JOINT INSTITUTE FOR NUCLEAR RESEARCH

The Laboratory of High Energies (LHE)

REPORT ON THE SUMMER STUDENT PROGRAM

MPD ECal module test in horizontal cosmic rays

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Participation period:

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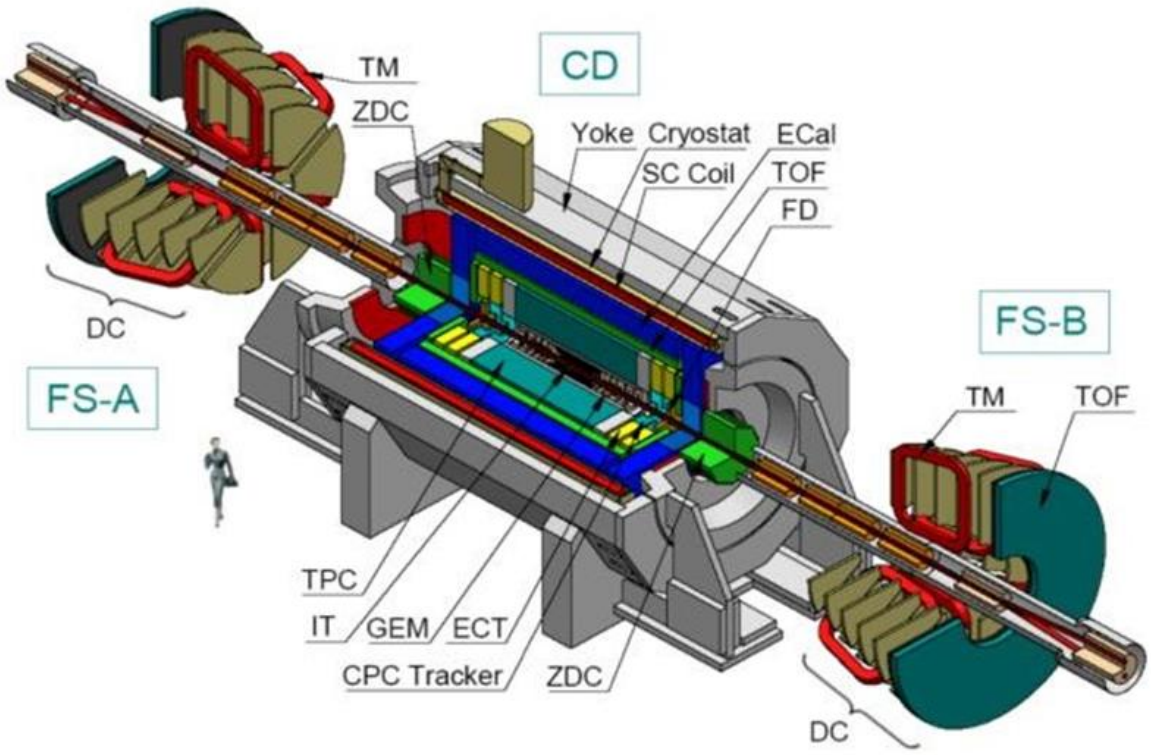
Introduction

As part of this internship, I conducted work on the development of a prototype electromagnetic colorimeter, developed under the NICA project, for the installation of MPD. The purpose of my work was to measure the main characteristics of the modules of the electromagnetic colorimeter of the “Shashlyk” type, for MPD installation. A series of experiments was conducted to determine the light output of the prototype module "Shashlyk". Based on prototype research and analysis of the data obtained, the design of the final sample for further production.

MPD (Multi-Purpose Detector)



https://img.radio.cz/AZbOe1xh8-JJfguhZzLNNriMFUM=/fit-in/1800x1800/1527162424__pictures/c/veda/detektor_mrd.jpg

The MPD installation includes a central part consisting of a vertex detector (IT), an internal tracker and a system for determining the energy, charge and type of charged particles (TOF, TPC), electromagnetic calorimeter (ECal) and the superconducting magnet surrounding them (SC Coil). At the ends of the central

part of the installation there are systems necessary for monitoring the beam (BBC, ZDC) and detectors that overlap the region of small scattering angles (FS-A, FS-B).

MPD ECal module test in horizontal cosmic rays

Research objects:

The four following 4 towers where assembled in rectangular tower 40x400 mm^2 (220 layers 1.5 mm Sc+0.3mm Pb). Total tower length 420mm. 16 WLSY11 (diameter =1.2mm) End painted in three reflector types:

1.1 IHEP Aluminum Evaporation

1.2 White Epoxy Resin with Titanium Oxygen

1.3 Silver Shine paint

1.4 No reflector: black scotch glued on WLS End

2. Light output and Attenuation length measured with Tyvek and without ones for this towers

3. Light output and Attenuation length measured for modules glued in one sector of 16 tower. White Epoxy Resin used for modules gluing and for light reflection on WLS Ends and modules surface.

