DEUTERON BEAM POLARIMETRY AT NUCLOTRON-NICA

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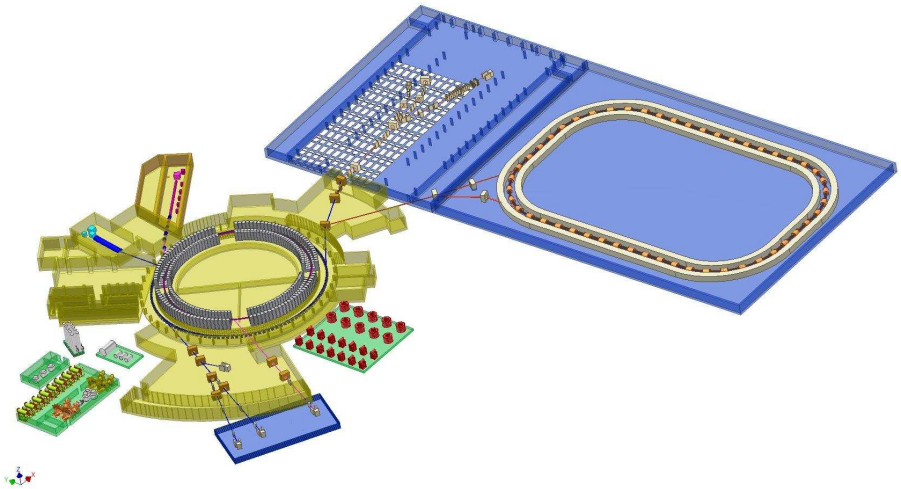
Content of the talk

- Introduction
- Current status of the beam polarimetry Nuclotron
- Conception: absolute calibration, permanent monitoring etc.
- Polarimetry at Nuclotron-M and NICA
- Conclusions

Spin-NICA activity

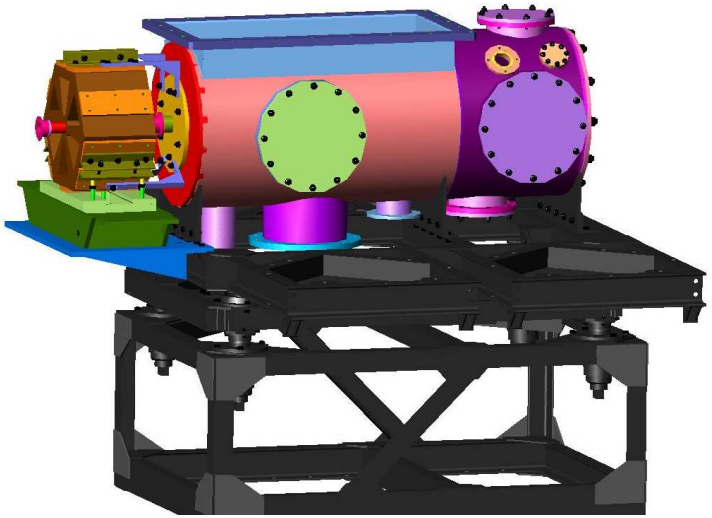


- Spin content of nucleon from DY and charmonium.
- Spin structure of cold dense matter.
- Both fixed target and collider experiments.
- Efficient polarimetry.

New facility is planned to work at $\sqrt{s_{NN}} = 4 \div 12$ GeV for deuterons and up to $\sqrt{s_{NN}} = 27$ GeV for protons.

Serious advantage is the availability of polarized deuterons (neutrons).

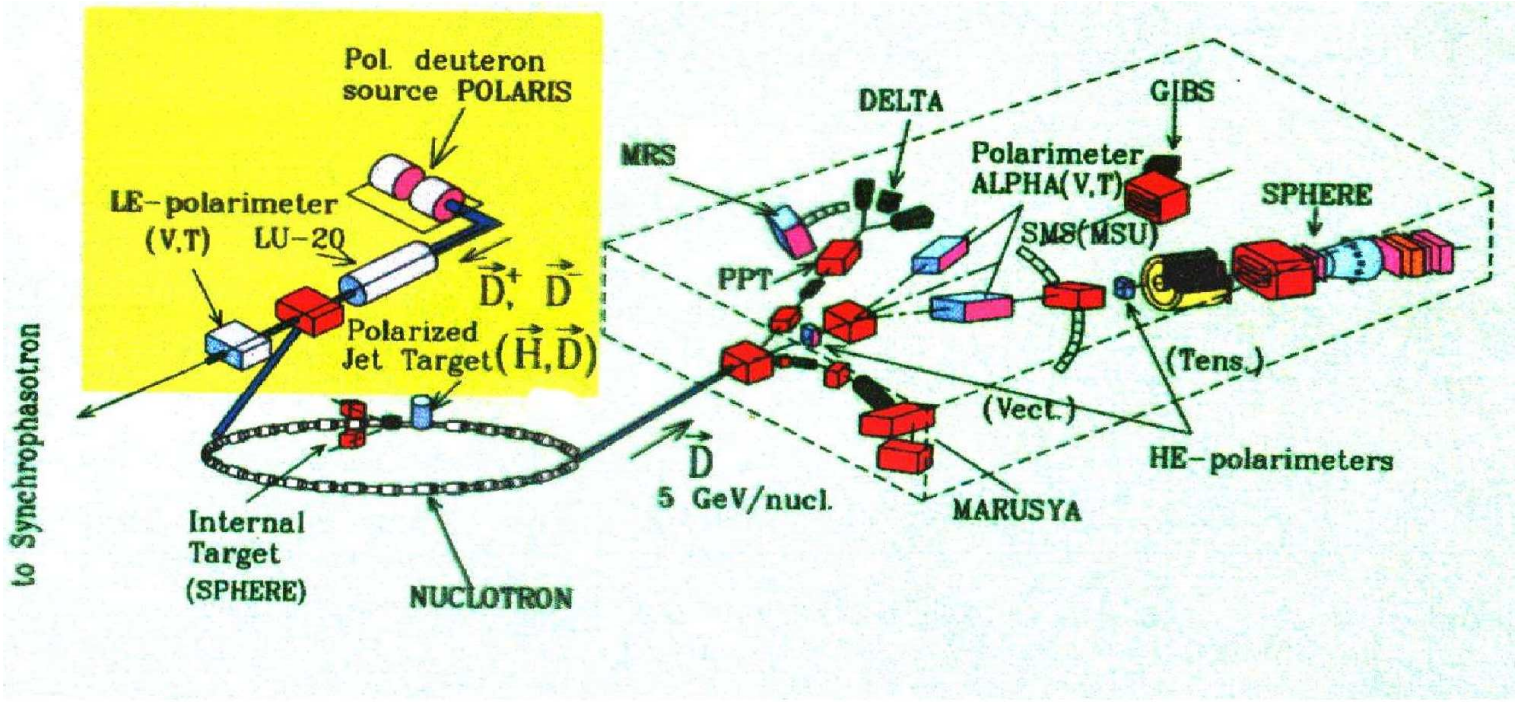
New Polarized Deuteron Source for LHEP



- New source will provide up to $5 \cdot 10^{10}$ ppp and higher values of polarization than POLARIS.
- Part of the IUCF source can be used for the construction.
- 400 k$ is required to put into operation new source.
- First operation was planned in 2010 y.

