ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ

Дубна

95-47

E2-95-47

E.L.Bratkovskaya, M.Schäfer*, W.Cassing*, U.Mosel*,
O.V.Teryaev, V.D.Toneev

ANISOTROPY OF DILEPTON EMISSION FROM NUCLEON-NUCLEON INTERACTIONS

Submitted to «Physics Letters B»

*Institut für Theoretische Physik, Universität Giessen, D-35392 Giessen, Germany

1995

During the last years a lot of work has been concentrated on the study of dilepton production in NN, pd, pA and AA reactions in order to learn about the hadron dynamics in the nuclear interior [1]-[8]. Leptonic probes are quite attractive since they provide weakly disturbed information on hot and dense nuclear matter at different stages of its evolution in heavy-ion collisions at energies of about a few GeV/u. On the other hand there are a lot of hadronic sources for dileptons because the electromagnetic field couples to all charges and magnetic moments. It is thus very desirable to have additional information which allows to disentangle the various sources experimentally.

In hadron-hadron collisions, the e^+e^- pairs are created due to the electromagnetic decay of time-like virtual photons. In turn, these virtual photons can result from the bremsstrahlung process or from the decay of baryonic and mesonic resonances including the direct conversion of vector mesons into virtual photons in accordance with the vector dominance hypothesis. In its rest frame, the decay of an unpolarized photon gives an isotropic angular distribution for a created lepton pair since there is no preferential direction. However, the coupling of the virtual photon to hadrons induces a dynamical spin alignment of both, resonances and virtual photons. We thus can expect that the angular distribution of a lepton (e.g. e^-) will be anisotropic with respect to the direction of the dilepton (i.e. virtual photon) emission. This *decay* anisotropy (defined for the given dilepton mass M) is carrying some information on the spin alignment of the virtual photon as well as on the spins of colliding or decaying hadrons and thereby should allow to disentangle different production processes.

In this letter we focus on the investigation of angular distributions of dileptons emitted from nucleon-nucleon interactions within two particular channels: the delta resonance and NN-bremsstrahlung. In a preceding study these anisotropy effects for different channels (bremsstrahlung, Dalitz decays of delta resonance, η, π^0, $\pi^+\pi^-$-annihilation, Drell-Yan process) were discussed in the framework of the soft photon approximation [9]; here we reanalyse the angular anisotropy on the basis of the microscopic One-Boson-Exchange (OBE) model developed for dilepton production in [10].

To characterize the decay anisotropy, we choose the polar θ and azimuthal φ angles of the momentum $\vec{l}_-$ of a created electron with respect to the momentum $\vec{q}$ of a virtual photon, where $\vec{l}_-, \vec{l}_+$ are measured in the rest frame of this virtual photon, i.e. $\vec{l}_- + \vec{l}_+ = 0$. The kinematical situation is illustrated in Fig. 1. In order to compare the shape of the

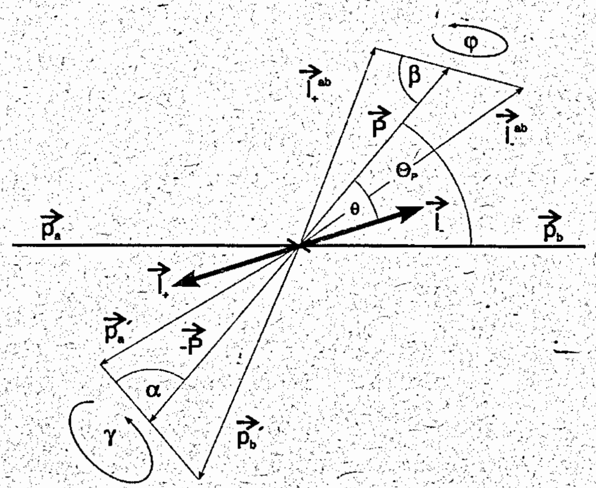

Fig. 1: *Illustration of the kinematical situation for e^+e^- pair production in pN interactions. $\vec{l}_-^{ab}, \vec{l}_+^{ab}$ are the lepton momenta in the nucleon center-of-mass system ($\vec{p}_a + \vec{p}_b = 0$) while $\vec{P}$ is half the total lepton momentum $l_-^{ab} + l_+^{ab}$. $\vec{l}_-, \vec{l}_+$ are the lepton momenta in the lepton center-of-mass system ($\vec{l}_- + \vec{l}_+ = 0$). Θ_P is the angle between the beam axis, given by the initial proton momentum $\vec{p}_a$, and the momentum $\vec{P}$. α and β are the angles between $\vec{P}$ and the relative momentum between both nucleons and both leptons, respectively. γ and φ are the additional rotational degrees of freedom around the $\vec{P}$ direction while θ is the polar angle of the lepton momentum $\vec{l}_-$ and $\vec{P}$ ($\vec{P} = \frac{\vec{q}}{2}$).*

