Simulation of TPC performance for the ALICE fixed target program

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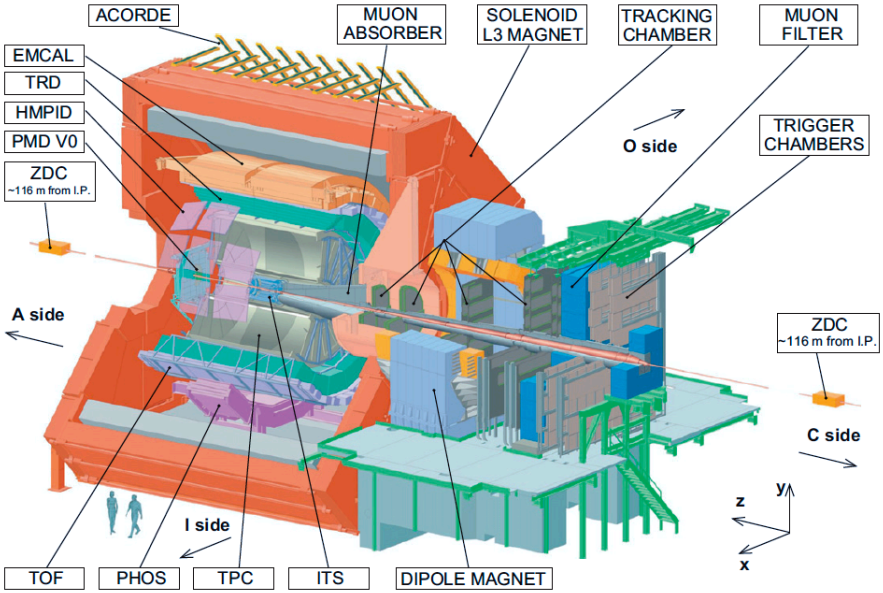
The ALICE Experiment

J. Alme et al. / Nuclear Instruments and Methods in Physics Research A 622 (2010) 316–367



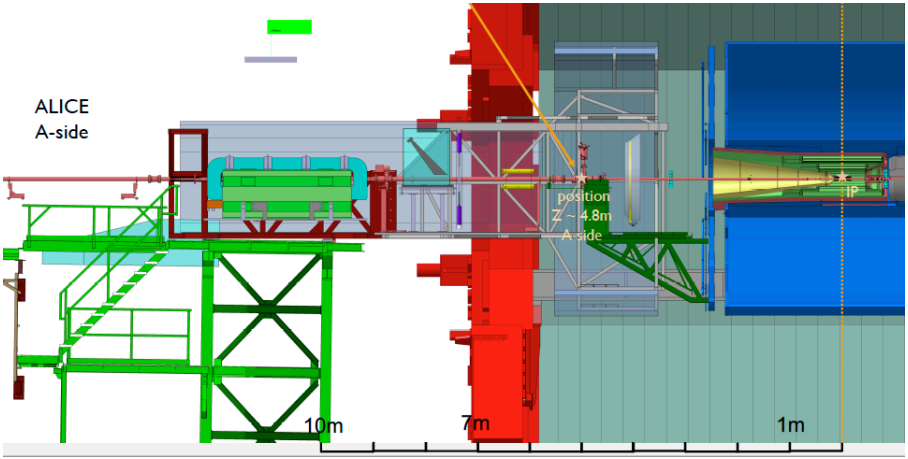
Physics Motivations for Fixed-Targed@ALICE

Main physics goals envisioned[2]

- Understanding of the large-x gluon, antiquark and heavy-quark content in the nucleon and nucleus:
  - Structure of nucleon and nuclei at large-x poorly known.
  - Study possible gluon EMC effect in nuclei.
  - Existence of possible non-perturbative source of c/b quarks in the proton: useful for HE neutrino and CR physics.
- Study heavy-ion collisions between SPS and RHIC energies towards large rapidities:
  - Explore the longitudinal expansion of QGP formation.
  - Study collectivity in small systems with new probes thanks to high luminosity (heavy quarks).
  - Test factorization of CNM effects with Drell-Yan.

