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# Some Database Related Utilities

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## 1. Introduction:

A big project, like the SSC, entails a huge amount of information, and it is very important to manipulate the information carefully. Consequently, it may be essential to store, organize, and manipulate this information using a database. An accelerator lattice and footprint parameter database is now being established as a lattice/footprint design tool.

Essentially, the database stores many tables which provide a structure for the information. To apply the information for different purposes, utility programs are needed. For example, a program DBSF has been written which translate database contents to an ASCII file, in the "standard" MAD input format. This allows the database and lattice design programs to be connected in a way which will facilitate standardization of the SSC design.

The following note describes a few utility programs for footprint survey design.

## 2. Code VSM

The VSM (Virtual Survey Monument) code is a coordinate translating program. According to the requirements of the survey system, the north direction and center of the ring are defined in a special way which is different from the MAD survey output. VSM reads a MAD survey file as input, and provides the proper data for the survey system.

Assume four monuments at the end of the arcs and specify their names relative to their positions, i.e., northwest, northeast, southeast, and southwest. Because the Collider ring is not symmetric, the four monuments constitute the corners of a parallelogram. If we link the diagonal corners with straight lines, the crossing point, the center of gravity of the parallelogram, is taken as the center of the collider ring. Offsets are given to the center point so that every coordinate has a positive value.

Draw a line through the northwest monument to the northeast monument and define this direction as EAST. A line perpendicular to EAST defines the NORTH direction. By finding the rotation angle between the 'x-z' frame from MAD and the 'EAST-NORTH' frame, VSM performs a transformation for all coordinates, adds offsets and gives an output with coordinates in the 'EAST-NORTH' frame.

The survey system also requires that distances be measured in units of feet. VSM provides new coordinates in both meters and feet. The FOOT unit used in VSM is the so called "international foot", i.e., 1 foot is 12 inches, and 1 inch is 2.54 centimeters. Note that the "U.S. survey foot" is slightly different. The $\theta$ angle unit is also converted from radians to degrees.

VSM is ready on SUN workstations. The executable file is in directory:

    /usr/pistachio/u1/chen/bin

To run VSM, two input files, the survey file and vsm.cmd, are necessary. The survey file derives from MAD survey output. The vsm.cmd specifies the offsets of the ring's center and the name of the monuments. The user can copy this file from

    /usr/pistachio/u1/chen/footprint/vsm

and then use the following command to run the program:

    %: VSM < *surveyfilename* >! *outputfilename*

The output file contains the data of input file in the new coordinates with units in meters and feet.

## 3. Code WANDER

Fig. 1 shows an approximate description of the Collider footprint. This approximate footprint consists of four symmetric arcs. It has a simple geometrical shape, as opposed to the complicated lattice geometry, and is easy to describe and understand. It is also provides a good approximation for purposes such as the purchase of land. On the other hand, the previous CDR has a similar footprint, and it is convenient to compare with the previous one.

WANDER can find four arcs to fit the lattice layout, and compare the arcs with real survey data.

WANDER needs two survey files as input. One contains the junction points of the arcs; the other contains the real survey data. Usually, the arc file is created by deleting most of the data in the survey file, but retaining the points which are considered to be the arc junction points. WANDER links the first two points of the arc, gets the direction of 'EAST', then does a coordinate transformation as in VSM. The same transformation will be applied to survey data as well, so that the two rings are comparable.

To fit the lattice layout a few constraints should be considered for choosing the four arcs. First, the circumferences of the two rings should be equal. Second, the arcs must be connected tangentially continuous. Also, the four arcs should be symmetric.

WANDER works out the arc lengths and rotation angles from the input data, so that the arc lengths remain unchanged. The radii of the arcs are calculated as arc length divided by subtended angle. The centers of the first and third arc, the ARC part of the Collider, are not aligned along the NORTH axis because of the asymmetry of the Collider. WANDER symmetrizes them by removing the EASTward displacement of the centers. On the other hand, to meet the tangential continuity requirement, the junction point of two arcs should be connected by a straight line determined by the centers of the two arcs, as shown in Fig. 1. The arc centers can be determined using geometric relations, angles and radii of the arcs. The position of the junction points could be a little different from the first input file data, but the constraints are satisfied.

