Open Charm Production in ALICE Fixed Target

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Motivation for Fixed Target Setup

Motivation:

- ★ Measurement in high x frontier.
- ★ Study longitudinal expansion of QGP.
- ★ Factorization of CNM effects & more [1]
- ★ Variable target system *e.g.*, C, W, Ti.
- ★ $\sqrt{s_{\rm NN}}$ =115 (*p*-*A*) and 72 GeV (*Pb*-*A*).

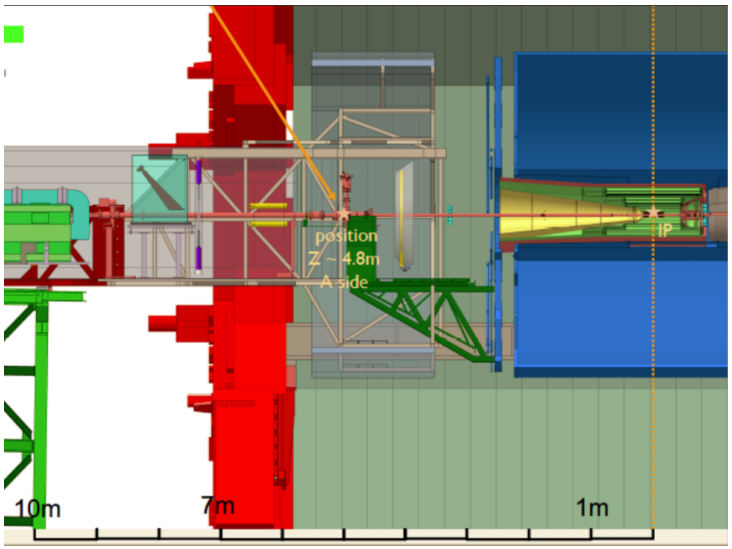
Fixed Target Setup in ALICE:

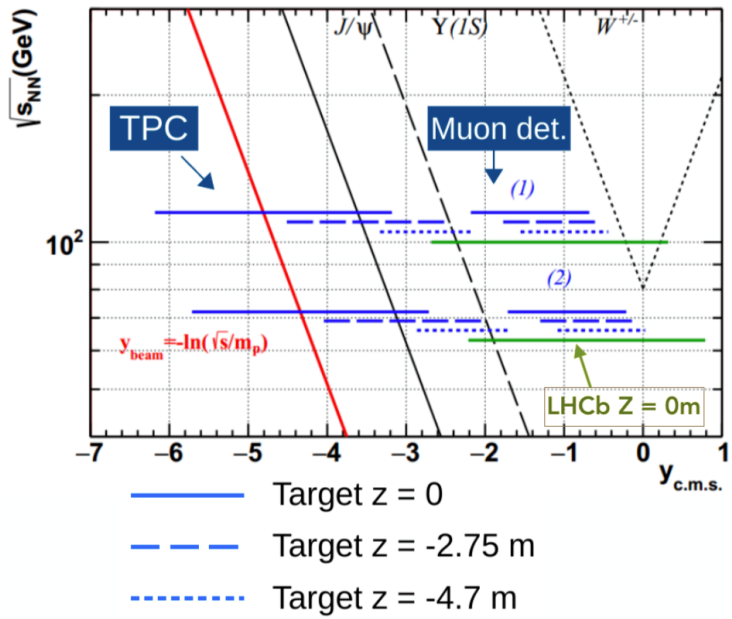
- ☐ proton beam halo can be channeled with bent crystal [2]
- ☐ Optimal Target position: ∼480 cm.
- ☐ Retractable taget setup.
- ☐ Smooth integration with ALICE setup.

Technical Challenges:

➤ How TPC responses to inclined tracks? (*i.e.*, -2.5 $\leq \eta \leq$ -1.0).

➤ Can we measure Λ, D^0 from FT event ?





[1] C. Hadjidakis *et.al.* Phys. Rep., Vol. 911, p1 (2021).
[2] M. Patecki, JACoW-HB2021-MOP26

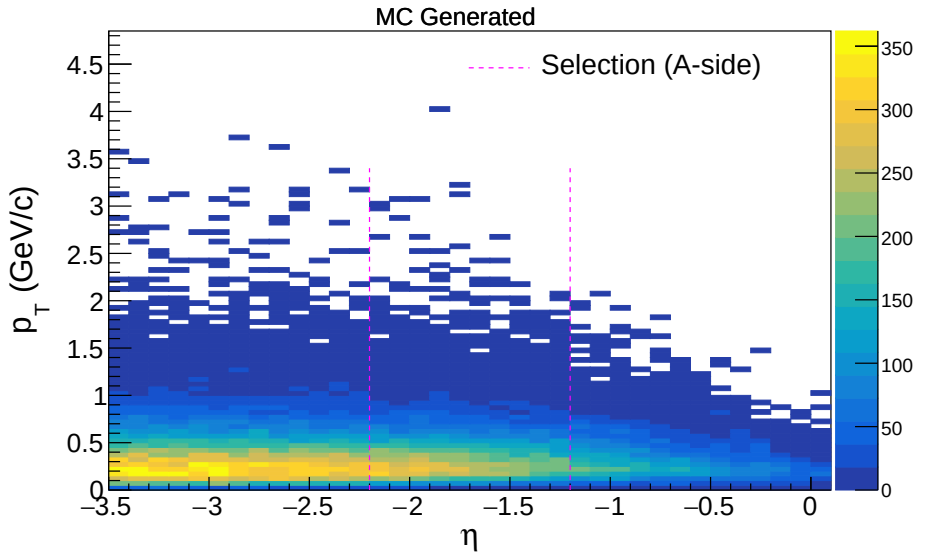
Simulation Configurations

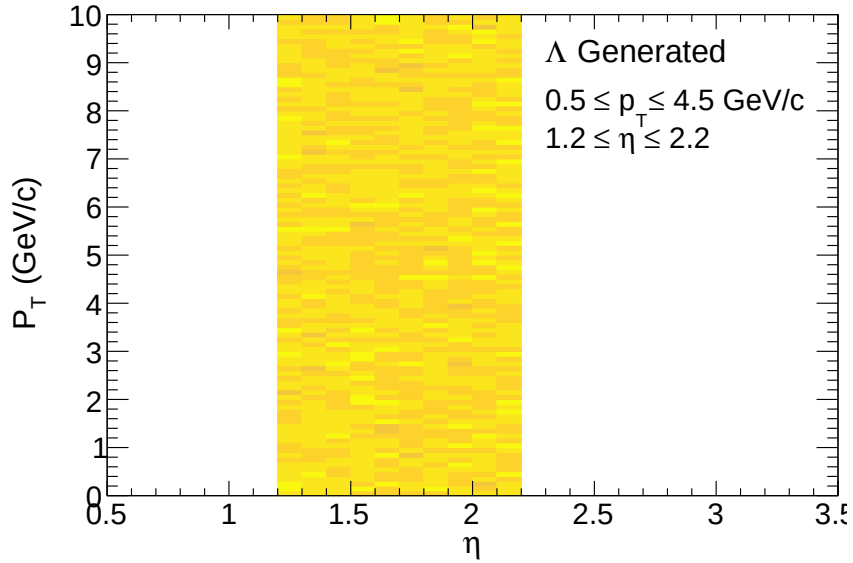
For Charged particles:

- System: proton on Tungsten (W).
- Energy: $\sqrt{s_{\mathrm{NN}}} = 115$ GeV/c.
- Generator: HIJING (w. Run-2 software).
- Reconstruction: with O2 (Run-3 software).
- No. of Events: ∼5000 events.
- Particles: $h^{\pm}$ (-2.2 $\leq \eta \leq$ -1.2).

