Studies of Few-Nucleon Systems via $^2H(p,pn)p$ Deuteron Breakup Reaction

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Neutron Detection in Deuteron Breakup Reaction

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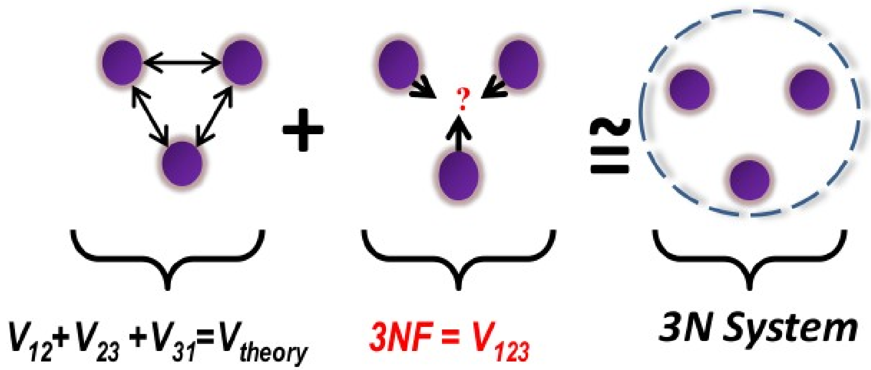
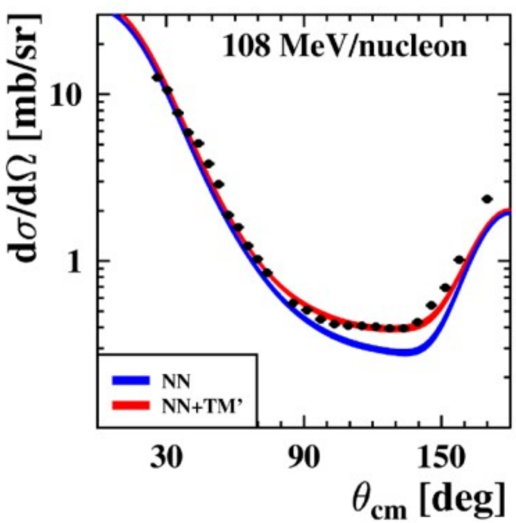
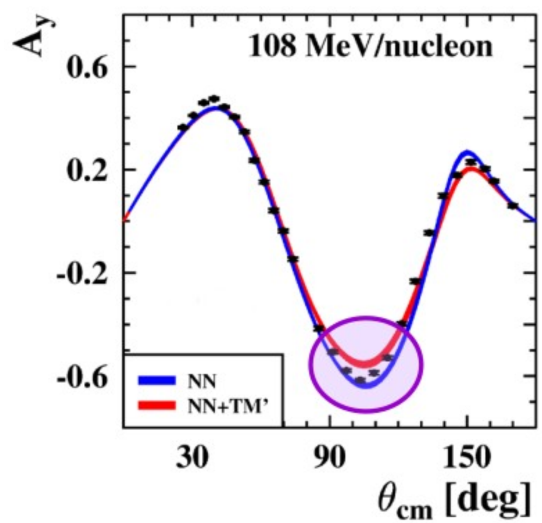
Outlook

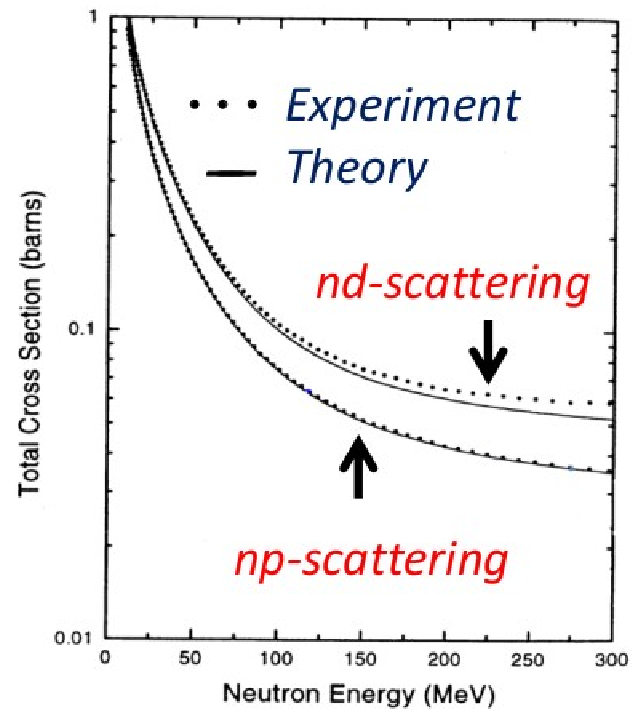
- Short Introduction
- Neutron detection
- Cross-section results
- Summary

Important role of the 3NF in Few-Nucleon systems









High precision data from Los Alamos
W. P. Abfalterer et al., PRL 81, 57 (1998)

Aim of the analysis

- Development of the method for neutron detection in BINA experiment
- Determination of differential cross-sections for deuteron breakup reactions:
  - dp→(pn)p
  - dd→(dn)p

  At 80 MeV/nucleon deuteron beam

Why neutron?

- Low energy detection threshold, different phase-space regions
- Comparing (pp) and (pn) cross-sections, access to Coulomb interaction
- Tool for studying charge-symmetry breaking on nucleon level, in dd breakup analyzing powers *(Howell, Phys. Rev. C. 48 (1993))*

Case 1: dp→(pn)p

- Simplest 3N system
- Strict calculation
- Large experimental data set from 2011
- Suitable for neutron detection development

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- (pn)p and (pp)n cross-sections can differ significantly
- Studying Coulomb interactions

Case 2: dd→(dn)p

- More complex 4N system
- Only aprox. Calculation (SSA)

