The MotionMonitor xGen Hardware Guide: Interface with PhaseSpace Cameras

Overview

The MotionMonitor xGen software can collect data from PhaseSpace cameras in realtime using ***The MotionMonitor xGen's*** Rigid Body 6DOF Tracking. This process assumes that each segment is being tracked by at least 3 LEDs rigidly attached directly to the skin or to a rigid plate. **The MotionMonitor xGen** records the position and orientation of LEDs assigned to each rigid body, computes the centroid and coordinate system of these rigid bodies and then uses that data to perform ***The MotionMonitor xGen***'s standard analytical and visualization routines. The user has the option to use a fixed marker set to locate joint centers or, alternatively, can digitize landmarks using a stylus whose position and orientation are tracked using one of the 6DOF sensors.

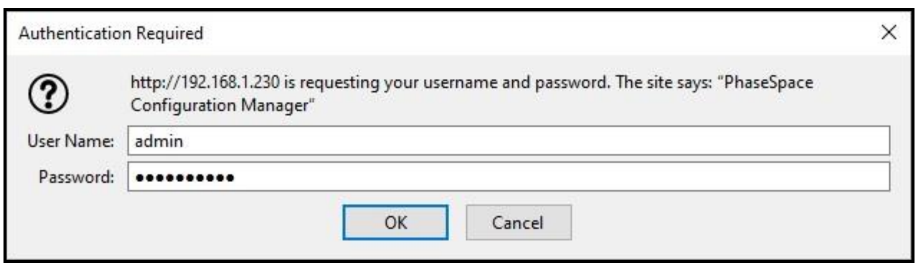
Rigid Body 6 DOF Tracking

Rigid Body 6 DOF tracking works on the following set of principles. The subject is instrumented with a minimum of 3 LEDs on each tracked body segment. The markers are relatively rigid (the more so the better) with respect to each other.

Within ***The MotionMonitor xGen*** rigid bodies are computed from the LED's (x,y,z) coordinates. The computed position and orientation of these rigid bodies are used within ***The MotionMonitor xGen*** to track objects, define subject segment lengths, locate joint centers, digitize and track landmarks of interest, etc.

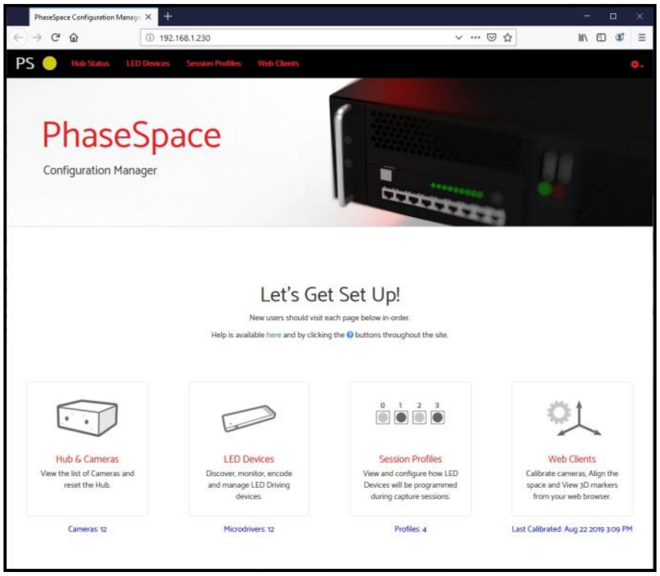
A step by step guide to setup this method follows:

1. Begin by opening the PhaseSpace Configuration Manager. An Ethernet connection must be established between the PhaseSpace server computer and ***The MotionMonitor xGen*** data collection computer. Open a web browser on the remote computer and enter the IP address for the server computer into the address bar. Please contact your Client Support Engineer (support@TheMotionMonitor.com or 773-244-6470) for assistance in determining the IP address for your PhaseSpace system. The PhaseSpace Configuration Manager will require the user to enter the username **admin** and the password **phasespace** to log in.

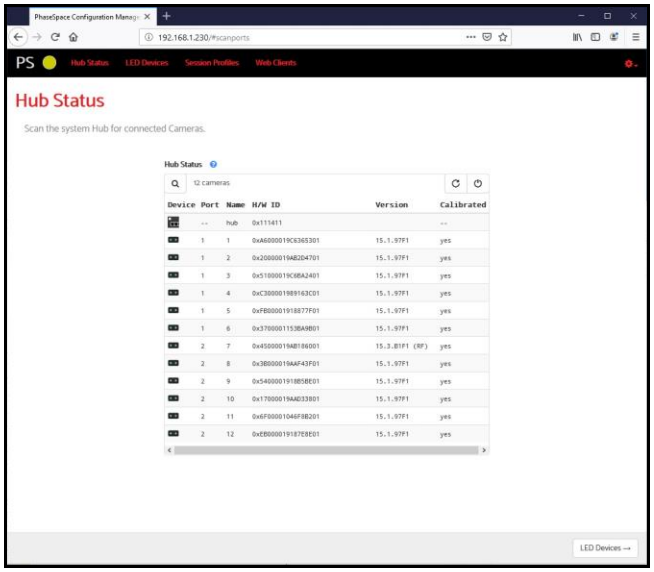


In general, following the initial configuration of your LED drivers and LEDs, steps 2 – 7 with the Configuration Manager, will only need to be performed if modifications have been made to the LEDs connected to the LED Drivers. Otherwise, steps 2 – 7 can be skipped.

After successfully logging into the PhaseSpace Configuration Manager, a home page similar to below will be displayed.

