

WCDA++ data analysis and study of event match

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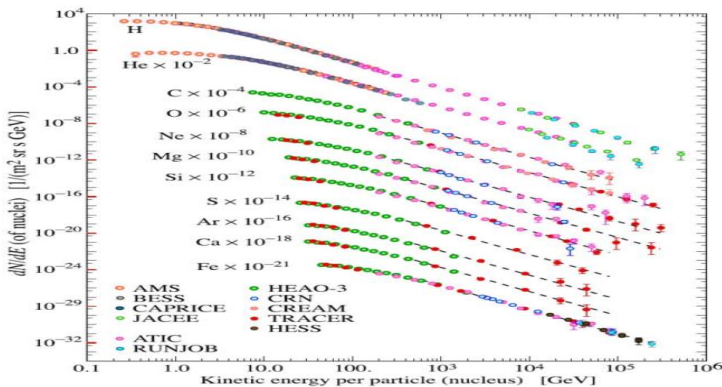
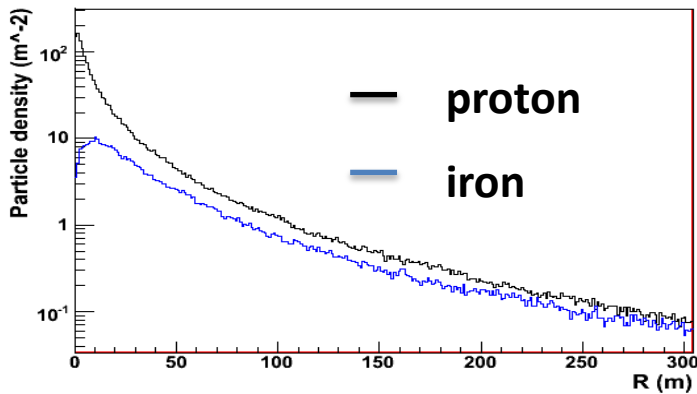
Institute of High Energy physics

Outline

- 1. WCDA ++ introduction and some simulation
- 2. single rate and muon spectrum of 1.5 inch PMTs
- 3. cosmic ray event match and correlation study
- 4. match of single background particles
- 5. summary

WCDA ++ introduction

- 1st WCDA pool, 900 1.5-inch PMTs aside the 8 inch PMTs
- Aim: work with WCDA and WFCTA to measure energy spectrum of different species of high energy cosmic rays.
- Function: core reconstruction, PID, energy scaler transfer



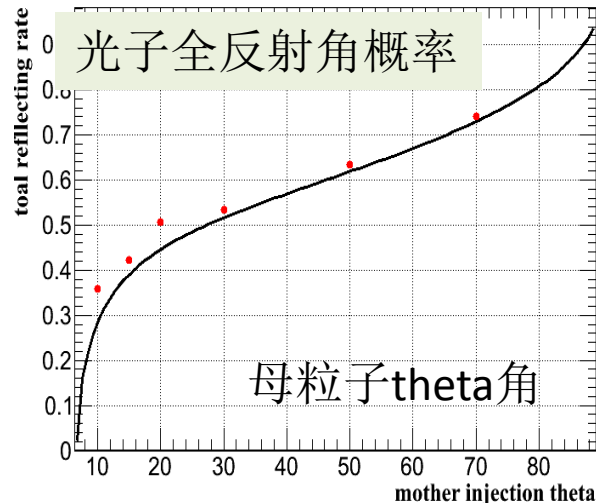
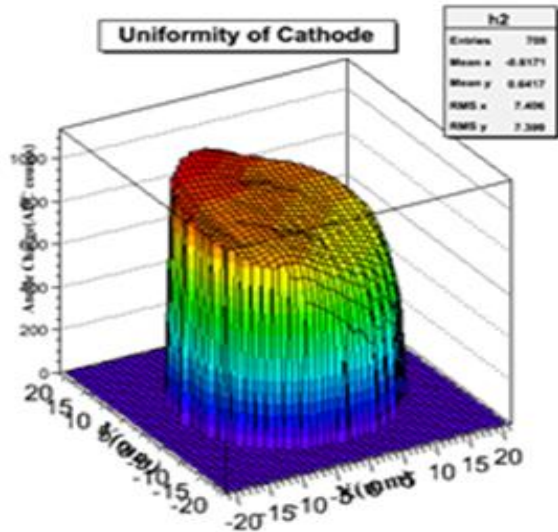
PMT performance

PMT XP3960, effective diameter 3.2cm, sealed in glass with air in it.
Electronic system supplied by Sichuang University

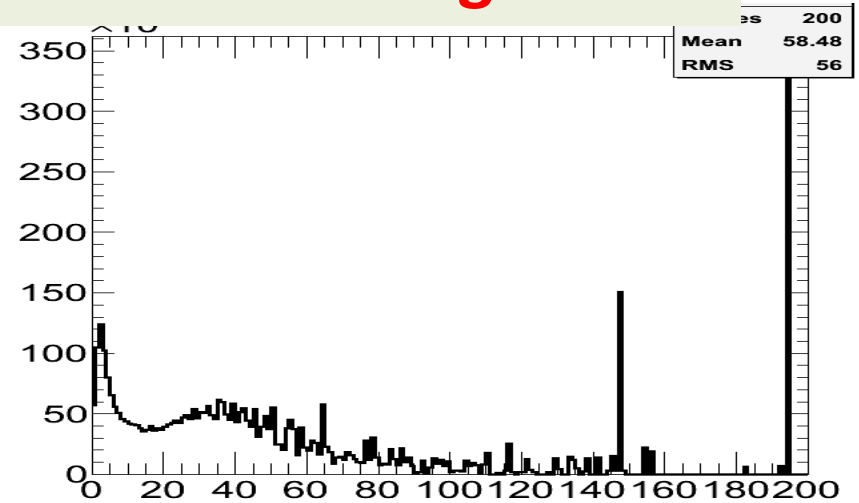
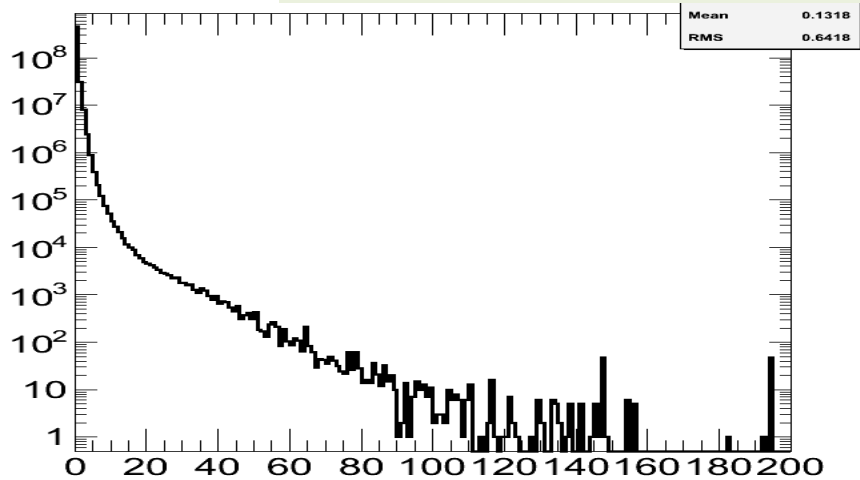
- PMT Test stage:

1. tested by Shangdong University in dwtail
2. batch test before installation, with electronics
3. Dry run after installation
4. with water

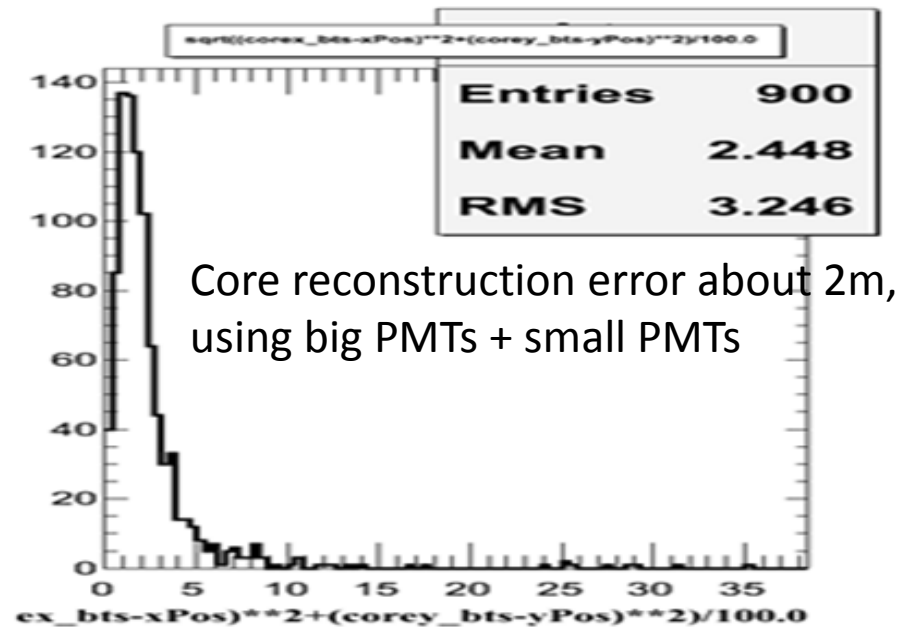
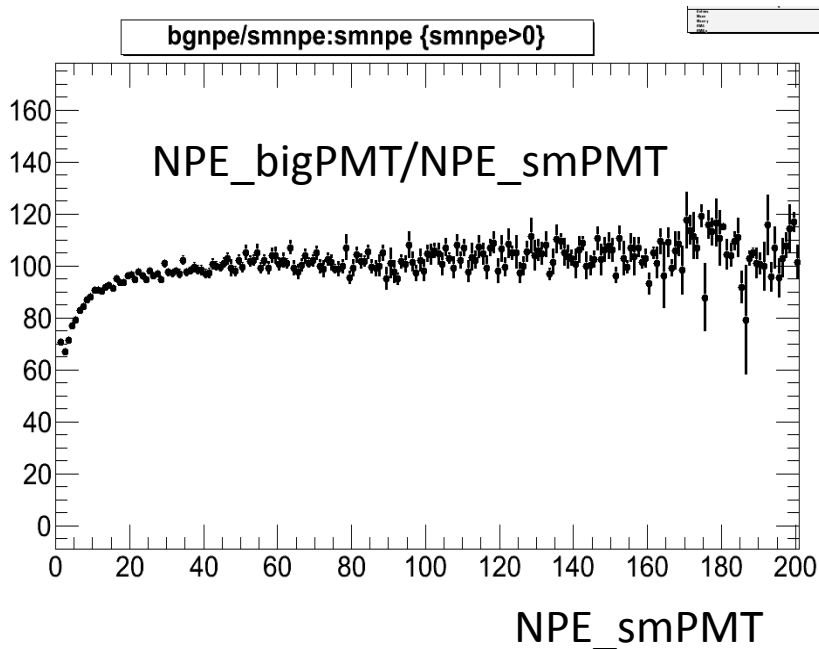
Three characteristics: Position inconsistency, total reflection effect, combined system



