# Study of new CHOD prototypes with SiPM read-out

Presented by Evgeny Gushchin (INR)

for

*IHEP (Protvino) and INR (Moscow) groups*

12.7.11

# Occupancy per cell in new CHOD design.

*Estimated from MC results of Spasimir Balev, 30/06/2011.*

*To be investigated:*

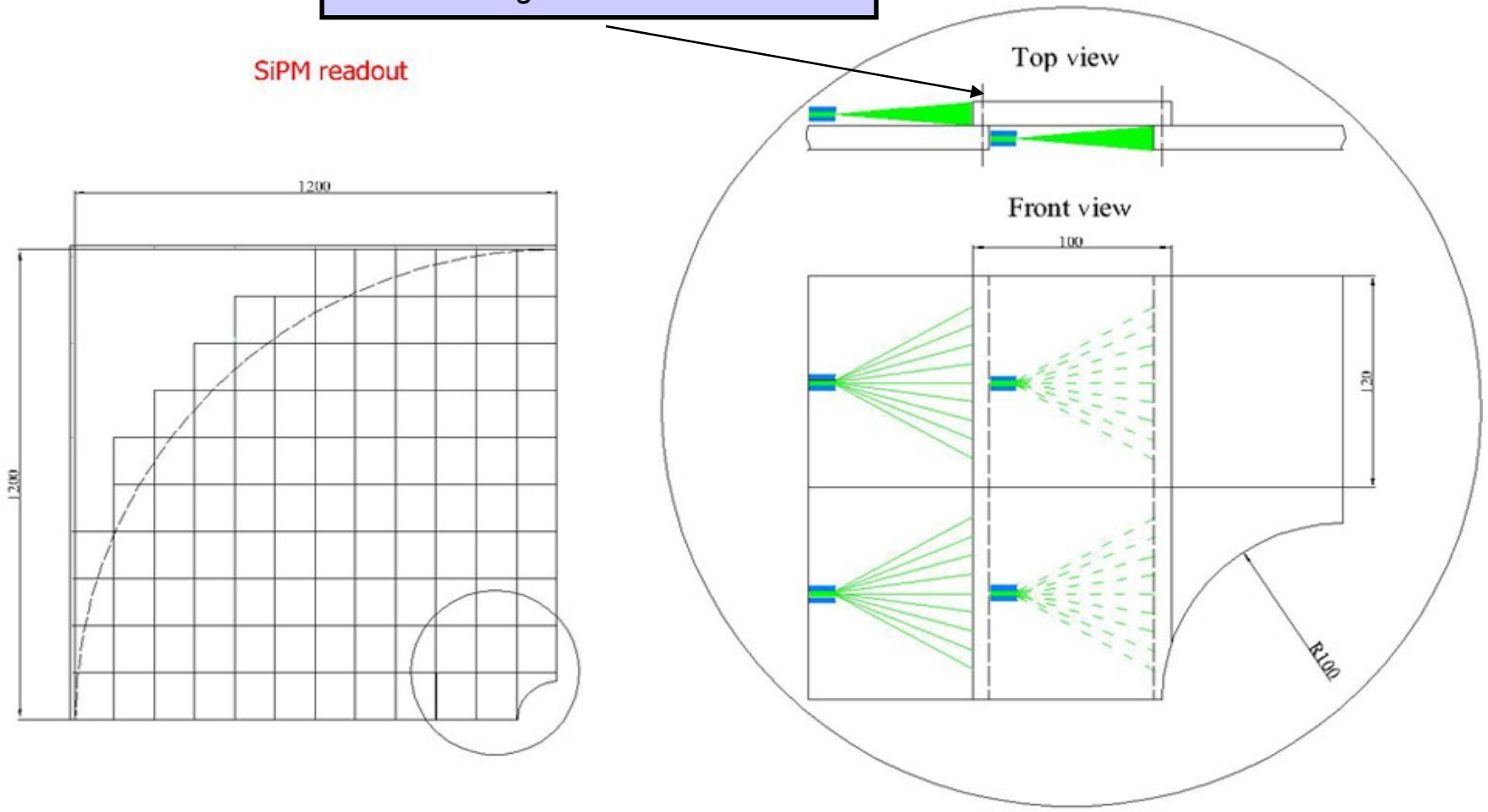
In case of extreme occupancy conditions the inner pads can be segmented to smaller sizes.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 68 | 68 | 61 | 53 | 33 | 10 | | |
| 119 | 118 | 109 | 104 | 82 | 74 | 14 | |
| 156 | 151 | 132 | 122 | 101 | 98 | 74 | 5 |
| 175 | 170 | 142 | 115 | 99 | 103 | 83 | 39 |
| 280 | 249 | 198 | 163 | 128 | 113 | 103 | 54 |
| 427 | 366 | 271 | 208 | 147 | 135 | 118 | 71 |
| 746 | 544 | 372 | 254 | 181 | 172 | 133 | 79 |
| beam | 820 | 476 | 295 | 195 | 168 | 134 | 78 |

