

# Study of the fast calorimeter prototype for modern

### 1. Introduction

Modern e<sup>+</sup>e<sup>-</sup> factories with high luminosity require fast response time of the detector subsystems to suppress severe beam background. Calorimeter is one of the important subsystems of the detector.

#### Tasks of the calorimeter

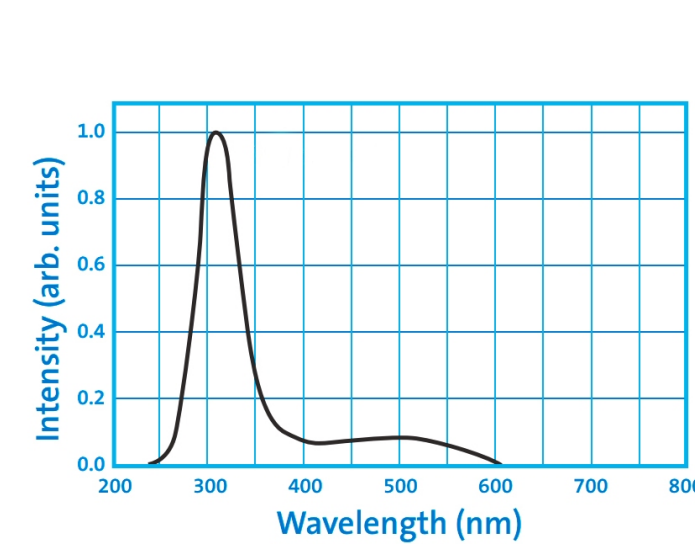
- detects  $\gamma$  with high efficiency and good energy and coordinate resolution
- monitor and measure luminosity
- generates signal for trigger of the detector
- provide particle identification

Using fast scintillating crystals for calorimeter allow one to provide good energy and time resolution and to suppress pileup noise.

### 2. Basic components

#### CsI crystal

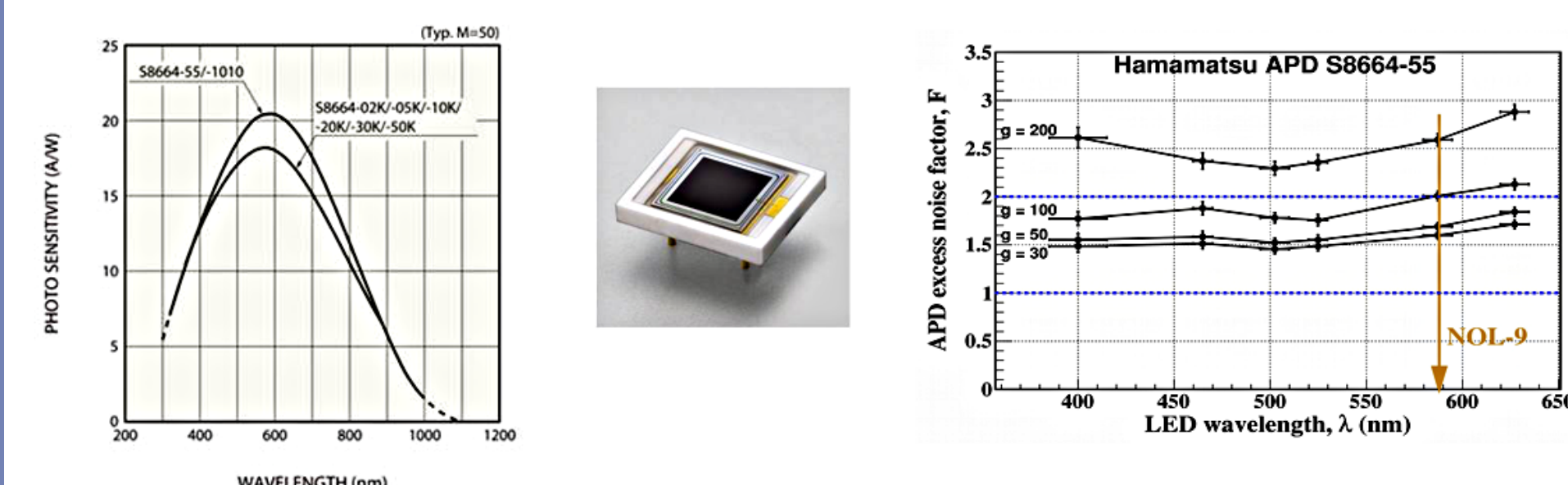
Crystal	$\tau, ns$	$\frac{N_{ph}}{MeV}$	Price, $\frac{\$}{cm^3}$
CsI(Tl)	1000	52000	3
CsI(pure)	30/1000	5000	5
LuAlO <sub>3</sub>	18	20500	15-30
LuAl <sub>5</sub> O <sub>12</sub>	60	5600	15-30
LuSiO <sub>5</sub>	12/40	26000	15-30



CsI(pure) is an optimal crystal, it has dominant 30 ns decay time component and modest price.

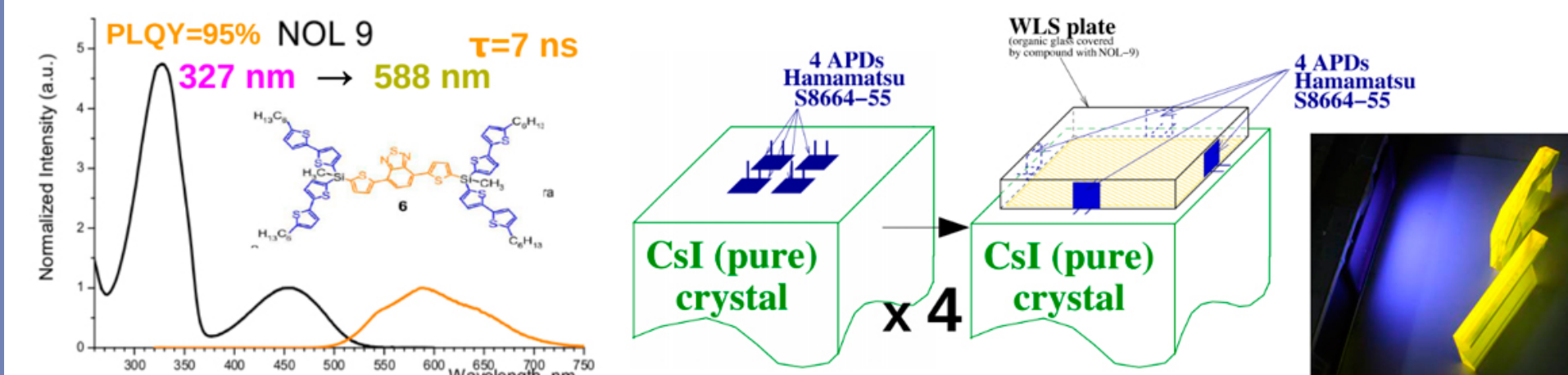
#### Avalanche Photodiodes (APD)

APD is compact, well studied and insensitive to the magnetic field, but it has small quantum efficiency (20-30%) for the wavelength of the scintillation light emitted by CsI(pure).



