Development of the new spectrometric channel for the SND electromagnetic calorimeter

Ilya Surin

Budker Institute of Nuclear Physics

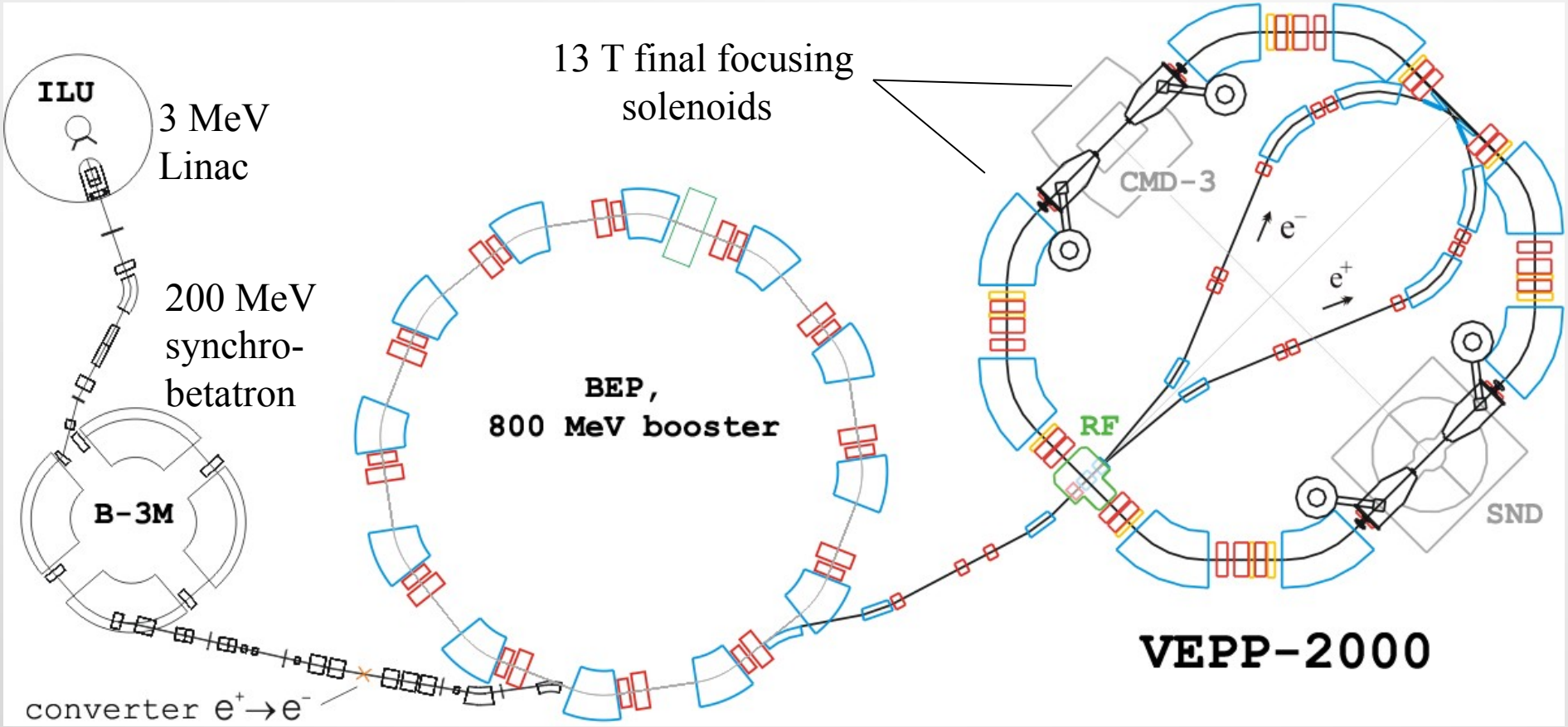
Novosibirsk, Russia

eCOL 2016, 22-25 August 2016,
CERN

Outline

- Introduction
- Brief overview of the VEPP-2000 and SND
- EMC of the SND detector
- Motivation
- New spectrometric channel
- Measurement results
- Conclusion

e^+e^- collider VEPP-2000 (2010-2013)



