Analysis of High Multiplicity Events on the TGC under Gamma Ray Flux

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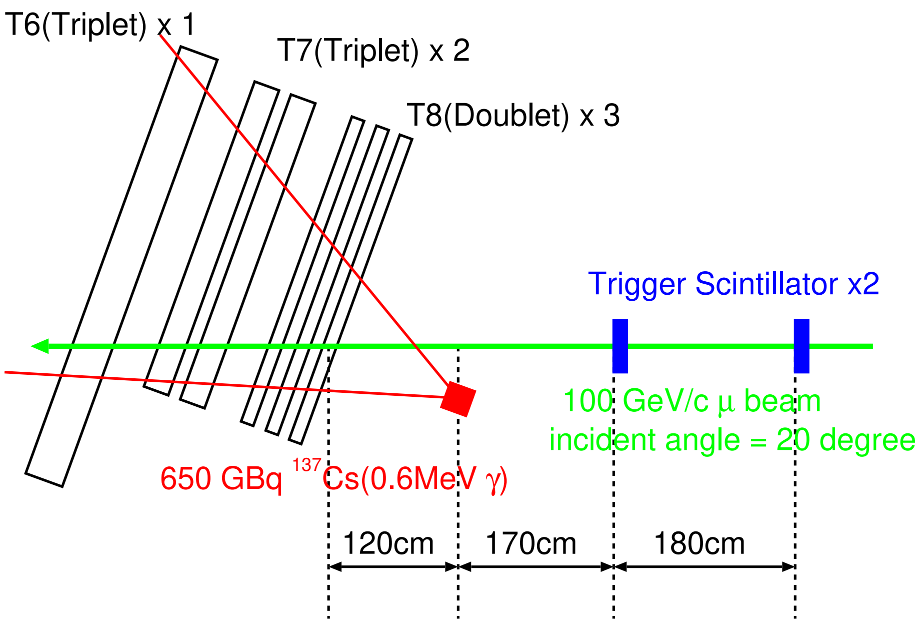
Contents

Beam Test @ X5 GIF

- 100 GeV/c μ beam
  - incident angle $= 20$ degree.
  - triggered by 2 forward scintillators
- under γ ray flux
  - $^{137}\mathrm{Cs}(0.6\mathrm{MeV}\gamma) \rightarrow$ relative intensity $1/1, 1/5, 1/20, 1/100, 0$
  - full irradiation=~ 10 times higher than that for the ATLAS condition.
- The hits of TGC in $\sim 3\mu$ sec range were recoreded.



- All the chambers were operated well under the gamma ray flux with enough efficiency for μ.
- Strangely high multiplicity of the strip hits were recorded

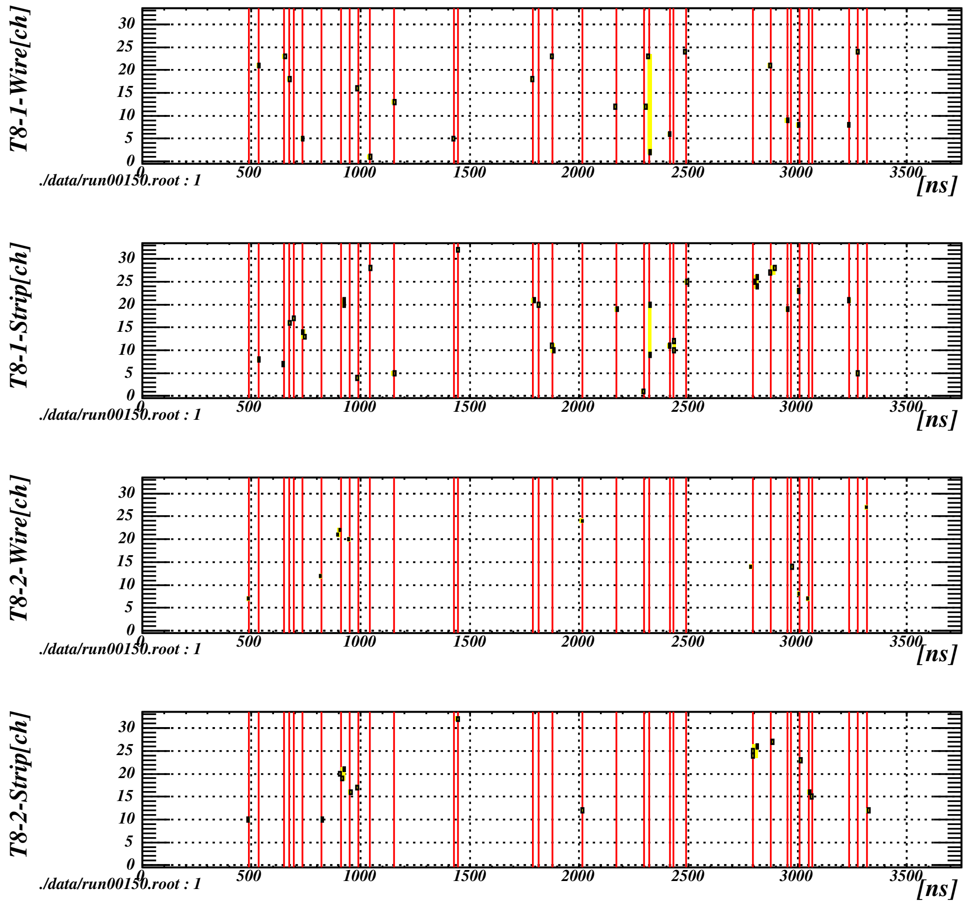
$\downarrow$

Analysis of such events is the main subject.

Clustering of the Raw Hits

The clustering of the raw hits in the doublet was done
to get associations between them.

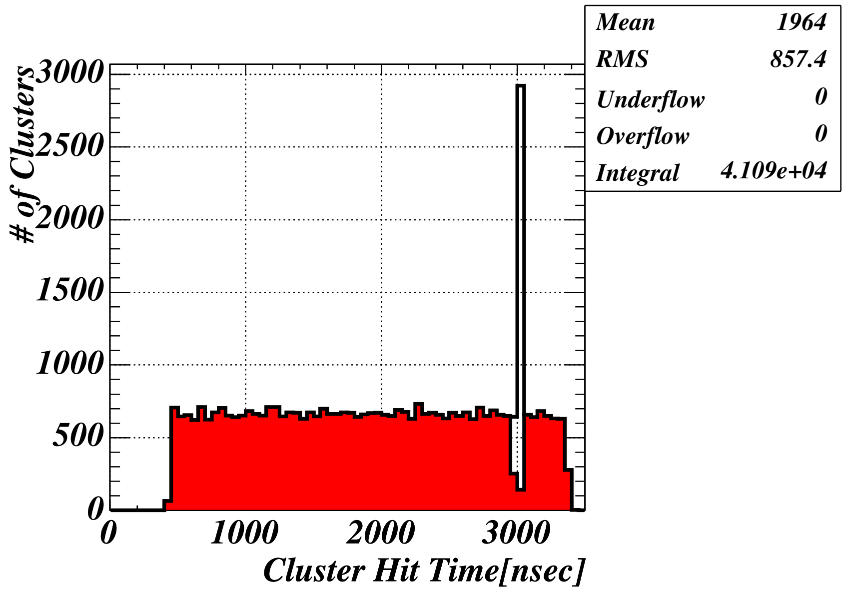
event display of raw hit channel v.s. raw hit time