#### Wavelength Shifting Plate

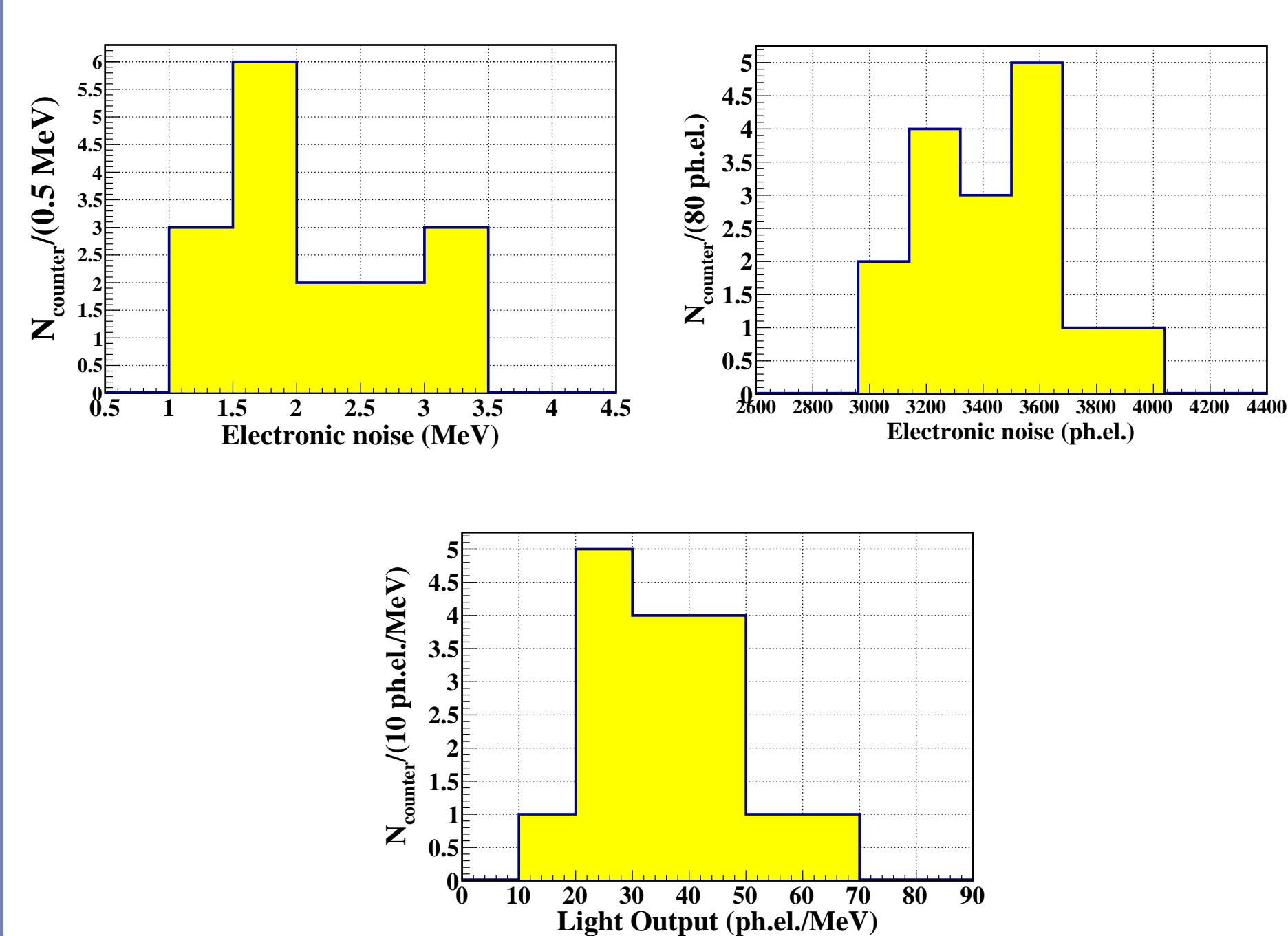
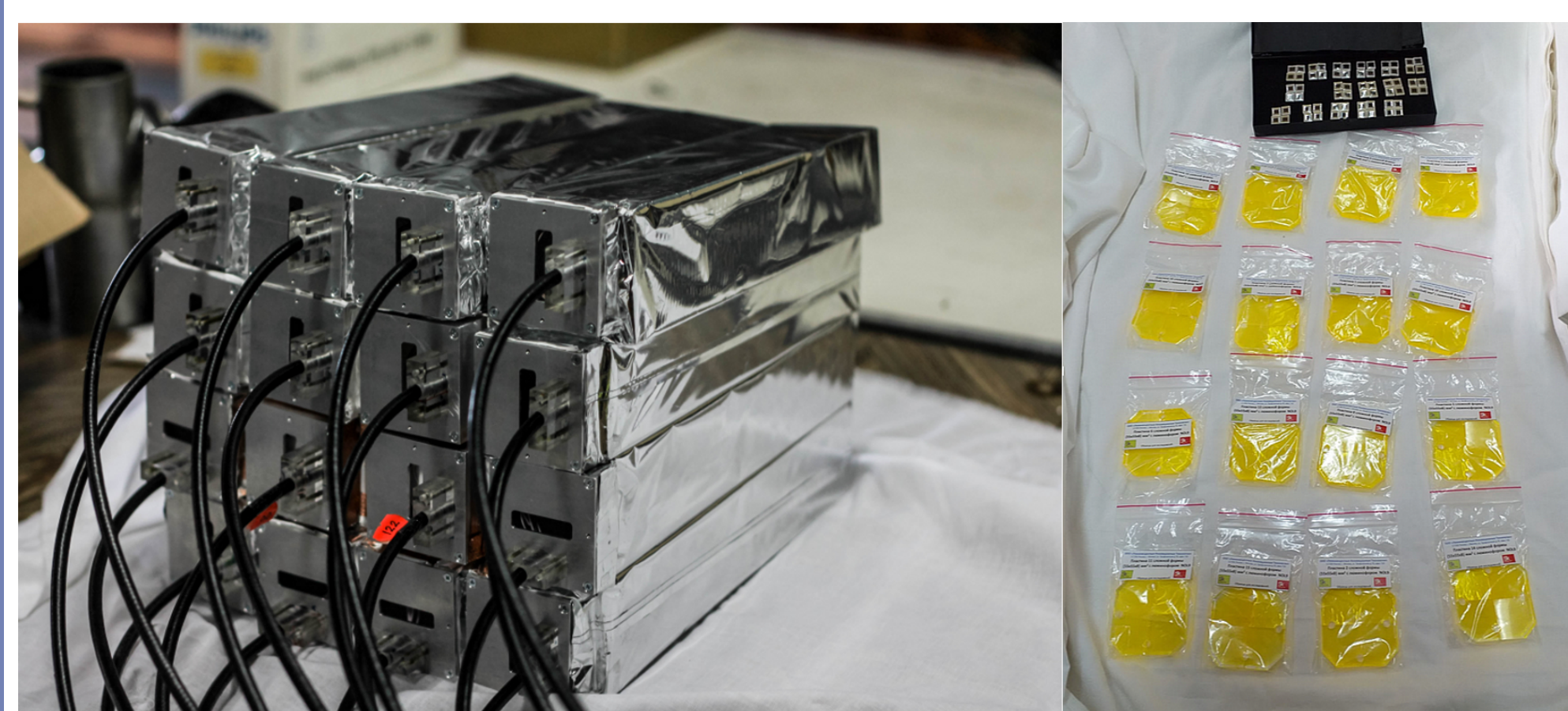
The wavelength of the light, emitted by CsI(pure) crystal is 320 nm. Photo sensitivity of the APD is low for that wavelength.



