Bichsel COV program

$\boxed{\text{PREP}}$ (EVANS) Prepare fundamental constants & coefficients

ATNU	N_a	No. of atoms/cm³	$= \overset{N_A}{6.0222 \times 10^{23}} \times \rho/A$
AW	A	Atomic number of Si	$= 28.086$
BETASQ	β^2	Incident particle velocity squared	
BG	$\beta\gamma$	〃 P/m	
EXTH	t	Si absorber thickness	input (μm) → calc (cm)
EMAX	E_M	Maximum energy loss (eV)	
EMIN		Minimum E loss (eV)	$= 1.7959$
GAM	γ	Incident particle γ	
NPM		Particle type $(1\text{–}6) = (p, \pi, \alpha, e, k, \mu)$	
PMASS	$M(\,)$	Particle mass (NPM) (MeV)	
PTM	M	Particle mass (MeV)	
PKE	T	Particle kinetic energy (MeV)	$= M(\gamma-1)$
RHO	ρ	Medium (Si) density (g/cm³)	$= 2.329$
RY	R_y	Rydberg constant (eV)	$= 13.6058$
SAXK	$k \cdot N_A \cdot \rho/\beta^2 \cdot A$	Crosssection Coefficient dE/dx (eV/cm)	$= \dfrac{2\pi z^2 e^4 N_A \cdot \rho}{mc^2 \cdot \beta^2 \cdot A} = \dfrac{(153540 \cdot z^2) \cdot \rho}{\beta^2 \cdot A}$
ZA	Z	Target atomic $Z = 14$	
ZI	z	Incident Particle charge	

EMAX:

$$\begin{cases} \dfrac{M(\gamma^2-1)}{\left(\dfrac{M}{2m} + \dfrac{\cancel{\gamma} m}{2M} + \gamma\right)} & \text{[Heavy projectile]} \\ M^2(\gamma-1)/2 & [e^+, e^-] \end{cases}$$

bug in original

Due to rounding error accidentally. Original should give 1.5

my extension

$\boxed{\text{PREPE}}$ Prepare energy bins for calculation

EMIN			
EFIN		Energy of last useful bin	$= \mathrm{MIN}(E_M, \mathrm{ETOP})$
ETOP		Last table bin Energy	$= E(\mathrm{NUME}) \cdot \sqrt{\mathrm{UM}}$ ← half bin up
N2		No. energy bins for each 2X	$= 64$
NUME		No. Tabled energy bins	$= 1250$
LEMX		Total energy bins	$= 1250 + 450$
LEH		Last useful table bin	$=$ Bin No. of EFIN

U	Logrithmic bin width factor	$= \ln 2/N2$	
UM	Multiplification bin factor	$= 2^{1/N2}$	
E(j)	Energy bins (eV)	$= EMIN \cdot 2^{j/N2}$	j=1, LEMX
DE(j)	Energy bin width (eV)	$= E(j+1) - E(j)$	
DI(j)	Energy bin log $\int$ factor	$= -N2 \cdot \ln(1-2^{-j/N2})/\ln 2$	

$\boxed{\text{EPRED}}$ Read in dielectric constant data file HEPS.TAB

EP(1,j)	$RE(\varepsilon(E)) = \varepsilon_1(E(j))$	j=1, NUME
EP(2,j)	$IM(\varepsilon(E)) = \varepsilon_2(E(j))$	
RIM(j)	$IM(-1/\varepsilon) = \varepsilon_2/\varepsilon^2$	
dfdE(j)	df/dE coefficient $= \frac{2Z}{\pi E_a^2} E(j) \cdot Im(-\frac{1}{\varepsilon(E)}) = 0.009246 \cdot E(j)\, Im(\frac{-1}{\varepsilon(E)})$	

$\boxed{\text{AERED}}$ Read in GOS calculation table MACOM.TAB A(E)
for Longitudinal excitation (K+L shell) ~~At large momentum transfer~~

SIG(6,j) $A(E(j)) = Z \sum_l E A_l(E) \rightarrow Z$ at large E   j=1−numE

$\boxed{\text{EMRED}}$ Read in GOS calculation table (M shell) EMERC.TAB A(E)

SIG(6,j)	$A(E(j))$	Replaces M-shell values in MACOM.	j=1,175
XKMN(j)	$K_1 a_0$	for energy loss E<11.9eV	j=1,175

