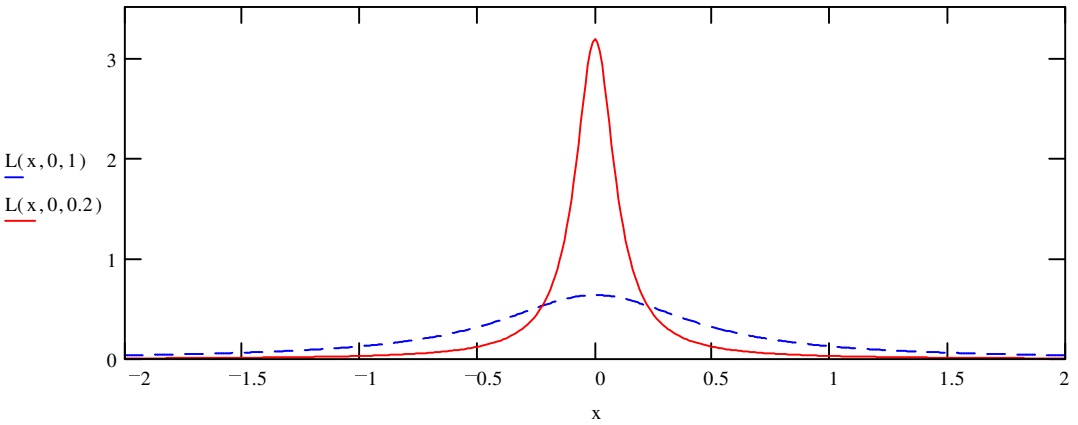
Simulating the Crossed Grid Charge Detector Response to an Event Charge Cloud

The charge distribution out the back of the MCP will fall on the wires of the grid. We will assume that only the area occupied by the wire will collect the charge (the rest goes to the other axis of the grid).

We'll assume that the lateral distribution of charge follows the Lorentz distribution

$$L(x,\mu,\Gamma) := \frac{1}{\pi}\cdot\frac{\frac{\Gamma}{2}}{(x-\mu)^2+\left(\frac{\Gamma}{2}\right)^2}$$

$x := -2, -1.99 .. 2$



Lateral charge distributions other than the Lorentzian, such as a gaussian or exponential distribution, might be considered should the Lorentzian not provide a reasonable match to the observed performance.

The amount of charge collected on each wire in the CGCD is found by integrating the lateral charge distribution over the lateral extent of the wire. We do this in coarse position units. Note that the extent of each wire is +/- 1/32 of its coarse position location.

$$I(u,z,\gamma) := \int_{u-\frac{1}{32}}^{u+\frac{1}{32}} L(x,z,\gamma)\,dx$$

This might be approximated by taking the value of the distribution at the wire location;

i.e.

$$I(u,z,\gamma) := L(u,z,\gamma)\cdot 0.0625$$

The charge collected on each tap is calculated by summing over the 15 wires between the tap and the taps on either side. The charge on each wire must be weighted by the fraction collected based on resistance division. The resulting numbers provide the ADC readouts that appear in telemetry.

$$f(i) := \frac{8 - |i|}{8}$$

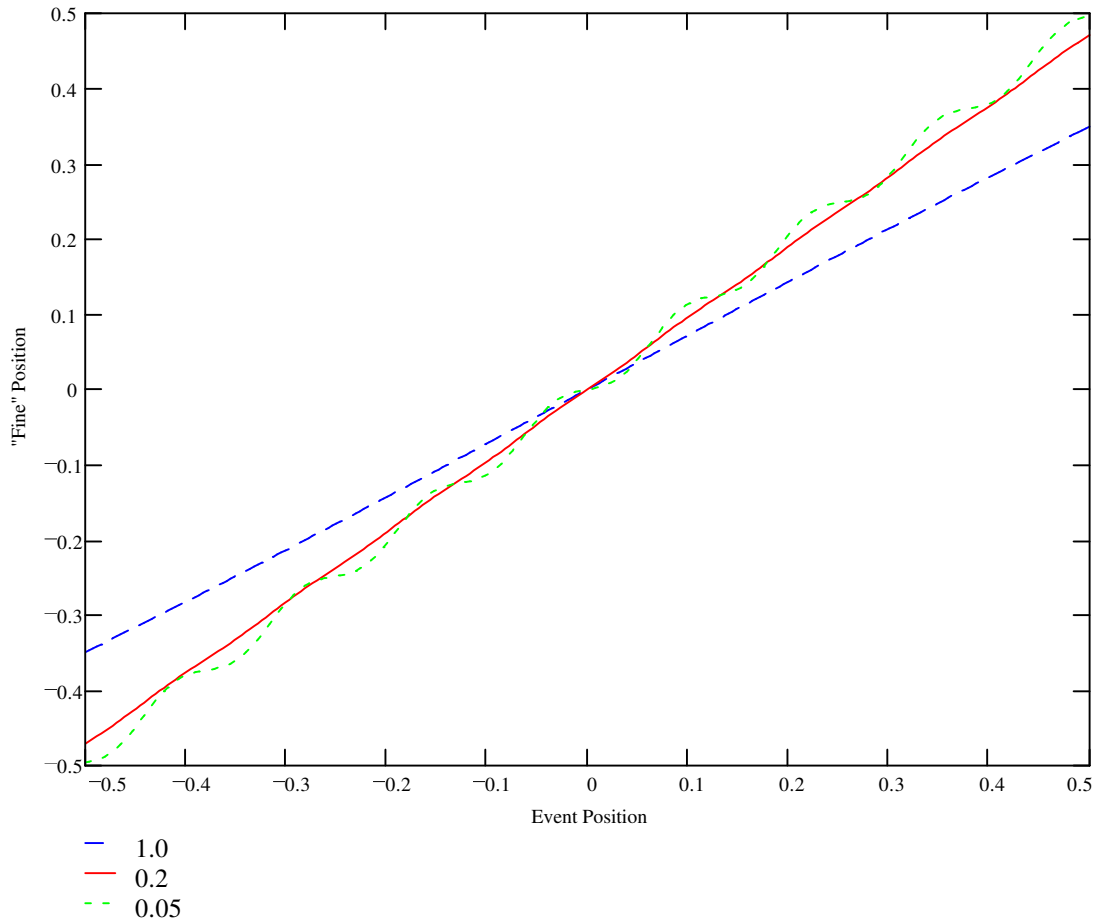
$$Q(z, \gamma, tap) := \sum_{i=-7}^{7} I\left(\frac{i}{8} + tap, z, \gamma\right) \cdot f(i)$$

