Active Collimator (Fall 2011)

Here is the documentation of work completed in the summer of 2011.
[Google Document from Summer 2011]

Project goals for the Fall of 2011 (2 credits)

1. Confirm or rule out the revised model that includes both positive currents from interactions in the block being read out, and negative currents from interactions in material elsewhere in the detector that back-scatter into the read-out block.[1]

9/8/2011(9:30-1:00)
After speaking with Igor, the process with which I will apply convolution theorem has become more apparent. I will make a Gaussian model of the beam that will have a sigma of a few millimeters. I will then multiply it by a " pick-up " Gaussian function that is wider than the beam function (sigma of about 10 cm). I will then multiply the product (in a piecewise manner) with the model of the beam and integrate the second product from negative infinity to positive infinity.

$$(f \otimes g)(t) = \int_{-\infty}^{+\infty} f(t-\tau) * g(\tau)\, d\tau$$

Where $g(\tau)$ is the model of the collimator, and $f(t-\tau)$is the Gaussian function model of the beam piecewise multiplied by the Gaussian "pickup" function.

$$f(x) = ae^{\frac{-(x-b)^2}{2c^2}}$$

where a is the height of the Gaussian; b is the position center, and c is the width of the bell.

This is only the 1-D version, I will expand the program, once I get it working, to encompass 2 dimensions.

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[1]Dr. Richard Jones

$$f(x,y) = ae^{-\left(\frac{(x-x_0)^2}{2\sigma_x^2}+\frac{(y-y_0)^2}{2\sigma_y^2}\right)}$$

<u>9/13/2011(9:30-12:30)</u>

The outline for the Gaussian beam function is saved under beamGauss.m
It is still very basic but it looks like this thus far:

```
xmin = -10;
xmax = 10;
ymin = -10;
ymax = 10;
spacing = .4;
xvals = xmin:spacing:xmax;
yvals = ymin:spacing:ymax;

a1 = 1;
c1 = 1;
c2 = 2;
```

For the Gaussian beam, I do not need to have values for x_0 and y_0 because the beam is centered at zero. For the Gaussian "pickup" function I will need to incorporate these values because the center of the function will change based on the cheese that is being studied at the time.

<u>9/15/2011(9:30-12:30)</u>
After speaking with Igor today, it seems that my task is a little more complex than I thought it was.

My new approach is as follows:

$$b \otimes T - b \otimes \left[\sum (w_i \otimes n_i)\alpha_i\right]$$

where b = Gaussian for the beam
T = tungsten cheese being considered

w_i = weighted Gaussian
n_i = everything except for the cheese being considered
a_i = “weight” for material

then:

$$f^k(t) \; = \; \int b(t \; - \; \tau)\, T^k(\tau)\, d\tau \; + \; \sum \alpha_i^k \int w_i(t \; - \; \tau) n_i(\tau) d\tau$$

and in code it should look something like this:

$$sum(sum(beamGauss2(x, y, x_0(n), y_0(n), \sigma)\; .* \;\; small\,())) \;\; * \;\; (dx)^2 + w_i(x, y, x_0, y_0, \sigma).*$$
$$(ashtray() \; + \; coffeecup() \; + \; faceplate() \;\; + \; large() \; + \; other\; small()\,) \;\; * \;\; \alpha_i^{small}$$

Also, a Gaussian function that will work for both the beam and the weighted function has been completed.

<u>9/20/2011(10:00-12:00)</u>
<u>9/22/2011(9:30-11:30)</u>
With the way that I am approaching this problem, both of my matrices are required to be the same size. The size(beamGauss2) = 51 by 51 matrix. If I have the spacing of getFullDet=.12 then the size of it will also be a 51 by 51 matrix. I will ask Igor how to fix this issue and make beamGauss2 a function that isn’t a matrix, and how to perform multiplication and sums with something that is not a matrix. Igor had mentioned that I take the mesh out of the beamGauss function but the parameters of the collimator will not be defined if I do that.

