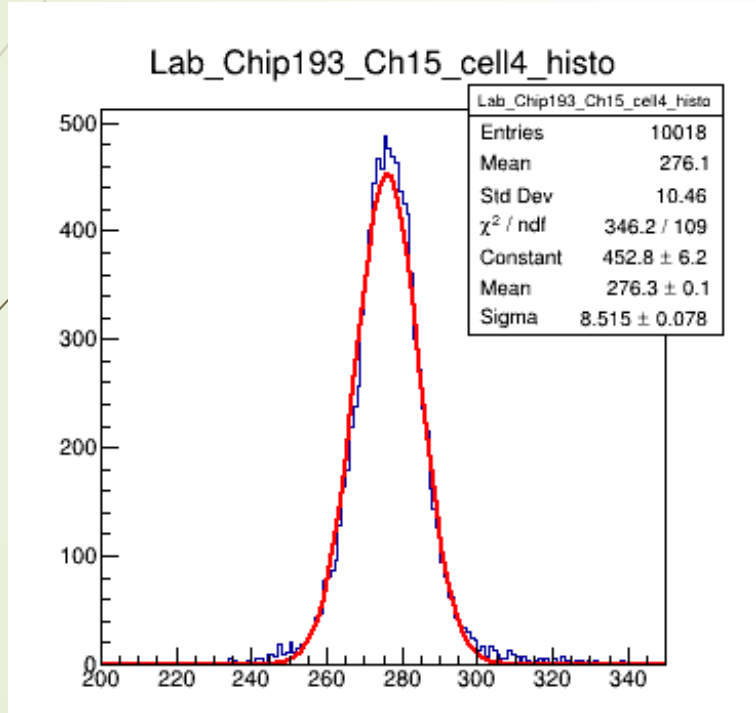
threshold

MIP measurement

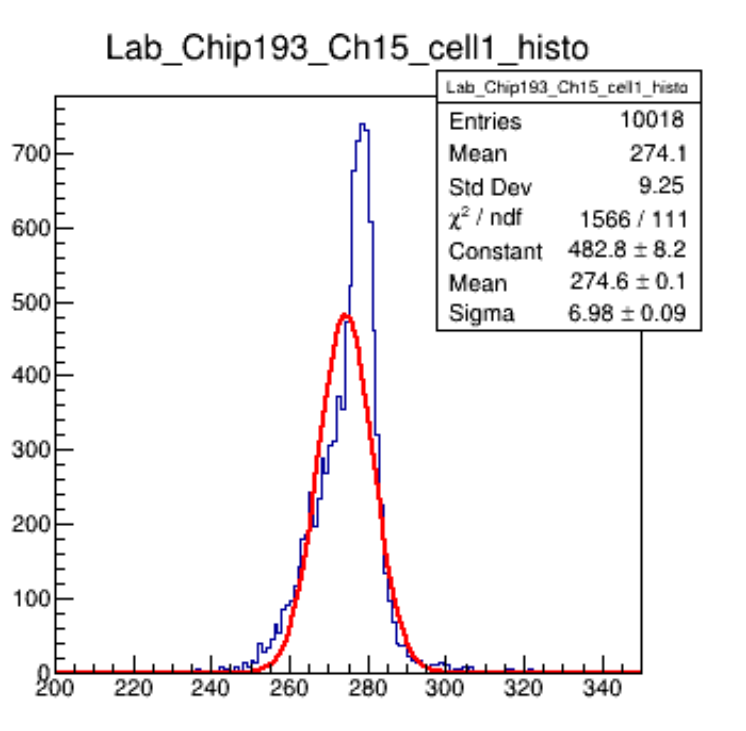
- The memory cells in a channel are properly functioning when the Pedestal shapes is gauss distribution.
- Test each memory cell whether the MIP signal is separated from the tail of Pedestal.

