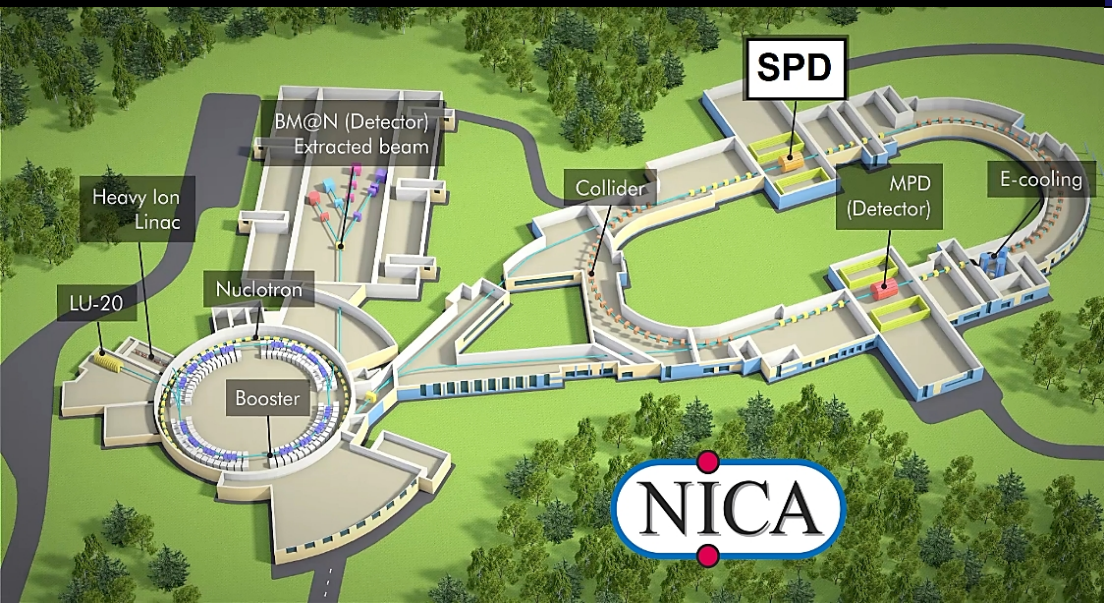
BBC status report

V.P.Ladygin for BBC team

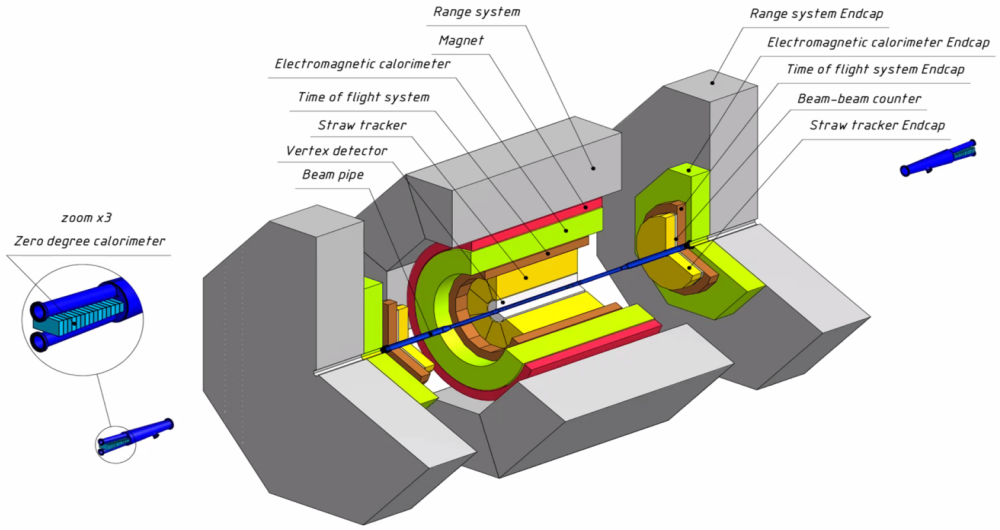
SPD collaboration meeting

4 October 2022

Introduction

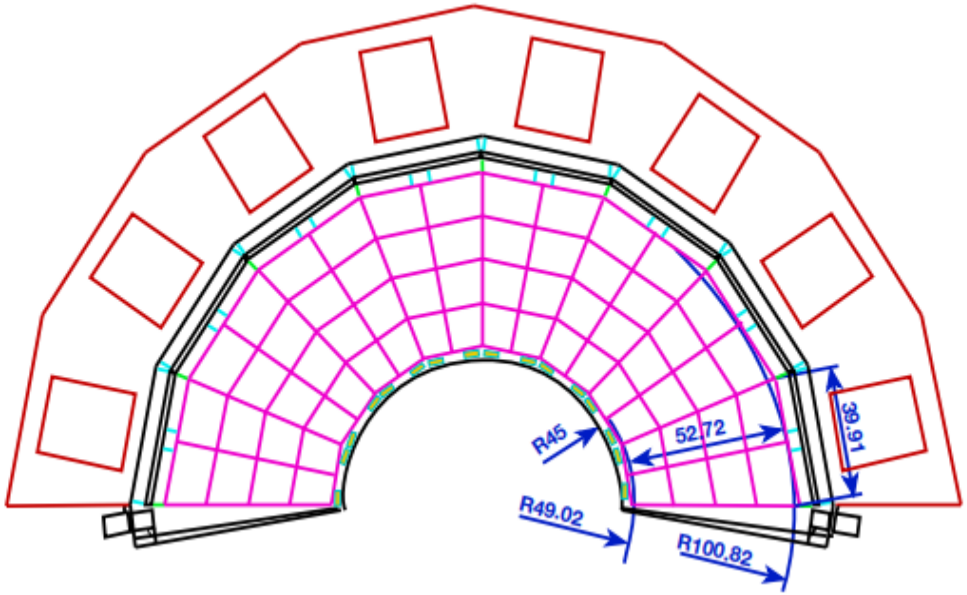


The Spin Physics Detector (SPD)



General

The Beam-Beam Counters (BBC) for SPD



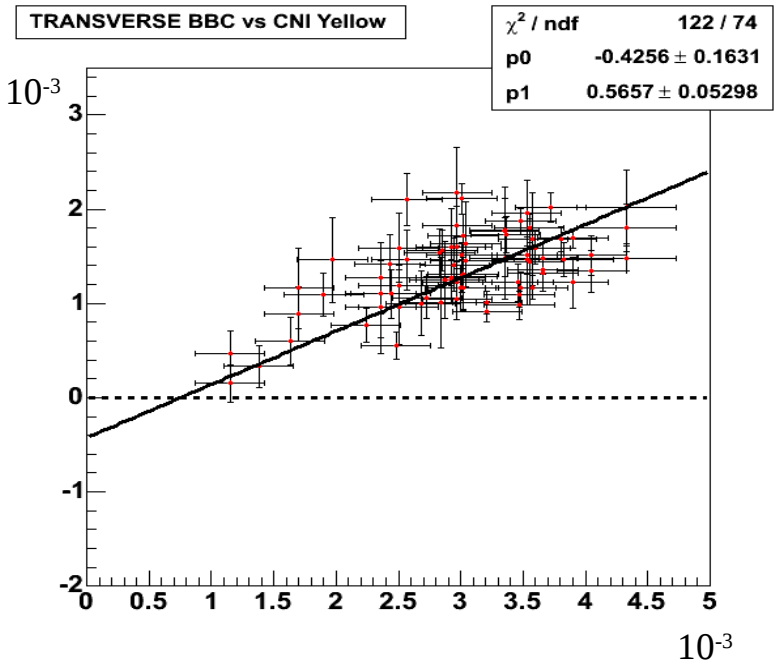
The main purpose is the permanent monitoring of the beam polarization using the azimuthal asymmetry of the inclusive charged particles yield.

Concept 2021:

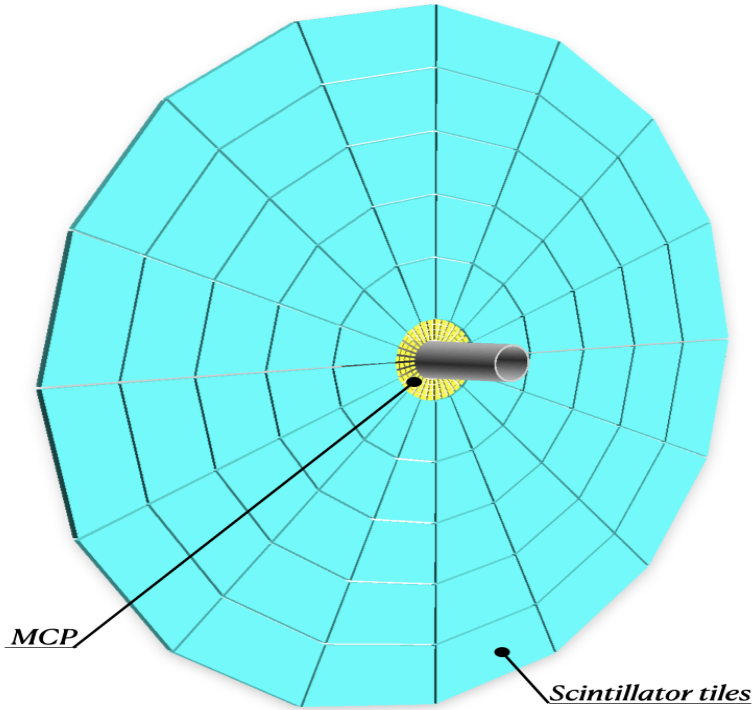
inner part – microchannel plates based detectors

outer part – high granularity scintillator tiles with SiPM readout

BBC: scintillation tiles



Correlation between CNI polarimeter and STAR BBC asymmetries.



Inner part can be used for luminosity estimation and, possibly, for local polarimetry using pp- and dp- elastic scattering.

Local polarimetry will be provided by the analysis of the azimuthal asymmetry in inclusive production of charged particles in forward direction.

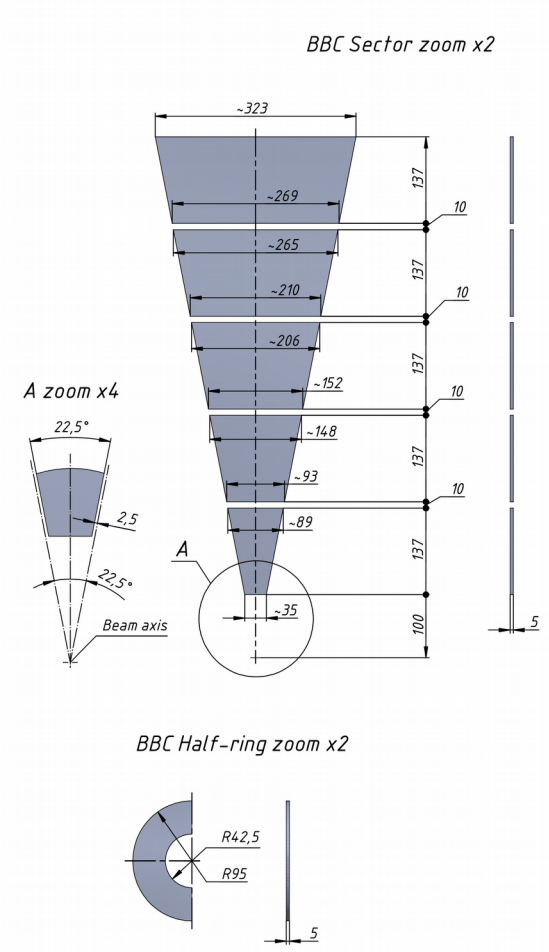
Introduction

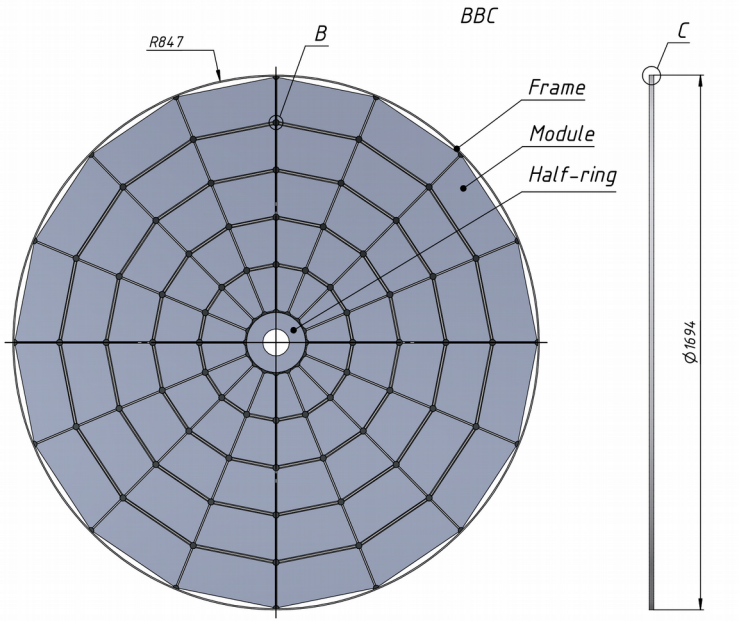
TDR version of BBC

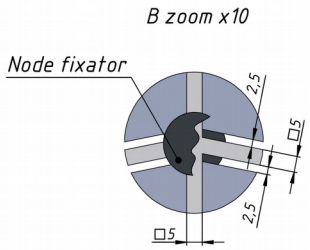
2 panels (z = ±171.6 cm.)
16 sectors by azimuth angle
6 sectors by polar angle
1.48 < η < 4.39

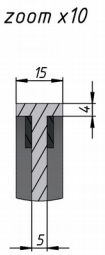
1 sector(extreme inner):
4.25 <r< 9.5 (cm.)

2-6 sector:
10.0 <r< 82.5 (cm.)



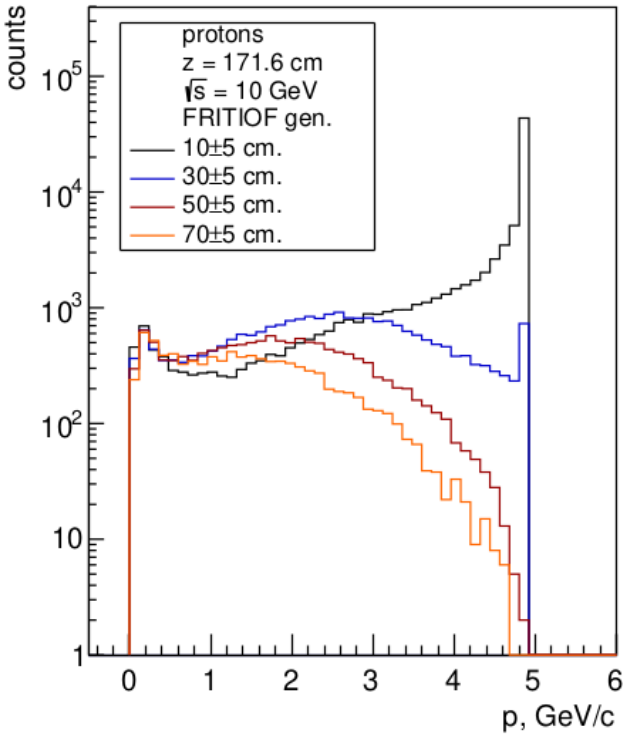


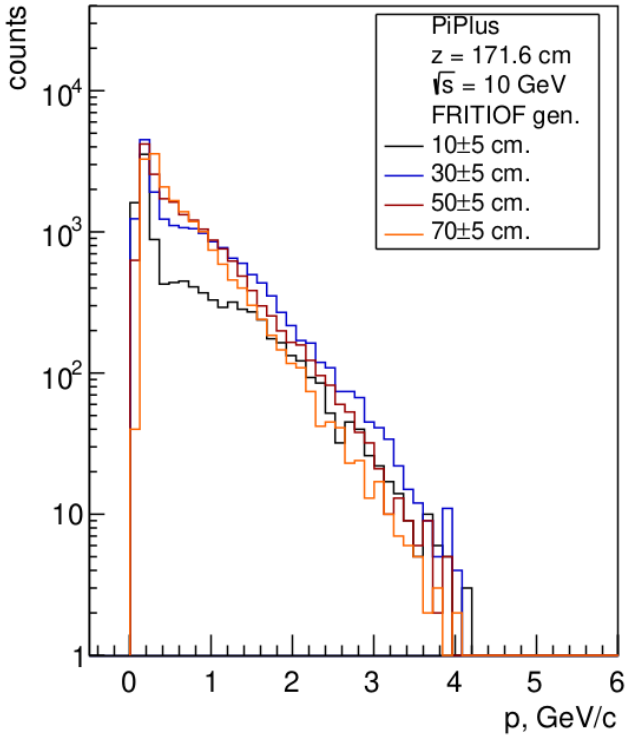


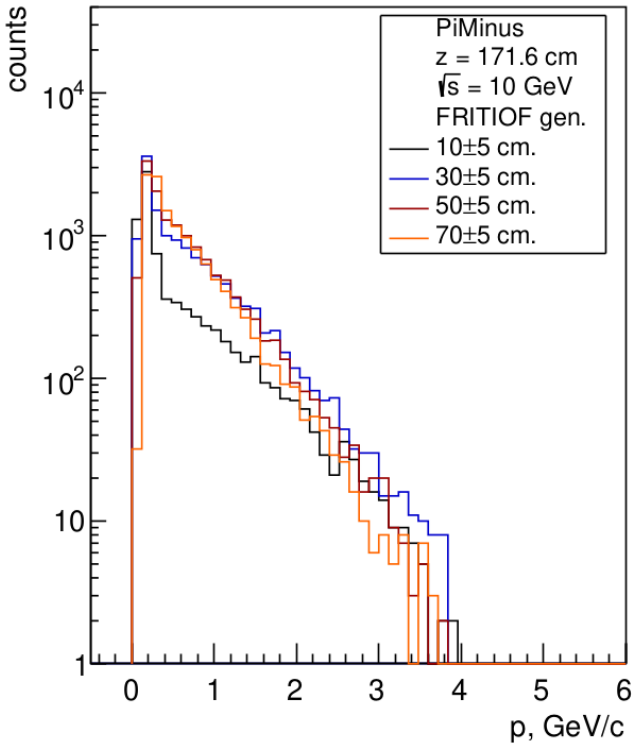


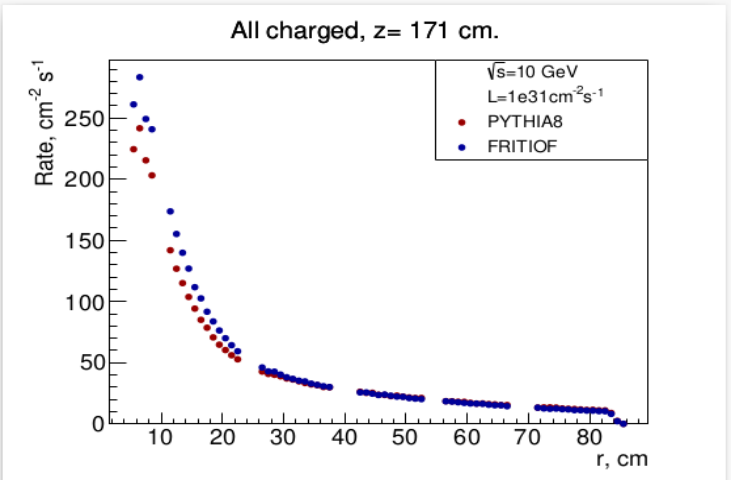
Simulation (pp)

