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Computer Code for Inclusive (ee') Electro-production Reactions and Radiative Corrections

Misak Sargsyan

Yerevan Physics Institute

Yerevan, Armenia, USSR

Abstract

This document is the manual for the program packages INCLUSIVE and RADIATION, which implement theoretical calculations of inclusive (e,e') processes, and radiative effects (for inclusive and exclusive reactions).

Introduction

Inclusive (e,e') processes have been studied extensively at electron accelerators and there exist many theoretical calculations which describe the cross section in the quasi-free region. For these reasons, such processes (mainly in quasi-free region) can be used as tools for calibration.

The program package INCLUSIVE is based on two theoretical approaches for electro-nuclear reactions: the Virtual Nucleon Impulse Approximation [2,3] and the Impulse Approximation Based on Light Cone Dynamics [1]. Both approaches predict the same values in the quasi-free region and alternatively describe the cross sections beyond the quasi-free region. A program to calculate the electron-proton inclusive cross section has also been implemented in the package INCLUSIVE.

For a correct comparison with the experimental data, radiation effects have to be taken into account. These calculations are performed in the program INCLUSIVE. Since radiative corrections can be used in other electro-production reactions, we treat the radiative effects in a separate program that also includes radiative correction for coincidence processes. These packages are presented in the code RADIATIVE. The current work consist of two parts. We first describe the program INCLUSIVE and how it is used. In the second part, we describe use of the code RADIATIVE.

2. Program INCLUSIVE

The program INCLUSIVE is used to calculate the inclusive (e,e') cross sections. It consists of the following three main subroutines:

– the program VN_INCL.FOR which calculates the inclusive electron-nucleus cross section in the framework of the Virtual Nucleon approach,

– the program LCD_INCL.FOR which calculates the same inclusive cross sections in the Light Cone Dynamic approximation,

– the program HYDRO.FOR which calculates the inclusive cross section on hydrogen.

2.1 Physics Contents

Calculations of electro-nucleus (for A>1) cross section are based on the assumption of the few-nucleon Short Range Correlation (SRC) structure for the high momentum component of the nuclear wave functions. This allows us, in the region of enhancement of SRC, to represent the electron-nucleus cross section by the scattering of virtual photon on individual few-nucleon correlations:

$$\sigma_{eA} = \sum_{j=2}^{A} a_j \sigma_{ej}$$

Our general aim is to describe the regions of scattered electron spectra (regions like the part of the electron spectrum between Delta resonance and Quasi-elastic peak (DIP), or the part of spectrum where X = $Q^2/2mq_0 > 1$) where the momenta of the interacting nucleons , which contribute to the cross section of quasi-elastic scattering, exceed the Fermi momentum and therefore effects such as relativisation and nucleon binding (off shell effects) become more important.

The program LCD_INCL.FOR takes this effect into account in the Light Cone Dynamic approach within the framework of the Frankfurt-Strikman model [1]. In the program VN_INCL.FOR the alternative approximation: the Virtual Nucleon approximation is used (De Forest Off Shell approximation [2] for quasi-elastic scattering and West approximation [3] for inelastic one).

The comparison of these models allow us to investigate the role of relativistic and binding effect in electro-nuclear inclusive reactions.

Note, with both the LCD_INCL and VN_INCL models, pair correlation contributions are only considered in the high momentum component of the wave function.

Therefore the calculations are applicable at X < 2. Note also, that in these two, and in the HYDRO.FOR program for inelastic scattering, the Bodek nucleon inelastic form-factor parametrisation [9] is used.

A typical calculation of the inclusive spectra by the LCD_INCL and VN_INCL codes are shown in the following figures:

In fig.1 a comparison of the cross section calculated by LCD_INCL (fig.1a) and by VN_INCL (fig.1b) with the experimental cross section of electron - deuteron cross section measured at SLAC [4b] is presented.

In fig.2 calculations of inclusive Al(ee')X cross section using LCD_INCL and VN_INCL are compared with experimental data [5].

In these two programs a wave function based on the Paris potential is used for the deuteron nucleus. For nuclei such as Al, Fe and Pb wave functions are obtained using the so called Quasi-particle Lagrange Method [6] in which effects related to the finite size of the nucleus are accounted for. For other nuclei the Fermi (table) momentum distributions are used. The difference in the momentum distributions obtained with this method from those obtained using the simple Fermi table distribution is presented in fig.3. As can be seen from fig.4 experimental quantities like the R $=2\sigma_{eAl}/A\sigma_{eD}$ [4a] are sufficiently sensitive to different shapes of the nucleon momentum distribution. The comparison of this theoretical calculation with inclusive data [4,5] for a wide range of nuclei (from H to Au) reveals an accuracy in the description of data at the few percent level. This allows us to extract (from existing experimental data) such delicate phenomena as the Q^2 dependence of the neutron magnetic form-factor (at high Q^2) [7a] and effects induced by the swelling of bound nucleons [7b].

Note that, to accurately perform such an analysis in LCD_INCL.FOR, one may optionally take into account the EMC effect, which is calculated on the basis of the color screening (mini-delocalization) model [8] and effects of bound nucleon swelling.

The program INCLUSIVE also allows one to account for radiative effects in the all three of the above presented subprograms.

2.2 INCLUSIVE program usage

To run the program, one has to use the INCLUSIVE.COM file, which provides the input and output file definitions, translation and compilation by MAKEFILE and program execution.

a) **INPUT FILE:** The input parameter definition is organized similarly to the CELEG program input [10], which simplifies running of the program. The parameters taken by the INIT_INCL.DAT file (with FORMAT(A10,A10,6F8.3)), are shown in fig.5. The meaning of each line is as follows:

INCIDENT ELECTRON 3.595 0.800 0.000 0.000 0.000 0.000

I – data is the initial electron energy in GeV.

