

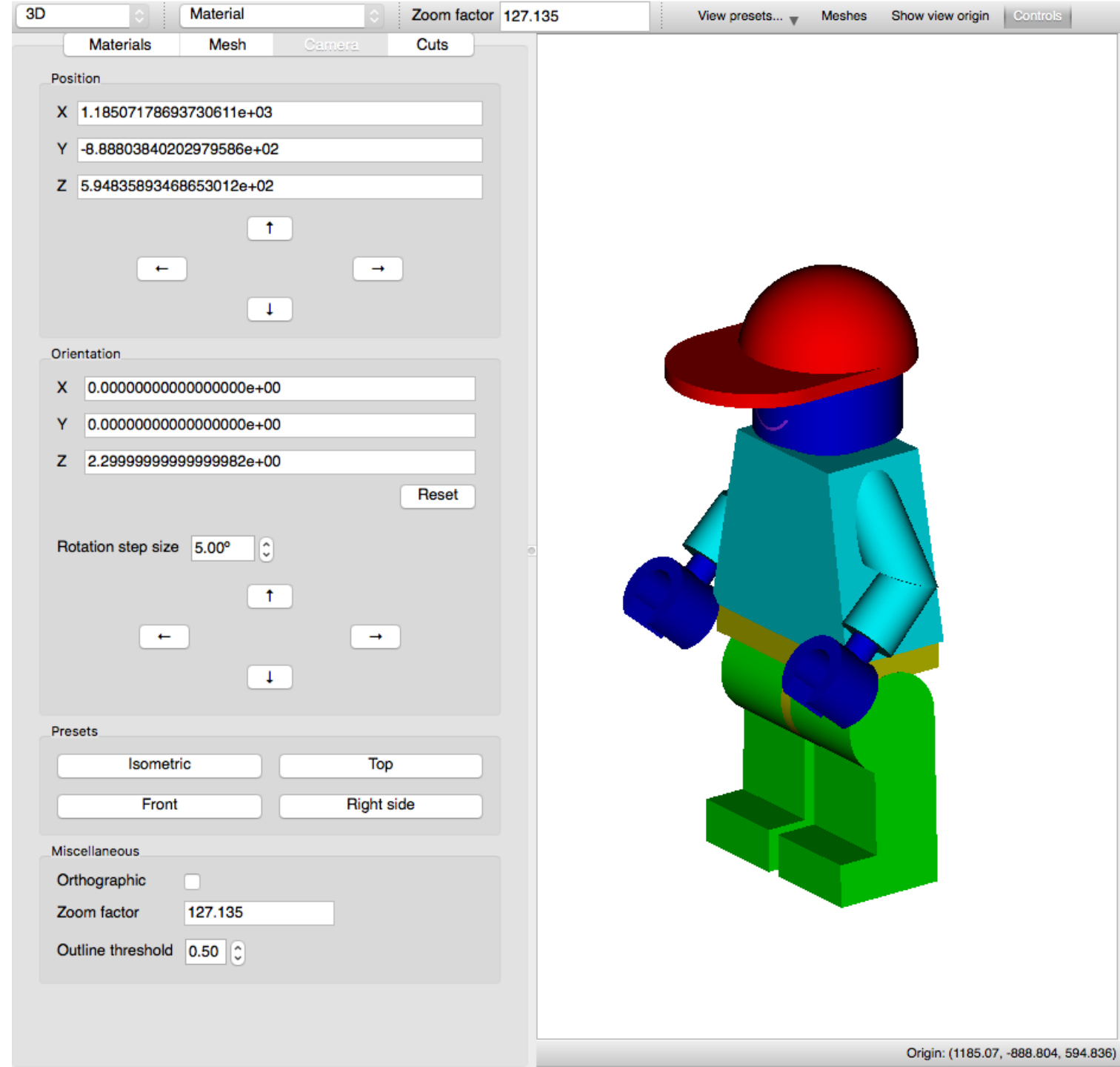
# 3D Visualization In Fulcrum

Rob Lefebvre, Seth Johnson, Adam Thompson,  
Tom Evans, William (BJ) Marshall, Brad Rearden

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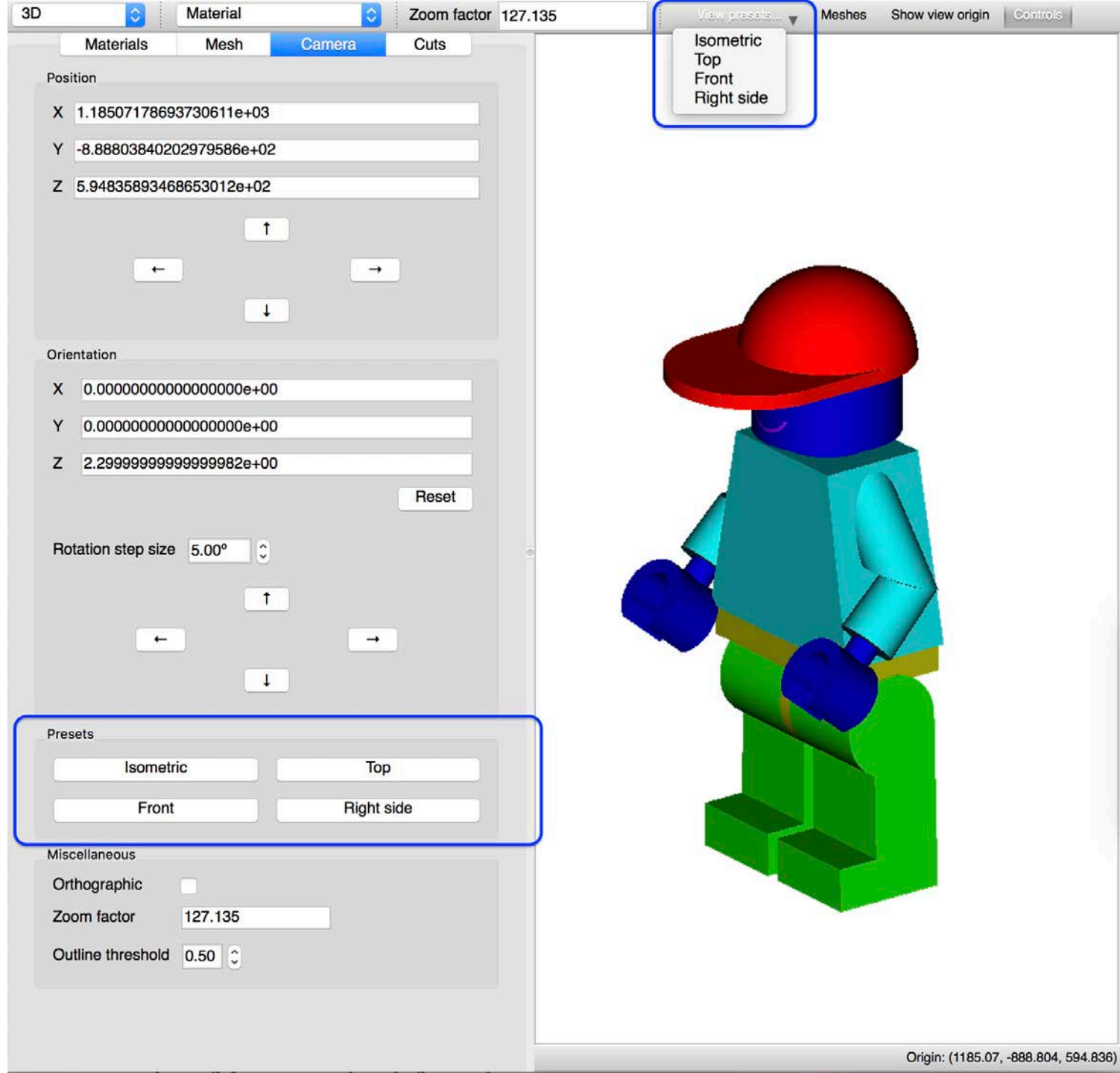
# Overview

- Camera
  - Presets
  - Panning
  - Zooming
  - Rotation
- Rendering modes
- Display metadata
- Material controls
  - Filter material table
- Geometry Cuts



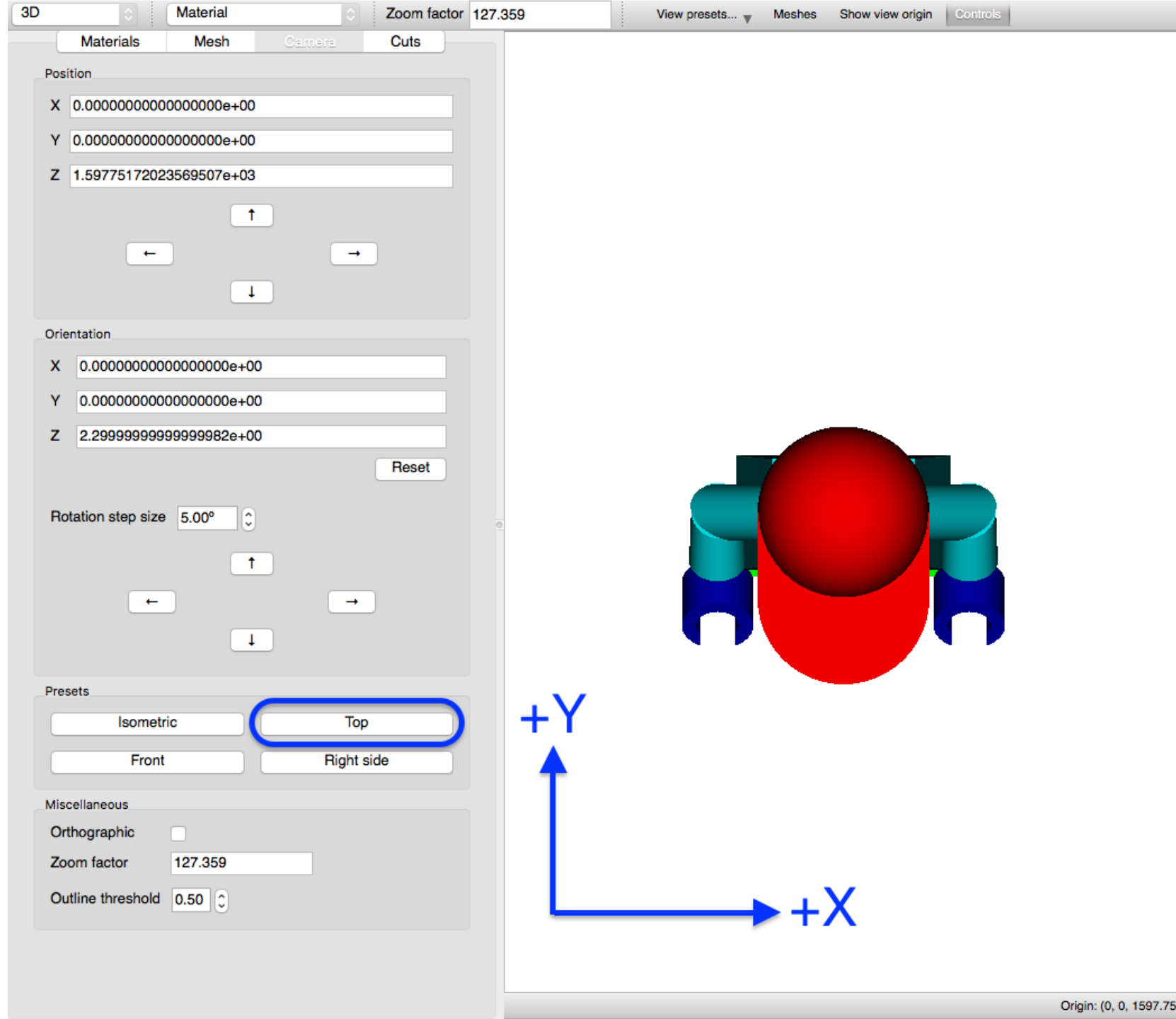
# Camera presets

- **Top:** camera is in  $+Z$  looking into  $-Z$
- **Front:** camera is in  $-Y$  looking into  $+Y$
- **Right side:** camera is in  $+X$  looking into  $-X$
- **Isometric:** camera is above and in front



# Camera presets:

- **Top**: camera is in  $+Z$  looking into  $-Z$
- Front: camera is in  $-Y$  looking into  $+Y$
- Right side: camera is in  $+X$  looking into  $-X$
- Isometric: camera is above and in front



# Camera presets:

- Top: camera is in +Z looking into -Z
- **Front**: camera is in -Y looking into +Y
- Right side: camera is in +X looking into -X
- Isometric: camera is above and in front

The screenshot shows a 3D software interface with a camera control panel on the left and a 3D view on the right. The camera control panel includes sections for Position, Orientation, Rotation step size, Presets, and Miscellaneous. The Presets section has four buttons: Isometric, Top, Front (highlighted with a blue circle), and Right side. The Miscellaneous section includes checkboxes for Orthographic and Zoom factor (127.354), and a dropdown for Outline threshold (0.50). The 3D view shows a character with a red helmet, blue face, cyan shirt, yellow belt, and green pants. A blue coordinate system is overlaid on the character, with the +Z axis pointing upwards and the +X axis pointing to the right.

# Camera presets:

- Top: camera is in +Z looking into -Z
- Front: camera is in -Y looking into +Y
- **Right side**: camera is in +X looking into -X
- Isometric: camera is above and in front

3D Material Mesh Camera Cuts Zoom factor 127.354 View presets... Meshes Show view origin Controls

