KIMS MUD detector and muon data analysis

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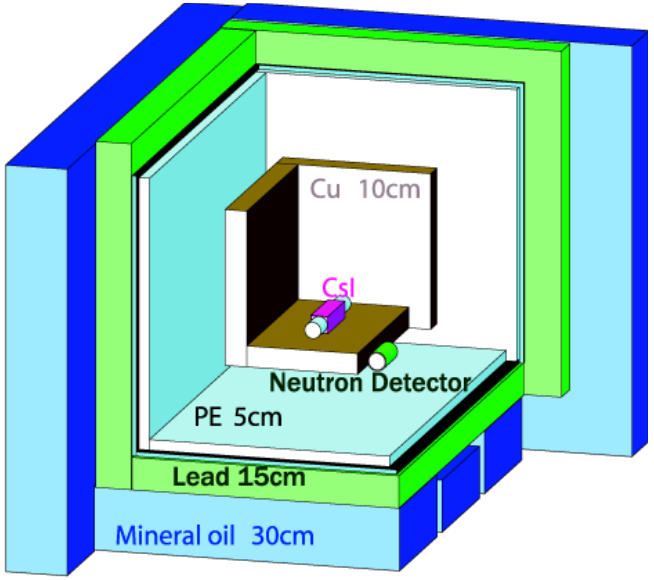
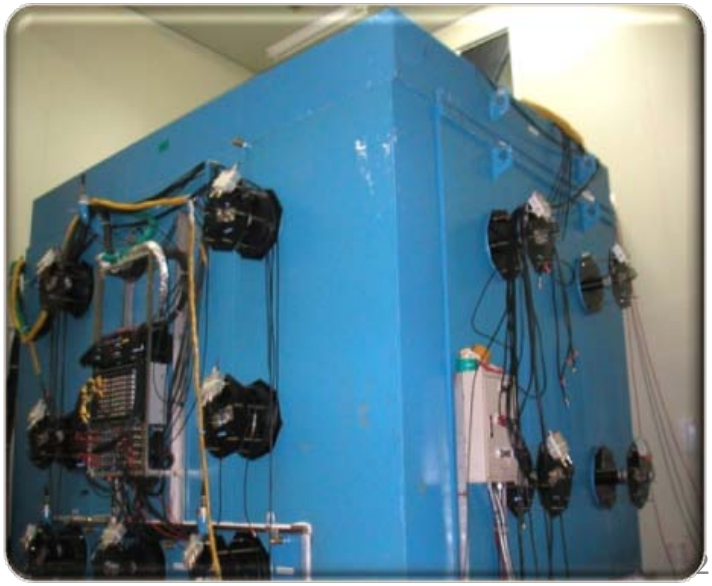
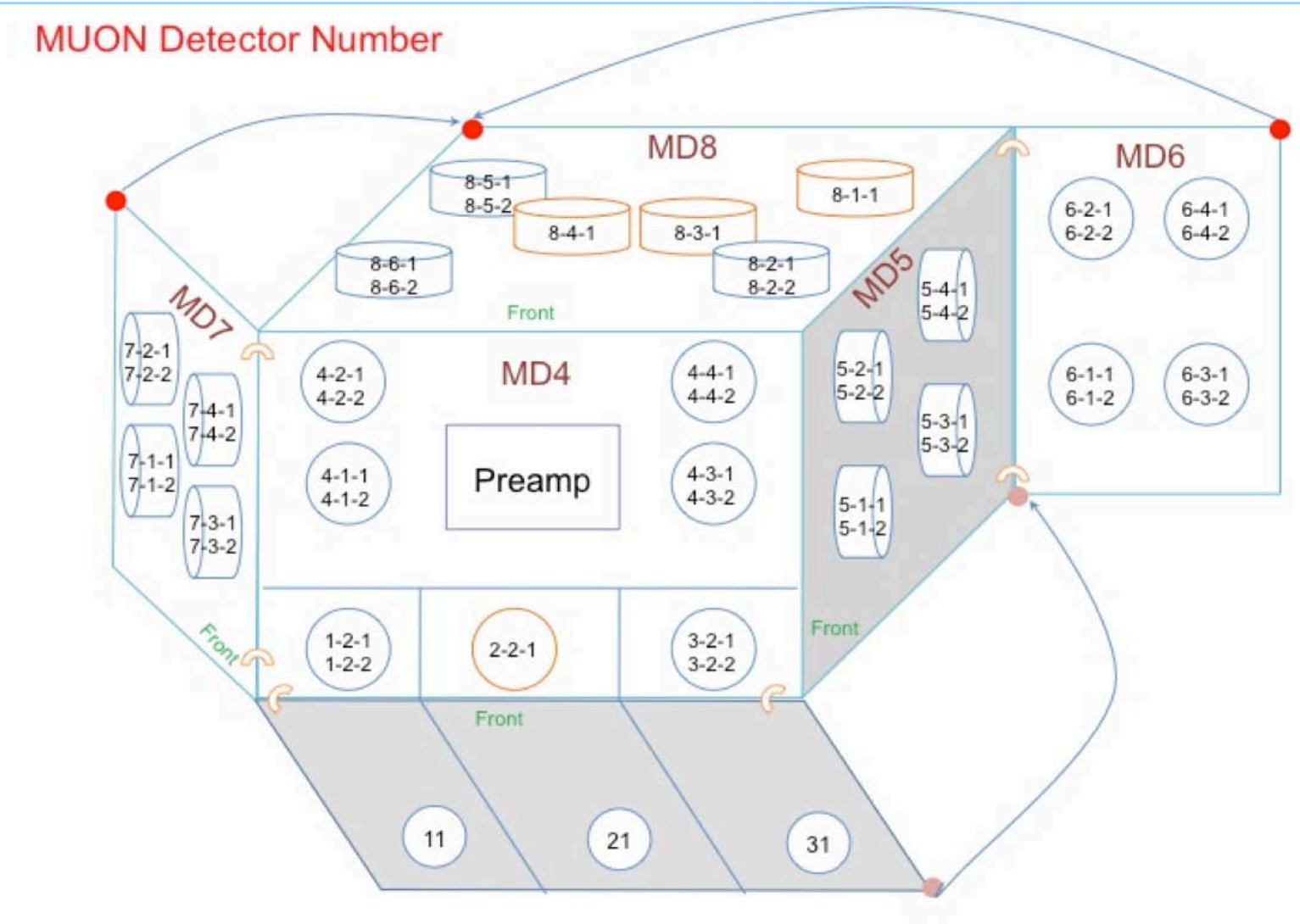
5th Chain-Korea workshop on dark matter and double beta decay

The KIMS Yangyang Underground Laboratory





MUD Detector



Outer Dimension : 2.25 x 2.25 x 3.15 cubic meter， **Thickness** : 30 cm
Material : A mixture of 95% Mineral Oil and 5% liquid scintillator

Underground muon energy

Muon path through mountains, with dE/dx of: $-\frac{dE_\mu}{dX} = a + b\,E_\mu\ ,$

$$E_\mu = (E_{\mu,0} + \epsilon)\, e^{-bX} - \epsilon\ .$$ ε=a/b

Table 24.2: Average muon range R and energy loss parameters calculated for standard rock [53]. Range is given in km-water-equivalent, or 10^5 g cm^{-2}.

E_μ	R	a	$b_{\rm brems}$	$b_{\rm pair}$	$b_{\rm nucl}$	$\sum b_i$	$\sum b$(ice)
GeV	km.w.e.	MeV g^{-1} cm^2	——	10^{-6} g^{-1} cm^2		——	
10	0.05	2.17	0.70	0.70	0.50	1.90	1.66
100	0.41	2.44	1.10	1.53	0.41	3.04	2.51
1000	2.45	2.68	1.44	2.07	0.41	3.92	3.17
10000	6.09	2.93	1.62	2.27	0.46	4.35	3.78

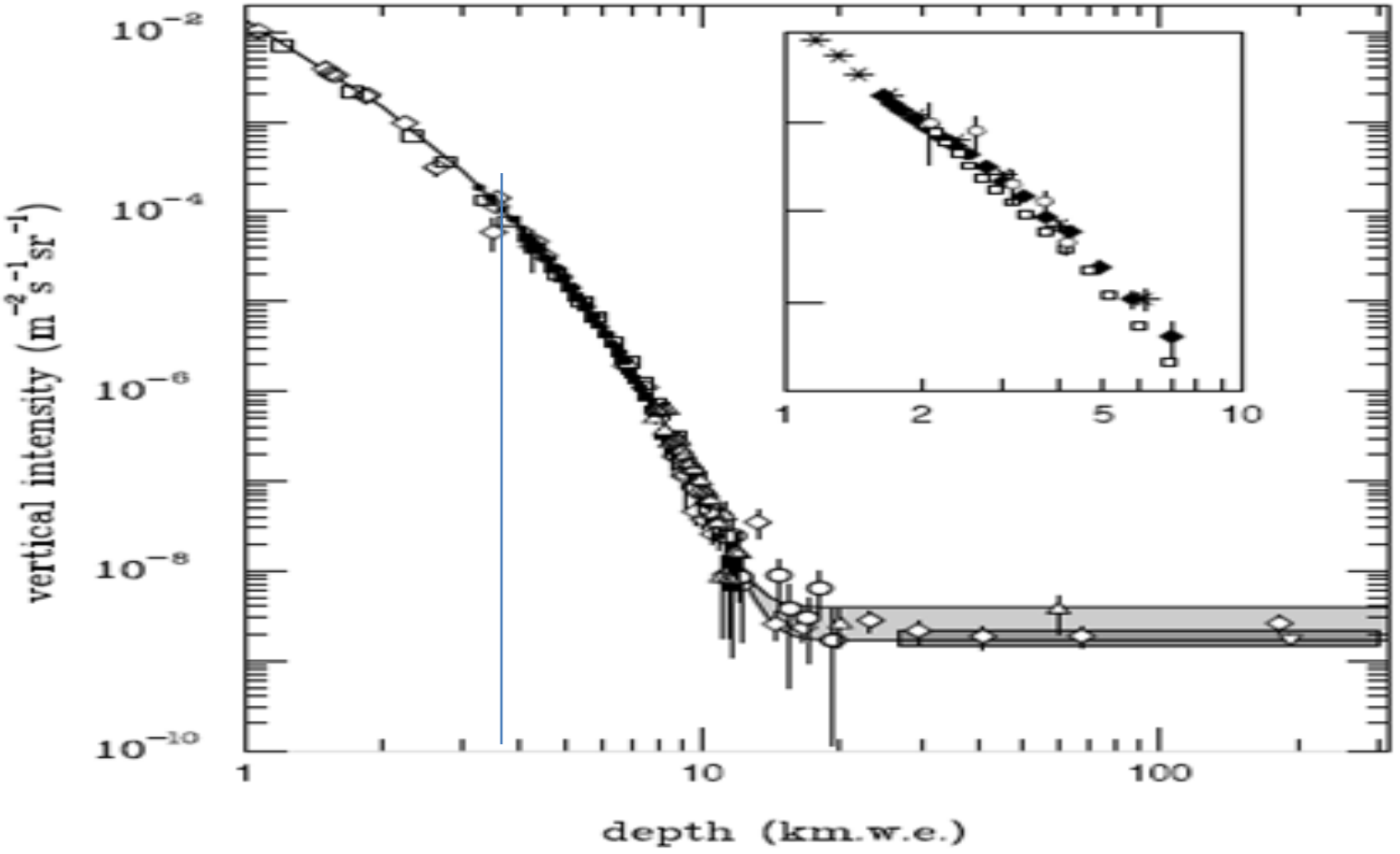
Yangyang underground depth: about 2 km.w.e

