Charge Current Event Topology

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Previous work using data generated with the Queens Monte Carlo (QMC) and oriented spherical analysis (BLE94) has shown variables related to the search for 2 Cherenkov cones in a SNO event to be the most sensitive (so far) to the difference between neutral current (NC) events and charge current (CC) events. Contrary to initial expectations the CC events were more succesfully fitted to multiple rings (two as compared to one) than the NC events. It was conjectured that large angle scattering in an electron trajectory was responsible for the CC multiple rings and that the low energy of the conversion electrons was responsible for the scarcity of multiple rings in NC events.

To test in isolation the hypothesis that CC events have a good probability of giving two Cherenkov cones, electron trajectories have been calculated using EGS4 and the trajectories analysed for aspects of the straight line segment distributions. In order to get enough detail in the computed trajectories the energy based step parameter of EGS4 (ESTEPE) was lowered from its default value of $.25 \cdot E$ to $.025 \cdot E$. It cannot be made arbitrarily small because of inaccuracies that would arise from multiple scattering distributions. This value is in the middle of the range recommended by M. Lay (LAY94) after consideration of thin and thick target experimental multiple scattering data. The alogrithms of EGS4 use Möliere scattering which includes both multiple small angle scattering and more rare large angle Rutherford scattering. The electrons were tracked until their energies dropped below the Cherenkov threshold. Since the production of Cherenkov photons is approximately a constant for unit length of track with E above threshold. The straight segments seen in these trajectories result in coherent rings projected onto the PMT sphere of SNO. One hundred 7.5 MeV eletron trajectories were computed and displayed graphically in 2-D projections using PAW. The events were examined by hand and analysed by being placed into one of 4 categories:

1. 1-ring : nearly straight trajectory; no segment of length $> .5$ cm at an angle of $> 25^0$ to another segment.
2. 2-rings: exactly 2 segments of length $> .5$ cm at an angle of $> 25^0$ to each other.
3. 3-rings: 3 or more segments of length $> .5$ cm at angles of $> 25^0$ to each other.
4. n-rings: continuous direction change which would give a smear of PMT's in SNO. Any number of rings may be found by analysis.

The $> 25^0$ threshold was chosen to optimize the two ring analysis based on the multiple scattering distributions in the previous work. It was seen that most of the scattering was less than 10^0 and thus rings with the highest PMT inclusion could be found for a template of 41 ± 10^0. Then the resolution for 2-ring separation would be $> 20^0$. Since the optimization of this threshold is related to the very fine scale trajectory structure and is therefore energy dependent, it must be studied further.

Twenty events from category 2 are shown in figure 1, one per page. The trajectories are shown in 3 planar projections, all electrons having started at (0,0,0) with direction (0,0,1). In the analysis of the 100 'events', 4 secondary e^-'s with $E_{ke} > 1.5$MeV have been neglected. As well 13 γ's with $E_\gamma > 2.0$MeV and $E_\gamma > E_{e^-}$ have been neglected.

Three (human) scanners gave the following categorizations:

category:	1	2	3	4
scanner1	20	71	8	1
scanner2	21	69	5	5
scanner3	19	71	7	3

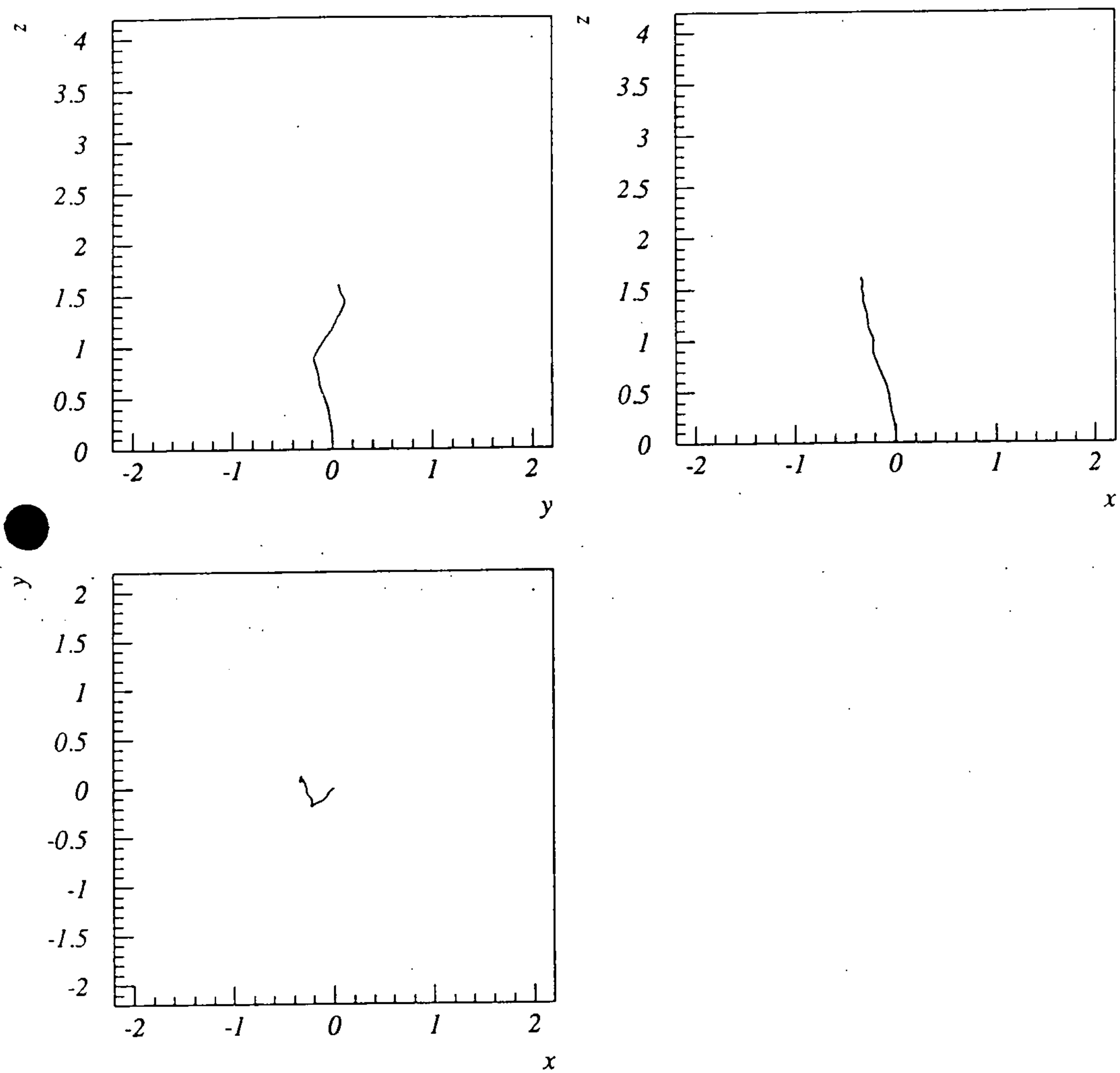
Thus analysis of the 100 events gives the following conclusions:

1. Hand analysis of segments was objective. Systematic error is ~1%
2. Multiple rings in CC events are common and spatially correlated.
3. ~ 80% of events would reconstruct to $\geq$2 rings separated by more than 25^0 with at least 10 out of the 75 pmt's in the second ring.
4. ~ 90% of these (the 80%) would be 2 and only 2 rings by the present criteria.

References

BLE94 I Blevis, Event identification from PMT hit patterns, SNO-STR-94-044

LAY94 M.D. Lay, Creation and Detection of Cherenkov Light in SNO. Ph.D. Thesis, U.Oxford. 1994.



