An Assessment of Electron Collision Cross Sections for Tetrafluoroethylene (C_2F_4)

56th Gaseous Electronics Conference (www.gec.org)
San Francisco, CA
October 2003

W. L. Morgan
Kinema Research, Monument, Colorado
morgan@kinema.com

S. J. Buckman
Australian National University, Canberra, Australia
stephen.buckman@anu.edu.au

Kinema Research & Software, L.L.C.
719.481.1305 • Fax: 719.481.1398
P.O. Box 1147 • Monument, CO 80132

ANU

Introduction

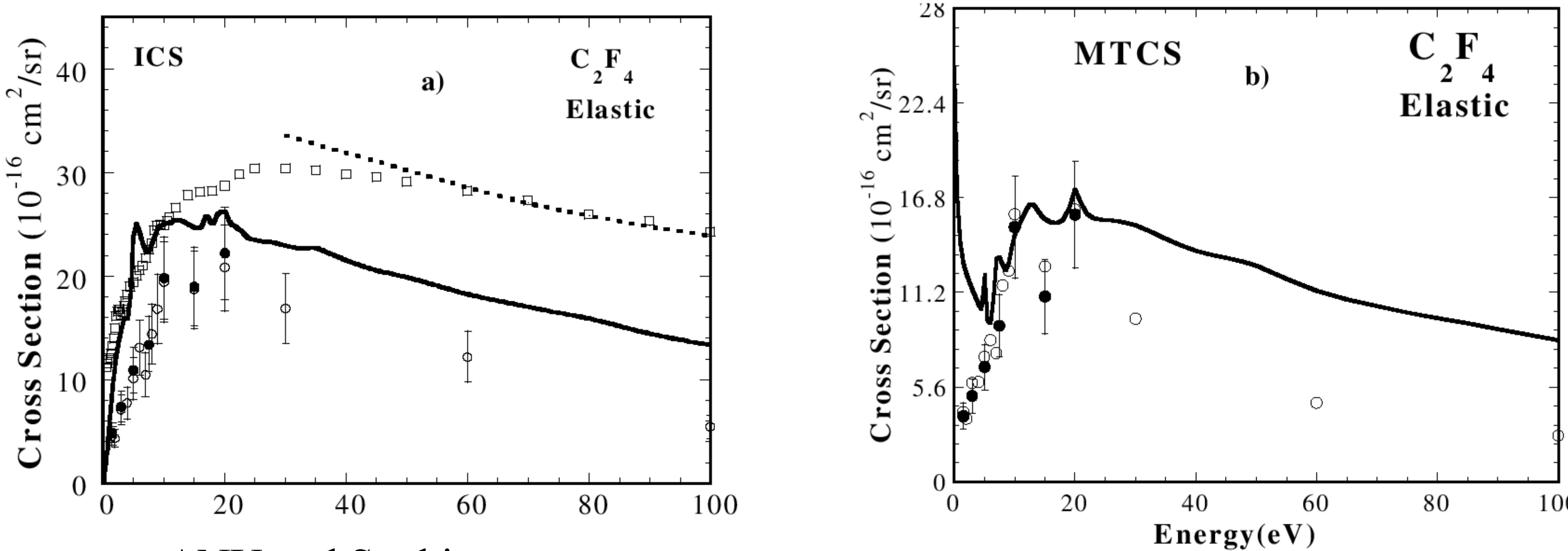
In this presentation we:

(1) Compare recent measurements of the momentum transfer and vibrational excitation cross sections for C_2F_4 with previous *ab initio* cross sections and cross sections derived from analysis of electron transport data (i.e., swarm analysis)

(2) Examine some of the sensitivities of transport coefficients to various cross sections