The muon can pass through should have energy about 1000 GeV

After lose energy in the rocks, the muon energy in the lab is about 80 GeV

The energy deposit in the top detecor is about 80 MeV

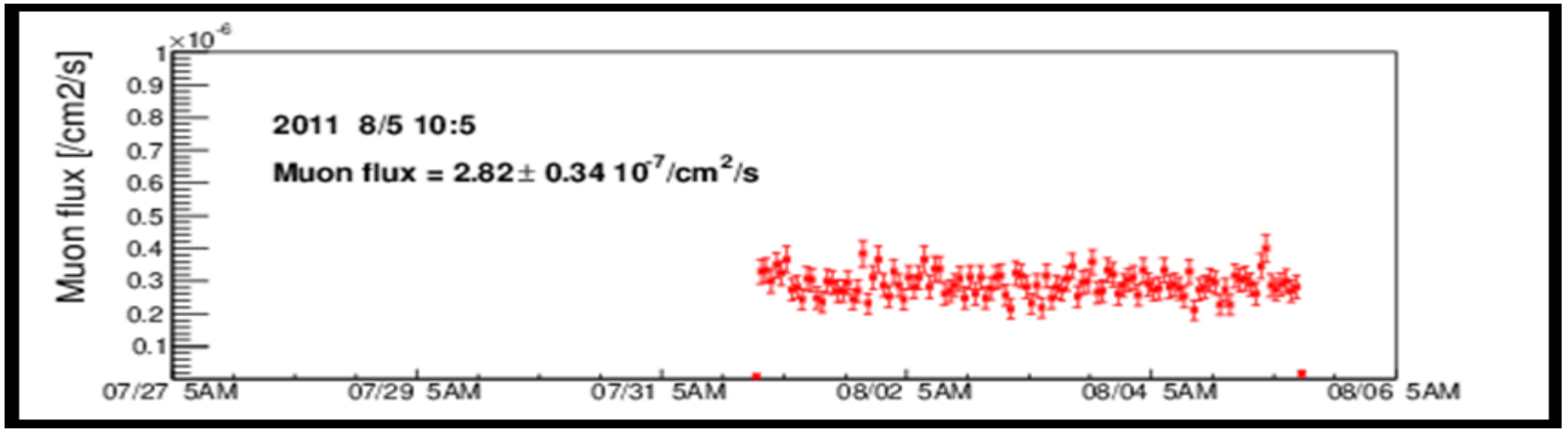
Underground muon intensity

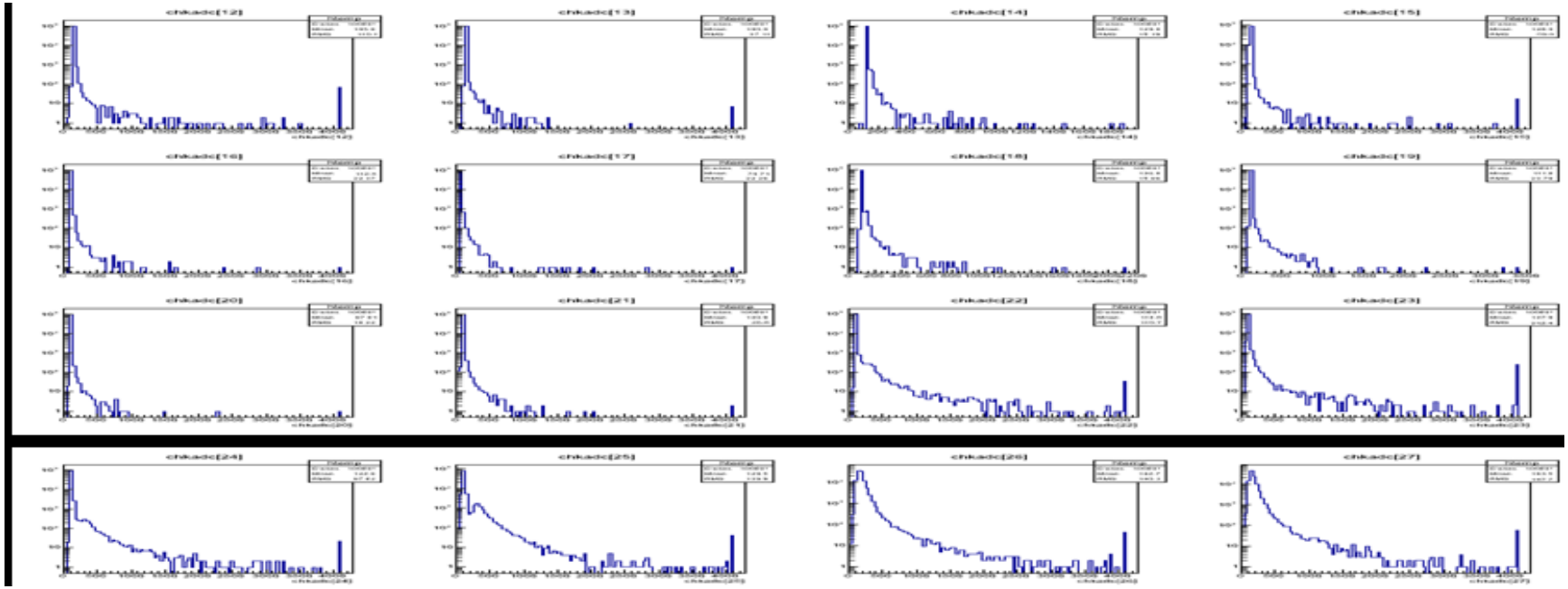


About 2000 km. w. e

The muon rate of KIMS should be at 10^{-3} ($m^{-2}s^{-1}sr^{-1}$) level

Online muon monitor of KIMS MUD rate

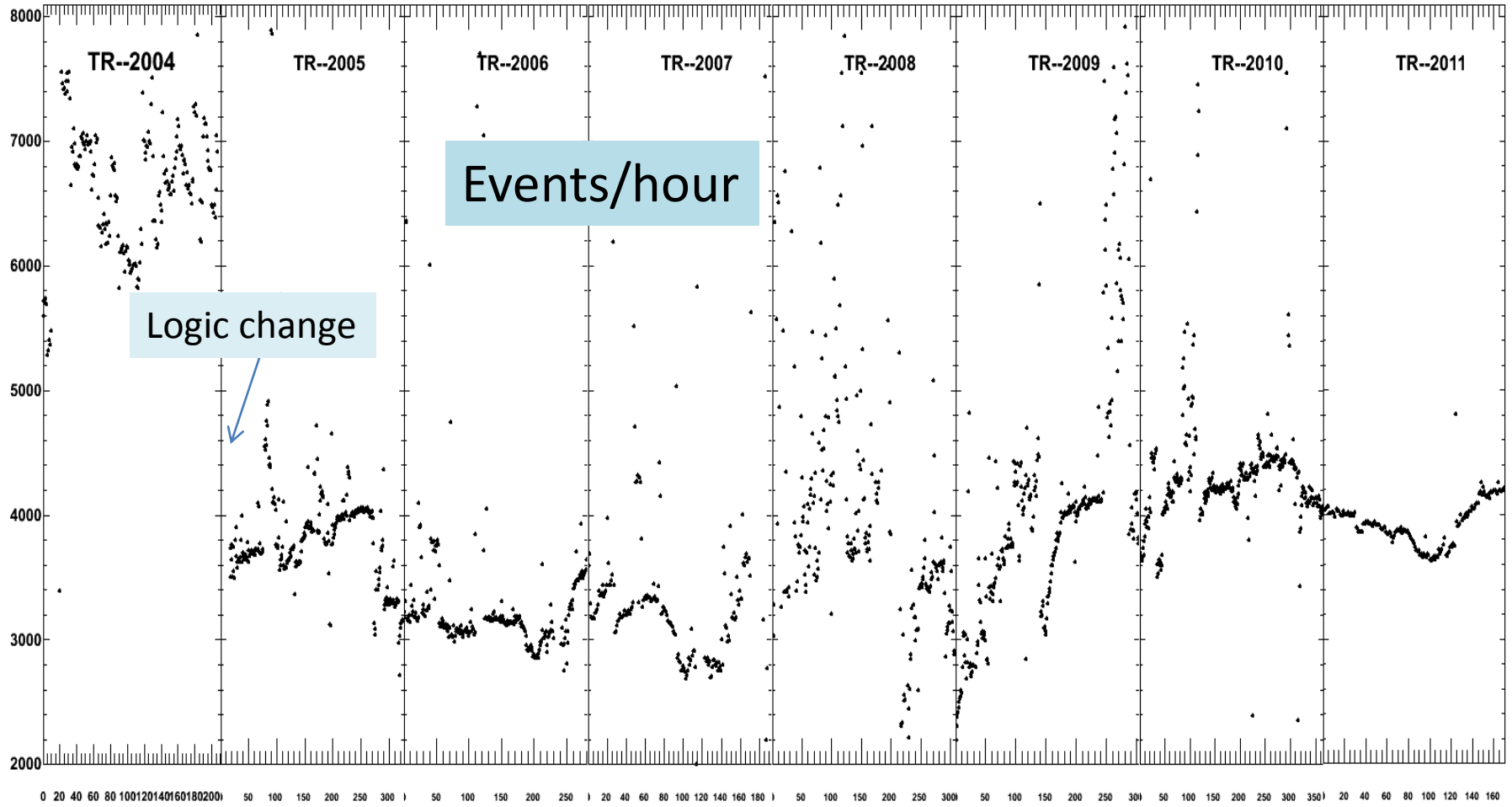




MUD data taking time of each year

Year	month taking	Nfiles	Total time	Time of T_1file<20 (5 for 2004)	Time of T_1file>40	Time of good
2004	7-12	211	2935.48 h 122.3 days	40.1147 0.01.3665	0	2895.36 98.6335
2005	1-12	326	7779.86 h 324.2 days	338.328 4.35%	128.038 1.645%	7313.5 94.00%
2006	1-12					
2007	3-11	191	5316.64 h 221.5 days	153.732 2.89%	579.901 10.907%	4583 86.201%
2008	1-12	309	6229.19 h 259.5 days	422.068 6.775%	239.2 3.839%	5567.92 89.38%
2009	1-12	304	7512.13 h 313.0 days	271.804 3.62%	530.04 7.0557%	6710.29 89.326%
2010	1-12	363	8159.54 h 340.0 days	163.443 2.003%	41.8636 0.51306%	7954.23 97.49%
2011	1-9	239	--	--	--	--

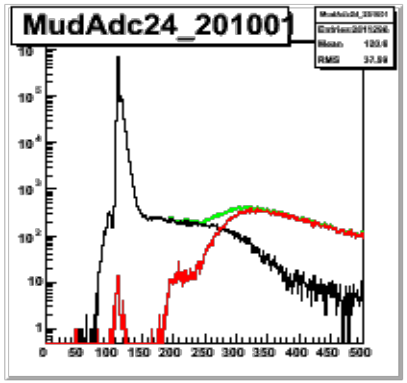
The trigger rate of KIMS MUD

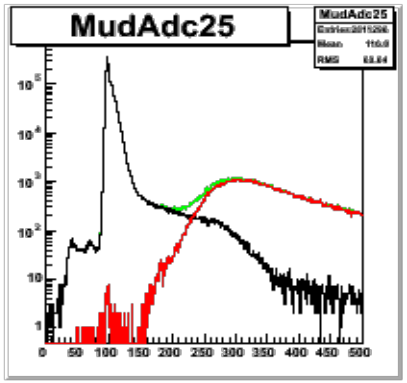


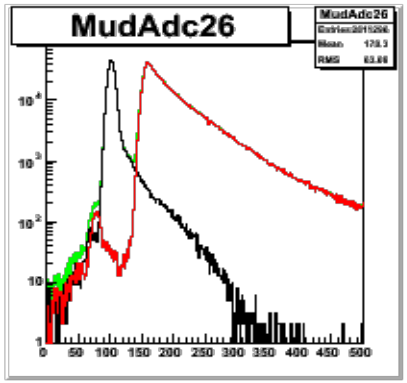
The total trigger: 2 or more channels have hits in the one detector within 300 ns