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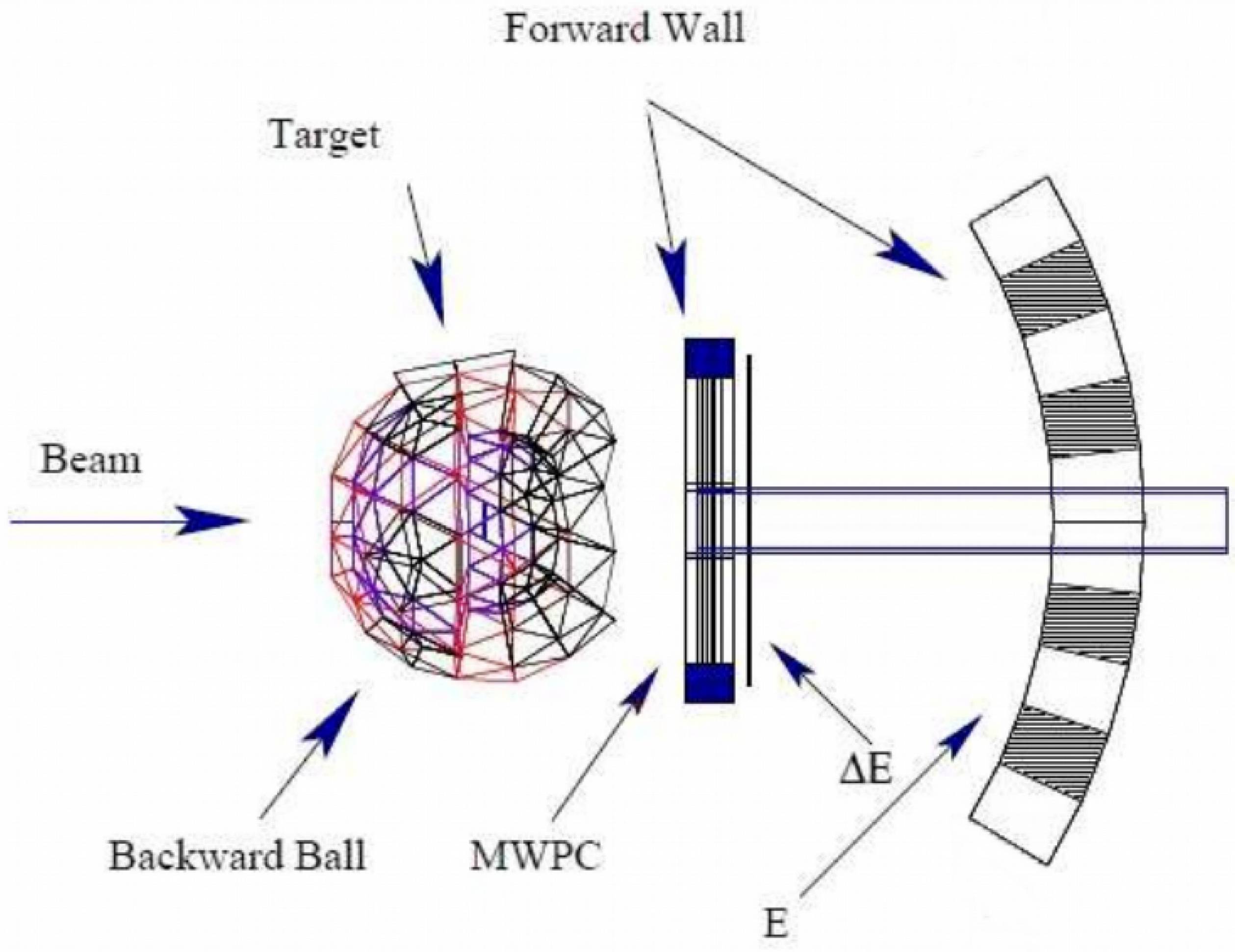
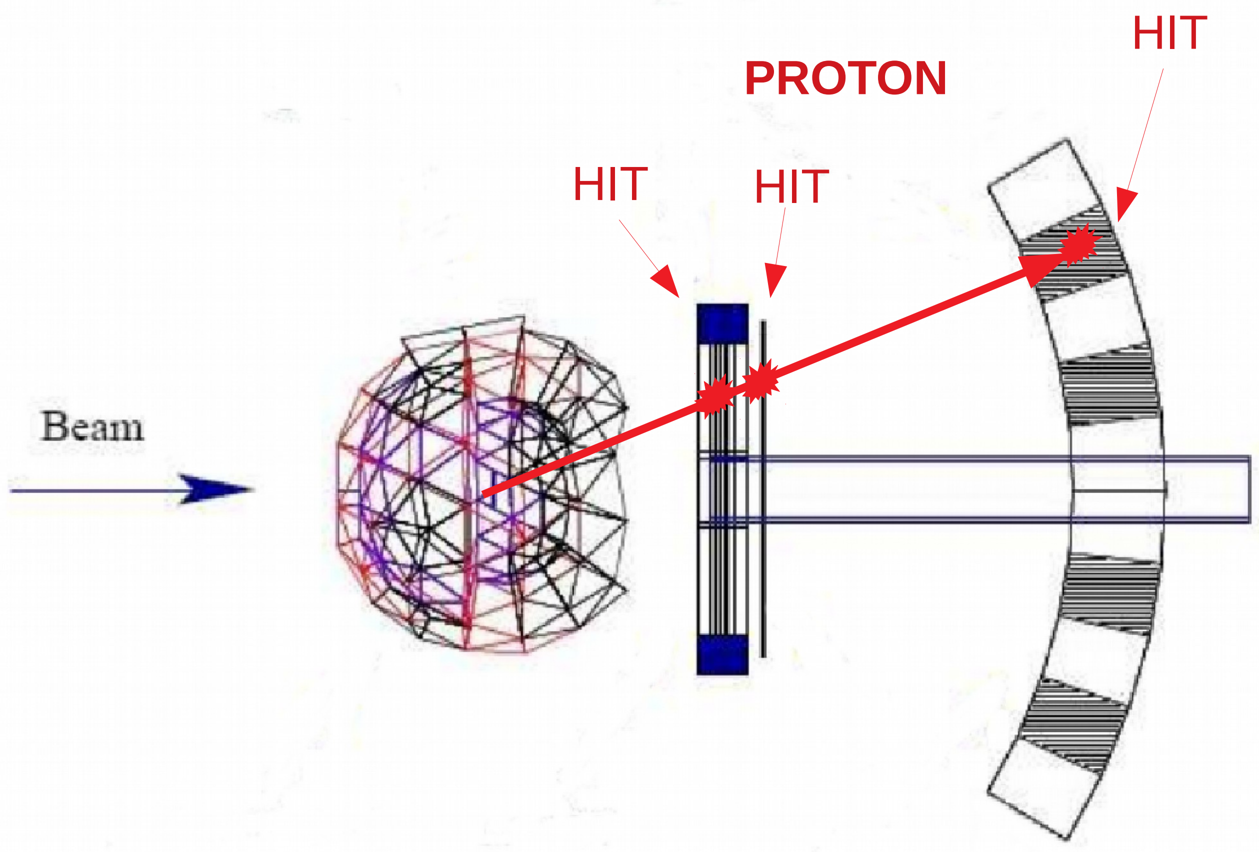
- More complex 4N system
- Only aprox. Calculation (SSA)

- Direct comparison dd→(dn)p And dd→(dp)n
- Coulomb in 4N
- Possible in the future: exclusive dd→(ppn)n

