Plasma Density Analysis for E-162 March 2001 Run (Run 6)

This note is a summary of the analysis of plasma density measurements associated with the first E-162 run (March, 2001). It is a substantial update of ARDB-252 which was based on some of the data and the collisional-recombination coefficients of D. R. Bates *et al.*[1]

The data are

1. Density measurements made on the 25 cm oven at UCLA by P. Muggli *et al*[2]
2. Combined information from scans of a) trigger time at a fixed incident intensity and b) incident intensity with the laser triggered at the beam arrival time.
3. Laser intensity scans at different laser trigger times.
4. Measurements of the incident UV fluence from UV calibration data recorded during the run.

They are interpreted in the following frameworks

1. A collisional-recombination analysis based on the work of D. R. Bates *et al.*[1]
2. A betatron focusing analysis similar to that used for electrons.

Collisional-Recombination Analysis

D. R. Bates *et al*[1] have performed recombination calculations for hydrogen plasmas. Plasma recombination, which ignores density reduction due to diffusion, is given by

$$\frac{dn}{dt} = -\alpha n^2 \tag{1.1}$$

The most important conclusion from their analysis is that the recombination coefficient, α, is not independent of plasma density for the densities of interest to E-162. Their results are shown in figure 1. At $n = 10^{13}$ cm^{-3}, α is roughly proportional to n rather than independent of it. They also conclude that the analysis and recombination coefficients should be valid for singly ionized alkali atoms. P. Muggli *et al*[2] make reference to a calculation for radiative recombination in Li

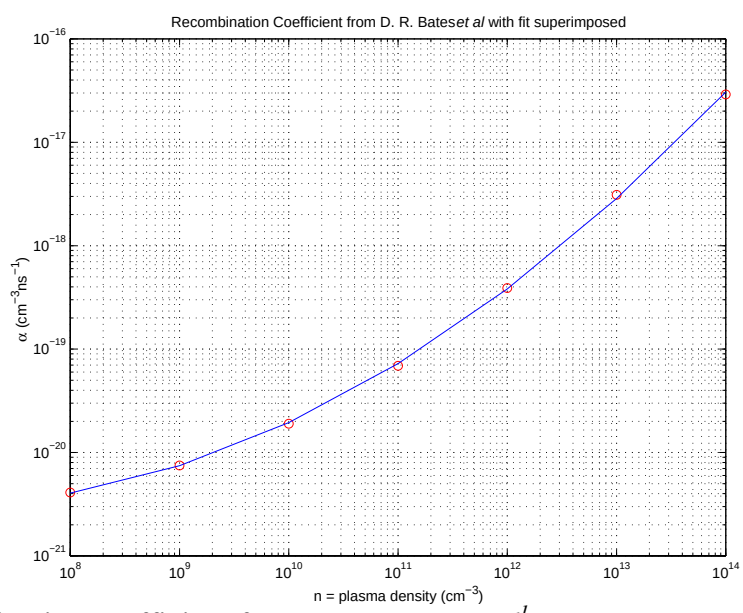


Figure 1: Recombination coefficient from D. R. Bates *et al*[1] at T = 1000 K. The line is a fit that is used when the evolution equation is integrated.

that has a ~30% lower radiative recombination rate.[3] This is small compared to the 3 orders of magnitude contributed by the collisional effects taken into account by Bates *et al*.
The fit shown in Figure 1 is used when integrating the evolution equation. It is

$$\alpha = \exp\left(p_1 \left(\ln n\right)^2 + p_2 \ln n + p_3 \right)$$
$$p = [0.0331463, -1.03288, -39.17675] \tag{1.2}$$
$$\alpha \text{ in units of cm}^{-3}\text{ns}^{-1};\ n \text{ in units of cm}^{-3}$$

Measurements with the 25 cm oven:[2] Interferometry at 674 nm was used to measure the time evolution of the plasma density. This wavelength is near a transition in Li, and that allows time evolution measurements although there is an overall scale factor that is uncertain. The data were fit with

$$\frac{dn}{dt} = -\alpha n^2 - \frac{n}{\tau} \tag{1.3}$$

where τ is a diffusion time scale. The two free parameters are τ and the initial plasma density that sets the overall scale. The evolution equation is integrated using the MATLAB differential equation integrator "ode45" in the MATLAB program "density_674". The results are shown in Figure 2 for $\tau = \infty$ and in Figure 3 for $\tau = 20$ μs and $\tau = 100$ μs. The conclusion from Figure 2 is that the data are well described by an initial density in the $n = 3\times10^{13}$ cm^{-3} to 4×10^{13} cm^{-3} and no diffusion ($\tau = \infty$). The initial plasma density is 30 to 40 times lower than the value from the raw interferometry data. From Figure 3 we see that the diffusion time could be as short as $\tau \sim 100$ μs but is inconsistent with $\tau \sim 20$ μs.

Measurements with combined scans: Information from scans of the trigger time at a fixed incident intensity and the incident intensity with the laser triggered at the beam arrival time can be combined by looking at common focusing features to give an "effective" incident UV energy

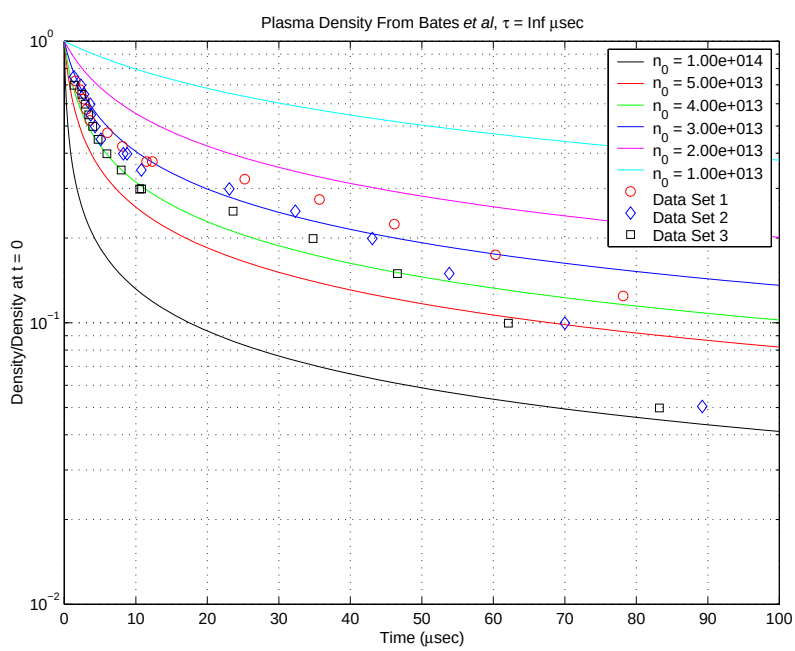


Figure 2: Density evolution data from P. Muggli *et al*[2] fit with eq. (1.3) with $\tau = \infty$ and the parametrization for α given by eq. (1.2).

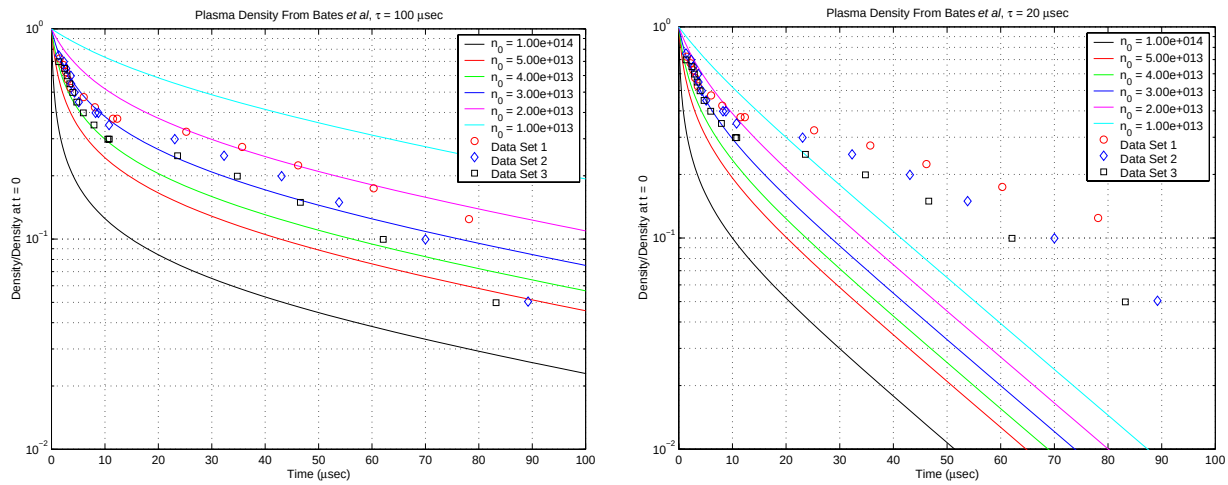


Figure 3: Density evolution data from P. Muggli *et al*[2] fit with eq. (1.3) with $\tau = 100$ μs (LHS) and $\tau = 20$ μs (RHS).

for different delay times. This incident energy is measured with the "Incident UV GADC". These data can be fit with eq. (1.3) using the parametrization in eq. (1.2). The results are shown in Figure 4. The free parameters in this fit are the initial plasma density, the proportionality constant between the Incident UV GADC and the plasma density, and the diffusion time. The MATLAB program used is "Bates_density".

Fits that constrain the diffusion time to $\tau = 30$ μsec, which is the asymptotic value for the data, and $\tau = 100$ μsec for comparison with the left-hand-side of Figure 3 are shown in Figure 5. It is clear that the shorter diffusion time is favored by the data. This seems to be in contradiction to the result presented above in Figures 2 and 3 where a large diffusion time is favored. A possible explanation (courtesy of Patrick Muggli) is

- In the case of the measurements with the 25 cm oven - the plasma was relatively uniform and the 674 nm interferometry performed in the center of the plasma. Diffusion would affect the

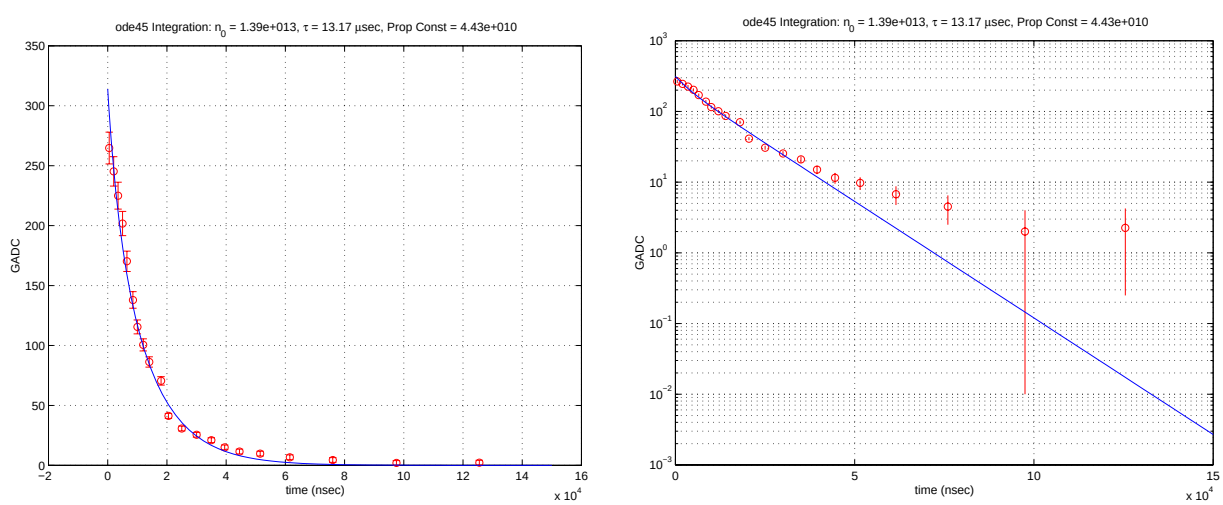


Figure 4: Fit of eq. (1.3) to the combined scans using the parametrization in eq. (1.2). The result of the fit is $n(t = 0) = 1.39\times10^{13}\text{cm}^{-3}$, $\tau = 13.2$ μsec, and the proportionality constant between the Incident GADC and plasma density = 4.43×10^{10} cm^{-3}/GADC. These results have some sensitivity to the errors. These have been taken to be max(0.05*GADC, 2).