Table 1. Intensity/cell kHz

# Approach to new CHOD design.

Rough idea is to mechanically attach pads to each other with Dowel pins.
*under investigation…*



# Prototypes tested in April 2011 in Protvino

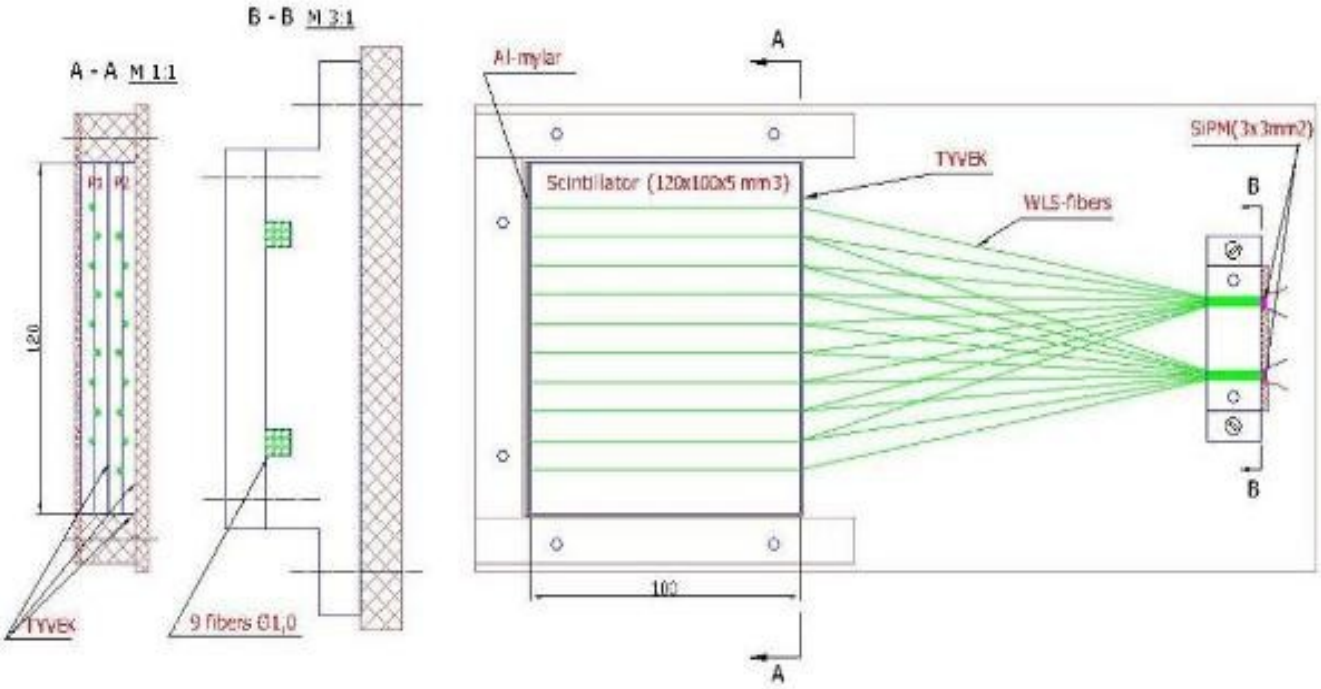
Prototype consists of 2 counters.