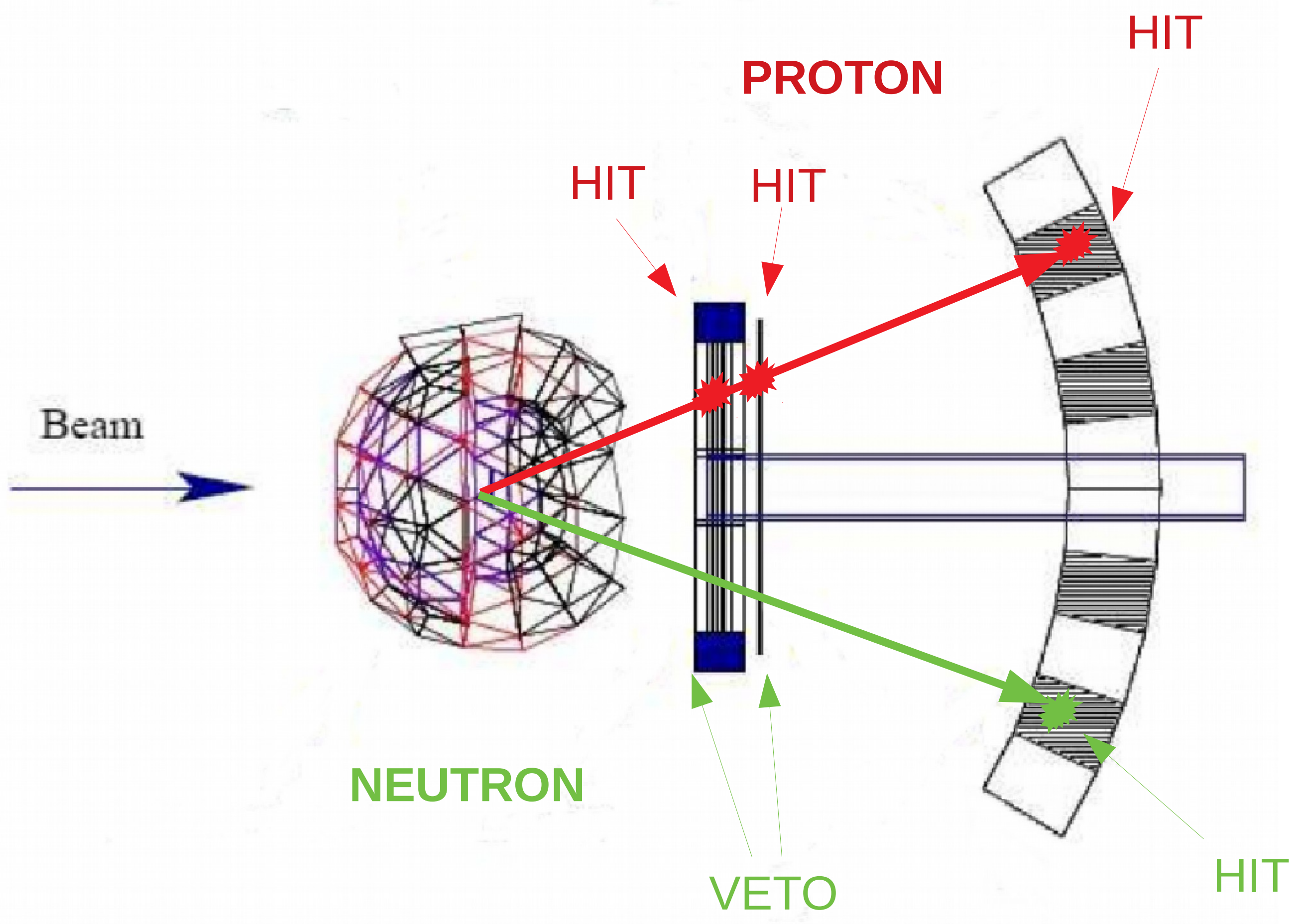
Neutron Detection in BINA



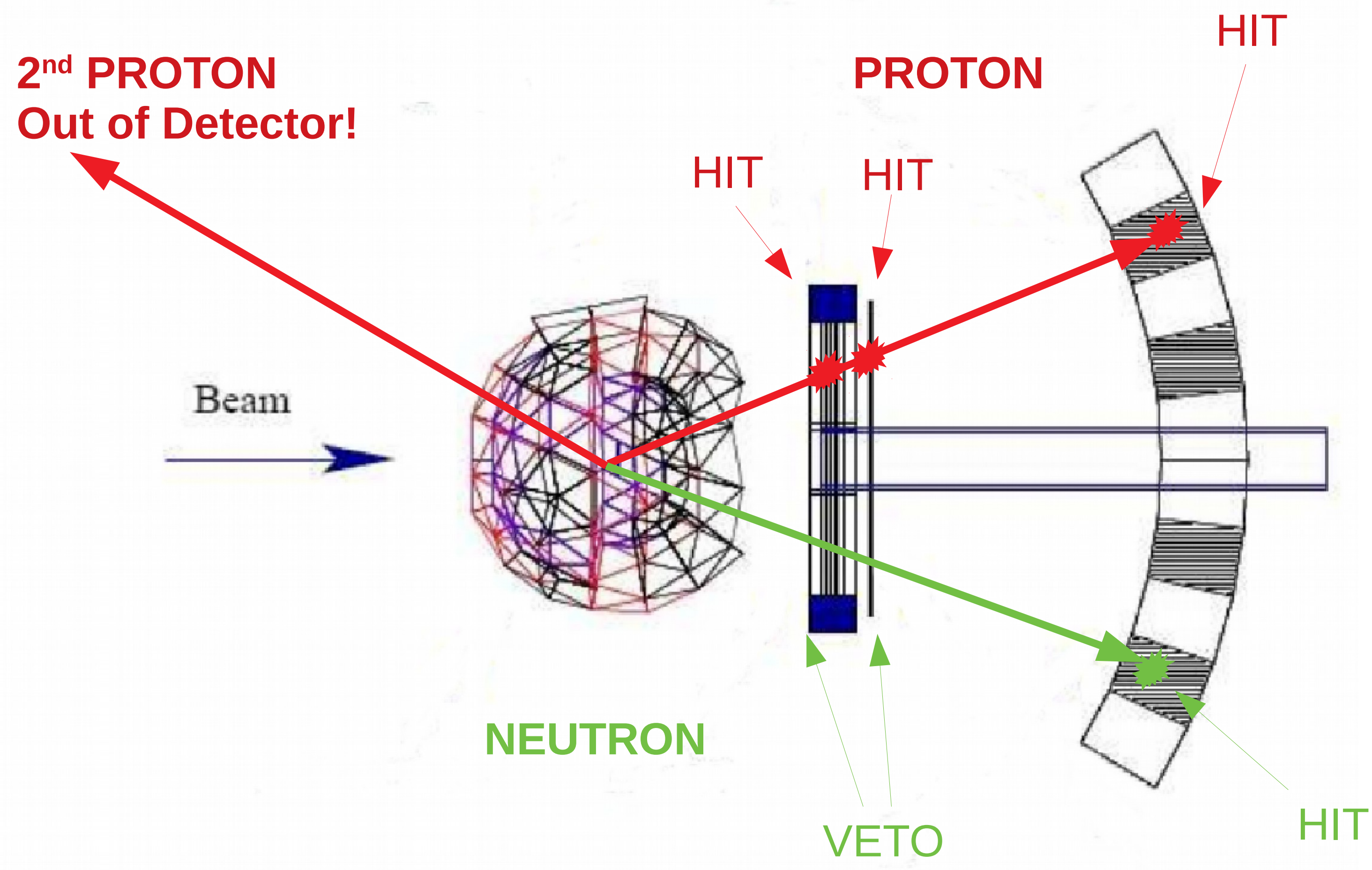
Neutron Detection in BINA



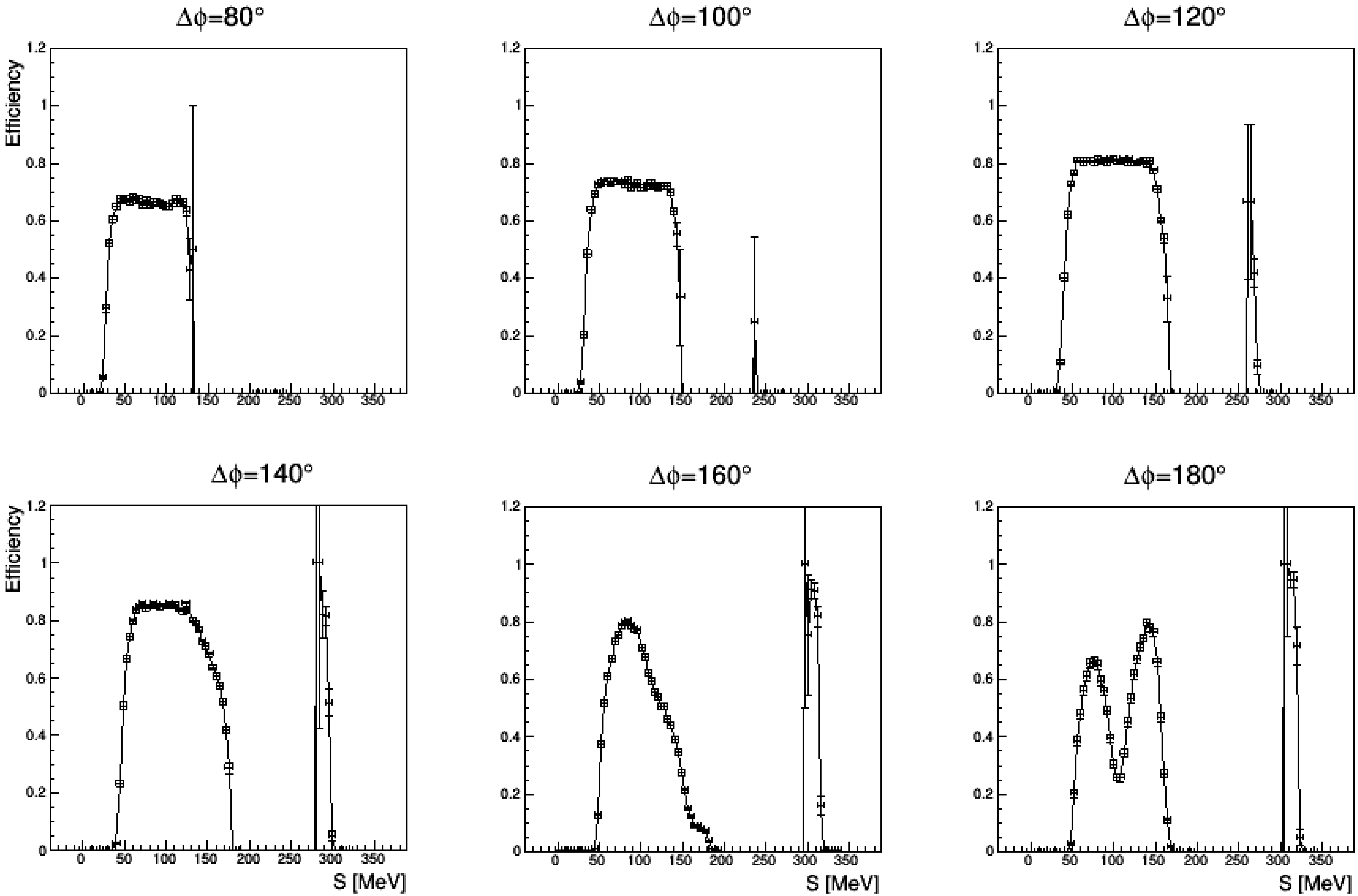
Neutron Detection in BINA



Neutron Detection in BINA



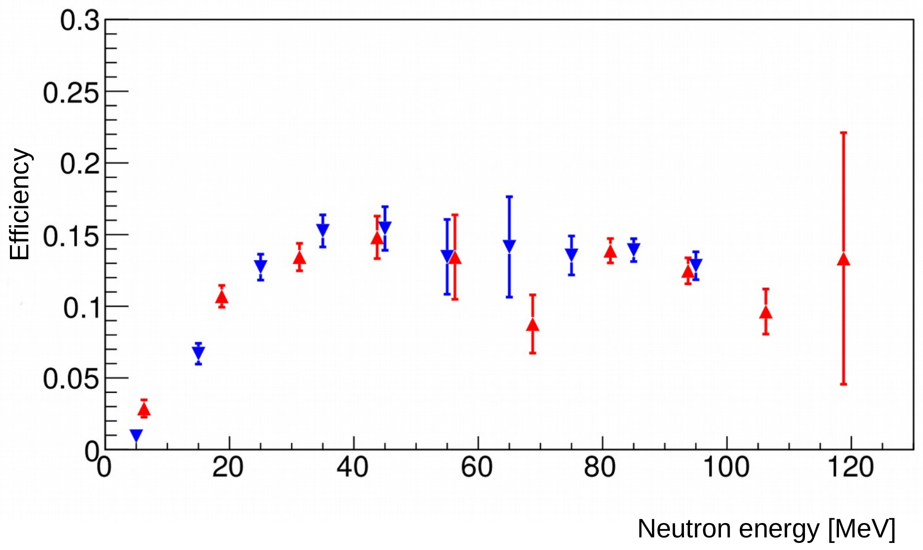
Configurational Efficiency



Neutron Detection in BINA

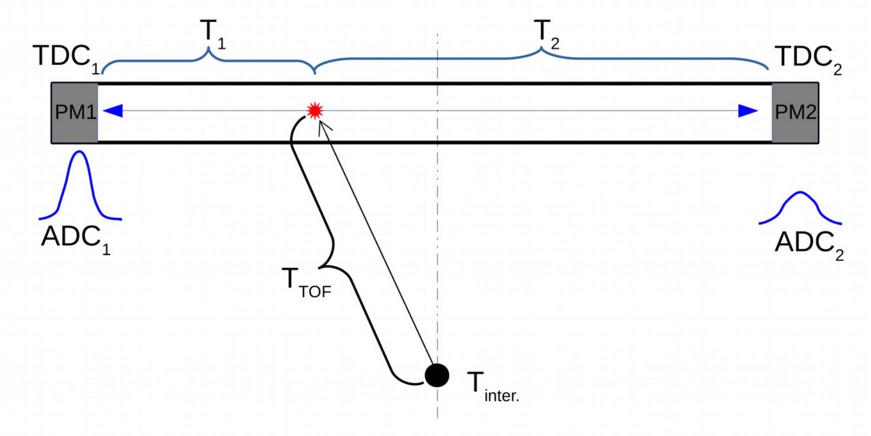
- Neutron interact with E scint.
- MWPC & ΔE as Veto
- Efficiency estimated on complete exclusive dp→(ppn)
- Efficiency ~10-15%

