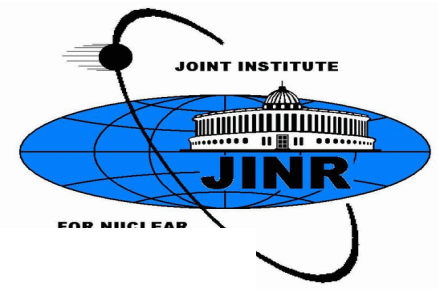
Studies of the Spin Structure of the short-range correlations using polarized He-3 target and light ions beams at Nuclotron

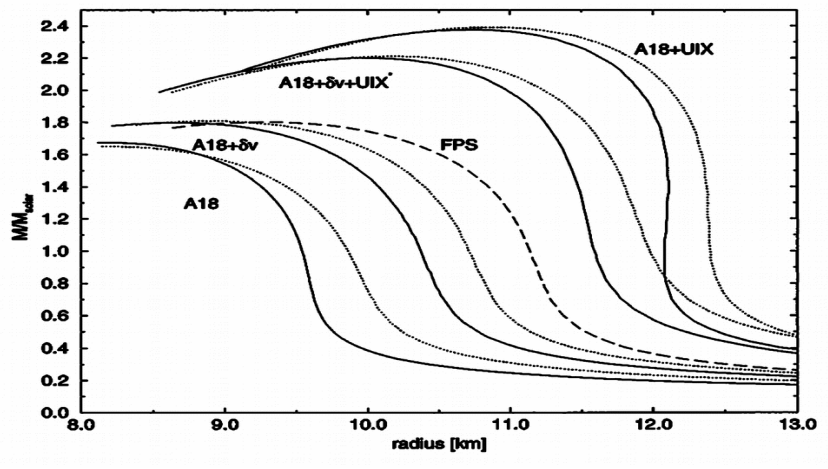


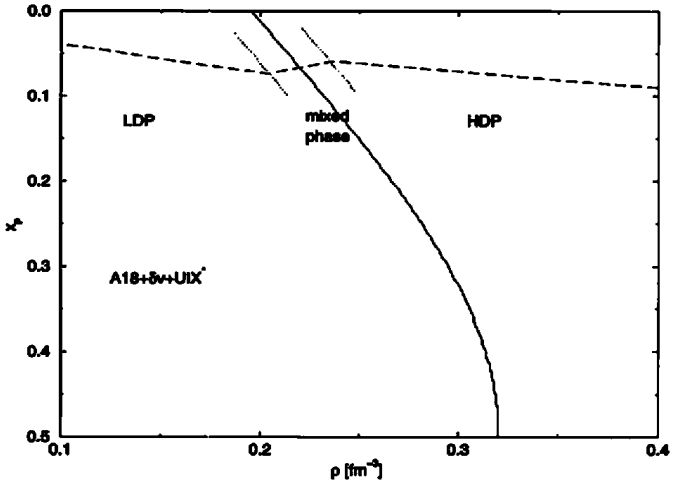
V.P. Ladygin on behalf of DSS collaboration

LHEP JINR, 8.07.2021

Few nucleons systems as a tool for dense matter studies

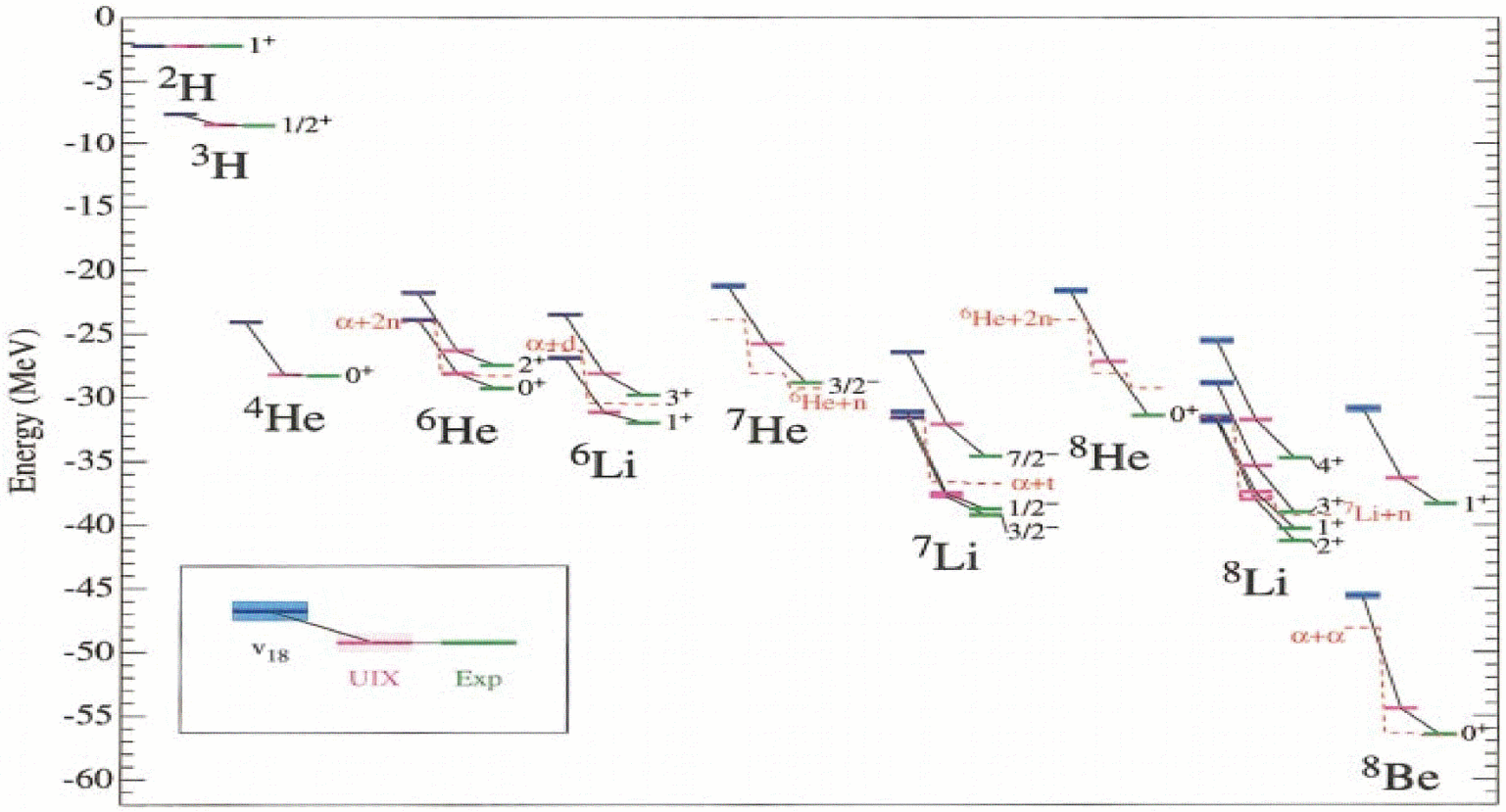
One of the traditional ways to obtain the information on the EOS at extreme densities (neutron stars) is the studies of the few nucleon systems.





