Jun. 24, 2015:
Sep. 22, 2015: update pp.32-35

Ground Muon Data Analysis

Preliminary Results

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CALET-TIM@Pisa June 24, 2015

Data Summary

	Time	Neve	Trig.	Trig. Mask (Single) IMC-	HV_{IMC4}
Period.①	150320 10:00 – 24:00 (14hrs)	9.2 x 10^5	Single + LE+HE	-X1 & Y2 & X3 & Y4 -Y1 & X2 & Y3 & X4 (each 30min. × 14)	-800V
Period.②	150321 00:00 – 12:00 (12hrs)	7.8 x 10^5	Single +LE+HE	-X1 & Y2 & X3 -Y1 & X2 & Y3 (each 30min. ×12)	-600V
Period.③	150321 12:00 – 27:00 (15hrs)	9.9 x 10^5	Single +LE+HE	-X1 & Y2 & X3 & Y4 -Y1 & X2 & Y3 & X4 (each 30min. × 15)	-800V

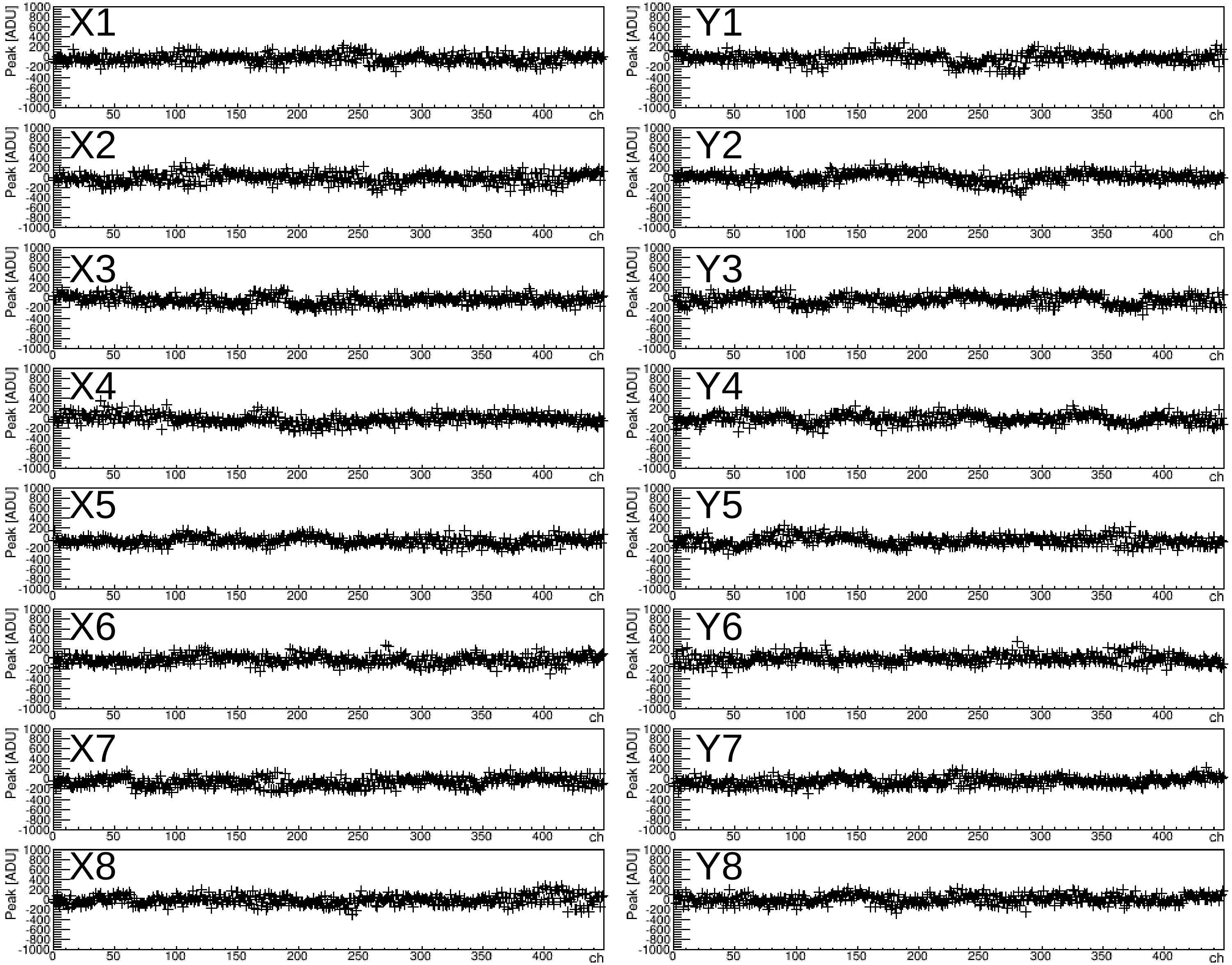
pedestal data is taken for 2 sec (100 events) every 30 minutes

- In this presentation, I show all channels, and analysis procedures
  - pedestal noise
  - muon signal
- I used “single” triggered events.