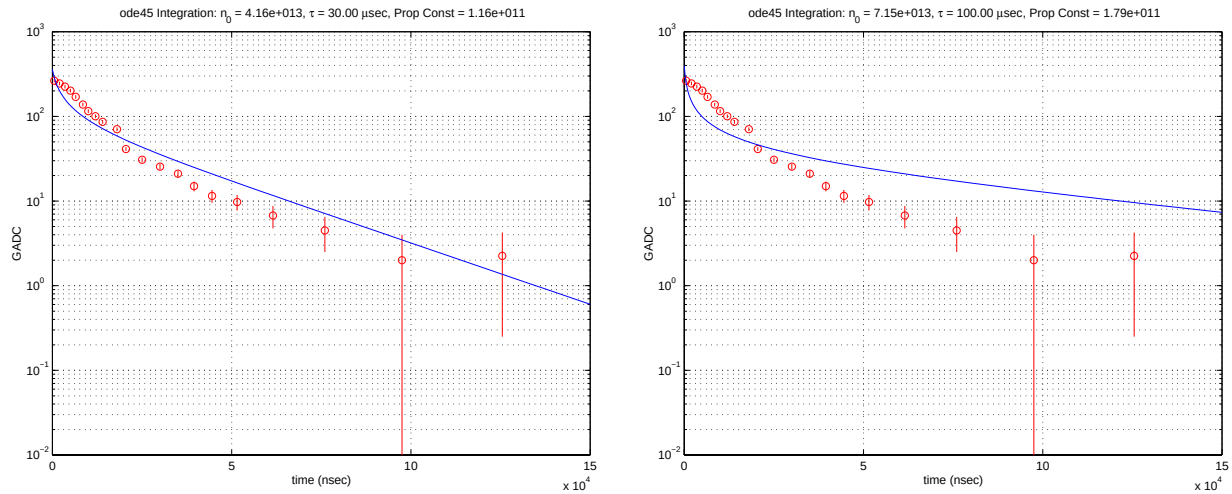


Figure 5: Fits of the combined scans with $\tau = 30$ μsec (LHS) and with $\tau = 100$ μsec (RHS).

edges of the plasma, but not the central density

- In the case of the combined scans – the plasma was not uniform and diffusion is more important.

A conclusion from this interpretation is that effective τ depends on the plasma uniformity. Since that can change day-to-day as optics damage and are replaced, it cannot be treated as a constant.

Measurements with different delay times: Laser intensity scans were taken on March 24 with different trigger delays. The runs with the associated trigger times and time stamp (Days Since 1/1/99) are in Table 1. The beam sizes on the downstream OTR and the Integrated Cherenkov have been fit with Gaussian distributions using Spring2.

The evolution of the plasma density is given by eq. (1.3) with two free parameters: (1) C_p ≡ the proportionality constant between the Incident UV GADC and the plasma density at $t = 0$ and (2) the diffusion time τ. The analysis (MATLAB program "decay_table") proceeds as follows.

1. Two sets of data are identified near the focusing minimum. They are shown in Figure 6. One is $\sigma_x(CV)$ at two trigger times, $t_1 = 15.98$ μs and $t_2 = 22.98$ μs. The one is $\sigma_y(DN)$ for , $t_1 = 6.98$ μs and $t_2 = 10.48$ μs. $\sigma_x(CV,t_1) = \sigma_x(CV,t_2)$ for

$$\frac{GADC(t_1 = 15.98\mu s)}{GADC(t_2 = 22.98\mu s)} = \frac{n_0(t_1)}{n_0(t_2)} \approx \frac{110}{330} = 0.3 \qquad (1.4)$$

2. Eq. (1.3) is integrated out to times t_1 and t_2 for different values of the initial density, n_0, and

Table 1: Data runs on March 24, 2001 with the laser trigger timing*1

Run	***Trigger Time (μs)***	***Days Since 1/1/99***	***Run***	***Trigger Time (μs)***	***Days Since 1/1/99***
03241cp	97.975	813.6302	03241cq	47.975	813.6345
03241cr	22.975	813.6381	03241cs	10.475	813.6416
03241ct	15.975	813.6459	03241cu	3.975	813.6497
03241cv	0.475	813.6542	03241cw*2	6.975	813.6578
03241cx	2.475	813.6616			

*1 These are the differences between the trigger time and the beam arrival time.
*2 No streak camera data taken for this run.

the diffusion time. The results are in Figure 7a. As an example, for a final density of $n(t_1)$ = 1×10^{12} cm^{-3} and τ = 9 μs, the initial density must be of $n_0 \sim 0.6\times10^{13}$ cm^{-3} $n(t_2)$ = 1×10^{12} cm^{-3} and τ = 9 μs, the initial density must be of $n_0 \sim 1.6\times10^{13}$ cm^{-3}. The initial density ratio is

$$\frac{n_0(n_1 = 1\times10^{12}, \tau, t_1)}{n_0(n_2 = n_1, \tau, t_2)} \approx \frac{0.6}{1.6} = 0.37 \tag{1.5}$$

The ratio can be calculated for a range of values of n_1 and τ and then plotted vs $n_0(t2)$. Figure 7b shows the result.

3. Finally, one can use the results in Figure 7b to develop a constraint between τ and the initial density for time t_2. The point of doing all this is that there is now a constraint from the between the initial density and the diffusion time that comes form the beam size data.
4. This analysis can be repeated for the $\sigma_y(DN)$ shown in Figure 6. The differences are the time t_1 and t_2 and the different ratio where $\sigma_y(DN, t_1) = \sigma_y(DN, t_2)$

$$\frac{GADC(t_1 = 6.98\mu s)}{GADC(t_2 = 10.48\mu s)} = \frac{n_0(t_1)}{n_0(t_2)} \approx \frac{150}{330} = 0.45 \tag{1.6}$$

5. The constraints from these two sets of data can be combined to give the result shown in Figure 8. The solid red curve is for the ration in eq. (1.4) and the ration for eq. (1.6) is between the dashed cyan and violet lines. The constraints are consistent with each other, but unfortunately do not provide really orthogonal information. The betatron focusing analysis that is presented below favors $n_0 = 3.3\times10^{13}$cm^{-3} for Incident UV GADC = 330, which is the value at t_2 for both sets of data, and τ = 12 μs (this diffusion time is consistent with the value from Figure 4). This point is plotted in Figure 8 and is seen to be consistent with the constraints. The parameter that enters much of the discussion below is the proportionality constant between the initial plasma density and the Incident UV GADC. This point is

$$C_p = \frac{n_0}{Incident\ UV\ GADC} = 10\times10^{10} cm^{-3} / GADC \tag{1.7}$$

Earlier work (based on the MATLAB program "density_analysis") attempted to vary C_p and τ independently where a qualitative criteria of a smooth connection of the various data set was used. However, the two-dimensional parameter space and not having a quantitative measure of smoothness led to a wide range of results that were difficult to interpret. The analysis presented above was developed as an alternative. A final check is to put the parameters in eq. (1.7) in the density analysis and look at the connections between the data. The result is in Figure 9, and the conclusion is that the procedure connects the data for all but when the trigger delay is 0.48 μs. At this short delay time the Gaussian fits are not meaningful.

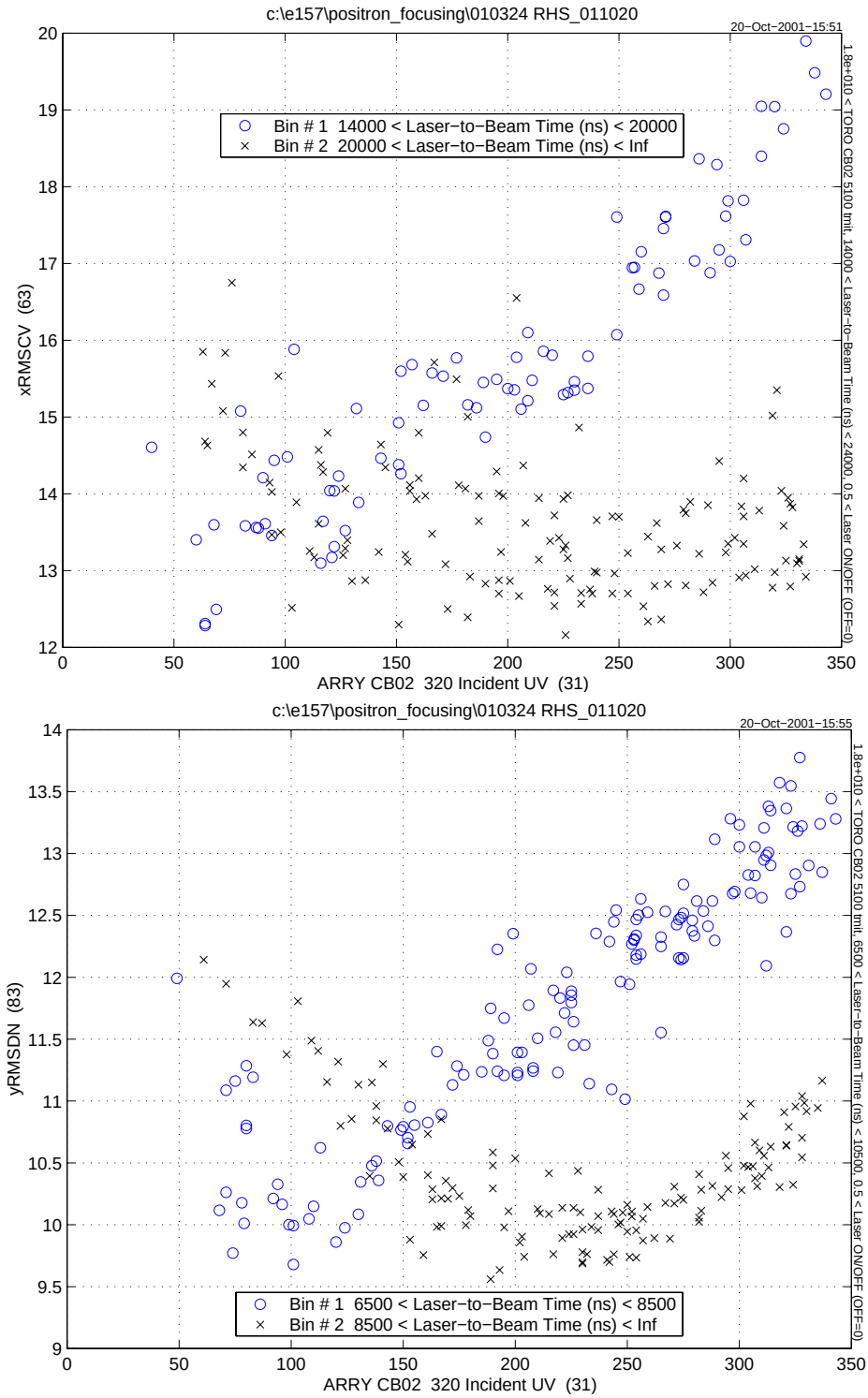


Figure 6: $\sigma_x(CV)$ at two trigger times, t_1 = 15.98 μs and t_2 = 22.98 μs and $\sigma_y(DN)$ for t_1 = 6.98 μs and t_2 = 10.48 μs.

