3-D two-point ray tracing in pictures

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Introduction

Two–point ray tracing carried out by means of the `CRT` program is controlled by many numerical parameters. To approach the optimum set of parameters is important and sometimes complex task. To plot the normalized ray parameters at the normalized ray domain, the decomposition of the normalized ray domain into homogeneous triangles, or the distribution of the ray endpoints, homogeneous triangles, and receivers at the reference surface may be very useful for the selection of the optimum numerical parameters controlling the shooting algorithm. Program `RPPLOT` has thus recently been developed to generate PostScript files with figures of the normalized ray domain and reference surface containing the above mentioned information. Program `RPPLOT` is designed as a post processing program to the `CRT` program.

This brief paper would like to illustrate the usage of the `RPPLOT` program on the example of two–point ray tracing in the model with a lenticular inclusion (Klimeš 1995). The example has been presented as a poster at the EAGE conference (Bulant 1997) in order to explain the shooting algorithm (Bulant 1996a,b).

The data for this computation may be found in the subdirectory `len` of the `CRT` package. To repeat the computation and to generate Figures 2,4,5,6,7, run program `crt.for` with main input data file `len-crt.dat`, and then program `rpplot.for` with main input data files `len-rp2.dat`, `len-rp4.dat`, ..., `len-rp7.dat`, respectively.

Two–point ray tracing in the model with a lenticular inclusion

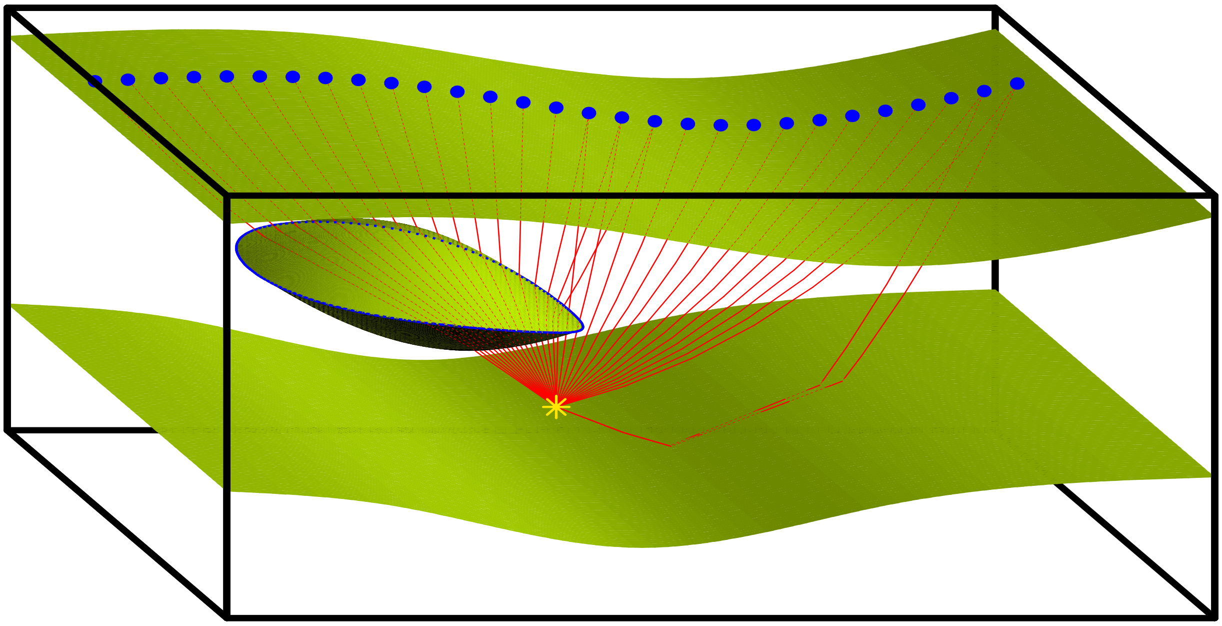


Figure 1. The two-point rays identified during the computation of a refracted wave in the model with a lenticular inclusion.