IMC

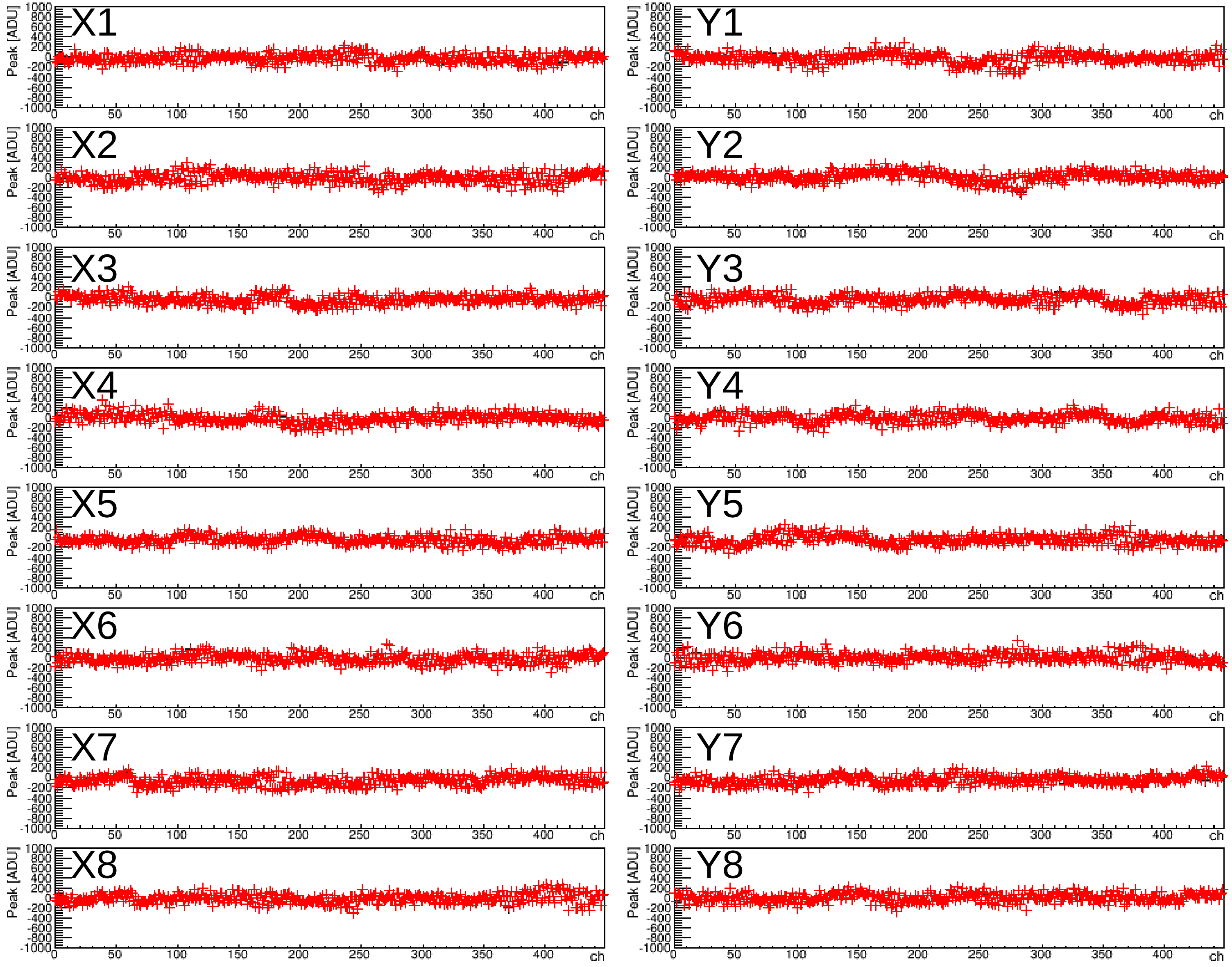
Mean of IMC Pedestal

●Period.①



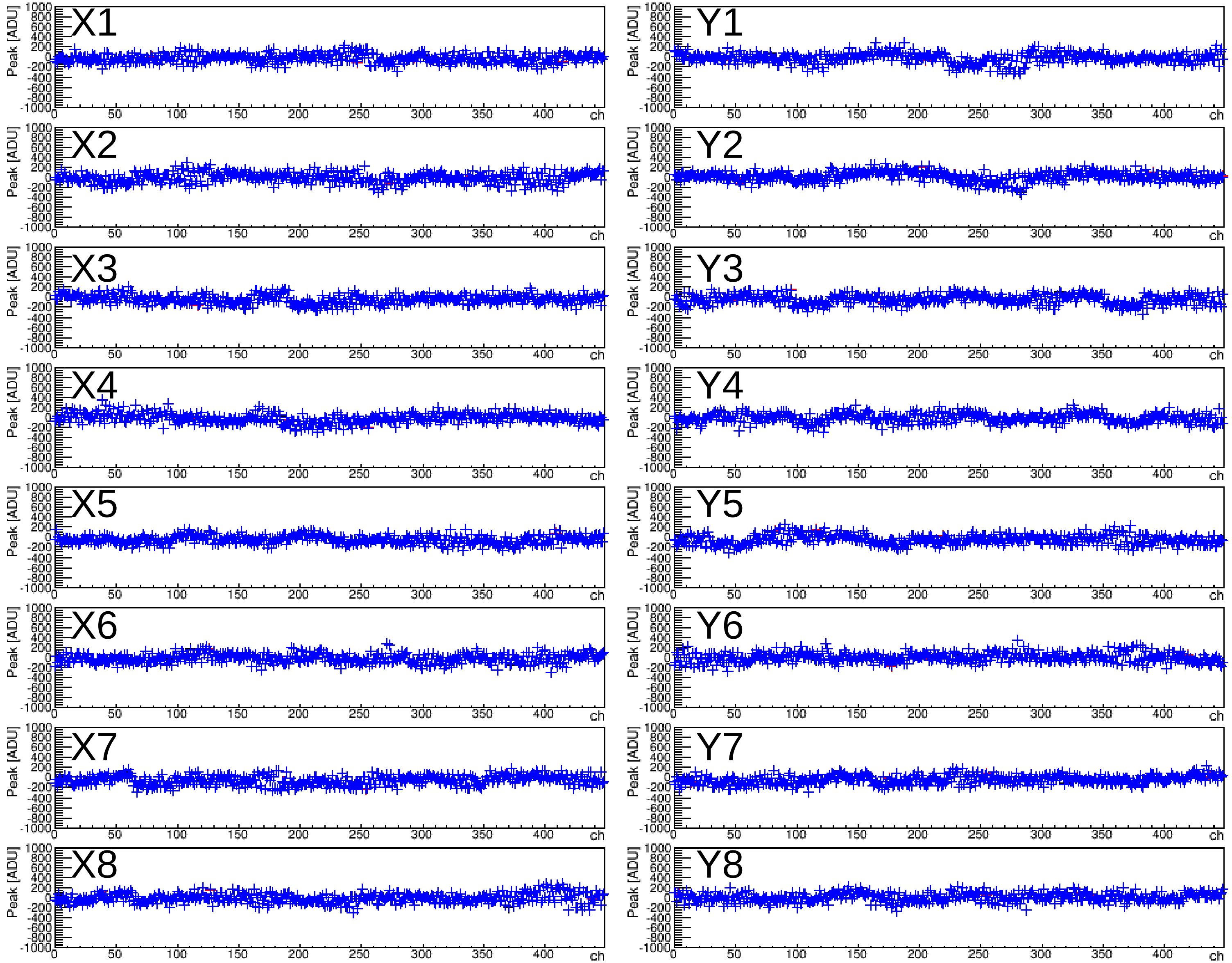
Mean of IMC Pedestal

●Period.①
●Period.②



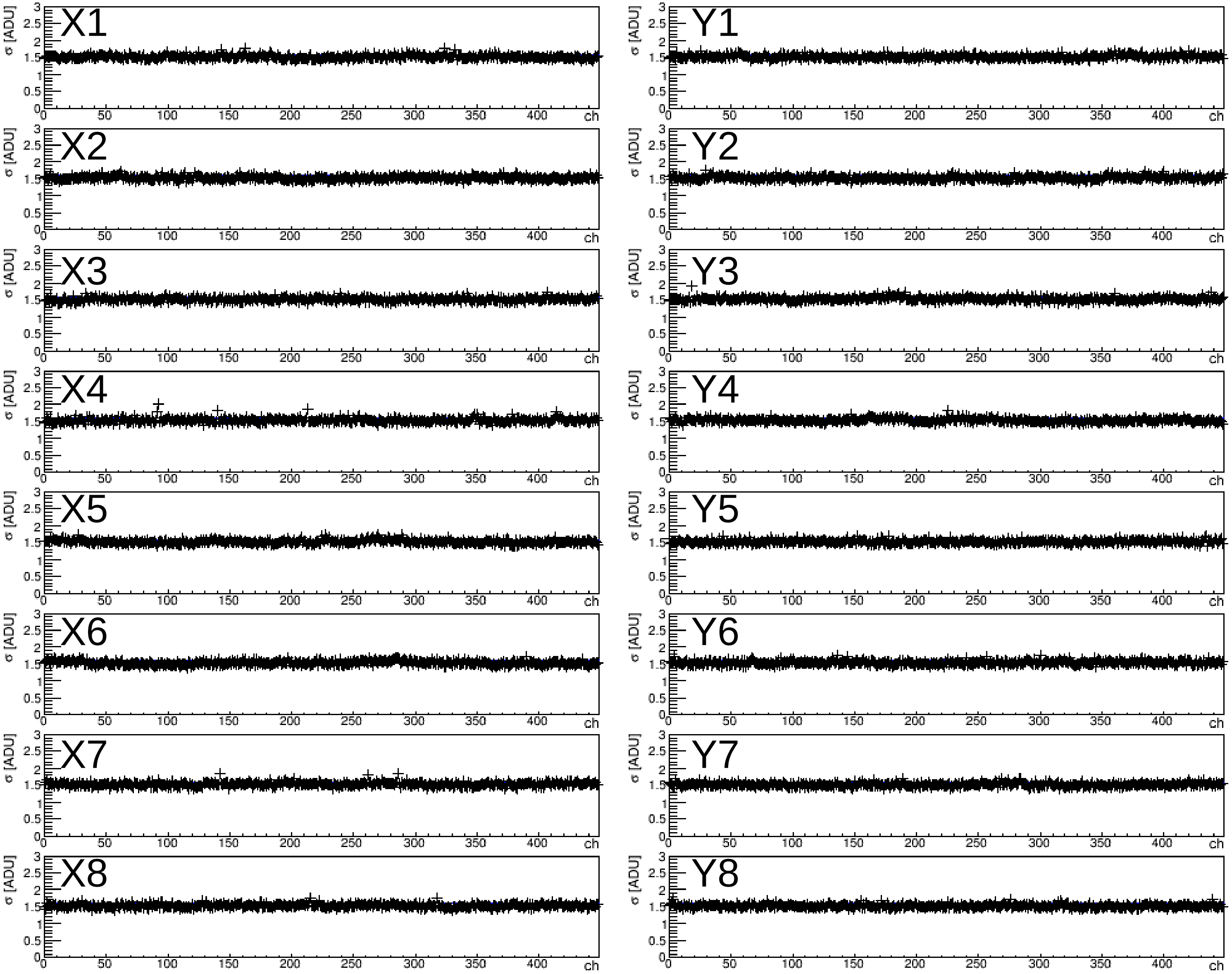
Mean of IMC Pedestal

●Period.①
●Period.②
●Period.③



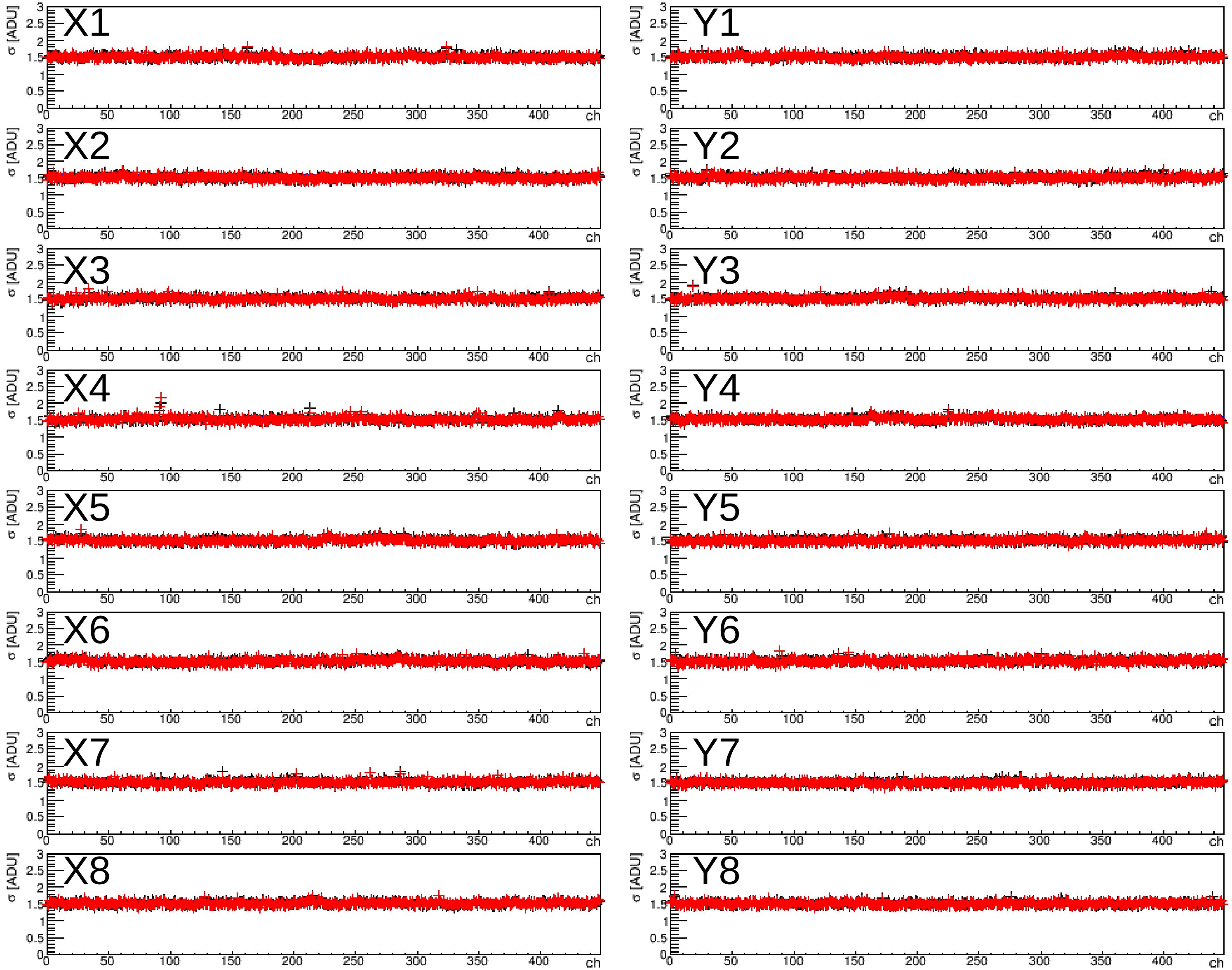
●Period.①

RMS noise (sigma) of IMC Pedestal



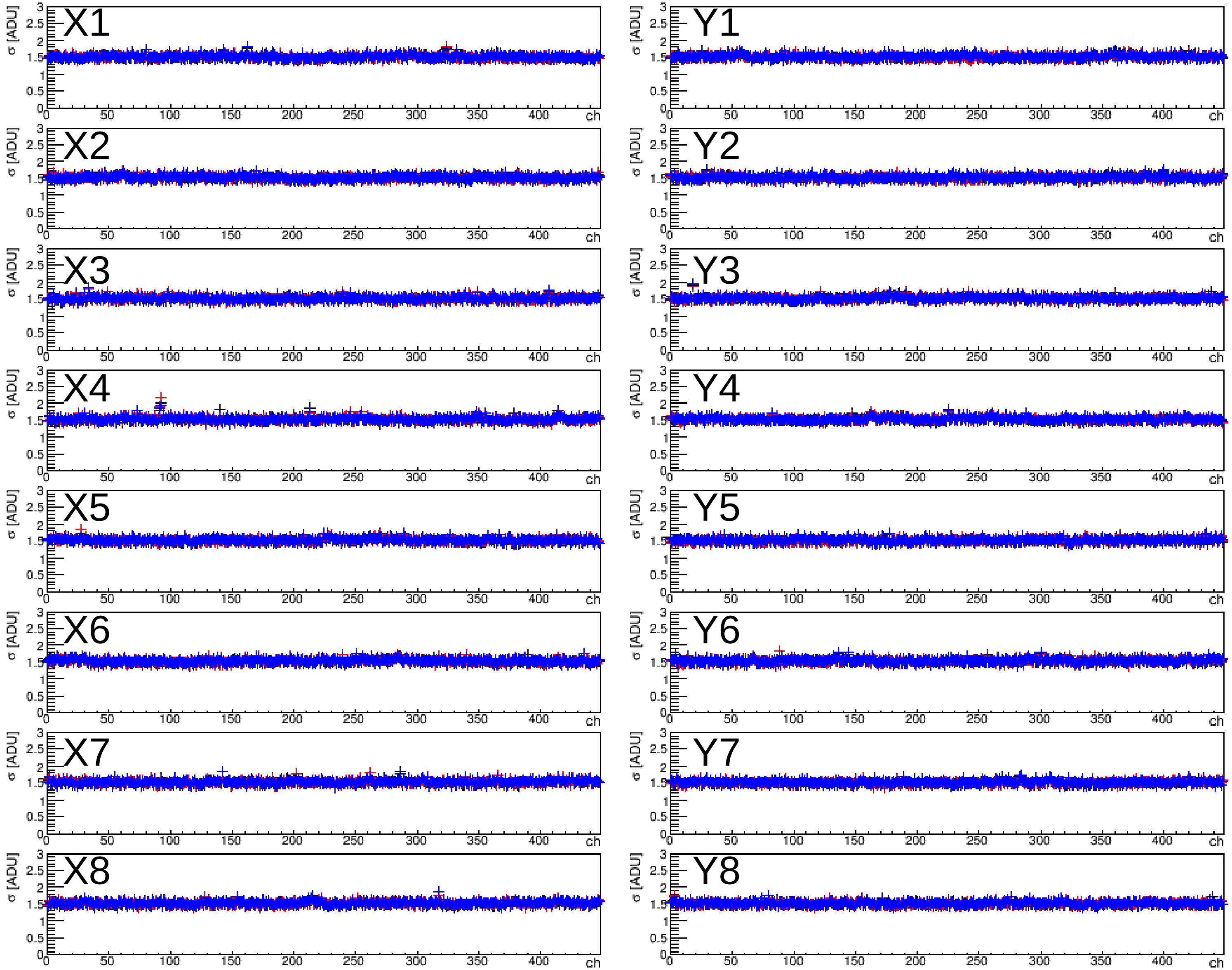
RMS noise (sigma) of IMC Pedestal

●Period.①
●Period.②



RMS noise (sigma) of IMC Pedestal

●Period.①
●Period.②
●Period.③



Muon Event Selection

Track reconstruction

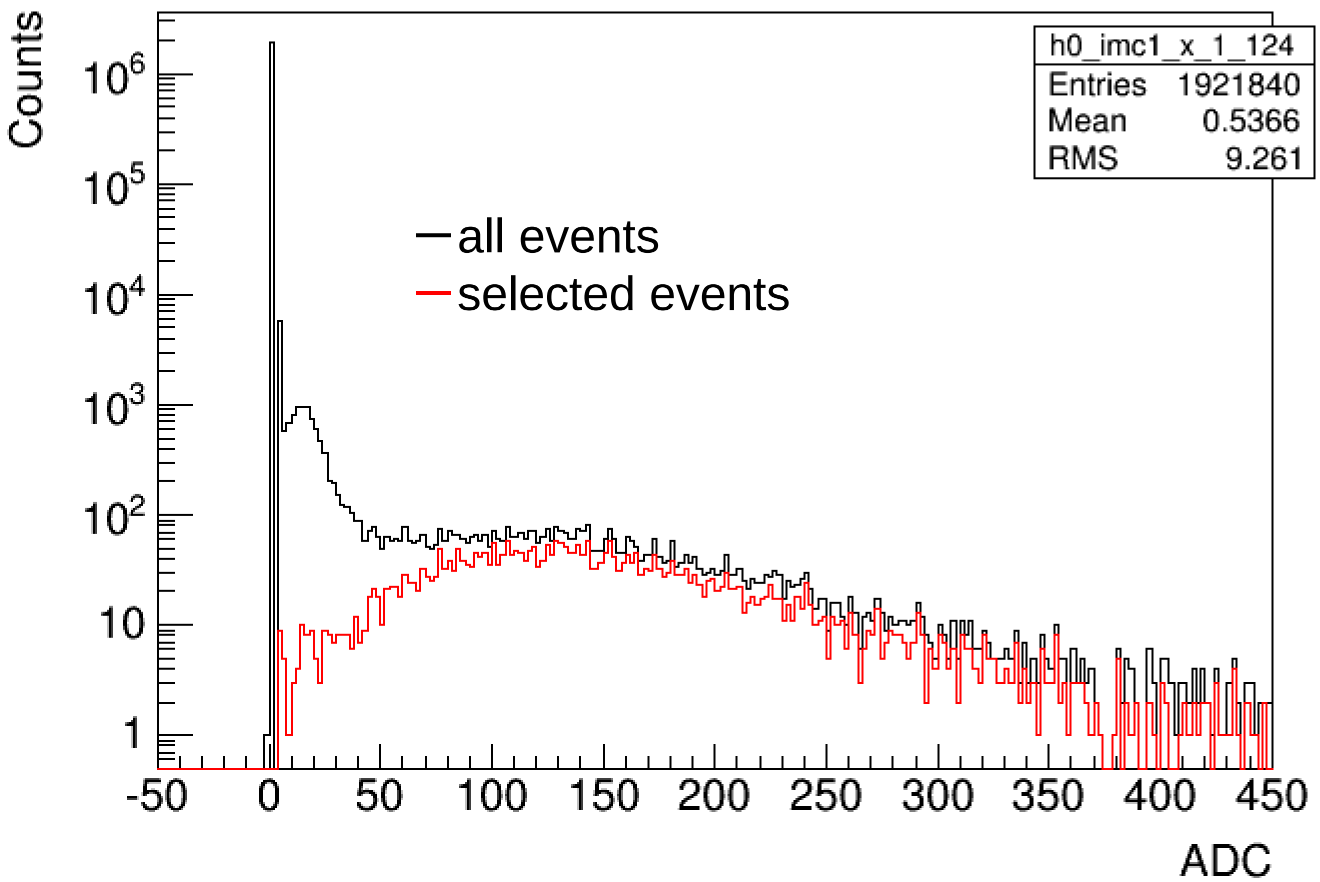
1. Select the most luminous fingers (>10 ADU) in each layer.
2. Fit the fibers by least square method
   - if χ^2/ndf>2, the worst channel is removed. and then, re-fit
   - if the point candidate become less than four, the event is discarded.

Select the particle hit channel

- check the neighbor channels from the vertex point in each layer, and select the most luminous fiber as a hit channel

