The very basics of SHADOW

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1.0 What is SHADOW?

SHADOW is a ray-tracing program specially optimized for the design of the synchrotron radiation beamline optics. It has been developed by F. Cerrina et al. at the University of Wisconsin. SHADOW generates and traces a *beam* along the *optical system*. The beam is a collection of *rays* in a given point of the beamline which are stored in a disk file. The optical system is a collection of *optical elements (o.e.)* (mirrors, multilayers, slits, screens, etc.) placed in a sequential order. Each ray is an array of 18 (or 12) variables or *columns*. Each variable of column has an special physical meaning The first six defines the geometry: spatial coordinates (Col. 1,2,3 or x, y and z, respectively) and the direction of the ray (cols. 4,5,6, or x',y' and z', respectively). The rest of the columns defines the history of the ray traversing the optical system (electric vector for s polarization (cols. 7,8,9) and p polarization (cols. 16-18), flag for lost ray (10), wavelength (11) etc.).

The *source* is the beam at the starting point. It is generated by SHADOW by sampling the spacial, angular, energy and other qualities of the synchrotron radiations sources (i.e, bending magnets, wigglers and undulators) into a finite number of rays, using a Monte Carlo method. At the source position the intensity of each ray (or better, its probability of observation) is set to 1. This intensity will decrease along the beamline because of the interaction of the ray with the optical elements. The source generated by SHADOW samples linearly the real source, which allows to scale the intensity with the number of photons.

SHADOW traces the source sequentially thought each individual optical element of the optical system. SHADOW solves the intercept of each ray at a given o.e., calculates the output direction and the decrease in intensity. This decrease is calculated for each ray using a physical model (i.e. Fresnel equations for mirrors, Dynamical Theory of the Diffraction for perfect crystals, etc.)

2.0 What do I need to run SHADOW

You have to download and inatall SHADOW. Follow the instructions in `http://www.xraylith.wisc.edu/shadow/shadow.html`. The SHADOW files are available from `ftp://shadow:shadow$94@shadow.xraylith.wisc.edu/shadow` or from `ftp://ftp.esrf.fr/pub/expg/shadow`. Then source the setup script (usually `source $SHADOW_ROOT/.shadowrc` in Unix) and type shadow to start the Graphical User Interface or type GO to start SHADOW in command mode.

3.0 The files generated by SHADOW

SHADOW generates a big amount of files. The most important ones are

`start.xx` an ASCII file with the namelist for the source or optical elements (`start.00` for the source, `start.01` for the first o.e, `start.02` for the second, and so on)

`end.xx` same of `start.xx` but with few parameters recalculated after the run

`begin.dat` binary file containing the beam at the source position

`mirr.xx` binary file containing the beam on each o.e. (i.e. `mirr.02` is the beam on the second o.e)

`star.xx` binary files with the beam at the image created by each o.e. The image of a given o.e. is the source for the following o.e.

`screen.xxyy` SHADOW can (optionally) create the image file in a different points of the beamline, or screens. Screens are associated to a given o.e. and can allow to define absorption (filters) or apertures (slits or beam-stoppers). `xx` refers to the o.e. order and yy refers to the screen order (i.e. `screen.0204` means the fourth slit associated to the 2nd. o.e). The coordinate system of SHADOW is (schematic):
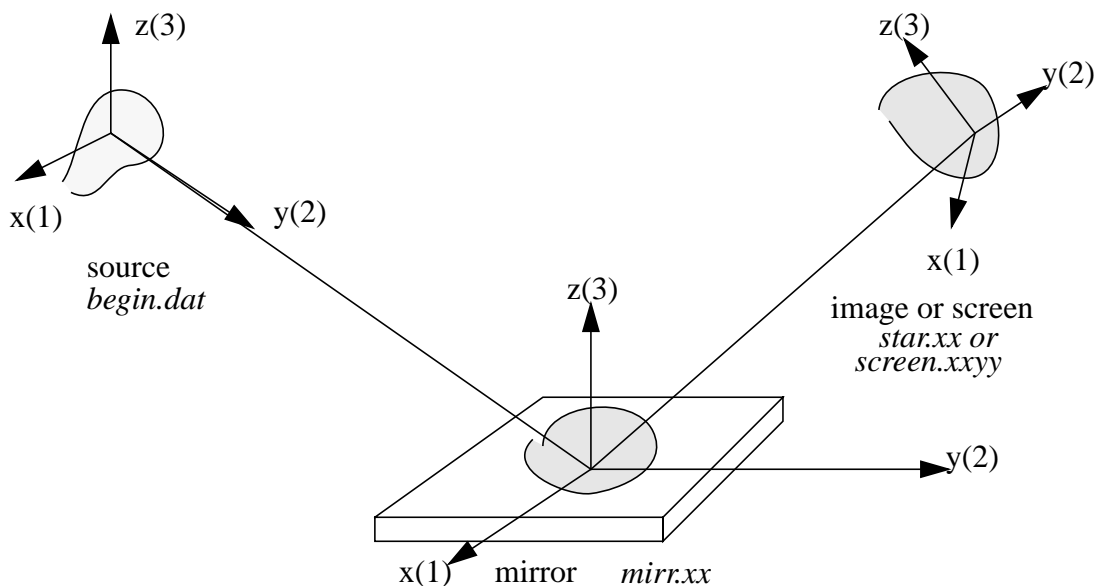

