What are nucleons and pions made of?

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What are nucleons and pions made of?

-Hadrons

-Parton Distribution Functions

-The Drell-Yan Process

-Amber Experiment

-Aim for this Internship

-Results and Data Analysis

-Types of Particles Detected

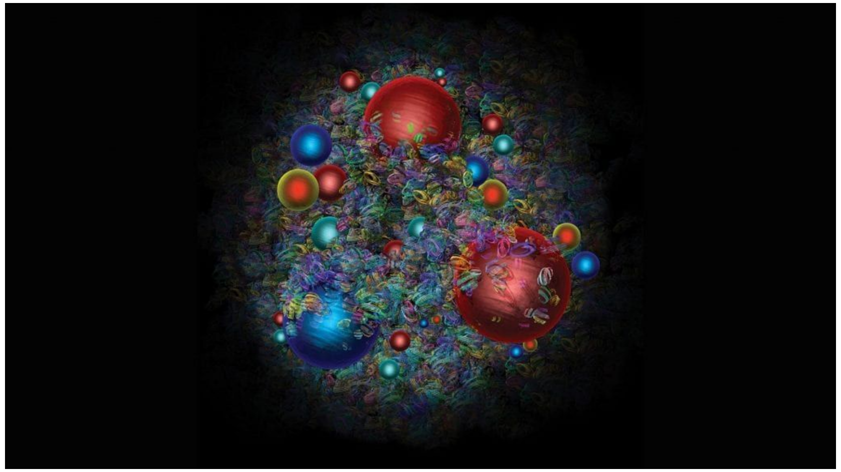
-Properties of the Particles

-Positions of the targets

-Resolutions and Geometric Acceptance Results

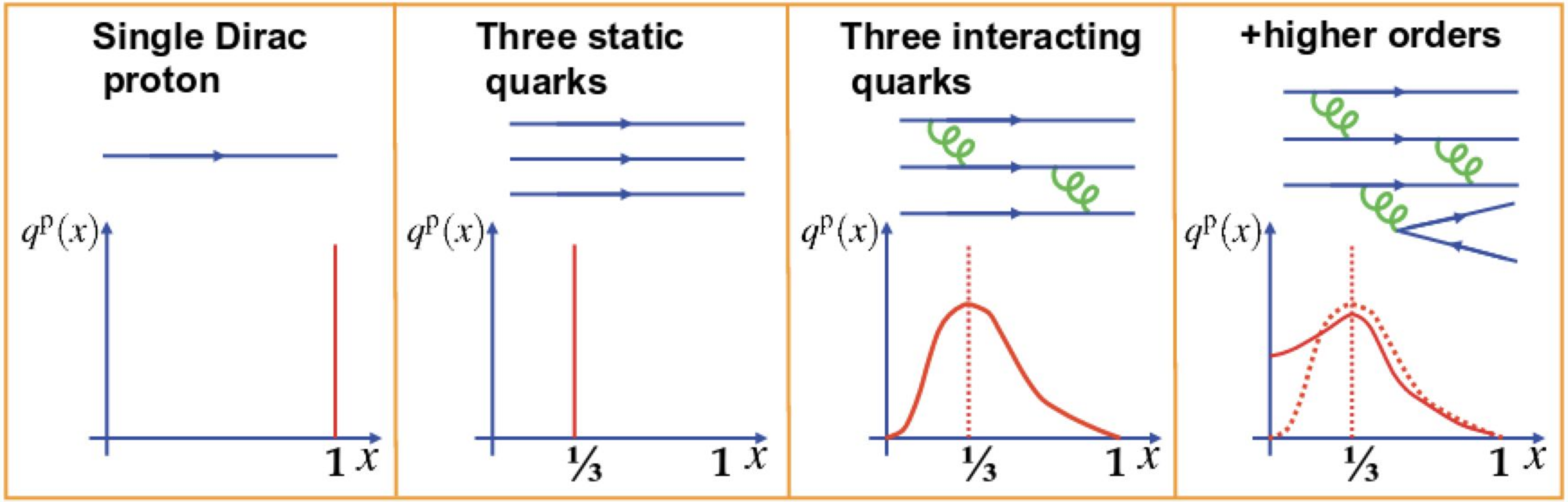
Hadrons

- Particles that are made out of quarks and gluons;
- Hadrons are made out of a lot of quarks and gluons, but that are a few types of quarks that exist in higher numbers called valence quarks;
- In various studies it is useful to know how the momentum of the Hadron is distributed between those quarks.



