INSTITUTE FOR NUCLEAR PROBLEMS OF BELARUSIAN STATE UNIVERSITY MINSK, BELARUS (INP BSU)

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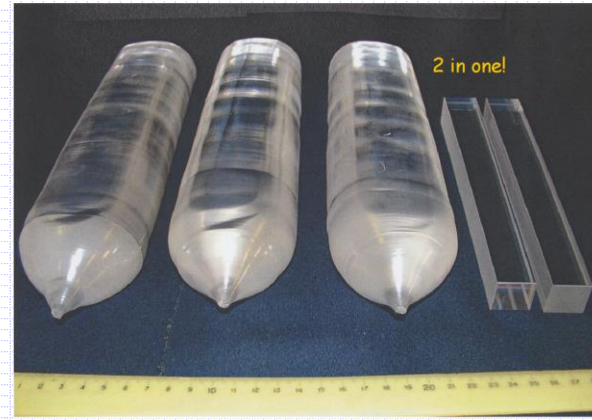
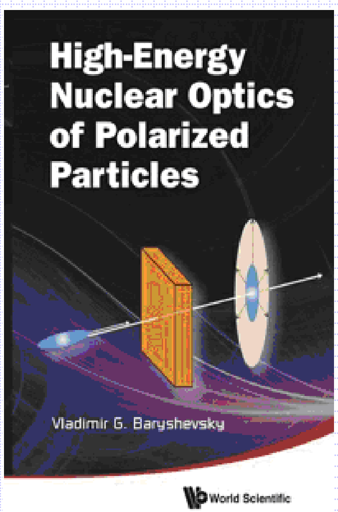
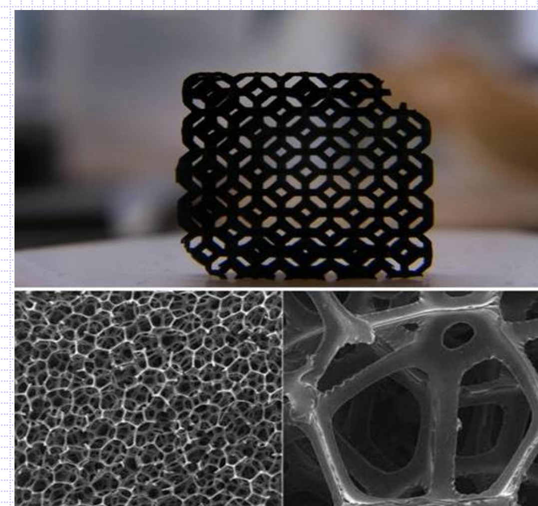
International Workshop “SPD at NICA-2019”
Dubna, June 4-8, 2019

INP BSU



Institute for Nuclear Problems of Belarusian State University (INP BSU) was founded in October,1986 and currently is the leading Belarusian research organization in the area of micro-world and nano-world physics and astrophysics.





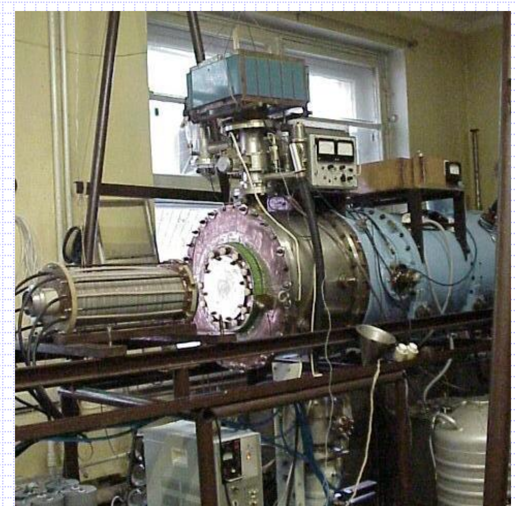
INP BSU: MAIN ACTIVITIES

- **Fundamental research:**
  - nuclear physics
  - interaction of ionizing radiations with matter
  - particle and high energy physics
  - astrophysics and cosmology
  - nanophysics

- **Applied research**

- **Organizational support** for scientific research carried out in the Joint Institute for Nuclear Research (Dubna) with the participation of organizations and institutions of Belarus

- **Training of scientific and technical personnel:**
  - including M.Sc., Ph.D. and D.Sc. studies in BSU,
  - improving of qualification of the teaching staff



http://www.inp.bsu.by/index.html

INP team

Physics

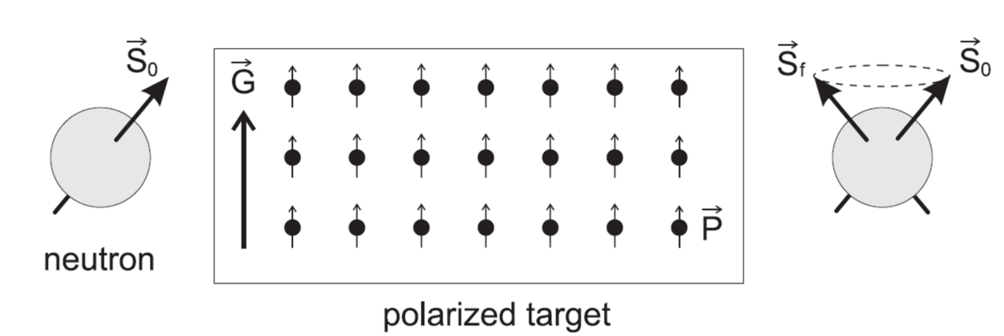
V.G. Baryshevsky, V.V. Tikhomirov,
A.R. Bartkevich, S.A. Anischenko,
A.A. Rouba, A.A. Gurinovich