For Λ and D^0 particles:

- Fast Decay simulation → we can decide if wee need full O^2 simulation for Λ and D^0.
- Generated Λ and D^0: Flat in p_{T} with -2.2 $\leq \eta \leq$ -1.2 and 0 $\leq \phi \leq 2\pi$.
- No. of Fast sim particle: ∼200K (per set).
- Decayed with TGenPhaseSpace (Root class).
- Topological cuts: Decay length, M_{inv}.
- Sec.Vertex resolution not simulated.





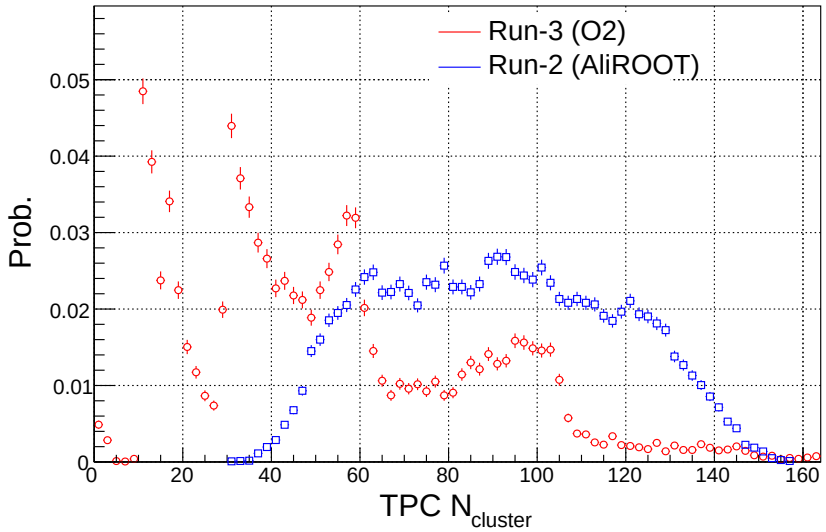
Some known issues with inclined tracks in O2

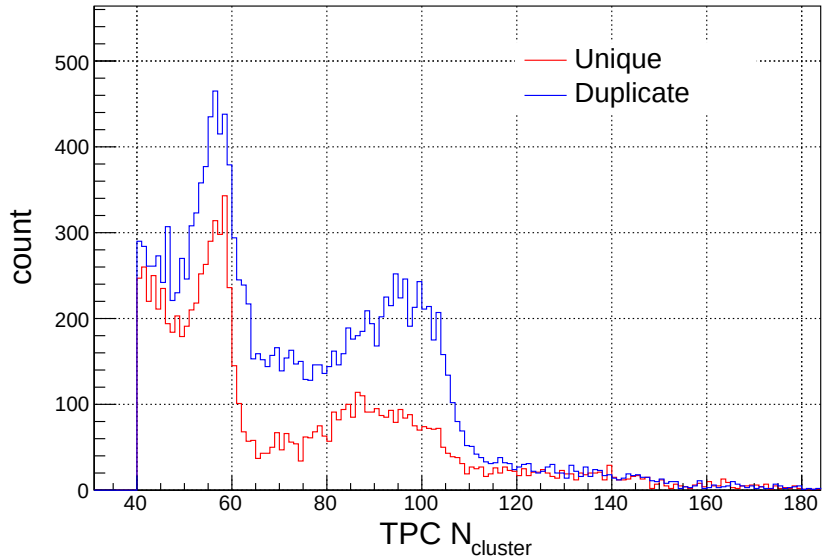
Known challenges of Fixed targed tracks:

- Inclined FT track cannot cross full TPC.
- TPC $N_{\rm cls}$ is on average lower than collider.
- Track segments not merging in O2
  $\rightarrow$ Mutiple track segments per MC track.
  $\rightarrow$ This was not a problem in Run-2.
- Need help from TPC experts!

Work arounds for the issue:

- For efficiency estimation $\rightarrow$ no $N_{\rm cls}$ cut, & unique set of tracks used (no duplicate).
- For p_T resolution: use $N_{\rm cls} \geq 70$
  $\rightarrow$ minimum quality cut.
- Permanent solution: waiting for TPC experts to fix this merging issue.





Simulation Results for charged tracks from FT events

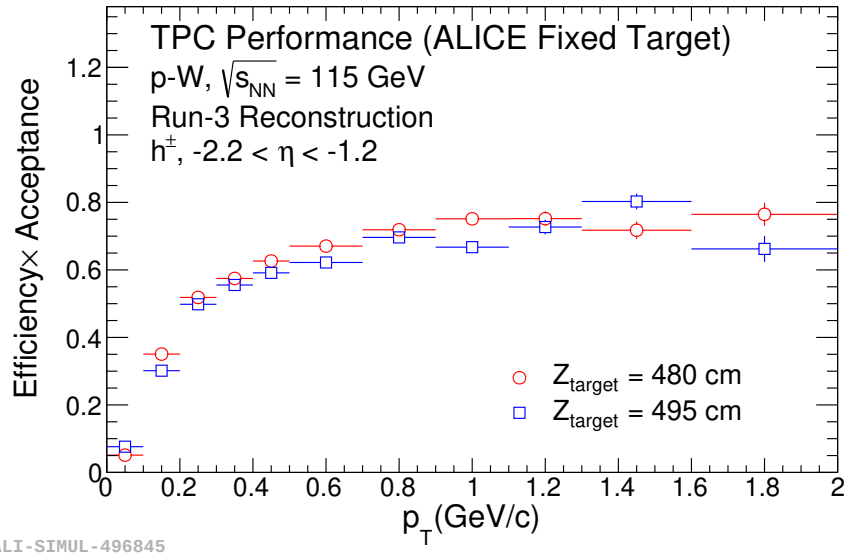
Observations:

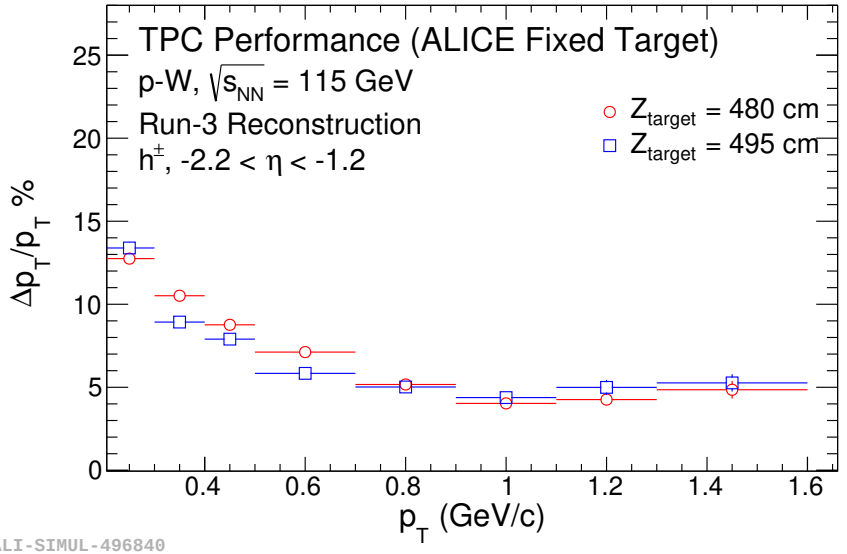
Tracking Efficieny for charged tracks:

- ★ Efficiency X Acceptance shown for Target positions = 480 cm and 495 cm.
- ★ Efficiency is similar for two positions.
- ★ Efficiency is lower than collider tracks. → But sufficient for analysis.

p_{T} Resolution of charged tracks:

- ★ p_{T} resolution estimated with $N_{cls} \geq 70$.
- ★ p_{T} resolution does not depend on target position.
- ★ p_{T} resolution is smaller than collider tracks. → collider tracks has higher N_{cls}.
- ★ Reasonably good p_{T} resolution, → without any dedicated tracker.

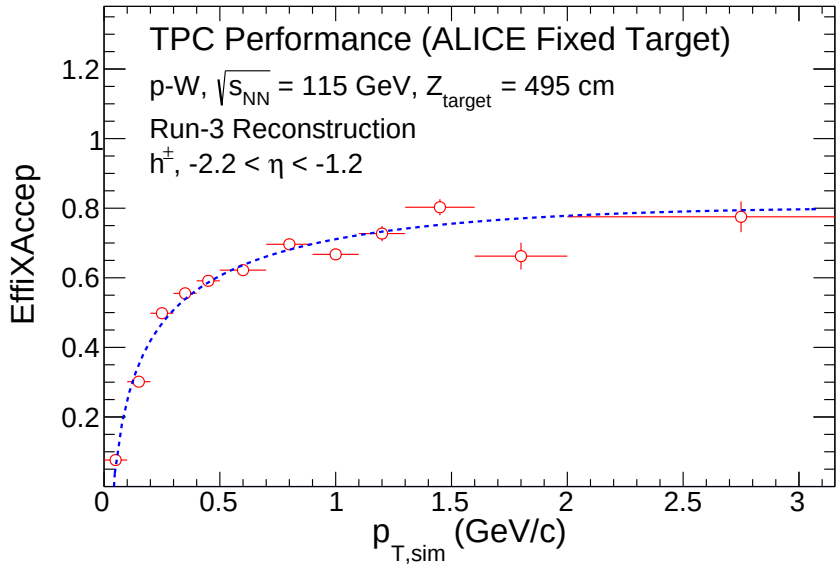




Simulation Results for charged tracks from FT events

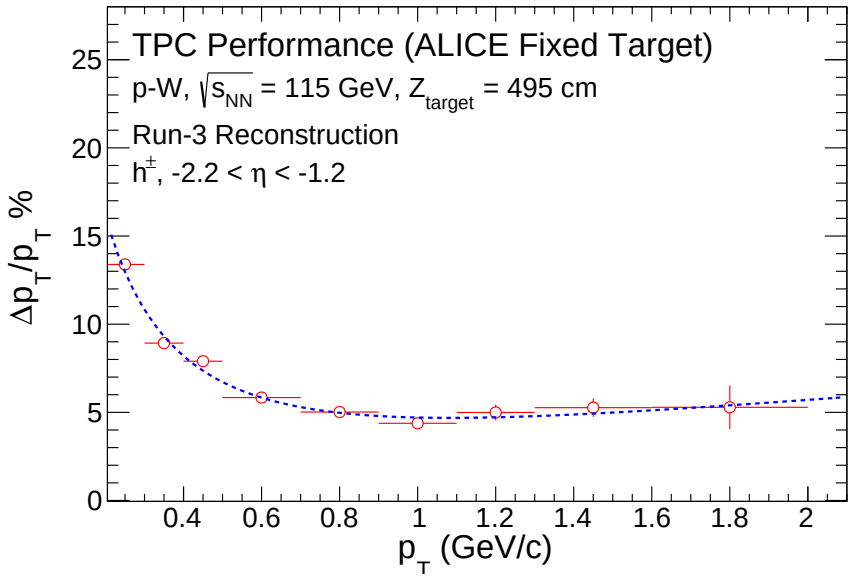
Observations:
Tracking Efficieny for charged tracks:

- ★ Efficiency X Acceptance shown for Target positions = 495 cm.
- ★ Efficiency is similar for two positions.
- ★ Fit with PolN and Log function
  → for continuous value for Fast decay sim.