Parton Distribution Function (PDF)

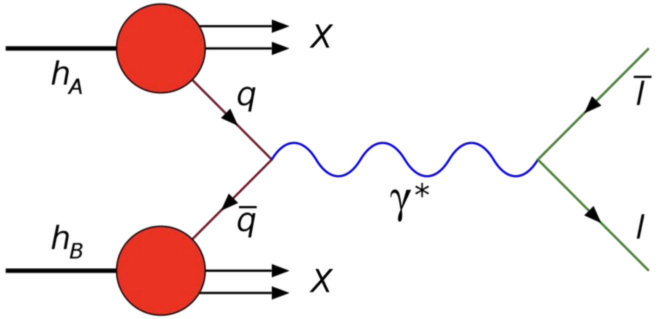
- This function gives us the probability density of a hadron with a certain relative momentum to the hadron;



Drell-Yan process

- In this process, a quark and an anti-quark from two distinct hadrons annihilate and a muon anti-muon pair is formed;

- The process' cross-section will give us information about the PDF's of both hadrons;

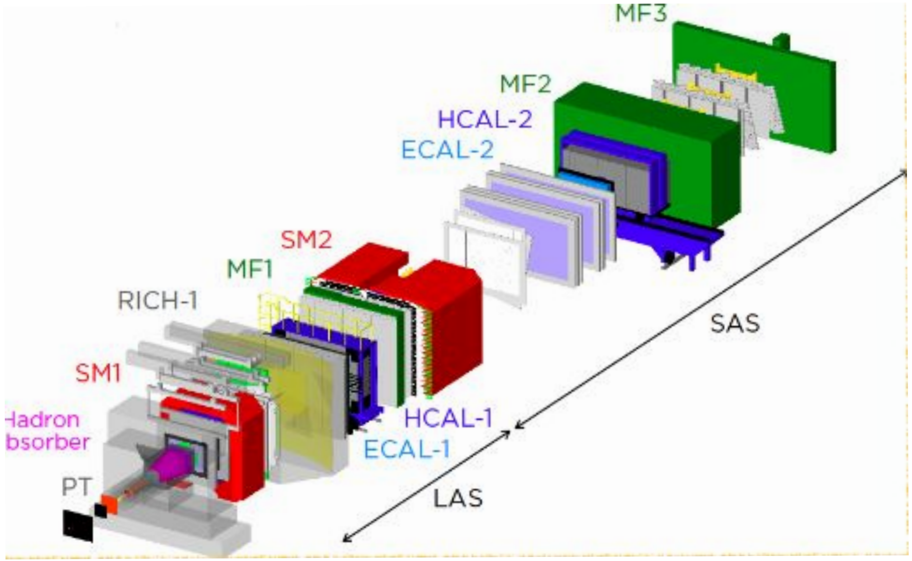


PDF PDF

$$\sigma^{DY} = \sum_{ab} \int dx_a \int dx_b \; f_a(x_a, Q^2) \; f_b(x_b, Q^2) \; \hat{\sigma}_{ab \to l\bar{l}}(x_a, x_b, \ldots)$$

AMBER experiment simulation

- A 190 GeV pion beam will collide with a thin (2cm) tungsten target and three longer (25cm each) carbon targets;
- This experiment is the successor to COMPASS and is expected to start the physics data taking in 2023.



Aim for this internship

- Complete Monte-Carlo simulation with a full description of the experimental setup and the reconstruction of the events:
    1. Calculate the geometrical acceptance of the experiment;
    2. Calculate the experimental resolutions, for:
        a. the vertex position along the beam line;
        b. the dimuon mass.

The geometrical acceptance represents the fraction of the generated events that fall in the acceptance of the detectors;

