MILAGRO MEMO
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Milagro Surveys from Ancient to Modern Periods

Introduction

After much historical and archaeological study, the various surveys done at Fenton Hill in the Ancient (pre-grid), Medieval (Milagrito), and Modern periods are described and compared. Various historic events (such as PMT string manufacture) are discussed in light (Cerenkov?) of these surveys. Since some post-modern work (Outrigger and WACT construction) needs outside the pond coordinates only available in surveys from the ancient period, a relation between that survey and later ones is determined.

Catalog of Surveys Done.

The surveys done to date include:

Pre-Grid Survey

> Some time in 1995 before the grid was in place (current best limit is before June of 1995).
>
> Includes top of pond corner bolts (which are almost but not precisely at the corners of the pond on the slats holding down the cover), bottom pond contour, and vertical and horizontal lines down the middle (Figure 1 and Table 1)
>
> Coordinates are +Y pointing true north and +X pointing true east.

Milagrisimo Survey.

> October 1995.
>
> 200 bottom grid crossing points (Figure 2 and Table 2).
>
> Coordinate system rotated by approximately $\pi + 0.4254$ radians = 180+24.37 degrees with respect to +Y = north coordinates. That is, in this system +Y points 24.37 degrees east of south and +X points 24.37 degrees south of west.

Milagrito Surveys.

> July 1996.
>
> Sparse survey of bottom plus additional points on slope.
>
> A comparison of the October 1995 and July 1996 surveys transformed to +Y along true North is given in Table 3.
>
> The data used for Milagrito reconstruction were from a combination of these two surveys transformed to +Y pointing to true north and are presented in Table 4 and Figure 3. This combination will be called the Milagrito survey in the rest of this memo.

Milagro transit survey.

> June 1998
>
> 180 points including sample of bottom and slope (Table 5 and Figure 4). Also included were 4 points (2 on North slope near bottom and 2 on south slope near bottom) which were used to mark equal water level heights while Milagrito was being drained.
>
> Uses +Y true north coordinates.

Milagro photographic survey.

Photos taken June 1998. Data available end of July, 1998.

Used photographs of crosses taped over grid crossing points to determine positions. Several points where cover was floating were inaccurate.

A comparison with the transit survey is given in Table 6. Note that the photographic survey analysis used some fitting to transit points. The best points of the transit and photographic surveys were used to determine the data in Table 7 (Figure 5). This table, plus various fixes for special cases which were not available from these surveys, were used to determine the Milagro PMT positions.

A construction map, reported by Peter in a note sent on May 9, 1997, gives the berm elevation as 8,692.3 feet and the pond bottom center liner at 8665.5 feet.

In addition the grid surveys, there have been a few measurements of PMT depths:

On September 16, 1998 a sparse sampling of the muon tube depths was performed during the water fill (Table 8). This showed that the muon layer was rotated with respect to the water plane by 1.54 ± 0.13 mrad about the pond x axis with pond north higher than south. Pond north, south, east, or west refer to a coordinate system where +Y points approximately north but parallel to the pond long axis and X points approximately east but parallel to the narrow axis (the rotation from true north and east is 24.37 degrees).

A full set of 25 by 18 shower layer PMT depth below water surface measurements was done on November 12 and 13, 1998, during the pond fill (Table 9).

The average depth below water surface was 28.4 cm.

Fit to PMT depths, subtracting out the effect of extra chain added or subtracted (see the string factory discussion below), showed the pre-chain-corrected pond north PMTs higher than the south ones corresponding to a rotation of 1.064 ± 0.072 mrad, and pond east higher than pond west by 0.199 ± 0.099 mrad.

Fit with the chain attached gives a final constructed PMT plane which is tilted by 0.475 ± 0.049 mrad Milagro south higher than north and 0.183 ± 0.068 mrad Milagro east higher than west. The largest residuals were +7.1 and -8.4 cm.

140 shower layer PMT depths below water level were measured on October of 1999 (Table 10) after the pond was completely filled.

11 PMTs near the pond entrance had their depths measured on September 15, 2000 (Table 11)

Some Survey Comparisons

As mentioned above, the October 1995 and July 1996 surveys are rotated from +Y pointing to true North. A fit of these coordinate systems to the 1998 surveys determines how to transform the coordinates of any point. A point whose coordinates are (x_{95},y_{95}) in the old surveys should be rotated to (x_{98},y_{98}) for comparison with later surveys where:

$$x_{98} = 105.8 - x_{95} * cos(\theta) + y_{95} * sin(\theta)$$

and

$$y_{98} = 2856.0 - x_{95} * sin(\theta) - y_{95} * cos(\theta)$$

and $\theta = 0.4254$ radians.

A comparison of the 1998 transit and the Milagrito surveys was done, after this rotation was applied, for the 58 points they had in common. Conclusions of this comparison:

The grid contracted between the two surveys roughly symmetrically about the pond center. This was especially of interest in calculating heights for the string factory, for which the photographic survey was not yet available and points not in the transit survey had to be taken from the Milagrito survey. This was also used for the final Milagrito survey. The fit results give a contraction which can be written as

$$y_{contracted} = 0.99747y + 1.12$$

and

$$x_{contracted} = 0.99848x - 1.07$$

which corresponds to a contraction of about .28 inches in y (.17 inches in x) per 9.3 feet of grid (one cell length). When the grid was built, the screws which pinned the PVC pipes in place were put into oversize holes to allow for thermal expansion and contraction. The contraction fit is consistent with the pipes having shifted by much of the amount allowed by this pinning method: (11/32 inch hole - 5/32 inch pinning screw) times 2 (two pinned ends per 9.3 foot segment)=0.38 inches for the pins initially put in with the pipes in the maximally extended position.

The contraction leads to a PMT elevation change which is negligible on the pond bottom but is up to about 2 cm on the slopes.

A fit showed that the two surveys are rotated with respect to each other by 0.47 ± 0.15 mrad with the north end coordinates higher in the old survey.

Any rotation about a vertical axis (that is, a rotation in the horizontal plane) was fit to be less than 0.3 mrad and therefore gives negligible contribution to a shift in height and was ignored.

Two north and two south points were marked on the cover near the bottom of the north and south slopes while Milagrito was being drained. The transit survey of these points, heights of 86.9 cm, 84.7 cm, 79.8 cm, and 807.7 cm for the NW, NE, SW, and SE points respectively, was used to determine to rotation of the transit survey with respect to the horizontal, calculated to be 0.92 mrad, N coordinates too high. The transit survey data points were rotated by this amount, so that the new fiducials were lower by 3.5 cm in the north end and higher by 1.1 cm in the south end of the pond.

A later comparison of the 1998 combined photographic and transit survey and the Milagrito surveys used 176 points the surveys have in common and gave:

The contraction is roughly about the pond center and is given in Milagro coordinates by:

$$y_{contracted} = (1 - [2.63 \pm 0.23] \times 10^{-3})y - (4.26 \pm 0.74)cm$$

and

$$x_{contracted} = (1 - [2.14 \pm 0.21] \times 10^{-3})x + (3.31 \pm 0.31)cm$$

This higher statistics comparison showed that the surveys are rotated from each other by only 0.263 ± 0.088 mrad, with old north higher.

A comparison of transit and photographic surveys shows them consistent to within 0.16 mrad, which should be the case since the photo survey numbers were derived from that of the transit.

String Factory

At the time the strings were being manufactured for Milagro, the photographic survey was not yet available. The Milagrito survey and transit survey were combined to give the best guess of cross elevations, called the String Factory Survey. Several corrections were applied in order to make this possible:

Disagreement between Milagrito and transit surveys were attributed to grid contraction and relative rotation between the two surveys, as described above. The Milagrito points were corrected for this before being included in the survey.

The rotation of the transit survey with respect to the water level, as discussed above, gave a 0.92 mr rotation which was applied to the transit survey and a $0.92 + 0.49 = 1.41$ mrad rotation which was applied to the Milagrito survey.

Later PMT depth measurements showed that this rotation was in error, probably due to cover shifts between when the 4 water level points were marked on the cover and when the transit survey was done. EM layer PMTs were brought back to an approximately horizontal plane by adjusting the number of chain links (2.25 cm per link) as follows:

Rows 21 to 25	Shorten by 2 links
Rows 16 to 20	Shorten by 1 link
Rows 11 to 15	Don't change
Rows 6 to 10	Lengthen by 1 link
Rows 1 to 5	Lengthen by 2 links

As the PMT depth measurements done in November 1998 are used in the reconstruction code, uncertainties in the string factory and surveys do not give errors in PMT height. However, for the muon layer only the calculated values are available, so it is reassuring to do a comparison for the EM layer where both methods are available. A fit of a plane throught the 450 values of [PMT photographic survey cross positions + planned string lengths + individual PMT corrections (such as chain added or subtracted) + measured PMT depth] should give an X-Y plane which has zero slope in height versus X or Y. The fit value in +Y along true north gives a Z vs. Y slope of -0.082 ± 0.058 mrad and Z vs X of 0.256 ± 0.072 mrad. Any deviation of the surveys from true horizontal is thus actually quite small.

A fit to the depth measurement shows that after the chain correction the built shower layer PMT plane deviates from the horizontal by 0.475 ± 0.049 mrad in pond Y (higher in south) and 0.183 ± 0.068 mrad in pond X (higher in east). The muon layer PMTs have the full constructed tilt remaining. The PMT heights used in the reconstruction code of course include this information. Also included in the final PMT height is a list of which muon layer PMTS have short or long PMT base housings.

A comparison of the 1998 and 1999 PMT depth measurements has 3 PMTs which are different by a lot, presumably because of string tangles that were not yet fixed. Not including these 3 PMTs, the water level after the fill was completed was higher than when the first (during the fill) measurement was done by 103.98 ± 0.10 cm. The EMS recorded difference was $637.7 - 527.0 = 110.7$ cm. The differences for various parts of the pond were:

Layer	Number PMTs compared	Depth(1999)-Depth(1998)
Highest Tier	81	104.2 ± 0.1
2nd Highest Tier	27	104.1 ± 0.3
3d Highest Tier	10	104.1 ± 0.1
Bottom of Grid	19	102.9 ± 0.3 cm

The water in the 1999 measurement was approximately 5 degrees C colder than when the 1998 survey was done. Grid contraction gives a calculated lowering of slope PMTS, which are pulled down the slope by the full contraction along the bottom, by 0.7 cm while bottom layer PMTs remain at approximately the same height. The differences of the bottom and slope PMTs 1999-1998 values are consistent with this, and we therefore assume an actual water height difference of 103.3 cm.

The 2000 and 1999 depth measurements are compared for the 11 PMTs for which there is 2000 data. The result is an average water level drop from 1999 to 2000 of -0.8 inches with individual PMT measured differences ranging from -0.25 to -1.5 inches.

Determination of Reconstruction PMT Coordinates

Since the difference along the grid bottom 1998 and 1996 surveys was attributed to grid settling (the contraction discussed above) the nominal X,Y coordinates for Milagrito reconstruction used these values when available. Grid settling gave a 1.7 cm shift in the PMTs on the slope. The temperature difference of Milagrito running (about 40 degrees F) versus when the survey was done (about 80 degrees F) with a PVC contraction of about 1/8 inch per grid length per 20 degrees C, gives a further shift in PMT height during data taking of about 1.3 cm. The resulting PMT heights were therefore set to 0 on the pond bottom, -3.0 on the first tier on east and west sides, and +66.0 for igloos.

The combination of 1998 transit and photographic surveys were used to determine Milagro X and Y PMT coordinates. For EM layer PMTs, the dip stick measurements were used, with the full set giving the average water level above the PMTs and individual measurements giving depth of each PMT with respect to this level. For the muon layer, the difference between the mechanical construction and attachment of the EM and Muon layers were used to determine the nominal difference between the two at the pond center. The tilt in the survey used for string manufacture was used to determine the height of other muon layer PMTs. In addition, various values were put in by hand for special cases. Figure 6 presents the code used to generate the Milagrito and Milagro surveys.

Comparison of Pre-Grid and Grid Survey Coordinate Systems

The reference points being used to determine the outrigger and WACT coordinates are the surveyed (close to the pond corner) corner bolt positions from the 1995 pre-grid survey. Since no other survey contains points outside the pond (except for the photographic one: in principle the photos could be reanalyzed to provide fiducials), it is necessary to find the relationship between these two coordinate systems for the outrigger, WACT, and PMT coordinates to be consistent. The methods used to determine this relationship are presented below.

In what follows, N,S,E,W refer to true North, South, East and West. N', S', E' and W' refer to a set of coordinates parallel to the pond slats with the N'S' axis running along the pond long dimension and N' is rotated 0.4254 radians West of North.

X,Y, and Z, the set of coordinates for any point as would be given in the true north system and X95, Y95, and Z95 the coordinate values with respect to the 1995 pre-grid survey. Here Y points N, X points E, and Z points up. There is no evidence of a rotation in axes from X95,Y95,Z95 to X,Y,Z, only an offset of (0,0,0).

The information we have:

A note from Peter Nemethy to Ken Butterfield requests a change of coordinate system from the original one to a new one, where the new ones is given in terms off (0,0) having certain offsets from the N' or W' pond slat positions. From the pre-grid survey, and measurements of the distance of bolts from the pond corners, we can determine where the pond center is in these coordinates. The result is that if the new coordinate system had perfectly followed the instructions in Peter's note, the coordinates of a point X95, Y95, Z95 in the new system is given by

$$X = X_{95} + 45.5$$

$$Y = Y_{95} - 100.8$$

with no information available about Z.

Gus tells us that the height of the center of the pond bottom was taken to be Z=0. Since the pond "center" means the center-most of the points measured in the pre-grid survey, this cannot by itself be used to relate the two surveys. A note from Ken Butterfield dated 7/16/96 states that the July 1996 survey is normalized in Z to the October 1995 survey by setting the height of grid crossing point 235 (=22,14) to 35 cm. Unfortunately, this gives no information about how Z relates to that of the pre-grid survey.

Comparison of surveys:

Two basic methods have been used to compare the surveys:

In Method 1, The grid survey + string length + PMT housing height gives the top of the PMT position in the grid coordinate system used in reconstruction. The year 2000 dip-stick measurements give the current height of the water above the PMTs. Peter Nemethy et. al. did measurements of an N' PMT distance to the N' slat and of the water surface to slat height difference. Using these numbers, and two different measurements (A and B) made of PMT to slat position gives

Method A	Method B
$X = X_{95} + 25 \pm 5$	$X = X_{95} + 14 \pm 5$
$Y = Y_{95} - 93 \pm 5$	$Y = Y_{95} - 68 \pm 9$
$Z = Z_{95} - 36 \pm 3$	$Z = Z_{95} - 42 \pm 5$

Where the uncertainties are estimates from the measurements done.

In Method 2, we subtract from the grid survey the height of the crosses above the pond bottom (11 cm) and get a pond contour near the points available from the pre-grid survey. This contour was fit to a function made of 4 connected straight lines in pond Z vs pond Y (see Figure 7). A similar function (but not the same near the N'S' center) is used for Z' vs X' (Figure 8). For the latter case the extra line near the west pond bottom is included to make up for any irregular contour near the drain. These functions were then compared with the points available in the '95 survey (Figure 9 and 10.) to yield the following relationship:

$$X = X_{95} + 16 \pm 34$$

$$Y = Y_{95} - 125 \pm 15$$

$$Z = Z_{95} - 48 \pm 2$$

Where the errors are the fit statistical errors. The Z value includes the the difference in the two surveys because the pipe plus connector height was measured in the grid surveys and the liner was measured in the pre-grid survey.

Summary:

Method 1A	Method 1B	Method 2	Original Note if precise
$X = X_{95} + 25 \pm 5$	$X_{95} + 14 \pm 5$	$X_{95} + 16 \pm 34$	$X_{95} + 45.5$
$Y = Y_{95} - 93 \pm 5$	$Y_{95} - 68 \pm 9$	$Y_{95} - 125 \pm 15$	$Y_{95} - 100.8$
$Z = Z_{95} - 36 \pm 3$	$Z_{95} - 42 \pm 5$	$Z_{95} - 48 \pm 2$	no information

Suggested numbers, obtained by combining 1A, 1B, and 2 weighted by errors are:

$$X = X_{95} + 19 \pm 4 \pm 5$$

$$Y = Y_{95} - 90 \pm 4 \pm 15$$

$$Z = Z_{95} - 44 \pm 2 \pm 5$$

where the first uncertainties are statistical from the weighted sum of methods 1A 1B and 2, and the second is a guess of systematics from the difference in results of these methods. The source for these systematics is unknown.

This implies the following for bolt coordinates:

	X95	Y95	Z95	-->	X	Y	Z
NE	1052.3	5132.4	814.1		1071.3	5042.4	770.1
NW	-4520.9	2643.0	813.3		-4501.9	2553.0	769.3
SE	4435.4	-2384.7	811.5		4454.4	-2474.7	767.5
SW	-1157.9	-4883.6	815.8		-1138.9	-4973.6	771.8

Outriggers and WACTs, whose positions are measured relative to these bolts, should therefore have their positions calculated relative to the X,Y,Z coordinates not the X95,Y95,Z95 coordinates.

Conclusions

History is useful, but its pursuit is better left to historians. Physicists should do a good job of documentation to prevent the need for such studies.

Acknowledgements

The Milagro surveys and initial analyses were performed by Ken Butterfield and Richard Bolton, who interacted strongly with Gus Sinnis in the process. PMT depth measurements were done by Peter Nemethy, Todd Haines, and others, a complete list of whom I do not have. Various other members of the Milagro collaboration did work (such as the string factory) pertinent to this analysis. My apologies for not attempting to list them all, since I would be certain to forget at least a few.

Table 1: Pre-Grid Survey.

POND	X	Y	Z
east west line profile at center			
POND_EW17_	-2777.4	-1306.6	814.1
POND_EW16_	-2764.4	-1275.4	820.2
POND_EW15_	-2705.6	-1245.1	792.4
POND_EW14_	-2147.0	-991.8	473.4
POND_EW13_	-1711.1	-791.1	230.9
POND_EW12_	-1301.5	-596.7	29.1
POND_EW11_	-1224.5	-561.3	1.5
POND_EW10_	-686.5	-309.4	4.8
POND_EW9_	-2.7	6.9	7.9
POND_EW8_	730.9	342.3	11.0
POND_EW7_	1305.8	584.9	16.8
POND_EW6_	1392.6	622.2	42.0
POND_EW5_	1776.1	778.0	239.7
POND_EW4_	2173.8	951.2	472.5
POND_EW3_	2473.2	1083.2	649.1
POND_EW2_	2736.3	1201.9	799.2
POND_EW1_	2820.0	1248.7	813.9
top corners of the pond			
POND_NEC_	1052.3	5132.4	814.1
POND_NWC_	-4520.9	2643.0	813.3
POND_SWC_	-1157.9	-4883.6	815.8
POND_SEC_	4435.4	-2384.7	811.5
bottom perimeter of pond			
POND_BSE_	2303.9	-1603.1	56.6
POND_BNW_	-2429.8	1820.6	70.4
POND_BNE_	277.5	2980.3	63.8
POND_BE_	1328.7	586.4	10.7
POND_BW_	-1230.8	-565.4	-5.6
POND_BSW_	-319.4	-2774.7	56.6
north south line profile at center			
POND_SN1_	1623.7	-3673.3	812.2
POND_SN2_	1561.0	-3532.4	766.2
POND_SN3_	1497.9	-3394.3	688.3
POND_SN4_	1433.2	-3258.2	604.0
POND_SN5_	1370.8	-3119.4	519.5
POND_SN6_	1298.5	-2964.3	426.8
POND_SN7_	1206.5	-2765.7	306.7
POND_SN8_	1125.4	-2589.1	209.2
POND_SN9_	1038.1	-2401.5	118.3

POND_SN10_	997.5	-2313.9	79.7
POND_SN11_	971.4	-2257.9	59.7
POND_SN12_	820.8	-1777.4	42.4
POND_SN13_	594.0	-1302.3	33.4
POND_SN14_	358.1	-792.5	21.0
POND_SN15_	0.8	-1.2	8.0
POND_SN16_	-330.9	704.8	18.7
POND_SN17_	-661.7	1424.4	36.9
POND_SN18_	-1016.1	2277.9	57.2
POND_SN19_	-1143.9	2437.4	62.6
POND_SN20_	-1168.2	2490.9	85.0
POND_SN21_	-1261.6	2702.7	193.3
POND_SN21_	-1261.6	2702.7	193.3
POND_SN23_	-1510.1	3265.9	503.6
POND_SN24_	-1650.9	3594.9	692.0
POND_SN25_	-1760.5	3834.3	815.0
POND_SN26_	-1768.5	3886.9	812.3

Table 2: October 1995 Survey.

