

Cosmic test of PCAL prototype

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Outline

- Details of prototype structure
- Description of cosmic test setup, electronics, DAQ ...
- Results of the cosmic test measurements
- Summary and future planes.

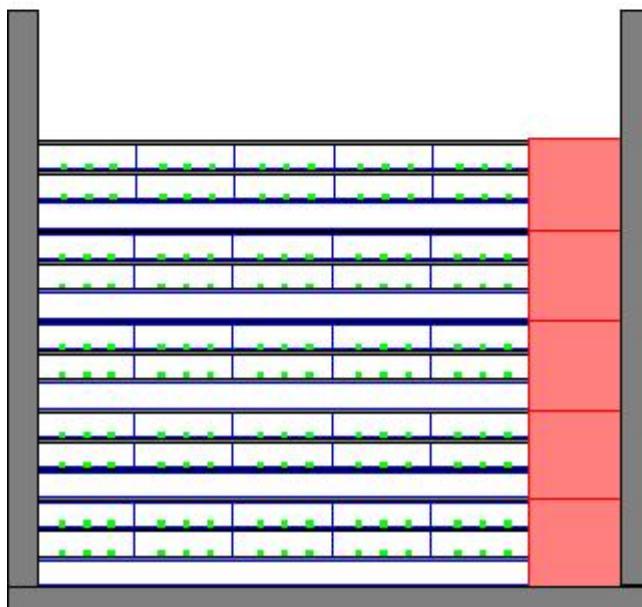
The main goals of the prototype test are:

- to check the design of individual elements,
- to test assembly procedures,
- study the pre-shower performance

PCAL design

Pcal components:

- Fermi Lab scintillator strip 45X10mm , 3 grooves
- WSF (KURARAY Y11, 1mm, Single clad)
- Lead 2.2mm
- Aluminum frame and support structure



Each scintillator layer is made of 5 strips.

There are 3 orientations or planes (labeled X, Y and Z).

Each plane contains 5 layers.

Plane X and plane Z have parallel orientation.

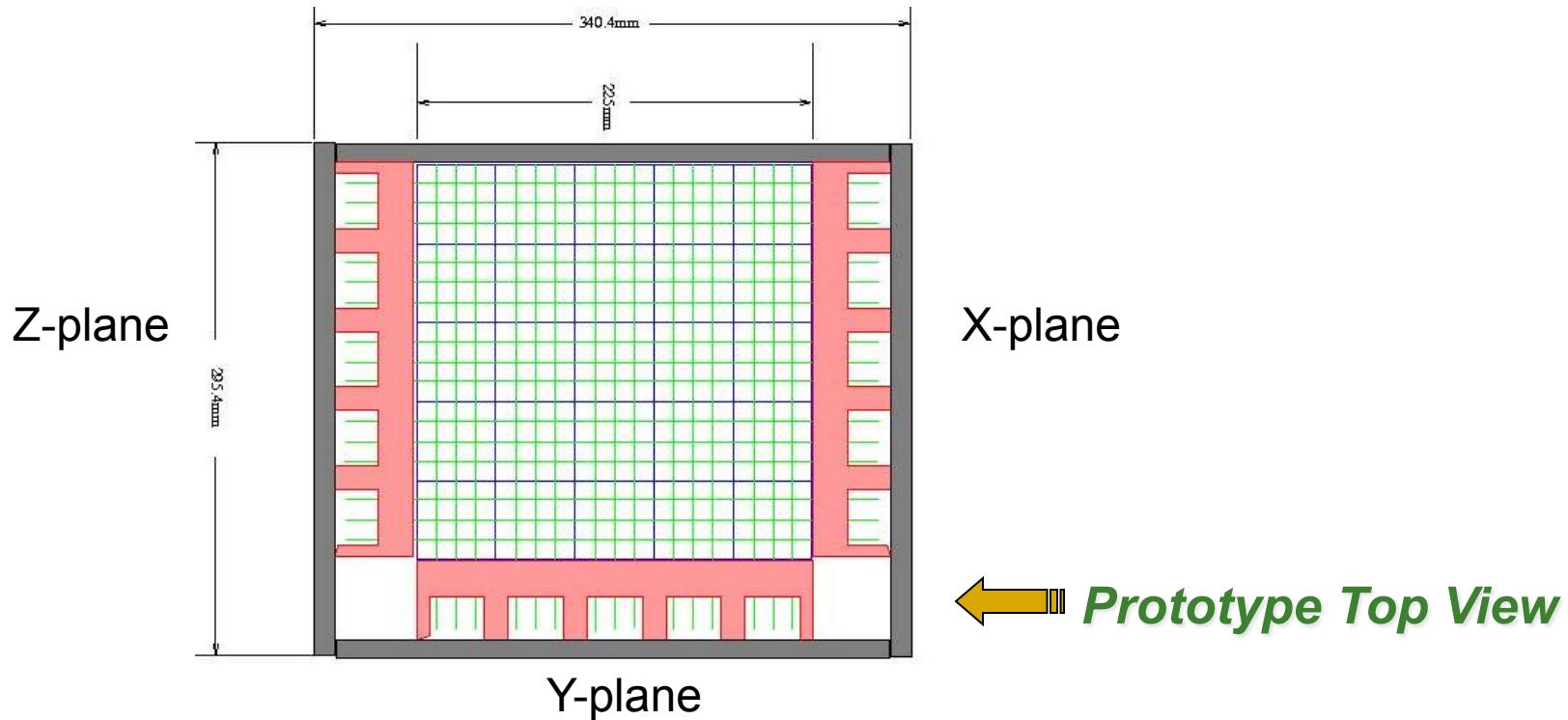
Plane Y is perpendicular to them.

◀ **Prototype Side View**

PCAL design

Altogether there are 75 scintillator strips, 225 fibers and 15 lead plates. For the purposes of readout, fibers from one strip of 5 layers of each view have been stacked together.