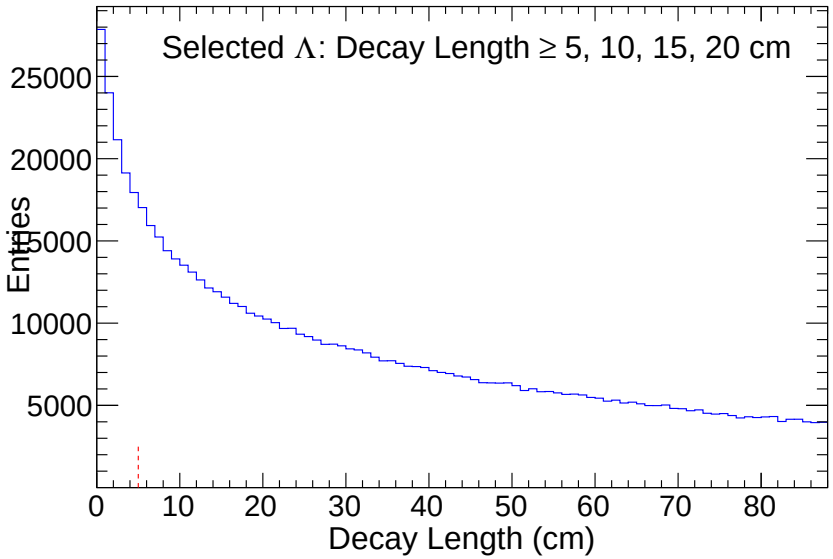


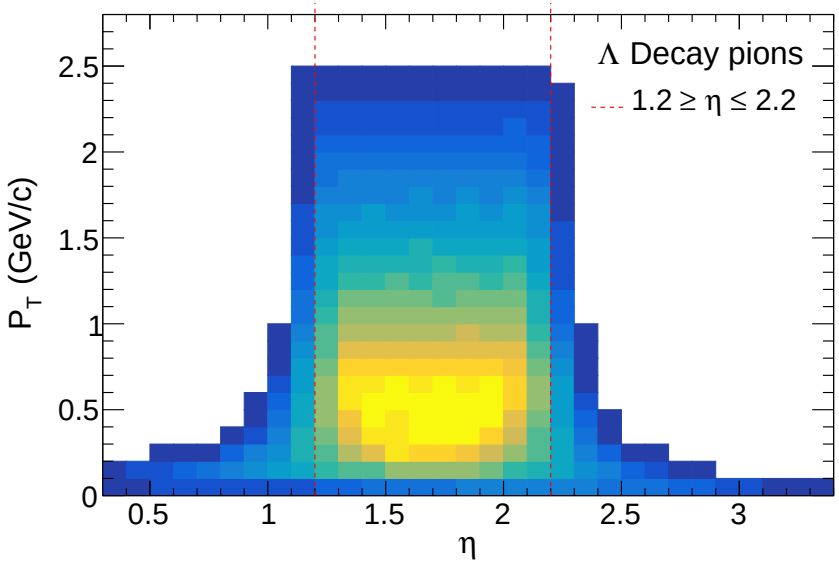
p_{T} Resolution of charged tracks:

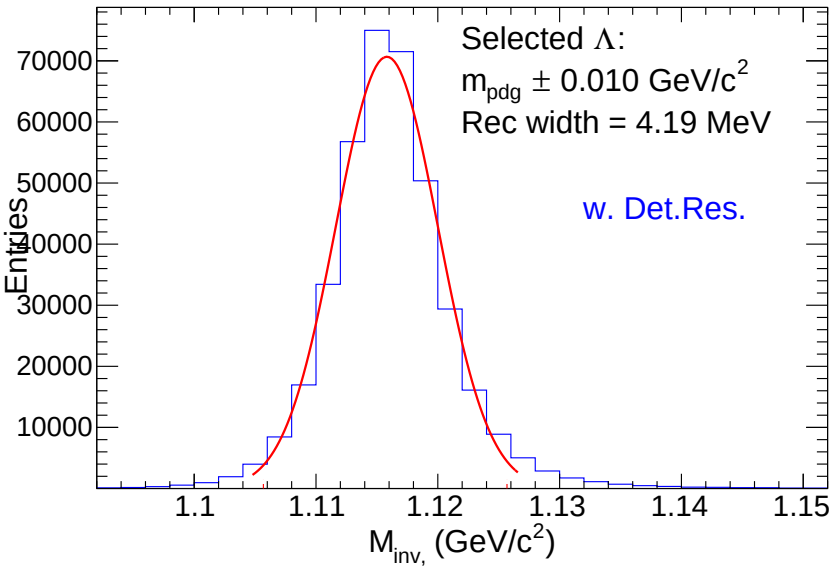
- ★ p_{T} resolution estimated with $N_{cls} \geq 70$.
- ★ p_{T} resolution does not depend on target position.
- ★ p_{T} resolution is smaller than collider tracks.
  → collider tracks has higher N_{cls}.
- ★ Fit with PolN and exp function
  → for continuous value for Fast decay sim.

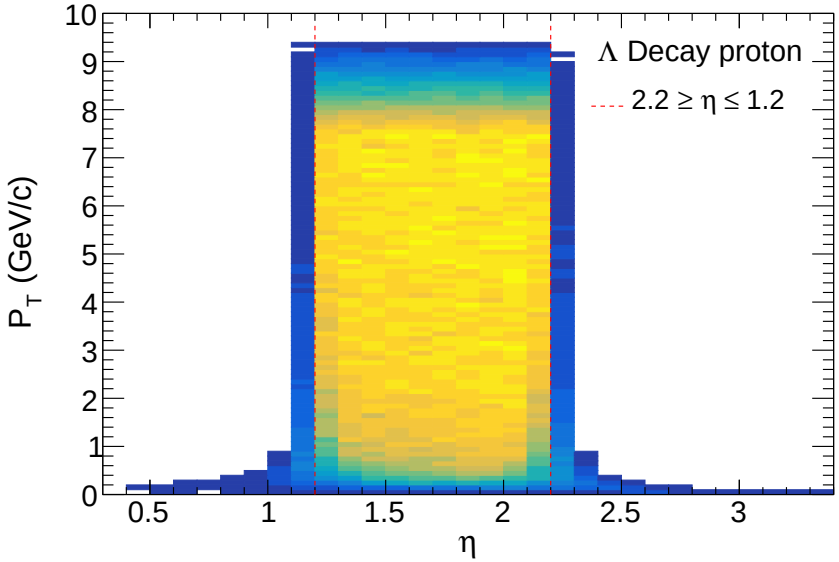


Some QA plot for Fast decay sim of Λ









Fast Simulation Results for Λ in FT event

Observations:

Tracking Efficieny for Λ:

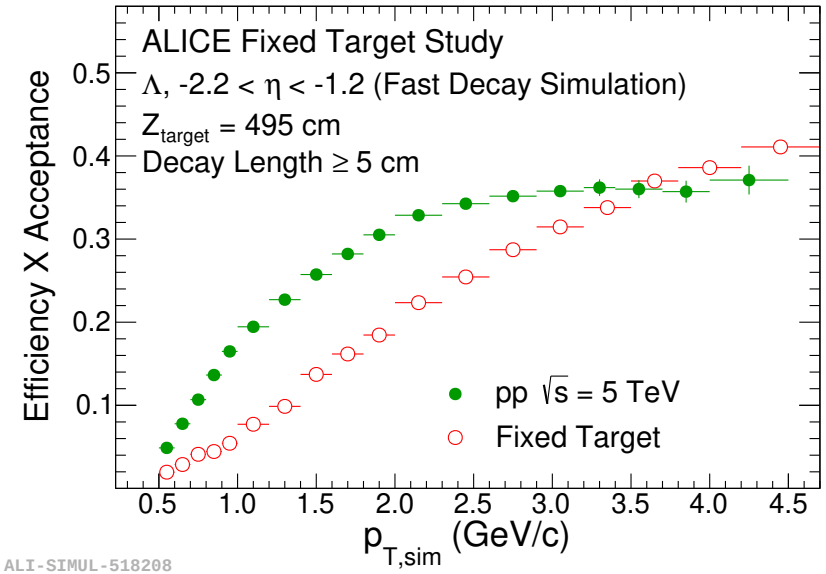
- ★ Efficiency X Acceptance shown for DL ≥ 5cm, and M_{inv} cut: $M_{pdg} \pm 10$MeV.
- ★ Efficiency is lower at low p_T compared to collider events. → sufficient for analysis.

