

# IORFoot Tutorial Angles

## Introduction

The IOR Foot analysis uses joint angles and planar angles to describe the motion of the foot.

\*\*\*\*

**The IOR Foot analysis has been described in the paper:**

\*\*\*\* Leardini, A., M.G. Benedetti, L. Berti, D. Bettinelli, R. Nativio, and S. Giannini. "Rear-foot, Mid-foot and Fore-foot Motion during the Stance Phase of Gait." *Gait & Posture* 25 (2007): 453-55 <sup>[1]</sup>

\*\*\*\* **Modifications to the IOR Foot Analysis are described in the paper:**

\*\*\*\* Portinaro, N., A. Leardini, A. Panou, V. Monzani, and P. Caravaggi. "Modifying the Rizzoli foot model to improve the diagnosis of pes-planus: application to kinematics of feet in teenagers." *Journal of Foot and Ankle Research* (2014) <sup>[2]</sup>

\*\*\*\* This tutorial describes the original analysis with all modifications from the 2014 paper.

\*\*\*\*

The 2007 paper is described

[[https://wiki.has-motion.com/doku.php?id=visual3d:tutorials:modeling:ior\\_foot\\_model#introduction](https://wiki.has-motion.com/doku.php?id=visual3d:tutorials:modeling:ior_foot_model#introduction)][here]].

## Downloads

Sample data for this tutorial can be downloaded [here](#).

The PPT images shown in this tutorial can be downloaded [here](#).

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## Modifications

Three modifications were made between the first<sup>[1]</sup> and second<sup>[2]</sup> papers. These modifications are outlined below.

### Mod 1: Hallux

Previously, varus & dorsiflexion at the first metatarso-phalangeal joint were represented by planar angles (F2Pt and F2Ps)<sup>[1]</sup>.

The 2014 paper creates a hallux segment and calculates the F2Pt and F2Ps angles as joint angles between the Hallux & Metatarsus segments<sup>[2]</sup>.

## Mod 2: Calcaneus

The original paper<sup>[1]</sup> only contained one target on the posterior calcaneus. The 2014 modifications<sup>[2]</sup> contain two targets on the posterior calcaneus.

The 2007 paper<sup>[1]</sup> described the CA target as the:

- CA - upper central ridge of the calcaneus posterior surface, i.e. Achilles' tendon attachment

The 2014 paper<sup>[2]</sup> described the HL target as the:

- HL - most distal point of attachment area of the Achilles tendon on the calcaneus

The CA<sup>[1]</sup> target will be referred to as the FCP (calcaneus proximal - the proximal attachment of the tendon) for the remainder of this tutorial.

The HL<sup>[2]</sup> target will be referred to as the FCD (calcaneus distal - FCC<sup>[3]</sup> [pg. 162]) for the remainder of this tutorial.

The FCP target will be used to indicate the origin of the calcaneus segment, and the orientation of the FCP/FCD targets will be used to indicate inversion/eversion of the calcaneus (Sha\_Cal\_Fro Angle). When placing these targets, make sure there is enough distance between them so that your camera system can recognize them as two separate targets.

The FCD target should be removed after the static trial.

## Mod 3: MLA Angle

Previously, the MLA angle was calculated using the CA target<sup>[1]</sup>.

The 2014 paper projects the FCP target onto the ground during the static trial (FCP\_proj), and tracks this projection using the calcaneus segment (FCP\_proj\_track)<sup>[2]</sup>.

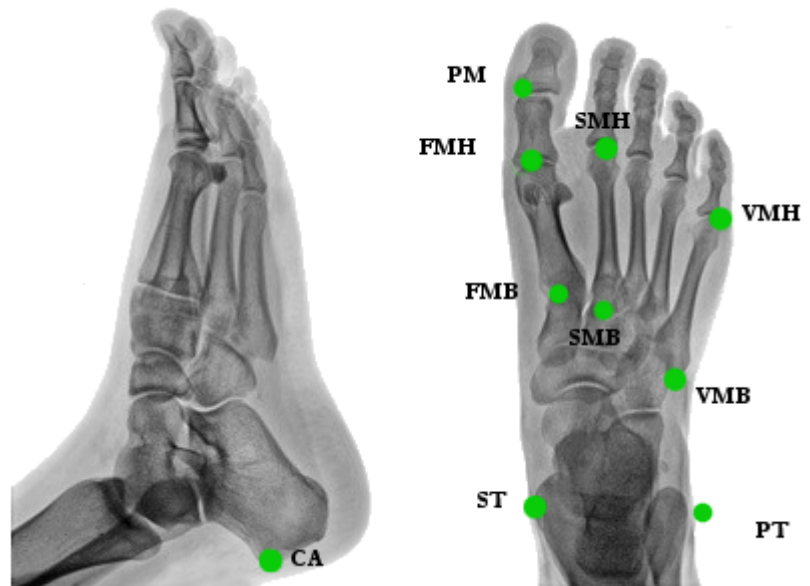
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## Target Placement

The following text contains a detailed explanation of how to palpate the necessary bony landmarks:

Serge van Sint Jan "Color Atlas of Skeletal Landmark Definitions: Guidelines for Reproducible Manual and Virtual Palpations" 2007 - Churchill Livingstone<sup>[3]</sup>

## Foot Targets



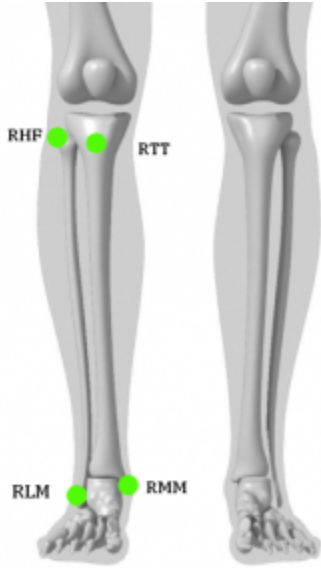
- **CA**<sup>[1]</sup> (**FCP**)<sup>[3]</sup> : p. 162 = Proximal posterior Surface of Calcaneus. \*
- **HL**<sup>[2]</sup> (**FCD**)<sup>[3]</sup> : p. 162 = Distal attachment of the Achilles' tendon. \*
- **ST**<sup>[1]</sup> (**FST**)<sup>[3]</sup> : p.164 = Sustentaculum Tali of Calcaneus.
- **PT**<sup>[1]</sup> (**FPT**)<sup>[3]</sup> : p.171 = Lateral apex of the peroneal tubercle.
- **TN**<sup>[1]</sup> (**FNT**)<sup>[3]</sup> : p.165 = Medial apex of the tuberosity navicular.
- **FMH**<sup>[1]</sup> (**FM1**)<sup>[3]</sup> : p.173 = Head of 1st Metatarsus.
- **SMH**<sup>[1]</sup> (**FM2**)<sup>[3]</sup> : p.173 = Head of 2nd Metatarsus.
- **VMH**<sup>[1]</sup> (**FM5**)<sup>[3]</sup> : p.173 = Head of 5th Metatarsus.
- **VMB**<sup>[1]</sup> (**FMT**)<sup>[3]</sup> : p.172 = Tuberosity of 5th Metatarsal
- **PM**<sup>[1]</sup> (**PD6**)<sup>[3]</sup> : p.175 = Proximal Distal Phalanx. \*\*
- **FMB**<sup>[1]</sup> = Base of First Metatarsal. \*\*\*
- **SMB**<sup>[1]</sup> = Base of Second Metatarsal. \*\*\*

\* Serge Van Sint Jan describes palpation for the FCC landmark (which should be the FCD), and the FCP landmark should be placed proximal to this landmark.

\*\* Serge Van Sint Jan describes palpation for the mediolateral borders of this landmark (PM6/PL6), the target should be placed at the midpoint.

\*\*\* There is no reference for this landmark in Serge Van Sint Jan text, please see the IOR Foot paper for further clarification

## Shank Targets

|                                                                                                                                                                                                                                                                                                                                                              |                                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| <p><b>HF<sup>[1]</sup> (FAX)<sup>[3]</sup></b> : p.154 = Apex of the styloid process</p> <p><b>TT<sup>[1]</sup> (TTC)<sup>[3]</sup></b> : p.144 = Tibial tuberosity</p> <p><b>LM<sup>[1]</sup> (FAL)<sup>[3]</sup></b> : p.158 = Apex of the Lateral malleolus</p> <p><b>MM<sup>[1]</sup> (TAM)<sup>[3]</sup></b> : p.148 = Apex of the Medial malleolus</p> |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|

## Segment Definition

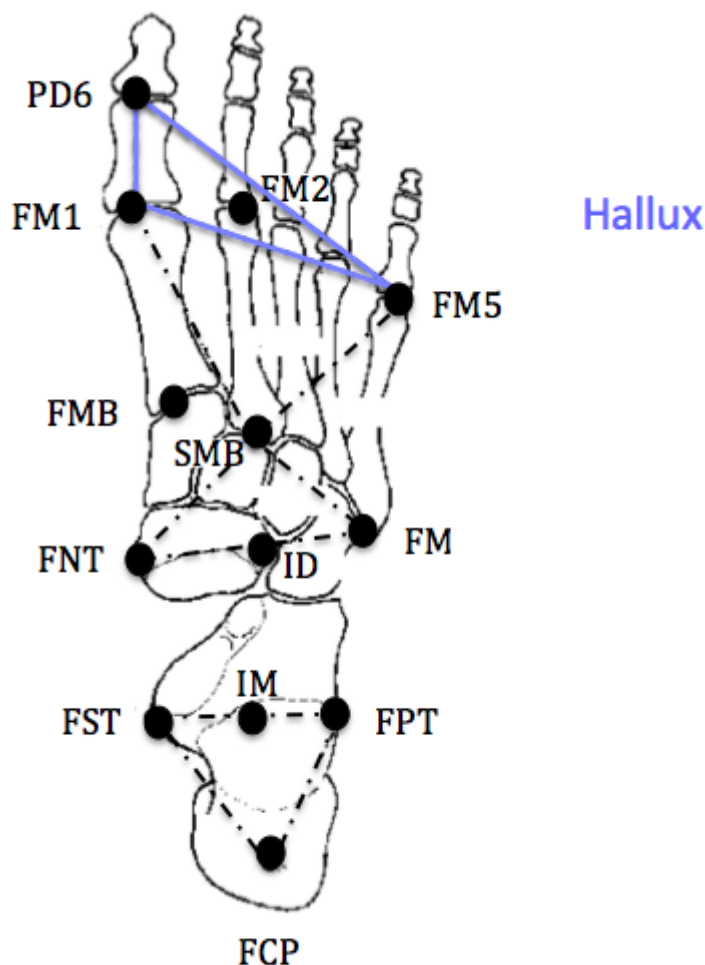
### Hallux (Hal)

## Segment Definition:

The FMH target is defined as the origin of Hal segment. The A/P (X) axis is defined from the FMH to PM target. The sagittal axis (Z axis) is along the plane defined by the FMH, FM, and VMH targets.

The Hal segment is a modification<sup>[2]</sup> to the original analysis<sup>[1]</sup>

Joint Angles:



- F2Pt<sup>[1]</sup> / Y component of the Met-Hal Angle<sup>[2]</sup>
- F2Ps<sup>[1]</sup> / Z component of the Met-Hal Angle<sup>[2]</sup>

Planar Angles:

- No planar angles

## Hallux Landmarks:

### 1. Create RHal\_Vert:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark: **Landmark Name:** RHal\_Vert
  1. **Define Orientation Using:**
    - **Starting Point:** RFMH
    - **Ending Point:** RPM
    - **Lateral Object:** RVMH
  2. Offset Using the Following **ML/AP/AXIAL** Offsets:
    - **ML:** 0.0 **AP:** DISTANCE(RFMH,RPM) **Axial:** 0.0
  3. **Do NOT Check:** Offset by Percent (1.0 = 100%)

#### 4. **Do NOT Check:** Calibration Only Landmark

### Hallux Definition

#### 1. Create RHal Segment:

1. In the **Segments** tab, select *RHal* in the Segment Name box.
2. Select **Kinematic Only**
3. Click on the **Create Segment** button.
4. In the **RHal** tab, enter these values:
  1. **Define Proximal Joint and Radius:**
    - **Lateral:** *None*
    - **Joint:** *RFMH*
    - **Medial:** *None*
    - **Radius:** *0.1*
  2. **Define Distal Joint and Radius:**
    - **Lateral:** *None*
    - **Joint:** *RPM*
    - **Medial:** *None*
    - **Radius:** *0.1*
  3. **Extra Target to Define Orientation:**
    - **Location:** *Lateral RHal\_Vert*
  4. **Select Tracking Targets:**  
*RHal\_Vert, RFMH, RPM*
5. Click on **Build Model**.
6. Click on **Close Tab** before proceeding.

#### 2. Modify the **Segment Coordinate System**:

1. Define the Segment Orientation as:
  - **A/P Axis:** *-Z*
  - **Distal to Proximal:** *-X*

The image to the right (and all other images in this tutorial) show a mediolateral view of the segment coordinate system after it has been modified.

