Study of Purity in Pion Identification With and Without LTCC

CLAS Collaboration Meeting

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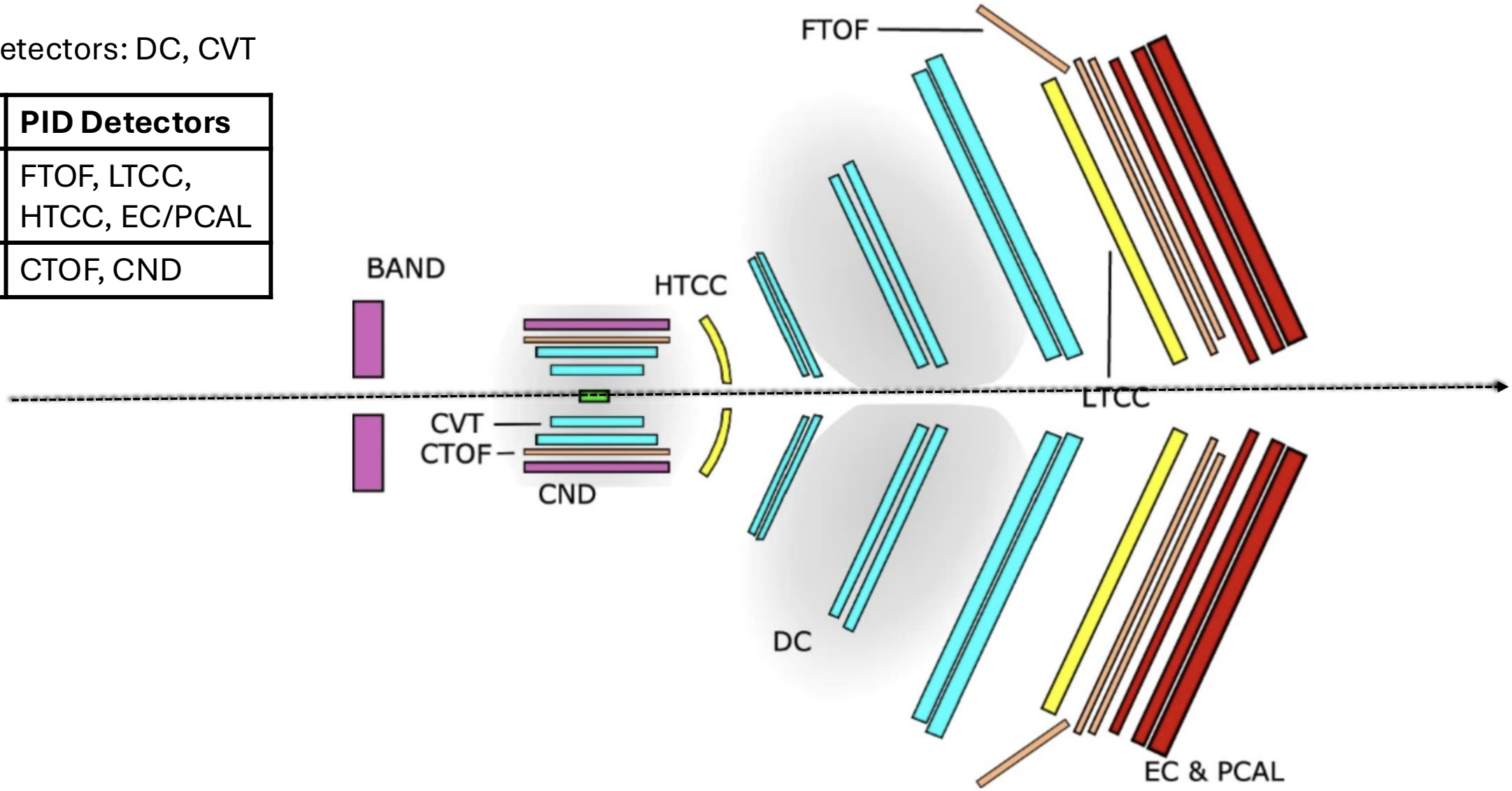
Outlook

1. **Particle Identification**
2. **Pion Efficiency & Contamination Studies**
3. **Summary and Outlook**
4. **Acknowledgement**

Particle Identification (PID)

Tracking Detectors: DC, CVT

	PID Detectors
Forward	FTOF, LTCC, HTCC, EC/PCAL
Central	CTOF, CND



P.S.: FT is not used in RG-D

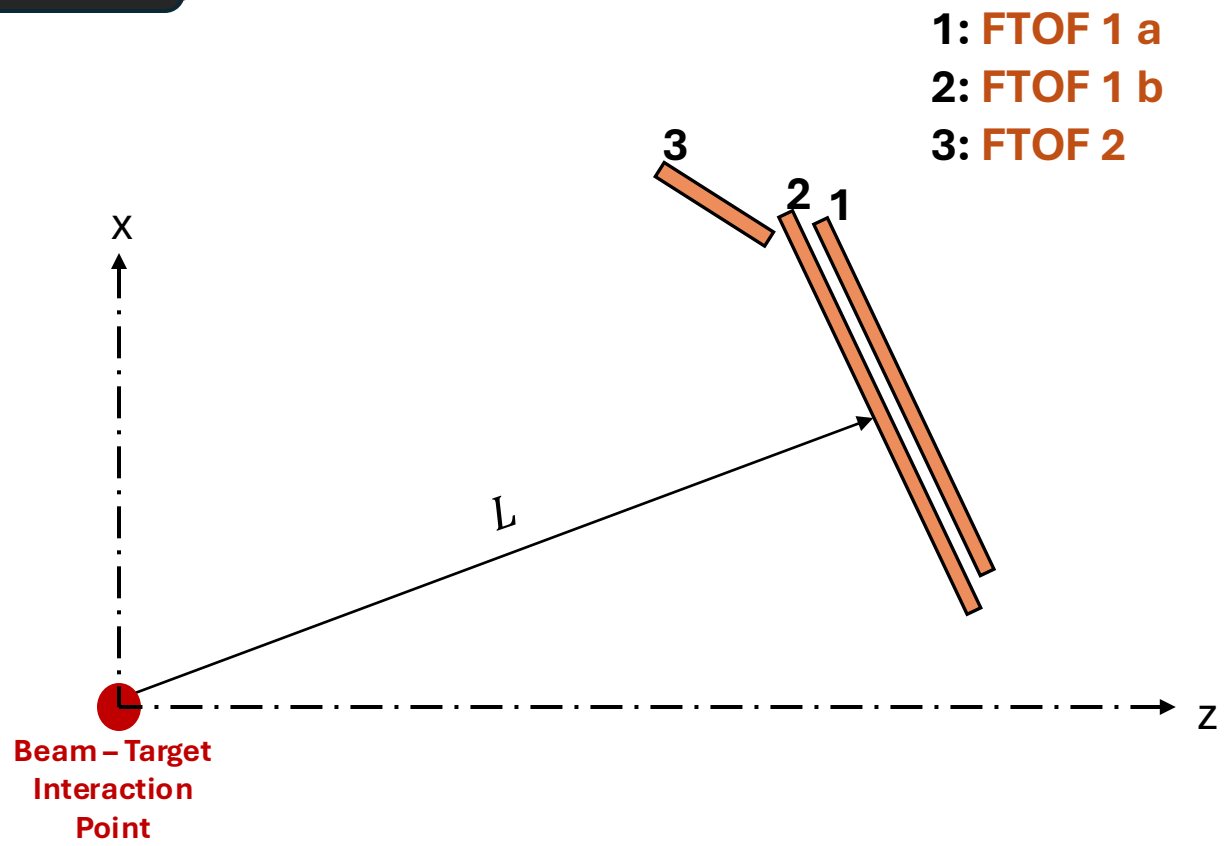
Image credit: https://doi.org/10.1140/epja/s10050-023-01117-1