angular distribution for different channels, it is convenient to represent the differential cross section for dilepton production in the following form:

$$S(M,\theta) \equiv \frac{d\sigma}{dM^2 d\cos\theta} = A(1 + B\cos^2\theta), \tag{1}$$

where M is the invariant mass of a lepton pair ($M^2 = q_0^2 - \vec{q}^2$). The anisotropy coefficient B then is defined by

$$B = \frac{S(M,\theta = 0^o)}{S(M,\theta = 90^o)} - 1. \tag{2}$$

Since the coefficient B is sensitive to the spin structure of the interacting hadrons, it is in general a function of M and the masses of the hadrons involved in the reaction. Before actually presenting the numerical results for B we briefly recall the basic concepts of the microscopic OBE-model adopted [10].

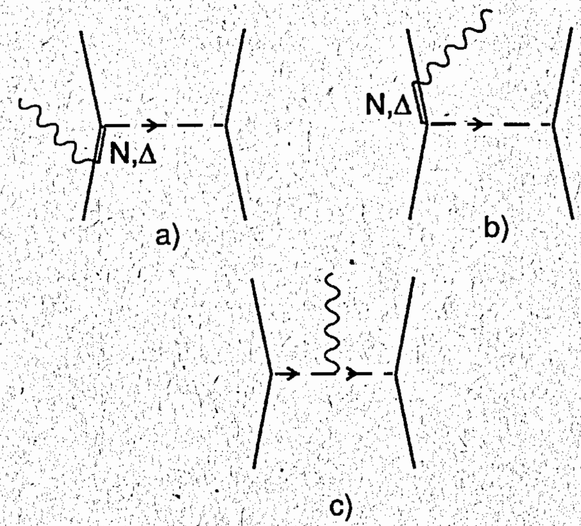

Fig. 2: *Feynman diagrams for (virtuell) photon emission after (a), before (b) and during (c) the nucleon-nucleon interaction. The double line denotes either an off-shell nucleon or a Δ resonance.*

We investigate hadronic interactions in first order covariant perturbation theory in the nucleon-nucleon interaction, where particles are produced from the external nucleon lines and from charged meson lines (Fig. 2). Particle emission between subsequent NN interaction vertices is omitted in our calculation, but we include the more important effects of excited nucleon states, i.e. in particular the Δ-resonances.

To determine all the coupling parameters involved in our calculation we directly fit the T-matrix by an effective nucleon-nucleon interaction based on One-Boson-Exchange diagrams. For lab energies up to 400 MeV such fits were performed, using up to 16 mesons, in [11, 12]. Here we restrict ourselves to the most essential mesons for fitting elastic nucleon-nucleon scattering data for lab energies in the range from 800 MeV up to 3 GeV. For the interaction between nucleons and mesons we use the Hamiltonian:

$$\begin{aligned} H_{int} &= g_\sigma \bar{\psi}\psi\sigma + g_\omega \bar{\psi}\gamma_\mu\psi\omega^\mu \\ &+ g_\rho \bar{\psi}\left(\gamma_\mu + \frac{\kappa\sigma_{\mu\nu}\partial^\nu}{2m_N}\right)\vec{\tau}\psi\vec{\rho}^\mu \\ &+ ig_\pi \bar{\psi}\gamma_5\vec{\tau}\psi\vec{\pi} + g_a\bar{\psi}\gamma_5\gamma_\mu\vec{\tau}\cdot\vec{a}^\mu\psi, \quad g_a = g_\pi/\sqrt{3}, \end{aligned} \tag{3}$$

where $\sigma, \omega, \vec{\rho}, \vec{\pi}$ and $\vec{a}$ denote the scalar, vector, isovector-vector, isovector-pseudoscalar and isovector-axialvector meson fields, respectively.

We account for the finite size of the hadrons by introducing a formfactor,

$$F_i(k^2) = \frac{\Lambda_i^2 - m_i^2}{\Lambda_i^2 - k^2}, \tag{4}$$

at each strong-interaction vertex where k is the four-momentum and m the mass of the exchanged meson.

