Analysis of INGRID detector data from beam commissioning :

efficiency and stability studies

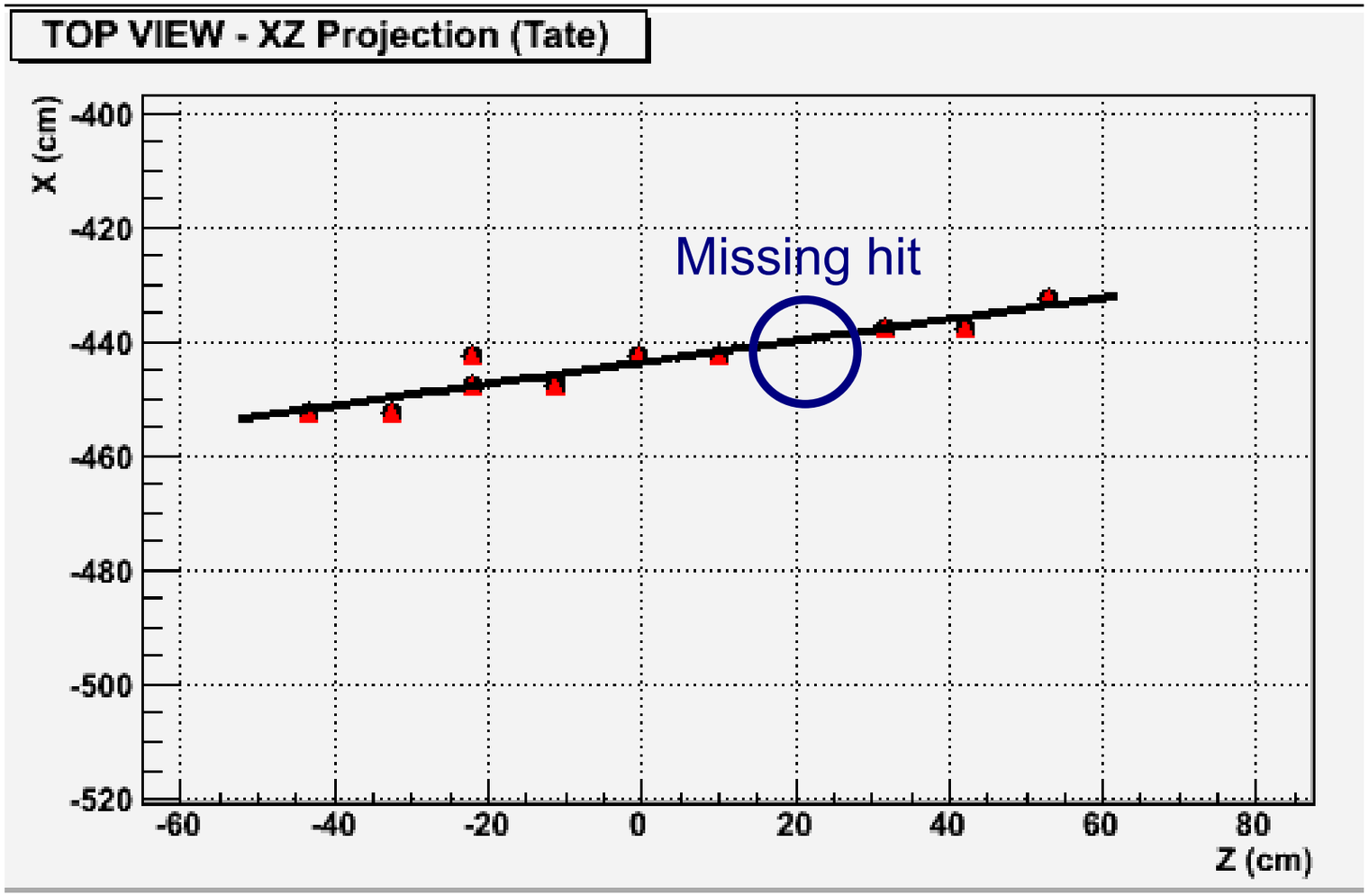
M. Besnier , C. Bronner– 22-04-10

I- Scintillator efficiency

C. Bronner

Efficiency of scintillators principle

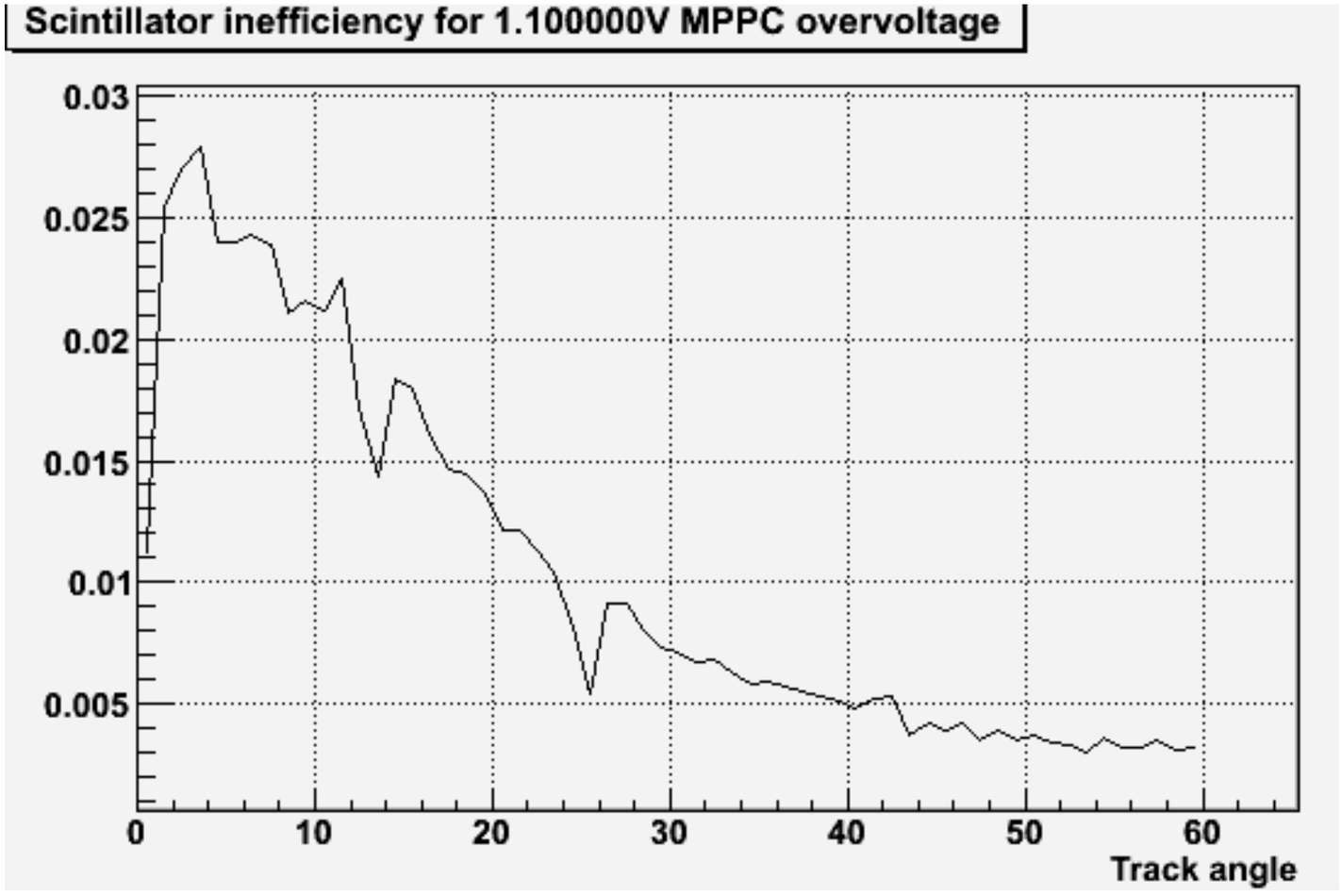
We want to evaluate the efficiency of scintillators.
For this we look for a scintillator failure: a track going through a scintillator without leaving a hit.

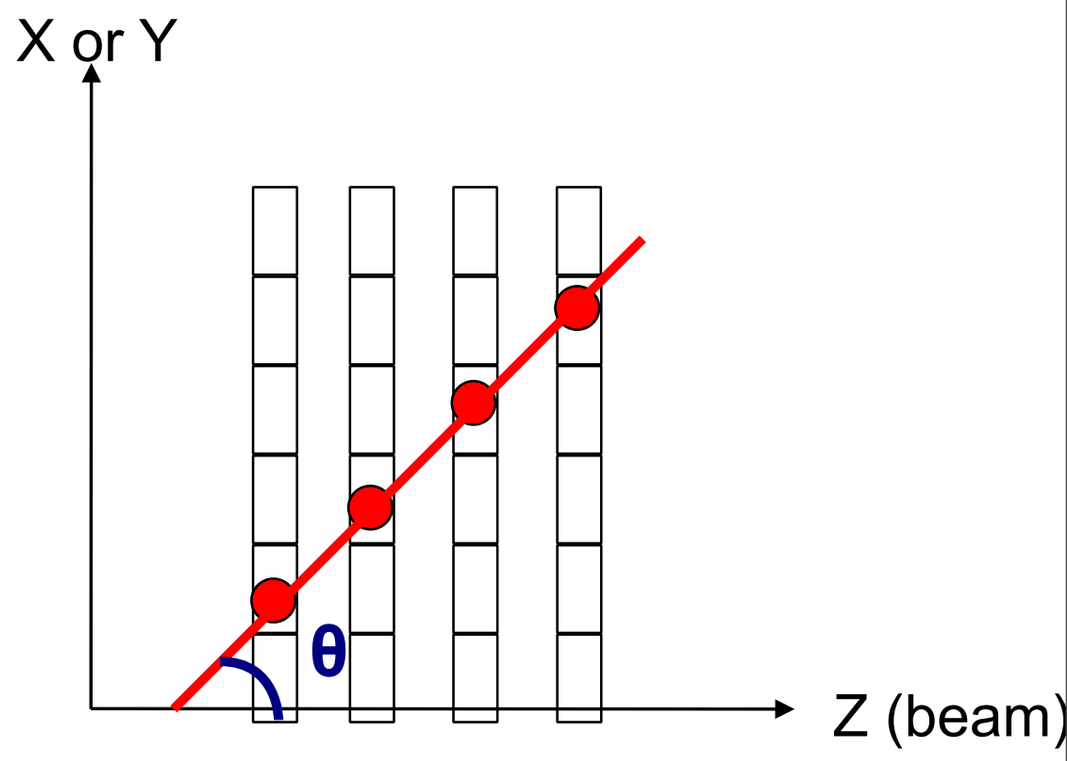


Data sample :
55 hours of cosmics data (~2.7*10^6 events)
MPPC overvoltage = 1.1V
“good track” selection : -track length>60cm (1/2 module)
- hit threshold= 5 pe
- etc….

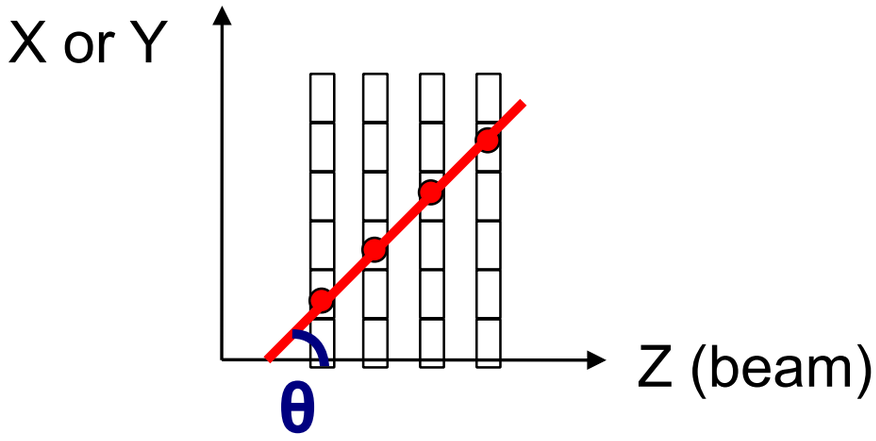
Efficiency of scintillators
Angle dependance

Inefficiency as a function of track angle



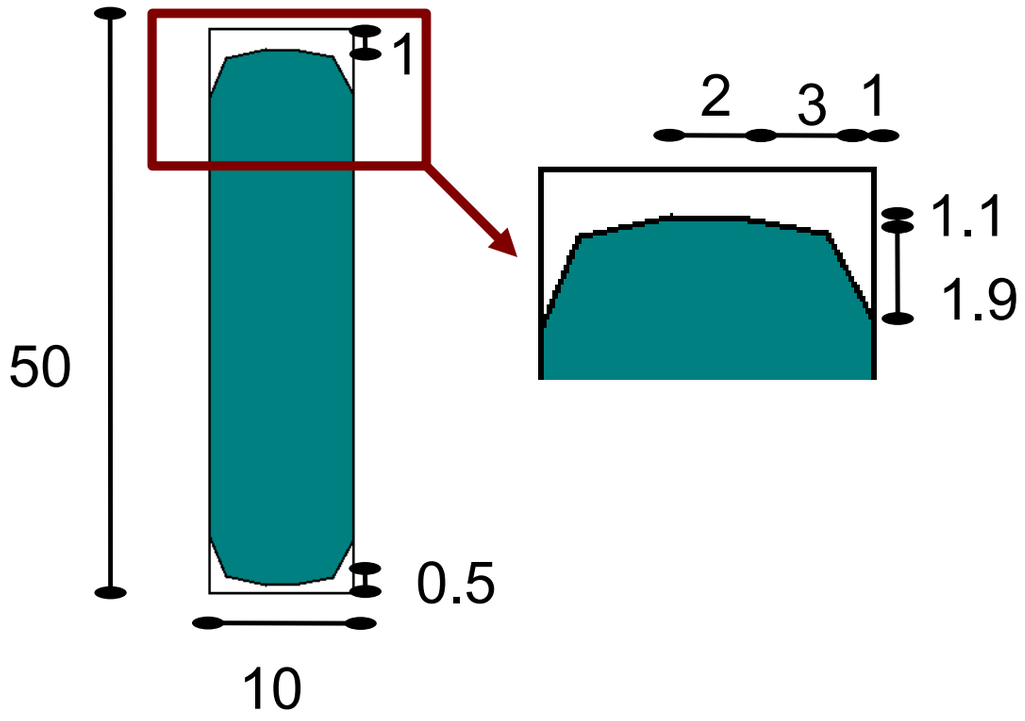


Monte Carlo study for efficiency



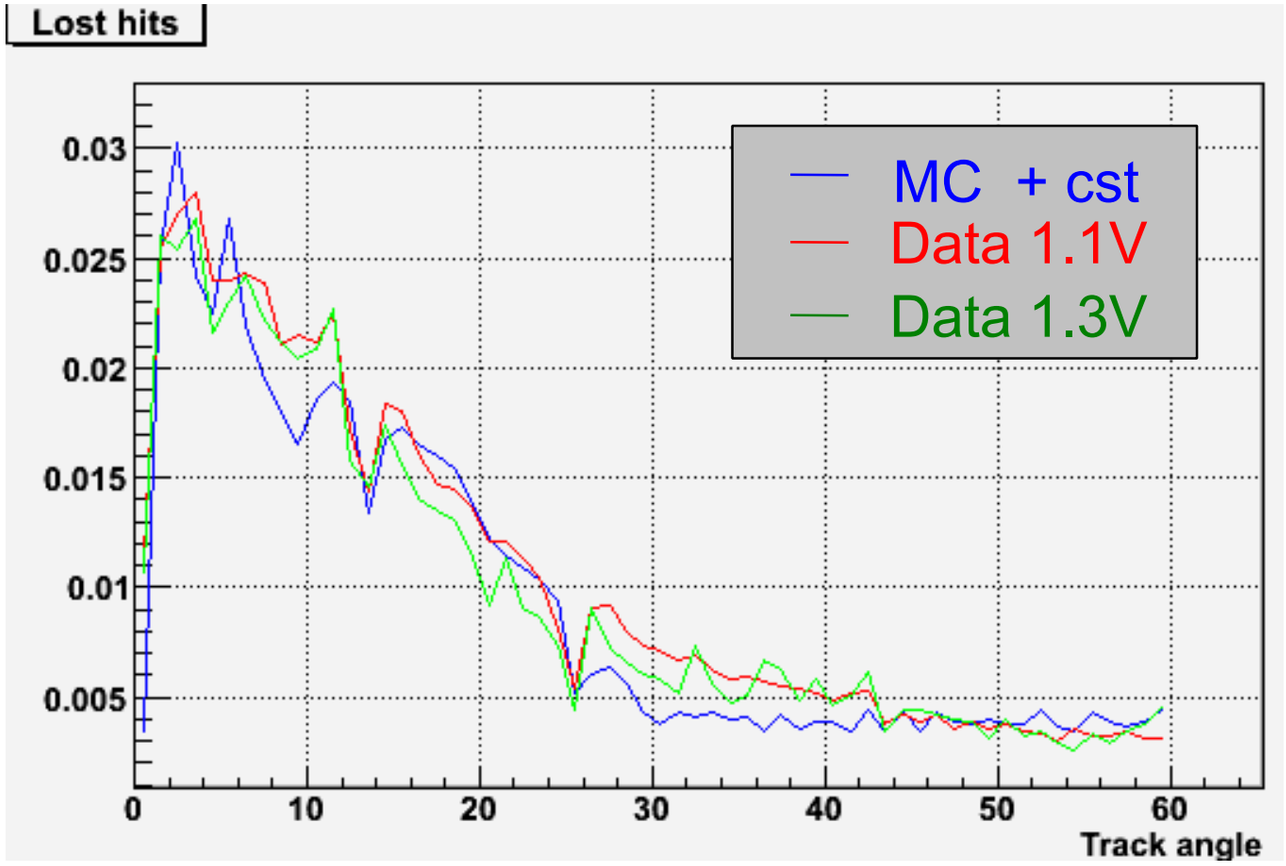
T2K

Use following model for a scintillator (dimensions in mm):