Pedestal measurement

Pedestal is gauss distribution

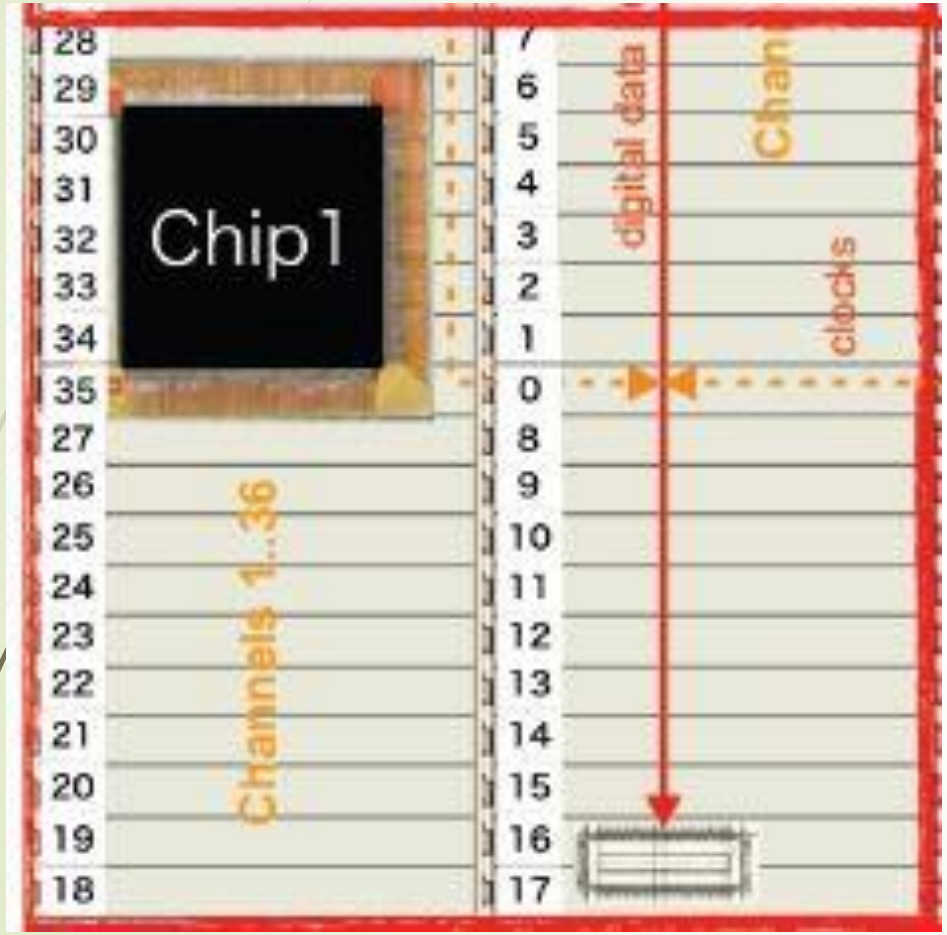


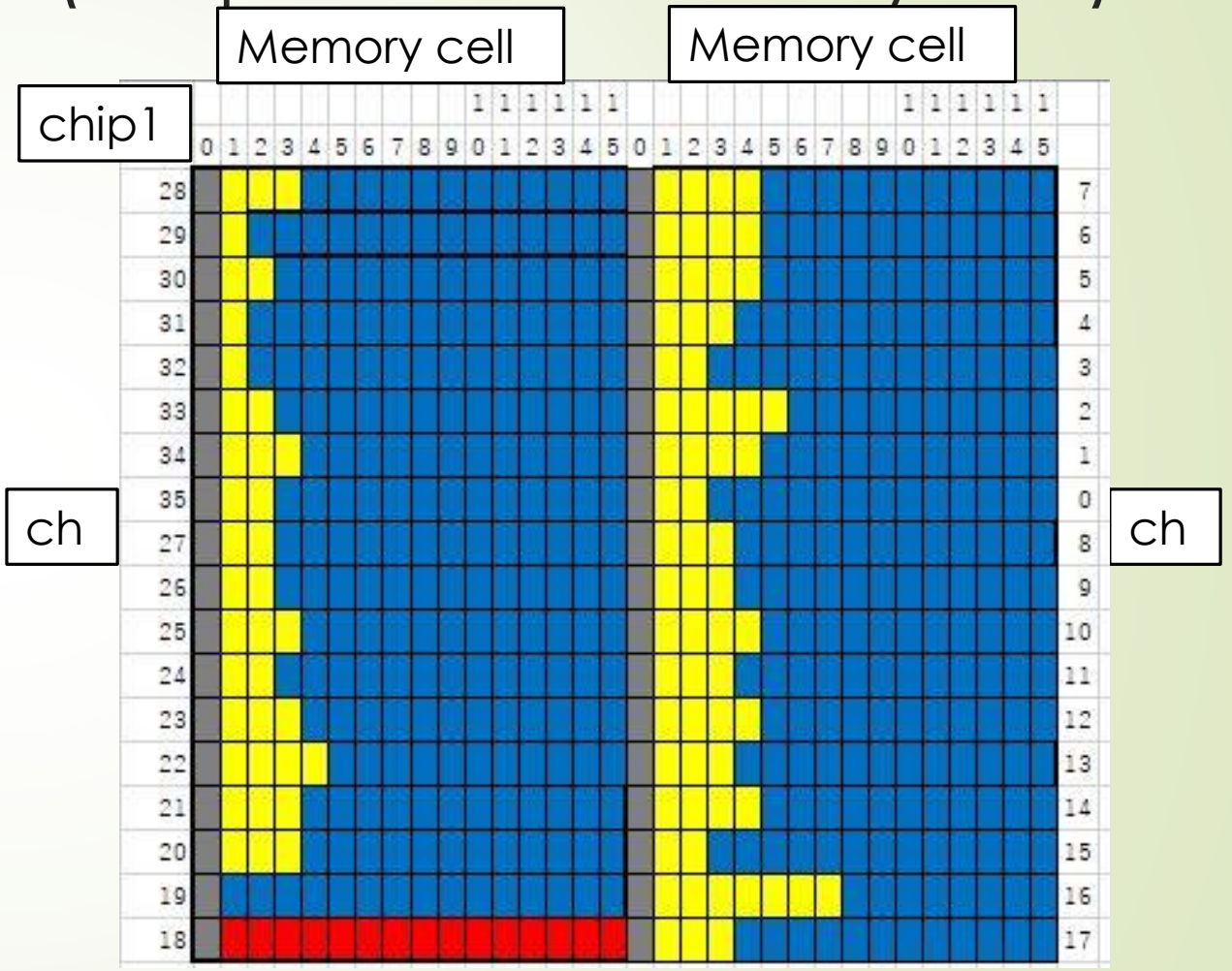
Pedestal is not gauss distribution



- Measured Pedestal of all chips(SPIROC), channel and memory cells.
- The types of Pedestal were classified into two types for each channel and memory cell.

Pedestal measurement(Chip1,ch VS memory cell)

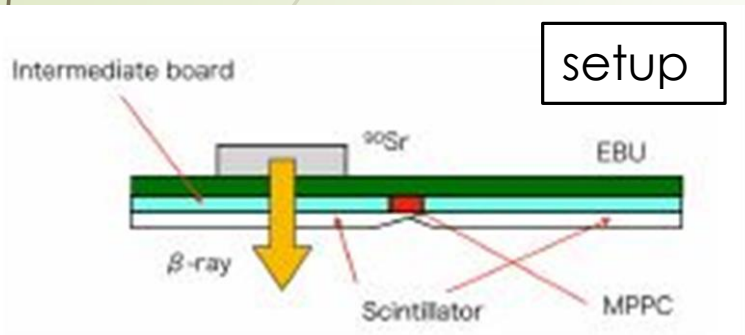




- We found lower memory cells tend to be classified into non-gauss distribution in all four SPIROC chips.

