

# Study of the fast calorimeter prototype for the Super Charm-Tau Factory

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## 1.Introduction

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

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

## 5.Optimization of light collection

For all measurements to increase light collection efficiency, CsI(Tl) crystal and PMMA plate without NOL-9 were used.

- Several types of optical epoxy resin to couple APDs to the side edges of the PMMA plate were studied.

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

- PMMA plates of different shapes were tested.

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

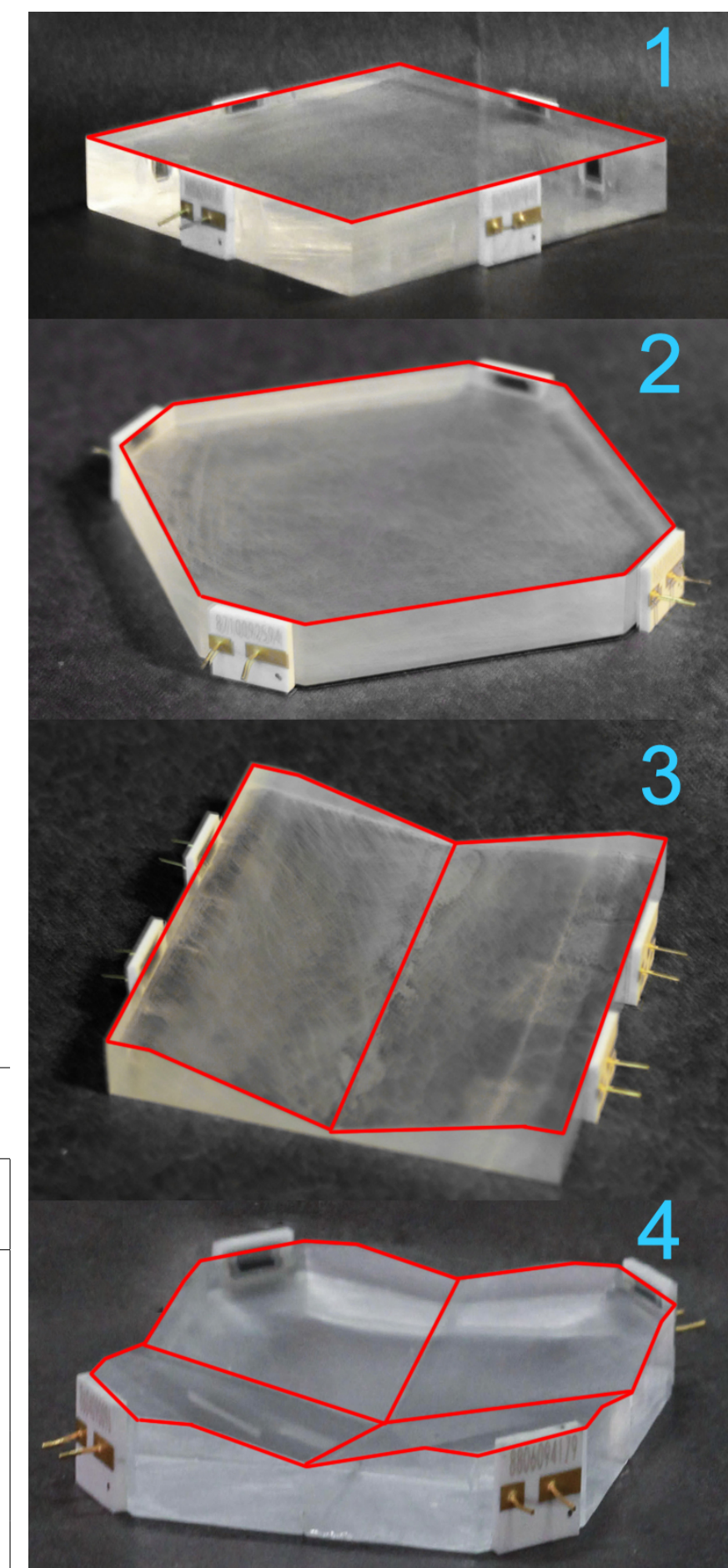
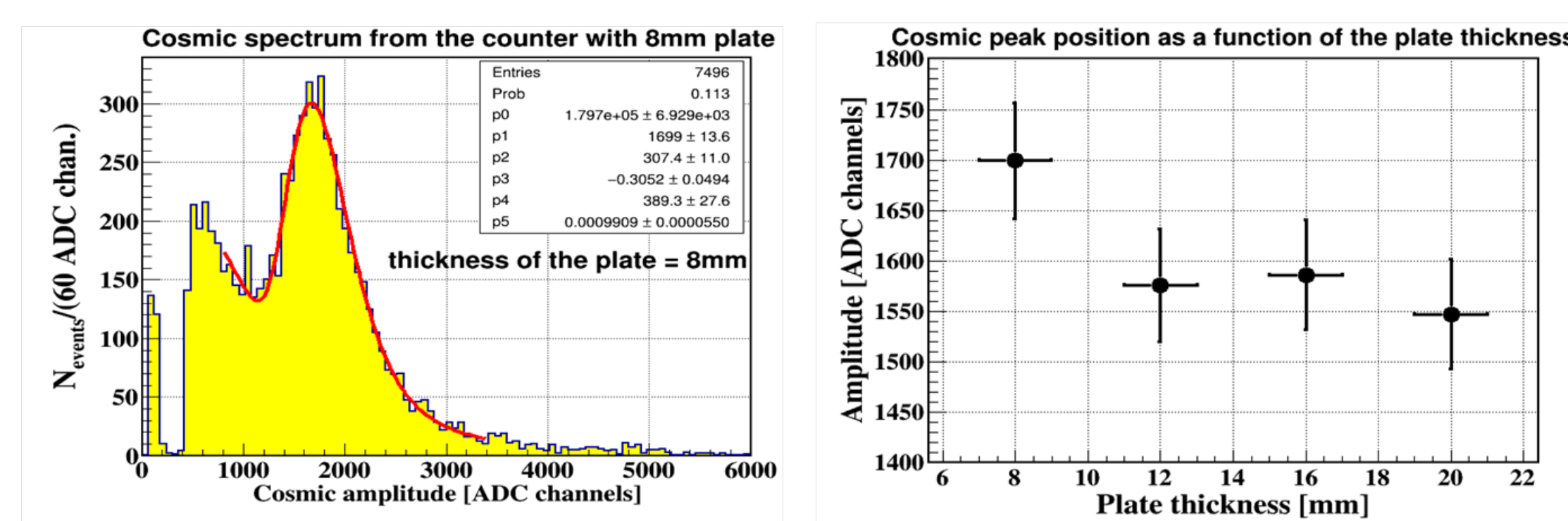