acc = rec/gen

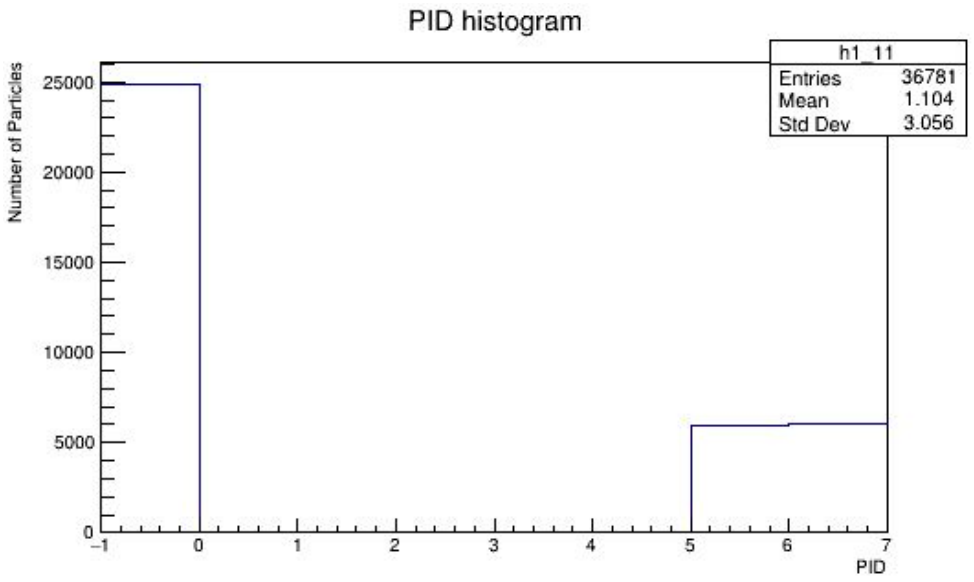
The experimental resolution represents the difference between the reconstructed and the generated event parameters.

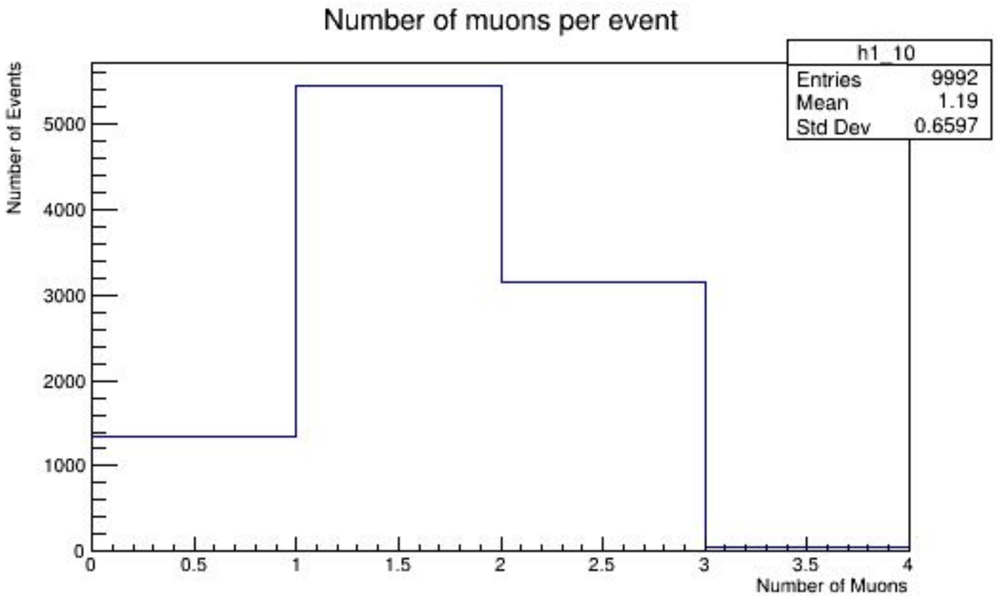
res = rec-gen

Results and Data Analysis
Types of particles detected

- Only events with at least 2 muons are filtered in, so we expect around 3000*2 in the muon tree;