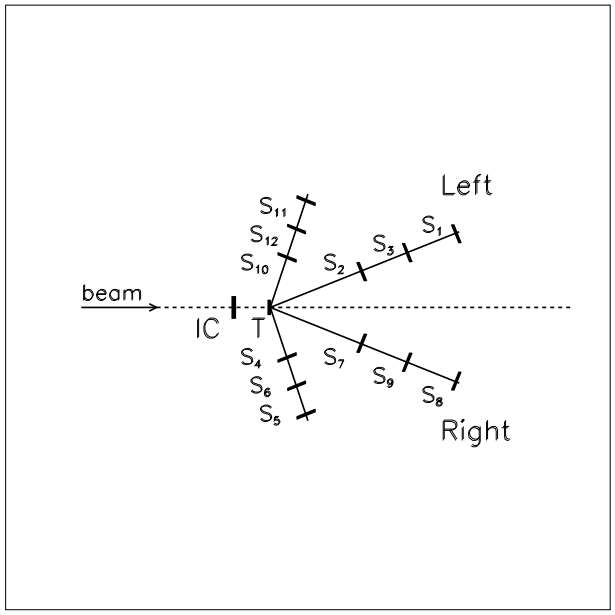
Figure of merit will be increased by a factor $\sim 10^3$

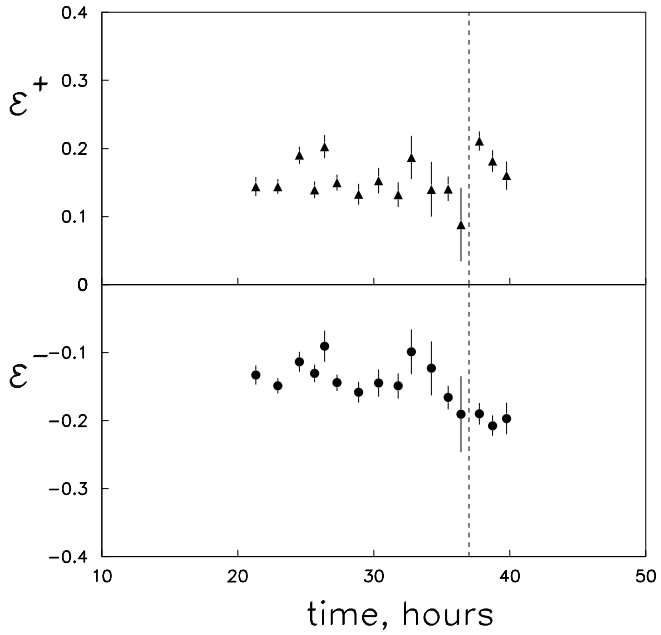
Nuclotron Accelerator Complex



- PIS on 360 kV terminal
- 10 MeV/A LINAC
- Tensor and vector LEPs
- Nuclotron Ring: 6 GeV/A
- ITS polarimeter
- Extraction beam line
- HE polarimeters
- Experimental setups

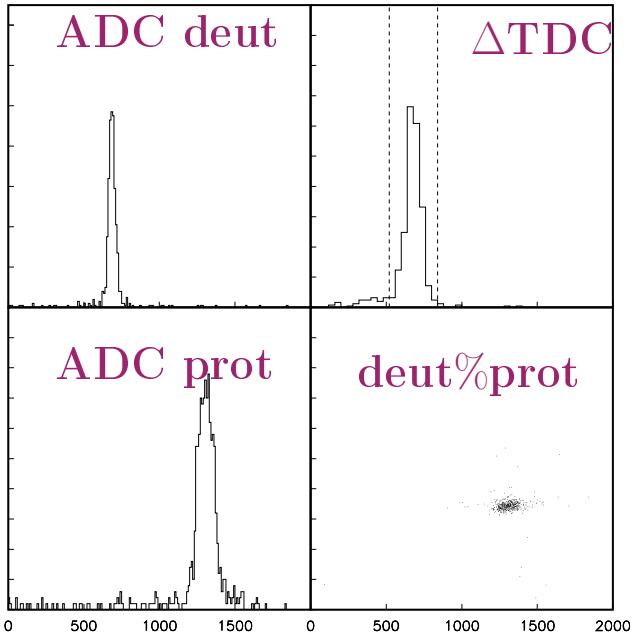
Vector polarization of the deuteron beam (2002)





- Vector polarimeter is based on the left-right asymmetry measurement in quasi-elastic **pp** scattering (**5%** of systematics).
- Measurements of the deuteron beam vector polarization have been performed at **3.5** and **5.0 GeV/c**.
- There is no depolarization at Nuclotron.

Vector and tensor polarizations measurements at 270 MeV (2005)



	Pol.	Mode 2-6	Mode 3-5
ITS	T	0.619± 0.023	-0.532± 0.019
ITS	V	0.210± 0.013	0.193± 0.011
LEP	T	0.69±0.13	-0.67± 0.16

- Polarimeter is based on the asymmetry measurement in dp elastic scattering. (2% of systematics).
- Measurements of the deuteron beam vector and tensor polarization have been performed at 270 MeV (RIKEN data).

Conception for deuteron beam polarimetry at Nuclotron-M

- Absolute calibration of the beam polarization.
- Efficient calibrated polarimeters. Polarization standard.
- Permanent monitoring of the beam polarization.
- Local polarimetry.