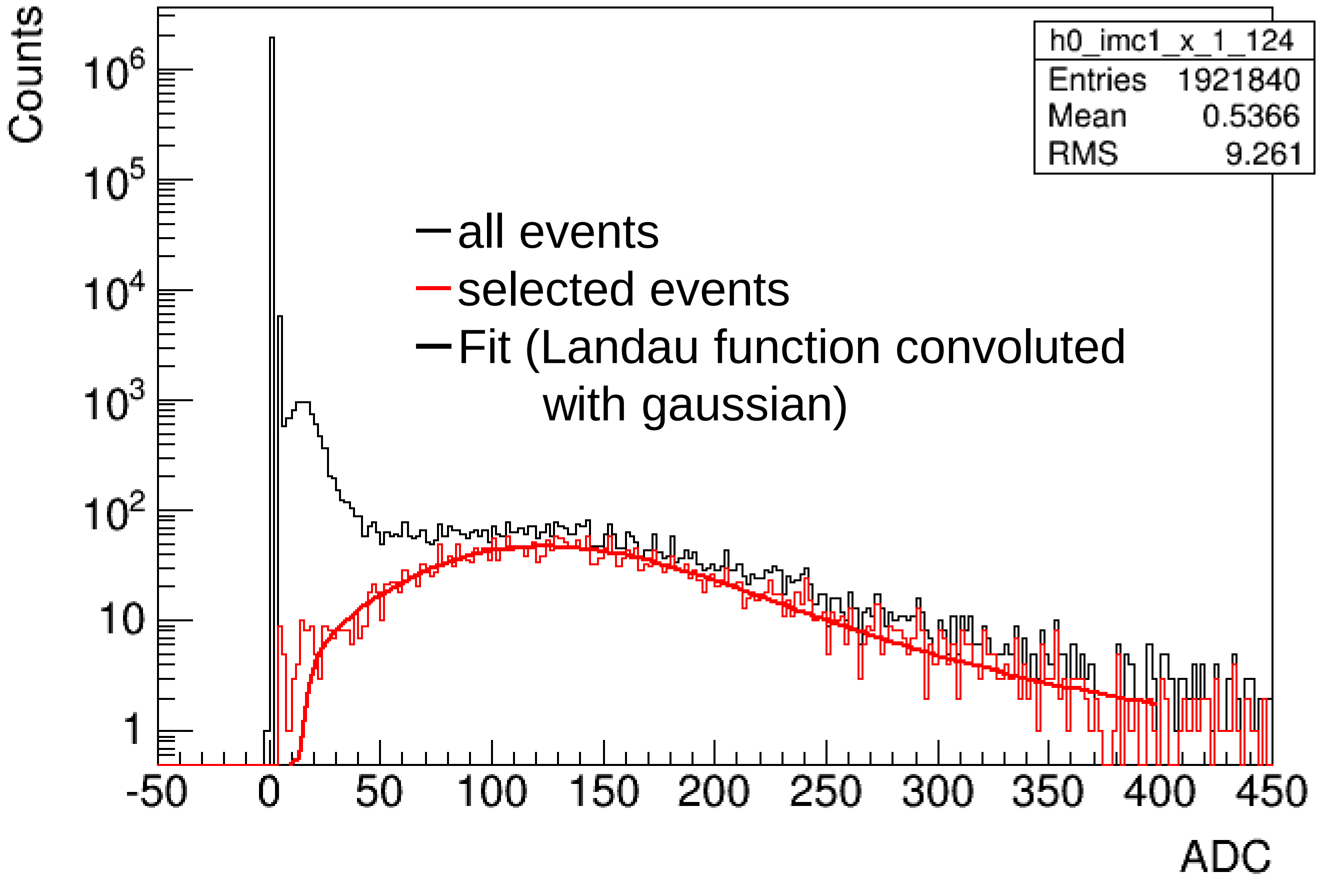
Muon signal

(Ex). ch X1-124



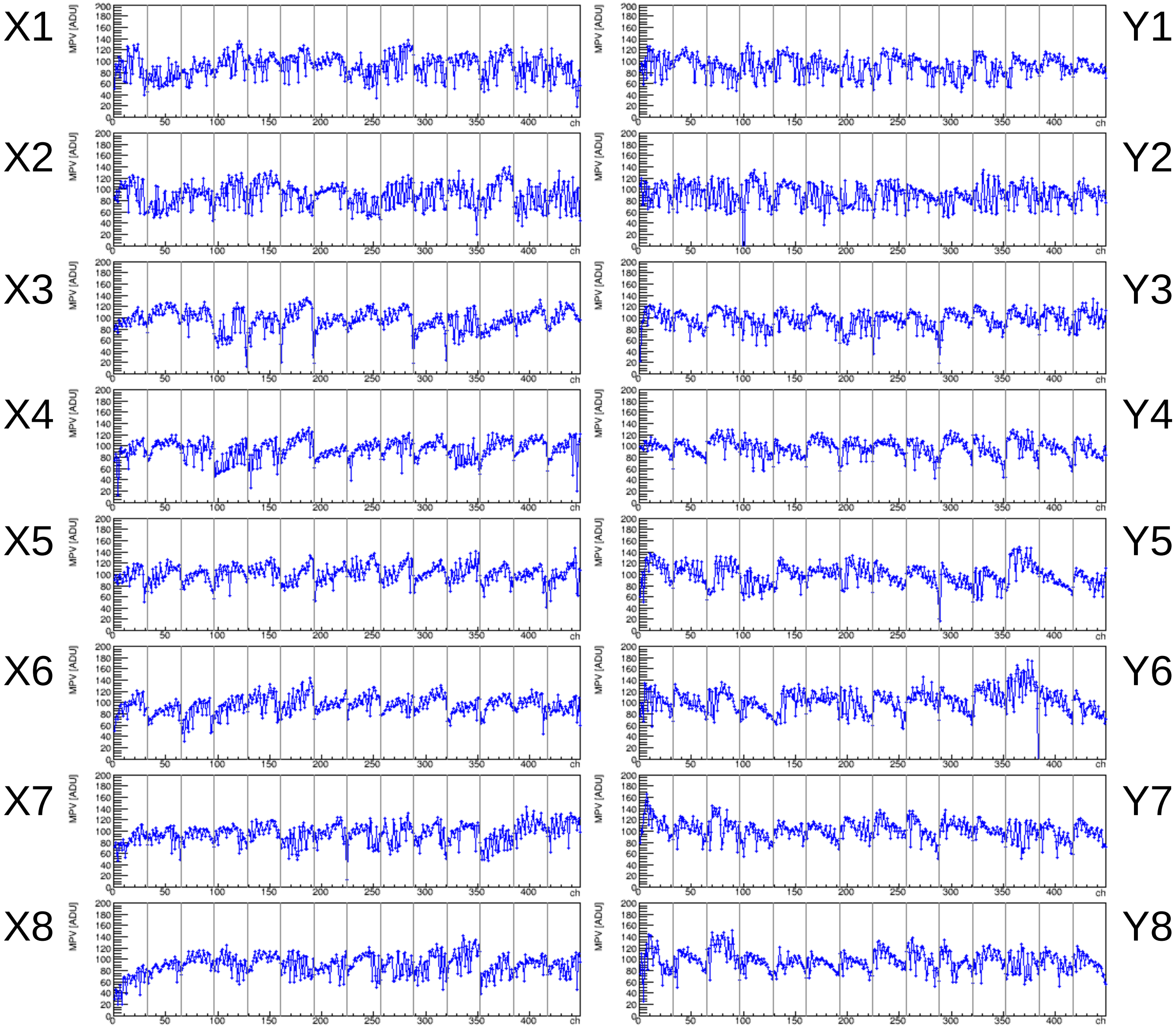
Muon signal

(Ex). ch X1-124



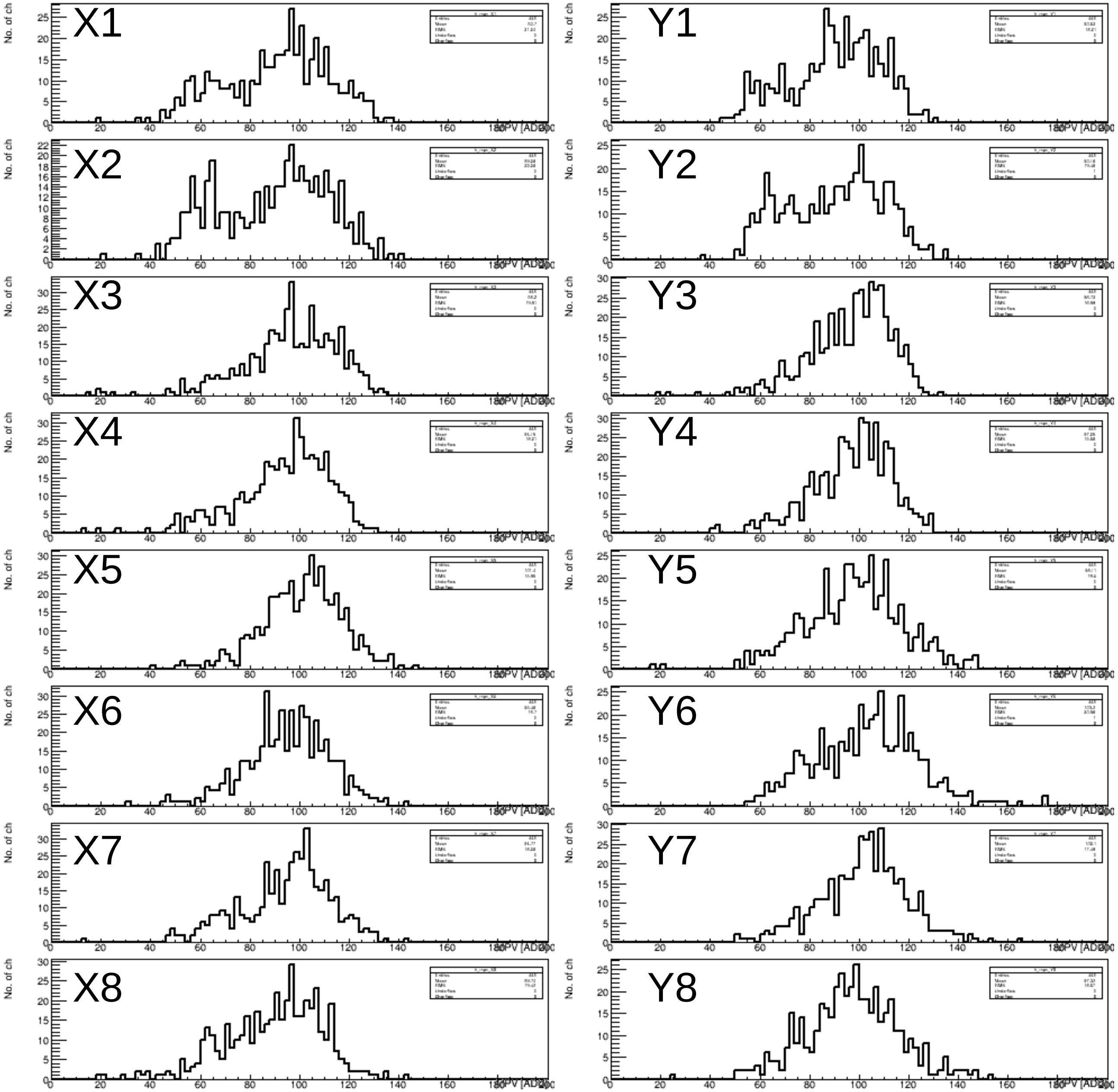
MPV of IMC muon signals

HV=-800V

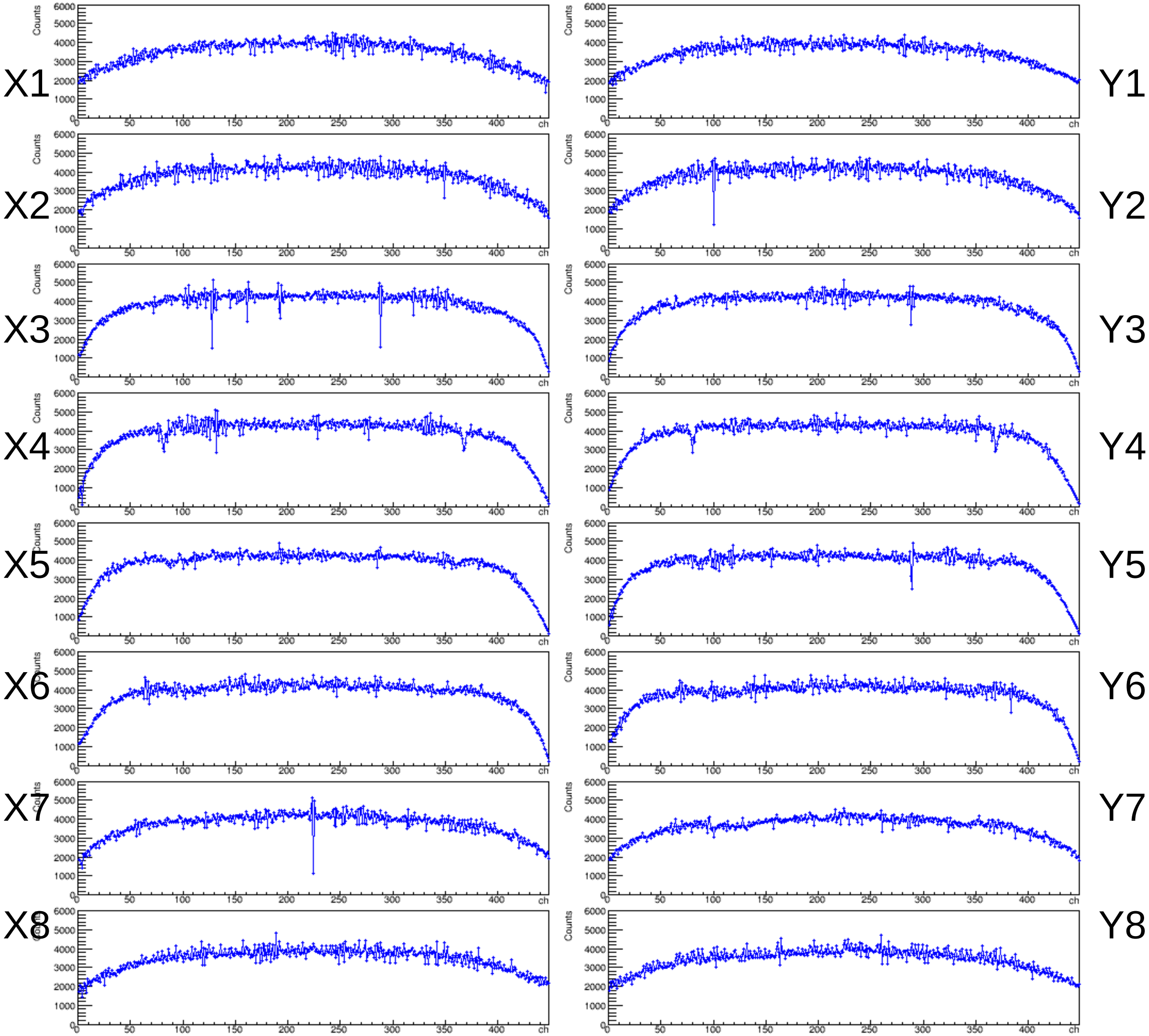


MPV of IMC muon signals

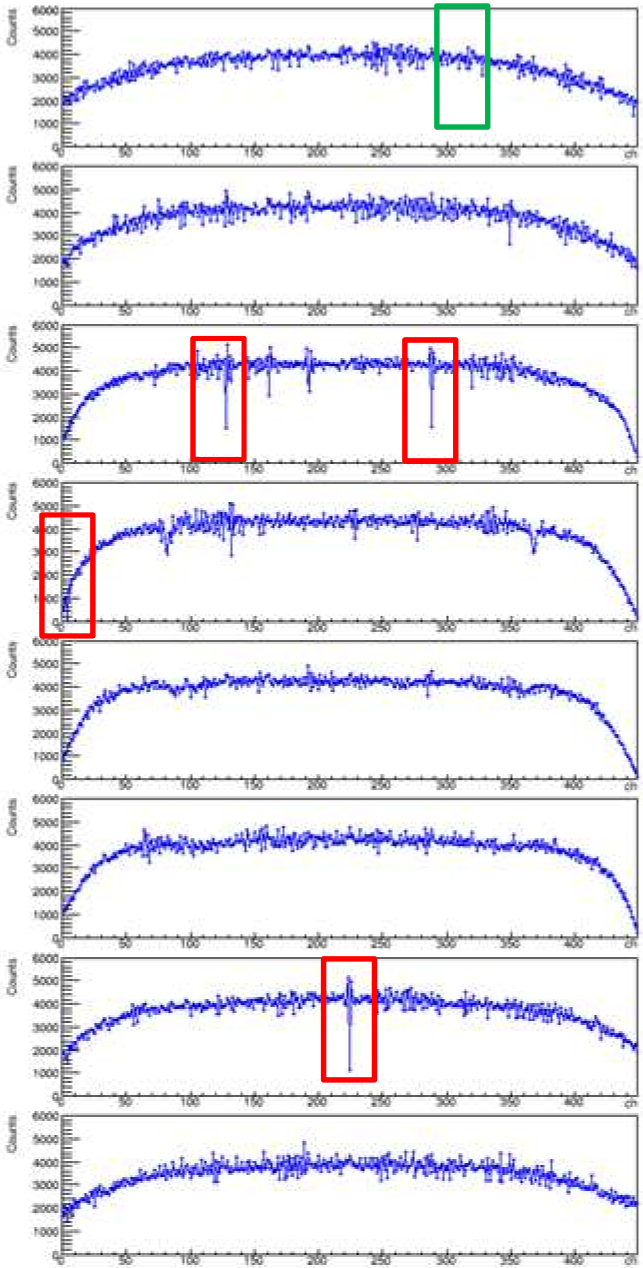
HV=-800V

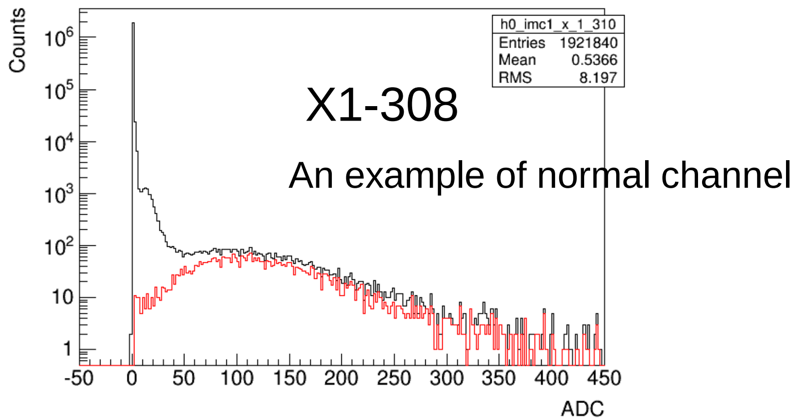


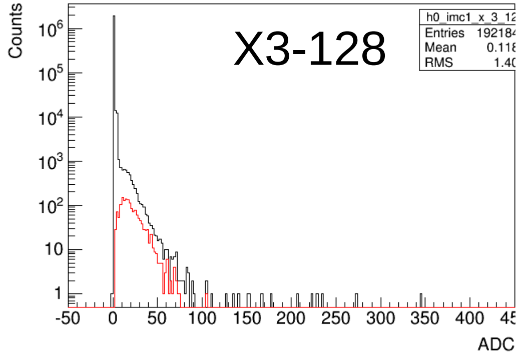
Hit map (the number of hit muon)

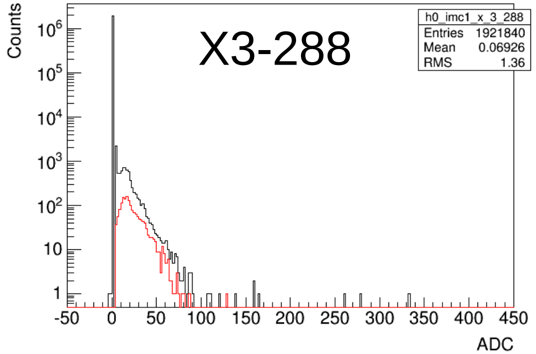


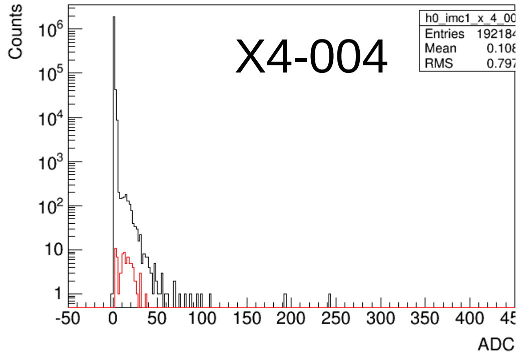
Small gain channels (X-side)

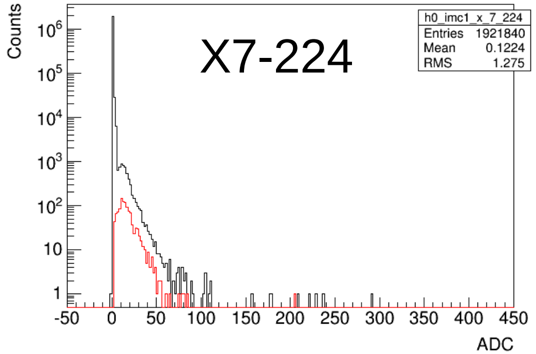




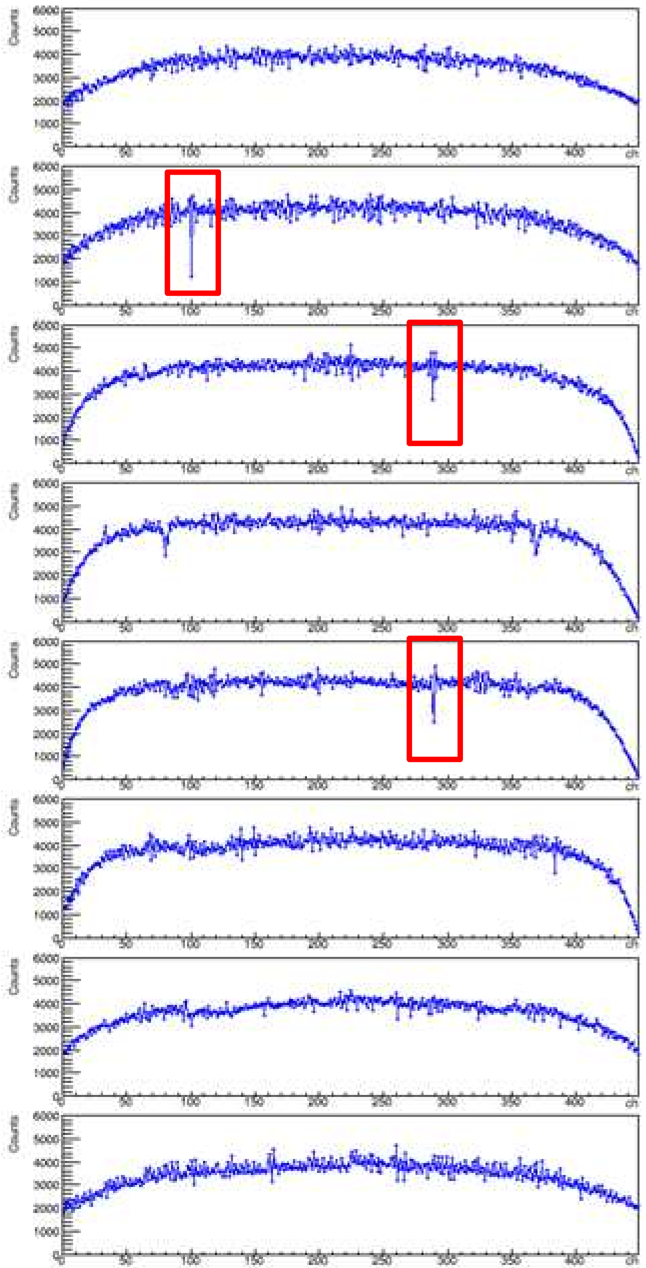


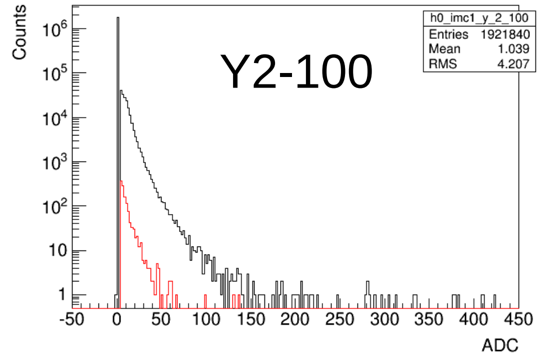


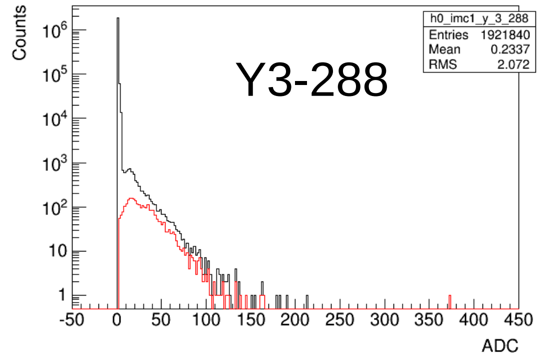


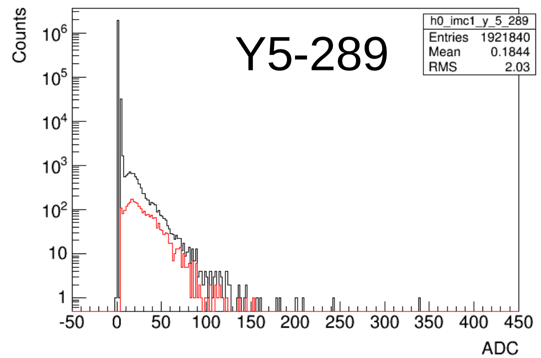


Small gain channels (Y-side)





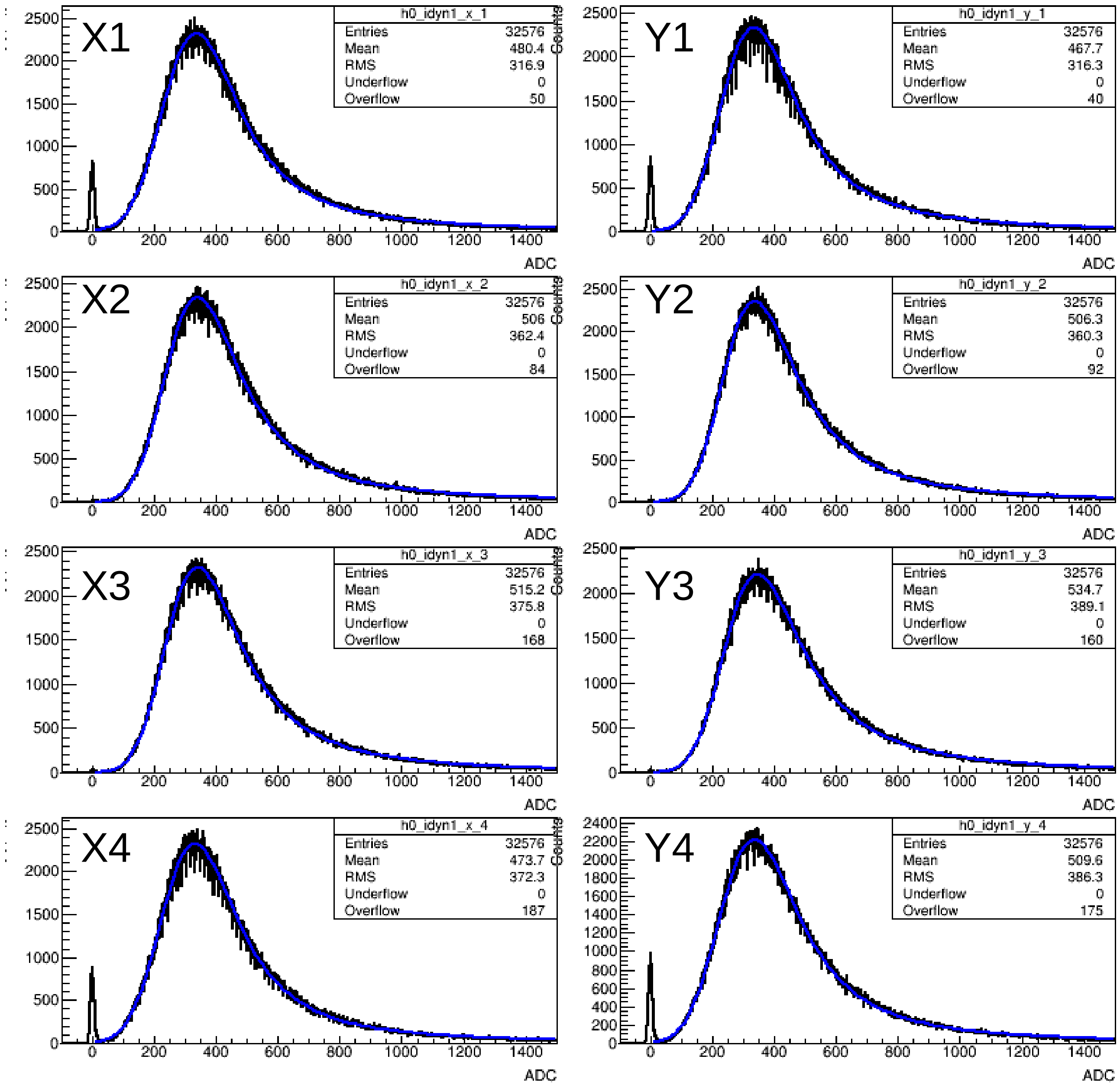




IMC-Dynode

IMC Dynode

HV: -800V



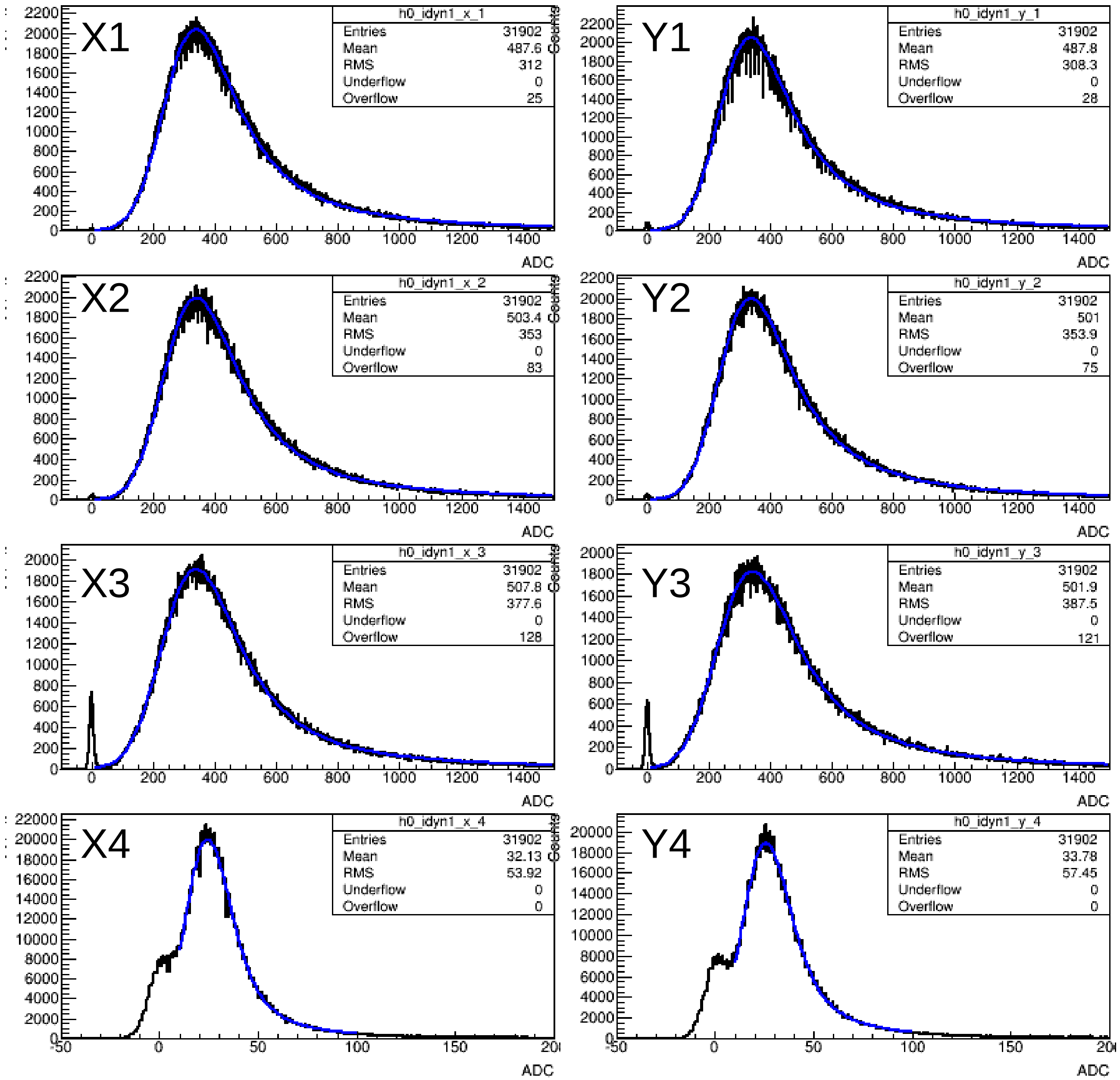
— all events

— fit (Landau func. convoluted with gaussian)

	MPV [ADU]		MPV [ADU]
X1	319.6	Y1	320.2
X2	329.0	Y2	328.2
X3	330.5	Y3	338.5
X4	314.3	Y4	320.3

IMC Dynode

(X123, Y123) HV: -800V, (X4 Y4) HV:-600V



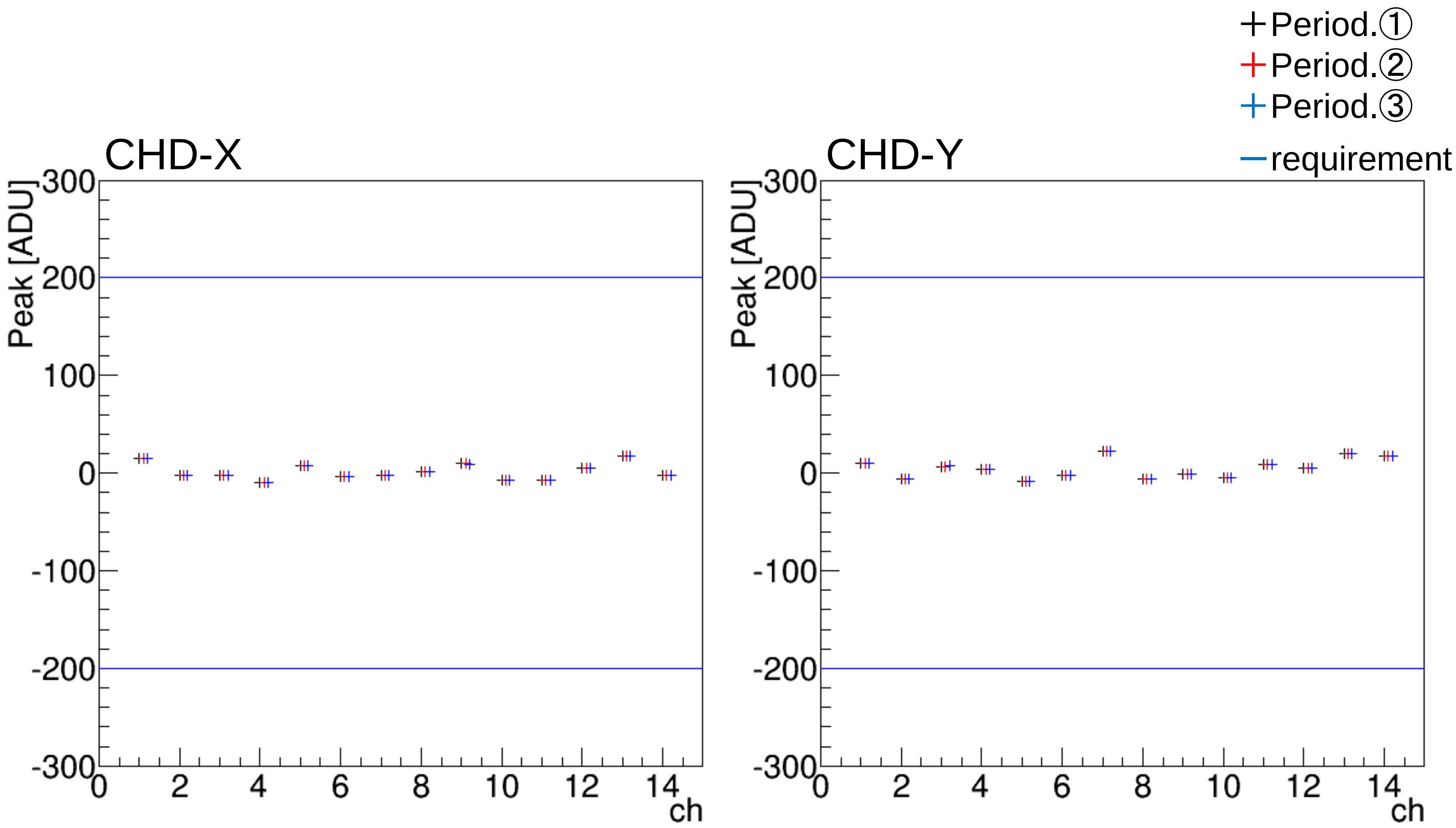
— all events
— fit (Landau func. convoluted with gaussian)