10 GeV







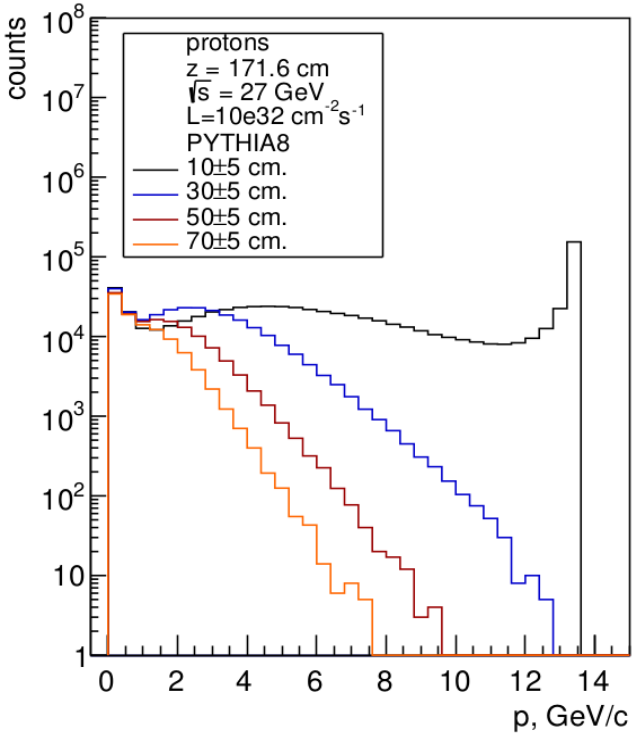


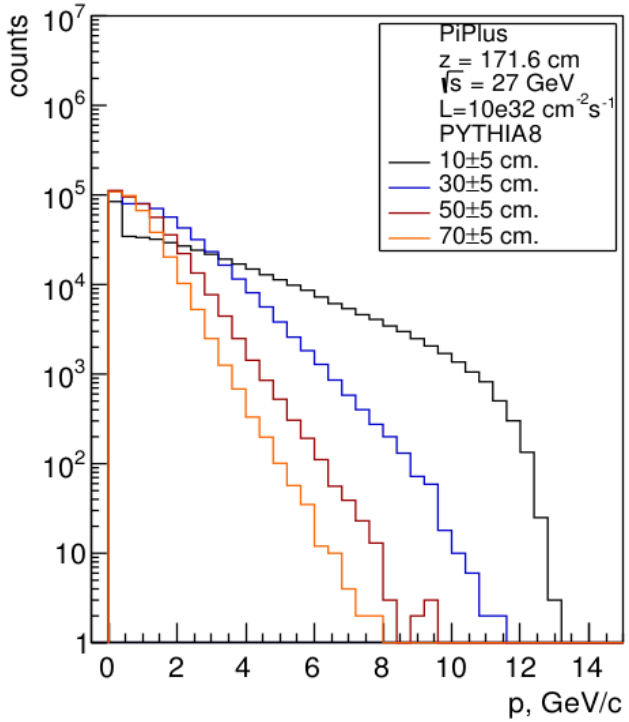
L = 1e31 cm^{-2} s^{-1}
σ_{tot} = 37.9 mub
N = L*σ = 379000 s^{-1}

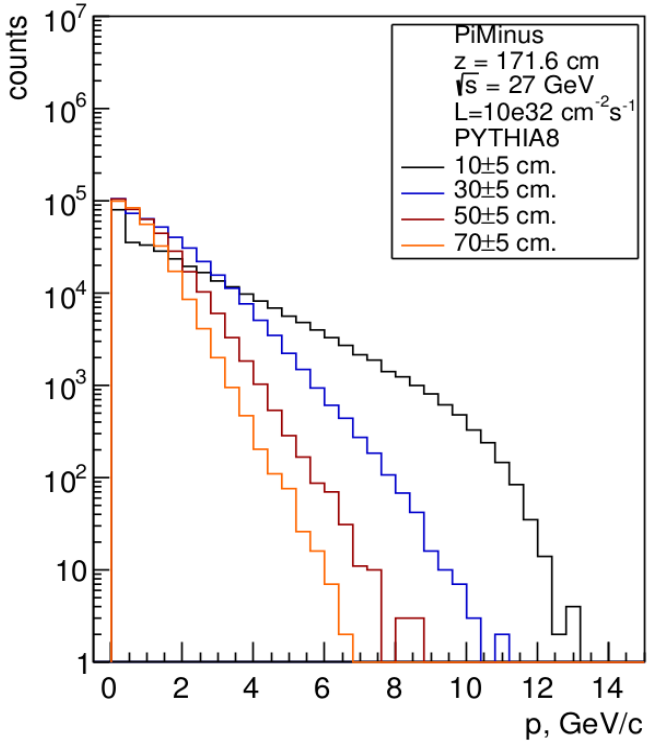
Z.Kurmanaliyev
(see talk at this meeting 6.10.22)

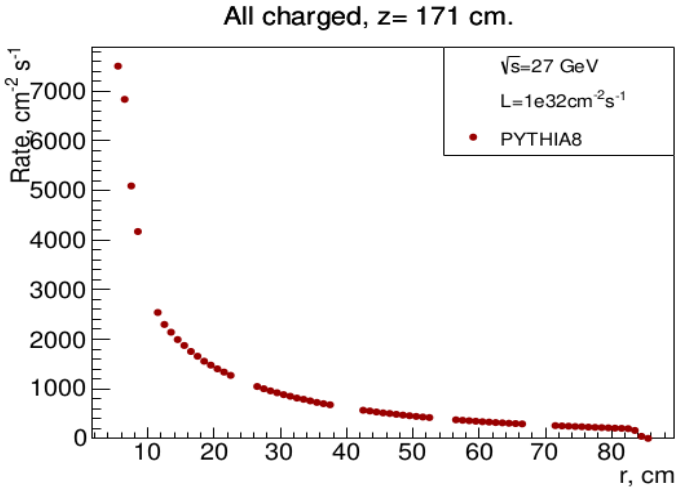
Simulation (pp)

27 GeV









$L = 1e32\ cm^{-2}\ s^{-1}$

$\sigma_{tot} = 40.0\ mub$

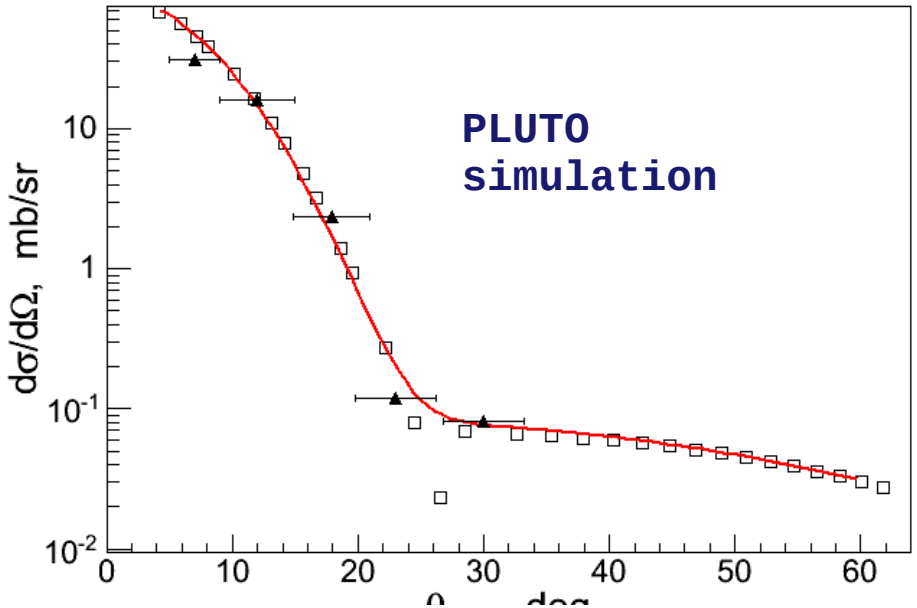
$N = L*\sigma = 4000000\ s^{-1}$

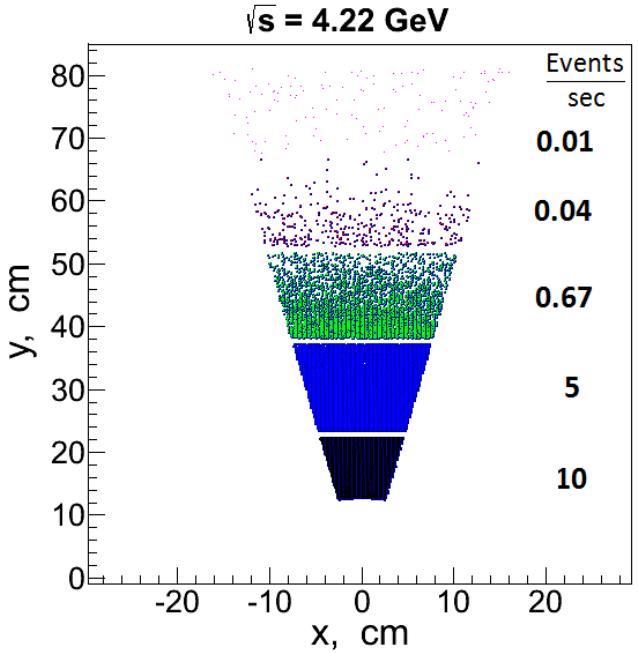
Z.Kurmanaliyev

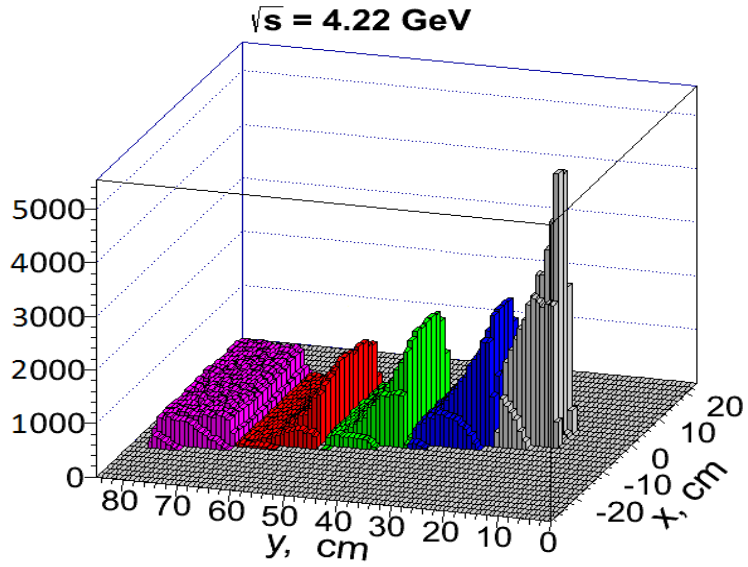
(see talk at this meeting 6.10.22)

Simulation (dd)

4.22 GeV





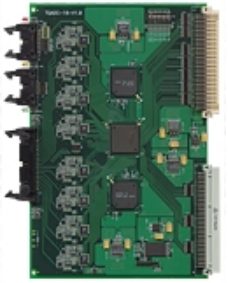


L = 1e30 cm^{-2} s^{-1}

A.Terekhin

FEE studies results

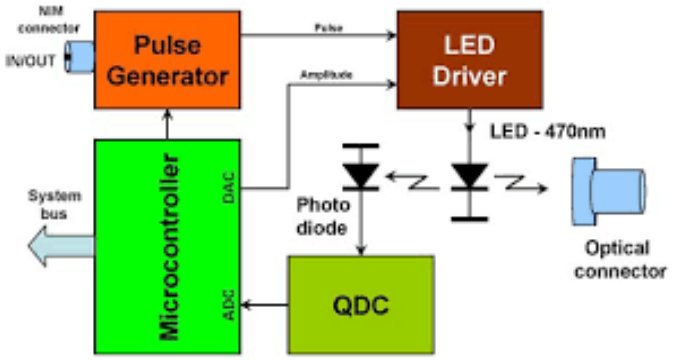
The stand for BBC



TQDC16
(16-channel
time and charge
digitizer)

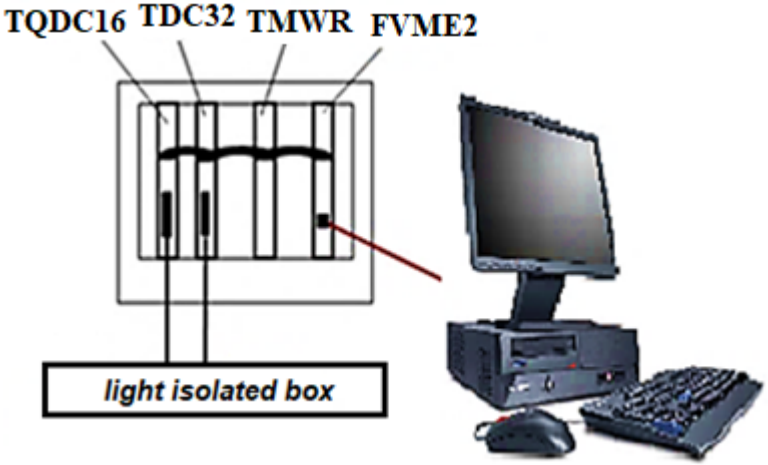
TDC32
(32-channel
time digitizer)

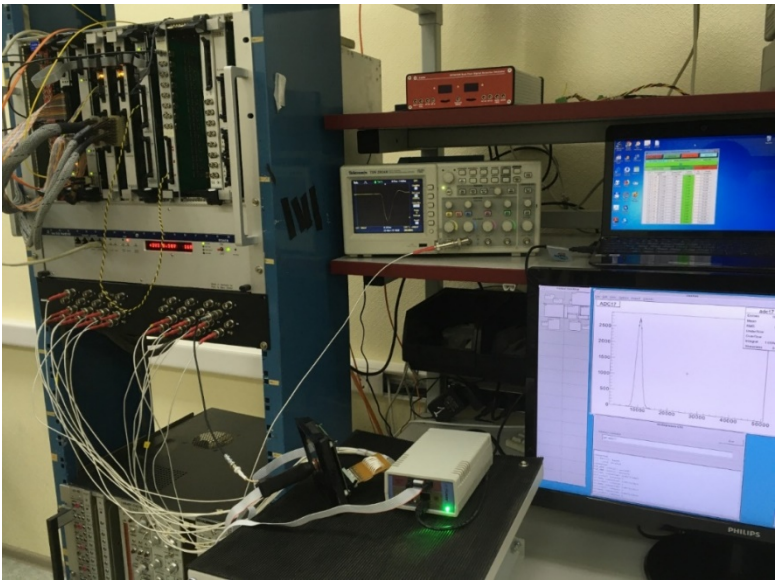
Schematic view of the LED



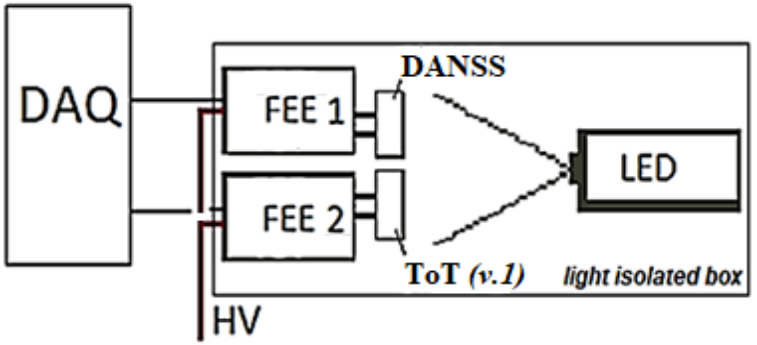
The data were accumulated with a VME based data-acquisition system (DAQ)

Isupov A.Yu. // EPJ Web Conf. 2019. V.10003. P.204





Schematic view of the test

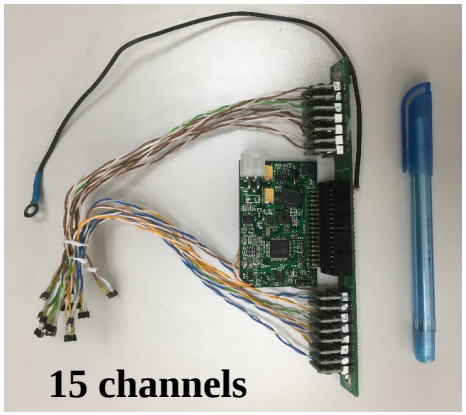


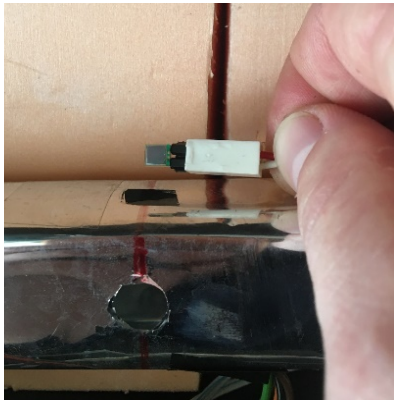
26.2 ± 0.3 °C

A.Isupov,Yu.Gurchin, S.Reznikov, A.Terekhin, A.Tishevsky, I.Volkov, V.L.