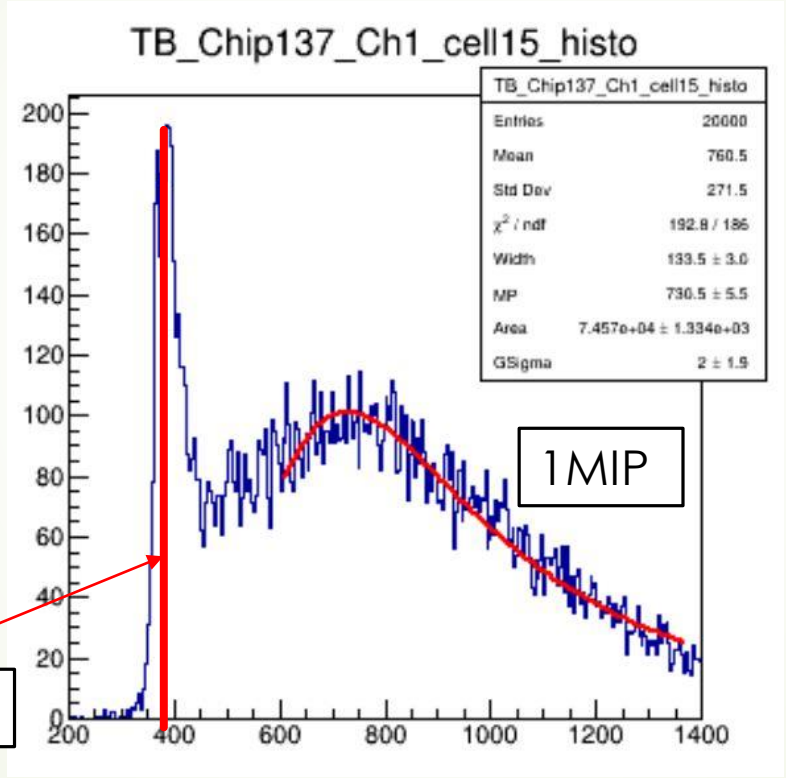
Blue : gauss distribution
Yellow: : non-gauss distribution
Orange : noisy Red : broken