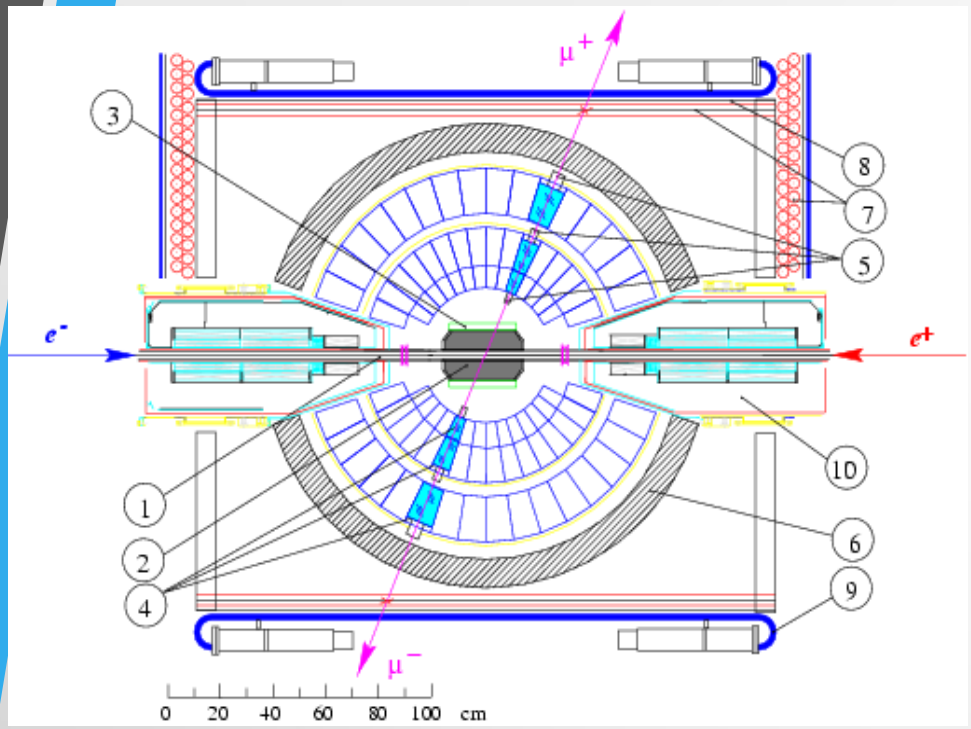
2E = 0.3-2.0 GeV

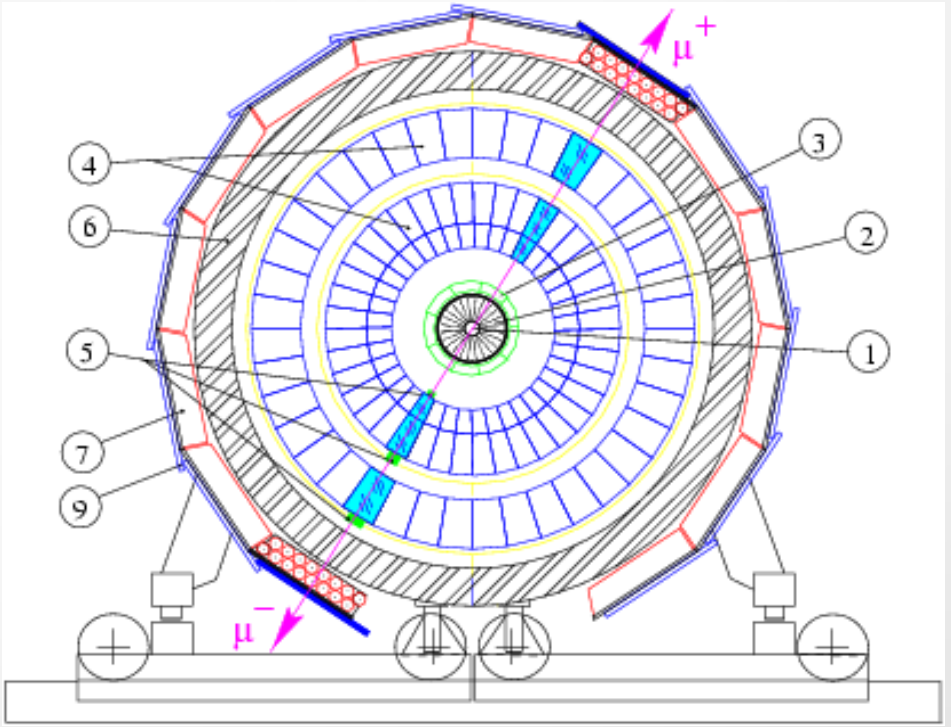
$L \sim 10^{32}$ cm^{-2}s^{-1} (2E = 2GeV)

