Calibration of prototypes of detectors of GAMMA-400 space-based gamma-ray telescope on synchrotron C-25P "PAKHRA" of Lebedev Physical Institute

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I .V. Arkhangelskaja[1], A. I. Arkhangelskiy[1], S. I. Suchkov[2], M.F. Runtso[1], Y. T. Yurkin[1], A. M. Galper[1,2], N. P. Topchiev[2], E. N. Chasovikov[1]
[1]National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Kashirskoe highway 31, Moscow, 115409, Russia
[2]Lebedev Physical Institute, Russian Academy of Sciences, Leninskiy prospekt 53, Moscow, 119991, Russia
E-mail: irene.belousova@usa.net

GAMMA-400 (Gamma Astronomical Multifunctional Modular Apparatus) will be space-based gamma-ray telescope represents the core of the scientific complex intended to perform a search for signatures of dark matter in the cosmic gamma-emission, measurements of diffuse gamma-emission characteristics, investigation of extended and point gamma-ray sources, studying of high energy component of gamma-ray bursts and solar flares emission.

Gamma-telescope GAMMA-400 consists of anticoincidence system (top and lateral sections - ACtop and AClat), the converter-tracker (C), time-of-flight system (2 sections S1 and S2), position-sensitive calorimeter CC1 detectors, electromagnetic calorimeter CC2, scintillation detectors of the calorimeter (S3 and S4) and lateral detectors of the calorimeter (LD).

Prototypes of anticoincidence detector and two calorimeters were tested on synchrotron C-25P "PAKHRA" of Lebedev Physical Institute in Russia. The prototype of anticoincidence detector consists of strip of polyvinyltoluene scintillator BC-408 with dimensions of 1280x100x10 mm³, the prototypes of calorimeters consist of CsI(Tl) crystals with size of 330x50x20 mm³ and 450x36x36 mm³. All detectors prototypes used SiPM readout. The results of measurements of detectors characteristics are discussed in the work presented.

1. GAMMA-400 apparatus short description.

GAMMA-400 (Gamma Astronomical Multifunctional Modular Apparatus) is gamma-telescope consists of three types of detectors: double (X,Y) tracking coordinate detectors (used in the converter-tracker (C) and position-sensitive calorimeter CC1), plastic and non-organic scintillators. Following detectors based on BC-408 plastics: time-of-flight system TOF (2 sections S1 and S2), top (ACtop) and lateral (AClat) sections of anticoincidence system, scintillation detectors of the calorimeter (S3 and S4), lateral detectors of the calorimeter (LD) (its installation required for particles registration from lateral directions). All detector systems ACtop, AClat, S1-S4, LD consist of two sensitive layers of 1 cm thickness each. Two calorimeters made of CsI(Tl): position-sensitive (CC1) and electromagnetic (CC2) ones. CC1 contain of 1 strips layers and 1 scintillation layers The thickness of CC1 and CC2 is ~2 X_0 (~0.1 λ_0) and ~16 X_0 (~0.7 λ_0) respectively (where λ_0 is nuclear interaction length). SiPm used in all scintillation detectors instead of PMT for minimization of power consumption.

GAMMA-400 is optimized for the gamma-quanta and charged particles with energy 100 GeV registration with the best parameters in the main aperture from upper direction.

2. Prototypes of anticoincidence detector and two calorimeters of GAMMA-400

The prototype of anticoincidence detector consists of strip of polyvinyltoluene scintillator **BC**-408 with dimensions of 1280x100x10 mm³, the prototypes of calorimeters consist of CsI(Tl) crystals with size of 330x50x20 mm³ and 450x36x36 mm³ – see fig.1.