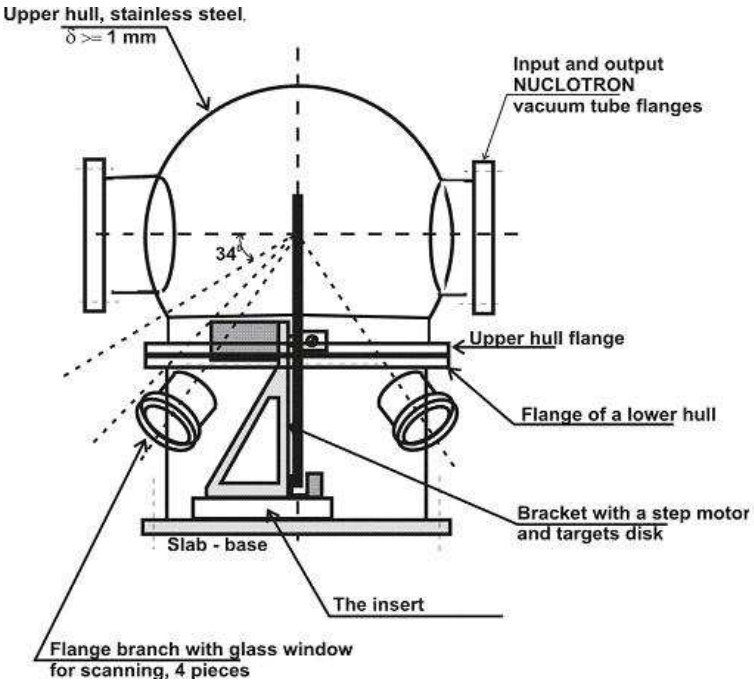
$$\sigma = \sigma_0(1 + \frac{3}{2}p_y \cdot A_y + \frac{1}{2}p_{yy} \cdot A_{yy})$$

If the analyzing powers take known from the theory values one can obtain the beam values polarization avoiding systematic error due to uncertainty of the analyzing powers of the polarimeter -

absolute calibration of the beam polarization

$A_{yy} = -\frac{1}{2}$ for $^{12}\mathrm{C}(\mathbf{d}, \alpha)^{10}\mathrm{B}^*[2^+]$ reaction (K.Suda et al.)

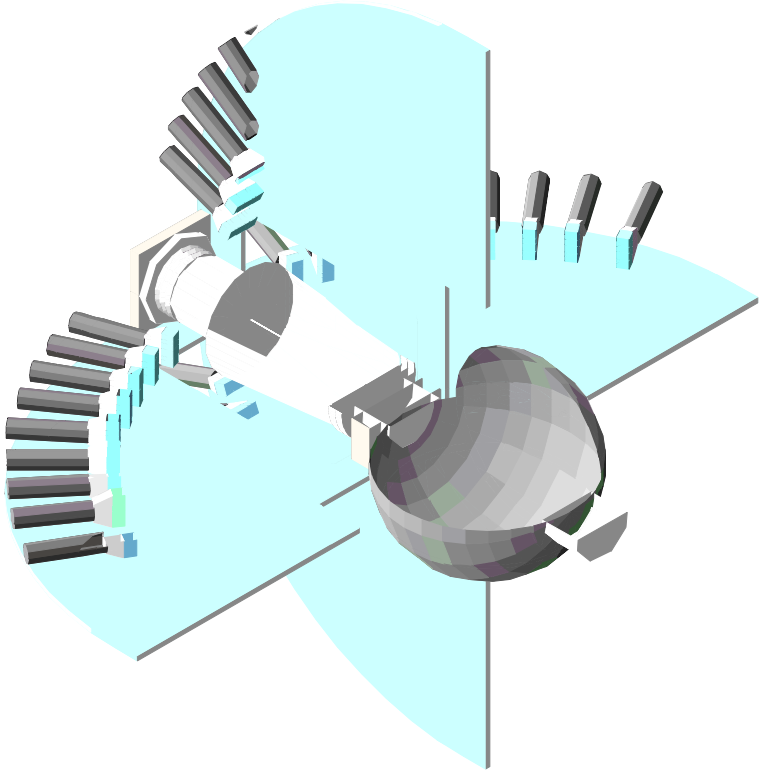
Joint CNS-JINR experiment at Internal Target Station at Nuclotron (DSS-project)



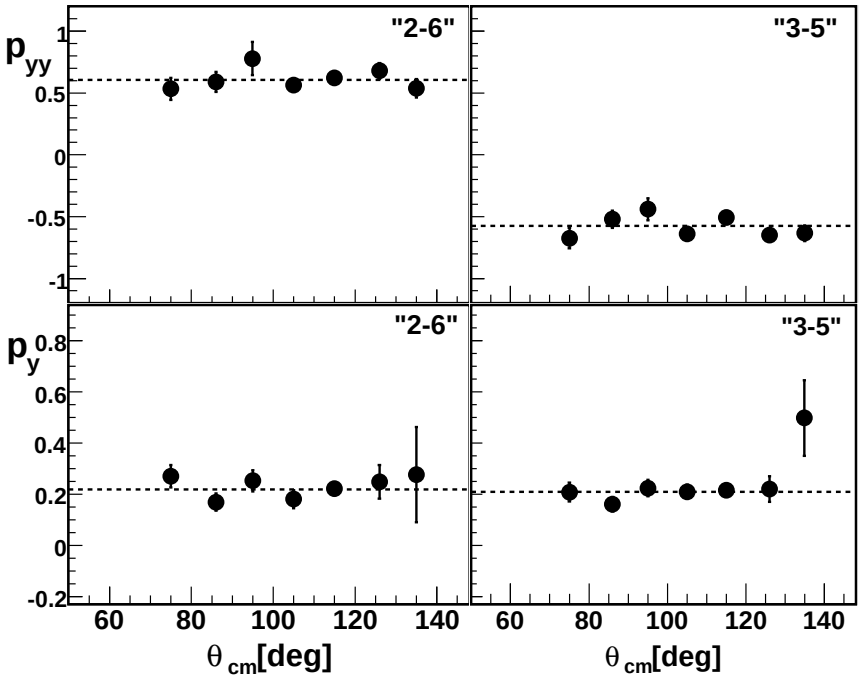
New Internal Target Station is very well suited for the measurements of the dp- elastic scattering observables at large angles in the cms.