Detectors and Electronics

AS. Lobko, O.V. Missevich, A.V. Solin,
A.A. Solin, I.F. Emelyanchik

Neutron nuclear precession (nuclear pseudomagnetism)

$$\psi(\vec{r}) = \begin{pmatrix} c_1 \ \psi_+ \ (\vec{r}) \\ c_2 \ \psi_- \ (\vec{r}) \end{pmatrix} = c_1 e^{i\vec{k}_\perp \vec{r}_\perp} e^{ik_z n_+ z} \begin{pmatrix} 1 \\ 0 \end{pmatrix} + c_2 e^{i\vec{k}_\perp \vec{r}_\perp} e^{ik_z n_- z} \begin{pmatrix} 0 \\ 1 \end{pmatrix}$$



V.G. Baryshevsky, M.I. Podgoretsky,
Nuclear precession of neutrons,
Zh. Eksp.Teor. Fiz., 47, 1050, (1964).
[Sov. Phys. JETP, 20, 704, (1965)]

$$p_{nx} = \cos[k_z \mathrm{Re}(n_+ - n_-)z] e^{-k_z \mathrm{Im}(n_+ + n_-)z} \langle\psi|\psi\rangle^{-1} ,$$

$$p_{ny} = -\sin[k_z \mathrm{Re}(n_+ - n_-)z] e^{-k_z \mathrm{Im}(n_+ + n_-)z} \langle\psi|\psi\rangle^{-1} ,$$

$$p_{nz} = \frac{1}{2}(e^{-2k_z \mathrm{Im} n_+ z} - e^{2k_z \mathrm{Im} n_- z})\langle\psi|\psi\rangle^{-1}$$

$$p_x^2 + p_y^2 + p_z^2 = 1 .$$

$$\theta = k_z \mathrm{Re}(n_+ - n_-)z = \frac{2\pi\rho}{k_z}\mathrm{Re}(f_+ - f_-)z$$

Neutron nuclear precession: experiments

- Abragam, A., Bacchella, G.L., Glattli, H. Meriel, P., Piesvaux, J., Pino, M. and Roubeau, P., **C.R. Acad. Sci., (Paris) B274 (1972) 423**

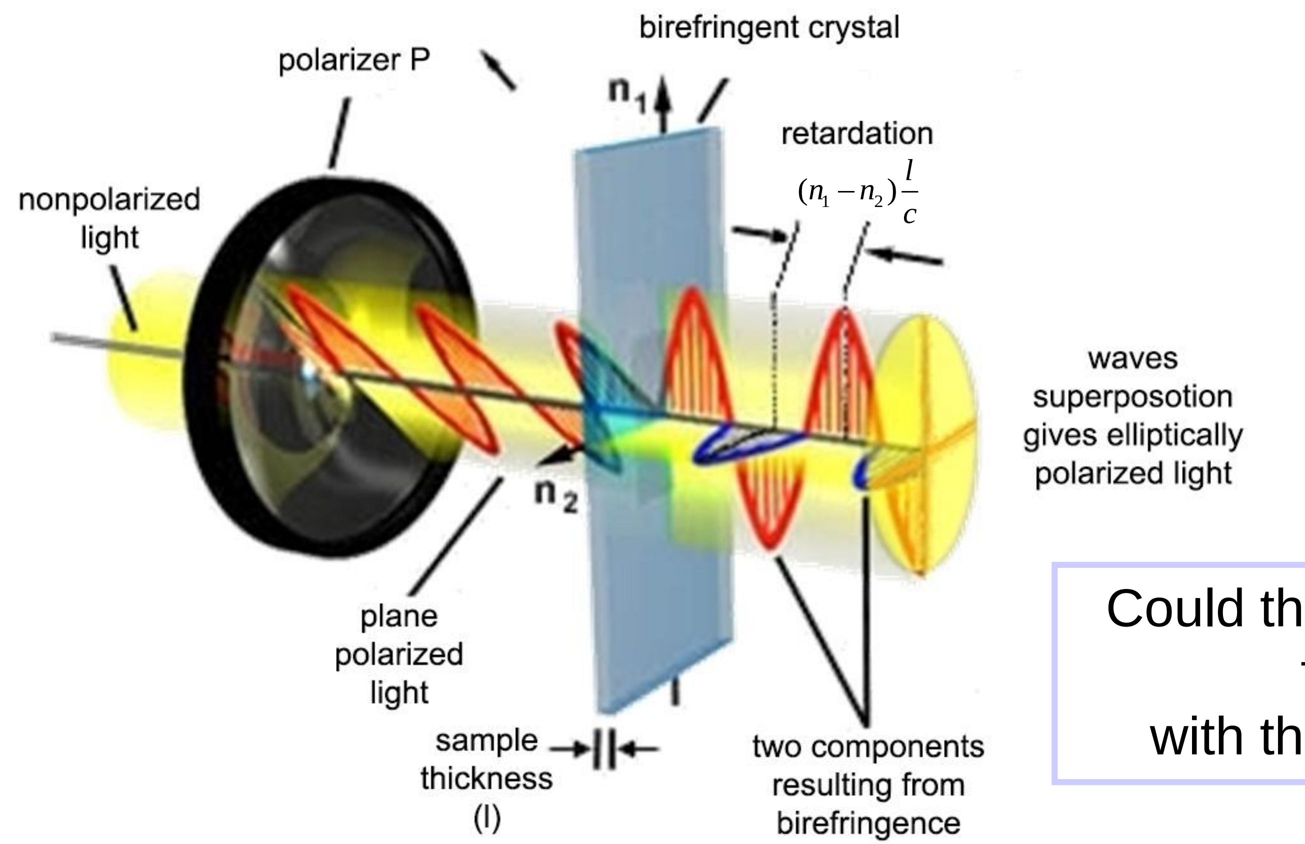
- Abragam, A. and Goldman, M., **Nuclear Magnetism: Order and Disorder**, **Oxford University Press, 1982.**