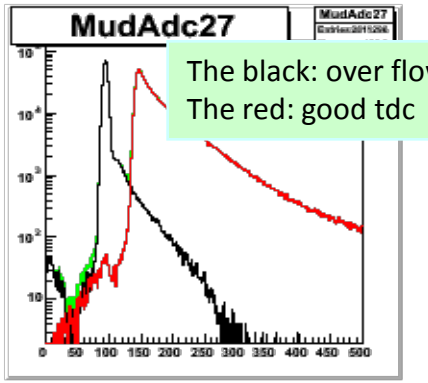
Trigger rate about 4000 events/hour

The performance of MUD data

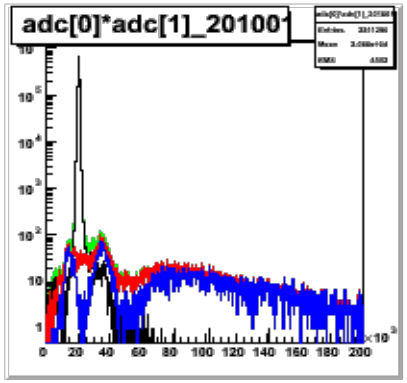


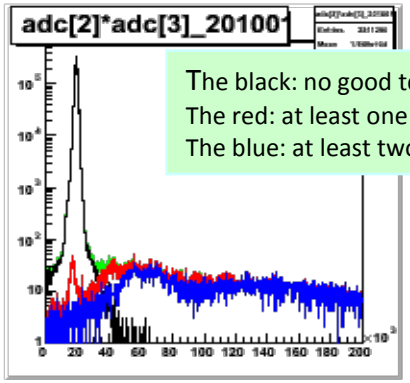


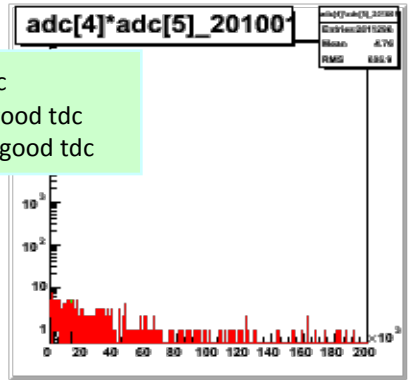


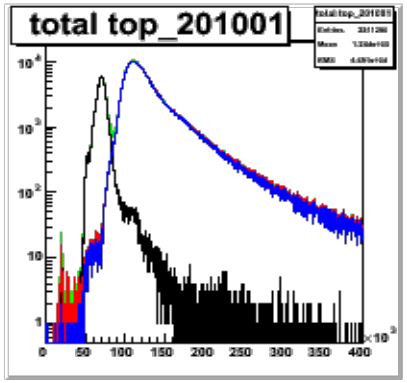


The black: over flow tdc
The red: good tdc

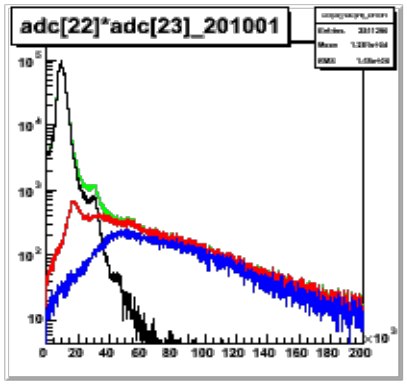


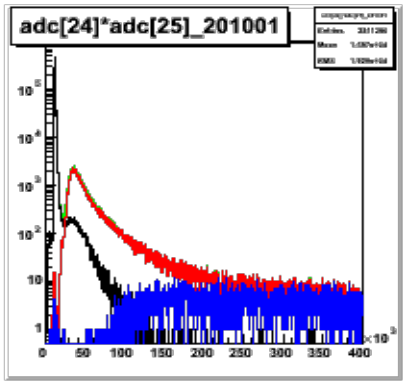


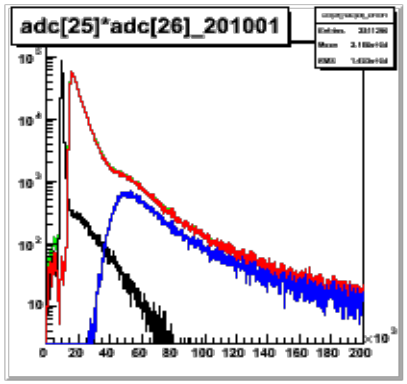


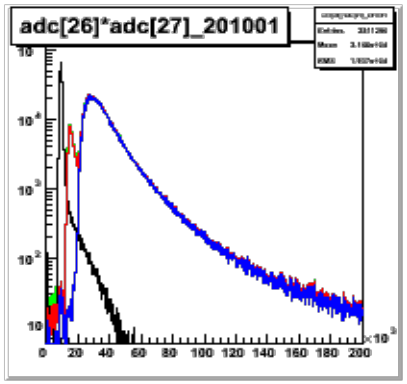


The black: no good tdc
The red: at least one good tdc
The blue: at least two good tdc