WANDER gives the radius of each arc, the coordinates of the arc center, and the errors between the two rings in its output. It also provides topdrawer files to illustrate the radial error and tangential error along the azimuth.

For a better approximation to the asymmetric layout, the four arc approximation may be rotated by a small angle. WANDER has included this function. Fig. 2 shows the maximum and minimum error related to the rotation angle. Without rotation, the maximun and minimum errors are 89.3 and -87.0 meters, with a difference of 176.3 meters. The minimum difference of the maximum and minimum error appears at 2 degrees. Here, the maximum and minimum errors are 36.1 and -26.0 meters. The maximum-minimum difference is 62.1 meters, which is less than half the case without rotating. Fig. 3(a, b) shows the error distribution along the ring without rotation and with 2 degree rotation, respectively.

WANDER is ready for use on SUN stations. It can be found in the directory:

/usr/pistachio/u1/chen/footprint/wander

The command file, wander.cmd, specifies the names of input and output files, limits of topdrawer, files, rotation angles, et cetera. The input files, both the arc data and the real layout data, should have MAD survey output format. The results can be displayed on terminal, or put into a file by using following commend:

%: wander >! *filename*

## 4. Train-set approximation and WANDA

The four arc approximation is a very rough approximation. The errors are usually a few tens of meters. It is good for an overall view, but not for detailed structure. During the period of design, the lattice may change frequently. A better but still relatively simple approximation is necessary to examine changes in the foot print. Train-set is an idea to meet this requirement.

Train-set consists of two components: straight line and arc. The length of each component is usually based on a half cell. For example, a regular half cell becomes one arc in train-set, instead of the usual bends, quadrupoles and straight sections. A complicated machine such as the SSC can be constructed entirely from regular cell arcs, dispersion suppressor cell arcs and empty cells, i.e, straight lines. It is very easy to reconstruct the whole footprint for different plans in this way.

A train-set which describes the Collider footprint is contained in a database called *collider_ts*. The arcs are defined as one sector bends, and a straight section is defined as drift. Of course there is no meaning in terms of an optical lattice. This model is only for the survey calculation.

The beamline name of the entire ring is *SSC*. A MAD input file can be created using the program **dbsf.** Type in

%: dbsf SSC collider_ts > *filename*

and **dbsf** will get the file describing the beamline in MAD input format. Before running MAD, a few command lines should be added to the end of the input file to run the survey routine. The monuments, called VSMNW, VSMNE, VSMSE and VSMSW, which are required for running **vsm**, are already set in the beamline. The survey data can be used by **vsm** directly.

WANDA is a program written for comparing the survey data of the train-set and real layout, or any two layouts. The input data files should be the survey data processed by **vsm**, so that the two rings have the same coordinate frame, and are comparable. The monument's names and their positions have to be the same as that used by train-set.

The comparing process is based on calculating the distance from a point to a line. The first layout is taken as the standard, and every pair of consecutive points is connected by a straight line. Each point from the second layout can then be determined between two connected points of the first layout according to its azimuth position, and the distance from the point to the line is then calculated. This distance is taken as the error, and written to a topdrawer file:*err.top*. The maximum, minimum and RMS errors are reported on the terminal. It is an approximation to take the error as the distance from a point to a line, instead of to an arc, but for a short and small bending arc, like a Collider half cell, this is acceptable.

WANDA is in the same directory as WANDER. A command file, WANDA.CMD, is needed to run WANDA. This is a file similar in structure to WANDER.CMD. It provides running imformation for WANDA.

As an example, we use WANDA to compare the Collider train-set with the real layout. Fig. 4 shows the error configuration along the ring. The maximum and minimum error is 0.709 and -0.692 meters respectively, which is about 1/100 of the four arc approximation.

## 5. An example

The following is an example of how to use these utilities:

Set to your user's directory, and copy command files to the directory

%: cp ~chen/footprint/wander/*.cmd .

*vsm.cmd, wander.cmd, wanda.cmd, madin.cmd* should then be in your directory. Make sure that the programs **dbsf, vsm** and **MAD** are ready for working by putting ~chen/bin and ~chen/footprint/wander in your path, and alias *dbsf* to "~peggs/stdcvt/dbsf/dbsf -sge".