POND_71_	-0.0	-0.0	31.2
POND_70_	-1.6	283.6	16.3
POND_69_	0.3	567.0	11.8
POND_56_	-0.3	849.8	3.2
POND_55_	-0.1	1132.1	-5.5
POND_54_	-0.9	1415.6	-9.6
POND_53_	0.8	1698.8	-16.6
POND_40_	0.5	1982.8	-18.2
POND_39_	0.2	2266.0	-19.2
POND_38_	0.4	2549.8	-19.4
POND_37_	-0.0	2833.8	-21.4
POND_24_	-0.3	3116.4	-17.5
POND_23_	-0.4	3399.6	-13.0
POND_22_	-0.1	3683.4	-5.3
POND_21_	0.4	3966.6	0.4
POND_8_	-1.8	4250.0	5.5
POND_7_	-2.4	4533.9	9.7
POND_6_	-0.9	4817.8	14.8
POND_5_	-0.0	5100.0	32.1
POND_75_	283.4	1.1	30.4
POND_74_	282.0	285.1	16.0
POND_73_	283.4	566.8	9.1
POND_60_	284.1	850.0	2.3
POND_59_	283.4	1133.7	-3.3
POND_58_	281.8	1416.9	-7.3
POND_57_	284.3	1700.3	-11.2
POND_44_	284.5	1983.3	-17.0
POND_43_	284.3	2265.8	-20.0
POND_42_	284.8	2550.0	-21.1
POND_41_	284.8	2833.1	-21.3
POND_28_	282.5	3116.0	-15.9
POND_27_	283.1	3399.1	-13.4
POND_26_	283.6	3682.9	-7.7
POND_25_	283.4	3966.1	-1.9
POND_12_	282.5	4249.4	4.6
POND_11_	280.8	4534.2	9.1
POND_10_	282.1	4816.7	16.4
POND_9_	282.1	5098.9	25.3
POND_79_	568.4	1.4	29.5
POND_78_	566.6	283.9	16.2
POND_77_	566.8	565.2	5.8
POND_64_	568.2	849.1	1.2
POND_63_	567.1	1133.3	-3.1
POND_62_	566.6	1417.1	-7.8
POND_61_	568.2	1700.9	-13.0
POND_48_	567.6	1983.6	-19.2
POND_47_	567.9	2267.2	-19.6

POND_46_	567.4	2550.6	-22.7
POND_45_	568.0	2833.7	-21.2
POND_32_	566.6	3116.9	-16.9
POND_31_	567.9	3400.8	-13.7
POND_30_	567.2	3683.3	-8.1
POND_29_	566.9	3966.2	-3.2
POND_16_	566.1	4249.7	1.8
POND_15_	565.3	4533.1	8.7
POND_14_	565.5	4817.4	18.2
POND_13_	565.2	5099.8	24.3
POND_147_	850.3	-3.6	27.5
POND_146_	849.1	281.0	16.5
POND_145_	850.2	563.8	9.2
POND_132_	850.8	847.5	2.7
POND_131_	849.1	1131.3	-2.1
POND_130_	849.4	1414.6	-9.0
POND_129_	851.0	1698.1	-15.2
POND_116_	850.6	1980.8	-20.9
POND_115_	851.2	2264.4	-20.1
POND_114_	851.8	2548.1	-23.9
POND_113_	851.3	2831.9	-25.3
POND_100_	849.8	3114.9	-21.3
POND_99_	850.5	3398.3	-15.5
POND_98_	850.6	3682.0	-12.2
POND_97_	850.6	3965.7	-2.0
POND_84_	850.1	4248.4	3.4
POND_83_	849.1	4532.7	6.7
POND_82_	849.8	4816.6	15.6
POND_81_	849.8	5099.1	23.3
POND_151_	1133.2	-0.0	28.3
POND_150_	1133.2	283.3	19.7
POND_149_	1134.3	564.9	12.1
POND_136_	1135.0	847.8	7.7
POND_135_	1132.8	1130.9	3.6
POND_134_	1133.4	1414.2	-5.7
POND_133_	1134.3	1697.0	-12.4
POND_120_	1134.5	1980.7	-18.4
POND_119_	1134.6	2264.1	-23.7
POND_118_	1134.6	2547.6	-23.9
POND_117_	1134.6	2831.2	-25.0
POND_104_	1132.8	3112.6	-22.2
POND_103_	1133.5	3396.7	-16.5
POND_102_	1133.4	3680.9	-7.7
POND_101_	1134.9	3964.0	-1.3
POND_88_	1134.8	4246.9	2.2
POND_87_	1133.4	4530.9	7.2
POND_86_	1134.1	4814.5	15.2
POND_85_	1133.4	5098.1	22.6
POND_155_	1415.8	-1.5	28.8
POND_154_	1415.9	280.6	20.7
POND_153_	1416.8	564.0	15.1

POND_140_	1417.0	846.8	11.5
POND_139_	1416.8	1131.0	0.2
POND_138_	1417.1	1414.5	-6.1
POND_137_	1417.0	1697.9	-13.2
POND_124_	1418.3	1980.6	-15.9
POND_123_	1417.4	2264.3	-21.3
POND_122_	1418.8	2548.6	-26.0
POND_121_	1418.0	2832.1	-24.9
POND_108_	1417.1	3115.6	-20.8
POND_107_	1417.3	3398.5	-17.7
POND_106_	1417.0	3681.0	-8.0
POND_105_	1418.5	3965.7	-5.8
POND_92_	1417.6	4249.5	-2.1
POND_91_	1416.9	4532.2	5.2
POND_90_	1416.1	4816.0	12.5
POND_89_	1416.8	5098.8	25.0
POND_159_	1701.1	1.2	29.7
POND_158_	1700.9	283.4	18.4
POND_157_	1701.4	566.5	16.5
POND_144_	1701.7	849.6	10.2
POND_143_	1700.3	1134.2	1.7
POND_142_	1700.8	1415.5	-7.1
POND_141_	1702.0	1699.5	-16.0
POND_128_	1701.4	1983.4	-17.6
POND_127_	1700.8	2266.8	-23.1
POND_126_	1702.6	2550.9	-26.2
POND_125_	1701.5	2834.3	-30.1
POND_112_	1700.7	3117.4	-25.2
POND_111_	1701.3	3399.5	-18.4
POND_110_	1699.3	3683.0	-13.0
POND_109_	1701.6	3966.5	-6.4
POND_96_	1699.9	4251.1	-1.4
POND_95_	1700.6	4533.5	4.0
POND_94_	1700.7	4817.0	15.2
POND_93_	1699.9	5100.5	22.7
POND_227_	1982.9	1.3	27.6
POND_226_	1983.4	282.3	19.9
POND_225_	1984.9	566.6	14.5
POND_212_	1983.5	849.6	7.9
POND_211_	1983.3	1133.6	1.4
POND_210_	1983.9	1416.9	-2.7
POND_209_	1984.6	1699.0	-12.5
POND_196_	1983.8	1982.6	-16.9
POND_195_	1984.6	2266.8	-21.1
POND_194_	1985.2	2549.6	-25.7
POND_193_	1985.3	2832.5	-28.2
POND_180_	1983.2	3116.5	-27.4
POND_179_	1984.2	3399.6	-22.2
POND_178_	1984.9	3683.3	-17.0
POND_177_	1985.5	3967.2	-4.9
POND_164_	1983.9	4250.7	0.9

POND_163_	1984.6	4533.9	7.1
POND_162_	1984.4	4817.2	12.8
POND_161_	1983.8	5100.2	18.2
POND_231_	2266.6	3.7	33.1
POND_230_	2267.4	286.4	18.9
POND_229_	2269.6	569.1	13.8
POND_216_	2268.5	852.2	10.7
POND_215_	2266.0	1135.1	3.2
POND_214_	2267.8	1418.6	-4.9
POND_213_	2269.8	1702.7	-11.2
POND_200_	2267.1	1984.5	-18.4
POND_199_	2267.6	2268.6	-25.0
POND_198_	2269.3	2551.0	-30.6
POND_197_	2267.9	2835.7	-27.7
POND_184_	2266.0	3119.2	-25.6
POND_183_	2267.5	3401.9	-18.2
POND_182_	2267.8	3685.3	-16.3
POND_181_	2268.2	3969.4	-8.4
POND_168_	2267.5	4252.6	0.5
POND_167_	2267.4	4536.4	7.7
POND_166_	2266.6	4821.0	12.6
POND_165_	2265.0	5104.1	17.3
POND_235_	2548.5	4.0	35.1
POND_234_	2550.0	286.6	21.2
POND_233_	2551.7	569.9	14.1
POND_220_	2549.4	852.6	6.2
POND_219_	2549.3	1135.7	1.4
POND_218_	2550.6	1419.4	-3.9
POND_217_	2551.9	1702.7	-8.3
POND_204_	2550.2	1986.0	-11.6
POND_203_	2550.6	2268.6	-22.5
POND_202_	2552.1	2551.5	-29.7
POND_201_	2551.0	2833.7	-28.1
POND_188_	2549.7	3117.6	-23.6
POND_187_	2550.0	3401.4	-18.2
POND_186_	2550.9	3684.8	-12.5
POND_185_	2552.0	3968.9	-2.9
POND_172_	2550.6	4252.7	-1.0
POND_171_	2551.3	4536.4	6.8
POND_170_	2550.7	4819.9	15.3
POND_169_	2549.7	5102.7	24.9
POND_239_	2834.8	0.5	70.0
POND_238_	2834.7	283.5	47.1
POND_237_	2834.7	566.4	43.7
POND_224_	2835.3	849.8	41.8
POND_223_	2832.6	1133.2	40.0
POND_222_	2832.3	1416.8	46.1
POND_221_	2831.2	1700.2	45.5
POND_208_	2831.4	1984.9	49.3
POND_207_	2833.4	2267.3	47.7
POND_206_	2833.3	2548.9	46.0

Table 3: Comparison of October 1995 and July 1996 Surveys.

Date: Tue, 16 Jul 1996 10:31:50 -0600
To: "Gus Sinnis" <gus@milagro>
From: kbutterfield@lanl.gov (Kenneth Butterfield)
Subject: PRELIMINARY RESULTS
Cc: RBOLTON@lanl.gov

Hi Gus,

I have preliminary results. We made two sets of measurements on the references and the rotation angle determined for each set was the same within a milli-radian. I used the good reference (at north end of pond) to set the displacement zero. The other reference point was under water and we used one of the shot filled bottles to extend above the surface. You need to make an adapter that is the height of the valve longer than the current adapters so that we can have more confidence in the measurements. The vector length between the two references varied on the order of 1-2 cm between the two readings. I set the height so that the height at pmt 235 was 35 cm as we did for the first data set. I have inclosed a comparison of the old and new positions. It looks as though the north south axis is shifted 2-3 cm but I need to look at the data a bit more to be sure. I am pretty sure the whole structure has maintained a solid shape which is reassuring.

Ken

(comparison of July 1996 and Oct 1995 positions
(original positions named POND
(new positions named JULY
(Ken Butterfield
(07/16/96
(height normalized to 35 cm at 235 for both data sets

JULY	X	Y	Z
JULY_5_	2210.0	-1783.4	30.4
POND_5_	2209.9	-1789.7	32
JULY_7_	1977.8	-1268.7	10.4
POND_7_	1978.6	-1273.0	9.7
JULY_9_	1953.2	-1902.5	25.1
POND_9_	1952.5	-1905.1	25.3
JULY_11_	1721.1	-1386.7	9.0
POND_11_	1720.7	-1390.1	9.1
JULY_21_	1742.5	-753.3	0.8

POND_21_	1742.0	-757.4	0.4
JULY_23_	1509.1	-237.5	-12.5
POND_23_	1508.7	-240.6	-13.0
JULY_28_	1135.2	-97.2	-15.6
POND_28_	1134.0	-99.0	-15.9
JULY_31_	992.8	-473.4	-13.1
POND_31_	991.6	-476.2	-13.7
JULY_37_	1274.7	277.4	-21.1
POND_37_	1275.0	274.6	-21.4
JULY_40_	923.3	1051.9	-17.1
POND_40_	923.5	1049.6	-18.2
JULY_56_	457.0	2083.6	3.9
POND_56_	456.7	2082.1	3.2
JULY_61_	290.1	1075.2	-11.5
POND_61_	289.9	1072.2	-13.0
JULY_70_	223.9	2599.2	16.8
POND_70_	224.2	2598.3	16.3
JULY_71A_	106.7	2856.7	31.8
JULY_71_	106.6	2856.1	31.=E9
POND_71_	105.8	2856.0	31.2
JULY_74_	-33.7	2481.7	16.6
POND_74_	-33.4	2479.9	16.0
JULY_79_	-409.9	2621.5	29.8
POND_79_	-411.4	2620.3	29.5
JULY_81_	1437.2	-2136.5	23.5
POND_81_	1435.5	-2139.5	23.3
JULY_82_	1319.8	-1878.8	16.0
POND_82_	1318.9	-1882.2	15.6
JULY_89_	920.7	-2370.0	25.6
POND_89_	918.9	-2373.2	25.0
JULY_91_	686.3	-1854.5	5.6
POND_91_	685.0	-1857.1	5.2
JULY_94_	547.0	-2231.0	15.5
POND_94_	544.0	-2233.6	15.2

JULY_102_	593.4	-962.3	-7.0
POND_102_	592.0	-964.6	-7.7
JULY_110_	77.7	-1198.0	-12.1
POND_110_	77.4	-1200.0	-13.0
JULY_134_	-341.6	1102.0	-4.5
POND_134_	-343.2	1100.1	-5.7
JULY_146_	-552.0	2250.5	17.1
POND_146_	-551.7	2249.7	16.5
JULY_151_	-924.9	2387.2	28.7
POND_151_	-926.4	2388.5	28.3
JULY_159_	-1439.2	2153.9	30.1
POND_159_	-1443.3	2153.1	29.7
JULY_161_	406.2	-2606.3	18.7
POND_161_	402.9	-2608.3	18.2
JULY_166_	31.2	-2466.7	13.2
POND_166_	30.1	-2470.7	12.6
JULY_168_	-202.6	-1950.5	0.7
POND_168_	-205.3	-1953.3	0.5
JULY_182_	-437.4	-1434.3	-16.6
POND_182_	-439.5	-1436.6	-16.3
JULY_187_	-812.3	-1293.0	-17.6
POND_187_	-813.8	-1294.5	-18.2
JULY_203_	-1279.0	-264.4	-22.1
POND_203_	-1281.6	-262.8	-22.5
JULY_210_	-1115.3	747.1	-2.2
POND_210_	-1116.8	746.8	-2.7
JULY_217_	-1513.3	250.0	-8.0
POND_217_	-1516.3	252.2	-8.3
JULY_219_	-1744.3	767.4	1.9
POND_219_	-1747.8	769.7	1.4
JULY_222_	-1883.6	388.1	46.2
POND_222_	-1889.7	396.8	46.1
JULY_224_	-2120.9	903.8	41.2
POND_224_	-2126.4	912.1	41.8

JULY_226_	-1581.7	1777.9	20.4
POND_226_	-1584.5	1780.5	19.9
JULY_231_	-1953.2	1916.2	33.2
POND_231_	-1957.4	1917.5	33.1
JULY_233_	-1979.7	1280.1	14.5
POND_233_	-1983.5	1284.1	14.1
JULY_235_	-2209.1	1797.1	35.0
POND_235_	-2214.1	1800.9	35.1
JULY_238_	-2355.8	1419.5	46.5
POND_238_	-2359.4	1428.2	47.1

Table 4: Milagrito Combined Surveys

1	1	1	1	2461.10	-1669.20	70.60
2	1	2	1	2353.40	-1408.30	45.80
3	1	3	1	2235.60	-1151.80	37.70
4	1	4	1	2117.80	-895.40	29.90
5	2	1	1	2204.30	-1784.60	31.30
6	2	2	1	2088.30	-1529.10	16.60
7	2	3	1	1973.10	-1271.10	11.50
8	2	4	1	1860.90	-1014.70	5.50
9	3	1	1	1948.80	-1904.50	26.50
10	3	2	1	1836.10	-1648.00	16.40
11	3	3	1	1720.70	-1390.10	9.10
12	3	4	1	1601.60	-1131.40	4.60
13	4	1	1	1695.00	-2022.70	24.30
14	4	2	1	1578.20	-1765.60	18.20
15	4	3	1	1461.10	-1506.60	8.70
16	4	4	1	1343.50	-1248.70	1.80
17	1	5	1	2001.60	-638.00	25.40
18	1	6	1	1883.40	-381.00	23.70
19	1	7	1	1766.50	-123.80	21.70
20	1	8	1	1650.20	133.60	20.30
21	2	5	1	1742.00	-757.40	0.40
22	2	6	1	1622.80	-498.50	-3.60
23	2	7	1	1508.70	-240.60	-13.00
24	2	8	1	1391.80	17.30	-17.50
25	3	5	1	1484.00	-873.80	-1.90
26	3	6	1	1367.00	-615.90	-7.70
27	3	7	1	1250.30	-357.10	-13.40
28	3	8	1	1134.00	-99.00	-15.90
29	4	5	1	1225.70	-990.80	-3.20
30	4	6	1	1108.80	-733.20	-8.10
31	4	7	1	991.60	-476.20	-13.70
32	4	8	1	875.60	-217.00	-16.90
33	1	9	1	1536.50	392.20	19.90
34	1	10	1	1416.00	647.80	31.10
35	1	11	1	1298.40	905.30	30.00
36	1	12	1	1184.00	1163.80	28.70
37	2	9	1	1271.20	274.20	-19.00
38	2	10	1	1157.40	533.10	-19.40
39	2	11	1	1040.50	791.70	-19.20
40	2	12	1	922.40	1048.50	-15.40
41	3	9	1	1015.30	157.80	-21.30
42	3	10	1	898.40	415.70	-21.10
43	3	11	1	781.60	674.80	-20.00
44	3	12	1	664.90	932.00	-17.00
45	4	9	1	757.50	40.40	-21.20
46	4	10	1	641.20	298.60	-22.70
47	4	11	1	523.90	556.40	-19.60

48	4	12	1	407.20	814.90	-19.20
49	1	13	1	1067.20	1420.90	26.00
50	1	14	1	952.60	1679.30	30.30
51	1	15	1	833.40	1936.10	33.30
52	1	16	1	719.10	2194.50	32.50
53	2	13	1	805.90	1308.20	-16.60
54	2	14	1	690.70	1566.90	-9.60
55	2	15	1	571.80	1820.80	-2.60
56	2	16	1	456.70	2082.10	3.20
57	3	13	1	548.30	1189.10	-11.20
58	3	14	1	433.70	1449.10	-7.30
59	3	15	1	315.40	1706.30	-3.30
60	3	16	1	197.70	1964.50	2.30
61	4	13	1	289.90	1072.20	-13.00
62	4	14	1	174.30	1331.30	-7.80
63	4	15	1	56.80	1589.70	-3.10
64	4	16	1	-61.50	1848.10	1.20
65	1	17	1	602.60	2451.60	35.20
66	1	18	1	487.40	2709.10	40.90
67	1	19	1	365.50	2963.90	67.40
69	2	17	1	339.50	2339.30	11.80
70	2	18	1	224.20	2598.30	16.30
71	2	19	1	107.20	2849.70	33.40
73	3	17	1	81.50	2222.80	9.10
74	3	18	1	-33.40	2479.90	16.00
75	3	19	1	-151.90	2738.10	30.40
77	4	17	1	-177.30	2107.30	5.80
78	4	18	1	-293.20	2363.70	16.20
79	4	19	1	-407.30	2617.10	31.90
81	5	1	1	1435.50	-2139.50	23.30
82	5	2	1	1318.90	-1882.20	15.60
83	5	3	1	1200.00	-1622.10	8.40
84	5	4	1	1084.20	-1364.70	3.40
85	6	1	1	1175.00	-2251.30	25.50
86	6	2	1	1059.00	-1997.50	15.20
87	6	3	1	942.70	-1738.90	7.20
88	6	4	1	824.30	-1480.80	2.20
89	7	1	1	918.90	-2373.20	25.00
90	7	2	1	802.90	-2115.30	12.50
91	7	3	1	685.00	-1857.10	5.20
92	7	4	1	567.70	-1599.80	-2.10
93	8	1	1	661.60	-2491.50	22.70
94	8	2	1	544.00	-2233.60	15.20
95	8	3	1	427.10	-1975.30	4.00
96	8	4	1	311.20	-1717.80	-1.40
97	5	5	1	967.10	-1107.30	-2.00
98	5	6	1	848.60	-847.60	-9.90
99	5	7	1	733.10	-590.50	-15.50
100	5	8	1	616.80	-332.10	-21.30
101	6	5	1	707.40	-1223.20	-1.30
102	6	6	1	592.00	-964.60	-7.70