Altogether we have eight parameters which have to be determined by elastic nucleon-nucleon scattering data. However, in the "effective interaction scheme" adopted it is not possible to reproduce all the data in the desired energy range from 800 MeV up to 3 GeV with energy independent parameters. Therefore we have kept the four cutoffs Λ energy independent and use for each meson a coupling constant depending smoothly on the total c.m. energy as

$$g(\sqrt{s}) = g_0 \exp(-l\sqrt{s}). \tag{5}$$

With these 12 parameters $(\Lambda, g(0), l)_i$ (given in Table 1) we fit the T-matrix to the relevant pp and pn data at the laboratory energies of 1.73, 2.24 and 3.18 GeV for proton-proton and proton-neutron scattering (cf. Ref.[10] for details).

	$\frac{g^2}{4\pi}$	l	m [GeV]	Λ [GeV]
π	12.562	0.1133	0.138	1.005
σ	2.340	0.1070	0.550	1.952
ω	46.035	0.0985	0.783	0.984
ρ	0.317	0.1800	0.770	1.607
	κ=6.033			

Table 1: *Coupling constants used in the calculations.*

As already mentioned above, it is necessary to include higher resonances for particle production in the energy region considered here. In this study we limit ourselves to the implementation of the Δ resonances. Due to isospin conservation only isospin-1-mesons can be exchanged, i.e. the pion and the ρ-meson. The corresponding vertex functions are:

$$\Gamma_\mu^{N\Delta\pi} = -\frac{f_{N\Delta\pi}}{m_\pi} k_\mu \vec{T}, \tag{6}$$

$$\Gamma_{\mu\alpha}^{N\Delta\rho} = -i\frac{f_{N\Delta\rho}}{m_\rho}\left(k_\nu \gamma^\nu g_{\mu\alpha} - k_\mu \gamma_\alpha\right)\gamma_5 \vec{T}, \tag{7}$$

where k_μ denotes the momentum of the outgoing meson, $\vec{T}$ the isospin-operator. From the decay $\Delta \rightarrow N + \pi$ we have determined the $N\Delta\pi$–coupling constant to $f_{N\Delta\pi} = 2.13$.

The Δ propagator is adopted from Ref. [13] and reads:

$$G_\Delta^{\mu\nu}(P_\Delta) = -\frac{(P_{\Delta\alpha}\gamma^\alpha + M_{\Delta 0})}{P_\Delta^2 - M_{\Delta 0}^2}\left(g^{\mu\nu} - \frac{1}{3}\gamma^\mu\gamma^\nu - \frac{2}{3M_{\Delta 0}^2}P_\Delta^\mu P_\Delta^\nu - \frac{1}{3M_{\Delta 0}}(\gamma^\mu P_\Delta^\nu - P_\Delta^\mu \gamma^\nu)\right). \tag{8}$$

The mass of the Δ in the denominator is modified by an imaginary width $M_{\Delta 0} \rightarrow M_{\Delta 0} - i\Gamma/2$ due to the fact that Δ's have a short lifetime due to the pionic decay which depends on the invariant energy of the delta or equivalently on the momentum k_π of the decaying pion in the restframe of the Δ. Nonrelativistic calculations of the Δ selfenergy lead to a k_π^3 dependence of the width [14]. We take [15]

$$\Gamma(M_\Delta^2) = \Gamma_0 \left[\frac{k_\pi(M_\Delta^2)}{k_\pi(M_{\Delta 0}^2)}\right]^3 \frac{k_\pi^2(M_{\Delta 0}^2) + \kappa^2}{k_\pi^2(M_\Delta^2) + \kappa^2},$$
$$k_\pi(M_\Delta^2) = \sqrt{\frac{(M_\Delta^2 + m_N^2 - m_\pi^2)^2}{4M_\Delta^2} - m_N^2}, \tag{9}$$

where M_Δ is the mass of an off-shell Δ. The constant Γ_0 is the free width of 0.12 GeV and κ is fixed to 0.16 GeV.