Forward Time of Flight (FTOF) : π^+ identification

$$\Delta t_{\pi^+} = \left(t_{hit}^{FTOF} - \frac{L}{\beta_{\pi^+}(p) \times c} \right) - t_{\text{start time}}$$

where, $\beta_{\pi^+}(p) = \frac{p}{\sqrt{p^2 + m_{\pi^+}^2}}$

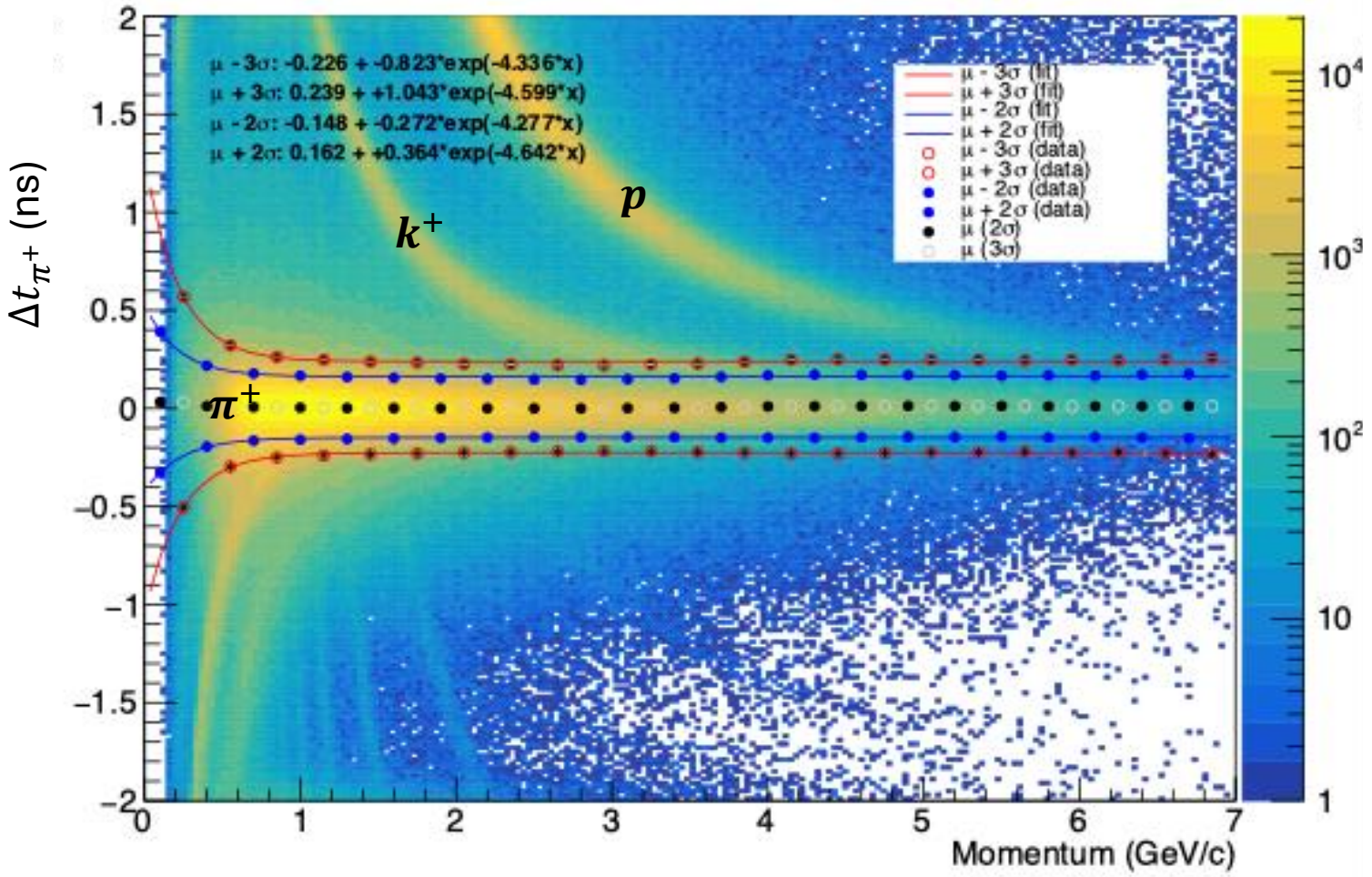
t_{hit}^{FTOF}	FTOF hit time of any +ve track
L	Path length from vertex to FTOF
p	Momentum
$\beta_{\pi^+}(p)$	Theoretical pion speed from 'p'
m_{π^+}	Mass of charged pion (0.13957 GeV/c)
c	Speed of light (29.97924 cm/ns)
$t_{\text{start time}}$	Particle's start time (RF-corrected)



π^+ Identification Cont'd

Experiment	RG-D
Target	Dual carbon foils (CxC)
Beam Energy	10.5 GeV
Trigger e^- selecton	• EB PID : 11 • Status < 0 • Forward Detector • |chi2pid| < 5 • Vz : [-10.56, 5] cm
π^+ candidate selection	• charge > 0 • Forward Detector • Δt_{π^+} cut • LTCC cut : nphe > 0

$$\Delta t_{\pi^+} = \left(t_{hit}^{FTOF} - \frac{L}{\beta_{\pi^+}(p) \times c} \right) - t_{\text{start time}}$$

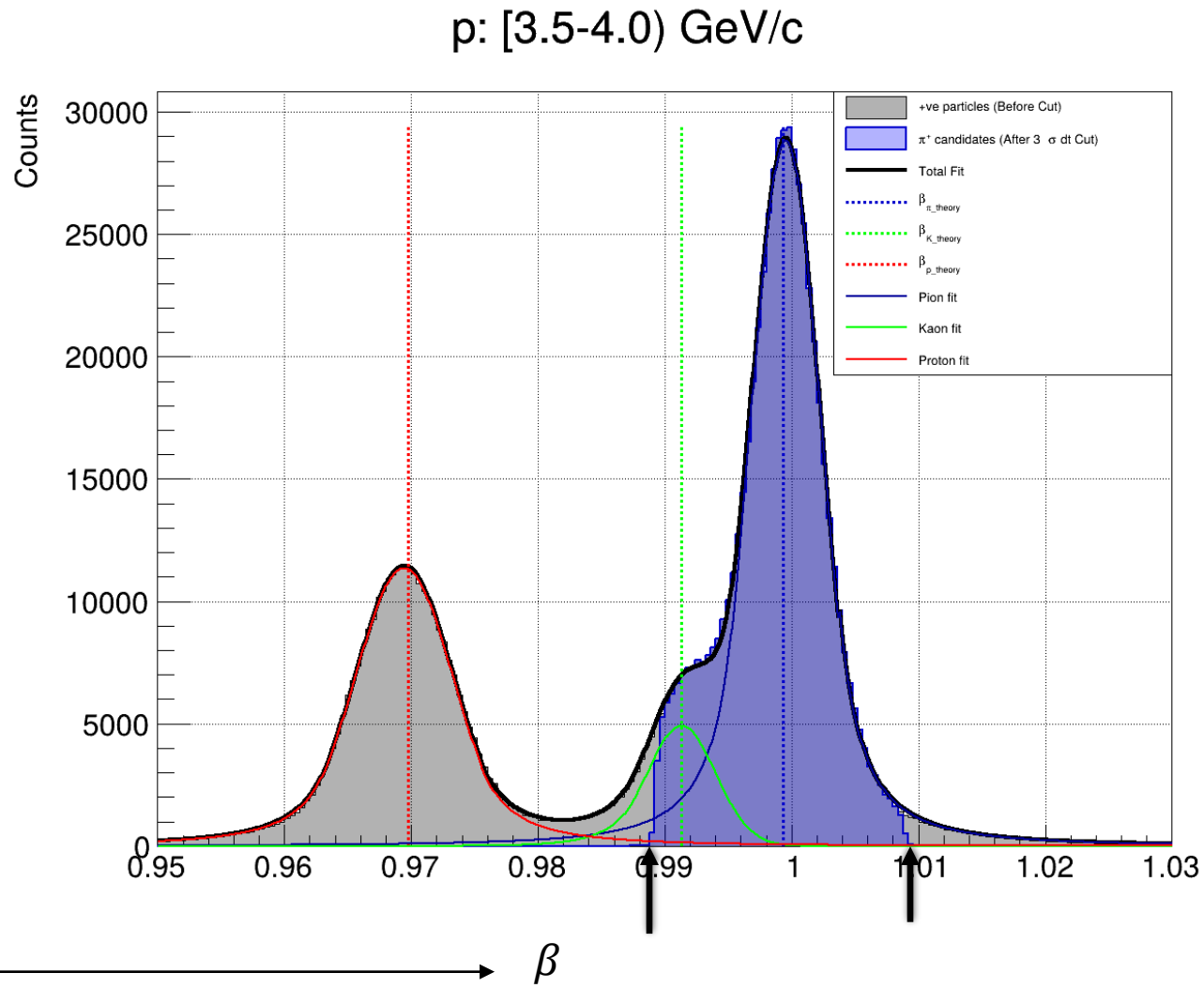


Δt for all positively charged particles under the pion hypothesis

π^+ Efficiency and Contamination: Data-driven (Experimental)

- **Pion efficiency** = (Number of π^+ surviving the selection cut) / (Total number of π^+ before the cut)
- **Kaon (or Proton) contamination** = (Integral of kaons/protons inside the π^+ timing-cut window) / (Total integral inside the π^+ timing-cut window)

