The data file METHANE: Additional Atomic and Molecular Data for EIRENE

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Contents

I Introduction

Additional atomic data fits, read by EIRENE:
Data for breakup of Hydrocarbons, taken from [1], i.e.: so called "Ehrhard-Langer database", 1987. This database has been superseded by the later "Janev-Reiter" cross section database [4], but is kept here for backward compatibility.
Format as in HYDHEL [2] or AMJUEL, both are available on same web side, as is this present file:

`www.eirene.de/html/a_m_data/html`

I.1 Calculation of Reaction Rate Coefficients

(taken from [2]):
The Maxwellian-averaged reaction rate coefficients for a particle of mass m and fixed energy $E = mV^2/2$ incident on a Maxwellian distribution of particles of mass M and temperature $T = Mu^2/2$ (hence: $u = \sqrt{2T/M}$, the thermal velocity) for the heavy-particle reactions is

$$\langle \sigma v \rangle (E,T) = \frac{1}{\pi^{1/2} u V} \int_{v_{th}}^{\infty} v_r^2 dv_r \sigma(E_r) \{ \exp[-(v_r - V)^2/u^2] - \exp[-(v_r + V)^2/u^2] \},$$

and for the electron reactions (taking $M = m_r \approx m_e, T \approx T_e, E = V = 0$), with m_e, T_e being the electron mass and electron temperature, respectively

$$\langle \sigma v \rangle (T) = \frac{4}{\pi^{1/2} u^3} \int_{v_{th}}^{\infty} v_r^3 dv_r \sigma(E_r) \exp(-v_r^2/u^2),$$

where $v_r = |\vec{V} - \vec{v}|$ is the relative (collision) velocity related to E_r by $E_r = m_r v_r^2/2, m_r = mM/(m+M)$ being the reduced mass of colliding particles, and v_{th} is the value of v_r at threshold, $E_r = E_{th}$. Note that for electron collisions our approximations result from $v_r \approx v_e$.
We used a number of mathematical techniques to assure the reaction rate integrals were computed accurately for the nearly five orders of magnitude variation in E and T.
For the calculation of reaction rate coefficients, it is necessary to know the cross section from threshold to very large values of the energy. However, the digitized data necessarily represent the cross section for a finite energy range and for a finite number of points (less than 100). Our solution to this problem is: (1) to calculate values of a within the digitized range by linear interpolation of $\ln \sigma$ in $\ln E$; and (2) to extrapolate σ outside the digitized range by a method depending on the type of reaction as discussed in [2].

I.2 Numerical Fits to σ and $\langle \sigma v \rangle$

(taken from [2]):

We derived numerical fits for σ and $\langle\sigma v\rangle$ so that these processes can be evaluated easily in numerical codes and in other instances that demand simple and/or repeated evaluations. Since σ and $\langle\sigma v\rangle$ vary over many orders of magnitude, we made polynomial fits for $\ln\sigma$ in terms of $\ln E$ and for $\ln\langle\sigma v\rangle$ in terms of $\ln T$:

$$\ln\sigma = \sum_{n=0}^{N} a_n (\ln E)^n \tag{1}$$

$$\ln\langle\sigma v\rangle = \sum_{n=0}^{N} b_n (\ln T)^n, \tag{2}$$

For the electron reactions, $\langle\sigma v\rangle$ is essentially independent of E within the range of energies considered here. A more useful fit for the heavy-particle reactions is a double polynomial fit in both E and T:

$$\ln\langle\sigma v\rangle = \sum_{n=0}^{N}\sum_{m=0}^{M} \alpha_{mn} (\ln E)^n (\ln T)^m. \tag{3}$$

Such a fit requires a large number of coefficients in order to be accurate, but can be used for arbitrary E and T. We tabulate the coefficients for a 9 x 9 double fit of this form.
An error is given in [2] for each fit as an indication of the quality of the fit. The error is defined as
$\frac{1}{N}\sum_{i=1}^{N}(\ln x_i - \ln x_{fit,i})^2$,
where N is the number of points fit, and x is σ or $\langle\sigma v\rangle$. An error of 10^{-4} is a good fit; that is, the fit is very close to the actual values, most likely well within the error in the data.

I.3 various notes regarding this particular data-set:

- In PPPL report [1] also the Born-type fitting is promised, but, apparently, never given. So do not use the aBorn, nBorn coefficients here.

- For some processes the original polynomial fit, eq. (1) (labeled **fit-flag=0**) for cross sections is very poor. See [3]. In one instant (H.1: reaction 2.1, cross section fit) we have scanned and digitalized the cross section data from [1] and redone the fit (same fitting expression). These are then referred to as H.1 ...label..._new, the original fit coefficients for these processes are H.1 ...label... This example indicates that the fitting procedure, rather than the fit-expression itself, was probably the origin of the poor quality of fits.

- For some processes newer cross section fits, from the 2002 "Janev-Reiter database" [4] have been included. These reactions are labeled by additional letters "jr", e.g. H.1 2.1jr, or by the single additional letter "t" (for "total cross section").

  The fitting expression for those is different from the 8th order polynomial fit in the original PPPL database from 1987. The flag: **fit-flag=3** is used for these.

  fit-flag=3 is the cross section fit expression given in the 2002 Janev-Reiter database [4] for so called I-DI (ionisation-dissociative ionisation) processes:

$$\sigma(E) = \frac{10^{-13}}{E E_{th}}\left[A_1 \ln(E/E_{th}) + \sum_{i=2}^{N} A_i (1 - E_{th}/E)^i\right] \tag{4}$$

which, at least, has proper asymptotic behaviour (assuming that always also dipole allowed channels contribute to the cross section). Parameter $A_0 = E_{th}$ is the ionisation (appearance) potential, i.e. the threshold energy of the process. Typically: N=6

We have then stopped adding newer cross section to the present database, because the full cross section database for hydrocarbon fragmentation, up until propane, is now given on the web page: www.hydkin.de. This present database now only serves for backward compatibility of code runs.

Record:

- update 2.3.01
  rate coeff. H.2, H.3 from [1]
  plots done

- update 7.5.01
  cross sections H.1 from [1]
  plots still to be done
  energetics and comments: still to be done

- update 11.5.01
  cross sections H.1 from [1]
  plots until 2.19.2 done,
  H.2 plots checked (labels, text) until 2.19.2

- update 16.5.01
  cross sections H.1 from [1]
  all plots done
  to be done: check extrapolation of sigma H.1 3.2
  to be done: check masses, reduced masses, etc. (as in HYDHEL?)

- update summer 2005
  Parameter fit-flag introduced. Default: fit-flag=0

  fit-flag=0 is the original polynomial fit expression as in [1], or [2], Eqs. (1,2)

I.4 End of preface

This next string is searched by EIRENE in subroutine SLREAC to initialize search for a particular set of fit coefficients. From here on, a character string **'H.n'** , n an integer, must only appear in the section title, but not in the text. Likewise: identifiers p0, a0, b0, ...,h0, k0 are used in SLREAC and must not appear in the text elsewhere, from here on.

```
.........................................
.                                       .
.       ##BEGIN DATA HERE##             .
.                                       .
.........................................
```

1 H.1 : Fits for cross sections

1.1 Reaction 2.1 $e + CH_4 \rightarrow CH_4^+ + 2e$

```
fit-flag 0
a0 -0.169266778385E+04   a1  0.236171577826E+04   a2 -0.143832466001E+04
a3  0.488702436959E+03   a4 -0.101380939759E+03   a5  0.131622236445E+02
a6 -0.104572481488E+01   a7  0.465440372297E-01   a8 -0.889674833827E-03
    Emin  1.43e+01    s(Emin)  1.00e-19   smax  1.80e-16   Error  2.39e-01
```

1.1.1 Reaction 2.1_new $e + CH_4 \rightarrow CH_4^+ + 2e$

Fit redone on digitalized data from report

```
fit-flag 0
a0 -1.160875903259D+03  a1  1.728794433758D+03  a2 -1.147825393593D+03
a3  4.290464376782D+02  a4 -9.864181332976D+01  a5  1.427765855698D+01
a6 -1.270560564160D+00  a7  6.356843504687D-02  a8 -1.369486002673D-03
    Emin  1.43e+01    s(Emin)  1.00e-19

Max. rel. Error:   5.6530 %
Mean rel. Error:   3.3022 %
```

1.1.2 Reaction 2.1jr $e + CH_4 \rightarrow CH_4^+ + 2e$

From Janev-Reiter 2002 database, fit-flag=3

```
fit-flag 3
a0  1.2630E+01          a1  1.3541E+00          a2 -1.4665E+00
a3  1.6787E-01          a4  6.1801E+00          a5 -1.5638E+01
a6  1.0767E+01          a7  0.0000E+00          a8  0.0000E+00
```

1.1.3 Reaction 2.1t $e + CH_4 \rightarrow$ total ionization

From Janev-Reiter 2002 database, fit-flag=3

```
fit-flag 3
a0  1.2630E+01          a1  2.3449E+00          a2 -2.6163E+00
a3  2.1843E-01          a4  1.0890E+01          a5 -2.9718E+01
a6  2.4582E+01          a7  0.0000E+00          a8  0.0000E+00
```

1.2 Reaction 2.2 $e + CH_3 \rightarrow CH_3^+ + 2e$

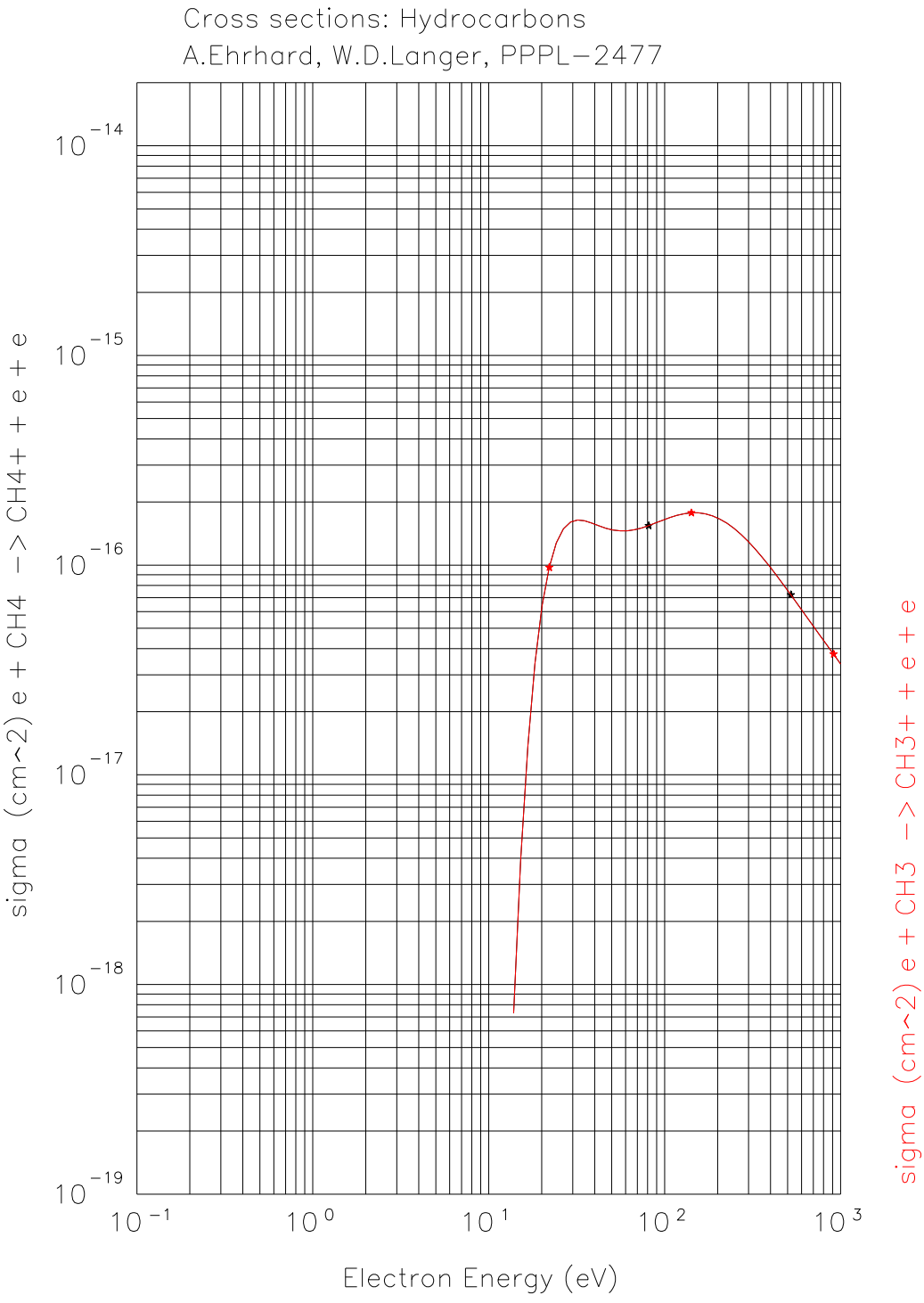
```
fit-flag 0
a0 -0.169266778385E+04   a1  0.236171577826E+04   a2 -0.143832466001E+04
a3  0.488702436959E+03   a4 -0.101380939759E+03   a5  0.131622236445E+02
a6 -0.104572481488E+01   a7  0.465440372297E-01   a8 -0.889674833827E-03
    Emin  1.43e+01    s(Emin)  1.00e-19   smax  1.80e-16   Error  2.39e-01
```

1.2.1 Reaction 2.2jr $e + CH_3 \rightarrow CH_3^+ + 2e$

```
fit-flag 3
a0  9.8000E+00          a1  1.9725E+00          a2 -2.1011E+00
a3  1.0593E+00          a4 -6.3438E+00          a5  8.0140E+00
a6 -4.2440E+00          a7  0.0000E+00          a8  0.0000E+00
```

1.2.2 Reaction 2.2t $e + CH_3 \rightarrow$ total ionization

```
fit-flag 3
a0  9.8400E+00          a1  2.4221E+00          a2 -2.4368E+00
a3 -7.4454E-01          a4  4.6634E-01          a5 -4.1606E+00
a6  4.5799E+00          a7  0.0000E+00          a8  0.0000E+00
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) e + CH4 −> CH4+ + e + e
sigma (cm^2) e + CH3 −> CH3+ + e + e
Electron Energy (eV)
10^−14
10^−15
10^−16
10^−17
10^−18
10^−19
10^−1
10^0
10^1
10^2
10^3

1.3 Reaction 2.3 $e + CH_2 \rightarrow CH_2^+ + 2e$

```
fit-flag 0
a0 -0.169266778385E+04   a1  0.236171577826E+04   a2 -0.143832466001E+04
a3  0.488702436959E+03   a4 -0.101380939759E+03   a5  0.131622236445E+02
a6 -0.104572481488E+01   a7  0.465440372297E-01   a8 -0.889674833827E-03
    Emin  1.43e+01    s(Emin)  1.00e-19   smax  1.80e-16   Error  2.39e-01
```

1.3.1 Reaction 2.3jr $e + CH_2 \rightarrow CH_2^+ + 2e$

```
fit-flag 3
a0  1.0400E+01           a1  1.7159E+00           a2 -1.7164E+00
a3 -6.5529E-01           a4  2.1724E+00           a5 -5.4186E+00
a6  3.1616E+00           a7  0.0000E+00           a8  0.0000E+00
```

1.3.2 Reaction 2.3t $e + CH_2 \rightarrow$ total ionization

```
fit-flag 3
a0  1.0910E+01           a1  2.9597E+00           a2 -2.6451E+00
a3 -3.7136E+00           a4  8.9168E+00           a5 -1.2872E+01
a6  5.8594E+00           a7  0.0000E+00           a8  0.0000E+00
```

1.4 Reaction 2.4 $e + CH \rightarrow CH^+ + 2e$

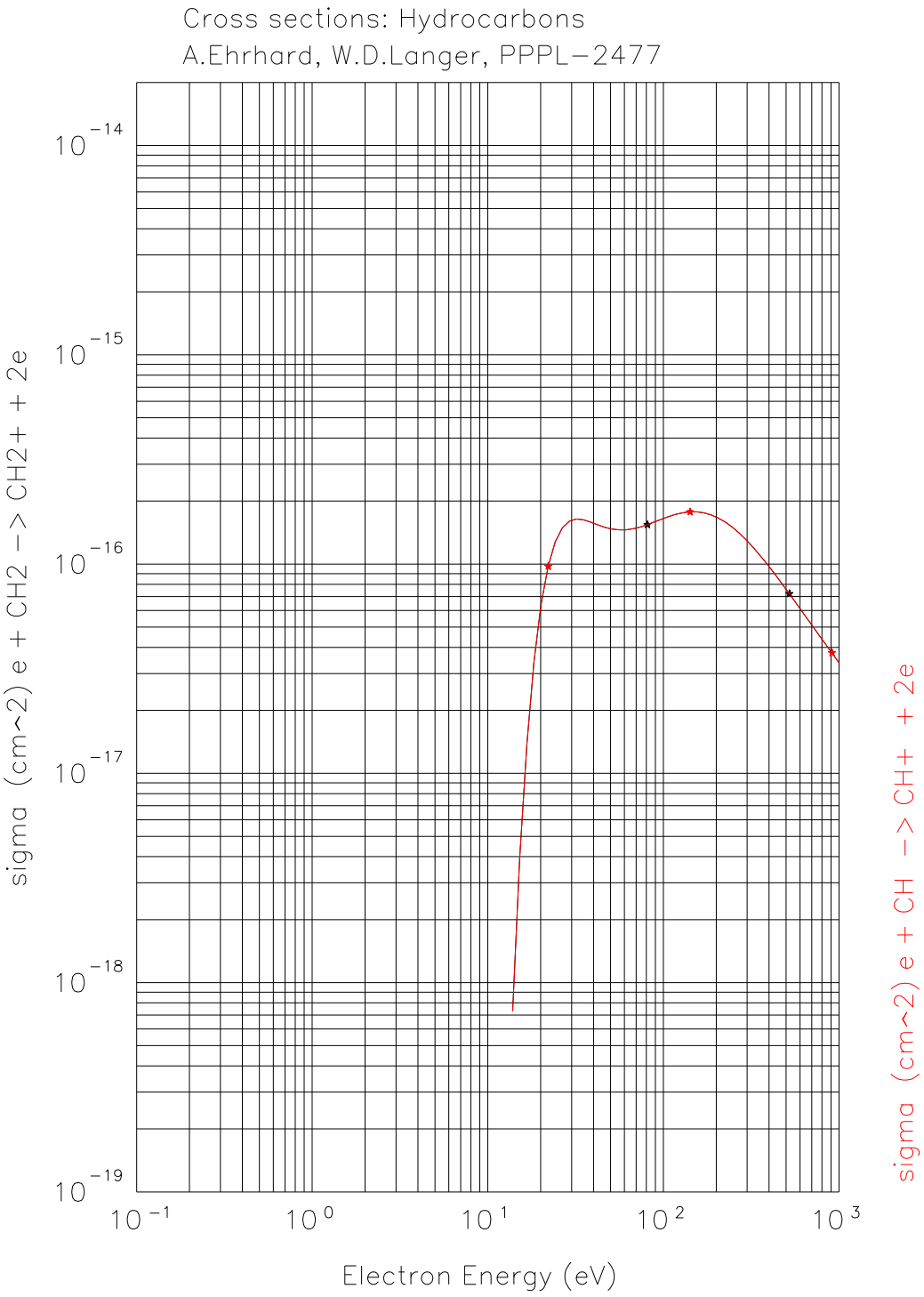
```
a0 -0.169266778385E+04   a1  0.236171577826E+04   a2 -0.143832466001E+04
a3  0.488702436959E+03   a4 -0.101380939759E+03   a5  0.131622236445E+02
a6 -0.104572481488E+01   a7  0.465440372297E-01   a8 -0.889674833827E-03
    Emin  1.43e+01    s(Emin)  1.00e-19   smax  1.80e-16   Error  2.39e-01
```

1.4.1 Reaction 2.4j $e + CH \rightarrow CH^+ + 2e$

```
fit-flag 3
a0  1.1300E+01           a1  1.4439E+00           a2 -1.2724E+00
a3 -2.2221E+00           a4  9.2822E+00           a5 -1.5506E+01
a6  8.2778E+00           a7  0.0000E+00           a8  0.0000E+00
```

1.4.2 Reaction 2.4t $e + CH \rightarrow$ total ionization

```
fit-flag 3
a0  1.1200E+01           a1  1.2258E+00           a2 -3.0764E+00
a3  2.6182E+01           a4 -1.4891E+02           a5  4.3224E+02
a6 -6.6387E+02           a7  5.1090E+02           a8 -1.5314E+02
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) e + CH2 −> CH2+ + 2e
sigma (cm^2) e + CH −> CH+ + 2e
Electron Energy (eV)
10^−14
10^−15
10^−16
10^−17
10^−18
10^−19
10^−1
10^0
10^1
10^2
10^3

1.5 Reaction 2.5 $e + CH_4 \rightarrow CH_3^+ + H + 2e$

```
a0 -0.211909364468E+04   a1  0.291412508925E+04   a2 -0.174624838796E+04
a3  0.585370972726E+03   a4 -0.120118043071E+03   a5  0.154617821191E+02
a6 -0.122034703755E+01   a7  0.540459492913E-01   a8 -0.102923174769E-02
    Emin  1.65e+01    s(Emin)  1.00e-19   smax  1.36e-16   Error  2.41e-01
```

1.5.1 Reaction 2.5.1jr $e + CH_4 \rightarrow CH_3^+ + H + 2e$

```
fit-flag 3
a0  1.4010E+01          a1  1.6074E+00          a2 -1.4713E+00
a3 -2.7386E-01          a4  1.9556E-01          a5  1.1343E-01
a6  9.0166E-03          a7  5.1090E+02          a8 -1.5314E+02
```

1.5.2 Reaction 2.5.2jr $e + CH_4 \rightarrow CH_2^+ + H_2 + 2e$

```
fit-flag 3
a0  1.6200E+01          a1  1.6252E-01          a2 -1.0708E-01
a3 -3.2252E-01          a4  8.7125E-01          a5 -1.8747E-02
a6  1.3071E-01          a7  5.1090E+02          a8 -1.5314E+02
```

1.5.3 Reaction 2.5.3jr $e + CH_4 \rightarrow CH^+ + H_2 + H + 2e$

```
fit-flag 3
a0  2.2200E+01          a1 -1.2458E-01          a2  1.6287E-01
a3 -3.3395E-01          a4  3.5738E+00          a5 -5.0472E+00
a6  2.8240E+00          a7  5.1090E+02          a8 -1.5314E+02
```

1.5.4 Reaction 2.5.4jr $e + CH_4 \rightarrow C^+ + 2H_2 + 2e$

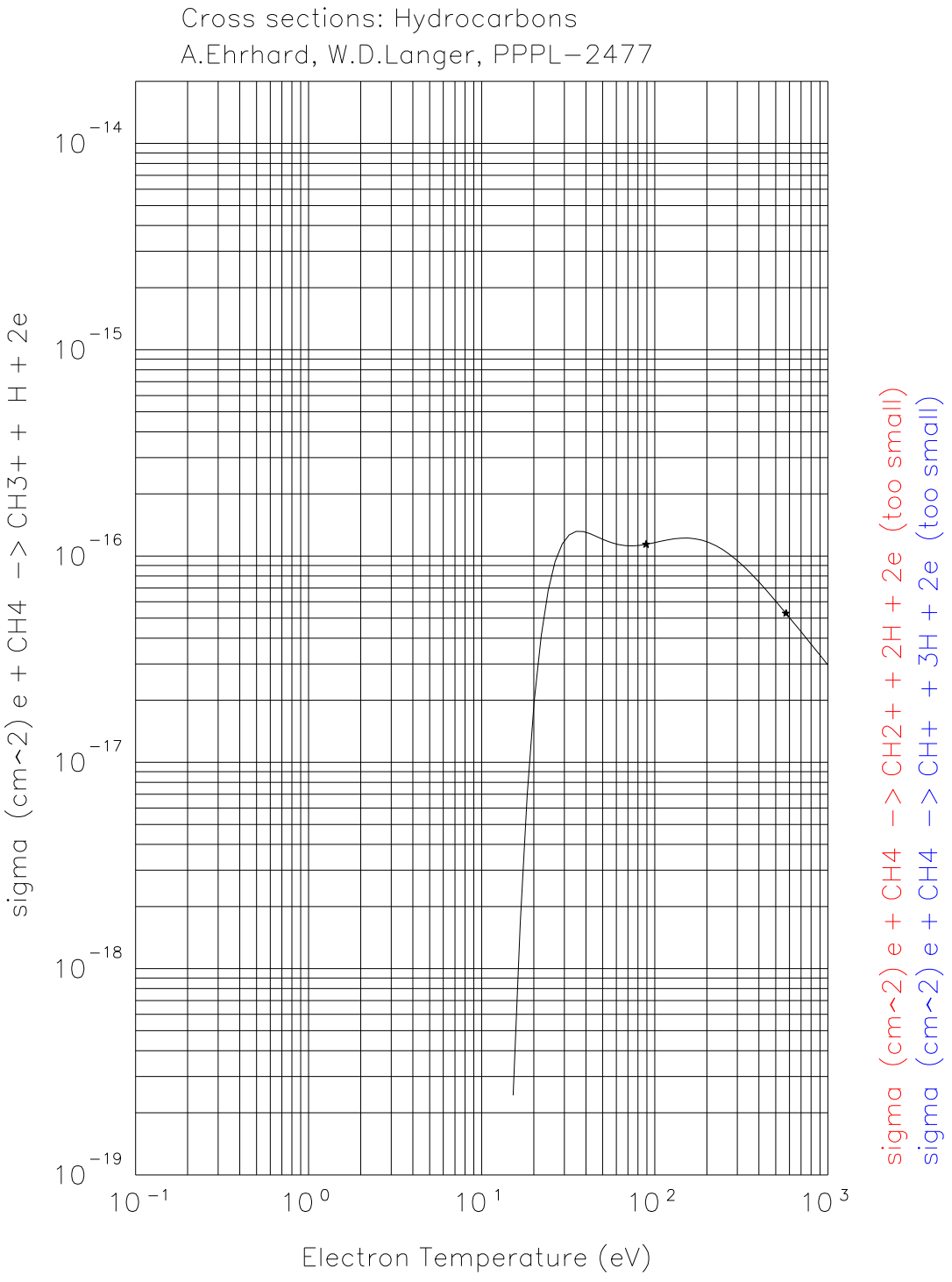
```
fit-flag 3
a0  2.2000E+01          a1 -6.2138E-02          a2  4.4747E-02
a3  1.7054E-01          a4 -2.2989E-01          a5  7.7426E-01
a6 -2.9020E-01          a7  5.1090E+02          a8 -1.5314E+02
```

1.5.5 Reaction 2.5.5jr $e + CH_4 \rightarrow CH_2 + H_2^+ + 2e$

```
fit-flag 3
a0  2.2300E+01          a1 -1.7615E-02          a2  1.8347E-02
a3 -5.0664E-02          a4  2.6118E-01          a5  1.5316E-01
a6 -1.7314E-01          a7  5.1090E+02          a8 -1.5314E+02
```