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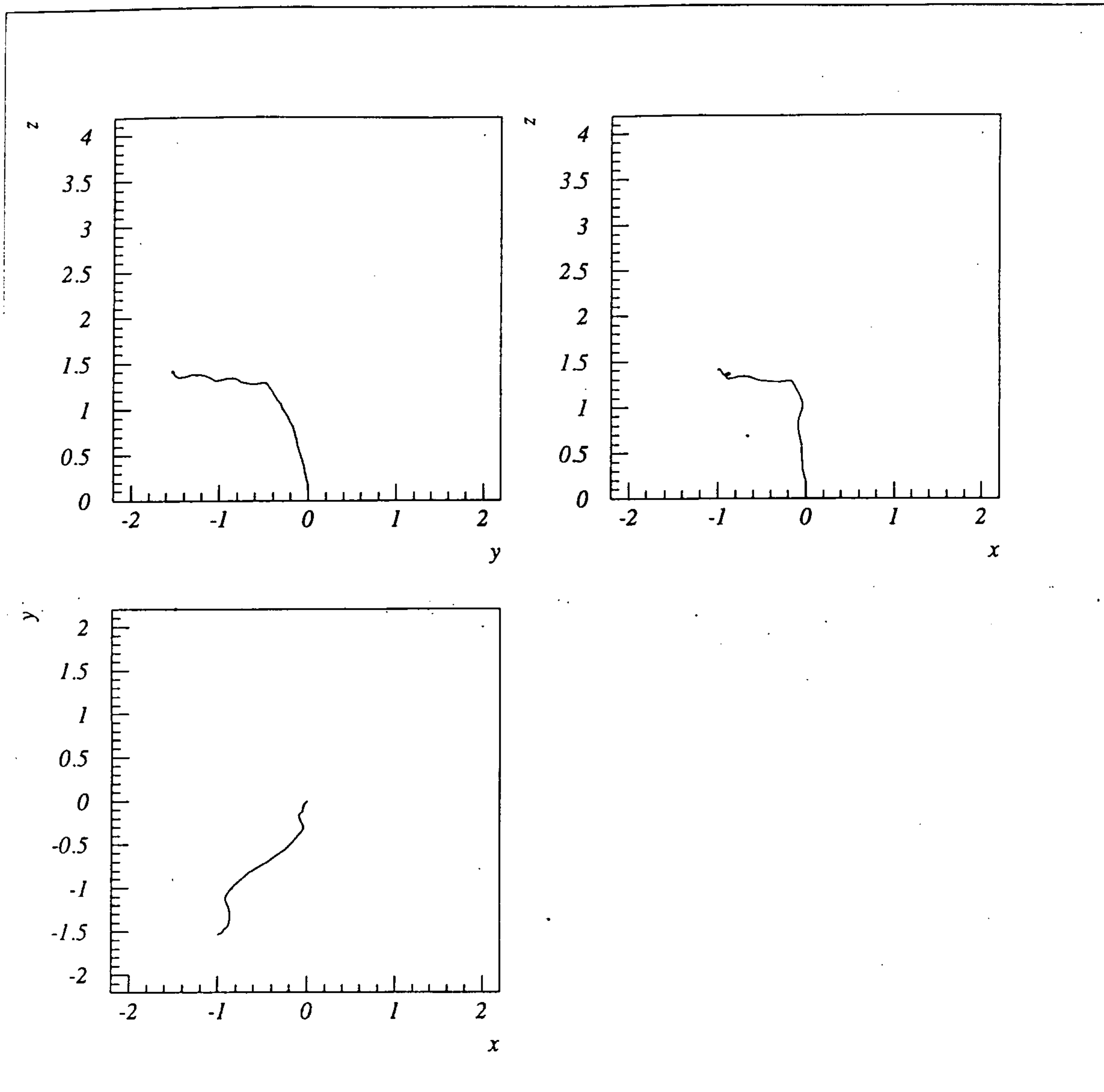
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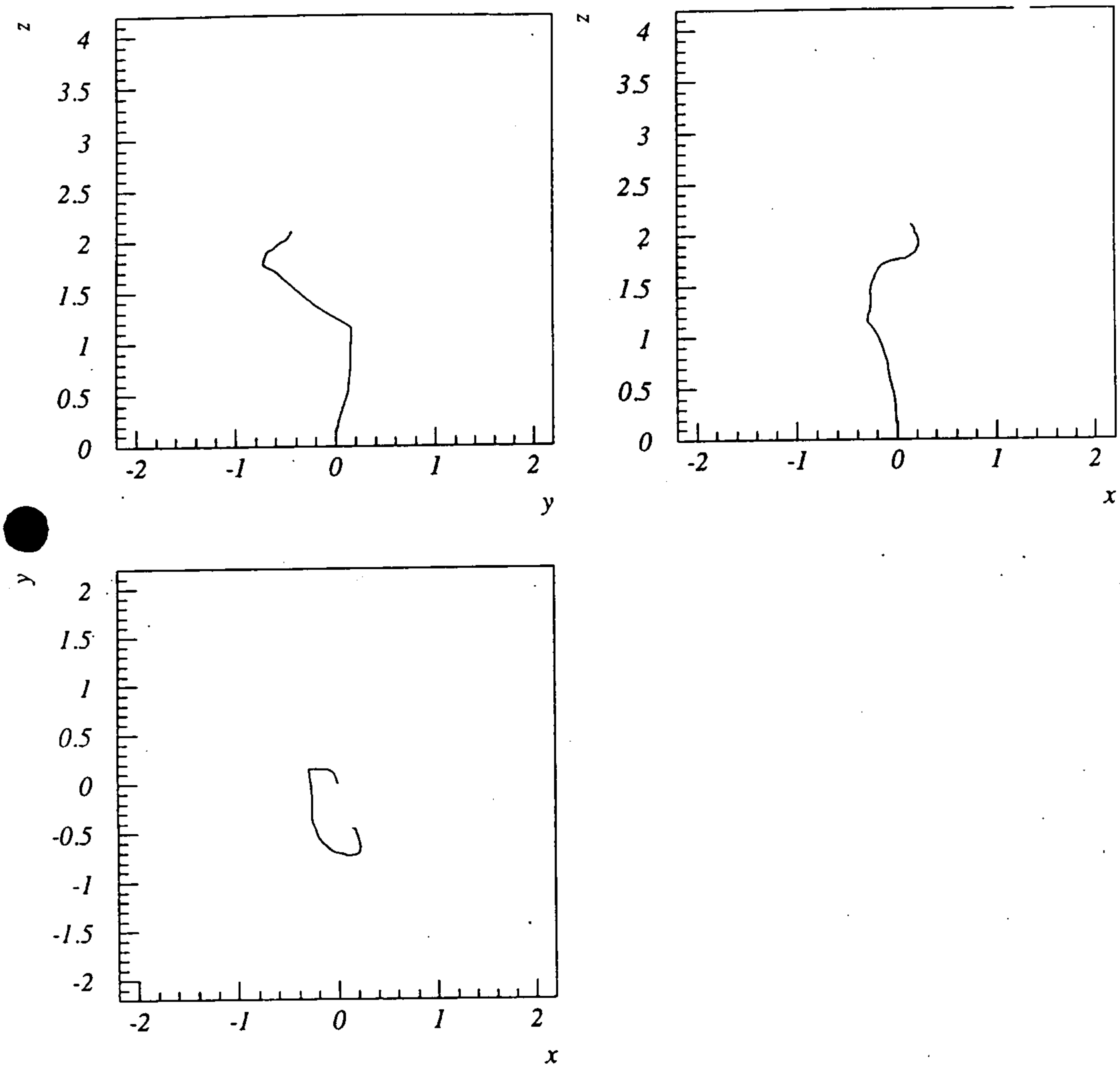

