Systematic Study of Three-Nucleon Systems Dynamics in the Cross Section of the Deuteron-Proton Breakup Reaction

Barbara Kłos for Wasa-at-Cosy Collaboration

Institute of Physics, University of Silesia

Motivations

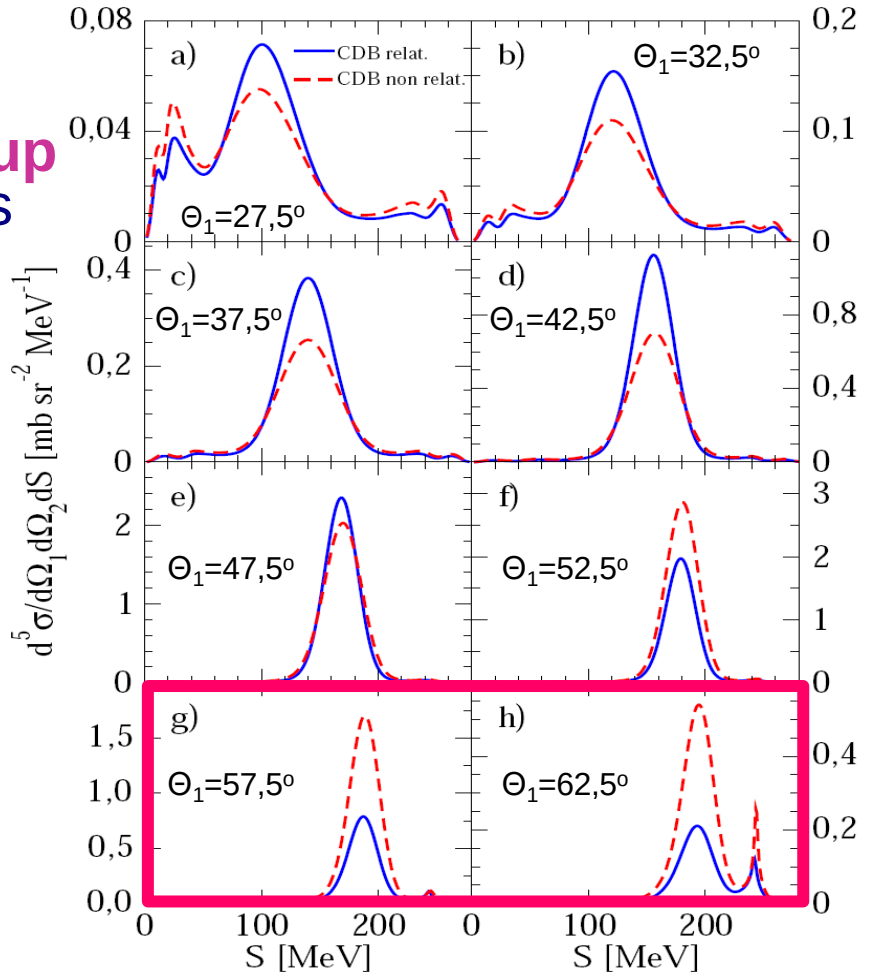
- The theoretical calculations in relativistic approach with 3NF included are available
- The investigations at relatively high energies are important to confirm theoretical predictions for relativistic effects and to unambiguously fix a relevance of the 3NF.
- The cross sections observables for the deuteron breakup in d+p system at medium and higer energy region are expected to be very sensitive to relativistic and three nucleon force effects

Relativistic Effects in the Cross Sections

R. Skibiński, Eur. Phys. J. A 30, 369, (2006)

calculations available for
N+d breakup @ **200 MeV**
➡ soon also for **d+N breakup**
at other medium energies

strong support of the
few-body theoretical group
at the Jagiellonian Univ.