NOL-9 allows one to improve APD photosensitivity by a factor of 3

### 4. Prototype

All plates, APD, preamplifiers and crystals were sorted. 16 counters were assembled from relevant components. Light output and electronic noises of all counters were measured.



### 3. Components preparation

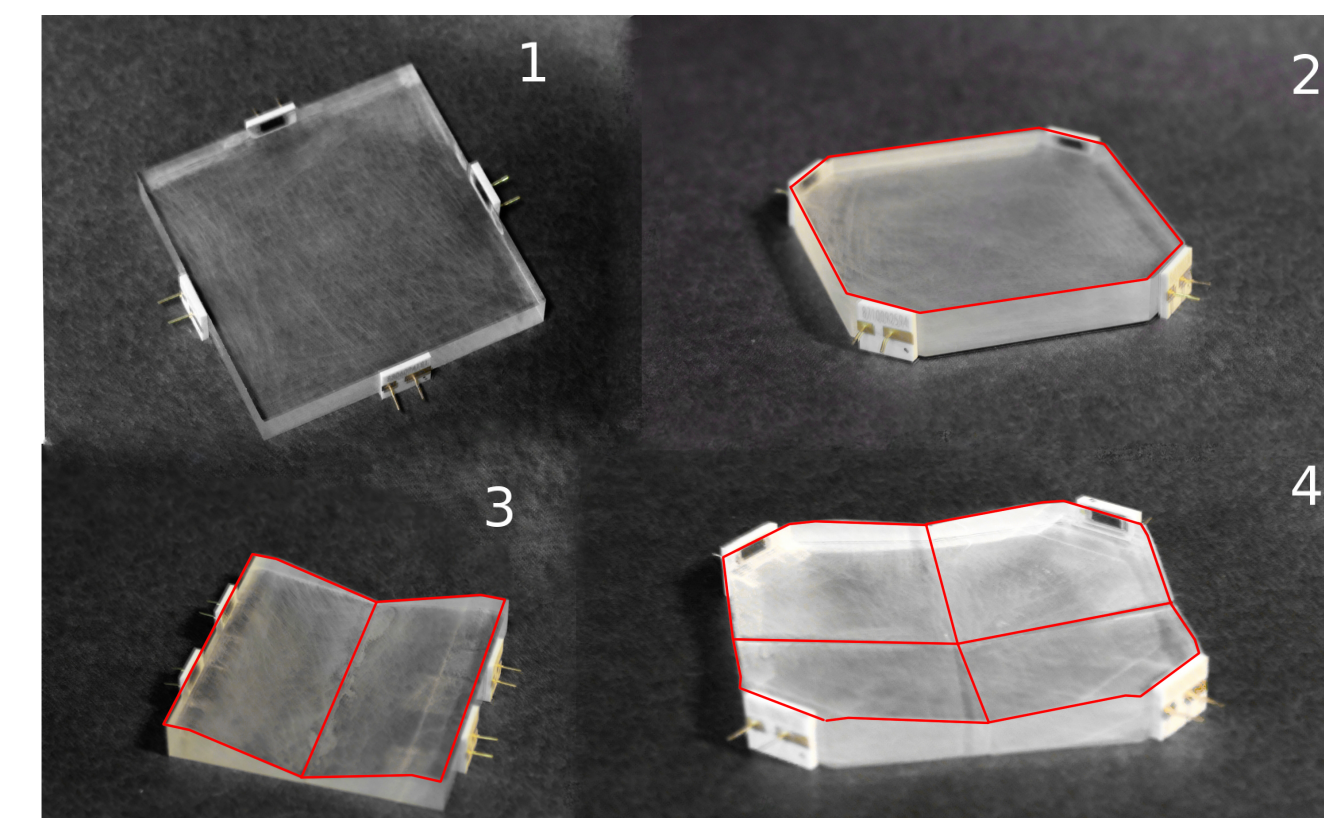
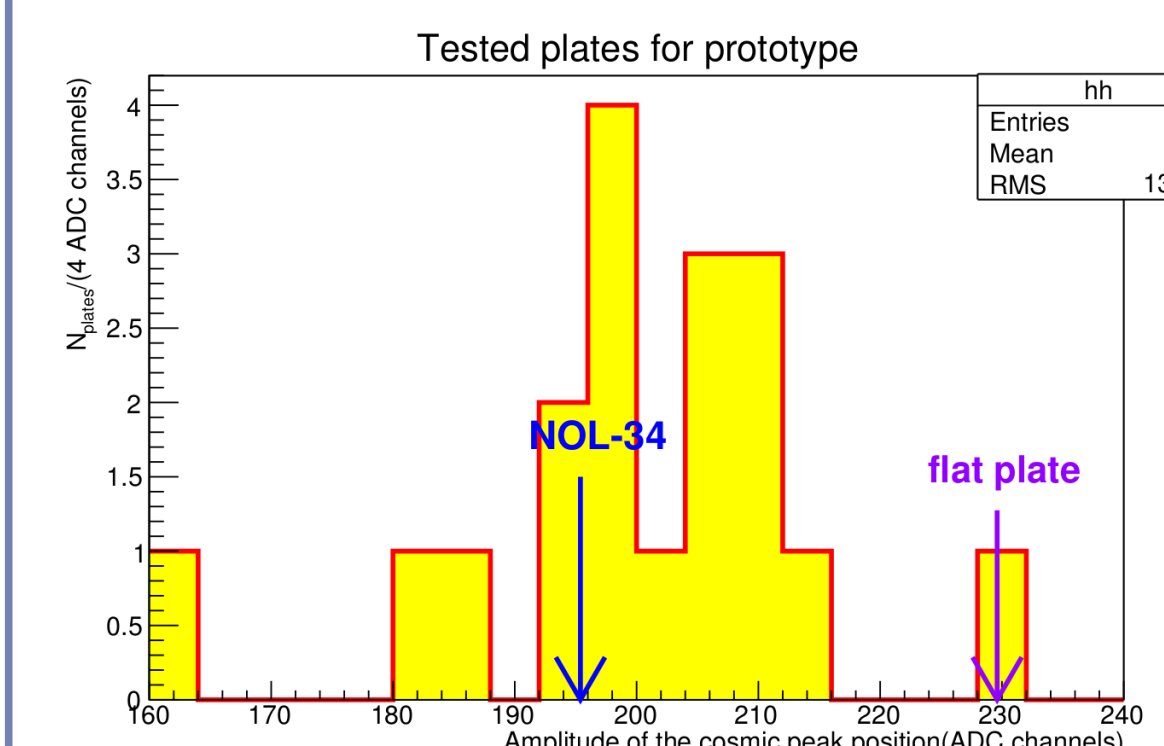
#### Optimization of light collection