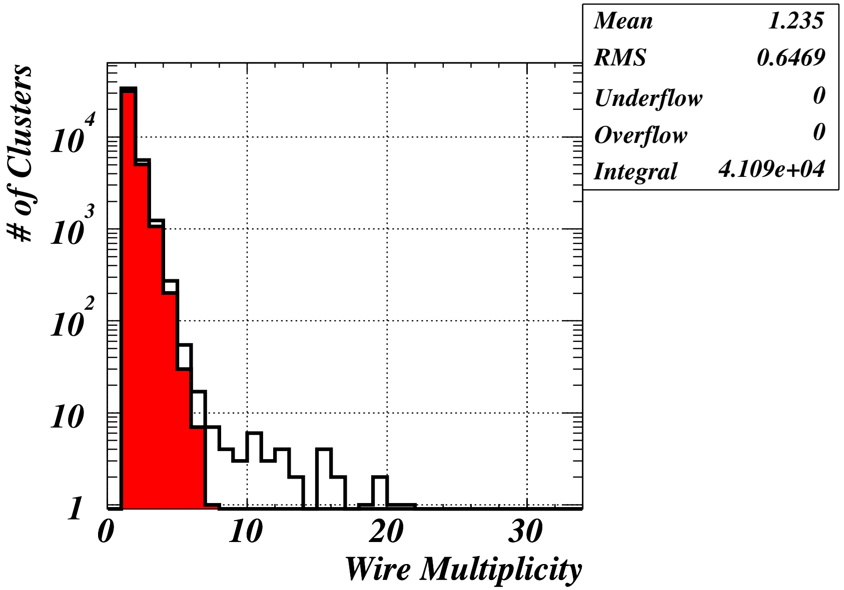


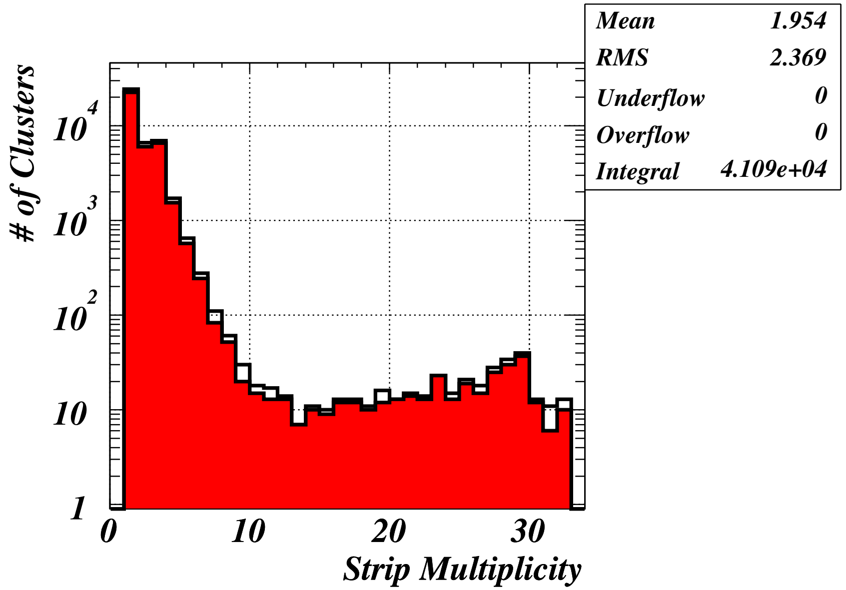
- Doublet(2 wire plains and 2 strip plains)
- Common clustering for 2 wire plains and 2 strip plains to get associations of raw hits in different plains.
- Hits within 15 ns are put into 1 cluster. (raw hits in other plains also clustered.)
- Cluster hit time is ...
  - fastest hit time in the plain in the cluster.
  - if no hit, use 9999 for the hit time.
- Vertical lines in the figure indicate the cluster. (mean time of the all raw hits in the cluster.)
- Yellow boxes also indicate the cluster.
  - t1: fastest hit time in the plain in the cluster
  - t2: last hit time in the plain in the cluster
  - x1: smallest channel in the plain in the cluster
  - x2: largest channel in the plain in the cluster

X5 Events∼timing&multiplicity∼

- HV$= 2.8$kV
  relative source intensity $= 1/5$
- Require coincidence of wire & strip cluster
- μ hits around 3000 nsec
  - 3000 ± 35nsec:μ region
  - other :γ region(red hist.)
- high strip multiplicity$\rightarrow$ main subject
- high wire multiplicity for $\mu \rightarrow$ next slide

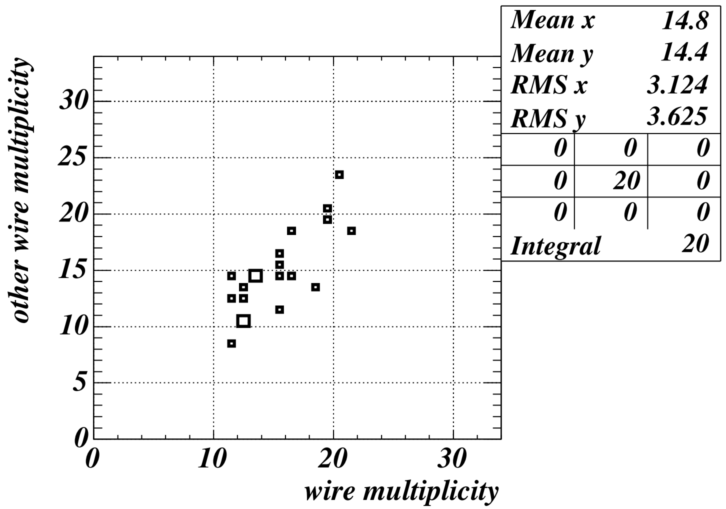


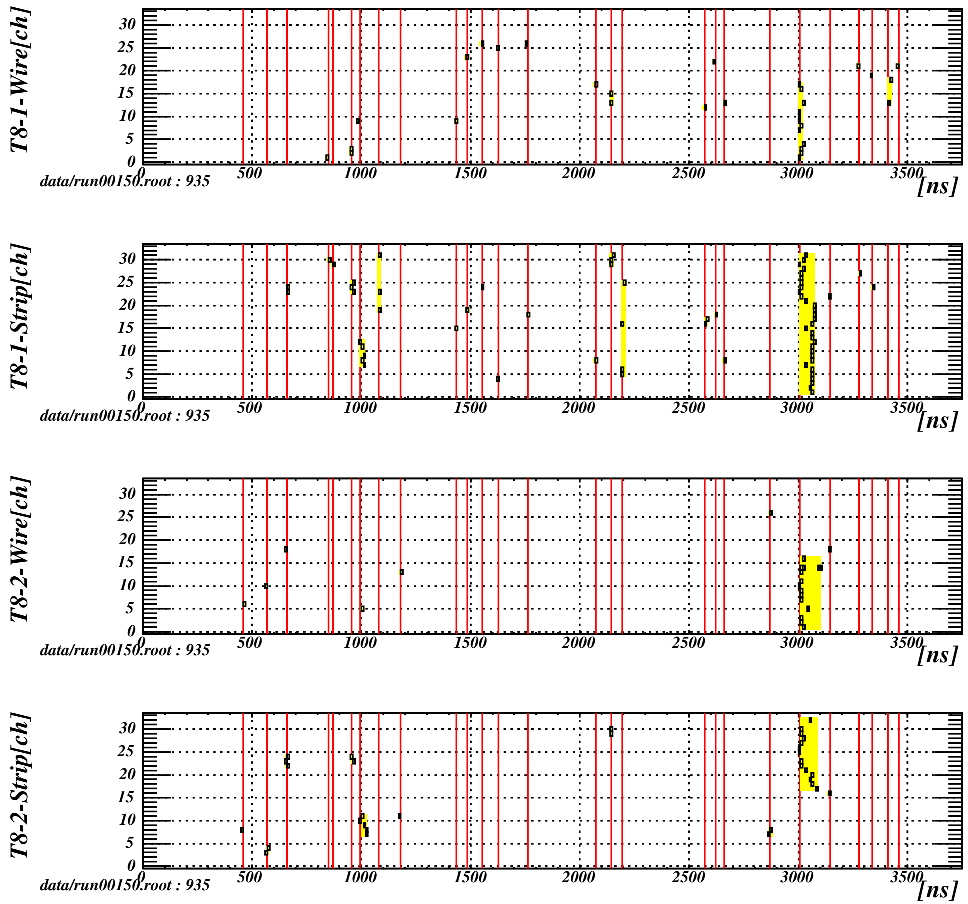




X5 Events~high wire multiplicity~

Almost all the clusters with wire multiplicity > 10 are in the μ region. Such clusters are analyzed here.

