Study of new CHOD prototypes with SiPM & PMT readout

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CHOD prototype

Two variants of readout were tested. One with SiPMs and one with PMTs

Cast scintillator with grooves for WLS-fibers (BFC 91 DC). Fibers are glued into grooves.

Scintillating pad are wrapped into reflective TYVEK paper

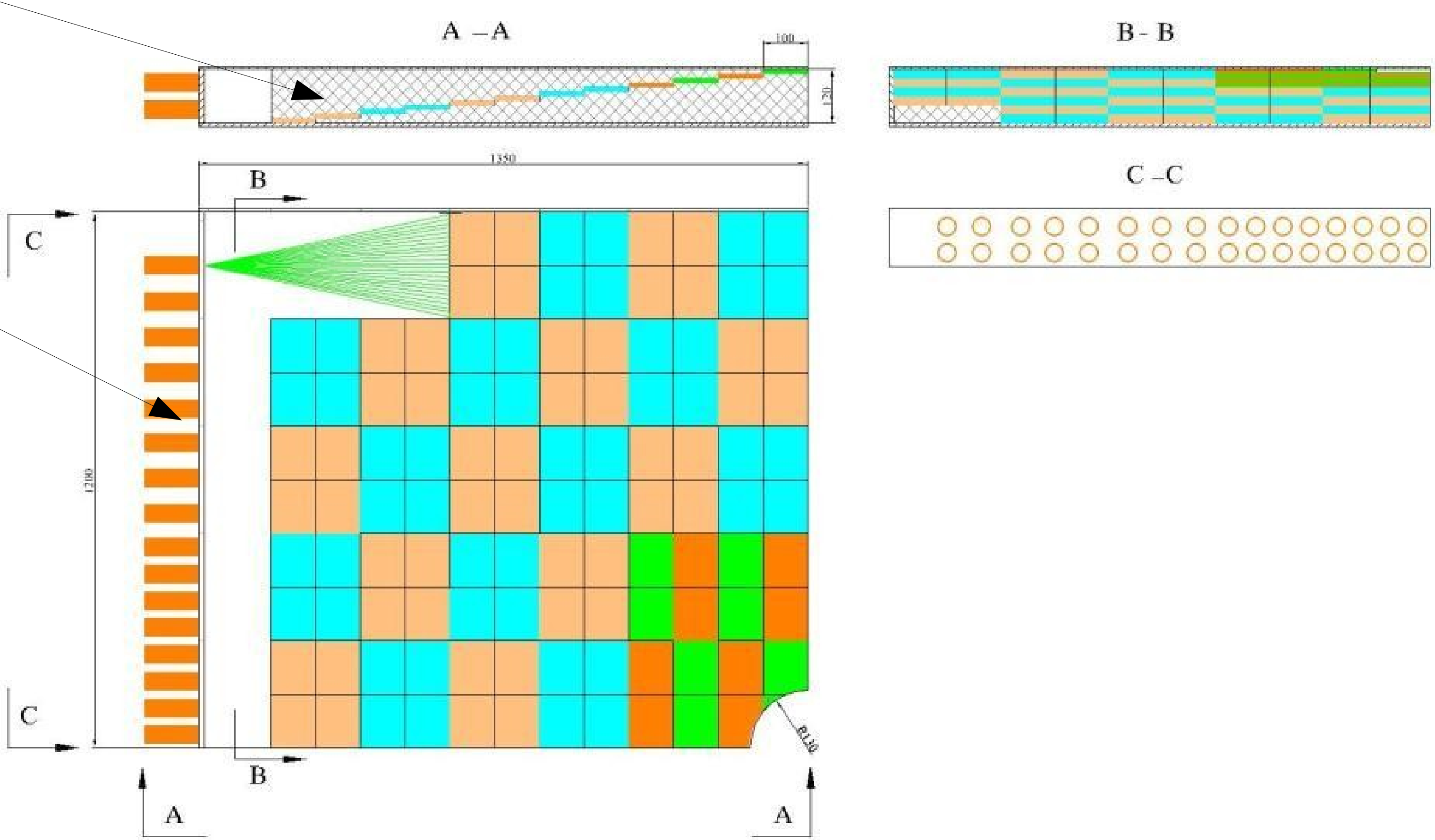
Escaping light is returned by Al-mylar for SiPM readout and via fiber loop for PMTs.

Proposed construction of CHOD

One quadrant of CHOD. Variant with PMTs

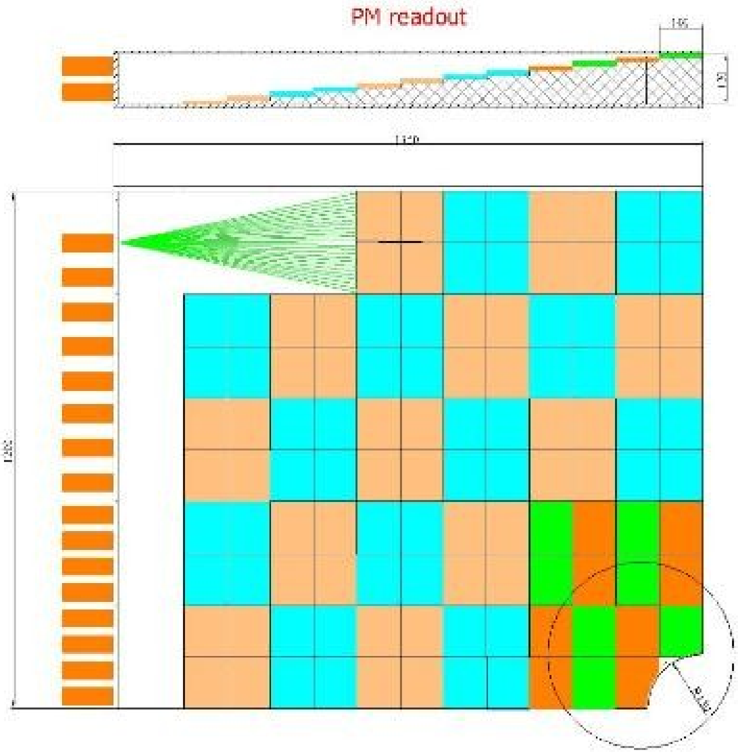
Low density styrofoam (gray)