The prototype thus requires $5(\text{strips}) \times 3(\text{planes}) \times 1(\text{tower}) = 15 \text{ PMTs}$.

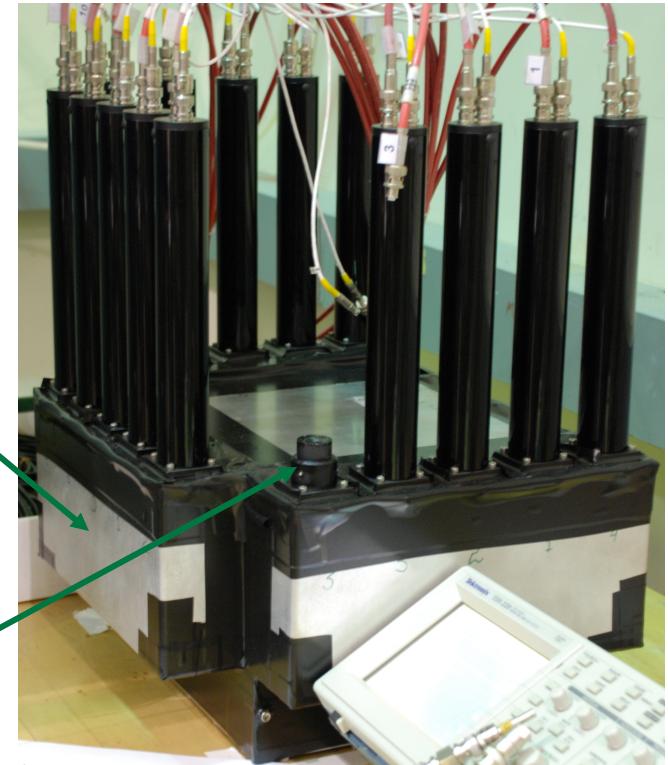


- Bundles of fibers were directed in narrow opening in the center of each side panels of prototype and then covered with aluminum cap.
- Each plane has 5 fiber holders.
- $3(\text{fibers}) \times 1(\text{strip}) \times 5(\text{layers}) = 15$ fibers were glued into individual fiber holder.
- It takes about 24 hours to harden the epoxy.
- The upper parts of fibers have been cut out and the surface of fiber holder has been polished.



*Aluminum
Cap*

*Fiber
holder*

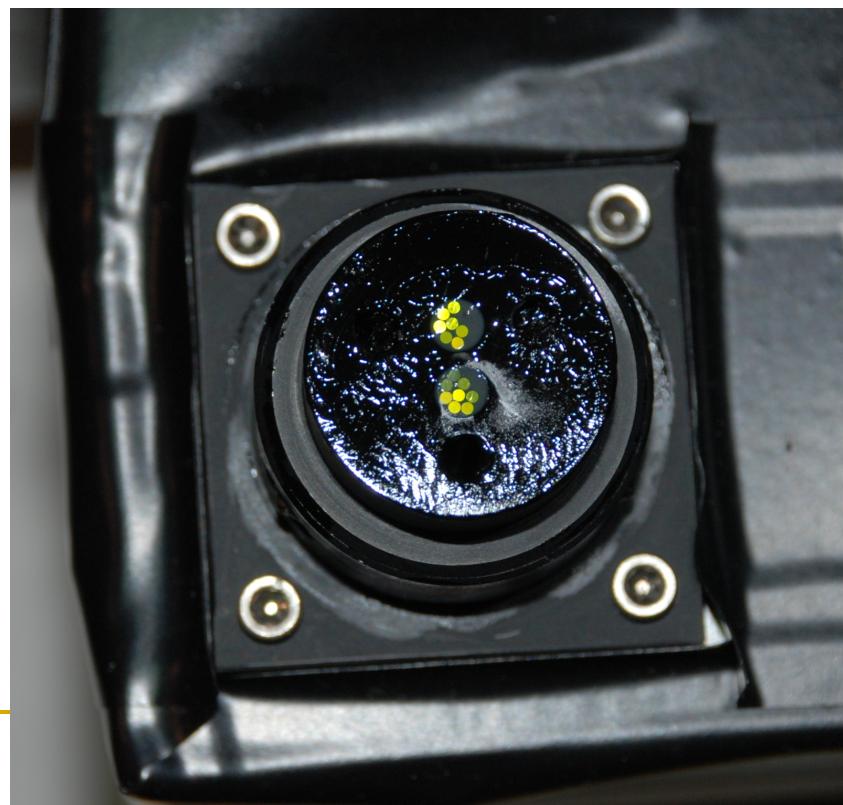




*Epoxy
DP190*

*Fiber
holder*

The PMT and the fiber holder are optically coupled using optical grease



*Individual fiber
holder with 15
fibers*

Some remarks on PCAL design

- Special care should be taken to have enough epoxy between the fibers and to avoid appearing bubbles inside of epoxy
- The fiber holes appeared to be too large, and only 2 out of 5 have been used
- A lot of work on polishing can be avoided by having proper cutting tool and careful cutting procedure

PMT assembling:

- Black plastic tube
- μ -metal cylinder
- Tube's cap with HV and signal connectors
- Holding spring
- Additional tightening ring, cap clamps and ball pins in fiber holder



