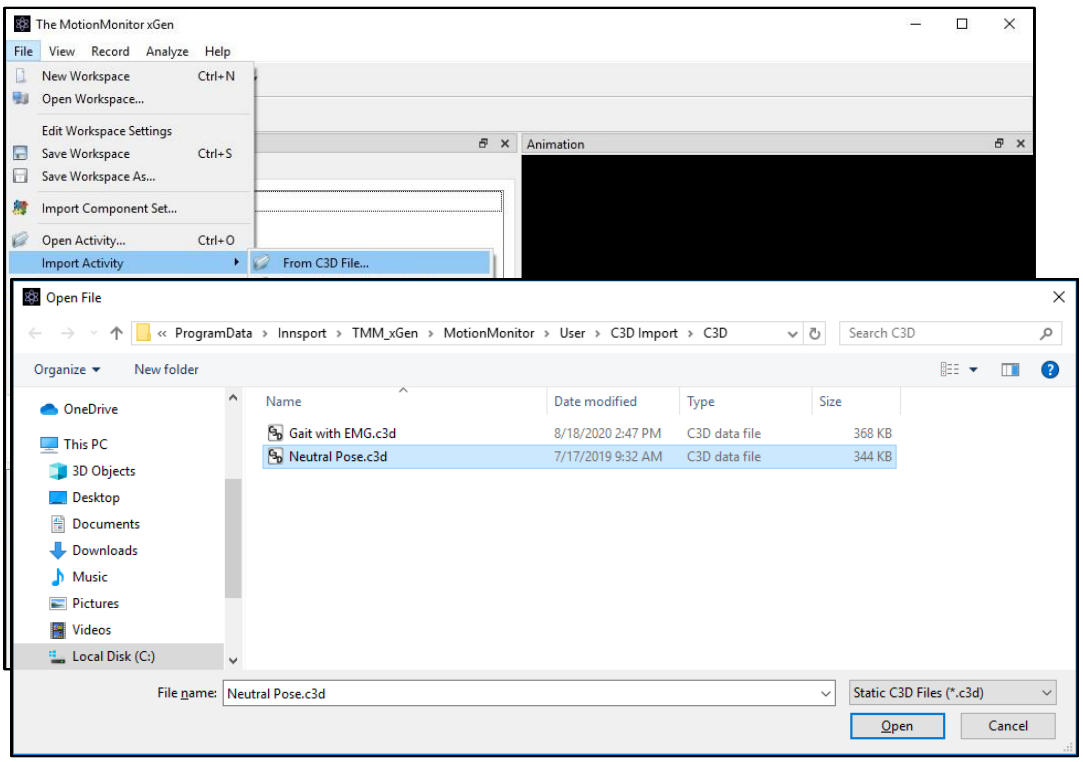
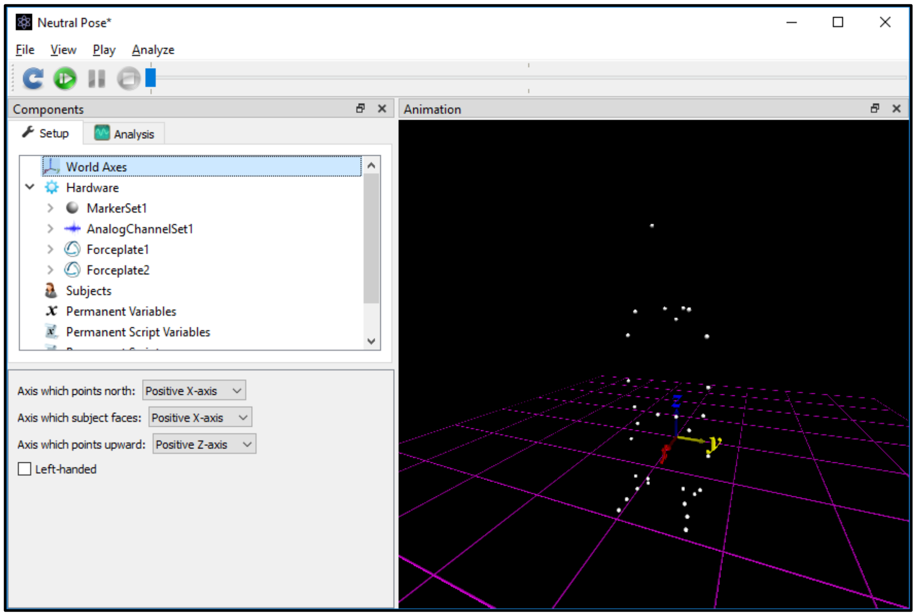
The MotionMonitor xGen Software Guide: C3D Model Builder (C3D Import)

This guide reviews the procedure for importing data captured by other motion capture systems including Vicon, Natural Point Optitrack, Motion Analysis Corp, Qualisys, Optotrak, Phoenix PTI, PhaseSpace, CodaMotion, BTS, Theia, KinaTrax or Polhemus Liberty and how to generate skeletal models from marker data, compute joint centers and define local coordinate systems. A tutorial video for importing C3D files can also be found at https://www.innsport.com/supportxgen.html.