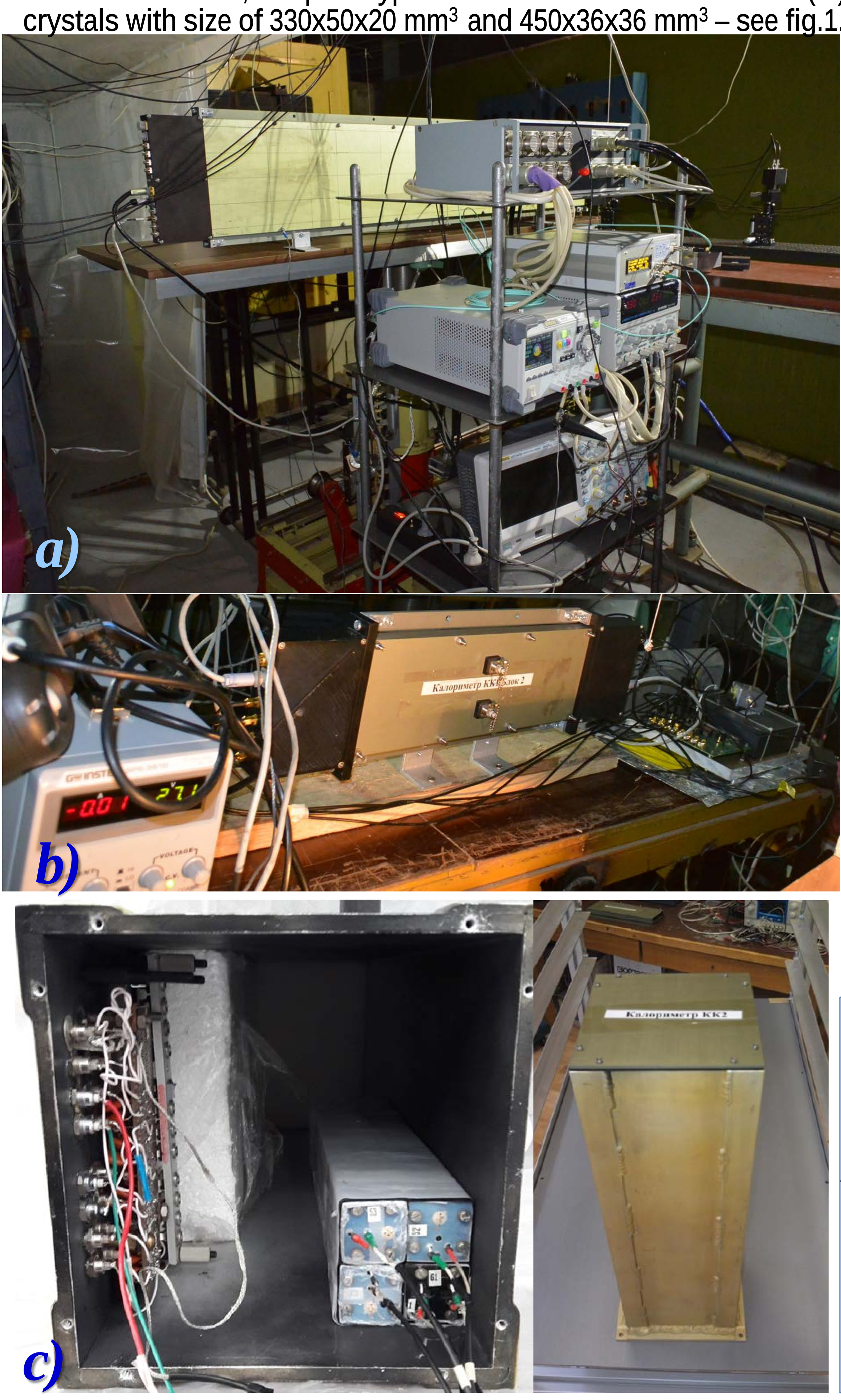

Fig. 1. Photos of prototypes of anticoincidence detector and two calorimeters of GAMMA-400 : a) AC, b) CC1, c) CC2

3. Prototype of detectors of GAMMA-400 calibration on synchrotron "PAKHRA".

Accelerator "PAKHRA" consist of accelerator hall in which synchrotron **C**-25**P** is located (see fig. 2), and experimental halls **№**1 and **№**2.. This synchrotron allows to form beam of electrons with maximum energy ~1 GeV, particle intensity up to $2{\cdot}10^{12}$ electrons/sec and repetition frequency of 50 Hz, which ejected in in experimental halls **№**1, where it interact with internal tungsten target thickness of 0.22X0 and formed beam of bremsstrahlung gammas (γ-beam **№**0) ejected in experimental halls **№**2 through collimator C0. Maximum energy of this gamma-beam is in the band 300-850 MeV and charged particles contaminant concentration ~ 0.15.