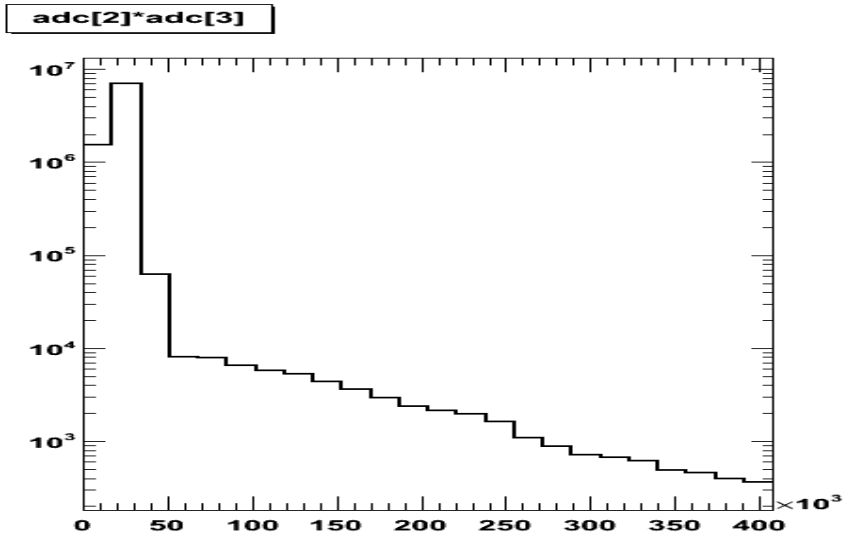


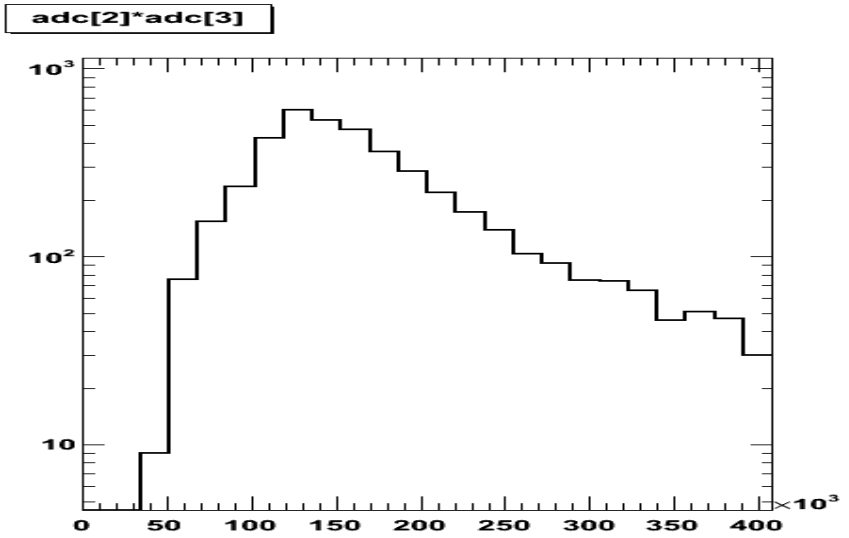


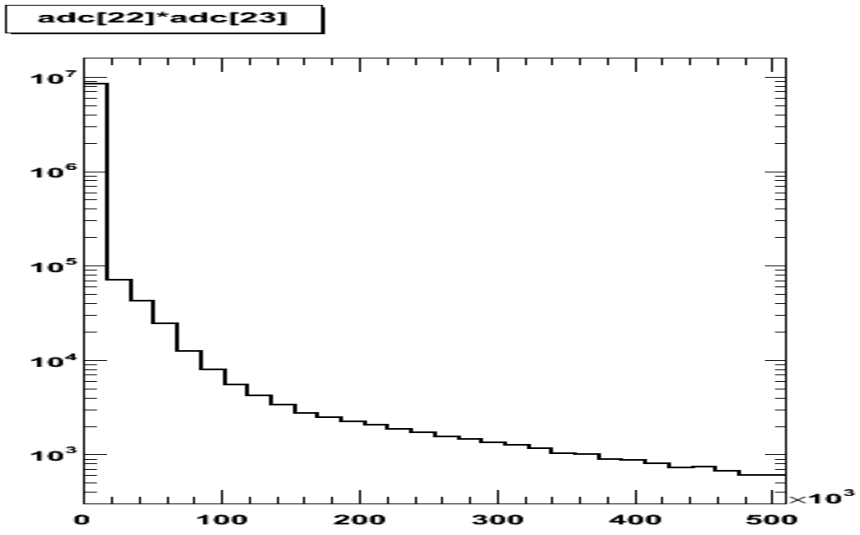


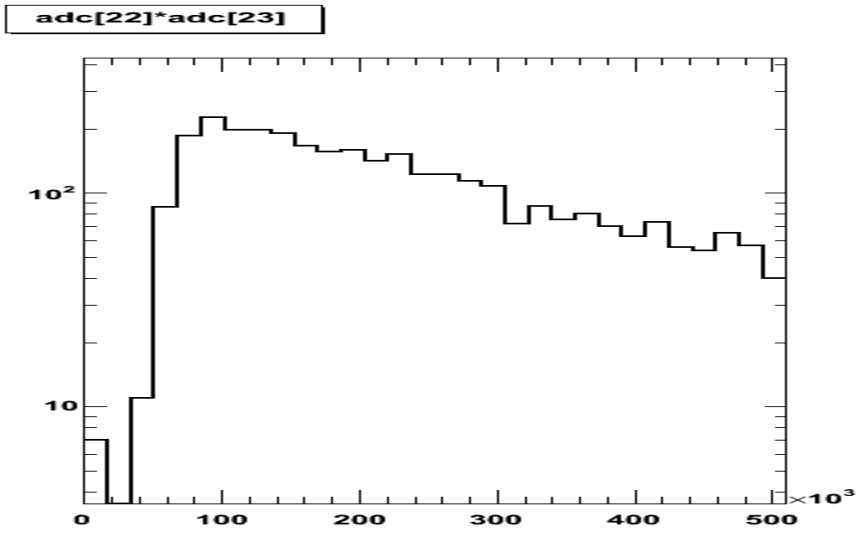


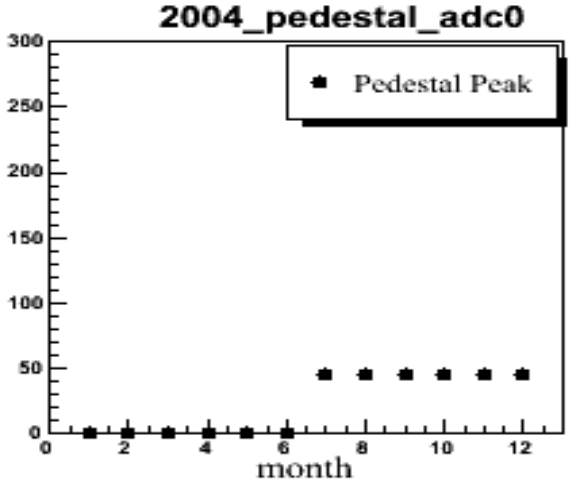
MUD ADC distribution

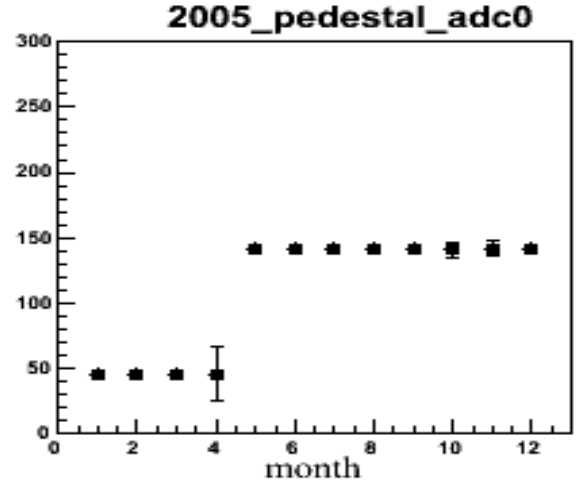


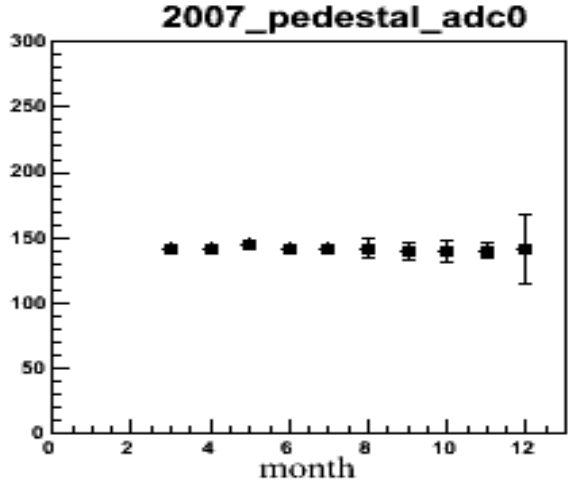


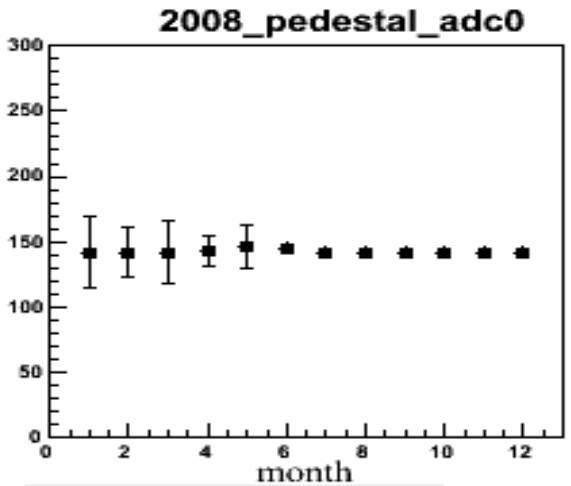


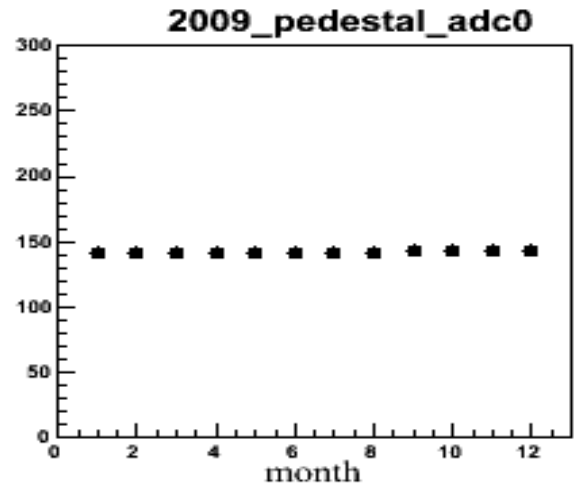



2004_pedestal_adc0
Pedestal Peak
month


2005_pedestal_adc0
month


2007_pedestal_adc0
month


2008_pedestal_adc0
month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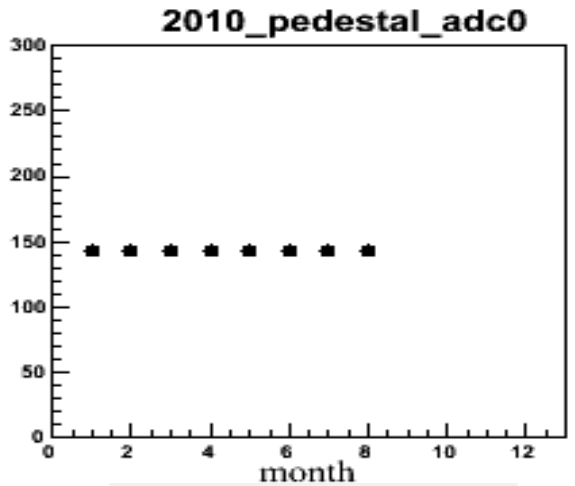
month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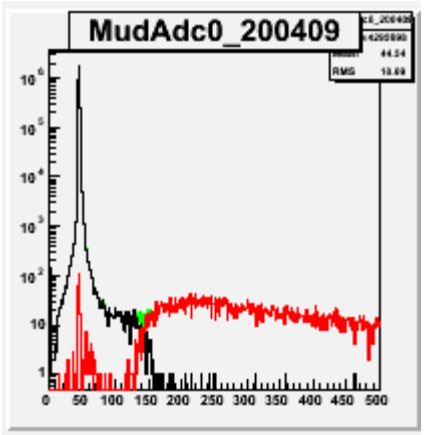
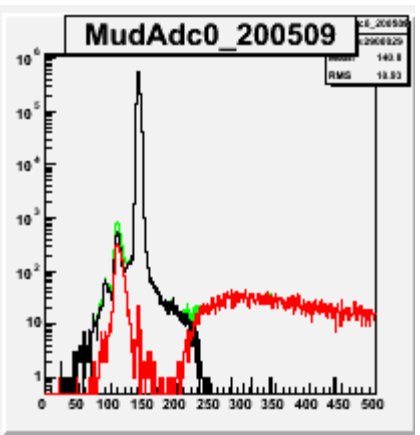
month


MudAdc0_200409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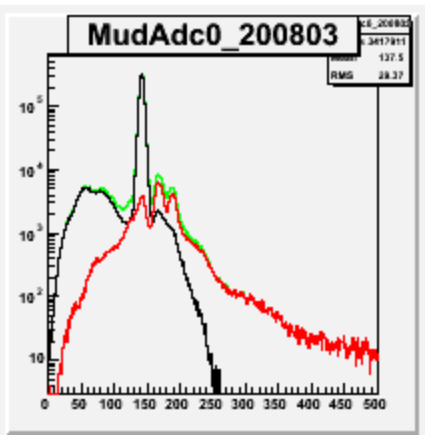
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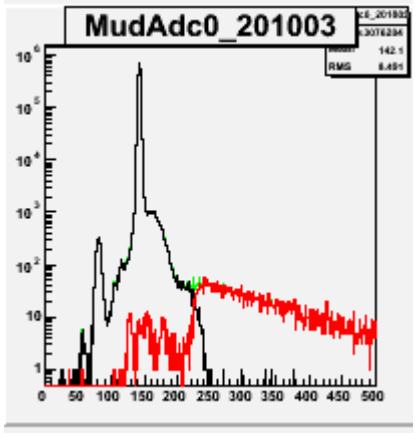
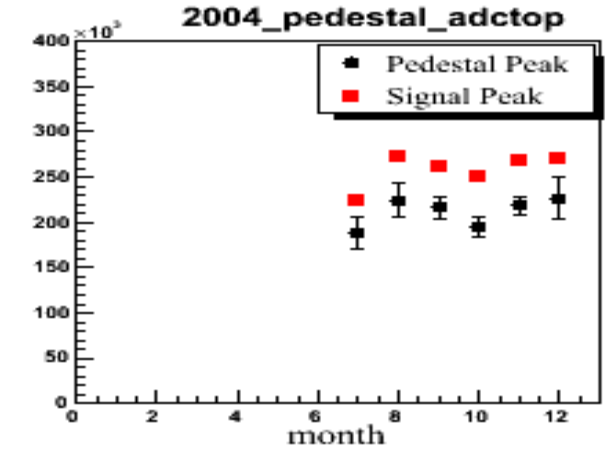
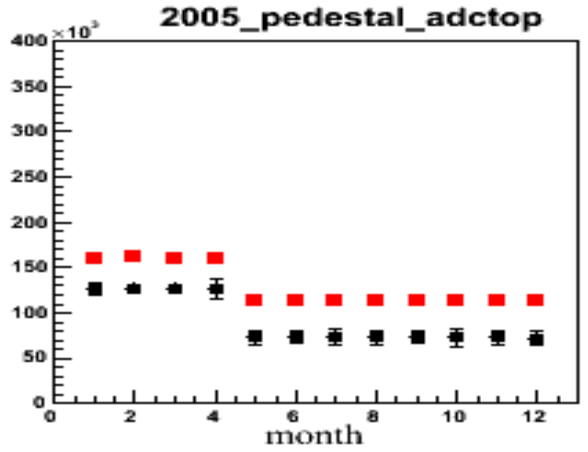
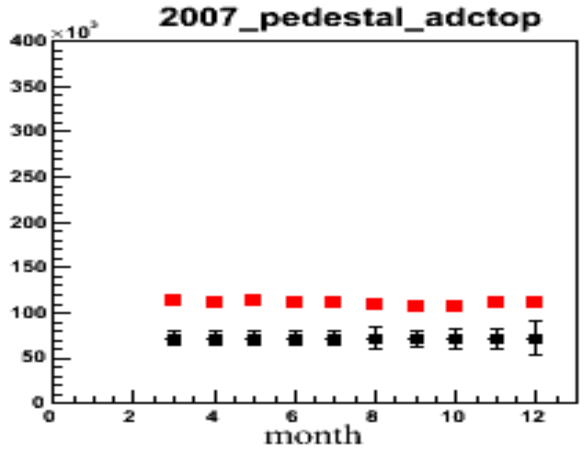
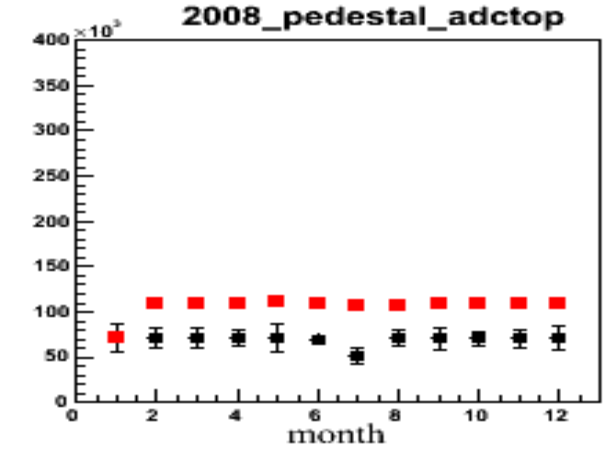

