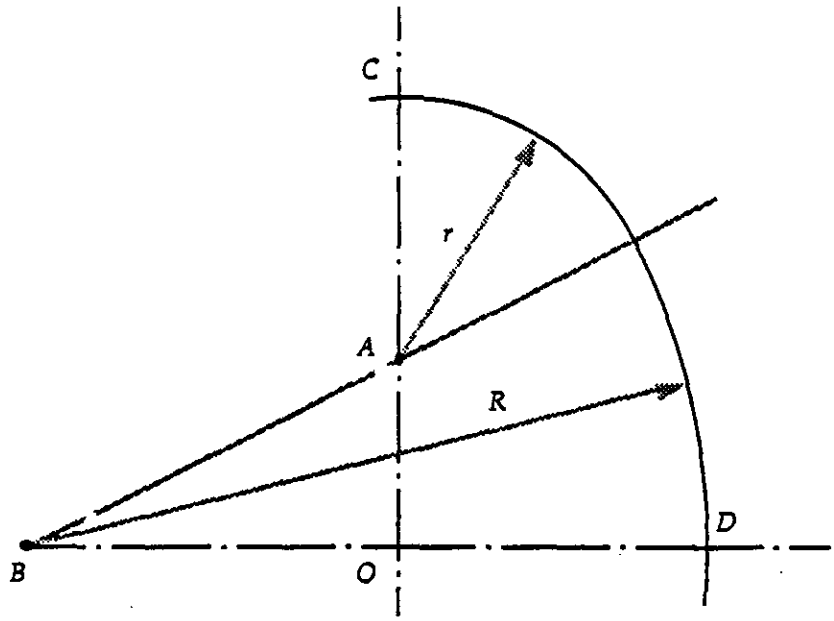
11/16/87
G. Drouet

# Construction of a Template

To build a simplified template (see figure below) we can use the data included in the parameter list and in the printout of the lattice called "MAD."




PARAMETER LIST

This document gives, among others:

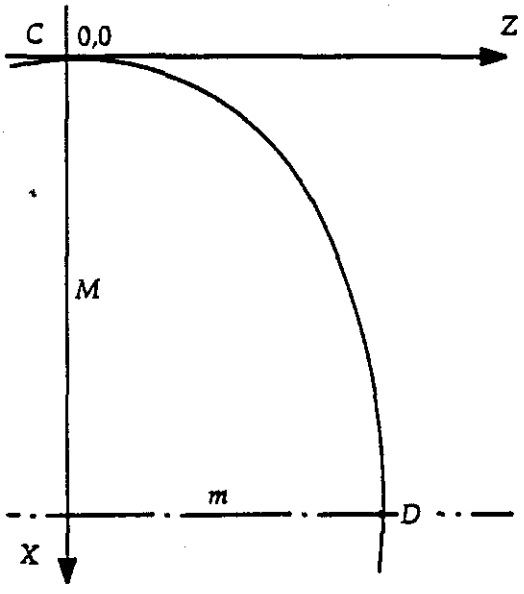
$L_c$: length of a standard cell
$\theta_c$ : bend angle of a cell
$\theta_m$: bend angle of a magnet
$n$ : nbr of dipoles/cell
$N$: nbr of dipoles in main ring

We calculate the average radius of the arc, assuming uniform bending within the cell:

$$r = \frac{L_c}{\theta_c} = \frac{L_c}{n\theta_m} = \frac{L_c N}{2\pi n}$$

MAD

The printout starts at $\begin{cases} X = 0 \\ Z = 0 \end{cases}$ which are the coordinates of point C in the figures above and below:




The coordinates of *D* correspond to half the major (*M*) and minor (*m*) axis.

To determine these coordinates we must find the higher value in the *Z* column ($^1/2$ minor axis: *m*) and read the corresponding value of *X* ($^1/2$ major axis: *M*).

The following page shows an example of a MAD output with the corresponding values for *m* and *M*
$\begin{cases} m = 11963.089 \text{ m} \\ M = 14851.718\ m \end{cases}$

THE TEMPLATE

The template is a diagram that approximates the actual geometry as calculated by the lattice and must follow this geometry as closely as possible.