Note that:

❏ The y(2) coordinate is along the beam direction

❏ The frame is rotated if one o.e. is rotated

❏ the position, orientation, etc. of any o.e. is always referred to the previous one

4.0 How to run SHADOW

Basically SHADOW is called using the `shadow` command (for the GUI) or the commands `GO source` for the source generation and `GO trace` for the tracing of the optical system. The data can be input using a prompt or menu mode. Sometimes SHADOW needs other files generated by pre-processors, in order to allow calculations of sophisticated cases (insertion devices, crystals, etc.). Few of them are mentioned in the following graphic
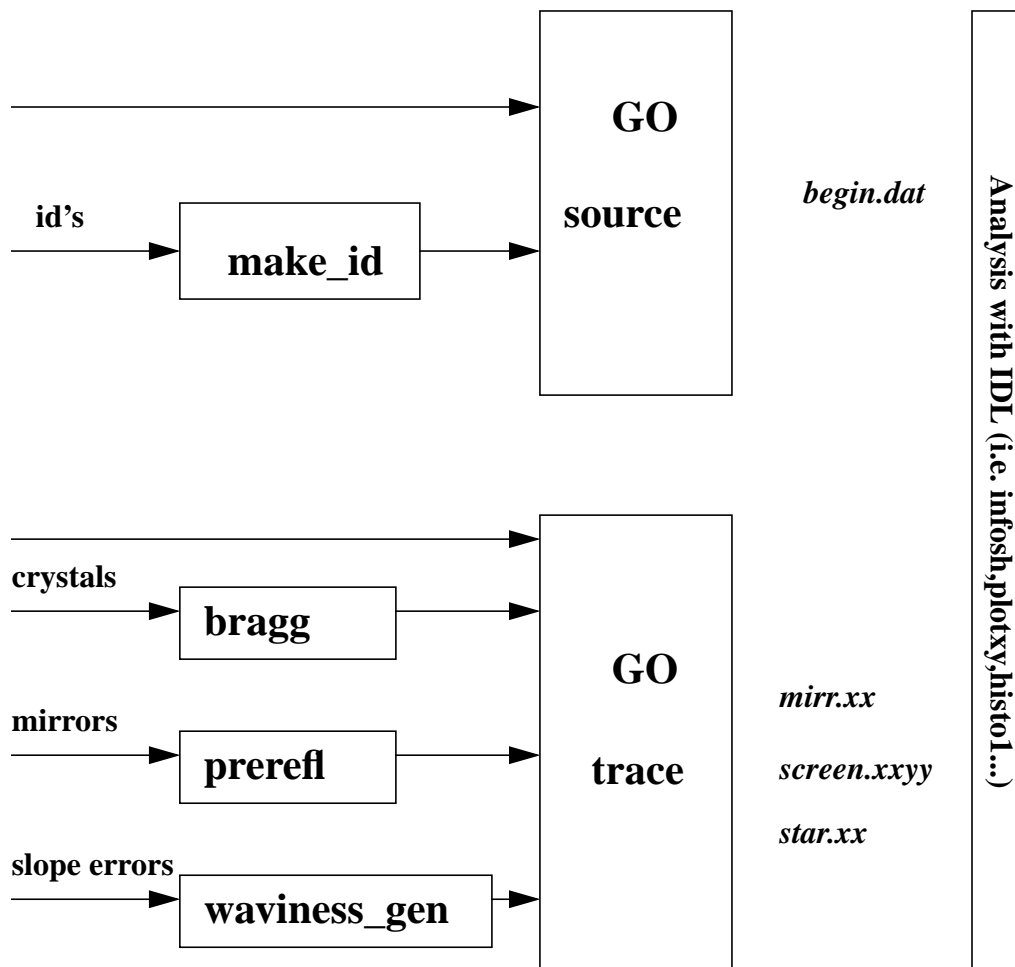
When one uses the prompt mode SHADOW asks for each individual parameter. The prompt mode is recommended for a first run. In the menu mode, recommended after a first run, one has to load (`load source` or `load system`) modify (`select source` or `sel oe`), save (`save source` or `save sys`) and run (`exit`) the current system.

After a successful run of SHADOW one has to analyze the results. For that purpose there is a set of utilities written in the IDL language, which allows visualization and histogramming of the results. They are available from `http://www.esrf.fr/computing/scientific/raytracing/`. Few of the basic utilities are: `infosh`, `histo1` and `plotxy`. Other IDL utilities are: `sourcinfo, mirinfo, sysinfo,`

`readsh, getshcol, intens, plot3, ray_prop`, etc. You can get on-line help of these utilities by using the IDL command `doc_library` (i.e. `doc_library,'plotxy'`).

Examples and demonstrations of different runs of SHADOW for different systems can be found in the directories `$SHADOW_ROOT/demo` and `$SHADOW_ROOT/doc`.

Other documentation and extensions for the ESRF (including this document) can be found at the latest mentioned Web address.

Personal support is available by e-mail: `srio@esrf.fr`