II – is the KeV values of the initial energy (Ei = 3.595 + 0.800/1000. = 3.5958GeV)

III,IV,V,VI - unused

TARGET AL 27.000 13.000 0.240 20.000 0.030 0.010

AL – initialize of target type (see tab.1)

I – atomic number A of target

II – charge number Z of target

III – Fermi momentum of target nucleus in (GeV/c)

IV – high momentum component in (%)

V – mean response energy in (GeV)

VI – difference of pair mass from deuteron mass (Mpair = Mdetr.- 0.010)

RAD_EFFECT	**NO**	**14.100**	**0.020**	**0.010**	**0.000**	**0.100**	**0.000**

I – target thickness in (mm)

II – radiative correction parameter in GeV (usually ≈ 0.02 GeV)

III – scattered electron energy resolution

IV – scattered electron angle resolution (*no used yet*)

V – relative accuracy for integration in the rad. correction

VI – unused

SWELLING	**V1**	**1.700**	**0.200**	**0.000**	**0.000**	**0.000**	**0.000**

V1 – average nucleon swelling, V2 - dynamic swelling effect

I – nucleon radius changes in % ([+] - increase, [-] - decrease)

II – probability of point like configuration in bound nucleon (≈ 0.2)

III-VI – unused

EMC	**YES**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**

EMC – effect including

I-VI – unused

ELEC_SPECT		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Ee' – RANGE	**YES**	**2.455**	**3.235**	**0.030**	**0.000**	**0.000**	**0.000**
THe – RANGE		**0.000**	**0.000**	**0.000**	**25.012**	**0.480**	**0.000**
Q0 – RANGE	**NO**	**0.150**	**1.200**	**0.050**	**0.000**	**0.000**	**0.000**
W2 – RANGE	**NO**	**0.900**	**2.000**	**0.050**	**0.000**	**0.000**	**0.000**
X – RANGE	**NO**	**1.000**	**1.801**	**0.050**	**0.000**	**0.000**	**0.000**

Selection type of electron spectra

I – low data

II – up data

III – step of data

IV,V – can be used to fix the scattered electron angle (in the 'THE -RANGE' line), if the data of I,II,III = 0.000 (see fig.5; ϑ_e' = 'IV' + 'V'/1000) .

VI – unused

INTEGRATION 0.050 0.000 0.050 0.015 0.000 0.000

I – relative accuracy of integration in quasi-elastic case

II – absolute accuracy of integration in quasi-elastic case

Note that for integrating by absolute accuracy one has to specify

'I' = 0.000

III – relative accuracy of integration in inelastic case

IV – initial step of integration with relative accuracy

V-VI – unused

VIRT.NUCL. YES

LIGHT – CONE NO

HYDROGEN NO

Selection of the model of calculation

QUASI – ELASTIC

INELASTIC

Selection of process

MEASURE MICROBARN

Scale of cross sections (it can be mili,micro,nano,pico) Note that all second character variables (as ELECTRON, MICROBARN etc.) must be entered at position twelve on each line of INIT_INCL.DAT file.

b) OUTPUT FILE: There are three different type of OUTPUT FILEs for non-radiative electron - nucleus (fig.6a), radiative (fig.6.b), and for the program HYDRO.FOR (fig.6c) where radiative and nonradiative cross sections are calculated simultaneously.

c): **REMARKS:** The numerical integration in the quasi-elastic case need some caution. The underintegral expression shows some sharp behaviour, which can cause the integration to fail at some kinematical conditions. If this is the case the integration should be done with higher relative accuracy (in spite of the slow execution), with proper choice of the initial step of integration.

3. Program RADIATION.OLB

The program library package RADIATION.OLB can be used to include radiation effects in the calculated cross section for inclusive (ee') and exclusive (ee'N) reactions and consist of the following subprograms:

- RAD_INIT_PAR.FOR - subroutine initializes the parameters for the radiation and ionization effects

- R_FACTOR.FOR - function initializes the factors for internal bremsstrahlung

- R_CROSS_SEC.FOR - function includes the radiative effects into the electro-production cross section

- TAIL_EL.FOR - function calculates the radiative tail from the electron elastic peak for electron - hydrogen inclusive reaction and the tail of the quasi-elastic peak at the exclusive A(ee'N) (A>1) reaction.

- TAIL_IN.FOR - function computes the radiative tail from inelastic inclusive and exclusive reactions.

3.1 Physics Contents

The calculation of the radiation effects for the inclusive electro-production processes is carried out using the method developed by Mo and Tsai [11], which provides a good description of existing inclusive data (see fig.6,7). For coincidence reactions there are some modifications of these method, which are generally dependent on the kinematic conditions of exclusive processes (a typical calculation of radiation effects for (e,e'p) scattering is shown in fig.7,8).

The radiative tail from elastic and inelastic processes is evaluated in the peaking approximation which uses the fact, that bremsstrahlung photons are mostly emitted in the direction of the incident and scattered electrons. Note that, in these calculations, apart of internal radiation, which takes place in the field of the nucleus off which the electron is scattered, the external radiation (Straggling) and ionization effects are taken into account as well.

3.2 RADIATION.OLB program usage

The subprograms for calculating the radiative corrections are of the **OLB** type, which simplifies use of this program packages by other users.

Any programs which will use these packages, for an initial initialization, call to the routine:

SUBROUTINE RAD_INIT_PAR(NAME,A,Z,T_T,RL)

where

NAME - name of target (see tab.1) (*character variable, input*)

Note, that the target name has to be entered after the gap (for example, for the Al^{27} target one use the ' AL').

A,Z - mass and charge number of target (*input*)

T_T - target thickness in (mm) (*input*)

RL - target thickness in Radiation Length (*output*)

To account for radiation effects in the calculated inclusive or exclusive cross section the following function can be used:

FUNCTION R_CROSS_SEC(EI,ES,UE,UB,PHI,PB,AM,DT,CROSS_SEC,K)

where

EI,ES - incident and scattered electron energy (*input*)

UE - angle of electron scattering (*input*)

UB - polar angle of registered nucleon (*input*)

PHI - azimuthal angle between the planes $(\vec{q}\vec{P}_e)$ and $(\vec{P}_N\vec{P}_e)$($\vec{q}$ - is the momentum of

virtual photon)(*input*)

PB - registered nucleon momentum(*input*)

AM - target mass(*input*)

DT - scattered electron energy cutoff parameter (for elastic eH scattering DT is the energy resolution, for inelastic scattering usually taken $\approx$ 0.02GeV) (*input*)

CROSS_SEC - user supplied function for nonradiative cross section, which has the form:

CROSS_SEC(EI,ES,UE) for (ee') reactions

CROSS_SEC(EI,ES,UE,UB,PHI,PB) for (ee'N) one

K = 1 for inclusive and 2 for exclusive processes

Note that the energy, momenta and angles are measured in GeV, GeV/c and rad. respectively and the coordinate system with $\hat{Z} \parallel \vec{P}_e$ is used.