103	6	7	1	474.70	-705.80	-16.50
104	6	8	1	358.10	-446.70	-22.20
105	7	5	1	449.90	-1341.70	-5.80
106	7	6	1	333.70	-1081.70	-8.00
107	7	7	1	216.90	-824.50	-17.70
108	7	8	1	100.30	-566.70	-20.80
109	8	5	1	192.30	-1459.20	-6.40
110	8	6	1	77.40	-1200.00	-13.00
111	8	7	1	-41.40	-942.60	-18.40
112	8	8	1	-157.20	-685.40	-25.20
113	5	9	1	498.00	-74.30	-22.80
114	5	10	1	381.20	183.40	-23.90
115	5	11	1	264.60	442.10	-20.10
116	5	12	1	147.80	699.60	-18.10
117	6	9	1	240.30	-191.10	-25.00
118	6	10	1	123.40	67.30	-23.90
119	6	11	1	6.40	325.50	-23.70
120	6	12	1	-110.40	583.70	-18.40
121	7	9	1	-17.40	-308.80	-24.90
122	7	10	1	-135.10	-51.00	-26.00
123	7	11	1	-251.20	208.60	-21.30
124	7	12	1	-369.00	466.70	-15.90
125	8	9	1	-274.80	-427.80	-30.10
126	8	10	1	-392.70	-170.10	-26.20
127	8	11	1	-508.20	89.40	-23.10
128	8	12	1	-625.80	347.30	-17.60
129	5	13	1	31.10	958.10	-15.20
130	5	14	1	-84.30	1217.00	-9.00
131	5	15	1	-200.40	1473.90	0.90
132	5	16	1	-319.60	1732.90	2.70
133	6	13	1	-228.20	842.00	-9.90
134	6	14	1	-343.20	1100.10	-5.70
135	6	15	1	-459.50	1358.50	3.60
136	6	16	1	-578.30	1615.40	7.70
137	7	13	1	-484.40	724.70	-13.20
138	7	14	1	-601.50	982.80	-6.10
139	7	15	1	-717.10	1239.80	3.00
140	7	16	1	-835.60	1500.00	11.50
141	8	13	1	-742.20	605.70	-13.30
142	8	14	1	-859.50	864.90	-7.10
143	8	15	1	-975.10	1121.40	1.70
144	8	16	1	-1093.80	1380.00	10.20
145	5	17	1	-436.10	1991.60	9.20
146	5	18	1	-551.70	2249.70	16.50
147	5	19	1	-667.10	2503.50	29.50
149	6	17	1	-694.80	1872.00	14.70
150	6	18	1	-809.60	2130.40	19.70
151	6	19	1	-926.40	2388.50	28.30
153	7	17	1	-952.10	1757.70	15.10
154	7	18	1	-1068.20	2016.30	20.70
155	7	19	1	-1181.00	2271.70	31.40

157	8	17	1	-1209.70	1634.90	19.80
158	8	18	1	-1326.70	1896.10	18.40
159	8	19	1	-1443.30	2153.10	29.70
161	9	1	1	403.60	-2602.40	21.90
162	9	2	1	285.60	-2350.80	12.80
163	9	3	1	168.50	-2092.80	7.10
164	9	4	1	52.30	-1834.60	0.90
165	10	1	1	148.40	-2727.90	17.30
166	10	2	1	30.10	-2470.70	12.60
167	10	3	1	-86.60	-2208.10	10.90
168	10	4	1	-205.30	-1953.30	0.50
169	11	1	1	-110.80	-2836.80	25.00
170	11	2	1	-228.40	-2581.00	18.30
171	11	3	1	-346.60	-2328.90	6.80
172	11	4	1	-463.10	-2070.20	-1.00
173	12	1	1	-370.70	-2950.70	72.50
174	12	2	1	-489.10	-2695.50	52.70
175	12	3	1	-604.20	-2437.90	43.40
176	12	4	1	-722.20	-2180.80	40.40
177	9	5	1	-63.30	-1574.30	-1.40
178	9	6	1	-182.70	-1318.10	-17.00
179	9	7	1	-298.20	-1058.20	-18.80
180	9	8	1	-414.90	-801.10	-27.40
181	10	5	1	-322.70	-1695.60	-8.40
182	10	6	1	-439.50	-1436.60	-16.30
183	10	7	1	-556.20	-1178.30	-18.20
184	10	8	1	-671.40	-920.20	-25.60
185	11	5	1	-578.80	-1808.40	0.00
186	11	6	1	-697.60	-1553.00	-12.50
187	11	7	1	-813.00	-1294.20	-14.60
188	11	8	1	-930.50	-1035.90	-23.60
189	12	5	1	-837.10	-1923.40	38.00
190	12	6	1	-954.70	-1665.50	37.60
191	12	7	1	-1070.80	-1408.40	39.90
192	12	8	1	-1190.00	-1151.50	43.00
193	9	9	1	-534.10	-543.30	-28.20
194	9	10	1	-650.70	-285.50	-25.70
195	9	11	1	-766.80	-27.60	-21.10
196	9	12	1	-883.40	231.60	-16.90
197	10	9	1	-790.10	-662.70	-27.70
198	10	10	1	-908.90	-404.10	-30.60
199	10	11	1	-1023.80	-146.10	-25.00
200	10	12	1	-1140.70	112.90	-18.40
201	11	9	1	-1048.80	-777.80	-28.10
202	11	10	1	-1161.20	-523.10	-26.90
203	11	11	1	-1281.60	-262.80	-22.50
204	11	12	1	-1397.80	-5.20	-11.60
205	12	9	1	-1305.60	-894.30	42.20
206	12	10	1	-1423.50	-634.80	46.00
207	12	11	1	-1539.80	-378.30	47.70
208	12	12	1	-1654.40	-120.20	49.30

209	9	13	1	-1001.10	489.50	-12.50
210	9	14	1	-1116.80	746.80	-2.70
211	9	15	1	-1231.80	1005.50	4.30
212	9	16	1	-1350.50	1263.70	7.90
213	10	13	1	-1256.80	369.60	-8.70
214	10	14	1	-1374.70	628.10	-4.90
215	10	15	1	-1490.10	887.10	3.20
216	10	16	1	-1609.00	1143.80	10.70
217	11	13	1	-1516.30	252.20	-8.30
218	11	14	1	-1632.00	510.80	-3.90
219	11	15	1	-1743.50	768.00	3.60
220	11	16	1	-1864.80	1027.60	6.20
221	12	13	1	-1771.80	139.20	45.50
222	12	14	1	-1889.70	396.80	46.10
223	12	15	1	-2006.90	655.10	40.00
224	12	16	1	-2122.30	908.50	41.20
225	9	17	1	-1468.50	1521.00	14.50
226	9	18	1	-1584.50	1780.50	19.90
227	9	19	1	-1694.40	2037.40	30.00
229	10	17	1	-1721.70	1401.50	16.50
230	10	18	1	-1841.50	1659.70	18.90
231	10	19	1	-1957.40	1917.50	33.10
233	11	17	1	-1983.50	1284.10	14.10
234	11	18	1	-2098.80	1542.80	21.20
235	11	19	1	-2214.10	1800.90	35.10
237	12	17	1	-2242.70	1170.50	43.70
238	12	18	1	-2359.40	1428.20	47.10
239	12	19	1	-2476.30	1686.00	70.00

Table 5: Milagro Transit Survey

a1a1 2223.0 -1983.3 80.7

a1a18 27.1 -2996.1 79.8

a25a1 254.5 3081.4 84.7

a25a18 -2072.7 2079.9 86.9

x10y14 -814.6 -1288.0 -17.7

x10y15 -1068.4 -1407.7 39.0

x10y16 -1335.3 -1524.9 170.0

x10y17 -1589.2 -1640.9 312.8

x10y18 -1846.2 -1754.7 460.3

x10y3 2023.0 -4.8 156.6

x10y4 1764.9 -124.9 20.8

x10y5 1503.4 -239.3 -12.2

x11y10 97.6 -561.8 -19.8

x11y13 -673.1 -914.9 -25.3

x11y14 -930.1 -1030.6 -23.8

x11y15 -1186.2 -1151.4 41.6

x11y16 -1451.1 -1266.9 172.3

x11y2 2162.6 362.4 306.2

x11y3 1906.8 250.0 158.2

x11y4 1648.5 134.0 19.0

x11y5 1384.5 23.8 -17.9

x12y1 2300.7 737.2 457.0

x12y14 -1049.3 -775.2 -27.8

x12y15 -1303.0 -893.9 40.9

x12y16 -1565.7 -1007.4 175.7

x12y3 1792.1 509.5 157.8

x12y4 1533.3 391.4 18.5

x12y5 1269.7 274.9 -20.9

x12y7 754.0 42.3 -20.2

x13y14 -1161.3 -524.0 -29.6

x13y15 -1418.4 -635.4 43.7

x13y16 -1681.7 -749.0 177.3

x13y17 -1939.9 -868.4 315.0

x13y18 -2197.9 -981.1 459.4

x13y3 1673.2 766.3 163.4

x13y4 1413.4 646.6 28.8

x13y5 1155.0 534.3 -19.6

x14y10 -252.9 209.5 -20.7

x14y13 -1025.4 -142.8 -25.3

x14y14 -1277.1 -265.5 -22.9

x14y15 -1534.0 -377.7 44.4

x14y16 -1798.7 -491.4 180.1

x14y2 1814.5 1136.4 307.5

x14y3 1555.4 1024.2 163.5

x14y4 1295.9 904.8 26.1

x14y5 1037.6 789.9 -19.0

x15y1 1951.4 1510.6 458.0

x15y14 -1393.7 -8.5 -12.0

x15y15 -1648.3 -118.8 45.8

x15y16 -1913.4 -234.1 177.3

x15y3 1438.8 1281.5 163.9

x15y4 1180.9 1162.7 26.5

x15y5 920.6 1047.1 -18.0

x15y7 404.4 814.4 -18.7

x16y14 -1512.6 247.8 -8.1

x16y15 -1765.8 138.3 42.8

x16y16 -2031.3 25.1 178.5

x16y17 -2286.4 -93.1 321.0

x16y3 1321.9 1538.1 164.4

x16y4 1063.7 1420.0 23.2

x16y5 803.7 1304.1 -16.8

x17y10 -599.3 983.2 -6.2

x17y13 -1372.9 628.8 -4.8

x17y14 -1626.3 507.2 -4.6

x17y15 -1882.2 396.4 41.9

x17y16 -2145.3 283.0 178.7

x17y17 -2405.0 166.5 317.1

x17y18 -2662.1 52.6 465.3

x17y2 1466.8 1911.3 306.0

x17y3 1208.7 1798.9 163.2

x17y4 948.9 1678.9 27.2

x18y1 1607.8 2288.4 445.9

x18y14 -1743.6 764.0 1.3

x18y15 -2000.3 652.9 36.9

x18y16 -2263.6 540.5 174.0

x18y3 1093.6 2057.0 158.3

x18y4 830.7 1934.5 30.5

x18y7 56.9 1588.9 -3.1

x19y14 -1860.8 1021.0 6.5

x19y15 -2119.3 908.5 38.2

x19y16 -2386.9 794.1 168.2

x19y3 979.6 2314.9 153.7

x19y4 715.1 2193.3 29.2

x1y11 1009.6 -3256.7 413.6

x1y15 -20.4 -3729.5 421.7

x1y17 -543.3 -3946.0 446.7

x1y18 -769.6 -4068.2 492.0

x1y2 3332.6 -2211.4 437.2

x1y5 2561.2 -2565.2 417.1

x1y8 1782.6 -2905.3 409.8

x20y10 -951.9 1755.5 15.4

x20y13 -1725.0 1402.6 13.0

x20y14 -1977.6 1278.0 13.4

x20y15 -2243.0 1165.6 43.4

x20y16 -2505.1 1053.2 167.5

x20y17 -2758.4 939.8 317.0

x20y18 -3014.0 825.2 464.0

x20y2 1121.4 2686.6 297.1

x20y3 864.4 2572.6 153.8

x20y4 597.2 2450.0 32.5

x21y1 1263.9 3063.0 446.9

x21y14 -2094.2 1537.6 21.7

x21y15 -2352.7 1425.7 44.9

x21y16 -2619.0 1311.3 176.8

x21y3 747.9 2829.9 165.1

x21y4 483.2 2709.5 37.5

x21y7 -293.9 2358.4 15.2

x22y14 -2209.1 1790.6 34.2

x22y15 -2468.7 1681.5 66.5

x22y16 -2736.1 1568.3 186.7

x22y3 637.5 3088.7 177.3

x22y4 367.9 2965.7 65.9

x22y5 107.7 2849.3 29.9

x23y12 -1807.5 2297.9 143.1

x23y14 -2323.6 2059.2 142.4

x23y15 -2578.6 1941.1 155.8

x23y16 -2835.5 1833.3 207.4

x23y17 -3103.1 1714.3 330.7

x23y18 -3368.7 1599.4 461.8

x23y2 784.1 3465.6 326.6

x23y2 785.4 3465.9 325.6

x23y3 518.1 3347.9 203.1

x23y3 518.7 3344.1 201.5

x23y4 257.2 3226.8 158.7

x23y6 -261.6 2998.3 152.8

x23y9 -1035.9 2648.7 144.8

x24y1 915.5 3836.4 469.4

x25y1 782.7 4088.6 492.9

x25y12 -2045.7 2810.6 431.1

x25y14 -2562.9 2568.3 430.4

x25y18 -3577.7 2121.0 497.7

x25y3 277.1 3864.3 436.9

x25y6 -497.8 3511.6 436.8

x25y9 -1270.2 3164.4 429.6

x3y1 3363.8 -1581.5 475.5

x3y10 1034.7 -2626.7 122.5

x3y13 263.4 -2980.7 123.6

x3y16 -508.7 -3322.4 209.2

x3y4 2580.8 -1926.9 151.8

x3y7 1811.6 -2280.0 123.0

x4y15 -367.5 -2951.2 72.4

x4y16 -634.4 -3070.6 189.6

x4y17 -890.9 -3188.8 333.9

x4y18 -1150.1 -3308.1 470.8

x4y4 2462.7 -1666.8 71.1

x5y10 797.8 -2105.3 13.9

x5y13 25.3 -2460.0 13.5

x5y14 -232.5 -2575.7 16.3

x5y15 -487.5 -2695.6 52.5

x5y16 -749.3 -2810.9 184.5

x5y3 2612.3 -1289.4 176.5

x5y4 2351.2 -1410.5 45.4

x5y5 2086.6 -1526.4 15.8

x6y1 3009.5 -807.4 457.2

x6y14 -349.7 -2319.2 7.8

x6y15 -601.6 -2438.1 42.7

x6y16 -867.4 -2552.8 171.0

x6y4 2233.1 -1152.7 36.8

x6y5 1971.5 -1268.2 11.0

x6y7 1456.8 -1501.6 10.2

x7y14 -465.6 -2060.9 -0.5

x7y15 -718.7 -2180.6 39.5

x7y16 -984.4 -2295.8 171.4

x7y17 -1239.2 -2416.3 315.5

x7y18 -1493.0 -2527.9 465.4

x7y4 2115.3 -896.9 29.2

x8y10 446.5 -1335.6 -3.5

x8y13 -323.7 -1688.3 -7.3

x8y14 -580.8 -1803.5 -2.4

x8y15 -836.0 -1923.0 37.2

x8y16 -1099.7 -2039.1 166.1

x8y3 2258.2 -519.2 156.9

x8y4 1998.3 -638.4 24.8

x9y1 2651.8 -35.4 454.4

x9y14 -697.7 -1545.1 -12.5

x9y15 -952.0 -1665.0 36.5

x9y16 -1217.7 -1781.5 164.6

x9y4 1880.8 -381.7 22.7

x9y5 1622.1 -496.3 -4.5

x9y7 1106.4 -730.4 -7.2

Table 6: Comparison of Milagro Transit and Photographic Surveys

	measured			calculated			diff.			
								ABS. diff.		
point	x	y	z	x	y	z	Dx	Dy	Dz	total
								|Dx|	|Dy|	|Dz|
a1a1	2223	-1983.3	80.7	2223.7	-1985.3	82.6	-0.7	2.0	-1.9	2.8
								0.7	2.0	1.9
a1a18	27.1	-2996.1	79.8	32.0	-2993.1	84.0	-4.9	-3.0	-4.2	7.1
								4.9	3.0	4.2
a25a1	254.5	3081.4	84.7	252.0	3083.0	89.0	2.5	-1.6	-4.3	5.2
								2.5	1.6	4.3
a25a18	-2072.	2079.9	86.9	-2071.	2079.7	90.3	-1.5	0.2	-3.4	3.7
								1.5	0.2	3.4
x10y17	-1589.	-1640.9	312.8	-1584.	-1639.2	315.6	-4.6	-1.7	-2.8	5.6
								4.6	1.7	2.8
x10y18	-1846.	-1754.7	460.3	-1845.	-1756.7	458.7	-0.6	2.0	1.6	2.6
								0.6	2.0	1.6
x11y10	97.6	-561.8	-19.8	99.7	-561.8	-20.8	-2.1	0.0	1.0	2.3
								2.1	0.0	1.0
x11y2	2162.6	362.4	306.2	2161.3	364.6	306.3	1.3	-2.2	-0.1	2.6
								1.3	2.2	0.1
x12y1	2300.7	737.2	457	2298.1	737.6	456.2	2.6	-0.4	0.8	2.7
								2.6	0.4	0.8
x12y7	754	42.3	-20.2	754.5	41.2	-20.8	-0.5	1.1	0.6	1.3
								0.5	1.1	0.6
x13y17	-1939.	-868.4	315	-1939.	-866.7	316.1	-0.3	-1.7	-1.1	2.0
								0.3	1.7	1.1
x13y18	-2197.	-981.1	459.4	-2193.	-980.5	459.0	-4.6	-0.6	0.4	4.7
								4.6	0.6	0.4
x14y10	-252.9	209.5	-20.7	-251.5	208.6	-21.3	-1.4	0.9	0.6	1.8
								1.4	0.9	0.6
x14y2	1814.5	1136.4	307.5	1813.8	1136.9	306.7	0.7	-0.5	0.8	1.2
								0.7	0.5	0.8
x15y1	1951.4	1510.6	458	1951.6	1508.4	458.1	-0.2	2.2	-0.1	2.2
								0.2	2.2	0.1
x15y7	404.4	814.4	-18.7	405.1	812.5	-19.0	-0.7	1.9	0.3	2.0
								0.7	1.9	0.3
x16y17	-2286.	-93.1	321	-2285.	-93.0	321.1	-0.7	-0.1	-0.1	0.7
								0.7	0.1	0.1
x17y10	-599.3	983.2	-6.2	-599.3	983.2	-6.3	0.0	0.0	0.1	0.1
								0.0	0.0	0.1
x17y17	-2405	166.5	317.1	-2401.	164.4	316.0	-3.1	2.1	1.1	3.9
								3.1	2.1	1.1
x17y18	-2662.	52.6	465.3	-2659.	51.2	464.1	-2.4	1.4	1.2	3.0
								2.4	1.4	1.2
x17y2	1466.8	1911.3	306	1466.5	1910.2	306.4	0.3	1.1	-0.4	1.2
								0.3	1.1	0.4
x18y1	1607.8	2288.4	445.9	1607.0	2285.1	444.4	0.8	3.3	1.5	3.7

