Differential Cross Section for Proton Induced Deuteron Breakup at 108 MeV

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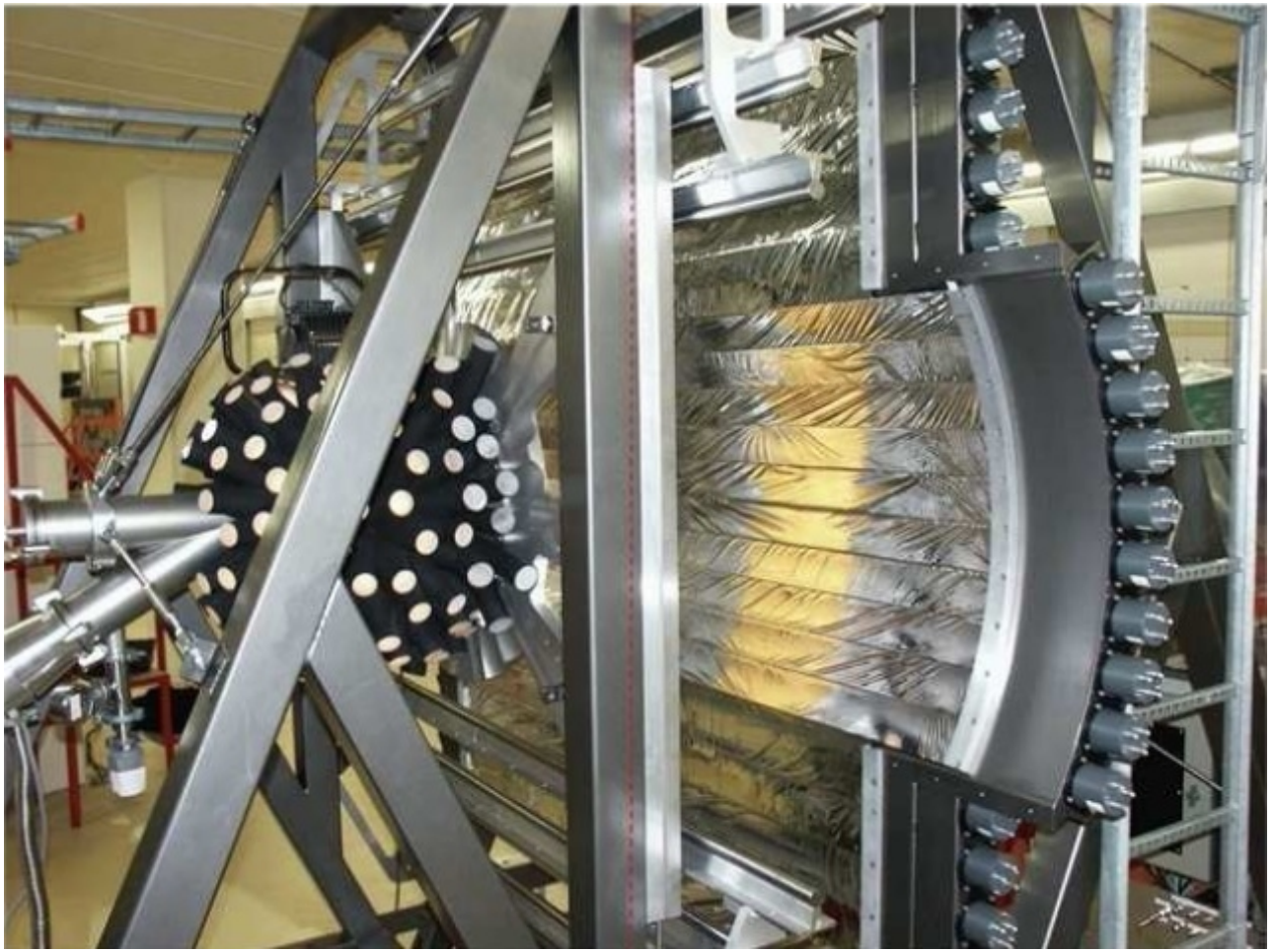
Studies of 3N System with BINA@CCB

1) Experimental program:

- Measurement of **^{2}H(p,pd)** elastic scattering at 108, 135 and 160 MeV
- Measurement of **^{2}H(p,pp)n** breakup reaction at 108 and 160 MeV for over 100 kinematic configurations

2) Aim:

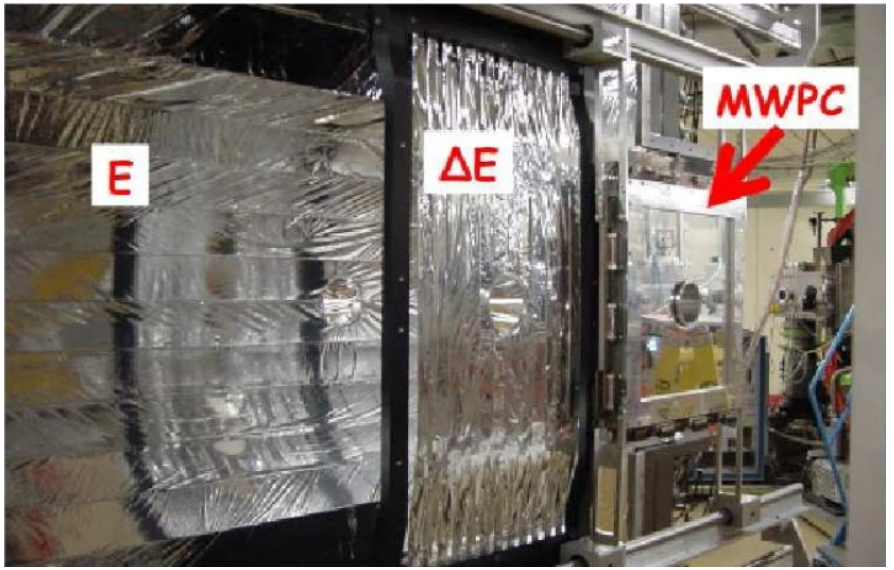
- Studies of **3NF**
- Verification of predicted **Coulomb** and **relativistic effects**
- Tests of upcoming **ChPT** calculations



The Forward Hodoscope - Wall

MWPC (Multi-Wire Proportional Chamber):

- active area of 38 x 38cm^2;
- 3 planes, X, Y (236 wires), and U (296) - distance between two adjacent wire planes is about 12 mm;
- the efficiency of MWPC is about 90%.