$\boxed{\text{SPECT}}$ Calculate total cross section spectrum

BEMX β^2/E_M

DEC $k \cdot Na/\beta^2$ (= SAXK) (eV/cm) $= \frac{12732 \cdot z^2}{\beta^2}$

SIG(1,j) $E(j)^2 \sigma_l'(E(j)) = \begin{cases} E(j) \cdot dfdE(j) \ln Q_1/Q_m & \\ 0 & E(j) < 11.9\text{eV AND } Q_1 \le Q_m \end{cases}$ $Q_m = E(j)^2/2\beta^2 m$

$$Q_1 = \begin{cases} [XKMN(j)]^2 \cdot Ry & E < 11.9\text{eV} \\ 0.025^2 \cdot Ry & 11.9 < E < 100 \text{ eV} \\ 1 \cdot Ry & 100\text{eV} < E \end{cases}$$

SIG(2,j) 0

SIG(3,j) $E^2(j) \cdot \sigma_t'(E(j)) = E^2(j) \cdot \frac{2Z}{\pi E_a^2} \left\{ \frac{\varepsilon_2}{\varepsilon} \ln[(1-\beta^2\varepsilon_1)^2 + \beta^4\varepsilon_2^2]^{-1/2} + [\beta^2 - \frac{\varepsilon_1}{\varepsilon^2}] \tan^{-1}\frac{\beta^2\varepsilon_2}{1-\beta^2\varepsilon_1} \right\}$

θ $0-\pi$

SIG(4,j) $E(j)^2 \sigma_u'(E(j)) = \begin{cases} 2 \cdot (1 - \beta^2 \frac{E(j)}{E_M}) \cdot A(E(j)) & \text{[Heavy]} \\ \left[1 + (\frac{E}{T-E})^2 + ((\frac{\gamma-1}{\gamma}) \cdot \frac{E}{T})^2 - \frac{(2\gamma-1) \cdot E}{\gamma^2(T-E)}\right] \cdot A(E) & \text{[electron]} \end{cases}$

SIG(5,j) $\sum_{L=1}^{4} SIG(L,j)$ Overall differential cross section $\times E^2$

TSIG(L)	$\sum_{j=1}^{LEH} SIG(L,j) \frac{dE(j)}{E^2(j)}$	= Total cross section $\int$	L=1−5
STP(L)	$\sum_{j=1}^{LEH} SIG(L,j) \frac{dE(j)}{E(j)}$	= Total $\langle \frac{dE}{dx} \rangle$ $\int$	
RM2(L)	$\sum_{j=1}^{LEH} SIG(L,j)\, dE(j)$	= Total second Moment M_2 $\int$	

FSG	DEC · TSIG(5)	= No. of Collisions/cm
dEdx	$10^{-6} \cdot$ DEC · STP(5)	$= \langle \frac{dE}{dx} \rangle_{\text{Restricted}}$ (MeV/cm) $\Delta E < 1.346$ MeV
S0	$\sum_{j=1}^{LEH} dfdE(j)\, dE(j)$	$= Z_{eff}$ (Should be ~14)
aVI	$\sum_{j=1}^{LEH} dfdE(j) \ln(E(j))\, dE(j)$	$= \ln(I_{eff}) Z_{eff}$ (should be ~ $\ln(174) \times Z_{eff}$)
~~S1~~	~~$\sum_{j=1}^{LEH} dfdE(j)\, E(j)\, dE(j)$~~	~~$\approx I_{eff} Z_{eff}$ (should be ≈ 174 eV)~~

$\boxed{\text{SPTS/HART}}$ Calculate corrected $\int \sigma$ & $\frac{dE}{dx}$ including high E tails.

Assume high E cross section $\sigma(E) \propto \frac{1}{\beta^2}(1 - \frac{\beta^2 E}{E_m}) \frac{1}{E^2}(1 + \frac{\langle d_1 \rangle}{E})$

i.e relativistic Rutherford X-sec · A(E) correction factor

$\langle d_1 \rangle \approx 720$ eV

RM0 $\propto \int_{E_{fin}}^{E_{max}} \sigma(E)\, dE$ = Risidual Cross-section for $E > E_{fin}$

RMO × Z × DEC/10^6 → #coll/cm

rst $\propto \int_{E_{fin}}^{E_{max}} \sigma(E)\, E\, dE$ = Risidual $\frac{dE}{dx}$ for $E > E_{fin}$

tdEdx Total corrected $\langle \frac{dE}{dx} \rangle$ (MeV/cm)

= ~~STP(5)~~ dEdx + 10^{-6} Z · DEC · rst

del2 $M_2 - M_2'' = RM2(5) \cdot DEC/10^6 - \frac{Z \cdot DEC}{10^6} \cdot \int_0^{E_{fin}} (1 - \frac{\beta^2 E}{E_M})\, dE$ (keV²/cm)