Elastic & Momentum Transfer Cross Sections

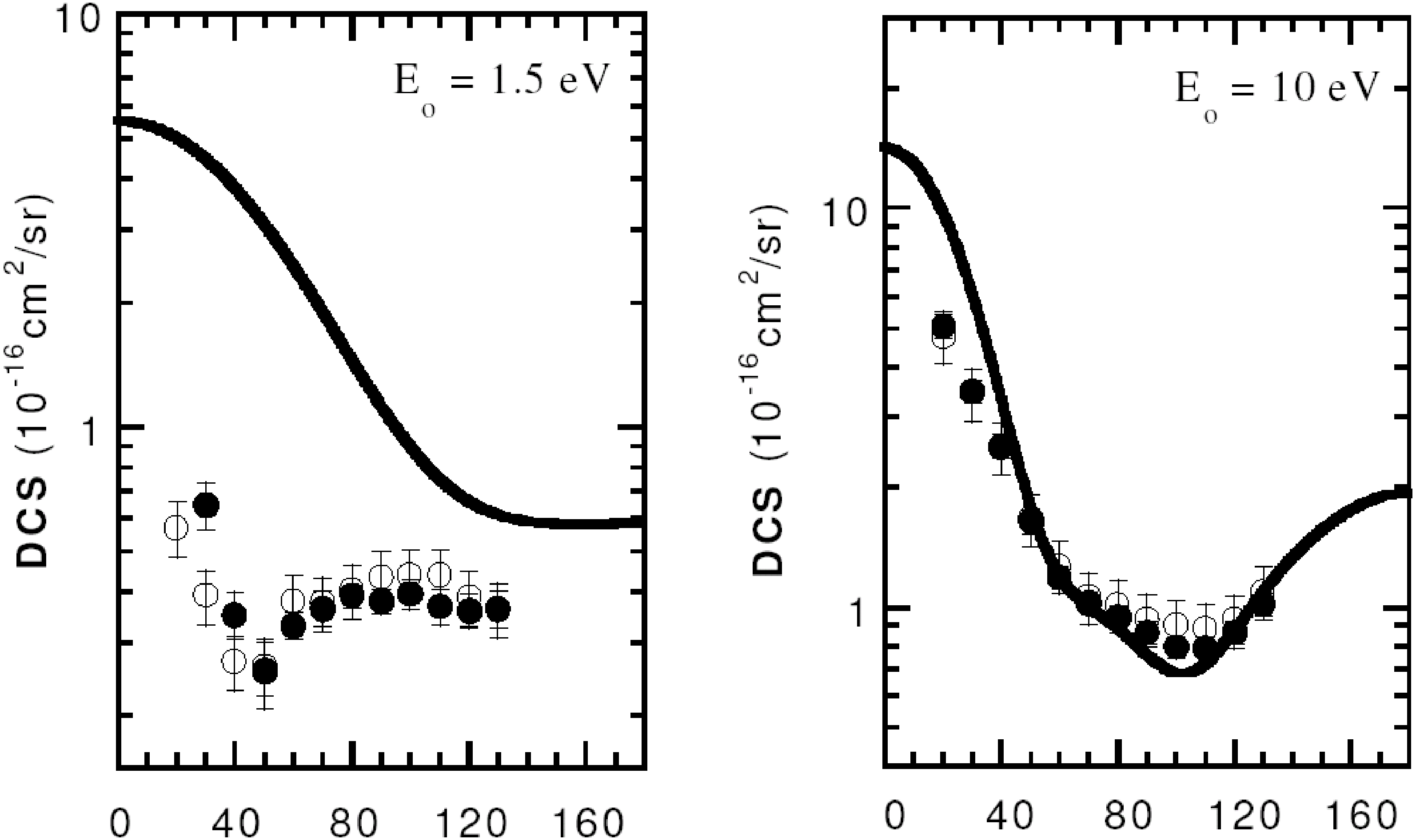
• Difference between measured and calculated σ_m ε at low energy is due to different behavior of differential cross section for θ<90°