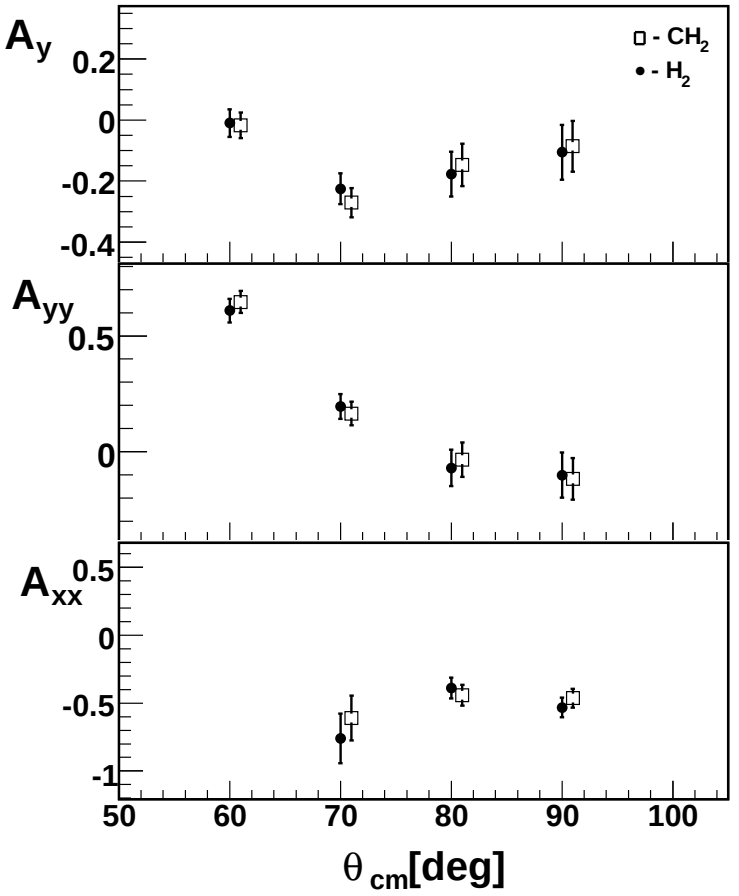
Main deuteron beam polarimeter at Nuclotron.

Measurements of the deuteron beam polarization at ITS using CNS detection system

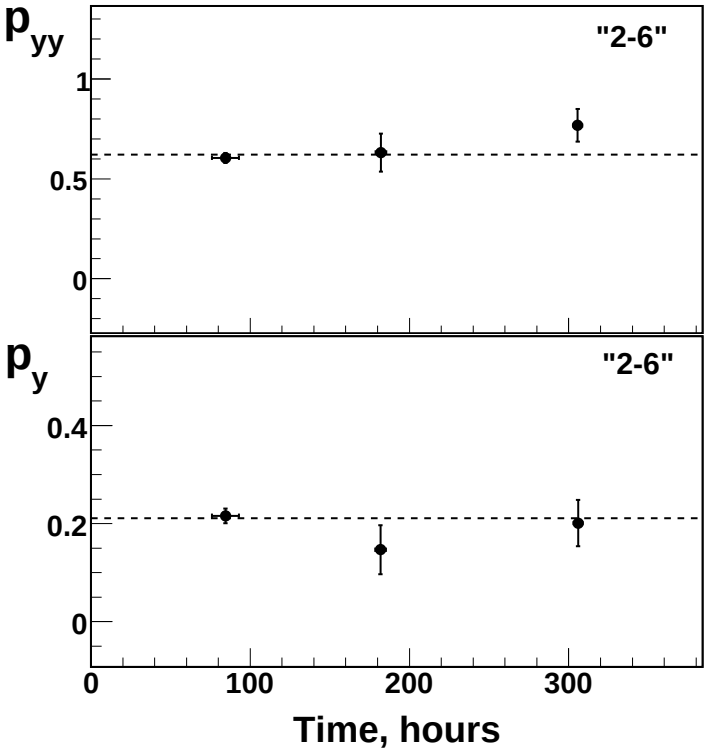


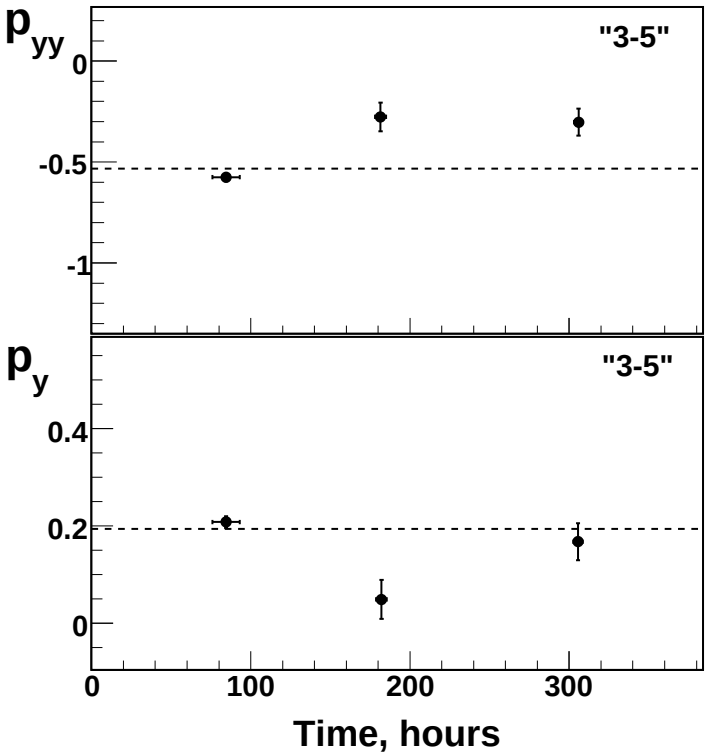
A_y, A_{yy} and A_{xx} in dp- elastic scattering at 880 MeV