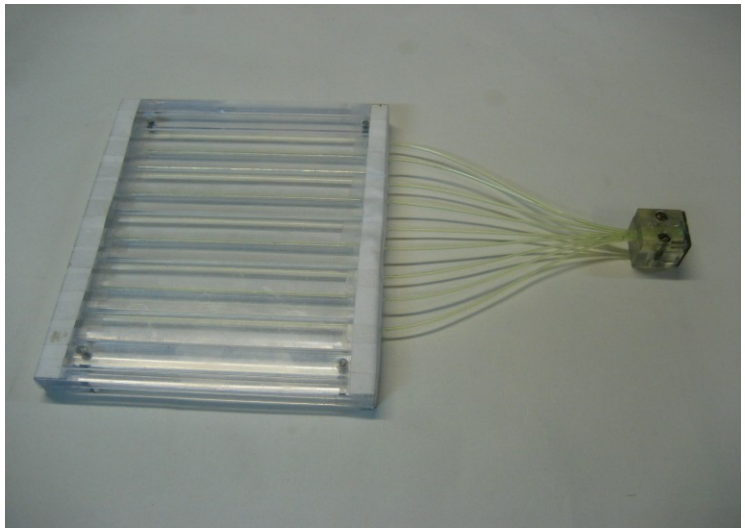
Size of each counter:
100 x 120 mm2

Each counter has double layer structure of scintillator pads read-out by 9 WLS fibers per counter.

WLS fibres are of BCF92 type with decay time 2.7 nsec.

Fibers used are ~ 30 cm long with cut and polished ends. On the read-out side the ends arranged in matrix 3x3 to fit APD. On other side the fibers are covered with aluminized Mylar to improve light collection.



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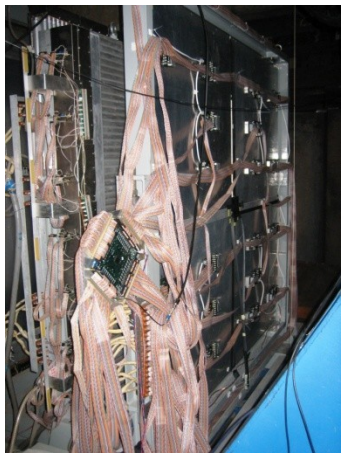
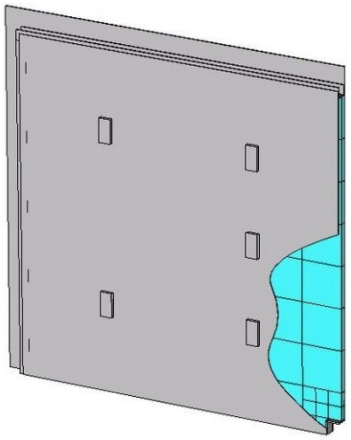
# Experience with matrix hodoscope with G-APD read-out

**OKA experiment: 2x2 m2 detector with ~400 cells with SiPM read-out was built since 2006 y.**

## Purpose

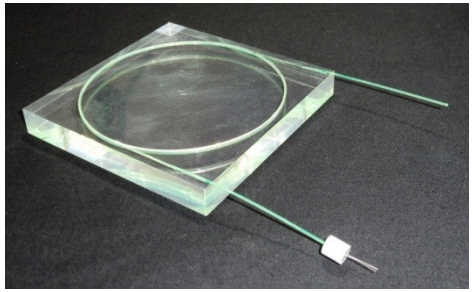
- fast trigger on multi-prong events
-rejection of background
- pad structure –> no left-right umbiguity -> reconstruction of multi-prong events





