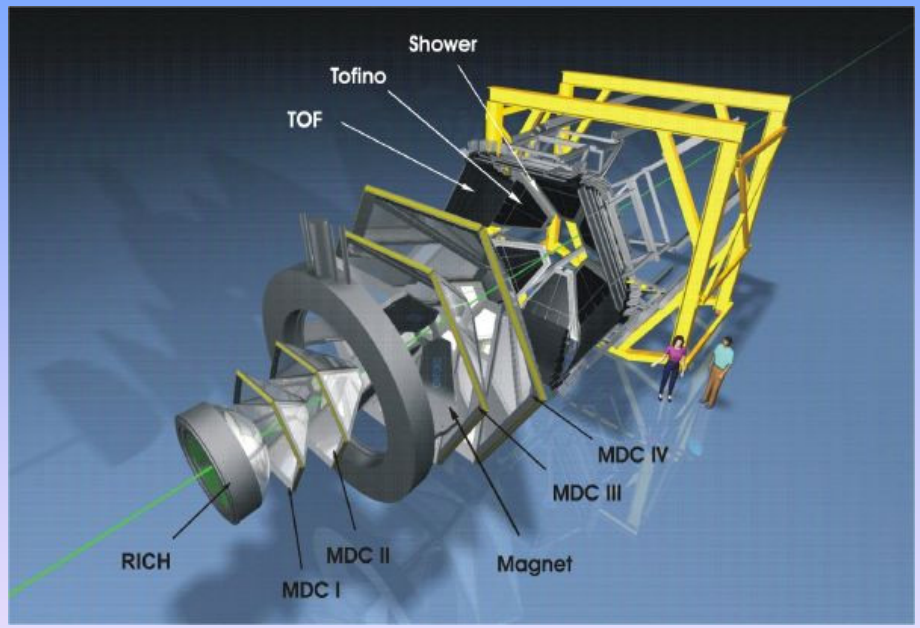
Cross section for *dp* elastic scattering at 1.25 GeV/u



P.K. Kurilkin (LHEP-JINR) for HADES collaboration

8 Oktober, Dubna, 2010

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- Introduction
- HADES spectrometer
- Data analysis
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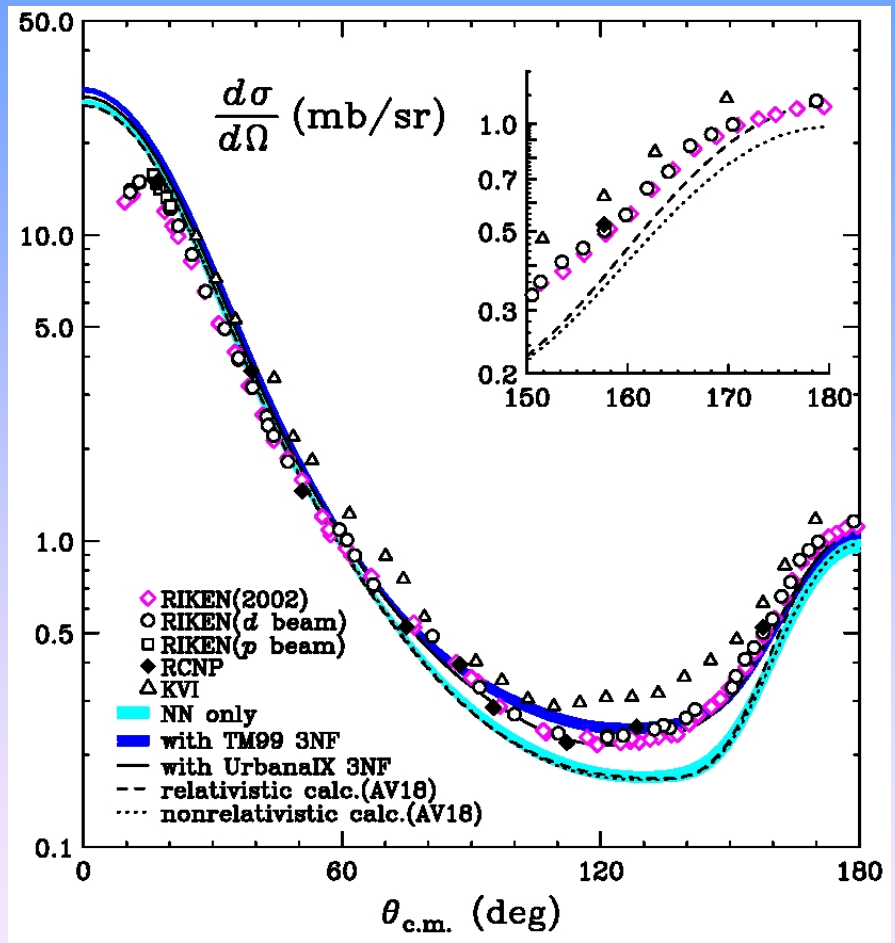
Motivation