The following function is used to calculate the radiative tail from the elastic peak in electron - hydrogen scattering and from the quasi-elastic peak in (ee'N) scattering:

FUNCTION TAIL_EL(EI,ES,UE,UB,PHI,PB,AM,CM,DT,CROSS_SEC,K)

where

CM - residual nucleus mass(*input*)

K = 1 elastic tail for H(ee') reaction, 2 quasi-elastic tail for A(ee'N) reactions(*input*)

The following function can be used for calculating the tail of inelastic processes (for (ee') and (ee'N) reactions):

FUNCTION TAIL_IN(EI,ES,UE,UB,PHI,PB,AM,CM,DT,EPS,K)

where

EPS - relative accuracy of integration(*input*)

K = 1 for inclusive reactions, 2 for coincidence one(*input*)

To provide the nonradiative cross section for this function, the user must include the following functions:

for (e,e') reactions;

```
FUNCTION ELIN(EI,ES,UE)
ELIN = CROSS_SEC(EI,ES,UE)
RETURN
END
```

where CROSS_SEC(EI,ES,UE) is the user supplied nonradiative (ee') cross section and for (e,e'N) reactions;

```
FUNCTION ELIN(EI,ES,UE,UB,PHI,PB)
ELIN = CROSS_SEC(EI,ES,UE,UB,PHI,PB)
RETURN
END
```

where CROSS_SEC(EI,ES,UE,UB,PHI,PB) is the user supplied nonradiative (ee'N) cross section

REFERENCES

1. L.L. Frankfurt and M.I. Strikman, Phys.Rep.160 (1988)236.
2. T.de Forest,Jr., Nucl.Phys. A392 (1983) 232.
3. W.B. Atwood,G.West,Phys.Rev., D7, 773, (1973).
4. a: S. Rock et al, Phys. Rev. Lett. 49 (1982) 1139, b:P. Bosted et al., Phys. Rev. Lett. 49 (1982) 1380.
5. D. Day, Nucl.Phys. A478 (1988) 397c.
6. M.V. Zverev and Ei.E.Saperstein. Yad.Fiz. 43 (1986) 304
7. a:M.M. Sargsyan, L.L. Frankfurt and M.I. Strikman, Z.Physics A335 (1990), b:M.M.Sargsyan, L.L.Frankfurt and M.I.Strikman, to be published.
8. L.L.Frankfurt and M.I.Strikman, Nucl.Phys., B250 (1985) 143.
9. A.Bodek et al., Phys.Rev. D20 (1979) 1471.
10. D. Joyce, CLAS NOTE - 89 -004.
11. L.W.Mo and Y.S.Tsai, Rev.Mod.Phys. 41 (1969) 205, SLAC-PUB-848, (1971).
12. E.D. Bloom et al., Proceedings of the International Conference High Energy Physics, Vienna, 1968.
13. 'Review of Particle Properties', Phys. Lett. 170B (1986).
14. M.D. Amaryan et al. CEBAF Proposal PR -89 -036, (1989)

Figure Captions

Fig.1 Cross section of D(ee')X [4b] as a function of x = $Q^2/2mq_0$ at the: $Q^2 \approx 2(GeV/c)^2$ (upper), $Q^2 \approx 2.5(GeV/c)^2$ (middle),$Q^2 \approx 3(GeV/c)^2$ (down) a) calculated by program LCD_INCL, b) - by program VN_INCL.

Fig.2 Cross section of $Al^{27}(ee')X$ as a function of x solid curve - LCD_INCL calculation, dashed curve - VN_INCL calculation.

Fig.3 Nucleon momentum distribution (for Al^{27}) plotted versus the nucleon momenta: a) table momentum distribution, b) proton QLM [6] momentum distribution, c) neutron QLM momentum distribution.

Fig.4 Ratios R = $2\sigma_{eAl}/A\sigma_{eD}$ [4a] as a function of x, at Ei = 9.761GeV, $\vartheta_e = 10^0$. Calculations performed by LCD_INCL program with a) QLM momentum distribution and b) table momentum distribution

Fig.5 Example of INIT_INCL.DAT file.

Fig.6 Examples of OUTPUT files (FINAL.DAT) a) for nonradiative LCD_INCL and VN_INCL calculation, where used the following labels: W2 - square of final hadron mass, Ee' - scattered electron energy, x = $Q^2/2mq_0$, QL_A, IN_A, TOT_A - quasi-elastic, inelastic cross sections for A>2, and their sum, QL_D, IN_D, TOT_D the same for the deuteron target, DGW2D - $d\sigma/dW^2d\Omega$ on deuteron, REL - R = $2\sigma_{eA}/A\sigma_{eD}$; b) for radiative LCD_INCL and VN_INCL calculation: T_QL, T_IN - radiative cross section and tail for quasi-elastic and inelastic scattering; c) for calculations of program 'HYDRO': S_el, S_in - nonradiative elastic (divided by energy resolution) and inelastic cross section, R_el, E_tl, R_in radiative elastic cross section, radiative tail from elastic peak and radiative inelastic tail and cross section.

Fig.7 Scattered electron spectra for raw and radiative corrected data [12]. Solid (radiative) and dashed (nonradiative) curve are result of calculation of program HYDRO and RADIATION.OLB.

Fig.8 Radiative cross section obtained by using the RADIATION.OLB for a) raw inclusive data on 5mm Carbon target and b) raw coincidence (ee'p) data on 10mm Carbon target [14]. Dashed curve - nonradiative calculation, solid curve radiative calculation by RADIATION.OLB and middle solid curve in b) radiative calculation for 0mm targets.

Table 1. Target types used in program (see [13])

H	–	H2	XE	–	Xe^{131}
D	–	D2	W	–	W^{184}
HE	–	He^4	PB	–	Pb_{208}
LI	–	Li^6	U	–	U_{238}
BE	–	Be^9	AIR	–	$Air, 20^C, 1atm.$
C	–	C^{12}	$H2O$	–	H_2O
N	–	$N2^{14}$	$SIO2$	–	Quartz
O	–	$O2^{16}$	$H2-26K$	–	Bubble chamber 26 K
NE	–	Ne^{20}	$D2-31K$	–	Bubble chamber 31 K
AL	–	Al^{27}	CH	–	Polystyrene, scintillator
SI	–	Si^{28}	$CH2$	–	Polyethylene
AR	–	Ar^{40}	$MYLAR$	–	Mylar
FE	–	Fe^{56}	$CO2$	–	CO_2
CU	–	Cu^{64}	$CH4$	–	Methane
SN	–	Sn^{119}	$FREON$	–	Freon

