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CMM Results from the Drift Chamber Endplates

Both the front and rear endplates have been completed at Brenner Tool and Die. All sense wire holes were measured on their coordinate measuring machine (CMM), as well as 320 clearing wire holes and 656 field wire holes from each plate. The results are summarized in the plots below.

The measurements were made with the gas side of the endplates upwards. Each hole was measured at four points at a depth of 5 mm below the upper (gas-side) surface of the endplate.

The location of the holes is excellent. The mean deviation of the measured hole center from the desired is about 25 μm, compared to our spec that all deviations should be less than 75 μm. [Recall that the machinist's 'true position tolerance' is on twice the deviation, and was spec'ed at 150 μm.]

In the first pass of measurements it was noted that about 100 sense wire holes on each plate appeared not to satisfy the true position tolerance. It was then noted that in most cases there was a small amount of material left in the holes from the deburring process. This material would obstruct the CMM probe which measures the holes from their interior, resulting in too small a hole diameter as well as a skewed hole center.

All holes were cleaned again, and sense wire holes with position deviations of greater than 50 μm were remeasured on the CMM. They all proved to be within the true position tolerance after the remeasurement.

For holes as small as ours, the CMM can give a measure of the hole diameter subject to a systematic error of a few μm. Therefore, every hole was tested with two precision X-class gauge pins (go/no-go pins) to verify that all hole diameters exceeded our minimum spec and were less than our maximum spec. The pin diameters were $2.5^{+0.001}_{-0}$ and $2.525^{+0}_{-0.001}$ mm for the smaller holes and $4.5^{+0.001}_{-0}$ and $4.525^{+0}_{-0.001}$ mm for the larger.

As can be seen in the following plots, the strong correlation to position deviation is with angle, likely related to a systematic error in the rotary table that supported the endplate during machining. The position deviation grows slowly with radius, likely related to the random error in angle of the rotary table.

The banding seen particularly in the position deviation plots of the rear endplate clearing wires is an artifact of sampling at only four angles combined with the correlation of position deviation with angle.

The hole diameter shows little correlation with any other parameter.

The Appendix discusses the summary-file structure.

1 Front Endplate

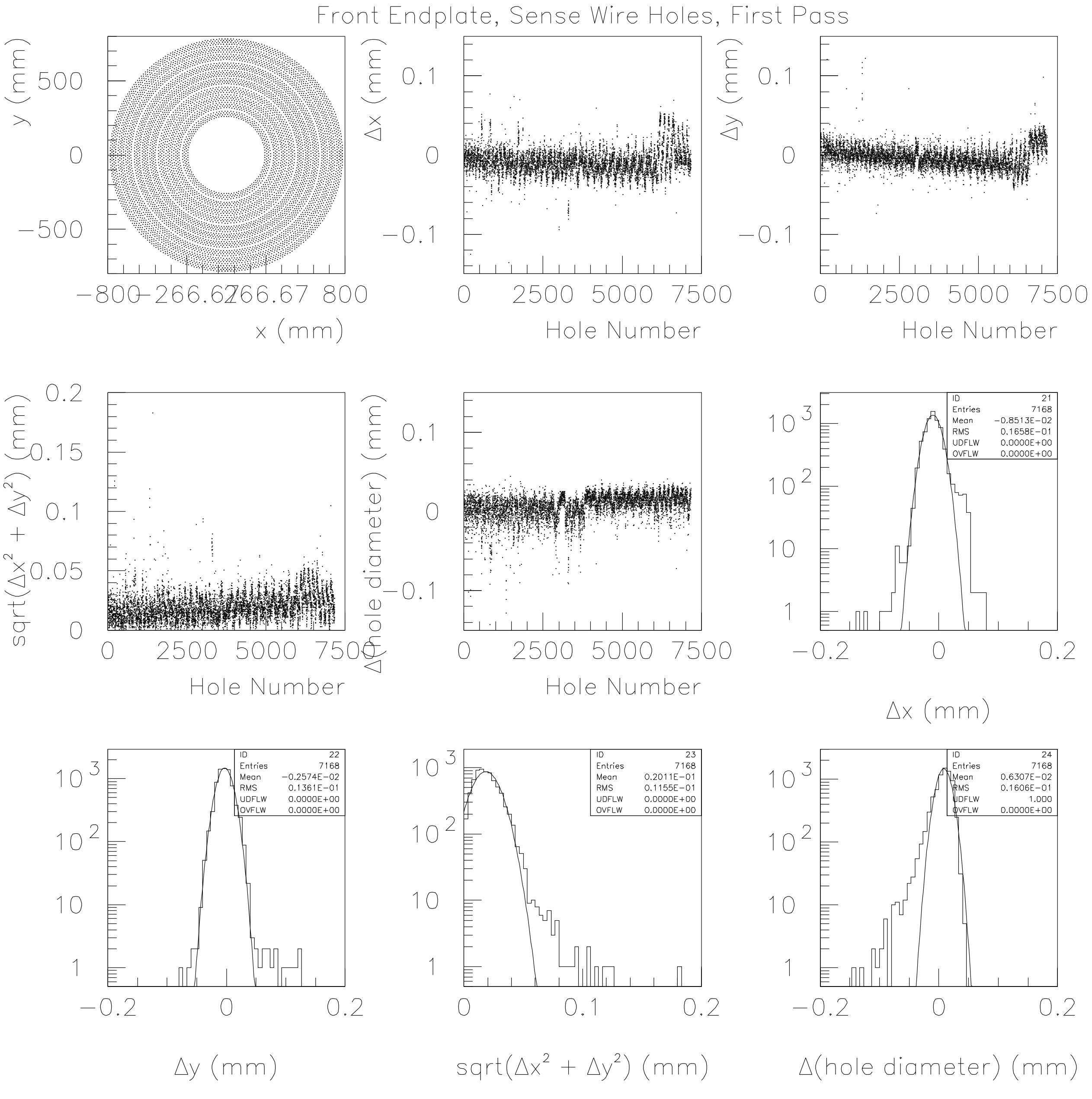

Figure 1: Initial measurements of the sense wire holes on the front endplate.

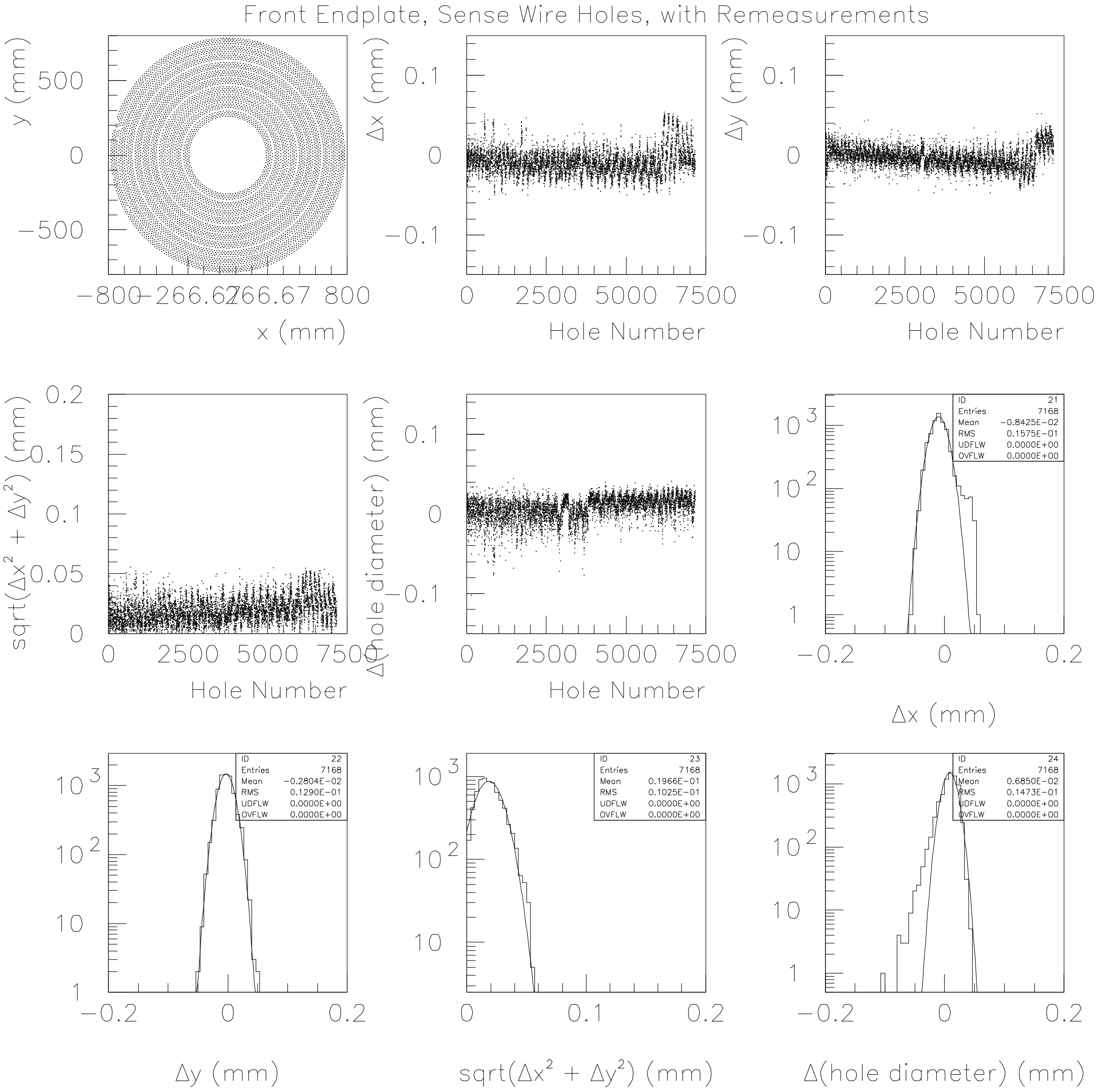

Figure 2: Results including remeasurements of the sense wire holes on the front endplate.

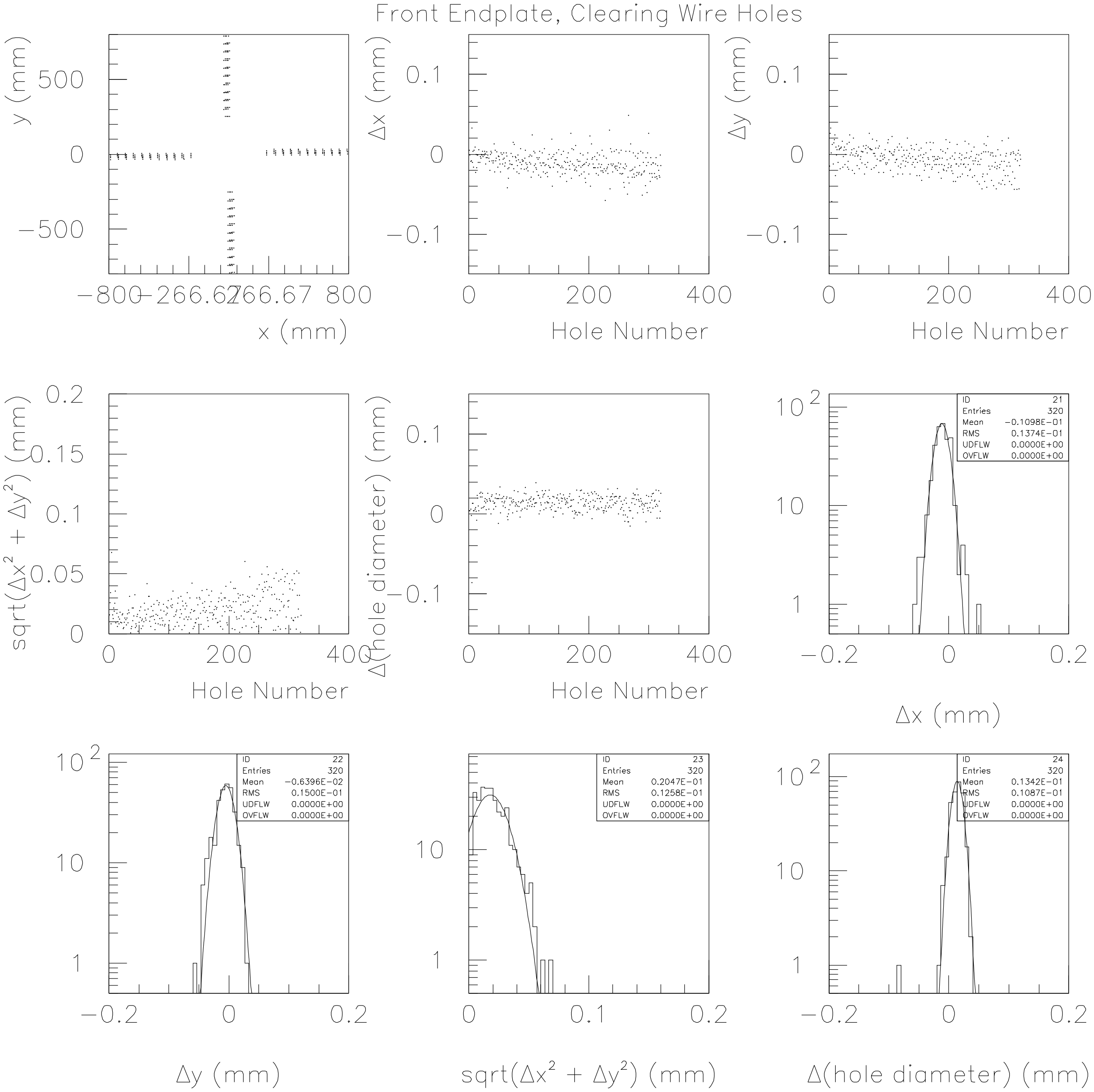

Figure 3: Measurements of the clearing wire holes on the front endplate.

