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Spin Note

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Partial Snake for AGS using Dipole Magnets

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To overcome the depolarizing resonances due to imperfections, arising at integral values of the spin tune $G\gamma$, one may use "partial snakes" (spin rotators precessing the spin through a small fraction of a complete 180° spin flip) . In the AGS this method has been employed successfully, using a solenoid with maximum strength 4 T-m in one 10 foot straight section. This solenoid acts as approximately a 5% snake (9° rotator).

A drawback of this scheme is that the solenoid also induces coupling between horizontal and vertical betatron oscillations; as a result depolarization can now arise when the spin tune is in resonance with the horizontal as well as the vertical orbit oscillations. This does, in fact, lead to a loss of polarization as observed in Experiment E-880.

This coupling effect would be greatly reduced if the solenoidal snake were replaced by one using transverse fields. Therefore it has been proposed to construct a partial snake using a helical magnet (with a pair of dipoles to restore the orbit)[1]. This can be accomplished by a helical magnet with a field of about 1.25 Tesla, with a full helix twist of 360° in a length of 1.5 m, flanked by a pair of short dipoles (Fig. 1). The maximum orbit excursion at the AGS injection energy of 1.5 GeV is 1.9 cm vertical, 1.6 cm horizontal. To keep the rotator angle at 5% of full spin flip at energies above injection, the field will have to be ramped up slightly, by a factor proportional to $\beta\gamma/(1+G\gamma)$, up to 1.61 Tesla at 24 GeV.

The construction of this helical magnet, with the rather tight pitch and an aperture large enough to accommodate the beam size plus the 2 cm orbit excursion, may present some difficulties. Therefore it may be prudent to explore an alternative: a snake made up of several short conventional dipole magnets with horizontal, vertical or slanted fields. In all cases we are restricted by the requirement that the total length must be short enough for the 10-foot straight section of the AGS (we aim at 2.8 m), and that the precession angle be 9 degrees (5% snakes).

The configuration of Fig. 2 appears to fulfill the requirement. We have five magnets: A central magnet with horizontal field and magnetic length 46cm, flanked by a pair of equal and opposite vertical-field magnets 43.5 cm long, and a pair of magnets with fields ±45° from the vertical, 32.5 cm long. The field strength at injection is 1.40 Tesla, increasing to 1.805 T at 24 GeV. The drawback is that the maximum excursion at injection is 4.7 cm, more than twice that of the helical case, but one may hope that building the flat dipoles with the necessary aperture will be less of a problem than in the helical case.

Still another configuration (Fig.3) employs four dipole magnets rather than five, tilted at various angles. The field requirements and maximum excursions are slightly larger than in the five-magnet case, but it may be advantageous to use four magnets rather than five.

Numerous variations of the parameters of these partial snakes may be tried.

[1] T. Roser et al, Spin Note AGS/RHIC/SN 072 (March 1998)