<u>9/27/2011(9:00-1:00)&(4:00-5:00)</u>
I am still using convolution theorem to find the “shape of the beam” using the model of the collimator and some Gaussian functions. =

I just finished speaking with Dr. Jones. Here is the approach that he suggested I take:

$$b \;\; \otimes \;\; \left[\sum w_i \;\; \alpha_i \right]$$

where b = Gaussian for the beam
w_i = weigh factor, +1 for the cheese being considered, in the interval (-1,0) for all other

material in the collimator package
a_i = “weight” for material (the collimator)

$$(f \otimes g)(t) = \int_{-\infty}^{+\infty} f(t - \tau) * g(\tau)\, d\tau$$

so, if f=b and g=$\sum w_i \; \alpha_i$

then

$$\left(b \otimes \left[\sum w_i \alpha_i\right]\right)(t) = \int_{-\infty}^{+\infty} b(t - \tau) * \left[\sum w_i \alpha_i\right](\tau)\, d\tau$$

I will need to have three functions: a_i is the collimator, b is the Gaussian, and that function has already been written out (I just need to fill in the height, it’s center point, and sigma), and w_i will be the only thing I need to create.
I want to end up with a 1-d function, and I think by taking the sum of w_i and a_i that’s what I will end up with.
It also may be possible to do it another way...
Since fft(b$\otimes$ g) = fft(b)*fft(g)

where b = the Gaussian beam shape and g =$\sum w_i \; \alpha_i$

I should be able to take the inverse Fourier transform and end up with the shape of the beam as seen that resembles the data that was collected.

<u>9/29/2011(9:00-2:00)</u>

The coefficient matrix:

	Ll	Sl	Sr	Lr	A	C	F
Ll	*	*	*	*	*	*	*
Sl	*	*	*	*	*	*	*
Sr	*	*	*	*	*	*	*
Lr	*	*	*	*	*	*	*

<u>10/3/2011(4:00-5:00)</u>

The plan until Tuesday evening is to work on the coefficient matrix and the shape of the beam to see if I can get the hypothetical beam signal to match the actual beam signal.

<u>10/4/2011(9:30-1:00)&(4:00-5:00)</u>

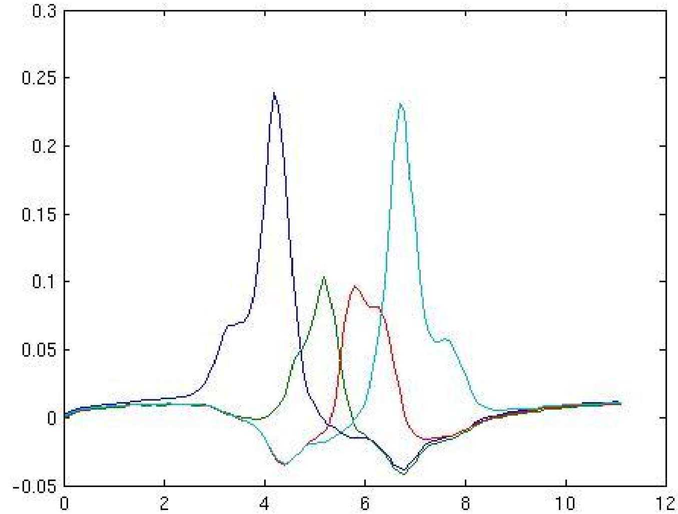
By multiplying my Gaussian beam function by:
$\sqrt{\pi/2}\left(1 + Erf\left[\frac{2*\sqrt{2}*x}{3}\right]\right)$ or another form for a different value of omega, the hope is to skew the Gaussian function so that the tail in the positive x direction is more pronounced.

<u>10/5/2011(3:30-5:00)</u>
Multiplying the Gaussian by an error function did not work. What did work however was adding another Gaussian to the original, and offsetting it. This added a "tail" to the original Gaussian function.
<u>10/6/2011(9:00-5:00)</u>
<u>10/13/2011(11:00-12:30)</u>
Igor has helped me create 4 functions that take the Gaussian function and sweep through the model collimator. By changing the coefficients given to each part of the collimator I hope to be able to replicate the actual beam data.
<u>11/1/2011(9:00-11:00)</u>
<u>11/3/2011(9:00-1:00)&(2:00-3:00)</u>
The mock-up has been used over the past month with a little success. Although the model beam data resembles the shape of the actual beam data there are quite a few inconsistencies. In order to rectify those inconsistencies, I have added bolts to the model collimator and zeroed out the ashtray. I have also made the skew on the Gaussian more pronounced. Although there has been a little improvement in the results