PMTs

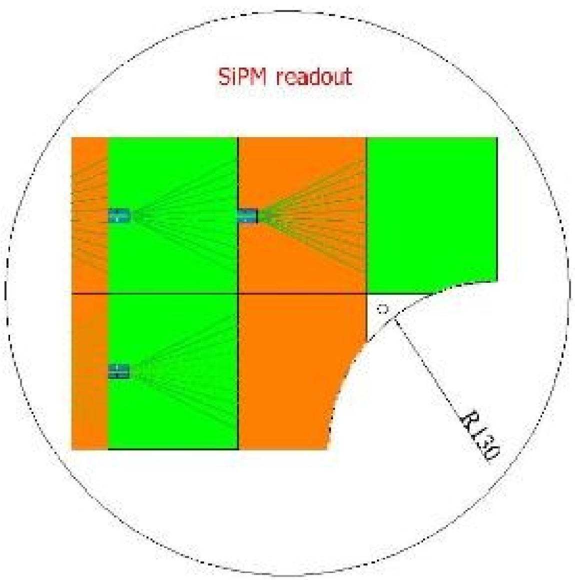


Pads are color coded

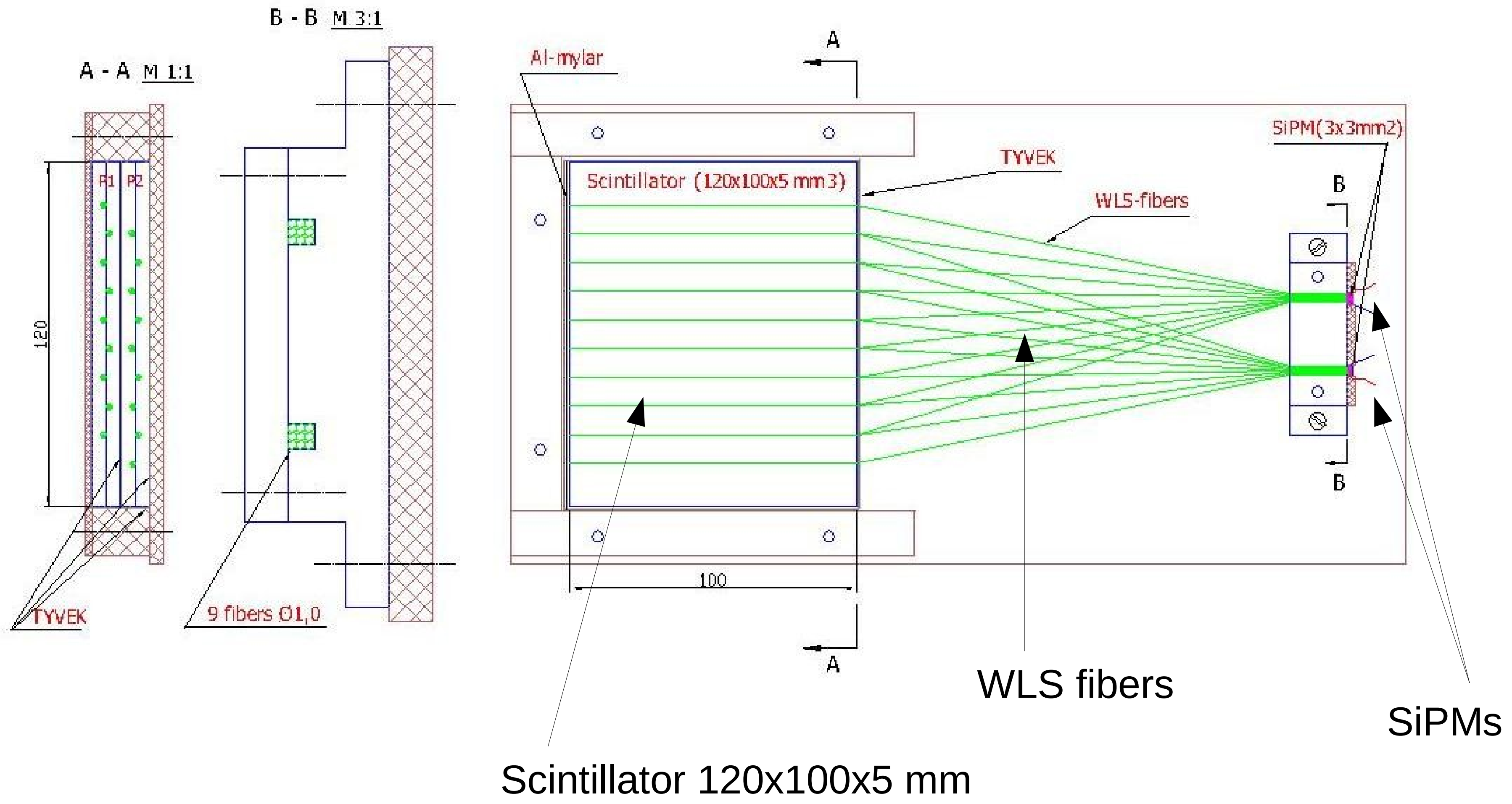
Proposed construction of CHOD



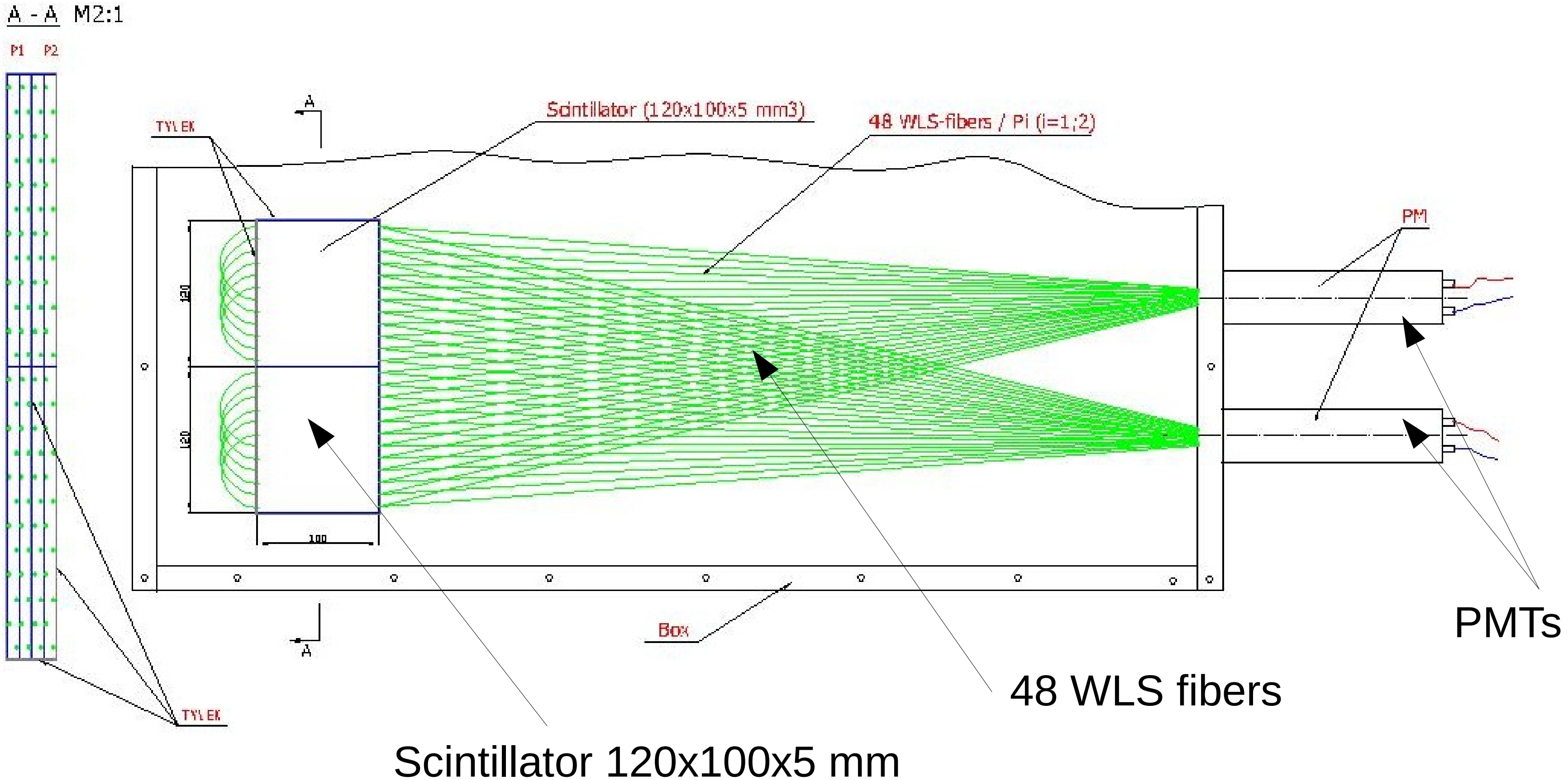
SiPM readout



CHOD with SiPM readout

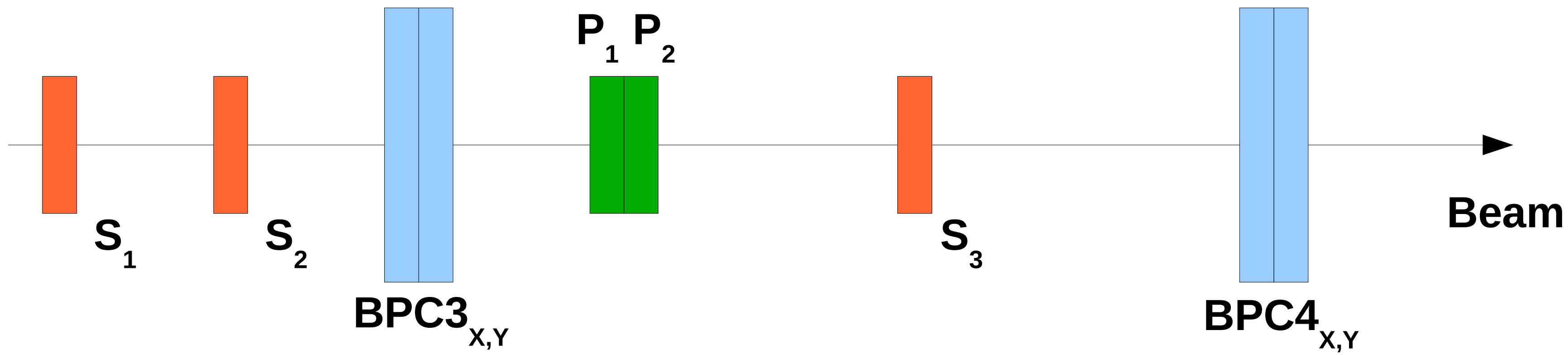


CHOD with PMT readout



FEU-85 selected by quantum efficiency were used

