Dear Doug,

In this paper I would like to describe you the procedure I am using to fit the data and problems that I have come across.

Before fitting the measured spectra I have first calculated the sum of all bins in the measured histogram (see figure 1), starting from the right side of the histogram:

$$\sum_{i=nbins}^{1} N_{\delta}(i) \approx \int_{\delta_{max}}^{delta} N(\delta)$$

I get a Fermi like function that I then use with a proper weight (the magnitude of the first bin of the measured histogram) to subtract the background from my data. After I have got a "clean" momentum spectrum I have used following formula to determine the mean value of the momentum.

$$f(E') = \sqrt{\frac{\pi}{2}} \frac{\sigma}{\alpha} \exp\left(\frac{1}{2\alpha}(\sigma^2/\alpha + 2(E'-b))\right) Erfc\left(\frac{|\alpha|}{\sqrt{2}\sigma\alpha}(\sigma^2/\alpha + (E'-b))\right) \quad ,$$

where b represents the mean momentum, sigma is the width of the Gaussian distribution and alpha describes the behavior of the radiative tail.

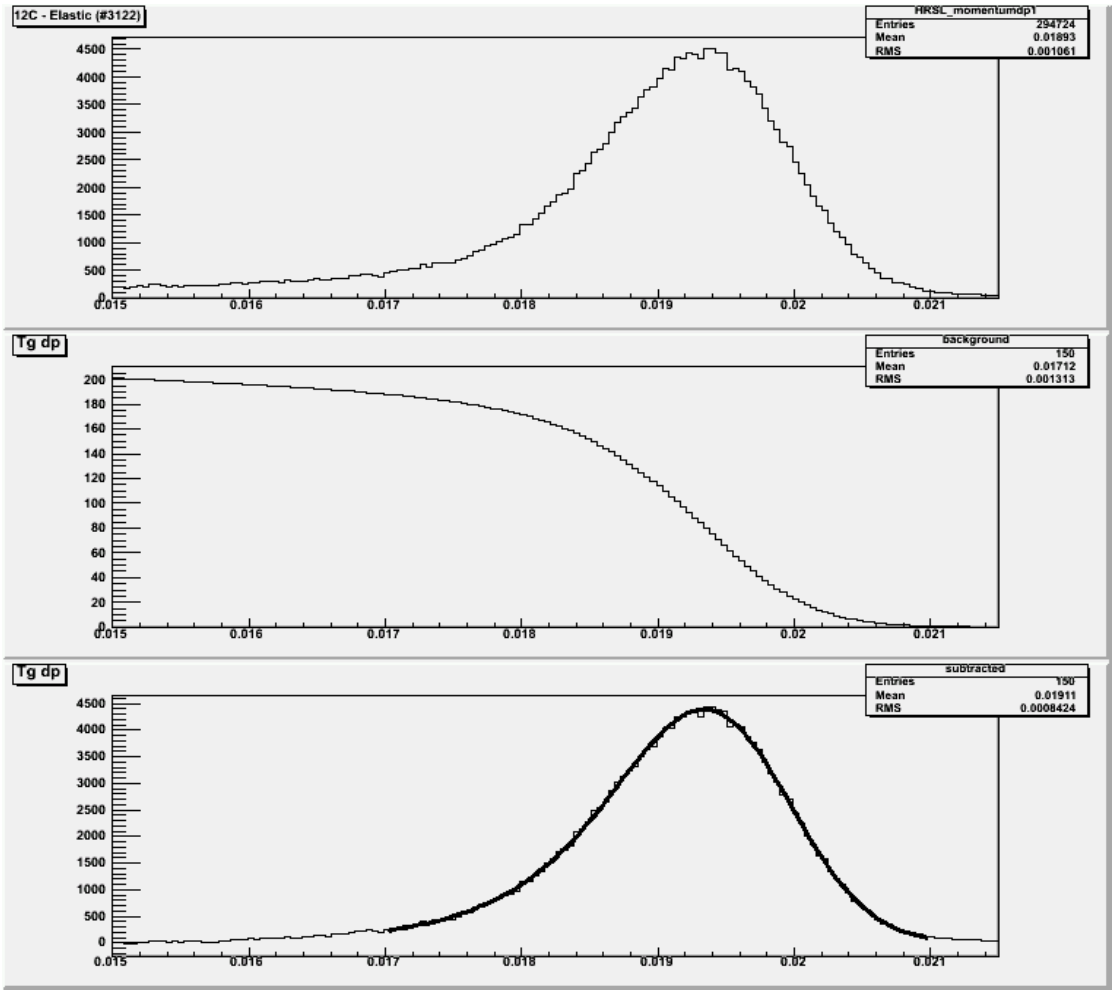

Illustration 1: The first graph shows the measured data, the second graph shows the sum of the bins in the first graph, starting from the left side of the graph. The third graph shows the subtracted data and corresponding analytical fit.