								0.8	3.3	1.5
x18y7	56.9	1588.9	-3.1	56.9	1586.9	-3.6	0.0	2.0	0.5	2.1
								0.0	2.0	0.5
x1y11	1009.6	-3256.7	413.6	1012.5	-3256.8	412.4	-2.9	0.1	1.2	3.1
								2.9	0.1	1.2
x1y15	-20.4	-3729.5	421.7	-13.7	-3728.6	420.0	-6.7	-0.9	1.7	7.0
								6.7	0.9	1.7
x1y17	-543.3	-3946	446.7	-528.5	-3951.1	443.2	-14.8	5.1	3.5	16.0
								14.8	5.1	3.5
x1y18	-769.6	-4068.2	492	-790.5	-4047.7	493.2	20.9	-20.5	-1.2	29.3
								20.9	20.5	1.2
x1y2	3332.6	-2211.4	437.2	3333.0	-2209.7	434.0	-0.4	-1.7	3.2	3.6
								0.4	1.7	3.2
x1y5	2561.2	-2565.2	417.1	2561.1	-2566.0	417.1	0.1	0.8	0.0	0.8
								0.1	0.8	0.0
x1y8	1782.6	-2905.3	409.8	1784.3	-2906.3	409.1	-1.7	1.0	0.7	2.1
								1.7	1.0	0.7
x20y10	-951.9	1755.5	15.4	-952.7	1754.2	14.5	0.8	1.3	0.9	1.8
								0.8	1.3	0.9
x20y17	-2758.	939.8	317	-2757.	937.7	315.5	-1.3	2.1	1.5	2.9
								1.3	2.1	1.5
x20y18	-3014	825.2	464	-3020.	825.6	462.2	6.3	-0.4	1.8	6.6
								6.3	0.4	1.8
x20y2	1121.4	2686.6	297.1	1123.8	2688.2	297.9	-2.4	-1.6	-0.8	3.0
								2.4	1.6	0.8
x21y1	1263.9	3063	446.9	1262.7	3065.0	447.1	1.2	-2.0	-0.2	2.3
								1.2	2.0	0.2
x21y7	-293.9	2358.4	15.2	-294.1	2359.0	15.1	0.2	-0.6	0.1	0.6
								0.2	0.6	0.1
x23y12	-1807.	2297.9	143.1	-1809.	2295.9	141.7	2.2	2.0	1.4	3.3
								2.2	2.0	1.4
x23y17	-3103.	1714.3	330.7	-3098.	1710.3	329.6	-4.8	4.0	1.1	6.3
								4.8	4.0	1.1
x23y18	-3368.	1599.4	461.8	-3363.	1595.3	459.6	-5.5	4.1	2.2	7.2
								5.5	4.1	2.2
x23y2	784.8	3465.7	326.1	784.1	3463.9	327.7	0.7	1.8	-1.6	2.5
								0.7	1.8	1.6
x23y6	-261.6	2998.3	152.8	-262.1	2998.2	153.1	0.5	0.1	-0.3	0.6
								0.5	0.1	0.3
x23y9	-1035.	2648.7	144.8	-1036.	2649.5	143.9	0.3	-0.8	0.9	1.2
								0.3	0.8	0.9
x24y1	915.5	3836.4	469.4	915.2	3836.3	470.0	0.3	0.1	-0.6	0.7
								0.3	0.1	0.6
x25y1	782.7	4088.6	492.9	783.9	4086.7	491.7	-1.2	1.9	1.2	2.5
								1.2	1.9	1.2
x25y12	-2045.	2810.6	431.1	-2040.	2805.6	429.8	-4.9	5.0	1.3	7.1
								4.9	5.0	1.3
x25y14	-2562.	2568.3	430.4	-2555.	2566.3	429.8	-7.2	2.0	0.6	7.5
								7.2	2.0	0.6
x25y18	-3577.	2121	497.7	-3580.	2120.8	496.5	2.8	0.2	1.2	3.1
								2.8	0.2	1.2

x25y3	277.1	3864.3	436.9	276.3	3866.6	435.8	0.8	-2.3	1.1	2.7
								0.8	2.3	1.1
x25y6	-497.8	3511.6	436.8	-495.2	3508.9	435.6	-2.6	2.7	1.2	3.9
								2.6	2.7	1.2
x25y9	-1270.	3164.4	429.6	-1269.	3163.4	428.0	-0.7	1.0	1.6	2.0
								0.7	1.0	1.6
x3y1	3363.8	-1581.5	475.5	3365.0	-1580.6	476.2	-1.2	-0.9	-0.7	1.7
								1.2	0.9	0.7
x3y10	1034.7	-2626.7	122.5	1037.4	-2626.0	122.9	-2.7	-0.7	-0.4	2.8
								2.7	0.7	0.4
x3y7	1811.6	-2280	123	1811.4	-2279.5	122.4	0.2	-0.5	0.6	0.8
								0.2	0.5	0.6
x4y17	-890.9	-3188.8	333.9	-886.0	-3186.5	332.9	-4.9	-2.3	1.0	5.5
								4.9	2.3	1.0
x4y18	-1150.	-3308.1	470.8	-1148.	-3312.0	471.0	-1.8	3.9	-0.2	4.3
								1.8	3.9	0.2
x5y10	797.8	-2105.3	13.9	798.8	-2103.8	12.5	-1.0	-1.5	1.4	2.3
								1.0	1.5	1.4
x6y1	3009.5	-807.4	457.2	3007.2	-806.5	455.4	2.3	-0.9	1.8	3.1
								2.3	0.9	1.8
x6y7	1456.8	-1501.6	10.2	1457.7	-1502.6	8.6	-0.9	1.0	1.6	2.1
								0.9	1.0	1.6
x7y17	-1239.	-2416.3	315.5	-1236.	-2415.6	315.5	-3.2	-0.7	0.0	3.3
								3.2	0.7	0.0
x7y18	-1493	-2527.9	465.4	-1490.	-2531.0	464.4	-2.8	3.1	1.0	4.3
								2.8	3.1	1.0
x8y10	446.5	-1335.6	-3.5	448.1	-1334.2	-4.5	-1.6	-1.4	1.0	2.3
								1.6	1.4	1.0
x8y3	2258.2	-519.2	156.9	2254.4	-519.2	165.2	3.8	0.0	-8.3	9.1
								3.8	0.0	8.3
x9y1	2651.8	-35.4	454.4	2653.3	-37.7	453.7	-1.5	2.3	0.7	2.8
								1.5	2.3	0.7
x9y7	1106.4	-730.4	-7.2	1107.3	-731.1	-7.3	-0.9	0.7	0.1	1.1
								0.9	0.7	0.1
						ave =	-0.9	0.2	0.2	3.8
								2.5	1.8	1.3
	set 12.1					st. dev	4.1	3.2	1.8	4.1
								3.3	2.6	1.3

Table 7: Transit and Photographic Surveys Combined.

x 1y 1	3577.4	-2103.5	490.0		
x 1y 2	3332.6	-2211.4	437.2	1	itest=1 for transit survey
x 1y 3	3074.8	-2334.2	422.9		
x 1y 4	2817.7	-2447.0	419.9		
x 1y 5	2561.2	-2565.2	417.1	1	
x 1y 6	2302.2	-2681.9	415.2		
x 1y 7	2044.7	-2797.0	411.4		
x 1y 8	1782.6	-2905.3	409.8	1	
x 1y 9	1525.4	-3021.8	409.4		
x 1y10	1269.6	-3137.7	411.2		
x 1y11	1009.6	-3256.7	413.6	1	
x 1y12	758.4	-3372.9	413.4		
x 1y13	494.1	-3493.7	411.8		
x 1y14	243.0	-3611.4	415.4		
x 1y15	-20.4	-3729.5	421.7	1	
x 1y16	-273.6	-3840.7	429.9		
x 1y17	-543.3	-3946.0	446.7	1	
x 1y18	-769.6	-4068.2	492.0	1	
x 2y 1	3471.4	-1842.7	481.3		
x 2y 2	3207.1	-1954.8	356.3		
x 2y 3	2953.0	-2070.6	292.9		
x 2y 4	2697.9	-2191.2	277.6		
x 2y 5	2442.7	-2310.0	272.6		
x 2y 6	2186.6	-2426.1	266.7		
x 2y 7	1927.9	-2540.7	261.2		
x 2y 8	1669.0	-2653.4	258.7		
x 2y 9	1411.1	-2767.7	258.8		
x 2y10	1153.0	-2885.2	259.6		
x 2y11	900.1	-3003.0	260.2		
x 2y12	637.7	-3119.8	261.3		
x 2y13	374.3	-3238.5	260.6		
x 2y14	126.5	-3353.7	267.8		
x 2y15	-131.2	-3471.4	275.6		
x 2y16	-387.4	-3582.0	292.4		
x 2y17	-634.4	-3695.8	347.6		
x 2y18	-887.6	-3825.2	484.0		
x 3y 1	3363.8	-1581.5	475.5	1	
x 3y 2	3102.1	-1693.0	337.1		
x 3y 3	2834.8	-1807.4	213.9		
x 3y 4	2580.8	-1926.9	151.8	1	
x 3y 5	2321.8	-2048.8	136.6		
x 3y 6	2067.2	-2166.1	129.9		
x 3y 7	1811.6	-2280.0	123.0	1	
x 3y 8	1551.7	-2392.6	123.1		
x 3y 9	1293.3	-2508.4	122.5		
x 3y10	1034.7	-2626.7	122.5	1	

```
x 3y11   780.6 -2747.6   119.4
x 3y12   523.6 -2864.2   120.5
x 3y13   263.4 -2980.7   123.6 1
x 3y14    30.5 -3093.5   128.4
x 3y15  -246.4 -3211.6   140.9
x 3y16  -508.7 -3322.4   209.2 1
x 3y17  -756.3 -3449.1   338.4
x 3y18 -1013.2 -3562.7   469.2
x 4y 1  3251.7 -1325.6   473.5
x 4y 2  2989.1 -1432.5   327.3
x 4y 3  2727.5 -1552.6   194.2
x 4y 4  2462.7 -1666.8    71.1 1
x 4y15  -367.5 -2951.2    72.4 1
x 4y16  -634.4 -3070.6   189.6 1
x 4y17  -890.9 -3188.8   333.9 1
x 4y18 -1150.1 -3308.1   470.8 1
x 5y 1  3130.1 -1066.7   463.9
x 5y 2  2872.1 -1179.4   316.4
x 5y 3  2612.3 -1289.4   176.5 1
x 5y 4  2351.2 -1410.5    45.4 1
x 5y15  -487.5 -2695.6    52.5 1
x 5y16  -749.3 -2810.9   184.5 1
x 5y17 -1002.8 -2929.7   328.2
x 5y18 -1260.9 -3050.2   467.8
x 6y 1  3009.5  -807.4   457.2 1
x 6y 2  2752.9  -922.4   313.1
x 6y 3  2493.1 -1033.2   167.5
x 6y 4  2233.1 -1152.7    36.8 1
x 6y15  -601.6 -2438.1    42.7 1
x 6y16  -867.4 -2552.8   171.0 1
x 6y17 -1118.2 -2672.1   318.7
x 6y18 -1372.6 -2789.1   464.5
x 7y 1  2889.9  -550.8   456.0
x 7y 2  2632.4  -664.0   307.7
x 7y 3  2373.2  -777.9   165.0
x 7y 4  2115.3  -896.9    29.2 1
x 7y15  -718.7 -2180.6    39.5 1
x 7y16  -984.4 -2295.8   171.4 1
x 7y17 -1239.2 -2416.3   315.5 1
x 7y18 -1493.0 -2527.9   465.4 1
x 8y 1  2772.3  -295.2   454.5
x 8y 2  2514.9  -406.9   305.9
x 8y 3  2258.2  -519.2   156.9 1
x 8y 4  1998.3  -638.4    24.8 1
x 8y15  -836.0 -1923.0    37.2 1
x 8y16 -1099.7 -2039.1   166.1 1
x 8y17 -1351.0 -2154.2   316.5
x 8y18 -1605.6 -2271.8   463.2
x 9y 1  2651.8   -35.4   454.4 1
x 9y 2  2397.6  -149.7   305.6
x 9y 3  2137.3  -264.0   156.5        bridged: z replaced by hand -6.3cm
```

x 9y 4	1880.8	-381.7	22.7	1
x 9y15	-952.0	-1665.0	36.5	1
x 9y16	-1217.7	-1781.5	164.6	1
x 9y17	-1471.0	-1900.3	312.0	
x 9y18	-1726.0	-2013.6	461.1	
x10y 1	2532.6	220.5	456.0	
x10y 2	2279.1	107.5	306.2	
x10y 3	2023.0	-4.8	156.6	1
x10y 4	1764.9	-124.9	20.8	1
x10y15	-1068.4	-1407.7	39.0	1
x10y16	-1335.3	-1524.9	170.0	1
x10y17	-1589.2	-1640.9	312.8	1
x10y18	-1846.2	-1754.7	460.3	1
x11y 1	2416.9	478.2	456.3	
x11y 2	2162.6	362.4	306.2	1
x11y 3	1906.8	250.0	158.2	1
x11y 4	1648.5	134.0	19.0	1
x11y15	-1186.2	-1151.4	41.6	1
x11y16	-1451.1	-1266.9	172.3	1
x11y17	-1708.5	-1383.9	316.6	
x11y18	-1965.9	-1498.8	461.7	
x12y 1	2300.7	737.2	457.0	1
x12y 2	2047.7	620.1	307.6	
x12y 3	1792.1	509.5	157.8	1
x12y 4	1533.3	391.4	18.5	1
x12y15	-1303.0	-893.9	40.9	1
x12y16	-1565.7	-1007.4	175.7	1
x12y17	-1825.0	-1126.8	317.4	
x12y18	-2082.5	-1241.9	460.3	
x13y 1	2185.0	992.2	456.9	
x13y 2	1930.0	878.4	308.4	
x13y 3	1673.2	766.3	163.4	1
x13y 4	1413.4	646.6	28.8	1
x13y15	-1418.4	-635.4	43.7	1
x13y16	-1681.7	-749.0	177.3	1
x13y17	-1939.9	-868.4	315.0	1
x13y18	-2197.9	-981.1	459.4	1
x14y 1	2068.9	1251.9	453.5	
x14y 2	1814.5	1136.4	307.5	1
x14y 3	1555.4	1024.2	163.5	1
x14y 4	1295.9	904.8	26.1	1
x14y15	-1534.0	-377.7	44.4	1
x14y16	-1798.7	-491.4	180.1	1
x14y17	-2056.3	-609.6	321.5	
x14y18	-2314.8	-723.5	464.0	
x15y 1	1951.4	1510.6	458.0	1
x15y 2	1698.4	1394.4	310.3	
x15y 3	1438.8	1281.5	163.9	1
x15y 4	1180.9	1162.7	26.5	1
x15y15	-1648.3	-118.8	45.8	1
x15y16	-1913.4	-234.1	177.3	1

x15y17	-2173.2	-350.6	320.2	
x15y18	-2429.1	-465.1	464.1	
x16y 1	1838.2	1768.3	454.0	
x16y 2	1581.1	1652.5	308.1	
x16y 3	1321.9	1538.1	164.4	1
x16y 4	1063.7	1420.0	23.2	1
x16y15	-1765.8	138.3	42.8	1
x16y16	-2031.3	25.1	178.5	1
x16y17	-2286.4	-93.1	321.0	1
x16y18	-2546.8	-206.8	464.3	
x17y 1	1723.3	2029.5	453.4	
x17y 2	1466.8	1911.3	306.0	1
x17y 3	1208.7	1798.9	163.2	1
x17y 4	948.9	1678.9	27.2	1
x17y15	-1882.2	396.4	41.9	1
x17y16	-2145.3	283.0	178.7	1
x17y17	-2405.0	166.5	317.1	1
x17y18	-2662.1	52.6	465.3	1
x18y 1	1607.8	2288.4	445.9	1
x18y 2	1352.9	2168.5	298.2	
x18y 3	1093.6	2057.0	158.3	1
x18y 4	830.7	1934.5	30.5	1
x18y15	-2000.3	652.9	36.9	1
x18y16	-2263.6	540.5	174.0	1
x18y17	-2521.5	423.8	319.0	
x18y18	-2781.9	311.7	462.9	
x19y 1	1490.8	2546.6	445.9	
x19y 2	1239.1	2427.6	299.2	
x19y 3	979.6	2314.9	153.7	1
x19y 4	715.1	2193.3	29.2	1
x19y15	-2119.3	908.5	38.2	1
x19y16	-2386.9	794.1	168.2	1
x19y17	-2643.3	681.7	315.8	
x19y18	-2903.5	570.1	461.3	
x20y 1	1375.2	2803.8	444.3	
x20y 2	1121.4	2686.6	297.1	1
x20y 3	864.4	2572.6	153.8	1
x20y 4	597.2	2450.0	32.5	1
x20y15	-2243.0	1165.6	43.4	1
x20y16	-2505.1	1053.2	167.5	1
x20y17	-2758.4	939.8	317.0	1
x20y18	-3014.0	825.2	464.0	1
x21y 1	1263.9	3063.0	446.9	1
x21y 2	1009.9	2942.5	302.5	
x21y 3	747.9	2829.9	165.1	1
x21y 4	483.2	2709.5	37.5	1
x21y15	-2352.7	1425.7	44.9	1
x21y16	-2619.0	1311.3	176.8	1
x21y17	-2876.8	1196.0	316.0	
x21y18	-3138.4	1083.8	462.0	
x22y 1	1155.2	3321.7	454.2	

x22y 2	900.4	3207.1	308.7		
x22y 3	637.5	3088.7	177.3	1	
x22y 4	367.9	2965.7	65.9	1	
x22y15	-2468.7	1681.5	66.5	1	
x22y16	-2736.1	1568.3	186.7	1	
x22y17	-2998.5	1449.4	319.6		
x22y18	-3258.0	1340.3	460.6		
x23y 1	1044.3	3585.4	462.6		
x23y 2	784.8	3465.7	326.1	1	
x23y 3	518.1	3347.9	203.1	1	
x23y 4	257.2	3226.8	158.7	1	
x23y 5	-6.0	3113.8	152.5		
x23y 6	-261.6	2998.3	152.8	1	
x23y 7	-519.6	2880.6	151.0		
x23y 8	-777.2	2763.1	148.3		
x23y 9	-1035.9	2648.7	144.8	1	
x23y10	-1292.2	2528.1	142.3		
x23y11	-1552.0	2415.3	139.9		
x23y12	-1807.5	2297.9	143.1	1	
x23y13	-2067.7	2181.5	140.4		
x23y14	-2323.6	2059.2	142.4	1	
x23y15	-2578.6	1941.1	155.8	1	
x23y16	-2835.5	1833.3	207.4	1	
x23y17	-3103.1	1714.3	330.7	1	
x23y18	-3368.7	1599.4	461.8	1	
x24y 1	915.5	3836.4	469.4	1	
x24y 2	649.0	3713.9	344.2		
x24y 3	397.7	3602.4	301.5		
x24y 4	135.8	3490.1	291.2		
x24y 5	-124.7	3376.3	294.0		
x24y 6	-377.8	3255.3	293.0		
x24y 7	-634.5	3138.5	288.4		
x24y 8	-893.1	3020.7	287.8		
x24y 9	-1152.1	2907.1	284.9		
x24y10	-1410.4	2788.5	283.6		
x24y11	-1668.0	2671.4	281.5		
x24y12	-1924.9	2554.9	281.9		
x24y13	-2183.1	2438.1	284.8		
x24y14	0.0	0.0	282.9		missing fr survey: added by hand
x24y15	0.0	0.0	294.3		missing fr survey: added by hand
x24y16	-2953.1	2084.7	302.6		
x24y17	-3212.2	1982.7	354.7		
x24y18	-3477.0	1857.2	475.9		
x25y 1	782.7	4088.6	492.9	1	
x25y 2	539.4	3971.3	443.8		
x25y 3	277.1	3864.3	436.9	1	
x25y 4	18.7	3747.7	432.5		
x25y 5	-236.8	3630.3	436.1		
x25y 6	-497.8	3511.6	436.8	1	
x25y 7	-753.2	3394.1	432.4		
x25y 8	-1012.7	3278.9	429.6		