Materials Mesh Camera Cuts

Position

X 1.59545172023569512e+03

Y 0.0000000000000000e+00

Z 2.29999999999999982e+00

Orientation

X 0.0000000000000000e+00

Y 0.0000000000000000e+00

Z 2.29999999999999982e+00

Reset

Rotation step size 5.00°

Presets

Isometric Top

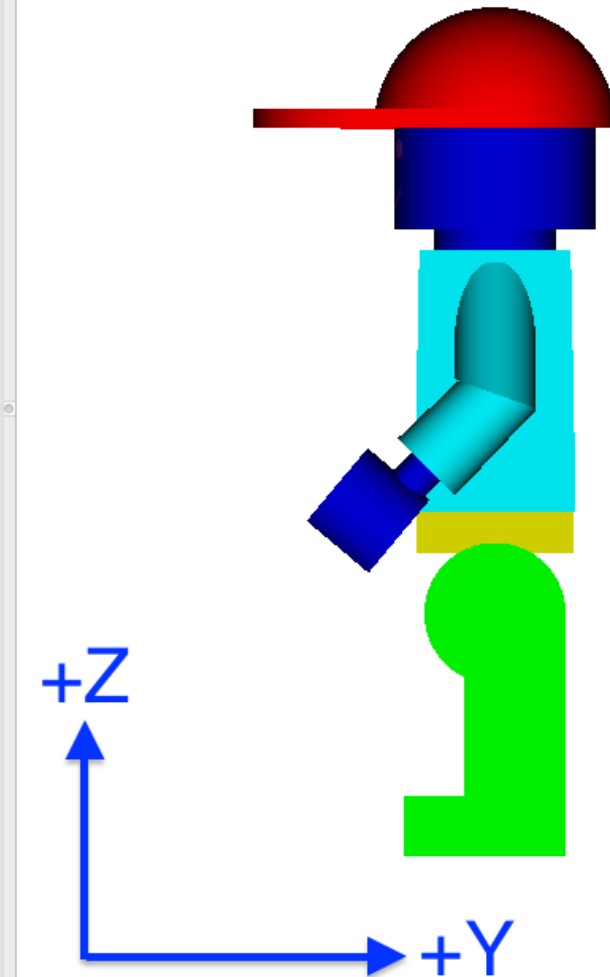
Front **Right side**

Miscellaneous

Orthographic

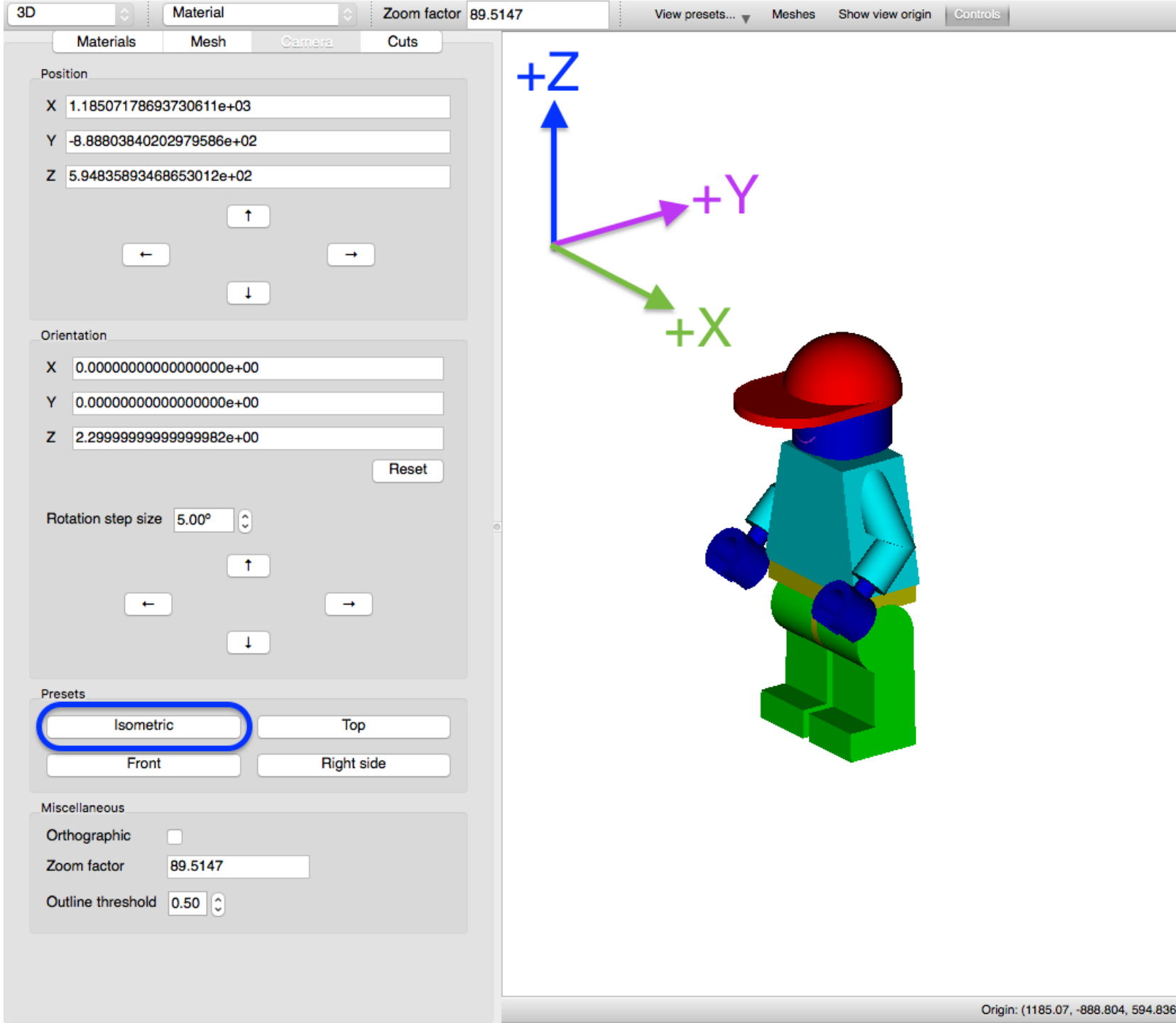
Zoom factor 127.354

Outline threshold 0.50



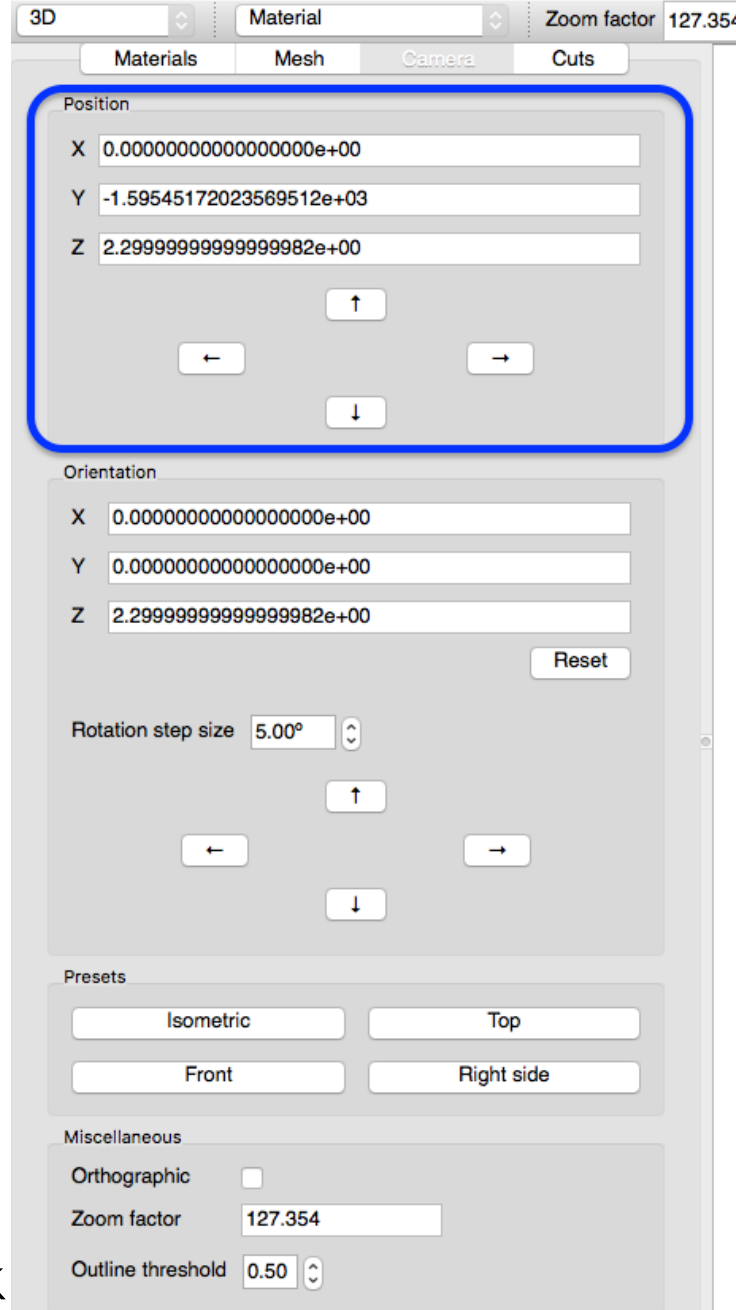
# Camera presets:

- Top: camera is in  $+Z$  looking into  $-Z$
- Front: camera is in  $-Y$  looking into  $+Y$
- Right side: camera is in  $+X$  looking into  $-X$
- **Isometric**: camera is above and in front

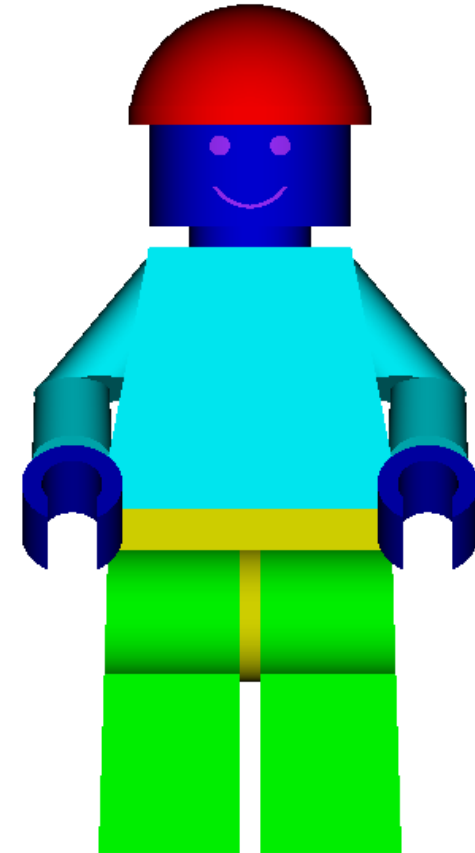


# Camera Panning

- **Position** fields allow absolute camera positioning
- **Up** arrow moves model up by moving camera down
- **Down** arrow moves model down by moving camera up
- **Left** arrow moves model left by moving camera right
- **Right** arrow moves model right by moving camera left
- **Double-click** at a point pans to re-center at click point



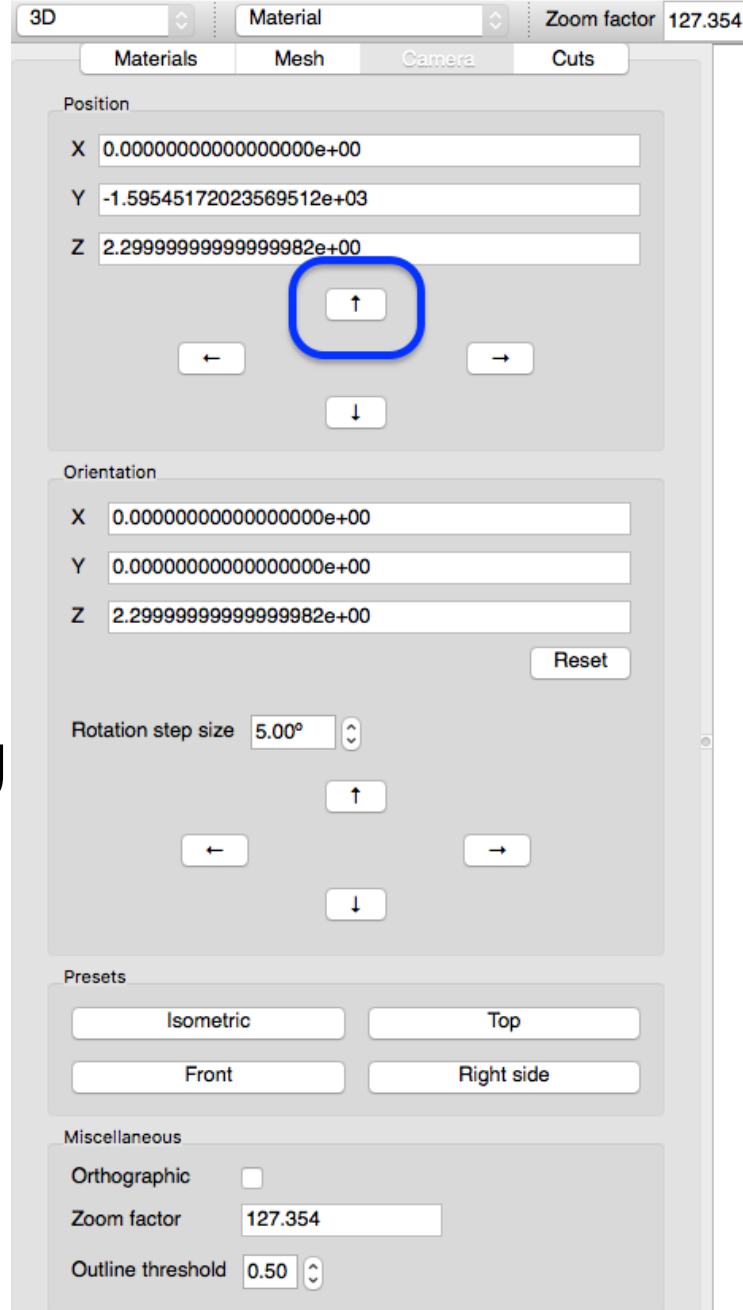
Shift+Mouse Drag  
to new location





# Camera Panning:

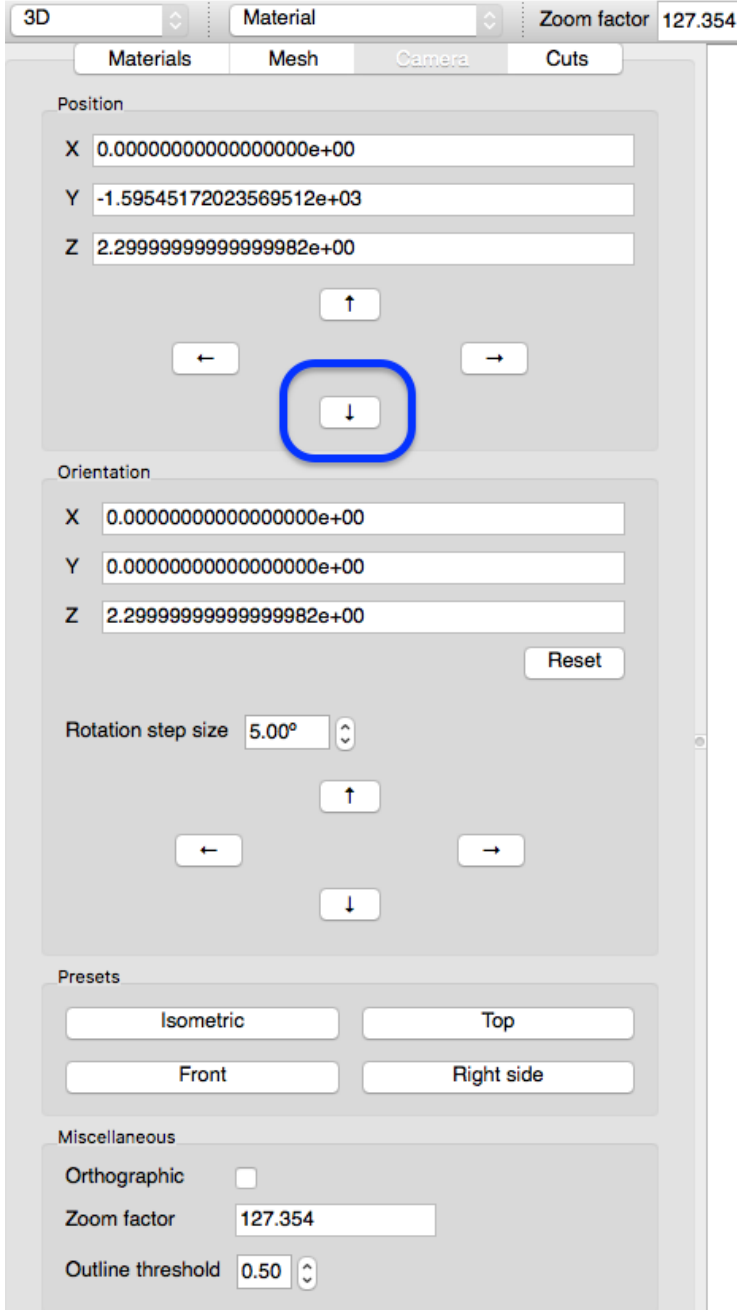
- Up arrow moves model up by moving camera down
- Down arrow moves model down by moving camera up
- Left arrow moves model left by moving camera right
- Right arrow moves model right by moving camera left
- Double-click at a point pans to re-center at click point



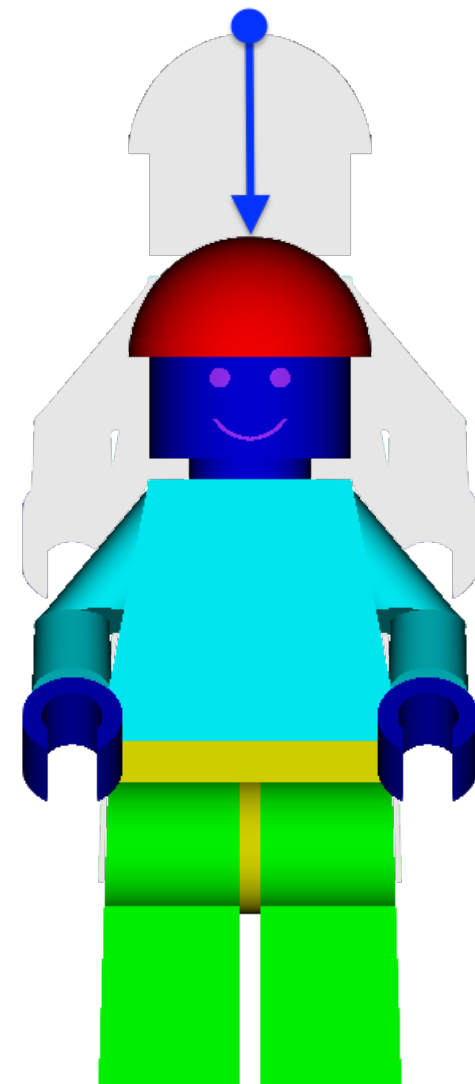
Shift+Mouse Drag  
to new location

# Camera Panning:

- Up arrow moves model up by moving camera down
- **Down** arrow moves model down by moving camera up
- Left arrow moves model left by moving camera right
- Right arrow moves model right by moving camera left
- Double-click at a point pans to re-center at click point

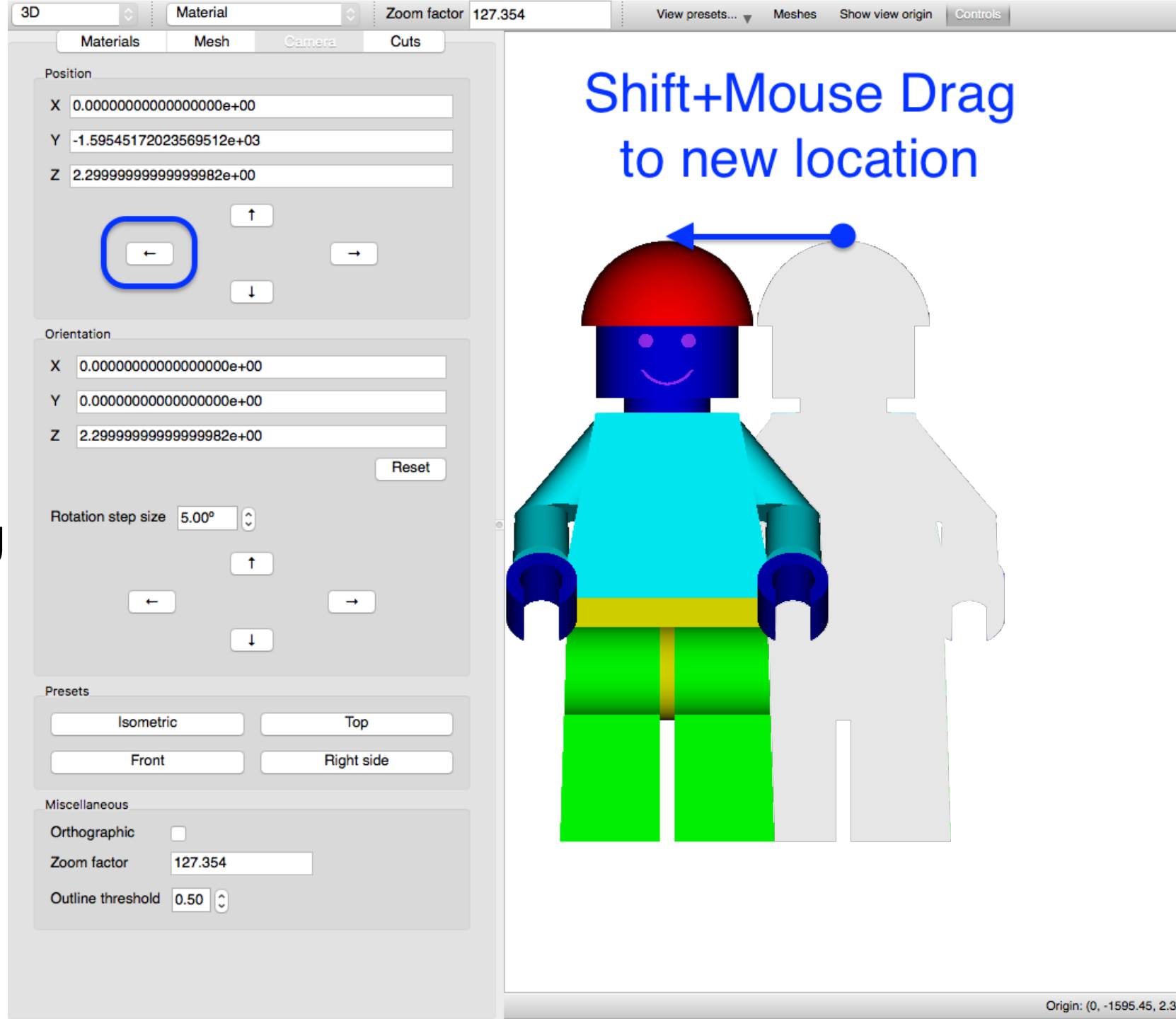


Shift+Mouse Drag  
to new location



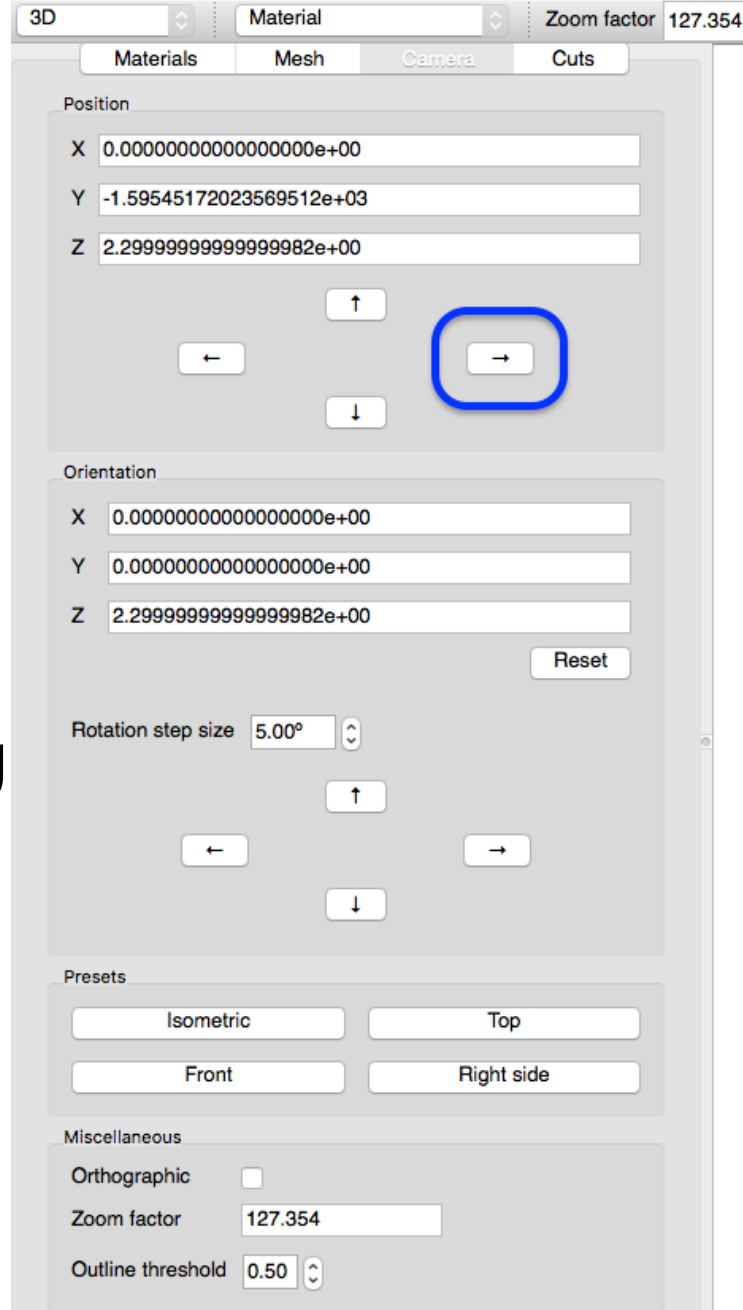
# Camera Panning:

- Up arrow moves model up by moving camera down
- Down arrow moves model down by moving camera up
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- Right arrow moves model right by moving camera left
- Double-click at a point pans to re-center at click point

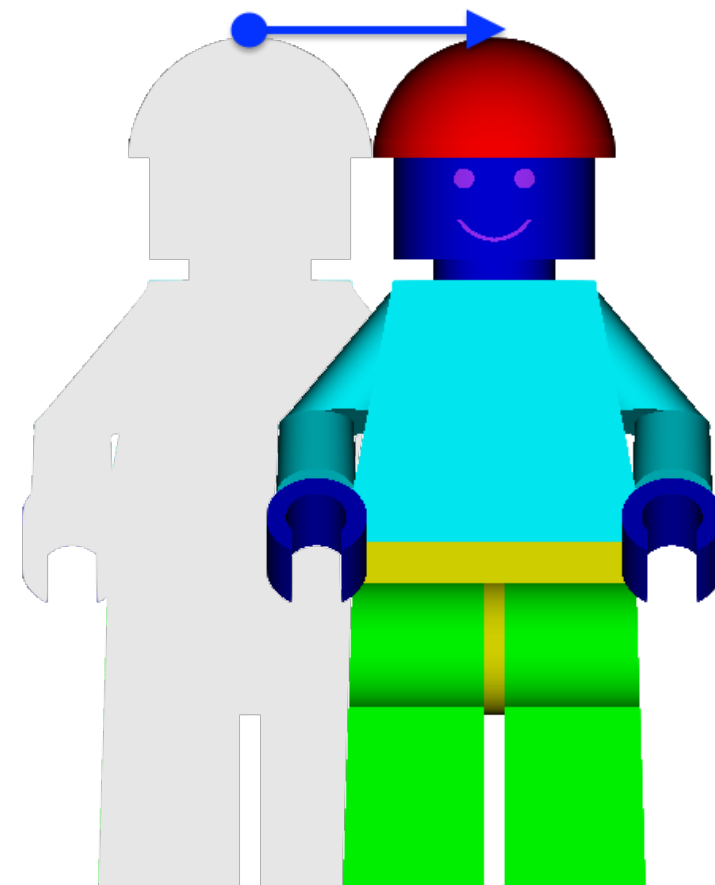


# Camera Panning:

- Up arrow moves model up by moving camera down
- Down arrow moves model down by moving camera up
- Left arrow moves model left by moving camera right
- **Right** arrow moves model right by moving camera left
- Double-click at a point pans to re-center at click point

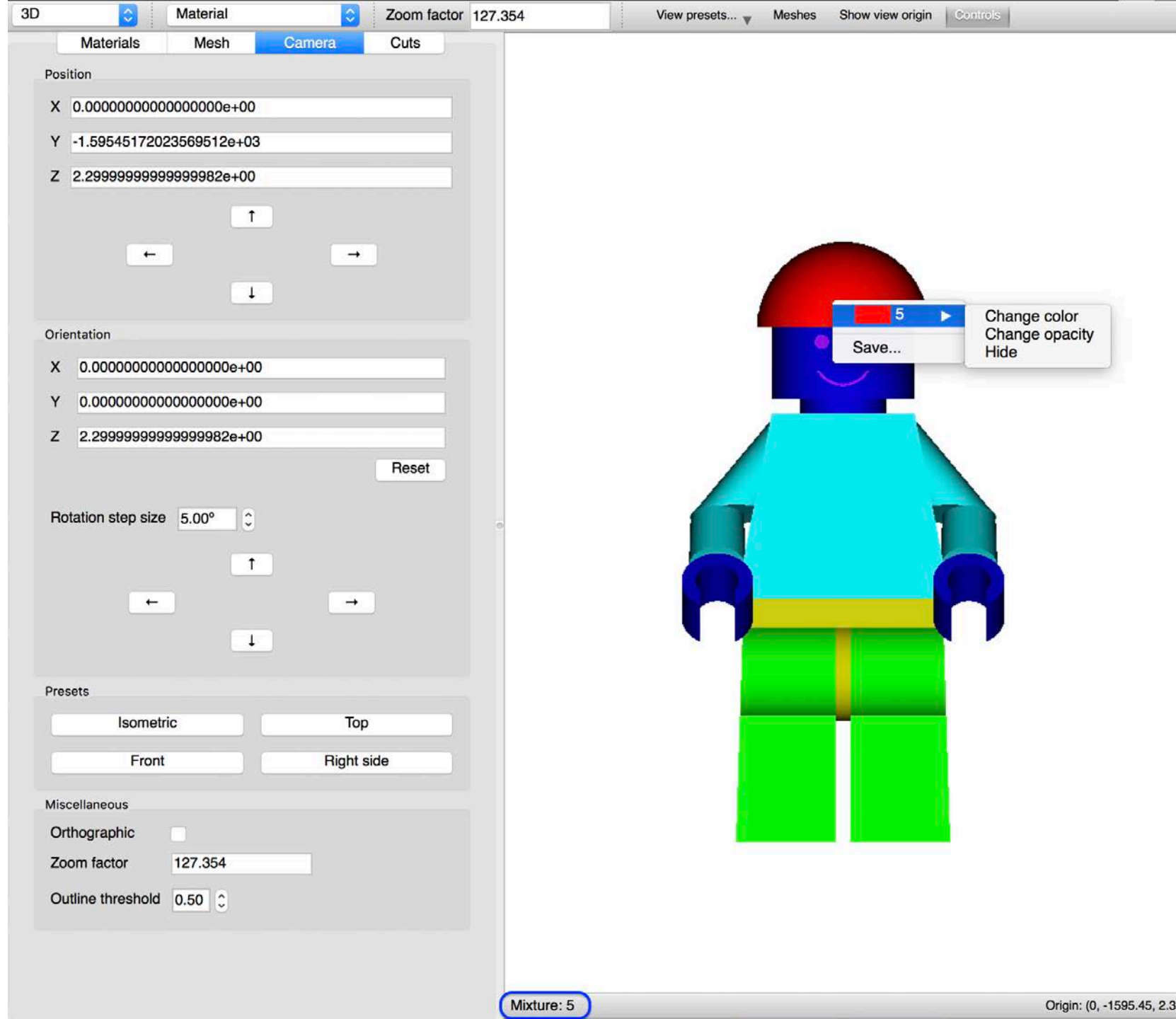


Shift+Mouse Drag  
to new location



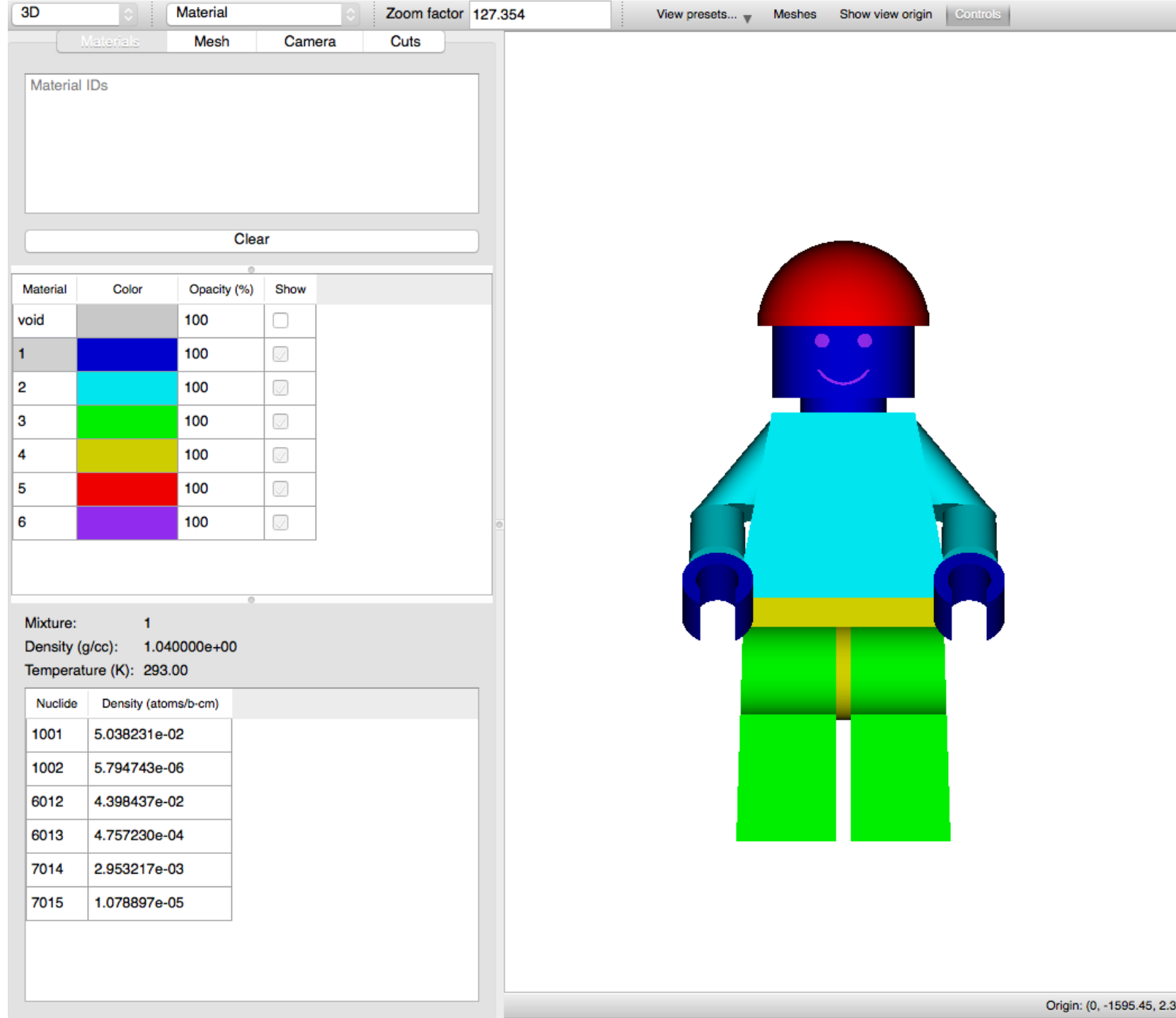
# Display metadata

- Mousing-over pixels reports the material under the cursor
- The user can also right-click on a pixel with material information and control
  - **visibility**,
  - **opacity**,
  - and **color**
  - for **one or more** materials under the given pixel.



# Materials Controls

- A table containing the full listing of known materials in the model.
- Table allows controlling
  - visibility,
  - opacity,
  - and **color**
  - for **all** material in the model.
- Mixture information changes as a function of selected material

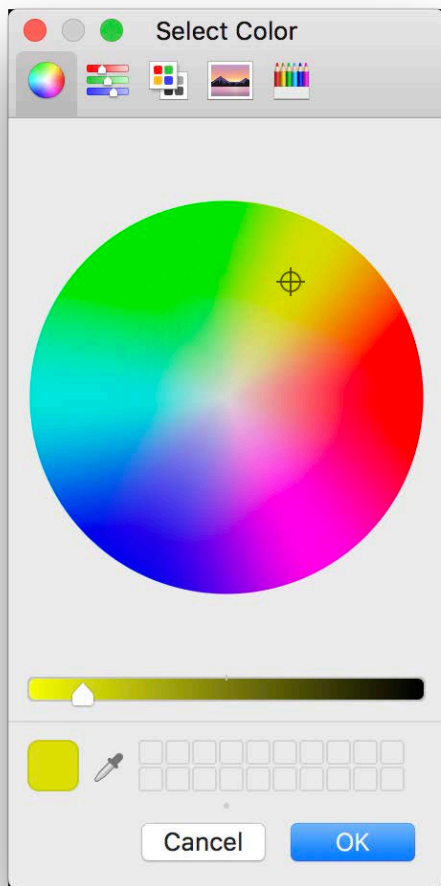


The screenshot displays a software interface with a top navigation bar containing '3D', 'Material', 'Zoom factor 127.354', 'View presets...', 'Meshes', 'Show view origin', and 'Controls'. Below this are tabs for 'Materials', 'Mesh', 'Camera', and 'Cuts'. The main area is divided into several sections:

- Material IDs:** A large empty text box with a 'Clear' button below it.
- Material Table:** A table with columns 'Material', 'Color', 'Opacity (%)', and 'Show'. It lists materials 1 through 6 with corresponding colors and checked 'Show' boxes.
- Mixture Information:** A section showing 'Mixture: 1', 'Density (g/cc): 1.040000e+00', and 'Temperature (K): 293.00'.
- Nuclide Table:** A table with columns 'Nuclide' and 'Density (atoms/b-cm)', listing nuclides 1001 through 7015 with their respective densities.

On the right side of the interface, a 3D model of a person is displayed, rendered with various colors: a red helmet, a blue face with a smile, a cyan shirt, a yellow belt, and green pants.

# Materials Controls: Color



3D Material Zoom factor 127.354 View presets... Meshes Show view origin Controls

Materials Mesh Camera Cuts

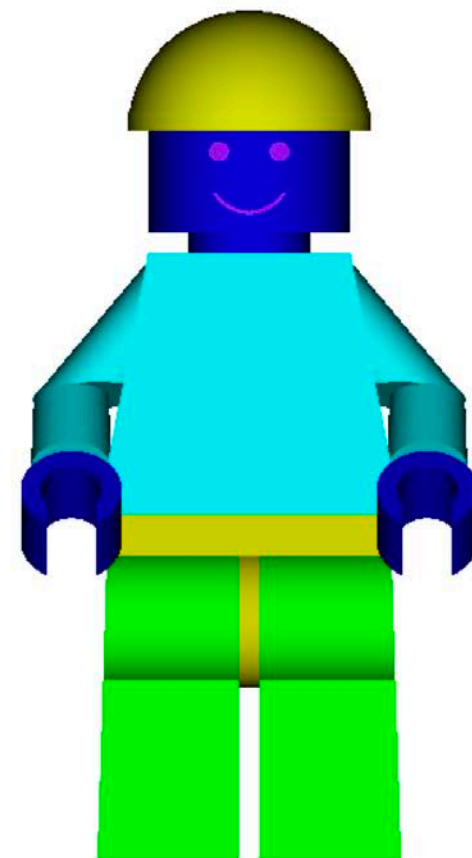
Material IDs

Clear

Material	Color	Opacity (%)	Show
void		100	<input type="checkbox"/>
1	Blue	100	<input checked="" type="checkbox"/>
2	Cyan	100	<input checked="" type="checkbox"/>
3	Green	100	<input checked="" type="checkbox"/>
4	Yellow	100	<input checked="" type="checkbox"/>
5	Orange	100	<input checked="" type="checkbox"/>
6	Purple	100	<input checked="" type="checkbox"/>

Mixture: 5  
 Density (g/cc): 1.040000e+00  
 Temperature (K): 293.00

Nuclide	Density (atoms/b-cm)
1001	5.038231e-02
1002	5.794743e-06
6012	4.398437e-02
6013	4.757230e-04
7014	2.953217e-03
7015	1.078897e-05



# Materials Controls: Visibility

3D Material Zoom factor 127.354 View presets... Meshes Show view origin Controls

Materials Mesh Camera Cuts

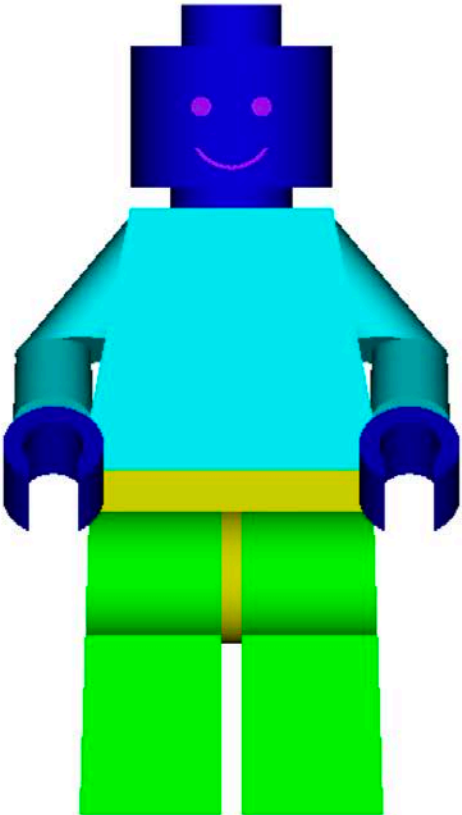
Material IDs

Clear

Material	Color	Opacity (%)	Show
void		100	<input type="checkbox"/>
1	Blue	100	<input checked="" type="checkbox"/>
2	Cyan	100	<input checked="" type="checkbox"/>
3	Green	100	<input checked="" type="checkbox"/>
4	Yellow	100	<input checked="" type="checkbox"/>
5	Red	100	<input type="checkbox"/>
6	Purple	100	<input checked="" type="checkbox"/>

Mixture: 5  
Density (g/cc): 1.040000e+00  
Temperature (K): 293.00

Nuclide	Density (atoms/b-cm)
1001	5.038231e-02
1002	5.794743e-06
6012	4.398437e-02
6013	4.757230e-04
7014	2.953217e-03
7015	1.078897e-05





# Materials Controls: Visibility

3D Material Zoom factor 127.354 View presets... Meshes Show view origin Controls

Materials Mesh Camera Cuts

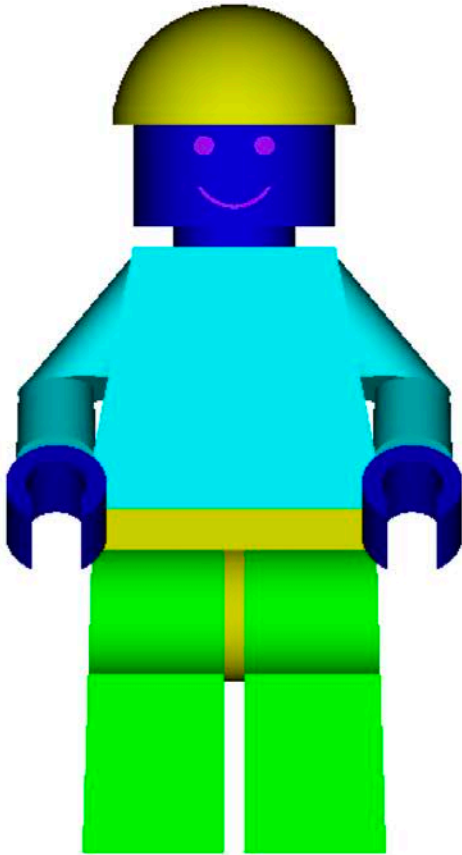
Material IDs

Clear

Material	Color	Opacity (%)	Show
void		100	<input type="checkbox"/>
1		100	<input checked="" type="checkbox"/>
2		100	<input checked="" type="checkbox"/>
3		100	<input checked="" type="checkbox"/>
4		100	<input checked="" type="checkbox"/>
5		100	<input checked="" type="checkbox"/>
6		100	<input checked="" type="checkbox"/>