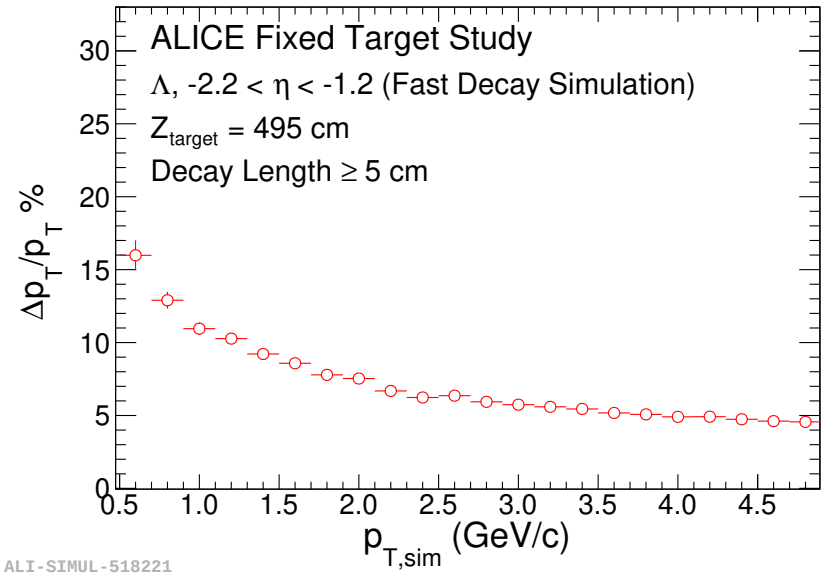
p_T Resolution of Λ:

- ★ p_T resolution estimated from Λ reconstructed with smeared daughters.
- ★ Pt resolution sufficient for analysis, → without any dedicated tracker for FT.
- ★ Caveats: The Λ efficiency should also depend on resolution of Sec. (V0-)Vertex, purity/mis-identification of daughters (π and p) → has not been estimated!

Note: Primary V_z resolution = 2.4 cm for FT.

ALICE Efficiency: Analysis Note Id 959.





Fast Simulation Results for Λ in FT event

Observations:

Tracking Efficieny for Λ:

- ★ Efficiency X Acceptance decreases with increasing decay length cut.
- ★ With larger decay length cuts, efficiency decreases. → Still sufficient for analysis.

p_{T} Resolution of Λ:

- ★ p_{T} resolution does not depend on decay length cut, → only depends on N_{cls}.
- ★ p_{T} resolution is sufficient for analysis, → without any dedicated tracker for FT.
- ★ Caveats: The Λ efficiency should also depend on resolution of Sec. (V0-)Vertex, purity/mis-identification of daughters (π and p) → has not been estimated!

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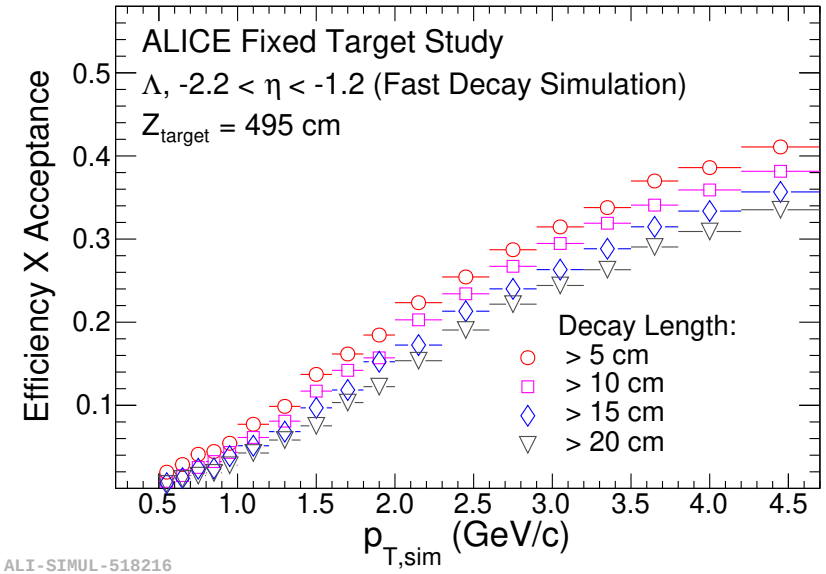
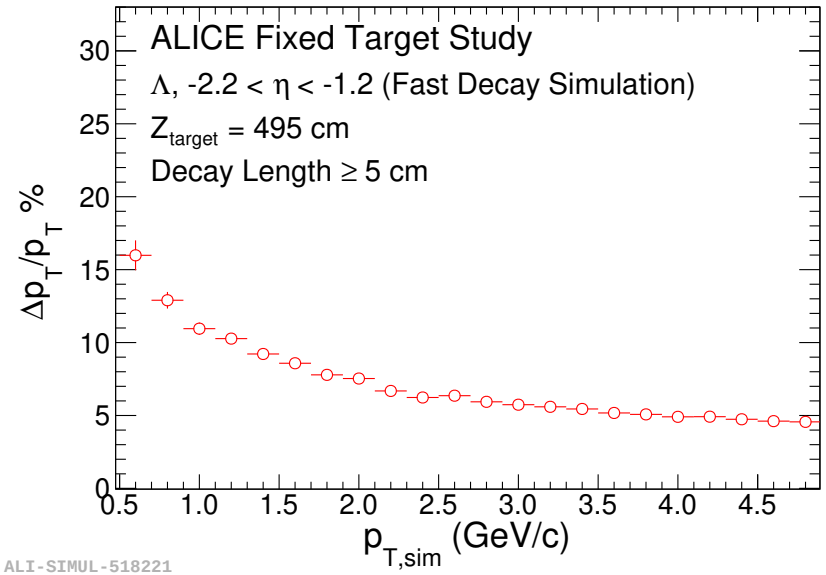
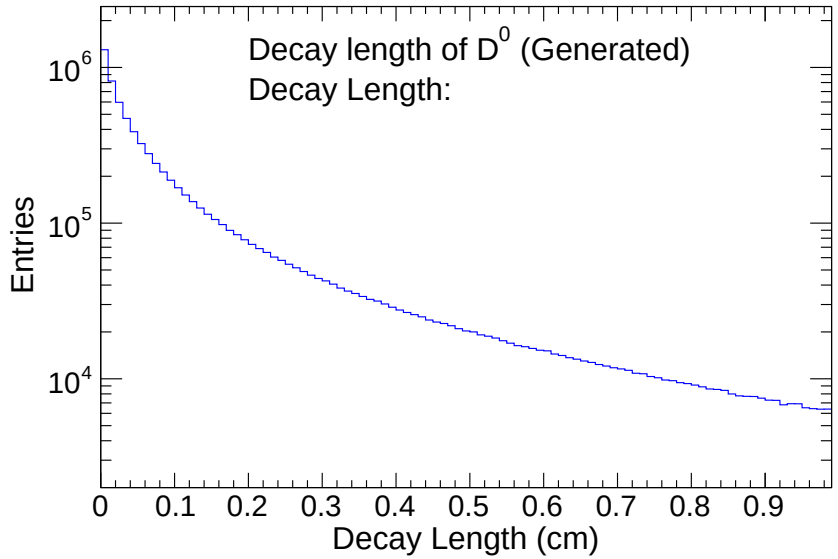
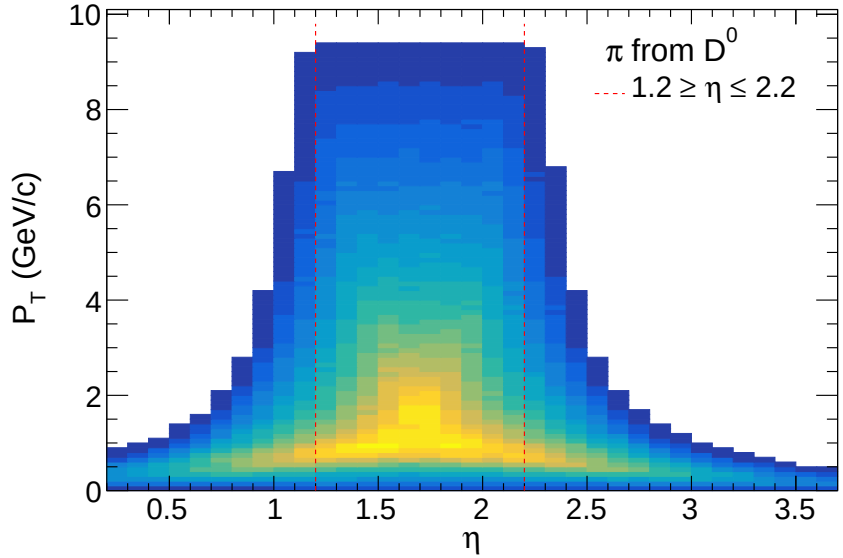
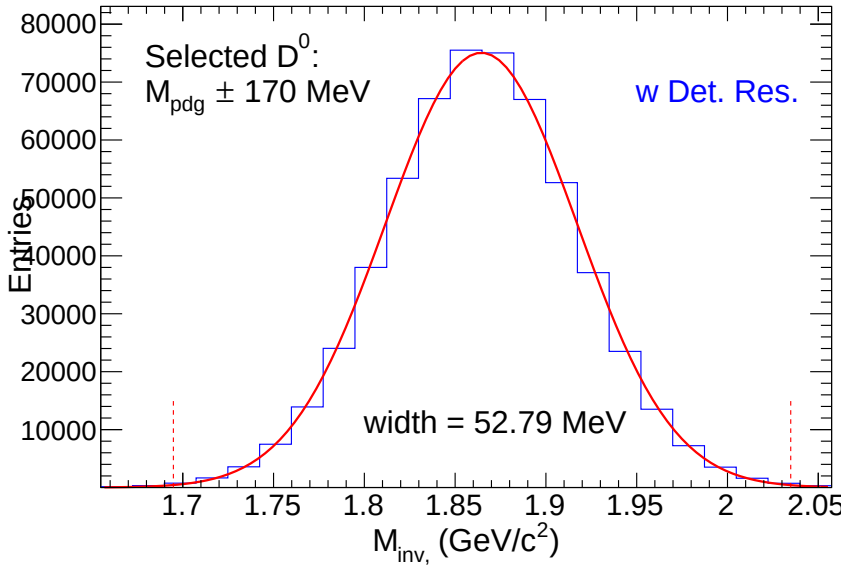


