Simulation of Track and Event Realistic Reconstruction of Cascade Hyperons at PANDA

Vitor Jose SHEN

Computing Session at
PANDA Collaboration Meeting

Tuesday, June 13, 2023

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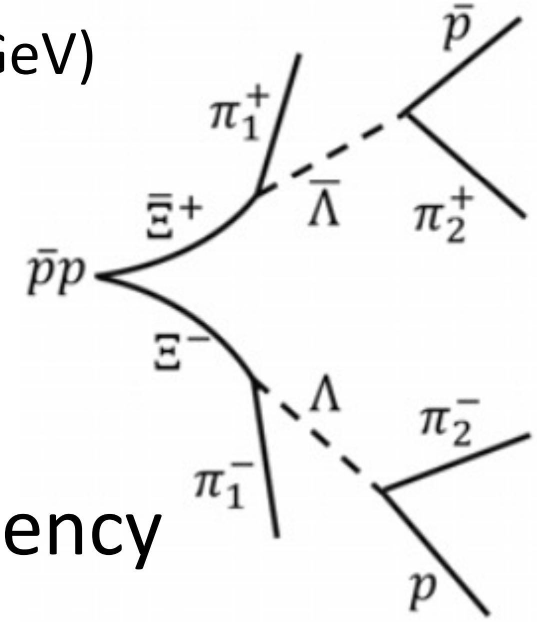
Simulation of Track and Event Realistic Reconstruction of Cascade Hyperons at PANDA*

V. J. SHEN

- $\bar{p}p \rightarrow \bar{\Xi}^{+}\,\Xi^{-} \rightarrow \bar{\Lambda}\pi^{+}\,\Lambda\pi^{-} \rightarrow \bar{p}\pi^{+}\pi^{+}\,p\pi^{-}\pi^{-}$
  - Previous simulation studies at only 2 $\bar{p}$ beam momenta (4.6, 7 GeV)
  - Extend to production threshold and several excess energies
  - the lightest hyperons to introduce a sequential decay

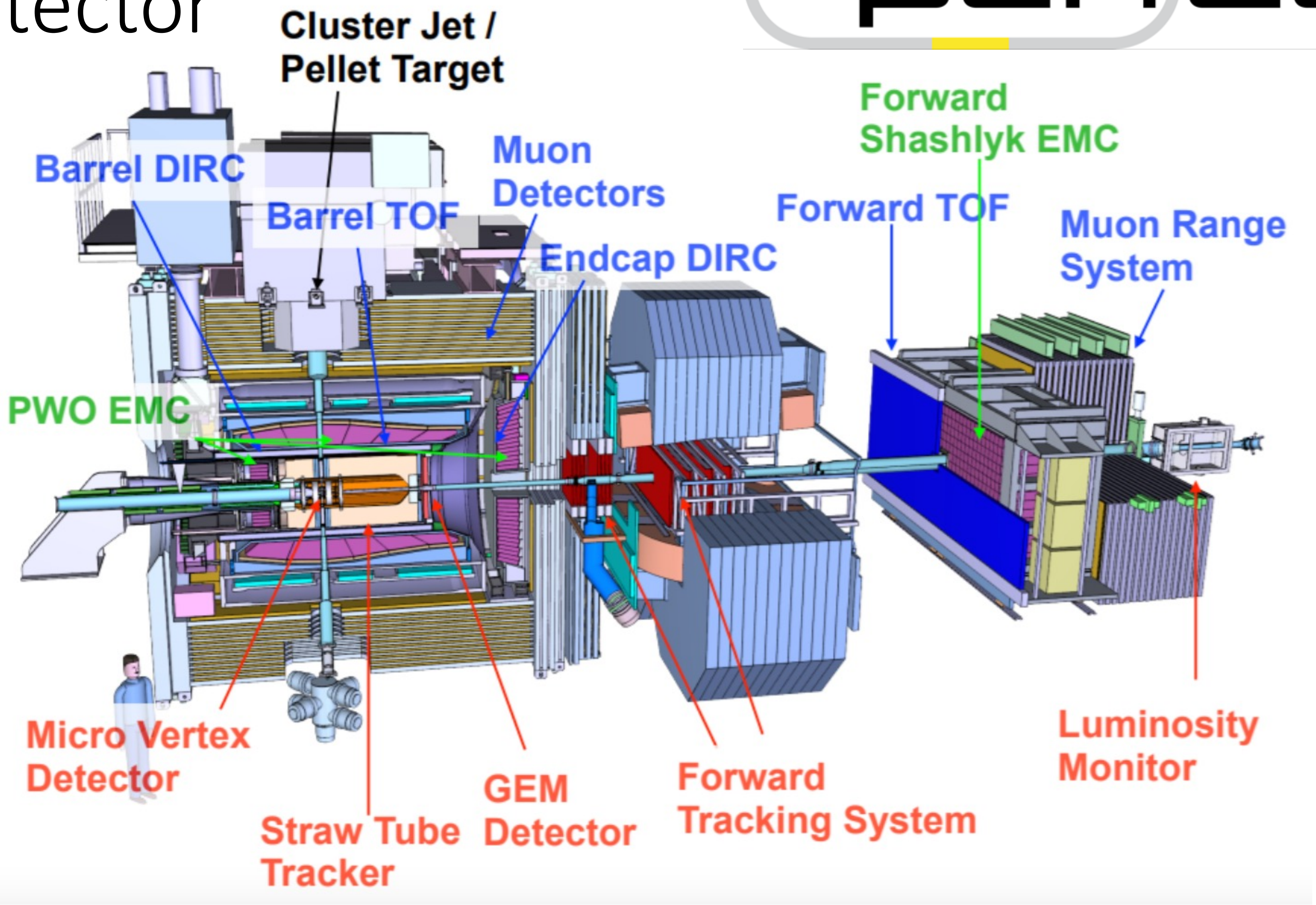


- PandaRoot (Simulation and analysis software of PANDA)
- Track Findings Evaluation and Reconstruction Efficiency
- Realistic Reconstruction Algorithms vs. Ideal Reconstruction

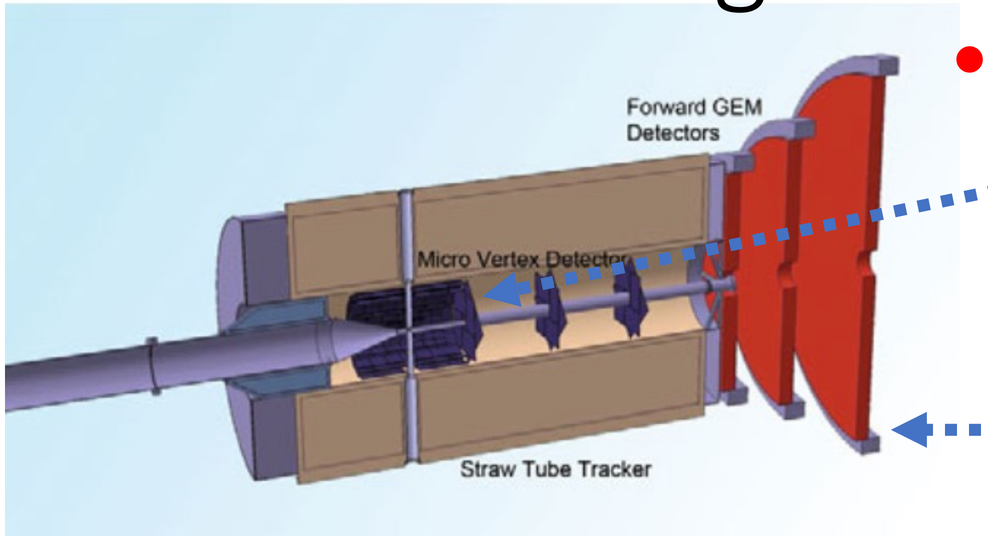
* My M.Sc. degree project at Uppsala University, supervised by Michael Papenbrock

PANDA Detector

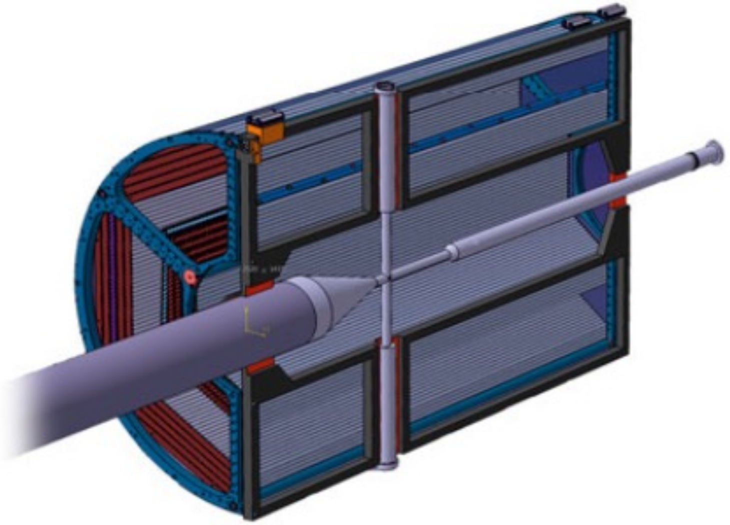
- Trackings
- PIDs
- EM Calorimeters
- Target

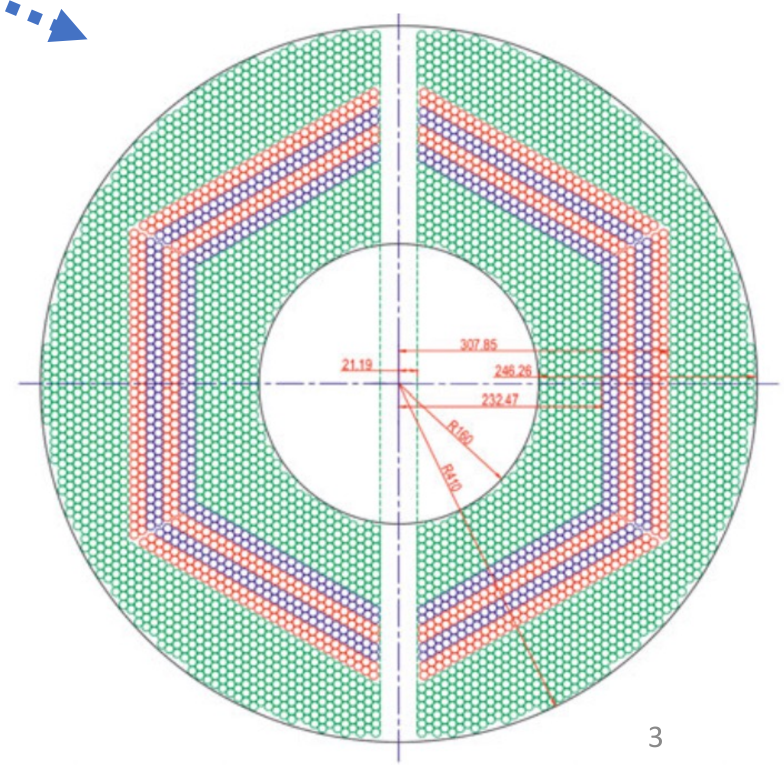


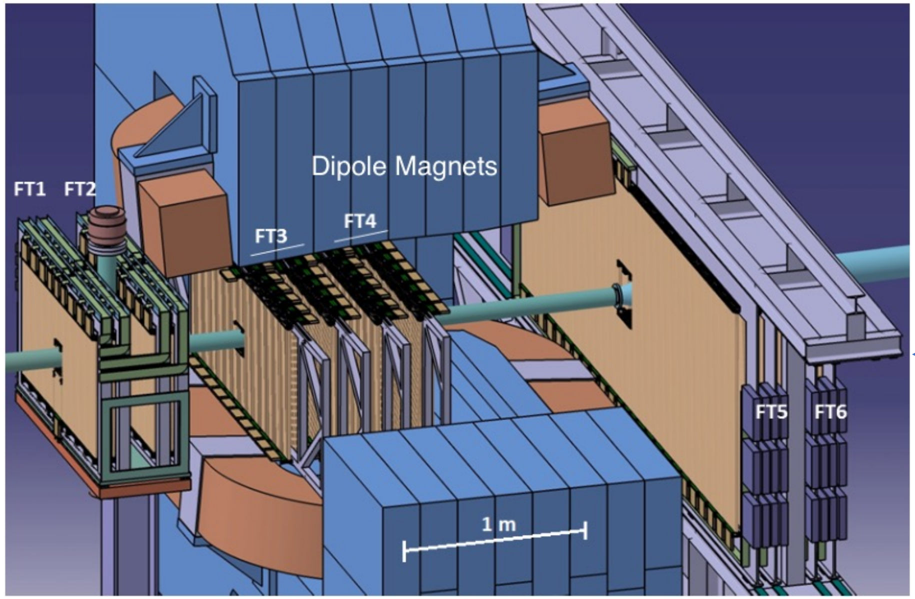
PANDA tracking detectors



- TS
  - MVD
  - STT
  - GEM







- FS
  - Forward Tracking System

(Some of the)Track Finders in PandaRoot

- ***Ideal Track Finder***
- ***Barrel Track Finder***
- **(STT) Cell Track Finder**
- **Hough Track Finder**
- **Apollonius Triplet Track Finder**
- ***Pz Finder***
- ***FTS Track Finder***

(Some of the)Track Finders in PandaRoot

Target Spectrosmeter (TS)		
Realistic	Primary	Secondary
3D	**Barrel Track Finder** Hough Track + Pz Finder	Cell Track + Pz Finder Apollonius Triplet Track + Pz Finder
2D	**Hough Track Finder**	Cell Track Finder **Apollonius Triplet Track Finder**

Forward Spectrosmeter (FS)
Realistic 3D
FTS Track Finder

Ideal Track Finder → ***Track Evaluation (Quality Assurance, QA)*** → **Event Reconstruction**

- Threshold production of Ξ+Ξ-

E_CM (GeV)	2.644
p_beam (GeV/c)	2.624

- Previous simulation studies:

Excess energy (MeV)	607	1231
E_CM (GeV)	3.251	3.875
p_beam (GeV/c)	4.6	7

- Excess energies above the production threshold at 1, 2, 3, 4, 5, 10, 15, 20 MeV:

Excess energy (MeV)	1	2	3	4
E_CM (GeV)	2.645	2.646	2.647	2.648
p_beam (GeV/c)	2.627	2.630	2.633	2.636
Excess energy (MeV)	5	10	15	20
E_CM (GeV)	2.649	2.654	2.659	2.664
p_beam (GeV/c)	2.639	2.654	2.669	2.684

Tracking QA at p_{beam}= 2.624GeV

- Hits Findings
- Ideal Tracks per Events
- The Ideal (Transverse, Longitude, and Total) Momentum
- The Transverse Momentum Resolution
- The Relative Transverse Momentum Resolution
- The Longitudinal Momentum Resolution
- The Relative Longitudinal Momentum Resolution
- The Total Momentum Resolution
- The Relative Total Momentum Resolution
- Track Efficiency vs. Transverse Momentum
- Track Efficiency vs. Longitudinal Momentum
- Track Efficiency vs. Total Momentum
- Track Efficiency vs. ϑ
- Track Efficiency vs.φ
- Quality of Tracking

