GP-PU Progress Report

Study of three-nucleon force effects in p–^{3}He elastic scattering

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Exotic Nuclear Physics Gr. D2
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Outline

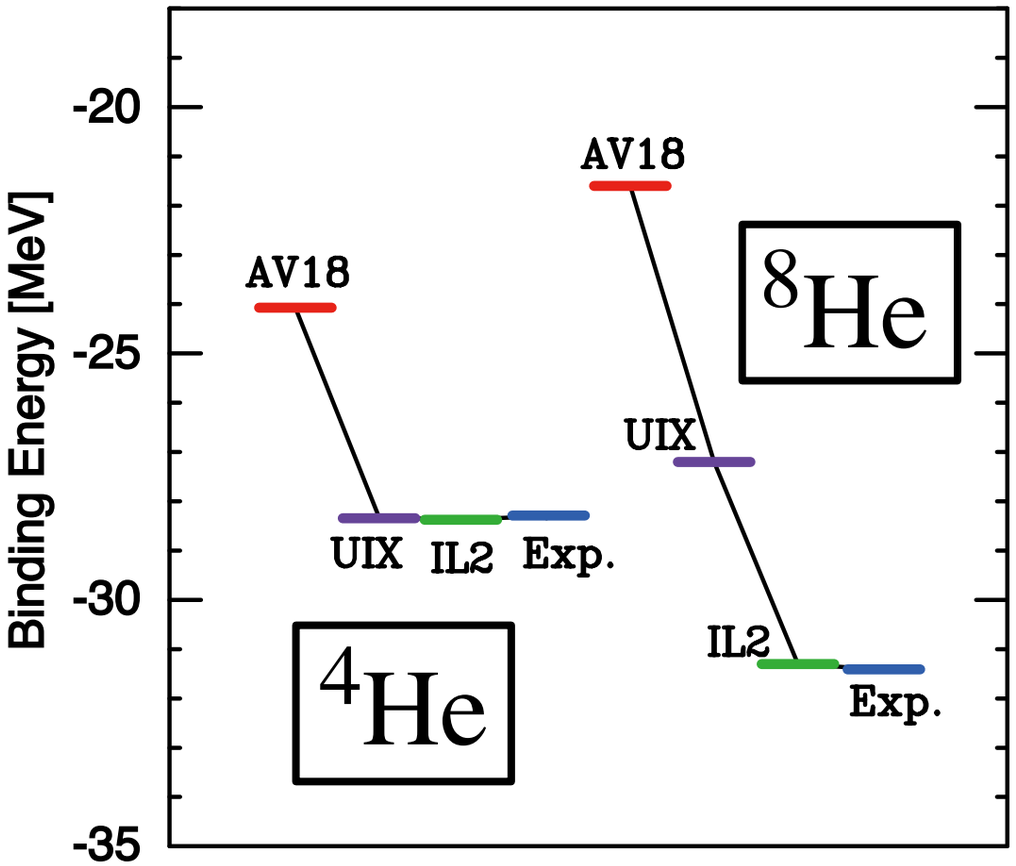
1. Overview of research
2. Experiment @ RCNP
    1. Dec. 17 RCNP pol.p + ^{3}He (E_p = 65 Me V)
    2. Nov. 18 RCNP pol.p + pol.^{3}He (E_p = 100 MeV)
3. Program status & Next plan