The *ΔE-E* telescopes:

- the *ΔE* array is made of vertically placed thin plastic strips;
- the *E* array is made of 10 horizontally placed thick bars;

- Angular acceptance of Wall:

  $\theta \in (10° - 35°)$

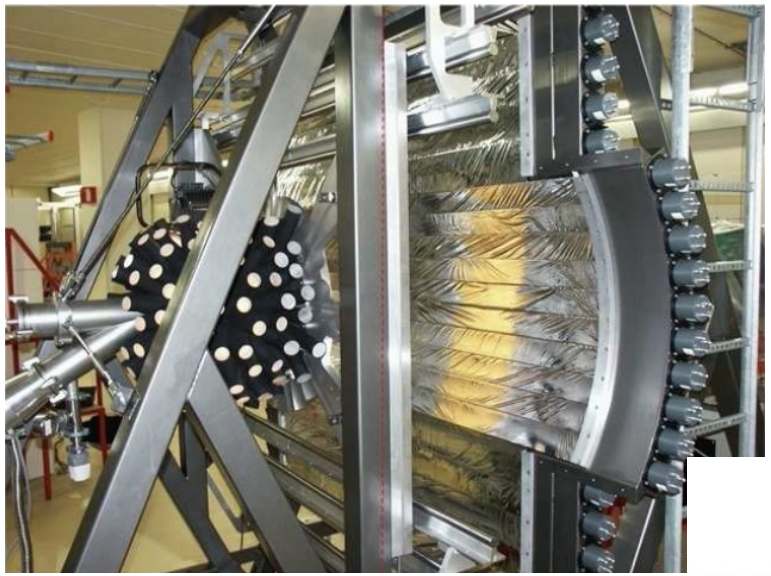
  $\varphi \in$ (full φ)

- Angular resolution:

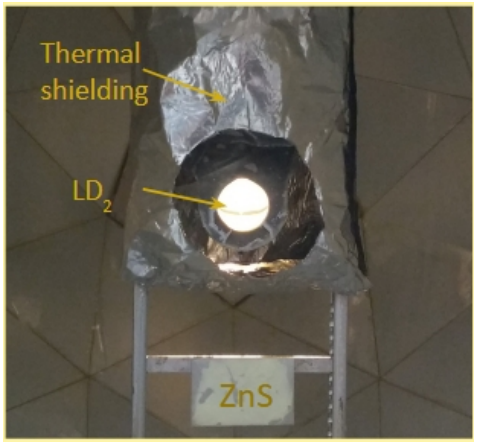
  $\Delta\theta \approx 0.5°$

  $\Delta\varphi \approx 0.5° - 3°$

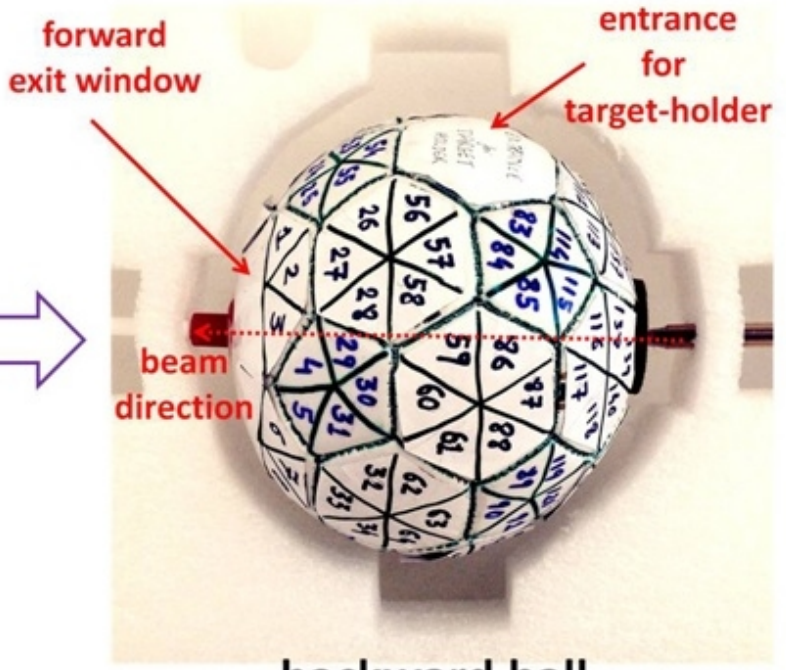
The Backward Part of Detector - Ball



- System of 149 phoswitches
- Liquid target system
- Together with Wall - angular acceptance of nearly 4π