Green area is efficient
White area is inefficient

Data corresponds to cosmics data with 5 pe threshold, and different MPPC overvoltages



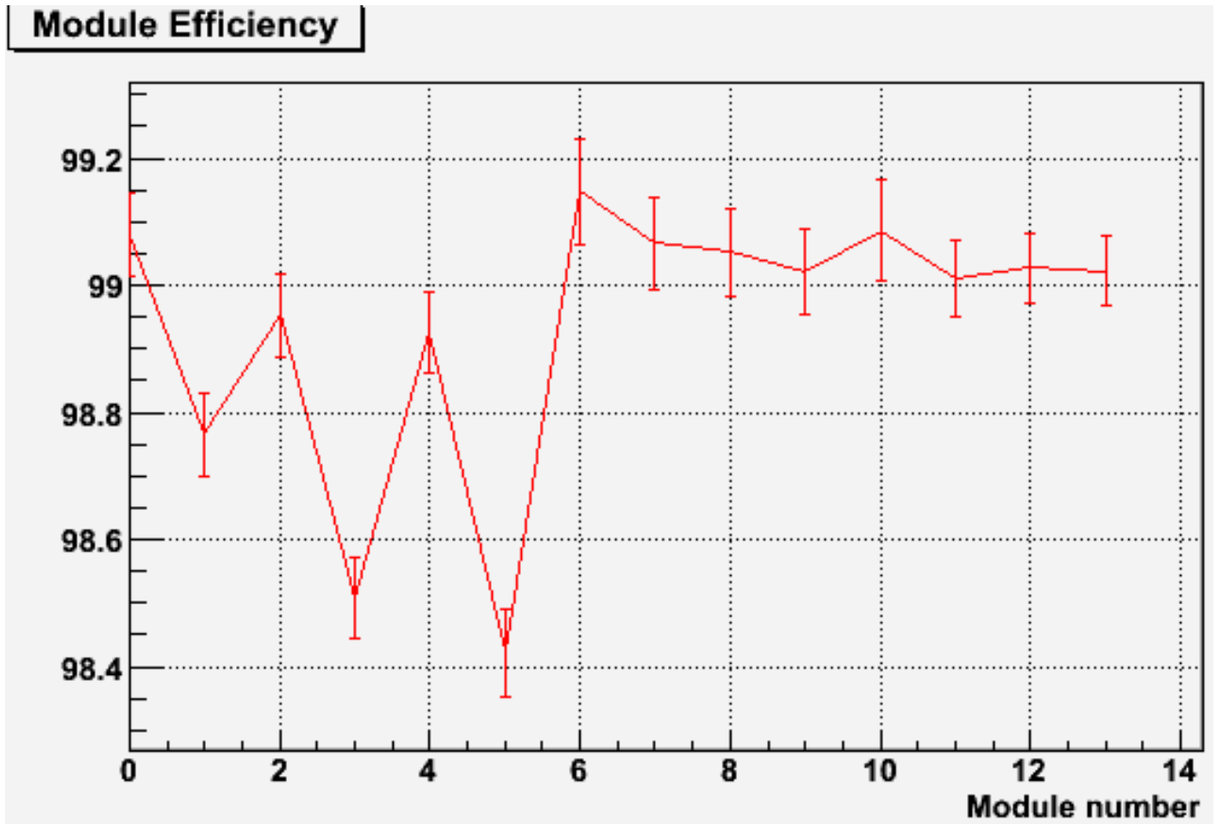
Added 0.35% constant inefficiency to MC

Module per module efficiency
Cosmic data

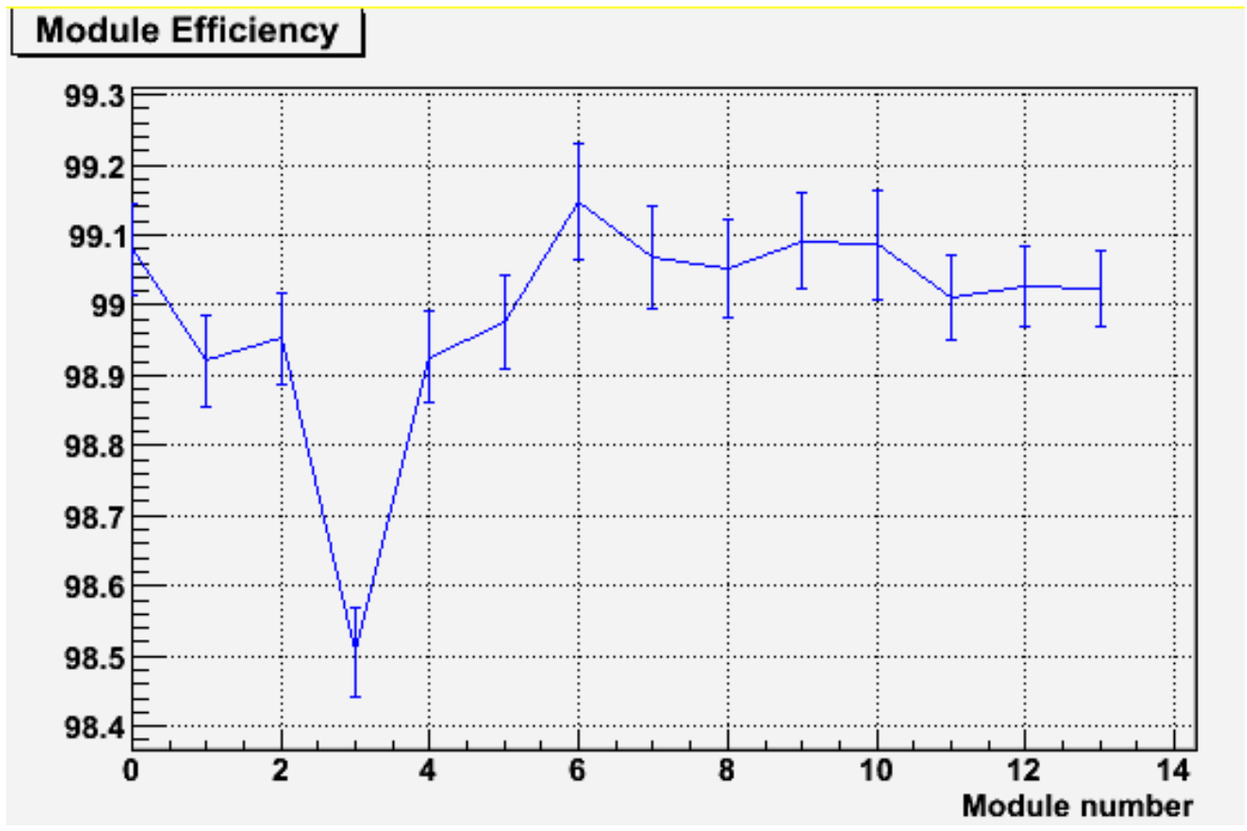
T2K

Stat error taken as 1/Sqrt(entries)

All channels



After removing dead channels



There is a problem for modules 1,3 and 5

Still a problem with module 3

Efficiency results

T2K

Cosmics: 55 hours of cosmics data (~2.7*10^6 events)
Beam: All beam runs of Jan-feb-march 2010

MPPC overvoltage = 1.1V
Threshold= 5 pe

	Cosmics	Beam
All	98.93%	97.00%
All -DC	98.98%	97.06%
All -DC -Mod3	99.02%	97.09%
Mod3	98.51%	96.80%

DC ≡ Dead Channels
Mod3 ≡ Module #3

Results are still preliminary (might need debugging)
+ study including a time clustering with a lower npe threshold is needed.

From cosmic and MC study, efficiency for beam should be ~98.3%
=>Efficiency is lower than predicted for beam

II- INGRID commissioning analysis and stability studies

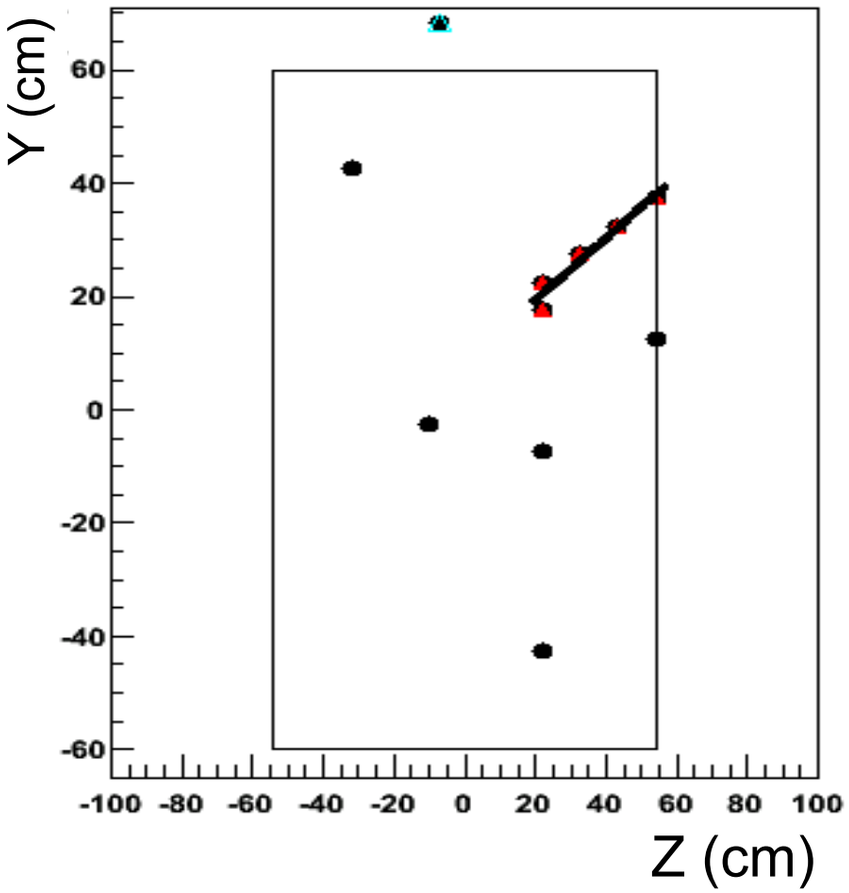
Reconstruction and analysis of **run 29,30 and 31**

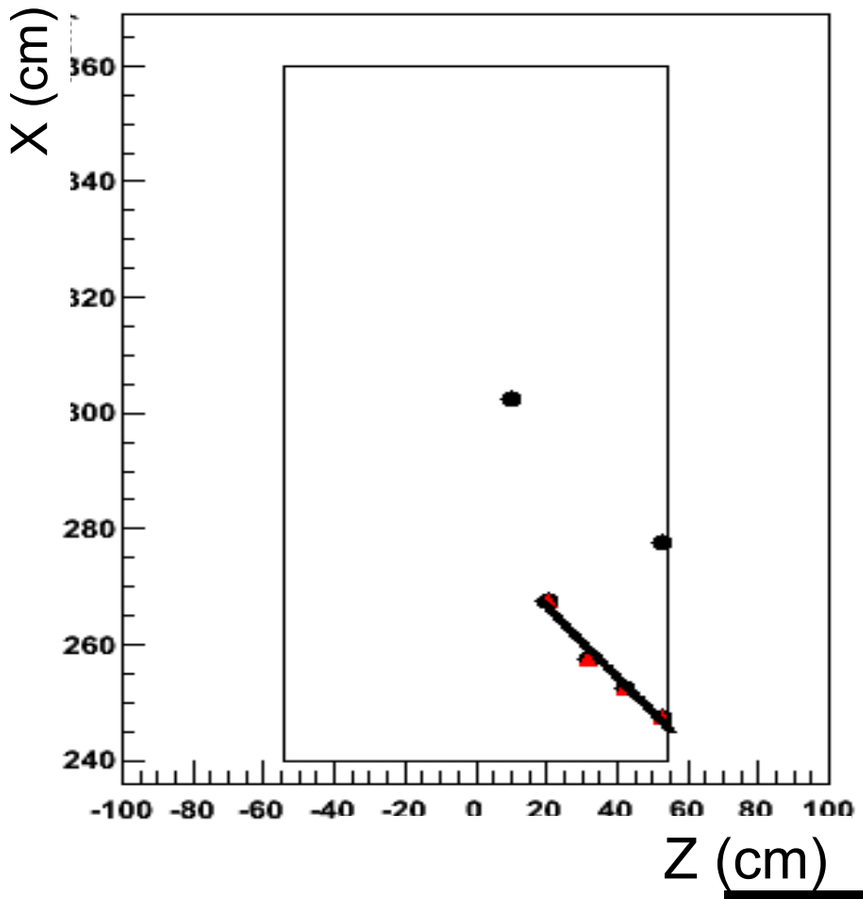
Total integrated intensity : 3.43 10^{18} pot with good spill

Number of reconstructed events : **107102** Rμ events
61730 neutrino events in FV

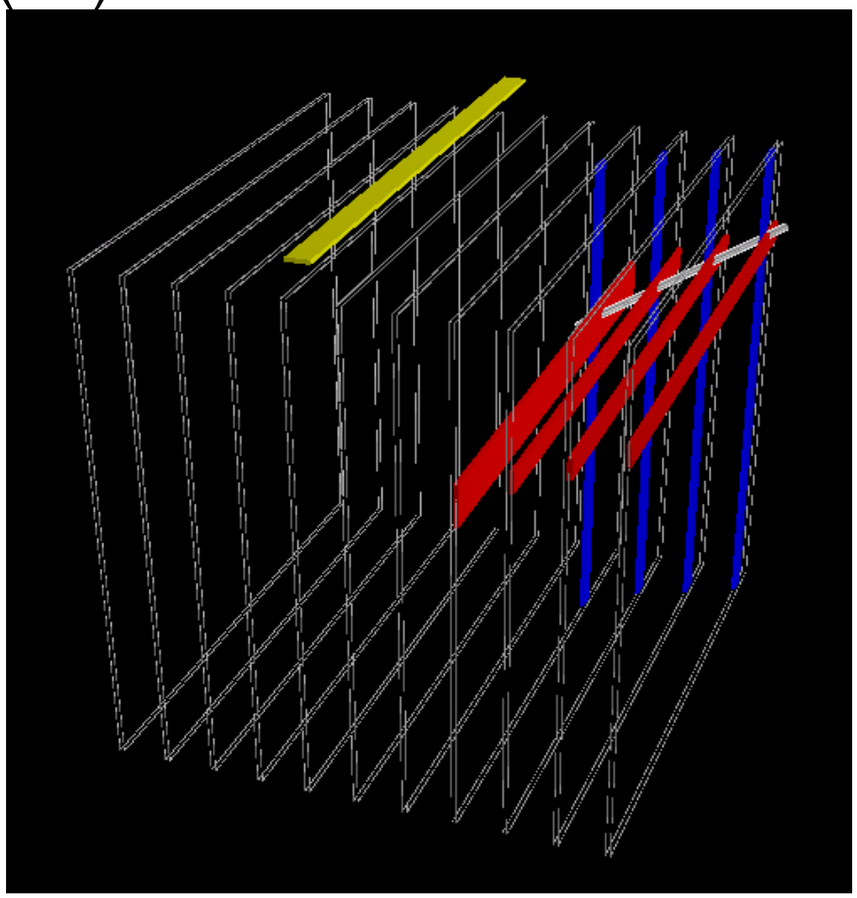
Details of the reconstruction ➔ see Otani san's presentation in nd280beam talk.