In: Seismic Waves in Complex 3-D Structures, Report 6 (Department of Geophysics, Charles University, Prague, September 1997)

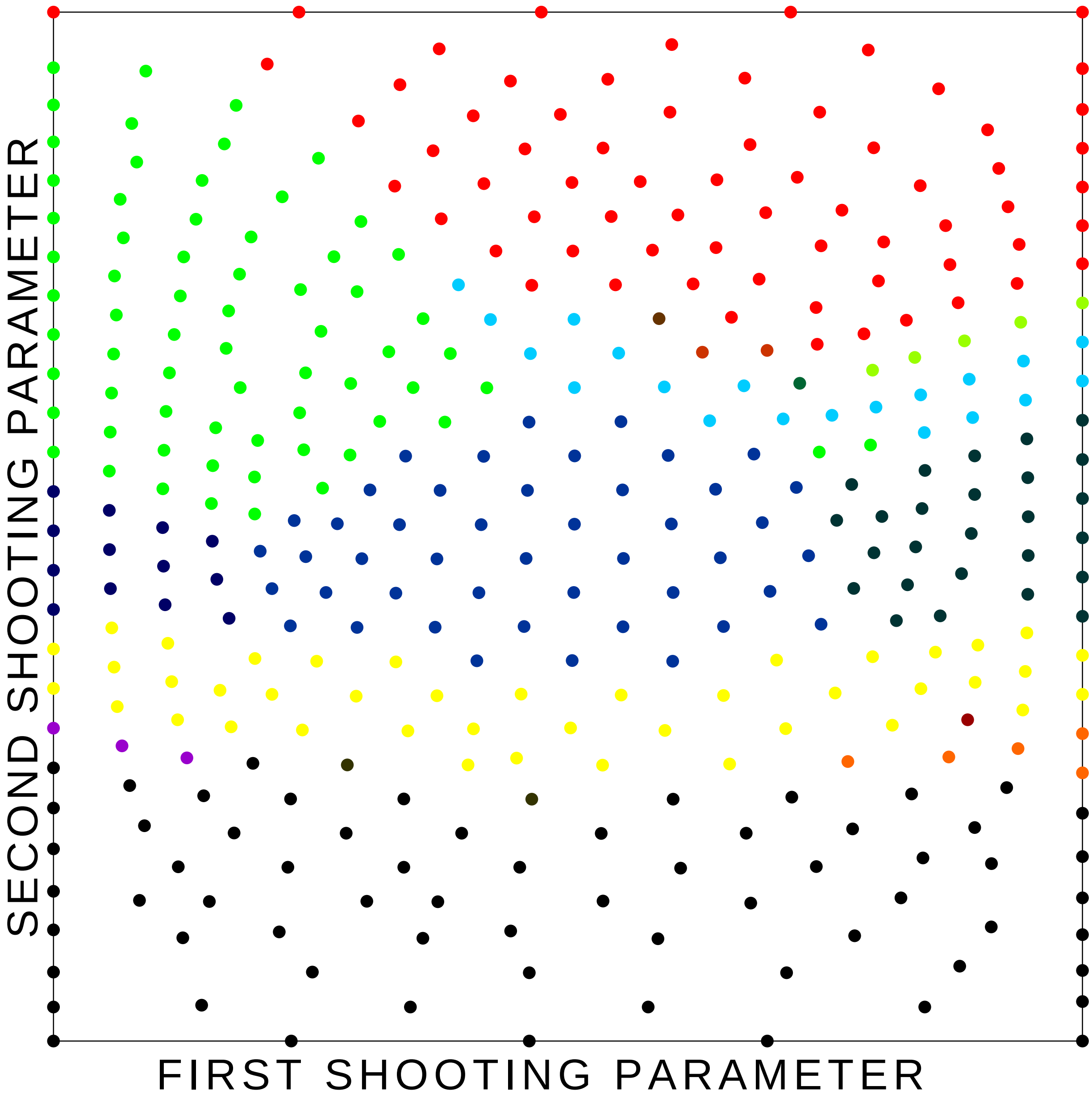
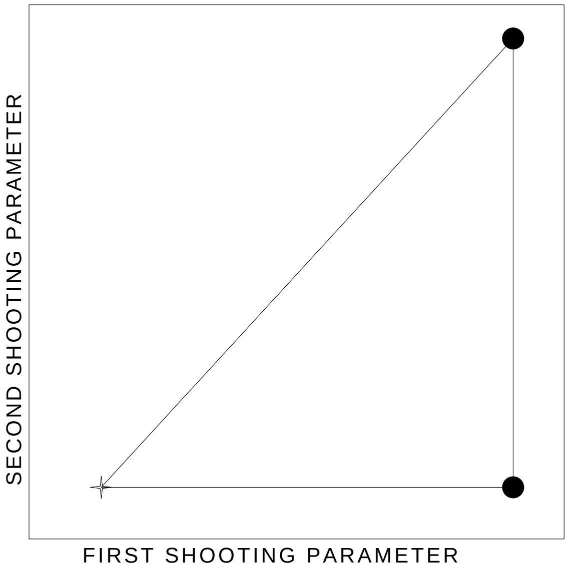
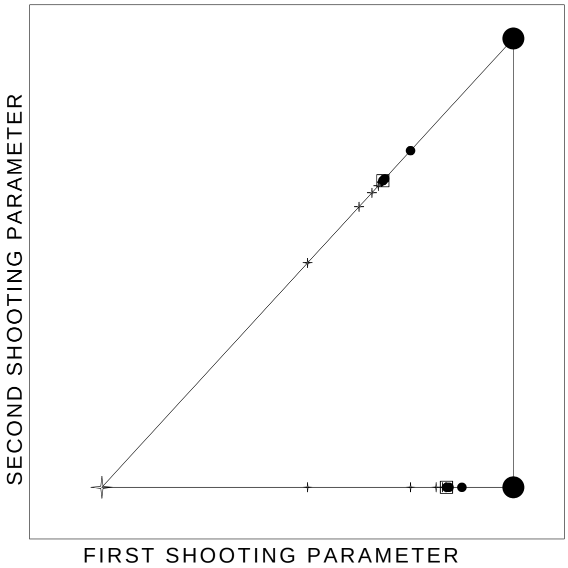