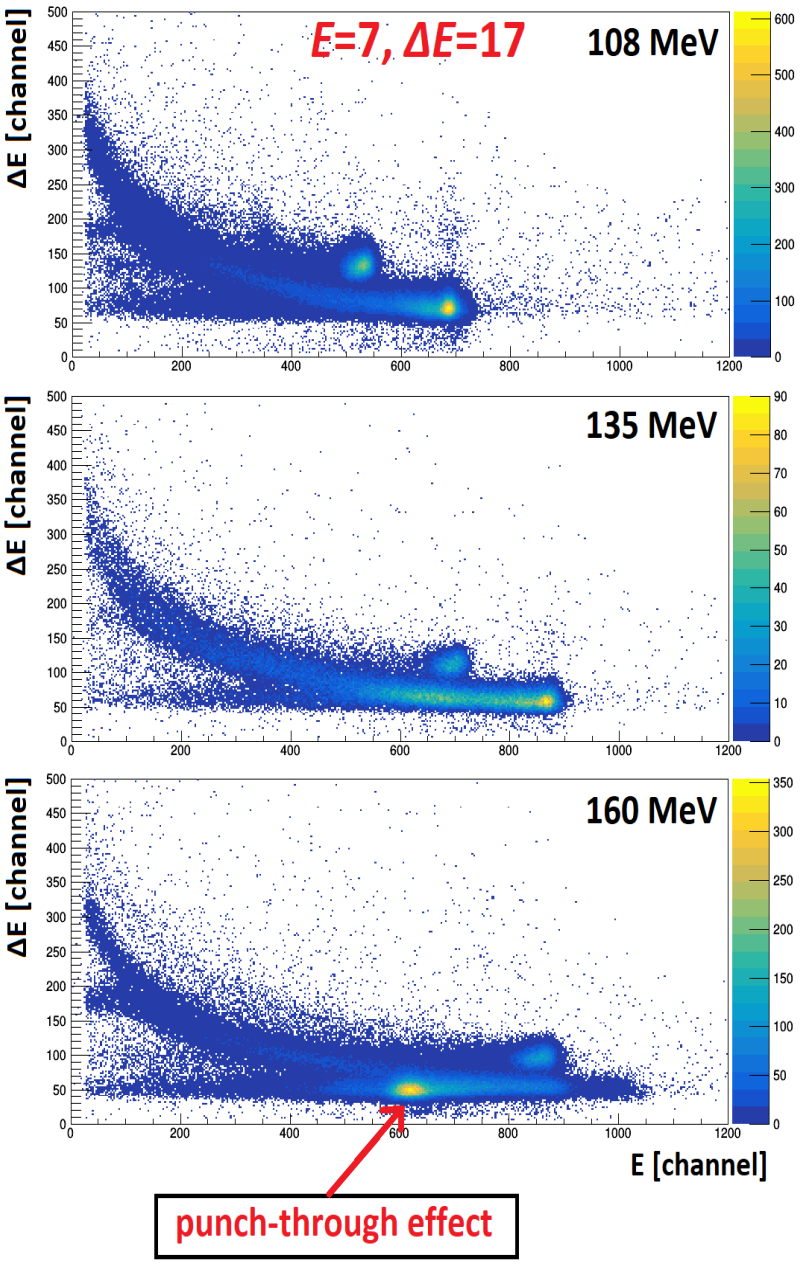
a soccer ball

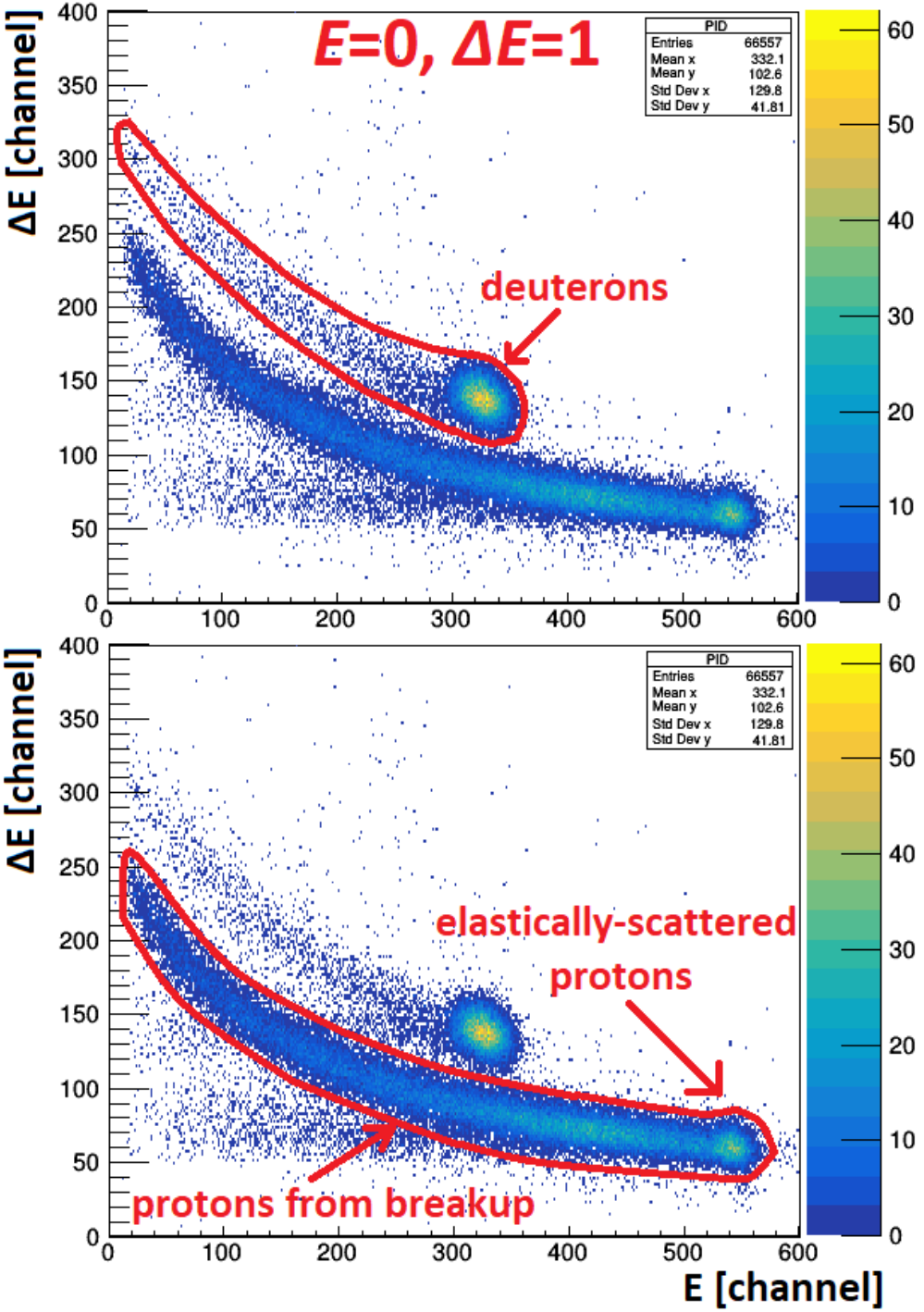


backward ball

Particle Identification (PID)

- Based on ***ΔE-E* technique**;
- The events of interest are the **coincidences of two charged particles:**
  1) pp (breakup reaction),
  2) pd (elastic scattering),
- allows us to identify **protons and deuterons**;





- **Graphical cuts** (“gates”) were defined **for each individual *ΔE-E* telescope;**
- Small overlap of gates is allowed;
- **three groups of events** are well visible:
  - ➔ the **spot of deuterons** coming from the elastic scattering,
  - ➔ the long **branch of protons** coming from the breakup reaction,
  - ➔ the **spot of elastically-scattered protons**.

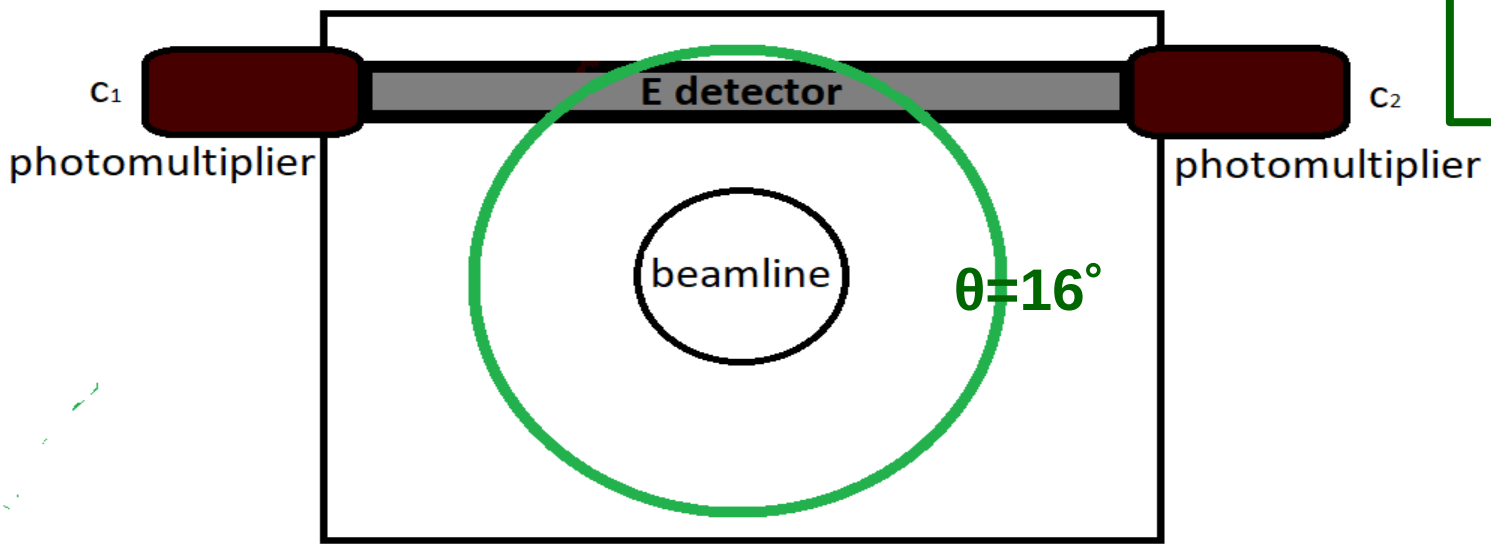
Calibration – Al target

- **Proton beam** energies:
  70, 83, 97, 108, 120 MeV;
- **Al(p,p)Al** scattering.

- **Events are defined by**:
  - ➔ the **side** (S = right / left),
  - ➔ the ***E* detector number** (N = 0, 1, …, 9),
  - ➔ the **polar angle** (θ = 12° - 34°; step = 2°).