INGRID Event displays

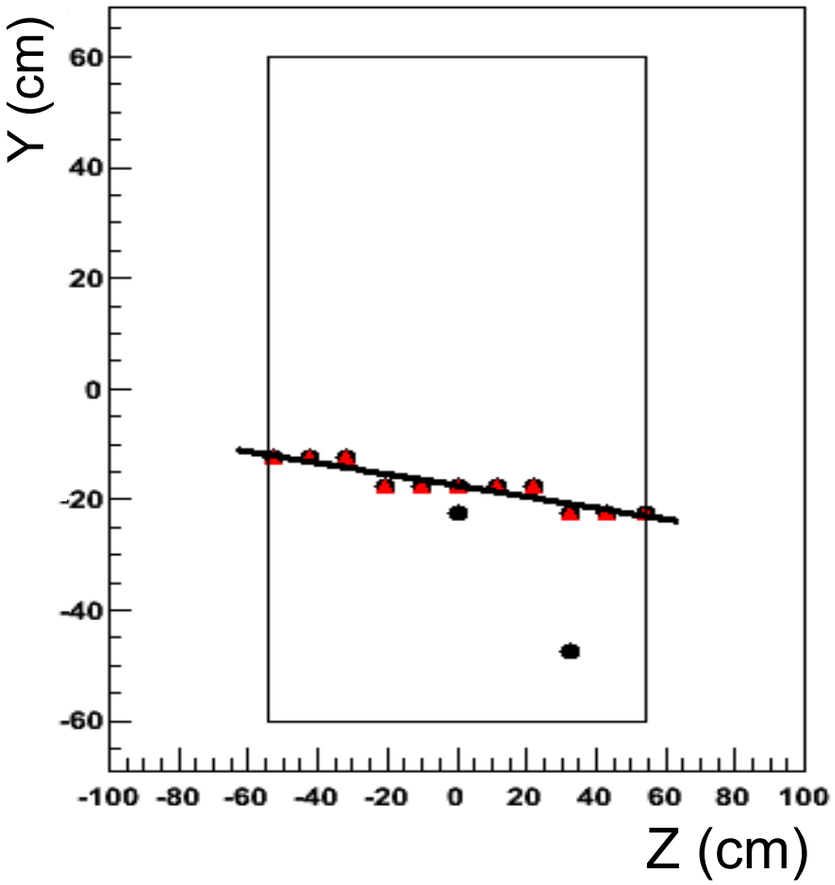


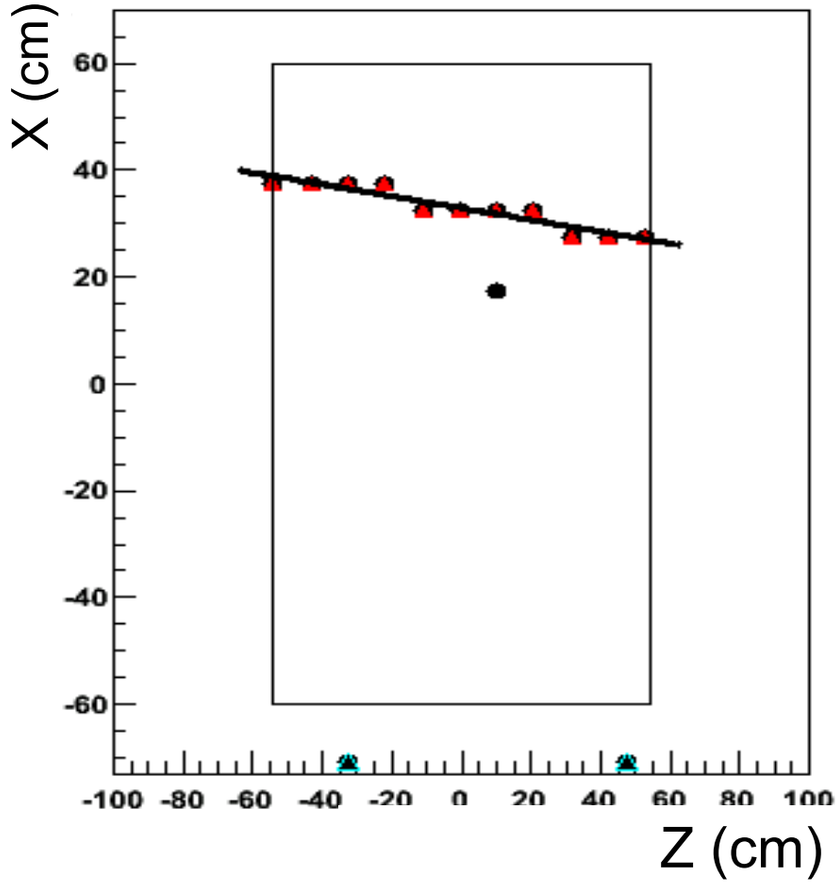


Neutrino



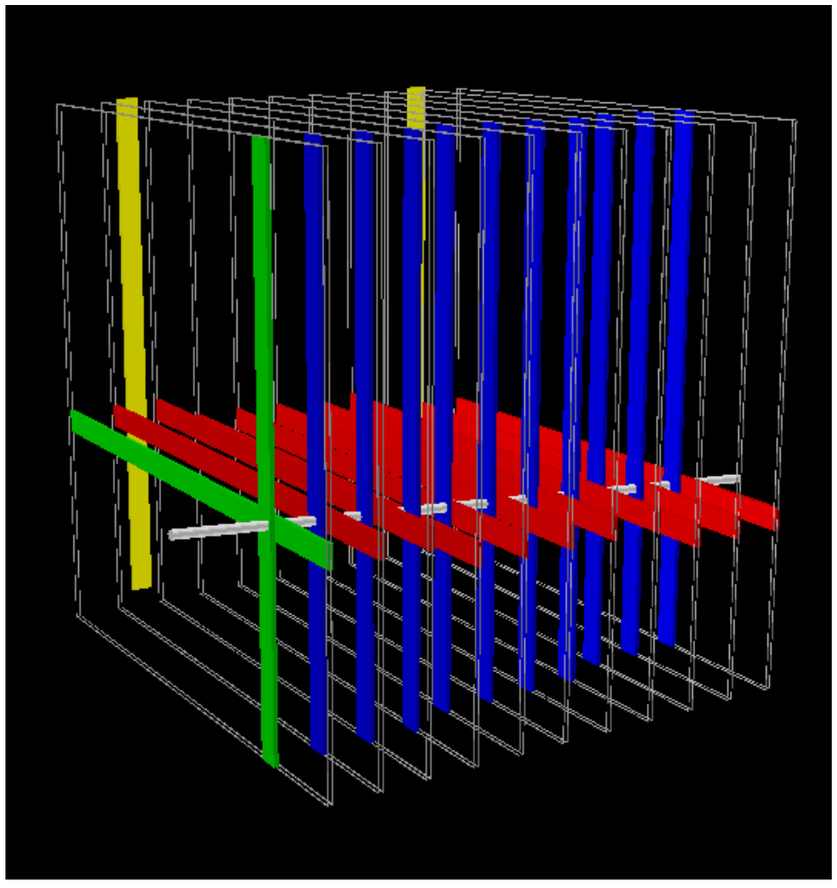
INGRID Event displays





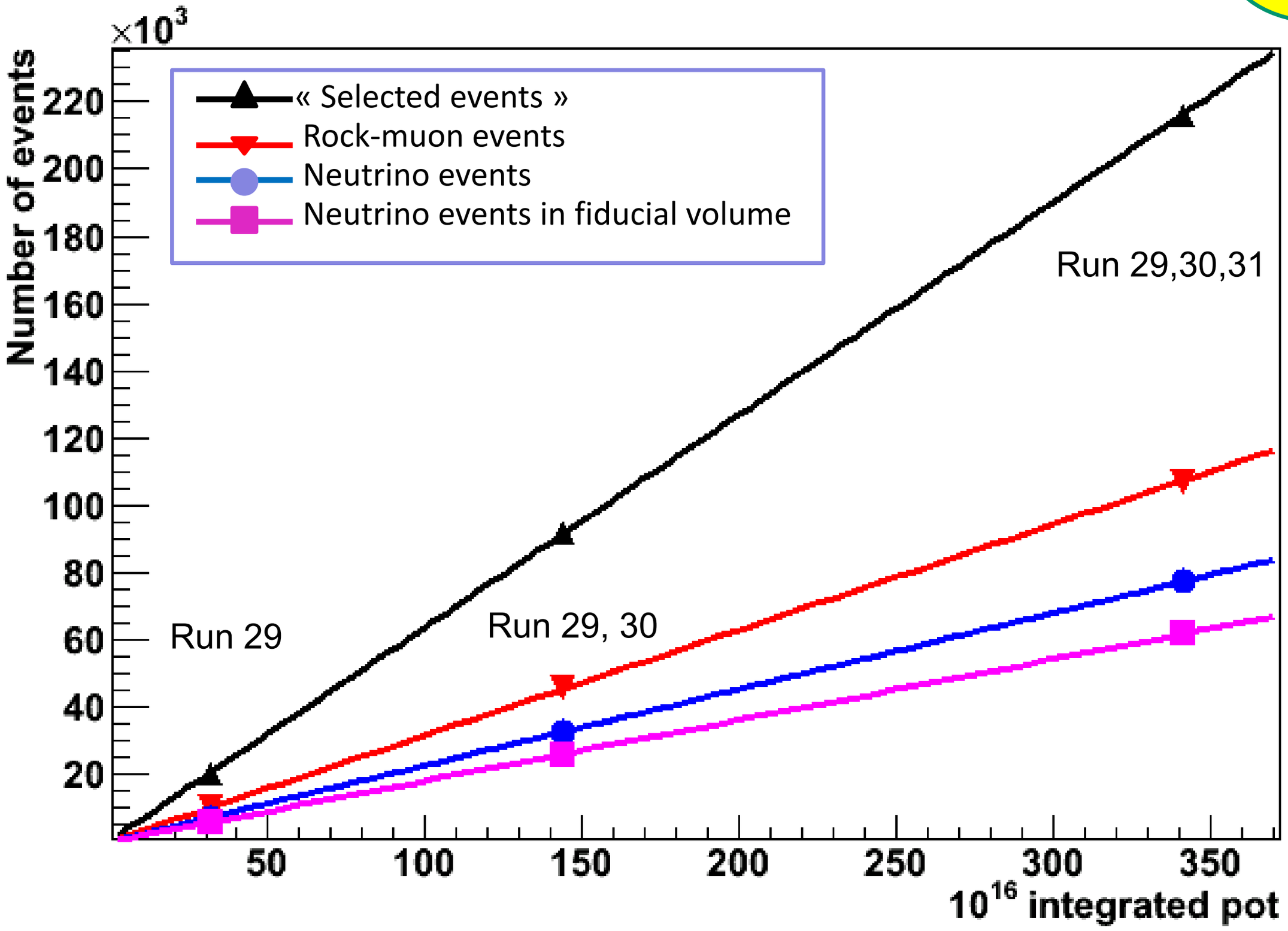
Rock muon

T2K



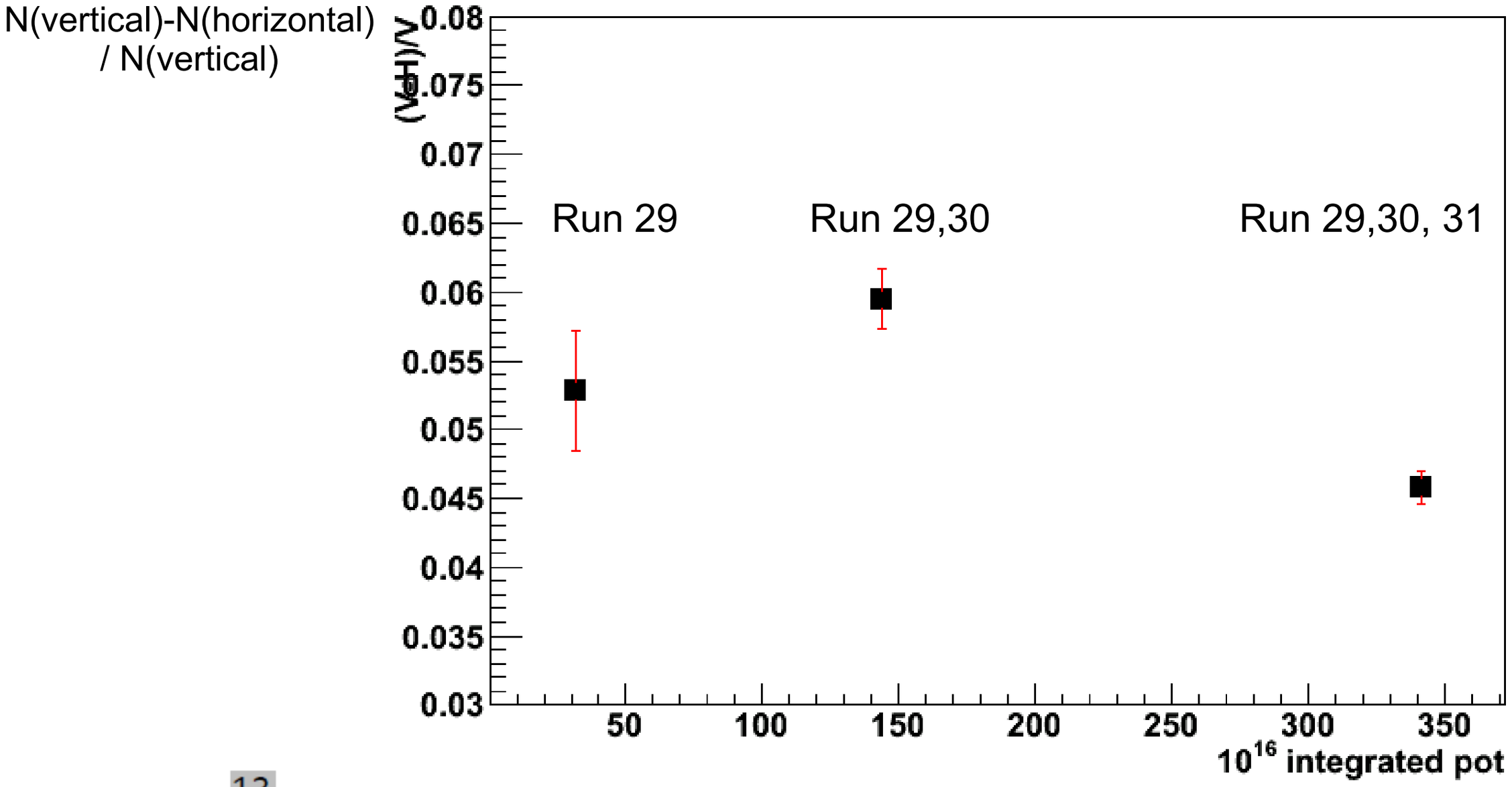
Stability of algorithms and detector response

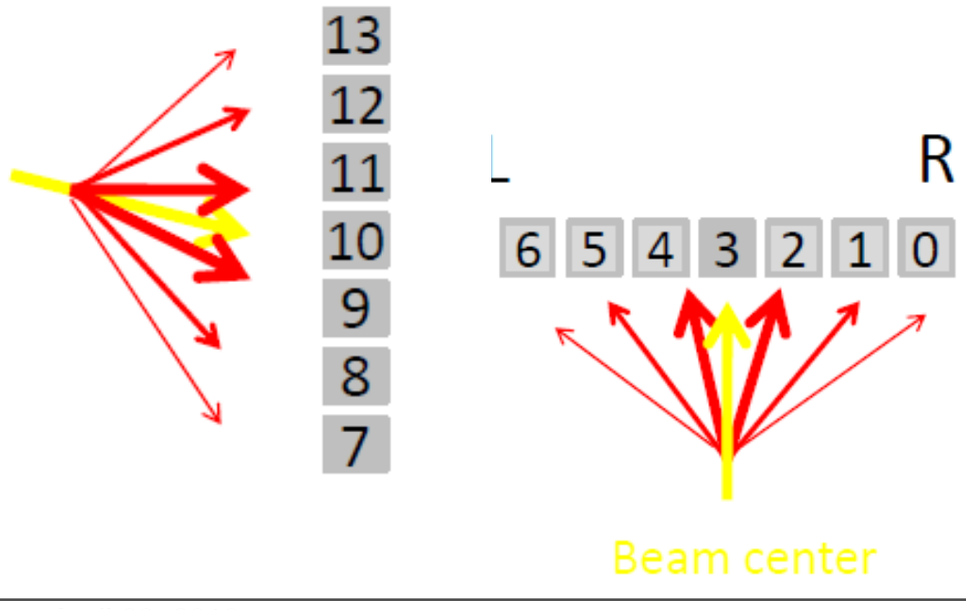
T2K



Nice linearuty of number of remaining events with integrated pot at each step of the reconstruction