Mixture: 5  
Density (g/cc): 1.040000e+00  
Temperature (K): 293.00

Nuclide	Density (atoms/b-cm)
1001	5.038231e-02
1002	5.794743e-06
6012	4.398437e-02
6013	4.757230e-04
7014	2.953217e-03
7015	1.078897e-05



# Materials Controls: Opacity

3D Material Zoom factor 127.354 View presets... Meshes Show view origin Controls

Materials Mesh Camera Cuts

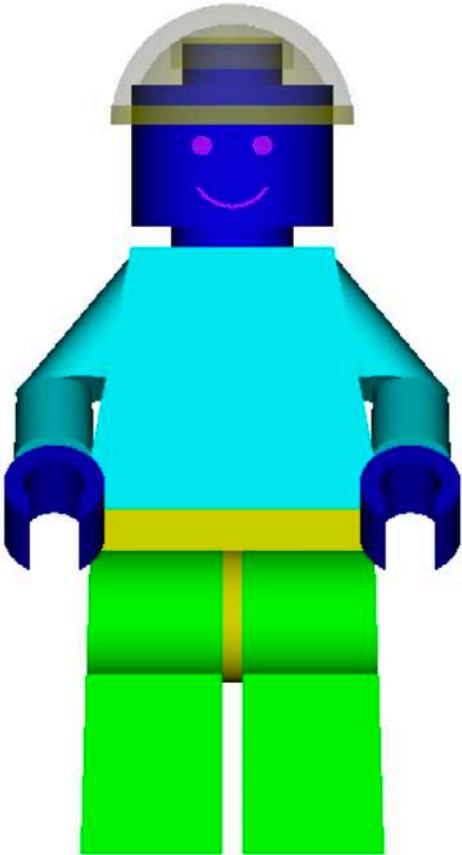
Material IDs

Clear

Material	Color	Opacity (%)	Show
void		100	<input type="checkbox"/>
1	Blue	100	<input checked="" type="checkbox"/>
2	Cyan	100	<input checked="" type="checkbox"/>
3	Green	100	<input checked="" type="checkbox"/>
4	Yellow	100	<input checked="" type="checkbox"/>
5	Blue	25	<input checked="" type="checkbox"/>
6	Purple	100	<input checked="" type="checkbox"/>

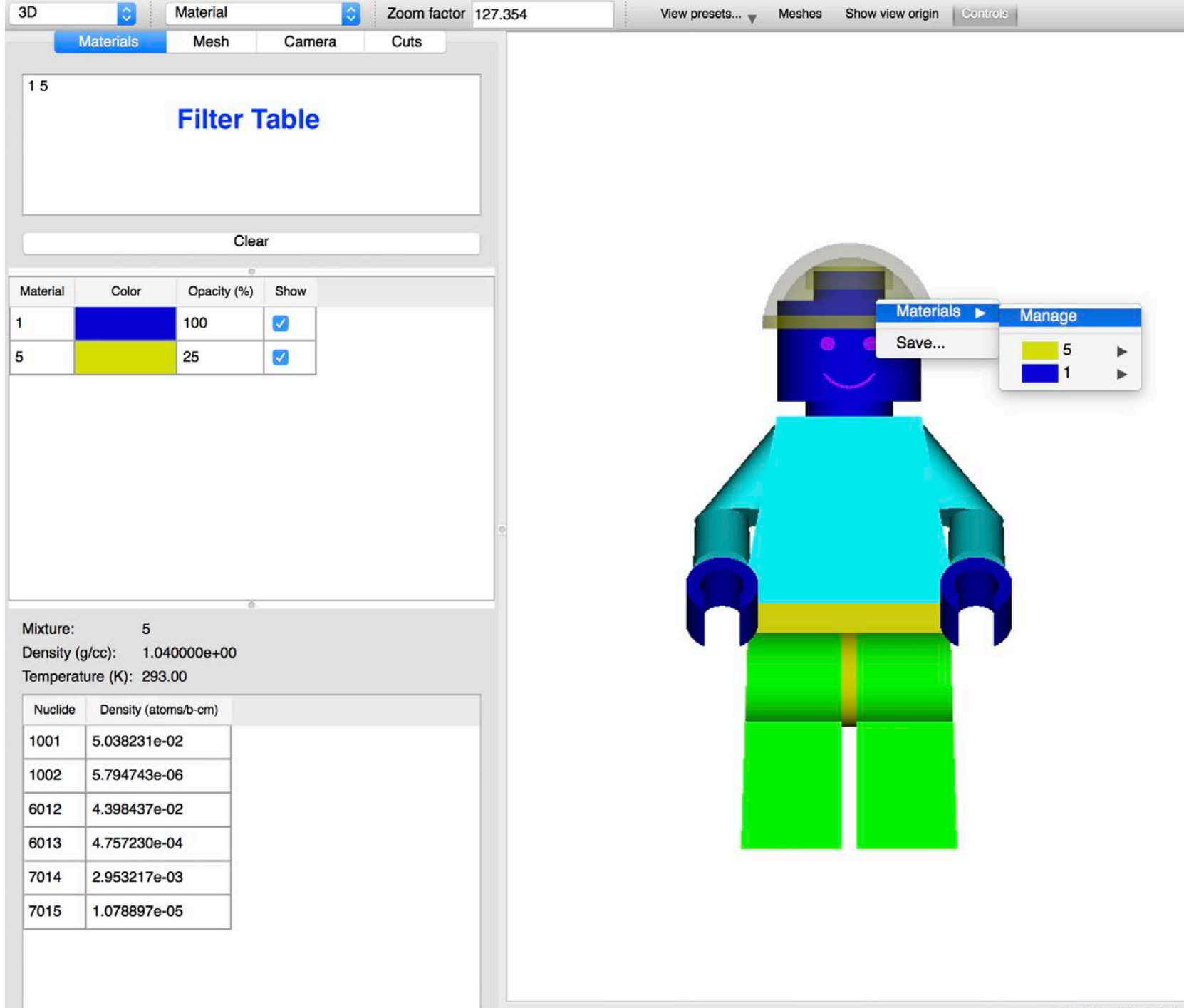
Mixture: 5  
Density (g/cc): 1.040000e+00  
Temperature (K): 293.00

Nuclide	Density (atoms/b-cm)
1001	5.038231e-02
1002	5.794743e-06
6012	4.398437e-02
6013	4.757230e-04
7014	2.953217e-03
7015	1.078897e-05



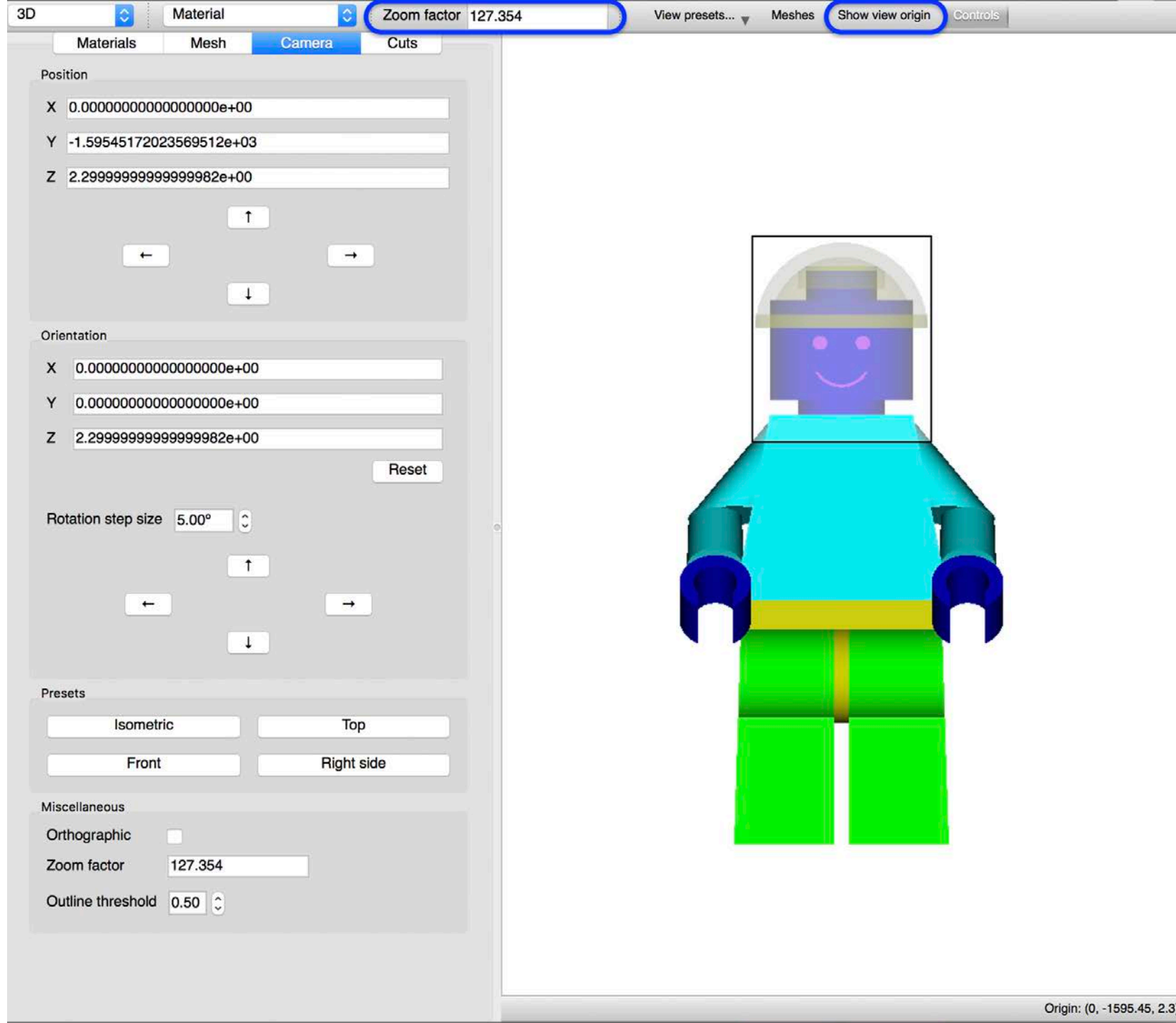
# Material Filter

- Users can type material identifiers (numbers) to filter material table rows.
- Same filtering capability conducted by right-clicking a pixel with multiple materials and selecting 'Manage'



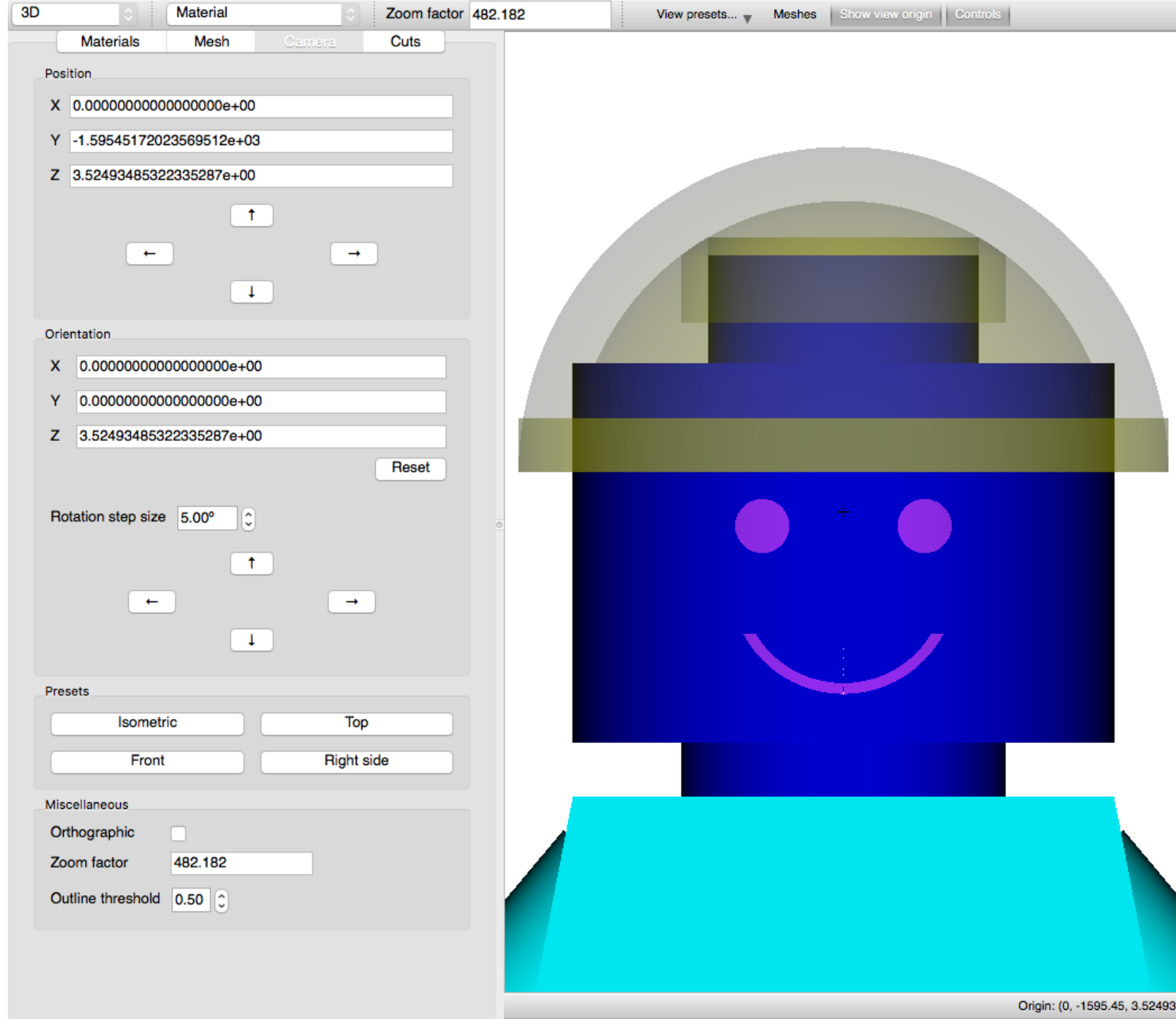
# Zooming

- Rectangle (or lasso) zoom is implemented just as it is in the 2D view
  - Click upper-left and drag to lower-right
- Quick zoom is implemented via a **Zoom factor** text field, allowing the user to enter a zoom (multiplication) factor.
  - **Show view origin** can assist in zoom factor focus



# Zooming

- Rectangle (or lasso) zoom is implemented just as it is in the 2D view
  - Click upper-left and drag to lower-right
- Quick zoom is implemented via a **Zoom factor** text field, allowing the user to enter a zoom (multiplication) factor.
  - **Show view origin** can assist in zoom factor focus



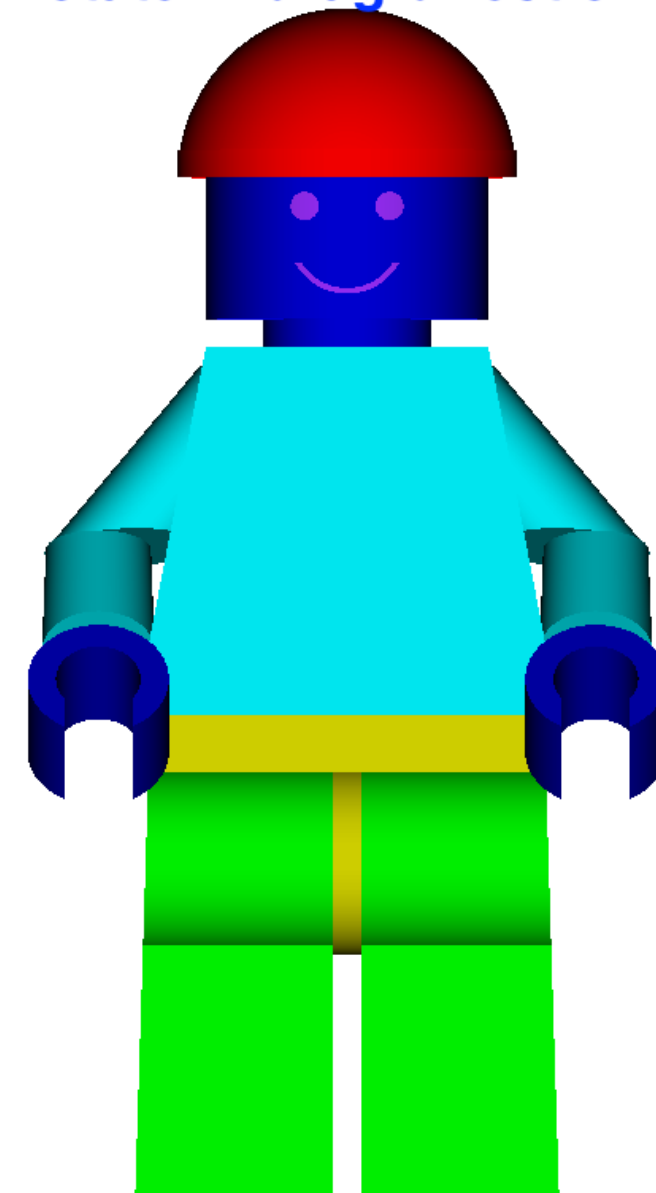
# Camera Rotation

- **Rotation step size** input field allows specifying explicit rotation.
- Up arrow rotates model up by rotating camera down
- Down arrow rotates model down by rotating camera up
- Left arrow rotates model left by rotating camera right
- Right arrow rotates model right by rotating camera left
- Arbitrary rotation is achieved by **Alt+click-and-drag**

The screenshot shows a 3D software interface with a top menu bar containing '3D', 'Material', 'Mesh', 'Camera', and 'Cuts'. Below the menu, there are three tabs: 'Materials', 'Mesh', and 'Camera'. The 'Camera' tab is active, displaying the following controls:

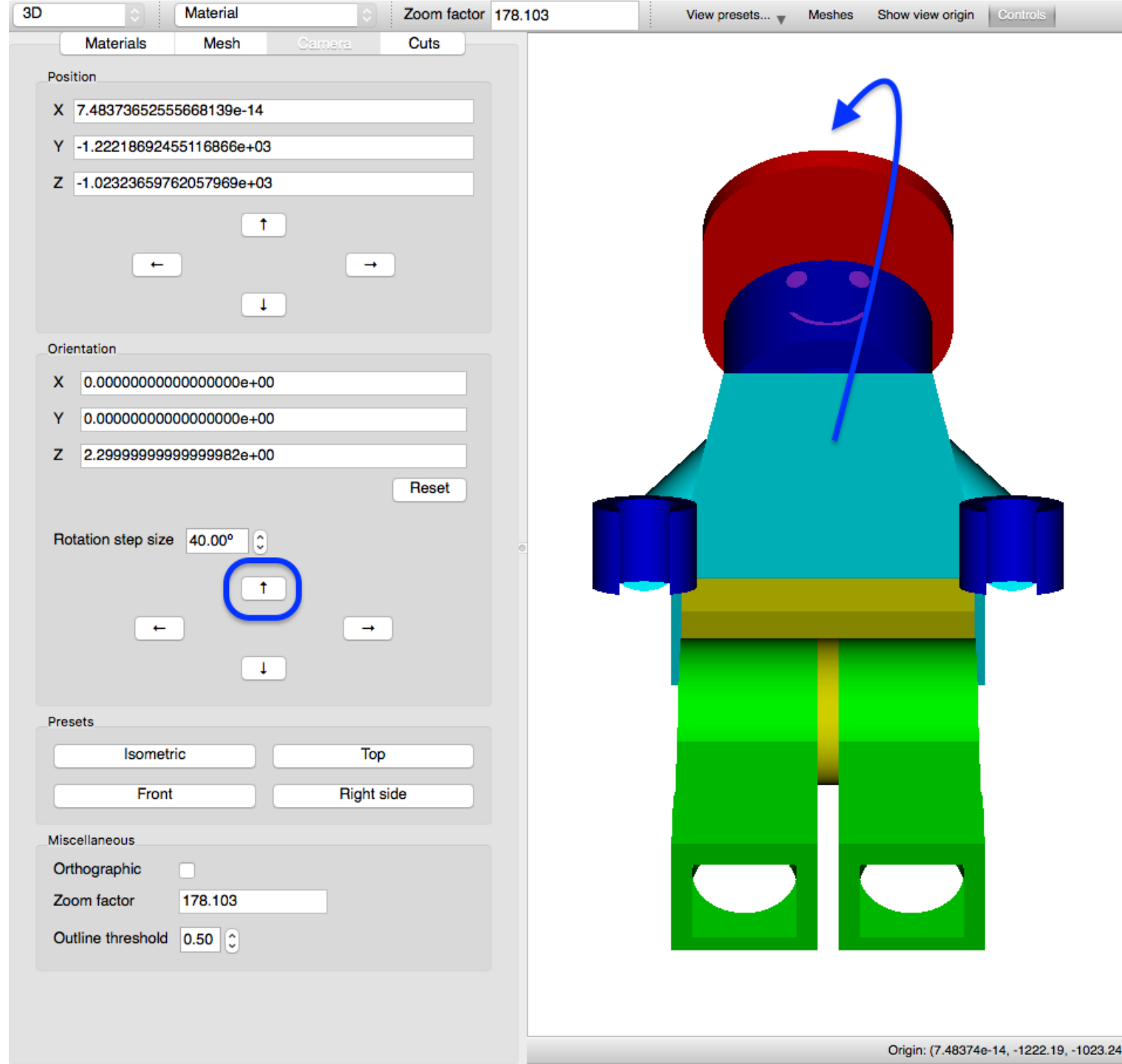
- Position:** X: 9.76932421190391436e-14, Y: -1.59545172023569535e+03, Z: 2.300000000000045191e+00. Below the fields are four directional arrows (up, down, left, right).
- Orientation:** X: 0.0000000000000000e+00, Y: 0.0000000000000000e+00, Z: 2.2999999999999982e+00. A 'Reset' button is located to the right of the Z field.
- Rotation step size:** A text input field containing '40.00°' with a dropdown arrow to its right. Below it are four directional arrows (up, down, left, right).
- Presets:** Four buttons labeled 'Isometric', 'Top', 'Front', and 'Right side'.
- Miscellaneous:** 'Orthographic' checkbox (unchecked), 'Zoom factor' input field (178.103), and 'Outline threshold' input field (0.50) with a dropdown arrow.

**Alt+Click and Drag**  
to rotate in drag-direction



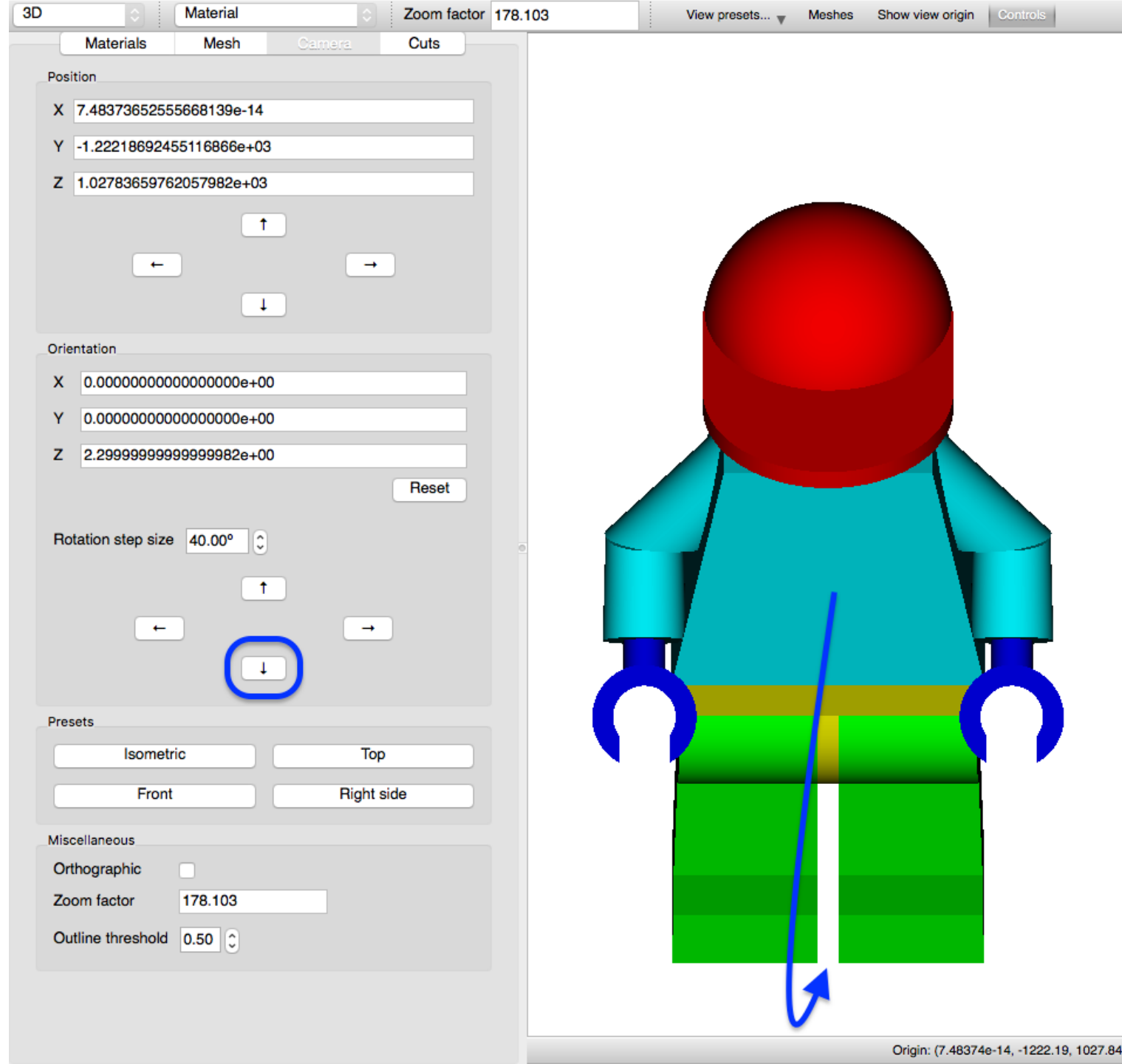
# Camera Rotation: Up

- **Rotation step size** input field allows specifying explicit rotation.
- **Up arrow rotates model up** by rotating camera down
- Down arrow rotates model down by rotating camera up
- Left arrow rotates model left by rotating camera right
- Right arrow rotates model right by rotating camera left
- Arbitrary rotation is achieved by **Alt+click-and-drag**



# Camera Rotation: Down

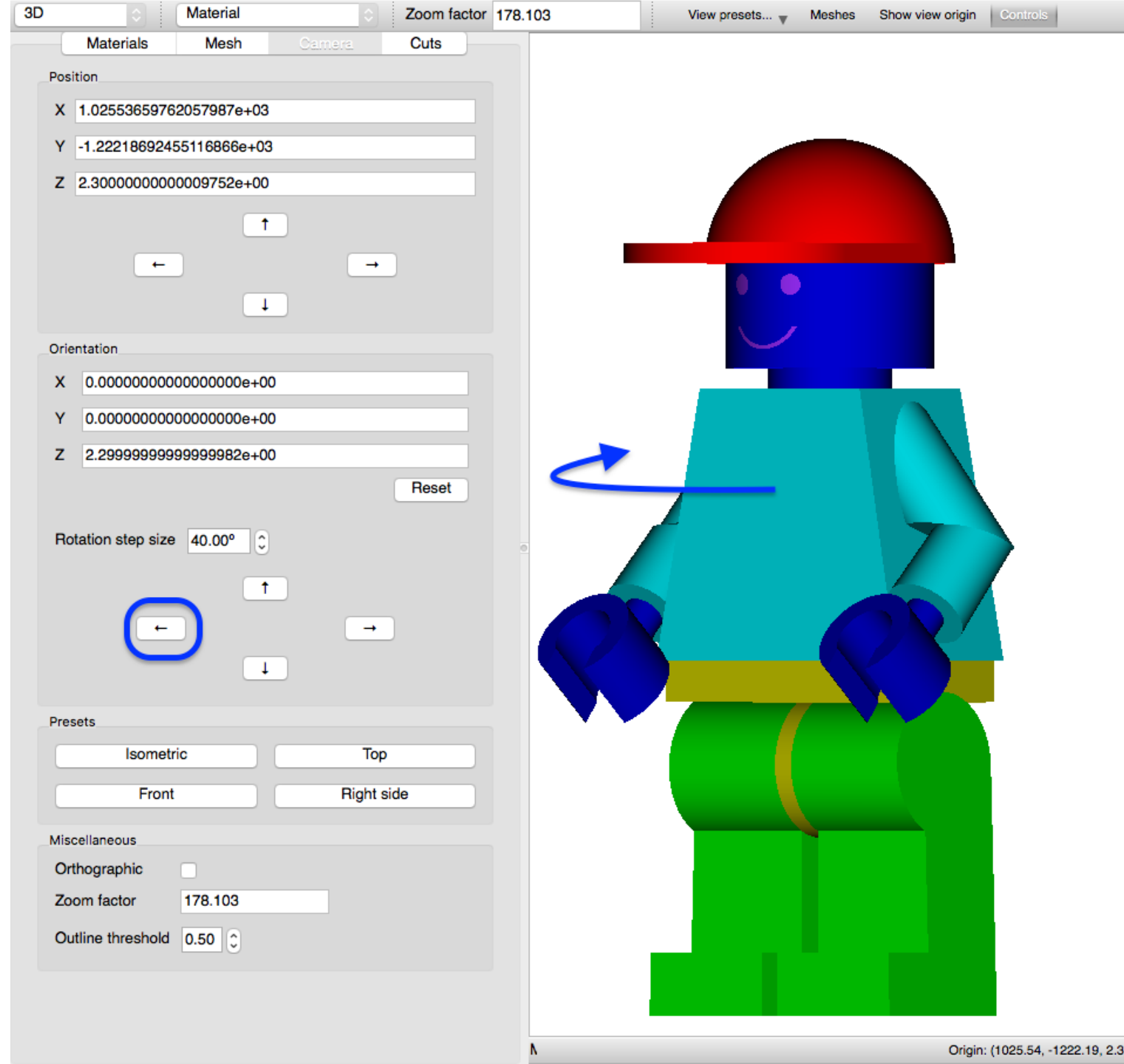
- **Rotation step size** input field allows specifying explicit rotation.
- Up arrow rotates model up by rotating camera down
- **Down arrow rotates model down** by rotating camera up
- Left arrow rotates model left by rotating camera right
- Right arrow rotates model right by rotating camera left
- Arbitrary rotation is achieved by **Alt+click-and-drag**





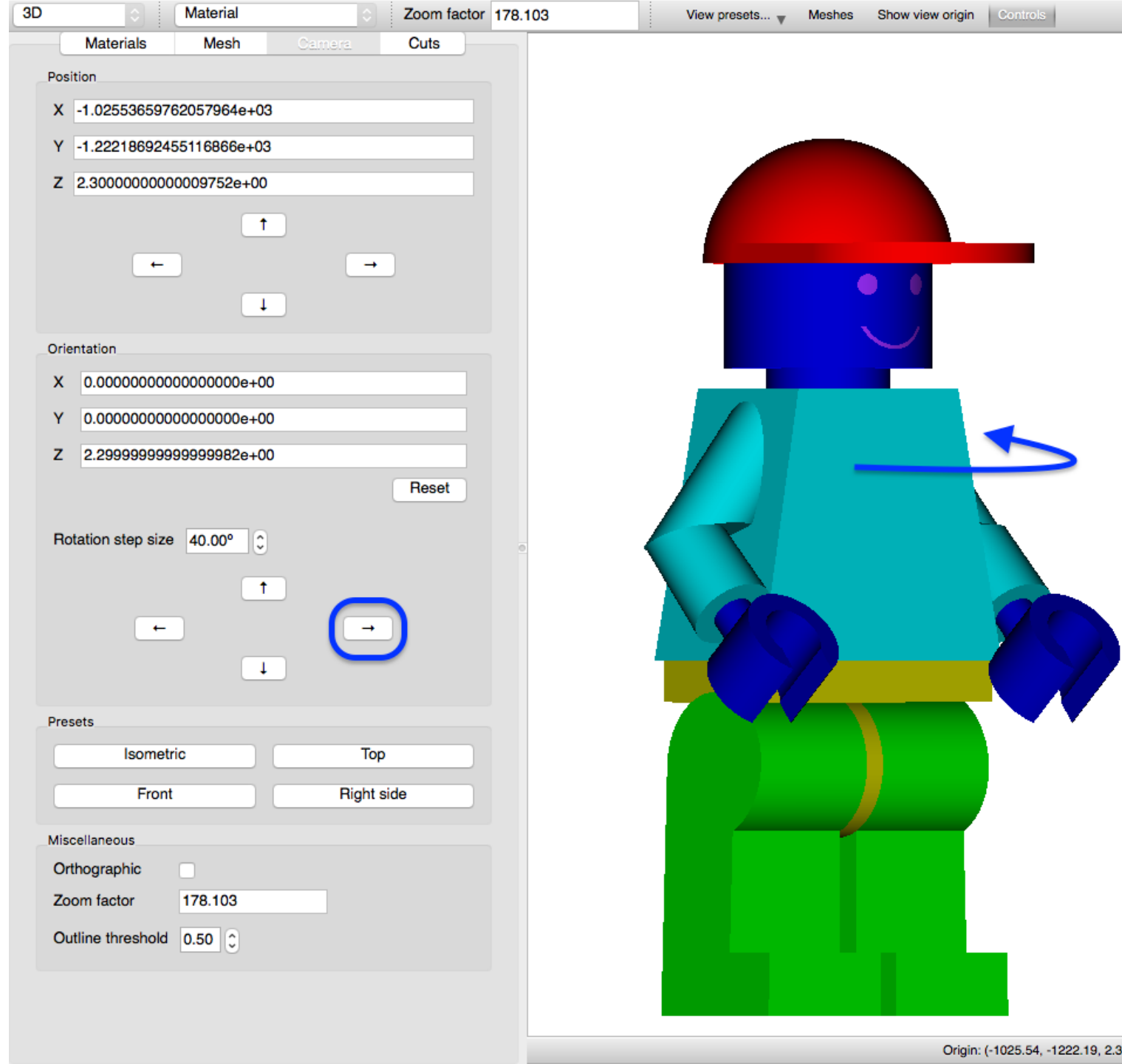
# Camera Rotation: Left

- **Rotation step size** input field allows specifying explicit rotation.
- Up arrow rotates model up by rotating camera down
- Down arrow rotates model down by rotating camera up
- **Left arrow rotates model left** by rotating camera right
- Right arrow rotates model right by rotating camera left
- Arbitrary rotation is achieved by **Alt+click-and-drag**



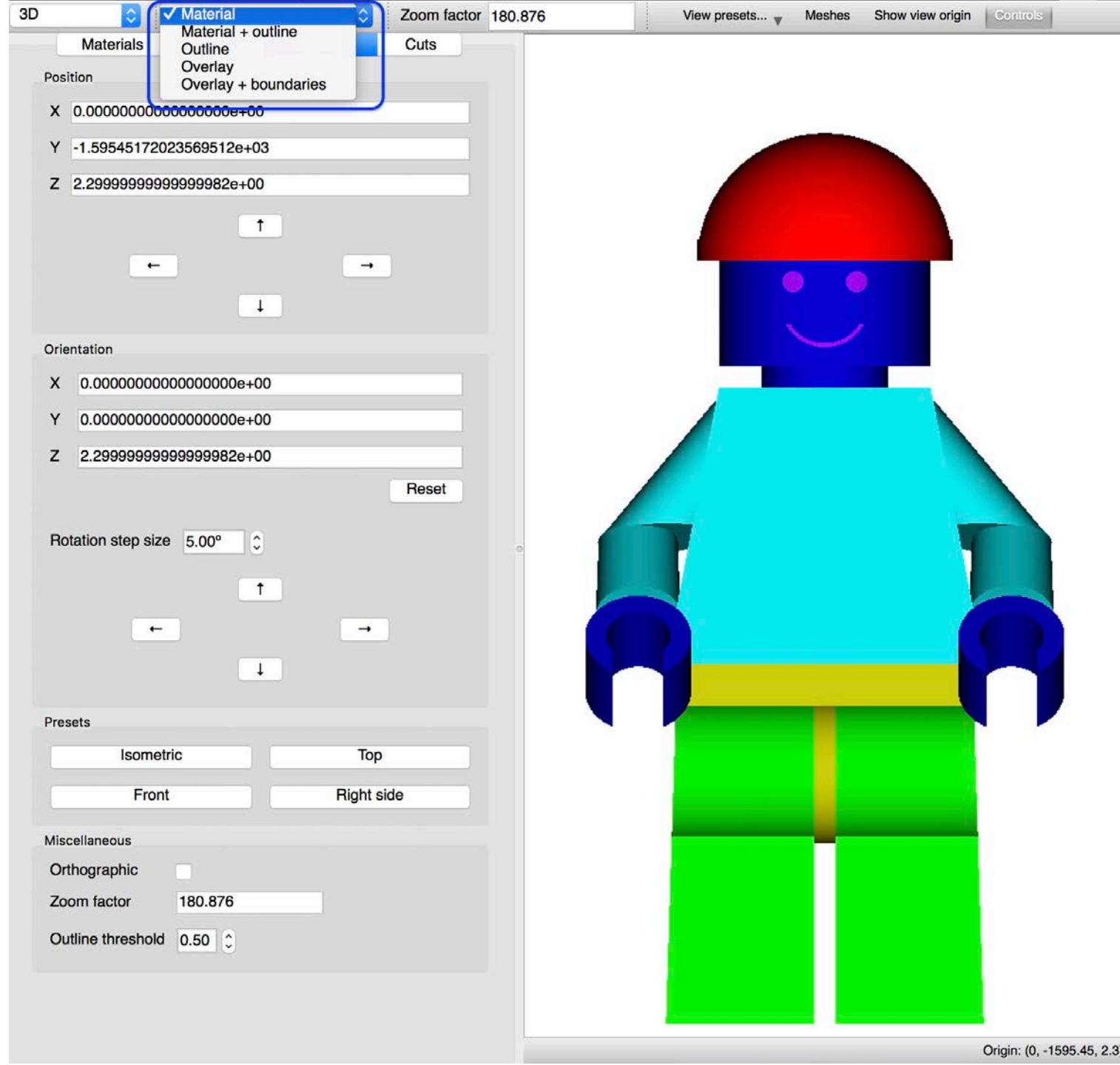
# Camera Rotation: Right

- **Rotation step size** input field allows specifying explicit rotation.
- Up arrow rotates model up by rotating camera down
- Down arrow rotates model down by rotating camera up
- Left arrow rotates model left by rotating camera right
- **Right arrow rotates model right** by rotating camera left
- Arbitrary rotation is achieved by **Alt+click-and-drag**