Momentum points for various targets and spectrometer angles that I have got with this procedure are shown in the figure 2 (please do not mind the error bars).

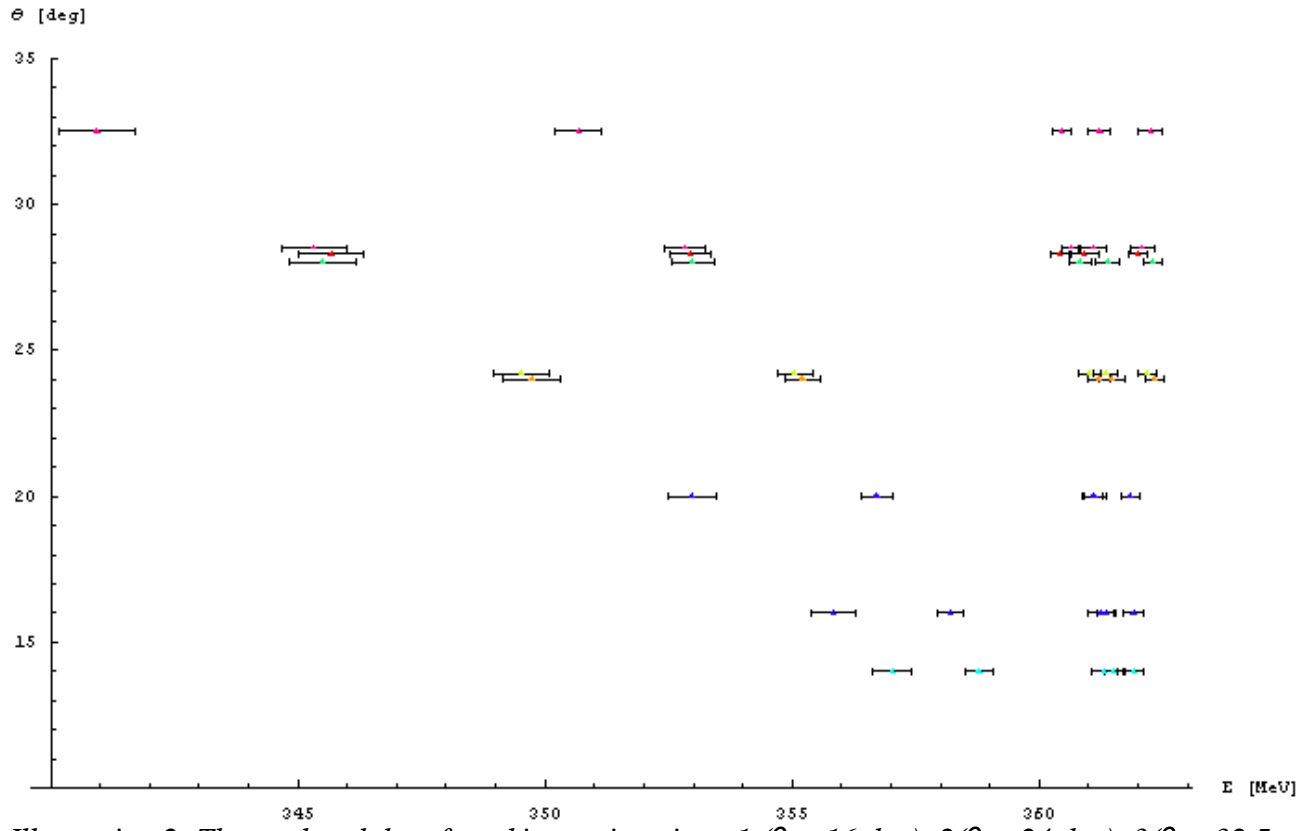

Illustration 2: The analyzed data from kinematic points: 1 (θ = 16 deg), 2(θ = 24 deg), 3(θ = 32.5 deg), 9(θ = 14 deg), 10(θ = 20 deg), 11(θ = 28.3 deg). Points with different colors correspond to different kinematic points.