Number of events in vertical modules vs horizontal modules





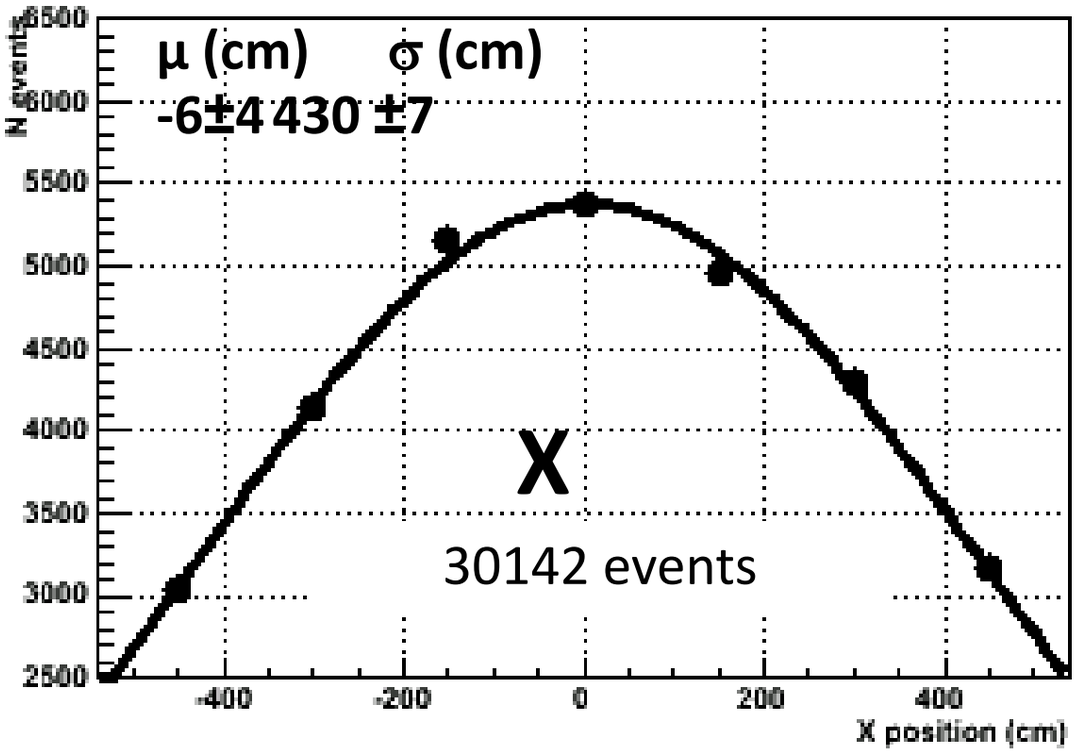
Vertical tower should have **~5% (±?)** more events than horizontal bar

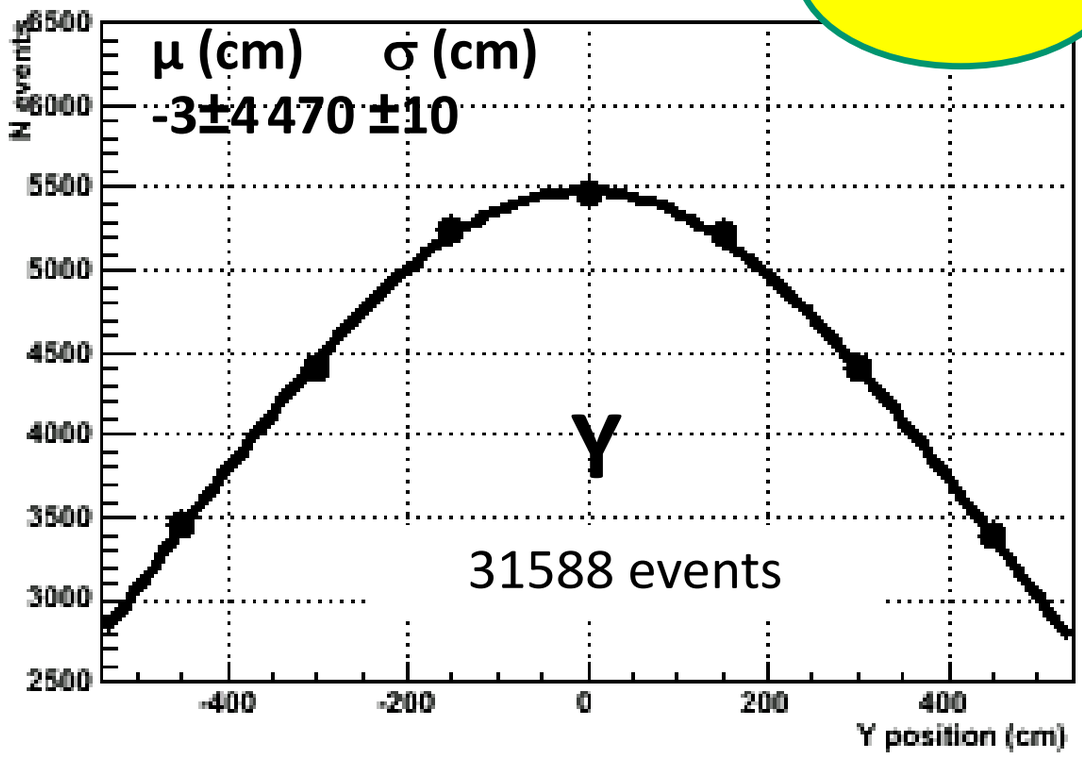
Note : no systematic errors included !

Profiles – all runs

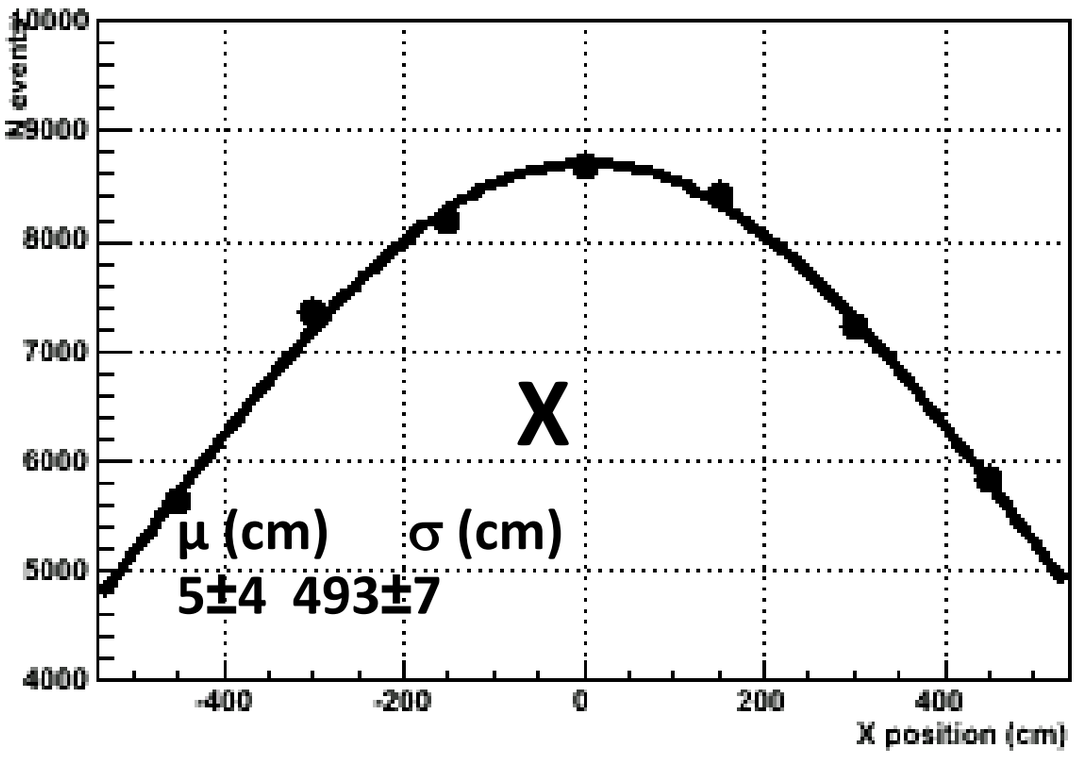
T2K

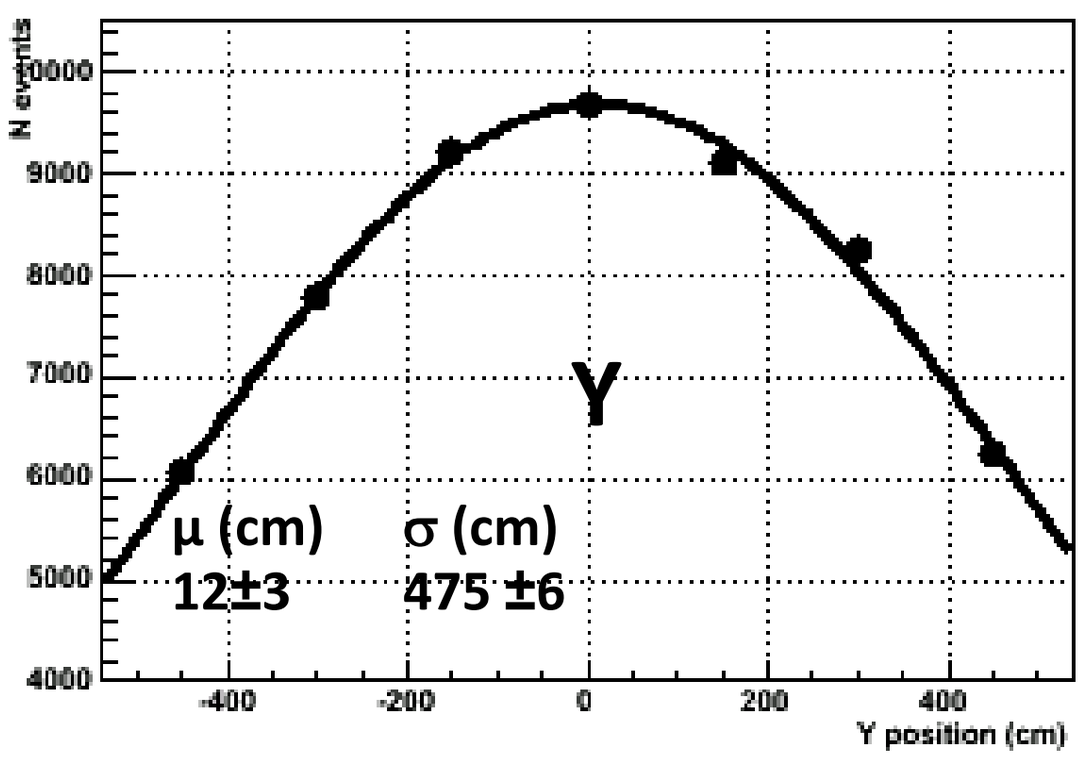
neutrinos





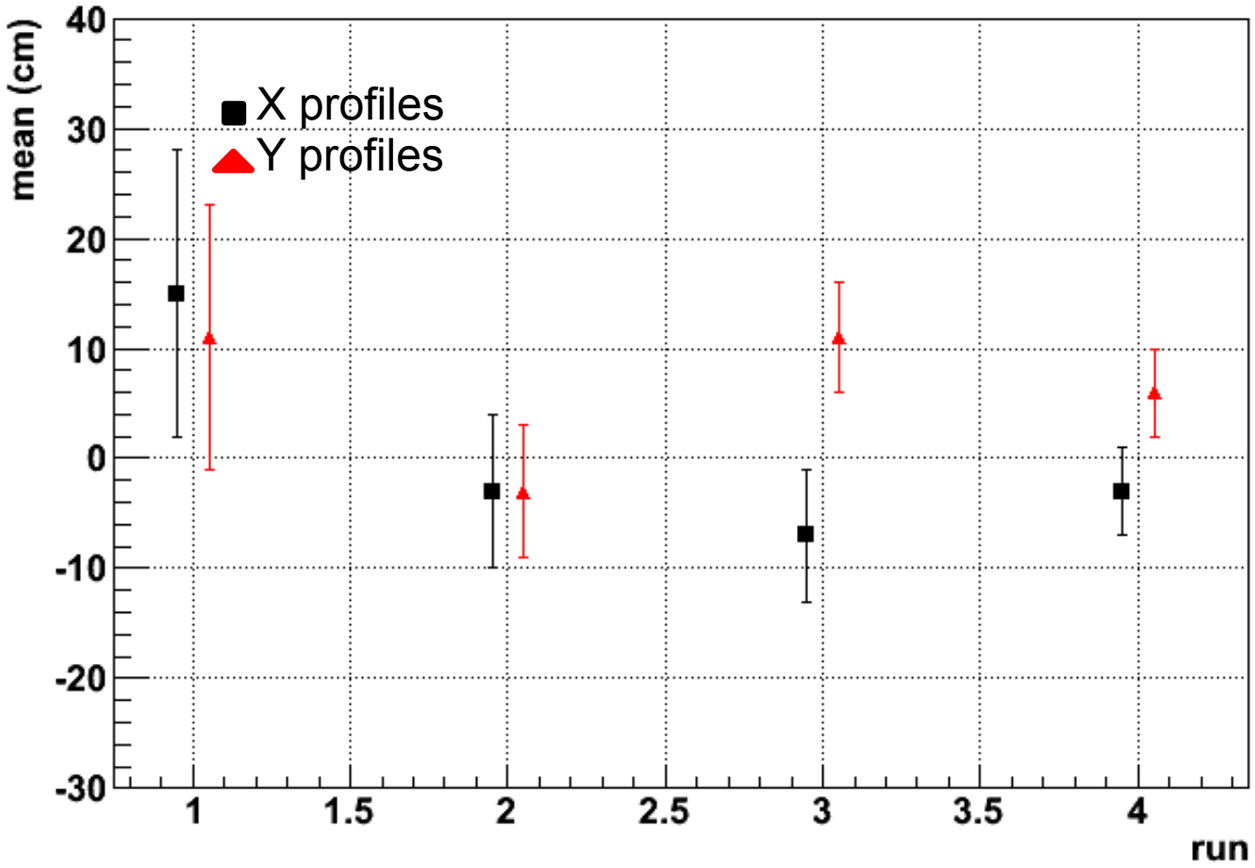
rock muons



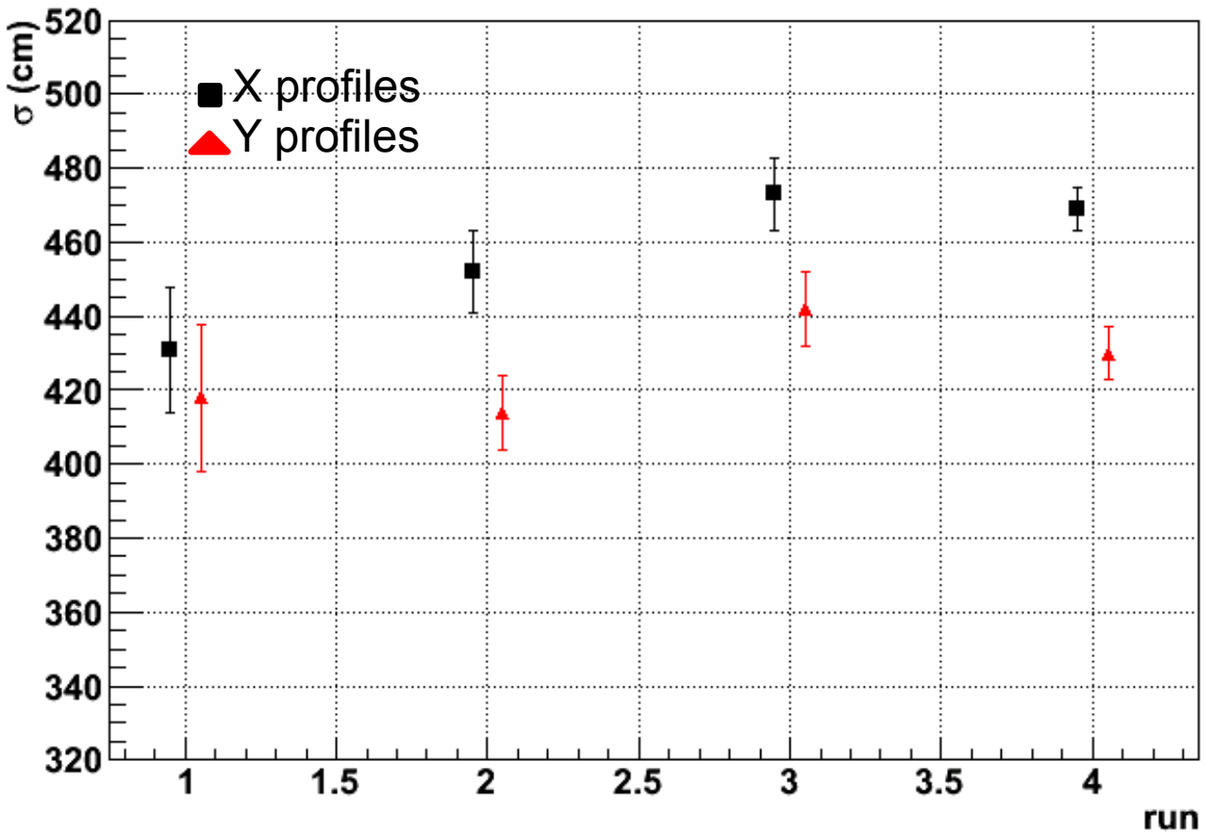


Vertical tower should have **~5 %** more neutrino events than horizontal bar

Evolution of the mean and width of neutrino profiles



Run 29 Run 30 Run 31 All runs



Run 29 Run 30 Run 31 All runs

Keep in mind :

- -no systematic errors
- -Rμ may be contaminated by neutrino events

Conclusion

- ***Commissioning neutrino runs have been reconstructed and analysed.***
- ***First efficiency studies have been realised with beam and cosmic data.***
- ***The present results show a good stability of beam, algorithms and detector response.***

INGRID activity

Akira murakami, kyoto-univ

4/23/2010 calibration & performance session
at T2K collaboration meeting

Run29, 30, 31 data taking

- Data taking of Run29,30,31
  - Total # of proton by CT5 : 3.4e18 protons.
  - Total # of good spill : 1.7e5 spills.
- There was no trouble, no miss spill during DAQ running.