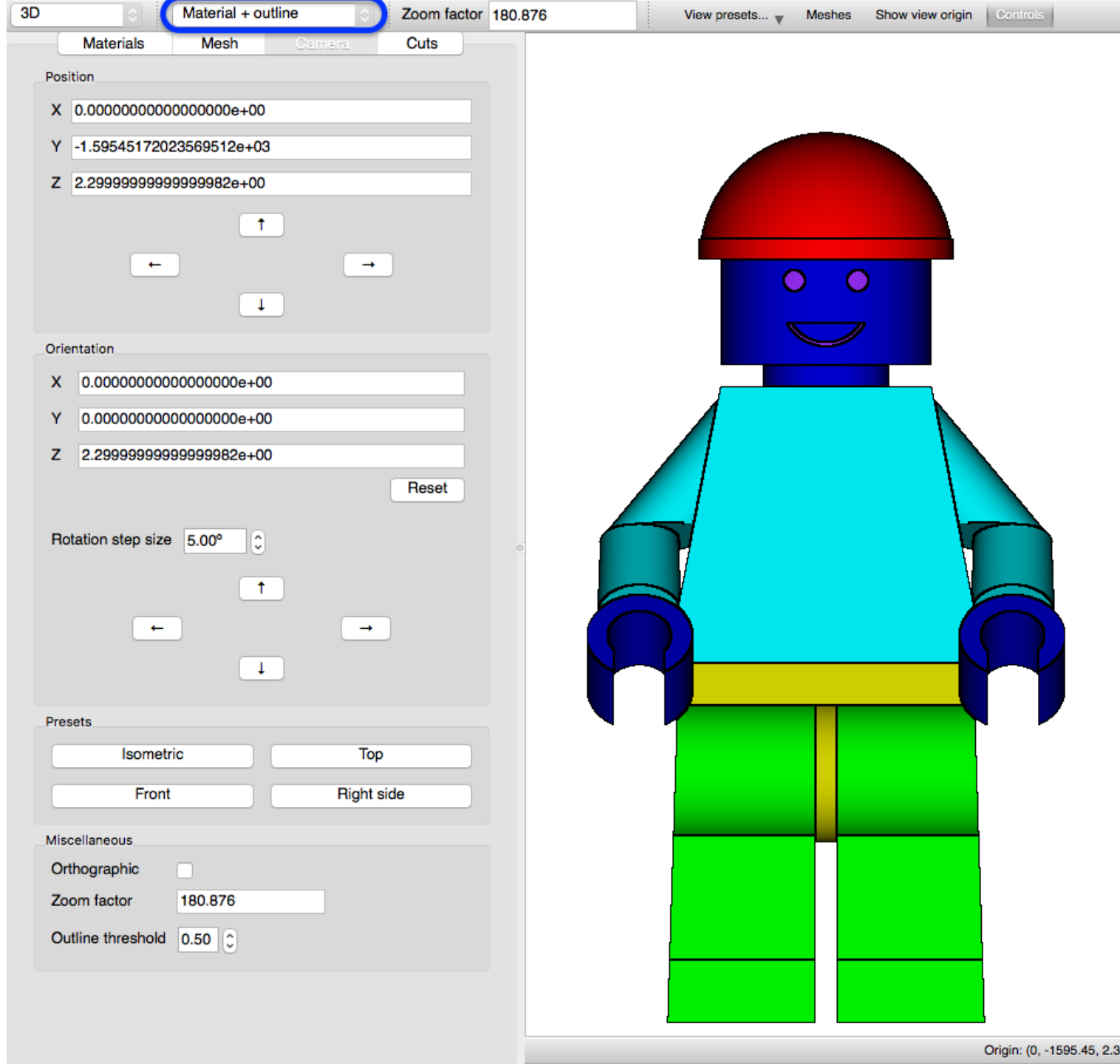
# Rendering modes

- **Material** renders only material colors, shaded according to surface normal
- **Material+Outline** renders same as **Material** with the addition of black outlines at boundaries
- **Outline** renders only material boundaries using Material colors
- Mesh data **Overlay** and **Overlay+boundaries** capabilities are slated for phase 2 development.



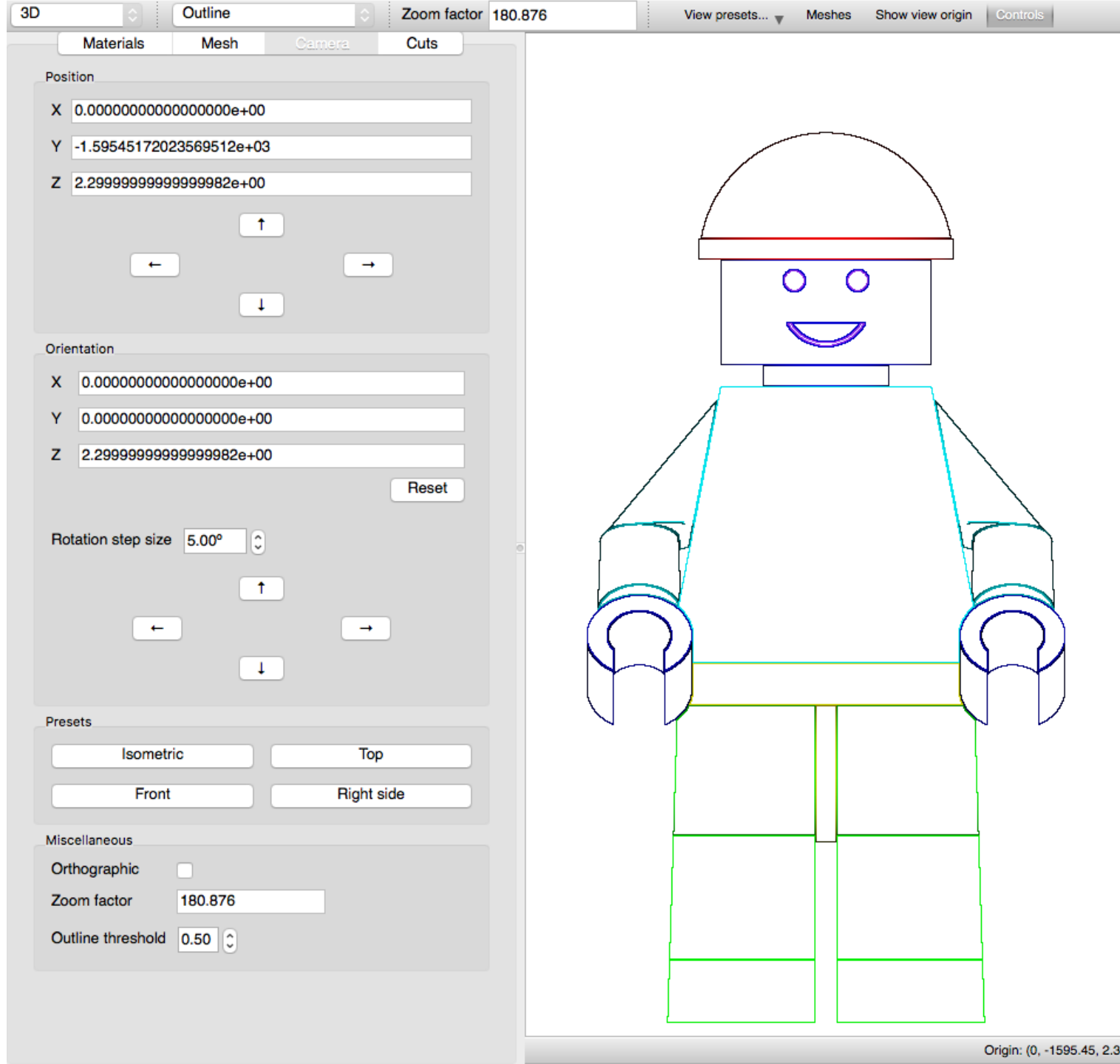
# Rendering modes: Material + outline

- renders same as **Material** with the addition of black outlines at boundaries



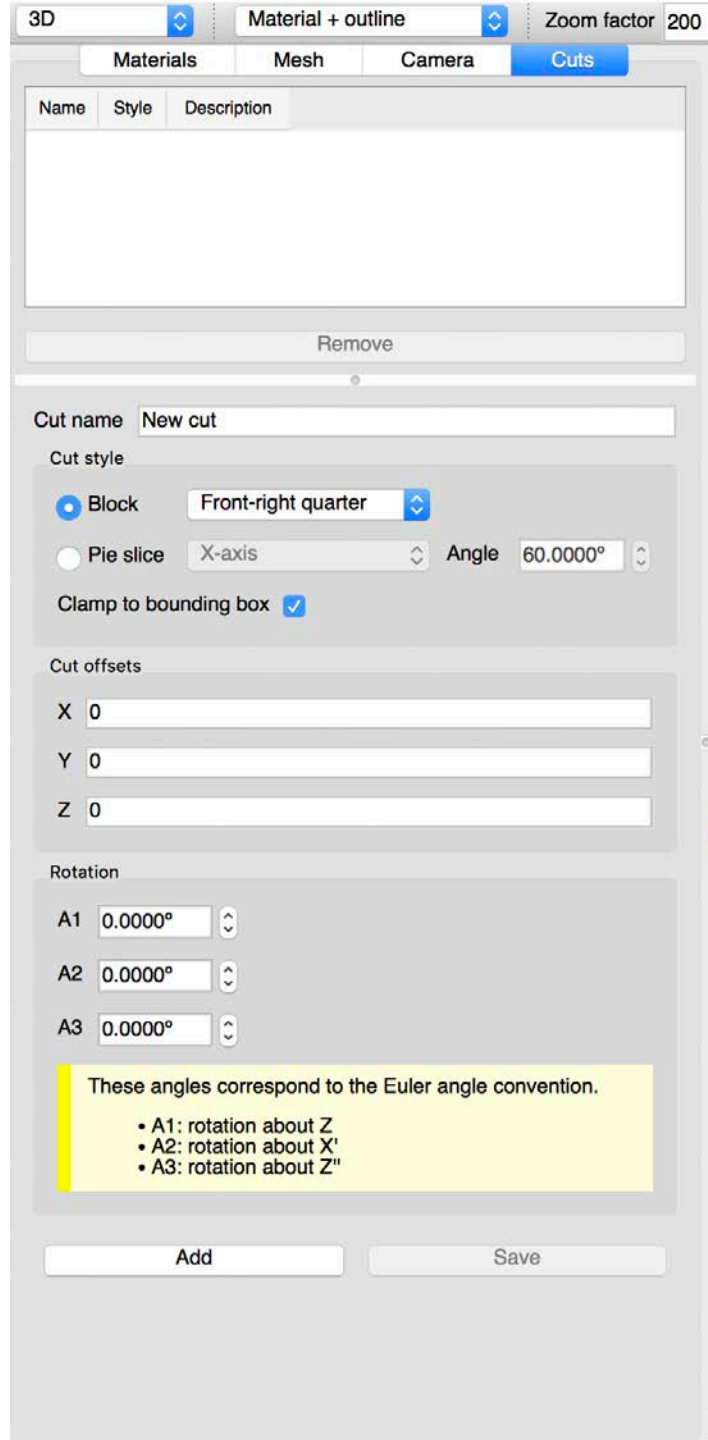
# Rendering modes: Outline

- renders only material boundaries using Material colors



# Model Cutting

- **Named Block** and **Pie slice** model cut styles
- Boundary box cut **clamping**
- **Cut offsets** allow for moving the origin of the cut
- **Rotation** uses Euler angle convention to rotate cuts to desired angles
- Ability to **remove** and **edit/save** existing cuts



# Model Cutting: Cut Styles

- **Block**

- Top half (+Z)
- Bottom half (-Z)
- Left half (-X)
- Right half (+X)
- Front half (-Y)
- Back half (+Y)
- Front-right quarter (-Y,+X)

- **Pie slice**

- X axis (opening in -Y)
- Y axis (opening in -Z)
- Z axis (opening in -Y)

3D Material + outline Zoom factor 200

Materials Mesh Camera **Cuts**

Name	Style	Description
------	-------	-------------

Cut name

Cut style

- Block
- Pie slice

Clamp to bound

Angle 60.0000°

- Top half
- Bottom half
- Left half
- Right half
- Front half
- Back half
- Front-right quarter

- X-axis
- Y-axis
- Z-axis

Cut offsets

X

Y

Z

Rotation

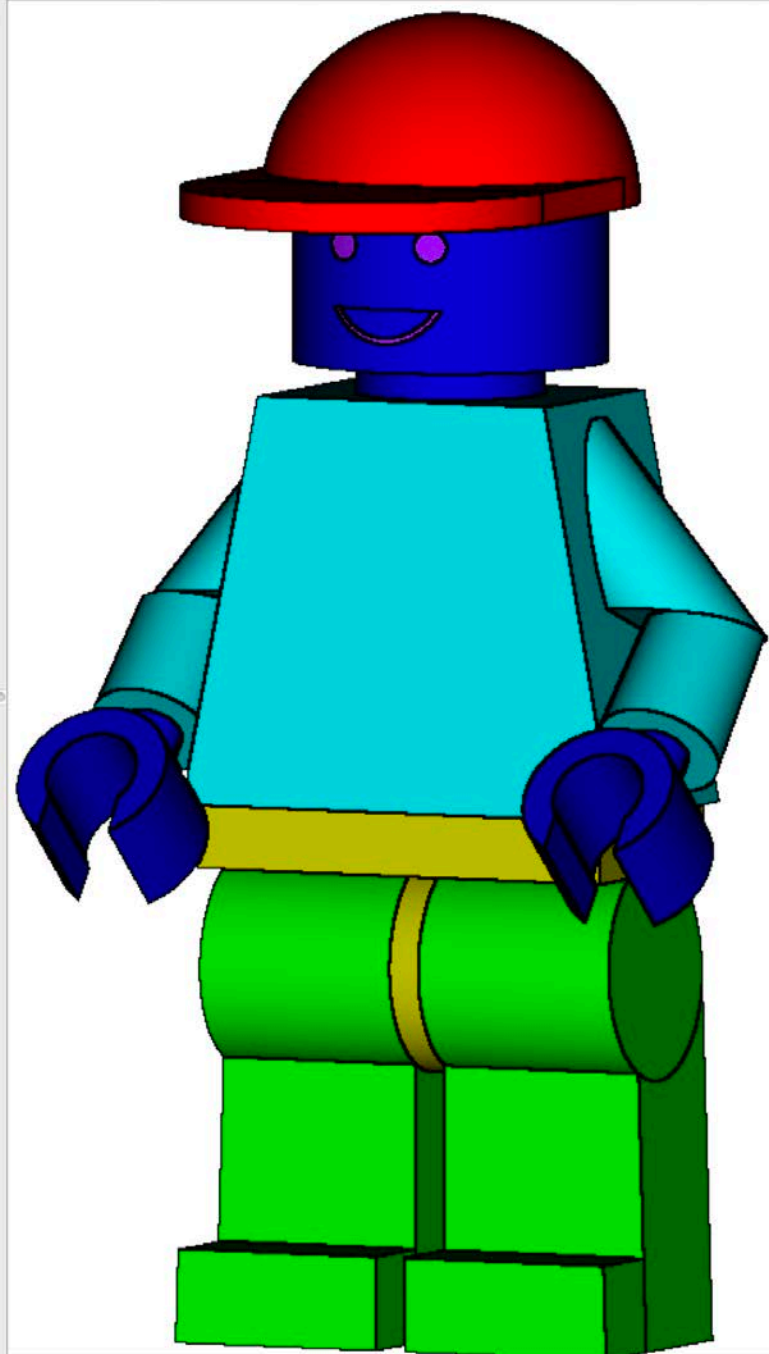
A1

A2

A3

These angles correspond to the Euler angle convention.

- A1: rotation about Z
- A2: rotation about X'
- A3: rotation about Z''



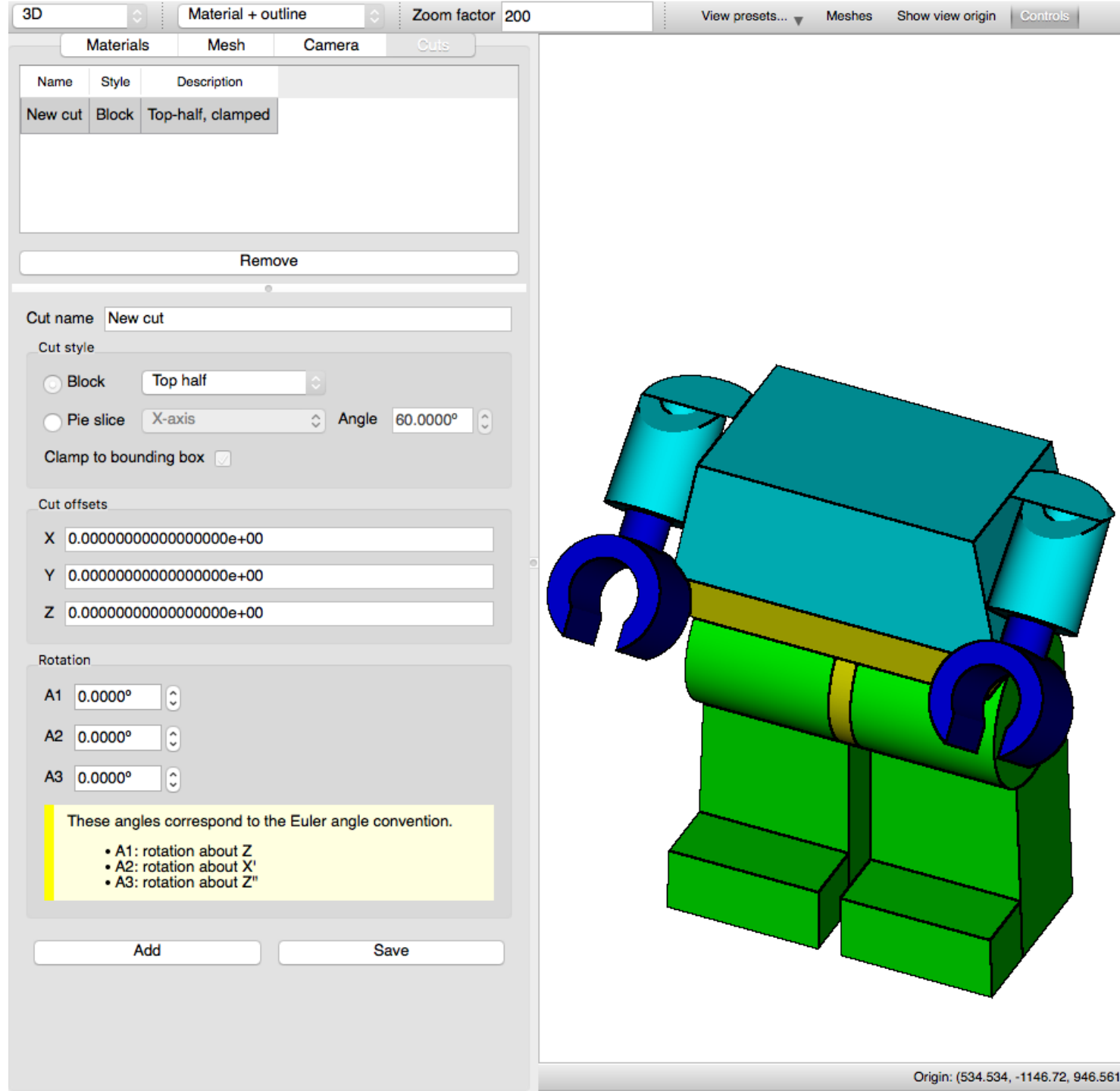
# Model Cutting: Cut Styles

- **Block**

- Top half (+Z)
- Bottom half (-Z)
- Left half (-X)
- Right half (+X)
- Front half (-Y)
- Back half (+Y)
- Front-right quarter (-Y,+X)