Relativistic effects in 2NF and contribution of 3NF play very important role. (A.Akhmal et al, Phys.Rev. C58 (1998) 1804)

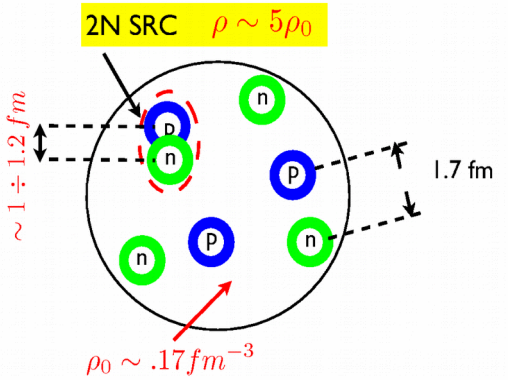
Importance of the spin part of 3NF for the light nuclei binding energies

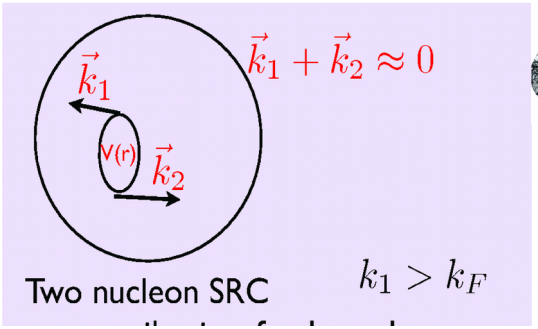


Spin parts of the 2N and 3N correlations are important to describe the light nuclei structure.

(S.C.Pieper et al., Phys.Rev.C64 (2001) 014001)

Short range correlations (SRCs)





Summary of the theoretical analysis of the experimental findings
practically all of which were predicted well before the data were obtained

More than ~90% all nucleons with momenta k≥300 MeV/c belong to two nucleon SRC correlations — BNL + Jlab +SLAC

Probability for a given proton with momenta 600> k > 300 MeV/c to belong to **pn** correlation is ~ 18 times larger than for **pp** correlation — BNL + Jlab

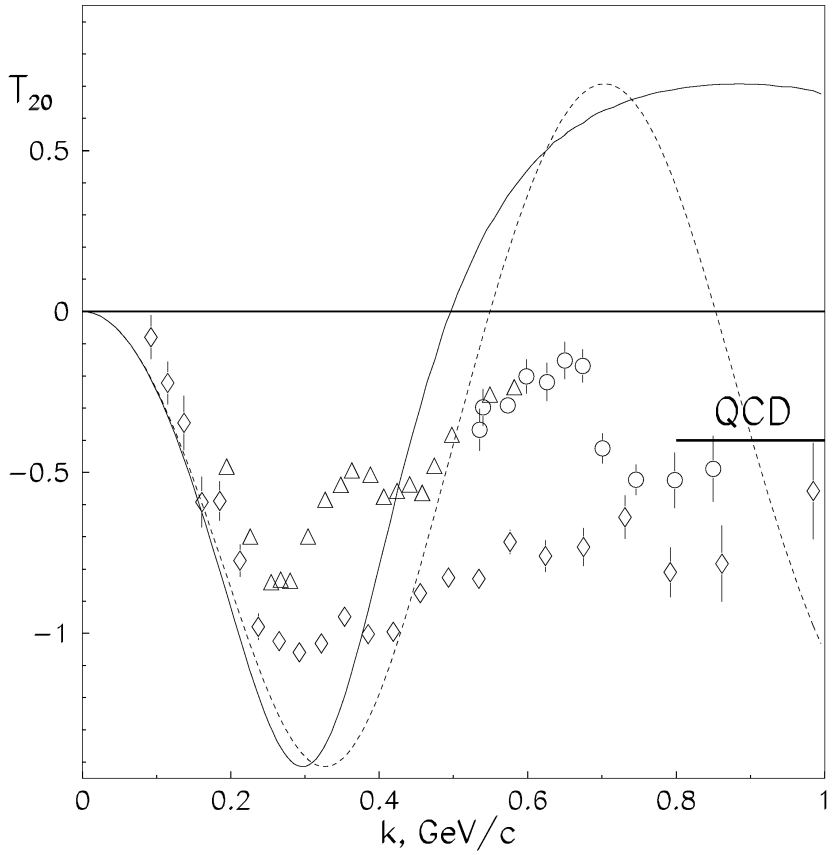
Probability for a nucleon to have momentum > 300 MeV/c in medium nuclei is ~25% — BNL + Jlab 04 +SLAC 93

Probability of non-nucleonic components within SRC is small - < 20% - 2N SRC mostly build of two nucleons not 6q, ΔΔ,... — BNL + Jlab +SLAC

Three nucleon SRC are present in nuclei with a significant probability — Jlab 05

Poor data base on the spin parts of the 2N and 3N short-range correlations. This motivates the necessity to study light nuclei structure at short distances.