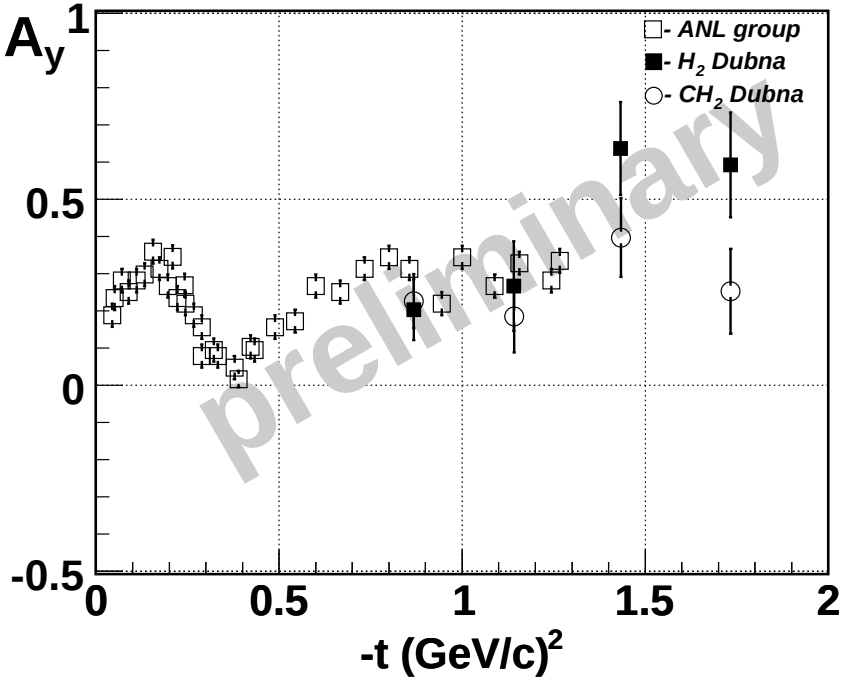


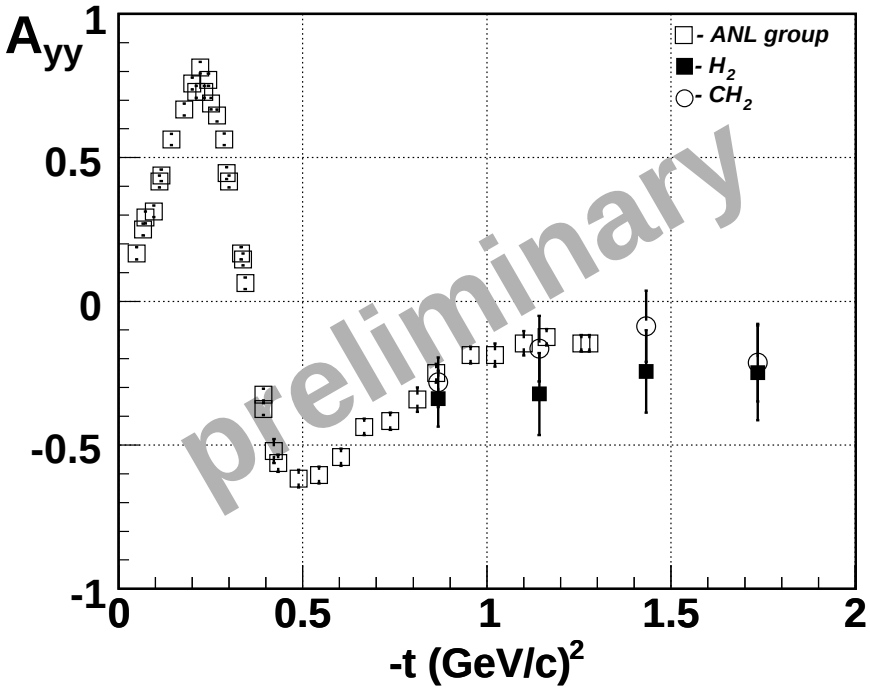
Long-term stability of beam polarization at 270 MeV





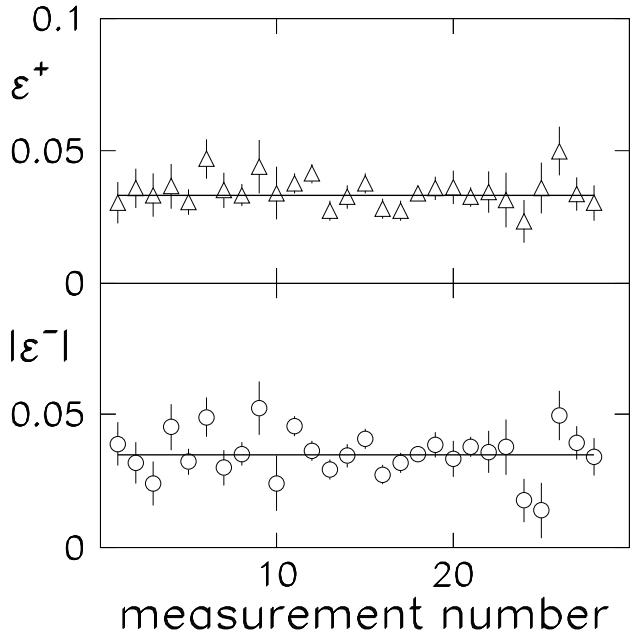
A_y and A_{yy} in dp- elastic scattering at 2000 MeV

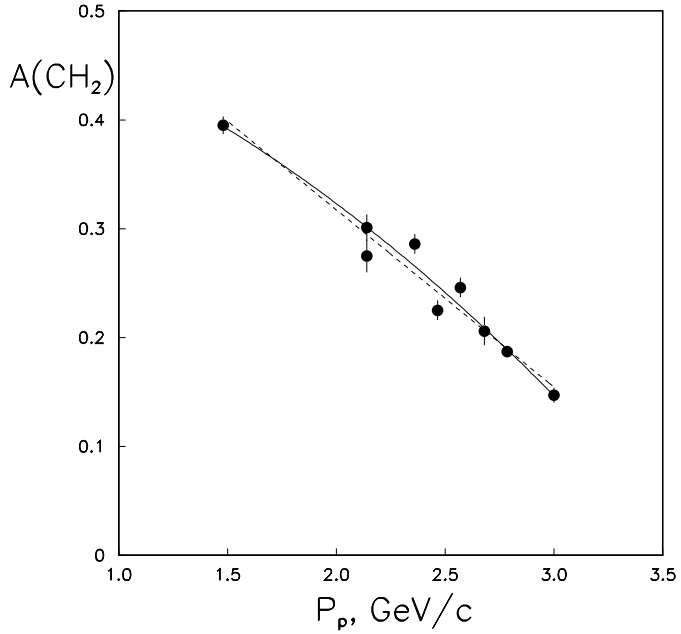




The values of A_y and A_{yy} are large enough to use for the polarimetry.

