BNL-103707-2014-TECH

AGS/RHIC/SN 082;BNL-103707-2014-IR

Making the ATR Line Spin Transparent

E. D. Courant

September 1999

Collider Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

DISCLAIMER

Alternating Gradient Synchrotron Department
Relativistic Heavy Ion Collider Project
BROOKHAVEN NATIONAL LABORATORY
Upton, New York 11973

Spin Note

AGS/RHIC/SN No. 082

Making the ATR Line Spin Transparent

E.D. Courant
BNL

September 1, 1999

Making the ATR Line Spin Transparent

E D Courant

September 1, 1999

The ATR line has two pitching magnets (bending the beam down by 12.5 milliradians and then up again) in order to provide for the difference in level between the AGS and RHIC. Between these there are six 2.5 degree horizontal bends. As a result the line is spin-transparent at a "magic energy" $G\gamma = 48$, at which the horizontal precession is just $G\gamma$ times 2.5 degrees = 720 degrees. However, because of spin resonances in the AGS, it is preferable to inject polarized protons into RHIC at lower energies, preferably around $G\gamma = 41.5$ .At this energy the spin is not preserved, necessitating complicated spin gymnastics to obtain a vertical spin in RHIC.

The spin precession between the two pitching magnets can be forced to be 720 degrees by the insertion of a "Type 3" partial snake, i.e. a device which rotates the spin around the vertical axis without net displacement of the orbit. With the preferred injection energy of $G\gamma = 41.5$ this rotation has to be 97.5 degrees; in general the desired rotation is $\varphi = 720(48- G\gamma)/48$ degrees. Several configurations are possible.

The conceptually simplest version (presented at the RHIC Spin meeting 7/28/99) encompasses seven bending magnets with alternate horizontal and vertical bends. Magnets 1,3,5 and 7 precess the spin by just half the desired precession angle φ (e.g. 47.25°) around the vertical axis, while 2,4,6 precess about the horizontal axis by 90°, 180°, 90° and therefore need 2.74 and 5.48 Tesla-meters (independent of φ). (Fig.1).

J W Glenn pointed out that the existing 18D36 and 18D72 magnets might serve for this purpose. But unfortunately they are just a bit too short - the 18D36 is just about one meter long and the 18D72 2 meters, with maximum field 2.2 T, which falls short of the 2.74 and 5.48 T-m needed for this configuration.