Muon background simulation of single PMT



Cosmic ray simulation of whole array



WCDA++ charge calibration method

- 1. LED fiber test
- 2. single muon signal
- 3. correlation of big and small PMTs

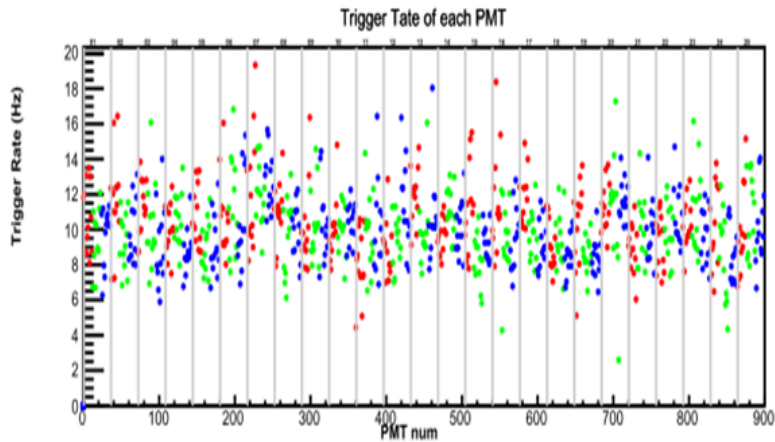
Emphasis of WCDA++ data analysis in the first stage

- 1. daily check to make sure every PMT works.
- 2. charge and time calibration, and muon peak
- 3. event match study to make whole work together

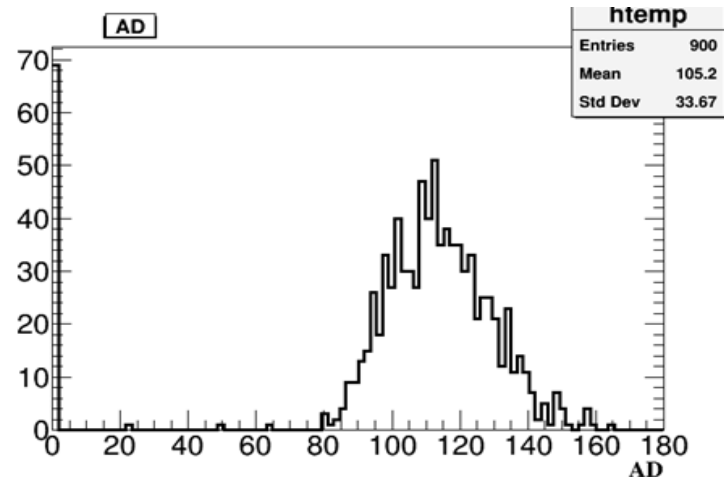
Data taking of WCDA++ now: hits of single channels bigger than threshold

Regular data check of WCDA++

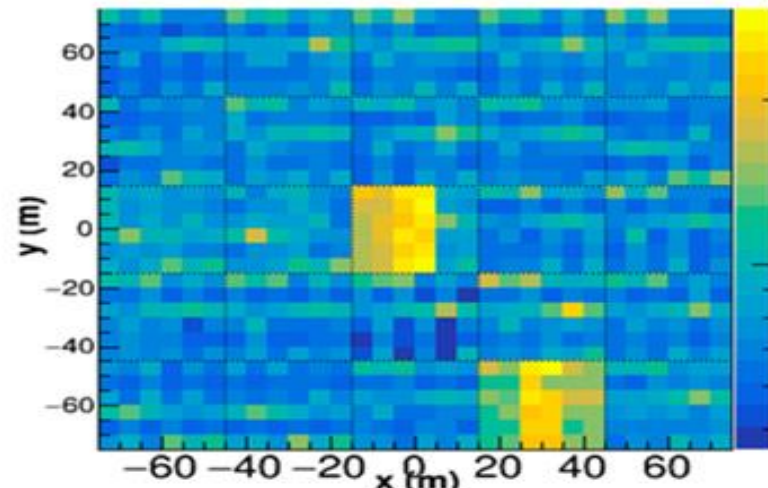
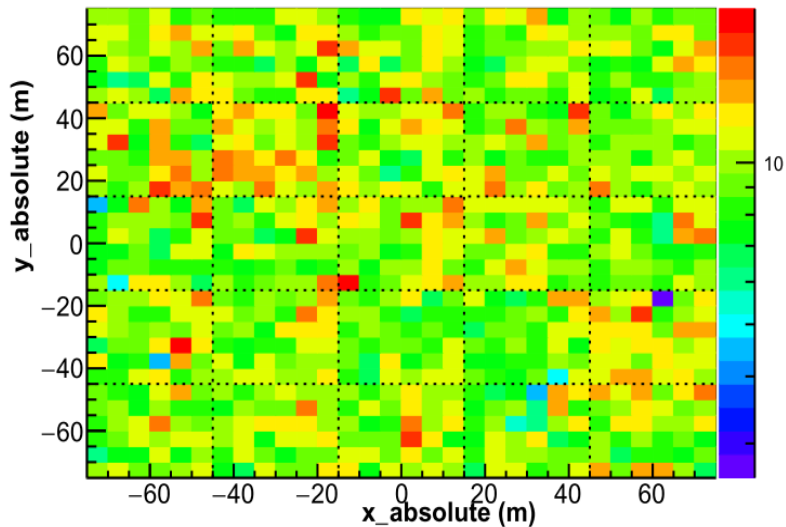
single rate, signal mean_RMS, ped mean+RMS, A/D



Trigger rate (Hz) of each PMT position

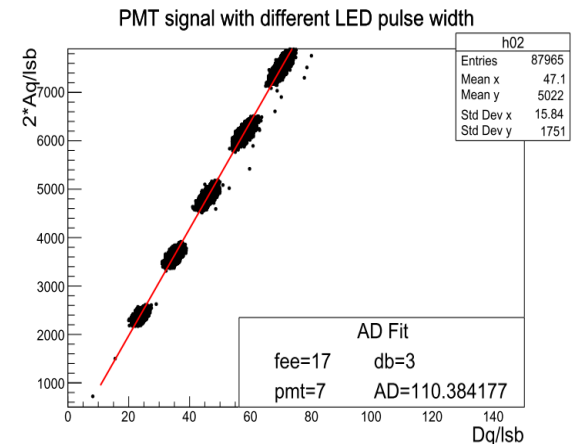
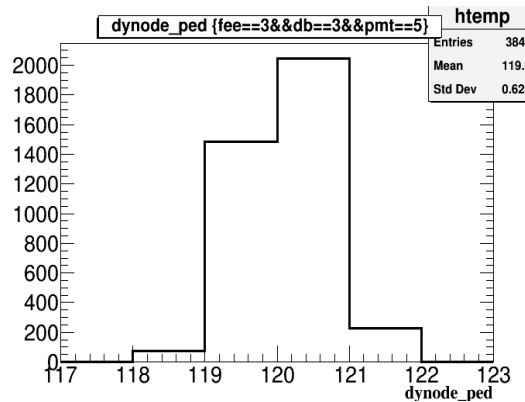
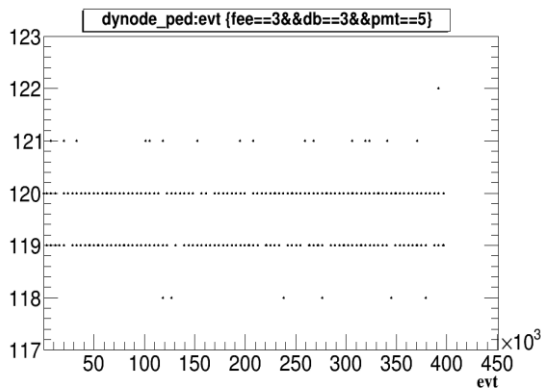
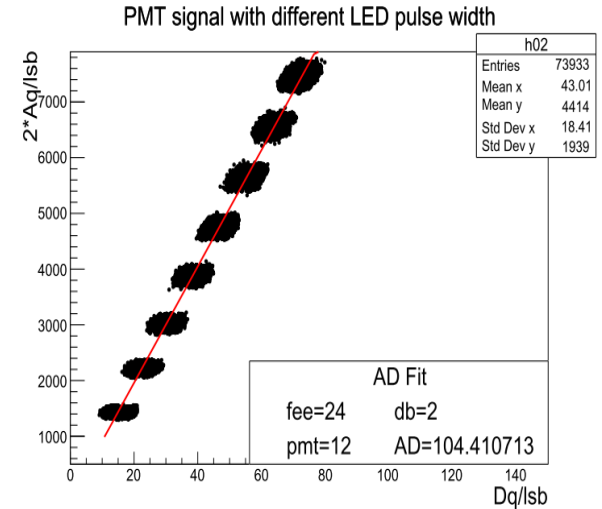
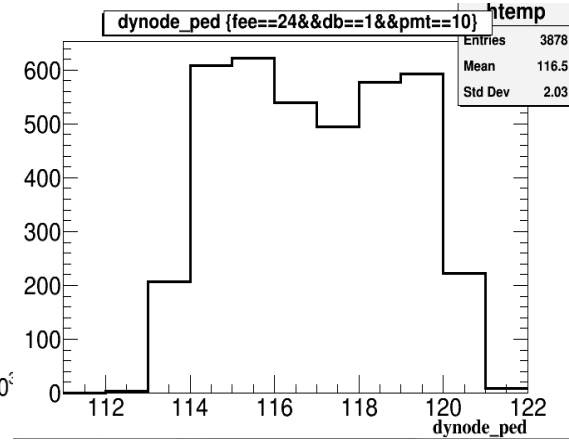
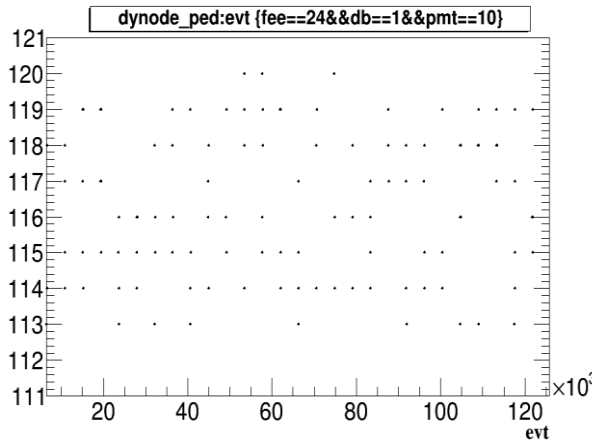