The event "fine" position is calculated using the 3-tap algorithm

$$X_{fine}(x, \gamma) := \frac{Q(x, \gamma, 1) - Q(x, \gamma, -1)}{Q(x, \gamma, -1) + Q(x, \gamma, 0) + Q(x, \gamma, 1)}$$

$$X_{real} := -\frac{128}{256}, -\frac{127}{256} .. \frac{128}{256}$$

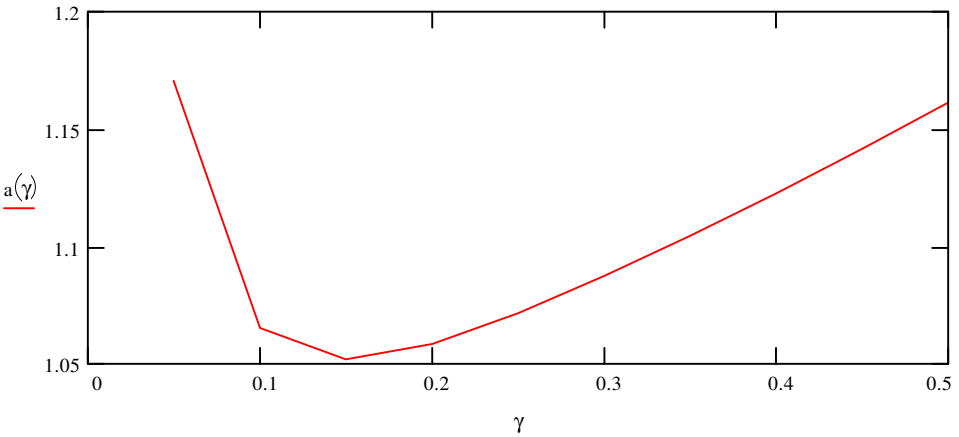
We can plot the derived fine position as a function of event position for different charge distribution widths.



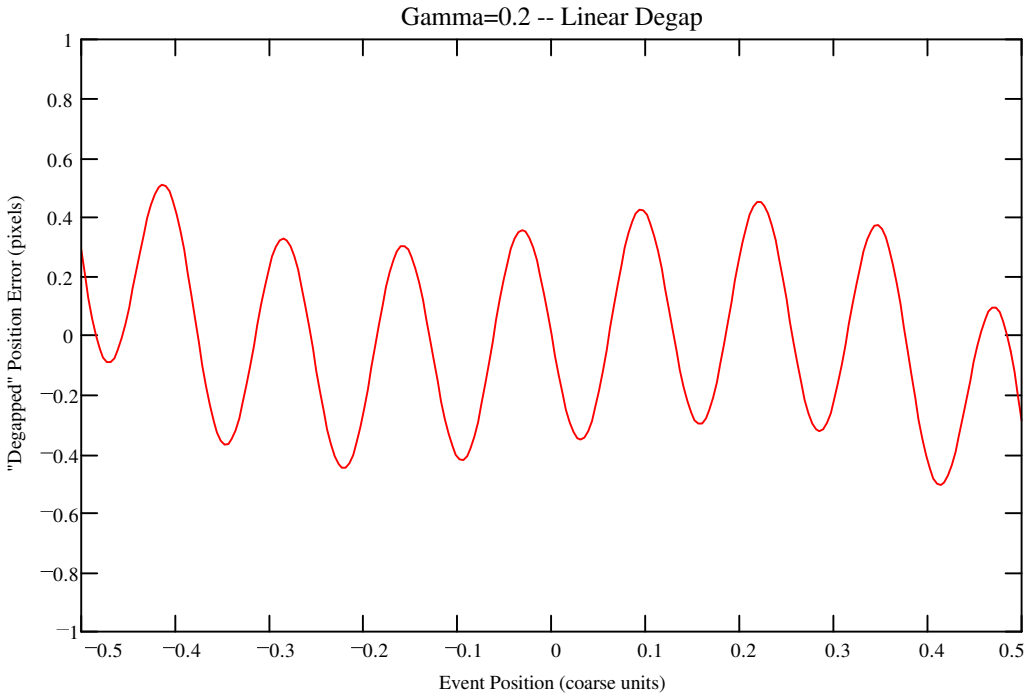
An approximate linear strectch factor can be calculated as a function of distribution width using the determined fine position as a function of event position.