Non-nucleonic degrees of freedom



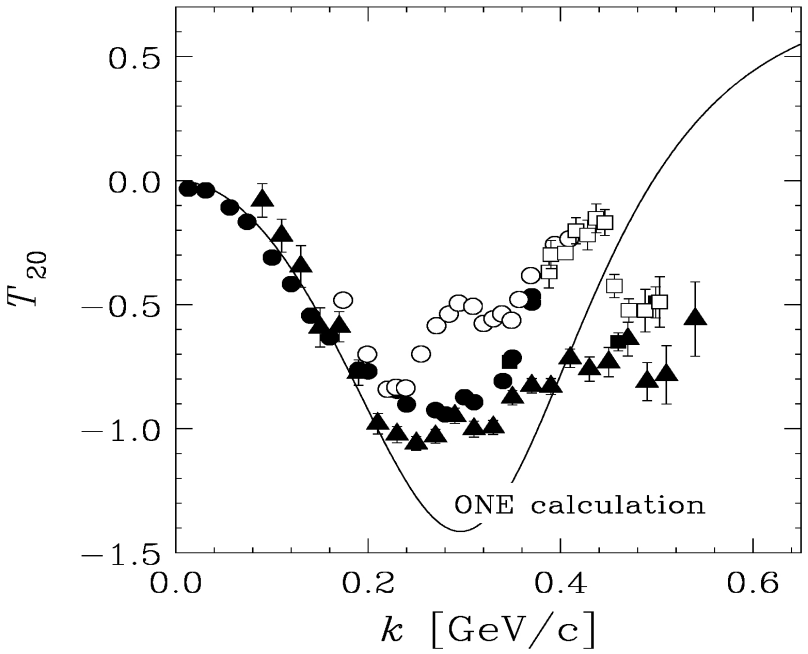
When the distances between the nucleons are comparable with the size of the nucleon, the nucleon-nucleon interaction is a non-local.

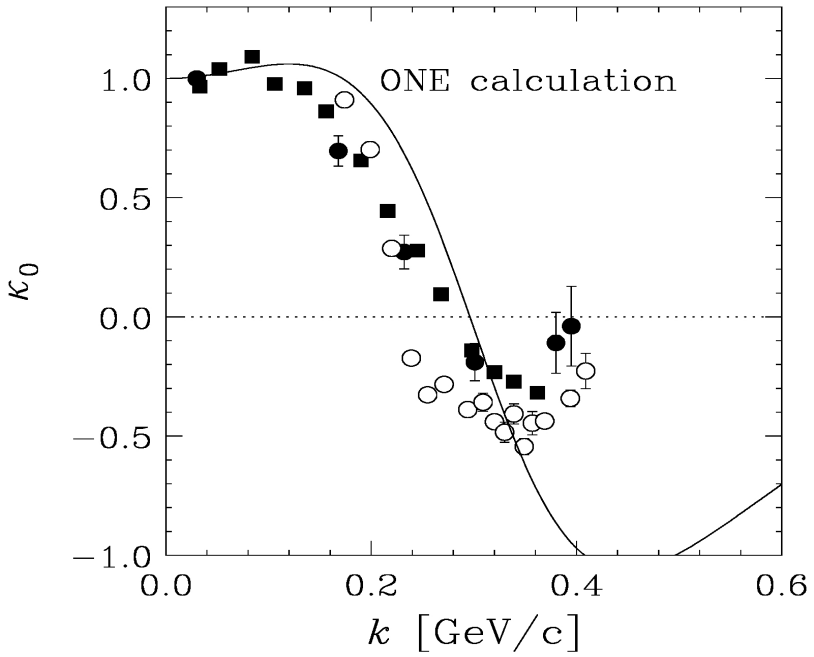
The fundamental degrees of freedom, quark and gluons in the frame of QCD, begin also to play a role at the internucleonic distances comparable with the size of the nucleon.

They can manifest as ΔΔ, NN*, N*N*, 6q etc.components.

Data:
V.Punjabi et al., Phys.Lett.B350 (1995) 178
L.S.Azhgirey et al., Phys.Lett.B391 (1997) 22
L.S.Azhgirey et al., Phys.Lett.B387 (1996) 37

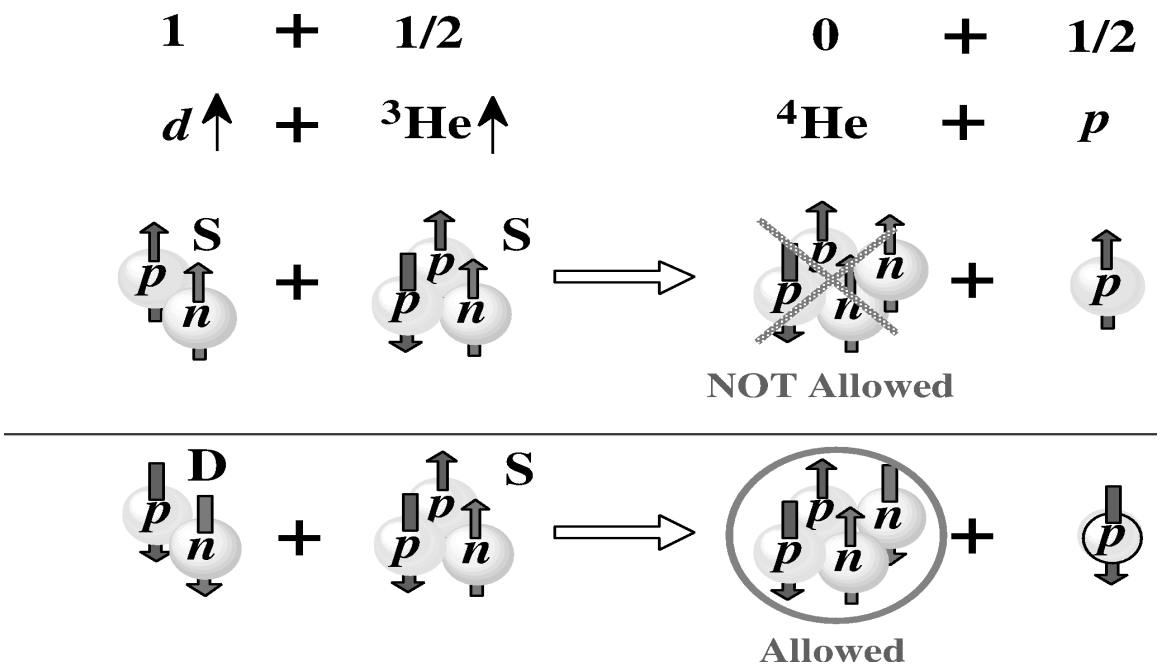
Observables in dp- backward elastic scattering and dp- inclusive breakup at Nuclotron energies