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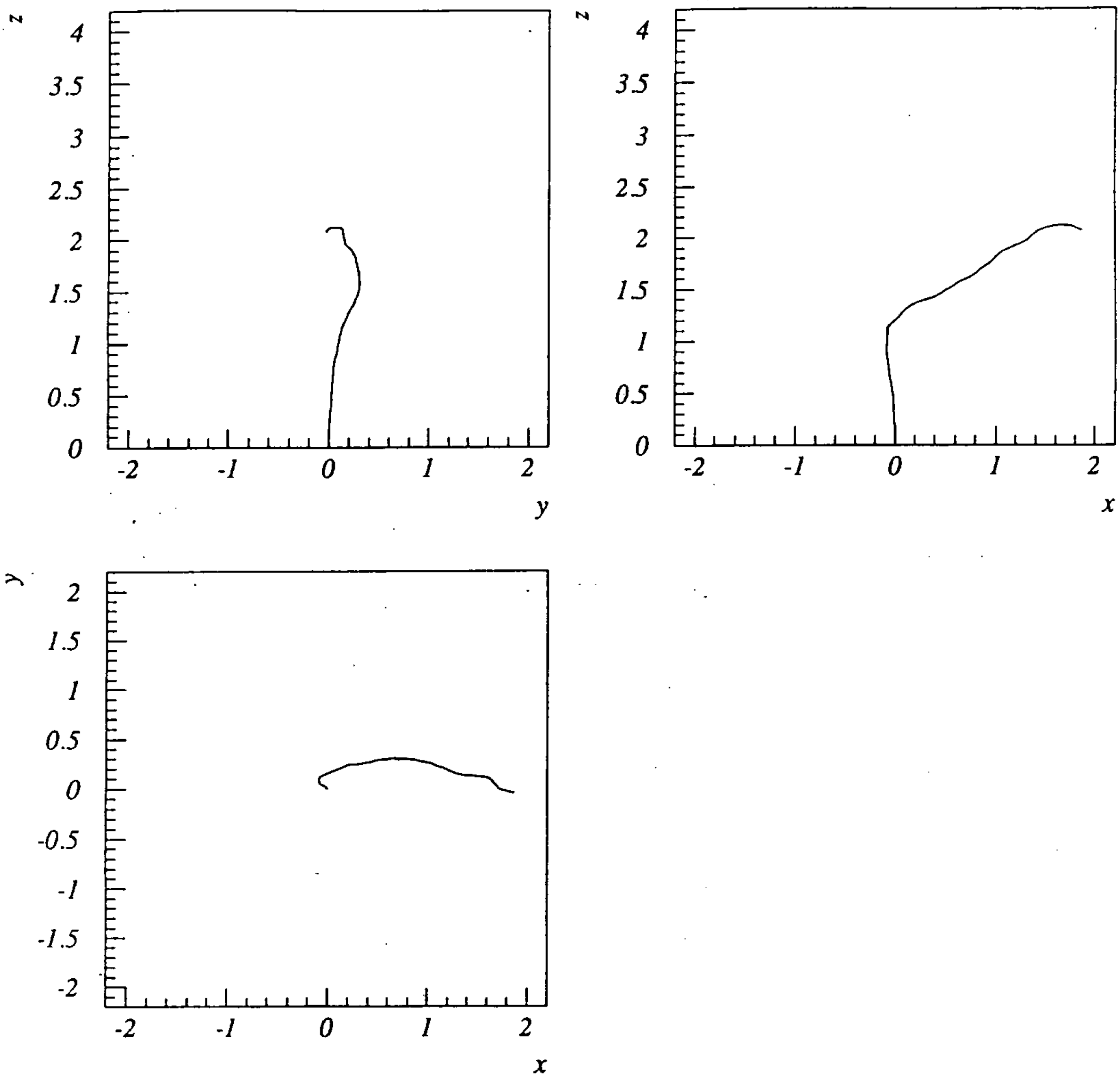
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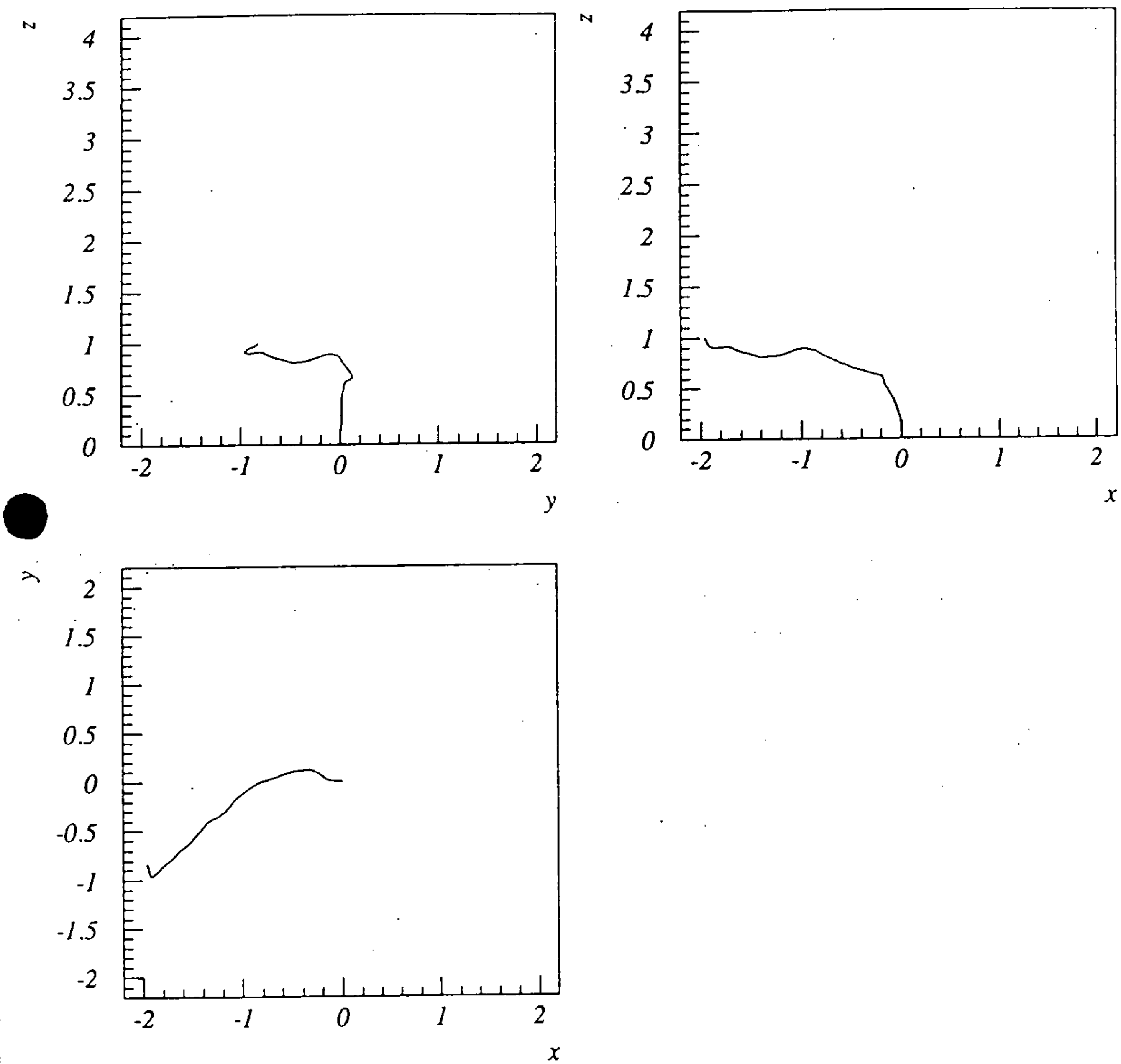
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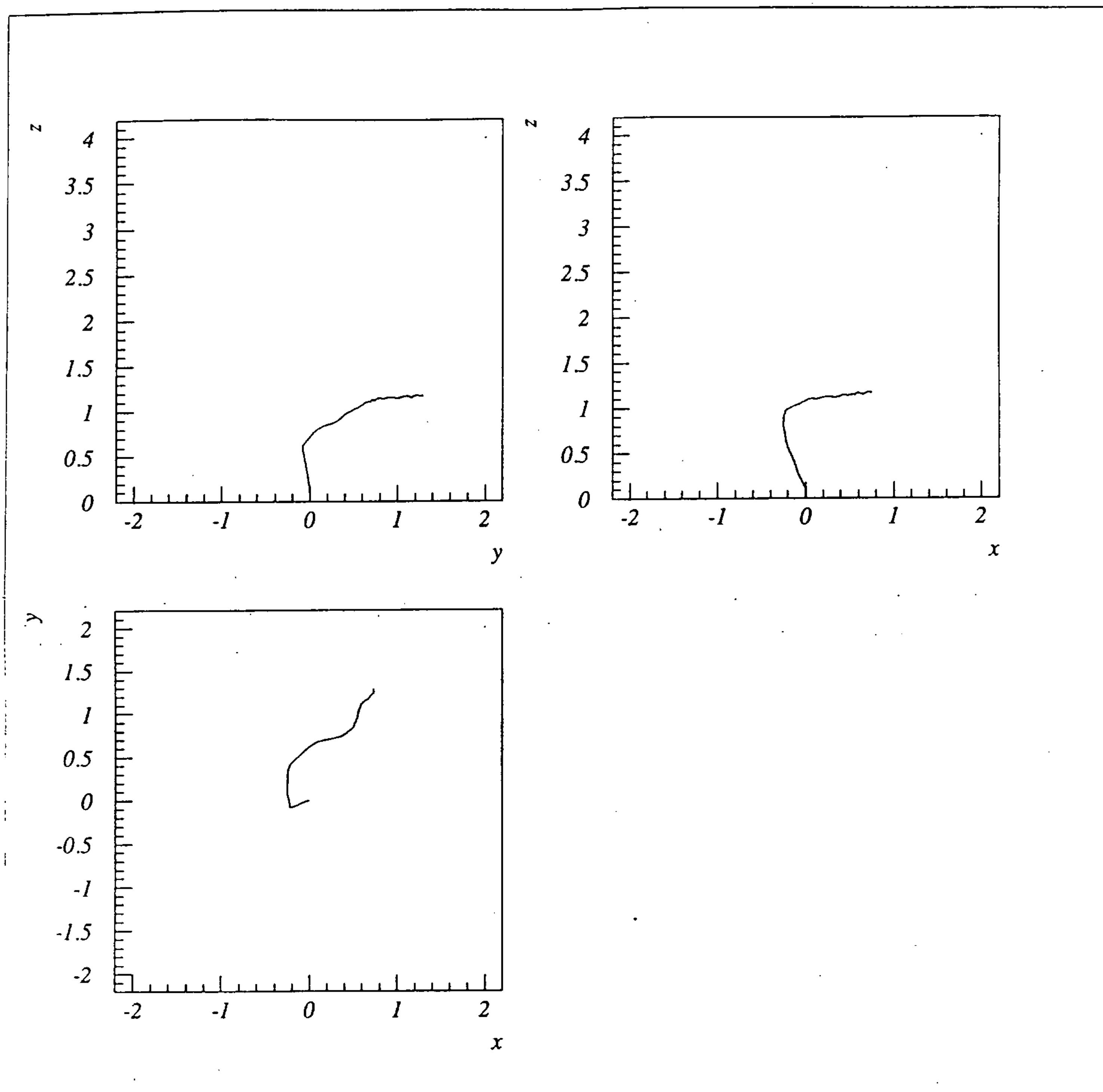
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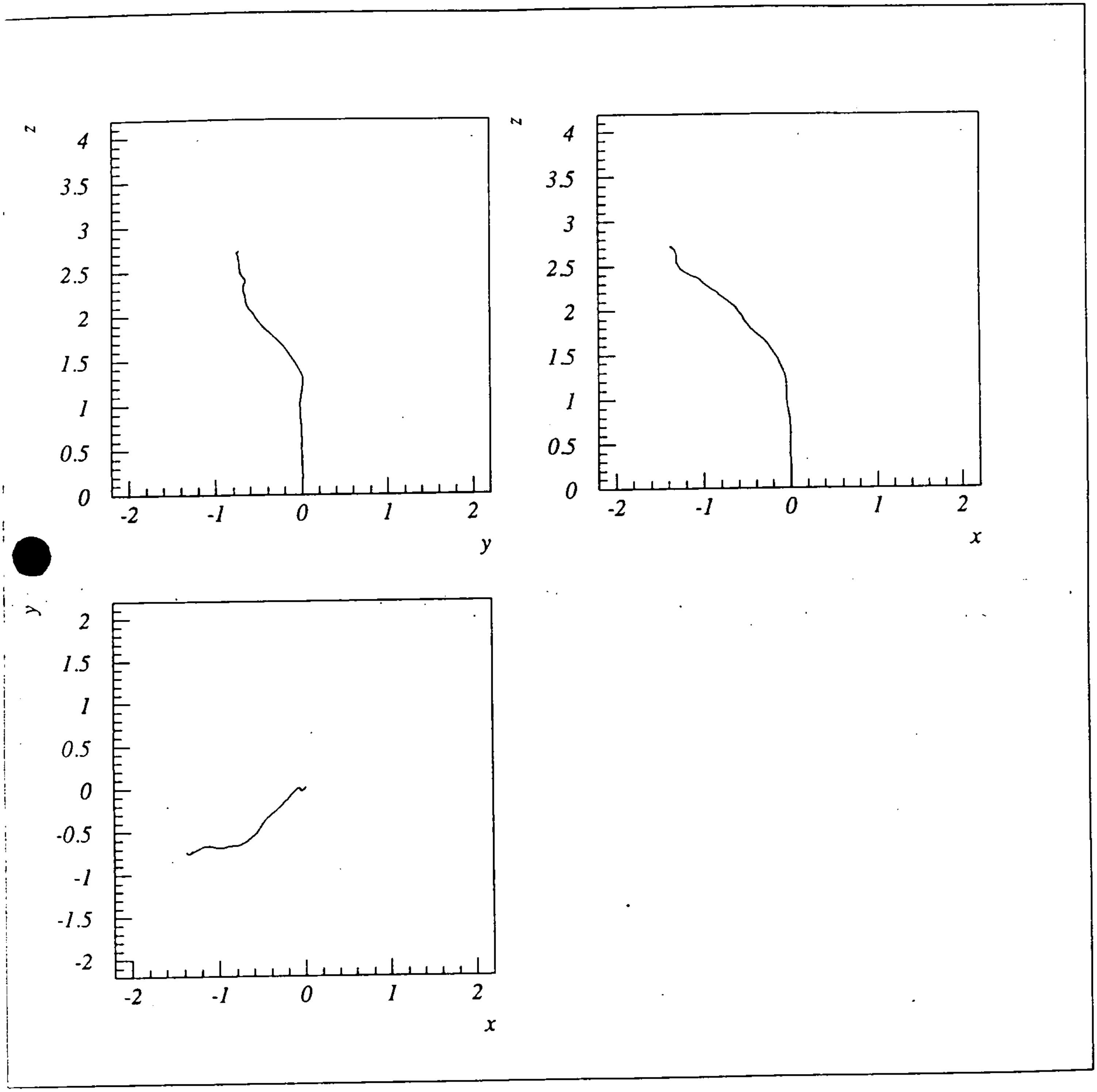
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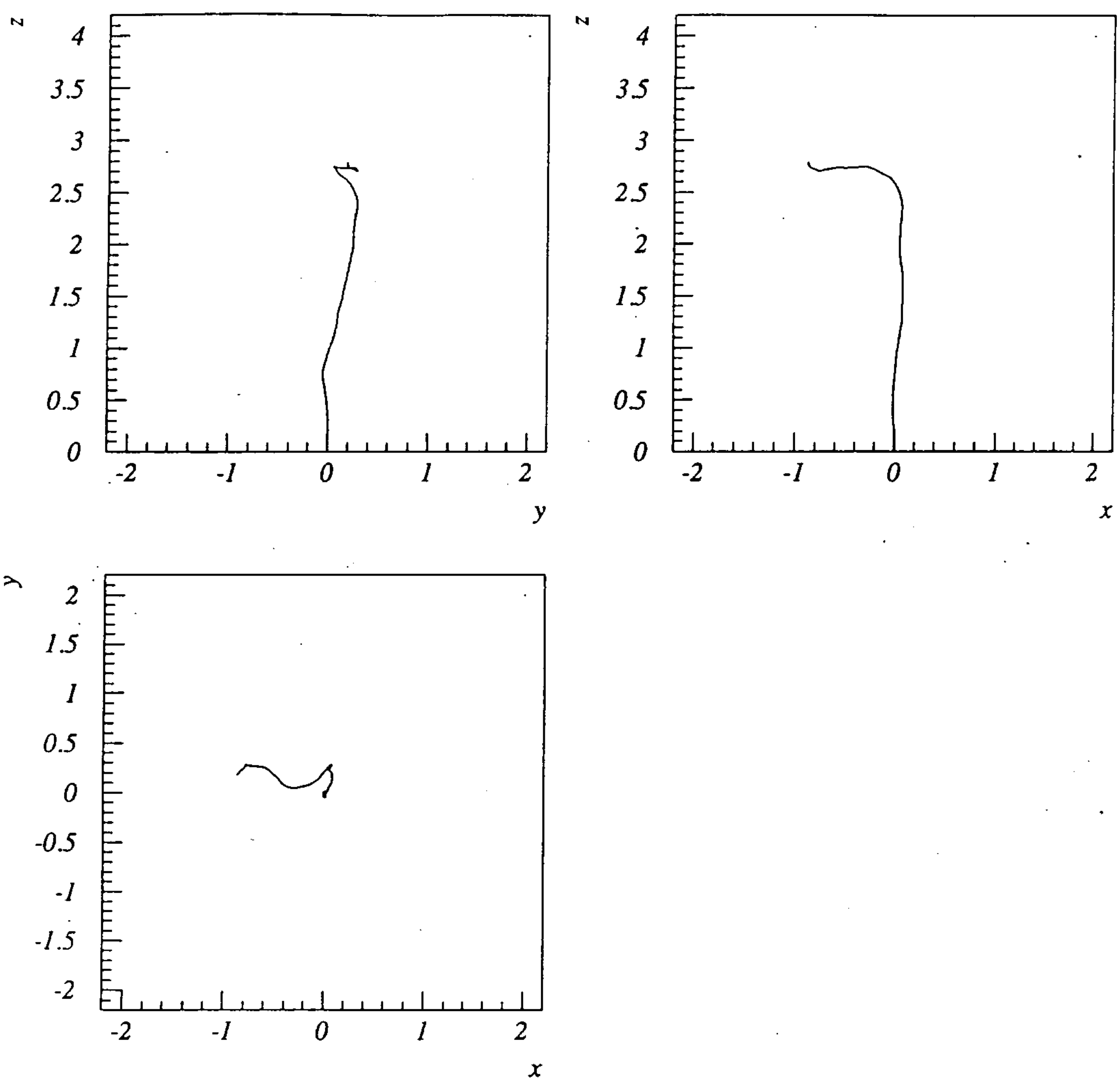
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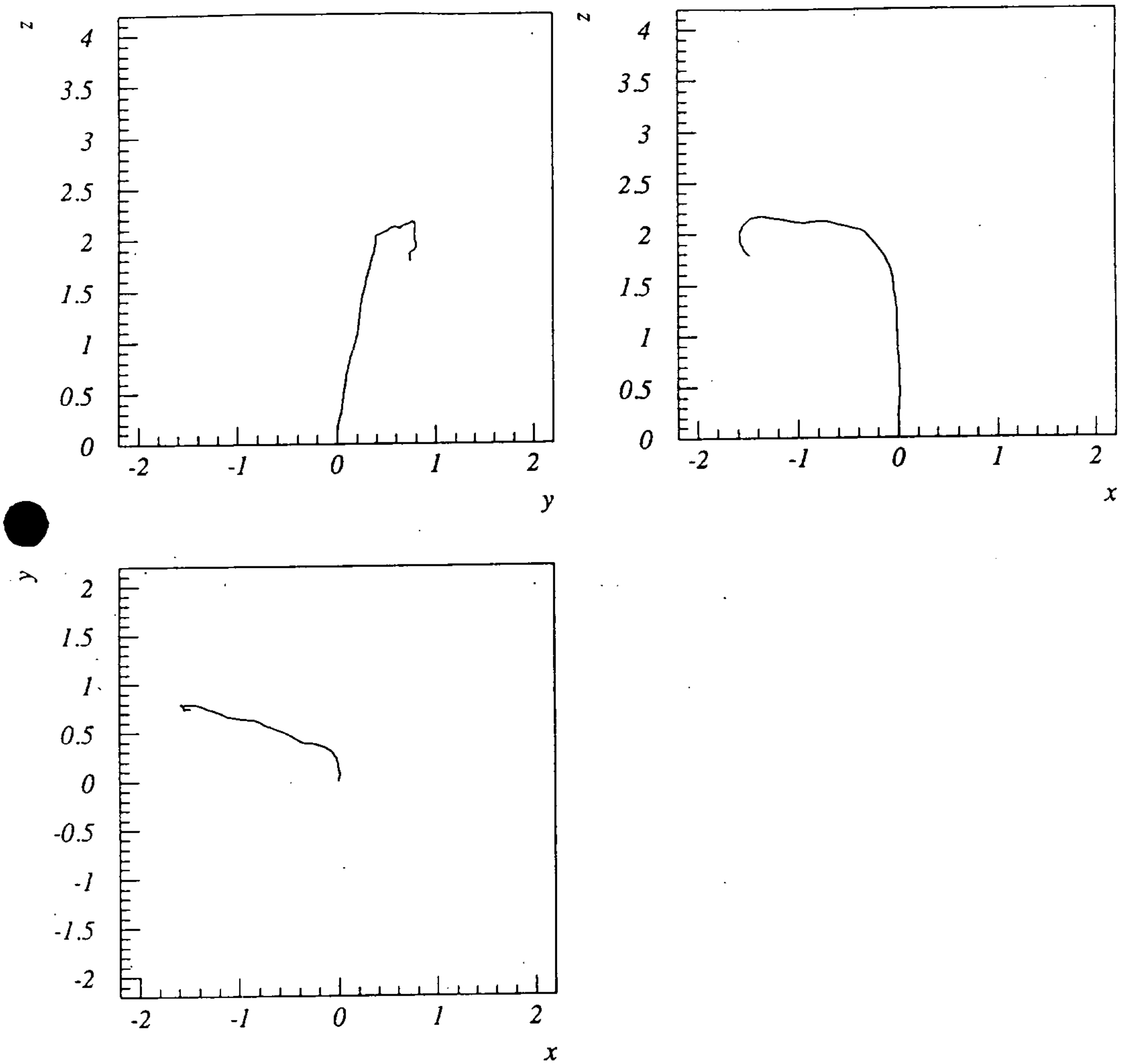