Permanent monitoring of the beam polarization

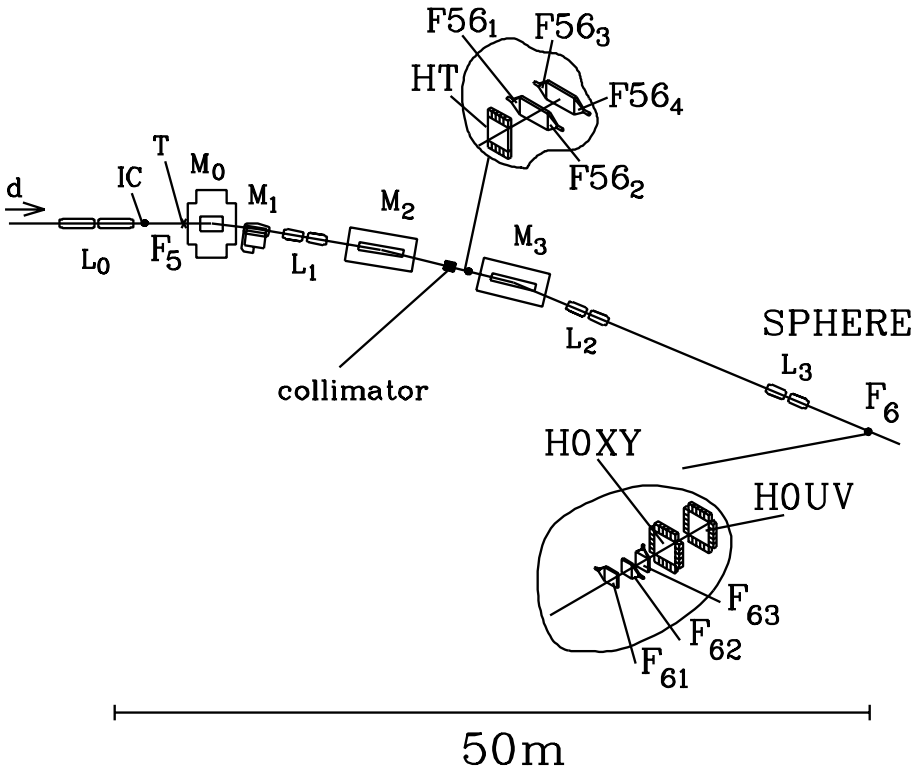


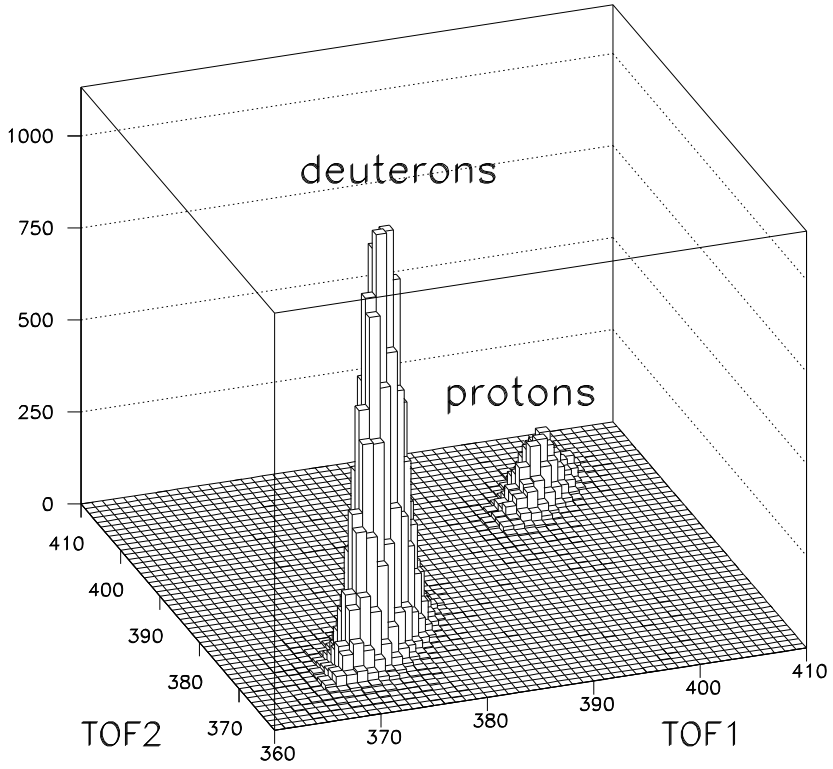


The asymmetry stability during several days of the beam time.

The knowledge of the effective analyzing power give the possibility to obtain the beam polarization values.

High energy tensor polarimeter based on $\mathbf{A(d,p)X}$

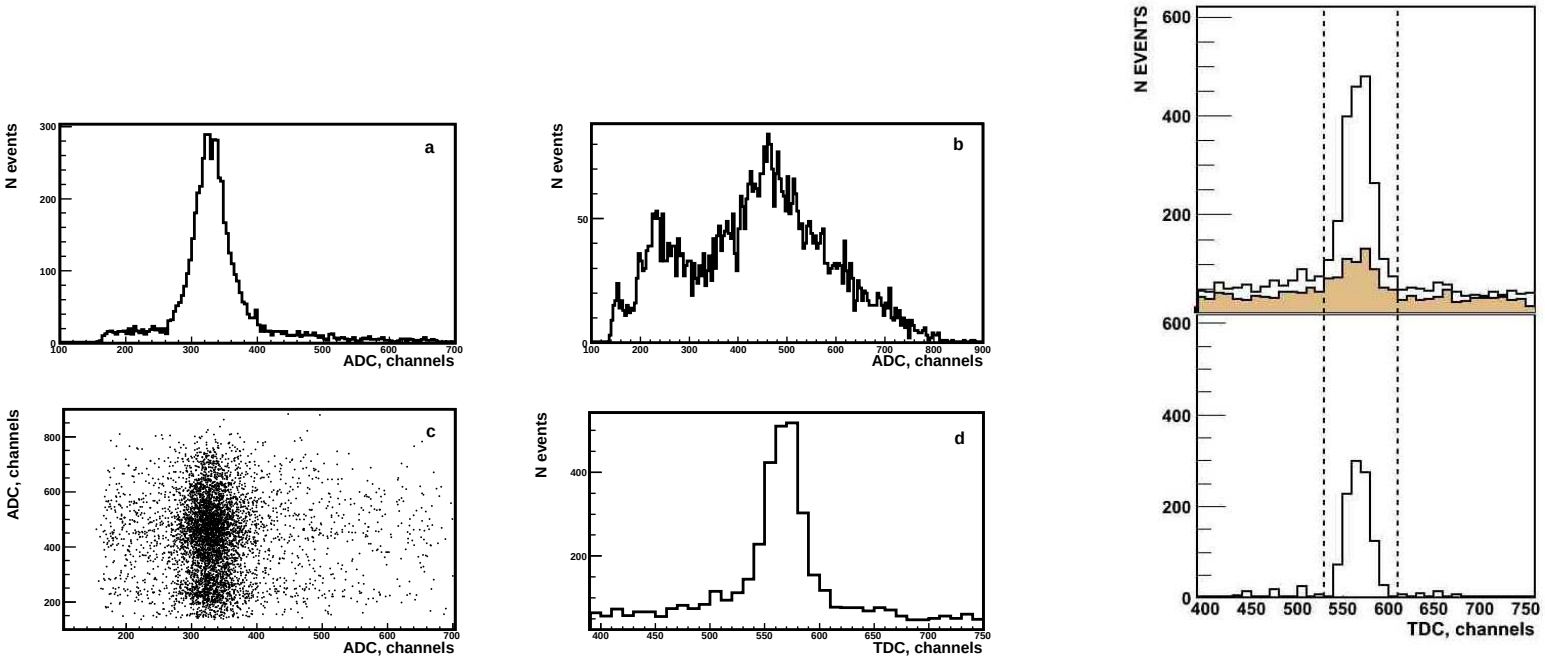




The effective analyzing power taken from different experiments was $\mathbf{T_{20} = -0.84 \pm 0.05}$. Small admixture of deuterons!