- The investigation of nuclear reactions involving deuterons has always played an important role in the development of representations of the nuclear structure and dynamics of nuclear interaction.
- A large volume of data on the deuteron has been accumulated from experiment on electron and hadron beams.
- A feature of modern investigations of the deuteron in electron beams is that are focused on revealing the deuteron internal structure at relatively small distances. Meson degrees of freedom. Relativistic effects.
- The investigation of hadron reactions, in particular the collisions of the relativistic deuterons with nucleons and nuclei also solves the problem of deuteron structure at small distances.
- The study of collisions of relativistic deuterons with nucleons and nuclei is extremely important for clarifying fundamental problems of the relativistic description of fast moving composite objects.

Three nucleon forces manifestation

- Nowadays a new generation of the NN potential (Nijmegen, CD-Bonn, AV18 etc.) was obtained. They reproduce data on the nucleon nucleon scattering up to 350 MeV with very good accuracy.
- However, these modern NN forces fail to provide experimental binding energies of few-nucleon systems (for the 3H underbinding is 0.8 MeV for CD-Bonn). Moreover the data on the dp elastic scattering and deuteron breakup are not described.
- Incorporation of the 3NF makes it possible to reproduce the binding energy of the three-nucleon bound system and also data on unpolarized of dp interaction.
- The cross section data for the dp elastic scattering are reproduced well up to 150 MeV taking into account 3NF.

pd elastic scattering at the energy 135 MeV



NN Forces only

NN interaction: CD-Bonn, AV18, Nijmegen I,II & 93

NN + TM'(99) 3NF

NN interaction: CD-Bonn, AV18, Nijmegen I,II

NN + Urbana IX 3NF

NN interaction: AV18

Relativictic calc. (AV18)

Nonelativictic calc. (AV18)

N.Sakamoto et al., Phys. Lett. B 367, 60 (1996)

H. Sakai et al., Phys. Rev. Lett. 84, 5288 (2000)

K. Sekiguchi et al., Phys. Rev. C65, 034003 (2002)

K. Ermish et al., Phys. Rev. C 68, 51001 (2003)

K. Sekiguchi et al., Phys. Rev. Lett. 95, 162301 (2005)

nd and pd elastic scattering measurements at the energy of 250 MeV

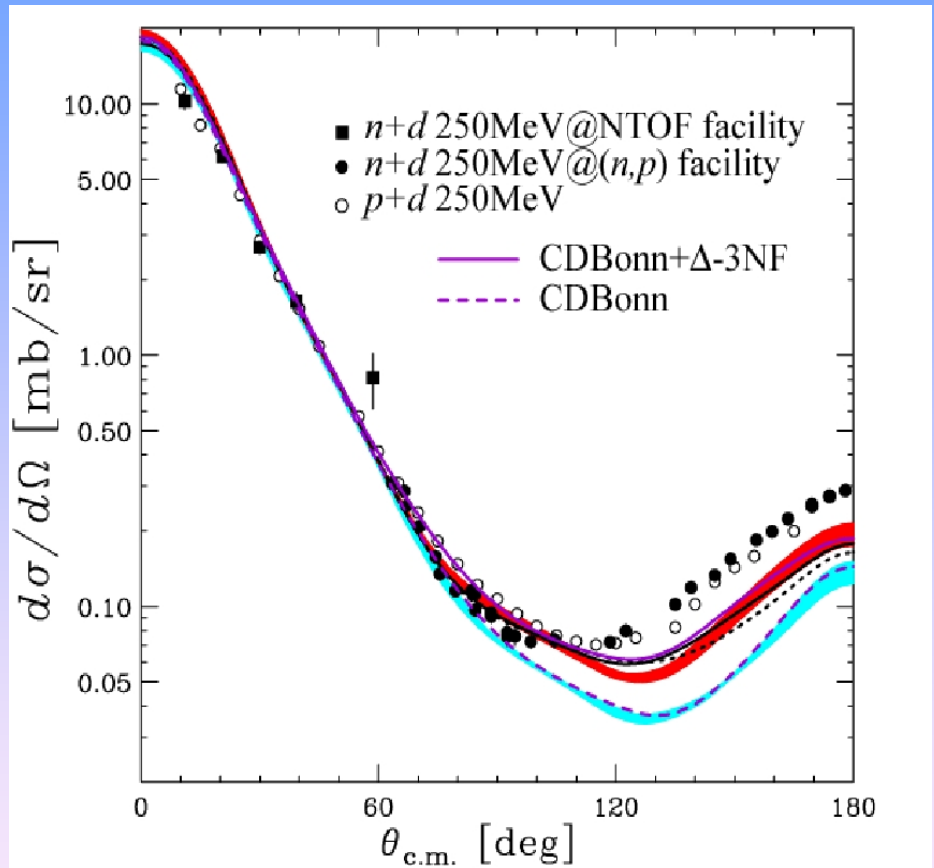
Faddeev calc (by Prof. H. Kamada)
- : *NN* only (CD-Bonn, AV18, Nijmegen-I,II,93)
- : *NN* with TM-3NF
- : AV18+UrbanaIX-3NF
- : CD-Bonn+TM'-3NF

