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Event reconstruction in ACTAR TPC: Adaptation for transfer experiments

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Abstract. Preliminary results of the performance of the RANSAC algorithm over data measured with the ACTAR TPC detector are herewith presented. With the aim of improving track reconstruction in highly contaminated events, an initial assessment of the algorithm is given for elastic reactions involving p, d with a beam of ^{20}O. Results show great possibilities for data/noise discrimination, which in the near future will be extended to small angle and more energetic events, which are key for transfer reactions.

1 A prime example of an active target

The ACtive TARget and Time Projection Chamber (ACTAR TPC) [1] is part of a new generation of detectors aimed to overcome the limitations of traditional devices, more prominent when performing transfer experiments with exotic nuclei, where the low-intensity beams require thicker targets.

An active (gaseous) time-projection chamber (TPC) allows us to tackle this by working in inverse kinematics, obtaining the vertex and the tracks with high resolution, provided a highly segmented pad, and correcting the energy lost by the particles during their propagation inside the gas.

Major advances in R&D, mainly in the field of gaseous detectors and data acquisition, combined with the experience gained with other successful active targets such as MAYA at GANIL or IKAR at GSI, have led to the development of ACTAR TPC.

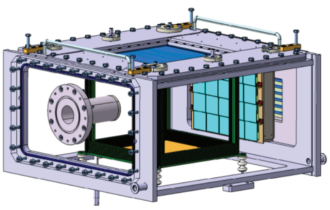

Figure 1. ACTAR TPC layout, from [1].

2 Track reconstruction with RANSAC

Detector electronics provide us with a collection of *hits*: XYZ position and collected charge. A fitting procedure (*algorithm*) has to be chosen so that we can associate those hits to *tracks*.

RANSAC (RANdom SAmple Consensus) fulfils our requirement: extracting a *model* (track) from a cloud of hits full of *outliers* (noise), which in our case is originated mainly from $\delta-$electrons [2, 3]. One can sum up the algorithm in three steps:

1. Generate N models, lines in our setup, by sampling iteratively 2 hits.
2. Given a *distance threshold*, one can rank each sampled model by counting the number of hits whose distance is below the said threshold (*inliers*).
3. Then, in descending order of inliers, a 3D linear regression is applied to the points belonging to the model, obtaining a track. Next, the points from the track are deleted from the cloud, and the sequence is halted when no more fits can be done.

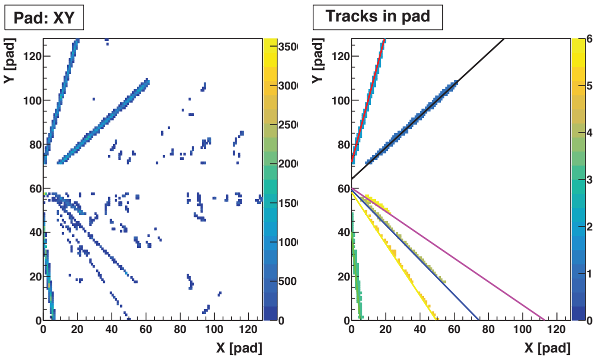

Figure 2. An example of RANSAC in our dataset.

3 Testing on data

The data for this test was gathered using a setup with ACTAR TPC and two silicon arrays placed at the left side and in front of the beam direction.

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Employing a ^{20}O beam at 35 MeV u^{-1} and a chamber filled with a mixture of 90 % D_2 and 10 % C_4H_{10}, we can measure elastic, inelastic and transfer reactions, such as:

$$^{20}\mathrm{O}(\mathrm{p},\mathrm{p})^{20}\mathrm{O}, \quad ^{20}\mathrm{O}(\mathrm{d},\mathrm{d})^{20}\mathrm{O},$$
$$^{20}\mathrm{O}(\mathrm{p},\mathrm{d})^{19}\mathrm{O} \quad \text{and} \quad ^{20}\mathrm{O}(\mathrm{d},\mathrm{t})^{19}\mathrm{O}$$

Note: during execution of the algorithm, beam hits were masked, since further development has yet to be done to adapt RANSAC to this intricate region.