•, o ANU and Sophia measurements

— Winstead and McKoy *ab initio* calculations

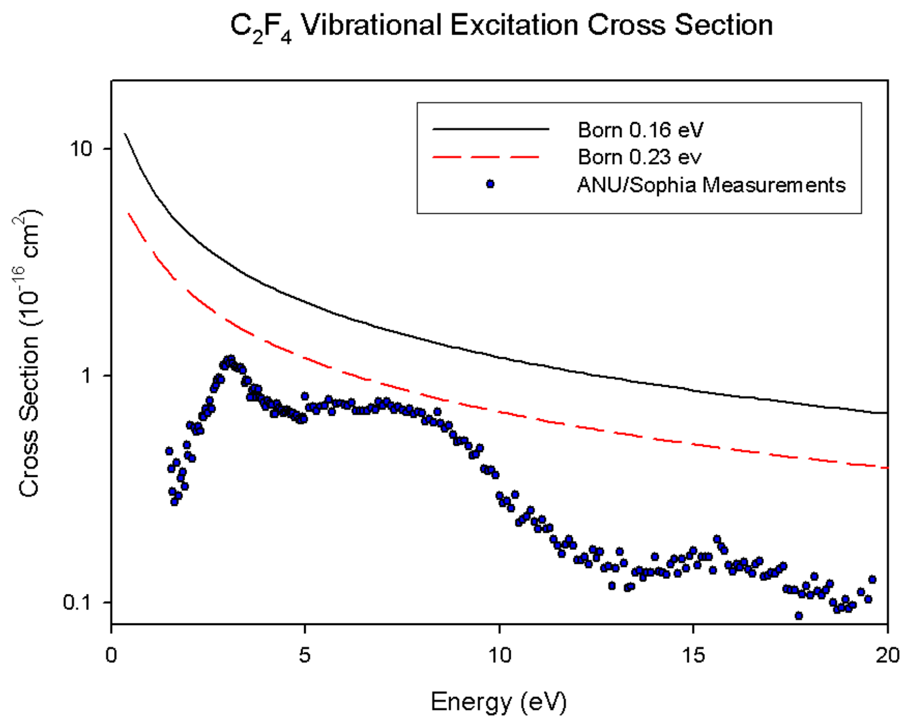
□ Szmytkowski, et al. total cross section measurements



E$_o$ = 1.5 eV
E$_o$ = 10 eV
DCS (10^{-16}cm^2/sr)
DCS (10^{-16}cm^2/sr)
10
1
10
1
0
40
80
120
160
0
40
80
120
160