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x25y 9 -1270.2  3164.4   429.6 1
x25y10 -1528.1  3044.2   424.8
x25y11 -1784.6  2927.9   427.0
x25y12 -2045.7  2810.6   431.1 1
x25y13 -2301.7  2692.0   430.5
x25y14 -2562.9  2568.3   430.4 1
x25y15 -2821.5  2461.3   429.0
x25y16 -3076.0  2343.7   437.6
x25y17 -3328.5  2212.7   447.6
x25y18 -3577.7  2121.0   497.7 1    slope:this line and above; bottom below
x 4y 5     0.0     0.0    28.4       missing from survey: added by hand
x 4y 6     0.0     0.0    26.5       missing from survey: added by hand
x 4y 7  1690.3 -2019.7    26.5
x 4y 8  1431.9 -2130.4    24.0
x 4y 9  1172.7 -2245.4    25.4
x 4y10   914.9 -2363.7    25.9
x 4y11   654.9 -2471.5    22.5
x 4y12   401.1 -2596.6    19.7
x 4y13   146.1 -2716.2    23.0
x 4y14     0.0     0.0    27.4       missing from survey, added by hand
x 5y 5  2086.6 -1526.4    15.8
x 5y 6  1825.6 -1640.3    16.4
x 5y 7  1570.3 -1757.7    18.6
x 5y 8  1313.1 -1871.9    16.5
x 5y 9  1055.3 -1988.3    15.9
x 5y10   797.8 -2105.3    13.9
x 5y11   541.2 -2223.4    15.5
x 5y12   282.1 -2339.9    12.8
x 5y13    25.3 -2460.0    13.5
x 5y14  -232.5 -2575.7    16.3
x 6y 5  1971.5 -1268.2    11.0
x 6y 6  1711.6 -1383.6     9.4
x 6y 7  1456.8 -1501.6    10.2
x 6y 8  1198.4 -1618.7     7.9
x 6y 9   939.2 -1731.9     8.3
x 6y10   683.1 -1848.4     6.0
x 6y11   424.1 -1967.9     4.6
x 6y12   168.1 -2082.9     7.2
x 6y13   -87.5 -2202.1     7.8
x 6y14  -349.7 -2319.2     7.8
x 7y 5  1851.2 -1010.7    11.4
x 7y 6  1595.0 -1127.1     4.8
x 7y 7  1338.6 -1243.5     2.5
x 7y 8  1080.4 -1359.2     4.4
x 7y 9   822.1 -1474.7     3.4
x 7y10   564.3 -1591.6    -1.5
x 7y11   308.4 -1710.1    -0.4
x 7y12    48.4 -1826.2     1.4
x 7y13  -203.9 -1944.5     0.2
x 7y14  -465.6 -2060.9    -0.5
x 8y 5  1733.2  -751.0    10.1
```

x 8y 6	1478.1	-869.8	-1.7
x 8y 7	1221.4	-987.0	-1.7
x 8y 8	962.8	-1100.8	-1.1
x 8y 9	705.2	-1217.3	-0.2
x 8y10	446.5	-1335.6	-3.5
x 8y11	191.0	-1452.1	-5.8
x 8y12	-67.9	-1567.6	-4.5
x 8y13	-323.7	-1688.3	-7.3
x 8y14	-580.8	-1803.5	-2.4
x 9y 5	1622.1	-496.3	-4.5
x 9y 6	1363.5	-612.0	-6.9
x 9y 7	1106.4	-730.4	-7.2
x 9y 8	846.8	-844.5	-10.6
x 9y 9	587.9	-958.7	-6.3
x 9y10	332.6	-1076.8	-7.1
x 9y11	74.6	-1194.2	-12.6
x 9y12	-183.1	-1309.2	-16.7
x 9y13	-436.7	-1430.3	-16.2
x 9y14	-697.7	-1545.1	-12.5
x10y 5	1503.4	-239.3	-12.2
x10y 6	1244.7	-356.8	-12.7
x10y 7	988.0	-472.7	-13.0
x10y 8	728.8	-586.8	-14.7
x10y 9	472.5	-702.9	-15.1
x10y10	214.7	-821.0	-17.2
x10y11	-43.5	-938.1	-17.6
x10y12	-300.9	-1053.3	-21.9
x10y13	-554.0	-1173.2	-15.9
x10y14	-814.6	-1288.0	-17.7
x11y 5	1384.5	23.8	-17.9
x11y 6	1127.3	-99.3	-15.5
x11y 7	873.1	-215.2	-16.0
x11y 8	615.7	-329.2	-20.5
x11y 9	356.3	-445.5	-21.3
x11y10	97.6	-561.8	-19.8
x11y11	-157.5	-676.8	-24.6
x11y12	-416.4	-795.4	-27.1
x11y13	-673.1	-914.9	-25.3
x11y14	-930.1	-1030.6	-23.8
x12y 5	1269.7	274.9	-20.9
x12y 6	1011.0	158.3	-20.4
x12y 7	754.0	42.3	-20.2
x12y 8	496.3	-71.8	-24.5
x12y 9	238.7	-188.6	-24.2
x12y10	-19.7	-305.2	-24.3
x12y11	-275.7	-420.9	-29.2
x12y12	-534.6	-539.8	-27.9
x12y13	-787.8	-658.3	-20.2
x12y14	-1049.3	-775.2	-27.8
x13y 5	1155.0	534.3	-19.6
x13y 6	895.0	413.7	-20.8

x13y 7	637.0	298.0	-22.0
x13y 8	376.5	182.8	-24.2
x13y 9	121.0	67.0	-21.9
x13y10	-134.8	-48.1	-22.5
x13y11	-392.0	-167.9	-25.8
x13y12	-650.6	-282.7	-25.2
x13y13	-904.3	-400.7	-13.4
x13y14	-1161.3	-524.0	-29.6
x14y 5	1037.6	789.9	-19.0
x14y 6	778.6	672.0	-19.9
x14y 7	521.4	555.0	-19.5
x14y 8	263.5	442.3	-19.7
x14y 9	6.0	326.7	-23.3
x14y10	-252.9	209.5	-20.7
x14y11	-509.2	90.3	-22.7
x14y12	-766.0	-24.6	-20.9
x14y13	-1025.4	-142.8	-25.3
x14y14	-1277.1	-265.5	-22.9
x15y 5	920.6	1047.1	-18.0
x15y 6	662.3	929.8	-17.2
x15y 7	404.4	814.4	-18.7
x15y 8	144.9	700.3	-20.5
x15y 9	-109.6	583.5	-17.9
x15y10	-369.3	467.5	-16.1
x15y11	-625.3	347.4	-17.5
x15y12	-884.0	231.8	-16.4
x15y13	-1139.1	113.3	-12.2
x15y14	-1393.7	-8.5	-12.0
x16y 5	803.7	1304.1	-16.8
x16y 6	546.0	1187.8	-11.5
x16y 7	288.1	1071.9	-12.6
x16y 8	29.6	957.9	-15.0
x16y 9	-228.5	842.3	-12.2
x16y10	-485.5	724.8	-13.1
x16y11	-742.2	608.2	-16.0
x16y12	-1001.0	489.5	-12.6
x16y13	-1256.8	371.3	-8.4
x16y14	-1512.6	247.8	-8.1
x17y 5	688.6	1563.2	-4.8
x17y 6	429.6	1446.5	-7.5
x17y 7	172.7	1329.3	-7.7
x17y 8	-85.1	1214.7	-9.1
x17y 9	-343.5	1100.7	-5.4
x17y10	-599.3	983.2	-6.2
x17y11	-856.8	865.7	-6.9
x17y12	-1115.3	749.3	-3.1
x17y13	-1372.9	628.8	-4.8
x17y14	-1626.3	507.2	-4.6
x18y 5	570.7	1821.0	-1.9
x18y 6	311.6	1703.3	-3.4
x18y 7	56.9	1588.9	-3.1

x18y 8	-202.5	1473.7	-2.5
x18y 9	-459.8	1358.5	3.2
x18y10	-718.3	1240.8	0.0
x18y11	-973.7	1123.2	1.6
x18y12	-1232.6	1007.2	1.0
x18y13	-1490.4	888.2	2.4
x18y14	-1743.6	764.0	1.3
x19y 5	453.0	2077.1	4.7
x19y 6	195.0	1960.9	1.9
x19y 7	-61.9	1844.9	0.9
x19y 8	-319.9	1730.4	2.3
x19y 9	-578.7	1616.0	7.3
x19y10	-835.6	1497.9	11.1
x19y11	-1092.5	1379.2	9.8
x19y12	-1349.7	1264.0	7.3
x19y13	-1606.7	1144.2	9.9
x19y14	-1860.8	1021.0	6.5
x20y 5	337.1	2332.8	11.8
x20y 6	77.8	2216.3	8.1
x20y 7	-179.3	2102.3	5.3
x20y 8	-438.0	1988.3	8.9
x20y 9	-694.8	1873.0	11.5
x20y10	-951.9	1755.5	15.4
x20y11	-1210.0	1642.6	16.3
x20y12	-1467.8	1521.3	13.9
x20y13	-1725.0	1402.6	13.0
x20y14	-1977.6	1278.0	13.4
x21y 5	222.0	2590.0	19.4
x21y 6	-36.0	2474.6	15.3
x21y 7	-293.9	2358.4	15.2
x21y 8	-552.6	2245.7	16.2
x21y 9	-811.4	2131.3	19.3
x21y10	-1067.8	2013.8	20.5
x21y11	-1324.0	1894.4	19.5
x21y12	-1583.2	1780.8	19.6
x21y13	-1838.2	1658.7	18.3
x21y14	-2094.2	1537.6	21.7
x22y 5	107.7	2849.3	29.9
x22y 6	-150.1	2734.5	38.2
x22y 7	-409.2	2617.3	31.1
x22y 8	-665.5	2501.6	29.5
x22y 9	-926.2	2388.5	35.2
x22y10	-1180.9	2272.5	36.1
x22y11	-1437.8	2153.7	32.7
x22y12	-1695.8	2038.2	31.6
x22y13	-1954.2	1916.6	41.1
x22y14	-2209.1	1790.6	34.2

Table 8: September 1998 Muon Layer PMT Depth Measurement.

Muon PMT depth during fill (cm)

	15	14	13	...	...	7	6	5
22	64	67	64			66	67	66
21	65	67	64			65	65	66
20	68	67	70			68	66	65
19	67	68	66			66	66	65
.								
.								
.								
7	72	72	72			70	75	71
6	70	75	75			70	70	72
5	74	75	73			73	73	73
4	65	75	74			73	76	74

Table 9: November 1998 PMT Depth Measurement.

Shower layer depth in cm. Pond south is up in this figure.

27	29	31	29	29	29	29	30	28	28	30	28	25	28	30	30	28	31	1
26	27	27	27	27	29	29	28	34	26	31	25	26	28	28	28	26	27	2
26	27	26	27	27	25	24	28	27	27	31	26	33	28	30	27	24	21	3
26	25	27	26	26	27	25	26	28	27	29	32	27	29	26	26	26	26	4
26	26	26	26	25	25	25	27	23	34	32	26	25	28	24	26	26	25	5
28	30	29	27	29	27	27	31	26	27	31	27	30	27	26	28	30	28	6
27	27	31	28	25	26	26	26	26	27	27	27	26	28	27	28	32	28	7
29	29	25	29	25	26	27	25	28	27	29	33	30	31	24	27	34	27	8
27	28	31	28	26	25	33	28	26	26	32	28	26	27	25	28	35	27	9
25	26	27	28	25	26	27	27	25	29	29	32	27	30	24	27	27	28	10
28	28	27	29	27	29	28	26	27	29	26	27	29	31	26	28	32	29	11
28	28	27	30	28	27	27	30	28	28	26	29	28	29	28	28	30	29	12
27	28	28	29	25	27	26	27	29	28	26	28	29	32	26	28	31	27	13
26	28	27	29	24	26	26	29	29	29	30	29	28	28	28	29	31	28	14
29	27	27	29	27	28	25	28	27	27	29	27	28	30	25	29	30	27	15
30	30	28	32	30	28	29	28	31	28	27	28	32	29	28	27	30	30	16
28	28	28	34	26	28	28	26	26	29	26	32	29	29	28	29	30	30	17
28	27	28	30	30	26	27	30	33	29	29	30	27	29	27	29	30	30	18
27	27	28	30	29	26	26	26	34	25	26	27	27	30	26	30	30	28	19
28	28	29	29	26	26	26	32	29	21	27	25	30	31	29	28	31	29	20
29	29	32	30	29	28	30	26	28	27	26	29	29	32	30	30	31	31	21
36	29	29	31	35	30	28	32	28	31	27	35	30	31	30	31	30	30	22
33	29	29	33	31	32	33	32	31	31	28	31	31	32	34	31	33	32	23

30	29	31	30	30	30	29	30	31	29	26	30	33	32	31	32	30	31	24
30	30	30	33	31	32	29	31	33	31	33	35	30	35	32	31	32	32	25
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	

Table 10: October 1999 PMT Depth Survey.

```
PMT Depth is 33.5 inches + the number below (in inches)

25,1    19.25
24,1    19.25
23,1    20.5
22,1    21.75
21,1    19.5
20,1    19
19,1    18
18,1    18.5
17,1    18.75
16,1    19
15,1    18.5
14,1    17.5
13,1    18
12,1    18.75
11,1    19
10,1    17.5
9,1     19
8,1     19.75
7,1     22.75
6,1     18.5
5,1     17.5
4,1     18
3,1     17.5
2,1     17.5
1,1     18
1,2     18
3,2     18
5,2     17.75
7,2     18.25
9,2     18.25
11,2    19
13,2    18.75
15,2    18
17,2    19
19,2    18.25
21,2    19
23,2    18
25,2    19
25,3    19.5
22,3    18.75
18,3    18.25
14,3    18
10,3    18.25
6,3     19
2,3     18.5
```

1,3	19.5
1,4	19
1,5	19
2,5	18.5
6,5	18.75
10,5	17.5
14,5	17
18,5	19.25
22,5	21
25,5	20
25,4	20.25
25,6	20.5
25,7	16.75
25,8	20
22,8	19
18,8	22.25
14,8	18
10,8	17.25
6,8	18.5
2,8	18.25
1,8	19
1,7	19
1,6	18.75
1,10	18.5
1,9	18.5
1,11	19.5
2,11	17.75
6,11	18.5
10,11	18
14,11	18
18,11	18.25
22,11	18.5
25,11	19.25
25,10	19.5
25,9	21
25,12	21
25,13	19.5
25,14	21.5
22,14	19
18,14	19
14,14	18.5
10,14	19
6,14	18.25
2,14	18.25
1,14	18.75
1,13	17.75
1,12	18.75
1,15	19.75
1,16	19.5
2,16	18.5
6,16	18.5

10,16	18
14,16	19
18,16	19
22,16	19.75
25,16	20
25,15	20.25
25,17	20
23,17	20.75
21,17	19.5
19,17	19
17,17	19.25
15,17	20
13,17	19.25
11,17	20
9,17	18
7,17	19.75
5,17	19
3,17	17
1,17	18.5
1,18	20.75
2,18	18
3,18	16
4,18	18
5,18	17.5
6,18	18.5
7,18	18.5
8,18	17.75
9,18	18
10,18	18.5
11,18	19
12,18	18.75
13,18	18.5
14,18	18.75
15,18	18.25
16,18	19
17,18	19
18,18	19.25
19,18	18.25
20,18	19
21,18	20
22,18	19
23,18	20.5
24,18	19.75
25,18	20

Table 11: September 2000 PMT Depth Survey.

```
PMT Depth is 33.5 inches + the number below (in inches)
Uncertainties are +- 1/2 inch