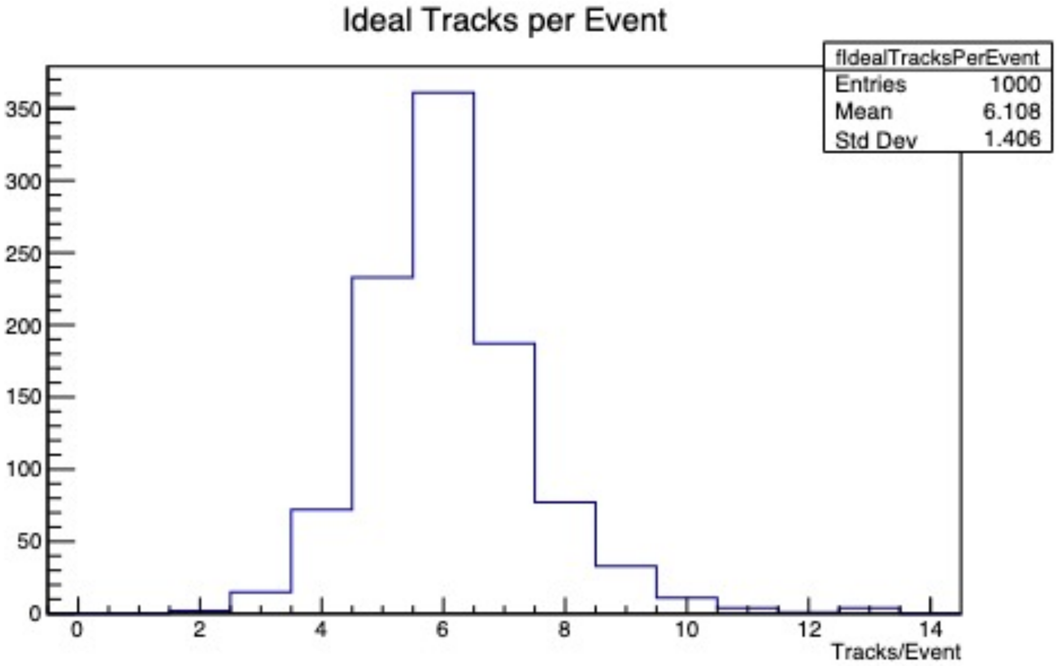
1K Events

Event Reconstruction Efficiency of the production threshold and 8 excess energies

