Search for NN→6q phase transition in the np-polarized measurements at energies T_{kin} = 1 ÷ 6 GeV

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Introduction

To advance studies of the **short range spin structure of *NN* interactions**, there were (*np*) spin observables measured for the first time at 0 up to the **highest nucleon internal momenta *k*** in *np*-core. **Both the bounded polarized (*np*)-couple** (in deuteron) and a **polarized free *np*-couple** were probed up to $\boldsymbol{k \approx 5\ \mathrm{fm}^{-1}}$ and $\mathbf{6\ fm^{-1}}$ respectively. The **highest energy polarized deuteron (up to 9 GeV/c)** and polarized monochromatic neutron beams (up to 4.5 GeV/c), provided now only by the JINR accelerators, were used [2,3] **for energy dependence measurements $T_{20}(k)$** up to $\boldsymbol{k \approx 5\ \mathrm{fm}^{-1}}$ [2a] in the ***d*→*p* stripping up to kinematic limit of *k***, and **$\Delta\sigma_L$(*np*) total *np* cross section differences** in new energy range of 1.2 – 3.7 GeV [3].

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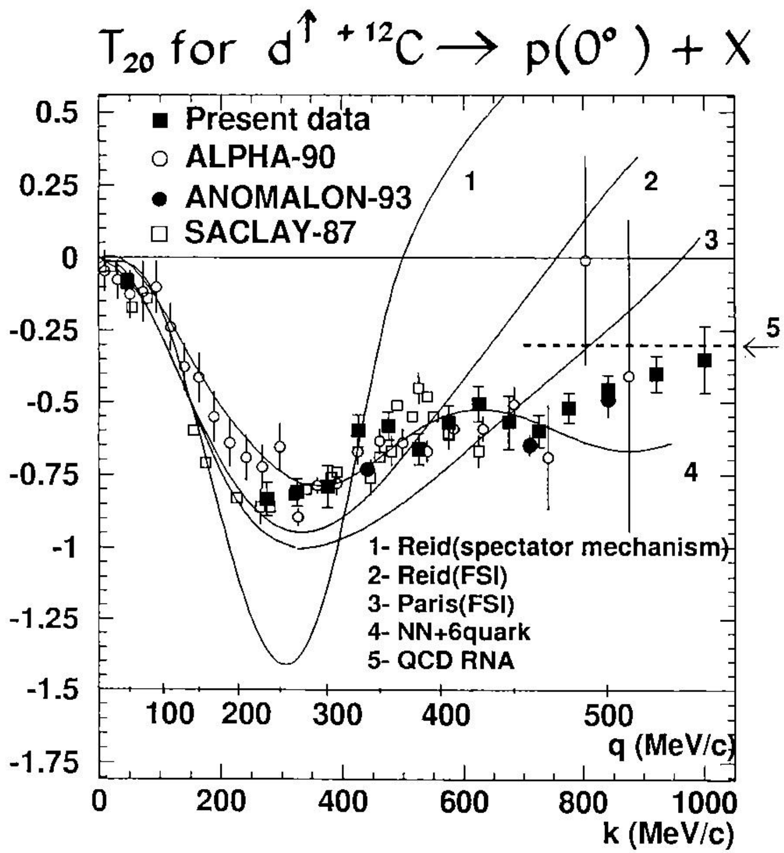
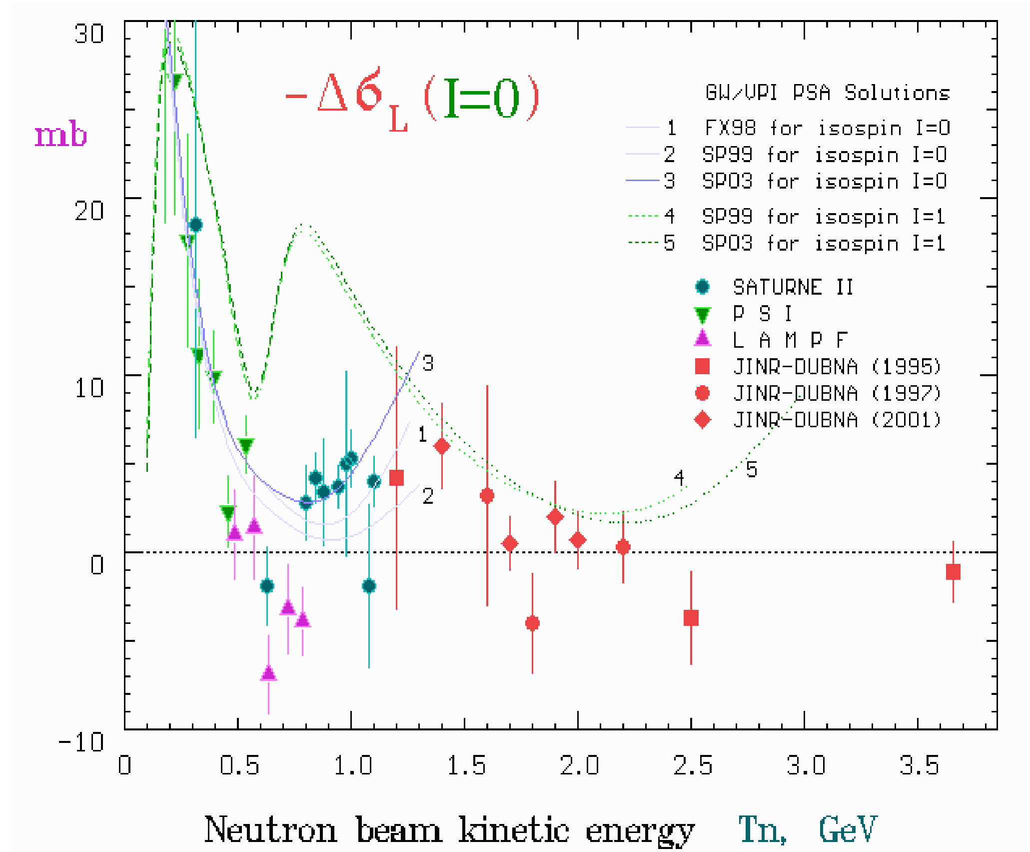
2 A.A.Nomofilov et al.,Phys.Lett. B325(1994),p.327; Phys.Rev.Lett.v.74,N25(1995),p.4997.

3 V.I.Sharov et al.,JINR Rapid Com.,3[77]-96, (1996) 13; 4[96]-99 (1999) 5; Z.Phys.C.71,N1, (1996) 65; Yad.Phys.68 N11(2005)p1857; Eur.Phys.J.C37,79(2004)


T20 for d↑ + 12C → p(0°) + X
Present data
ALPHA-90
ANOMALON-93
SACLAY-87
1- Reid(spectator mechanism)
2- Reid(FSI)
3- Paris(FSI)
4- NN+6quark
5- QCD RNA
q (MeV/c)
k (MeV/c)


−Δσ_L (I=0)
mb
GW/VPI PSA Solutions
1 FX98 for isospin I=0
2 SP99 for isospin I=0
3 SP03 for isospin I=0
4 SP99 for isospin I=1
5 SP03 for isospin I=1
SATURNE II
P S I
L A M P F
JINR-DUBNA (1995)
JINR-DUBNA (1997)
JINR-DUBNA (2001)
Neutron beam kinetic energy Tn, GeV

These data [2,3] are in agreement with the **SATURNE II ones over the lower *k*-momentum common range of 2.5 fm^{-1}**. Several years ago Dubna (in collaboration with groups from 12 laboratories) began the **transmission measurements [3] using both a polarized neutron beam and a polarized proton target**. For the first time we measured the **energy dependence of the $\Delta\sigma_L$(*np*),** neutron-proton total cross section difference for the pure longitudinal (L) spin states for parallel and antiparallel (*np*) spins, over a **new kinetic energy range of 1.2--3.7 GeV** for a quasi-monochromatic polarized neutron beam. The **$-\Delta\sigma_L$(*np*) energy dependence [3] shows an anomalous fast decrease to zero above 1.1 GeV** and a **structure around 1.8 GeV** predicted in Ref. [4]. The authors [4a] used the Cloudy Bag Model and an R-matrix connection to long-range meson-exchange force region with the short-range region of asymptotically free quarks; this **hybrid model gives the lowest exotic six-quark configurations in the isosinglet $^3S_1$ state with the mass M =2.63 GeV T_{kin} =1.81 GeV).** It is close to the energy where **the structure is discovered** by our **$-\Delta\sigma_L$(I=0)** energy dependence determination.

