New electronics of the spectrometric channel for the SND detector electromagnetic calorimeter

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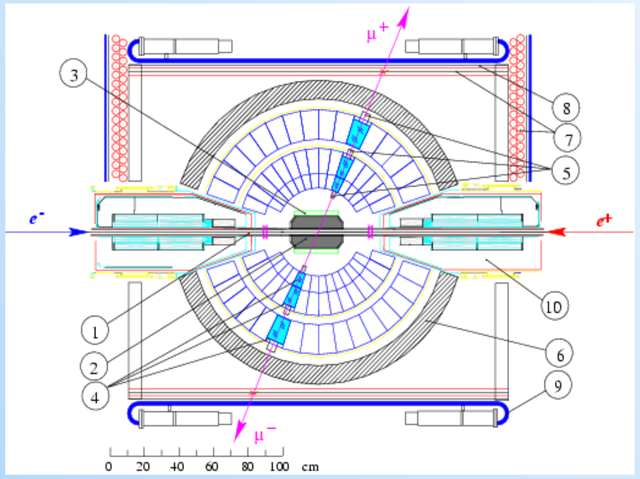
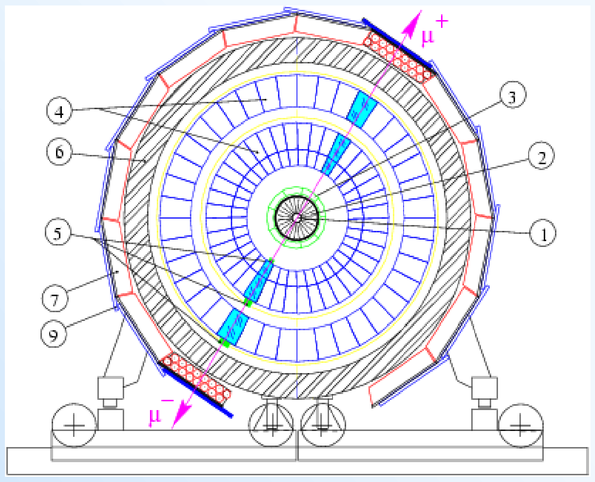
Abstract: The Spherical Neutral Detector (SND) is intended for study of electron-positron annihilation at VEPP-2000 e^+e^- collider, which is located at BINP (Novosibirsk, Russia). The main part of the SND detector is a three-layer electromagnetic calorimeter (EMC). The SND team plans to perform a precision study of the reaction e^+e^- to neutron-antineutron near threshold. One of the necessary condition for this task is a time resolution in the calorimeter of about 1 ns or better. To achieve that, new modules for shaping and digitizing signal have been designed and tested. A time resolution of about 1 ns and an amplitude resolution of about 250 keV are reached.

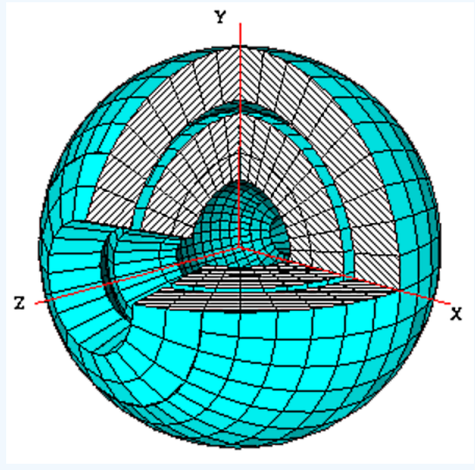
Spherical Neutral Detector

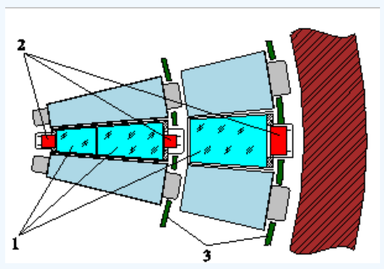




1 – VEPP-2000 beam pipe, 2 – tracking system, 3 – aerogel Cherenkov counter, 4 – NaI(Tl) counters, 5 – vacuum phototriodes, 6 – absorber, 7-9 – muon system, 10 – VEPP-2000 superconducting focusing solenoids

Electromagnetic calorimeter





The segment of the EMC:
NaI(Tl) crystals (1), vacuum phototriodes (VPT) (2), aluminum supporting spheres (3).