Figure 2: Shapes of plates used for study

- PMMA plates of the shape 4 and different thicknesses were tested



The best variant is type 4 plate with the thickness of 8 mm. BC600 is used to couple APD.

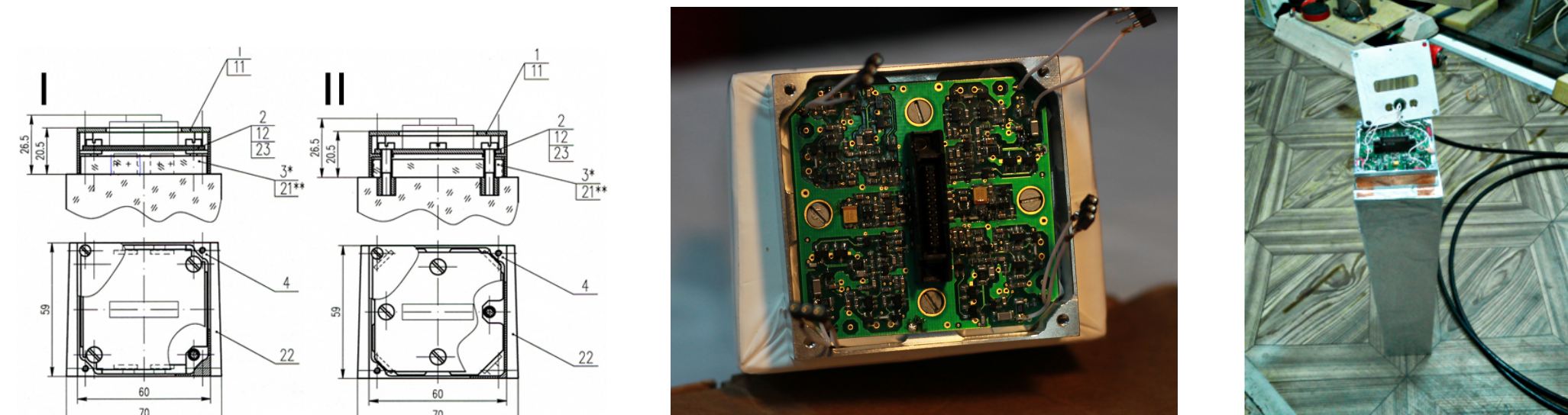
## 6.Electronics

- 4-channel charge sensitive preamplifier 53 × 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
- 4-channel CAMAC Shaper-ADC board
- CR-(RC)<sup>4</sup> filter ( $\tau = 30$  ns), 40 MHz 12-bit pipelined ADC, 256-word circular buffer

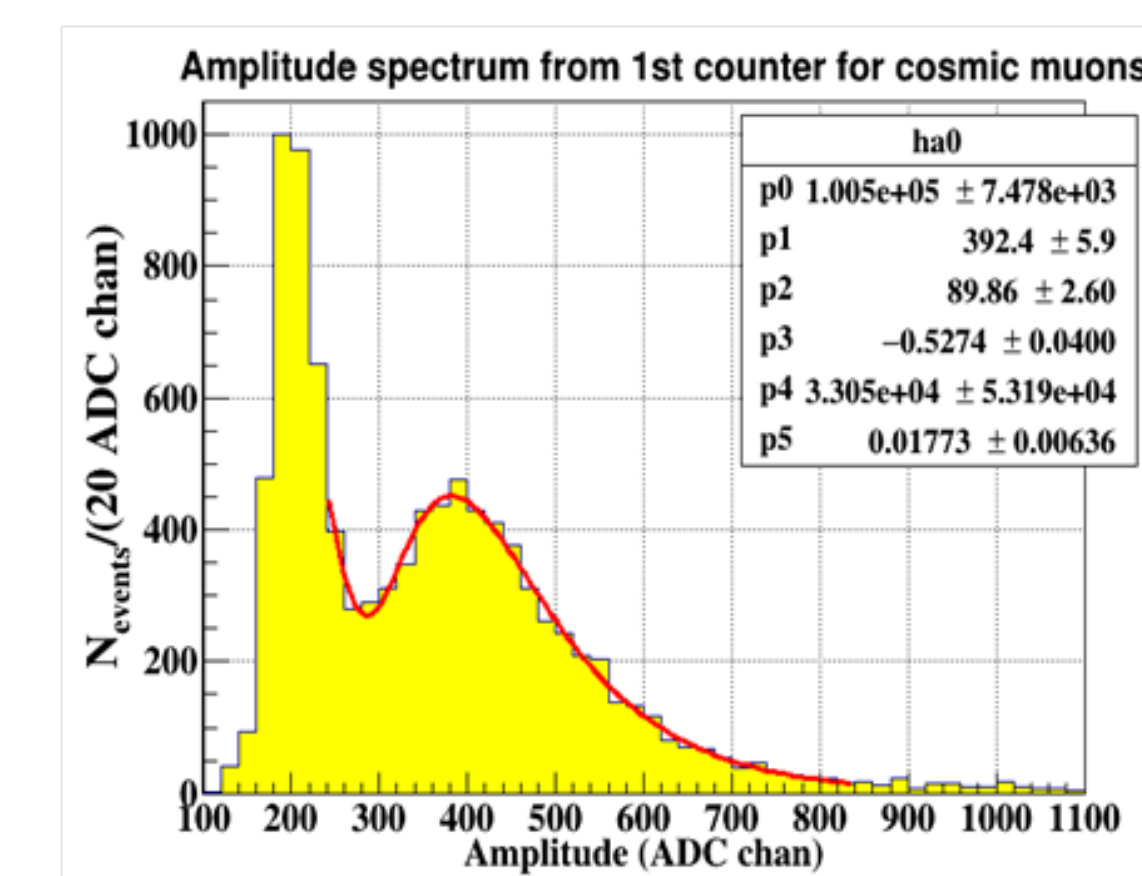
- To comply with the new 4-ch preamp additional differential receiver and summator (DRS) boards have been produced and mounted in the Shaper-ADC boards