MIP measurement use β ray of 90Sr

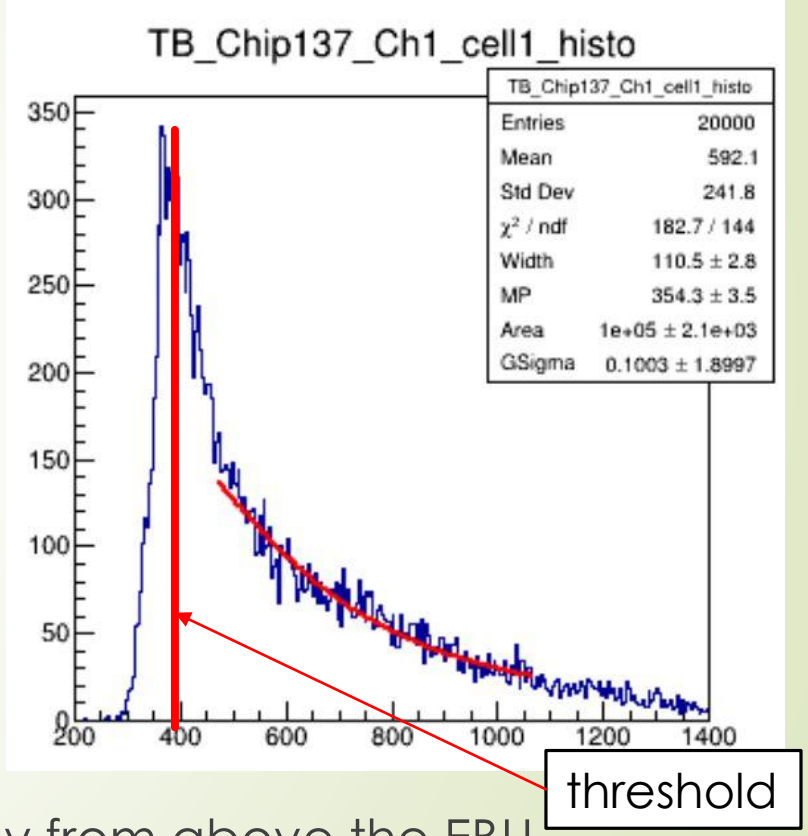


Use 90Sr without collimater, MIP measurment

MIP is separated Pedestal tail

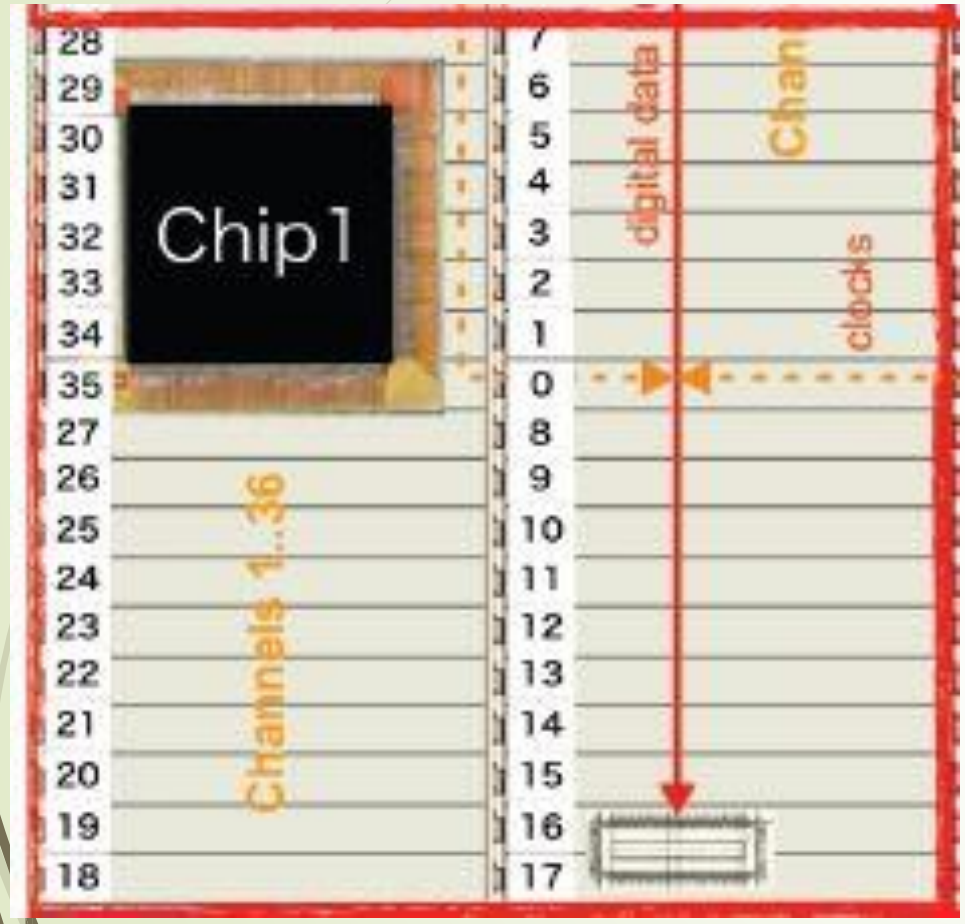


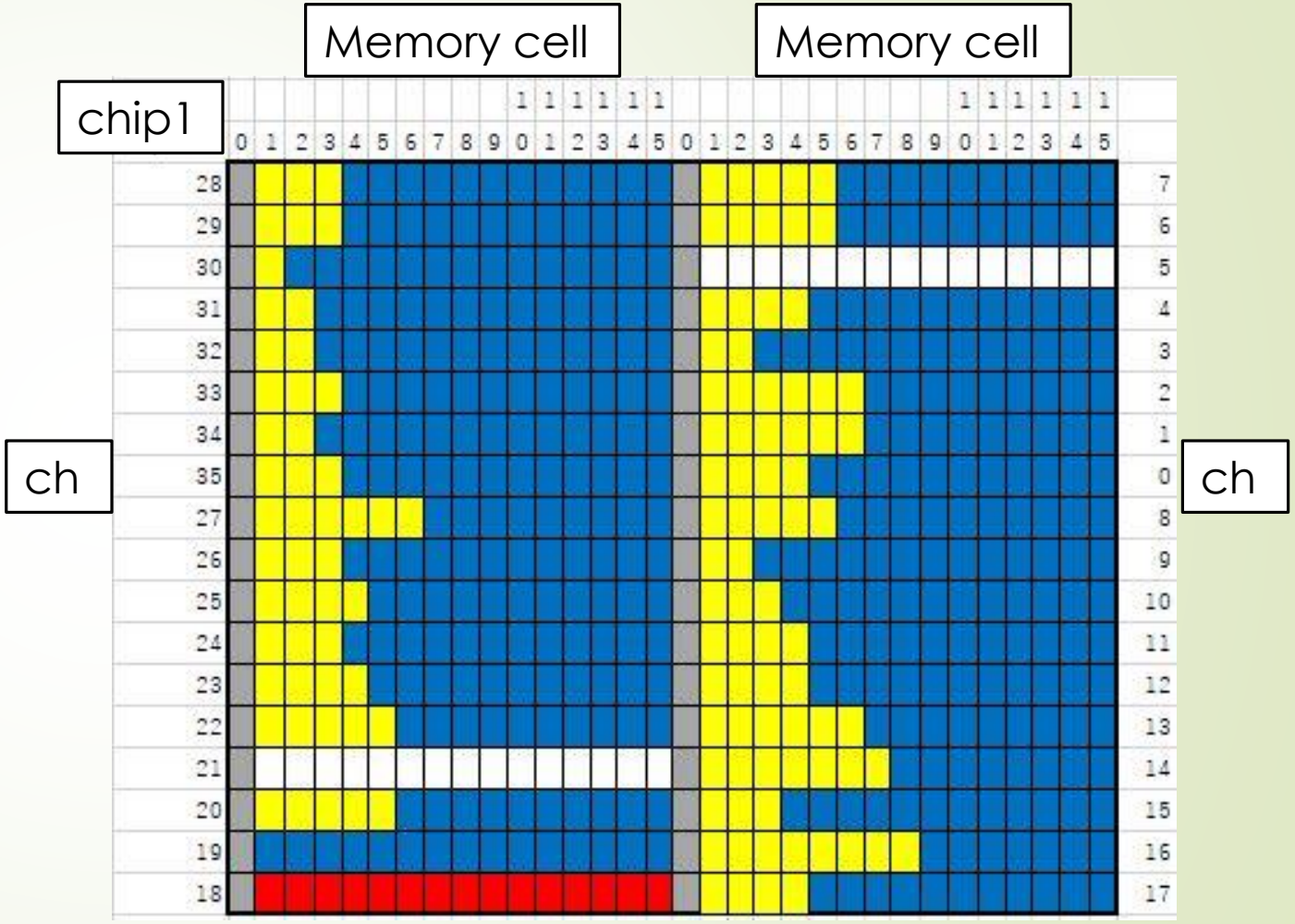
MIP is not separated Pedestal tail



- MIP measurement was performed by injecting 90Sr β ray from above the EBU.
- It was measured whether the MIP was separated for each memory cell.
- MIP's distribution was fitted with gaussian landau convoluted.

MIP measurement use β ray of 90Sr(chip1,ch VS memory cell)





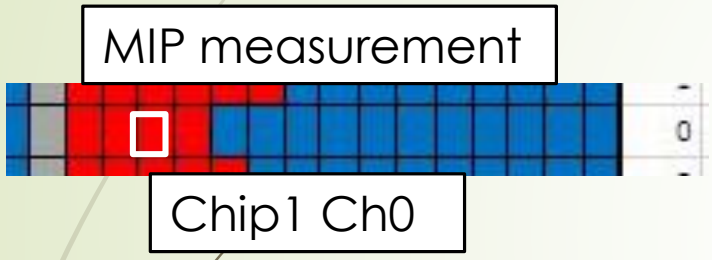
- We found lower cells tend to be classified into MIP is not separated in all four SPIROC chips.
- The result are similar for the pedestal shape measurement.