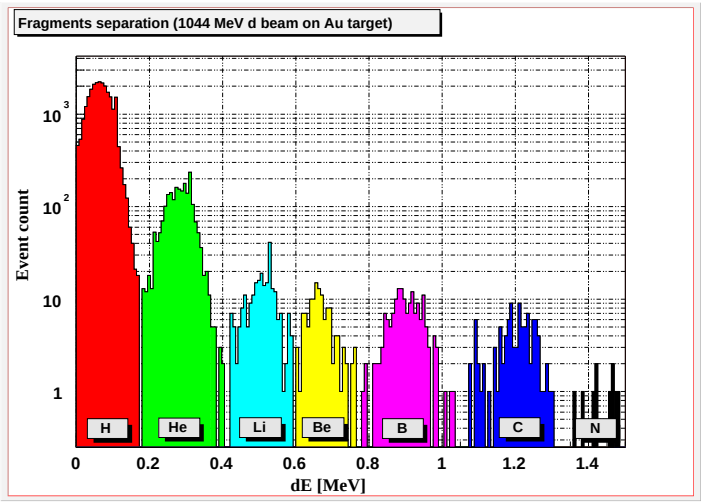
But! serious problems with dead-time for analyzing power.

dp- elastic scattering at 1600 MeV at extracted beam



Feasibility of the dp- elastic scattering events selection using information on the energy losses in the scintillators and timing information was demonstrated at T_d=1600 MeV and $\theta_{lab} \sim 8^\circ$.

CNI polarimeter based on the dC elastic scattering.



- pC elastic scattering in CNI region is used for polarimetry at AGS and RHIC.
- The experience to detect slow nuclear fragments at ITS exists.
- Spin structure of dC elastic scattering is complicate: 5 complex amplitudes.

  Energy dependence for analyzing powers is not clean.

  Serious theoretical analysis is required.

In-flight conclusions for deuteron polarimetry at Nuclotron-M

- The main polarimeters for deuterons must satisfy to the following requirements:

  a) to be able to measure both tensor and vector polarizations due to mixed spin modes of new PIS

  b) to measure the direction of the polarization vector

  c) analyzing powers must be obtained by the absolute method of the beam polarization measurements

  Such a polarimeter exists at ITS

- In the nearest run with polarized deuterons-

  -measurements of the beam polarization at 270 MeV at ITS.

  -calibration of ITS polarimeter at 270-2000 MeV.

  -simultaneous calibration of ITS, F3 and T20 polarimeters at 1600 MeV. Polarization standard for Nuclotron-M.

- This procedure will provide the error of $\sim 3\%$ at the energies of 270-2000 MeV and better than 5% at higher energies.

In-flight conclusions for deuteron polarimetry at Nuclotron-M

- Permanent monitoring of the beam polarization:

  -the use of 2 flattops of the Nuclotron field: one of them for ITS polarimeter.

  -small scattering angle polarimeter at F3.

  - CNI polarimeter.

- Local polarimetry:

  -main polarimeters are based on the scintillation counters and can work in the counting mode.

  - DELTA setup - asymmetry in π^0 production

- Low energy polarimeter for new source should be changed.

  Instead of $^4\mathrm{He}(\mathrm{d},\mathrm{d})^4\mathrm{He}$ and $^3\mathrm{He}(\mathrm{d},\mathrm{p})^4\mathrm{He}$ reactions at 10 MeV the reactions having both tensor and vector analyzing powers should be used: $\mathrm{d}(\mathrm{d},\mathrm{p})\mathrm{t}$ or $\mathrm{d}(\mathrm{p},\mathrm{p})\mathrm{d}$.

  In any case silicon detectors must be changed for new ones.

Beam polarization measurements at NICA

- Main question:

  Wheather we need an absolute polarimeter at NICA?

  (Polarized Jet Target = PIS in cost).

- pC CNI polarimeter at ITS at Nuclotron should work (experience of AGS). If it is calibrated, one can reproduce the same inside collider NICA.

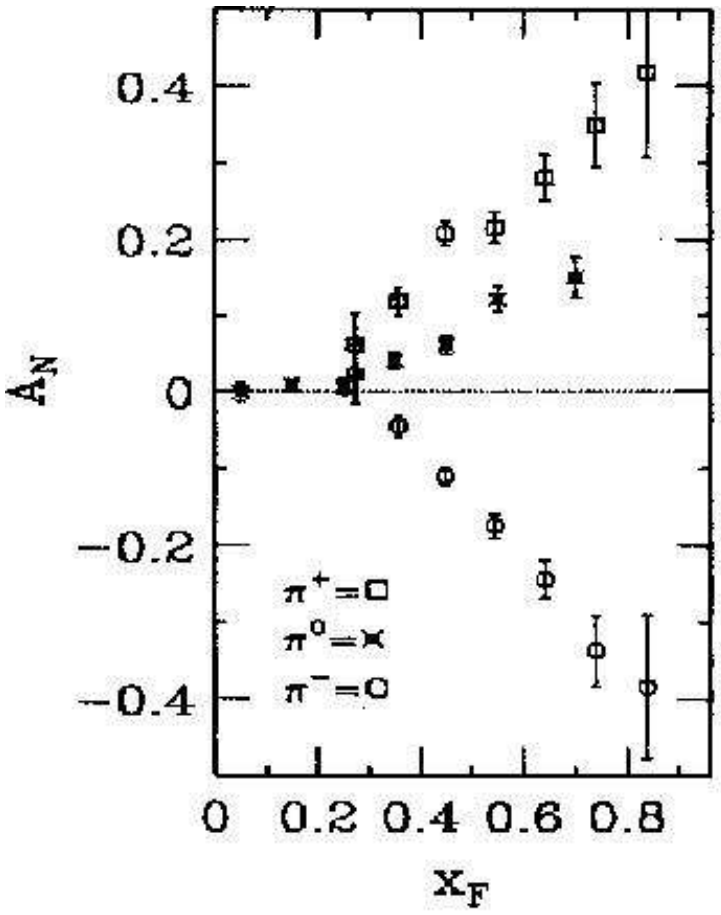
- dC CNI polarimetry - no experience.

  The main problem is the tensor polarization of the beam.

- Huge amount of theoretical work on the pp, dd, pC, dC elastic scattering in CNI region is required.