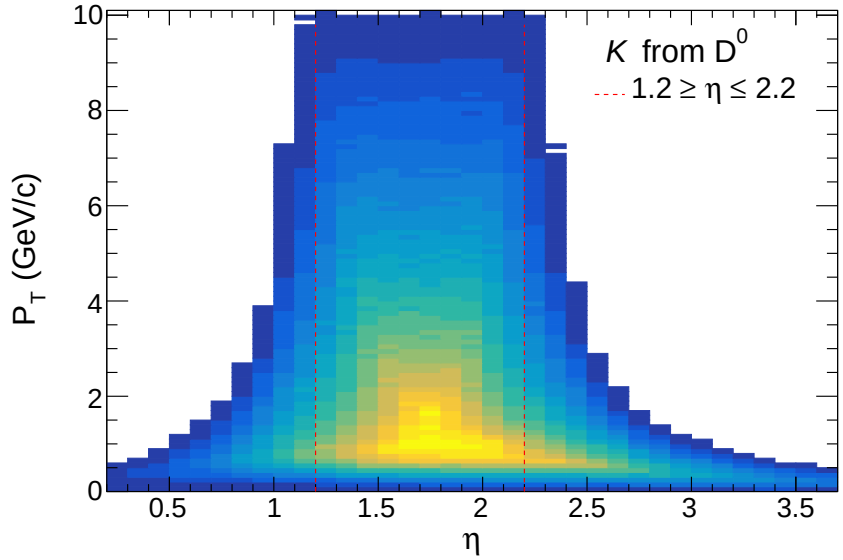


Some QA plot for Fast decay sim of D^0









Fast Simulation Results for D^0 in FT event

Observations:

Tracking Efficieny of D^0 with DL cut:

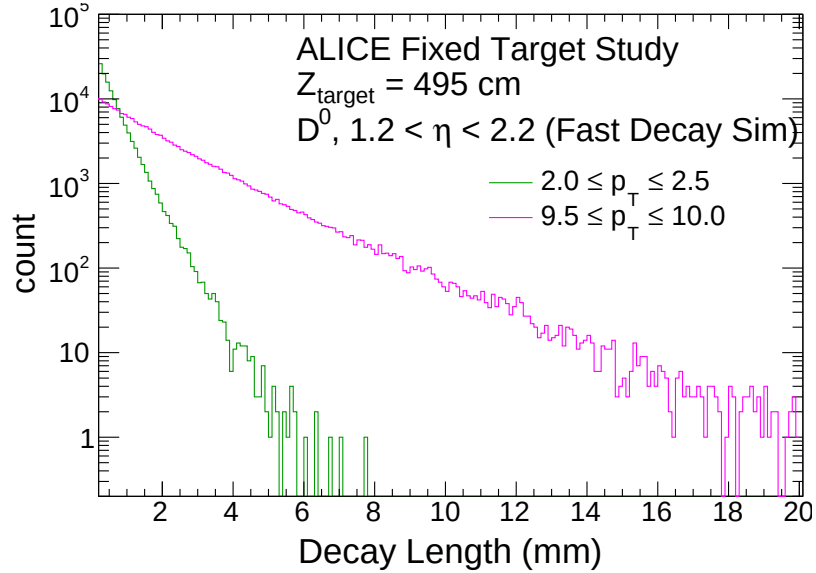
- ★ Top Fig: Simulated decay length of D^0.
- ★ Most of D^0 decays within target $\rightarrow \geq$90% within 1cm.
- ★ Rec.vertex method not feasible for D^0 $\rightarrow$ use combinatorial method to select D^0 in FT events.