## One quadrant of MH

-63 large tiles ~120x120x15 $mm^3$,
8 small tiles ~40x40x15 $mm^3$



## Tile

-material – polystyrene+PTP+POPOP (Kharkov)
- light reflection envelop – TYVEK (not shown)
- light readout – APD

## APD(CPTA, Moscow)

- number of pixels – 556
- active area – 1.1x1.1 $mm^2$
- pixel size - 40x40 $mkm^2$
- gain - $0.3x10^6$
- PDE @ 525 nm – 30%

## Performance

- **efficiency – 97%**
- **time resolution -1.8 ns**
- **decision time – 60 ns**

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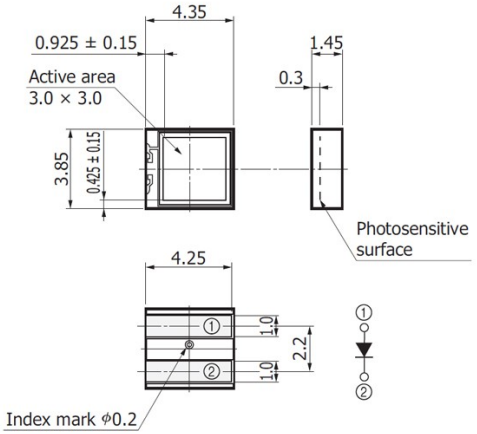
## SiPM parameters:

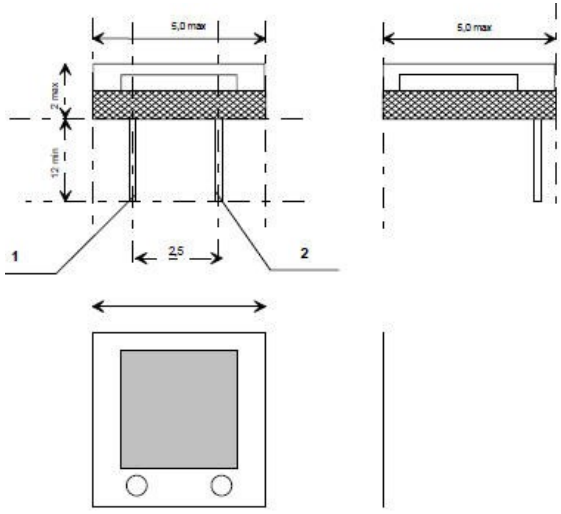
For tests with CHOD prototypes we used two types of SiPM: MPPC from Hamamatsu and MRS APD from CPTA (Moscow). Both APDs have 9 mm2 sensitive surface and close performance. Internal time resolution (single photoelectron) is expected to be better than 250 psec for both.

| | S10931-050P MPPC HAMAMATSU | CPTA 140-40 MRS APD | Units |
|---|---|---|---|
| | | | |
| Area | 3*3=9,0 | 3*3=9,0 | mm2 |
| Number of pixels | 3600 | 8100 | |
| Working voltage | 71 | 40 | volt |
| Max sensitivity | 440 | 600 | nm |
| Quantun efficiency | 50 (440nm)<br>45 (520nm) | 40(600nm)<br>30(520nm) | % |
| Dark current, Id | 4<br>(M=7.5*$10^5$) | 4<br>(M=4*$10^5$) | mkA |
| capacitance, Capd | 320 | 300 | pF |