1.5.6 Reaction 2.5.6jr $e + CH_4 \rightarrow CH_3 + H^+ + 2e$

```
fit-flag 3
a0  2.1100E+01          a1 -3.4698E-01          a2 -1.6026E-02
a3  4.3296E+00          a4 -1.5155E+01          a5  2.4766E+01
a6 -1.0873E+01          a7  5.1090E+02          a8 -1.5314E+02
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) e + CH4 −> CH3+ + H + 2e
sigma (cm^2) e + CH4 −> CH2+ + 2H + 2e (too small)
sigma (cm^2) e + CH4 −> CH+ + 3H + 2e (too small)
Electron Temperature (eV)
10^−14
10^−15
10^−16
10^−17
10^−18
10^−19
10^−1
10^0
10^1
10^2
10^3

1.6 Reaction 2.6 $e + CH_4 \rightarrow CH_2^+ + 2H + 2e : small, out$

regarded as small, less than 7% of total ionization of CH_4

1.7 Reaction 2.7 $e + CH_4 \rightarrow CH^+ + 3H + 2e : small, out$

regarded as small, less than 2% of total ionization of CH_4

1.8 Reaction 2.8 $e + CH_3 \rightarrow CH_2^+ + H + 2e$

```
a0 -0.228826621396E+04   a1  0.317559699023E+04   a2 -0.191836836676E+04
a3  0.648277188716E+03   a4 -0.134091968704E+03   a5  0.173967938071E+02
a6 -0.138374840426E+01   a7  0.617530205532E-01   a8 -0.118495369632E-02
    Emin  1.64e+01    s(Emin)  1.00e-19   smax  1.04e-16   Error  1.70e-01
```

1.8.1 Reaction 2.8.1jr $e + CH_3 \rightarrow CH_2^+ + H + 2e$

```
fit-flag 3
a0  1.4000E+01           a1  1.2824E+00           a2 -1.3906E+00
a3  6.2993E-01           a4  9.4521E-01           a5 -5.3629E+00
a6  4.3087E+00           a7  0.0000E+00           a8  0.0000E+00
```

1.8.2 Reaction 2.8.2jr $e + CH_3 \rightarrow CH^+ + H_2 + 2e$

```
fit-flag 3
a0  1.6000E+01           a1  1.1666E-01           a2 -1.1254E-01
a3  1.5594E-01           a4 -7.3177E-02           a5 -2.1307E-01
a6  5.5290E-01           a7  0.0000E+00           a8  0.0000E+00
```

1.8.3 Reaction 2.8.3jr $e + CH_3 \rightarrow CH_2 + H^+ + 2e$

```
fit-flag 3
a0  1.8480E+01           a1 -2.1667E-02           a2  3.2699E-02
a3 -1.3308E-01           a4  1.1473E+00           a5 -1.9437E+00
a6  1.5827E+00           a7  0.0000E+00           a8  0.0000E+00
```

1.8.4 Reaction 2.8.4jr $e + CH_3 \rightarrow C^+ + H_2 + H + 2e$

```
fit-flag 3
a0  1.9540E+01           a1 -9.5279E-03           a2  1.7251E-02
a3 -5.1275E-02           a4  4.0755E-01           a5 -6.5843E-01
a6  5.1835E-01           a7  0.0000E+00           a8  0.0000E+00
```

1.8.5 Reaction 2.8.5jr $e + CH_3 \rightarrow CH + H_2^+ + 2e$

```
fit-flag 3
a0  2.0180E+01           a1 -4.4067E-03           a2  8.6072E-03
a3 -2.0148E-02           a4  1.6728E-01           a5 -2.6542E-01
a6  2.1110E-01           a7  0.0000E+00           a8  0.0000E+00
```

1.9 Reaction 2.9 $e + CH_2 \rightarrow CH^+ + H + 2e$

```
a0 -0.377119692218E+04   a1  0.527299342886E+04   a2 -0.319065230939E+04
a3  0.108064386864E+04   a4 -0.224176293652E+03   a5  0.291886797605E+02
a6 -0.233152108508E+01   a7  0.104555009356E+00   a8 -0.201720090675E-02
    Emin  1.85e+01    s(Emin)  1.00e-19   smax  6.55e-17   Error  1.44e-01
```

1.9.1 Reaction 2.9.1jr $e + CH_2 \rightarrow CH^+ + H + 2e$

```
fit-flag 3
a0  1.5530E+01           a1  8.1919E-01           a2 -7.5016E-01
a3 -3.8063E-03           a4  1.4065E+00           a5 -3.6447E+00
a6  2.6220E+00           a7  0.0000E+00           a8  0.0000E+00
```

1.9.2 Reaction 2.9.2jr $e + CH_2 \rightarrow C^+ + H_2 + 2e$

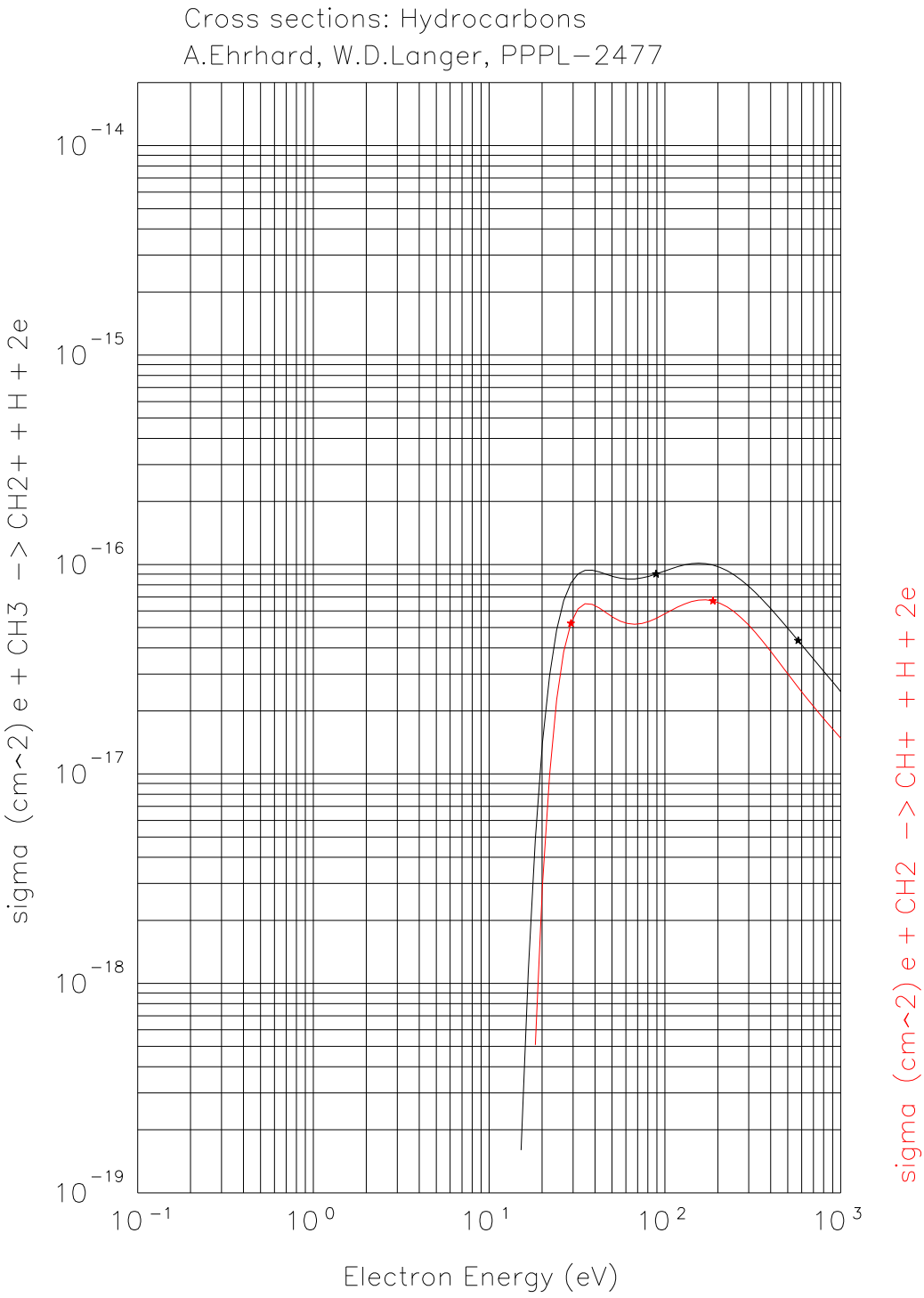
```
fit-flag 3
a0  1.7100E+01            a1  3.8400E-02           a2 -2.91786E-02
a3 -0.98490E-01           a4  0.73008E+00          a5 -1.2111E+00
a6  0.85722E+00           a7  0.0000E+00           a8  0.0000E+00
```

1.9.3 Reaction 2.9.3jr $e + CH_2 \rightarrow CH + H^+ + 2e$

```
fit-flag 3
a0  2.2300E+01           a1 -5.8168E-02           a2  8.2064E-02
a3  5.2048E-02           a4  3.1915E-01           a5 -1.3363E-01
a6  2.3477E-01           a7  0.0000E+00           a8  0.0000E+00
```

1.9.4 Reaction 2.9.4jr $e + CH_2 \rightarrow C + H_2^+ + 2e$

```
fit-flag 3
a0  2.4800E+01           a1  2.7682E-02           a2  5.0215E-02
a3  3.7494E-04           a4  5.1300E-01           a5 -6.1525E-01
a6  6.2835E-01           a7  0.0000E+00           a8  0.0000E+00
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) e + CH3 −> CH2+ + H + 2e
sigma (cm^2) e + CH2 −> CH+ + H + 2e
Electron Energy (eV)
10^−14
10^−15
10^−16
10^−17
10^−18
10^−19
10^−1
10^0
10^1
10^2
10^3

1.10 $e + CH \rightarrow ...$

1.10.1 Reaction 2.10.1 $e + CH \rightarrow C^+ + H + 2e$

```
a0 -0.421903733505E+04   a1  0.603831545088E+04   a2 -0.374256813546E+04
a3  0.130036787286E+04   a4 -0.277134100167E+03   a5  0.371202146386E+02
a6 -0.305395210909E+01   a7  0.141215119057E+00   a8 -0.281219742185E-02
    Emin  1.86e+01    s(Emin)  1.00e-19   smax  3.27e-17   Error  1.06e-01
```

1.10.2 Reaction 2.10.1jr $e + CH \rightarrow C^+H + 2e$

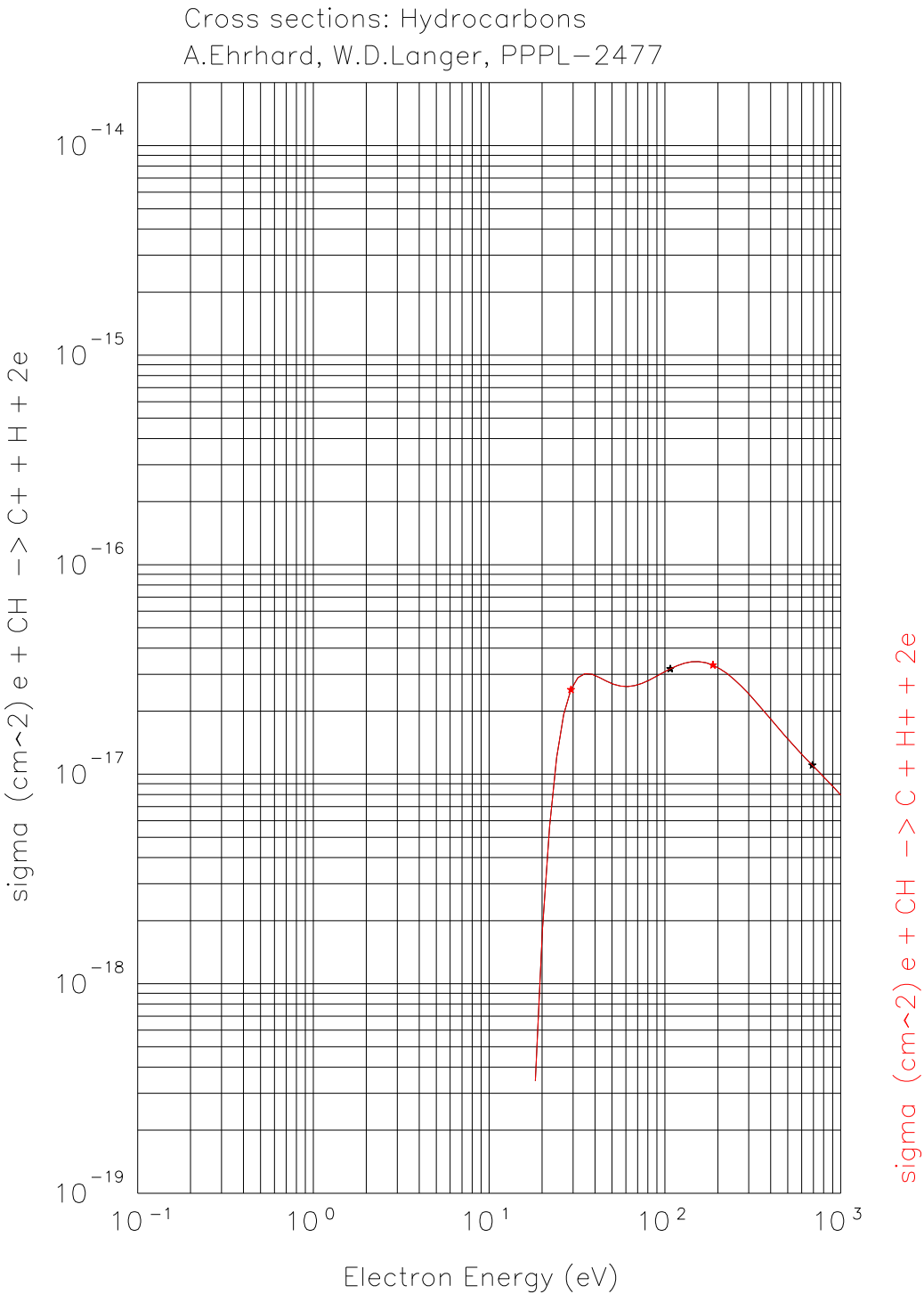
```
fit-flag 3
a0  1.4800E+01           a1  4.3045E-01           a2 -4.1305E-01
a3 -5.6881E-01           a4  3.2957E+00           a5 -5.6549E+00
a6  3.4295E+00           a7  0.0000E+00           a7  0.0000E+00
```

1.10.3 Reaction 2.10.2 $e + CH \rightarrow C + H^+ + 2e$

```
a0 -0.421903733505E+04   a1  0.603831545088E+04   a2 -0.374256813546E+04
a3  0.130036787286E+04   a4 -0.277134100167E+03   a5  0.371202146386E+02
a6 -0.305395210909E+01   a7  0.141215119057E+00   a8 -0.281219742185E-02
    Emin  1.86e+01    s(Emin)  1.00e-19   smax  3.27e-17   Error  1.06e-01
```

1.10.4 Reaction 2.10.2jr $e + CH \rightarrow C + H^+ + 2e$

```
fit-flag 3
a0  1.7140E+01           a1  4.4144E-02           a2 -1.8579E-02
a3 -4.1046E-01           a4  2.3115E+00           a5 -4.1040E+00
a6  2.7436E+00           a7  0.0000E+00           a7  0.0000E+00
```

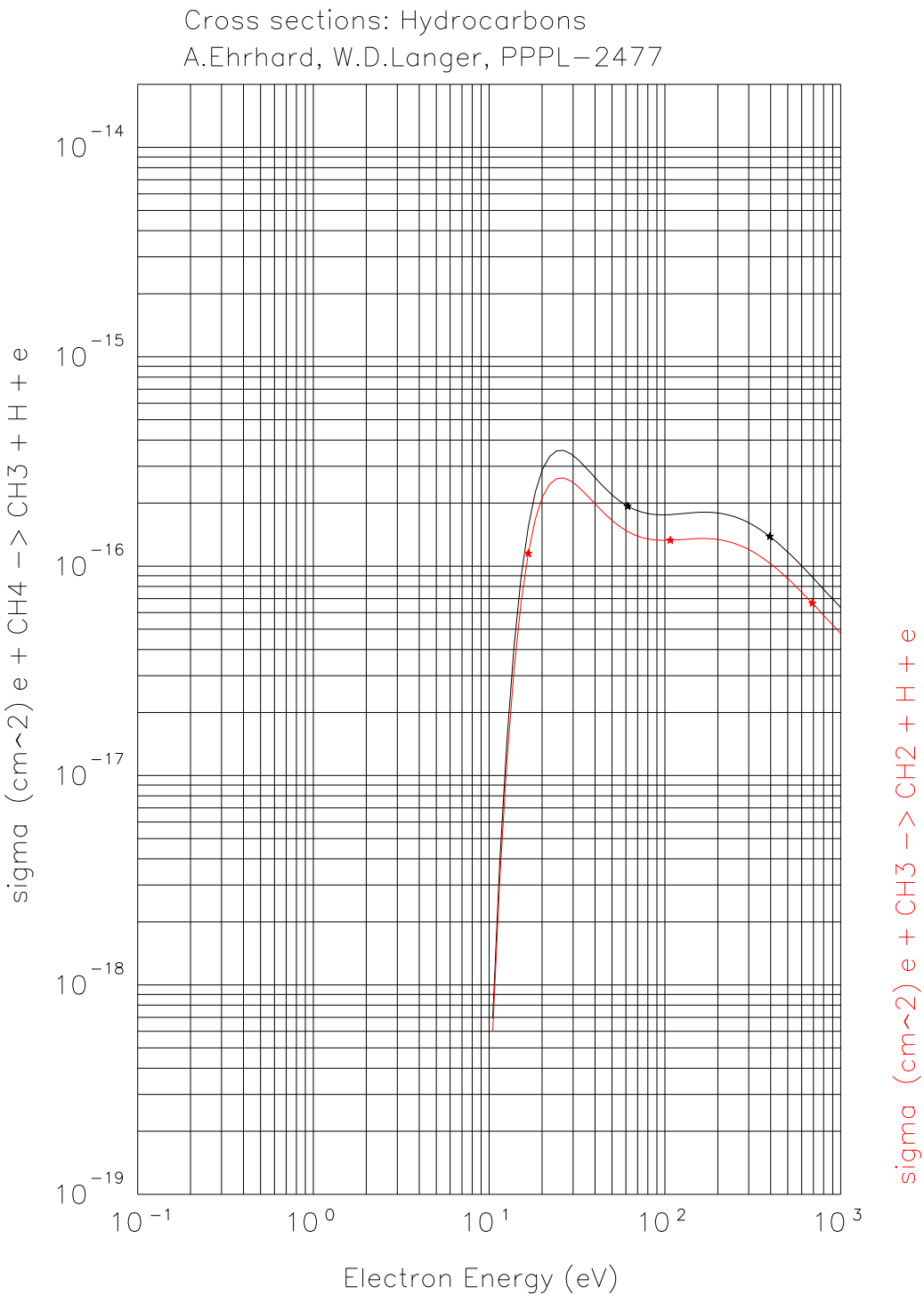

Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) e + CH −> C+ + H + 2e
sigma (cm^2) e + CH −> C + H+ + 2e
Electron Energy (eV)
10^−14
10^−15
10^−16
10^−17
10^−18
10^−19
10^−1
10^0
10^1
10^2
10^3

1.11 Reaction 2.11 $e + CH_4 \rightarrow CH_3 + H + e$

```
a0 -0.705625885263E+03   a1  0.912281197066E+03   a2 -0.524464814891E+03
a3  0.166467770077E+03   a4 -0.319662366673E+02   a5  0.381028444598E+01
a6 -0.275919136712E+00   a7  0.111218319868E-01   a8 -0.191437881340E-03
    Emin  1.09e+01    s(Emin)  1.00e-19   smax  2.50e-16   Error  1.95e-01

    aBorn,1= 5.03649e-16  nBorn,1= 7.52472e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  8.98e-01

    aBorn,2= 5.82458e-16  nBorn,2= 7.99270e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  8.03e-01
```

1.12 Reaction 2.12 $e + CH_3 \rightarrow CH_2 + H + e$

```
a0 -0.683937621328E+03   a1  0.881760590516E+03   a2 -0.506645834896E+03
a3  0.160743398200E+03   a4 -0.308567667329E+02   a5  0.367709527818E+01
a6 -0.266222927105E+00   a7  0.107294922039E-01   a8 -0.184666744394E-03
    Emin  1.09e+01    s(Emin)  1.00e-19   smax  1.87e-16   Error  1.74e-01

    aBorn,1= 3.77711e-16  nBorn,1= 7.52448e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  8.50e-01

    aBorn,2= 4.36843e-16  nBorn,2= 7.99270e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  7.54e-01
```

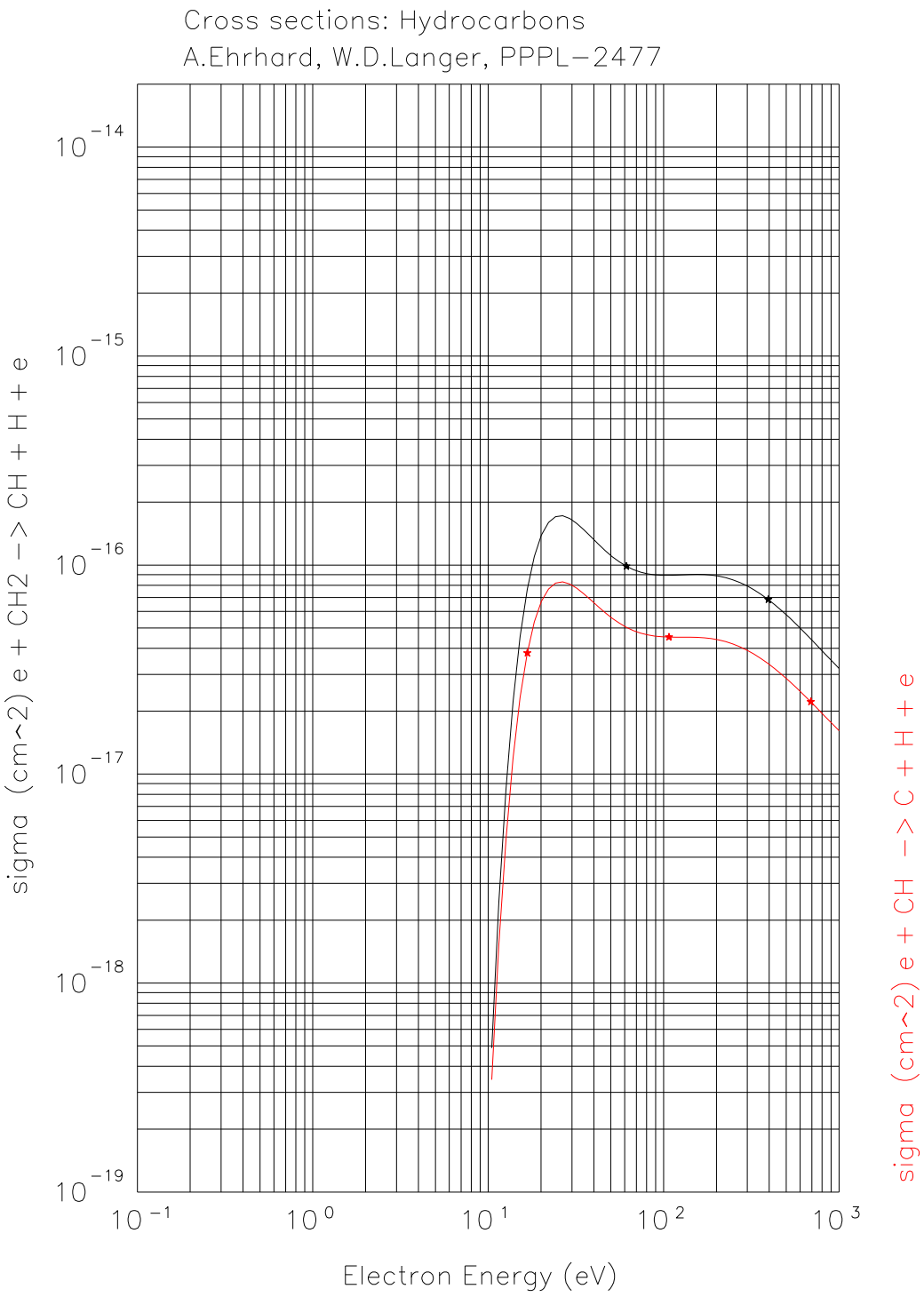

Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) e + CH4 −> CH3 + H + e
sigma (cm^2) e + CH3 −> CH2 + H + e
Electron Energy (eV)
10^−14
10^−15
10^−16
10^−17
10^−18
10^−19
10^−1
10^0
10^1
10^2
10^3

1.13 Reaction 2.13 $e + CH_2 \rightarrow CH + H + e$

```
a0 -0.653568955905E+03   a1  0.839036140795E+03   a2 -0.481709580399E+03
a3  0.152734752051E+03   a4 -0.293049328497E+02   a5  0.349083923412E+01
a6 -0.252665833025E+00   a7  0.101810135268E-01   a8 -0.175202194753E-03
    Emin  1.09e+01    s(Emin)  1.00e-19   smax  1.25e-16   Error  1.47e-01

    aBorn,1= 2.51784e-16  nBorn,1= 7.52414e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  7.86e-01

    aBorn,2= 2.91229e-16  nBorn,2= 7.99270e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  6.89e-01
```