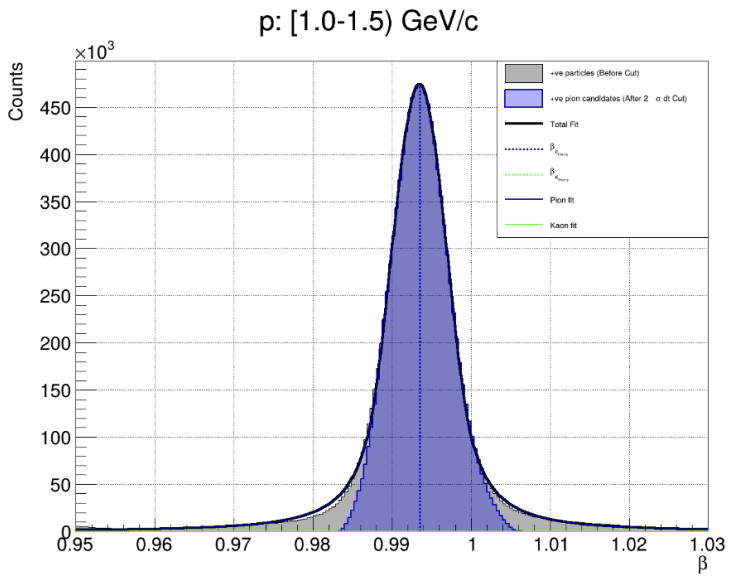
$$\text{Reconstructed } \beta = \frac{\text{L}}{\left(t_{hit}^{FTOF} - t_{\text{start time}}\right) \times c}$$