RMS of dynode_ped

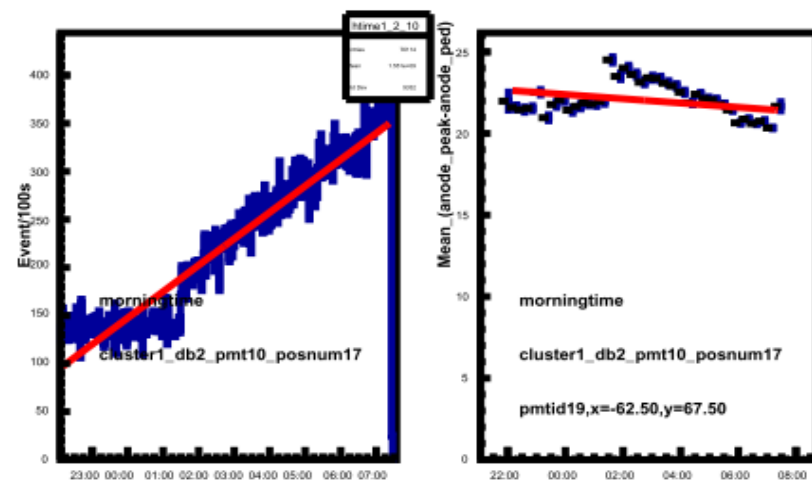
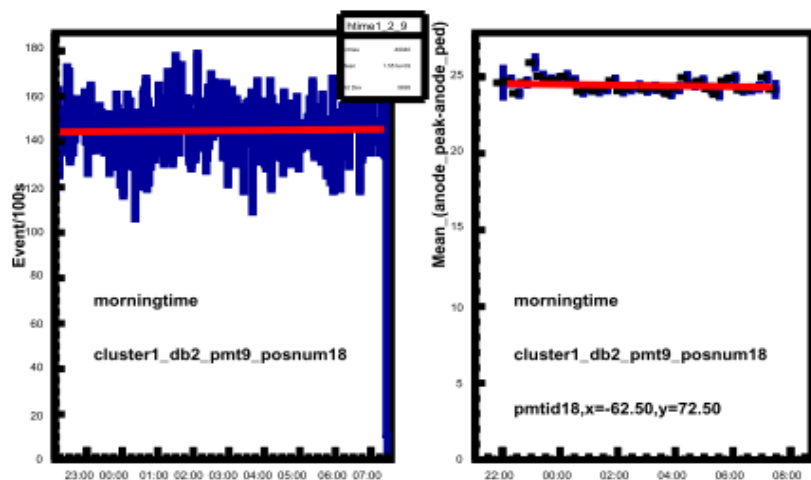
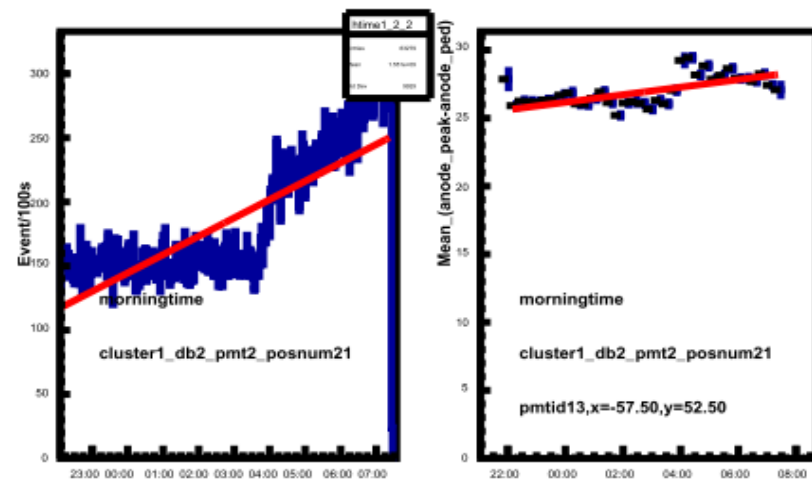
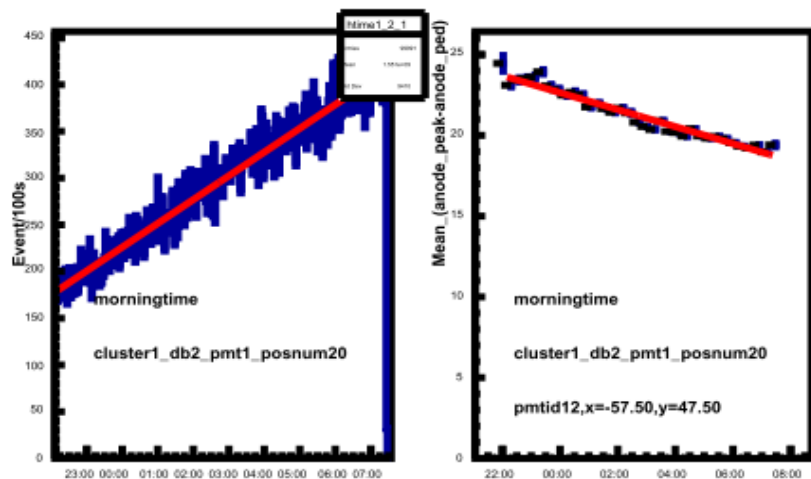