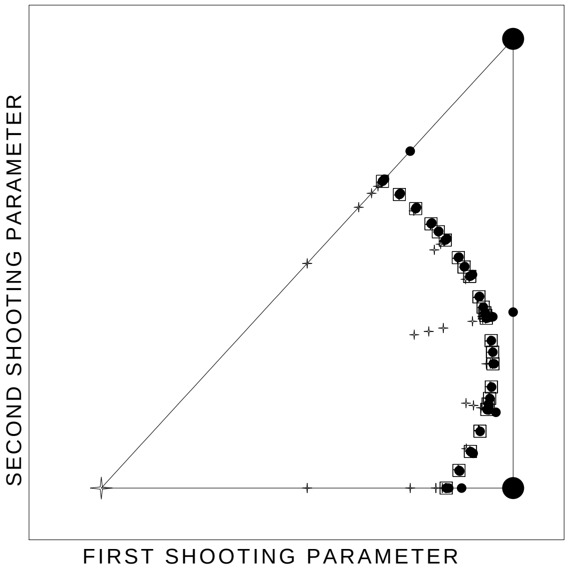
Figure 2. (`RPPLOT` input data set `len-rp2.dat`)
A set of basic rays is traced and a 2D domain of ray take-off parameters is covered by basic triangles. The basic rays are colour-coded according to their ray history. Interpolation is not possible inside the basic triangles formed by basic rays of different ray history, and these triangles must be divided into homogeneous triangles.