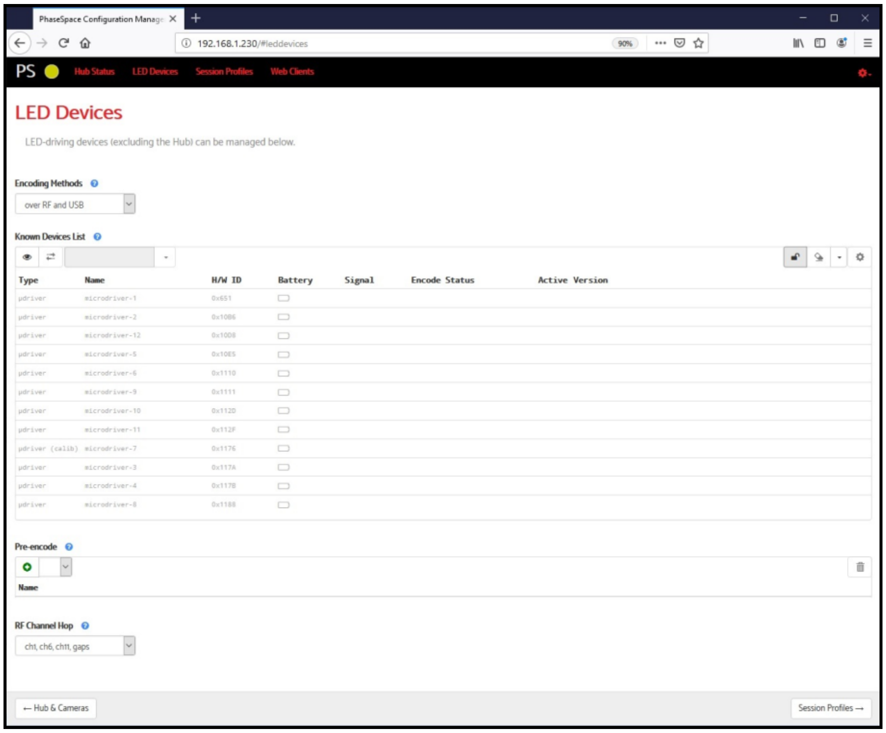


2. Clicking on the Hub Status link from the top of the PhaseSpacce Configuration Manager or on the Hub & Cameras page link will display the Hub Status page and display the connected cameras, as seen below.

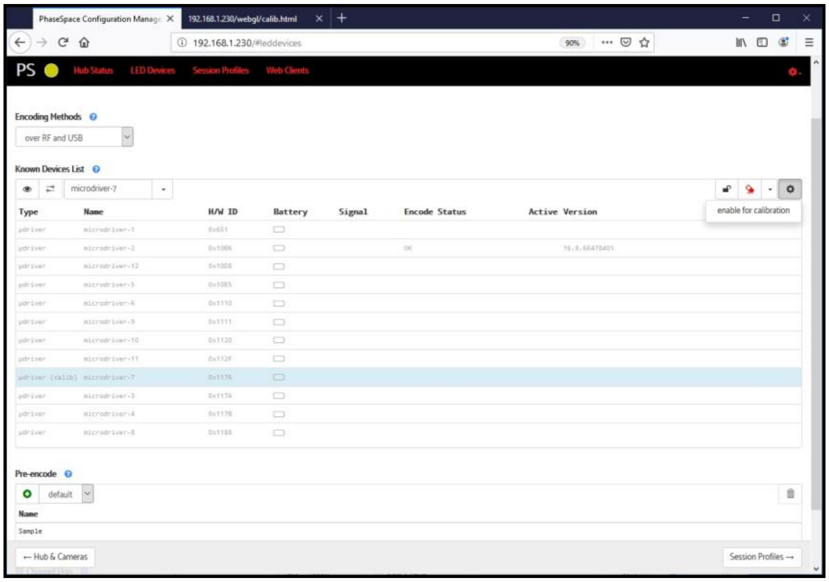


If all cameras are not found, click the magnifying glass (start stream) icon or the Reset the hub icon to try querying the camera system or check camera connections and reboot the PhaseSpace Server. **Do not connect or disconnect cameras while the PhaseSpace server is on**. The “Previous/Hub” port for the first camera in a string is connected to the PhaseSpace server. The “Next” port for this camera is connected to the “Previous/Next” port for the next camera. Cameras can be linked together, with up to 6 cameras connected in a string. The optimal positioning of cameras is that they are equidistant from the center of the capture volume. The LED power (LED brightness) cannot be adjusted on an individual camera basis. So, if cameras are significantly different distances from the center of the capture volume, the LED power setting will not be optimized for all cameras.

3. The LED Devices links will open the LED Devices page, which is where LED drivers and microdrivers can be added and removed from the Known Devices List as well as monitored. The Name of each driver can also be modified through the edit field above the Name column when a device is highlighted from the list. To discover a new device, it must be powered on. Note that LED drivers will power off if left idle for extended periods of time. The Encoding Methods should be set to over RF and USB.

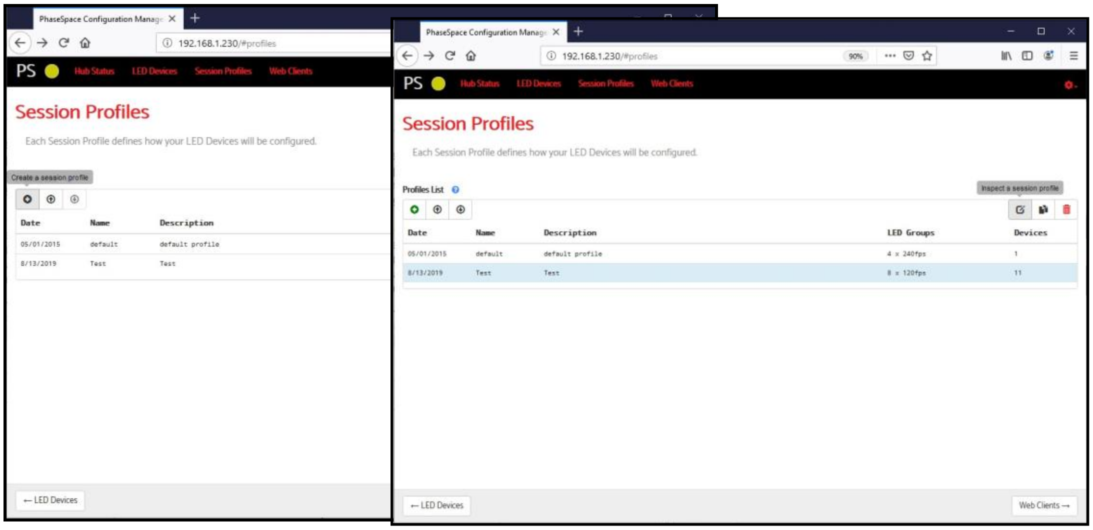


The LED driver that will be connected to the calibration wand will need to be assigned as such, as seen below. During calibration, the LEDs on the calibration wand will be the only LEDs activated.