[2]For detailed physics motivations with performance: arXiv:1807.00603

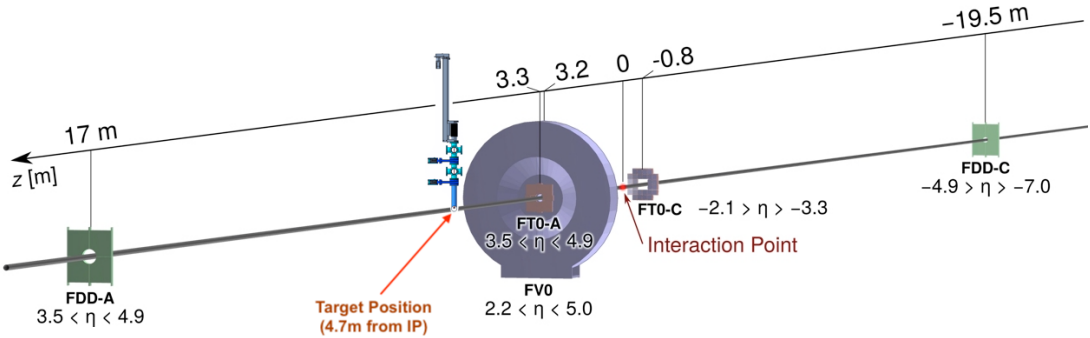
The Fixed Taget Position



- Favoured position from integration studies: b/w 4.7 - 4.8m (from IP) on A-side.
- Other position: outside L3 magnet but far from ALICE IP. Also additional detectors needed (vertex, tracking).

[3]Figure Credit: Laure Massacrier

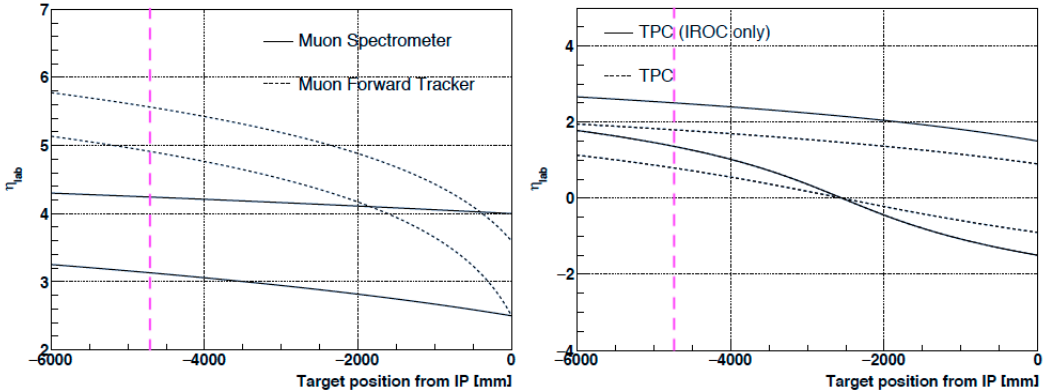
The Fixed Taget Position



- Tracks from FT events would be shadowed by FT0/FV0.
- The FT drive mechanism and support system may cause shadowing for FOCAL Detector (not included in the sketch).

[3]Figure Credit: Felix Reidt

ALICE Acceptance in Fixed Taget mode



- The TPC would have coverage $1.35 < \eta < 2.51$
- The ITS coverage would be too small to do any physics.

[4]Figure Credit: Laure Massacrier

Simulation Goals and Configuration

– Goals:

- Impact of large dip angles on TPC cluster finding and tracking (ongoing).
- Determining distortion corrections with Run 3 rates (future plan).

– Configuration:

- Simulation Software optimised for Run-2 data is used.
- Simulation Method: OCDB (Online Condition Database) → Simulation → Reconstruction.
- Collision System: $p - A$ at $\sqrt{s_{NN}}$ =115 GeV (p on W/Pb Target).
- Target Position (or IP) on beam axis = 480cm.
- TPC acceptance (for IP = 480 cm)^3 is -1.38 $< \eta <$ -2.51
- Event Statistics: ∼5000 p-W (central and Minimum Bias),
- HIJING event generator is used to simulate p-A collisions (Lab frame).
- Selected tracks: Charged Hadrons ($\pi^{\pm}$, $K^{\pm}$, p, $\bar{p}$).

Caveats and Run-3 specifications

– Specifications in Run-3:

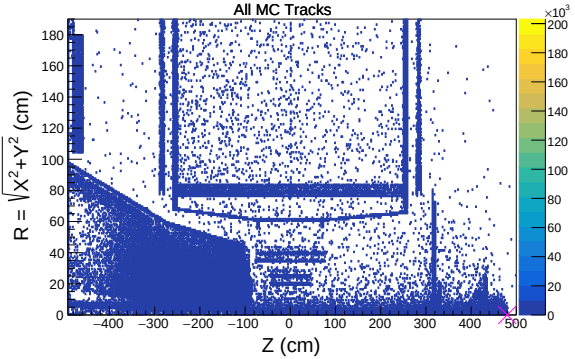
- In Run-3 data taking, TPC would record data continuously. Therefore, it is important to differentiate b/w start time of a collider and FT event.
  → Can only be tested in Run-3 simulation framework (O2).
  → Alternate solution: Time shared data-taking (*i.e.* collider mode is paused during FT data taking period).