The experimental setup for cosmictest

1. Time of Flight method was used for cosmic trigger and coordinate measurements with accuracy 4 cm (200ps)

2. Two double readout scintillators 50 cm length 5 cm width and 10 mm thick where used this setup

3. Constant Fraction Discriminator (CFD Caen 458)

4. TDC LeCroy (50 ps/ch) – for Time measured

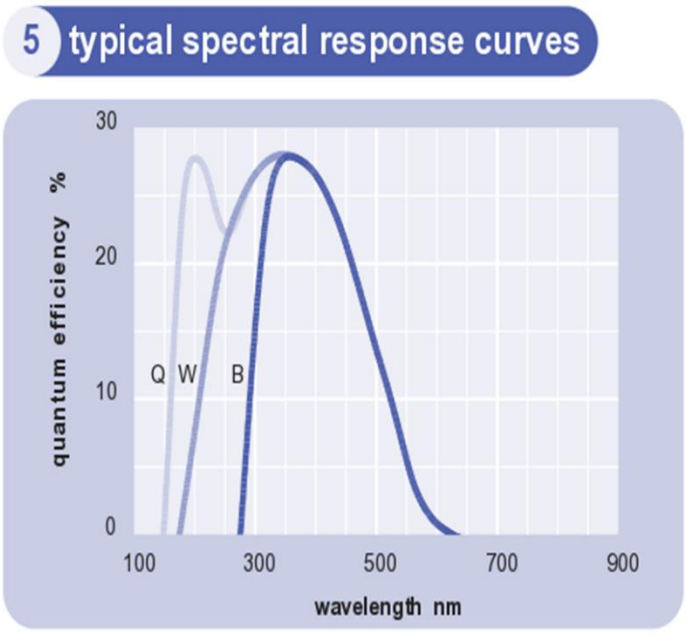
5. ADC LeCroy 2248A – Charge measured

6. Fast PM EMI 9142 – for Trigger end ECal cell

7. Power Supply –Basedon Crowcroft Walton (JINR Astakhov)

8. DAQ –MIDAS data acquisition system in CAMC Crate

Photomultiplier PM 9142-wb

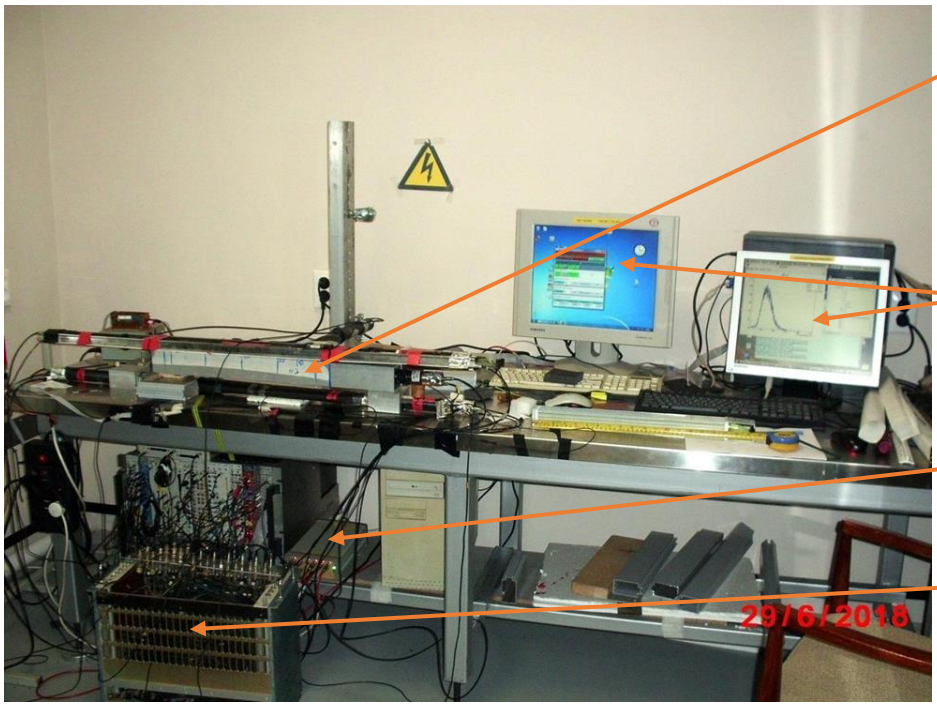


PM 9142 WB - fast – 1.8 ns rice time

Quant efficiency (500 nm) ~ 12 %

Y11 – emission spectra

Experimental setup for cosmic test

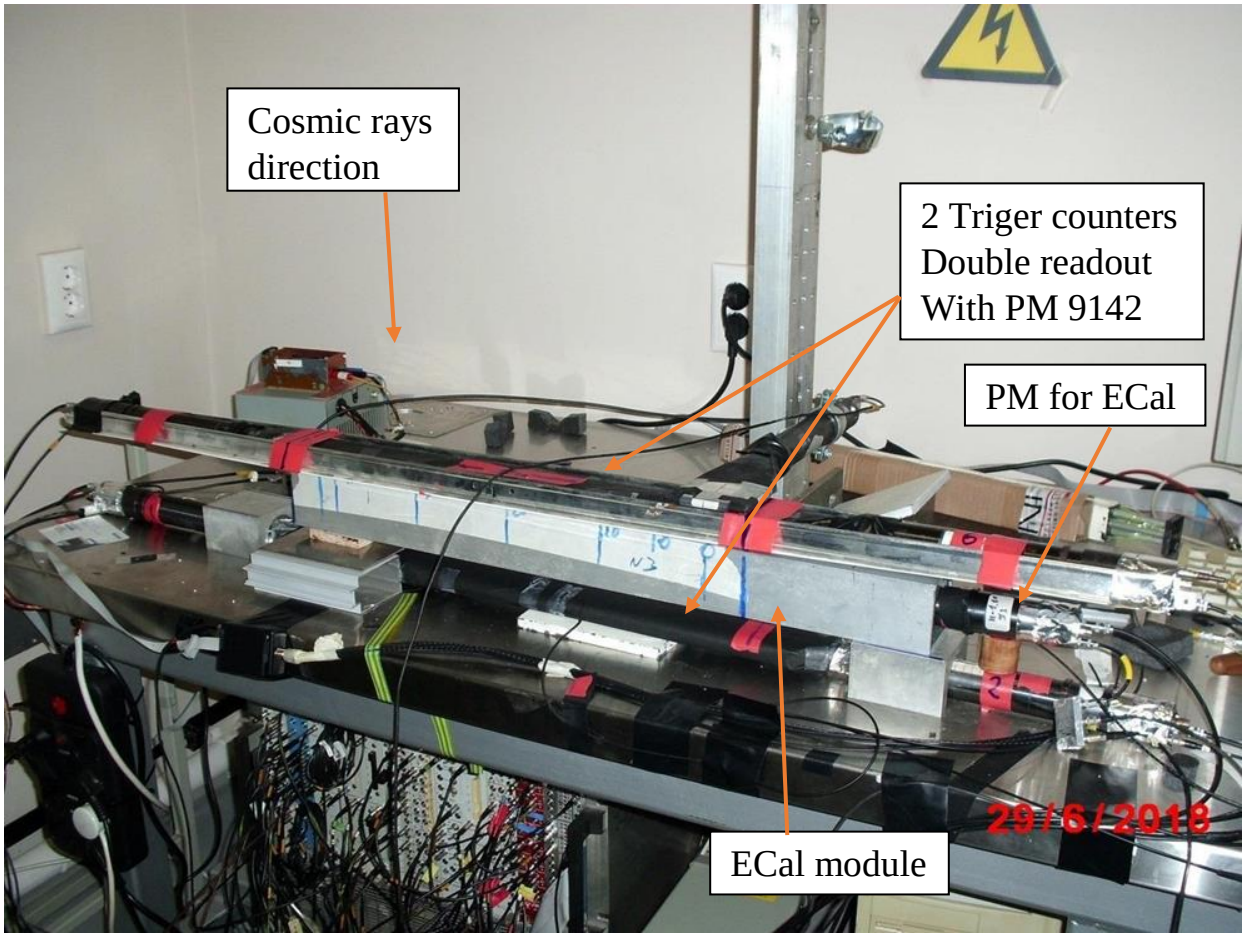


Setup for cosmic

2 PC for HV control and DAQ

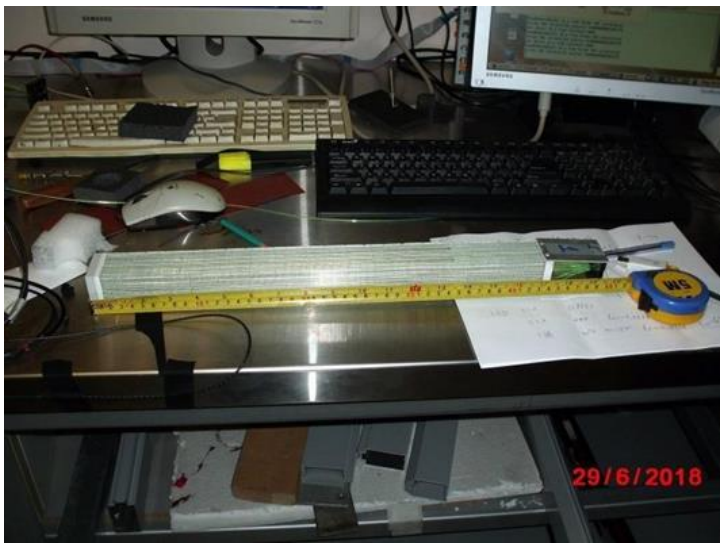
HV power supply for PM's