Neutron Efficiency from BINA data

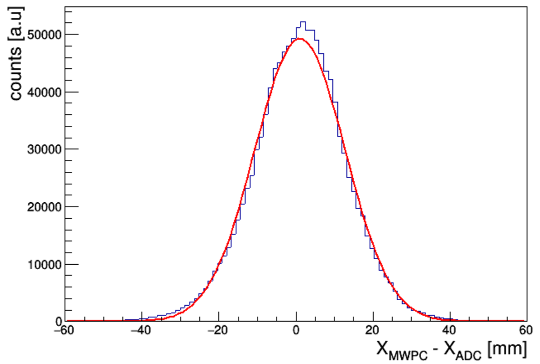


Position reconstruction

- X position based on asymmetry of ADC and TDC signal
- Resolution σ~12 mm

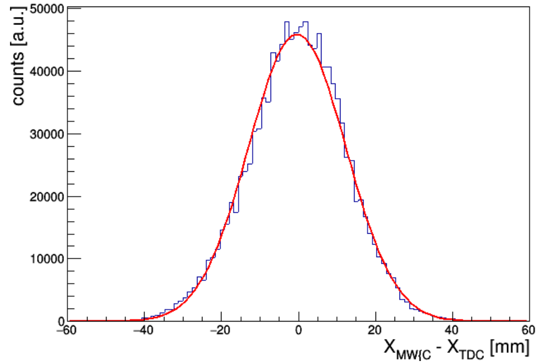


ADC asym.



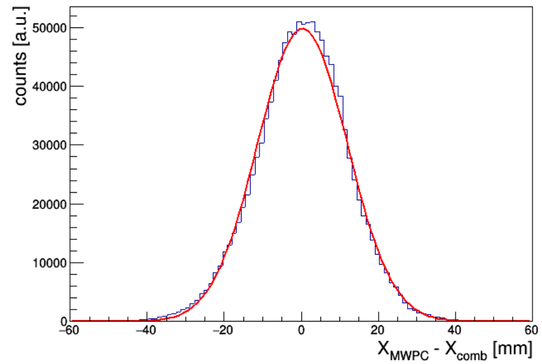
σ=12 mm

TDC asym.



σ=12.6 mm

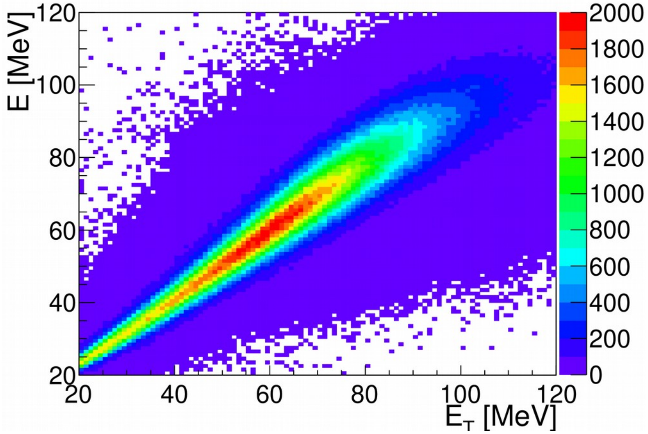
Combined information

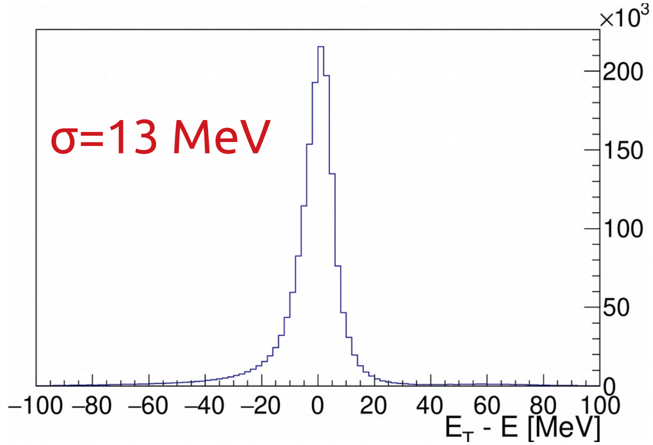


σ=11.6 mm

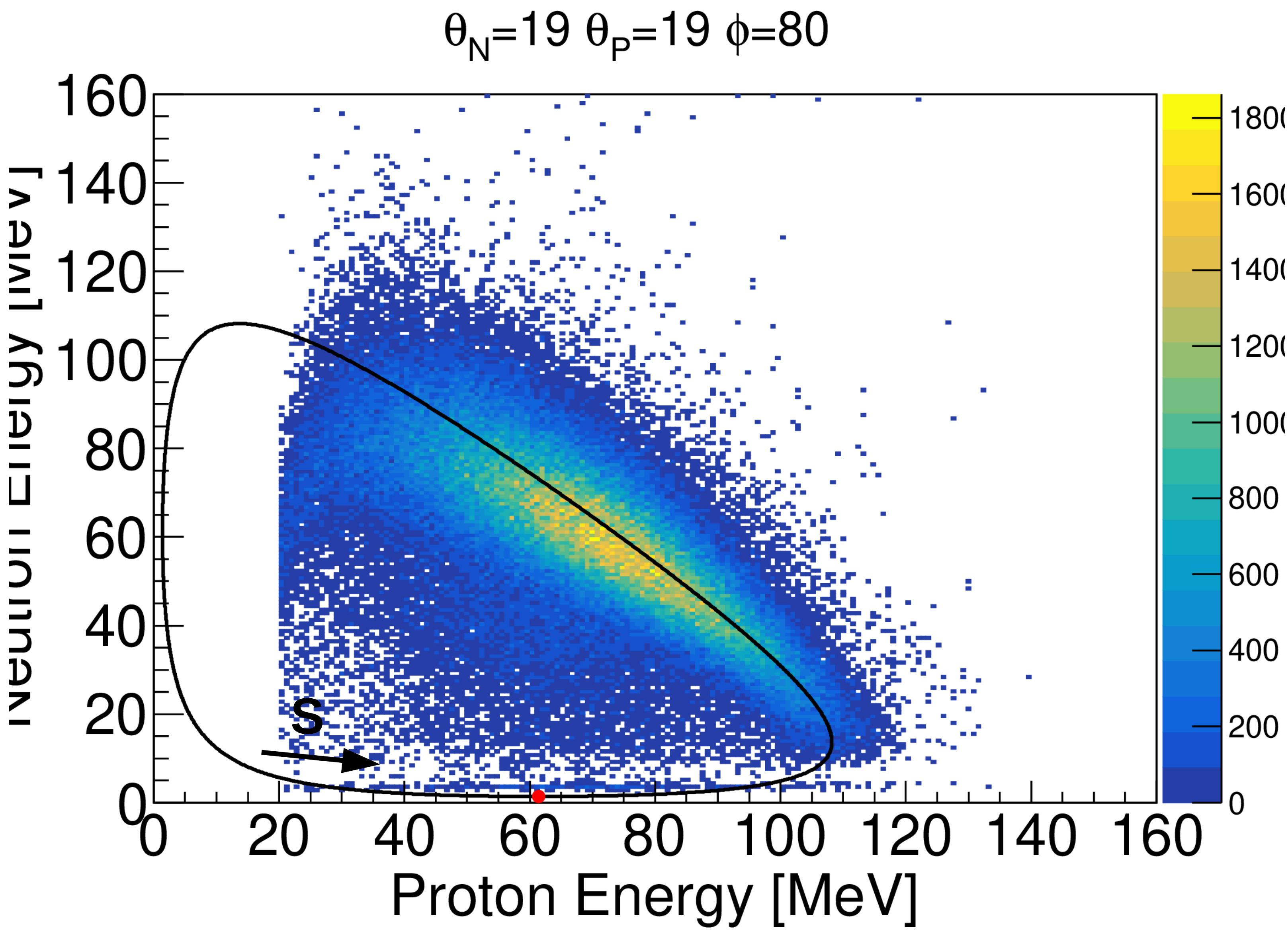
Energy reconstruction

- Based on Time-of-Flight method
- Charged particle needed to calculate reaction time
- Calibrated on events with two protons