- Piegsa, F.M. , Van den Brandt, B., Glattli, H., Hautle, P., Kohlbrecher, J., Konter, J.A., Schlimme, B.S and Zimmer, O. A, Ramsey apparatus for the measurement of the incoherent neutron scattering lengthof the deuteron, **Nucl. Instrum. Methods A 589, 2 (2008) 318.**

- Van den Brandt, B., Glattli, H., Griesshammer, H. W.,Hautle, P., Kohlbrecher, J., Konter, J. A. and Zimmer, O. The spin dependent nd scattering length: A proposed high accuracy measurement, **Nucl. Instrum. Methods A 526 (2004) 91.**

- Van den Brandt, B., Glattli, H., Hautle, P., Konter, J.A.,Piegsa, F.M. and Zimmer, O. The measurement of the incoherent neutron scattering length of the deuteron, **Nucl. Instrum. Methods A 611 (2009) 231.**

Birefringence effect



Could the similar effect exist for particles with the nonzero mass ?

V.G. Baryshevsky, *Birefringence of particles (nuclei, atoms) of spin S≥1 in matter*, **Phys. Lett. A 171, 5-6 (1992) 431**

V.G. Baryshevsky, *Spin oscillations of high-energy particles (nuclei) passing through matter and the possibility of measuring the spin-dependent part of the amplitude of zero-angle elastic coherent scattering*, **J. Phys. G 19, 2 (1993) 273**

Deuteron spin dichroism: experiments

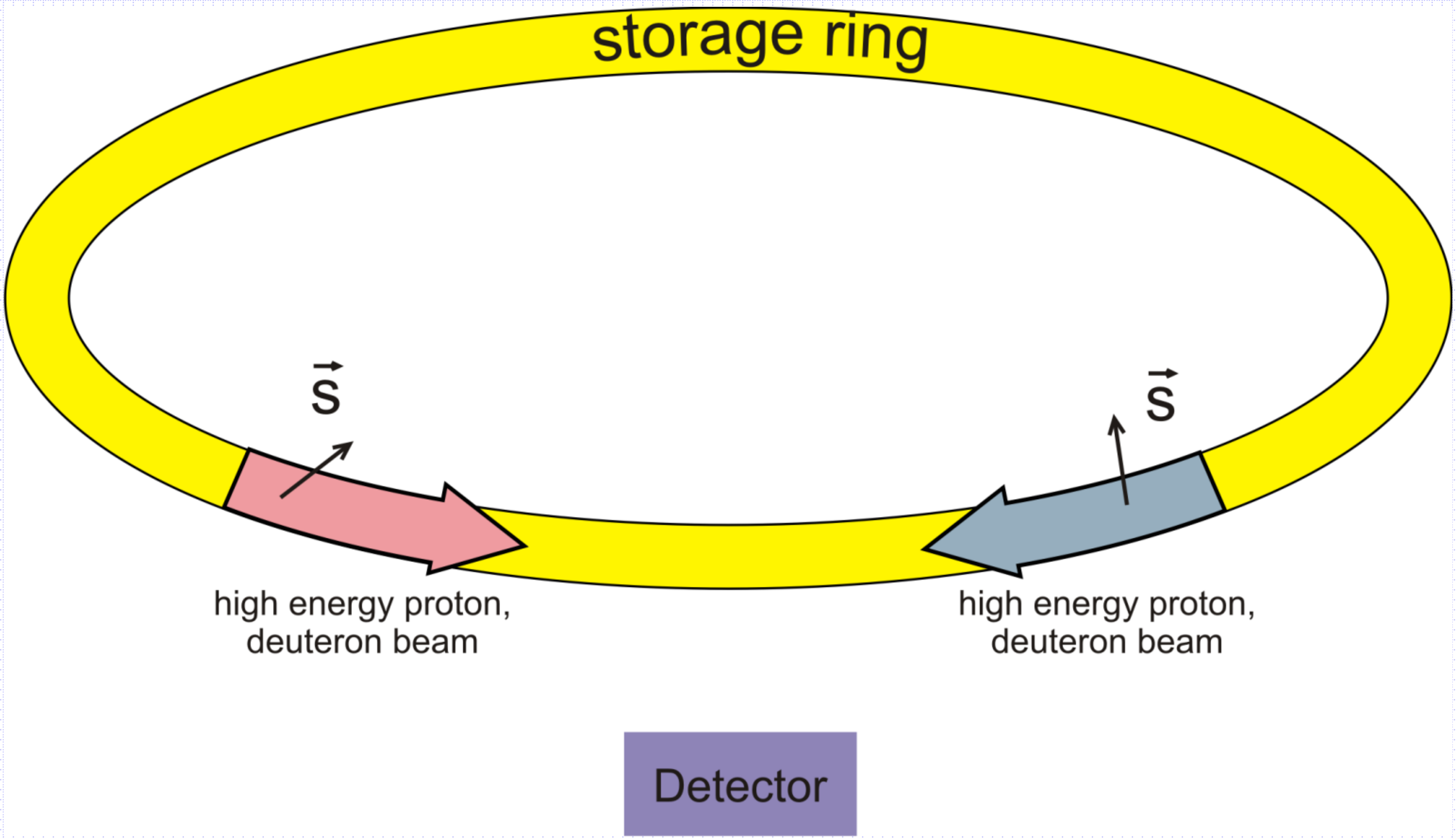
***First observation of spin dichroism with deuterons up to 20 MeV in a carbon target* (LANL arxive: hep-ex/0501045)**

