Progress Report: Optimization of dpol_breakup Experiment Configuration

Simulation Framework and Configuration Study

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December 1, 2025

Outline

Input Momentum Analysis (QMD Model)

- **Objective**: Analyze the momentum distribution of breakup products to guide detector configuration.
- **Data Source**: QMD simulation data for ^{208}Pb target.
- **Methodology**:
  - Analyzed Proton and Neutron momentum in Y-polarization and Z-polarization modes.
  - Used Python/ROOT notebook (`zpol_ypol_show_approx_P.ipynb`) for visualization.
  - Focused on P_z vs $P_\perp$ distributions.

Observed Statistics (from Log)

- **Proton** P_z: Mean ≈ 600 MeV/c (Y-pol), ≈ 635 MeV/c (Z-pol).
- **Neutron** P_z: Mean ≈ 612 MeV/c.
- $P_\perp$: Typically $50 - 90$ MeV/c.

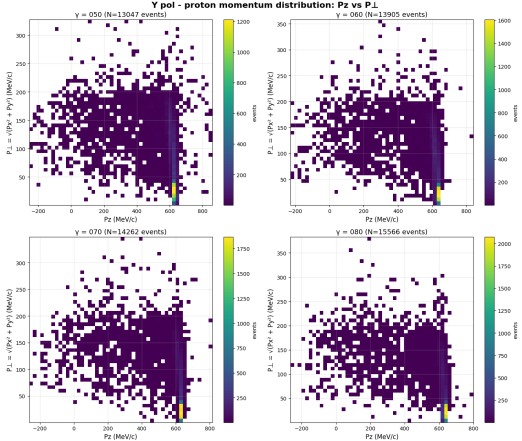
Reference Kinematics

To optimize the detector coverage, we select the following reference momentum for protons:

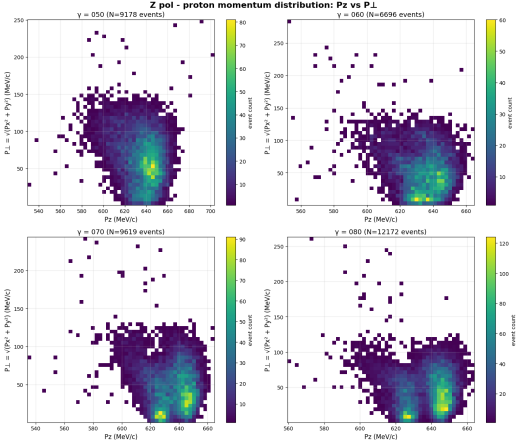
- $P_z = 600$ **MeV/c**
- $P_x = \pm 100$ **MeV/c**

Proton Momentum Distributions

Y-Polarization



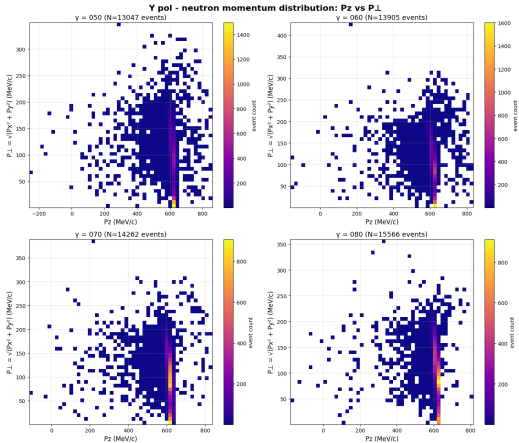
Z-Polarization



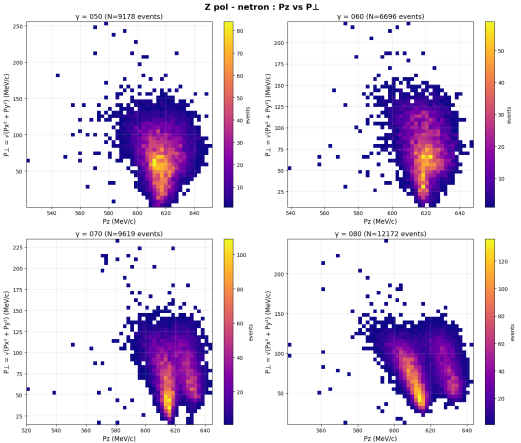
Proton P_z vs $P_\perp$ distributions showing the region of interest around $P_z \approx 600$ MeV/c.

Neutron Momentum Distributions

Y-Polarization



Z-Polarization



Neutron distributions show similar P_z trends.

Simulation Framework: geo_acceptance Library

A C++ library was developed to simulate particle trajectories and evaluate acceptance.

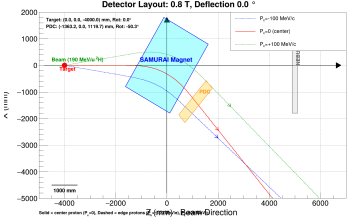
Library Structure

- `BeamDeflectionCalculator`:
  - Computes particle trajectories in the magnetic field using Runge-Kutta integration.
  - Supports SAMURAI field maps (0.8T, 1.0T, 1.2T, 1.4T).
- `DetectorAcceptanceCalculator`:
  - Manages detector geometries (e.g., PDC).
  - Determines if trajectories intersect with active areas.
- `GeoAcceptanceManager`:
  - Orchestrates the data flow from input generation to acceptance analysis.

Optimization Strategy

1. **Trajectory Calculation**:
   - Trace protons with reference momentum ($P_z = 600, P_x = \pm 100$ MeV/c) through the magnetic field.
   - Identify the central, left, and right boundary trajectories.
2. **PDC Positioning**:
   - Determine the optimal center position for the Plastic Detector Counter (PDC) to cover the reference trajectories.
3. **Acceptance Verification**:
   - Run `qmdrawdata` with Z-axis randomization.
   - Inject data into the simulation to calculate the geometric acceptance ratio.