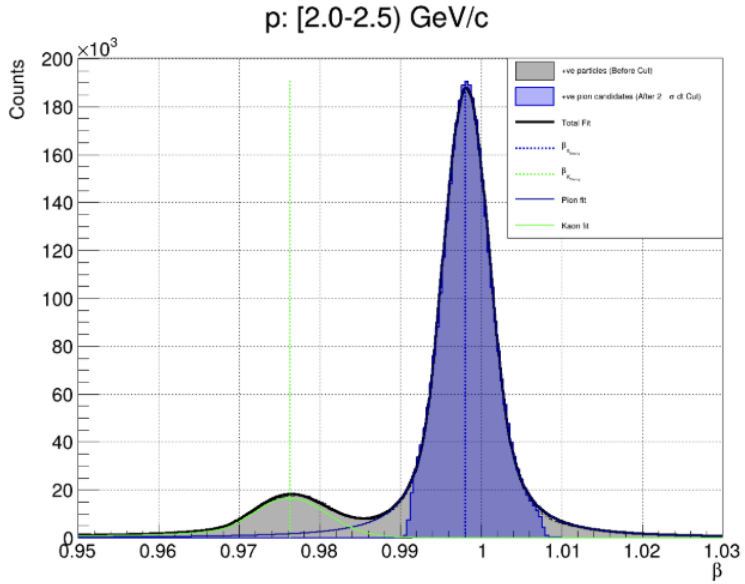


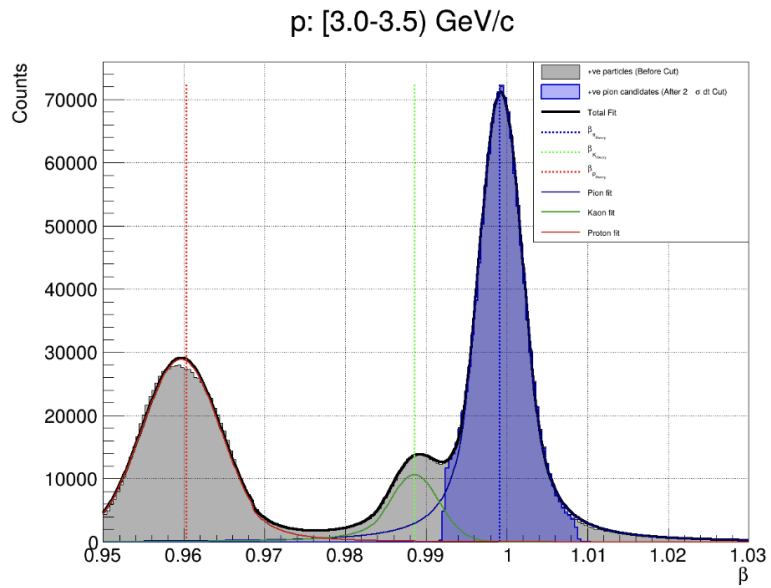
π^+ Efficiency and Contamination Cont'd

Momentum Range : [1.0 - 3.5) GeV/c

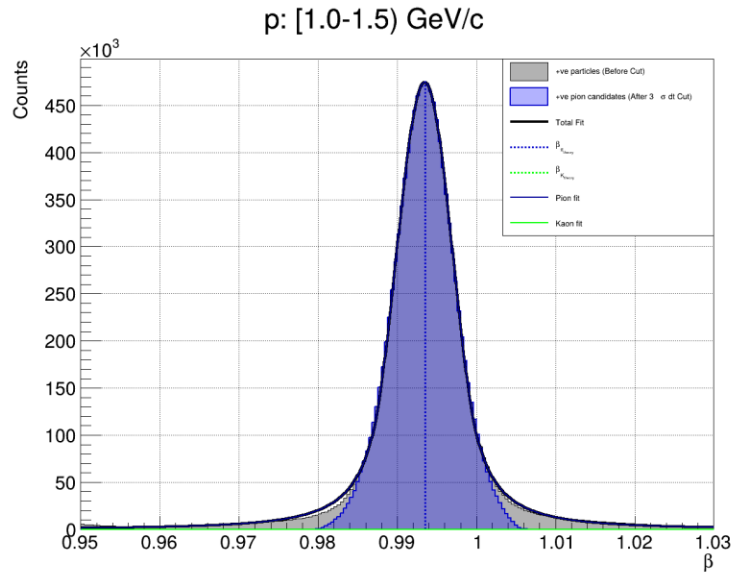
$2\sigma : \Delta t_{\pi^+}$ cut

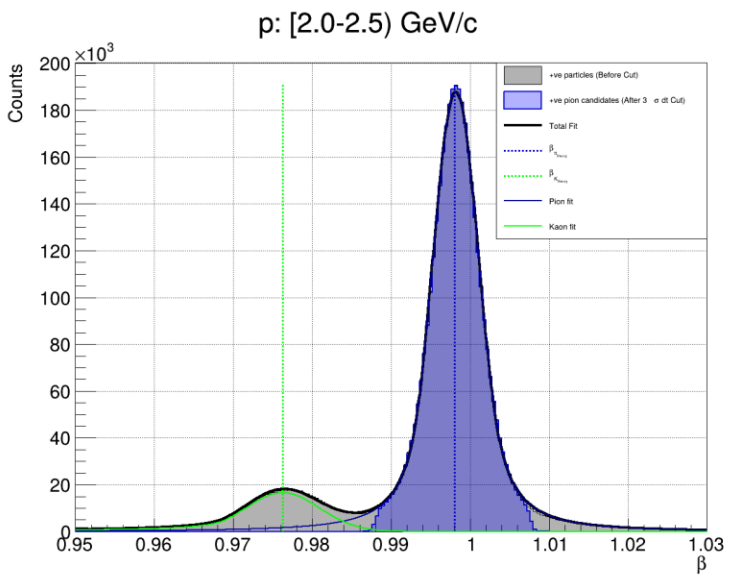


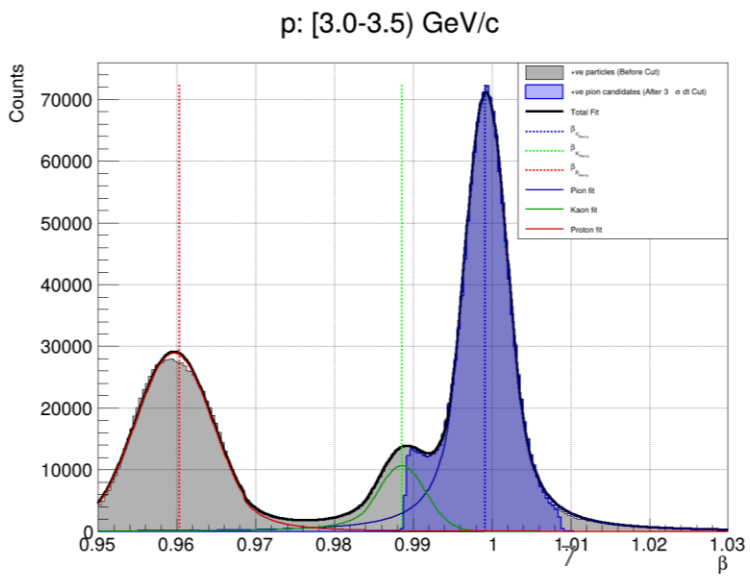




$3\sigma : \Delta t_{\pi^+}$ cut

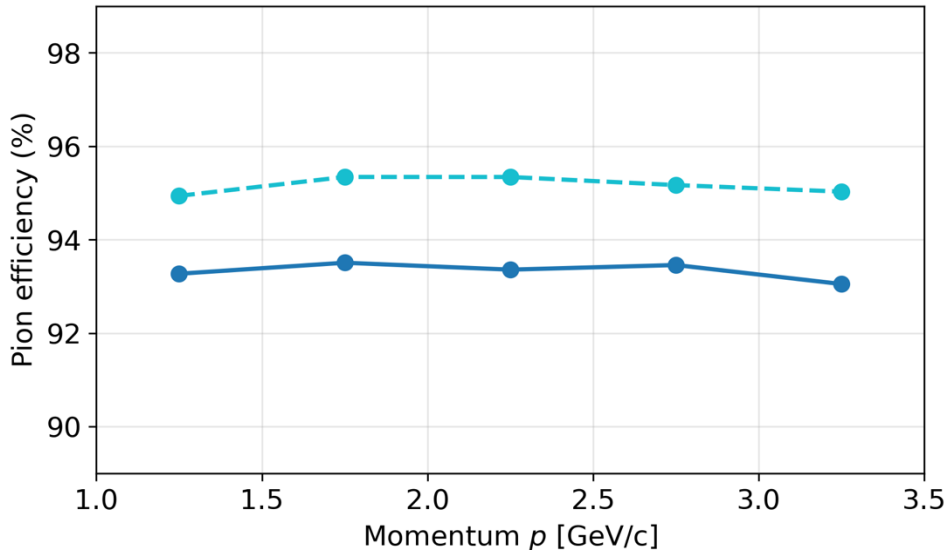


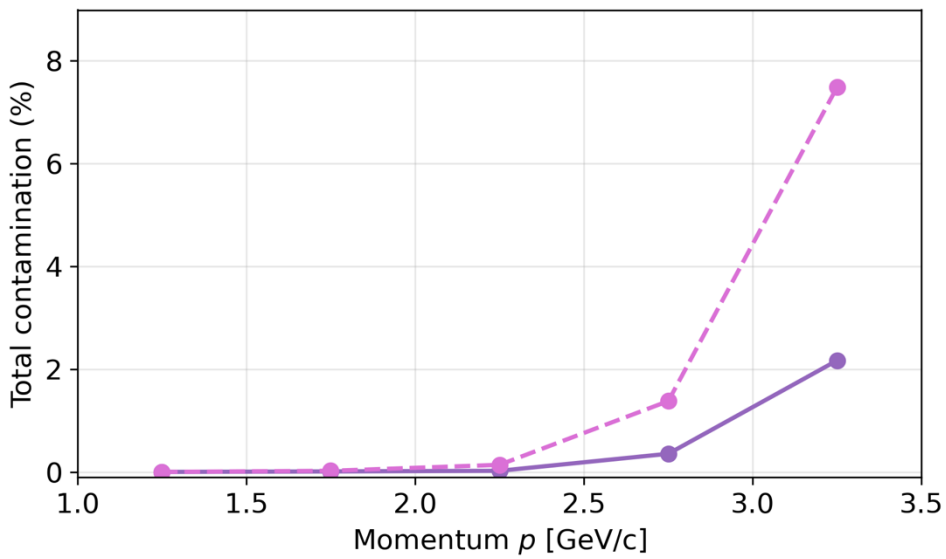




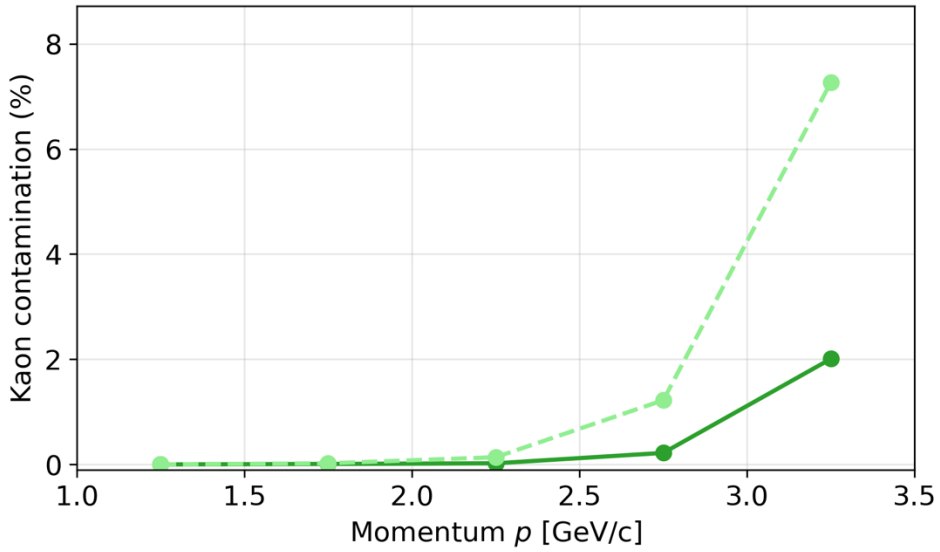
π^+ Efficiency and Contamination Cont'd

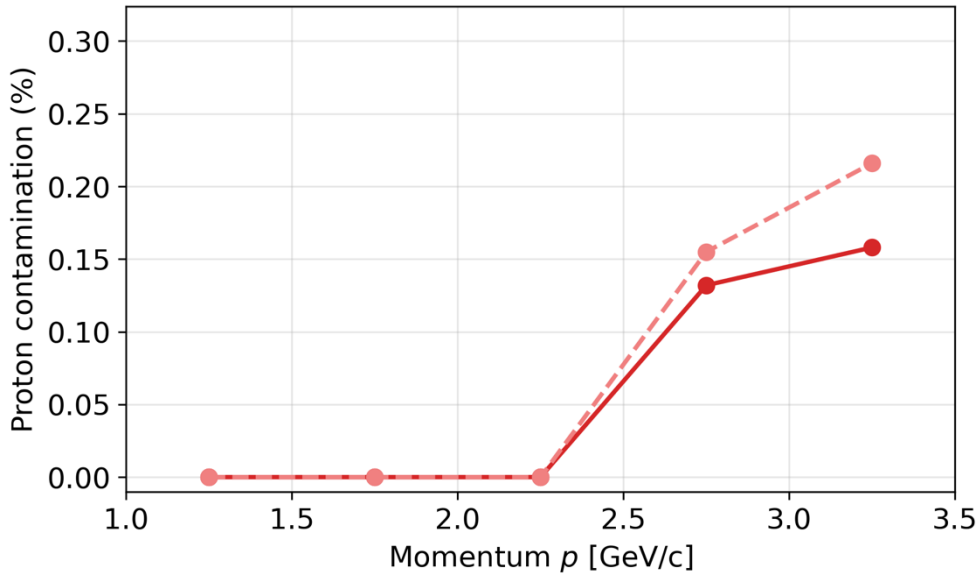
- ✓ Momentum Range : [1.0 - 3.5) GeV/c
- ✓ Only Δt_{π^+} cut; No LTCC





- ● Only Δt_{π^+}
- ------- 3σ cut
- ——— 2σ cut





π^+ Efficiency and Contamination Cont'd

Momentum Range : [3.5 - 6.5) GeV/c

- ✓ Momentum Range : [3.5 - 6.5) GeV/c
- ✓ Both FTOF and LTCC has been used
- ✓ Since LTCC is installed only in sectors 2, 3, 5, and 6, only these four sectors are used in this part of the study.