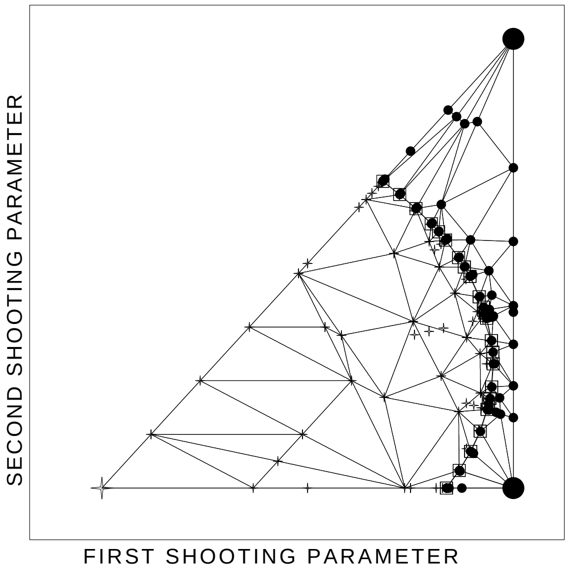
1. An inhomogeneous basic triangle in the ray domain is formed by basic rays of different ray histories. Basic rays are symbol–coded according to their history, and they are plotted as larger symbols.



2. Searching for boundary rays on the sides of the inhomogeneous triangle by halving intervals. Auxiliary rays are plotted as smaller symbols according to their history, and boundary rays are plotted as boxes.



3. The boundary between the two ray histories is demarcated by pairs of boundary rays. All the boundary rays of the same ray history together with the basic ray(s) create a homogeneous polygon.



4. Both homogeneous polygons are covered by homogeneous triangles. Note that the distance between the two boundary rays in each pair is so small that only one box mark can be distinguished.

Figure 3. Division of a basic triangle into homogeneous triangles.