- **Pie slice**

- X axis (opening in -Y)
- Y axis (opening in -Z)
- Z axis (opening in -Y)





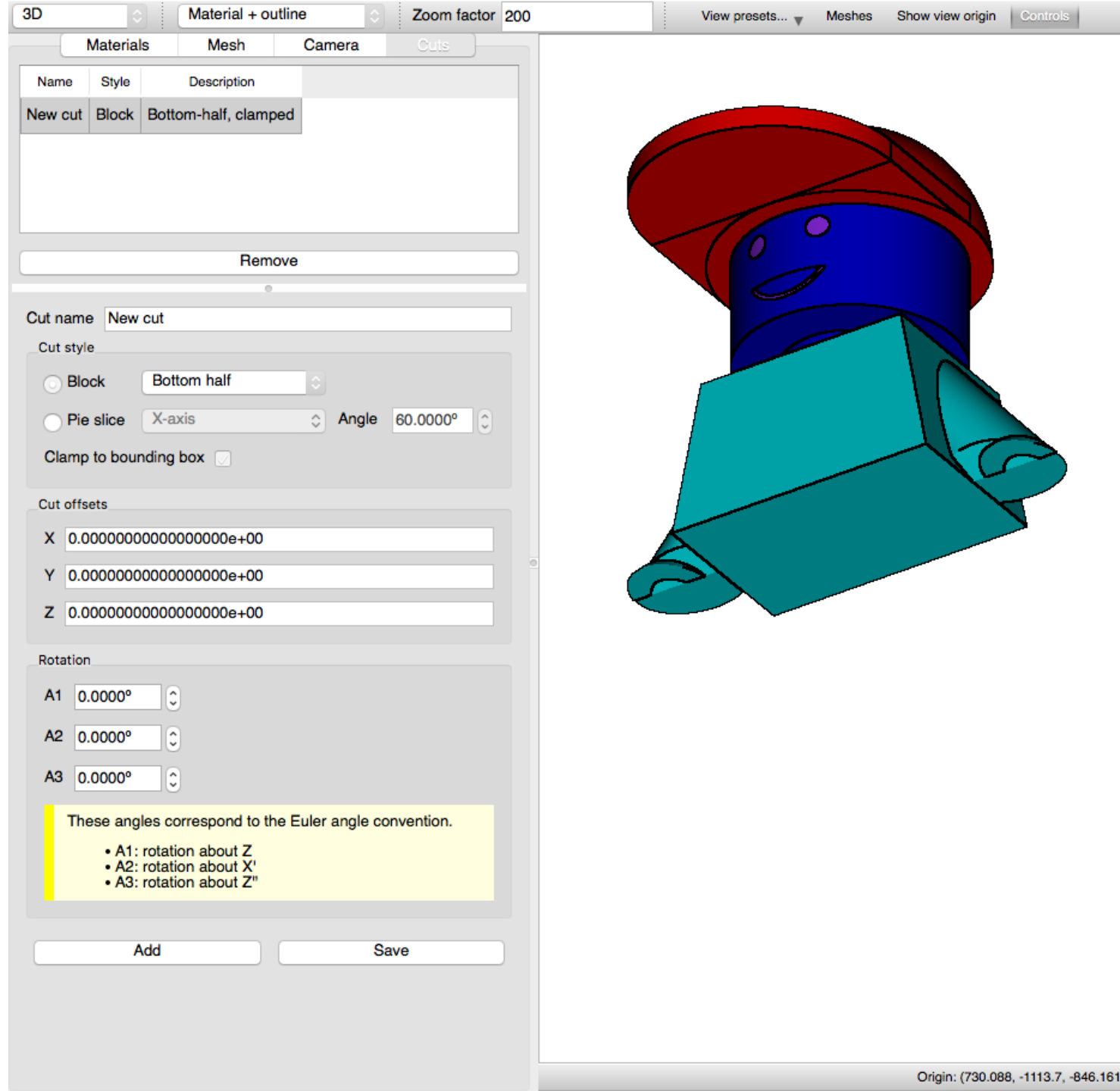
# Model Cutting: Cut Styles

- **Block**

- Top half (+Z)
- **Bottom half (-Z)**
- Left half (-X)
- Right half (+X)
- Front half (-Y)
- Back half (+Y)
- Front-right quarter (-Y,+X)

- **Pie slice**

- X axis (opening in -Y)
- Y axis (opening in -Z)
- Z axis (opening in -Y)



# Model Cutting: Cut Styles

- **Block**

- Top half (+Z)
- Bottom half (-Z)
- **Left half (-X)**
- Right half (+X)
- Front half (-Y)
- Back half (+Y)
- Front-right quarter (-Y,+X)

- **Pie slice**

- X axis (opening in -Y)
- Y axis (opening in -Z)
- Z axis (opening in -Y)

3D Material + outline Zoom factor 200

Materials Mesh Camera Cuts

Name	Style	Description
New cut	Block	Left-half, clamped

Remove

Cut name New cut

Cut style

Block

Pie slice  Angle

Clamp to bounding box

Cut offsets

X

Y

Z

Rotation

A1

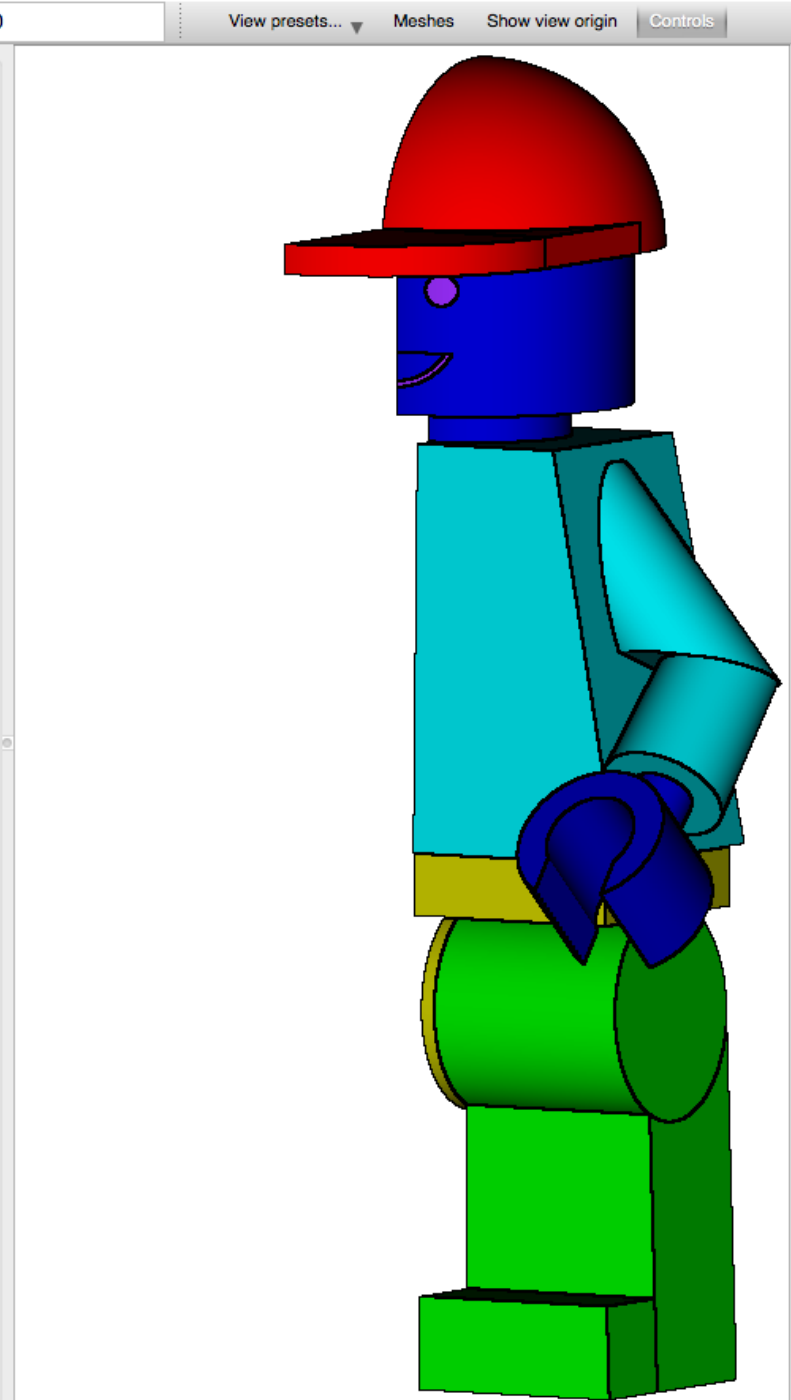
A2

A3

These angles correspond to the Euler angle convention.

- A1: rotation about Z
- A2: rotation about X'
- A3: rotation about Z''

Add Save



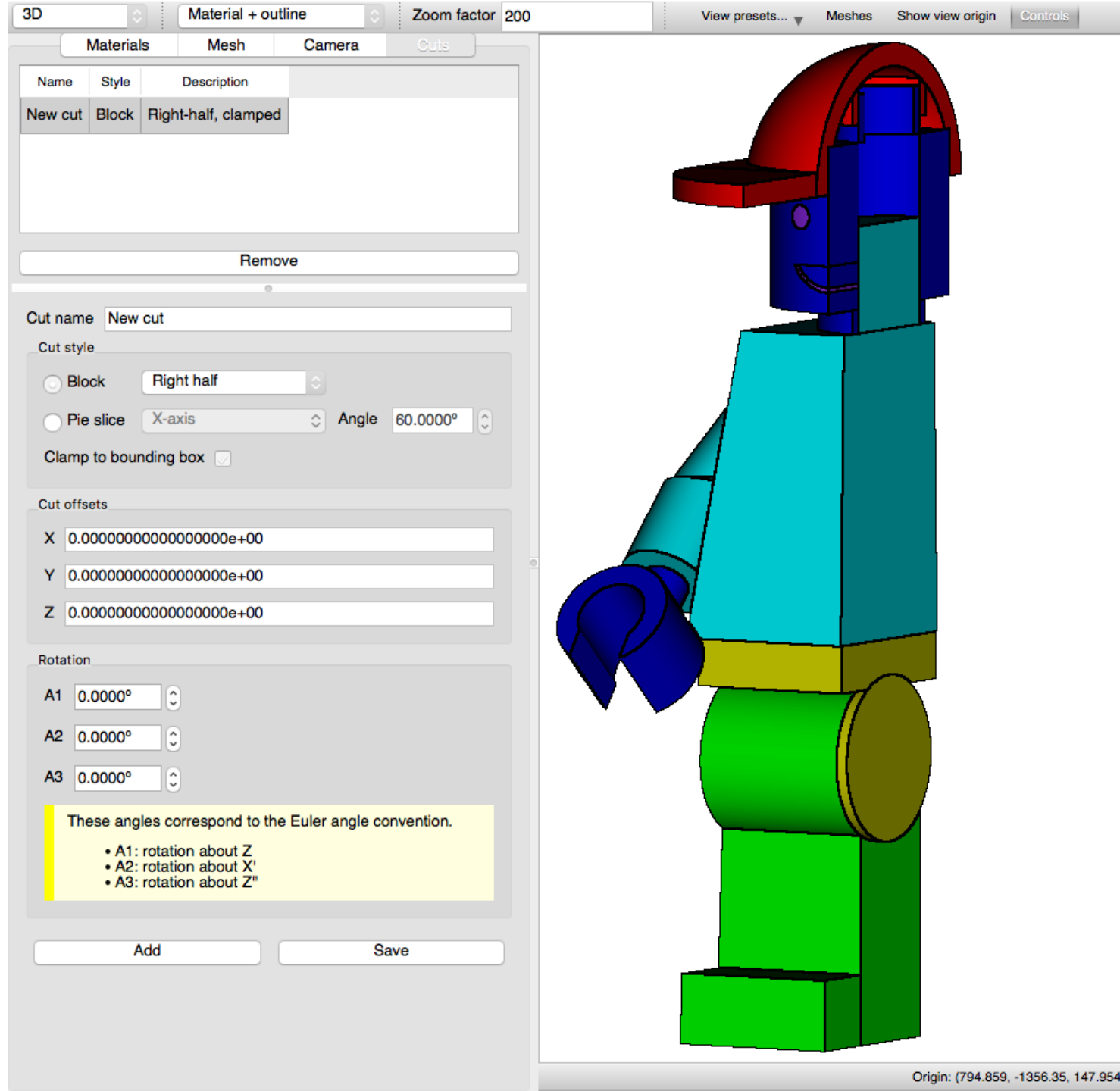
# Model Cutting: Cut Styles

- **Block**

- Top half (+Z)
- Bottom half (-Z)
- Left half (-X)
- **Right half (+X)**
- Front half (-Y)
- Back half (+Y)
- Front-right quarter (-Y,+X)

- **Pie slice**

- X axis (opening in -Y)
- Y axis (opening in -Z)
- Z axis (opening in -Y)



# Model Cutting: Cut Styles

- **Block**

- Top half (+Z)
- Bottom half (-Z)
- Left half (-X)
- Right half (+X)
- **Front half (-Y)**
- Back half (+Y)
- Front-right quarter (-Y,+X)

- **Pie slice**

- X axis (opening in -Y)
- Y axis (opening in -Z)
- Z axis (opening in -Y)

3D Material + outline Zoom factor 200

Materials Mesh Camera Cuts

Name	Style	Description
New cut	Block	Front-half, clamped

Remove

Cut name New cut

Cut style

Block Front half

Pie slice X-axis Angle 60.0000°

Clamp to bounding box

Cut offsets

X 0.0000000000000000e+00

Y 0.0000000000000000e+00

Z 0.0000000000000000e+00

Rotation

A1 0.0000°

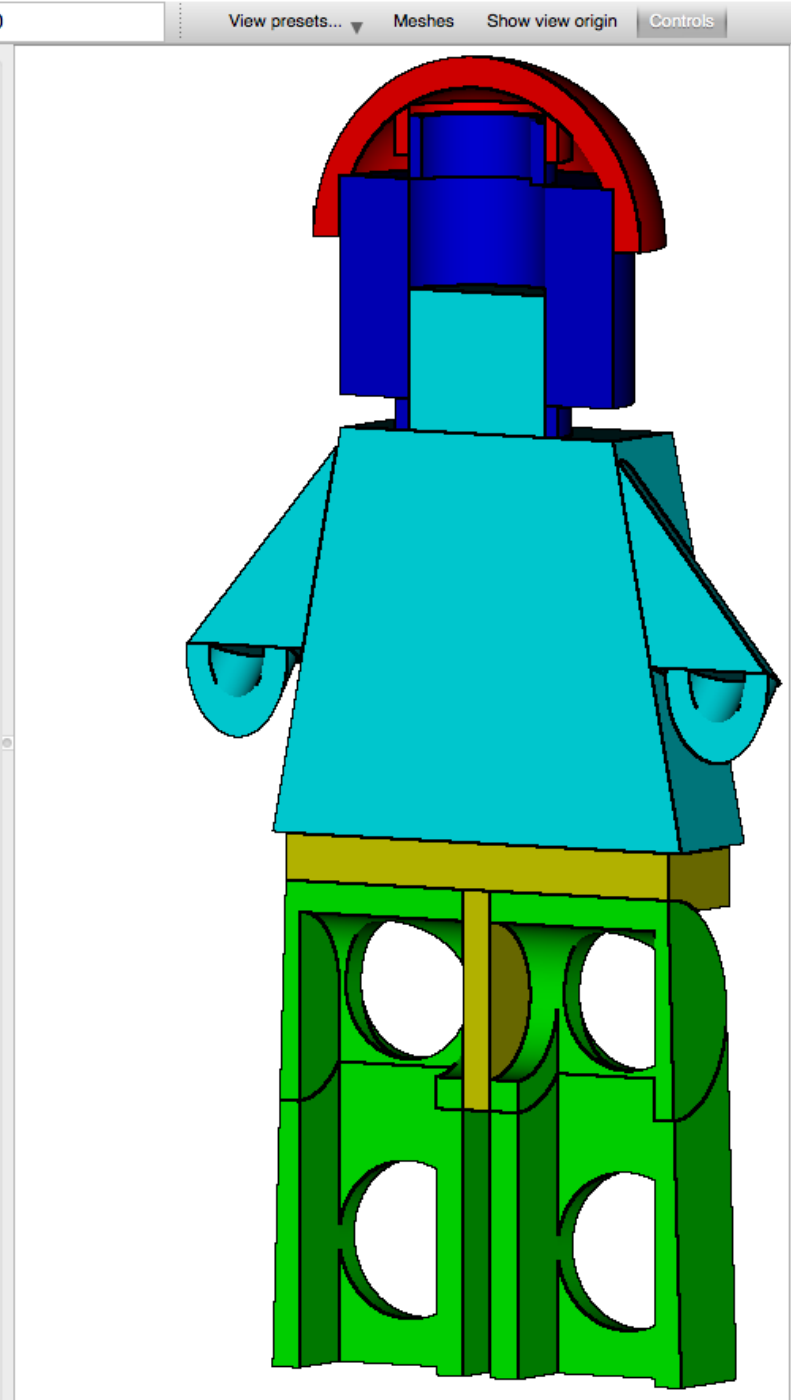
A2 0.0000°

A3 0.0000°

These angles correspond to the Euler angle convention.