	MPV [ADU]		MPV [ADU]
X1	319.6	Y1	320.2
X2	329.0	Y2	328.2
X3	330.5	Y3	338.5
X4	314.3	Y4	320.3
X4*	21.8	Y4*	23.3

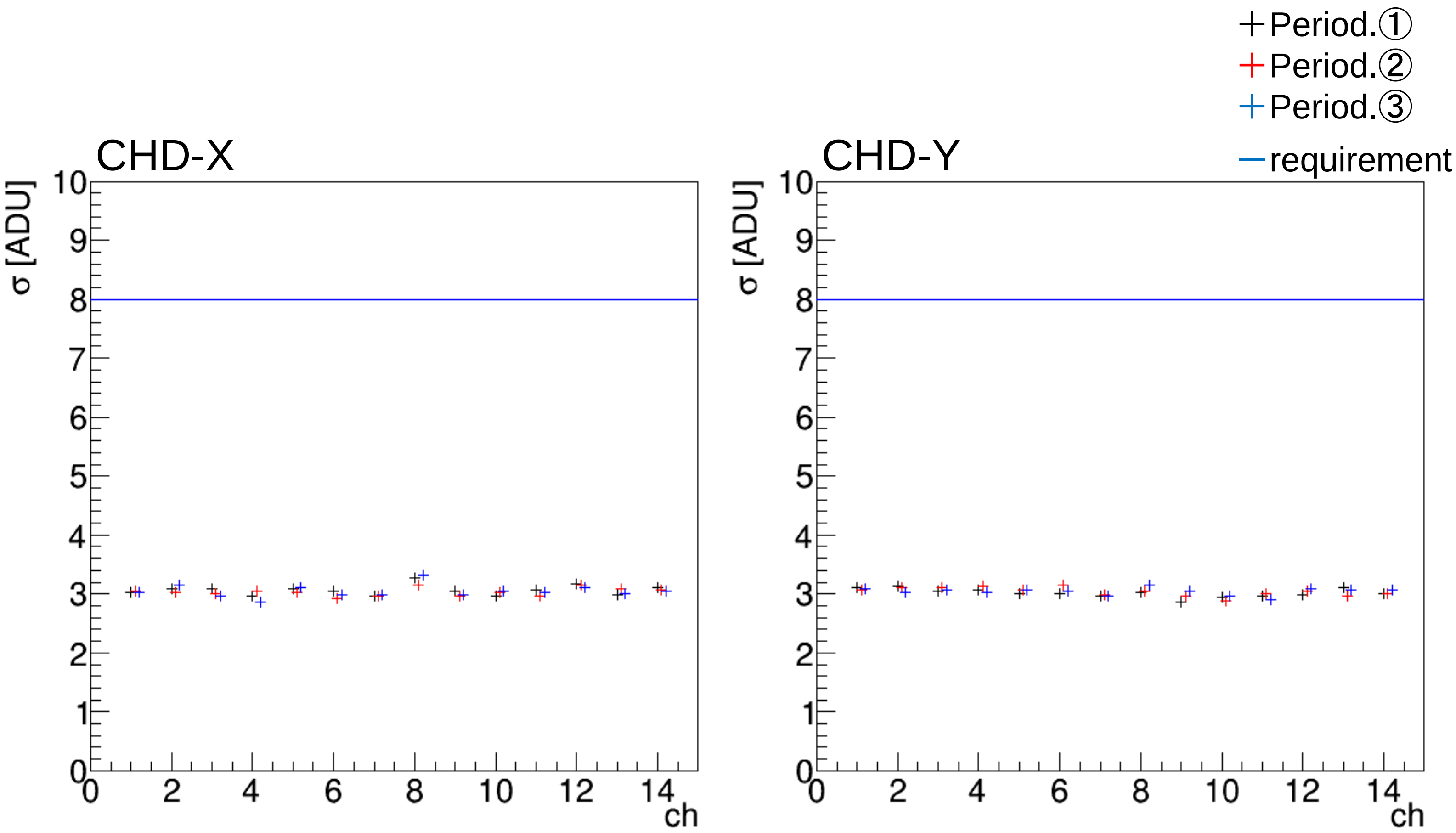
(*) HV:-600V

CHD

Mean of CHD Pedestal



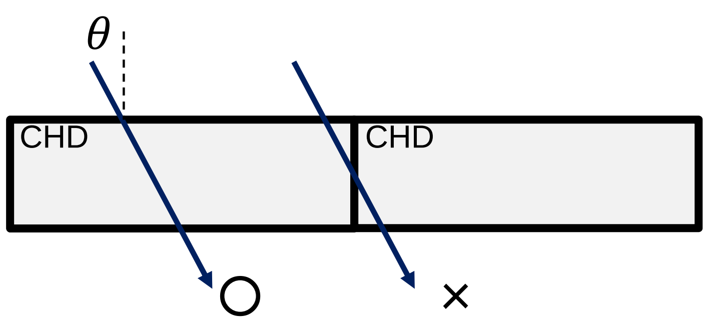
RMS Noise (sigma) of CHD Pedestal

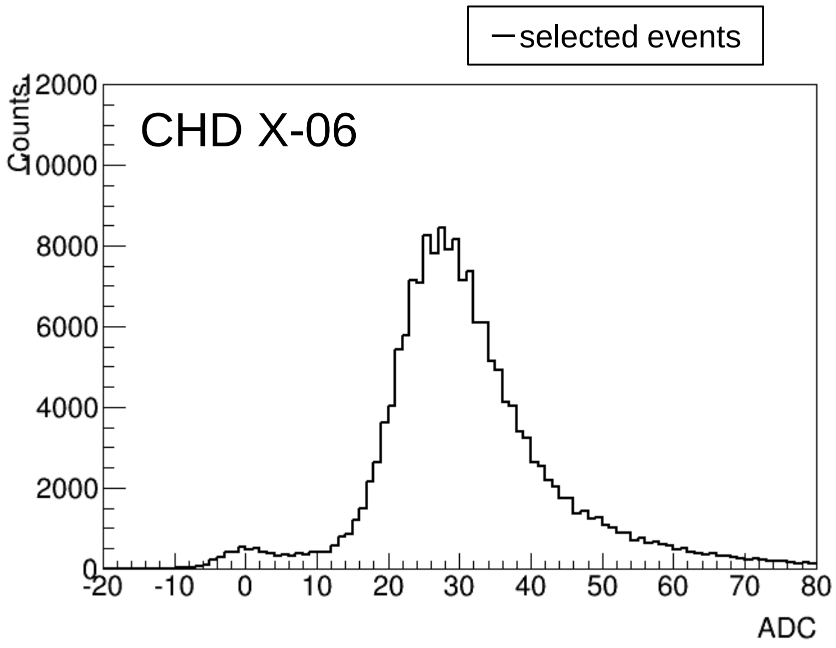


Muon event selection

- Use reconstructed track by IMC
- select the full contained events
- Correct data by the zenith angle in each event

$$d_{ver} = d \times \cos\theta$$

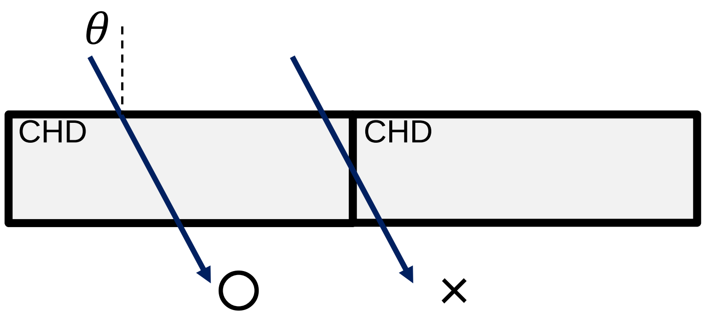


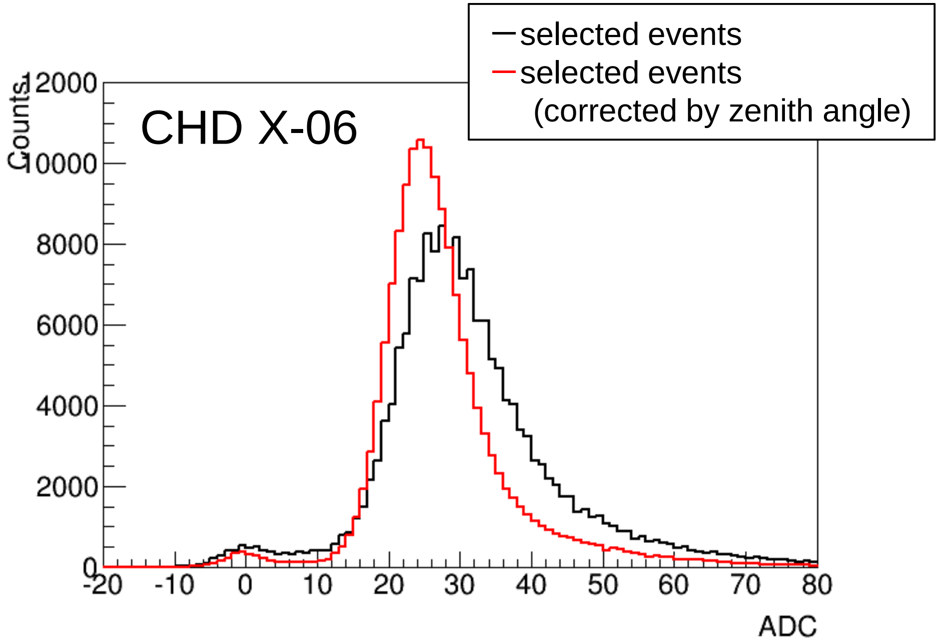


Muon event selection

- Use reconstructed track by IMC
- select the full contained events
- Correct data by the zenith angle in each event

$$d_{ver} = d \times \cos\theta$$

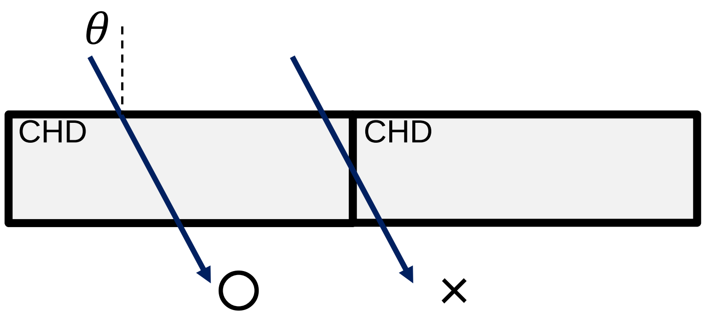


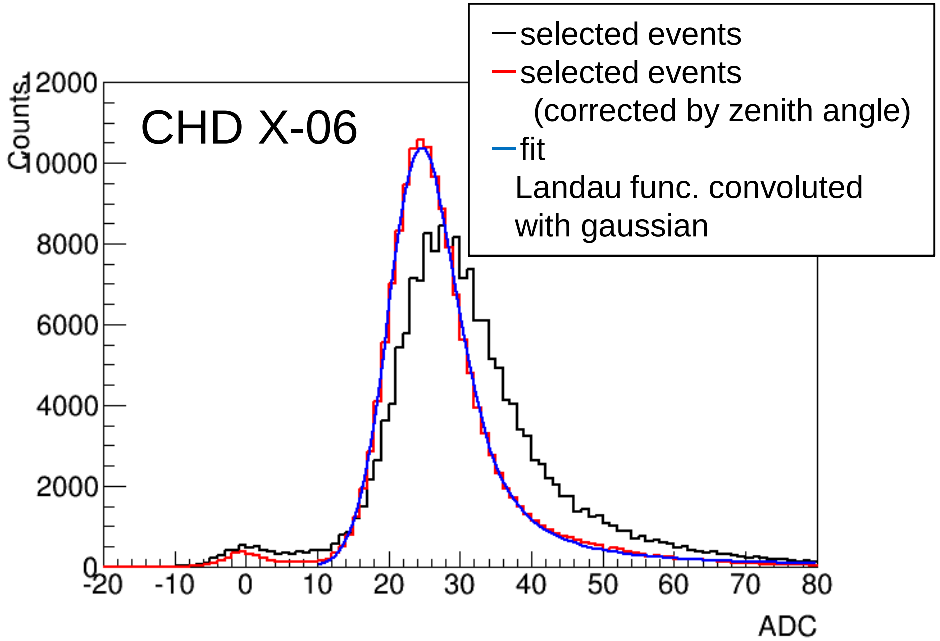


Muon event selection

- Use reconstructed track by IMC
- select the full contained events
- Correct data by the zenith angle in each event

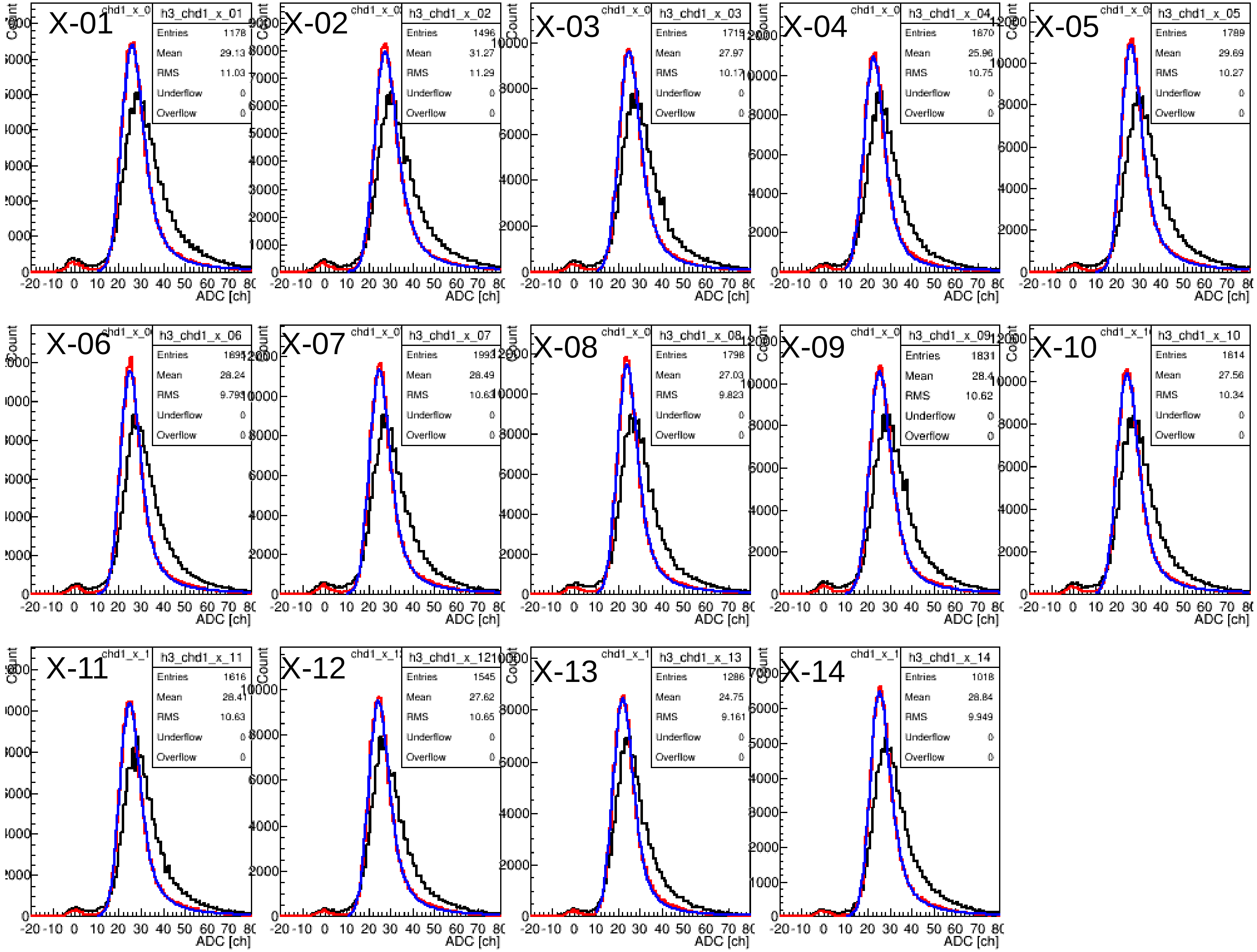
$$d_{ver} = d \times \cos\theta$$



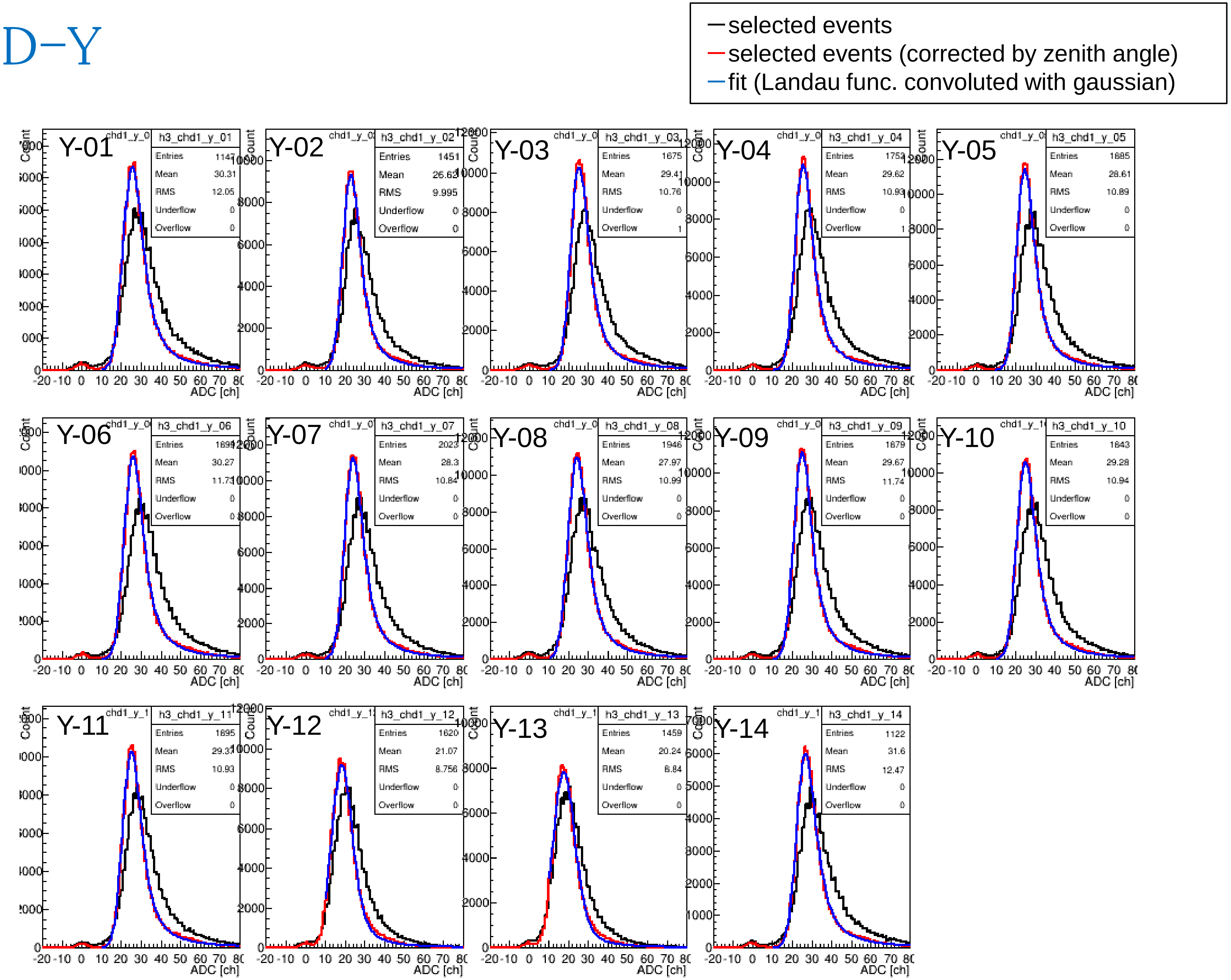


CHD−X

—selected events
—selected events (corrected by zenith angle)
—fit (Landau func. convoluted with gaussian)