Circumference 24.388 m

There are two detectors on VEPP-2000: SND and CMD-3

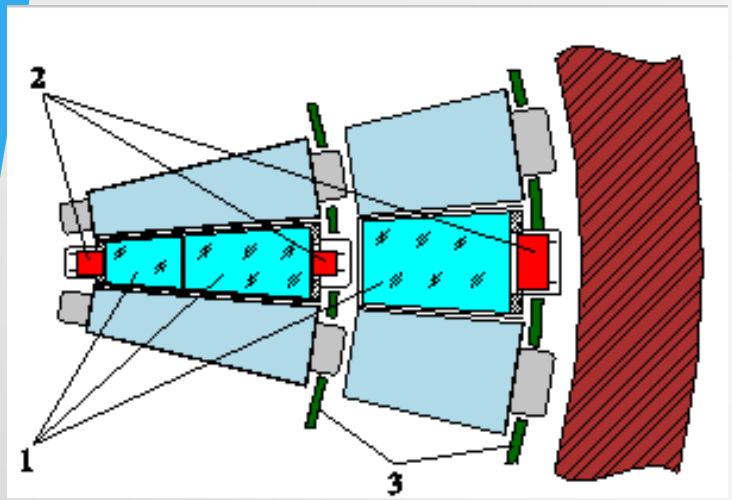
Spherical Neutral Detector

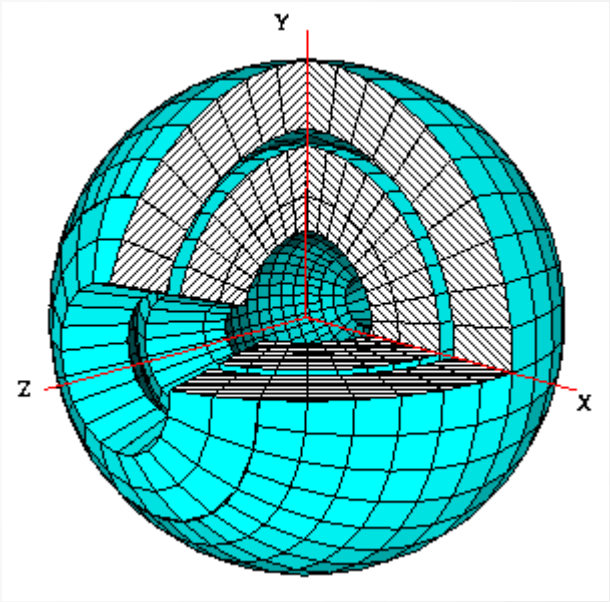




1 – pipeline, 2 – tracking system, 3 – aerogel Cherenkov counters, 4 – NaI(Tl) electromagnetic calorimeter, 5 – vacuum phototriodes, 6 – iron absorber, 7-9 – muon system, 10 – VEPP-2000 focusing SC solenoid

SND EMC





NaI(Tl) crystals layout inside the calorimeter:

1 - NaI(Tl) crystals, 2 - vacuum phototriodes, 3 - aluminum supporting hemispheres.

SND calorimeter general parameters:

Total weight of NaI - 3.5 tons

1632 crystals

13.4 X_0NaI=(2.9+4.8+5.7)X_0 (34.7 cm)

VPT readout

0.9·4π solid angle

Δφ=Δθ=9°

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

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

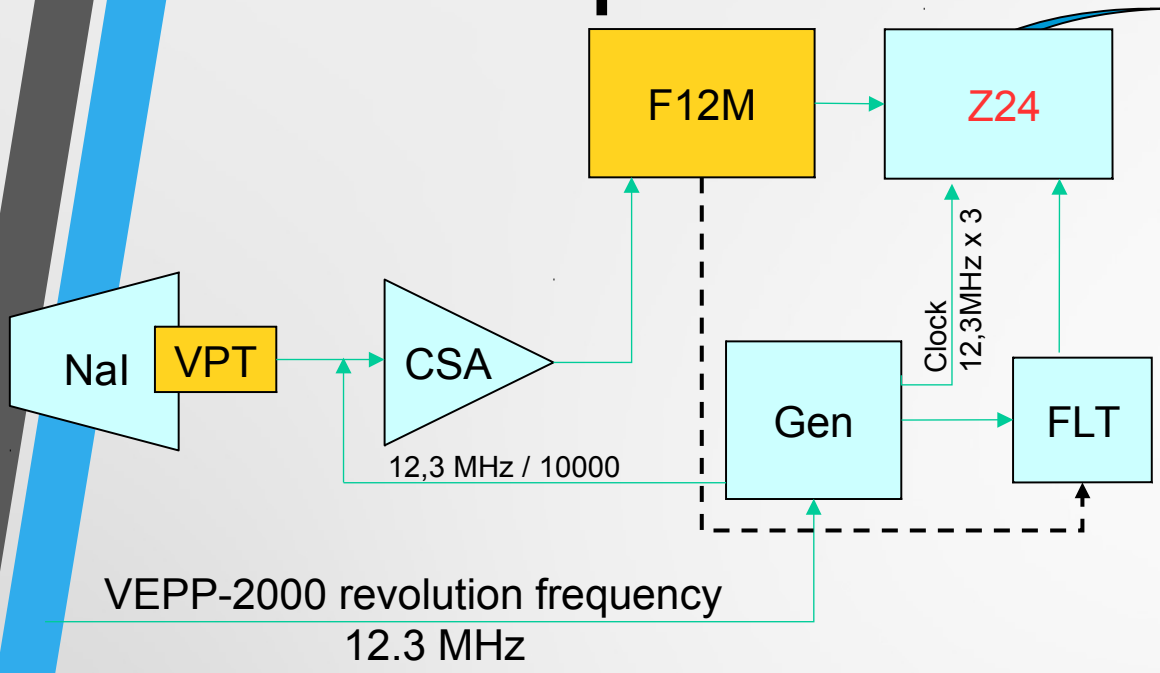
Motivation

1) To measure precisely $e^+e^- \rightarrow n\bar{n}$ cross section near threshold we should improve time resolution (~1 ns) of the EMC spectrometric channel

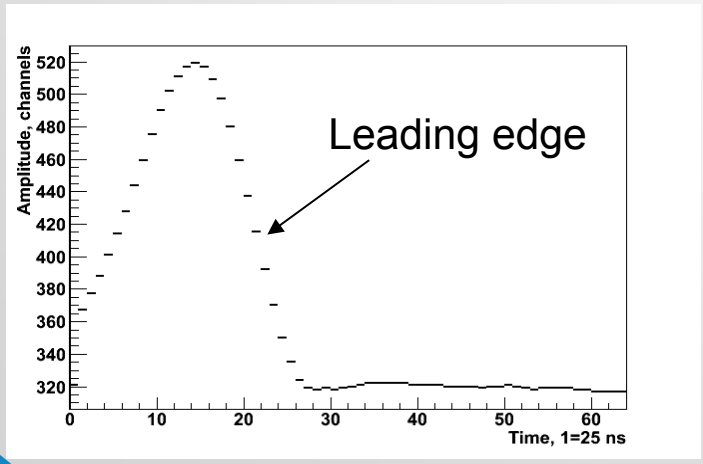
2) This new channel is also needed for increasing operation rate of the EMC electronics

3) To develop perspective approaches in electronics design and fitting algorithms. It may be used in calorimeter electronics of the detector for the Super c-tau Factory.

