Short summary of Helium 2010 analysis

The previous data base contained only a lumped sum for the triplet and singlet excitations in helium. The analysis was driven by a request by Oleg Kiselev To explain the results of Masaoka et al Nucl Instr and Meth B 171(2000)360 which require a large surpression of the Hornbeck Molnar associative ionisation contribution to the avalanche gain in a low temperature pure helium proportional detector.

The new data base now splits the excitation into 49 levels . The x-sections for these levels were obtained from 3 mainly theoretical calculations. At this point it should be noted that Helium calculations are now more accurate than experimental measurements. The first set of calculations are from Klaus Bartschat and use the RMPs method to give accurate resonance structures in the x-sections at threshold and up to 30 ev. The second group of calculations are from Ralchenko et al and are polynomial fits to both the theory and experiment from threshold to 2000 ev . I have not used the values of Ralchenko from threshold since they do not fit the resonance structure at threshold . The Ralchenko fits are used from 30 ev up to the 1 to 2 kev . Above 1 to 2 kev the individual x-sections that are not dipole allowed follow quite closely to power laws depending on the forbiddenness of the transition. The dipole allowed transitions are smoothly fitted above 1 to 2 kev to the BEF scaling formula of Kim.

The elastic and ionisation x-sections are only changed by less than 0.5% from the previous data base to ensure agreement with the experimentally measured total x-section.

The results of calculations with the new data base show very small changes in drift and diffusion at less than 1%.

The Townsend gain coefficient also showed some changes from the previous data base but at less than the 5% level.

A first attempt was made to find the maximum possible amount of Hornbeck-Molnar ionisation in the Townsend coefficient. The experiments measuring the Townsend coefficient are 1) Chanin and Rork and 2) Davies and Milne . The values of Chanin and Rork are typically 10% larger than Davies and Milne . It is possible that the Chanin values are higher because of some impurity in the gas giving Penning ionisation, however, they are both consistent within experimental errors.

The calculated values without Hornbeck Molnar are slightly lower than the Davies and Milne measurements but outside the error bars of the Chanin and Rorke values. By including a 25% contribution from energy levels that are excited in Helium and are also above the threshold for the Hornbeck –Molnar process good agreement can be obtained with the average value of the two experiments .

The threshold for the Hornbeck-Molnar process is taken as 22.9 ev, only the 3 3P and above states can contribute . The excited states in Helium are described in the L-S coupling scheme in the data base unlike the other noble gases that use the Paschen notation..

The following table gives the calculated Townsend with and without the Hornbeck-Molnar contribution at 20C and 1 Atmosphere:

(kv/cm) Electric Field	1/cm Townsend	1/cm Townsend with Hornbeck Molnar
2.0	0.012	0.049
3.0	0.44	0.98
4.0	2.2	3.9
5.0	5.7	9.1
6.0	11.4	16.5
8.0	28.0	38.0
10.0	46.8	57.6
15.0	109.4	126.8
20.0	180.7	202.1
30.0	325.9	353.0
40.0	460.9	491.3
50.0	581.9	613.1
60.0	683.9	717.8
80.0	847.4	881.8

The change in Townsend is largest at low field but the electric fields in the proportional tube of Masaoka vary up to 60 kev/cm/atmosphere. The reduction in the Townsend coefficient observed at low temperature (4.2K) by Masaoka is attributed to the reduction in the Hornbeck Molnar process however their reduction of 20 to 30% in the Townsend coefficient is much larger than the above numbers would indicate . An estimate would be about 10% reduction in gain if the whole Hornbeck Molnar process is surpressed at low temperature. (A proper integral of the above numbers for the experimental situation should be done.)

The Hornbeck Molnar process can also change the W value and Fano factor in pure Helium. The following numbers are calculated at the W plateau level

Without Hornbeck-Molnar	With Hornbeck_Molnar
W=46.27 F=0.199	W=44.32 F= 0.190

The experimental situation regarding the W and F value is very bad the older data from the 1950s is affected by impurities in the gas and the resultant penning effects values in the range from 42.0 to 46.0 exist for the W value. Modern data are no better a recent measurement in a triple Gem was totally dominated by impurities from outgassing in the Gem..

In conclusion Helium seems to offer the possibility of giving an unambiguous measurement of the Hornbeck-Molnar process but the data on Townsend gain in the pure gas are not accurate enough to give an unambiguous sign. The experimental W and F values are so uncertain as to give no restriction. A best case assumption would be to take the Hornbeck-Molnar fraction for levels above 22.9 ev in the range from 0 to 30% as outside limits.