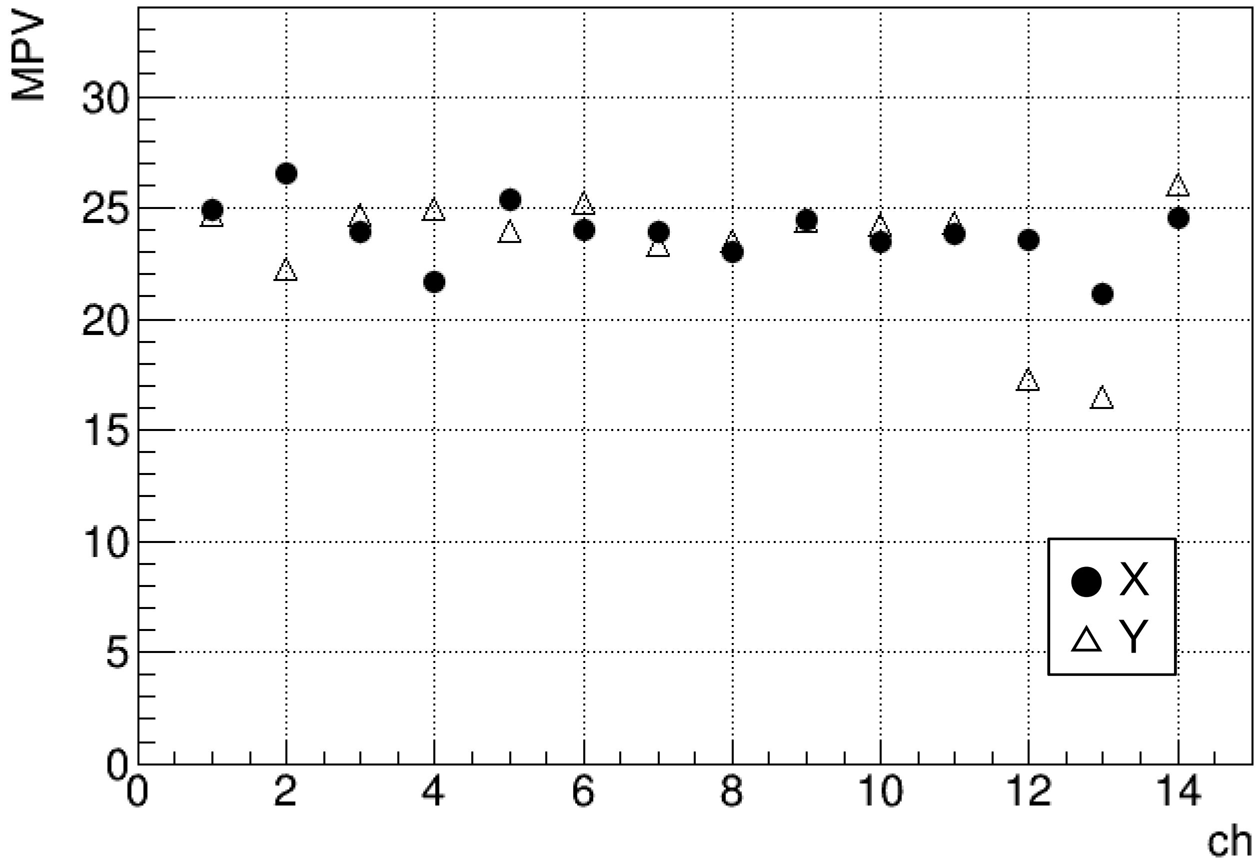


CHD−Y



selected events
selected events (corrected by zenith angle)
fit (Landau func. convoluted with gaussian)
Y-01
Y-02
Y-03
Y-04
Y-05
Y-06
Y-07
Y-08
Y-09
Y-10
Y-11
Y-12
Y-13
Y-14
ADC [ch]

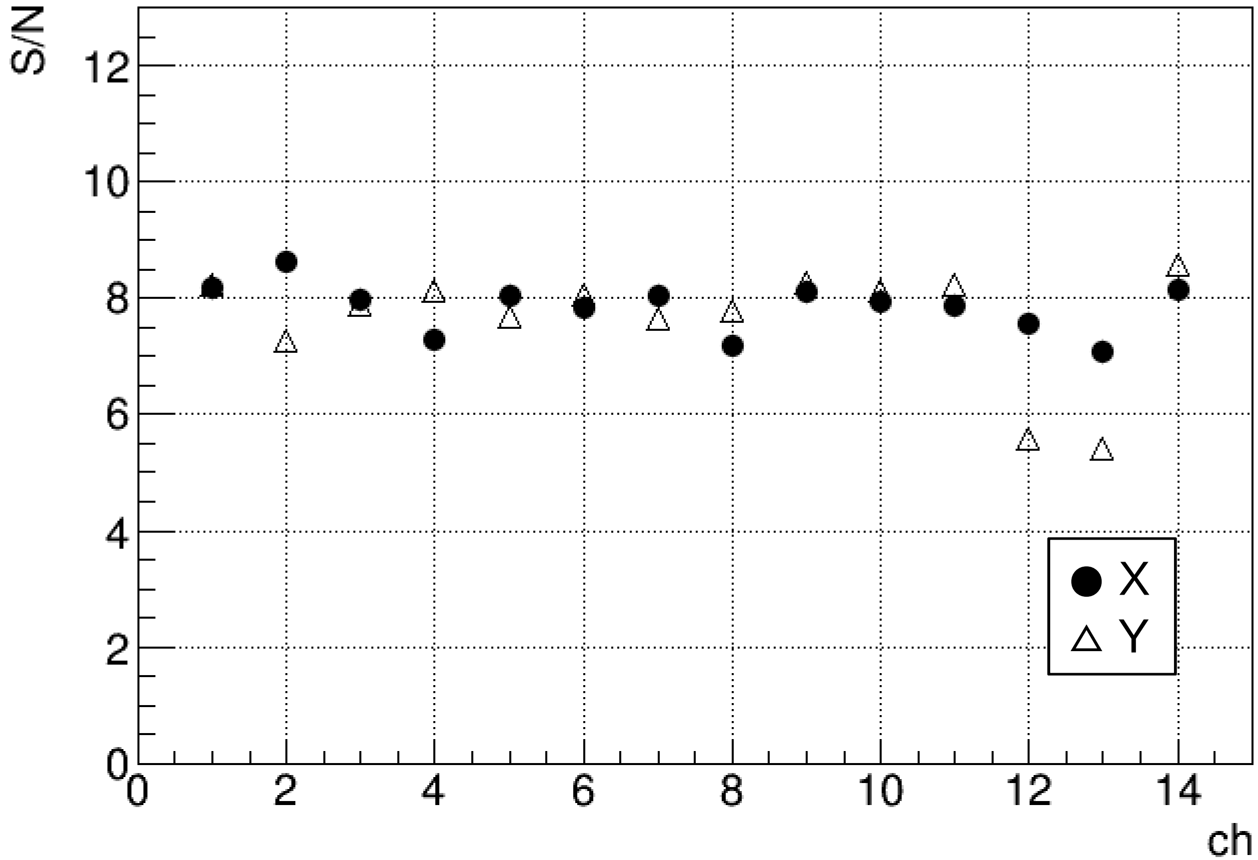
MPV of CHD



S/N of CHD

$$\frac{S}{N} \equiv \frac{\mu}{\sigma}$$

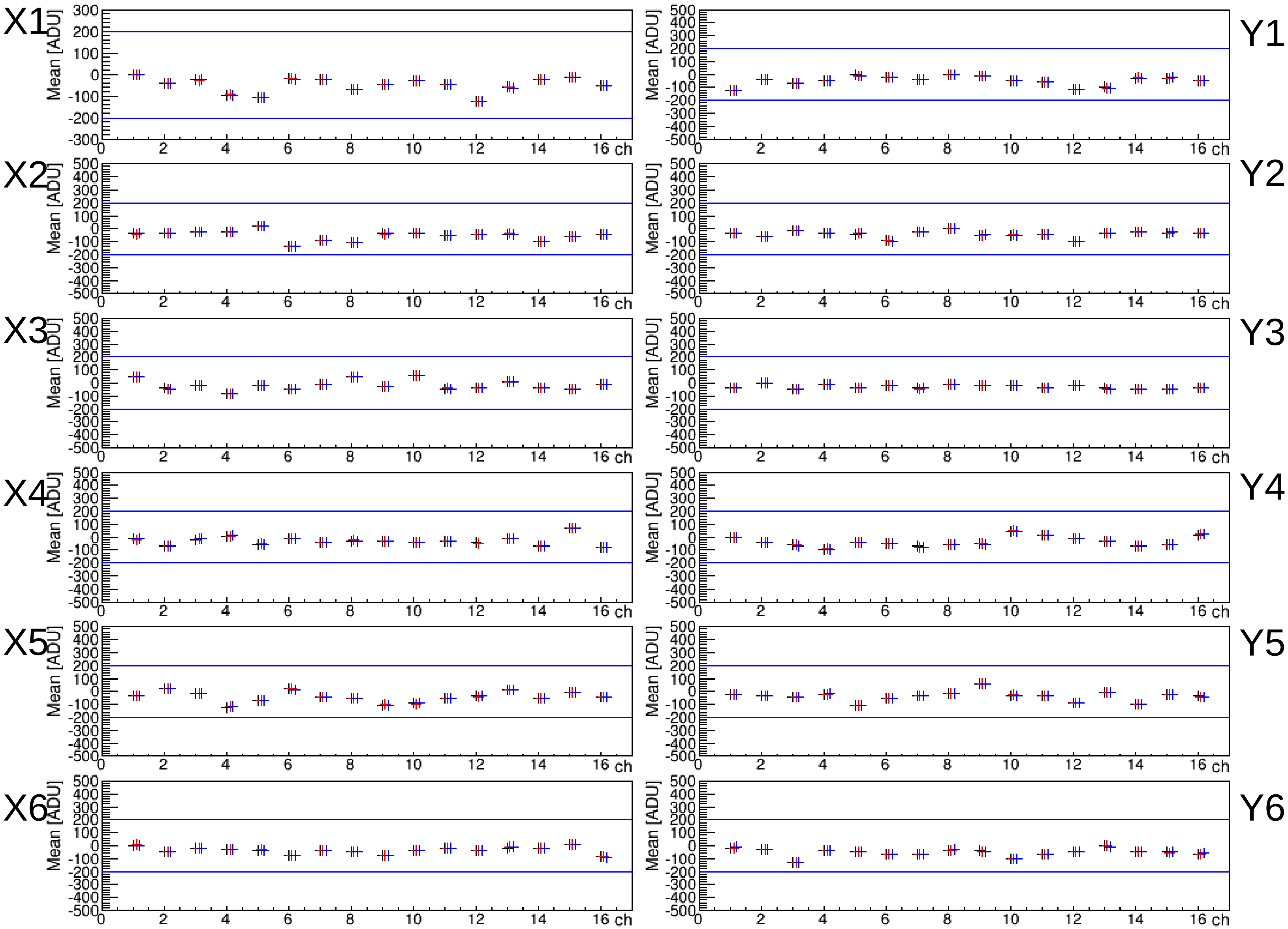
μ: MPV of muon signal
σ: Sigma of pedestal



TASC

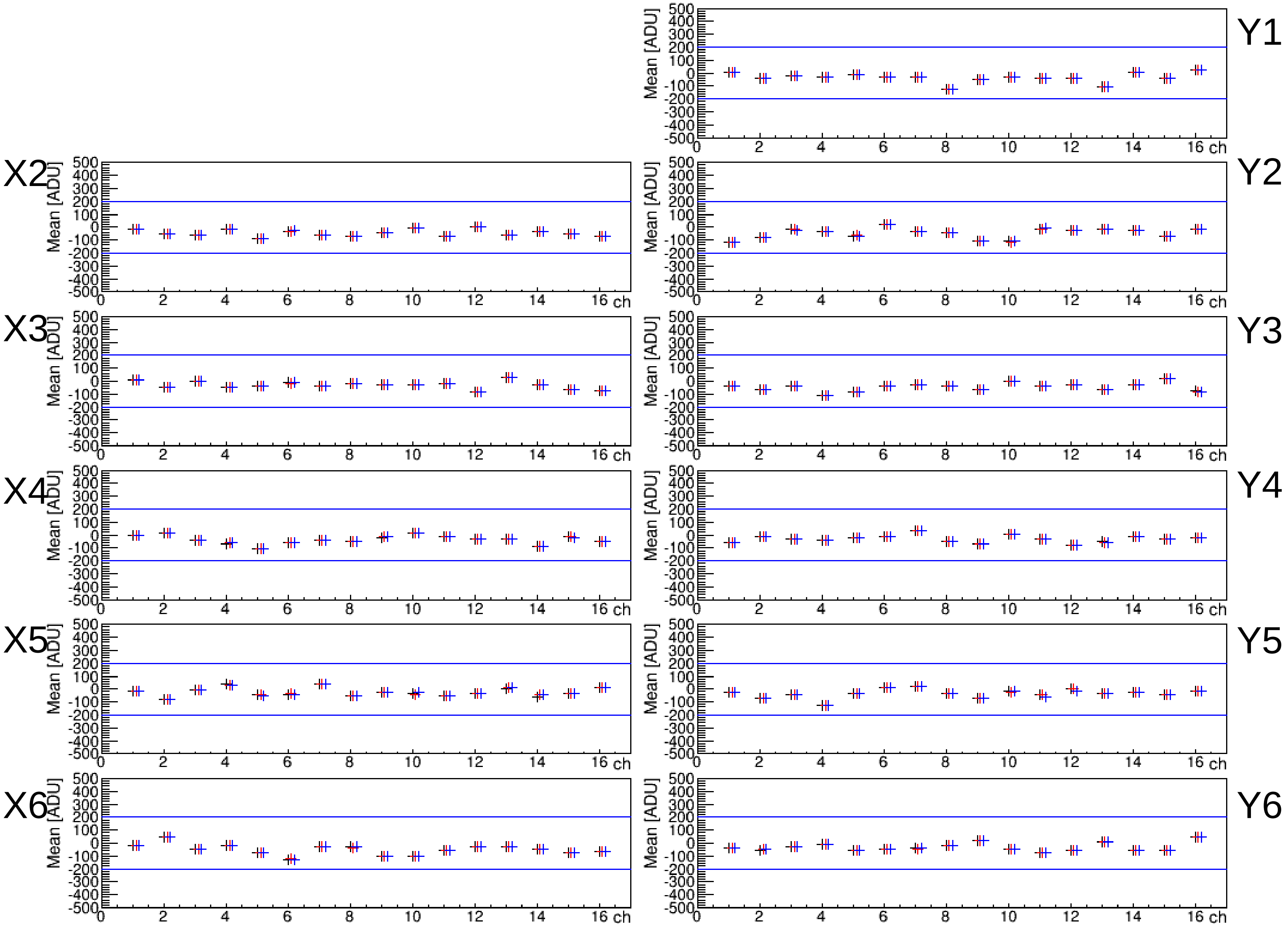
Mean of Pedestal (X1: PMT, X2–Y8:APD–H)

●Period.①
●Period.②
●Period.③



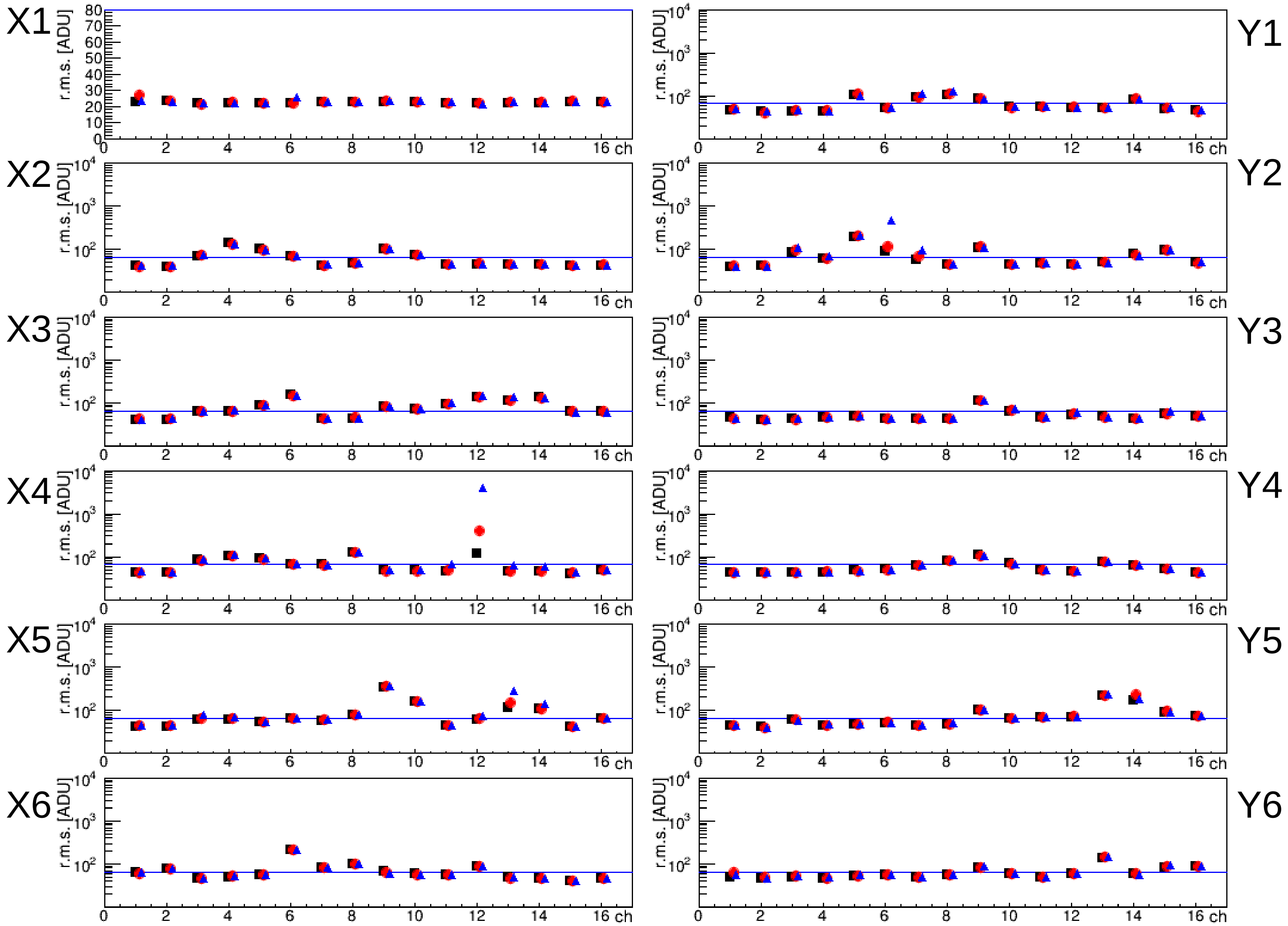
Mean of Pedestal (X2-Y8:PD-H)

●Period.①
●Period.②
●Period.③



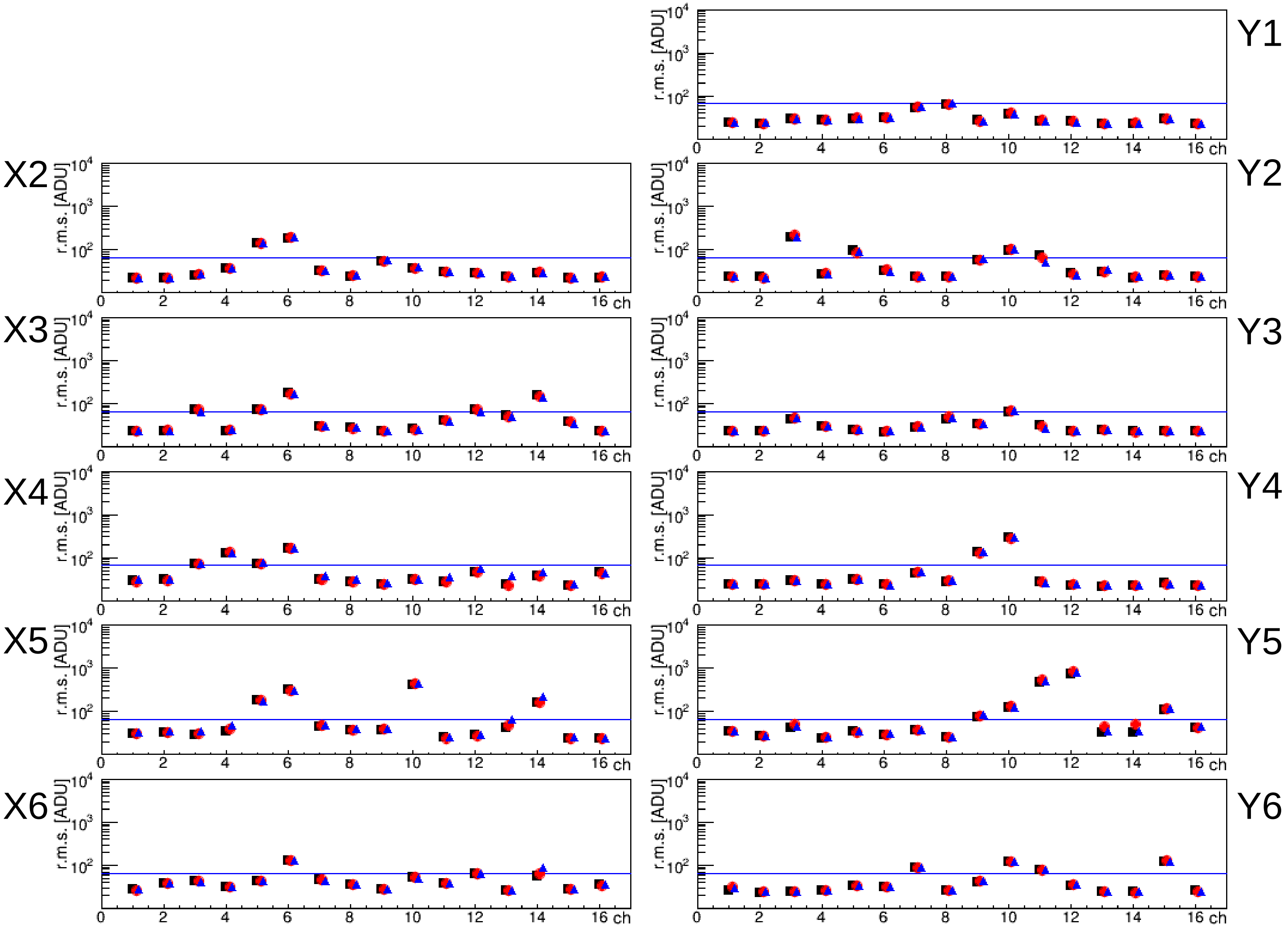
RMS noise of Pedestal (X1: PMT, X2–Y8:APD-H)

●Period.①
●Period.②
●Period.③



RMS noise of Pedestal (X2-Y8:PD-H)