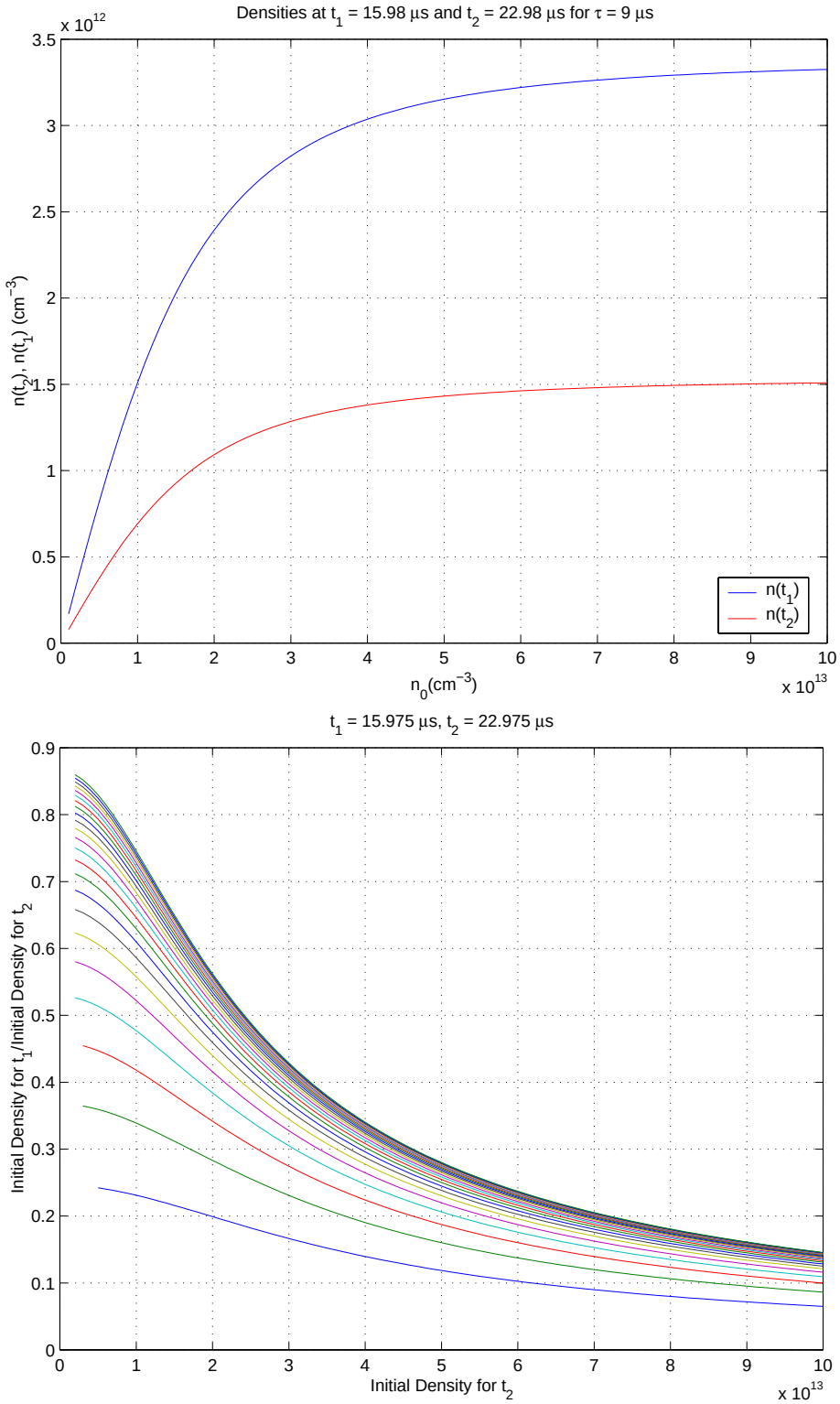


Figure 7: (a, top) Densities at time t_1 and t_2 for different initial densities and $\tau = 9$ µs. (b, bottom) Ratio of initial densities to produce the same final densities at t_1 and t_2 plotted vs the initial density at t_2 and for a range $\tau = 5{:}2{:}50$ µs.

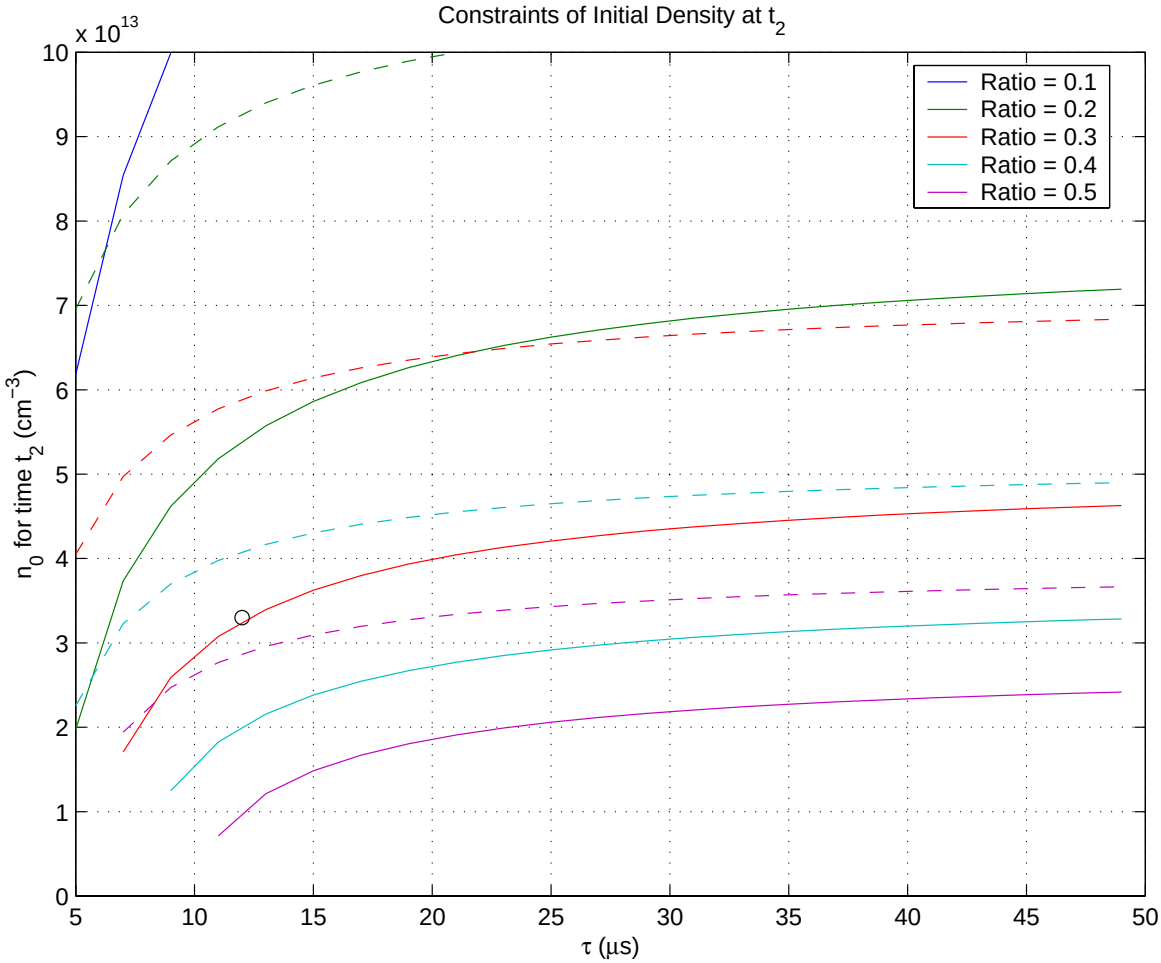


Figure 8: The constraints between the initial density at t_2 vs diffusion time for the $\sigma_x(CV)$ at two trigger times, t_1 = 15.98 μs and t_2 = 22.98 μs (SOLID) and $\sigma_y(DN)$ for t_1 = 6.98 μs and t_2 = 10.48 μs (DASHED). The color codes for the lines are the same. The black circle indicates the value $n_0 = 3.3\times10^{13}$ cm^{-3}, τ = 12 μs favored by the betatron analysis.

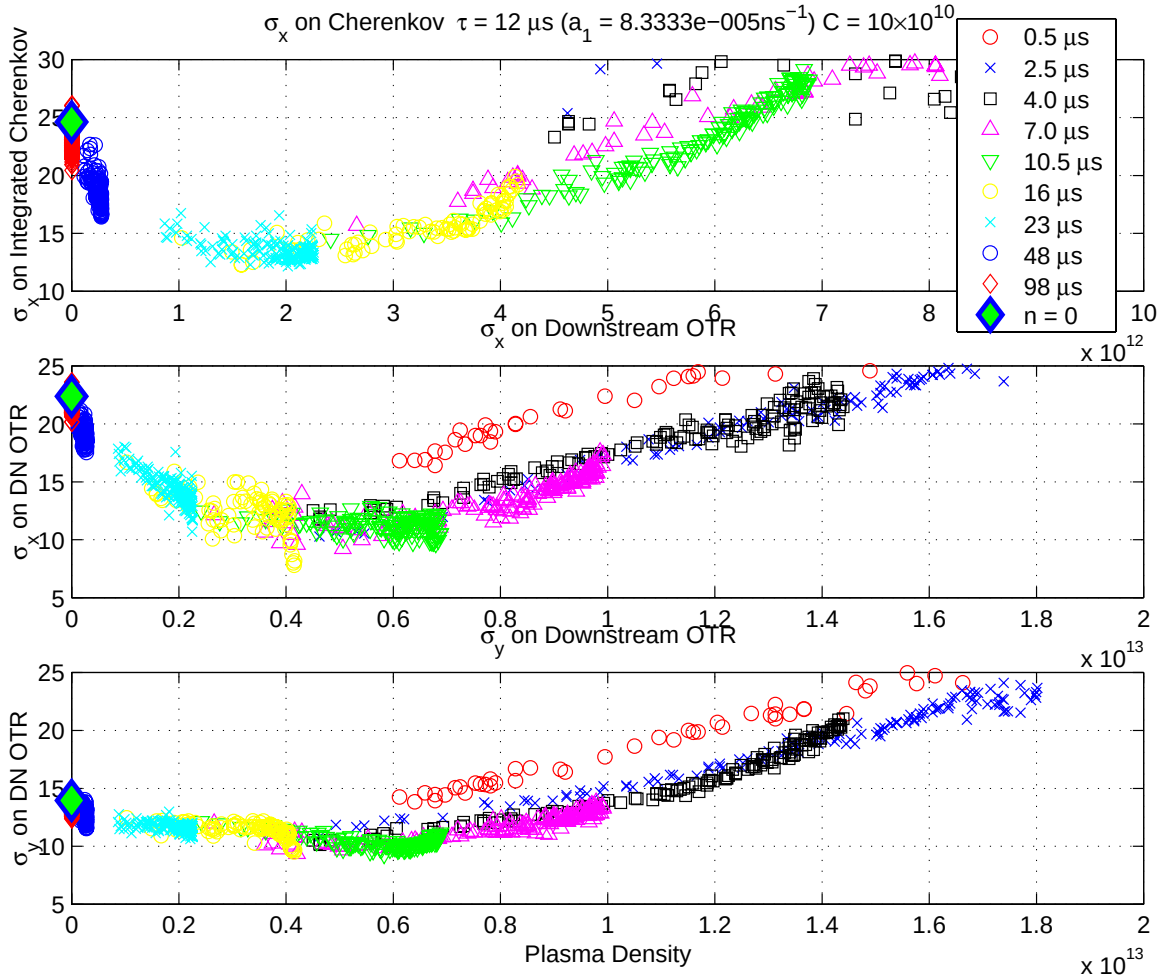


Figure 9: Plots of $\sigma_x(CV)$, $\sigma_x(DN)$, and $\sigma_y(DN)$ for the runs in Table 1 with $C_p = 10^{11}\text{cm}^{-3}$/GADC and $\tau = 12$ μs.

Betatron Focusing Analysis

This analysis follows the thick-lens analysis that has become common for electron focusing, but for positrons there is only a single minimum as to the multiple minima for electrons. Streak camera data taken on 3/24/01 have shown that it is a good approximation that the beam is focused alone its entire length at the minimum $\sigma_x(CV)$ in the top panel of Figure 9. Therefore, the plasma can be treated as a thick lens near the first minimum, and the problem becomes one of determining the density that produces a thick "plasma lens".