MudAdc0_201003


2004_pedestal_adctop
Pedestal Peak
Signal Peak
month


2005_pedestal_adctop
month


2007_pedestal_adctop
month


2008_pedestal_adctop
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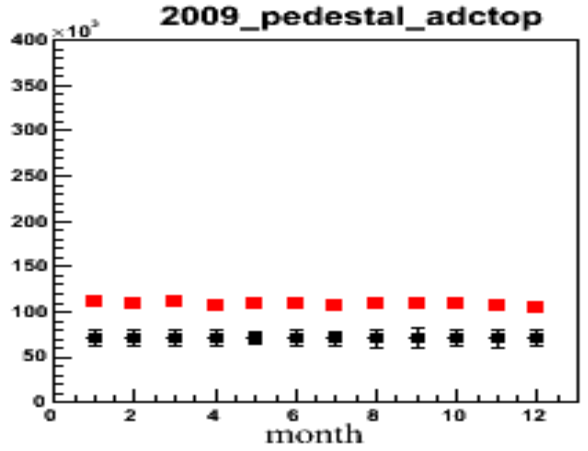
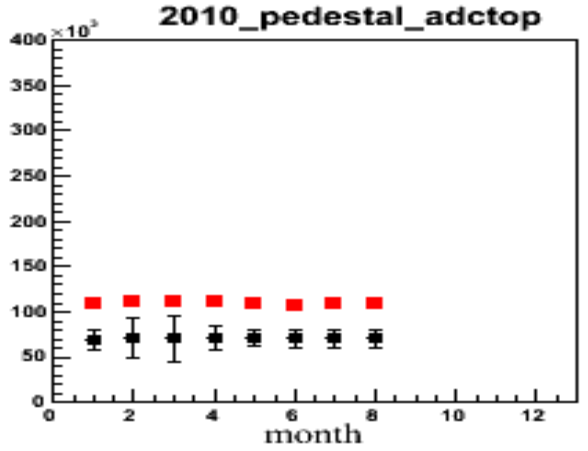
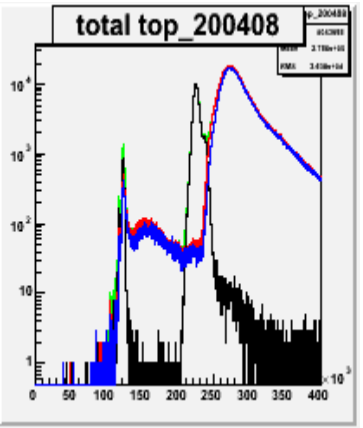
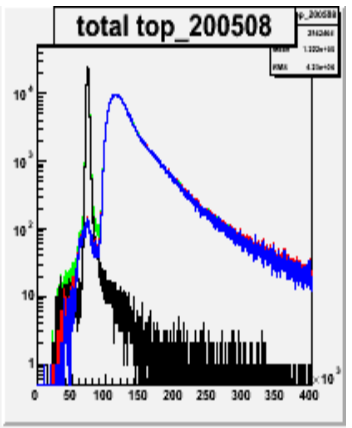
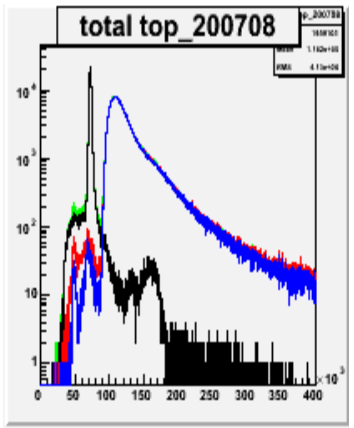
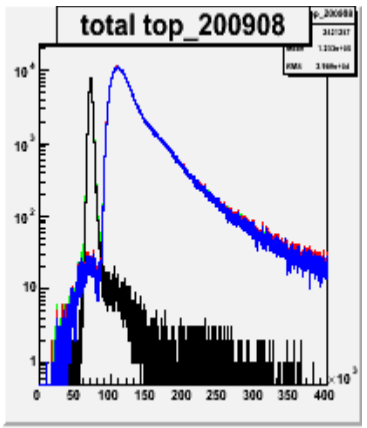

2009_pedestal_adctop
month

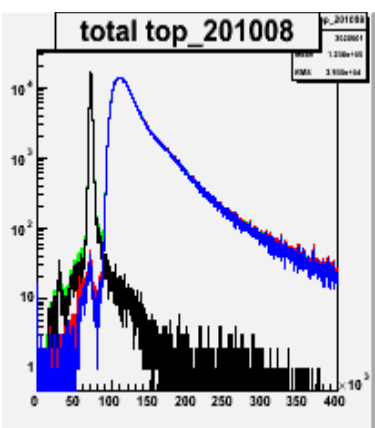

2010_pedestal_adctop
month


total top_200408

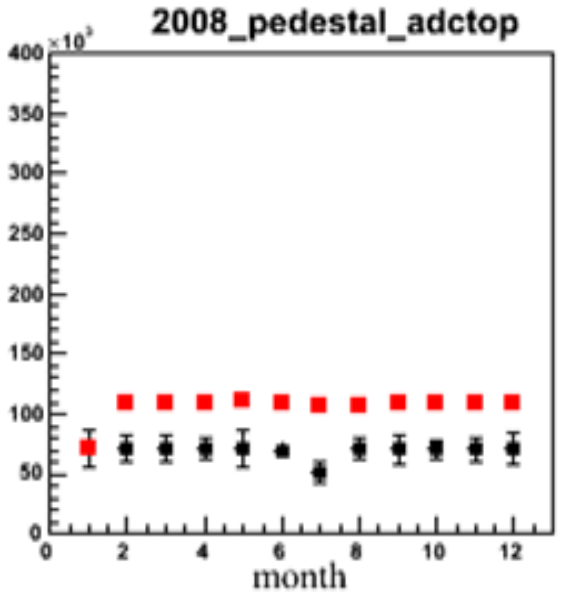

total top_200508

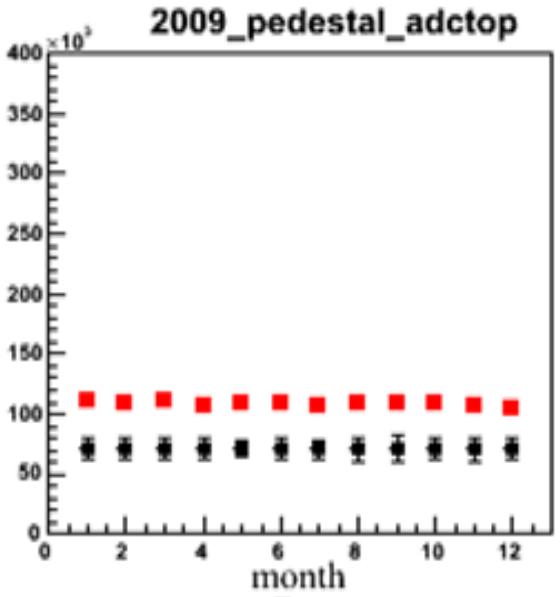

total top_200708

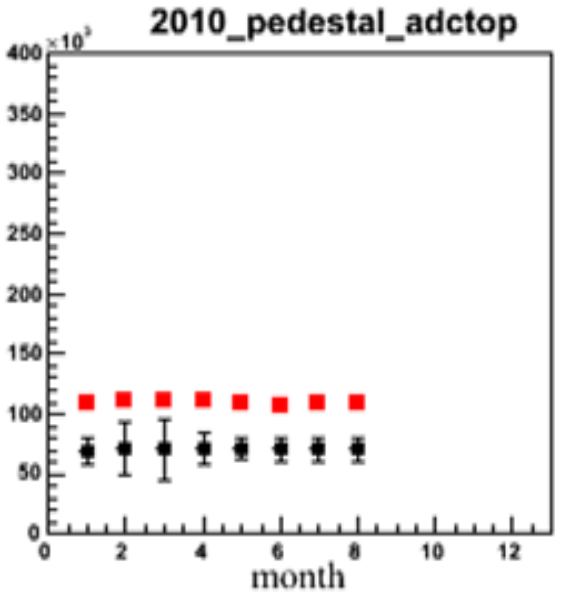

total top_200908


total top_201008

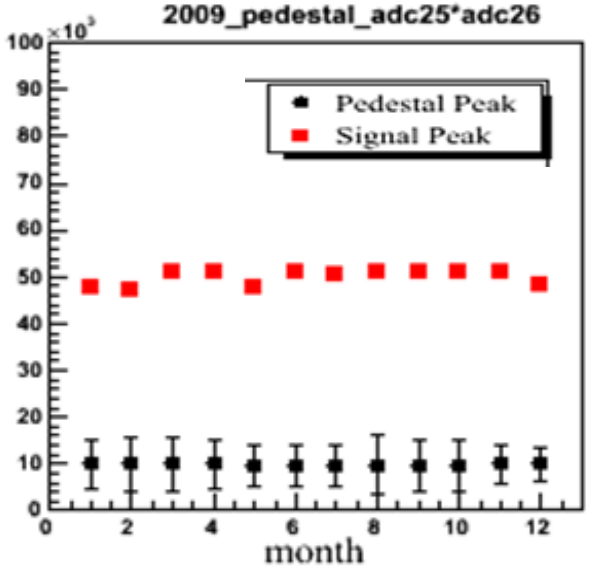
Check the total ADC amplitude (energy) in the top detector at different time

