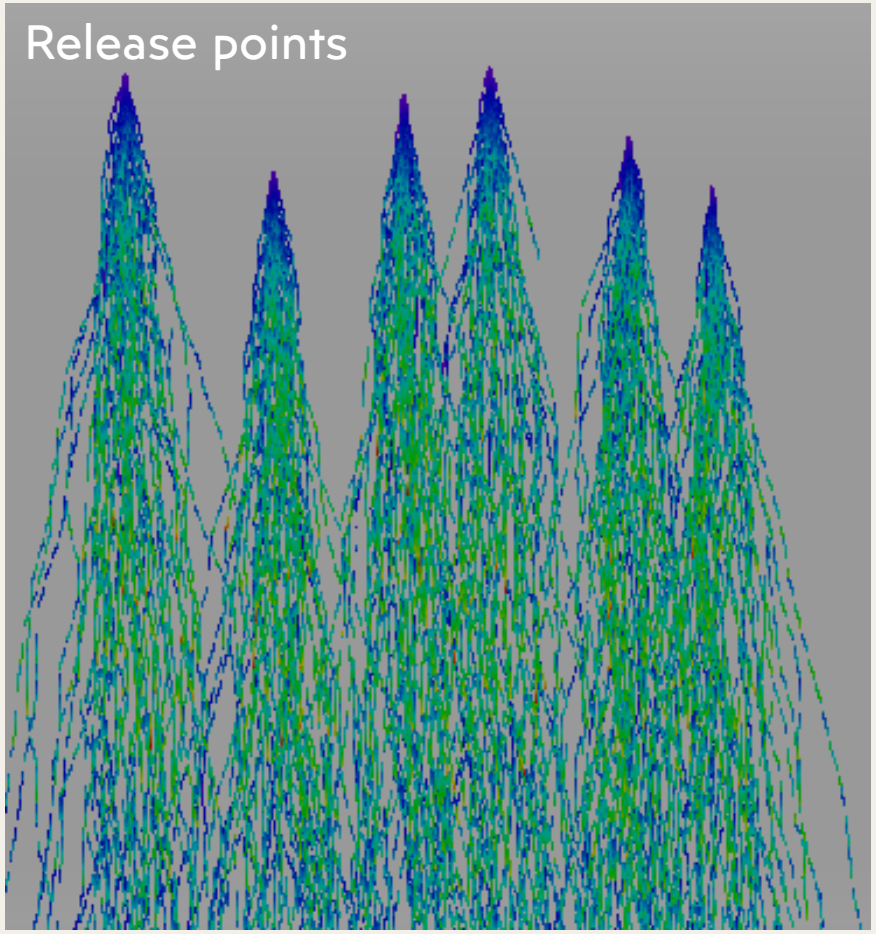
Starting Zones and Initial Conditions

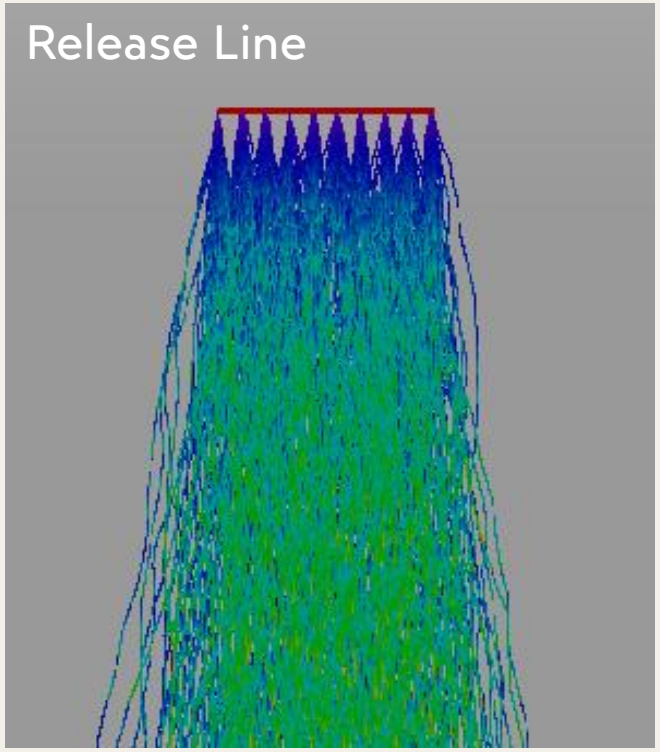
Defining the Initial State of Rockfall Simulations in RAMMS

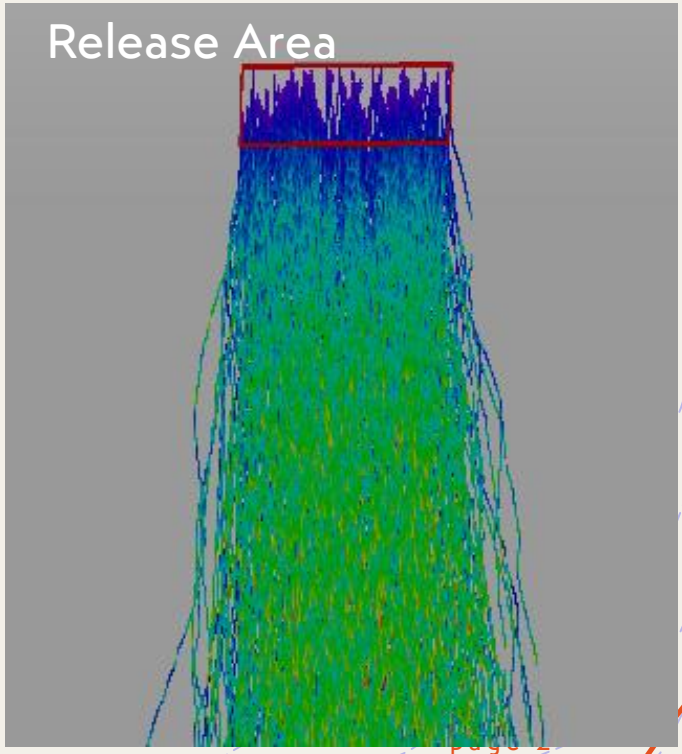
Marc Christen and Perry Bartelt
RAMMS AG, Davos Wiesen, Switzerland

Overview of Initial Conditions



There are three basic methods to define the location and number of starting zones: **Point**, **Line** and **Area**.

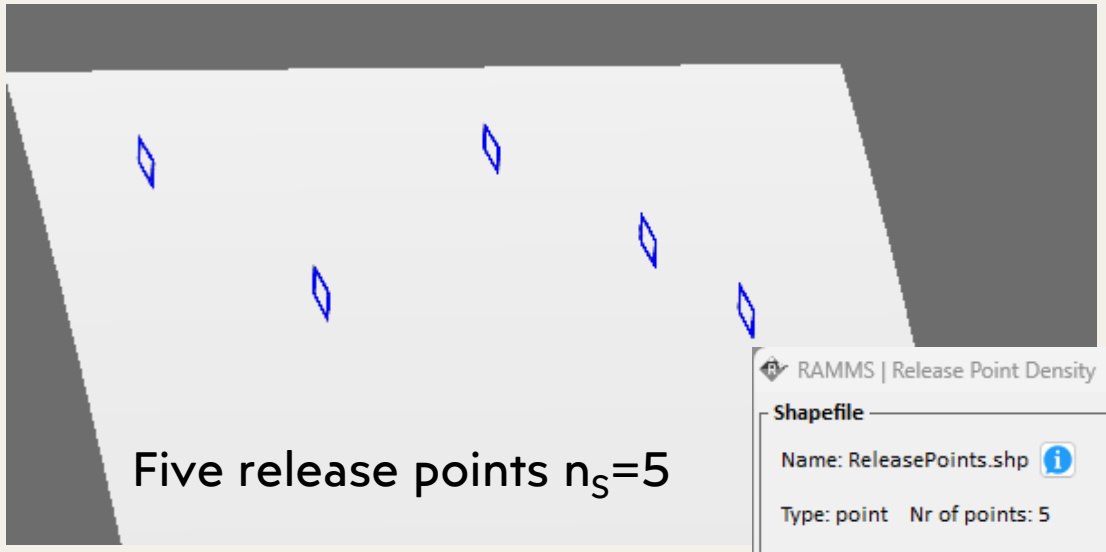


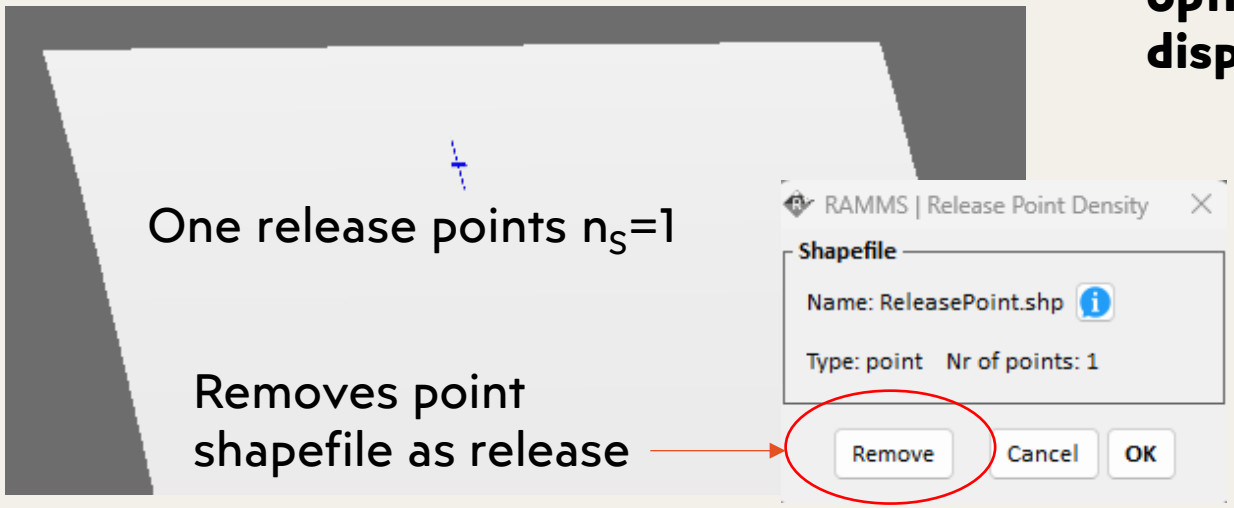


These methods define the **number of starting locations (n_s)** used in the simulation.

