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H1LUMI - A Fast Simulation Package for the H1 Luminosity System

S. Levonian
DESY, Hamburg *and* Lebedev Physical Institute, Moscow

Abstract

A fast program module is described, including a simple event generator and the H1 luminosity system simulation. It is ideally suited for the acceptance studies for different processes involving small angle scattered electrons and photons emitted along the direction of the primary e-beam. Some results are presented, obtained with the help of this package.

1 Basic Facts

Version:	`H1LUMI 1.00`, from April 1993.
Computer type:	Any computer having `FORTRAN 77` compiler.
Language:	`FORTRAN 77`.
Program size:	2200 lines including test job and steering banks.
Source code:	`F11LEV.H1LUMI.CMZ` at DESY IBM.
External packages required:	`BOS` [1], `FPACK` [2], `H1UTIL` [3] and `CERN` library [4].
Typical speed:	in average 1000 events per second at IBM 3090: a) complete `H1LUMI` module needs 1.7 ms/event, b) `LGEN+LSIM` – 0.8 ms/event (no module steering), c) `LGEN` – 0.25-0.4 ms/event.

2 Introduction

The H1 luminosity system is designed as a multipurpose device. Its main task is a fast relative luminosity measurement with a statistical precision of $\sim 2\%$ per second at design luminosity of 1.5×10^{31} cm^{-2}s^{-1}. In addition it provides electron beam monitoring for the HERA machine, absolute luminosity measurement in the H1 interaction region with an accuracy of $\sim 5\%$, tagging of the photoproduction events and energy measurement for small angle scattered electrons and radiative photons from initial state radiation.

One of the most important problems for all these tasks is a precise calculation of the system acceptance for different processes and beam conditions. A typical Monte Carlo statistics required is of the order of 10^5 events per given conditions. In order to understand the influence of the electron beam tilt one needs then to calculate a whole matrix of acceptances $A(\theta_x, \theta_y, \text{process})$ which involves a huge Monte Carlo statistics of the order of 10^7 events. Therefore, a fast simulation is absolutely necessary for the luminosity system.

H1LUMI is a package developed for this purpose. It is a module (in a strict H1 sense [5]) consisting of two independent parts: `LGEN` – the event generator and `LSIM` – the fast simulation of the luminosity detectors. This means, that each

```
CALL  H1LUMI
```

will generate one event according to the steering parameters, simulate the response of the luminosity detectors and create a set of standard H1 BOS banks (see below). It is possible however to call `LGEN` and `LSIM` separately, depending on the task, as described in section 5.

3 Event Generation

`LGEN` is a specific event generator designed for the luminosity system study. It is an upgraded version of `LGENER` created in 1987 [6]. `LGEN` allows to generate electrons and photons emitted under very small angles with respect to the initial e-beam direction (180° in the H1 coordinate system) from the different sources, corresponding to the different `LGEN` modes.

1. Bremsstrahlung on the proton beam $ep \to ep\gamma$ according to the Bethe-Heitler formula [7] in the ultra-relativistic limit and small angle approximation [8]:

$$\frac{d\sigma_{ep}}{dy} = \frac{4\alpha r_e^2}{y}\left[1 + (1-y)^2 - \frac{2}{3}(1-y)\right]\left[\ln\frac{s(1-y)}{Mmy} - \frac{1}{2}\right] \qquad (1)$$

Here $y = 1 - E'/E_e$, E_e and E' are the energies of the primary and scattered electrons, s is a total energy squared of the ep collision, M and m are the proton and electron masses respectively and r_e is a classical electron radius. The beam size effect [9] is not taken into account in the generation. In the region of the H1 measurements ($y > 0.2$) the corresponding correction is small (0.4%). There exists however a simple function allowing to calculate this correction for the given E_γ interval (see section 5).

