Alternating Gradient Synchrotron Department
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*Spin Note*

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# Dipole Partial Snakes for AGS

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A helical partial snake has previously been proposed[1]. But there may be practical difficulties in constructing the necessary short helix with sufficient field and aperture.

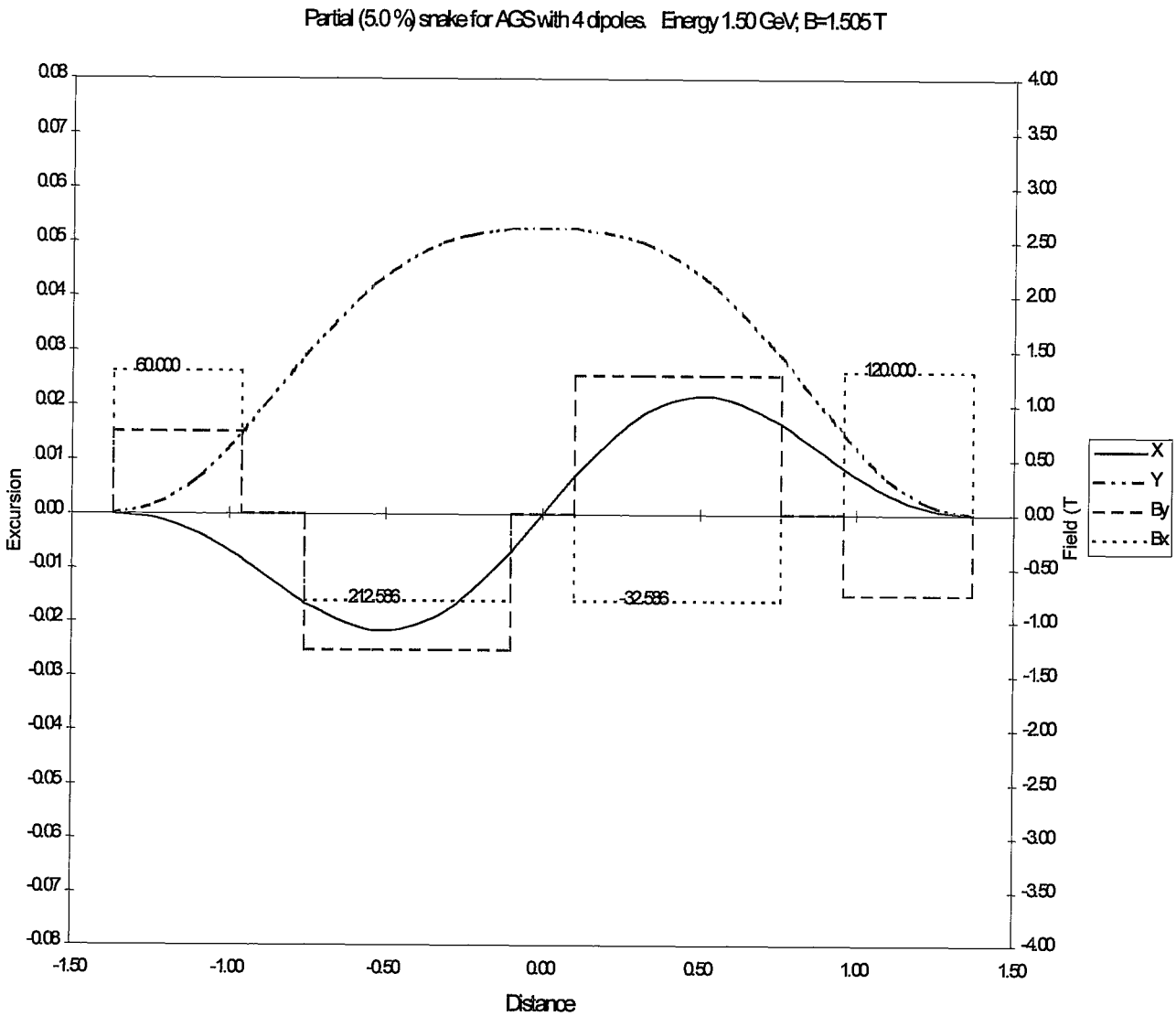
An alternative is to use dipoles. S Y Lee[2] has proposed a sequence of seven short dipoles, with alternate horizontal and vertical fields, that would just fit into a 10-foot straight section of the AGS.