- Several types of optical epoxy resin to couple APDs to the side edges of the PMMA plate were studied with CsI(Tl) crystal and PMMA plate without NOL-9.
- PMMA plates of different shapes were tested with CsI(Tl) crystal and plate without NOL-9.

resin/grease	cosmic peak position
BC630 (grease)	1058 $\pm$ 14
BC600 (resin)	1444 $\pm$ 17
BC630 (grease)	974 $\pm$ 11
Polytec (resin)	1159 $\pm$ 15

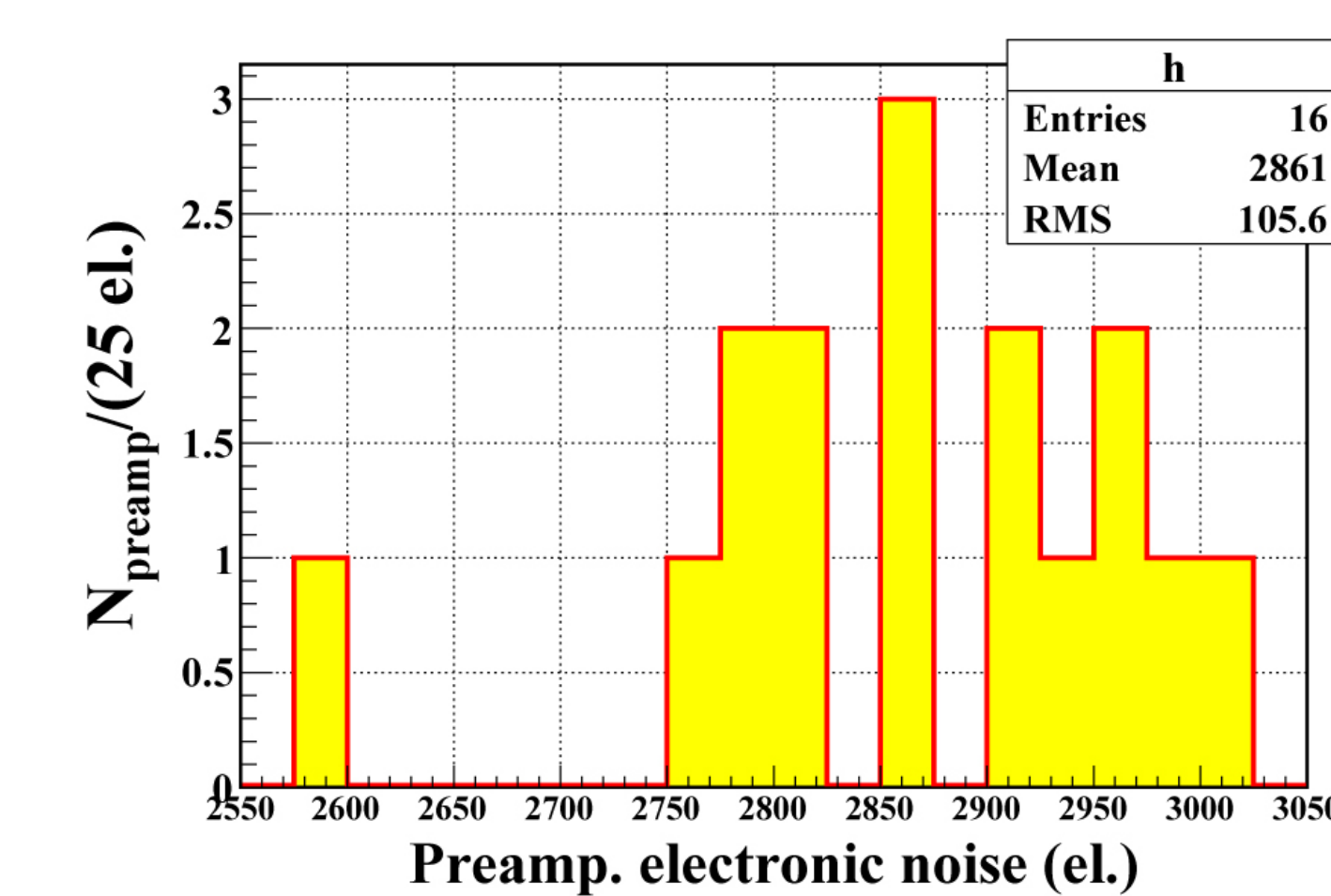
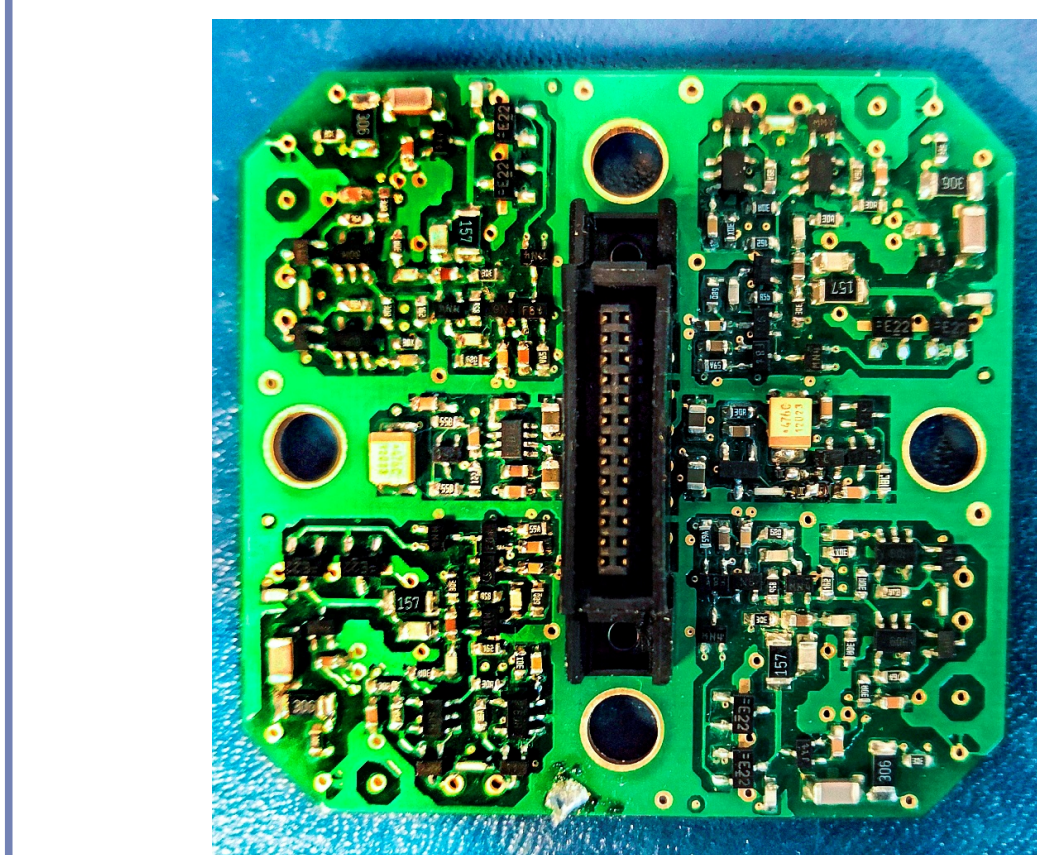
Plate configuration	Peak position
Shape thk, mm	ADC channel
1 8	1444 $\pm$ 17
2 8	1224 $\pm$ 14
3 8	1688 $\pm$ 18
3 5	1584 $\pm$ 16
4 8	1658 $\pm$ 19
4 5	1515 $\pm$ 17