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## Metatarsus (Met)

### Segment Definition:

The FM2 landmark is projected onto the plane defined by the FM1, FM5, and SMB landmarks. The line from the SMB to FM2 projection are used to define the X axis (A/P) axis of the Met segment. The sagittal axis (Z axis) is along the plane defined by the FM1, FM5, and SMB targets.

The FMB target is not used to define the segment, but it will be used to track the segment (in addition to the other targets).

Joint Angles:

The screenshot shows a software window with tabs: Workspace, Signals and Events, Models, Reports, and CalT. The 'Landmarks' tab is active. Within it, there are sub-tabs: Segments, Landmarks, Muscles, and Subject Data / Metrics. The 'Landmarks' sub-tab is selected, and within it, 'Functional', 'Digitizing', and 'RMET\_DIST' are visible. The 'RMET\_DIST' sub-tab is active.

The 'Landmark Name' field is set to 'RMET\_DIST'.

Under 'Define Orientation Using:', there are several options:

- ☐ Existing Segment (dropdown menu)
- ☒ Targets and/or Landmarks:
  - Starting Point: RFMH (Reference)
  - Ending Point: RVMH (On a line)
  - \*Lateral object: RSMB (On a plane)
  - \*Project From: RSMH (Projection onto a line or plane)
  - \* = Optional

Under 'Landmark Offset from Start Point (Reference) or Segment Origin:', there are two options:

- ☐ Offset to Existing Calibration Target or Landmark (dropdown menu)
- ☒ Offset Using the Following ML/AP/AXIAL Offsets:
  - ML: [text input field]
  - AP: [text input field]
  - AXIAL: [text input field]
  - ☐ Offset by Percent (1.0 = 100%) (Meters when not checked)

At the bottom, there is a checkbox for 'Calibration Only Landmark: (Not generated for assigned motion file(s))' which is checked.

Buttons at the bottom: Undo Changes, Apply, Build Model, Close Tab.

- Mid-Met Angle
- Cal\_Met Angle
- F2Pt<sup>[1]</sup>/ Y component of the Met-Hal Angle<sup>[2]</sup>
- F2Ps<sup>[1]</sup>/ Z component of the Met-Hal Angle<sup>[2]</sup>

Planar Angles:

- S2F is projected onto the plane of the Met segment
- S2FV is projected onto the plane of the Met segment

## Metatarsus Landmarks:

### 1. Create RMET\_DIST:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark: **Landmark Name:** RMET\_DIST
  1. **Define Orientation Using:**
    - **Starting Point:** RFMH
    - **Ending Point:** RVMH
    - **Lateral Object:** RSMB

- **Project From:** RSMH
- 2. **Do NOT Check:** Offset by Percent (1.0 = 100%)
- 3. **Check:** Calibration Only Landmark

## Metatarsus Definition

### 1. Create RMet Segment:

The screenshot shows the 'RMet' tab in the software interface. The 'Define Proximal Joint and Radius' section has 'Lateral' set to 'None', 'Joint Center' set to 'RSMB', and 'Medial' set to 'None'. The 'Radius (Meters)' is set to '0.1'. The 'Define Distal Joint and Radius' section has 'Lateral' set to 'None', 'Joint Center' set to 'RMET\_DIST', and 'Medial' set to 'None'. The 'Radius (Meters)' is set to '0.1'. The 'Extra Target to Define Orientation (if needed)' section has 'Location' set to 'Medial' and 'RFMH' selected. The 'Select Tracking Targets (Ctrl-Left Mouse Click to Multiselect)' section has a checkbox for 'Use Calibration Targets for Tracking' which is unchecked. Below this, there is a grid of checkboxes for various targets: RF2P\_Offset, LAB\_O, LAB\_X, LAB\_Y, RFMH\_proj, RFMB\_proj, RSMH\_proj, RSMB\_proj, RVMH\_proj, RVMB\_proj, LCA, LFMB, LFMH, LHF, LLM, LMM, LPM, LPT, LSMB, and LSMH. At the bottom, there is a 'Depth (Meters):' field and buttons for 'Close Tab', 'Guess Properties', 'Apply', and 'Build Model'.

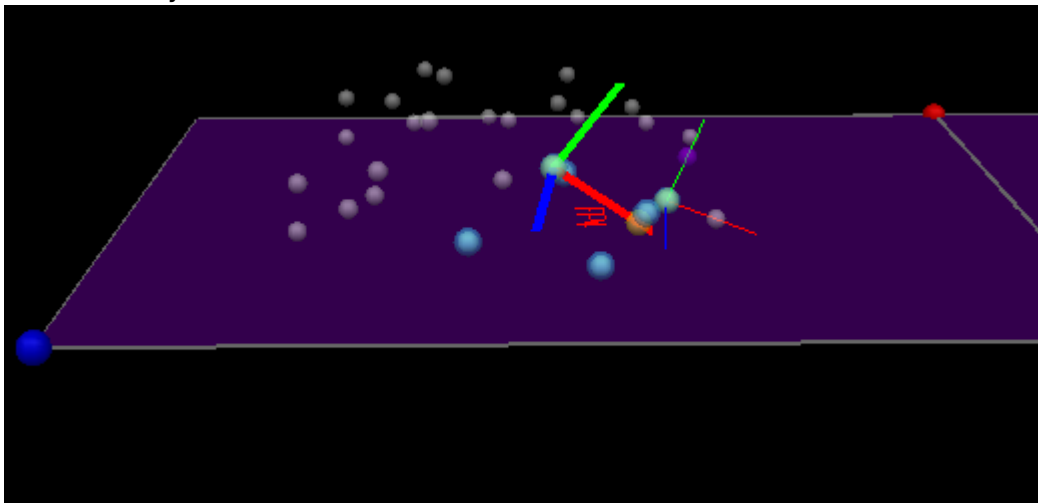
1. In the **Segments** tab, select *RMet* in the Segment Name box.
2. Select **Kinematic Only**
3. Click on the **Create Segment** button.
4. In the **RMet** tab, enter these values:
  1. **Define Proximal Joint and Radius:**
    - **Lateral:** *None*
    - **Joint:** *RMSB*
    - **Medial:** *None*
    - **Radius:** *0.1*
  2. **Define Distal Joint and Radius:**
    - **Lateral:** *None*
    - **Joint:** *RMET\_DIST*

- **Medial:** *None*
- **Radius:** *0.1*
- 3. **Extra Target to Define Orientation:**
  - **Location:** *Medial RFMH*
- 4. **Select Tracking Targets:**  
*RFMB, RFMH, RSMB, RSMH, RVMH*
- 5. Click on **Build Model**.
- 6. Click on **Close Tab** before proceeding.

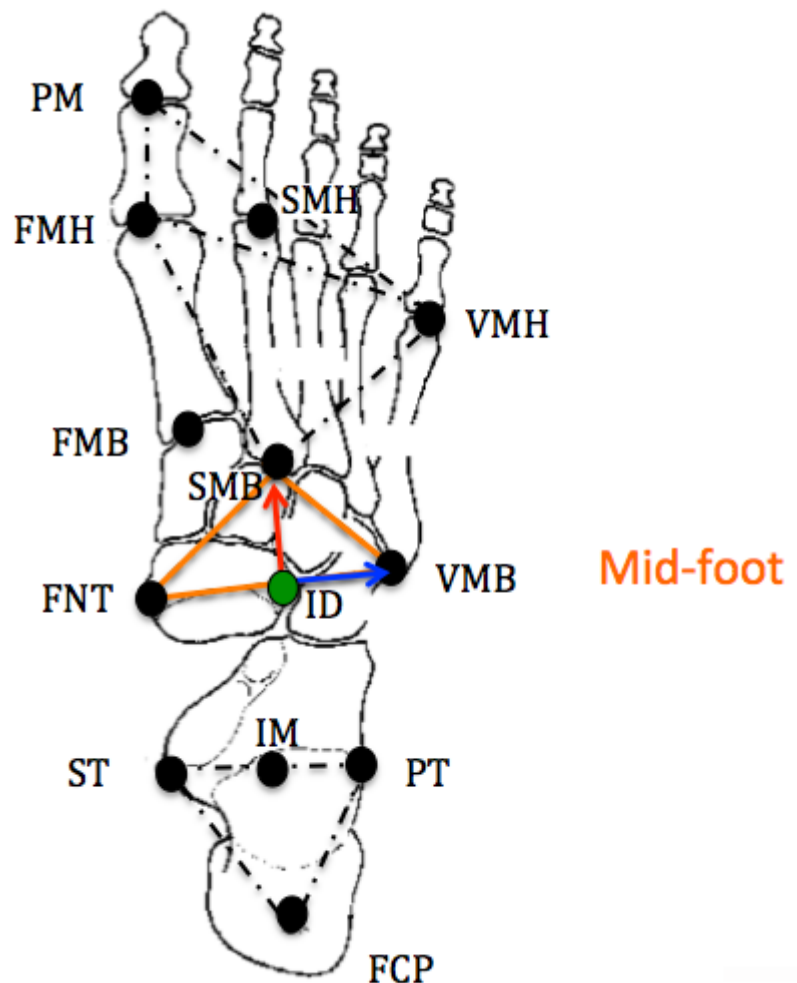
## 2. Modify the **Segment Coordinate System**:

1. Define the Segment Orientation as:
  - **A/P Axis:** +Y
  - **Distal to Proximal:** -X

The image below (and all other images in this tutorial) show a mediolateral view of the segment coordinate system after it has been modified.



## Mid-foot (Mid)



### Segment Definition:

The midpoint between the TN and VMB targets is used to define the origin of the Mid segment. The A/P (X) axis is defined along the line from this midpoint to the SMB target. The sagittal (Z) axis is along the plane defined by the ID, TN and SMB targets.

Joint Angles:

- Cal-Mid Angle
- Mid-Met Angle

Planar Angles:

- Not used for planar angles.

### Mid-foot Landmarks:

#### 1. Create RID:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark: **Landmark Name:** RID

1. **Define Orientation Using:**
  - **Starting Point:** RTN
  - **Ending Point:** RVMB
2. Offset Using the Following **ML/AP/AXIAL** Offsets:
  - **Axial:** 0.5
3. **Check:** Offset by Percent (1.0 = 100%)
4. **Check:** Calibration Only Landmark

Workspace | Signals and Events | Models | Reports | Cal

Segments | Landmarks | Muscles | Subject Data / Metrics

Landmarks | Functional | Digitizing | RID

Landmark Name: RID

Define Orientation Using:

Starting Point: RTN (Reference)

Targets and/or Landmarks: Ending Point: RVMB (On a line)

\*Lateral object: (On a plane)

\*Project From: (Projection onto a line or plane)

\* = Optional

Existing Segment:

Landmark Offset from Start Point (Reference) or Segment Origin

Offset to Existing Calibration Target or Landmark:

Offset Using the Following ML/AP/AXIAL Offsets

ML:

AP:

AXIAL: 0.5

☒ Offset by Percent (1.0 = 100%) (Meters when not checked)

☒ Calibration Only Landmark (Not generated for assigned motion file(s))

Undo Changes | Apply | Build Model | Close Tab

## Mid-Foot Definition

### 1. Create RMid Segment:

1. In the **Segments** tab, select *RMid* in the Segment Name box.
2. Select **Kinematic Only**
3. Click on the **Create Segment** button.
4. In the **RMet** tab, enter these values:
  1. **Define Proximal Joint and Radius:**
    - **Lateral:** None
    - **Joint:** RID
    - **Medial:** None
    - **Radius:** 0.1

## 2. Define Distal Joint and Radius:

- **Lateral:** *None*
- **Joint:** *RMSB*
- **Medial:** *None*
- **Radius:** *0.1*

## 3. Extra Target to Define Orientation:

- **Location:** *Medial RTN*

## 4. Select Tracking Targets:

*RSMB, RTN, RVMB*

5. Click on **Build Model**.

6. Click on **Close Tab** before proceeding.

Workspace | Signals and Events | Models | Reports | Cal

Segments | Landmarks | Muscles | Subject Data / Metrics

Segments | Segment Properties | IK Constraints | RMid

Define Proximal Joint and Radius

Lateral: None | Joint Center: RID | Medial: None

Radius (Meters): 0.1

Define Distal Joint and Radius

Lateral: None | Joint Center: RSMB | Medial: None

Radius (Meters): 0.1

Extra Target to Define Orientation (if needed)

Location: Medial | RTN

Select Tracking Targets (Ctrl-Left Mouse Click to Multiselect)

☐ Use Calibration Targets for Tracking

|                                      |                                    |                               |                               |
|--------------------------------------|------------------------------------|-------------------------------|-------------------------------|
| <input type="checkbox"/> RF2P_Offset | <input type="checkbox"/> RFMB_proj | <input type="checkbox"/> LCA  | <input type="checkbox"/> LMM  |
| <input type="checkbox"/> LAB_O       | <input type="checkbox"/> RSMH_proj | <input type="checkbox"/> LFMB | <input type="checkbox"/> LPM  |
| <input type="checkbox"/> LAB_X       | <input type="checkbox"/> RSMB_proj | <input type="checkbox"/> LFMH | <input type="checkbox"/> LPT  |
| <input type="checkbox"/> LAB_Y       | <input type="checkbox"/> RVMH_proj | <input type="checkbox"/> LHF  | <input type="checkbox"/> LSMB |
| <input type="checkbox"/> RFMH_proj   | <input type="checkbox"/> RVMB_proj | <input type="checkbox"/> LLM  | <input type="checkbox"/> LSMH |