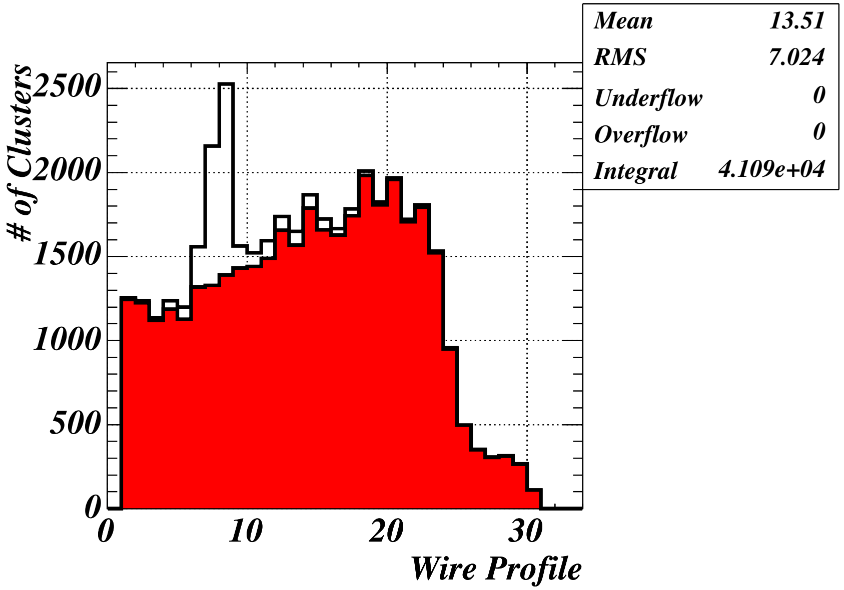


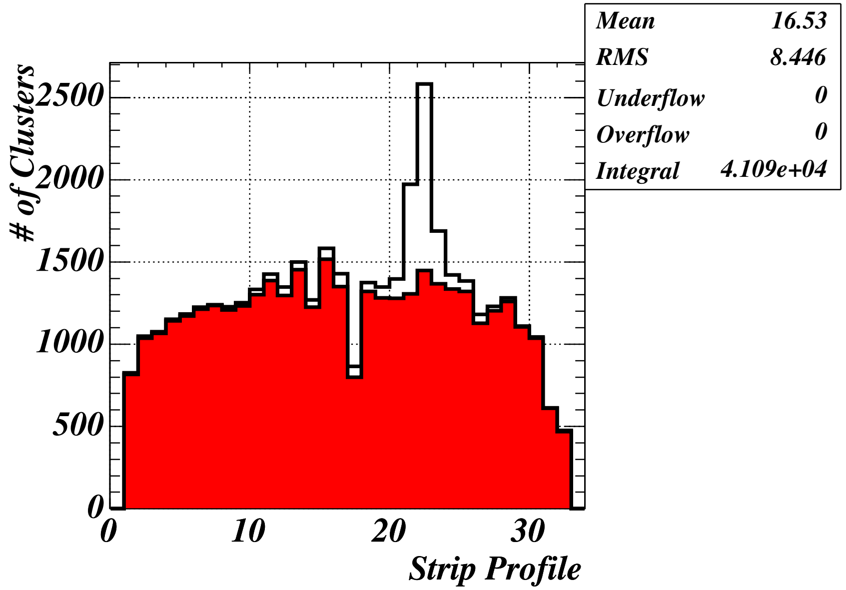


- Good correlation of wire and other wire (i.e. on the other side of the doublet) multiplicity
- There are coincident hits on all the plains for the doublet.
- Hit channels of both wrie plains looks correlated. (by just viewing the event display)

It seems that they are real hits originating from the beam.
(Delayed strip hits may be produced by leading hits.)

X5 Events∼profile∼

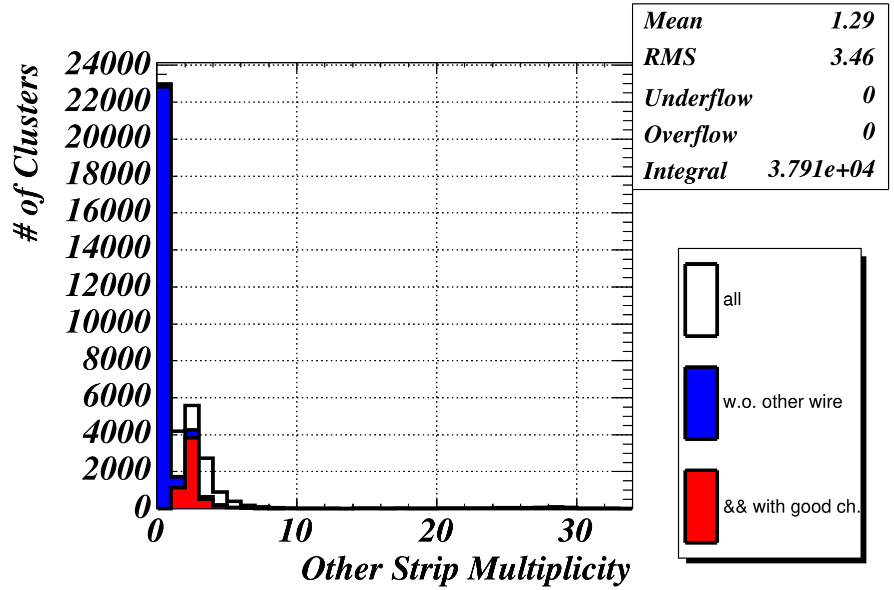




- The μ profile is clearly seen.
- The γ profile was not uniform.

  (,which depended on the positions of the TGC, source and its shield.)
- The gap at 17th channel of the strip$\rightarrow$?

X5 Events∼the other side of the doublet∼



- Only γ region was analyzed. (almost all of the μ region should have both wire and strip hits).
- The wire and strip coincidence on one side (side A) is required.$\rightarrow$ open hist.
- Without wire hits on the other side(side B)$\rightarrow$ blue hist.
- && with strip hits whose channels correspond to the channels for the side A.$\rightarrow$ red hist.
  $\rightarrow$ which will be called as 'doublet hit'.
  $\rightarrow$ probably cross talk.
- strip doublet hit ratio $=$
  # of clusters@red hist/ # of clusters@blue hist $= 19\%$

Summary for the X5 Events

- The wire multiplicity : main is 1, mean is ~ 1.
- The strip multiplicity : main is 1, mean is ~ 2.
- High wire multiplicity events for μ.
  $\rightarrow$ It seems they are real hits by the beam.
- High strip multiplicity for both μ and γ.
  $\rightarrow$ To be discussed in the following slides.
- Continuous profile for γ.
  (except for the 17th channel of the strip for the TGC analyzed.)
- The doublet hit ratio for the 0.6 MeV γ is ~ 20%.
  (HV$= 2.8$kV,Strip V$_{\rm th} = 60$mV)
  $\rightarrow$ probably strip cross talk ratio to the other side of the doublet.