 25,11  19
 25,10  19
 25,9   20
 25,8   19
 25,7   16
 25,6   19
 24,10  19
 23,10  19
 22,10  19
 21,10  15
 20,10  16
```

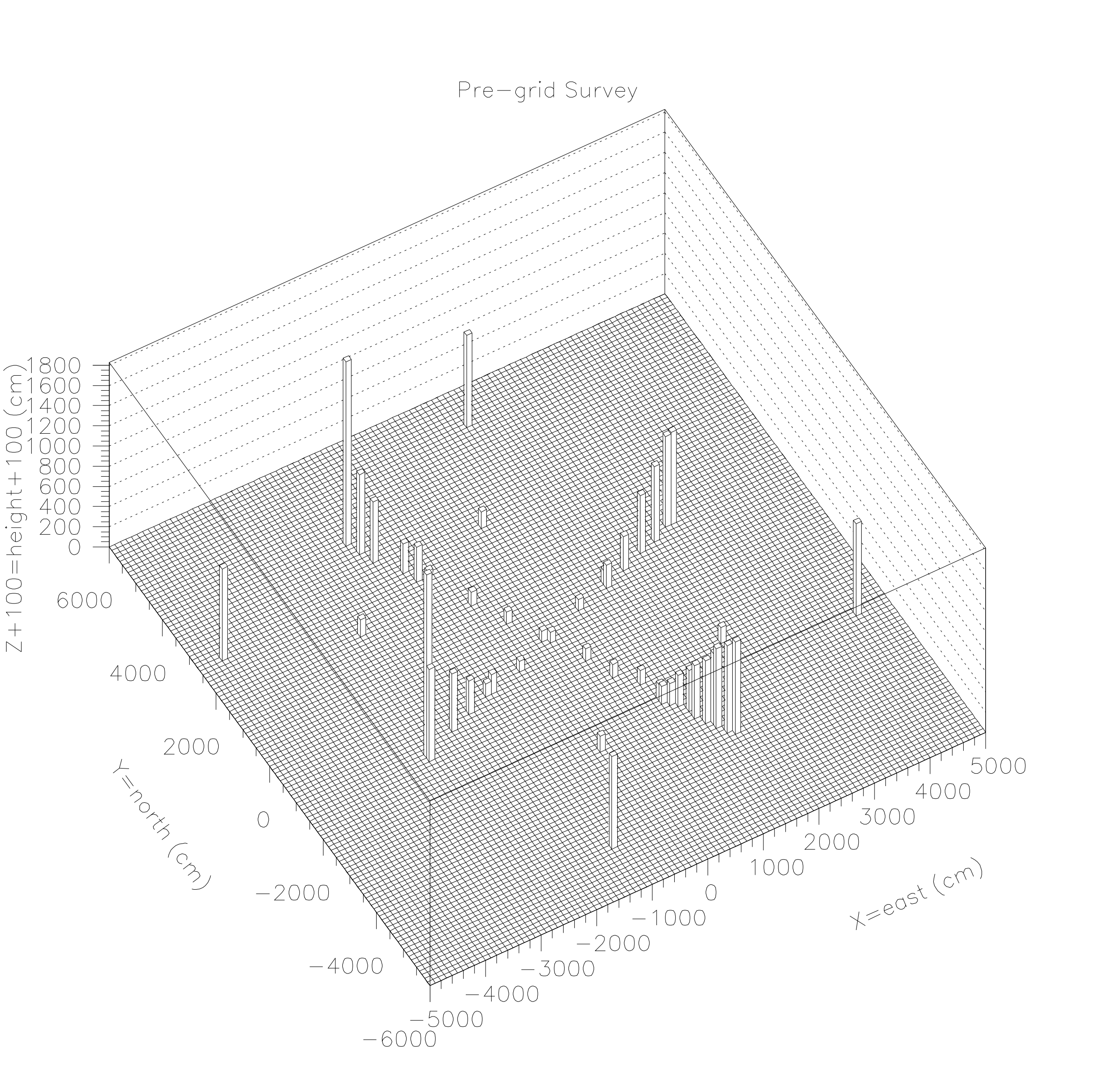


Figure 1: 1995 Milagro pre-grid Survey.

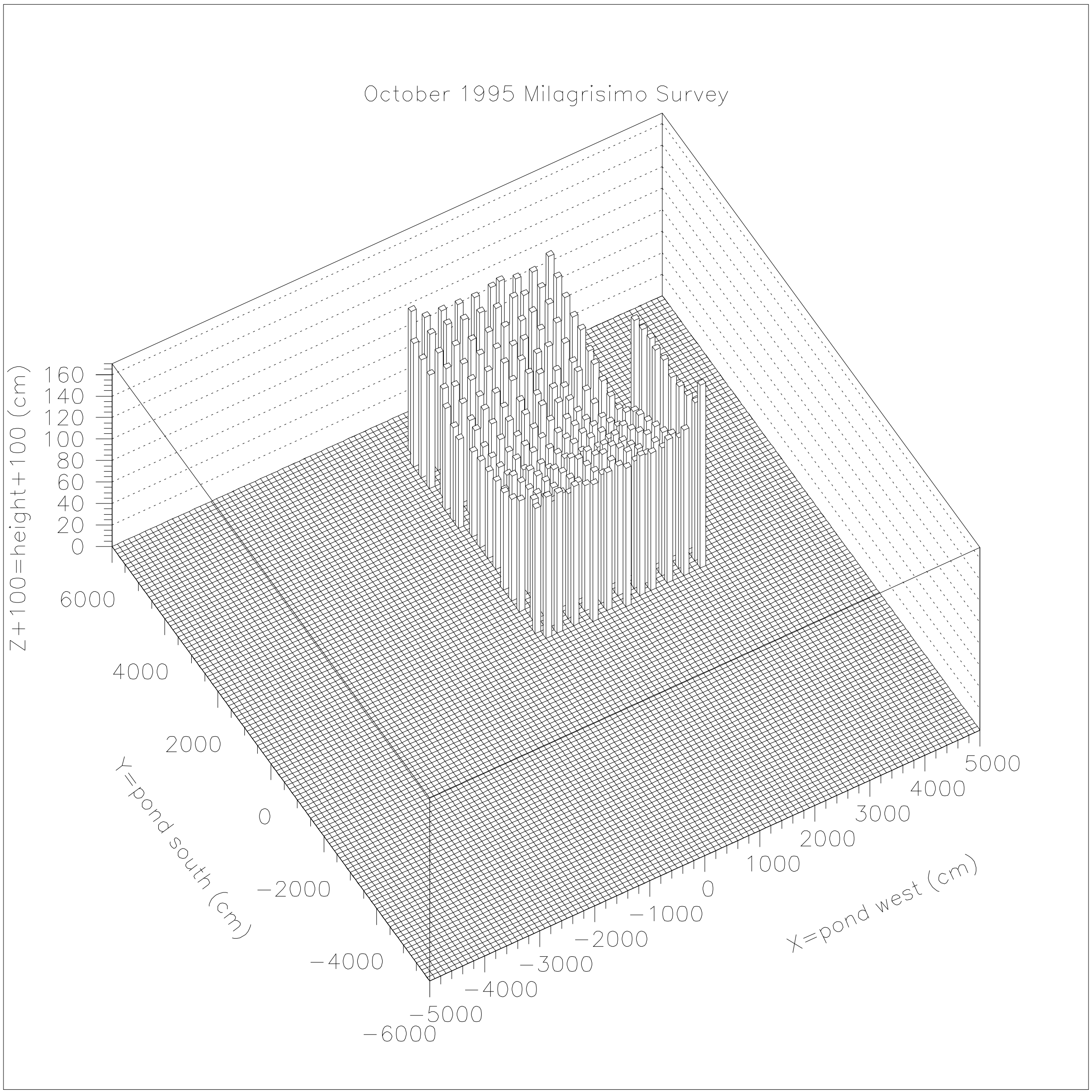


Figure 2: October 1995 Survey.

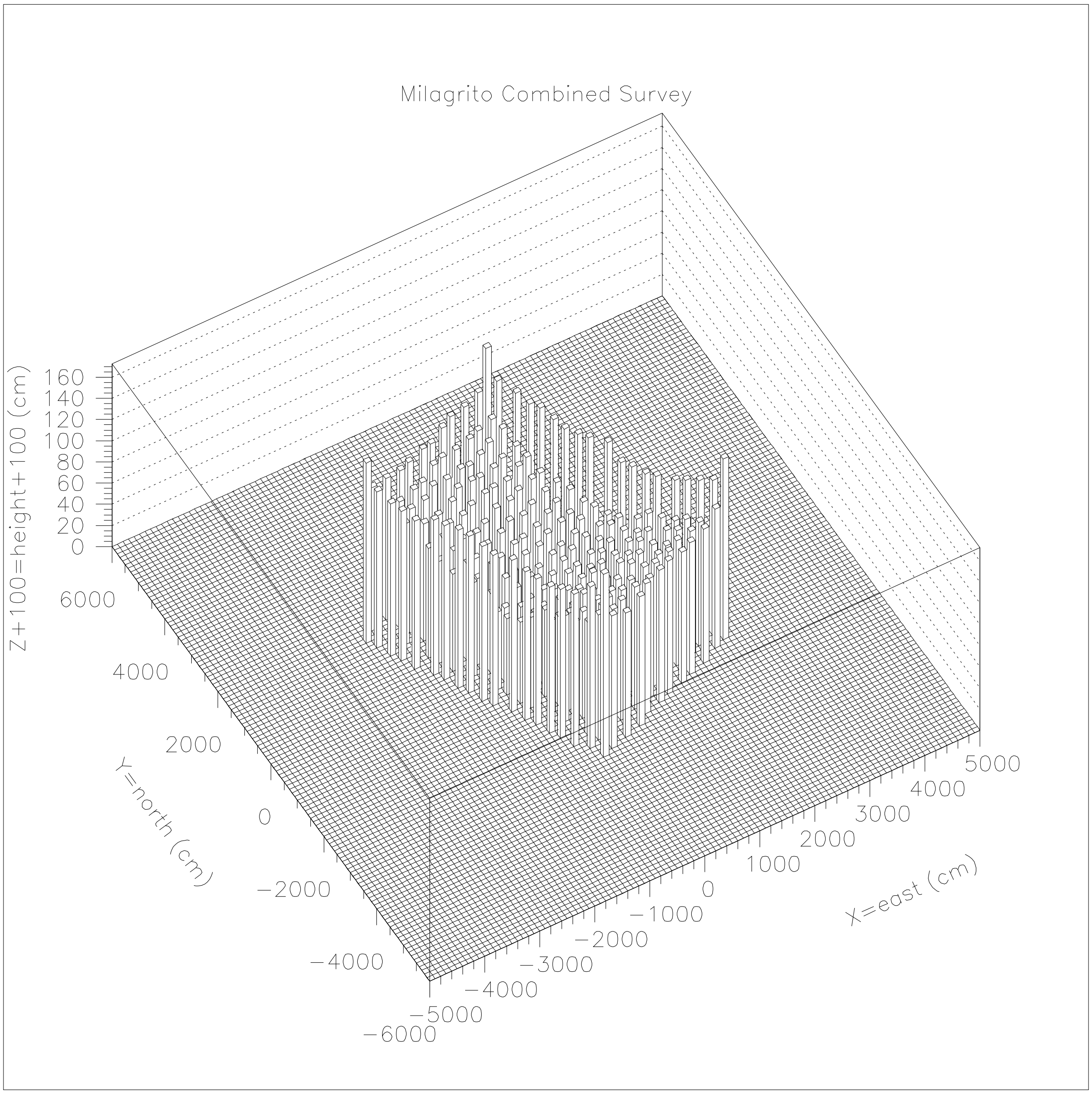


Figure 3: Milagrito Combined Survey.

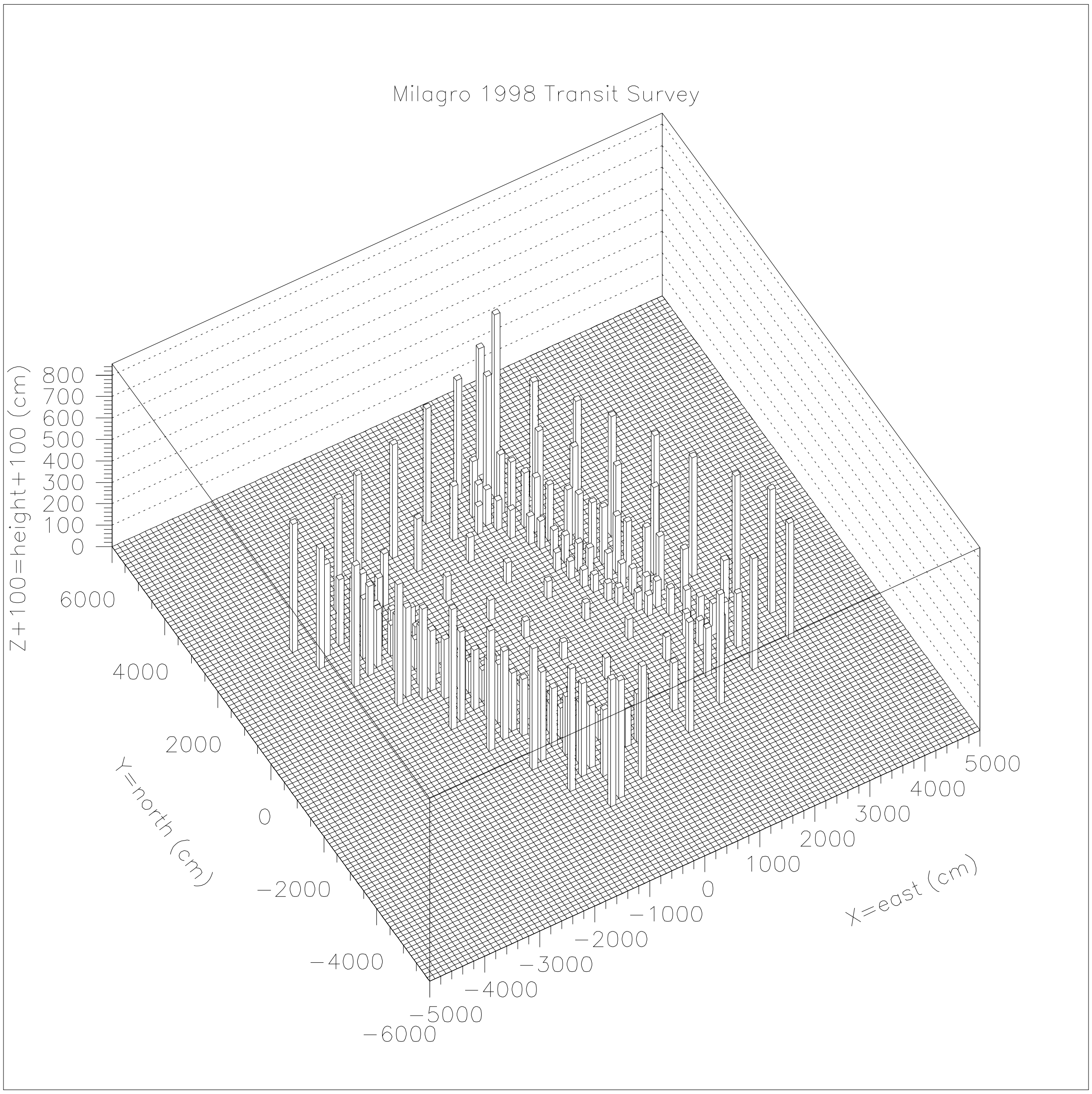


Figure 4: Milagro 1998 Transit Survey.

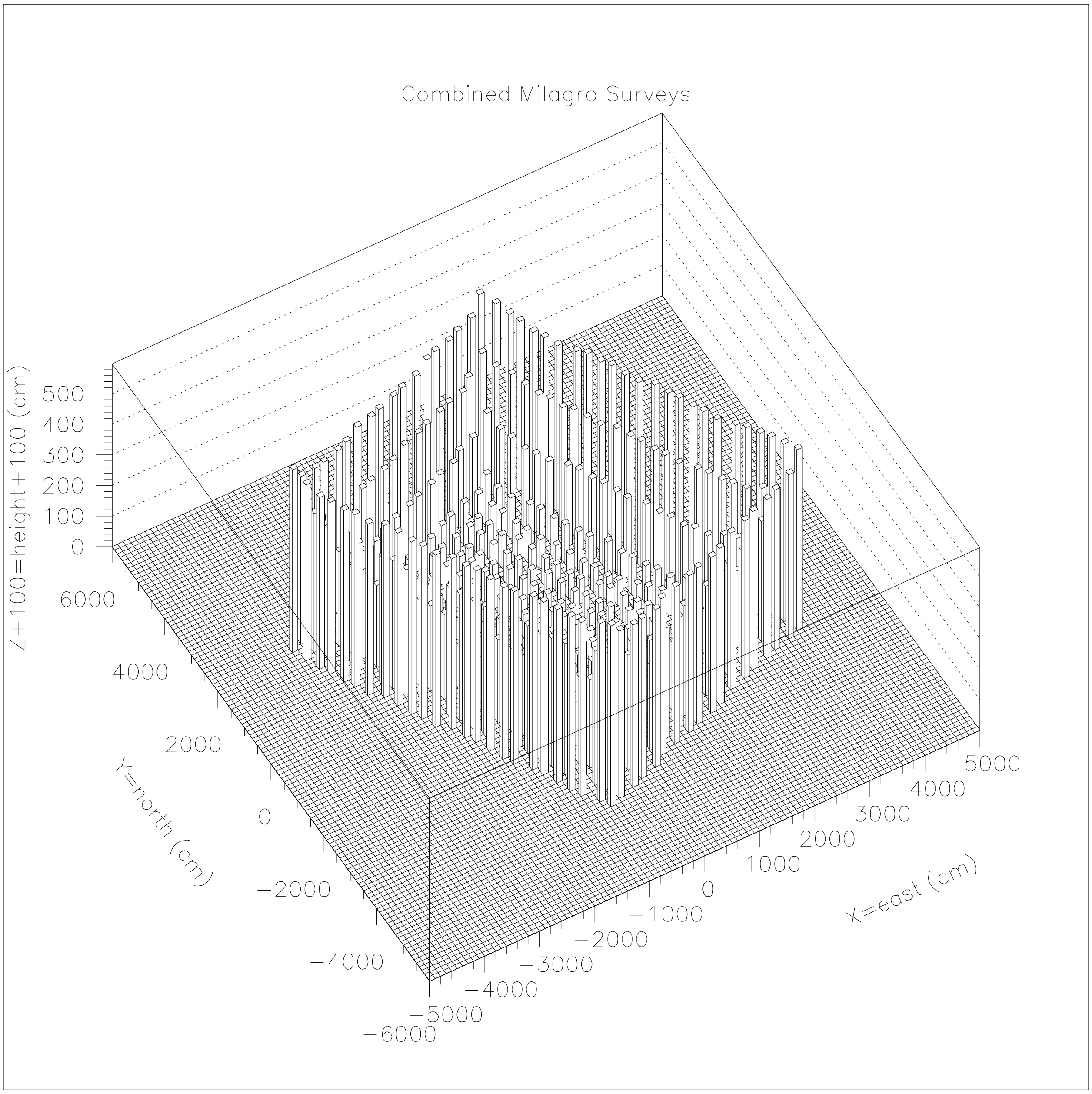


Figure 5: 1998 Combined Milagro Surveys.

Figure 6: FORTRAN (sorry) code used to generate Milagrito and Milagro surveys and laser ball heights.

```
c
c     final_coords_3.f
c
c     This routine reads in the following files and creates a
c     MILAGRO survey file to be used in the reconstruction program
c
c     /usr/people/mincer/milagro/survey/em_pmt_depths is the file
c          gotten from Peter N. (slightly modified) that gives the
c          measured waer level of the EM PMTs
c
c     /usr/people/mincer/milagro/survey/survey_photo.data is the file
c          gotten from Peter N. that contains a mixture of transit and
c          photo survey points that covers full MILAGRO
c
c     a data includes changes to x and y coordinates.  These are
c     rotated to changes in a system consistent with the following where
c     y points to true North, X to true east.

      implicit none
c
c     general:
c
      integer i,j,k,m
c
c     write parameters
c
      integer ityp,iwrit,iwrit0
c
c     survey parameters
c
      real*4 xphot(450),yphot(450),zphot(450)
      integer iphot(450),jphot(450),photij(18,25)
      real*4 tranphot(450)
      integer dmeas(18,25)
      real*4 emlevl,mulevl,mu2lev,dellev
      real*4 xcross(18,25),ycross(18,25),zcross(18,25)
      real*4 xcromu(18,25),ycromu(18,25),zcromu(18,25)
      real*4 xmu(18,25),ymu(18,25),zmu(18,25)
      real*4 xem(18,25),yem(18,25),zem(18,25)
      integer iphomx, idepth
      real*4 x0,y0,z0
c
c     parameters for muon layer plane detrmination
c
      real*4 ydef, rang
c
c     coordinate position changes
```

```
c
      real*4 delx(10),dely(10)
      integer idel(10),jdel(10),numdel
      real*4 delxmu(20),delymu(20)
      integer idelmu(20),jdelmu(20),numdmu
      real*4 rotdx,rotdy
      real*4 fixx(15),fixy(15)
      integer ifix(15),jfix(15),numfix
      real*4 fixxmu(10),fixymu(10),fixzmu(10)
      integer ifixmu(10),jfixmu(10),nfixmu
      integer jhoumu(18,25)
      real houdel
      real*4 del_west(25),del_east(25)
c
c     rotation parameters to MILAGRO coordinates
c
      real*4 ymilag,phimil,comil,simil,deltx,delty
      real*4 rotfac,ymiddl
c
c     parameters for string lengths
c
      character*26 emname,muname,astrin(1000)
      real*4 lstrin(1000),strlen(18,25),strlmu(18,25)
      integer istrin(1000),jstrin(1000),nstrmu,nstrem
c
c     laser balls:
c
      real*4 xlaser(30),ylaser(30),zlaser(30)
      real*4 fixlax(3),fixlay(3)
      integer ifixla(3),nfixla,interp(30)
      integer exlo(30),exhi(30),wylo(30),wyhi(30)
ccc      real*4 lblev,watrlv,emslev,emslv0
      real*4 dlasb,dwlv99,wtlv99,dpls99(30)
c
c     PMT numbering scheme:
c
      integer emi(450),emj(450),mui(750),muj(750)
      integer scheem(18,25),schemu(18,25)
c
c     Milagrito corrected positions and numbering:
c
      real*4 xgrito(300),ygrito(300),zgrito(300),grxfix,gryfix
      integer numgri(18,25),igrito,jgrito
      integer grmtoi(300),grmtoj(300),iglopm(18),nmiglo
c
c
c
      data nmiglo/18/
      data iglopm/ 70, 71, 74, 75, 78, 79,146,147,154,155,
     +            158,159,226,227,230,231,234,235/
c
```

```
c     string length fixes:
c
c     These changes were already included
c     in the stringlen2 file, so need not replace
c     that read.  They are listed here for completeness,
c     but not used in the program.
c
cc      real*4 stmufx(25)
cc      integer istmfx(25),jstmfx(25),nstmfx
cc      data istmfx/6*5,
cc     +                 19*15/
cc      data jstmfx/   5,    6,    9,   16,   21,  22,
cc     +             4,    5,    6,    7,    8,    9,   10,
cc     +            11,   12,   13,   14,   15,   16,   17,  18,   19,
cc     +            20,   21,   22/
cc      data stmufx/20.3, 25.8, 44.4, 59.9, 25.7, 5.1,
cc     +          12.6, 19.7, 31.5, 32.1, 31.4, 42.4, 44.1,
cc     +          47.5, 49.4, 53.1, 56.0, 49.3, 45.0, 41.0, 37.1, 36.7,
cc     +          26.7, 18.7,  3.2/
cc      data nstmfx/25/
c
      data emname/'  EM LAYER:  i, j, length '/
      data muname/'  MU LAYER:  i, j, length '/
c
c     Fixes of survey:
c
c     on Peter's list of fixes:
c     following changes are in "analytic continuation"
c     of the integer MILAGRO numbering scheme:
c     delx is positive pointing 24 degrees S of W
c     dely is positive pointing 24 degrees W of N
c     del's are corrections to survey values
c
c
c     em layer:
c
      data idel(1),idel(2),idel(3)/    16,    15,    15/
      data jdel(1),jdel(2),jdel(3)/    15,    16,    17/
      data delx(1),delx(2),delx(3)/  15.2,  15.2,  15.2/
      data dely(1),dely(2),dely(3)/ -15.2, -15.2,  30.5/
      data numdel/3/
c
c     muon layer:
c
      data (idelmu(i),i=1,5)/     5,     5,    15,    15,    15/
      data (jdelmu(i),i=1,5)/    13,    14,     8,    14,    15/
      data (delxmu(i),i=1,5)/  12.7,   6.4,   8.6,   6.4, -12.7/
      data (delymu(i),i=1,5)/5*0.0/
c
      data (idelmu(i),i=6,10)/    15,    15,    16,    10,    15/
      data (jdelmu(i),i=6,10)/    16,    17,     3,    23,    23/
```

```
      data (delxmu(i),i=6,10)/ -15.2,  -9.5, -10.2, -17.8,  40.6/
      data (delymu(i),i=6,10)/5*0.0/
c
      data (idelmu(i),i=11,15)/     8,     8,     8,     8,     8/
      data (jdelmu(i),i=11,15)/     5,     9,    13,    17,    21/
      data (delxmu(i),i=11,15)/   9.5,   7.6,   8.9,  10.2,  10.2/
      data (delymu(i),i=11,15)/5*0.0/
c
      data (idelmu(i),i=16,20)/    12,    12,    12,    12,    12/
      data (jdelmu(i),i=16,20)/     5,     9,    13,    17,    21/
      data (delxmu(i),i=16,20)/   8.9,   7.6,   9.5,  10.2,  10.2/
      data (delymu(i),i=16,20)/5*0.0/
c
      data numdmu/20/
c
c     Peter's muon measurements:
c
      data del_west/6*0.0,7.6,7.6,9.5,10.2,
     *              16.2,19.1,14.6,7.6,3.8,5.1,5.1,1.9,0.0,2.5,
     *              3.8,5.1,3*0.0/
      data del_east/3*0.0,3*2.5,4*0.0,
     *              10*0.0,
     *              3.2,7.0,3*0.0/
c
c     points missing from transit survey
c
      data (ifix(i),i=1,5)/      3,     14,     15,      5,      6/
      data (jfix(i),i=1,5)/      9,     24,     24,      4,      4/
      data (fixx(i),i=1,5)/ 2139.9,-2441.6,-2698.3, 2203.0, 1943.9/
      data (fixy(i),i=1,5)/ -263.9, 2317.1, 2201.9,-1784.6,-1901.1/
c
      data (ifix(i),i=6,10)/     14,     13,     13,     13,     13/
      data (jfix(i),i=6,10)/      4,      9,     10,     12,     13/
      data (fixx(i),i=6,10)/ -112.1, -440.4, -557.8, -792.0, -906.0/
      data (fixy(i),i=6,10)/-2831.7,-1427.2,-1170.7, -657.5, -403.4/
c
      data (ifix(i),i=11,15)/     13,     13,      0,      0,      0/
      data (jfix(i),i=11,15)/     15,     16,      0,      0,      0/
      data (fixx(i),i=11,15)/-1138.9,-1256.8,      0,      0,      0/
      data (fixy(i),i=11,15)/  111.7,  368.7,      0,      0,      0/
c
      data numfix/12/
c
c     special muon layer points:
c
      data (ifixmu(i),i=1,4)/      4,      4,     16,     16/
      data (jfixmu(i),i=1,4)/      3,     23,      3,     23/
      data (fixxmu(i),i=1,4)/ 2706.4,  387.1, -382.5,-2705.0/
      data (fixymu(i),i=1,4)/-1865.9, 3286.6,-3265.6, 1887.4/
c
c     note that z fix is offset from nearest inner (down slope)
```