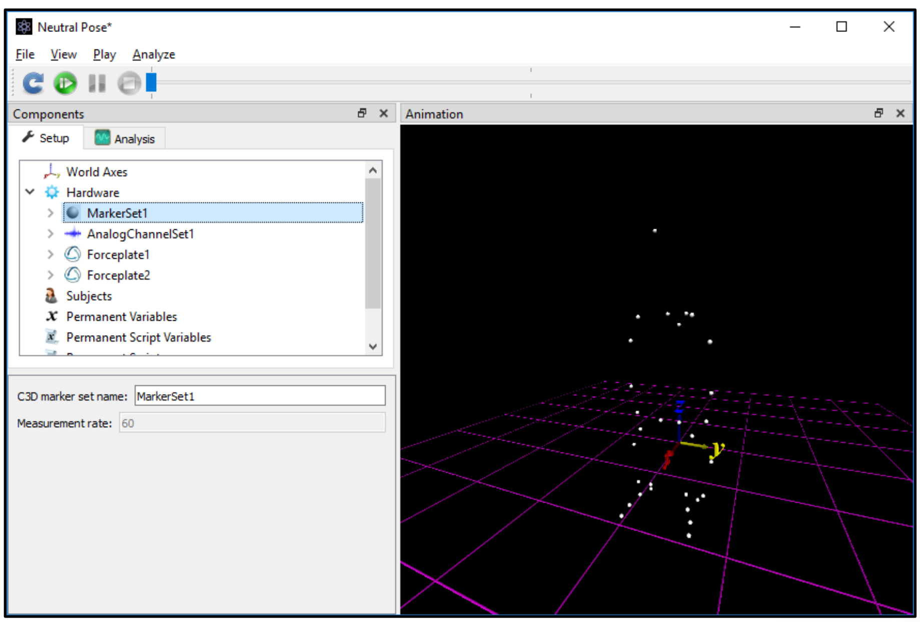
1. The process of importing C3D data and generating a biomechanical model is started by loading the Static C3D file through the *"File|Import Activity|FromC3D File"* menu. Use the file explorer window to browse to the location of the Static C3D file. The model is built from a non-moving subject trial, containing only a "static" pose. This file can consist of either a single frame or multiple frames of data. Note: Data from Markerless systems, which contain Rotational data and no Point data, do not require a traditional static C3D file. A static file still needs to be selected, but it can contain data where the subject is moving. The subject will need to be defined in a particular manner that will be described later in this document.



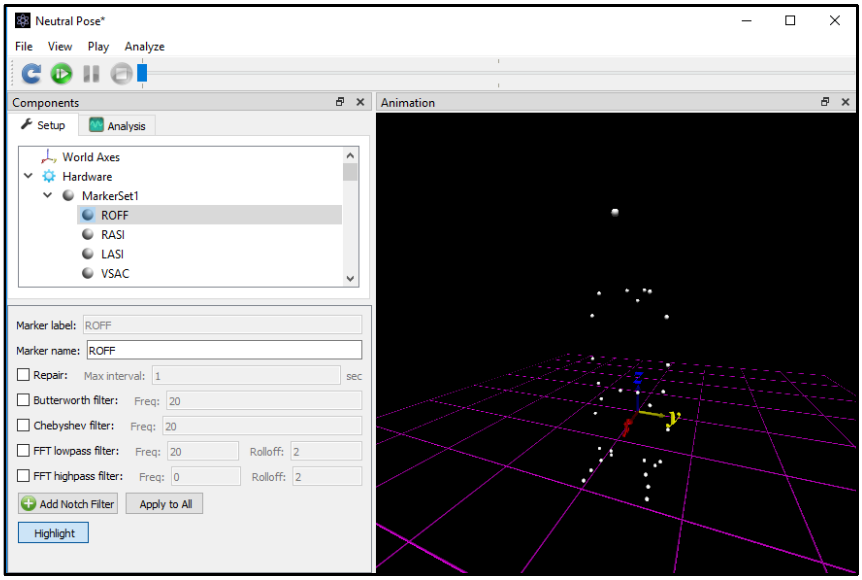
2. The selected static C3D file will open as a ***The MotionMonitor xGen*** activity file, including the hardware that existed in the C3D file. This usually consists of markers, analog data and force plates or EMG. From the World Axes Parameters Panel in the Components Setup tab, select the appropriate World Axes directions for the "Axis which the subject faces" and "Axis which points upward". These selections need to match the directions for the Static C3D file. For dynamic trials, the subject can be facing any direction, but the "Axis which points upward" should be consistent across all C3D files.



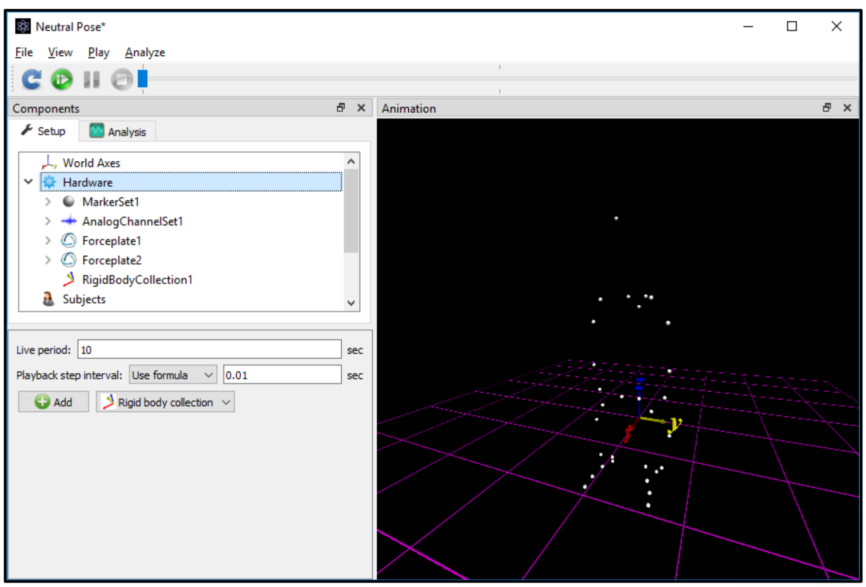
The *MarkerSet1* represent markers from a camera system, or landmarks & joint centers from subjects that were defined in the originating hardware application and then output as elements of the C3D file.