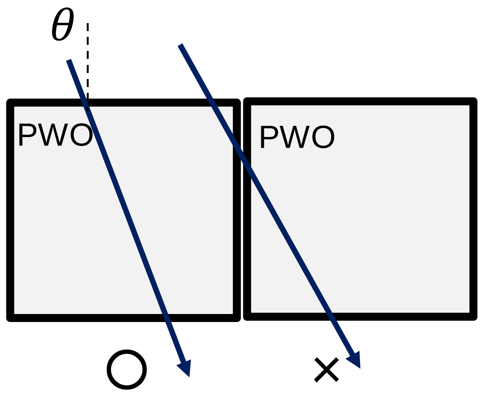
●Period.①
●Period.②
●Period.③



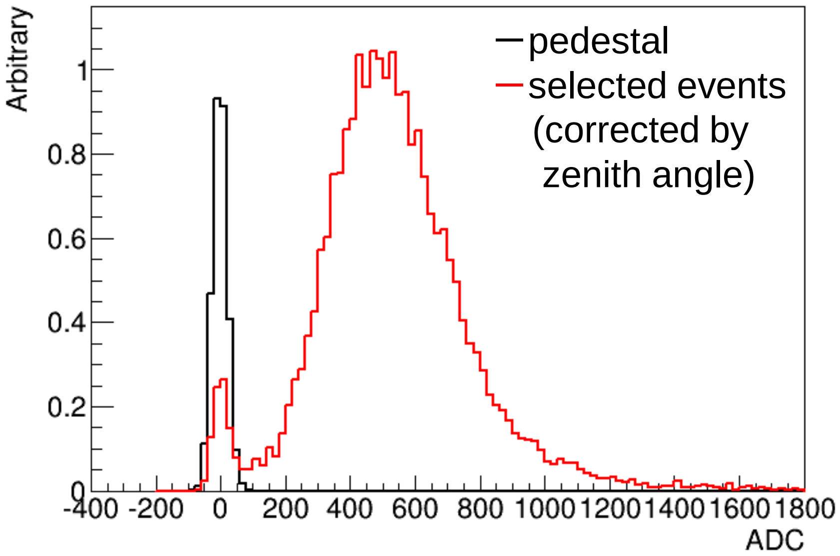
Muon event selection & Fitting

- Use reconstructed track by IMC
- select the full contained events
- Correct the zenith angle in each event

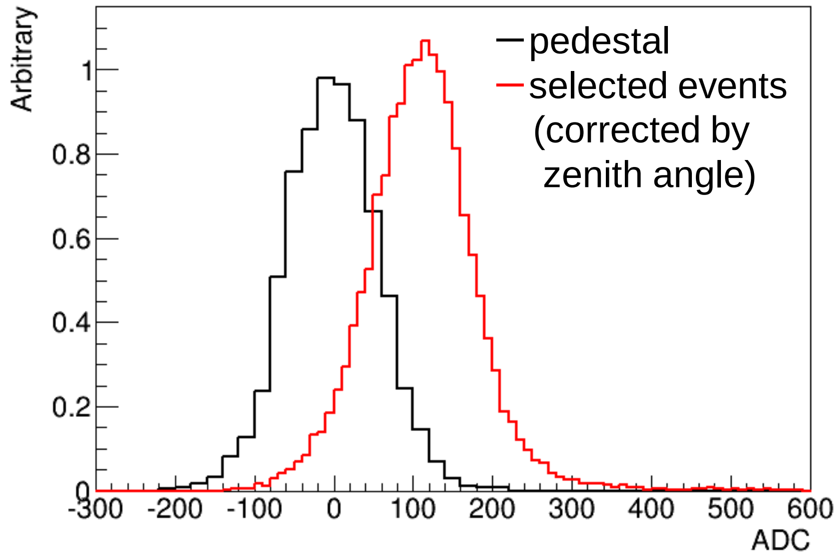
$$d_{ver} = d \times \cos\theta$$



X1-10 (PMT)



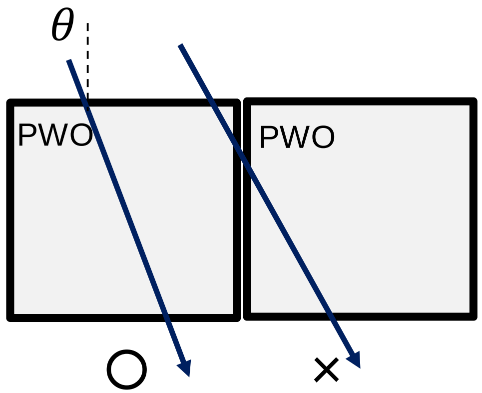
Y1-10 (APD)



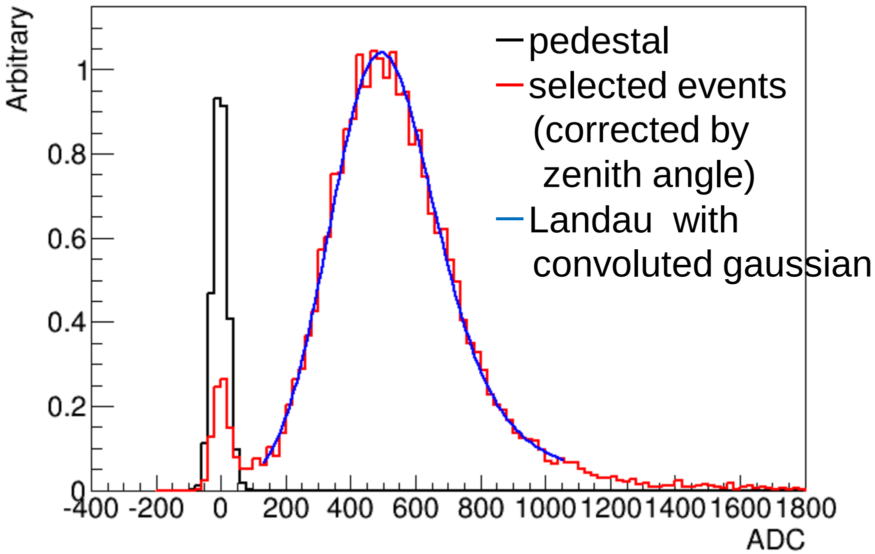
Muon event selection & Fitting

- Use reconstructed track by IMC
- select the full contained events
- Correct the zenith angle in each event

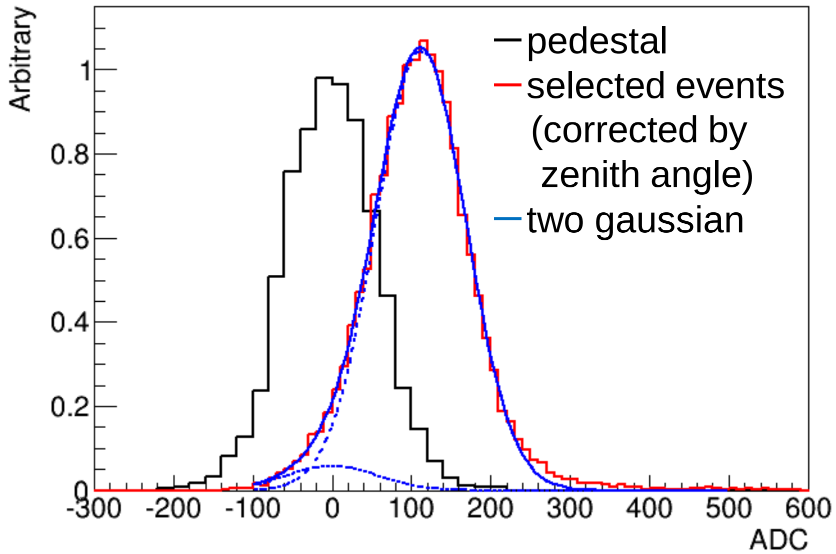
$$d_{ver} = d \times \cos\theta$$



X1-10 (PMT)



Y1-10 (APD)



$F(x) = A_1 G_1(x) + A_2 G_2(x)$

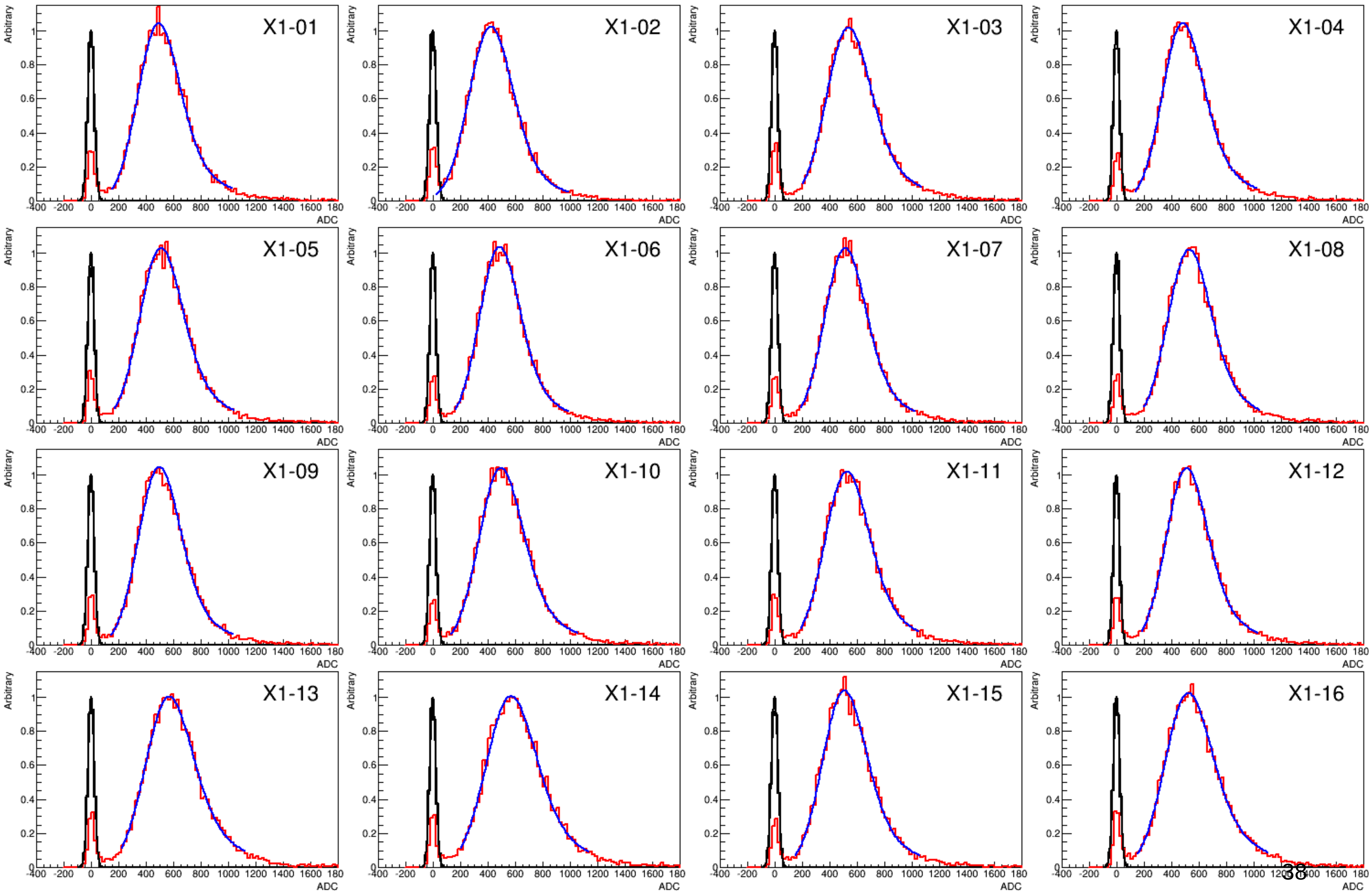
G_1: gaussian (pedestal),
(the parameter is fixed by pedestal)

G_2: gaussian (muon)

TASC X1

—pedestal
—selected events
—Landau with convoluted gaussian

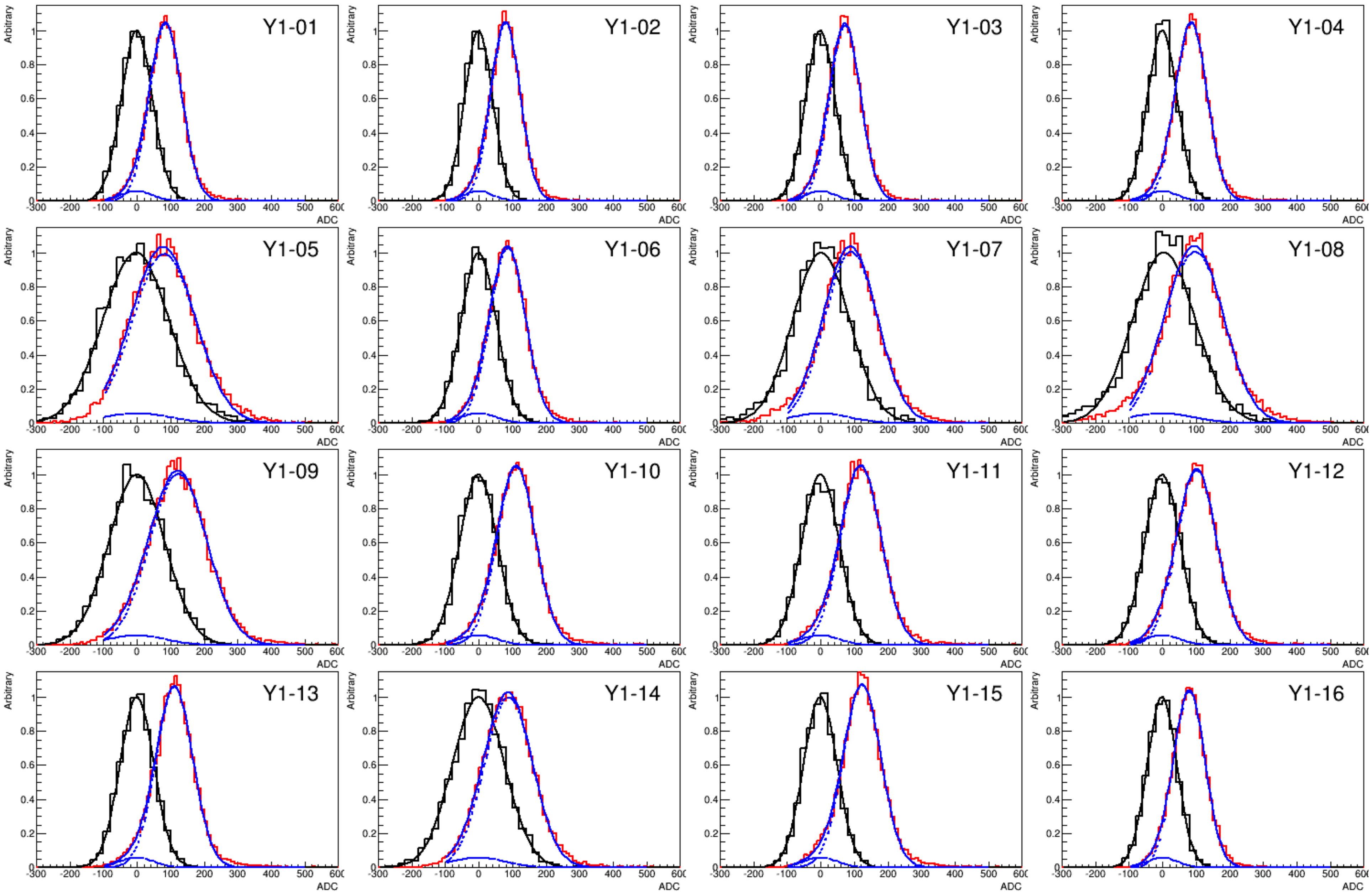
Period.①



TASC Y1

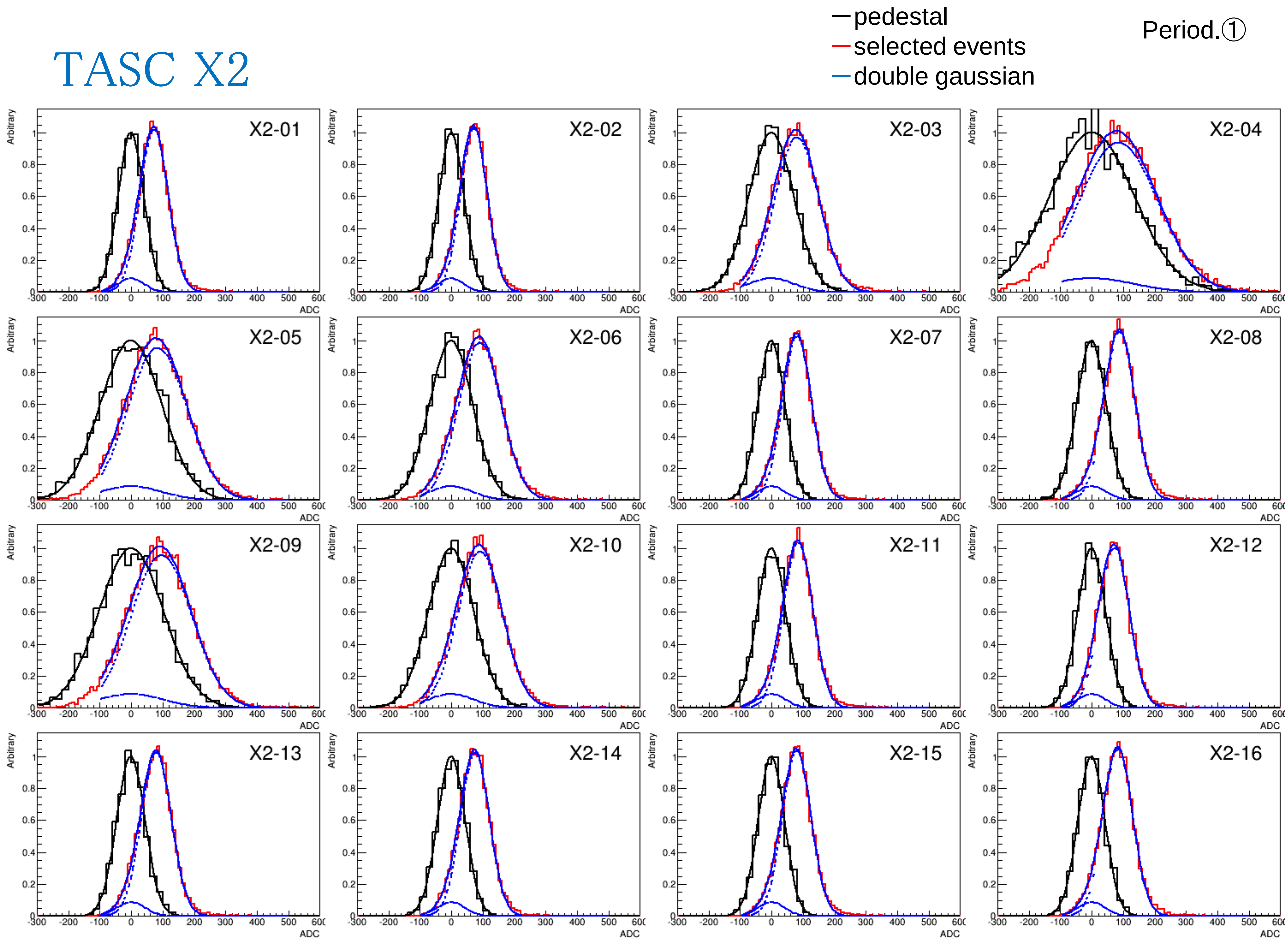
—pedestal
—selected events
—double gaussian

