ITSAMS Central System Response

Here is calculated the response of the ITSAMS central system to translational and rotational motion of the SSD support cones. The ITS cones with their central cylinders make thing very rigid. But to compute the type of motion of the ladders inside, due to some motion of the SSD support cones the trick is to ignore the rigidity due to the central cylinders and consider the two cones as free to move. In addition, since the fixations of the ladders on the cones is force free, it can be assumed that they are free to move about their pivot points. Lastly, because of the large radius and the large number of ladders on layer 6, we can flatten out the problem and consider, first, the motion of a cone along the x axis.

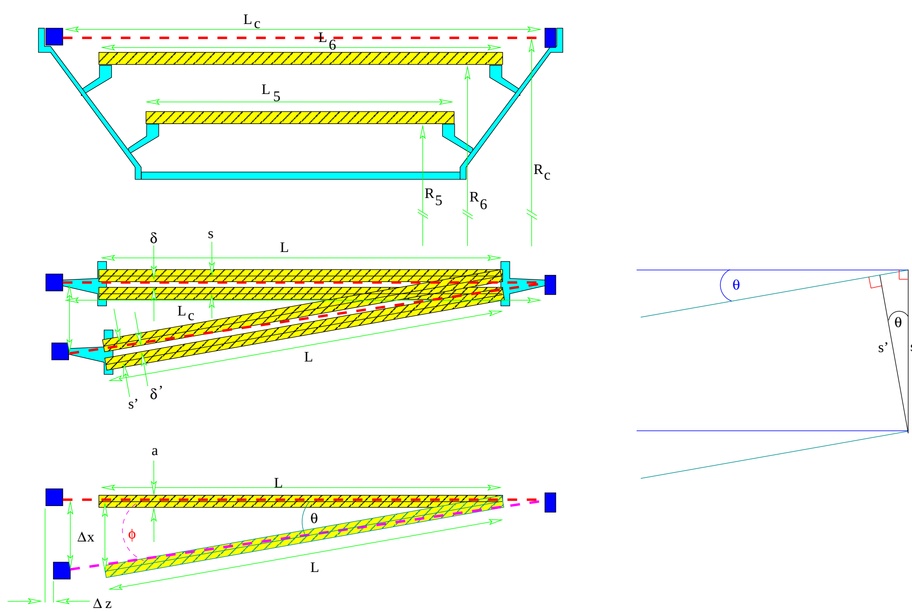

Figure 1: This diagram shows the relation ship of the different variables and the how two neighboring ladders might move with respect to one another.

To begin with consider the setup as shown n figure 1. There it is shown the variables and their relations. In table 1. From the left hand diagram the following relation can be found

$$\cos\theta = \frac{s}{s'}. \tag{1}$$

With a being the width of a ladder, s being the distance between two ladders, and δ the gap, we also get the following relations

$$s - a = \delta \tag{2}$$

$$s' - a = \delta' \tag{3}$$

or

$$s - s' = \delta - \delta'. \tag{4}$$

Where the $'$ variables being for the same values after the translation of one of the SSD cones. From these equations we find

$$s - s' = s\,(1 - \cos\theta) = \delta - \delta' \tag{5}$$

$$\frac{\delta - \delta'}{s} = 1 - \cos\theta. \tag{6}$$

From the lower diagram in figure 1 we get the relation

$$\sin\theta = \frac{\Delta x}{L}. \tag{7}$$

This then results in

$$\frac{\delta - \delta'}{s} = 1 - \cos\theta = 1 - \sqrt{1 - \frac{\Delta x^2}{L^2}}. \tag{8}$$

Expanding the $\sqrt{}$ in a power series we get

$$\frac{\delta - \delta'}{s} \simeq 1 - \left(1 - \frac{1}{2}\frac{\Delta x^2}{L^2}\right) \tag{9}$$

$$\delta - \delta' \simeq \frac{s}{2}\frac{\Delta x^2}{L^2}. \tag{10}$$

Plugging in the above numbers gives for equation 8 and 10 gives

$$\delta - \delta' = 0.4678[cm] - \sqrt{0.21883684[cm^2] - 19.1857 \times 10^{-6}\Delta x^2} \tag{11}$$

and

$$\delta - \delta' \simeq 20.506 \times 10^{-6}[cm^{-1}]\Delta x^2. \tag{12}$$

So for a maximal deviation, that set by the camera dynamic range, of $2[mm]$ this gives a reduction of the space between two ladders of only $0.0082[\mu m]$. Figure 2 graphs these functions.