Overview of research

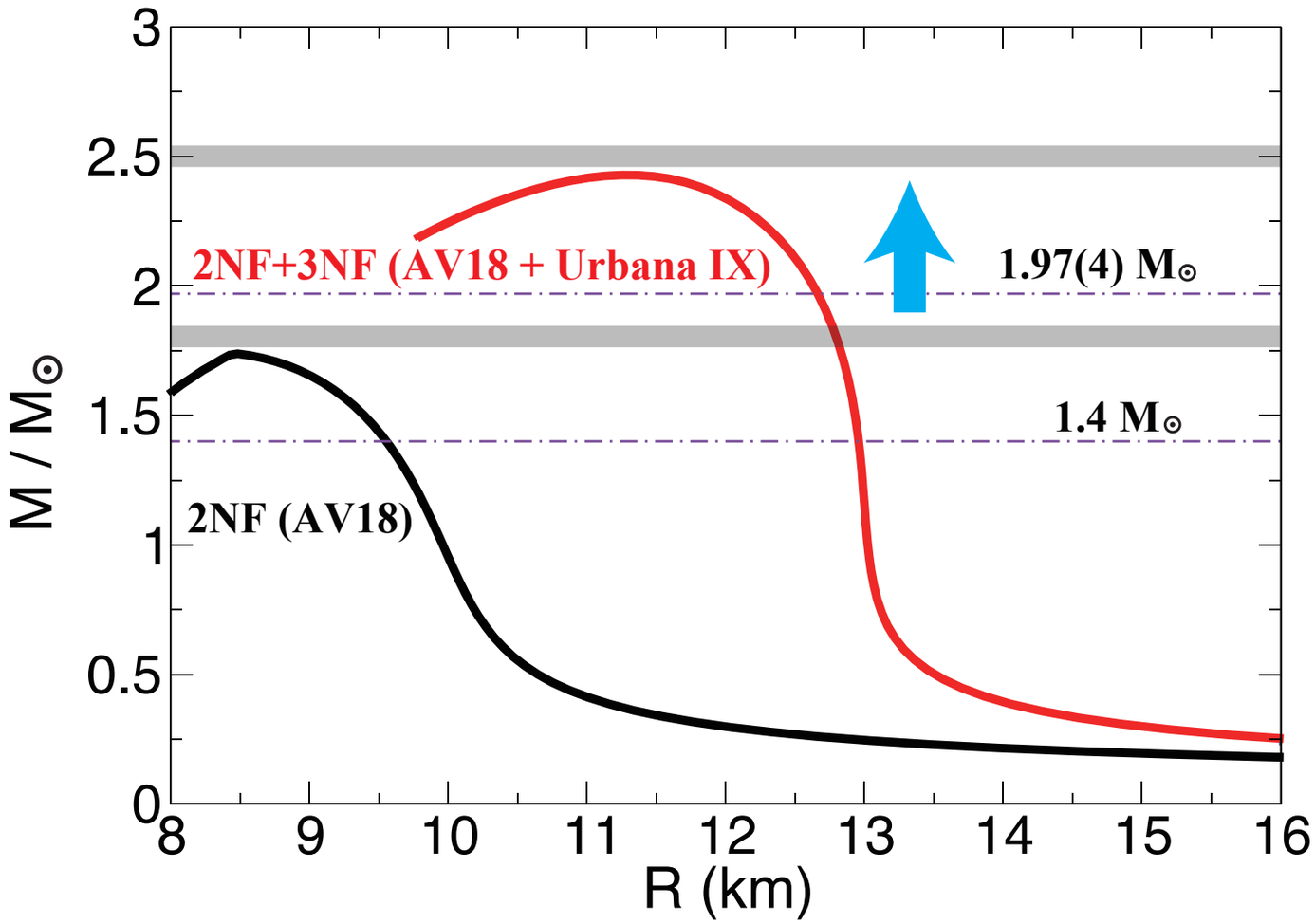
3-Nucleon Forces (3NF)

Important Roles to Fully Understand Properties of Nucleus.

Ex.) Binding Energy of Light Nuclei, Equation of State of a Neutron Star



S. C. Pieper et al. PRC 64, 014001 (2001)



A. Akmal et al. PRC 58, 1804 (1998)

Overview of research

Few Nucleon Scattering

Good Probe to Study the Dynamical Aspects of 3NFs.

