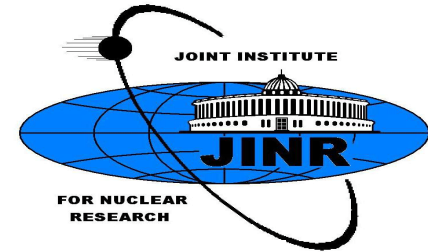


First results on measurements of the proton beam polarization at internal target at Nuclotron.



DSS *pin* **structure**
neutron

V.P.Ladygin on behalf of the DSS collaboration

5-th Nuclotron Users workshop, 5-6 October, 2017

Outline

- **Motivation**
- **Setup for the polarization measurements**
- **Results on proton beam polarization measurements (unpolarized and polarized case)**
- **Conclusion**

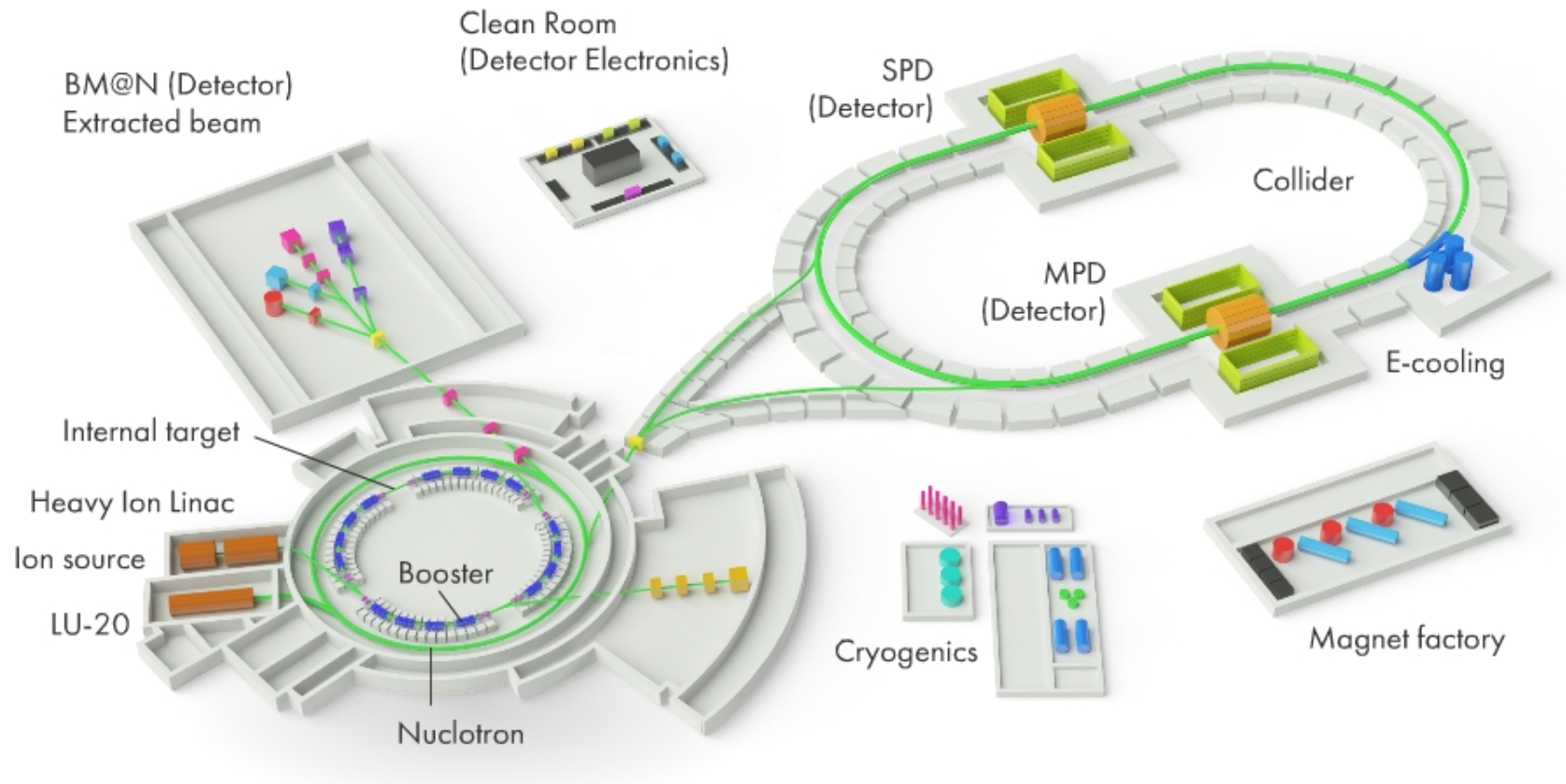
DSS collaboration:

Bulgaria-JINR-Japan-Romania-Russia

+

Nuclotron accelerator and SPI teams, NEOAFI, NPO “Zaryad”, ...