Results: En-Ep Histograms



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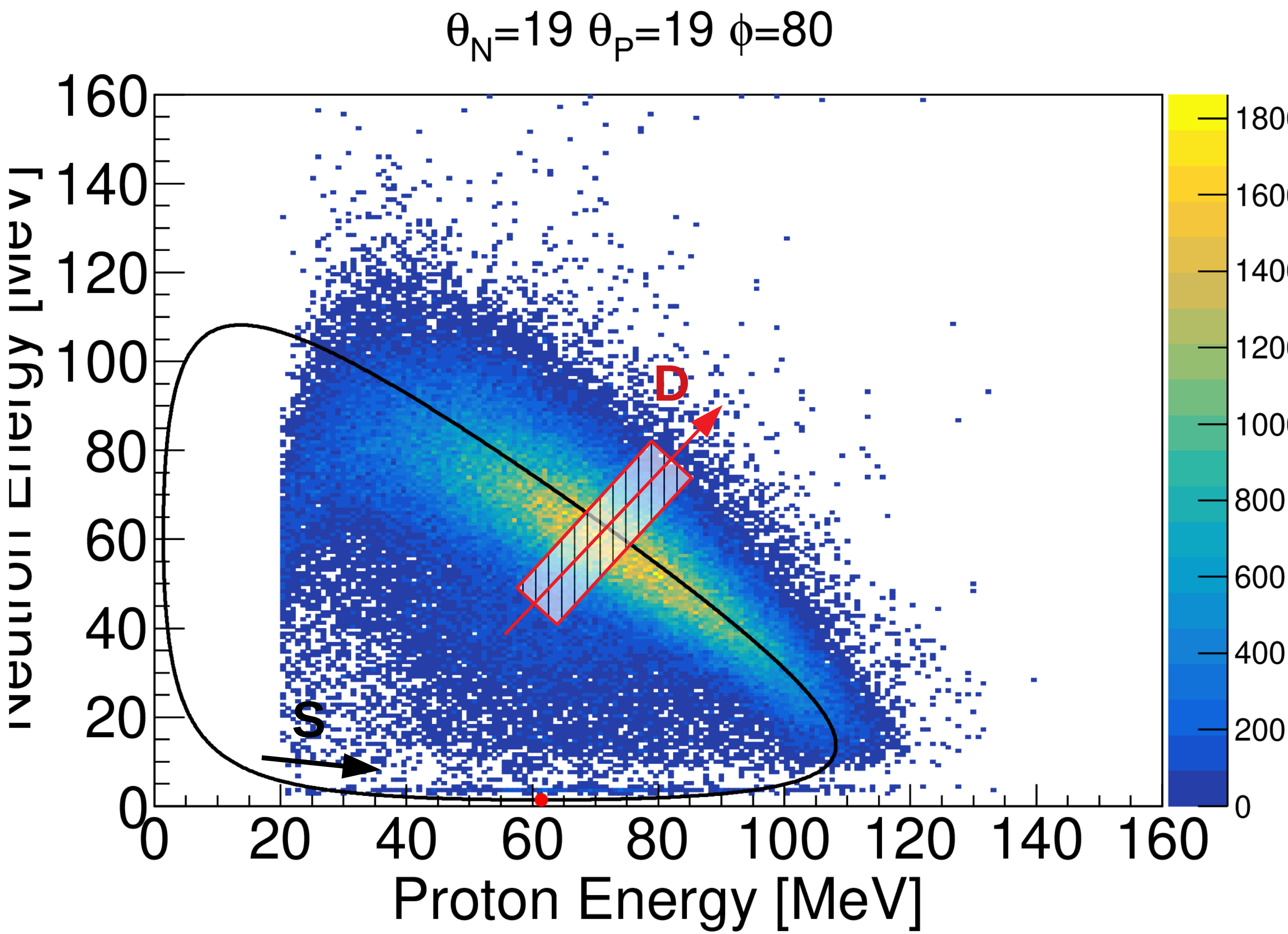

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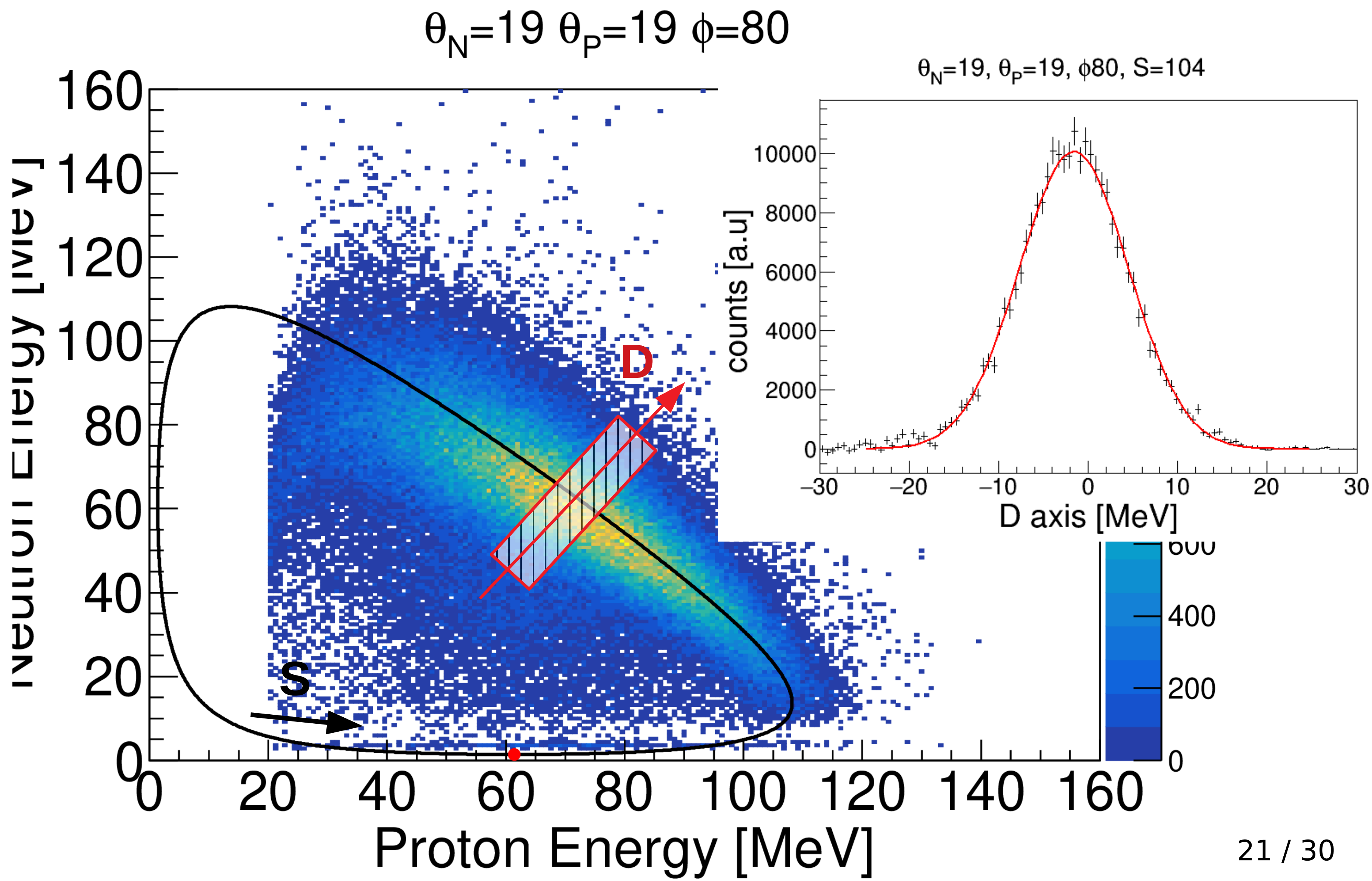