Most works well with good performance, with a few some problems

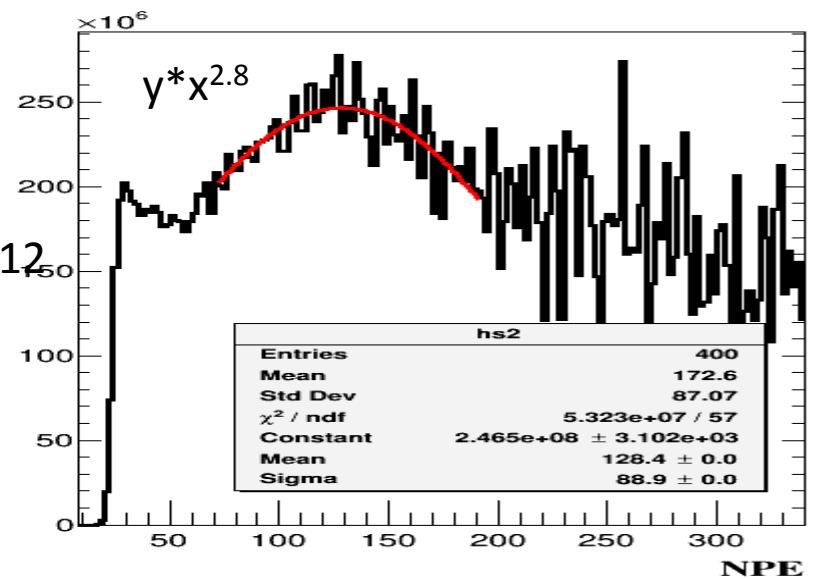
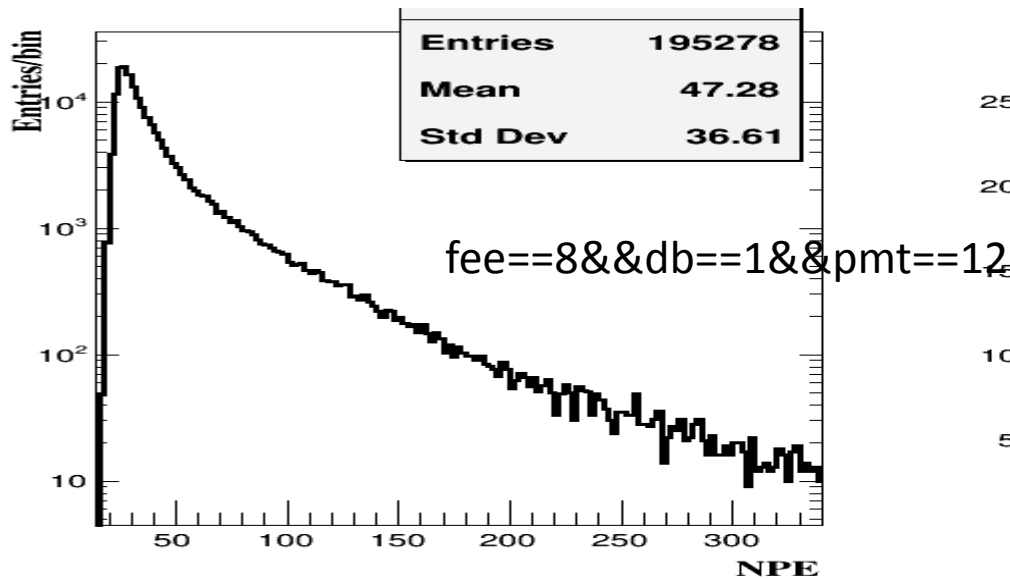
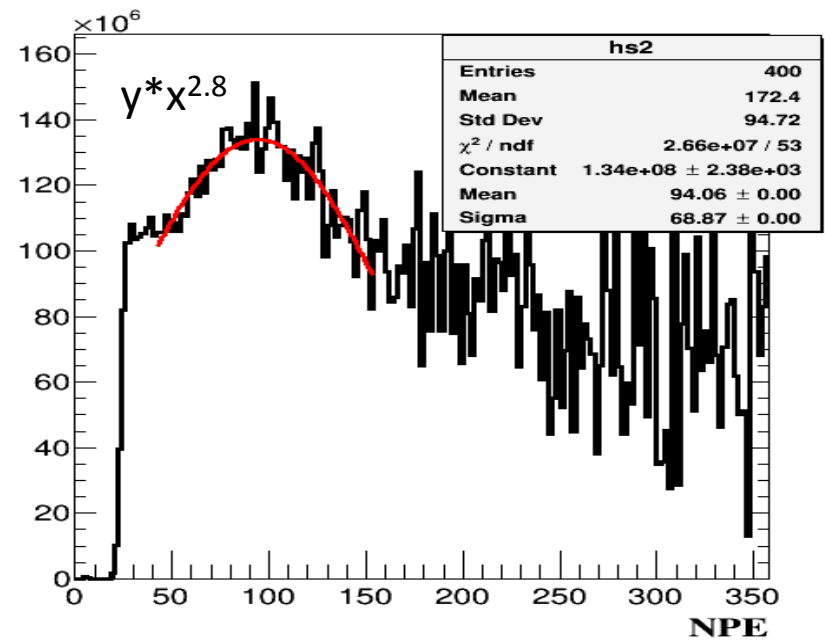
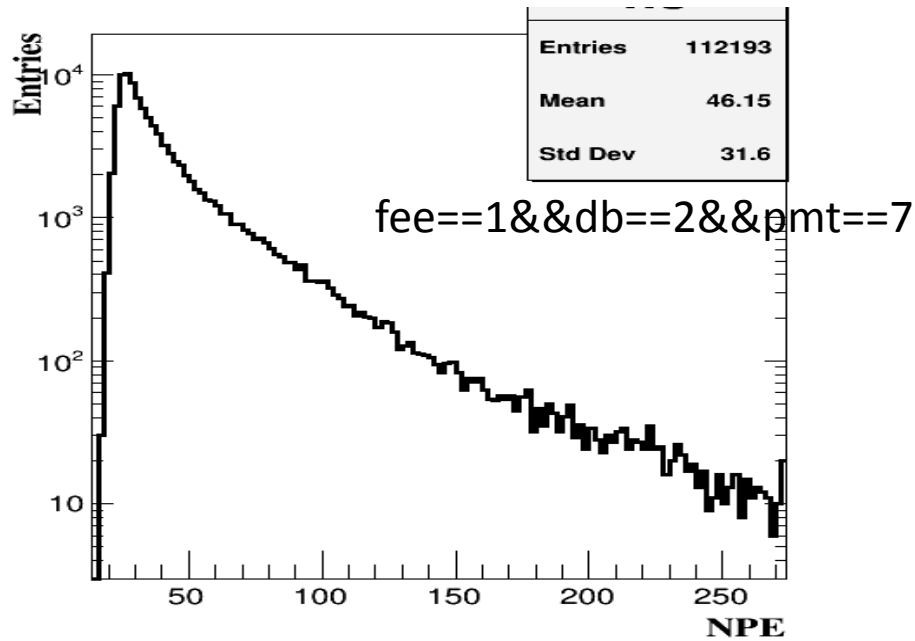
1. The ped of some channels broad.
2. three channels with A/D abnormal
3. one cluster with power unstable
4. some broken and prepared



The water submerged most small PMTs at 2019/03/01



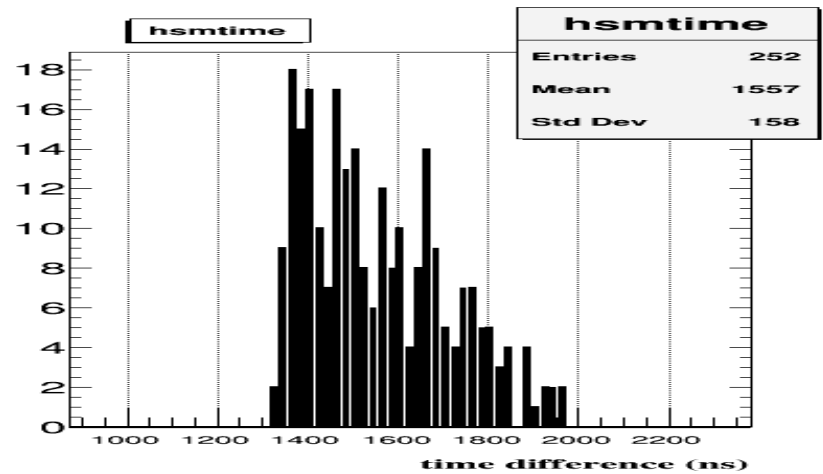
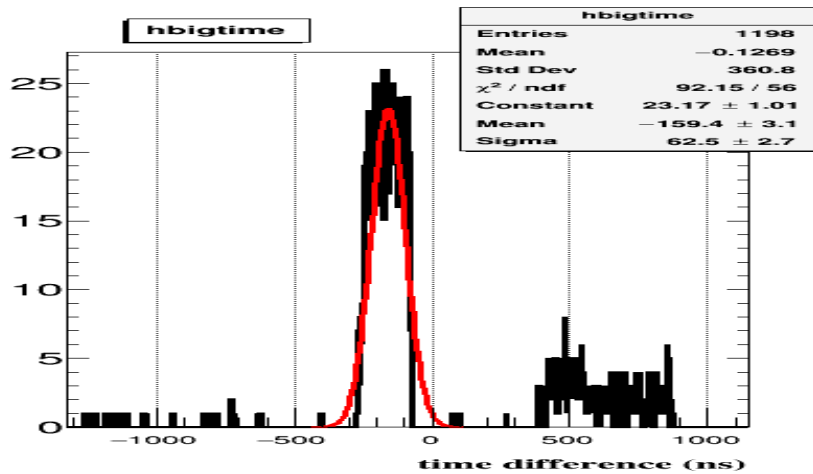
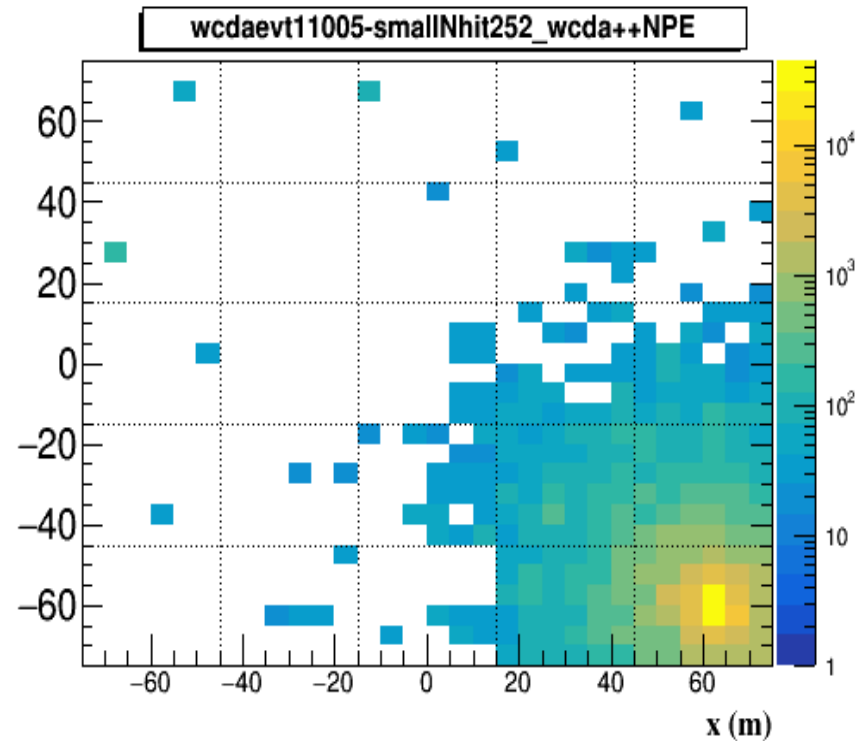
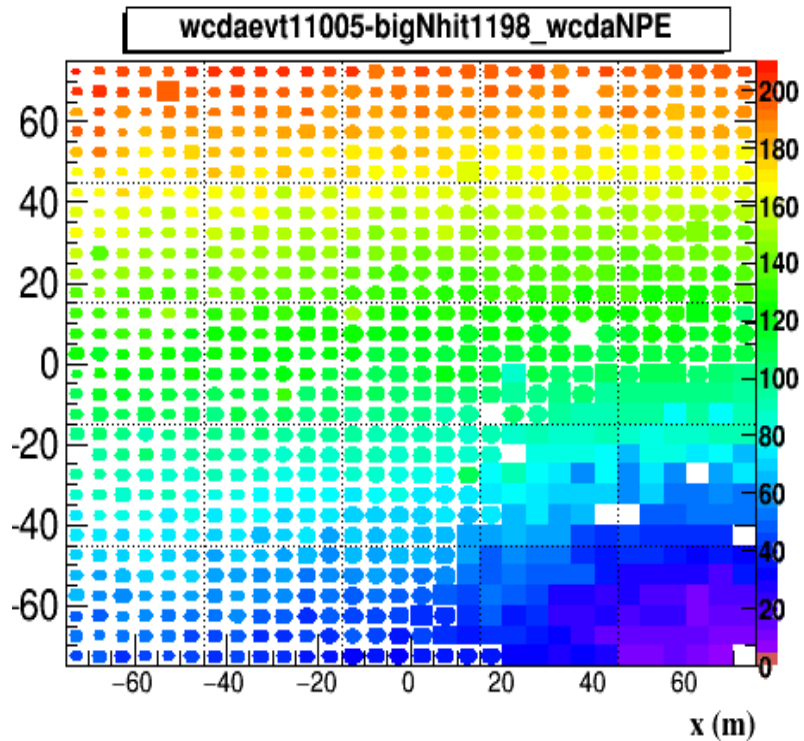
WCDA++ NPE of single muon (in water)