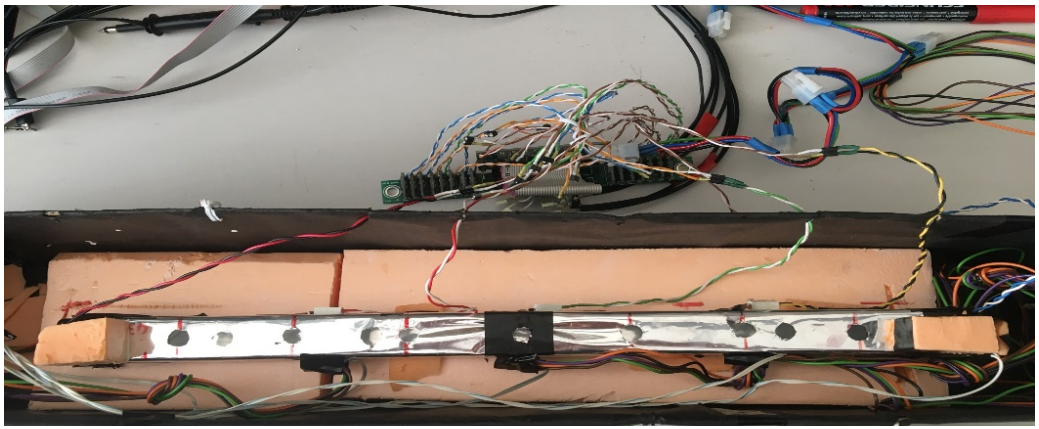
FEE studies results

Tests with scintillator



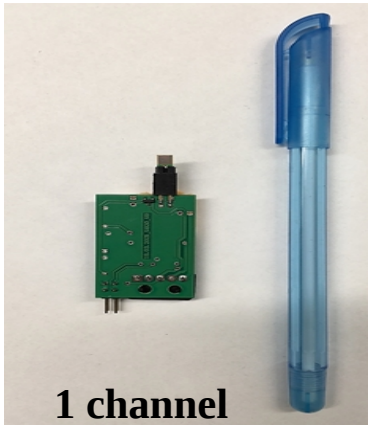


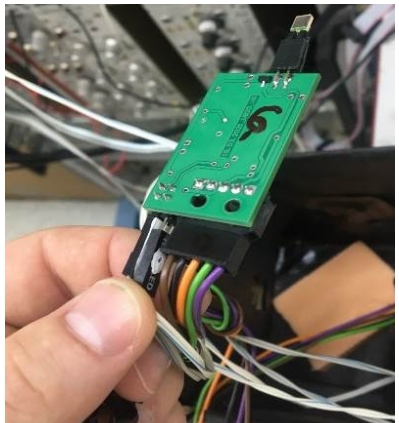
5 channels FEE of DANSS experiment (main option for ZDCs).
Together with
I.Alexeev, D.Svirida (KRI ITEP)



Plastic Scintillator
40 x 2 x 2 (cm³)

10 pcs HAMAMATSU
(S12572-010P)

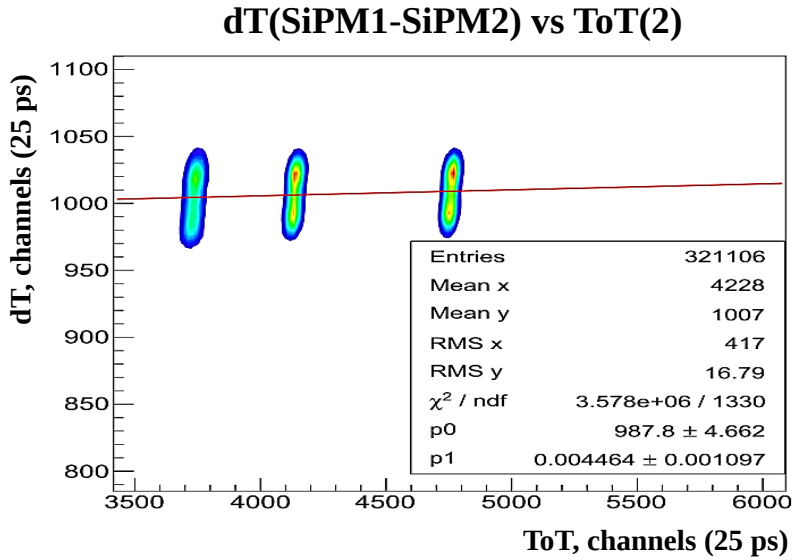


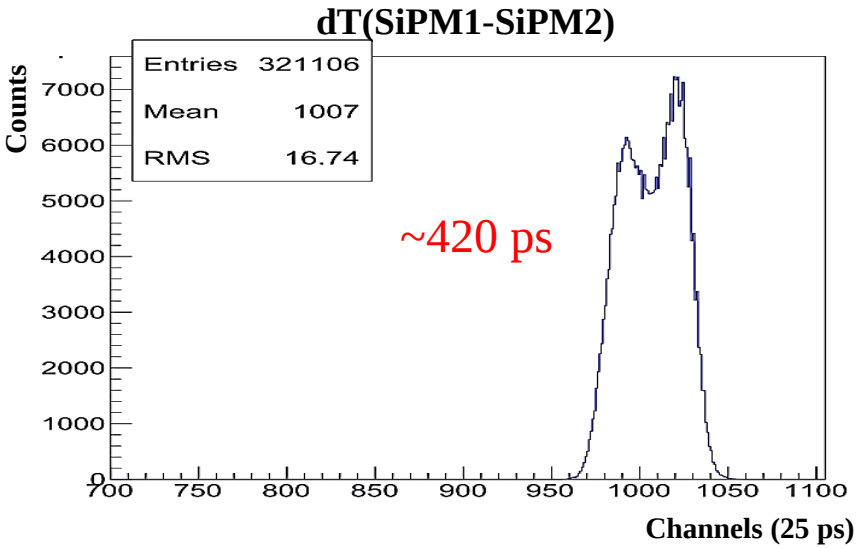


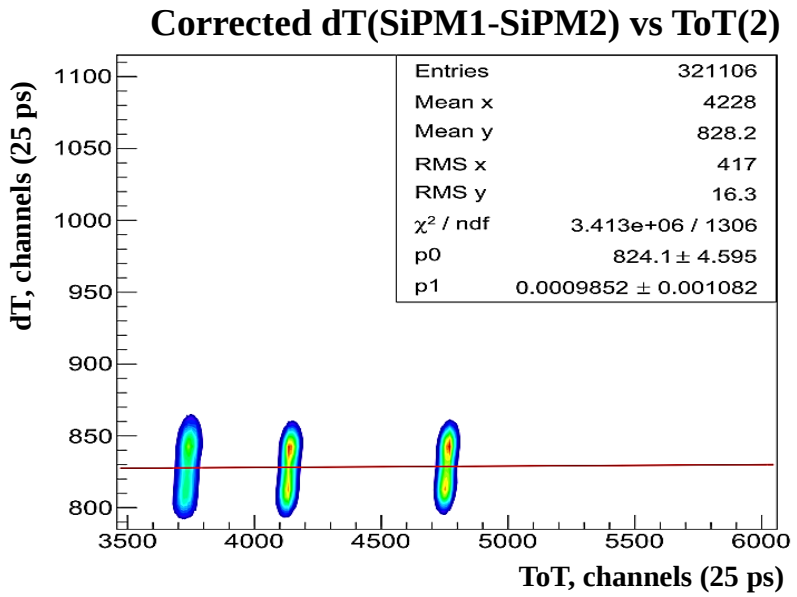
5 channels FEE ToT (v02 and v03)
Together with
P.Polozov, T.Kulevoy (KRI ITEP)

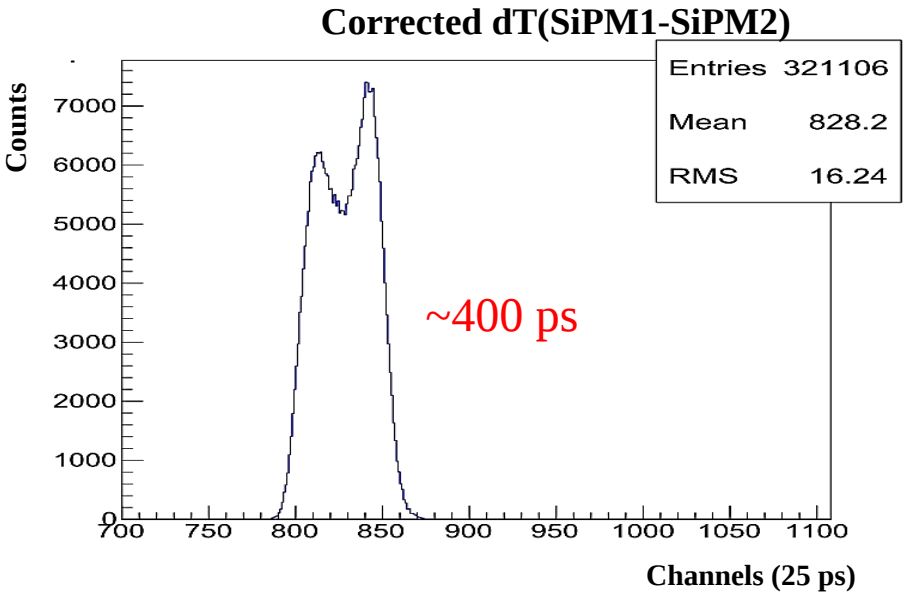
FEE studies results

The time difference histogram FEE ToT (version 02)



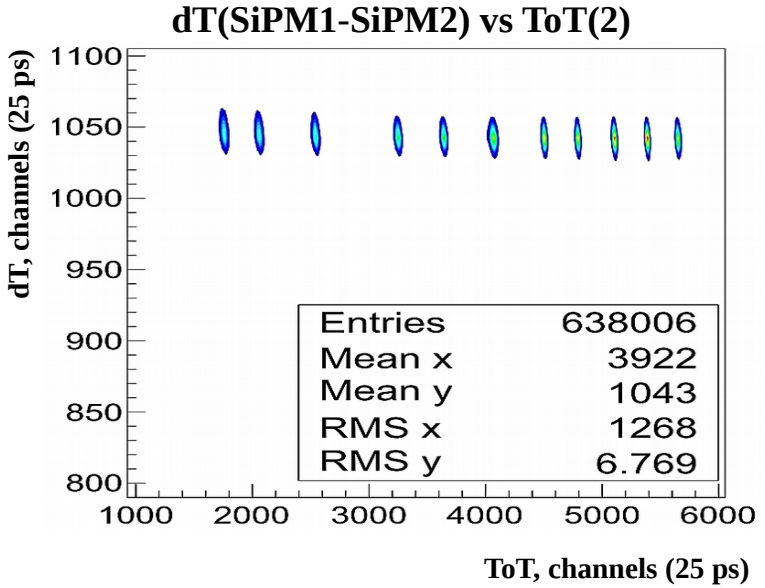


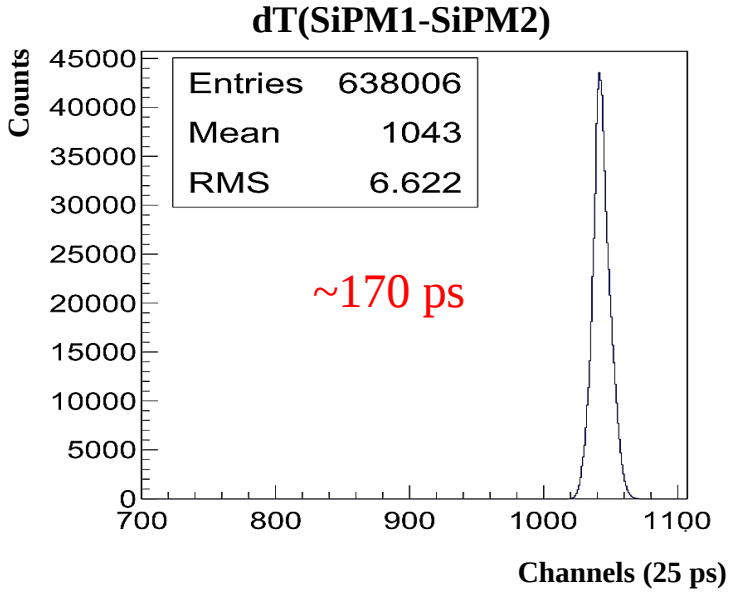


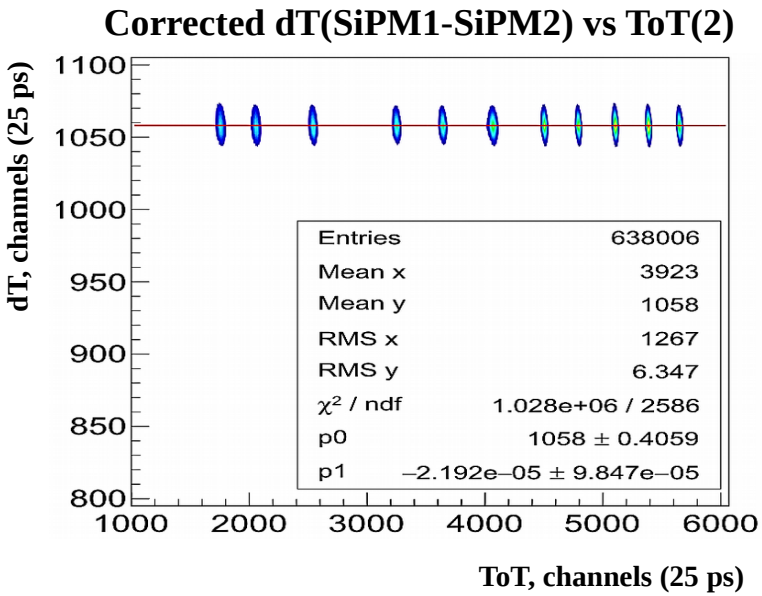


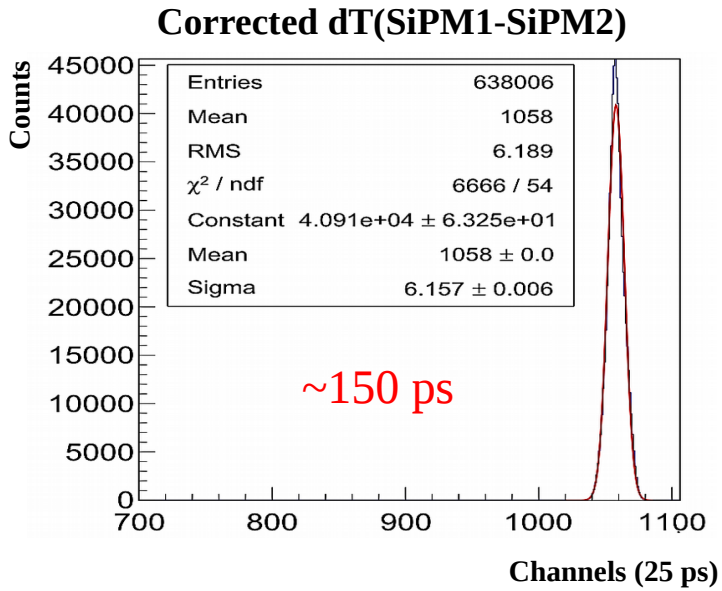
FEE studies results

The time difference histogram FEE ToT (version 03)



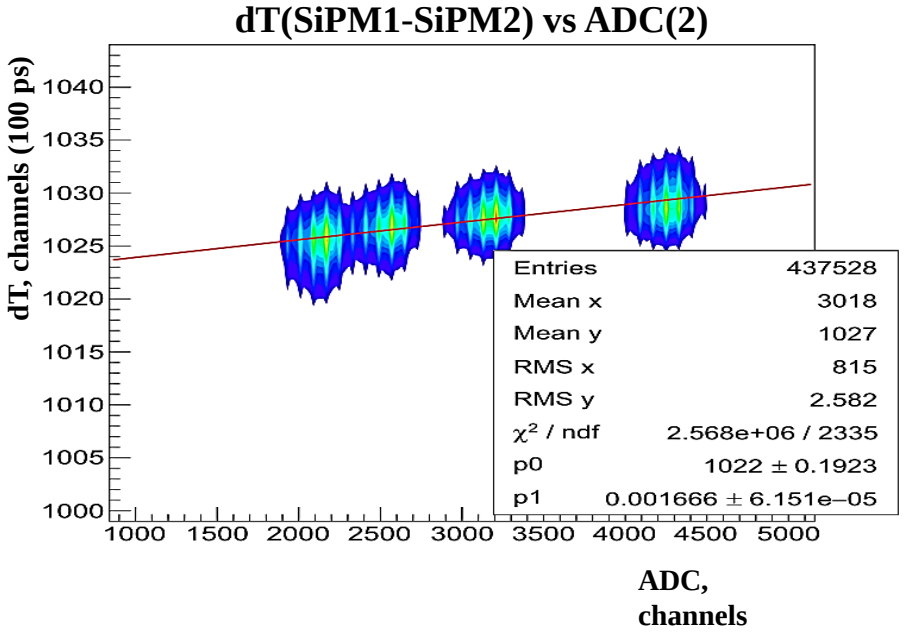


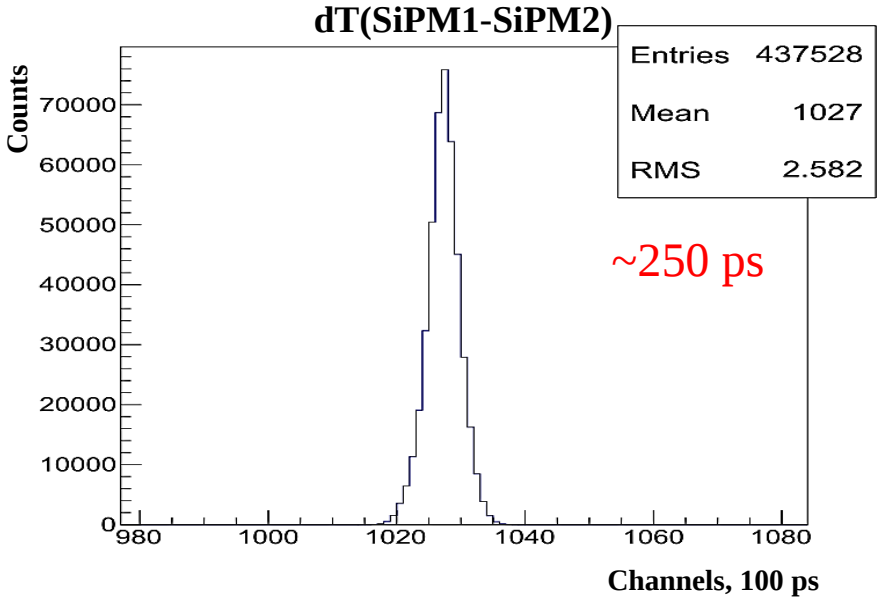


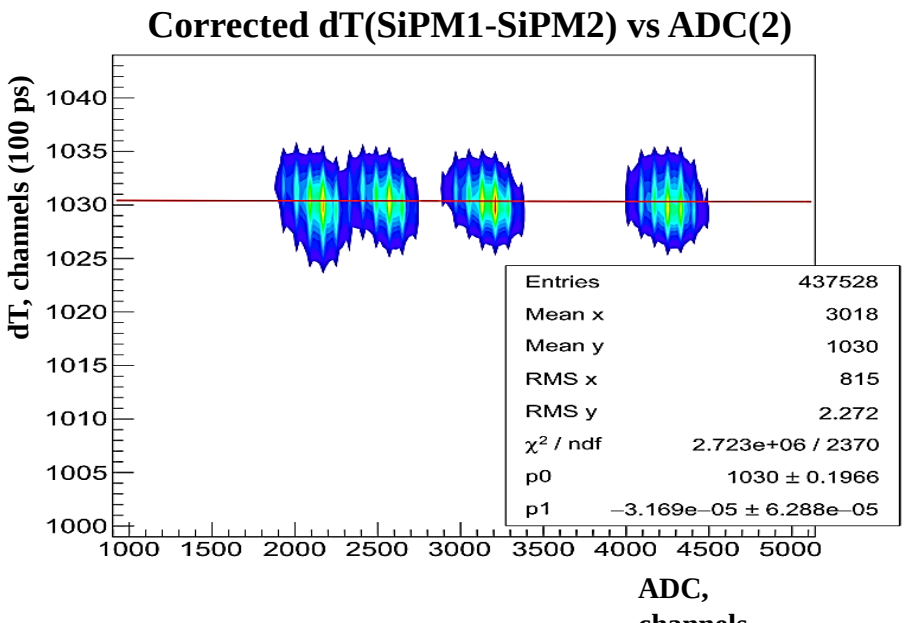


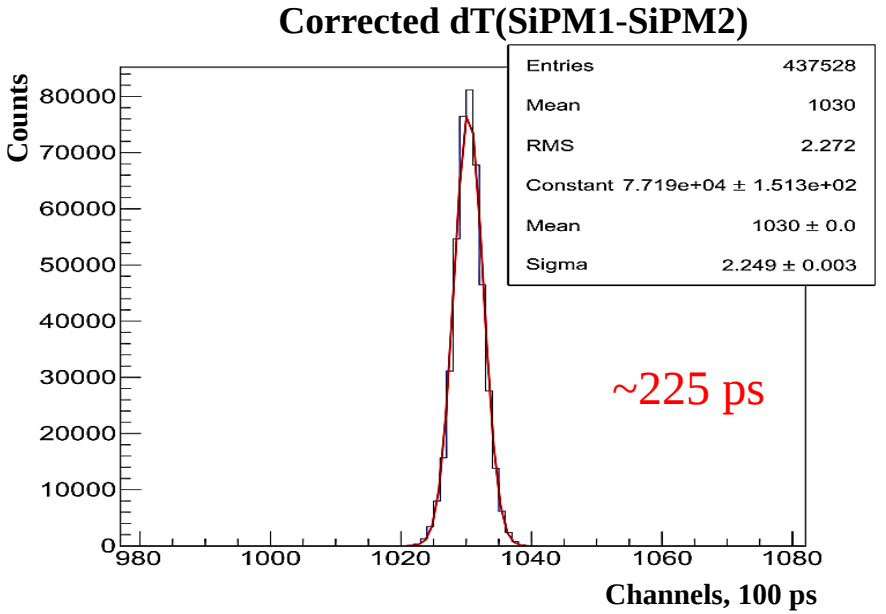
FEE studies results

The time difference histogram for FEE DANSS





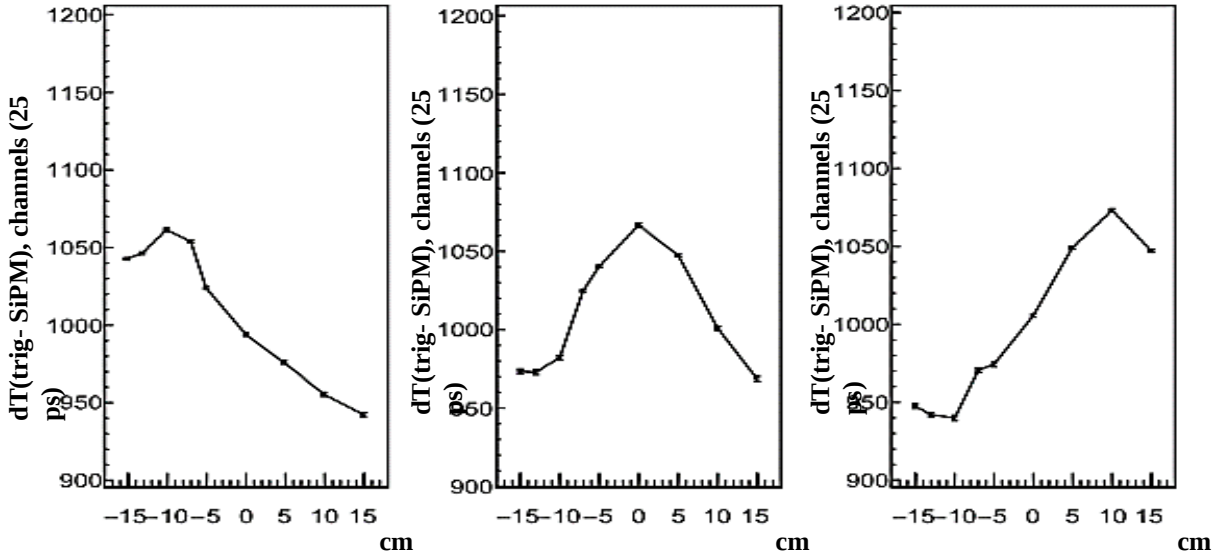




FEE studies results

Comparison of electronics Scanning by source position (Amplitude 4000)