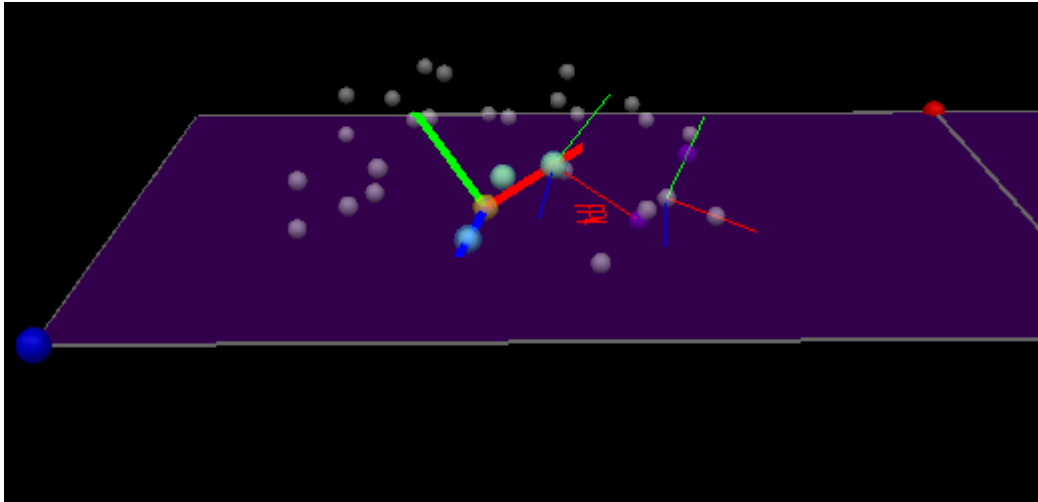
Depth (Meters):

Close Tab | Guess Properties | Apply | Build Model

## 2. Modify the Segment Coordinate System:

1. Define the Segment Orientation as:

- **A/P Axis:** +Y
- **Distal to Proximal:** -X

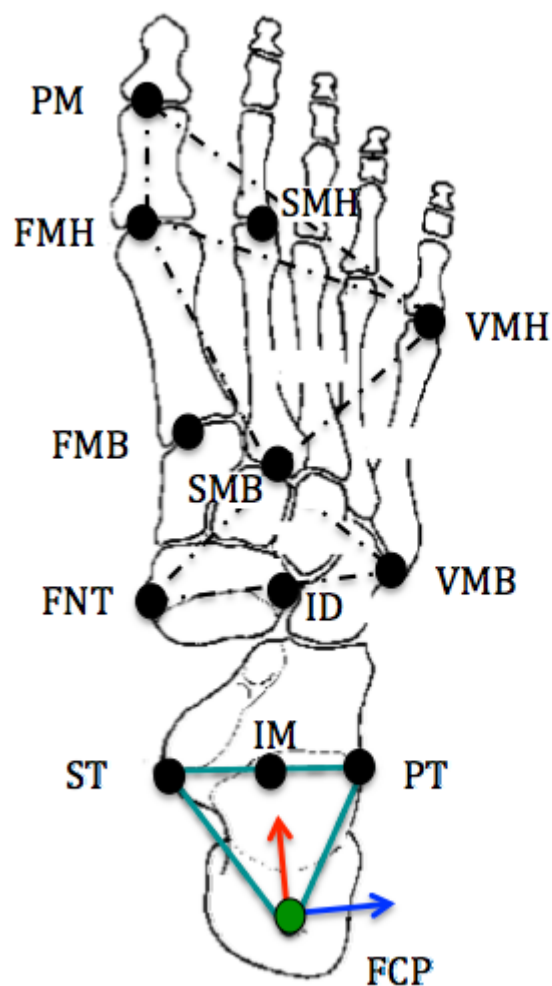


## Calcaneus (Cal)

### Segment Definition:

The origin is at the FCP target. The A/P (X) axis is along the line from the FCP to midpoint of the ST and PT targets (IC landmark). The sagittal (Z) axis is along the plane defined by the FCP, ST and TN targets.

Joint Angles:



- Sha-Cal Angle
- Cal-Mid Angle Z rotation & Y Rotation\*

- Cal-Met Angle

\* The 2014 paper<sup>[2]</sup> modified the definition of inversion/eversion for the calcaneus segment relative to the shank segment. This is now calculated as the Sha\_Cal\_Fro angle which is a four point planar angle.

Planar Angles:

- Not used for planar angles.

## Calcaneus Landmarks:

### 1. Create RIC:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark:
  1. **Landmark Name:** RIC
  2. **Define Orientation Using:**
    - **Starting Point:** RST
    - **Ending Point:** RPT
  3. Offset Using the Following **ML/AP/AXIAL** Offsets:
    - **Axial:** 0.5
  4. **Check:** Offset by Percent (1.0 = 100%)
  5. **Check:** Calibration Only Landmark

Workspace | Signals and Events | Models | Reports | Cal

Segments | Landmarks | Muscles | Subject Data / Metrics

Landmarks | Functional | Digitizing | RIC

Landmark Name: RIC

Define Orientation Using:

Starting Point: RST (Reference)

Ending Point: RPT (On a line)

\*Lateral object: (On a plane)

\*Project From: (Projection onto a line or plane)

\* = Optional

Existing Segment:

Landmark Offset from Start Point (Reference) or Segment Origin

Offset to Existing Calibration Target or Landmark:

Offset Using the Following ML/AP/AXIAL Offsets

ML:

AP:

AXIAL: 0.5

☒ Offset by Percent (1.0 = 100%) (Meters when not checked)

☒ Calibration Only Landmark (Not generated for assigned motion file(s))

Undo Changes | Apply | Build Model | Close Tab

## Calcaneus Definition

### 1. Create RMid Segment:

1. In the **Segments** tab, select *RCal* in the Segment Name box.
2. Select **Kinematic Only**
3. Click on the **Create Segment** button.
4. In the **RCal** tab, enter these values:
  1. **Define Proximal Joint and Radius:**
    - **Lateral:** *None*
    - **Joint:** *RFCP*
    - **Medial:** *None*
    - **Radius:** *0.1*
  2. **Define Distal Joint and Radius:**
    - **Lateral:** *None*
    - **Joint:** *RIC*
    - **Medial:** *None*
    - **Radius:** *0.1*
  3. **Extra Target to Define Orientation:**
    - **Location:** *Medial RST*
  4. **Select Tracking Targets:**

*RFCP, RPT, RST*

5. Click on **Build Model**.
6. Click on **Close Tab** before proceeding.

Segments | Landmarks | Muscles | Subject Data / Metrics

Segments | Segment Properties | IK Constraints | RCal

Define Proximal Joint and Radius

Lateral: None | Joint Center: RFCP | Medial: None

Radius (Meters): 0.1

Define Distal Joint and Radius

Lateral: None | Joint Center: RIC | Medial: None

Radius (Meters): 0.1

Extra Target to Define Orientation (if needed)

Location: Medial | Target: RST

Select Tracking Targets (Ctrl-Left Mouse Click to Multiselect)

☐ Use Calibration Targets for Tracking

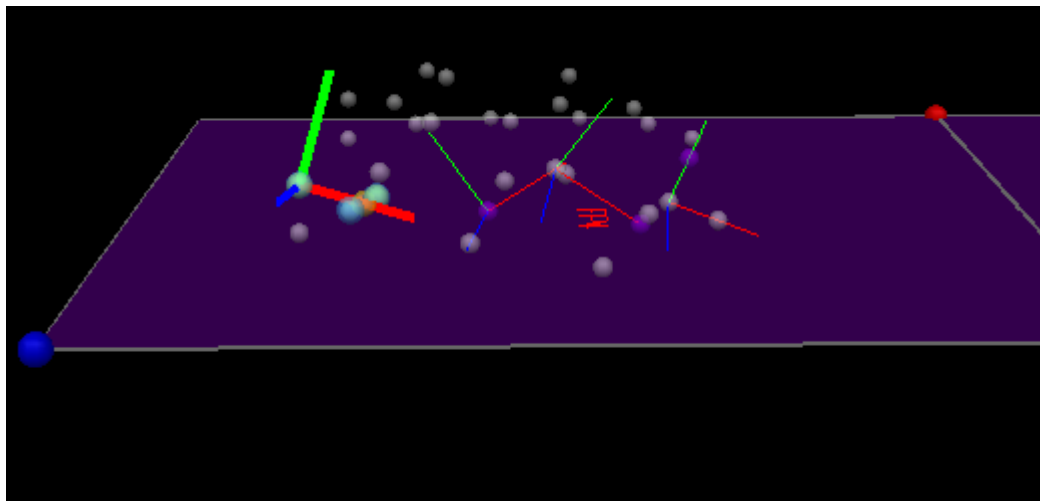
|                                    |                                    |                                          |
|------------------------------------|------------------------------------|------------------------------------------|
| <input type="checkbox"/> RHal_Vert | <input type="checkbox"/> RFMB_proj | <input type="checkbox"/> RFCP_proj_track |
| <input type="checkbox"/> LAB_O     | <input type="checkbox"/> RSMH_proj | <input type="checkbox"/> RSK_PROX_track  |
| <input type="checkbox"/> LAB_X     | <input type="checkbox"/> RSMB_proj | <input type="checkbox"/> RSK_DIST_track  |
| <input type="checkbox"/> LAB_Y     | <input type="checkbox"/> RVMH_proj | <input type="checkbox"/> RFCD_track      |
| <input type="checkbox"/> RFMH_proj | <input type="checkbox"/> RVMB_proj | <input type="checkbox"/> RFCD_TEST       |

Depth (Meters):

Close Tab | Guess Properties | Apply | Build Model

## 2. Modify the **Segment Coordinate System**:

1. Define the Segment Orientation as:
  - **A/P Axis:** +Y
  - **Distal to Proximal:** -X

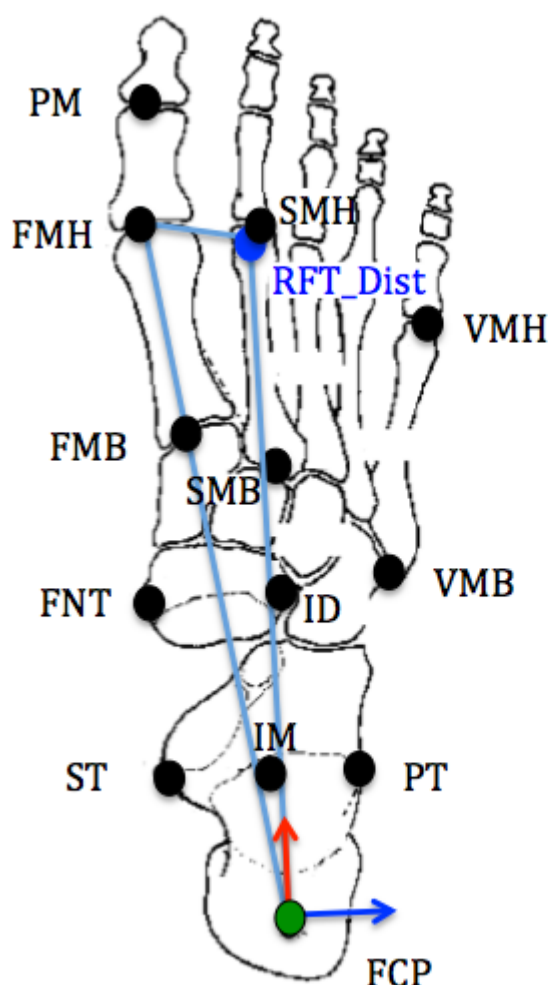


## Virtual Foot (Foo)

### Segment Definition:

The origin is at the FCP target. The A/P (X) axis is along the line from the FCP to RFT\_DIST landmark. The sagittal (Z) axis is along the plane defined by the FCP, FMH and VMH targets.

This foot segment should be set to "kinematic only" since the origin is not at the point of rotation (the mid point of the RIMM & RLM targets). The IORFoot analysis does not calculate kinetics, so no kinetic foot segment is described in this model. To create gait events, you will need a kinetic foot segment. An example of a kinetic foot segment is created in the sample download files for this tutorial.