CC calc (by Honnover group)
- : CD-Bonn
- : CD-Bonn+Δ-3NF

Calculations even including 3NF underestimate the data at $\Theta_{c.m}$ ~110-180 deg

Relativistic calculations improve the fit of the data only at $\Theta_{c.m}$ >160 deg

H.Sakai, FB18, Santos, Brazil, (2006)



Y. Maeda et al., Phys. Rev. C 76, 014004 (2007)

K. Hatanaka et al., Phys. Rev. C 66, 044002 (2002)

Short internucleonic distances

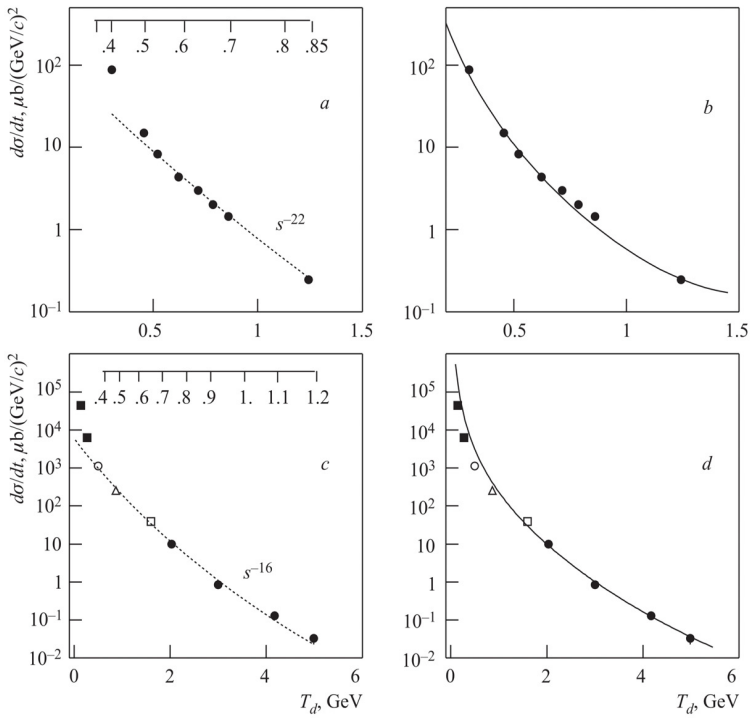
- When the distances between the nucleons are comparable with the size of the nucleon, the nucleon-nucleon interaction is non-local.
- Fundamental degrees of freedom in the frame of QCD are the quarks and gluons. These degrees begin to play a role at the internucleonic distances comparable with the size of the nucleon. ($\Delta\Delta$, N*N, N*N*, 6q components in the deuteron)
- At high energy s and large transverse momenta p_t the constituent counting rules are working. For the binary reactions:

$$\frac{d\sigma}{dt}(AB \to CD) = \frac{f(t/s)}{s^{n-2}}$$

$$n = N_A + N_B + N_C + N_D$$

(Matveev, Muradian, Tavkhelidzhe, Brodsky, Farrar et al.)