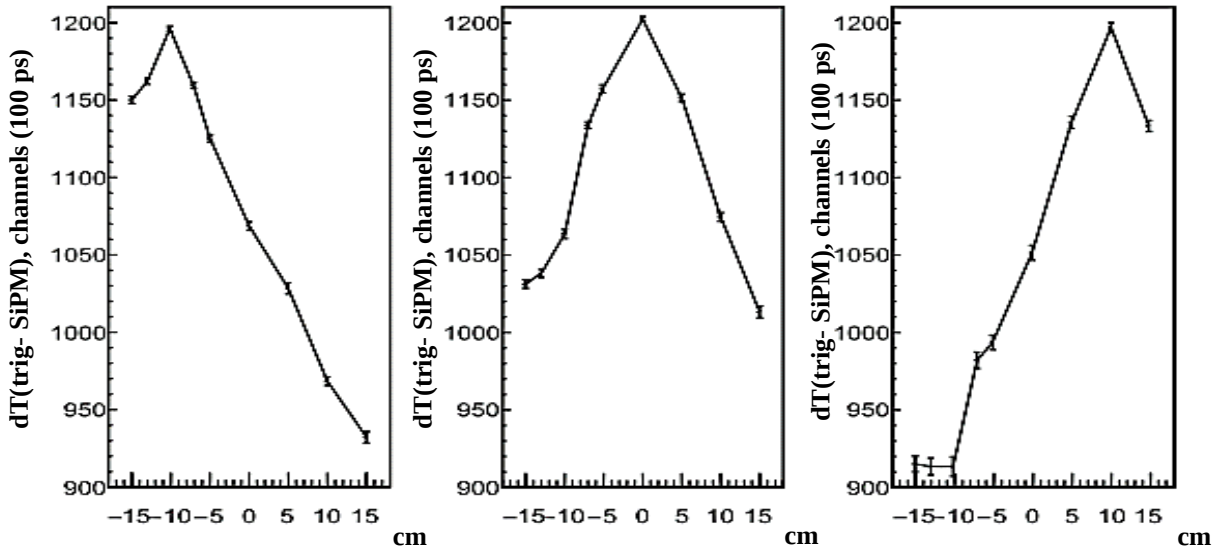
FEE ToT



SiPM2 **SiPM3** **SiPM4**

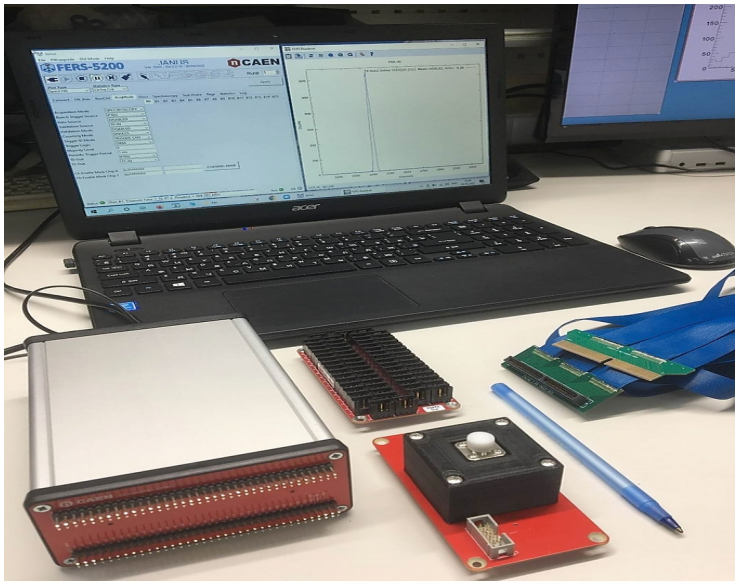
(plastic center)

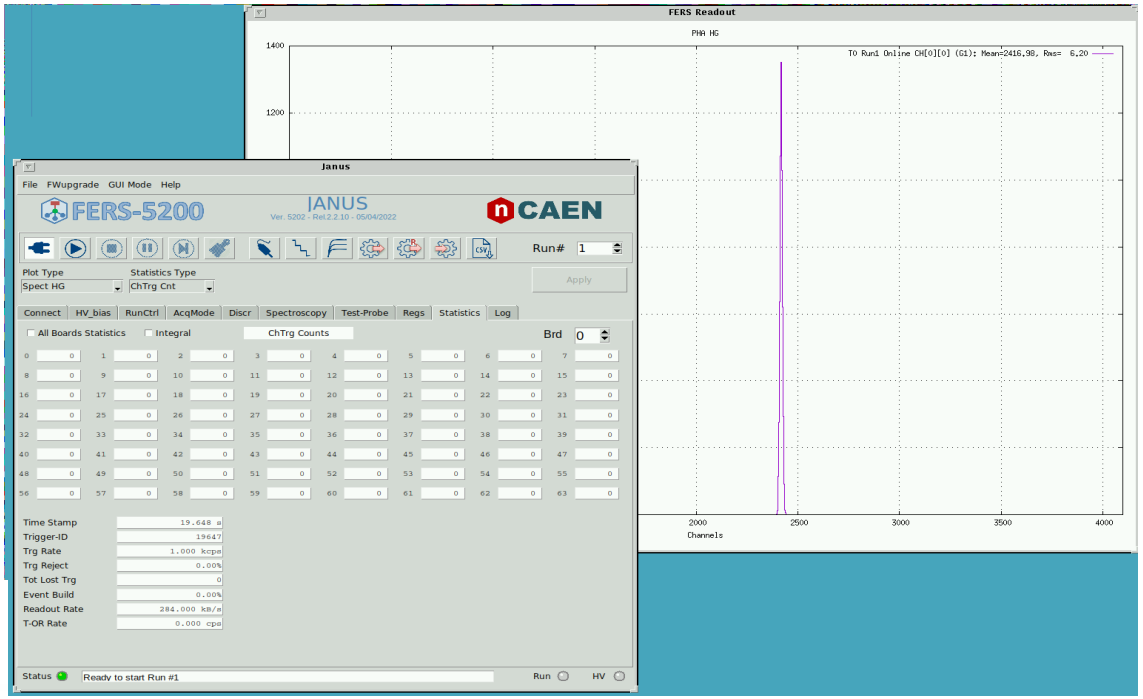
FEE DANSS

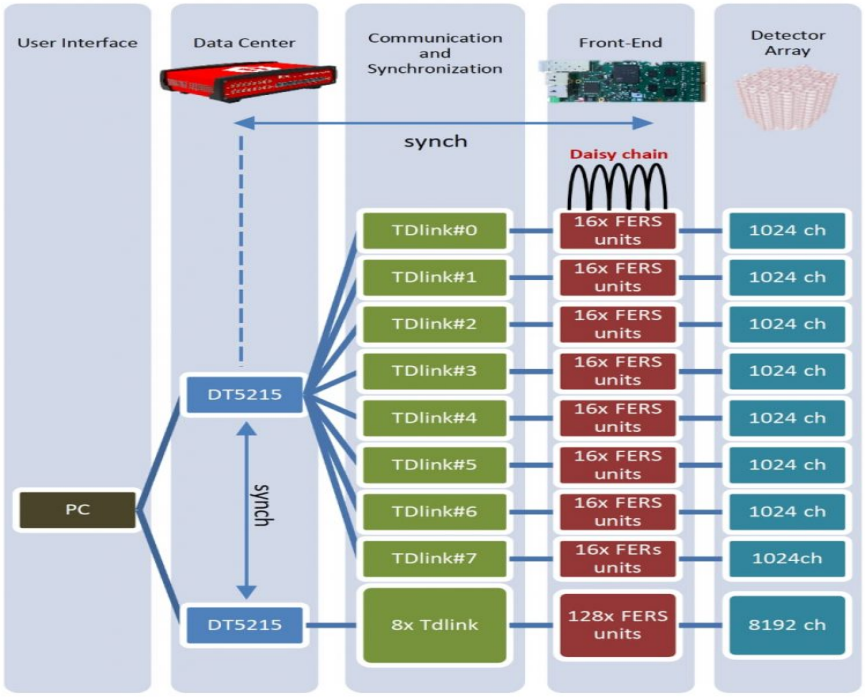


FEE studies results

FERS5200 application





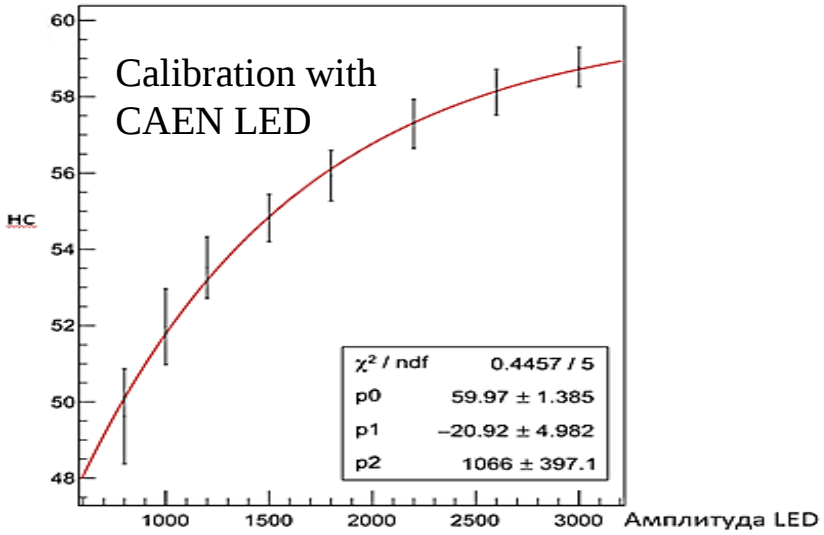


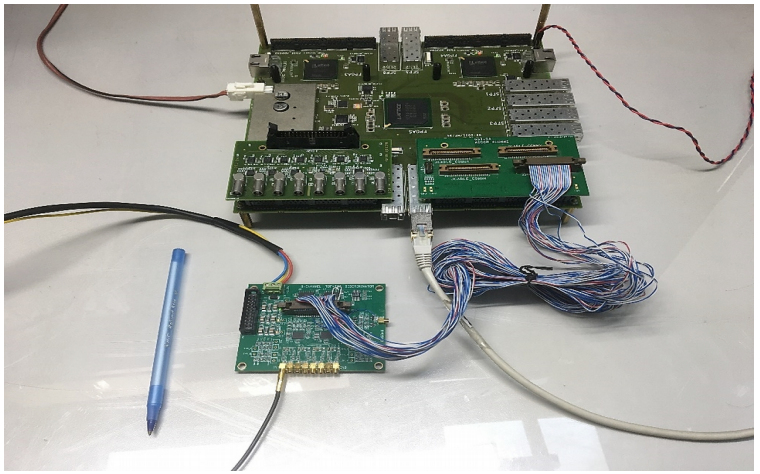
FERS5200 is an extendable high speed system based on the DT5202 64-channel module for SiPM.
The system can be extended up to 8192 channels using data concentrator DT5215.
Fine for testbeam and Phase0 experiments.

First tests with one DT5202 module are started.
We expect the delivery of the DT5202 and DT5215.

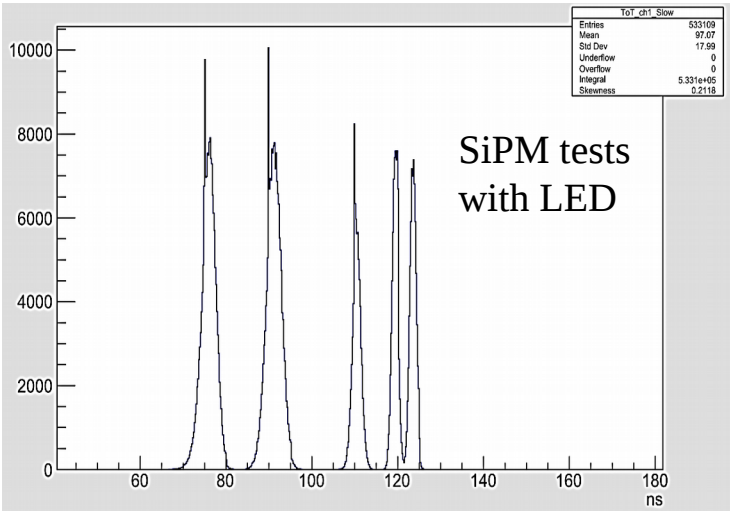
FEE studies results

TRB3 application





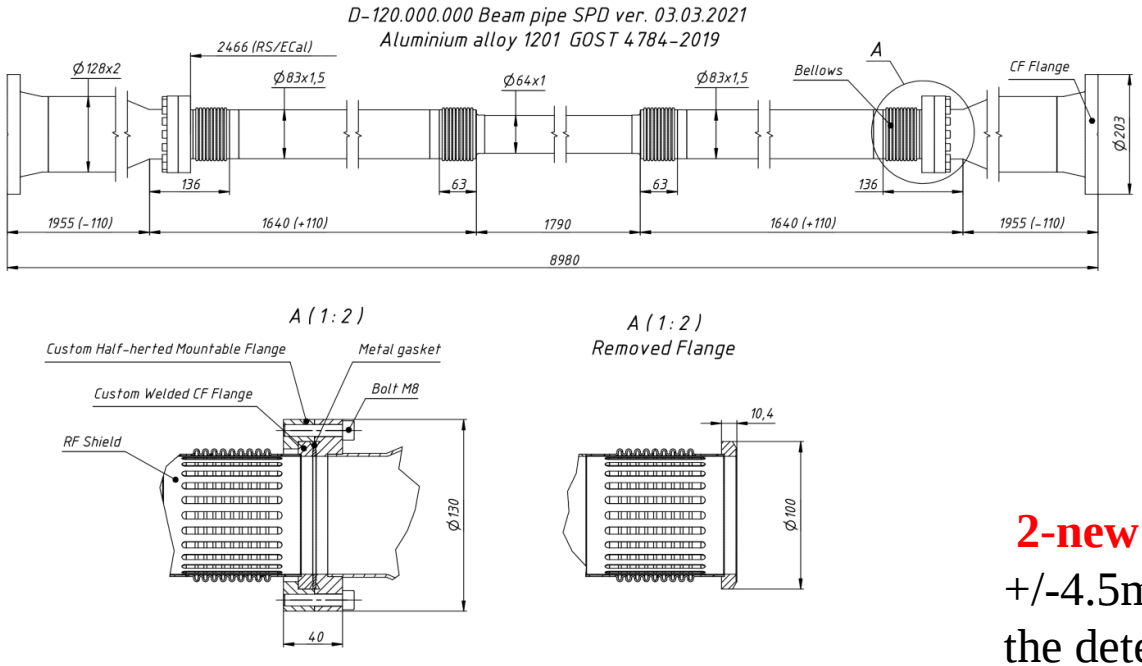
FPGA TDC time resolution is better than 10ps

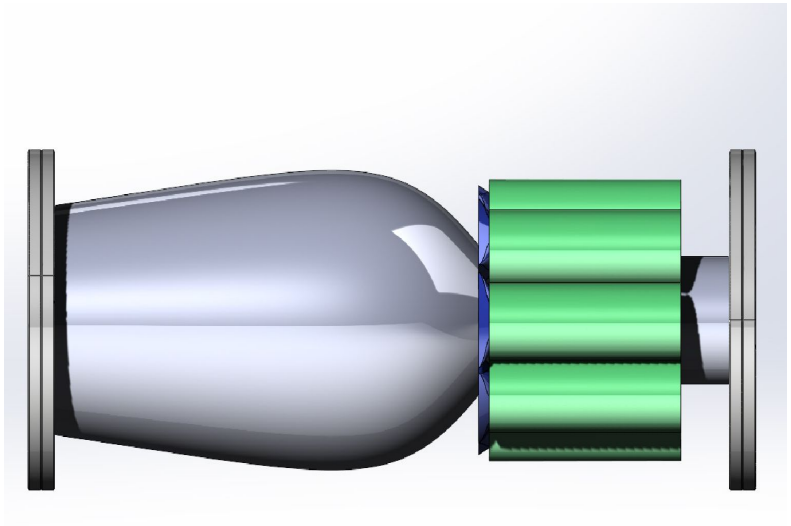


Together with **V.Chmil (JINR)**
S.Morozov, E.Usenko (INR)

New BBC stations

MCP part





2-new high granularity detectors placed at about +/-4.5m from IP outside the beampipe. Option with the detector inside the beampipe is cancelled.

-MCP based TOPAZ PMTs
-Good time resolution 50ps
-Tests with laser and with 200 MeV electrons (LINAC-200) has been performed.
-Tests in SPD testzone and at ITS at Nuclotron are under preparation
-Combined detector (MCP+ Scintillators) for small angle scattering monitoring and physics

Team **A.Baldin et al.(JINR)**
G.Feofilov et al. (StPSU)
A.Kubankin et al. (BNRU)
…..

S- well adopted technology, can be used both for the polarized and HI collisions for local polarimetry and event plane determination, respectively.