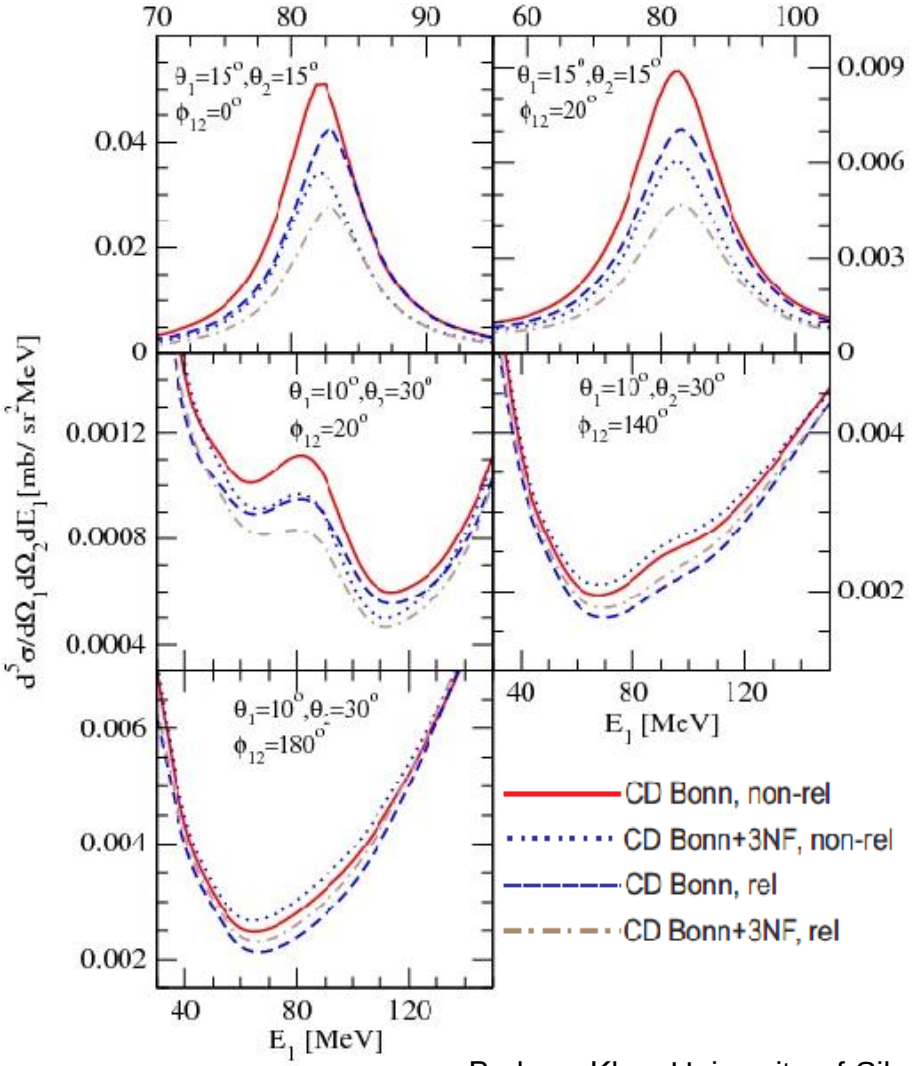


$\theta_2=37.5^0$, $\varphi_{12}=180^0$

very strong effects,
(dynamical & kinematical)
even up to 60% !!

3NF effects in the Cross Sections

H. Witała et al., Phys. Rev. C83, 044001, (2011)



N+d breakup @ 200 MeV
calculations

3NF effects increase
with increasing energy

measurement
at higher energies

relativistic component
also seizable

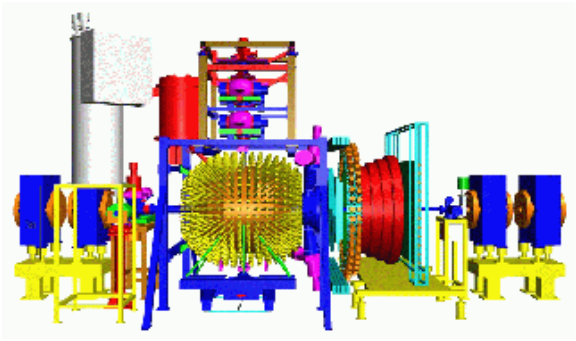
very poor database !
systematic and precise
data needed !