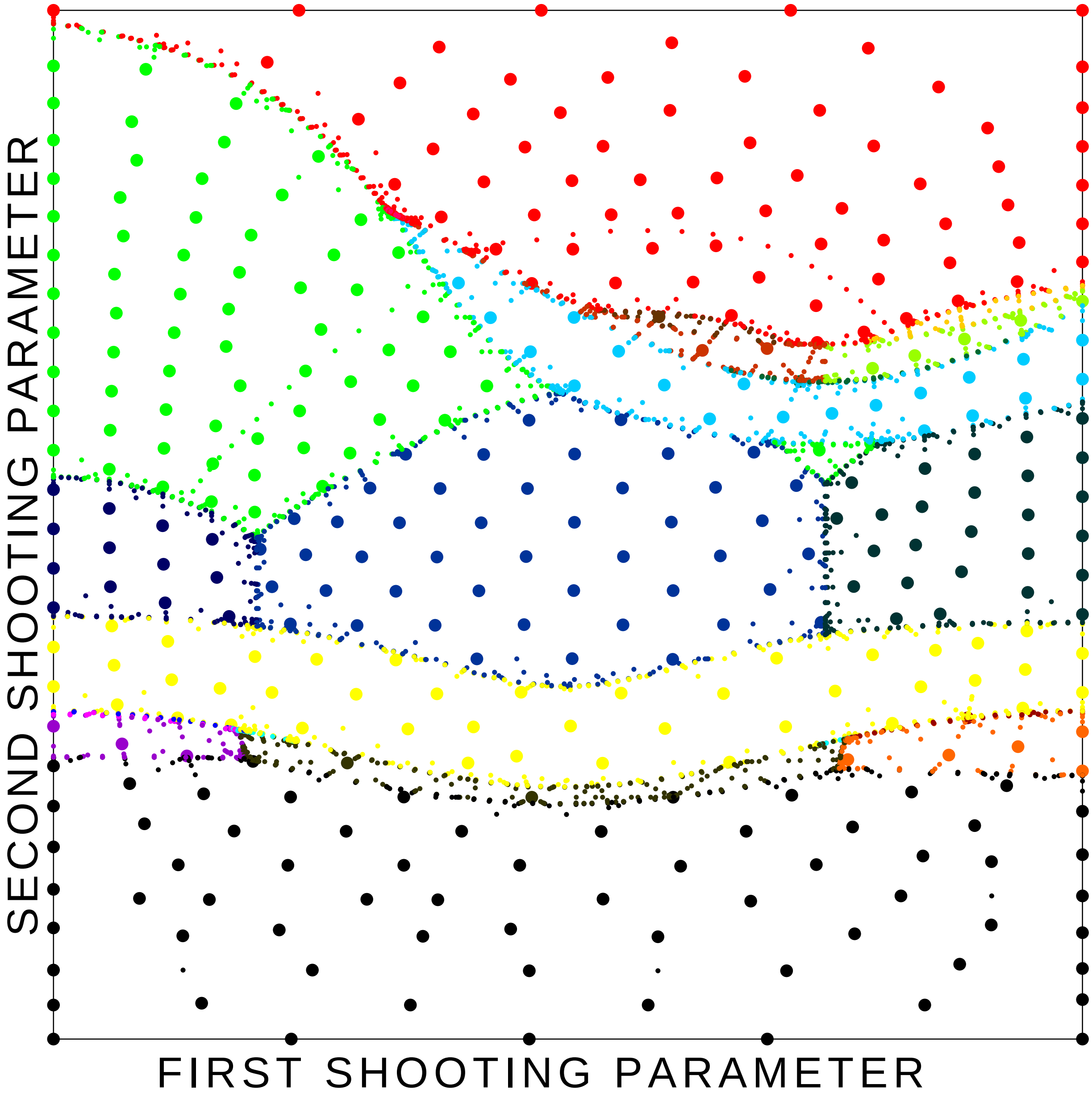


Figure 4. (`RPPLOT` input data set `len-rp4.dat`)
Ray parameters of all the rays traced during the computation of a refracted wave, on a 2D domain of the normalized ray take-off parameters. Bold dots represent the basic rays, small dots other kinds of rays (auxiliary rays shot when searching for boundary rays, boundary rays between different ray histories, rays required to divide too large homogeneous triangles, auxiliary rays shot when approaching the two–point rays, two–point rays).