- Momentum Dependence
- Spin, Iso-Spin Dependence

Direct comparison

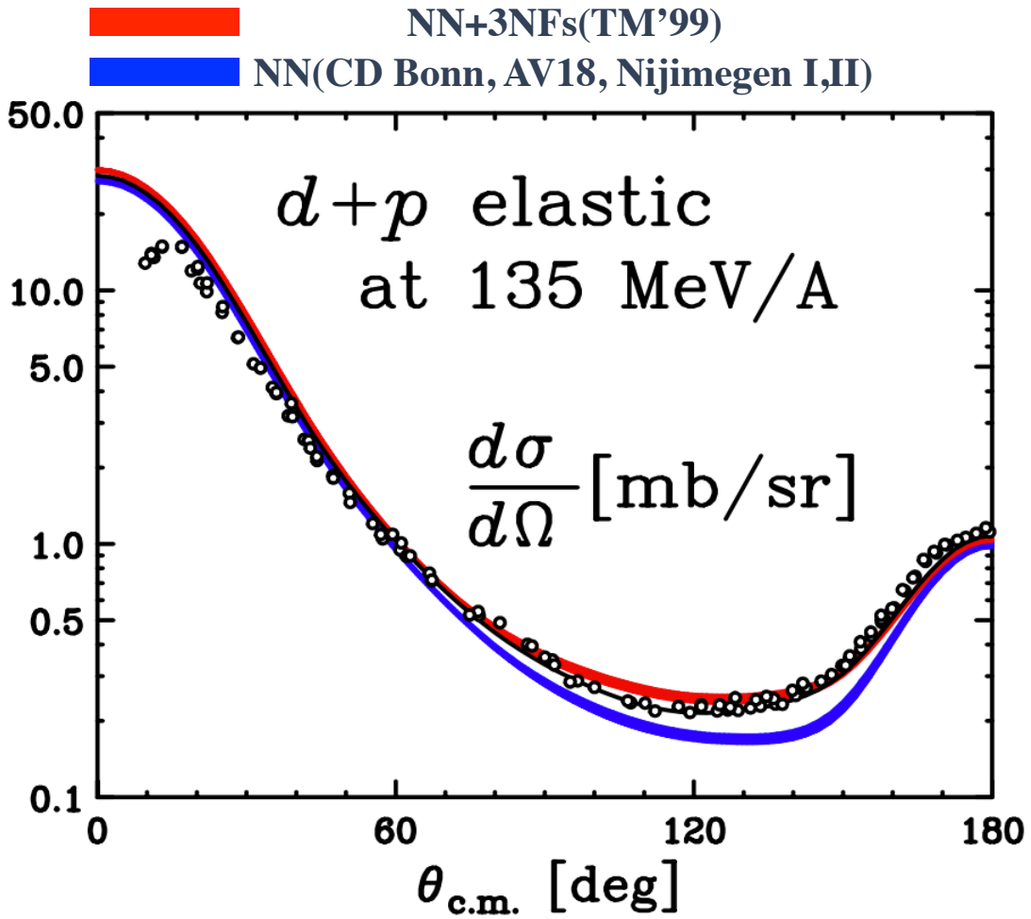
Theory : Rigorous Calculations

- Faddeev Calculations of 3,4-N System

Experiment : Precise Data

- Observables ($d\sigma/d\Omega$, A_y , C_y)

Obtain the Fundamental Informations of 3NF



Kimiko Sekiguchi et al. PRC 65,034003

Overview of research

p-^{3}He Scattering System

- 3NF effects in 4N system
- the 3NF with Isospin *T*=3/2 channel

3NF Effects

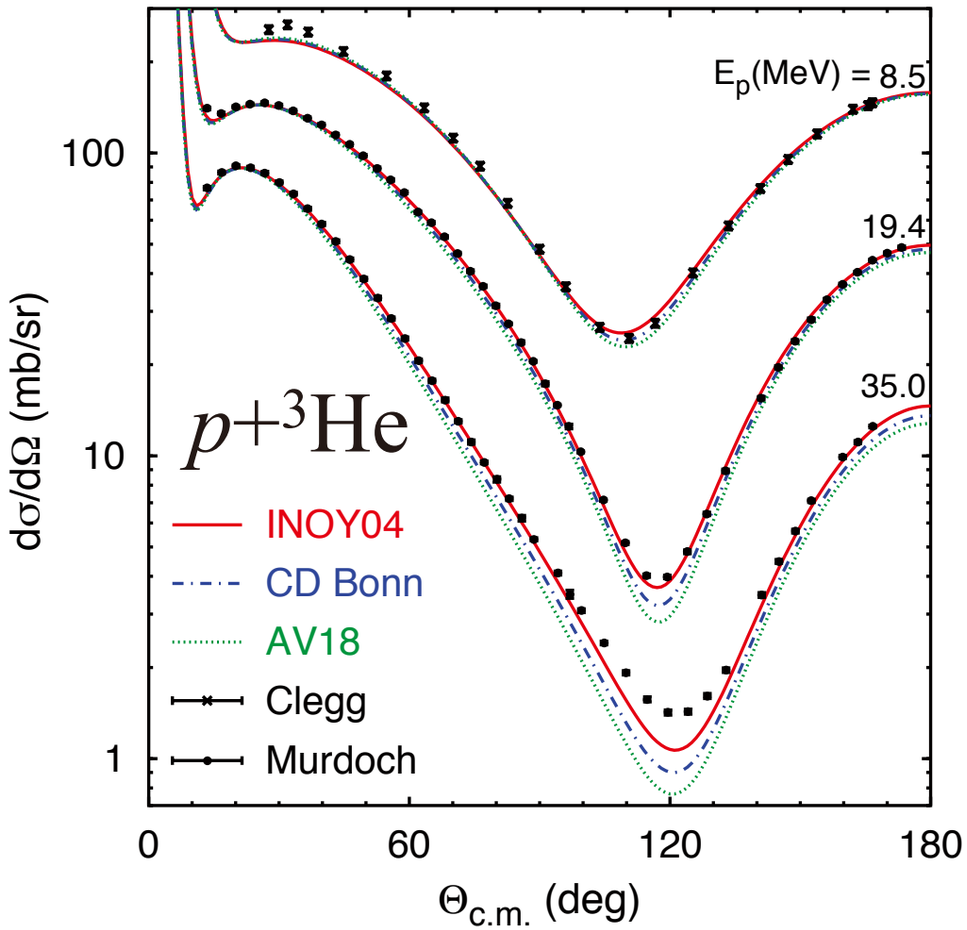
Following the results of the *d-p* system

- 3NF effects are expected in the cross section minimum at intermediate energies (E > 60 MeV).

Theoretical Progress

Theoretical calculations are available

- Above 4-Body break up threshold energy.



A. Deltuva et al. PRC 87,054002

It is interesting to study 3NF in *p*-^{3}He system at intermediate energies.

Overview of research

Experiment

- Measurement *p*-^{3}He Elastic Scattering using polarized proton beams and polarized ^{3}He target.
- Precise Data Covering Wide Angler Range

3NF effects can be seen in the cross section minimum.