Experiment WASA 214

p(d,pp)n measurement **@ WASA detector**

at FZ-Jülich (Germany)

January 2013



Assumptions:

- unpolarized deuterons
- energies of 340, 380, 400 MeV in supercycle mode
  pellet H_2 target
- determination of energies and emission angles of both protons
- simultaneous measurement of the d-p elastic scattering channel
  - ❑ Absolute cross section normalization
  - ❑ Geometry checks

Studies of nuclear dynamics in the d-p Breakup Reaction using the WASA Detector

University of Silesia, Katowice, Poland

Jagiellonian University, Kraków, Poland

University of Warsaw , Warszawa, Poland

Institute of Nuclear Physics PAN, Kraków, Poland

Forschungszentrum Juelich, Germany

Experimental setup

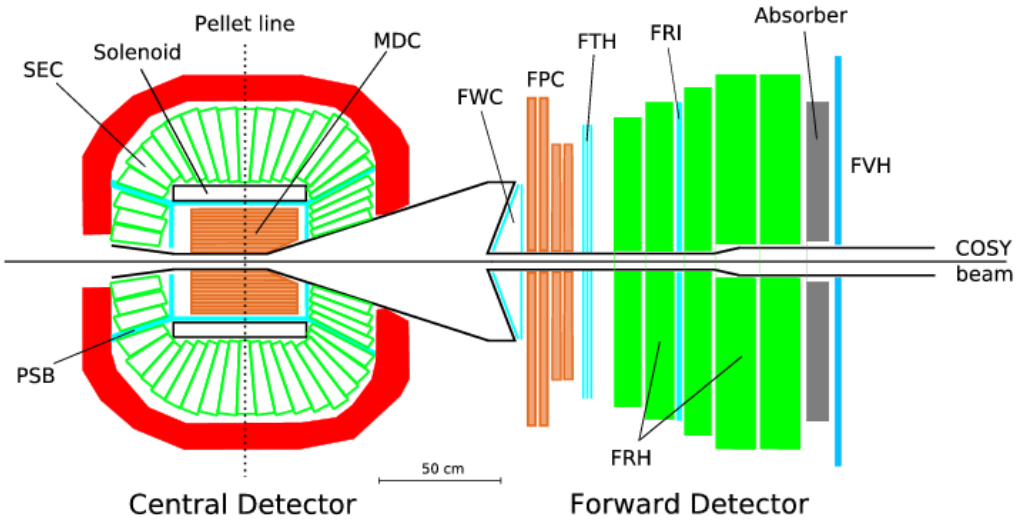
Pellet target system: protons, deuterons