1.14 Reaction 2.14 $e + CH \rightarrow C + H + e$

```
a0 -0.602213115696E+03   a1  0.766817973920E+03   a2 -0.439580920775E+03
a3  0.139210557546E+03   a4 -0.266853682380E+02   a5  0.317653666493E+01
a6 -0.229795280408E+00   a7  0.925597833062E-02   a8 -0.159243386462E-03
    Emin  1.09e+01    s(Emin)  1.00e-19   smax  6.25e-17   Error  1.06e-01

    aBorn,1= 1.25872e-16  nBorn,1= 7.52358e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  6.88e-01

    aBorn,2= 1.45614e-16  nBorn,2= 7.99270e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  5.88e-01
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) e + CH2 −> CH + H + e
sigma (cm^2) e + CH −> C + H + e
Electron Energy (eV)
10^−14
10^−15
10^−16
10^−17
10^−18
10^−19
10^−1
10^0
10^1
10^2
10^3

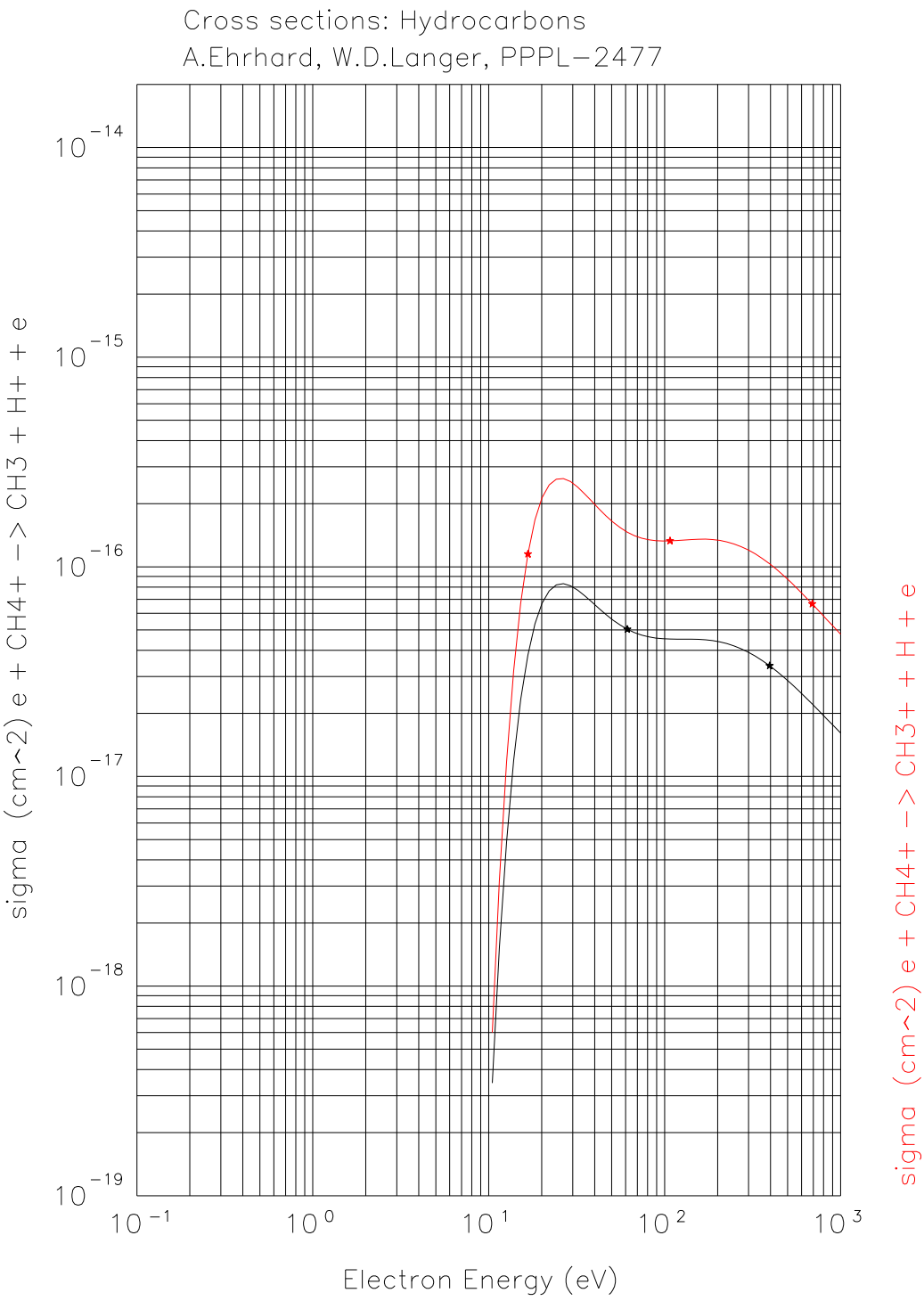
1.15 $e + CH_4^+ \rightarrow ...$

1.15.1 Reaction 2.15.1 $e + CH_4^+ \rightarrow CH_3 + H^+ + e$

```
a0 -0.602213115696E+03   a1  0.766817973920E+03   a2 -0.439580920775E+03
a3  0.139210557546E+03   a4 -0.266853682380E+02   a5  0.317653666493E+01
a6 -0.229795280408E+00   a7  0.925597833062E-02   a8 -0.159243386462E-03
    Emin  1.09e+01    s(Emin)  1.00e-19   smax  6.25e-17   Error  1.06e-01

    aBorn,1= 1.25872e-16  nBorn,1= 7.52358e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  6.88e-01

    aBorn,2= 1.45614e-16  nBorn,2= 7.99270e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  5.88e-01
```

1.15.2 Reaction 2.15.2 $e + CH_4^+ \rightarrow CH_3^+ + H + e$

```
a0 -0.683937621328E+03   a1  0.881760590516E+03   a2 -0.506645834896E+03
a3  0.160743398200E+03   a4 -0.308567667329E+02   a5  0.367709527818E+01
a6 -0.266222927105E+00   a7  0.107294922039E-01   a8 -0.184666744394E-03
    Emin  1.09e+01    s(Emin)  1.00e-19   smax  1.87e-16   Error  1.74e-01

    aBorn,1= 3.77711e-16  nBorn,1= 7.52448e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  8.50e-01

    aBorn,2= 4.36843e-16  nBorn,2= 7.99270e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  7.54e-01
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) e + CH4+ −> CH3 + H+ + e
sigma (cm^2) e + CH4+ −> CH3+ + H + e
Electron Energy (eV)
10^−14
10^−15
10^−16
10^−17
10^−18
10^−19
10^−1
10^0
10^1
10^2
10^3

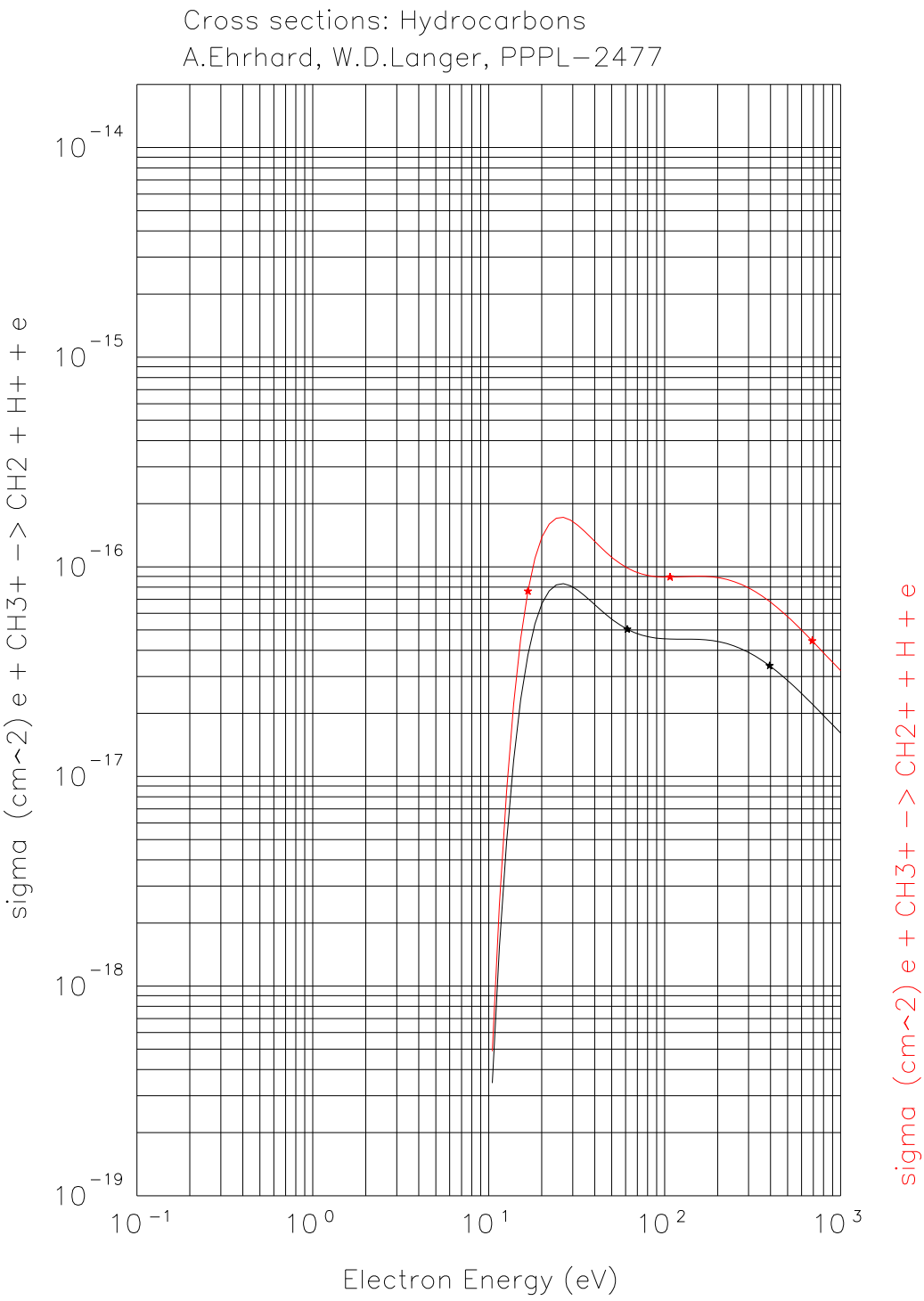
1.16 $e + CH_3^+ \rightarrow ...$

1.16.1 Reaction 2.16.1 $e + CH_3^+ \rightarrow CH_2 + H^+ + e$

```
a0 -0.602213115696E+03   a1  0.766817973920E+03   a2 -0.439580920775E+03
a3  0.139210557546E+03   a4 -0.266853682380E+02   a5  0.317653666493E+01
a6 -0.229795280408E+00   a7  0.925597833062E-02   a8 -0.159243386462E-03
    Emin  1.09e+01    s(Emin)  1.00e-19   smax  6.25e-17   Error  1.06e-01

    aBorn,1= 1.25872e-16  nBorn,1= 7.52358e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  6.88e-01

    aBorn,2= 1.45614e-16  nBorn,2= 7.99270e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  5.88e-01
```

1.16.2 Reaction 2.16.2 $e + CH_3^+ \rightarrow CH_2^+ + H + e$

```
a0 -0.653568955905E+03   a1  0.839036140795E+03   a2 -0.481709580399E+03
a3  0.152734752051E+03   a4 -0.293049328497E+02   a5  0.349083923412E+01
a6 -0.252665833025E+00   a7  0.101810135268E-01   a8 -0.175202194753E-03
    Emin  1.09e+01    s(Emin)  1.00e-19   smax  1.25e-16   Error  1.47e-01

    aBorn,1= 2.51784e-16  nBorn,1= 7.52414e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  7.86e-01

    aBorn,2= 2.91229e-16  nBorn,2= 7.99270e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  6.89e-01
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) e + CH3+ −> CH2 + H+ + e
sigma (cm^2) e + CH3+ −> CH2+ + H + e
Electron Energy (eV)
10^−14
10^−15
10^−16
10^−17
10^−18
10^−19
10^−1
10^0
10^1
10^2
10^3

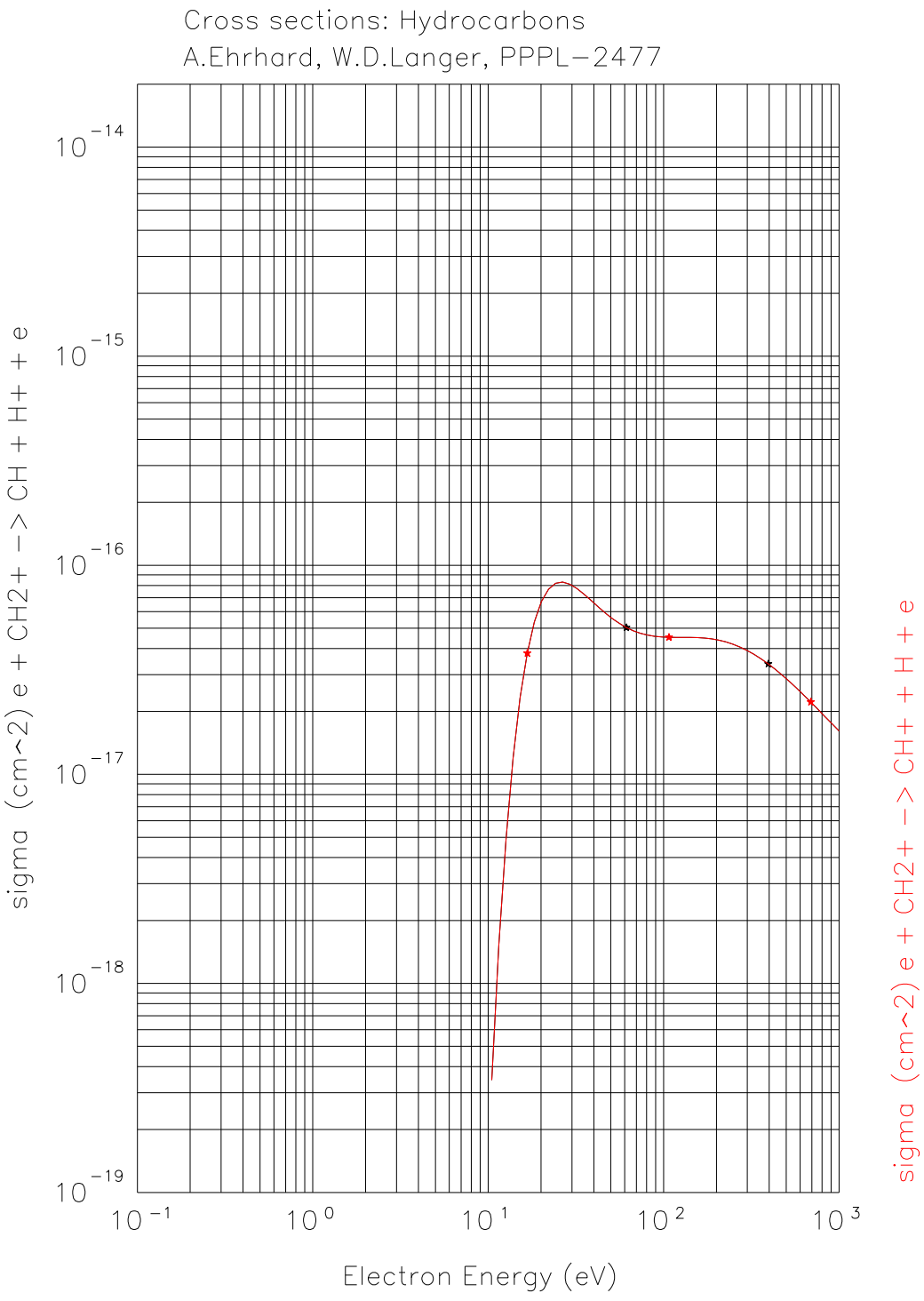
1.17 $e + CH_2^+ \rightarrow ...$

1.17.1 Reaction 2.17.1 $e + CH_2^+ \rightarrow CH + H^+ + e$

```
a0 -0.602213115696E+03   a1  0.766817973920E+03   a2 -0.439580920775E+03
a3  0.139210557546E+03   a4 -0.266853682380E+02   a5  0.317653666493E+01
a6 -0.229795280408E+00   a7  0.925597833062E-02   a8 -0.159243386462E-03
    Emin  1.09e+01    s(Emin)  1.00e-19   smax  6.25e-17   Error  1.06e-01

    aBorn,1= 1.25872e-16  nBorn,1= 7.52358e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  6.88e-01

    aBorn,2= 1.45614e-16  nBorn,2= 7.99270e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  5.88e-01
```

1.17.2 Reaction 2.17.2 $e + CH_2^+ \rightarrow CH^+ + H + e$

```
a0 -0.602213115696E+03   a1  0.766817973920E+03   a2 -0.439580920775E+03
a3  0.139210557546E+03   a4 -0.266853682380E+02   a5  0.317653666493E+01
a6 -0.229795280408E+00   a7  0.925597833062E-02   a8 -0.159243386462E-03
    Emin  1.09e+01    s(Emin)  1.00e-19   smax  6.25e-17   Error  1.06e-01

    aBorn,1= 1.25872e-16  nBorn,1= 7.52358e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  6.88e-01

    aBorn,2= 1.45614e-16  nBorn,2= 7.99270e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  5.88e-01
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) e + CH2+ −> CH + H+ + e
sigma (cm^2) e + CH2+ −> CH+ + H + e
Electron Energy (eV)
10^−14
10^−15
10^−16
10^−17
10^−18
10^−19
10^−1
10^0
10^1
10^2
10^3

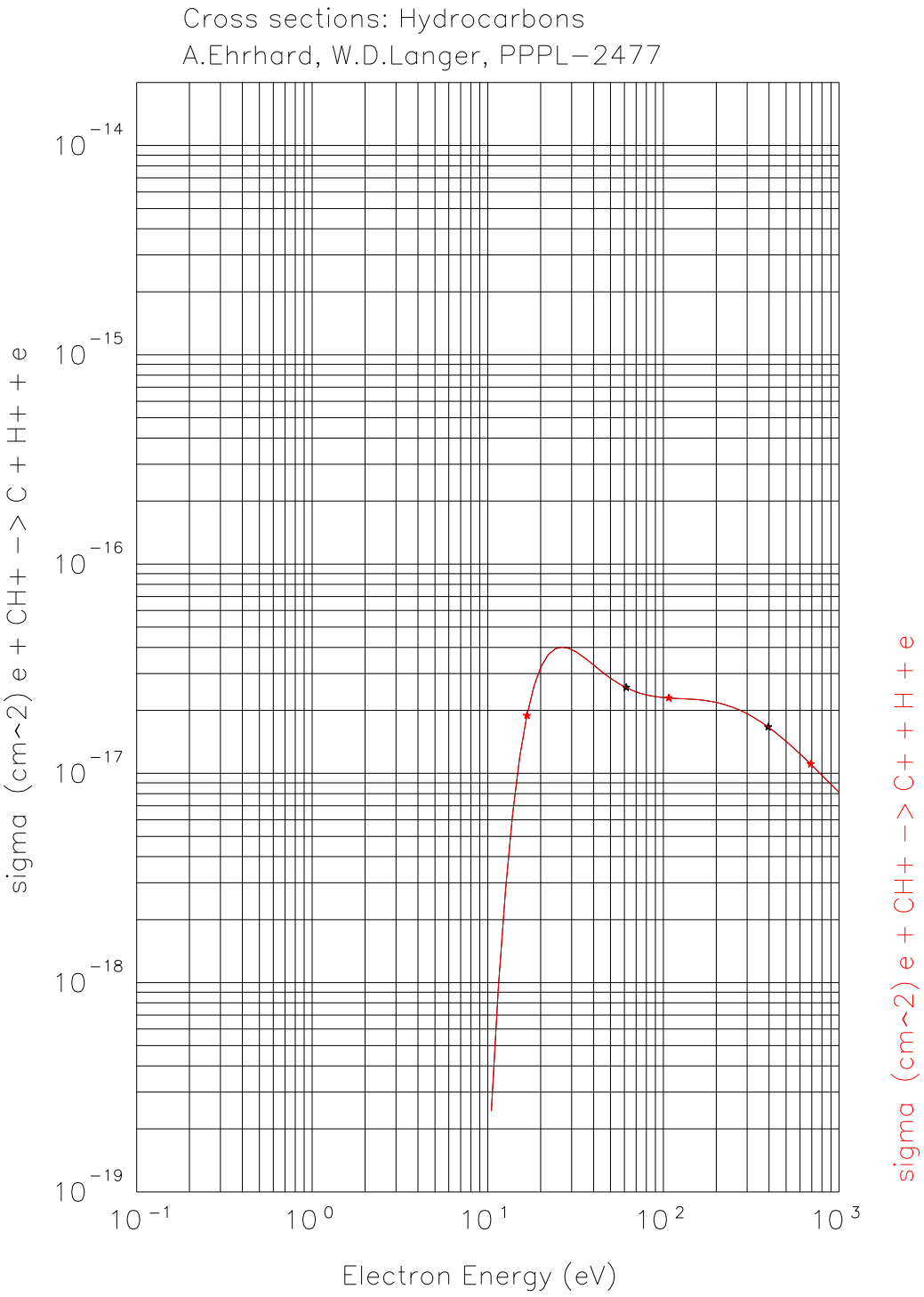
1.18 $e + CH^+ \rightarrow ...$

1.18.1 Reaction 2.18.1 $e + CH^+ \rightarrow C + H^+ + e$

```
a0 -0.551597585772E+03   a1  0.695683299342E+03   a2 -0.398112948071E+03
a3  0.125906437668E+03   a4 -0.241097720035E+02   a5  0.286764934848E+01
a6 -0.207327639127E+00   a7  0.834755316875E-02   a8 -0.143575890964E-03
    Emin  1.09e+01    s(Emin)  1.00e-19   smax  3.12e-17   Error  7.25e-02

    aBorn,1= 6.29278e-17  nBorn,1= 7.52310e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  6.03e-01

    aBorn,2= 7.28072e-17  nBorn,2= 7.99270e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  5.00e-01
```

1.18.2 Reaction 2.18.2 $e + CH^+ \rightarrow C^+ + H + e$

```
a0 -0.551597585772E+03   a1  0.695683299342E+03   a2 -0.398112948071E+03
a3  0.125906437668E+03   a4 -0.241097720035E+02   a5  0.286764934848E+01
a6 -0.207327639127E+00   a7  0.834755316875E-02   a8 -0.143575890964E-03
    Emin  1.09e+01    s(Emin)  1.00e-19   smax  3.12e-17   Error  7.25e-02

    aBorn,1= 6.29278e-17  nBorn,1= 7.52310e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  6.03e-01

    aBorn,2= 7.28072e-17  nBorn,2= 7.99270e-01
    Emin  1.09e+01    s(Emin)  1.00e-19   Error  5.00e-01
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) e + CH+ −> C + H+ + e
sigma (cm^2) e + CH+ −> C+ + H + e
Electron Energy (eV)
10^−14
10^−15
10^−16
10^−17
10^−18
10^−19
10^−1
10^0
10^1
10^2
10^3

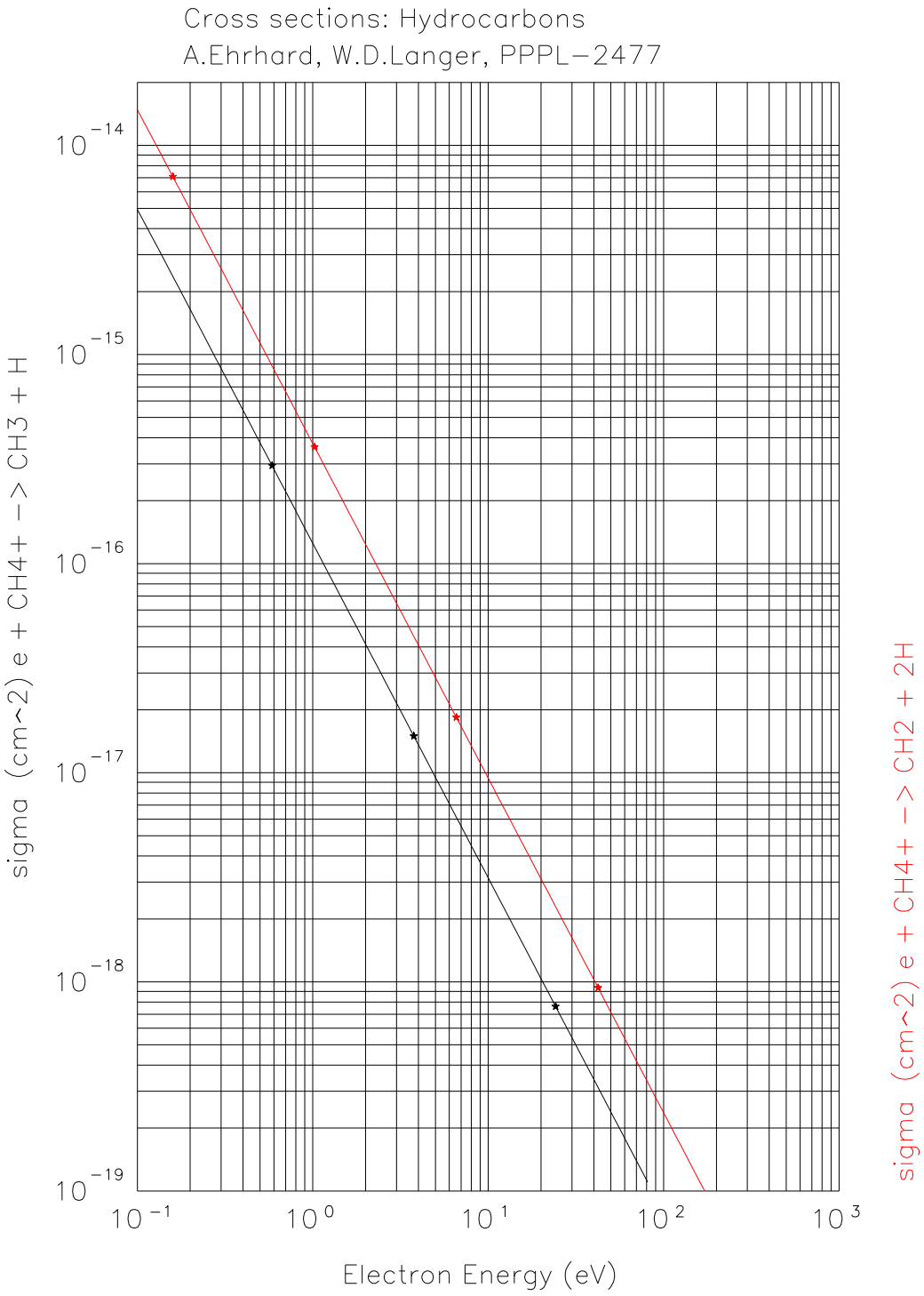
1.19 $e + CH_4^+ \rightarrow ...$

1.19.1 Reaction 2.19.1 $e + CH_4^+ \rightarrow CH_3 + H$

```
a0 -0.366179275925E+02   a1 -0.159953879341E+01   a2 -0.133770959514E-02
a3 -0.214948597505E-03   a4  0.880334751829E-03   a5 -0.160564046387E-03
a6 -0.127213042638E-03   a7  0.497254228266E-04   a8 -0.490234417863E-05
    Emin  1.00e-01    s(Emin)  4.92e-15   smax  4.92e-15   Error  1.80e-07
```

1.19.2 Reaction 2.19.2 $e + CH_4^+ \rightarrow CH_2 + 2H$

```
a0 -0.355194624471E+02   a1 -0.159910455155E+01   a2 -0.811711732232E-03
a3 -0.759375888860E-03   a4  0.655191066942E-03   a5  0.291239360579E-04
a6 -0.116285646012E-03   a7  0.295945520369E-04   a8 -0.226628068741E-05
    Emin  1.00e-01    s(Emin)  1.48e-14   smax  1.48e-14   Error  2.16e-07
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) e + CH4+ −> CH3 + H
sigma (cm^2) e + CH4+ −> CH2 + 2H
Electron Energy (eV)
10^−14
10^−15
10^−16
10^−17
10^−18
10^−19
10^−1
10^0
10^1
10^2
10^3