The cosine- and sine-like trajectories starting at the plasma entrance to a distance $s = L$ downstream of the plasma exit are

$$C = \cos\phi - \frac{L\phi\sin\phi}{L_{oven}}$$
$$S = L_{oven}\frac{\sin\phi}{\phi} - L\cos\phi \tag{2.1}$$

where the phase advance in the plasma is

$$\phi = \sqrt{\frac{2\pi r_e n}{\gamma}}L_{oven} \tag{2.2}$$

The incoming optics bring the beam to a focus a distance s_w from the plasma entrance (in the absence of the plasma and negative s_w corresponds to a focus in front of the plasma entrance). The Twiss parameters at the plasma entrance are

$$\beta_0 = \beta^* + \frac{s_w^2}{\beta^*};\ \alpha_0 = \frac{s_w}{\beta^*};\ \gamma_0 = \frac{1}{\beta^*} \tag{2.3}$$

The β function at $s = L$ is

$$\beta = \beta^*\left(1 + \frac{s_w^2}{\beta^*}\right)C^2 + \frac{1}{\beta^*}S^2 - \frac{s_w}{\beta^*}\times 2CS \tag{2.4}$$

This is minimized at L = -.9 m for the DN OTR and L = 12 m for the Cherenkov using the MATLAB program "betamin_010909". The nominal horizontal focusing parameters are used: $\beta^* = 0.3m;\ s_w = -0.83m;\ s_w/\beta^* = -2.76$. The analysis is shown in Figure 10. The results are

$$\hat{C}:\quad \phi = 0.34\pi \Rightarrow n = 1.8\times 10^{12}\,cm^{-3}$$
$$DN:\quad \phi = 0.52\pi \Rightarrow n = 4.3\times 10^{12}\,cm^{-3} \tag{2.5}$$

where eq. (2.2) has been used. The point indicated by the circle in Figure 8 and the spot sizes in Figure 9 are consistent with these values.

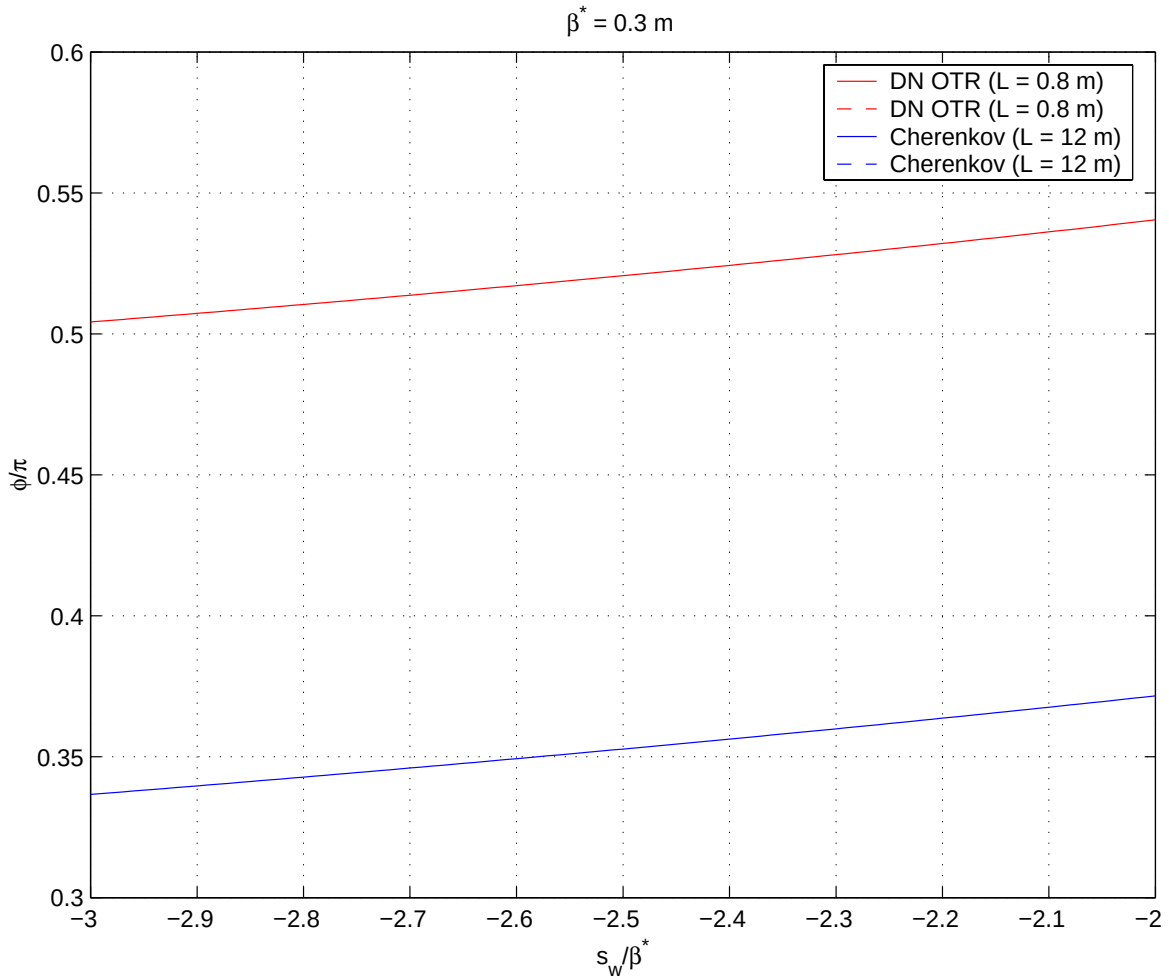


Figure 10: Values of the phase advance in the plasma to produce spot size minima at the Integrated Cherenkov and DN OTR. (Note – There are dashed lines appearing in the legend key. These are for the next focus and were eliminated when the plot was manually scaled.)

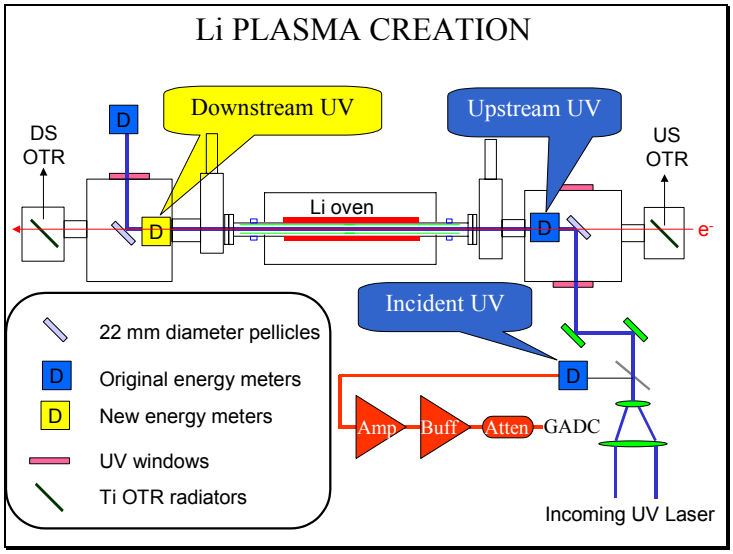


Figure 11: The Incident, Upstream and Downstream UV energy meters

UV Measurements

The UV energy meter configuration is shown in Figure 11. The Incident UV meter measures the UV energy before the input window and pellicle. Its purpose is to measure the shot-by-shot variation in the incident UV, but it must be calibrated against the Upstream UV meter that takes account of damage of the window and pellicle. The beam is turned off for these calibration runs. The ratio of the Downstream to Upstream energy meters gives the transmission through the Lithium oven and the vapor density.

The UV calibration runs are documented in the EXCEL file that is at the end of this note. There were a number of changes and uncertainties during Run 6. The changes were due to optical attenuators being placed at various locations in the UV transport, changes in the gains of the amplifiers that amplify signals from the energy meters, and changes in attenuators at the outputs of the buffer amplifiers that drive the digitizers (GADC's). The summary file came from reading the log book and analyzing data to get a self consistent picture. The comments in the EXCEL file should be complete and are not repeated here. For Run 6:

- The March 24 data were taken with an optical attenuator in the UV path <u>after</u> the Incident UV meter.
- The optical attenuator was moved to <u>before</u> the Incident UV meter on March 29. The attenuator was a multi-layer mirror that was rotated to change the attenuation. Due to an aperture and/or reflections the ratio of the Upstream to Incident UV meters depended on the attenuator angle. Data taken on April 3 & 4 is key to determining the angle dependence of this ratio. Results are shown in Figure 12a for the

$$Upstream\ Energy\ Meter\ Slope = \frac{d(Upstream\ Energy)}{d(Incident\ GADC)} \tag{3.1}$$

For angle A (in degrees) the correction factor to get the UV incident on the plasma is given by the fit in Figure 12b

$$f = 1.020511 - 0.112177A - 0.0005698A^2 + 0.0014548A^3 \tag{3.2}$$

This correction should be applied for non-zero attenuator angles.

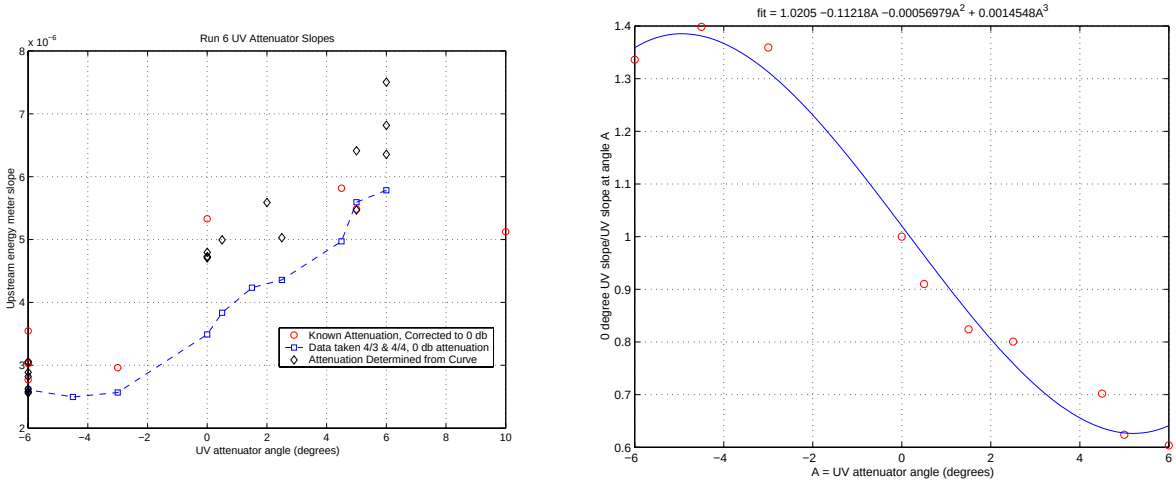


Figure 12: The upstream energy meter slope vs optical attenuator angle. (a, LHS) The blue squares are data taken on April 3 & 4 under known conditions and with roughly constant UV damage to the window and pellicle. The red circles are data taken at different times under known conditions, but with the possibility of different amounts of damage. The black diamonds are data taken under uncertain conditions. However, these conditions can be determined by analyzing the entire set of UV calibration runs and are documented in the EXCEL file. (b, RHS) The correction factor to be applied to runs with the attenuator rotated.

1. Data were taken with and without a 12.17 mm^2 aperture in front of the input window. They showed that

$$\frac{Iris\ IN}{Iris\ OUT} = 5.23\times10^{-2} \tag{3.3}$$

independent of the attenuator angle.