NICA complex



Both collider (SPD, MPD) and fixed target (SP@N, DSS...) spin experiments require polarized proton beam

SPD program on GPDs

Measurements of asymmetries in the lepton pair (Drell-Yan) production in collisions of non-polarized, longitudinally and transversally polarized protons and deuterons beams are suggested to be performed at the collider NICA of the JINR using the specialized Spin Physics Detector (SPD). These measurements can provide an access to all leading twist collinear and Transverse-Momentum Dependent distribution functions of quarks and anti-quarks in nucleons. The measurements of asymmetries in production of J/Ψ and direct photons, which supply complimentary information on the nucleon structure, will be performed simultaneously with Drell-Yan data using dedicated triggers. The set of these measurements permits to tests the quark-parton model of nucleons at the QCD twist-2 level with minimal systematic errors. Physics motivations and possible layout of SPD will be presented as well as the plans for polarized beams at NICA.

taken from <http://nica.jinr.ru>

Spin program with protons

Collider:

Single and double spin asymmetries in the pion (kaon) inclusive production.

Hyperon production in polarized proton-proton collisions...

Fixed target:

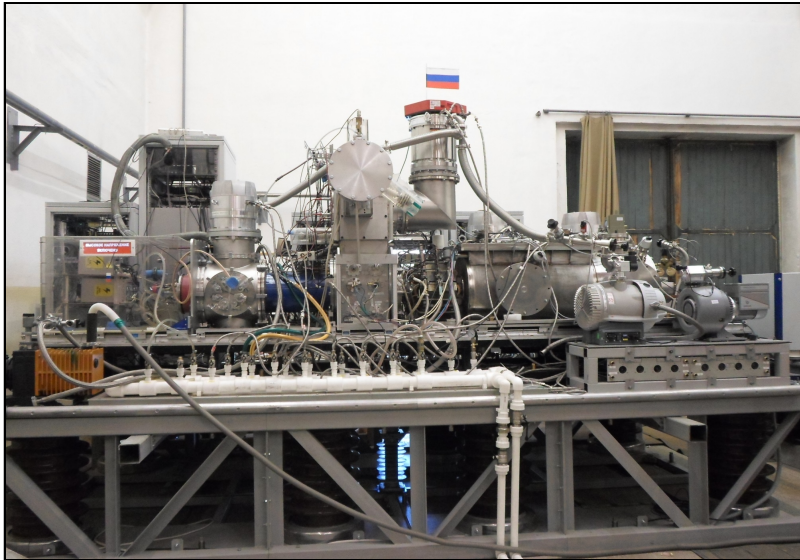
Polarized proton-proton, proton-neutron and proton-deuteron elastic scattering.

Spin structure of the short range nucleon correlations.

Spin structure of 3- nucleon forces ...

This requires good knowledge of the proton beam polarization!

New Source of Polarized Ions



New SPI for deuterons was put into operation in 2016.

Part of the **IUCF** source was used for the design.

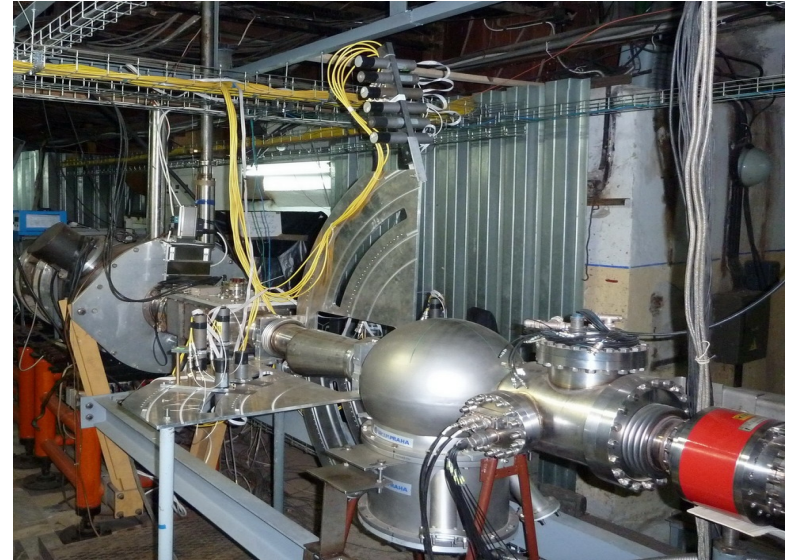
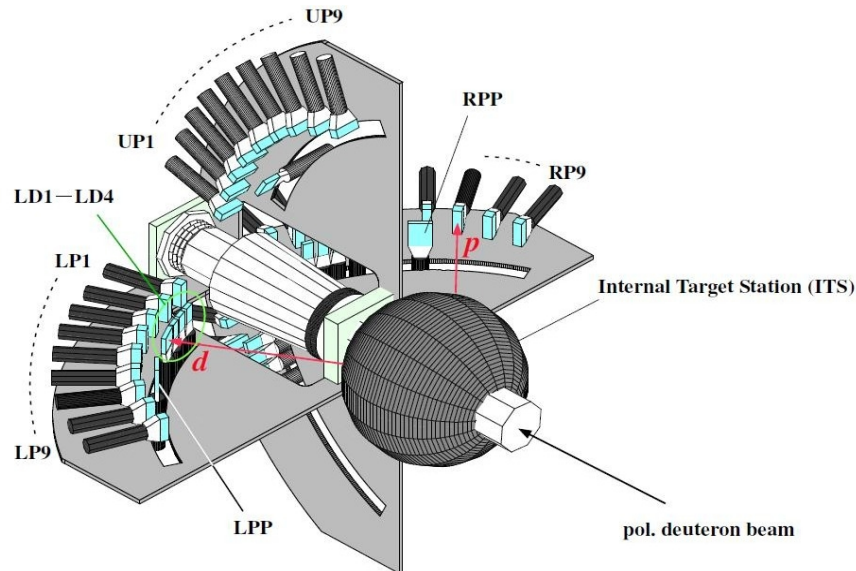
SPI provides up to $2 \cdot 10^9$ ppp (in future up to $2 \cdot 10^{10}$ ppp)