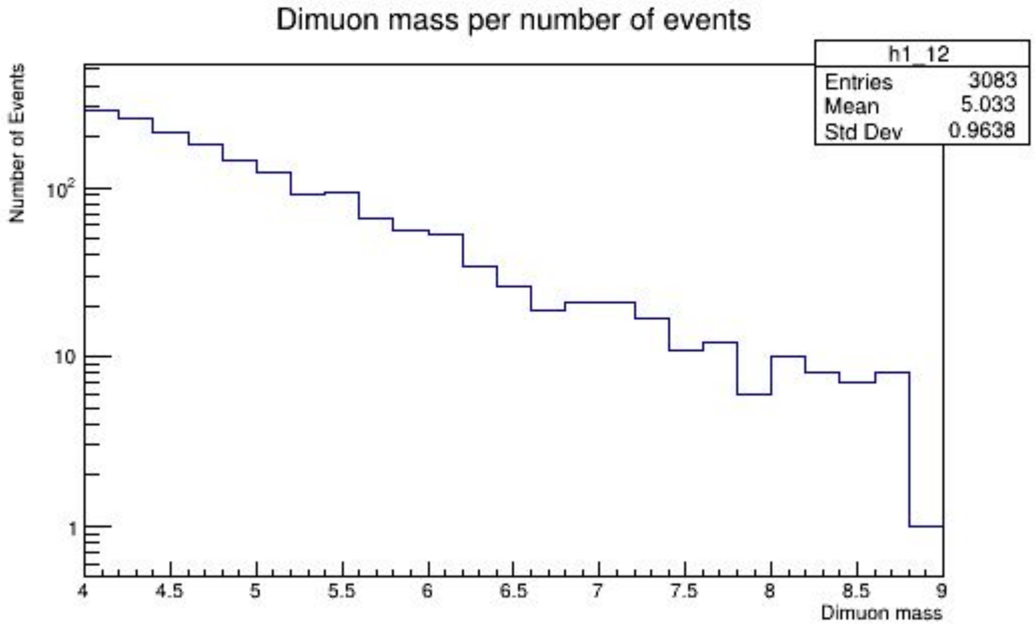
- As we can see in the histogram on the left, there are a lot of other particles that are filtered out.



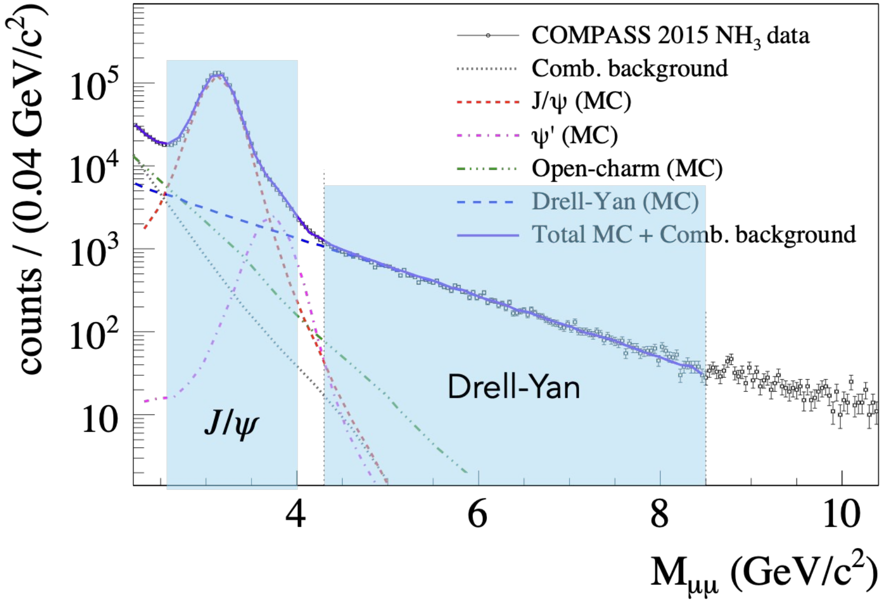


Results and Data Analysis
Properties of the particles

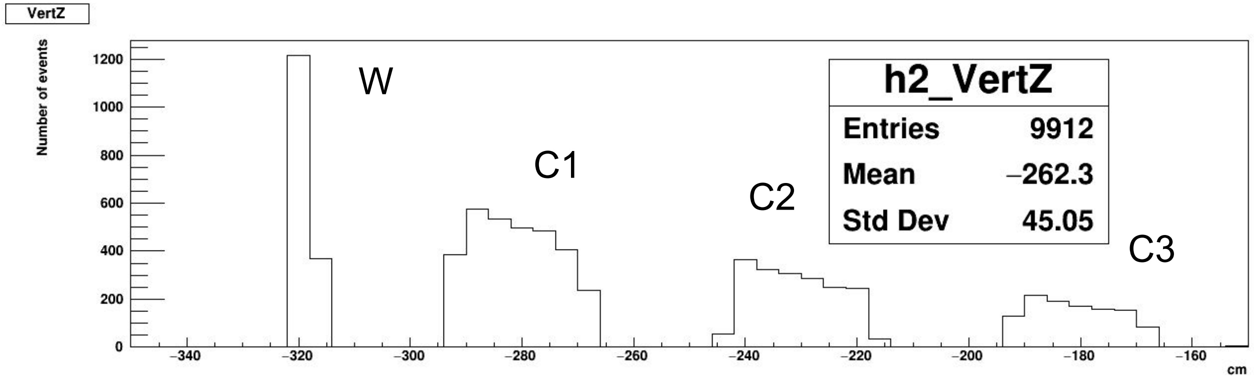
- As expected from observing the COMPASS experiment, the dimuon mass frequency decreases exponentially when we increase its value linearly.