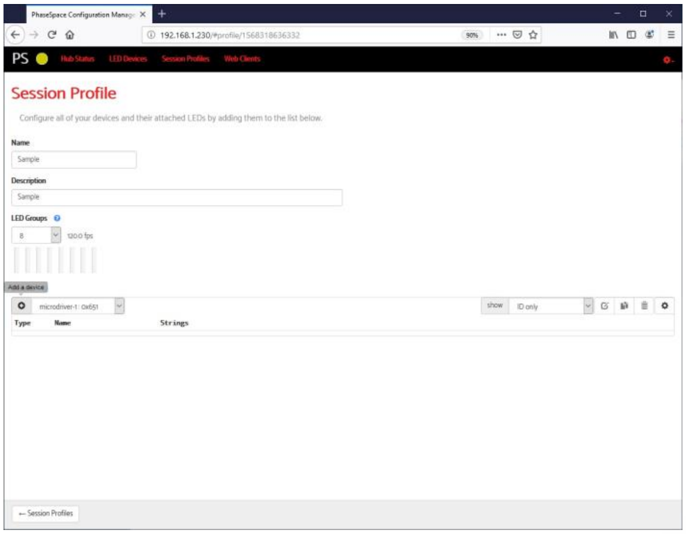


The LED Driver Profile will also be encoded through this page, but we will revisit this feature after first creating our profile, see step 7.

4. Click on the Create Profiles link to create new profiles or modify existing profiles. Highlight a profile and click on the Inspect a session profile icon or double click the profile to modify an existing profile, as seen below on the right. Click on the Create a session profile icon, to create a new profile, as seen below on the left.

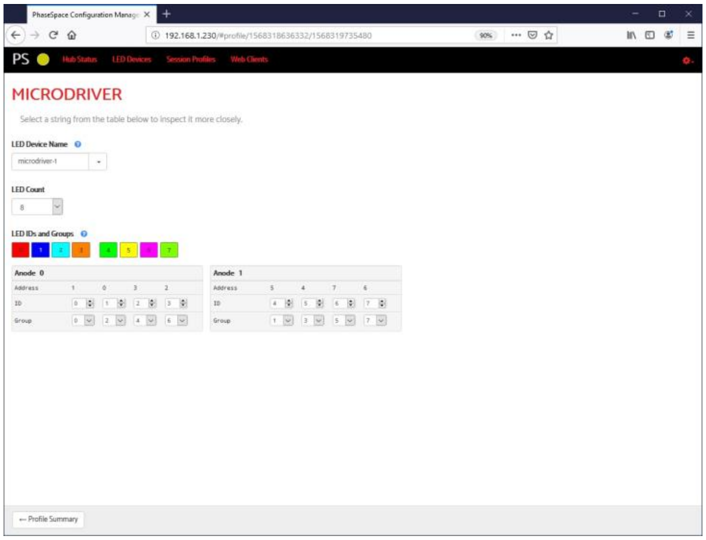


For a new Profile, enter a name and description to help with identifying what the profile will be used for (i.e Full Body Setup, Lower Body Setup, etc.). The LED Groups essentially determines the frequency at which LEDs turn on and off. Only 1 LED group will be on at any given time. An LED group can contain up to 64 LEDs. Each individual LED will operate at 960Hz, which is the PhaseSpace camera capture rate, divided by the number of LED groups. For example, if 1 is selected for the number of LED groups, all LEDs (up to 64), will operate at 960Hz and are therefore on for every frame. If 8 LED groups is selected, each LED will operate at an effective measurement rate of 120Hz, with only 1 LED group on at any given time. Assigning LEDs to groups can help reduce CPU usage and prevent LEDs from being occluded by each other. The measurement rate associated with the LED group selected will typically also be the measurement rate selected in The ***MotionMonitor xGen*** and, if needed, will be used in determining the required interpolation value in ***The MotionMonitor xGen***, see step 16.

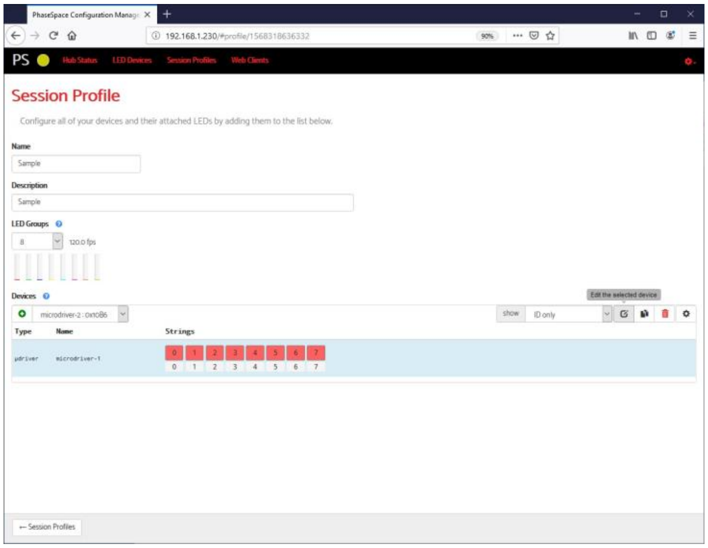


Select the desired LED driver and click the Add a device icon to add a device to the Profile, which were added from the LED Devices page previously.

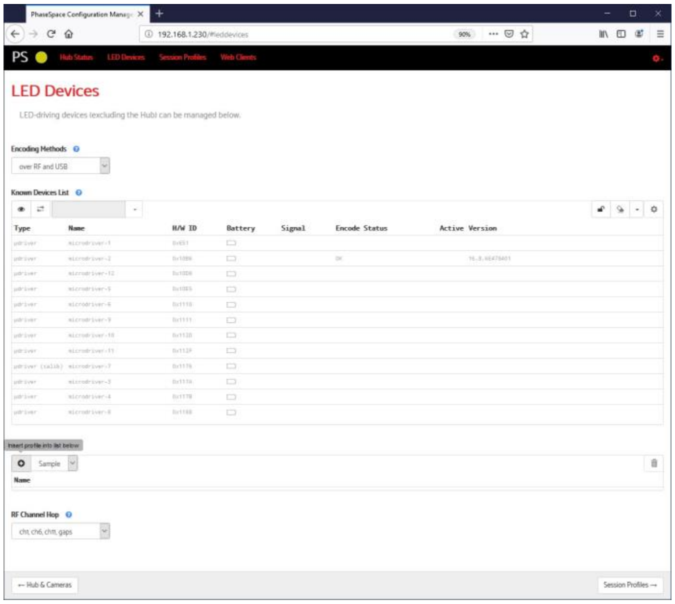
5. After adding a device, select the number of LEDs connected to the driver from the LED Count drop list. The ID field will determine the order that the LEDs stream to The MotionMontior xGen (i.e. ID 0 will be the first marker). The Group field determines what group the LEDs are in, where only one group of LEDs is on at any given time.