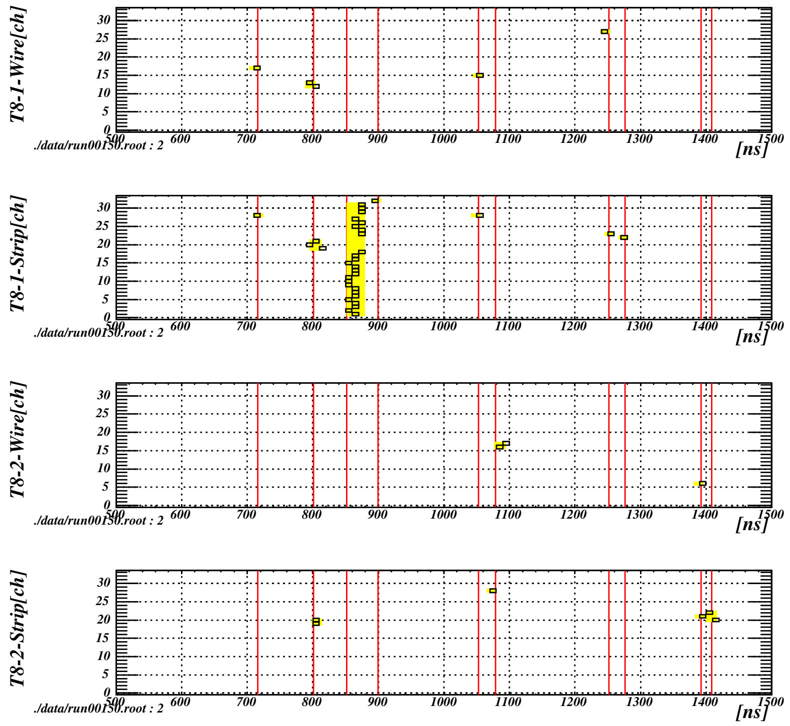
High Strip Multiplicity Events

Characteristics of the high strip multiplicity events

- Leading Hits
  - -. wire & strip hits
  - -. strip multiplcity ~ 3
- Delay
  - -. $50 \sim 100[\mathrm{ns}]$
- Multiple Strip Hits
  - -. almost all but leading strips
- Cross talk to the strips on the other side of the doublet
  - -. corresponding strip channel

example) Run00150, source$1/5$

HV=2.8kV,Vth(wire)=-50mV,Vth(strip)=$+60$mV



More Exampls

example) Run00150, source$1/5$

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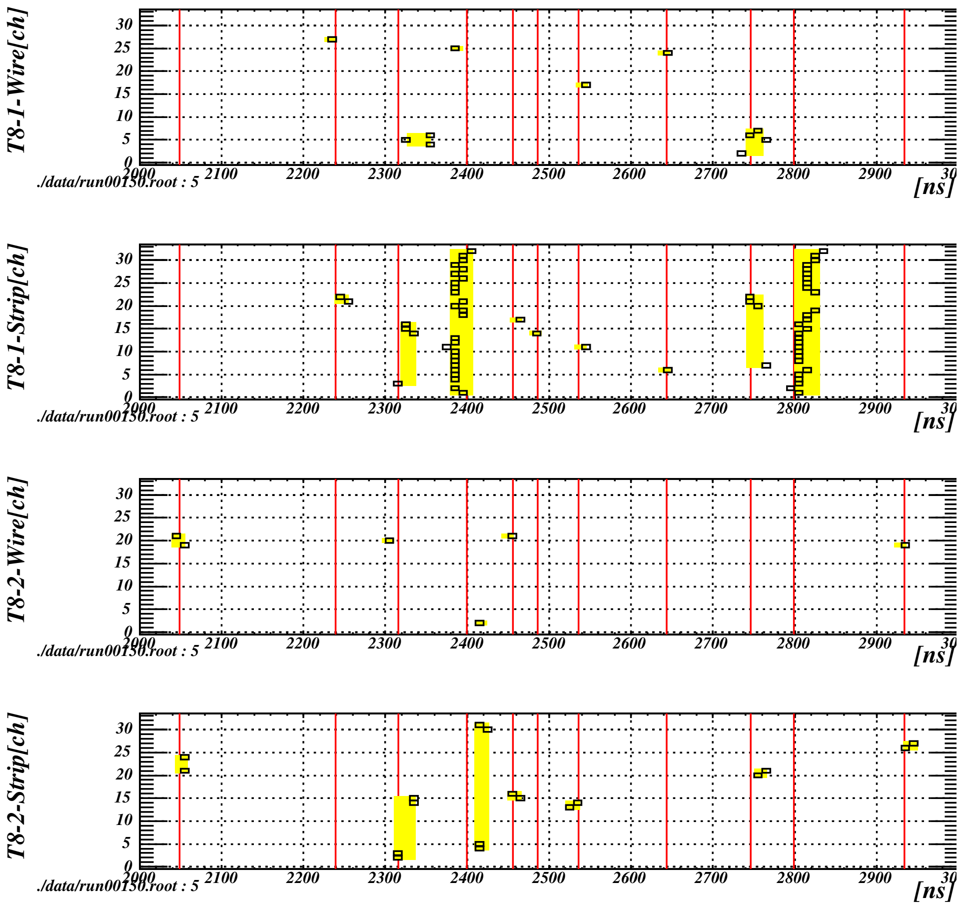

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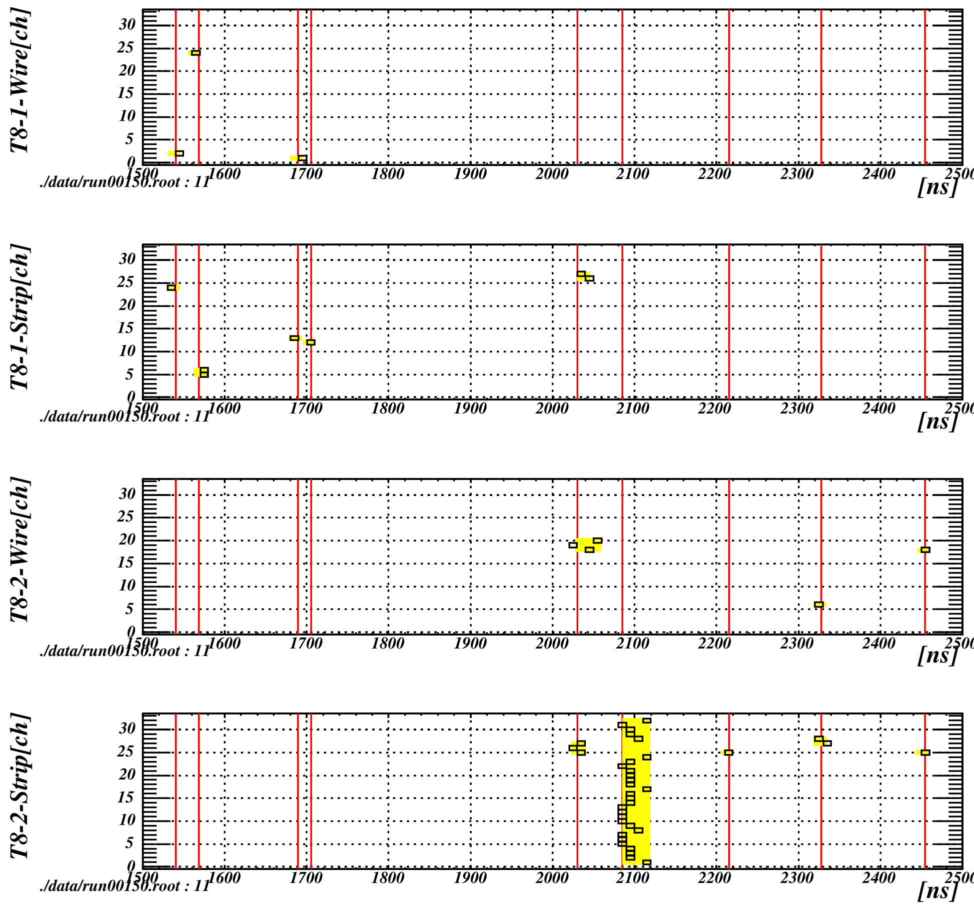
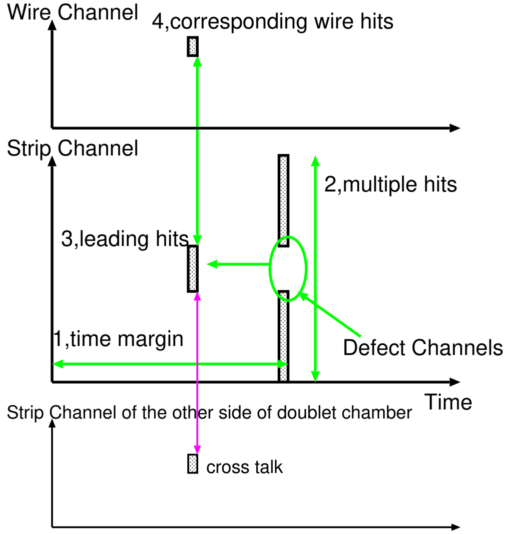