LTCC redesigned for π^+/π^- identification above ~3.5 GeV

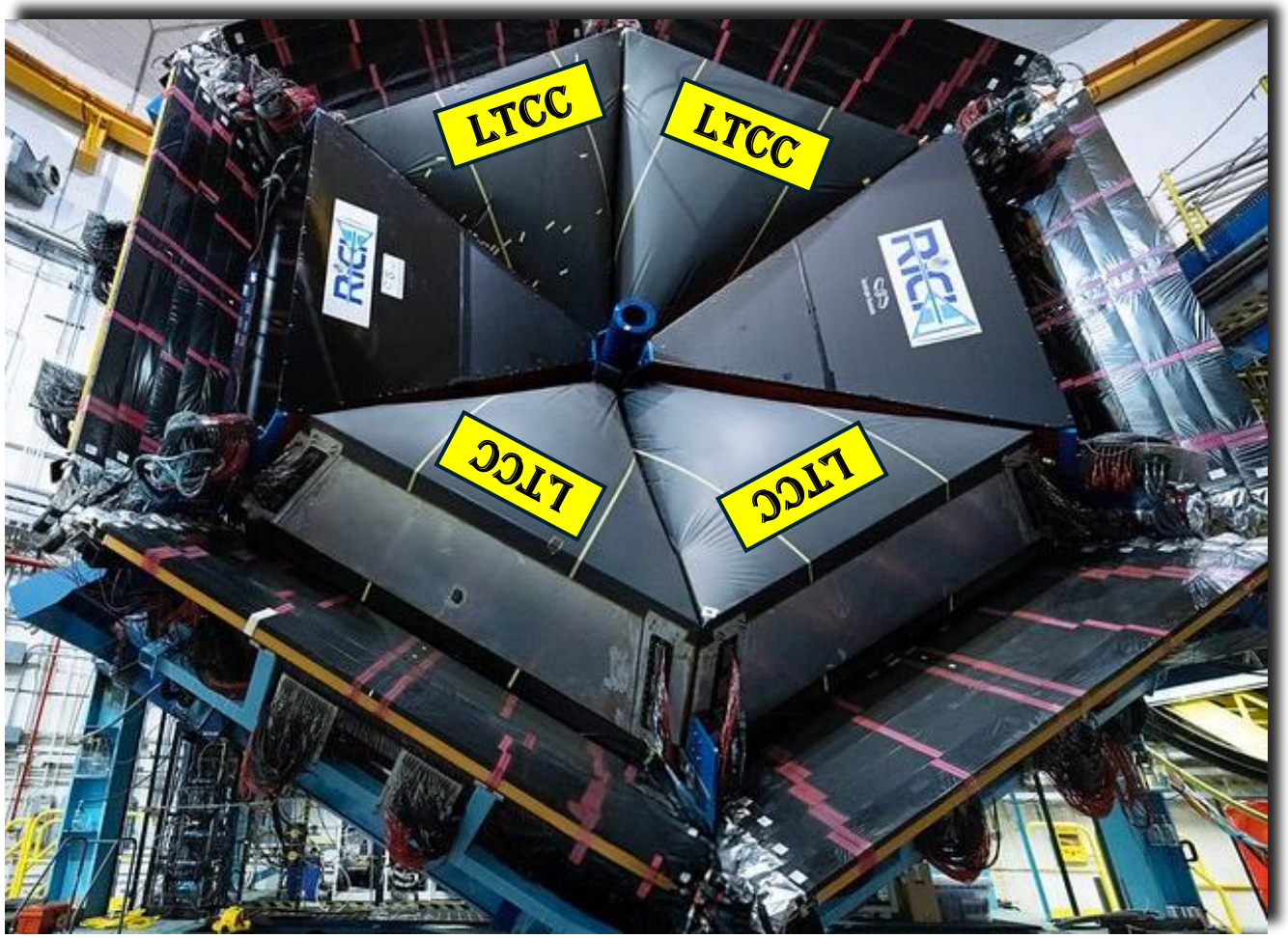
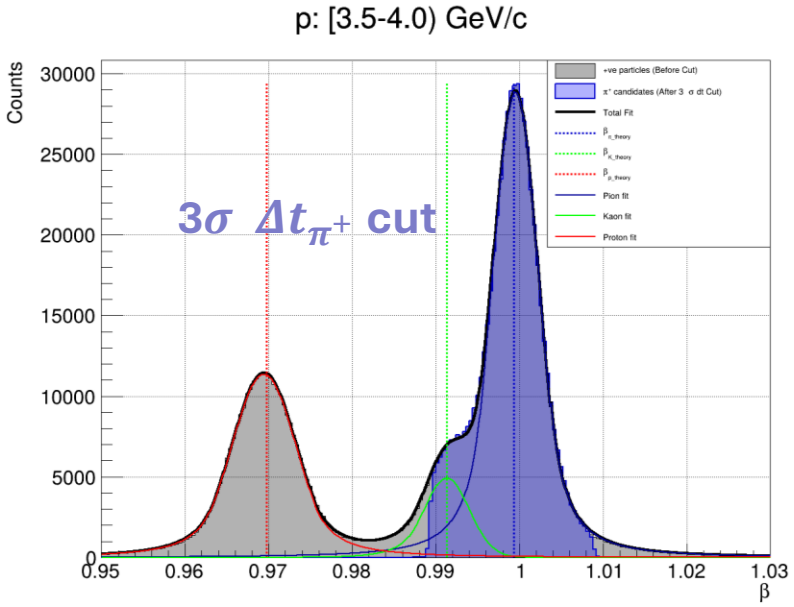
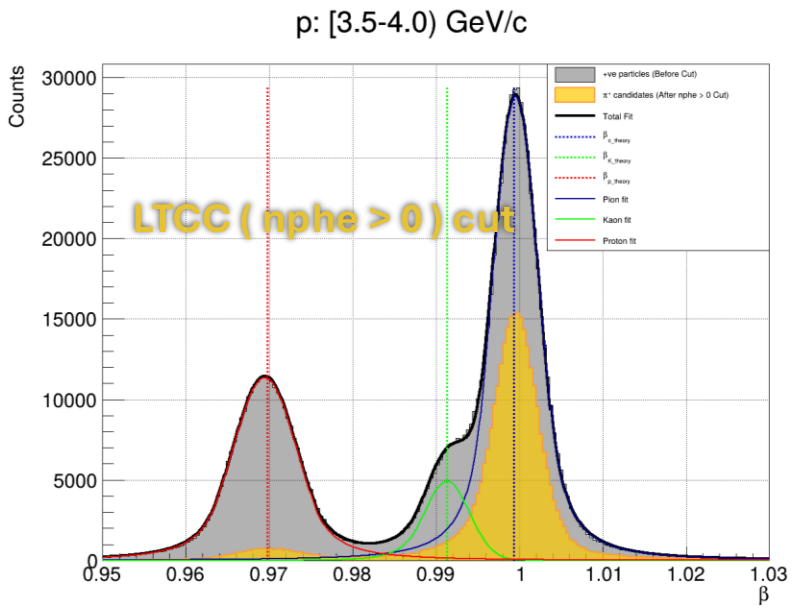
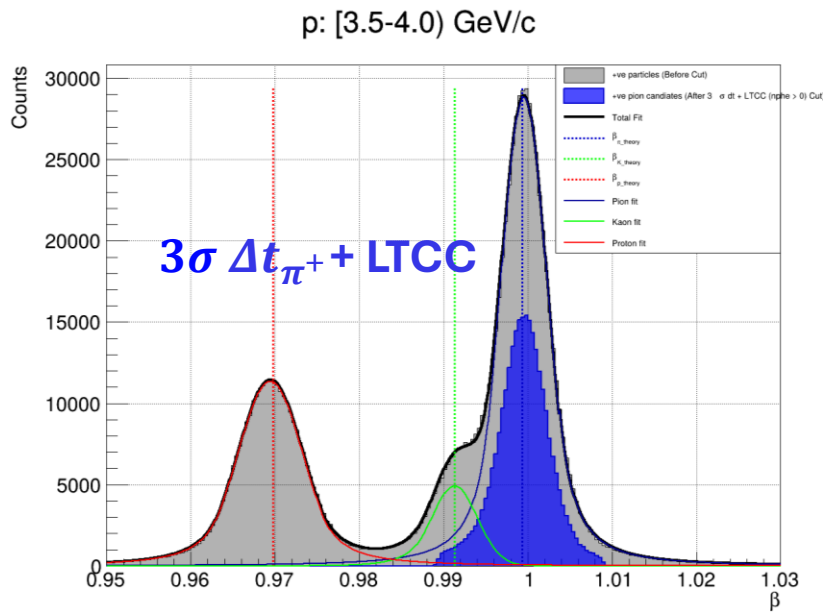


Image credit: Jlab.org/news

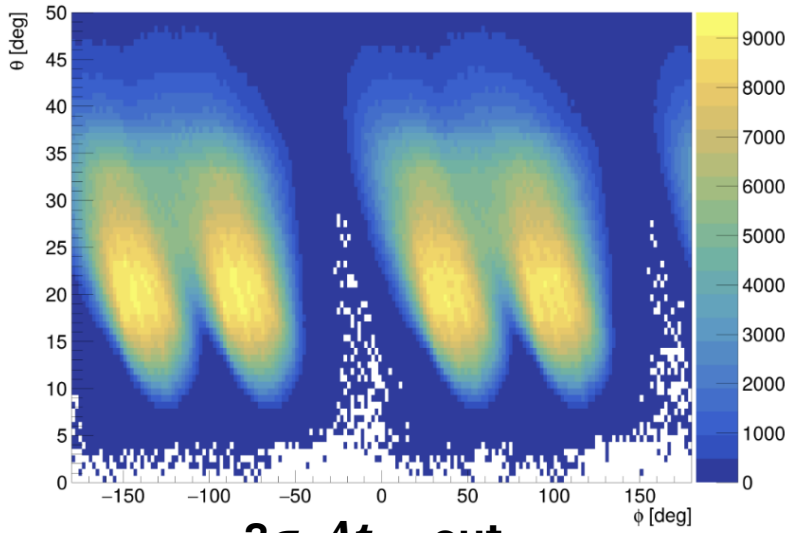
π^+ Efficiency and Contamination Cont'd



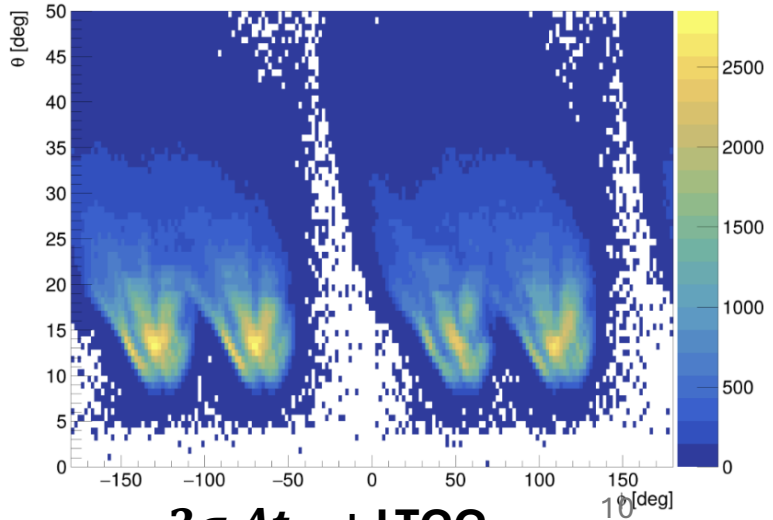




- ✓ The β plots shown correspond to the momentum bin [3.5–4.0).
- ✓ Similar studies have been performed for the other bins: [4.0–4.5), [4.5–5.0), [5.0–5.5), [5.5–6.0), and [6.0–6.5).