Effects of a rotation about the z axis

The effect of a rotation about the z axis is equivelent to the above translation except that the translation Δx must be scaled down by the ratio of the radii. Specificaly equation 8 becomes

$$\frac{\delta - \delta'}{s} = 1 - \sqrt{1 - \frac{R_c^2}{R_6^2}\frac{\Delta x^2}{L^2}} \tag{13}$$

for layer 6 and equation 10 becomes

$$\delta - \delta' \simeq \frac{s}{2}\frac{R_c^2}{R_6^2}\frac{\Delta x^2}{L^2}. \tag{14}$$

Consiquently, deviation of the camera, of $0.236[cm]$ is equivlent to the above deviation of $2[mm]$.

Table 1: :A list of variables and their values. $'$ variables indecate quantities after the displacement.

Variable	Description	Value
a	The width of a ladders.	0.42cm
s, s'	The distance between two neighboring ladders.	0.4678cm
δ, δ'	The gap between two neighboring ladders.	0.0478cm
θ	The angle between the original ladder position and that after the cone has been moved.	-
ϕ	The angle between the original laser beam path and that after the cone has been moved.	-
Δx	The distance, along x, the cone has moved.	-
Δz	The distance, along z, the cone has moved.	-
L	The length of an arbitrary ladders.	
L_c	The length between the camera and the mirror.	141.36cm
L_6	The length of a ladders on layer 6.	106.8cm
L_5	The length of a ladders on layer 5.	95.07cm
R_c	The radial distance to the laser path.	510.0cm
R_6	The radial distance to the layer 6 ladder.	431.5cm
R_5	The radial distance to the layer 5 ladder.	381.5cm

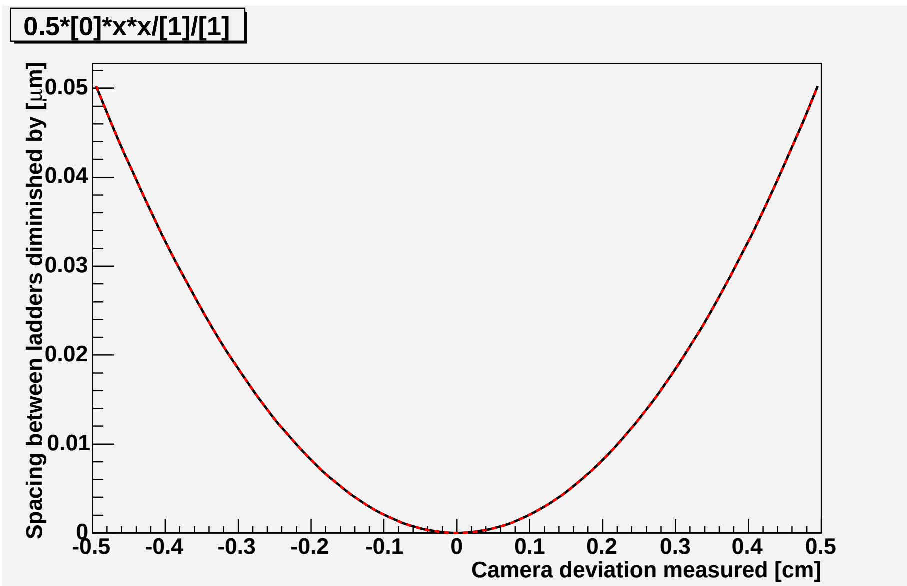

Figure 2: Graphed here are the 2 equations 11, red, and 12, black.