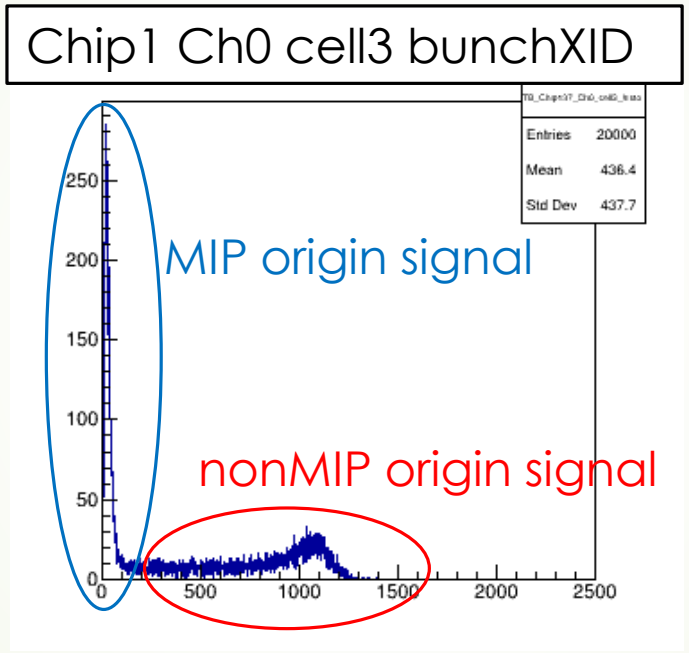
Blue : MIP is separated

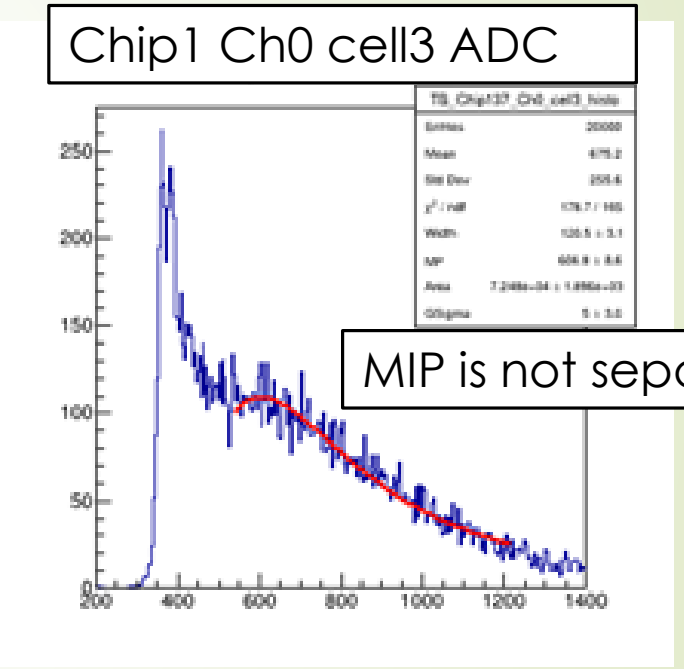
Yellow: : MIP is not separated

Orange : noisy Red : broken

BunchXID measurement from MIP







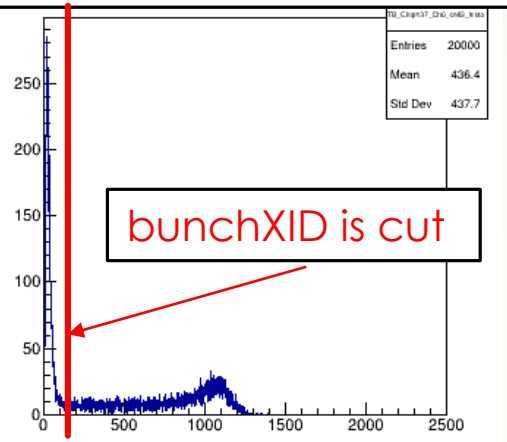
- There is a bunchXID signal that is not derived from MIP.