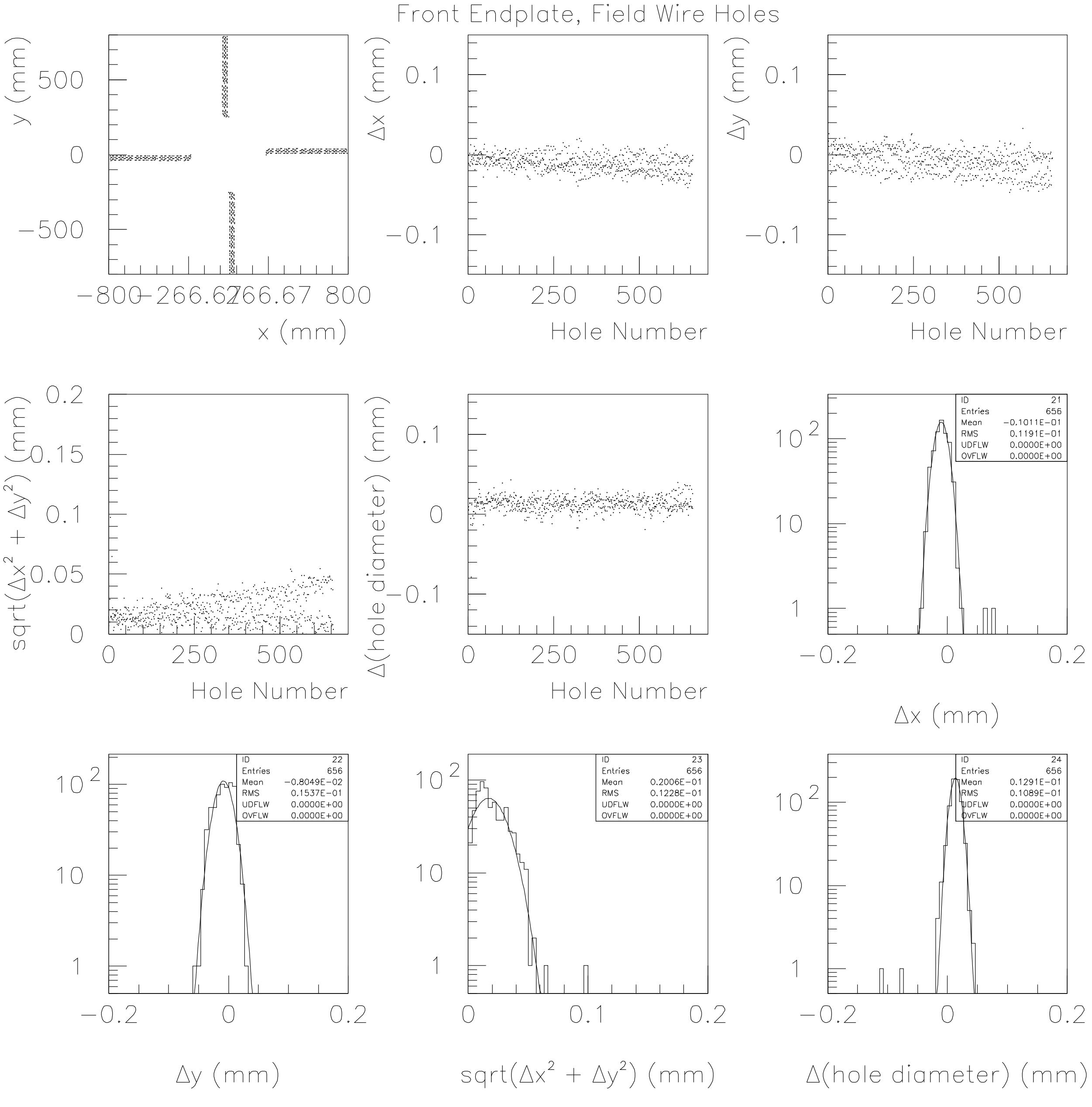

Figure 4: Measurements of the field wire holes on the front endplate.

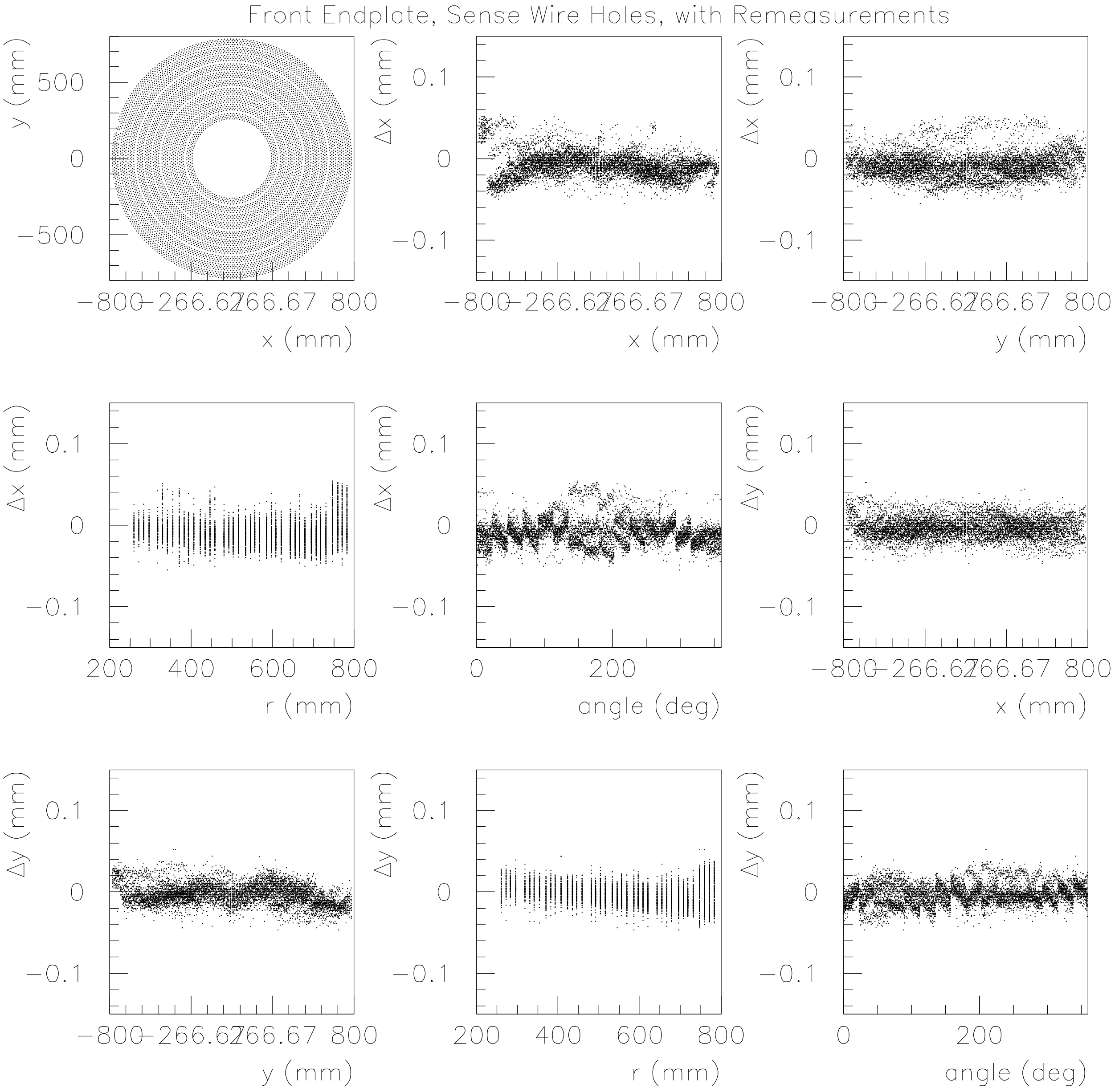

Figure 5: Results including remeasurements of the sense wire holes on the front endplate.

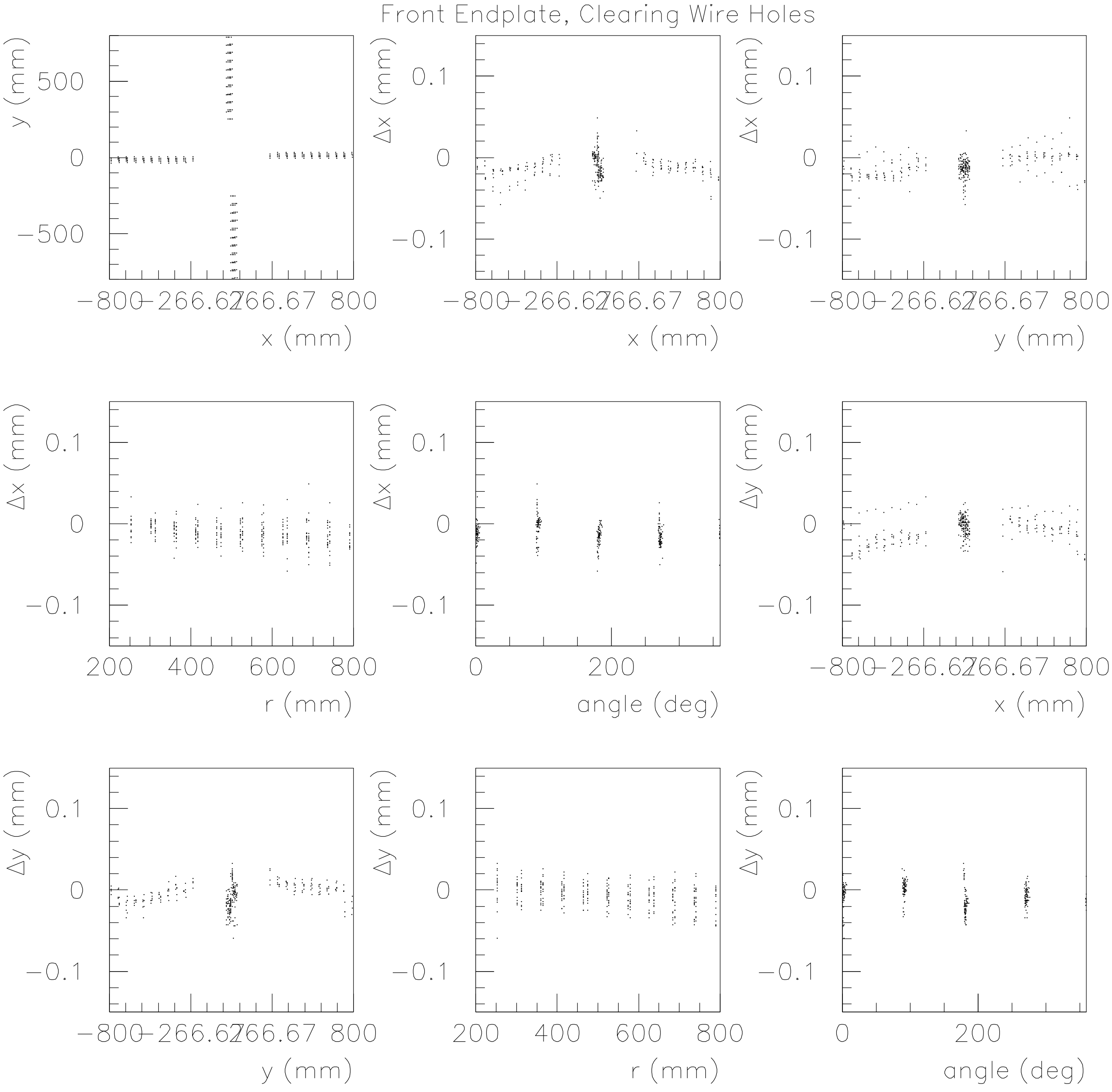

Figure 6: Measurements of the clearing wire holes on the front endplate.

