

Exploring Lambda SIDIS Production in Target and Current Fragmentation Regions

CNUGS Student Seminars

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Outline

Physics Motivation

- Hadronization in SIDIS
- Kinematic Variables
- Physics Observables

Previous Measurements

- HERMES Multiplicity Ratios
- CLAS6 Lambda Results

Experimental Setup

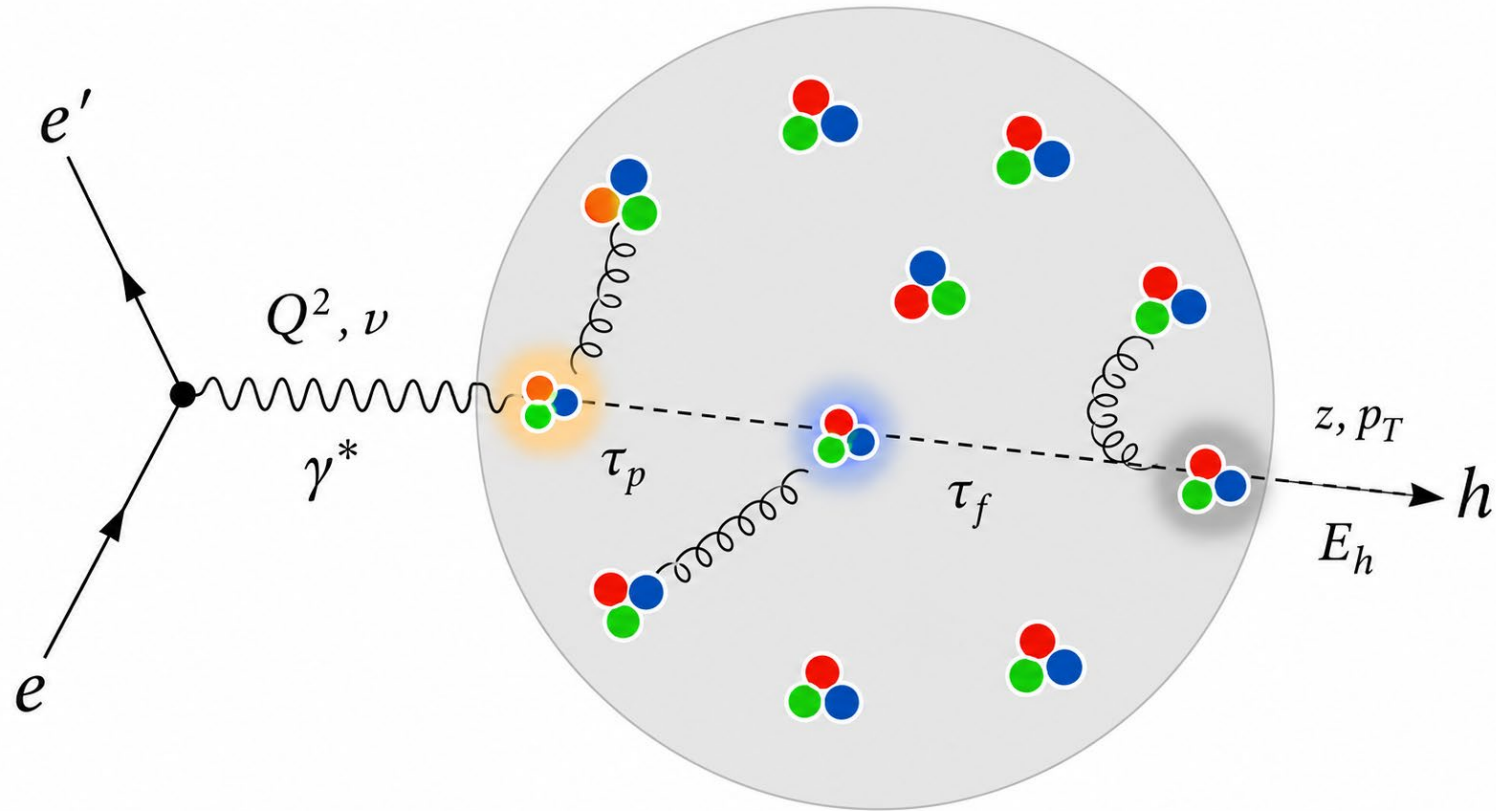
- RG-E Dual Target Setup
- CLAS12 Detector

Preliminary Analysis

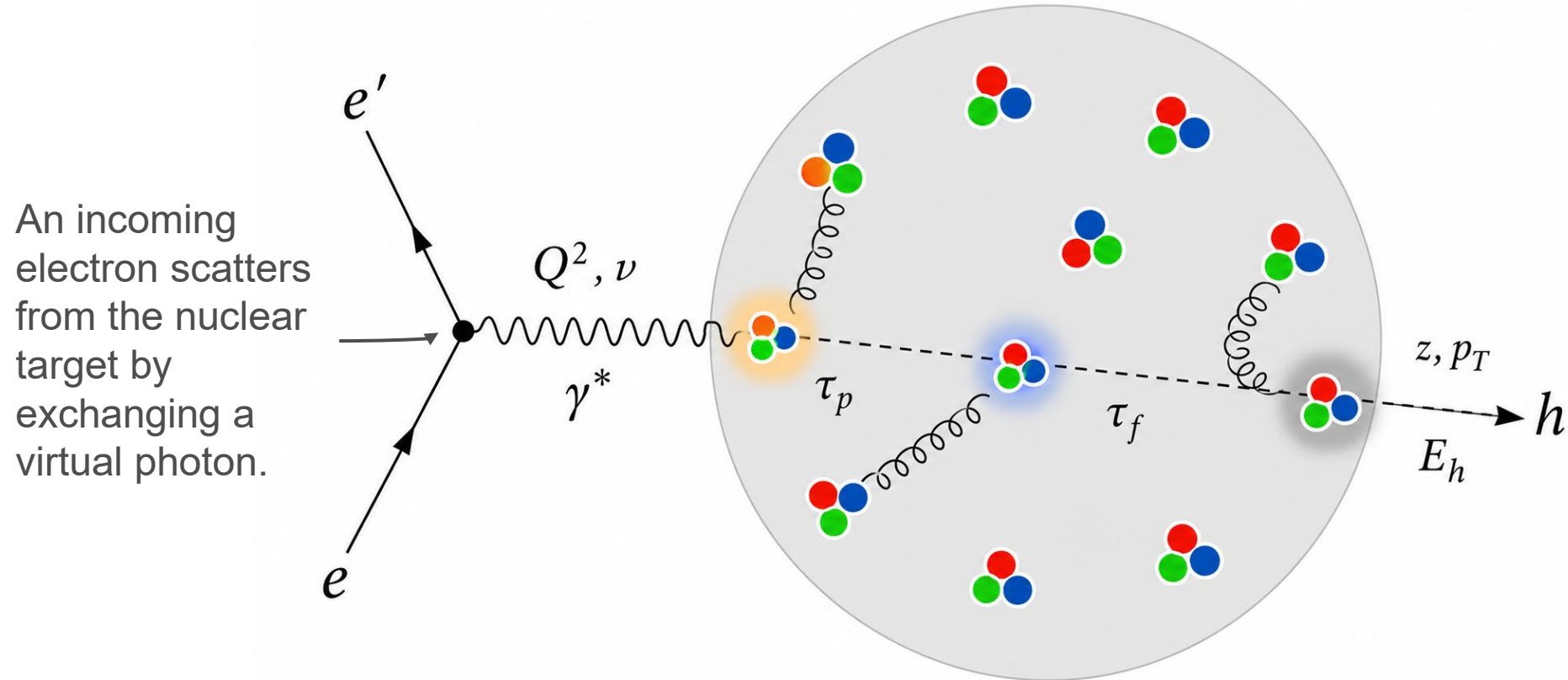
- Cuts and Corrections
- Invariant Mass Distributions
- Event Mixed Background

Physics Motivation

Hadronization in SIDIS



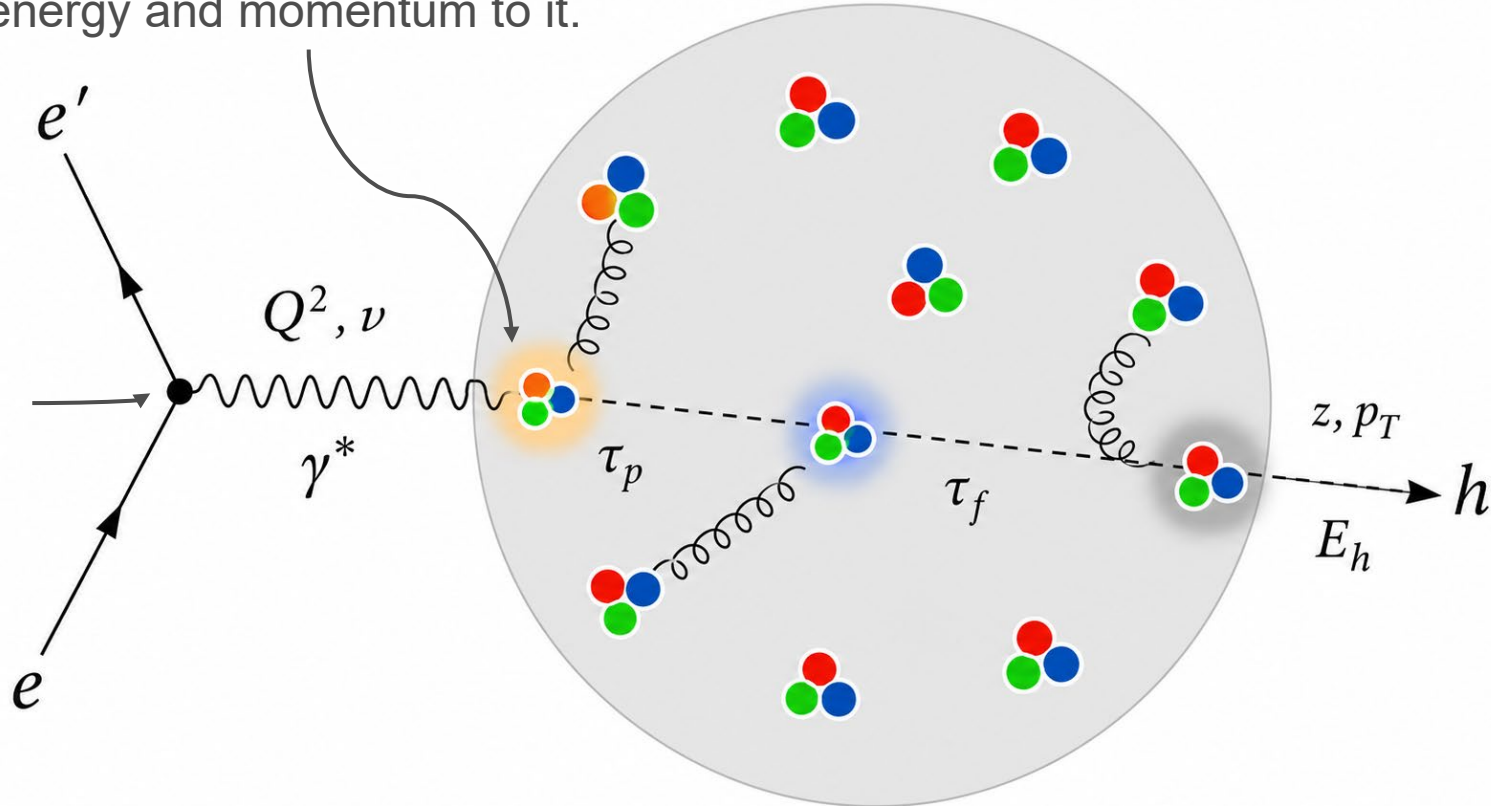
Hadronization in SIDIS



Hadronization in SIDIS

The virtual photon interacts with a quark inside one of the bound nucleons, transferring energy and momentum to it.

An incoming electron scatters from the nuclear target by exchanging a virtual photon.