**MPPC (HAMAMATSU)**




**MRS APD (CPTA)**

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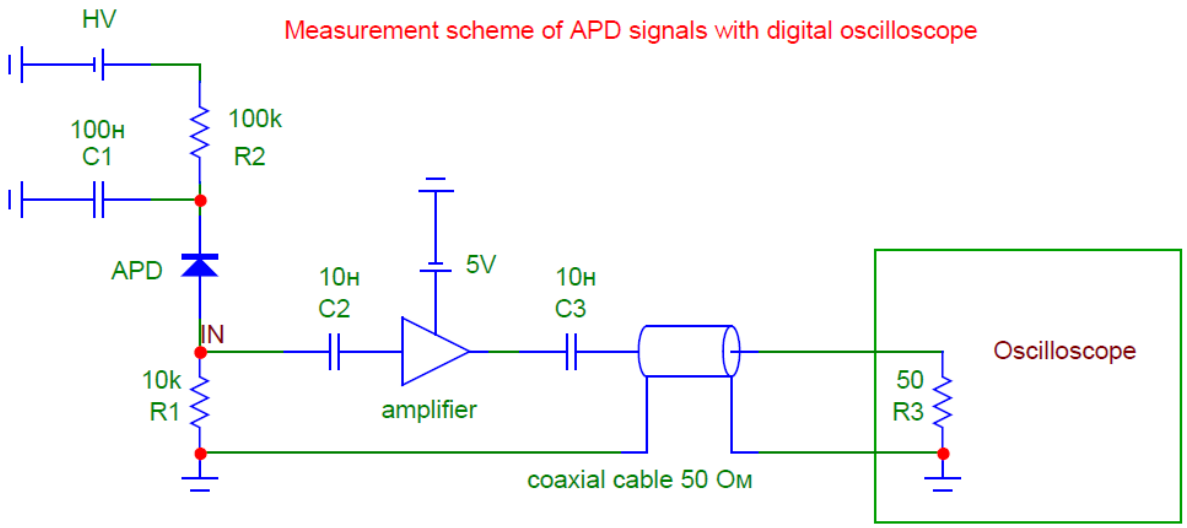
# Experimental setup and measurement scheme.

**Setup:**
- beam of accelerator U-70
- cosmic

**Trigger:**
Self-triggering mode on ch. A.

**Time measurements:**
Relatively ch.A vs ch.B

PC USB Digital oscilloscope “Picoscope 5203”
Bandwidth 250 MGHz
Sampling frequency 500 MGHz
Resolution 8 bits




Amplifier:
Bandwidth 500 MGHz
Gain 0.2 mA/V

Coaxial cable was 30 m long with beam setup

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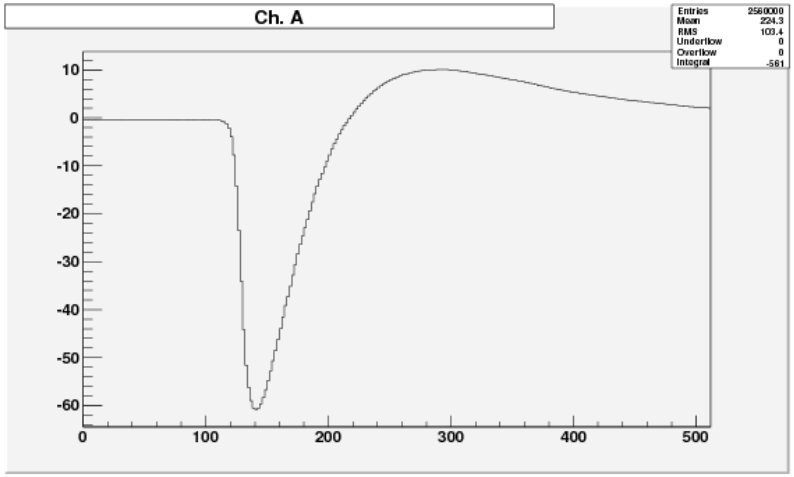
# Signal shape and timing method