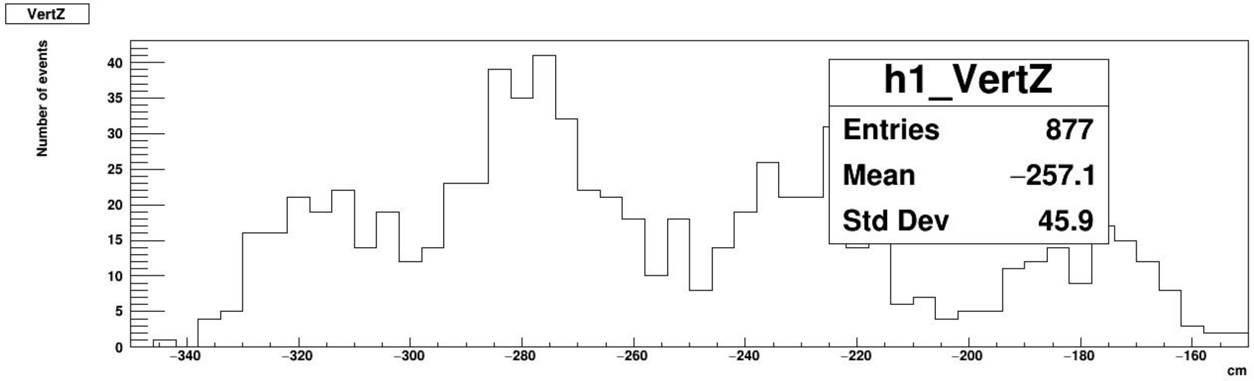


(GeV



Results and Data Analysis
Position of the targets



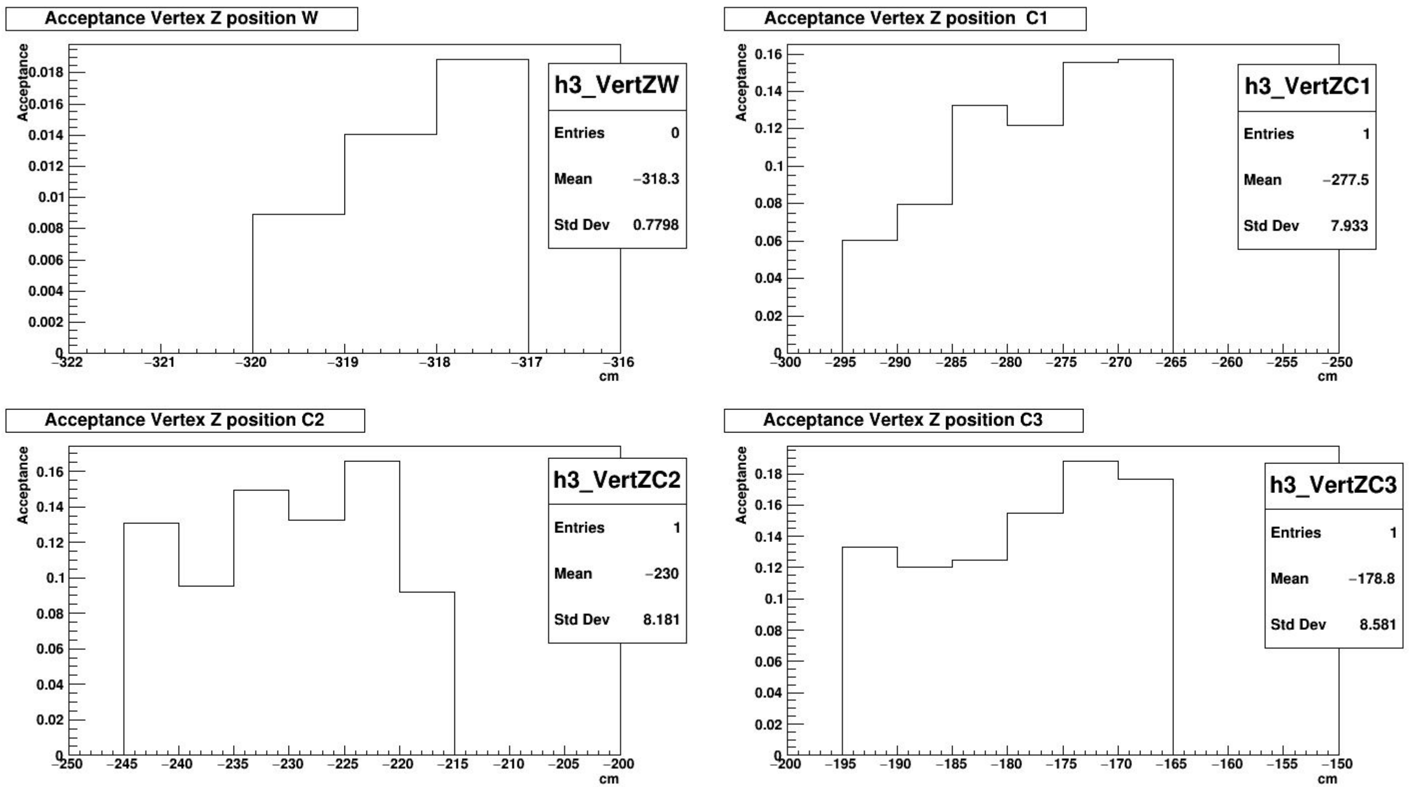


The different targets can be seen clearly in the upper histogram;

In the second histogram, we have a lot of smearing between the position of the different targets, that can be quantified as an experimental resolution.