Some remarks on PCAL design

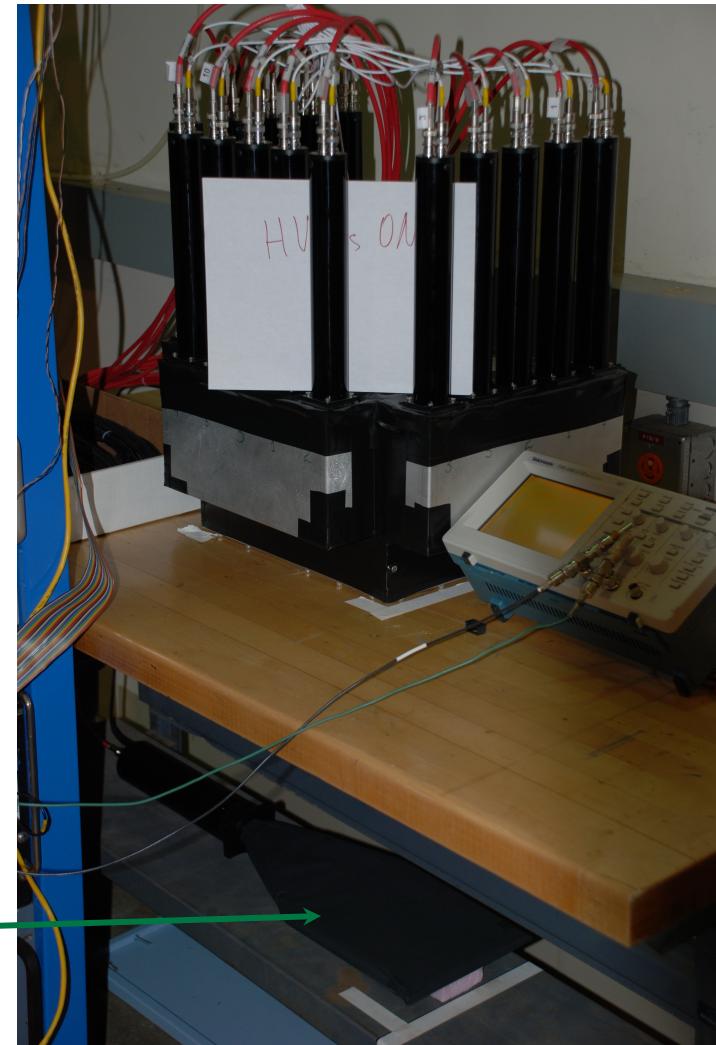
- Design mechanism to fix μ -metal cylinder inside the plastic tube
- Match all the sizes of PMT assembling (clamps, spring, etc)
- Have one ground connector inside of tube's cap to avoid unnecessary soldering
- Shape connectors holes of tube's cap to avoid its rotating

Test setup

To test prototype performance the following has been done:

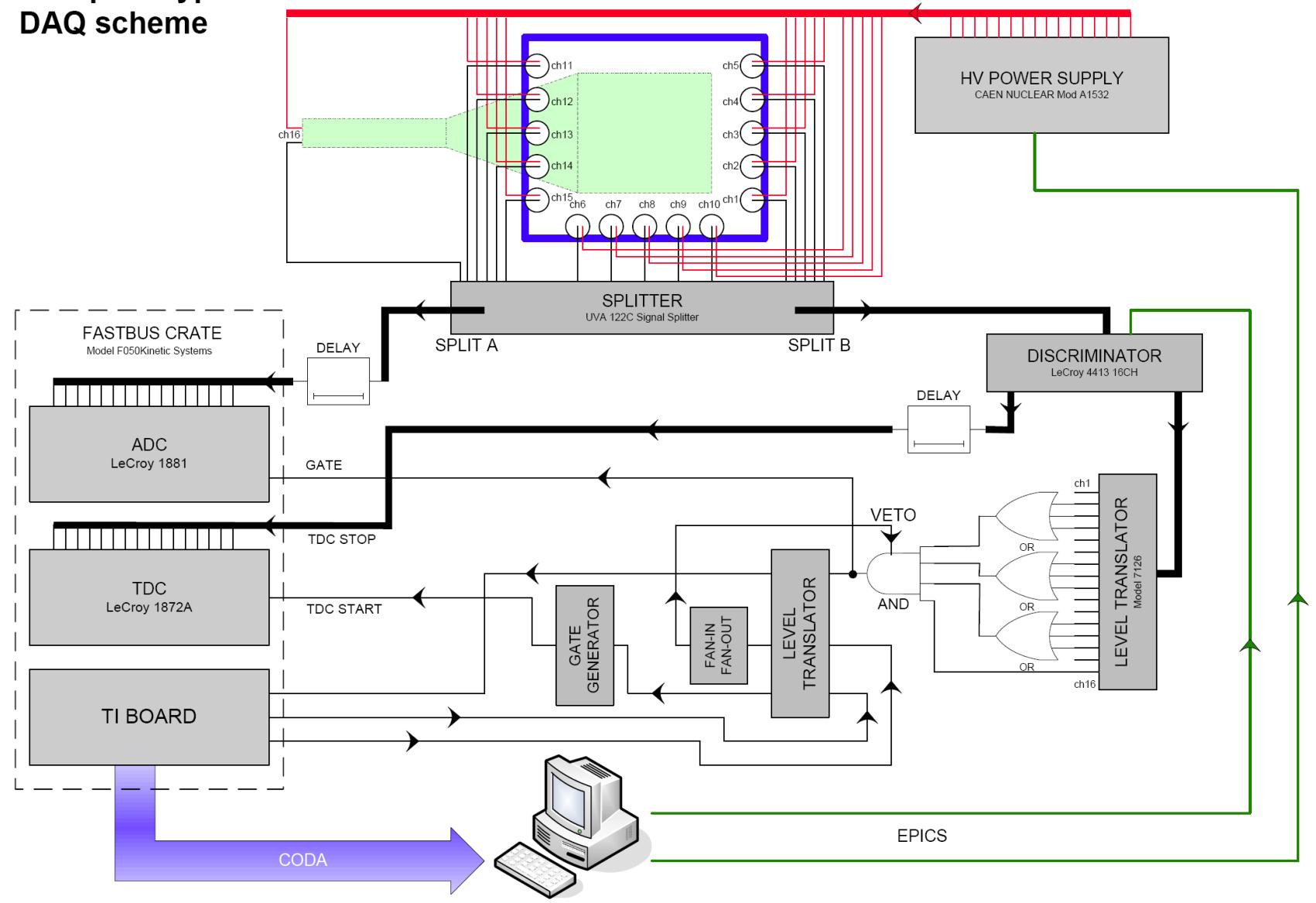
- For the purposes of selecting cosmic rays with vertical trajectories additional counter has been placed at about 65cm below the prototype
- DAQ and electronics setup have been assembled

Counter consist of scintillator plate ($20 \times 22\text{cm}$), conventional lightguide and PMT.