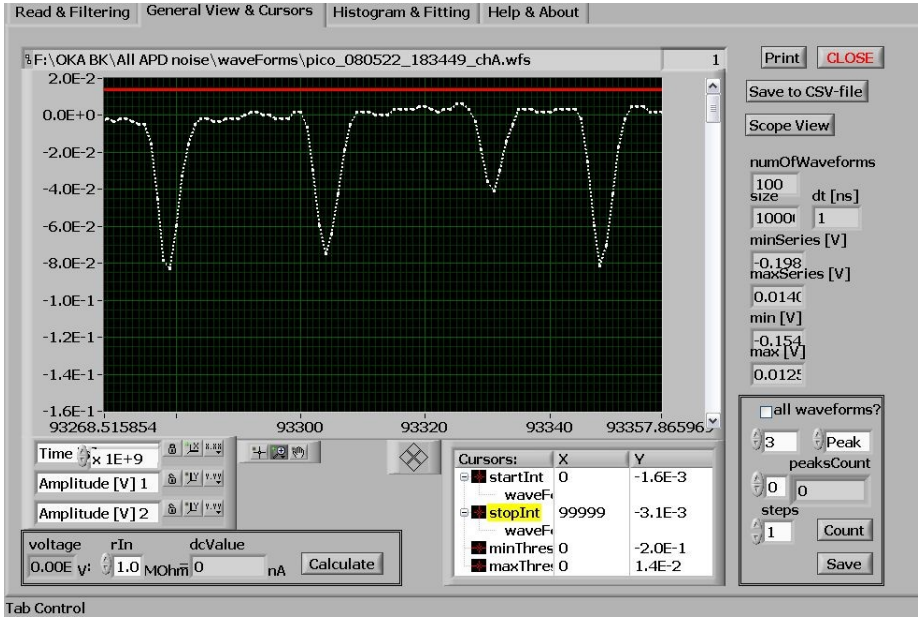
The method of time measurements was based on digitized signal form analysis. The main idea was to emulate constant fraction discriminator with analysis of recorded pulse shapes.




To adopt the digitization frequency of 500 MS/s the shape of signals was tuned to be rather slow with the rise time of about 12 nsec.

Pulse arrival time was defined as crossing time of given threshold normalized to the maximum of pulse amplitude. The best result was obtained with the threshold of 10% of pulse height.

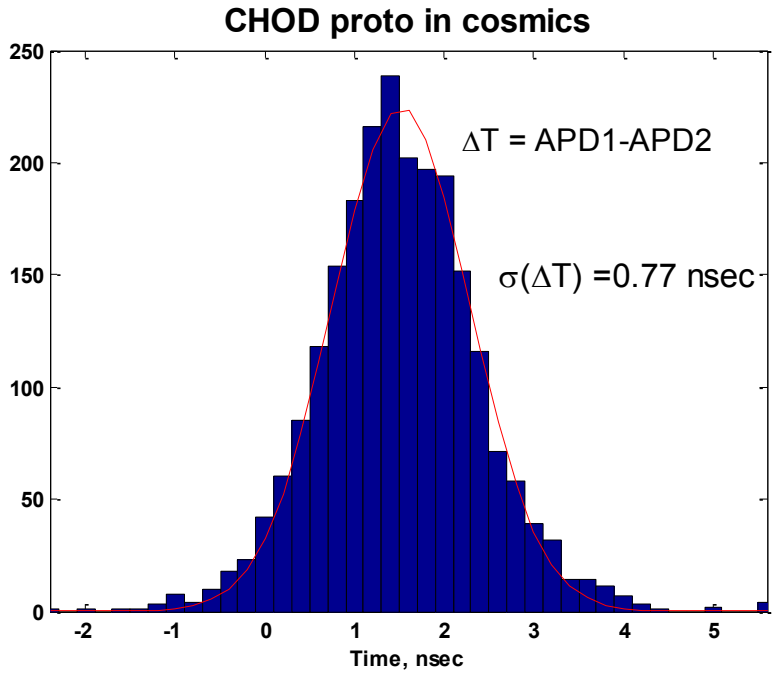
Later on the signal from APD can be shorten by pole/zero cancelation method to few nsec pulse width.




As an example the signal shapes obtained with 1 mm CPTA APD is shown. Noise pulse width was ~8 nsec at the base line with rise time of ~2 nsec.
Time grid has 20 nsec pitch with 1 nsec between samples.

Such signal timing should fit occupancies up to 1 MHz.