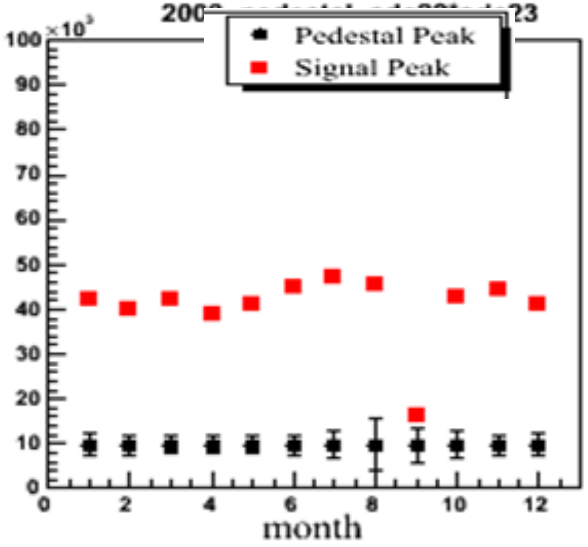


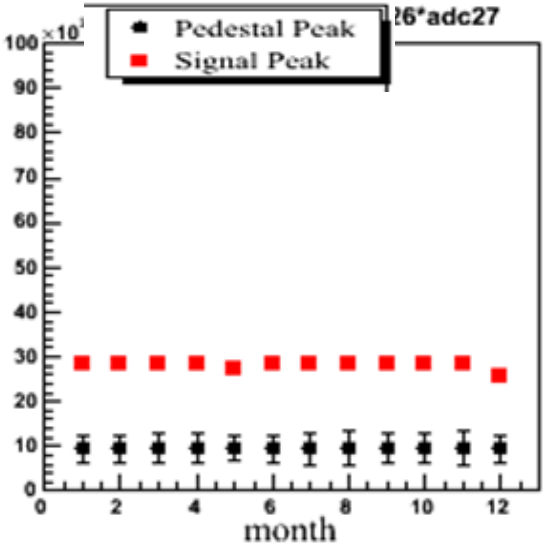




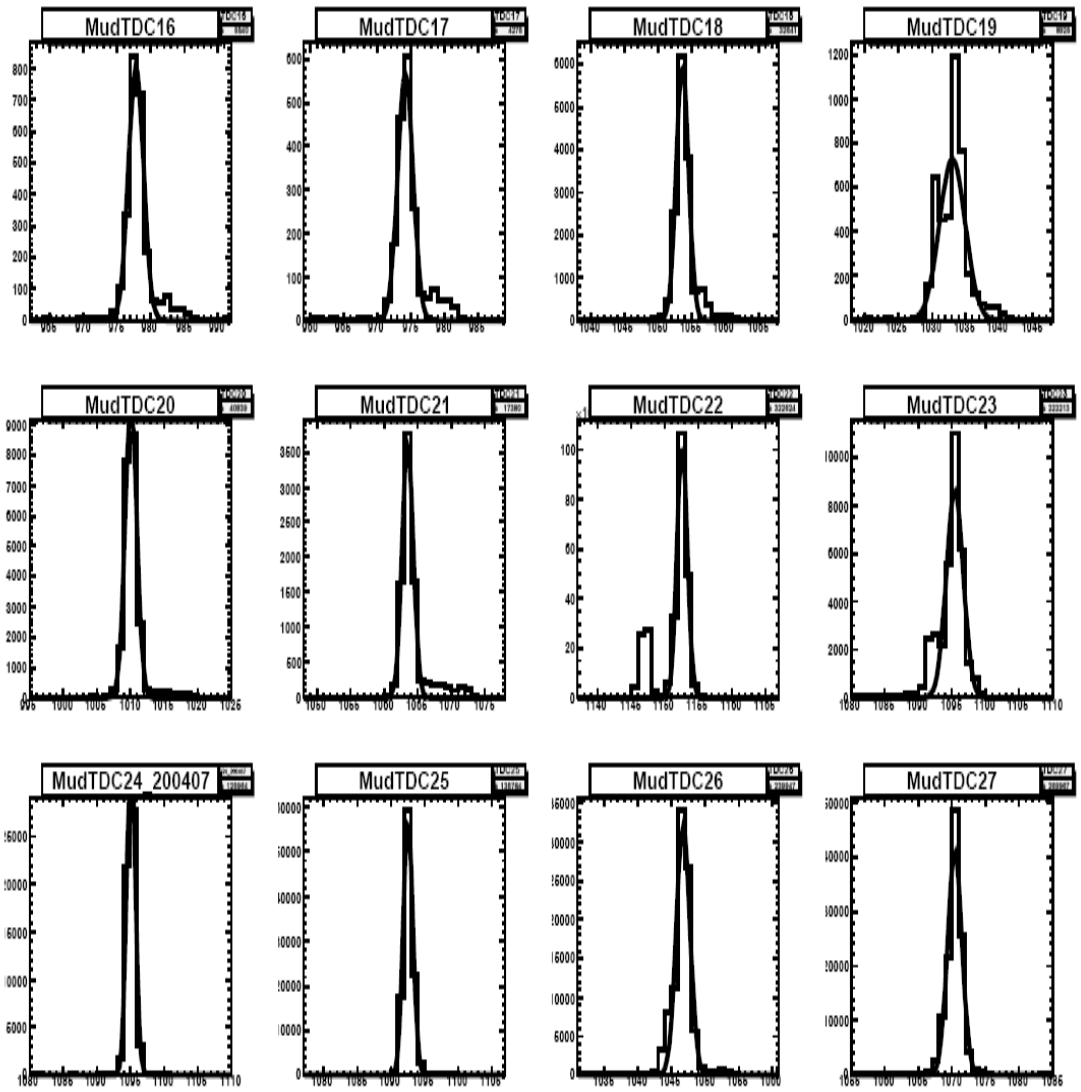
Check the ADC*ADC of every two PMT of top detector

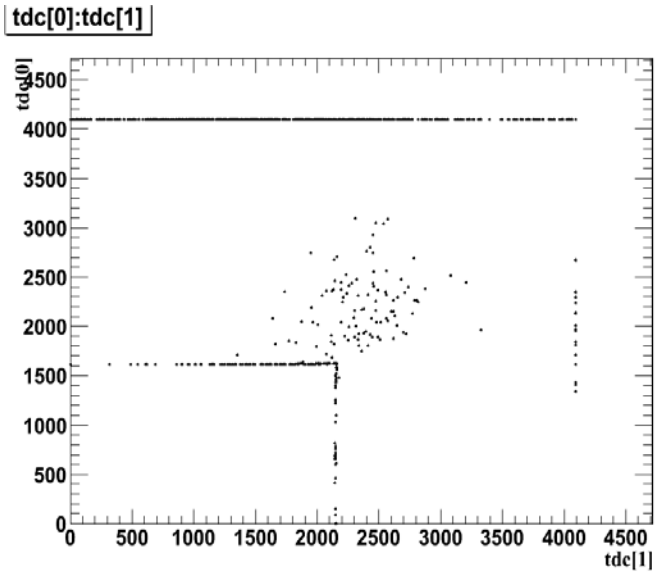


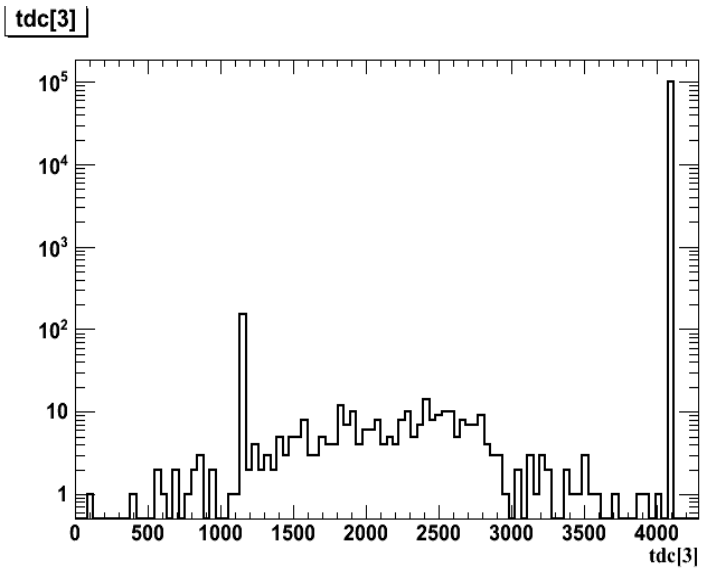




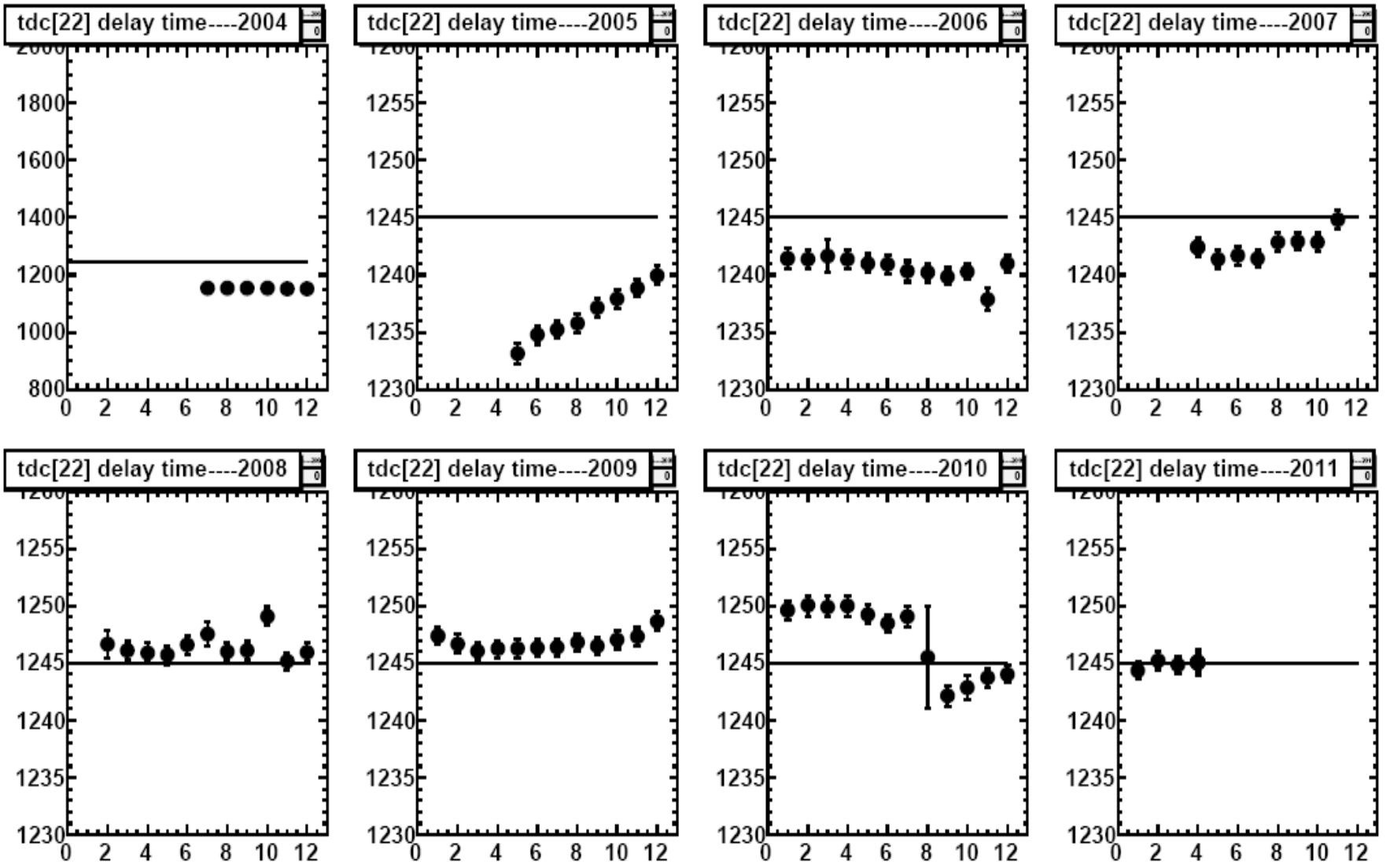
MUD TDC distribution

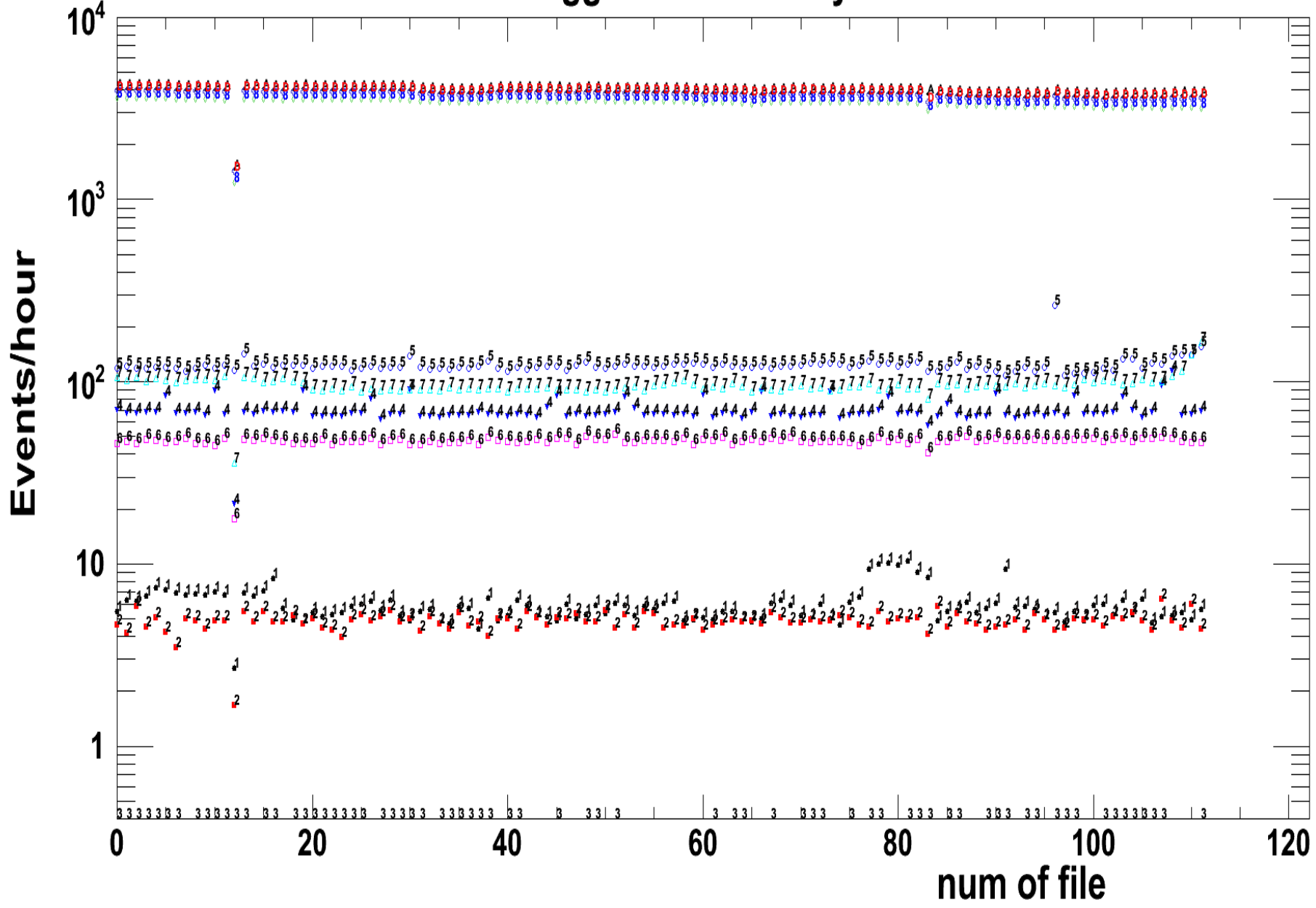






The TDC delay time check (vs time)