If the dipoles have fields at odd angles, neither horizontal nor vertical, it would be possible to accomplish the job with fewer magnets. Four solutions, two with four and two with five magnets, are presented below, together with the seven-magnet version (one of these is essentially the same as I proposed before[3].

Still another configuration, proposed by T. Roser[4] employs six dipoles in the form of two interleaved horizontal and vertical three-bumps (rotated by 45 degrees).

The tables below show some of the parameters of these schemes. We see that, to keep the field for a 5% snake at full energy ($G\gamma = 41.5$, energy 20.8 GeV) at 2 Tesla or below and to fit into the ten-foot straight section of the AGS, some of the schemes require 15 cm spacing between the magnets, while 5 B and 4A can work with 20 cm spaces. At injection energy (1.5 GeV) the four-magnet scheme 4A requires the largest gap aperture (excursion along the field) The gaps between magnets are rather short (15 cm) to fit comfortably in the ten foot straight section of the AGS.

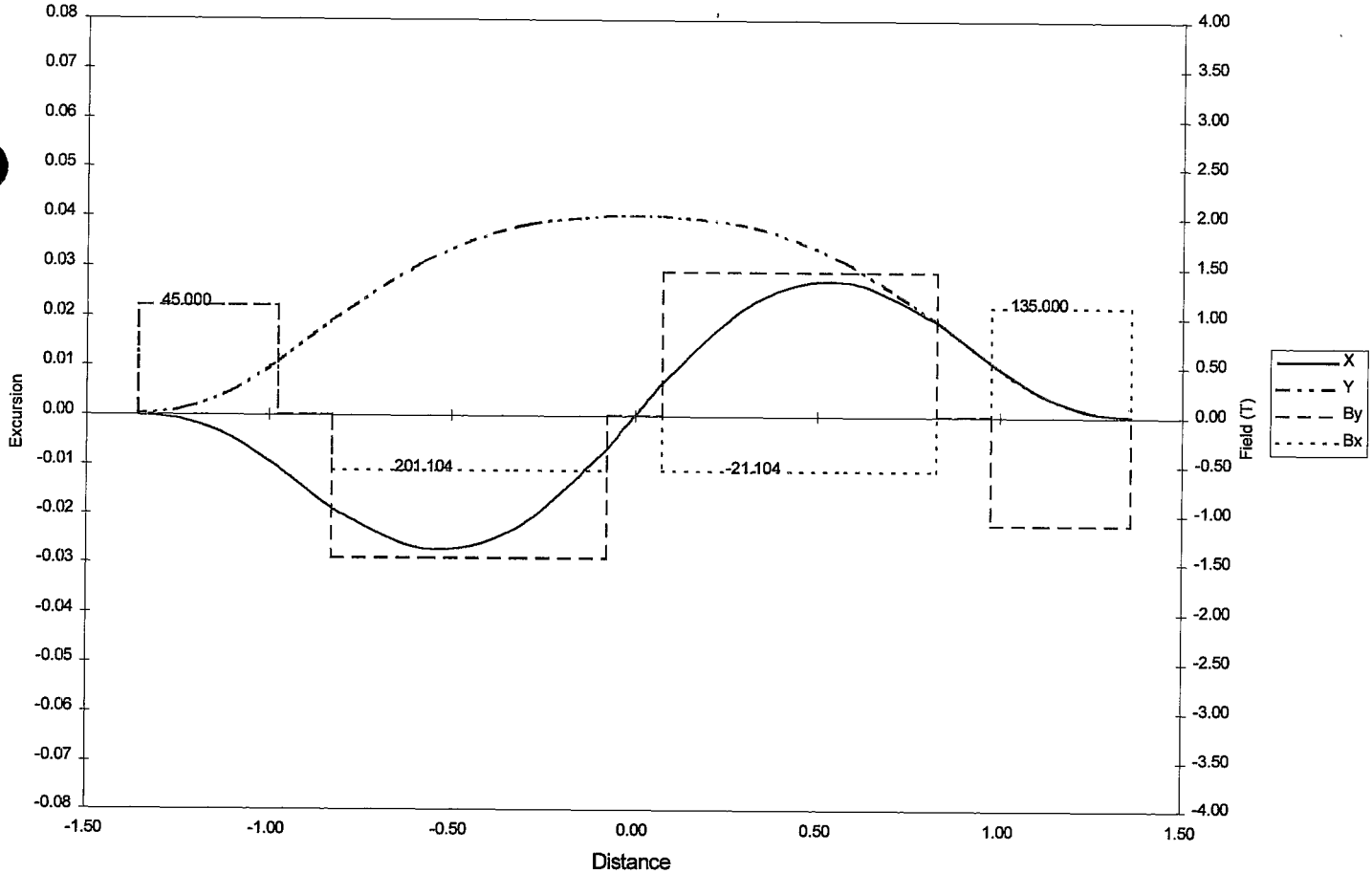
[1] T. Roser et al, Spin Note 72 (March 1998)
[2] S. Y Lee, private communication to T. Roser
[3] E. D. Courant, Spin note 75 (Oct. 1998)
[4] T. Roser, private communication