1.20 Reaction 2.20 $e + CH_3^+ \rightarrow CH_2 + H$

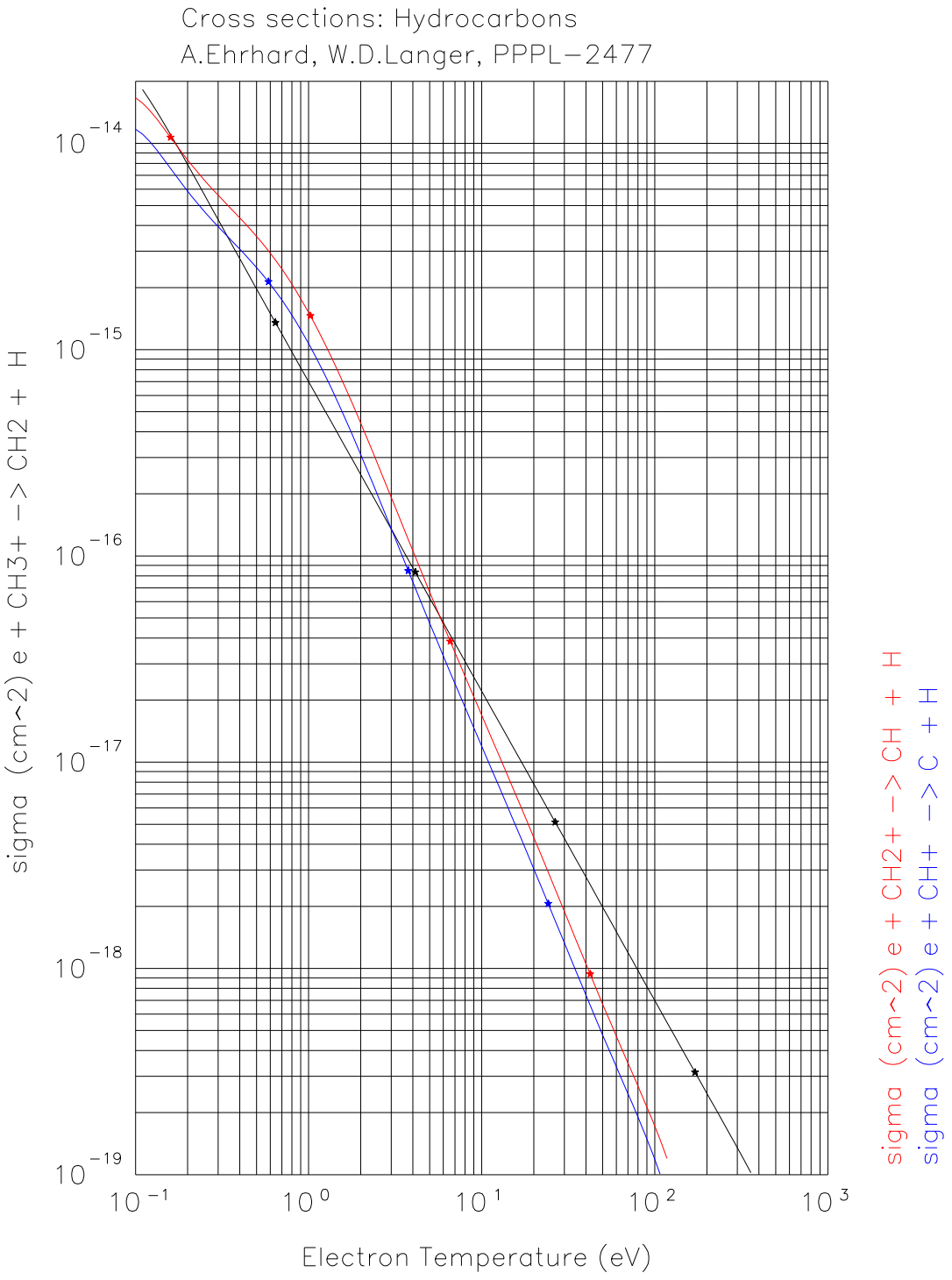
```
a0 -0.348962779993E+02   a1 -0.149082861257E+01   a2 -0.775734732829E-03
a3 -0.864296710624E-02   a4  0.309605594810E-02   a5  0.116819148732E-02
a6 -0.794186905281E-03   a7  0.144432505169E-03   a8 -0.872164481751E-05
    Emin  1.00e-01    s(Emin)  2.00e-14   smax  2.00e-14   Error  2.05e-05
```

1.21 Reaction 2.21 $e + CH_2^+ \rightarrow CH + H$

```
a0 -0.341233034761E+02   a1 -0.152051768627E+01   a2 -0.437521002311E+00
a3  0.427327544208E-01   a4  0.780084366294E-01   a5 -0.186997155186E-01
a6 -0.516732967369E-02   a7  0.216723825702E-02   a8 -0.193980965483E-03
    Emin  1.00e-01    s(Emin)  1.70e-14   smax  1.70e-14   Error  5.89e-04
```

1.22 Reaction 2.22 $e + CH^+ \rightarrow C + H$

```
a0 -0.344703316020E+02   a1 -0.152421005957E+01   a2 -0.442108793371E+00
a3  0.473229860751E-01   a4  0.799874371093E-01   a5 -0.202935602535E-01
a6 -0.527198550208E-02   a7  0.233642879113E-02   a8 -0.215637255883E-03
    Emin  1.00e-01    s(Emin)  1.20e-14   smax  1.20e-14   Error  5.80e-04
```

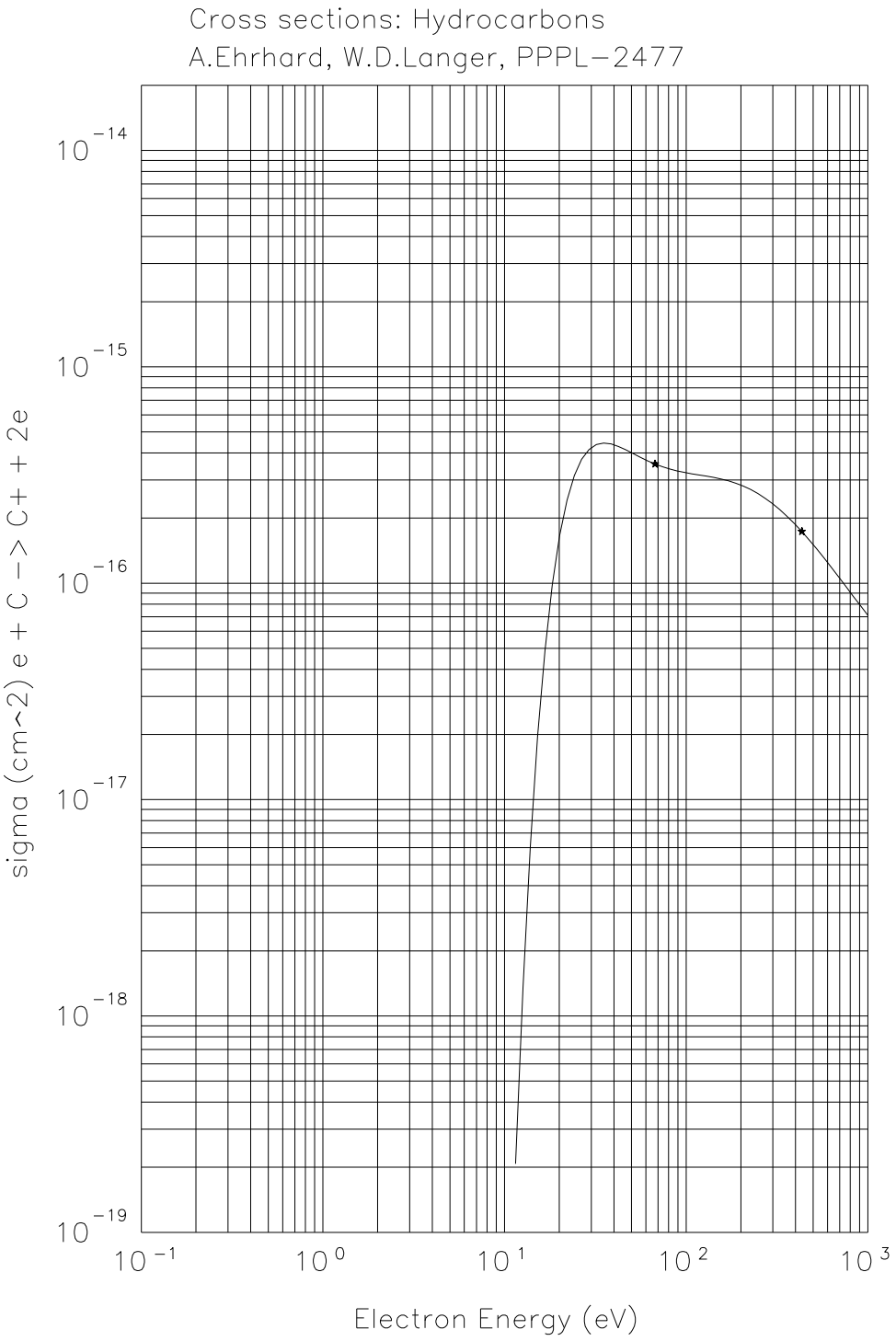

Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) e + CH3+ −> CH2 + H
sigma (cm^2) e + CH2+ −> CH + H
sigma (cm^2) e + CH+ −> C + H
Electron Temperature (eV)
10^−14
10^−15
10^−16
10^−17
10^−18
10^−19
10^−1
10^0
10^1
10^2
10^3

1.23 Reaction 2.23 $e + C \rightarrow C^{+} + 2e$

```
a0 -0.766164594485E+03   a1  0.961500272765E+03   a2 -0.537522682703E+03
a3  0.166763380897E+03   a4 -0.314151047974E+02   a5  0.368267365381E+01
a6 -0.262730712133E+00   a7  0.104475731519E-01   a8 -0.177612034255E-03
    Emin  1.25e+01    s(Emin)  1.00e-19   smax  4.20e-16   Error  1.52e-01
```

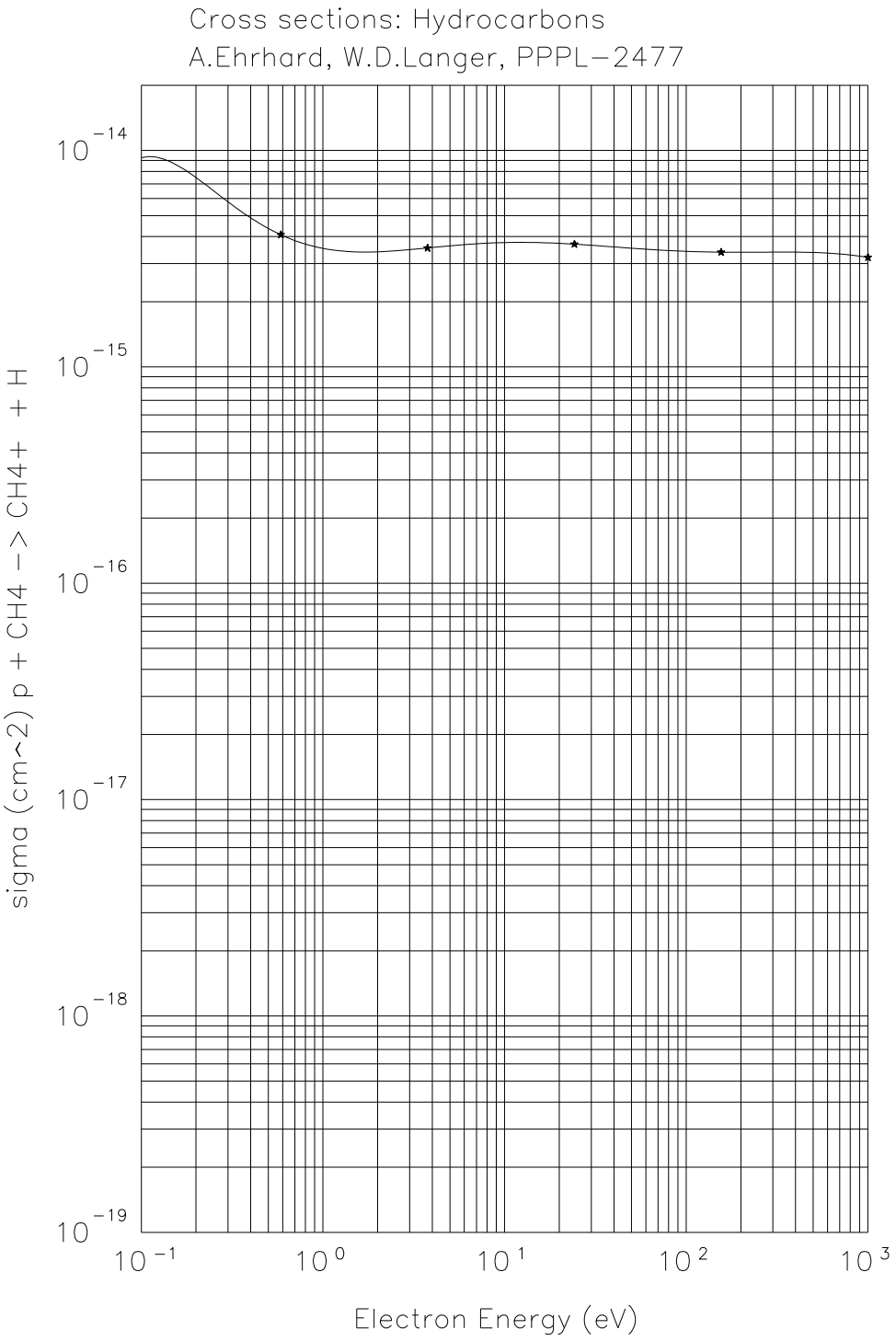
1.23.1 Reaction 2.23jr $e + C \rightarrow$ ionization

```
fit-flag 3
a0  1.1260E+01           a1  2.1143E+00           a2 -1.9647E+00
a3 -0.6084E+00           a4  0.0000E+00           a5  0.0000E+00
a6  0.0000E+00           a7  0.0000E+00           a8  0.0000E+00
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) e + C − > C+ + 2e
10 −14
10 −15
10 −16
10 −17
10 −18
10 −19
10 −1
10 0
10 1
10 2
10 3
Electron Energy (eV)

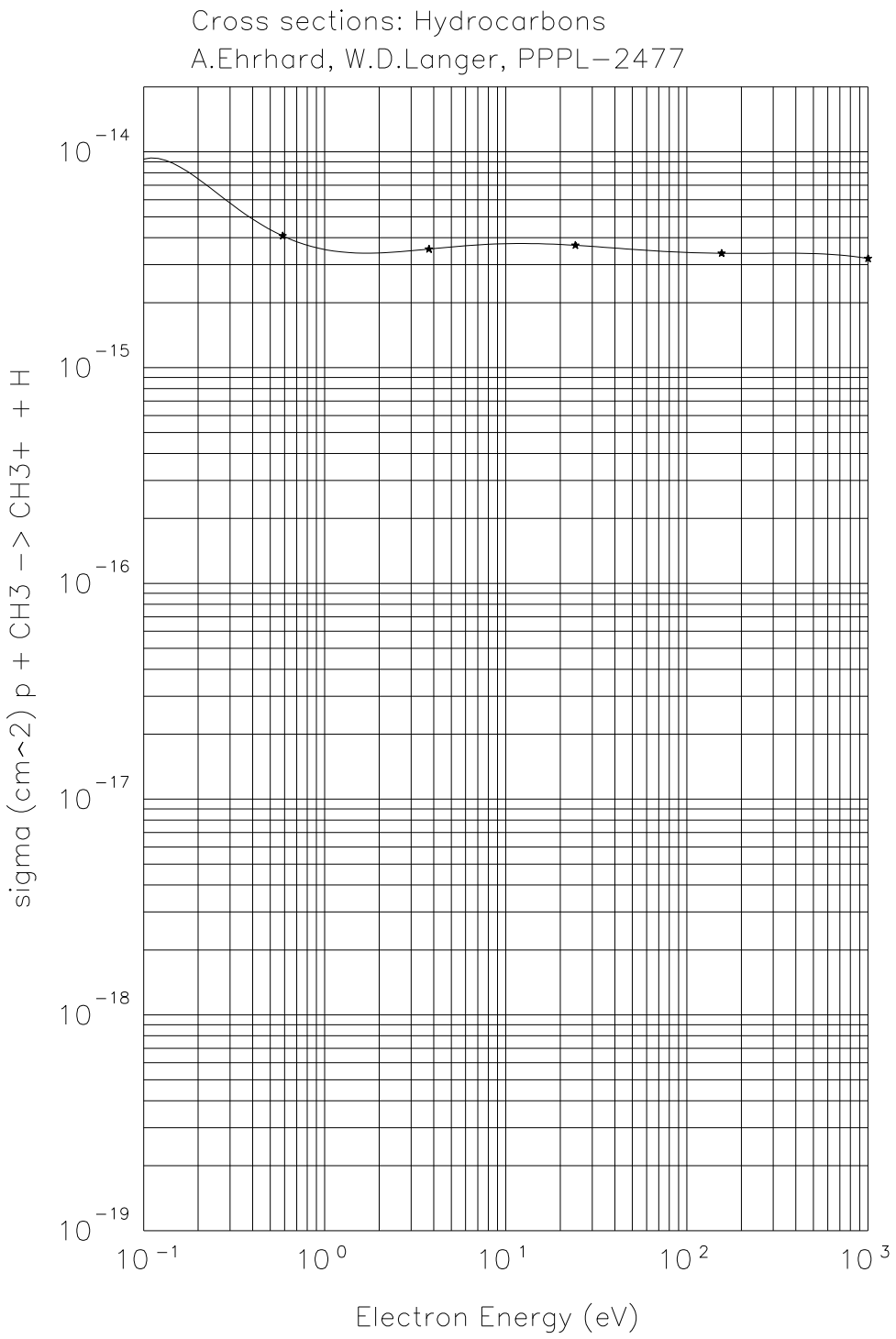
1.24 Reaction 3.1.1 $p + CH_4 \rightarrow CH_4^+ + H$

```
a0 -0.332785010669E+02   a1 -0.160838348919E+00   a2  0.188689900582E+00
a3 -0.416653411113E-01   a4 -0.121087201227E-01   a5  0.625773788611E-02
a6 -0.972335337363E-03   a7  0.651859890082E-04   a8 -0.161815039286E-05
    Emin  1.00e-01    s(Emin)  1.01e-14   smax  1.01e-14   Error  9.87e-03
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) p + CH4 −> CH4+ + H
10 −14
10 −15
10 −16
10 −17
10 −18
10 −19
10 −1
10 0
10 1
10 2
10 3
Electron Energy (eV)

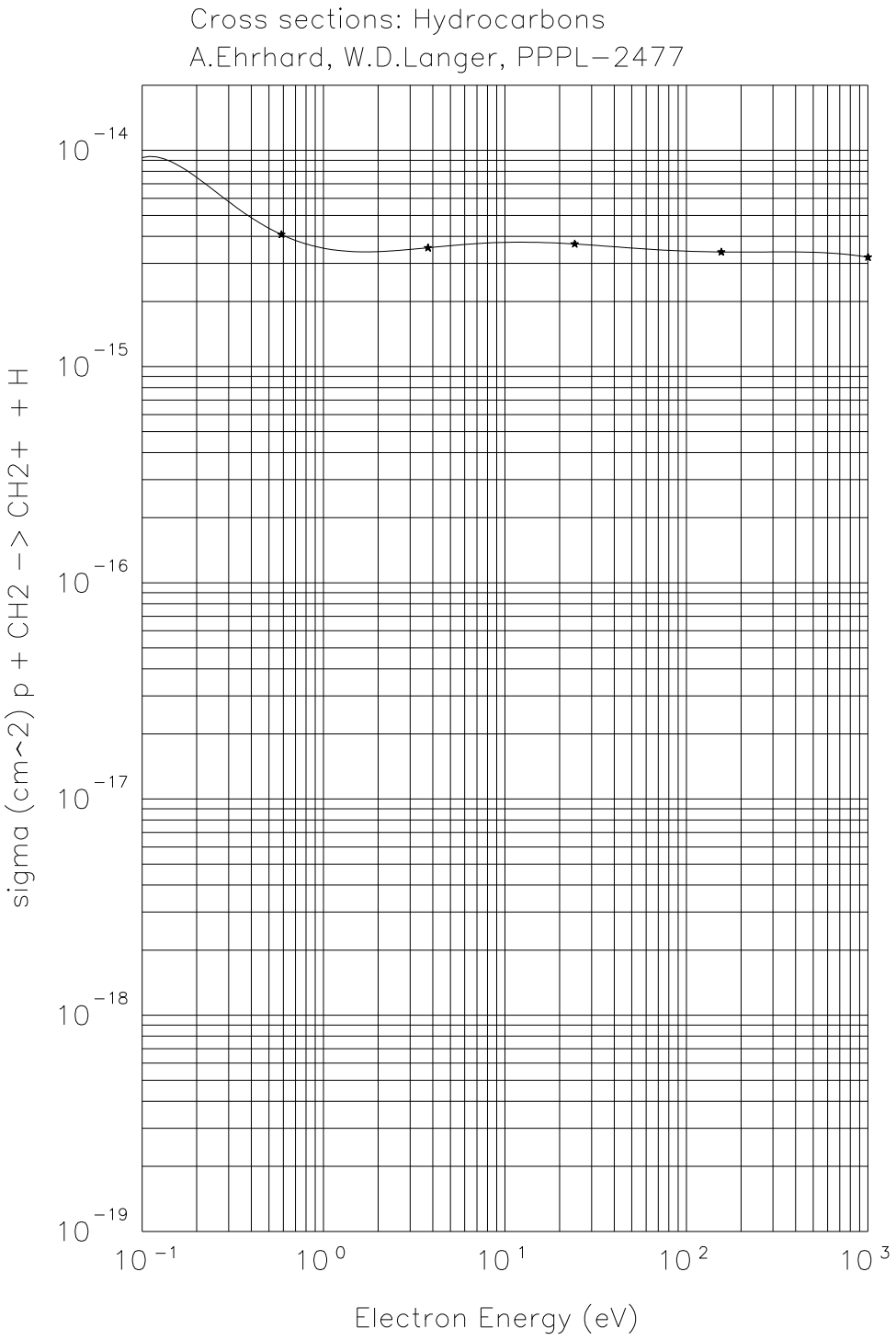
1.25 Reaction 3.1.2 $p + CH_3 \rightarrow CH_3^+ + H$

```
a0 -0.332785010669E+02   a1 -0.160838348919E+00   a2  0.188689900582E+00
a3 -0.416653411113E-01   a4 -0.121087201227E-01   a5  0.625773788611E-02
a6 -0.972335337363E-03   a7  0.651859890082E-04   a8 -0.161815039286E-05
    Emin  1.00e-01    s(Emin)  1.01e-14   smax  1.01e-14   Error  9.87e-03
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) p + CH3 −> CH3+ + H
10 −14
10 −15
10 −16
10 −17
10 −18
10 −19
10 −1
10 0
10 1
10 2
10 3
Electron Energy (eV)

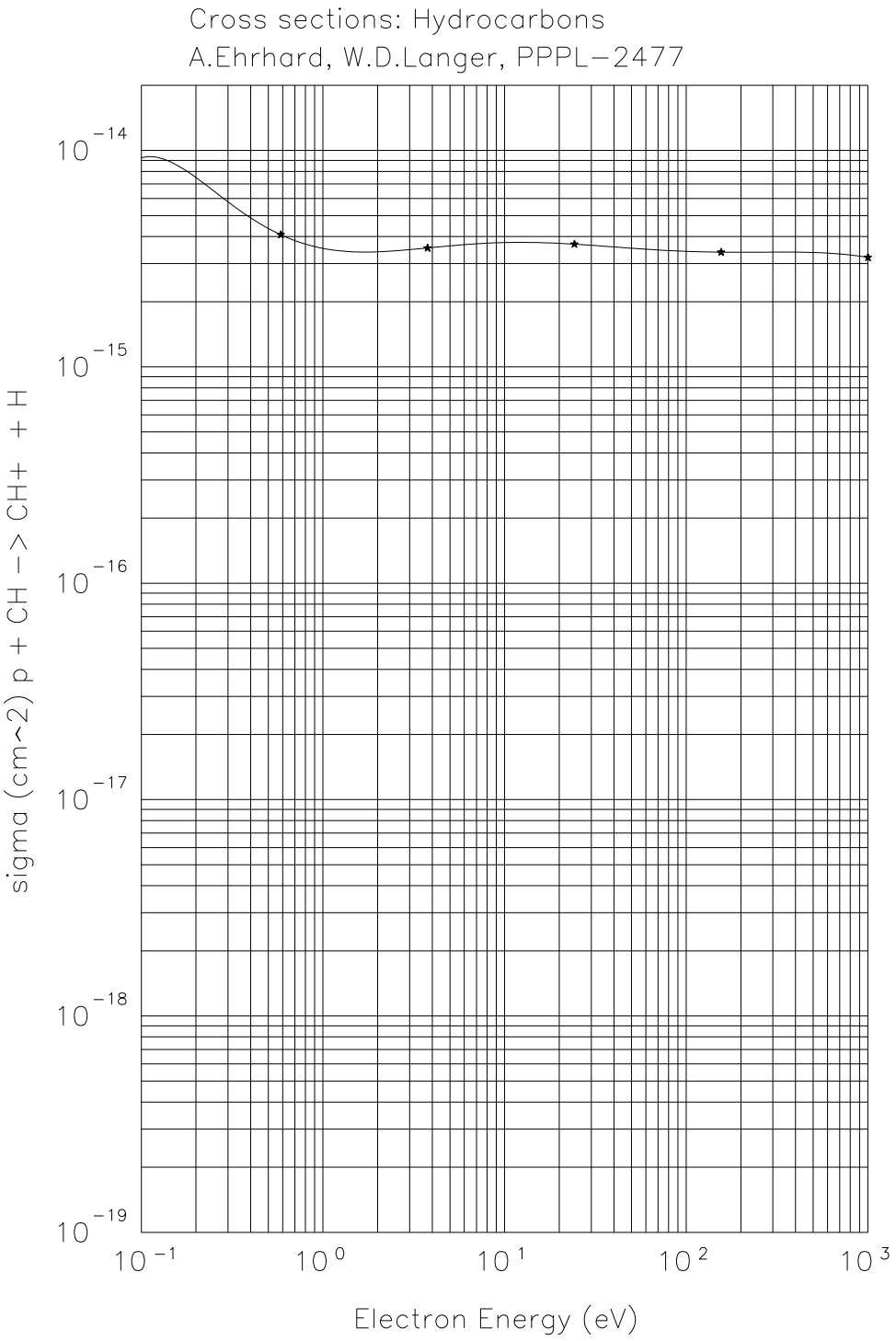
1.26 Reaction 3.1.3 $p + CH_2 \rightarrow CH_2^+ + H$

```
a0 -0.332785010669E+02   a1 -0.160838348919E+00   a2  0.188689900582E+00
a3 -0.416653411113E-01   a4 -0.121087201227E-01   a5  0.625773788611E-02
a6 -0.972335337363E-03   a7  0.651859890082E-04   a8 -0.161815039286E-05
    Emin  1.00e-01    s(Emin)  1.01e-14   smax  1.01e-14   Error  9.87e-03
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) p + CH2 −> CH2+ + H
10 −14
10 −15
10 −16
10 −17
10 −18
10 −19
10 −1
10 0
10 1
10 2
10 3
Electron Energy (eV)