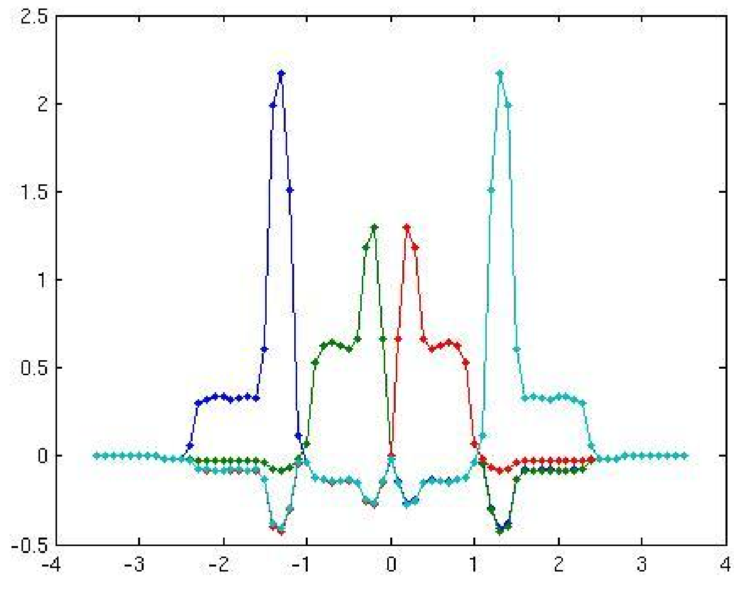
I am still hopeful that a better replication of the beam data can be made. The inconsistencies are so much that they cannot be ignored. I hope to resolve them within the next week now that I have added the bolts to the model. Because there are so many variables I am having a hard time keeping things organized and approaching this in an orderly fashion. Instead, I have found myself just changing whatever seems appropriate and hoping it works. I will need to find a way to organize my data; the changes made to the variables and the plot of the results. I think once I get that, I will have a better hold on the process of analyzing this data.

<u>10/8/2011(3:00-5:00)</u>
Worked on the online safety certification. It is now complete

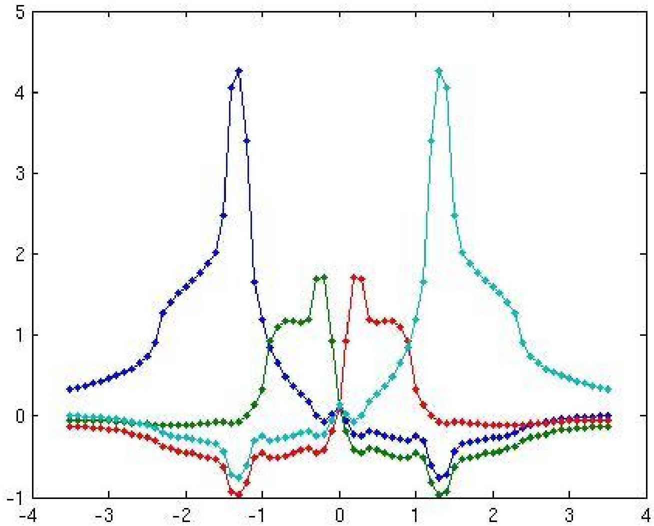
<u>10/10/2011(10:15-12:45)</u>
Today the plan is to make a function that better mimics the beam. The goal is to have a Gaussian function in the center surrounded by $1/r^2$ for the tails of the Gaussian.
<u>10/16/2011(2:00-4:00)</u>
In the lab meeting last week a better beam shape was made. I will run the scan with this modified beam shape to see if the results are better. I will change coefficients as needed, and add or subtract bolts as well. Hopefully by the end of tomorrow I will have an appropriate model for the collimator and beam shape.
<u>11/17/2011(9:30-1:00)</u>