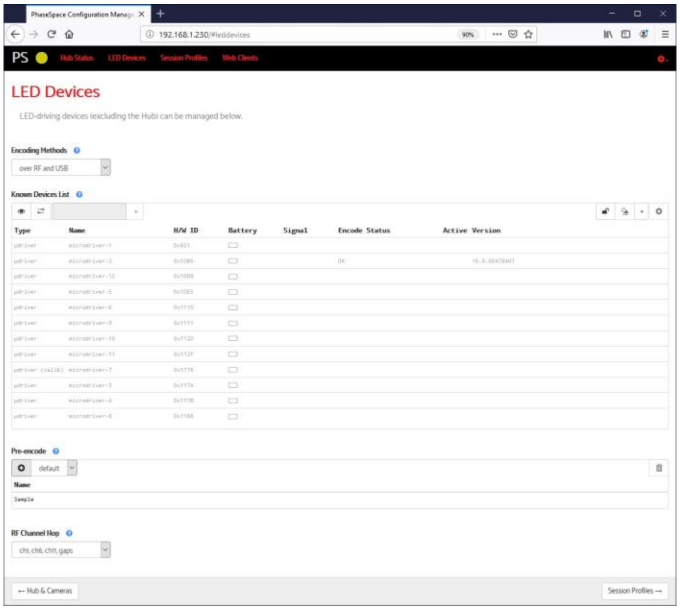


6. To modify an existing device already added to the profile, highlight the device and click on the Edit the selected device icon.



7. After all the desired devices have been added to the profile or the profile has been updated, the profile can be added to the profile drop list in the LED Devices page from the Insert profile into list below icon, as seen below.



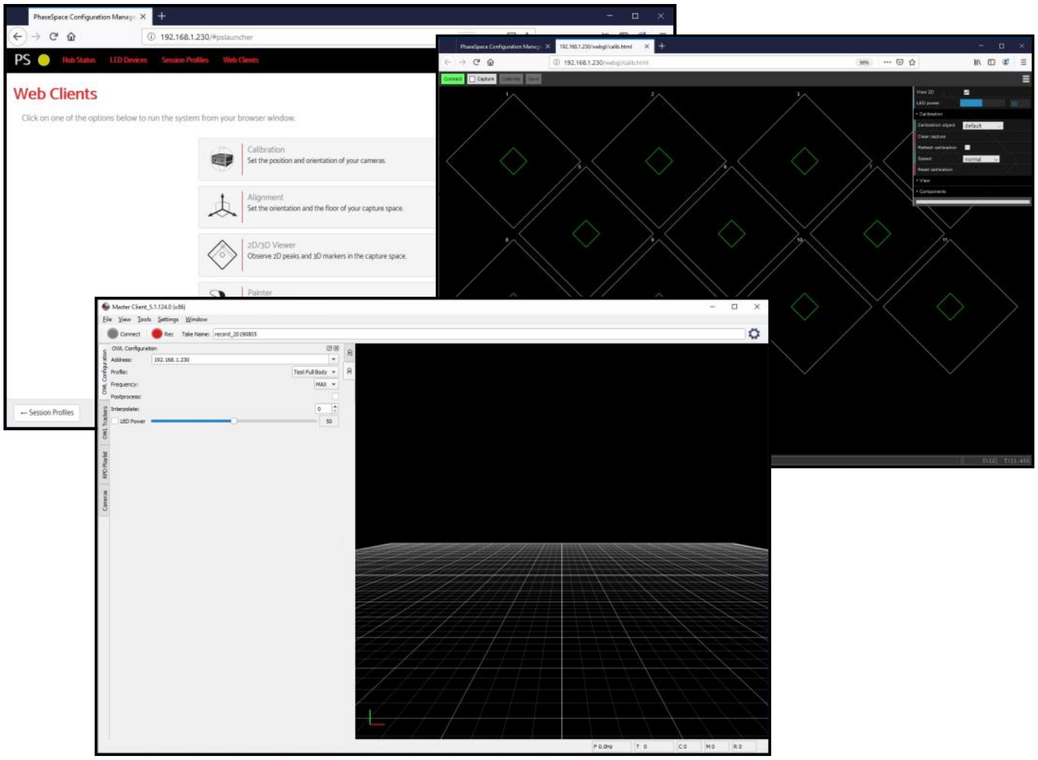


The RF Channel Hopping scheme can be selected from the RF Channel Hop drop list. In most situations, this should be left in the default setting, Ch1, Ch6, Ch11, gaps.

These updates will be saved automatically and encoded to the drivers.

8. If any cameras have been moved, a new calibration will need to be performed. Even if no cameras have been moved, it's recommended to recalibrate the cameras on a regular basis. If no calibration is required, skip to #15, otherwise continue to the next step.

9. To begin the calibration process, launch the Calibration Web Client through the PhaseSpace Configuration Manager Web Clients tab or go to Tools|Calibration menu from the Master Client application (both shown below). The Master Client application is generally the preferred method for performing a calibration. Make sure that the calibration wand is connected to the proper driver, as specified through the LED Devices page, in step 3.



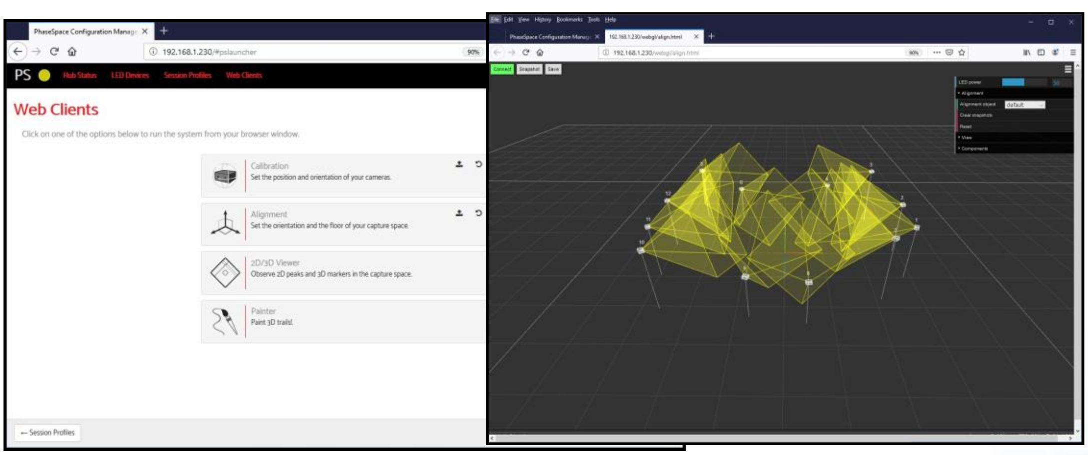
10. At this time, if connected, the LEDs on the calibration wand should turn on. Adjust the cameras as needed by placing the calibration wand in the middle of the data collection space and confirm that the wand appears in the middle of the 2D display for each camera. Also, adjust the cameras to ensure that they can see the calibration wand throughout the measurement space where data will be collected.