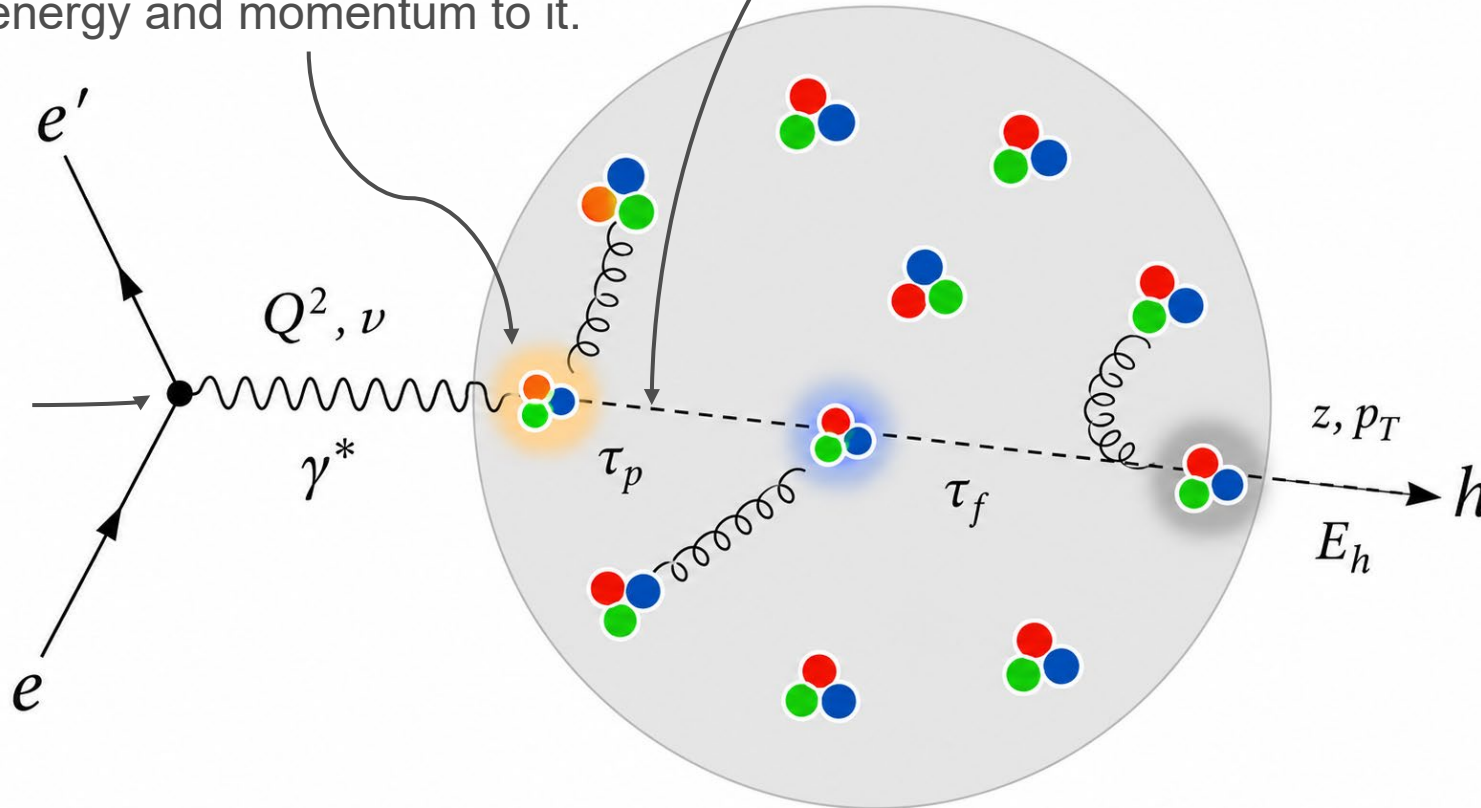


Hadronization in SIDIS

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This struck quark moves through the nuclear medium as a colored object, but because colored particles cannot exist freely, it begins to neutralize its color by producing additional quark-antiquark pairs.

An incoming electron scatters from the nuclear target by exchanging a virtual photon.

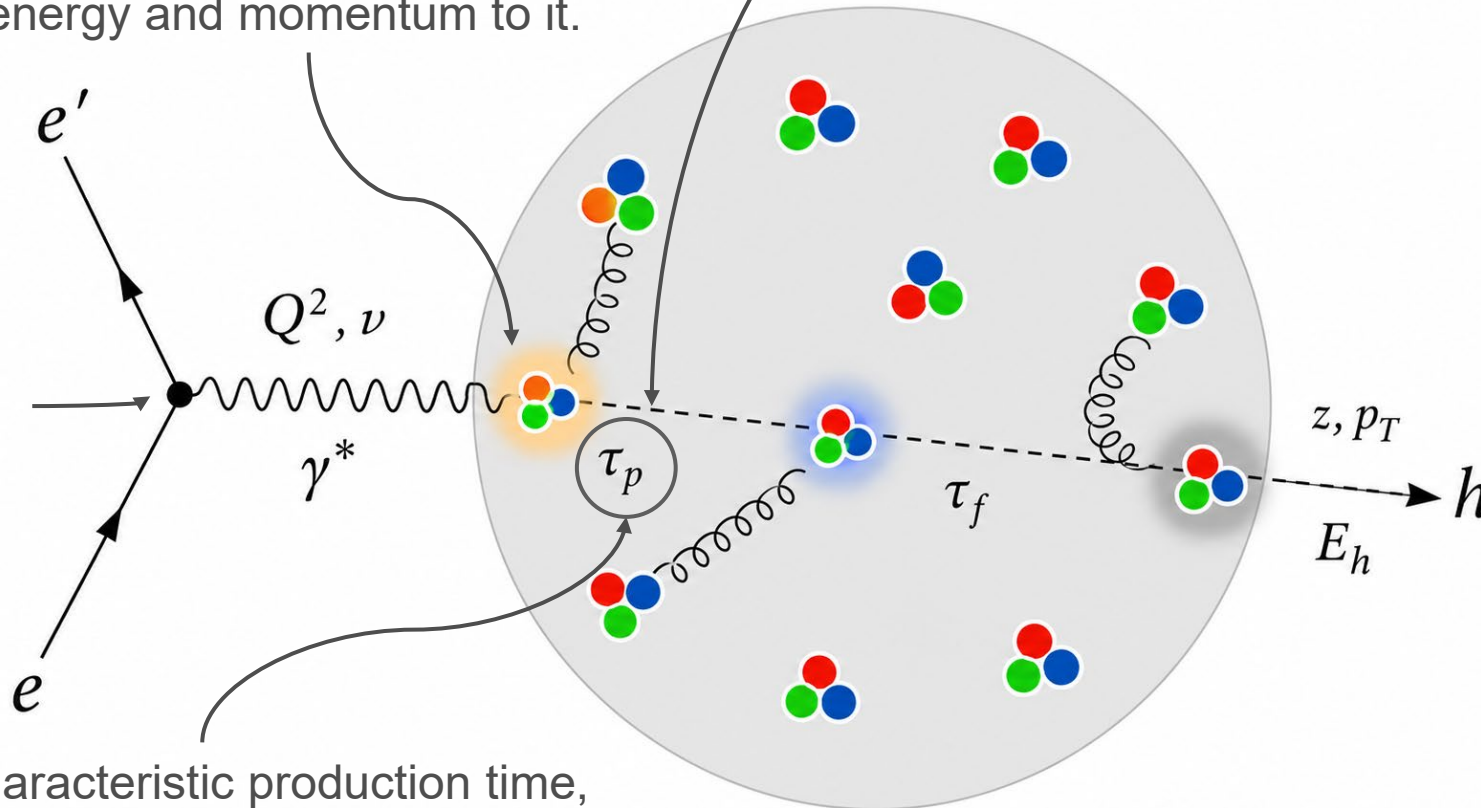


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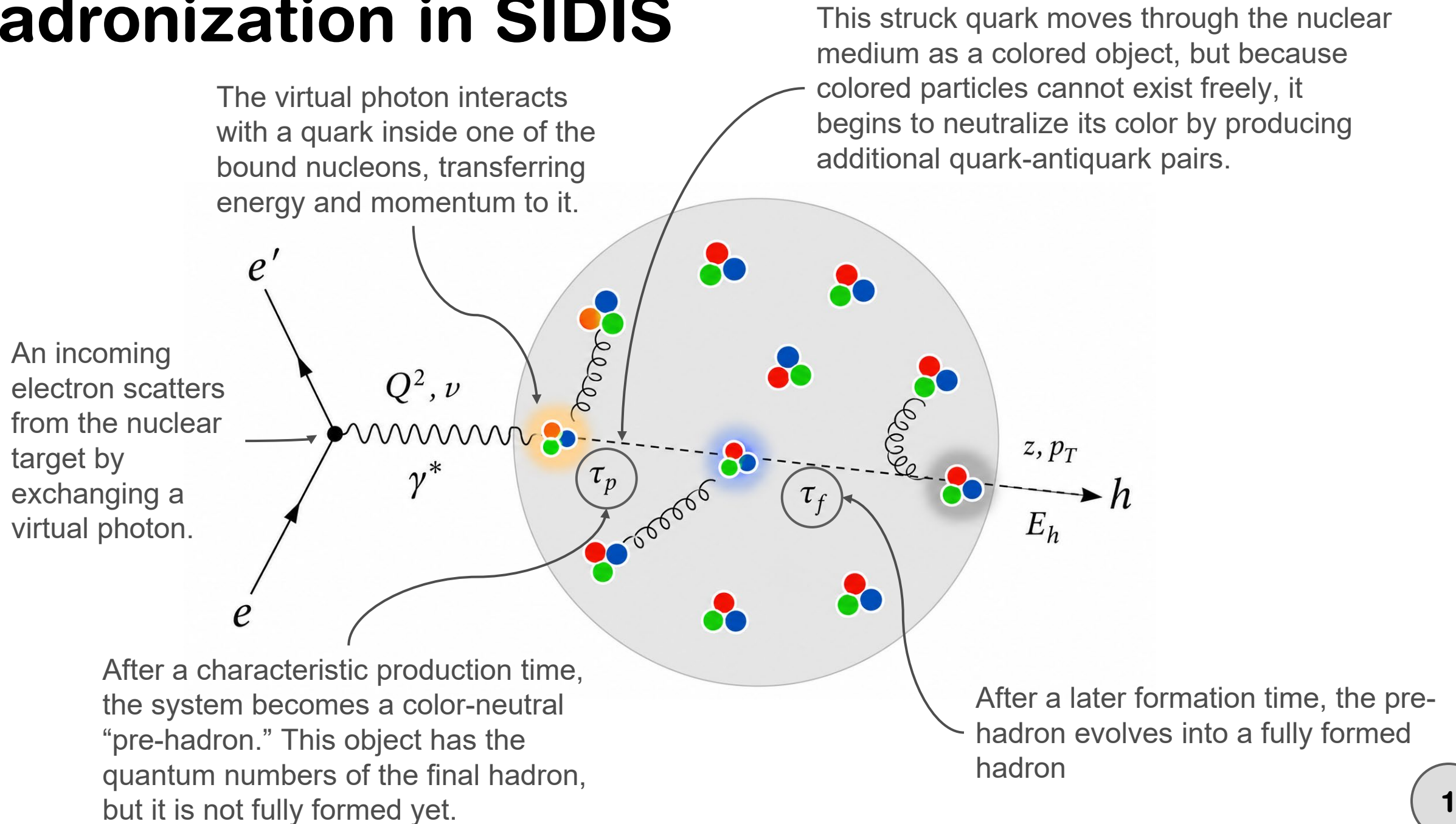
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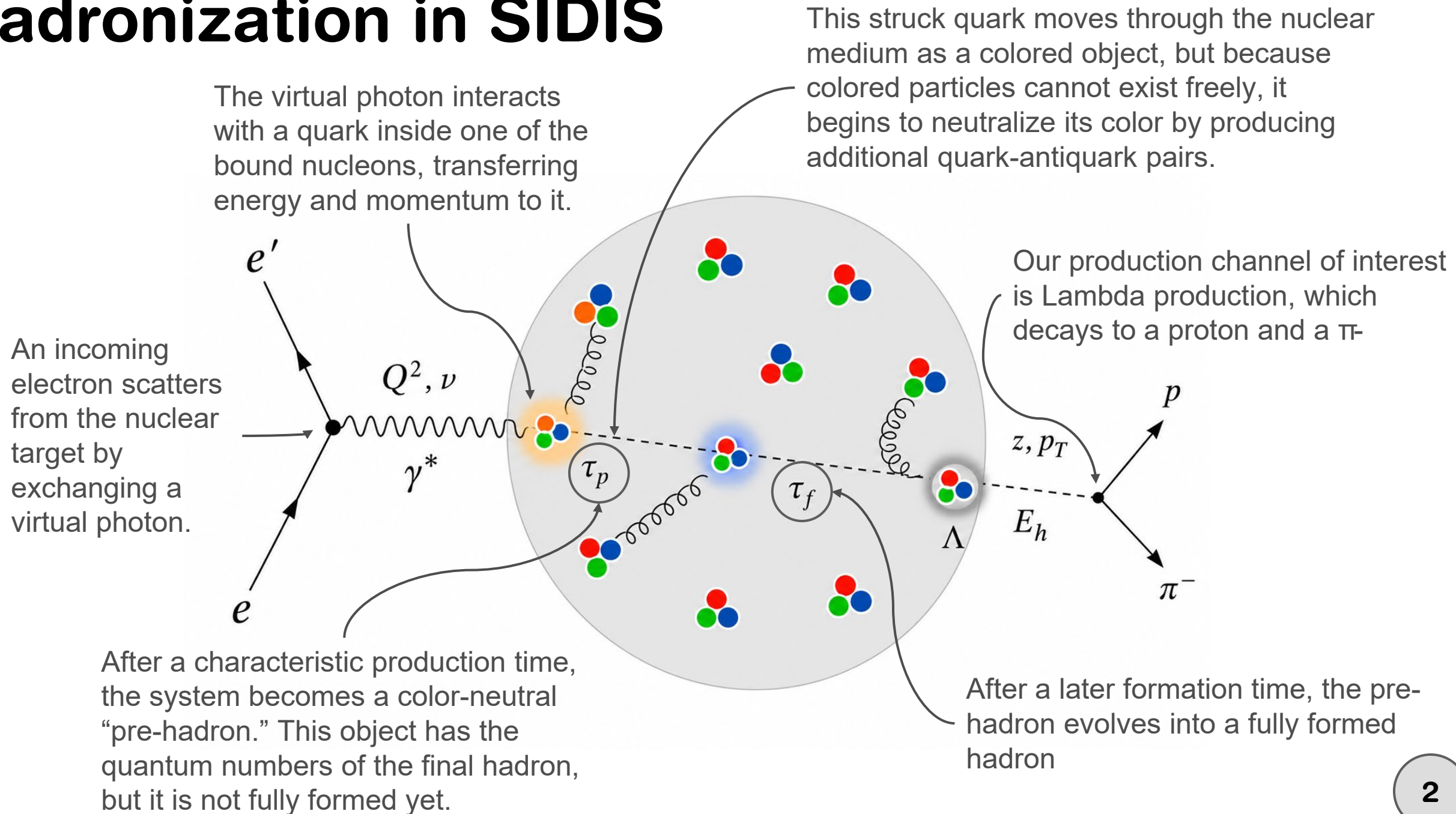


After a characteristic production time, the system becomes a color-neutral "pre-hadron." This object has the quantum numbers of the final hadron, but it is not fully formed yet.