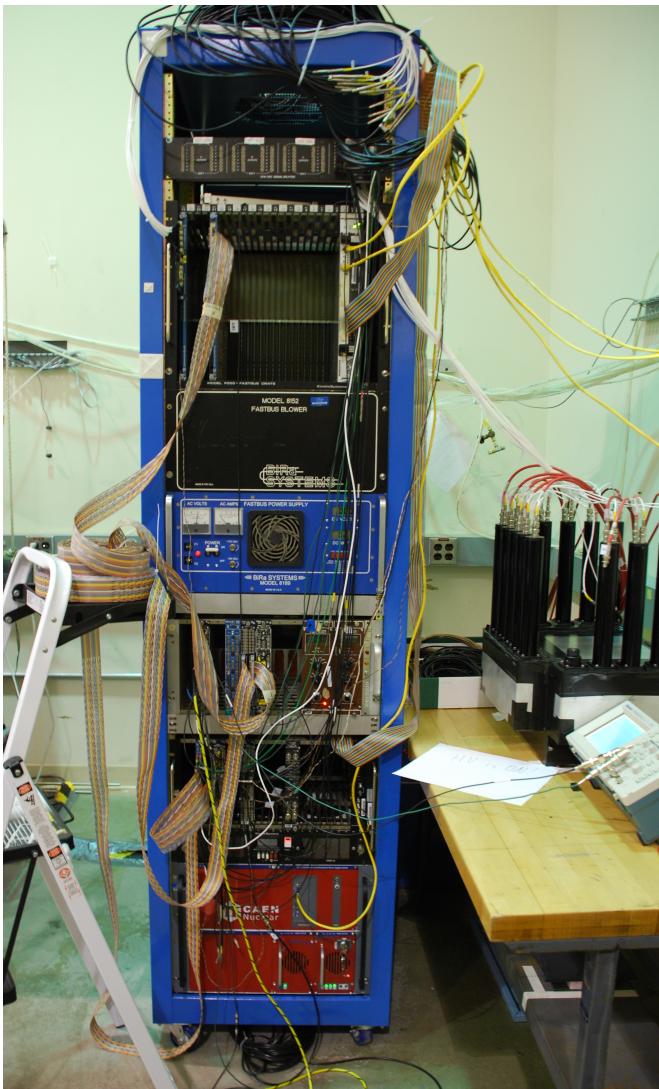


Test setup

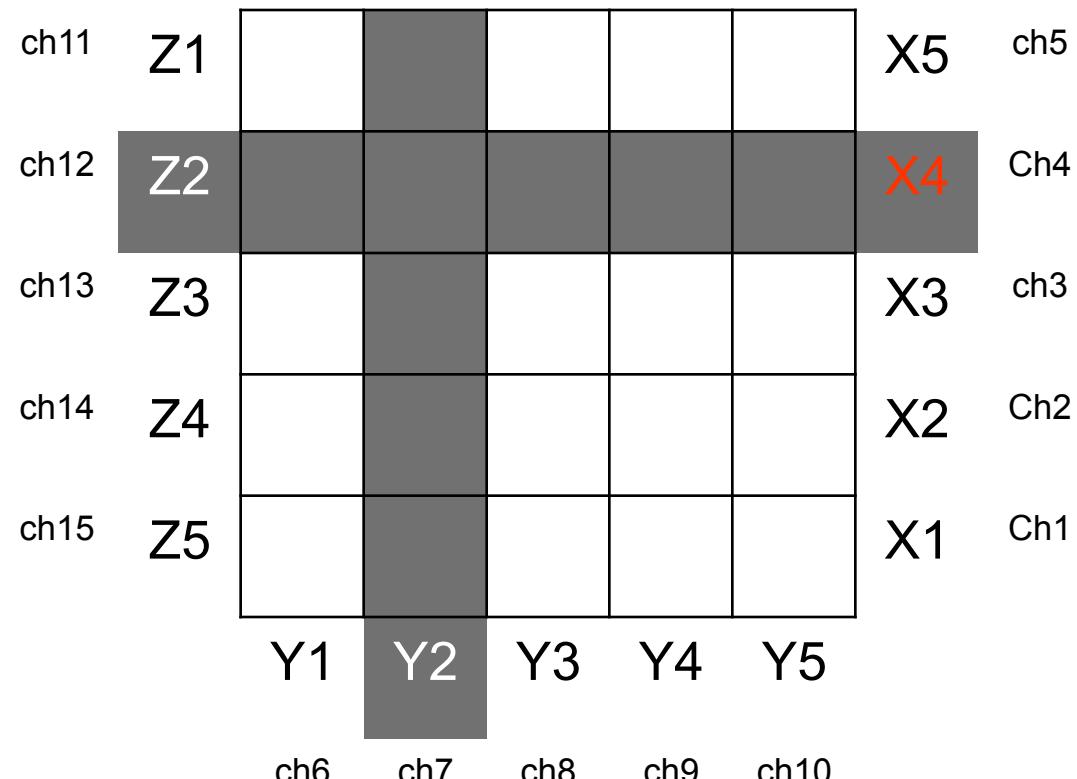
PCAL prototype DAQ scheme



Test setup