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4 E.L.Lomon et al. at the proper references in [3];
M.Matsuda et al, Few-Body Systems Suppl.12,457(2000)

Since $-\Delta\sigma_T$ contains **no uncoupled spin-triplet** contribution, a **$^3S_1$ resonance effect in this observable less deluted by other spin-states than in $-\Delta\sigma_L$**. The measurement **$-\Delta\sigma_T$ (*np*)** and the determination of the **$-\Delta\sigma_T(I=0)$** energy dependence provide a significant and **sensitive check of the predicted resonance**. Moreover, in difference ($\Delta\sigma_L - \Delta\sigma_T$) the spin-singlet contribution vanishes. For this reason, **the accurate $-\Delta\sigma_T$ (*np*) measurements near to T_{kin} = 1.8 GeV are desirable [3b,c]. The I=0 spin dependent total cross section differences represent a considerable advantage for studies of the $^3S_1$ state around 1.8 GeV, since this partial wave is expected to be dominant**. This is in contrast with the I=1 system where lowest lying exotic six-quark configuration was predicted in the spin-singlet state $^1S_0$ above 2 GeV. This state is not dominant and is strongly diluted in the forward direction.

The obtained high momentum dependences of these (*np*) spin observables **[2,3] are surprising for all traditional nuclear models**. Their predictions are **wrong for** the highest momentum (asymptotic) **behaviour of these observables related with almost fully overlapping nucleons in fact**.

In [3] we discussed the QCD motivated model of a nonperturbative flavour-dependent interaction between quarks, induced by a strong fluctuation of vacuum gluon fields, i.e. **instantons**. Concerning this model, we refer to our previos papers, since no new relevant prediction is available. The **former prediction at high energy disagree with the experimental data [3]** on $-\Delta\sigma_L$(*np*) energy dependence.

To exactly reveal a discovered structure at 1.8 GeV we are need in obtain the complete L,T data set [1] of np spin observables at 0 which is needed for the first direct reconstruction of all three isosinglet amplitudes of forward *NN* elastic scattering over a GeV energy range. With this **very ambitious aim the following will be simultaneously measured for the first time at each chosen T_n: $-\Delta\sigma_L$ and A_{00kk}, a spin correlation parameter for *np→pn*** charge-exchange (180 in the c.m.) **with the L polarization of n beam and p target; $-\Delta\sigma_T$ and A_{00nn} with the T-polarized beam and target.** The proper equipment mounted in the last year was successfully tested (in simultaneous measurements of n beam transmission through D_2/H_2 targets and *n→p* charge-exchange on them). The Dubna group fulfilled first measurements under 0 of the ratios R_{dp} ”elastic" *np* charge-exchange yields on D/H targets and defined of the ratios $r^{nf/fl}(0)$ nonflip and spin-flip contributions to *np→pn* process. In the region of $T_n \approx 1.8$ GeV one can expect an anomaly [3] of $r^{nf/fl}$ - energy dependence (as in the case [3] of the measurements of $-\Delta\sigma_L$ **if one follows the QCD-motivated reasoning (Lomon et al., Matsuda et al.) [4] about a phase transition at this energy of the *NN* system into the exotic six-quark configuration** in the isosinglet and the spin-triplet state $^3S_1$ with the mass M ≈ 2.63 GeV.

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1 In book ed. Baldin A.M. Research Program of LHE JINR (Dubna 1999) 37-43,"Delta-Sigma Experiment" Spokesmen V.I.Sharov, L.N.Strunov.

1b R.Binz Ph.D.Thesis.Freiburg (1991).

For **the exhaustive analysis of this structure [3] using Argand diagrams for *Re* and *Im* parts of each of the three *NN* forward scattering amplitudes** it is required to measure in Dubna not only the complete set [1] of np-spin observables at 0 but also to carry out **pilot measurements in the same energy region of the ratio** $R_{dp}(0) = d\sigma d\Omega(nd) / d\sigma d\Omega(np)$ **for yields of "elastic" $n \rightarrow p$ charge-exchange non-polarized neutrons on D/H targets that independently defines [1b] the** $r^{nf/fl}$ **ratio at 0 the spin-nonflip contribution in $np \rightarrow pn$ to the spin-flip contribution in this process:** $r^{nf/fl} = 2/3R_{dp}^{-1} - 1$.

The results of our measurements of $r^{nf/fl}$ ratio energy dependence over 0.55 – 2 GeV will be done in the current report.

Accelerators and Tools

1. THE SYNCHROPHASOTRON AND NUCLOTRON OF THE JINR VBLHE

2. RELATIVISTIC (1–6) GEV:
   POLARIZED NEUTRON BEAM WITH *L* OR *T* ORIENTATION OF POLARIZATION (WITH THE HELP OF NEW POLARIZED *d*-SOURCE "CIPIOS" WITH INTENSITY UP TO $5 \cdot 10^{10}$ *d/CYCLE*) , REVERSION OF POLARIZATION DIRECTION CYCLE BY CYCLE AND AVERAGE POLARIZATION VALUE OF ≈ 0.8
   AND *UNPOLARIZED DEUTERON BEAM*

3. *LARGE POLARIZED PROTON TARGET (PPT)* WITH VOLUME OF 140 cm^3
   AND POLARIZATION VALUE OF 0.7–0.8
   HYDROGEN-H_2 AND DEUTERIUM-D_2 TARGETS

4. EXPERIMENTAL SET-UP "DELTA-SIGMA" WITH :
   TRANSMISSION NEUTRON DETECTORS
   MAGNETIC SPECTROMETER WITH PROPORTIONAL CHAMBERS
   TIME-OF-FLIGHT SYSTEM TOF
   DETECTORS FOR D_2/H_2TARGET SURROUNDING DTS
   MODERN DATA ACQUISITION SYSTEM

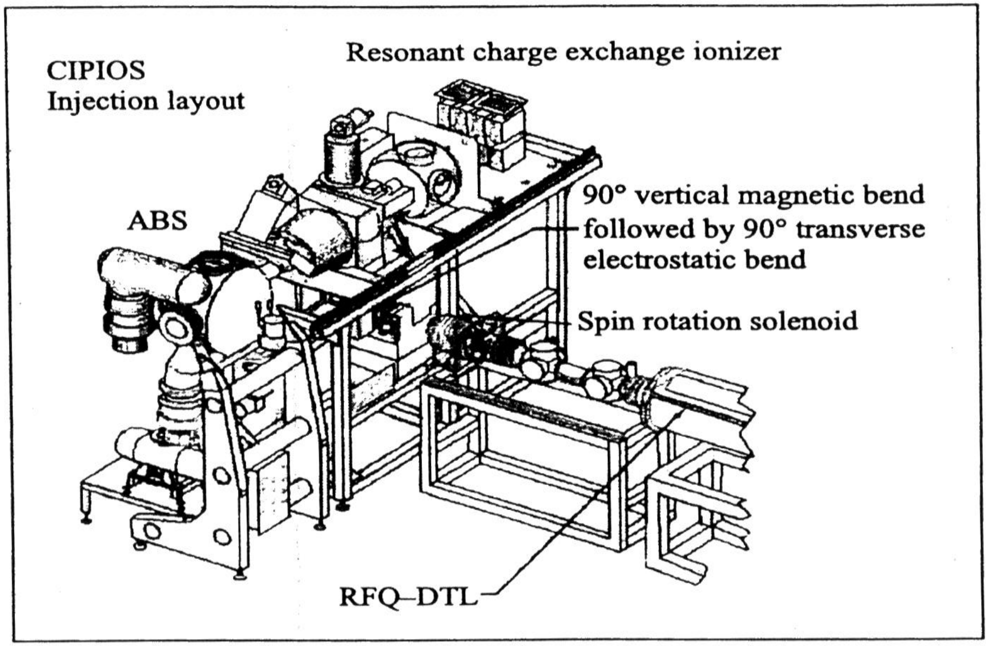
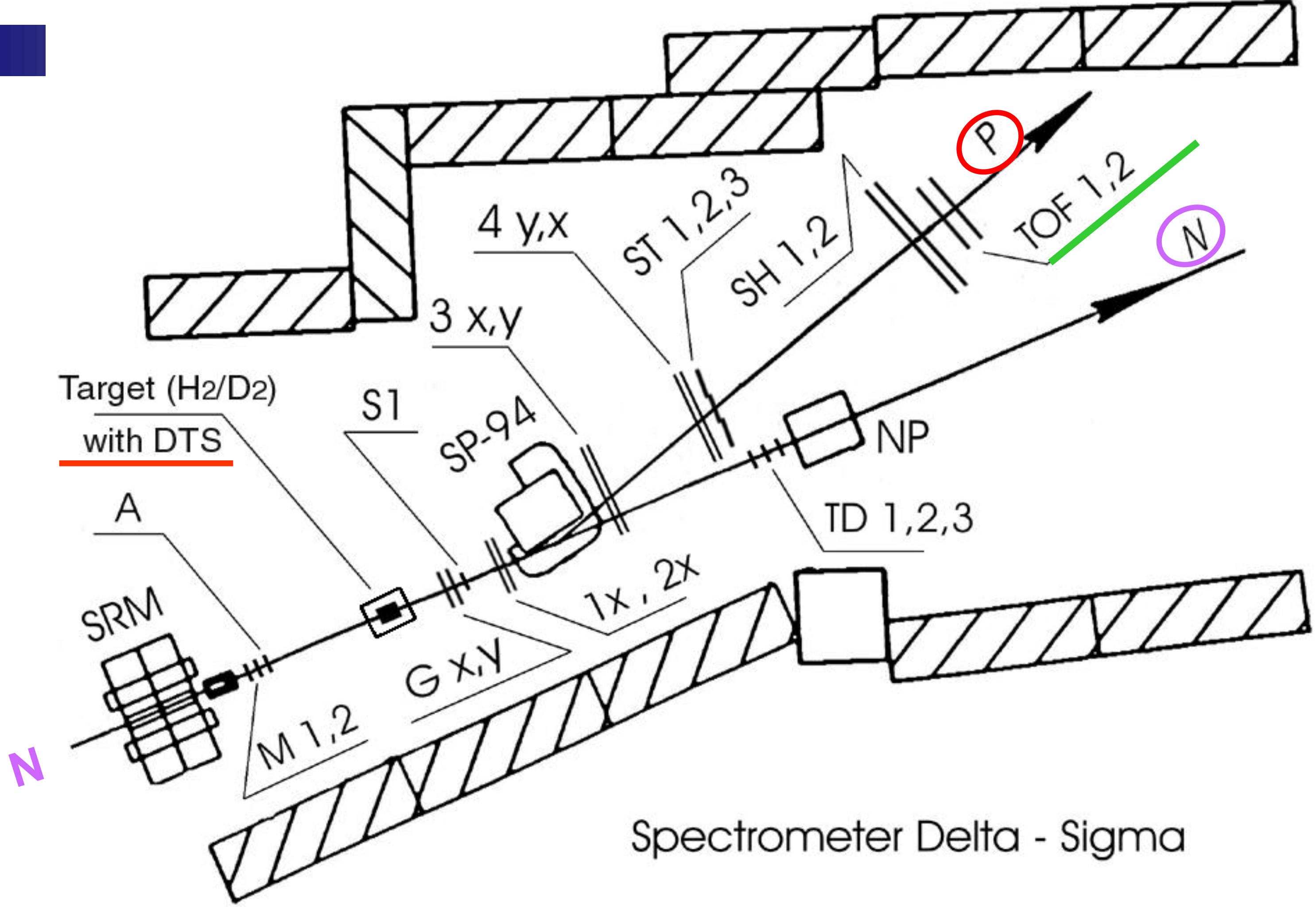