Results and Data Analysis

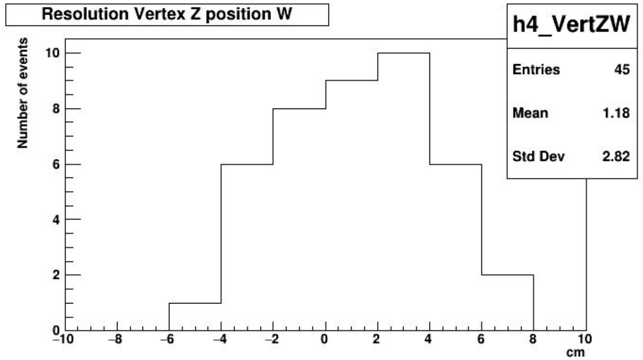
Resolutions and Geometric Acceptance Results

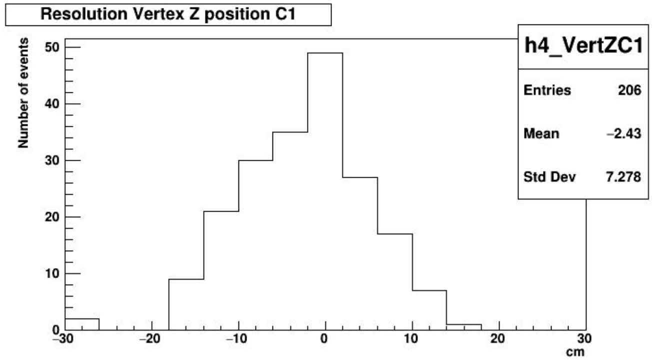


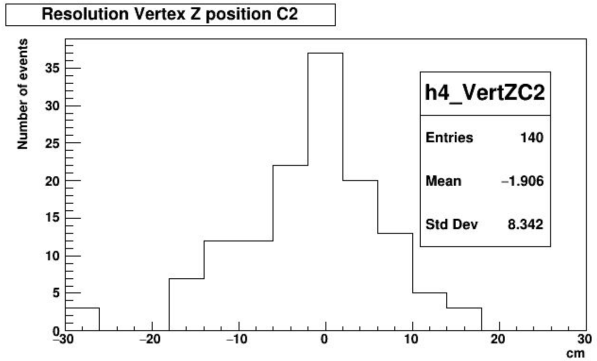
It's also observable that the acceptance increases as the target's position gets closer to the detectors.