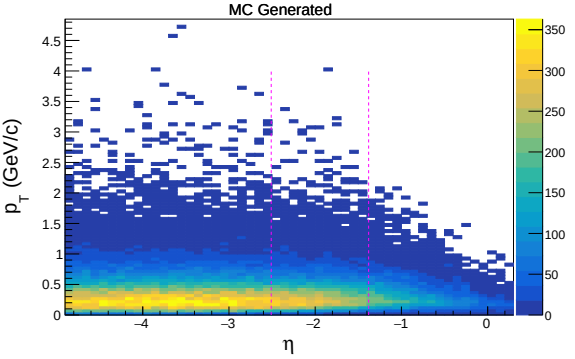
- Caveat: In the current simulation, we consider all events selected.

- TPC Space-Charge Distortions in Run-3 data taking rate would be different than Run-2. Distortion correction map depends with dip angles, drift lengths.
  → Would be evalulated for FT tracks using Run-3 Simulation Software (O2).

- Caveat: In the current simulation, TPC distortion maps of Run-2 have been used.

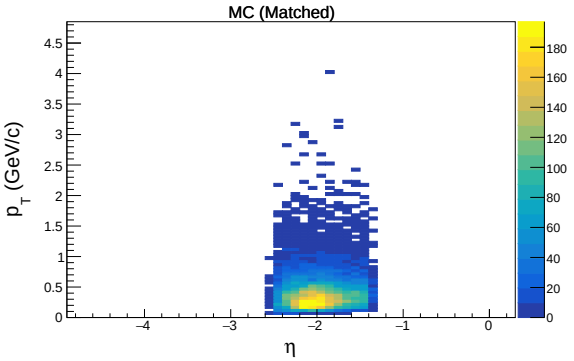
General QA: Secondary tracks and Acceptance (p-W MB)

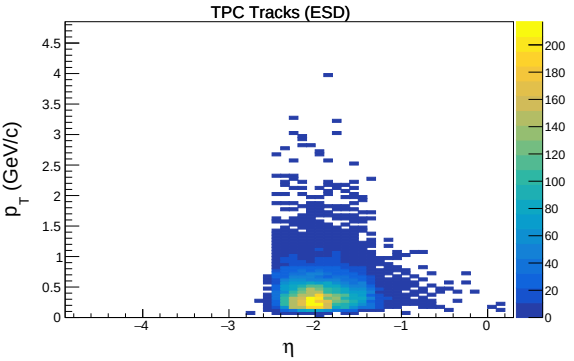




- Left: Secondary Tracks allow to see detector structures.
- Right: Particles are boosted in the A-side (due to Fixed Target collision).
- Dotted line on $\eta - p_{\mathrm{T}}$ plot shows the TPC acceptance (-1.38 $< \eta <$ -2.51).

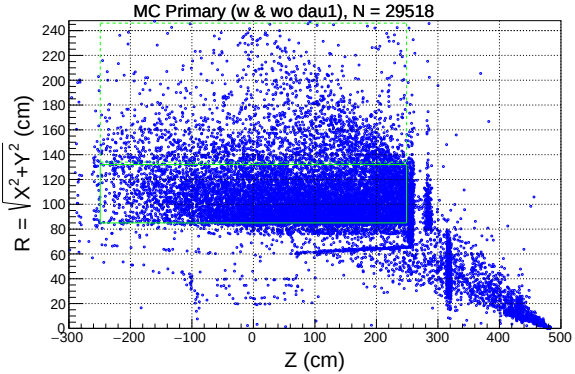
General QA: η-p_{T} of MC and Reconstructed TPC tracks (p-W MB)

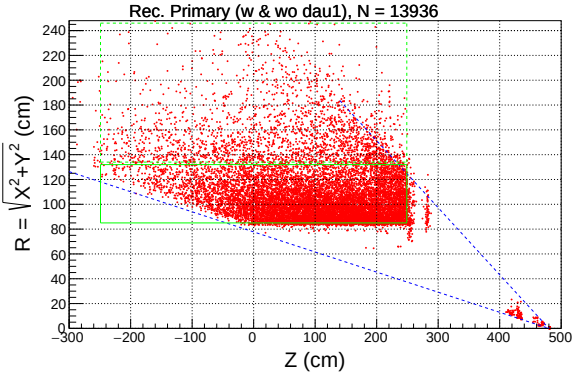




- Left: η-p_{T} of MC tracks (reconstructed) chosen within $-2.51 < \eta_{\mathrm{MC}} < -1.38$.
- Right: η-p_{T} from reconstructed track parameters $\rightarrow$ equivalent to real data.
- Observation The η-p_{T} for reconstructed TPC tracks is smeared at low p_{T}.