Period.①



TASC X2

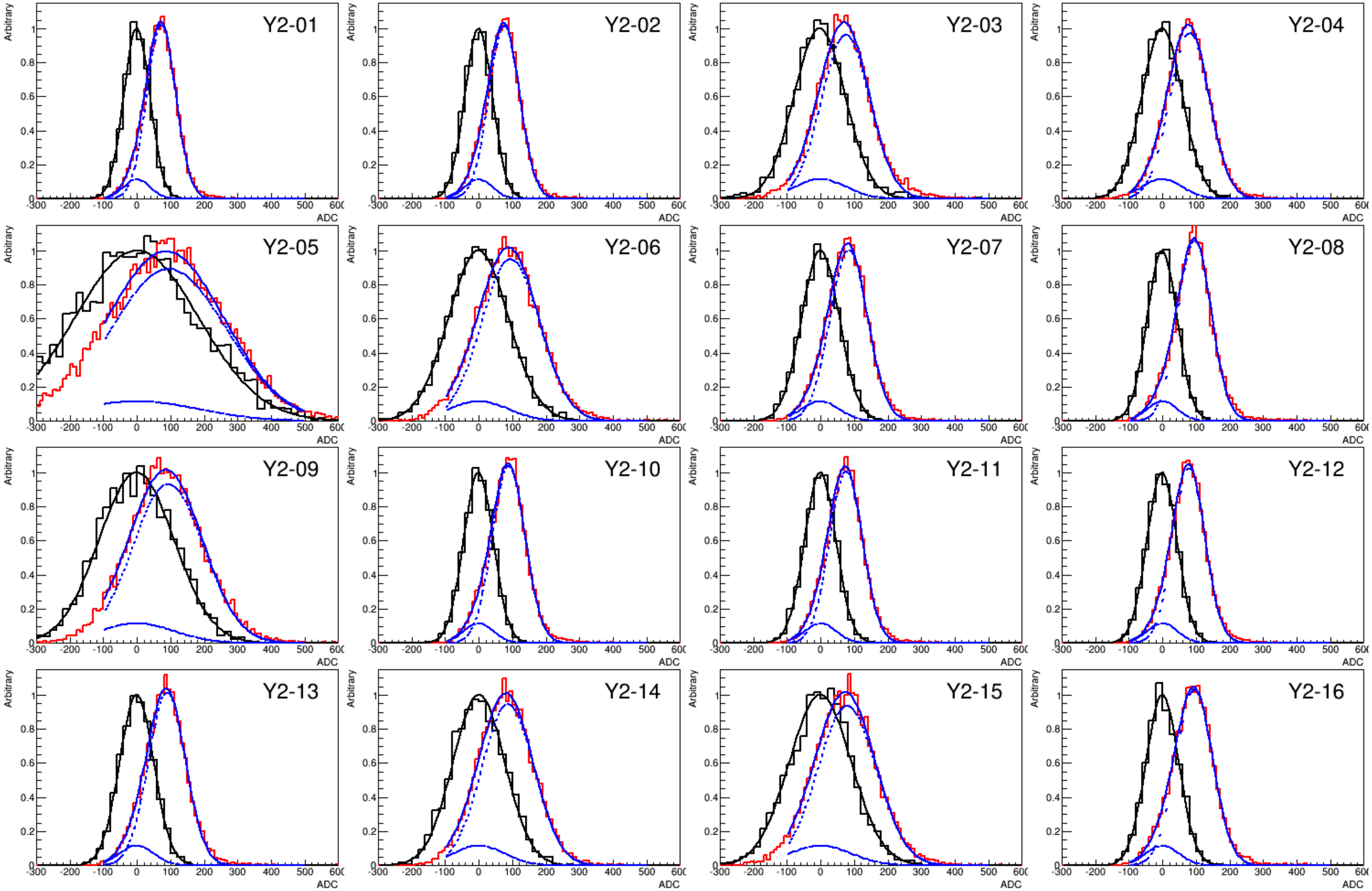
Period.①



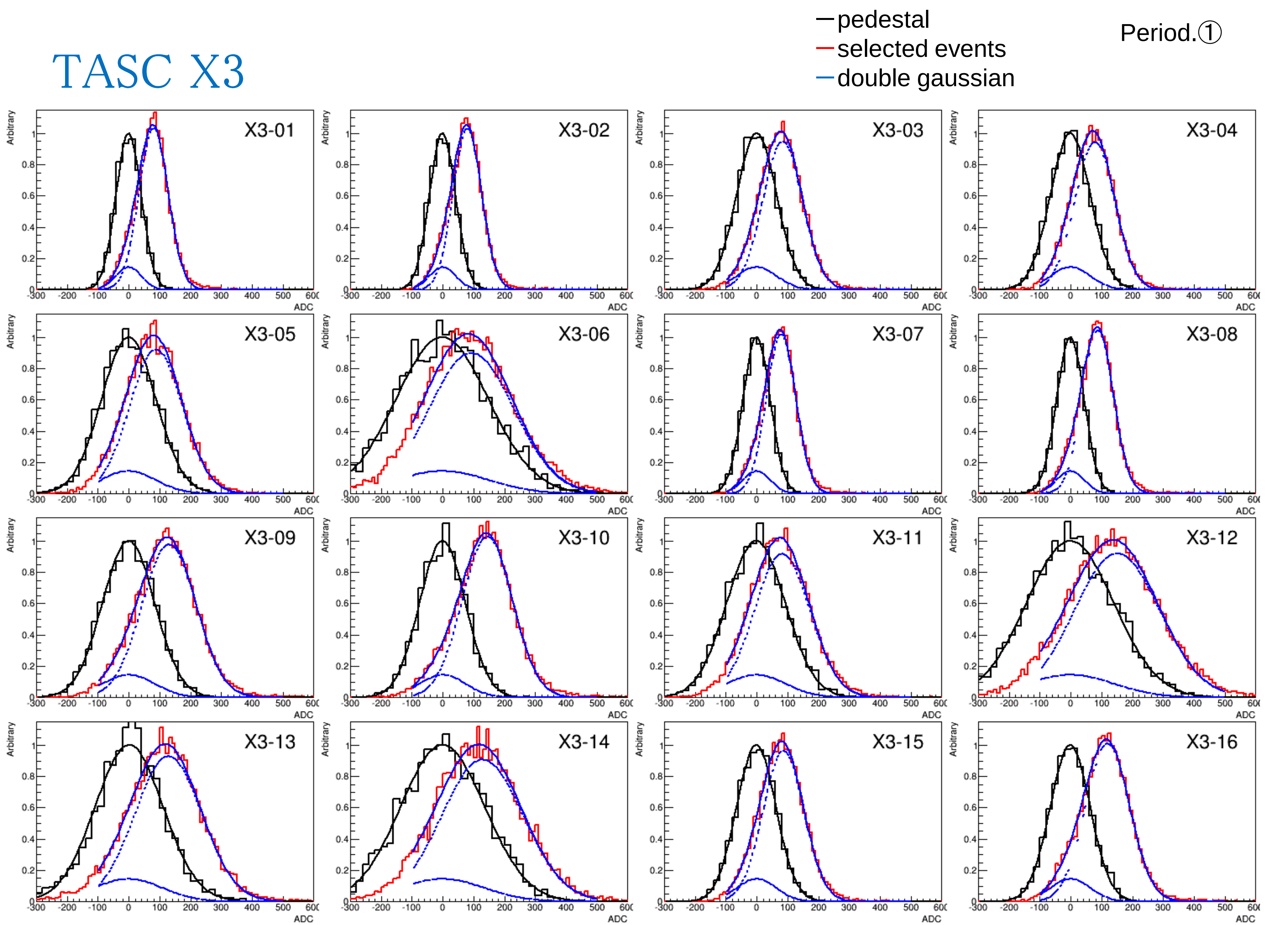
TASC Y2

—pedestal
—selected events
—double gaussian

Period.①



TASC X3

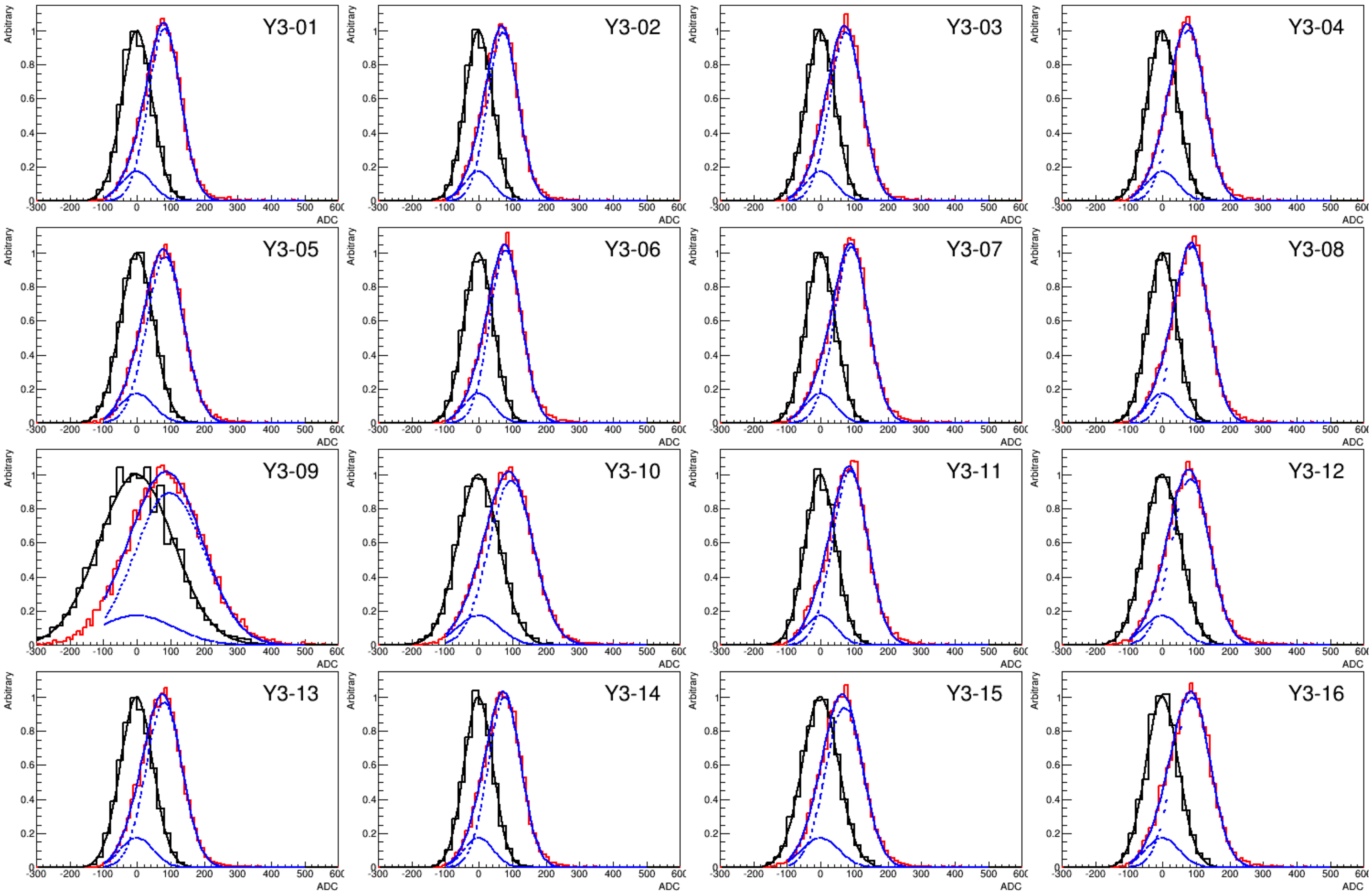


pedestal
selected events
double gaussian
Period.①
X3-01
X3-02
X3-03
X3-04
X3-05
X3-06
X3-07
X3-08
X3-09
X3-10
X3-11
X3-12
X3-13
X3-14
X3-15
X3-16
Arbitrary
ADC