As in the case of nucleon-nucleon scattering (4), we use formfactors for the nucleon-Δ vertex but now of dipole form [16] in order to keep the self-energy of the nucleon finite[1],

$$F_i^*(k^2) = \left(\frac{\Lambda_i^{*2} - m_i^2}{\Lambda_i^{*2} - k^2}\right)^2, \quad i = \pi, \rho. \tag{10}$$

The three new parameters f_ρ, Λ_π^* and Λ_ρ^* are fitted to the existing data [15] for mass-differential cross sections for $N + N \rightarrow N + \Delta$ in the energy range 1 - 2.5 GeV. In a fit to experimental data of the $pp \rightarrow n\Delta^{++}$ reaction at 3 energies (970 MeV, 1.48 GeV, 2.02 GeV) we have obtained

$$\Lambda_\pi^* = 1.421\text{GeV}, \quad \Lambda_\rho^* = 2.273\text{GeV}, \quad f_{N\Delta\rho} = 7.4. \tag{11}$$

We note that in this case a good fit can be obtained already without a $\sqrt{s}$ dependence, except at the highest energy. (The results in comparison to the experimental data are given in Ref. [10].)

[1] A monopole formfactor would not change any of the results reported below if we use a somewhat smaller cut-off.

Having fixed the fundamental couplings of the OBE-model we now turn to the calculation of the dilepton anisotropy. For the dilepton emission via a **delta resonance**, formed in the $NN \to \Delta N \to NNe^+e^-$ process, the dilepton differential cross section can be written in the form:

$$\frac{d\sigma}{dM^2 d\cos\theta} = \int d\Omega_N\, d\vec{P}\, \frac{1}{(\varepsilon_+^{ab}+\varepsilon_-^{ab})E_a|\vec{p}_a|(2\pi)^7}\, \frac{M^2\sqrt{M^2+4|\vec{P}|^2}}{8|\vec{Q}_L|^3}\, |T|^2 \qquad (12)$$
$$\times \frac{2m_N m_e|\vec{Q}_N||\vec{Q}_L|}{\left|(\varepsilon_+^{ab}+\varepsilon_-^{ab})|\vec{Q}_L| + (\varepsilon_-^{ab}-\varepsilon_+^{ab})|\vec{P}|\cos\beta\right| \cdot \left|(E_a'+E_b')|\vec{Q}_N| + (E_a'-E_b')|\vec{P}|\cos\alpha\right|},$$

where p_a, p_b and p_a', p_b' are the four momenta of initial and outgoing nucleons, respectively, E_a, E_b and $\vec{p}_a, \vec{p}_b$ are the energy and momentum of nucleons in the nucleon-nucleon center-of-mass system ($\vec{p}_a + \vec{p}_b = 0$); $\varepsilon_-^{ab}, \varepsilon_+^{ab}$ and $\vec{l}_-^{ab}, \vec{l}_+^{ab}$ are the energy and momentum of leptons in the same reference frame. $\vec{P} = \frac{1}{2}(\vec{l}_-^{ab} + \vec{l}_+^{ab})$ is half of the total lepton momentum, $\vec{Q}_L = \vec{l}_-^{ab} - \vec{P}$, and $\vec{Q}_N = \vec{p}_a\,' - \vec{P}$. α and β are the angles between $\vec{P}$ and $\vec{Q}_N$ and $\vec{P}$ and $\vec{Q}_L$, respectively. The angle β is related with the polar angle θ via $\cos\beta = \frac{\sqrt{M^2+4|\vec{P}|^2}}{2|\vec{Q}_L|}\cos\theta$ with $|\vec{Q}_L| = \frac{1}{2}\sqrt{M^2 + 4|\vec{P}|^2\cos^2\theta}$.

The transition matrix element T is obtained by summing all Feynman diagrams over the exchanged mesons π, ρ: $|T|^2 = |\sum_i (T_\pi^{(i)} + T_\rho^{(i)})|^2$, where the term $|T|^2$ tacitly already includes a sum over final spin and average over initial spin degrees of freedom. For example, the matrix element for the t-channel including π-exchange is given by

$$T_\pi^{(t)} = J_\mu^\Delta\; J^N\; L^\mu, \qquad (13)$$

where the lepton current L_μ is defined as

$$L_\mu = \overline{u}(l_-)\gamma_\mu v(l_+), \qquad (14)$$

and l_-, l_+ are the four momenta of the leptons. The hadron current for the $N\Delta N$-line is

$$J_\mu^\Delta = \overline{u}(p_a)\; G_{\alpha\beta}^\Delta(P_\Delta)\; k_\alpha\; \Gamma_{\beta\mu}^{N\Delta\gamma}\; u(p_a'), \qquad (15)$$

where $k = p_a - P_\Delta$ is the four momentum of the exchanged pion, and $G_{\alpha\beta}^\Delta(P_\Delta)$ is the delta propagator (8). The $N\Delta\gamma$ vertex function is taken in the form:

$$\Gamma_{\beta\mu}^{N\Delta\gamma} = -i\frac{f_{N\Delta\gamma}}{m_\pi}(q_\nu\gamma^\nu g_{\beta\mu} - q_\beta\gamma_\mu)\gamma_5, \quad f_{N\Delta\gamma} = 0.32\,, \qquad (16)$$

where $q = l_- + l_+$ is the four momentum of virtual photon. The coupling constant has been obtained from the experimental partial width of the Δ of 0.6% for the decay into a real photon. The hadron current for the NN-line is

$$J^N = \overline{u}(p_b)\Gamma^{NN\pi}u(p_b'). \qquad (17)$$

We stress that we take into account the interference between all diagrams with π, ρ meson exchange.