Large variety of the spin modes for deuterons.

Source provides also polarized protons.

First test in March of 2017!

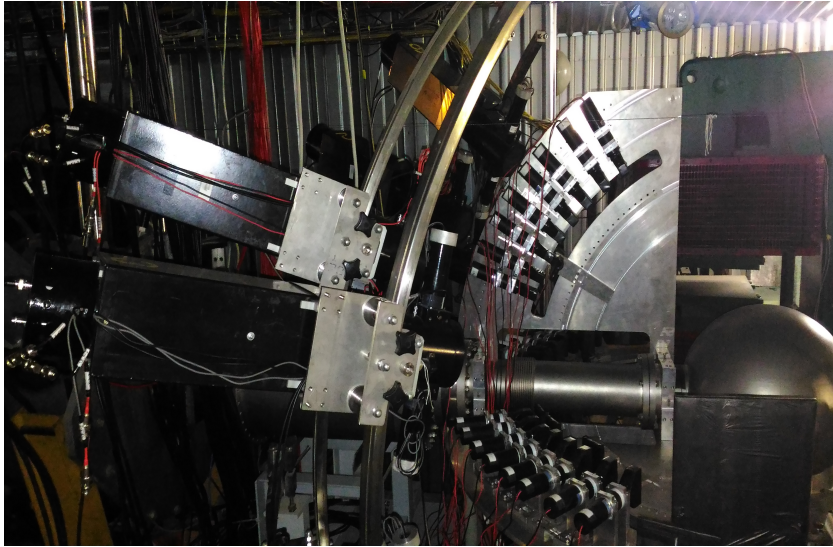
DSS setup to study dp - elastic scattering at ITS



- Deuterons and protons in coincidences using scintillation counters
- Internal beam and thin CH_2 target (C for background estimation)
- Polarization measurement at 270 MeV at 8 different angles

For details see talk of Ya.Skhomenko

Upgrade of the **Delta-LNS (DSS)** setup at ITS at Nuclotron



New infrastructure, cabling

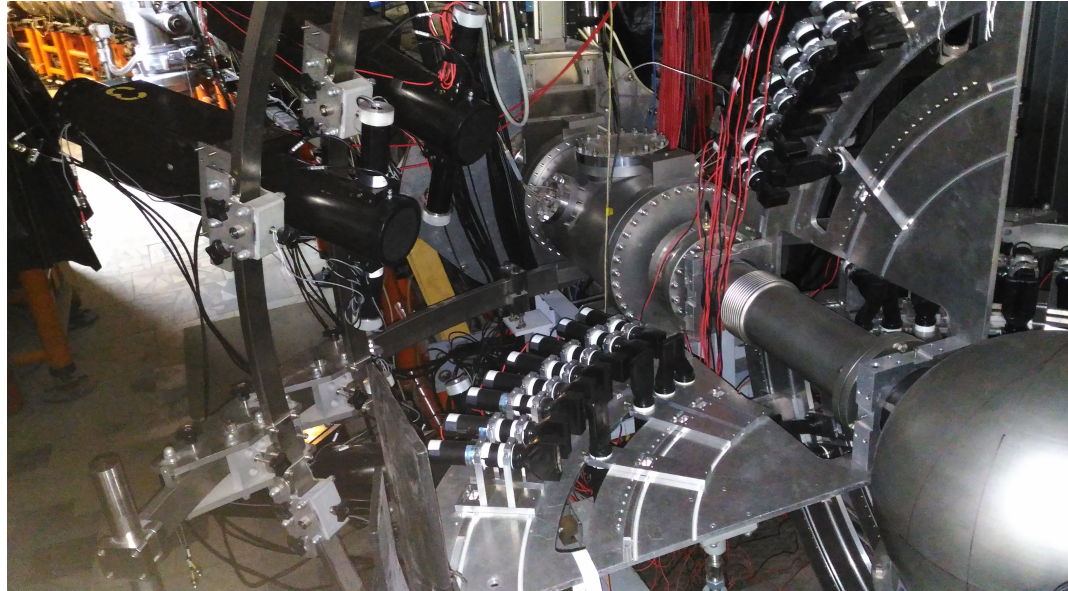
New HV system (Mpod)

