



Time-Of-Flight PID Performance

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ToF Simulation Meeting: October 13, 2026

Previous Presentations

- (September 29, 2026)Time-of-Flight PID Performance: [Link](#)

Motivation & Physics Goals

- **Dataset:** sartre1.39-1.0_coherent_phi_eAu_bsat_10x100_ab.*.edm4eic.root
- Coherent exclusive vector meson production is a key channel for imaging gluon spatial distributions inside nuclei.
- We focus on the ϕ meson decaying into two kaons ($\phi \rightarrow K^+ K^-$).
- Backgrounds from misidentified particles (e.g., π from $\rho \rightarrow \pi^+ \pi^-$ falsely tagged as K) distort the ϕ invariant mass spectrum.
- While official TOF likelihoods provide integrated PID, performing an **independent geometric hit-to-track association** allows us to directly validate raw kinematics (β , m^2) and establish systematic baselines.

Methodology: Geometric Matching Algorithm

- **Propagation:** `CentralTrackSegments` are extrapolated to find the reconstructed track position on the candidate TOF barrel surface.
- **Hit Association:** The 3D distance between the extrapolated track point and all `TOFBarrelRecHits` is calculated.
- **Nearest-Hit Assignment:** The TOF hit with the minimum 3-D distance is assigned to the track.
- **Calculation:** Using the directly assigned hit, we extract raw hit times (t_{TOF}) and track path lengths (L) to compute particle kinematics from first principles.

Geometric Association: 3D Match Distance

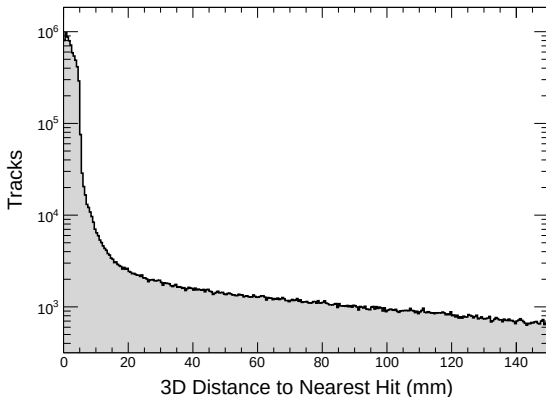
Distance Formulation

$$d = \sqrt{(\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2}$$

where $\Delta x = x_{\text{hit}} - x_{\text{trk}}$, etc.

Selection Criteria

- The distribution of distance d to the nearest TOF hit demonstrates a sharp peak at zero.
- A maximum match threshold is enforced at $d < 150$ mm (red dashed line) to reject spurious ghost assignments.



TOF Kinematics I: $1/\beta$ vs Momentum

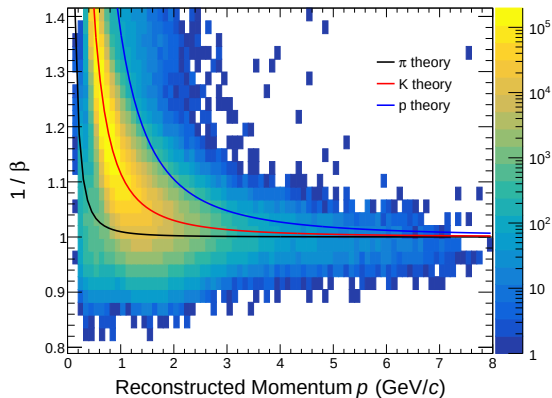
Velocity Reconstruction

$$1/\beta_{\text{meas}} = \frac{c \cdot t_{\text{TOF}}}{L}$$

Theoretical Curves

$$1/\beta_{\text{theory}} = \frac{E}{p} = \frac{\sqrt{p^2 + m_0^2}}{p}$$

- Velocity is reconstructed entirely from geometric match parameters.



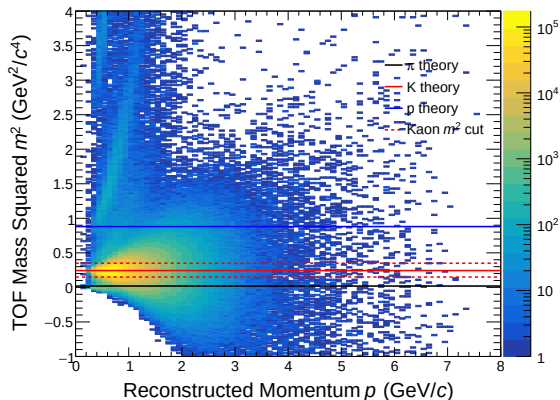
TOF Kinematics II: Mass Squared vs Momentum

Mass Squared Calculation

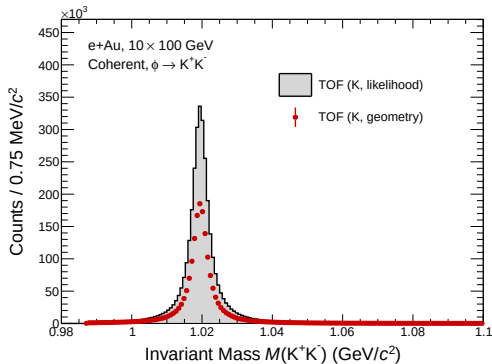
$$m^2 = p^2 \left(\frac{1}{\beta^2} - 1 \right)$$

Kaon Selection Window

- To identify kaons strictly from our geometric kinematics, we apply a mass-squared window.
- **Cut Range:** $0.15 \leq m^2 \leq 0.35 \text{ GeV}^2/c^4$ (indicated by red dashed lines).