Fig. 1. The CIPIOS polarized source

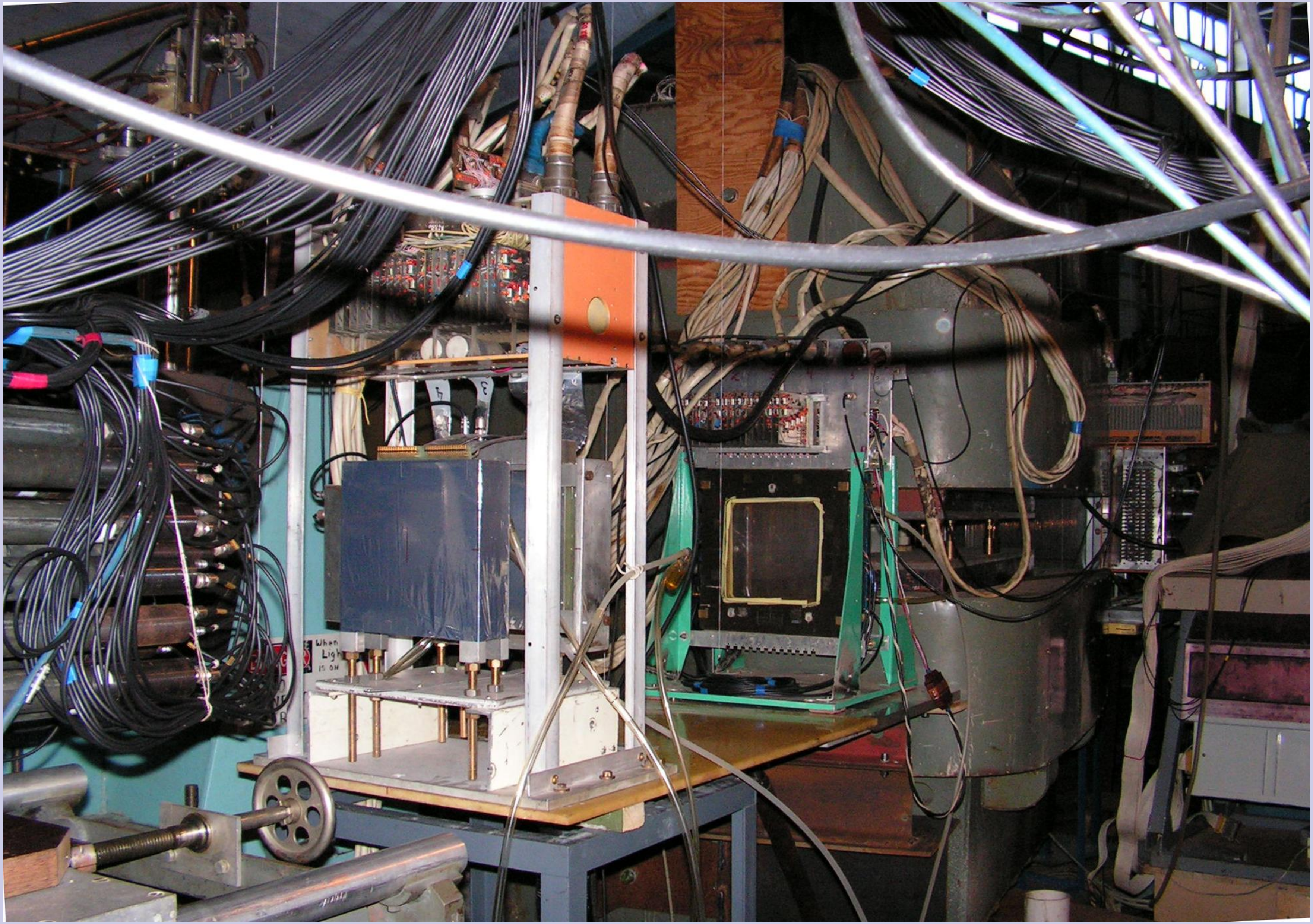
A very important event in 2004 was signing an agreement between the Indiana University and JINR on handing over the CIPIOS polarized ion source to be mounted at the Nuclotron. The source parameters are: pulsed 1 to 4 Hz; 25 keV beam energy; polarized H or d; normal polarization $> 80\%$; 1.5 mA (peak) from source; > 25 mA (peak) unpolarized.