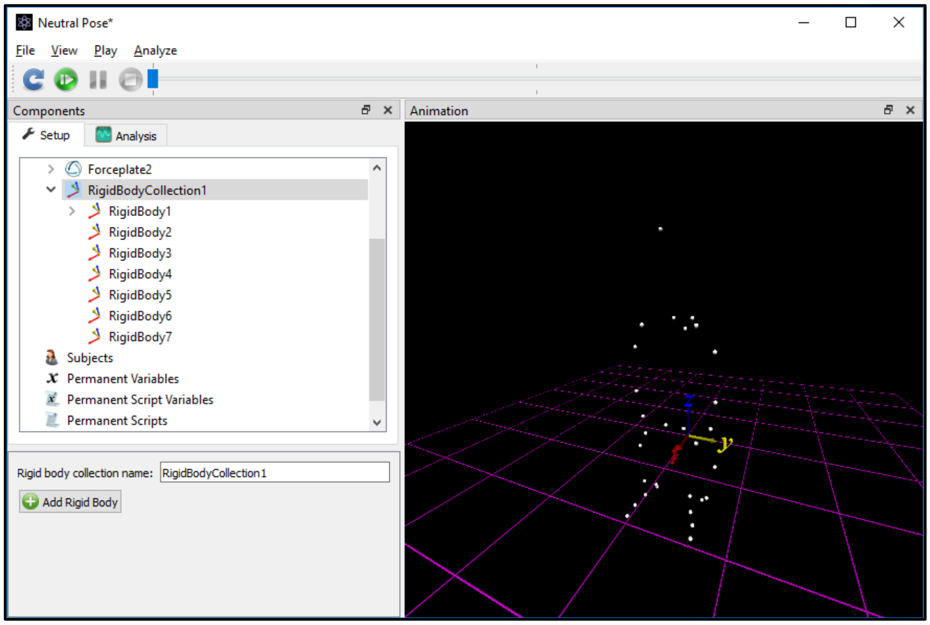
Expanding the *MarkerSet1* reveals the marker names included in the set. These names are generated by the system which created the C3D file. Selection of a marker name as shown below, opens the marker properties panel. The marker can be re-named, repaired by filling a gap with a 3rd order spline, or smoothed with one of the filters in the properties panel. The marker can also be identified in the animation window by selecting the “highlight” button which causes it to “blink”.



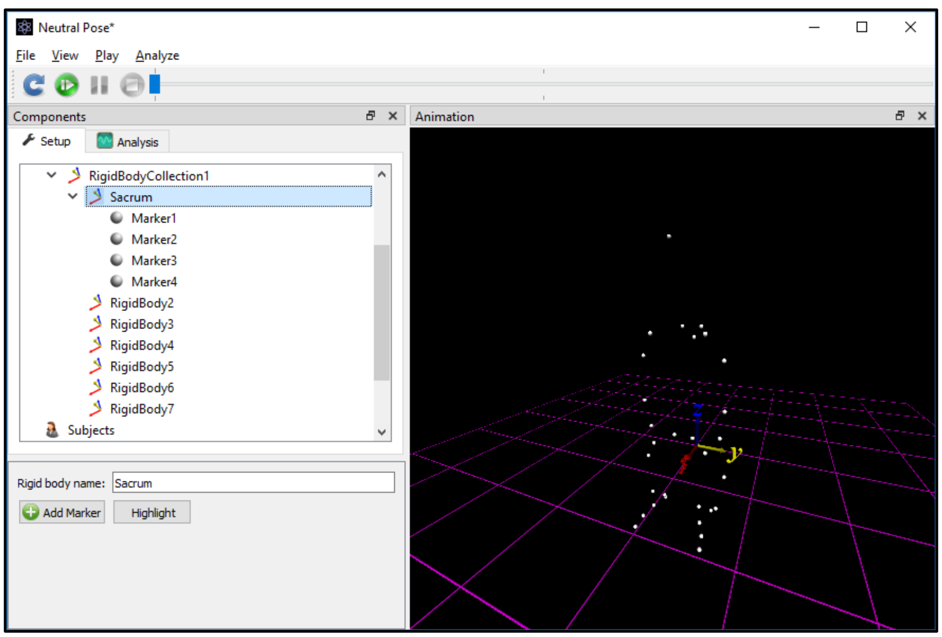
3. Adding a Rigid body collection hardware device allows for rigid bodies to be added that will have 6 degrees of freedom which can then be used to track position and orientation. The rigid body could be a cluster of markers that move rigidly together or individual markers affixed to landmarks that are expected to move together in a rigid fashion. For example, markers affixed to the tibial condyle, tibial plateau and malleolus would be thought to move rigidly with the shank. A tutorial video for creating rigid bodies can be found at https://www.innsport.com/supportxgen.html.



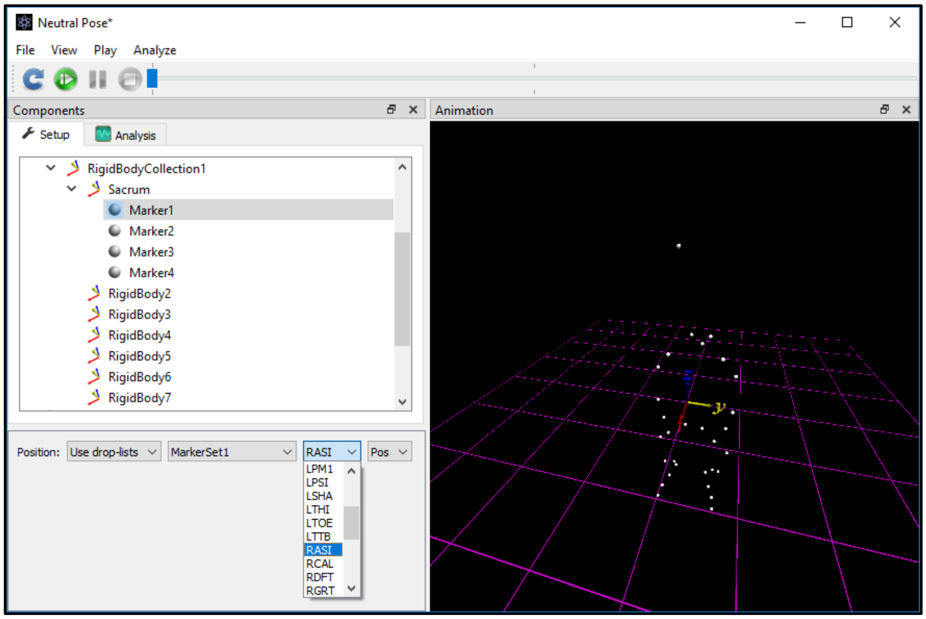
In this example we will add 7 rigid bodies…one for each segment of the lower extremity.