Four magnets (Scheme 4A)
Total length 2.741 m, space between magnets 0.2 m

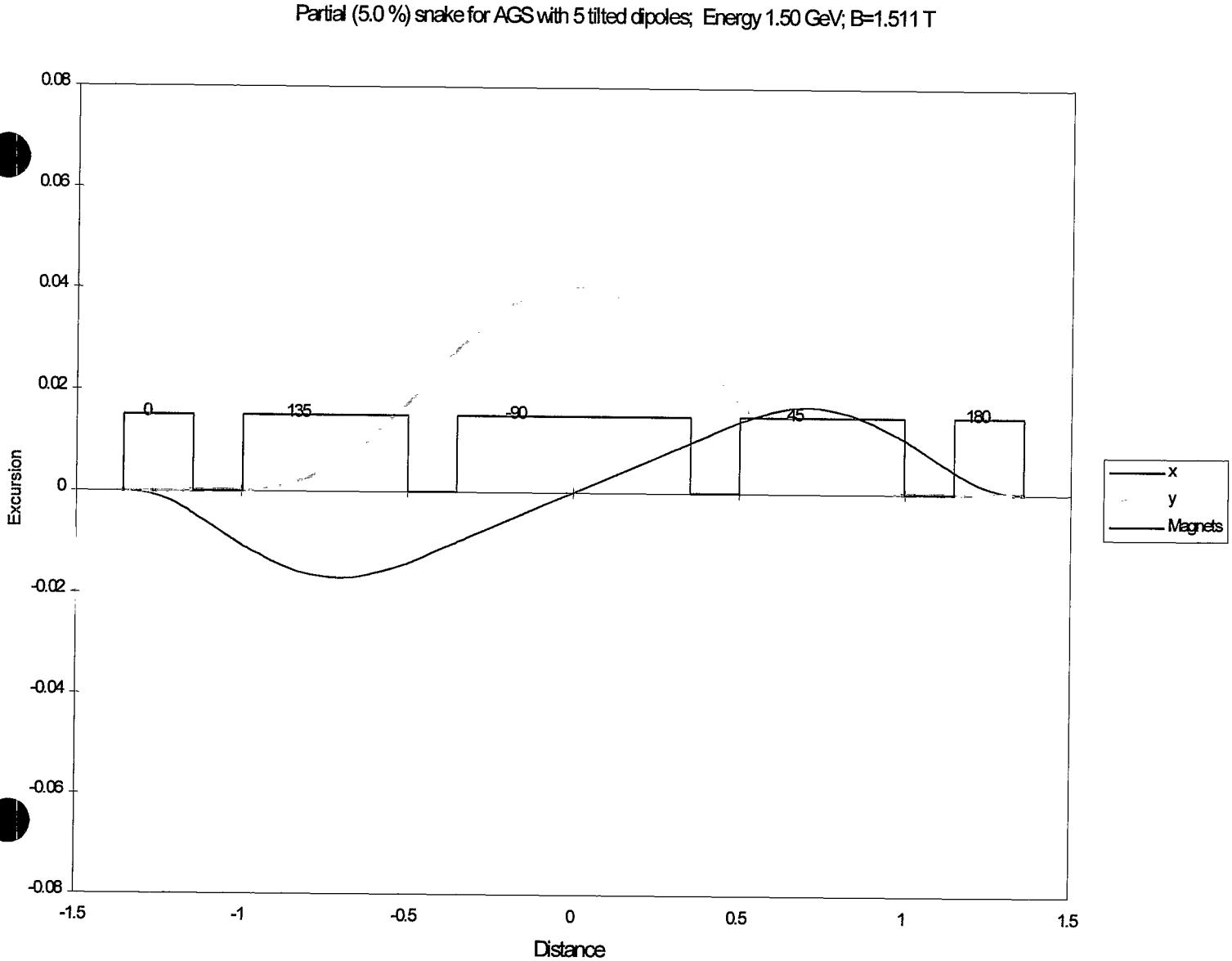
| | Magnet 1 | Magnet 2 | Magnet 3 | Magnet 4 |
|---|---|---|---|---|
| Length | .41 | .66 | .66 | .41 |
| Field (5% snake, 1.5 GeV) | 1.505 | 1.505 | 1.505 | 1.505 |
| Field for $G\gamma = 41.5$ | 1.932 | 1.932 | 1.932 | V |
| Direction from vertical | 60 | 212.59 | -32.59 | 60 |
| Xmax at 1.5 GeV (cm) | .84 | 2.16 | 2.16 | .84 |
| Ymax (cm) | 1.46 | 5.24 | 5.24 | 1.46 |
| R along B | 0 | 4.04 | 4.04 | 0 |
| R across B | 1.69 | 4.23 | 4.23 | 1.69 |