CAMAC for Trigger logic and TDC and QDC

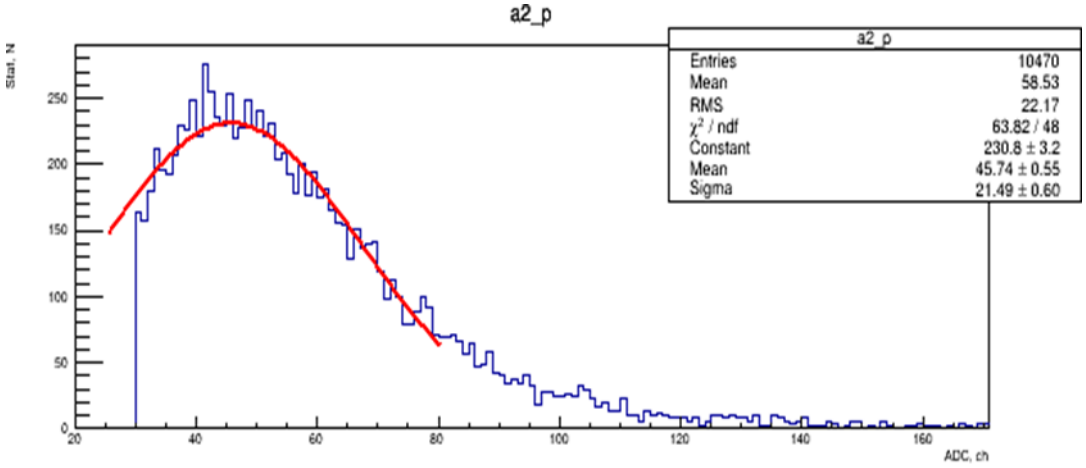


At this installation, measurements were made of the modules on cosmic rays. The modules were wrapped in gray paper.

The measurements were carried out for the duration of the day for each module. In addition to the signal from cosmic rays, an LED signal was input. The LED signal served to verify the correct operation of the equipment.



The measurement results are processed in the ROOT package for computers on the Linux platform. Various histograms and distribution schedules are constructed.



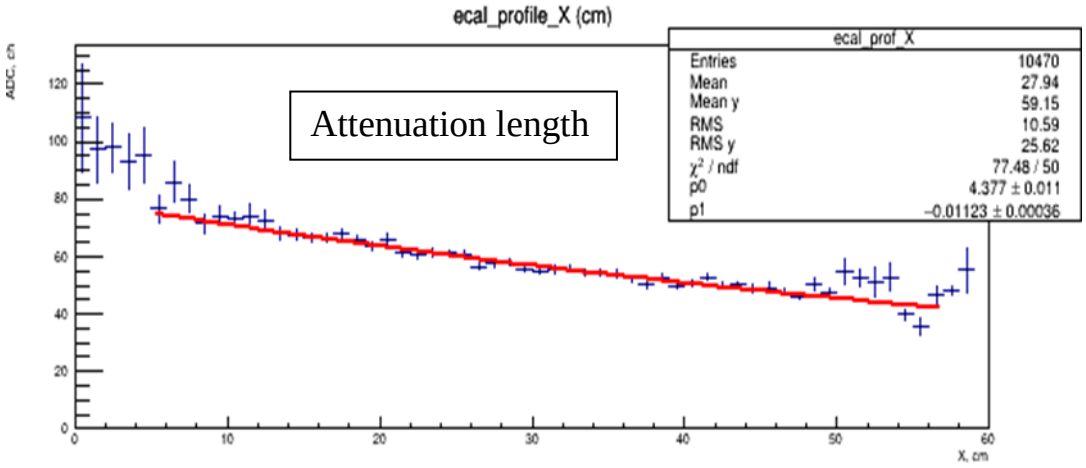
Experiment (Run 232)

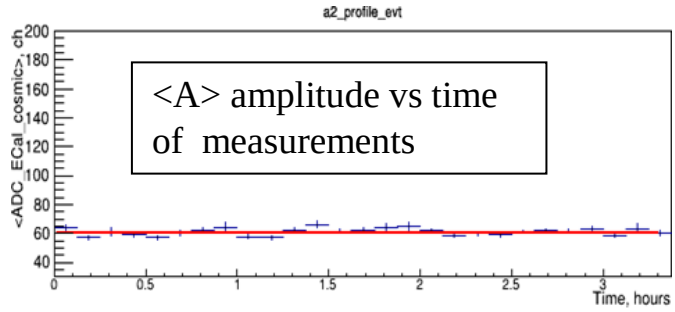
Gaussian fit

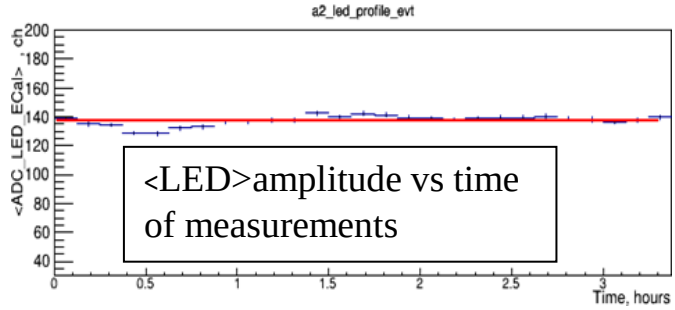
Max = 46

Mean =58

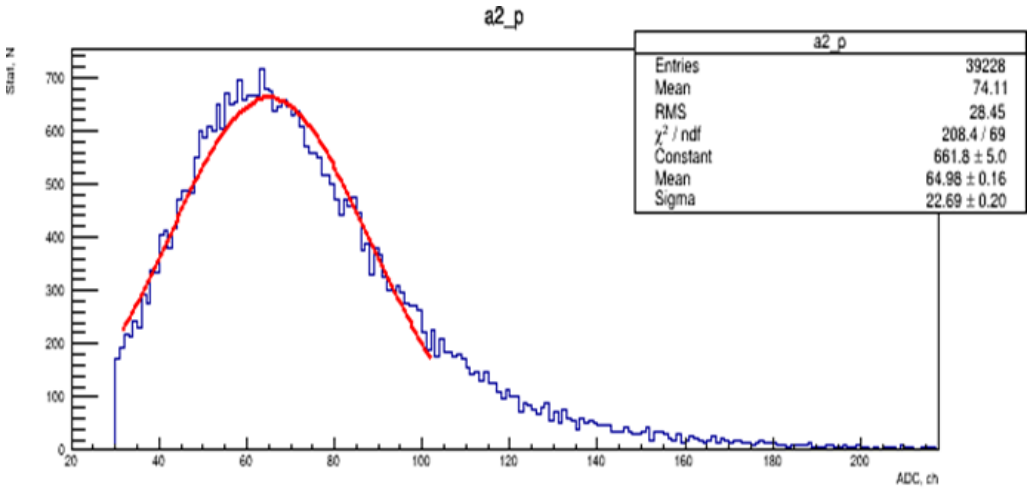
L_0=84 cm







The uncoated module was replaced by a module whose end of the fibers was painted with white paint (White Epoxy Resin with Titanium Oxygen).