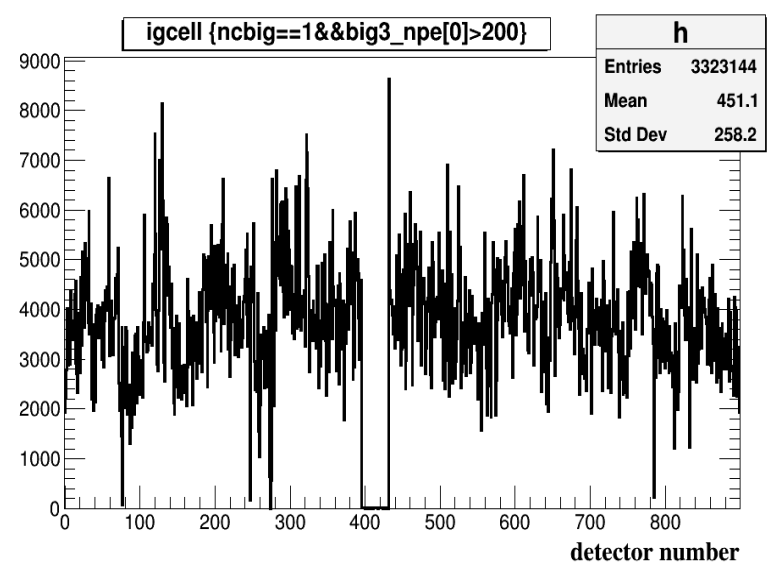
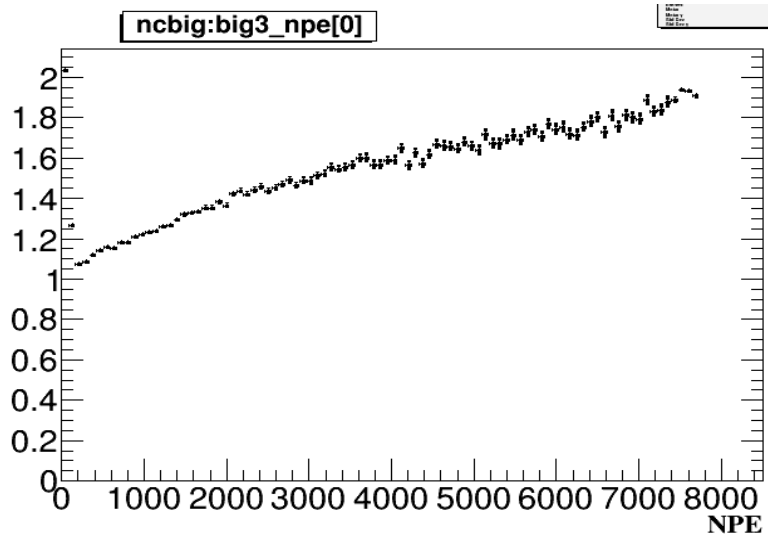
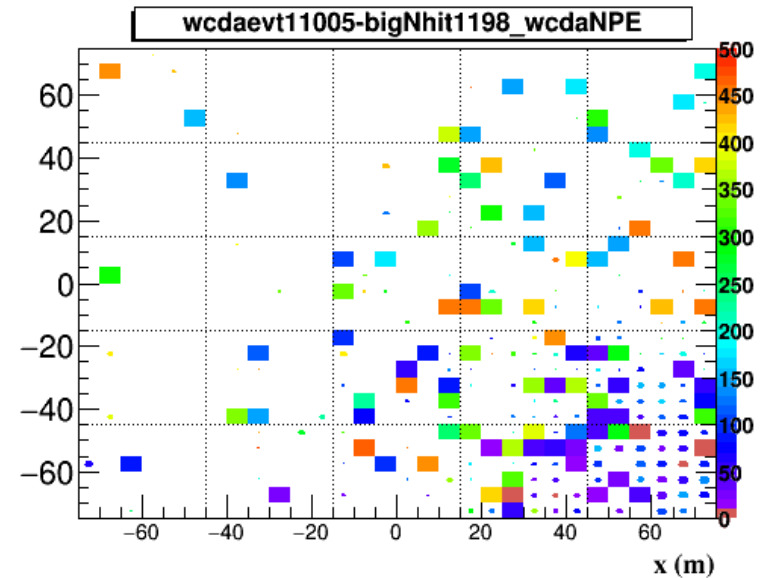
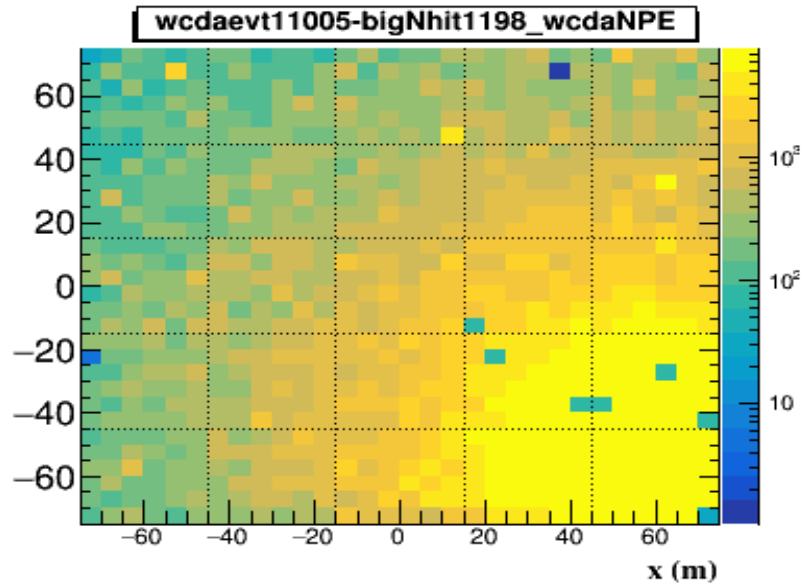
Event match of cosmic ray events with big and small PMTs

- 1. Sort the hits of small PMTs with time
- 2. Find the cosmic ray events of big PMTs, gather the small PMTs in $\pm 2\mu\text{s}$ time window. Fill new events with big and small PMT hits
- 3. Each unit match to study the correlation
- Automatically matched the data of more than 10 days