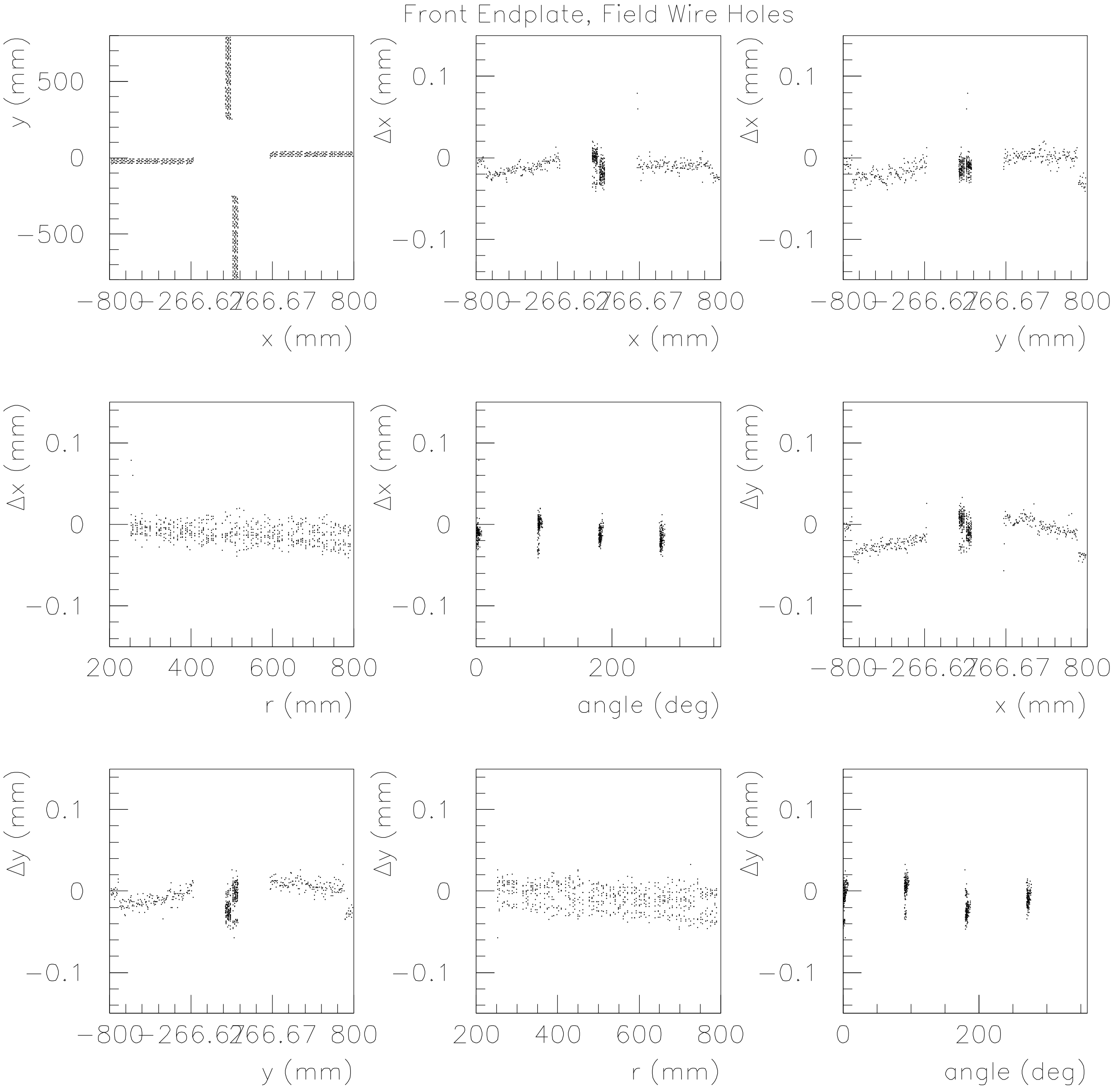

Figure 7: Measurements of the field wire holes on the front endplate.

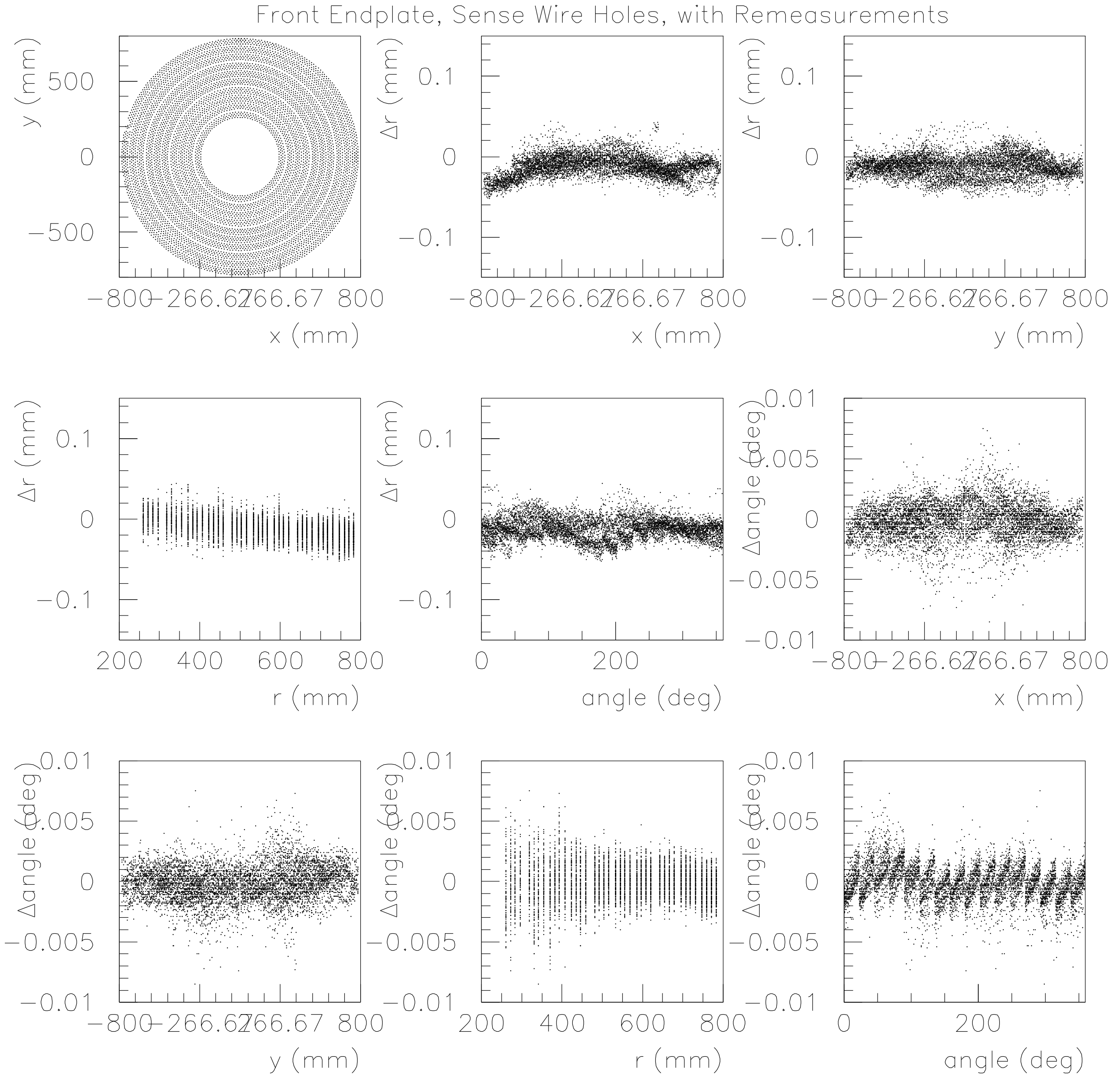

Figure 8: Results including remeasurements of the sense wire holes on the front endplate.

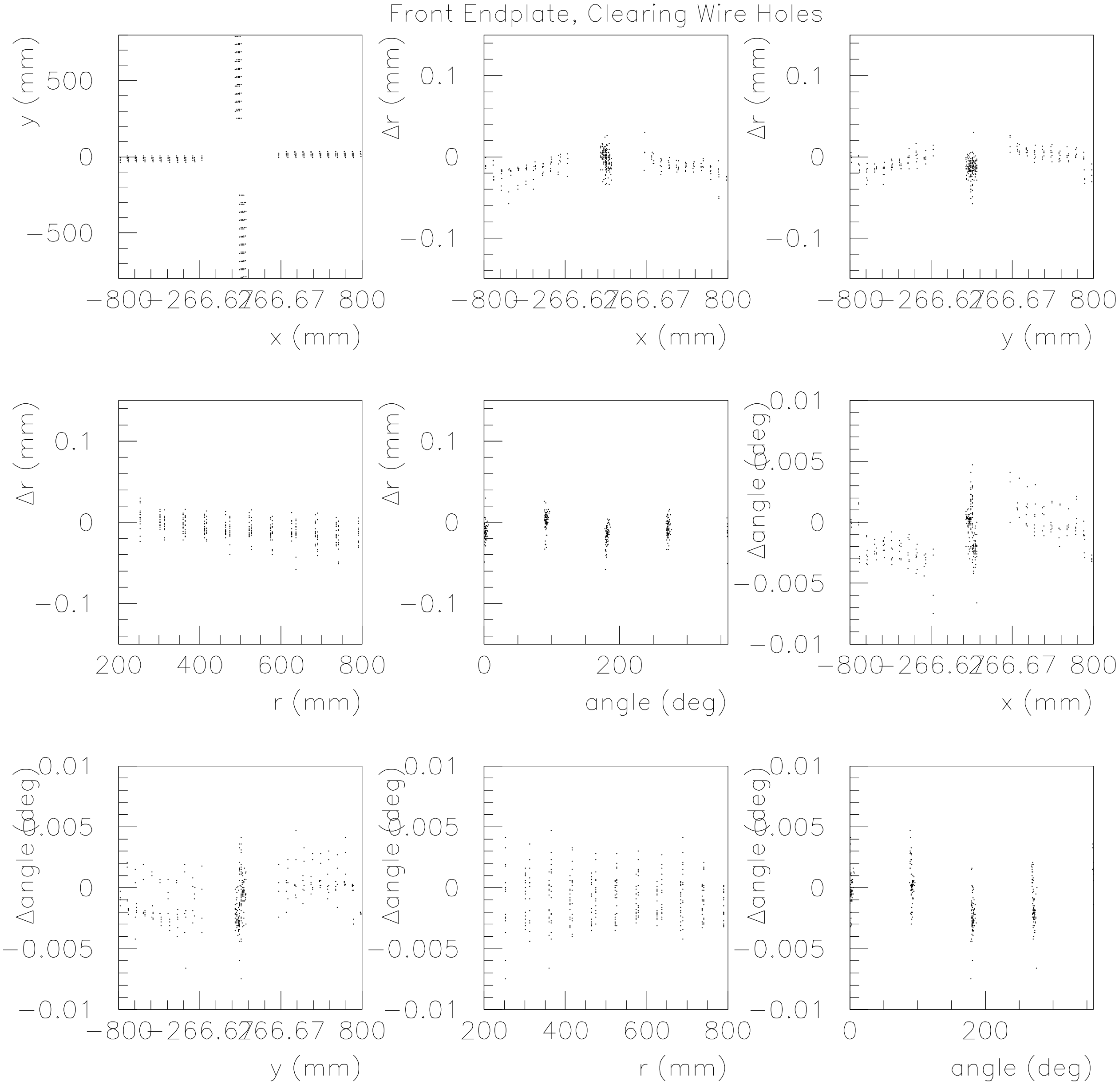

Figure 9: Measurements of the clearing wire holes on the front endplate.

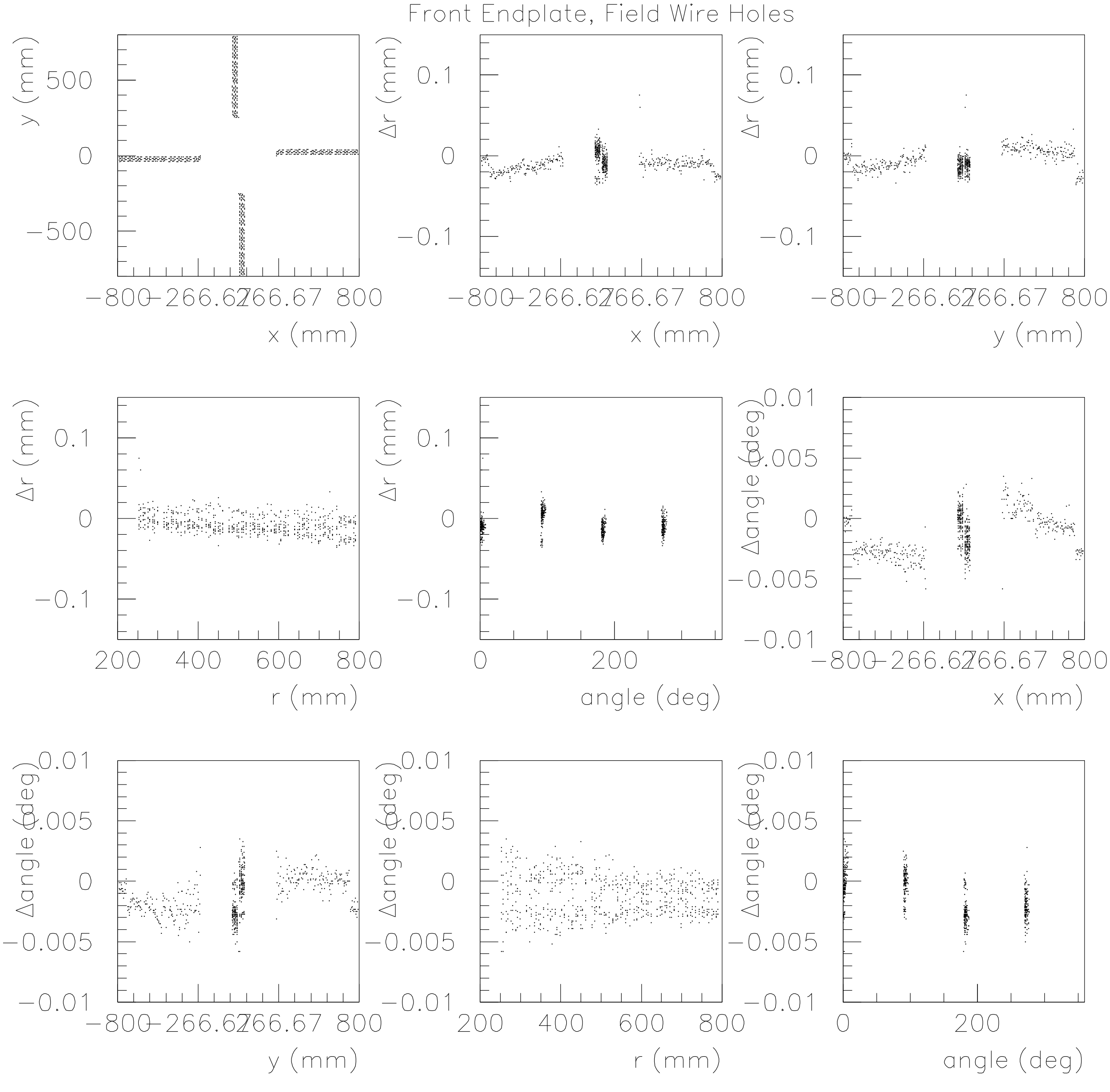

Figure 10: Measurements of the field wire holes on the front endplate.