```
c     grid crossing height
c
      data (fixzmu(i),i=1,4)/  13.3,    10.4,   15.2,   14.6/
      data nfixmu/4/
c
c     muon layer with shorter PMT's has flag set to 1
c
      data houdel/1.6/
c
      data (jhoumu(i,3), i=4,16)/1,1, 1,1,1,1,1, 0,1,1,1,1, 0/
      data (jhoumu(i,4), i=4,16)/1,1, 1,1,1,1,0, 1,1,1,0,0, 0/
      data (jhoumu(i,5), i=4,16)/1,1, 1,1,1,0,1, 0,0,1,1,1, 0/
c
      data (jhoumu(i,6) ,i=4,16)/0,1, 1,0,1,0,1, 1,1,1,1,1, 1/
      data (jhoumu(i,7) ,i=4,16)/0,1, 1,1,1,0,0, 0,1,1,1,1, 0/
      data (jhoumu(i,8) ,i=4,16)/0,1, 1,1,1,1,1, 0,1,0,1,0, 0/
      data (jhoumu(i,9) ,i=4,16)/0,0, 0,0,0,0,0, 0,1,1,1,1, 0/
      data (jhoumu(i,10),i=4,16)/0,0, 0,0,0,1,1, 0,1,1,1,1, 1/
c
      data (jhoumu(i,11),i=4,16)/0,1, 0,0,0,0,1, 1,0,1,1,0, 1/
      data (jhoumu(i,12),i=4,16)/1,1, 0,1,1,1,1, 1,1,1,1,0, 0/
      data (jhoumu(i,13),i=4,16)/0,0, 0,0,1,1,1, 1,1,1,1,1, 1/
      data (jhoumu(i,14),i=4,16)/0,0, 0,0,0,0,0, 0,1,1,0,0, 0/
      data (jhoumu(i,15),i=4,16)/0,1, 1,1,1,1,1, 1,1,1,1,1, 0/
c
      data (jhoumu(i,16),i=4,16)/0,0, 1,0,1,1,0, 1,1,1,1,1, 0/
      data (jhoumu(i,17),i=4,16)/1,1, 0,1,1,0,1, 1,0,1,0,0, 0/
      data (jhoumu(i,18),i=4,16)/0,0, 0,0,0,0,0, 0,0,1,1,1, 0/
      data (jhoumu(i,19),i=4,16)/1,0, 1,1,1,1,1, 1,0,0,1,1, 0/
      data (jhoumu(i,20),i=4,16)/1,0, 1,1,1,1,1, 0,1,1,1,0, 1/
c
      data (jhoumu(i,21),i=4,16)/1,1, 0,0,0,0,0, 0,1,0,0,0, 0/
      data (jhoumu(i,22),i=4,16)/0,0, 0,0,0,1,0, 0,0,0,0,0, 1/
      data (jhoumu(i,23),i=4,16)/1,1, 1,1,1,1,1, 1,1,1,1,1, 0/
c
c angle fit to coordinate differences 95 vs 98:
c
      data rotfac/-0.001052/,phimil/0.42356/
c
c     emlevl is estimated water height when  EM layer depth measurement
c     was done, using -25.0 as baseline height of j=13 row.
c     correction to this baseline done via dellev parameter
c
c     ems water level during calibration is 646.6 from lazar 3/15/99
c
ccc      data emslv0/527.0/,emslev/646.6/
      data emlevl,mulevl,mu2lev/577.7,84.6,201.7/,dlasb/6.0/
ccc      data dellev/0.4/
c     use -25.0 from original survey 8/10/00
      data dellev/0.000000000/
      data ydef, rang/-1243.6, 0.00092/
```

```
c
c     water level for 10/99 dip stick measurements was made when laser
c     ball heights were measured.
c     use 99 water level as:
c     (PMT depth in 99 dip stick measurement)
c                             - (PMT depth in 98 dip stick measurement)
c                             + 98 dip stick measurement water level
c     dwlv99 = the first two terms
c
      data dwlv99/103.3/
c
c     flag laser balls which get extrapolated from exlo to exhi
c     with a 1.  If 0, interpolate between exlo and exhi
c
      data interp/4*0,1,1,18*0,1,1,4*0/
      data exlo/ 1, 9,18, 3, 7,12,16, 3, 7,12,
     +          16, 3, 7,12,16, 3, 7,12,16, 3,
     +           7,12,16, 3, 7,12,16, 1, 9,18/
      data wylo/ 1, 1, 1, 3, 2, 2, 3, 7, 7, 7,
     +           7,11,11,11,11,14,14,14,14,18,
     +          18,18,18,22,24,24,22,24,25,24/
      data exhi/ 1,10,18, 3, 7,12,16, 3, 7,12,
     +          16, 3, 7,12,16, 3, 7,12,16, 3,
     +           7,12,16, 3, 7,12,16, 1,10,18/
      data wyhi/ 2, 1, 2, 4, 3, 3, 4, 8, 8, 8,
     +           8,12,12,12,12,15,15,15,15,19,
     +          19,19,19,23,23,23,23,25,25,25/
c
c     laser ball fixes
c
cc      data ifixla/    11,    19,    29/
cc      data fixlax/ -32.4, -30.5, 104.1/
cc      data fixlay/  32.4,   0.0,   0.0/
cc      data nfixla/3/
c
c     new laser ball fix information 11/10/99
c
      data ifixla/    29,     0,     0/
      data fixlax/ 104.1,   0.0,   0.0/
      data fixlay/   0.0,   0.0,   0.0/
      data nfixla/1/
c
c     laser ball depth measurements 8/99
c
      data dpls99/ 7.0,10.0, 8.0, 6.0, 6.0, 6.0, 8.0, 6.0, 8.0, 8.0,
     +             6.0,10.0, 6.0,10.0, 6.0, 8.0, 6.0, 6.0, 9.0, 7.0,
     +             6.0, 6.0, 6.0, 8.0, 6.0, 8.0, 9.0,10.0,10.0, 8.0/
c
c     nominal heights:
c
c     em layer:
```

```
c
      emlevl=emlevl+dellev
c
c     Current water level from ems differences between now and
c     when em layer dip-stick measurements were made.
c
cc      watrlv=emlevl+emslev-emslv0
c
c     yo-yo laser ball height comes from water
c     level minus offset dlasb
c
cc      lblev=watrlv-dlasb
c
c     1999 water level, used for laser ball measurements:
c
      wtlv99=emlevl+dwlv99
c
      mulevl=mulevl+dellev
      mu2lev=mu2lev+dellev
c
c     rotation parameters
c
      comil=cos(phimil)
      simil=sin(phimil)
      deltx=105.8*comil+2856.0*simil
      delty=2856.0*comil-105.8*simil
c
c     read in PMT numbering scheme
c
      do m=1,450
        emi(m)=0
        emj(m)=0
      enddo
      do m=1,750
        mui(m)=0
        muj(m)=0
      enddo
      do j=1,25
        do i=1,18
          scheem(i,j)=0
          schemu(i,j)=0
        enddo
      enddo
      open(unit=19,file=
     +     '/usr/people/mincer/milagro/survey/tubescheme.txt'
     +     ,err=9999,type='old')
      do m=1,723
        read(19,7400)k,j,i,ityp
 7400   format(1x,4i4)
        if(ityp.eq.1)then
          emi(k)=i
```

```
          emj(k)=j
          scheem(i,j)=k
        else
          mui(k)=i
          muj(k)=j
          schemu(i,j)=k
        endif
      enddo
      close(19)
c
c     read in manufactured string lengths
c
      open(unit=21,file=
     +     '/usr/people/mincer/milagro/survey/stringlen2'
     +     ,err=9999,type='old')
      nstrmu=0
      nstrem=0
      do i=1,900
        read(21,7500,end=7750)astrin(i),istrin(i),jstrin(i),lstrin(i)
 7500   format(a26,2i4,10f12.1)
        if(astrin(i).eq.emname)then
          strlen(istrin(i),jstrin(i))=lstrin(i)
          nstrem=nstrem+1
        elseif(astrin(i).eq.muname)then
          strlmu(istrin(i),jstrin(i))=lstrin(i)
          nstrmu=nstrmu+1
        endif
      enddo
 7750 continue
      close(21)
      write(*,*)' read in ',nstrem,' em string lengths'
      write(*,*)' read in ',nstrmu,' mu string lengths'
c
c     input the 4 corner muon string lengths:
c     i=4 and 16 for j=3 and 23
c
      strlmu(4,3)=0.0
      strlmu(4,23)=0.0
      strlmu(16,3)=0.0
      strlmu(16,23)=0.0
c
c     read in measured em layer PMT depths
c
      idepth=0
      open(unit=11,
     *     file='/usr/people/mincer/milagro/survey/em_pmt_depths',
     *     err=9999,type='old')
      do j=1,25
        read(11,7000,end=7150)(dmeas(i,j),i=1,18)
        idepth=idepth+18
 7000   format(18i3/)
```

```
        do i=1,18
          zem(i,j)=emlevl-dmeas(i,j)
        enddo
      enddo
 7150 continue
      write(*,*)' successfully input ',idepth,' EM PMT depths'
      close(11)
c
c     read in x y coordinates of the crosses from photo
c                 plus transit survey
c
      open(unit=19,file=
     +     '/usr/people/mincer/milagro/survey/survey_photo.data'
     +     ,err=9999,type='old')
      iphomx=0
      do i=1,900
        read(19,7200,end=7350)jphot(i),iphot(i),
     +                        xphot(i),yphot(i),zphot(i),tranphot(i)
 7200   format(1x,i2,1x,i2,3f8.1,i2)
        iphomx=iphomx+1
        xcross(iphot(i),jphot(i))=xphot(i)
        ycross(iphot(i),jphot(i))=yphot(i)
        zcross(iphot(i),jphot(i))=zphot(i)
        photij(iphot(i),jphot(i))=i
      enddo
 7350 continue
      write(*,*)' successfully input ',iphomx,' photo survey cross ',
     +                                               'positions'
      close(19)
c
c     cross points needing other data:
c
      do k=1,numfix
        xcross(ifix(k),jfix(k))=fixx(k)
        ycross(ifix(k),jfix(k))=fixy(k)
      enddo
c
c     EM layer PMT x-y positions:
c
      do j=1,25
        do i=1,18
          xem(i,j)=xcross(i,j)
          yem(i,j)=ycross(i,j)
        enddo
      enddo
c
c     offsets of individual EM PMT's:
c
      do k=1,numdel
c
c       rotate fixes to x,y coordinates
```

```
c       from grid coordinates
c
        rotdx=-comil*delx(k)-simil*dely(k)
        rotdy=-simil*delx(k)+comil*dely(k)
c
c       do correction
c
        xem(idel(k),jdel(k))=xcross(idel(k),jdel(k))+rotdx
        yem(idel(k),jdel(k))=ycross(idel(k),jdel(k))+rotdy
      enddo
c
c     write out EM PMT survey file
c
      open(unit=20,file=
     +     '/usr/people/mincer/milagro/survey/final_survey_3.data'
     +     ,err=9999,type='new')
      iwrit=0
      ityp=1
cc      do j=1,25
cc        do i=1,18
cc          iwrit=iwrit+1
cc          write(20,9100)iwrit,j,i,ityp,xem(i,j),yem(i,j),zem(i,j)
cc 9100     format(4i4,3f10.2)
cc        enddo
cc      enddo
c
c     write out PMTs according to patch numbers
c
      do m=1,450
        i=emi(m)
        j=emj(m)
        iwrit=iwrit+1
        write(20,9100)scheem(i,j),j,i,ityp,xem(i,j),yem(i,j),zem(i,j)
 9100   format(4i4,3f10.2)
      enddo
      write(*,*)' wrote',iwrit,' EM layer PMT positions'
c
c     nominal muon crossing points:
c
      do j=4,22
        xcromu(4,j)=0.5*(xcross(3,j)+xcross(4,j))
        ycromu(4,j)=0.5*(ycross(3,j)+ycross(4,j))
        zcromu(4,j)=0.5*(zcross(3,j)+zcross(4,j))
        xcromu(5,j)=xcross(5,j)+0.5*(xcross(5,j)-xcross(6,j))
        ycromu(5,j)=ycross(5,j)+0.5*(ycross(5,j)-ycross(6,j))
        if(del_east(j).lt.0.0001)then
          zcromu(5,j)=zcross(5,j)+0.5*(zcross(5,j)-zcross(6,j))
        else
          zcromu(5,j)=zcross(5,j)+del_east(j)
        endif
        do i=6,14
```

```
          xcromu(i,j)=0.5*(xcross(i,j)+xcross(i-1,j))
          ycromu(i,j)=0.5*(ycross(i,j)+ycross(i-1,j))
          zcromu(i,j)=0.5*(zcross(i,j)+zcross(i-1,j))
        enddo
        xcromu(15,j)=xcross(14,j)+0.5*(xcross(14,j)-xcross(13,j))
        ycromu(15,j)=ycross(14,j)+0.5*(ycross(14,j)-ycross(13,j))
        if(del_west(j).lt.0.0001)then
          zcromu(15,j)=zcross(14,j)+0.5*(zcross(14,j)-zcross(13,j))
        else
          zcromu(15,j)=zcross(14,j)+del_west(j)
        endif
        xcromu(16,j)=0.5*(xcross(15,j)+xcross(16,j))
        ycromu(16,j)=0.5*(ycross(15,j)+ycross(16,j))
        zcromu(16,j)=0.5*(zcross(15,j)+zcross(16,j))
      enddo
      do i=5,15
        xcromu(i,3)=0.50000*(xcross(i,3)+xcross(i-1,3))
        ycromu(i,3)=0.50000*(ycross(i,3)+ycross(i-1,3))
        zcromu(i,3)=0.50000*(zcross(i,3)+zcross(i-1,3))
        xcromu(i,23)=0.50000*(xcross(i,23)+xcross(i-1,23))
        ycromu(i,23)=0.50000*(ycross(i,23)+ycross(i-1,23))
        zcromu(i,23)=0.50000*(zcross(i,23)+zcross(i-1,23))
      enddo
c
c     muon crossing points needing other data:
c     i=4 and 16 for j=3 and 23
c
      do k=1,nfixmu
        i=ifixmu(k)
        j=jfixmu(k)
        xcromu(i,j)=fixxmu(k)
        ycromu(i,j)=fixymu(k)
        if(i.eq.4)then
          zcromu(i,j)=zcross(4,j)+fixzmu(k)
        elseif(i.eq.16)then
          zcromu(i,j)=zcross(15,j)+fixzmu(k)
        else
          write(*,*)' FIX not i=4 or 23 for mu corner'
        endif
      enddo
c
c     muon positions
c
      do j=4,22
        zmu(4,j)=mu2lev
        zmu(16,j)=mu2lev
        do i=5,15
          zmu(i,j)=mulevl
        enddo
      enddo
      do i=5,15
```

```
          zmu(i,3)=mu2lev
          zmu(i,23)=mu2lev
        enddo
c
c       following is not quite right, but use it for
c       comparison with true numbers
c
        zmu(4,3)=mu2lev
        zmu(4,23)=mu2lev
        zmu(16,3)=mu2lev
        zmu(16,23)=mu2lev
        do j=3,23
          do i=4,16
            xmu(i,j)=xcromu(i,j)
            ymu(i,j)=ycromu(i,j)
c
c           correct for PMT housings:
c
            if(jhoumu(i,j).eq.1)then
              zmu(i,j)=zmu(i,j)-houdel
            endif
          enddo
        enddo
c
c       individual offsets
c
        do k=1,numdmu
c
c         rotate fixes to x,y coordinates
c         from grid coordinates
c
          rotdx=-comil*delxmu(k)-simil*delymu(k)
          rotdy=-simil*delxmu(k)+comil*delymu(k)
c
c         do correction
c
          xmu(idelmu(k),jdelmu(k))=xcromu(idelmu(k),jdelmu(k))+rotdx
          ymu(idelmu(k),jdelmu(k))=ycromu(idelmu(k),jdelmu(k))+rotdy
        enddo
c
c       rotate to water level z
c
        ymiddl=delty-ymu(10,13)*comil+xmu(10,13)*simil
        do j=3,23
          do i=4,16
            if( (j.eq.3.or.j.eq.23).and.(i.eq.4.or.i.eq.16))then
c
c             use photo survey + string length
c             for upper four corners of outside muon ring
c
              zmu(i,j)=zcromu(i,j)+strlmu(i,j)+43.2
```

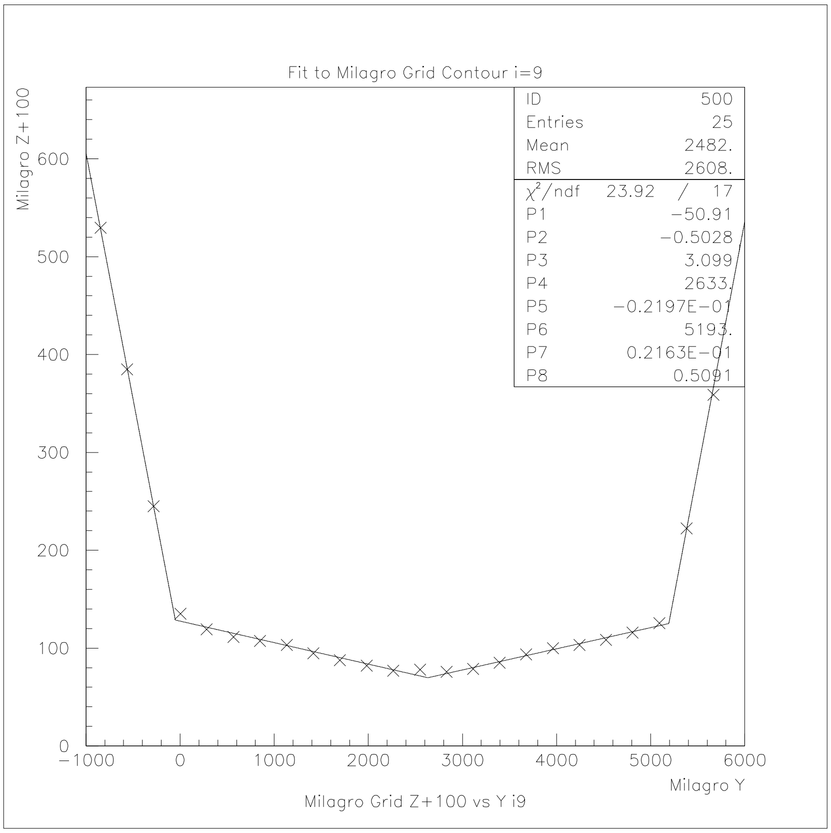
```
            if(jhoumu(i,j).eq.1)then
              zmu(i,j)=zmu(i,j)-houdel
            endif
c
          else
c
c           use plane fit to string coordinates for
c           all other muon counters
c
c
c           first rotate y coordinate to milagro x y
c
ccc            ymilag=delty-ymu(i,j)*comil+xmu(i,j)*simil
c
c           add z offset due to plane tilt
c
ccc            zmu(i,j)=zmu(i,j)+rotfac*(ymilag-ymiddl)
c
c           do rotation correctly by undoing original rotation used in
c           string length calculation   8/10/00
c
            zmu(i,j)=zmu(i,j)+rang*(ymu(i,j)-ydef)
c
          endif
c
        enddo
      enddo
c
c     write out MUON PMT survey file
c
c
c     assign muon layer positions from
c     465 to 737 according to numbering scheme from
c     Andy 2/25/99
c
      iwrit0=iwrit
      ityp=2
cc      do j=3,23
cc        do i=4,16
cc          iwrit=iwrit+1
cc          write(20,9100)iwrit,j,i,ityp,xmu(i,j),ymu(i,j),zmu(i,j)
cc        enddo
cc      enddo
c
c     write out PMTs according to patch numbers
c
      do m=465,737
        i=mui(m)
        j=muj(m)
        iwrit=iwrit+1
        write(20,9100)schemu(i,j),j,i,ityp,xmu(i,j),ymu(i,j),zmu(i,j)
```