Fig. 2. Accelerator hall in which synchrotron C-25P is located

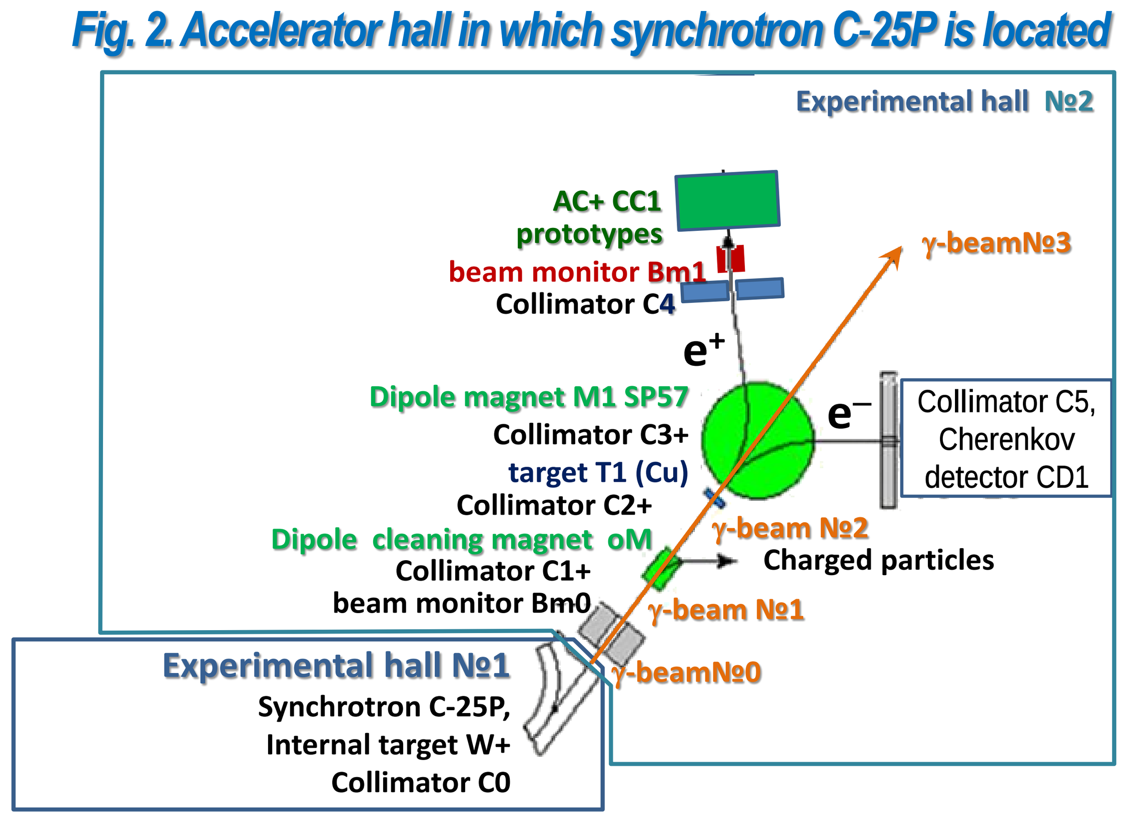

Fig. 3. Scheme of beam forming and apparatus installation on synchrotron C - 25P "PAKHRA"