For the cross section of dilepton production in **non-resonance** processes $NN \to NNe^+e^-$ we use the same expression (12) as in the delta case. The Feynman diagrams for the Born terms look like (a) and (b) in Fig. 2, but it is necessary to add the diagrams with the emission of a virtual photon from the other nucleon line for the pp-channel and the pn-channel, because we also include the coupling to the anomalous magnetic moment of the nucleon. As a consequence now also the neutron lines can contribute to the radiation of dileptons. The amplitude T includes the sum over the five meson-exchange diagrams taking into account the interference between all diagrams with the different mesons $(\pi, \sigma, \rho, \omega, a)$,

$$T^\gamma = \sum_{iM} J_\mu^{(iM)}\; J_N^{(iM)}\; L^\mu, \quad i = \text{diagram}, \quad M = \pi, \sigma, \rho, \omega, a. \qquad (18)$$

The hadron current for the $NN\gamma$-line is (for diagram (a) in Fig. 2):

$$J_\mu^{(aM)} = \overline{u}(p_a)\gamma_\mu\frac{(p_{a_\nu}\gamma^\nu - q_\nu\gamma^\nu + m_N)}{((p_a - q)^2 - m_N^2)}\Gamma^{NNM}u(p_a'), \qquad (19)$$

where Γ^{NNM} is the nucleon-nucleon-meson vertex ($M = \pi, \sigma, \rho, \omega, a$). Finally, we also perform calculation in while we treat the resonance and nonresonance graphs coherently by summing up over the T-matrix (13) and (18).

As a first computed observable we show in Fig. 3 the invariant mass spectra for dileptons both for pp and pn collisions at the two bombarding energies of 1.0 and 2.1 GeV. In all cases the dominant contribution arises from the resonance amplitude where the intermediate, off-shell particle is a Δ; in fact the total yield is almost equal to the contribution of the Δ amplitude alone. The pn amplitude for these graphs is about a factor 2–3 larger than for the pp reactions; this factor is mainly determined by different isospin factors.

The graphs involving only intermediate nucleon lines are significantly larger for pn than for pp reactions (factors 6 and 4 at 1 and 2.1 GeV, respectively), which is due to

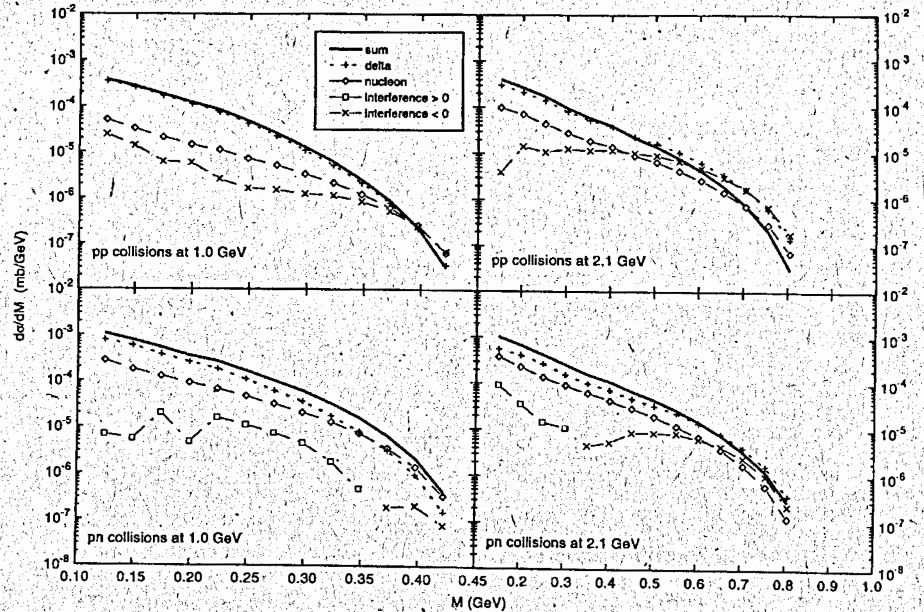

Fig. 3: *Result of calculations for the cross section of dilepton production in proton-nucleon scattering at 1.0 and 2.1 GeV. The diamonds display the contribution of non-resonance diagrams; the resonance contribution to this reaction is given by the crosses(+). The squares and the crosses(x) gives the positive, respectively negative interference between resonances and non-resonance amplitudes. The coherent sum of all contributions is given by the solid line. The individual contributions for the proton-proton reaction are shown in a) and for the proton-neutron reaction in b).*