TASC Y3

—pedestal
—selected events
—double gaussian

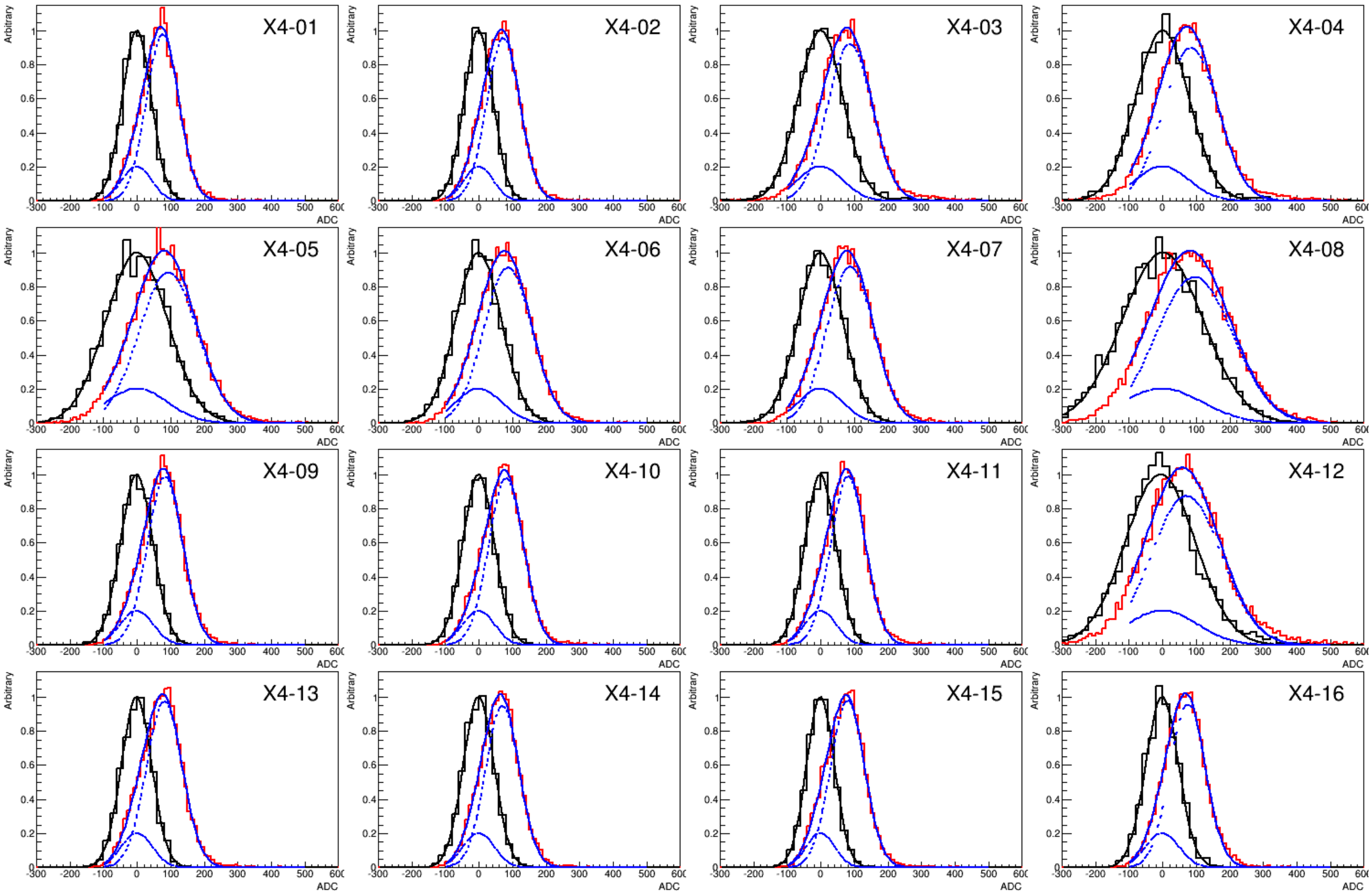
Period.①



TASC X4

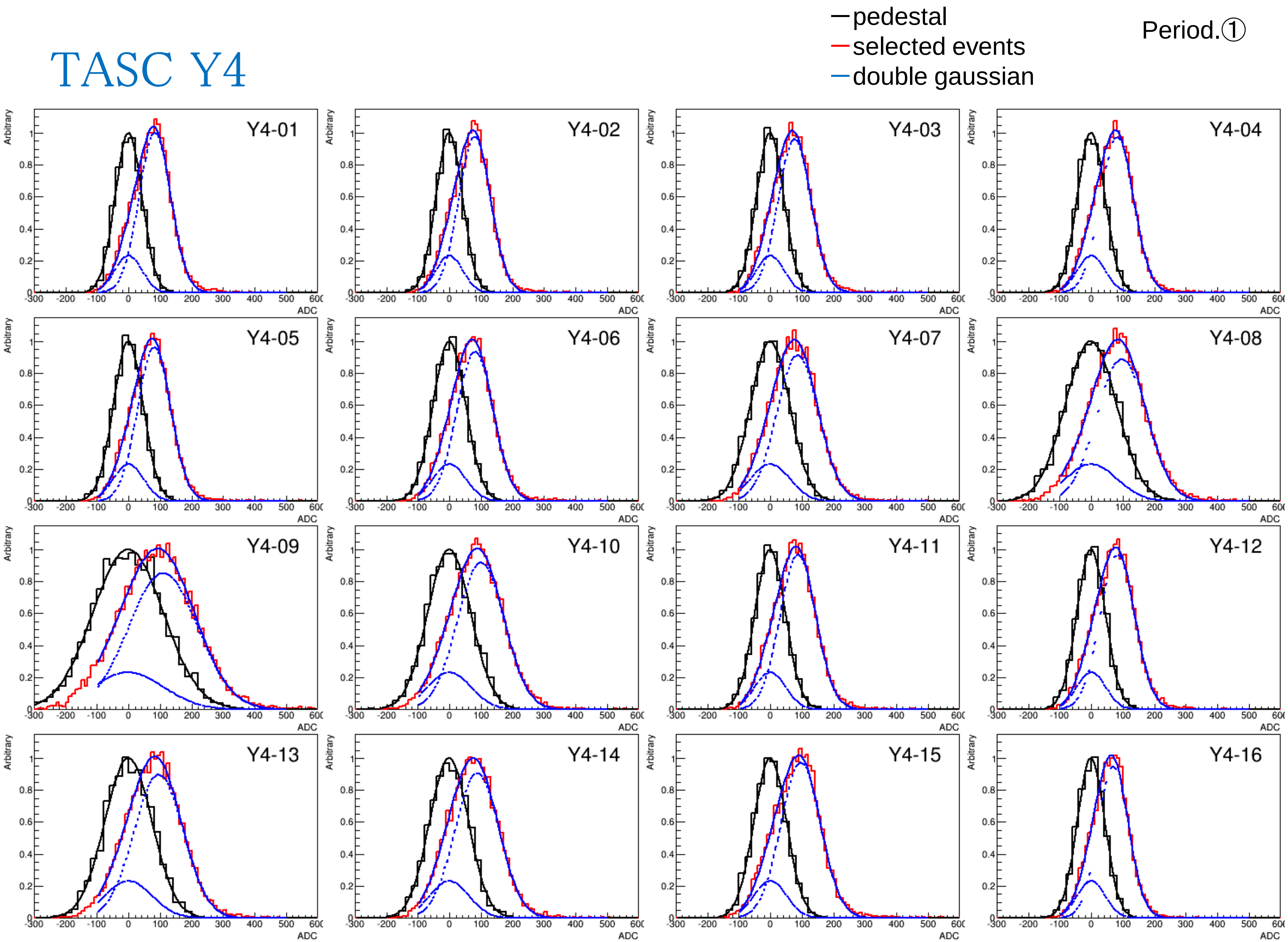
Period.①

—pedestal
—selected events
—double gaussian



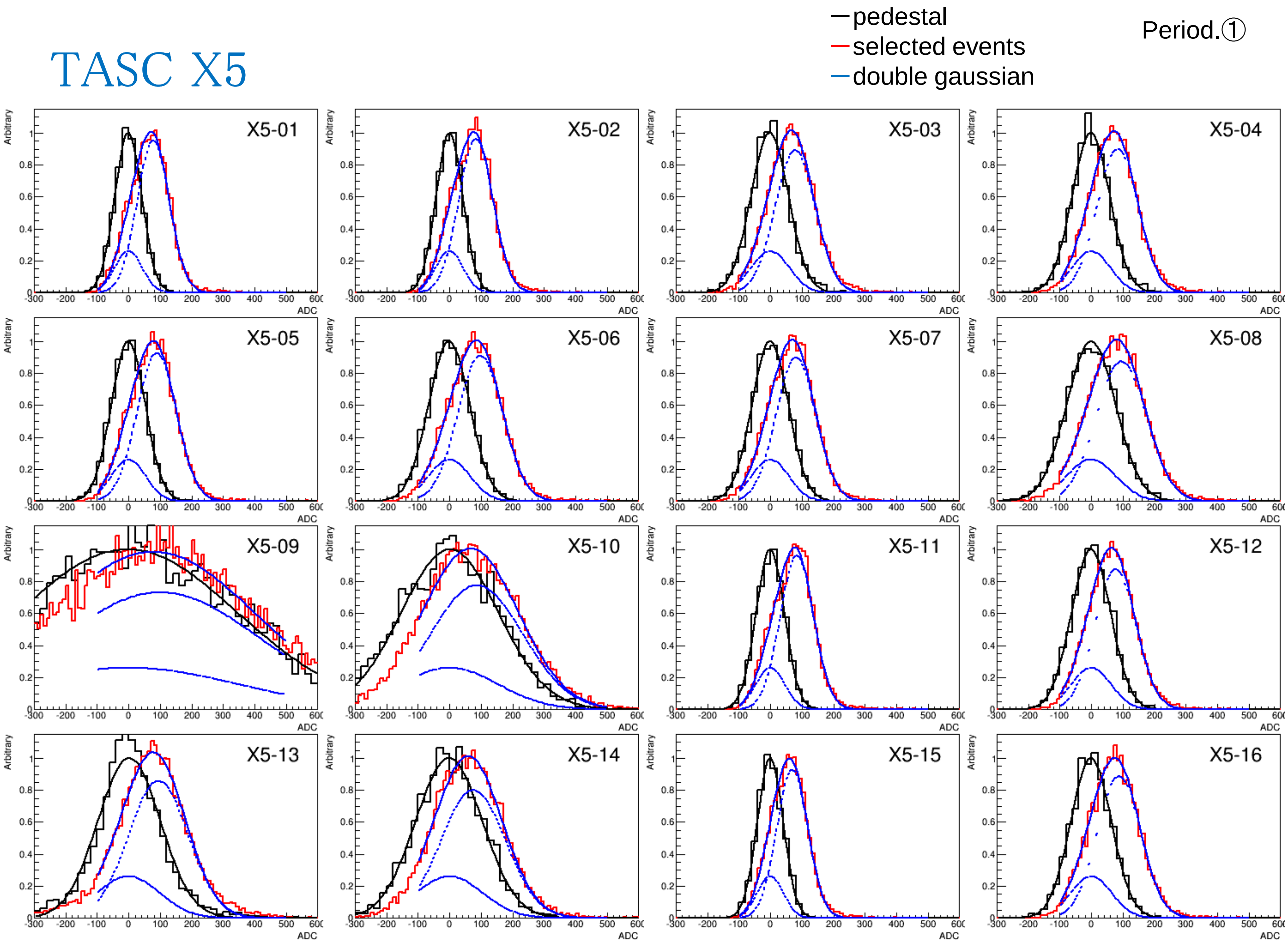
TASC Y4

Period.①

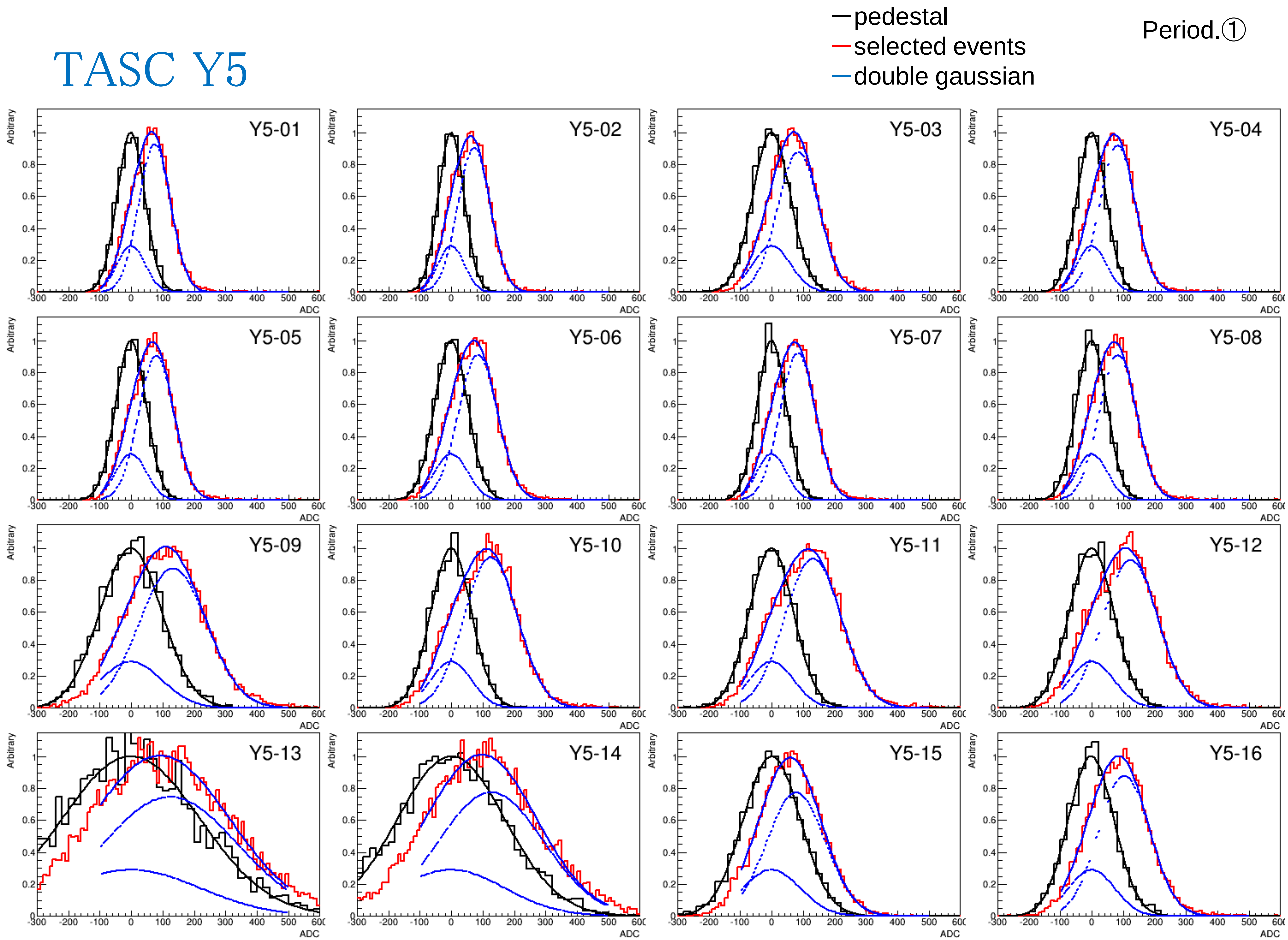


TASC X5

Period.①



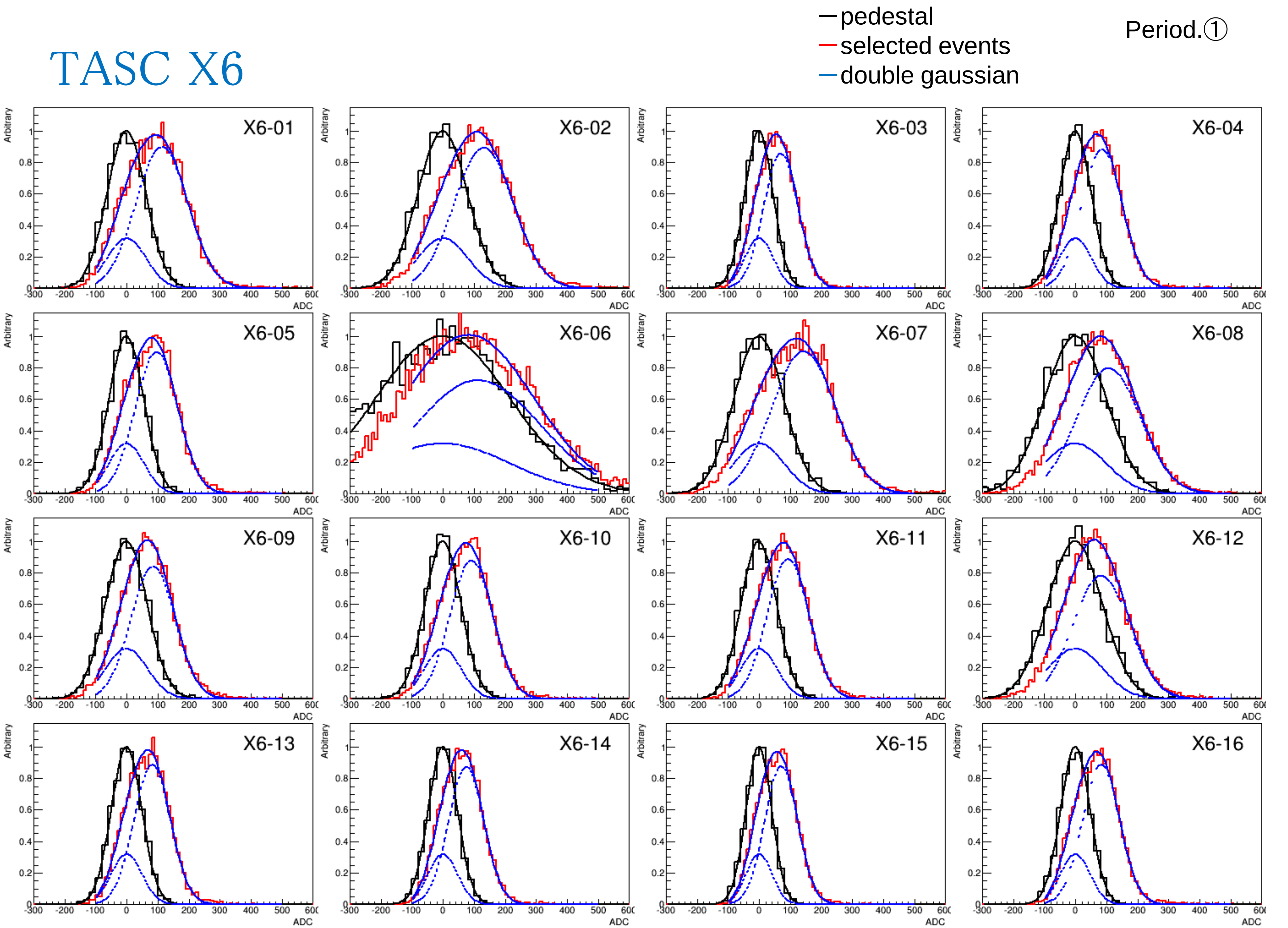
TASC Y5



pedestal
selected events
double gaussian
Period.①
Y5-01
Y5-02
Y5-03
Y5-04
Y5-05
Y5-06
Y5-07
Y5-08
Y5-09
Y5-10
Y5-11
Y5-12
Y5-13
Y5-14
Y5-15
Y5-16
Arbitrary
ADC

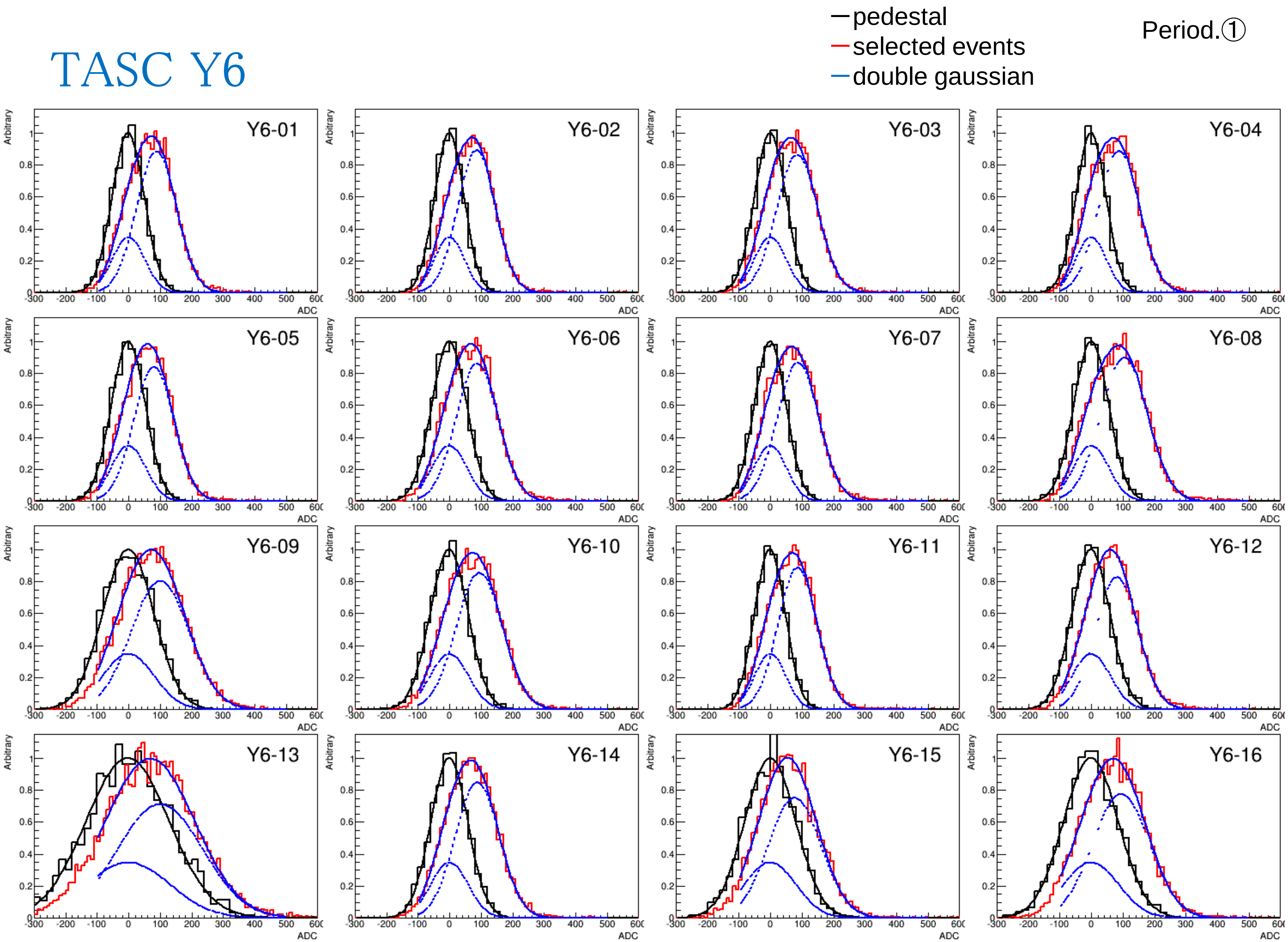
TASC X6

Period.①



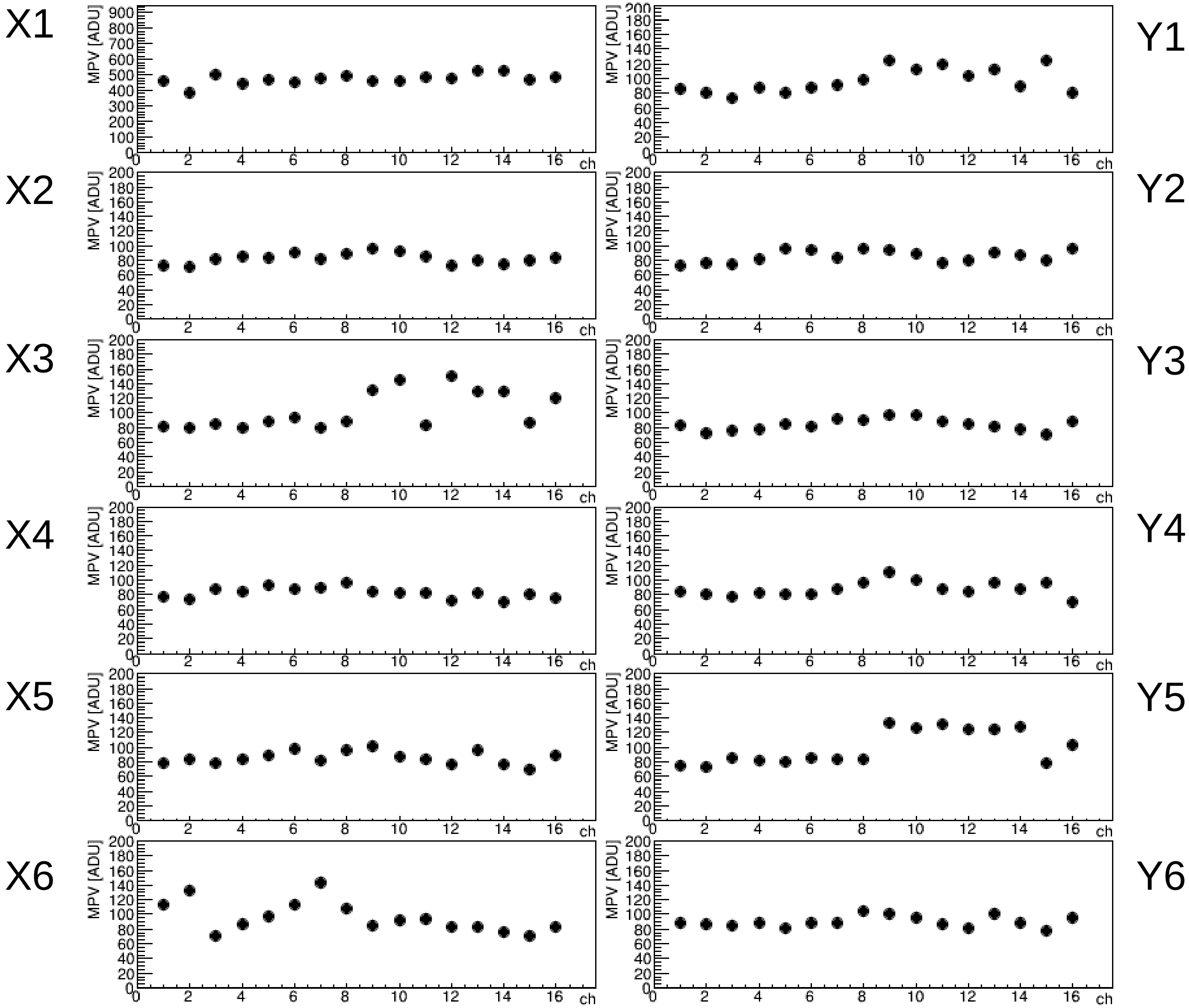
TASC Y6

Period.①



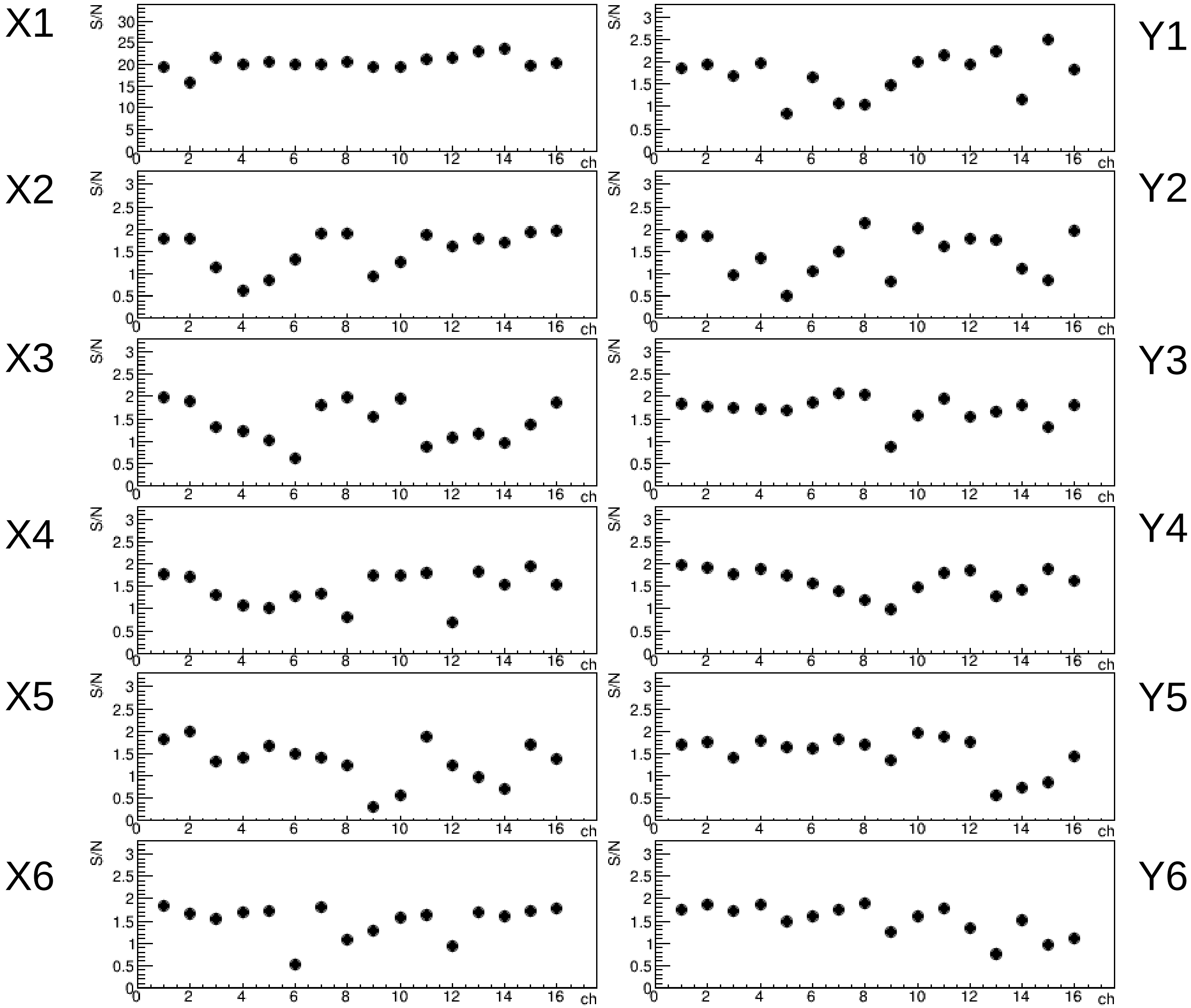
MPV of TASC

Period.①

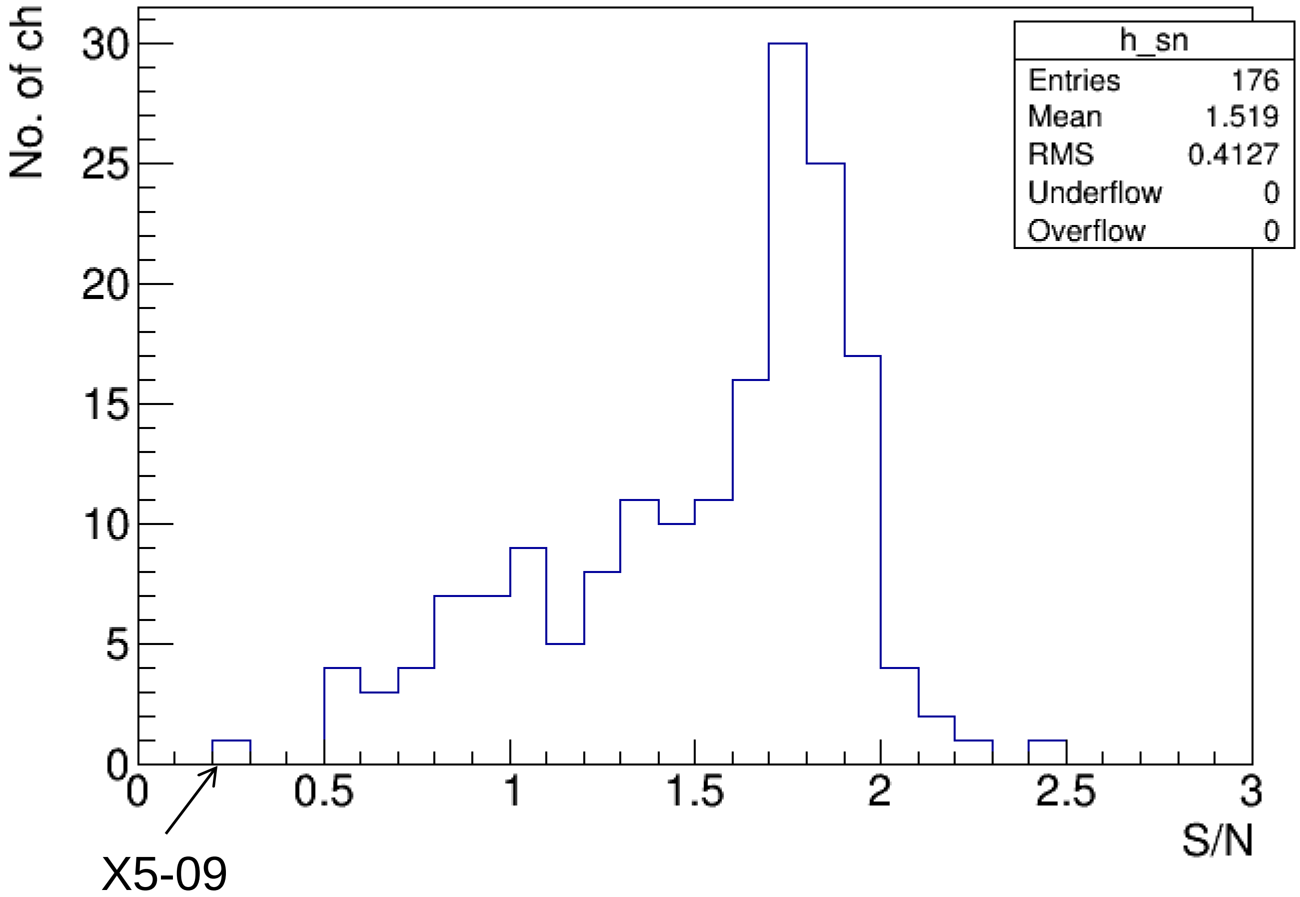


S/N of TASC

Period.①



S/N of TASC APD-high



Conclusion

- We took cosmic ray muon data
  - 2.7 x 10^6 events (~40hrs)
- We checked all channel signals
  - dead/small signal channel
    - IMC: X 4ch, Y 3ch
    - CHD: none
    - TASC: (S/N<0.5) 1ch
- We are going to do more detail analysis
  - position alignment
  - crosstalk
  - position dependence of light yield
  - etc.