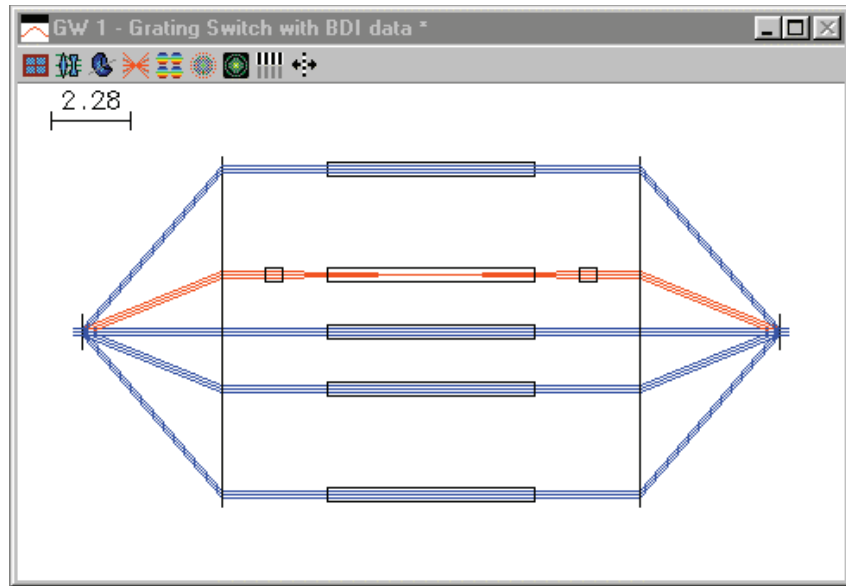## *Grating Switch*

Array ray tracing can be combined with multiconfiguration (zoom) data to handle a wide variety of different systems. Here, we show as an example a grating switch, which uses diffraction gratings to disperse a beam into several different channels and then recombine it for further transmission. The particular system shown here is a simple 5x one-dimensional switch, but the techniques used are also applicable to 2D arrays. The final system is shown below.

The switch shown here doesn't actually do anything useful, it is just an example of how to set up such a system in OSLO. It consists of four 600 line/mm gratings, 5 glass rods, and 2 lenses, arranged as shown. An input beam enters the system from the left, is diffracted into several orders (5 shown), redirected by a second grating, transmitted through various channels, and then recombined by a symmetrical set of gratings into an output beam that exits to the right.

There are several steps needed to set up such a system in OSLO, some optical ones needed for design/evaluation, and some cosmetic ones need to draw a picture of the final system. An important consideration is that OSLO, being fundamentally a design program, does not split rays; for each input ray there is one output ray. In the above figure, 15 rays are traced, 3 for each channel. In order to handle the multichannel arrangement of the system, we use zoom data, with each configuration representing one chanel. Although the present system has only 5 channels, OSLO accommodates an unlimited number of zoom configurations, so the potential exists to extend the method used here to dozens or even hundreds of channels.

The switch shown here switches channels by diffraction into various orders. In the layout, we associate a diffraction order with each zoom position, ordered 0, 1, 2, -2, -1. This is combined with array ray tracing so that each configuration uses one channel. Because diffraction orders are spaced according to the sines of angles, the various channels are not equally spaced, so a tabular array is used to define them.

In array ray tracing, each channel must be the same, but in the present system there is a need for one of the channels to be different from the others. This is accommodated by a capability in OSLO to handle what are called *skip* surfaces. A skip surface is one that redirects the ray trace to another surface (further on). For example, in the present system surface 4 is made a skip surface with a target of 6, in all configurations except cfg 2. The result is that surfaces 4 and 5 are ignored except in configuration 2.

The data for the grating switch is shown in the spreadsheet below, and the special data listing that follows.