$$a(\gamma) := \frac{\sum_{n=-128}^{128} \frac{n}{256}}{X_{fine}\left(\frac{n}{256}, \gamma\right)} \qquad 257$$

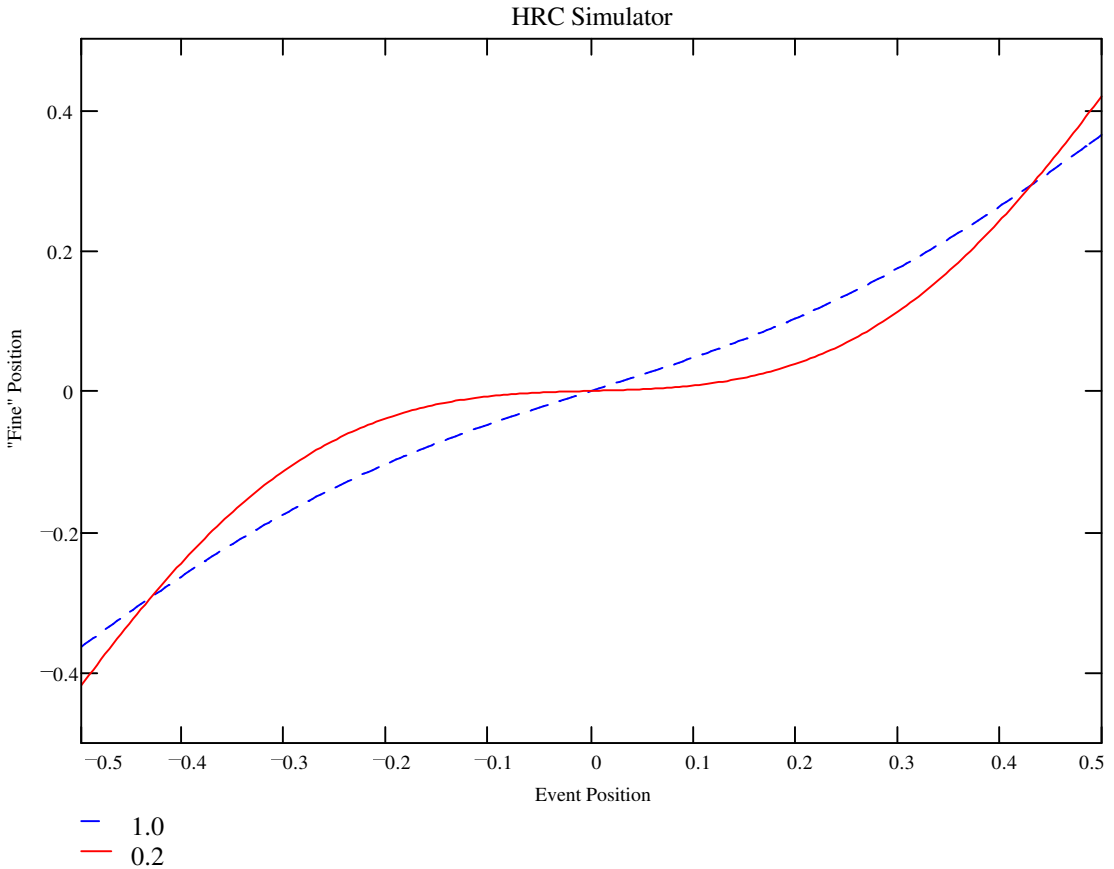
$\gamma := 0.05, 0.1 .. 0.5$



$b := a(0.2)$



The current version of the ASC HRC simulator does not follow the above calculational scheme and as a result does a poor job of simulating the actual behavior of the MCP readout.

Instead of calculating the contribution of the charge on each wire to the tap readout, the simulator uses the value of the distribution at the location of the tap relative to the event position. This becomes a very poor representation of the charge that would appear on the tap for distributions that are narrow relative to the tap spacing. While the size of the gaps shrinks for narrow distributions when this approximation is used, the fine position distribution peaks toward the center too much.

$$X_{fine_sim}(z,\gamma) := \frac{L(1,z,\gamma) - L(-1,z,\gamma)}{L(-1,z,\gamma) + L(0,z,\gamma) + L(1,z,\gamma)}$$