- We measured the observables for *p*—^{3}He elastic scattering

<u>Dec. 2017 RCNP(Ep = 65 MeV)</u>

: differential cross section $(d\sigma/d\Omega)$, Analyzing power $(A_y(p))$

<u>Nov. 2018 RCNP(Ep = 65, 100 MeV)</u>

: $A_y(p)$, $A_y(^3\mathrm{He})$ & Spin correlation coefficient (C_{yy})

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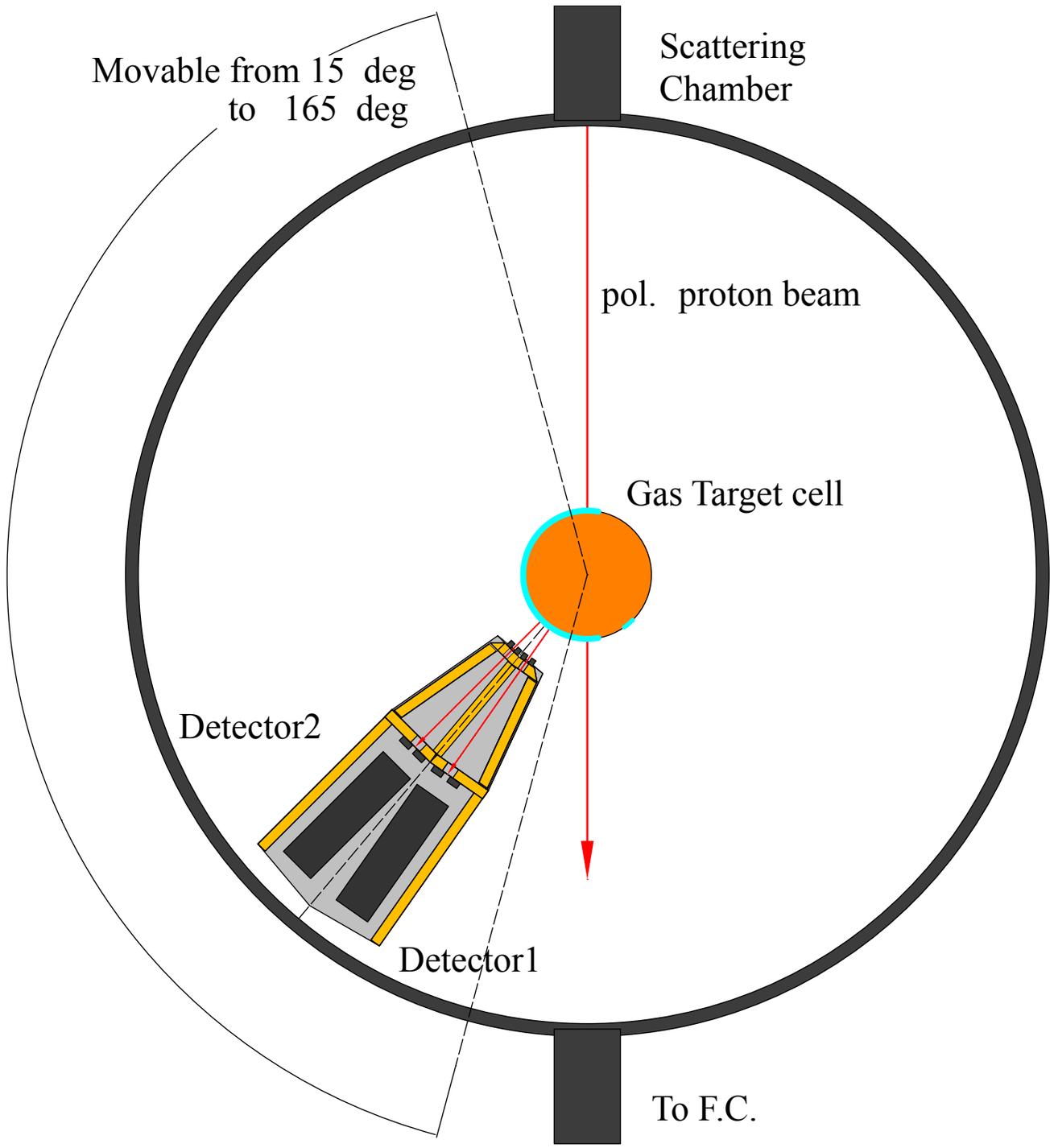
Experiment

Outline of Experiment (Dec17RCNP)