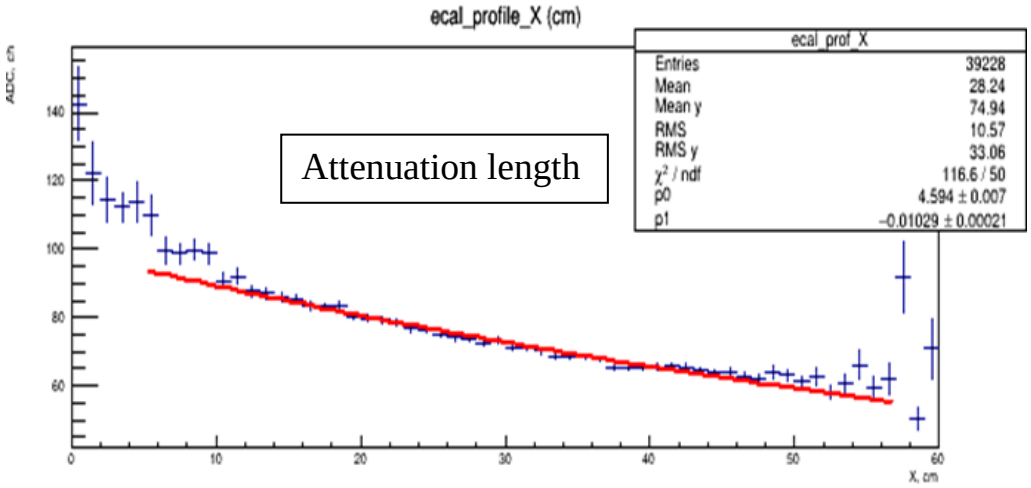
Experiment (Run 220)