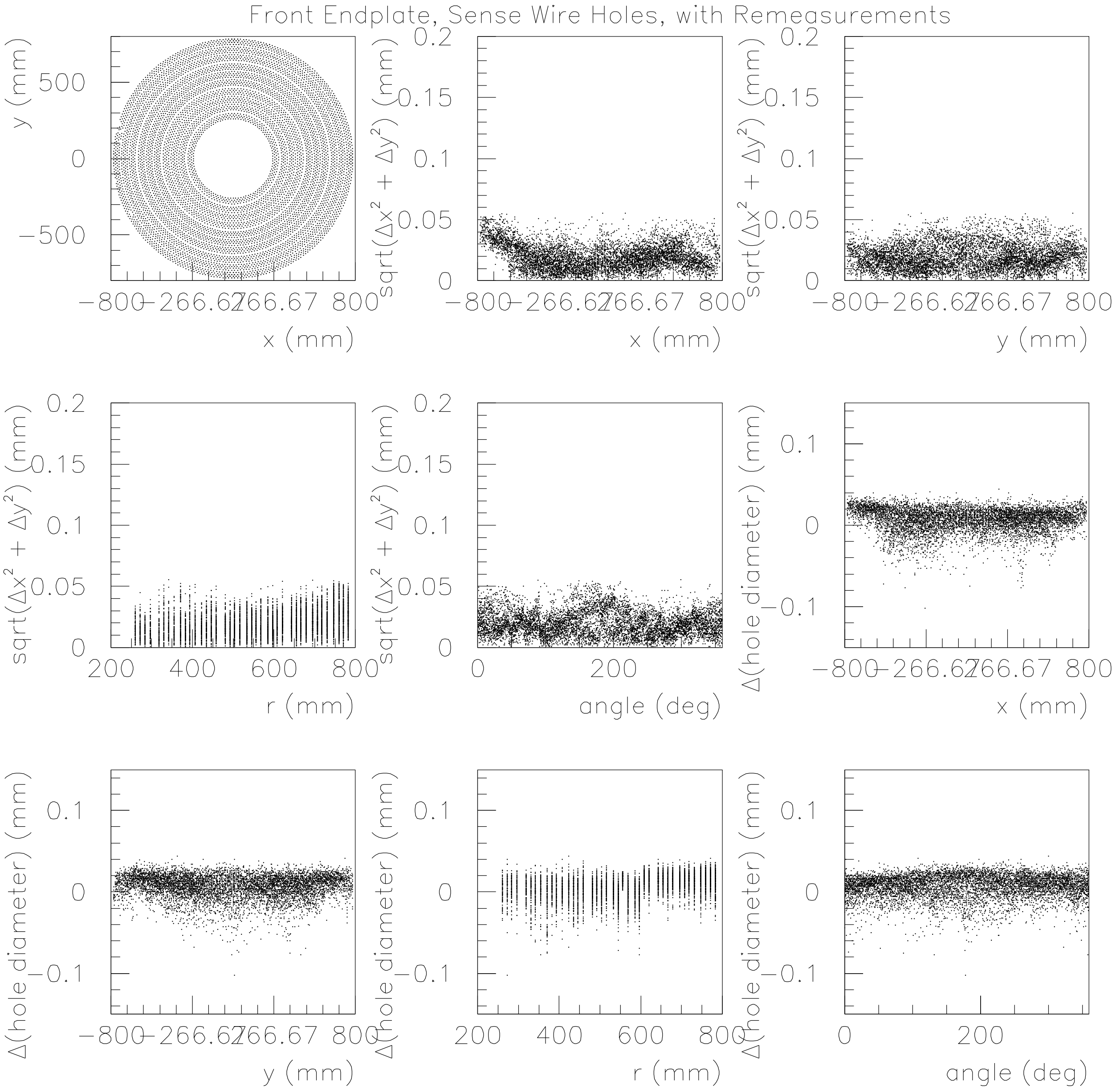

Figure 11: Results including remeasurements of the sense wire holes on the front endplate.

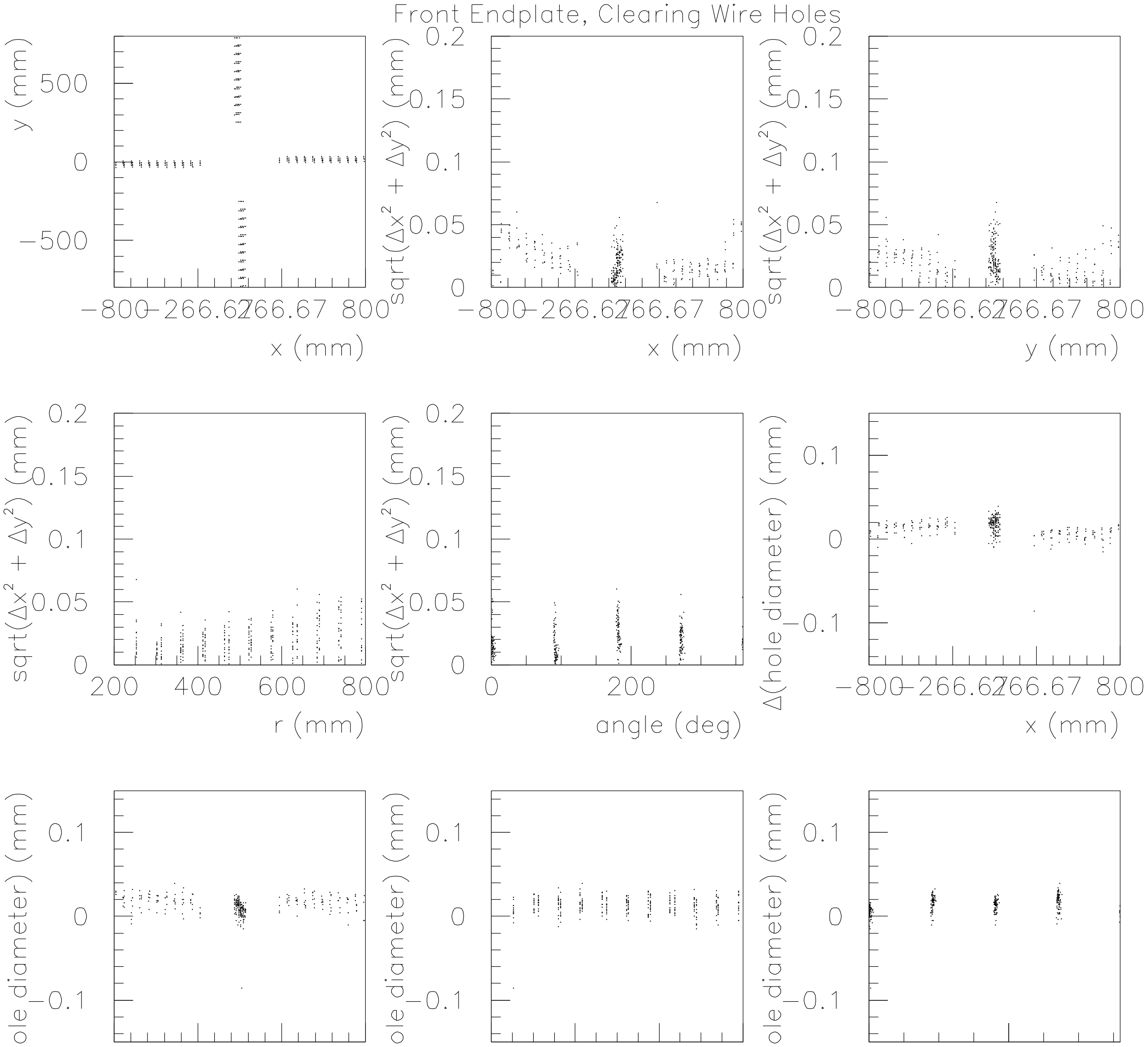

Figure 12: Measurements of the clearing wire holes on the front endplate.

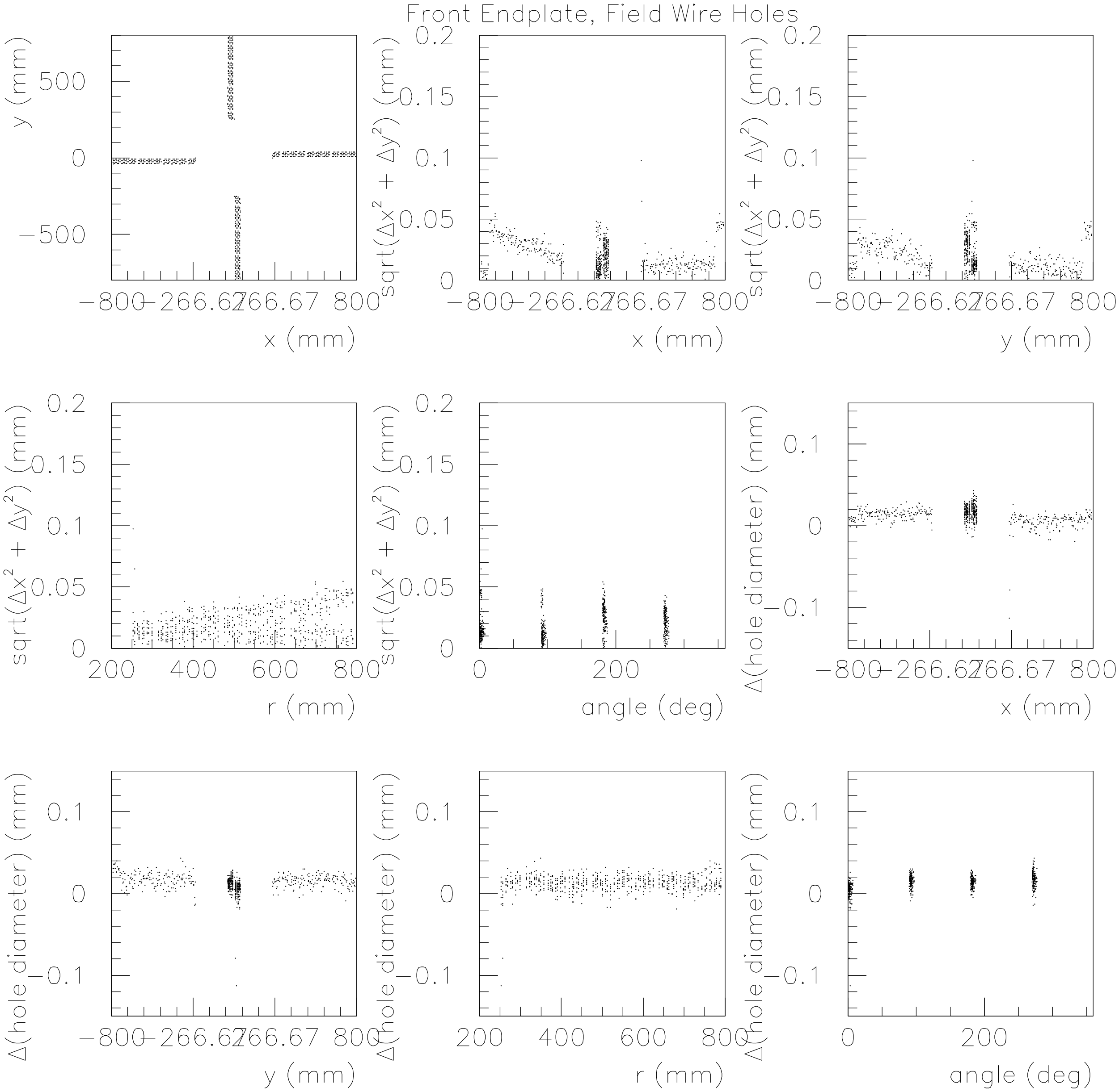

Figure 13: Measurements of the field wire holes on the front endplate.