11. From the center of your data collection space, move the calibration wand closer to and further away from a camera. In the center of the space the LEDs should appear as markers on the screen. If mostly red crosshairs appear and the number of markers is minimal, move the wand closer to and further away from the camera. If moving closer to the camera changes the cross hairs to markers then your LED intensity is too low. If the cross hairs turn to markers as you move away from the camera then the LED intensity is too high for your collection environment. It's best to have the cameras positioned similar distances from the center of your capture volume. **Note**: If the Power is set too high the cameras can become saturated, resulting in LED dropouts. Similarly, if the power is set too low, the cameras may not be able to locate LEDs. Environmental settings such as ambient lighting and camera placement can affect power requirements.

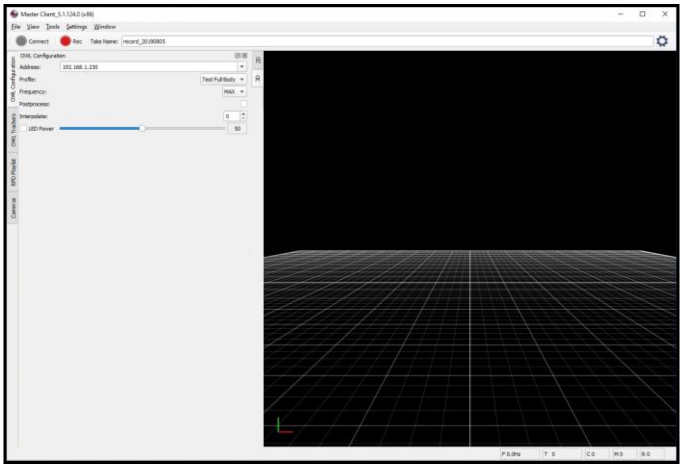
12. To start the calibration sequence, click the “Capture” button to begin collecting data. While holding the wand vertically, trace out cylindrical patterns. Begin with a tight path, extending the path, and then walking in a larger circle, while also moving the calibration wand from the floor up to the top of the data collection space. This method will ensure that robust calibration data is collected. It may also be required that you face the calibration wand towards each camera from the opposite side of your data collection space, depending on your camera configuration. As calibration is performed, the 2D camera views will fill in with green squares to indicate that calibration data has been collected for that portion of the camera’s field of view. Once each camera has an adequate amount of calibration data, click the “Calibrate” button to apply the calibration. If insufficient calibration data has been collected, the application will present a message alerting you to this and the calibration should be performed again.

13. Once the system is calibrated, a 3D view will display the camera positions along with a trace of the marker positions through the calibration capture. Things to note here are that the camera positions appear appropriate relative to one another and relative to the measurement space. Also check that the trace for the markers on the calibration wand follows a smooth curved path that you can easily track. An error value will be reported in parentheses after the final pass in the calibration status window. This number will depend on factors such as the size of the measurement space and the number of cameras, but should be relatively consistent from calibration to calibration, if cameras have not been moved. Click the “Save” button to save the calibration.

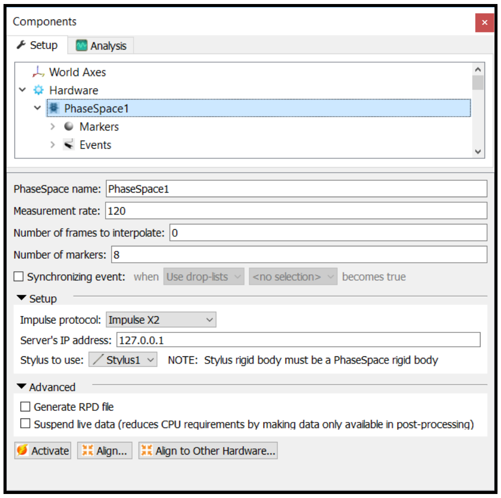
14. Whenever a new calibration is performed a new alignment must also be performed. An alignment can be performed using the Alignment Web Client through the PhaseSpace Configuration Manager Web Clients tab (shown below) or the Tools| Alignment menu in the Master Client application. The Master Client application is the preferred method for performing a camera alignment. The alignment process will include taking snapshots with the base of the calibration wand at the origin, down the positive x-axis, and then the positive z-axis. When a reading has been taken at each of these positions the screen will flash green, indicating that it’s OK to proceed to the next position. If a different world axes alignment is desired, it can be configured through the PhaseSpace parameters panel in ***The MotionMonitor* xGen**, see step 16. To increase efficiency, these positions should be taken at identical locations each time an alignment is performed, in order to ensure that your World axes or force plate alignment in ***The MotionMonitor xGen*** does not need to be re-defined/aligned. When performing an alignment, ensure that the wand is touching the plane of the ground and is held in a vertical or perpendicular orientation, relative to the ground.



15. Within the Master Client application, select the desired profile from the drop list in the Owl Configuration tab and click the Connect button. This will provide a visualization to ensure that your environment is properly calibrated and aligned as well as prepare the PhaseSpace system for streaming the proper profile to ***The MotionMonitor xGen***. The LED power can also be adjusted here as well, whose settings will also be retained when activating the PhaseSpace LEDs within ***The MotionMonitor xGen*** application.



16. In ***The MotionMonitor xGen***, go to the Setup tab in the Components Window and add or click on the PhaseSpace hardware component in order to configure the hardware. From the Setup section of the PhaseSpace parameters panel, select the proper Impulse Protocol from the drop-list for your PhaseSpace hardware version. Contact your Client Support Engineer (support@TheMotionMonitor.com or 773-244-6470) for questions regarding which protocol version should be used with your hardware. The IP address should match what was used for the PhaseSpace Configuration Manger or Master Client application. The Measurement rate and Number of frames to interpolate should be set according to the number of LED groups set in step 4. If setting the Measurement rate to a value that is greater than 960/(# of Groups), an interpolation value will be needed in order to prevent gaps in LED data from frames when the LEDs were not on. The Number of markers should match the number of LEDs configured for the PhaseSpace Profile encoded to the LED driver in step 7.