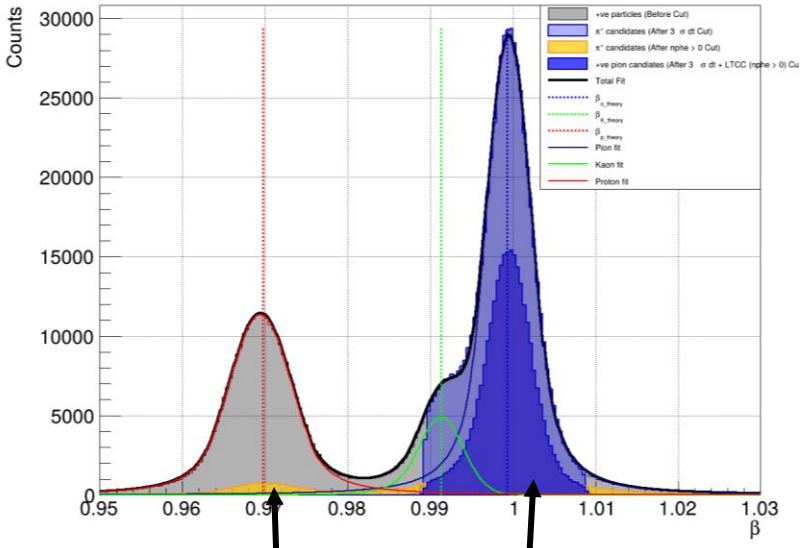


$3\sigma\ \Delta t_{\pi^+}$ cut

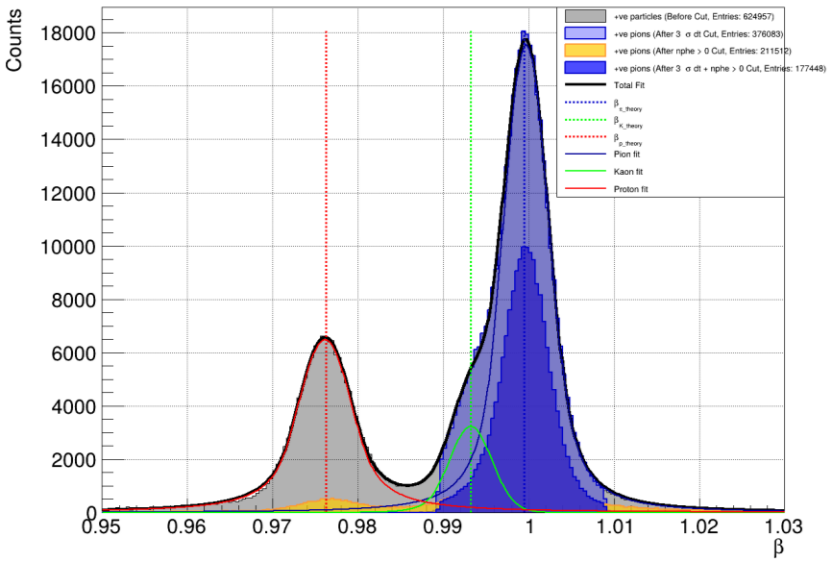


$3\sigma\ \Delta t_{\pi^+}$ + LTCC

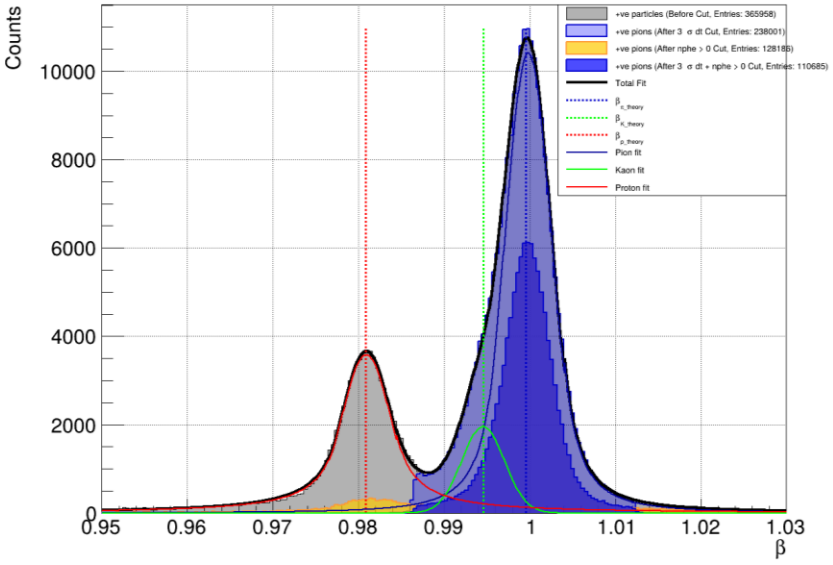
p: [3.5-4.0) GeV/c



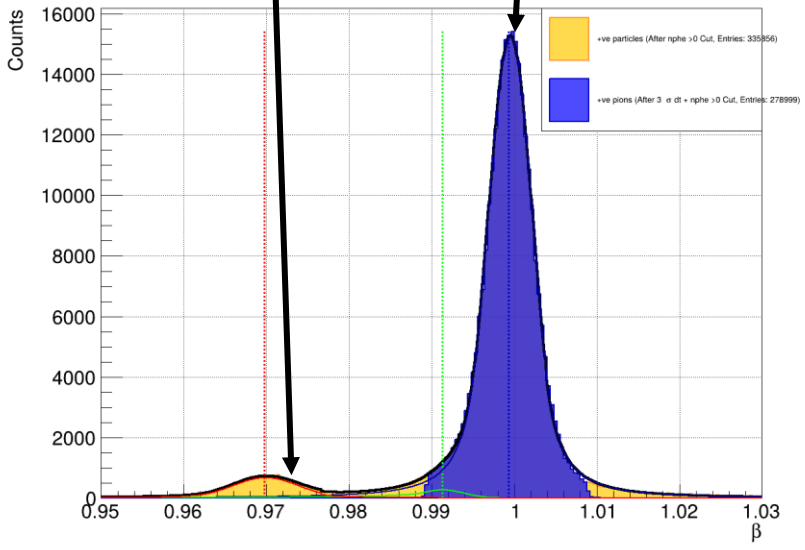
p: [4.0-4.5) GeV/c



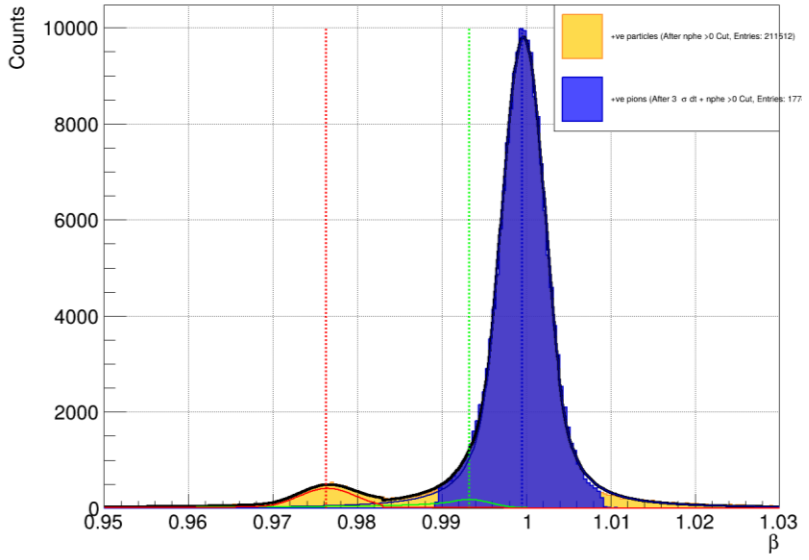
p: [4.5-5.0) GeV/c



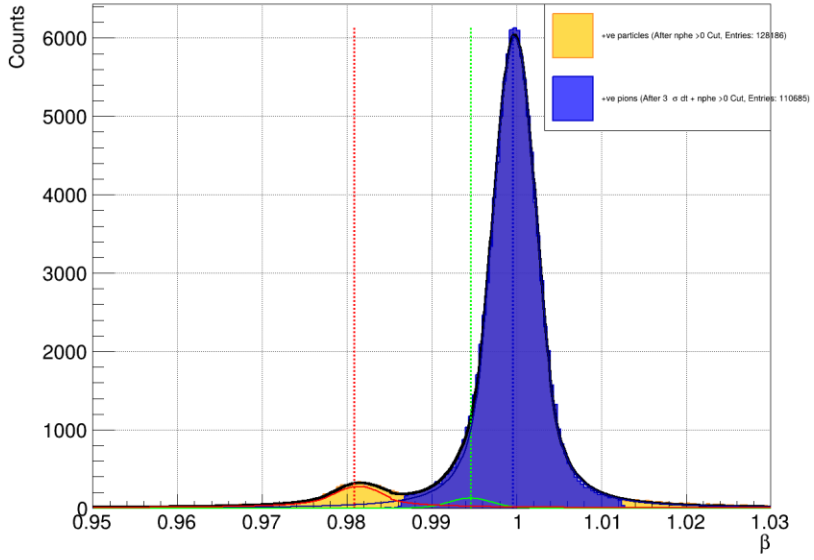
p: [3.5-4.0) GeV/c



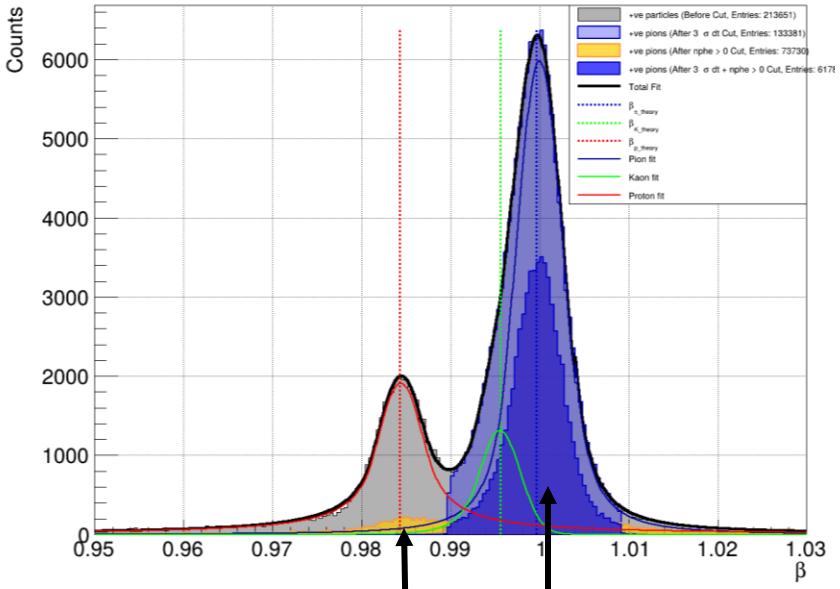
p: [4.0-4.5) GeV/c



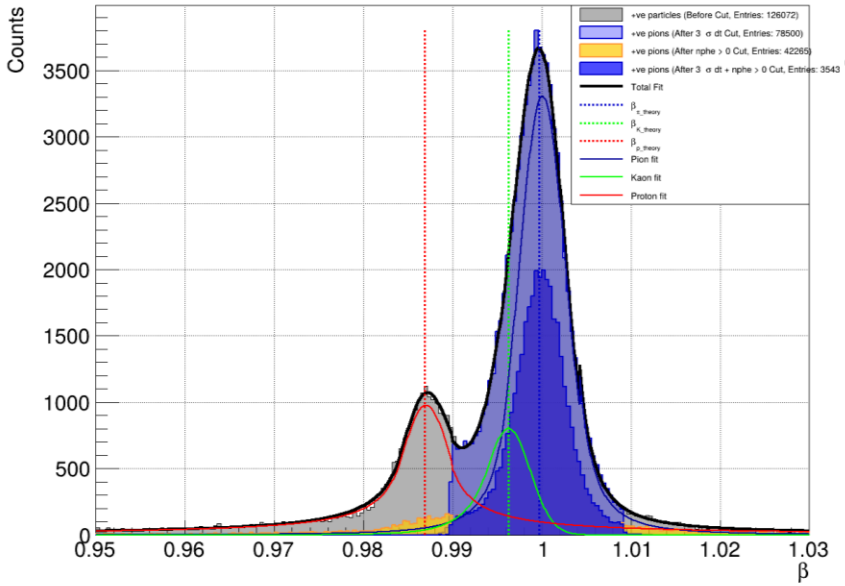