Positioning on the beam



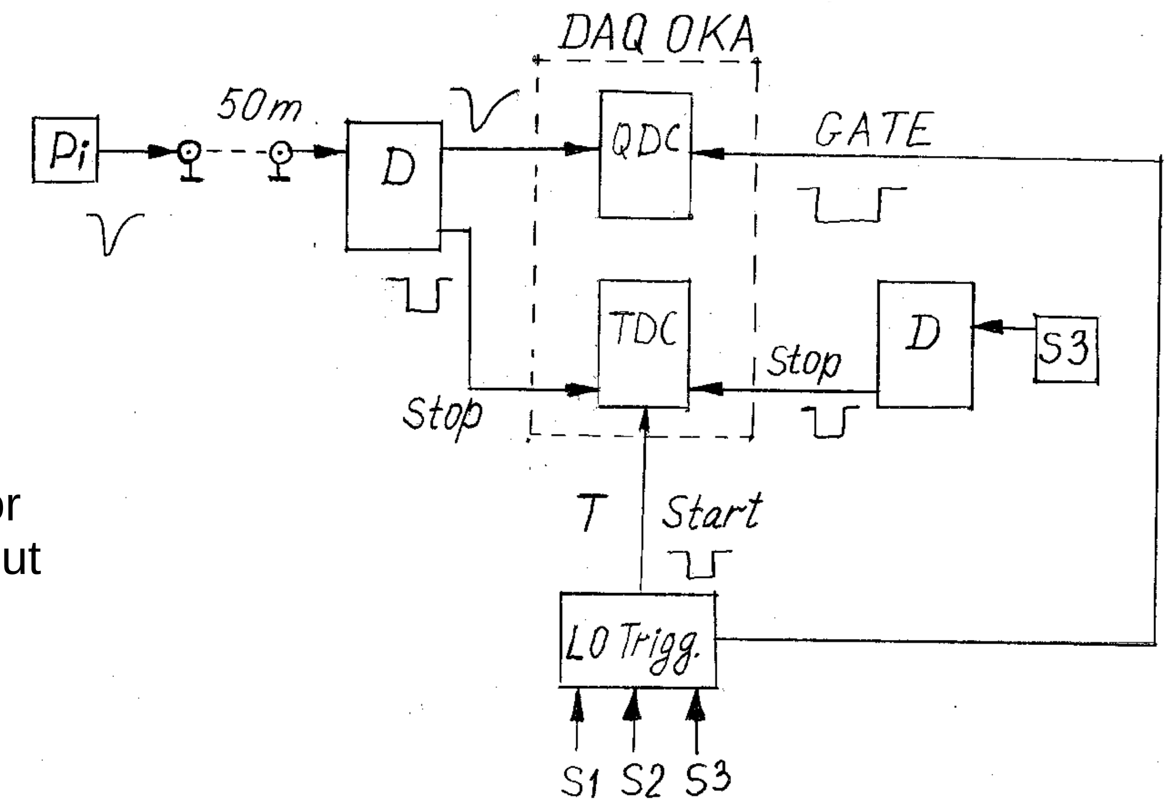
Prototype was placed between two doublets of proportional chambers (BPC). So it's possible to reconstruct trajectory of passing particle

Prototype have two PMTs: P_1, P_2

Stintillating counters S_1 S_2 S_3 participate in trigger. Additionally S_3 is used in time measurements.