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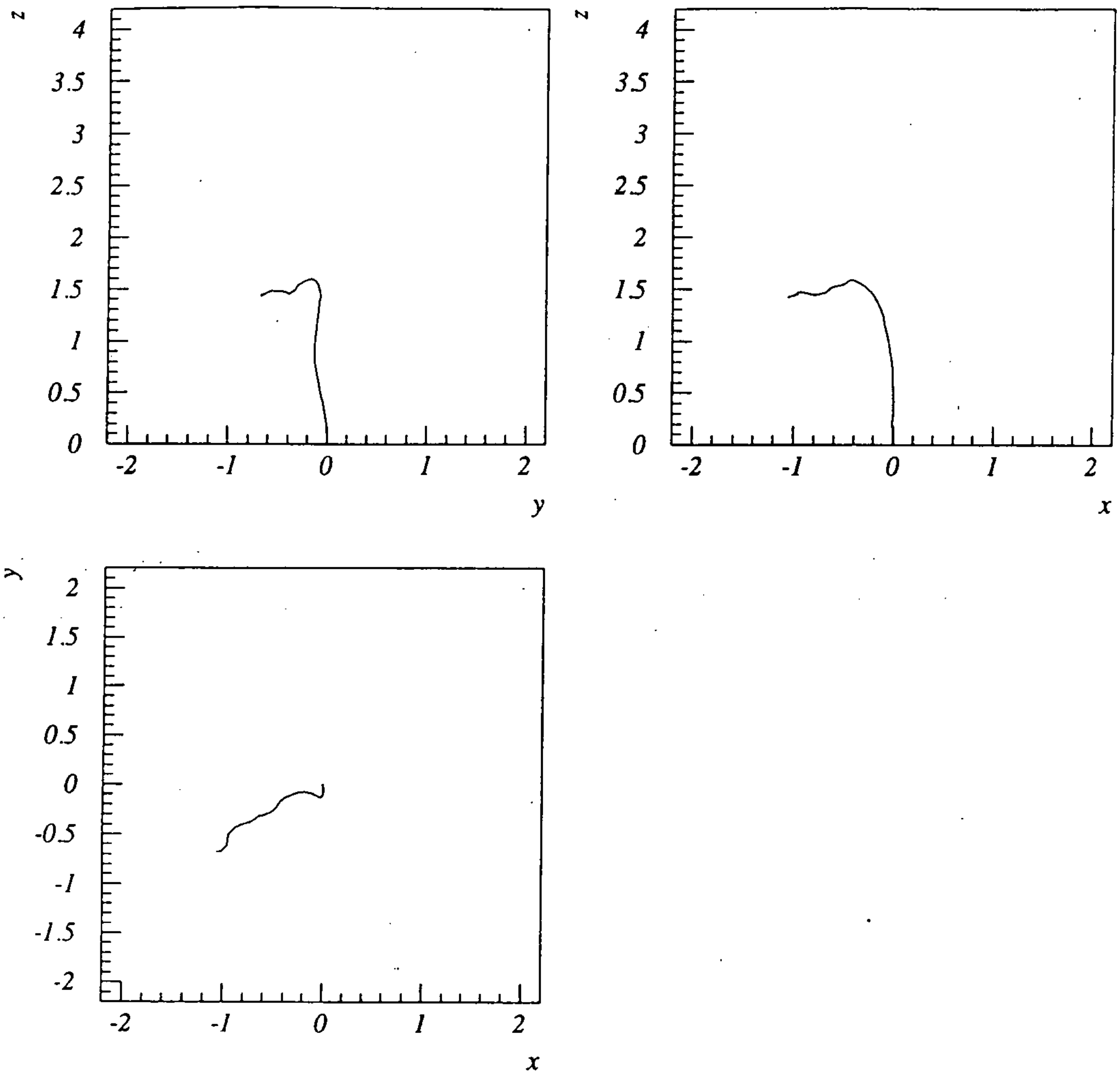