BunchXID measurement from MIP

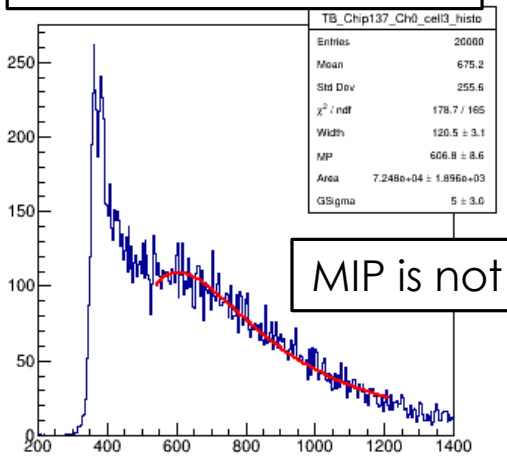
MIP measurement

Chip1 Ch0

Chip1 Ch0 cell3 bunchXID

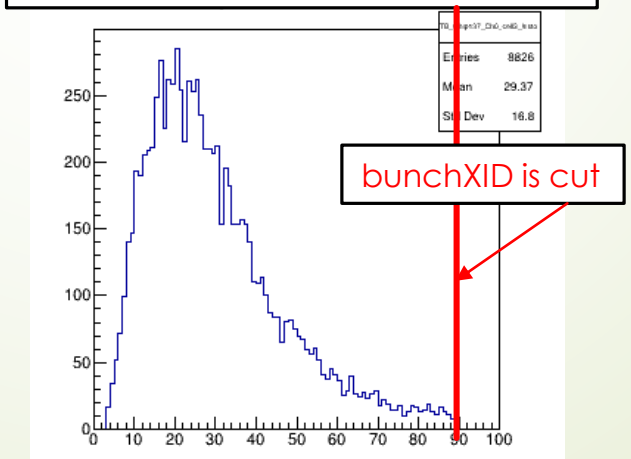


Chip1 Ch0 cell3 ADC

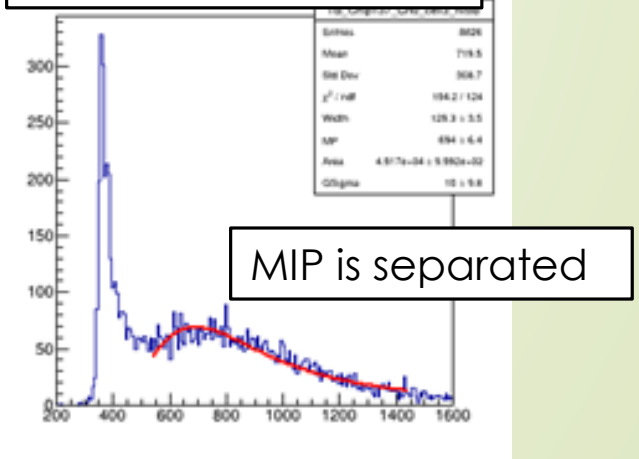


bunchXID is cut more than 90

Chip1 Ch0 cell3 bunchXID

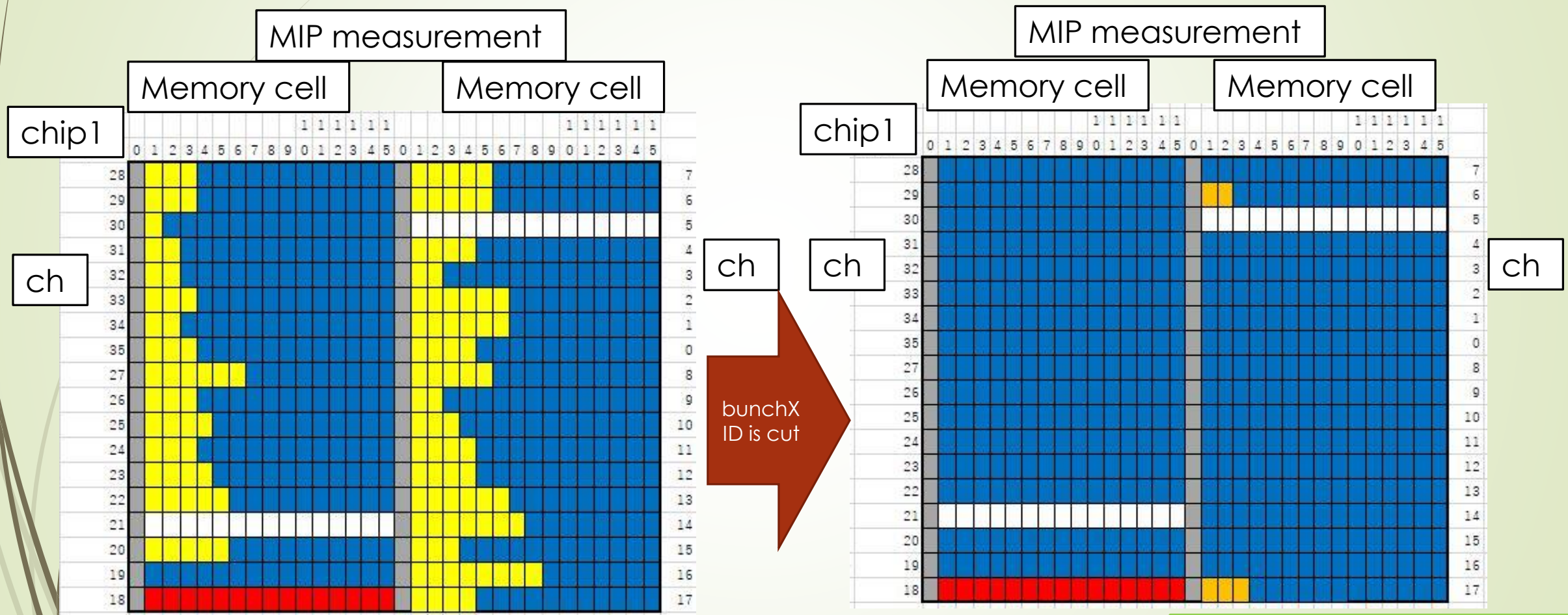


Chip1 Ch0 cell3 ADC



- When bunchXID other than MIP signal is cut, MIP is separated in ADC.

MIP measurement when bunchXID is cut (chip1,ch VS memory cell)



- When bunchXID is cut, MIP's are separated in small numbers of memory cell.

Blue : MIP is separated
Yellow: : MIP is not separated
Orange : noisy Red : broken