2 Rear Endplate

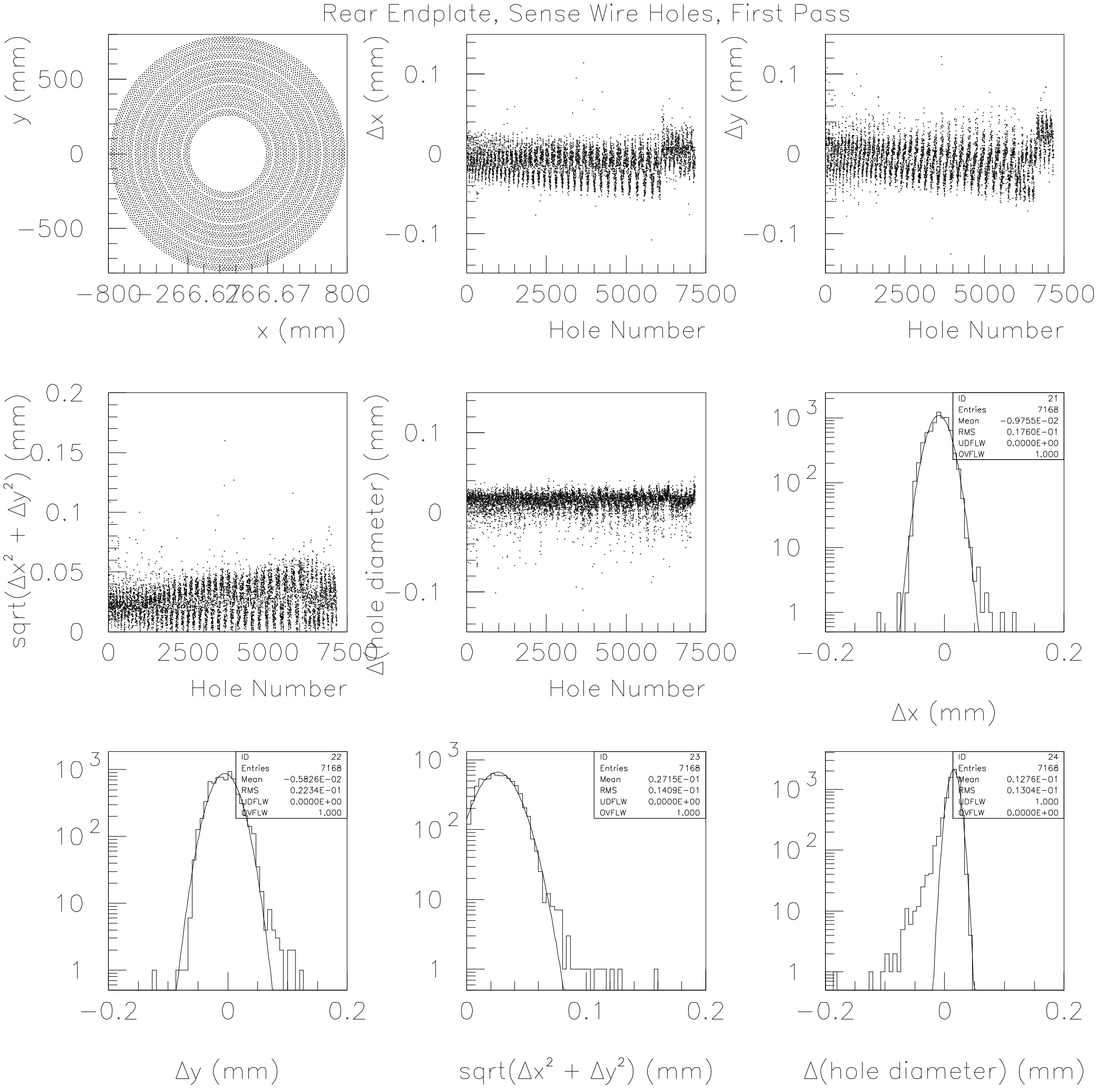

Figure 14: Initial measurements of the sense wire holes on the rear endplate.

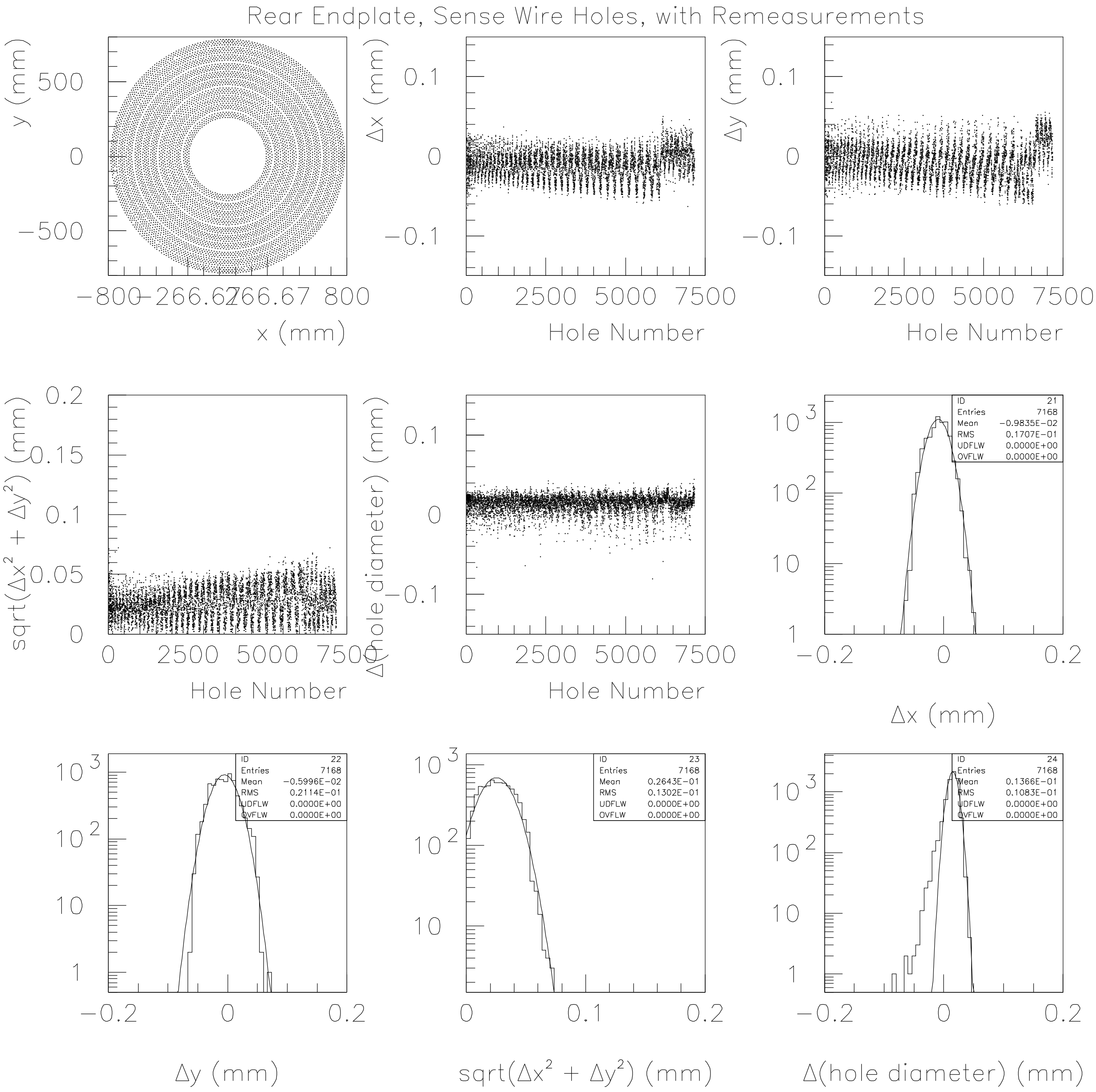

Figure 15: Results including remeasurements of the sense wire holes on the rear endplate.

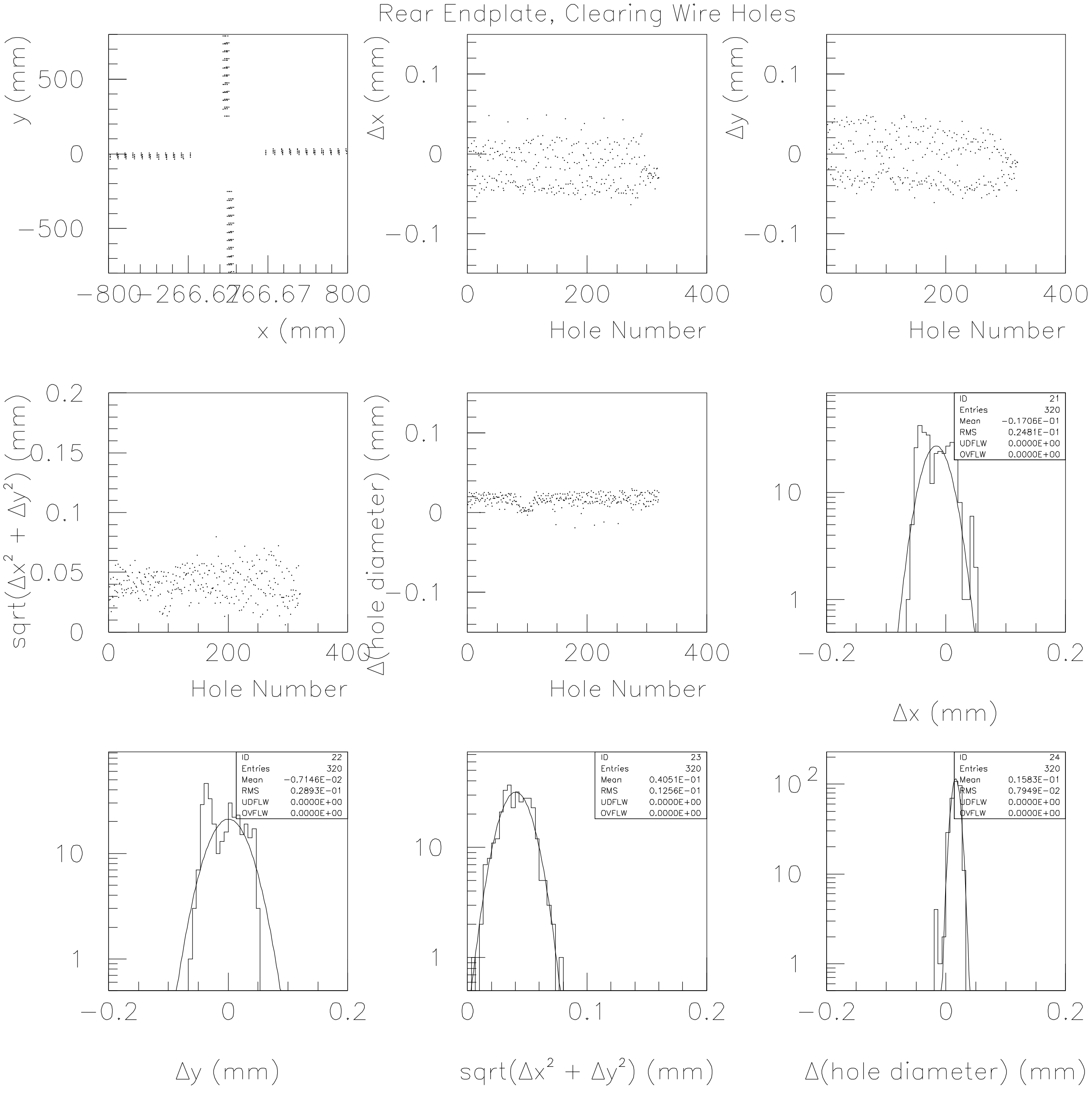

Figure 16: Measurements of the clearing wire holes on the rear endplate.