Pellet diameter: 25-35 μm

Rate in beam: 5-6 kHz

Effective target density: 10^{15} cm^{-2}

Beam diameter:2-4 mm



Schematic view of the detection system

Central Detector

Angle acceptance 20º-169º

Neutral and charged particles

Energies γ up to 800MeV

Energy resolution: ~8%

Momenta of electrons 20-600MeV/c

Energy resolution: ~2%

Momenta of protons 200-800MeV/c

Energy resolution: ~6%

Forward Detector

Angle acceptance 3º-18º

Angle resolution 0.2º

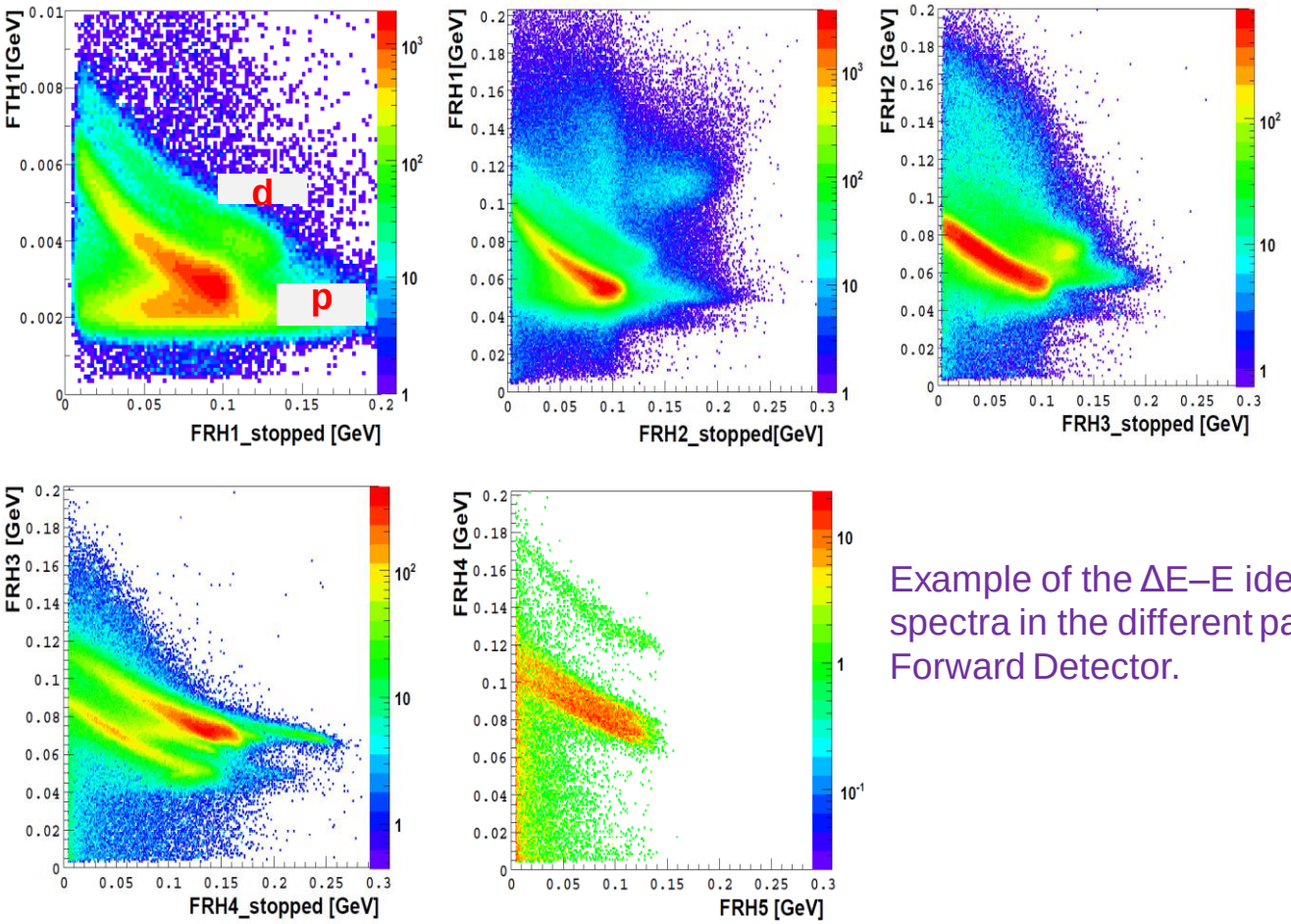
Maximum kinetic energy: protons (300MeV), deuterons(400MeV)