Partial (5.0 %) snake for AGS with 4 dipoles. Energy 1.50 GeV; B=1.558 T



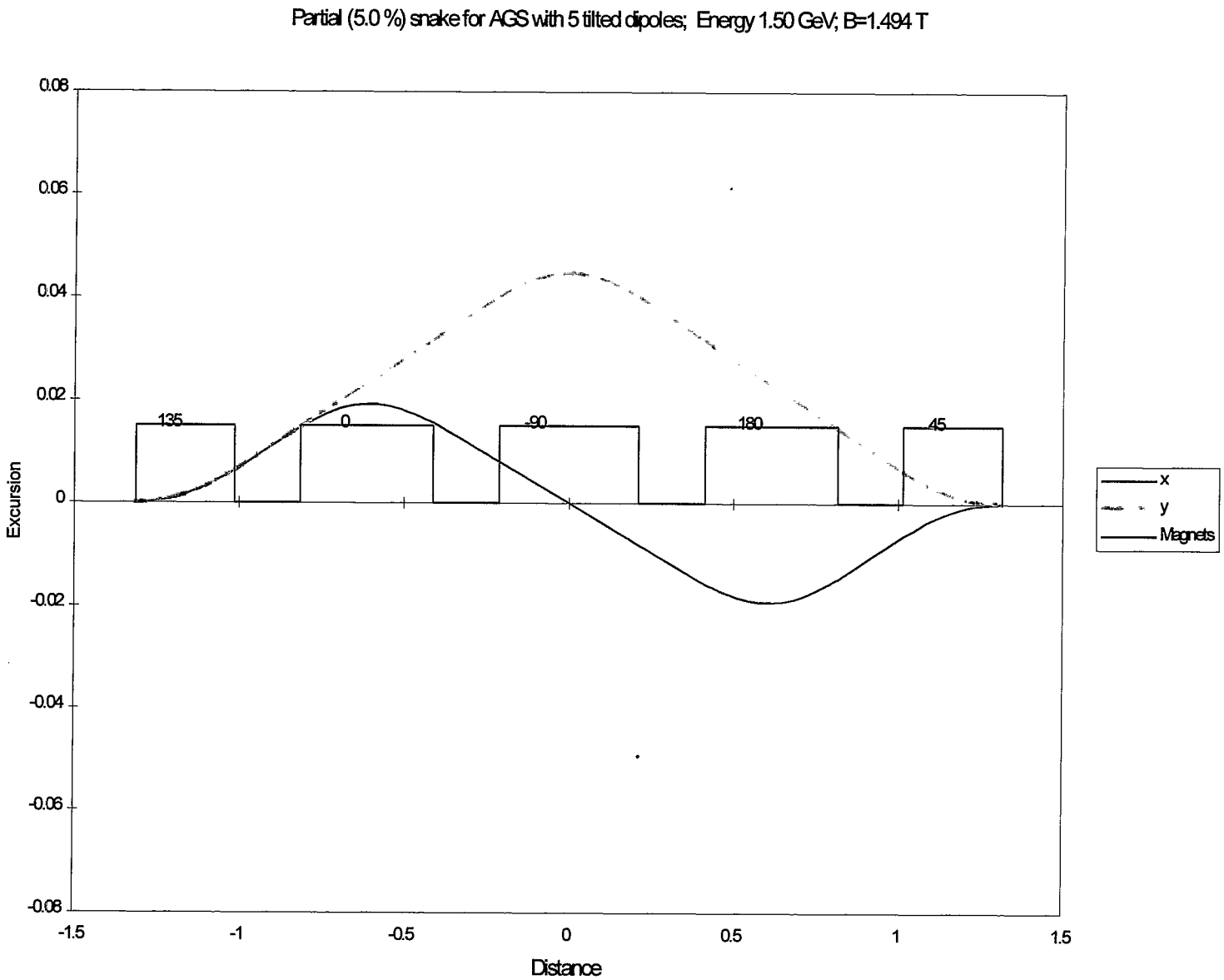

Four magnets (Scheme 4B)
Total length 2.718 m, space between magnets 0.15 m

| | Magnet 1 | Magnet 2 | Magnet 3 | Magnet 4 |
|---|---|---|---|---|
| Length | .383 | .751 | .751 | .383 |
| Field (5% snake, 1.5 GeV) | 1.558 | 1.558 | 1.558 | 1.558 |
| Field for $G\gamma = 41.5$ | 2.000 | 2.000 | 2.000 | 2.000 |
| Direction from vertical | 135 | -21.10 | 201.10 | 45 |
| Xmax at 1.5 GeV (cm) | 1.07 | 2.72 | 2.72 | 1.07 |
| Ymax (cm) | 1.07 | 4.03 | 4.03 | 1.07 |
| R along B | 0 | 3.51 | 3.51 | 0 |
| R across B | 1.52 | 3.65 | 3.65 | 1.52 |



