Spherical Neutral Detector tracking system for experiments at VEPP-2000 e^+e^- collider

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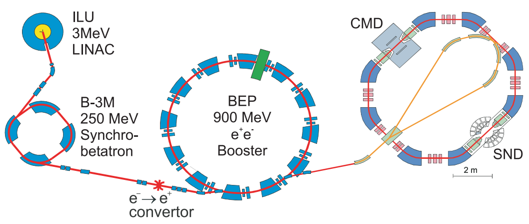
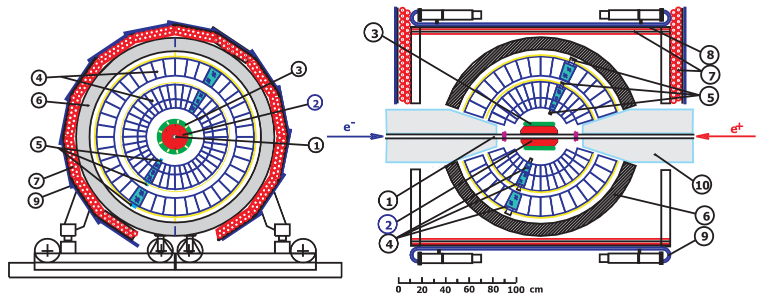
VEPP-2000 e^+e^- collider



C.m.s. energy range	0.4–2 GeV
Luminosity	10^{31} cm^{-2} s^{-1} $(2E = m_\phi)$ 10^{32} cm^{-2} s^{-1} $(2E = 2$ GeV$)$
Detectors	Cryogenic Magnetic Detector Spherical Neutral Detector

Spherical Neutral Detector

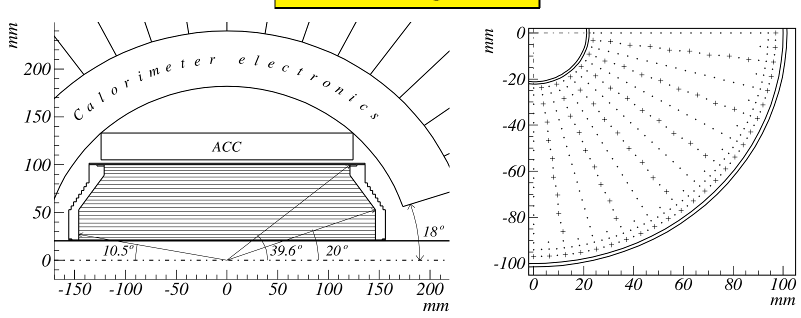


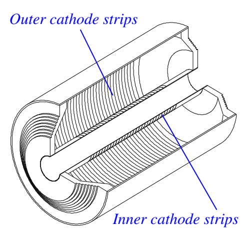
1 — VEPP-2000 beam pipe, 2 — tracking system, 3 — aerogel Cherenkov counter, 4 — NaI(Tl) crystals, 5 — vacuum phototriodes, 6 — spherical iron absorber, 7 — muon tubes, 8 — iron plates, 9 — scintillation counters, 10 — VEPP-2000 superconducting solenoids

SND physical program

- Precise measurement of hadronic cross-sections: $e^+e^- \to \pi^+\pi^-, K^+K^-, K_SK_L, \pi^+\pi^-\pi^0, K K\pi, \pi^+\pi^-\pi^0\pi^0, \pi^+\pi^-\pi^+\pi^-, \ldots$
- Study of vector mesons: $e^+e^- \to \rho, \omega, \phi, \rho', \omega', \ldots$
- Study of nucleon formfactors in $e^+e^- \to p\bar{p}, n\bar{n}$
- Two-photon physics: $\gamma\gamma \to \pi^0, \eta, \eta', \pi^0\pi^0, \ldots$

SND tracking system





- Drift chamber with jet cells
- Proportional chamber near the outer wall
- Cathode strips on the inner and outer walls
- Gas mixture: Ar + 10 % CO_2