2. Electron-nucleus bremsstrahlung events [10, 11], which are the main source of the background for the luminosity measurements:

$$\frac{d\sigma_{eZ}}{dy} = \frac{4\alpha r_e^2}{y}\left\{\left[1 + (1-y)^2 - \frac{2}{3}(1-y)\right](Z^2 L_{rad} + Z L'_{rad}) + \frac{1}{9}(1-y)(Z^2 + Z)\right\} \quad (2)$$

   where $L_{rad} = \ln(184 Z^{-1/3})$ and $L'_{rad} = \ln(1194 Z^{-2/3})$.
   For both ep and eZ bremsstrahlung the energy transfer to a target (of the order of m^2/M) is neglected, such that always $E' + E_\gamma = E_e$. Photon scattering angles also in both cases are generated according to the distribution:

$$\frac{d\sigma}{d\theta} \sim \frac{\theta}{((m/E_e)^2 + \theta^2)^2} \quad (3)$$

3. Quasi-real photoproduction (low Q^2 ep-scattering) in the equivalent photon approximation (EPA) [12] valid at $Q^2 \to 0$:

$$\frac{d^2\sigma_{ep}}{dx\,dy} = \frac{\alpha}{2\pi}\sigma_{\gamma p}(ys)\frac{1 + (1-y)^2}{y} \cdot \frac{1-x}{x} \quad (4)$$

   where $x = Q^2/ys$, and the total photoproduction cross section is parametrized according to [13]:

$$\sigma_{\gamma p}(s) = 68 s^{0.0808} + 125 s^{-0.4525} \quad [\mu\text{b}]$$

   with s in GeV^2. Note, that in this mode the $ep \to e'X$ reaction is treated in an inclusive way, such that only one particle per event is being generated (scattered electron).

4. HERA reference trajectory electrons. In case of the beam smearing is requested (see below) this means that electrons are generated according to the e-beam phase space ellips [14, 15].

5. Uniformly distributed electrons:

$$\frac{d\sigma}{dE'} = C_1, \quad \frac{d\sigma}{d\theta} = C_2, \quad \frac{d\sigma}{d\phi} = C_3.$$

The last two modes can be used for the technical studies, like checks of the magnetic beam line implementation in the simulation part etc.

For all modes the beam smearing in coordinates (x, y, z) and angles (θ_x, θ_y) according to the e- and p-beam emittances can be switched on or off, as well as the global shift of the reference electron orbit in the transverse (xy) plane.

In case of the bremsstrahlung from the rest gas a uniformly distributed vertex is generated along the z-axis (more exactly, along the electron reference trajectory) within the region -22 m $< z <$ 6 m.

The basic part of the generator is in use since 1987 [6]. It is fast (3800 bremsstrahlung events, or $\sim$ 2400 photoproduction 'events' per second can be generated on IBM 3090) and efficient (all events have equal weights = 1.0 for any cuts in phase space requested for the generation).

A similar generator, corresponding to the first two modes of `LGEN` and including the beam size effect, is described in [16].

Fig. 1 shows that the theoretical shapes of the energy (1) and angular (3) distributions for the bremsstrahlung photons are well reproduced by `LGEN`. It also demonstrates how important the beam smearing effect is for very small angles. This is clear comparing a typical scattering angles $\theta \sim \mathcal{O}(m/E_e) \sim 20$ μrad at $E_e = 26 - 30$ GeV with those of beam divergence, of the order of 100 μrad. Fig. 2 shows the energy and Q^2 distributions of the scattered electrons accompanying quasi-real photoproduction events. Again, the smearing in the e-beam strongly deteriorates the original shape of the Q^2-distribution below $\sim 10^{-4}$ GeV^2.

4 Simulation

The second part of the package simulates the H1 luminosity system. The H1 luminosity monitor consists of two arms: the electron tagger (ET) and the photon detector (PD). Since the angular distributions for both the electrons and photons are strongly peaked in the direction of the primary e-beam, the detectors should be placed close to the beamline and very far from the interaction region in order to cover these small angles.

The general view of the luminosity system is shown in Fig. 3. Scattered electrons are deflected by a set of warm low-beta quadrupoles and a bending magnet located in the region 5.8 m $< -z <$ 23.8 m, pass the exit window at $-z = 27.3$ m and hit the ET at $-z = 33.4$ m. The bremsstrahlung photons leave the proton beam pipe through the photon exit window at $-z = 92.3$ m, where the proton beampipe bends upward, and hit the PD at $-z = 102.9$ m. A $2X_0$ Pb filter followed by a $1X_0$ water Čerenkov counter, located in front of the PD, protects the detector from the high synchrotron flux. From the p-beam side the PD is shielded by the iron wall of 2m length against the proton halo. The water counter can be used as a veto (VC) to select only clean events where the photons pass through the filter without interacting.