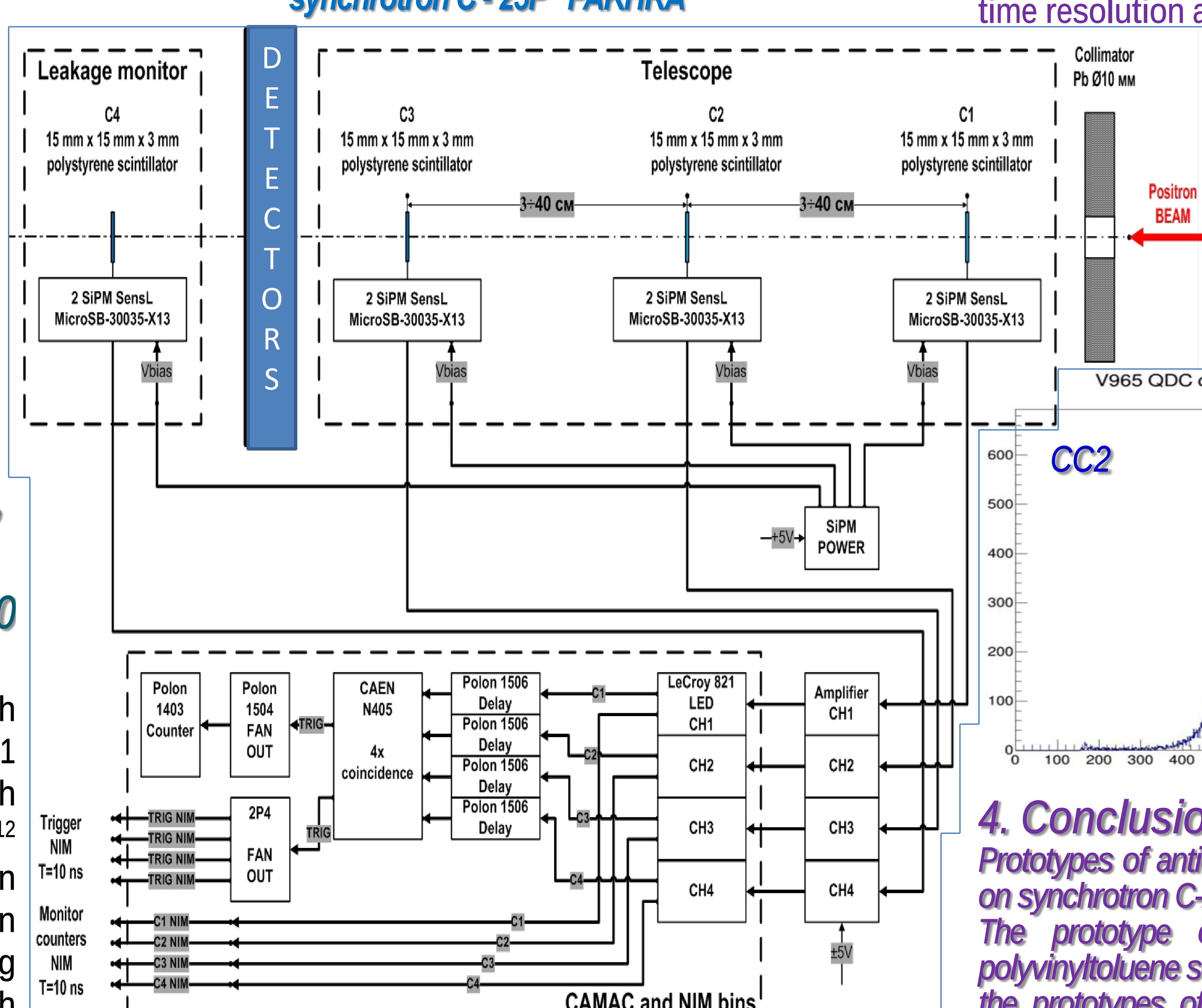

Fig. 6. Experimental setup, including beam monitor. The dash-dotted line represents the beam line

Then γ-beam **№**1 formed after passing of collimator C1, gives signal «start» due interaction with beam monitor Bm0 consist of , NaI–based detector. After that γ-beam **№**2 formed using dipole cleaning magnet oM which removed most part of charged particles from γ-beam **№**1 and collimator C2. Gammas of γ-beam **№**2 passed through collimator C3 and interact with copper target T1 thickness from 0.1 mm up to 5 mm formed secondary electron and positron beams with energies from 25 MeV up to 300 MeV separated by dipole magnet **M**1 SP57. Scheme of beam forming and apparatus installation on