Readout with OKA electronics

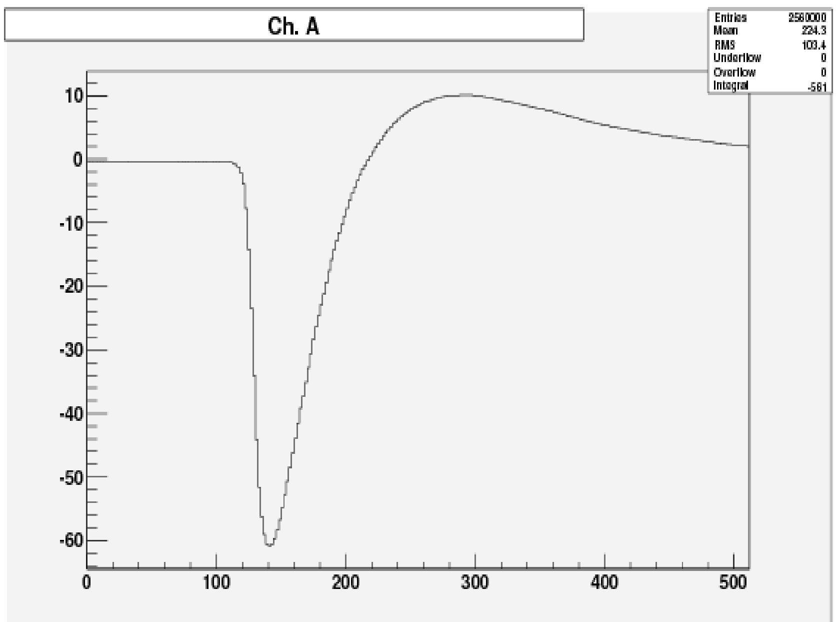
P_i, i = 1,2
prototypes in study
S3
Counter 3
D
leading edge discriminator
with additional linear output
L0 Trig
level 0 trigger