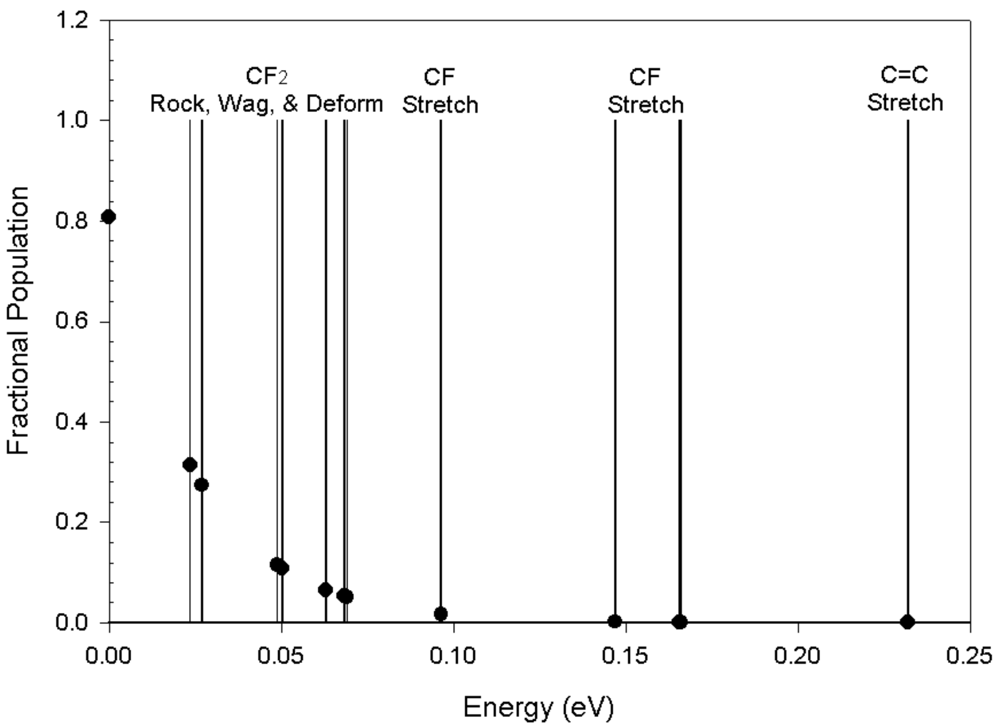
Vibrational Excitation Cross Section

• Yoshida, et al. made use of model vibrational excitation cross sections having a Born energy dependence



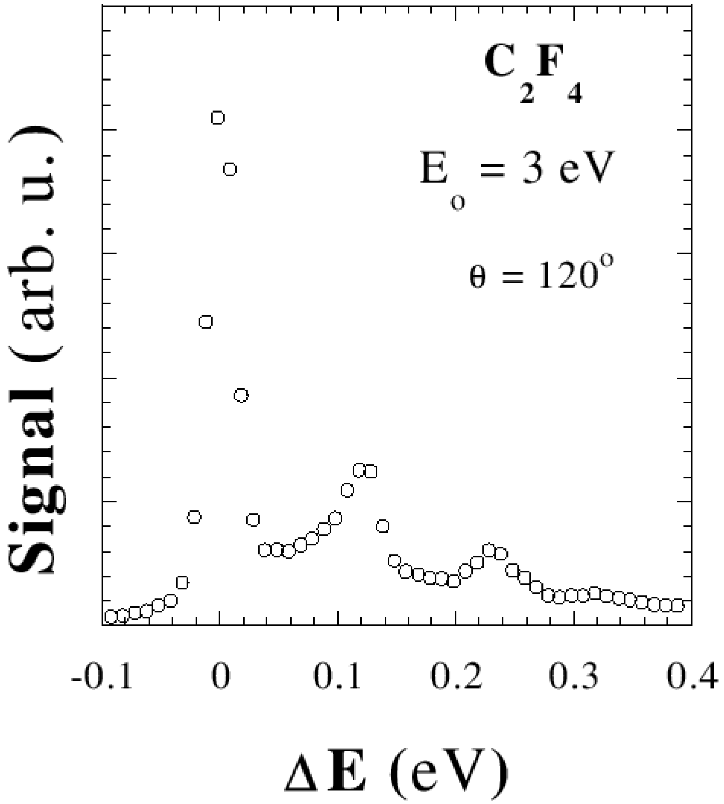
Vibrational Excitation Spectrum

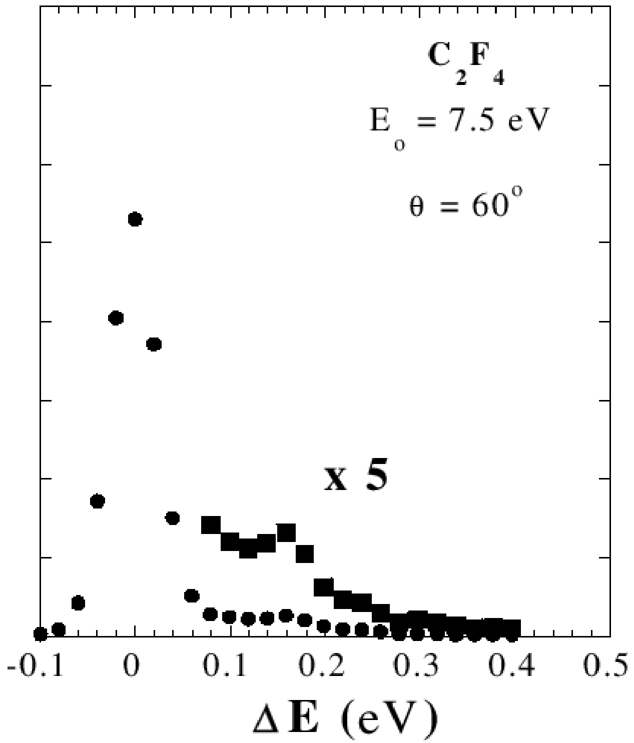
- 12 fundamental vibrational modes of C_2F_4