W- dependence on the foreign technologies, sanctions influence

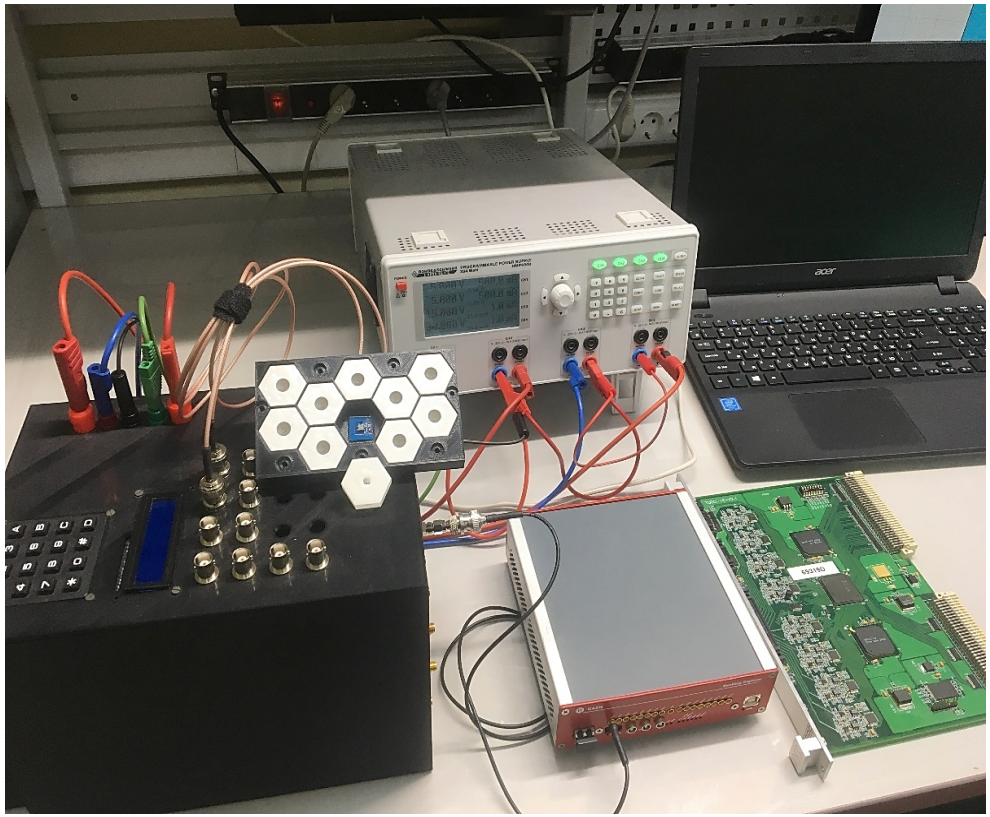
1. Fast scintillator for BBC prototype:
 Conract on delivery of BC408 redoned for EJ-204: tiles for prototype are obtained!
 We also consider the possibility to use the scintillator produced at Dubna.
2. SiPMs for BBC prototype:
We have to replace the HAMAMATSU on the SENSL SiPMs.
The contract is signed. We obtained MicroFC-x0035-SMT last week.
3. Part of the equipment is not accessible. Delivery time for available equipment (CAEN) increased significantly, paper procedure (EUS) is more complicated.

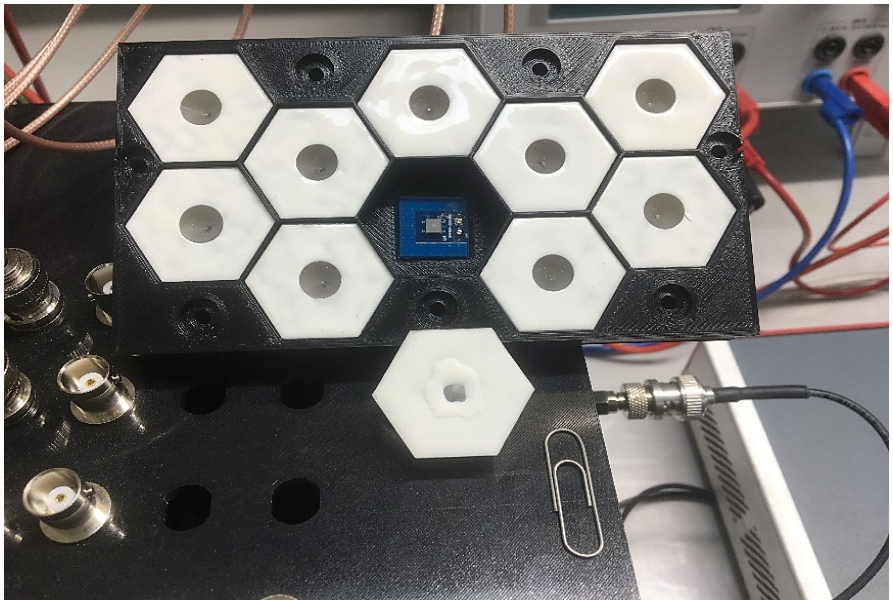
O- included in the SPD 1-st stage, good opportunity for young researchers from different countries.

T- …

New collaborators

CTEPP Un.AB, Santiago, Chile





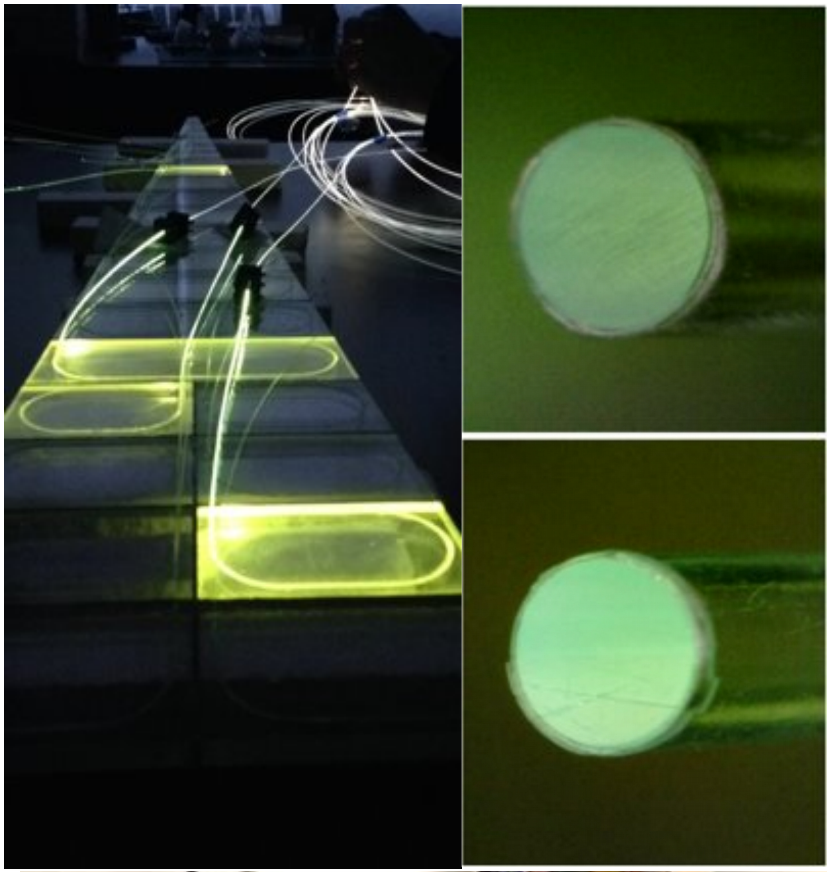
10 honey-comb scintillators,
FEE, micro PC control.

Tests at JINR are in preparation.

Together with **E.R.Calderon (CTEPP)**

New collaborators

MEPhI, Moscow

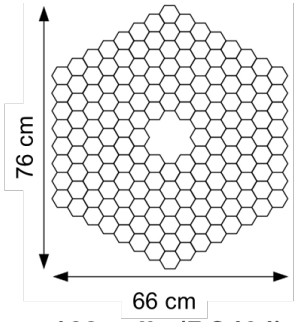


MEPhI group
(**G.Nigmatkulov et al.**)
has an experience:
1. in the development of the STAR event plane detector (EPD) based on the scintillator+SiPM technology (WLS gluing, optocables etc.),

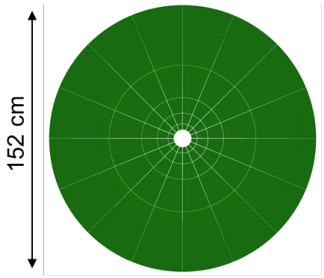
2. in HI physics at STAR.

New collaborators

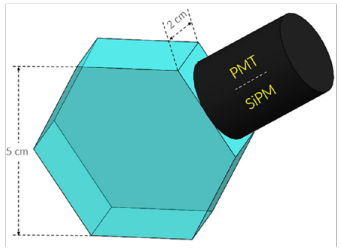
CINVESTAV, Mexico

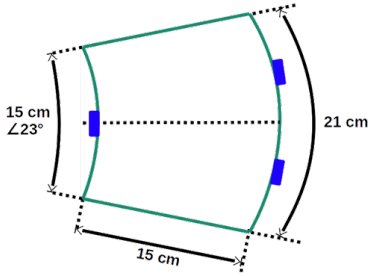


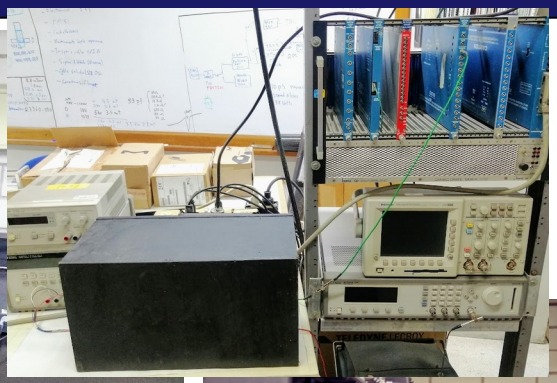
162 cells (BC404)
distributed in 6 rings



80 cells (BC404, 22.5°)
distributed in 5 rings







CINVESTAV group
(**Luis Manuel Montano-Zetino et al.**)

Experience with Be-Be and miniBe-Be detectors at MPD.

HIC at ALICE, MPD.

Scintillator (BC400 series) prototype test
Electronics involve
SiPM (Hamamatsu&SENSL) characterization
Data analysis
Time resolution measurements
Acquisition of materials

Conclusions

Obtained results

I. The scintillation detector prototype with SiPM readout has been studied using 2 types of FEE developed at KRI ITEP. The results on the time resolution are promising.
II. First tests with CAEN FERS5200 system has been started. Other options of FEE are under consideration.
III. The first turn of the simulation for TDR version of the BBC has been performed both for pp- and dd- collisions.
IV. The MCP based TOPAZ PMT have been tested with laser and with 200 MeV electrons. Good time resolution of 50ps has been obtained.

Conclusions

To do list

- Further test of scintillator prototypes with different types of electronics (with new collaborators contributions).
- Preparation and tests of the scintillator prototypes for SPD testzone and ITS.
- Test of the MCP detectors at SPD testzone and LINAC-200.
- Optimization of the inner part of BBC via simulation for pp- and dd-scattering.
- Simulation of new BBC detectors placed at +/-4.5m from IP.

- BBC dedicated meeting in October-November 2022.

Thank you for the attention!

Backup

Current option for BBC

1. 2 BBCs: Left and Right

2. Inner part covers 30-60 mrad

– 4 layers *32 sectors = 96 channels MCP

3. Outer part covers 60-500 mrad

– 5-6 layers *16 sectors* 2 SiPM = up to 192 channels

Simulation for polar angle granularity is required!

4. FEE several options are considered

5. TDC 25ps/bin (HPTDC) or better

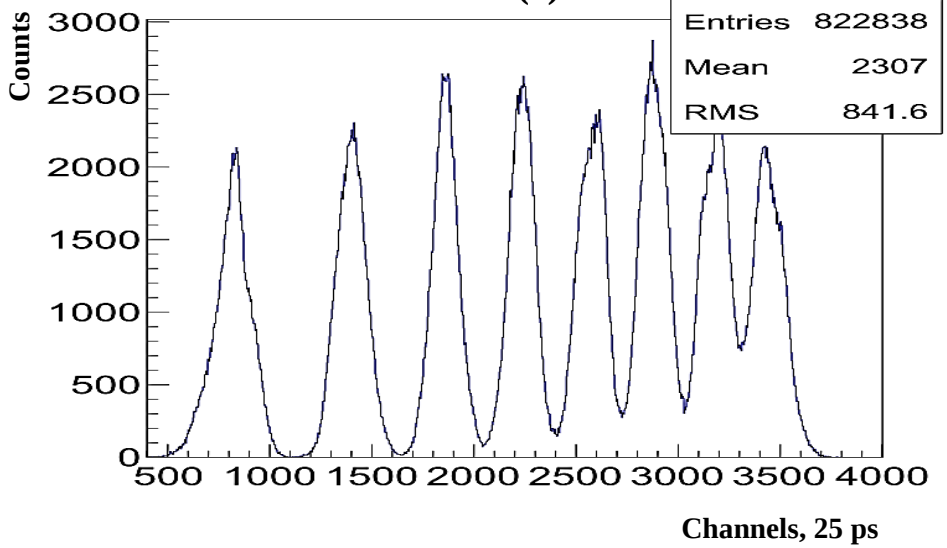
6. Holding carbon plastic

7. Needed place about 5 cm in front of PID (TOF)

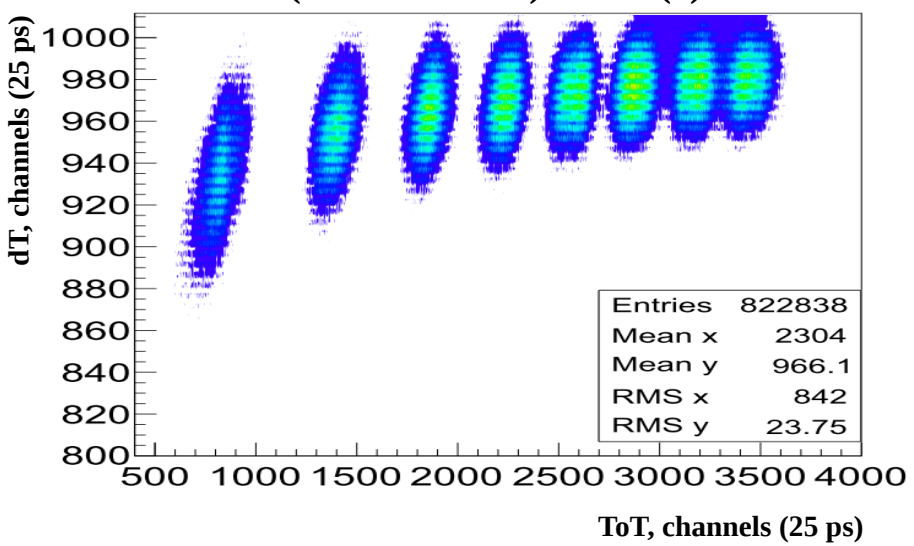
8. Weight 50-80 kg

Extracting correction parameters FEE ToT (version №1)

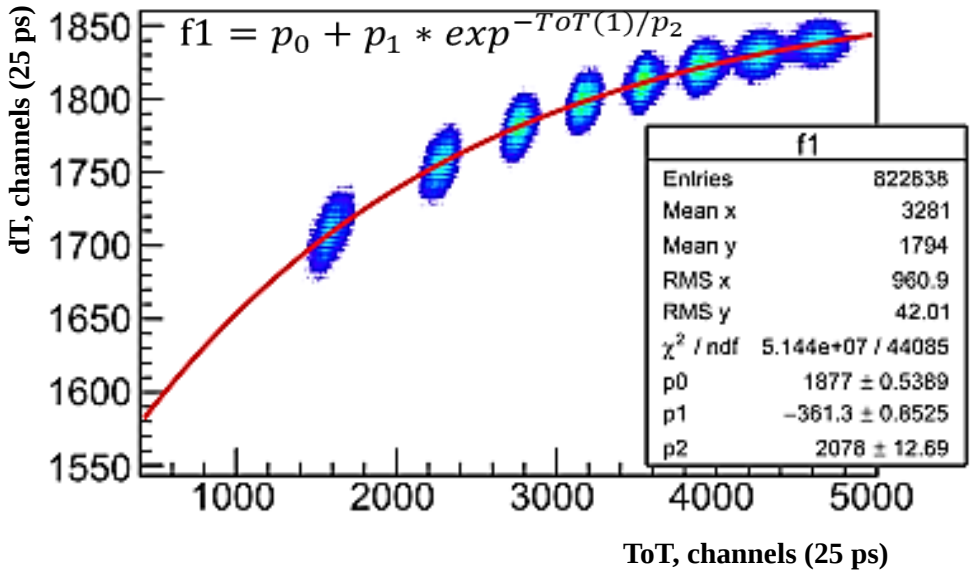
ToT(2)



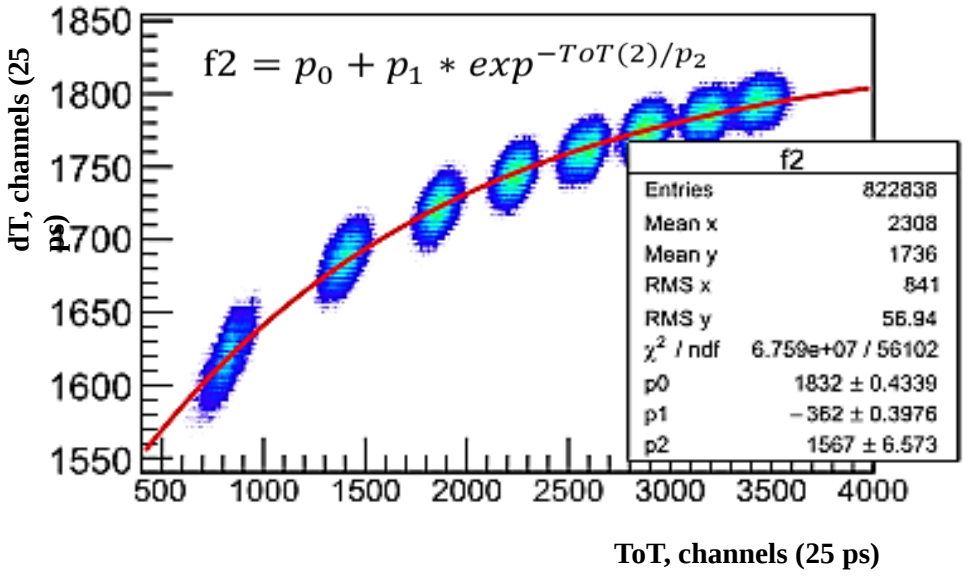
dT(SiPM1-SiPM2) vs ToT(2)



dT(trig-SiPM1) vs ToT(1)

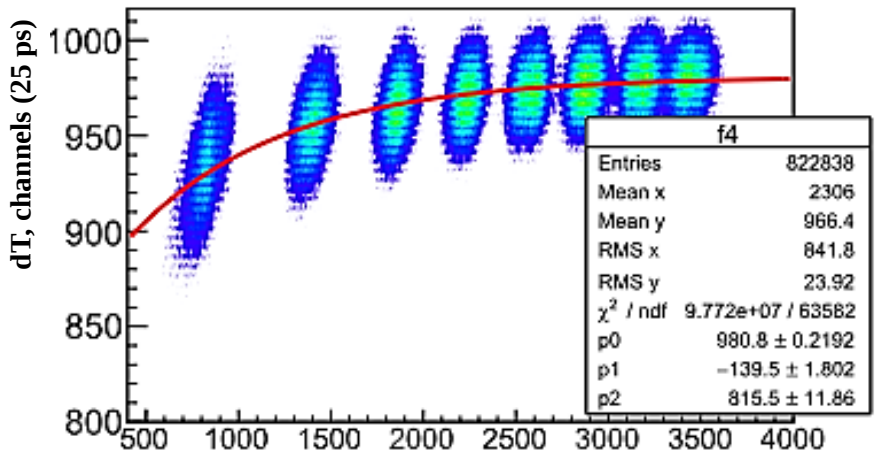


dT(trig-SiPM2) vs ToT(2)