Quark degrees of freedom



Yu. N. Uzikov

(JEPT Lett, 81, pp. 303-306, 2005)

For the reaction dd → ^{3}Hen

$$N_A + N_B + N_C + N_D - 2 = 22$$

For the reaction dp → dp

$$N_A + N_B + N_C + N_D - 2 = 16$$

The regime corresponds to CCR occurs already at $T_d \sim 500$ MeV

The investigation of the energy dependence of the cross section in dp elastic scattering is very desirable to obtain the information on the deuteron internal structure.

HADES experiment at SIS18, GSI

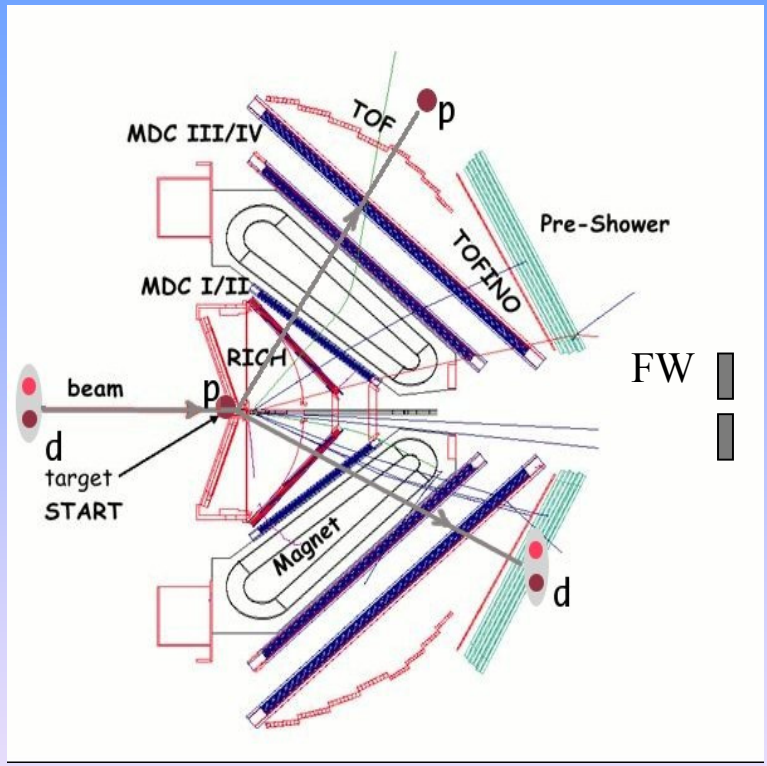
Spectrometer with …

High geometrical acceptance
Full azimuth, polar angles 18˚ - 85˚
Pair acceptance ≈ 0.35

High invariant mass resolution (2.5% at ρ/ω pole mass)
Low-mass tracking (superconducting toroidial magnet & multi-wire drift chamber (MDC), single cell resolution ≈100 mm)

Powerful PID capabilities: d/p/K/p/e
RICH, TOF/TOFino, Pre-Shower,
FW hodoscope: added 2007

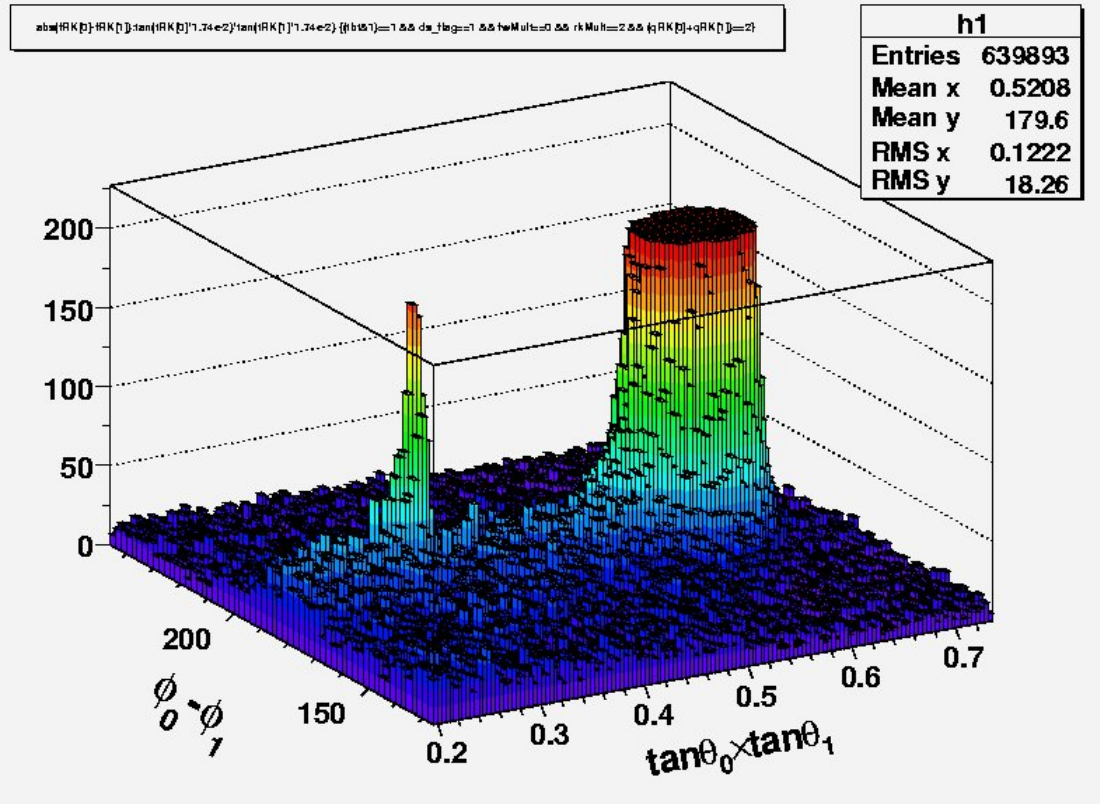
High background rejection & rate capability, dedicated LVL2 trigger:
LVL1: charge particle multiplicity
LVL2: single electron trigger