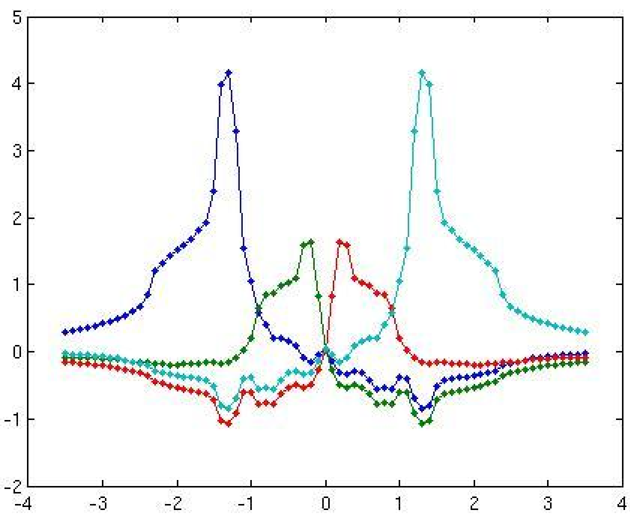
The original beam data.



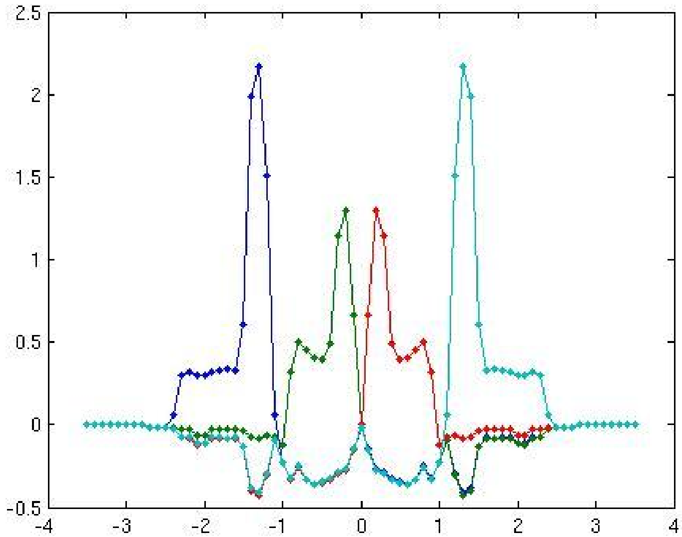
To compare, this is a simple Gaussian, with no bolts.



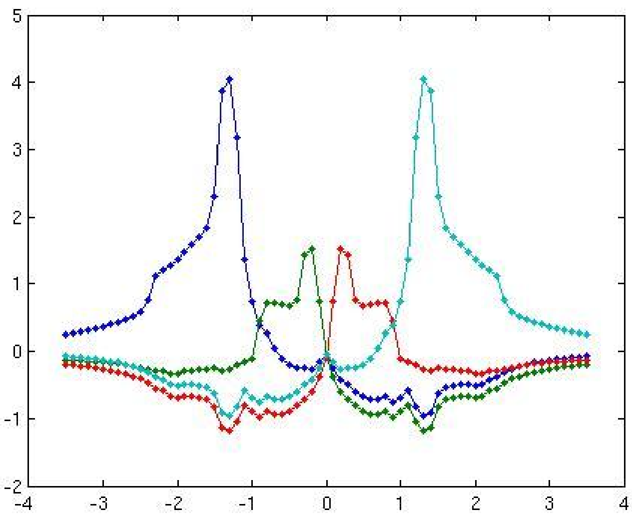
This is the $1/r^2$ added to the Gaussian, with no bolts.



$1/r^2$ added to Gaussian with smaller bolts



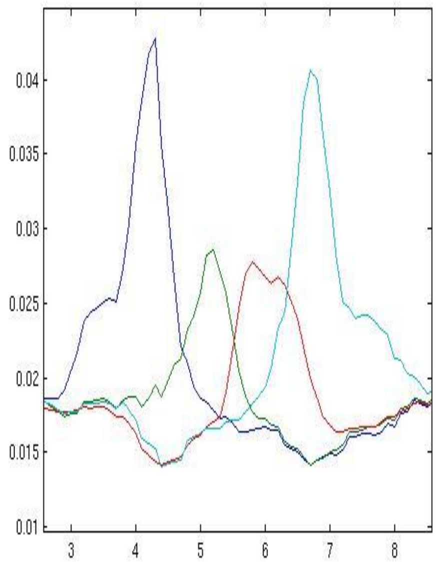
This is the simple Gaussian with larger bolts.