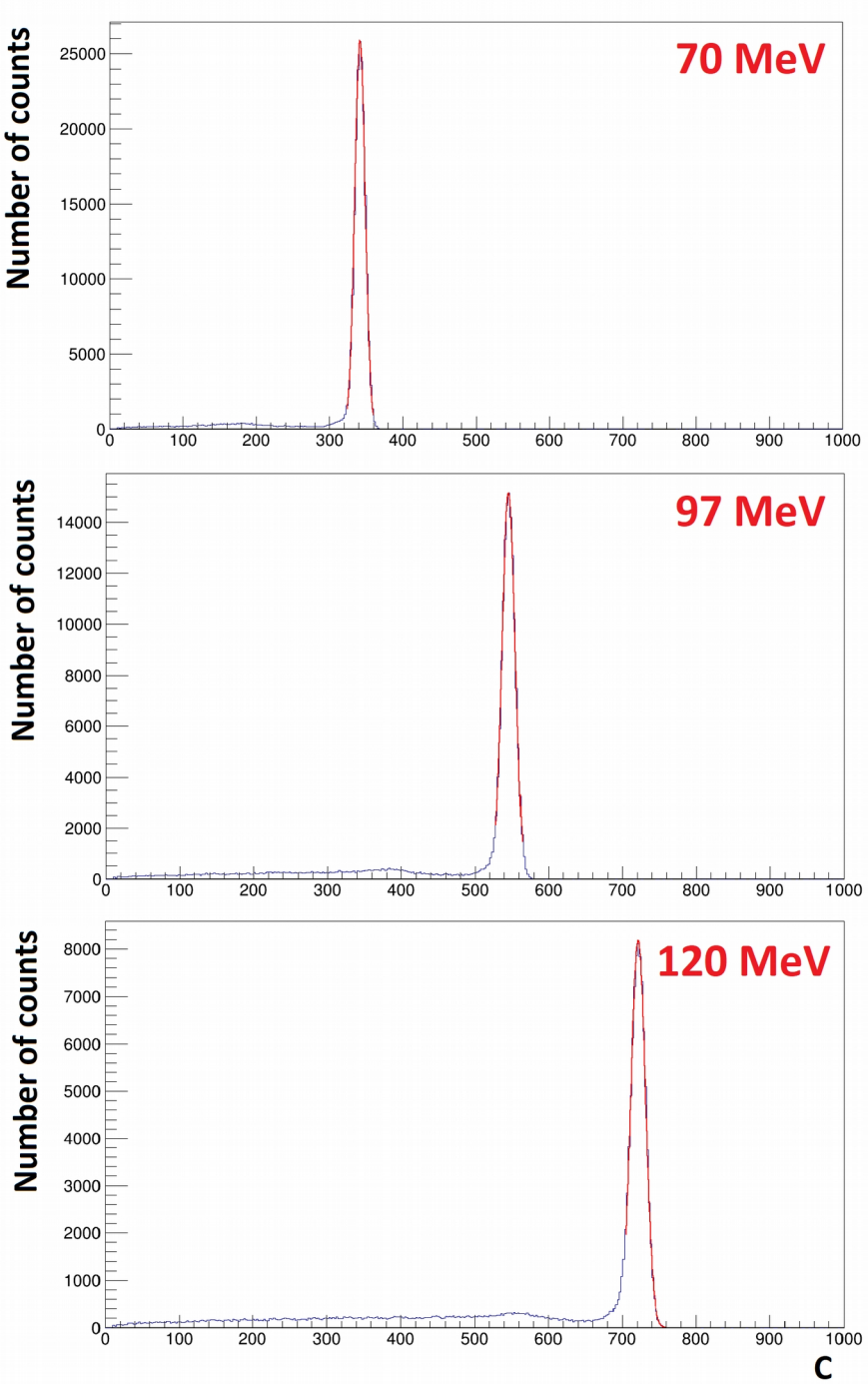
- Energy for each detector:

$$C = \sqrt{c_1 * c_2}$$



supress effects of light attenuation along the bar

Experimental data



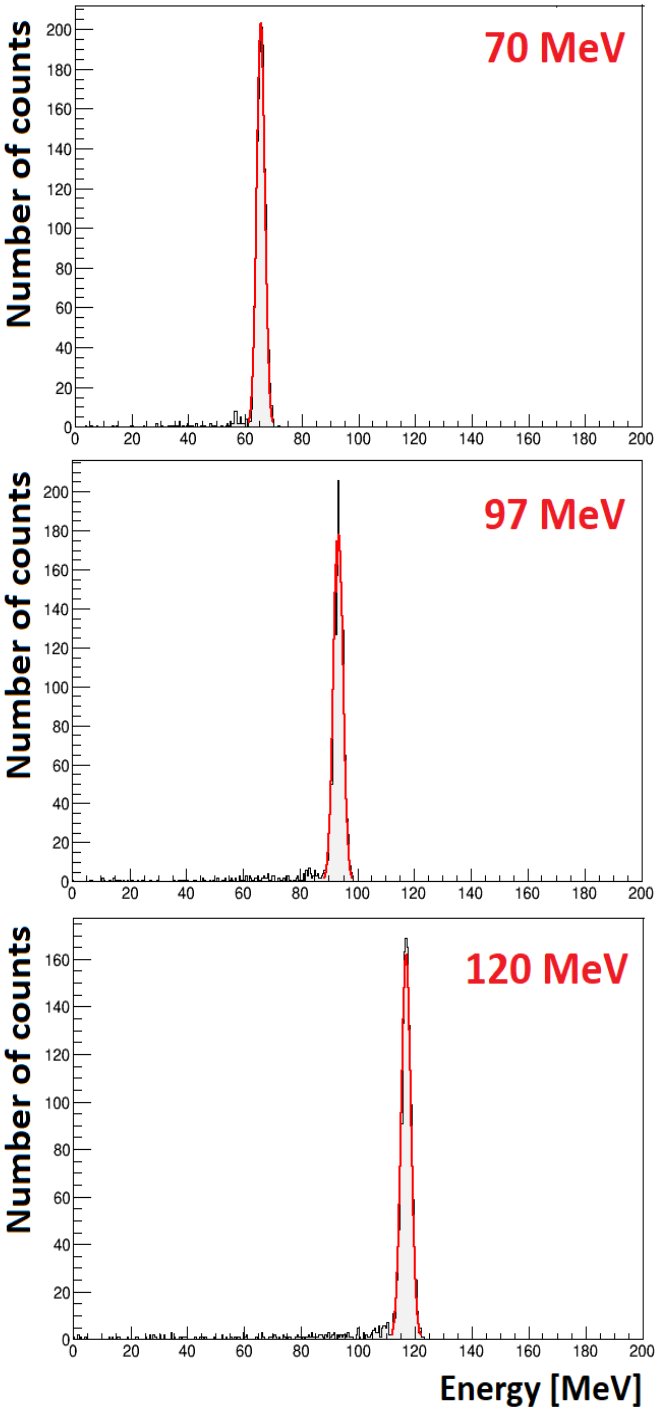
Al(p,p)Al
scattering

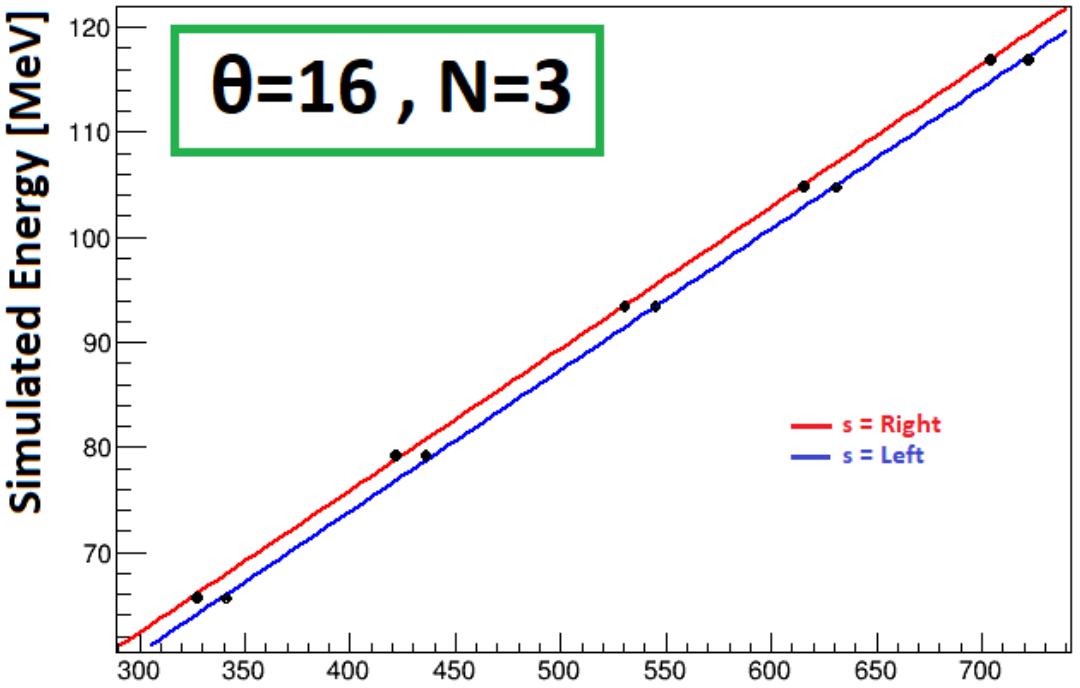
E detector number:
N=3

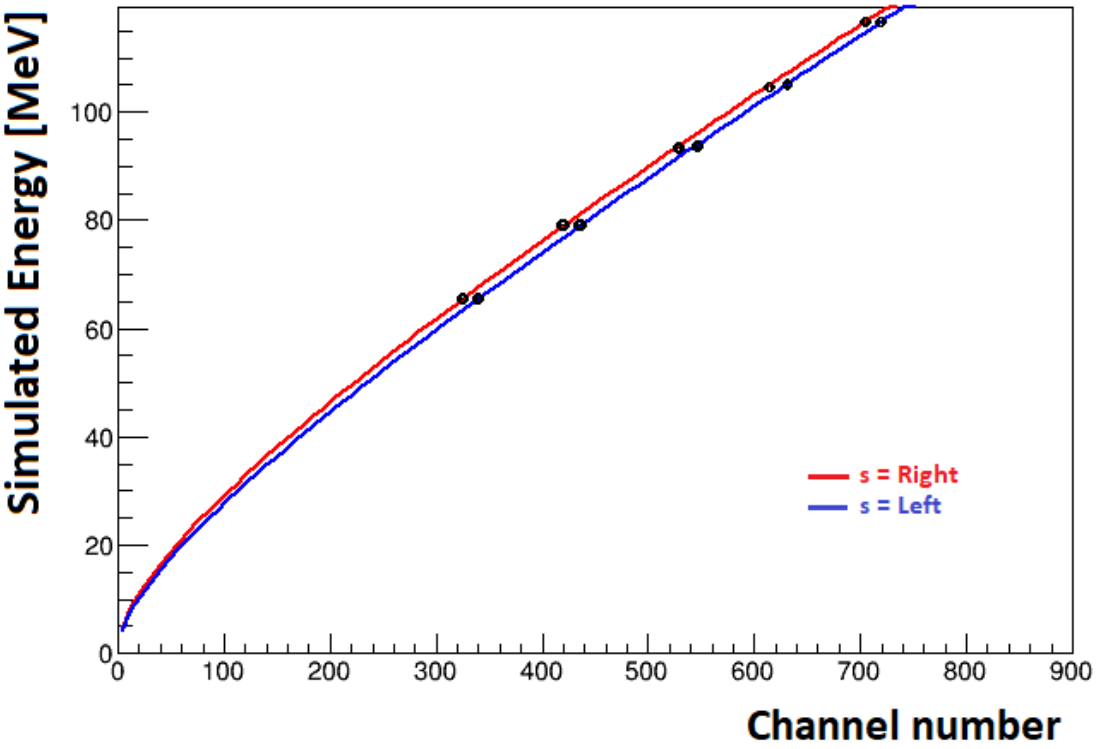
Theta angle:
θ=16°± 1°

Side:
S=left

Monte Carlo Simulation







1. Linear calibration

- y = aC + b
- Range: > 50 MeV

$$C = \sqrt{c_1 * c_2}$$

2. Quenching

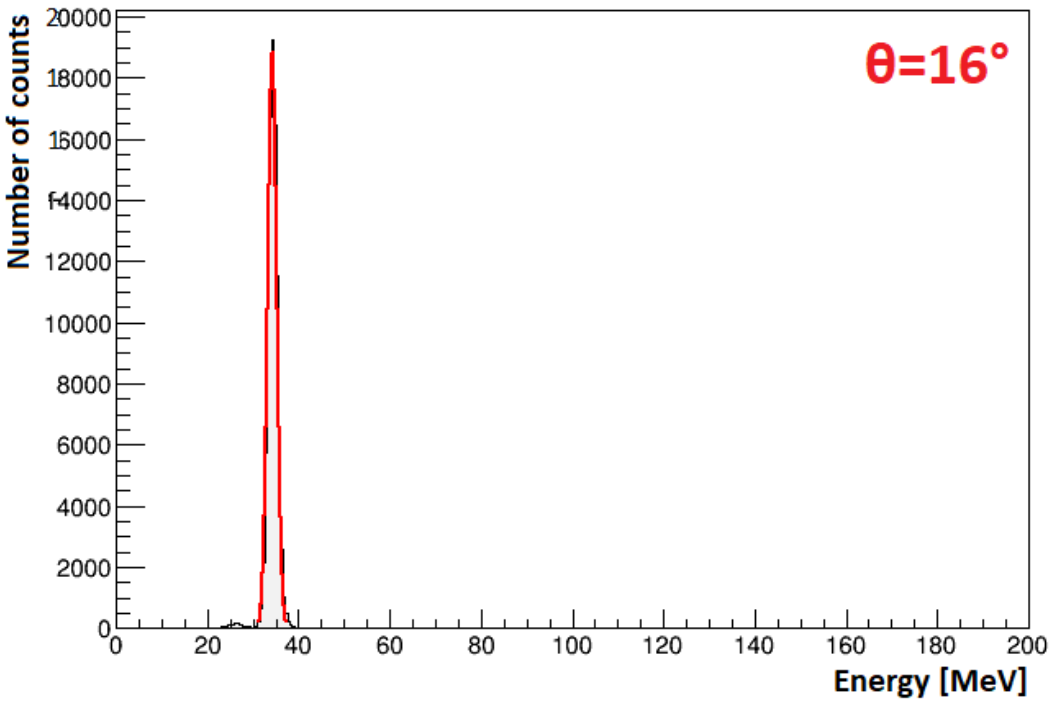
- $y = aC + b\sqrt{c}$
- Range: 0-50 MeV