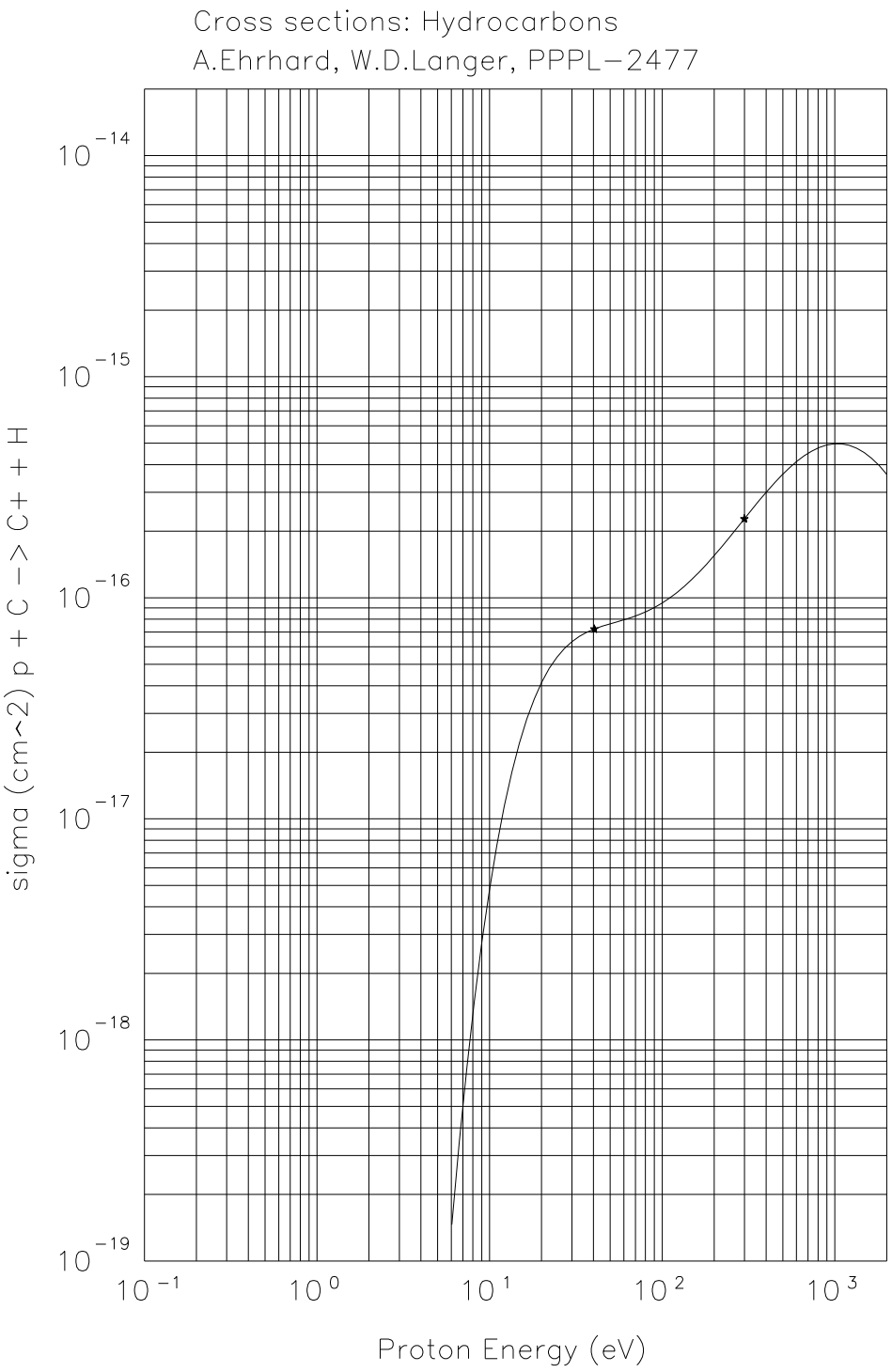
1.27 Reaction 3.1.4 $p + CH \rightarrow CH^+ + H$

```
a0 -0.332785010669E+02   a1 -0.160838348919E+00   a2  0.188689900582E+00
a3 -0.416653411113E-01   a4 -0.121087201227E-01   a5  0.625773788611E-02
a6 -0.972335337363E-03   a7  0.651859890082E-04   a8 -0.161815039286E-05
    Emin  1.00e-01    s(Emin)  1.01e-14   smax  1.01e-14   Error  9.87e-03
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) p + CH − > CH+ + H
10 −14
10 −15
10 −16
10 −17
10 −18
10 −19
10 −1
10 0
10 1
10 2
10 3
Electron Energy (eV)

1.28 Reaction 3.2 $p + C \rightarrow C^{+} + H$

```
   a0 -0.746546017717E+02   a1  0.224885971594E+02   a2  0.163656143962E+01
   a3 -0.451832290018E+01   a4  0.148578839824E+01   a5 -0.228696960906E+00
   a6  0.186034046629E-01   a7 -0.769858960603E-03   a8  0.127082863138E-04
  al0 -1.000000000000E 60  al1  0.000000000000E 00  al2  0.000000000000E 00
ELABMIN=  5.75000E 00 eV
       Emin  5.75e+00    s(Emin)  1.00e-19   smax  6.77e-16   Error  1.29e-02
```


Cross sections: Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
sigma (cm^2) p + C −> C+ + H
10 −14
10 −15
10 −16
10 −17
10 −18
10 −19
10 −1
10 0
10 1
10 2
10 3
Proton Energy (eV)

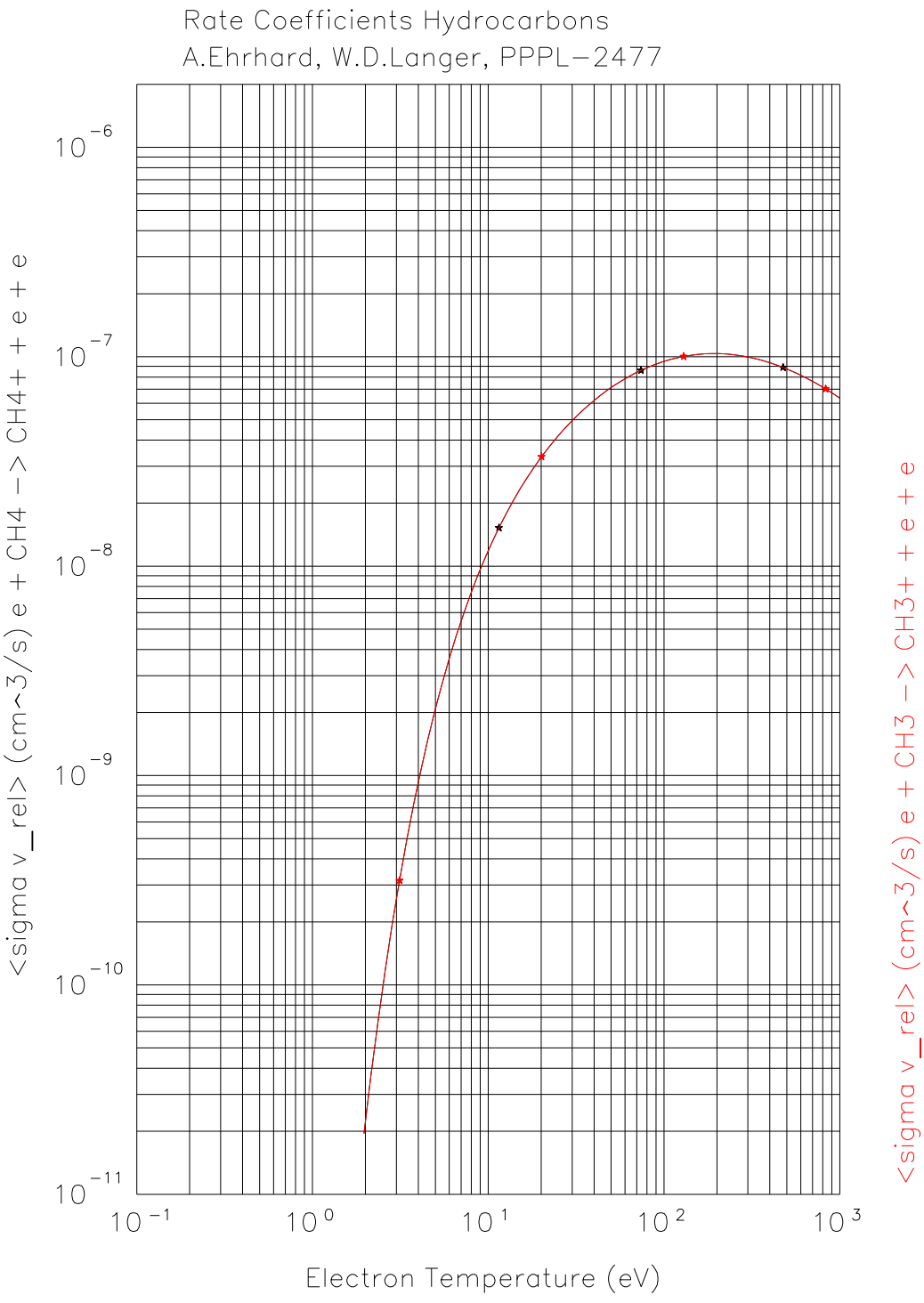
2 H.2 :

2.1 Reaction 2.1 $e + CH_4 \rightarrow CH_4^+ + 2e$

```
b0 -3.130271609338e+01   b1  1.296168986190e+01   b2 -5.500277167544e+00
b3  1.468759127748e+00   b4 -2.515405069844e-01   b5  2.710024229192e-02
b6 -1.786606299569e-03   b7  6.605572407734e-05   b8 -1.051047534357e-06
    Tmin  1.58e+00   sv(Tmin)  3.52e-12  svmax  1.04e-07   Error  3.54e-06
```

2.2 Reaction 2.2 $e + CH_3 \rightarrow CH_3^+ + 2e$

```
b0 -3.130271609338e+01   b1  1.296168986190e+01   b2 -5.500277167544e+00
b3  1.468759127748e+00   b4 -2.515405069844e-01   b5  2.710024229192e-02
b6 -1.786606299569e-03   b7  6.605572407734e-05   b8 -1.051047534357e-06
    Tmin  1.58e+00   sv(Tmin)  3.52e-12  svmax  1.04e-07   Error  3.54e-06
```

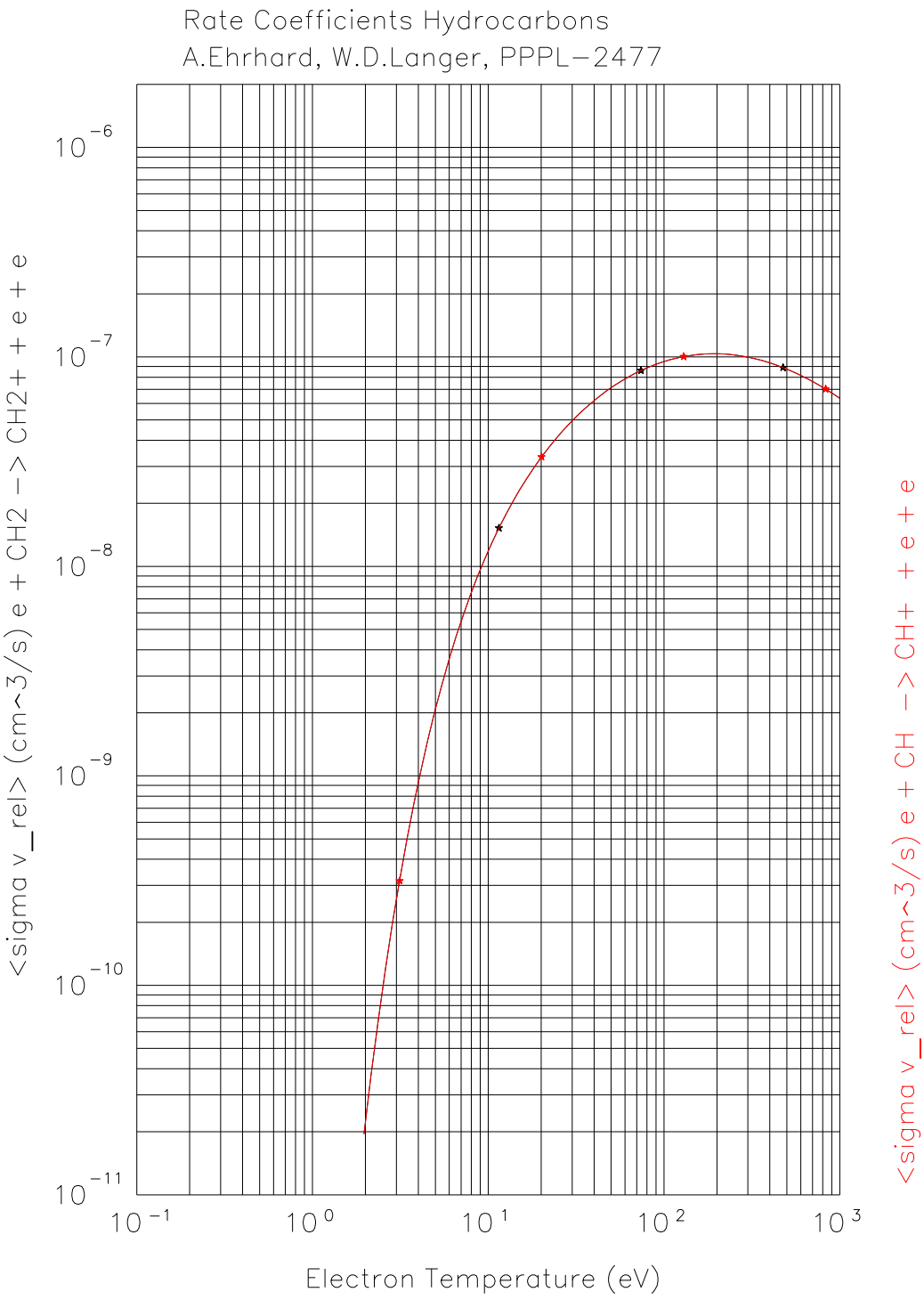

Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) e + CH4 −> CH4+ + e + e
<sigma v_rel> (cm^3/s) e + CH3 −> CH3+ + e + e
Electron Temperature (eV)
10^−6
10^−7
10^−8
10^−9
10^−10
10^−11
10^−1
10^0
10^1
10^2
10^3

2.3 Reaction 2.3 $e + CH_2 \rightarrow CH_2^+ + 2e$

```
b0 -3.130271609338e+01   b1  1.296168986190e+01   b2 -5.500277167544e+00
b3  1.468759127748e+00   b4 -2.515405069844e-01   b5  2.710024229192e-02
b6 -1.786606299569e-03   b7  6.605572407734e-05   b8 -1.051047534357e-06
    Tmin  1.58e+00   sv(Tmin)  3.52e-12  svmax  1.04e-07   Error  3.54e-06
```

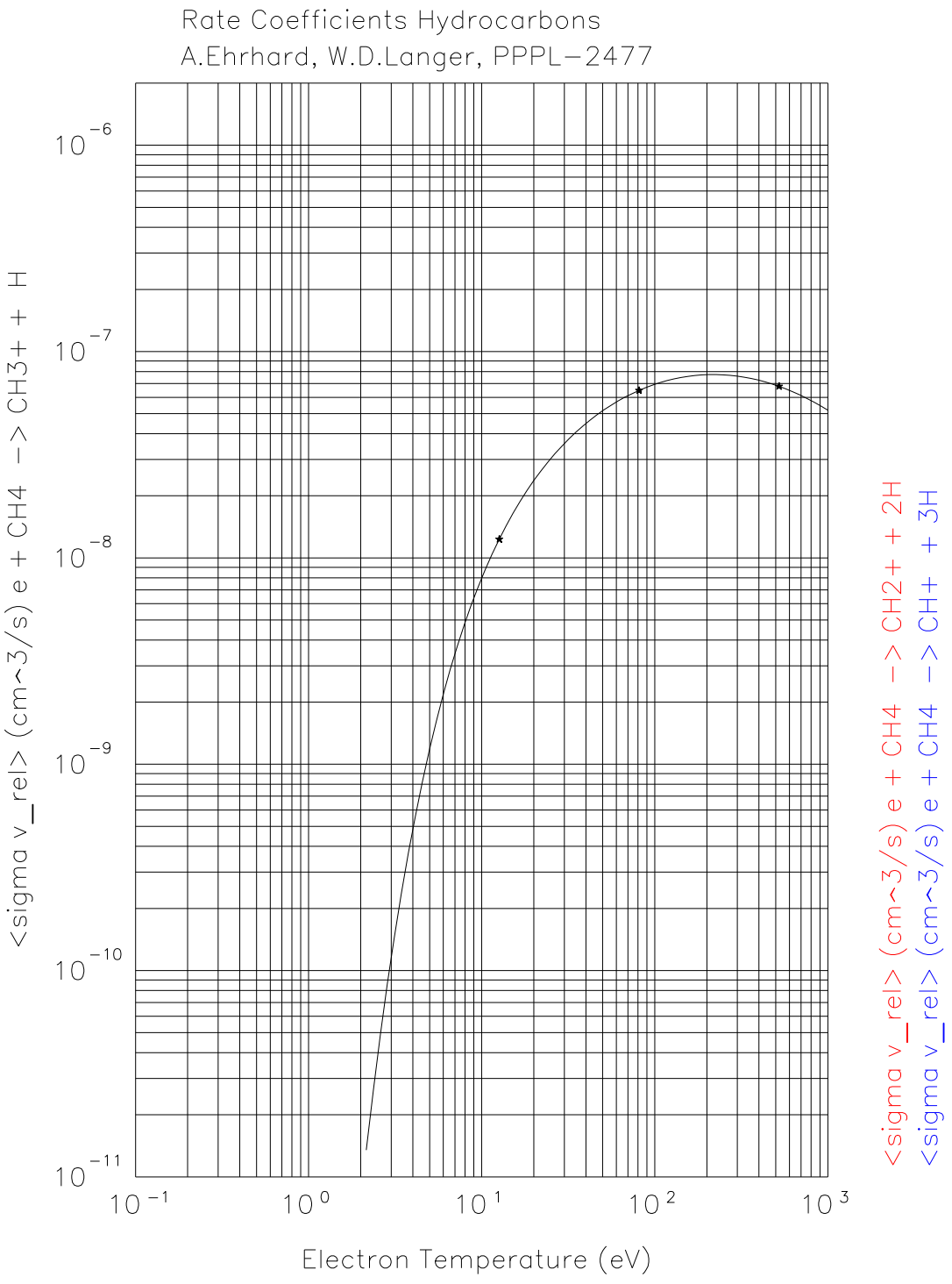
2.4 Reaction 2.4 $e + CH \rightarrow CH^+ + 2e$

```
b0 -3.130271609338e+01   b1  1.296168986190e+01   b2 -5.500277167544e+00
b3  1.468759127748e+00   b4 -2.515405069844e-01   b5  2.710024229192e-02
b6 -1.786606299569e-03   b7  6.605572407734e-05   b8 -1.051047534357e-06
    Tmin  1.58e+00   sv(Tmin)  3.52e-12  svmax  1.04e-07   Error  3.54e-06
```


Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) e + CH2 −> CH2+ + e + e
<sigma v_rel> (cm^3/s) e + CH −> CH+ + e + e
Electron Temperature (eV)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
10^-1
10^0
10^1
10^2
10^3

2.5 Reaction 2.5 $e + CH_4 \rightarrow CH_3^+ + H + 2e$

```
b0 -3.306634718031e+01   b1  1.416521389189e+01   b2 -5.811967385794e+00
b3  1.470177820879e+00   b4 -2.390021646165e-01   b5  2.491401203694e-02
b6 -1.636717239458e-03   b7  6.236047157828e-05   b8 -1.054699569134e-06
    Tmin  2.00e+00   sv(Tmin)  7.39e-12  svmax  7.67e-08   Error  3.07e-05
```


Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) e + CH4 −> CH3+ + H
<sigma v_rel> (cm^3/s) e + CH4 −> CH2+ + 2H
<sigma v_rel> (cm^3/s) e + CH4 −> CH+ + 3H
Electron Temperature (eV)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
10^-1
10^0
10^1
10^2
10^3

2.6 Reaction 2.6 $e + CH_4 \rightarrow CH_2^+ + 2H + 2e : small, out$

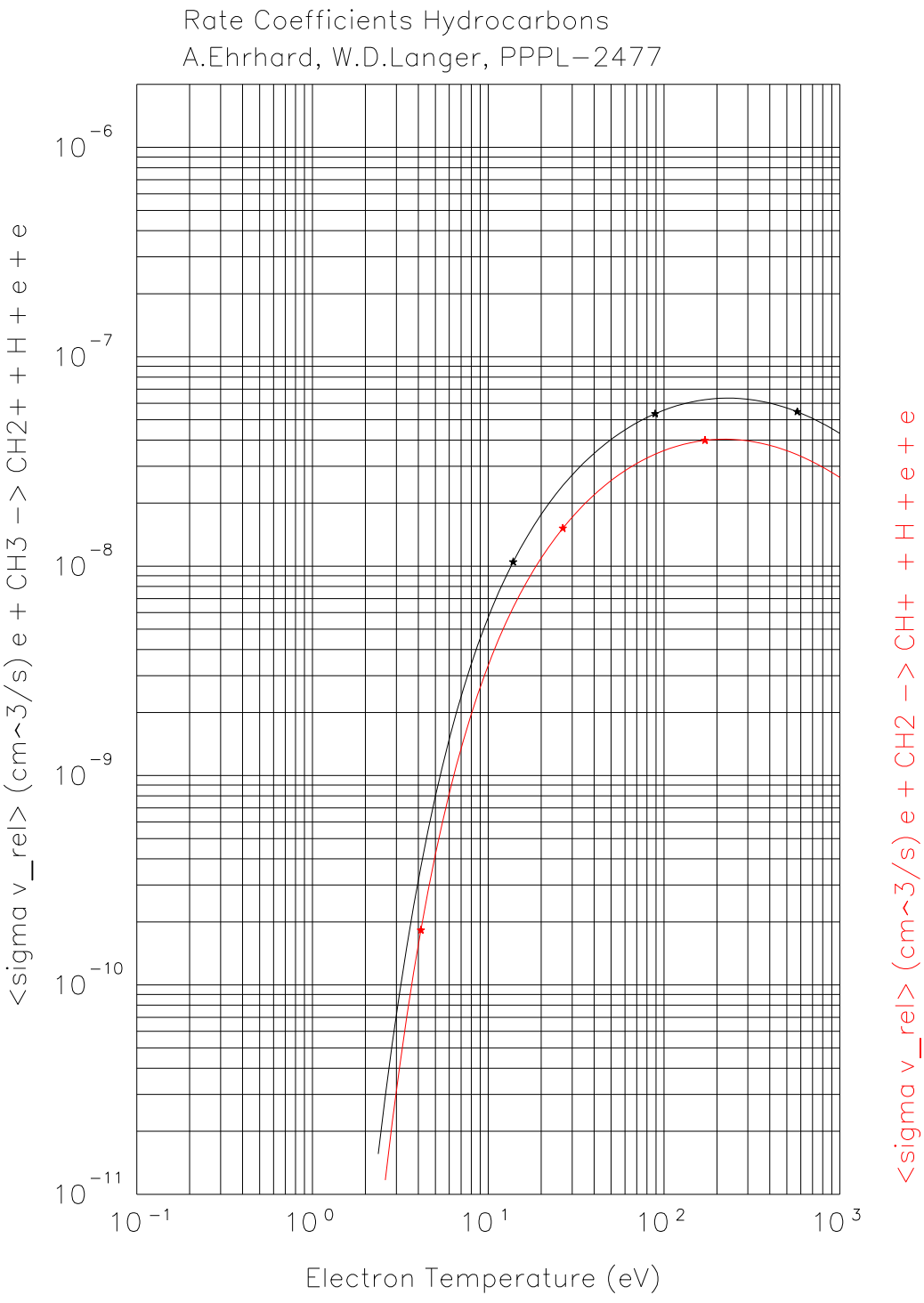
2.7 Reaction 2.7 $e + CH_4 \rightarrow CH^+ + 3H + 2e : small, out$

2.8 Reaction 2.8 $e + CH_3 \rightarrow CH_2^+ + H + 2e$

```
b0 -3.388016314847e+01   b1  1.465034994470e+01   b2 -6.016241495970e+00
b3  1.516215017478e+00   b4 -2.428453509838e-01   b5  2.456763798440e-02
b6 -1.540625099005e-03   b7  5.523892168286e-05   b8 -8.715463490510e-07
    Tmin  2.00e+00   sv(Tmin)  4.24e-12  svmax  6.33e-08   Error  2.84e-06
```

2.9 Reaction 2.9 $e + CH_2 \rightarrow CH^+ + H + 2e$