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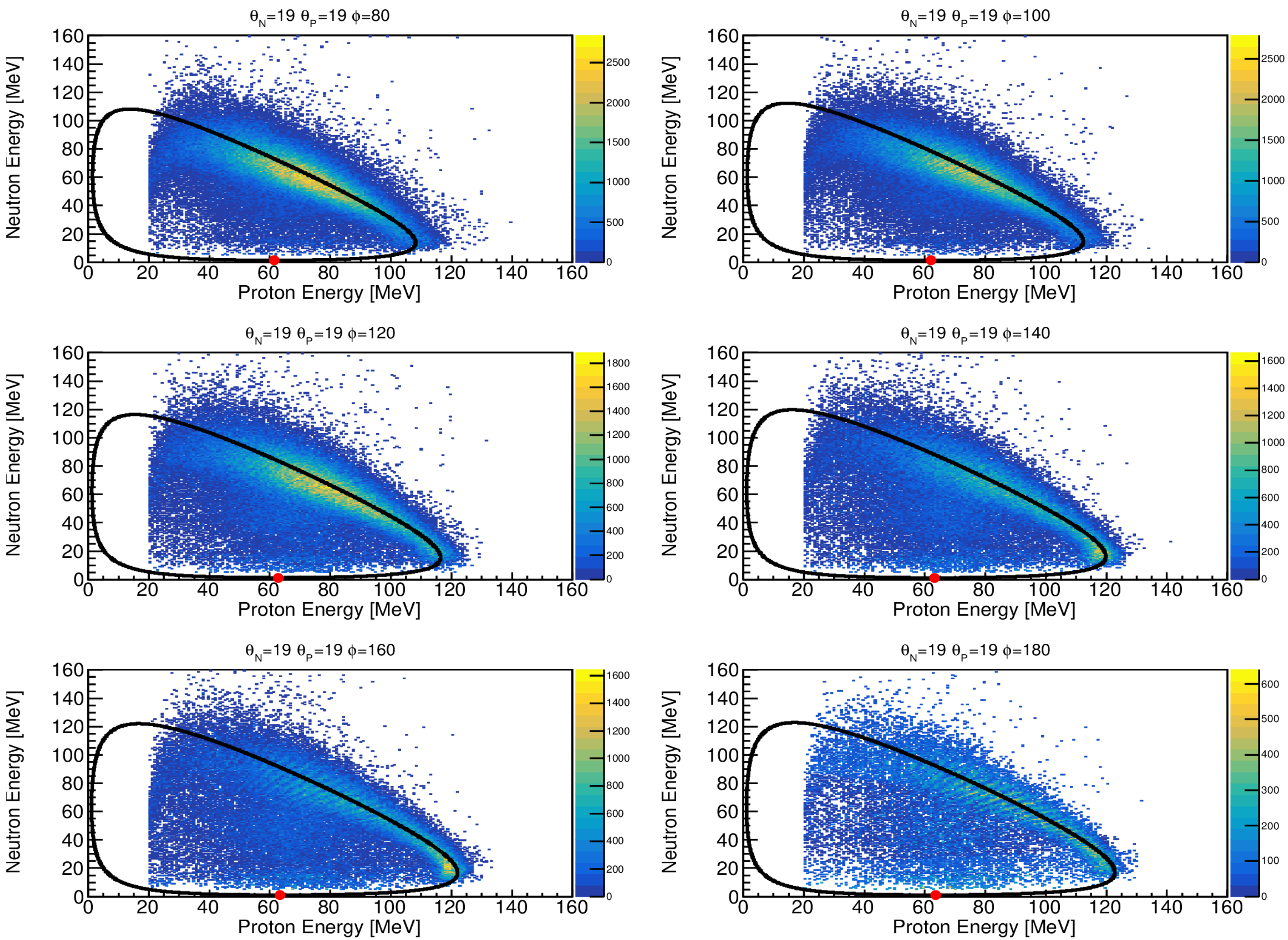
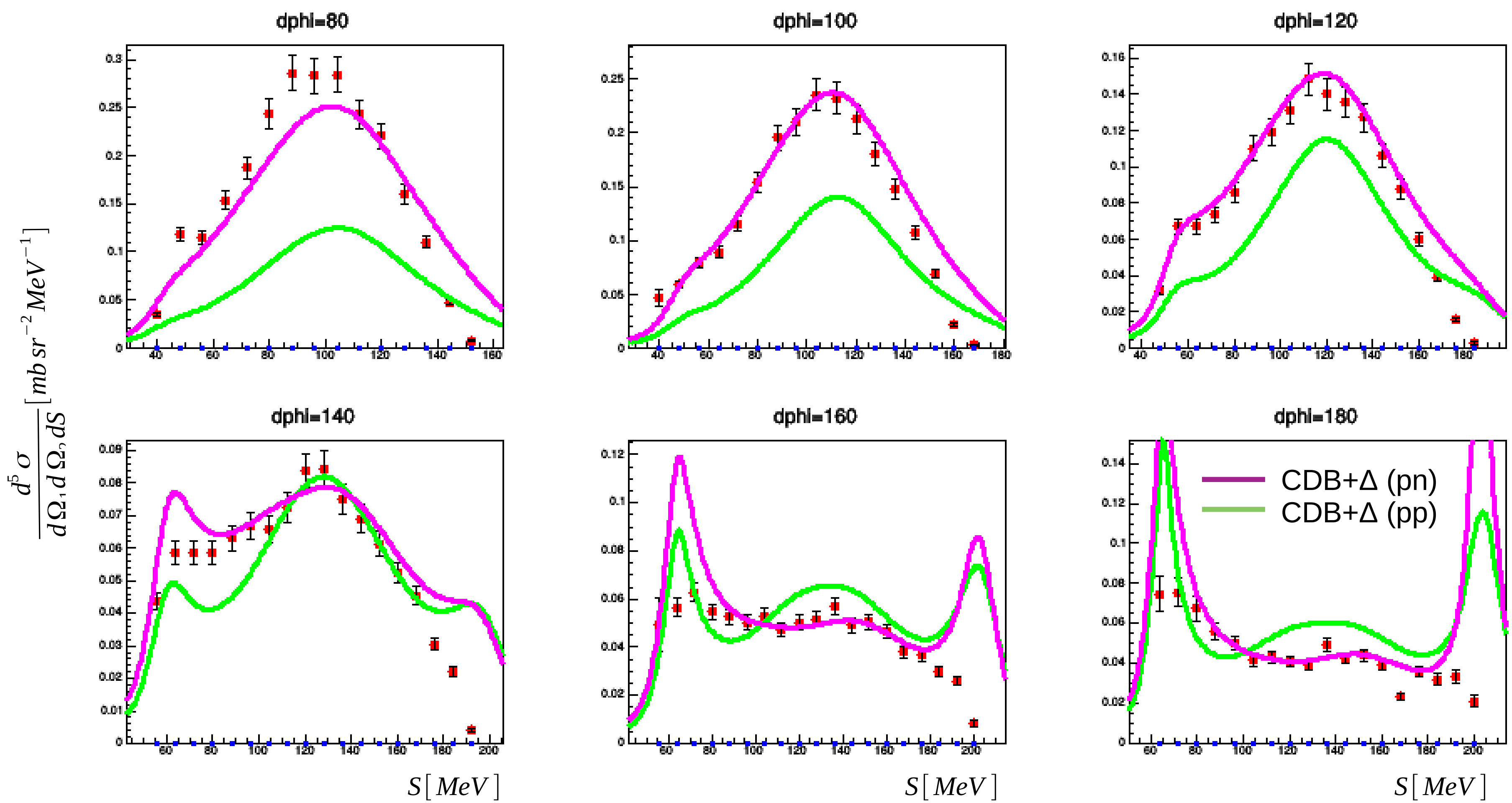


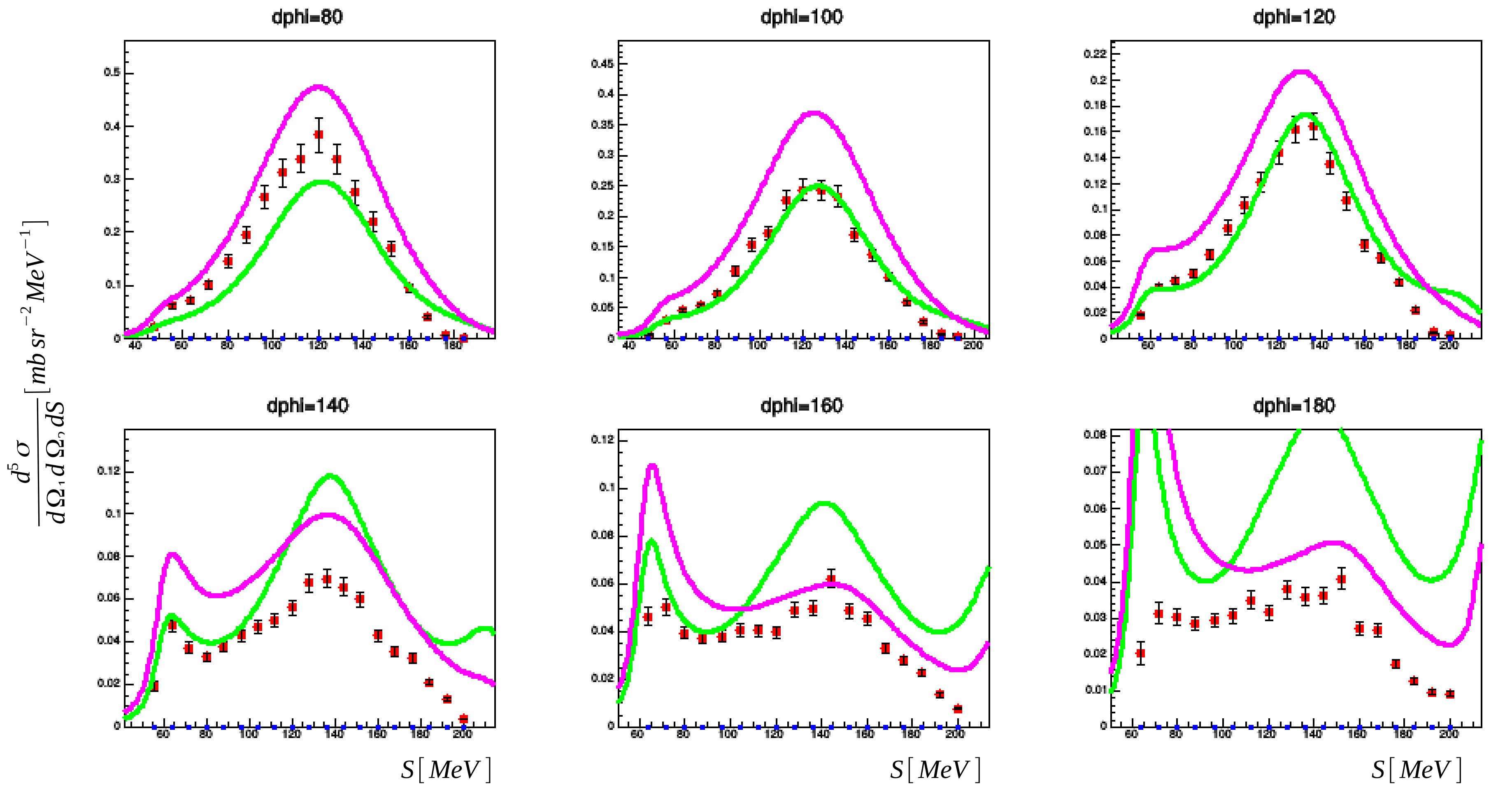
Results: dp→(pn)p

Differential cross-section for configuration of $Th_{proton}=23°$ $Th_{neutron}=23°$