4 Preliminary results

Once tracks have been reconstructed, the reaction vertex and the silicon impact point can be obtained directly from our fits, given the detector layout. Afterwards, we can extract the light recoil ID, which constitutes an excellent measurement of our algorithm performance. Figure 3 depicts an example of this identification, where we plot the energy measured in the silicon detectors against the *averaged* (per unit of track length) deposited charge in the pad plane.

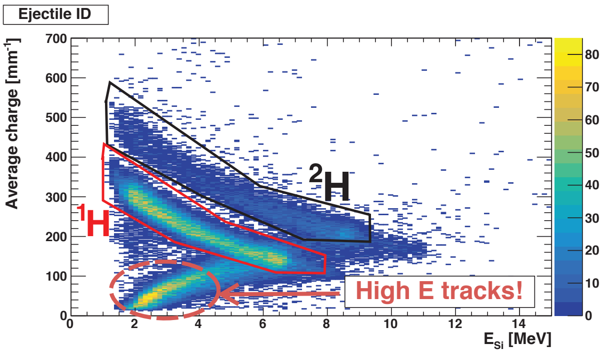

Figure 3. Light recoil ID for events triggering the side arrays.

Unlike the previous clustering algorithm still in use, this RANSAC implementation shows its great potential to reconstruct extremely energetic tracks, whose energy deposit is lower, both in the pad plane and in the silicon layer, as they suffer punchthrough.

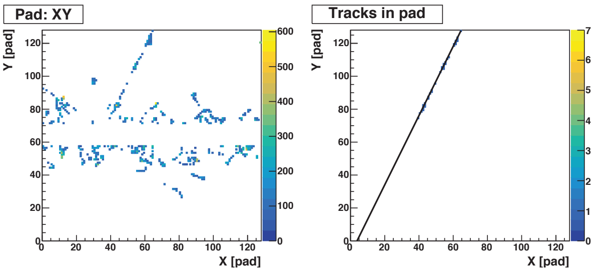

Figure 4. ID of a high E event that punched through the silicon layer.

Besides, more data from other experiments will be needed to perform in-depth studies concerning the adaptability of the algorithm under variations in the number of outgoing particles or the amount of background pollution. A final assessment of the algorithm is expected soon.

5 Current status and future prospects

After evaluating our results, RANSAC exhibits great capabilities when it comes to identifying low-charge depositing tracks and finding multiple track events. The cleaning of $\delta-$electron contamination achieved with this algorithm, a major matter of concern for some experiments, is also noteworthy.

However, a few drawbacks still require major modifications. Firstly, there is the issue of the time consumption: the sampling step represents most of the CPU time consumption per event. A pre-clustering stage or a *filter* could be added to reduce the hit matrix dimensionality and improve execution times.

Secondly, very thick and long tracks may be split or identified by RANSAC as different particles. A post-clustering step could be implemented, merging aligned clusters or tracks with similar fit parameters.

Finally, δe^- rejection should be further improved, as it is crucial for front silicon detectors, where tracks are shorter and emerge in a narrower angular window.

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References

[1] B. Mauss, P. Morfouace, T. Roger, J. Pancin, G. Grinyer, J. Giovinazzo, V. Alcindor, H. Álvarez Pol, A. Arokiaraj, M. Babo et al., Nucl. Instrum. Methods Phys. Res. A **940**, 498 (2019)

[2] Y. Ayyad, W. Mittig, D. Bazin, S. Beceiro-Novo, M. Cortesi, Nucl. Instrum. Methods Phys. Res. A **880**, 166 (2018)

[3] J. Zamora, G. Fortino, Nucl. Instrum. Methods Phys. Res. A **988**, 164899 (2021)