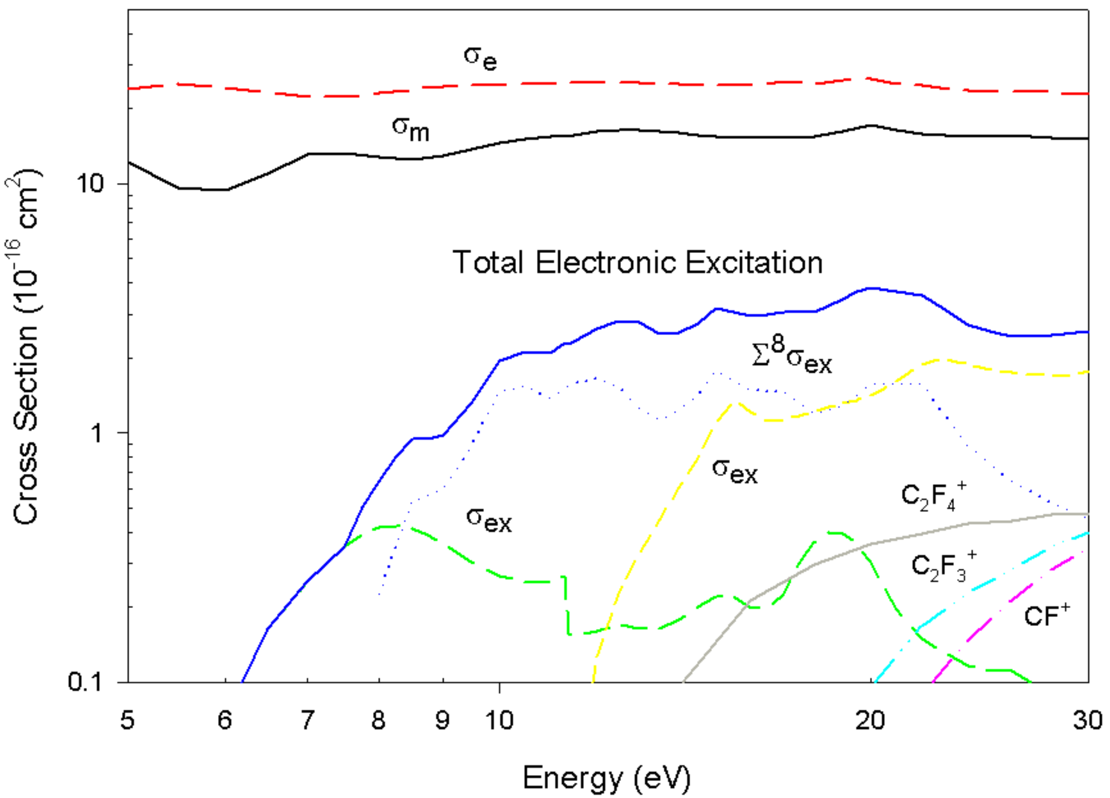
Electron Energy Loss Spectrum

- Strongest features at 0.16 & 0.23 eV





Winstead & McKoy *ab initio* Cross Sections



Swarm Analyses

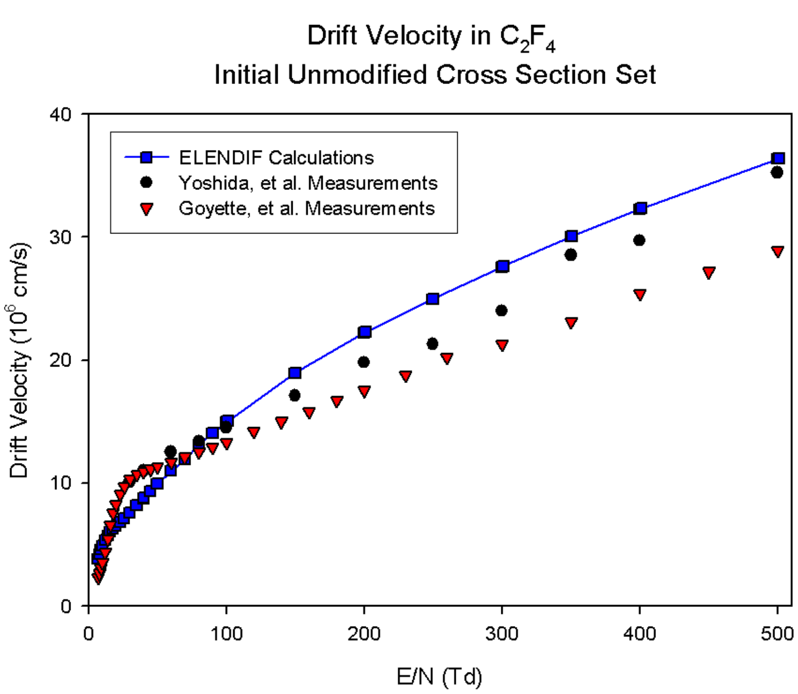
In these analyses we use programs for solving Boltzmann's equation [ELENDIF (2-term) & Monte Carlo] and optimization algorithms [Downhill or Creeping Simplex, neural