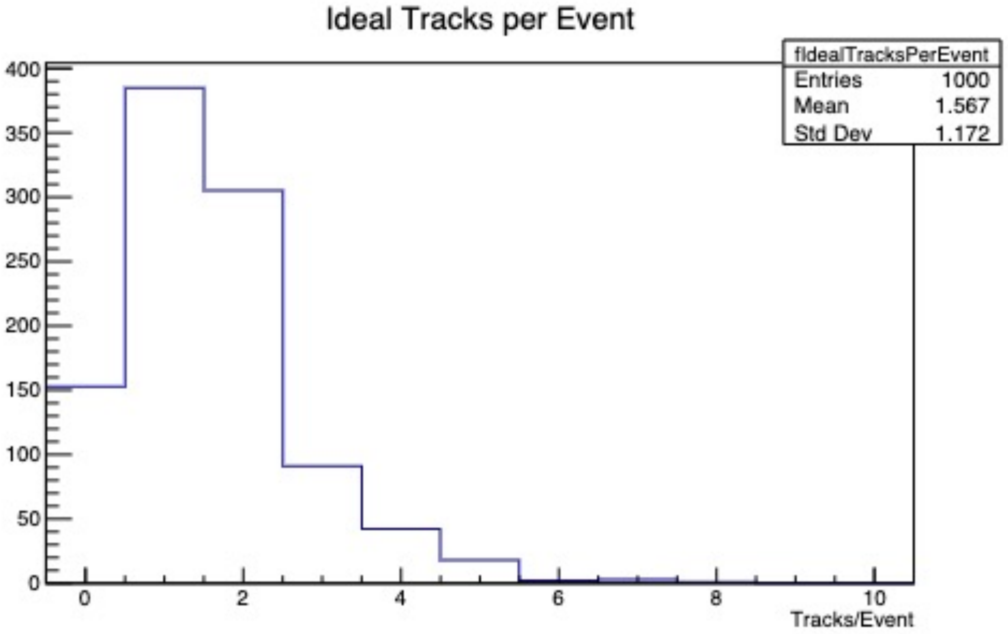
10K Events

- Combinatorics
- After Full Truth Match
- Reconstruction Efficiency

Ideal Tracks per Event

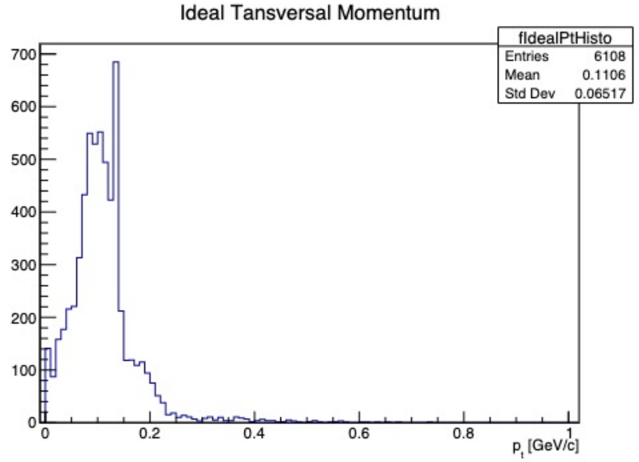


(a) Ideal Tracks per Event at TS

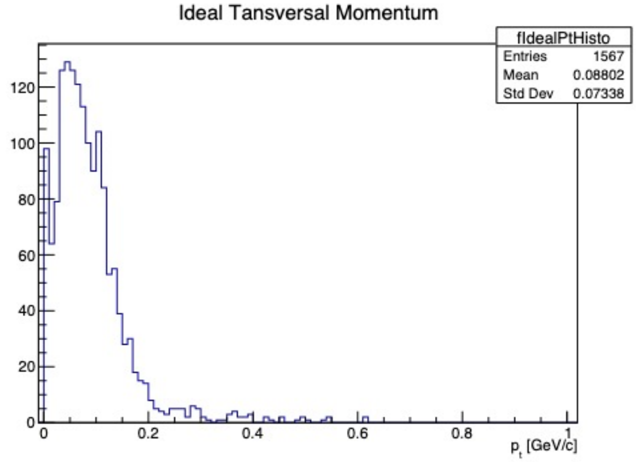


(b) Ideal Tracks per Event at FS

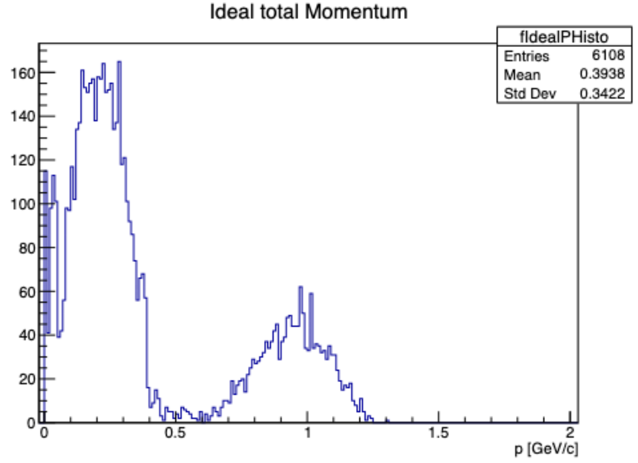
Ideal Momentum



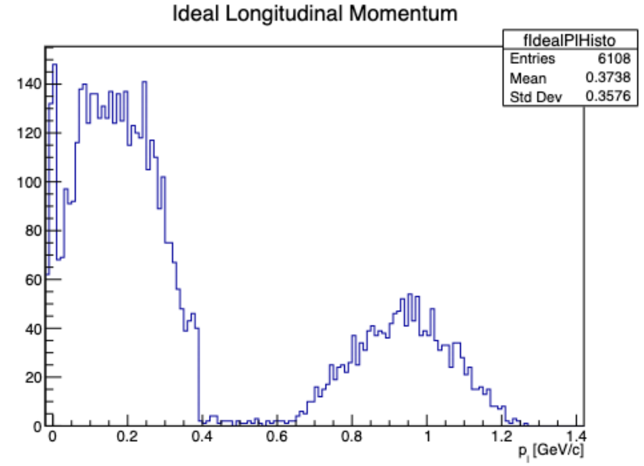
(a) Ideal Transversal Momentum at TS



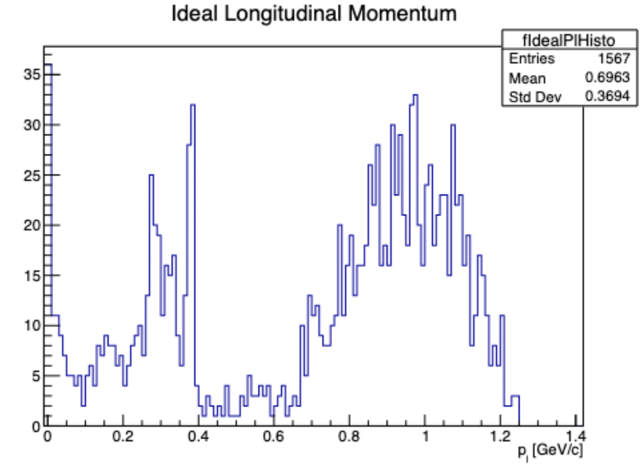
(b) Ideal Transversal Momentum at FS



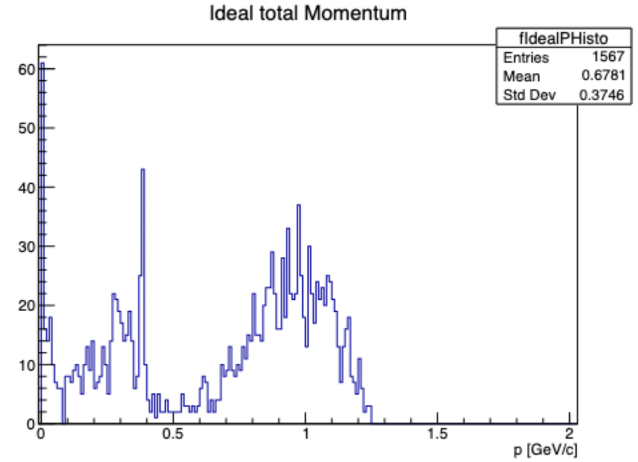
(a) Ideal Total Momentum at TS



(a) Ideal Longitudinal Momentum at TS

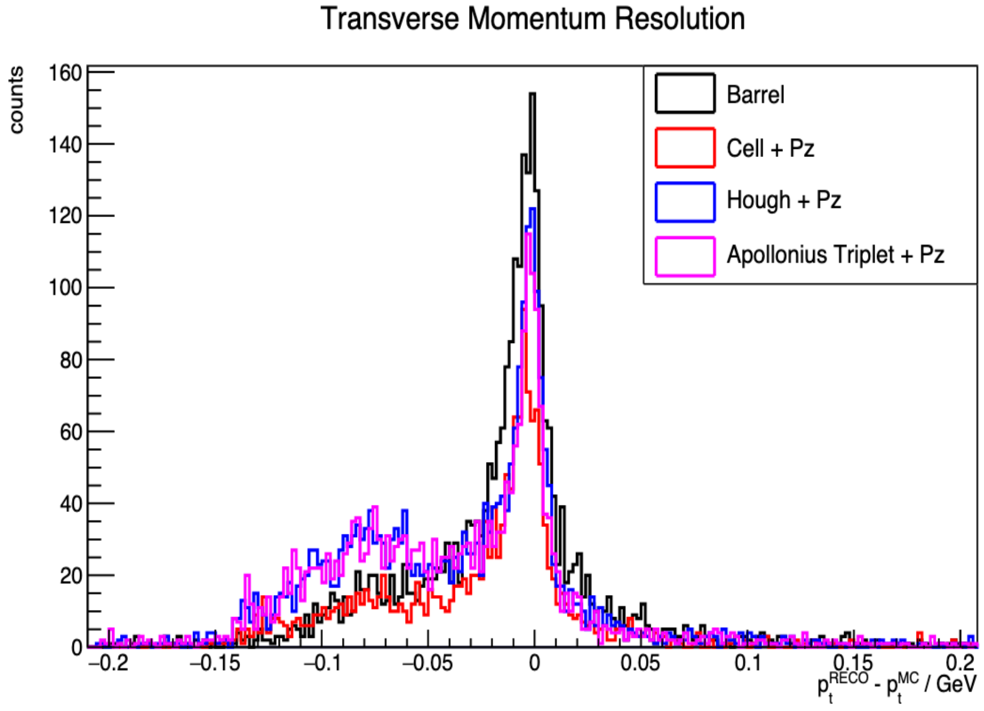


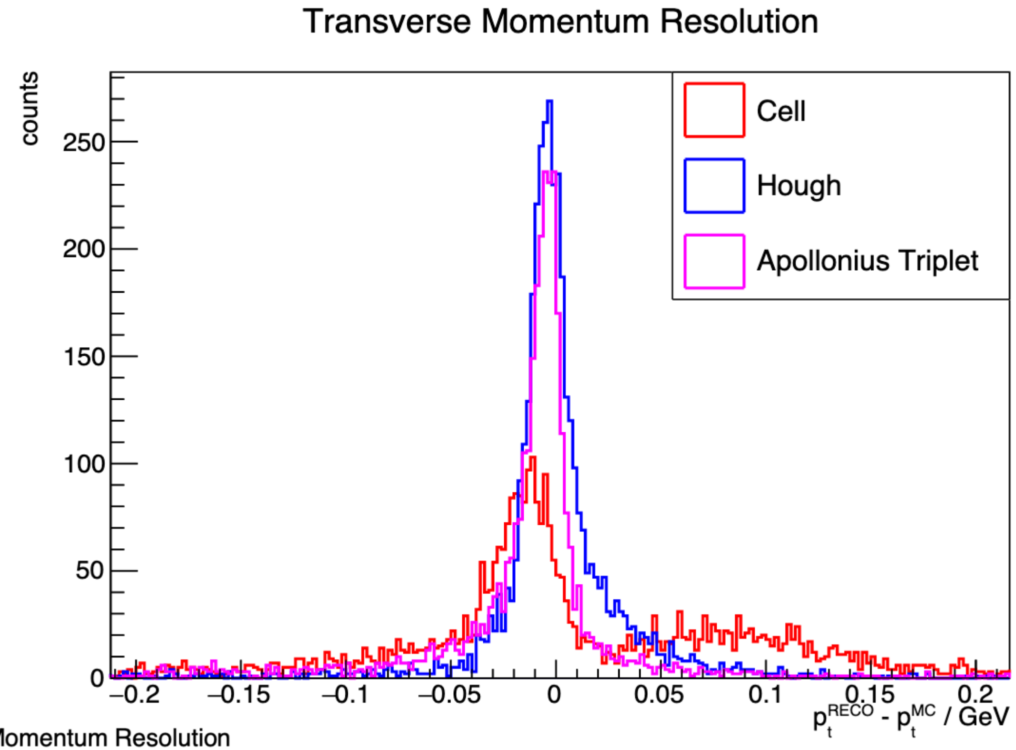
(b) Ideal Longitudinal Momentum at FS

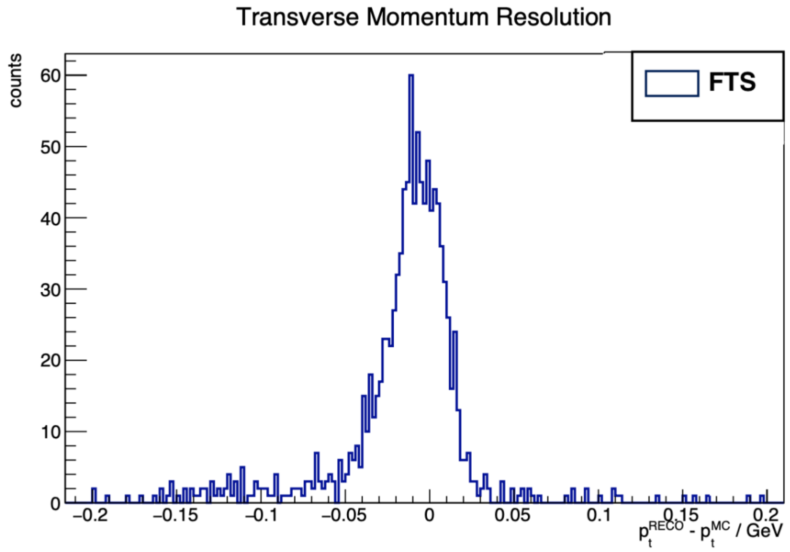


(b) Ideal Total Momentum at FS

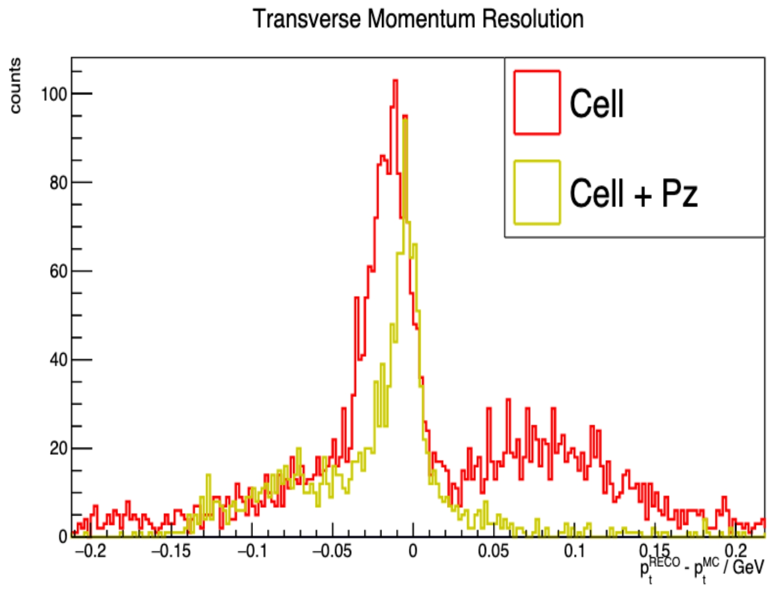
Transverse Momentum Resolution

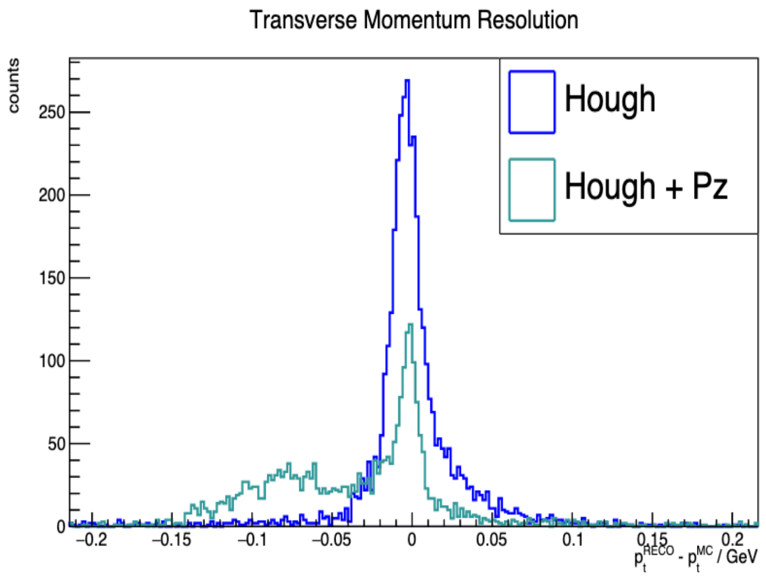


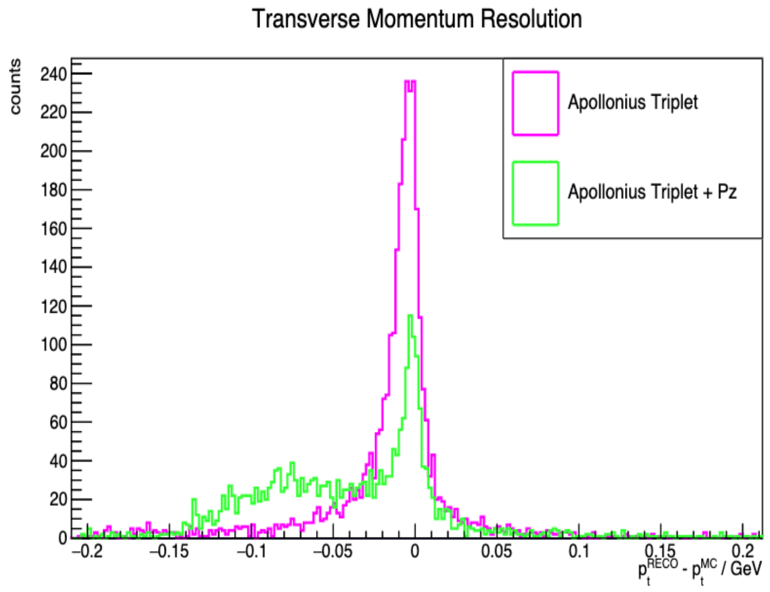




Transverse Momentum Resolution (II)







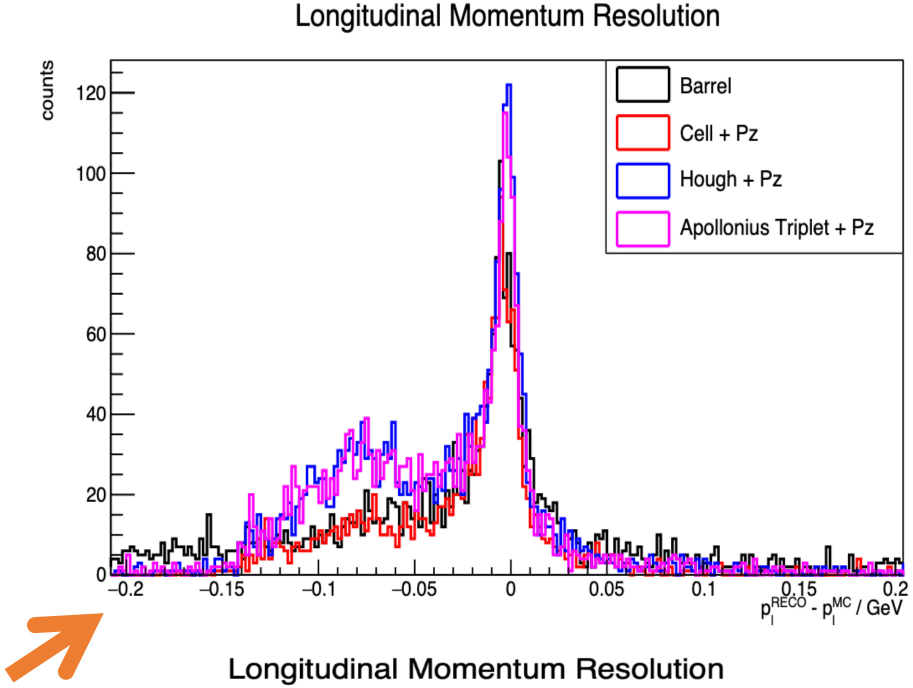
Relative transverse momentum resolution

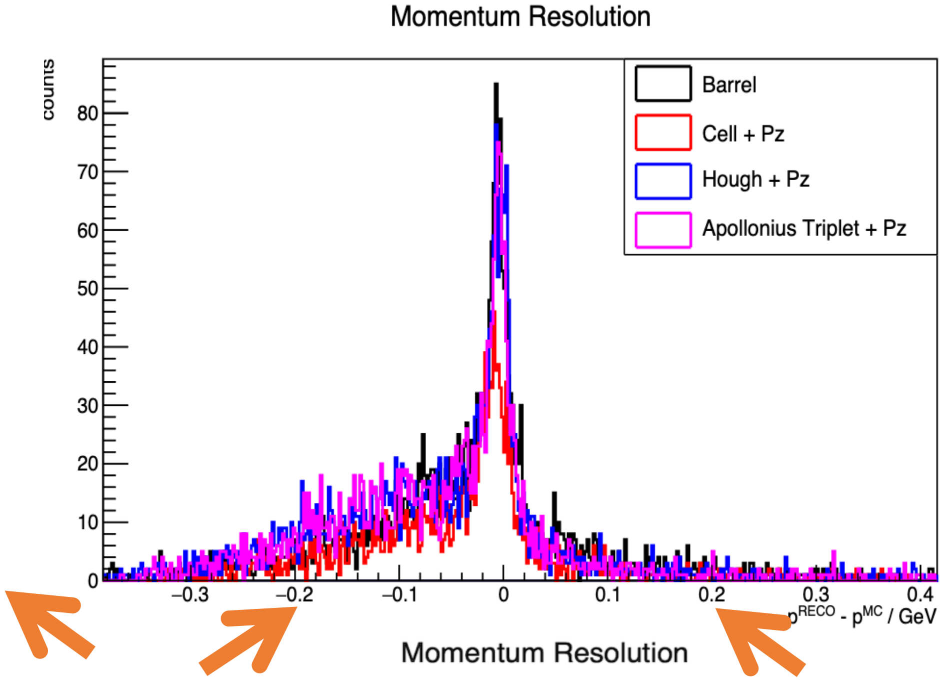
$$(p_t^{RECO} - p_t^{MC}) / p_t^{MC}$$

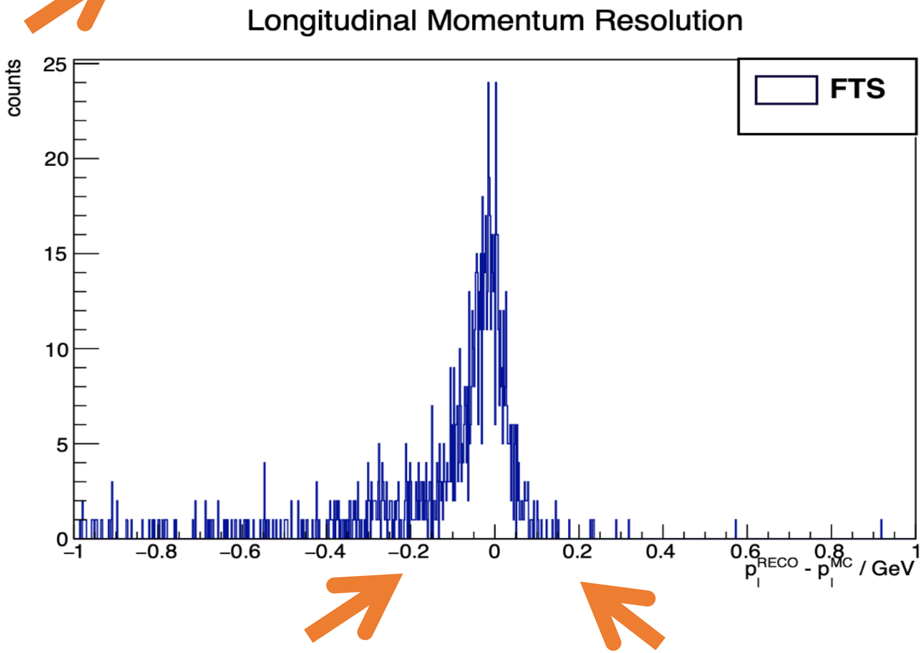
Track Finder:	Relative transverse momentum resolution [GeV/c]
Cell	0.1148 ± 0.0062
Hough	0.07472 ± 0.00184
Apollonius	0.05856 ± 0.00228
Barrel	0.05936 ± 0.00433
Cell + Pz	0.05061 ± 0.00497
Hough + Pz	0.05035 ± 0.00279
Apollonius	0.04726 ± 0.00260
FTS	0.04062 ± 0.0486

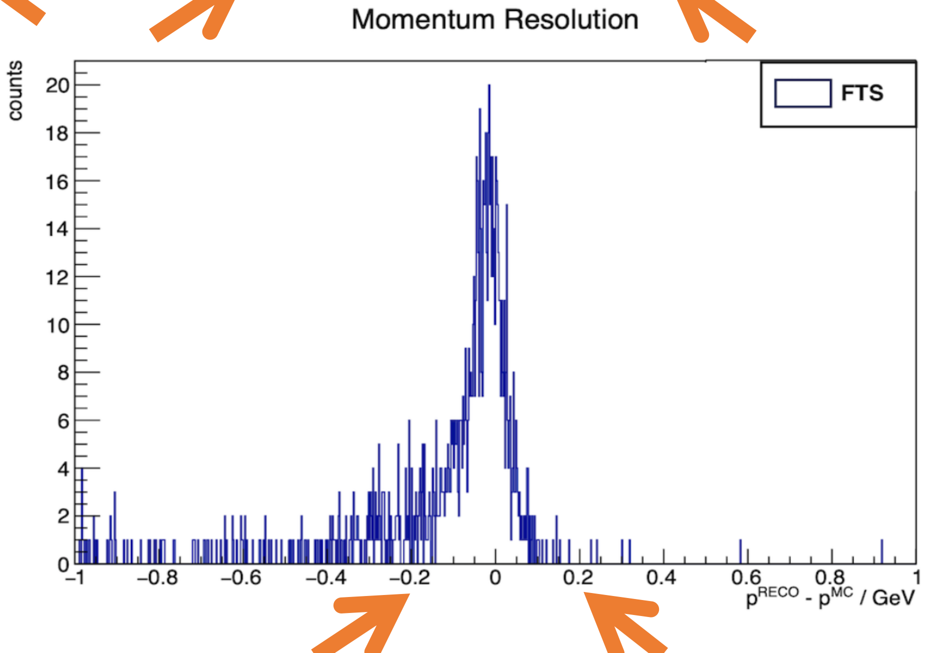
Total and Longitudinal Momentum Resolution