Gaussian fit

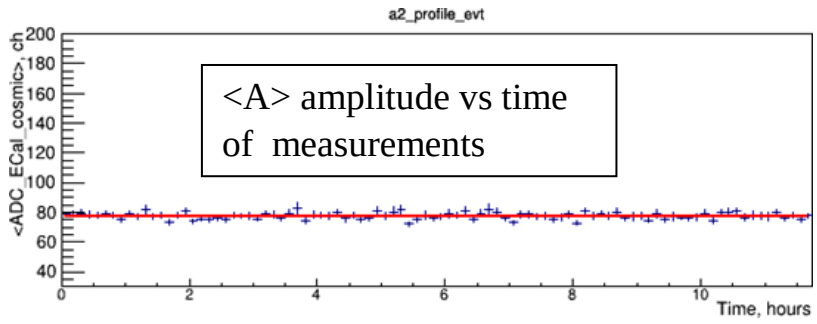
Max = 65

Mean =64

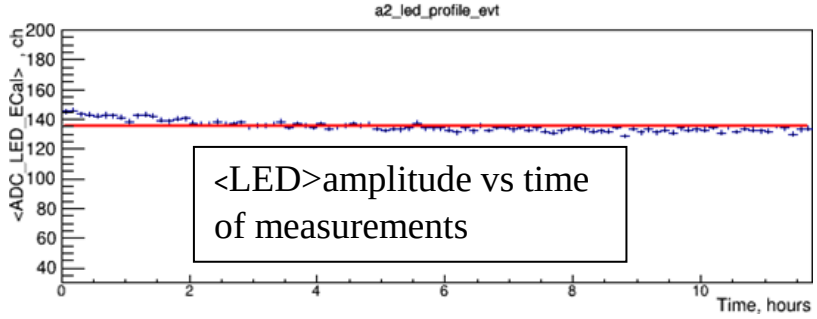
L_0=88 cm



Attenuation length

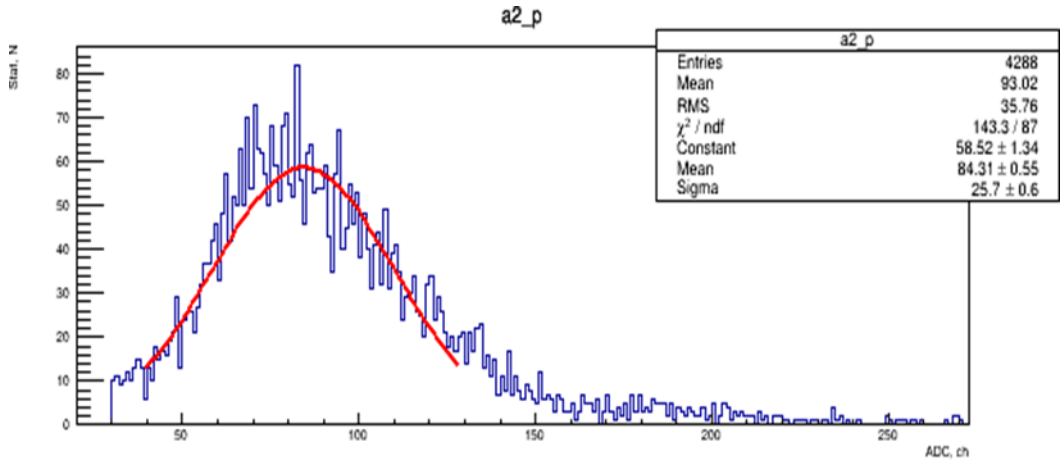


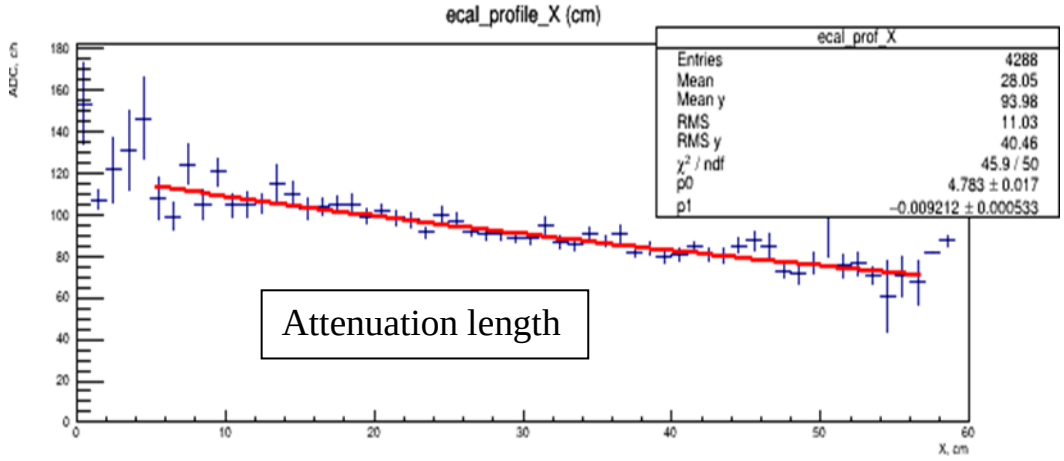
<A> amplitude vs time of measurements

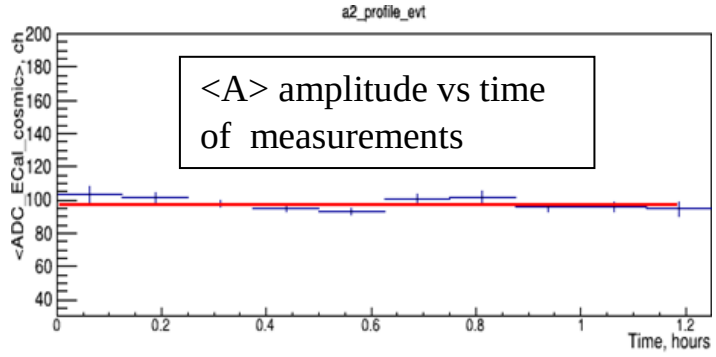


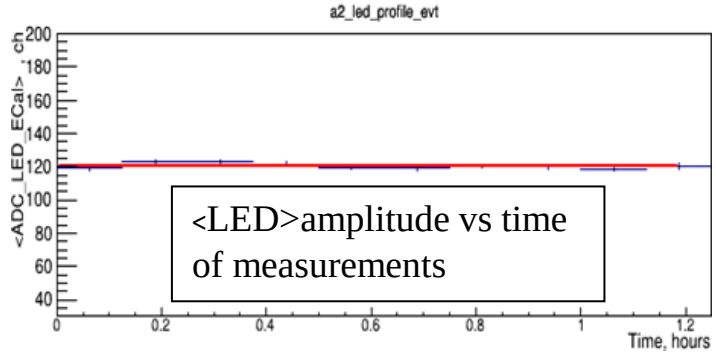
<LED>amplitude vs time of measurements

The uncoated module was replaced by a module whose end was covered with an IHEP Aluminum Mirror. (This coverage showed the best results from 3 modules under investigation.)







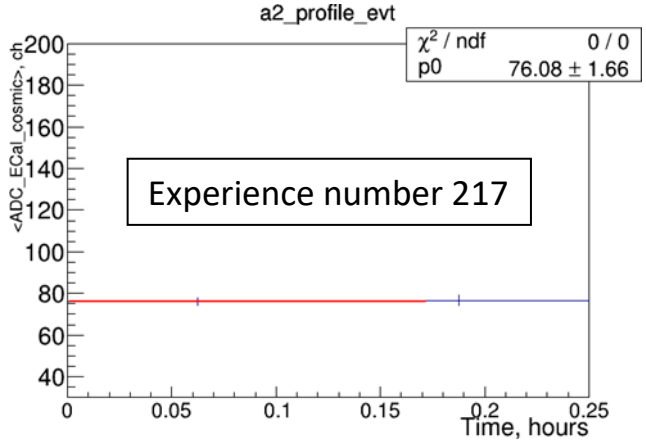


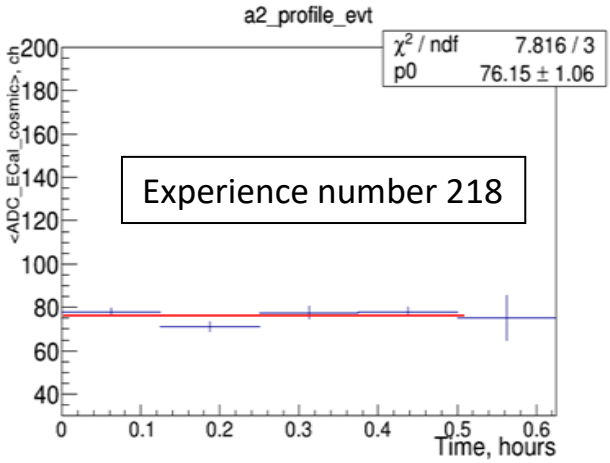
A number of experiments were carried out for each of the samples to check the repeatability of the experiment.

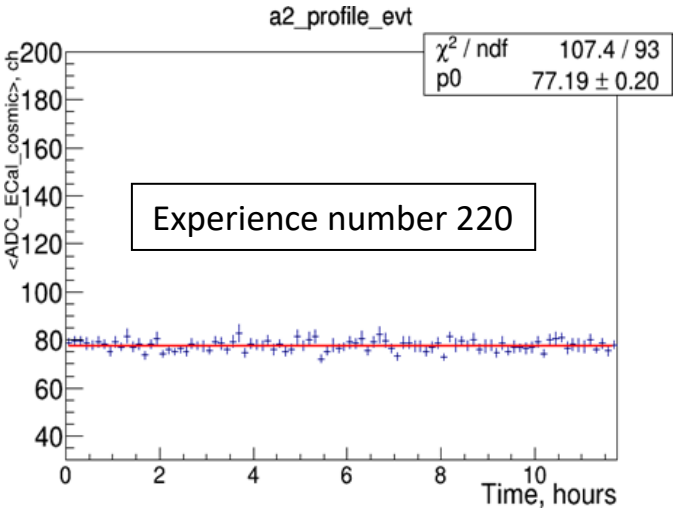
These graphs show the amplitude values and the measurement time.

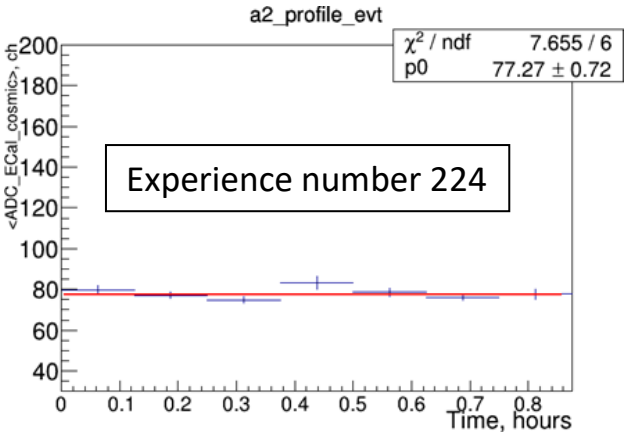
Test with White paint (modules where covered in graypaper)

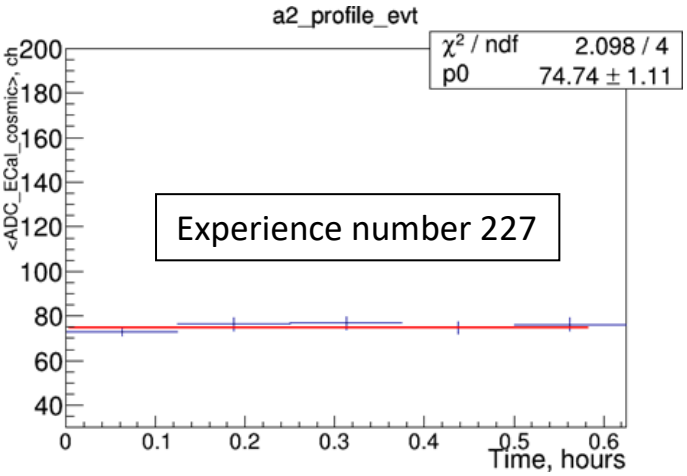
Amplitudes vs time of measurements for corresponded runs