Schematic view of the HADES spectrometer

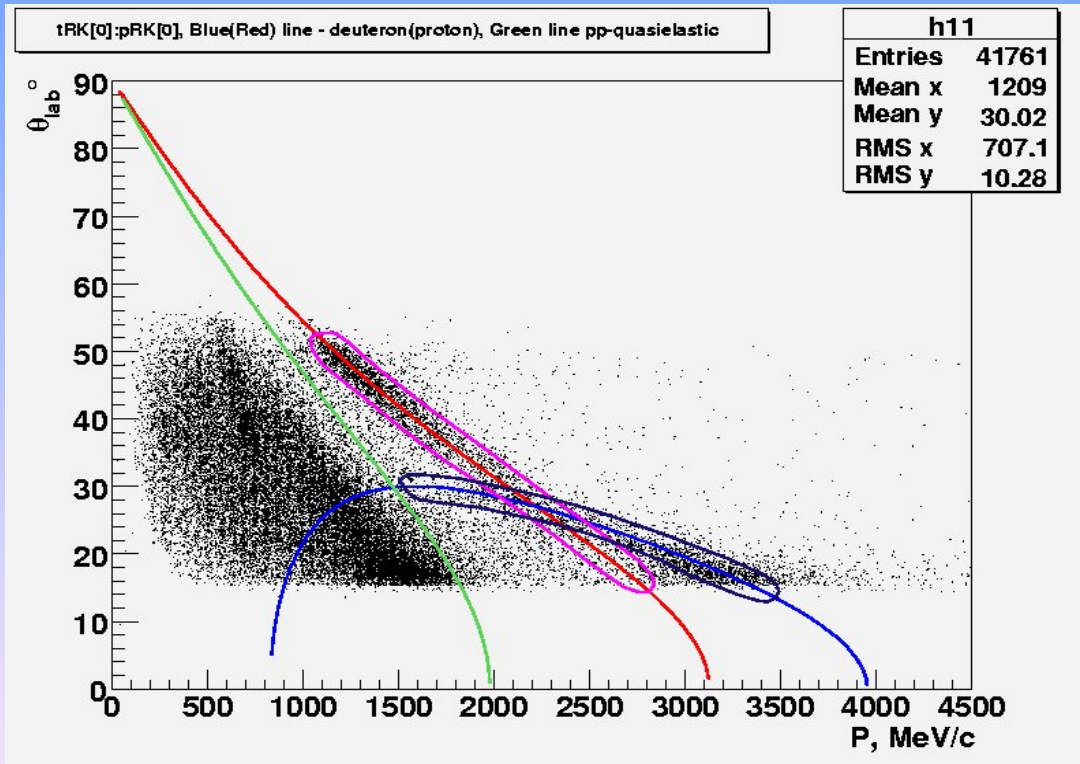
The large acceptance of HADES makes it a unique tool for the study of short-range correlations in the channels without the meson production