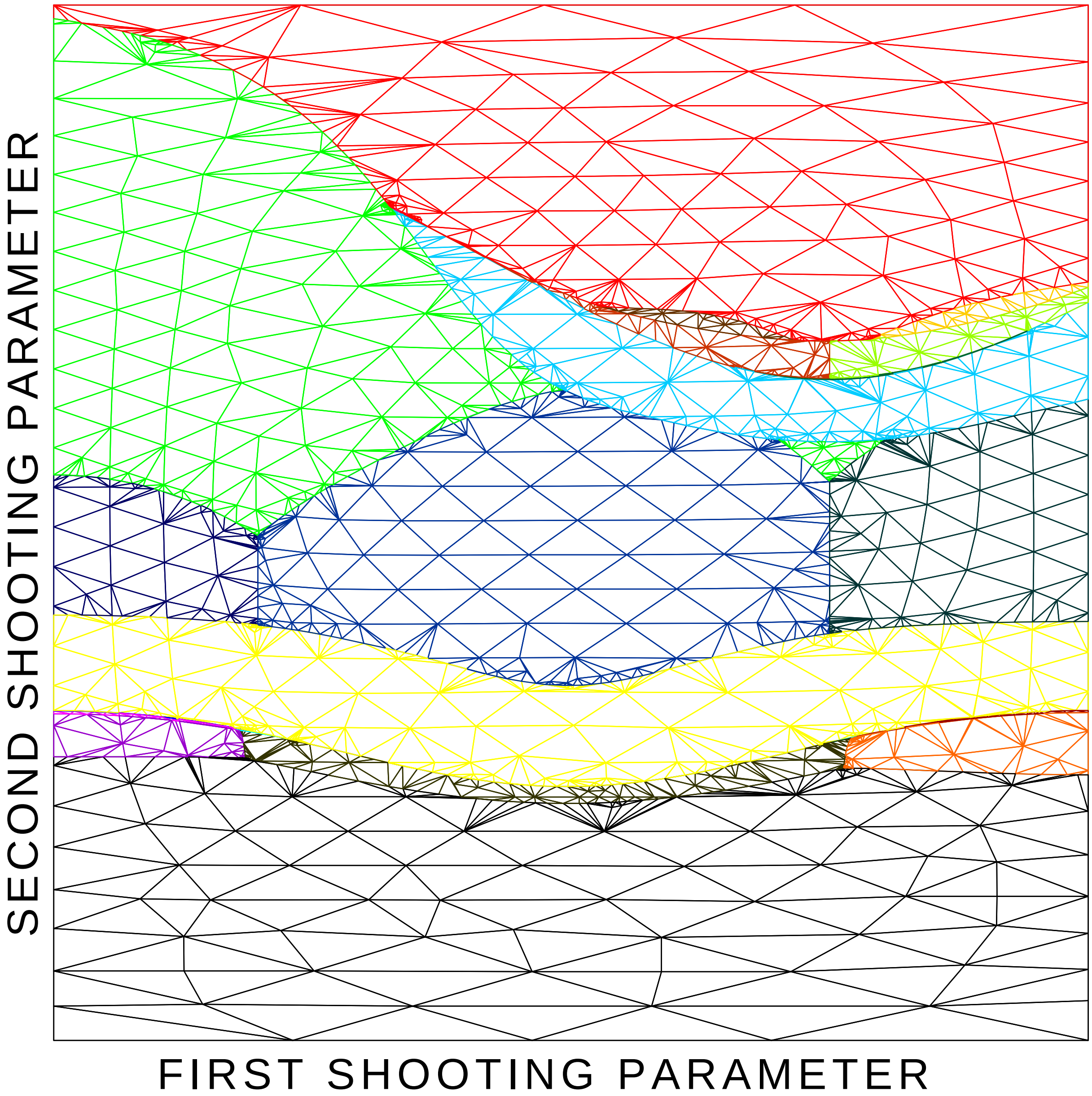


Figure 5. (`RPPLOT` input data set `len-rp5.dat`)
The 2D domain of ray take-off parameters is covered by homogeneous triangles. Now the two-point rays may be found inside individual homogeneous subdomains formed by homogeneous triangles of the same ray history. Note the fine division into triangles along the boundaries between ray histories, facilitating an accurate demarcation of the boundaries.