Dimensions

Sensitive length	242 ÷ 292 mm
Inner diameter	40 mm
Outer diameter	200 mm
Solid angle (4 layers)	$0.94 \cdot 4\pi$
Sensitive volume	7.4 dm^3
Material budget	0.038 X_0

Design parameters

Gas gain	$5 \cdot 10^5$
$\sigma_{R-\varphi}$ (drift time)	150 μm
σ_z (charge division)	1.5 mm
σ_z (cathode strips)	300–600 μm
$\sigma_{dE/dx}/\langle dE/dx\rangle$	0.25
σ_θ	0.3°
σ_φ	0.2°
σ_R	0.2 mm
π/K separation (dE/dx)	at $p \leqslant 300$ MeV

- Small size
- Extremely high density of readout electronics channels

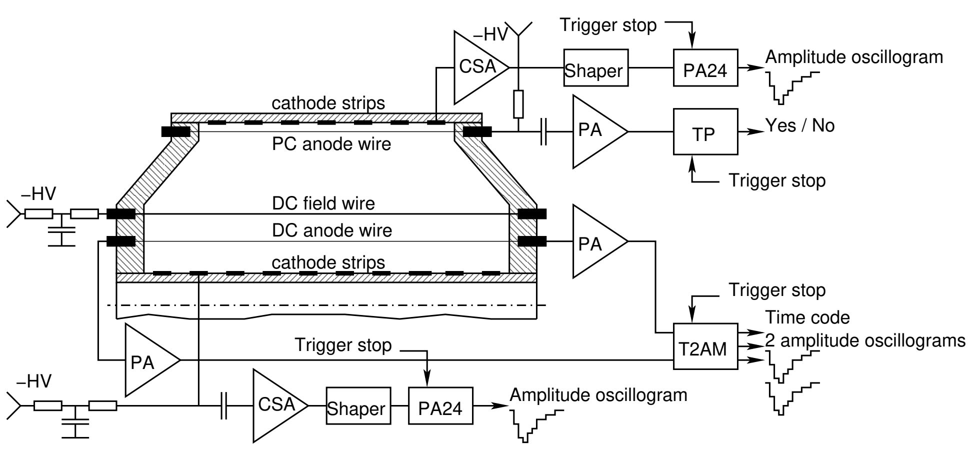
Drift chamber structure

Number of drift cells	24
Total number of DC anode wires	216
DC anode wire material	W-Re(Au)
DC anode wire diameter	20 μm (layer 1) 15 μm (layers 2–9)
DC field wire material	Ti-Cu (Au)
DC field wire diameter	120 μm
DC shield wire material	Ti-Cu (Au)
DC shield wire diameter	120 μm
Drift cell angular size $\Delta\varphi$	15°
Drift layer radial size Δr	6 mm (layer 1) 8 mm (layers 2–9)

Proportional chamber structure

Number of inner cathode strips	128
Number of outer cathode strips	160
PC anode wire material	W-Re (Au)
PC anode wire diameter	20 μm
PC field wire material	Ti-Cu (Au)
PC field wire diameter	120 μm
PC Wire spacing	3 mm
PC radial size Δr	6 mm
Strip patching Δz	6 mm
Strip angular size $\Delta\varphi$	90°

Tracking system electronics



- KLYUKWA standard
- T2AM module: 4×(TDC + 2 Flash ADC)
- PA24 module: 24-channel Flash ADC
- TP module: 16-channel discriminator

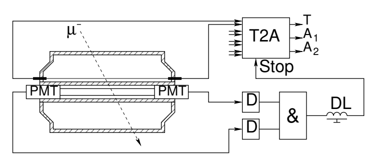
Drift chamber:
216 anode wires → 54 T2AM modules
Proportional chamber:
12 groups of 8 anode wires → 1 TP module
288 cathode strips → 12 PA24 modules

948 channels $\left\{\begin{array}{l}\text{216 time channels}\\ \text{720 amplitude channels}\\ \text{12 Yes/No channels}\end{array}\right.$