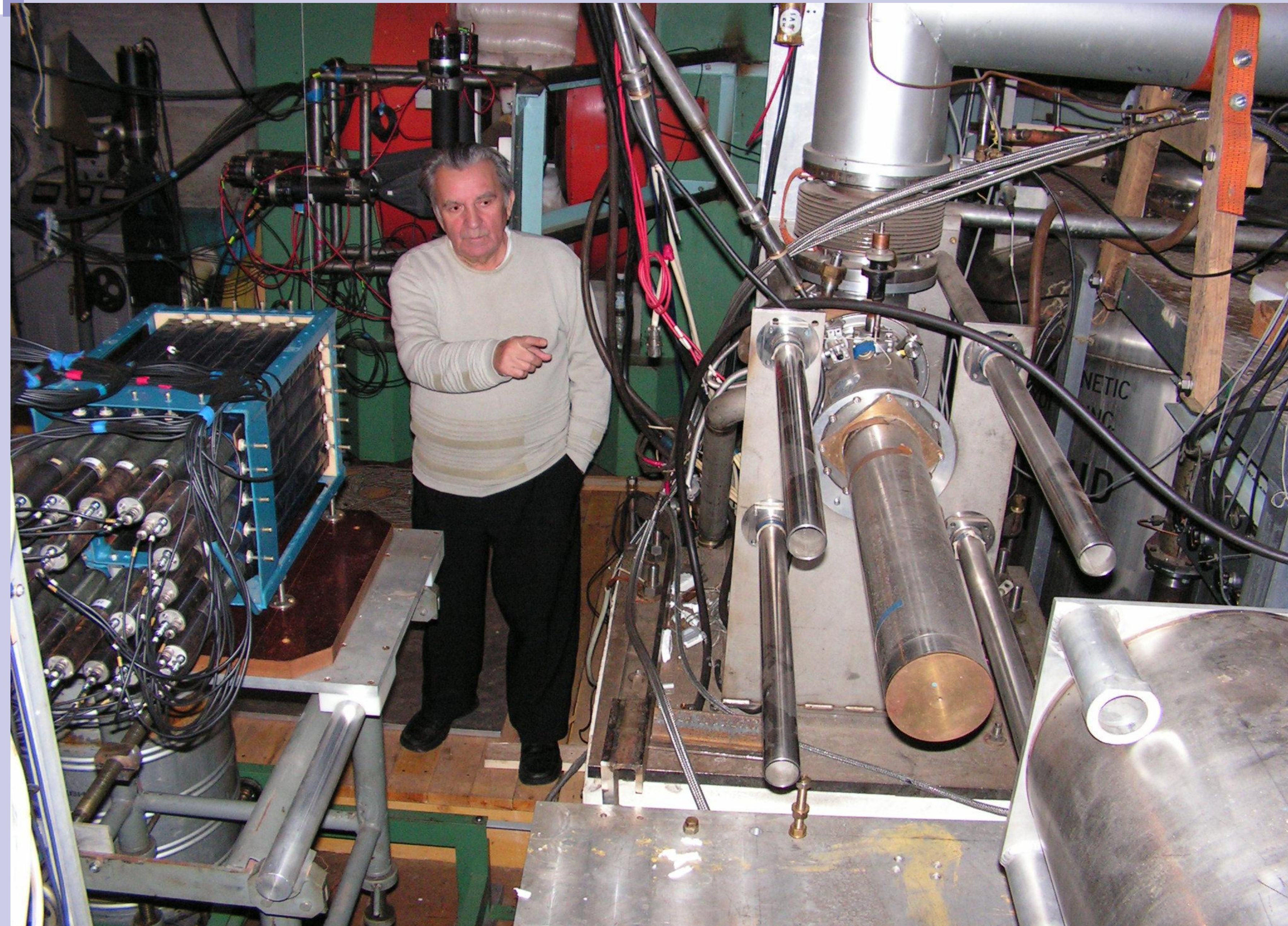
Using this source at the Nuclotron will make it possible to provide an intensity of the external beam of polarized deuterons up to $5 \cdot 10^{10}$ per cycle. Reaching such an intensity of polarized deuterons is the main task in 2005–2007. INR RAS (Troitsk) will take an active part in this work.

A.I. Malakhov: Czech. J. Phys. 55 (2005) A65--A74.

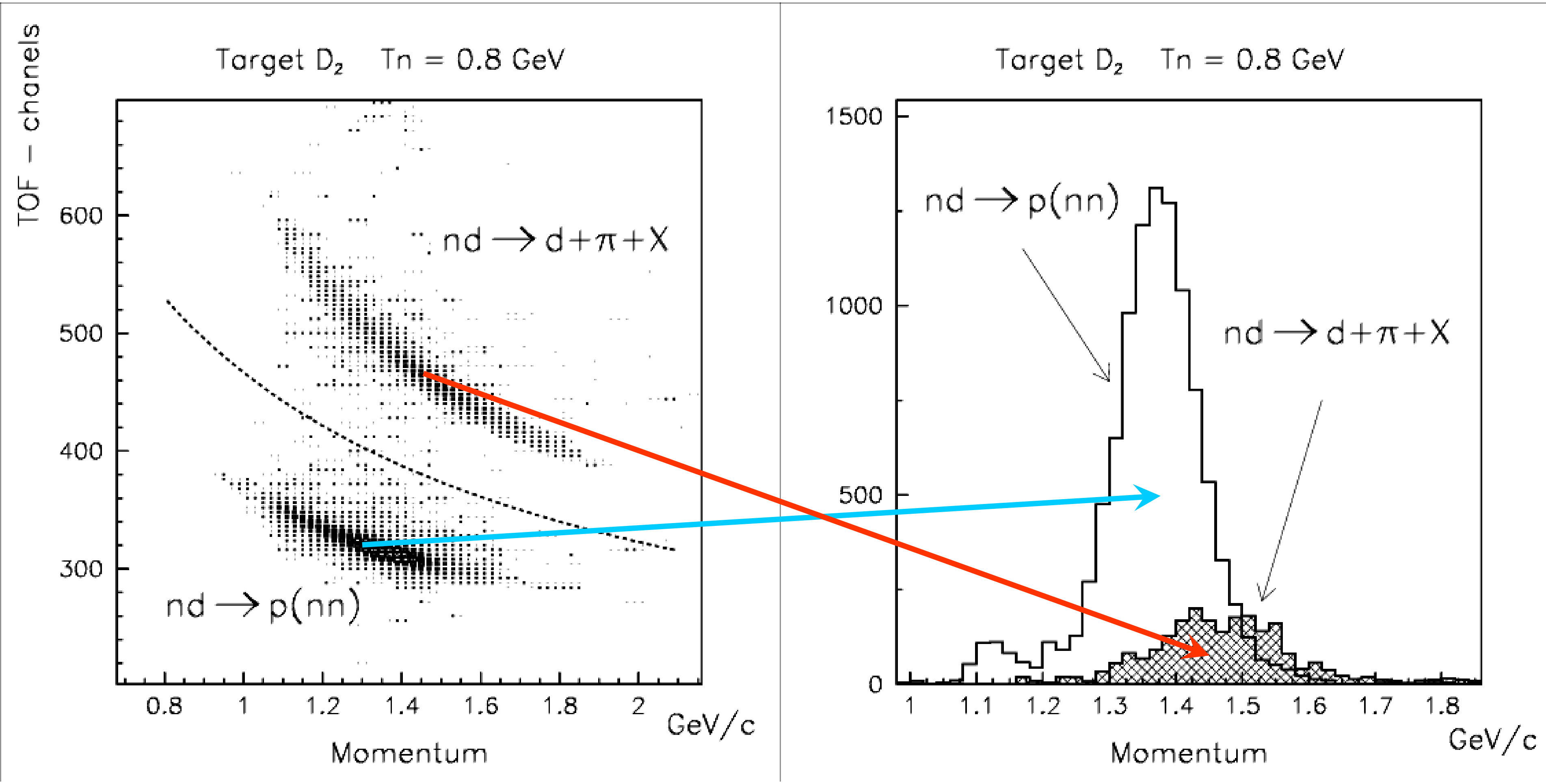


Delta Sigma **setup: SP-94 - analyzing magnetic dipole; Gx,y, 1x, 2x, 3x,y, 4x,y - two sets of multiwire propotional chambers; MPT-polarized proton target or liquid D_2/H_2 target, surrounded by DTS system for detecting of Δ recoils which decay to π, *p* and γ; trigger counters – A, S1, ST1,2,3 and time-of-flight system – S1, TOF1,2, TD1,2,3 – neutron transmission counters, M1,2 – monitors.**