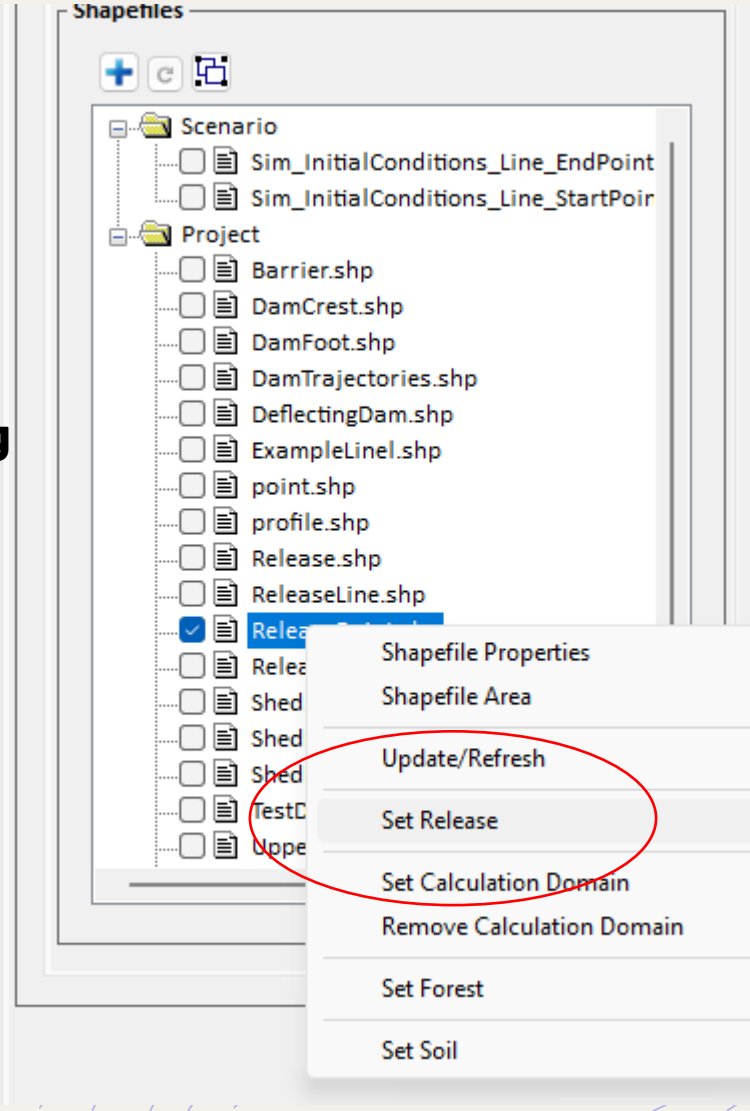
Release points

Sets one or several **release points in the simulation domain.**

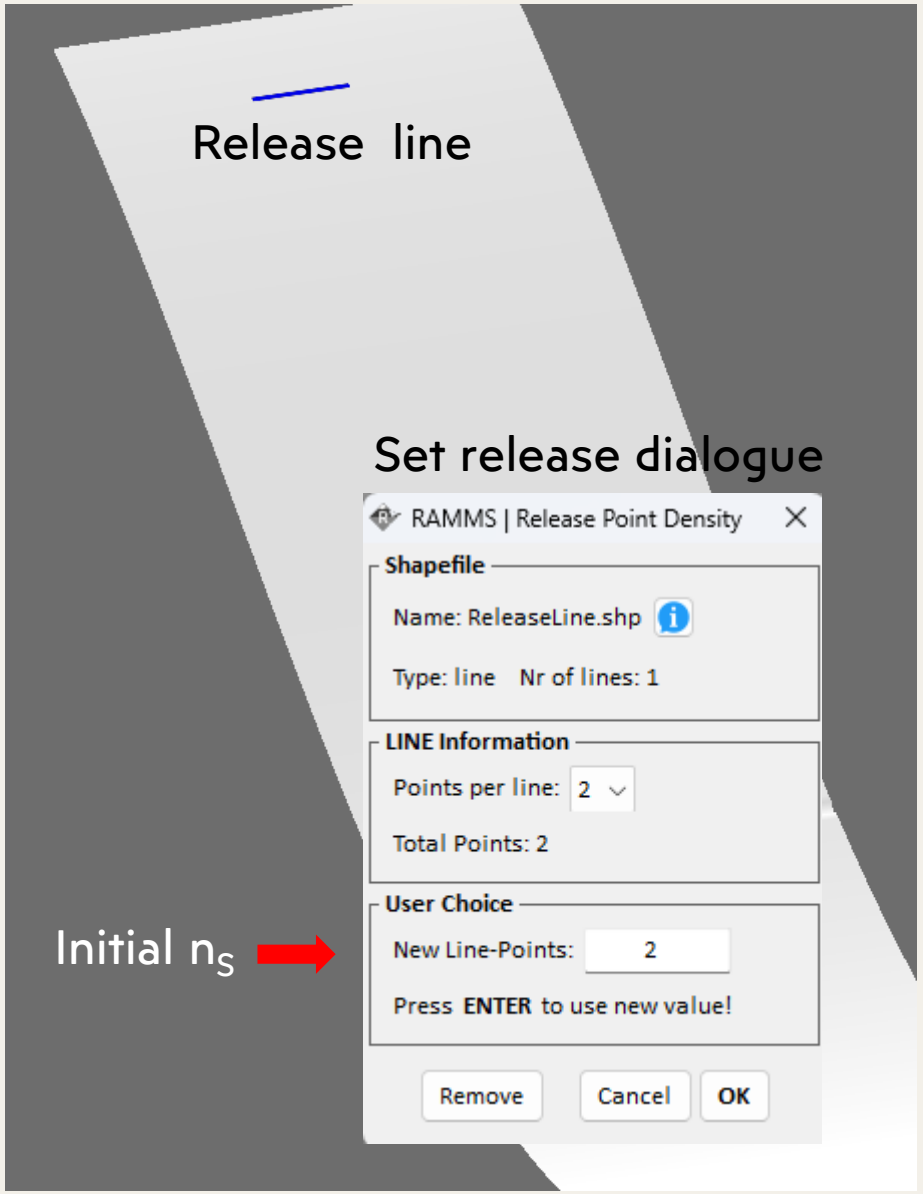




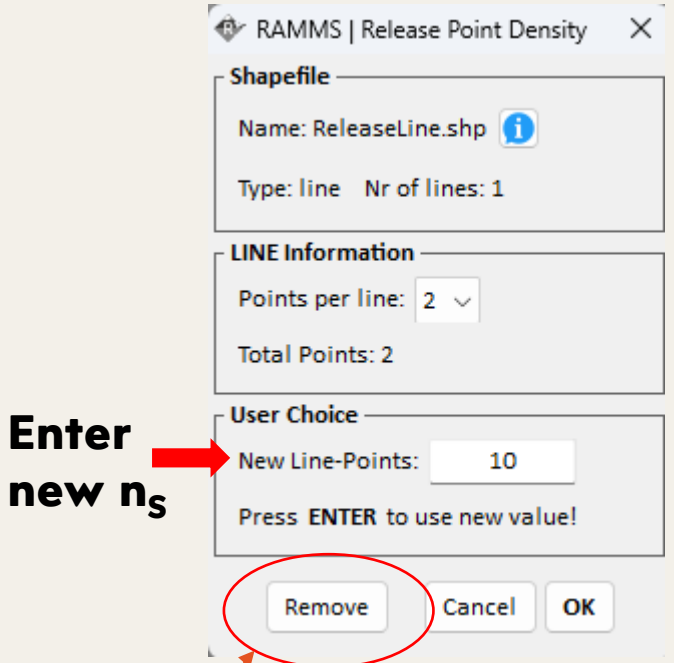
The point file is assigned to a release zone using the "Set release" option in the file display



Release Line

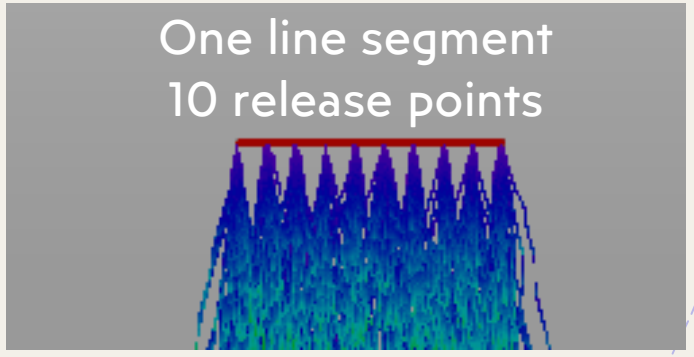


Release points n_s are **evenly distributed along a line, or a series of lines**

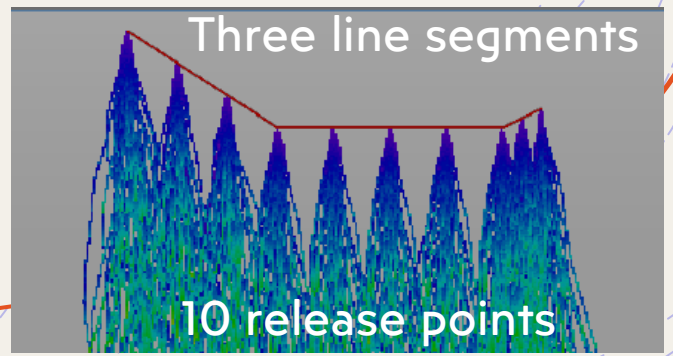


Enter new n_s

Removes line as release. **Sets** n_s back to original number of points per line.