p: [4.5-5.0) GeV/c



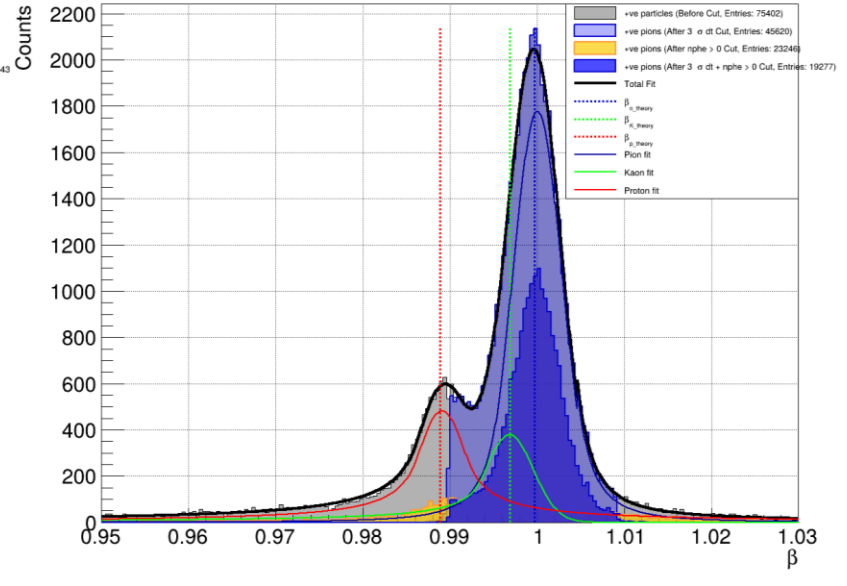
p: [5.0-5.5) GeV/c



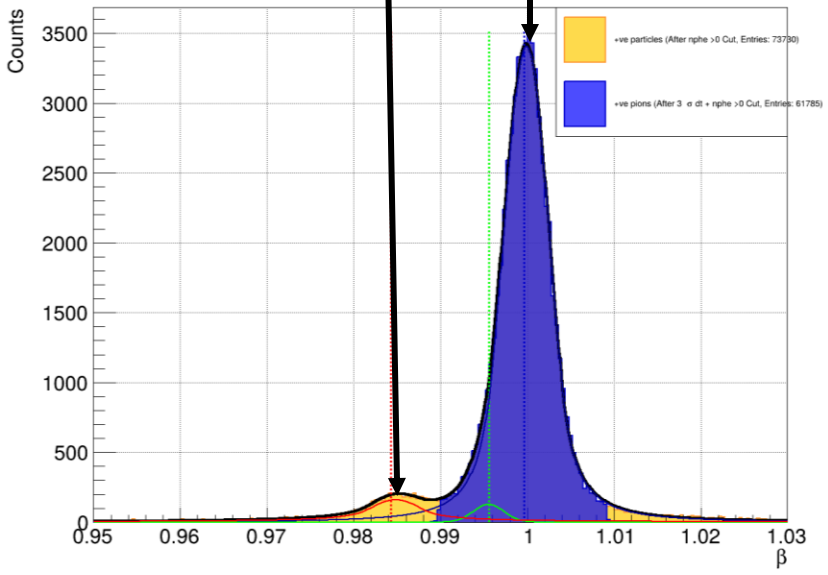
p: [5.5-6.0) GeV/c



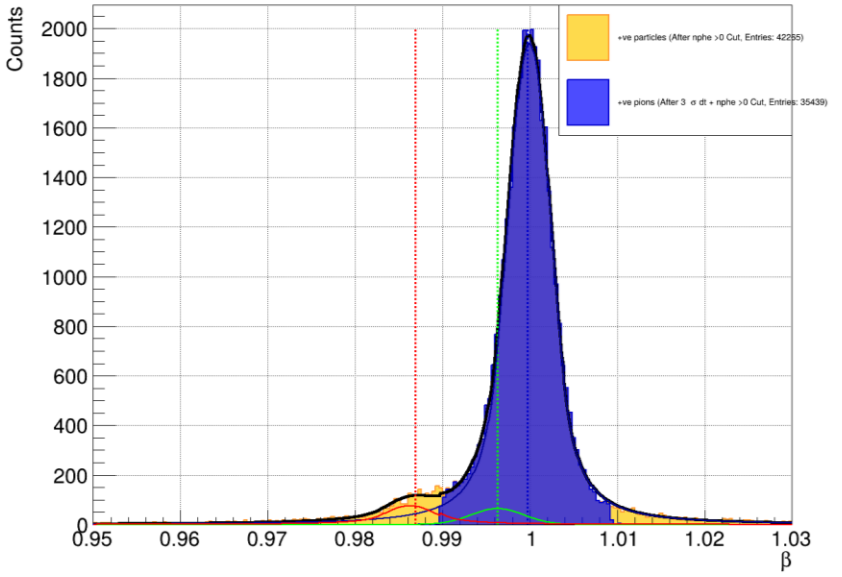
p: [6.0-6.5) GeV/c



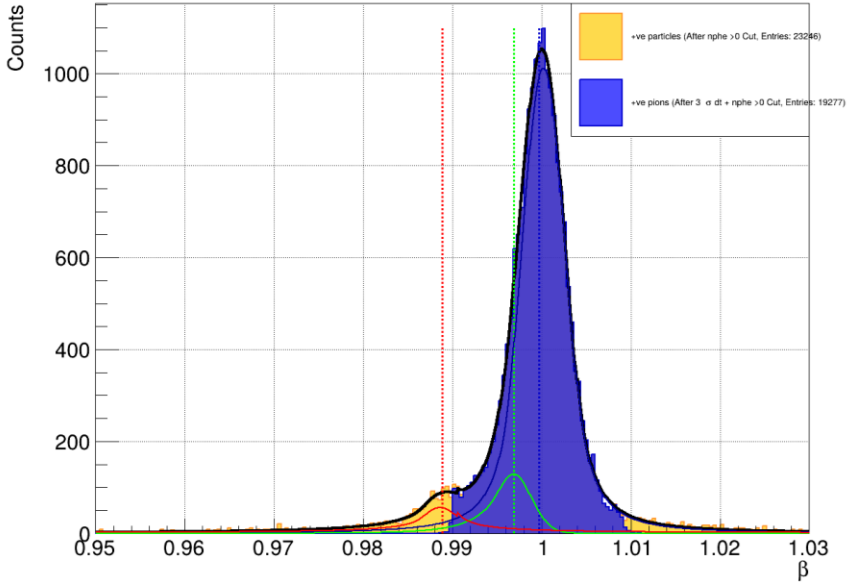
p: [5.0-5.5) GeV/c



p: [5.5-6.0) GeV/c



p: [6.0-6.5) GeV/c



π^+ Efficiency and Contamination Cont'd

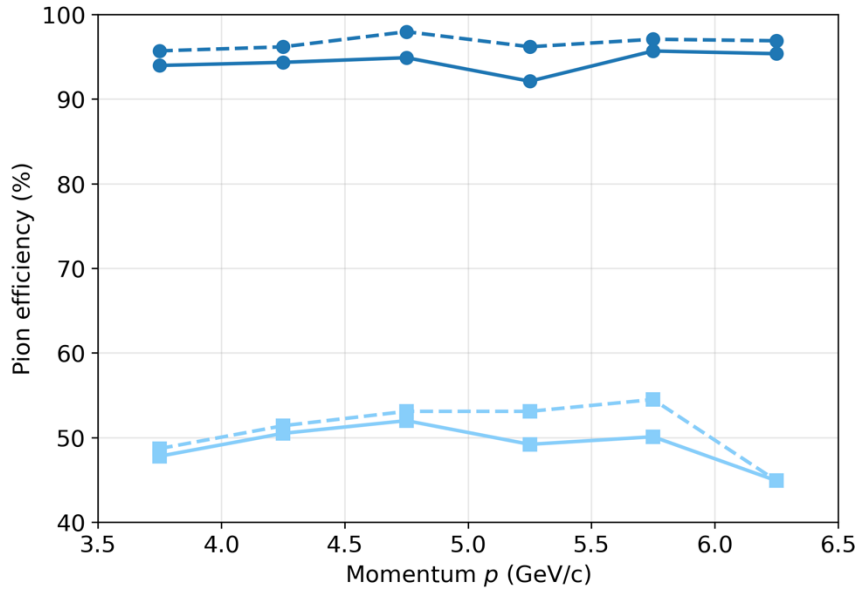
- ✓ Momentum Range : [3.5 - 6.5) GeV/c
- ✓ Δt_{π^+} cut; With LTCC cut

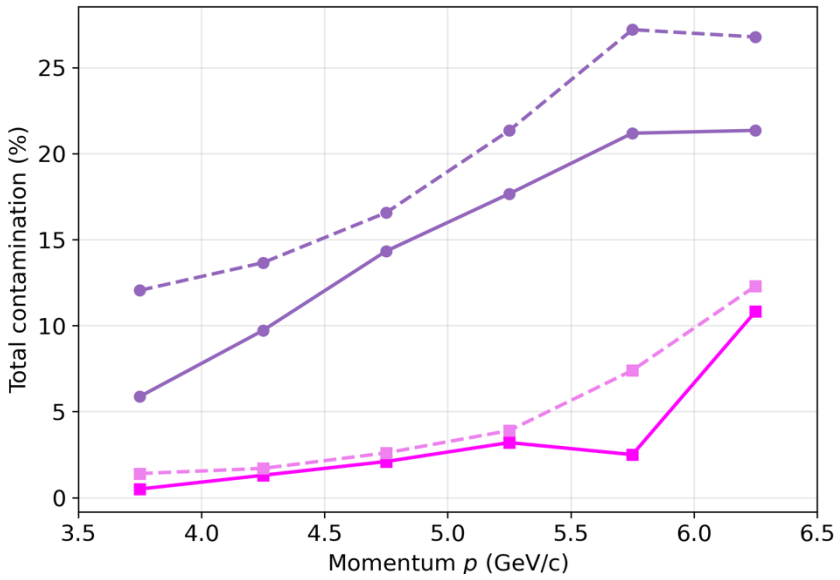