dp elastic scattering at 1.25 GeV/u



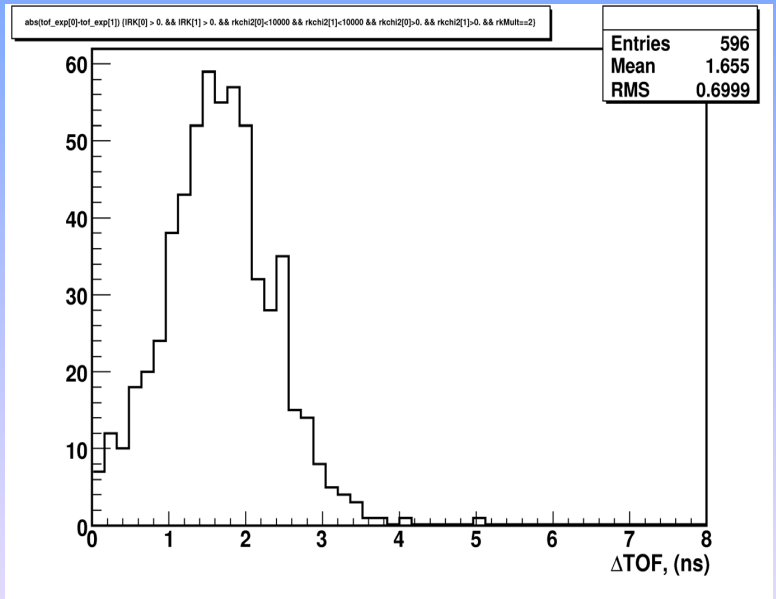
Correlation between difference of azimuthal angles of tracks and their polar angles tangent product.

Angle-momentum correlation for *dp* elastic scattering at 1.25 GeV/u

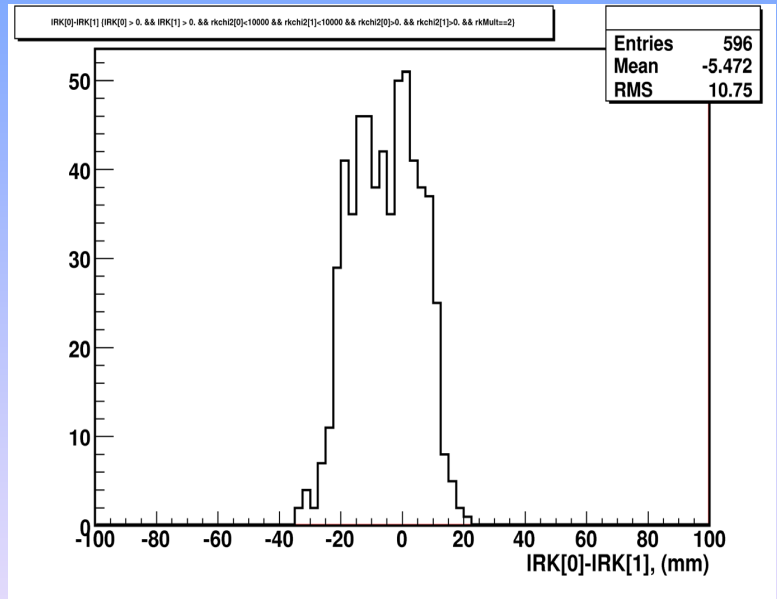


$$\left|\left|\varphi_1-\varphi_2\right|-180^\circ\right|\le 5^\circ, \quad 0.22 \le \tan\Theta_1 * \tan\Theta_2 \le 0.4$$