- There was important data taken on March 29 with the delay fixed with the laser triggered 10.48 μs before the electron beam and the attenuator rotated to vary the UV intensity.
- Data were taken subsequent to the run, on April 18, with a 5.94 mm^2 aperture in the beam. The result for that run was that the fluence and incident UV photon flux measured at the Upstream energy meter are

$$Fluence = \frac{1}{Area}\frac{d(Upstream\ Energy)}{d(Incident\ GADC)} = 27\frac{\mu J}{cm^2\ Count}$$

$$Incident\ Flux = 2.62\times10^{13}\frac{\gamma's}{cm^2 Count} \tag{3.4}$$

$$Amplifier\ Gain = 10\times's;\ Attenuator = 0\,db$$

(There is some uncertainty about the gain that is documented in the attached EXCEL file, but an amplifier gain of 10× is a good explanation of the data.) With a neutral density of 5.3×10^{15}cm^{-3} and an absorption cross section of 1.8×10^{-18}cm^2 the initial plasma density is

$$n_0 = 2.50\times10^{11}\frac{cm^{-3}}{Count}$$

$$Amplifier\ Gain = 10\times's;\ Attenuator = 0\,db \tag{3.5}$$

$$Vapor\ Density = 5.3\times10^{15}\,cm^{-3};\ \sigma = 1.8\times10^{-18}\,cm^2$$

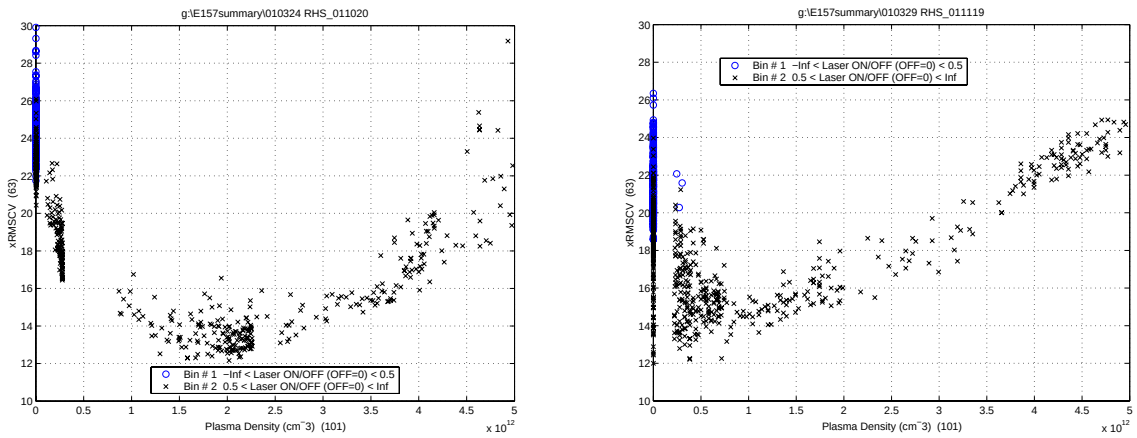


Figure 14: Comparison of the horizontal beam size on the Integrated Cherenkov for the data of March 24 (LHS) and March 29 (RHS).

These values can be used for the runs on March 29 taking into account the differences between the apparatus on March 29 and April 18. One difference is that the amplifier gain was 100×'s and there was 6 db of attenuation ⇒ effective gain = 50× on March 29. Another difference is that there appears to have been a factor of two change in the UV transmission between those two dates. A "standard slope" for the Upstream energy meter (eq. (3.1)) can be determined taking account of amplifier gains and attenuators. On April 18 that slope was 2.7×10^{-5} J/channel and on March 29 it was 5.3×10^{-5} J/channel. With these factors the constant C_p in eq. (1.7) is

$$C_p = 2.5\times10^{11}\times\frac{10}{50}\times\frac{5.3\times10^{-5}}{2.7\times10^{-5}} = 10\times10^{10}\,cm^{-3}/GADC \tag{3.6}$$

Remarkably, this is the same value as determined by the recombination analysis.

This value can be used together with a diffusion time τ = 12 μs to determine the plasma density for the runs on March 29. The results for the Cherenkov are shown in Figure 14 above. The conclusion is that there is a factor of 2 – 3 difference in the density based on this comparison of the horizontal beam size on the Cherenkov. Figure 15 shows the comparison of the horizontal sizes on the Downstream OTR. They agree on the location of the minimum in the range of 5×10^{12} cm^{-3} but the shapes do not agree well. The underlying reason is that with a diffusion time, τ = 12 μs and a delay time of 10.5 μs, the initial density must be high reach 6–7$\times10^{12}$ cm^{-3}, and for these high initial densities, the recombination rate is so high that the initial plasma density does little to determine the final density.

Overall Conclusion

The density has been determined by several different methods. There is not very good agreement on the details, but remarkably the plasma density is determined reasonably well.

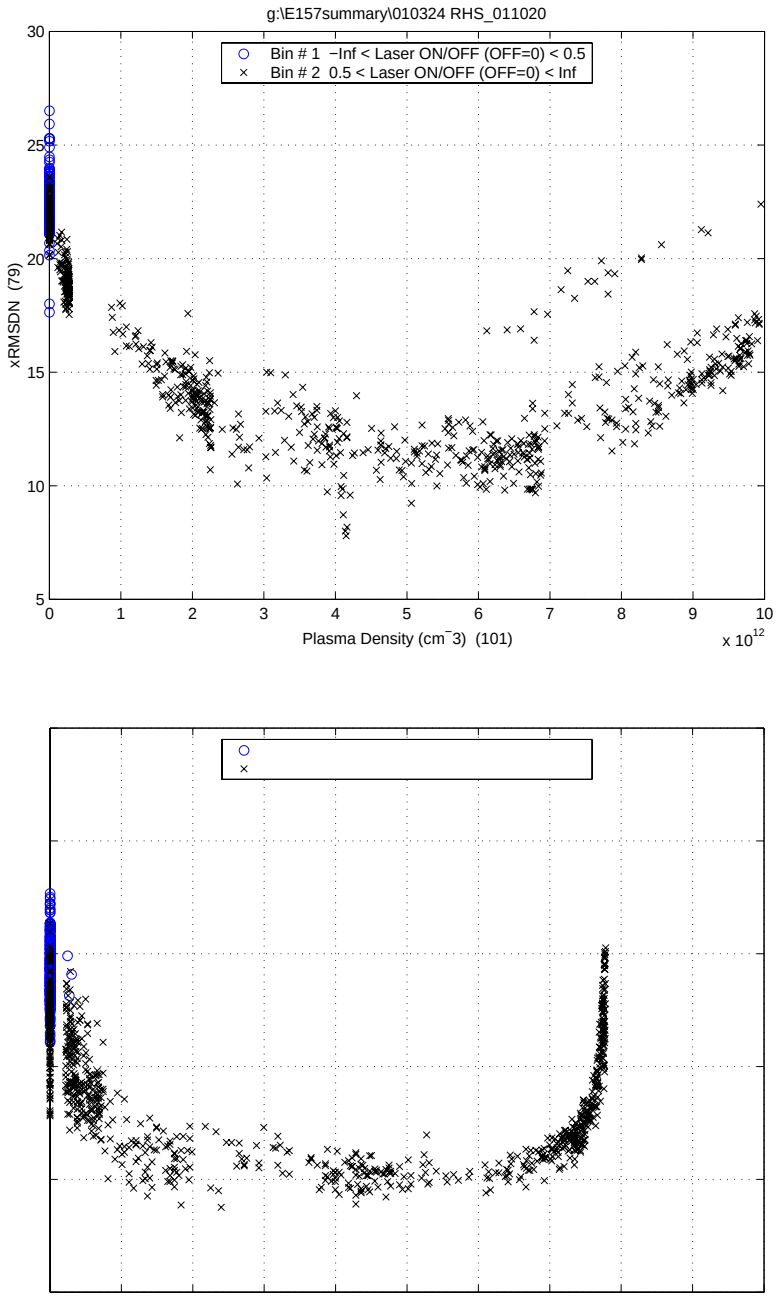


Figure 15: Comparison of the horizontal beam size on the Downstream OTR for the data of March 24 (top) and March 29 (bottom).

[1] D. R. Bates et al, Proc of Royal Society **267**, 19 (1962).
[2] P. Muggli *et al*., IEEE Trans. Plasma Sci. **27**, 791 (1999).
[3] J. Lahiri and S. T. Manson, Phys. Rev. E **48**, 3643 (1993).

Run 6 UV Calibration Runs

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	**Date**	**Time**	**LOG**	**No laser run**	**US run**	**DS run**	**US slope**	**DS slope**	**transmission**	**density (cm^{-3})**	**comment**	**Atten on Incident UV (db)***	**Relative US ratio**	**Relative DS ratio**	**Absolute US ratio**	**Absolute DS ratio**	**US/DS energy @ 300 incident**
2	**10-Mar**	**Original calibration for run 6 performed using the data starting at IX - 23 and analyzed in RHS book 2, page 112. Results UPCON=7.46e-6 J/GADC count DNCON=7.94e-6J/GADC count No notation of amplifier gains and buffer amplifier attenuator settings when these data were taken Upstream and DNstream gains reported the next day (IX - 27) to be 10X's**															
3	10-Mar										energy meter calibrations Upstrm = 7.46 microJ/channel Dnstrm = 7.94 microJ/channel						
4	11-Mar		IX 27	The US & DS energy meter gains are stated to be 10X's							Energy Meter Amplifier Gains US=10x,DS=10x						
5	17-Mar	16:00	IX 51	03172ca	03172cc	03172cb	7.2560E-06	2.1590E-06	29.75%	4.81E+15			1.00	1.00	1.00	1.00	2.2/0.68
6	19-Mar	21:00	IX 63	03192cc	03192cd	03192ce	5.8300E-06	1.6950E-06	29.07%	4.90E+15			0.80	0.79	0.80	0.79	1.77/0.58
7	20-Mar	0:30	IX 69	03200ca	03200cb	03200cc	5.6750E-06	1.7430E-06	30.71%	4.68E+15			0.97	1.03	0.78	0.81	no plot
8	20-Mar	17:50	IX 77	**Attenuator placed between the last turning mirrors of the UV telescope. This changes the ratio between the incident UV and the UP & DN energy meters. The change in slope is a factor of 10.77 (= 0.7582/0.0704) based on the slopes for runs 03202ca (no attenuator, slope = d(UPstream)/d(Incident) = 0.7582) and 03202cd (final attenuator, slope = d(UPstream)/d(Incident) = 0.0704)**														
9	20-Mar	19:00	IX 78	oven pressure from 421 to 396 mT, density estimate ~ 5e15													
10	21-Mar	3:40	IX 81	03210ca	03210cb	03210cc	5.5960E-07	3.9575E-07	70.71%	1.38E+15	These data were taken with a 10X's attenuator in the UV and after oven changes. Downstream data has noise comparable to slope being measured						1.8/1.4 poor
11	21-Mar	6:45	IX 84	03210cl	03210cm	03210cn	5.0706E-07	4.0400E-07	79.67%	9.02E+14	Downstream data has noise comparable to slope being measured						no plot
12	21-Mar	Value of the upstream slope in 03211cd (below) is consistent with no optical attenuator and amplifier gains as they were prior to page IX 77 (gains = 10X's). For example compare with IX 63 and IX 69															
13	21-Mar	9:30	IX 86	03211ca	03211cd	03211ce	5.7680E-06	1.6010E-06	27.76%	5.09E+15	No opt. attenuator, US, DS=10x		1.02	0.92	0.79	0.74	?/0.55
14	21-Mar	Runs 03211ci, 03211cg, 03211ch are reported to be at 100X's amplifier gain with no optical attenuator inserted. Changes in offsets between 03211ca and 03211ci indicates that the amplifiers gains were changed. The only way the slopes can be explained in that the optical attenuator was inserted.															
15	**21-Mar**	**The slopes recorded below while the amplifiers are at 100X's gain were reduced by a factor of 10 from those reported by uv_analysis to account for the increased gain (because the calibration constants were not changed in uv_analysis)**															
16	21-Mar	9:30	IX 86	03211ci	03211cg	03211ch	6.2120E-07	1.7800E-08	28.66%	4.96E+15	UV attenuator in and US and DS amplifier gains raised from 10X's to 100X's		0.11	0.01	0.09	0.01	2.0/0.55
17	21-Mar	9:30	IX 86	Optical attenuator reported to have an attenuation of 8.27 on bottom of page													
18	22-Mar	13:00	IX 107	03221cu	03221cv	03221cw	6.1400E-07	2.3540E-07	38.34%	3.80E+15	downstream data has noise and slope is poorly determined 9/7/2001 - cannot find SCP files to reanalyze data		0.99	13.22			no plot
19	23-Mar	5:00	IX 112	States that nominal X10 attenuator removed from the UV path, but apparently that was not done. See IX 125 which records that X10 attenuation found in UV light													