After that I have estimated the energy losses of electrons in the various targets. For this purpose I have used the MCEEP. I have made the simulations for E_beam = 362MeV, and for all targets and for different angles. I have analyzed the simulated data with the same procedure that I have used to analyze my real measurements. Once I have determined the momenta of scattered electrons I have compared them with the momenta of the ideal experiment without energy losses. From the differences between the simulated and ideal momenta (see figure 3) I was then able to estimate the energy losses of the electrons for various targets:

Target	Δ E
Hydrogen	1.427 MeV
Deuterium	1.533 MeV
Carbon Single	0.456 MeV
Carbon Optics	0.570 MeV
Aluminum (first slit only)	0.702 MeV
Tantalum	0.393 MeV

After that I was ready to fit my data and to determine the beam energy and the central momenta of the spectrometers for all the kinematic settings. I have made the analysis for the both spectrometers separately. .

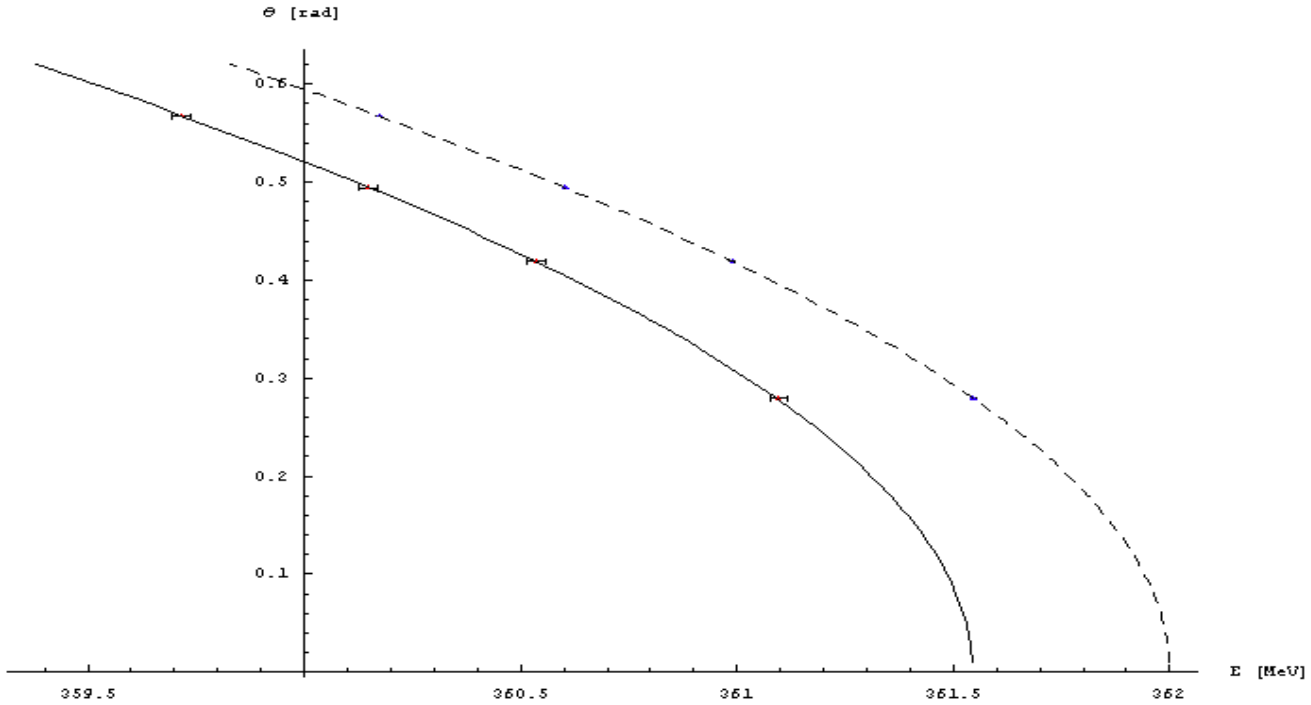

Illustration 3: The red dots show the simulated momenta with MCEEP for the one slit Carbon target at different angles. The blue dots show the momenta of scattered electrons at the same kinematic points for the ideal case without energy losses.

HRSL – analysis:

I have used the following function to fit the data:

$$\delta + 1 + \Delta\delta = \frac{\delta_c}{1 + \frac{E_{beam}}{M}(1 - \cos\theta)} \quad \text{and} \quad E_{beam} = \delta_c E_c \quad \text{and} \quad \Delta\delta = \frac{\Delta E}{E_c(simulated)}$$

First I have fitted data for every kinematic setting separately and got the following results:

Kinematic	theta	chi^2	E_beam	δc	E_c
Kin2, Run2	24 deg	0.089	363.937 MeV	1.01862	357.28 MeV
Kin2, Run1	24 deg	0.105	362.83	1.01909	356.03
Kin11, Run1	28.3 deg	0.0815	361.263	1.02538	352.321
Kin11, Run2	28.3 deg	0.129	358.529	1.02463	349.911
Kin3, Run1	32.5 deg	0.0311	357.555	1.03229	346.371
Kin 1, Rin1	16.0 deg	0.094	344.137	1.01829	337.958