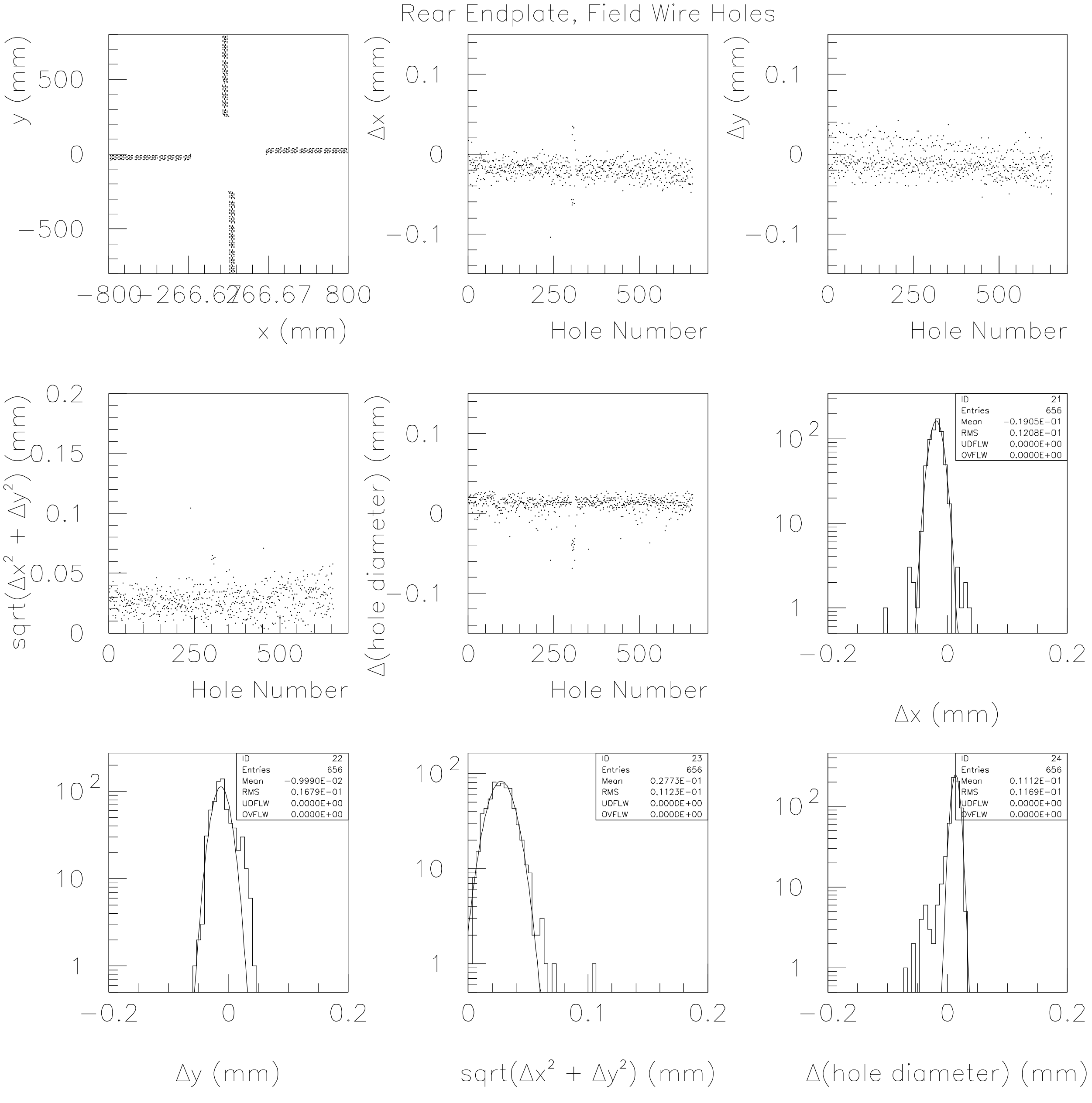

Figure 17: Measurements of the field wire holes on the rear endplate.

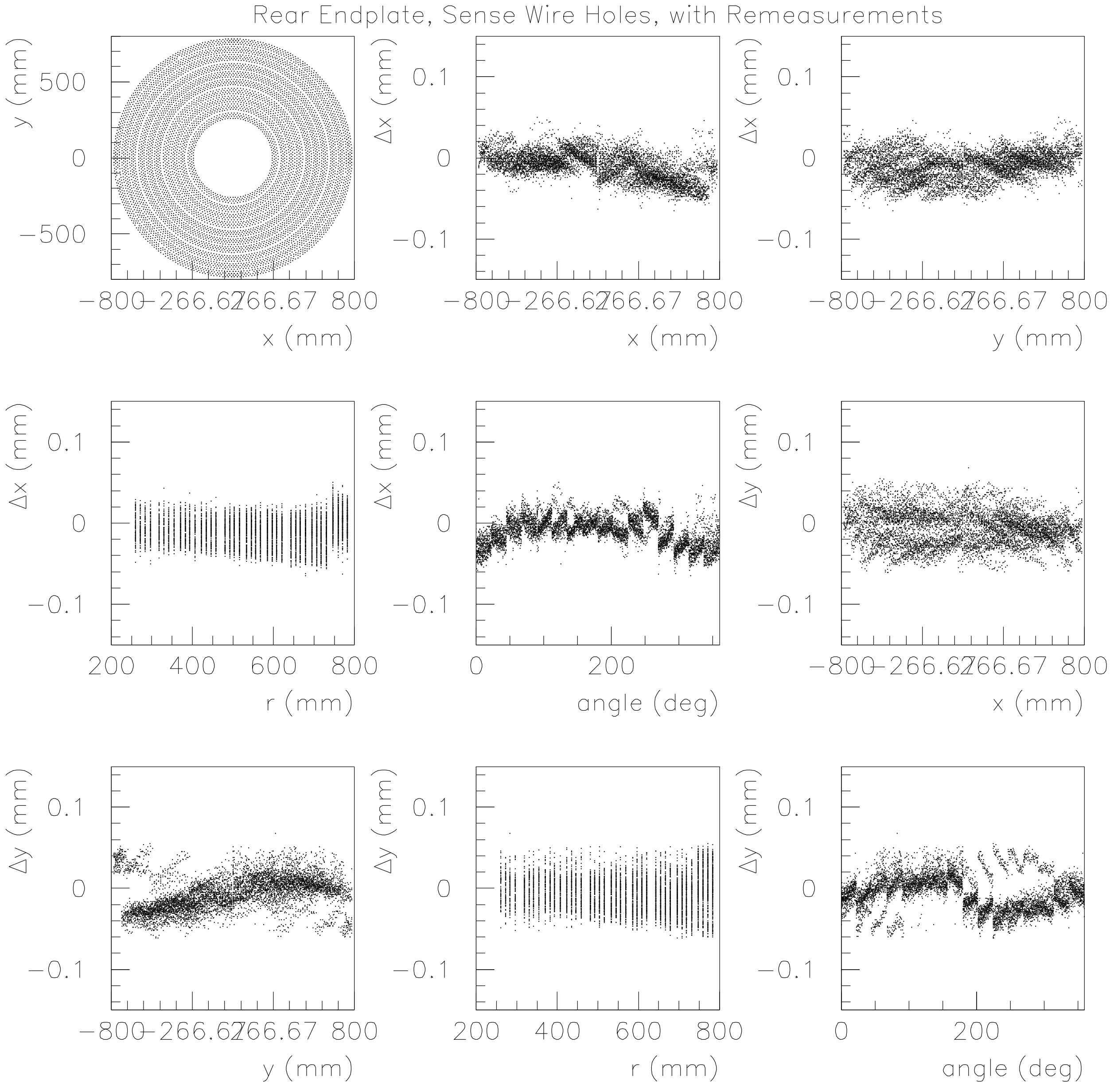

Figure 18: Results including remeasurements of the sense wire holes on the rear endplate.

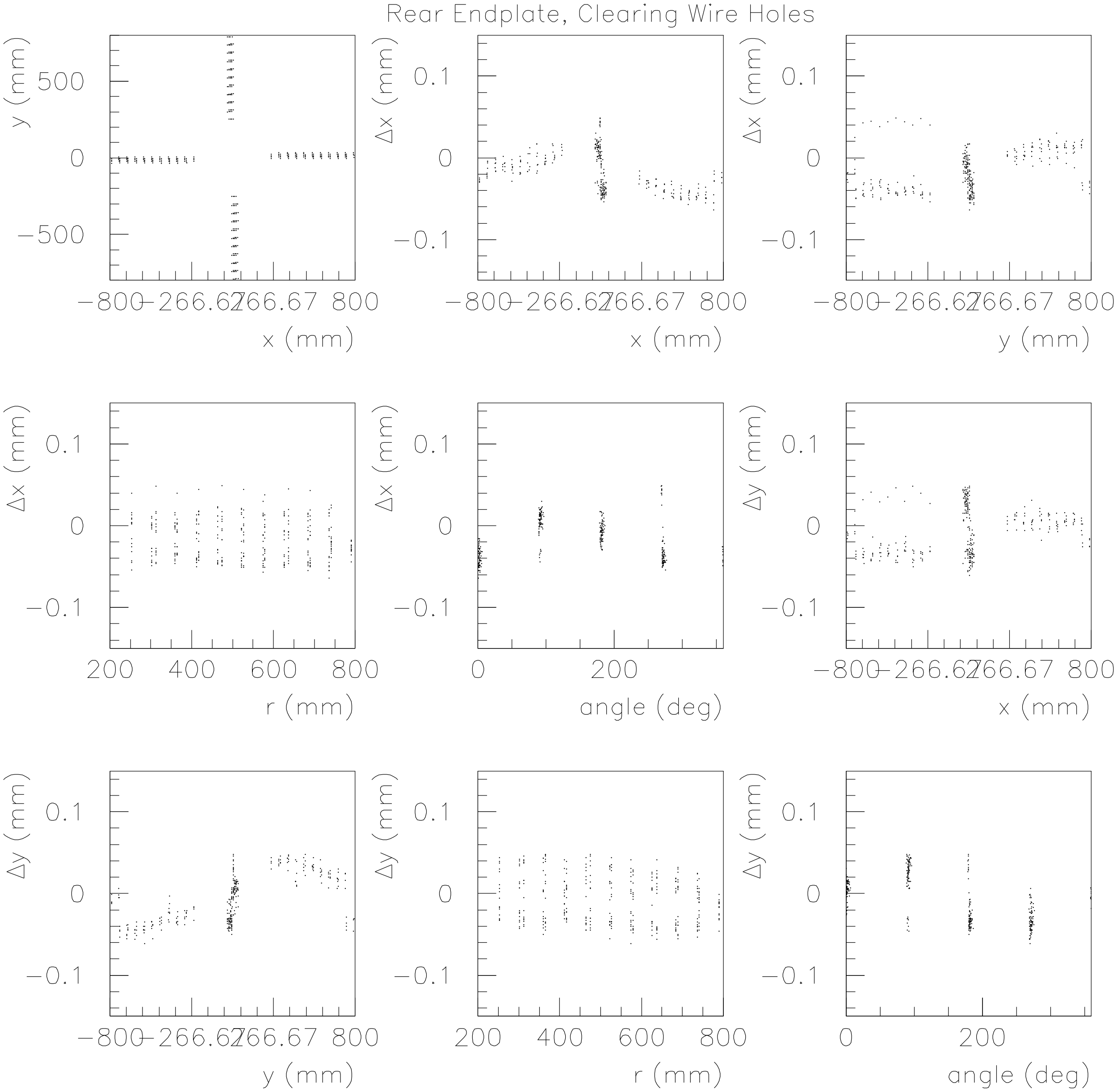

Figure 19: Measurements of the clearing wire holes on the rear endplate.

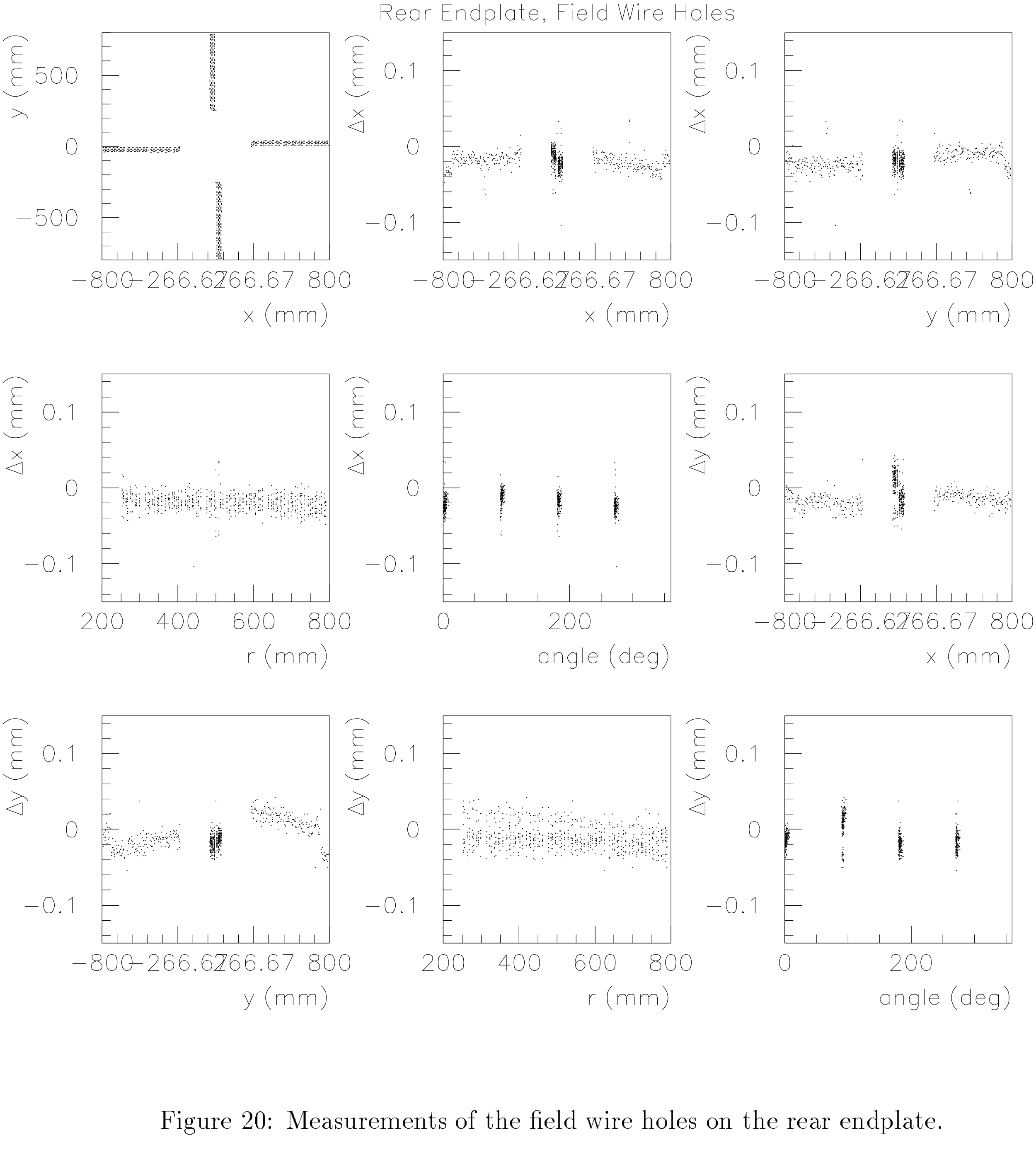

Figure 20: Measurements of the field wire holes on the rear endplate.