SND calorimeter general parameters:

Total weight of NaI - 3.5 tons, 1632 crystals, VPT readout

13.4 X_0NaI=(2.9+4.8+5.7)X_0 (34.7 cm), $0.9 \cdot 4\pi$ solid angle

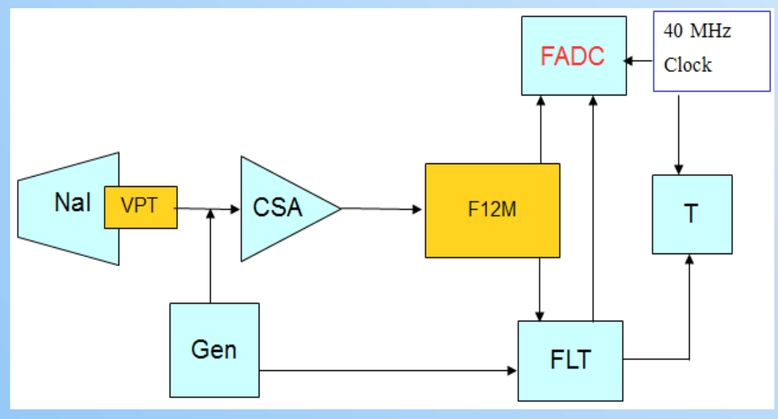
$\Delta\varphi=\Delta\theta=9°$

Energy resolution $4.2\%/\sqrt[4]{E(GeV)}$

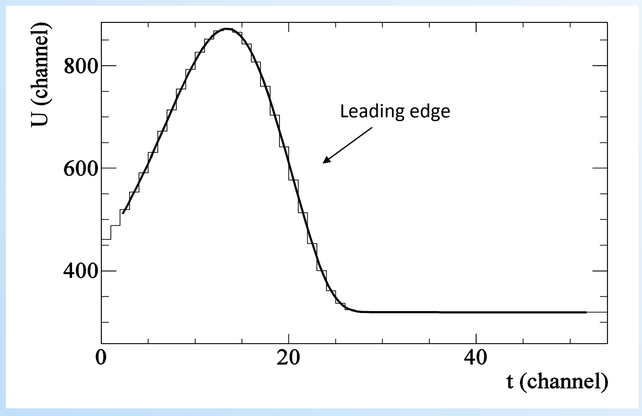
Angular resolution $0.82° / \sqrt{E(GeV)} \oplus 0.63°$

Stage 1

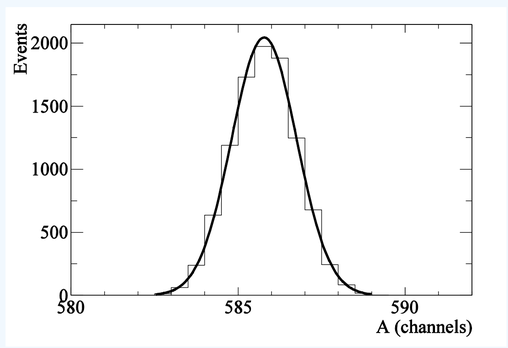
New spectrometric channel



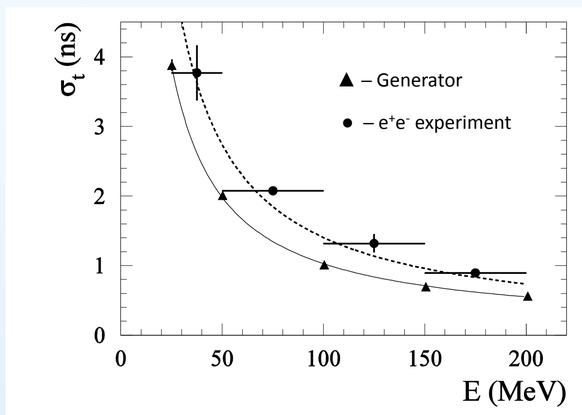
The layout of the SND EMC spectrometric channel used for test measurement. It consists of the SND calorimeter crystal (NAI), a vacuum phototriode (VPT), a charge-sensitive preamplifier (CSA), a shaper module (F12M), a time-to-digital converter (T), a flash analog-to-digital converter module (FADC, 24 channels, 12 bit, freq 40 MHz), the SND detector first-level trigger system (FLT), a calibration generator (Gen), and a 40 MHz clock generator