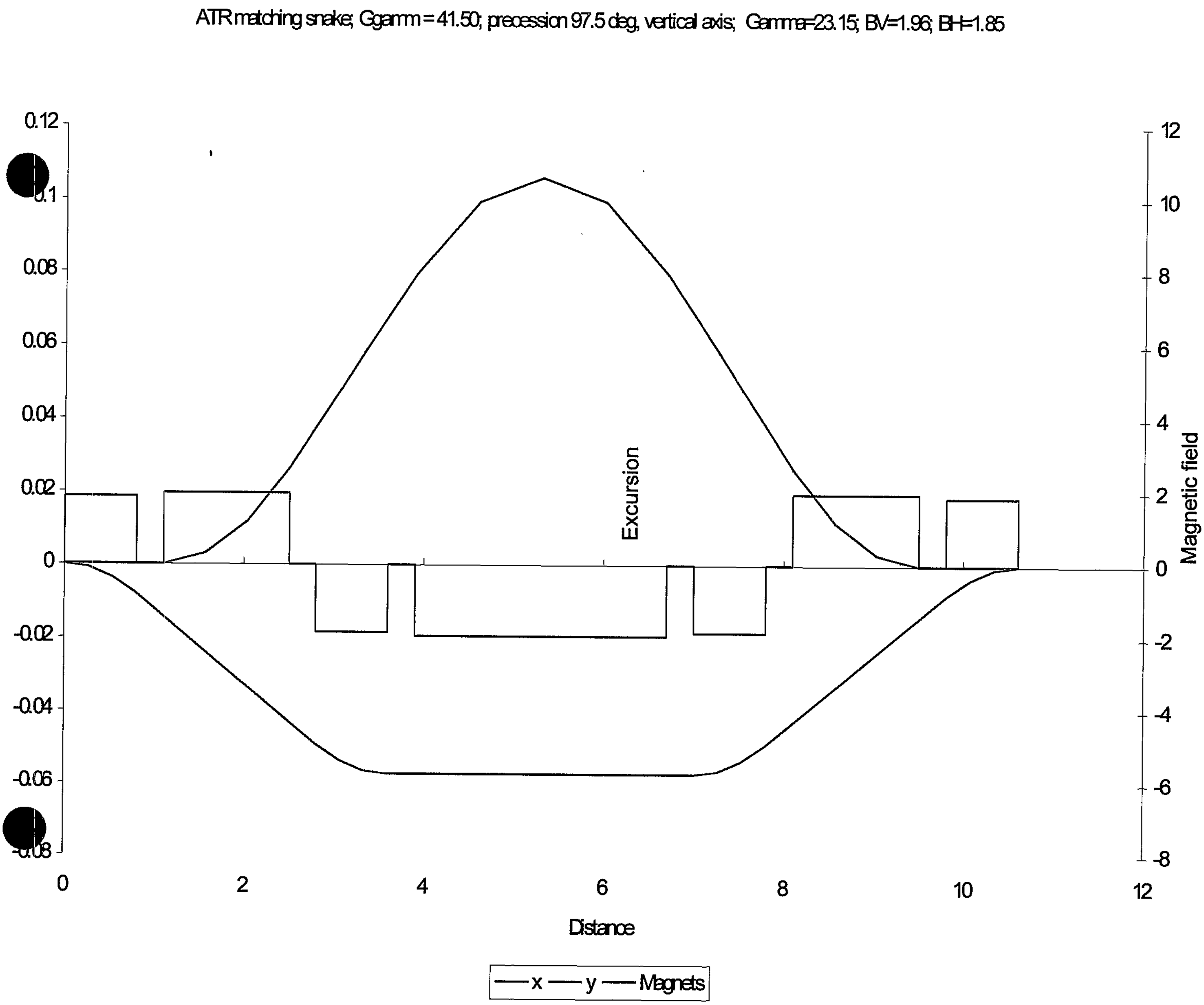
An alternate configuration can be achieved, with somewhat shorter magnets, but the magnets have to be tilted from horizontal and vertical. The configuration is again symmetric about the midpoint of the central magnet. I have found a configuration that employs magnets just matching the 18D36 and 18D72 (assuming that are effectively 1.0 and 2.0 meters long). The fields are (for $G\gamma = 41.5$) about 17 degrees from vertical and horizontal (Fig. 2). For different injection energies this tilt angle also comes out to be different, so the "snake" would preferably be mounted on a rotatable base.

A third scheme employs five magnets instead of seven, again tilted in odd directions. A scheme - again symmetric - with five equal magnets can be devised. The field direction of magnets 1 and 5 is ± 104.5 degrees from that of the central magnet; again the field direction varies with energy.

In any of these schemes the snake magnets may be inserted between any pair of bending magnets in the W line between the two pitch magnets; probably the best place is between dipoles WD3 and WD4, where there may be enough clearance below the beam to allow the insertion of magnets that are lying on their sides or tilted at some angle.

Optics calculations show that none of these schemes change the dispersion functions by more than a few cm, and change the betatron phase advances by less than about .02 units.