`LSIM` simulates the electron and photon arms in the following way:

- scattered electrons are traced through the beamline, taking into account the fields in HERA magnets and the aperture of the channel. If e' is not passing through the aperture as sketched in Fig. 4, it is immediately lost: no e.m. shower is being produced. The only effect of the material in front of ET which is taken into account is a multiple scattering in the exit window (1 mm of steel) and in the air gap of 6.1 m;

- photons are just extrapolated along the direction of their momenta $\vec{p}_\gamma$. The most restrictive part of the γ-aperture is within the QS10 p-quadrupoles, which cut more than the collimator of 4.5 cm radius in front of the VC at $-z \simeq 100$ m (see Fig. 3,4). Again, in case the photons hit any material in front of the PD, they are considered to be lost. Note, that the filter and VC are not explicitely implemented in the present version! The effect of the $2X_0$ dead and $1X_0$ active material is described in terms of a somewhat worse overall resolution of the PD (see input steering bank for `LSIM`);

- all electrons and photons reaching the lumi detectors (ET or PD respectively) produce a response which is parametrized according to the experimentally measured resolution functions [17]:

$$\frac{\sigma(E)}{E} = a + \frac{b}{\sqrt{E}},$$
$$\sigma(x,y) = f(\Delta x, \Delta y, d),$$

where a and b are input parameters for `LSIM`, Δx, Δy are distances from the impact point to the closest cell boundary in the ET or PD hodoscope and d is the corresponding cell size;

- optionally (according to the steering) the standard output banks `LETR, LPDR` and `LRXY` [18] are created.

Fig. 5 and 6 show some results of the H1 luminosity system simulation for $ep \to ep\gamma$ and low Q^2 $ep \to e^{'}X$ events respectively. The systematic error in the acceptance calculation due to the possible error in the Electron Tagger position measurement is illustrated by Fig. 7. (Note, that the typical presicion of the horizontal ET position measurement is 0.5-1 mm). One can see a strong compensating effect in case of the e-tagged photoproduction events.

Finally, in Table 1 some relevant cross sections are presented for the different e-beam energies and $E_p = 820$ GeV. The non-tagged electroproduction cross section corresponds to the events where scattered electrons disappear in the beampipe ($Q^2 < 4$ GeV^2), with the additional cut of $W_{\gamma p} > 40$ GeV ($E_\gamma > 0.5$ GeV).

E_e[GeV]	$E_\gamma > 1$ MeV		$E_\gamma > 1$ GeV		ET×PD		$\sigma^{ep}_{non-tagged}$ ($E_\gamma > 0.5$ GeV)	σ^{ep}_{tagged}
	$\sigma_{(1)}$	$\sigma^{corr}_{(1)}$	$\sigma_{(1)}$	$\sigma^{corr}_{(1)}$	σ_{vis}	σ^{corr}_{vis}		
12	610.4	532.6	110.7	109.6	26.8	26.7	13.0	1.08
26.7	702.1	604.4	165.4	162.2	28.6	28.5	20.3	1.45
30	716.0	615.0	174.0	170.4	28.9	28.8	21.7	1.53
35	734.5	629.6	185.7	181.3	29.1	29.0	23.4	1.56

Table 1: Cross sections for the luminosity events [mb] (1) before and after correction on the beam size effect, and for the quasi-real photoproduction events [μb] (4) at $E_p = 820$ GeV.

5 Code description

The source code, including sample job and input steering banks, is kept in `F11LEV.H1LUMI.CMZ` at DESY IBM. The user can either call `H1LUMI` in his application, or call `LGEN` and `LSIM` separately. In the first case, all communications with the code are done only via banks. In the second case some knowlege about few common blocks is necessary in addition.
Units: cm, GeV, rad, mb.

```
PARAMETER       (NPG=2)
COMMON /LLGOUT/ NE, KE(NPG,2), PE(NPG,5), VERT(3)
```

This common contains outgoing particle parameters and vertex coordinates in the H1 coordinate system, as produced by `LGEN`.

`NE`	number or particles in the event (2 for the bremsstrahlung, otherwise 1);
`KE`	particle codes (*a la* `JETSET 6.3` [19]);
`PE`	particle 5-vectors: p_x, p_y, p_z, E, m;
`VERT`	event vertex: x, y, z.