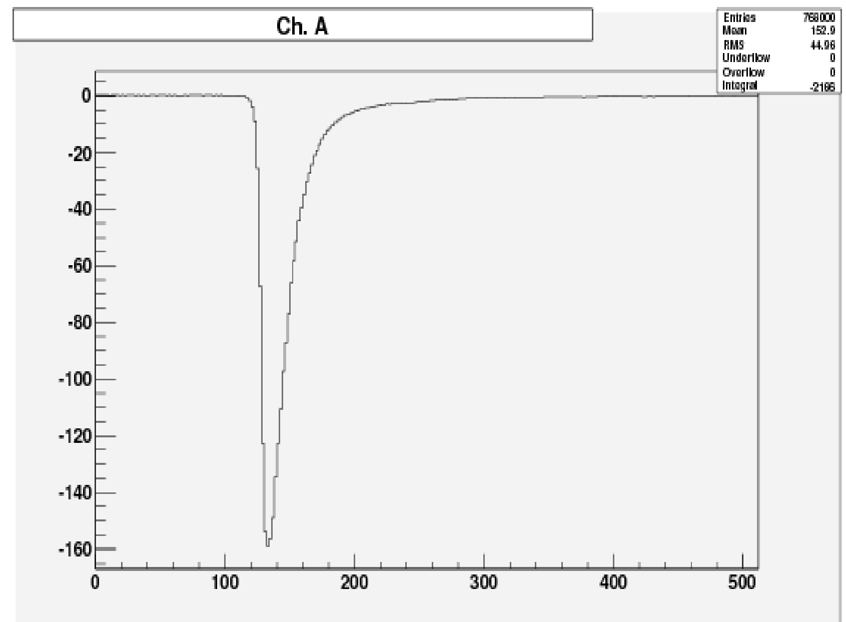


Only prototype with PMT readout was tested this way

Shapes of signals

Averaged signal shapes were obtained with picoscope





Signal from SiPM

Threshold — 30mV

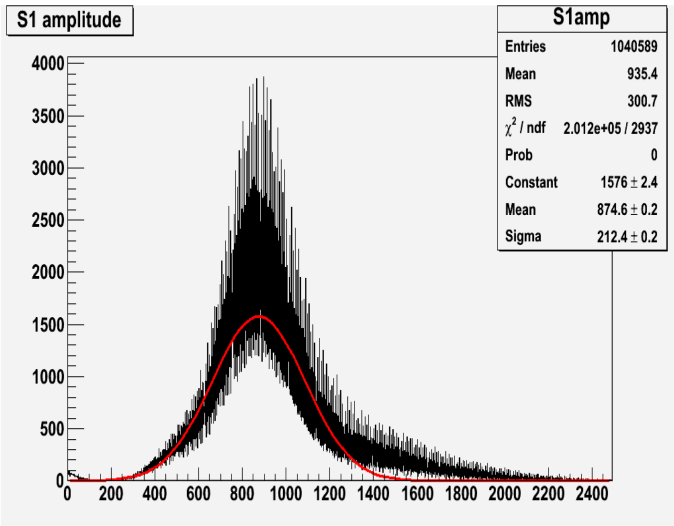
Signal from PMT

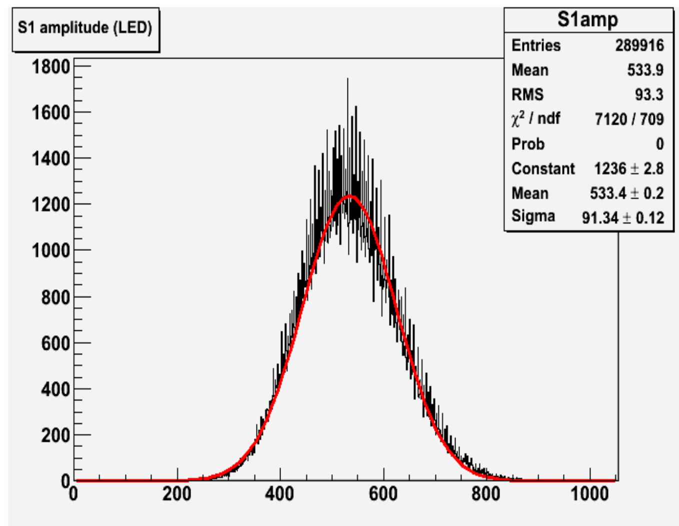
Threshold — 100mV

Number of photoelectrons

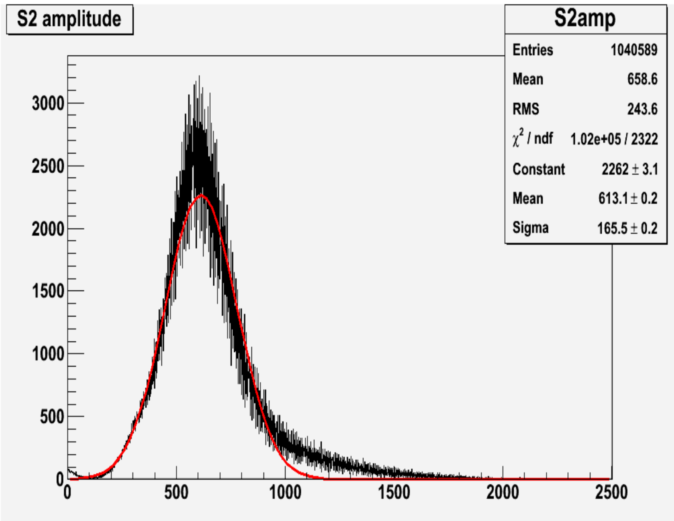
Beam

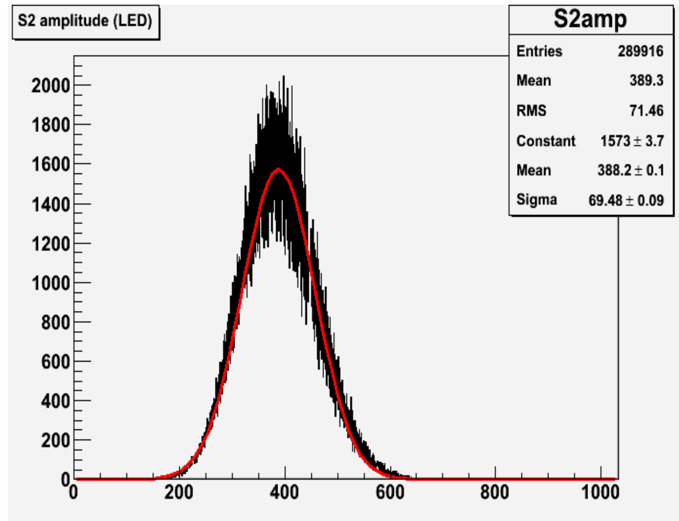
LED





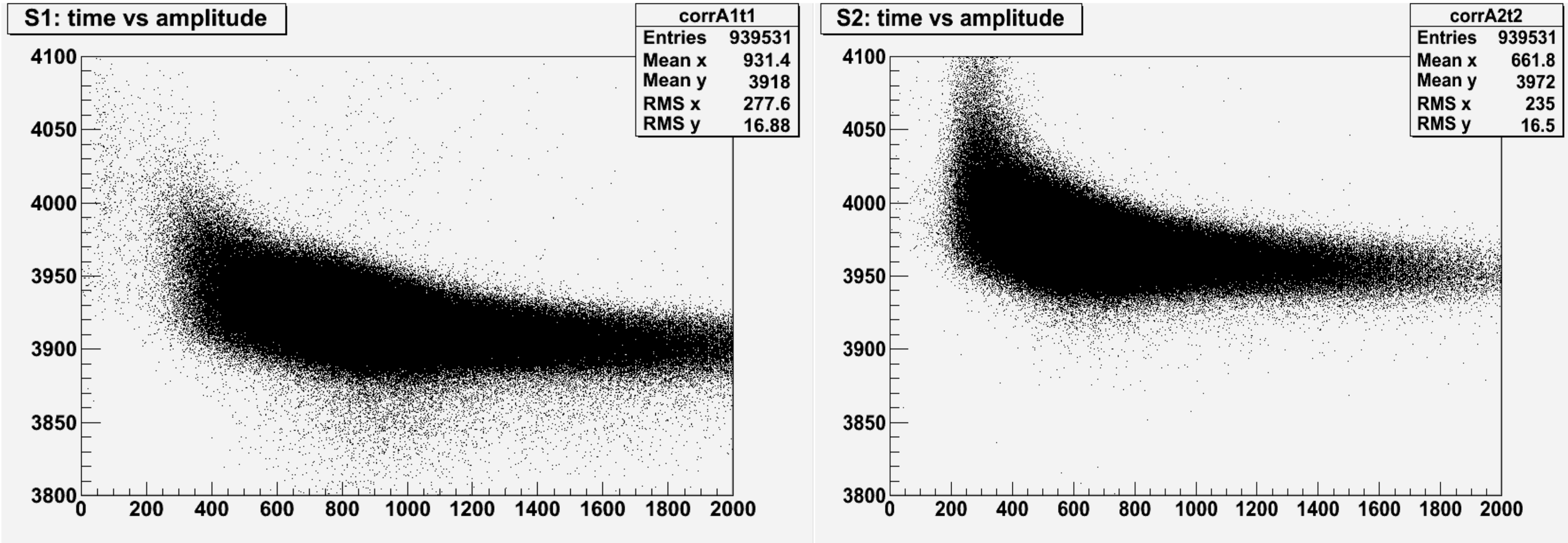
P1: $N_{ph} \approx 56$





P2: $N_{ph} \approx 50$

Correction for amplitude

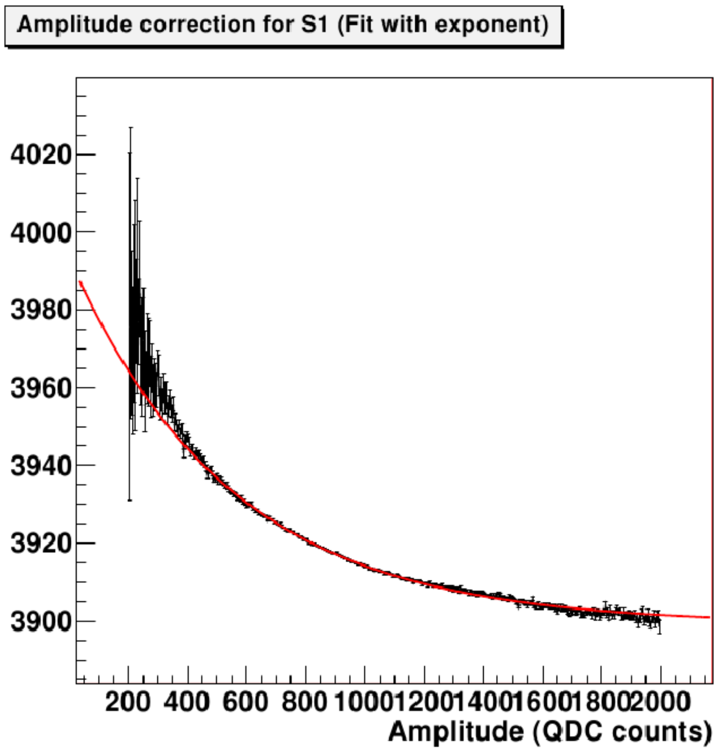


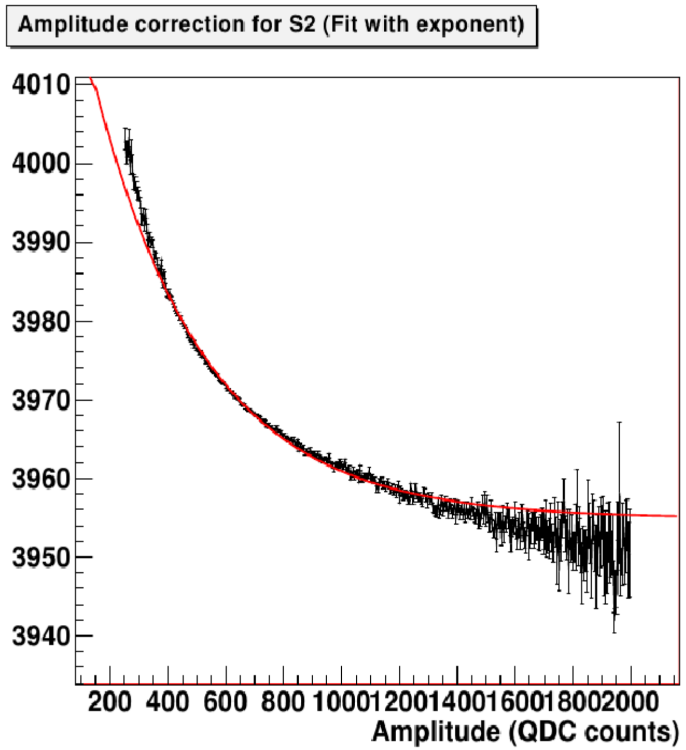
Fixed threshold discriminator introduce dependency on amplitude which worsens time resolution. So it should be taken into account.