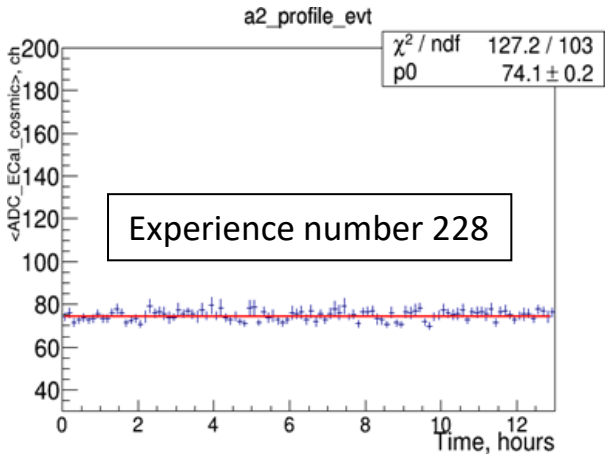






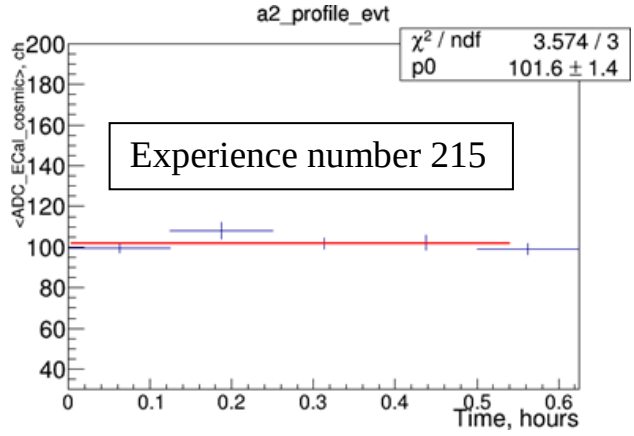


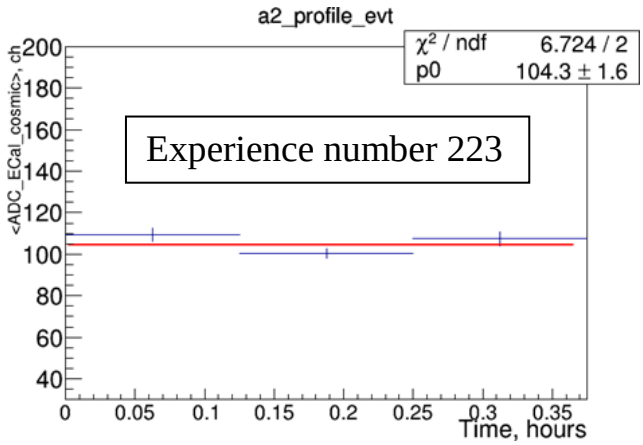


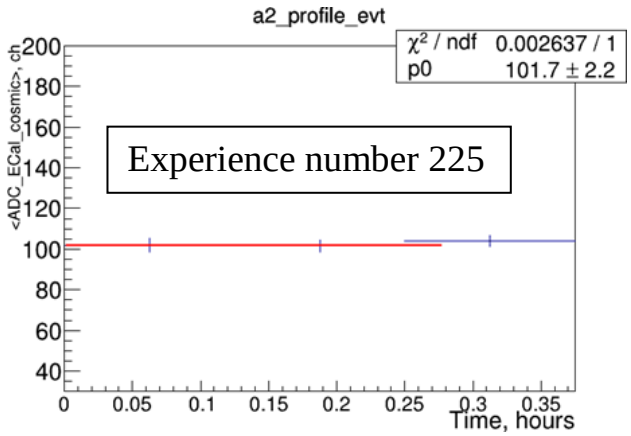


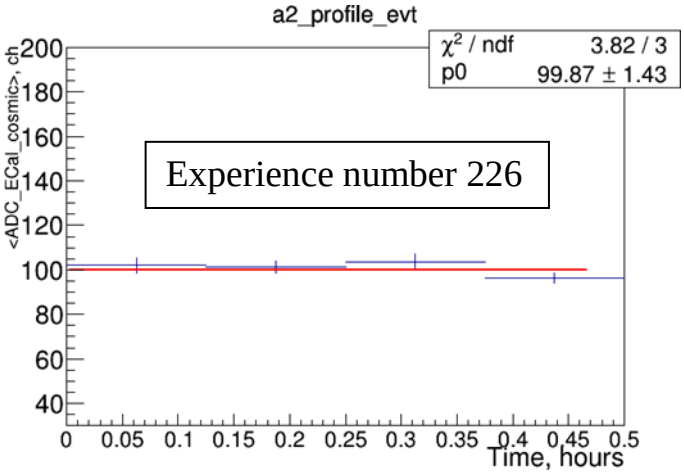
Test with Mirror: IHEP Aluminum Evaporation (modules where covered in graypaper)

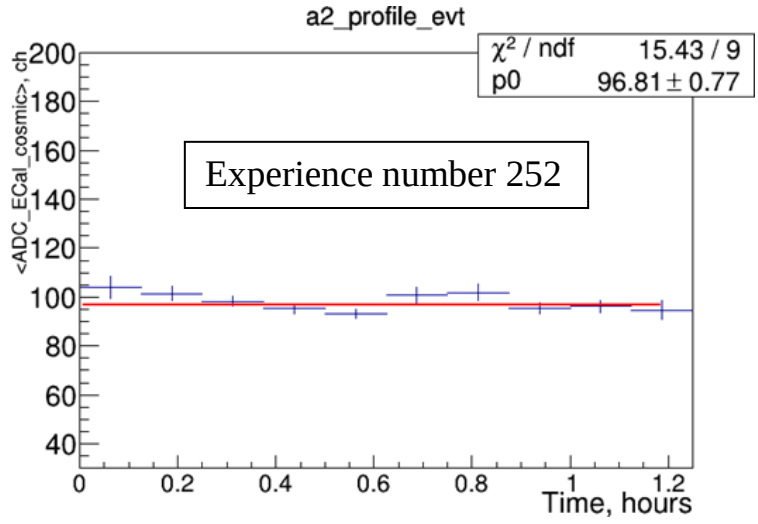
Amplitudes vs time of measurements for corresponded runs