To avoid confusion, we choose to have the same minor and major axis for the actual geometry and the template.

Therefore, one can draw the diagram without major deviations, by using two radii and two turning points as shown in the figure on page 1, the arcs being continuous at their junction.

SSC 90 DEGREE CELL LATTICE A. GARREN "MAD" VERSION: 6.01/03 RUN: 2-JUN-0 19:09:43
SURVEY OF BEAM LINE ",SP ", RANGE = #S / #E" PAGE 1

| POS. NO. | ELEMENT NAME | ELEMENT OCC. NO. | SEQUENCE SUM(L) M | SEQUENCE ARC M | I I I | POSITIONS X M | POSITIONS Y M | POSITIONS Z M | I I I | ANGLES THETA RAD | ANGLES PHI RAD | ANGLES PSI RAD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BEGIN | ,SP | 1 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 |
| 1 | #POL | 1 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 |
| 15 | #QFG | 1 | 142.812500 | 142.812500 | | -0.272111 | 0.000000 | 142.811856 | | -0.006559 | 0.000000 | 0.000000 |
| 27 | #QDG | 1 | 228.500000 | 228.500000 | | -1.103229 | 0.000000 | 228.495113 | | -0.013117 | 0.000000 | 0.000000 |
| 39 | #QFG | 2 | 314.187500 | 314.187500 | | -2.498578 | 0.000000 | 314.171039 | | -0.019676 | 0.000000 | 0.000000 |
| 51 | #QDG | 2 | 399.875000 | 399.875000 | | -4.453073 | 0.000000 | 399.836033 | | -0.026235 | 0.000000 | 0.000000 |
| 2419 | #CLF | 1 | 16280.625000 | 16280.625000 | | -9565.081860 | 0.000000 | 11529.126021 | | -1.393713 | 0.000000 | 0.000000 |
| 2420 | #QFG | 3 | 16280.625000 | 16280.625000 | | -9565.081860 | 0.000000 | 11529.126021 | | -1.393713 | 0.000000 | 0.000000 |
| 2432 | #QDG | 3 | 16366.312500 | 16366.312500 | | -9649.476657 | 0.000000 | 11543.952667 | | -1.400271 | 0.000000 | 0.000000 |
| 2444 | #QFG | 4 | 16452.000000 | 16452.000000 | | -9733.966402 | 0.000000 | 11558.228319 | | -1.406830 | 0.000000 | 0.000000 |
| 2456 | #QDG | 4 | 16537.687500 | 16537.687500 | | -9818.548325 | 0.000000 | 11571.947268 | | -1.413389 | 0.000000 | 0.000000 |
| 2486 | #IP | 1 | 17137.500000 | 17137.500000 | | -10411.504496 | 0.000000 | 11662.375386 | | -1.419947 | 0.000000 | 0.000000 |
| 2516 | #QFG | 5 | 17737.312500 | 17737.312500 | | -11004.548806 | 0.000000 | 11752.223654 | | -1.426506 | 0.000000 | 0.000000 |
| 2528 | #QDG | 5 | 17823.000000 | 17823.000000 | | -11089.386922 | 0.000000 | 11764.257167 | | -1.433065 | 0.000000 | 0.000000 |
| 2540 | #QFG | 6 | 17908.687500 | 17908.687500 | | -11174.302443 | 0.000000 | 11775.731731 | | -1.439623 | 0.000000 | 0.000000 |
| 2552 | #QDG | 6 | 17994.375000 | 17994.375000 | | -11259.291027 | 0.000000 | 11786.651975 | | -1.446182 | 0.000000 | 0.000000 |
| 2637 | #QDG | 7 | 18679.875000 | 18679.875000 | | -11941.134134 | 0.000000 | 11856.693837 | | -1.492093 | 0.000000 | 0.000000 |
| 2649 | #QFG | 7 | 18765.562500 | 18765.562500 | | -12026.578733 | 0.000000 | 11863.138353 | | -1.498651 | 0.000000 | 0.000000 |
| 2661 | #QDG | 8 | 18851.250000 | 18851.250000 | | -12112.063573 | 0.000000 | 11869.025066 | | -1.505210 | 0.000000 | 0.000000 |
| 2673 | #QFG | 8 | 18936.937500 | 18936.937500 | | -12197.585326 | 0.000000 | 11874.348709 | | -1.511768 | 0.000000 | 0.000000 |
| 2703 | #IP | 2 | 19651.000000 | 19651.000000 | | -12910.650224 | 0.000000 | 11912.069502 | | -1.518327 | 0.000000 | 0.000000 |
| 2733 | #QDG | 9 | 20365.062500 | 20365.062500 | | -13623.743664 | 0.000000 | 11949.246823 | | -1.524886 | 0.000000 | 0.000000 |
| 2745 | #QFG | 9 | 20450.750000 | 20450.750000 | | -13709.352593 | 0.000000 | 11952.910517 | | -1.531444 | 0.000000 | 0.000000 |