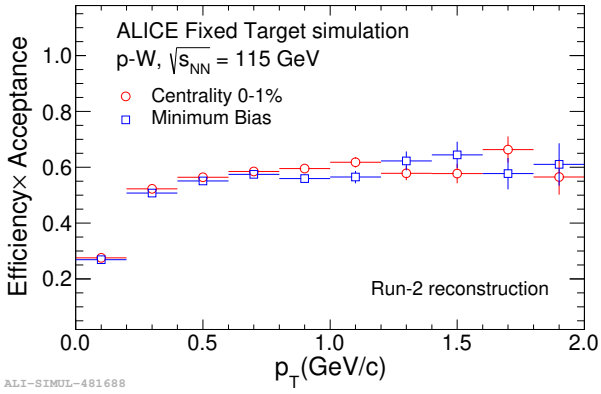
RZ-distribution of primary tracks with daughter (p-W MB)

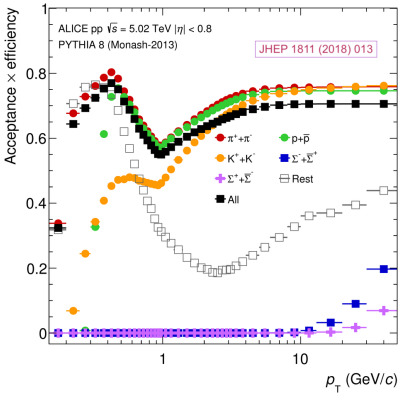




- Left: MC primary tracks, Right: Reconstructed Tracks, Green Box: TPC active volume.
- Both Figures show origin point (in RZ plane) for 1^{st} daughter from MC Primary track
- Relaxing the tracking cuts improves reconstruction for inclined tracks.
- Most of the tracks within TPC active volume are reconstructed.

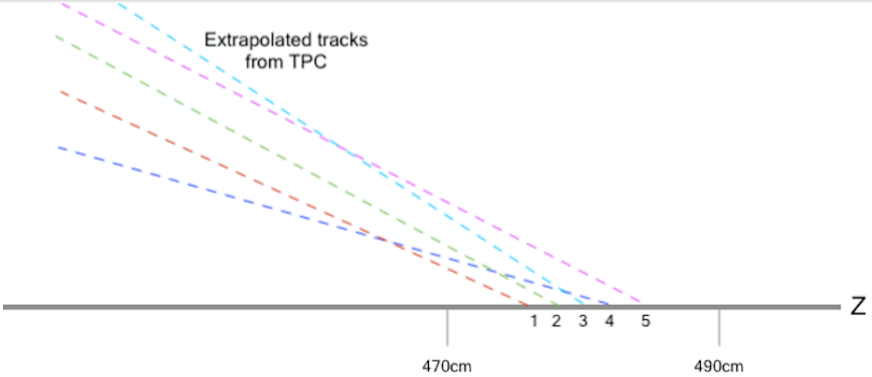
Track Efficiency for Selected Events (p-W and p-Pb)





- Left: Track efficiency for Fixed Targed events (p on Tungsten).
- Right: Track efficiency in ALICE for pp collider events at $\sqrt{s_{NN}}$ =2.76 TeV.
- Caveat: Run-2 Simulation! To be re-evaluated using Run-3 Simulation Software (O2).

Vertex Finder Method for Fixed Targed Events



1. Select tracks with $475 < \mathrm{DCA_z} < 485$ cm and $\mathrm{DCA_R} < 5$ cm (Distance of Closest Approach).
2. Find 3D crossing point (*p1, *p2) for all pairs (1-2,1-3,... 2-3,2-4... $= N_{\mathrm{pair}}$).
3. Sum(Z) $= \Sigma_{pair}$ $(w_1 \mathrm{p1[2]} + w_2 \mathrm{p2[2]})$, $w_1 = \sigma_{z,2}/(\sigma_{z,1} + \sigma_{z,2})$ and $w_2 = (1 - w_1)$.
4. $\mathrm{V}_z = \mathrm{Sum(Z)}/N_{\mathrm{pair}}$. Similar way for V_x, V_y.