## 7.Counter

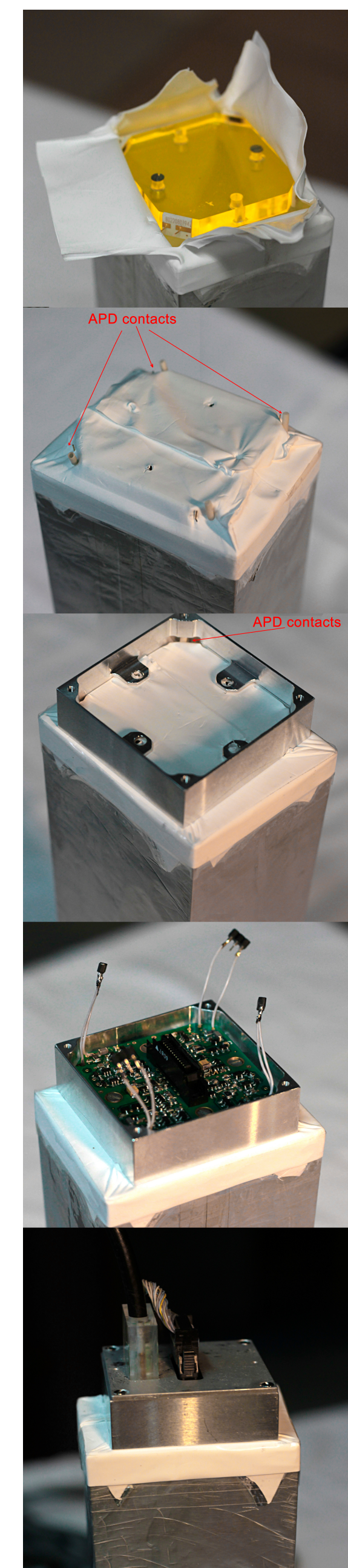
The counter based on CsI(pure) with simple NOL-9 plate and 4 APD Hamamatsu S8664-55 fixed with BC600 optical resin was assembled.



- For primary study of the counters we use APD with high dark current ( $I_d$  60 nA).
- WLS plate with shape 2 (see Figure 2) was used for the first counter
- Cosmic particles were registered by that counters



Light output of such counter was measured.  
LO= (80±20) ph.e./MeV (before APD gain)



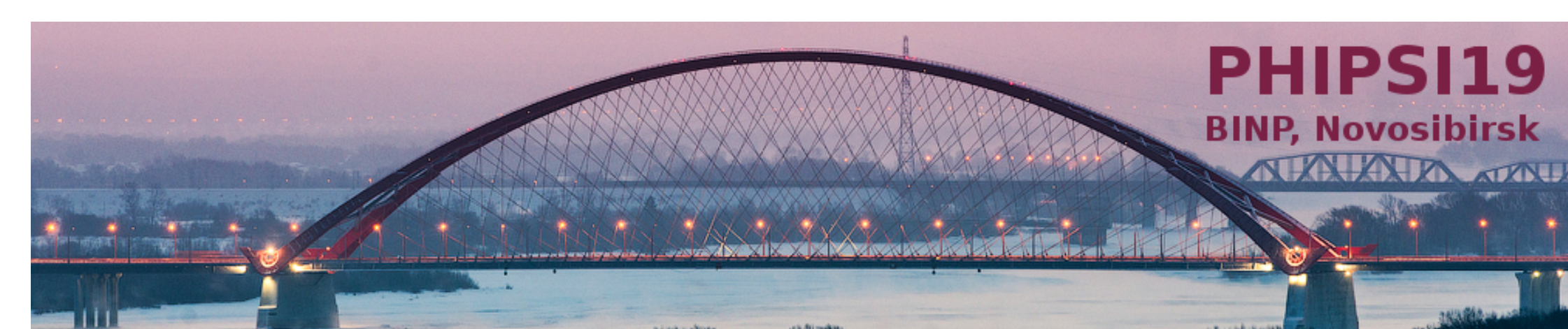
Optimal shape of type 3 and 4 allows one to improve light collection efficiency by a factor of 1.6

## 8.Summary and plans

- CsI(pure) is an appropriate crystal for fast calorimeter for the Super Charm-Tau Factory.
- Combination of special shape PMMA plate with the nanostructured organosilicon luminophores (NOL-9) and 4 APD Hamamatsu S8664-55 will allow one to get a 6 times increase of light output of the counter based on CsI(pure) crystal
- Production of 16 PMMA plates for the prototype is in progress. 16 CsI(pure) crystals have been prepared, aluminum shielding boxes are being produced.
- Preamplifiers were designed, produced and tested in the counter.
- Four CAMAC 4-channel Shaper-ADC boards are almost ready.
- Prototype made of 16 counters will be studied soon on the test beam facility at VEPP-4M.