- 16 PMMA plate with shape 4 and NOL-9 were made. Also, one plate with shape 2 and NOL-34 was made. APDs were sorted and coupled with plates by BC-600. All these plates were used in a standard counter with CsI(pure) crystal and custom made preamplifier.

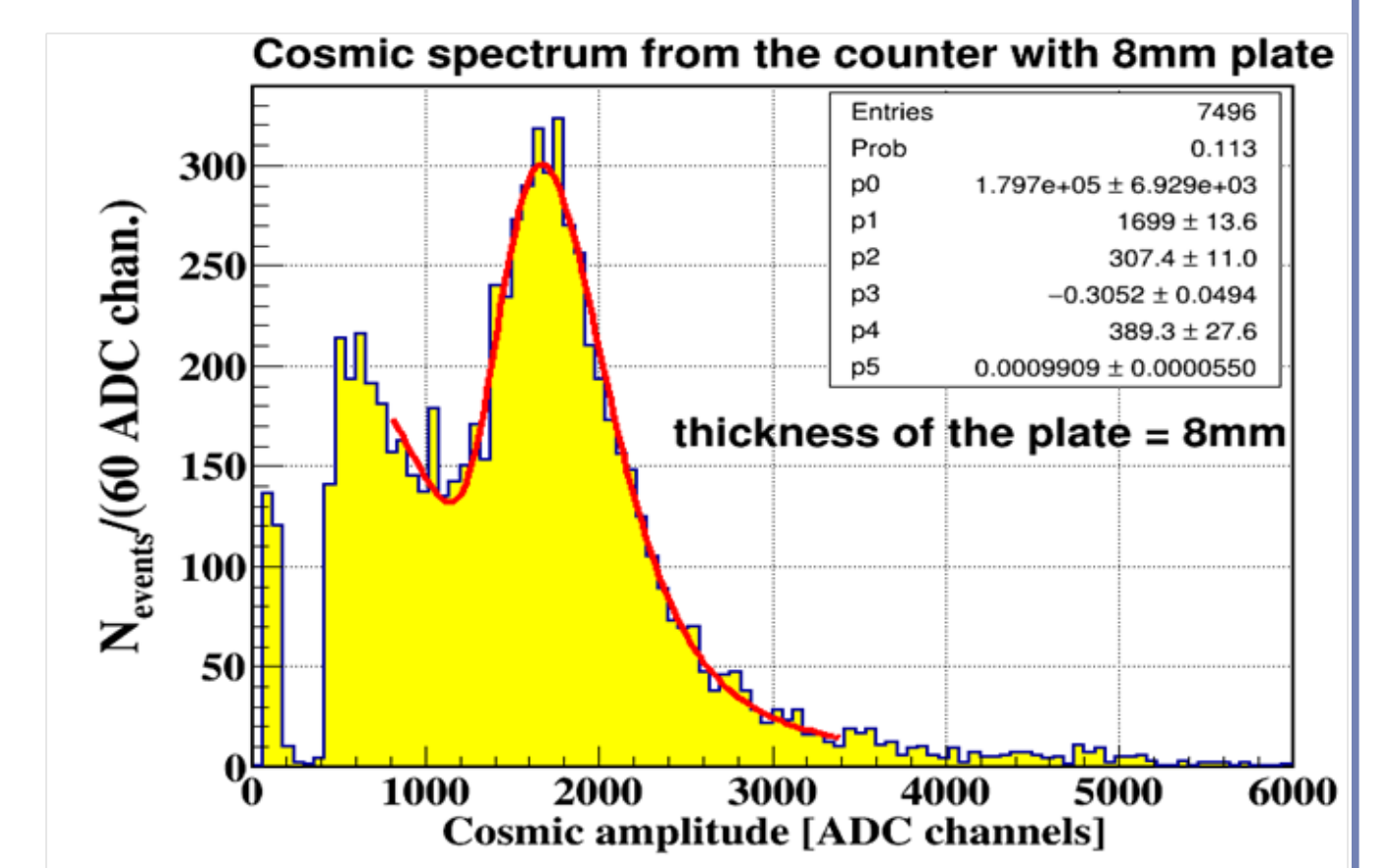
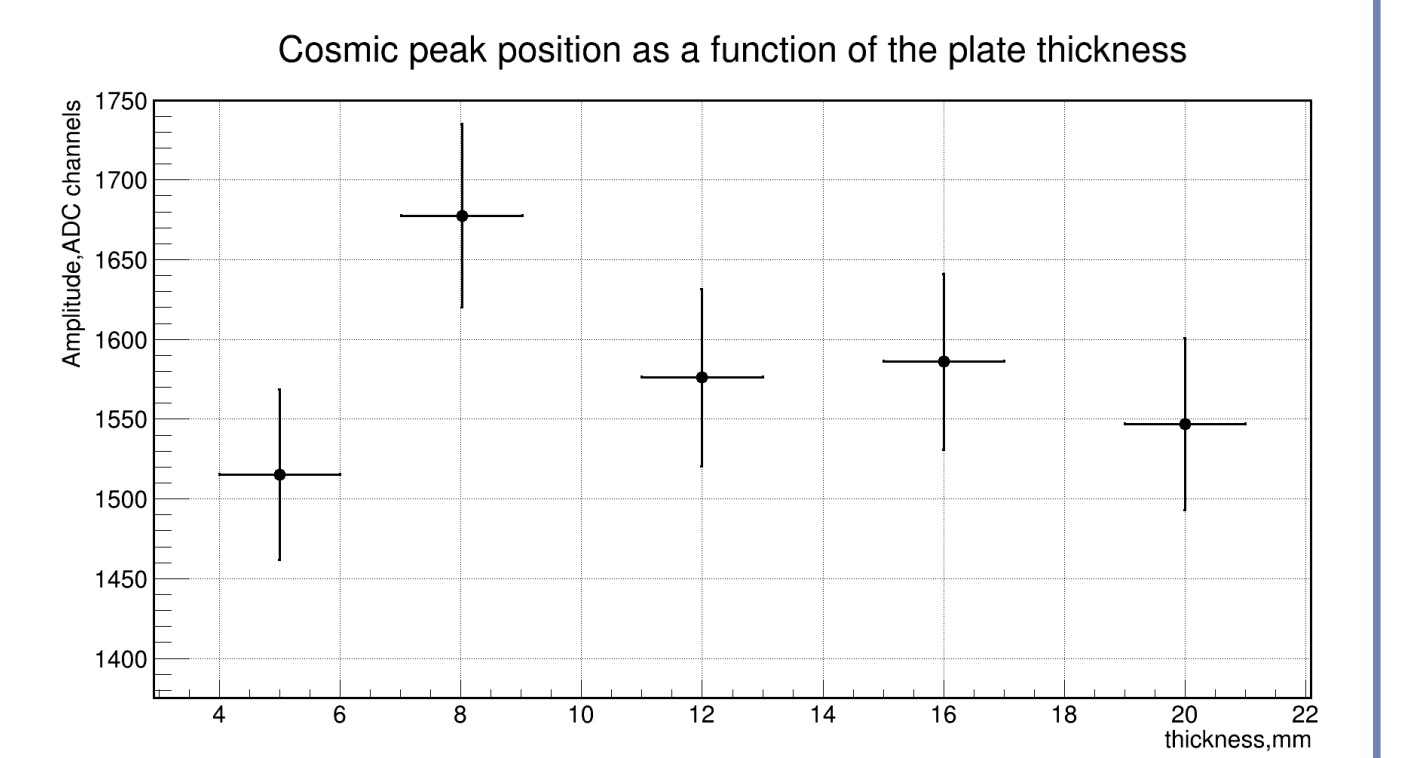