| 2757 | #QDG | 10 | 20536.437500 | 20536.437500 | | -13794.983792 | 0.000000 | 11956.010371 | | -1.538003 | 0.000000 | 0.000000 |
| 2769 | #QFG | 10 | 20622.125000 | 20622.125000 | | -13880.633398 | 0.000000 | 11958.551277 | | -1.544562 | 0.000000 | 0.000000 |
| 2770 | #QFG | 11 | 20622.125000 | 20622.125000 | | -13880.633398 | 0.000000 | 11958.551277 | | -1.544562 | 0.000000 | 0.000000 |
| 2782 | #QDG | 11 | 20707.812500 | 20707.812500 | | -13966.297907 | 0.000000 | 11960.526914 | | -1.551120 | 0.000000 | 0.000000 |
| 2794 | #QFG | 12 | 20793.500000 | 20793.500000 | | -14051.973484 | 0.000000 | 11961.943545 | | -1.557679 | 0.000000 | 0.000000 |
| 2806 | #QDG | 12 | 20879.187500 | 20879.187500 | | -14137.656532 | 0.000000 | 11962.795943 | | -1.564238 | 0.000000 | 0.000000 |
| 2836 | #IP | 3 | 21593.250000 | 21593.250000 | | -14851.718318 | 0.000000 | 11963.089197 | | -1.570796 | 0.000000 | 0.000000 |
| 2866 | #QFG | 13 | 22307.312500 | 22307.312500 | | -15565.780105 | 0.000000 | 11962.795942 | | -1.577355 | 0.000000 | 0.000000 |
| 2878 | #QDG | 13 | 22393.000000 | 22393.000000 | | -15651.463152 | 0.000000 | 11961.943544 | | -1.583914 | 0.000000 | 0.000000 |
| 2890 | #QFG | 14 | 22478.687500 | 22478.687500 | | -15737.138729 | 0.000000 | 11960.526912 | | -1.590472 | 0.000000 | 0.000000 |
| 2902 | #QDG | 14 | 22564.375000 | 22564.375000 | | -15822.803238 | 0.000000 | 11958.551276 | | -1.597031 | 0.000000 | 0.000000 |
| 2903 | #QDG | 15 | 22564.375000 | 22564.375000 | | -15822.803238 | 0.000000 | 11958.551276 | | -1.597031 | 0.000000 | 0.000000 |
| 2915 | #QFG | 15 | 22650.062500 | 22650.062500 | | -15908.452845 | 0.000000 | 11956.010370 | | -1.603590 | 0.000000 | 0.000000 |
| 2927 | #QDG | 16 | 22735.750000 | 22735.750000 | | -15994.084044 | 0.000000 | 11952.910515 | | -1.610148 | 0.000000 | 0.000000 |
| 2939 | #QFG | 16 | 22821.437500 | 22821.437500 | | -16079.692972 | 0.000000 | 11949.246821 | | -1.616707 | 0.000000 | 0.000000 |
| 2969 | #IP | 4 | 23535.500000 | 23535.500000 | | -16792.786413 | 0.000000 | 11912.069499 | | -1.623266 | 0.000000 | 0.000000 |
| 2999 | #QDG | 17 | 24249.562500 | 24249.562500 | | -17505.851311 | 0.000000 | 11874.348705 | | -1.629824 | 0.000000 | 0.000000 |
| 3011 | #QFG | 17 | 24335.250000 | 24335.250000 | | -17591.373063 | 0.000000 | 11869.025062 | | -1.636383 | 0.000000 | 0.000000 |
| 3023 | #QDG | 18 | 24420.937500 | 24420.937500 | | -17676.857904 | 0.000000 | 11863.138349 | | -1.642941 | 0.000000 | 0.000000 |
| 3035 | #QFG | 18 | 24506.625000 | 24506.625000 | | -17762.302503 | 0.000000 | 11856.693833 | | -1.649500 | 0.000000 | 0.000000 |
| 3128 | #QFG | 19 | 25192.125000 | 25192.125000 | | -18444.145609 | 0.000000 | 11786.651970 | | -1.695411 | 0.000000 | 0.000000 |
| 3140 | #QDG | 19 | 25277.812500 | 25277.812500 | | -18529.134194 | 0.000000 | 11775.731726 | | -1.701969 | 0.000000 | 0.000000 |
| 3152 | #QFG | 20 | 25363.500000 | 25363.500000 | | -18614.049715 | 0.000000 | 11764.257162 | | -1.708528 | 0.000000 | 0.000000 |
| 3164 | #QDG | 20 | 25449.187500 | 25449.187500 | | -18698.887830 | 0.000000 | 11752.223648 | | -1.715087 | 0.000000 | 0.000000 |
| 3194 | #IP | 5 | 26049.000000 | 26049.000000 | | -19291.932140 | 0.000000 | 11662.375379 | | -1.721645 | 0.000000 | 0.000000 |
| 3224 | #QFG | 21 | 26648.812500 | 26648.812500 | | -19884.888311 | 0.000000 | 11571.947261 | | -1.728204 | 0.000000 | 0.000000 |