Tracking QA

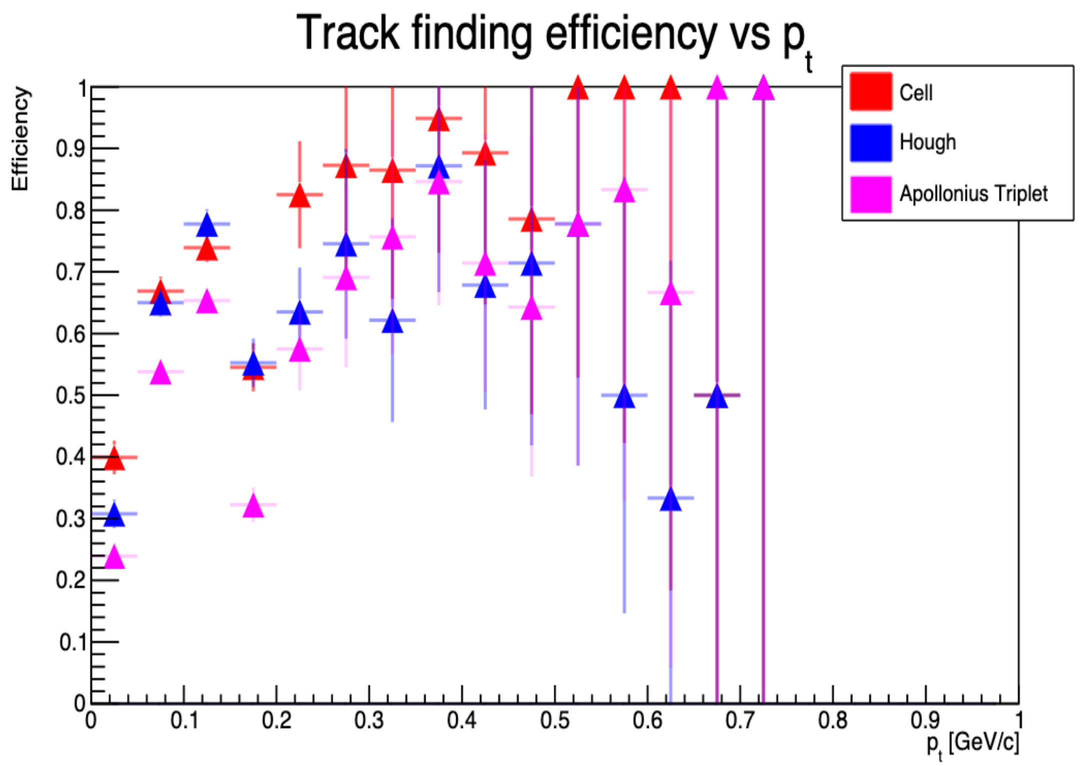


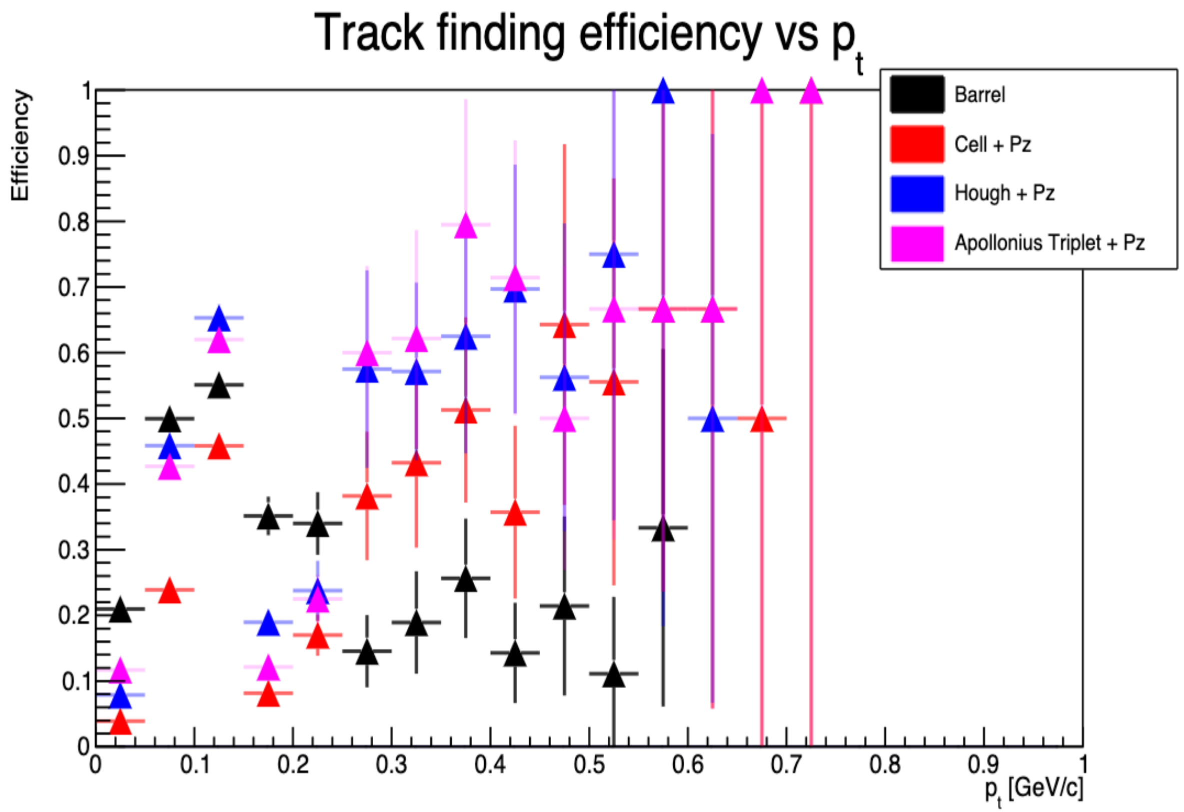




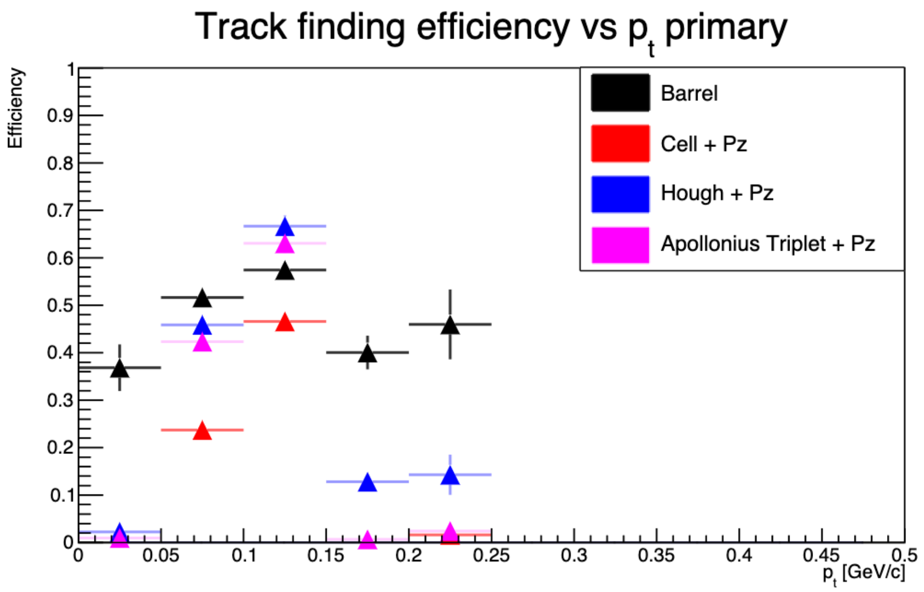


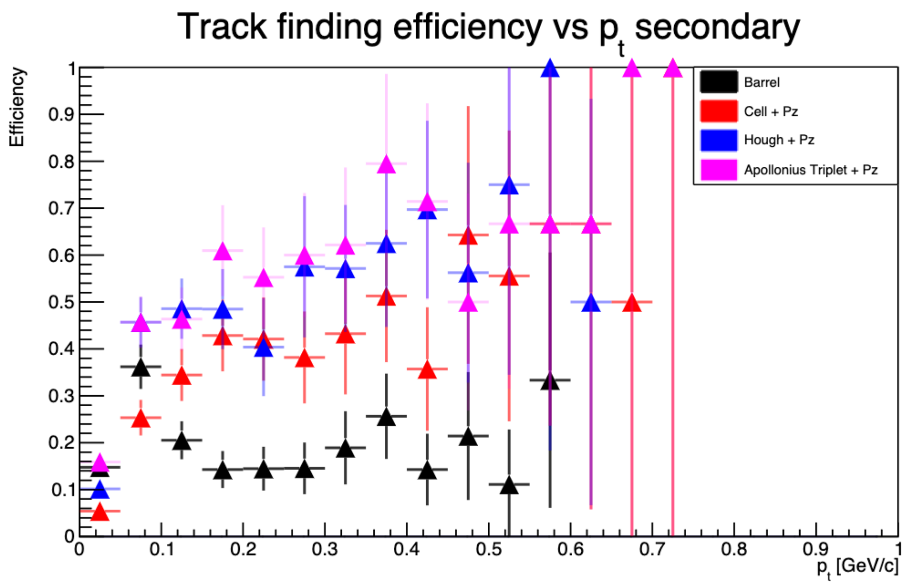
Track Finding Efficiency vs. Transverse Momentum