Energy resolution:3-8%

Particle identification ΔE-E

Data Analysis

- Event Selection and Particle Identification in the Forward Detector



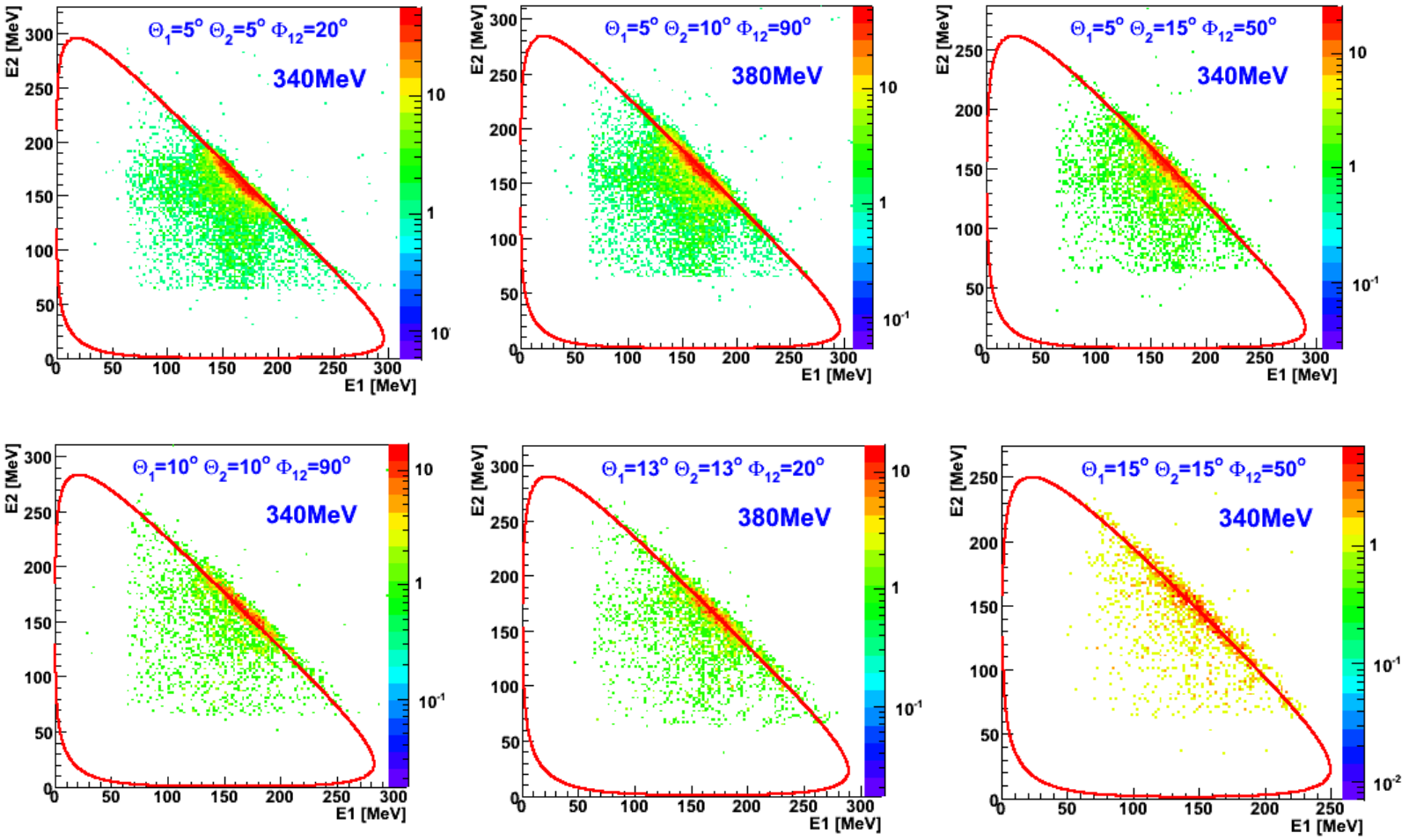
Example of the ΔE–E identification spectra in the different parts of the Forward Detector.

General information of d-p experiment @Wasa

deuteron beam energy	340,380,400 MeV
reaction channels	dp → dp dp → ppn dp → ^{3}He + γ dp → dp γ
luminosity	~10^{29}/s/cm^2
deuterons in flat top	(1.3-1.4)*10^8
total trigger rate	~6*10^4 events/s (trigger in) ~3*10^4 events/s (trigger out)
coincidence rate per bin	0.05-0.1 breakup events/s
Δσ /σ	~1%
collected data	20.1 TB

Data Analysis -Breakup Reaction

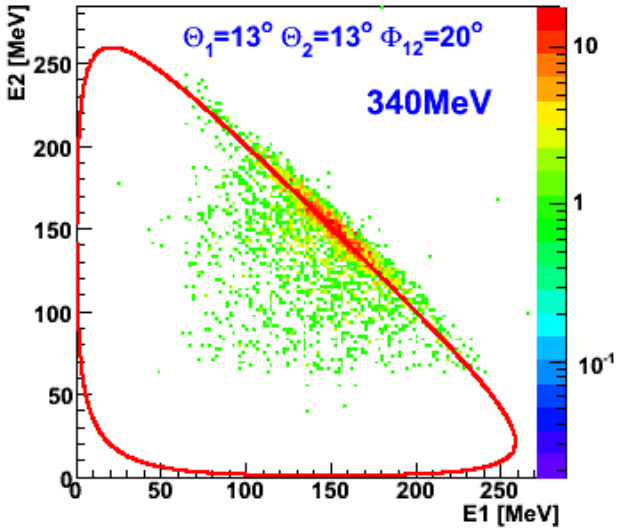
- Dependence on kinematical configurations