To build the diagram we must calculate the distances $OA$, $OB$, and the radius $R = BD$

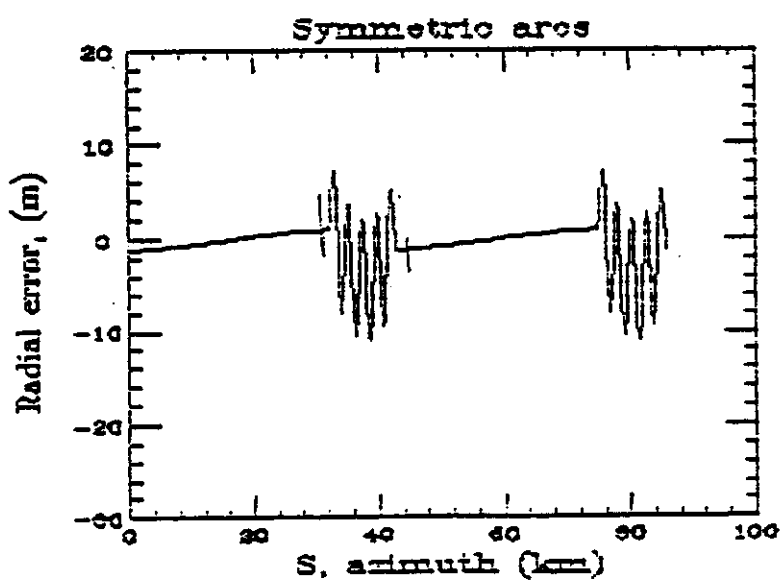
- $OA = M - r$
- $OB = R - m$

where

- $R = \frac{(M-r)^2}{2(m-r)} + \frac{m+r}{2} = BD$

APPLICATION TO THE ISP

$$\text{data} \begin{cases} L_C = 229.14 \text{ m} \\ N = 3848 \\ n = 12 \\ M = 48\,331 \\ m = 39\,315 \end{cases}$$

- $r = \frac{229.14 \times 3848}{0.3048 \times 2\pi \times 12} = 38\,367'$
- $OA = M - r = 9964'$
- $R = \frac{(M-r)^2}{2(m-r)} + \frac{m+r}{2} = 91\,205'$
- $OB = R - m = 51\,890'$

<u>Remark</u>: The maximum deviation between the template and the real geometry was 33 feet (template outside the real geometry) and 23 feet (template inside the real geometry), and was limited to the experimental straights and the dispersion-suppressor areas (see figure below).