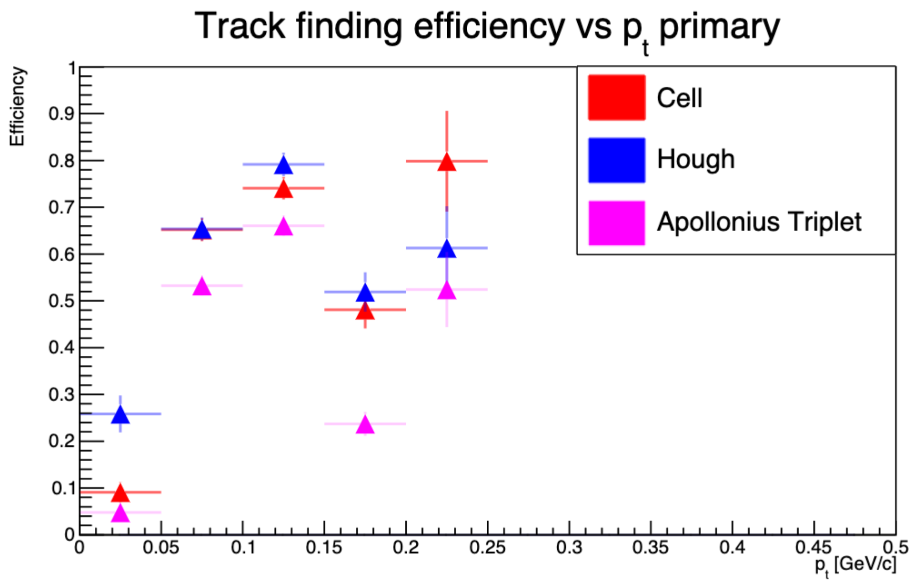


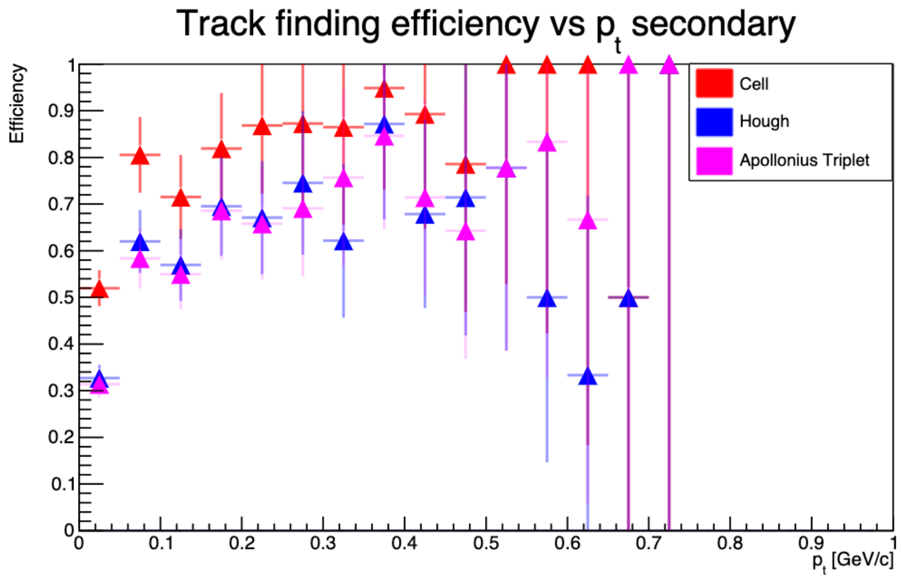


Track Finding Efficiency vs. Transverse Momentum

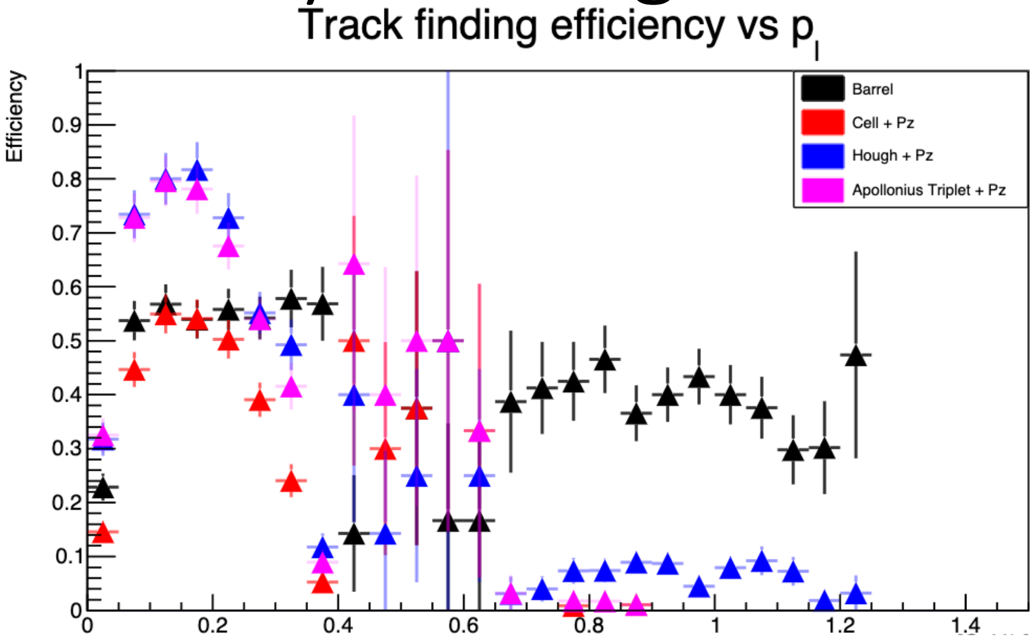


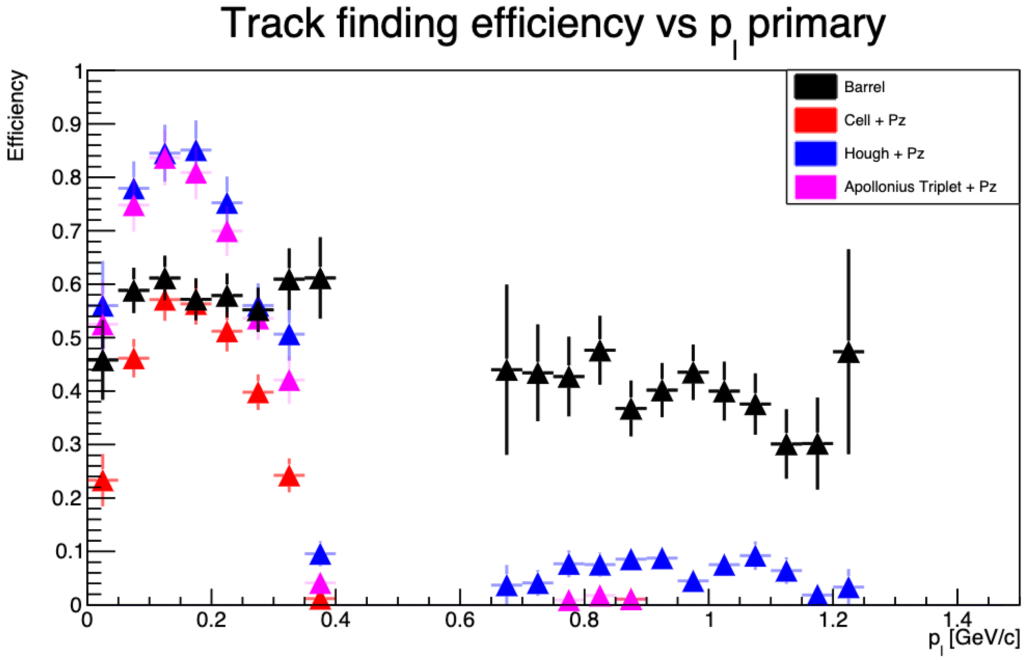


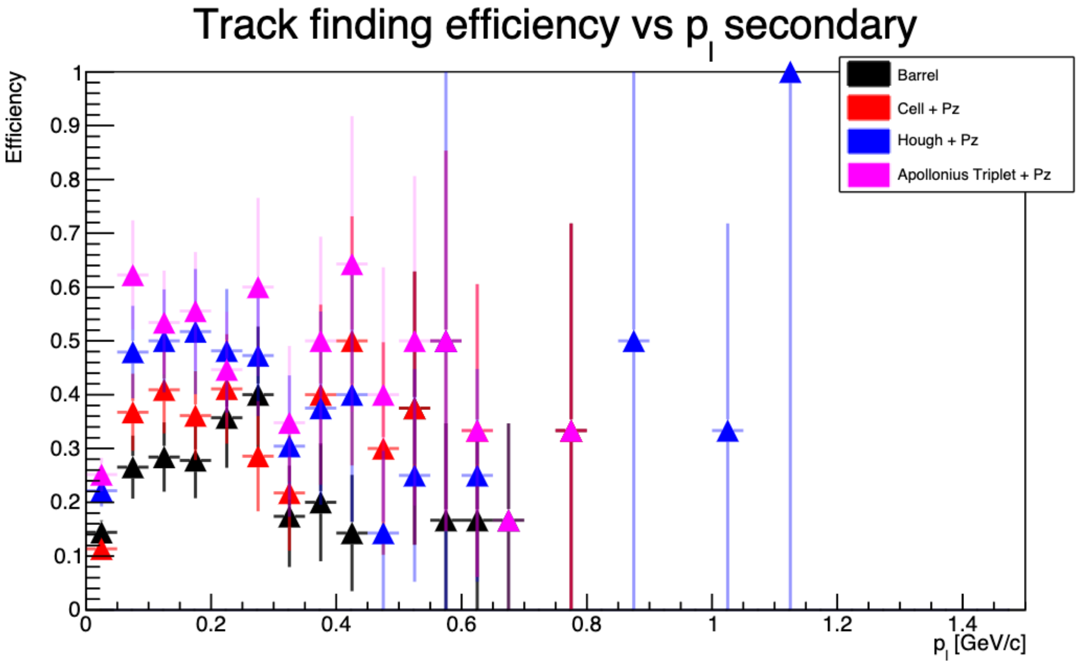




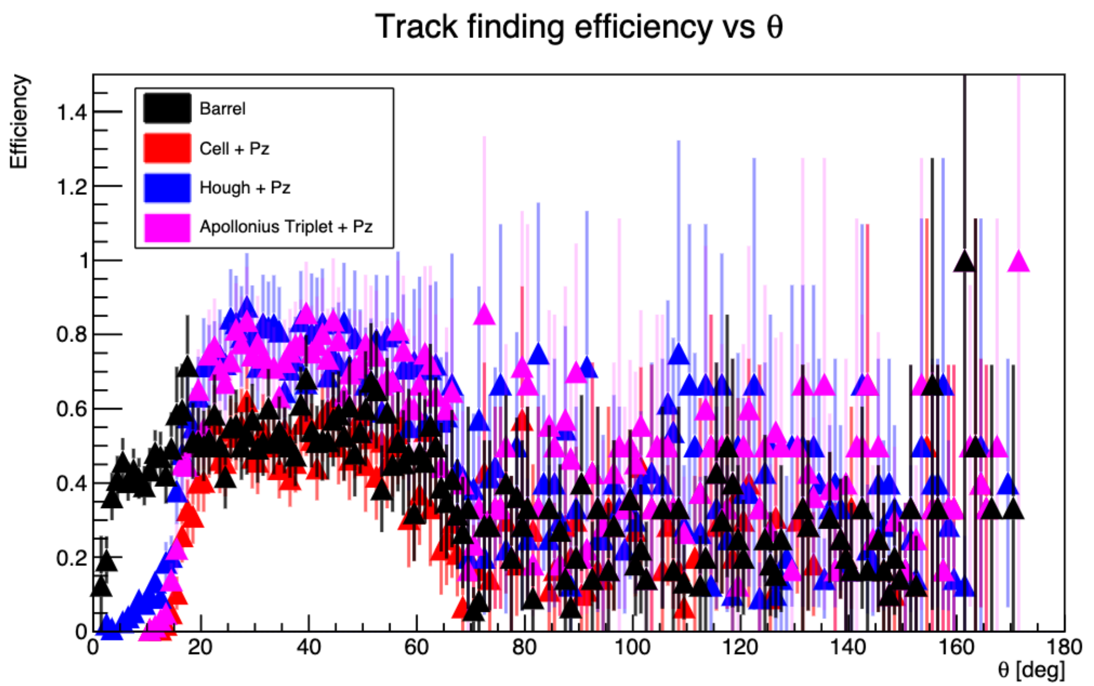
Track Finding Efficiency vs. Longitudinal Momentum

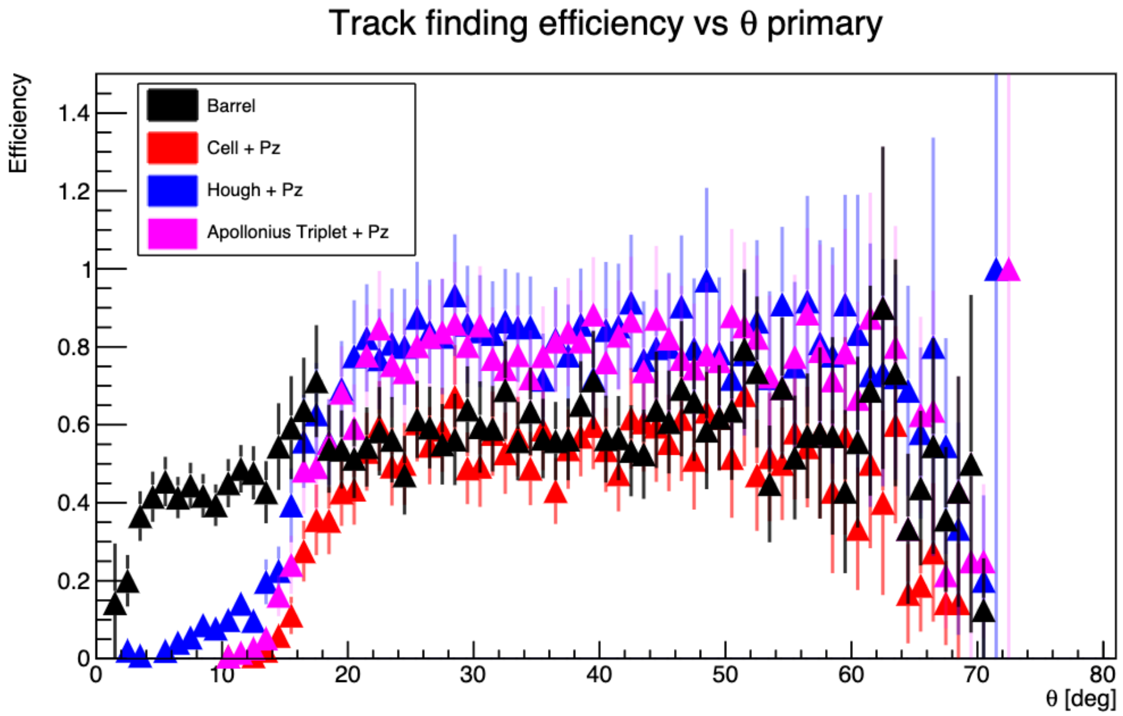


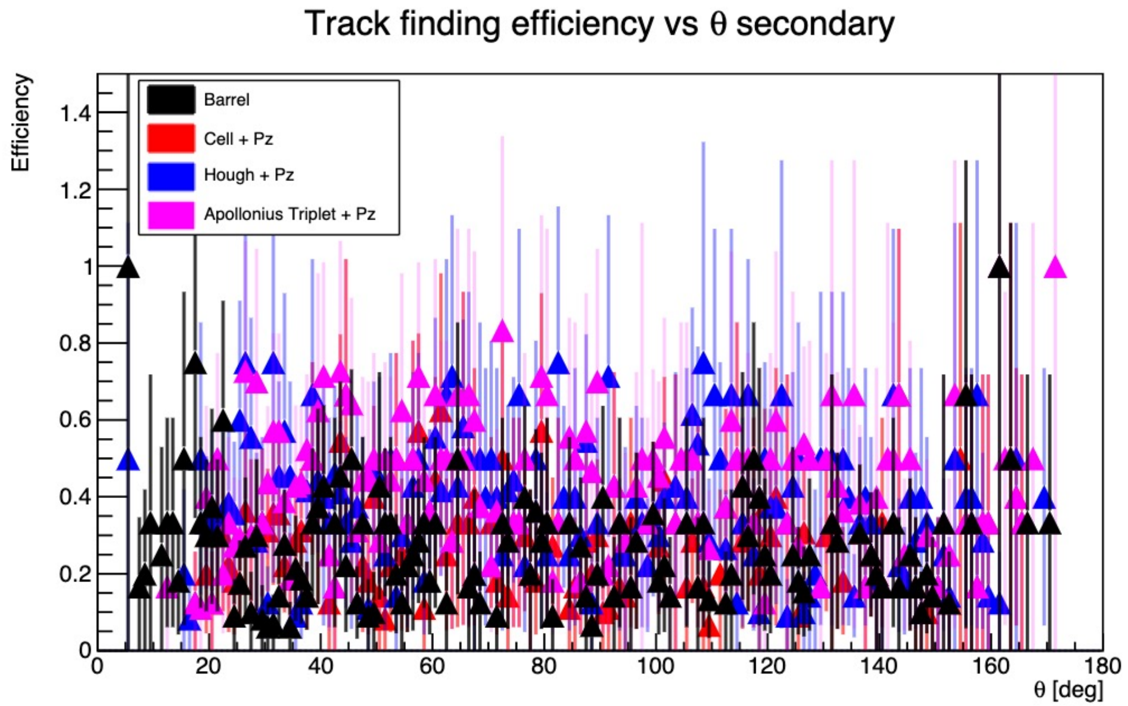




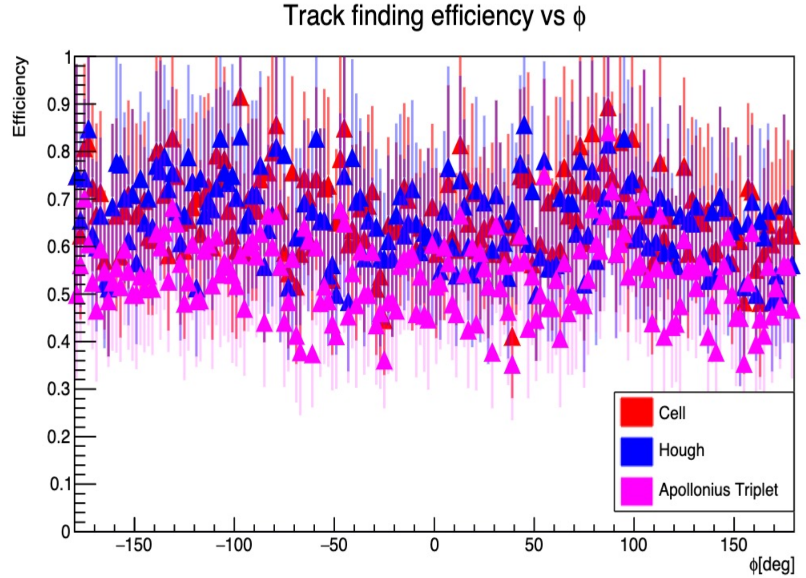
Track Finding Efficiency vs. Polar Angle

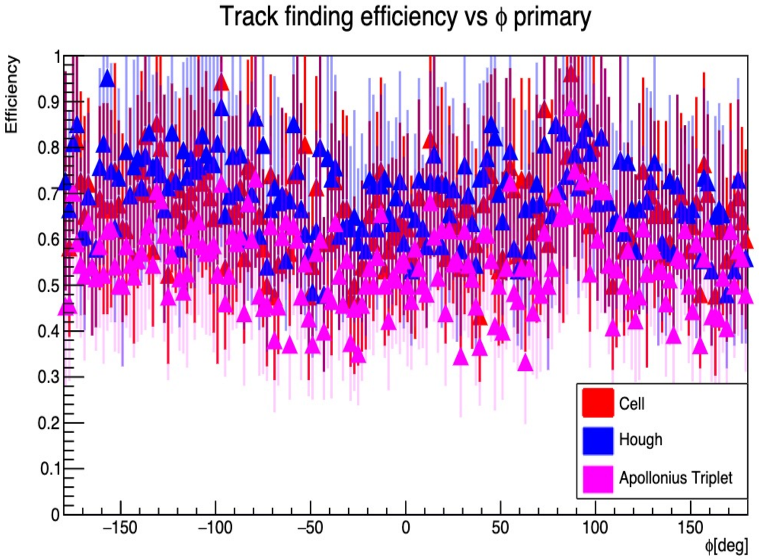


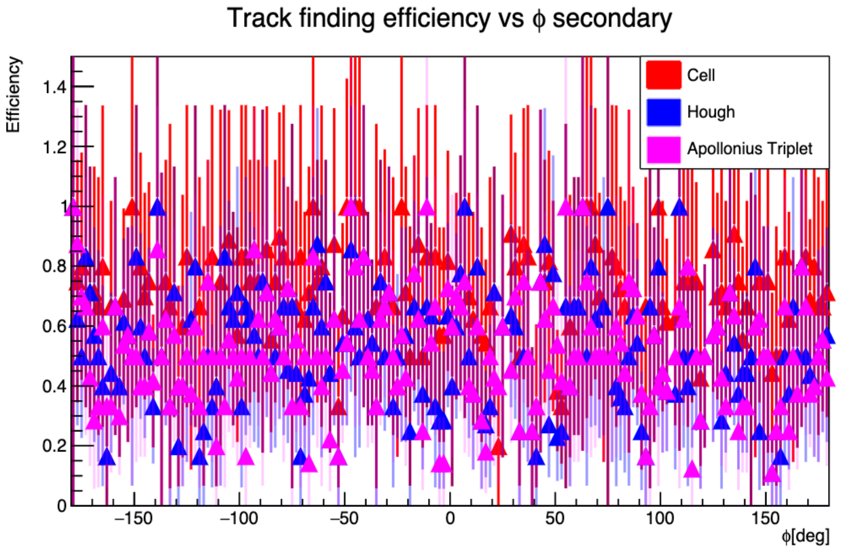


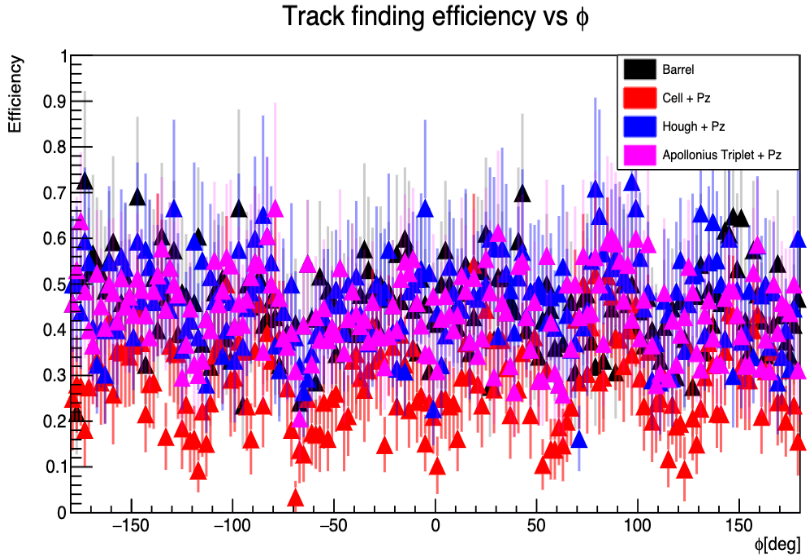


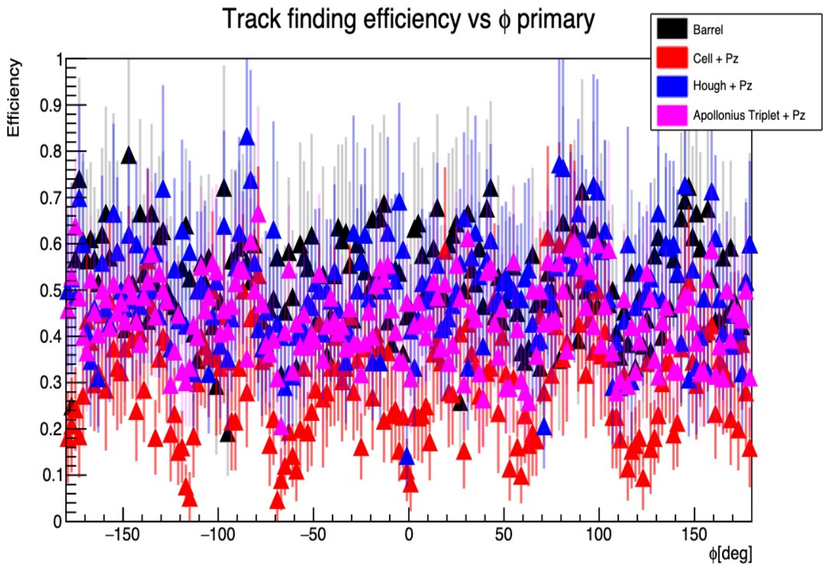
Track Finding Efficiency vs. Azimuthal angle