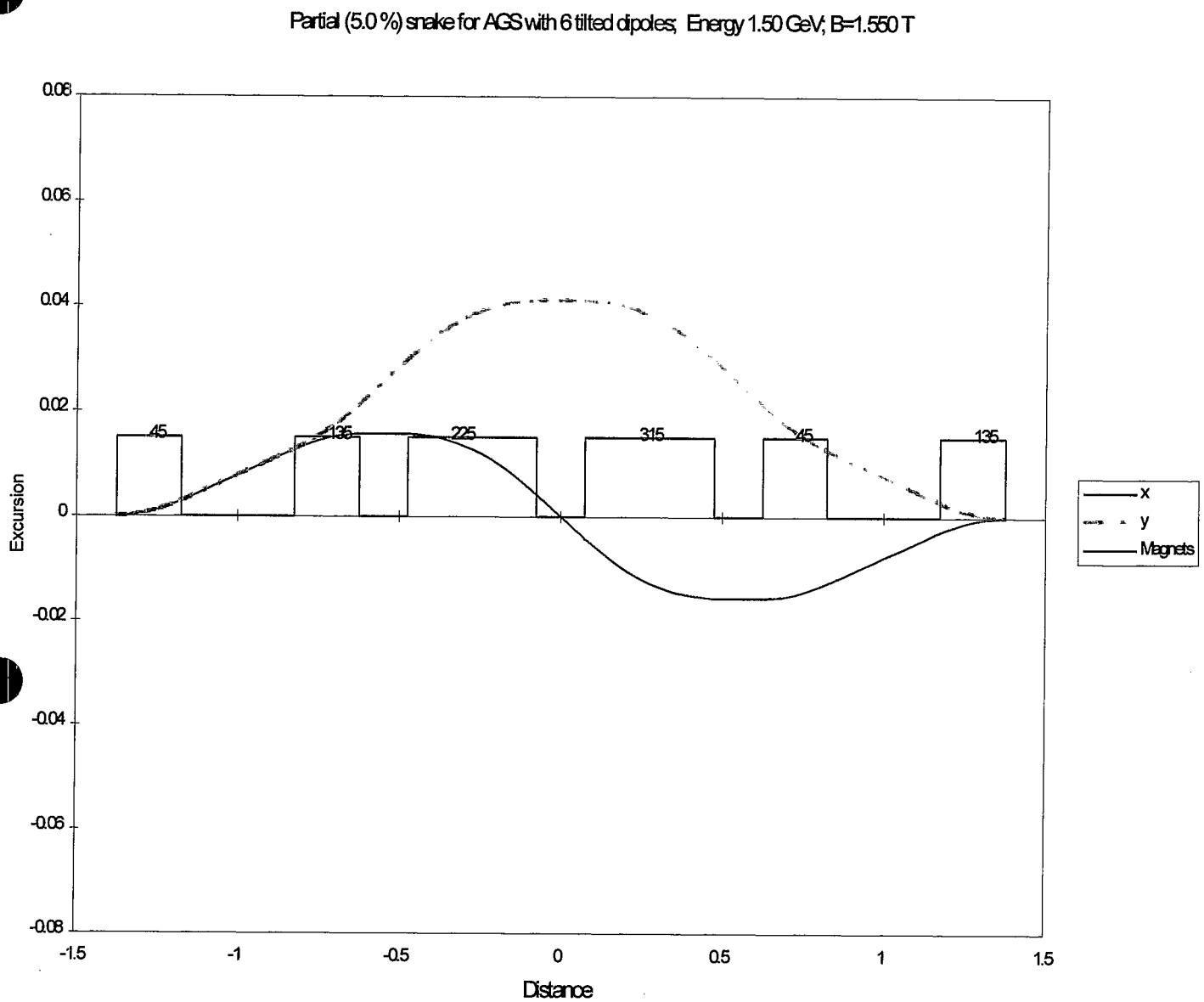

Five magnets (scheme 5A)
Total length 2.72 m, space between magnets 0.15 m

| | Magnet 1 | Magnet 2 | Magnet 3 | Magnet 4 | Magnet 5 |
|---|---|---|---|---|---|
| Length | 0.210 | 0.497 | 0.704 | 0.497 | 0.210 |
| Field (5% snake, 1.5 GeV) | 1.508 | 1.508 | 1.508 | 1.508 | 1.508 |
| Field for $G\gamma = 41.5$ | 1.936 | 1.936 | 1.936 | 1.936 | 1.936 |
| Direction from vertical | 180 | 45 | -90 | 135 | 0 |
| Xmax at 1.5 GeV (cm) | .44 | 1.70 | 1.00 | 1.70 | .44 |
| Ymax (cm) | 0 | 1.75 | 4.05 | 1.75 | 0 |
| R along B | 0 | 2.25 | 1.00 | 2.25 | 0 |
| R across B | .44 | .98 | 4.05 | .98 | .44 |