* on Incident UV attenuation => known value

Run 6 UV Calibration Runs

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	**Date**	**Time**	**LOG**	**No laser run**	**US run**	**DS run**	**US slope**	**DS slope**	**transmission**	**density (cm^{-3})**	**comment**	**Atten on Incident UV (db)***	**Relative US ratio**	**Relative DS ratio**	**Absolute US ratio**	**Absolute DS ratio**	**US/DS energy @ 300 incident**
20	23-Mar		IX 115	laser refill & statement that UV attenuator changed in preparation for higher plasma densities. Unclear whether this is a restatement of the change noted above on IX 112													
21	24-Mar	10:30	IX 119	The calibration runs 03241cb - 1cd taken just before a series of important positron focusing runs													
22	24-Mar	10:30	IX 119	Slope from analysis of upstream data = 8.27e-6; recorded below as 8.27e-7 because of X100 amplifier gain. Slope from downstream data also changed by 1/10 because of amplifier gain. See 3/21 note above													
23	24-Mar	10:30	IX 119	03241cb	03241cc	03241cd	8.2700E-07	3.3500E-07	40.49%	3.59E+15	laser attenuation changed since previous calibration downstream data indicates some saturation confirmed by 03241ce plasma density appears low and transmission seems high		1.35	1.42			2.5/1.4
24	24-Mar	10:45	IX 121	US pellicle translated before 03241cf													
25	24-Mar		IX 122	There is a beautiful set of runs starting at 0341cp which are streaks for different trigger delays													
26	24-Mar	16:30	IX 123	03242cd	03242ce	03242cf	8.4600E-07	4.7600E-07	56.30%	2.28E+15	plasma density still low. Upstream pellicle translated after previous calibration & before this one. See note above		1.02	1.42			2.5/1.5
27	24-Mar	17:50	IX 125	Documentation, changes & measurements in response to apparent change in plasma transmission. BEFORE ANY CHANGES 1) Gains on upstream and downstream amplifiers stated to be X100 2) There was X10 greater attenuation of the UV light than we had thought. Probably related to confusion on IX 112 & IX 115 noted above 3) Oven conditions recorded CHANGE MADE switch DS amplifier with amplifier previously used on the Molectron. Gain = 100X													
28	24-Mar	18:05	IX 125	03242ci	03242cl	03242cm	8.4700E-07	6.3600E-07	75.00%	1.14E+15	Upstream slope has not changed, but apparent continuing decrease in plasma density						2.6/2.0
29	24-Mar		IX 126	DS energy meter cycled and shifted to see if it would affect downstream slope. The slope changed but still was not sensible													
30	24-Mar		IX 127	Amplifier gains restored to 10X's just before 03242cp. Attenuation in UV beam after incident changed at same time (had not been removed!) Attenuation unknown													
31	25-Mar	15:40	IX 137	03251cy	03251cz	03251da	1.0210E-05	2.8300E-06	27.72%	5.09E+15	before pellicle changed						3.1/0.86
32	25-Mar	19:00	IX 141	pellicle and window changed before 03261ca, pellicle centered													19:00
33	26-Mar		IX 145	Downstream GADC checked because of a suspicion on IX 127 that there was a problem, None found													
34	26-Mar	10:00	IX 145	03261ca	03261cb	03261cc	1.3065E-05	3.2080E-06	24.55%	5.57E+15	First calibration with pellicle changed (IX 141). Change in absorption		1.00	1.00	1.00	1.00	≈3.95/1.02
35	27-Mar	3:30	IX 153	03270ca	03270cb	03270cc	1.2880E-05	2.8340E-06	22.01%	6.01E+15			0.99	0.88	0.99	0.88	≈3.9/0.92
36	27-Mar	7:00	IX 157	03270cn	03270co	03270cp	1.2240E-05	2.9220E-06	23.88%	5.68E+15			0.95	1.03	0.94	0.91	3.7/0.96
37	28-Mar	3:20	X 12	03280cc	03280cd	03280ce	1.2190E-05	2.8955E-06	23.75%	5.70E+15			1.00	0.99	0.93	0.90	3.65/0.99
38	28-Mar	7:00	X 16	03280cs	032b0ct	03280cu	1.1750E-05	2.7440E-06	23.36%	5.77E+15			0.96	0.95	0.90	0.86	3.5/0.86
39	28-Mar		X 16	laser refill before 03281ca													
40	28-Mar	11:00	X 17	03281cd	03281ce	03281cf	1.1750E-05	2.5830E-06	21.99%	6.01E+15			1.00	0.94	0.90	0.81	3.6/0.83

* on Incident UV attenuation => known value

Run 6 UV Calibration Runs

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	**Date**	**Time**	**LOG**	**No laser run**	**US run**	**DS run**	**US slope**	**DS slope**	**transmission**	**density (cm^{-3})**	**comment**	**Atten on Incident UV (db)***	**Relative US ratio**	**Relative DS ratio**	**Absolute US ratio**	**Absolute DS ratio**	**US/DS energy @ 300 incident**
41	29-Mar	1:10	X 27	03290ca	03290cb	03290cc	1.1010E-05	2.0130E-06	18.28%	6.74E+15							3.2/0.69
42	29-Mar	2:15	X 27	**optical attenuator moved to before incident UV meter. Now affects Incident, UP & DN This attenuator was on a remotely controlled rotation stage to allow different intensity ranges controlled from 407C**													
43	29-Mar	3:00	X 28	03290ce = a scan taken with attenuator angle varied, 26 kV, 124 mJ. At attenuator angle = -6 degrees, Incident UV GADC = 120													
44	29-Mar	6:00	X 30	**Incident amplifier gain changed from 10X to 100X This should decrease the slopes by a factor of 10 when compared to previous measurements**													
45	29-Mar	7:00	X 31	03290cf	03290cg	03290ch	1.3370E-05	7.4130E-06	55.47%	2.34E+15	slopes are poorly measured, but neither shows a factor of 10 increase						
46				Light Green => value added to run_6_uv.m													
47	29-Mar	10:00	X 32	03291cb	03291cc	03291cd	1.0660E-05	2.0110E-06	18.87%	6.62E+15	UV attenuator = 0 degree 6 db attenuator on Incident UV	6*					
48	29-Mar	10:30	X 32	03291ce	03291cg	03291cf	1.2710E-05	8.8030E-06	69.22%	1.46E+15	UV attenuator angle = +6 degree electrical attenuator value unclear low UV energy, noisy data	6					
49	29-Mar	10:45	X 32	03291ch	03291ci	03291cj	5.6440E-05	1.2220E-05	21.66%	6.07E+15	attenuator angle = -6 degree 20 db added to Incident UV buffer amplifier output	26					
50	29-Mar	11:00	X 33		03291ck		5.7760E-05				same conditions as 03291ci (line above). Check on repeatability of measurement	26					
51	29-Mar	11:00	X 33		03291cl		6.1060E-06				same conditions as 03291cl (line above) except 20dB removed from incident UV	6					
52	29-Mar		X 33	Comment on the runs above: The UV attenuator was moved to a position in front of the Incident UV meter. For the Incident UV measurement, the dynamic range to accommodate different UV attenuator angles was obtained by putting electrical attenuators on the outputs of the buffer amplifier that drives the GADC. There is a discussion on the bottom of page X 33 that indicates ~factor of 2 errors in the ratio between Upstream and incident UV measurements when the electrical attenuator is accounted for. 9/11/2001 - The data taken at the end of the run (4/3 & 4/4) show that this is consistent with the ratio of the slopes measured at that time.													
53	29-Mar		X 34	The plot for 03290ce gives the incident UV GADC reading for 124 mJ at different UV attenuator angles. Subsequent to that run the Incident UV amplifier gain was raised from 10X to 100X (X 30). The data recorded on X 34 are energy scans from 50 to 100 mJ after that energy change. They can be used to check whether any additional changes were made to the Incident UV measurement. The numbers below give the expected maximum GADC based on the formula that maximum GADC = 10 X 100/124 X GADC recorded in 03290ce. 03292ce, 0 deg, max GADC = 160, expect 145 03292cg, 4 deg, max GADC = 900, expect 750 03292ch, 6 deg, max GADC = 900, expect 950. Conclusion = the only change made was to increase the incident UV amplifier gain from 10X to 100X													
54	29-Mar		X 34	There is a beautiful set of runs starting at 03292cb which are different UV attenuator angles with trigger timing = -12504 nsec and laser HV being scanned in the 22 to 25.5 KV region. No explicit statement of value of electrical attenuator Run just before (03291cl) had 6 db attenuation determined from complete run 6 analysis Next calibration (03300ca - cc) had 6db on the Incident UV								**6**					

* on Incident UV attenuation => known value

Run 6 UV Calibration Runs

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	**Date**	**Time**	**LOG**	**No laser run**	**US run**	**DS run**	**US slope**	**DS slope**	**transmission**	**density (cm^{-3})**	**comment**	**Atten on Incident UV (db)***	**Relative US ratio**	**Relative DS ratio**	**Absolute US ratio**	**Absolute DS ratio**	**US/DS energy @ 300 incident**
55	30-Mar	5:20	X 39	03300ca	03300cb	03300cc	1.0250E-05	9.7630E-06	95.25%	1.93E+14	UV attenuator angle = +10 degrees, Poor quality data. Log contains clear statement that there was a 6db attenuator on the Incident UV buffer amplifier output	6*					NA
56	30-Mar	6:00	X 40	03300cf	03300cg*	03300ch	5.5890E-06	1.5690E-06	28.07%	5.04E+15	UV attenuator angle = +2 degrees * 03300cg saved as 03300cj because of multicamera problem	0					NA
57	30-Mar	6:40	X 42	03300cm	03300cn	03300co	4.7090E-06	1.1740E-06	24.93%	5.51E+15	UV attenuator angle = 0 degrees (see X 41)	0					
58	30-Mar			The factor of 2 change in slope of 03000cn as compared to 03291cc indicates that there was no electrical attenuation on the output of the buffer amplifier. Suspect change occurred after 03300cc													
59	30-Mar	11:30	X 46	03301cj	03301cf	03301ch	6.8160E-06	3.3770E-06	49.54%	2.79E+15	UV attenuator angle = +6 degrees Poor quality data on downstream energy meter scan	0					
60	30-Mar	12:10	X 46	03301cn	03301cl	03301cm	4.9940E-06	1.1180E-06	22.38%	5.94E+15	UV attenuator angle = 0.5 deg	0					1.5/0.42
61	30-Mar	15:25	X 48	03301cq	03301co	03301cp	7.5040E-06	2.0570E-06	27.41%	5.14E+15	UV attenuator = 6 degree Poor quality data on downstream UV meter	0					
62	30-Mar	15:30	X 48	03301ct	03301cr	03301cs	4.7290E-06	1.0650E-06	22.52%	5.92E+15	UV attenuator = 0 degree	0					
63	30-Mar	15:35	X 48	03301cw	03301cu	03301cv	3.0500E-06	7.0900E-07	UV attenuator = -6 degree Slope values obtained by hand making corrections for saturation of incident UV GADC. This saturation is indication that there was no attenuation on the output of the Incident UV buffer amplifier			0*					
66	31-Mar			comparisons of 03310ct (below) and 03301cu give slopes that are in agreement assuming no attenuator on Incident UV in 03301cu													
67	31-Mar	1:15	X 57	03310cb	03310cc	03310cd	4.7970E-06	1.2940E-06	26.98%	5.20E+15	UV attenuator = +1 degree	0					
68	31-Mar	1:20	X 57	03310cb	03310ce	03310cf	6.4120E-06	2.1180E-06	33.03%	4.40E+15	UV attenuator = +5 degree	0					
69	31-Mar		X 60	clear statement that there is no 6 db on the output of the Incident UV buffer amplifier													
70	31-Mar	3:15	X 61	6 db attenuation on output of Incident UV buffer amp and UV attenuator rotated to -3 degrees prior to run 03310co													
71	31-Mar	3:25	X 61	12 db attenuation on output of Incident UV buffer amp and UV attenuator rotated to -6 degrees prior to run 03310cp													
72	31-Mar		X 61	clear statements about these attenuator values for the two sets of calibration runs below													
73	31-Mar	4:10	X 61	03310cs	03310ct	03310cu	1.419E-05	2.490E-06	17.54%	6.91E+15	UV attenuator = -6 degrees, Incident UV attenuator = 12 db	12*					
74	31-Mar	4:15	X 61	03310cs	03310cv	03310cw	5.924E-06	1.260E-06	21.27%	6.14E+15	UV attenuator = -3 degrees, Incident UV attenuator = 6 db	6*					
75	31-Mar	20:00	X 72	03312ci	03312cj	03312ck	1.094E-05	6.187E-06	56.57%	2.26E+15	UV attenuator = + 5 deg	6					
76	1-Apr	0:30	X 75	04010ca	04010cb	04010cc					UV attenuator angle unstated, 1 deg was last recorded value Upstream energy meter not inserted in 04010cb						