## Foot Landmarks:

### 1. Create RFT\_DIST:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark:
  1. **Landmark Name:** RFT\_DIST
  2. **Define Orientation Using:**
    - **Starting Point:** RCA
    - **Ending Point:** RFMH
    - **Lateral Object:** RVMH
    - **Project From:** RSMH
  3. **Do Not Check:** Offset by Percent (1.0 = 100%)
  4. **Check:** Calibration Only Landmark

Segments | Landmarks | Muscles | Subject Data / Metrics

Landmarks | Functional | Digitizing | RFT\_DIST

Landmark Name:

Define Orientation Using:

Starting Point  (Reference)

☒ Targets and/or Landmarks: Ending Point  (On a line)

\*Lateral object  (On a plane)

\*Project From  (Projection onto a line or plane)

\* = Optional

☐ Existing Segment

Landmark Offset from Start Point (Reference) or Segment Origin

☐ Offset to Existing Calibration Target or Landmark

☒ Offset Using the Following ML/AP/AXIAL Offsets

ML

AP

AXIAL

☐ Offset by Percent (1.0 = 100%) (Meters when not checked)

☒ Calibration Only Landmark (Not generated for assigned motion file(s))

Undo Changes Apply Build Model Close Tab

## Foot Definition

### 1. Create Right Virtual Foot Segment:

1. In the **Segments** tab, select *Right Virtual Foot* in the Segment Name box.

2. Select **Kinematic Only**
3. Click on the **Create Segment** button.
4. In the **Right Virtual Foot** tab, enter these values:
  1. **Define Proximal Joint and Radius:**
    - **Lateral:** *None*
    - **Joint:** *RFCP*
    - **Medial:** *None*
    - **Radius:**  $0.5 * \text{DISTANCE}(\text{RST}, \text{RPT})$
  2. **Define Distal Joint and Radius:**
    - **Lateral:** *None*
    - **Joint:** *RFT\_DIST*
    - **Medial:** *None*
    - **Radius:**  $0.5 * \text{DISTANCE}(\text{RFMH}, \text{RVMH})$
  3. **Extra Target to Define Orientation:**
    - **Location:** *Medial RFMH*
  4. **Select Tracking Targets:**  
*RFCP, RFMH, RVMH*
5. Click on **Build Model**.
6. Click on **Close Tab** before proceeding.

Segments | Landmarks | Muscles | Subject Data / Metrics

Segments | Segment Properties | IK Constraints | Right Virtual Foot

Define Proximal Joint and Radius

Lateral: None | Joint Center: RFCP | Medial: None

Radius (Meters):  $0.5 * \text{DISTANCE}(\text{RST}, \text{RPT})$

Define Distal Joint and Radius

Lateral: None | Joint Center: RFT\_DIST | Medial: None

Radius (Meters):  $0.5 * \text{DISTANCE}(\text{RFMH}, \text{RVMH})$

Extra Target to Define Orientation (if needed)

Location: Medial | Target: RFMH

Select Tracking Targets (Ctrl-Left Mouse Click to Multiselect)

☐ Use Calibration Targets for Tracking

|                                   |                              |                               |                                          |
|-----------------------------------|------------------------------|-------------------------------|------------------------------------------|
| <input type="checkbox"/> RHa_Vert | <input type="checkbox"/> LHF | <input type="checkbox"/> LSMB | <input type="checkbox"/> LVMB            |
| <input type="checkbox"/> LFCD     | <input type="checkbox"/> LLM | <input type="checkbox"/> LSMH | <input type="checkbox"/> LVMH            |
| <input type="checkbox"/> LFCP     | <input type="checkbox"/> LMM | <input type="checkbox"/> LST  | <input type="checkbox"/> RFCD            |
| <input type="checkbox"/> LFMB     | <input type="checkbox"/> LPM | <input type="checkbox"/> LTN  | <input checked="" type="checkbox"/> RFCP |
| <input type="checkbox"/> LFMH     | <input type="checkbox"/> LPT | <input type="checkbox"/> LTT  | <input type="checkbox"/> RFMB            |

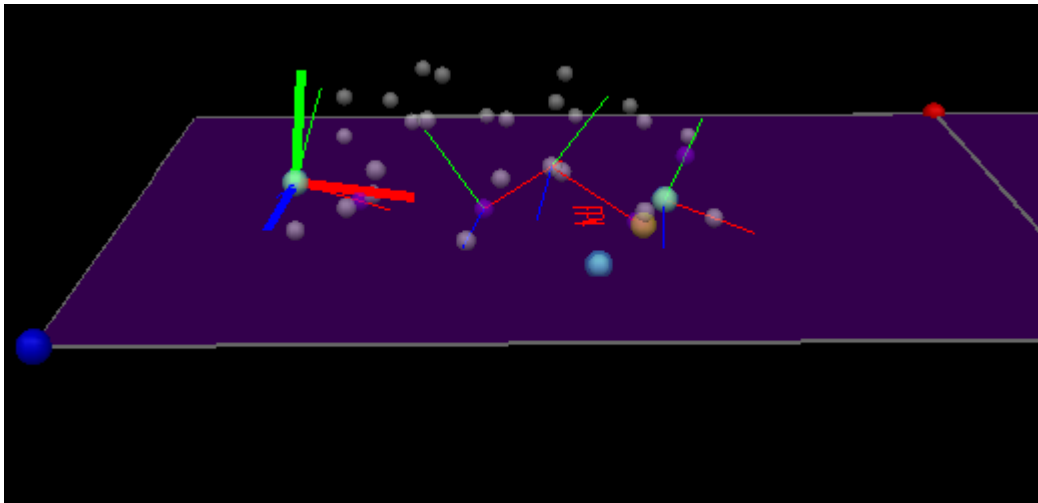
Depth (Meters):

Close Tab | Guess Properties | Apply | Build Model

## 2. Modify the **Segment Coordinate System**:

1. Define the Segment Orientation as:

- **A/P Axis:** +Y
- **Distal to Proximal:** -X



---

## Shank (Sha)

### Shank Landmarks:

1. Create RIM:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark:
  1. **Landmark Name:** RIM
  2. **Define Orientation Using:**
    - **Starting Point:** RLM
    - **Ending Point:** RMM
  3. **Check:** Offset by Percent (1.0 = 100%)
  4. **Check:** Calibration Only Landmark

Workspace | Signals and Events | Models | Reports | Cal

Segments | Landmarks | Muscles | Subject Data / Metrics

Landmarks | Functional | Digitizing | RIM

Landmark Name: RIM

Define Orientation Using:

Starting Point: RLM (Reference)

Ending Point: RMM (On a line)

\*Lateral object: (On a plane)

\*Project From: (Projection onto a line or plane)

\* = Optional

Existing Segment:

Landmark Offset from Start Point (Reference) or Segment Origin

Offset to Existing Calibration Target or Landmark:

Offset Using the Following ML/AP/AXIAL Offsets

ML:

AP:

AXIAL: 0.5

☒ Offset by Percent (1.0 = 100%) (Meters when not checked)

☒ Calibration Only Landmark (Not generated for assigned motion file(s))

Undo Changes | Apply | Build Model | Close Tab

## 2. Create RSK\_PROX:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark:
  1. **Landmark Name:** RSK\_PROX
  2. **Define Orientation Using:**
    - **Starting Point:** RIM
    - **Ending Point:** RLM
    - **Lateral Object:** RHF
    - **Project From:** RTT
  3. **Do Not Check:** Offset by Percent (1.0 = 100%)
  4. **Check:** Calibration Only Landmark

The screenshot shows a software window with tabs: Workspace, Signals and Events, Models, Reports, and Cal. The 'Models' tab is active, showing sub-tabs: Segments, Landmarks, Muscles, and Subject Data / Metrics. The 'Landmarks' sub-tab is selected, and within it, 'Functional', 'Digitizing', and 'RSK\_PROX' are visible. The 'RSK\_PROX' dialog box is open, showing the following fields and options:

- Landmark Name:** RSK\_PROX
- Define Orientation Using:**
  - Starting Point: RIM (Reference)
  - Ending Point: RLM (On a line)
  - \*Lateral object: RHF (On a plane)
  - \*Project From: RTT (Projection onto a line or plane)
  - \* = Optional
  - Existing Segment: (empty)
- Landmark Offset from Start Point (Reference) or Segment Origin:**
  - Offset to Existing Calibration Target or Landmark: (empty)
  - Offset Using the Following ML/AP/AXIAL Offsets:
    - ML: (empty)
    - AP: (empty)
    - AXIAL: (empty)
  - Offset by Percent (1.0 = 100%) (Meters when not checked): ☐
- ☒ Calibration Only Landmark (Not generated for assigned motion file(s))
- Buttons: Undo Changes, Apply, Build Model, Close Tab

## Shank Definition

### 1. Create Right Virtual Foot Segment:

1. In the **Segments** tab, select *Right Shank* in the Segment Name box.
2. Select **Kinematic Only**
3. Click on the **Create Segment** button.
4. In the **Right Shank** tab, enter these values:
  1. **Define Proximal Joint and Radius:**
    - **Lateral:** *None*
    - **Joint:** *RSK\_PROX*
    - **Medial:** *None*
    - **Radius:** *DISTANCE(RSK\_PROX,RHF)*
  2. **Define Distal Joint and Radius:**
    - **Lateral:** *None*
    - **Joint:** *RIM*
    - **Medial:** *None*
    - **Radius:** *0.5\*DISTANCE(RLM,RMM)*
  3. **Extra Target to Define Orientation:**
    - **Location:** *Lateral RLM*
  4. **Select Tracking Targets:**

*RHF, RLM, RMM, RTT*

5. Click on **Build Model**.
6. Click on **Close Tab** before proceeding.

The screenshot shows the 'Right Shank' configuration window in the IORFoot 2014 software. The window has tabs for 'Segments', 'Landmarks', 'Muscles', and 'Subject Data / Metrics'. The 'Segments' tab is active, showing 'Segment Properties' and 'IK Constraints' for the 'Right Shank'.

**Define Proximal Joint and Radius**

Lateral: None | Joint Center: RSK\_PROX | Medial: None

Radius (Meters):  $\text{DISTANCE(RSK\_PROX, RHF)}$

**Define Distal Joint and Radius**

Lateral: None | Joint Center: RIM | Medial: None

Radius (Meters):  $0.5 * \text{DISTANCE(RLM, RMM)}$

**Extra Target to Define Orientation (if needed)**

Location: Lateral | RLM

**Select Tracking Targets (Ctrl-Left Mouse Click to Multiselect)**

☐ Use Calibration Targets for Tracking

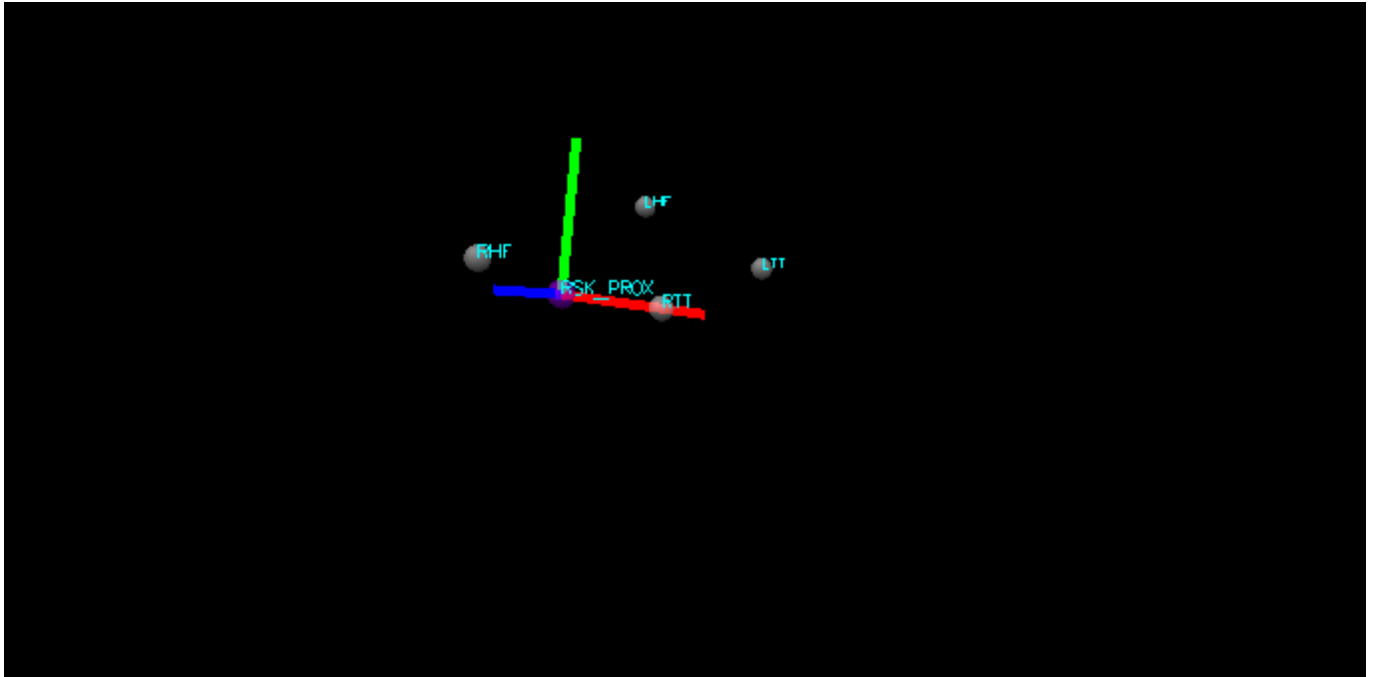
|                                      |                                    |                               |                               |
|--------------------------------------|------------------------------------|-------------------------------|-------------------------------|
| <input type="checkbox"/> RF2P_Offset | <input type="checkbox"/> RFMB_proj | <input type="checkbox"/> LCA  | <input type="checkbox"/> LMM  |
| <input type="checkbox"/> LAB_O       | <input type="checkbox"/> RSMH_proj | <input type="checkbox"/> LFMB | <input type="checkbox"/> LPM  |
| <input type="checkbox"/> LAB_X       | <input type="checkbox"/> RSMB_proj | <input type="checkbox"/> LFMH | <input type="checkbox"/> LPT  |
| <input type="checkbox"/> LAB_Y       | <input type="checkbox"/> RVMH_proj | <input type="checkbox"/> LHF  | <input type="checkbox"/> LSMB |
| <input type="checkbox"/> RFMH_proj   | <input type="checkbox"/> RVMB_proj | <input type="checkbox"/> LLM  | <input type="checkbox"/> LSMH |