$\rightarrow$ Vertex reconstruction efficiency $\approx$ 60% for central (<20%) events.
$\rightarrow$To be re-evaluated in Run-3 software.

Summary and Outlook

Summary:

1. TPC Tracking efficiency is estimated for ALICE Fixed Target Program.
2. Tracking efficiency for Fixed Targed Event $\approx 60\% \rightarrow$ independent of centrality.
3. Event reconstruction efficiency (with TPC only) is found to be $\approx 60\%$ for central events while 30% for MB p-W events $\rightarrow$ without any additional Vertex detector.

– Caveats:

- Whether FIT Detector in Run-3 be used for FT events (for timing) $\rightarrow$ To be evaluated in O2 software (with detector experts).

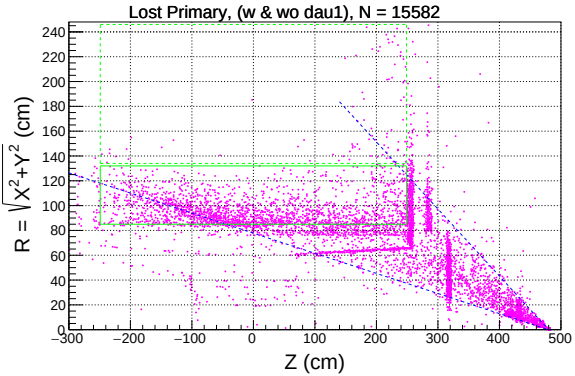
Next plans:

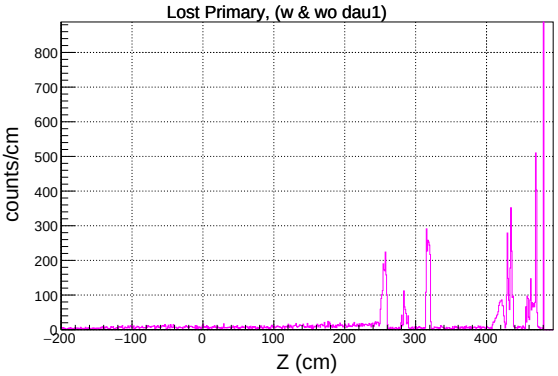
- Perform All simulations in ALICE Run-3 software (O2).
- Study Tracking performance (efficiency).
- Study Vertex/Event recontruction efficiency.
- Study Vertex position resolution with TPC only tracks.
- Evaulate TPC distortion map for inclined tracks.

[1]Thanks to Ruben Shahoyan, David Rohr, Marco van Leeuwen, and Other ALICE Experts

Back Up

RZ-distribution of lost primary tracks with daughter (p-W MB)





- Only fewer tracks are not reconstructed inside TPC acceptance
  → May be very low length tracks (<70cm).
- Most of the lost tracks are outside TPC volume
  → lost in other Detector or Support structure.

ALICE Detector acceptance in FT

Detector	Target location Z = 0	Target location Z = -135 mm	Target location Z = -2750 mm	Target location Z = -4700 mm
Upgraded ITS layer 0	$-2.50 < \eta_{lab} < 2.50$	$-0.02 < \eta_{lab} < 3.19$	$5.45 < \eta_{lab} < 5.55$	$6.01 < \eta_{lab} < 6.07$
Upgraded ITS layer 6	$-1.30 < \eta_{lab} < 1.30$	$-1.13 < \eta_{lab} < 1.45$	$2.24 < \eta_{lab} < 2.78$	$2.91 < \eta_{lab} < 3.22$
TPC	$-0.90 < \eta_{lab} < 0.90$	$-0.86 < \eta_{lab} < 0.94$	$0.08 < \eta_{lab} < 1.50$	$0.78 < \eta_{lab} < 1.79$
TPC (IROC only)	$-1.50 < \eta_{lab} < 1.50$	$-1.45 < \eta_{lab} < 1.55$	$0.17 < \eta_{lab} < 2.19$	$1.35 < \eta_{lab} < 2.50$
TOF	$-0.90 < \eta_{lab} < 0.90$	$-0.87 < \eta_{lab} < 0.93$	$-0.26 < \eta_{lab} < 1.34$	$0.27 < \eta_{lab} < 1.58$

ALICE Run-3/4 Design