Hadronization in SIDIS



Hadronization in SIDIS



SIDIS Kinematics

- ❖ ν : electron energy loss or struck quark's initial energy
- ❖ Q^2 : four-momentum transferred squared
- ❖ $W = \sqrt{M^2 + 2\nu M - Q^2}$: total mass of the hadronic final state, where M is the nucleon mass
- ❖ $y = \nu/E_{beam}$: electron energy fraction transferred to a struck quark
- ❖ $z_h = E_h/\nu$: struck quark's initial energy fraction carried by the formed hadron
- ❖ p_T : hadron transverse momentum measured relative to the virtual photon direction

SIDIS Kinematics

- ❖ ν : electron energy loss or struck quark's initial energy
- ❖ Q^2 : four-momentum transferred squared
 - ❑ $Q^2 > 1 \text{ GeV}^2$: to probe the intrinsic structure of nucleons
- ❖ $W = \sqrt{M^2 + 2\nu M - Q^2}$: total mass of the hadronic final state, where M is the nucleon mass
 - ❑ $W > 2 \text{ GeV}$: to avoid contamination from the resonance region
- ❖ $y = \nu/E_{beam}$: electron energy fraction transferred to a struck quark
 - ❑ $y < 0.85$: to reduce radiative effects based on former HERMES studies
- ❖ $z_h = E_h/\nu$: struck quark's initial energy fraction carried by the formed hadron
- ❖ p_T : hadron transverse momentum measured relative to the virtual photon direction

Physics Observables

Multiplicity Ratio

$$R_A^h = \frac{N_{SIDIS}^{h(A)} / N_{DIS}^{e(A)}}{N_{SIDIS}^{h(LD_2)} / N_{DIS}^{e(LD_2)}}$$

R_A^h describes the attenuation of formed hadrons, h , in the medium

Transverse Momentum Broadening

$$\Delta p_T^2 = \langle p_T^2 \rangle_A - \langle p_T^2 \rangle_{LD_2}$$

Δp_T^2 is due to the energy loss of the propagating struck quark(s) and/or the elastic and inelastic scattering of prehadrons and hadrons

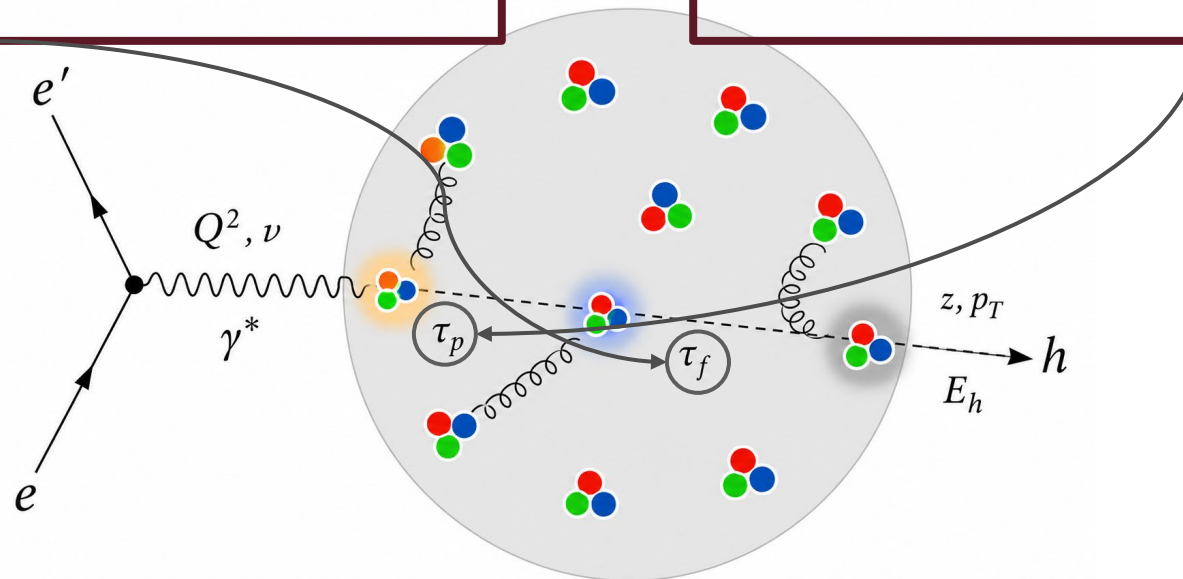
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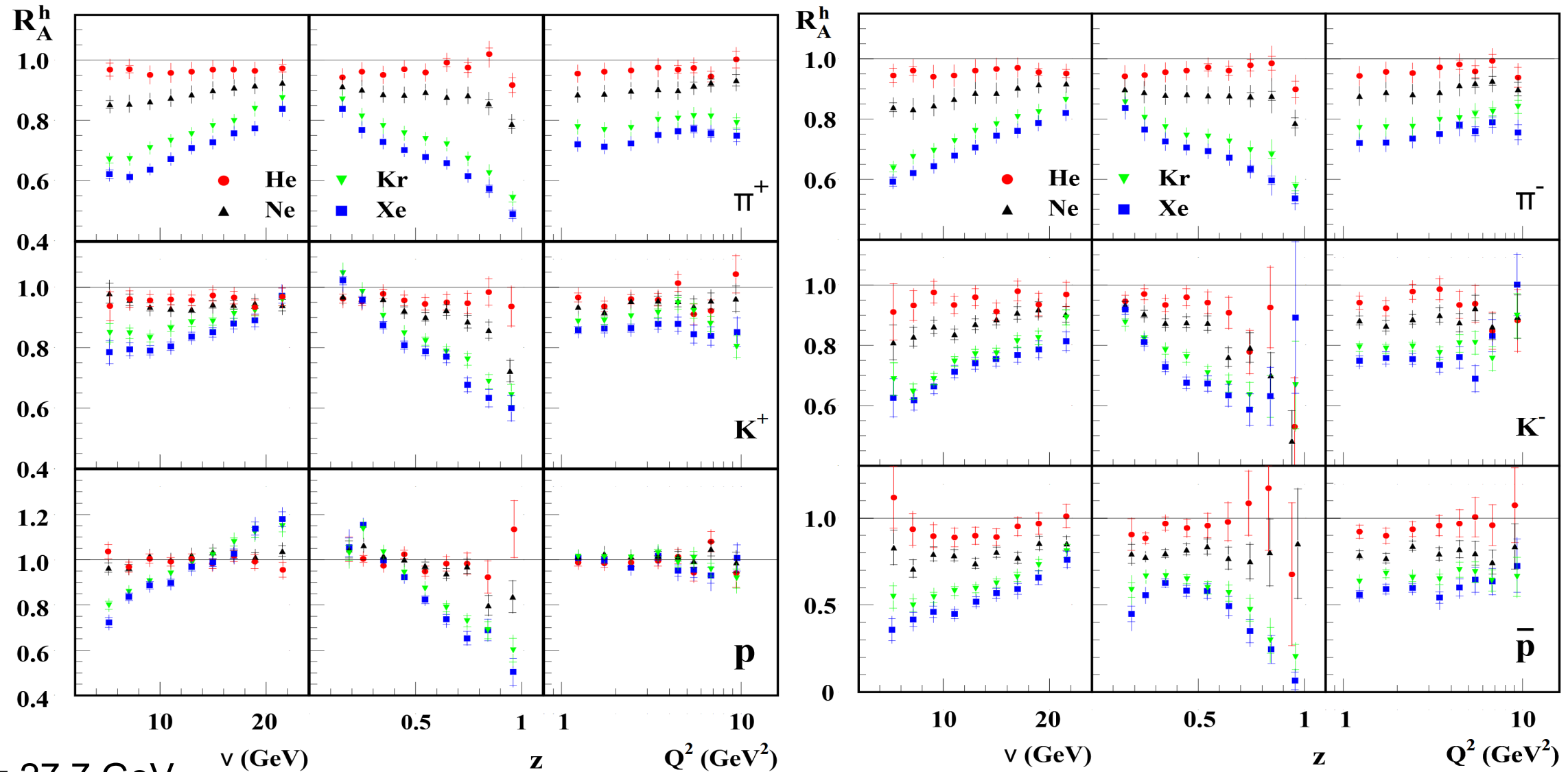
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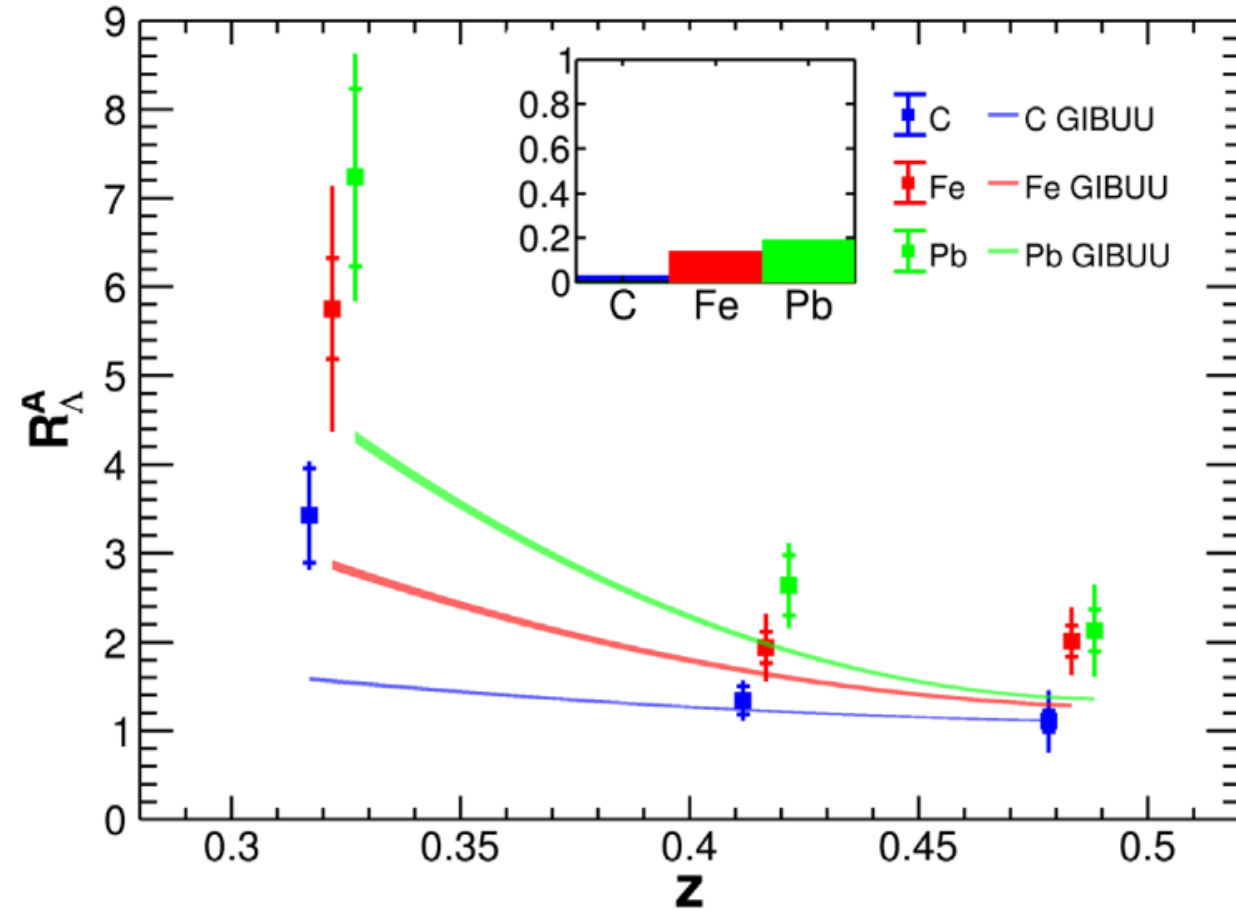
Previous Measurements