- **V. Baryshevsky, A. Rovba** (Research Institute of Nuclear Problems, Minsk, Belarus)
- **R. Engels, F. Rathmann, H. Seyfarth, H. Stroher, T. Ullrich** (Institut fur Kernphysik, Forschungszentrum Julich, Germany)
- **C. Duweke, R. Emmerich, A. Imig, J. Ley, H. Paetz gen. Schieck, R. Schulze, G. Tenckhoff, C. Weske** (Institut fur Kernphysik, Universitat zu Koln, Germany)
- **M. Mikirtytchiants, A. Vassiliev** (PNPI, Russia)

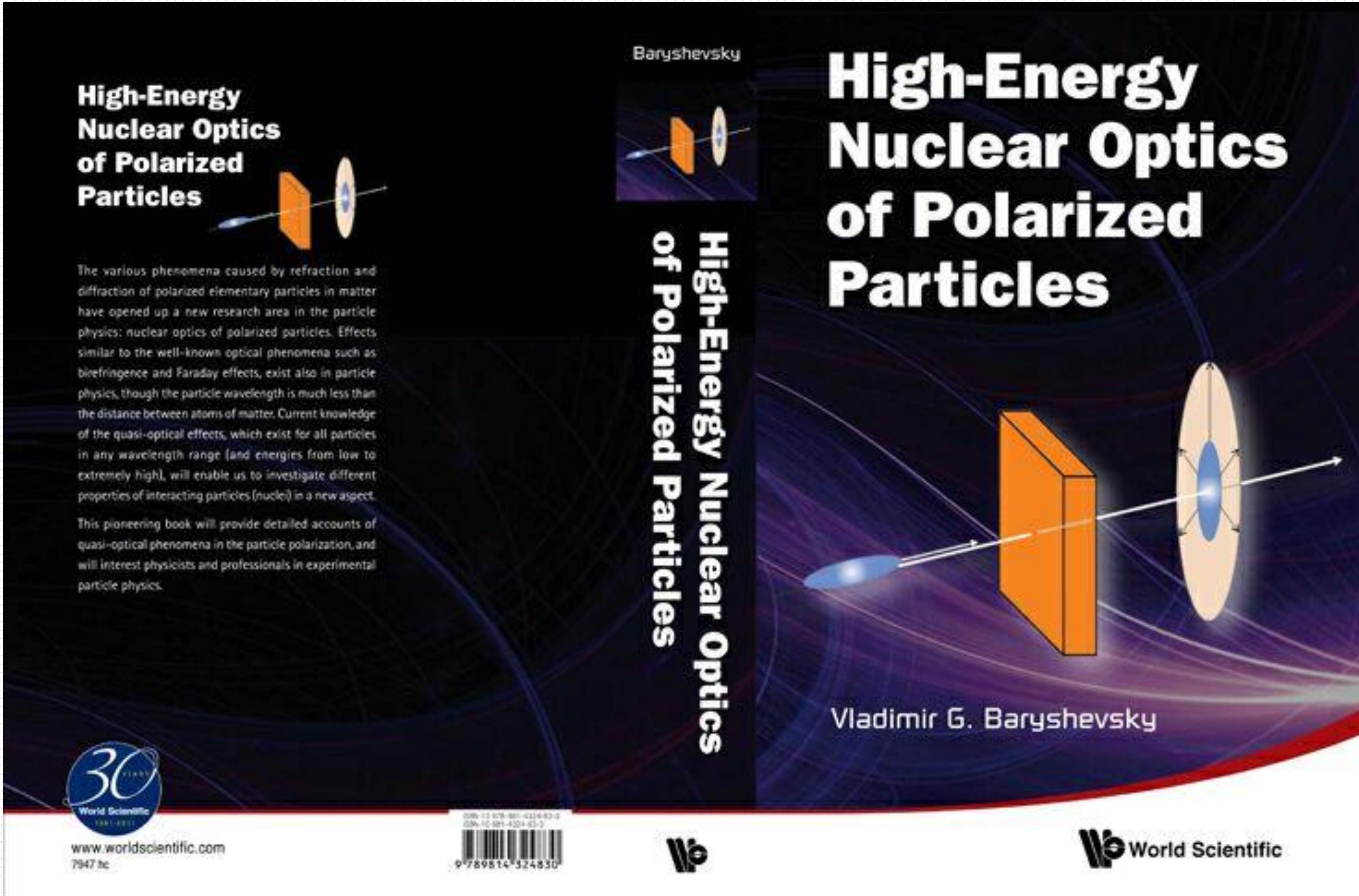
- H. Seyfarth, R. Engels, F. Rathmann, H. Stroher, V. Baryshevsky, A. Rouba, C. Duweke, R. Emmerich, A. Imig, K. Grigoryev, M. Mikirtychiants, and A. Vasilyev, *Production of a beam of tensor-polarized deuterons using a carbon target*, **Phys. Rev. Lett. 104, 22 (2010) 222501**.
- L. S. Azhgirei, Yu. V. Gurchin, A. Yu. Isupov, A.N. Khrenov, A. S. Kiselev, A.K. Kurilkin, P.K. Kurilkin, V.P. Ladygin, A.G. Litvinenko, V.F. Peresedov, S.M. Piyadin, S.G. Reznikov, P.A. Rukoyatkin, A.V. Tarasov, T.A. Vasiliev, V.N. Zhmyrov, and L.S. Zolin, *Observation of Tensor Polarization of Deuteron BeamTraveling through Matter*, **Physics of Particles and Nuclei Letters 5, 5 (2008) 432**.