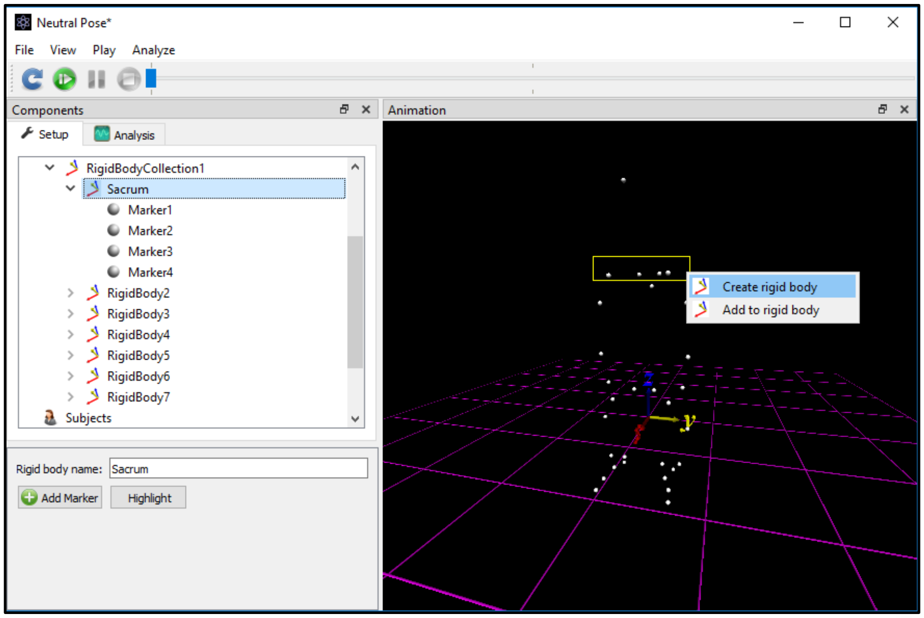
Once the Rigid Bodies are added, the user can select the rigid body and name it appropriately using the properties panel. A rigid body should include at least three markers that are attached to the segment and will track rigidly with the underlying bone. In the image below we have renamed the first segment as Sacrum and added 4 markers via the Add Marker button in the parameters panel.



Use the drop list to select a marker from *MarkerSet1*. For the Sacrum we will add Left and Right PSIS and ASIS markers.

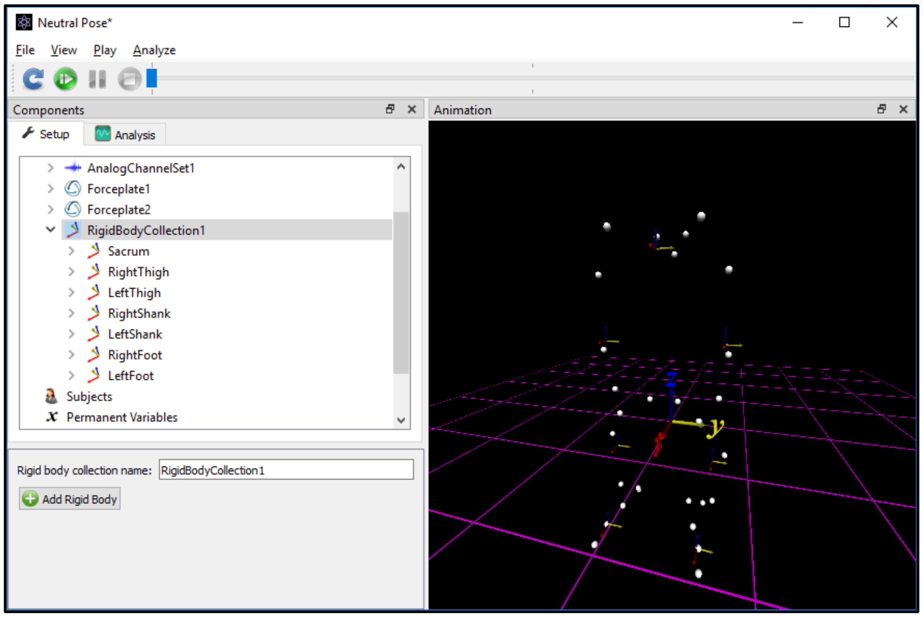


An alternative method for adding markers to a rigid body is to lasso the markers in the animation window. To do this hold down the shift and left mouse button as you lasso the markers to be included as part of the rigid body. You can also lasso individual markers and add them to existing rigid bodies or create a rigid body to be added to a Rigid body collection from here.



After selecting the markers to include in the rigid body, use the Highlight button to turn the group of selected markers on and off. This will ensure you have selected the markers that were intended.