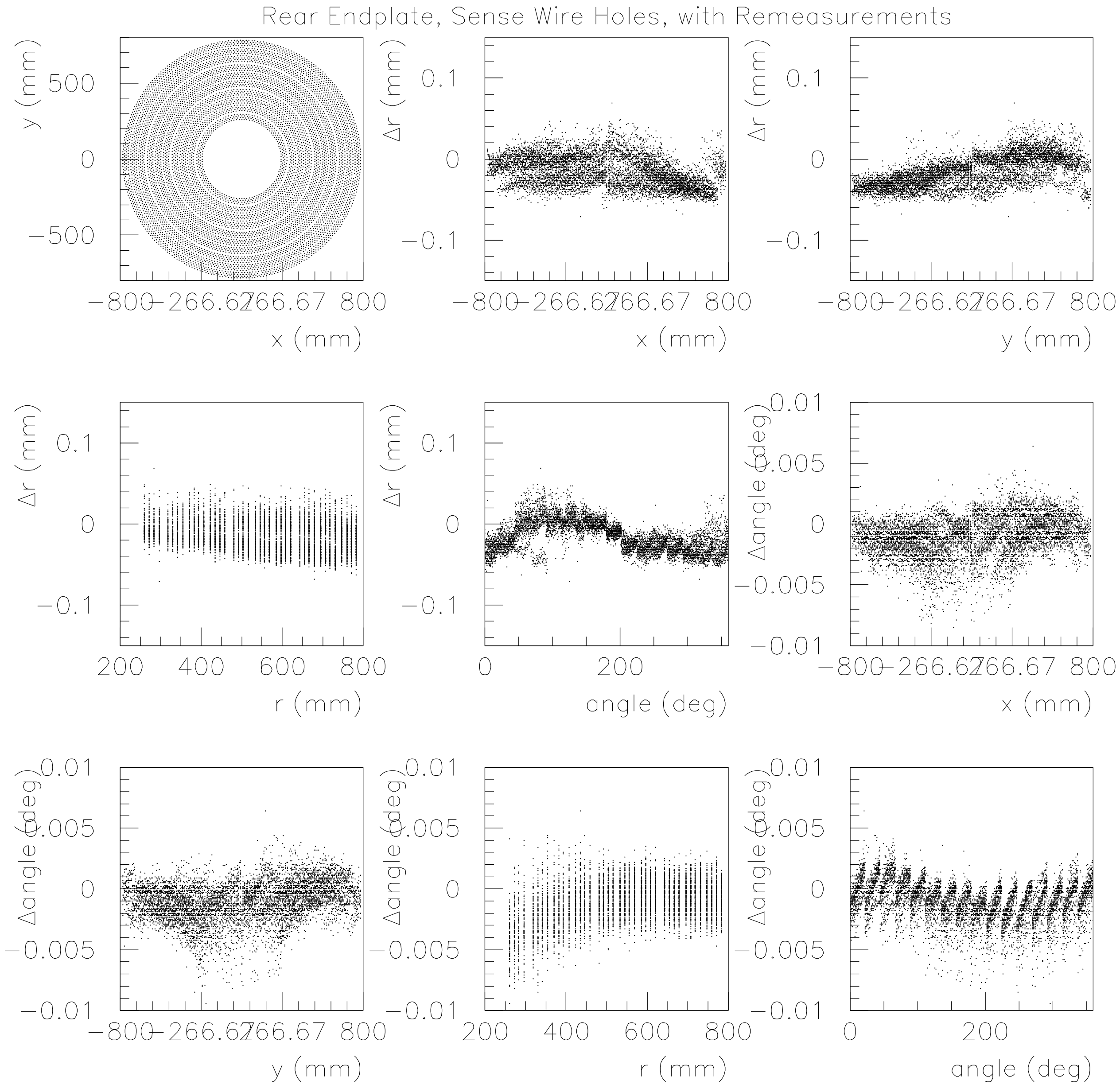

Figure 21: Results including remeasurements of the sense wire holes on the rear endplate.

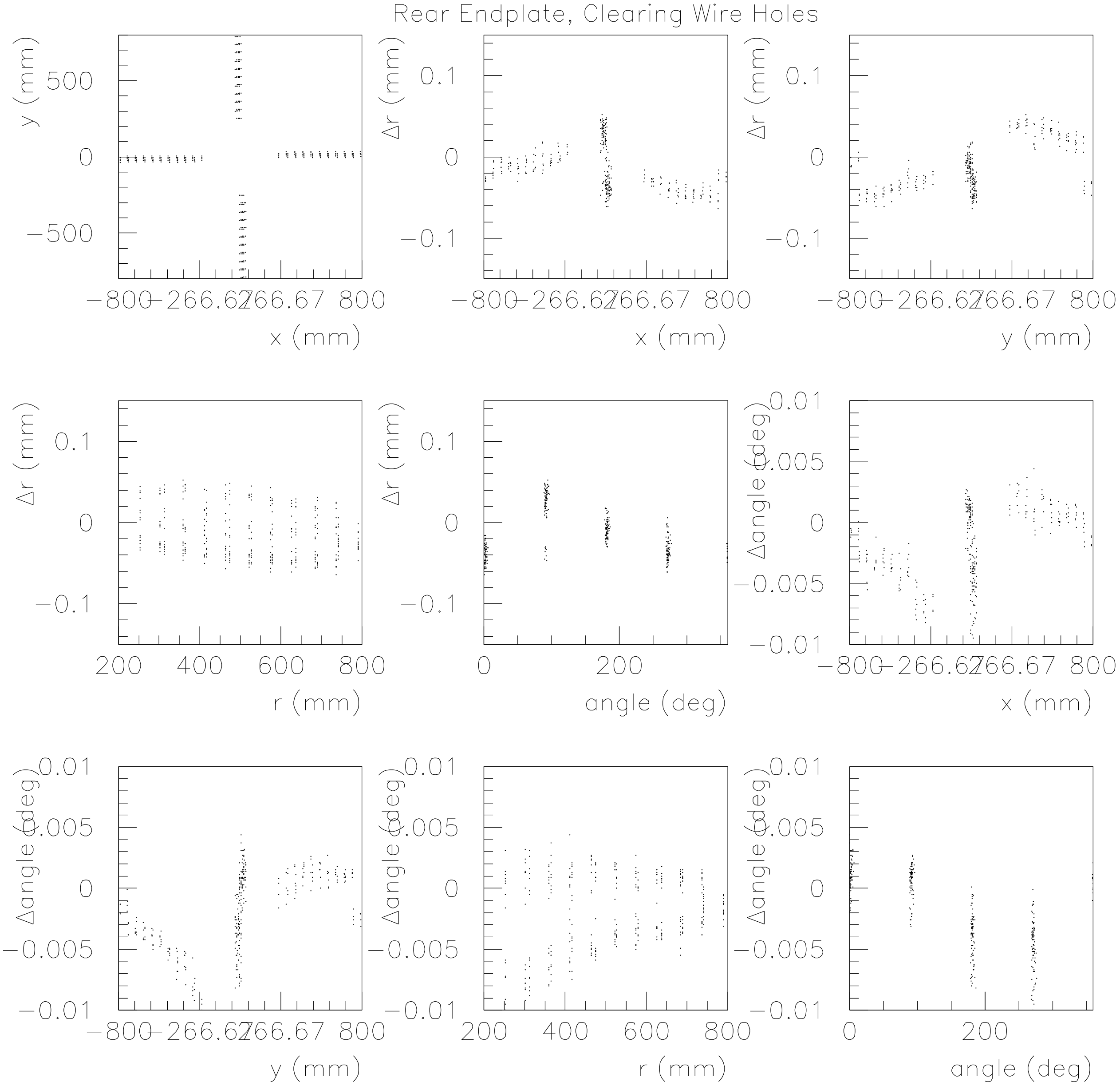
Rear Endplate, Clearing Wire Holes

Figure 22: Measurements of the clearing wire holes on the rear endplate.

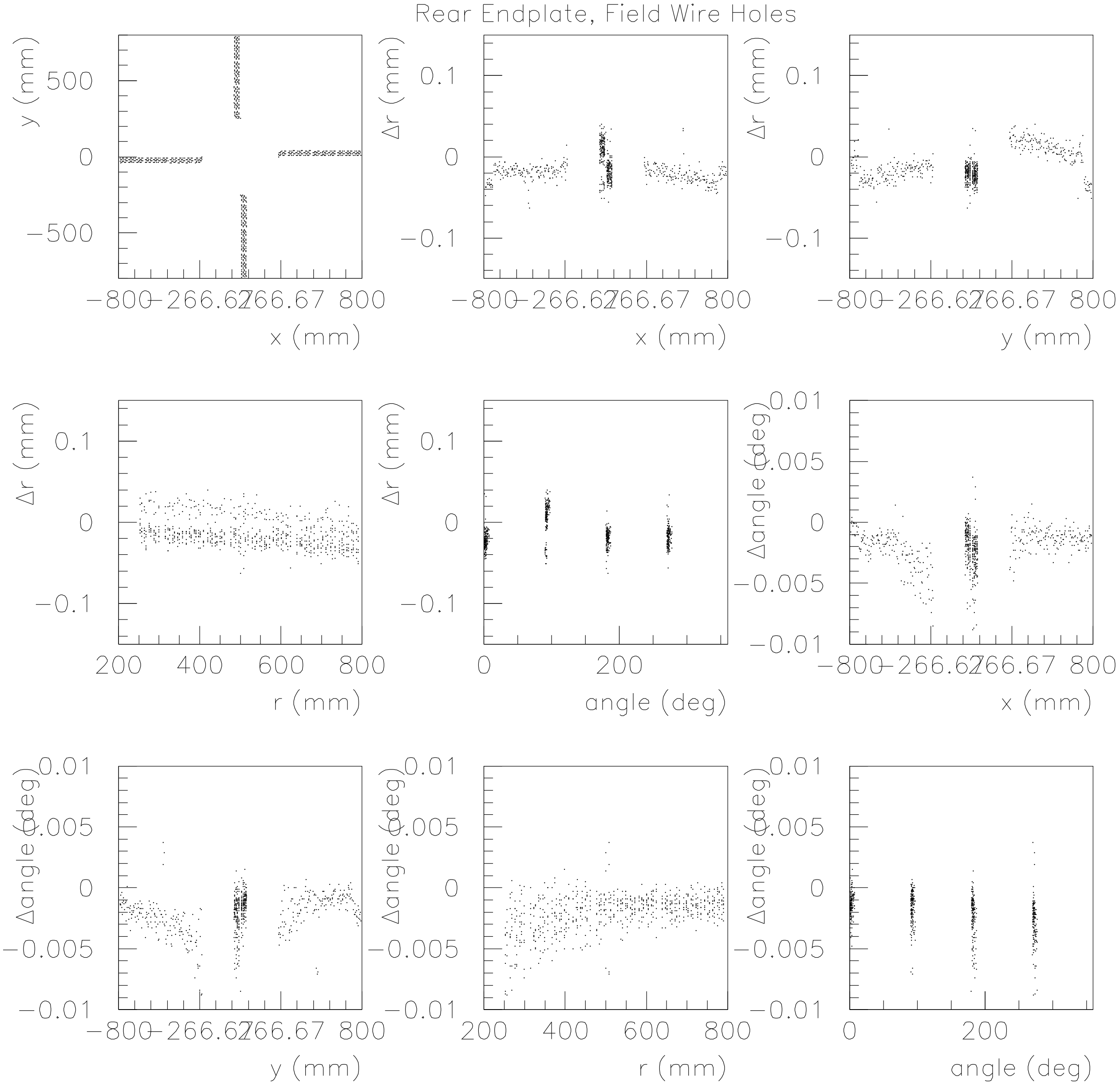

Figure 23: Measurements of the field wire holes on the rear endplate.