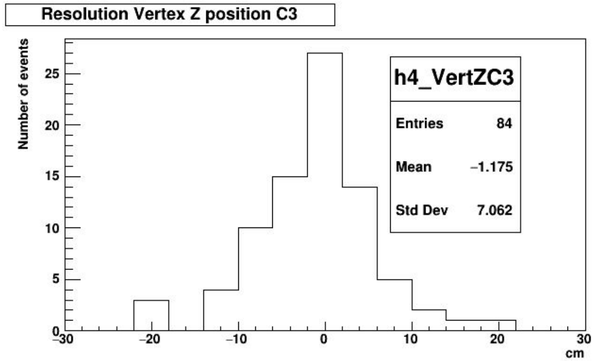
Results and Data Analysis

Resolutions and Geometric Acceptance Results









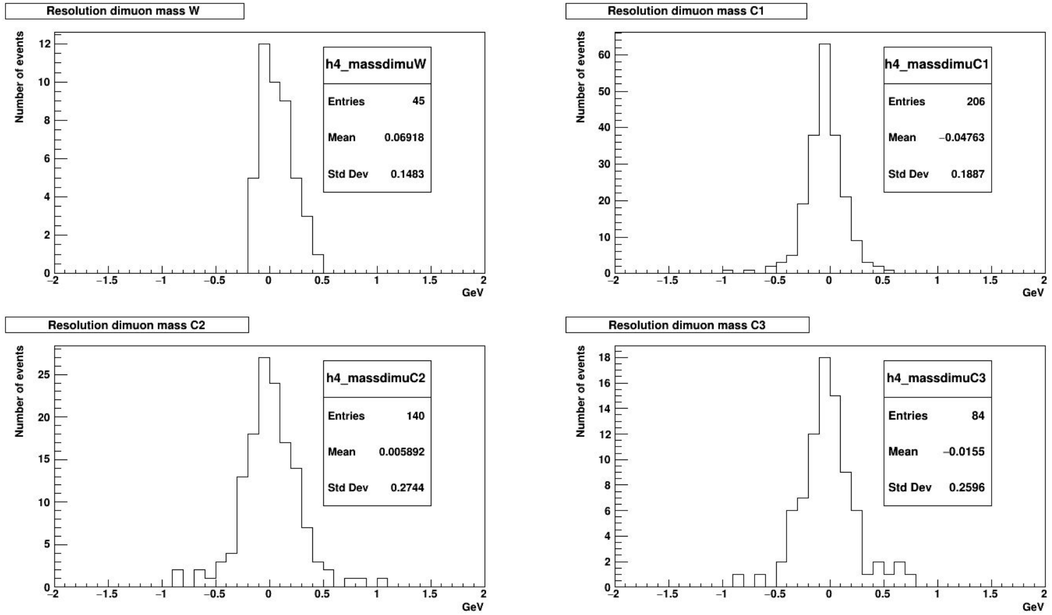
We expect a Gaussian centered around the origin. Due to the target's thickness, especially the carbon ones, the function that models the resolution of the Z vertex position will be a sum of Gaussian functions;

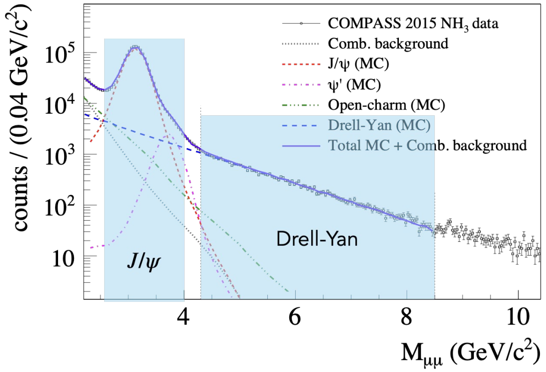
Our histograms have the rough outlines of a Gaussian function but because we have a low number of entries the shape will not have a perfect fit;

A better resolution meas a lower standard deviation value.

Results and Data Analysis

Resolutions and Geometric Acceptance Results





The mass resolution is modeled by a Gaussian function, centered around 0;

We expect that the resolution gets better when the targets are near the detectors. That can be observed between C2 and C3 but not between C1 and C2

Conclusions

- The closer the targets are to the detectors and among each other the better the acceptance. The longer the targets are the worse is the resolution but the higher is the statistics.

- So it is essential to balance between the position and the dimensions of the targets.

- The resolutions can be improved by including detectors in between the targets and the hadron absorber.

- The next steps in our study would be to increase the statistics to better evaluate the resolutions and after that to evaluate the impact in the reconstruction of the inclusion of the new detectors between the target and the absorber.