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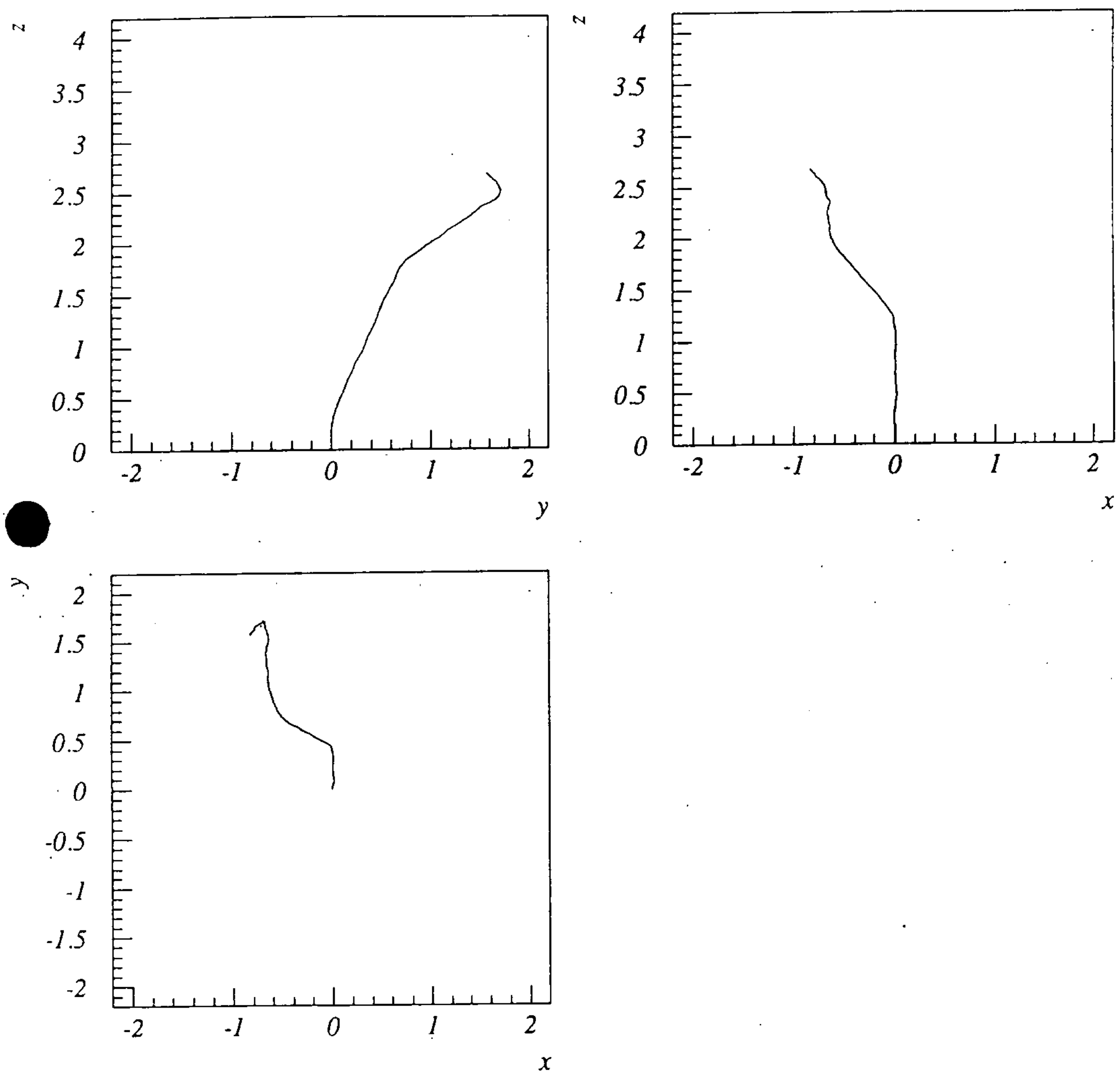

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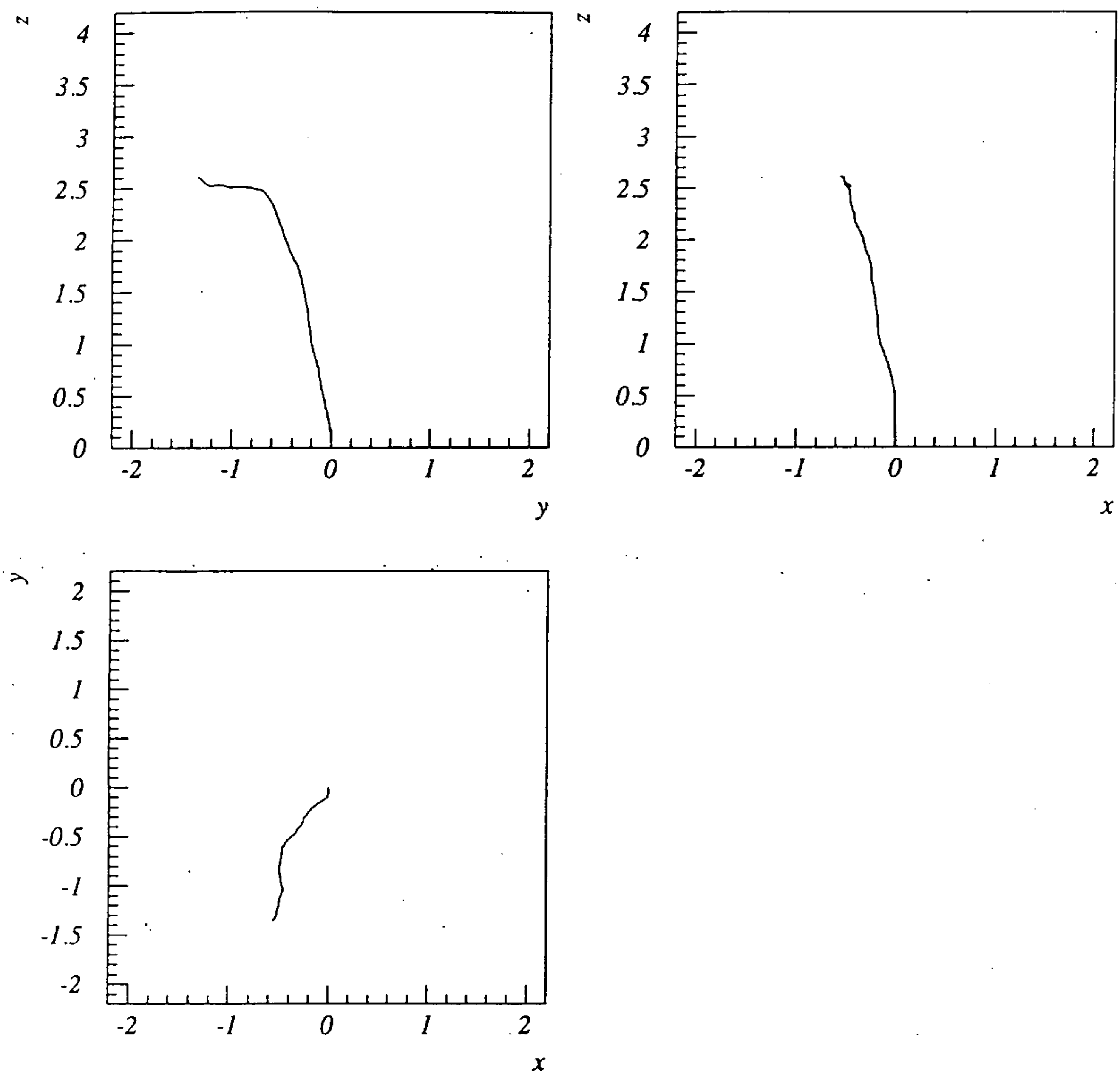