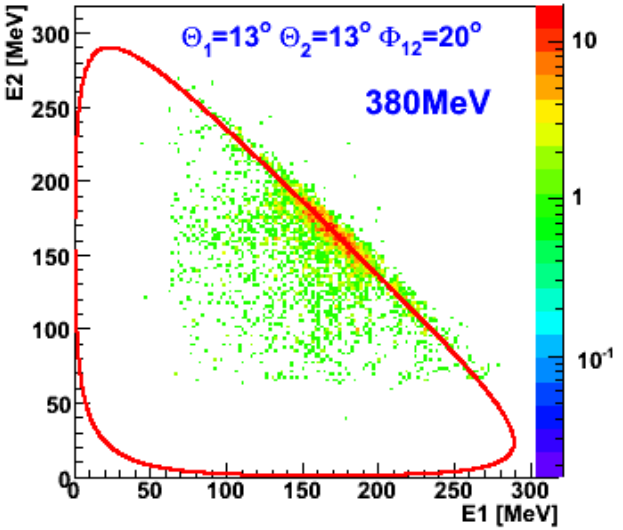


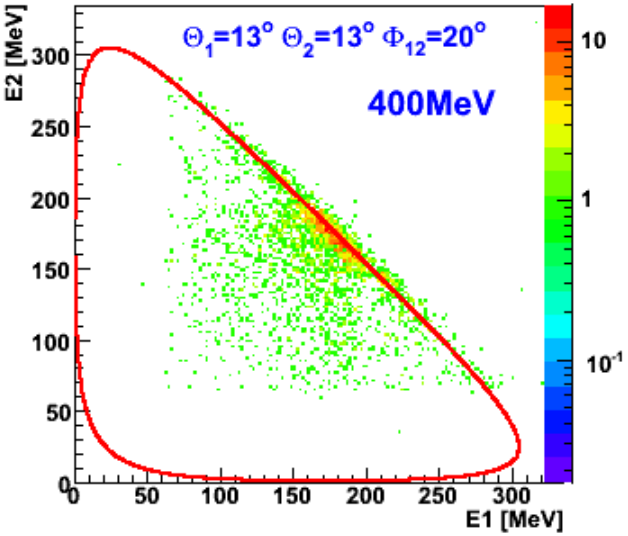
Examples of the E_1-E_2 coincidence spectra of the two protons registred at chosen kinematical configurations. The solid line shows a three-body kinematical curve.