Configuration Study: 0.80 T



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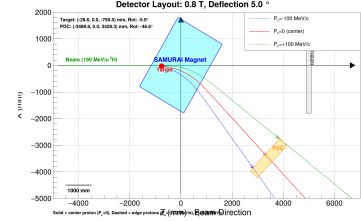

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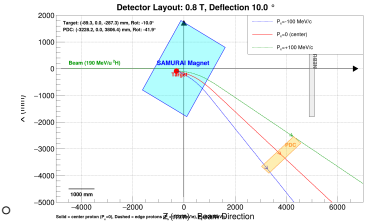

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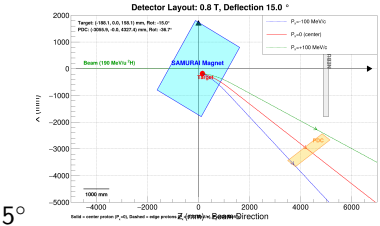

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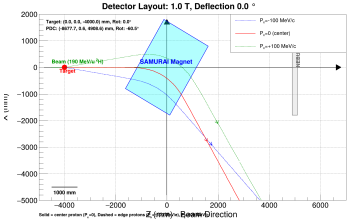
Configuration Study: 1.00 T



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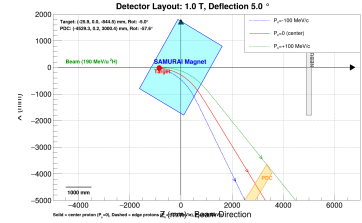

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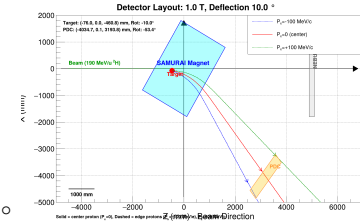

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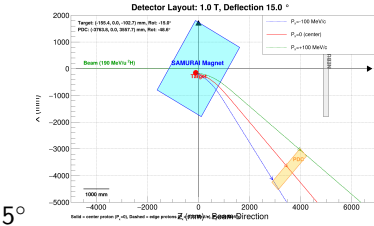

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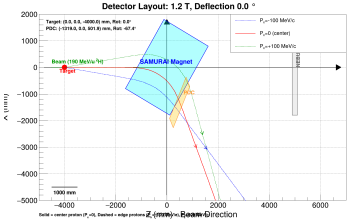
Configuration Study: 1.20 T



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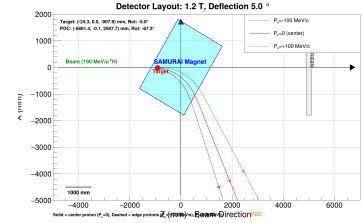

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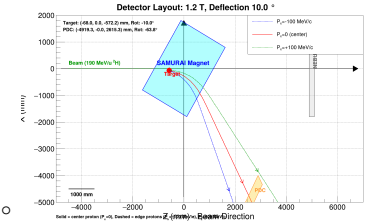

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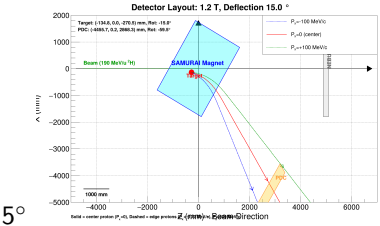

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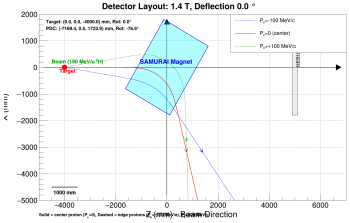
Configuration Study: 1.40 T



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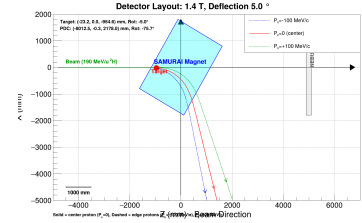

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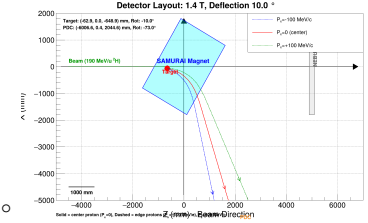

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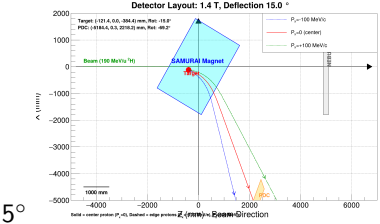

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Geometric Acceptance Summary

Field (T)	Angle (°)	PDC Acc. (%)	NEBULA Acc. (%)	Coincidence (%)
0.8	0	36.13	68.96	35.26
0.8	5	34.06	86.41	34.03
0.8	10	35.12	72.29	32.69
1.0	0	18.00	68.86	17.95
1.0	5	32.62	85.87	32.57
1.0	10	34.43	70.09	31.68
1.2	0	34.49	68.92	33.45
1.2	5	30.08	85.44	29.99
1.2	10	33.53	68.74	30.42
1.4	0	18.67	68.98	18.59
1.4	5	25.32	85.14	25.24
1.4	10	31.91	67.39	28.55

Table: Summary of geometric acceptance for different magnetic field configurations and deflection angles.

Summary and Future Work

- **Analysis**: Confirmed $P_z \approx 600$ MeV/c as the key kinematic region for protons.
- **Framework**: Implemented `geo_acceptance` library for reliable trajectory simulation.
- **Progress**: Optimization of PDC position based on magnetic deflection is underway.