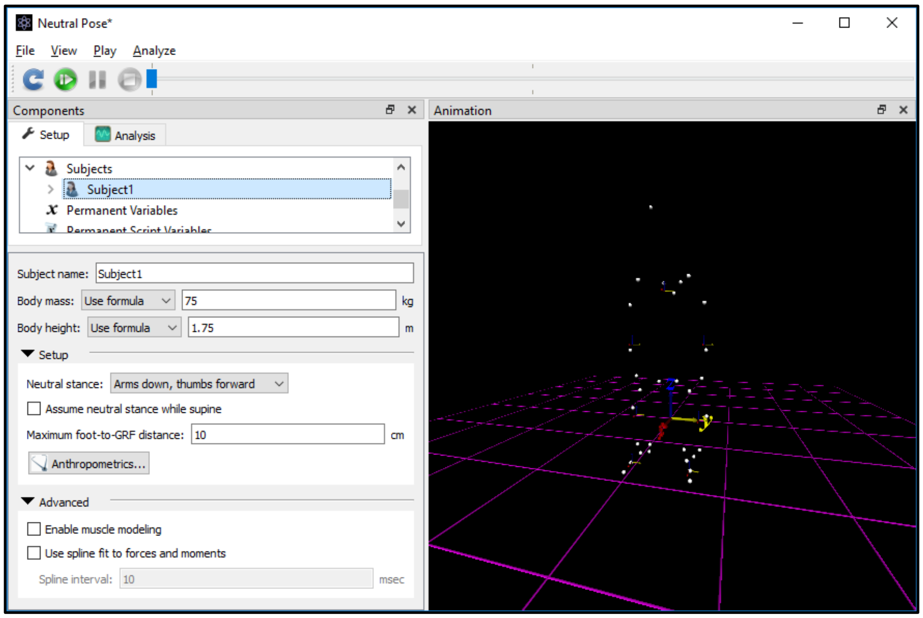
In addition to the markers, each rigid body will have a small coordinate axes which marks the centroid of the rigid body as well as its orientation.



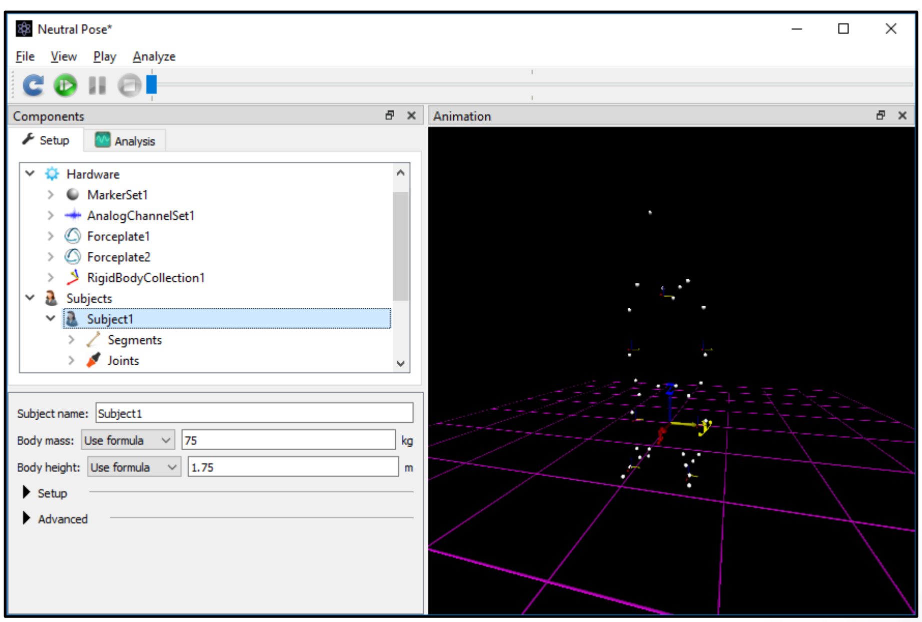
One should note that markers can be used on multiple rigid bodies if they are in fact rigid in the specified rigid body. For example, a marker on the femoral joint line could be used with 2 other markers on the thigh and 2 other markers on the Shank to form 2 rigid bodies.

When you have defined each of the rigid bodies, they can be used together with individual markers to define your subject.

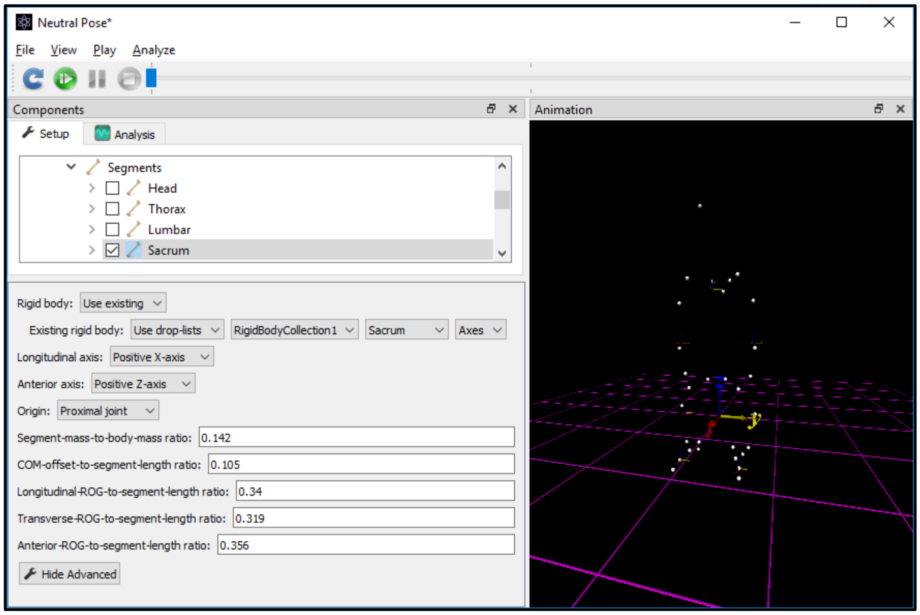
4. To start the biomechanical modeling process, first select Subjects in the Setup Components tab and then by right clicking, or from the properties panel at the bottom of the dialog, add a subject. This will generate a default subject name of Subject1. Selecting Subject1 will bring up the parameters panel for the subject. These parameters should be completed before proceeding. Tutorial videos for Setting up a Subject can be found at https://www.innsport.com/supportxgen.html. Note: If importing data from a Markerless system, the "Assume rigid bodies to be aligned with segment axes" checkbox in the Subject 1 parameters panel needs to be enabled and the "Longitudinal axis of rigid bodies" and "Anterior axis of rigid bodies" need to be selected based on the Rotational data axes that correspond to the Longitudinal and Anterior directions for the subject.