```
b0 -3.611375048015e+01   b1  1.702018604424e+01   b2 -7.450989420377e+00
b3  2.011285031949e+00   b4 -3.461964892218e-01   b5  3.776562998994e-02
b6 -2.546859178541e-03   b7  9.730219545464e-05   b8 -1.613604371753e-06
    Tmin  2.51e+00   sv(Tmin)  9.21e-12  svmax  4.03e-08   Error  3.91e-06
```


Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_ rel> (cm^3/s) e + CH3 −> CH2+ + H + e + e
<sigma v_ rel> (cm^3/s) e + CH2 −> CH+ + H + e + e
Electron Temperature (eV)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
10^-1
10^0
10^1
10^2
10^3

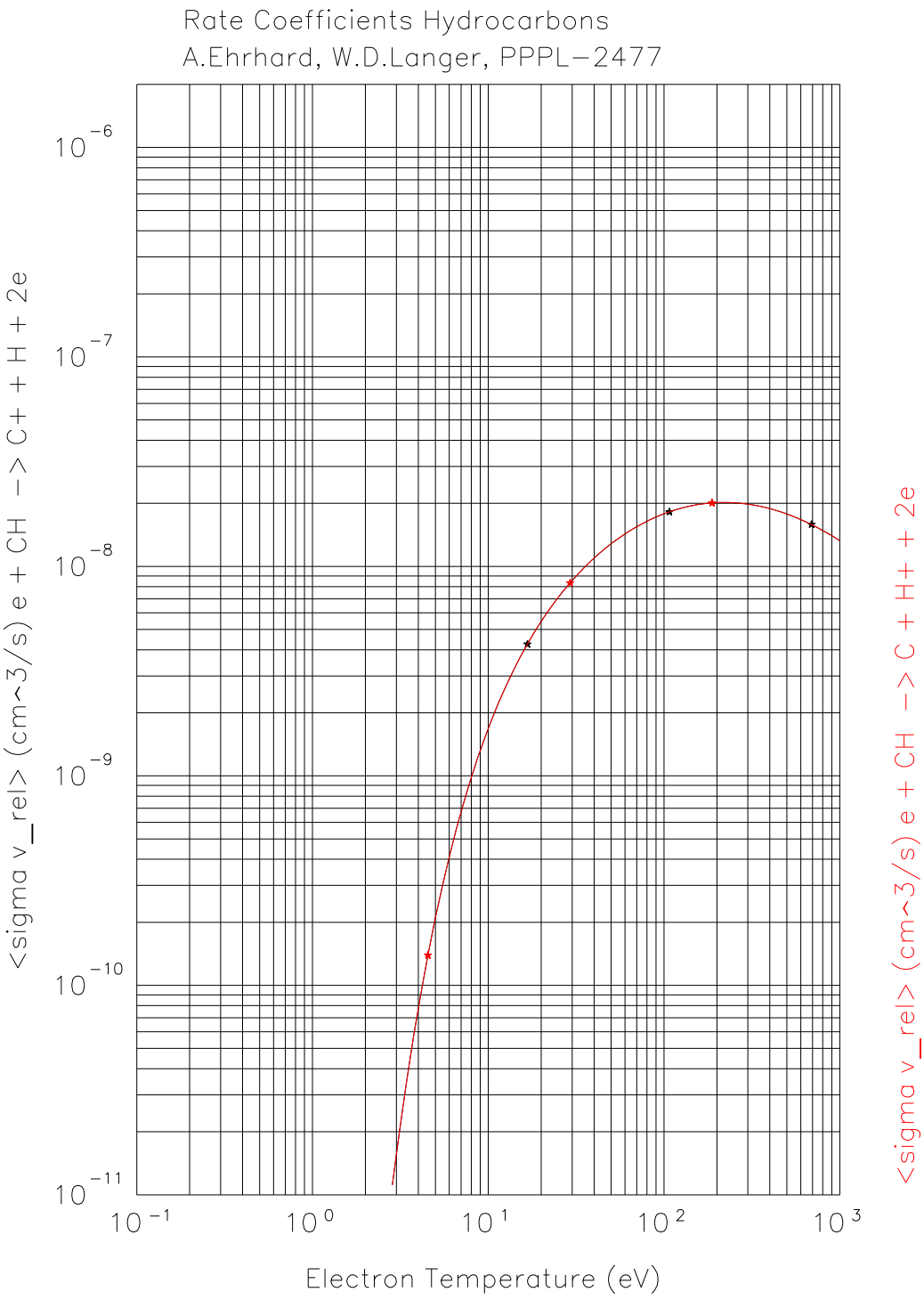
2.10 $e + CH \rightarrow ...$

2.10.1 Reaction 2.10.1 $e + CH \rightarrow C^+ + H + 2e$

```
b0 -3.680913942497e+01   b1  1.702452241875e+01   b2 -7.454313548061e+00
b3  2.012620972667e+00   b4 -3.465080963663e-01   b5  3.780928049163e-02
b6 -2.550477120094e-03   b7  9.746560933107e-05   b8 -1.616702702130e-06
    Tmin  2.51e+00   sv(Tmin)  4.60e-12  svmax  2.01e-08   Error  3.89e-06
```

2.10.2 Reaction 2.10.2 $e + CH \rightarrow C + H^+ + 2e$

```
b0 -3.680913942497e+01   b1  1.702452241875e+01   b2 -7.454313548061e+00
b3  2.012620972667e+00   b4 -3.465080963663e-01   b5  3.780928049163e-02
b6 -2.550477120094e-03   b7  9.746560933107e-05   b8 -1.616702702130e-06
    Tmin  2.51e+00   sv(Tmin)  4.60e-12  svmax  2.01e-08   Error  3.89e-06
```

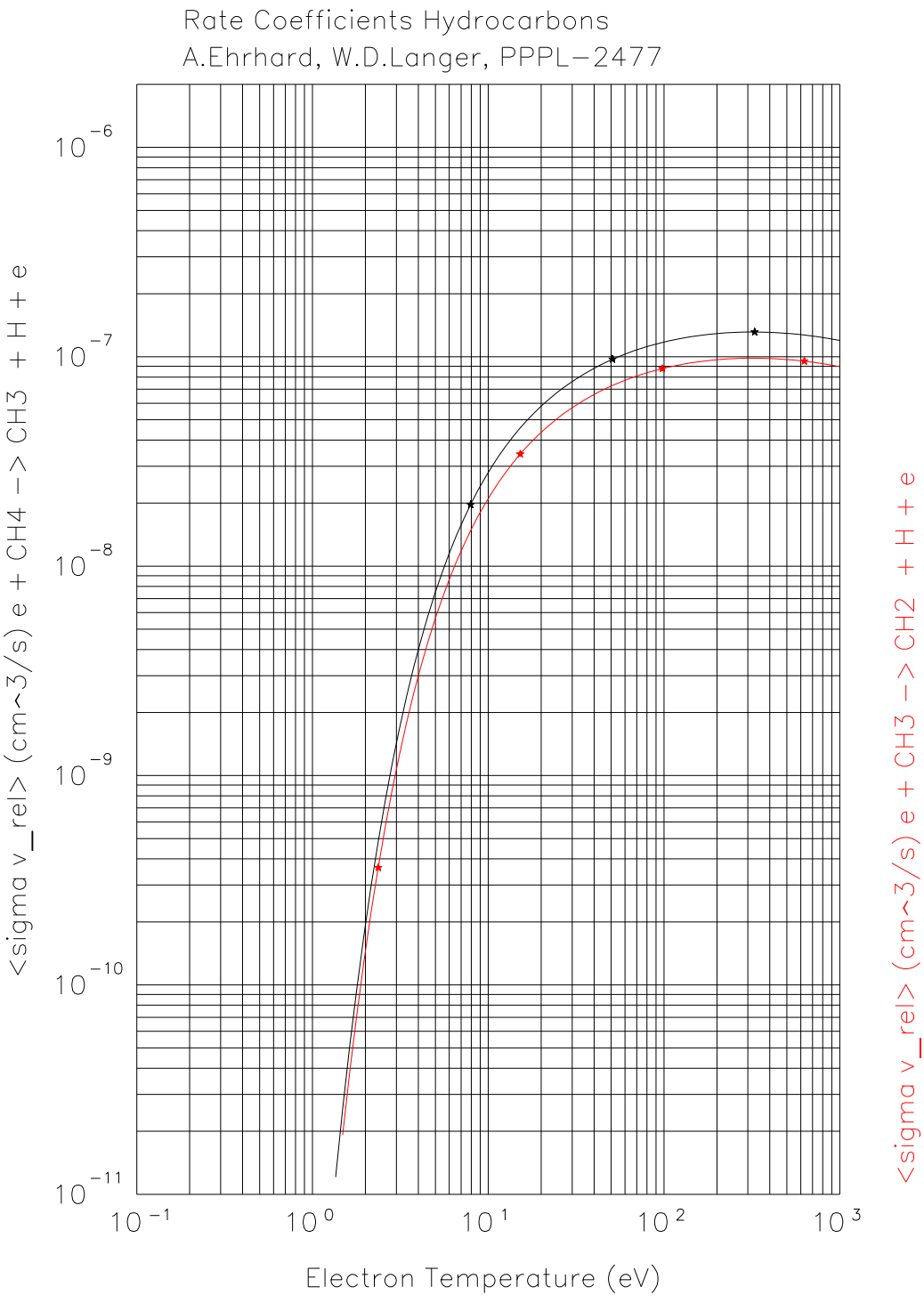

Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) e + CH −> C+ + H + 2e
<sigma v_rel> (cm^3/s) e + CH −> C + H+ + 2e
Electron Temperature (eV)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
10^-1
10^0
10^1
10^2
10^3

2.11 Reaction 2.11 $e + CH_4 \rightarrow CH_3 + H + e$

```
b0 -2.807275946645e+01   b1  1.108212341826e+01   b2 -4.959611559863e+00
b3  1.392349178986e+00   b4 -2.573267587051e-01   b5  3.121418393954e-02
b6 -2.395406694410e-03   b7  1.050840706958e-04   b8 -1.996822469861e-06
    Tmin  1.26e+00   sv(Tmin)  6.42e-12  svmax  1.31e-07   Error  1.49e-05
```

2.12 Reaction 2.12 $e + CH_3 \rightarrow CH_2 + H + e$

```
b0 -2.836044146959e+01   b1  1.108212347679e+01   b2 -4.959611754095e+00
b3  1.392349312989e+00   b4 -2.573268016867e-01   b5  3.121419141368e-02
b6 -2.395407419896e-03   b7  1.050841076770e-04   b8 -1.996823241480e-06
    Tmin  1.26e+00   sv(Tmin)  4.82e-12  svmax  9.84e-08   Error  1.49e-05
```

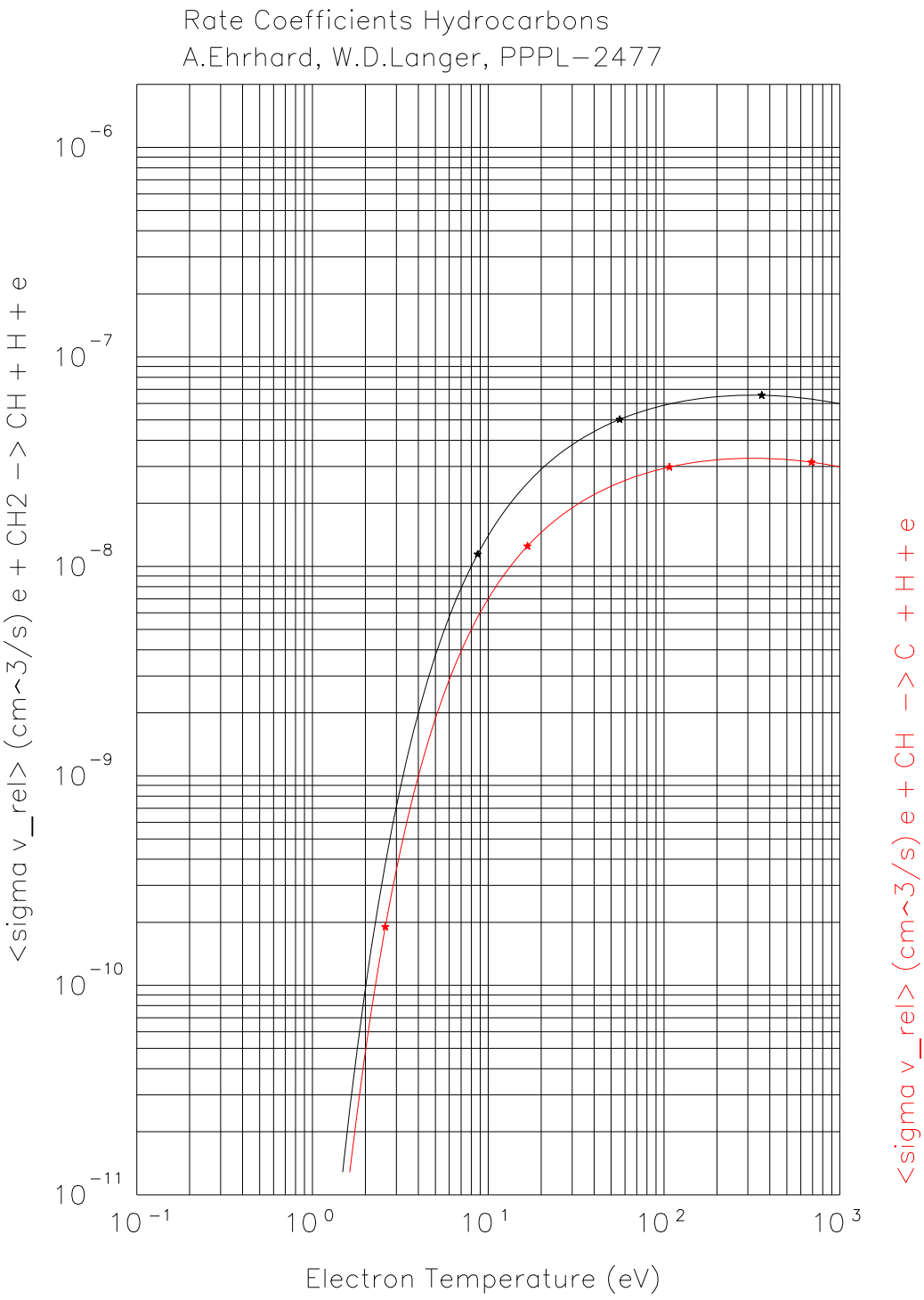

Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) e + CH4 −> CH3 + H + e
<sigma v_rel> (cm^3/s) e + CH3 −> CH2 + H + e
Electron Temperature (eV)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
10^-1
10^0
10^1
10^2
10^3

2.13 Reaction 2.13 $e + CH_2 \rightarrow CH + H + e$

```
b0 -2.876590642619e+01   b1  1.108212244292e+01   b2 -4.959610449105e+00
b3  1.392348609760e+00   b4 -2.573266019767e-01   b5  3.121415917105e-02
b6 -2.395404444673e-03   b7  1.050839615167e-04   b8 -1.996820276763e-06
    Tmin  1.26e+00   sv(Tmin)  3.21e-12  svmax  6.56e-08   Error  1.49e-05
```

2.14 Reaction 2.14 $e + CH \rightarrow C + H + e$

```
b0 -2.945957131327e+01   b1  1.108352512038e+01   b2 -4.960967637555e+00
b3  1.392993579033e+00   b4 -2.574970898281e-01   b5  3.124045642701e-02
b6 -2.397756481445e-03   b7  1.051969352717e-04   b8 -1.999073436426e-06
    Tmin  1.26e+00   sv(Tmin)  1.60e-12  svmax  3.28e-08   Error  1.50e-05
```


Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) e + CH2 −> CH + H + e
<sigma v_rel> (cm^3/s) e + CH −> C + H + e
Electron Temperature (eV)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
10^-1
10^0
10^1
10^2
10^3

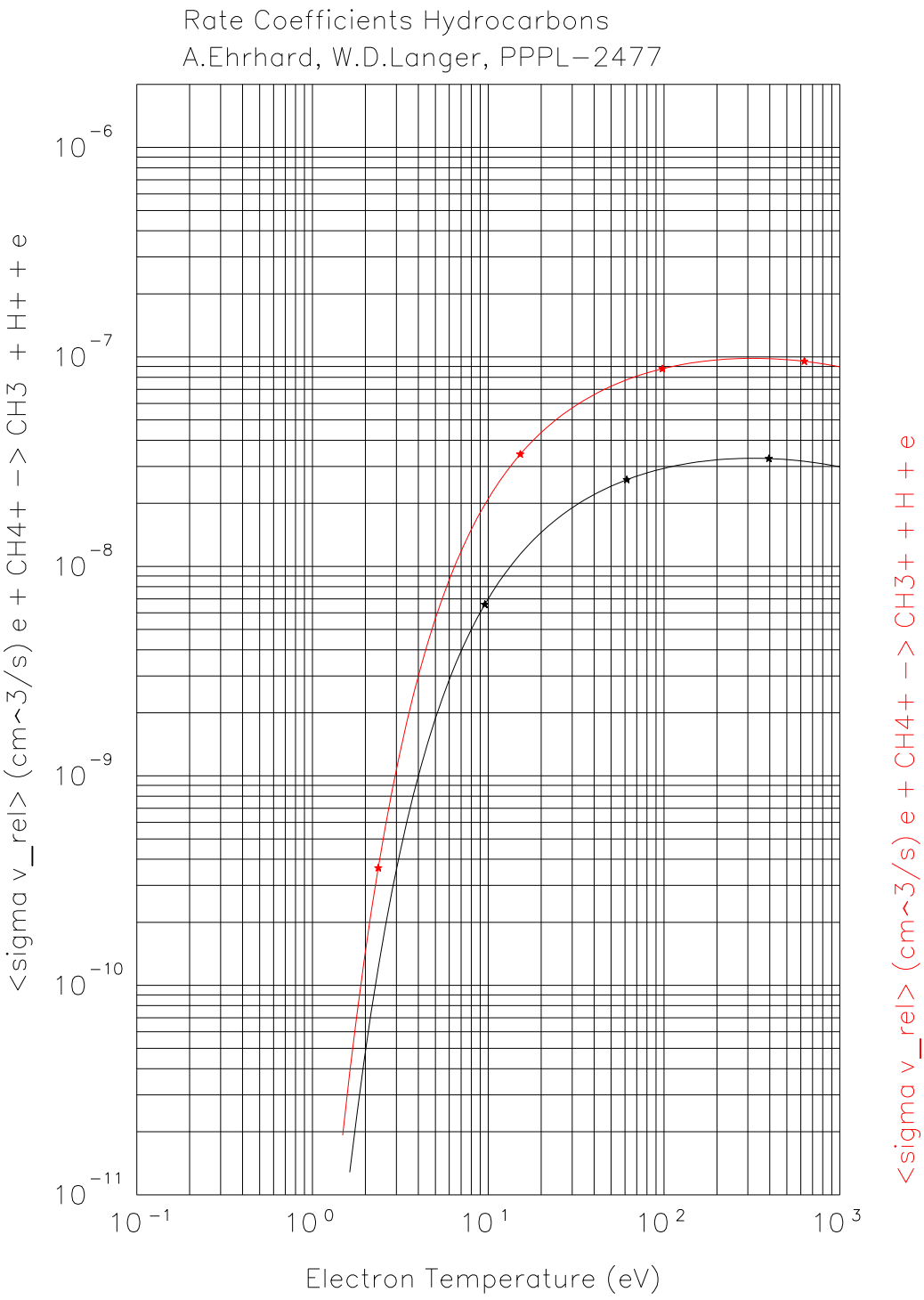
2.15 $e + CH_4^+ \rightarrow$

2.15.1 Reaction 2.15.1 $e + CH_4^+ \rightarrow CH_3 + H^+ + e$

```
b0 -2.945957131327e+01   b1  1.108352512038e+01   b2 -4.960967637555e+00
b3  1.392993579033e+00   b4 -2.574970898281e-01   b5  3.124045642701e-02
b6 -2.397756481445e-03   b7  1.051969352717e-04   b8 -1.999073436426e-06
    Tmin  1.26e+00   sv(Tmin)  1.60e-12  svmax  3.28e-08   Error  1.50e-05
```

2.15.2 Reaction 2.15.2 $e + CH_4^+ \rightarrow CH_3^+ + H + e$

```
b0 -2.836044146959e+01   b1  1.108212347679e+01   b2 -4.959611754095e+00
b3  1.392349312989e+00   b4 -2.573268016867e-01   b5  3.121419141368e-02
b6 -2.395407419896e-03   b7  1.050841076770e-04   b8 -1.996823241480e-06
    Tmin  1.26e+00   sv(Tmin)  4.82e-12  svmax  9.84e-08   Error  1.49e-05
```


Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) e + CH4+ −> CH3 + H+ + e
<sigma v_rel> (cm^3/s) e + CH4+ −> CH3+ + H + e
Electron Temperature (eV)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
10^-1
10^0
10^1
10^2
10^3

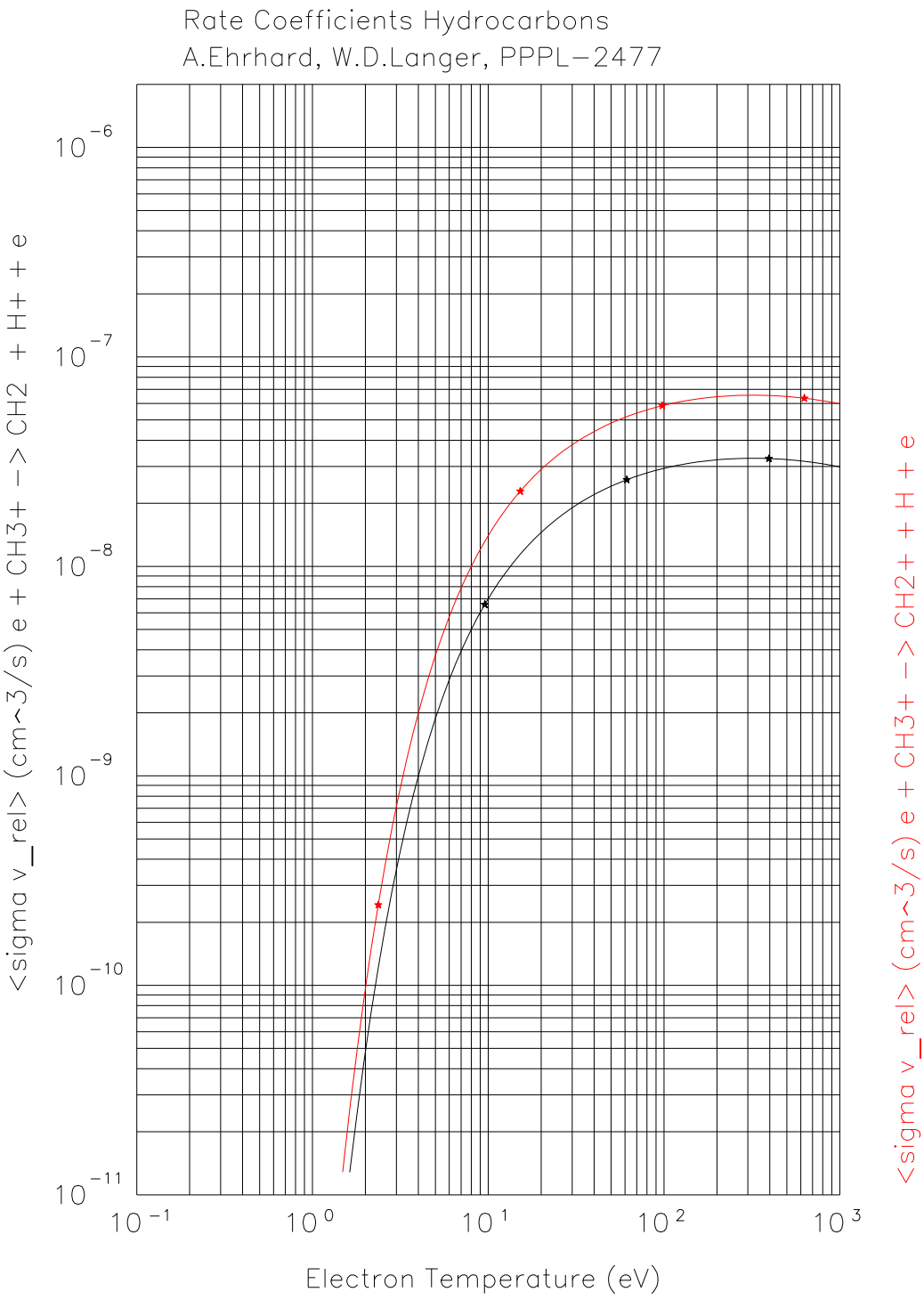
2.16 $e + CH_3^+ \rightarrow ...$

2.16.1 Reaction 2.16.1 $e + CH_3^+ \rightarrow CH_2 + H^+ + e$

```
b0 -2.945957131327e+01   b1  1.108352512038e+01   b2 -4.960967637555e+00
b3  1.392993579033e+00   b4 -2.574970898281e-01   b5  3.124045642701e-02
b6 -2.397756481445e-03   b7  1.051969352717e-04   b8 -1.999073436426e-06
    Tmin  1.26e+00   sv(Tmin)  1.60e-12  svmax  3.28e-08   Error  1.50e-05
```

2.16.2 Reaction 2.16.2 $e + CH_3^+ \rightarrow CH_2^+ + H + e$

```
b0 -2.876590642619e+01   b1  1.108212244292e+01   b2 -4.959610449105e+00
b3  1.392348609760e+00   b4 -2.573266019767e-01   b5  3.121415917105e-02
b6 -2.395404444673e-03   b7  1.050839615167e-04   b8 -1.996820276763e-06
    Tmin  1.26e+00   sv(Tmin)  3.21e-12  svmax  6.56e-08   Error  1.49e-05
```


Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) e + CH3+ −> CH2 + H+ + e
<sigma v_rel> (cm^3/s) e + CH3+ −> CH2+ + H + e
Electron Temperature (eV)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
10^-1
10^0
10^1
10^2
10^3

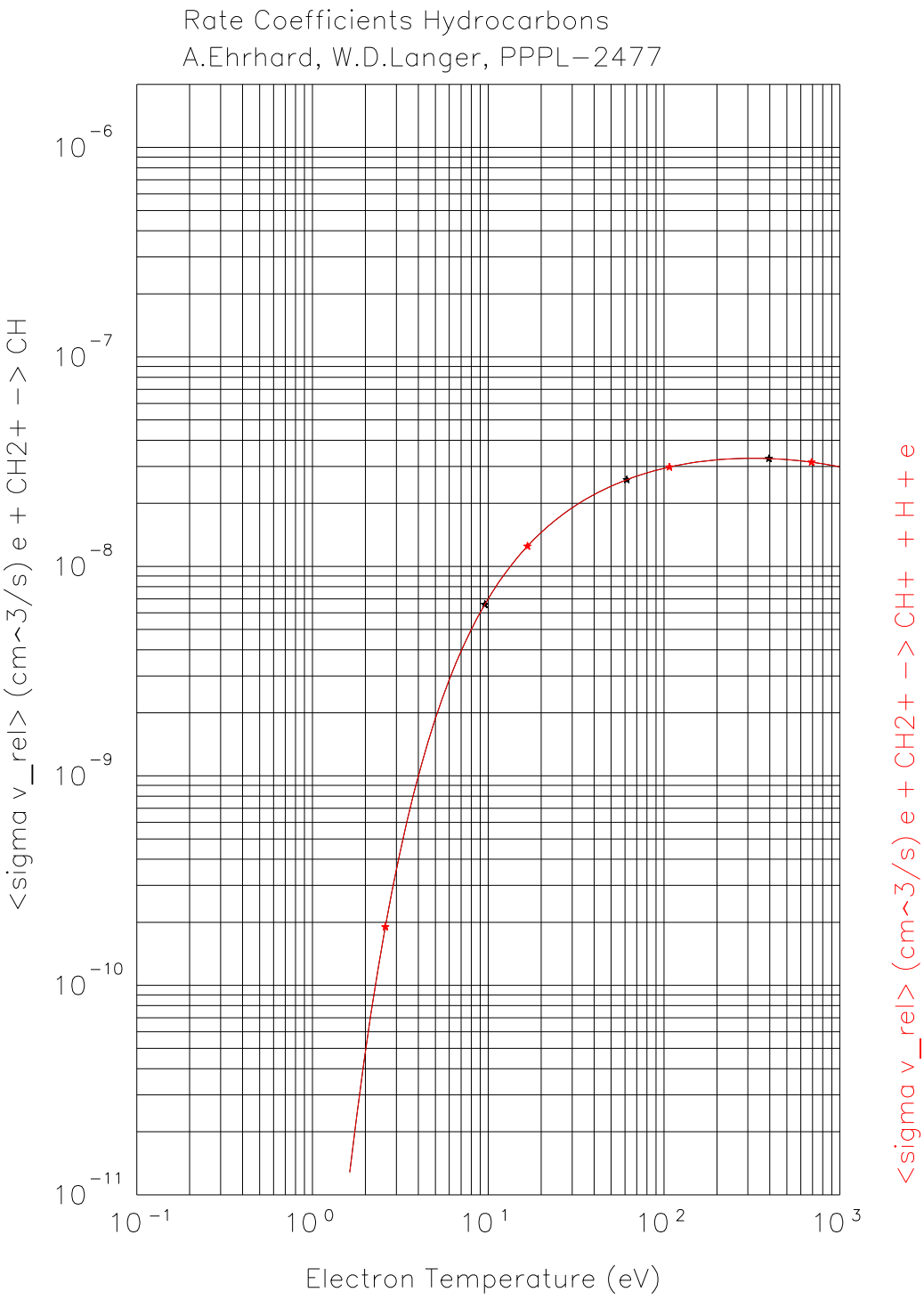
2.17 $e + CH_2^+ \rightarrow ...$

2.17.1 Reaction 2.17.1 $e + CH_2^+ \rightarrow CH + H^+ + e$