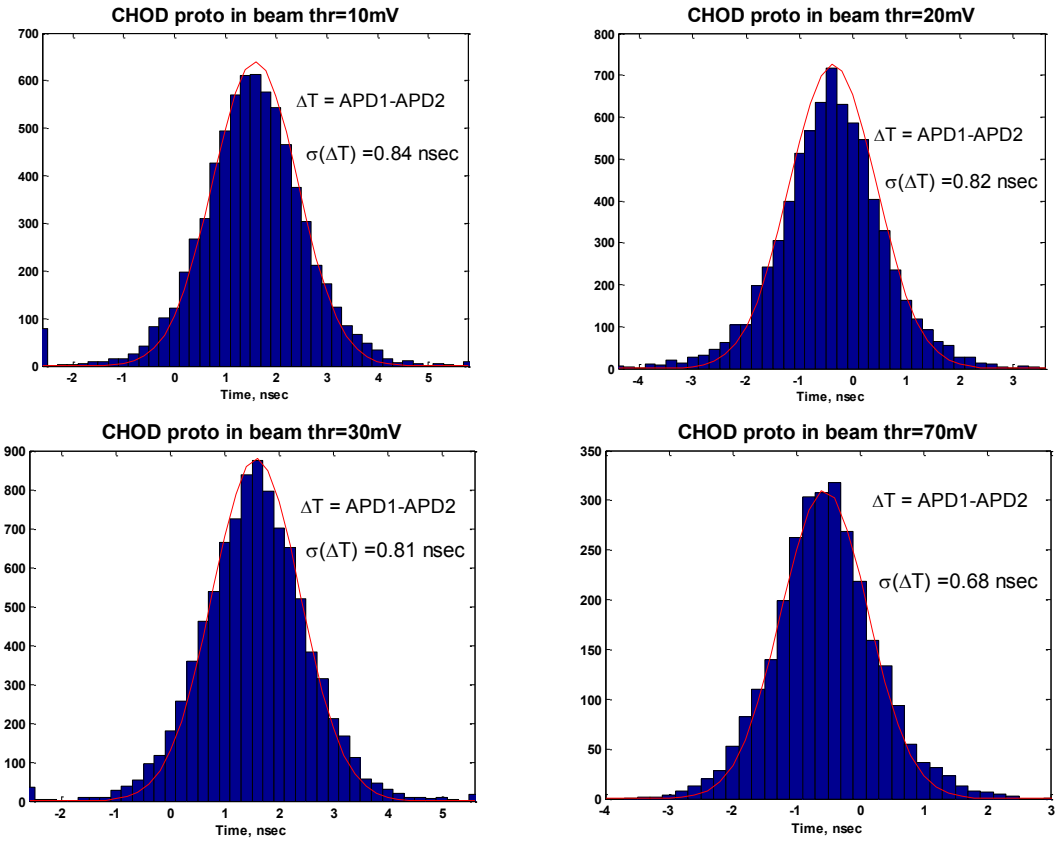
# Results: time resolution with cosmics




Distribution of arrival time difference between two counters.
Trigger threshold was 30 mV.

Roughly, result for single counter should be divided by sqrt(2).

# Results: time resolution with beam




Distribution of arrival time difference between two counters.
Trigger threshold was varied from 10 to 70 mV.

# Plans and conclusion

**Summary of the results:**

- Time resolution was measured with rather slow setup. Estimation of time resolution of single channel is to be ~0.4-0.6 nsec depending on the pulse amplitudes.
- Light yield of CHOD prototypes with APD is estimated ~60-100 p.e./mip. Will be measured more precisely.
- Current understanding is that with faster shaping and constant fraction discriminator the time resolution can be obtained better than 0.5 nsec.

**Plans:**

On the base of obtained results it is quite encouraging to built prototype with 5x5 cells with Geiger APD read-out to be tested in April 2012 in OKA beam and later in autumn 2012 in CERN.

Meanwhile more intermediate measurements can be done to compare different APD and to test read-out electronics.