Underneath the subject will be nodes for Segments and Joints.

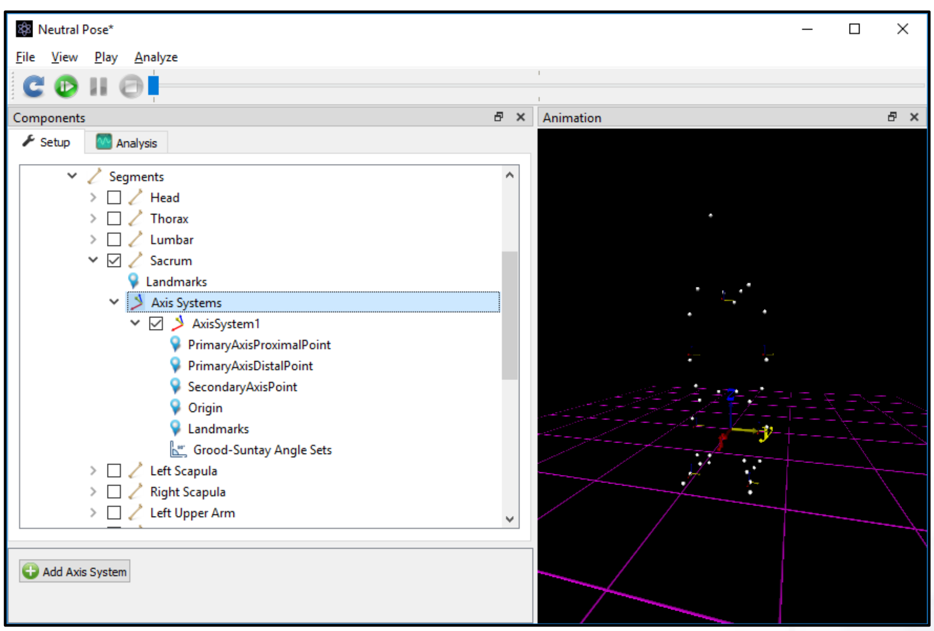


5. Expand the Segments node and enable the segments to include in the model. Selecting a segment will generate a properties panel at the bottom of the dialog.



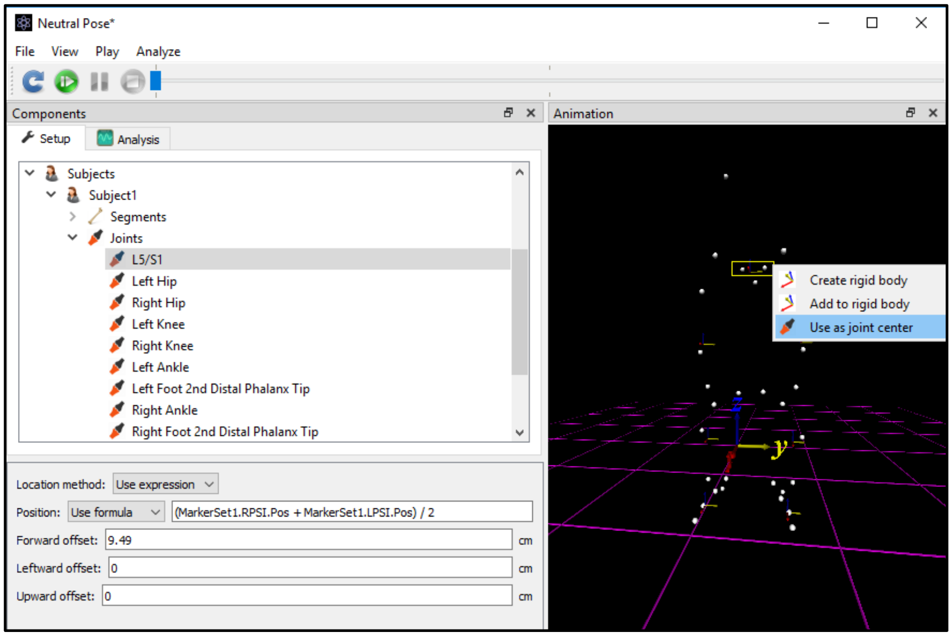
Using the drop-lists we can select the appropriate rigid body name from the Rigid body collection created in the previous steps. Rigid bodies are defined by an “axes” variable that contains a position vector and orientation matrix. This rigid body will be used to track the position and orientation of the segment. The segment properties panel can also be used to add anthropometric data for the body segment.

Expanding the segment node displays Landmarks and Axis Systems nodes for the segment. Landmarks can be added to track additional points of interests for a segment and Axis Systems can be added to define custom, anatomically based, local coordinate systems. In this example we will use the default Axis System method, which is generated by default and requires no definition. The AxisSystem1 that is exposed in the image below will be ignored.



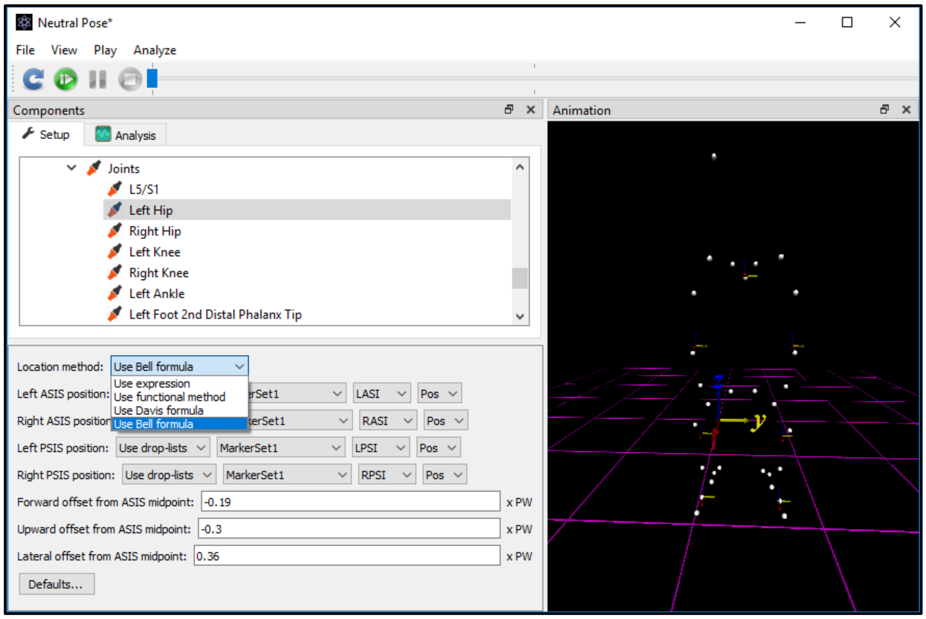
6. Joints associated with each segment are automatically added to the Joints node.