#### Electronics

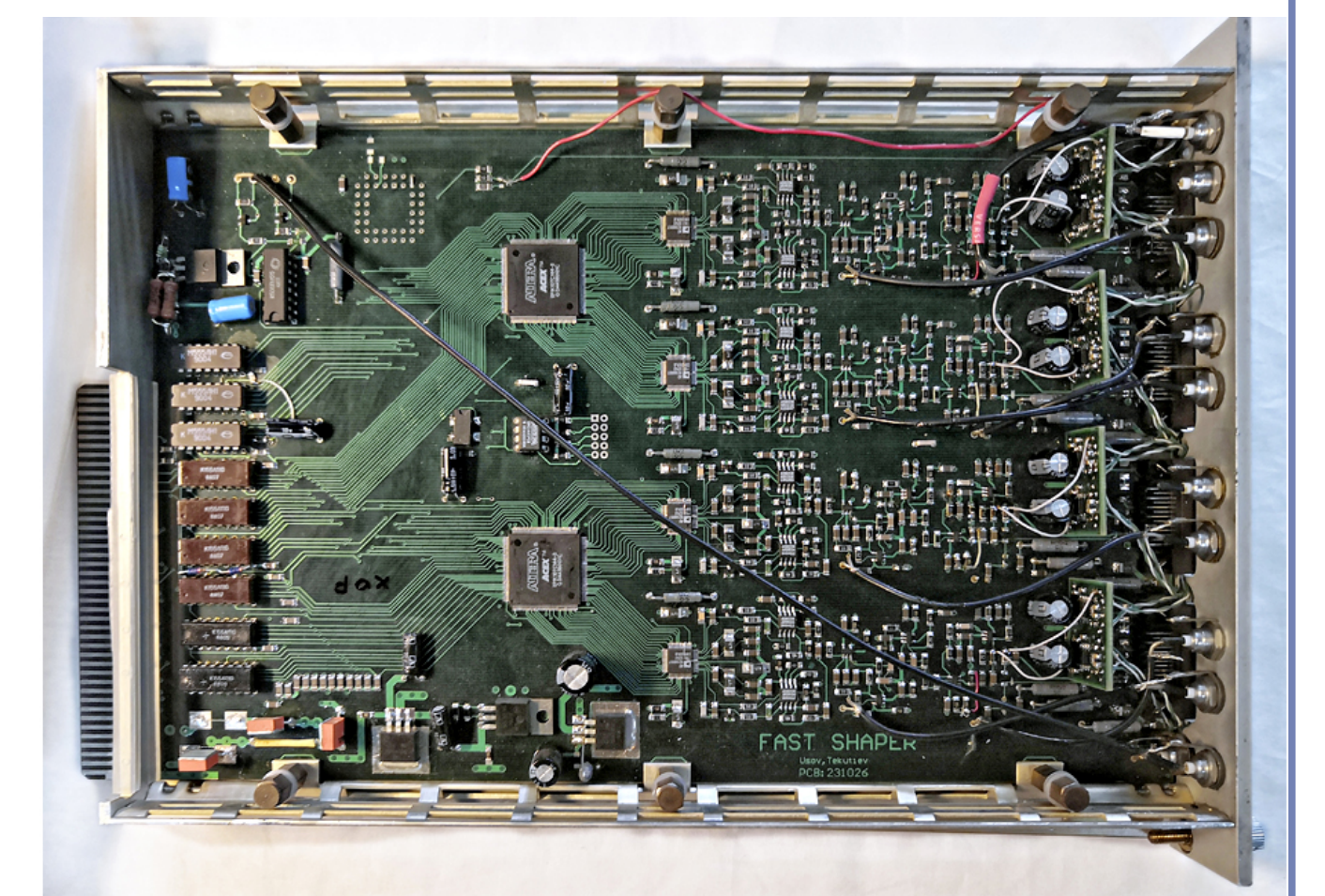
- 4-channel charge sensitive preamplifier 53  $\times$  55mm<sup>2</sup> was developed for counter.
- Each channel: sensitivity of 0.2 V/pC, 2 input FET 2SK932 (high transconductance), differential output, HV bias circuit, test pulse input
- 16 custom charge sensitive preamplifiers were produced. Electronic noise factor of each preamplifier was measured.



- PMMA plates of the shape 4 without NOL-9 and different thicknesses were tested.