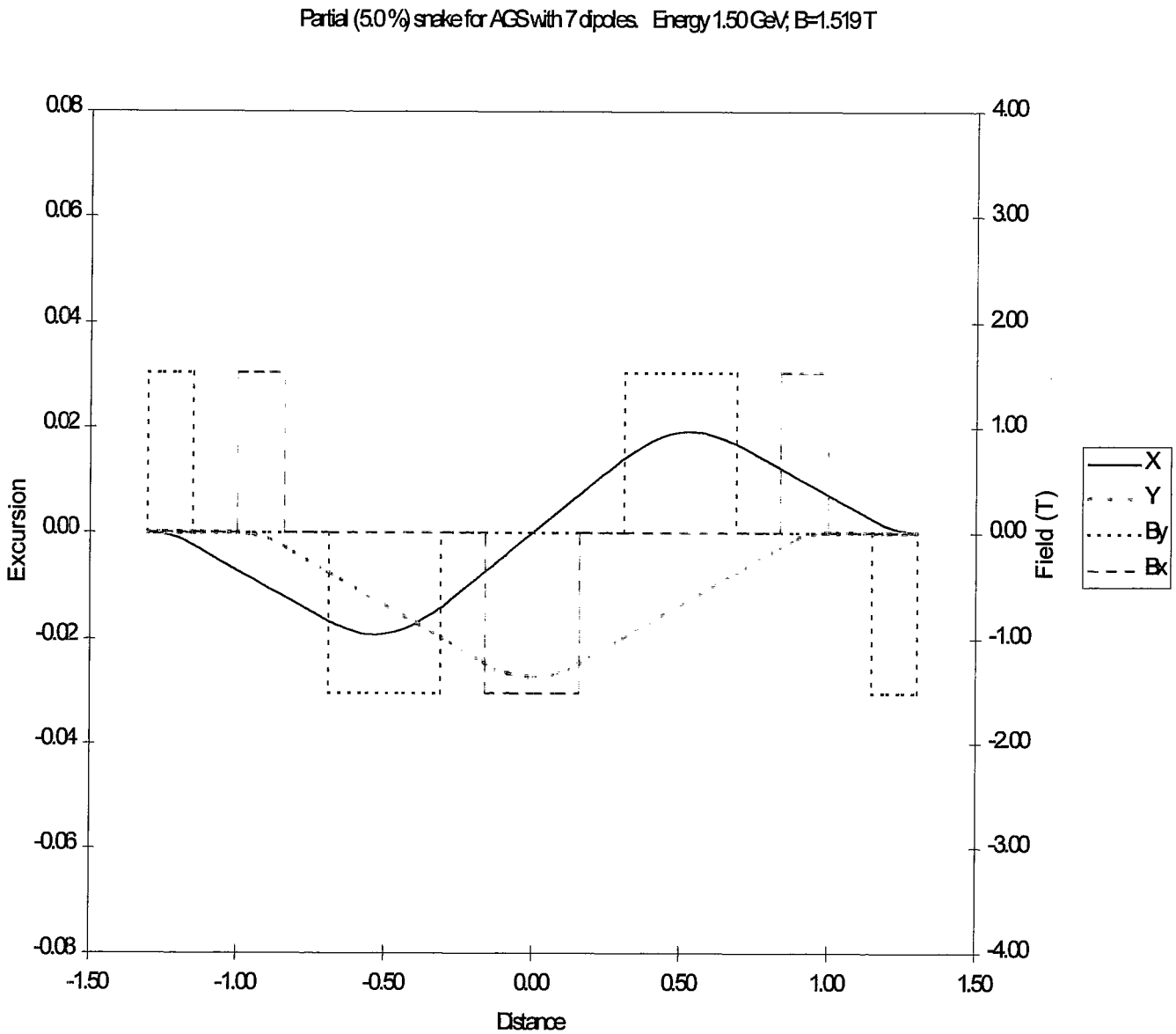

Five magnets (scheme 5B)
Total length 2.63 m, space between magnets 0.20 m

| | Magnet 1 | Magnet 2 | Magnet 3 | Magnet 4 | Magnet 5 |
|---|---|---|---|---|---|
| Length | .30 | .403 | .424 | .403 | .3 |
| Field (5% snake, 1.5 GeV) | 1.494 | 1.494 | 1.494 | 1.494 | 1.494 |
| Field for $G\gamma = 41.5$ | 1.918 | 1.918 | 1.918 | 1.918 | 1.918 |
| Direction from vertical | 180 | 45 | -90 | 135 | 0 |
| Xmax at 1.5 GeV (cm) | .63 | 1.90 | .81 | 1.90 | .63 |
| Ymax (cm) | .63 | 3.18 | 4.47 | 3.18 | .63 |
| R along B | 0 | 3.18 | .81 | 3.18 | 0 |
| R across B | .90 | 1.90 | 4.47 | 1.90 | .90 |




Six magnets (T. Roser)
Total length 2.75 m, spaces 0.15 and 0.35 m)

| | Magnet 1 | Magnet 2 | Magnet 3 | Magnet 4 | Magnet 5 | Magnet 6 |
|---|---|---|---|---|---|---|
| Length | .2 | .2 | .4 | .4 | .2 | .2 |
| Field (5% snake, 1.5 GeV) | 1.530 | 1.530 | 1.530 | 1.530 | 1.530 | 1.530 |
| Field for $G\gamma = 41.5$ | 1.964 | 1.964 | 1.964 | 1.964 | 1.964 | 1.964 |