Data Analysis –Breakup Reaction

- Beam energy dependence



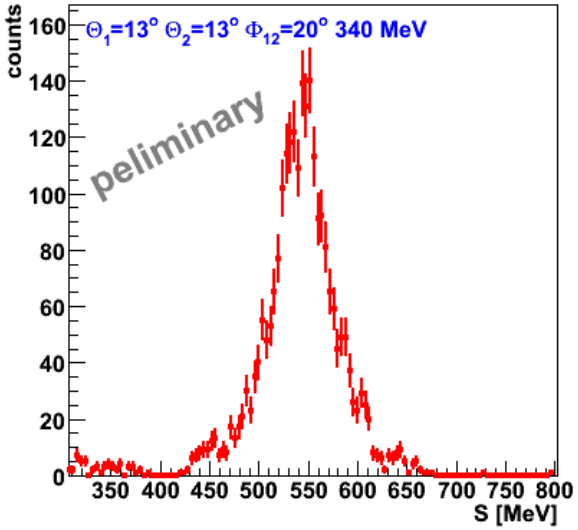


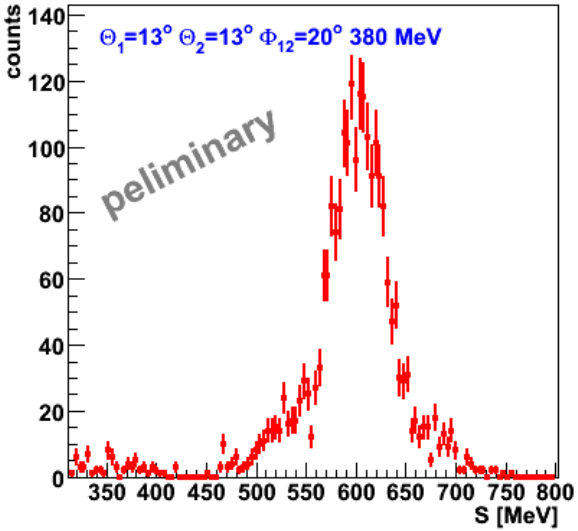


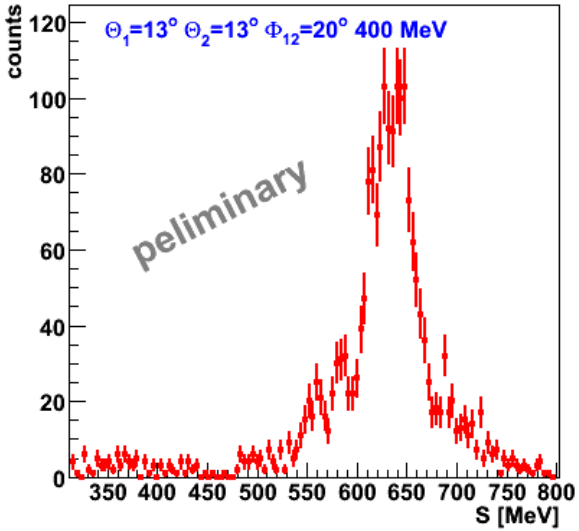
The E_1-E_2 coincidence spectra of the two protons registred at one kinematical configuration in measurements at three beam energies. The solid line shows a three-body kinematical curve.

Data Analysis –Breakup Reaction in FD

- Cross Section Distributions







Examples of the preliminary, non-normalized events rate obtained for one chosen kinematical configuration of breakup reaction (θ_1=5°±1°, θ_2=10°± 1°, and φ_{12}=90°±5°) presented as a function of the S value (arc-length along the kinematics with the starting point at E_2 minimum).

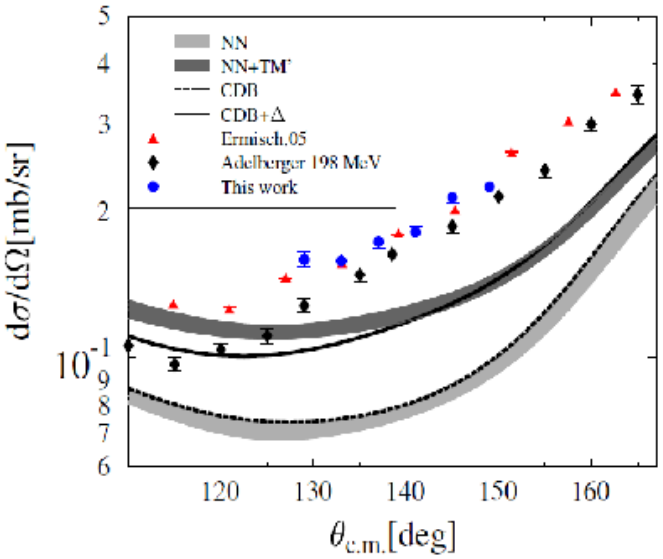
Ultimate Goal:

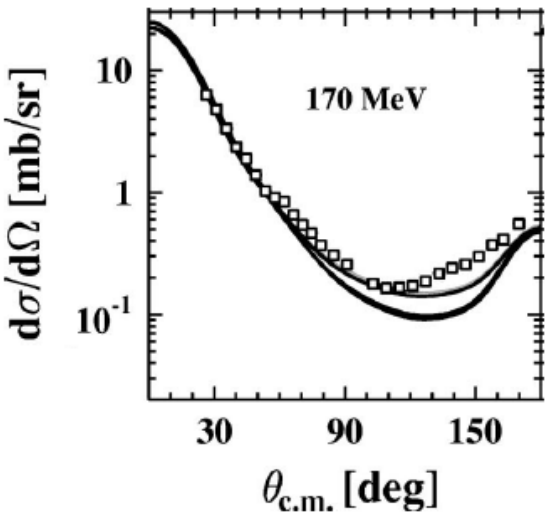
- Determination of the differential cross sections for the the deuteron breakup process in d+p system at three different energies of 340, 380 and 400 MeV, for a large set of kinematical configurations covering significant part of the reaction phase space.

- The data will be compared to the theoretical predictions for three nucleon systems with the aim to investigate relativistic effects and influence of 3NF.

THANK YOU
FOR
YOUR ATTENTION !

Elastic scattering data for cross sections normalization





elastic p+d:
@198 MeV (Adelberger)
stat.err.~3%
@170, @190 MeV
(Ermish, Mardanpour)
stat.err. ~3%
syst.err.~ 7%

K. Ermish, Phys. Rev. C 68, 051001, (2003)
R.E. Adelberger, Phys. Rev. D 5, 2139 (1972)
H. Mardanpour, Ph.D. Thesis, 2008