New VME DAQ

40 counters for dp-elastic scattering studies

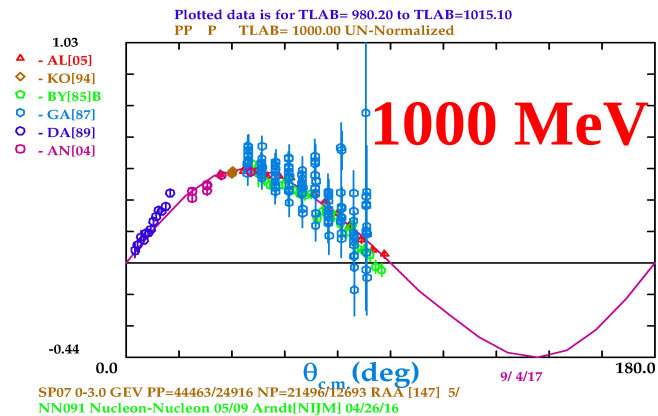
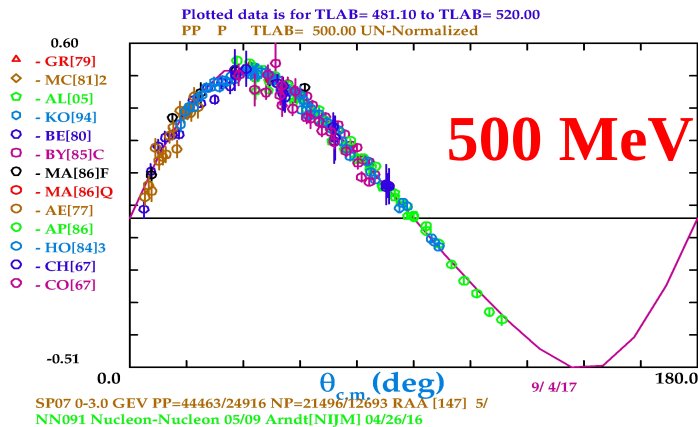
8 dE-E detectors for dp -breakup studies

Setup to study **dp**- elastic scattering at ITS at Nuclotron in 2016.



- Deuterons and protons in coincidences using scintillation counters
- Internal beam and thin **CH₂** target (**C** for background estimation)
- Permanent polarization measurement at **270** MeV
- The data were taken for three spin modes of SPI: unpolarized, “2-6” and “3-5” (p_z, p_{zz}) = (0,0), (1/3,1) and (1/3,-1)
- Typical values of the polarization was 70-75% from the ideal values