Correction for amplitude

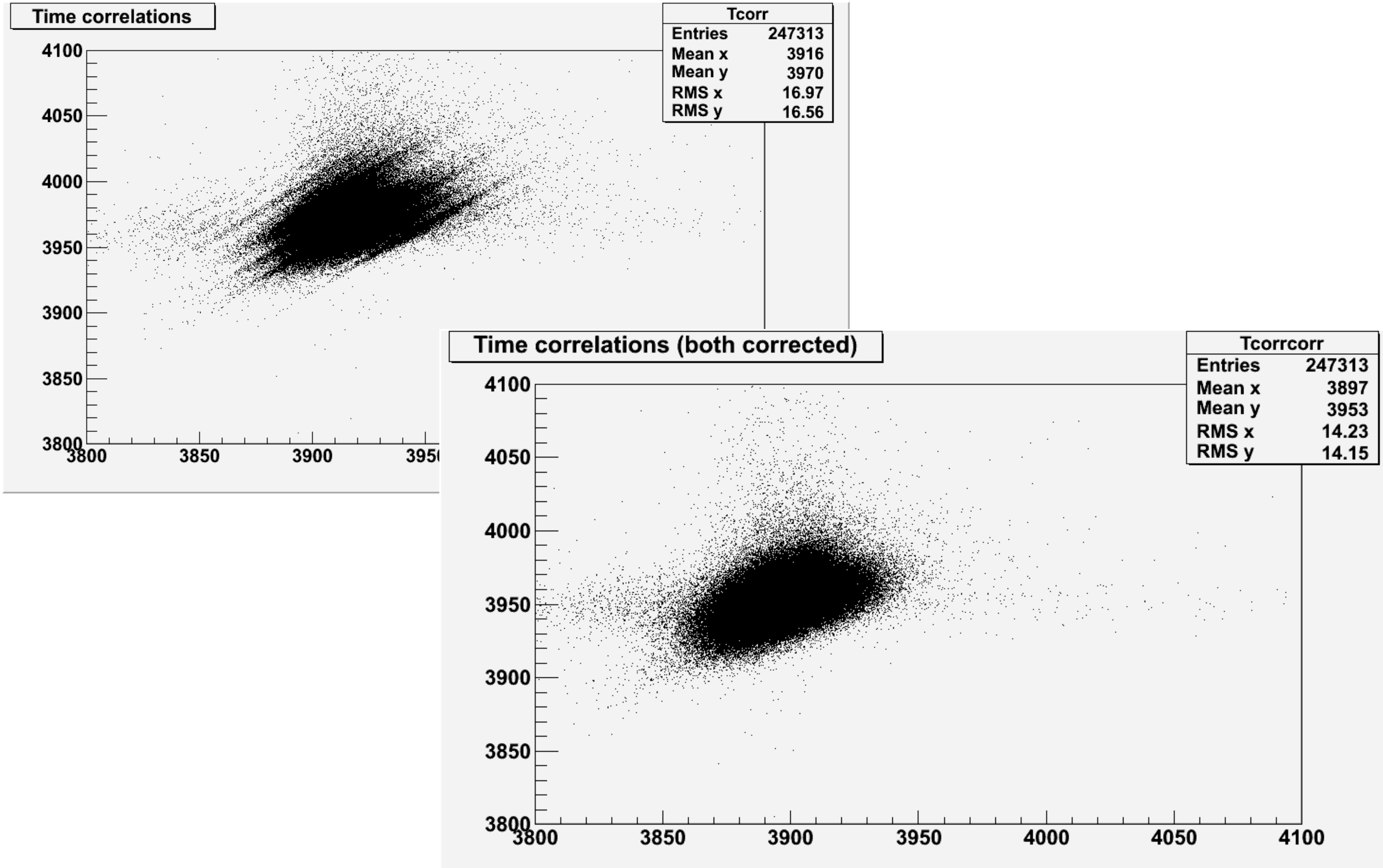
Individual slices of histograms above were fitted with gaussian to determine mean time for different amplitudes.

Resulting data was fitted with sum of constant and exponent.

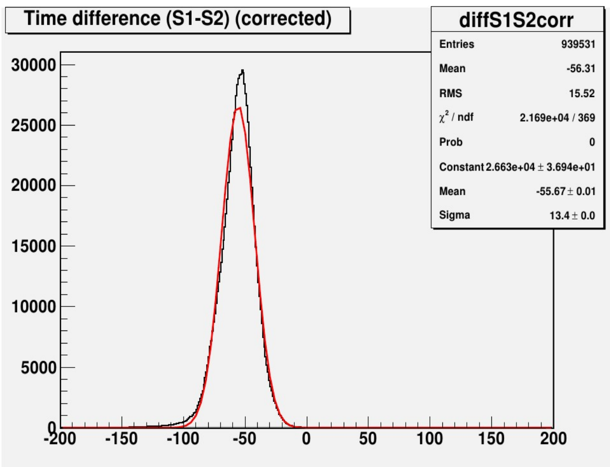


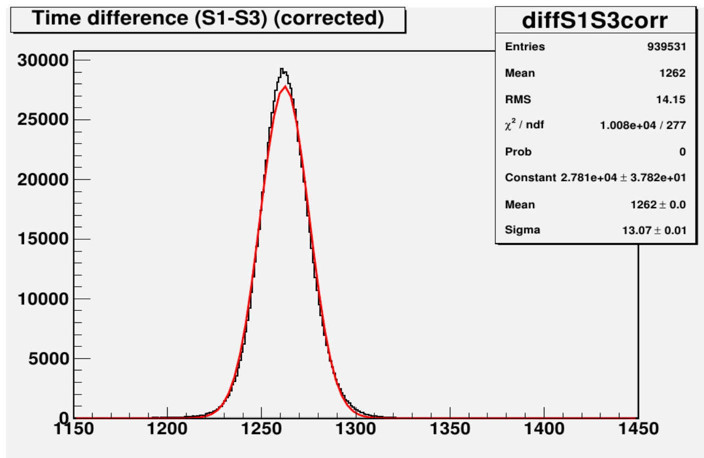


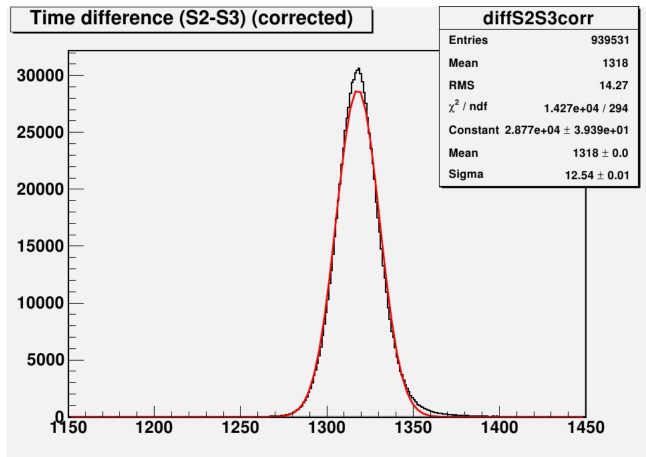
Time correlations



Time resolution







	No corrections (ns)	Corrected (ns)
σ_{12}	—	1.34
σ_{13}	1.44	1.31
σ_{23}	1.37	1.25

Time resolution

We have 3 counters (P1, P2 and S3) and we know they relative times. Therefore we can extract time resolution for every counter.

$$\sigma_{12}^2 = \sigma_1^2 + \sigma_2^2$$
$$\sigma_{13}^2 = \sigma_1^2 + \sigma_3^2 \quad \Rightarrow \quad \sigma_1^2 = \frac{1}{2}\left(\sigma_{12}^2 + \sigma_{13}^2 - \sigma_{23}^2\right)$$
$$\sigma_{23}^2 = \sigma_2^2 + \sigma_3^2$$

Time resolution

Variant with PMTs

	No corrections (ns)	Corrected (ns)
σ_1	1.15	1.0
σ_2	1.06	0.9
σ_3	0.85	

Time resolution

Prototype with SiPM readout was tested on OKA beam. Signals were registered with PicoScope. Details will be presented in separate talk.