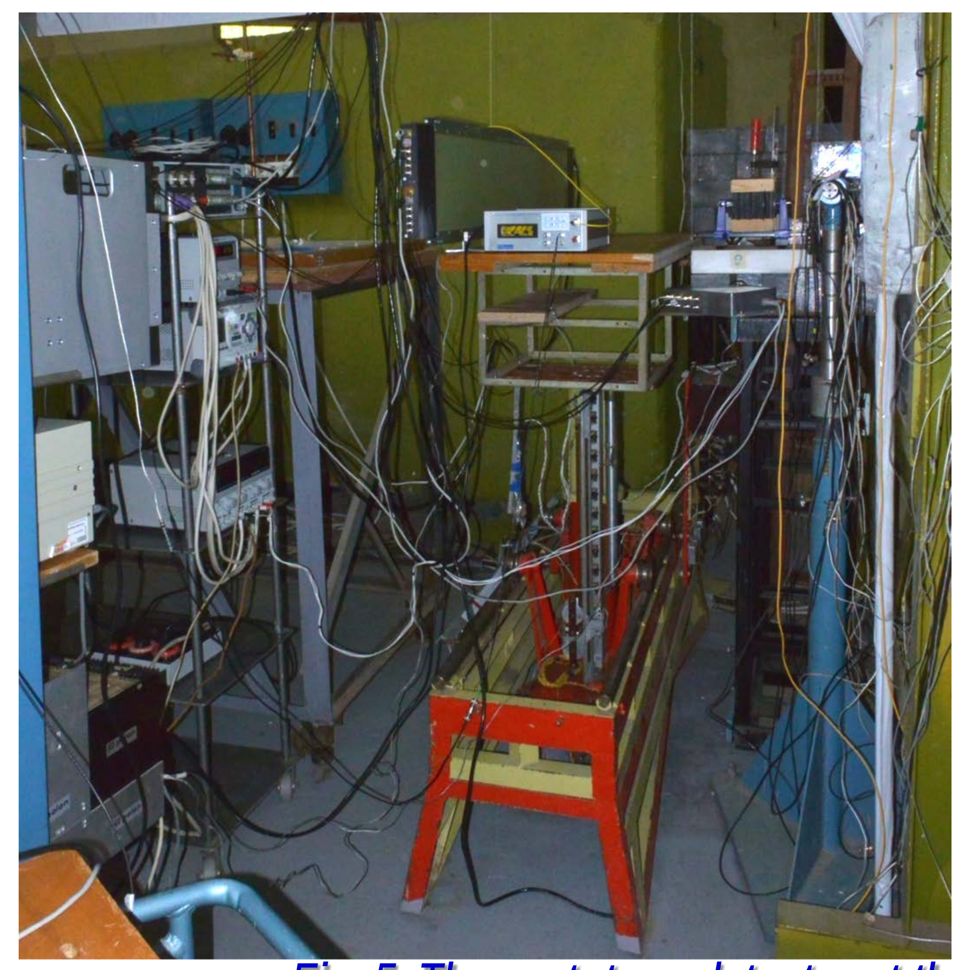

Fig. 5. The prototype detector at the experimental hall №2 of synchrotron C-25P

synchrotron **C** - 25**P** "PAKHRA" is presented at fig.2.

Studies of light yield, time and coordinate resolution of the prototype detectors were performed. The tested detector prototypes viewed from opposite shortest ends by two photosensor blocks of silicon photomultipliers SensL MicroFC-60035-SMT and front-end electronics. The studied prototype of detector AC was installed on remote controlling platform (Fig. 5) permits to horizontally moving the detector with respect to beam position in the range of ±40 cm. The photo of beam monitor Bm1 and scheme of experimental setup and are presented in Figures 4 and 6.

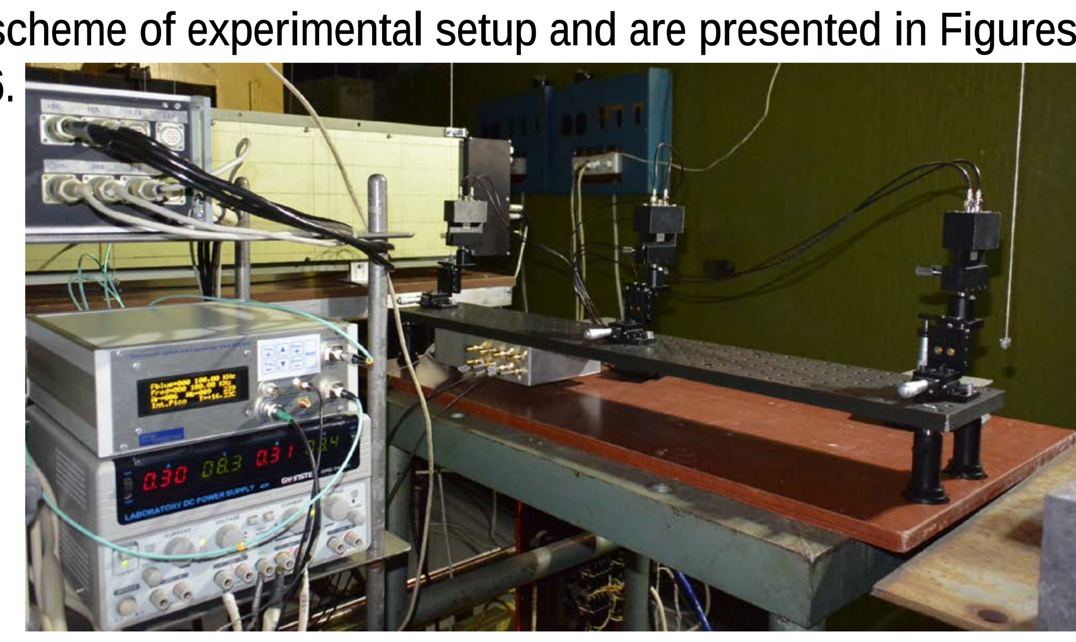

Fig. 4. Photo of beam monitor Bm1

Spectra measured by prototypes of CC1, CC2 and AC prototype time resolution are presented at fig. 7.