the destructive interference between the radiation from both particles in the case of pp scattering. The total yield from pn is larger than that from pp by only about a factor of 4 at 1 GeV and a factor of 2.5 at 2.1 GeV (both at $M = 0.2$ GeV).

At first sight the mass-spectra of the nucleon graphs and the Δ graphs alone look very similar. However, a closer inspection shows that at 1 GeV both merge at the high end of the mass spectrum. In this situation a sizeable interference of both contributions also takes place. Note also that the increase of the bombarding energy leads to a hardening of the spectra, but not to an increase of the value at small M.

In Fig. 4 we show the results of our calculations for the differential cross section for

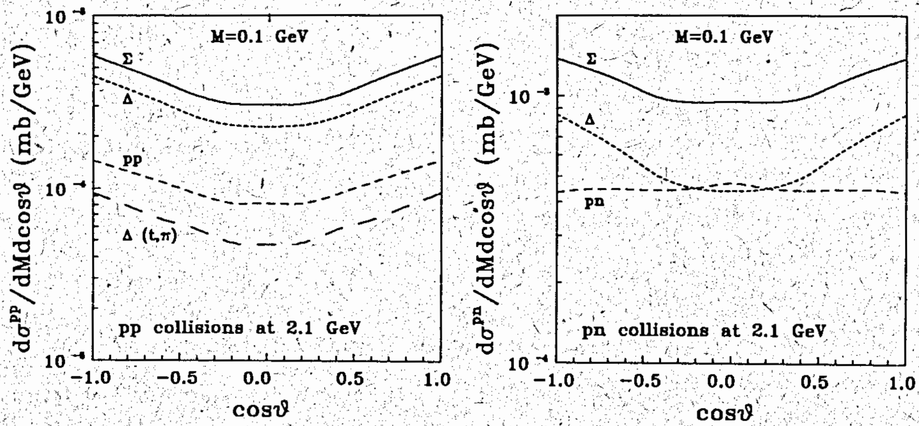

Fig. 4: *The differential cross section for dileptons in pp and pn reactions as a function of $\cos\theta$ for fixed $M = 0.1$ GeV at 2.1 GeV bombarding energy. The "Δ" labels the contribution of the delta resonance term, the "$\Delta(t,\pi)$" denotes the contribution of the t-channel with a single π–meson exchange only; "pp", "pn" denote the Born terms for the pp, pn collisions, respectively, and "Σ" the sum of all channels including the interferences.*

dileptons in pp and pn reactions as a function of $\cos\theta$ for fixed $M = 0.1$ GeV at 2.1 GeV bombarding energy. The "Δ" labels the contribution of the delta resonance term, the "$\Delta(t,\pi)$" denotes the contribution of the t-channel with π–meson exchange only; "pp", "pn" denote the Born terms for the pp, pn collisions, respectively, and "Σ" the sum of all channels including the interferences. As seen from this figure, the absolute value of the cross section related to the mechanism with an intermediate delta is sensitive to the model. Taking into account all diagrams of delta production and their interferences changes the value of the cross section by about a factor 4. However, the form of the cross section remains the same as it can be seen from the curves labeled "Δ" and "$\Delta(t,\pi)$", respectively.

The anisotropy coefficients B for pp and pn collisions as functions of M at 1.0 and 2.1 GeV are plotted in Fig. 5. As was shown in Ref. [9] the B values are ranging from +1 (for pseudoscalar meson (π^0, η) Dalitz decay) to -1 (for $\pi^+\pi^-$ annihilation or ρ decay) and depend on both, the invariant mass M and the process considered. The solid curves with label "Σ" correspond to the calculation in the "full" OBE-model accounting for all mesons exchanges and all diagrams including the interferences. The "Δ" labels the contribution of the delta resonance term, "*pp*", "*pn*" denote the Born terms for the *pp*, *pn* collisions, respectively. For the case of the delta we also present the results of a calculation involving only the π-exchange in the t-channel given by the long dashed curve labeled "$\Delta(t,\pi)$" for the *pp* reaction at 2.1 GeV. The dotted and the long dashed line in this Fig. are almost identical since the coefficient B, which is defined as a ratio of differential cross sections (cf. eq. (2)), is not sensitive to the absolute value of the cross section, whereas the angular distributions are quite similar (l.h.s. of Fig. 4).