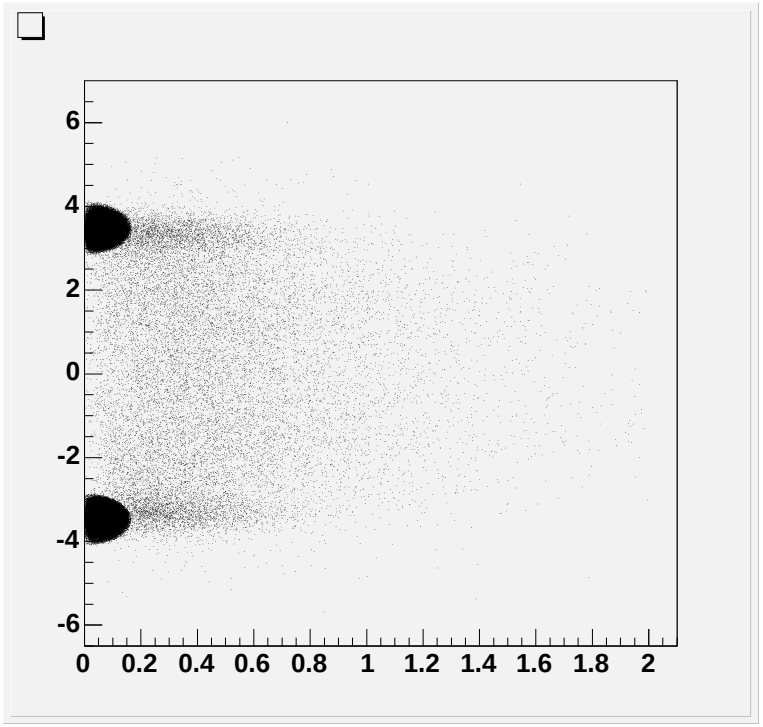
Special point for polarimetry inside collider ring is required!

Permanent nucleon beam polarization monitoring at NICA from $\vec{N} + \vec{N} \to \pi + X$ process

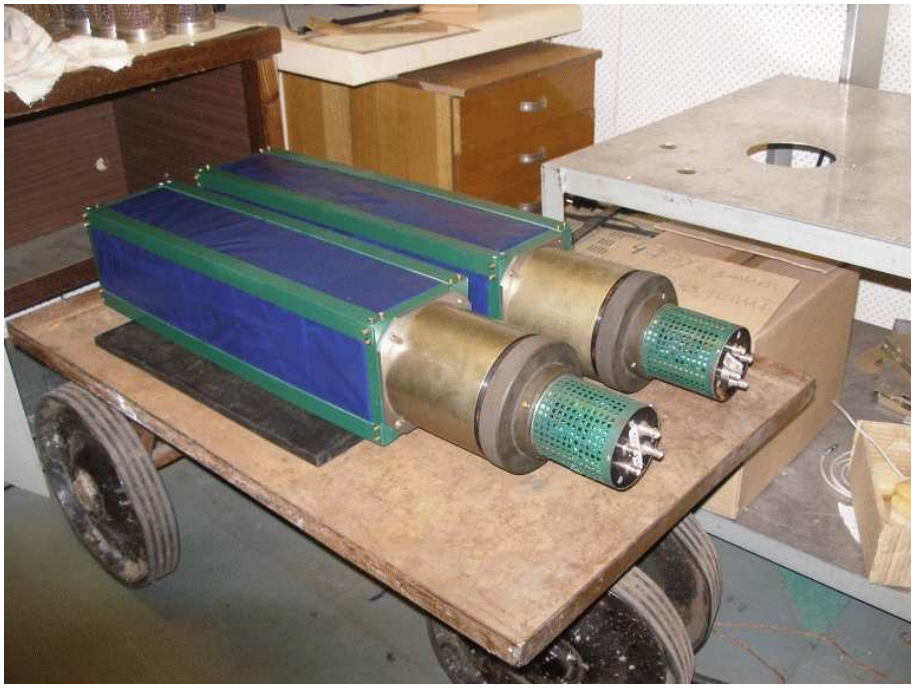


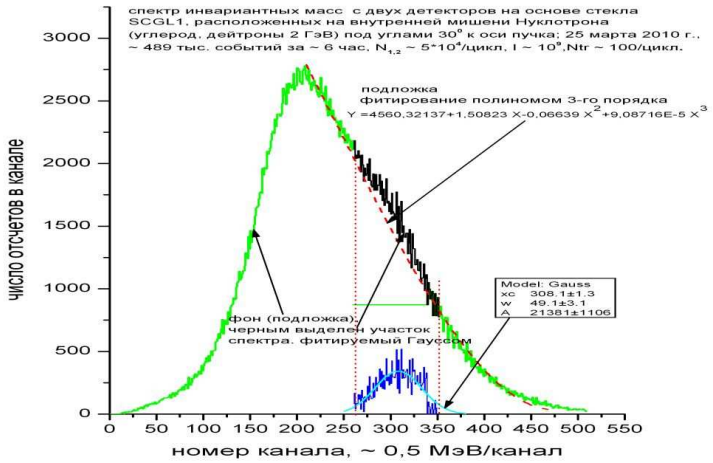
- The perturbative regime in SSA for meson production occurs already at T_N =22 GeV ($\sqrt{s_{NN}} \sim 7$ GeV).
  Large analyzing powers for inclusive pion production at NICA energies.
- For dd and dA collisions necessary to have spectator detector.
- The detection of π^0's is preferable.
  (no momentum reconstruction).
- However, figure of merit for $\pi^\pm$ is higher!
- Serious problem is the possible initial energy dependence.

SSA in π production in $\vec{d}\vec{d}$ collisions



SCG1 scintillating glass from PINOT spectrometer (JINR-INR-Italy collaboration)





30 blocks $15 \times 15\text{cm}^2$ ($0.675\ \text{m}^2$) of 14X_0 thick

Tests at Nuclotron beam have been performed in March 2010

Conclusions

- The proposed conception of the polarimetry will provide the precision in the determination of the deuteron beam polarizations $\sim 3\%$ in the energy range 270-2000 MeV and better than $\sim 5\%$ over whole energy range of Nuclotron-M.
- Strong feed-back with accelerator team and theoreticians is required to choose the scheme of the polarimetry for NICA.
- Special interaction point is required to provide measurement of the beam polarization and permanent monitoring of the beam at NICA.

Collaboration:

LHEP-JINR, DLNP-JINR, CNS, INR, MSU

(?) RCNP, Italy

THANK YOU

FOR YOUR ATTENTION