```
b0 -2.945957131327e+01   b1  1.108352512038e+01   b2 -4.960967637555e+00
b3  1.392993579033e+00   b4 -2.574970898281e-01   b5  3.124045642701e-02
b6 -2.397756481445e-03   b7  1.051969352717e-04   b8 -1.999073436426e-06
    Tmin  1.26e+00   sv(Tmin)  1.60e-12  svmax  3.28e-08   Error  1.50e-05
```

2.17.2 Reaction 2.17.2 $e + CH_2^+ \rightarrow CH^+ + H + e$

```
b0 -2.945957131327e+01   b1  1.108352512038e+01   b2 -4.960967637555e+00
b3  1.392993579033e+00   b4 -2.574970898281e-01   b5  3.124045642701e-02
b6 -2.397756481445e-03   b7  1.051969352717e-04   b8 -1.999073436426e-06
    Tmin  1.26e+00   sv(Tmin)  1.60e-12  svmax  3.28e-08   Error  1.50e-05
```


Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) e + CH2+ −> CH + H + e
10^−6
10^−7
10^−8
10^−9
10^−10
10^−11
10^−1
10^0
10^1
10^2
10^3
Electron Temperature (eV)

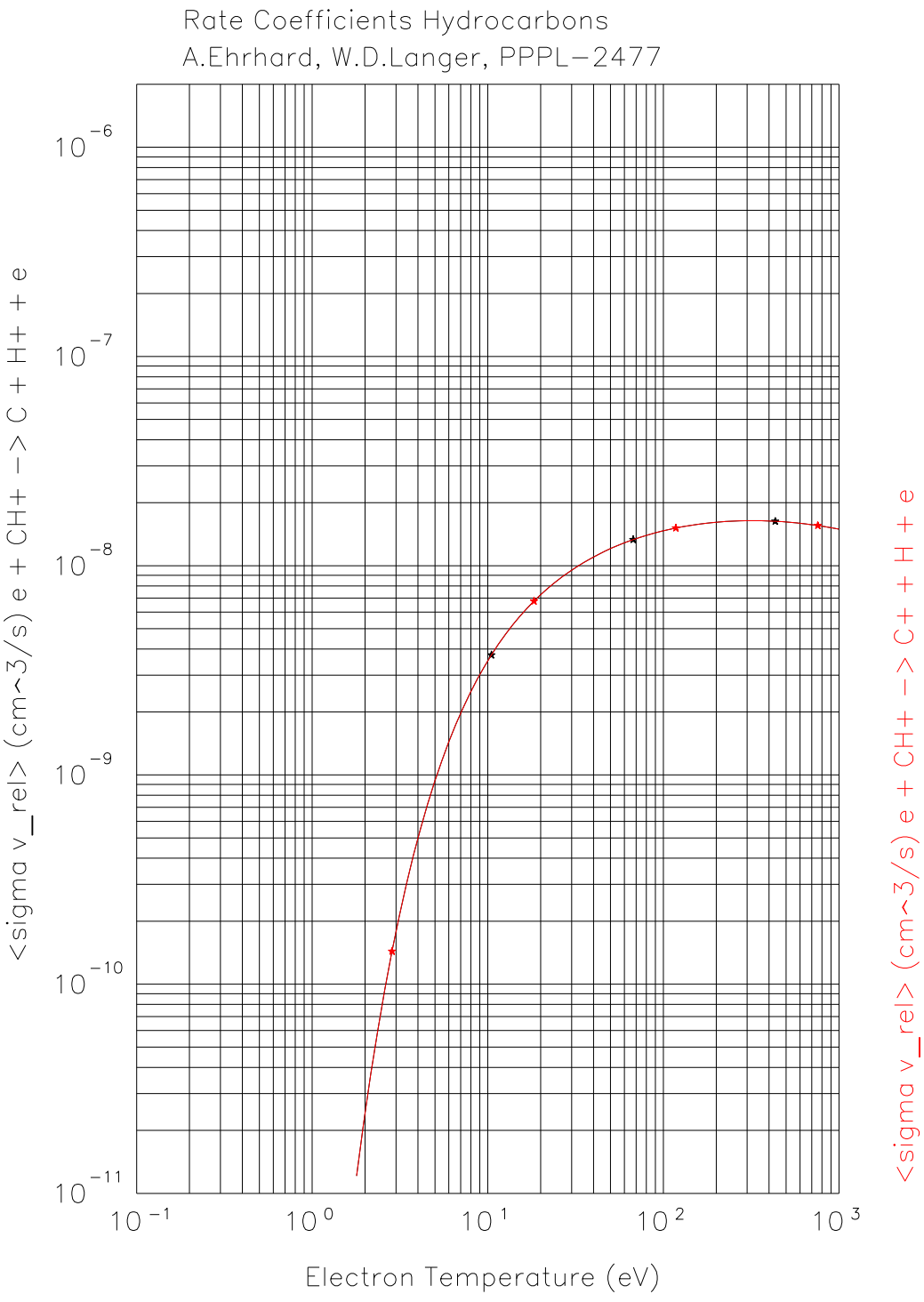
2.18 $e + CH^+ \rightarrow C + H^+ + e$

2.18.1 Reaction 2.18.1 $e + CH^+ \rightarrow C + H^+ + e$

```
b0 -3.012032364373e+01   b1  1.099522112261e+01   b2 -4.875231901753e+00
b3  1.352160807859e+00   b4 -2.466874895760e-01   b5  2.957131757726e-02
b6 -2.248347614716e-03   b7  9.801598372843e-05   b8 -1.855784198949e-06
    Tmin  1.58e+00   sv(Tmin)  5.25e-12  svmax  1.64e-08   Error  1.37e-05
```

2.18.2 Reaction 2.18.2 $e + CH^+ \rightarrow C^+ + H + e$

```
b0 -3.012032364373e+01   b1  1.099522112261e+01   b2 -4.875231901753e+00
b3  1.352160807859e+00   b4 -2.466874895760e-01   b5  2.957131757726e-02
b6 -2.248347614716e-03   b7  9.801598372843e-05   b8 -1.855784198949e-06
    Tmin  1.58e+00   sv(Tmin)  5.25e-12  svmax  1.64e-08   Error  1.37e-05
```


Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) e + CH+ −> C + H+ + e
<sigma v_rel> (cm^3/s) e + CH+ −> C+ + H + e
Electron Temperature (eV)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
10^-1
10^0
10^1
10^2
10^3

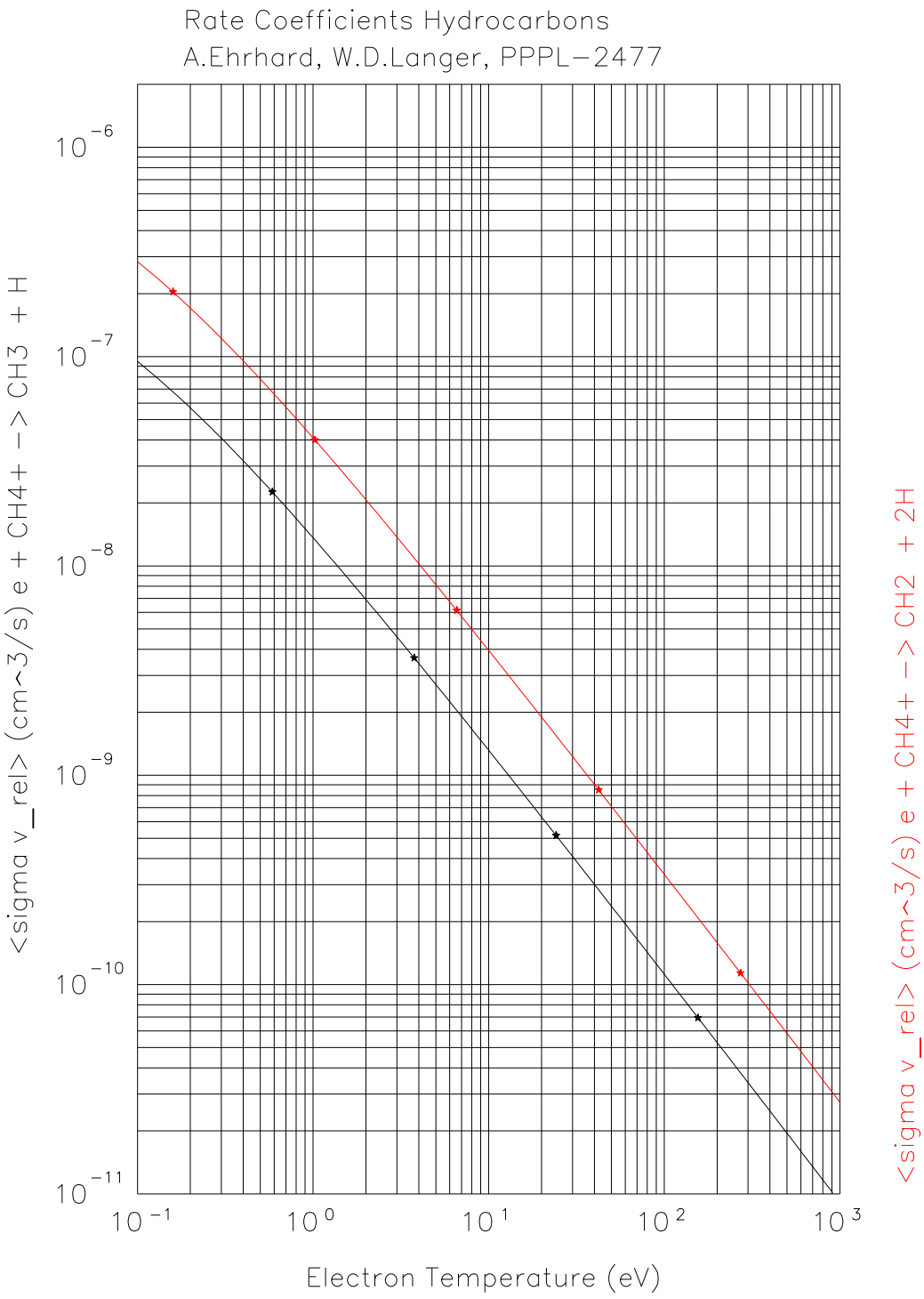
2.19 $e + CH_4^+ \rightarrow ...$

2.19.1 Reaction 2.19.1 $e + CH_4^+ \rightarrow CH_3 + H$

```
b0 -1.811008536904e+01   b1 -9.609633964487e-01   b2 -3.424995112490e-02
b3  6.125083185220e-03   b4 -7.398087967535e-04   b5  1.023424811982e-05
b6  1.489613542998e-05   b7 -2.305875698910e-06   b8  1.121715693015e-07
    Tmin  1.00e-01   sv(Tmin)  9.47e-08  svmax  9.47e-08   Error  2.32e-09
```

2.19.2 Reaction 2.19.2 $e + CH_4^+ \rightarrow CH_2 + 2H$

```
b0 -1.701143581095e+01   b1 -9.608594282939e-01   b2 -3.434403515564e-02
b3  6.062830823689e-03   b4 -6.960604032613e-04   b5  1.300409033176e-05
b6  9.608674057752e-06   b7 -1.294529653721e-06   b8  5.355898675023e-08
    Tmin  1.00e-01   sv(Tmin)  2.84e-07  svmax  2.84e-07   Error  5.51e-09
```


Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) e + CH4+ −> CH3 + H
<sigma v_rel> (cm^3/s) e + CH4+ −> CH2 + 2H
Electron Temperature (eV)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
10^-1
10^0
10^1
10^2
10^3

2.20 Reaction 2.20 $e + CH_3^+ \rightarrow CH_2 + H$

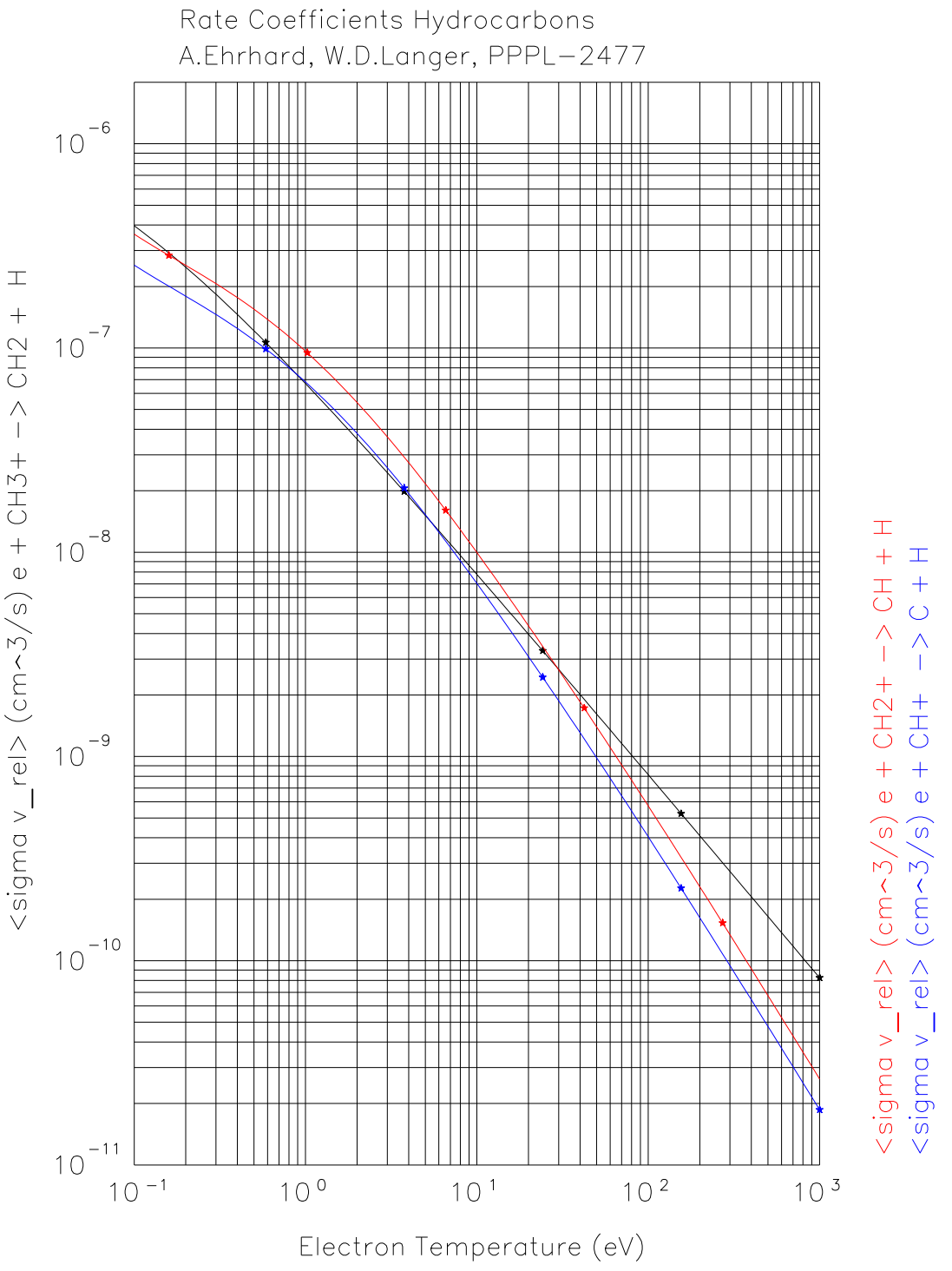
```
b0 -1.651879578335e+01   b1 -8.845965948845e-01   b2 -3.234169762966e-02
b3  5.931429828017e-03   b4 -6.065683500746e-04   b5 -6.807256725287e-06
b6  1.013117512304e-05   b7 -1.075059322040e-06   b8  3.738529146504e-08
    Tmin  1.00e-01   sv(Tmin)  3.97e-07  svmax  3.97e-07   Error  1.79e-08
```

2.21 Reaction 2.21 $e + CH_2^+ \rightarrow CH + H$

```
b0 -1.615383183840e+01   b1 -7.586474440302e-01   b2 -1.130528453633e-01
b3 -6.965630710151e-04   b4  4.528628288339e-03   b5 -6.557967171201e-04
b6 -1.975435184873e-05   b7  1.058151325615e-05   b8 -6.041276398828e-07
    Tmin  1.00e-01   sv(Tmin)  3.60e-07  svmax  3.60e-07   Error  2.03e-06
```

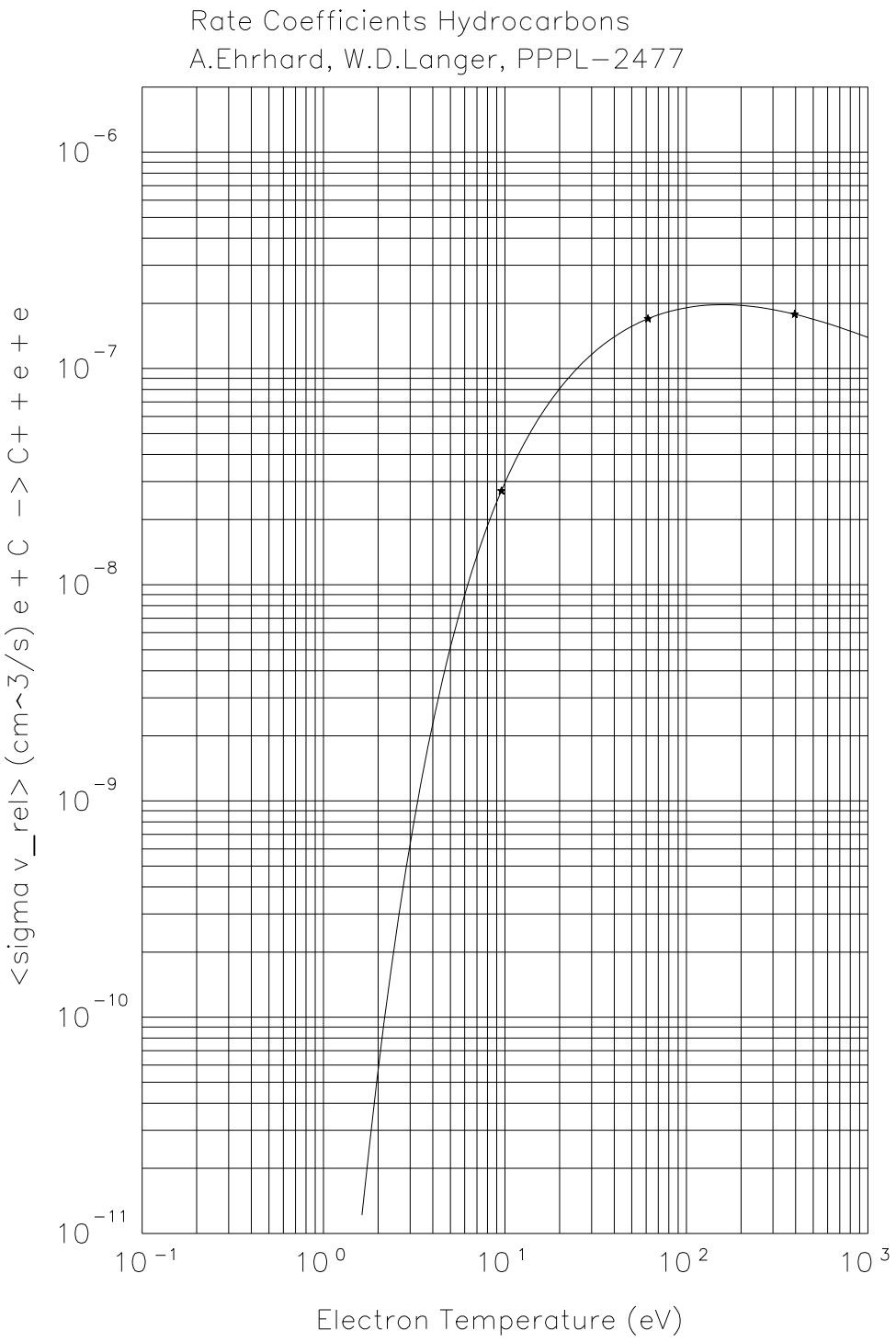
2.22 Reaction 2.22 $e + CH^+ \rightarrow C + H$

```
b0 -1.650186471548e+01   b1 -7.577994435524e-01   b2 -1.137373258287e-01
b3 -1.208054036514e-03   b4  4.852655512390e-03   b5 -6.277507371151e-04
b6 -5.978237115279e-05   b7  1.788694174879e-05   b8 -1.012452989015e-06
    Tmin  1.00e-01   sv(Tmin)  2.54e-07  svmax  2.54e-07   Error  1.56e-06
```


Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) e + CH3+ −> CH2 + H
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
10^-1
10^0
10^1
10^2
10^3
Electron Temperature (eV)
<sigma v_rel> (cm^3/s) e + CH2+ −> CH + H
<sigma v_rel> (cm^3/s) e + CH+ −> C + H

2.23 Reaction 2.23 $e + C \rightarrow C^{+} + 2e$