- Detector setting
  - ΔV of MPPC = 1.1 V
  - Integration time = 480 nsec
  - TDC threshold is 2.5 p.e.

Flow chart of event selection

Make timing cluster(more than 4 hits within 100nsec)

# of active planes > 1 &&
p.e./active layer > 6.5

On time

Beam related event

↓

Report about this events

# of active planes > 2 &&
p.e./active layer > 6.5

Tracking

Track matching

On time

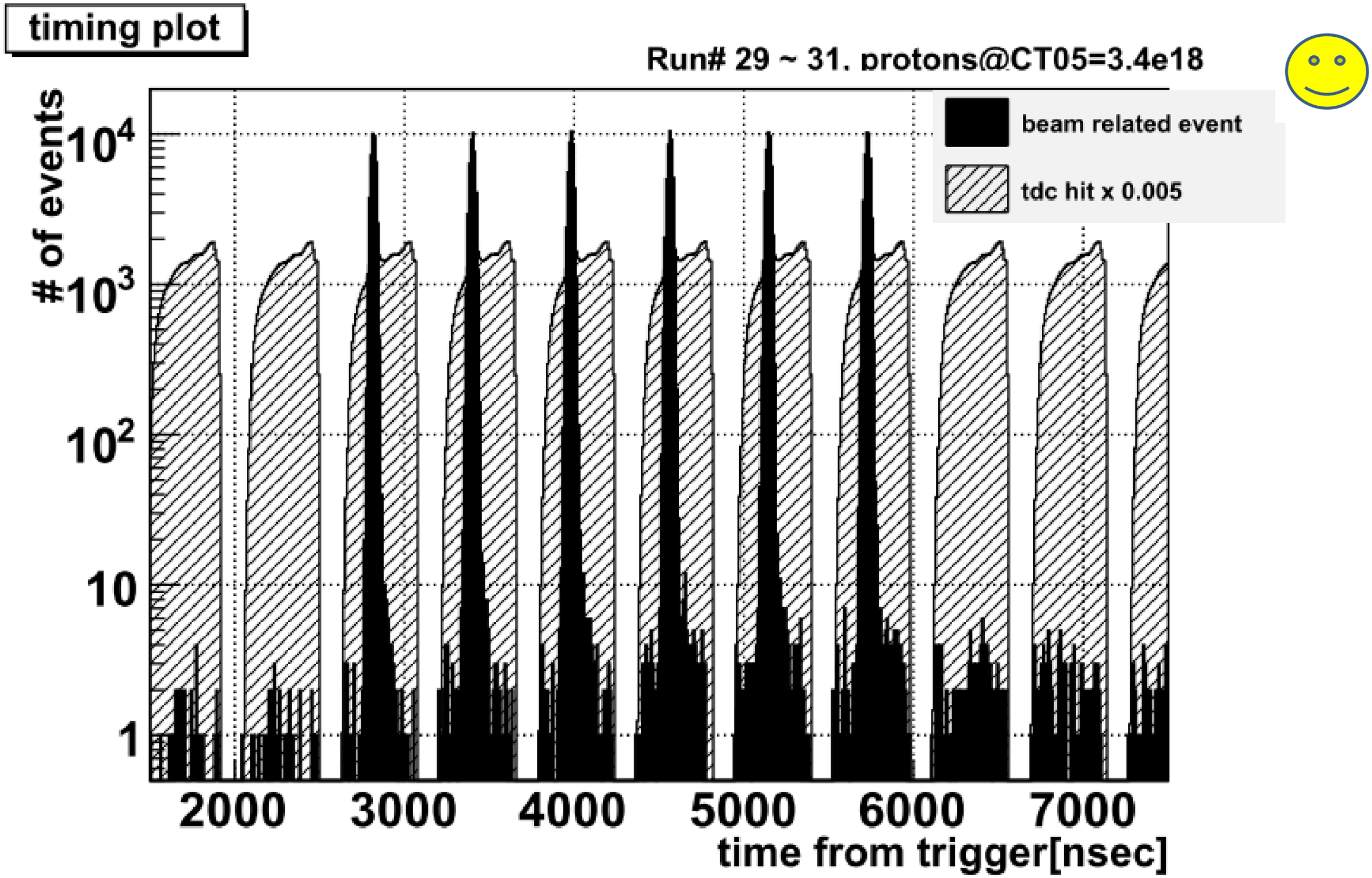
Upstream VETO

Fiducial volume

neutrino event

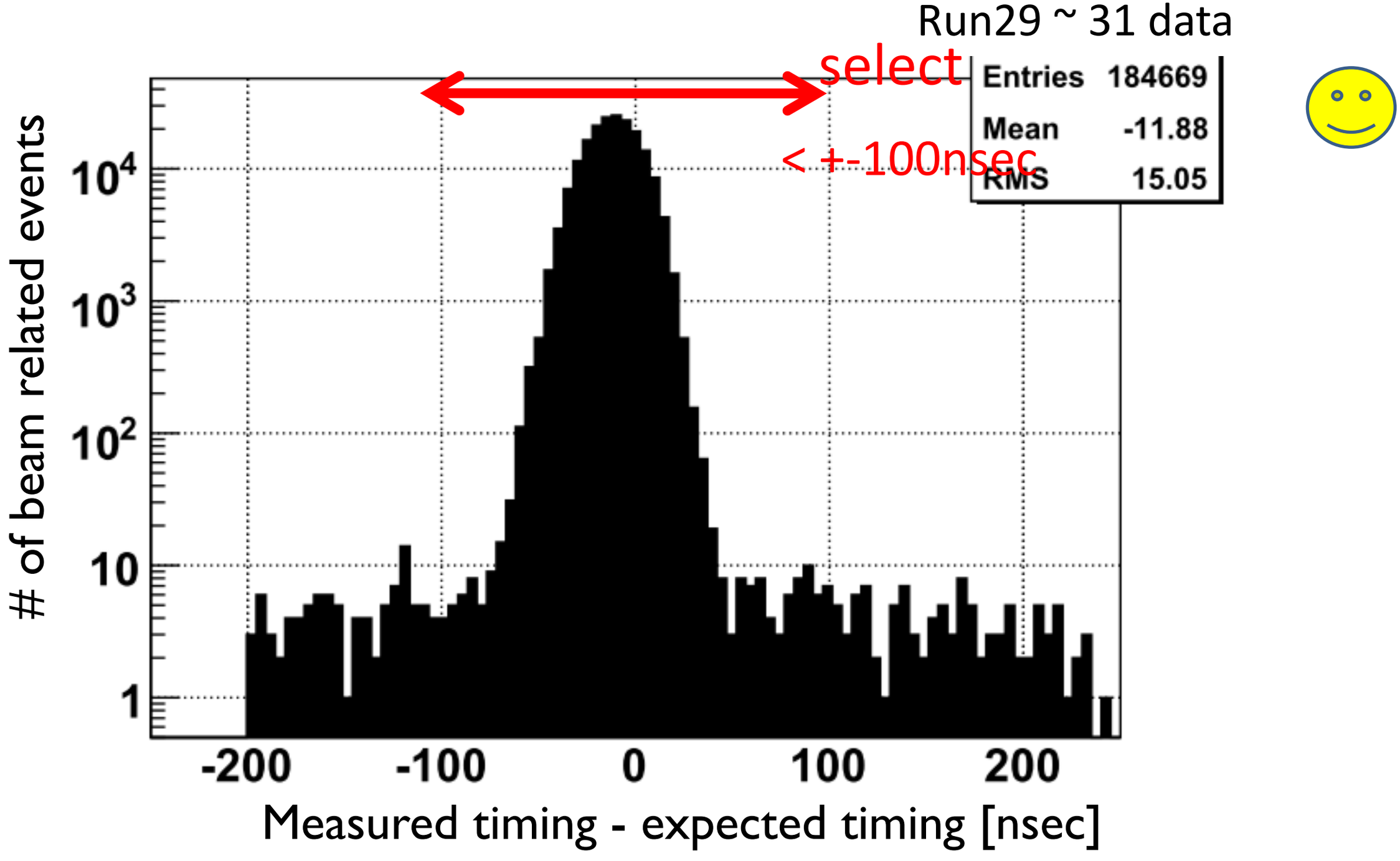
data set: Run29 ~ 31,
172818 spills, 3.4×10^{18}protons@CT05

Beam timing


timing plot
Run# 29 ~ 31, protons@CT05=3.4e18
beam related event
tdc hit x 0.005
# of events
10^4
10^3
10^2
10
1
2000
3000
4000
5000
6000
7000
time from trigger[nsec]

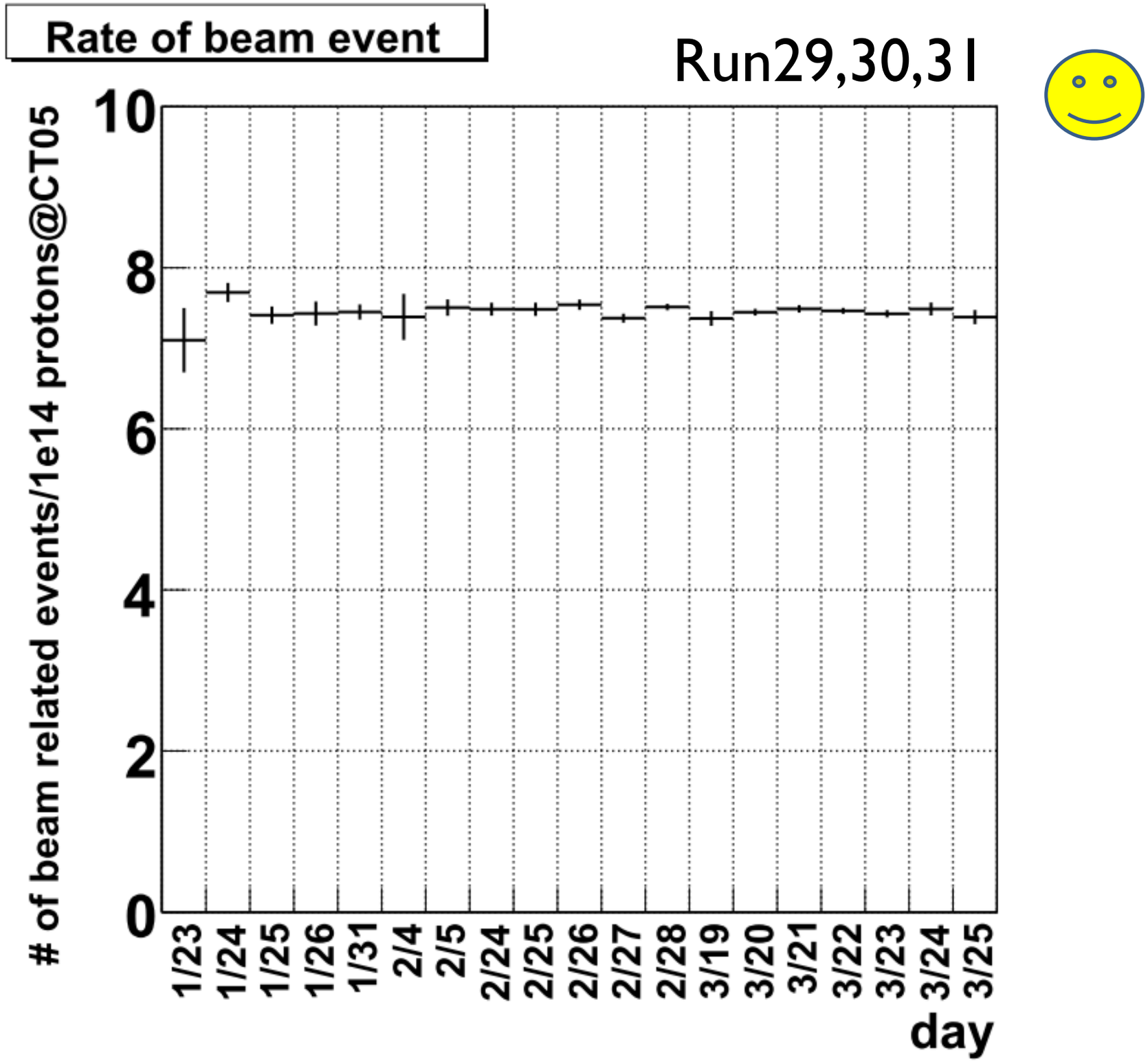
Beam timing from expectation

Events in 100 nsec difference from expected beam timing calculated from CT5 timing are "on time" events.



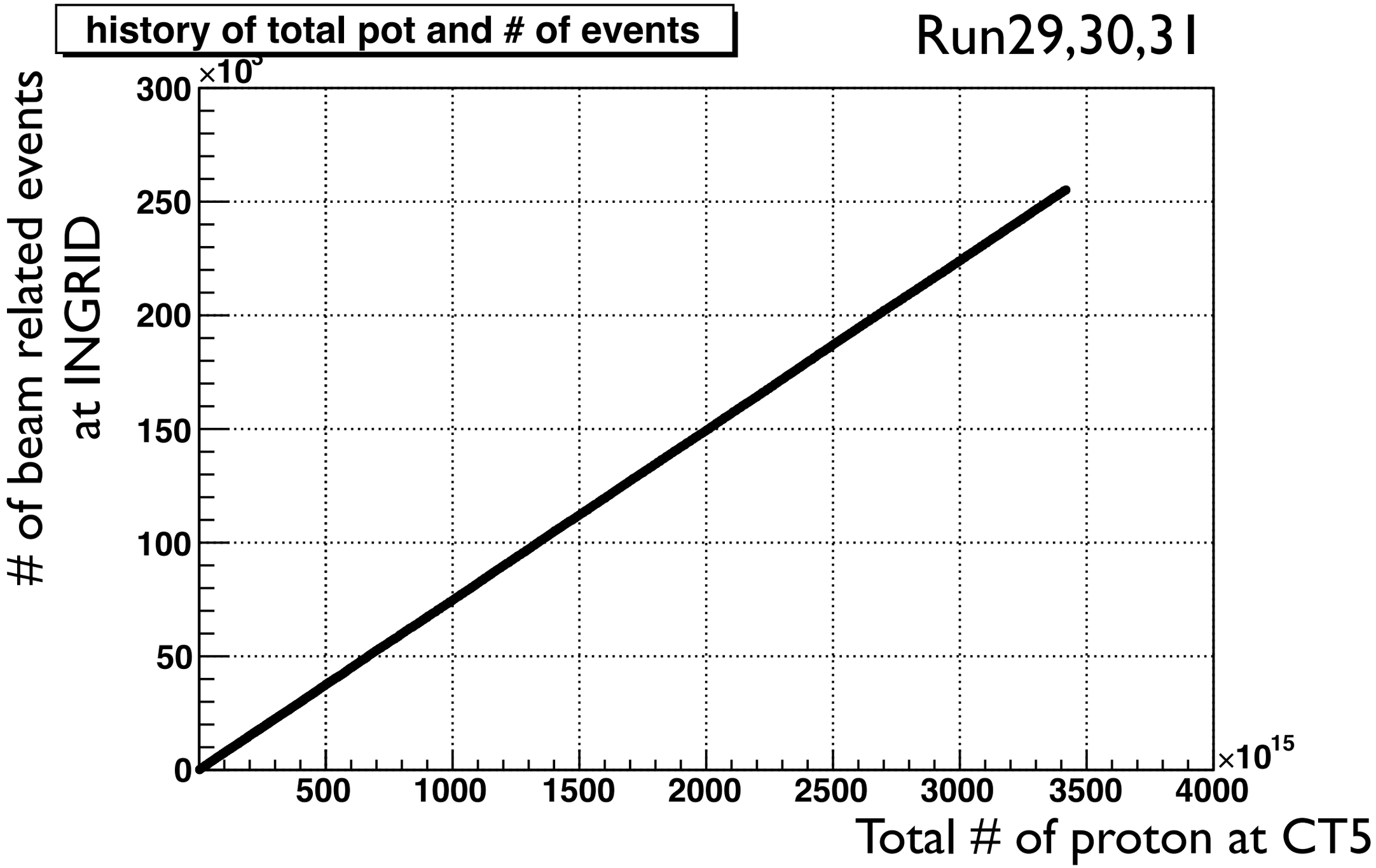
Stability of data taking

~ beam related events ~



Stability of data taking

~ beam related events ~

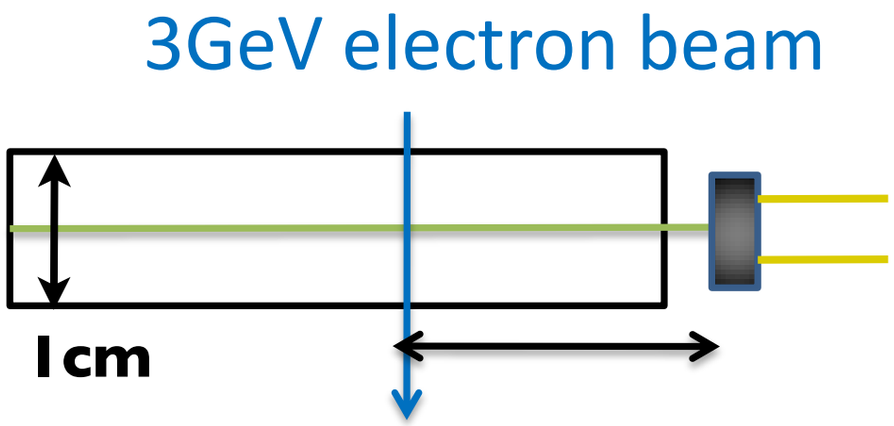


Data taking is stable.