Extract train-set data from databsae

%: dbsf SSC collider_ts >! ssc_ts.dat

Add MAD command

%: cat ssc_ts.dat madin.cmd >! ssc_ts.in

Run MAD

%: mad ssc_ts

A survey data output file, ssc_ts.out, is generated. Then, use VSM to transform the coordinate frame

%: vsm < ssc_ts.out >! ssc_ts.point

The file *ssc_ts.point* provides the data survey system required. Another survey file, *g4.survey*, which is MAD survey output for the real lattice, should be transformed to the survey system required format

%: vsm < ~chen/footprint/wander/g4.survey >! g4.point

Compare these two layout with WANDA by typing

%: wanda

Results are reported on terminal and in a topdrawer file. If the SUN station is running X-window, the error distribution can be plotted by typing

%: td err.top

The whole process is simple and well organized. If there are changes in the lattice plan, one need only modify the database and repeat the process.

## 6. Conclusions

Using the database is an excellent method to store and manipulate the SSC lattice information, but utility programs are also important for connecting database with user applications. Based on database and utility programs, some well organized processes can be established, so that it is possible to deal with many plans and compare them. It could be very useful in making decisions.

In this paper, several utility programs are introduced. They are used for processing survey data of footprints. This is also an example of a working process based on database.

**Acknowlegement**

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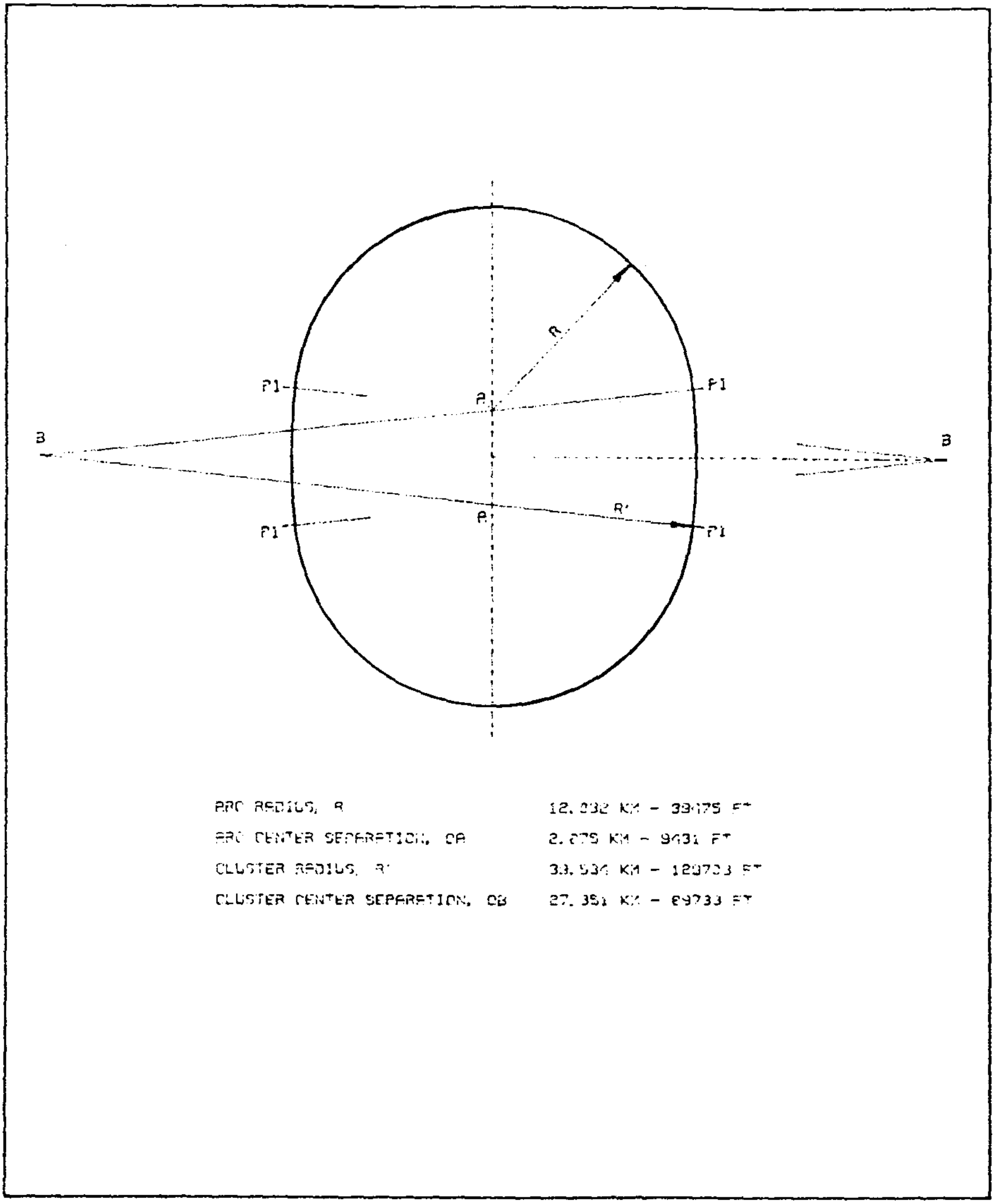