to be continued (NICA; COSY) …..

Storage ring. How spin rotation and dichroism influence on measurement results in spin collaboration experiments?



V.G. Baryshevsky *Rotation of particle spin in a storage ring with a polarized beam and measurement of the particle EDM, tensor polarizability and elastic zero-angle scattering amplitude //* J. Phys. G: Nucl. Part. Phys. 35 (2008) 035102 (23 pp)



High-Energy Nuclear Optics of Polarized Particles
The various phenomena caused by refraction and diffraction of polarized elementary particles in matter have opened up a new research area in the particle physics: nuclear optics of polarized particles. Effects similar to the well-known optical phenomena such as birefringence and Faraday effects, exist also in particle physics, though the particle wavelength is much less than the distance between atoms of matter. Current knowledge of the quasi-optical effects, which exist for all particles in any wavelength range (and energies from low to extremely high), will enable us to investigate different properties of interacting particles (nuclei) in a new aspect.
This pioneering book will provide detailed accounts of quasi-optical phenomena in the particle polarization, and will interest physicists and professionals in experimental particle physics.
World Scientific
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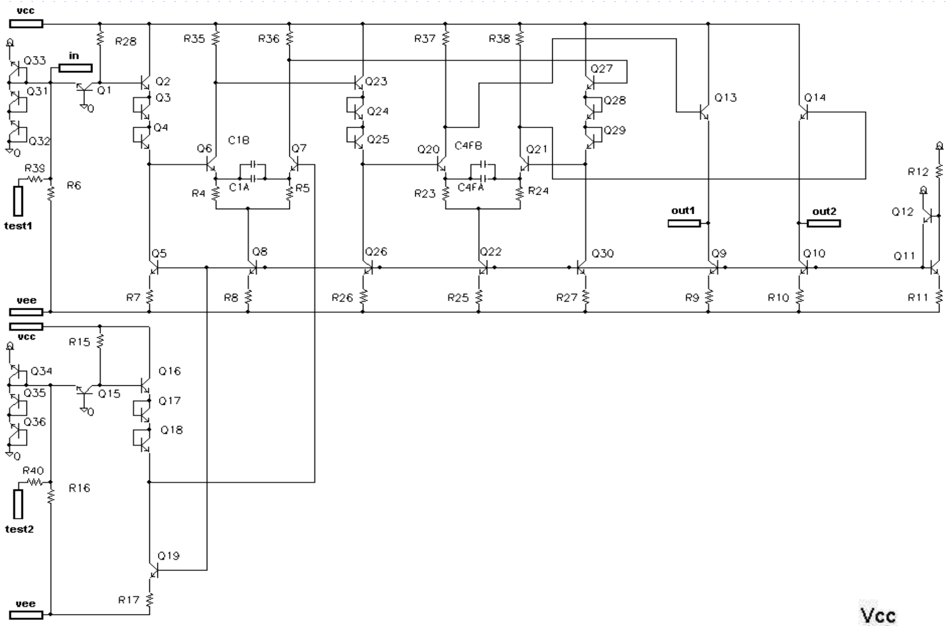
High-Energy Nuclear Optics of Polarized Particles
High-Energy Nuclear Optics of Polarized Particles
Vladimir G. Baryshevsky
World Scientific