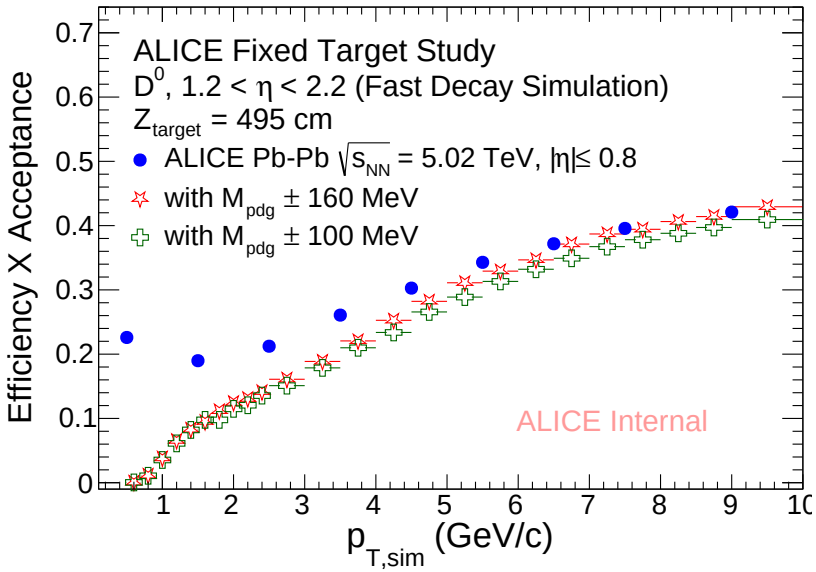
Tracking Efficieny of D^0 w/o DL cut:

- ★ EfficiencyXAcceptance is sufficient for analysis.
- ★ Combinatorial background study for S/B $\rightarrow$ Use model for background π, K.
- ★ Caveats: The D^0 results should also depend on on the purity/mis-identification of daughter π and K $\rightarrow$ not estimated!

Note: Primary V_z resolution = 2.4 cm for FT.

ALICE Efficiency: JHEP 01(2022)174.





Fast Simulation Results for D^0 in FT event

Observations:

p_T resolution of D^0:

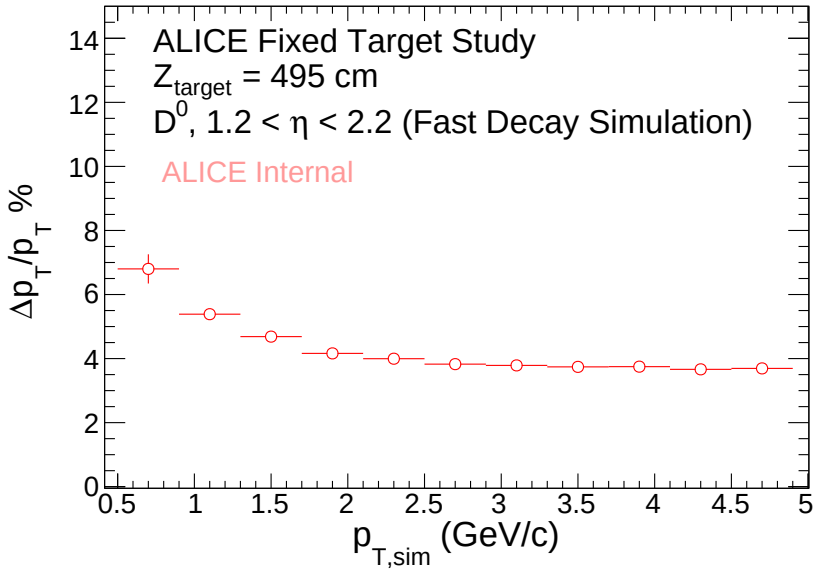
- ★ p_T resolution does not depend on decay length, → only depends on N_{cls}.
- ★ Minimum requirement TPC $N_{cls} \geq 70$.
- ★ p_T resolution is sufficient for analysis, → without any dedicated tracker for FT.

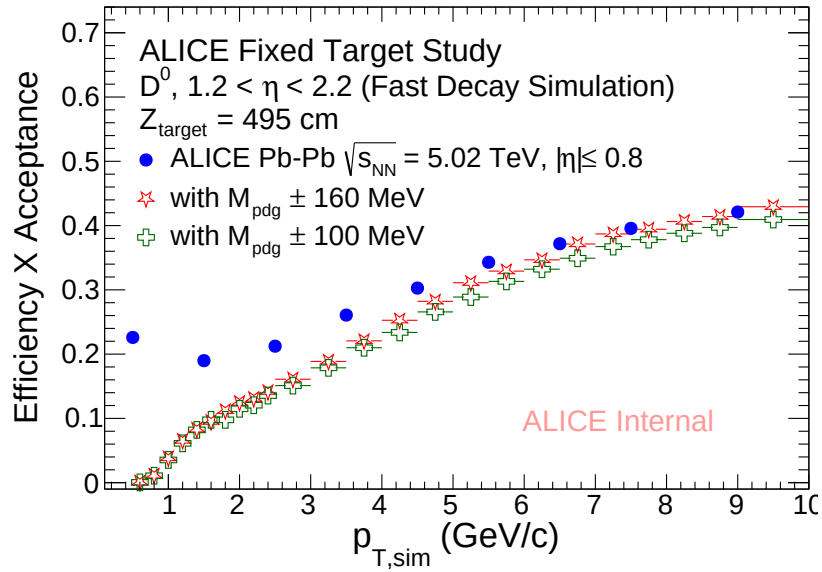
Tracking Efficieny of D^0 w/o DL cut:

- ★ EfficiencyXAcceptance is sufficient for analysis.
- ★ Combinatorial background study for S/B → Use model for background π, K.
- ★ Caveats: The D^0 results should also depend on on the purity/mis-identification of daughter π and K → not estimated!

Note: Primary V_z resolution = 2.4 cm for FT.