Time-of-flight difference between d and p

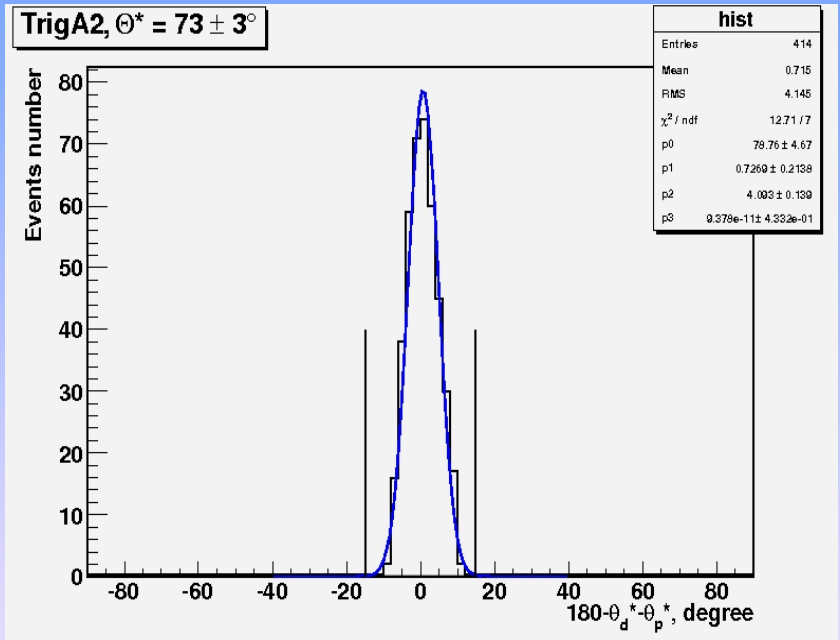


Absolute value of the time difference between two tracks for the region which graphical cut of the deuteron and proton overlap.

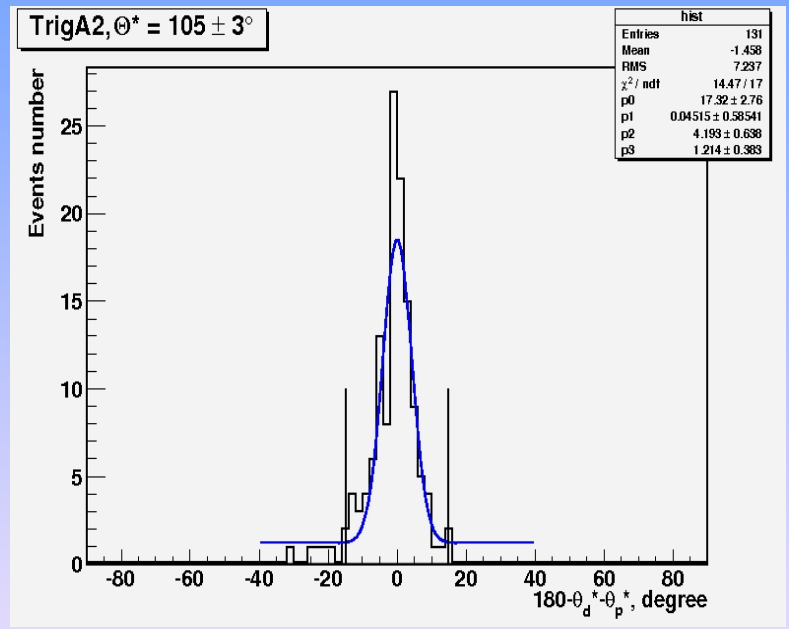


Difference between length of two tracks for the region which graphical cut of the deuteron and proton overlap.

Selection of the dp elastic events



Difference of 180° and the sum of θ angles for both particles for the region 73º ± 3º



Difference of 180º and the sum of θ angles for both particles for the region 105º ± 3º

Efficiency and acceptance correction for dp elastic scattering at 1.25 GeV/u

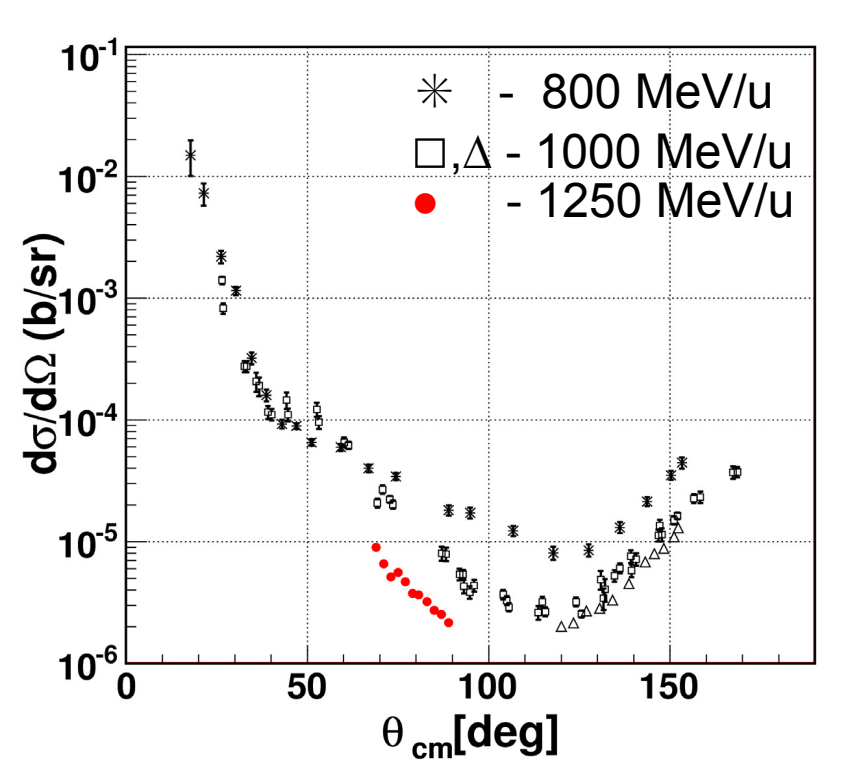
- rkMult ≥ 2
- For p bellow 2.0 GeV/c (pp at 1.25GeV) matrixes has been used
- For d (pp at 1.25GeV) matrixes has been used with $P_p = P_d/2$
- Θ_{lab} [d,p] > 18°
- $F_{acc} = 2.1$