HERMES Multiplicity Ratios

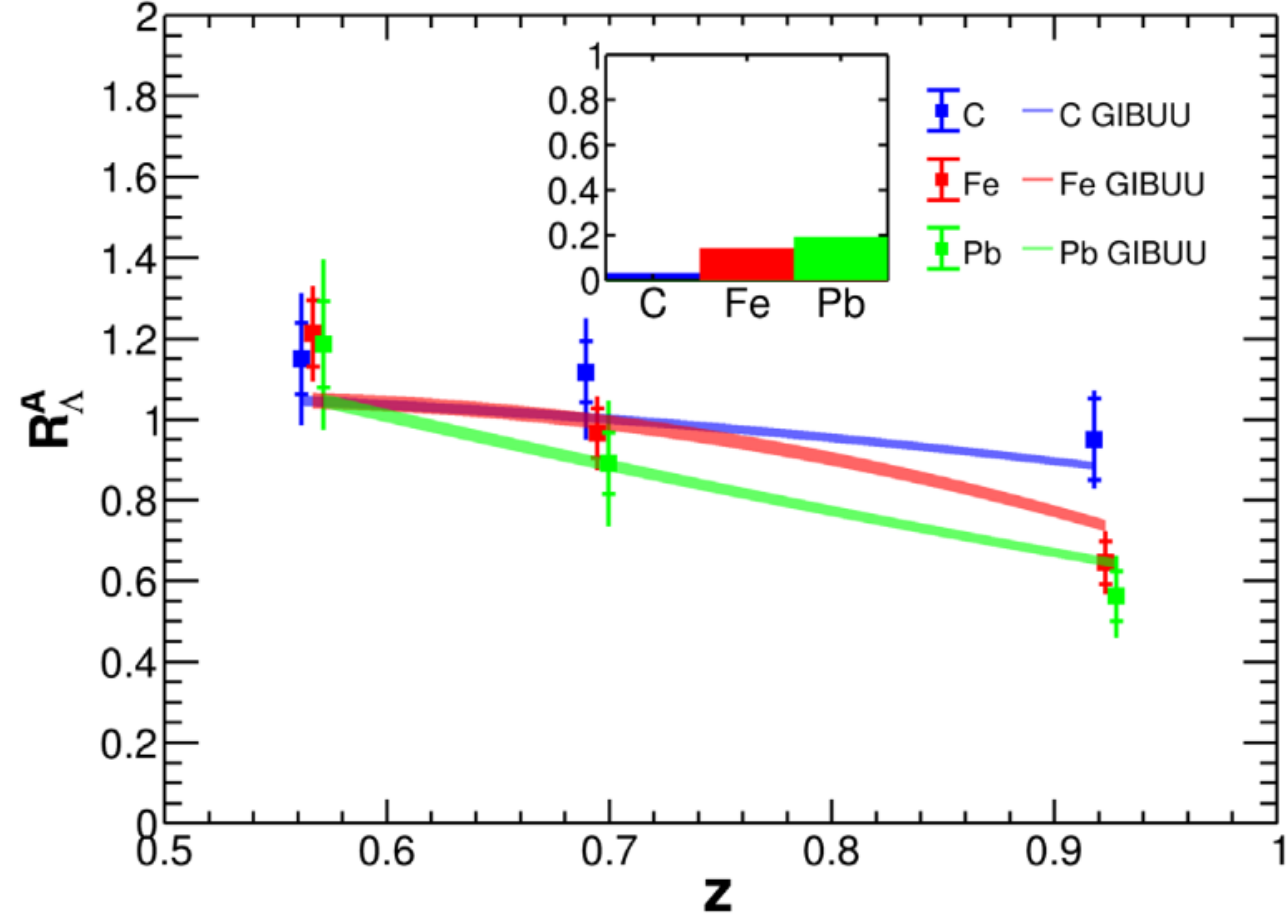


CLAS6 Lambda Multiplicity Ratios

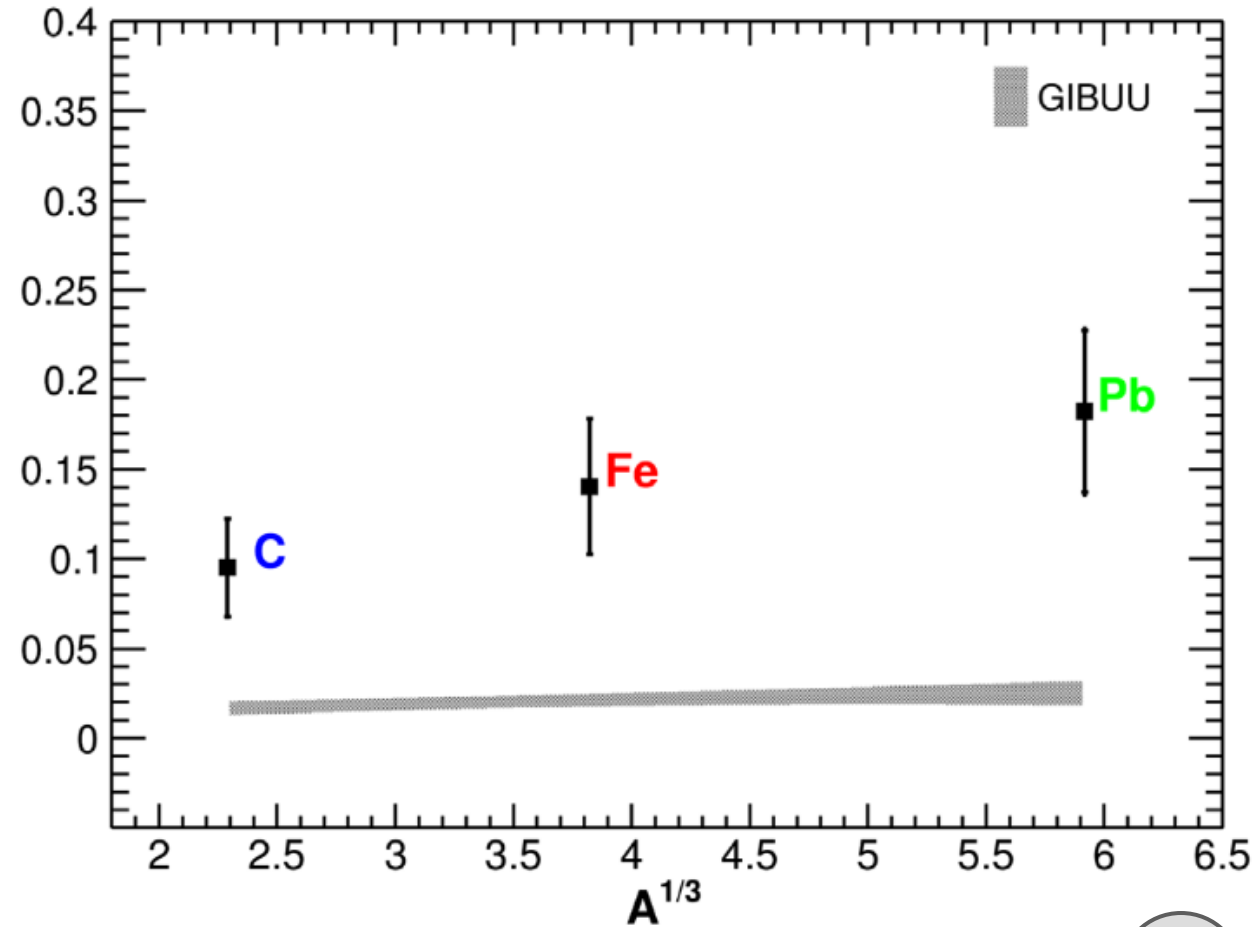
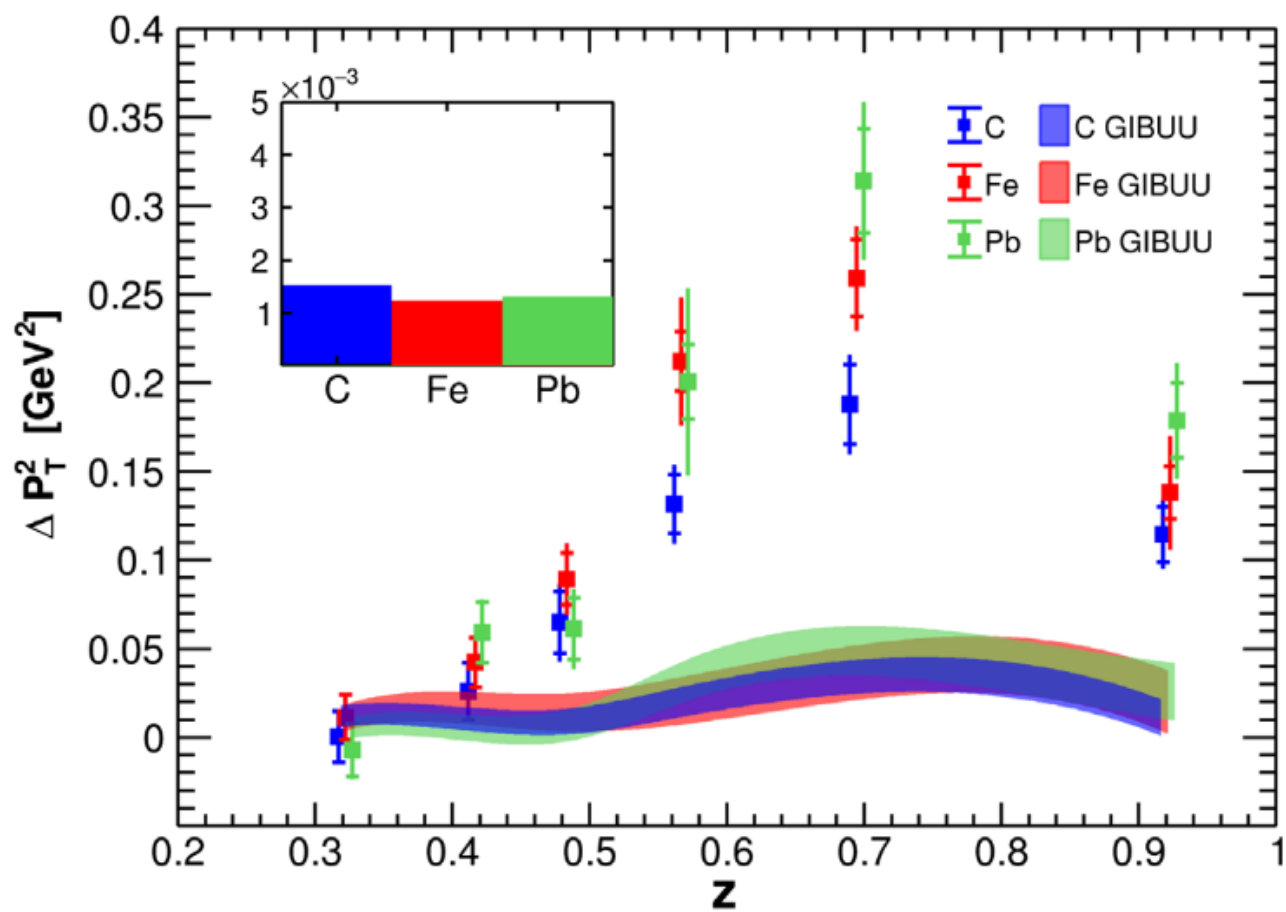
Target fragmentation