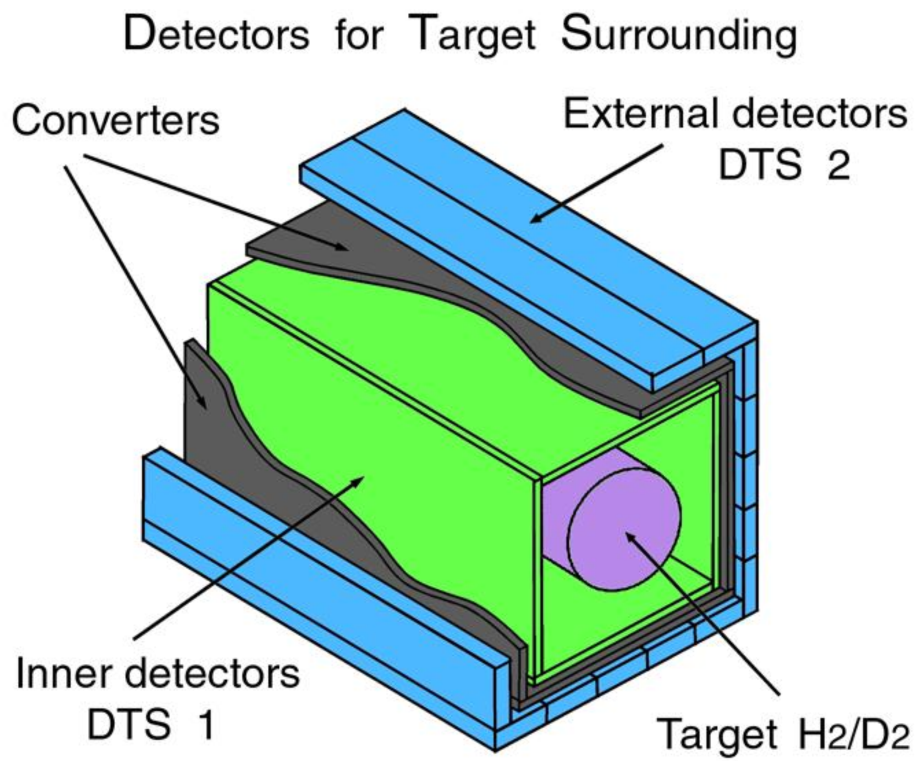


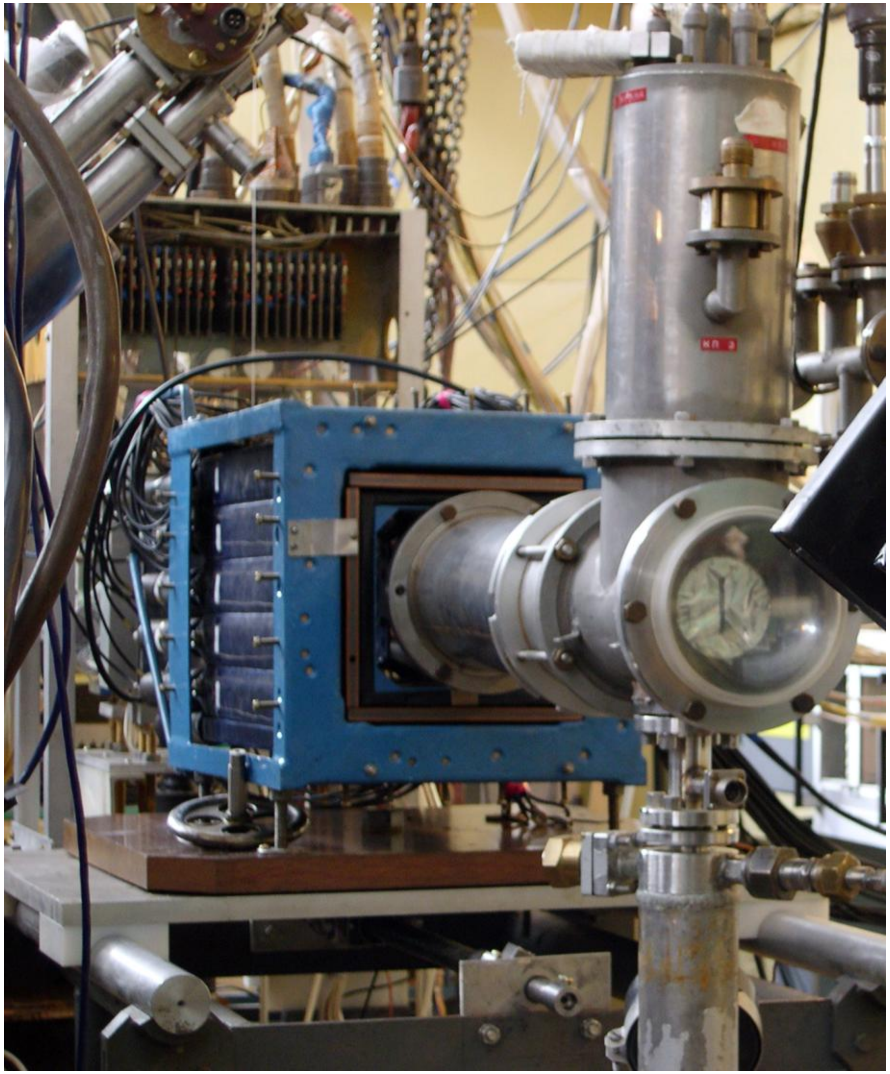


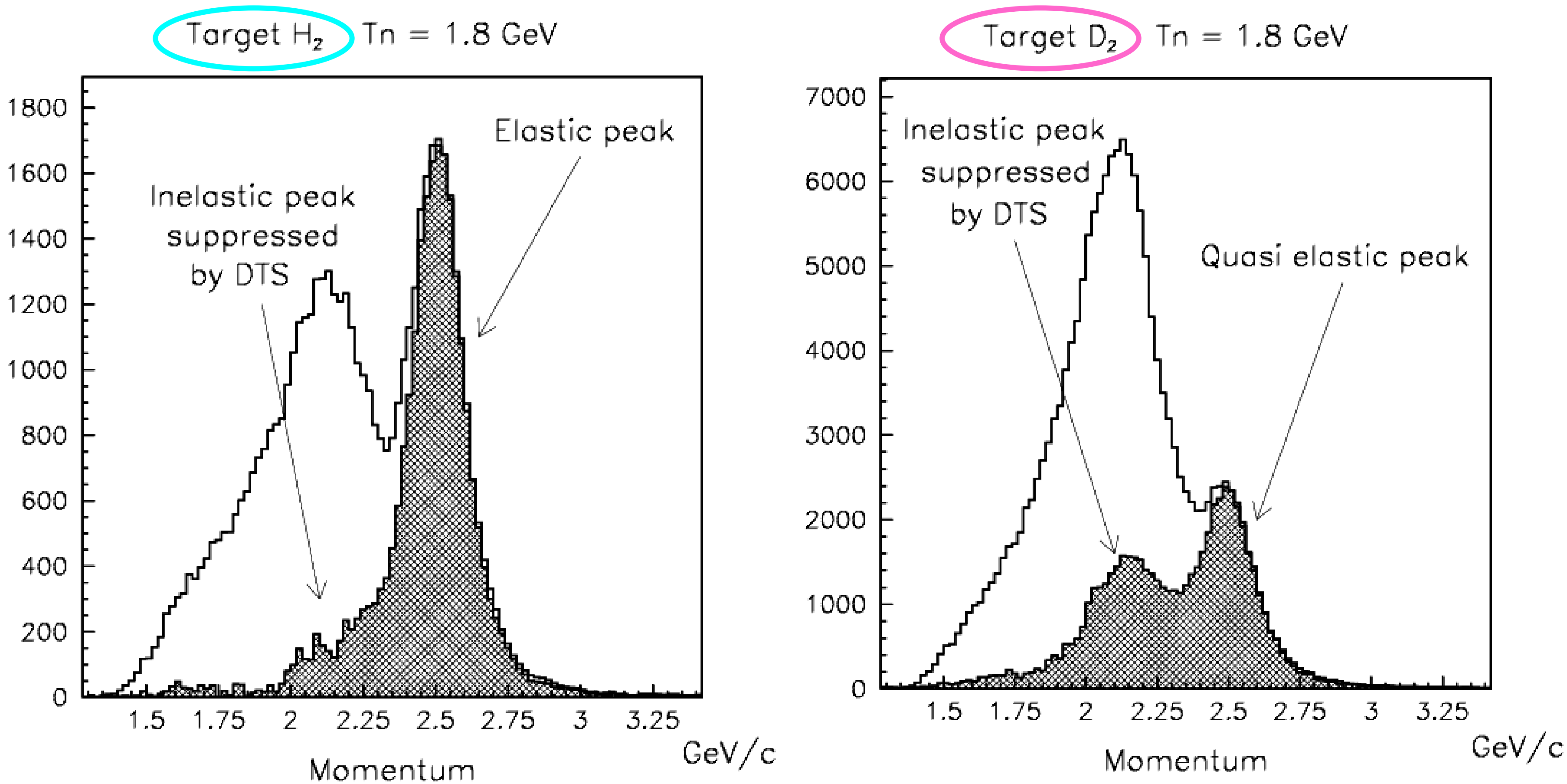
Separation the *nd→d+π+X* yield from the *nd→p(nn)* process with the help of TOF system and momentum spectrum magnetic analyzis



DTS system for detecting of Δ recoils which decay to *π*, *p* and *γ*







The rejection of the inelastic background using **DTS**. The ***shaden hists*** in the both figures present momenta spectra of charged secondaries when the signal from the DTS is in anticoincidence with the spectrometer trigger. The ***transparent hists*** show the same as ones but without the information from the DTS.

The $\Delta\sigma_{L,T}$ (np) observables

In this contribution, we use *NN* formalism and notations for elastic nucleon-nucleon scattering observables.

The general expression for the total cross section of a polarized nucleon beam trasmitted through a polarized proton target, with arbitrary directions of beam and target polarizations is (S.M.Bilenky and R.M.Ryndin, Phys.Lett. 6 (1963) 217, R.J.N. Phillips, Nucl.Phys. 43 (1963) 413):

$$\sigma_{tot} = \sigma_{0tot} + \sigma_{1tot} (P_B P_T) + \sigma_{2tot}(P_B k)(P_T k) \qquad (1)$$

where P_B and P_T are the beam and target polarizations, and k is the unit vector in the incident beam direction.