These are not good results, because the beam energy is varying to much. We assume that the beam energy is the same for all kinematic points. Therefore I have used the following iterative procedure to determine the "mean" beam energy: In the first step I have assumed that the Hall probes give the correct values for the spectrometer central momentum (field). With these values of the central momentum (I kept them fixed in this step) I have than tried to determine the beam energy for every kinematic point. In the next step I calculated the mean value of these energies. In the last step I fixed the beam energy in my fit function to this mean value and fitted only the central momenta of the

spectrometer. Once I got them I used them as a new approximations of the central momenta of the spectrometer in the first step of my routine. I have repeated this routine until the chi^2 of the whole system converged to its final (minimal) value. Results of this analysis are the following:

Kinematic	theta	chi^2	E_beam	E_c
Kin2, Run2	24 deg	0.122547	358.179 MeV	351.659 MeV
Kin2, Run1	24 deg	0.126535	358.179	351.49
Kin11, Run1	28.3 deg	0.0922925	358.179	349.327
Kin11, Run2	28.3 deg	0.13002	358.179	349.573
Kin3, Run1	32.5 deg	0.0318687	358.179	346.97
Kin 1, Rin1	16.0 deg	0.154646	358.179	351.71

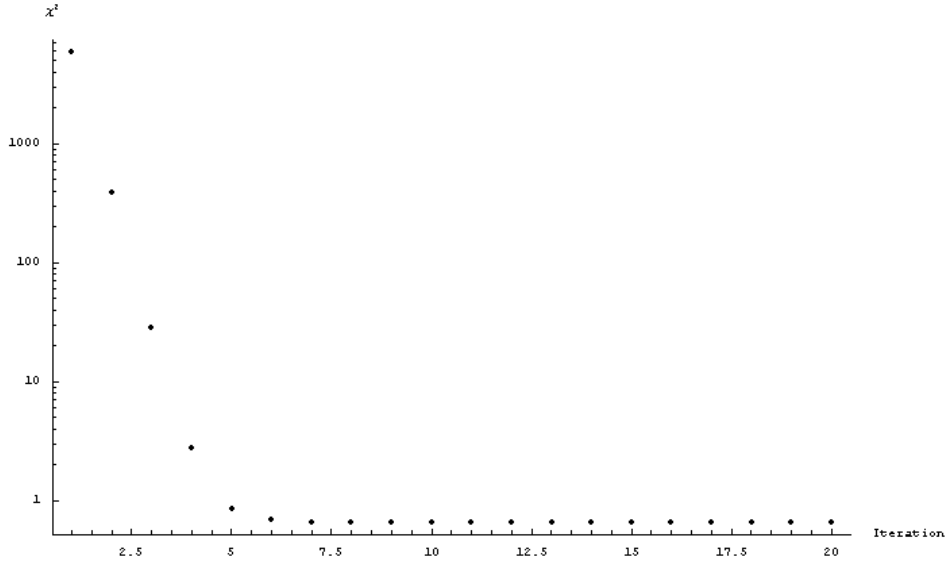

Illustration 4: Graph shows Total Chi^2 depending of the number of iterations.

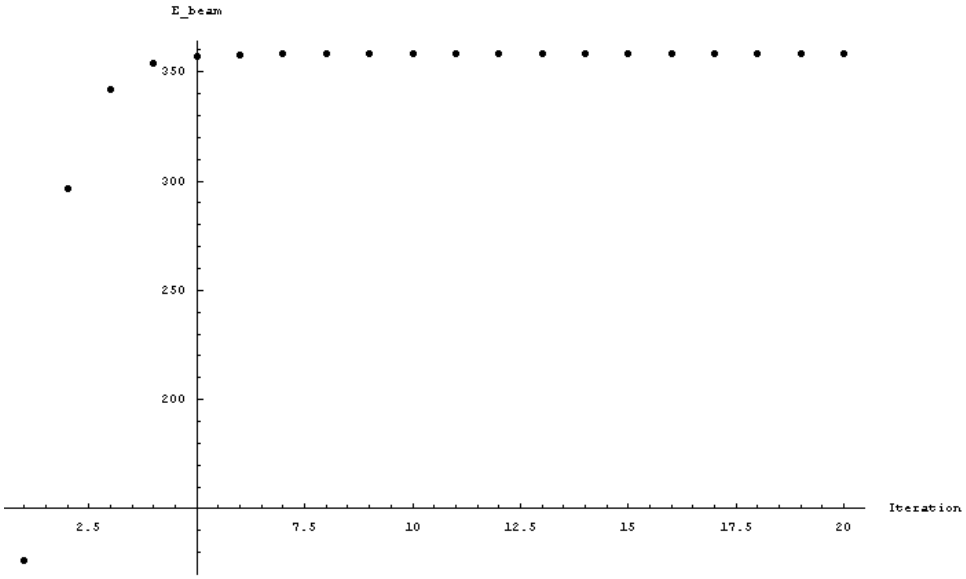

Illustration 5: Graph shows how the mean beam energy changes with the number of iterations