Current fragmentation



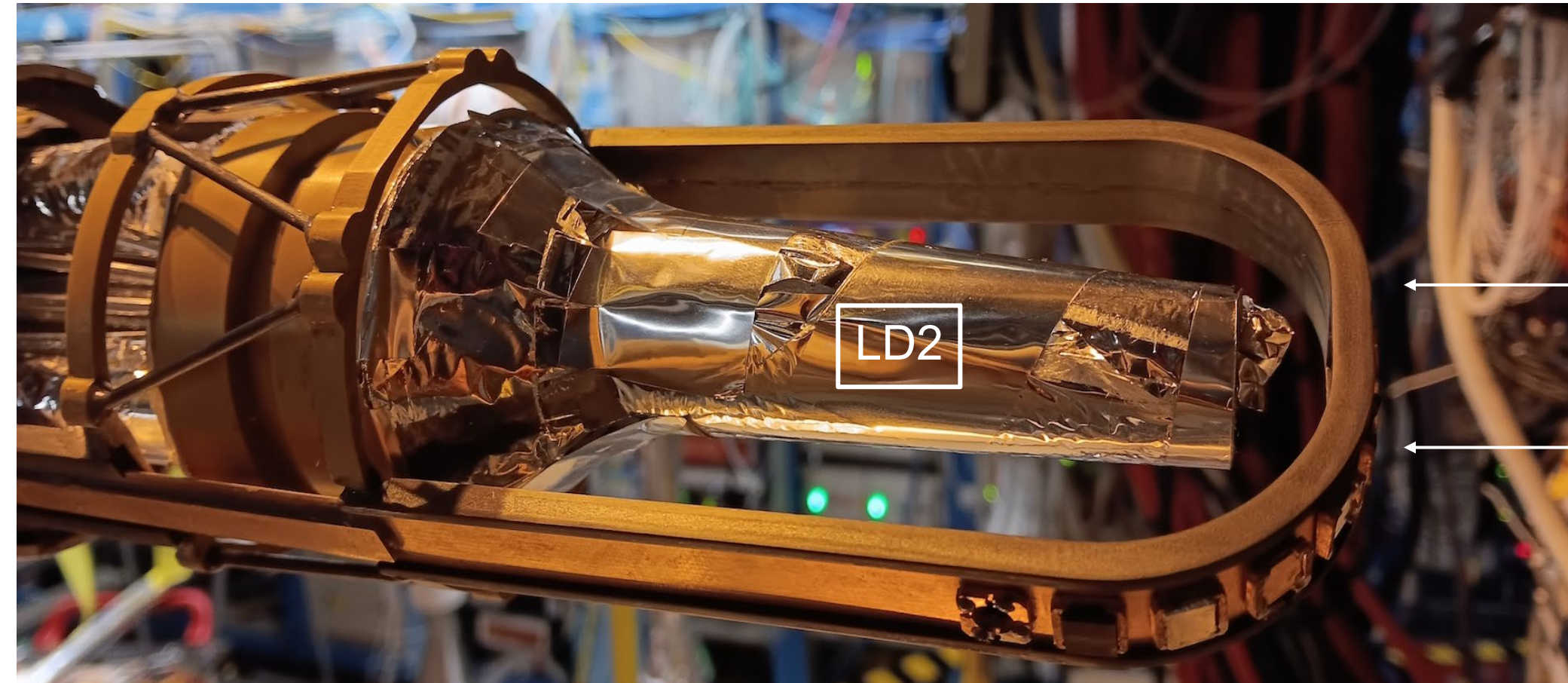
CLAS6 Lambda P_T Broadening



Experiment Setup

RG-E Target Setup

Dual target assembly with an LD2 cell and a series of solid foils



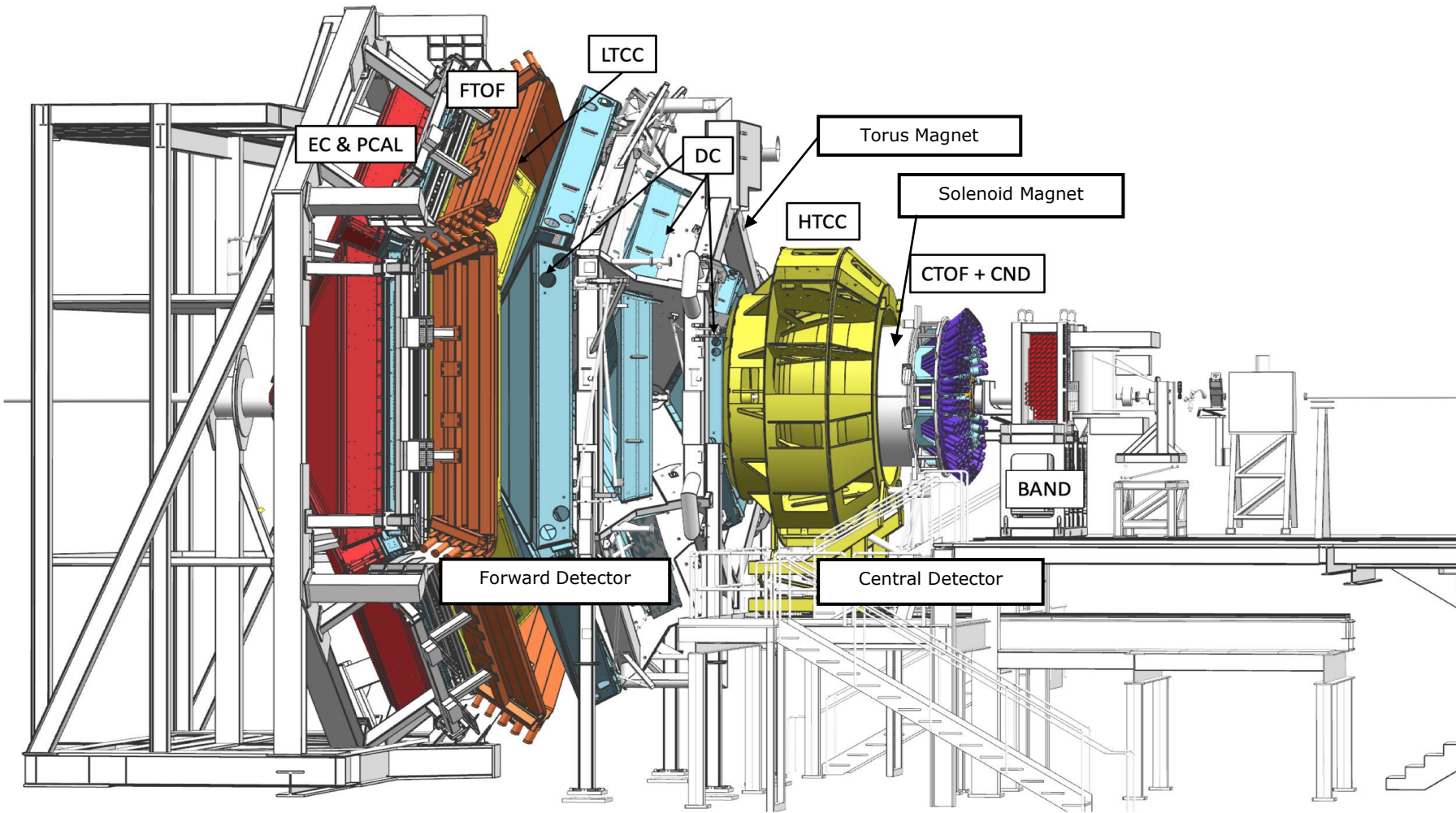
Solid foils:

- C
- Al
- Cu
- Sn
- Pb

The CLAS 12 Detector

A large acceptance detector with two detector regions:

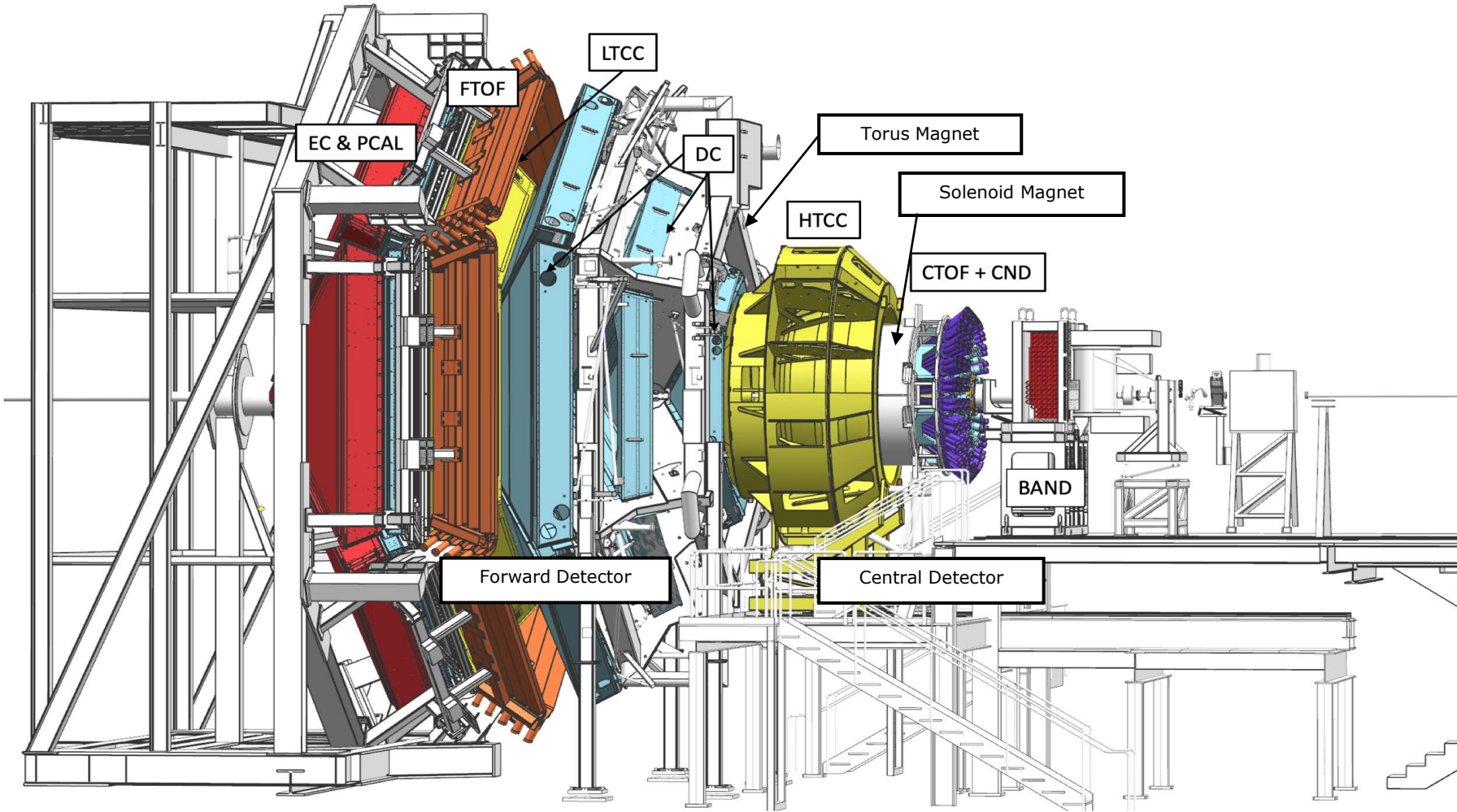
- ❑ Forward 5° to 35°
- ❑ Central 35° to 135°



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Capable of

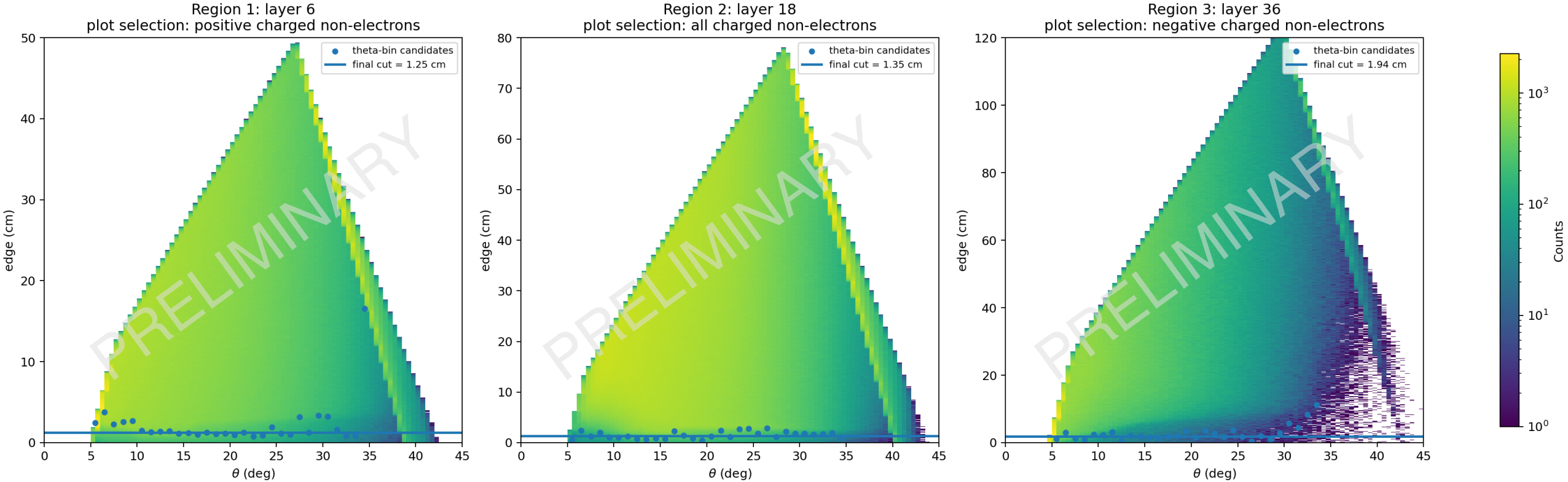
- ❑ tracking
- ❑ timing
- ❑ calorimetry
- ❑ particle ID

over a large angular and momentum range

Preliminary Analysis

Removing Inefficient Regions of Detectors

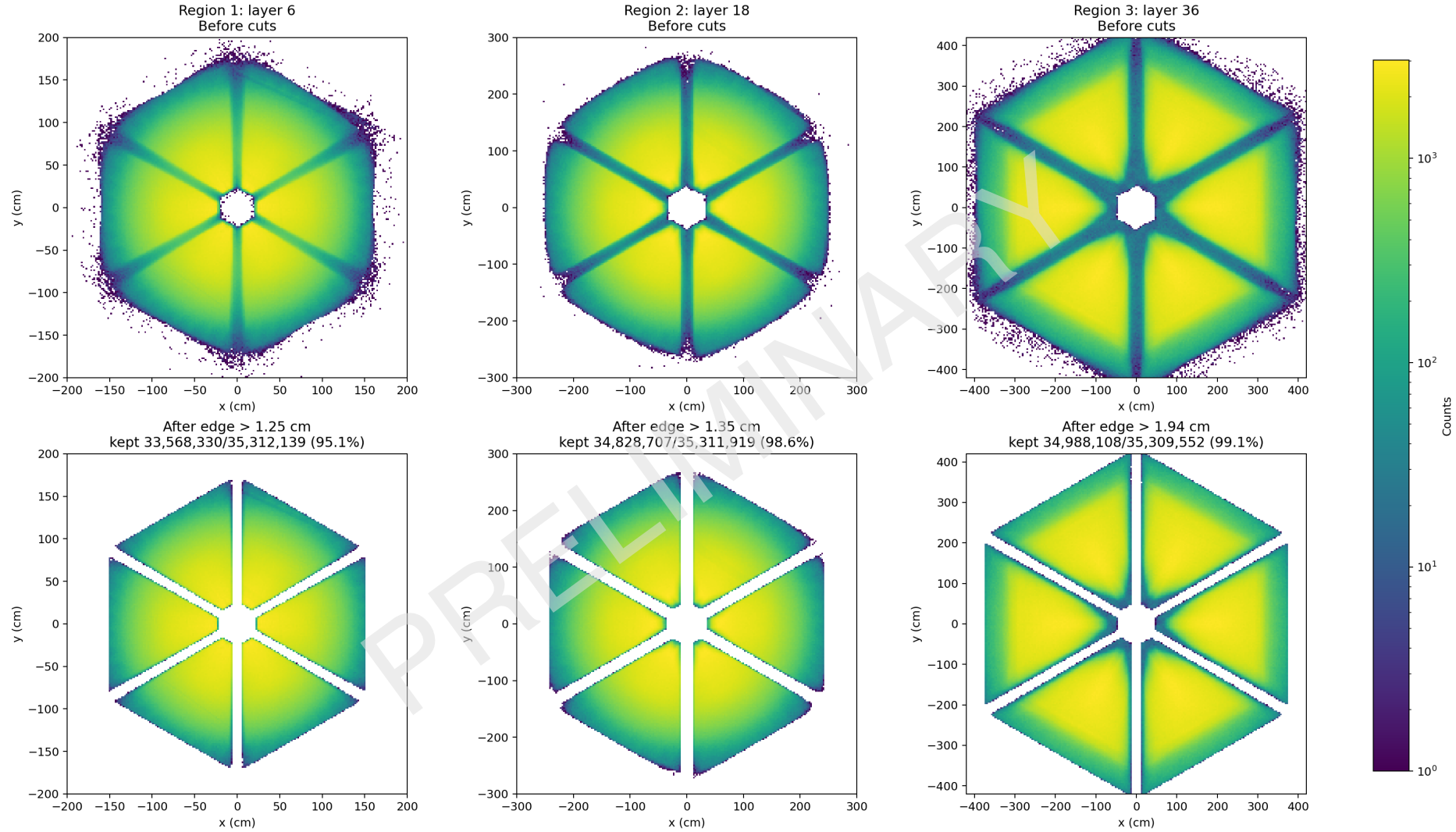
A cut on the distance to the nearest edge was used to remove the areas of the Drift Chamber with low efficiency