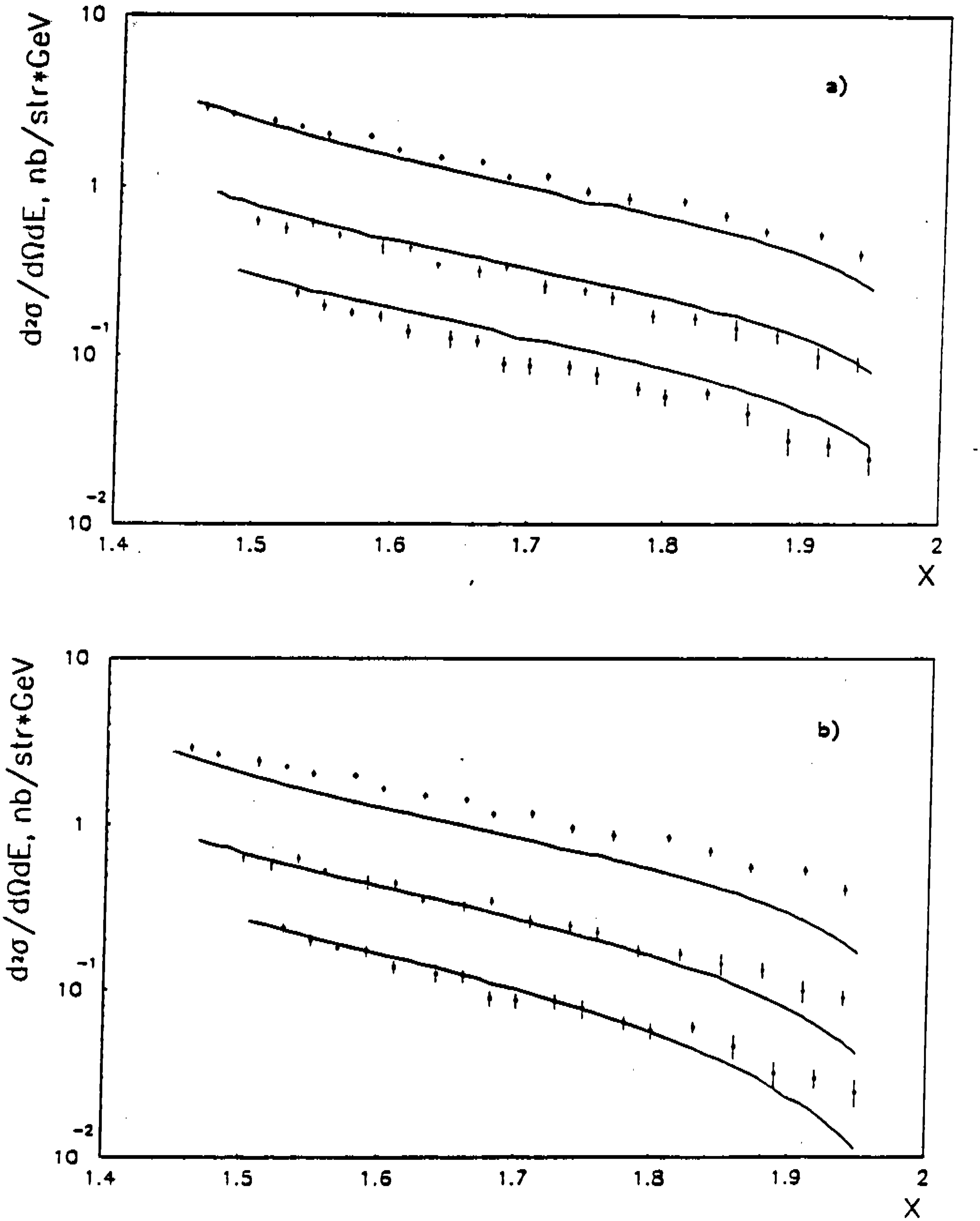


Fig. 1

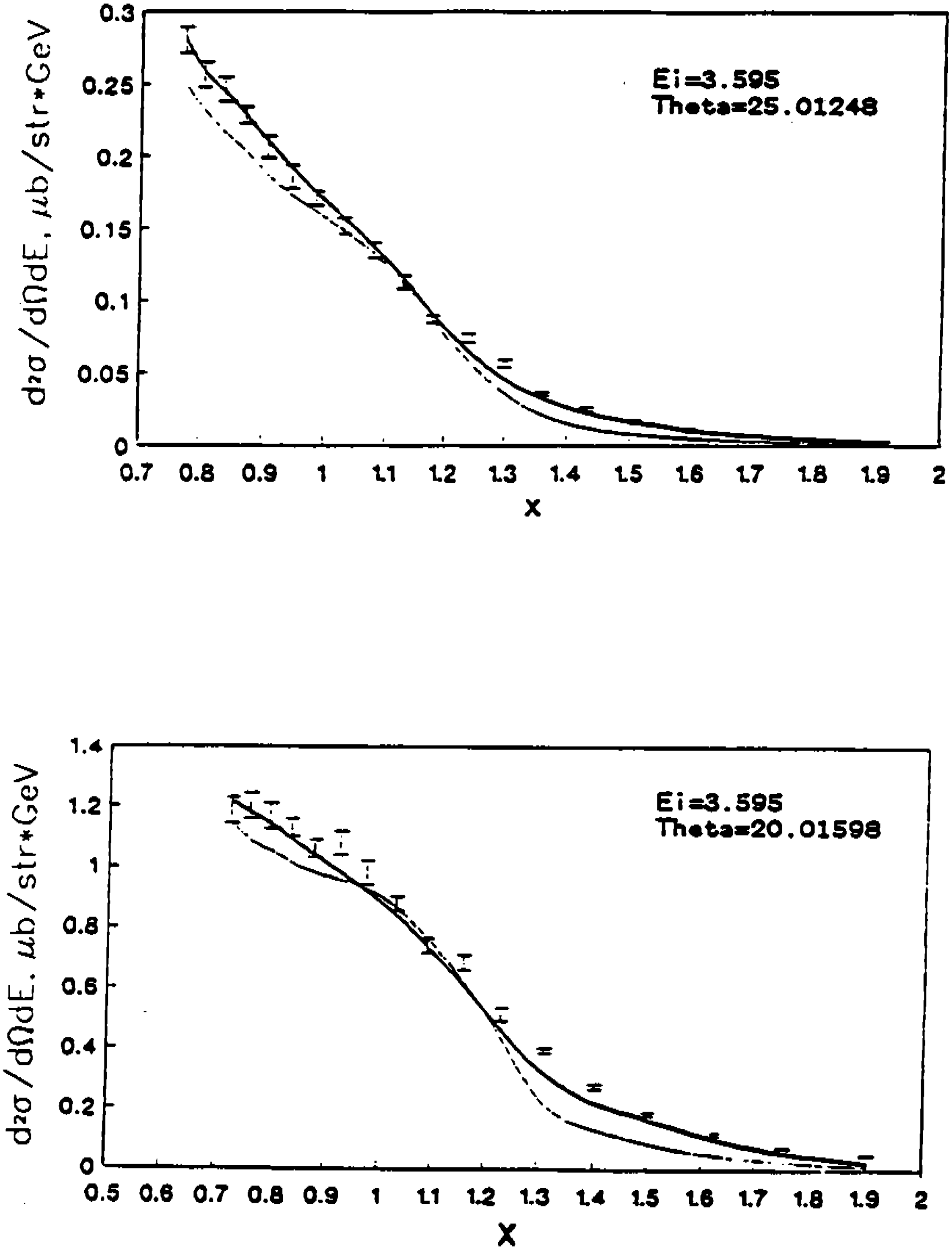

Ei=3.595
Theta=25.01248
d2σ/dΩdE, μb/str*GeV
0.3
0.25
0.2
0.15
0.1
0.05
0
0.7 0.8 0.9 1 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2
X
Ei=3.595
Theta=20.01598
d2σ/dΩdE. μb/str*GeV
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.5 0.6 0.7 0.8 0.9 1 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2
X