* on Incident UV attenuation => known value

Run 6 UV Calibration Runs

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	**Date**	**Time**	**LOG**	**No laser run**	**US run**	**DS run**	**US slope**	**DS slope**	**transmission**	**density (cm^{-3})**	**comment**	**Atten on Incident UV (db)***	**Relative US ratio**	**Relative DS ratio**	**Absolute US ratio**	**Absolute DS ratio**	**US/DS energy @ 300 incident**
77	1-Apr	7:25	X 79	04010cq	04010cr	04010cs	4.326E-06	1.017E-06	23.51%	5.75E+15	UV attenuator = -6 degrees. Data taken during beam steering experiment. UV beam is clipped & that will affect calibrations. 9/10/2001 - cannot find scp file for 04010cq removed tape clipping beam on X 79						
78	1-Apr	13:30	X 81	04011ca	04011cb	04011cc	5.167E-06	1.064E-06	20.59%	6.27E+15	UV attenuator = -6 degrees	6					
79	1-Apr	15:10	X 82	04011cd	04011ce	04011cf	2.394E-07	1.315E-07	54.83%	2.38E+15	8.56 mm^2 iris in beam						
80	1-Apr	15:20	X 82	04011cg	04011ch	04011ci	3.009E-07	2.209E-07	73.39%	1.23E+15	12.17 mm^2 iris in beam						
81	1-Apr	15:25	X 82	04011cj	04011ck	04011cl	5.605E-07	2.596E-07	46.32%	3.05E+15	21.29 mm^2 iris in beam						
82	1-Apr	15:30	X 83	04011cm	04011cn	04011co	5.248E-06	1.081E-06	20.61%	6.27E+15	Aperture wide open UV attenuator = -6 degrees	6					
83	2-Apr	18:30	X 103	04022ck	04022cl	04022cm	5.117E-06	1.079E-06	21.09%	6.18E+15	UV attenuator = -6 degrees	6					
84	2-Apr	19:20	X 104	04022co	04022cq	04022cr	1.006E-05	3.619E-06	35.97%	4.06E+15	UV attenuator = +2.5 degrees	6					
85	3-Apr			Laser refilled during OWL shift													
86	3-Apr	3:25	X 110	04030cg	04030ch	04030ci	2.770E-06	6.927E-07	UV attenuator = -6 degrees Incident UV GADC saturated => 0 db on Incident UV Slopes corrected for saturation			0*					
87	3-Apr	3:30	X 110	04030cg	04030cj	04030ck					UV attenuator = -1.5 degrees Energy meters not inserted						
88	3-Apr		X 113	UV attenuator angle recorded as - 6 degrees for 04030cm													
89	3-Apr		X 114	Incident UV electrical attenuator changed from 6 db to 12 db. No statement about when it was increased from 0 db (run 04030ch, ci to 6 db													
90	3-Apr	7:15	X 115	04030cr	04030cs	04030ct	1.140E-05	2.353E-06	20.64%	6.26E+15	UV attenuator angle = 0.5 degrees, 12 db attenuation on Incident UV		some tape blocking part of UV beam as part of steering expt for 04030cr through 04030cx				
91	3-Apr	7:20	X 115	04030cr	04030cu	04030cv					UV attenuator angle = -1.5 degrees, 12 db attenuation on Incident UV, energy meters not inserted						
92	3-Apr	7:20	X 115	04030cr	04030cw	04030cx	6.123E-06	1.489E-06	24.32%	5.61E+15	UV attenuator angle = -6 degrees, 12 db attenuation on Incident UV						
93	3-Apr	13:35	X 118	04031ca	04031cd	04031ce	1.211E-05	2.248E-06	18.56%	6.68E+15	UV attenuator = -6 degrees 12 db attenuation recorded on pages X 115 & X 121	12*					
94	3-Apr	13:50	X 119	04031ca	04031cf	04031cg	2.326E-05	1.074E-05	46.16%	3.07E+15	UV attenuator = +4.5 degrees 12 db attenuation recorded on pages X 115 & X 121	12*					
95	3-Apr		X 121	12 db attenuator removed from Incident UV after 04032cg													
96	3-Apr	20:30	X 123	04032df	04032dg	04032dh	5.485E-06	1.366E-06	24.91%	5.52E+15	UV attenuator = +5 degrees 0 db attenuation	0*					

* on Incident UV attenuation => known value

Run 6 UV Calibration Runs

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	**Date**	**Time**	**LOG**	**No laser run**	**US run**	**DS run**	**US slope**	**DS slope**	**transmission**	**density (cm^{-3})**	**comment**	**Atten on Incident UV (db)***	**Relative US ratio**	**Relative DS ratio**	**Absolute US ratio**	**Absolute DS ratio**	**US/DS energy @ 300 incident**
97	series of runs with and without Iris #2 (12.17 mm^2) in place. Runs with Iris in place indicated by yellow shading Slope values obtained from correlate using a scale factor of 7.460e-6 determined from run 04030cw 0 db attenuation for these runs																
98	3-Apr	23:34	X 128		04032dl		3.918E-07				UV attenuator = 6 degrees, Iris IN, Slope is not meaningful because data in noise	0*					
99	3-Apr	23:35	X 128		04032dm		5.784E-06				UV attenuator = 6 degrees Iris OUT 4 bad events (17, 19, 21, 23) removed before taking slope	0*					
100	3-Apr	23:38	X 128		04032dn		5.714E-07				UV attenuator = 5 degrees Iris IN, Slope is not meaningful because data in noise	0*					
101	3-Apr	23:40	X 128		04032do		5.594E-06				UV attenuator = 5 degrees Iris OUT	0*					
102	3-Apr	23:42	X 128		04032dp		4.641E-07				UV attenuator = 4.5 degrees Iris IN, data are noisy, slope not meaningful	0*					
103	3-Apr	23:45	X 128		04032dq		4.971E-06				UV attenuator = 4.5 degrees Iris OUT	0*					
104	3-Apr	23:47	X 128		04032dr		1.563E-07				UV attenuator = 2.5 degrees Iris IN, data are noisy, slope not meaningful	0*					
105	3-Apr	23:51	X 128		04032ds		1.454E-07				UV attenuator = 2.5 degrees Iris IN, data are noisy, slope not meaningful	0*					
106	3-Apr	23:53	X 128		04032dt		4.358E-06				UV attenuator = 2.5 degrees Iris OUT	0*					
107	3-Apr	23:55	X 128		04032du		2.338E-07				UV attenuator = 1.5 degrees Iris IN, first meaningful Iris IN slope	0*					
108	3-Apr	23:56	X 128		04032dv		4.234E-06				UV attenuator = 1.5 degrees Iris OUT	0*					
109	3-Apr	23:58	X 128		04032dw		2.036E-07				UV attenuator = 0.5 degrees Iris IN	0*					
110	3-Apr	23:59	X 128		04040ca		3.835E-06				UV attenuator = 0.5 degrees Iris OUT	0*					
111	4-Apr	0:02	X 128		04040cb		1.856E-07				UV attenuator = 0 degrees Iris IN	0*					
112	4-Apr	0:03	X 128		04040cc		3.490E-06				UV attenuator = 0 degrees Iris OUT	0*					
113	4-Apr	0:05	X 128		04040cd		1.351E-07				UV attenuator = -3 degrees Iris IN, events with Incident uV saturated removed before fitting	0*					

* on Incident UV attenuation => known value

Run 6 UV Calibration Runs

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	**Date**	**Time**	**LOG**	**No laser run**	**US run**	**DS run**	**US slope**	**DS slope**	**transmission**	**density (cm^{-3})**	**comment**	**Atten on Incident UV (db)***	**Relative US ratio**	**Relative DS ratio**	**Absolute US ratio**	**Absolute DS ratio**	**US/DS energy @ 300 incident**
114	4-Apr	0:06	X 128		04040ce		2.568E-06				UV attenuator = -3 degrees Iris OUT, events with Incident uV saturated removed before fitting	0*					
115	4-Apr	0:08	X 128		04040cf		1.265E-07				UV attenuator = -4.5 degrees Iris IN, events with Incident uV saturated removed before fitting	0*					
116	4-Apr	0:09	X 128		04040cg		2.496E-06				UV attenuator = -4.5 degrees Iris OUT, events with Incident uV saturated removed before fitting	0*					
117	4-Apr	0:11	X 128		04040ch		1.281E-07				UV attenuator = -6 degrees Iris IN, events with Incident uV saturated removed before fitting (eliminated most of data)	0*					
118	4-Apr	0:13	X 129		04040ci		2.612E-06				UV attenuator = -6 degrees Iris OUT, events with Incident uV saturated removed before fitting	0*					
119	4-Apr	0:18	X 129		04040cj		1.426E-07				UV attenuator removed Iris IN, events with Incident uV saturated removed before fitting (eliminated most of data)	0*					
120	4-Apr	0:21	X 129		04040ck		2.377E-06				UV attenuator removed Iris OUT, events with Incident uV saturated removed before fitting (eliminated most of data). Iris IN/Iris OUT = 0.060 which is 15% higher than the value measured with the UV attenuator in place	0*					
121	4-Apr		X 129	12 db attenuation added to Incident UV after run 04040cr													
122	4-Apr			**End of Run**													
123																	
124		**9/11/2001 - Analysis of above runs. This applies to the data starting 3/29 where the UV attenuator was placed in front of the incident energy meter**															
125		The upstream and downstream energy meters had gain = 10X (IX 127) The incident UV had gain = 100X, and different attenuators were added to the output of the buffer amplifier that goes to the Incident UV GADC There are two types of runs where the value of that attenuation is known: 1) Runs where there is a clear statement about the value of that attenuation and 2) Data taken on 4/3 and 4/4 of the slope vs UV attenuator angle where attenuation = 0 db. For both data sets the attenuation value is denoted by a* in the column labelled "Atten on Incident UV" A curve of slope vs attenuator angle can be derived from these runs.															
126		Using this curve the attenuation value for other runs can be determined with a fair amount of certainty by choosing values of 6 db, 12 db, 20 db or 26 db that bring points close to the curve while being consistent with comments about attenuations															