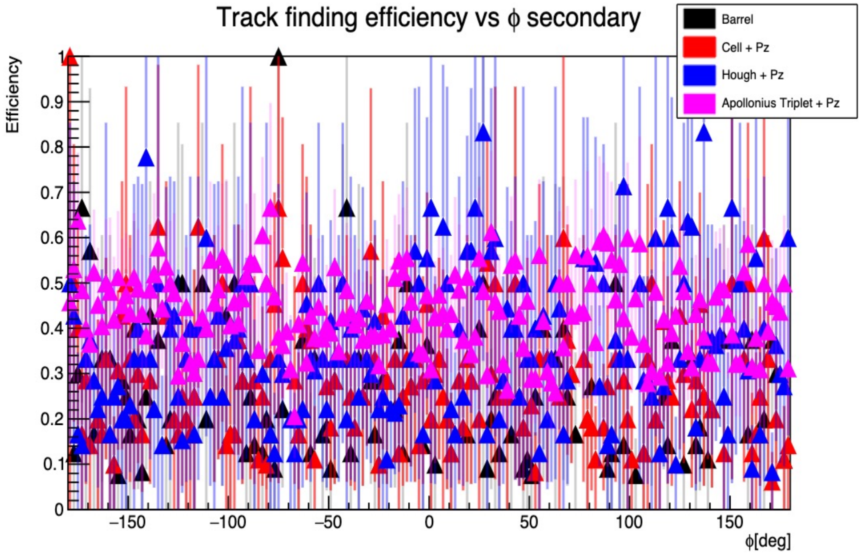




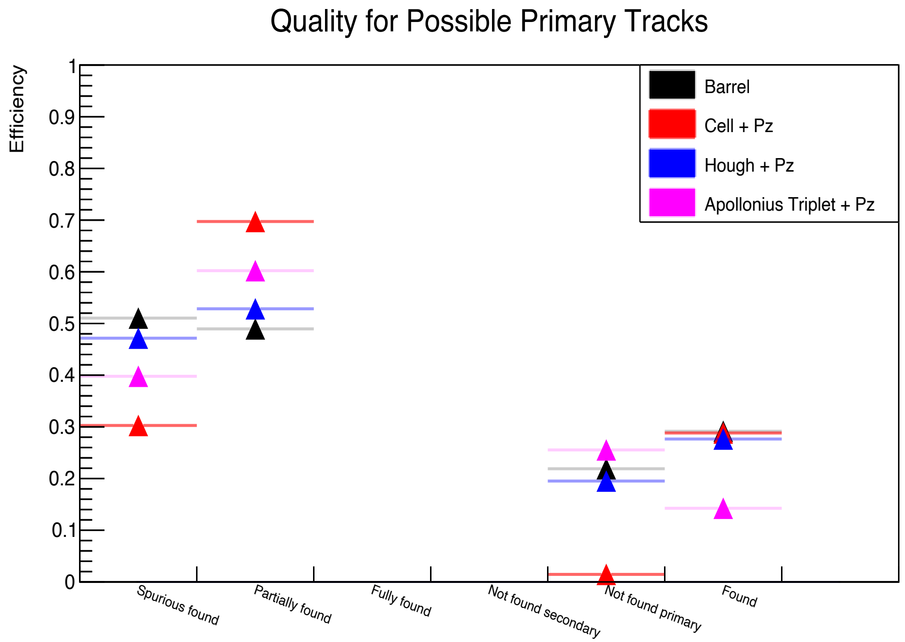


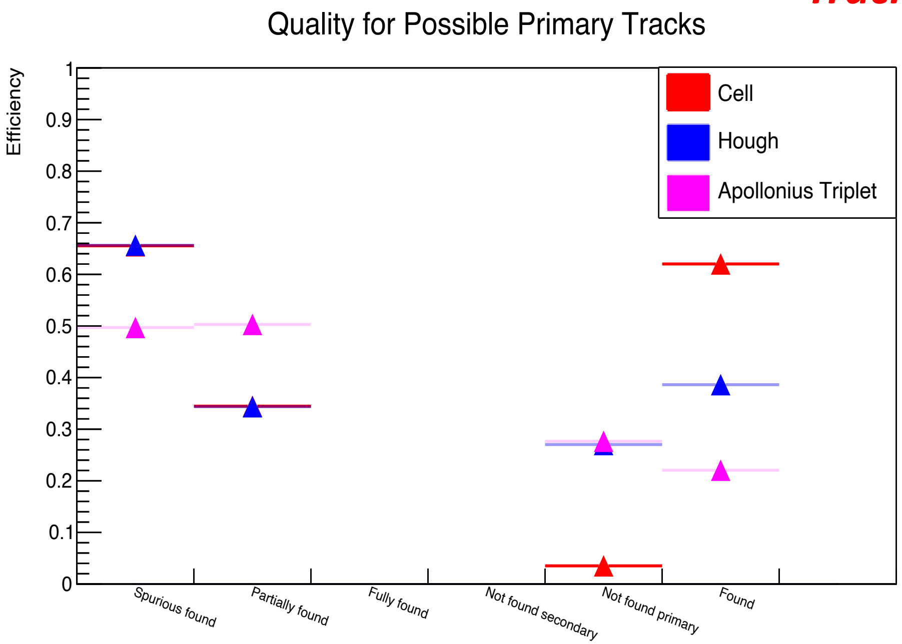


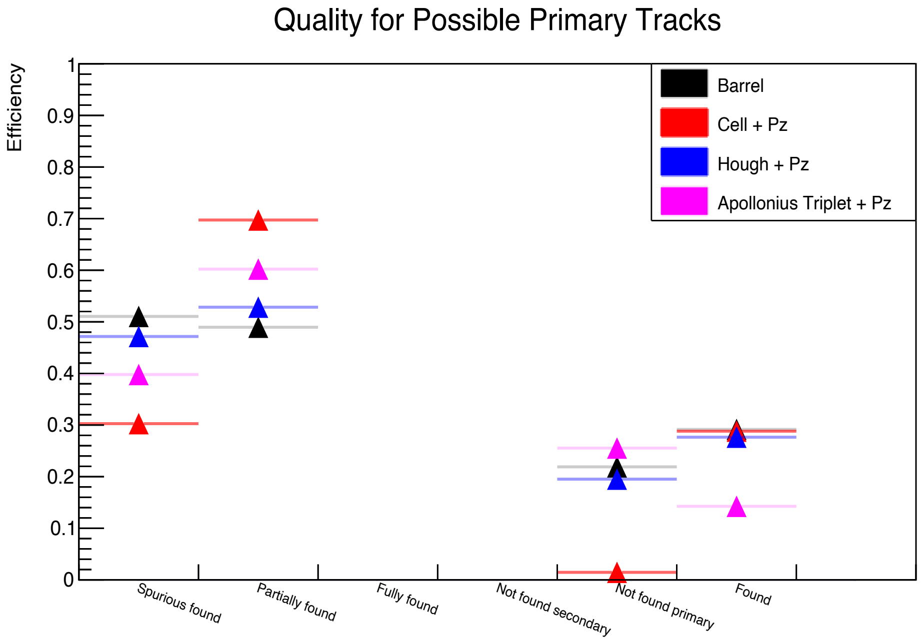


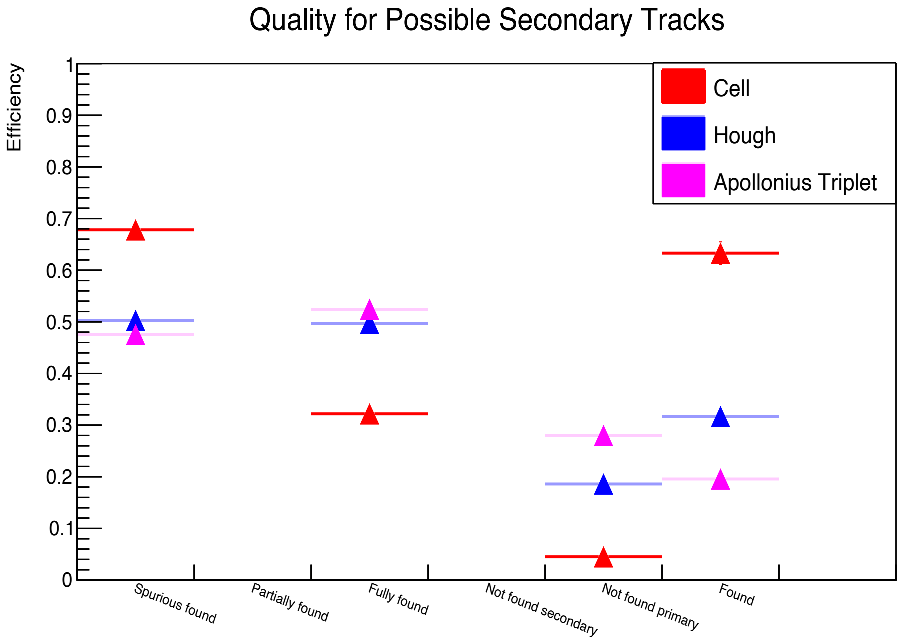


Quality of Tracking



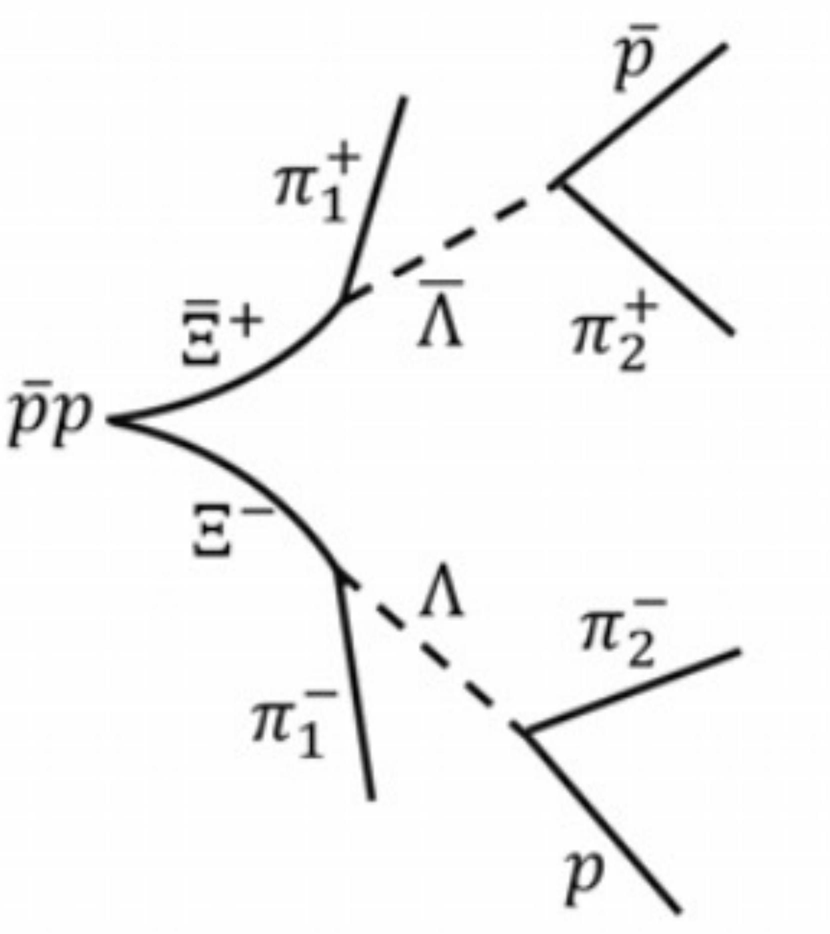






Combinatorics and FTM

- **Proton** **and** **π ⁺**
- **Antiproton** **and** **π ⁻**
- **Lambda** **and** **π ⁺**
- **Anti-Lambda** **and** **π ⁻**

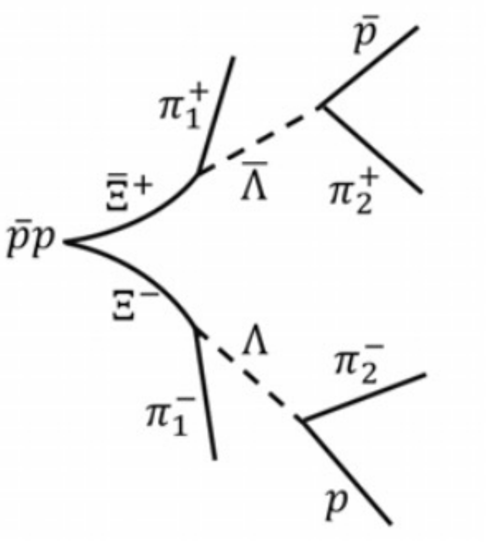


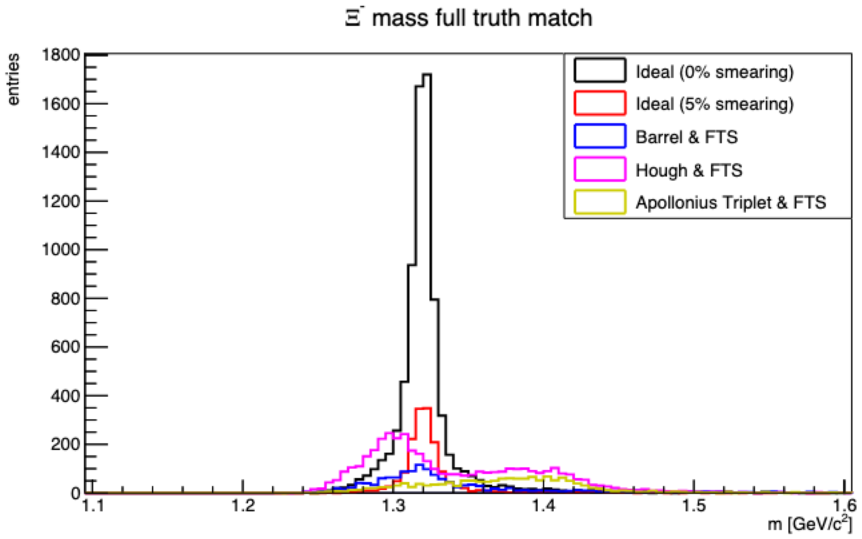
- **Full Truth Match**
  - Correct PID
  - Correct decay mother-daugtehr relationship

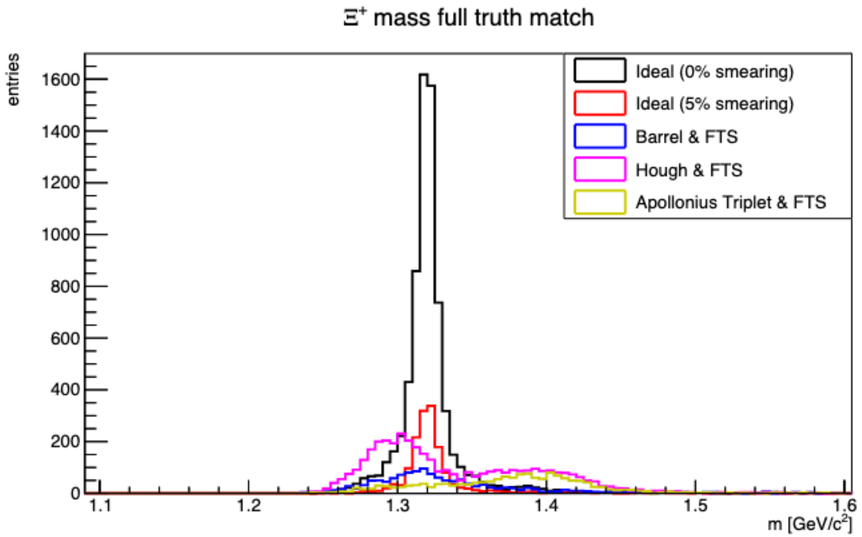
Event Reconstruction (Full Truth Match)