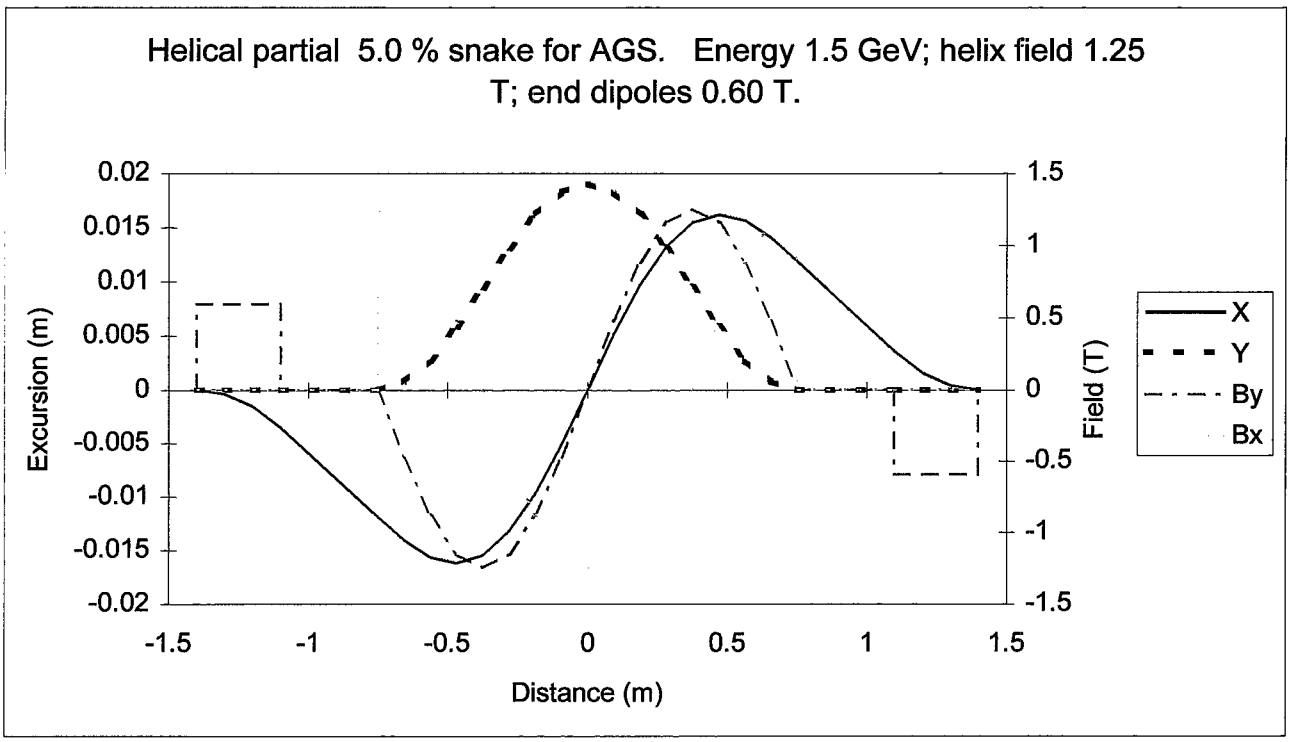

Fig. 1: Snake with helical magnet

BL(tot)	1.5172
Ltot (m)	2.8000
xmax (cm)	1.6225
ymax (cm)	1.8984

Element	Length (m)	B direction from horiz.	B Field (Tesla)
Dipole	0.3000	90.000	0.597
Space	0.350		
Helix	1.500	0 to 360	1.250
Space	0.350		
Dipole	0.300	-90.000	0.597

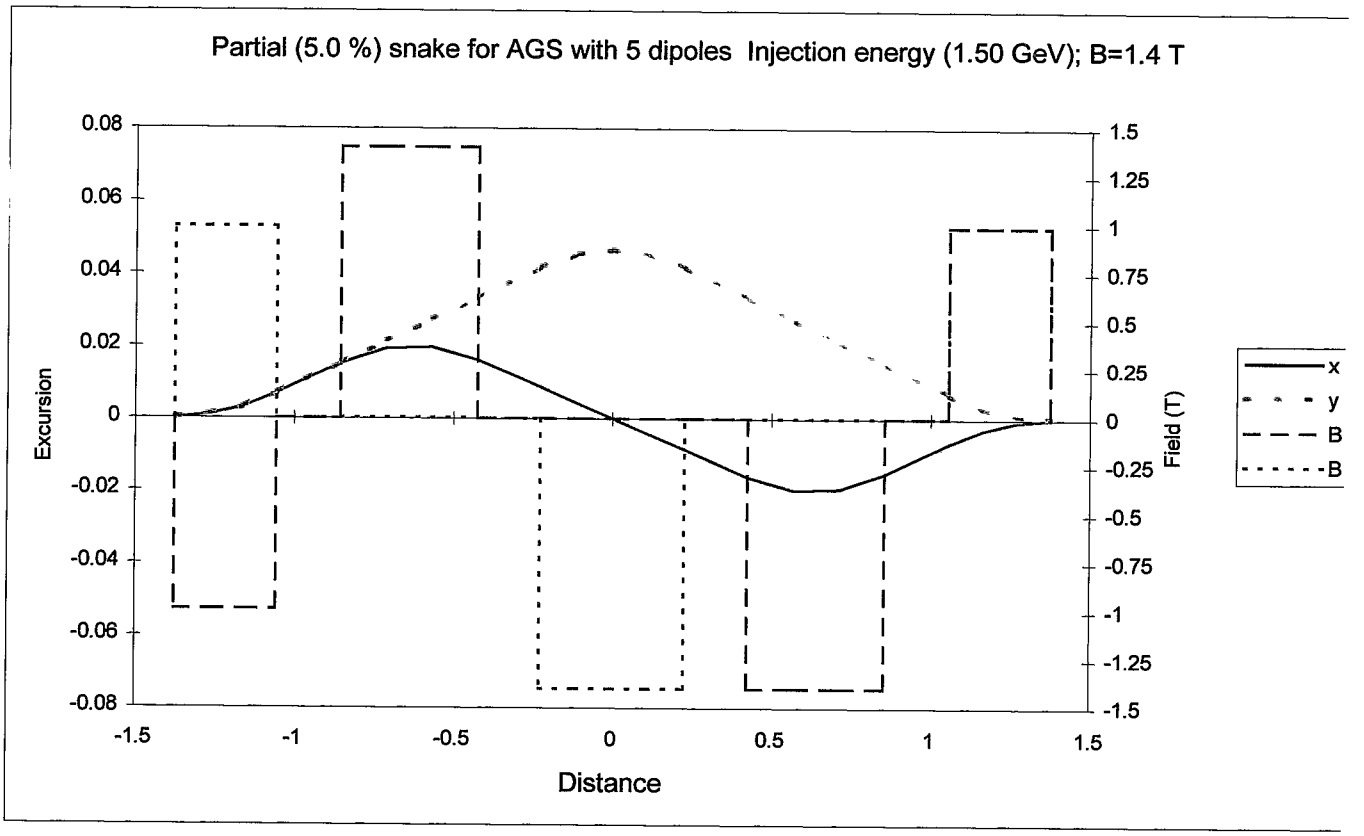

Fig. 2: Snake with dipole magnets

BL (tot)	2.735
Length	2.751
xmax (cm)	1.965
ymax (cm)	4.657

	Length	Field	Angle fr. vertical
Magnet	0.320	1.4014	45.000
gap	0.200		
Magnet	0.429	1.4014	180.000
gap	0.200		
Magnet	0.453	1.4014	-90.000
gap	0.200		
Magnet	0.429	1.4014	0.000
gap	0.200		
Magnet	0.320	1.4014	135.000