● Only Δt_{π^+}

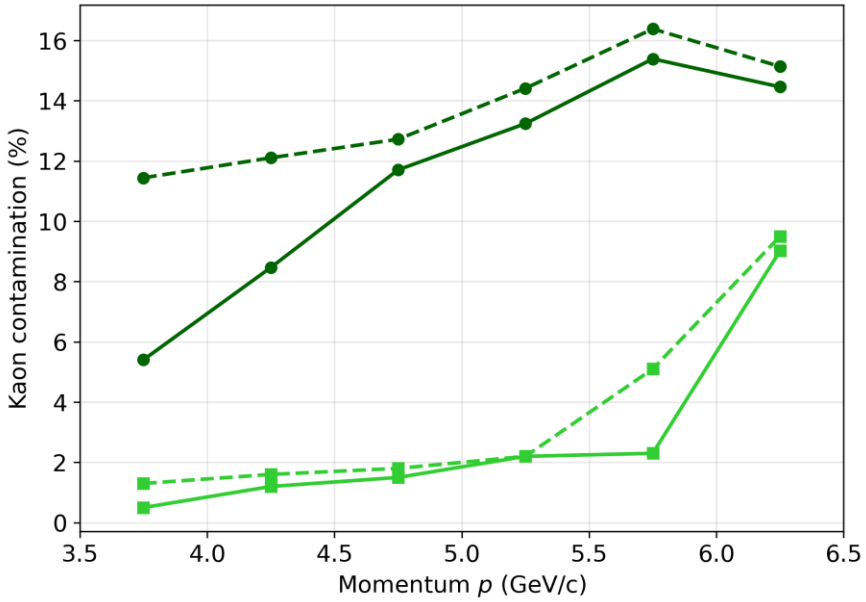
■ Δt_{π^+} + LTCC

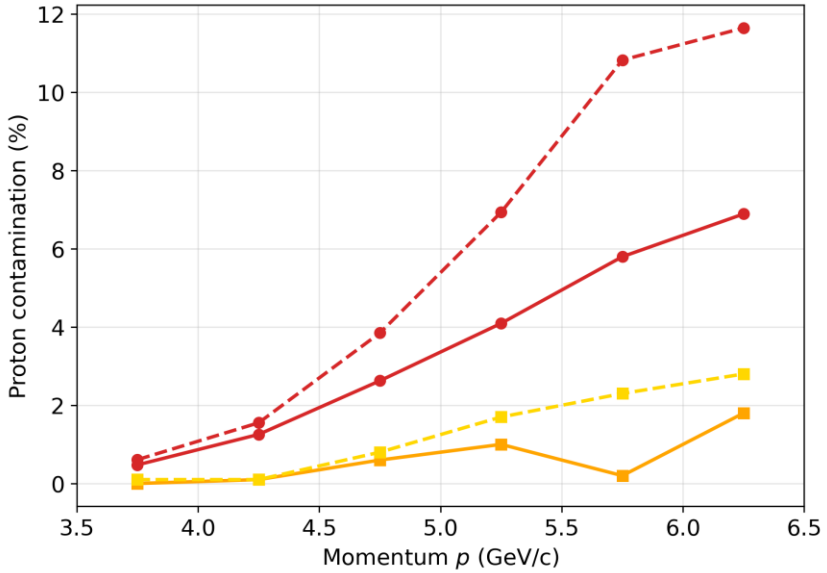
------- 3σ cut

——— 2σ cut









Summary and Outlook

- ✓ The π^+ efficiency and contamination study has been done for 1–3.5 GeV/c using only the FTOF timing cuts, and for 3.5–6.5 GeV/c using the FTOF timing together with the LTCC.
- ✓ Results will guide the choice of PID cuts and systematics evaluation.
- ➢ **Next:** finalize the PID cuts and apply them to RG-D data

Acknowledgement

Thank
You