Fig. 1 Four-arc approximation of the Collider footprint.

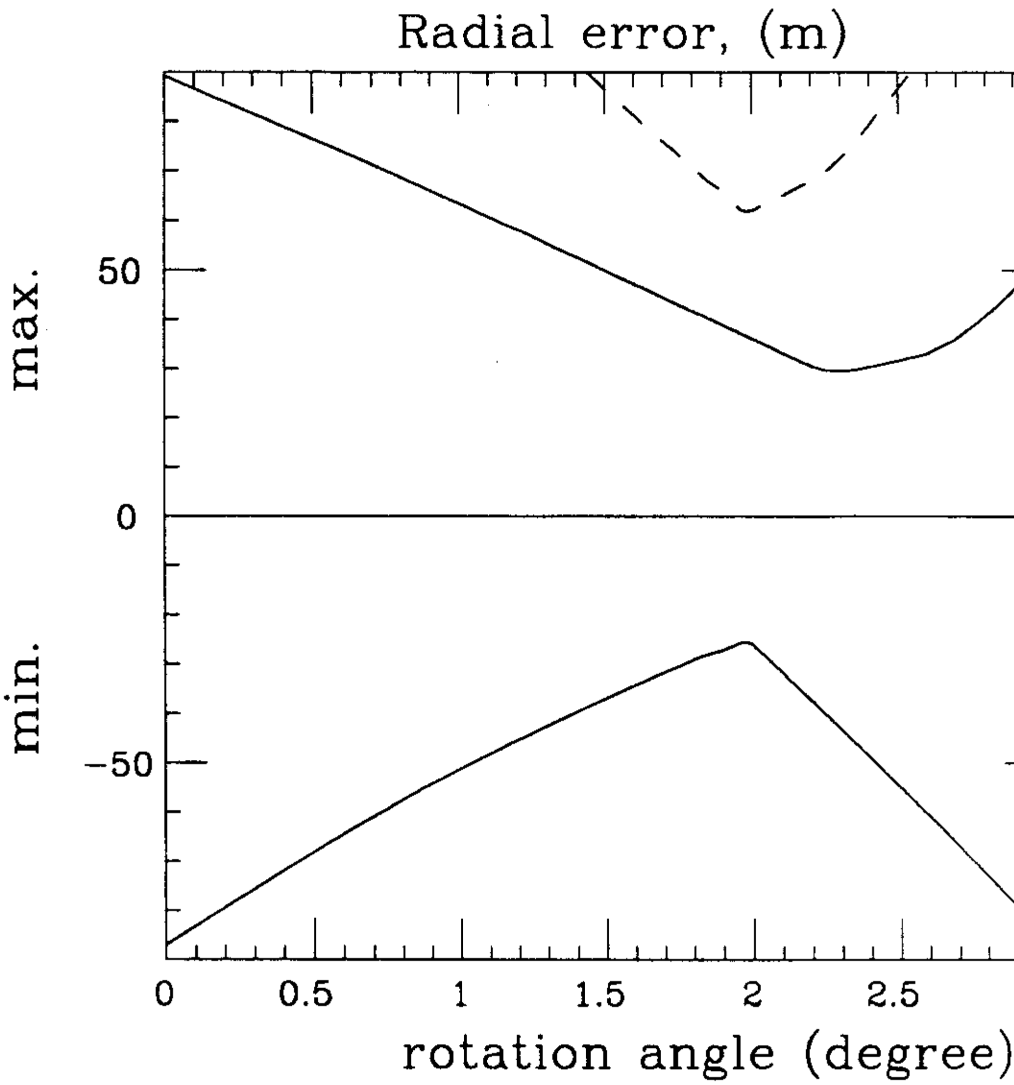
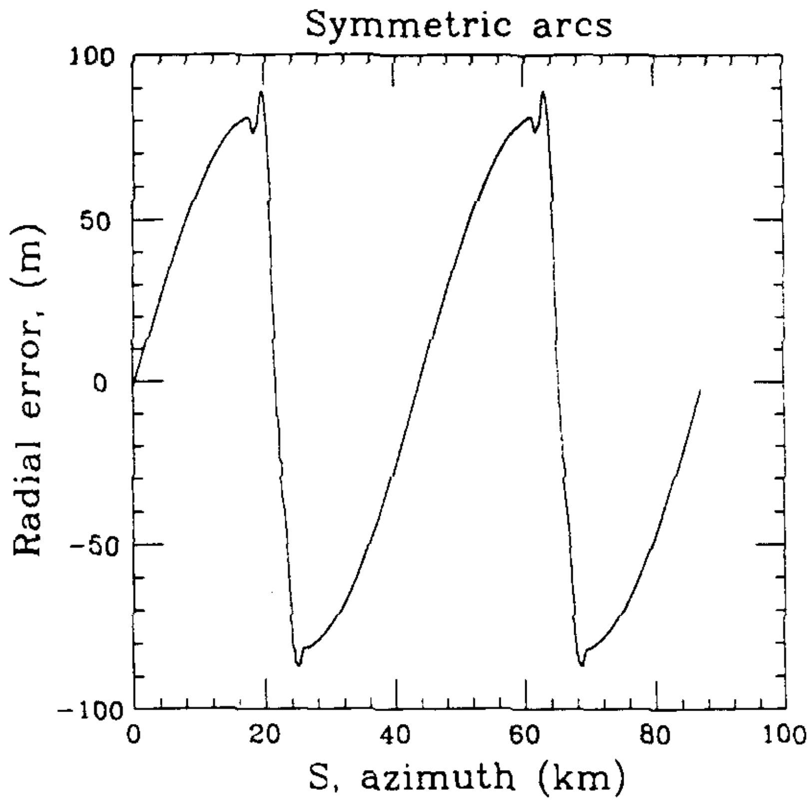
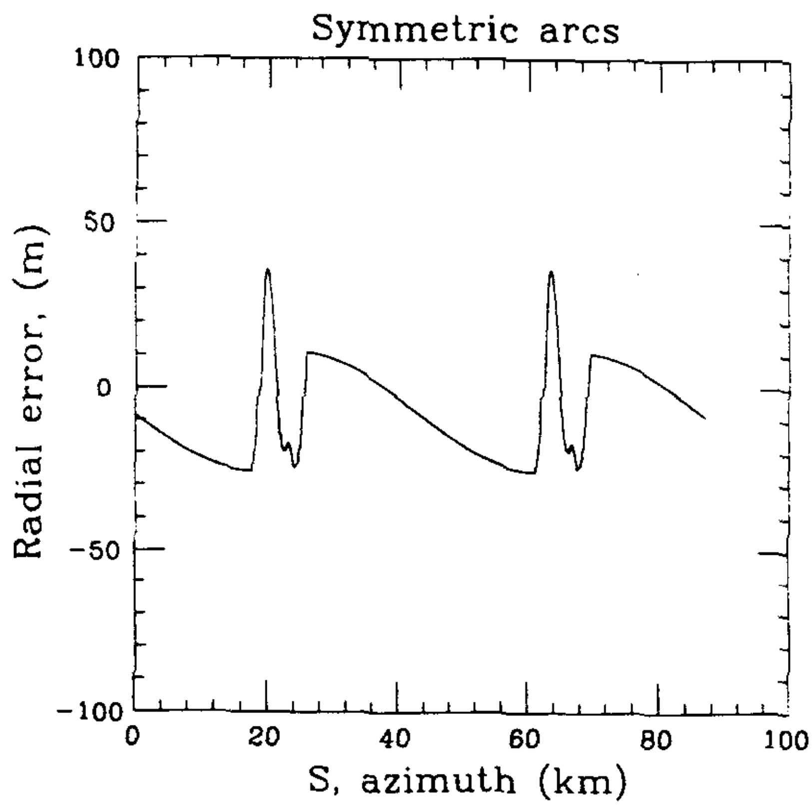



**Fig. 2** The radial error versus rotation angle.




(a) without rotation




(b) with 2 degree rotation

Fig. 3 The error distribution along the ring.