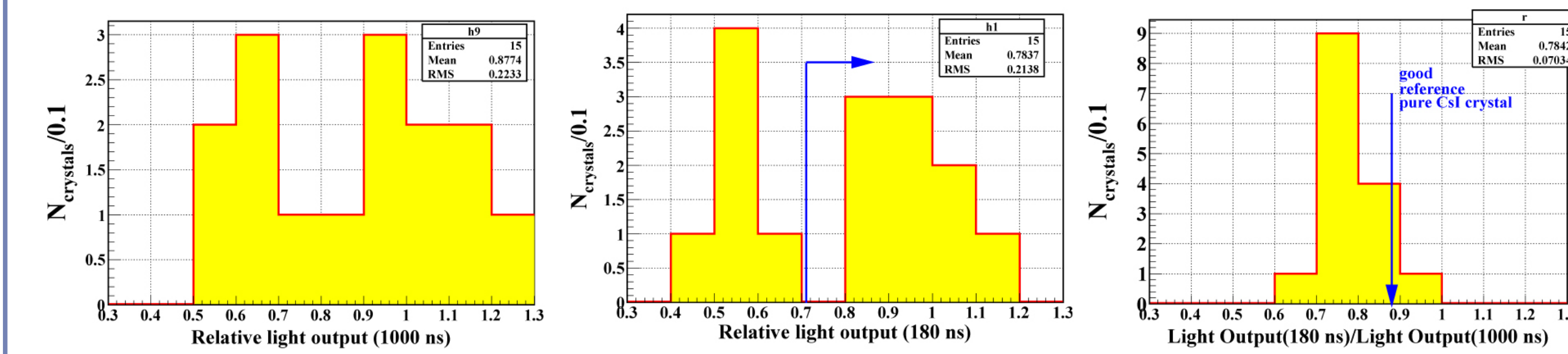


- Four 4-channel CAMAC Shaper-ADC boards were modified with summator. These boards used for processing data from counter.
- CR-(RC)<sup>4</sup> filter ( $\tau = 30 ns$ ), 40 MHz 12-bit pipelined ADC, 256-word circular buffer



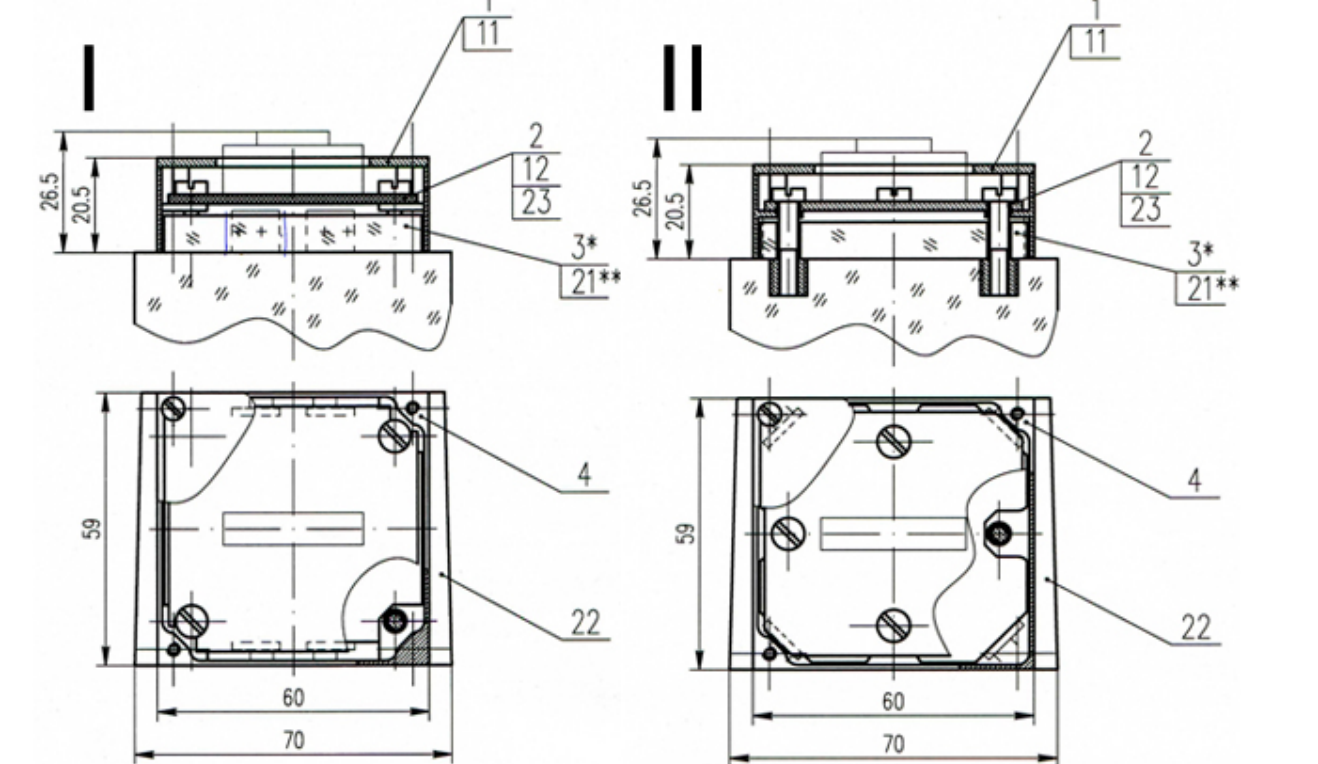
#### Crystals

- Light output and relation of fast to total components of crystals have been measured.
- Crystals with best characteristics and suitable sizes were chosen for prototype