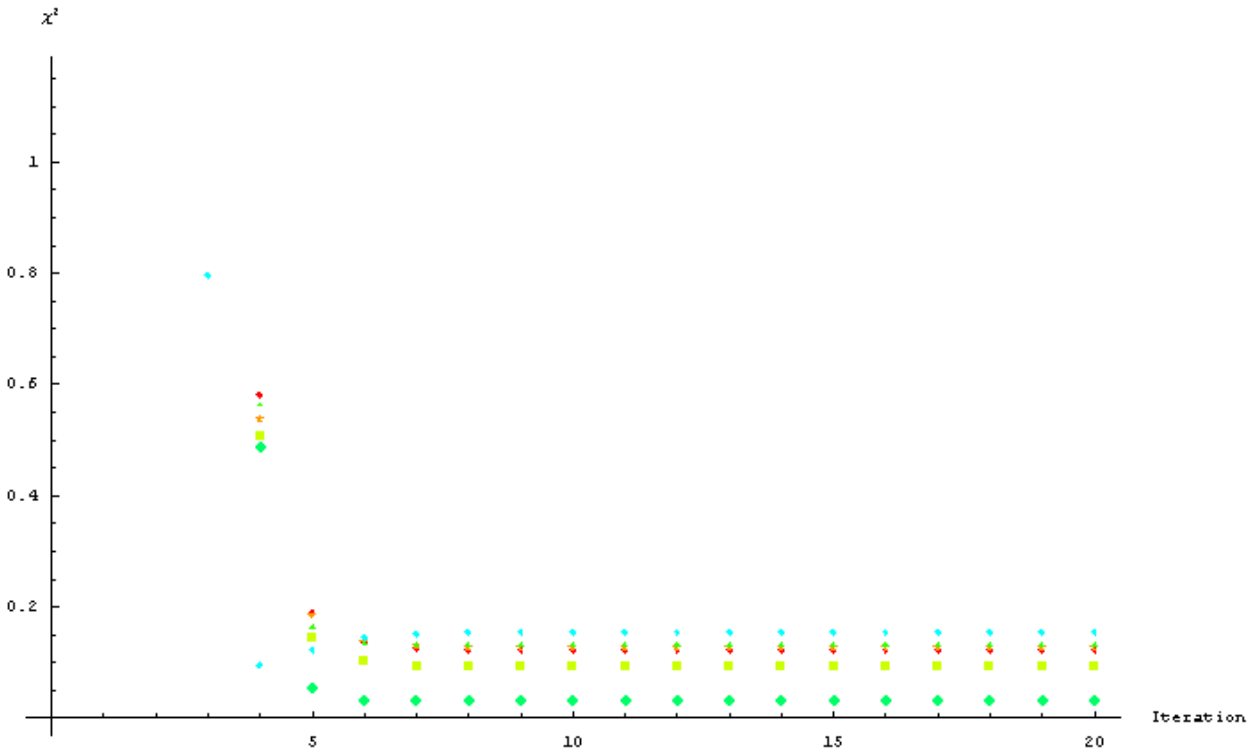

Illustration 6: Graph shows how chi^2 for each kinematic point changes with the number of iterations