The Advanced setting for Generate RPD file is a diagnostics capability that generates a file containing the raw camera data from the PhaseSpace hardware, which can be opened in

PhaseSpace applications. This file can be used by a Client Support Engineer to troubleshoot PhaseSpace hardware or tracking issues.

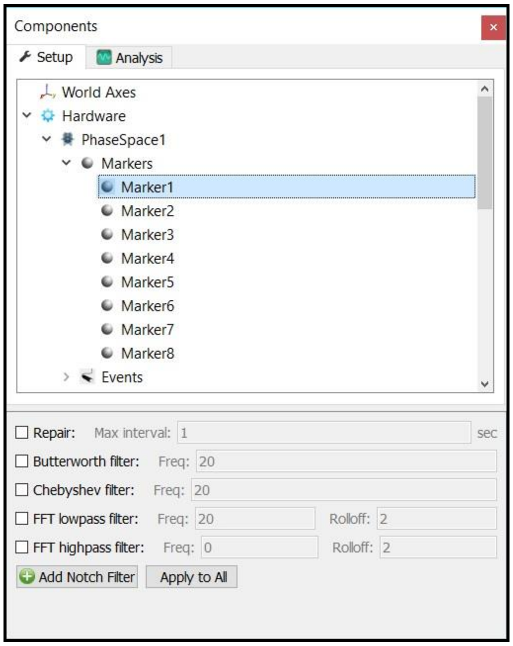
The Stylus to use field refers to the stylus that is used for any alignment of the world axes using the Align or Align to Other Hardware buttons.

Suspending live data can reduce CPU requirements while performing recordings but would prevent any PhaseSpace data from being available in any of the Live windows. This setting can typically remain disabled.

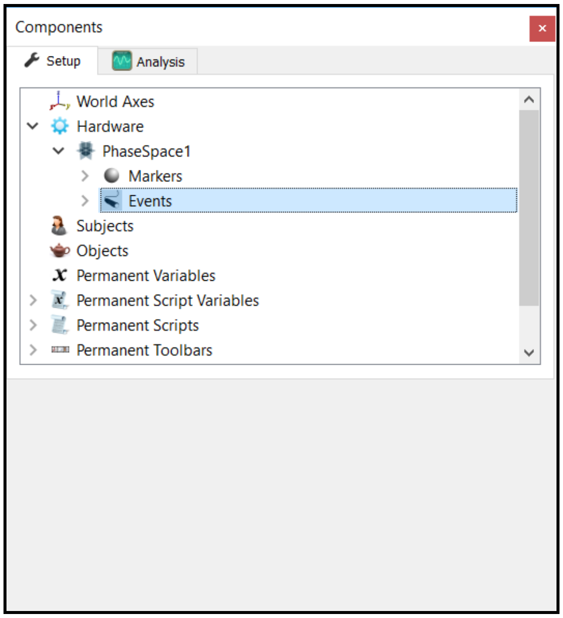
For information on using the Synchronizing event, please see the Synchronizing PhaseSpace section at the end of this document

Click the Activate button to initialize communication with the PhaseSpace hardware.

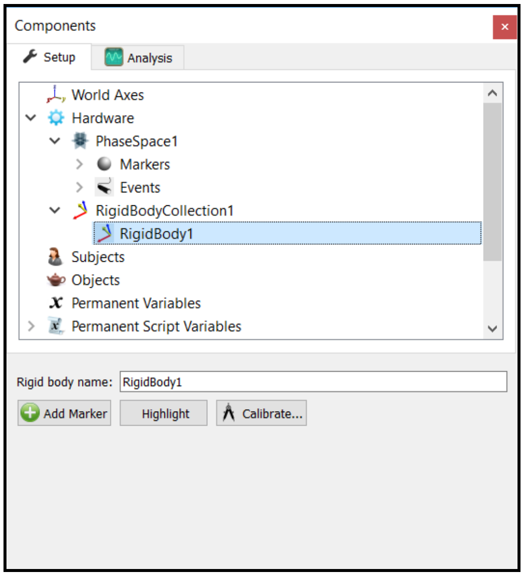
17. After successfully activating the PhaseSpace device, the marker list will be populated under the Markers header for the PhaseSpace component. Data repair (marker interpolation) and smoothing settings can be enabled or disabled here, pre or post data collection.

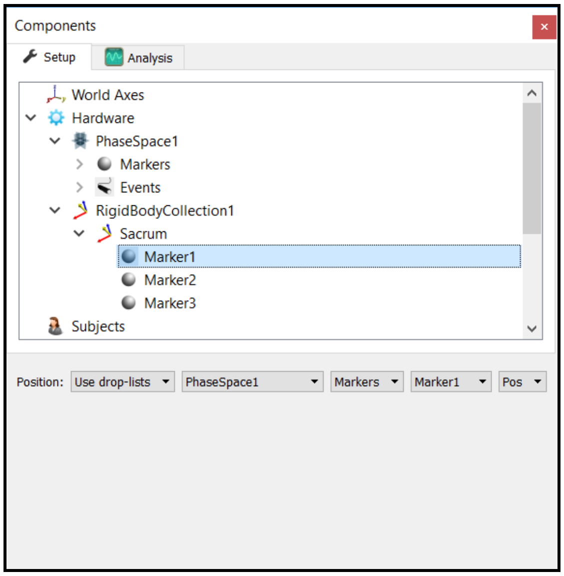


18. There will also be an Events header that is populated for the PhaseSpace component. Events refer to the Input (TTL) BNC or DB 9 connector, depending on your version of PhaseSpace hardware, on the PhasSpace Base Station/Server Hub, if your PhaseSpace system was configured with this option. Please see the Synchronizing PhaseSpace section at the end of this document for more information on using PhaseSpace Events.