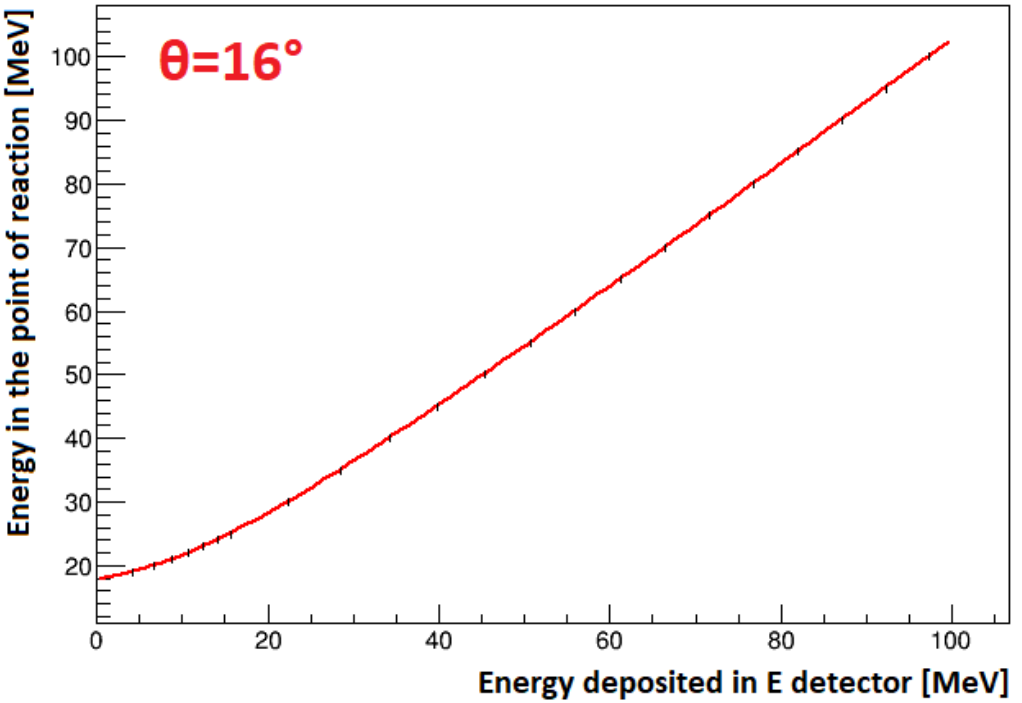
Calibration - LD_2 target

Most important!

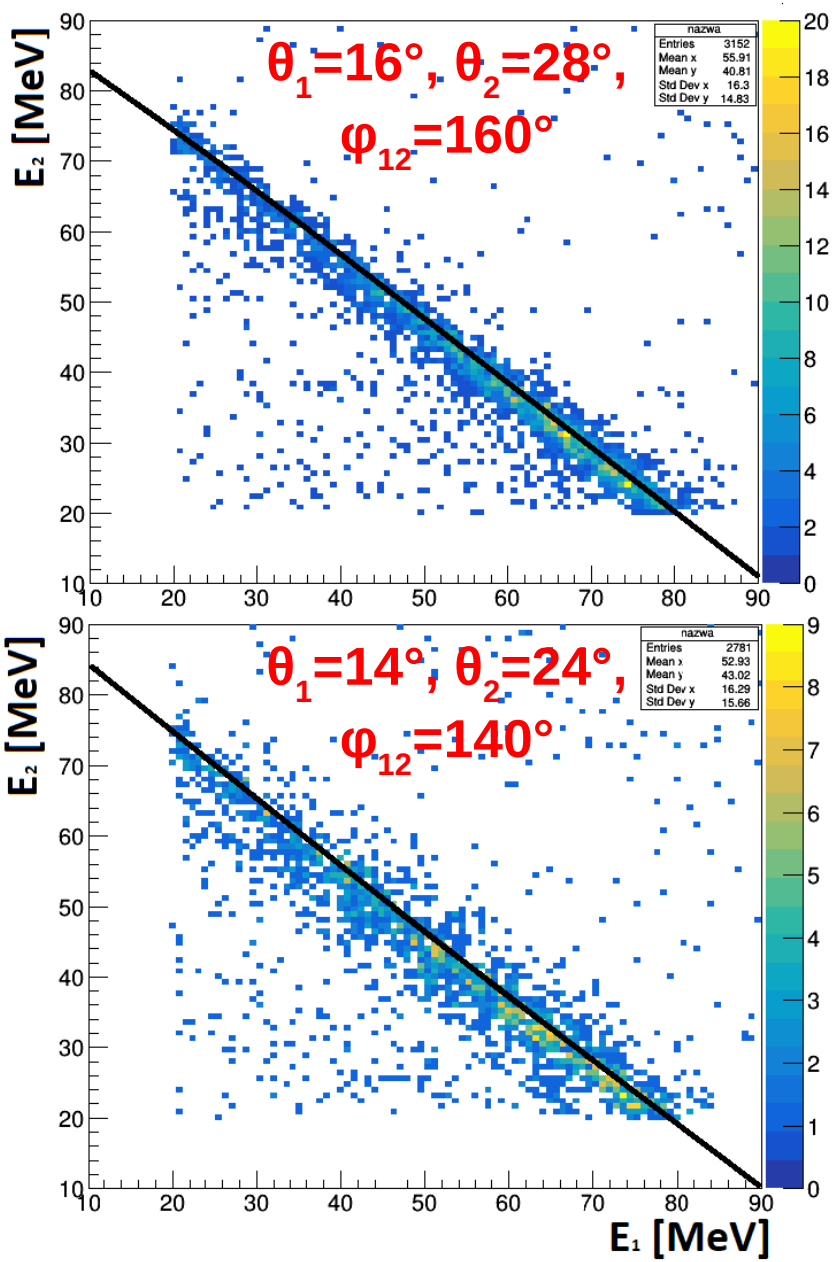
- to obtain an information about the E_{loss} between the reaction point to *E* detector

- Simulation:
- ➔ proton beam (15-100 MeV),
- ➔ θ angle (12°-34°).





Kinematical configuration

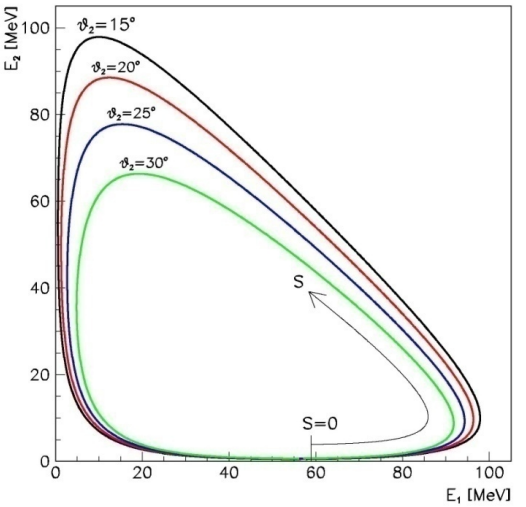


- ^{2}H(p,pp)n reaction kinematics determined by proton momenta $\vec{p}_1, \vec{p}_2$
- Configuration was defined by emission angles of two outgoing protons:
  - ➔ $\theta_1 \pm 1°$, $\theta_2 \pm 1°$, $\varphi_{12} \pm 5°$,
- The central line of the experimental band is lying on the theoretical kinematics