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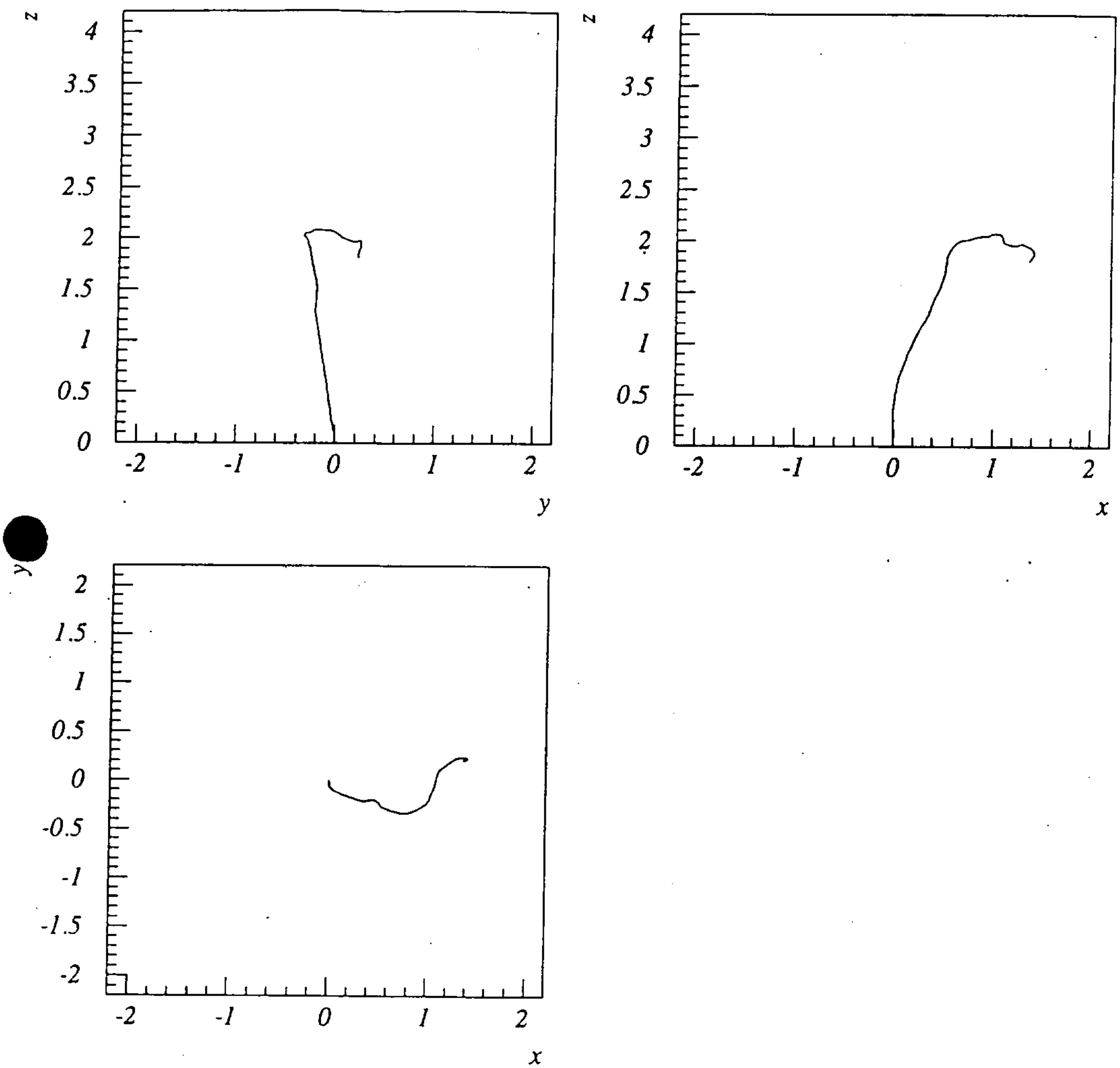

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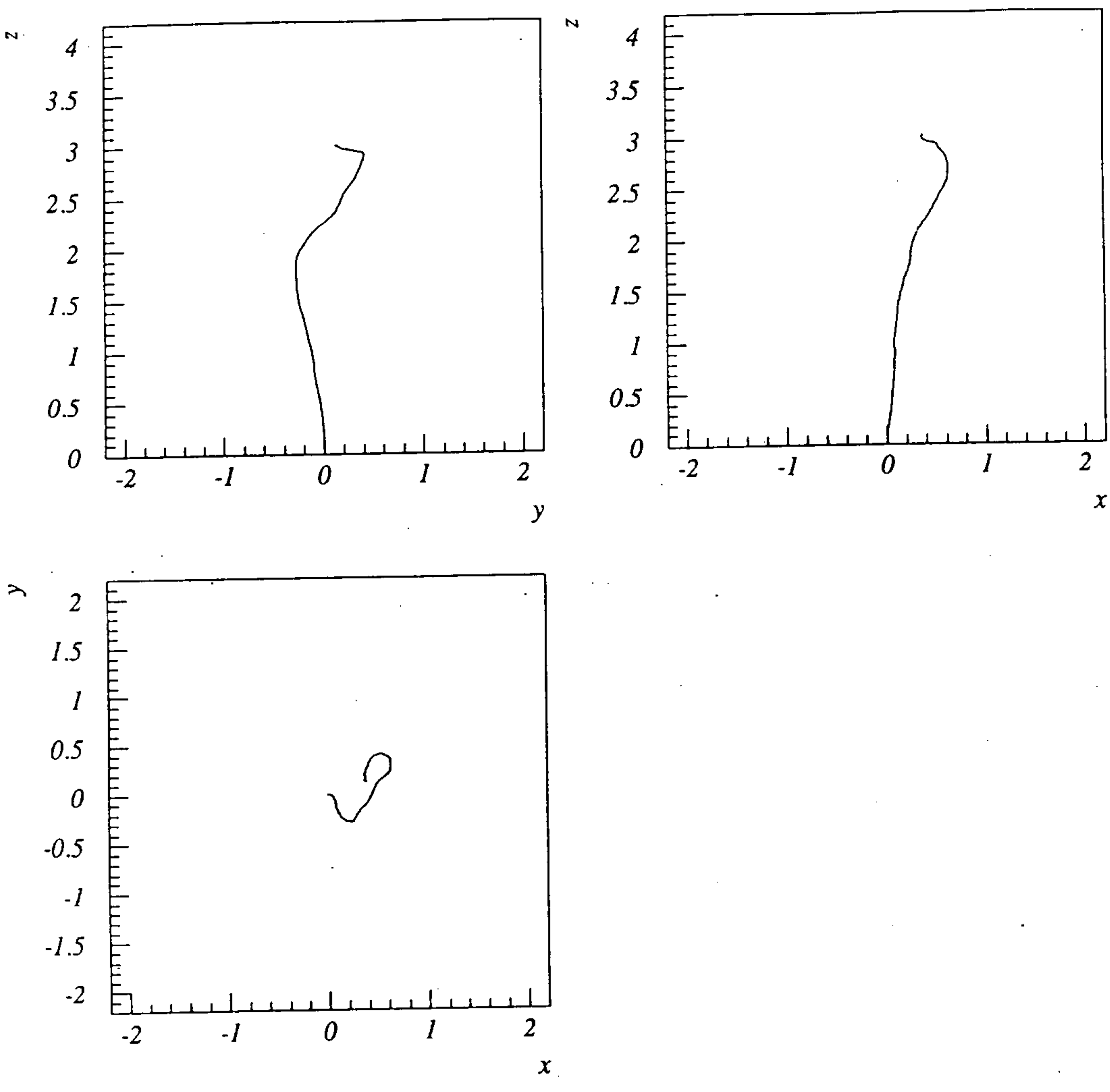
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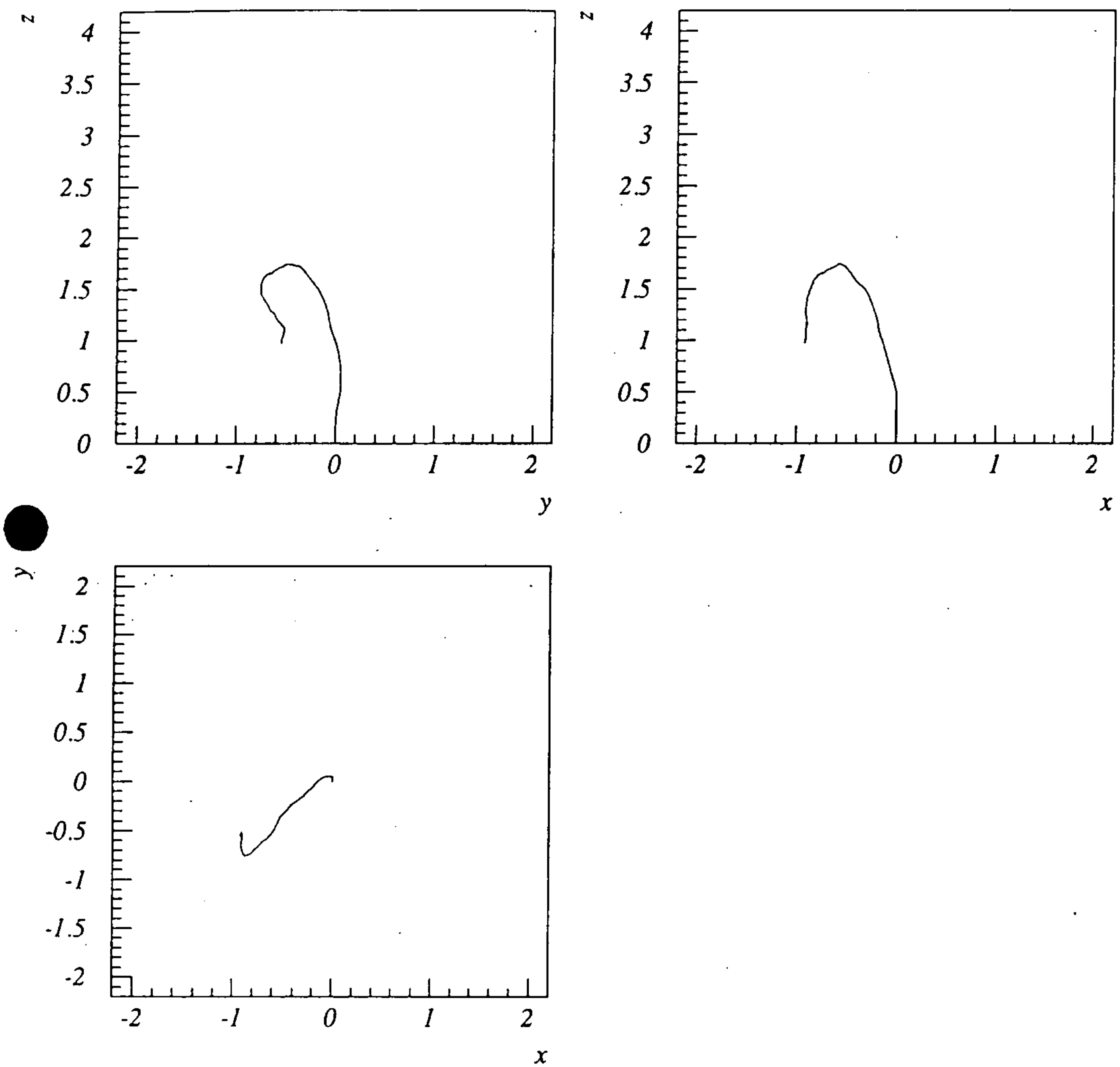
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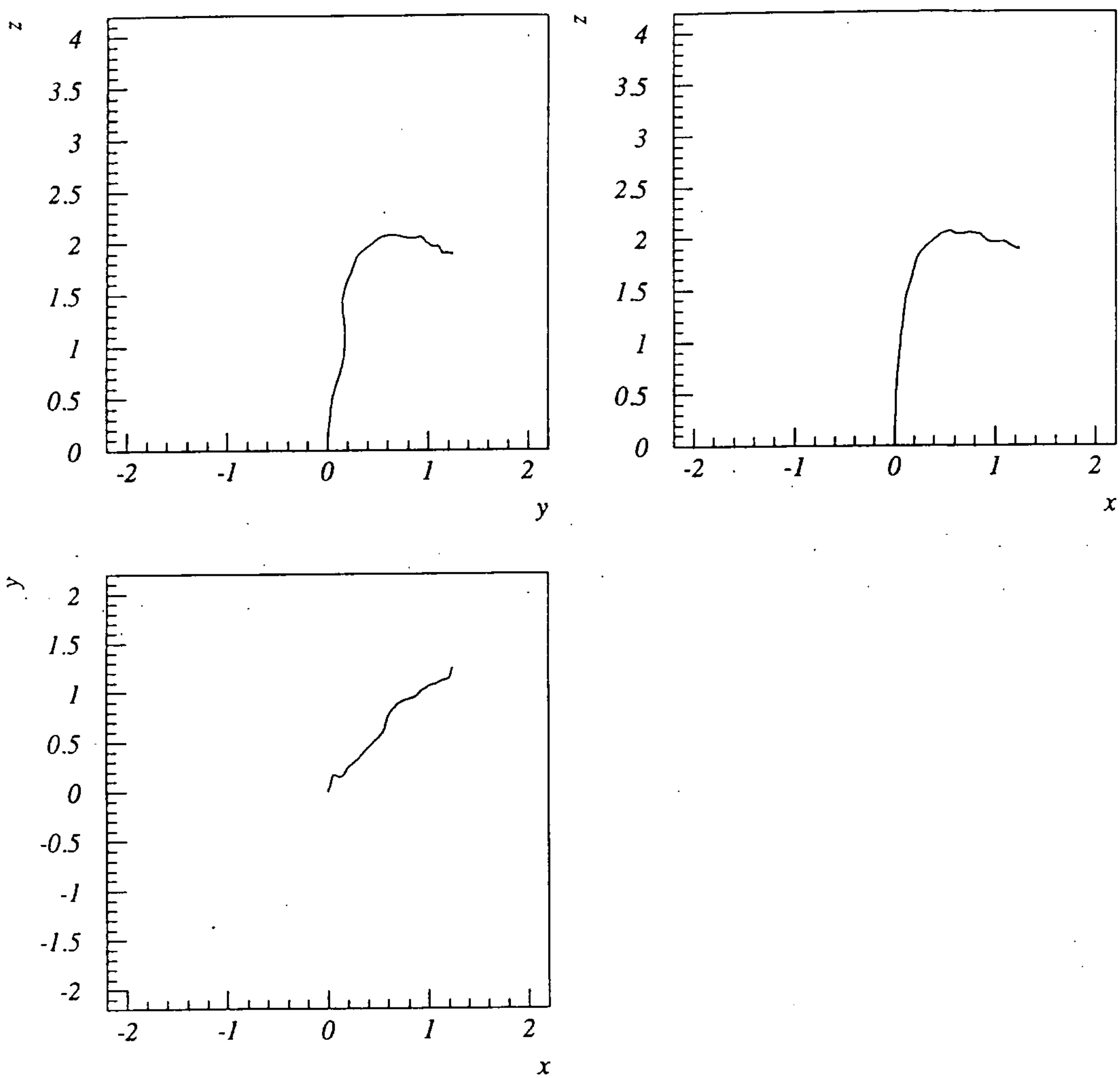