```
b0 -3.003325031029e+01   b1  1.210620585621e+01   b2 -4.784495376444e+00
b3  1.191377262469e+00   b4 -1.959147085306e-01   b5  2.063978055880e-02
b6 -1.323291115275e-03   b7  4.667595732505e-05   b8 -6.915444216285e-07
    Tmin  1.58e+00   sv(Tmin)  9.64e-12  svmax  1.97e-07   Error  9.04e-07
```


Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) e + C − > C+ + e + e
10 −6
10 −7
10 −8
10 −9
10 −10
10 −11
10 −1
10 0
10 1
10 2
10 3
Electron Temperature (eV)

3 H.3 :

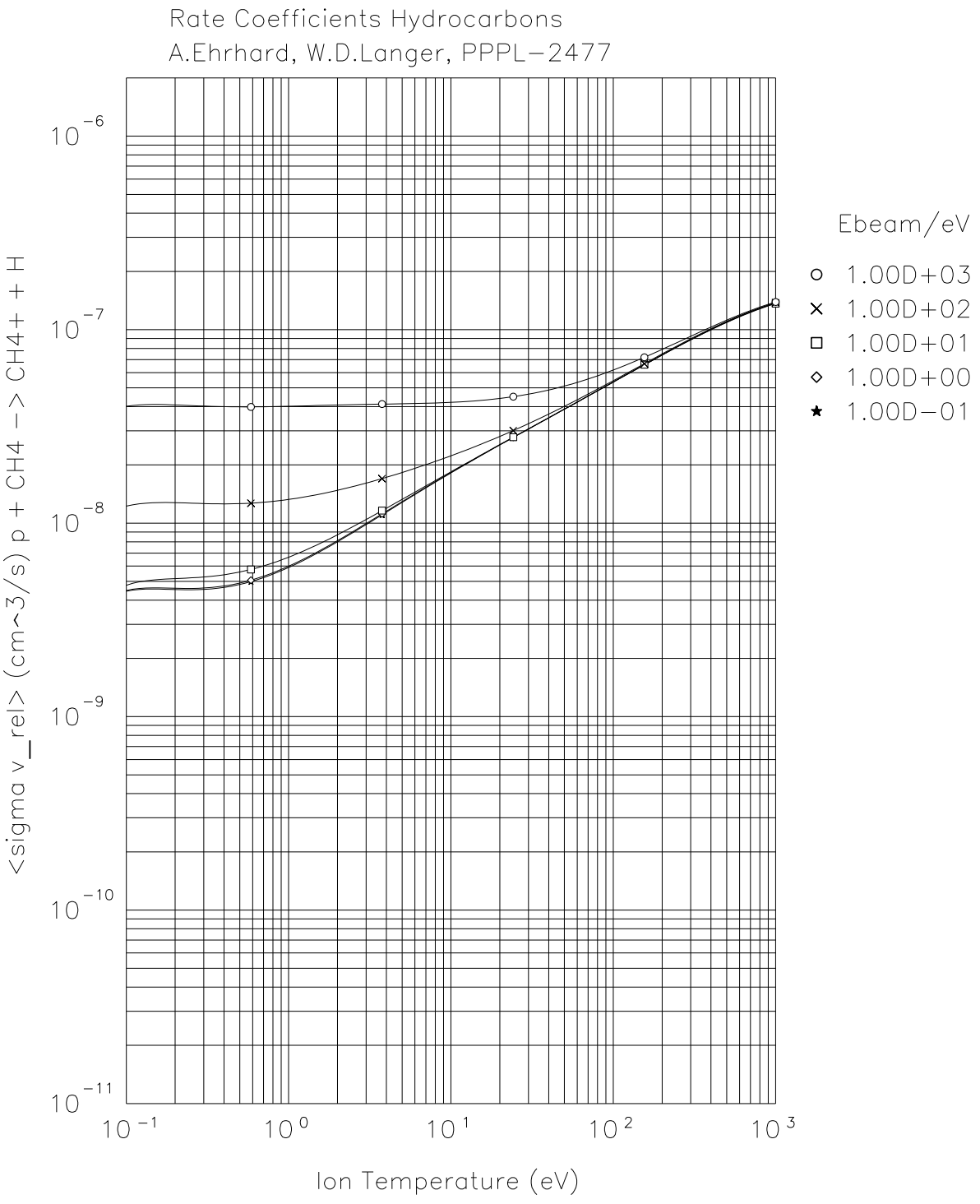
3.1 Reaction 3.1.1 $p + CH_4 \rightarrow CH_4^+ + H$

E Index	0	1	2
T Index			
0	-1.893309642087e+01	1.630850139987e-02	-4.714272469978e-03
1	3.776884529381e-01	1.048145245940e-02	7.227733247236e-05
2	1.093763179118e-01	-8.946299454637e-03	5.444574390551e-05
3	-2.977414700946e-02	6.502084407985e-04	1.092361098382e-03
4	-3.266919857975e-03	5.754254352327e-04	-4.134810722987e-04
5	2.833761994929e-03	-1.586203199222e-04	2.109974461716e-05
6	-4.972454353280e-04	1.695706232098e-05	8.410801850446e-06
7	3.578860489665e-05	-8.046520550513e-07	-1.200952674126e-06
8	-9.350695669585e-07	1.323413496981e-08	4.527497936811e-08

E Index	3	4	5
T Index			
0	2.425492370093e-03	3.068101950239e-03	-1.633878600590e-04
1	-7.529649417774e-03	-2.850523369529e-04	6.156392408384e-04
2	1.707309355637e-03	-4.053883564956e-04	-9.550753935009e-05
3	3.818918718530e-04	-6.507215186222e-05	-2.145885656470e-05
4	-1.147415418920e-04	7.428734189103e-05	-4.614052740801e-06
5	2.696892676495e-06	-1.176543808697e-05	2.542597558870e-06
6	1.009068906397e-06	2.076254405295e-07	-2.044216076319e-07
7	-6.821482596551e-08	7.011617376997e-08	-4.372775978657e-09
8	7.145677893147e-10	-3.693880360696e-09	6.489051753343e-10

E Index	6	7	8
T Index			
0	-1.023569804176e-04	1.421483822630e-05	-5.300227927218e-07
1	-1.035125430666e-04	6.780400601184e-06	-1.596091897574e-07
2	3.495664394328e-05	-3.364738102350e-06	1.057092818237e-07
3	4.842220252995e-06	-3.124588766143e-07	6.085162418331e-09
4	-1.313512598842e-06	1.834508345923e-07	-6.495489280153e-09
5	-7.794570475980e-08	-1.593741872383e-08	9.506440609074e-10
6	1.818970018754e-08	6.647545290109e-10	-8.054668689989e-11
7	1.989805345252e-10	-8.636301826823e-11	5.648949950364e-12
8	-6.425242445187e-11	5.232989348622e-12	-2.053898151891e-13

Error 4.76e-04


Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) p + CH4 −> CH4+ + H
10^−6
10^−7
10^−8
10^−9
10^−10
10^−11
10^−1
10^0
10^1
10^2
10^3
Ion Temperature (eV)
Ebeam/eV
1.00D+03
1.00D+02
1.00D+01
1.00D+00
1.00D−01

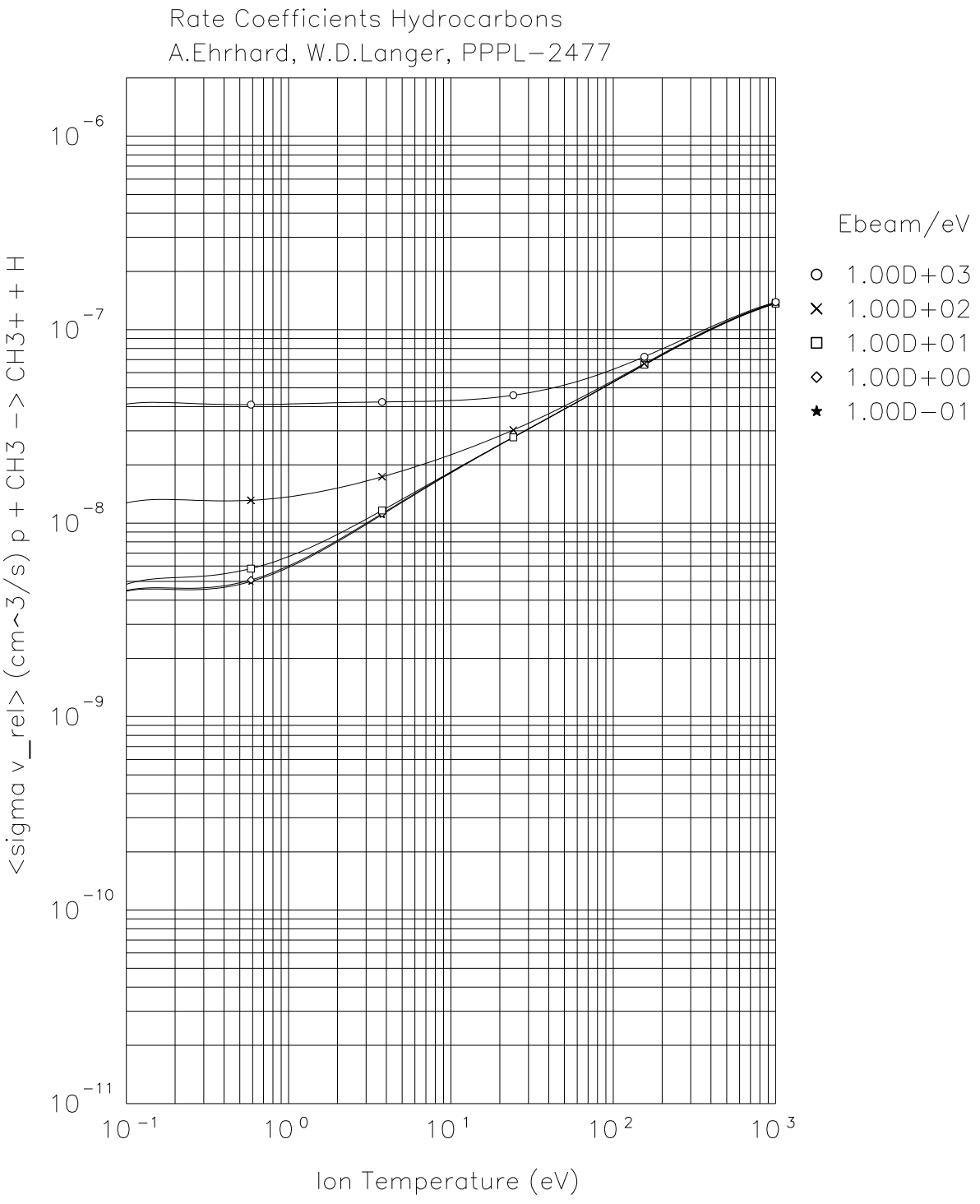
3.2 Reaction 3.1.2 $p + CH_3 \rightarrow CH_3^+ + H$

E Index	0	1	2
T Index			
0	-1.893015025400e+01	1.389143067153e-02	-6.781236636920e-03
1	3.779899373076e-01	1.026502385650e-02	-7.698088894683e-04
2	1.089496905822e-01	-9.157490505951e-03	2.969884378880e-04
3	-2.975011439547e-02	8.301595755376e-04	1.176745452526e-03
4	-3.248776015585e-03	5.779936403988e-04	-4.344370519201e-04
5	2.830654621739e-03	-1.747494577437e-04	1.958192848998e-05
6	-4.971444551136e-04	2.030387364220e-05	9.119763233765e-06
7	3.579805599493e-05	-1.073274942848e-06	-1.262470635022e-06
8	-9.356043099030e-07	2.095831478302e-08	4.696957441923e-08

E Index	3	4	5
T Index			
0	4.708492665561e-03	3.222294058983e-03	-4.354492180290e-04
1	-7.715282476671e-03	-1.893334421394e-04	6.225946617245e-04
2	1.668665562961e-03	-4.418488177370e-04	-8.252345657352e-05
3	3.570817130729e-04	-7.121562671774e-05	-1.995855695331e-05
4	-1.118613768332e-04	7.742141754581e-05	-5.506766569456e-06
5	5.038579776254e-06	-1.212485117935e-05	2.573708762225e-06
6	4.127343809761e-07	2.242442284292e-07	-1.896502386406e-07
7	-1.677674612550e-08	6.952443112677e-08	-6.036487436644e-09
8	-8.131627877359e-10	-3.668215799893e-09	6.997898343755e-10

E Index	6	7	8
T Index			
0	-4.825375453335e-05	9.977523040655e-06	-4.110277889686e-07
1	-1.082000663592e-04	7.268416351651e-06	-1.753527041780e-07
2	3.335975599670e-05	-3.282019035422e-06	1.042369042400e-07
3	4.851555584220e-06	-3.281444793300e-07	6.823060985962e-09
4	-1.238095500910e-06	1.822869211146e-07	-6.562368829665e-09
5	-8.352452578849e-08	-1.532146244890e-08	9.290573255333e-10
6	1.719741056841e-08	5.973202009088e-10	-7.531799873037e-11
7	3.408657452954e-10	-8.362107501242e-11	5.246746788544e-12
8	-6.905194380153e-11	5.201295647464e-12	-1.947010286302e-13

Error 4.91e-04


Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) p + CH3 −> CH3+ + H
Ion Temperature (eV)
Ebeam/eV
1.00D+03
1.00D+02
1.00D+01
1.00D+00
1.00D−01

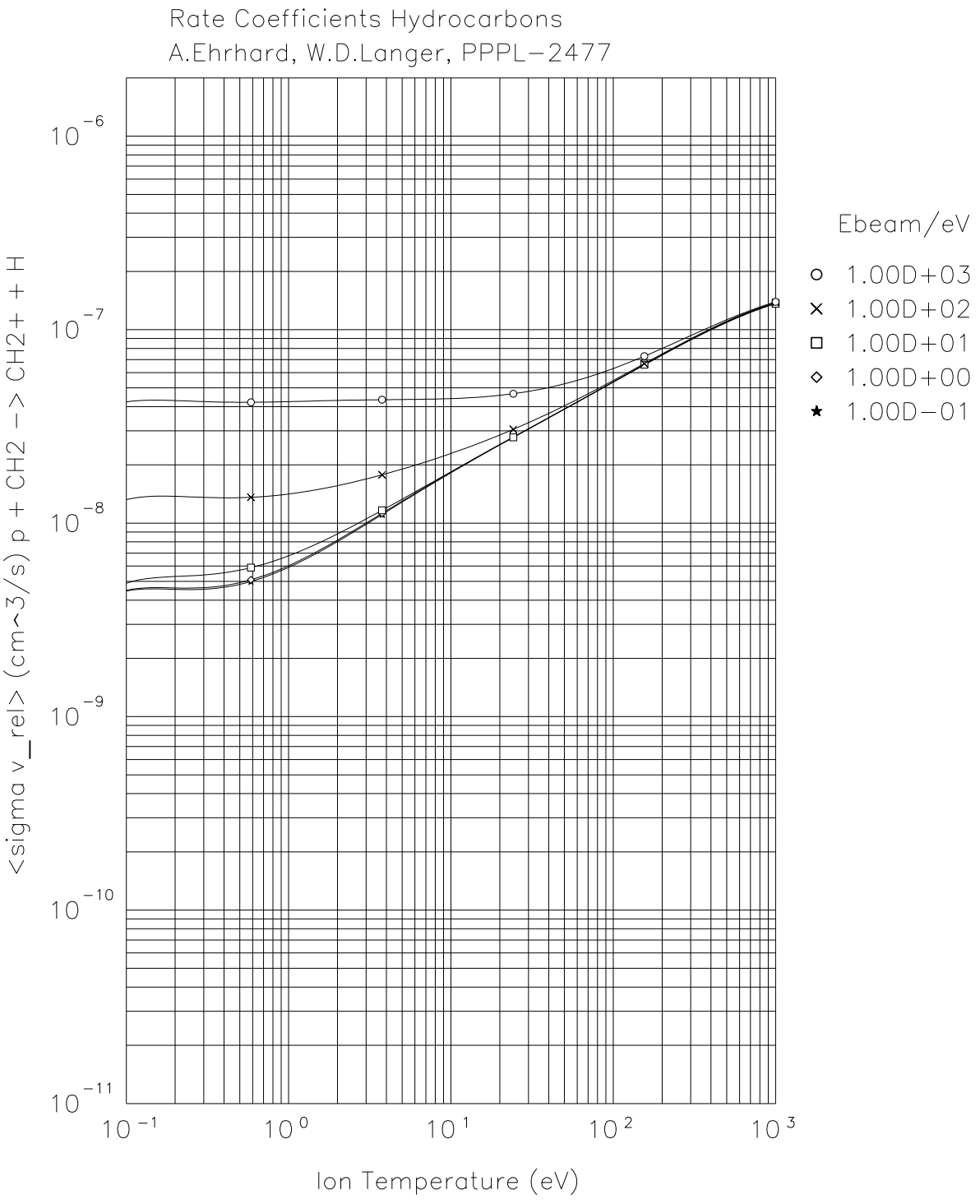
3.3 Reaction 3.1.3 $p + CH_2 \rightarrow CH_2^+ + H$

E Index / T Index	0	1	2
0	-1.892741490024e+01	1.152420986793e-02	-8.780888101054e-03
1	3.788098456684e-01	9.000972529774e-03	-1.876509952765e-03
2	1.090725061232e-01	-9.695960467242e-03	3.111706544768e-04
3	-3.000449680436e-02	1.485532220237e-03	1.296841607829e-03
4	-3.279542407570e-03	5.652830426608e-04	-4.203504358609e-04
5	2.865807364045e-03	-2.405403814714e-04	1.313418239934e-05
6	-5.035888740641e-04	3.590614373961e-05	8.783410077194e-06
7	3.626463829777e-05	-2.452619126791e-06	-1.106391575461e-06
8	-9.475996387093e-07	6.404591761204e-08	3.871143936175e-08

E Index / T Index	3	4	5
0	7.182298047960e-03	3.357963007674e-03	-7.270848383381e-04
1	-7.660318957536e-03	-8.703197824891e-05	6.084573282880e-04
2	1.683720541775e-03	-4.531927064772e-04	-7.859006453761e-05
3	2.498887361524e-04	-7.270758931961e-05	-1.376436553543e-05
4	-1.079342884921e-04	7.556045192812e-05	-5.321560049855e-06
5	1.451569314628e-05	-1.264521083892e-05	2.224266459969e-06
6	-1.669615482481e-06	5.659788755108e-07	-1.750602933349e-07
7	1.489259906003e-07	2.449872435024e-08	-2.024691997811e-09
8	-5.407280151576e-09	-1.865823448547e-09	4.236089219820e-10

E Index / T Index	6	7	8
0	1.091981451234e-05	5.291983408387e-06	-2.784485237271e-07
1	-1.087411664036e-04	7.436649225082e-06	-1.821937118550e-07
2	3.281188936769e-05	-3.249845228521e-06	1.035835180270e-07
3	3.861915548886e-06	-2.675185753286e-07	5.504045770260e-09
4	-1.242543887401e-06	1.823296753458e-07	-6.572917931547e-09
5	-2.170386158459e-08	-1.910235275312e-08	1.007926779341e-09
6	1.111261631954e-08	9.817255419496e-10	-8.193222019769e-11
7	1.746373535520e-10	-7.478956586819e-11	4.831022711092e-12
8	-4.326898079558e-11	3.656578646932e-12	-1.519531987892e-13

Error 5.11e-04


Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) p + CH2 −> CH2+ + H
Ion Temperature (eV)
Ebeam/eV
1.00D+03
1.00D+02
1.00D+01
1.00D+00
1.00D−01

3.4 Reaction 3.1.4 $p + CH \rightarrow CH^+ + H$

E Index	0	1	2
T Index			
0	-1.892389432736e+01	8.886284345584e-03	-1.109300880346e-02
1	3.791545123515e-01	8.475134434604e-03	-2.973010109645e-03
2	1.085777338734e-01	-9.990530830098e-03	6.446889461501e-04
3	-2.997534308810e-02	1.713544431587e-03	1.373586207056e-03
4	-3.260996214109e-03	5.763633536150e-04	-4.480196094509e-04
5	2.863922977162e-03	-2.617206664923e-04	1.438290421753e-05
6	-5.038991956580e-04	3.992826597099e-05	9.107700403461e-06
7	3.631854565763e-05	-2.755740015697e-06	-1.146833082454e-06
8	-9.497184774037e-07	7.230406803998e-08	4.006171386613e-08

E Index	3	4	5
T Index			
0	9.891958133741e-03	3.522032366810e-03	-1.049400447938e-03
1	-7.781044625266e-03	3.464768381132e-05	6.045693040532e-04
2	1.634731775121e-03	-5.010651980603e-04	-6.225015839420e-05
3	2.215628364409e-04	-7.914800428968e-05	-1.192386073197e-05
4	-1.054043956245e-04	7.984411714572e-05	-6.435098464842e-06
5	1.697295195994e-05	-1.324570737982e-05	2.296164298139e-06
6	-2.255156800466e-06	5.933171429767e-07	-1.616686267082e-07
7	1.977586178919e-07	2.504023290886e-08	-4.009927544303e-09
8	-6.828266134182e-09	-1.922660210612e-09	4.965121146332e-10

E Index	6	7	8
T Index			
0	7.576825283904e-05	1.828073909406e-07	-1.344276753890e-07
1	-1.118911888932e-04	7.823262706391e-06	-1.953022685282e-07
2	3.093317830888e-05	-3.165066380853e-06	1.025231510021e-07
3	3.821918256505e-06	-2.803647165215e-07	6.180674471800e-09
4	-1.163155113152e-06	1.828672477268e-07	-6.733895111826e-09
5	-2.867987544661e-08	-1.865893333810e-08	9.972303921835e-10
6	1.025765387662e-08	9.006547570731e-10	-7.616327775842e-11
7	3.376813463046e-10	-7.111784442785e-11	4.338865744046e-12
8	-5.003679679618e-11	3.658641743778e-12	-1.394548455624e-13

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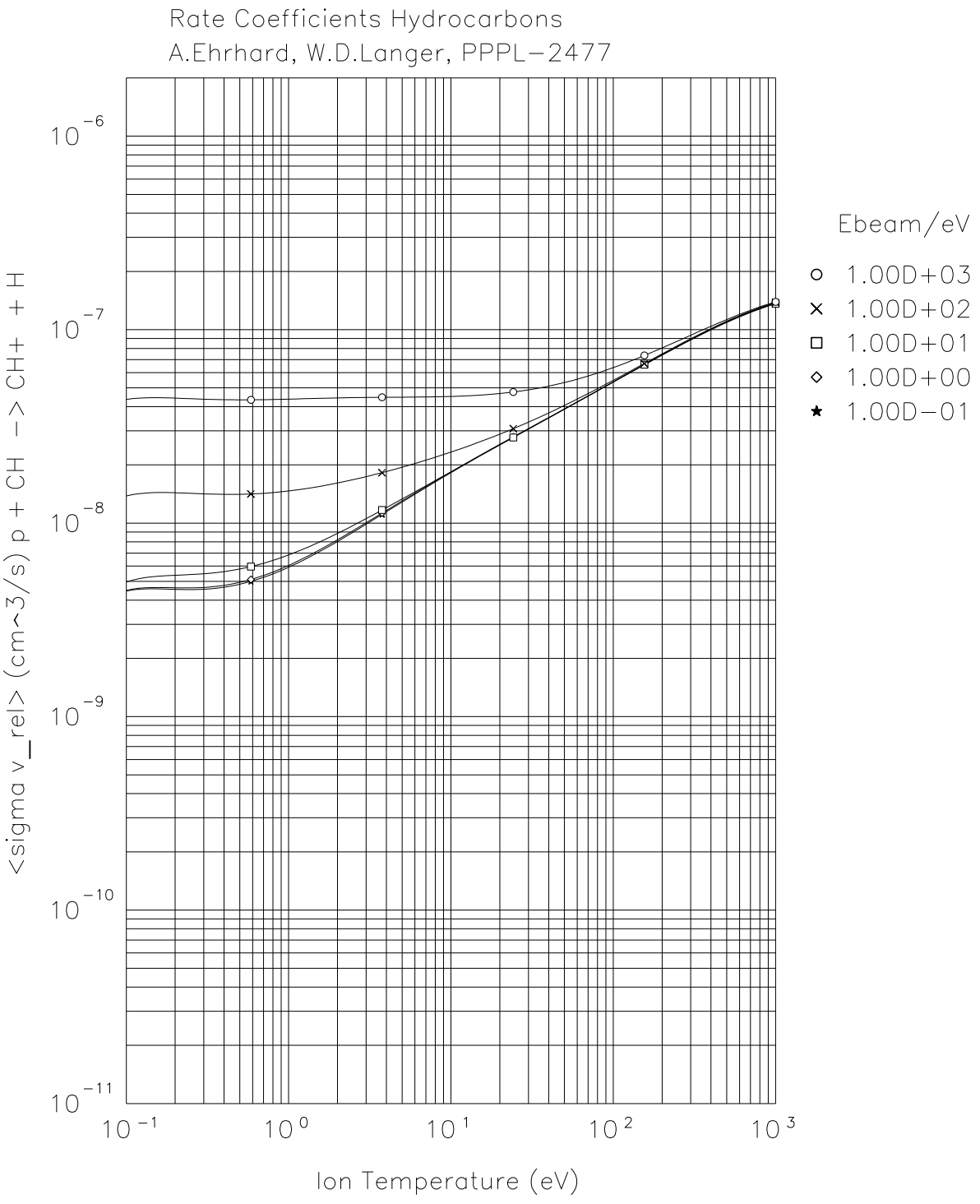

Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) p + CH − > CH+ + H
10^−6
10^−7
10^−8
10^−9
10^−10
10^−11
10^−1
10^0
10^1
10^2
10^3
Ion Temperature (eV)
Ebeam/eV
1.00D+03
1.00D+02
1.00D+01
1.00D+00
1.00D−01

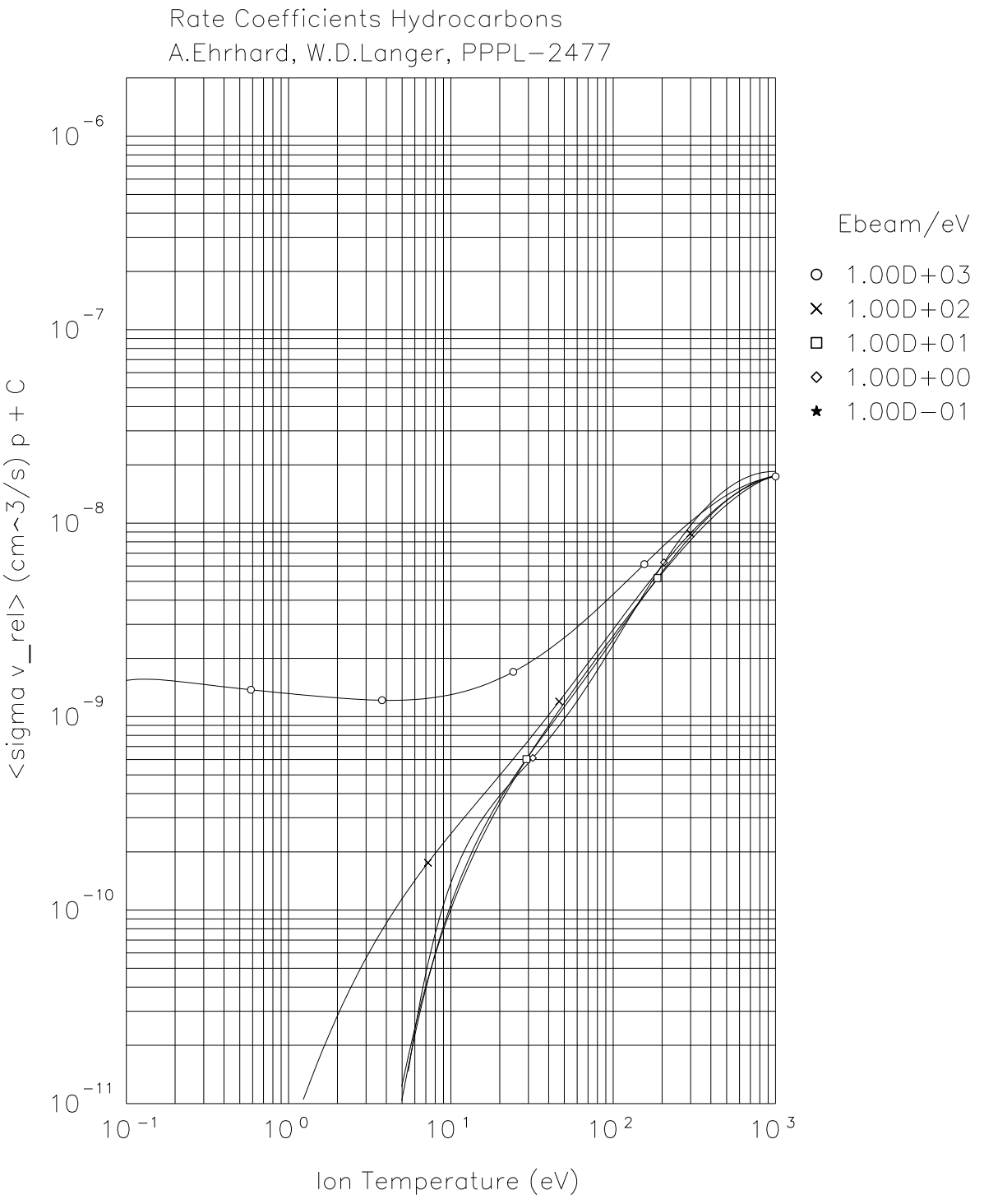
3.5 Reaction 3.2 $p + C \rightarrow C^{+} + H$

E Index / T Index	0	1	2
0	-5.443659700109e+01	4.073411220060e+00	1.343537080718e+00
1	3.519668118251e+01	-7.442349347208e+00	-1.679246081597e+00
2	-1.440577315368e+01	4.967811697956e+00	3.770572537247e-01
3	2.389215208509e+00	-1.609634901952e+00	1.813516675472e-01
4	4.009158278020e-02	2.721115624720e-01	-1.057427190049e-01
5	-6.925835962750e-02	-2.269114466358e-02	2.167917859821e-02
6	9.718717487684e-03	5.787459308821e-04	-2.219154740081e-03
7	-5.743071740355e-04	3.197508385415e-05	1.138421156169e-04
8	1.283086677986e-05	-1.673461633606e-06	-2.333743575530e-06

E Index / T Index	3	4	5
0	-3.742953182096e-01	1.562786664968e-01	-5.050566764114e-02
1	8.354823234939e-01	-2.057568648831e-01	3.971780176781e-02
2	-4.826530418539e-01	1.210673763876e-01	-1.728640079568e-02
3	9.844891930043e-02	-3.512672315597e-02	4.843632501303e-03
4	1.991164735704e-03	4.344502662194e-03	-7.697368486675e-04
5	-3.840068723237e-03	4.523377512297e-05	4.856982614492e-05
6	6.052986380212e-04	-6.560347179004e-05	2.224934908993e-06
7	-3.961495494005e-05	5.987253800332e-06	-4.426701306196e-07
8	9.679360311336e-07	-1.731952061869e-07	1.580906137037e-08

E Index / T Index	6	7	8
0	7.600393480264e-03	-5.219982007449e-04	1.343520388572e-05
1	-4.808567649579e-03	3.000417510833e-04	-7.344906981331e-06
2	1.539570238715e-03	-7.810375205427e-05	1.691291158136e-06
3	-3.320115825286e-04	1.084787340601e-05	-1.243722459881e-07
4	5.109863768673e-05	-1.095330615678e-06	-7.965630839833e-09
5	-4.687932503830e-06	1.337796016066e-07	9.339085034104e-11
6	1.375628810844e-07	-1.328023738582e-08	2.989117828849e-10
7	9.667766366726e-09	6.171653468413e-10	-2.961480504137e-11
8	-5.791521078290e-10	-8.319090984891e-12	8.282715522960e-13

Error 8.02e-03


Rate Coefficients Hydrocarbons
A.Ehrhard, W.D.Langer, PPPL−2477
<sigma v_rel> (cm^3/s) p + C
Ion Temperature (eV)
Ebeam/eV
1.00D+03
1.00D+02
1.00D+01
1.00D+00
1.00D−01

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[3] V. Dose, P. Pecher and R. Preuss: J. Phys. Chem. Ref. Data, **29**, No. 5, (2000) 1157

[4] R. Janev, D. Reiter, Phys. of Plasmas, **9**, (2002) 4071