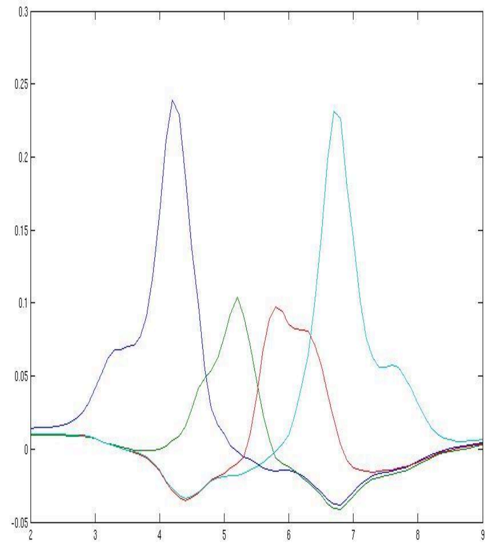


This is the $1/r^2$ added to the Gaussian with larger bolts.

<u>11/29/2011(9:00-11:00)&(12:00-1:00)&(4:00-5:00)</u>

It was found in the last weekly meeting that there is more symmetry in the beam than previously thought. On the left side, data from wedge 2,3, and 4 all line up at the bottom of the data. On the right side, the data from wedge 1,2 and 3 meet up and follow the same path. I will be looking at data from other runs, runs with different gain, to see if there is a way to extrapolate down to zero energy to see if the negative currents are still there.



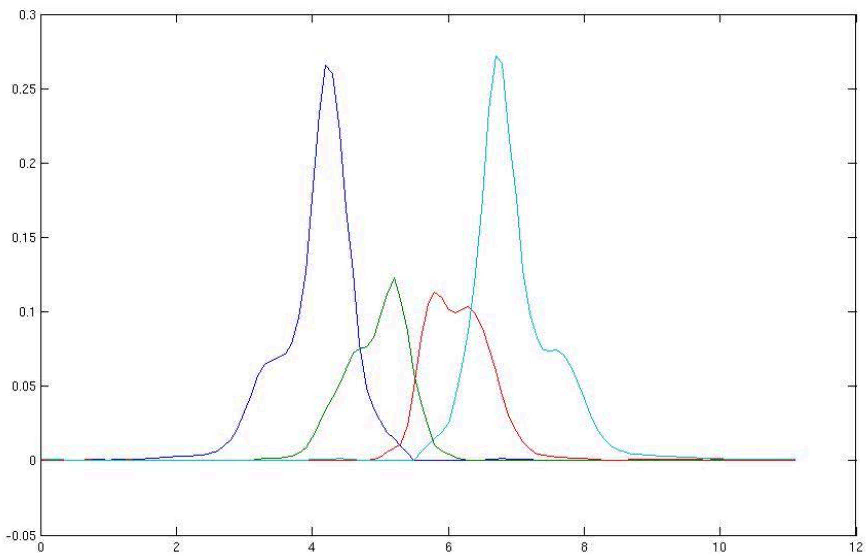


The figure on the left is run2, after the beam data was flipped, the beam current was divided out, and the data was offset to zero. The figure on the right is run3 modified in the same way as run2. They both display similar characteristics although run3 is smoother than run2. They both have the same dip, in the same places. I will try and compare the gain strength with the dips in data to see if there is a correlation. On further investigation it was discovered that there is no beam data that encompasses the dips with a different gain. The run that I was originally going to use for the third data point is too small to use. Normally the scans were through 11 inches of movement, the third data set is .2 inches. A new approach is needed.

2/8/2011(10:00-3:00)

The next plan of attack it to subtract the baseline from the beam data. This will make the beam data fall on or above zero voltage. I will then write a program that convolves a decaying exponential with the beam data in hopes to replicate the original beam data (without the baseline subtraction).