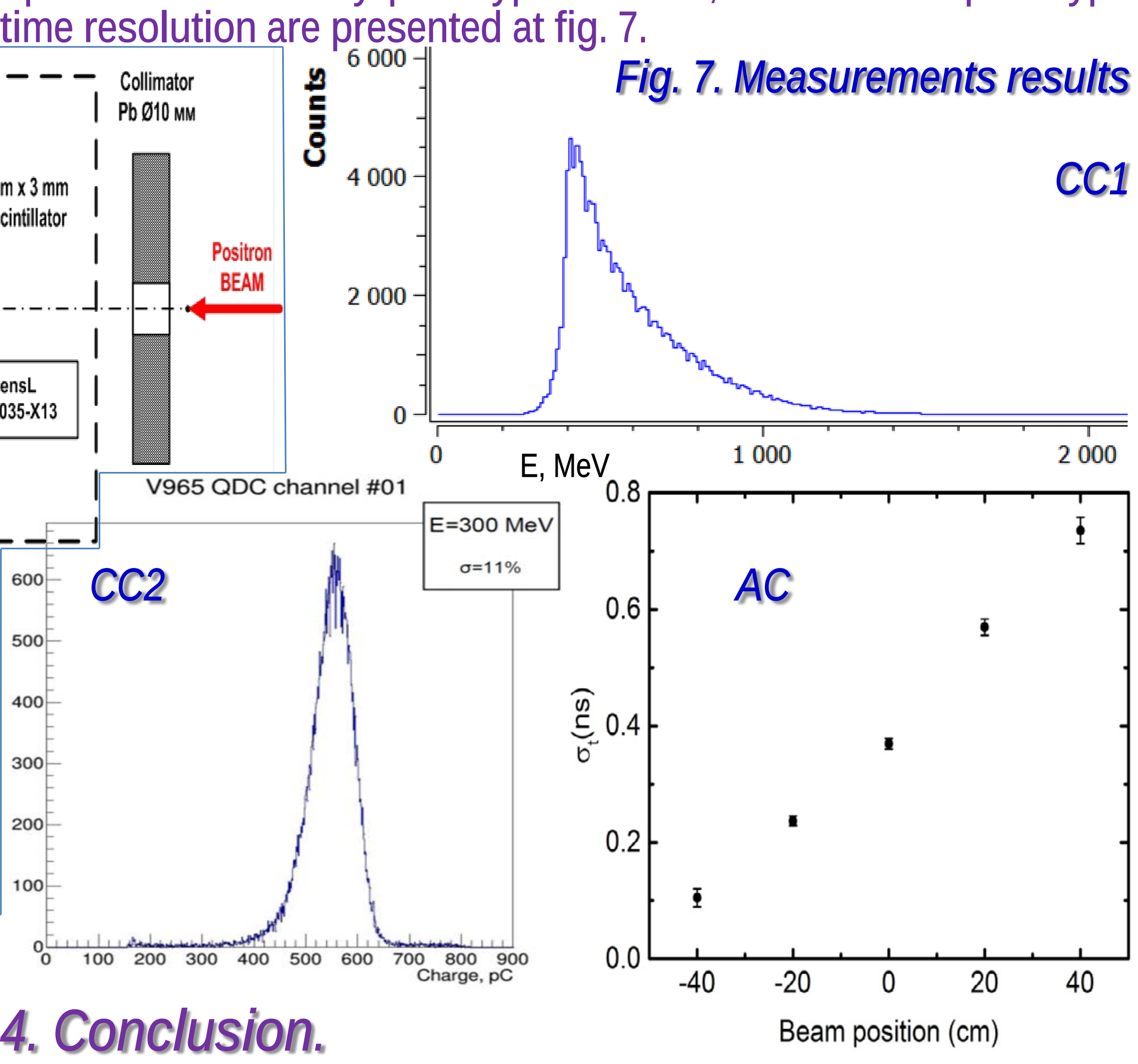

Fig. 7. Measurements results

4. Conclusion.

Prototypes of anticoincidence detector and two calorimeters were tested on synchrotron C-25P "PAKHRA" of Lebedev Physical Institute in Russia. The prototype of anticoincidence detector consists of strip of polyvinyltoluene scintillator BC-408 with dimensions of 1280x100x10 mm³, the prototypes of calorimeters consist of CsI(Tl) crystals with size of 330x50x20 mm³ and 450x36x36 mm³. All detectors prototypes used SiPM readout. The results of measurements of detectors characteristics are discussed in the work presented.