Fig. 2

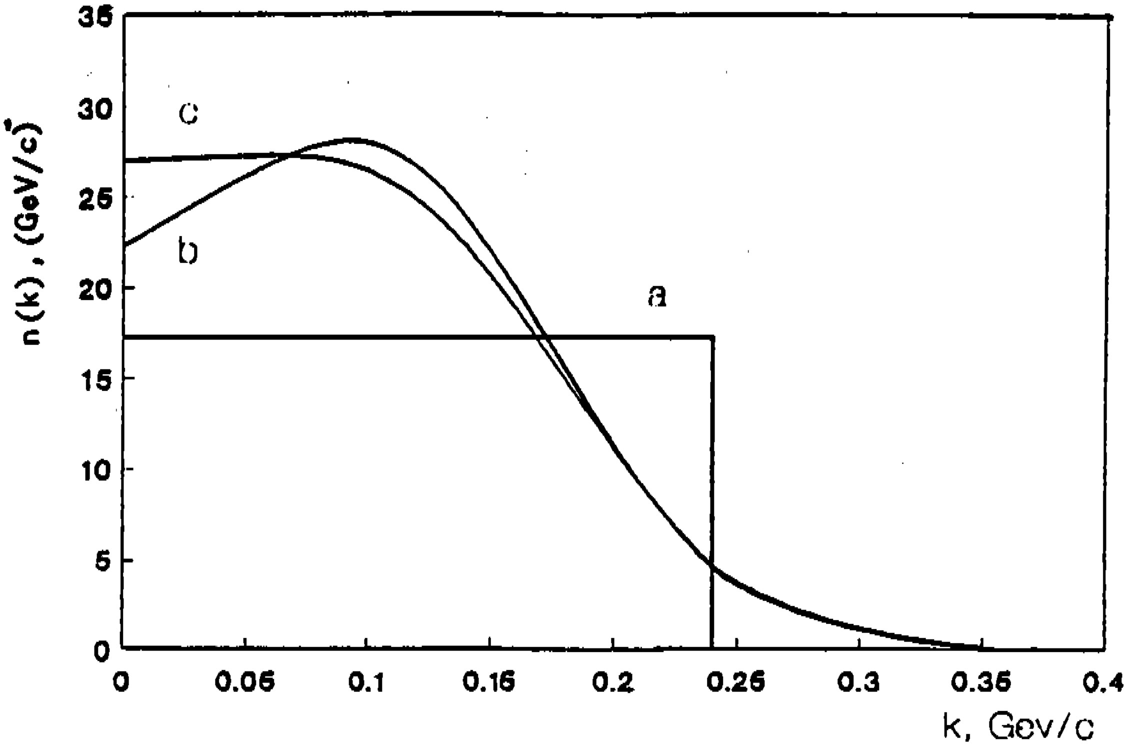


Fig. 3

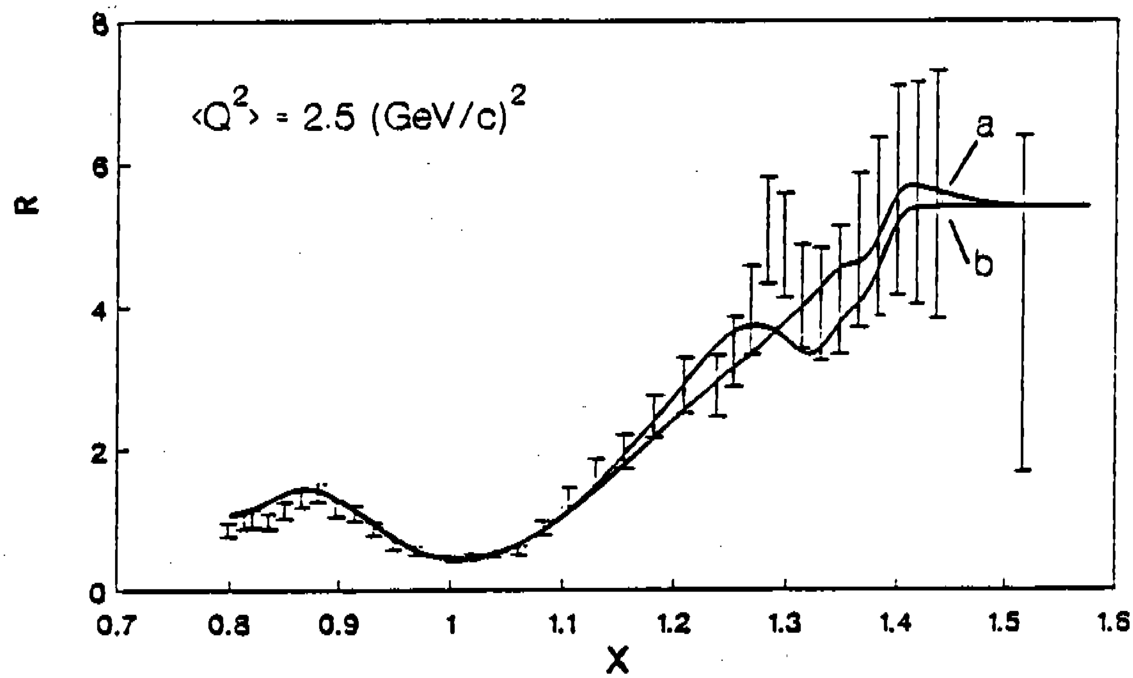


Fig. 4

PROGRAM OF INCLUSIVE (ee') ELECTROPRODUCTION

UENPC
YERPHI-1990
JUNE

INCIDENT	ELECTRON	3.595	0.000	0.000	0.000	0.000	0.000
TARGET	AL	27.000	13.000	0.240	30.000	0.025	0.000
RAD_EFFECT	NO	10.000	0.020	0.010	0.010	0.050	0.000
SWELLING	V1	0.000	0.150	0.000	0.000	0.000	0.000
EMC	YES	0.000	0.000	0.000	0.000	0.000	0.000
ELEC_SPECT		0.000	0.000	0.000	0.000	0.000	0.000
Ee' -RANGE	YES	2.710	3.430	0.015	0.000	0.000	0.000
THe -RANGE		0.000	0.000	0.000	20.015	0.980	0.000
QO -RANGE	NO	0.150	1.200	0.050	0.000	0.000	0.000
W -RANGE	NO	0.900	0.910	0.025	0.000	0.000	0.000
X -RANGE	NO	1.420	1.460	0.010	0.000	0.000	0.000
INTEGRATION		0.000	0.002	0.050	0.015	0.000	0.000