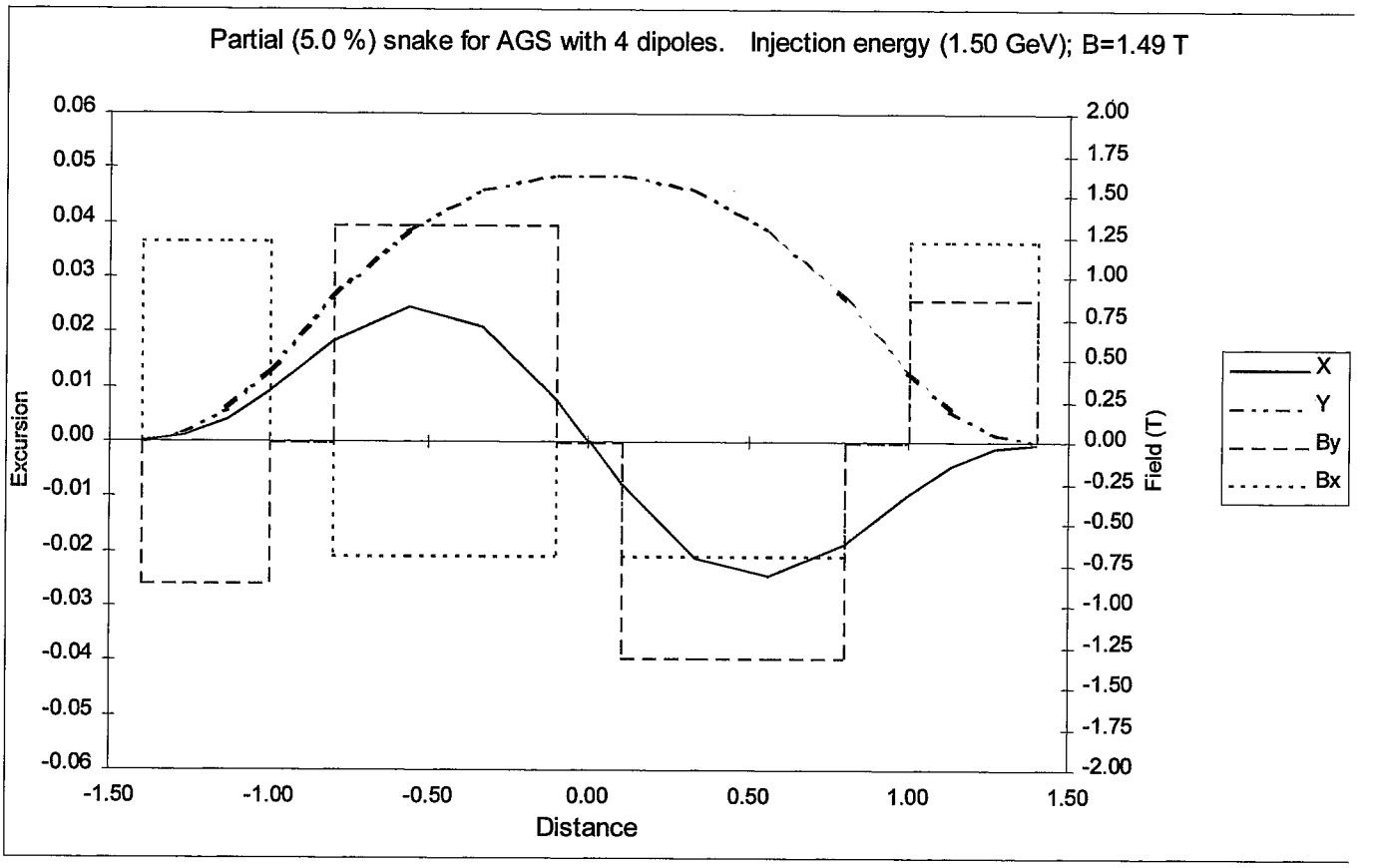

Fig. 3. Partial Snake with 4 Dipoles.

BL (tot)	3.289
Length	2.800
xmax (cm)	2.445
ymax (cm)	4.868

	Length	Field	Angle fr. vertical
Magnet	0.400	1.495	54.574
gap	0.200		
Magnet	0.700	1.495	207.752
gap	0.200		
Magnet	0.700	1.495	-27.752
gap	0.200		
Magnet	0.400	1.495	125.426