12/13/2011(3:30-5:00)



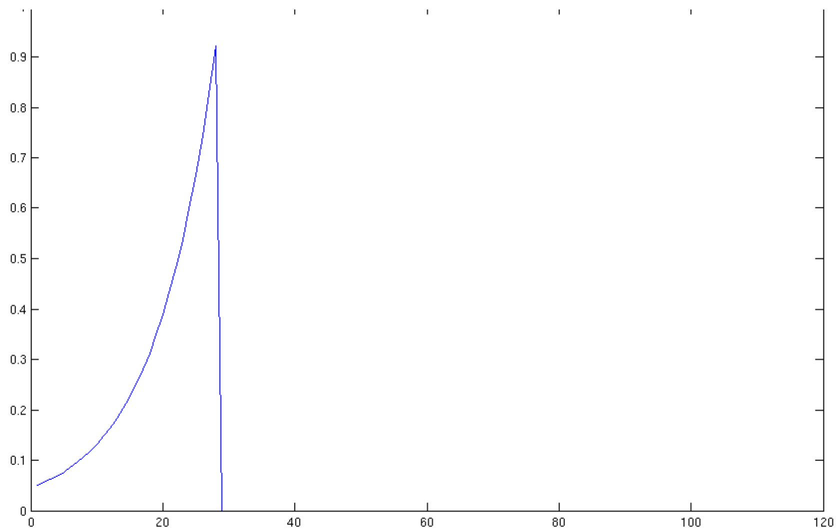
This figure was created by subtracting out the baseline from each of the wedge data. You can clearly see that the bumps on the data from wedge 1, 3, and 4 line up. The bump on wedge three, however, does not follow this pattern.

The next goal is to write a program convoluting a decaying exponential with this model to recreate the original beam data.

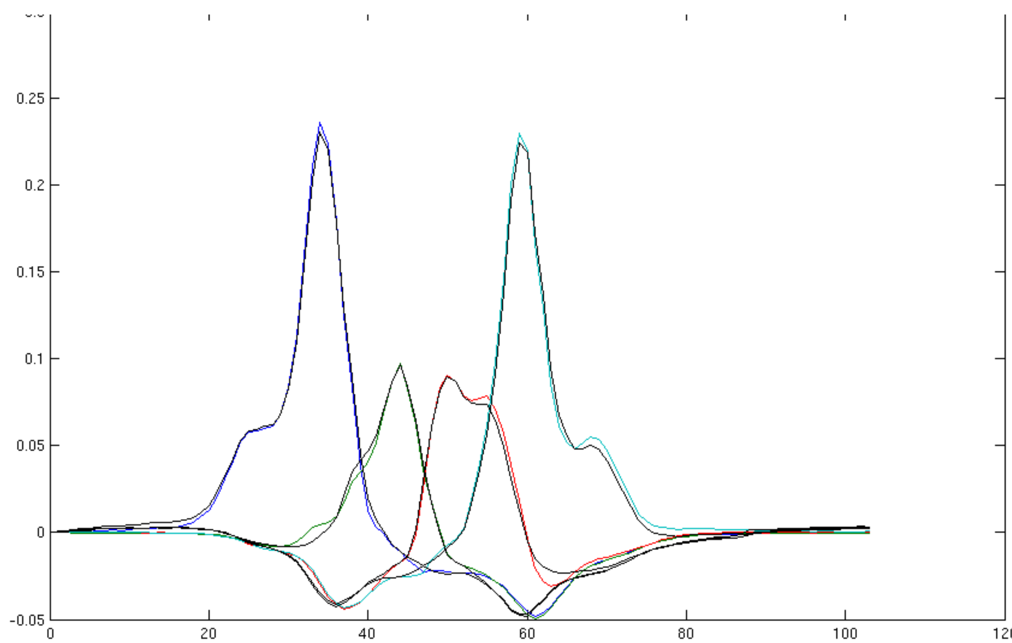
12/14/2011(10:30-11:30)&(3:30-5:00)

12/15/2011(8:00-3:00)

12/16/2011(10:00-5:00)



This is the reflected decaying exponential used in the convolution. It will be convoluted with the the beam data with the baseline taken out.



At first, I did not think that the convolution of two, always positive functions, would lead to a result with negative values. To fix this problem, convolution was performed on each of the wedge data. The results of each convolution were used to introduce a negative value to itself and the rest of the data.

In this figure the black lines are the original beam data, and the colored lines represent the fit, achieved using convolution theorem. Although the fit represents the actual data very well there are still some inconsistencies, namely the shift in the negative portions of the fit. Although the dips in the original data favor the right side of the peaks, the fit seems to favor the right side even more. This is, however, the best fit we have achieved in the seven months of work on this issue. I think the fit suggests that, yes, there was a charging up effect on the collimator as the beam swept along the surface.