networks, and Bayesian statistical theory] for exploring the relationships between the electron impact cross sections and the electron transport coefficients.

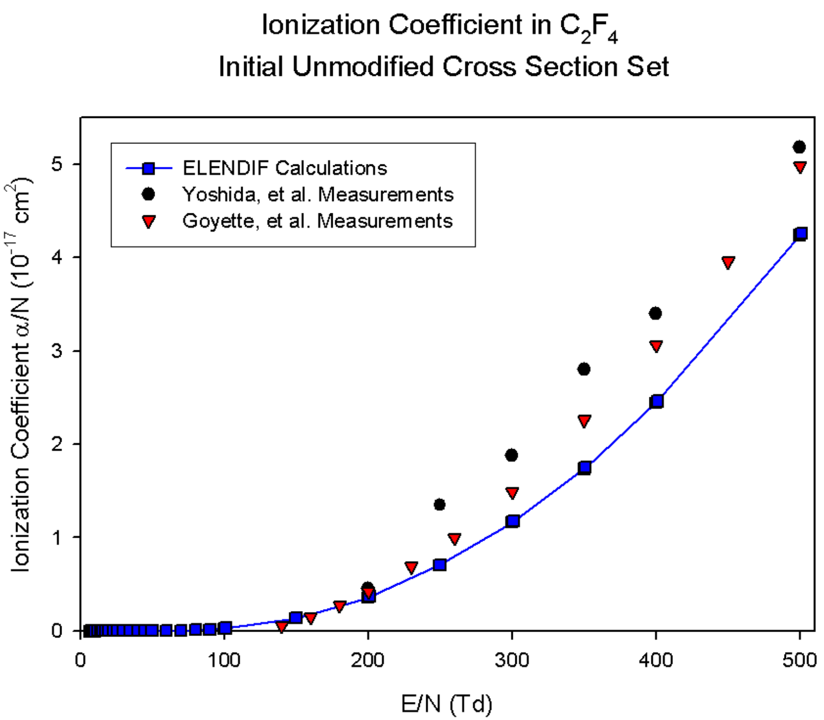
$$\left\{ \begin{matrix} \sigma_m(\varepsilon) \\ \{\sigma_i(\varepsilon)\} \end{matrix} \right\} \Rightarrow \left\{ \begin{matrix} v_d(E/N) \\ D/\mu(E/N) \\ \{k_i(E/N)\} \end{matrix} \right\}$$