In Ref. [9] the dilepton cross section from the Δ channel was approximated by a product of the delta production cross section and the differential width of the Δ Dalitz decay. The B value in this approximation is +1 as for the case of pseudoscalar meson (π^0, η) Dalitz decay. We note that though this approximation reproduces the form of the inclusive dilepton spectrum calculated within the OBE-model, it should be considered as rather unrealistic for the study of more subtle microscopic effects such as polarization phenomena and spin effects. Only for nearly real photons ($M \to 0$) the coupling to the hadronic part (or delta alignment) becomes negligable. Thus we obtain a rather complicated behavior for the coefficient B in the OBE-model instead of $B = +1$ in [9].

For the same reasons the functional dependence of B for the Born terms changes very strongly with M: the dashed curves in Fig. 5 labeled "*pn*" are the results in the OBE-model, the dashed curves labeled "*pn* (SPA)" are the result from [9] based on the soft photon approximation (SPA) for the dilepton bremsstrahlung. Here again the results are close at the lower energy (1 GeV) and low dilepton mass M. Note that at small M an increase of the virtual photon energy leads to a decrease of B in the soft-photon approximation while B increases with M in the OBE-calculation and remains positive for all M contrary to the SPA.

In summary we can conclude that the angular anisotropy B of dilepton pairs is very sensitive to the microscopic details of the interaction and can be used to determine the relative weight of the hadronic production channels in pN reactions as a function of the invariant mass M. It remains to be seen whether this angular anisotropy can also be used to distinguish between the various reaction channels in heavy-ion induced dilepton production.

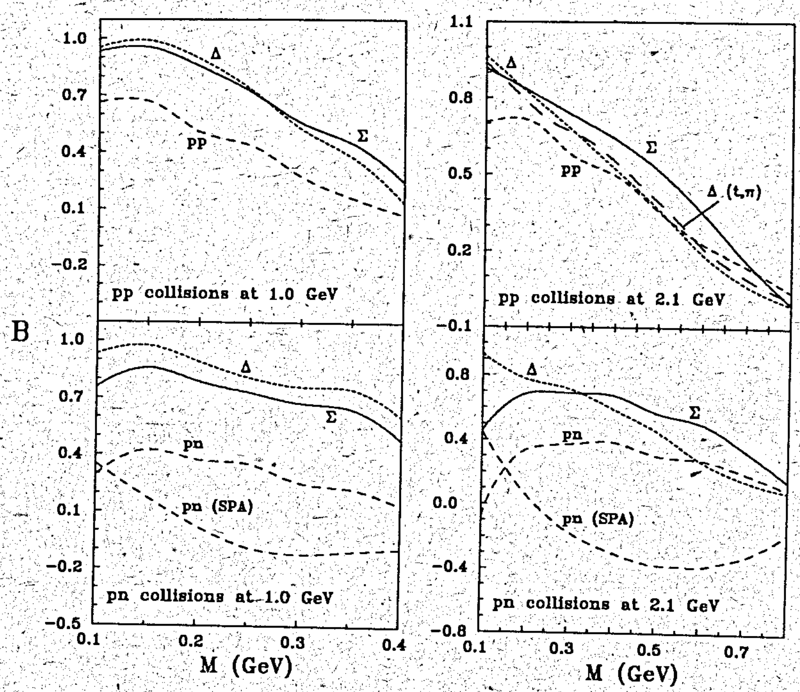

Fig. 5: *The anisotropy coefficients B for pp and pn collisions as functions of M at 1.0 and 2.1 GeV. The solid curves with label "Σ" correspond to the calculation in the "full" OBE-model accounting for all mesons exchanges and all diagrams. The "Δ" labels the contribution of the delta resonance term, "pp", "pn" denote the Born terms for the pp, pn collisions, respectively. For the case of the delta we also present the results of a calculation involving a single π-exchange in the t-channel in terms of the long dashed curve labeled "Δ(t, π)" at 2.1 GeV (upper right). The result for the bremsstrahlung contribution in the soft photon approximation from [9] is given by the dashed lines labeled "pn (SPA)".*

The authors acknowledge stimulating discussions with S.S. Shimanskiy and A.I. Titov. E.L.B. is grateful to the Institute for Theoretical Physics of the University of Giessen for the support and kind hospitality during her visit. Part of this research was stimulated by discussions during the INT-94-3 program on 'Hot and Dense Nuclear Matter' in Seattle. Furthermore, this research was supported by BMFT and GSI Darmstadt and partly performed in the framework of the Grants $N^{\underline{o}}$ MP8000 and RFE000 from the International Science Foundation.