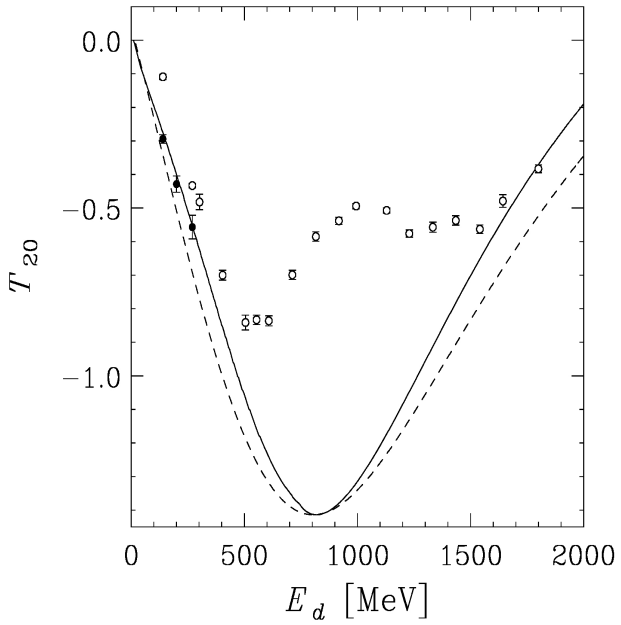
Reaction mechanisms are very important.
Hard to perform complete experiments:
4 complex amplitudes for dp- backward elastic scattering,
so at least 10 observables are needed -
VL, NL, J.Phys.G.23 (1997) 847

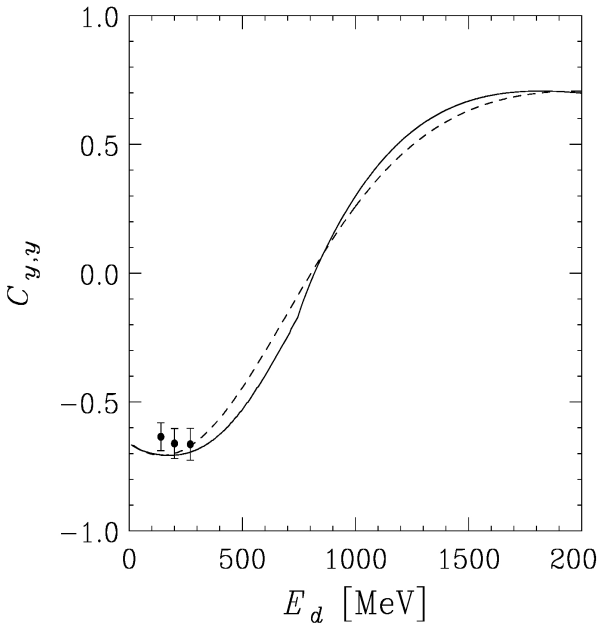
New tool to study the short range spin structure of the deuteron in $d^3He \rightarrow p^4He$ -reaction at Nuclotron energies

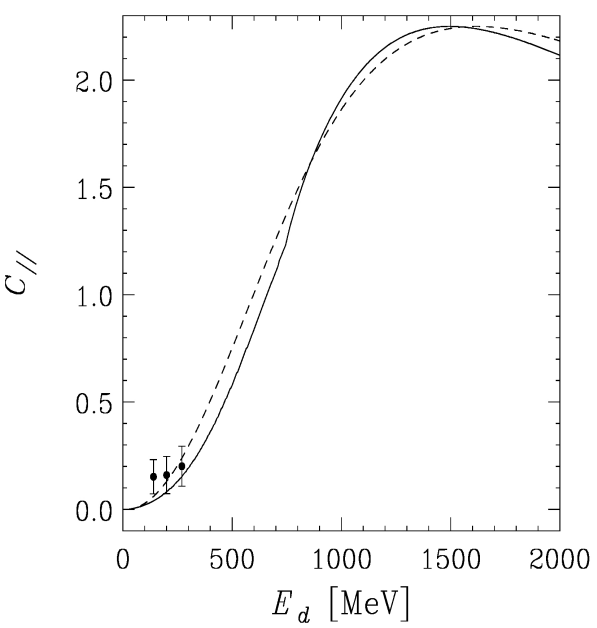


Sensitive to D-wave in deuteron.
Reaction mechanism: Delta-isobar contribution is suppressed.
Easy to perform complete experiments:
2 complex amplitudes → cross section, T_{20} and $C_{y,y}$

Results on the spin observables in the $d^3He \rightarrow p^4He$ -reaction at RIKEN (Japan)