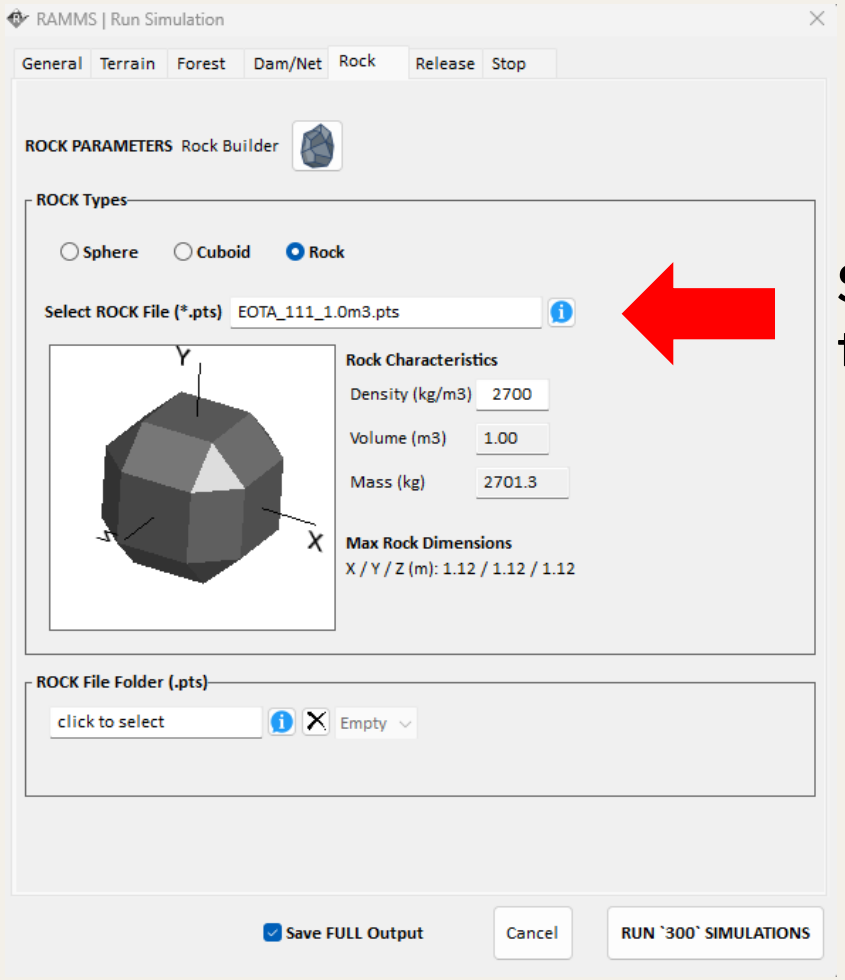


Divides the release points corresponding to length of segment, always uses segment end points.

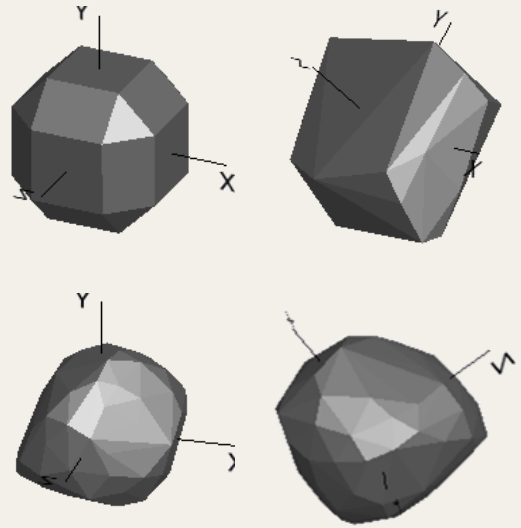


Defining the Rock

The **Rock Tab** defines the rock $n_R = 1$ or rocks $n_R > 1$ used at the starting locations. Total number of simulations n_S x n_O x n_R.