Event show of one matched cosmic ray event

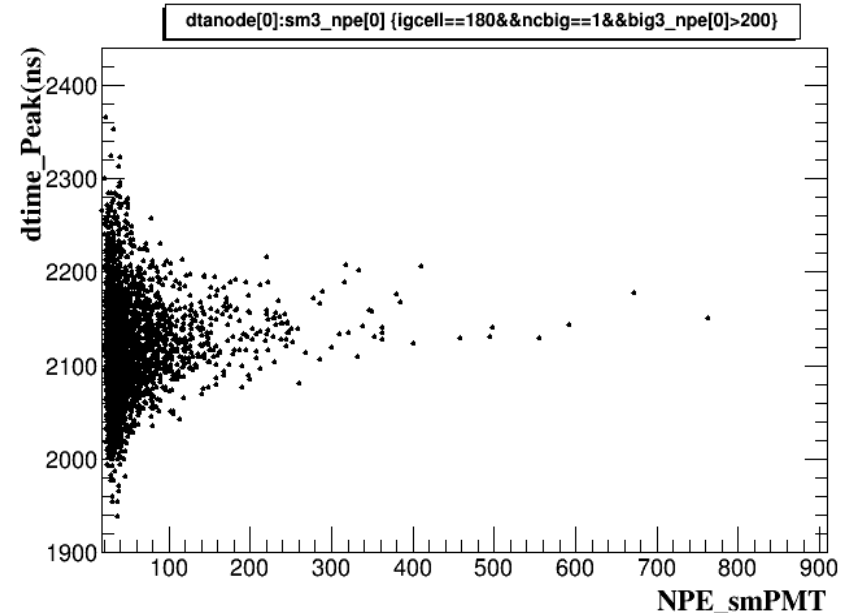
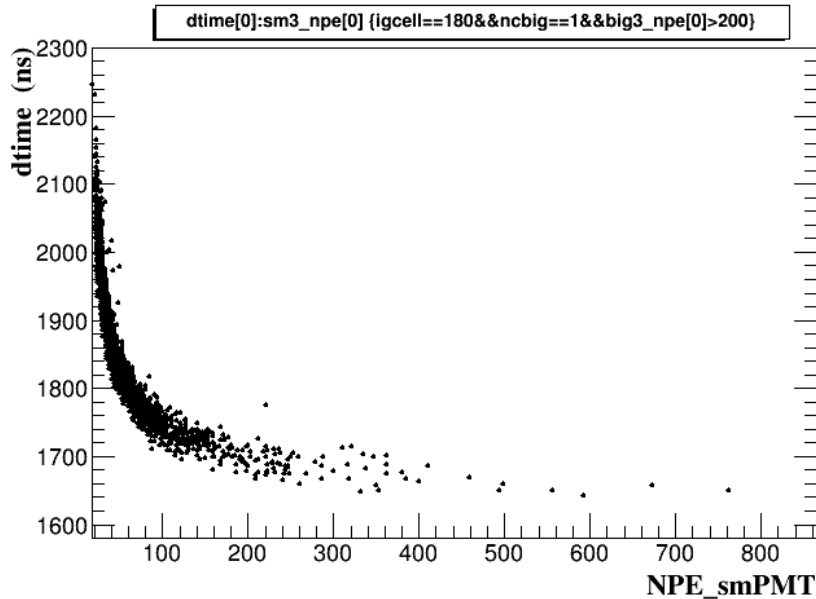
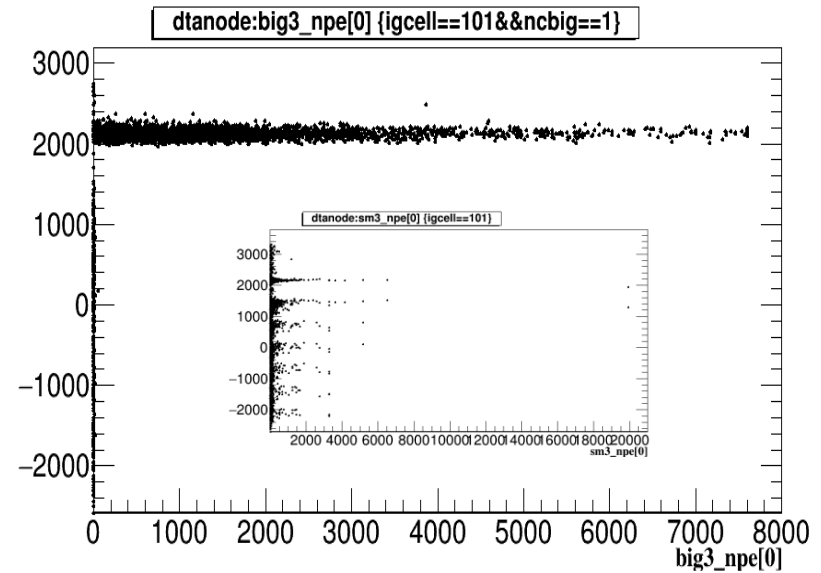


The after pulse and random signals of big PMTs

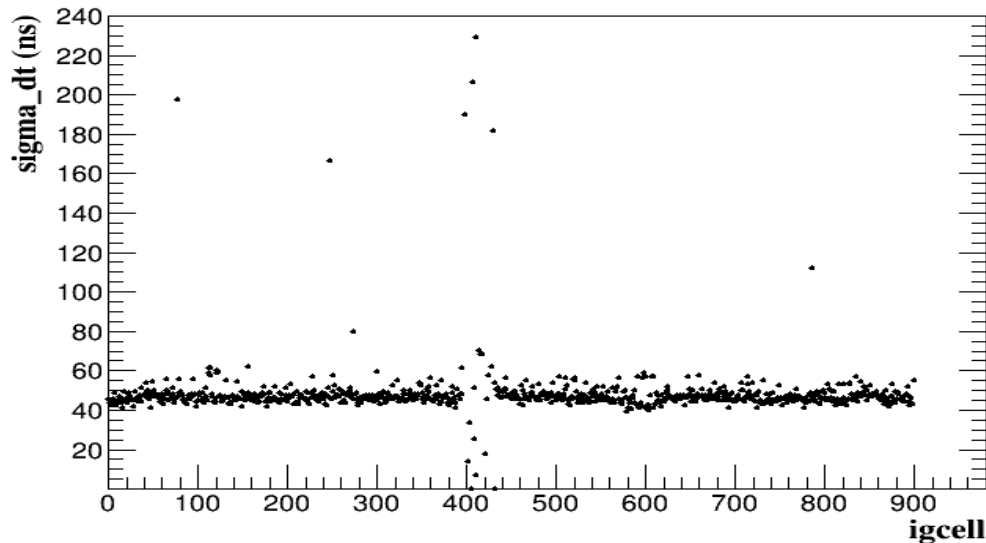
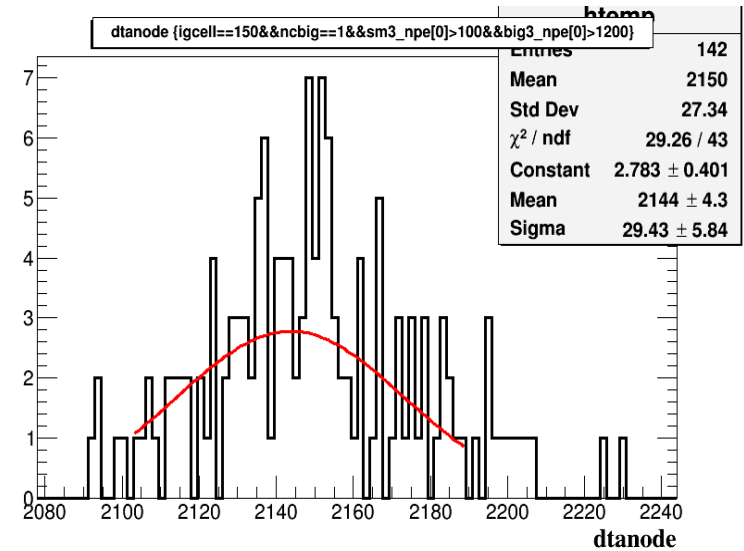
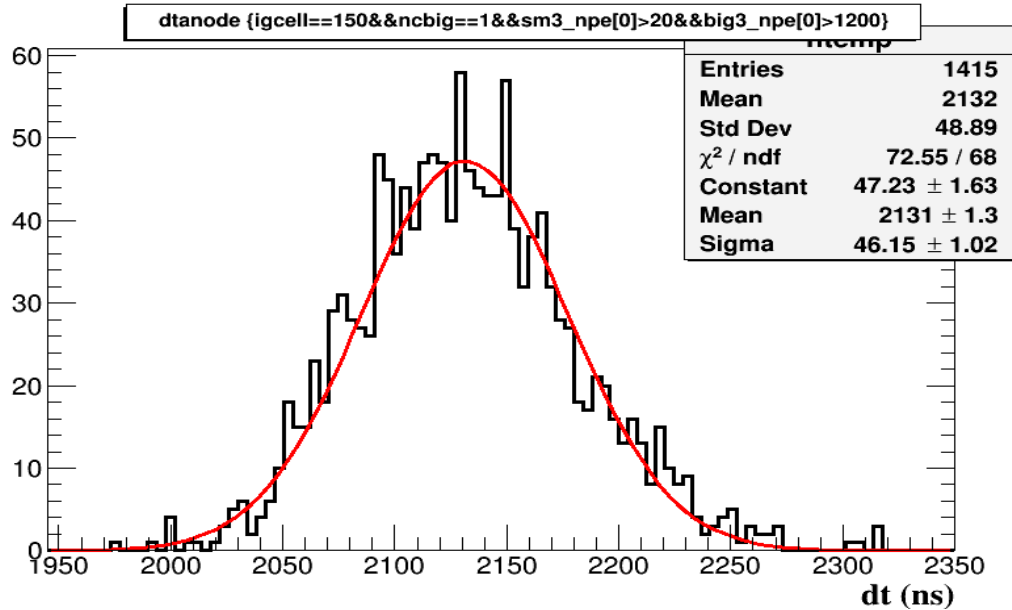


The resolution of time difference

The time resolution of small PMTs with small signals is larger than big signals, because of electronic design