Physics Performance: $\phi \rightarrow K^+ K^-$ Invariant Mass



- **Comparison:** Oppositely charged track pairs matched to TOF.

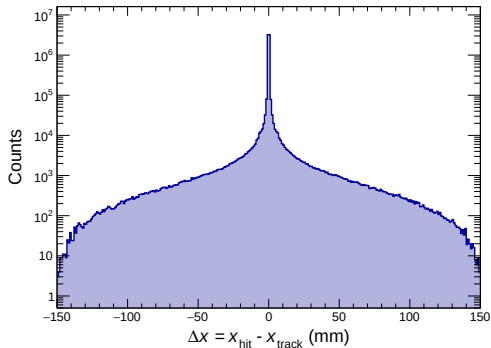
Summary & Outlook

- An independent geometric track-to-hit matching algorithm was successfully implemented for the TOF barrel.
- The direct extraction of hit times and path lengths yields accurate kinematic separation ($1/\beta$ and m^2) that closely follows theoretical expectations.
- **Outlook:** Further refine the geometric matching algorithm and use these verified kaons to study the diffractive $|t|$ distributions.

Thank you.

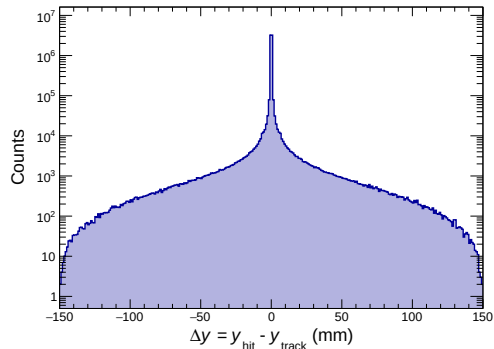
Appendix: Geometric Residuals (Δx , Δy)

Δx Residual



Distribution: $\Delta x = x_{\text{hit}} - x_{\text{track}}$.

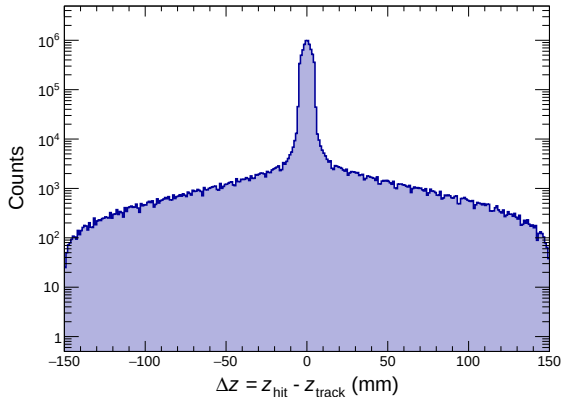
Δy Residual



Distribution: $\Delta y = y_{\text{hit}} - y_{\text{track}}$.

Appendix: Geometric Residuals (Δz)

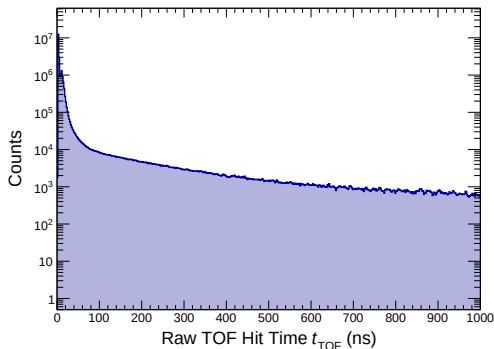
Δz (Longitudinal) Residual



- **Distribution:** $\Delta z = z_{\text{hit}} - z_{\text{track}}$.

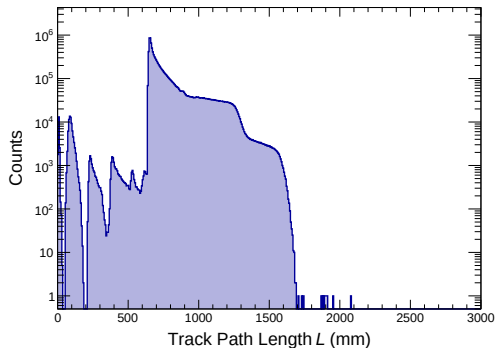
Appendix: Raw Kinematic Variables

Raw TOF Hit Time



Observable: t_{TOF} directly extracted from TOFBarrelRecHits.

Track Path Length



Observable: Path length L extracted directly from the geometrically matched TrackPoint.