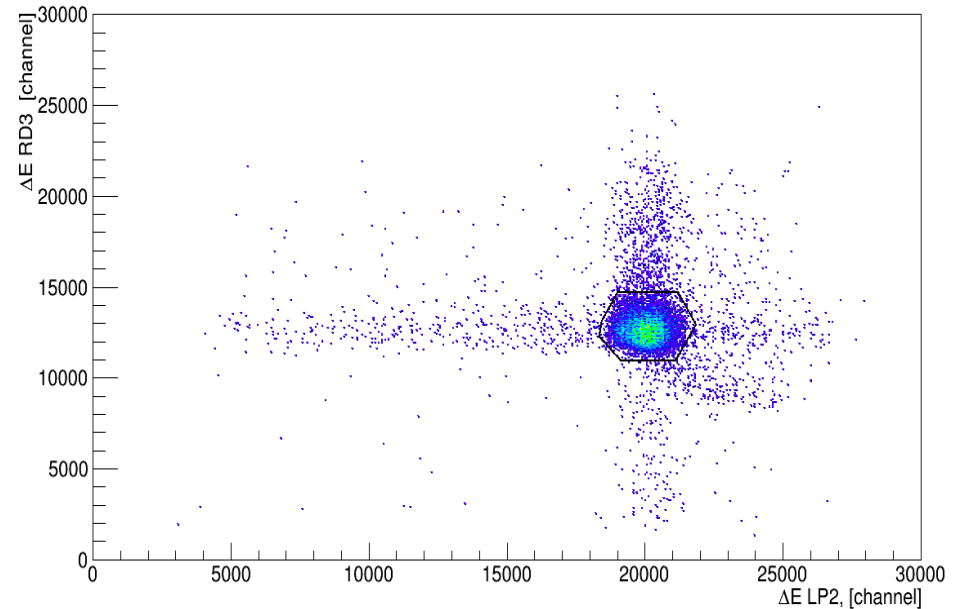
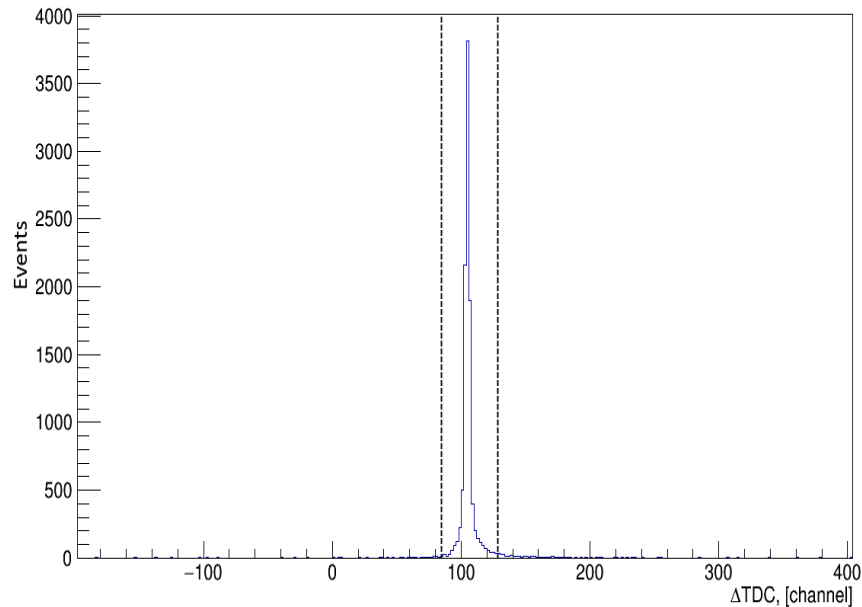
Use of **pp**-quasielastic scattering at ITS for the beam polarization measurements



The use of only proton detectors to detect **pp**-quasielastic scattering. Measurement at **8** different angles symmetric with respect to **90°** in cms.

However, due to current detector support the positions of the scintillation counters is not optimal – no coverage at small (and large) scattering angles.

Deuteron beam polarization measurements using **dp**-elastic scattering at **270 MeV**.