Multiple Hits Selection

1. Hits are late enough (keep time margin for leading hits.)
2. Multiplicity (# of hit channels in a cluster) ≥ 24
3. With leading strip hits
   corresponding to the defect channels of the multiple hits
   (A leading strip hit is found within 225 nsec from the multiple hits and
   the channel is one of the defect channels of the multiple hits.)
   If not found, the cluster was divided into two (faster and latter parts) to check if the leading hits were merged into the cluster for the multiple hits.



4. With leading wire hits corresponding to the leading strip hits
   (The leading wire hits are found within 30 nsec from the leading strip hits.)

The numbers of clusters remained by the cuts are showen. The multi.hit.ratio = # of clusters@cut3&cut4/# of clusters @cut1.

HV[kV]	2.8		2.7	
γ intensity	$1/5$	$1/20$	$1/5$	$1/20$
no cut	$59,940$	$37,089$	$45,636$	$31,889$
cut 1	$58,007$	$36,076$	$44,252$	$31,022$
cut 2	$1,524$	$1,014$	271	222
cut 3&4	$1,499$	983	269	218
multi.hit.ratio[%]	2.5	2.7	0.61	0.70

Doublet hit

1. Multiple hits selection on the side A of the doublet
2. Without wire hits on the side B
   corresponding to the leading wire hits on the side A.
3. With strip hits on the side B
4. Ths strip hit channels on the side B correspond to the leading strip channels on the side A.

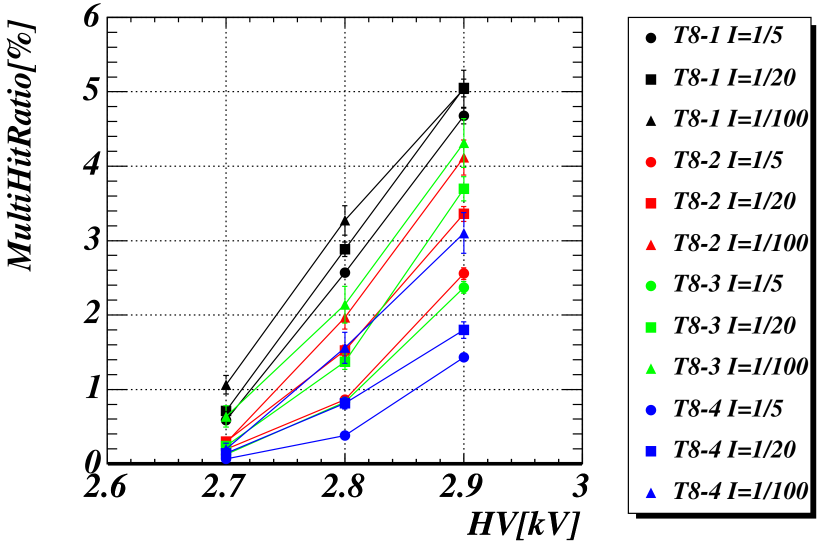
Then such cluster is called as doublet hit.
$\rightarrow$ Such strip hits are probably cross talks from the strip hits on the other side of the doublet.

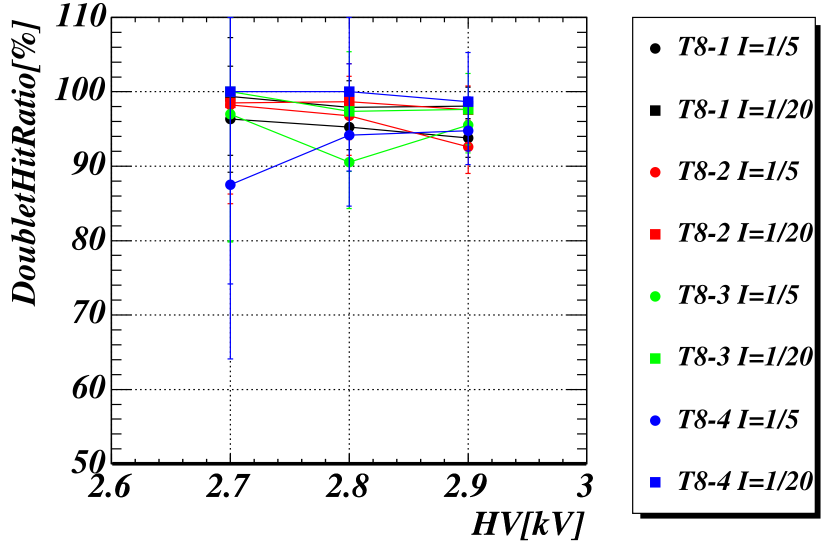
HV[kV]	2.8		2.7	
γ intensity	$1/5$	$1/20$	$1/5$	$1/20$
multiple.hit(cut 1)	$1,499$	983	269	218
cut2	$1,054$	783	200	165
cut3	$1,015$	772	191	163
doublet hit(cut4)	$1,000$	762	189	163
doublet.hit.ratio[%]	95	97	95	99

The numbers of clusters remained by the cuts are showen.
The doublet.hit.ratio = # of clusters@cut4/# of clusters @cut2.