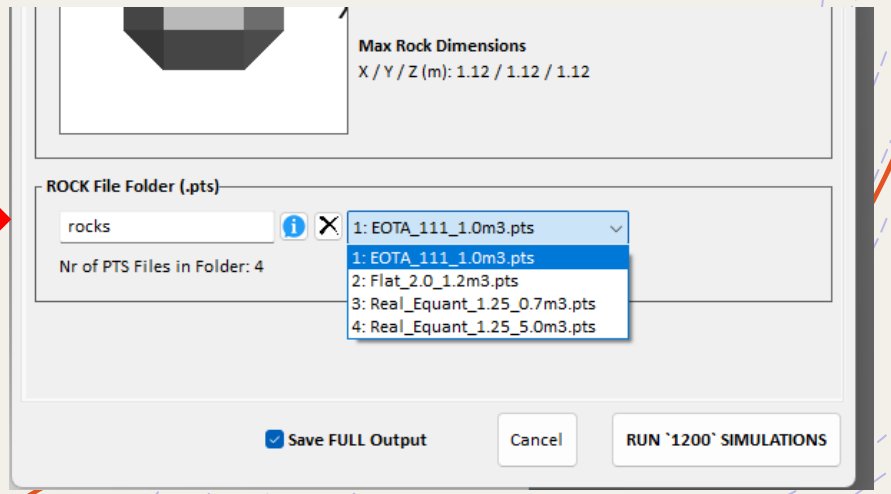


Single rock used in the simulations n_R=1

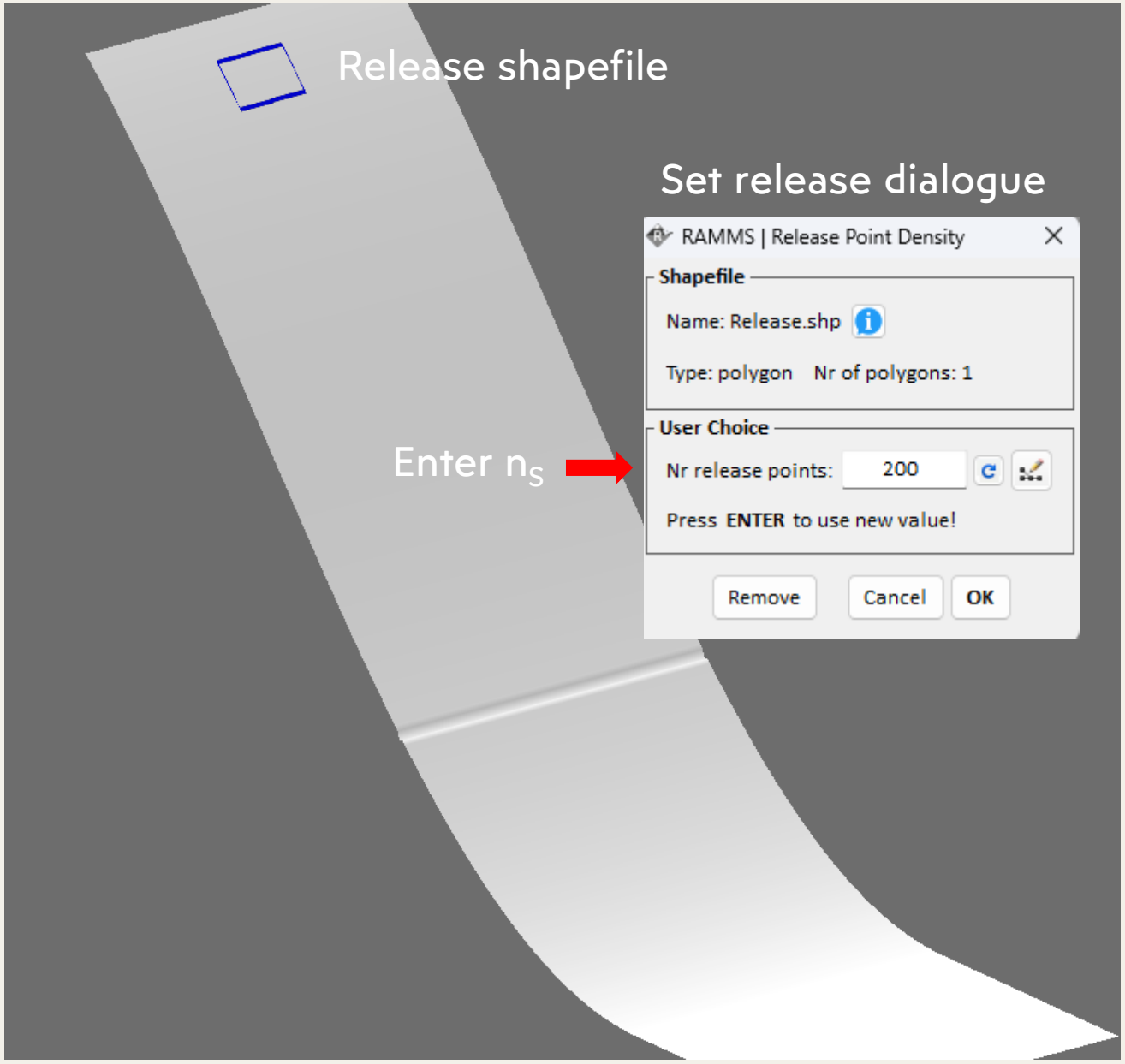


Different rock shapes and volumes

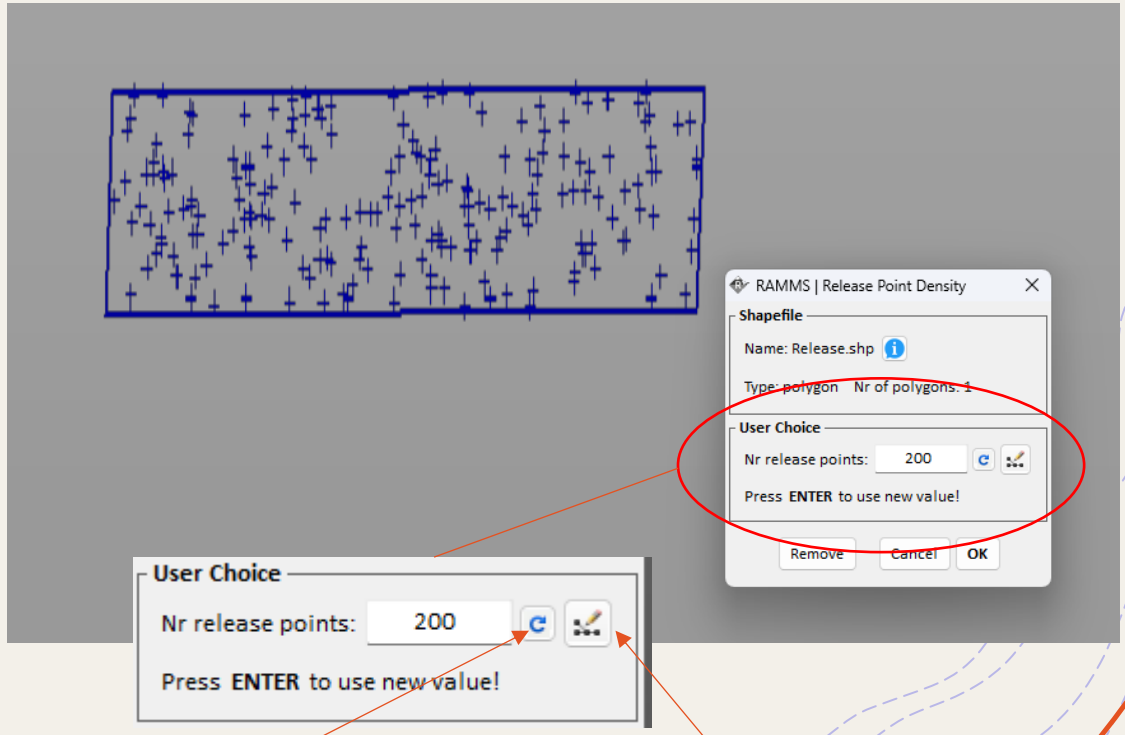
All the rocks used in a rock folder n_R>1



Release Area



Release points n_S are **randomly distributed** in release area, which can be changed/updated



Used to **set new** random locations

Used to **visualize** random locations

Release Tab

To start the simulation more information than the starting locations is required: **random orientations**, **initial velocities** and **z-offset**

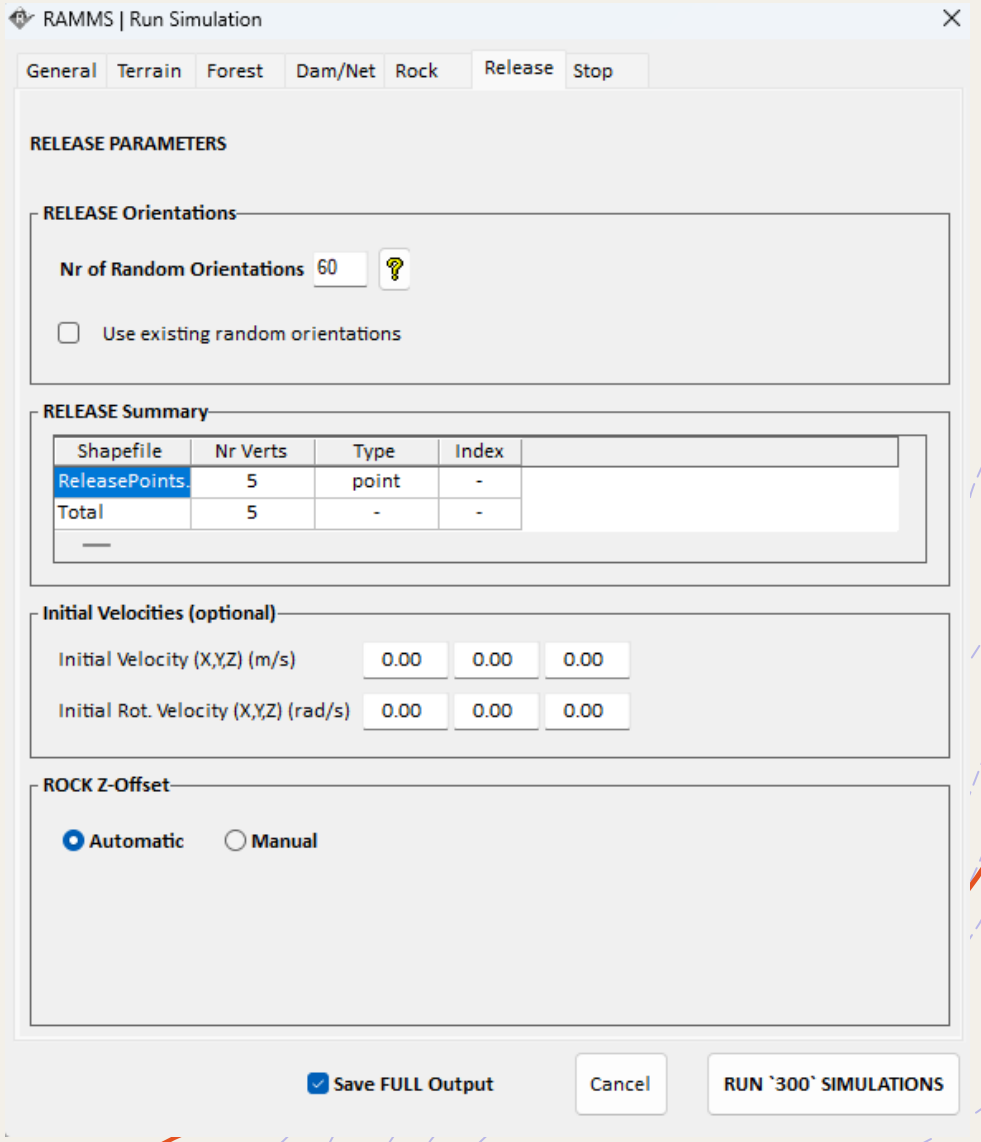
Random orientations n_0

Summary of starting conditions

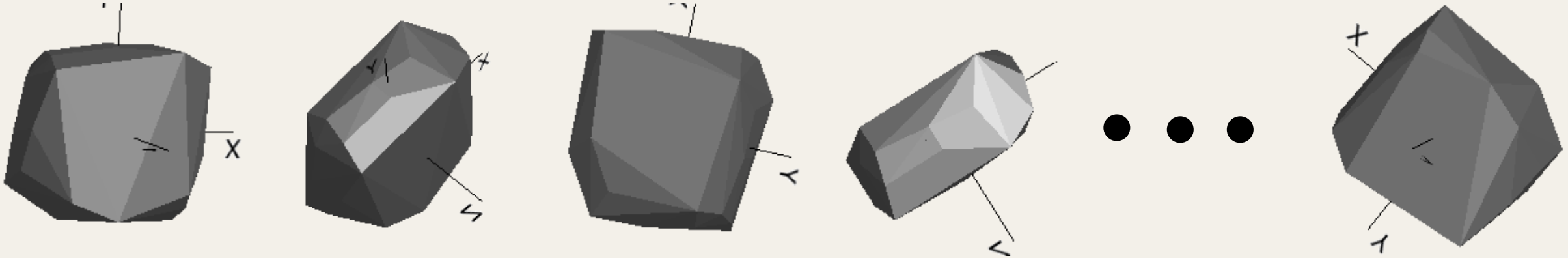
Initial velocities and rotations

Rock z-offset

The **Release Tab** is used to set additional starting conditions



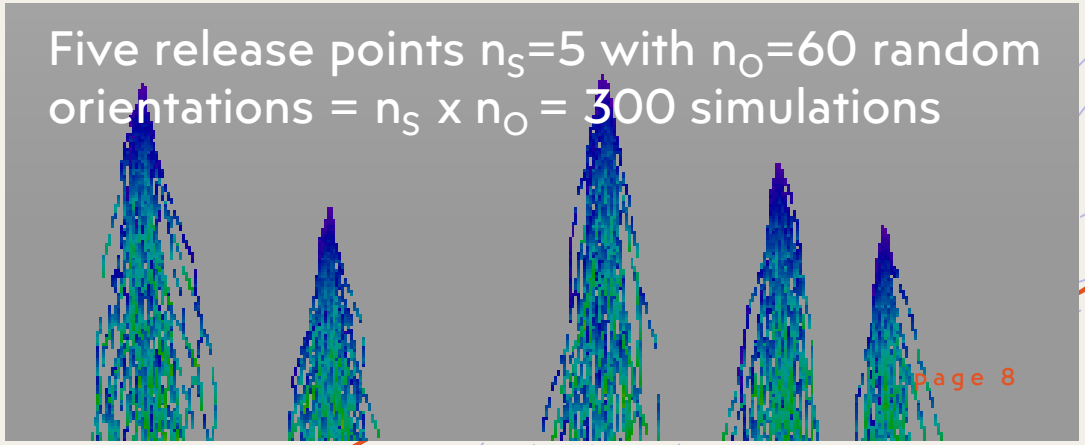
Random Orientations



n_O=1 n_O=2 n_O=3 n_O=4 n_O

At every **starting location** (point, line, area) we **rotate the rocks randomly** to define the number of **random orientations n_O.** Because the rocks have different shape, will get a **statistical distribution of runout trajectories.**