VIRT.NUCL. YES
LIGHT-CONE NES
HYDROGEN NO

QUASIELASTIC
INELASTIC

MEASURE MICROBARN

Fig. 5

PROGRAM OF INCLUSIVE (ee') ELECTROPRODUCTION

UENPC
YERPHI-1990
JUNE

INCIDENT	ELECTRON	3.595	0.000	0.000	0.000	0.000	0.000
TARGET	AL	27.000	13.000	0.240	30.000	0.025	0.000
RAD_EFFECT	NES	10.000	0.020	0.010	0.010	0.050	0.000
SWELLING	V1	0.000	0.150	0.000	0.000	0.000	0.000
EMC	NO	0.000	0.000	0.000	0.000	0.000	0.000
ELEC_SPECT		0.000	0.000	0.000	0.000	0.000	0.000
Ee' -RANGE	YES	2.710	3.430	0.015	0.000	0.000	0.000
THe -RANGE		0.000	0.000	0.000	20.015	0.900	0.000
Q0 -RANGE	NO	0.150	1.200	0.050	0.000	0.000	0.000
W -RANGE	NO	0.900	0.910	0.025	0.000	0.000	0.000
X -RANGE	NO	1.420	1.460	0.010	0.000	0.000	0.000
INTEGRATION		0.050	0.000	0.050	0.015	0.000	0.000
VIRT.NUCL.	YES	0.000	0.000	0.000	0.000	0.000	0.000
LIGHT-CONE	NES	0.000	0.000	0.000	0.000	0.000	0.000
HYDROGEN	NES	0.000	0.000	0.000	0.000	0.000	0.000
QUASIELASTIC		0.000	0.000	0.000	0.000	0.000	0.000
INELASTIC		0.000	0.000	0.000	0.000	0.000	0.000
MEASURE	MICROBARN	0.000	0.000	0.000	0.000	0.000	0.000

Date -- 900703 -- Time -- 1056 --

ENERGY OD INCIDENT ELECTRONS (GeV) = 3.59500

TARGET THICNESS IN MM	=	10.00000
ATOMIC WEIGHT A	=	27.00000
CHARG NUMBER Z	=	13.00000
PAIR MASS IN NUCLEAR	=	1.875000
RESPONSE ENERGY IN GEV	=	2.5000000E-02
FERMI MOMETUM	=	0.2400000
VALUE OF HIGH COMPONENT	=	0.3000000
LEVINGER PARAMETER	=	5.702053
NUCLEON DIPOL PARAMETER	=	0.7100000

=CROSS SECTION IN (mcbn/GeV/Str)=

ANGLE OF SCATTERED ELECTRONS (degr.) = 20.01590

W2	Ee'	X	QL_A	IN_A	TOT_A	QL_D	IN_D	TOT_D	DGW2D	REL	Q2
1.3642	2.7100	0.7087	0.516E+00	0.601E+00	0.112E+01	0.669E-02	0.700E-01	0.767E-01	0.332E-01	0.108E+01	1.1769
1.3296	2.7250	0.7249	0.558E+00	0.598E+00	0.116E+01	0.805E-02	0.571E-01	0.651E-01	0.282E-01	0.130E+01	1.1835
1.2949	2.7400	0.7417	0.590E+00	0.529E+00	0.112E+01	0.983E-02	0.462E-01	0.561E-01	0.238E-01	0.151E+01	1.1900
1.2602	2.7550	0.7590	0.632E+00	0.471E+00	0.110E+01	0.121E-01	0.348E-01	0.469E-01	0.203E-01	0.174E+01	1.1966
1.2255	2.7700	0.7771	0.670E+00	0.412E+00	0.108E+01	0.160E-01	0.251E-01	0.411E-01	0.178E-01	0.196E+01	1.2030
1.1909	2.7850	0.7957	0.702E+00	0.318E+00	0.102E+01	0.192E-01	0.189E-01	0.380E-01	0.185E-01	0.199E+01	1.2095
1.1562	2.8000	0.8151	0.734E+00	0.265E+00	0.100E+01	0.247E-01	0.136E-01	0.382E-01	0.165E-01	0.194E+01	1.2160

Fig. 6a

PROGRAM OF INCLUSIVE (ee') ELECTROPRODUCTION

UENPC
YERPHI-1990
JUNE

INCIDENT	ELECTRON	3.595	0.000	0.000	0.000	0.000	0.000
TARGET	AL	27.000	13.000	0.240	30.000	0.025	0.000
RAD_EFFECT	YES	10.000	0.020	0.010	0.010	0.050	0.000
SWELLING	V1	0.000	0.150	0.000	0.000	0.000	0.000
EMC	NO	0.000	0.000	0.000	0.000	0.000	0.000
ELEC_SPECT		0.000	0.000	0.000	0.000	0.000	0.000
Ee' -RANGE	YES	2.710	3.430	0.015	0.000	0.000	0.000
THe -RANGE		0.000	0.000	0.000	20.015	0.980	0.000
Q0 -RANGE	NO	0.150	1.200	0.050	0.000	0.000	0.000
W -RANGE	NO	0.900	0.910	0.025	0.000	0.000	0.000
X -RANGE	NO	1.420	1.460	0.010	0.000	0.000	0.000
INTEGRATION		0.000	0.050	0.050	0.015	0.000	0.000
VIRT.NUCL.	YES	0.000	0.000	0.000	0.000	0.000	0.000
LIGHT-CONE	NES	0.000	0.000	0.000	0.000	0.000	0.000
HYDROGEN	NES	0.000	0.000	0.000	0.000	0.000	0.000
QUASIELASTIC		0.000	0.000	0.000	0.000	0.000	0.000
INELASTIC		0.000	0.000	0.000	0.000	0.000	0.000
MEASURE	MICROBARN	0.000	0.000	0.000	0.000	0.000	0.000

Date -- 900703 -- Time -- 1112 --

ENERGY OD INCIDENT ELECTRONS (GeV) = 3.59500

TARGET THICNESS IN MM	=	10.00000
ATOMIC WEIGHT A	=	27.00000
CHARG NUMBER Z	=	13.00000
PAIR MASS IN NUCLEAR	=	1.875000
RESPONSE ENERGY IN GEV	=	2.5000000E-02
FERMI MOMETUM	=	0.2400000
VALUE OF HIGH COMPONENT	=	0.3000000
LEVINGER PARAMETER	=	5.702053
NUCLEON DIPOL PARAMETER	=	0.7100000