Multiple Hit Ratio

The multiple strip hit ratio and strip doublet hit ratio for the γ region



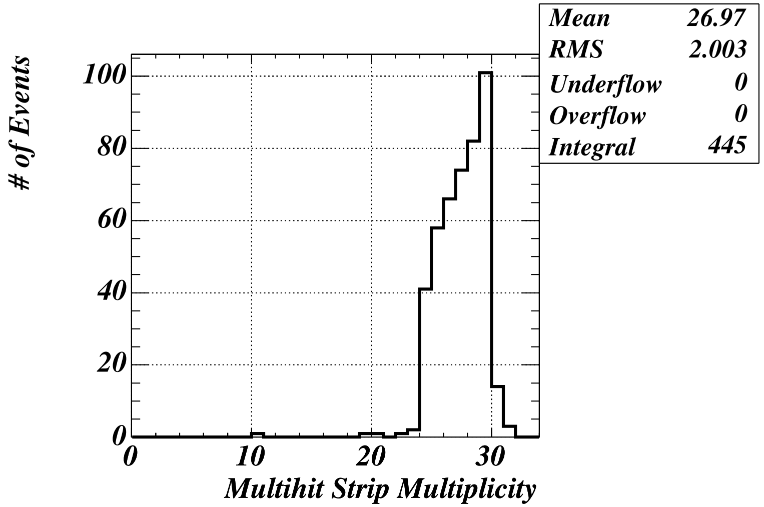


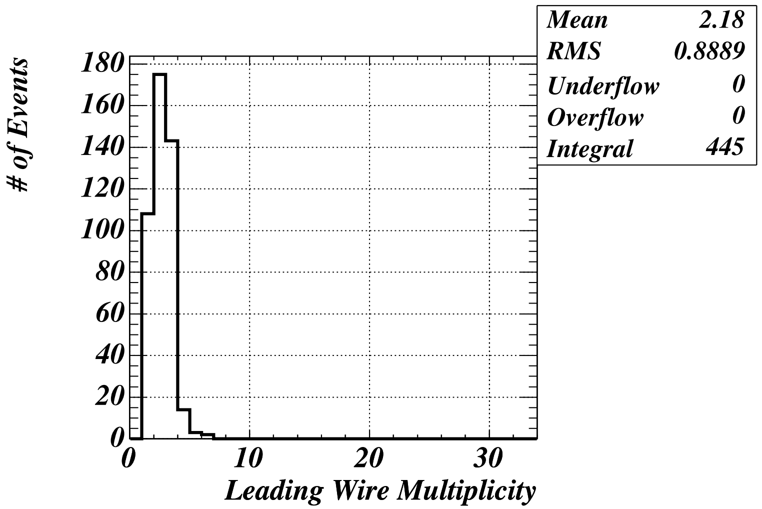
- HV dependecne of the multiple hit ratio. $\rightarrow$ it depends on the amount of the output charge.
- Chamber individuality of the multiple hit ratio.
- Lower multiple hit ratio for higher γ flux $\rightarrow$ due to HV drop?
- ~ 100 % strip cross talk ratio for the leading hit. (no apparent HV dependece.)
  $\rightarrow$ all the leading hits with multiple strip hits are big enough to generate cross talks?
- Multiple strip hit ratio for μ region at source intensity $= 0$ is ~ 0.5%.
  (less HV dependence.)

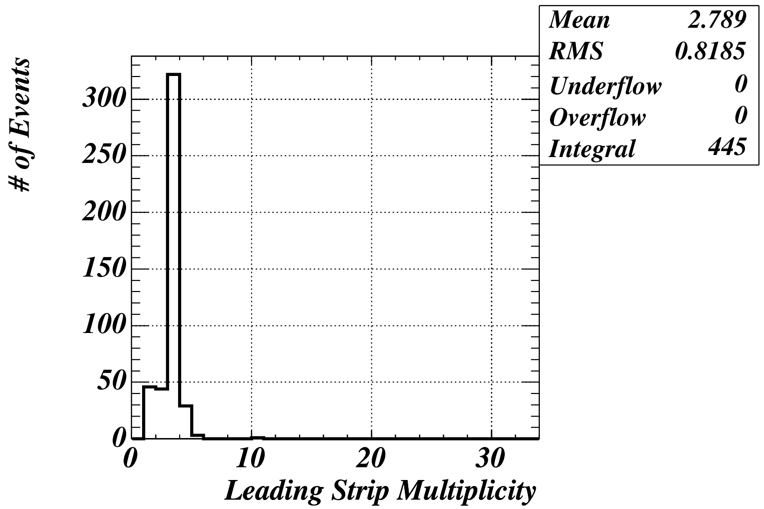
Multiplicity∼Multiple & Leading hit∼

Strip Multiple hits

- Multiplicity of multihit strip
  - $\geq 24 \cdots$ original cut
  - $< 24 \cdots$ produced when one cluster was divided into two.
- Multiplicity of leading wire ~ 2, $>$ typical γ hit
- Multiplicity of leading strip ~ 3, $>$ typical γ hit



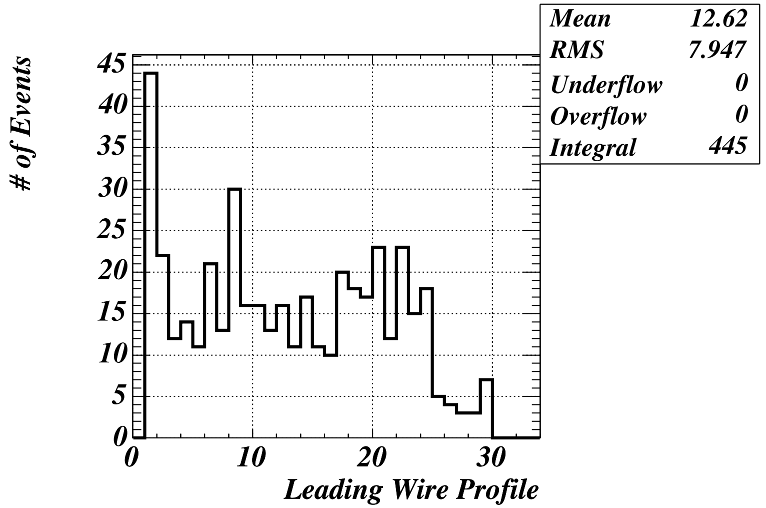


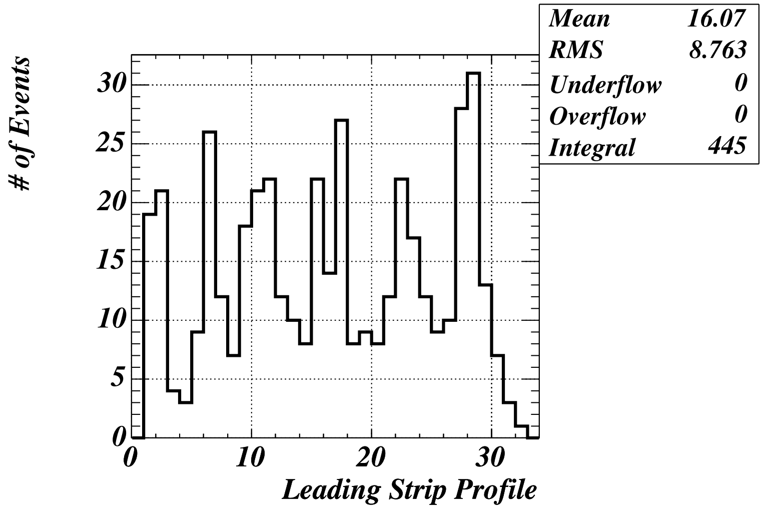


Profile of the leading hit

Leading Hit

- The leading hits on the wires are more likely to occur at the edge wire groups.
  $\rightarrow$ due to higher electric field at edge wires?
- There are 5 gaps in the leading strip profile.
  $\rightarrow$ correspond to the wire supports?
  $\rightarrow$ higher electric field between the wire supports?