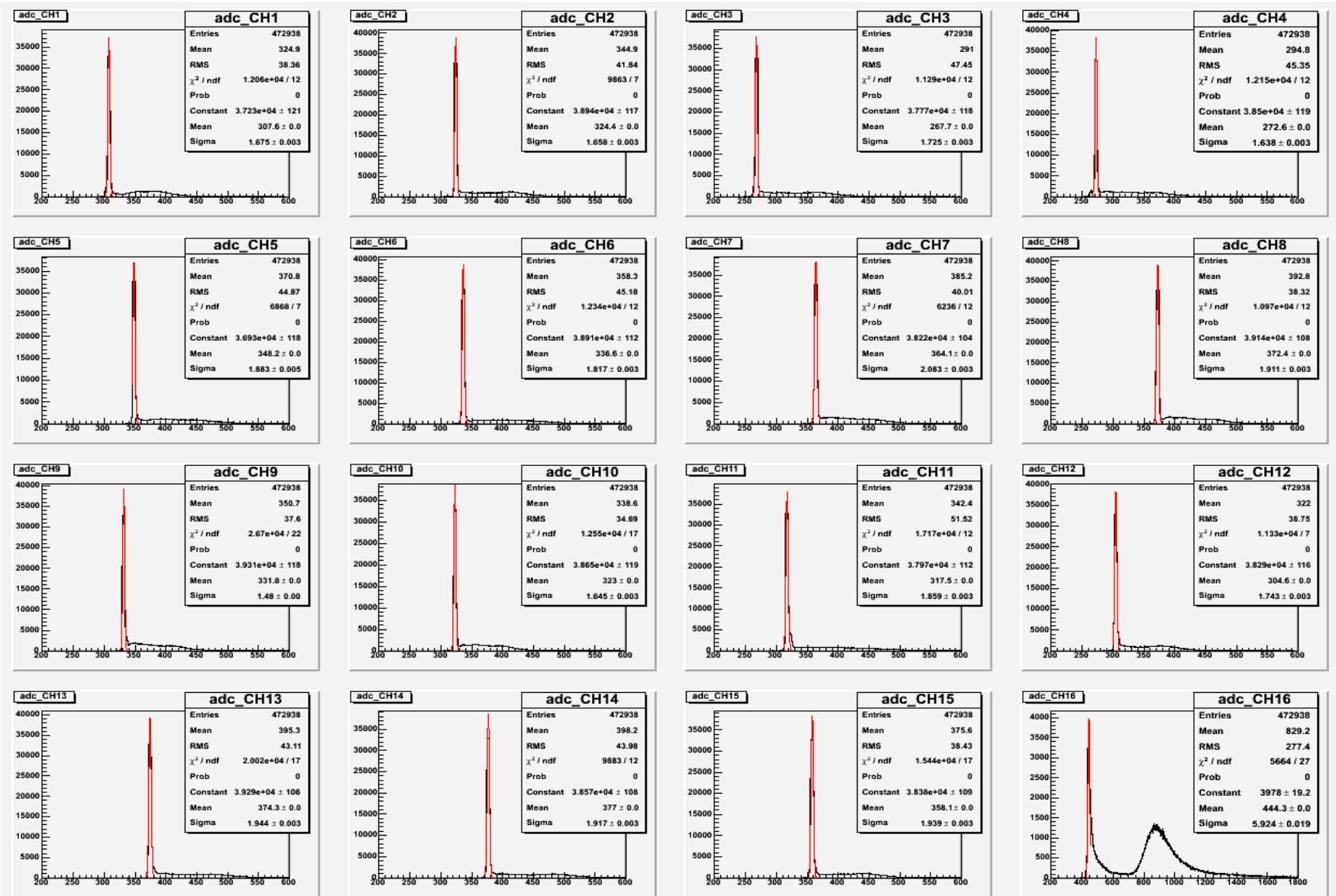
Trigger scheme was the coincidence between counter signal and any of 5 X-plane signals