   There are many ways to define the position of the joint. One could use the drop-lists and select individual markers as in previous examples. One could also use formulas. For example L5/S1 could be defined more appropriately as the midpoint of RPSI and LPSI. Right clicking in the edit field and selecting “insert variable” or “insert operator” provides a series of dropdown menus to select the data of interest. Or formulas can be typed directly into the field if preferred. Alternatively, markers to be used in defining a joint center location can be lassoed in the animation window. To do this hold down the shift and left mouse button as you lasso the markers to be included. Then right-click and select the “Use as joint center” option.



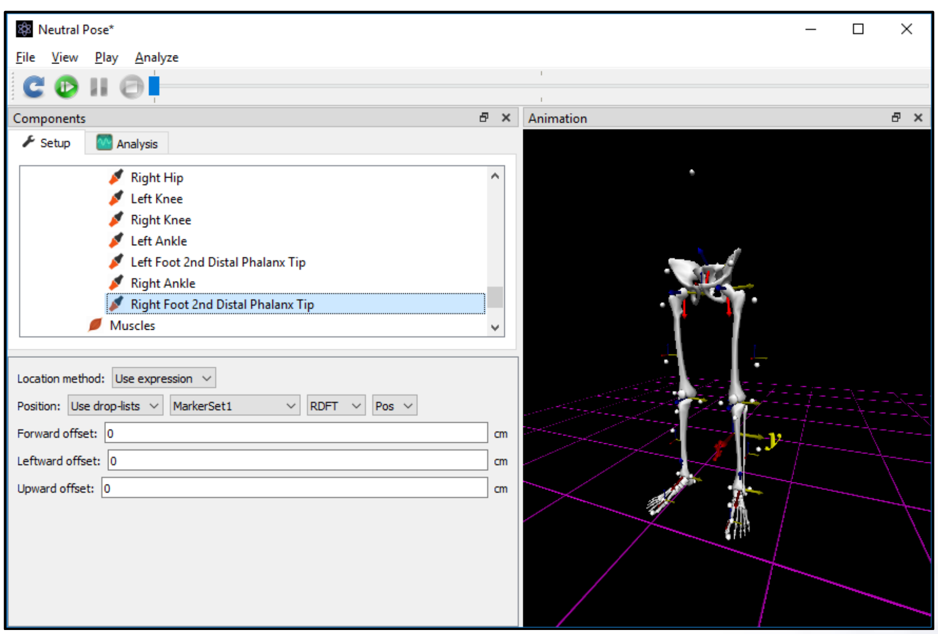
   Offsets can be applied to “Position” point using standard mathematical notation in the Forward, Leftward and Upward Offset fields. These directions are in the reference frame of the subject. A negative will move the opposite direction, so a negative value in the “Leftward” field would result in a rightward offset. In the case of L5/S1 that is defined by surface markers, we can add a forward offset to approximate the distance of a surface marker to the true rotational center of the spinal column.

Hip joint centers can use a functional method, Bell or Davis linear regression methods or user defined computations. For Bell and Davis, the formula coefficients are auto-filled with their default values which can be modified by the user. For the functional method, the file path for a C3D file must be selected, whose dynamic data will be used to calculate the hip joint center of rotation. In our example, we will use the Bell Method with default values.

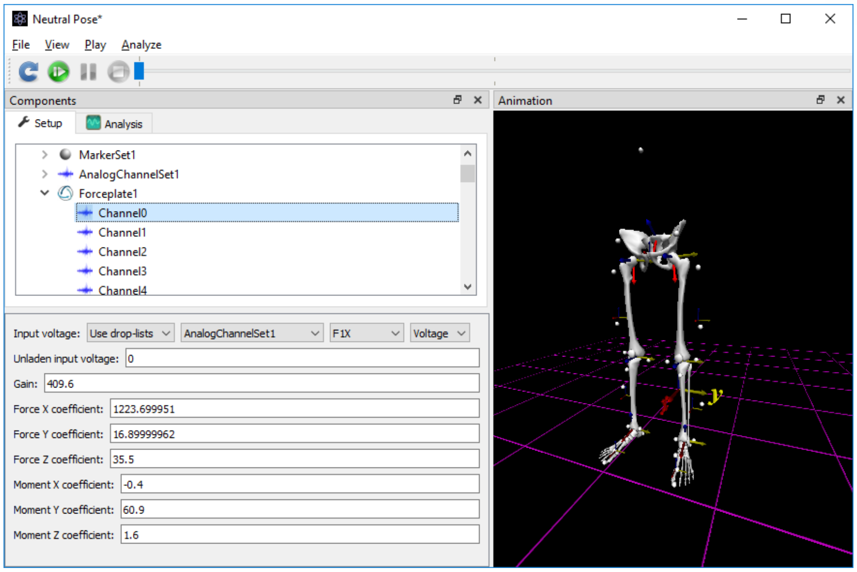


The shoulder joint also includes linear regression and functional methods for defining the joint center.