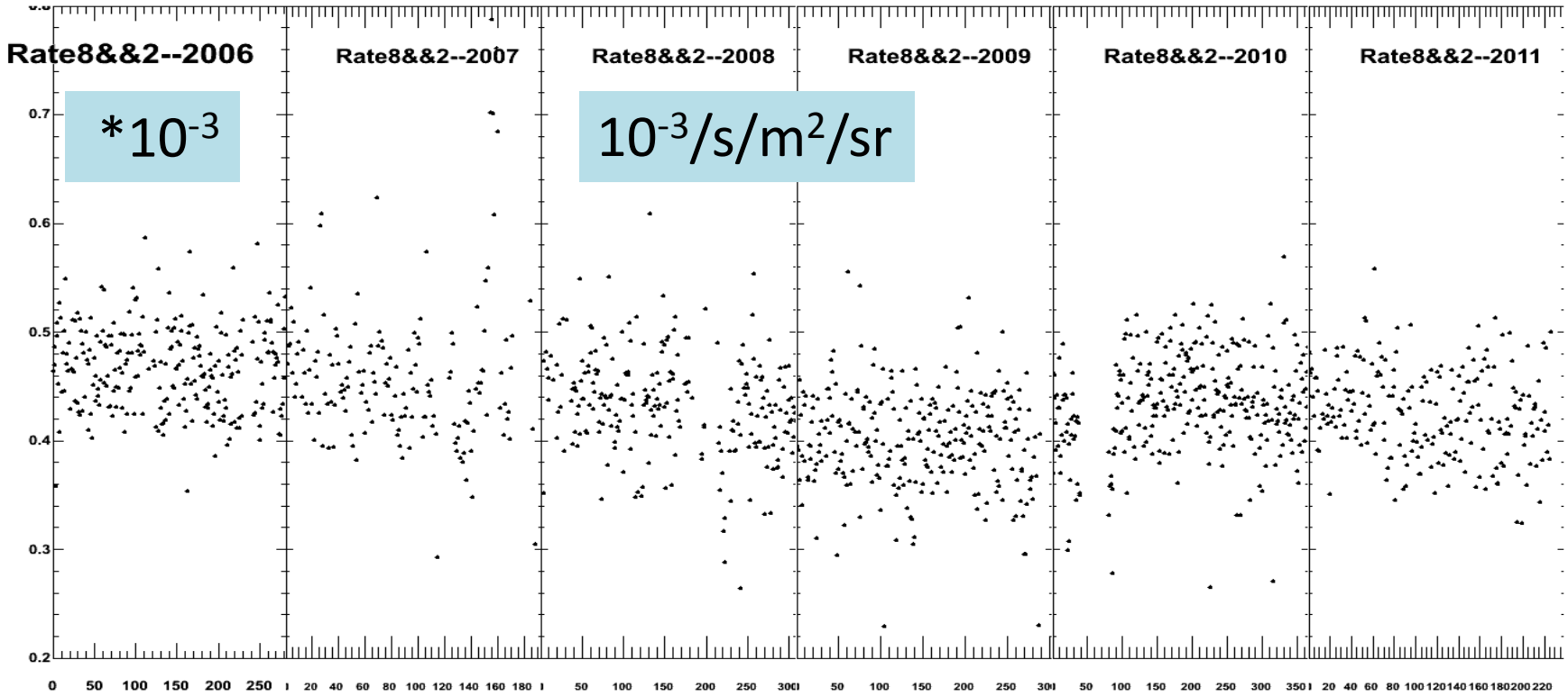



KIMS MUD Trigger Rate---2011 year
Events/hour
num of file
10^4
10^3
10^2
10
1
0
20
40
60
80
100
120

The muon rate with coincidence of top and bottom detector2

1. data quality check of every file to select good files
2. Adc and Tdc performance check
3. Combine the Adc, Tdc cuts of different PMT and detectors

10^{-3}/m2/s/sr



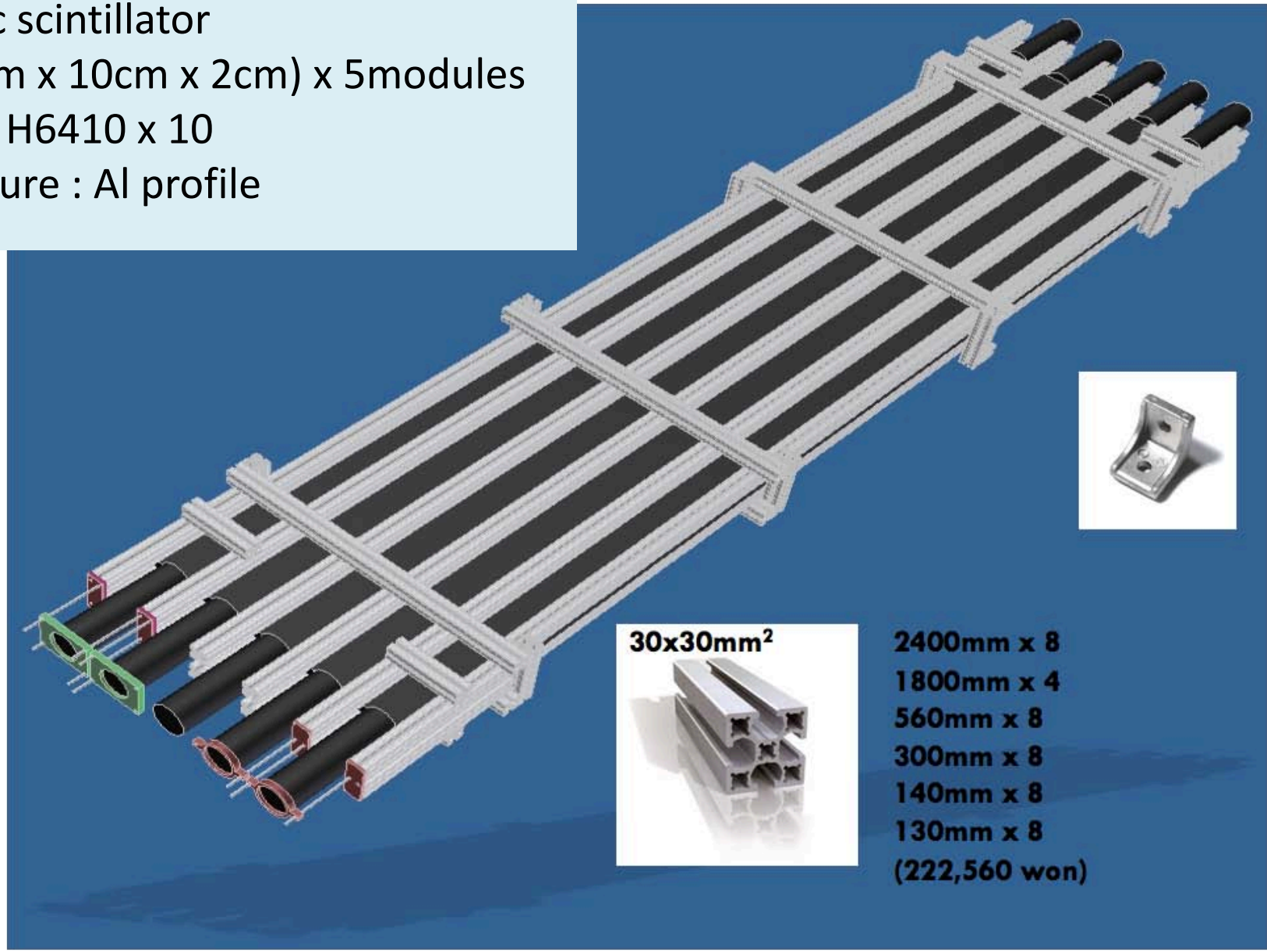
KIMS MUD muon rate

- Offline: about $0.5*10^{-3}$ /m^2/s/sr,
- Online: about $0.45*10^{-3}$ /m^2/s/sr
- Theory expected: at 10^{-3} /m^2/s/sr

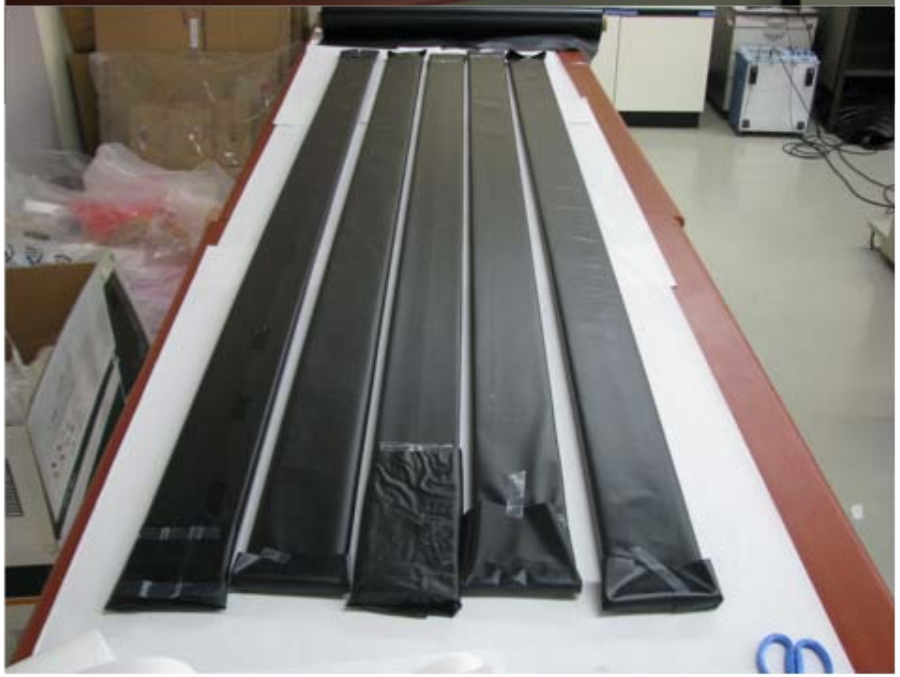
- The selection method still can be optimized
- More accurate result can be given