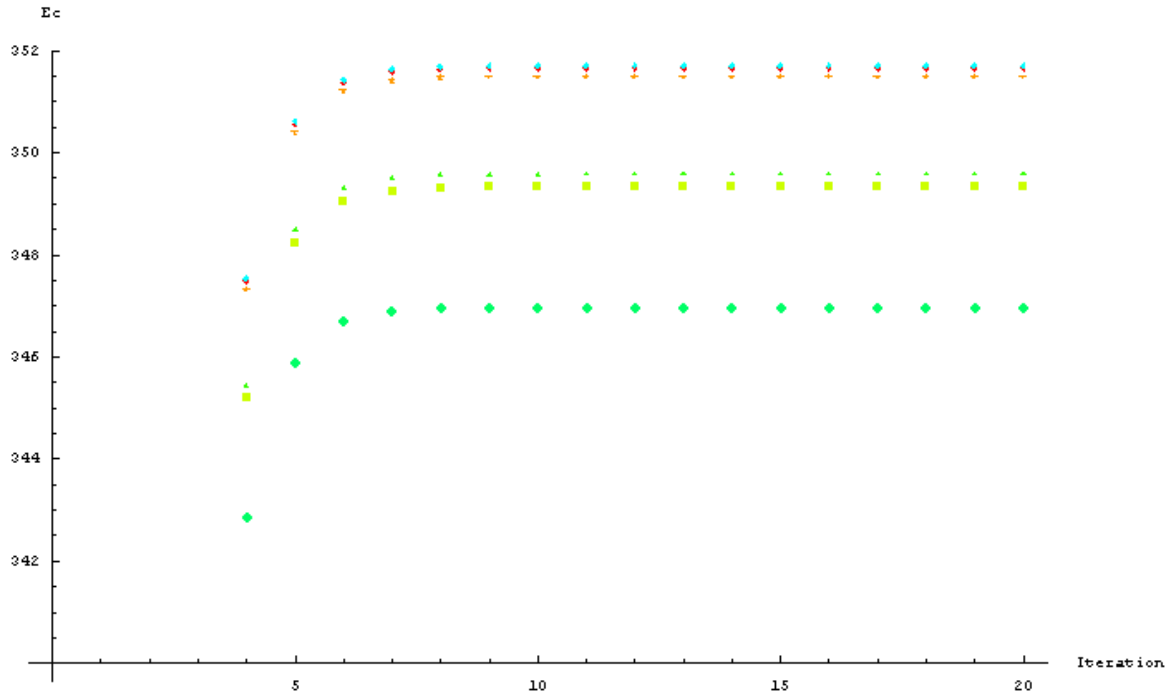

Illustration 7: Graph shows how the central beam energy of the spectrometer for the given kinematic point changes with the number of iterations.