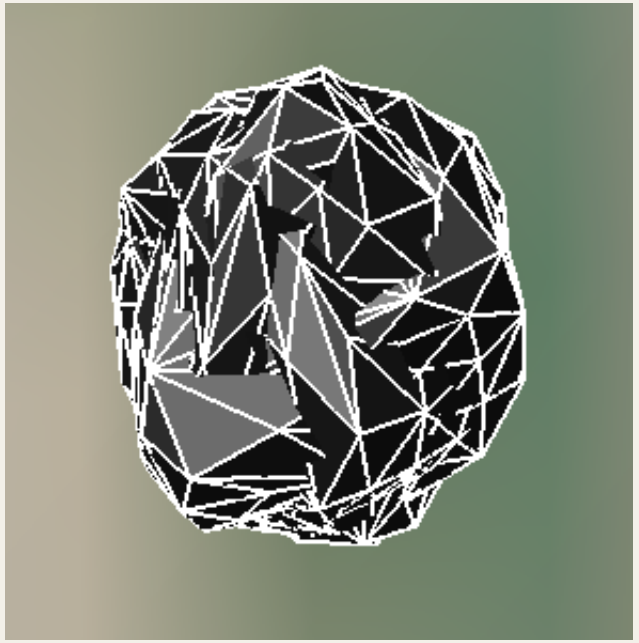
Enter n_O



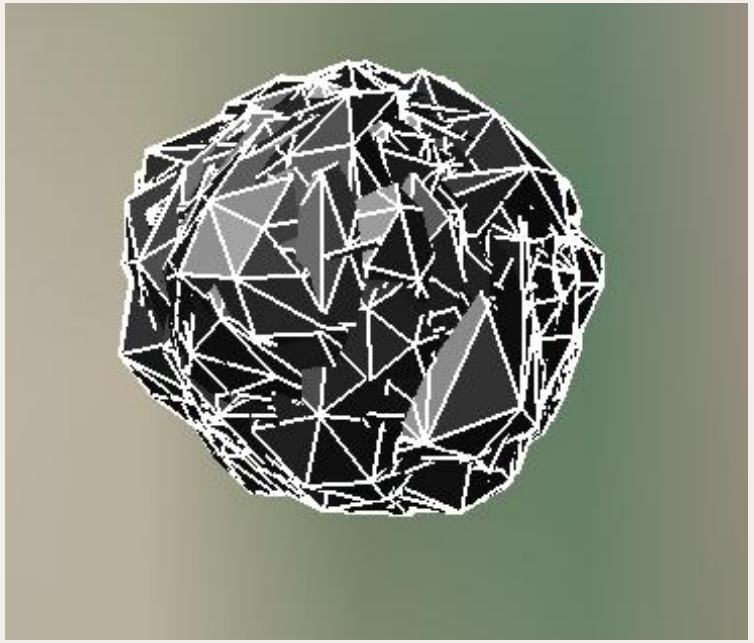
Importance of Random Orientations

Rock shape causes different **impact configurations** at the first contact.
Randomly rotating the rock generates **multiple physically possible trajectories**.

5 Orientations

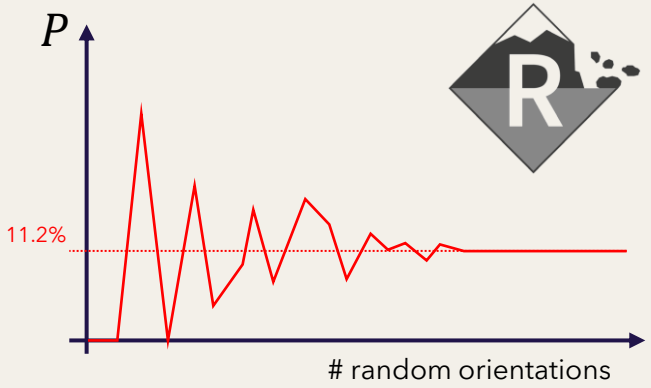


25 Orientations

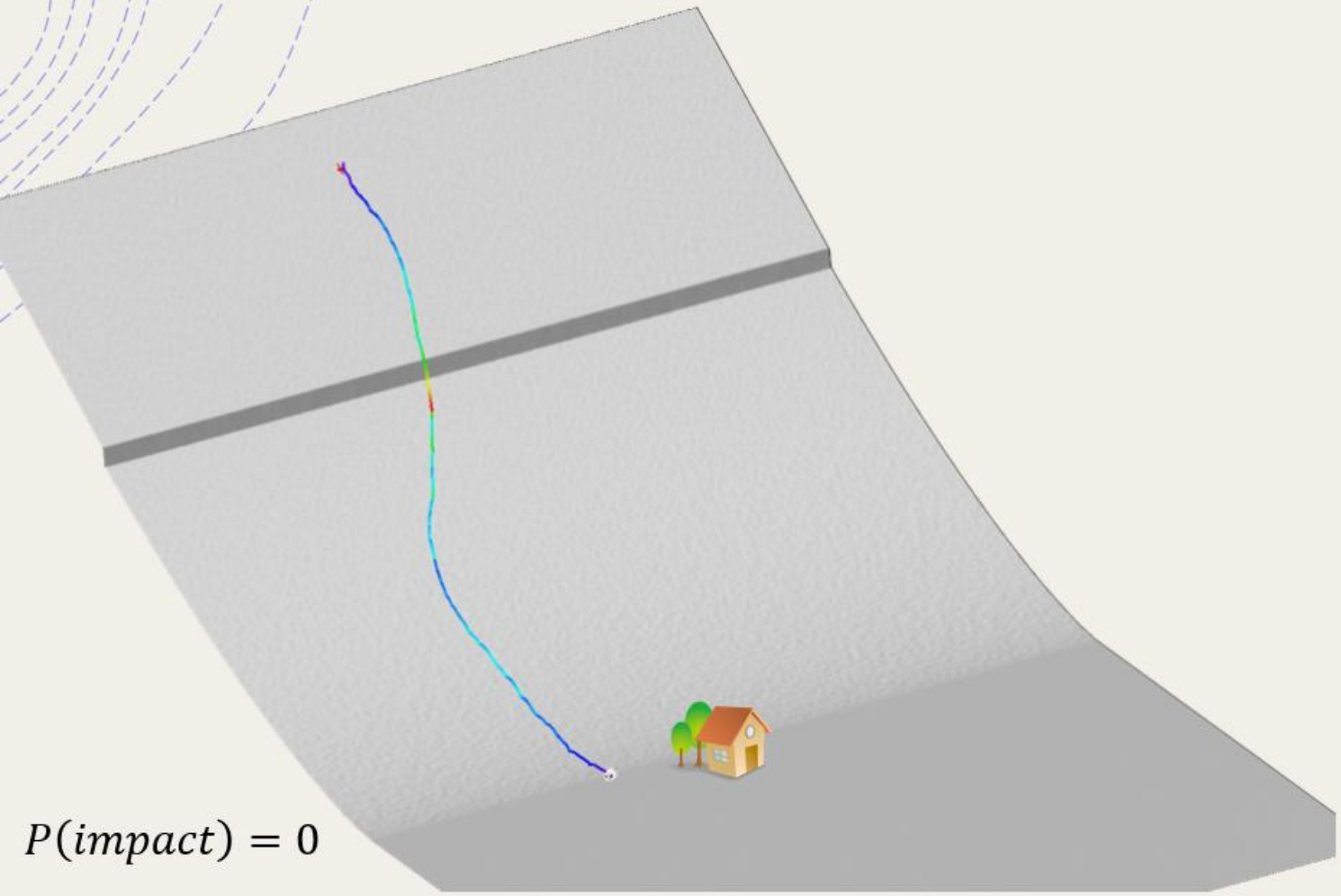


Increasing the number of orientations (n_O) improves the **statistical convergence of the simulation results**.