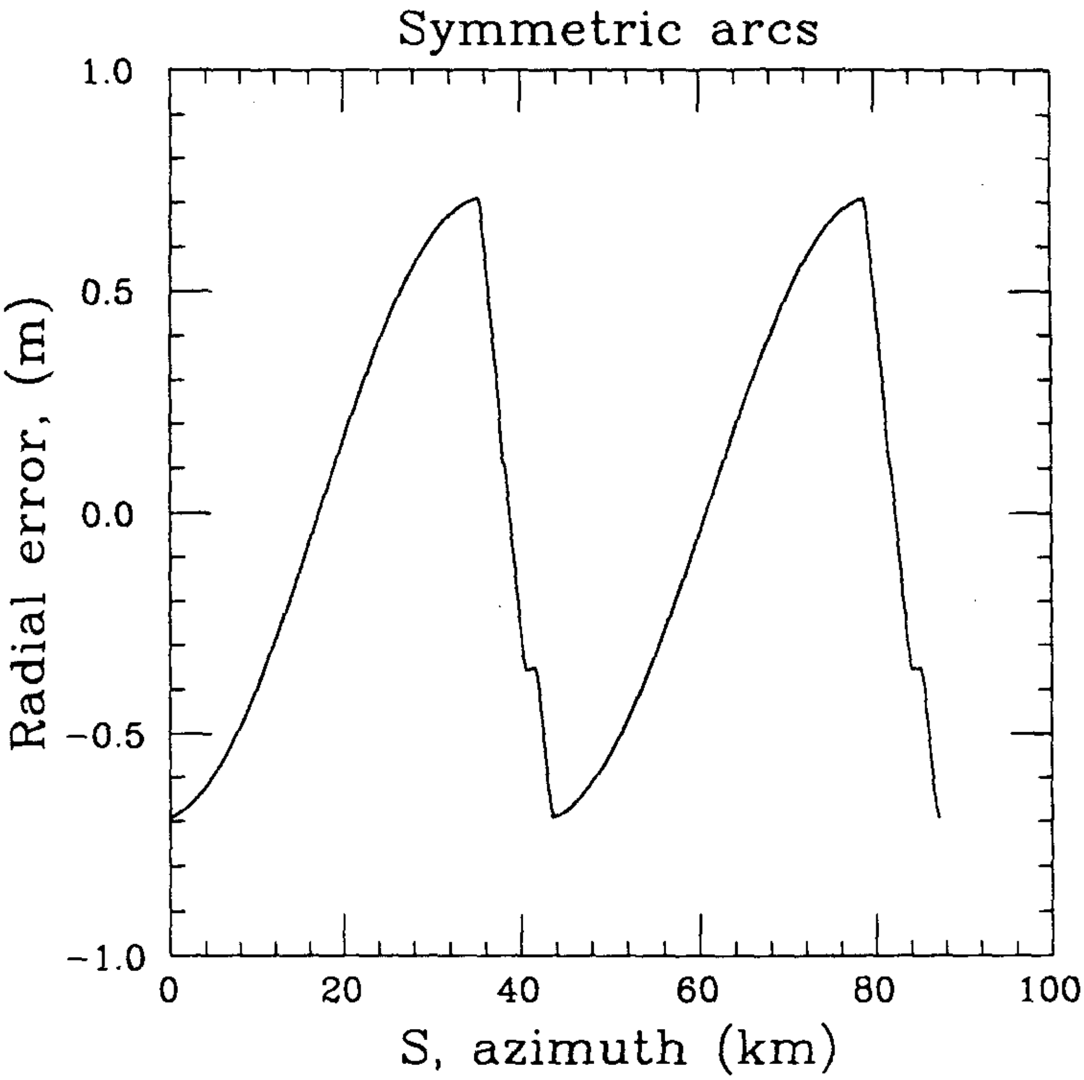



Fig. 4 The error configuration between the trainset and real lattice.