(Ep = 65 MeV) : $d\sigma/d\Omega$, A_y

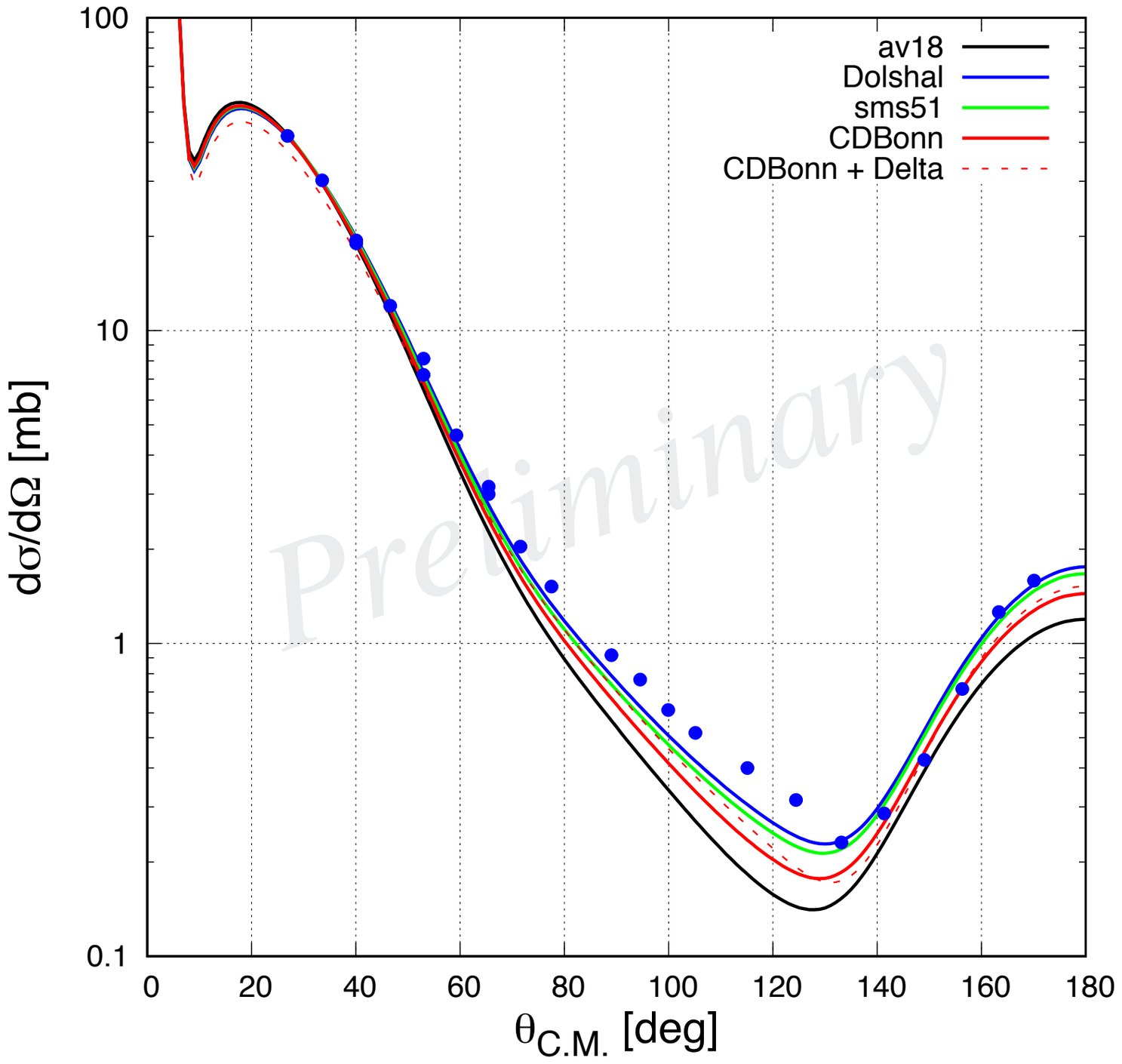
- Two pairs of ΔE-E detectors were set 10 deg apart
- The effective target thickness was determined by using the Double-Slit system
- Measured angles :
  $\theta_{lab.}$ = 20°~165°
  $\theta_{C.M.}$=26.9–170.1



Results

Differential Cross Section

- Statistical errors are only shown
- The data have moderate agreement to the theoretical calculations
- The data are larger than each theoretical calculations at cross section minimum.