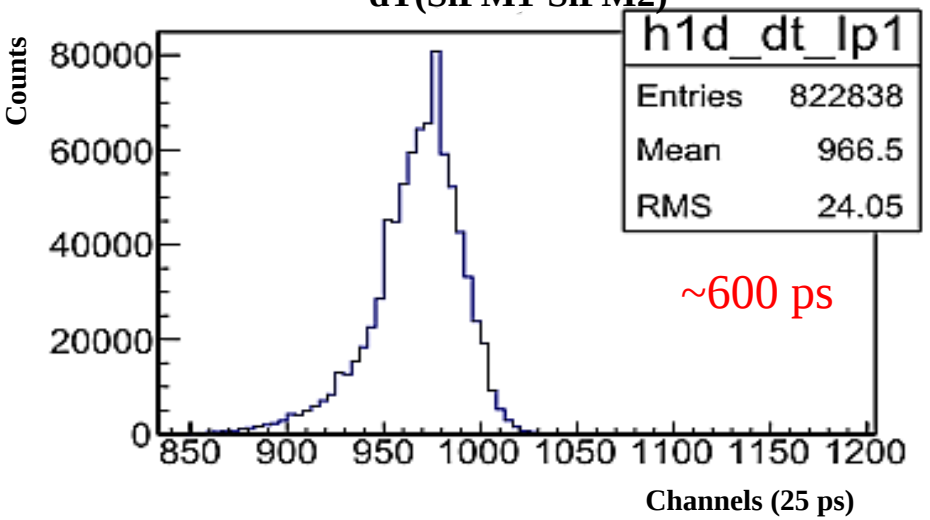


The time difference histogram FEE ToT (version №1)

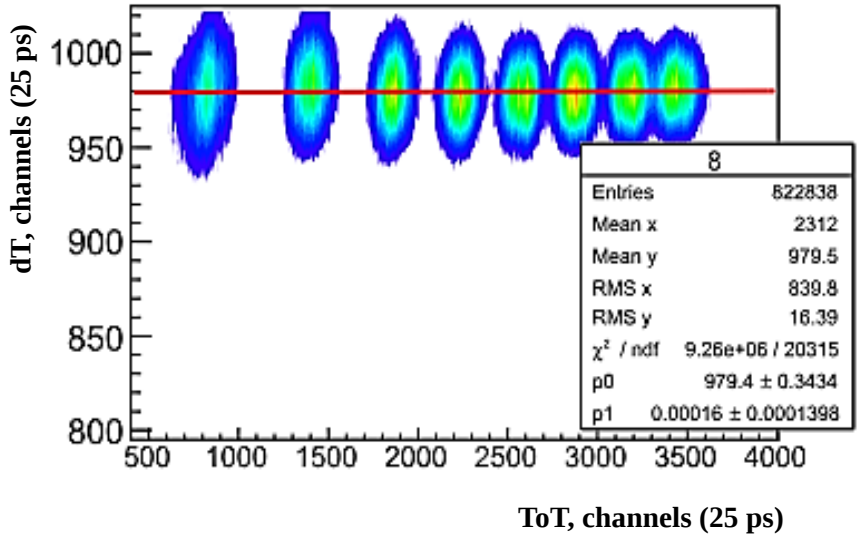
dT(SiPM1-SiPM2) vs ToT(2)



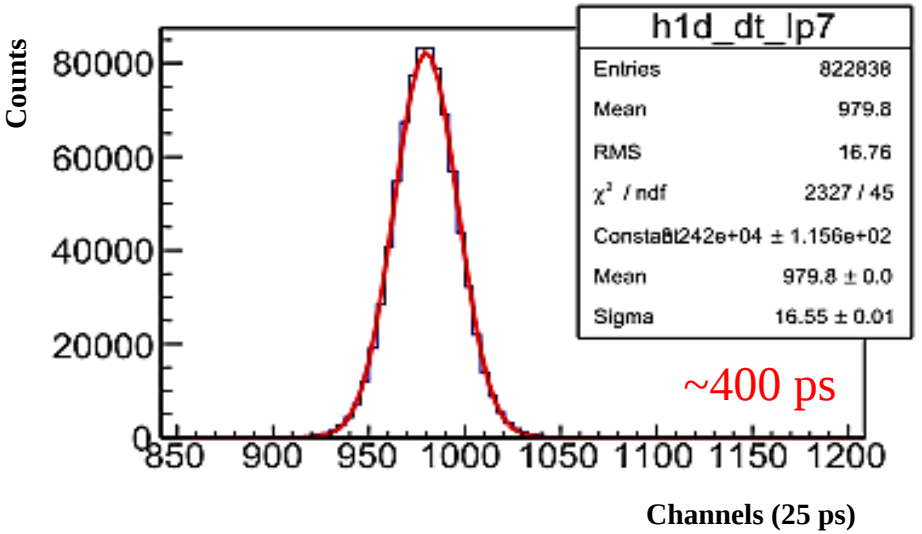
dT(SiPM1-SiPM2)



Corrected dT(SiPM1-SiPM2) vs ToT(2)

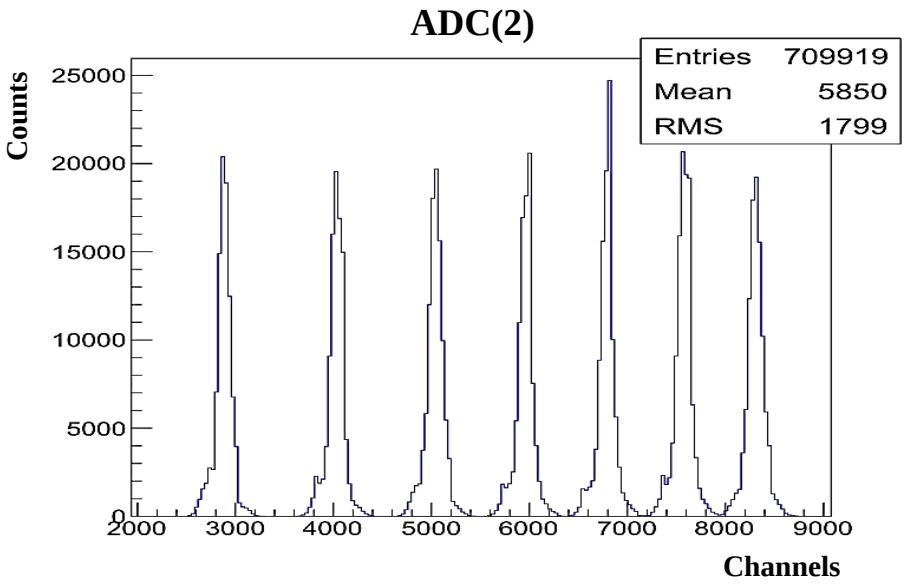


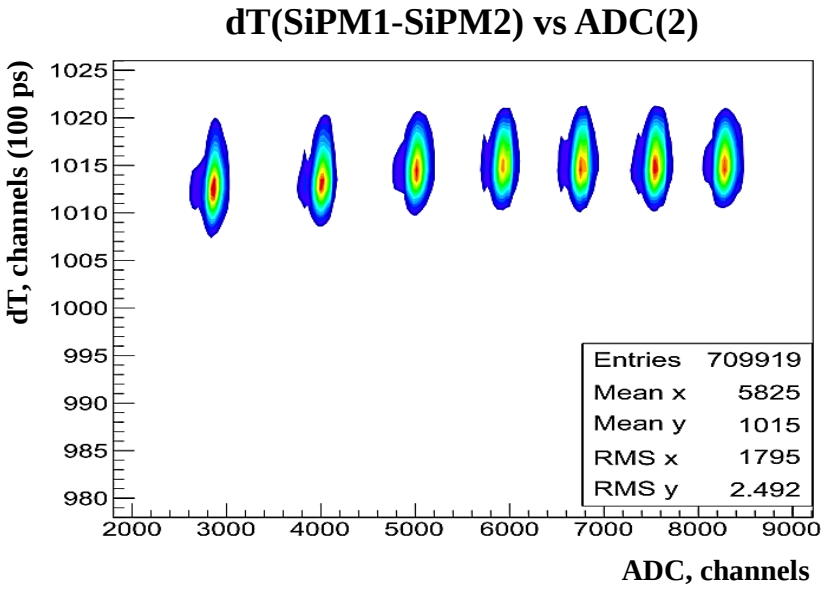
Corrected dT(SiPM1-SiPM2)

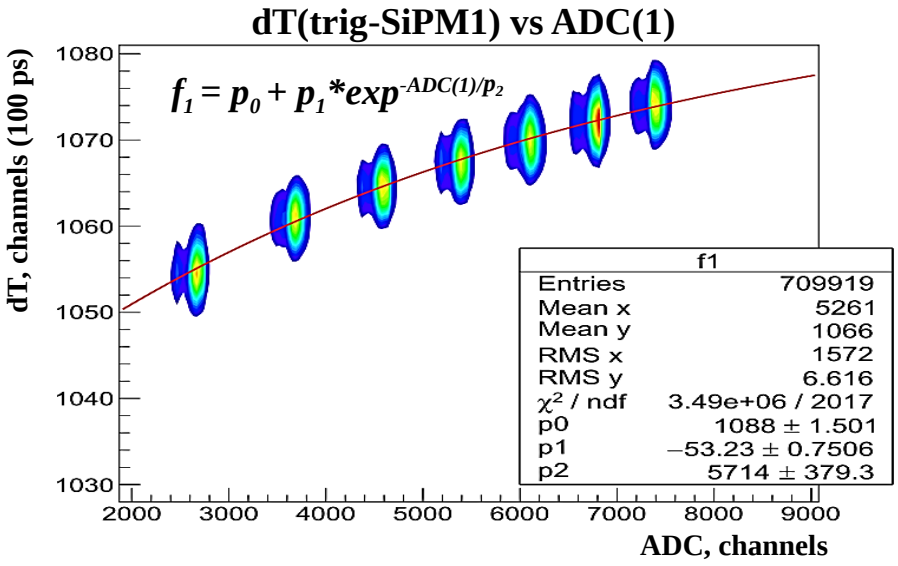


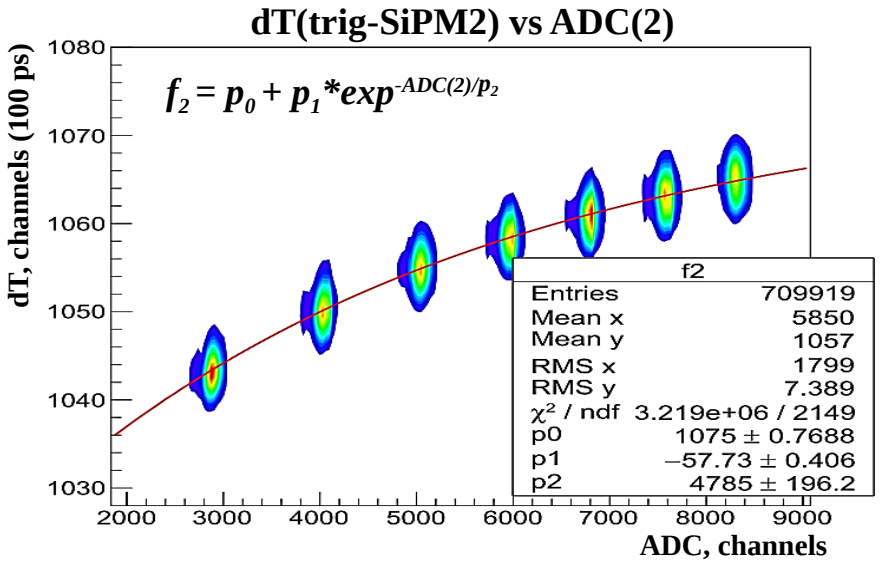
A.V. Tishevskiy et al., J.Phys.Conf.Ser, V.1690, 012051 (2020)