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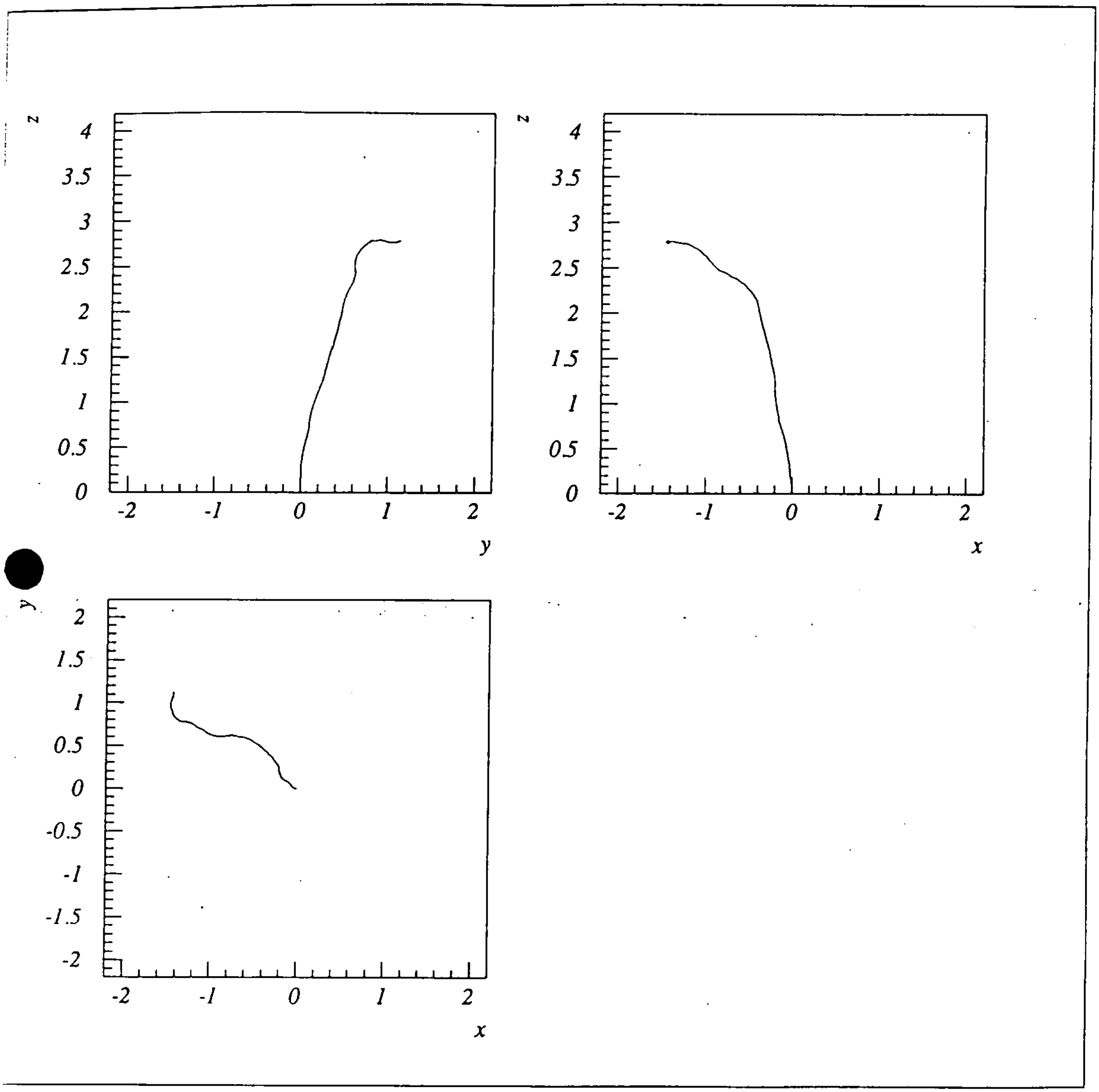