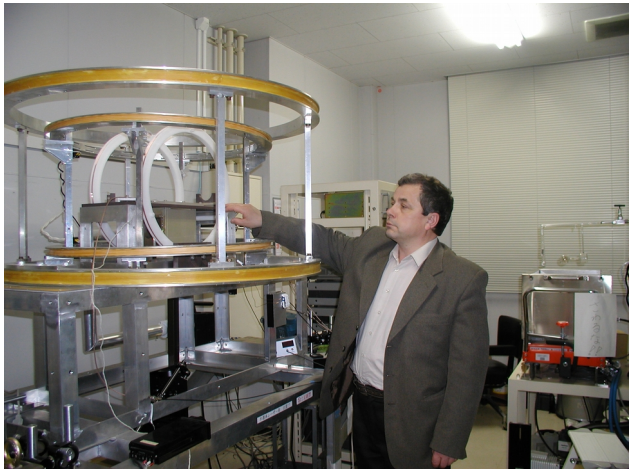




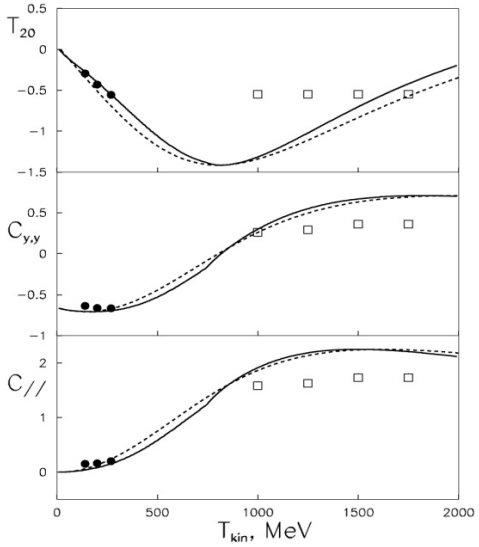
Sensitive to D-wave in deuteron.
Reaction mechanism: ONE is valid.

Polarization observables for polarized deuteron induced reactions

Target position is in F3-F5



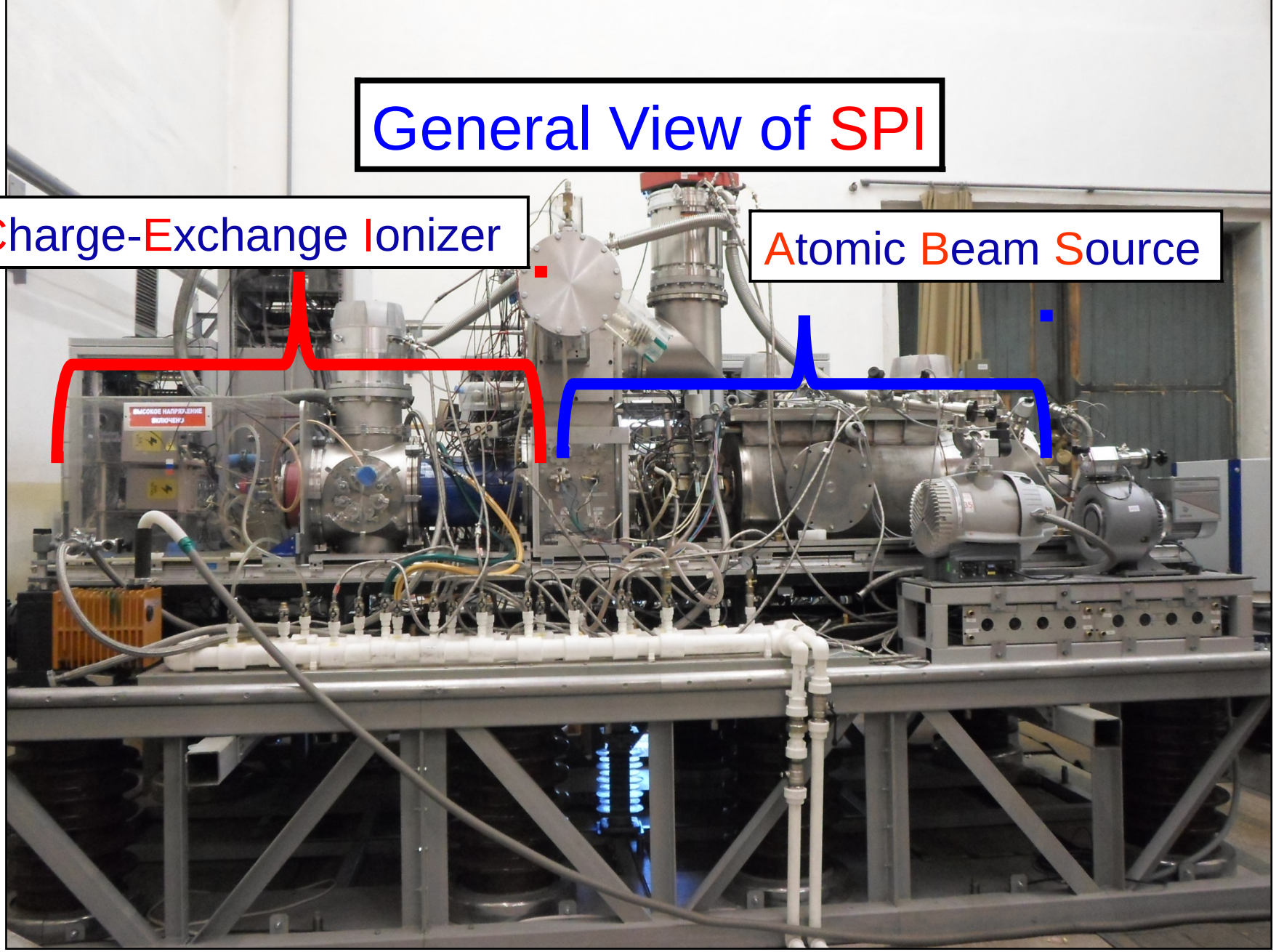
^{3}He(d,p)^{4}He



- **The measurements of the tensor analyzing power T_{20} and spin correlation $C_{y,y}$ in the ^{3}He(d,p)^{4}He reaction in the kinetic energy range between 1.0 and 1.75 GeV can be performed at Nuclotron.**