"The new
season's funniest"
-USA Today

Unmodified Cross Sections Yield Poor Agreement with Measured Transport Data

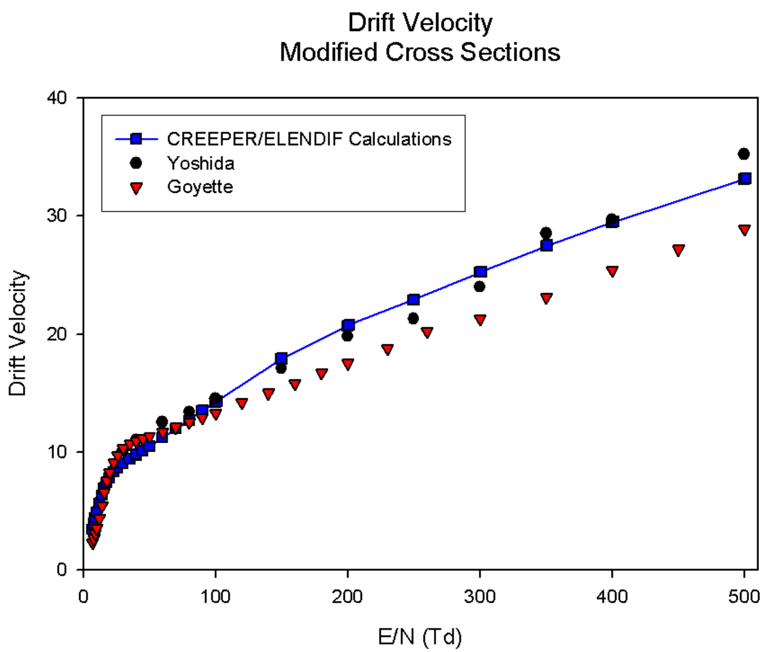
- $V_d = -1/3(2e/m)^{1/2}(E/N) \int [df_o(\varepsilon; E/N)/d\varepsilon]\varepsilon d\varepsilon/\sigma_m(\varepsilon)$
- $\alpha/N = k_i/Vd$ where $k_i = (2e/m)^{1/2} \int \sigma_i\ (\varepsilon)\ f_o(\varepsilon, E/N)\varepsilon d\varepsilon$

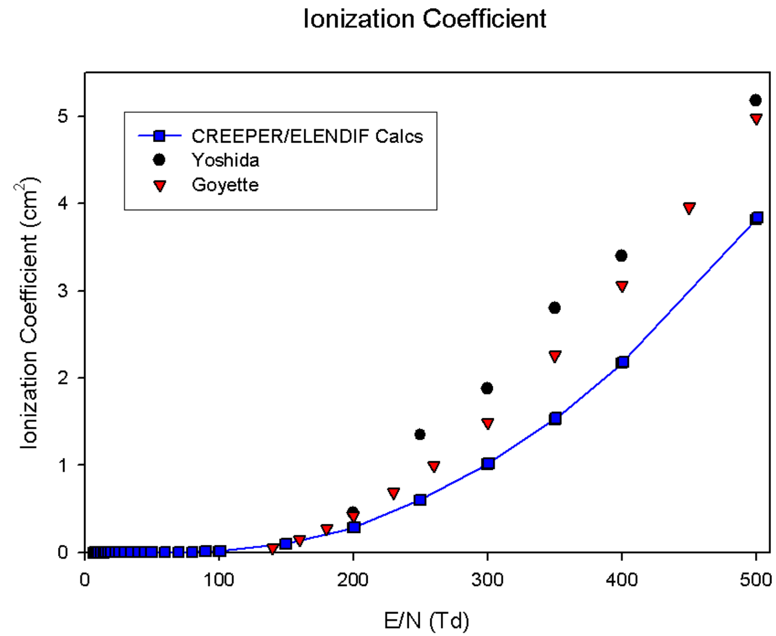




Modifying σ_m and σ_v Improves Agreement with Swarm Data

- $\sigma_m(\varepsilon) = 1.14 \times \sigma_m$ (Measured)
- $\sigma_v(\varepsilon) = 2.36 \times \sigma_v$ (Measured)