```
      enddo
      write(*,*)' wrote',iwrit-iwrit0,' MUON layer PMT positions'
      close(20)
c
c     Laser ball positions:
c
      open(unit=20,file=
     *     '/usr/people/mincer/milagro/survey/lb_pos_3.data'
     *     ,err=9999,type='new')
      do k=1,30
ccc        zlaser(k)=lblev
        zlaser(k)=wtlv99-dpls99(k)-dlasb
        if(interp(k).eq.0)then
          xlaser(k)=0.5*( xcross(exlo(k),wylo(k))+
     +                    xcross(exhi(k),wyhi(k)) )
          ylaser(k)=0.5*( ycross(exlo(k),wylo(k))+
     +                    ycross(exhi(k),wyhi(k)) )
c
c         test
c
c          zlaser(k)=0.5*( strlen(exlo(k),wylo(k))+
c     +                    strlen(exhi(k),wyhi(k)) )+188.3
c end test
        else
          xlaser(k)=1.5*xcross(exhi(k),wyhi(k))-
     +              0.5*xcross(exlo(k),wylo(k))
          ylaser(k)=1.5*ycross(exhi(k),wyhi(k))-
     +              0.5*ycross(exlo(k),wylo(k))
c
c    test
c
c          zlaser(k)=1.5*strlen(exhi(k),wyhi(k))-
c     +              0.5*strlen(exlo(k),wylo(k))+188.3
c end test
        endif
      enddo
c
c     offsets of individual laser balls:
c
      do k=1,nfixla
c
c       rotate fixes to x,y coordinates
c       from grid coordinates
c
        rotdx=-comil*fixlax(k)-simil*fixlay(k)
        rotdy=-simil*fixlax(k)+comil*fixlay(k)
c
c       do correction
c
        i=ifixla(k)
        xlaser(i)=xlaser(i)+rotdx
```

```
        ylaser(i)=ylaser(i)+rotdy
      enddo
c
c     write out laser balls:
c
      do k=1,30
        if(interp(k).eq.0)then
          write(20,9750)k,exlo(k),wylo(k),exhi(k),wyhi(k),xlaser(k),
     +                 ylaser(k),zlaser(k)
 9750     format(' ball ',i3,' interp between (',i2,',',i2,') and (',
     +            i2,',',i2,') x,y,z = ',3f10.1)
        else
          write(20,9760)k,exlo(k),wylo(k),exhi(k),wyhi(k),xlaser(k),
     +                 ylaser(k),zlaser(k)
 9760     format(' ball ',i3,' extrap from    (',i2,',',i2,') to  (',
     +            i2,',',i2,') x,y,z = ',3f10.1)
        endif
      enddo
      close(20)
c
c     Corrected grito survey:
c
c
c     read in grito numbering scheme:
c
      do m=1,300
        grmtoi(m)=-999
        grmtoj(m)=-999
        xgrito(m)=-999999.9
        ygrito(m)=-999999.9
      enddo
      do j=1,25
        do i=1,18
          numgri(i,j)=-999
        enddo
      enddo
      open(unit=19,file=
     +     '/usr/people/mincer/milagro/survey/gritoSurvey.txt'
     +     ,err=9999,type='old')
      write(*,*)' opened grito tube scheme'
      iwrit=0
      do m=1,300
        read(19,9800,end=9850)k,i,j,ityp
 9800   format(1x,4i4)
        grmtoi(k)=i
        grmtoj(k)=j
        numgri(i,j)=k
        write(*,*)' k,i,j,numgri ',k,i,j,numgri(i,j)
        iwrit=iwrit+1
      enddo
 9850 continue
```

```
      write(*,*)' read ',iwrit,' grito PMTs'
      close(19)
      write(*,*)' closed grito tube scheme'
c
c     fill grito arrays
c
      do j=1,19
        do i=1,12
          write(*,*)'i,j,numgri(i,j)',i,j,numgri(i,j)
        enddo
      enddo
      do j=1,25
        do i=1,18
          if(j.ge.4 .and. j.le.22 .and. i.ge.4 .and. i.le.15)then
c
c           contraction parameters:
c
            grxfix=-(real(i)-9.5)*0.53
            gryfix=-(real(j)-3.0)*0.53
            rotdx=-comil*grxfix-simil*gryfix
            rotdy=-simil*grxfix+comil*gryfix
            igrito=i-3
            jgrito=j-3
            m=numgri(igrito,jgrito)
            write(*,*)'igrito,jgrito,numgri ',igrito,jgrito,m
            if(m.gt.0)then
              xgrito(m)=xcross(i,j)+grxfix
              ygrito(m)=ycross(i,j)+gryfix
              if(i.ne.4 .and. i.ne.15)then
                zgrito(m)=0.0
              else
                zgrito(m)=-3.0
              endif
c
c           change height of igloo pmts
c
              do k=1,nmiglo
                if(m.eq.iglopm(k))zgrito(m)=zgrito(m)+66.0
              enddo
            endif
          endif
        enddo
      enddo
c
c     write out grito revised positions
c
      open(unit=20,file=
     *     '/usr/people/mincer/milagro/survey/final_grito_survey_3.data'
     *     ,err=9999,type='new')
      iwrit=0
      do m=1,300
```

```
        if(xgrito(m).gt.-900000.0)then
          i=grmtoi(m)
          j=grmtoj(m)
          iwrit=iwrit+1
          write(20,9900)m,i,j,ityp,xgrito(m),ygrito(m),zgrito(m)
 9900     format(4i4,3f11.2)
        endif
      enddo
      write(*,*)' wrote',iwrit,' Milagrito PMT positions'
      close(20)
      goto 10000
 9999 continue
      write(*,*)' bounced here on error'
10000 continue
      end
```



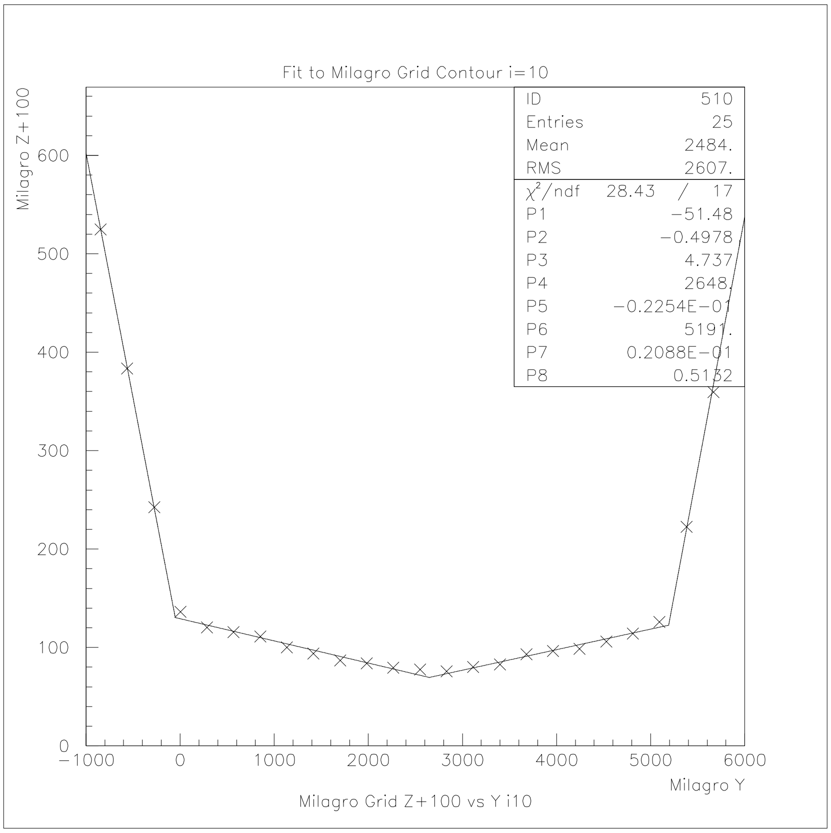
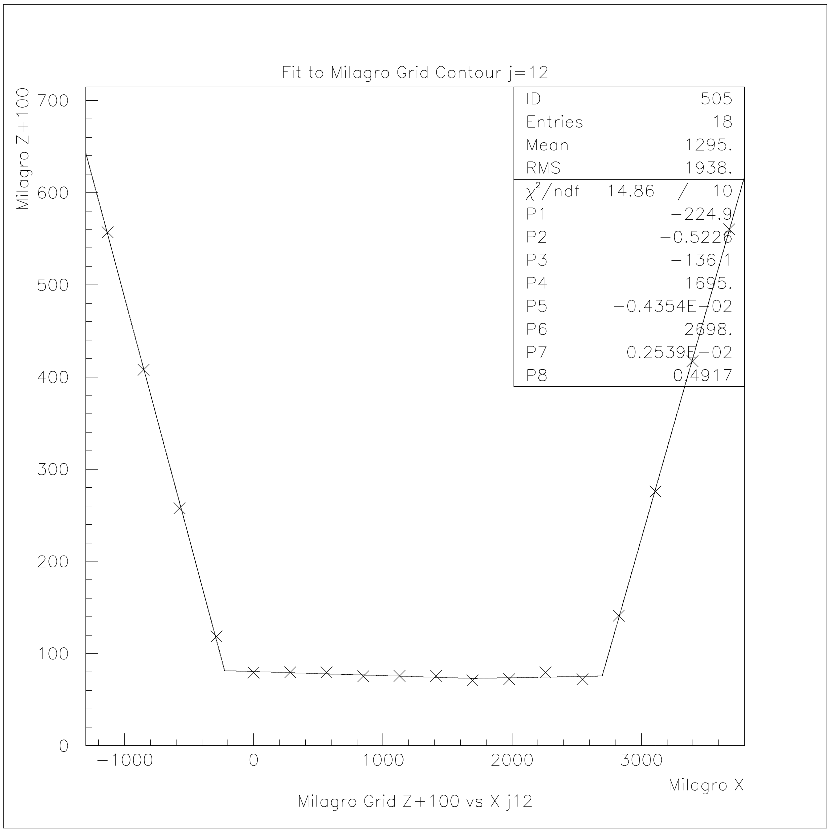


Figure 7: Fit to Milagro north-south grid contour (a) 9th shower layer column counting from east, (b) 10th shower layer column, counting from east.



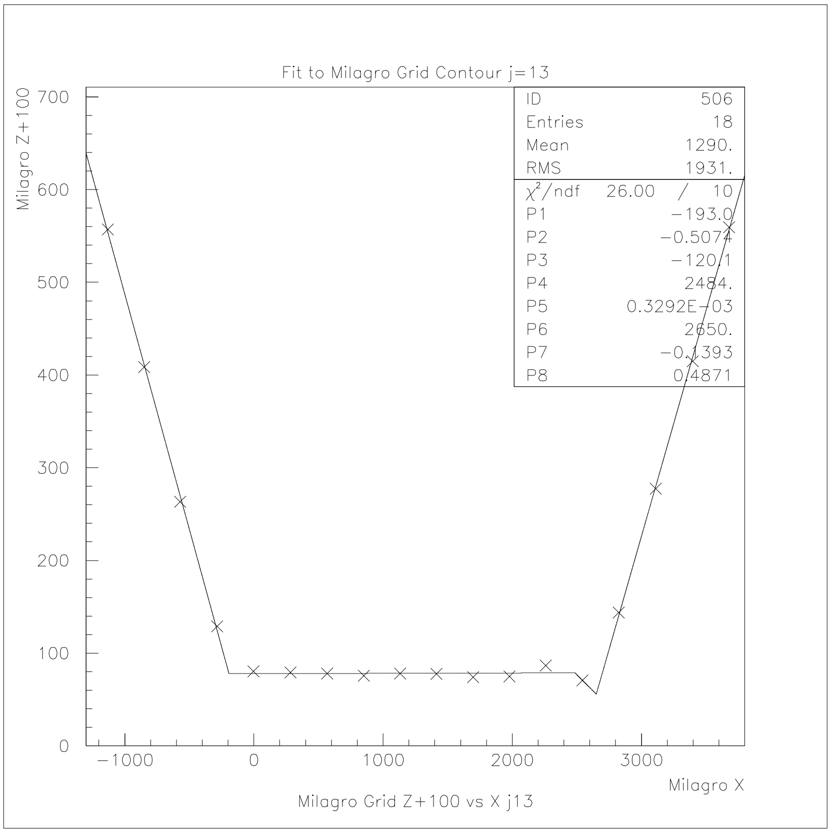
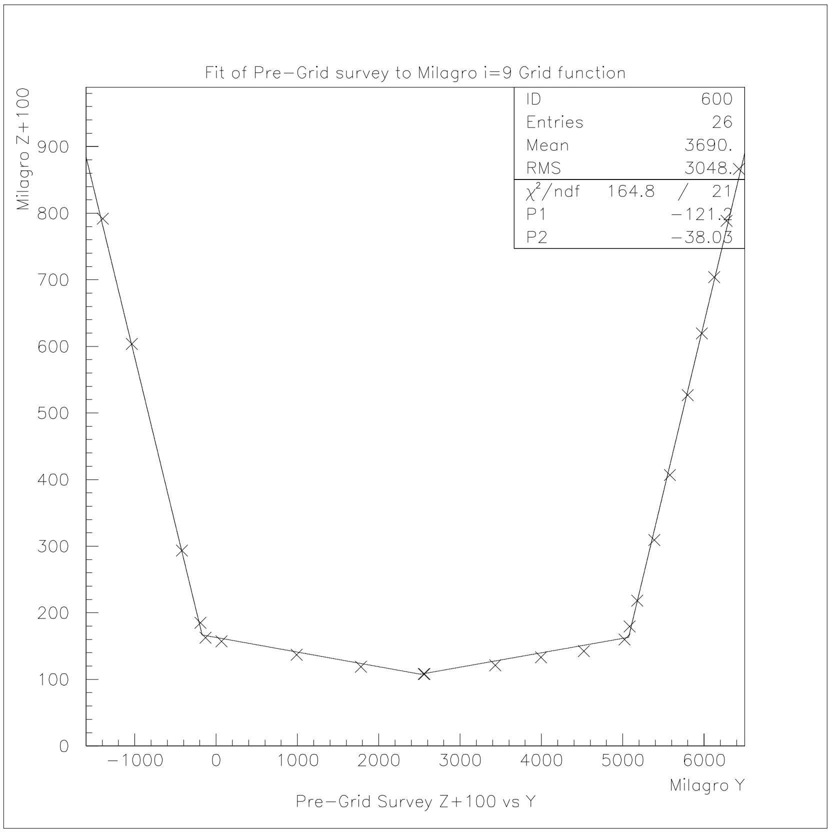


Figure 8: Fit to Milagro east-west grid contour (a) 12th shower layer row counting from south, (b) 13th shower layer row, counting from south.



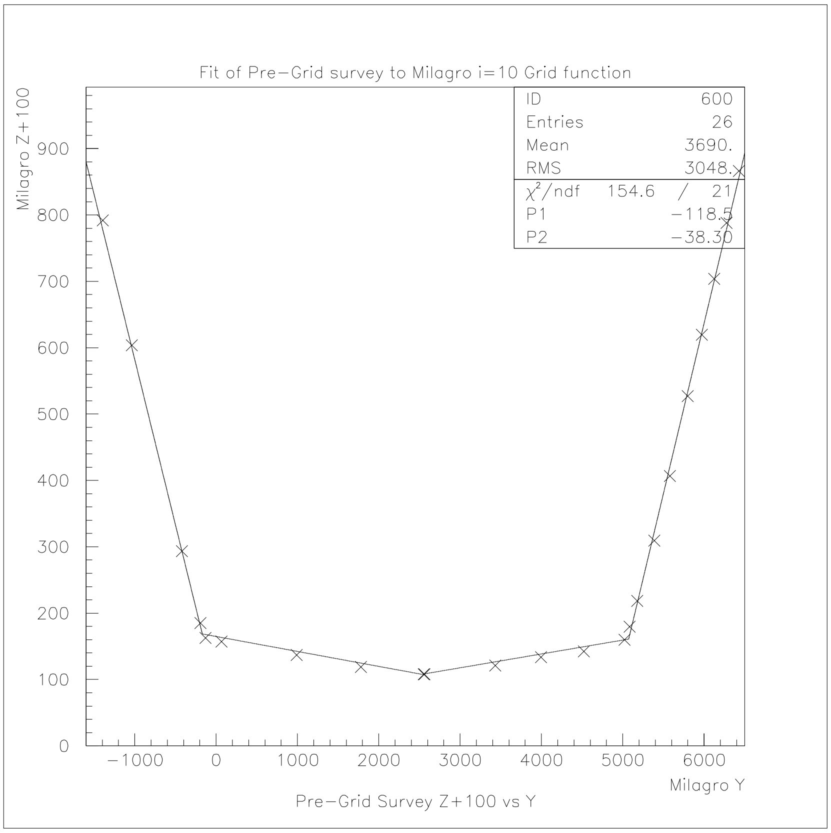
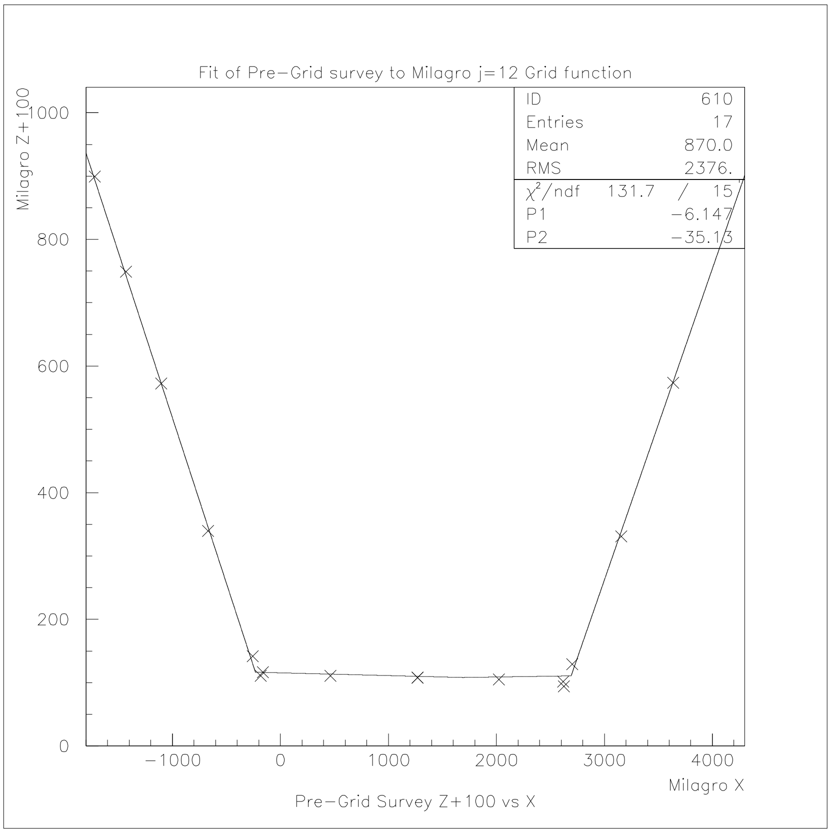


Figure 9: Fit of pre-grid survey points to fit Milagro contours (a) 9th shower layer column counting from east, (b) 10th shower layer column, counting from east.



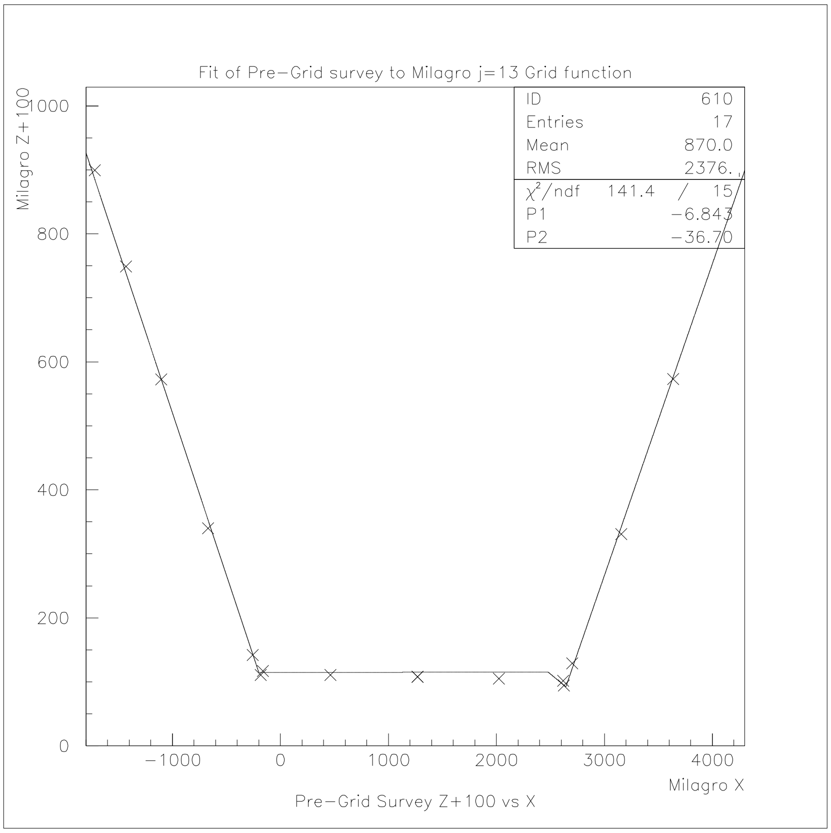


Figure 10: Fit of pre-grid survey points to fit Milagro contours (a) 12th shower layer row counting from south, (b) 13th shower layer row, counting from south.