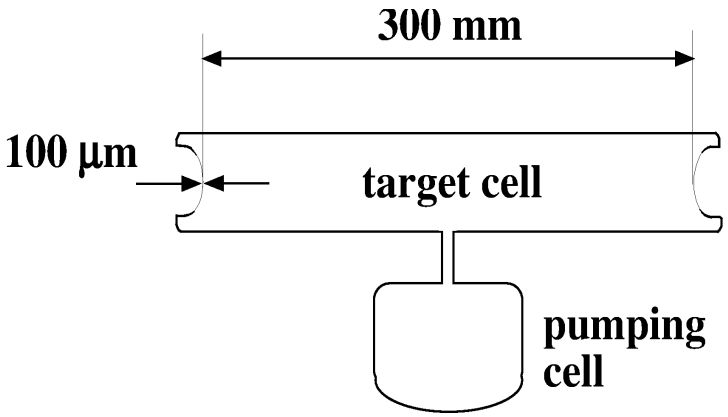
- **Also the polarization observables for the p(d,p)d, d(d,p)t and d(A,p(0°))X at intermediate and high energies also can be studied.**

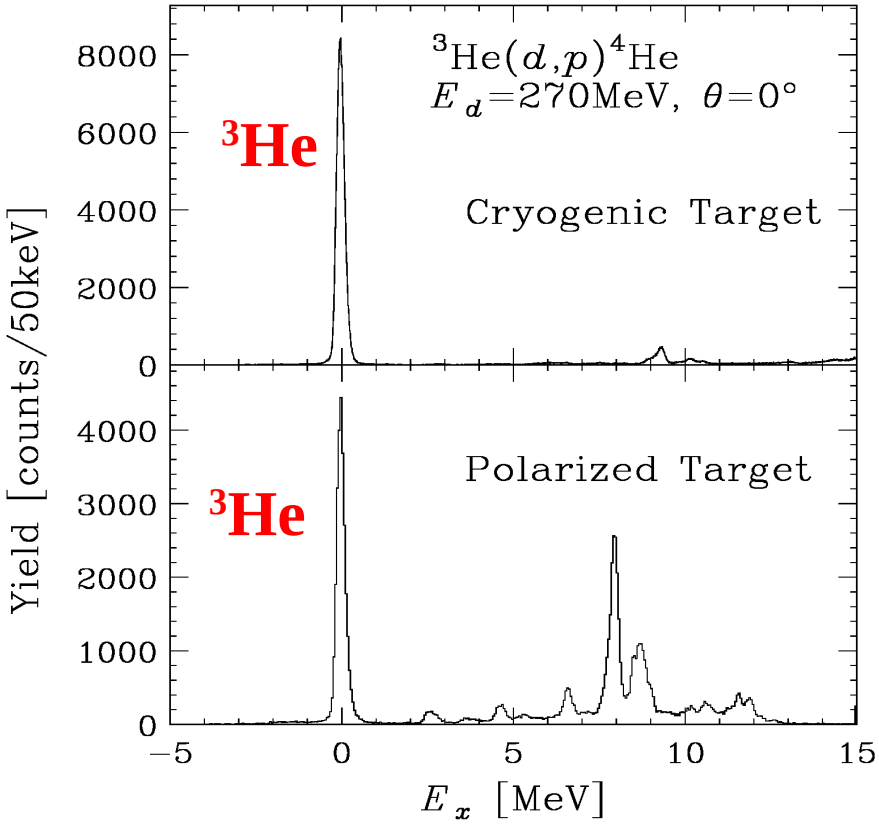
General View of SPI



Spin modes required (Pz, Pzz): (0,0), (0,-2), (+1,+1), (-1,+1)

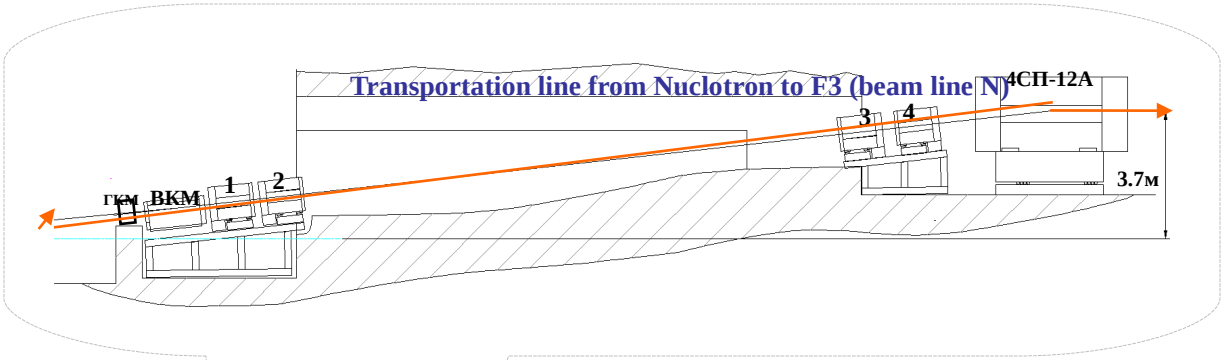
Polarized target for the $d^3He \rightarrow p^4He$ -reaction studies





One needs to minimize the cell windows thickness.

Transportation line of the Nuclotron extracted beam

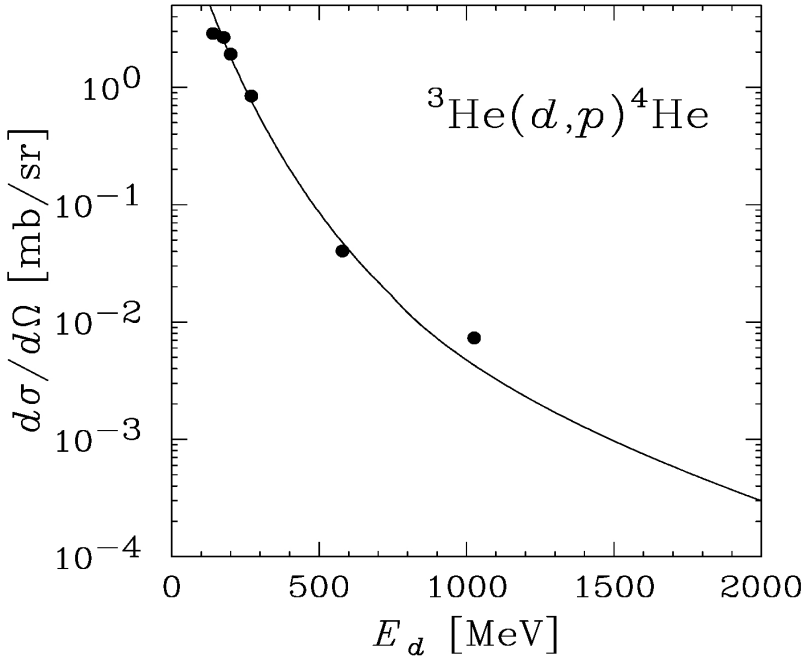


Spin physics with He-3 can be associated with different target positions: at F5, F4 and F3.