Depth (Meters):

Buttons: Close Tab, Guess Properties, Apply, Build Model

## 2. Modify the **Segment Coordinate System**:

1. Define the Segment Orientation as:
  - **A/P Axis: +X**
  - **Distal to Proximal: +Y**

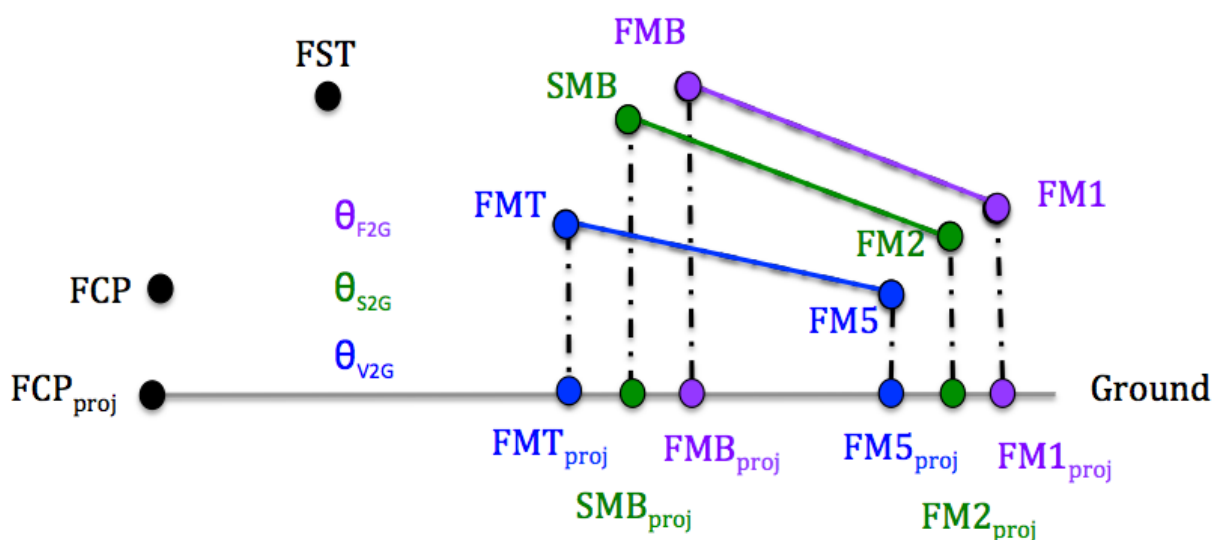


## Sagittal Planar Angles

The F2G, S2G, and V2G angles are planar angles relative to the ground.  
The MLA angle is the angle between the Medial Longitudinal Arch/Navicular drop.

### F2G, S2G, and V2G Landmarks:

The F2G, S2G and V2G angles are calculated in the plane orthogonal to the ground. These landmarks will need to be projected onto the ground. To project landmarks onto the ground, the Lab\_O, Lab\_X and Lab\_Y landmarks will need to be created to identify the plane of the ground.



## 1. Create Lab\_O:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark:
  1. **Landmark Name:** Lab\_O
  2. Offset Using the Following **ML/AP/AXIAL** Offsets:
    - **ML:** 0.0 **AP:** 0.0 **Axial:** 0.0
  3. **Do Not Check:** Offset by Percent (1.0 = 100%)
  4. **Do Not Check:** Calibration Only Landmark

The screenshot shows the 'Landmarks' tab in the IORFoot software. The 'Landmark Name' is set to 'LAB\_O'. Under 'Define Orientation Using:', the 'Existing Segment' is selected as 'LAB'. The 'Landmark Offset from Start Point (Reference) or Segment Origin' section shows 'Offset Using the Following ML/AP/AXIAL Offsets' selected, with X, Y, and Z offsets all set to 0.0. The 'Offset by Percent' checkbox is unchecked. The 'Calibration Only Landmark' checkbox is also unchecked. At the bottom, there are buttons for 'Undo Changes', 'Apply', 'Build Model', and 'Close Tab'.

## 2. Create Lab\_X:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark:
  1. **Landmark Name:** Lab\_X
  2. Offset Using the Following **ML/AP/AXIAL** Offsets:
    - **ML:** 0.05 **AP:** 0.0 **Axial:** 0.0
  3. **Do Not Check:** Offset by Percent (1.0 = 100%)
  4. **Do Not Check:** Calibration Only Landmark

Workspace | Signals and Events | Models | Reports | Cal

Segments | Landmarks | Muscles | Subject Data / Metrics

Landmarks | Functional | Digitizing | LAB\_X

Landmark Name: LAB\_X

Define Orientation Using:

Starting Point (Reference)

Targets and/or Landmarks: Ending Point (On a line)

\*Lateral object (On a plane)

\*Project From (Projection onto a line or plane)

\* = Optional

Existing Segment LAB

Landmark Offset from Start Point (Reference) or Segment Origin

Offset to Existing Calibration Target or Landmark

Offset Using the Following ML/AP/AXIAL Offsets

X 0.05

Y 0.0

Z 0.0

Offset by Percent (1.0 = 100%) (Meters when not checked)

Calibration Only Landmark (Not generated for assigned motion file(s))

Undo Changes Apply Build Model Close Tab

### 3. Create Lab\_Y:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark:
  1. **Landmark Name:** Lab\_Y
  2. Offset Using the Following **ML/AP/AXIAL** Offsets:
    - **ML:** 0.0 **AP:** 0.05 **Axial:** 0.0
  3. **Do Not Check:** Offset by Percent (1.0 = 100%)
  4. **Do Not Check:** Calibration Only Landmark

Workspace | Signals and Events | Models | Reports | Cal

Segments | Landmarks | Muscles | Subject Data / Metrics

Landmarks | Functional | Digitizing | LAB\_Y

Landmark Name: LAB\_Y

Define Orientation Using:

Starting Point (Reference)

Targets and/or Landmarks: Ending Point (On a line)

\*Lateral object (On a plane)

\*Project From (Projection onto a line or plane)

\* = Optional

Existing Segment LAB

Landmark Offset from Start Point (Reference) or Segment Origin

Offset to Existing Calibration Target or Landmark

Offset Using the Following ML/AP/AXIAL Offsets

X 0.0

Y 0.05

Z 0.0

Offset by Percent (1.0 = 100%) (Meters when not checked)

Calibration Only Landmark (Not generated for assigned motion file(s))

Undo Changes Apply Build Model Close Tab

#### 4. Create RFMH\_proj:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark:
  1. **Landmark Name:** RFMH\_proj
  2. **Define Orientation Using:**
    - **Starting Point:** LAB\_O
    - **Ending Point:** LAB\_X
    - **Lateral Object:** LAB\_Y
    - **Project From:** RFMH
  3. **Do Not Check:** Offset by Percent (1.0 = 100%)
  4. **Do Not Check:** Calibration Only Landmark

Workspace | Signals and Events | Models | Reports | Cal

Segments | Landmarks | Muscles | Subject Data / Metrics

Landmarks | Functional | Digitizing | RFMH\_proj

Landmark Name: RFMH\_proj

Define Orientation Using:

Starting Point: LAB\_O (Reference)

☒ Targets and/or Landmarks: Ending Point: LAB\_X (On a line)

\*Lateral object: LAB\_Y (On a plane)

\*Project From: RFMH (Projection onto a line or plane)

\* = Optional

☐ Existing Segment

Landmark Offset from Start Point (Reference) or Segment Origin

☐ Offset to Existing Calibration Target or Landmark

☒ Offset Using the Following ML/AP/AXIAL Offsets

ML:

AP:

AXIAL:

☐ Offset by Percent (1.0 = 100%) (Meters when not checked)

☐ Calibration Only Landmark (Not generated for assigned motion file(s))

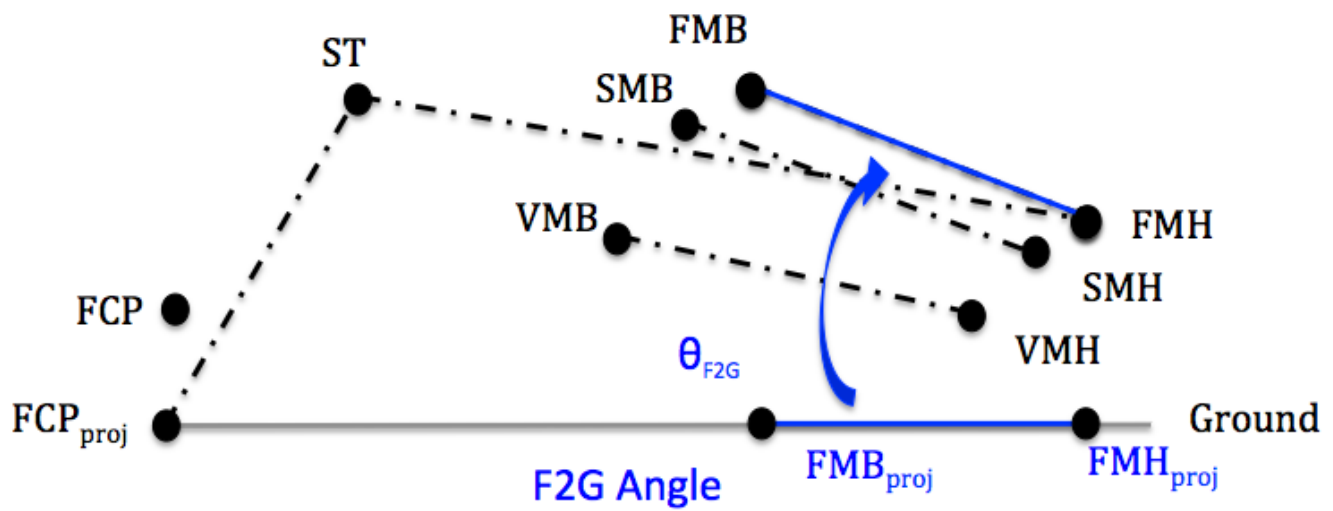
Undo Changes | Apply | Build Model | Close Tab

**Create landmarks 7-17 by following the same format as the RFMH\_proj landmark for:**

- 5. RFMB 6. RSMH 7. RSMB 8. RVMH 9. RVMB 10. LFMH 11. LFMB 12. LSMH 13. LSMB 14. LVMH 15. LVMB

## F2G Angle

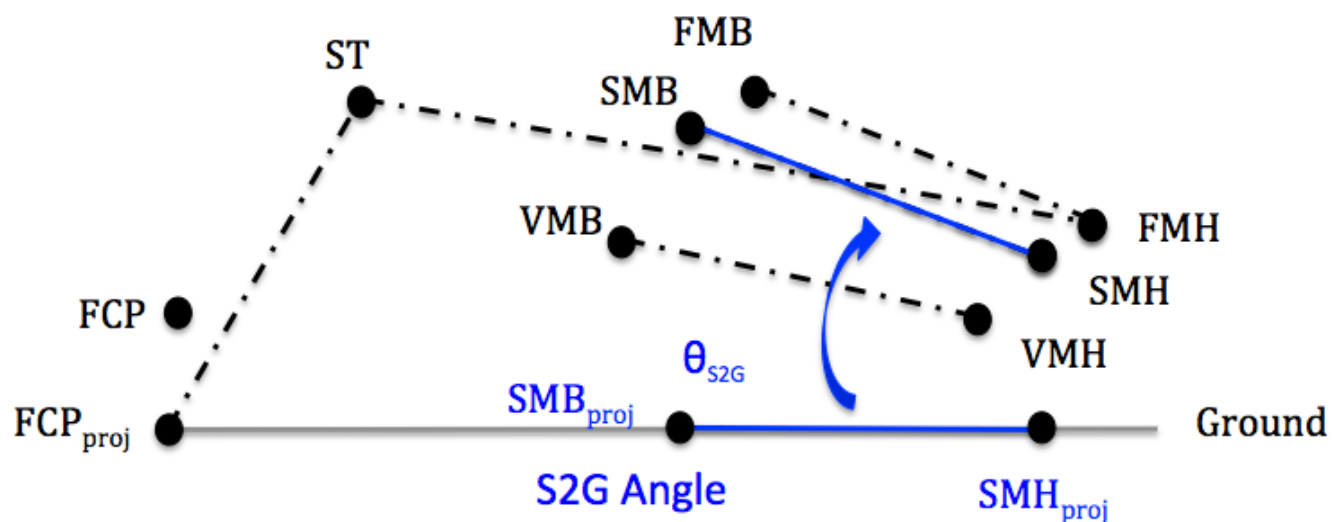
F2G Angle - 3D angle of the first metatarsus relative to the ground