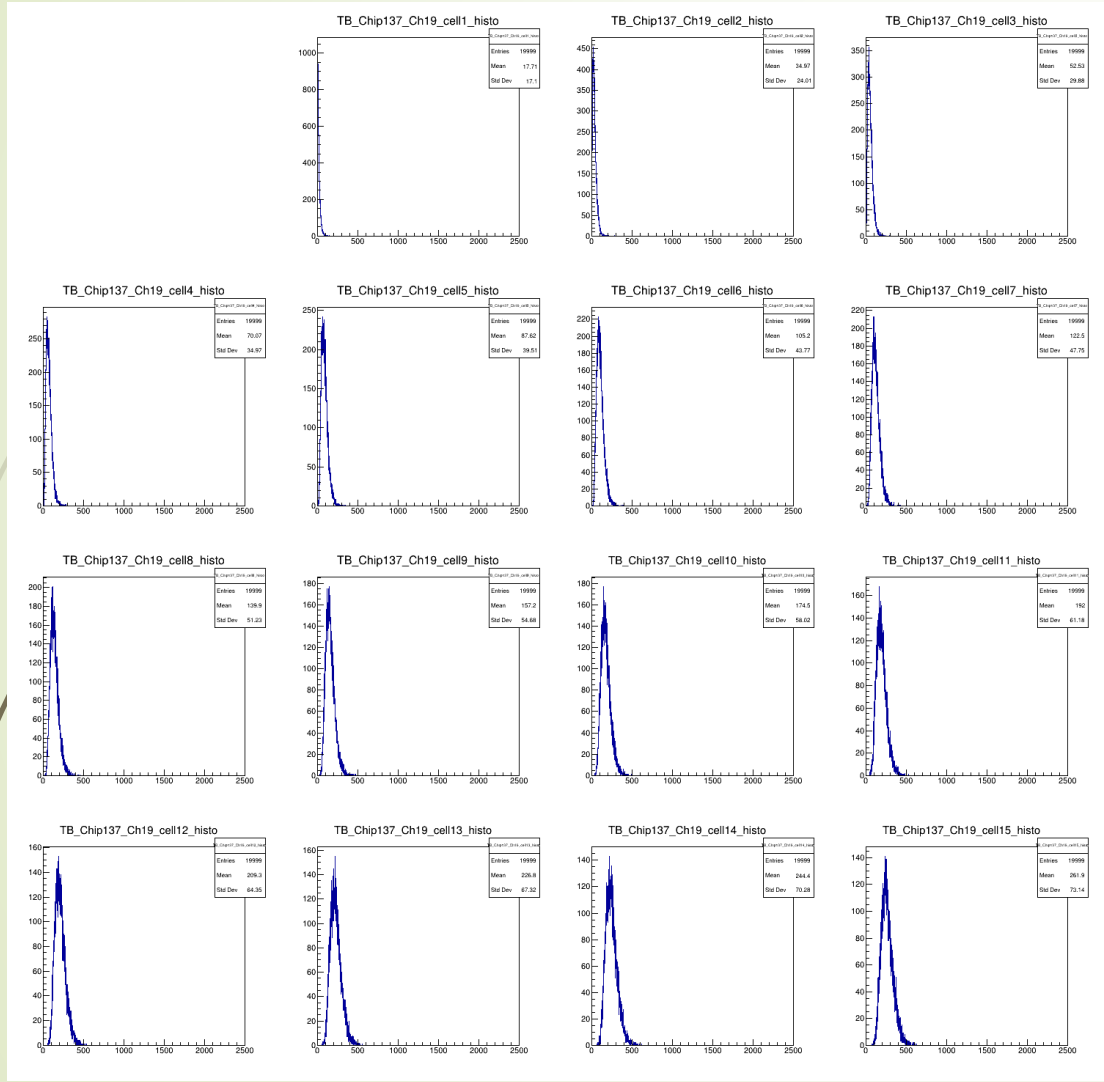
summary

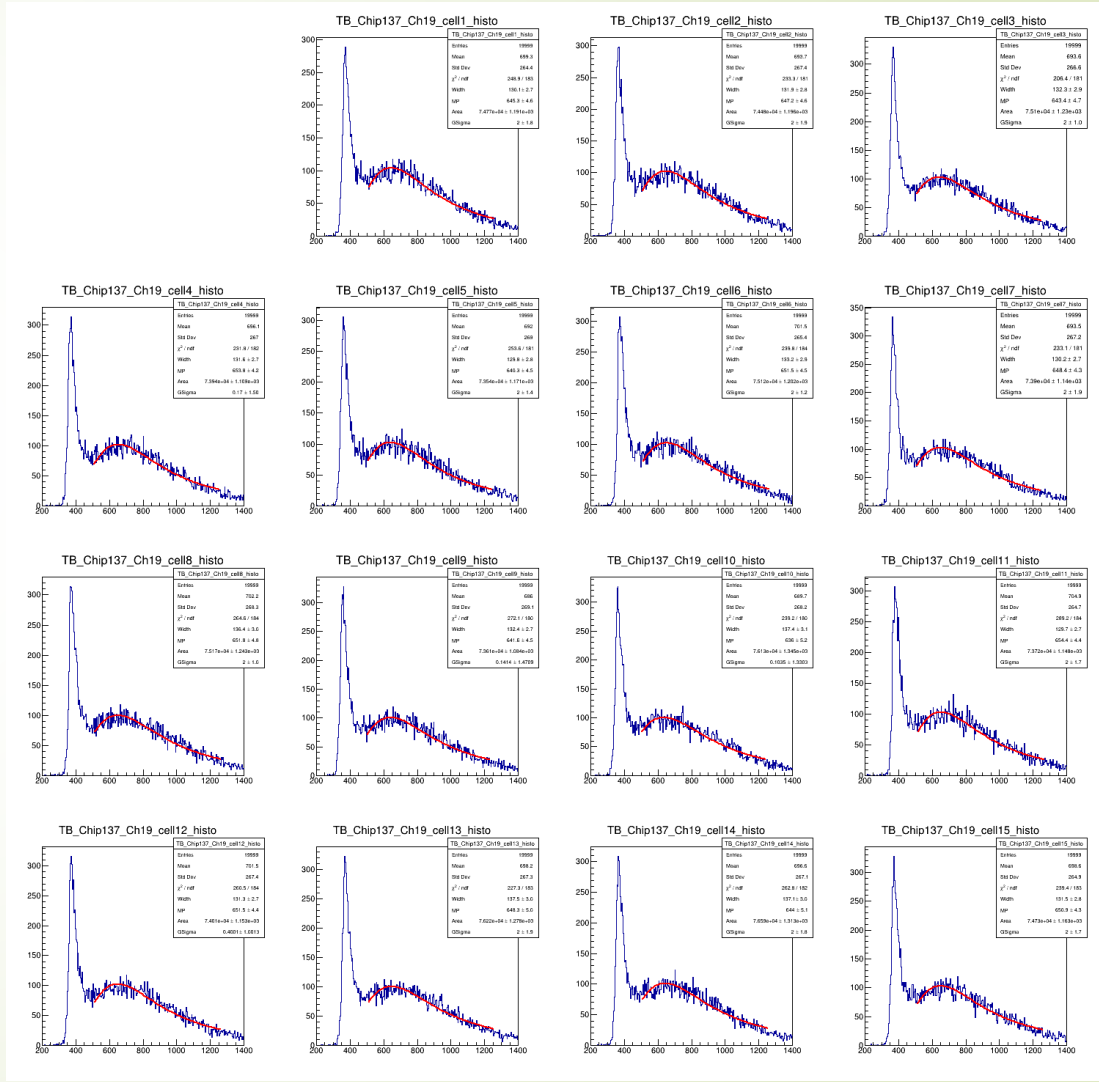
- **Summary**
- Characteristic of small number of memory cells, pedestals are not gauss distribution and MIP's are not separated.
- When buchXID cut applied MIP's can be separated in small number of memory cells.
- bunchXID has nonMIP origin signal.

- **next**
- We will measure the gain per photon of the MPPC using the LED.
- Find why Pedestal is not gaussian in a small number of memory cell.