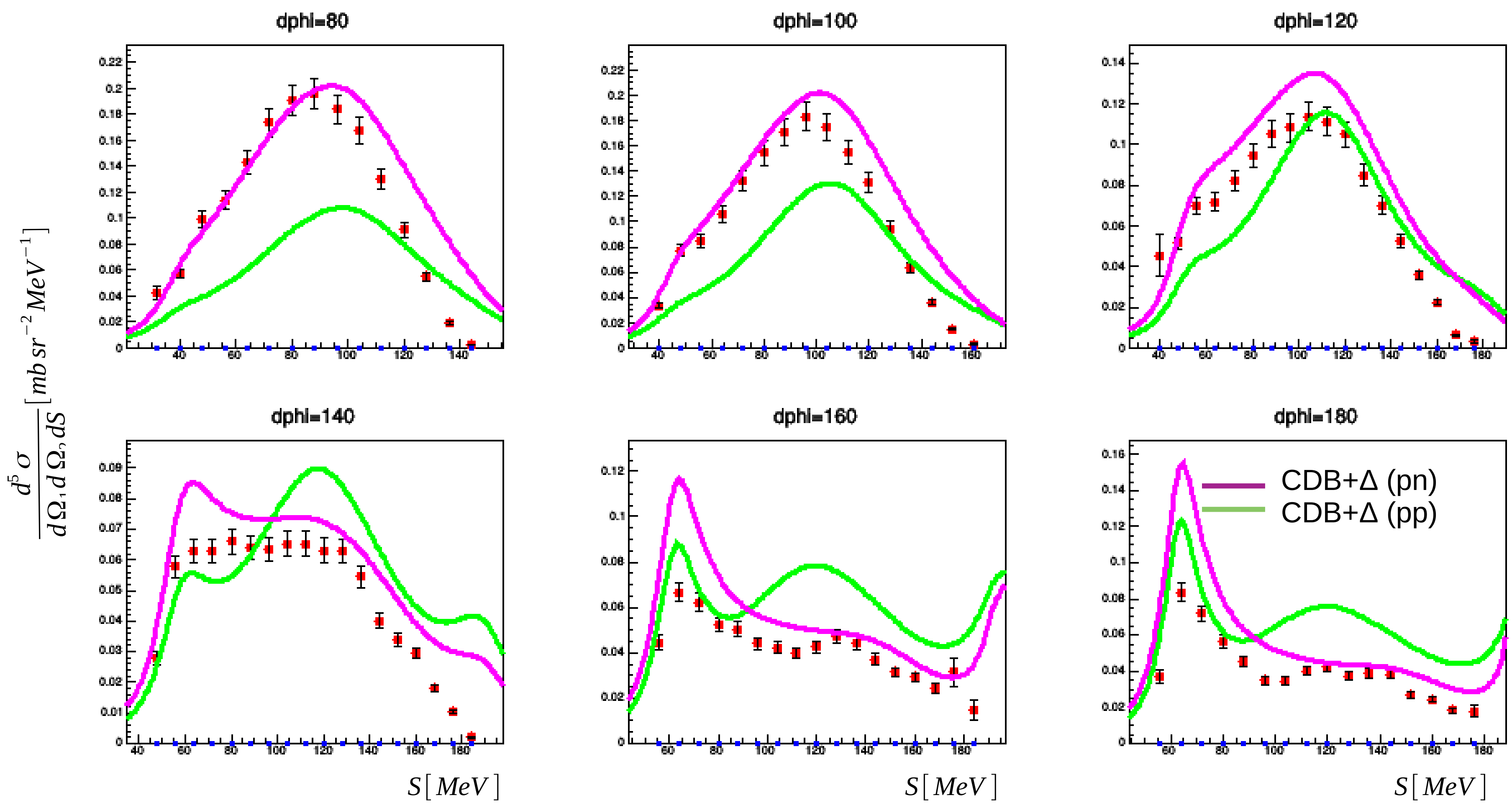
Results: dp→(pn)p

Differential cross-section for configuration of Th_{proton}=19° $Th_{neutron}$=19°



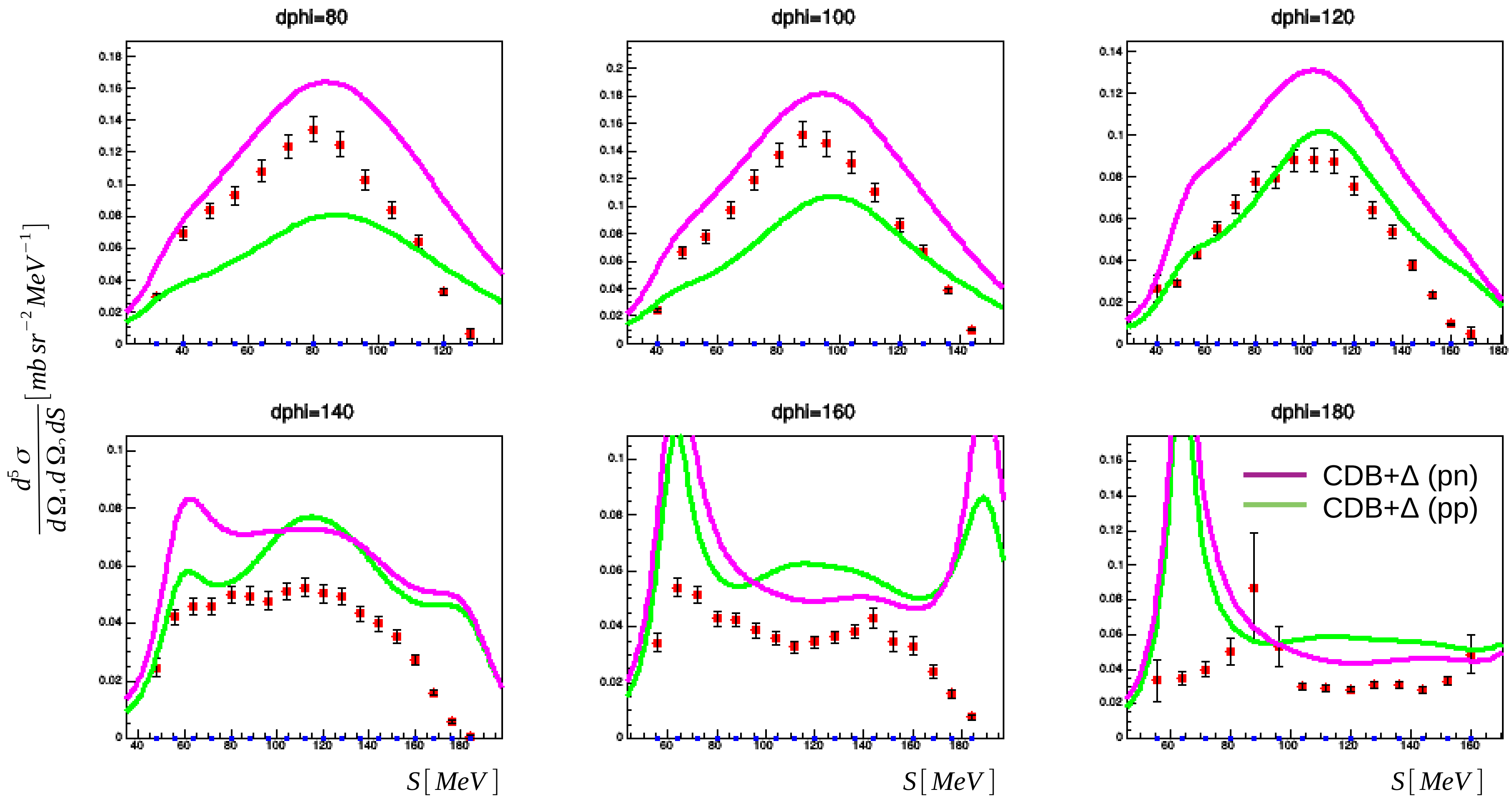
Results: dp→(pn)p

Differential cross-section for configuration of Th_{proton}=27° $Th_{neutron}$=21°