=CROSS SECTION IN (mcbn/GeV/Str)=

ANGLE OF SCATTERED ELECTRONS (degr.) = 20.01598

W2	Ee'	X	T_QL	T_IN	T_TOT	Q0	Q2
1.3642	2.7100	0.7087	0.424E+00	0.328E+00	0.752E+00	0.8850	1.1769
1.3295	2.7250	0.7249	0.440E+00	0.310E+00	0.750E+00	0.8700	1.1835
1.2949	2.7400	0.7417	0.439E+00	0.271E+00	0.711E+00	0.8550	1.1900
1.2602	2.7550	0.7590	0.448E+00	0.235E+00	0.683E+00	0.8400	1.1965
1.2255	2.7700	0.7771	0.448E+00	0.202E+00	0.650E+00	0.8250	1.2030
1.1909	2.7850	0.7957	0.445E+00	0.157E+00	0.602E+00	0.8100	1.2095
1.1562	2.8000	0.8151	0.484E+00	0.129E+00	0.613E+00	0.7950	1.2160

Fig. 6b

PROGRAM OF INCLUSIVE (ee') ELECTROPRODUCTION

UENPC
YERPHI-1990
JUNE

INCIDENT	ELECTRON	3.595	0.000	0.000	0.000	0.000	0.000
TARGET	H	1.000	1.000	0.240	30.000	0.025	0.000
RAD_EFFECT	YES	10.000	0.020	0.010	0.010	0.050	0.000
SWELLING	V1	0.000	0.150	0.000	0.000	0.000	0.000
EMC	NO	0.000	0.000	0.000	0.000	0.000	0.000
ELEC_SPECT		0.000	0.000	0.000	0.000	0.000	0.000
Ee' -RANGE	YES	2.710	3.430	0.015	0.000	0.000	0.000
THe -RANGE		0.000	0.000	0.000	20.015	0.980	0.000
Q0 -RANGE	NO	0.150	1.200	0.050	0.000	0.000	0.000
W -RANGE	NO	0.900	0.910	0.025	0.000	0.000	0.000
X -RANGE	NO	1.420	1.400	0.010	0.000	0.000	0.000
INTEGRATION		0.000	0.002	0.050	0.015	0.000	0.000
VIRT.NUCL.	NES	0.000	0.000	0.000	0.000	0.000	0.000
LIGHT-CONE	NES	0.000	0.000	0.000	0.000	0.000	0.000
HYDROGEN	YES	0.000	0.000	0.000	0.000	0.000	0.000
QUASIELASTIC		0.000	0.000	0.000	0.000	0.000	0.000
INELASTIC		0.000	0.000	0.000	0.000	0.000	0.000
MEASURE	MICROBARN	0.000	0.000	0.000	0.000	0.000	0.000

Date -- 900621 -- Time -- 2241 --

ENERGY OF INCIDENT ELECTRONS (GeV) = 3.59500

TARGET THICNESS IN MM = 10.00000
ATOMIC WEIGHT A = 1.000000
CHARG NUMBER Z = 1.000000

=CROSS SECTION IN (mcbn/GeV/Str)=

ANGLE OF SCATTERED ELECTRONS (degr.) = 20.01590

Elastic scattering at Ee' = 2.919306 GeV
Elastic cross section in (nbn/GeV/Str) = 17.09110
Radiative elastic cross sect. in (nbn/GeV/Str) = 12.02071

W	Ee'	X	S_el	S_in	S_sum	R_el	E_tl	R_in	R_sum	Q2
1.1680	2.7100	0.7087	0.000E+00	0.452E-01	0.452E-01	0.000E+00	0.604E-02	0.384E-01	0.424E-01	1.1769
1.1530	2.7250	0.7249	0.000E+00	0.326E-01	0.326E-01	0.000E+00	0.637E-02	0.201E-01	0.326E-01	1.1835
1.1379	2.7400	0.7417	0.000E+00	0.236E-01	0.236E-01	0.000E+00	0.675E-02	0.187E-01	0.254E-01	1.1900
1.1226	2.7550	0.7590	0.000E+00	0.166E-01	0.166E-01	0.000E+00	0.721E-02	0.131E-01	0.203E-01	1.1966
1.1070	2.7700	0.7771	0.000E+00	0.109E-01	0.109E-01	0.000E+00	0.776E-02	0.849E-02	0.162E-01	1.2030
1.0913	2.7850	0.7957	0.000E+00	0.563E-02	0.563E-02	0.000E+00	0.843E-02	0.436E-02	0.128E-01	1.2096
1.0753	2.8000	0.8151	0.000E+00	0.376E-03	0.376E-03	0.000E+00	0.920E-02	0.290E-03	0.957E-02	1.2160
1.0590	2.8150	0.8352	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.104E-01	0.000E+00	0.104E-01	1.2226
1.0425	2.8300	0.8561	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.118E-01	0.000E+00	0.118E-01	1.2291
1.0258	2.8450	0.8779	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.138E-01	0.000E+00	0.138E-01	1.2356