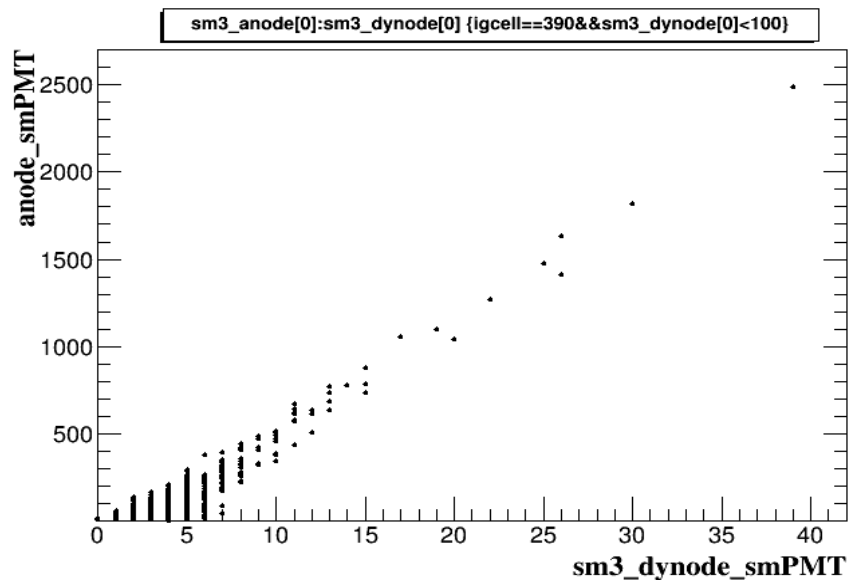
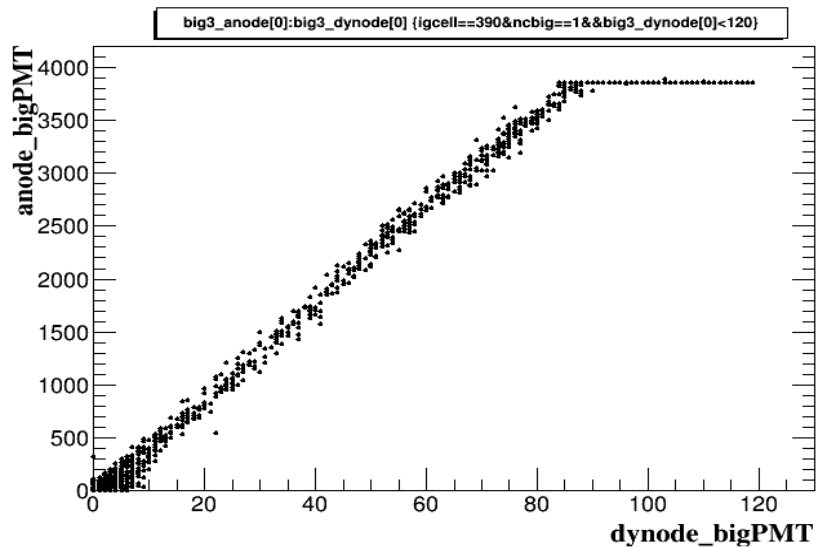
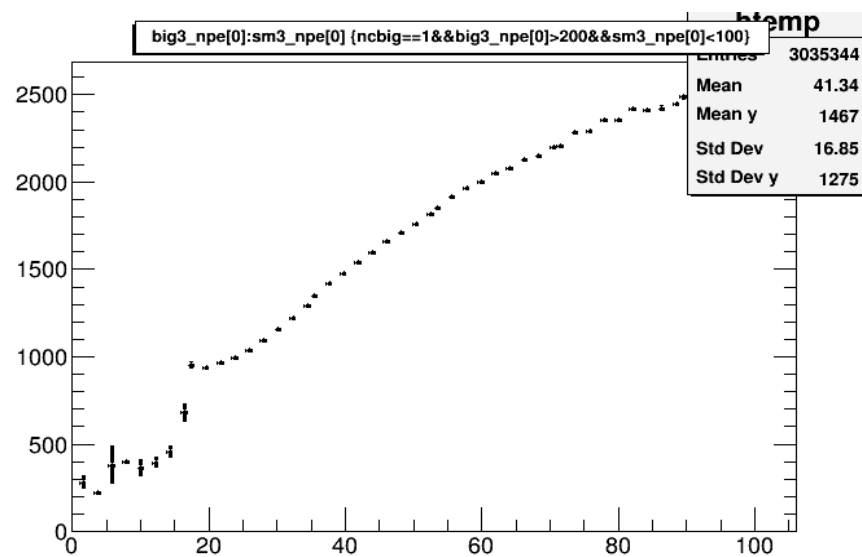
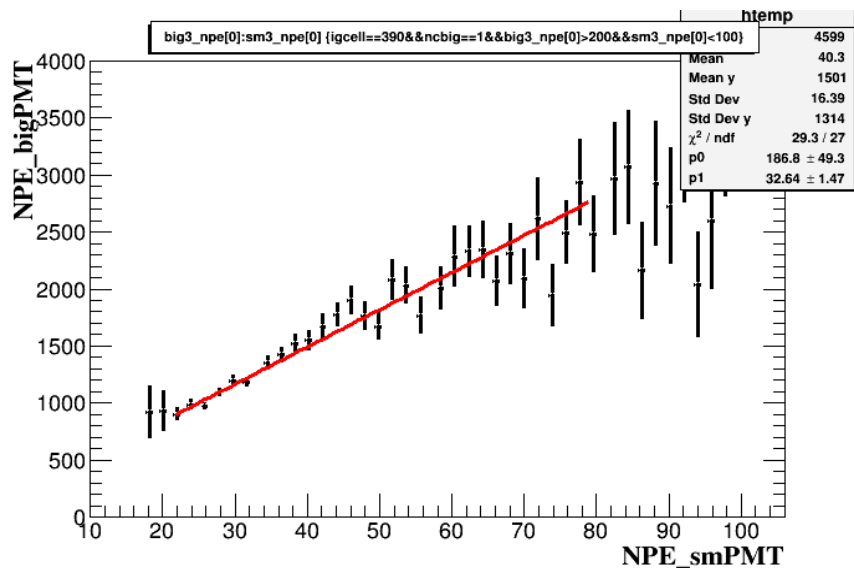


The time resolution of each PMT



The time resolution of most small PMTs is about 50 ns in the work region, and about 30 ns for big signals

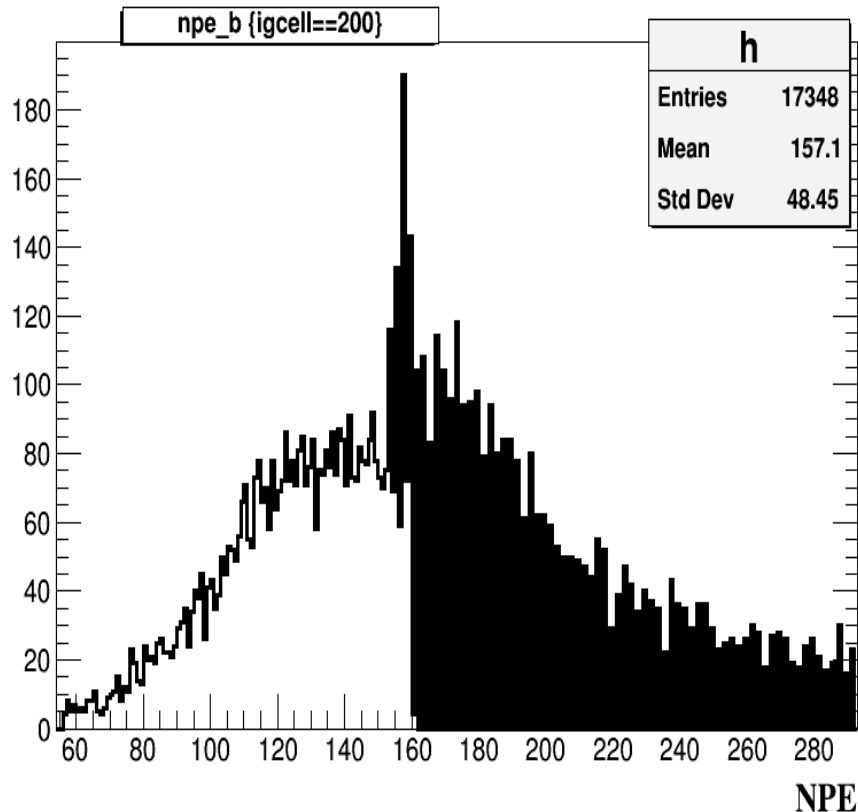
The correlation between big and small PMT of each unit can be studied using the matched data, as well as the A/D and data check.



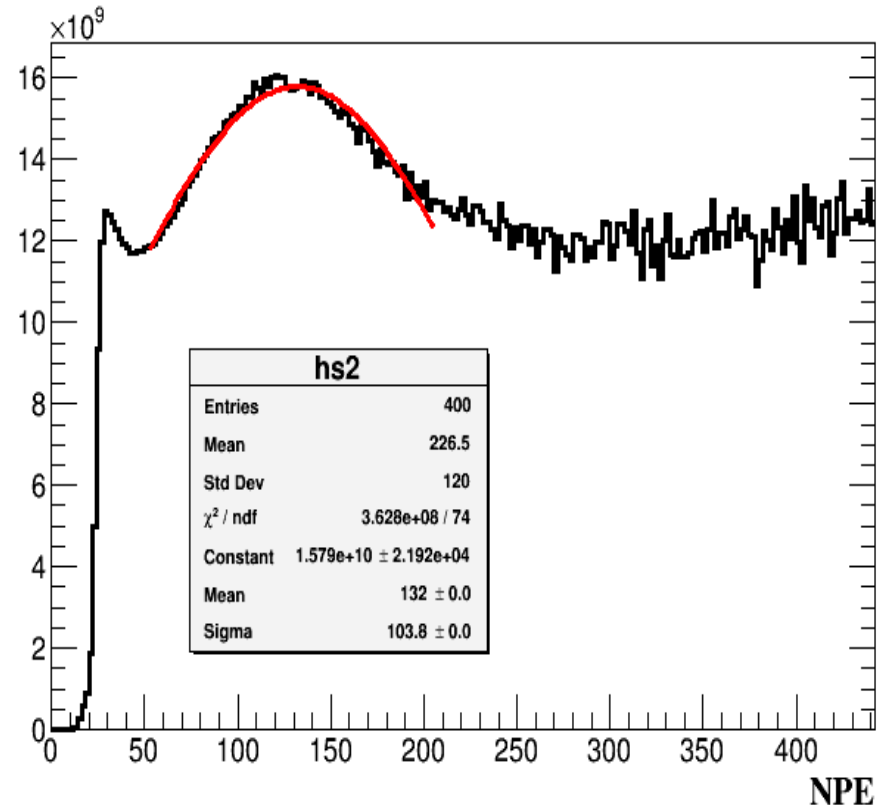
Match of single background particles

Single background data of big and small PMTs, require hits $\pm 4\mu\text{s}$ time window for both big and small PMTs in the same cell