BM@N has too bad momentum resolution.

SPD HE testzone, 4V spectrometers?

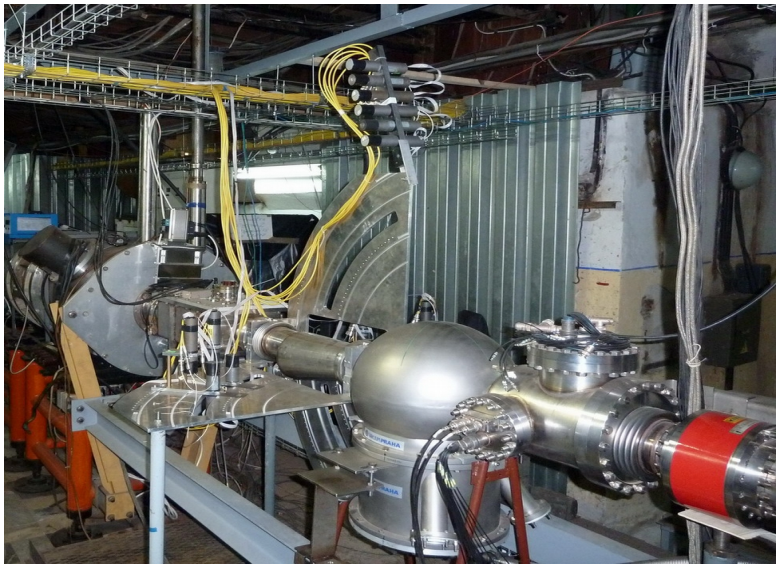
Beam time estimations for the ^{3}He(**d**, **p**)^{4}He reaction



- Target = $\mathbf{6.6 \times 10^{21}}$ $\mathbf{cm^{-2}}$
- Beam = $\mathbf{2 \times 10^{10}}$ **ppp**
- Solid Angle = $\mathbf{3 \times 10^{-3}}$ **mr**
- Expected precision for $\mathbf{C_{y,y}}$ is $\mathbf{\pm 0.05}$

E_d [GeV]	P_p [GeV/c]	hours
1.00	1.679	16
1.25	1.952	24
1.50	2.221	40
1.75	2.484	90
	TOTAL	170

Beam polarimetry at Internal Target Station at Nuclotron (DSS-project)



Internal Target Station is very well suited for the measurements of the deuteron, proton, (^{3}He) via large angles scattering.

In the case of ^{3}He beam one needs to use nuclear target!

Expected results for the Stage-1 of the He-3 project

The measurements of the polarization observables in the ^{3}He(d, p)^{4}He reaction can be performed using polarized ^{3}He target and deuteron beam from SPI at Nuclotron for the reasonable beam-time.

The obtained data will be sensitive to the short range spin structure of the deuteron in the vicinity of the D-wave dominance.

The full determination of the ^{3}He(d, p)^{4}He reaction matrix element in the model independent way will be possible.

Possible physics for the Stage-2 of the He-3 project

Internal beam:

Polarimetry of the ^{3}He beam using ITS polarimeter (DSS setup).

Study of the energy dependence of the ^{3}He-p elastic scattering analyzing power.

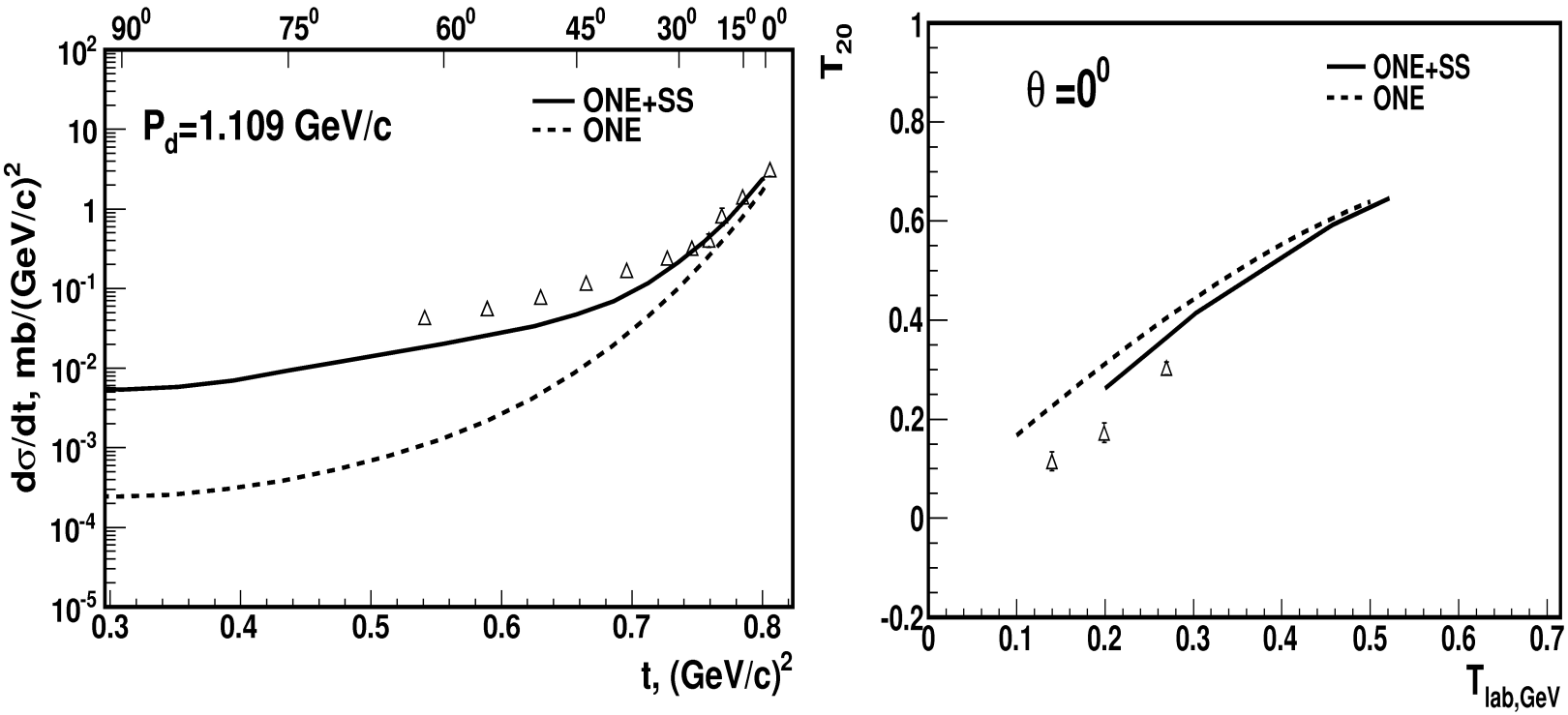
External beam:

Study of the energy dependence of the ^{3}He-p elastic scattering analyzing powers and spin correlations .

Study of the ^{3}He-p exclusive breakup reaction.

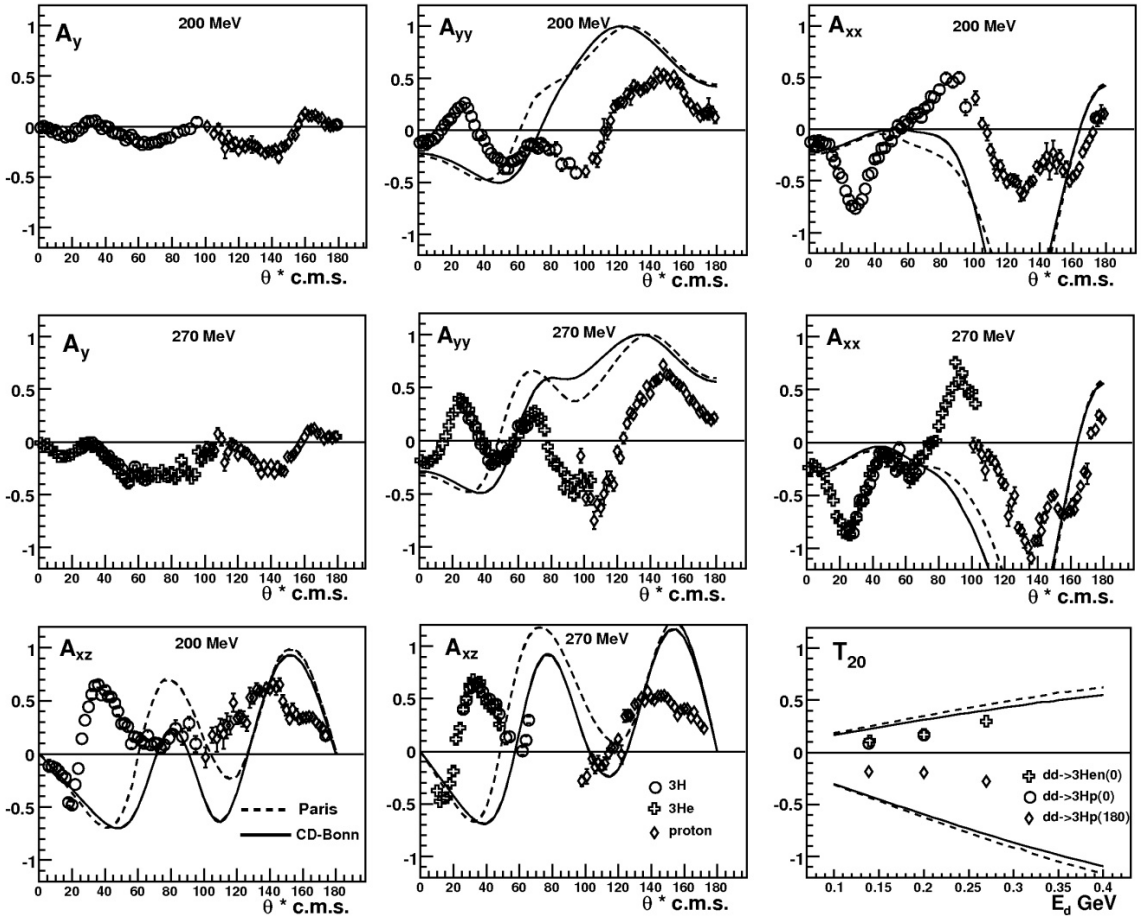
Thank you for the attention

dd →³Hen(³Hp) reactions at Nuclotron energies



The relativistic multiple scattering model can be successfully used to describe the dd →³Hen(³Hp) reactions in a GeV region at the Nuclotron.
The calculations require a large amount of CPUs.
The results will be published in Few Body Systems (talk N.B.Ladygina).

Polarization observables from the dd → ^{3}Hen(^{3}Hp) reactions (Japan-JINR)



The solid curve is the result of the ONE calculations using CD-Bonn ^{3}He and deuteron wave functions. The dotted curve is the result of the ONE calculations using ^{3}He and deuteron wave functions derived from Paris potential. The ^{3}He wave function were taken from the work (V.Baru Eur.Phys.J.A16:437-446,2003).