

# GRAPHICAL USER INTERFACE

The main window of MUSEN consists of 5 main regions (Fig. 1):

- *Main menu* – access to all components, options and simulation tools;
- *Toolbar* – quick access to selected components or actions;
- *3D scene view* – three dimensional representation of the scene;
- *Scene view options* – various options how current scene could be represented (coloring, cutting planes, visible objects, etc.);
- *Time selection slider* – possibility to select specified time point.

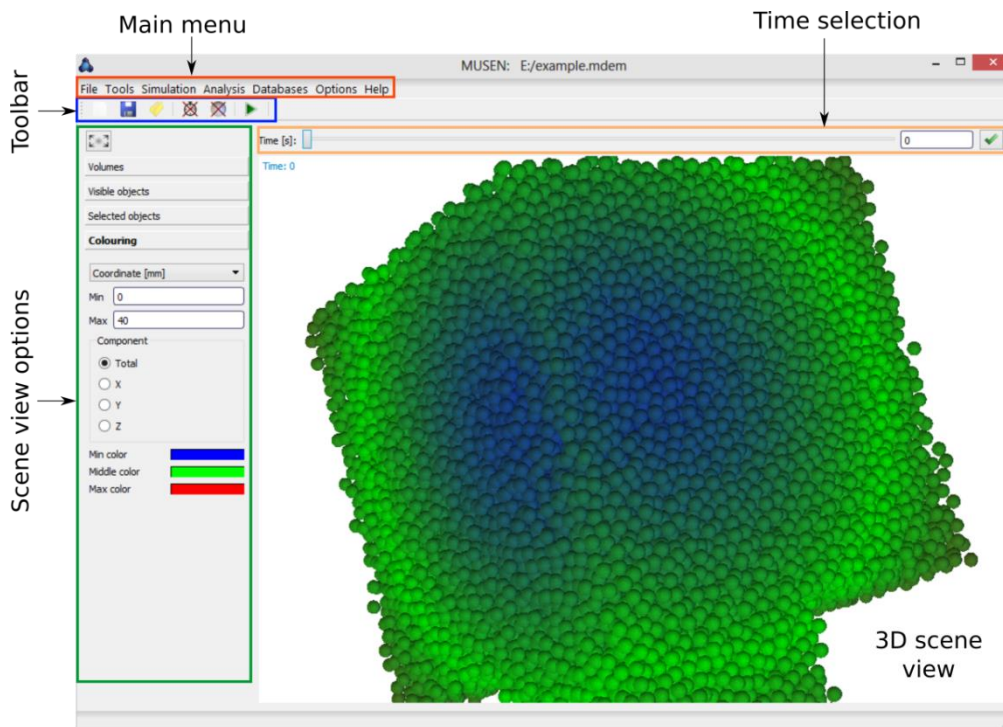


Figure 1. Main window of MUSEN system

# MAIN MENU

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## File

- *New* – create new empty file in binary format (\*.mdem);
- *Save* – save current scene as file in binary format (\*.mdem);
- *Save data snapshot* – save new scene into binary format, where only current selected time point will be saved as time point “0” (can be effectively used to continue previous simulations);
- *Export as text* – export data into text format;
- *Import from text* – import data from text (all current objects and time points will be removed);
- *Export geometries as STL* – export geometries as a standard lithography file;
- *Save as image* – save 3D view as \*.png (without background) or \*.jpg (with white background);
- *Save set of images* – can be effectively used as intermediate step for video generation;
- *Load* – load binary data file (\*.mdem);
- *List of recently opened files* – recently opened files for reuse if required;
- *Exit* – to close the application MUSEN without saving.

## Scene

- *Bonds Generator* – generate bonds between primary particles;
- *Package Generator* – generate packings of spherical particles in the appropriate geometry;
- *Geometries Editor* – select geometries, modify geometries and set their time-dependent properties like, velocity in all axes. Can also modify the meshing of the geometry to increase accuracy of particles being generated;
- *Materials editor* – select materials, modify the compounds, interactions and mixtures present in the materials database, that can be selected in databases;
- *Objects Editor* – manual scene editing, can manually edit particles generated by the package generator, add newer and different bonds, like solid and liquid bonds, as well as set individual velocities;
- *Scene Editor* – move, shift or set velocity for a whole scene, as well as set boundary conditions for the system;
- *Delete of particles, bonds and time points* – all possible, for resetting/reinitialization of items in the scene.

## Simulation

- *Dynamic Generator* – generate new particles (agglomerates) during simulation;
- *Start Simulator* – main simulator. Can save collisions and add GPU based computations to save time.

## Analysis

- *Agglomerates Analyzer* – analyze agglomerates. Save the agglomerate properties as a csv file for analysis;
- *Bonds Analyzer* – analyze solid bonds. Save the bond properties as a csv file for analysis;
- *Collision Analyzer* – analyze collisions (only if data with collisions \*.coll) exists. Save the collision properties as a csv file for analysis;
- *Geometries Analyzer* – used to analyze forces acting on geometrical objects. Save the breakage properties as a csv file for analysis;
- *Particle Analyzer* – analyze individual particles for the required properties, and save their properties as a csv file;
- *Sample Analyzes* – analyze a spherical volume, which is user modifiable to find porosity, mass etc. at a particular time step. Can also be used to find PSD and velocity of particles in the user-defined analysis sphere and export as a csv;
- *Scene Info* – general information about scene (objects number, etc.).