Results

Proton Analyzing Power

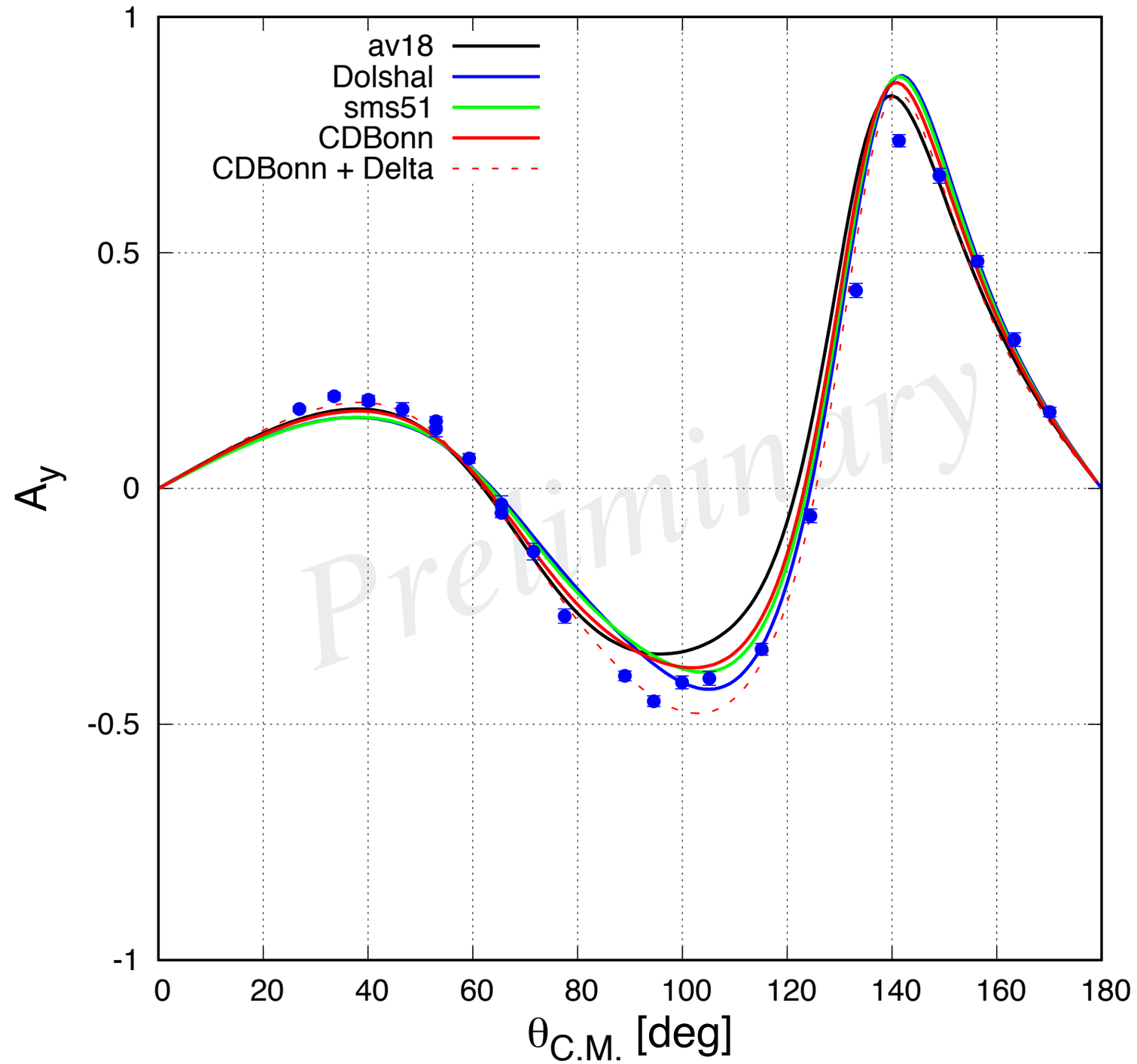
- The proton analyzing power is expressed by

$$A_y^p = \frac{N^u - N^d}{p_y^d N^u + p_y^u N^d}$$

$N^{u,d}$: Number of events

$p^{u,d}$: beam polarization

- Statistical errors are only shown
- Small but clear discrepancy between the data and the calculations can be seen at the angle where analyzing power takes maximal and minimal value