NPE of big PMT

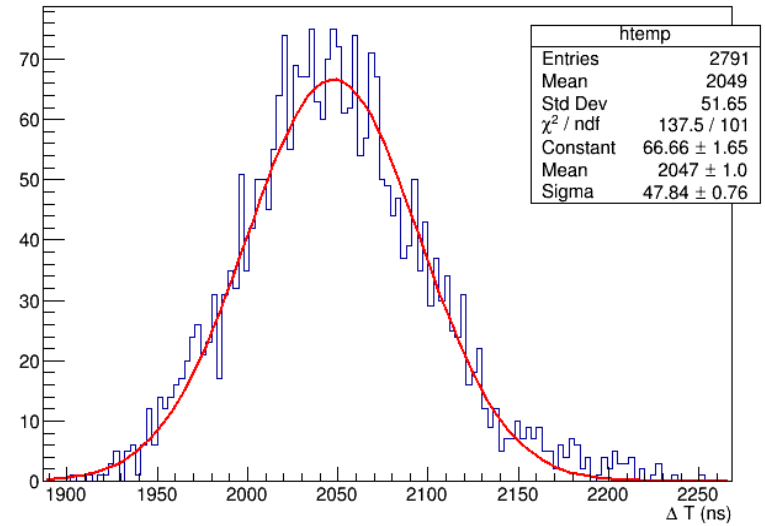
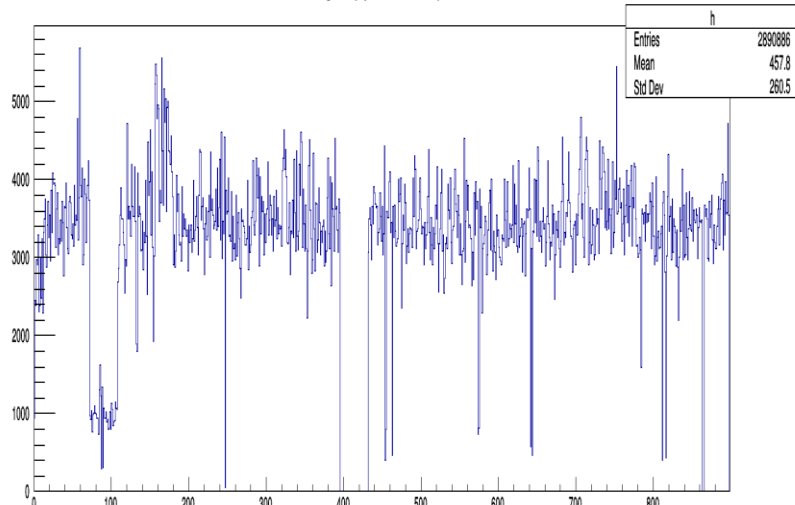


NPE of small PMTs

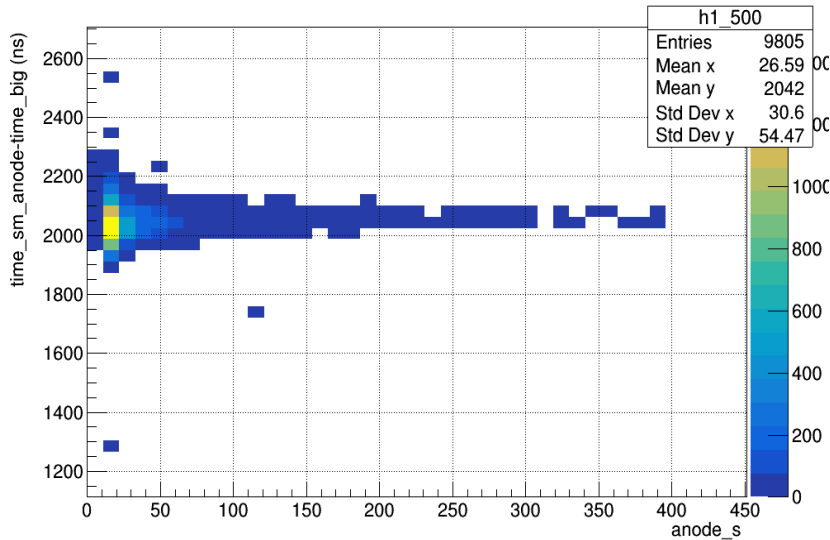


Time difference with the matched background events

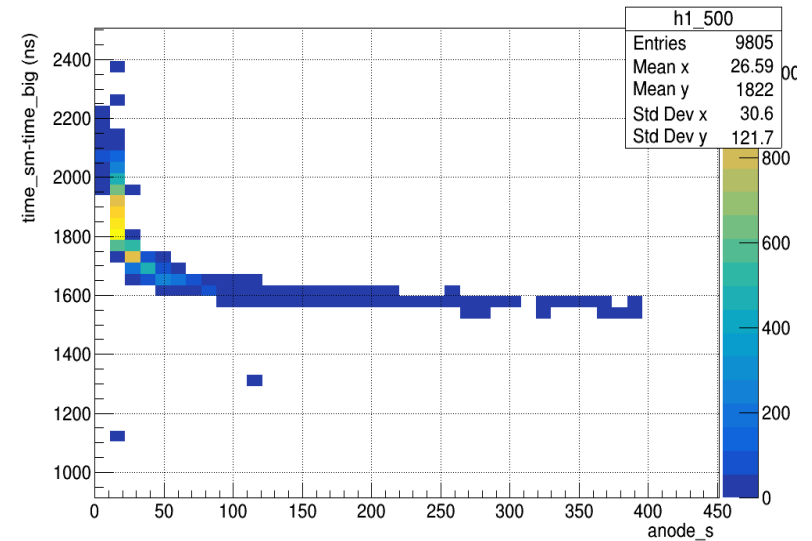
igcell (dynode_b>600)



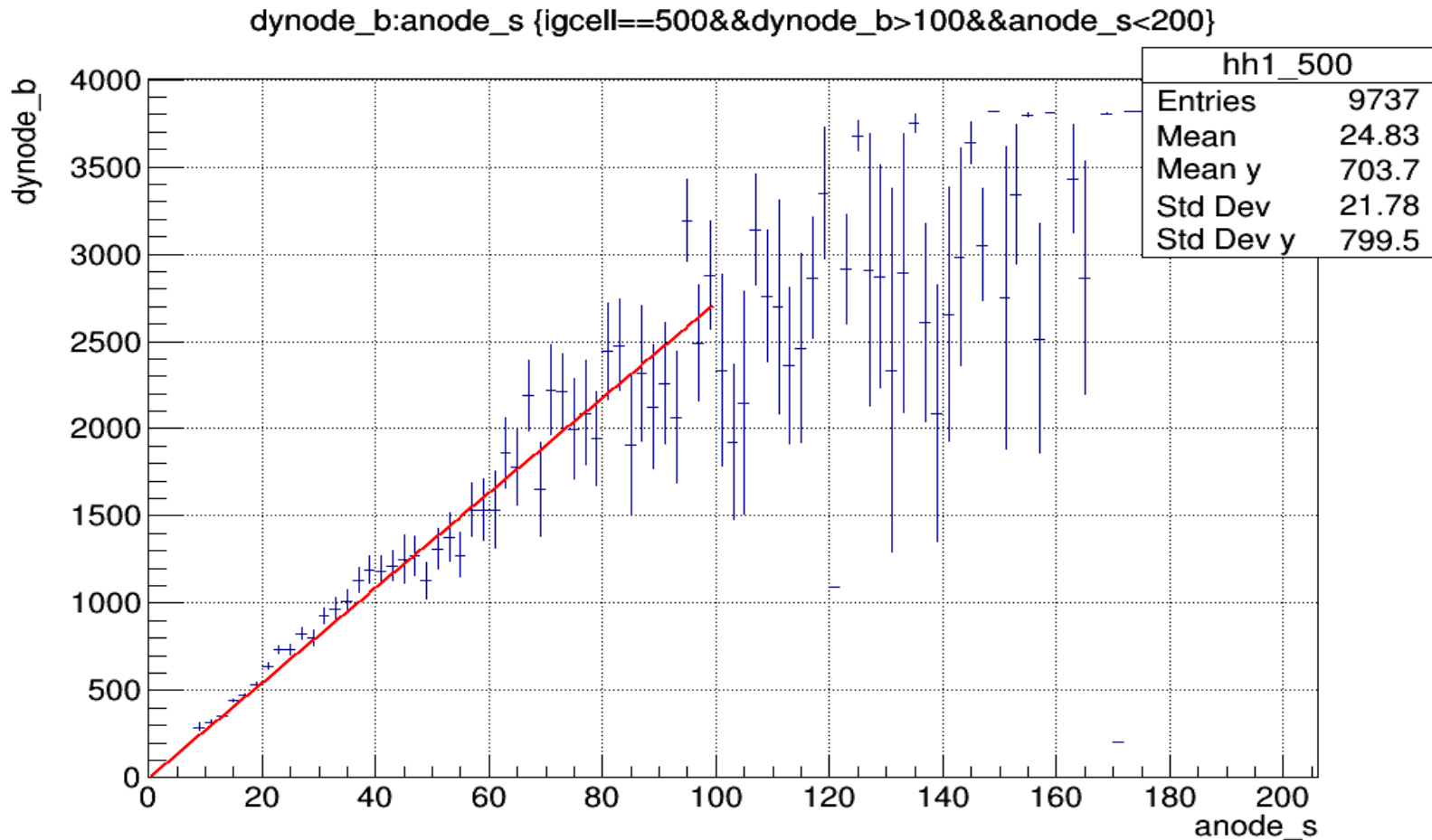
time_df_anode:anode_s {igcell==500&&dynode_b>100&&anode_s<400}



time_df_anode_s {igcell==500&&dynode_b>100&&anode_s<400}



The correlation between big and small PMT of each unit can also be studied using matched background events, with same results form matched cosmic ray events



Summary

- Most WCDA++ small PMTs works well
- Regular data check and detail checks works
- Cosmic ray matched well as well as match of background particles, which gives good events and clear signals for calibration
- Charge calibration with LED and muon peak and correlation between big and small PMTs works well
- The time resolution studied clearly

Welcome to join the analysis!

谢谢!