Pixels Map

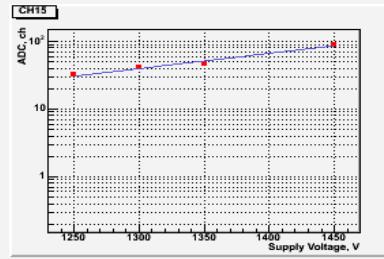
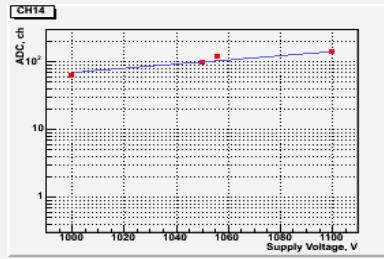
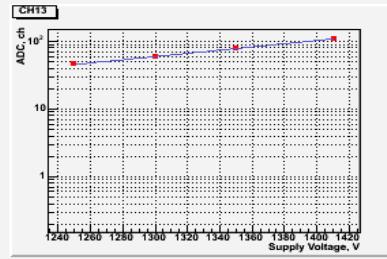
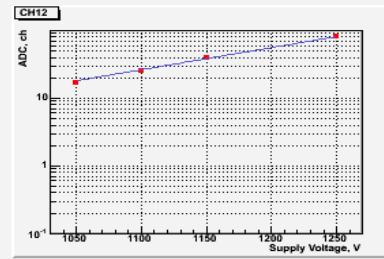
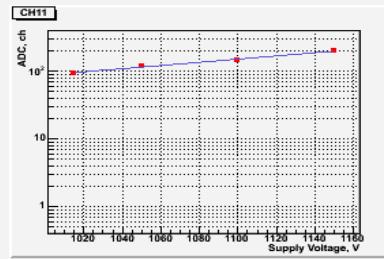
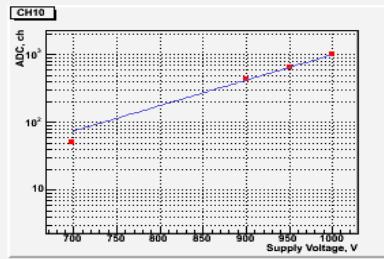
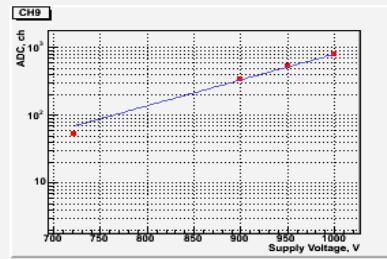
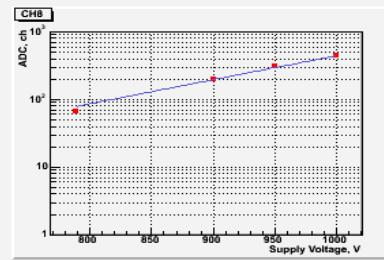
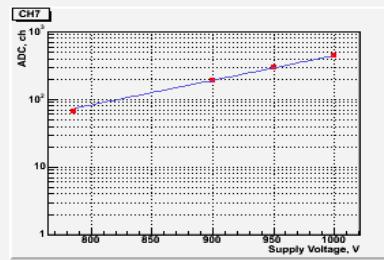
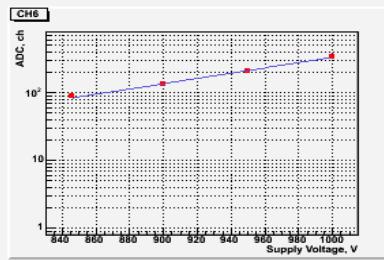
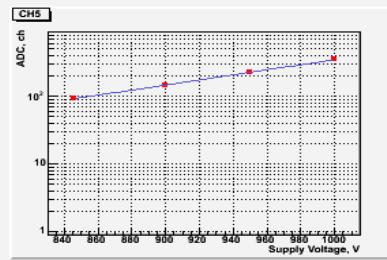
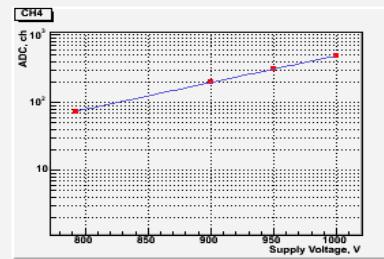
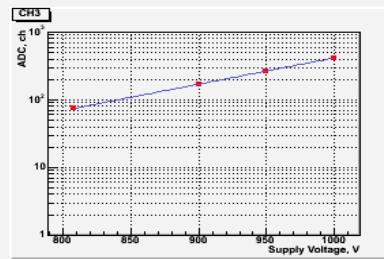
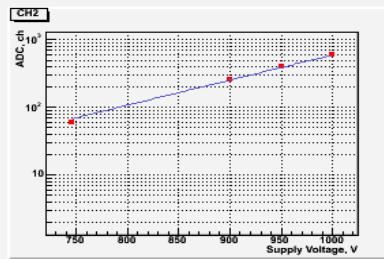
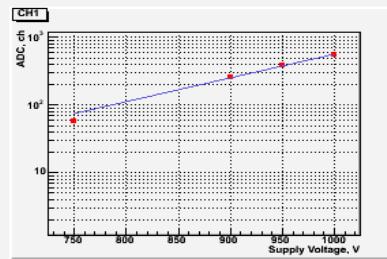
Pedestals

Series of measurements have been done with cosmic runs



Gain Curve

In order to have approximately 10MeV/chADC measurements with different HV settings have been performed .