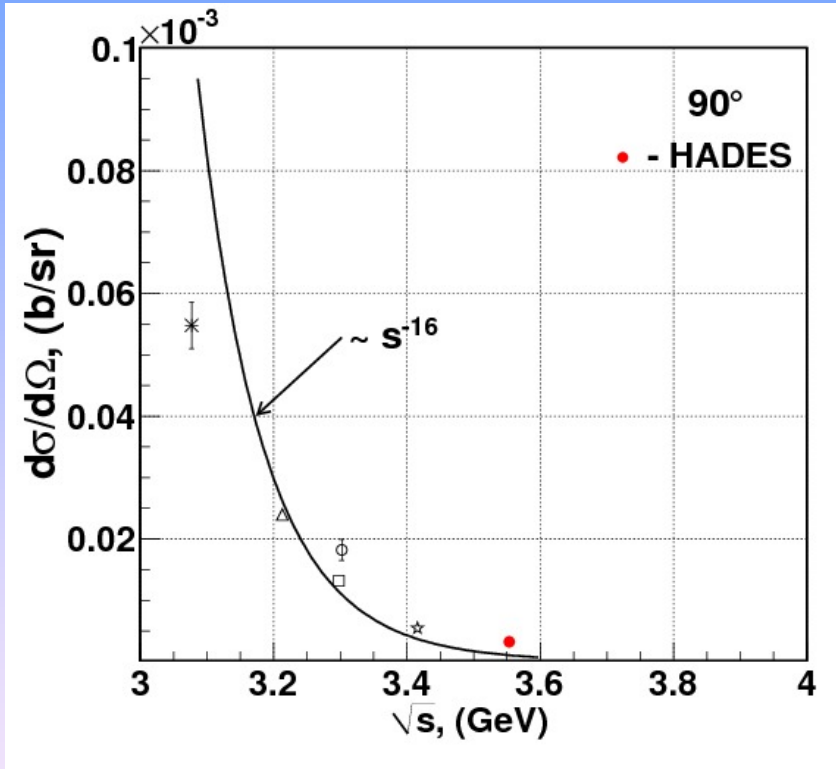
$$\frac{d\sigma_{dp}}{d\Omega^*} = \frac{\sigma_{pp}}{N_{pp}^{total}} * \frac{\Delta N_{dp}}{\Delta\Omega^*}$$

$$dN_{dp} = 4 * 32 * dN_{dp}^{\exp}$$

$dN_{dp}^{\exp}$ is eff. and acc. corrected
Npp = 5.41e9, σpp= 22.1 mb

Differential cross section of dp elastic scattering at 1.25 GeV/u





E. Winkelman et al., Phys. Rev. C 21, 2535 (1980)
G.W. Bennet et al., Phys. Rev. Lett. 19, 387 (1967)
E.Coleman et al., Phys. Rev. Lett. 16, 741 (1966)

N.E. Both et al., Phys. Rev. D 4, 1261 (1971)
E. Gulmez et al., Phys. Rev. C 5, 2067 (1991)

Conclusion

- The preliminary results on the differential cross section in dp elastic scattering are obtained at 1.25 GeV/u and large scattering angles in the c.m. with the HADES spectrometer.
- The data cover new kinematical region corresponding to high transverse momenta.
- The behaviour of the cross section data at 1.25 GeV/u at the fixed angles in c.m. are in satisfactory agreement with the behaviour of the world data obtained at lower energies as well as with the constituent counting rules predictions.

Thank you for your attention!!!