Back up

Chip193 ch19 ADC, bunchXID

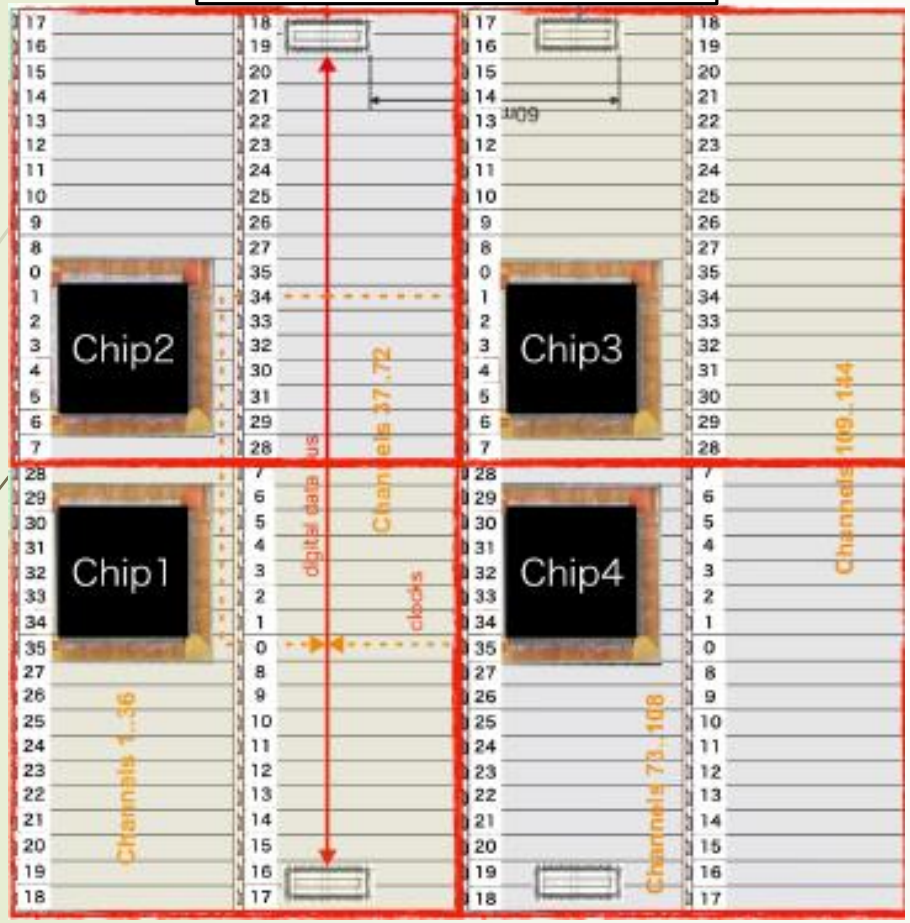




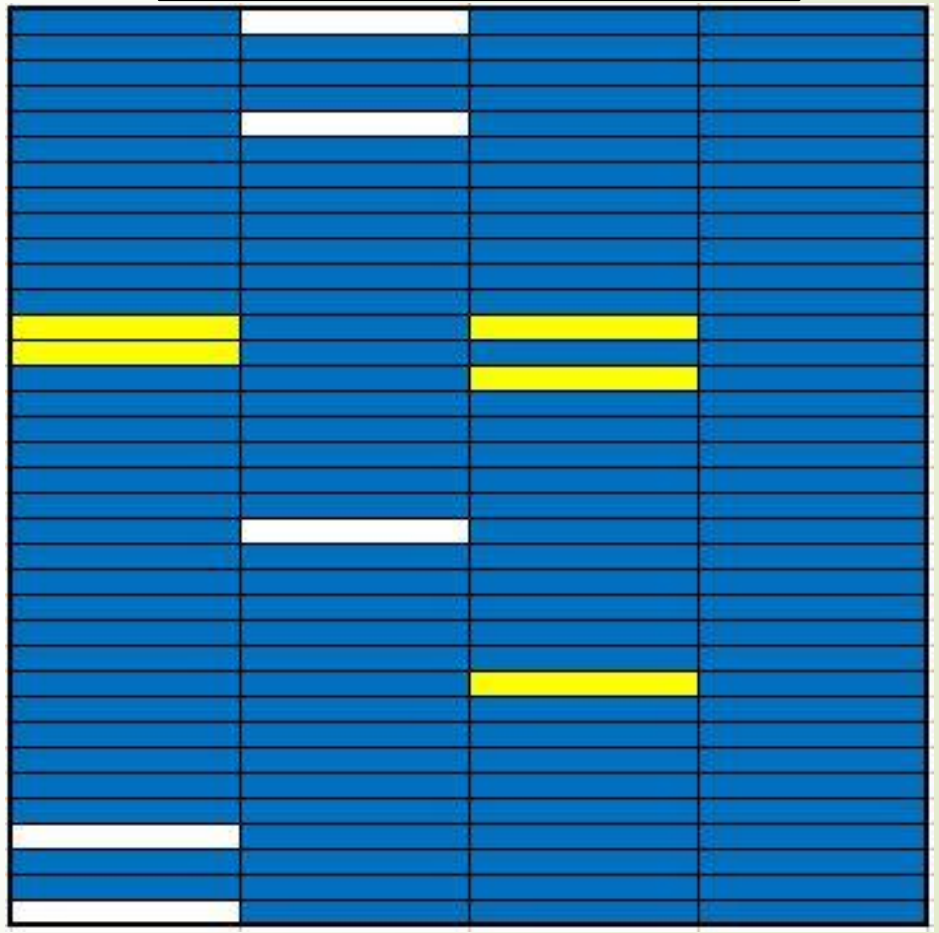
- Only ch19's bunchXID and ADC shows that.

Use 90Sr without collimater, MIP measurement(all channel、cell>10)

channel-map of EBU



Map of result of 90Sr test

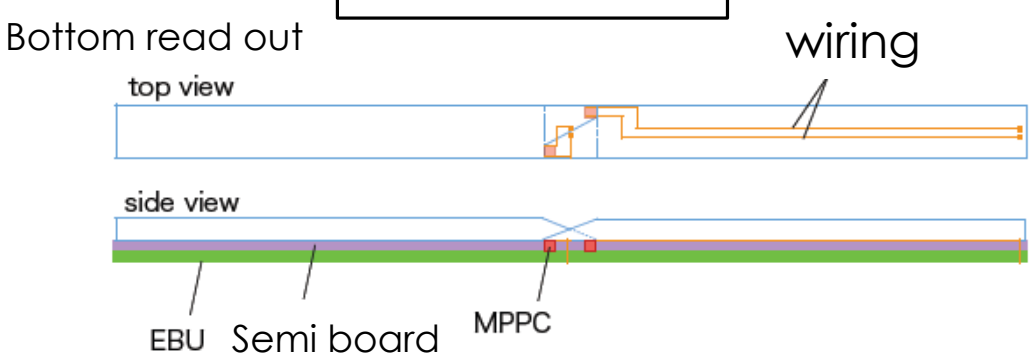


- 134/144ch confirms 90Sr peak is separation.

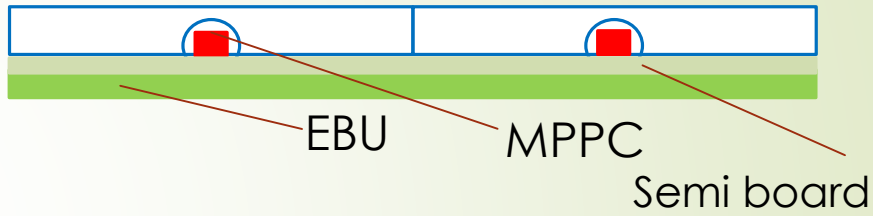
MIP is separation
MIP is noisy
MIP is not measurment

Direction to new EBU

bottomreadout



Centerholereadout



- The new EBU will make a hole in the center of the scintillator and put the MPPC in the hole.
- EBU and MPPC join EBU and MPPC by using intermediate base.
- Eliminates insensitive areas just like wedge scintillators.

※2014年度修士論文東京大学大学院　家城斉『国際リニアコライダーのためのシンチレータ電磁カロリメータの新しいシンチレーション光読み出しデザインの開発』より引用