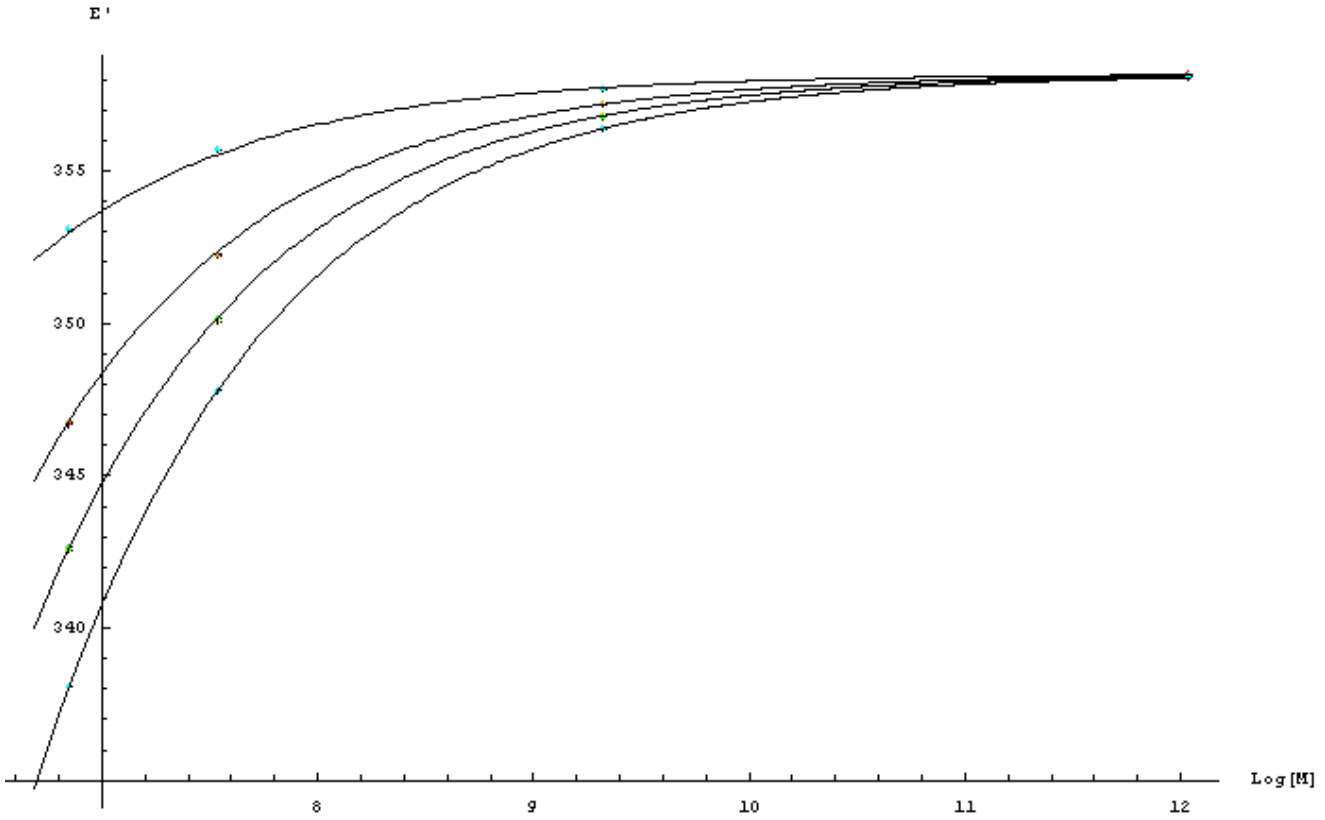

Illustration 8: Graph shows the measured points and their analytic fits.

HRSR- analysis

To analyze HRSR data I have used the same technique as I did for the HRSL data. The results that I got are:

Kinematic	theta	chi^2	E_beam	E_c
Kin11, Run2	28.3 deg	0.849	345.04 MeV	335.557MeV
Kin 10, Run 1	20 deg	0.05286	345.04	335.654
Kin 9, Run 1	14.0 deg	0.0826	345.04	335.597
Kin1, Run1	16.0 deg	0.0931	345.04	335.61

It can be clearly seen that there is a big difference between the beam energy that I got from HRSL analysis and beam energy got with HRSR analysis. This of course can not be right. Therefore, I tried to understand what causes this difference. While I was examining my analysis I looked at the graphs of the magnetic fields inside the spectrometer and how they change during the experiment. There I found a thing that is bothering me. If I look at the data for the HRSL spectrometer all its magnets are set to the same momentum. However, when I look at the data for HRSR, I realized, that the dipole is set to a bigger momentum than the quadrupole magnets. Therefore I suspected that this wrongly set momentum causes the difference in my analysis. If the momentum of the dipole is set to the wrong value than the electrons will deflect more/less inside this spectrometer than they should, and consequently come to the wrong point in the focal plane. However, the transport matrix which is used to reconstruct the momentum of the particle does not know that and will consequently give me the wrong momentum of the particle.

To check my hypothesis I made a simple simulation for tracking electrons through the HRS spectrometer, and tried to estimate the error in the momentum, caused by the wrong magnetic field inside the dipole magnet. I have found out, that in my simulation the central trajectory (\delta = 0%) of the spectrometer with the wrong magnetic field , corresponds to the trajectory with \delta = -1.8% in the spectrometer with the correctly set magnetic field. That would mean that if the magnetic field is truly to big in the dipole magnet, we would measure smaller momenta than they really are. Is this possible?

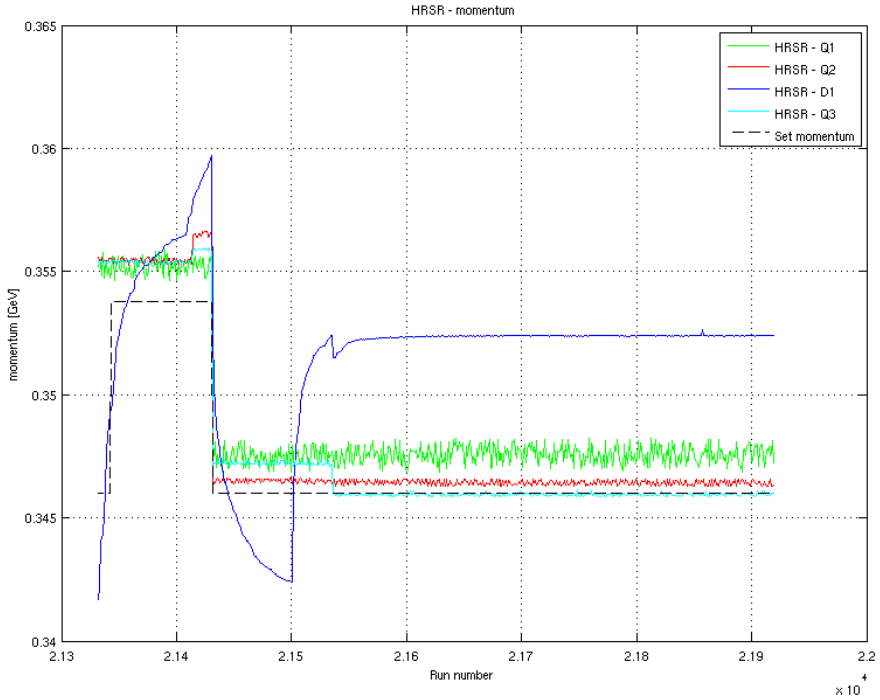

Illustration 9: Graph shows calculated momenta (from the Hall probe data) for various magnets inside the HRSR spectrometer.