### 1. Create RF2G planar angle:

1. Define **Resulting Signal** Name: RF2G
2. Calculate a **4 point angle** between the following targets:
  1. TARGET::ORIGINAL::RFMB
  2. TARGET::ORIGINAL::RFMH
  3. TARGET::ORIGINAL::RFMH\_proj
  4. TARGET::ORIGINAL::RFMB\_proj
  - **Angle Direction:** Right Hand Rule
  - **3D Space:** Always 0 to 180 degrees





\\

### 1. Create RS2G planar angle:

1. Define **Resulting Signal** Name: RS2G
2. Calculate a **4 point angle** between the following targets:
  1. TARGET::ORIGINAL::RSMB
  2. TARGET::ORIGINAL::RSMH
  3. TARGET::ORIGINAL::RSMH\_proj
  4. TARGET::ORIGINAL::RSMB\_proj
    - **Angle Direction:** Right Hand Rule
    - **3D Space:** Always 0 to 180 degrees

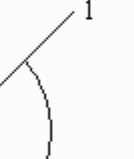
**Compute the angle between two vectors, represented by 3 or 4 points**

---

**Resulting Signal**

|        |           |
|--------|-----------|
| Name   | RS2G      |
| Folder | PROCESSED |

---



|   |                             |
|---|-----------------------------|
| 1 | TARGET::ORIGINAL::RSMB      |
| 2 | TARGET::ORIGINAL::RSMH      |
| 3 | LANDMARK::ORIGINAL::RSMH_pr |
| 4 | LANDMARK::ORIGINAL::RSMB_pr |

**Specify 3 or 4 points**

☐ 3 Point

☒ 4 Point

---

**Angle Direction**

☒ Right Hand Rule

☐ Left Hand Rule

---

**Use Range**

☒ 0 to 360 degrees

☐ -180 to 180 degrees

---

**Projected onto Plane**

☐ XY      If the angle is projected onto one of the principle planes, the direction of the normal to the two vectors is the third principle axes. The Right Hand Rule and the Range are with respect to this normal.

☐ XZ

☐ YZ

---

**3D Space**

☒ 3D      Always 0 to 180 degrees (Unspecified Direction)

☐ 3D      Specify a Vector Normal to the Two Vectors

---

**Example**

With respect to the figure. Assume the two vectors lie in the XY plane; Rotation is about the Z-axis.

3D: Angle = 95 degrees

Projected onto XY: Use RHR: Use 0- to 360:    Angle=265 degrees

Projected onto XY: Use RHR: Use -180 to 180: Angle=-95 degrees

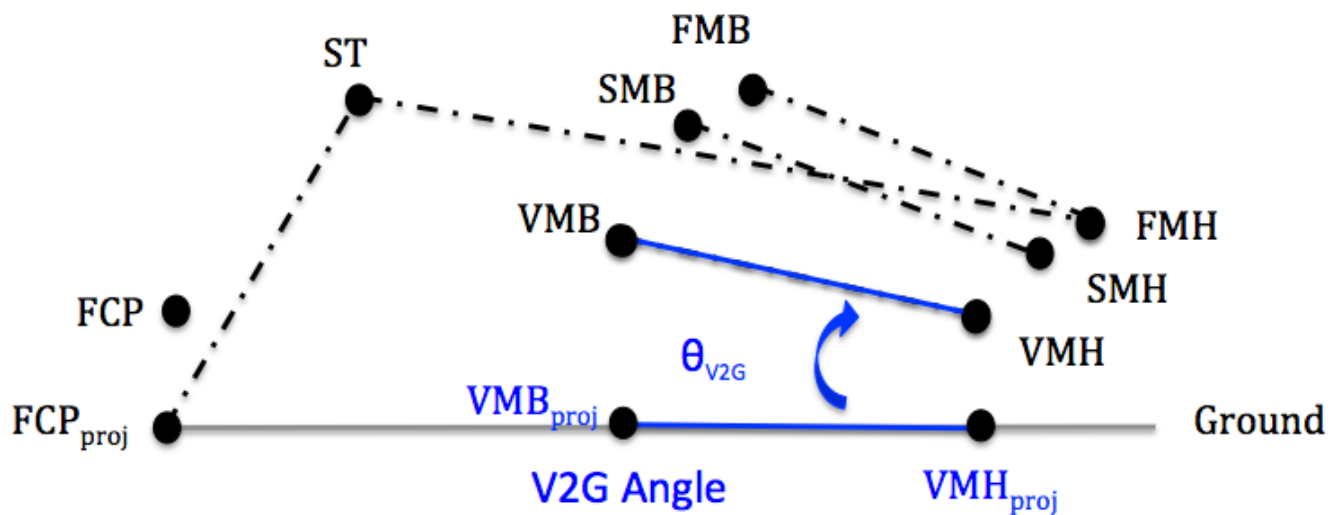
Cancel
OK

## 2. Create LS2G planar angle:

1. When defining the left signal, use the same definitions as for the right angle.

### V2G Angle

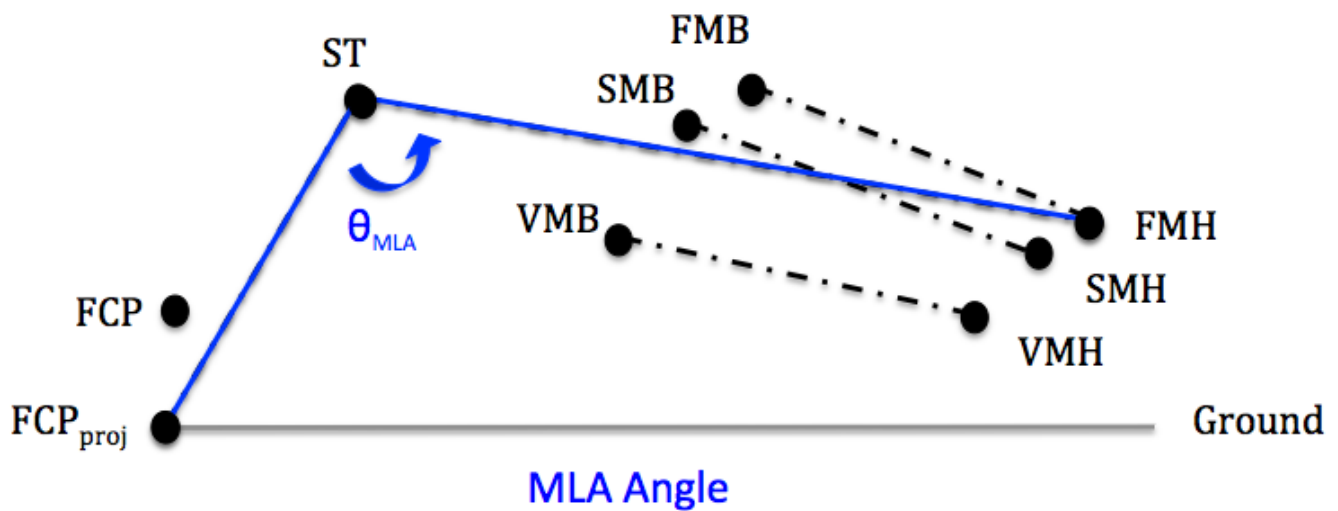
V2G Angle - 3D angle of the fifth metatarsus relative to the ground



### 1. Create RV2G planar angle:

1. Define **Resulting Signal** Name: RV2G
2. Calculate a **4 point angle** between the following targets:
  1. TARGET::ORIGINAL::RVMB
  2. TARGET::ORIGINAL::RVMH
  3. TARGET::ORIGINAL::RVMH\_proj
  4. TARGET::ORIGINAL::RVMB\_proj
    - **Angle Direction:** Right Hand Rule
    - **3D Space:** Always 0 to 180 degrees





### MLA Angle Landmarks:

The MLA angle is calculated using the proximal heel target projected onto the ground, tracked using the calcaneus segment.

To accomplish this, two landmarks must be created:

1. The projection of the proximal heel target onto the ground
2. Track the proximal heel target projection using the calcaneus segment

To create these landmarks, the **LAB\_O**, **LAB\_X** and **LAB\_Y** landmarks must be created and the calcaneus segment must be defined.

**NOTE:** The image for the MLA Angle shows the PROCESSED target folder being used for the signal definition. If you have used the ORIGINAL target data for the other planar angles, you should continue to use the ORIGINAL folder.

#### 1. Create RFCP\_proj:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark:
  1. **Landmark Name:** RFCP\_proj
  2. **Define Orientation Using:**
    - **Starting Point:** LAB\_O
    - **Ending Point:** LAB\_X
    - **Lateral Object:** LAB\_Y
    - **Project From:** RFCP
  3. **Do Not Check:** Offset by Percent (1.0 = 100%)
  4. **Check:** Calibration Only Landmark

## 2. Create LFCP\_proj:

1. When defining the left signal, use the same definitions as for the right landmark.

## 3. Create RFCP\_proj\_track:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark:
  1. **Landmark Name:** RFCP\_proj\_track
  2. **Define Orientation Using:**
    - **Starting Point:** RFCP\_proj
    - Click **Existing Segment:** RCal
  3. **Do Not Check:** Offset by Percent (1.0 = 100%)
  4. **Do Not Check:** Calibration Only Landmark



## 4. Create LFCP\_proj\_track

1. When defining the left signal, use the same definitions as for the right landmark.

## MLA Definition:

### 1. Create RMLA planar angle:

1. Define **Resulting Signal** Name: RMLA
2. Calculate a **3 point angle** between the following targets:
  1. LANDMARK::ORIGINAL::RFCP\_track
  2. TARGET::ORIGINAL::RST
  3. 3 - TARGET::ORIGINAL::RFMH
    - **Angle Direction:** Right Hand Rule
    - **Use Range:** -180 to 180 degrees
    - **Projected onto Plane:** XY
    - **Note:** The reference segment will need to be changed to RMF within the text option.
    - Command text should have the internal name (e.g. RMF) and not the display name "Right Virtual Foot". [Segment Default Names](#)

Compute the angle between two vectors, represented by 3 or 4 points

Resulting Signal  
 Name: RMLA  
 Folder: PROCESSED

Specify 3 or 4 points  
☒ 3 Point  
☐ 4 Point

Angle Direction  
☒ Right Hand Rule  
☐ Left Hand Rule

Use Range  
☒ 0 to 360 degrees  
☐ -180 to 180 degrees

Projected onto Plane  
☒ XY  
☐ XZ  
☐ YZ  
 If the angle is projected onto one of the principle planes, the direction of the normal to the two vectors is the third principle axes. The Right Hand Rule and the Range are with respect to this normal.

3D Space  
☒ 3D Always 0 to 180 degrees (Unspecified Direction)  
☐ 3D Specify a Vector Normal to the Two Vectors

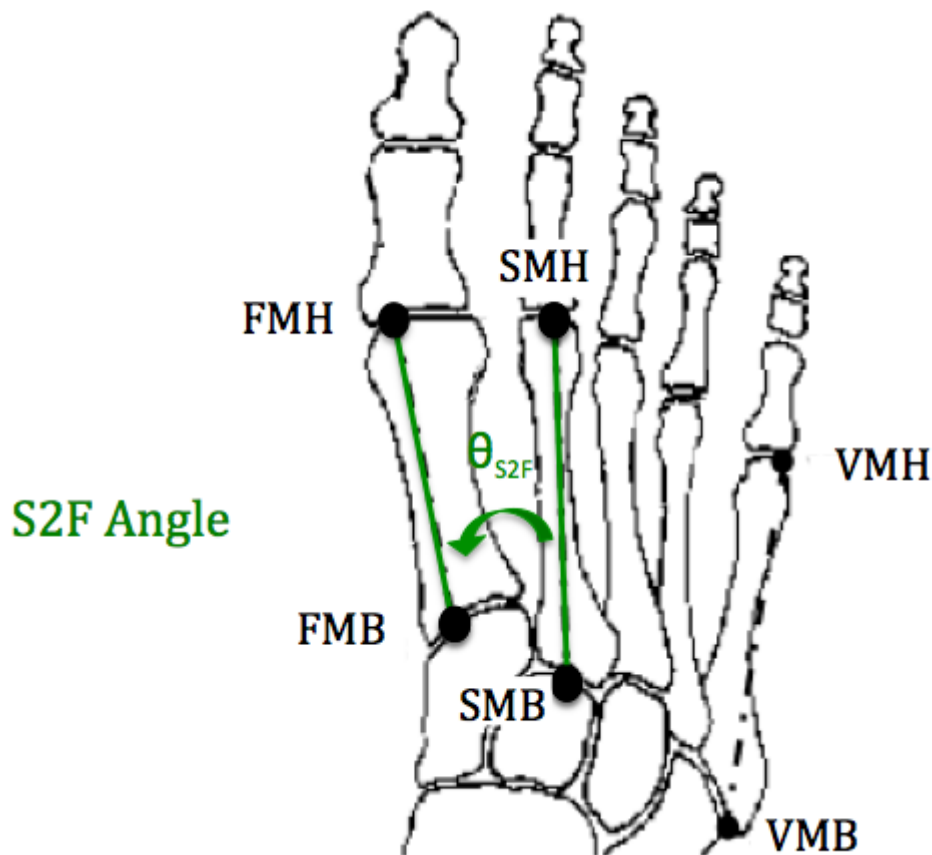
### 2. Create LMLA planar angle:

1. When defining the left signal, use the same definitions as for the right angle.
  - **Note:** The reference segment will need to be changed to **Left Virtual Foot** within the text option.