ALICE Efficiency: JHEP 01(2022)174





Summary and Outlook

Summary:

1. Tracking efficiency and p_{T} resolution measured for Fixed Target setup in ALICE.
2. Efficiency and Resolution for charged particles $\approx$ 70% and 5% for p_{T} $\sim$1 GeV/c.
3. Charged particle response is used as proxy for decay daughter of Λ & D^0.
4. Fast Decay Simulation of Λ:
   - Efficiency and p_{T} resolution are sufficient for analysis (without extra detector).
   - Tracking efficiency and resolution has weak dependence on Target position.
5. Fast Decay Simulation study of D^0:
   - Sec. vertex method cannot be used for FT events $\rightarrow$ not feasible.
   - Combinatorial method shows that D^0 reconstruction efficiency is sufficient for analysis

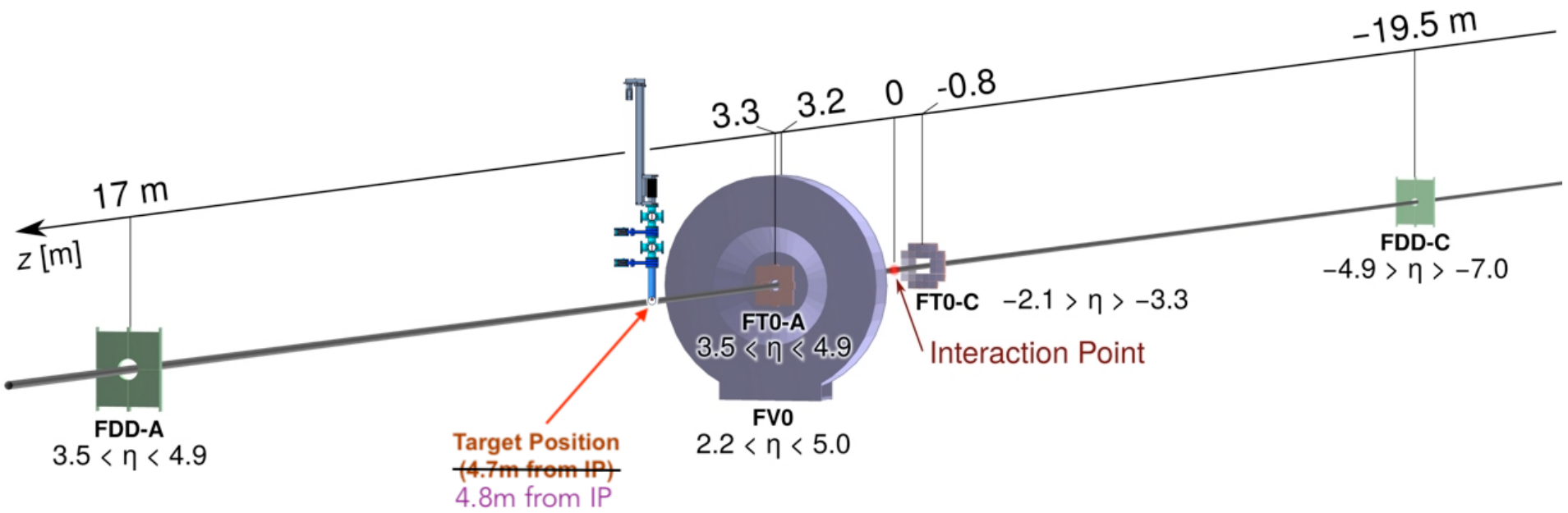
★ Caveats:
– Effects of purity of daughters (for Λ, D^0), and sec.vertex resolution (for Λ) have not been estimated yet.

Outlook:

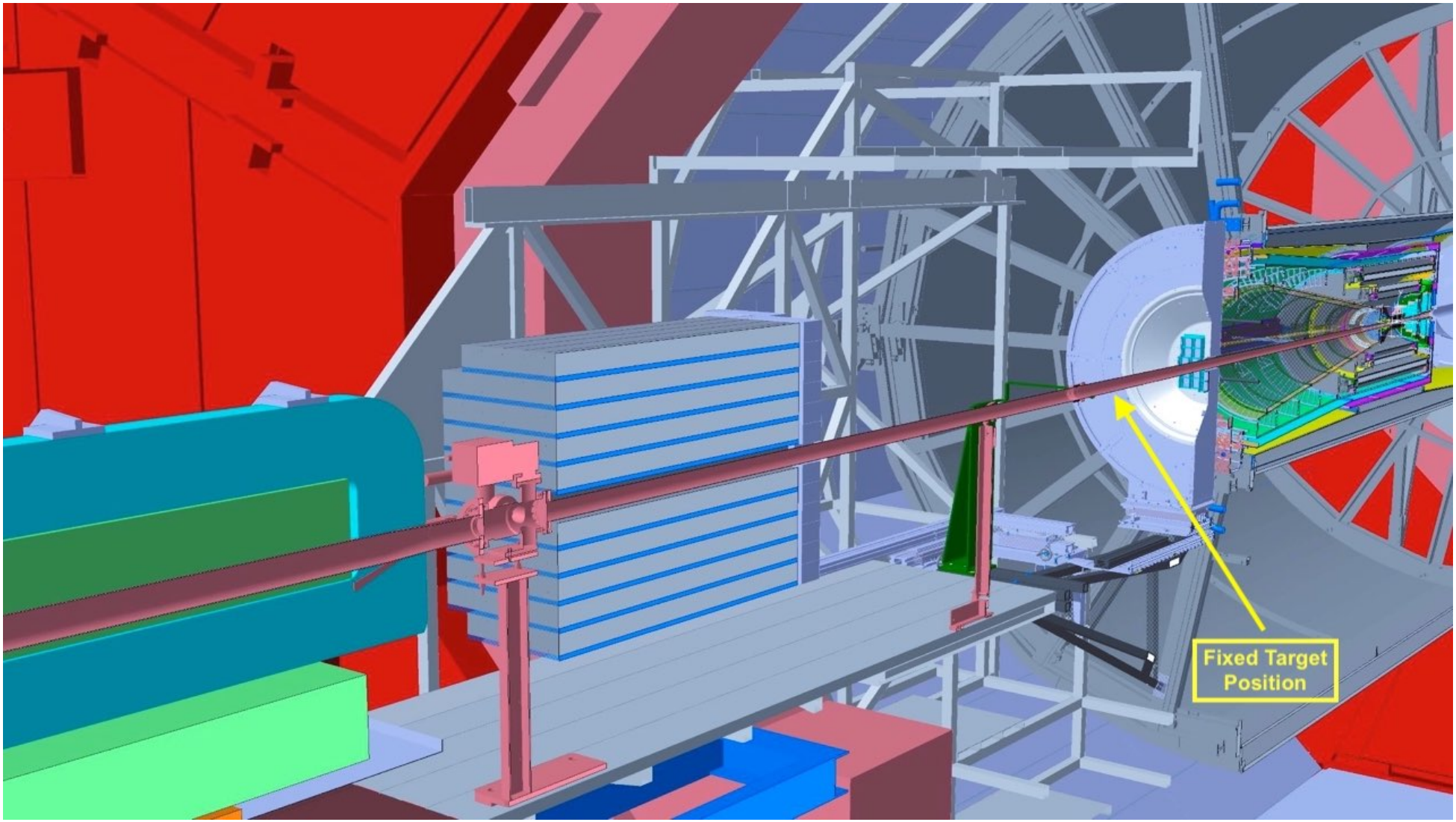
- Do full simulation of Λ, D^0 to see effects of daughter mis-idenfitication, sec. vertex resolution etc.
- Estimate S/B and Significance of D^0 signal for Combinatorial Method.
- Physics Performance study using the detector responses.

★ This Project is funded by the European Union's Horizon 2020 program (grant agreement No 824093).

Back up



Target Position sketch-I



Target Position sketch-II

Vertex Resolutions (Run-2 AliRoot Simulation)