* on Incident UV attenuation => known value

Run 6 UV Calibration Runs

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	**Date**	**Time**	**LOG**	**No laser run**	**US run**	**DS run**	**US slope**	**DS slope**	**transmission**	**density (cm^{-3})**	**comment**	**Atten on Incident UV (db)***	**Relative US ratio**	**Relative DS ratio**	**Absolute US ratio**	**Absolute DS ratio**	**US/DS energy @ 300 incident**
127	16-Apr		X 134	**Data taken on 4/16/01 - 4/18/01 were measurements of upstream and downstream slopes**													
128	16-Apr		x 134	vacuum spool piece inplace													
129	16-Apr	23:10	X 134	zerop	04162ca		5.622E-07				Upstream & Downstream Gain = 10X. Incident UV gain = 100X, 12 db attenuator in place. Iris #2 = 12.17 mm^2 located before the vacuum window Dummy laser off file, zerop, made to allow use of uv-analysis	12*					
130				Run 04162ca shows that there was a change in a property of the data acquisition between the data taken on these days and the data taken during the main portion of the run. The GADC now saturates at ~ 960 vs ~ 1750 during the data taking in March and April. The slope above was determined by using correlate to remove events where the GADC was saturated.													
131	16-Apr	23:15	X 134	zerop	04162cb	04160ca	5.965E-06	4.71E-06	78.89%	9.41E+14	Upstream & Downstream Gain = 10X. Incident UV gain = 10X, Iris #2 = 12.17 mm^2 in place slope change consistent with amplifier gain change & no change in attenuator	12*					
132	16-Apr		X 134	laser refill after 04162cb													
133	Values below corrected for amplifier gain change																
134	17-Apr	1:30	X 135	zerop	04160cc	04160cb	1.093E-04	9.42E-05	86.16%	5.91E+14	Upstream & Downstream Gain = 1X. Incident UV gain = 10X, Iris OPEN Iris IN/Iris OUT = 0.0548 when account is taken of the change in amplifier gains	12*					
135	17-Apr	1:30	X 135	zerop	04160cd		9.868E-05				Upstream & Downstream Gain = 1X. Incident UV gain = 10X, Iris = 46.52 mm^2 at exit Iris(12.17 mm^2)/Iris(46.52 mm^2) = 0.605 vs ratio of areas = 0.262	12*					
136	17-Apr	1:35	X 135	zerop	04160ce		1.055E-04				Upstream & Downstream Gain = 10X. Incident UV gain = 10X, Iris = 46.52 mm^2 at exit slope agrees 10X increase in gain	12*					

* on Incident UV attenuation => known value

Run 6 UV Calibration Runs

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	**Date**	**Time**	**LOG**	**No laser run**	**US run**	**DS run**	**US slope**	**DS slope**	**transmission**	**density (cm^{-3})**	**comment**	**Atten on Incident UV (db)***	**Relative US ratio**	**Relative DS ratio**	**Absolute US ratio**	**Absolute DS ratio**	**US/DS energy @ 300 incident**
137	17-Apr	1:40	X 135	zerop	04160cf	04160cg	1.308E-05	1.10E-05	83.84%	6.99E+14	Upstream & Downstream Gain = 10X. Incident UV gain = 100X, Iris 0= 46.52 mm^2 just before beam splitter to Incident UV	12*					
138	17-Apr		comment on page 139 that there is 97% transmissionin vacuum. Wrong UV meter calibrations were used, comment incorrect														
139	17-Apr		X 138	vacuum spool piece removed													
140	18-Apr		X 139	Runs below taken with the pellicle off center as was the condition for the runs with large delays													
141	18-Apr	1:24	X 141	zerop	04180ca		7.168E-06				One iris centered on UV window, other iris off-center on Incident UV meter. Some curvature in data	6*	Upstream & Downstream gain = 100X, Incident UV gain =1000, 6 db on iIncident UV rectangular Iris = 2.03 mm X 2.92 mm = 5.94mm^2. Both Iris' centered on both detectors				
142	18-Apr	1:30	X 141	04180cc	04180cb						cb = run with several thicknesses of paper to prove no light leakage	6*					
143	18-Apr	1:35	X 142	zerop	04180cd		7.257E-06				Both Iris' centered on both detectors	6*					
144	18-Apr	1:55	X 142	zerop	04180ce		6.299E-06				One iris centered on incident UV other high on upstream	6*					
145	18-Apr	2:00	X 142	zerop	04180cf		1.097E-06				One iris centered on incident UV other low on upstream	6*					
146	18-Apr	2:40	X 143	zerop	04180cg		1.789E-07				Upstream gain = 100X & 0 db, Incident UV gain = 100X & 12 db. Slope corrected for saturation	12*					
147	18-Apr	2:47	X 143	zerop	04180ch						Incident attenuation increased to 20 db, but S&H was saturating	20*					
148	18-Apr	2:50	X 143	zerop	04180ci		4.362E-07				Incident UV = 10x, 0 db, Molectron 100X, 0 db	0*					
149	18-Apr	2:55	X 144			04180cj		0.67278 (from correlate)			Molectron, located at 0 cm wrt start of oven, connected to downstream Gain = 1000X, 5.94 mm^2 rectangular aperture in front of molectron	0*					
150	18-Apr	3:00	X 144			04180ck		0.68745 (from correlate)			repeat of 04180cj	0*					
151	18-Apr	3:05	X 144			04180cl		1.6449 (from correlate)			Molectron on downstream UV meter, gain = 100X, iris removed	0*					

* on Incident UV attenuation => known value

Run 6 UV Calibration Runs

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	**Date**	**Time**	**LOG**	**No laser run**	**US run**	**DS run**	**US slope**	**DS slope**	**transmission**	**density (cm^{-3})**	**comment**	**Atten on Incident UV (db)***	**Relative US ratio**	**Relative DS ratio**	**Absolute US ratio**	**Absolute DS ratio**	**US/DS energy @ 300 incident**
152	18-Apr	3:20	X 145	04180co	04180cm	04180cn	1.325E-05	1.335E-05	99.45%	2.17E+13	Incident UV meter 10x, 0 db Upstream meter 100X, 6db (questionable, see standard slope analysis) Downstream meter 100X, 6db E162 normal data taking conditions	0*					
153		**Analysis of runs 04180cj & 04180ck**															
154		9/13/2001 - These runs give a slope d(Molectron)/dI_1 = 0.680. The raw molectron calibration is 0.786 V/J. There are two factors that must be taken into account. 1) The molectron was amplified by a 1000X amplifier, and 2) there is a correction factor of 0.54 (see IX 23) which is the ratio of the voltage read by the S&H and the peak voltage. Taking account of these two factors, the Molectron calibration for this run is 0.786V/J*1000*0.54 = 424 V/J. Using this calibration the slope is dE/dI_1 = 1.60 microJ/GADC count = 0.680J/424V = 1.60 microJ/mV = 1.60 microJ/GADC count. The molectron had a 5.94 mm^2 mask in front of it. Taking this into account $1/AdE/dI_1$ = 27.0 microJ/cm^2/GADC count (Note: this value is substantially different than the value of 10.7mJ/cm^2 at GADC =750 for two reasons - incorrect reading of the graph in the log and not taking the S&H/Peak ratio into account)															
155		**With Incident UV amplifier gain = 10X, the fluence is $1/AdE/dI_1$ = 27.0 microJ/cm^2/GADC count**															

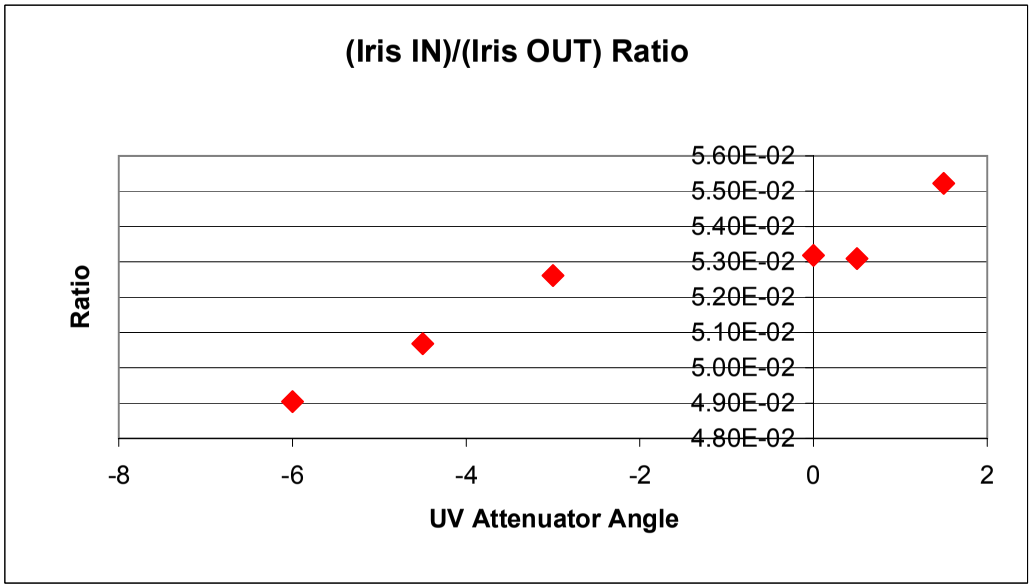
* on Incident UV attenuation => known value

RHS Annoatated energy meter calibration run 6

Run 6 UV Calibration Runs

11/19/2001
7:13 PM

Iris In slope	IRIS out slope	angle	(Iris IN)/(Iris OUT)
2.34E-07	4.23E-06	1.5	5.52E-02
2.04E-07	3.84E-06	0.5	5.31E-02
1.86E-07	3.49E-06	0	5.32E-02
1.35E-07	2.57E-06	-3	5.26E-02
1.27E-07	2.50E-06	-4.5	5.07E-02
1.28E-07	2.61E-06	-6	4.90E-02
	Average		5.23E-02



Run 6 UV Calibration Runs

	Standard Slope = Slope (J/incident channel) at US Gain = 10, US attenuator = 0 db, Incident Gain = 10, Incident attentuator = 0db										
US Run	**Date**	**Log**	**Raw US Slope (from fit)**	**US Gain**	**US Atten (db)**	**Effective US Gain**	**Inc Gain**	**Inc Atten (db)**	**Effective Inc Gain**	**Standard Slope (J/incident UV)**	**Comment**
Standard				**10**	**0**	**10**	**10**	**0**	**10**		
03241cc	24-Mar	IX 119	8.27E-06	100	0	100	10	6	5	4.14E-07	UV attenuator **between** Incident and Upstream UV's
03242ce	24-Mar	IX 123	8.46E-06	100	0	100	10	6	5	4.23E-07	UV attenuator **between** Incident and Upstream UV's
03251cz	25-Mar	IX 137	1.02E-05	10	0	10	10	6	5	5.12E-06	UV attenuator **between** Incident and Upstream UV's. Setting different from 03241cc above
03291cc	29-Mar	X 32	1.07E-05	10	0	10	100	6	50	5.34E-05	UV attenuator **in front of both** Incident and Upstream UV's at 0 degreee Why not consistent??
03300cn	30-Mar	X 42	4.71E-06	10	0	10	100	0	100	4.71E-05	UV attenuator **in front of both** Incident and Upstream UV's at 0 degreee
04040cc	4-Apr	X 128	3.49E-06	10	0	10	100	0	100	3.49E-05	UV attenuator **in front of both** Incident and Upstream UV's at 0 degreee
04160cc	17-Apr	X 135	1.09E-05	1	0	1	10	12	3	2.74E-05	
04180cm	18-Apr	X 145	1.34E-05	100	6	50	10	0	10	2.68E-06	These two rows contain two different analyses of run 04180cm.
04180cm	**18-Apr**	**X 145**	**1.34E-05**	**10**	**6**	**5**	**10**	**0**	**10**	**2.68E-05**	

The top row uses the gains stated in the log book, but the standard slope using those is wrong by a factor of 10. This is taken to be an error in the log book. The second row uses a reduced US amplifier gain, and this gives a standard slope that in agreement. Incident gain =100 rather than 10 would also produce agreement in the standard slope. The range of GADC values provides an argument against that solution, however. A comparison of maximum values for runs 04180cm and 04160cc gives the following.

Max Incident UV: (04180cm)/(04160cc) = 730/170 = 4.3. Max US UV: (04180cm)/(04160cc) = 1300/240 = 5.4

This is consistent with a factor of 5 (row 14) vs a factor of 50 (row 13) chnage in the US gain, and a factor of 3 change in the Incident gain (rows 13 & 14) vs the alternative that would be a factor of 30 change if the incident gain was 100