Design for new detector

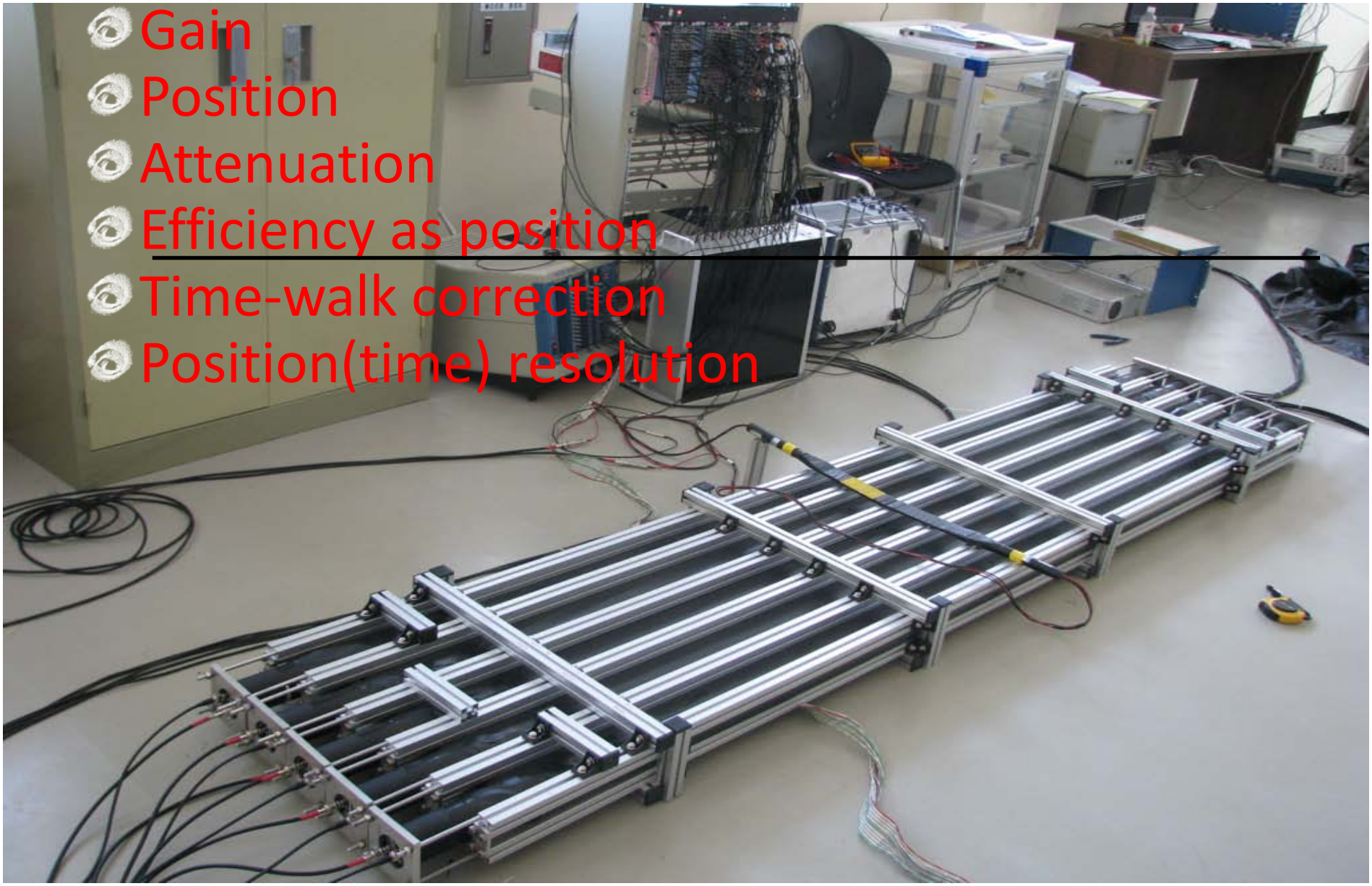
- plastic scintillator
- (220cm x 10cm x 2cm) x 5modules
- PMT : H6410 x 10
- Structure : Al profile



Assembling

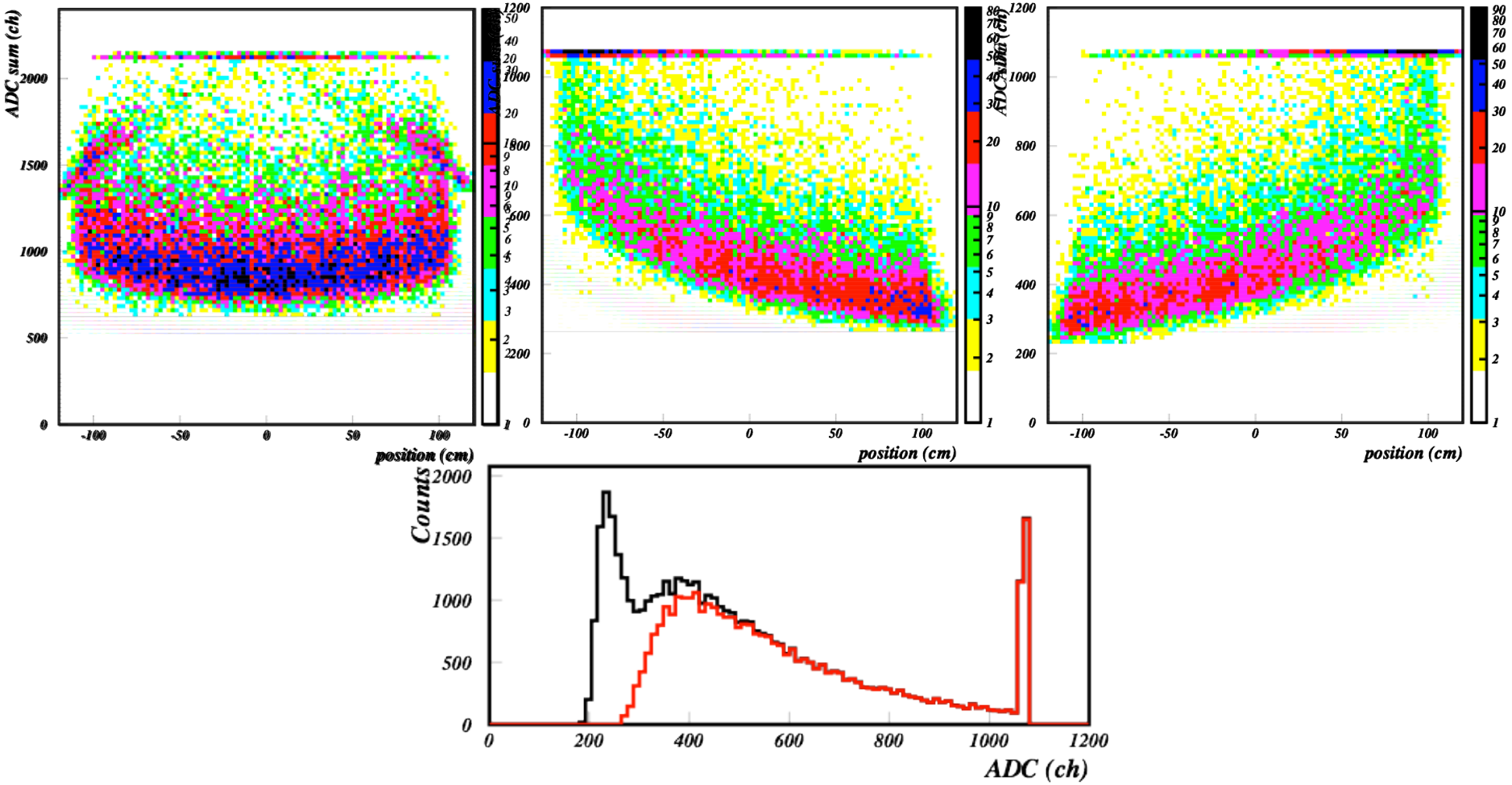


Cosmic test

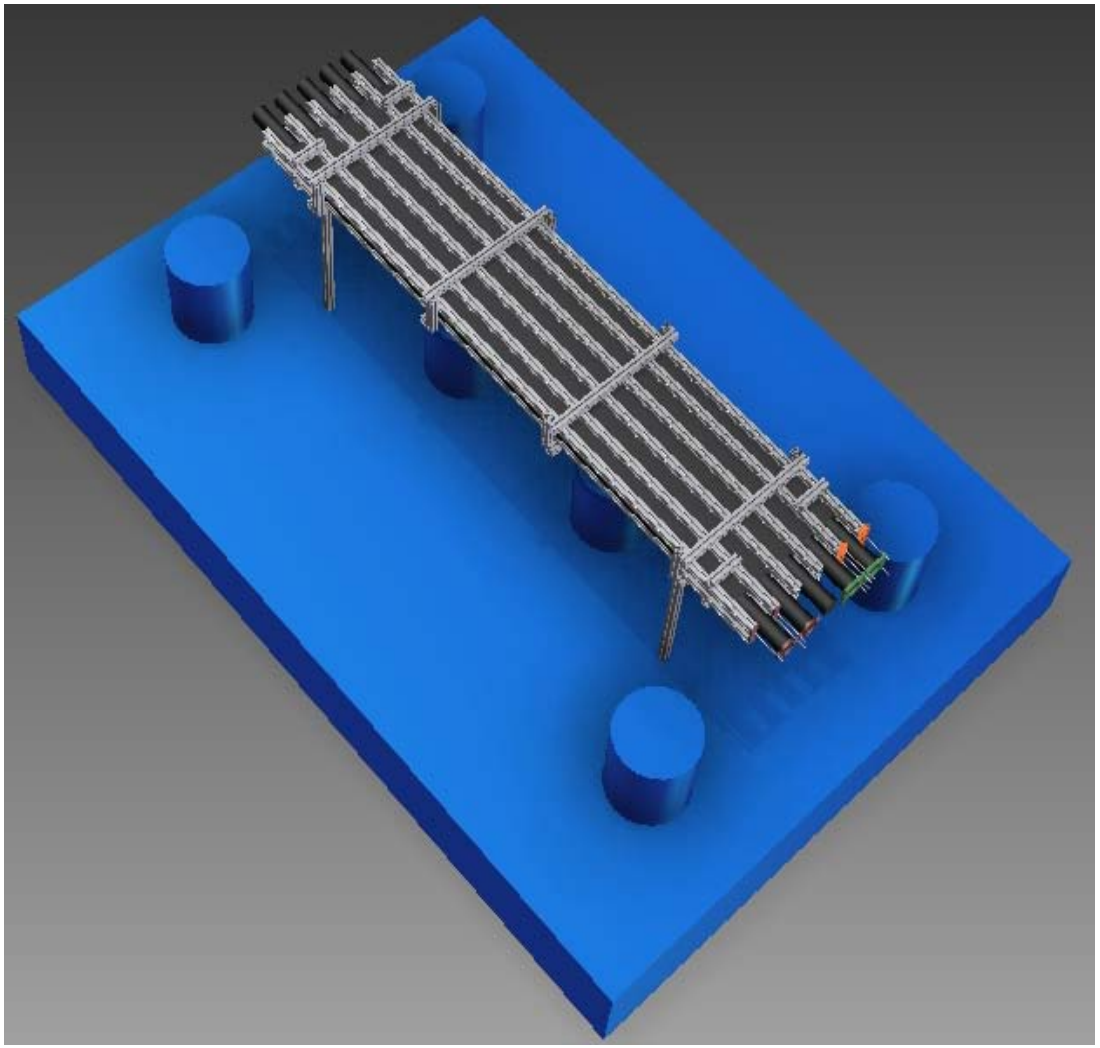

Gain
Position
Attenuation
Efficiency as position
Time-walk correction
Position(time) resolution

Cosmic-Ray Test Bench

Muon event selection



Installation plan



need 2 times shutdown data taking

- for installation of detector
- for installation of trigger

Summary and plan

Have done:

- data quality and detector check
- Muon event rate calculation
- New sintillator layer test and trigger system check

Next:

- Optimize the cuts for muon selection, to give more accurate rate
- Angular distribution study
- Coincidences study of MUD and neutron detector

- Install new scintillator on the top, to check the efficiency of each detector and PMT
- Replace all the PMTs