Results: dp→(pn)p

Differential cross-section for configuration of Th_{proton}=27° $Th_{neutron}$=25°

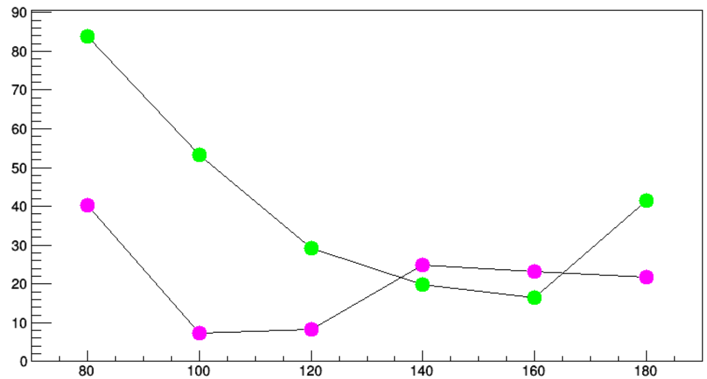


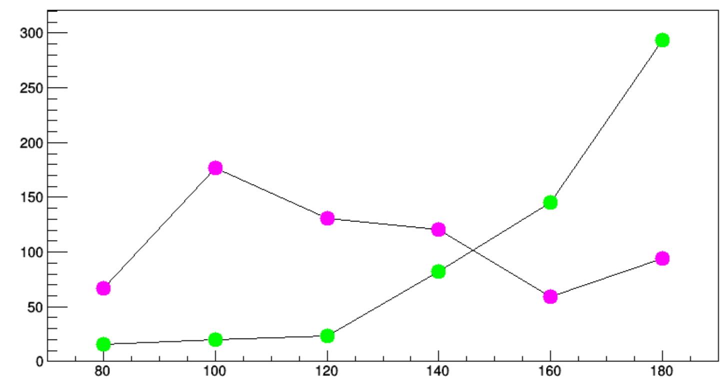
Comparison with theory: chi-squared test

Th_{proton}=23° $Th_{neutron}$=23°

Th_{proton}=19° $Th_{neutron}$=19°

chi2/d.o.f





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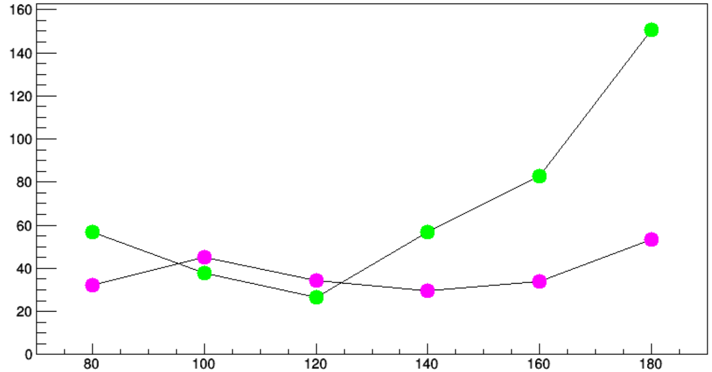

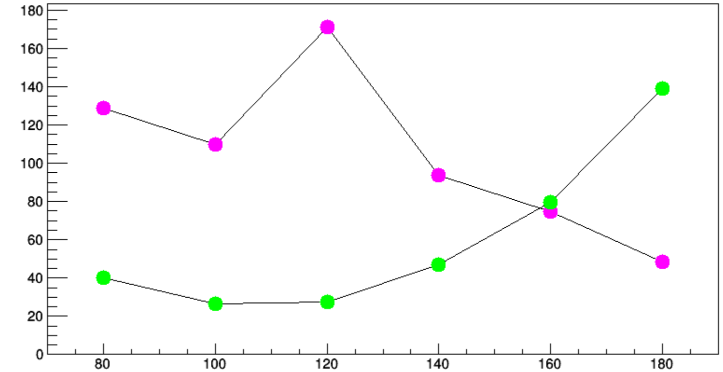

$\Delta\varphi_{12}$ [°]

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Comparision with theory

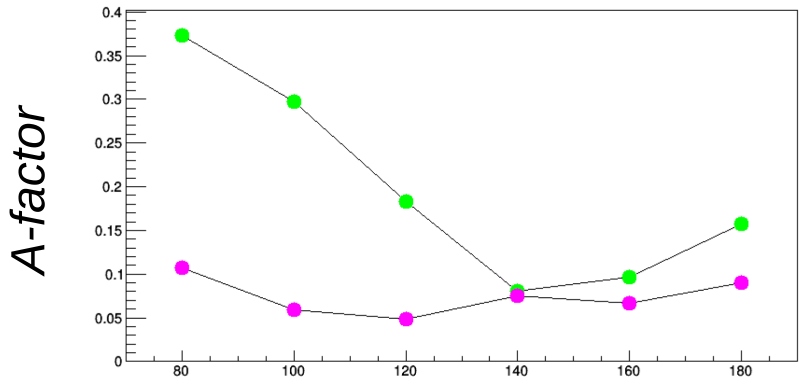
- The quality of the agreement was studied with A-deviation factor:

$$A = \frac{1}{N} \sum_{i=1}^{N} \frac{\left|\sigma_i^{\exp} - \sigma_i^{theory}\right|}{\sigma_i^{\exp} + \sigma_i^{theory}}$$

- *A* belongs to [0,1]
- Good for larger discrepancies

Comparison with theory

Th$_{proton}$=23° Th$_{neutron}$=23°



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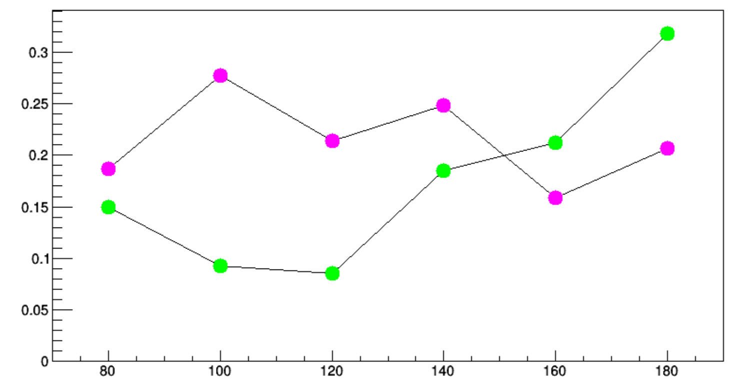

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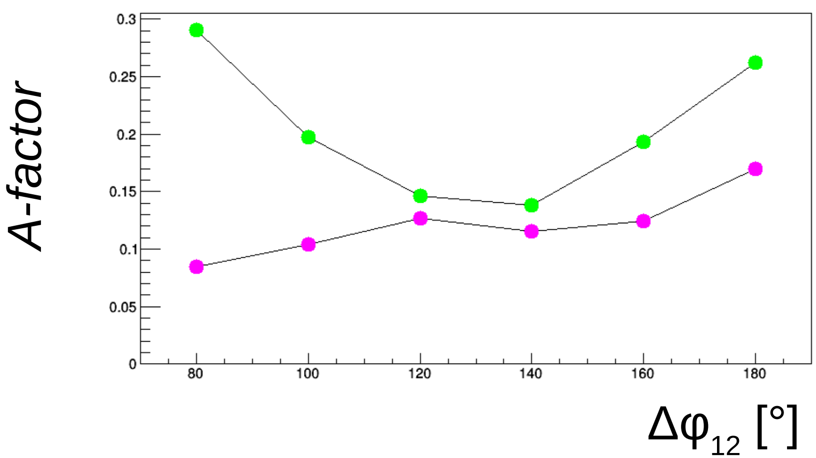

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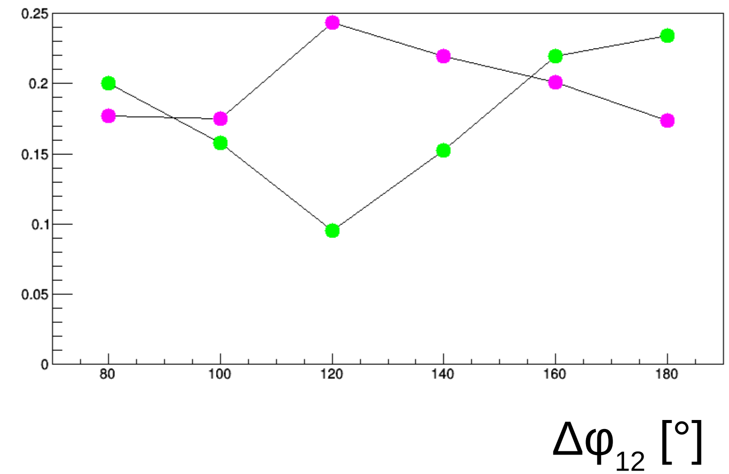

Summary

- The neutron detection methods in BINA experiment are developed
- First results of dp→(pn)p cross-section
- NOW: Systematic erros studies
- The dd→(dn)p reaction analysis is still in progress