The term σ_{0tot} is the spin-independent total cross section, and σ_{1tot} and σ_{2tot} are the spin-dependent contributions which connect with the observables $\Delta\sigma_T$ and $\Delta\sigma_L$ by the relations:

$$-\Delta\sigma_T = 2\sigma_{1tot} \qquad (2)$$

$$-\Delta\sigma_L = 2(\sigma_{1tot} + \sigma_{2tot}) \qquad (3)$$

Values of σ_{0tot}, $\Delta\sigma_T$ and $\Delta\sigma_T$ are connected with the imaginary parts of the three forward scattering amplitudes $a + b$, c and d via **three optical theorems**:

$$\sigma_{0tot} = (2\pi/K)\, Im\, [a(0) + b(0)], \qquad (4)$$

$$-\Delta\sigma_T = (4\pi/K)\, Im\, [c(0) + d(0)], \qquad (5)$$

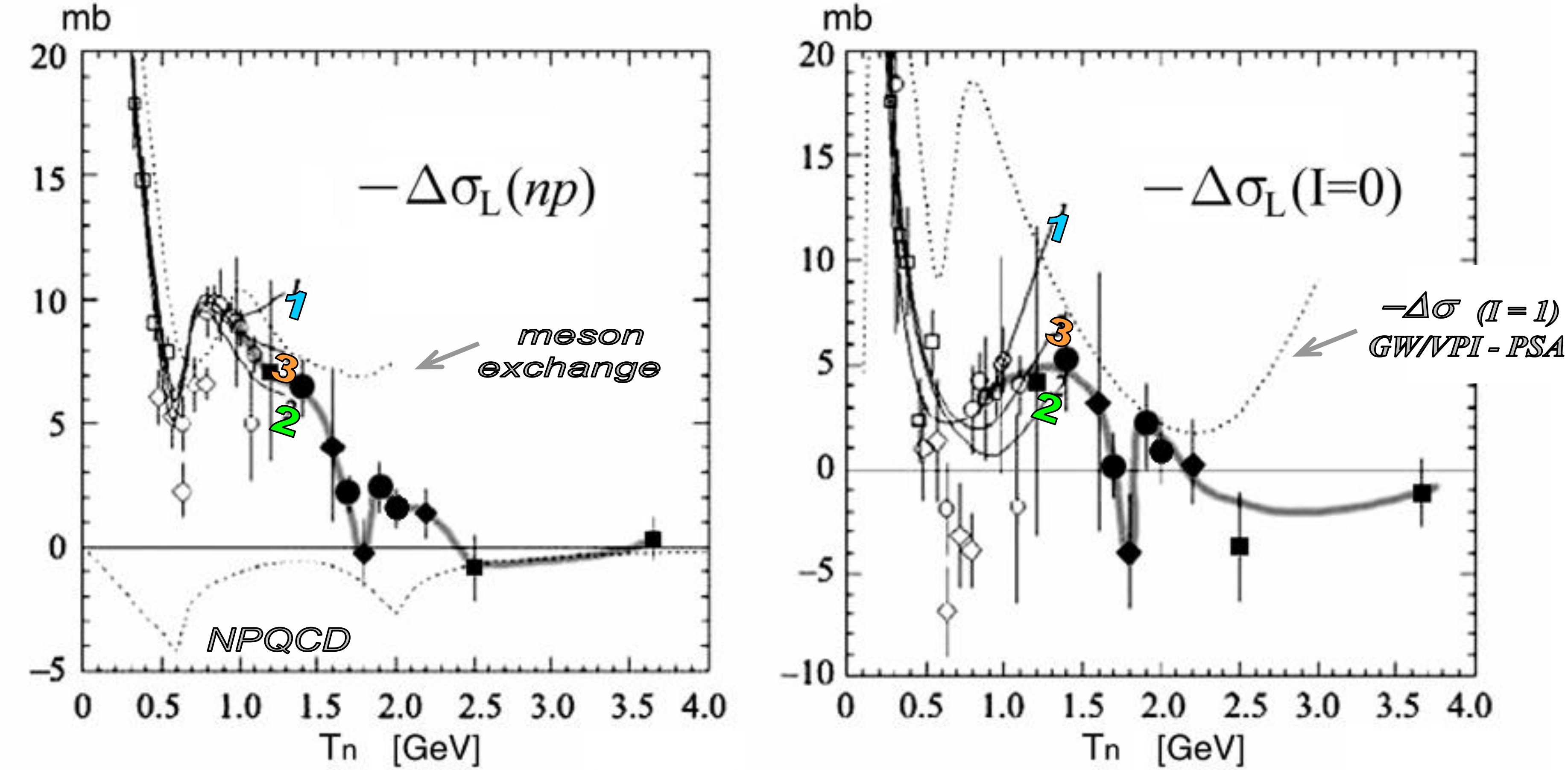
$$-\Delta\sigma_L = (4\pi/K)\, Im\, [c(0) - d(0)]. \qquad (6)$$

where K is the c.m. momentum of the incident nucleon. Relations (5) and (6) allow one to extract the imaginary parts of the spin-dependent invariant amplitudes $c(0)$ and $d(0)$ at an angle 0° from the measurement values of $\Delta\sigma_L$ *and* $\Delta\sigma_T$.

Using the measured values of $\Delta\sigma_{L,T}$ (*np*) and the existing $\Delta\sigma_{L,T}$ (*pp*) data at the same energy, one can deduce $\Delta\sigma_{L,T}$ (I=0) *as:*

$$\boxed{\Delta\sigma_{L,T}(I=0) = 2\Delta\sigma_{L,T}(np) - \Delta\sigma_{L,T}(pp).} \qquad (7)$$

1, 2, 3 — GW/VPI - PSA



Energy dependences of the $-\Delta\sigma_L(np)$ and $-\Delta\sigma_L(I=0)$ respectively (black simbols – data of our experiment Delta-Sigma; open simbols – other world data; dotted curves at the left hist are the meson exchange model [16] (top curve) and the NPQCD by N.Kochelev (down curve); dotted curve at the right hist is the $-\Delta\sigma_L(I=1)$ dependence from GW/VPI-PSA; full curves 1,2,3 at the both hists: 1) **FA95 solution**, 2) **SP99 solution** and 3) **SP03 solution**.

The $-\Delta\sigma_L(np)$ data measured in Dubna, inclusive the **new accurate latest data [3b,c]** between 1.4 and 2 GeV, are plotted in Fig.5. Their **energy dependence (see darkned curve in Fig.5) connect well with the** also free-neutron **$-\Delta\sigma_L$ data from Saclay**. The JINR data show a **fast unexpected decrease above 1.1 GeV**, and suggest a minimum in the vicinity of 1.8 GeV. The solid curves 1–3 represent the fits of $\Delta\sigma_L$ from solution of the energy dependence (ED) phase shift analisis below 1.3 GeV. **Above 0.6 GeV the PSA fits are only in qualitative** agreement with the measured values. Moreover, **above 1.0–1.3 GeV the tendencies of the ED PSA (curves 1–3) are in disagreement** with the energy dependence of the Dubna data.

Below 2.0 GeV, a usual meson exchange theory gives the $-\Delta\sigma_L(np)$ energy dependences [8] which disagree with data above 1 GeV Fig.5, the left panel).

The presented values of isosinglet I=0 part of $-\Delta\sigma_L$ are calculated from *np* results and from *pp* data using Eq.7 (see Fig.5, the right panel).The Dubna results show a plateau around 1.4 GeV, followed by a fast decrease and suggest a **minimum in the vicinity 1.8 GeV**. **This structure is better pronounced in the $-\Delta\sigma_L$(I=0) energy dependence than in the $-\Delta\sigma_L(np)$ one**. **Above 0.5 GeV the PSA solutions are not in agreement with data**.

In [3] we discussed the Kochelev model of a nonperturbative contribution to $\Delta\sigma_L$ flavour-dependent interaction between quarks, induced by a strong fluctuation of vacuum gluon fields, i.e. instantons. The **former prediction disagrees with the latest experimental $\Delta\sigma_L$ data [3].**

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8 T.-S.H. Lee.: Phys. Rev. 29 (1984) 59.

The manifestation of exotic dibaryons in the energy $\Delta\sigma_L$ dependence of *np* observables was predicted [4] by the Cloudy Bag Model and R-matrix connection to long-range meson-exchange force region with the short-range region of asymptotically free quarks. **This hybrid model gives the lowest lying exotic six-quark configurations in the isosinglet $^3S_1$ state with the mass M = 2.63 GeV and $T_{kin}(n)$ = 1.81 GeV). It is close to the energy where the structure with a minimum is suggested by our results**.

A complete *np* data set at 0 /180 and **D**irect **R**econstruction of **S**cattering **A**mplitudes for (I=0) would allow to discuss possible energy-dependent structures at the level of complex scattering amplitudes and not only at the level observables.