EMC Spectrometric Channel

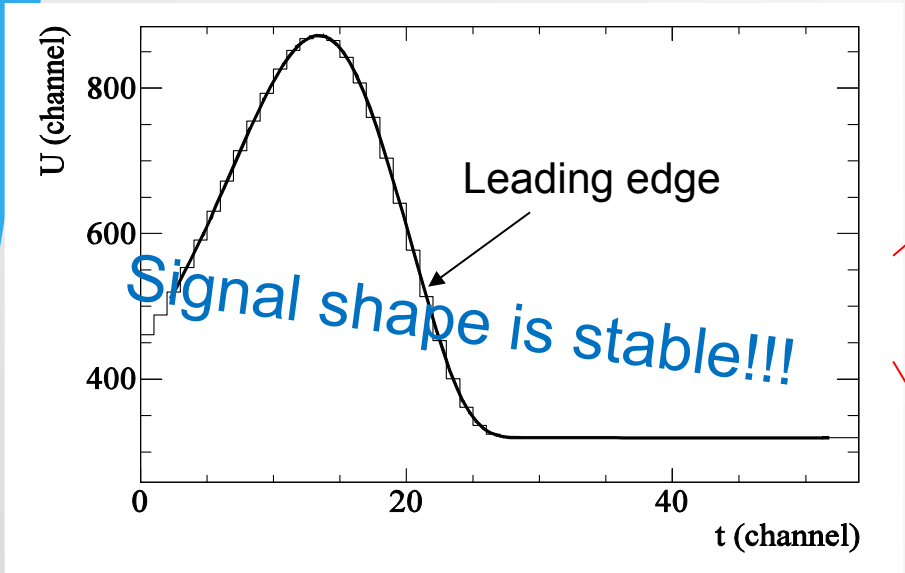


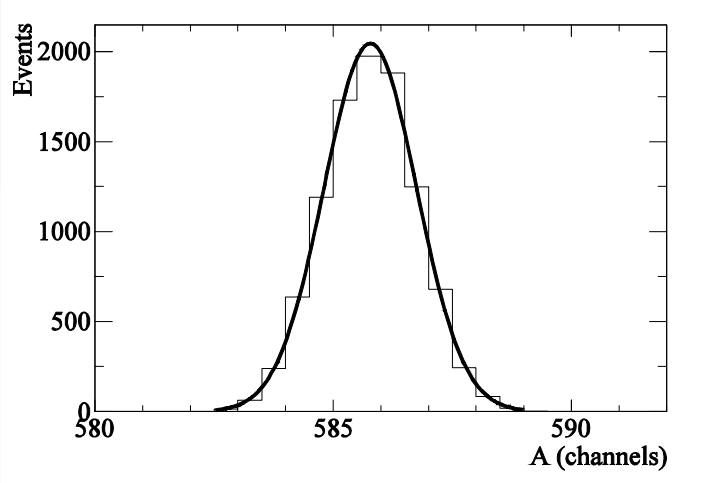
The channel is based on Z24 module, which consists of 40 MHz flash ADCs and FPGA Xilinx Zynq-7000. We achieve high time and amplitude resolution by processing oscillograms, which are obtained by flash ADC.



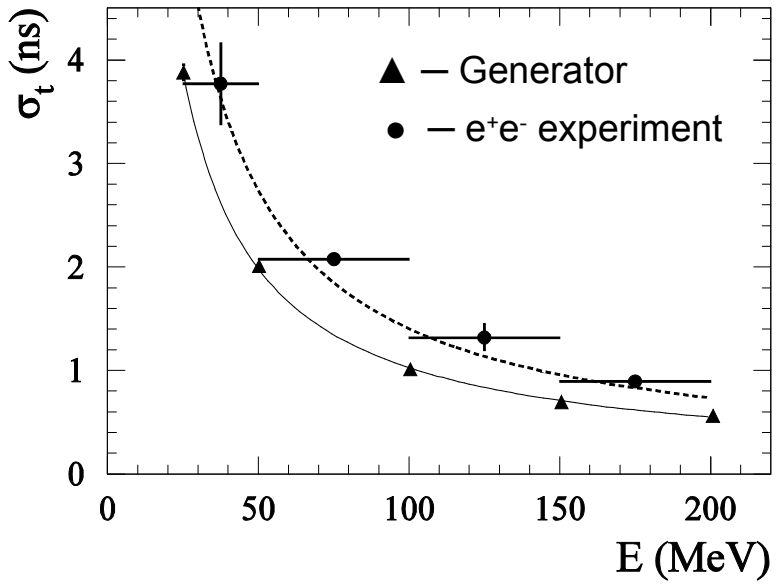
Z24– flash ADC (12 bit, freq 40 MHz) + FPGA Xilinx Zynq-7000
NaI – NaI(Tl) scintillator,
VPT – vacuum phototriode,
CSA – charge-sensitive preamplifier,
Gen – calibration generator,
F12M – shaping module,
FLT – first-level trigger