Extracting correction parameters FEE DANSS

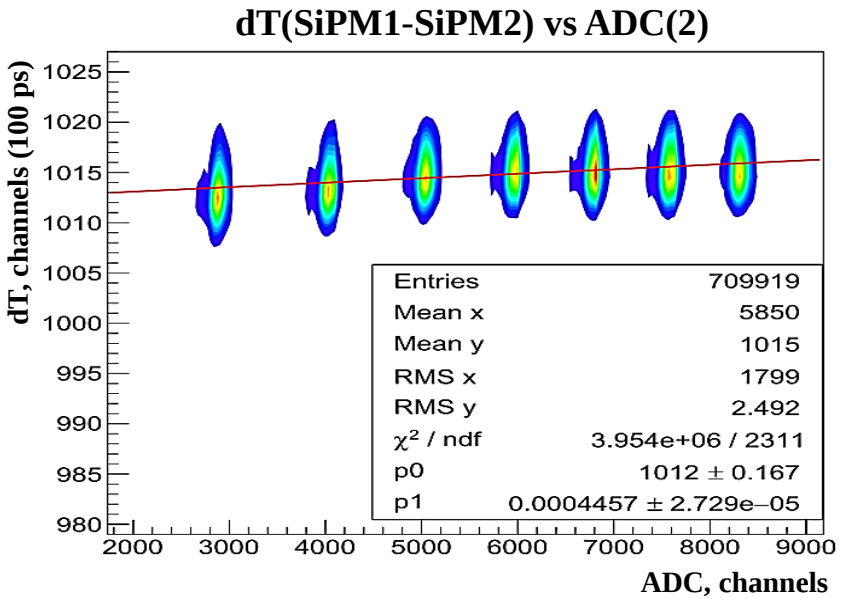


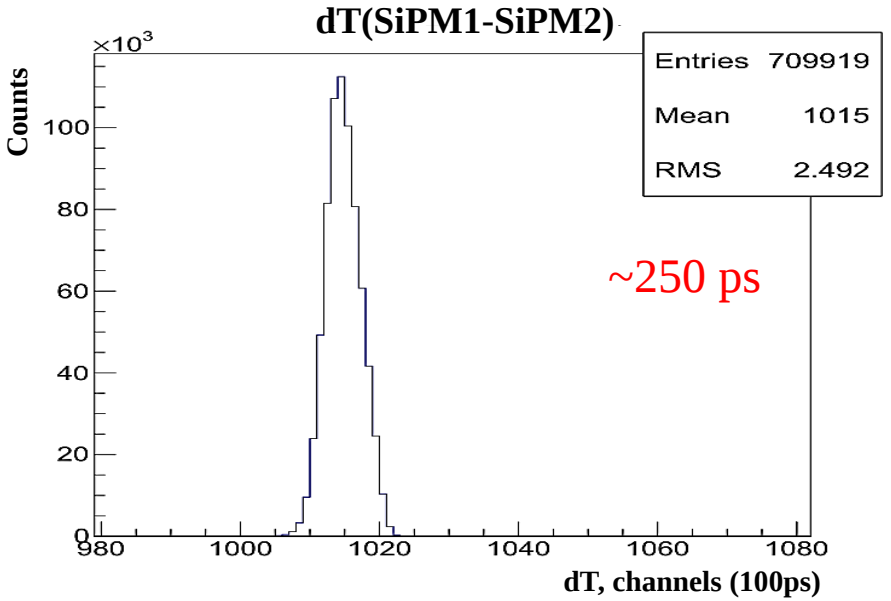


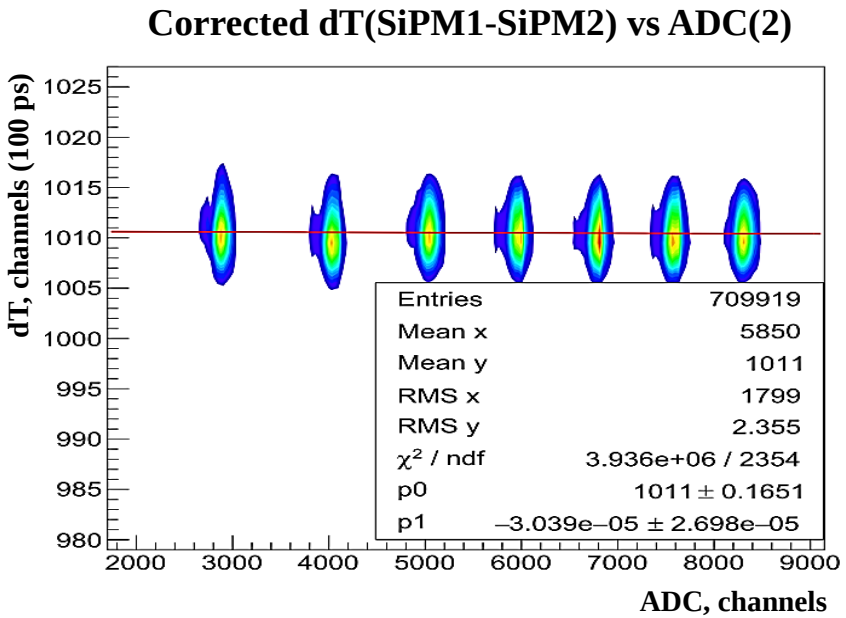


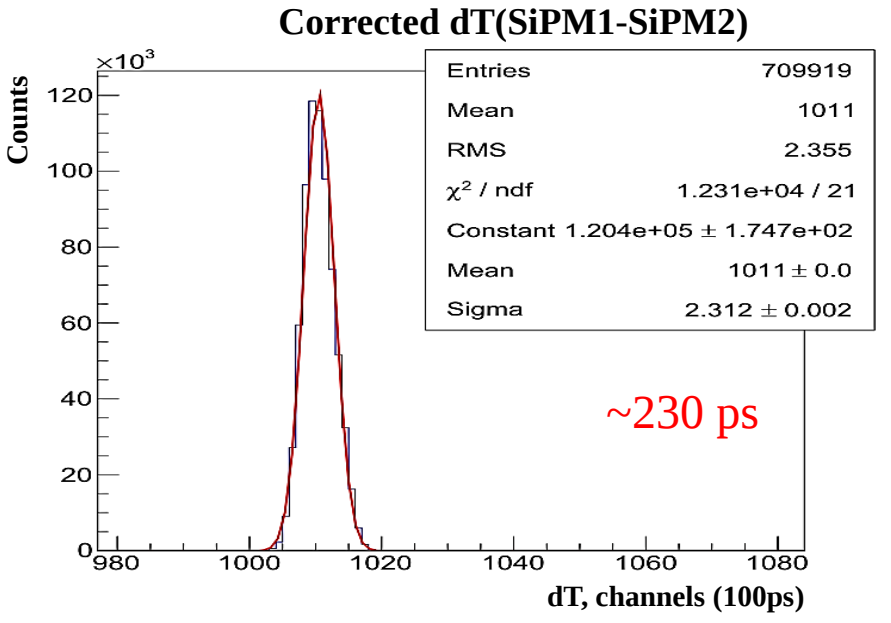


The time difference histogram FEE DANSS

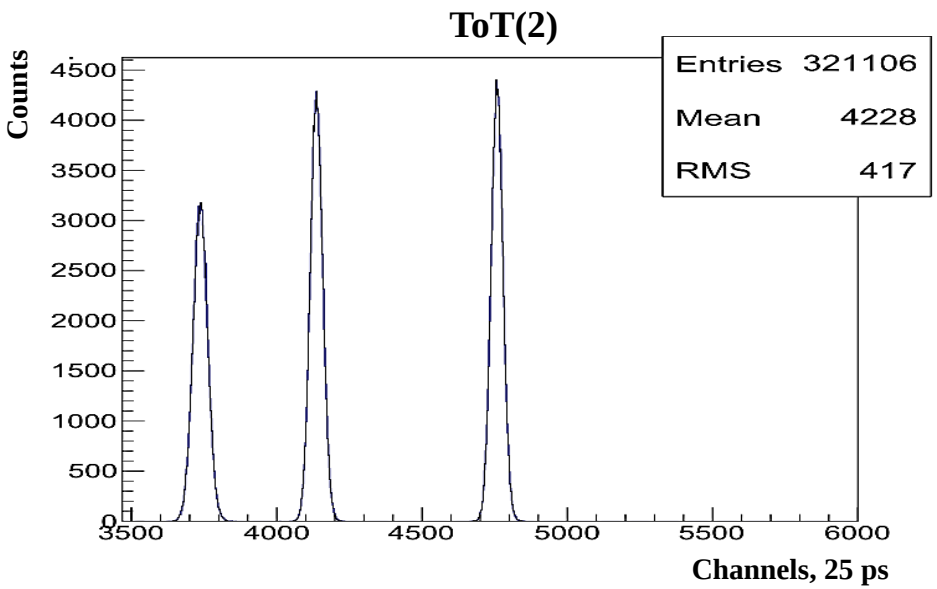


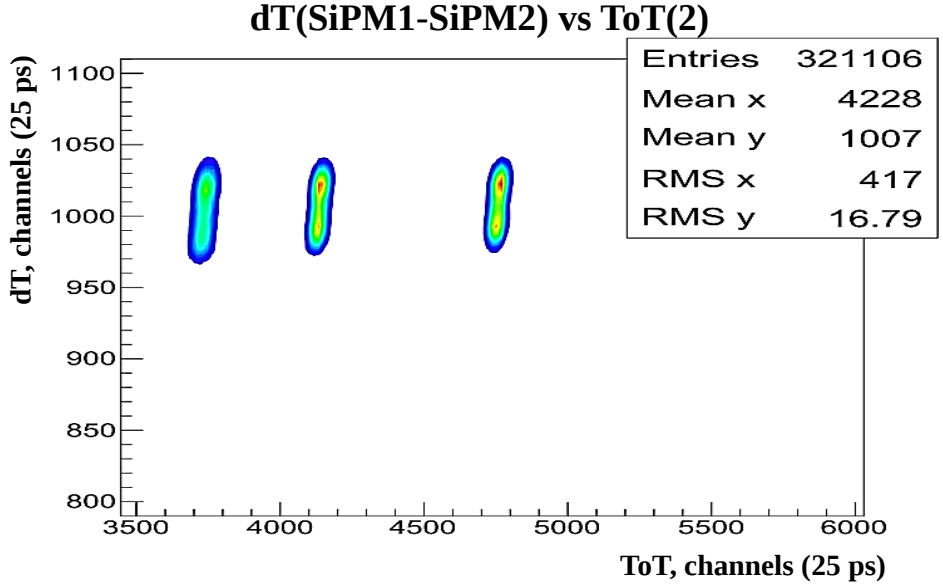


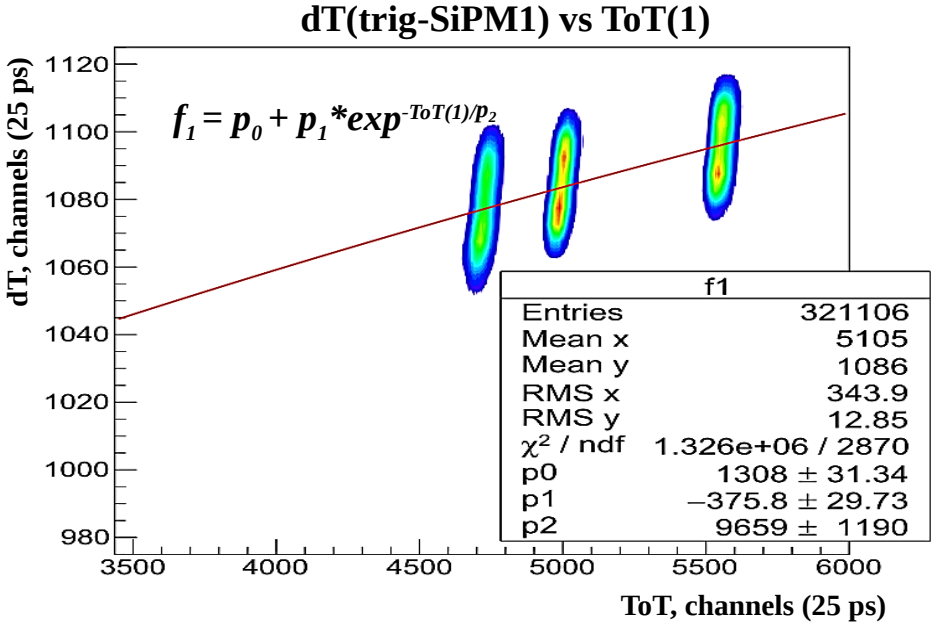


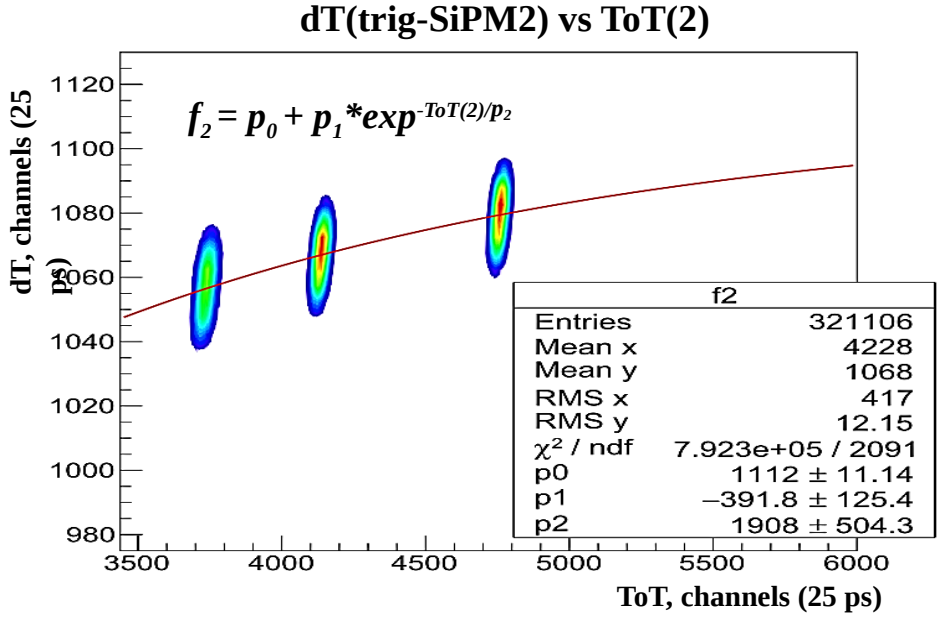


Extracting correction parameters FEE ToT (version №2)





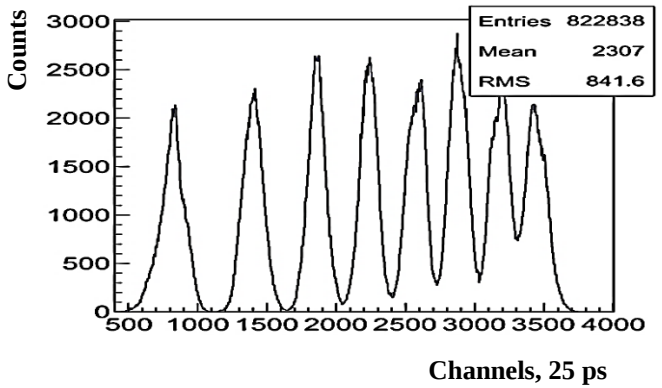


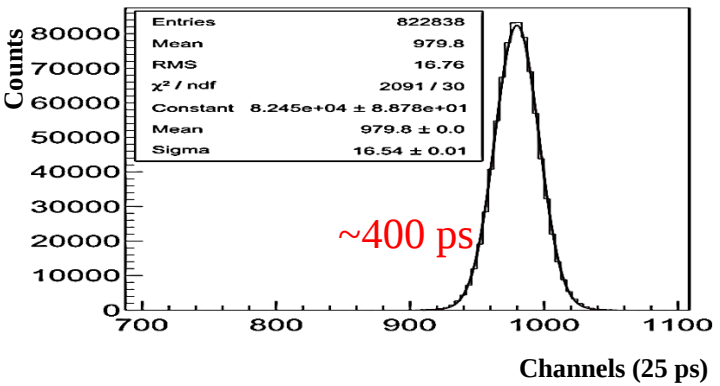


Comparison of FEE ToT versions

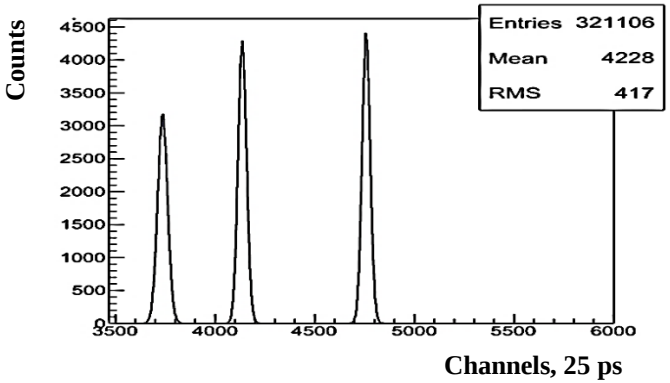
ToT | **Corrected dT(SiPM1-SiPM2)**

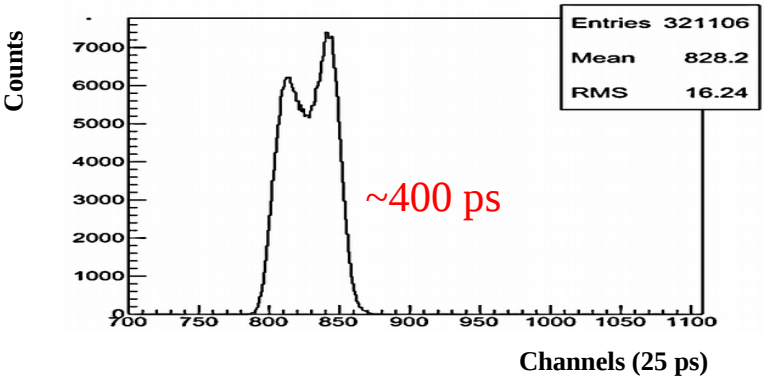
v.1



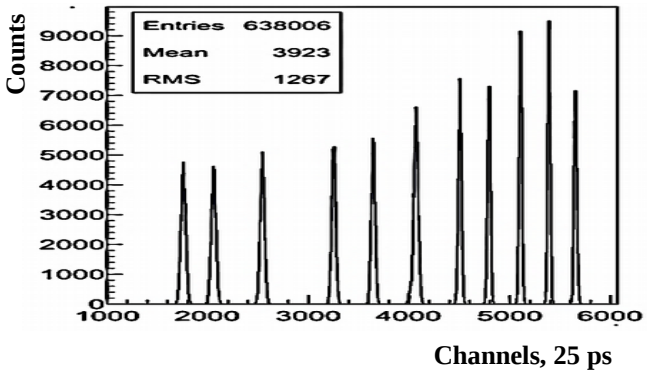


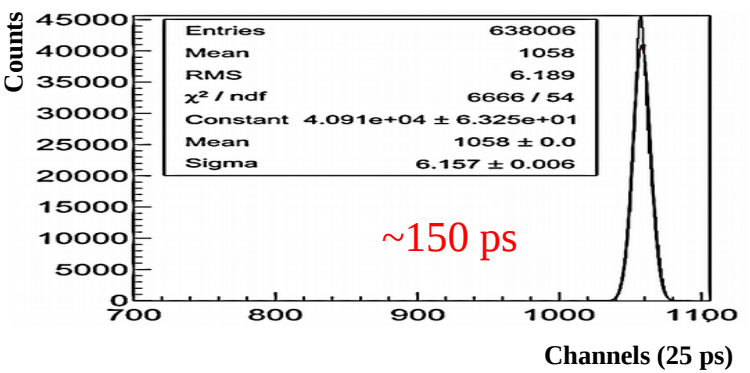
v.2



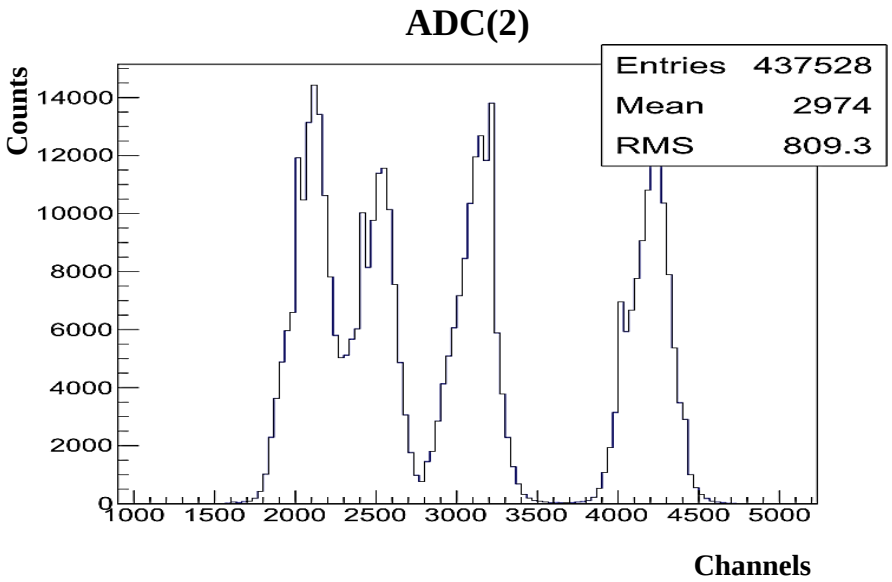


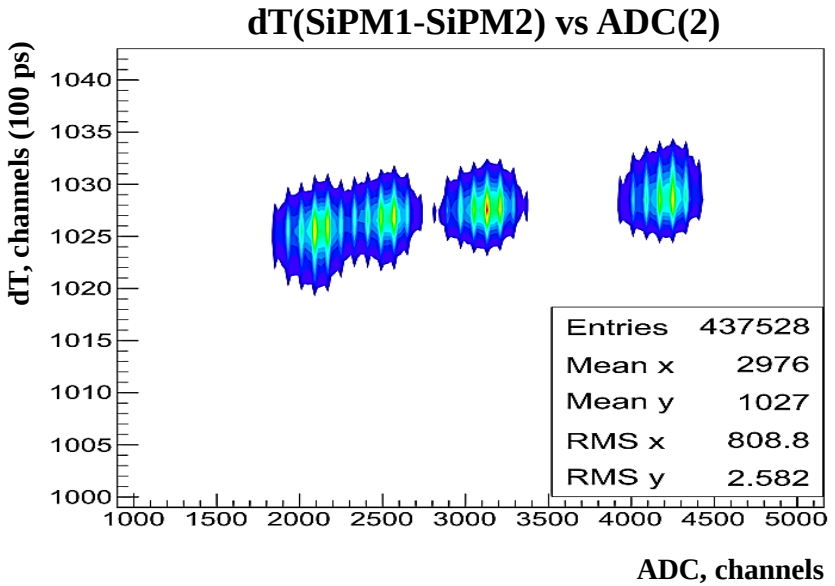
v.3

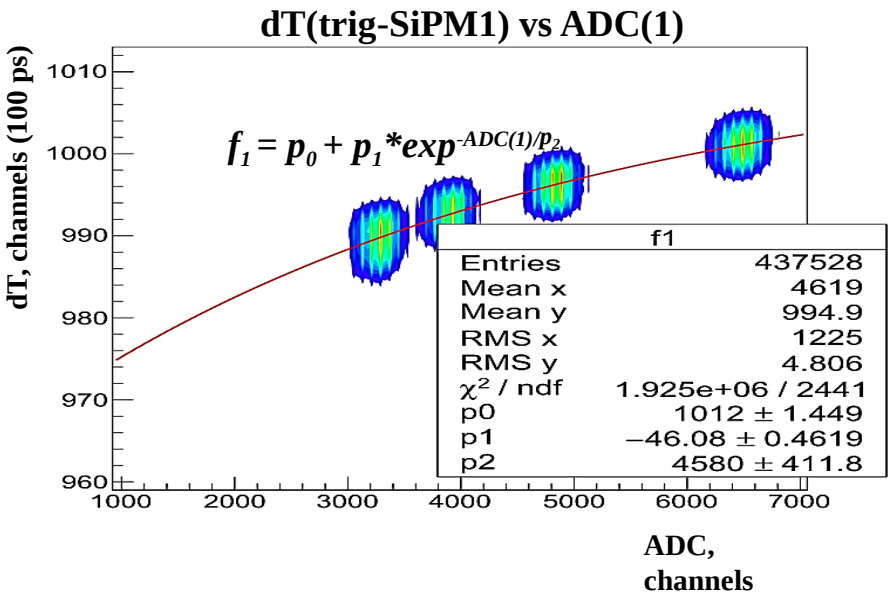


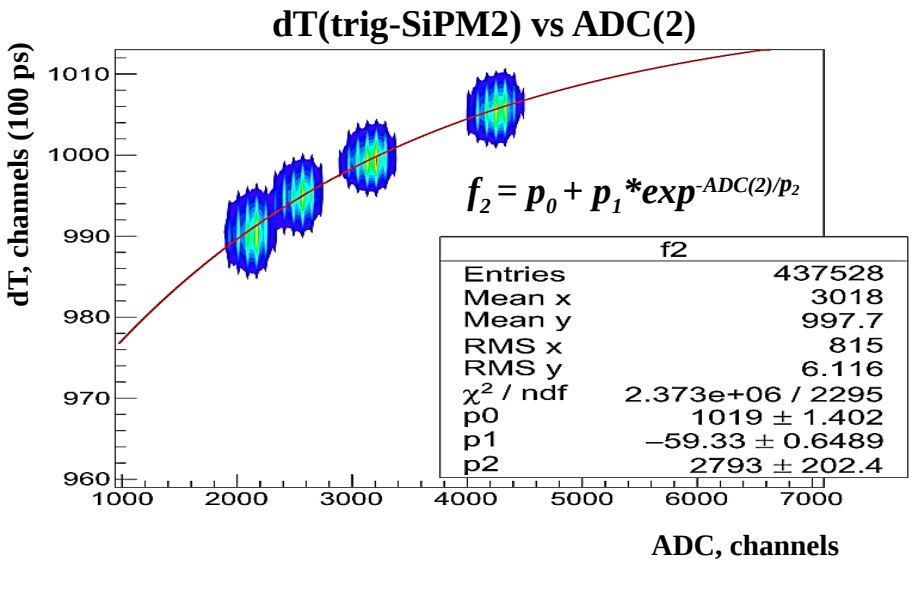


Extracting correction parameters FEE DANSS

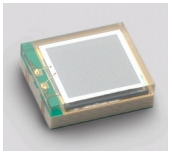








Properties of SiPM, Front-end electronics

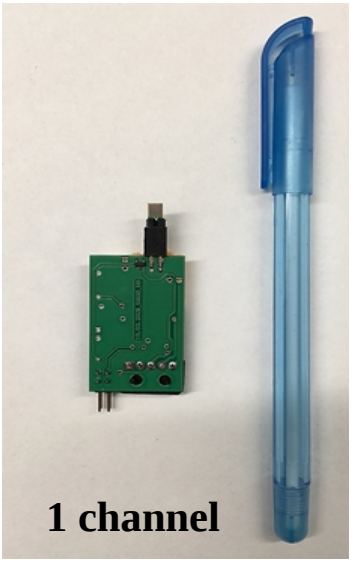


S12572-010P, **HAMAMATSU**
(3x3 мм^2, 10 μm/cell)