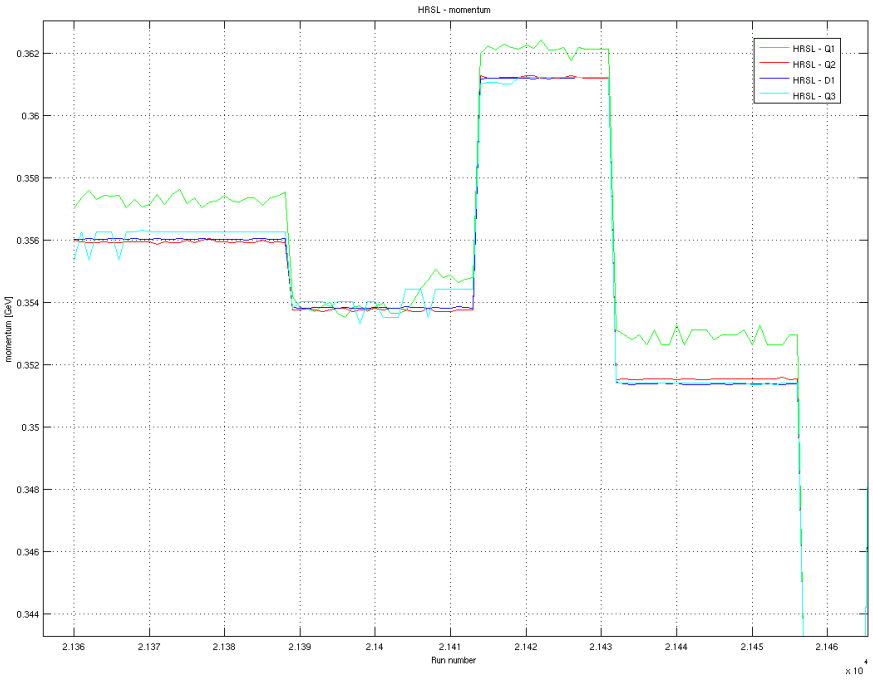

Illustration 10: Graph shows calculated momenta (from the Hall probe data) for various magnets inside the HRSL spectrometer.

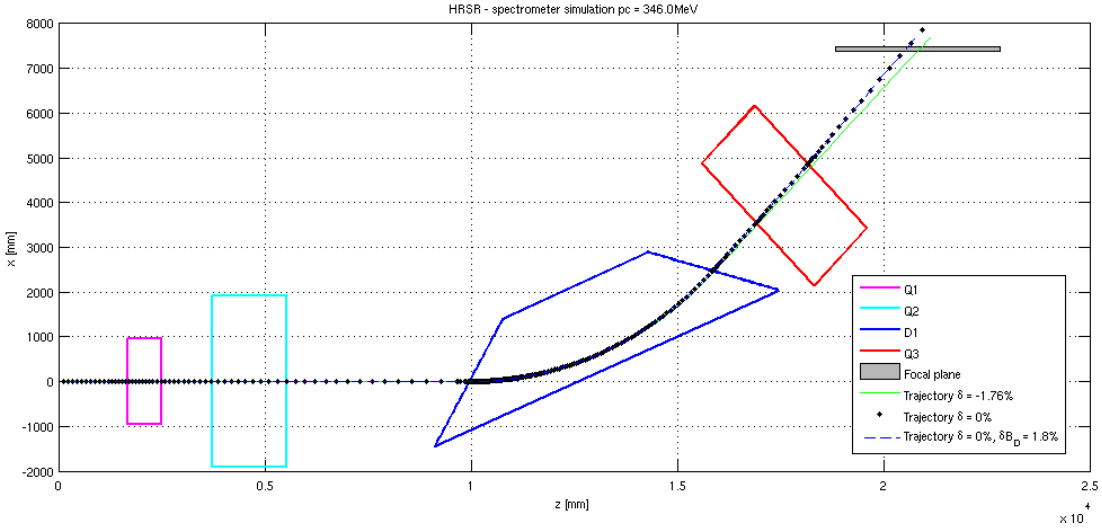

Illustration 11: Results of the simple simulation for particle transport inside the HRSR.