Developments in detector and technologies

INP BSU (NC PHEP BSU) has solid expertise for development of custom integrated circuits (IC) for many years.
Two custom monolithic 8-channel ICs trans-impedance amplifiers Ampl-8.3 and fast comparators Disc-8.3 have been developed and produced for 50 thousand channels of the Forward Muon System of the Dzero experiment (Fermilab), 8 thousand channels for Muon System of the COMPASS (CERN), one thousand channels in the PiBeta (PSI), and 3200 channels with straw-tubes of SVD-2 (IHEP, Protvino). Now we engineer 8-channel custom low-impedance amplifier for the muon system of the PANDA project (GSI) and 9-channel amplifier for electromagnetic calorimeters of the NICA experiment setups.

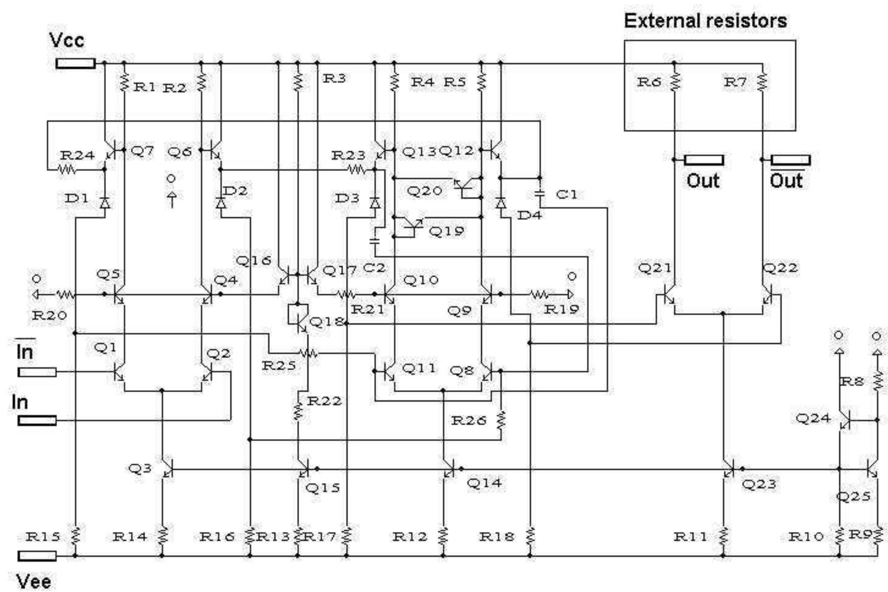
Custom 8-channel transimpedance amplifier Ampl-8.3 and comparator Disc-8.3 ICs

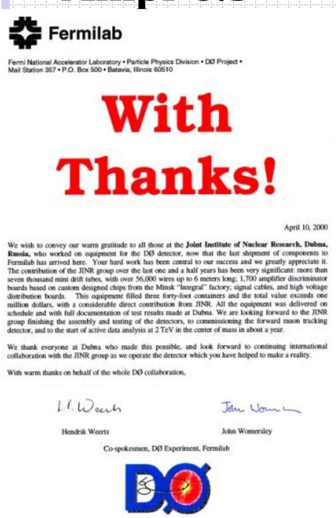


FNAL, D0: 50000 channels

Ampl-8.3

Disc-8.3




Fermilab

Fermi National Accelerator Laboratory • Particle Physics Division • DØ Project • Mail Station 357 • P.O. Box 500 • Batavia, Illinois 60510

With Thanks!

April 10, 2000

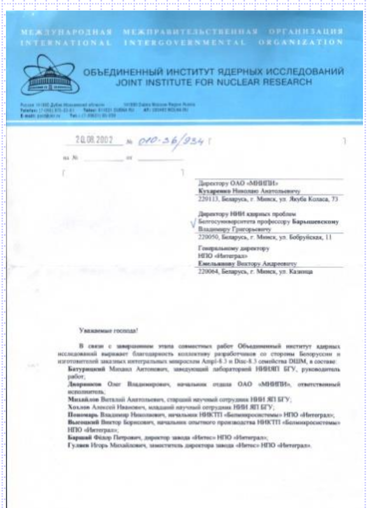
We wish to convey our warm gratitude to all those at the **Joint Institute of Nuclear Research, Dubna, Russia,** who worked on equipment for the DØ detector, now that the last shipment of components to Fermilab has arrived here. Your hard work has been central to our success and we greatly appreciate it. The contribution of the JINR group over the last one and a half years has been very significant: more than seven thousand mini drift tubes, with over 56,000 wires up to 6 meters long; 1,700 amplifier discriminator boards based on custom designed chips from the Minsk "Integral" factory; signal cables, and high voltage distribution boards. This equipment filled three forty-foot containers and the total value exceeds one million dollars, with a considerable direct contribution from JINR. All the equipement was delivered on schedule and with full documentation of test results made at Dubna. We are looking forward to the JINR group finishing the assembly and testing of the detectors, to commissioning the forward muon tracking detector, and to the start of active data analysis at 2 TeV in the center of mass in about a year.