| Direction from vertical | 45 | 135 | 225 | 315 | 45 | 135 |
| Xmax at 1.5 GeV (cm) | .28 | 1.56 | 1.56 | 1.56 | 1.56 | .28 |
| Ymax (cm) | .28 | 2.13 | 4.12 | 4.12 | 2.13 | .28 |
| R along B | 0 | 2.61 | 2.61 | 2.61 | 2.61 | 0 |
| R across B | .40 | .40 | 3.21 | 3.21 | .40 | .40 |




Seven magnets (S Y Lee)
Total length 2.61 m; space between magnets 0.15 m

| | Magnet 1 | Magnet 2 | Magnet 3 | Magnet 4 | Magnet 5 | Magnet 6 | Magnet 7 |
|---|---|---|---|---|---|---|---|
| Length | .154 | .160 | .379 | .320 | .379 | .160 | .154 |
| Field (5% snake, 1.5 GeV) | 1.519 | 1.519 | 1.519 | 1.519 | 1.519 | 1.519 | 1.519 |
| Field for $G\gamma = 41.5$ | 1.950 | 1.950 | 1.950 | 1.950 | 1.950 | 1.950 | 1.950 |
| Direction from vertical | 180 | -90 | 0 | 90 | 180 | -90 | 0 |
| Xmax at 1.5 GeV (cm) | .24 | 1.21 | 1.92 | ±.72 | 1.92 | 1.21 | .24 |
| Ymax (cm) | 0 | .26 | 1.97 | 2.72 | 1.97 | .26 | 0 |
| R along B | 0 | .1.21 | 1.97 | .72 | 1.97 | 1.21 | 0 |
| R across B | .24 | .26 | 1.92 | 2.72 | 1.92 | .26 | .24 |