Removing Inefficient Regions of Detectors

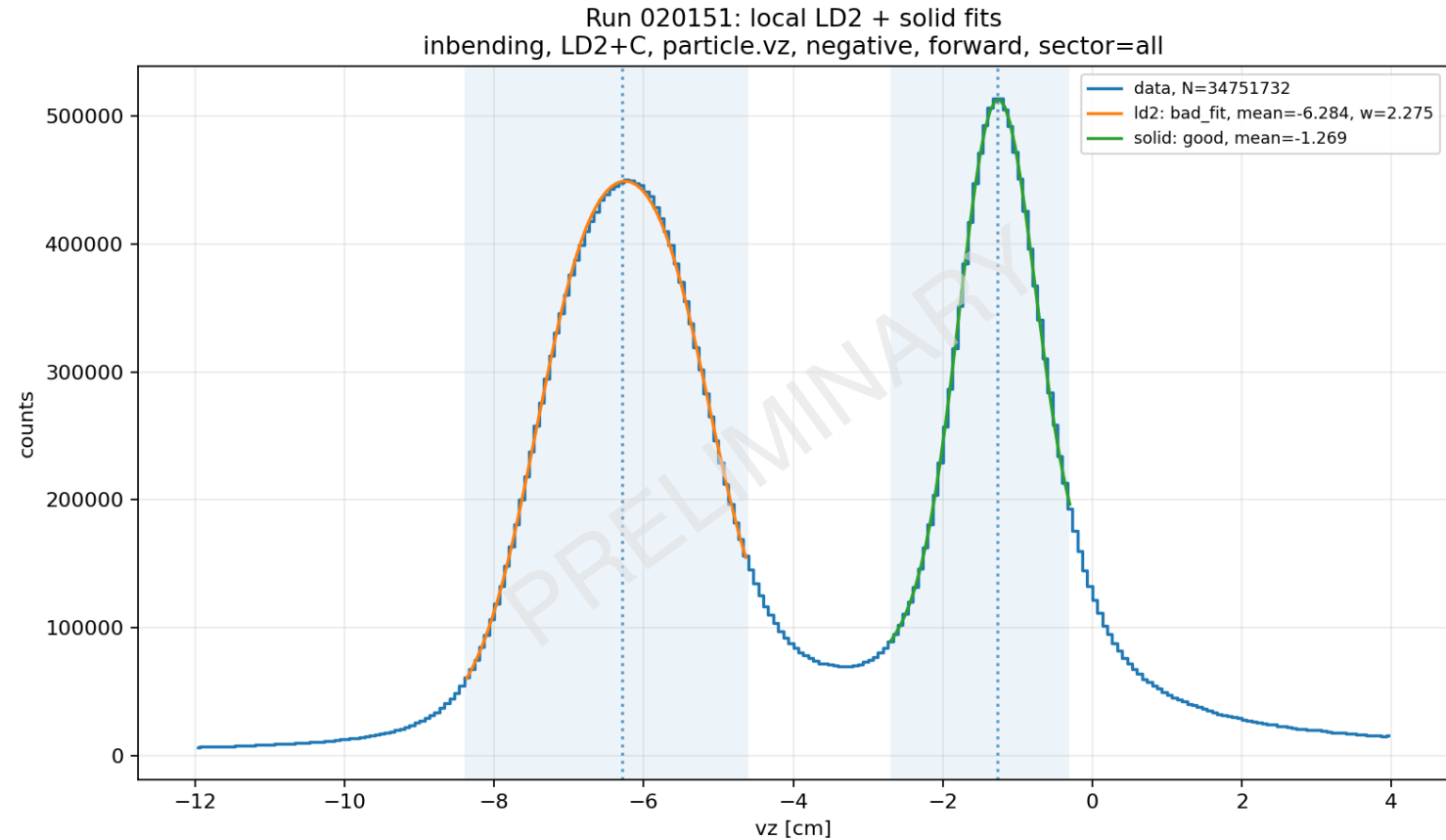
We use a cut on the distance to the nearest edge to remove the areas of the Drift Chamber with low efficiency

Positive charged non-electrons: x-y occupancy before and after final region-level edge cuts
Total kept 103,385,145/105,933,610 (97.6%)



Separating Targets using Vertex Cuts

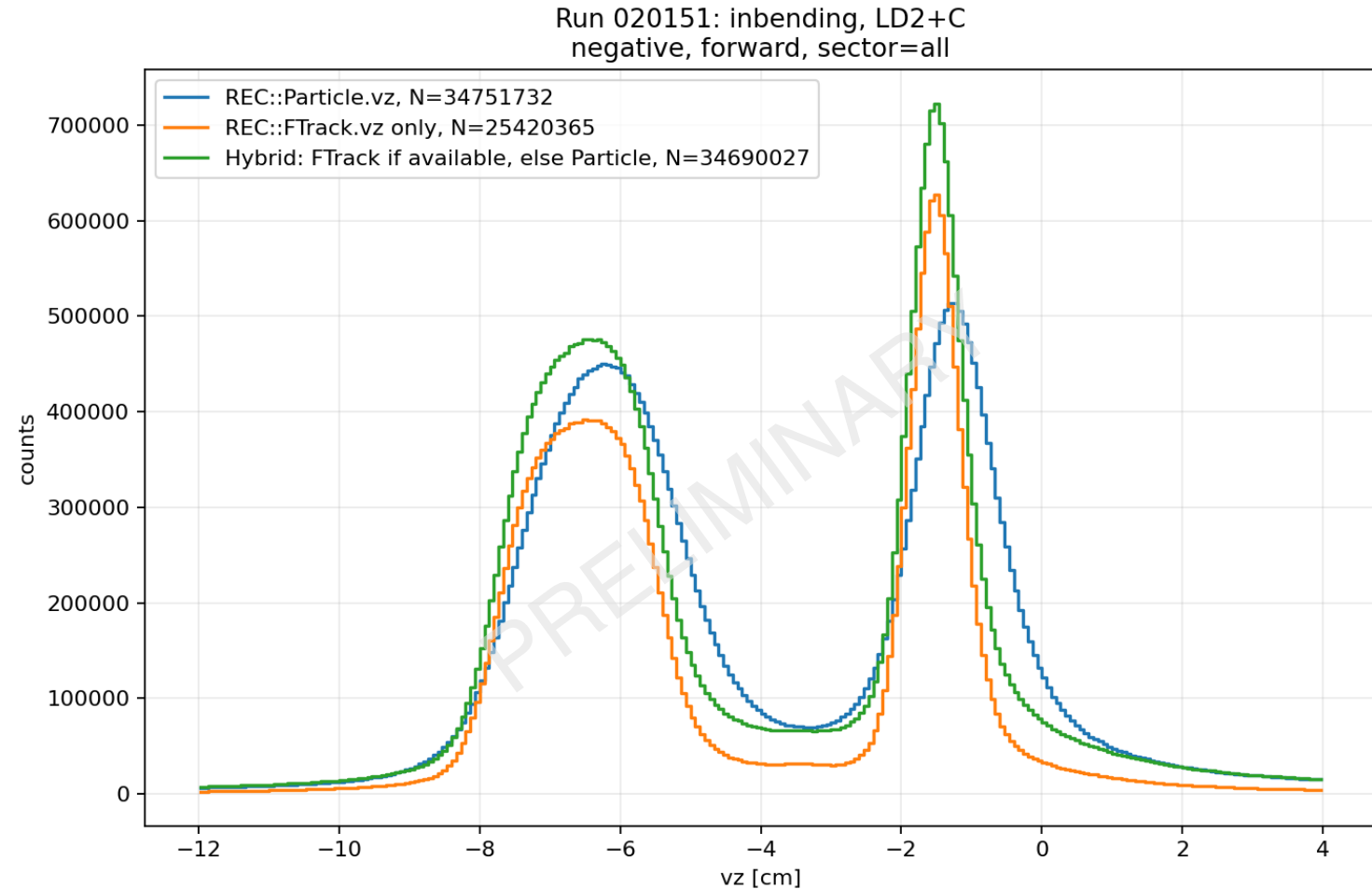
❖ The first look at processed data shows poor target separation



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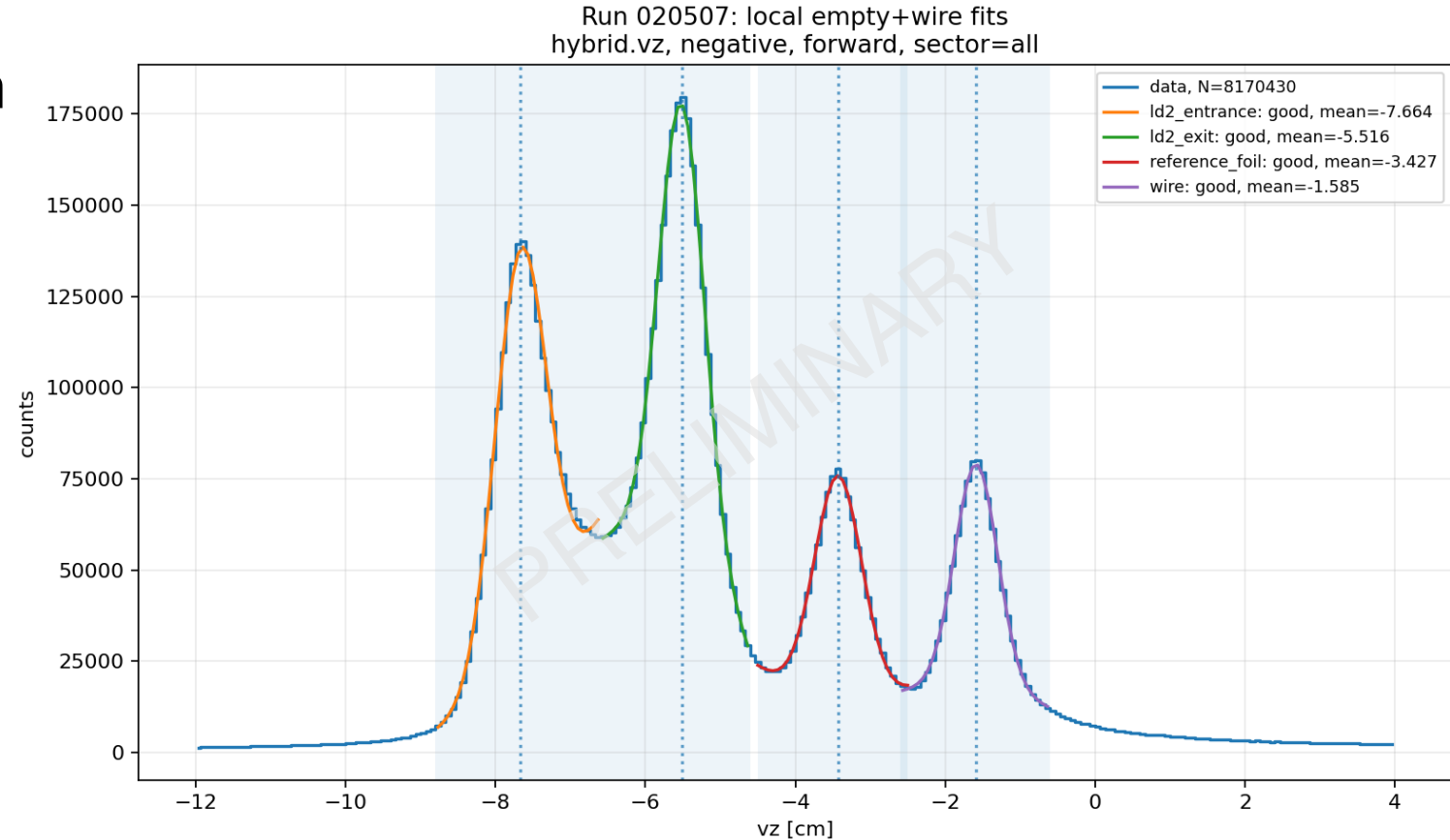
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❖ After adding information from the Forward Micromegas Tracker, the resolution improved