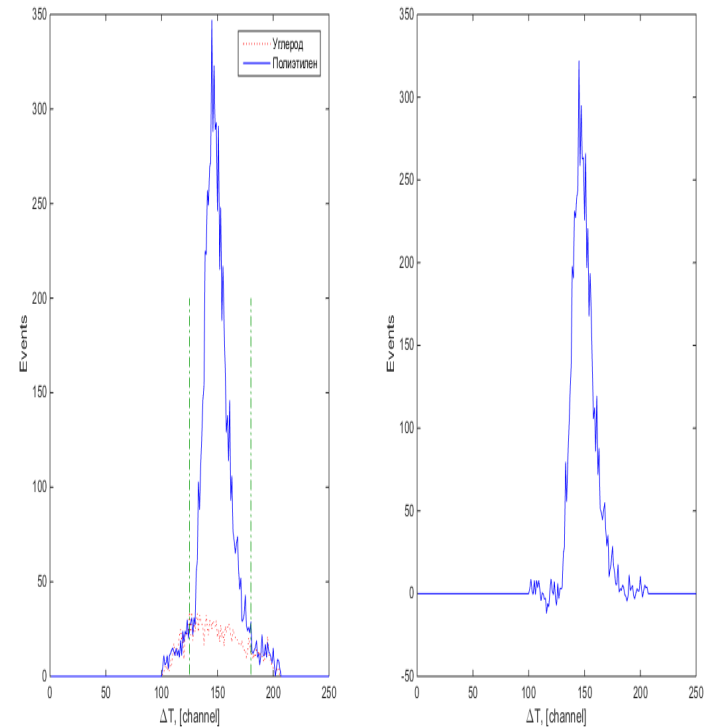
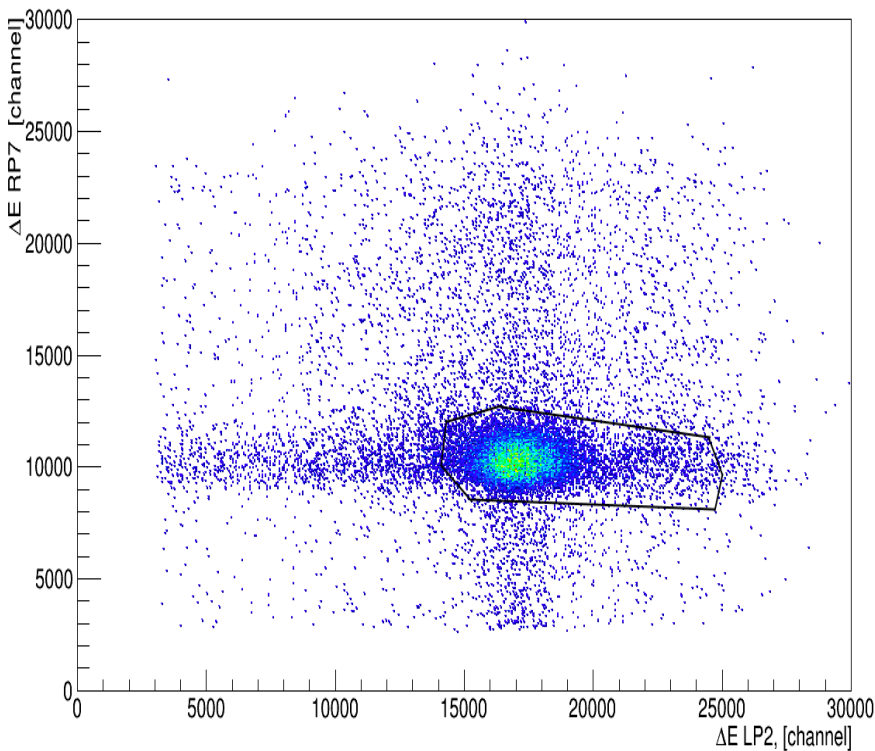


dp- elastic scattering events are selected using time difference and amplitude correlations at **8** angles.

$P_Z^+ = -0.232 \pm 0.018$, $P_{ZZ}^+ = +0.595 \pm 0.013$,

$P_Z^- = -0.243 \pm 0.013$, $P_{ZZ}^- = -0.736 \pm 0.011$.

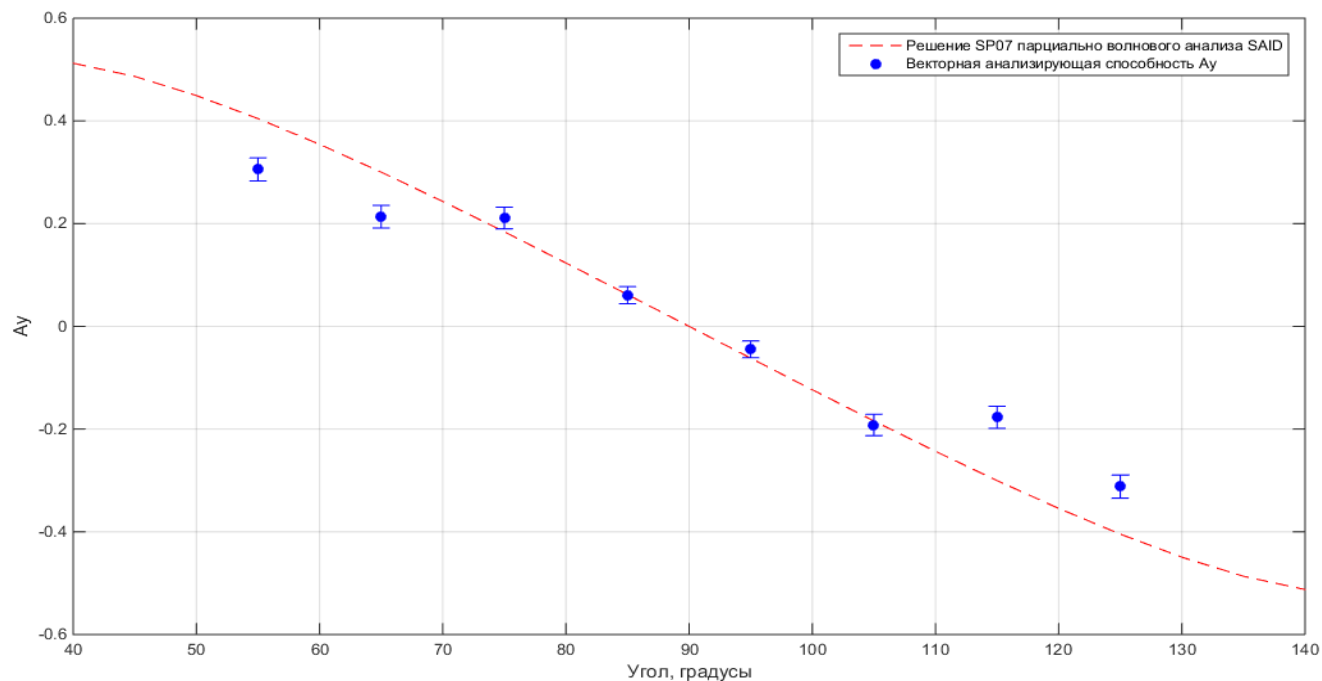
Selection of **pp**- quasielastic scattering at **500 MeV**.