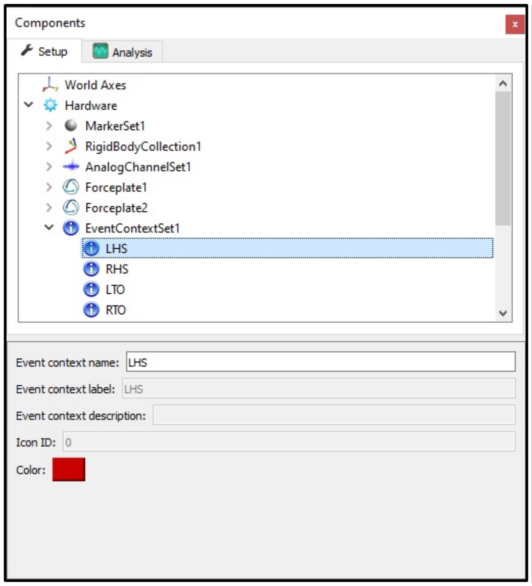
As joint definitions are entered, bones will begin to appear in the animation window. The definitions can be augmented in real-time, and the user can continue to build until the model is fully defined.

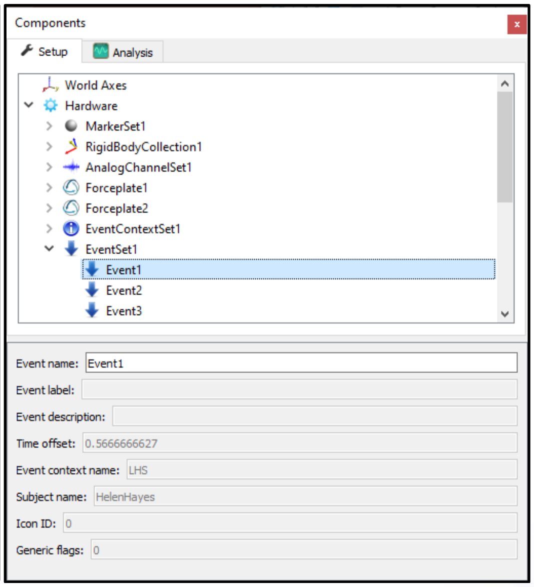


7. The remaining elements of the C3D file such as analog data and force plates will fill automatically. For example, ForcePlate1 is receiving Fx data from the AnalogChannelSet1 channel labeled F1X as a voltage. Gain and the sensitivity matrix for each channel is entered automatically from the C3D file and requires no user intervention.



8. In addition to the Point, Rotational and Analog data types that will be imported from the C3D file, any Event data from the C3D file will also be populated under the Hardware node in the Setup Components tab.

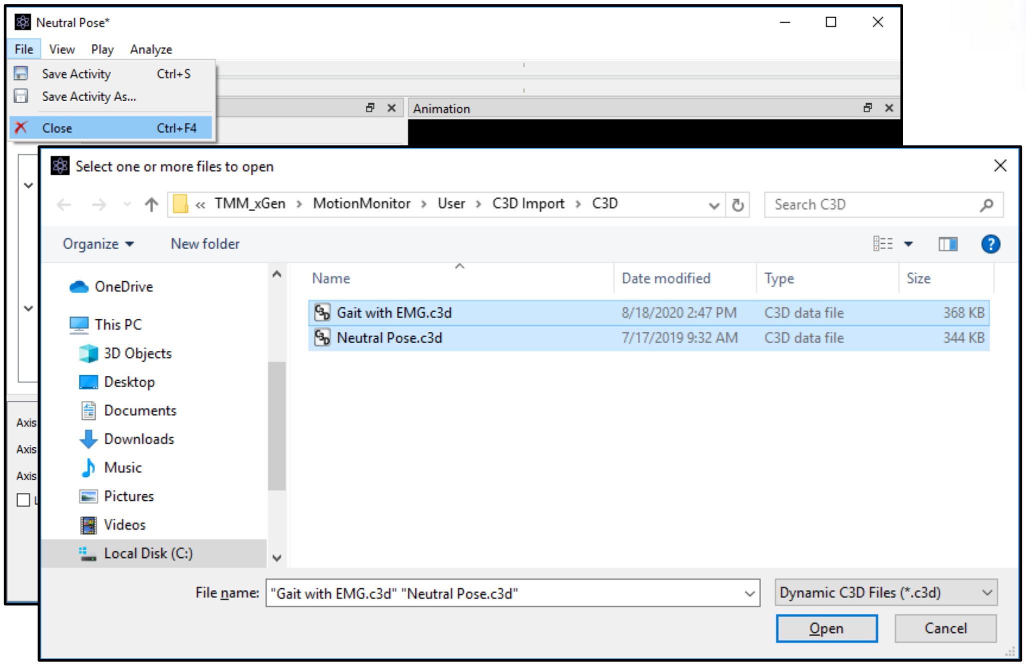




The Event Contexts includes the name, label, description, ID and color for events. The Event Set contains specific data for the actual event, including which Event Context the event belongs to, when the event occurred, and other information assigned to the event in the C3D file. An example for events would be that the Event Context Set includes right and left heel strikes and toe offs. The Event Set would then contain the actual events for when right and left heel strikes and toe offs occurred, which there could be multiple of during each trial. For more information on Events, refer to The MotionMonitor xGen Software Guide: C3D Model Builder (C3D Export) document.

9. Finally, as a last step, you will want to import all of the dynamic activities associated with your static C3D file and save your settings of the model you have created.

   This is accomplished by selecting *File|Close* in the ***The MotionMonitor xGen*** activity window for the Static C3D file, which in turn will open a Window's file explorer dialog where the files to be imported can be selected.



When the files have imported, a message will appear in the "Live" or main application window announcing success. At this point the settings for the model can be saved as a workspace. In the future, the user can load this workspace before importing a static file and the model definitions will be automatically applied.