## Databases

- *Agglomerates* – database of agglomerates, can also create new agglomerates as a set of smaller particles;
- *Geometries* – database of geometries, can also use user-made geometries from «solidworks» as a .stl file;
- *Materials* – database of materials, where new materials can also be added, and other parameters adjusted like interaction and mass fraction of mixtures.

## Options

- *Default Units* – select desired units for MUSEN to operate in;
- *Model Manager* – modify the models to be used for the simulation;
- *Settings* – visual modification of the 3D scene window for better viewing/performance.

## 3D VIEW AND TIME SELECTION

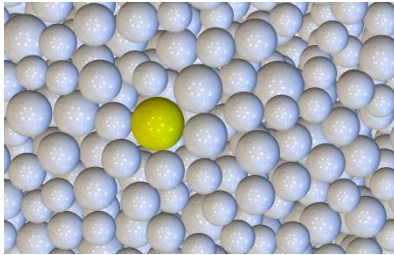
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There exist various features to change view angle or position:

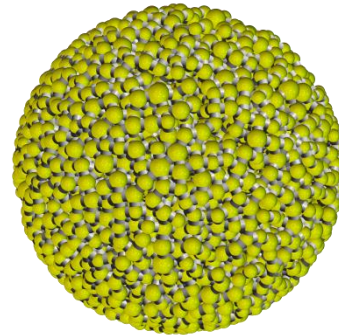
- *Left button + mouse move* – scene rotation;
- *Right button + mouse move* – shift scene;
- *Mouse wheel* – increase/decrease zoom;
- *Shift + Left mouse button + mouse move* – rotate scene around Z axis.

Separate objects can be selected on the scene:

- *Ctrl + left mouse click* – selection of single object;
- *Ctrl + right mouse click* – selection of group of objects (connected with solid bonds).



a) selected particle



b) selected agglomerate

Figure 2. Objects selection in 3D view

Time selection allows to specify needed time point which will be visualized on the scene. All time-dependent data (particle positions, velocities, etc.) is stored for specific set of time points. With *Step Backward* and *Step Forward* buttons the next of previous saved time point will be selected. To select any other time point time slider or edit tab can be used. **In this case linear interpolation will be used to approximate data.**



Figure 4. Possibility to select specific time in MUSEN

## SCENE VIEW OPTIONS

Scene view options have four different tabs to change properties of three-dimensional scene representation:

- *Volumes* – cut scene view with a specific cutting plane and/or with specific geometry;
- *Visible objects* – specify which objects should be made visible. Specification can be done by type (particles, bonds, geometries) or by material;
- *Selected object* – information about selected object. When group of objects is selected, then average parameters are shown: center of mass and averaged velocity of this object;
- *Colouring* – in this tab the coloring options can be specified. By double-click on specific color it can be selected. Some properties such as objects velocities are vectors, therefore the component of this vector can be selected. If *Total* is specified, then the length of the vector will be used as property. If the option *Max overlap* is selected, then the coloring is made according to the maximal value of the overlap between particles. This means if specific particle has overlaps with several other particles, then only maximal value will be considered.

If coloring according to *Coordination Number* is selected, then the F5 key should be pressed anytime, when scene has been modified or when another time point has been selected. Connection of particles with bonds is also considered by approximation of coordination number.

By coloring according to *Force* the component *Total* area represents length of the vector and it is always positive. To distinguish between compression and tension of the bonds the option *Bond Force* should be selected. Negative – means tension, positive – compression.

*Adjust Boundaries* will automatically set coloring minimal and maximal values for coloring palette.

Double-click on specific color allows to change it, as it is shown in *Fig. 4*.

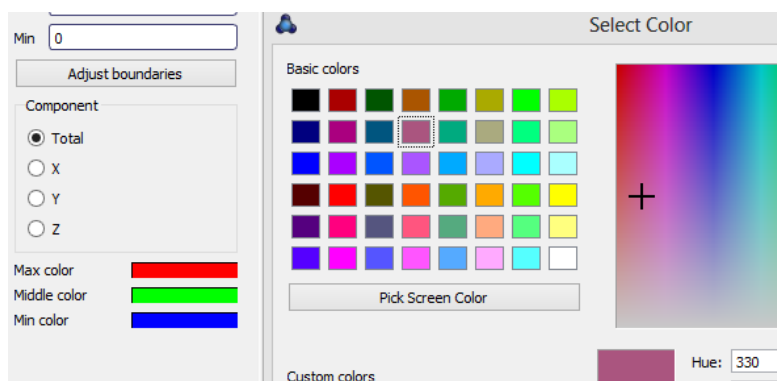


Figure 4. Color selection to change boundaries