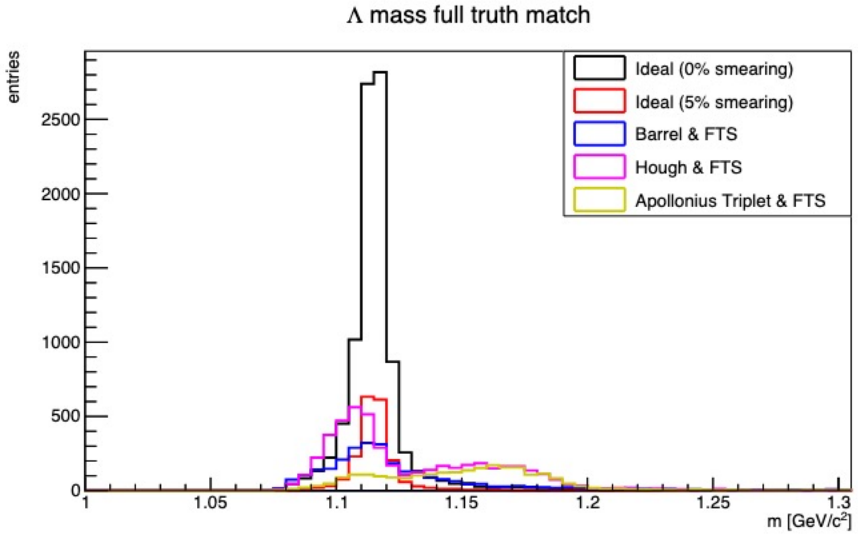
Y	q	$c\tau$ (cm)	T (s)	M (GeV/c^2)	Decay
Λ	uds	7.89	2.632×10^{-10}	1.116	$p\pi^-$ (63.9%) $n\pi^0$ (35.8%)

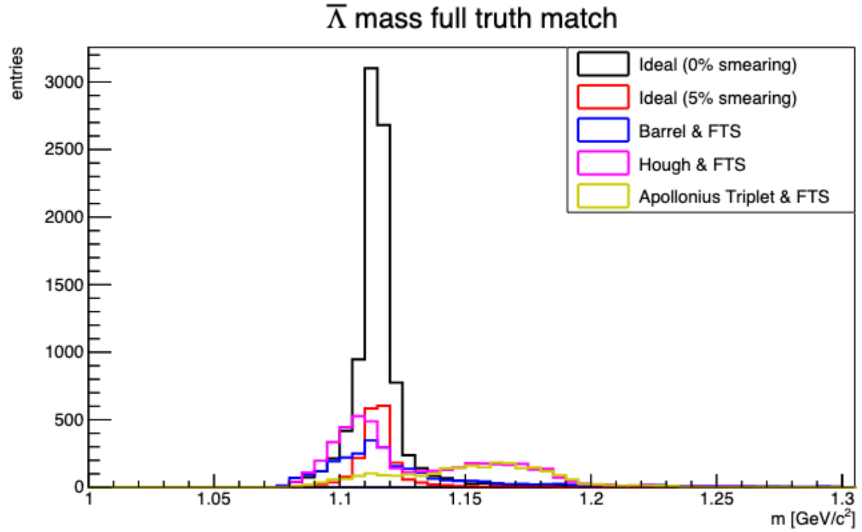
Y	q	$c\tau$ (cm)	T (s)	M (GeV/c^2)	Decay
Ξ^-	dss	4.91	1.639×10^{-10}	1.322	$\Lambda\pi^-$ (99.887%)







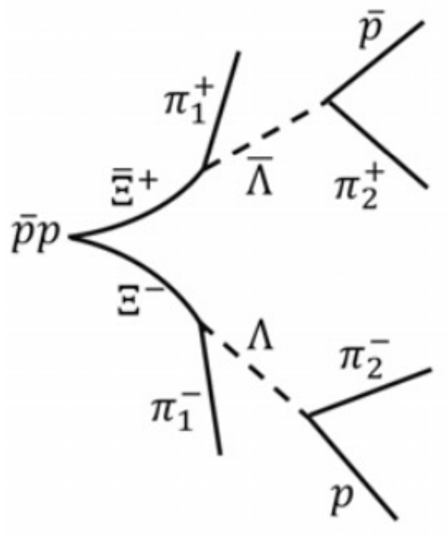


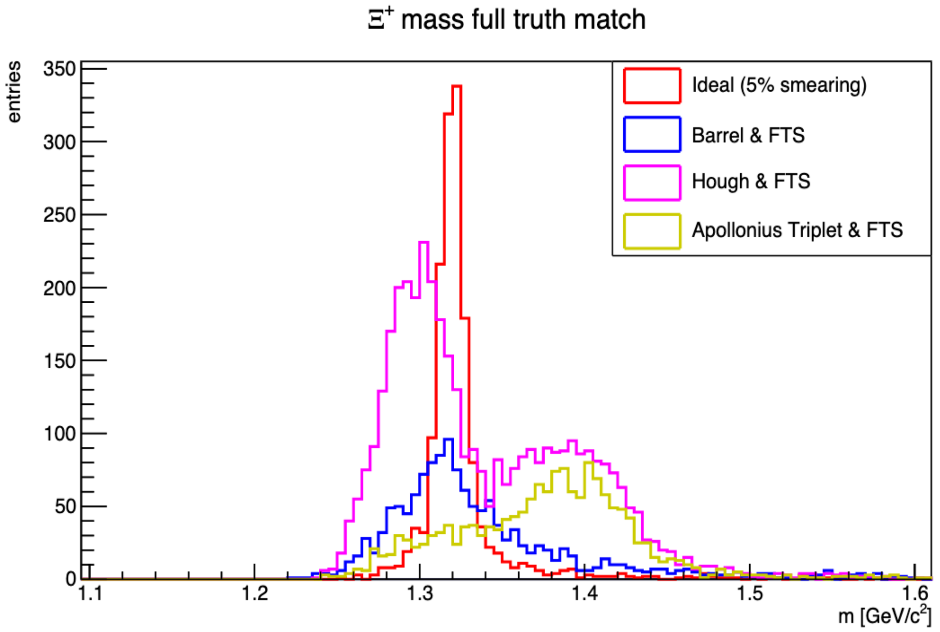


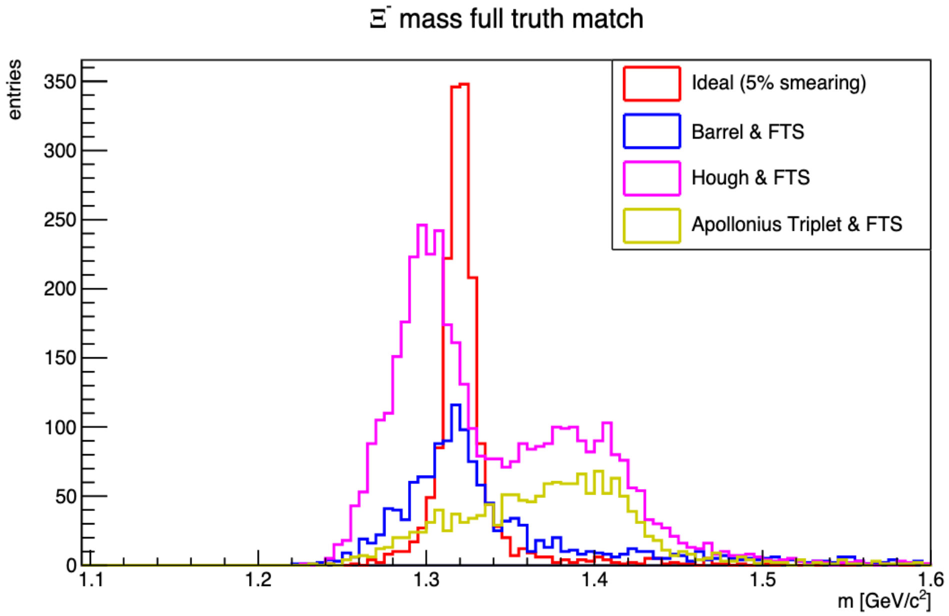
Event Reconstruction (Full Truth Match)

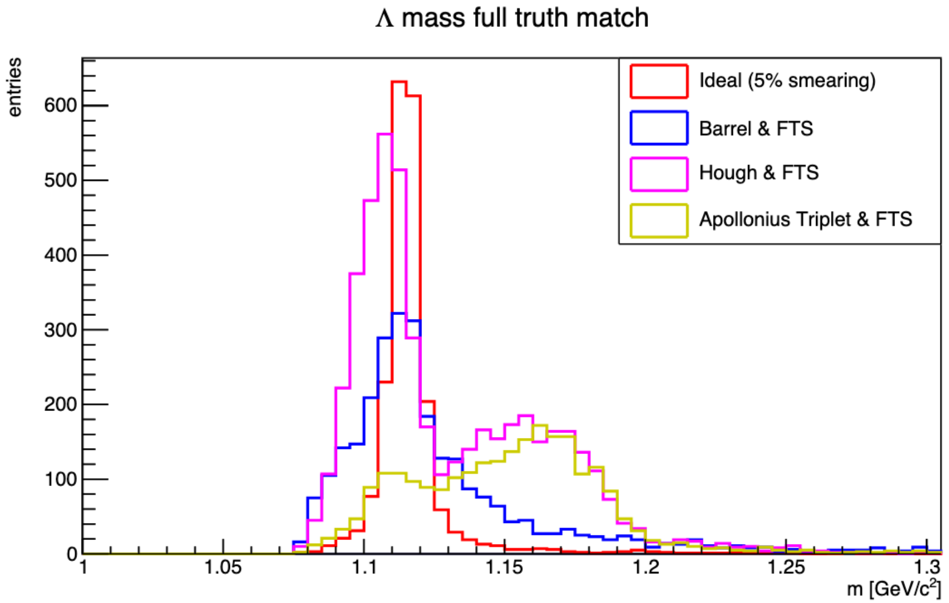
Y	q	$c\tau$ (cm)	T (s)	M (GeV/c^2)	Decay
Λ	uds	7.89	2.632×10^{-10}	1.116	$p\pi^-$ (63.9%)
					$n\pi^0$ (35.8%)

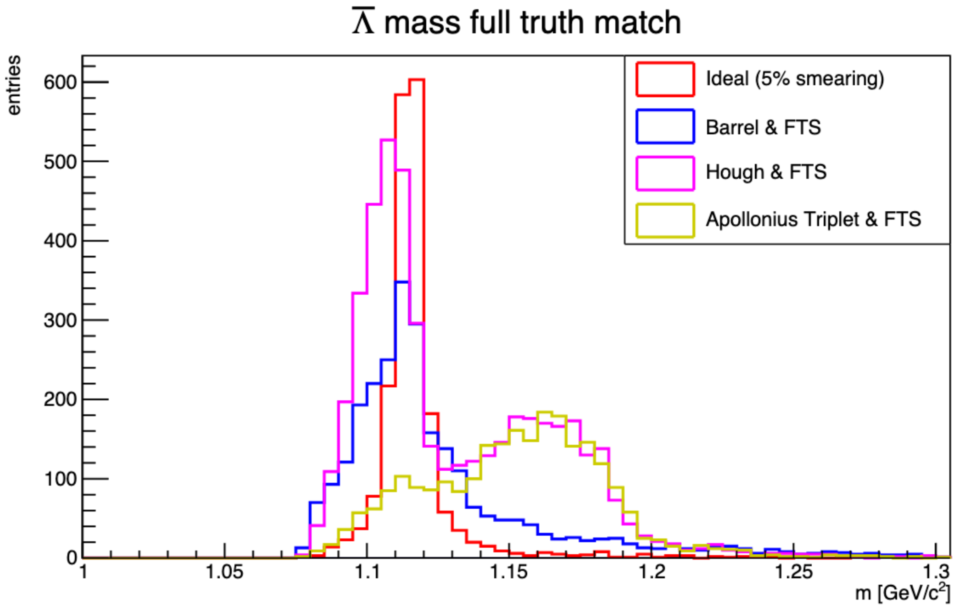
Y	q	$c\tau$ (cm)	T (s)	M (GeV/c^2)	Decay
Ξ^-	dss	4.91	1.639×10^{-10}	1.322	$\Lambda\pi^-$ (99.887%)