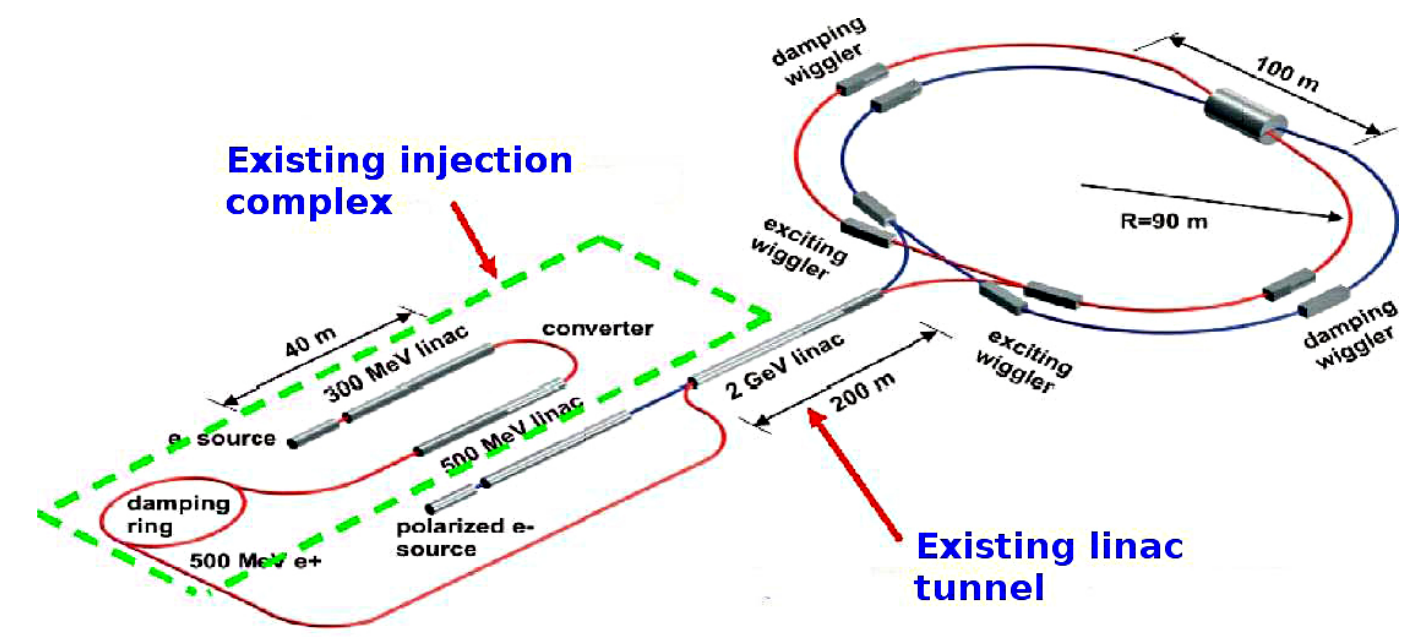
## References

- H. Aihara et al., PoS PhotoDet 2015 (2016) 052.  
O. Borschhev et al., Nanophotonic Materials XII9545(oct2015), 954509  
Super Charm-Tau Factory, Conceptual design report. Novosibirsk, 2011.



Project of Super Charm-Tau Factory is discussed in Budker Institute of Nuclear Physics