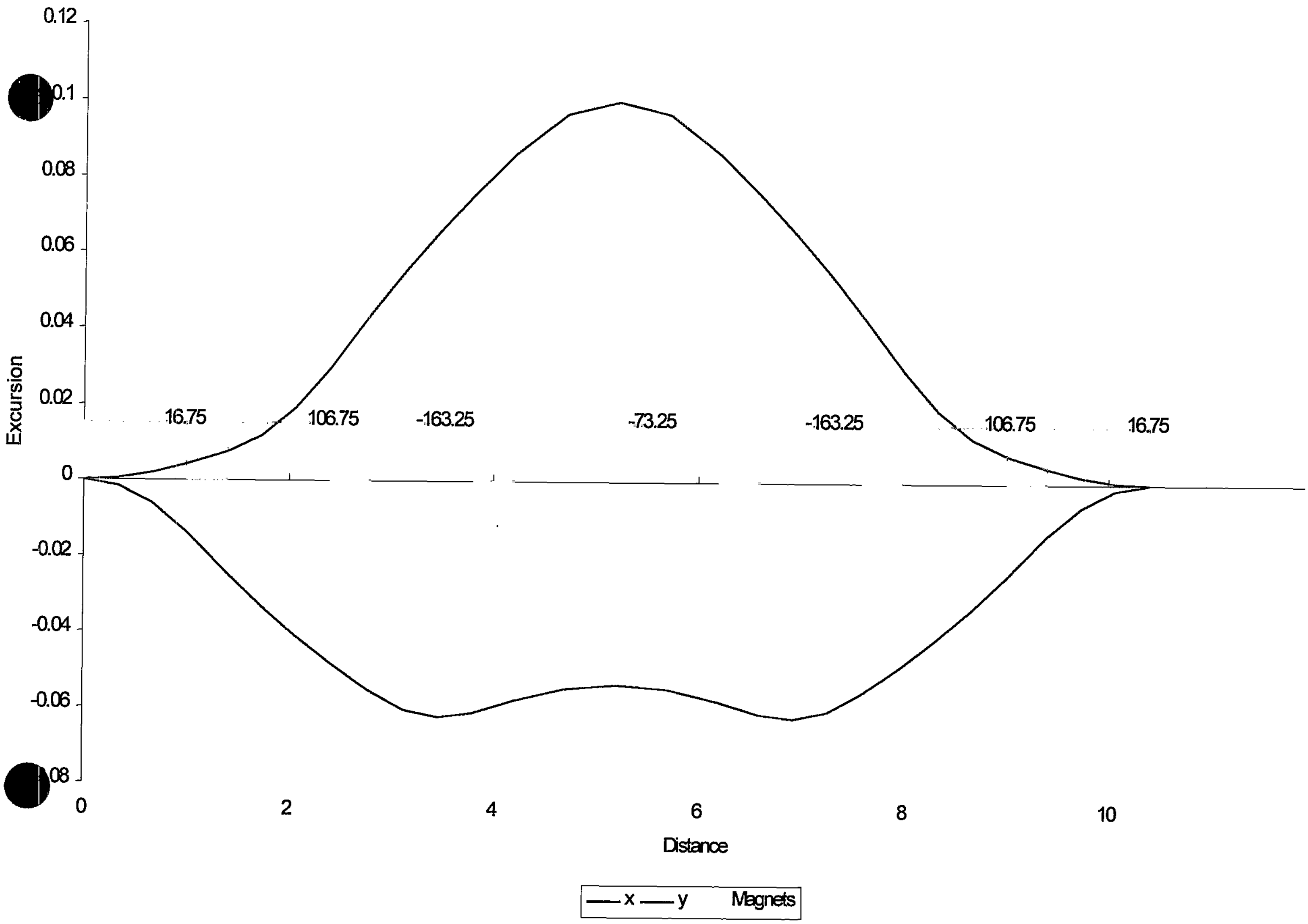
The tables and graphs below show that all these schemes require rather large magnet apertures; the maximum orbit excursion in the direction of the gap (along the field) at $G\gamma = 41.5$ is 7, 6 and 12 cm while the excursion across the gap (which is probably less crucial) is 11, 9, and 10 cm. From this point of view scheme B is probably the best.