pp- quasi-elastic scattering events are selected using time difference and amplitude correlations with further carbon background subtraction.

Analysis was performed by **I.Volkov** (Belgorod SNRU)

Comparison with SAID SP07 solution at 500 MeV.



The agreement of the data with PWA is very good.

(Tensor analyzing power is consistent with zero.)

Therefore, **DSS** proposed to use this method to measure the proton beam polarization at ITS in **2017**.

Conditions of the **proton** run in March 2017.

Injection of **5 MeV** protons into Nuclotron ring.
Acceleration up to **500 MeV**- no serious depolarization resonances (**talk of Yu.Filatov**).

Unpolarized protons: $I \sim 1.5 \cdot 10^8$ ppp

Polarized protons: $I \sim 2-3 \cdot 10^7$ ppp

IPol=1 P=-1 (WFT 1→3)

IPol=2 P=0 (unpolarized)

IPol=3 P=-1 (WFT 1→3)

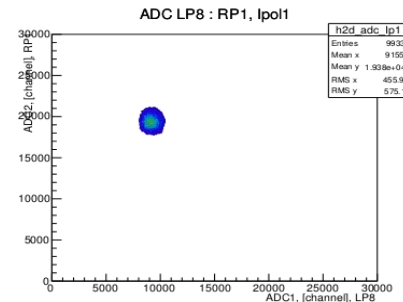
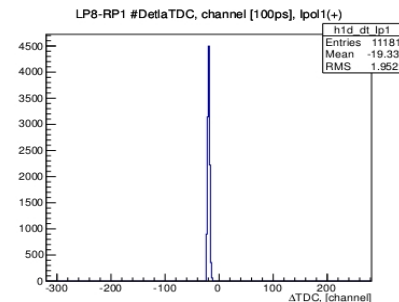
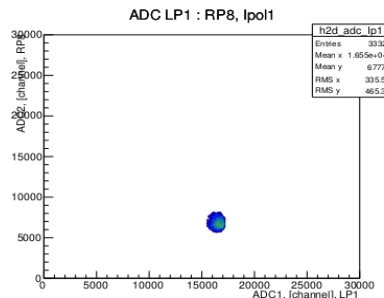
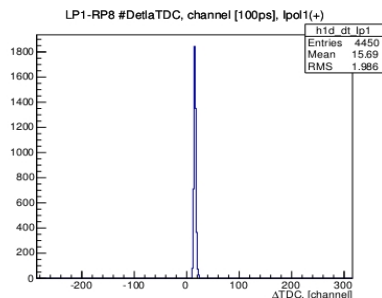
Therefore, **DSS** setup had polarized beam 2/3 of time.

Selection of pp- elastic scattering at 500 MeV.

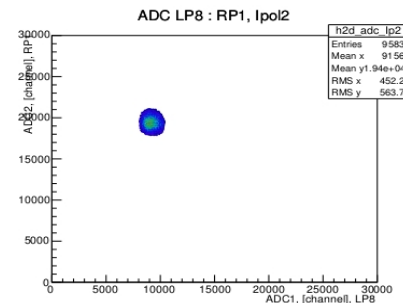
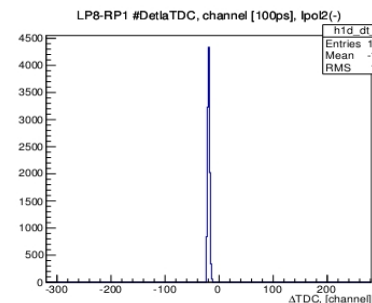
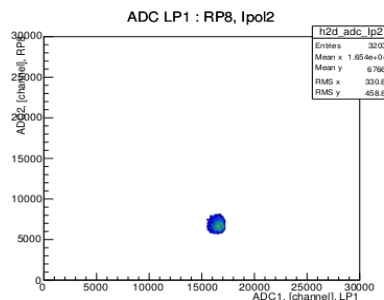
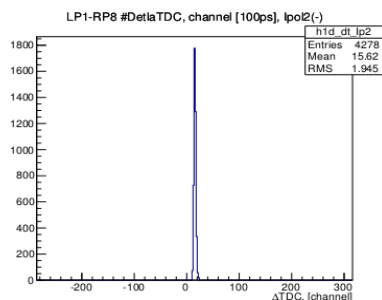
55°