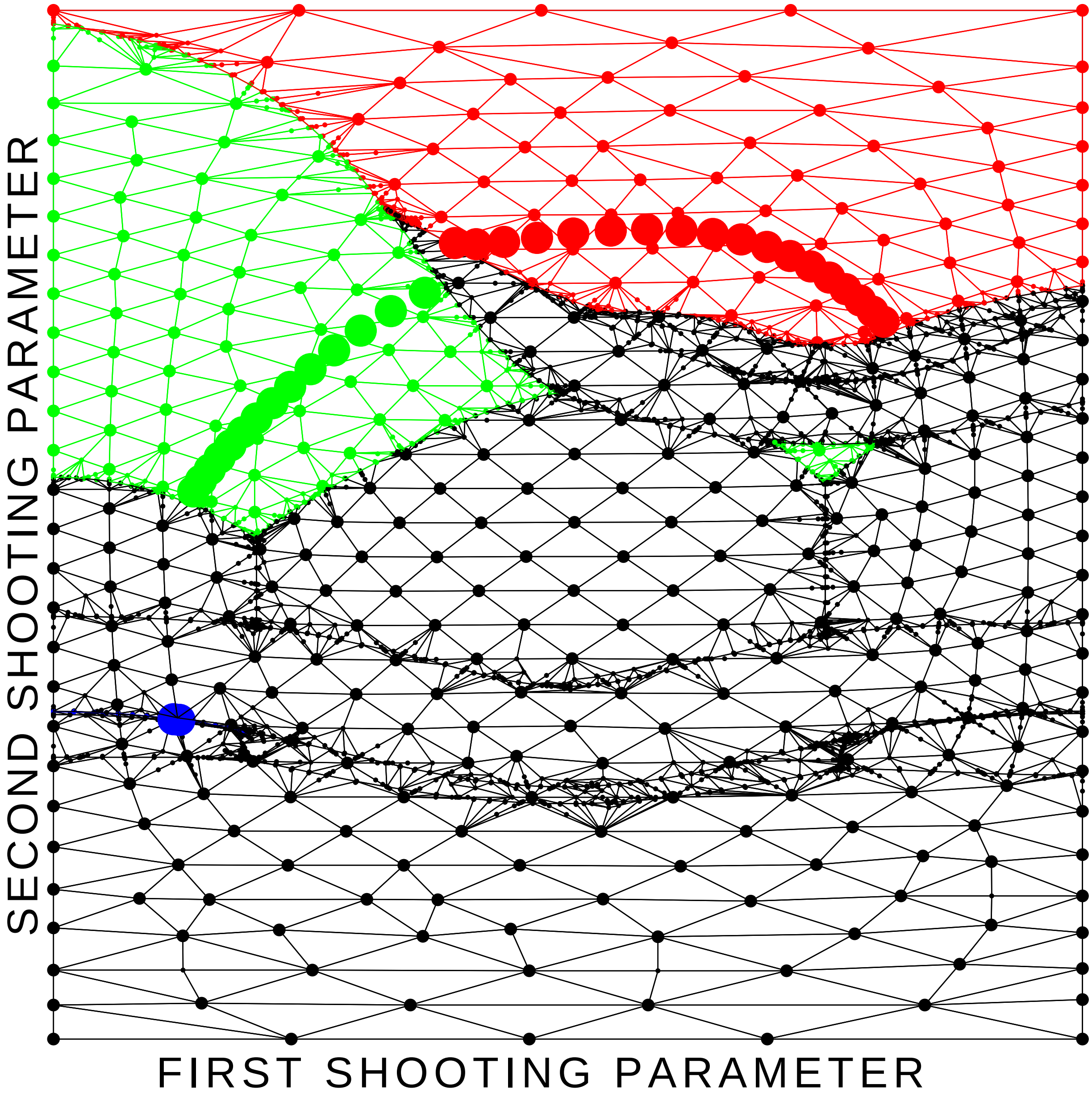


Figure 6. (`RPPLOT` input data set `len-rp6.dat`)
There are three ray histories corresponding to the successful rays, reaching the surface of the model. These are direct rays (green), rays refracted through the lens (red), and the rays refracted through the lowermost layer (blue). Rays of other histories (unsuccessful) are displayed in black here. The largest dots denote the found two-point rays.