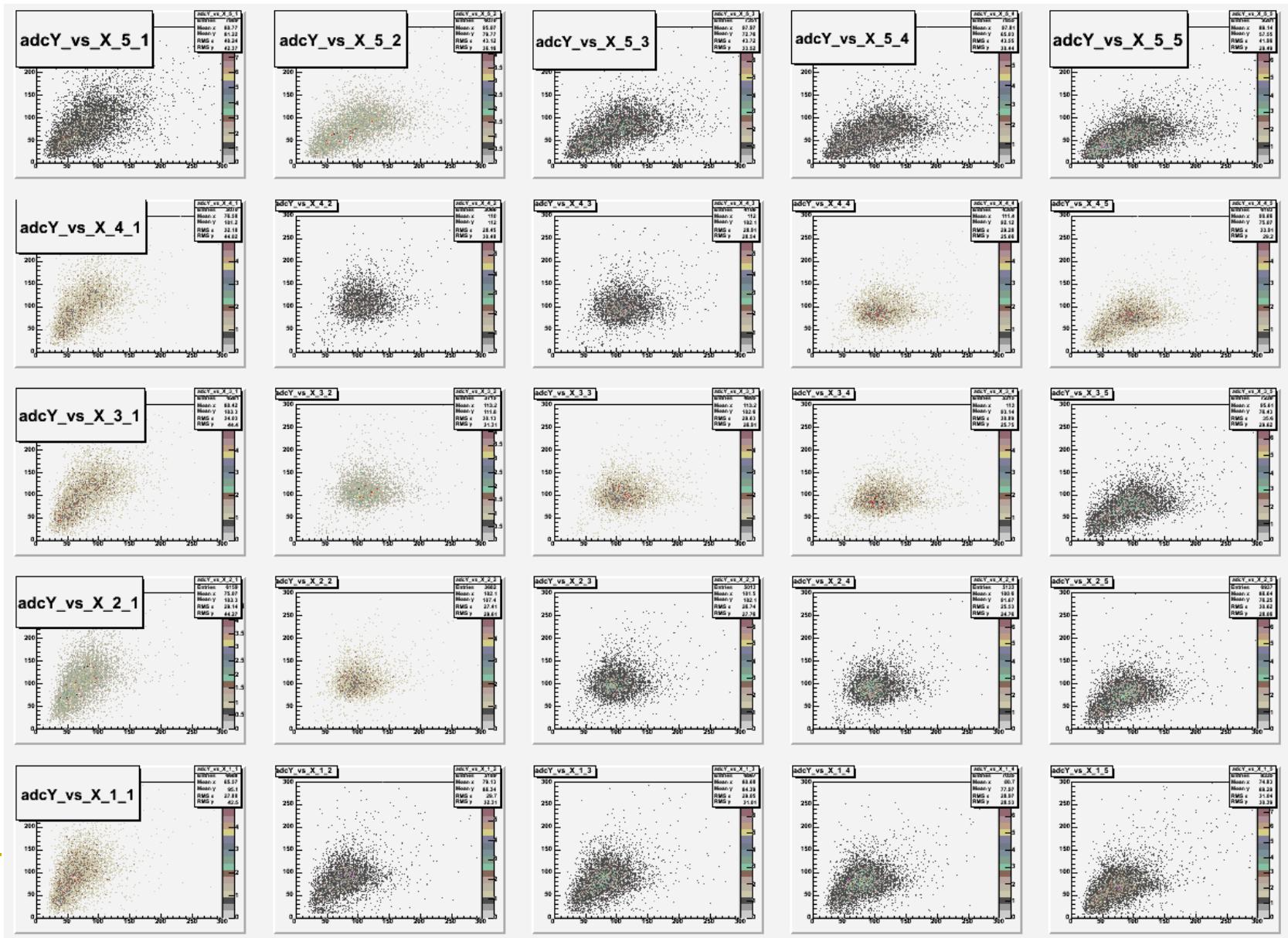
MIP selection

To calibrate the prototype response to energy deposition of *Minimum Ionizing Particles* (MIPs) has been studied.

Selection criteria:

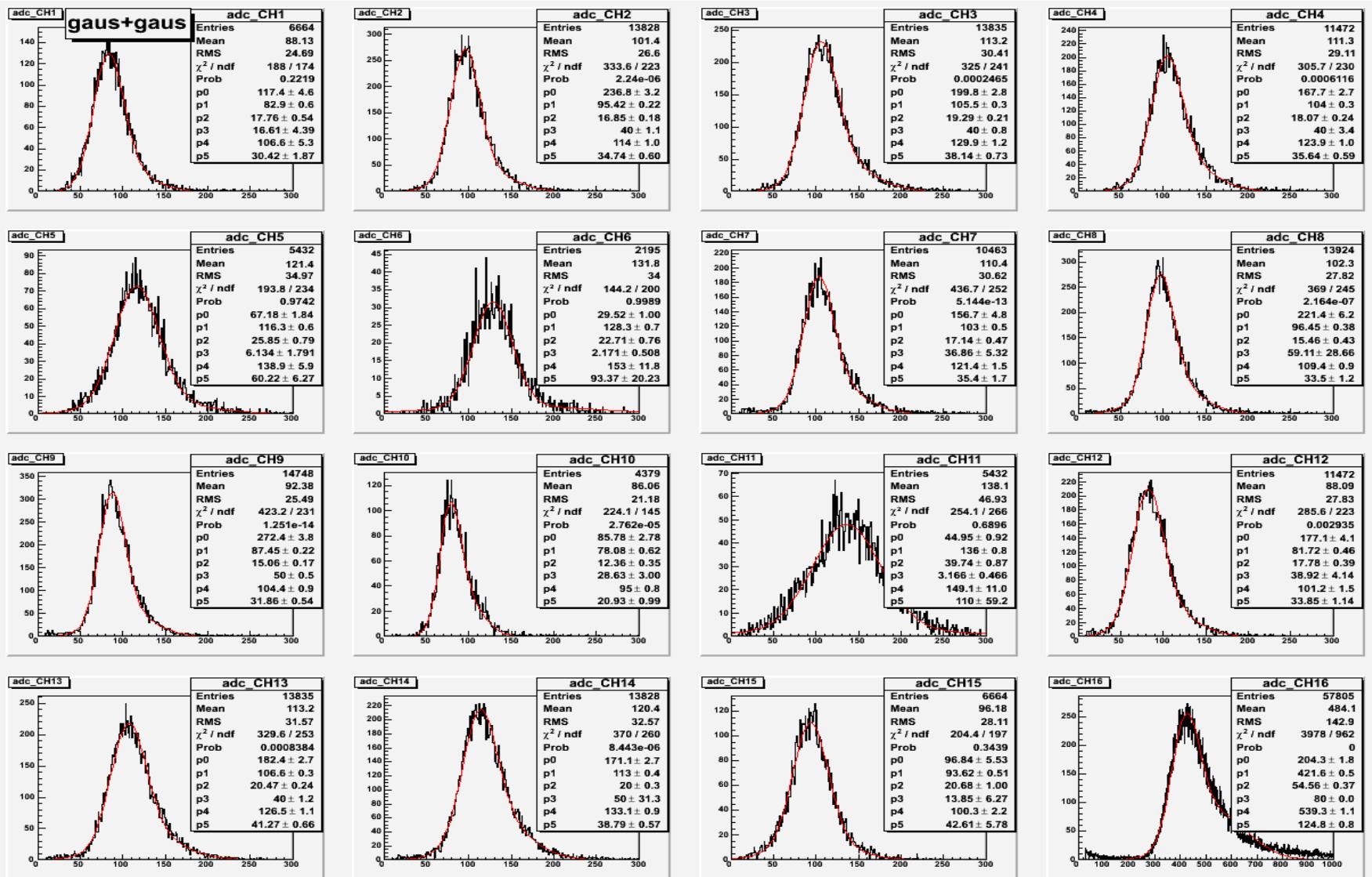
- For internal pixels(PMTs) – one hit from each plane. (<5 σ from pedestal for other channels on this plane)
- For side pixels (PMTs) – one hit from each plane + additional cuts to avoid side angle hits
- Additional cuts - 1 σ cut on amplitude of corresponding signals from internal pixels (PMTs)

MIP selection



ADC signals

For each PMT, a MIP's peak position, at given HV, was determined using two Gaussian fit to the ADC distribution.