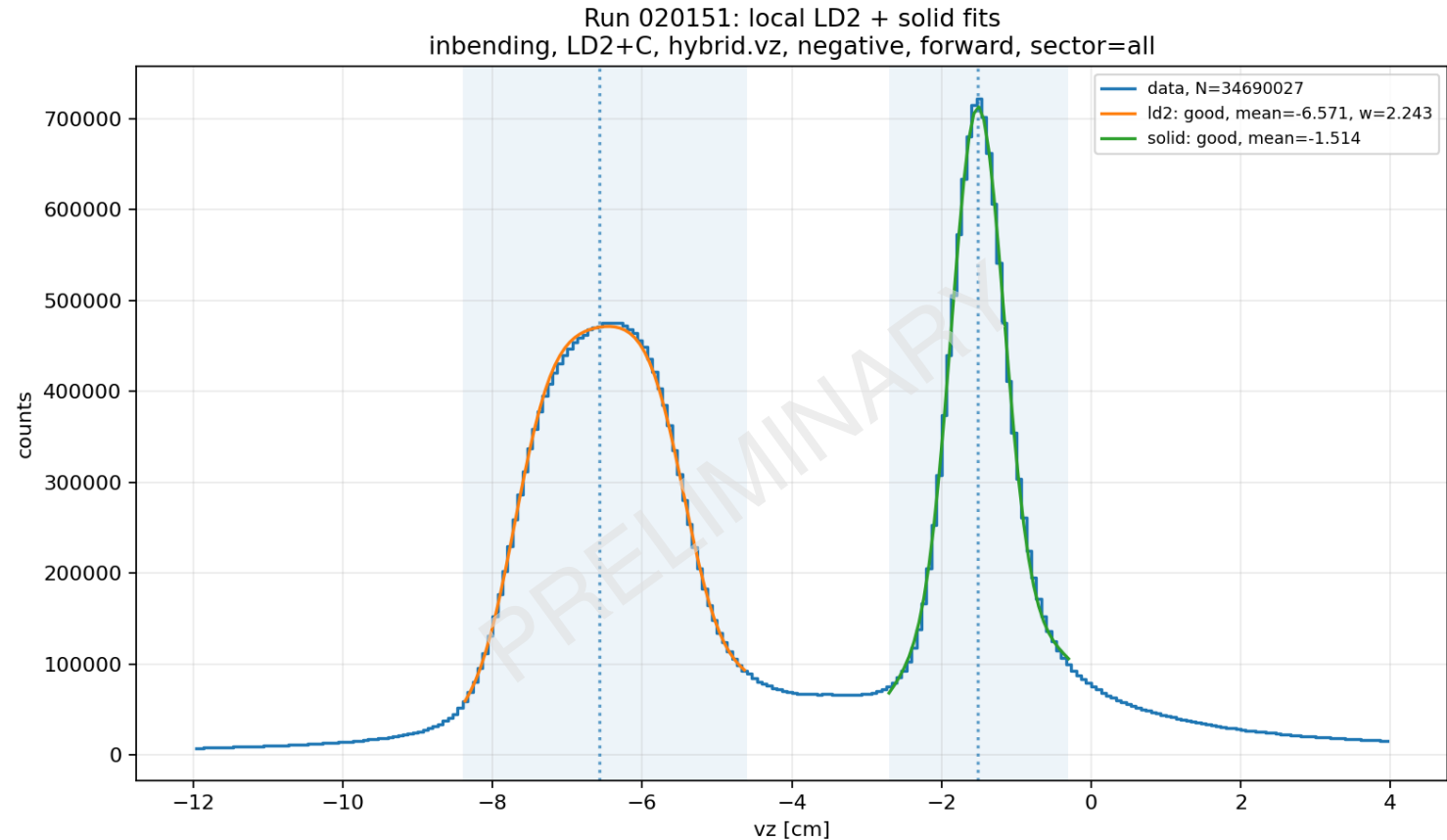
Separating Targets using Vertex Cuts

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Separating Targets using Vertex Cuts

- ❖ The first look at processed data shows poor target separation
- ❖ After adding information from the Forward Micromegas Tracker, the resolution improved
- ❖ An empty target run was used to find the position and limits of the reference foil
- ❖ A box convoluted Gaussian, and a Crystal Ball function were used to fit and separate the targets



Refining Particle Identification

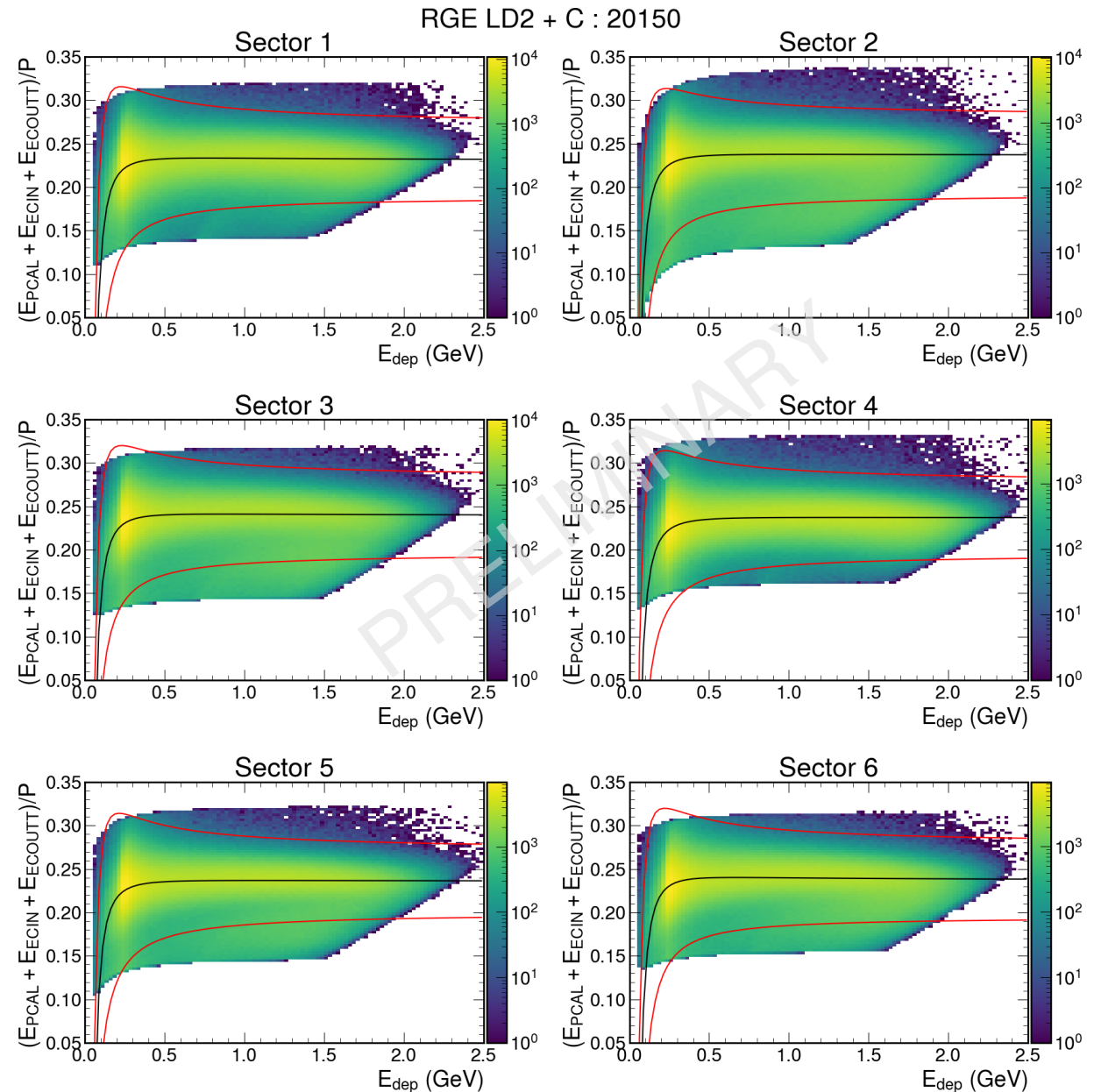
❖ As a starting point, all particles were required to have:

- Reconstructed PID = PDG value
- 5σ cut on confidence of PID

Particle	PDG Value
Electron	11
Proton	2212
τ^-	-211

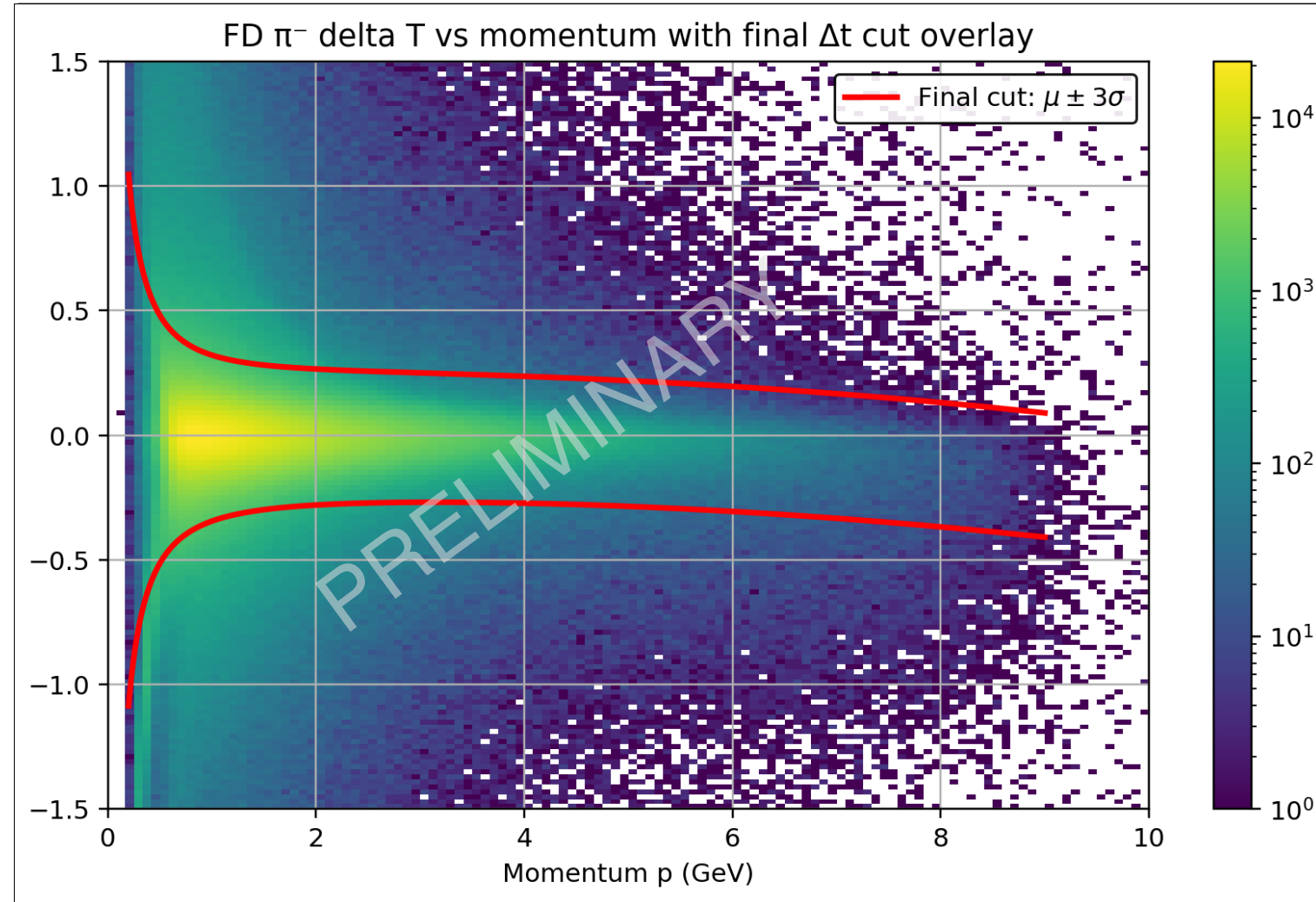
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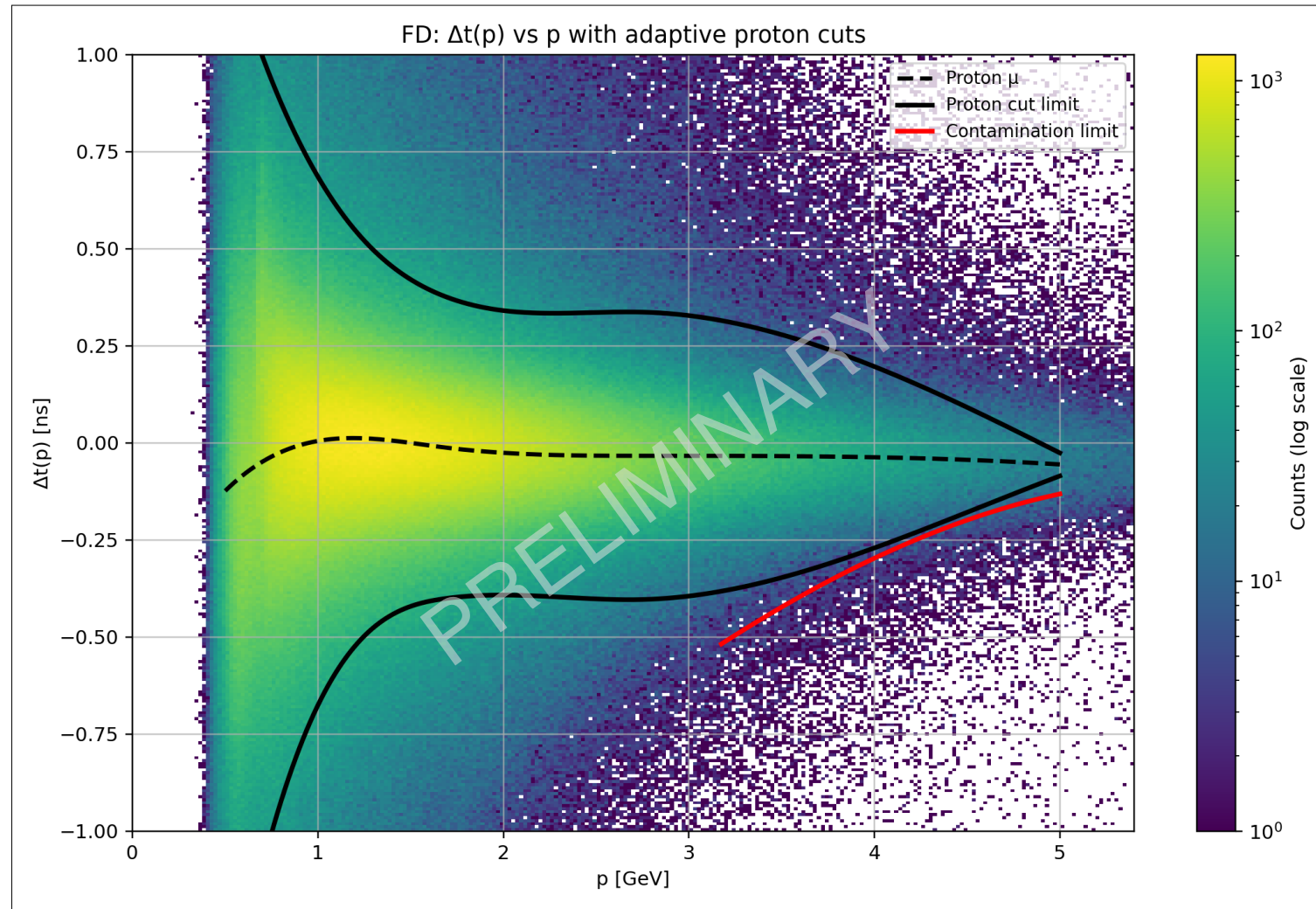
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- ❖ ΔT vs momentum cuts were developed to refine the proton and π^- identification