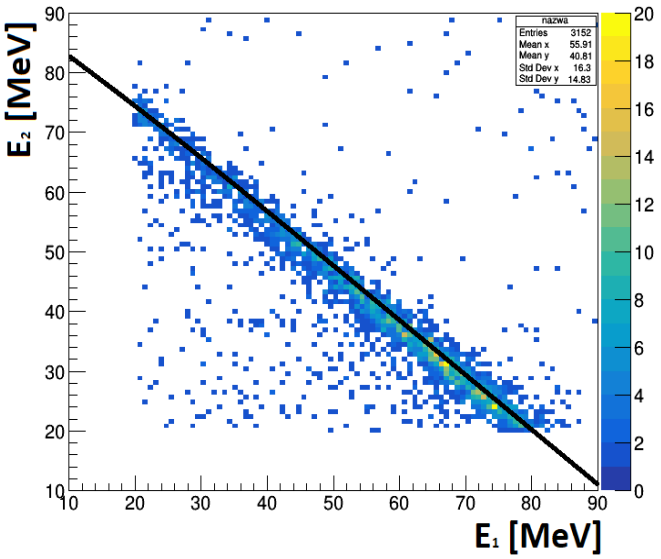
It confirms the correct energy calibration

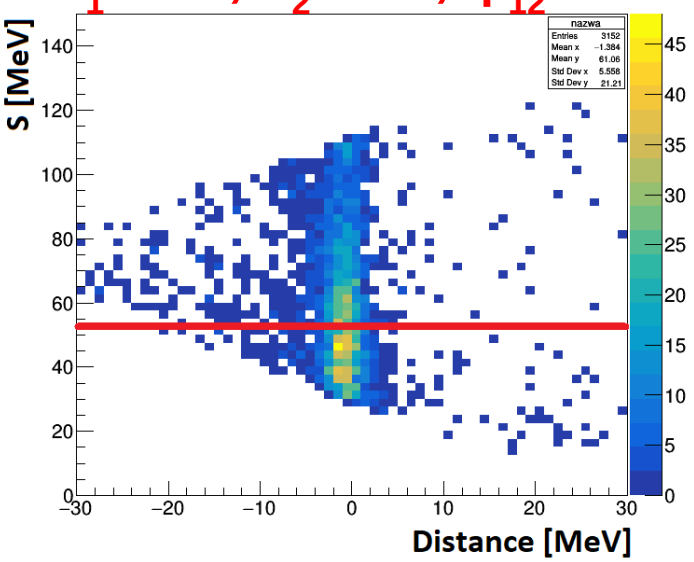
Preparing for Background Subtraction

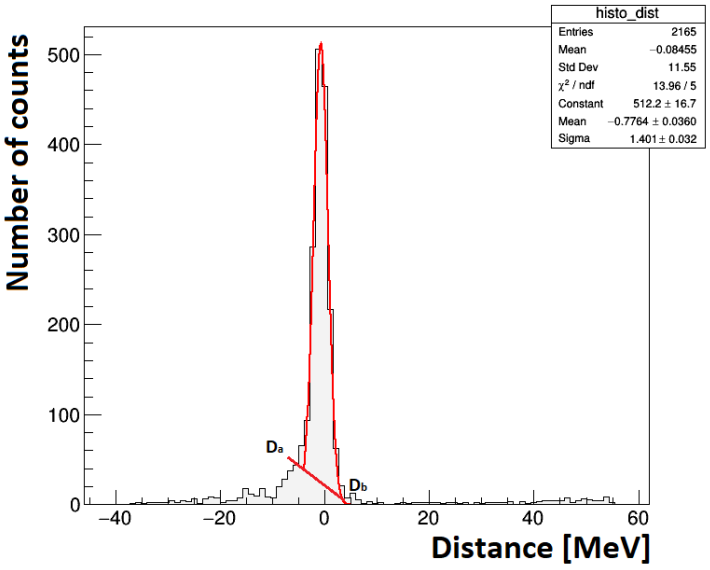
- Transformation of E_2 vs E_1 spectrum to S (**arclength variable**) vs Distance of the points from kinematical curve;
- Each slice on the S vs Distance spectrum is treated separately;
- The background is approximated by a linear function between the two limits of integration;
- The events below linear function is subtracted;