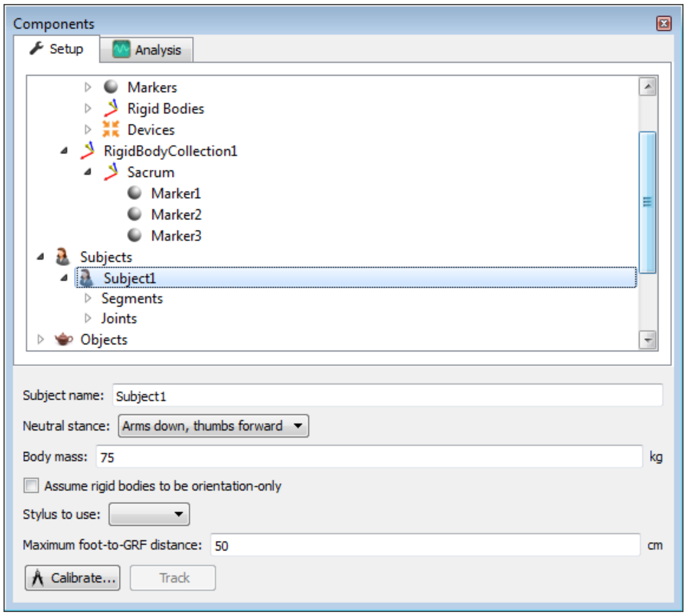
19. 6 DOF rigid bodies are defined through ***The MotionMonitor xGen*** as seen in the dialogs below. Rigid Body Collections can be added to the Setup Components dialog window as a Hardware device. Multiple Rigid Bodies can be added to a Rigid Body Collection, each of which can be defined using different combinations of marker assignments. Remember that 3 or more markers are required to create a Rigid Body. Markers can be selected for a rigid body either by selecting them through the drop-list menu or defining them using a formula. Do not include markers in the rigid body definitions which will be removed for dynamic recordings. An alternative method for selecting markers to be included in a Rigid Body is to hold the shift button on the keyboard and the left-click button on the mouse to drag and lasso markers in the animation window. Clicking on the Highlight button will highlight the selected Rigid Body markers in the Animation Window.





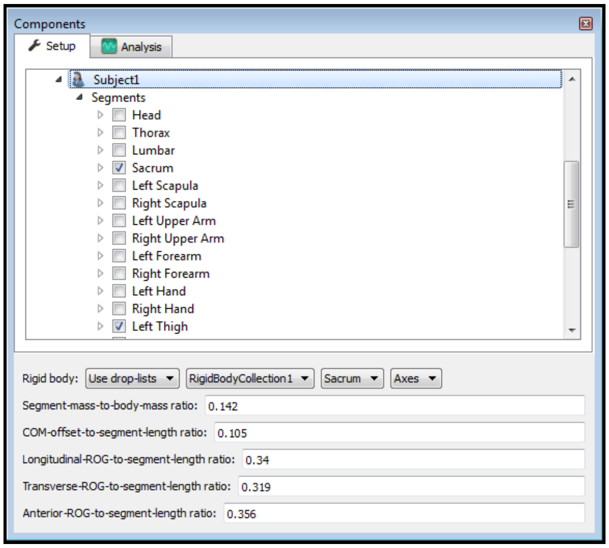
The Calibrate Rigid Bodies button takes a reading of the markers, computes centroids, creates sensor axes, establishes the relationship between markers and generally prepares the system to track the cluster of markers as 6 DOF data. Rigid Bodies can be calibrated one by one or all at the same time by going to the top level of the Rigid Bodies Collection and clicking the Calibrate All button. After this step, markers and their "sensor" axes can be viewed in Animation window or graphed and recorded as position and orientation data.

20. The next step is to define your biomechanical model within ***The MotionMonitor xGen***, which entails selecting which body segments you'll be tracking, assigning rigid bodies to track each body segment, defining segment endpoints or joint centers and generating customized segment axes, if desirable. To begin this process, right click on the Subjects header within the Components Setup tab and add a new subject.

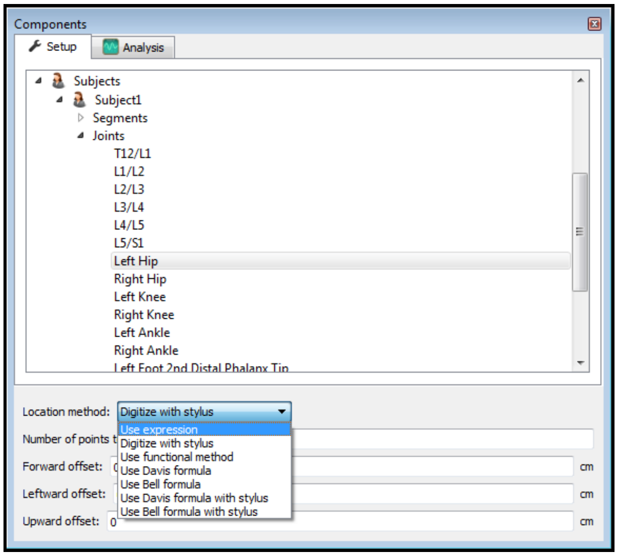


As seen above, a name can be assigned to the subject and basic anthropometric data can be entered. Confirmation for the orientation of the subject during the static reading and selection of a stylus to be used for digitizing, if required, are also selected here. The Calibrate button can be clicked after all of the required setup information has been entered.

21. The Segments header located under the Subject is where the desired segments to be tracked can be enabled as well as where the assignment for which rigid body will be used to track the segment is defined. Additional basic anthropometric information can be defined here for each segment as well.



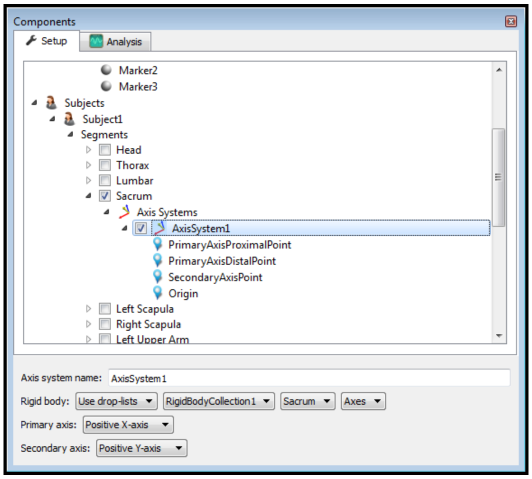
22. Each body segment which is enabled will require the definition of a proximal and distal endpoint or joint centers. The required joint centers will be automatically populated based on the selection of segments.



23. As seen above, each joint center can be defined using a digitizing method or expression based on marker positions. Alternatively, the hip and shoulder joints can be defined using linear regression algorithms or functional (rotational) methods.

24. Once these definitions are completed, the Subject Calibrate button can be clicked. A warning message will be displayed for any definitions have not been appropriately defined.