We thank everyone at Dubna who made this possible, and look forward to continuing international collaboration with the JINR group as we operate the detector which you have helped to make a reality.

With warm thanks on behalf of the whole DØ collaboration,

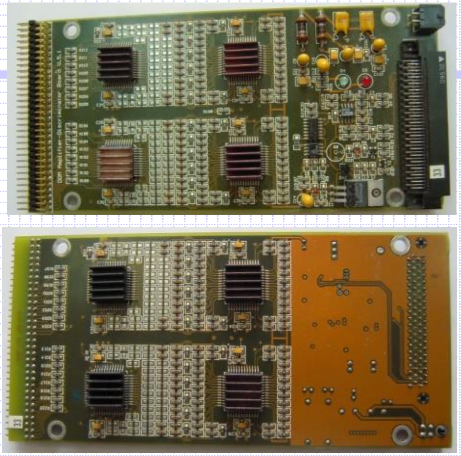
Hendrik Weerts John Womersley

Co-spokesmen, DØ Experiment, Fermilab

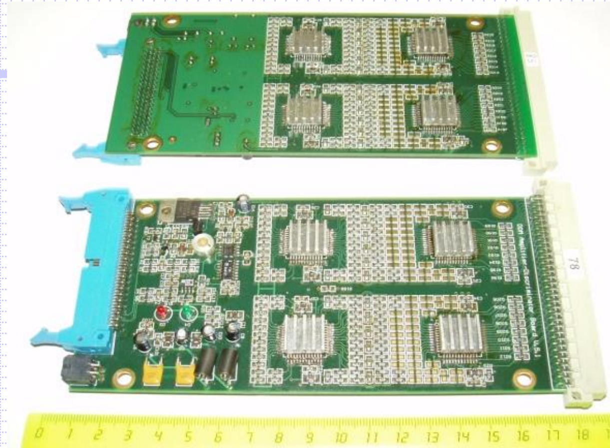

МЕЖДУНАРОДНАЯ МЕЖПРАВИТЕЛЬСТВЕННАЯ ОРГАНИЗАЦИЯ
INTERNATIONAL INTERGOVERNMENTAL ORGANIZATION

ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ
JOINT INSTITUTE FOR NUCLEAR RESEARCH

CERN, COMPASS: 8000 ch.

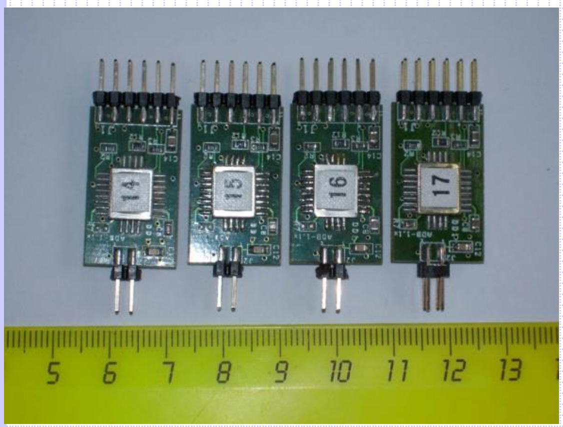


IHEP, SVD-2: 3200 ch.



JINR, VBLHEP: 8640 ch.

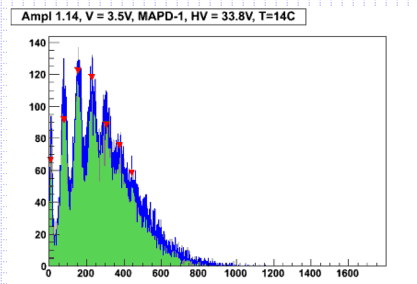
Custom IC set for SiPM used in hodoscopic systems



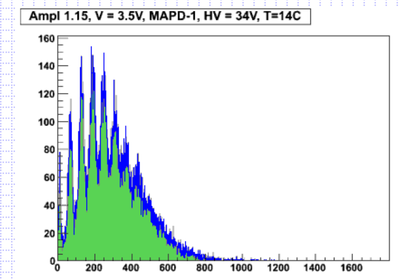
board set for SiPM

MAPD-1

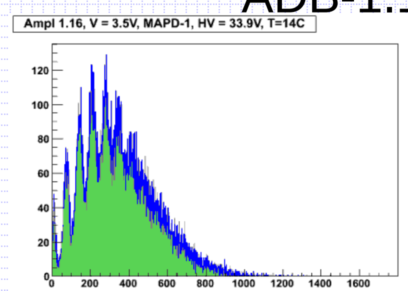
(ADB-1.14 – ADB-1.17)