Stochastics in RAMMS

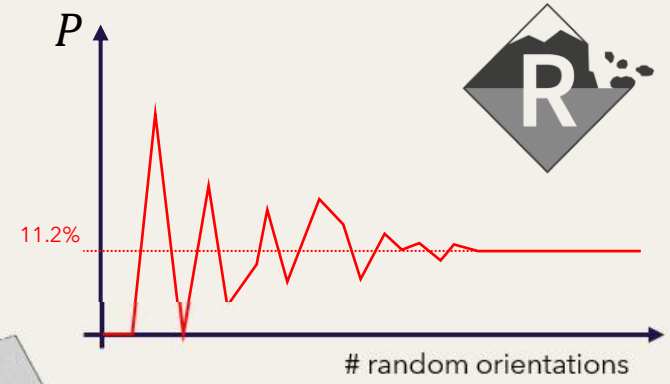


1 random orientation

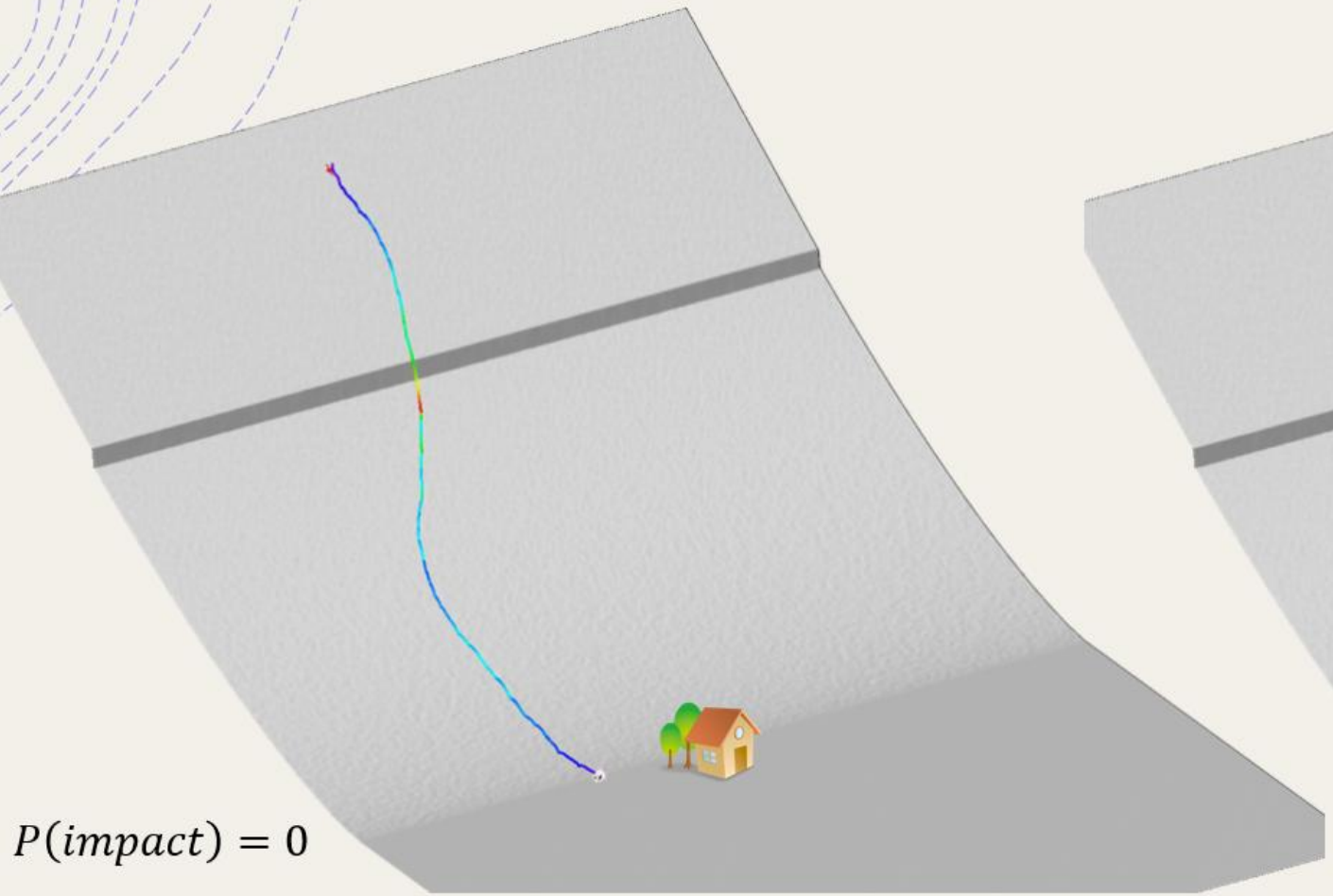


$P(impact) = 0$

Stochastics in RAMMS

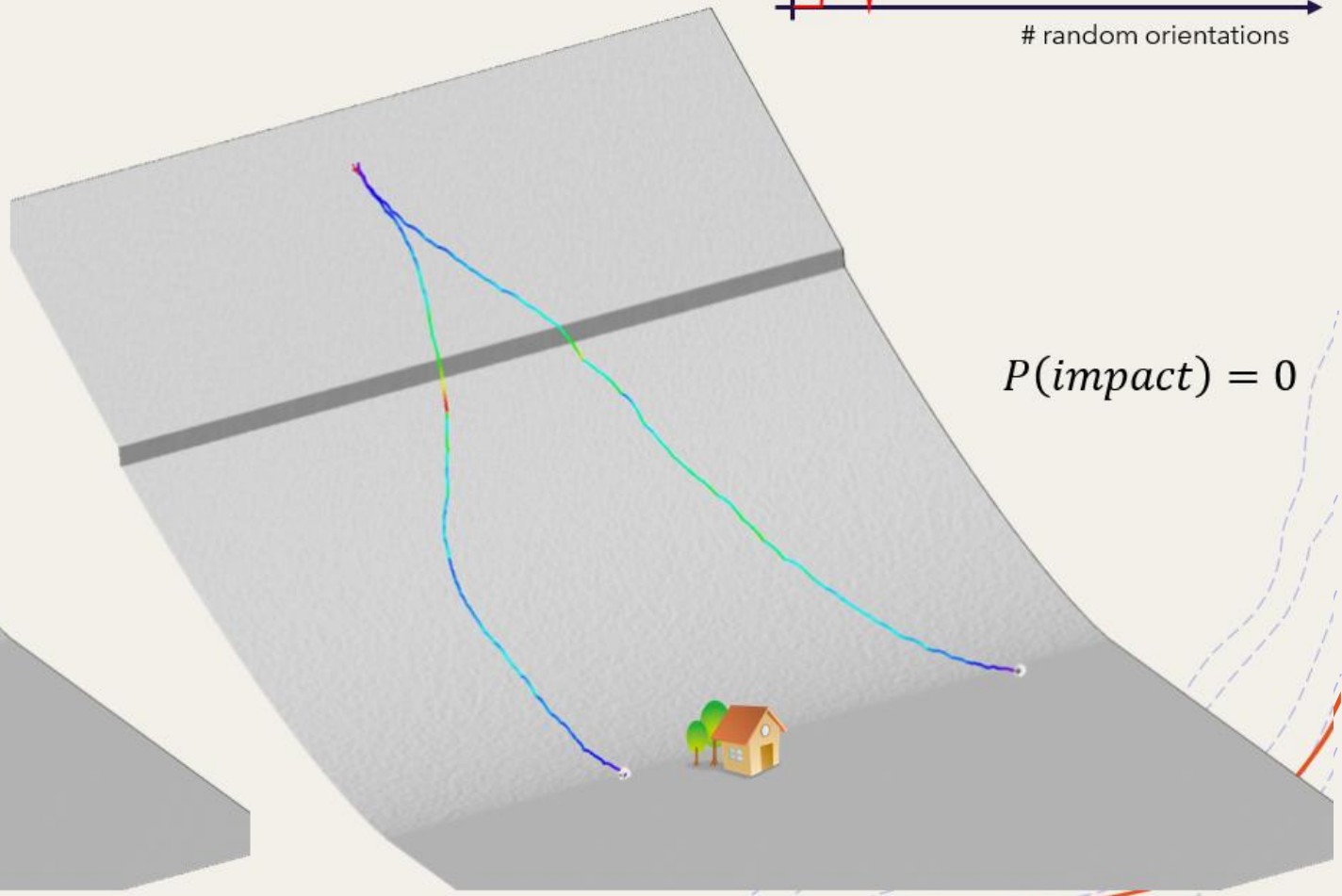


1 random orientation



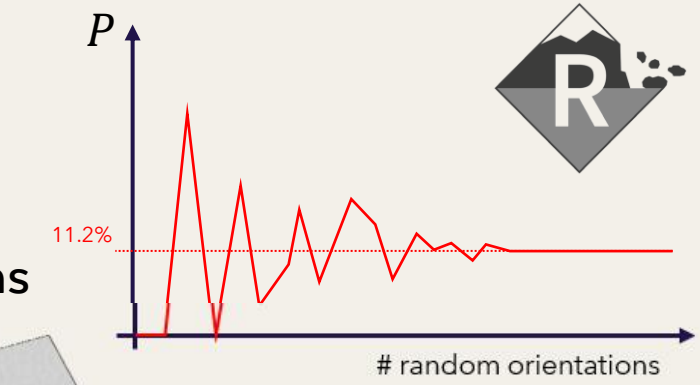
$P(impact) = 0$

2 random orientations



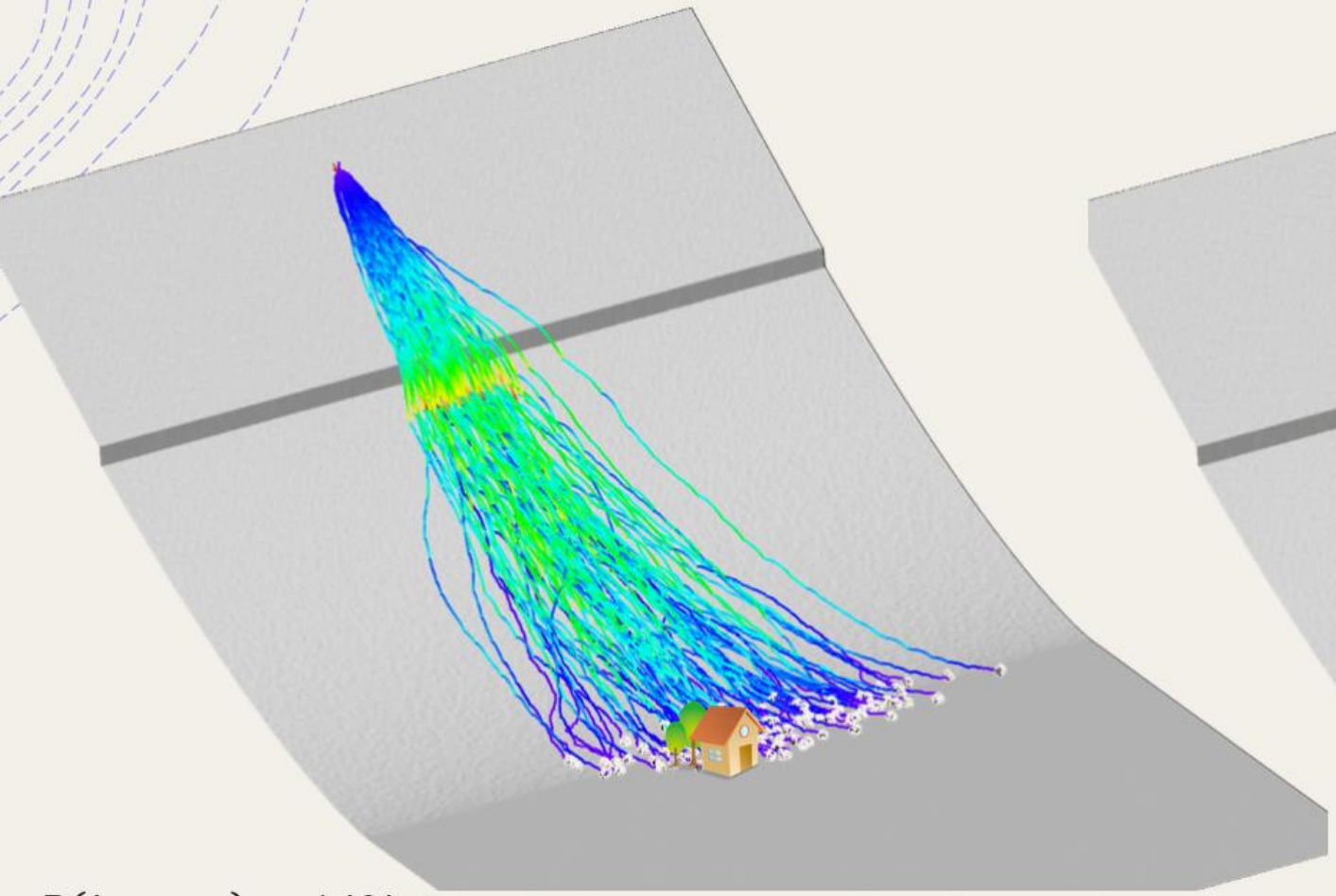
$P(impact) = 0$

Stochastics in RAMMS

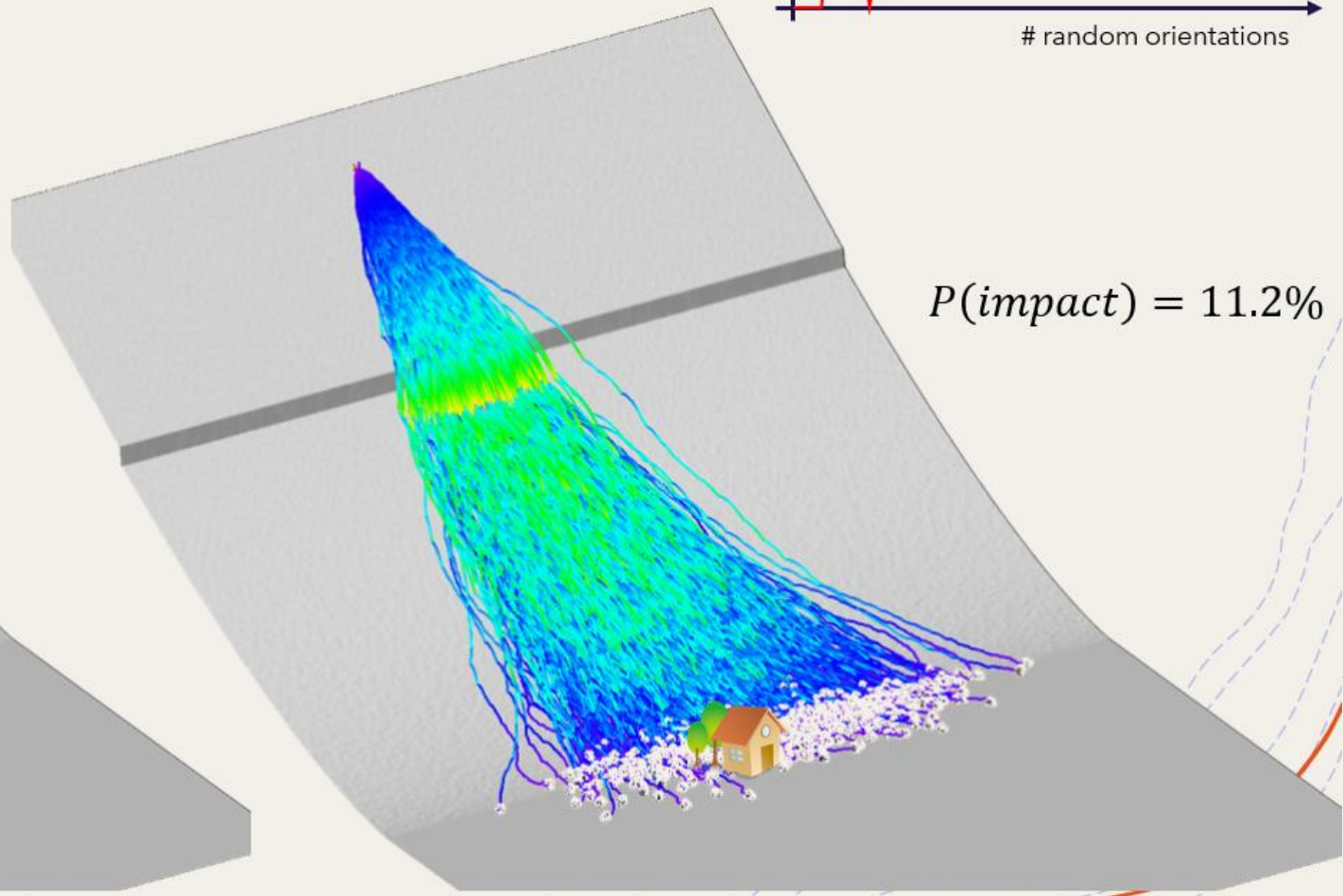


100 random orientations

1000 random orientations



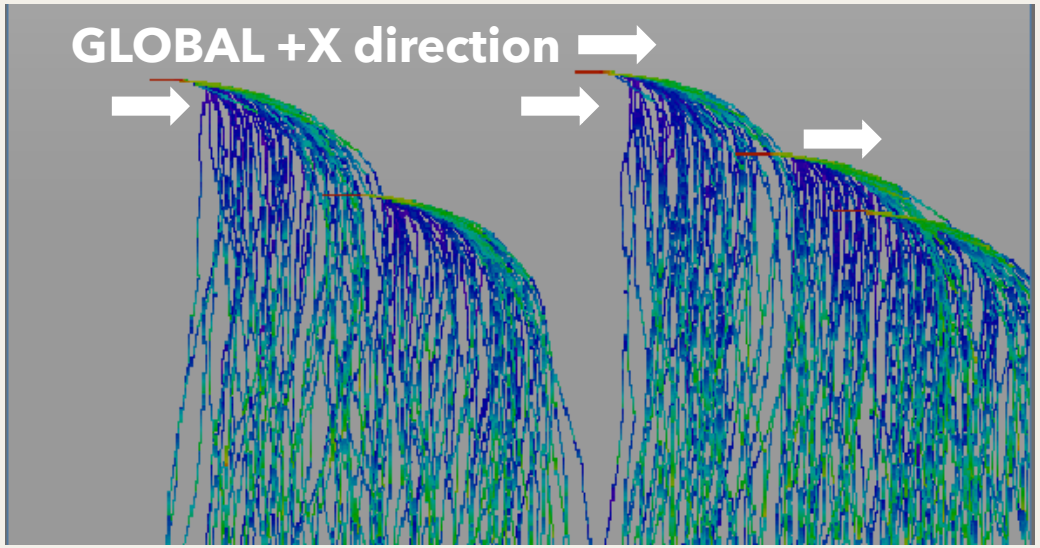