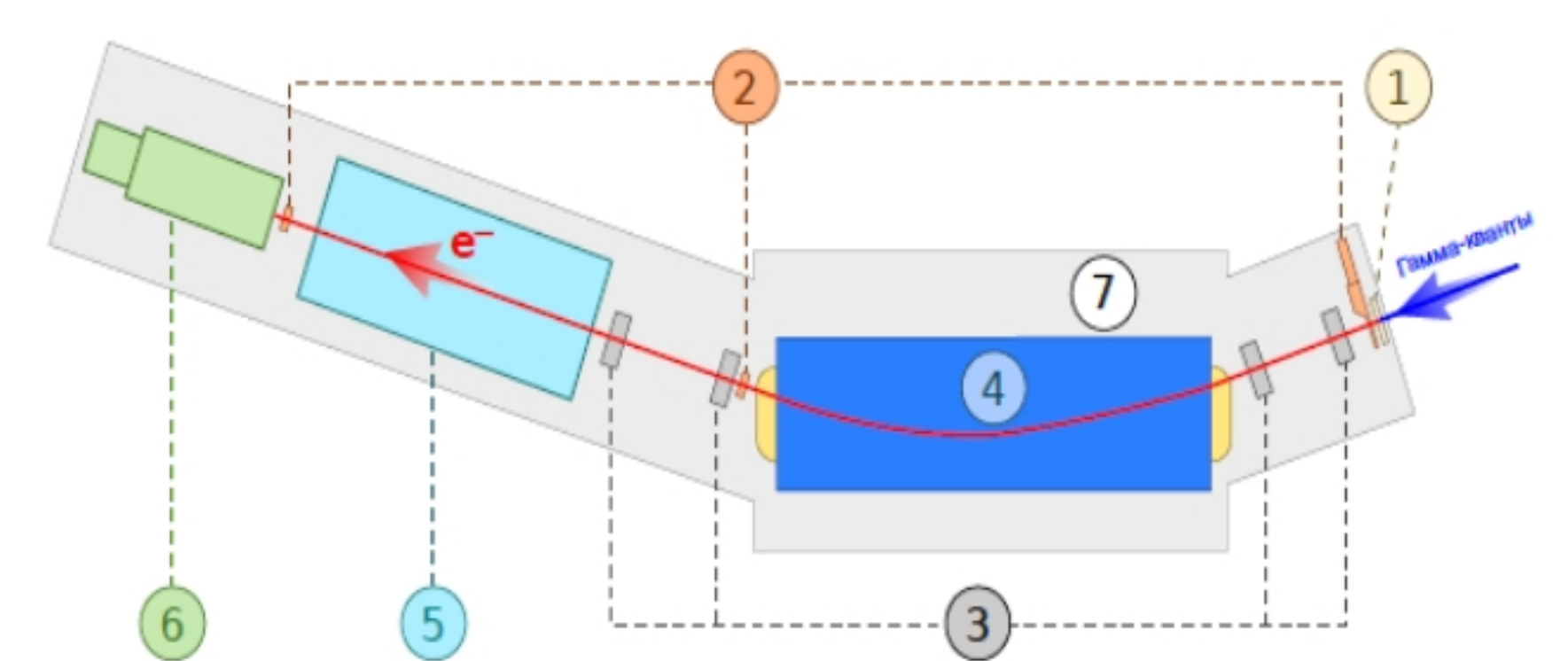
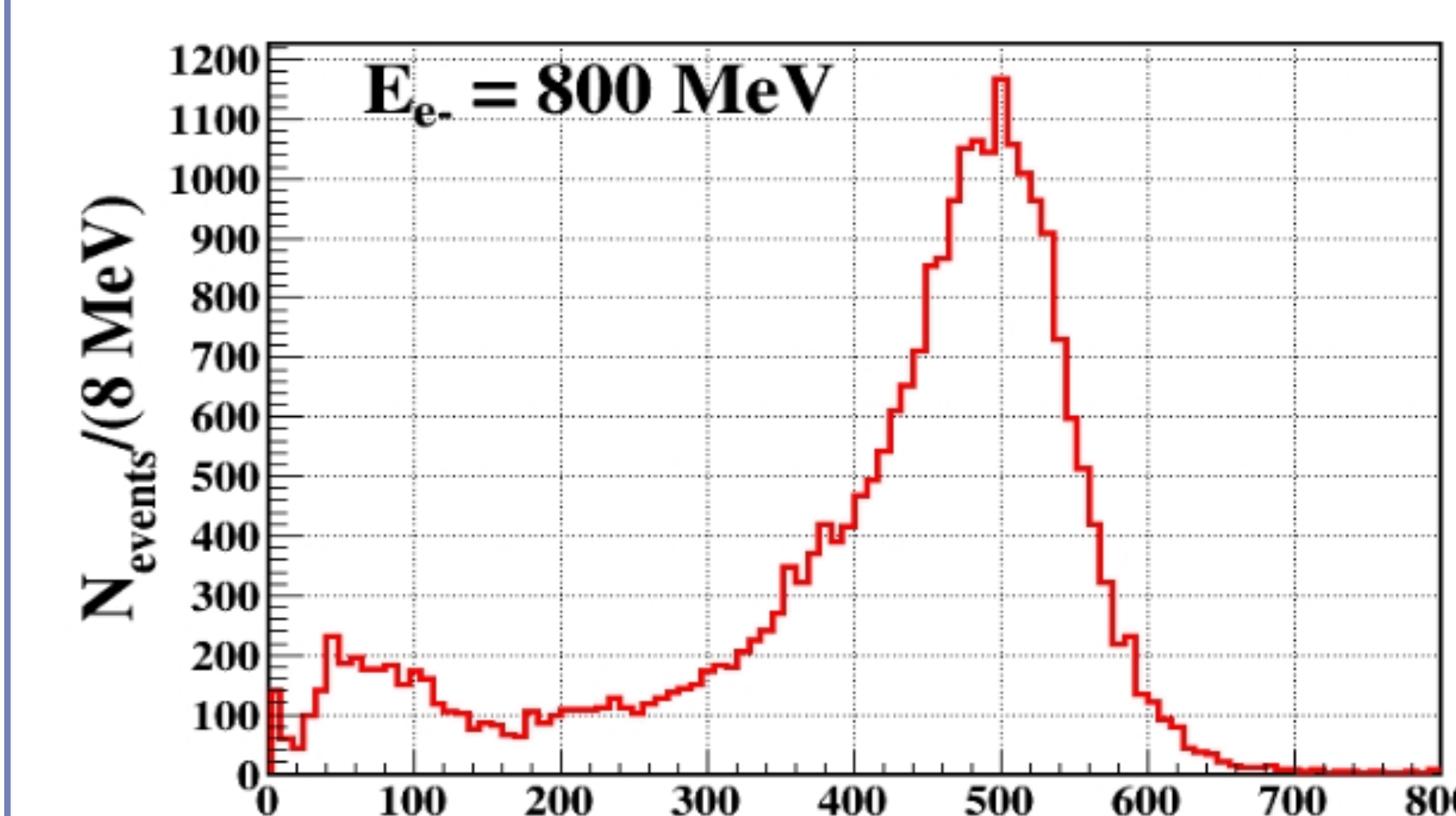
#### Aluminum boxes

- Two types of mechanical construction were tested, variant II was chosen.



#### Test beam study of 1 counter

- In June 2019 we performed test beam studies with 1 fully assembled CsI(pure) counter with NOL-9 covered plate of shape 2.
- Electron beam with the energies 0.8, 1.5, 2.0, 2.5 and 3.0 GeV hit the center of the pure CsI crystal. Signals from the counter were recorded with the trigger from the external plastic scintillation detector and from CsI counter itself.
- In total about 1.2M events were recorded, got expected energy deposition spectra from the counter.



### 5. Summary

- CsI(pure) is an appropriate crystal for the fast calorimetry.
- All component's characteristics were studied.
- Scheme of temperature compensation has been developed and now it is under testing.
- Testing of the prototype on registration of cosmic particles is under process.
- The prototype made of 16 counters will be studied soon on the test beam facility at VEPP-4M.