Surface Data

Gen | Setup | Wavelength | Field Points | Variables | Draw Off | Group | Notes

Lens: Grating Switch   << Zoom >>   1 of 5   Efl -7.5558e+35

Ent beam radius   0.100000 | Field angle   5.7296e-05 | Primary wavln   0.632800

SRF	RADIUS	THICKNESS	APERTURE RADIUS	GLASS	SPECIAL
OBJ	0.000000	1.0000e+20	1.0000e+14	AIR	
AST	0.000000	4.000000	0.500000 A	AIR	FD
2	0.000000	0.000000	5.000000	AIR	F
3	0.000000	3.000000	5.000000	AIR	FD
SKP	3.500000	0.500000	0.200000	BK7 C	F
SKP	-3.500000	1.250000	0.200000	AIR	
6	0.000000	6.000000	0.200000	BK7 C	
7	0.000000	3.000000	0.200000	AIR	
SKP	3.500000	0.500000	0.200000	BK7 C	F
SKP	-3.500000	0.000000	0.200000	AIR	
10	0.000000	12.000000	5.000000	AIR	C
11	0.000000	4.000000	5.000000	AIR	FD
12	0.000000	2.000000	0.500000	AIR	FD
IMS	0.000000	0.000000	5.000000		

```
*TILT/DECENTER DATA
 10      RCO    3

*SURFACE TAG DATA
  1      GOR    0           GSP     0.001667    GBO   0           GDP         --
         DRW ON
  2      DRW ON
  3      GOR    0           GSP     0.001667    GBO   0           GDP         --
         DRW ON
  4      SKP    6
  8      SKP   10
 11      GOR    0           GSP     0.001667    GBO   0           GDP         --
         DRW ON
 12      GOR    0           GSP     0.001667    GBO   0           GDP         --
         DRW ON

*LENS ARRAY DATA
 SRF 3:
 TYPE Tabular    END SURF 10    MAX CHANNELS 5            DRAW ALL CHANNELS: Yes
 CH NBR     X CTR         Y CTR         Z CTR      TLA        TLB          TLC
    1       --            --            --         --         --           --
    2       --          1.641655        --         --         --           --
    3       --          4.668182        --         --         --           --
    4       --         -4.668182        --         --         --           --
    5       --         -1.641655        --         --         --           --

*CONFIGURATION DATA
TYPE   SN    CFG  QUALF          VALUE
GOR     1     2     0                1
GOR     3     2     0               -1
GOR    11     2     0               -1
GOR    12     2     0                1
SKP     4     2     0                0
SKP     8     2     0                0
TH      3     2     0         1.250000
TH      7     2     0         1.250000
GOR    12     3     0                2
GOR     1     3     0                2
GOR    11     3     0               -2
GOR     3     3     0               -2
GOR     3     4     0                2
GOR    11     4     0                2
GOR    12     4     0               -2
GOR     1     4     0               -2
GOR    12     5     0               -1
GOR     1     5     0               -1
GOR     3     5     0                1
GOR    11     5     0                1
```

Surfaces 1 and 3 accommodate the gratings that diffract the beam into various orders and redirect the orders so they are parallel to the axis of the system. Since there is no refractive index associated with these surfaces, they need to be tagged (SPECIAL>>Surface Control>>General) in order to be drawn. Surface 3 also serves as the channel surface for the array. Surface 2 is a dummy surface in contact with the channel surface, used for drawing *bdi* data (to be discussed), and has no optical function.

Surface 3 is marked as an array surface (SPECIAL>>Surface Control>>Tabular array), and holds the *y*-decentration data for each channel. In order to determine the data values, a chief ray is traced from the edge of the field (here defined to be at 1 micro-radian) using the **Chf** button in the text window. The required data from the spreadsheet buffer is copied to the clipboard using CTRL+click, and pasted into the appropriate cell in the tabular array spreadsheet. Note that you must activate an array element by clicking on the row button prior to entering data for it.

Surface 4 is tagged as a skip surface, as discussed above (SPECIAL>>Surface Control>>General) and data for a bi-convex lens is entered on surfaces 4 and 5. Surfaces 6 and 7 define a BK7 glass rod that will be seen in all configurations. Surface 8 is tagged as a skip to surface 10, and surfaces 8 and 9 define a second BK7 lens like the first.

The configuration data for the system mostly defines the requisite diffraction orders so that the channels are numbered 0, 1, 2, -2, -1 corresponding to cfg 1, 2, 3, 4, 5. In addition, the *skip* parameter is turned off in configuration 2, and the thickness of surface 3 is changed in configuration 2 so that the glass rod is not moved.