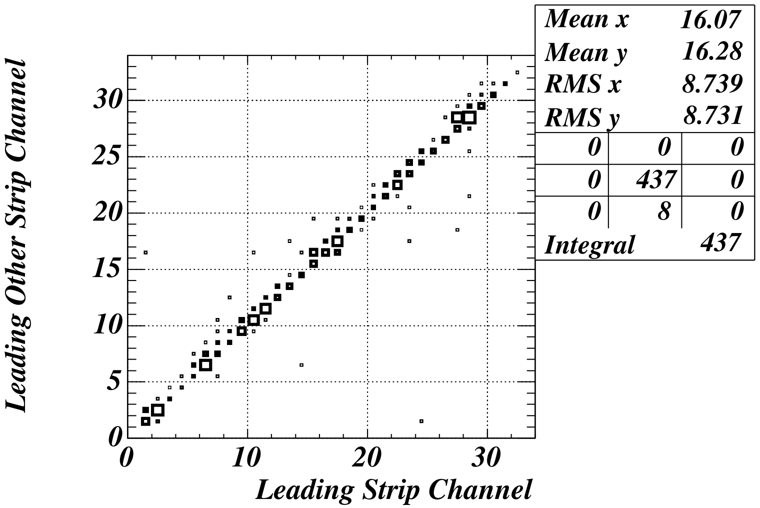


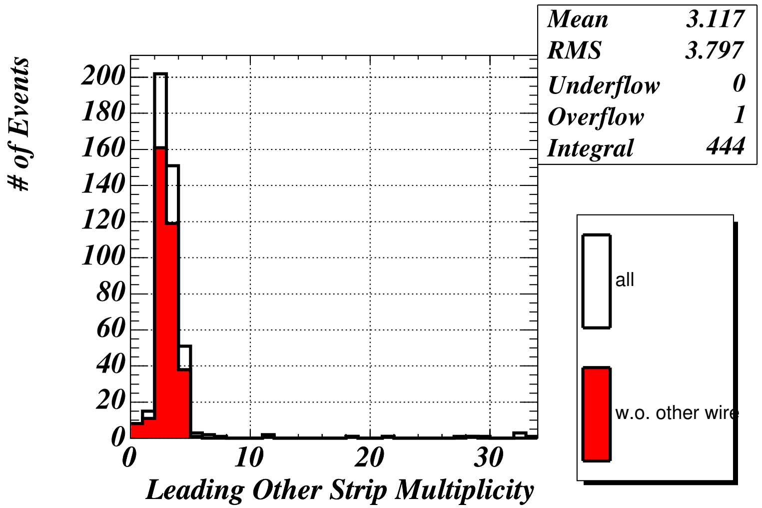


Doublet Hit

On the other side of the doublet

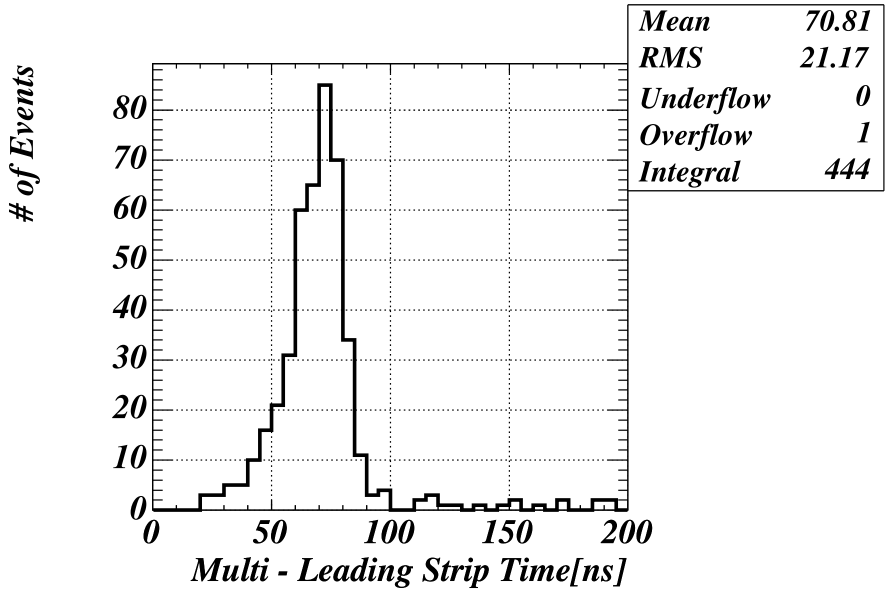
- Strip hit channels of the other side of the chamber almost correspond to the original strip hit channels.
- The clusters with strip hits without corresponding wire hits (red hist) are very likely to the cross talks.
- The strip multiplicity of such clusters indicates cross talk ratio is almost 100 %.





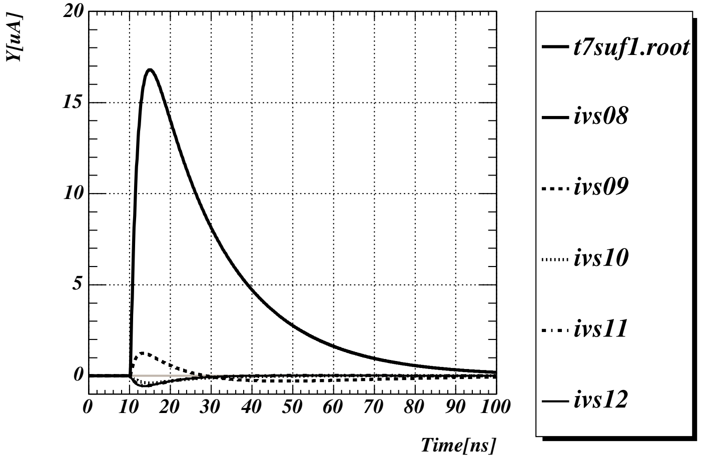
Delay

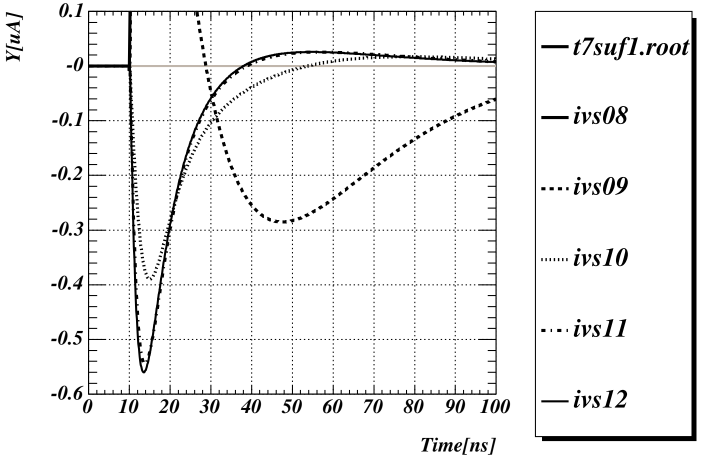
- There is some duration between leading hits and multiple strip hits.
- The delay of the multiple strip hits from the leading hits is $25 \sim 100$ ns.
- What mechanism does make it possible?
  $\rightarrow$ simulation of the pulse shape at the next page.



Simulation of the Pulse Shape

- HV$=2.8$kV@960hPa=2.95kV@1013hPa $\rightarrow\sim 0.5$pC gas amplified charge for MIPs (most probable).
- Energy deposite (most probable) in the TGC for 0.6MeV γ is ~ 2 times larger than that for MIPs.
  (according to Geant4 simulation.)
- The figures below are the simulated pulse shapes of the strips for 1 pC charge produced by the gas amplification in T7.
  (The right one is the enlarged figure of the left one.)
  $\leftarrow$ This simultaion accounted for many capacitances and resistors of the TGC but not verified yet.
- *ivs08* corresponds to the strips@avalanche, *ivs09* corresponds to the neighboring strip,
  ivs10, ivs11, ... correspond to more outer strips.
- All strips have capacitive couplings to the wire groups.
  -. The charge flows into the wire group@avalanche from all the strips.
  -. The charge flows into the neighboring strips from the strip@avalanche.
- V$_{\rm th}$ level is estimated around 1.5μA (equivalent to 60mV). $\rightarrow$ Is this right?
  $\rightarrow$ An output pulse for ~ 50 pC charge would make multiple strip hits with ~ 50 ns delay.
  The pulse first falls and rises then overshoots and crosses the threshold.