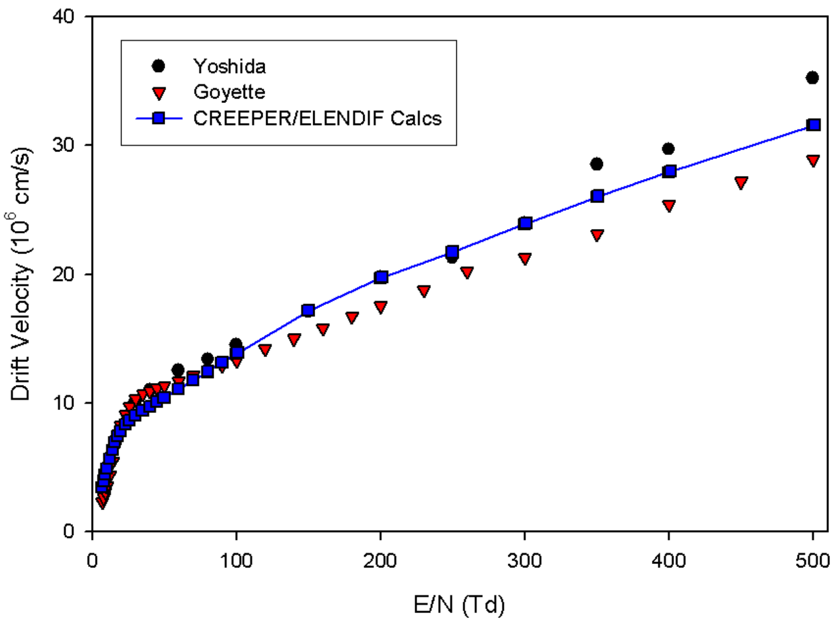




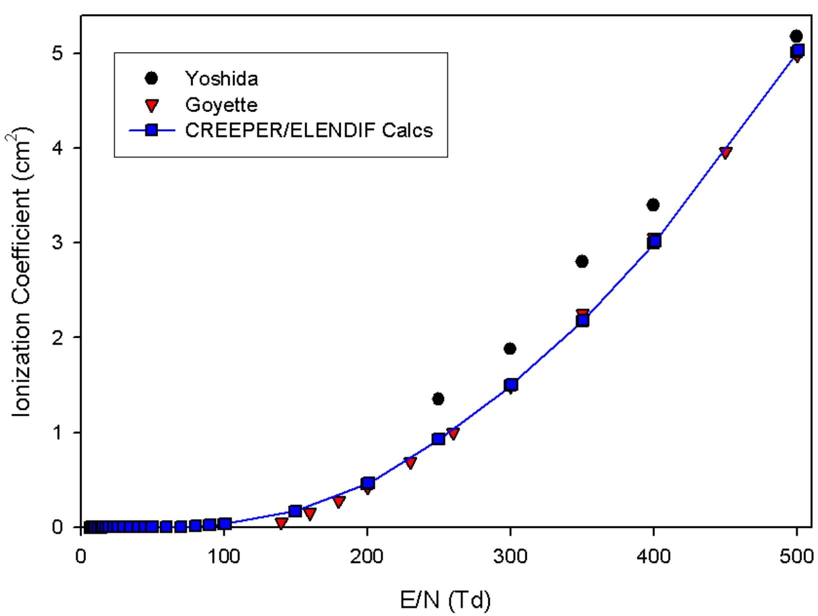
Modification of σ_e Further Improves Agreement with Swarm Data

- $\sigma_e(\varepsilon) = 0.65 \times \sigma_e$ (Calculated) for 8 state 7.5 eV composite process

Drift Velocity



Ionization Coefficient



Sensitivity Analyses

- For each $\{V_d(E/N)\}$ there may several sets of $\{Q_m(\varepsilon), Q_v(\varepsilon), Q_e(\varepsilon)\}$ within some error bar

- From Bayes' Theorem:

$$f(Q|V_d) = f(V_d|Q)\ f(Q)\ /\ f(V_d)$$