What can be deduced from the existing and planned $\Delta\sigma_L$(*np*) experiments? First of all **$-\Delta\sigma_T$** contains no uncoupled spin-triplet contribution, hence a $^3S_1$ resonance effect in this observable may be **less diluted by other spin-states than in $-\Delta\sigma_L$**. **The measurement $-\Delta\sigma_T$(*np*) and the determination of the $-\Delta\sigma_T$(I=0) energy dependence provide a significant and sensitive check of the predicted resonance**. Moreover, in difference ($\Delta\sigma_L - \Delta\sigma_T$) the spin-singlet contribution vanishes. For this reason, the **accurate $-\Delta\sigma_{L,T}$(*np*) measurements, in small energy steps, near to T_{kin} = 1.8 GeV are desirable**. **The I=0 spin dependent total cross section differences represent a considerable advantage for studies of the $^3S_1$ state around 1.8 GeV**, **since this partial wave is expected to be dominant**. This is In contrast with the I=1 system.

Measurements of the $A_{00kk}(np)$ and $A_{00nn}(np)$ from $np \rightarrow pn$ process.

According to [**F.Lehar, Private Comm. May 11.2005**]:

$$[d\sigma/d\Omega]_{pol}(E,\theta) = d\sigma/d\Omega(E,\theta)\,[1 + A_{00n0}(E,\theta)\,P_B^{\,n} + A_{000n}(E,\theta)\,P_T^{\,n} +$$
$$+ A_{00nn}(E,\theta)\,P_B^{\,n}\,P_T^{\,n} + A_{00ss}(E,\theta)\,P_B^{\,s}\,P_T^{\,s} +$$
$$+ A_{00kk}(E,\theta)\,P_B^{\,k}\,P_T^{\,k} + A_{00sk}(E,\theta)\,(P_B^{\,s}\,P_T^{\,k} + P_B^{\,k}\,P_T^{\,s})], \qquad (8)$$

where $d\sigma/d\Omega$ is a cross section for unpolarized nucleons.

If the scattered particles are detected at 0° angle then analyzing powers $A_{00n0}(E,0) = A_{000n}(E,0) = 0$ and parameters $A_{00sk}(E,0) = 0$ and $A_{00ss}(E,0) = A_{00nn}(E,0)$. Thus, only two non-vanishing spin-dependent quantities $A_{00nn}(E,0)$ and $A_{00kk}(E,0)$ remain in (8).

Due to symmetries of amplitudes, which hold separately for isospins I=0 and I=1, the same relations are valid at Θ c.m = π. Moreover the amplitude e(0) = e(π) for any isospin. The measurement *np* observables at Θ c.m = π are connected with the invariant amplitudes as follows:

$$d\sigma/d\Omega\,(\pi) = ½\,[\,|a|^2 + |b|^2 + |c|^2 + |d|^2\,], \qquad (9)$$
$$d\sigma/d\Omega\,A_{00nn}(\pi) = ½\,[\,|a|^2 - |b|^2 - |c|^2 + |d|^2\,], \qquad (10)$$
$$d\sigma/d\Omega\,A_{00kk}(\pi) = Re\,a^*\,d + Re\,b^*\,c. \qquad (11)$$

where all experimental quantities and amplitudes are Θ c.m = π.

These equations can be transformed to:

$$d\sigma/d\Omega\,(1 + A_{00kk}) = |b + c|^2 = A + (Re\,b + Re\,c)^2, \qquad (12)$$

$$d\sigma/d\Omega\,(1 - A_{00kk} - 2A_{00nn}) = |b - c|^2 = B + (Re\,b - Re\,c)^2, \qquad (13)$$

$$d\sigma/d\Omega\,(1 - A_{00kk} + 2A_{00nn}) = |b + c - 2d|^2 = C + (Re\,b + Re\,c - 2Re\,d)^2, \qquad (14)$$

where terms *A*, *B*, *C* contain the imaginary parts of amplitudes only. The real parts of the amplitudes *b*, *c* and *d* can be determined from Eqs. (12-14) using known imaginary ones. A knowledge of I = 1 system is assumed in order to use the amplitude symmetries for the transformation of I = 0 amplitudes from $\Theta = 0$ to $\Theta = \pi$ and vice versa.

R_{dp} ratio for charge-exchange at t = 0 and ratio $r^{nfl/fl}(np \to pn)$

Energy dependence of the ratio

$$R_{dp} = d\sigma/d\Omega(nd \to pnn) \; / \; d\sigma/d\Omega(np \to pn) \qquad (15)$$

for the quasi-elastic $nd \to p(nn)$ and elastic $np \to pn$ charge exchange process at 0° was measured at high intensity non-polarized neutron beam from the Nuclotron using the magnetic spectrometer and hydrogen and deuterium targets.
The R_{dp} is connected with charge exchange amplitudes by:

$$R_{dp} = \frac{d\sigma/d\Omega(nd)}{d\sigma/d\Omega(np)} = \frac{2}{3} \cdot \frac{1}{1 + r^{nfl/fl}_{np \to pn}(0)} \qquad (16)$$

, where:

$$r^{nfl/fl}_{np \to pn}(0) = \frac{\left|a^{CEX} + b^{CEX}\right|^2}{\left|a^{CEX} - b^{CEX}\right|^2 + 2\left|c^{CEX}\right|^2 + \left|d^{CEX}\right|^2} \qquad (17)$$

and using the symmetry properties of *NN* amplitudes we have:

$$r^{nfl/fl}_{np \to pn}(0) = \frac{|a + c|^2}{|a - c|^2 + 2|b|^2 + |d|} \quad , \qquad (18)$$

where all amplitudes a, b, c and d are taken now from the $np \to np$ scattering at $\Theta_{CM} = \pi$.

$$d\sigma/d\Omega(np)(\pi)=(d\sigma/d\Omega)_{np}^{nfl}+(d\sigma/d\Omega)_{np}^{fl} \tag{19}$$

We have [6] in the impulse approximation frame:

$$d\sigma/d\Omega(nd\to pnn)=\left[1-F\right](d\sigma/d\Omega)_{np}^{nfl}\ +\left[1-\frac{1}{3}F\right](d\sigma/d\Omega)_{np}^{fl} \tag{20}$$

F(0)=1, in forward direction, hence we have:

$$d\sigma/d\Omega\ (nd)\ =\ \frac{2}{3}(d\sigma/d\Omega)_{np}^{sfl} \tag{21}$$

and according to (19), (21)

$$r_{np\to pn}^{nfl/fl}(0)\ =\ \frac{2}{3}\ \frac{1}{R_{dp}}\ -1 \tag{22}$$

Relation (21) demonstrate the using of a deuteron as a filter for non spin-flip amplitudes at $t \approx 0$, i.e. non spin-flip contribution, due to the Pauli principle, vanishes for $nd \to p(nn)$ quasi-elastic reaction with two slow neutrons with parallel spins.

The obtained values of $r^{nfl/fl}$ **give an additional relation (18) or (17) which allows to avoid ambiguities of the real parts extraction by DRSA procedure**.