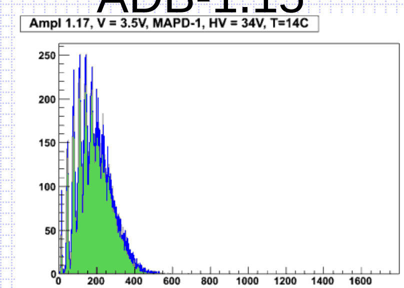
ADB-1.14



ADB-1.15



-1.16



ADB-1.17

Photoelectrons counting

A front-end ASIC for perspective straw detectors

NA64 (CERN); CBM (DESY); B@NM, NICA-MPD, **-SPD** (JINR**)**

A front-end ASIC called AST-1-1 was developed at the Belarus State University together with the Detector Systems Sector of the JINR VBLHEP. It is specifically designed to read signals from straw detectors. Each AST-1-1 chip processes signals from eight straw tubes, providing eight LVDS outputs to the TDC.

NA64, CBM, B@MN straw tubes readout PCB

The front-end electronics PCB of the straw tubes readout for **NA64, CBM, B@MN** experiment**s** is shown in figure 5. On this board, called the NA64, signals from 32 tubes are first processed by one of four custom-designed monolithic amplifier-shaper-discriminator chips. On the NA64 boards, the supply voltage is set at 2.8 V.

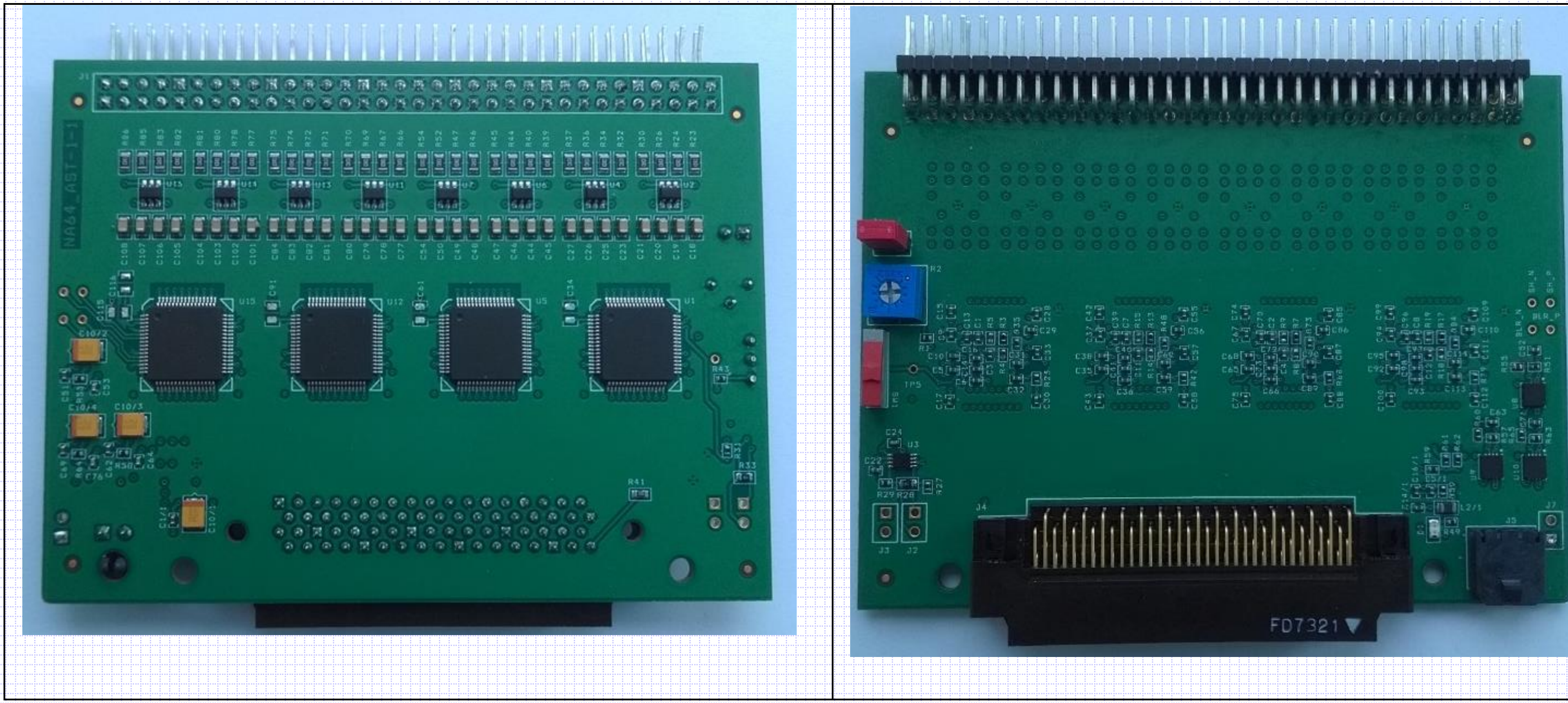


Fig. 5 Front-end electronics PCB for straw detectors

Plans

Design and manufacture of a readout electronics system for the NICA-SPD straw detector based on AST-1-1 chip

………………………………………………………

Thank you for attention!