$P(impact) = 14\%$



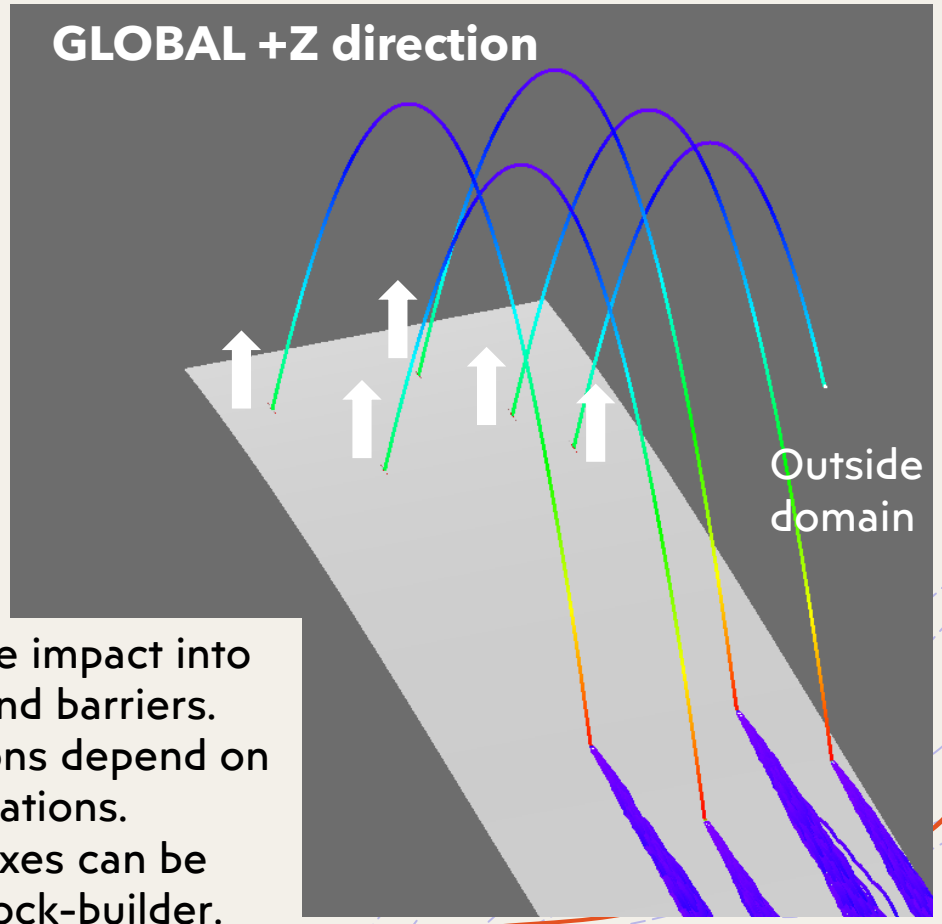
$P(impact) = 11.2\%$

Initial Velocities and Rotations

It is also possible to specify an initial velocity **(in three GLOBAL directions)** and initial rotations (**around three LOCAL axes**).



Used to simulate volcanic bombs

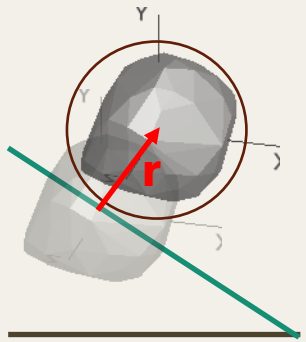


1. Used to initiate impact into dams, sheds and barriers.
2. LOCAL rotations depend on random orientations.
3. LOCAL rock-axes can be visualized in rock-builder.