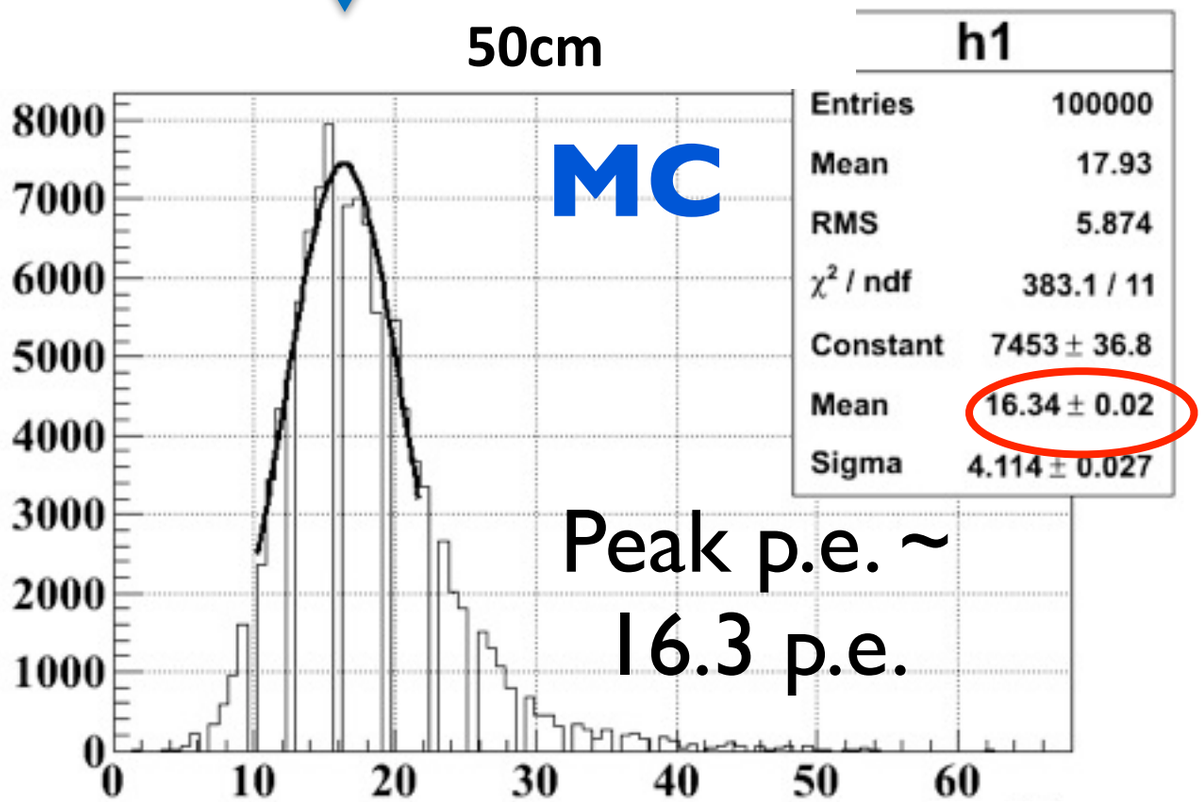
Status of INGRID Detector MC

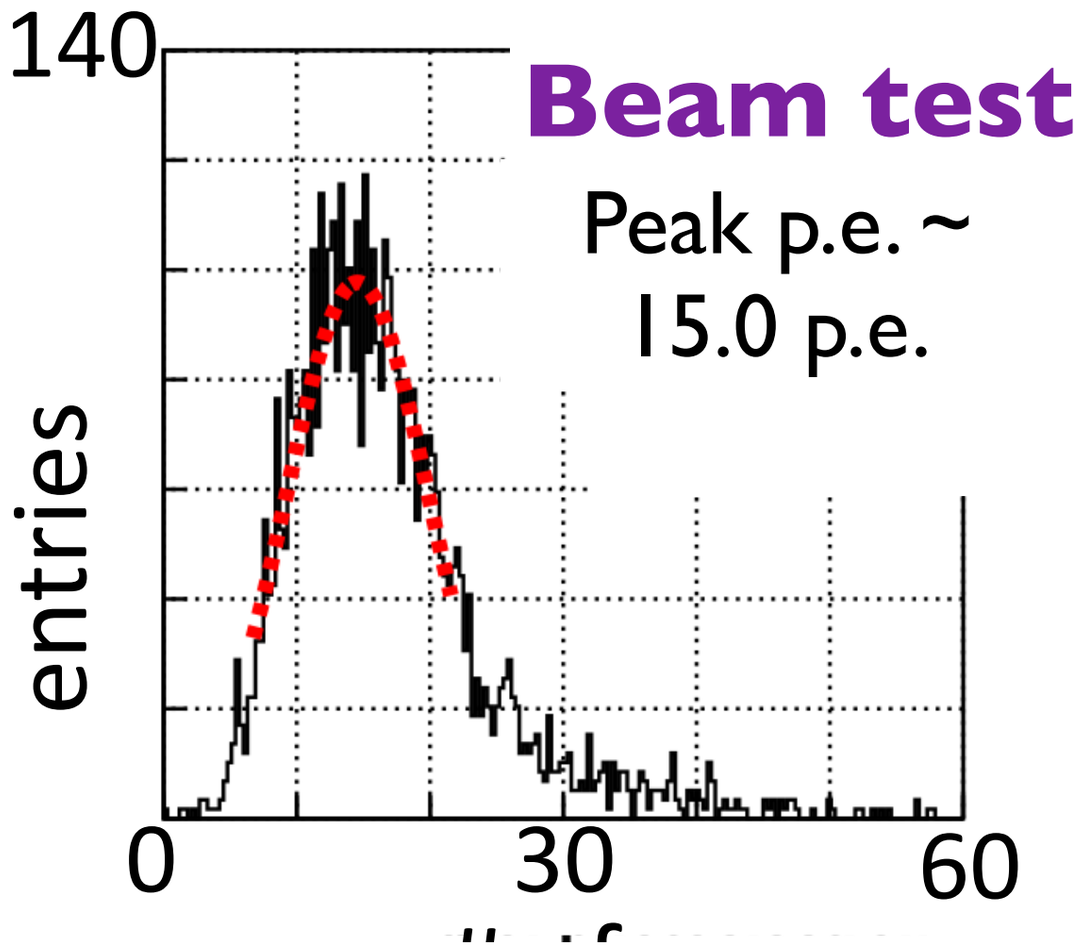
- Progress in updating INGRID MC.
  - Add some detector responses.
  - There are other detector responses needed to add.
- Problem of neutrino vector (reported by Ichikawa-san) is discussed & improved.
- Comparison between MC and real data (cosmic, beam).
  - Now progress one by one.

Comparison with beam test (1ch)



After add some detector responses, simulate beam test measurement.





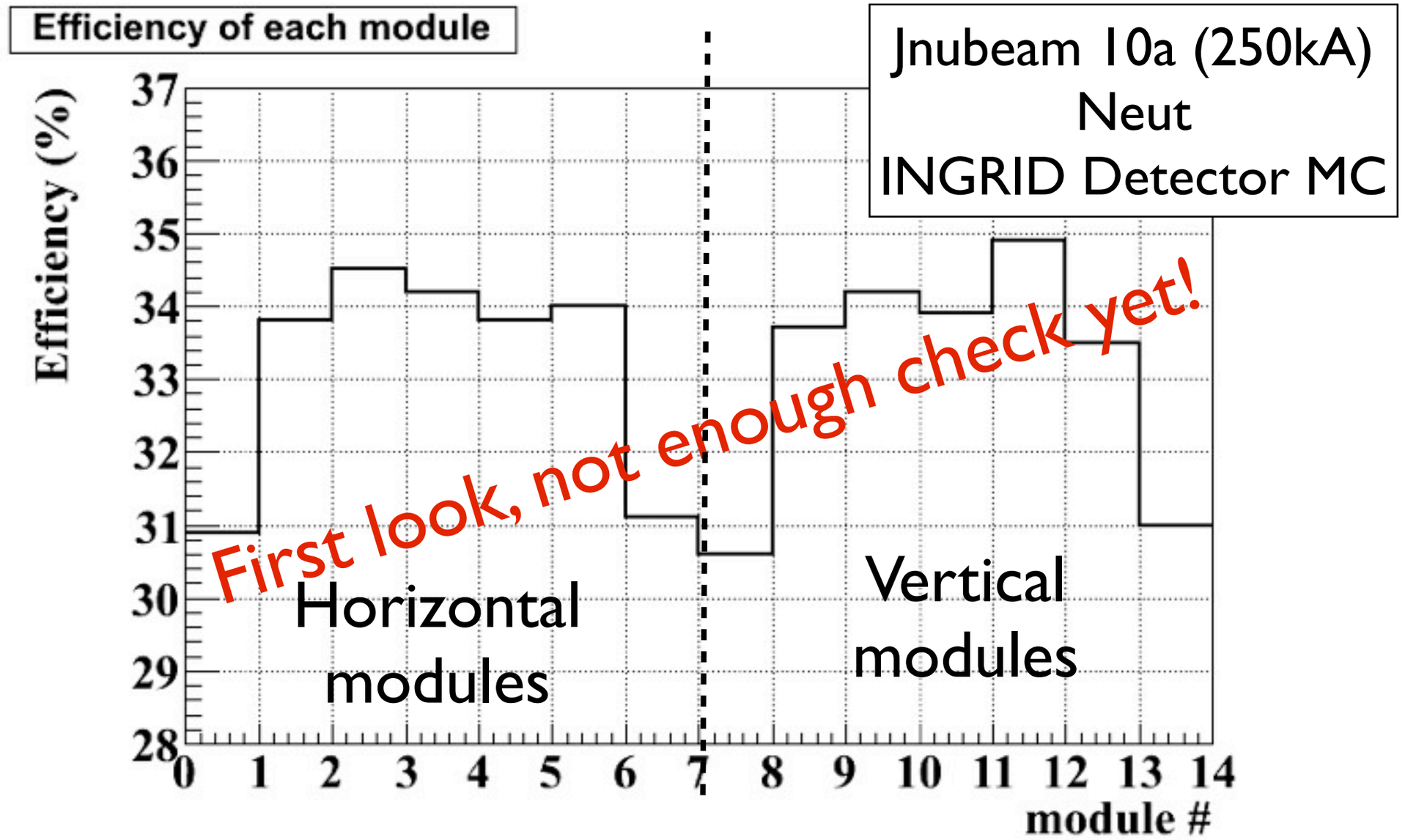
Roughly 10% difference between MC and data.

→More study is needed.

Efficiency of each module (MC)

Efficiency = (# of events after neutrino event selection) /
(# of neutrino interaction within modules)

Neutrino event selection will be reported by Otani-san in ND280-beam talk.



Checking & tuning MC is going on.

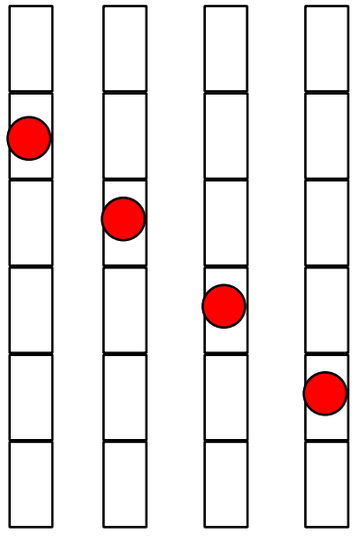
Summary

- Data taking of INGRID is stable.
  - No critical trouble and no miss spills during DAQ running.
- MC tuning & study is going on.
  - There are some effects needed to add more.
  - Comparison between MC and real data (beam, cosmic) is going on.
- MC will be used to estimate systematic errors.