Prelimitry result display good time resolution which satisfies expreriment requirements.

$$\sigma_{12} \approx 0.8\text{-}1\text{ns}$$
$$\sigma_1 \approx \sigma_2 \approx 0.4\text{-}0.7\text{ns}$$

Nonuniformity

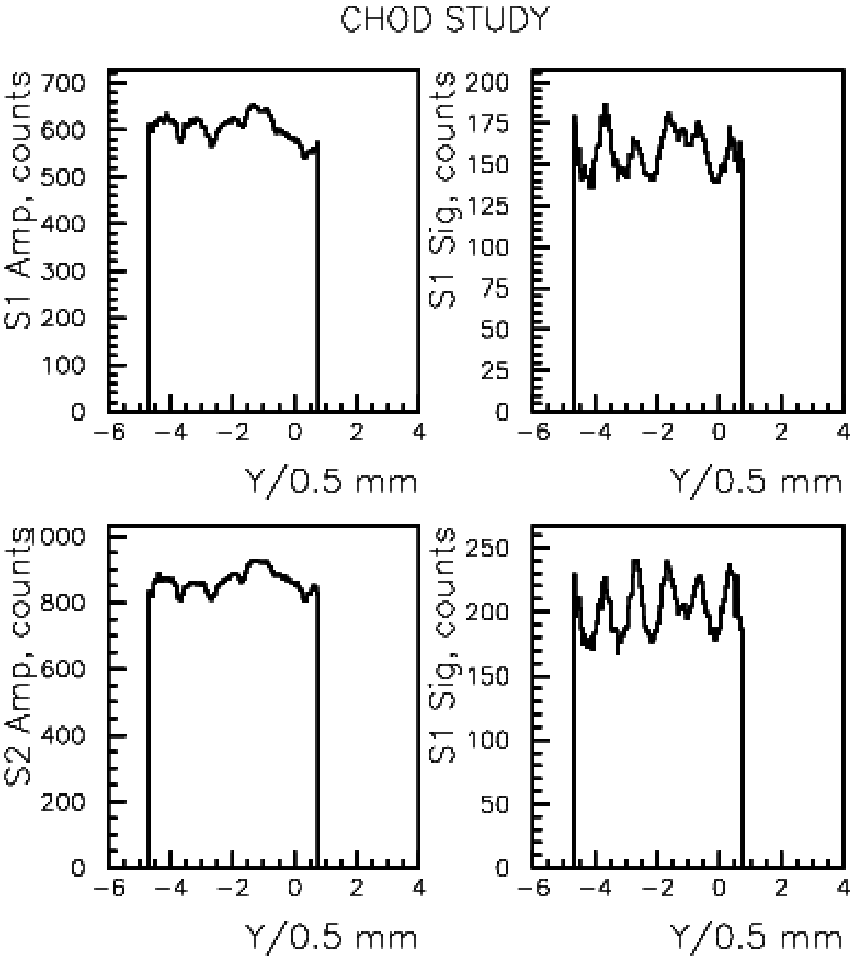
BPCs allow to reconstruct trajectory of passing particle and study nonuniformity in both amplitude and time

Nonuniformity of amplitude

Nonuniformity in direction across WLS fibers:
- ±6% for amplitude
- ±20% for std. dev.

Bin size is 0.5mm.
X axis in cm
Y axis in QDC counts

Fibers are clearly visible.
Join of scintilating pads could be seen at Y=-1cm



P_1

P_2

Amplitude Std. dev.

Nonuniformity of time

Nonuniformity in direction **across** WLS fibers:

±0.2ns for mean time

±0.1ns for resolution

Bin size if 0.5mm

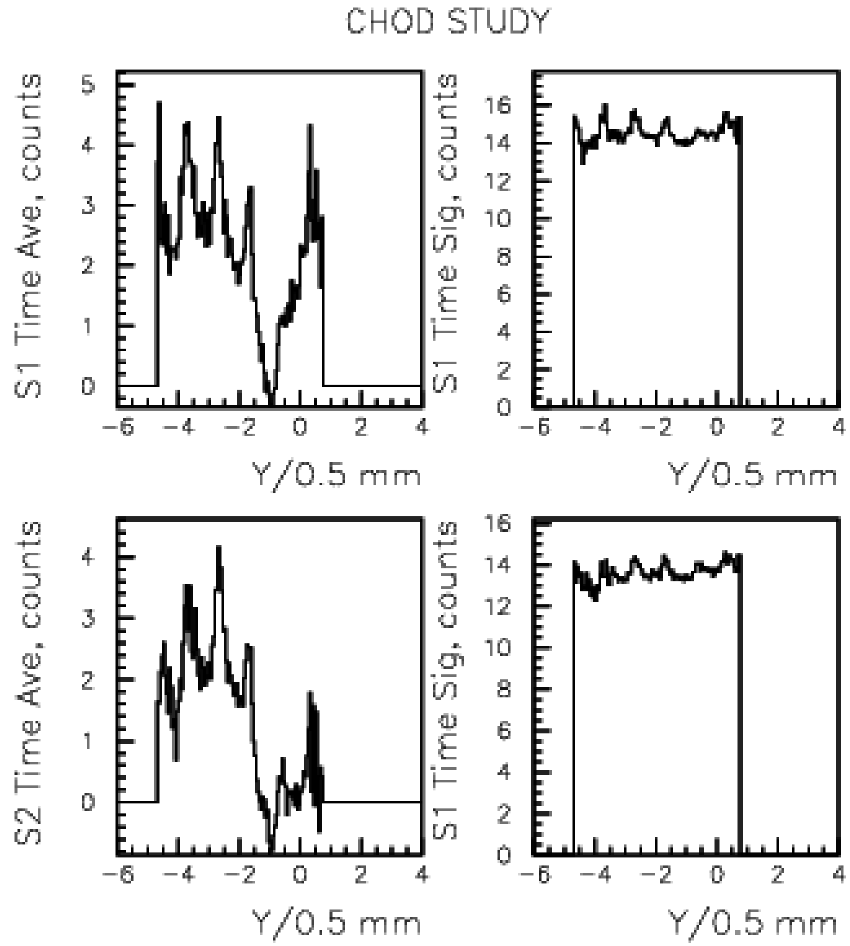
X axis is in cm

Y axis is in TDC counts

(1 count = 0.1ns)