- A1: rotation about Z
- A2: rotation about X'
- A3: rotation about Z''

Add Save



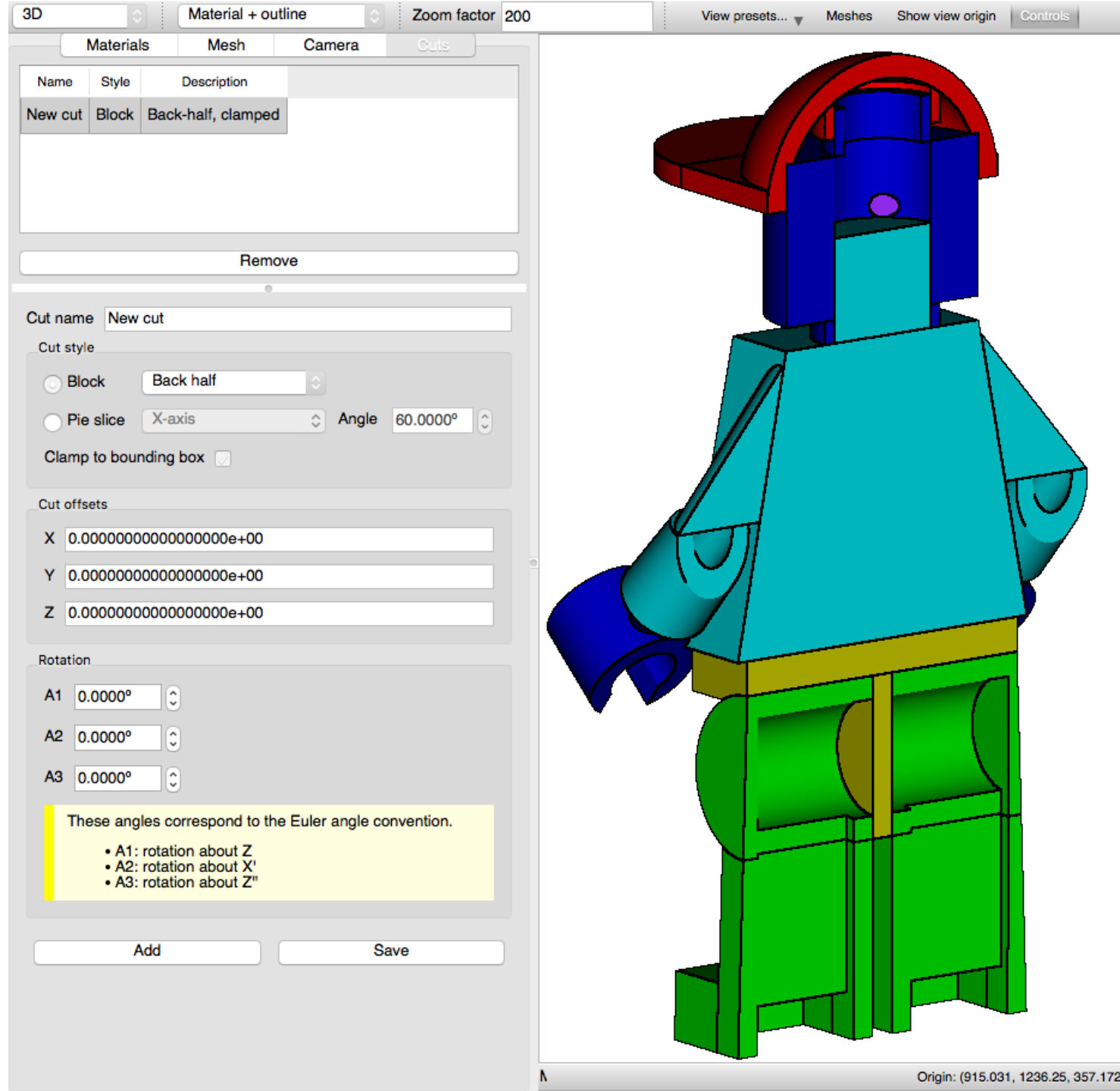
# Model Cutting: Cut Styles

- **Block**

- Top half (+Z)
- Bottom half (-Z)
- Left half (-X)
- Right half (+X)
- Front half (-Y)
- **Back half (+Y)**
- Front-right quarter (-Y,+X)

- **Pie slice**

- X axis (opening in -Y)
- Y axis (opening in -Z)
- Z axis (opening in -Y)



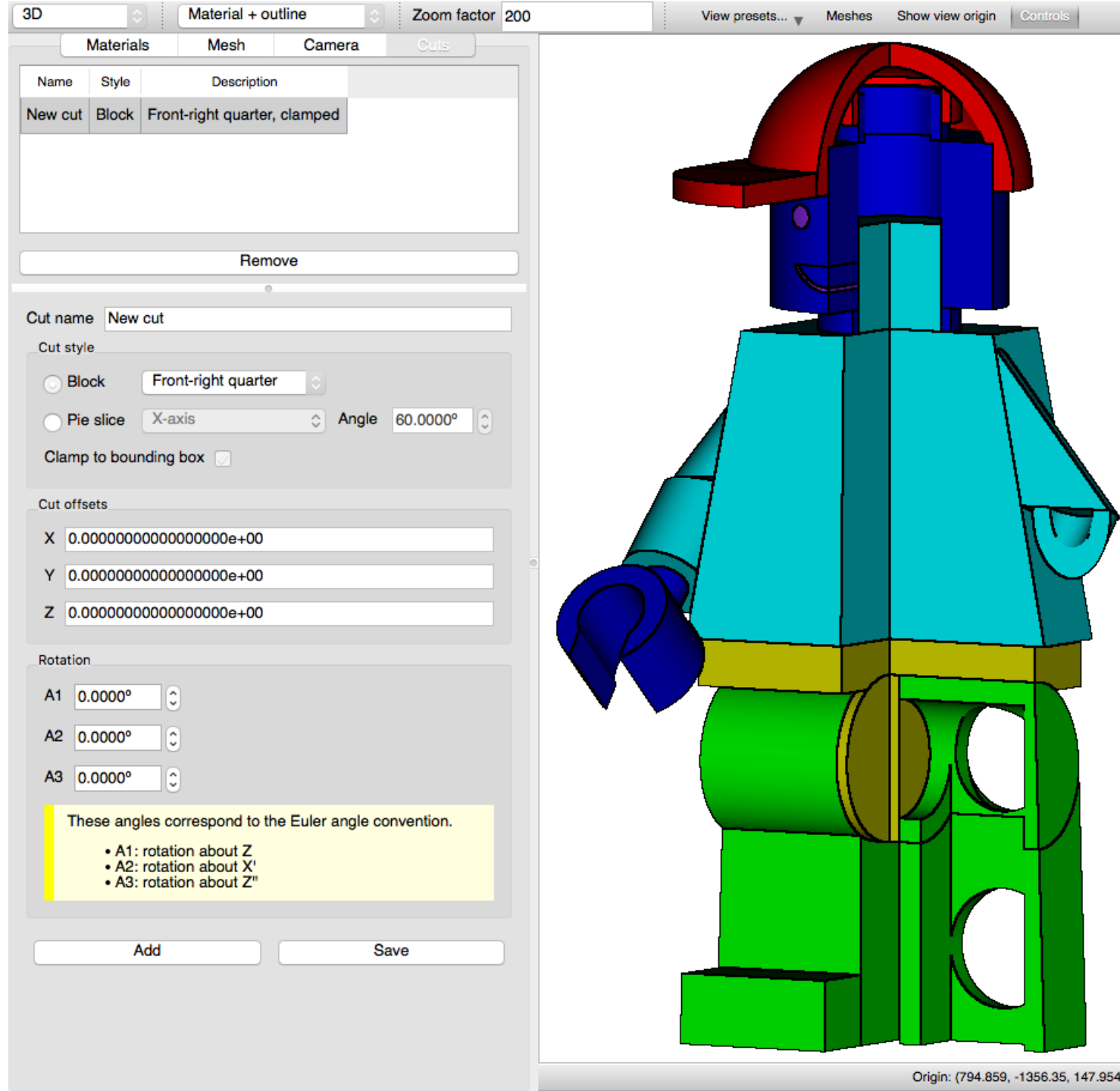
# Model Cutting: Cut Styles

- **Block**

- Top half (+Z)
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- Left half (-X)
- Right half (+X)
- Front half (-Y)
- Back half (+Y)
- Front-right quarter (-Y,+X)

- **Pie slice**

- X axis (opening in -Y)
- Y axis (opening in -Z)
- Z axis (opening in -Y)



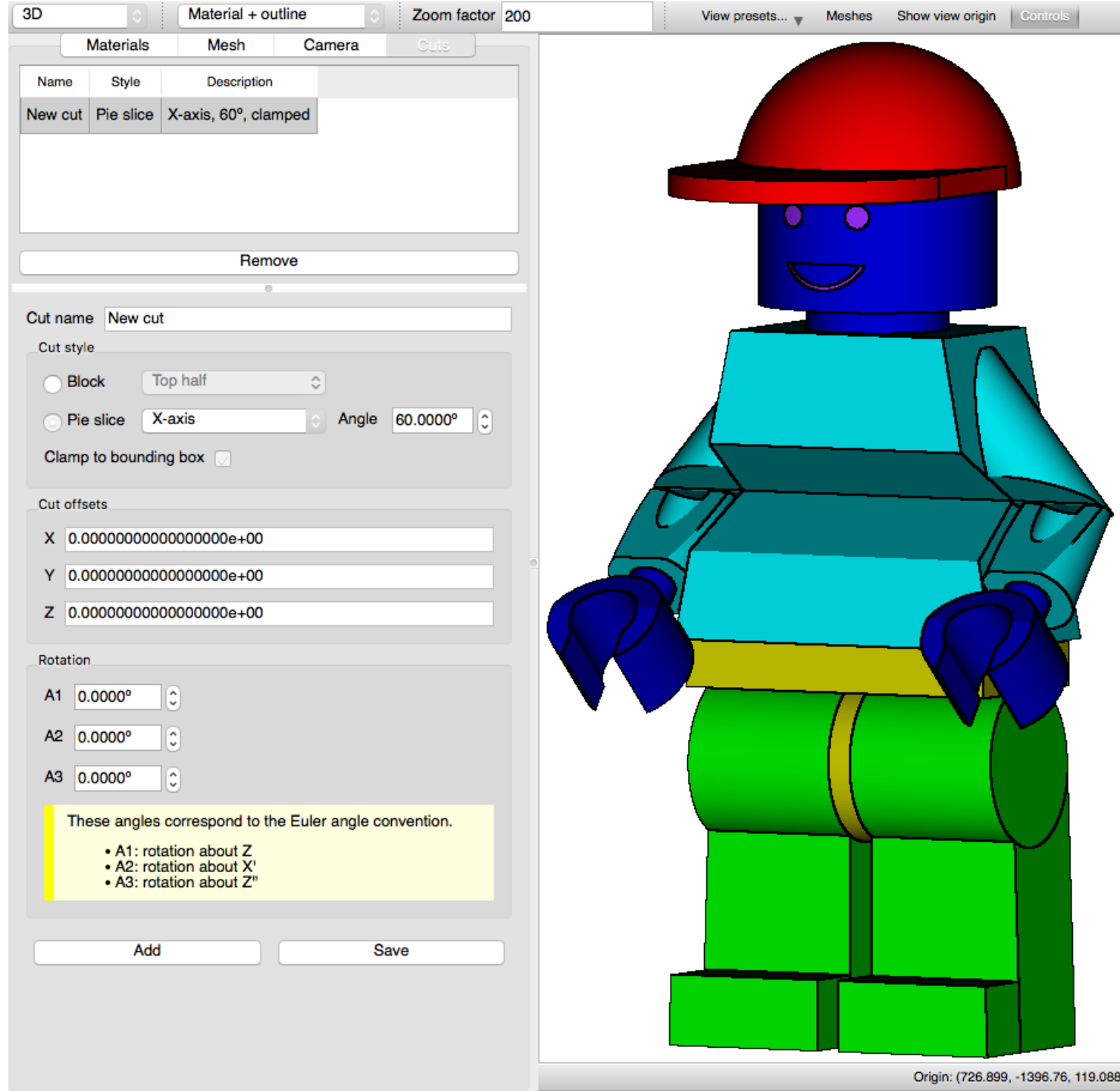
# Model Cutting: Cut Styles

- **Block**

- Top half (+Z)
- Bottom half (-Z)
- Left half (-X)
- Right half (+X)
- Front half (-Y)
- Back half (+Y)
- Front-right quarter (-Y,+X)

- **Pie slice**

- X axis (opening in -Y)
- Y axis (opening in -Z)
- Z axis (opening in -Y)



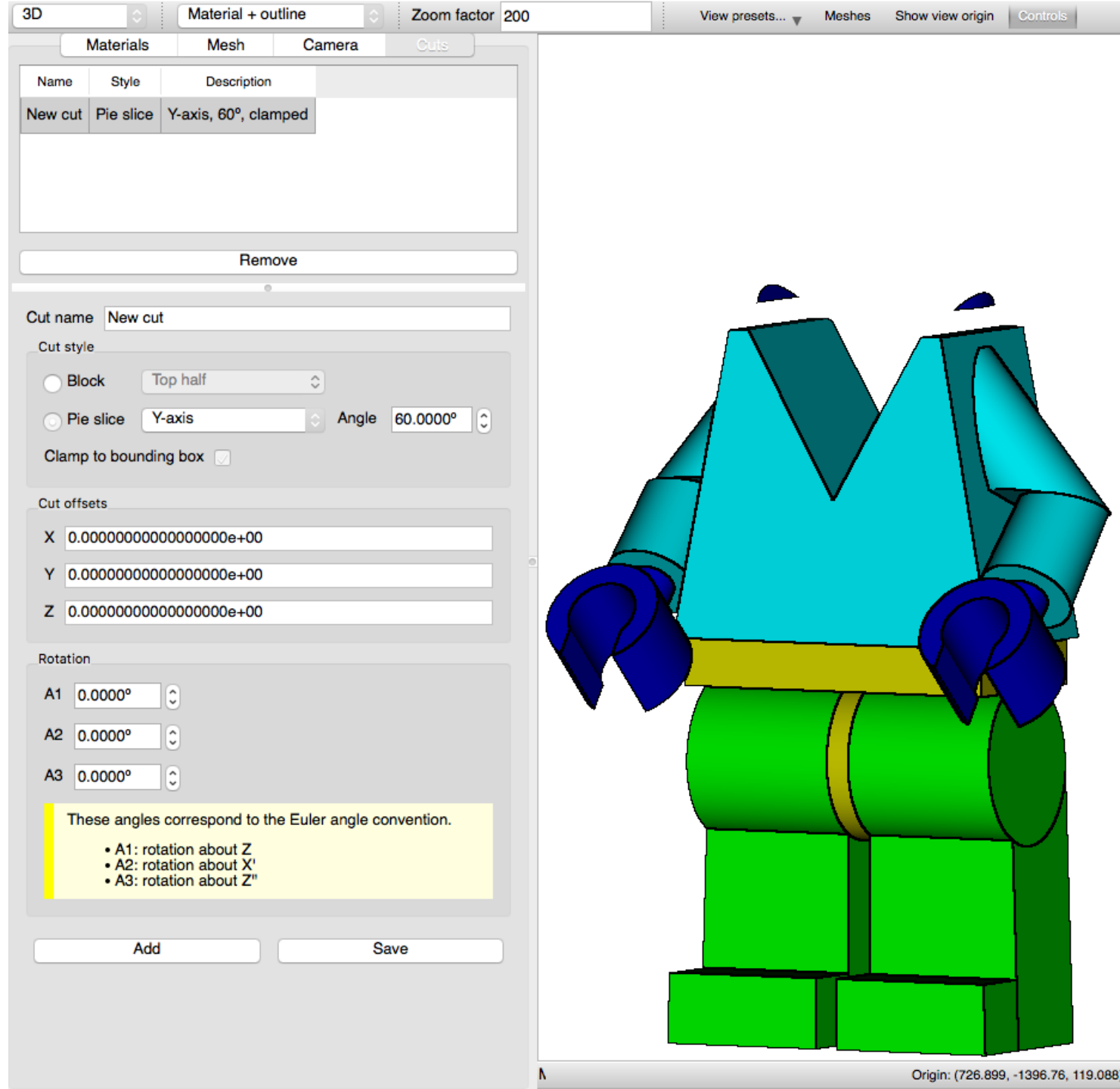
# Model Cutting: Cut Styles

- **Block**

- Top half (+Z)
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- Left half (-X)
- Right half (+X)
- Front half (-Y)
- Back half (+Y)
- Front-right quarter (-Y,+X)

- **Pie slice**

- X axis (opening in -Y)
- Y axis (opening in -Z)
- Z axis (opening in -Y)





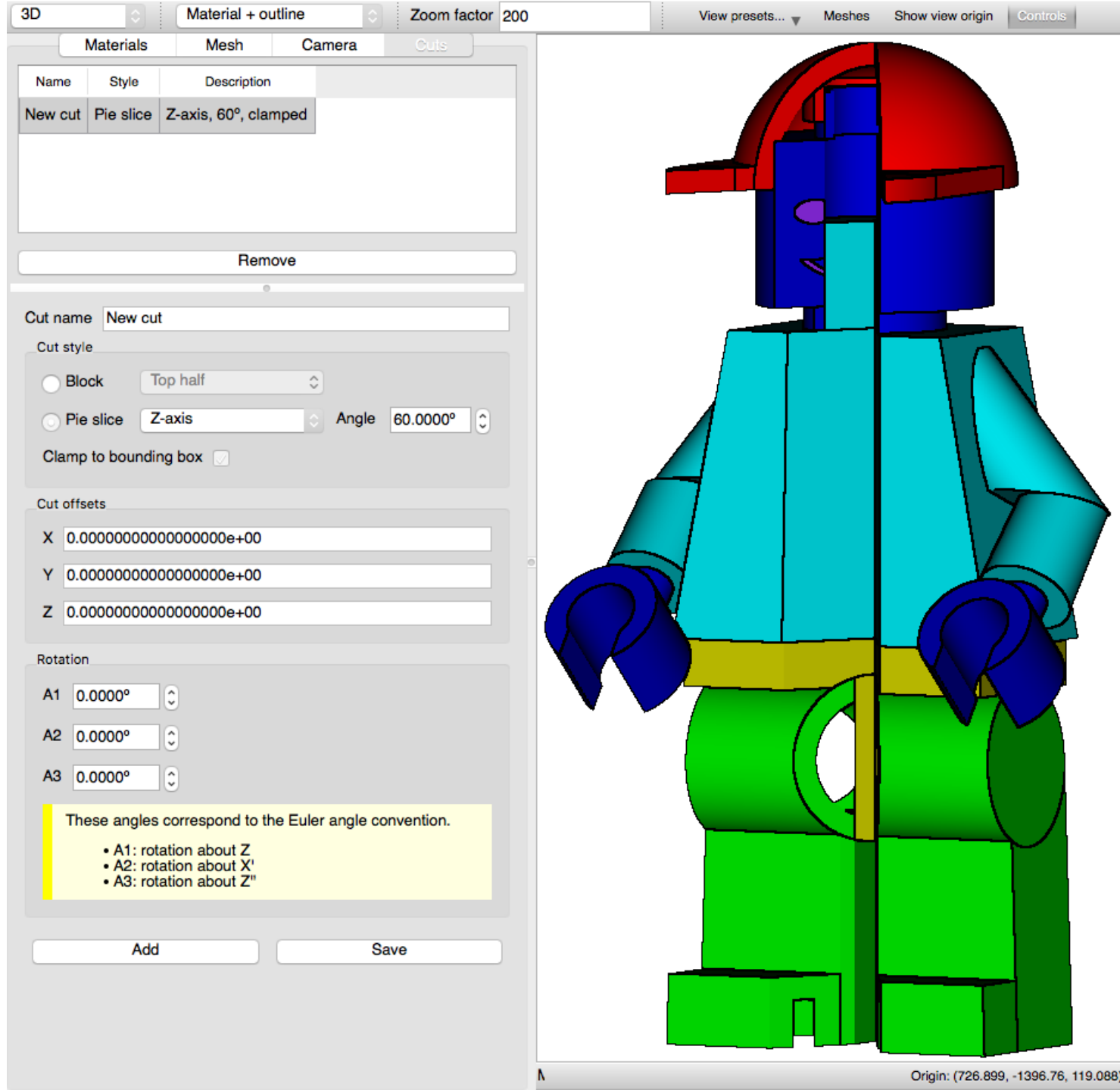
# Model Cutting: Cut Styles

- **Block**

- Top half (+Z)
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- Left half (-X)
- Right half (+X)
- Front half (-Y)
- Back half (+Y)
- Front-right quarter (-Y,+X)

- **Pie slice**

- X axis (opening in -Y)
- Y axis (opening in -Z)
- Z axis (opening in -Y)



# 3D Visualization in Fulcrum Summary

- Camera
  - Presets
  - Panning
  - Zooming
  - Rotation
- Rendering modes
- Display metadata
- Material controls
  - Filter material table
- Geometry Cuts