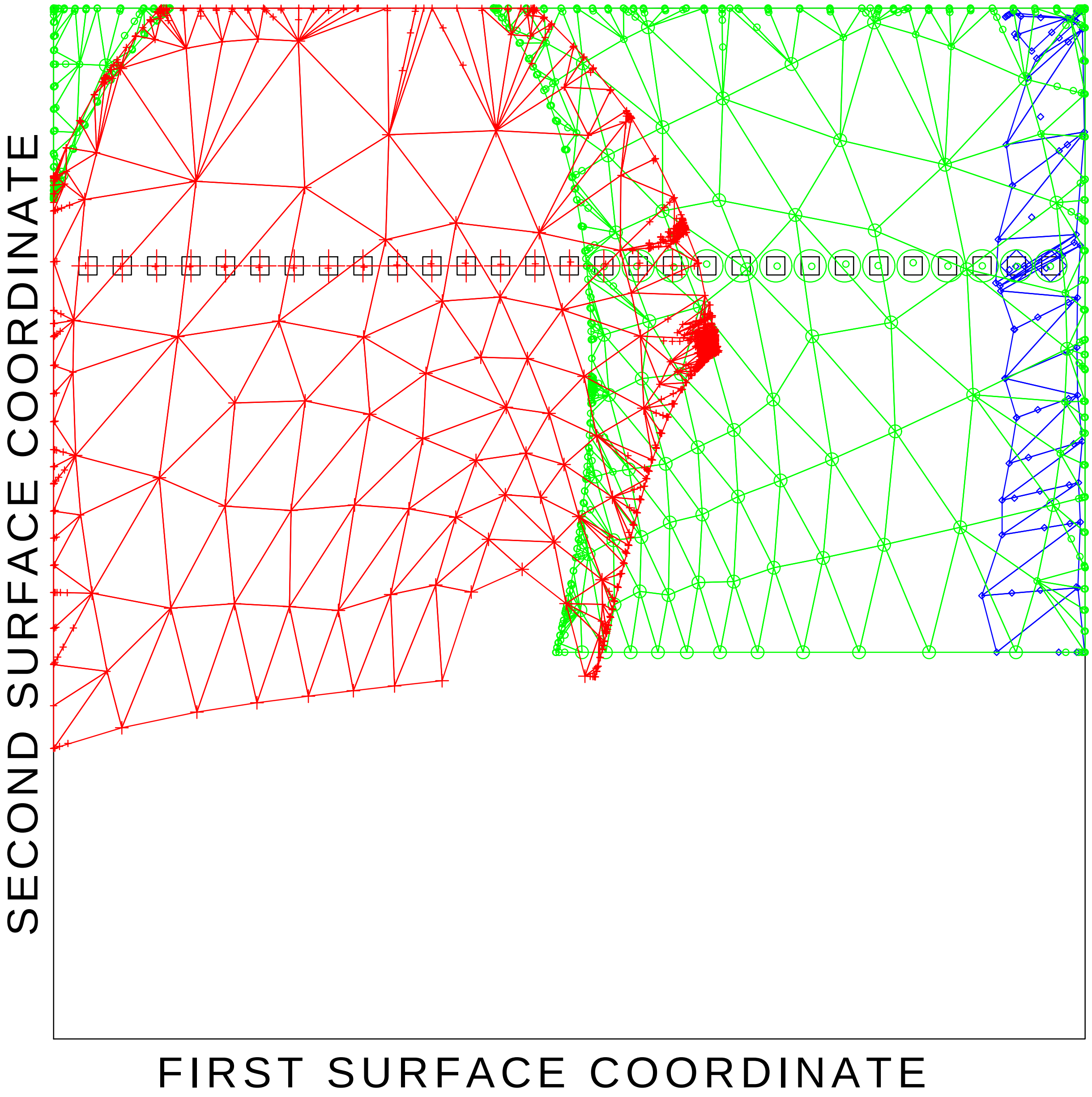


Figure 7. (`RPPLOT` input data set `len-rp7.dat`)
Distribution of the homogeneous triangles on the surface of the model. Black squares denote the receivers situated along a profile, the largest symbols correspond to the found two-point rays.

References

Bulant, P. (1996a): Two–point ray tracing in 3-D. PAGEOPH, **148**, 421–447.

Bulant, P. (1996b): Two–point ray tracing and controlled initial–value ray tracing in 3-D heterogeneous block structures. In: Seismic Waves in Complex 3-D Structures, Report 4, pp. 61–75, Dep. Geophys., Charles Univ., Prague. Revised version submitted to Geophysics.

Bulant, P. (1997): Controlled initial–value ray tracing and two–point ray tracing in 3D. Extended Abstracts of 59th EAGE Conference (Geneva), P025, EAGE, Zeist.

Klimeš, L. (1995): Examples of seismic models. In: Seismic Waves in Complex 3-D Structures, Report 3, pp. 5–35, Dep. Geophys., Charles Univ., Prague.