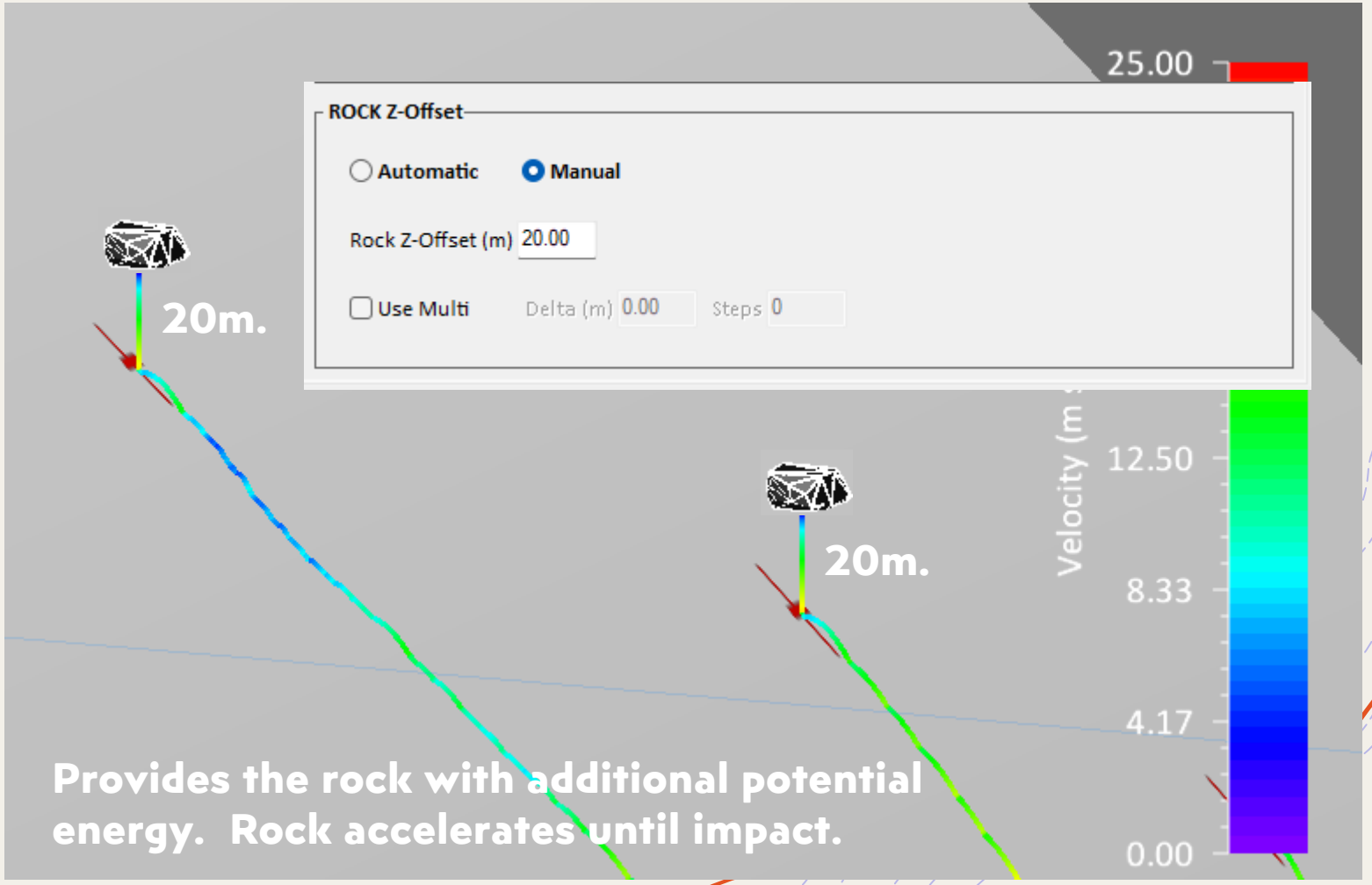
Z-Offset

Two modes to set the SLOPE-PERPENDICULAR distance of starting location above the DEM: Automatic and Manual

Automatic: Automatic mode
Rock moved in normal direction out of the terrain (by radius of bounding rock-sphere). This ensures the rock does not intersect the terrain.
STANDARD



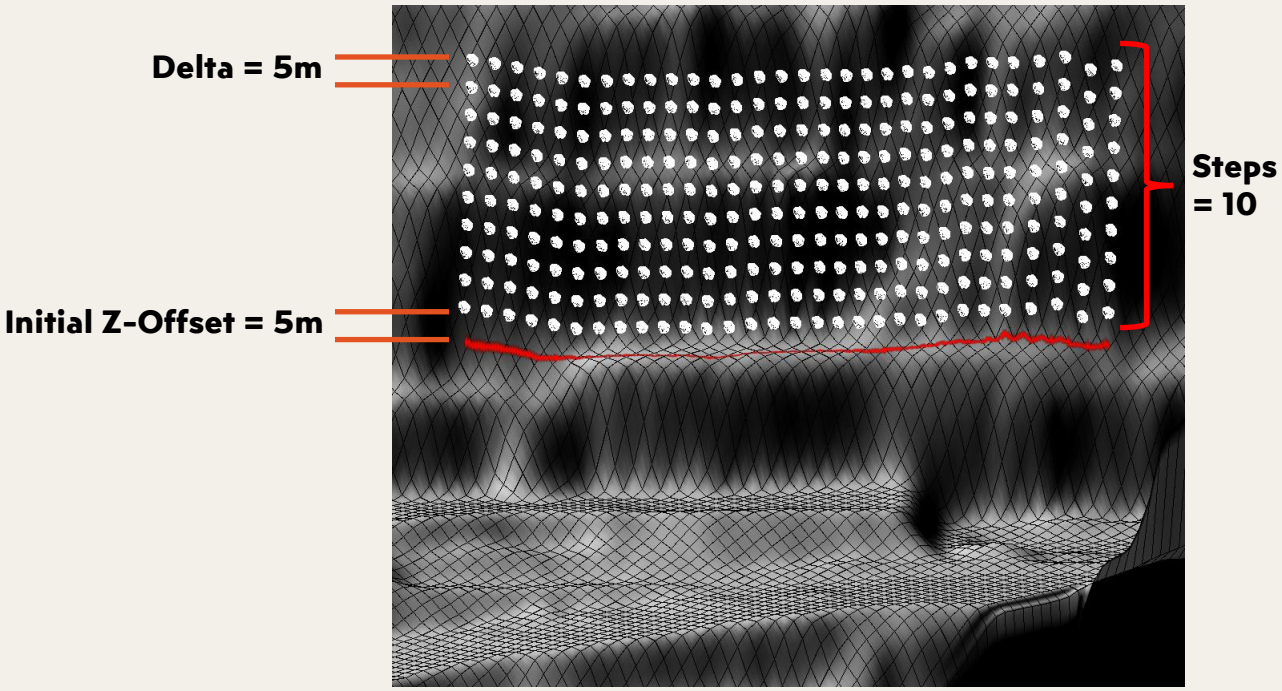
Manual: Center of mass (of rock) moved vertically upwards by given Z-offset.

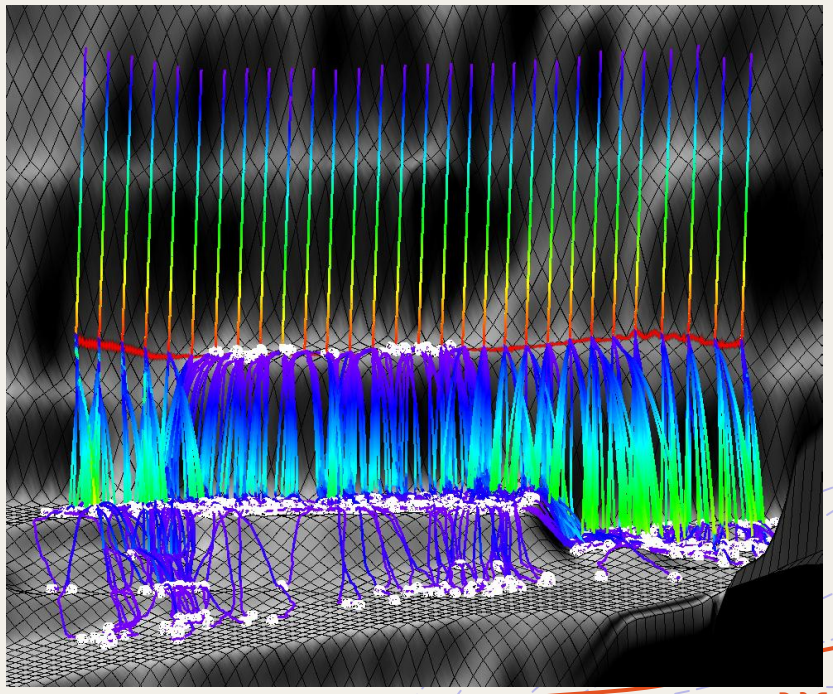


Z-Offset

Manual: Manual offset can be used to cover a whole steep cliff wall. Draw a line shapefile at the base of the cliff, specify nr of points on the line, click **Manual** Z-Offset, enable the **Multi** checkbox and enter **Delta/Steps** to cover the whole wall.

→ This setup will multiply the nr of simulation by 10!





Summary

1. **Release geometry defines where rocks start.** Three release types determine the number of starting locations n_S (**Point**, **Line**, **Area**). This controls the **spatial distribution of trajectories**.

2. **Rock shapes define rock behaviour.** The **Rock Tab** defines the number of rocks n_R (single rock, multiple rocks / rock library). Different shapes lead to different **impact behaviour and runout distances**.

3. **Random orientations generate trajectory variability.** At every starting location the rock is rotated randomly n_O. This creates a **statistical distribution of rockfall trajectories**.

Summary

4. **Initial conditions define the initial energy** $E = mgh + \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$. Energy depends on **release height (z-offset)**, **initial velocity**, **initial rotation.** These strongly influence the **first impacts and trajectory evolution**.

5. **Rockfall trajectories are inherently statistical.** Small differences in starting location, rock shape, rock orientation produce **different trajectories and runout distances**.

6. **Total number of simulations** $N = n_S \times n_R \times n_O$. More simulations provide a **better statistical representation of possible rockfall paths**.