Fig. 6c

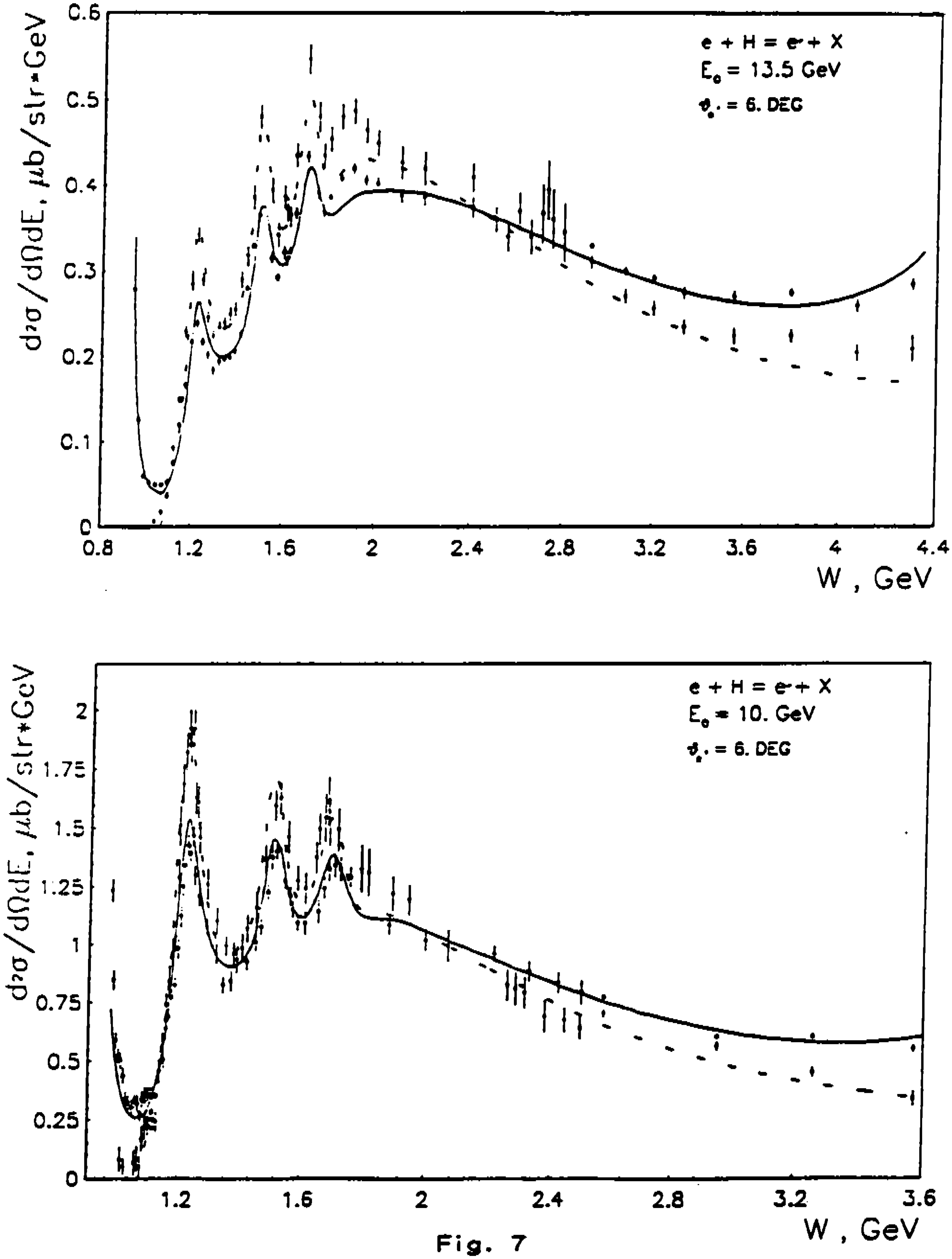
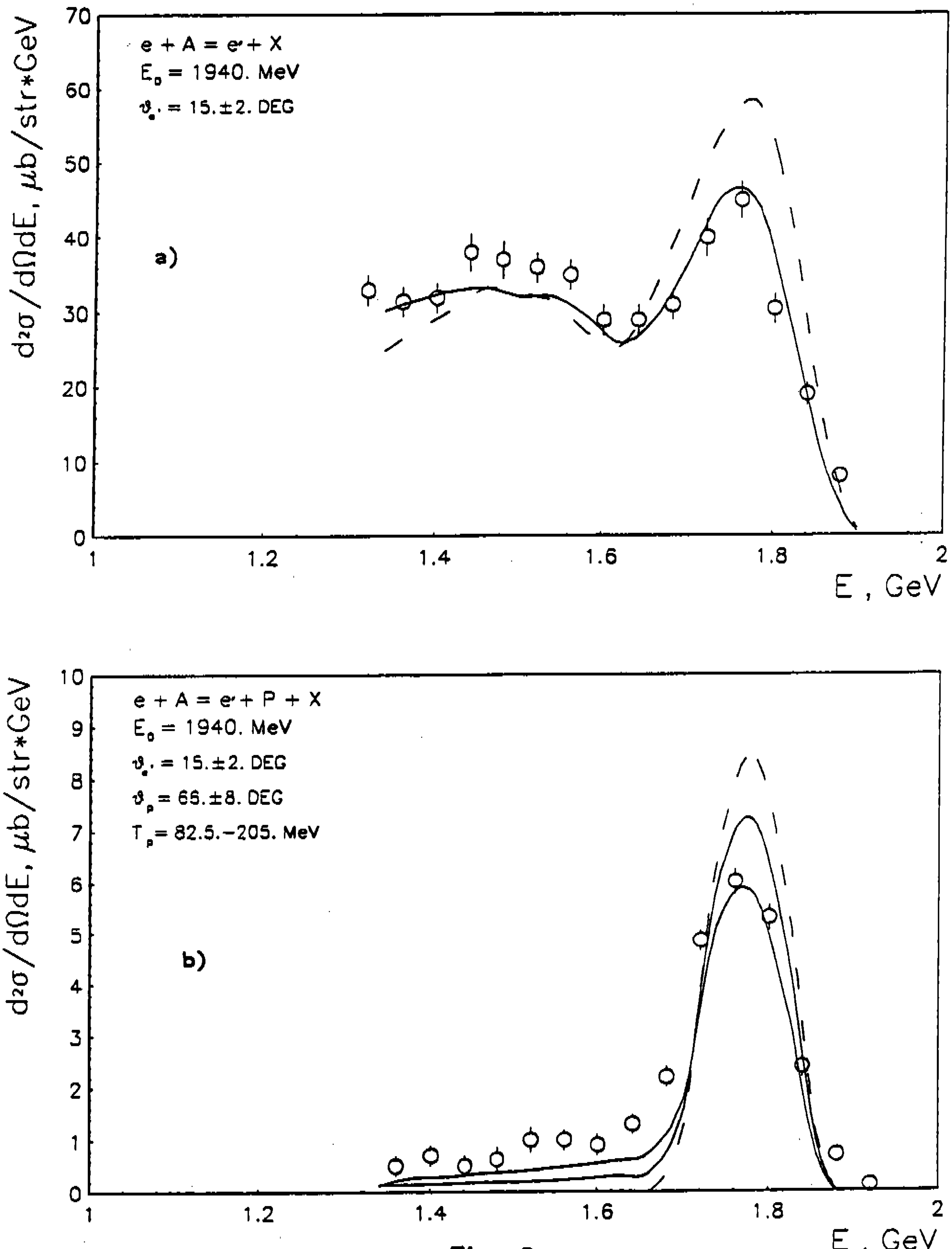

d²σ/dΩdE, μb/str*GeV
e + H = e + X
E₀ = 13.5 GeV
ϑ = 6. DEG
W , GeV
d²σ/dΩdE, μb/str*GeV
e + H = e + X
E₀ = 10. GeV
ϑ = 6. DEG
W , GeV

Fig. 7



e + A = e' + X
E0 = 1940. MeV
ϑe' = 15.±2. DEG
a)
d2σ/dΩdE, μb/str*GeV
E , GeV
e + A = e' + P + X
E0 = 1940. MeV
ϑe' = 15.±2. DEG
ϑp = 66.±8. DEG
Tp = 82.5.−205. MeV
b)
d2σ/dΩdE, μb/str*GeV
E , GeV

Fig. 8