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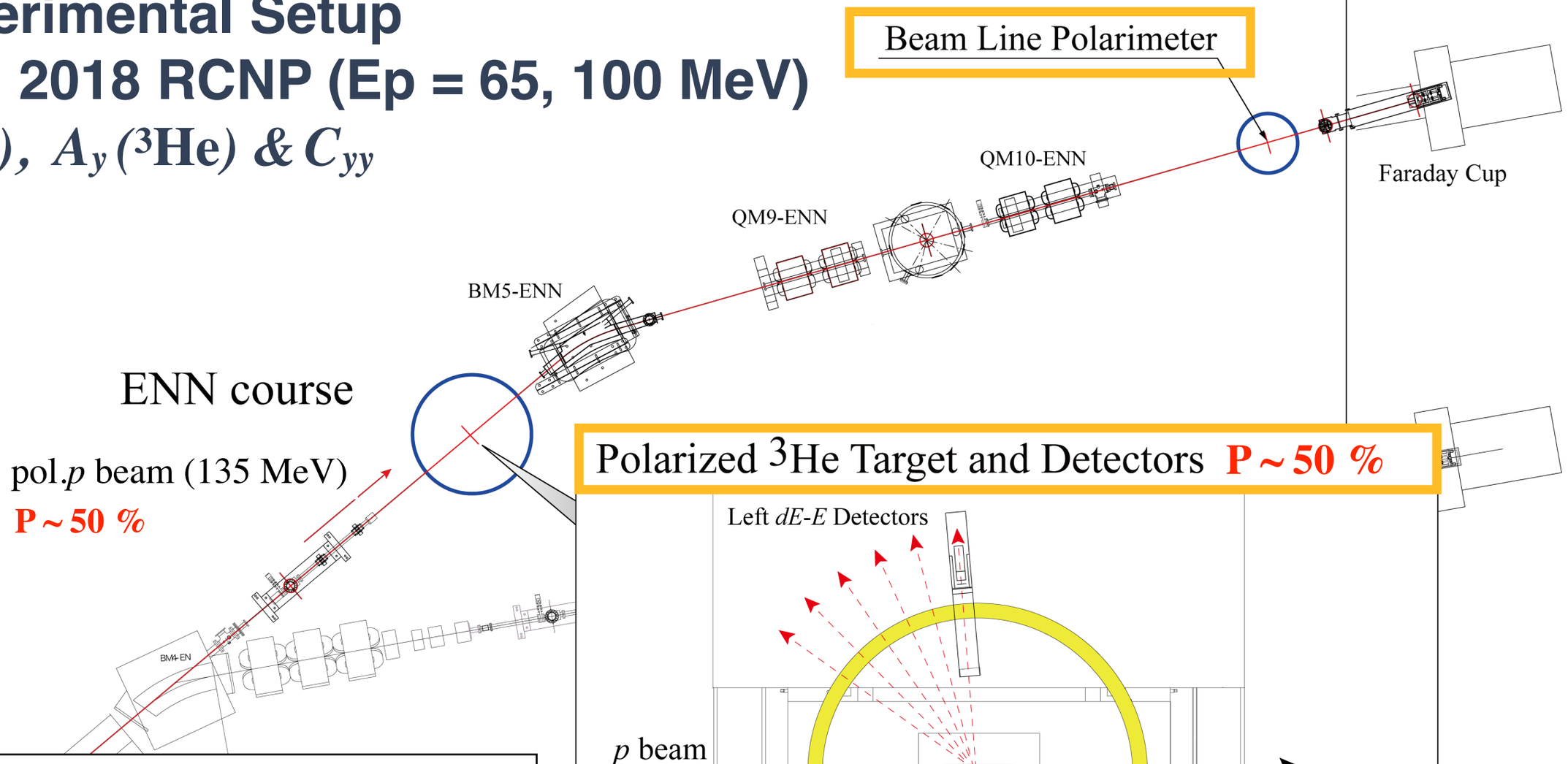
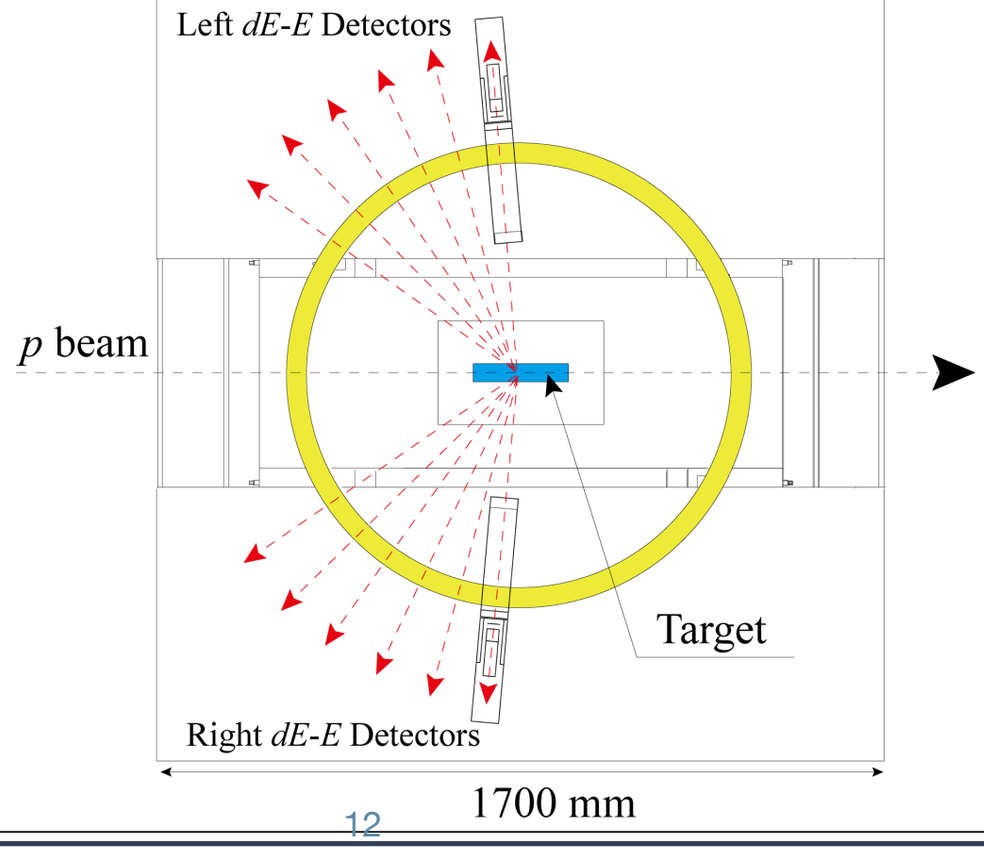
Experiment

Experimental Setup
Nov. 2018 RCNP (Ep = 65, 100 MeV)
$A_y(p)$, $A_y(^3\mathrm{He})$ & C_{yy}



Polarized ^{3}He Target and Detectors **P ~ 50 %**



- Detectors
  - *dE* : Plastic Scintillator (0.5 mm^t)
  - *E* : NaI(Tl) (55 mm^t)
  - 2 sets × 5 angles = 10 sets
- Measured Angles
  - $\theta_{c.m.}$ = 47° — 156°
  - (θ_{lab} = 35° — 145°)