Tracking system prototype

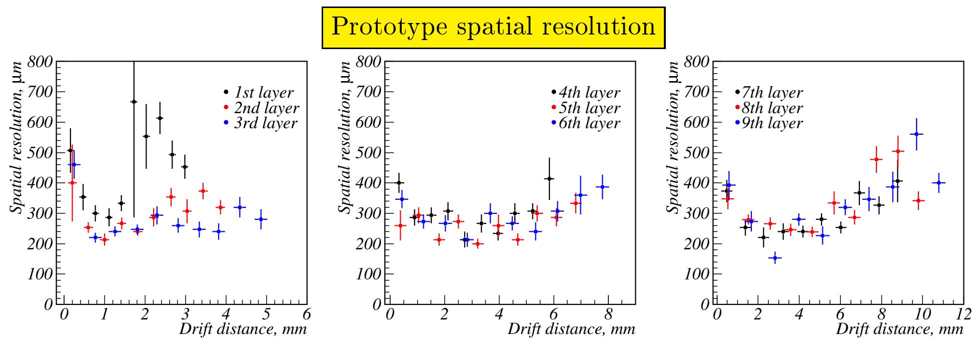
- Full-scale dimensions
- Wire structure is tensed in one quadrant of gas volume

Prototype tests with cosmic muons



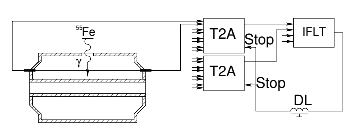
PMT — photomultiplier tube, T2A — old version of T2AM module, D — discriminator, DL — delay line

Prototype spatial resolution



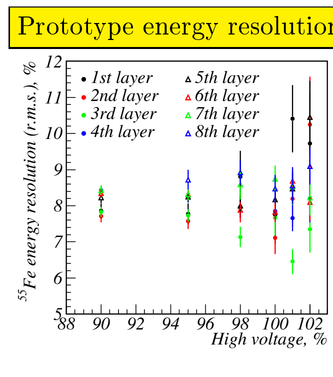
Results are in good agreement with expected design resolution (150 μm)

Prototype tests with ^{55}Fe

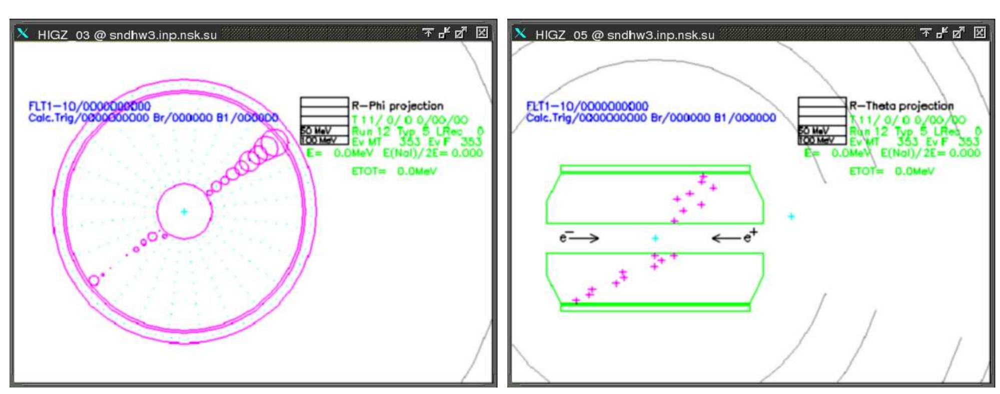


T2A — old version of T2AM module, IFLT — interface of first level trigger module, DL — delay line

Prototype energy resolution



An example of cosmic event detected by tracking system



Conclusions

- Results of prototype tests show good agreement between obtained and design resolution values

Current system status

- SND tracking system is fully assembled
- Wire tension measurement, hermeticity and high voltage tests have been performed
- The system is fully connected with the electronics
- Test runs with cosmic rays are being performed