New EMC electronic channel for the SND detector at VEPP-2000 $e^+e^-$ collider

This content has been downloaded from IOPscience. Please scroll down to see the full text.
2015 J. Phys.: Conf. Ser. 587 012026
(http://iopscience.iop.org/1742-6596/587/1/012026)

View the table of contents for this issue, or go to the journal homepage for more

Download details:

IP Address: 188.184.3.52
This content was downloaded on 24/06/2015 at 12:16

Please note that terms and conditions apply.
New EMC electronic channel for the SND detector at VEPP-2000 $e^+e^-$ collider

I K Surin$^{1,*}$, M N Achasov$^{1,2}$, A G Bogdanchikov$^1$, V P Druzhinin$^{1,2}$, V B Golubev$^{1,2}$, S V Koshuba$^{1,2}$, D P Kovrizhin$^{1,2}$, S I Serednyakov$^{1,2}$, A I Tekut’ev$^1$ and Yu V Usov$^1$

$^1$Budker Institute of Nuclear Physics, 11 akademika Lavrentieva prospect, Novosibirsk, 630090, Russia
$^2$Novosibirsk State University, 2 Pirogova street, Novosibirsk, 630090, Russia

* corresponding author e-mail: I.K.Surin@inp.nsk.su

Abstract. A new measuring electronics channel with FADC is proposed for the electromagnetic calorimeter of the SND detector, taking data at $e^+e^-$ collider VEPP-2000. This system is intended to raise detection efficiency of the low-speed anti-neutrons, produced in $e^+e^-\rightarrow n$ anti-n reaction. The proposed channel provides time resolution of about 1 ns.

1. Introduction

One of the important experiments with SND$^{[1]}$ at $e^+e^-$ collider VEPP-2000$^{[2]}$ is $e^+e^-\rightarrow n\text{ anti-n reaction cross measurement section near threshold}^{[3]}$. Low speed of the anti-neutrons allows to use time measurements for event selection of this process. Time delay between anti-neutrons annihilation signal and signal from ultrarelativistic particles is about from 3 to 9 ns. Existing electronic channel can't provide time resolution better than 5 ns. Due to this, development new electronic was started. This new channel is also needed for EMC electronics operation rate increasing.

![Figure 1. SND calorimeter general parameters: Total weight of NaI – 3.5 tons, Total crystals – 1632, Thickness – 13.4 $\times$ NaI=(2.9+4.8+5.7) $\times$ 0 (34.7 cm), VPT readout 0.9-4$\pi$ solid angle, Angular segmentation $\Delta \varphi=\Delta \theta=9^\circ$, Energy resolution 4.2%/\sqrt{E(\text{GeV})}$, Angular resolution 0.82%/\sqrt{E(\text{GeV})} \oplus 0.63^\circ.](image)

2. Brief overview of the SND EMC

The three-layer spherical NaI(Tl) electromagnetic calorimeter (fig. 1) is the main part of SND. Each calorimeter layer is divided into separate counters in the following way: in the azimuthal direction it is
divided into 40 equal parts by planes with 9 degrees angle between adjacent ones. The total solid angle covered by the calorimeter is equal to 0.9 of $4\pi$ (more parameters see below). As photosensitive devices for the calorimeter counters the vacuum phototriodes are used. The quantum efficiency of their photocathodes is about 15%, average gain is 10 and light collection efficiency is about 10%. Signals from phototriodes are amplified by charge-sensitive preamplifiers located directly on the counters. Output signals are transferred to shaping amplifiers via 20m-long twisted pairs. For trigger requests the calorimeter crystals are logically organized into “towers” (fig. 2). A tower consists of counters located within 18 degrees interval in the same polar and azimuthal directions in all three layers.

![Figure 2. NaI(Tl) crystals layout inside the calorimeter: 1 — NaI(Tl) crystals, 2 — vacuum phototriodes, 3 — aluminum supporting hemispheres.](image)

3. New EMC electronic channel

Figure 4 is illustrated the new EMC electronic channel. The signal from VPT (or calibration generator) comes to module containing computer-controlled attenuator and shaping amplifier and further goes to the new FADC module (24 channels, 12 bit, freq 40 MHz). FLT signal is used as “stop” for FADC oscillogram reading. T module provides time measurement between FLT signal and the pulse of 40 MHz clock generator (it's needed for time resolution measurement).

![Figure 4. FADC – flash ADC (24 channels, 12 bit, freq 40 MHz), NaI – NaI(Tl) scintillator, VPT – vacuum phototriode, CSA – charge-sensitive preamplifier, Gen – calibration generator, SHA – shaping amplifier, ATT – computer-controlled attenuator, FLT – first-level trigger, T – time-to-digital converter](image)
Obtained by FADC oscillograms are processed for measurement of time and amplitude resolution. Several methods of oscillogram shape fitting were investigated. As a result of this investigation, optimal method of fitting was found. The method is based on approximation signal oscillogram by cubic spline.

Time resolution is calculated as a difference between time measured by T module and fractional tick (a time less than 25 ns) obtained by oscillogram fitting.

4. Measurement results

Pulse calibration generator is very important for all these measurements, because its signal has the same shape as a signal obtained from VPT output. Using this generator gives us opportunity to find correct experimental devices settings for experiments with $e^+e^-$ beams.

To obtain objective data about amplitude and time resolution of new electronic channel the measurements have to be carried out in real experiments with beams. In this way we can consider possible outside influences to these measurements.

Figures 4 and 5 illustrate dependences of time and amplitude resolutions from energy deposition inside single NaI(Tl) crystal. The results were obtained using the calibration generator.

As you can see, the amplitude resolution has weak dependence on energy deposition. High amplitude resolution better than 0.15 MeV has been obtained.

Energy deposition dependence of time resolution is shown in fig. 5. Such kind of dependence indicates, that new electronic channel will provide high time resolution about 1 ns or better, if energy deposition in crystal is more than 100 MeV.

Obtained time resolution is determined by several factors. There are CSA noise, signal shape fluctuation caused by statistical fluctuation of photoelectron flux, discreteness of FADC (25 ns) and T module (0.15 ns).

Time resolution was also measured in real experiment SND at $e^+e^-$ collider VEPP-2000 (see fig. 6). Beams energies were c.m.s. energy about 1 GeV and currents of electron and positron beams were about 30 mA. If energy deposition is more than 200 MeV, time resolution is being about 1.2 ns. This result already has corresponded requirements for new electronic channel.

5. Conclusion

New EMC electronic channel for the SND detector has been developed and tested. High amplitude resolution better than 0.15 MeV has been obtained. Time resolution ~1.2 ns has been obtained.
Figure 6. The time resolution, which was obtained on experimental Bhabha events.

Acknowledgments
This work was supported by the Ministry of Education and Science of the Russian Federation, RFFI grants 12-02-00065-a, 12-02-01250-a, 13-02-00375-a, 13-02-00418-a, 14-02-00129-a, 14-02-31375-mol_a, Russian Federation President’s grant for supporting leading scientific Schools NSh 2479.2014.2, Russian Federation President’s grant MK-4285.2014.2

References
1. M. N. Achasov et al, Nuc. instr. Meth. A vol 449, p 125 (2000)
2. D. Berkaev et al, Nucl. Phys. Proc. Suppl vol 225-227, p 303, (2012)
3. A.A.Botov, A.D.Bukin, D.A.Bukin, V.B.Golubev, V.P.Druzhinin, S.I.Serednyakov, K.Yu.Skovpen, Nucl. Phys. B, Proc. Suppl. vol 162, p 41 (2006).