# Transverse Planar Angles

## S2F Angle

S2F Angle - Angle between the first and second metatarsus projected on to the transverse plane of the Met segment



### S2F Definition: 1. Create RS2F planar angle:

1. Define **Resulting Signal** Name: RS2F
2. Calculate a **4 point angle** between the following targets:
  1. TARGET::ORIGINAL::RSMH
  2. TARGET::ORIGINAL::RSMB
  3. TARGET::ORIGINAL::RFMB
  4. TARGET::ORIGINAL::RFMH
  - **Angle Direction:** Right Hand Rule
  - **3D Space:** -180 to 180 degrees
  - **Projected onto Plane:** XZ
  - **Note:** The reference segment will need to be changed to RMet within the text option.

Compute the angle between two vectors, represented by 3 or 4 points

Resulting Signal  
 Name: RS2F  
 Folder: PROCESSED

Specify 3 or 4 points  
☐ 3 Point  
☒ 4 Point

Angle Direction  
☒ Right Hand Rule  
☐ Left Hand Rule

Use Range  
☐ 0 to 360 degrees  
☒ -180 to 180 degrees

Projected onto Plane  
☐ XY  
☒ XZ  
☐ YZ  
 If the angle is projected onto one of the principle planes, the direction of the normal to the two vectors is the third principle axes. The Right Hand Rule and the Range are with respect to this normal.

3D Space  
☐ 3D Always 0 to 180 degrees (Unspecified Direction)  
☐ 3D Specify a Vector Normal to the Two Vectors

Example  
 With respect to the figure. Assume the two vectors lie in the XY plane; Rotation is about the Z-axis.  
 3D: Angle = 95 degrees  
 Projected onto XY: Use RHR: Use 0- to 360: Angle=265 degrees  
 Projected onto XY: Use RHR: Use -180 to 180: Angle=-95 degrees

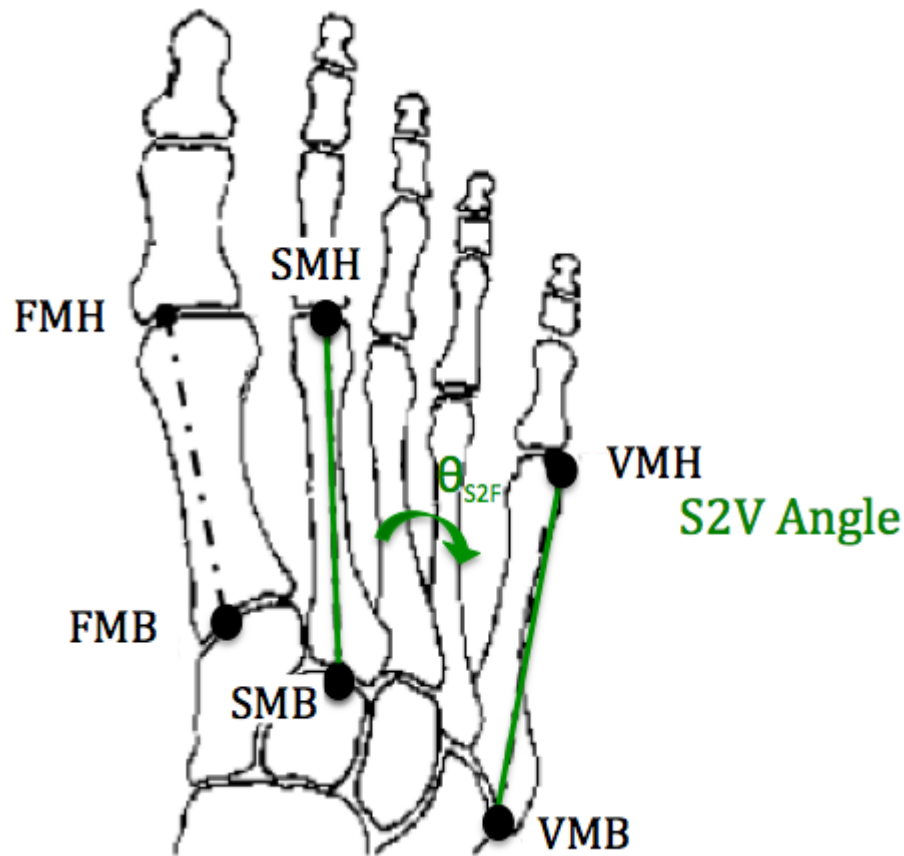
Cancel OK

## 2. Create LS2F planar angle:

- When defining the left signal, use the same definitions as for the right angle.
  - Angle Direction:** Left Hand Rule
  - Note:** The reference segment will need to be changed to LMet within the text option.

## S2V Angle

S2V Angle - Angle between the fifth and second metatarsus projected on to the transverse plane of



the Met segment\\

#### **S2V Definition: 1. Create RS2V planar angle:**

1. Define **Resulting Signal** Name: RS2V
2. Calculate a **4 point angle** between the following targets:
  1. TARGET::ORIGINAL::RSMH
  2. TARGET::ORIGINAL::RSMB
  3. TARGET::ORIGINAL::RVMB
  4. TARGET::ORIGINAL::RVMH
  - **Angle Direction:** Left Hand Rule
  - **3D Space:** -180 to 180 degrees
  - **Projected onto Plane:** XZ
  - **Note:** The reference segment will need to be changed to RMet within the text option.

Compute the angle between two vectors, represented by 3 or 4 points

Resulting Signal  
 Name: RS2V  
 Folder: PROCESSED

Specify 3 or 4 points  
☐ 3 Point  
☒ 4 Point

Angle Direction  
☐ Right Hand Rule  
☒ Left Hand Rule

Use Range  
☐ 0 to 360 degrees  
☒ -180 to 180 degrees

Projected onto Plane  
☐ XY If the angle is projected onto one of the principle planes, the direction of the normal to the two vectors is the third principle axes. The Right Hand Rule and the Range are with respect to this normal.  
☒ XZ  
☐ YZ

3D Space  
☐ 3D Always 0 to 180 degrees (Unspecified Direction)  
☐ 3D Specify a Vector Normal to the Two Vectors

Example  
 With respect to the figure. Assume the two vectors lie in the XY plane; Rotation is about the Z-axis.  
 3D: Angle = 95 degrees  
 Projected onto XY: Use RHR: Use 0- to 360: Angle=265 degrees  
 Projected onto XY: Use RHR: Use -180 to 180: Angle=-95 degrees

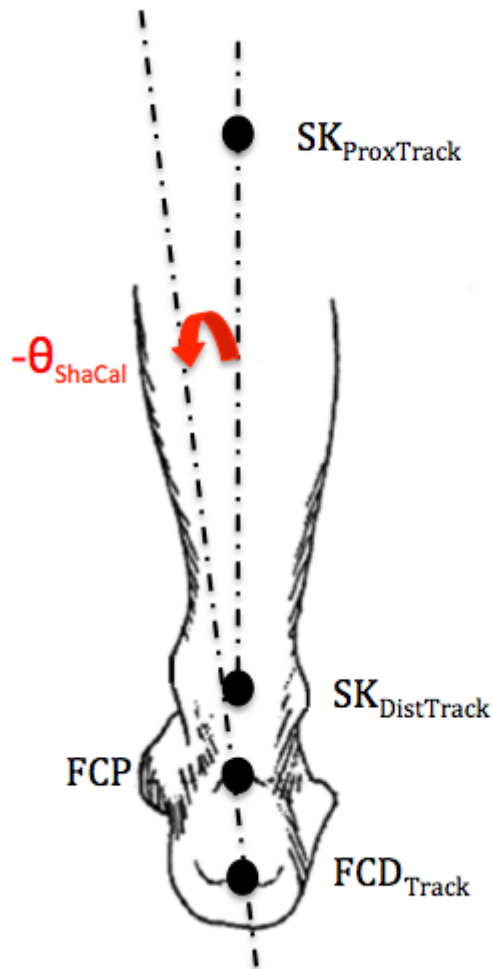
Cancel OK

## 2. Create LS2F planar angle:

- When defining the left signal, use the same definitions as for the right angle.
  - Angle Direction:** Right Hand Rule
  - Note:** The reference segment will need to be changed to LMet within the text option.

## Calcaneus Inv/Eve

Sha\_Cal\_Frontal Angle - Angle of the calcaneus segment relative to the shank segment  
 This planar angle will be used to replace the inversion/eversion angle of the Sha\_Cal joint angle  
 0 degrees indicates the calcaneus is aligned with the shank.



## Sha\_Cal\_Frontal Landmarks

### 1. Create RSK\_PROX\_TRACK:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark:
  1. **Landmark Name:** RSK\_PROX\_track
  2. **Define Orientation Using:**
    - **Existing Segment:** RSK
  3. Offset Using the Following **ML/AP/AXIAL** Offsets:
    - **X:** 0.0 **Y:** 0.0 **Z:** 0.0
  4. **Check:** Offset by Percent (1.0 = 100%)
  5. **Do Not Check:** Calibration Only Landmark

Segments | Landmarks | Muscles | Subject Data / Metrics

Landmarks | Functional | Digitizing | RSK\_PROX\_track

Landmark Name: RSK\_PROX\_track

Define Orientation Using:

Starting Point  (Reference)

☐ Targets and/or Landmarks: Ending Point  (On a line)

\*Lateral object  (On a plane)

\*Project From  (Projection onto a line or plane)

\* = Optional

☒ Existing Segment: Right Shank

Landmark Offset from Start Point (Reference) or Segment Origin

☐ Offset to Existing Calibration Target or Landmark

☒ Offset Using the Following ML/AP/AXIAL Offsets

ML

AP

AXIAL

☒ Offset by Percent (1.0 = 100%) (Meters when not checked)

☐ Calibration Only Landmark (Not generated for assigned motion file(s))

Undo Changes Apply Build Model Close Tab

## 2. Create RSK\_DIST\_TRACK:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark:
  1. **Landmark Name:** RSK\_DIST\_track
  2. **Define Orientation Using:**
    - **Existing Segment:** RSK
  3. Offset Using the Following **ML/AP/AXIAL** Offsets:
    - **X:** 0.0 **Y:** 0.0 **Z:** -1.0
  4. **Check:** Offset by Percent (1.0 = 100%)
  5. **Do Not Check:** Calibration Only Landmark

The screenshot shows the 'RSK\_DIST\_track' landmark configuration window. The 'Landmarks' tab is active. The 'Landmark Name' is 'RSK\_DIST\_track'. Under 'Define Orientation Using:', 'Existing Segment' is selected and set to 'Right Shank'. Under 'Landmark Offset from Start Point (Reference) or Segment Origin', 'Offset Using the Following ML/AP/AXIAL Offsets' is selected. The offsets are: ML = 0.0, AP = 0.0, and AXIAL = -1. The checkbox 'Offset by Percent (1.0 = 100%) (Meters when not checked)' is checked. The checkbox 'Calibration Only Landmark (Not generated for assigned motion file(s))' is unchecked. At the bottom are buttons for 'Undo Changes', 'Apply', 'Build Model', and 'Close Tab'.