125°

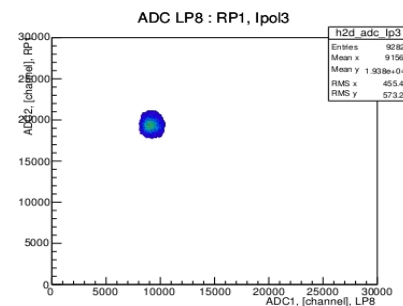
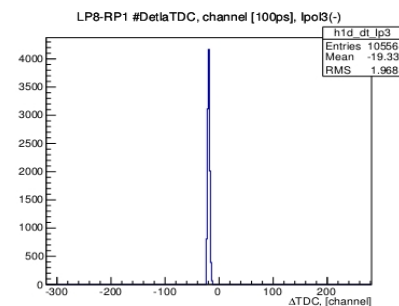
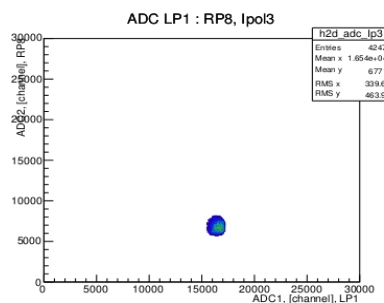
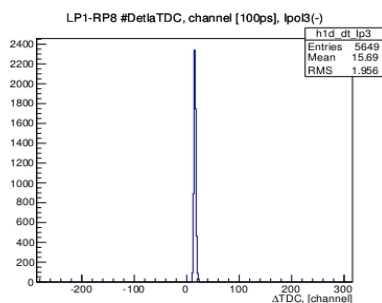
“_”



“0”



“_”



Results for **pp**- elastic scattering at **500 MeV**.

Having the asymmetries for **8** angles (**55°-125°** in the cms) we obtained the averaged value of the proton beam polarization

Unpolarized protons: **$P = 0.017 \pm 0.021$**

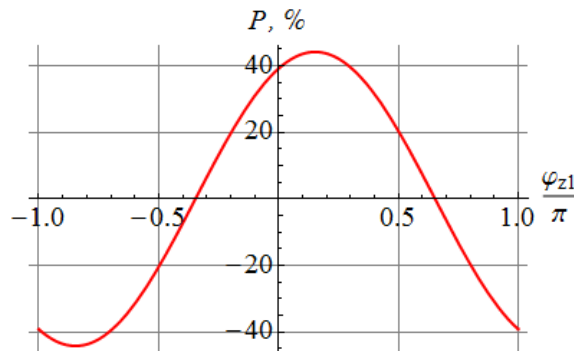
Polarized protons: **$P = -0.354 \pm 0.022$** (preliminary)

Analysis was performed by **P.Kurilkin**

Discussion of the results for polarized **pp-** elastic scattering at **500 MeV**.

Is **$P = -0.354 \pm 0.022$** small or large? Good enough (as at KEK).

1. Current magnetic option of the Nuclotron injection line **$P_{\text{max}} = 0.392$**
2. Additional solenoid at the SPI exit **$P_{\text{max}} = 0.442$**



3. Additional solenoid at the SPI exit+ Kx1 solenoid **$P_{\text{max}} = 1.000$**

$$\mathbf{P}_{\text{PSI}} = 0.90 \pm 0.06 !$$

Yu.Filatov

Conclusions

The **DSS** deuteron beam polarimeter placed at ITS has been used to measure the proton beam polarization at **500 MeV** using **pp**- (quasi)elastic scattering.

The obtained value of the vertical proton polarization is **-0.354 ± 0.022** .

However, this value corresponds to polarization at the exit of SPI of **0.90 ± 0.06** taken into account the current magnetic option of the Nuclotron injection line.

The current version of the **DSS** deuteron beam polarimeter can be applied for the proton beam polarization measurement at the energy range of **200-1000 MeV**. The extension of the proton polarimetry at ITS to the higher energies (up to **3500 MeV**) is possible by the enlargement of the angular span of the polarimeter: new detector support, new scintillation counters etc.

The availability of the polarized proton beam will allow to extend the physics program at ITS, namely, to perform the experiments on the measurements of the nucleon analyzing power A_y^p in **pd**- elastic scattering at **135-1000 MeV** and in **pd**- nonmesonic breakup at the energies between **135-250 MeV** for different kinematic configurations etc.

Spin structure of SRCs with polarized proton beam!

Thank you for the attention!