## Collider



- Longitudinal polarization of  $e$

- Occupancy up to 300 kHz

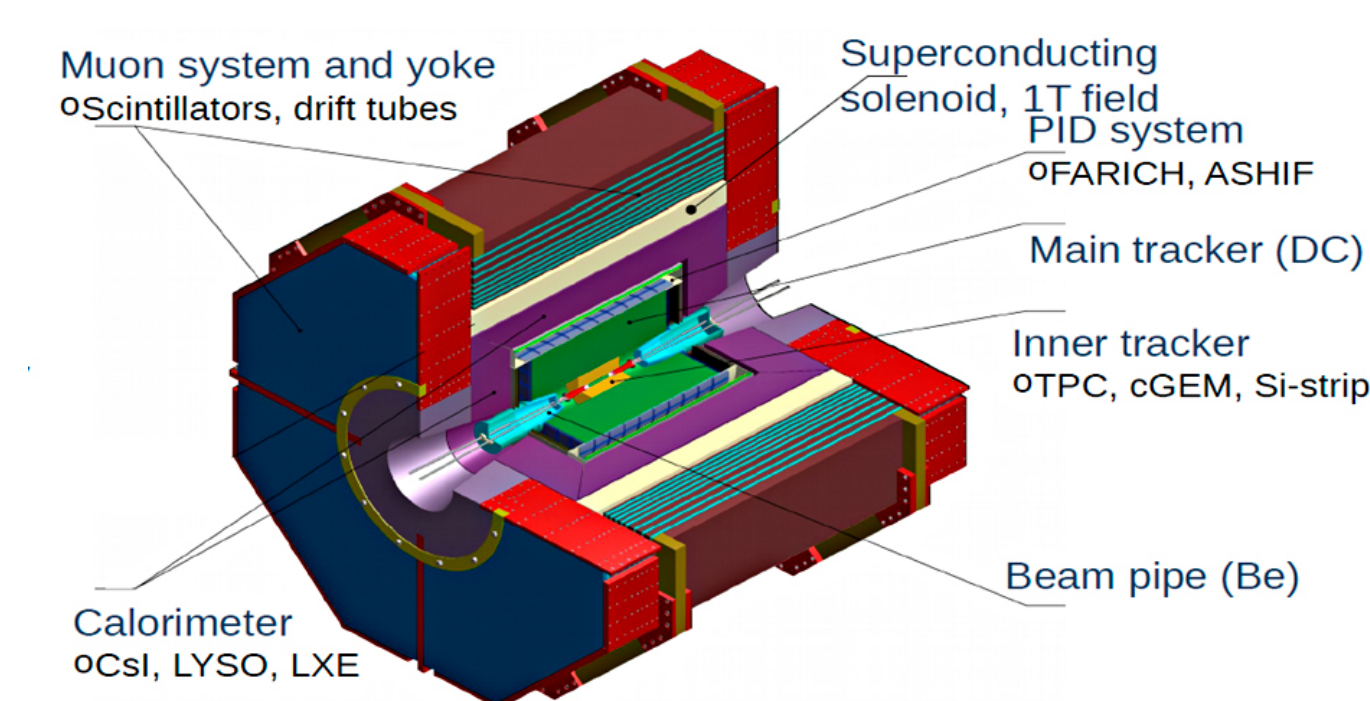
- Good energy and momentum resolution

- High reconstruction efficiency to soft tracks

- Perfect  $\pi/K$  and  $\pi/\mu$

- Minimal CP detector asymmetry

Super Charm-Tau Factory 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.



## 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.CsI crystal

Crystal	$\tau, ns$	$N_{ph}/MeV$	Price, \$ $cm^{-3}$
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