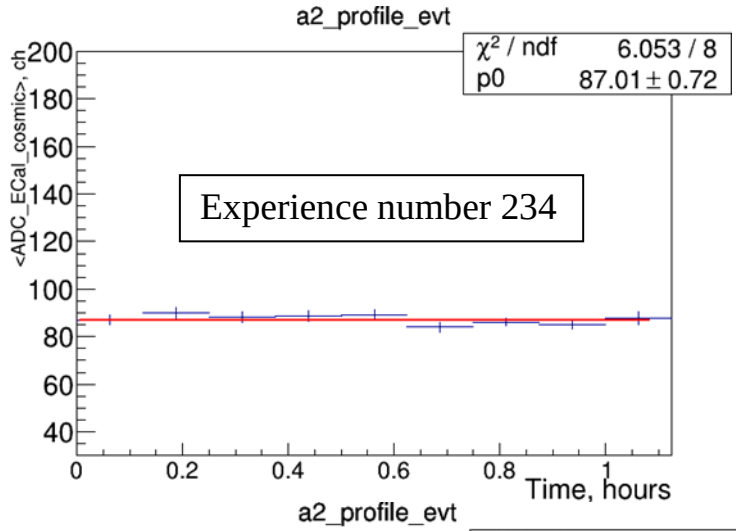


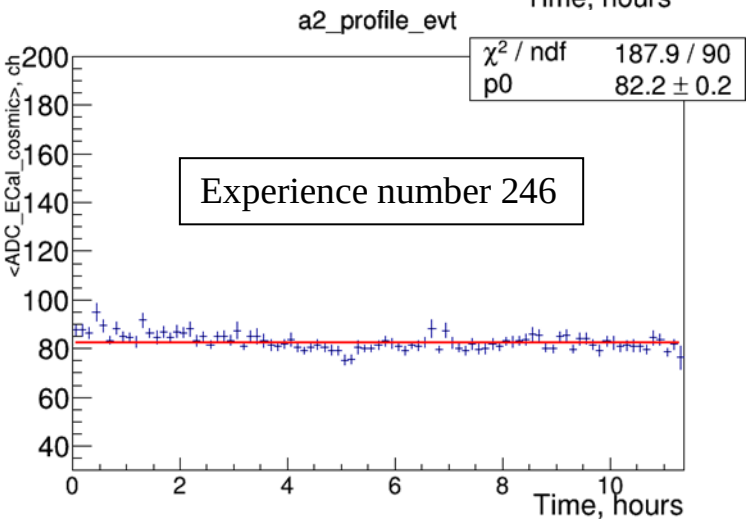


Separately, the Silver Shine coating was investigated. From this coverage were forced to abandon. Silver Shine had the property of crumbling after application.

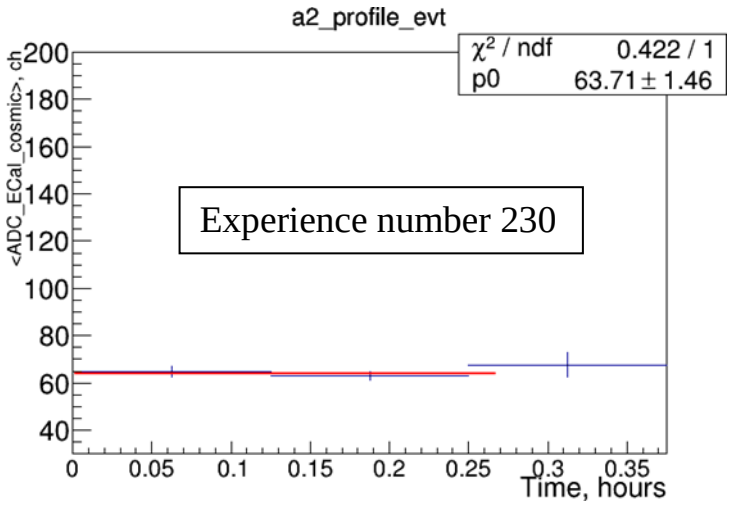
Amplitudes vs time of measurements for corresponded runs

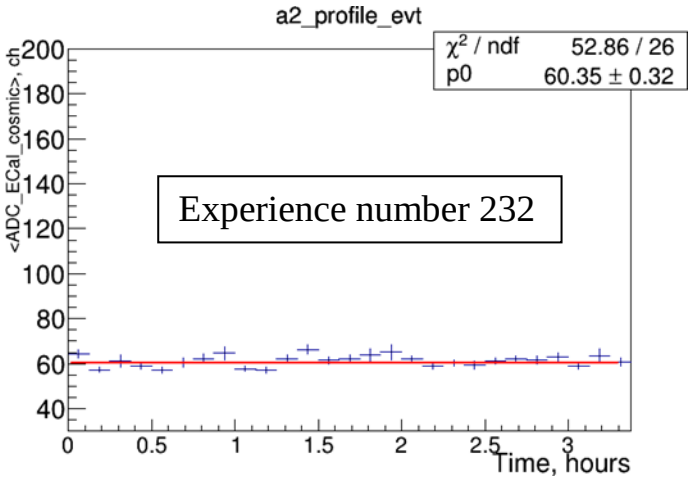
Silver Shine





No coverage





Single module (modules where covered in graypaper)

White - White Epoxy Resin with Titanium Oxygen

IHEP –Aluminum Evaporation (IHEP)

Silver - Silver Shine coverage

Coverage	Run	Statistic	<A>	1/IHEP, %	Led	Sig (Led)	NPE (Led)	NPE (Cosmic)	Knpe, npe/ch	Err, Knpe	L_0, cm	NPE/GeV	Error NPE/Ge V, %
white	218	1143	63		149	24	16	16	0,261	0,012	107	668	4,5
white	220	39228	65		134	24	15	15	0,237	0,036	88	638	15,1
white	224	2901	66		115	22	16	16	0,238	0,035	74	655	14,6
white	228	41420	61		132	24	15	15	0,239	0,034	93	607	14,1
white	227	1842	60		132	22	17	17	0,275	0,002	93	691	0,8
<mean>			**63**	**71%**							**91**	**654**	**9,6**
IHEP	215	1860	88		127	21	25	0,289	0,016	96	96	1060	5,6
IHEP	223	1272	93		252	30	27	0,289	0,016	91	91	1122	5,6
IHEP	226	1532	86		181	25	25	0,291	0,018	97	97	1046	6,3
IHEP	252	4288	84		119	21	24	0,282	0,009	108	108	992	3,3
<mean>			**88**	**100%**							**98**	**1055**	**5,2**
No coverage	230	862	48		141	22	14	14	0,295	0,022	89	**594**	**7,6**
No coverage	232	10470	43		137	23	11	11	0,295	0,014	84	**467**	**5,3**
<mean>			**46**	**52%**							**86**	**530**	**6,4**
Silver	246	41436	70	79%	123	22	18	18	0,258	0,015	94	749	5,7

<A> – mean value for muonpeak;

Led - mean value for LEDpeak;

Sig(Led) – mean sigma for LEDpeak;

Npe/Gev=NPE(Cosmic)*10*1000/240;

240 MeV – signal in single module irradiated by ~1000 MeV mu beam along his axis;

10 – factor = ratio longitudinal/ transverse beam direction in module.