Fibers could be seen as well. Join is clearly visible

NOT corrected for amplitude



P_1

P_2

Mean time Variance

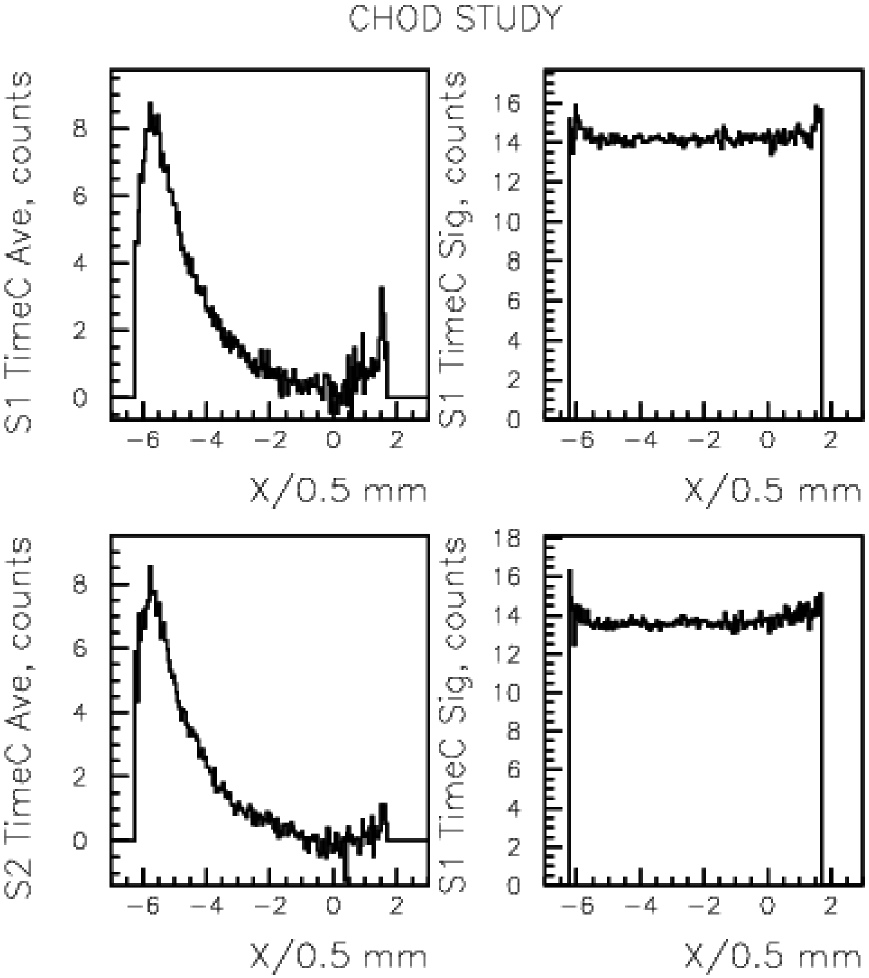
Nonuniformity of time

Nonuniformity in direction **along** WLS fibers:

±0.4ns for mean time resolution is nearly constant

Bin size if 0.5mm
X axis is in cm
Y axis is in TDC counts
(1 count = 0.1ns)

Corrected for amplitude



P_1

P_2

Mean time Variance

Results

Number of photoelectrons

P1: N_{ph} ≈ 56 **P2: N_{ph} ≈ 50**

Time resolution

	No corrections (ns)	Corrected (ns)
σ_1	1.15	1.0
σ_2	1.06	0.9
σ_3	0.85	

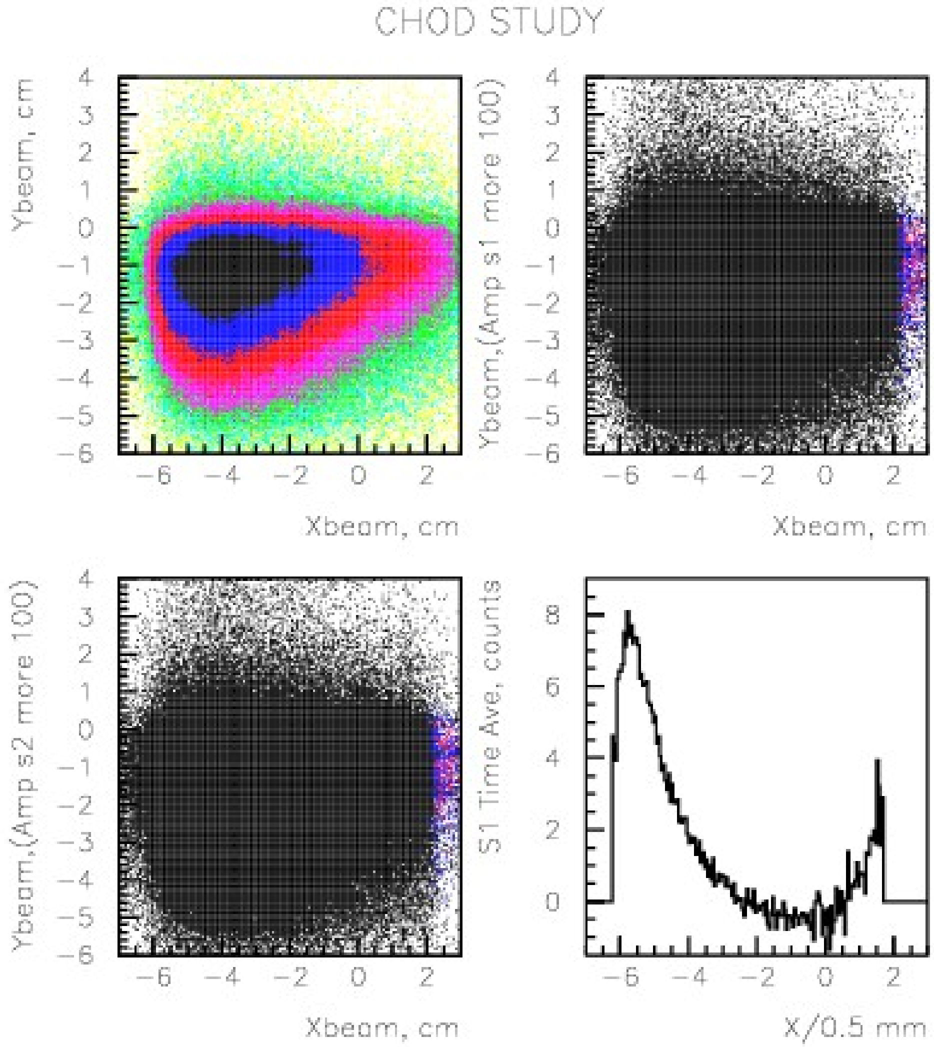
Measurements with picoscope give:

- SiPM: $\sigma_{12} \approx 0.8$-1ns, or $\sigma_1 \approx \sigma_2 \approx 0.4$-0.7ns
- PMT: $\sigma_{12} \approx 1.1$-1.2ns, or $\sigma_1 \approx \sigma_2 \approx 0.7$-0.75ns

Good spatial uniformity for both amplitude and time resolution

Backup slides

Beam shape



CHOD STUDY
Ybeam, cm
Xbeam, cm
Ybeam,(Amp s1 more 100)
Xbeam, cm
Ybeam,(Amp s2 more 100)
Xbeam, cm
S1 Time Ave, counts
X/0.5 mm