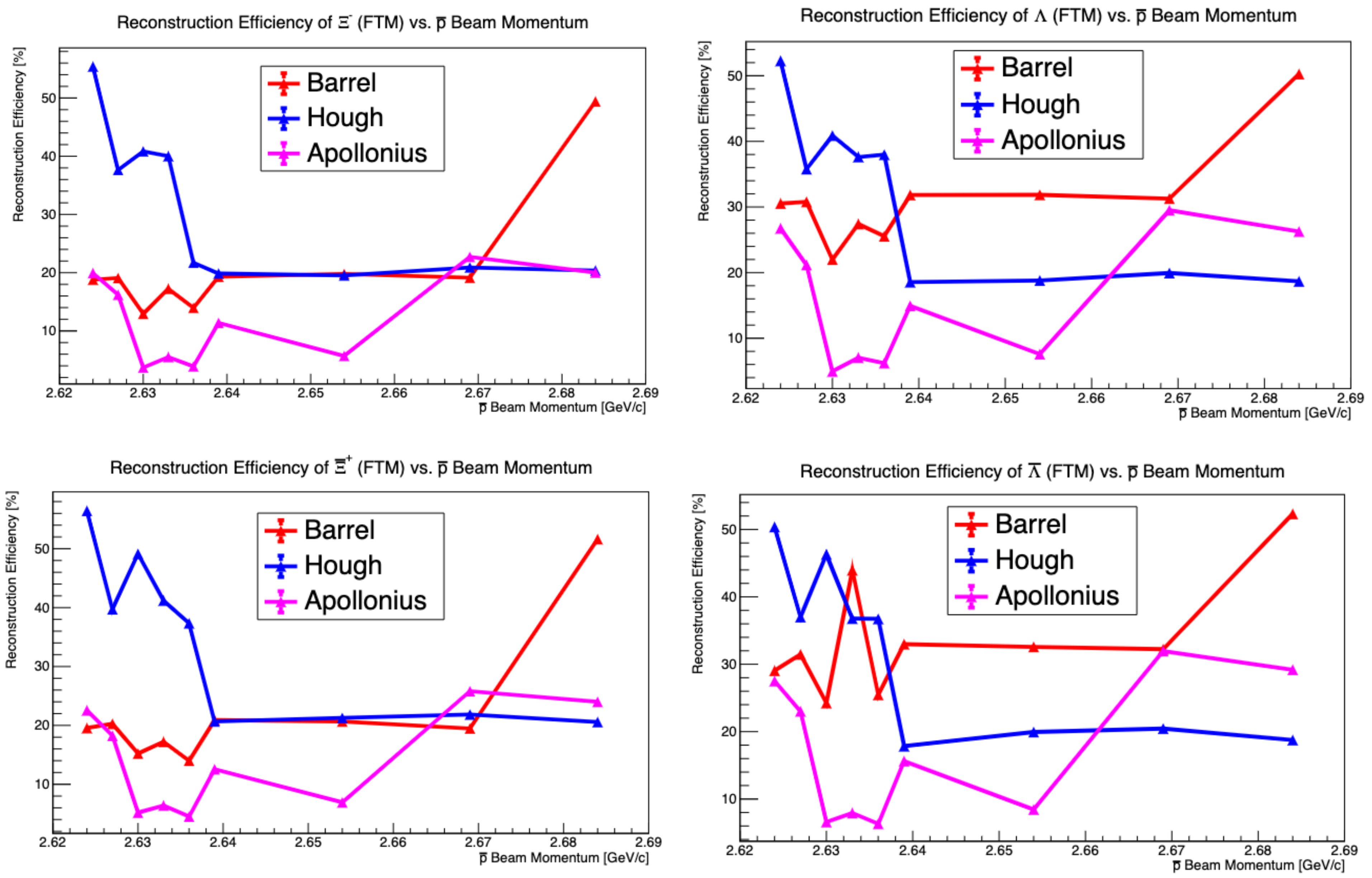




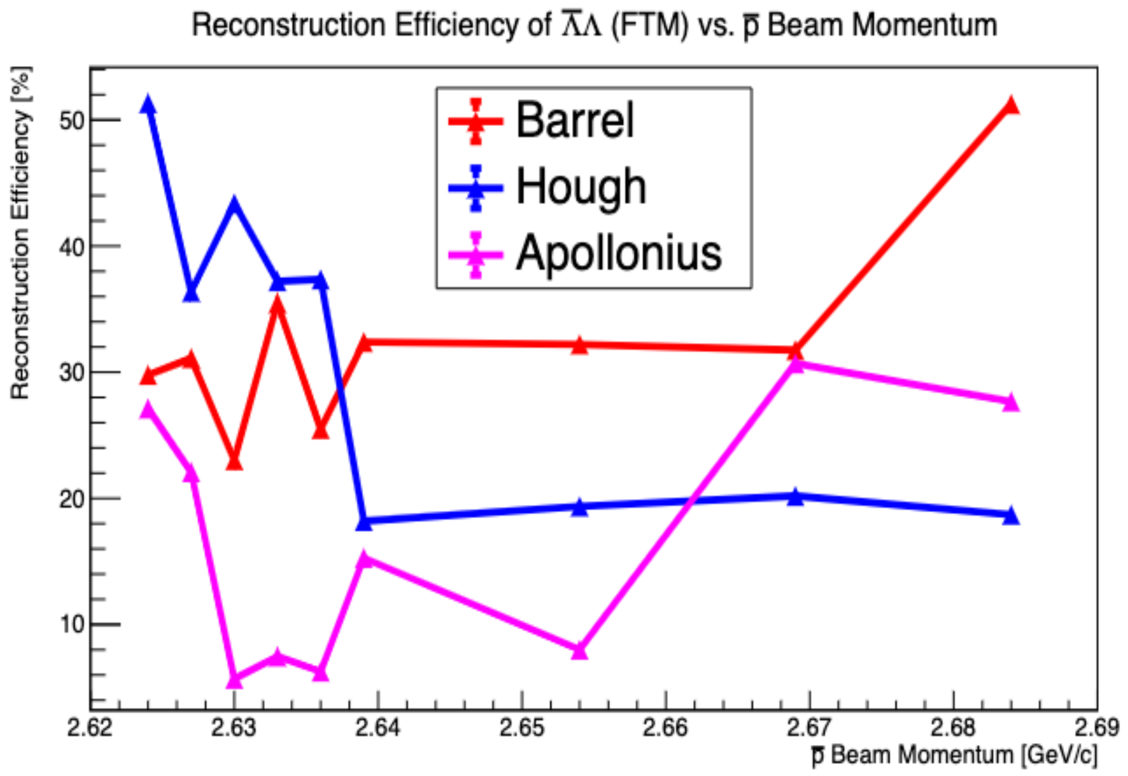


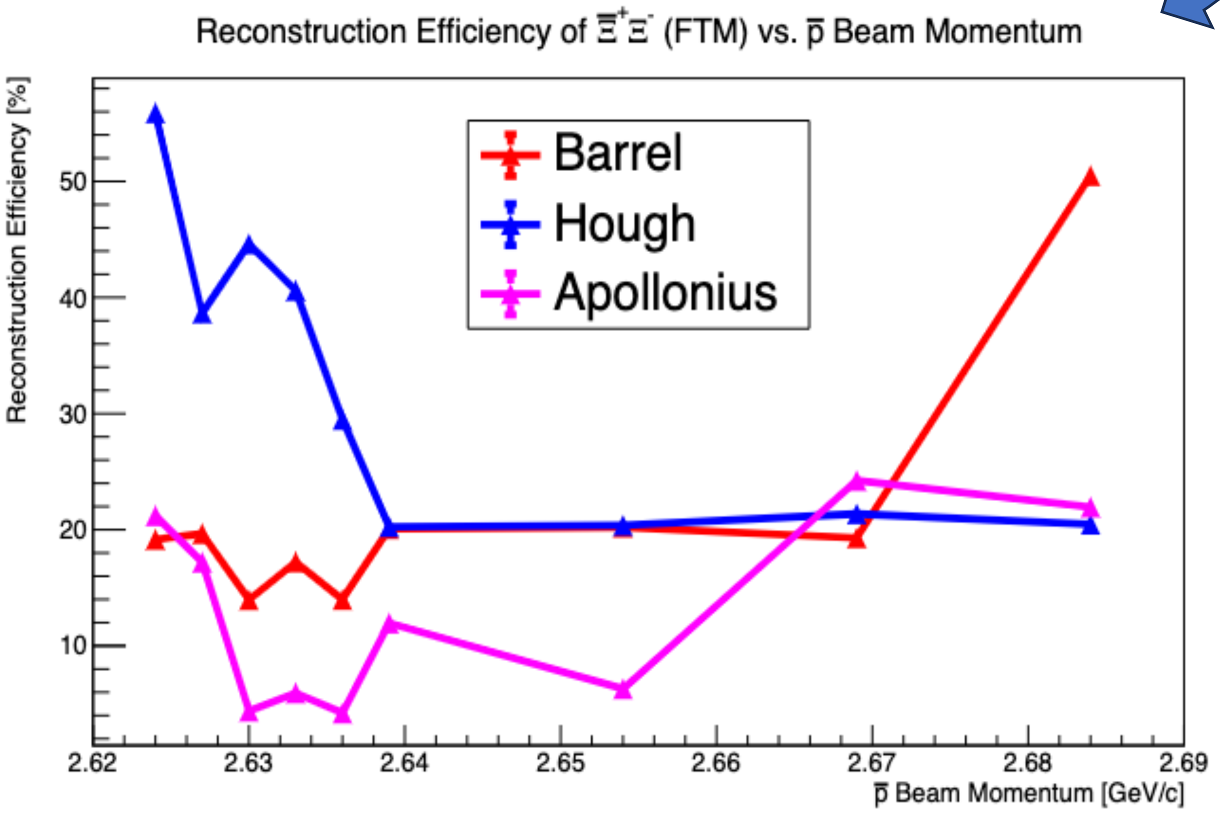


The (Event) Reconstruction Efficiency (I)



The Final: (Event) Reconstruction Efficiency*





*The Reconstruction Efficiency is obtained by comparing the the reconstructed events from Ideal Track Finder (0% smearing) and each Realistic Track Finders

The End:
Thanks for your attention!

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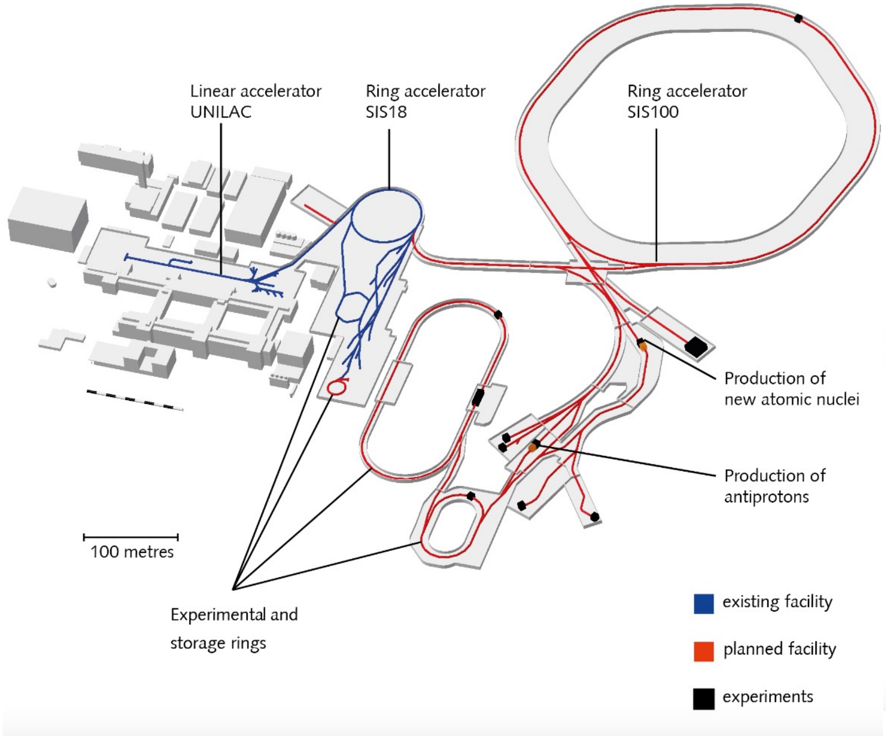
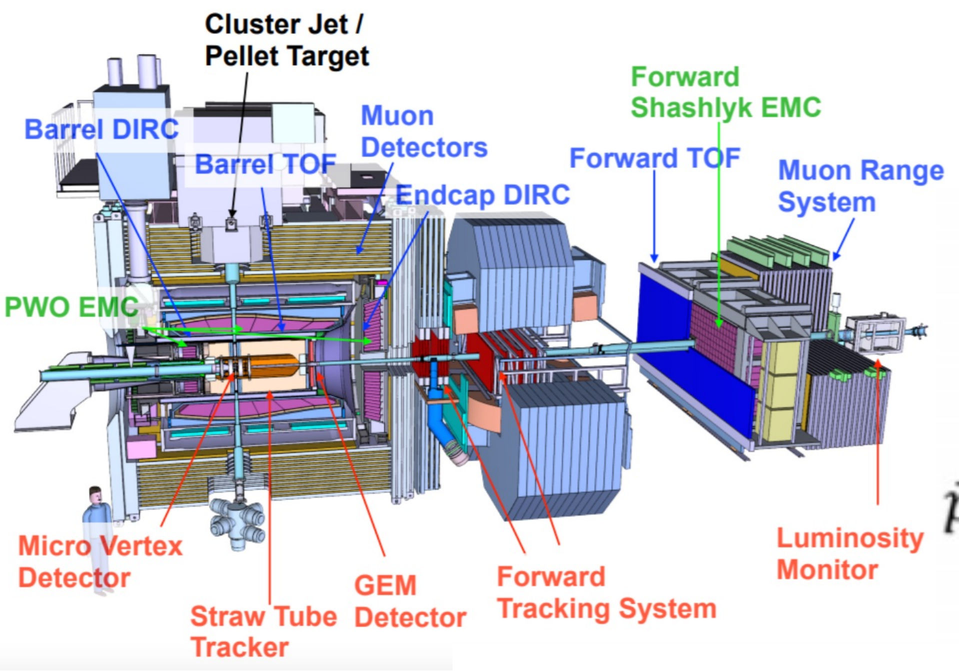
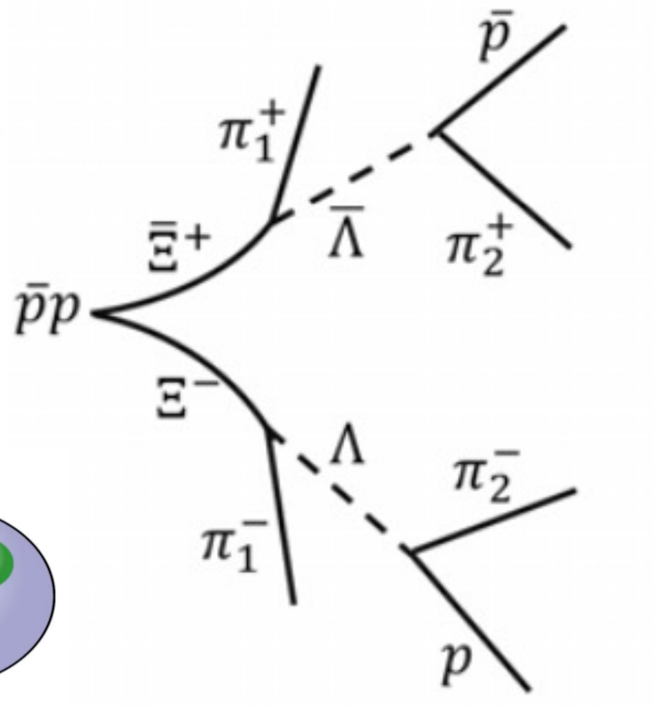
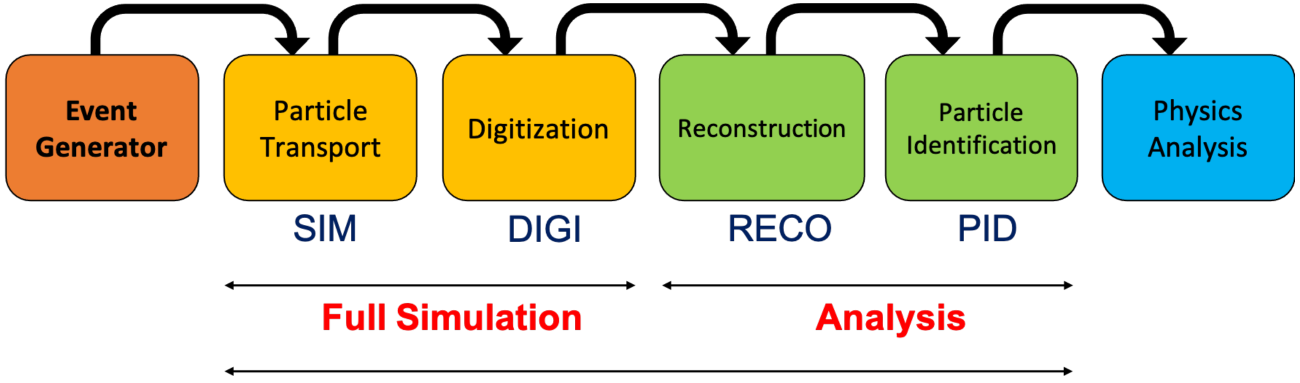
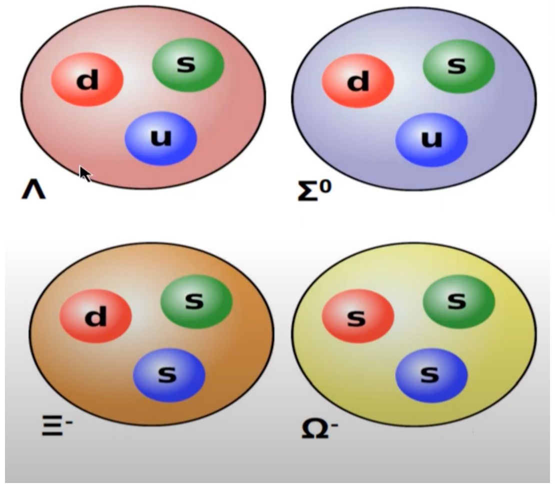
Appendix:Briefly Introduction











Fast Simulation

Appendix: Typical Hyperons

Y	q	$c\tau$ (cm)	T (s)	M (GeV/c^2)	Decay
Λ	uds	7.89	2.632×10^{-10}	1.116	$p\pi^-$ (63.9%)
					$n\pi^0$ (35.8%)
Σ^+	uus	2.404	8.018×10^{-11}	1.189	$p\pi^0$ (51.57%)
					$n\pi^+$ (48.31%)
Σ^0	uds	2.22×10^{-9}	7.4×10^{-20}	1.193	$\Lambda\gamma$ (100%)
Σ^-	dds	4.434	1.479×10^{-10}	1.197	$n\pi^-$ (99.848%)
Ξ^0	uss	8.71	2.0×10^{-10}	1.315	$\Lambda\pi^0$ (99.524%)
Ξ^-	dss	4.91	1.639×10^{-10}	1.322	$\Lambda\pi^-$ (99.887%)
Ω^-	sss	2.461	8.21×10^{-11}	1.672	ΛK^- (67.8%)
					$\Xi^0\pi^-$ (23.6%)
					$\Xi^-\pi^0$ (8.6%)