NPE(Led)=(Led/Sig(Led))^2 - Photoelectrons Number - photo statisticfactor;

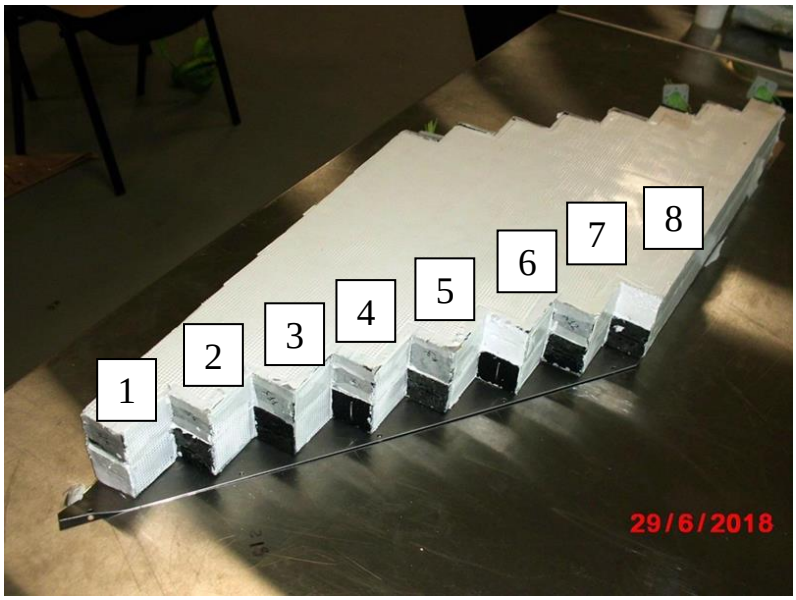
Knpe= NPE(Led)/Led – the readout gain –Photoelectrons number per ADC channel;

L_0 – attenuation length from exp(a-1/L_0), where a – constant term;

Coverage Aluminum Evaporation (IHEP) showed better results, white paint (White Epoxy Resin with Titanium Oxygen) was 25% worse.

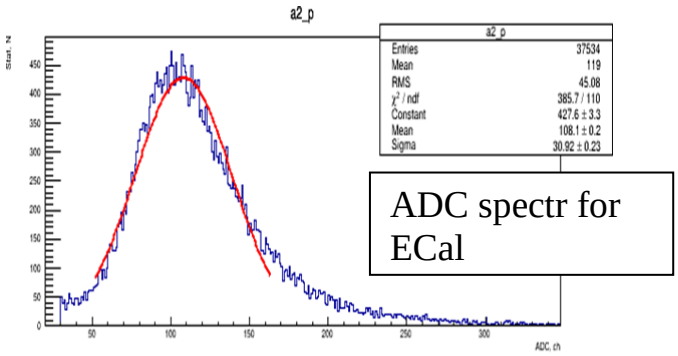
Several uncoated 16 modules were glued in one block. The paint was both a coating and glue

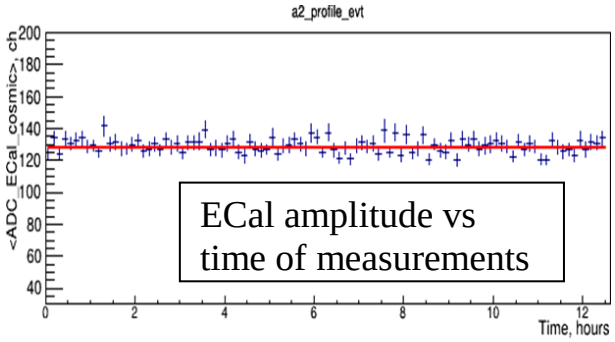
16 Modules assembling

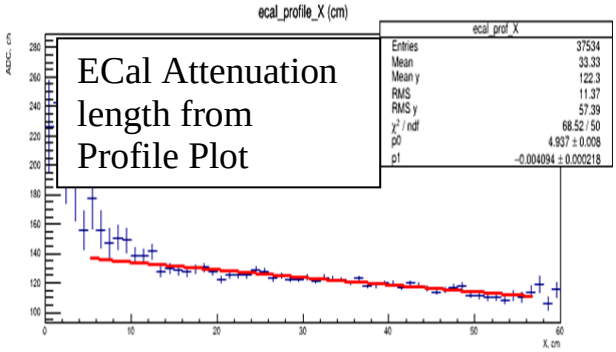


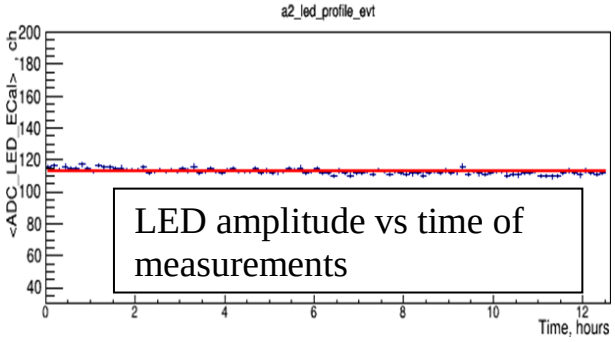
The unit was placed in a black box, without access to light. Separately, the indicators of each module were measured.

Measurement results (Run 300) of the module (5-down) glued in one block









Measurement results of the 16 modules glued in one block

Coverage	Run	Statistic	<A>	Led	Sig_Led	NPE_Led	NPE(Cosmic)	Knpe	Err	L0	NPE/GeV	Err NPE/GeV
6-up	264	1843	116	130	22	32	32	0,261	0,004	377	1320	1,5
6-down	266	1236	114	121	19	39	39	0,237	0,071	340	1615	20,9
6-up	272	21055	93	100	20	24	24	0,238	0,009	326	1002	3,4
4-down	274	10160	102	114	21	27	27	0,239	0,007	473	1114	2,6
4-up	294	28774	118	100	19	32	32	0,275	0,001	381	1328	0,4
5-up	297	5906	118	108	20	34	34	0.285	0,016	285	1401	5,6
5-down	300	37534	109	112	20	29	29	0,268	0,001	228	1217	0,3
7-down	302	42722	96	113	21	24	24	0,251	0,018	225	1006	7,1
7-up	304	6352	117	106	20	31	31	0,263	0,006	192	1282	2,2
8-up	305	38457	99	102	20	25	25	0,254	0,015	388	1048	5,9
8-down	306	76866	48	88	20	11	11	0,232	0.037	206	463	15,9
Meat			**103**					**0,269**			**1163**	**6**

Conclusions

In these experiments, data were obtained that showed that the coating Aluminum evaporation gives the best light output. But because of a high cost of production white paint can be considered as an alternative in the project. Paint gives a 25% worse light output, but its cost is somewhat lower than that of Aluminum Evaporation (IHEP).

Bibliography

1 MPD NICA Technical Design Report of the Electromagnetic colorimeter (Ecal) http://mpd.jinr.ru/wp-content/uploads/2018/01/TDR_ECAL_v2.1.pdf

2 G.I. Britvich et. al. A surface reflector on the end of WLS fiber BCF-92 for the VVS detector CKM. Preprint CKM-59. January 28, 2002.