Summary

- The multiple hits of the strip were found in every chambers examined.
  (4 of T8 strip plains and 4 of T7 strip plains)
- HV dependence of the strip multiple hit ratio($0 \sim 5$%).
  $\rightarrow$ It dependes on the gas amplification.
- Lower multiple hit ratio for higher γ flux.
  $\rightarrow$ due to HV drop?
- Higher multiplicity of the leading hits (wire and strip).
  $\rightarrow$ Higher output charge of leading hits makes mutliple strip hits.
- The leading wire hits are more likely to occur at the edge.
  $\rightarrow$ due to higher electric field at the edge wires?
- Profile of the leading strip hits shows 5 gaps
  $\rightarrow$indicating wire supports? $\rightarrow$higher electric field among the wire suppports for that TGC?
- ~ 100 % strip cross talk ratio for the leading hit (no apprent HV dependecne).
  $\rightarrow$ Almost all the leading hits are big enough to create such cross talks
- $25 \sim 100$ ns delay of the multiple strip hits from the leading hits.
- A pulse for ~ 50 pC gas amplification charge would make multiple strip hits with ~ 50 ns delay.
  $\rightarrow$ It shows some possibility that a big pulse would make such multiple hits,

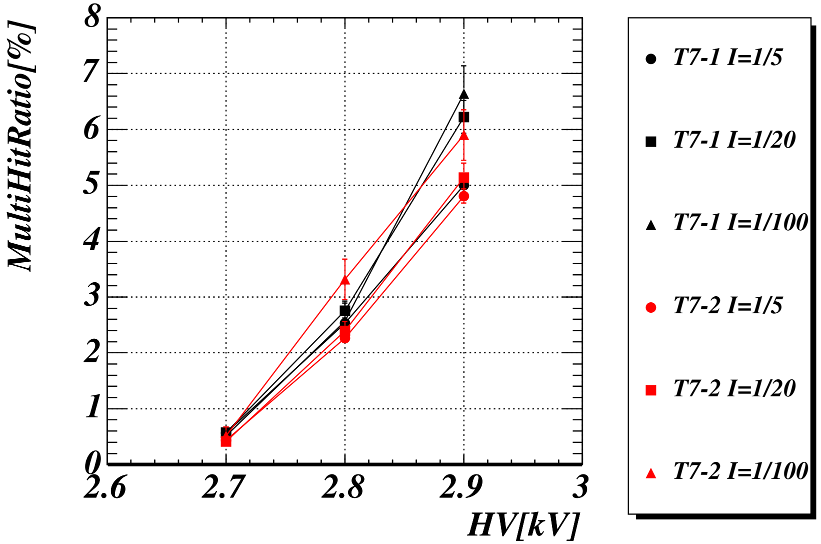
  although this simulation is not valid yet.

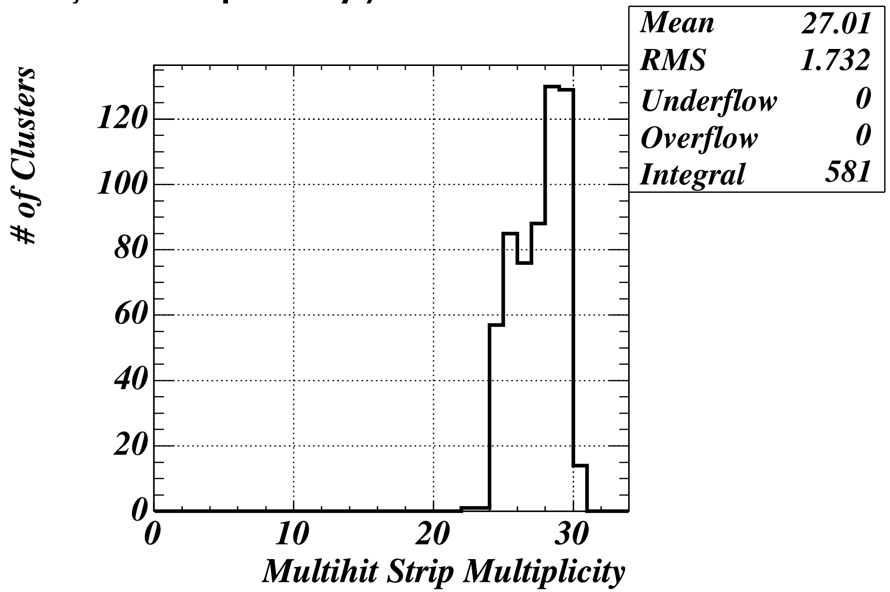
Discussion

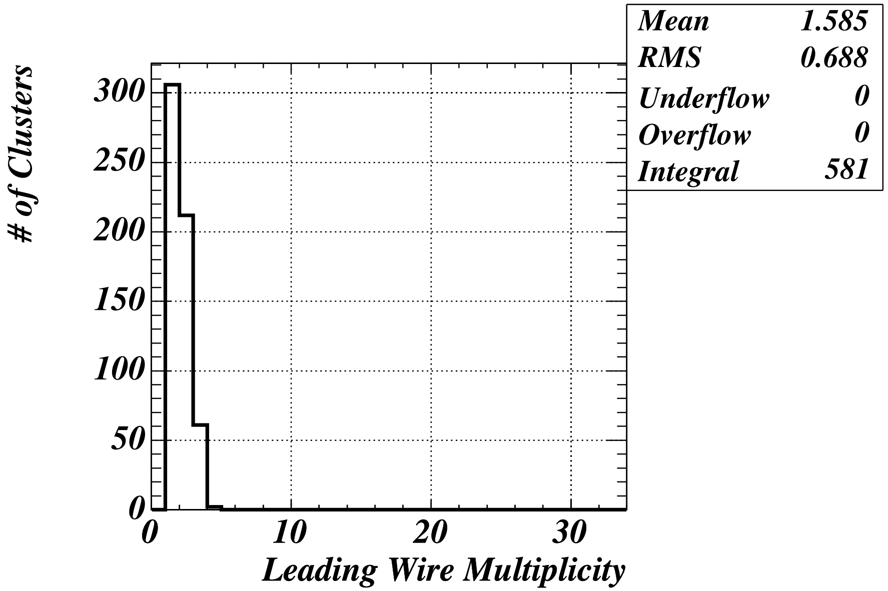
- My hypothesis ...
  - Some aspects of the μ beam made the high wire multiplicity.
    (real hits)
  - A big pulse made multiple strip hits.
    (cross talks)
- If so, the problem is the big pulse (in the view of the stable operation and aging).
- It is necessary to reproduce the situation at Lab. and do further investigations.
- Need further understanding of the TGC operation ...

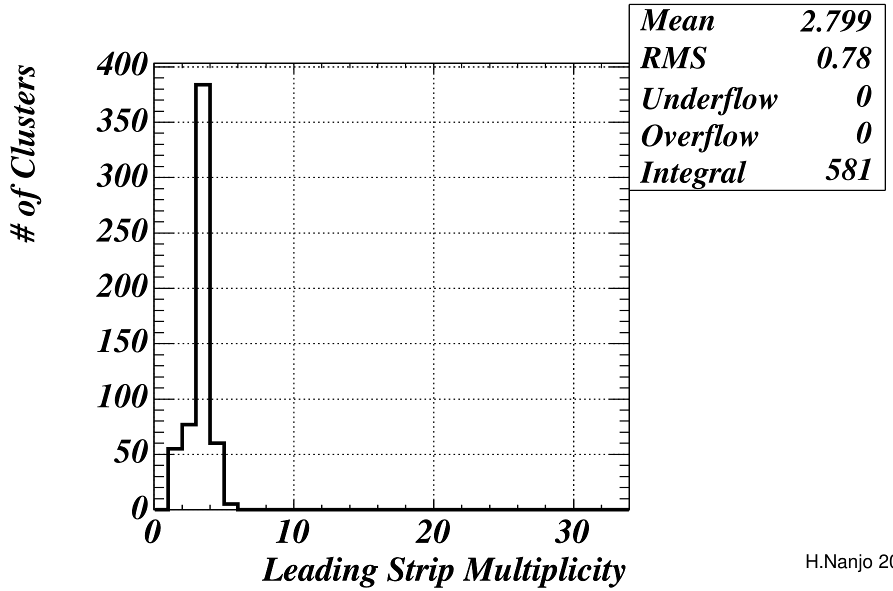
Appendix∼T7(I)∼

Similar situation for the T7 for γ (multi.hit.ratio, multiplicity).









Appendix~T7(II)~

Similar situation for the T7 for γ (profile, delay).