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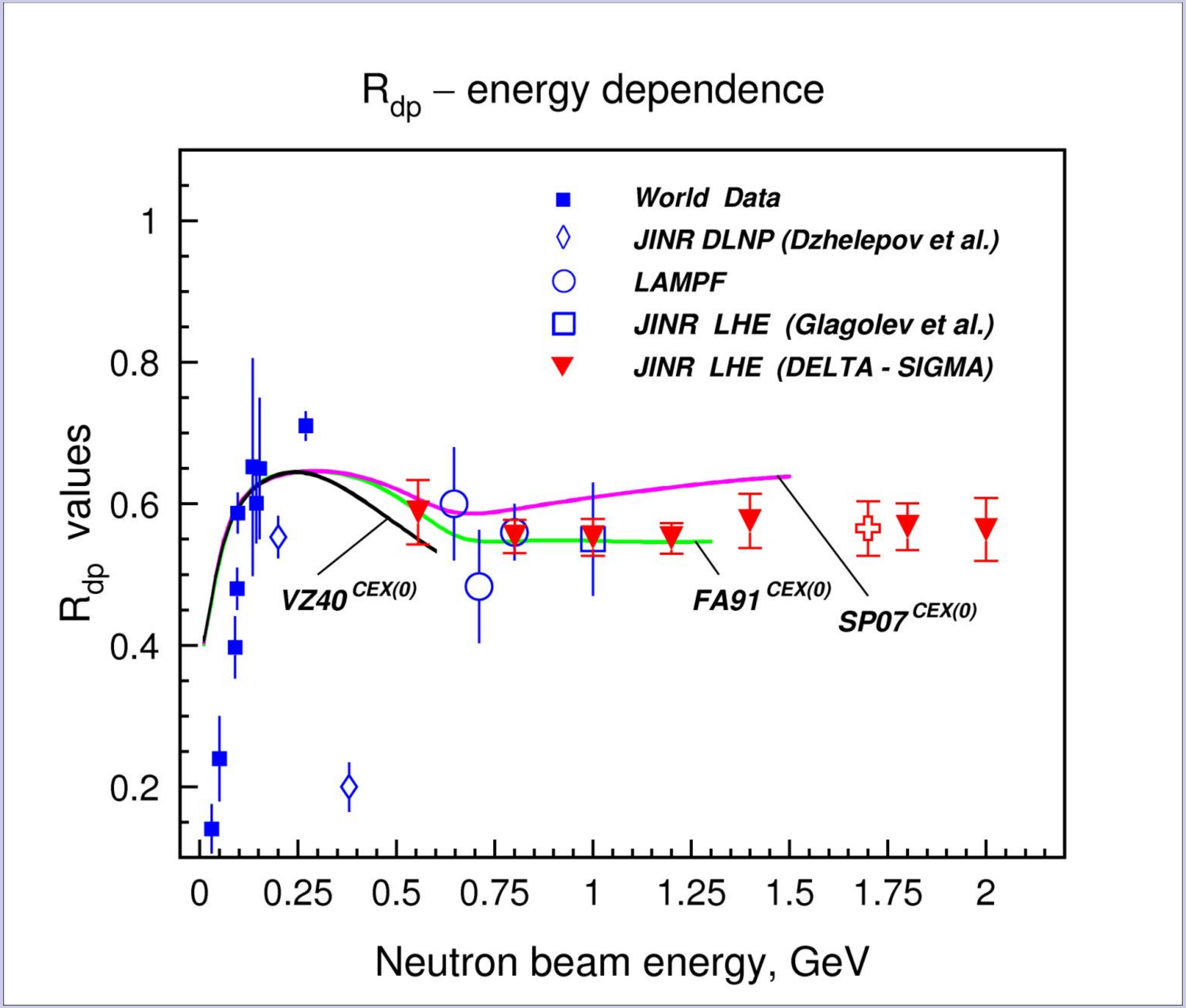
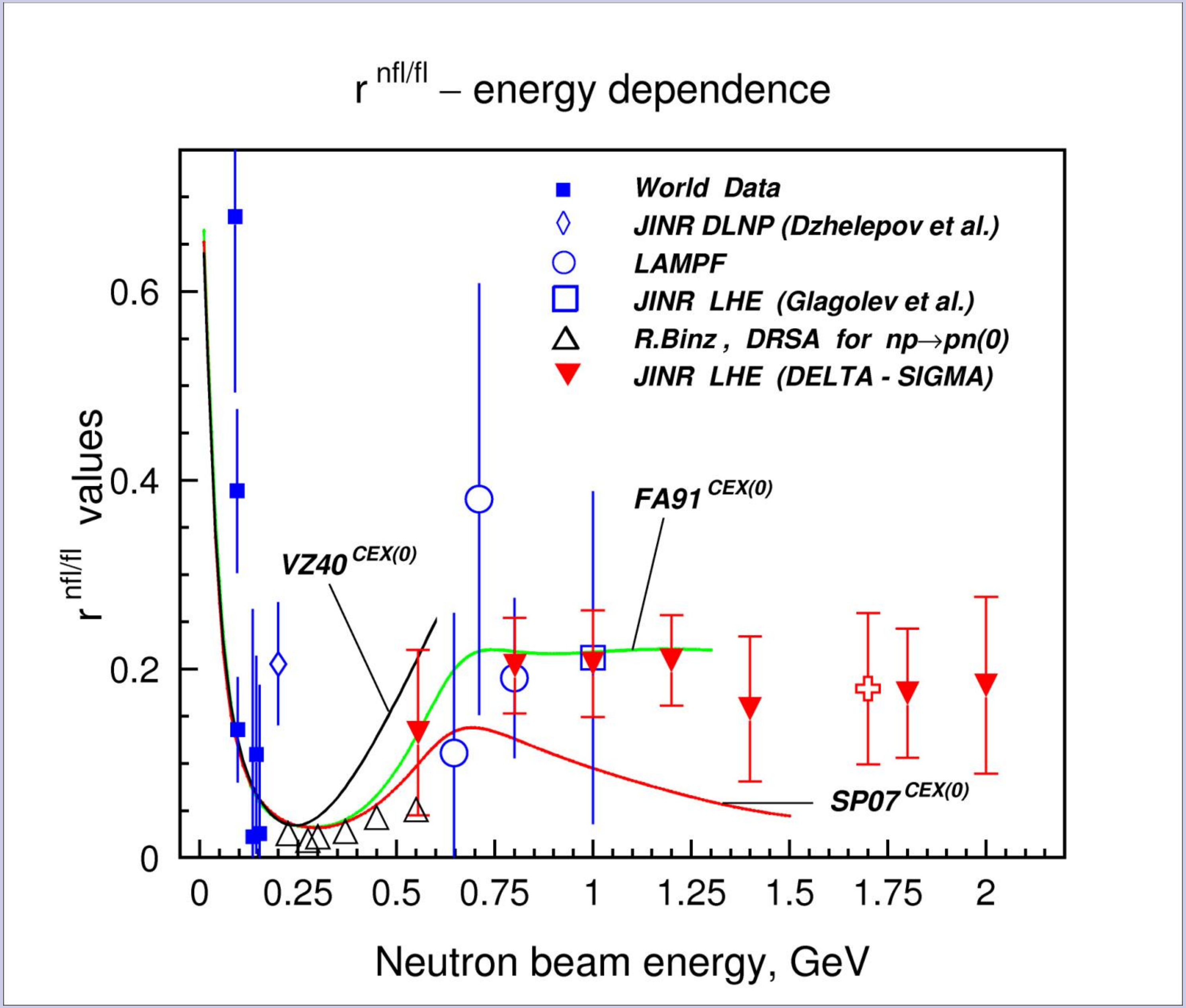
6 R. Lednicky, V.L. Lyuboshitz et al.: in Proc. XVI Int. Seminar ISHEPP Dubna} June (2002), Dubna JINR (2004) v.1 p.199.

DELTA-SIGMA results



DELTA-SIGMA results



Conclusions

1. New $-\Delta\sigma_L(np)$ accurate results complete in the main the measurement of the $-\Delta\sigma_L(np)$ and $-\Delta\sigma_L(I{=}0)$ energy dependences at the Dubna Synchrophasotron region. The comparison of the **$\Delta\sigma_L(I{=}0)$ and $\Delta\sigma_L(I{=}1)$** energy behaviours shows that they are **significantly different** in the whole region of measured energies.
2. **An unexpected anomalous rapid decrease of $-\Delta\sigma_L(np)$, $-\Delta\sigma_L(I{=}0)$ values above 1.1 GeV** was confirmed in the latest run and a **minimum around 1.8 GeV** is observed, which **was predicted as a signal of *NN* system phase transition** at this energy, with excitation of lowest lying exotic 6q-state $^3S_1(I{=}0)$ with mass 2.63 GeV [4].
3. **The necessity of the complete *np* data set at 0 /180 for direct reconstruction of all three isosinglet amplitudes at 0 in the kinetic energy region above 1.1 GeV (especially around 1.8 GeV) is emphasized**.
4. The possibility of **such measurements was demonstrated** in $-\Delta\sigma_L(np)$ and $np\to pn$ at 0 investigation with Delta-Sigma set-up. A **number of physical and methodical results on investigation** of the quasi-elastic $nd\to p(nn)$ and the elastic $np\to pn$ charge exchange process at 0 over a few GeV region are also presented. **The possibilities for R_{dp} measurements, using prepared magnetic spectrometer, were demonstrated up to T_n = 2 GeV**.

   The $r^{nf/fl}(0)$ ratio of non spin-flip to spin-flip parts in $np\to pn$ forward scattering was firstly obtained at T_n = 0.55 — 2.0 GeV by the R_{dp} measurements.

5 Our “road map” **current “Delta Sigma” project** for the coming 2008-2010 years it needs to be done:

1. **to continue our $r^{nf/fl}(0)$ measurements by $R_{dp}(0)$ up to highest Dubna T_n with small errors, especially around T_n = 1.8 GeV**

1. **to prepare T-mode of PPT-target polarization and to obtain high intensity L/T-polarized *n* beam, with new polarized *d* source [15] at the Nuclotron (CIPIOS)**

1. **to exactly reveal the structure observed in $-\Delta\sigma_L$(*np*)(I=0) at 1.8 GeV, to obtain a complete *np* data set at 0 /180 in the Nuclotron energy region**

1. **to fulfill the Direct Reconstruction of all three elastic forward *NN* Scattering Amplitudes (*Re* and *Im parts*),** and as a result

1. **to fulfill the Argand diagram exhaustive analysis of energy dependencies of elastic scattering amplitudes at 0 at energies 1 6 GeV, first of all around T_n = 1.8 GeV, and**

   to reach the discovery [4] of *NN*→6q phase transitions