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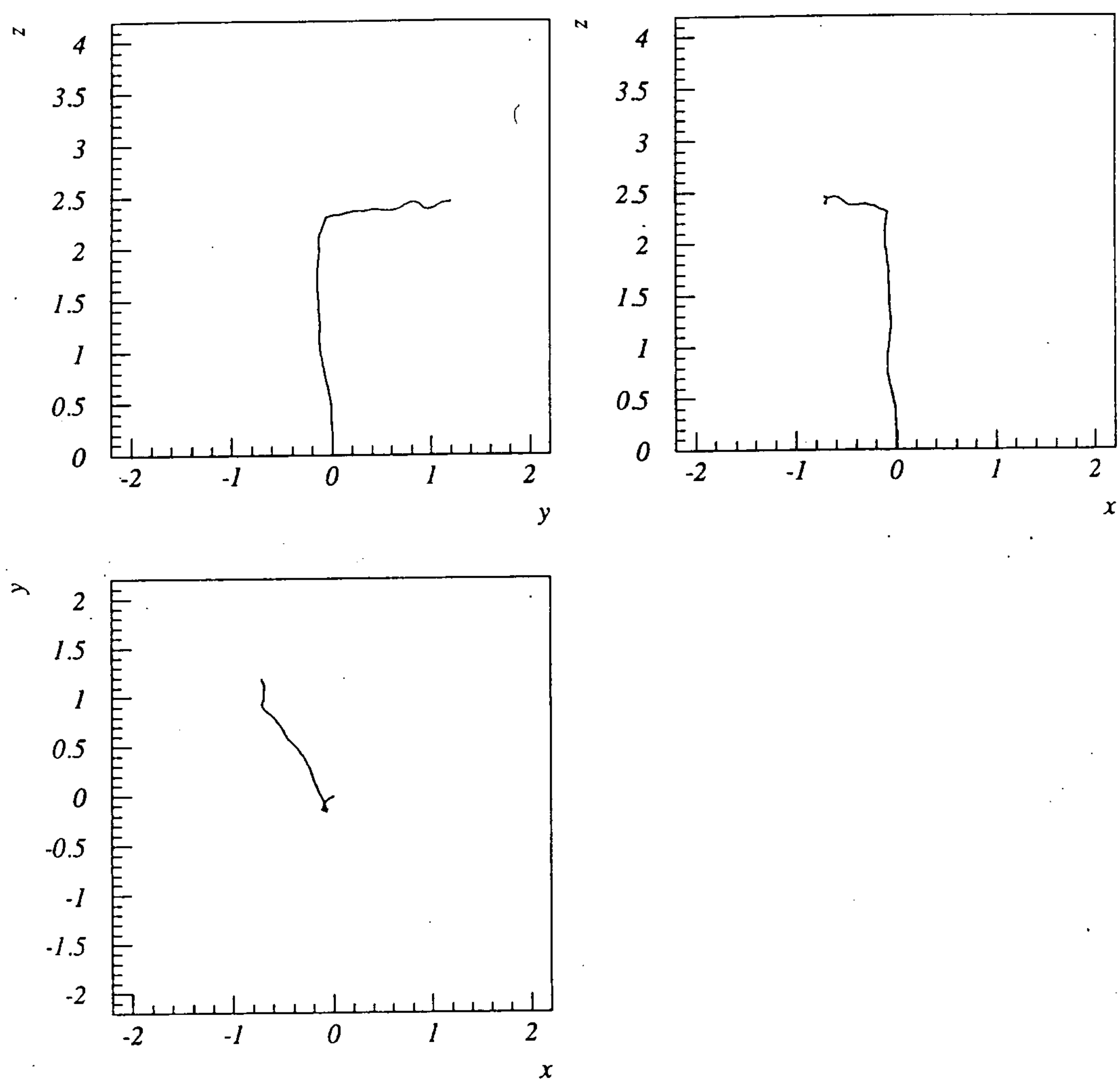
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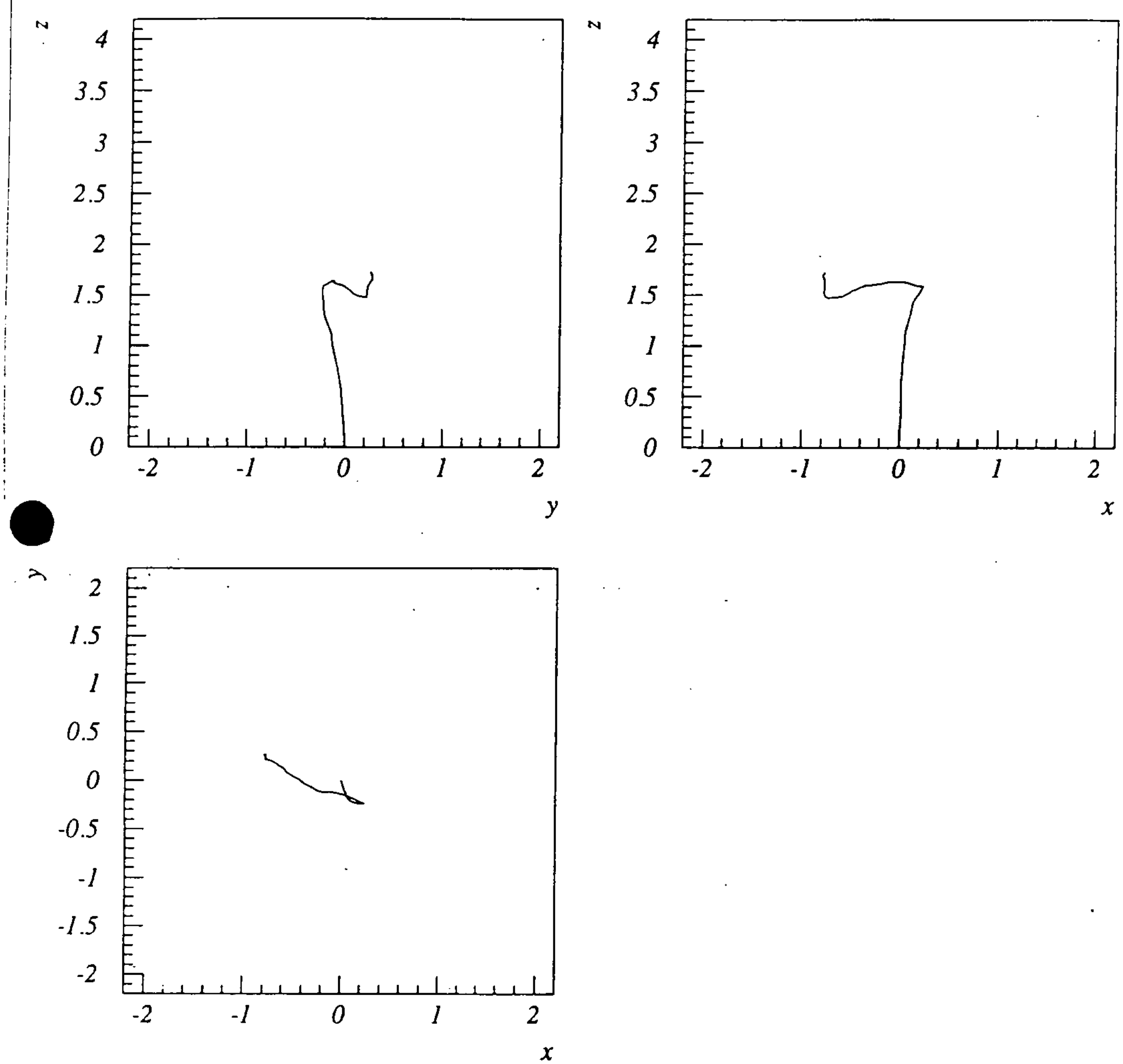
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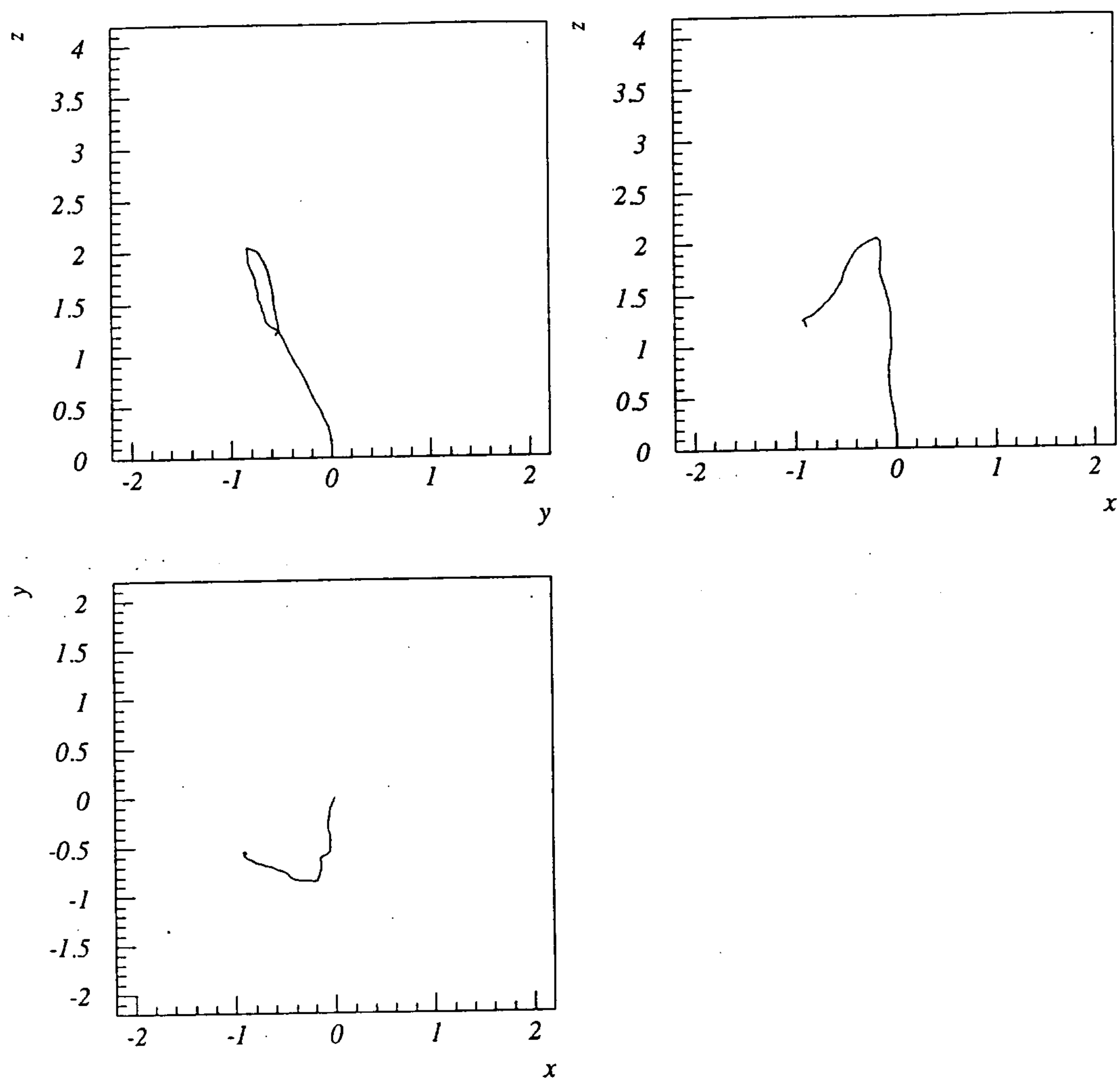
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