References

[1] C. Gale and J. Kapusta. Phys. Rev. **C35** (1985) 2107; Phys. Rev. **C40** (1988) 745.

[2] L.H. Xia, C.M. Ko, L. Xiong and J.Q. Wu, Nucl. Phys. **A485** (1988) 721.

[3] C.L. Korpa and S. Pratt, Phys. Rev. Lett. **64** (1990) 1502; C.L. Korpa et al., Phys. Lett. **B246** (1990) 333.

[4] M. Herrmann, B. Friman and W. Nörenberg, Nucl. Phys. **A545** (1992) 267c; Nucl. Phys. **A560** (1993) 411.

[5] L. Xiong, Z.G. Wu, C.M. Ko and J.Q. Wu, Nucl. Phys. **A512** (1990) 772.

[6] Gy. Wolf, G. Batko, W. Cassing, et al., Nucl. Phys. **A517** (1990) 615.

[7] V.D. Toneev, K.K. Gudima and A.T. Titov, Preprint GSI-92-05, Darmstadt, 1992; Sov. Jour. of Nucl. Phys. **55** (1992) 1715; K.K. Gudima, A.I. Titov and V.D. Toneev, Phys. Lett. **B 287** (1992) 302.

[8] Gy. Wolf, W. Cassing, W. Ehehalt and U. Mosel, Progr. Part. Nucl. Phys. **30** (1993) 273; Gy. Wolf, W. Cassing and U. Mosel, Nucl. Phys. **A552** (1993) 549.

[9] E.L. Bratkovskaya, O.V. Teryaev, V.D. Toneev, Preprint of Institute for Nuclear Theory, NK-12, University of Washington, DOE/ER/40561-167-INT94-15-01. Submitted to Phys. Lett. **B**.

[10] M. Schäfer, H.C. Dönges, A. Engel and U. Mosel, Nucl. Phys. **A575** (1994) 429.

[11] C. F. Horowitz, Phys. Rev **C31** (1985) 1340

[12] D. P. Murdock and C. F. Horowitz, Phys. Rev **C35** (1987) 1442

[13] M. Benmerrouche et al., Phys. Rev. **C39** (1989) 2339

[14] W. Weise, Nucl. Phys. **A278** (1977) 402

[15] V. Dmitriev, O. Sushkov and C. Gaarde, Nucl. Phys. **A459** (1986) 503

[16] B.J. Verwest, Phys. Lett. **83B** (1979) 161

Received by Publishing Department on February 7, 1995.

Братковская Е.Л. и др.

E2-95-47

Анизотропия вылета дилептонов в нуклон-нуклонных взаимодействиях

Исследованы угловые характеристики (анизотропии) вылета e^+e^--пар в нуклон-нуклонных взаимодействиях при промежуточных энергиях на основе модели однобозонного обмена, параметры которой извлекаются из данных по упругому NN-взаимодействию. Показано, что анизотропия очень чувствительна к спиновой структуре амплитуды рождения дилептонов и, как следствие, позволяет идентифицировать их различные источники. В работе вычислены коэффициенты анизотропии для тормозного излучения в NN-рассеянии и для распада дельта-резонанса.

Работа выполнена в Лаборатории теоретической физики им. Н.Н.Боголюбова ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна, 1995

Bratkovskaya E.L. et al.

E2-95-47

Anisotropy of Dilepton Emission from Nucleon-Nucleon Interactions

We study the angular characteristics of e^+e^--pairs produced in nucleon-nucleon interactions at intermediate energies on the basis of a one-boson-exchange model fitted to elastic NN–scattering. Due to spin and angular momentum constraints, the dilepton anisotropy is found to be sensitive to the contribution of different sources. The anisotropy from NN-bremsstrahlung and delta–resonance is calculated and compared to the Dalitz decay from pseudo-scalar and vector mesons.

The investigation has been performed at the Bogoliubov Laboratory of Theoretical Physics, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna, 1995