Scheme A

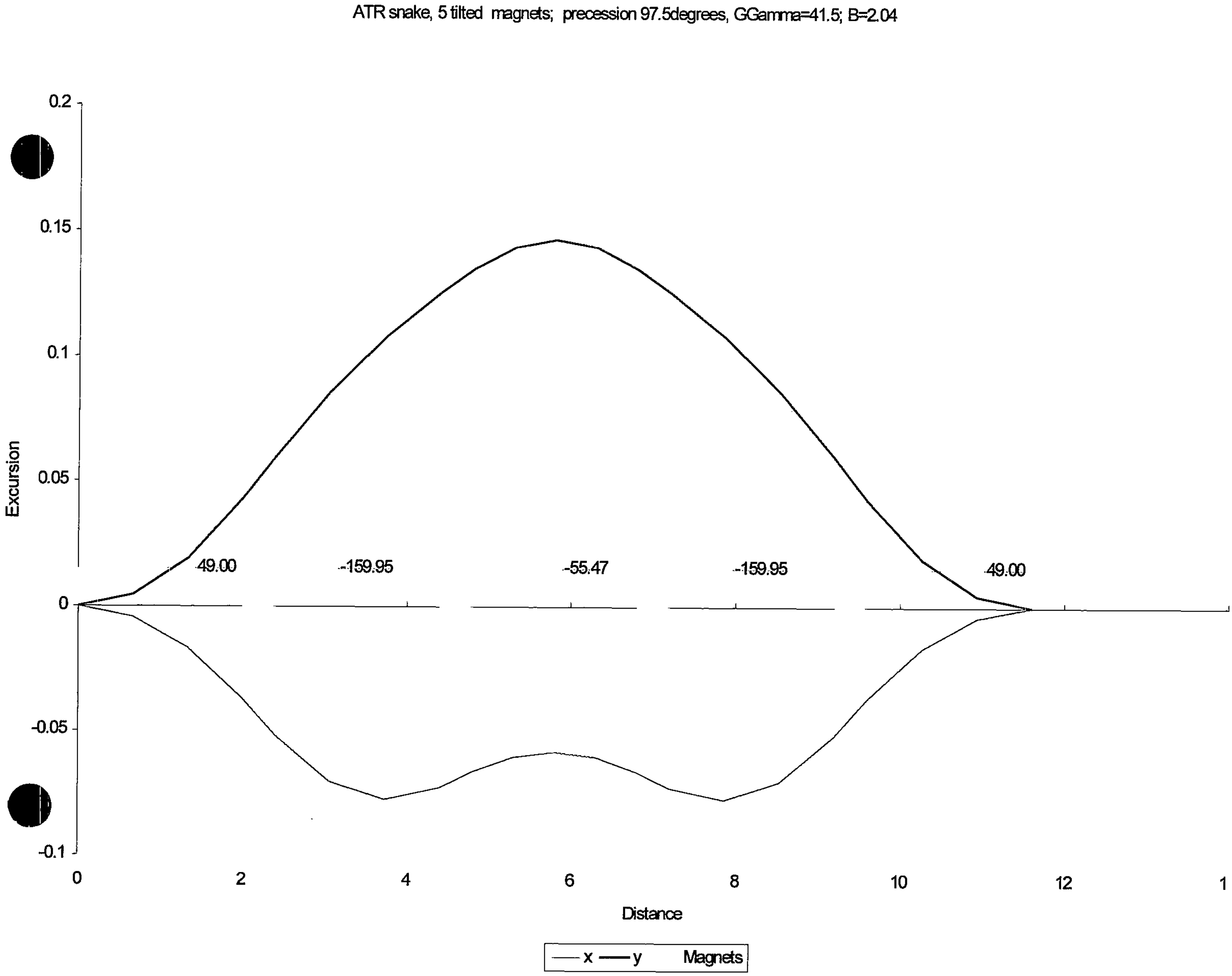
		Magnet 1	Magnet 2	Magnet 3	Magnet 4	Magnet 5	Magnet 6	Magnet 7
Gγ = 41.5	Length	0.8	1.4	0.8	2.8	0.8	2.8	0.8
	Field	1.85	1.96	1.85	1.96	1.85	1.96	1.85
	Direction from vertical	0	90	180	-90	180	90	0
Excursion	Max along B	0	.4.31	6.81	5.74	6.81	4.31	0
	Max across B	.82	2.65	5.74	10.60	5.74	2.65	.82
Gγ = 46.5	Field	0.43	1.96	0.43	1.96	0.43	1.96	0.43
	Direction from vertical	0	90	180	-90	180	90	0
Excursion	Max along B	0	.89	6.08	1.18	6.08	.89	0
	Max across B	.17	2.36	1.18	9.46	1.18	2.36	.17

ATR matching snake, 7 magnets tilted by 16.75 degrees; precession 97.5degrees, GGamma=41.5; B=2.08



Scheme B

Gγ = 41.5	Length	1.0	1.0	1.0	2.0	1.0	1.0	1.0
		Magnet 1	Magnet 2	Magnet 3	Magnet 4	Magnet 5	Magnet 6	Magnet 7
	Direction from vertical	16.7	106.7	-163.3	-73.3	-163.3	106.7	16.7
Excursion	Max along B	0	5.45	5.45	8.43	5.45	5.45	0
	Max across B	1.43	1.43	8.03	8.03	8.03	1.43	1.43
Gγ = 46.5	Field	1.18	1.18	1.18	1.18	1.18	1.18	1.18
	Direction from vertical	33.6	123.6	-146.4	-56.4	-146.4	123.6	33.6
Excursion	Max along B	0	2.77	2.77	4.08	2.77	2.77	0
	Max across B	.73	.73	4.08	4.08	4.08	.73	.73



Scheme C

		Magnet 1	Magnet 2	Magnet 3	Magnet 4	Magnet 5
Gγ = 41.5	Length	2.00	2.00	2.00	2.00	2.00
	Field	2.042	2.042	2.042	2.042	2.042
	Direction from vertical	49.025	-159.930	-55.452	-159.930	49.025
Excursion	Max along B	0	8.74	12.02	8.74	0
	Max across B	5.64	10.16	7.90	10.16	7.90
Gγ = 46.5	Field	1.146	1.146	1.146	1.146	1.146
	Direction from vertical	58.089	-150.866	-46.389	-150.866	58.089
Excursion	Max along B	0	4.58	6.02	4.58	0
	Max across B	2.83	5.01	3.96	5.01	2.83