Surface 10 is the EAR (end-of-array) surface. Note that the array definition automatically places an RCO (return-coordinates) transfer to the channel surface, so that surface 11 (the first of the final grating surfaces) is located with respect to the channel surface, and hence does not require any configuration specification. Surface 12 contains the final grating that recombines the beams from the various array channels. At this point, the system is set up as shown below.
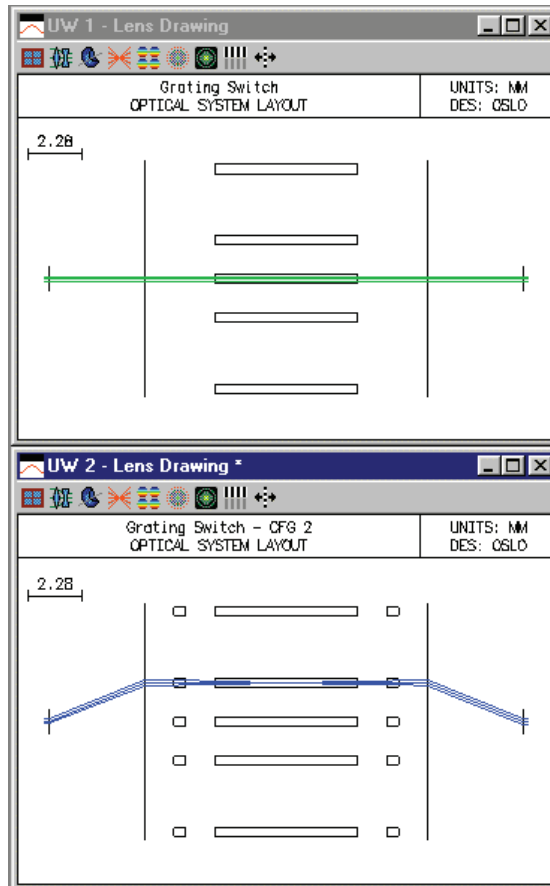
In order for the darwing rays to change color in configuration 2, you should set up your Len drawing operating conditions as shown below.
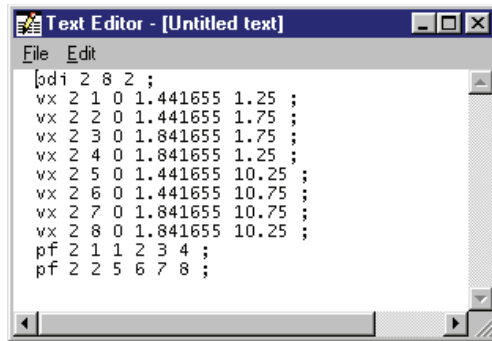
Number of field points for ray fans:	2			Points for aspheric profiles:	41				
Frac Y Obj	Frac X Obj	Rays	Min Pupil	Max Pupil	Offset	FY	FX	Wvn	Cfg
1.000000	0.000000	3	-1.000000	1.000000	0.000000	⦿	○	1	0
1.000000	0.000000	3	-1.000000	1.000000	0.000000	⦿	○	1	2

The drawings show the system functioning optically as expected, with the lenses exerting focusing action only in configuration 2. However, for consmetic reasons, the drawings are less than satisfactory, partly because only one configuration is shown at a time, and partly because lenses are shown in all the channels, although they are only active in one. In order to circumvent these problems, we need to set up some additional data for drawing purposes only.

First, we can remove the extra lens drawings by marking the lens surfaces *not drawn* in the SPECIAL>>Surface Control>>General spreadsheet. Then, of course, the lenses disappear in configuration 2 as well, but this can be accommodated using *bdi* data. BDI data are one form of drawing data that can be attached to a lens surface, and allow the construction of 3D drawings that cannot be produced by the internal routines in OSLO. For the present system, we will only need to make a plan view of the system, so we can represent each lens by a single facet, i.e a rectangular box. There is no special bdi editor in OSLO, so bdi data is normally entered using the internal OSLO text editor. Since the data are a series of commands, the internal OSLO editor is generally preferred over an external text editor, since the command lines can be selected and executed directly from the editor.

The data required for the present system is shown in the figure below. It consists of 8 vertices defining the two rectangles, attached to and located relative to surface 2. Note that surface 2 is outside the array channel. The y data are computed as the sum of the chief ray height in cfg 2, plus or minus the lens aperture, and the z data are computed relative to surface 2.

```
Text Editor - [Untitled text]
File  Edit
bdi 2 8 2 ;
vx 2 1 0 1.441655 1.25 ;
vx 2 2 0 1.441655 1.75 ;
vx 2 3 0 1.841655 1.75 ;
vx 2 4 0 1.841655 1.25 ;
vx 2 5 0 1.441655 10.25 ;
vx 2 6 0 1.441655 10.75 ;
vx 2 7 0 1.841655 10.75 ;
vx 2 8 0 1.841655 10.25 ;
pf 2 1 1 2 3 4 ;
pf 2 2 5 6 7 8 ;
```

Once the bdi data is entered satisfactorily, the lenses should be drawn properly, but the problem still exists that only one configuration is shown at a time. To solve this, we need to overlay the drawings from all configurations. To do this, we turn off the Graphics Autoclear preference (shown on the default status bar), make a drawing in each configuration, and then turn the preference back on. It is easiest to do this using commands, viz.

```
Stp gacl off;
Cfg 1; pen 1; drl; pen 2; ddr;
Cfg 2; pen 1; drl; pen 3; ddr;
Cfg 3; pen 1; drl; pen 2; ddr;
Cfg 4; pen 1; drl; pen 2; ddr;
Cfg 5; pen 1; drl; pen 2; ddr;
Stp gacl on;
```

This should produce a drawing like the one at the beginning of this example. If you are nort able to reproduce this, it is possible that you have not defined your default drawing rays the same as here.