The oscillogram is fitted with the function $U(t)=A \cdot F(t - \Delta t) + P$, where F(t) is a function describing signal shape (cubic spline). A – signal amplitude, P – pedestal, Δt – the shift of the arrival time



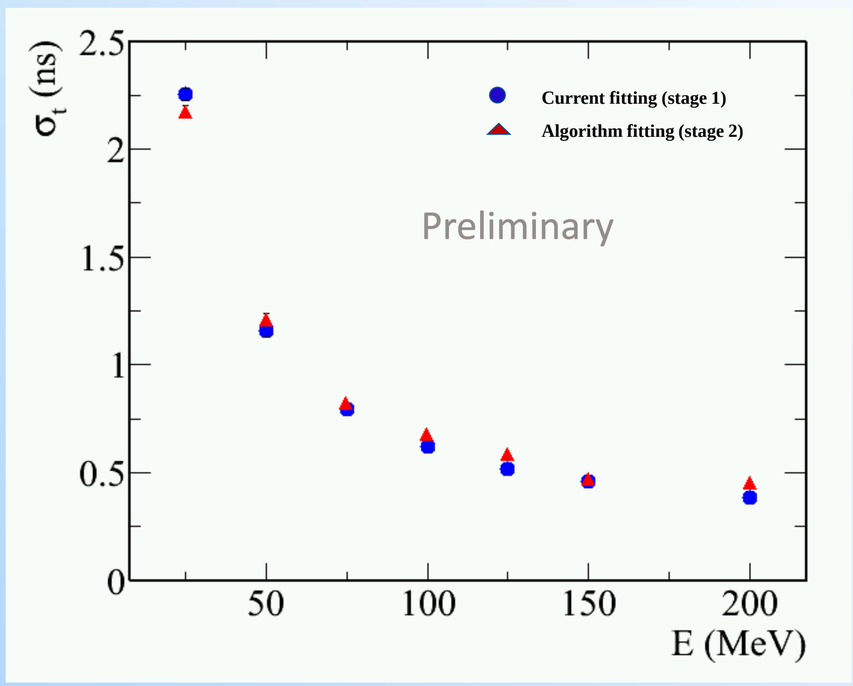
Amplitude resolution ~ 250 keV



Time resolution ~ 1 ns

Stage 2

At this stage we perform optimization of F12M shaping parameters to reduce the level of noise. Also we redesign the FADC module, because the current version cannot provide necessary operation rate without significant increasing communication and computing resources. The new design has an aim to determine parameters A,P, Δt inside FADC. The algorithm used in FADC minimizes $\chi^2=(u_i - AF(t_i - \Delta t) - P)S^{-1}_{ij}(u_j - AF(t_j - \Delta t) - P)$, where u_i is the signal sample, and S_{ij} is the noise covariance matrix. The algorithm has been tested (see Fig.) and adopted for implementation in FPGA Zynq 7000 (Xilinx), which is planned to supply a new version of the FADC.



Conclusion

The prototype of the new spectrometric channel for the electromagnetic calorimeter of the SND detector, which takes data at the VEPP-2000 e^+e^- collider, has been tested. Time resolution of about 1.3 ns and amplitude resolution of about 0.25 MeV have been obtained at the energy deposition in the calorimeter crystal of 100 MeV. A new algorithm of fitting the calorimeter pulse which will be implemented in FPGA has been designed. With the new algorithm and new shaper a time resolution is about 0.6 ns and an amplitude resolution of about 170 keV have been obtained.