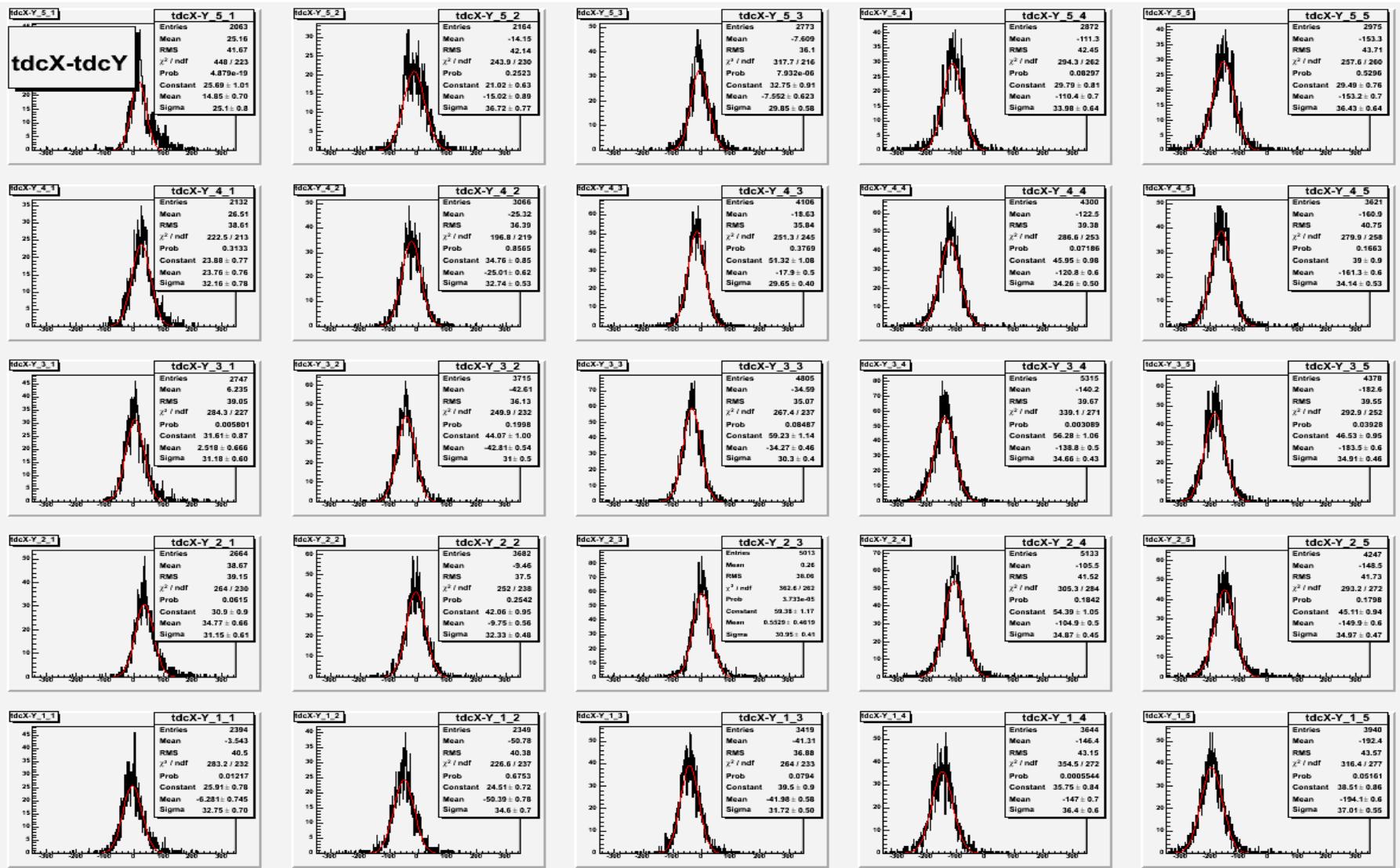


Mean ADC channel above pedestal for 10MeV energy deposition

CHANNEL	PMT	TYPE	PLANE	# OF FIBERS	HV, (V)	ADC, (ch)
1	HAMAMATSU	R6095	X	15	786	82.9 ± 0.5
2	HAMAMATSU	R6095	X	15	791	95.4 ± 0.2
3	HAMAMATSU	R6095	X	15	841	105.5 ± 0.3
4	HAMAMATSU	R6095	X	15	825	104.0 ± 0.3
5	HAMAMATSU	R6095	X	14	855	116.3 ± 0.6
6	HAMAMATSU	R6095	Y	15	865	128.3 ± 0.7
7	HAMAMATSU	R6095	Y	14	822	102.9 ± 0.5
8	HAMAMATSU	R6095	Y	15	818	96.4 ± 0.3
9	HAMAMATSU	R6095	Y	15	762	87.4 ± 0.2
10	HAMAMATSU	R6095	Y	15	733	78.0 ± 0.6
11	PHOTONIS	XP2802	Z	15	1024	135.9 ± 0.8
12	PHOTONIS	XP1912	Z	10	1277	81.7 ± 0.4
13	HAMAMATSU	R7899EG	Z	15	1395	106.6 ± 0.3
14	Electron Tubes	9124B	Z	15	1051	112.9 ± 0.3
15	HAMAMATSU	R7899EG	Z	15	1478	93.6 ± 0.5

TDC signals

Time resolution has been estimated as a difference of TDC values between corresponding channels when criteria for MIP was satisfied.



Mean and Sigma of TDC distribution in ns (tdcX-tdcY)

Mean	Sigma									
0.74	1.25	-0.75	1.83	-0.37	1.49	-5.51	1.69	-7.66	1.82	5
1.18	1.60	-1.25	1.63	-0.89	1.48	-6.04	1.71	-8.06	1.70	
0.12	1.55	-2.14	1.54	-1.71	1.51	-6.94	1.73	-9.17	1.74	
1.73	1.55	-0.48	1.61	0.02	1.54	-5.24	1.74	-7.49	1.74	
-0.31	1.63	-2.51	1.73	-2.09	1.58	-7.34	1.82	-9.70	1.85	
1		2		3		4		5		

Conclusions and future plans

- Some remarks to design of individual parts of prototype has been made:
 - Numbers and sizes of holes inside of fiber holder, single ground connector in the cap of plastic tube, etc
 - Size tolerance of all components
- Preliminary calibration for given HV settings

Next steps:

- Photoelectron statistics studies
- Beam test of prototype

Support slides