Off-line Fitting & Results





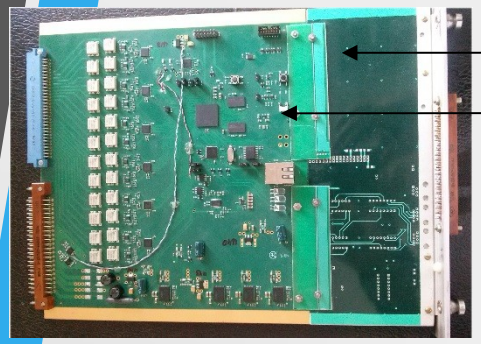
Amplitude resolution ~ 250 keV



Time resolution ~ 1 ns

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

Z24 Module & Fitting Algorithm

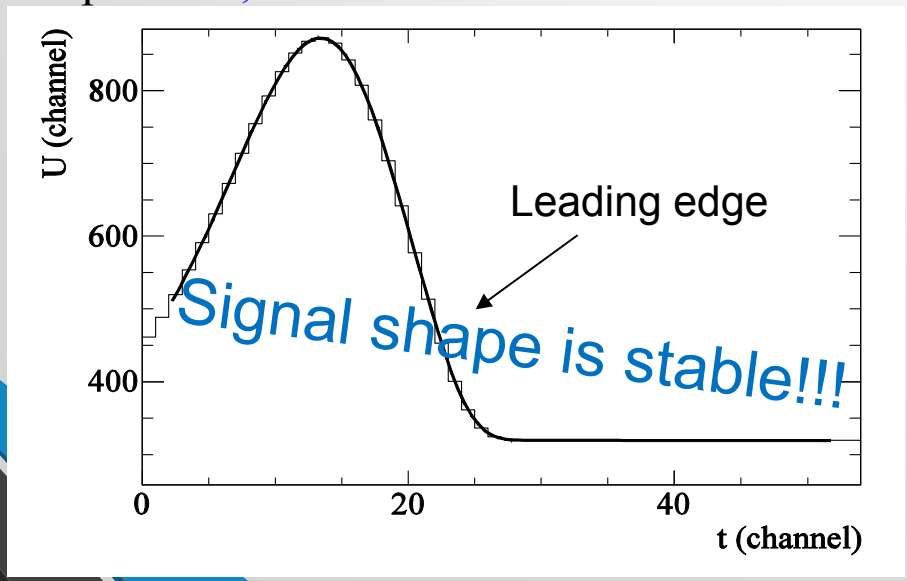


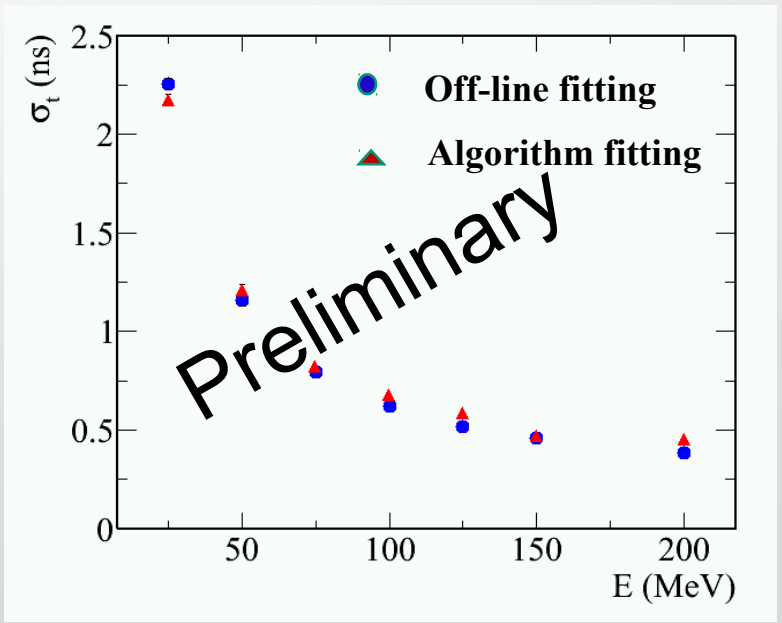
Z24 (test version)

FPGA Xilinx Zynq-7000
The FPGA includes Dual-core ARM® Cortex™-A9 Based Application Processor Unit. It allows us to upload OS Xilinx Petalinux and C++ fitting **algorithm** into the module.

Flash ADC AD9228
4 FADC channels into 1 package. Z24 has 6 FADC packages (24 FADC channels)
Resolution 12 bit
Max freq 40 MHz

The algorithm used in Z24 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, $F(t)$ is a function describing signal shape (cubic spline), A – signal amplitude, P – pedestal, Δt – the shift of the arrival time and S_{ij} is the noise covariance matrix.





Conclusion

- The prototype (FADC only) of the new spectrometric channel for the electromagnetic calorimeter of the SND detector has been tested
- New algorithm for operating with FPGA Xilinx Zynq-7000 has been developed and tested. Test results are consistent with previous ones obtained by off-line fitting procedure.
- High amplitude resolution better then 0.15 MeV has been obtained.
- Time resolution ~ 1 ns has been obtained.
- Design of the Z24 module may be applied in calorimeter electronics of the detector for the Super c-tau Factory.

Thank you for your attention