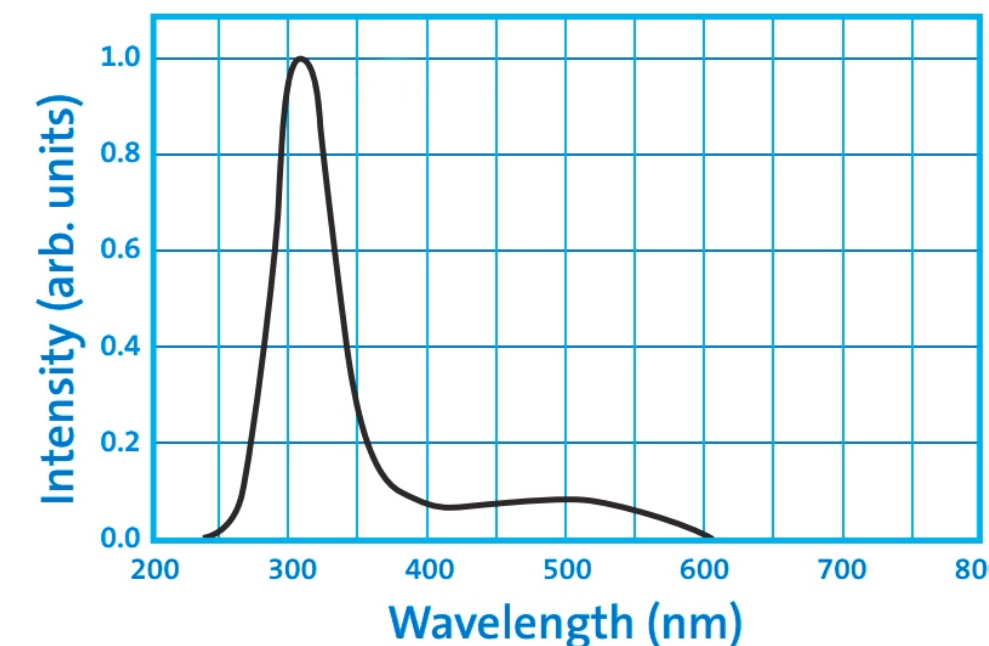
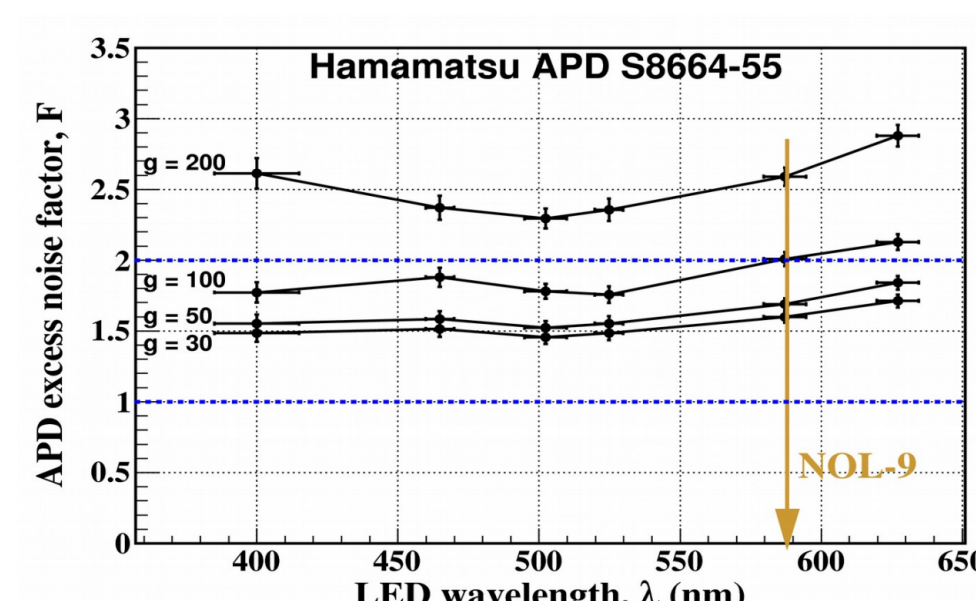
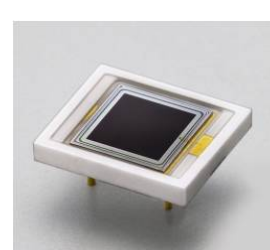
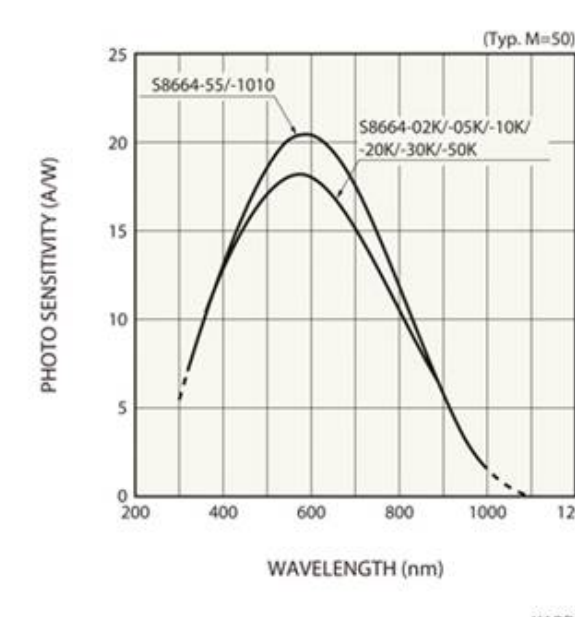


Figure 1: Spectrum of CsI(pure)

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

## 3.Avalanche Photodiodes (APD)

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



## 4.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.