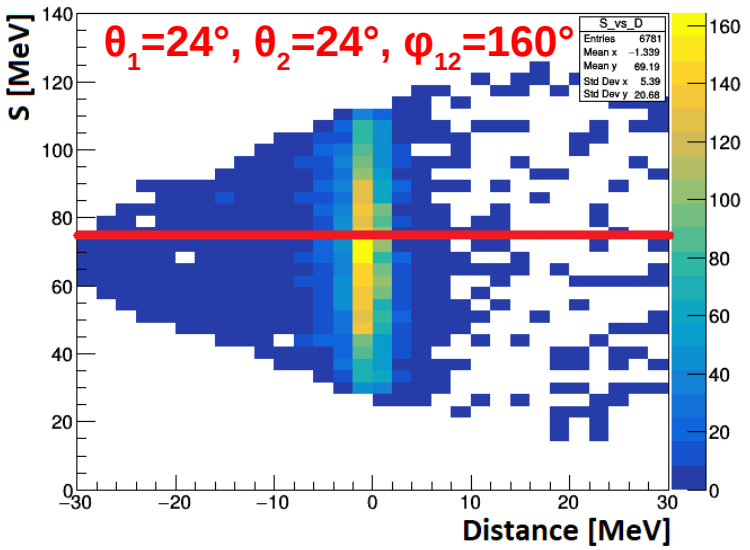


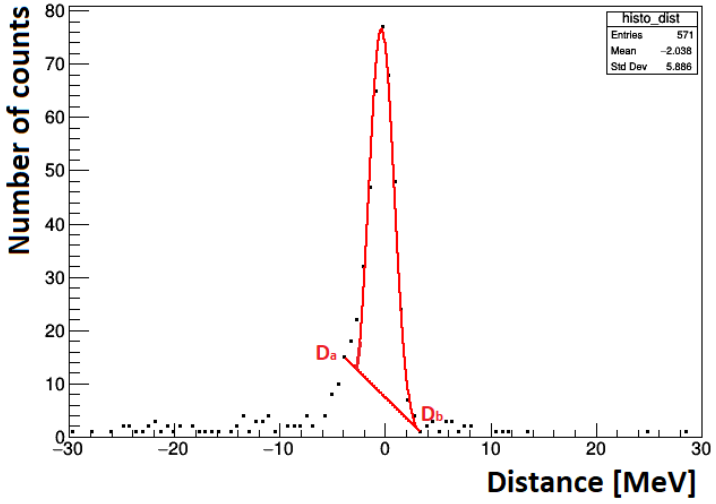
θ_1=16°, θ_2=28°, φ_{12}=160°

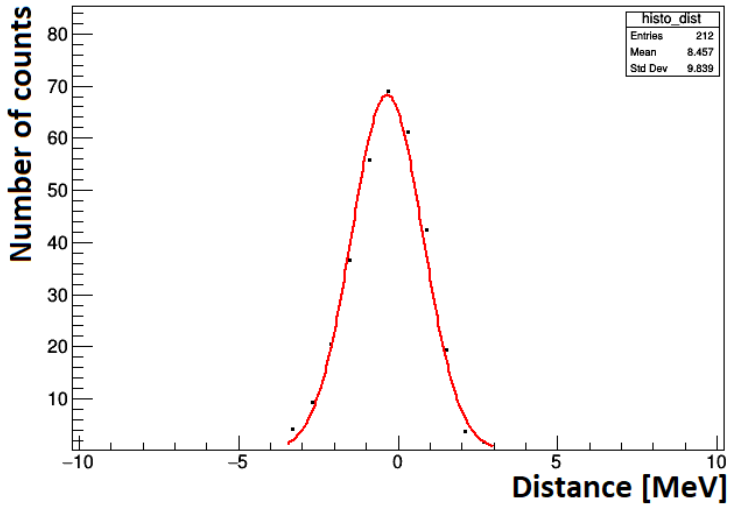


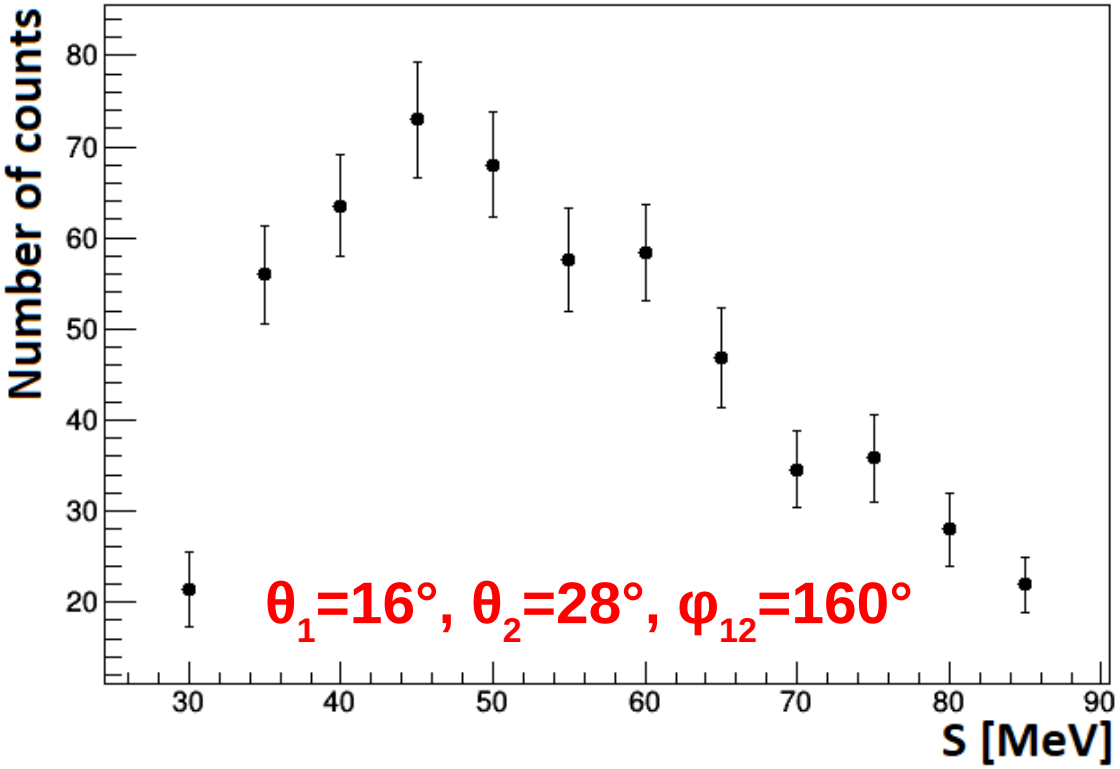


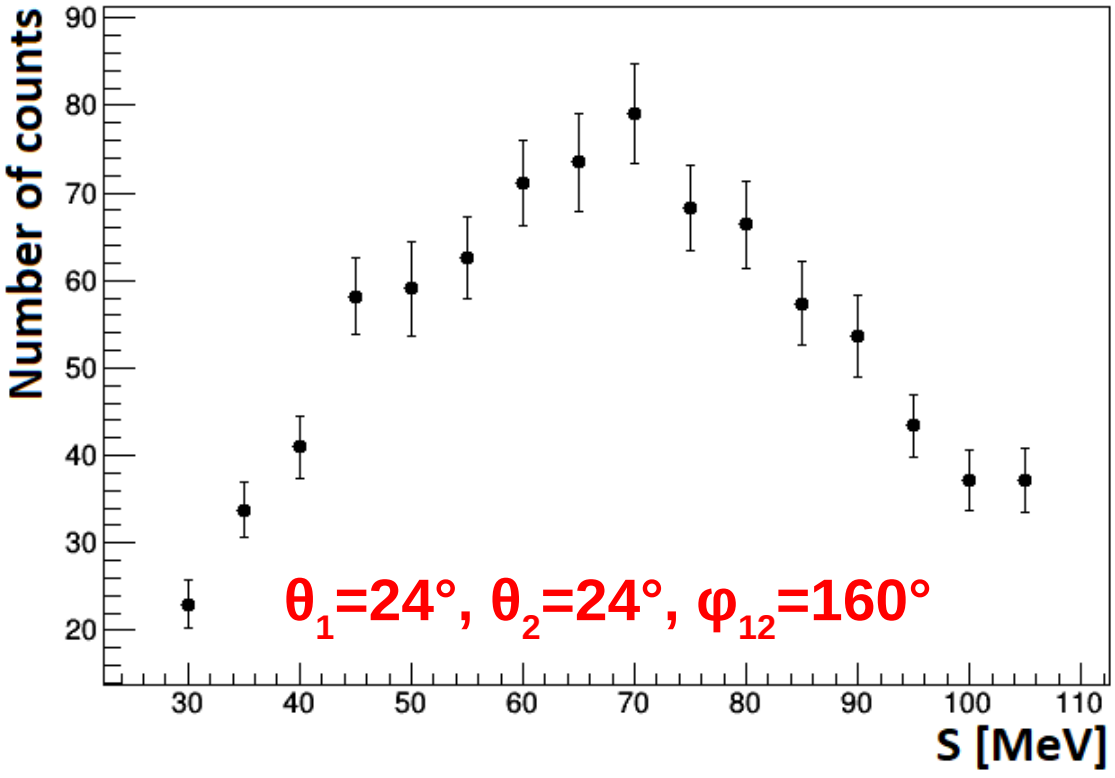



θ1=24°, θ2=24°, φ12=160°
S_vs_D
Entries 6781
Mean x −1.339
Mean y 69.19
Std Dev x 5.39
Std Dev y 20.68
S [MeV]
Distance [MeV]


histo_dist
Entries 571
Mean −2.038
Std Dev 5.886
Da
Db
Number of counts
Distance [MeV]


histo_dist
Entries 212
Mean 8.457
Std Dev 9.839
Number of counts
Distance [MeV]


θ1=16°, θ2=28°, φ12=160°
Number of counts
S [MeV]


θ1=24°, θ2=24°, φ12=160°
Number of counts
S [MeV]

Summary of Data Analysis

1. Particle Identification
2. Energy Calibration
3. Selection of Kinematics Configuration of Breakup Reaction
4. Background subtraction
5. Determination of Detection Effficiency
6. Normalization to Cross Section of Elastic Scattering
7. Comparison of Differential Cross Section for $^{2}H(p,pp)n$ Reaction at 108 MeV

DONE

TO DO

!

Outlook

- The preliminary analysis of the data taken with the **BINA detector at CCB** demonstrates a proper and efficient functioning of the forward part of this detector;
- **New data will be collected** with high statistic for 108, 135 and 160 MeV.

Thank you for your attention!