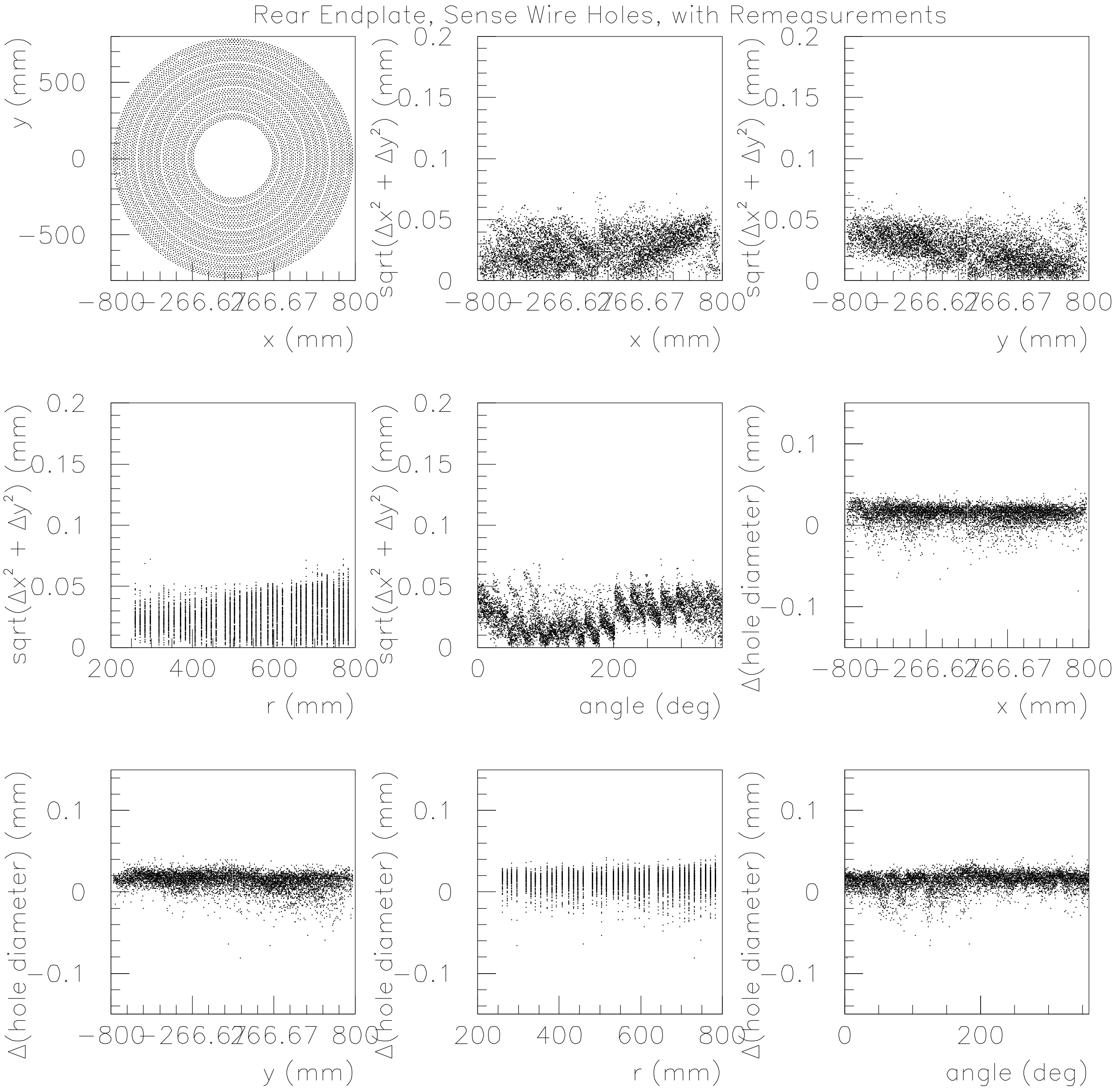

Figure 24: Results including remeasurements of the sense wire holes on the rear endplate.

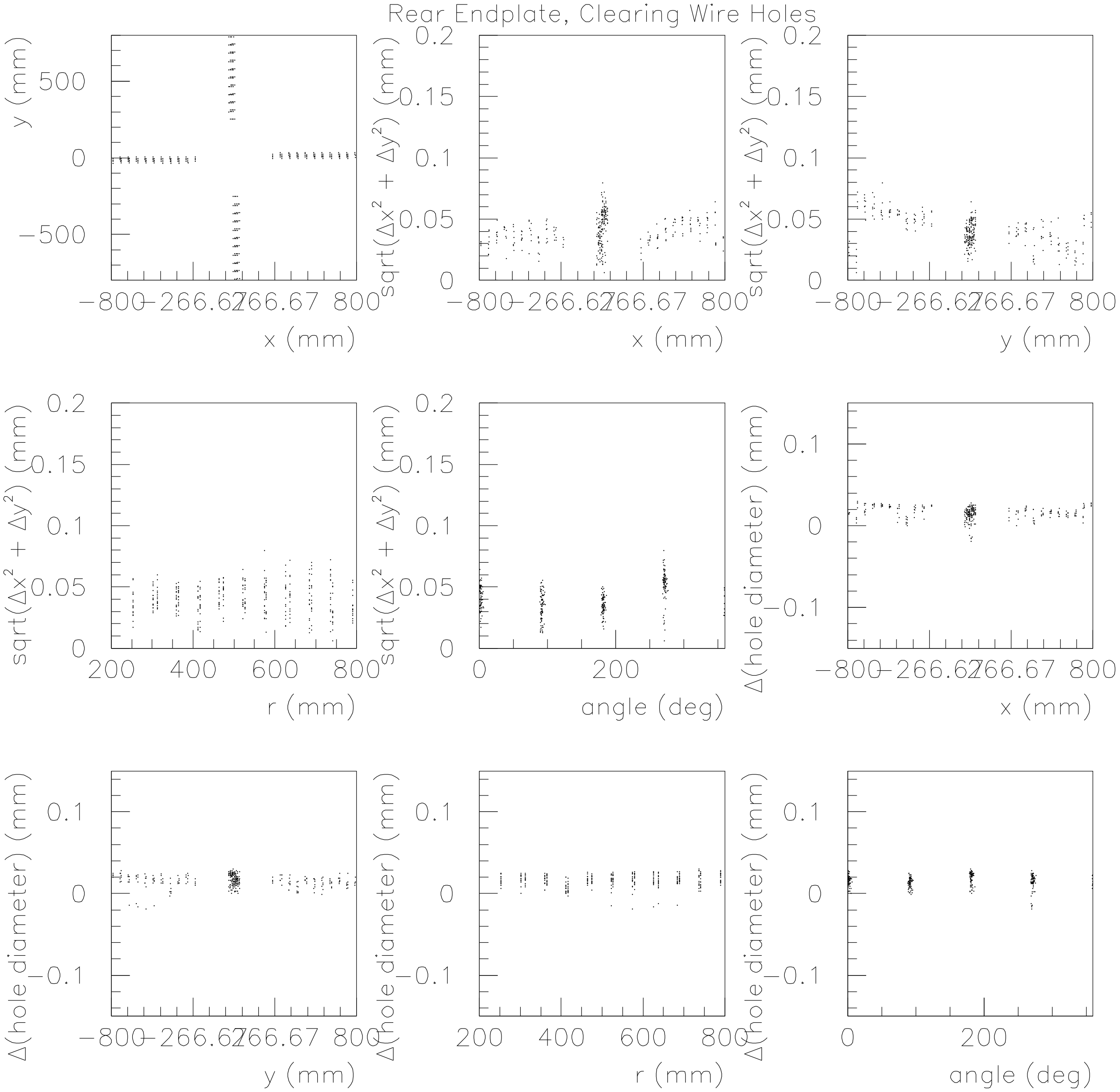

Figure 25: Measurements of the clearing wire holes on the rear endplate.

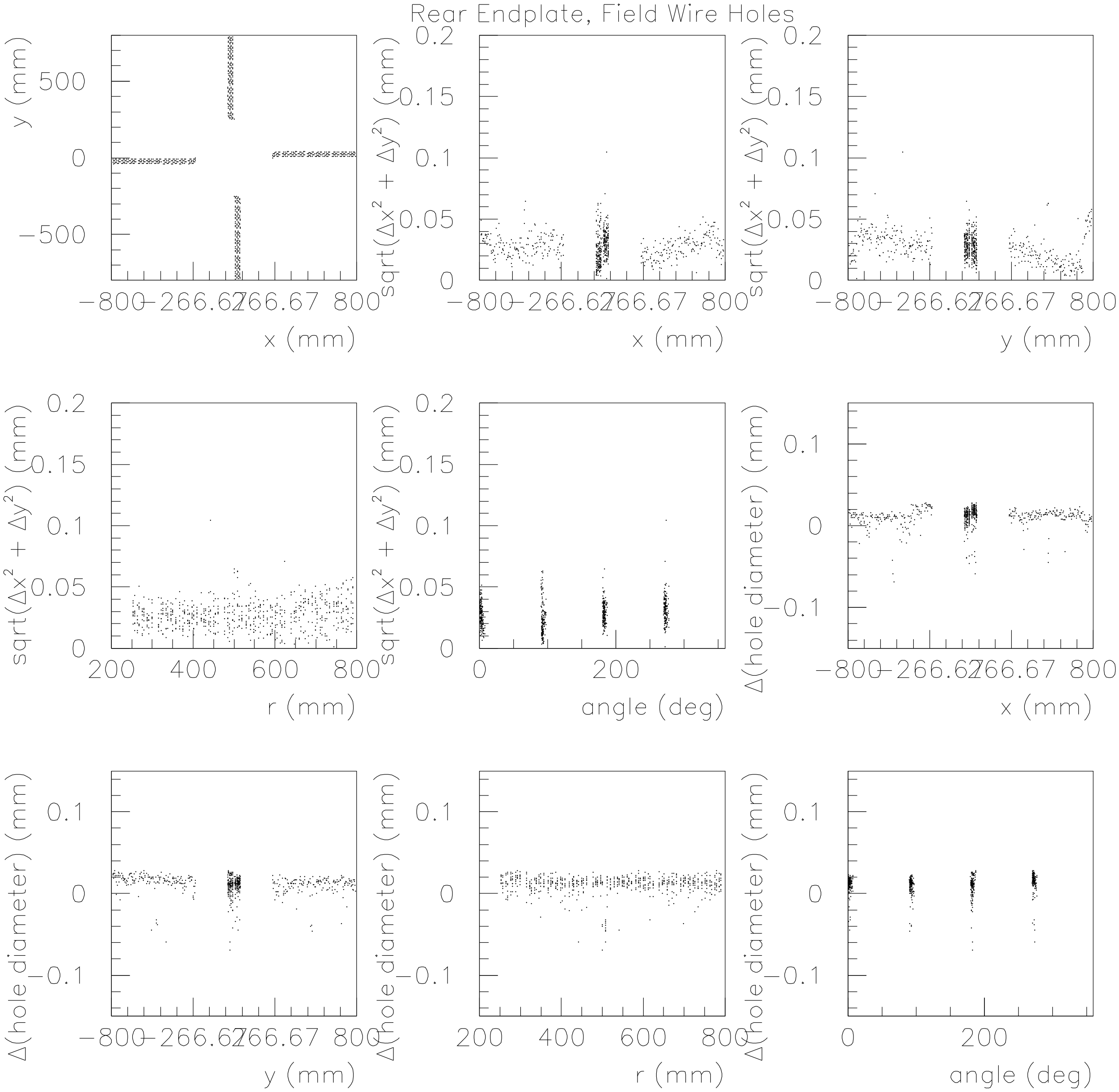

Figure 26: Measurements of the field wire holes on the rear endplate.

3 Appendix: Summary-File Structure

The CMM results are contained in eight ASCII files available in the Princeton Technical Notes Web Page:

`front_clear.dat`
`front_field.dat`
`front_sense1.dat` = original measurements
`front_sense2.dat` = file including remeasurements
`rear_clear.dat`
`rear_field.dat`
`rear_sense1.dat`
`rear_sense2.dat`

Each file contains one record per measured hole, each with 20 floating-point numbers separated by spaces. The records were written with a FORTRAN format `(1x,4f7.0,16f10.4)`. The record length is 190 bytes.

The 20 variables are

1. $TYPE = 1 =$ clearing, $2 =$ field, $3 =$ sense wire.
2. $LAYER =$ drift chamber layer number from 1 (inner) to 40 (outer). However, travel limitations of the CMM required layers 37-40 to be measured in two parts. Layer 41 is the second part of layer 37, *etc.*
3. My $HOLE\ NUMBER$. These are sequential, expect that remeasured holes have the $HOLE\ NUMBER$ replaced by the sequential $HOLE\ NUMBER$ taken from the remeasurement file.
4. Brenner's $HOLE\ NUMBER$. I kept this to aid in possible discussions with Brenner.
5. $XMEAS =$ measured x-coordinate of the center of the hole. All distances are measured in mm.
6. $XTHEO =$ desired x-coordinate of the center of the hole.
7. $XDEV = XMEAS - XTHEO$.
8. $YMEAS$.
9. $YTHEO$.
10. $YDEV = YMEAS - YTHEO$.
11. $XYDEV = \sqrt{(XDEV)^2 + (YDEV)^2} =$ deviation between actual and desired hole center = one half of the machinist's 'true position' deviation.
12. $RMEAS =$ radius of center of hole.
13. $RTHEO$.

14. $RDEV$.

15. $AMEAS$ = measured angle in degrees of the hole relative to the x-axis.

16. $ATHEO$.

17. $ADEV$.

18. $DMEAS$ = measured diameter of the hole.

19. $DTHEO$.

20. $DDEV = DMEAS - DTHEO$.