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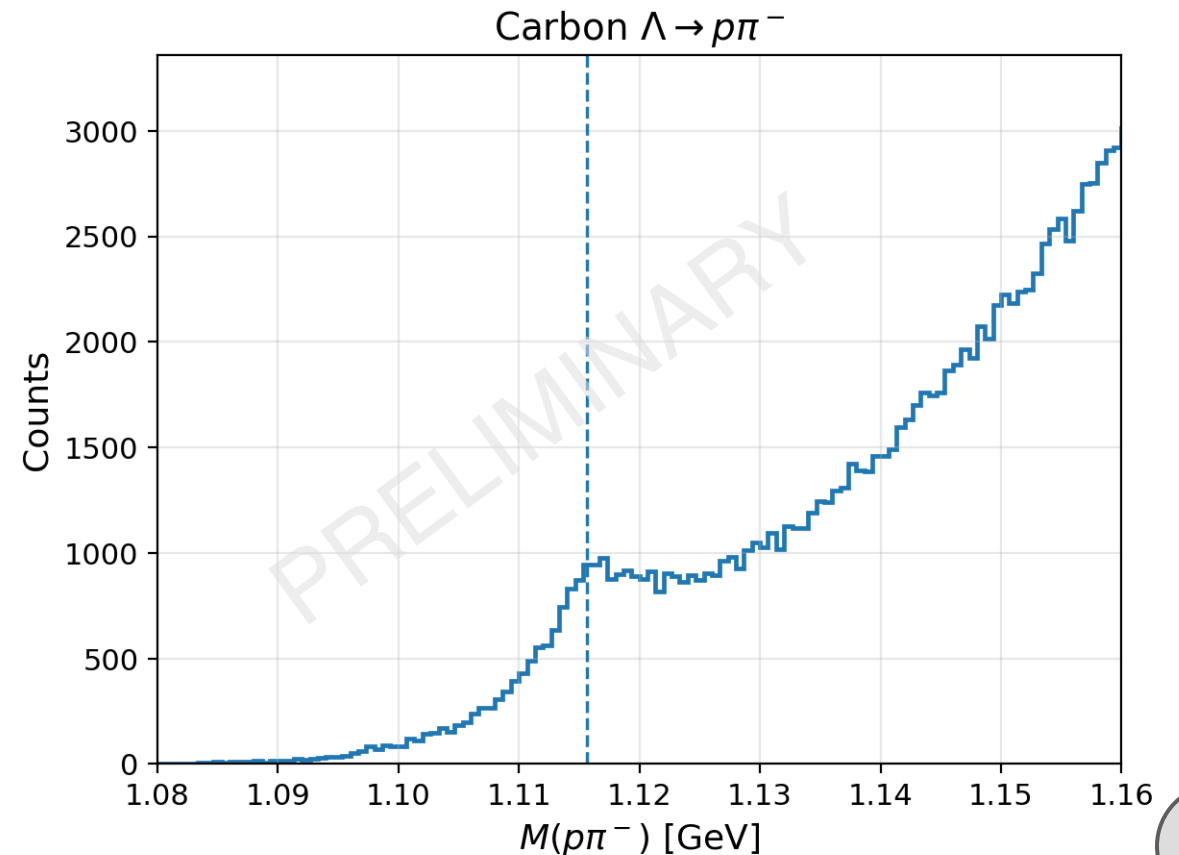
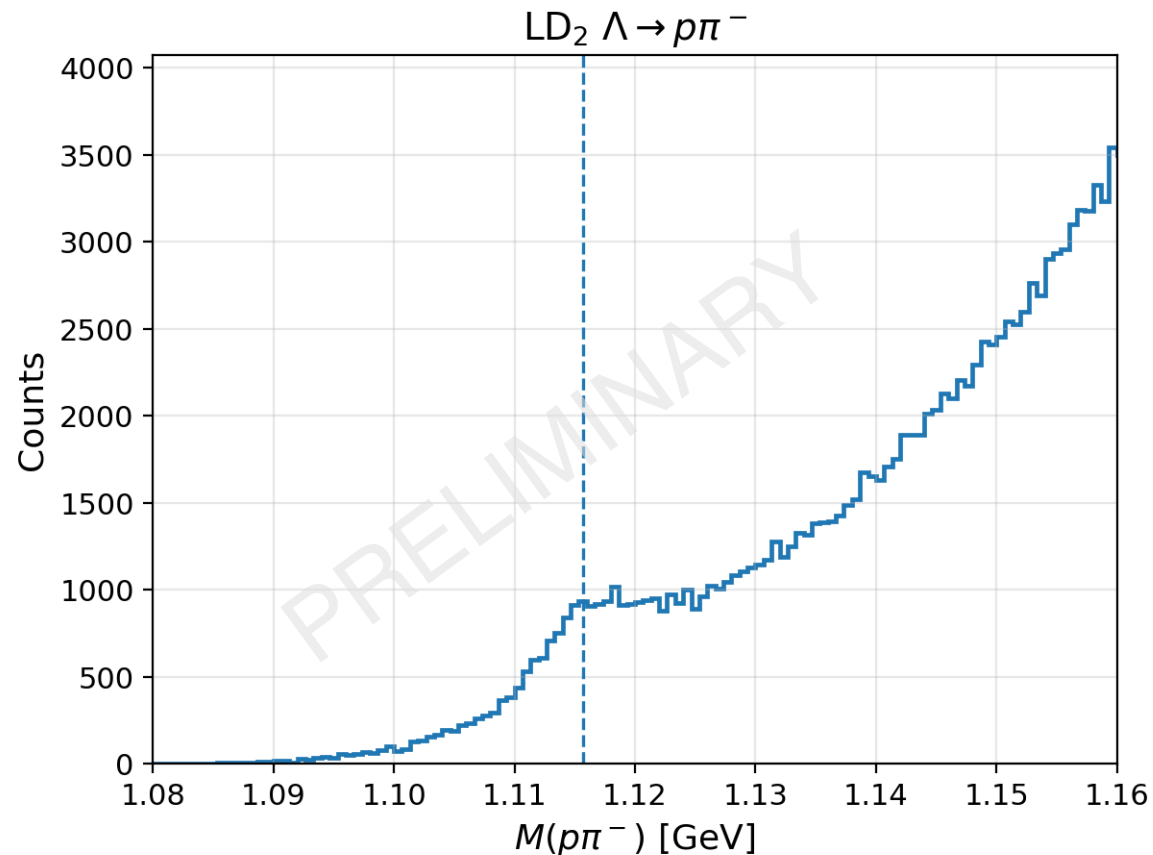
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Lambda Invariant Mass Distributions

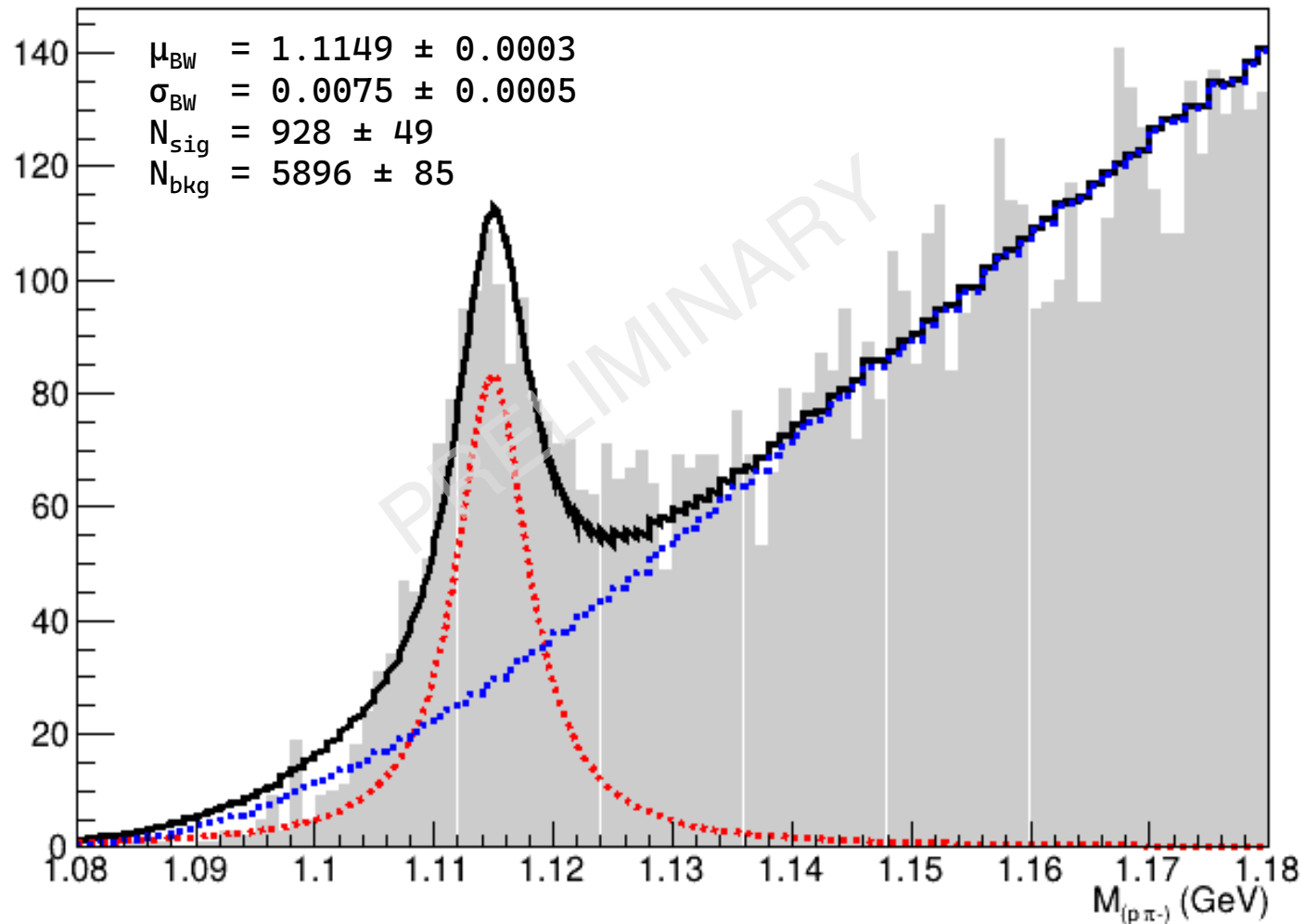
- ❖ A Λ signal is reconstructed through the $p\pi^-$ invariant mass distribution
- ❖ Detached vertex cuts are being developed to refine the Lambda peak

Λ invariant mass



Event Mixing

Protons and pions from the same event are mixed with pions and protons from uncorrelated events to model the combinatorial background underneath the Λ peak



Note: This is a proof-of-concept plot with extremely tight cuts.

Next Steps

Refine the analysis chain: cuts, corrections, and systematic checks

Expand the analysis to the central detector

Extract Λ production observables in the CFR and TFR regions

Summary

- ❖ Λ electroproduction in SIDIS is a useful channel for studying strange hadronization in different fragmentation regions.
- ❖ A Λ signal is reconstructed through the $p\pi^-$ invariant mass distribution after event and PID selections.
- ❖ Event mixing provides a data-driven way to model combinatorial background, enabling future physics extraction
- ❖ Extracting physics observables is underway

Thank You!

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