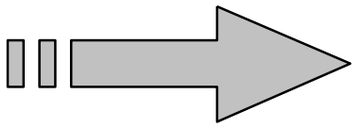
Back up

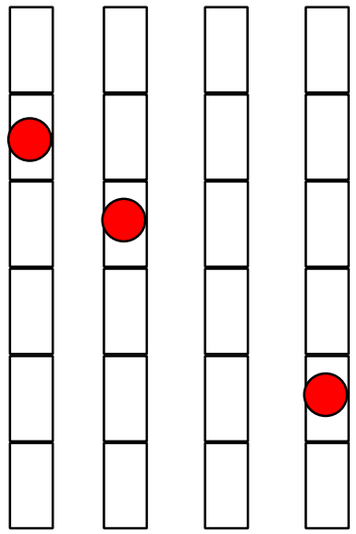
Efficiency of scintillators Algorithm

Testing 3rd plane

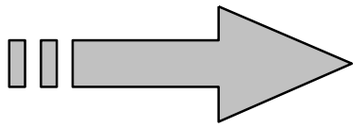


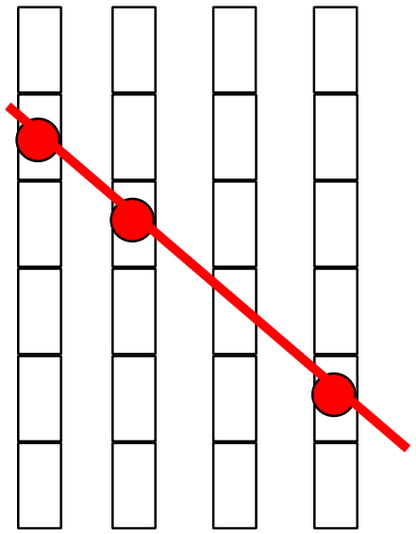
"turn off" studied plane



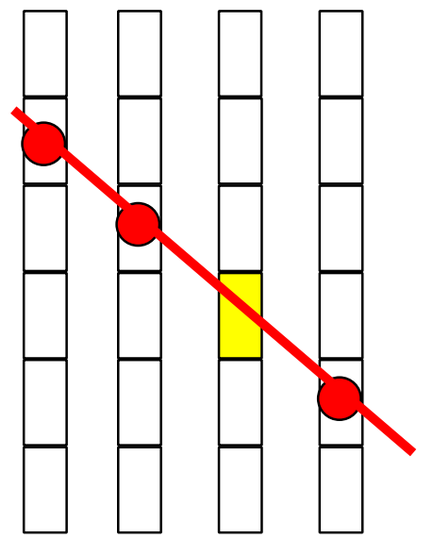


Do tracking

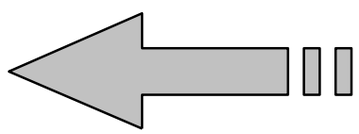


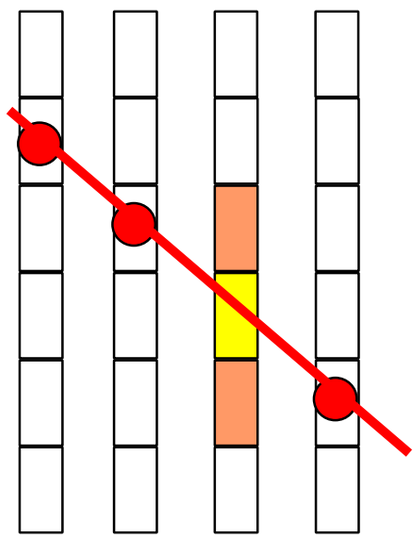


Determine scintillator where there should be a hit



Check there was a hit in this scintillator or surrounding ones





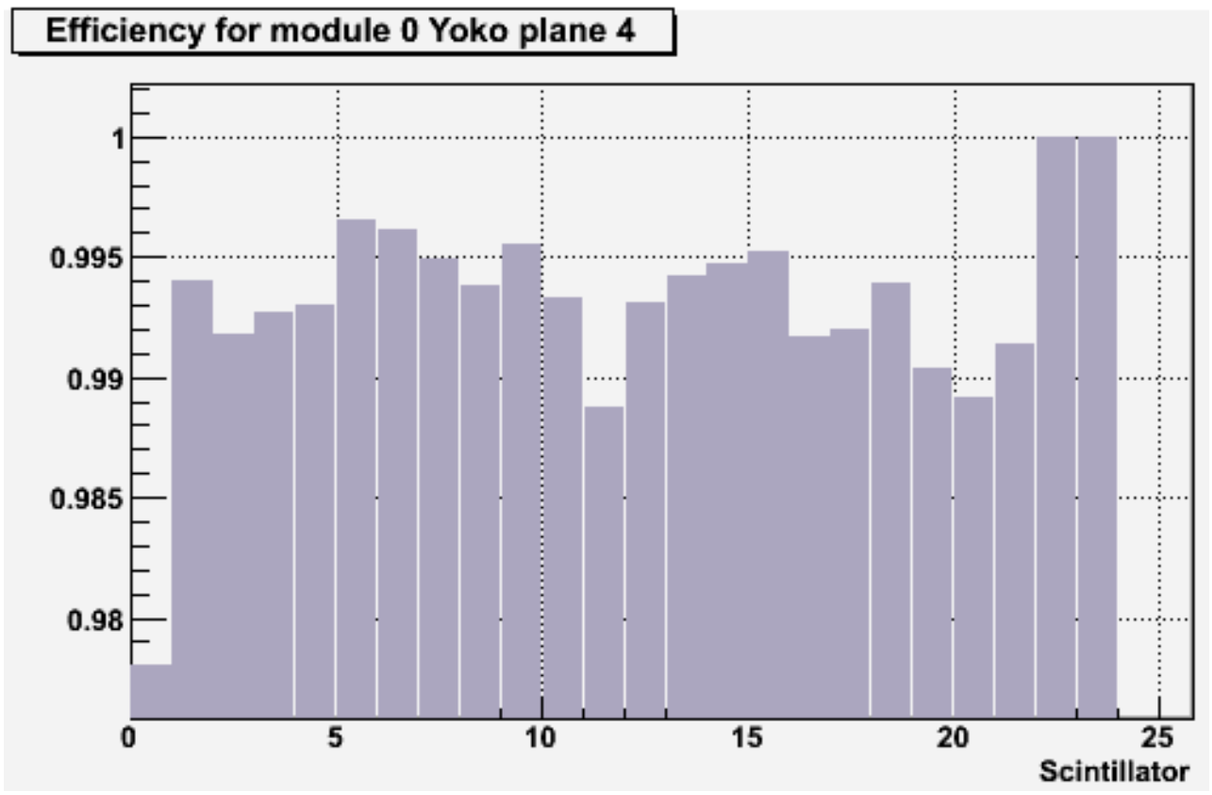
Statistics

Scintillator per scintillator efficiency not regular for beam. Probably comes from statistics.

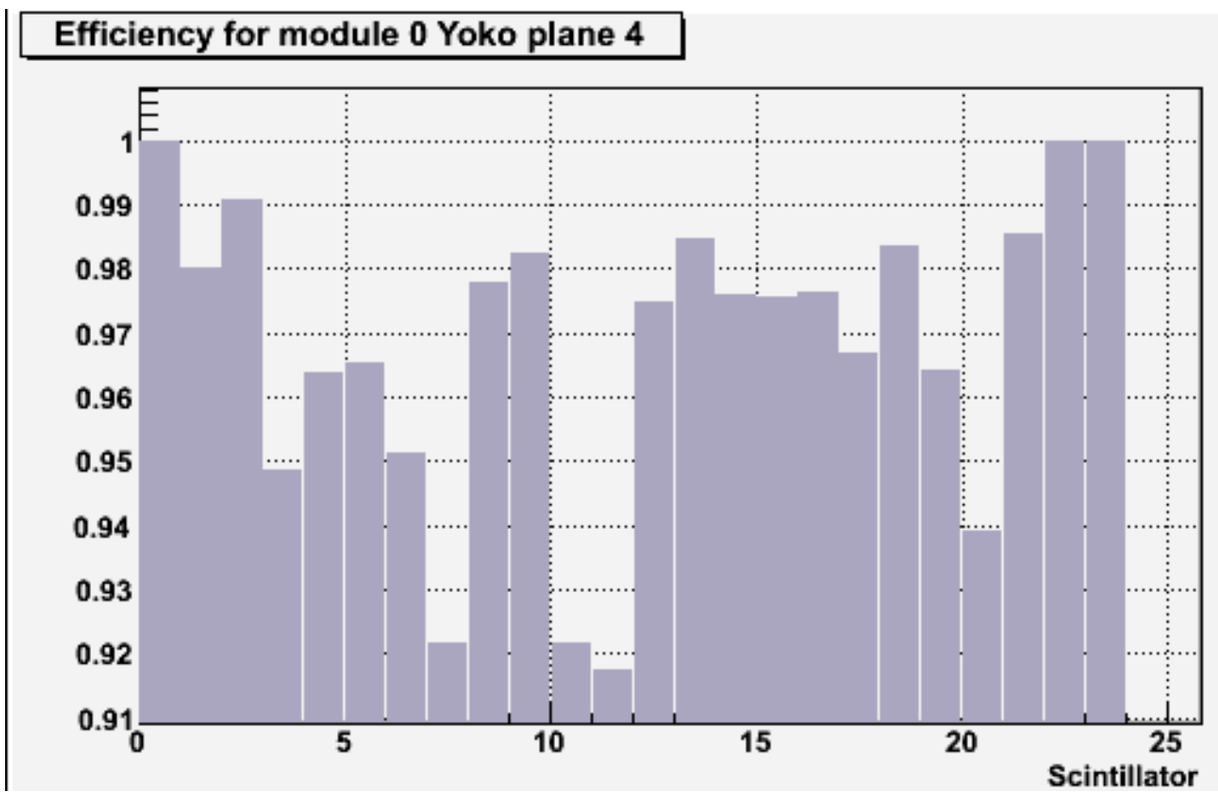
Cosmics: total entries= 32.693.787
stat error =0.017% for overall efficiency
stat error ~1% for one channel
Now trying to increase statistics

Beam: total entries= 1.067.314
stat error = 0.097% for overall efficiency
stat error ~10% for one channel

Example: module 0, Yoko TKP 4



Cosmics



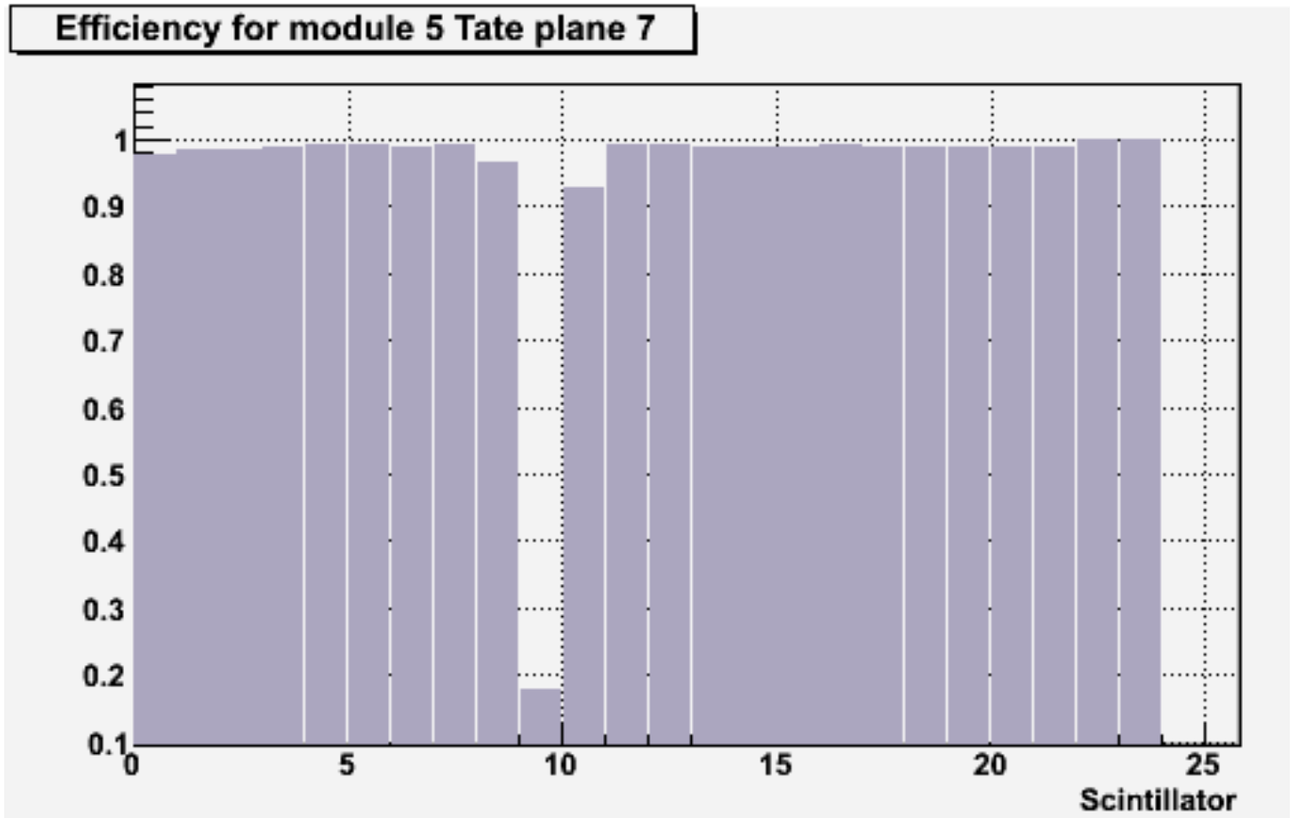
Beam

Dead channels

There are 7 known dead channels, out of 7392 considered channels.
This would give ~0.09% inefficiency.

Those channels were found by looking at their adc distribution, and are also seen by looking at their efficiency:

Scintillators efficiency of X plane 7 of module 5

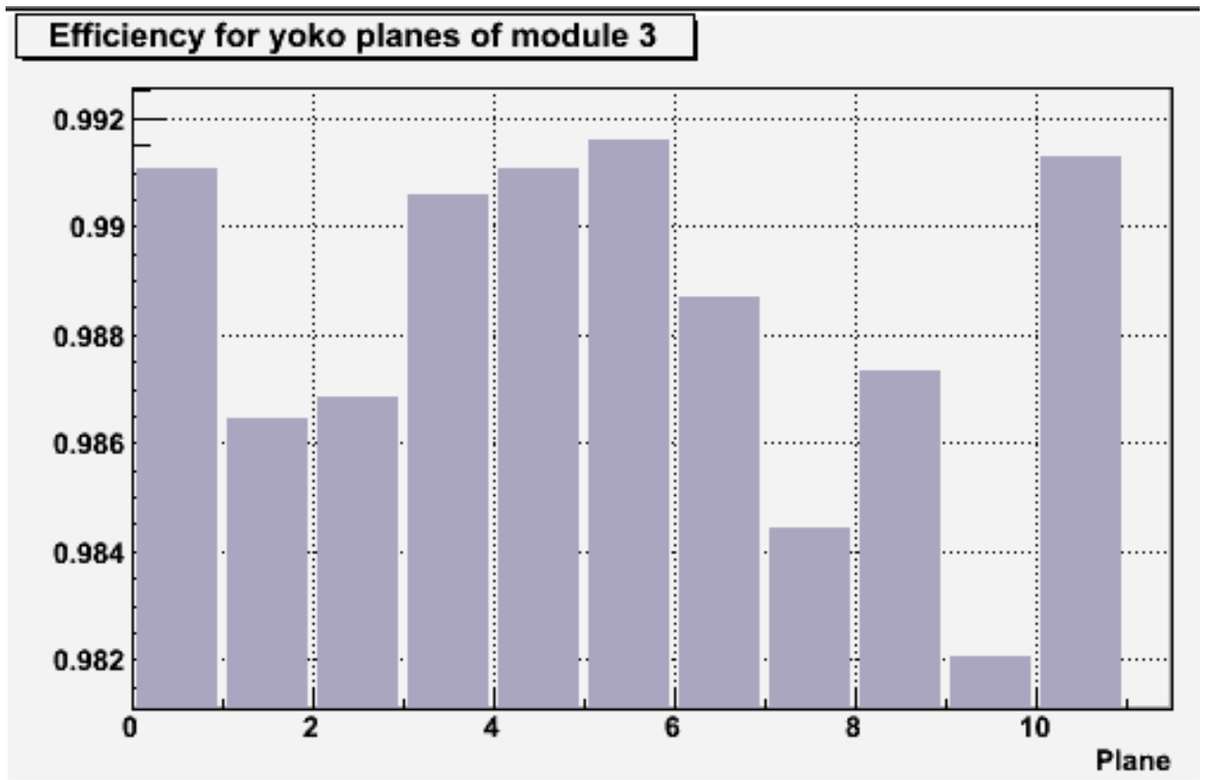


We can see that channel #9 is a dead channel

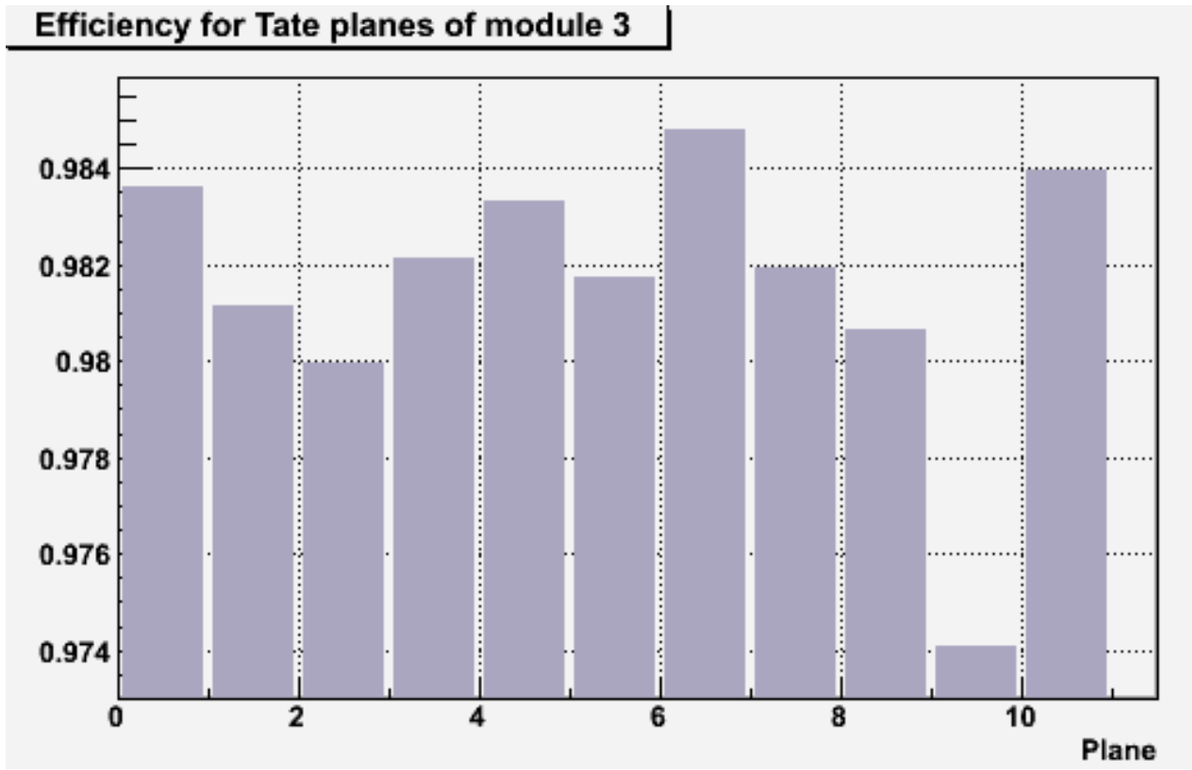
Module 3 efficiency

Plane by plane efficiency for module 3

Y scintillators



X scintillators



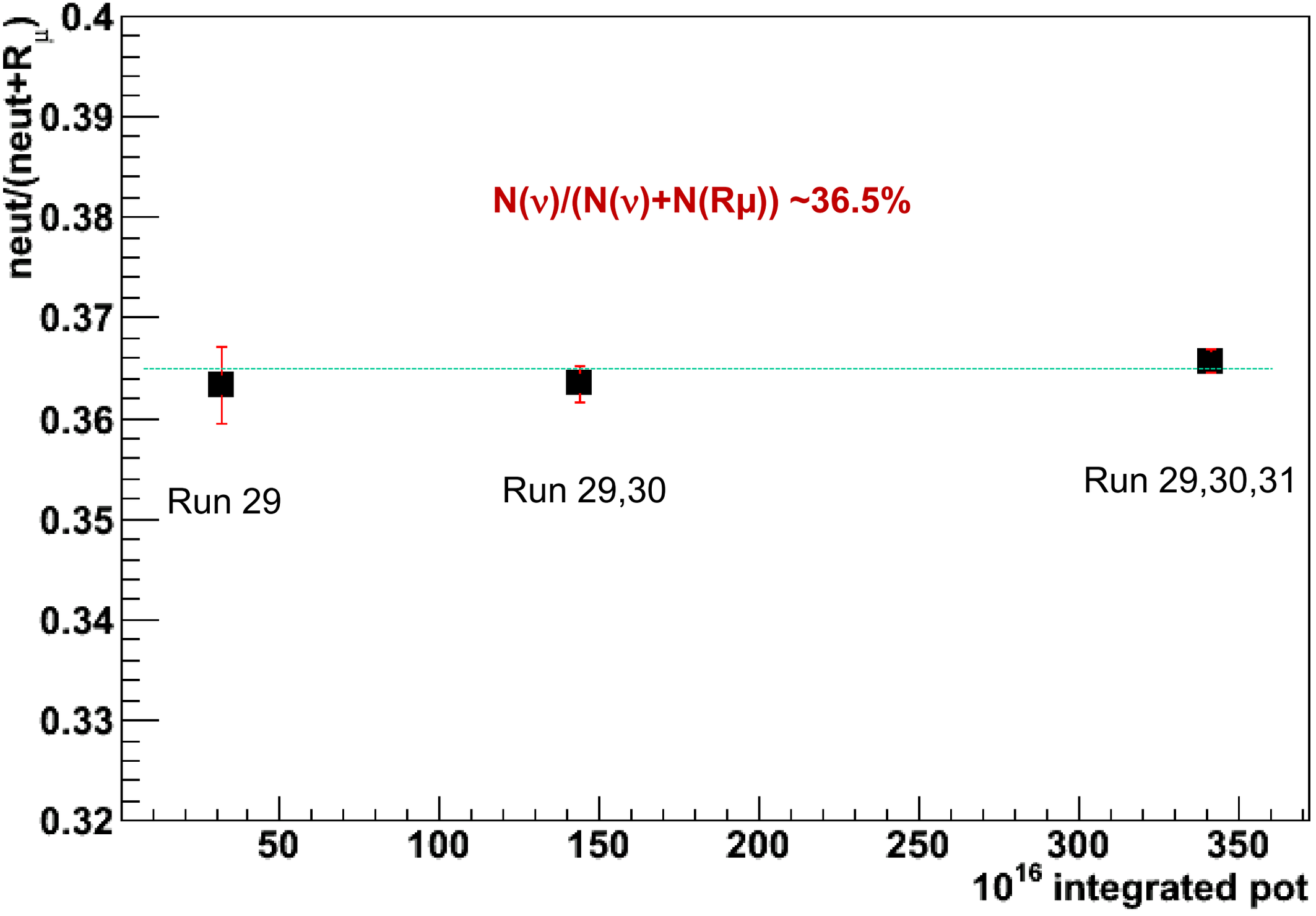
All modules average efficiencies:

Y scintillators: 99.29%

X scintillators: 98.67%

Module 3 clearly has lower efficiency than other modules

Number of rock muons compared to neutrino events



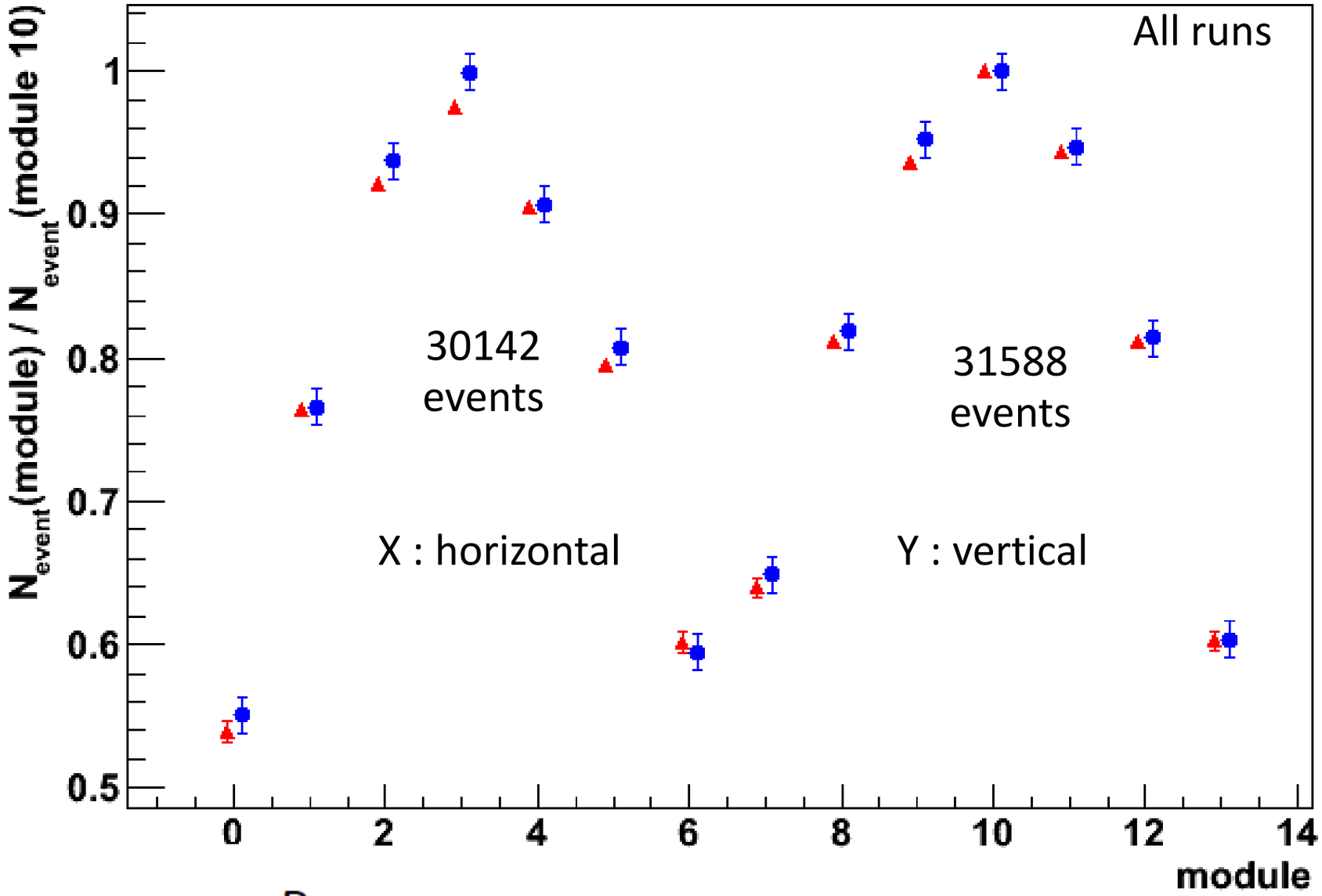
But here, rock muons may have a neutrino events contamination due to the module/module reconstruction

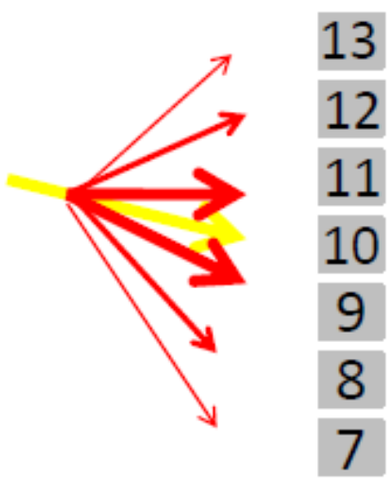
Number of events in each module

Number of neutrino events in each module comparison wrt number of events in module 10 (center vertical)

▲ Neutrino events

● Neutrino events in fiducial volume





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12
11
10
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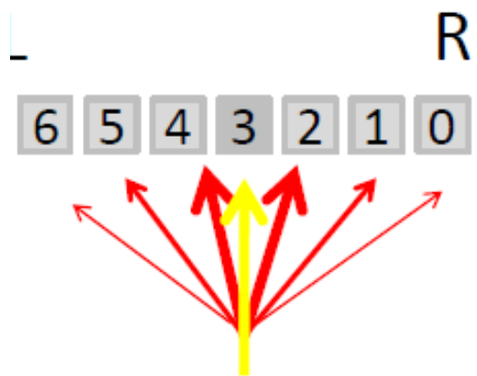
8
7



Vertical tower should have **~5 (±?) %** more events than horizontal bar :

Check : 30142*1.05=31649

Compatible with 31588 observed events.

MC tuning item

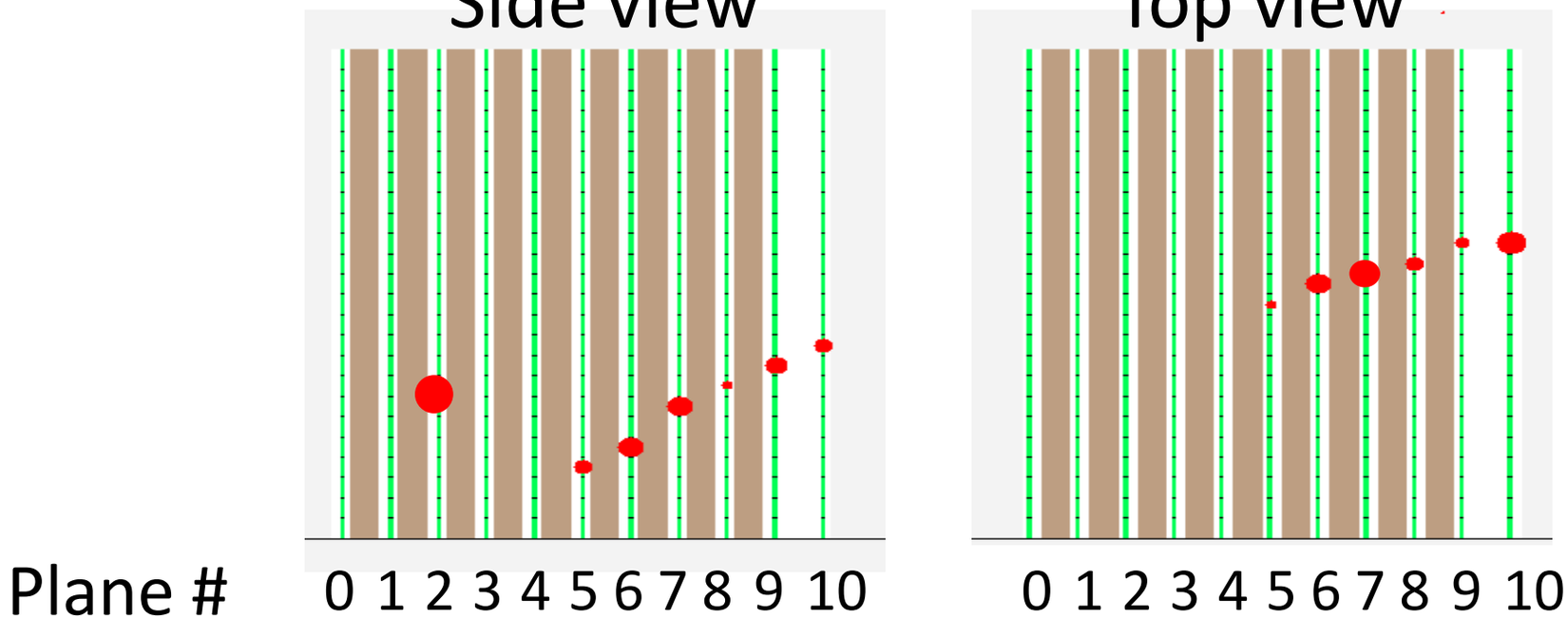
- Fiber attenuation → added to MC
- Scintillator quenching → added to MC
- MPPC response → added to MC
- MPPC dirk current noise → not yet
- MPPC - Fiber coupling constant → not yet
- Hit efficiency for each channel → not yet
- Hit time → not yet
- Electric response (p.e. > ADC, time > TDC, logical delay) → not yet

Many items are needed to consider.
But, not need for install all of these item soon.

Variables for selection of beam event

- Active plane(Plane#0 is not used. only plane#1 ~ 10)
  - Coincidence hit at side and top view(TDC threshold = 2.5p.e.)
- p.e. / active layer
  - (Total p.e. in active planes) / (# of active planes × 2)

example

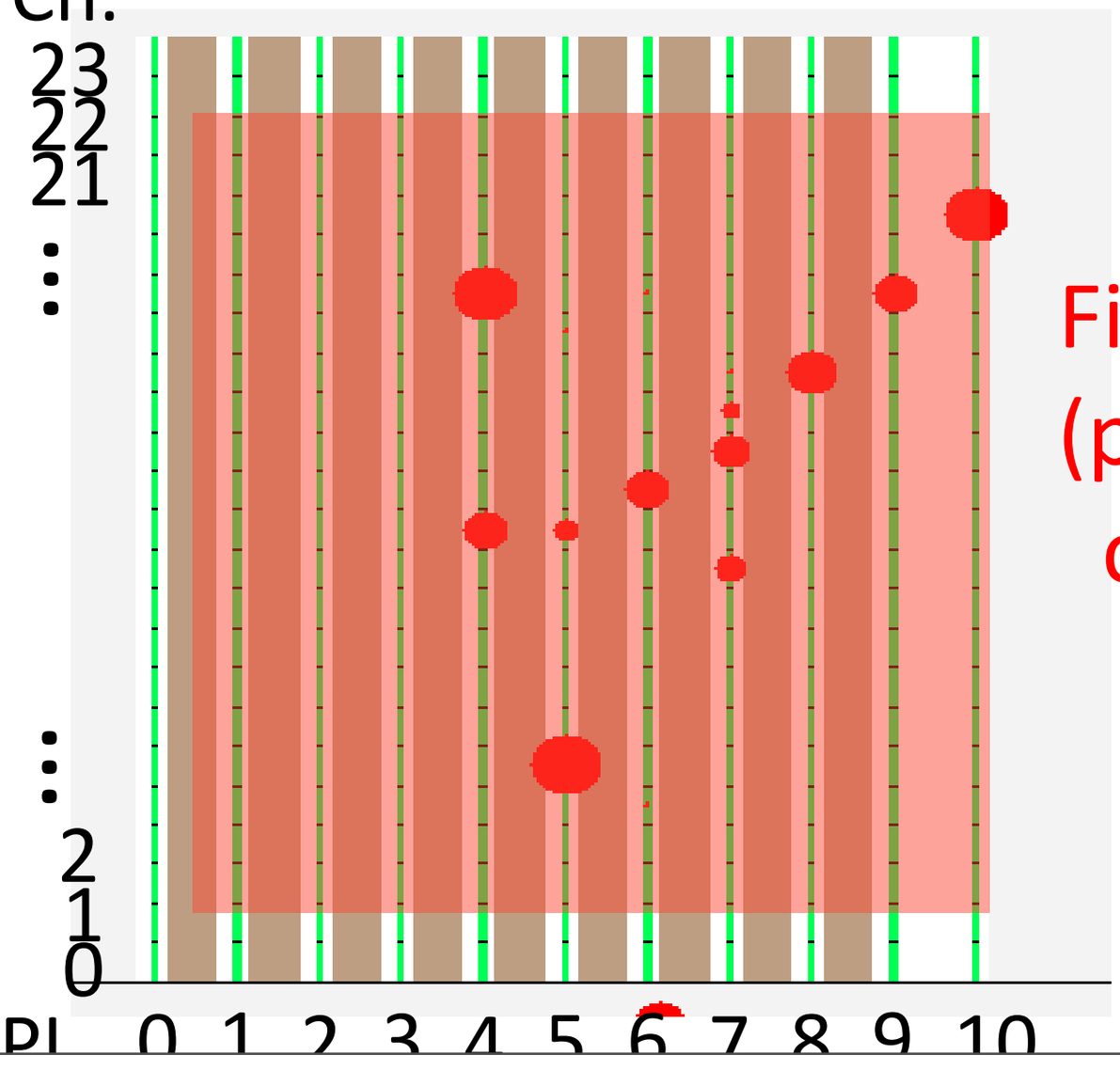


- # of active planes = 6(plane# 5 ~ 10)
- p.e. / active layer = total p.e. in plane# 5~10 / (6x2)

Fiducial volume cut

Because there is a gap(10~20cm) b/w tracking planes and VETO, particle from out side can not be rejected.

➡ We defined fiducial volume and selected the event whose vertex is within fiducial.



Fiducial volume (plane 1 ~ 10 ch.2 ~ 21)

INGRID plan

N^{SK} from N^{INGRID} w/ systematic error by the July ASG meeting.

- Already done
  - N^{INGRID} with some syst. error
- Next step
  - Estimate rest of syst. error(next page) and finalize N^{INGRID} with some syst. error