25. Additionally, if alternative or anatomically based local coordinate systems are desired, they can be defined by right clicking on a segment and selecting Add Axis System. First, the Rigid Body axes tracking the segment and general axes layout are selected. Then, points can be defined for the proximal and distal endpoints of the primary axis, a point along the secondary axis and a point for the Origin. The default local coordinate axes generated by ***The MotionMonitor xGen*** are defined as having a long axes through the joint centers and A/P and M/L axes being orthogonal to the long axes and parallel to the world when the subject was standing in the neutral position.



26. At this point, the ***The MotionMonitor xGen*** subject is fully defined and can be used for **biomechanical models, recording activities, performing computations and reducing data**. For more information on these aforementioned topics, visit https://themotionmonitor.com/support/ where you can review training and tutorial videos covering these topics and more.

27. By saving a Workspace file, File|Save Workspace As, in ***The MotionMonitor xGen***, all of the setup selections will be retained as a template and can easily be re-loaded using File|Load Workspace.

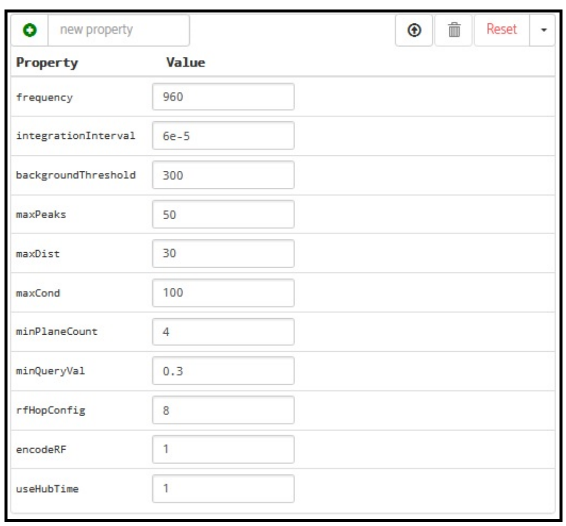
Synchronizing PhaseSpace…

The recommended method for actively synchronizing data with PhaseSpace motion tracking systems is to use a synchronizing pulse. This method ensures synchronicity while also providing a means for validating that data are synchronized.

Note: These instructions assume that the PhaseSpace Base Station/Server Hub is equipped with a BNC or DB 9 TTL Input port. Also, some PhaseSpace server hubs no longer require additional Configuration settings be implemented. Please contact your Client Support Engineer (support@TheMotionMonitor.com or 773-244-6470) to help determine if you need to implement steps 1-3 below or if they can be skipped for your hardware configuration.

1. Launch the PhaseSpace Configuration Manager. Refer to step 1, from above, for instructions on launching this application.

2. From the Settings icon, select the System Configuration menu. The useHubTime property should be defined as seen below. For more information on configuring and the use of PhaseSpace Events, contact your Client Support Engineer (support@TheMotionMonitor.com or 773-244-6470).



Note: The System Settings should only be edited upon the instruction of a Client Support Engineer. Any improper modifications could render the system inoperable.

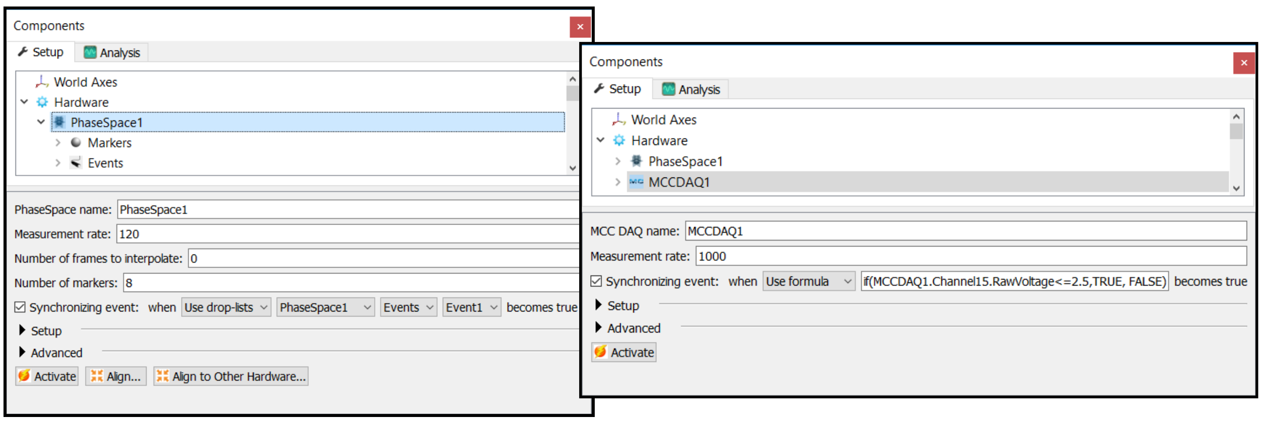
Configuring the Synchronizing Pulse

a. Use an RCA Y-cable to split the output signal from your event marker assembly, if provided with your ***The MotionMonitor xGen*** system. Otherwise, any common analog signal that splits to the different hardware devices in ***The MotionMonitor xGen*** can be used.

b. From the event marker assembly or other common analog signal, connect it to the Input (TTL) BNC connector or DB 9 connector, depending on your version of PhaseSpace hardware, on the PhaseSpace Base Station/Server Hub. A similar cable can also be used to connect to other peripheral devices, such as a Measurement Computing A/D device with BNC connectors.

c. In ***The MotionMonitor xGen***, ensure that all data sources are enabled.

d. Next, configure each hardware device receiving the synchronizing pulse. From the parameters panel for each hardware device enable the Synchronizing event and specify the condition to use for synchronization. For instance, a PhaseSpace Event variable could be selected from the drop-lists and the transition of this event becoming TRUE would be the synchronizing event. Other hardware devices may require the use of a formula. As an example, with Measurement Computing, the Synchronizing event could be defined as when the voltage for a specified channel crosses a threshold voltage. Under these conditions, the expression would become TRUE and this would be used as the Synchronizing event for this hardware's data stream.



e. In this case, the system is now configured to actively synchronize the collection of PhaseSpace and Measurement Computing analog data. In order to ensure that each activity is properly synchronized, the synchronizing pulse will need to occur within the recording buffer period that gets saved as an activity. ***The MotionMonitor xGen*** will then automatically locate and align the events in the specified data streams based on the settings entered above.