### 3. Create RFCS\_track Joint Center:

1. Click **Landmarks**
2. Click **Add New Landmark** button
3. Create Landmark:
  1. **Landmark Name:** RFCD\_track
  2. **Define Orientation Using:**
    - **Existing Segment:** RCal
  3. Offset to Existing Calibration Target or Landmark: RFCD
  4. **Do Not Check:** Offset by Percent (1.0 = 100%)
  5. **Do Not Check:** Calibration Only Landmark

Segments | Landmarks | Muscles | Subject Data / Metrics

Landmarks | Functional | Digitizing | RFCD\_track

Landmark Name: RFCD\_track

Define Orientation Using:

Starting Point (Reference)

Targets and/or Landmarks: Ending Point (On a line)

\*Lateral object (On a plane)

\*Project From (Projection onto a line or plane)

\* = Optional

Existing Segment: RCal

Landmark Offset from Start Point (Reference) or Segment Origin

Offset to Existing Calibration Target or Landmark: RFCD

Offset Using the Following ML/AP/AXIAL Offsets

ML: 0.000757331

AP: -0.0289862

AXIAL: 0.00769544

Offset by Percent (1.0 = 100%) (Meters when not checked)

Calibration Only Landmark (Not generated for assigned motion file(s))

Undo Changes | Apply | Build Model | Close Tab

## Sha\_Cal\_Frontal Definition

### 1. Create RSha\_Cal\_Fro planar angle:

1. Define **Resulting Signal** Name: RSha\_Cal\_Fro
2. Calculate a **4 point angle** between the following targets:
  1. LANDMARK::ORIGINAL::RSK\_PROX\_TRACK
  2. LANDMARK::ORIGINAL::RSK\_DIST\_TRACK
  3. LANDMARK::ORIGINAL::RFCD\_TRACK
  4. TARGET::ORIGINAL::RFCP
    - **Angle Direction:** Left Hand Rule
    - **3D Space:** -180 to 180 degrees
    - **Projected onto Plane:** YZ
    - **Note:** The reference segment will need to be changed to RSK within the text option.

Compute the angle between two vectors, represented by 3 or 4 points

Resulting Signal  
Name: RSha\_Cal\_Fro  
Folder: PROCESSED

Diagram showing four points (1, 2, 3, 4) forming an angle.

1: LANDMARK::ORIGINAL::RSK\_PRC  
2: LANDMARK::ORIGINAL::RSK\_DIS  
3: LANDMARK::ORIGINAL::RFCD\_tra  
4: TARGET::PROCESSED::RFCP

Specify 3 or 4 points  
☐ 3 Point  
☒ 4 Point

Angle Direction  
☐ Right Hand Rule  
☒ Left Hand Rule

Use Range  
☐ 0 to 360 degrees  
☒ -180 to 180 degrees

Projected onto Plane  
☐ XY  
☐ XZ  
☒ YZ  
If the angle is projected onto one of the principle planes, the direction of the normal to the two vectors is the third principle axes. The Right Hand Rule and the Range are with respect to this normal.

3D Space  
☐ 3D Always 0 to 180 degrees (Unspecified Direction)  
☐ 3D Specify a Vector Normal to the Two Vectors

## 2. Create LSha\_Cal\_Fro planar angle:

1. When defining the left signal, use same definitions **except** set:

- **Angle Direction:** Right Hand Rule
- **Note:** The reference segment will need to be changed to LSK within the text option.

## Joint Angles

Joint Angle definitions for the:

- Sha\_Foo\_Angle
- Sha\_Cal\_Angle
- Cal\_Mid\_Angle
- Mid\_Met\_Angle
- Cal\_Met\_Angle
- Met\_Hal\_Angle

The Met\_Hal\_Angle calculations are used to replace the F2Ps & F2Pt planar angles from the 2007 paper<sup>[1]</sup>.

## Joint Angle Definitions

### 1. Define the RSha\_Foo\_Angle:

1. Open the **Compute Model Based** dialog
2. Select **JOINT\_ANGLE** from the drop down list
  - **Data Name:** RSha\_Foo\_Angle
  - **Segment:** Right Virtual Foot
  - **Reference Segment:** Right Shank
  - **Cardan Sequence:** Z-X-Y
3. **Use Negative:** X: TRUE Y: TRUE Z: FALSE

**Compute Model Based Data**

Data Name: RSha\_Foo

Folder: ORIGINAL

Result Folder will always be Original

Joint Angle (degrees):

Segment and Reference Segment define the angle desired. Normalization is relative to standing posture. The Cardan Sequence defines the order of rotations. Warning!!! If you are using the anatomical axes (ML, AP, or AXIAL) the sign of the angle follows the Right Hand Rule about the actual corresponding segment coordinate system axes.

Model Based Item Properties

Use Negative

JOINT\_ANGLE

Normalization: Normalization Off

Segment: Right Virtual Foot

Reference Segment: Right Shank

Cardan Sequence: Z-X-Y

Done Reset Dialog Cancel

### 2. Define RSha\_Cal\_Angle:

1. Open the **Compute Model Based** dialog
2. Select **JOINT\_ANGLE** from the drop down list
  - **Data Name:** RSha\_Cal\_Angle
  - **Segment:** RCal
  - **Reference Segment:** Right Shank
  - **Cardan Sequence:** Z-X-Y
3. **Use Negative:** X: TRUE Y: TRUE Z: FALSE

**Compute Model Based Data**

Data Name:

Folder:

Result Folder will always be Original

Joint Angle (degrees):

Segment and Reference Segment define the angle desired. Normalization is relative to standing posture. The Cardan Sequence defines the order of rotations. Warning!!! If you are using the anatomical axes (ML, AP, or AXIAL) the sign of the angle follows the Right Hand Rule about the actual corresponding segment coordinate system axes.

Model Based Item Properties:  Use Negative

☒ X ☒ Y ☒ Z

Normalization:

Segment:

Reference Segment:

Cardan Sequence:

### 3. Define the Cal\_Mid\_Angle:

1. Open the **Compute Model Based** dialog
2. Select **JOINT\_ANGLE** from the drop down list
  - **Data Name:** RCal\_Mid\_Angle
  - **Segment:** RMid
  - **Reference Segment:** RCal
  - **Cardan Sequence:** Z-X-Y
3. **Use Negative: X: TRUE Y: TRUE Z: FALSE**

**Compute Model Based Data**

Data Name:

Folder:

Result Folder will always be Original

Joint Angle (degrees):

Segment and Reference Segment define the angle desired. Normalization is relative to standing posture. The Cardan Sequence defines the order of rotations. Warning!!! If you are using the anatomical axes (ML, AP, or AXIAL) the sign of the angle follows the Right Hand Rule about the actual corresponding segment coordinate system axes.

Model Based Item Properties:  Use Negative

☒ X ☒ Y ☐ Z

Normalization:

Segment:

Reference Segment:

Cardan Sequence:

### 4. Define the RMid\_Met\_Angle:

1. Open the **Compute Model Based** dialog
2. Select **JOINT\_ANGLE** from the drop down list
  - **Data Name:** RMid\_Met\_Angle
  - **Segment:** RMet

- **Reference Segment:** RMid
- **Cardan Sequence:** Z-X-Y

3. **Use Negative:** X: TRUE Y: TRUE Z: FALSE

**Compute Model Based Data**

Data Name:

Folder:

Result Folder will always be Original

Joint Angle (degrees):

Segment and Reference Segment define the angle desired.  
Normalization is relative to standing posture.  
The Cardan Sequence defines the order of rotations.  
Warning!!! If you are using the anatomical axes (ML, AP, or AXIAL) the sign of the angle follows the Right Hand Rule about the actual corresponding segment coordinate system axes.

Model Based Item Properties:  Use Negative

☒ X  
☒ Y  
☐ Z

Normalization:

Segment:

Reference Segment:

Cardan Sequence:

Create Reset Dialog Close

## 5. Define the RCal\_Met\_Angle:

1. Open the **Compute Model Based** dialog
2. Select **JOINT\_ANGLE** from the drop down list
  - **Data Name:** RCal\_Met\_Angle
  - **Segment:** RMet
  - **Reference Segment:** RCal
  - **Cardan Sequence:** Z-X-Y
3. **Use Negative:** X: TRUE Y: TRUE Z: FALSE

**Compute Model Based Data**

Data Name:

Folder:

Result Folder will always be Original

Joint Angle (degrees):

Segment and Reference Segment define the angle desired.  
Normalization is relative to standing posture.  
The Cardan Sequence defines the order of rotations.  
Warning!!! If you are using the anatomical axes (ML, AP, or AXIAL) the sign of the angle follows the Right Hand Rule about the actual corresponding segment coordinate system axes.

Model Based Item Properties:  Use Negative

☒ X  
☒ Y  
☐ Z

Normalization:

Segment:

Reference Segment:

Cardan Sequence:

Create Reset Dialog Close

## Met\_Hal\_Angle:

The Met\_Hal angle is the angle of the hallux relative to the metatarsus segment.

This sagittal and transverse angles of the Met\_Hal\_Angle angles create the F2Ps & F2Pt planar angles from the 2007 paper[1]. Since the targets used to track this segment are nearly colinear, useful information cannot be calculated from rotations in the coronal plane.

**F2Ps** - the angle between the lines FMH-PM and FMB-FMH projected onto the sagittal plane of the metatarsus

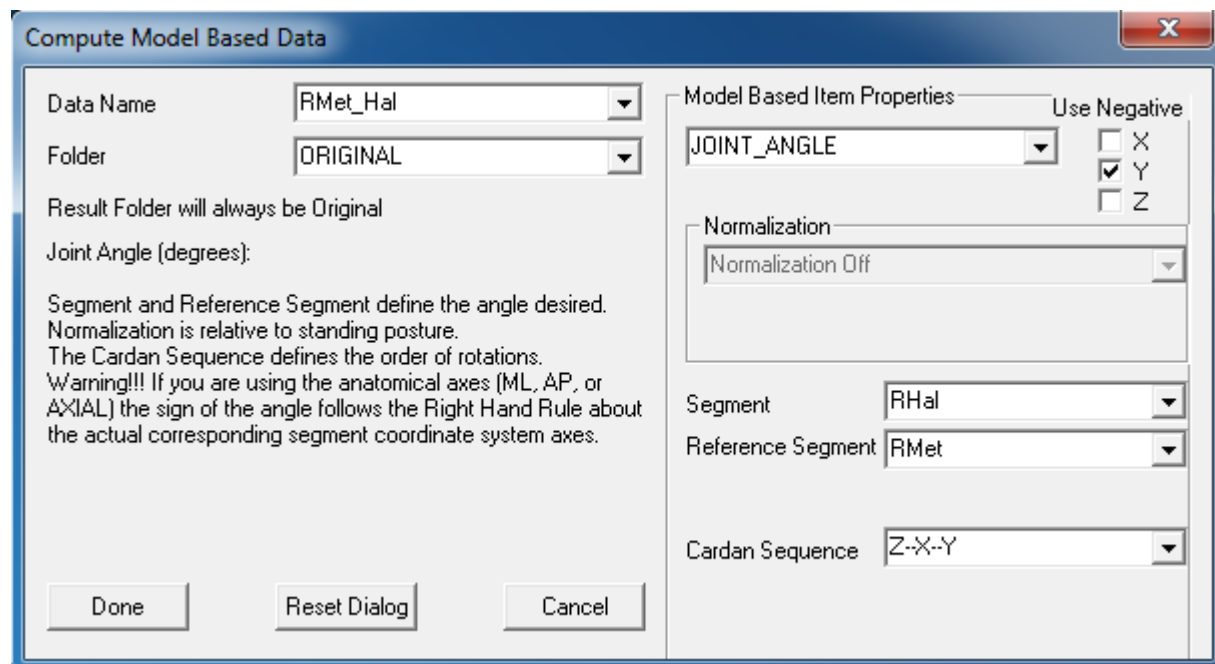
Represents: dorsiflexion of the first metatarso-phalangeal joint

**F2Pt** - the angle between the lines FMH-PM and FMB-FMH projected onto the transverse plane of the metatarsus

Represents: valgus of the first metatarsophalangeal joint

## 6. Define the RMet\_Hal\_Angle:

1. Open the **Compute Model Based** dialog
2. Select **JOINT\_ANGLE** from the drop down list
  - **Data Name:** RMet\_Hal\_Angle
  - **Segment:** RHal
  - **Reference Segment:** RMet
  - **Cardan Sequence:** Z-X-Y
3. **Use Negative:** X: FALSE Y: TRUE Z: FALSE



## References

1. ↑ [1.00](#) [1.01](#) [1.02](#) [1.03](#) [1.04](#) [1.05](#) [1.06](#) [1.07](#) [1.08](#) [1.09](#) [1.10](#) [1.11](#) [1.12](#) [1.13](#) [1.14](#) [1.15](#) [1.16](#) [1.17](#) [1.18](#) [1.19](#) [1.20](#) [1.21](#) [1.22](#) [1.23](#) [1.24](#) [1.25](#) [1.26](#) [1.27](#) [1.28](#) Leardini, A., M.G. Benedetti, L. Berti, D. Bettinelli, R. Nativio, and S. Giannini. "Rear-foot, Mid-foot and Fore-foot Motion during the Stance Phase of Gait." *Gait & Posture* 25 (2007): 453-55
2. ↑ [2.00](#) [2.01](#) [2.02](#) [2.03](#) [2.04](#) [2.05](#) [2.06](#) [2.07](#) [2.08](#) [2.09](#) [2.10](#) [2.11](#) [2.12](#) [2.13](#) Portinaro, N., A. Leardini, A. Panou, V. Monzani, and P. Caravaggi. "Modifying the Rizzoli foot model to improve the diagnosis of pes-planus: application to kinematics of feet in teenagers." *Journal of Foot and Ankle Research* (2014)
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