Experiment

Experimental Setup
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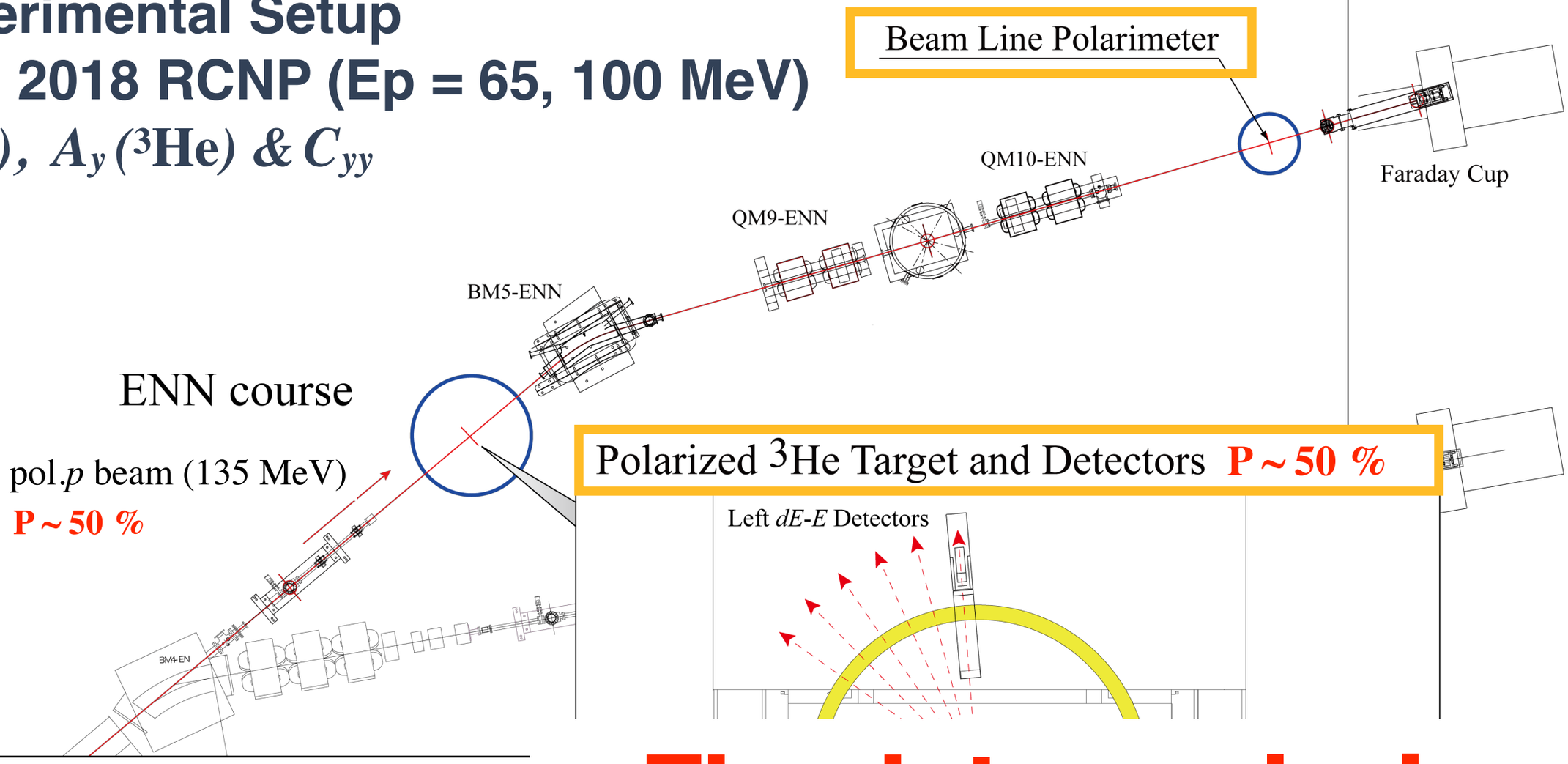
$A_y(p)$, $A_y(^3\mathrm{He})$ & C_{yy}



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The data analysis is in progress now!!

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Academic activities

International Conferences (Oral presentation)

- The 22nd International Conference on Few-Body Problems in Physics (FB22 Caen, France)

- 5th Joint Meeting of the Nuclear Physics Divisions of the APS and JPS (Hawaii18 Hawaii, USA)

The plan of next term

Polarization measurement of polarized ^{3}He target by using thermal neutron (July 2019)

We are planning the more accurate measurement of the polarization of polarized ^{3}He target.

This experiment has be performed at RIKEN.

Oversea visiting

I'd like to join the experiment at some accelerator facilities (plans are below)

- Jefferson Lab. : experiment using polarized ^{3}He target.

- Poland : Few-nucleon scattering (p—d break up channel)

- TRIUMF : experiment by using the newly installed UCN source.

I also attend the European Few-Body conference at Sep. 2019 (Guilford, UK)