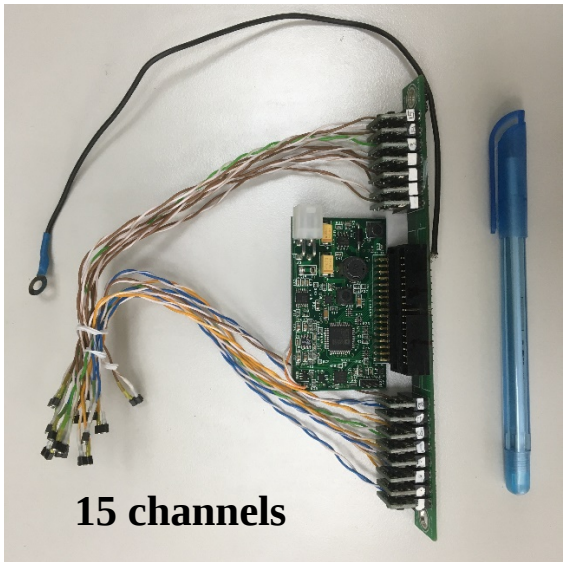
Applications:

✓ BBC

Advantages	Disadvantages
low bias voltage	sensitivity to external temperature changes



FEE ToT

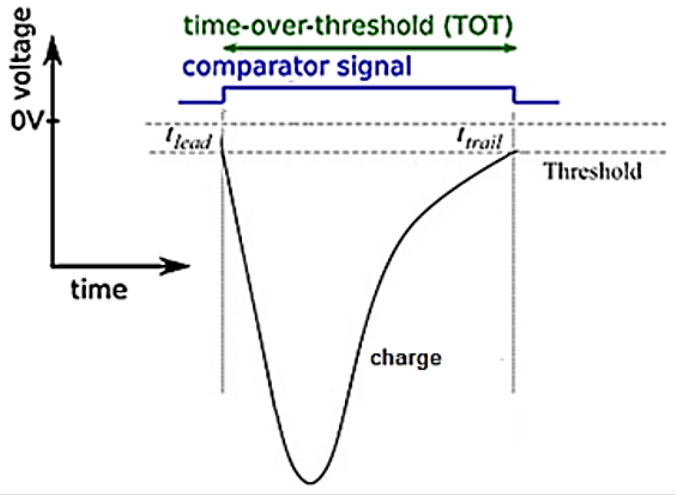


FEE DANSS (DANSS experiment)

Properties

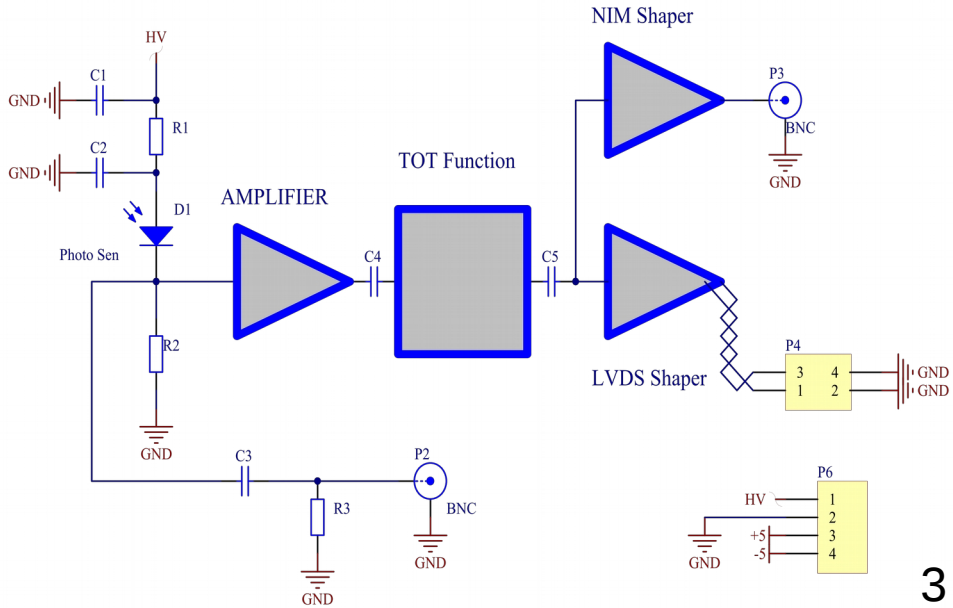
- pixel density 10^4- 2x10^4 mm^{-2},
- size from 1x1 to 6x6 mm^2,
- wide dynamic range 5-15000 p.e.,
- photon detection efficiency from ~ 15%,
- high counting rate ~ 10^5 Hz

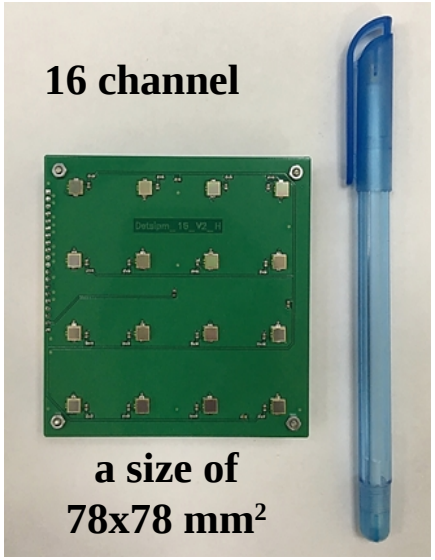
The Time-over-Threshold (ToT) method

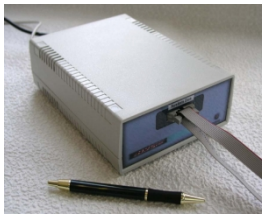


The ToT is a well-known method which allows to measure the energy deposited in the material.

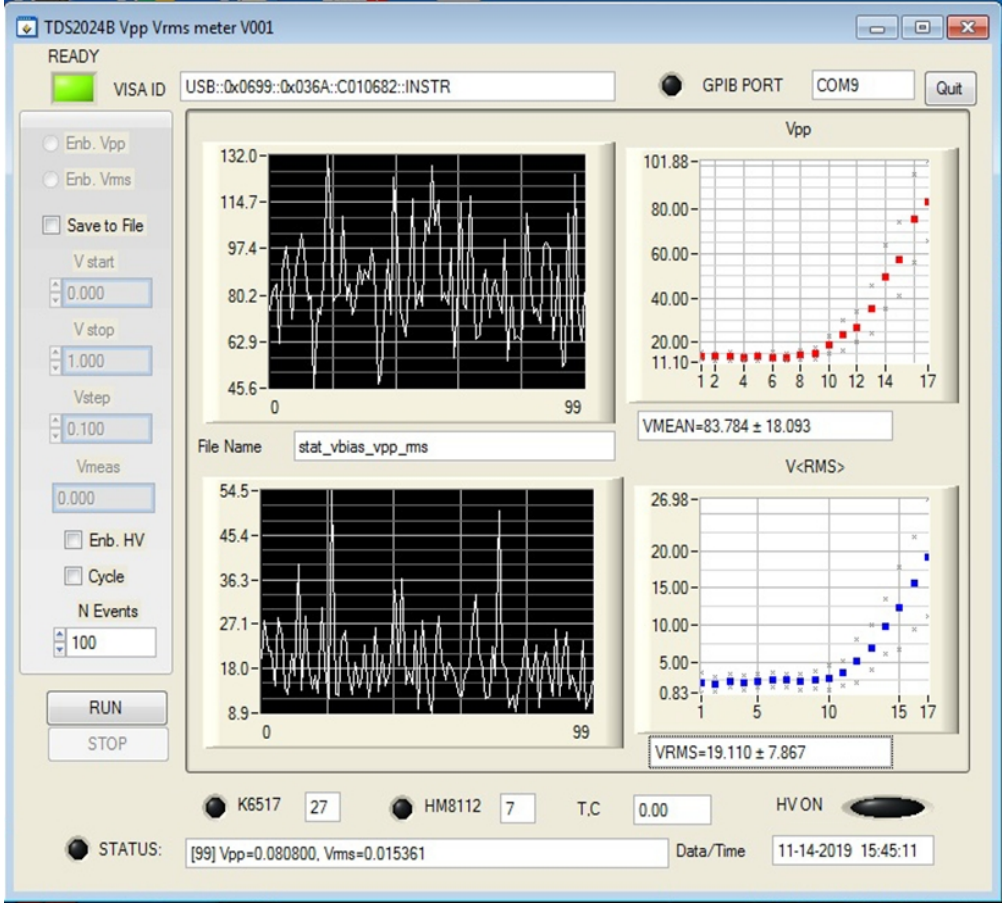
Front-end electronics with ToT technique







Ch.	Set Voltage(V) @20C		T Compensated Set Voltage	Current Voltage(V)	Kt (V/C)	Output Voltage(V)
0	1.356	1.356	1.356	1.356	0	73.646
1	1.239	1.239	1.239	1.239	0	73.763
2	1.247	1.247	1.247	1.247	0	73.755
3	1.648	1.648	1.648	1.648	0	73.354
4	1.351	1.351	1.351	1.351	0	73.651
5	1.125	1.125	1.125	1.125	0	73.877
6	1.399	1.399	1.399	1.399	0	73.603
7	1.323	1.323	1.323	1.323	0	73.679
8	1.341	1.341	1.341	1.341	0	73.661
9	1.224	1.224	1.224	1.224	0	73.778
10	1.297	1.297	1.297	1.297	0	73.705
11	1.348	1.348	1.348	1.348	0	73.654
12	1.608	1.608	1.608	1.608	0	73.394
13	1.315	1.315	1.315	1.315	0	73.687
14	1.225	1.225	1.225	1.225	0	73.777
15	1.299	1.299	1.299	1.299	0	73.703
Ped	75.000	75.002	74.998	75.002	0	Pedestal V

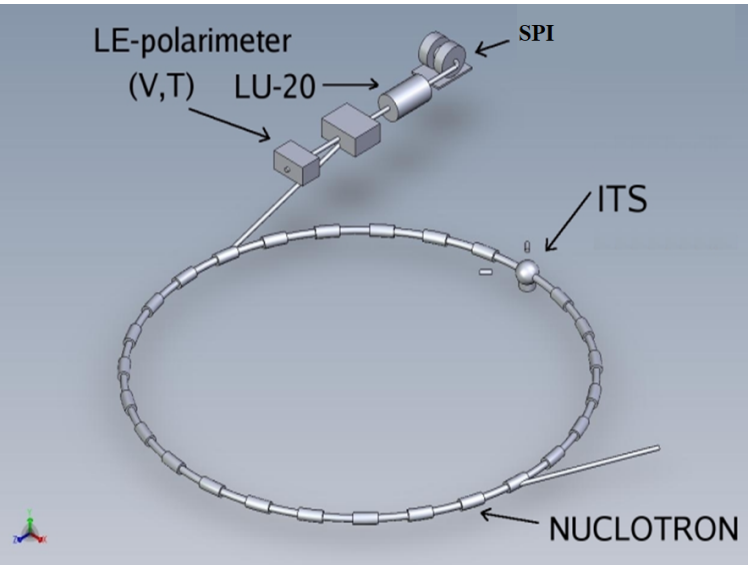


It's the 16-channel prototype of detector. This prototype is implemented on two PCBs. They contain power supply for sixteen SiPMs. The bias voltage is set by the HVsys program, which allows to set the total and the individual voltage.

Averaging peak-to-peak amplitudes was performed on 100 measurements with corresponding error to reduce the contribution of noise signal pulses and increase accuracy.

Tishevskiy A.V. et al. // to be published in Phys.Atom.Nucl., 2020, Vol. 83, No. 11

Experimental conditions

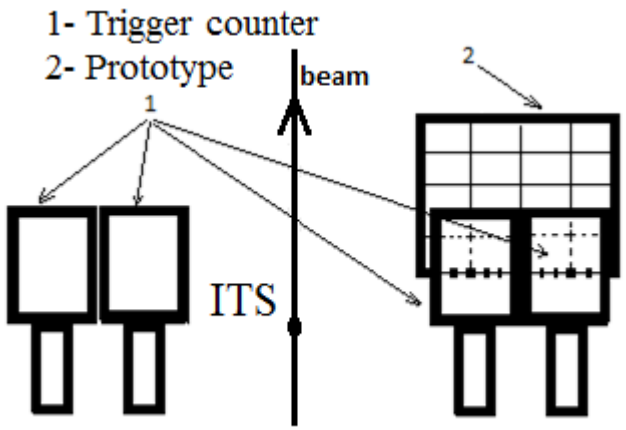


the energy 4 GeV / nucleon

the intensity $1x10^6$—$8.5x10^8$

U_{bias} =23,0 – 24,7 V

The trigger was the coincidence of two scintillation counters from different sides of the Nuclotron ion pipe.



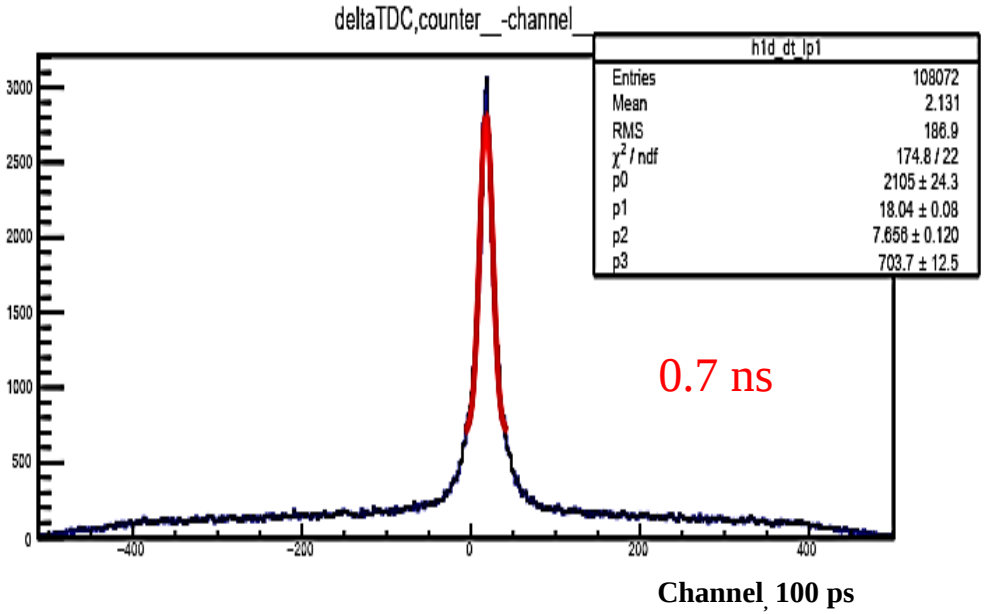
Hamamatsu H741MOD photo-multiplier tube

$$\begin{cases} \sigma_1^2 = \sigma_L^2 + \sigma_R^2 \\ \sigma_2^2 = \sigma_L^2 + \sigma_{Ch}^2 \\ \sigma_3^2 = \sigma_R^2 + \sigma_{Ch}^2 \end{cases} \quad (1)$$

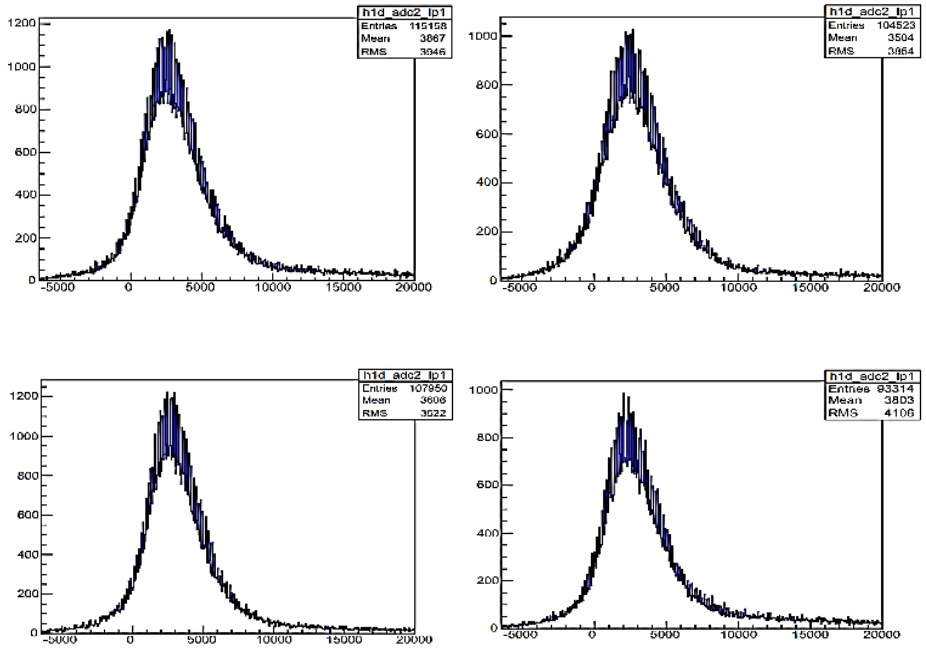
$$\begin{cases} \sigma_L^2 \approx \sigma_R^2 = \sigma_0^2 \\ \sigma_1^2 = 2\sigma_0^2 \end{cases} \quad (2)$$

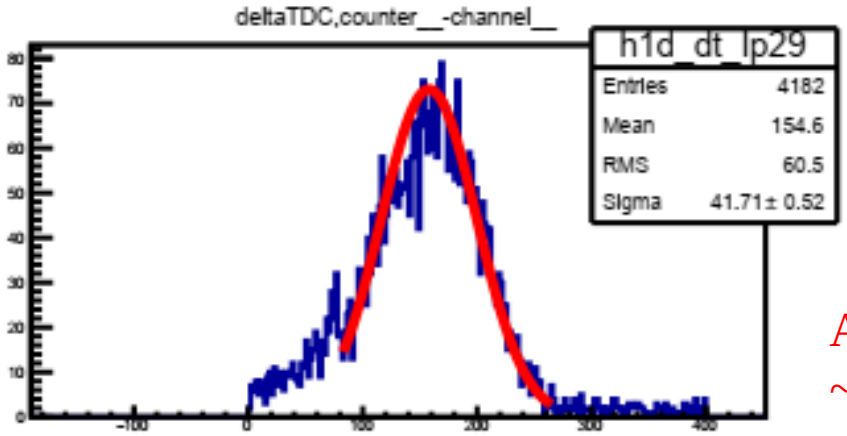
$$\sigma_{Ch} = \sqrt{\sigma_2^2 - \sigma_0^2}$$
$$\sigma_{Ch} = \sqrt{\sigma_3^2 - \sigma_0^2} \quad (3)$$

The time difference histogram



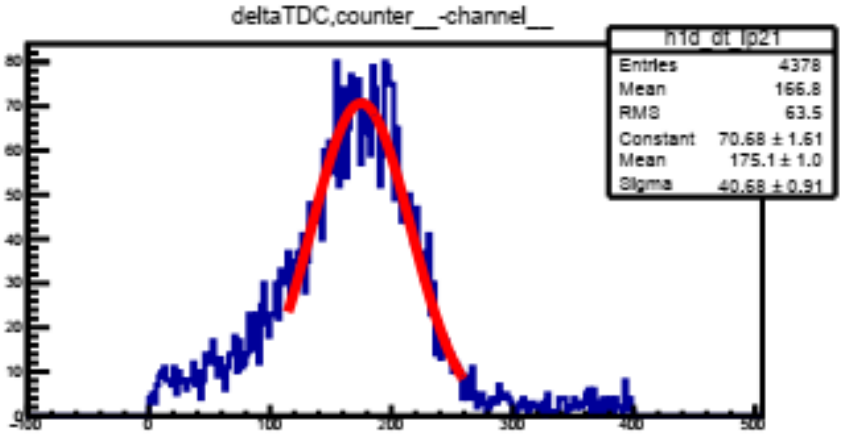
Channel, 100 ps





Channel, 100 ps

Average
~ 4.0 ns



Channel, 100 ps