Simulation results:

```
 COMMON /LLSOUT/ IFLAGE, EE, XET, YET, DEE, DXE, DYE,
+                IFLAGG, EG, XPD, YPD, DEG, DXG, DYG
```

`IFLAGE`	electron flag (0 when e' hits ET, $\neq 0$ if e' is lost);
`EE,XET,YET`	reconstructed electron energy and hit coordinates w.r.t. the detector center;
`DEE,DXE,DYE`	difference between the reconstructed and true values.
...	The same is repeated for the γ-arm.

User callable routines.

```
CALL LGEN (MODE)
```

Generate one event according to the steering.

Input: steering banks (see next section) and `MODE`.
Output: common block `/LLGOUT/` and (optionally) `HEAD, GHD, GKI, GTR, GVX` banks.

If `MODE` > 0 then the banks are created, otherwise, they are created only if the output file with the symbolic name `BOSOUTPUT` is specified via the `OPEN` command [20].

```
CALL LSIM
```

Simulate H1 luminosity system for one event.

Input: steering bank `LSIM` (see next section) and common block `/LLGOUT/`.
Output: common block `/LLSOUT/` and (optionally) `LETR, LPDR, LRXY` banks.

```
CALL H1LUMI
```

Executes the following code (for the `MODULS, MODULF` see [5, 3]):

```
CALL MODULS ('H1LUMI',IVERSQ,' ')
CALL LGEN (1)
CALL LSIM
CALL MODULF
```

Utility routine allowing to estimate beam size effect [9]:

```
CALL BREMX (EE,EP,EGMIN,EGMAX,SBH,SCORR,IERR)
```

Input: `EE,EP` - beam energies, `EGMIN,EGMAX` - E_γ-interval,
Output: `SBH` - Bethe-Heitler cross section (1),
`SCORR` - cross section (1) corrected for the HERA beam size effect,
`IERR` = 1 if wrong E_γ interval was requested.

6 Input steering banks

All program steering, as well as the beamline layout description, is done via a set of BOS banks:

GNAM	generator name and version (optional),
GSTP	generator steering parameters,
GGRP	general run parameters,
LSIM	steering parameters for LSIM code,
LGAL	luminosity system geometry: magnets,
LGAA	luminosity system geometry: apertures.

An example job below shows a full set of these banks with the comments. Additional commands LOOK and NEVENT are treated in the main program given in the appendix. An average user should not touch the content of the two last banks (LGAL, LGAA).

```
//    JOB CLASS=E,TIME=(00,00),MSGLEVEL=(2,0),NOTIFY=F11LEV
//*MAIN RELPRI=LOW,LINES=5
//*
//*******************************************************************
//**   JCL for the fast H1 LUMI system simulation
//**
//**   AUTHOR :      S.Levonian                             8.03.93
//*******************************************************************
//*
//JOBLIB   DD  DISP=SHR,DSN=F11LEV.H1LOOK.EXEC
//RUN      EXEC PGM=H1LUMI,REGION=1500K
//*
//FT06F001 DD  SYSOUT=*,DCB=(RECFM=FBA,LRECL=133,BLKSIZE=133,BUFNO=2)
//FT05F001 DD  *
*===================================================================
* OPEN  BOSOUTPUT UNIT=1 FILE=F11LEV.LUMI.ZGAS WRITE RECL=27720 &
*       NREC=100 NREC2=50
*===================================================================
TIMESTOP 2
END
*------------------------------------------------------------------*
LOOK   'F11LEV.XLOOK.LUMI.TEST'
*------------------------------------------------------------------*
NEVENT 100000 1 !  number of events to be generated / printed
*
GNAM  0 /     'H1LUMI' '01.00'
*
GSTP  0 /     ! Generator Steering Parameters
*             ! ============================
     -1       !  LPROC = -2    bremsstrahlung on residual gas
              !         -1    luminosity events: ep -> epgamma
              !          0    low Q**2 (photoproduction)
              !          1    uniformly distributed electrons
              !          2    HERA beam electrons
      1       !  ISMEAR   switch on/off beam smearing (1/0)
    4.0       !  ZGAS     average <Z> for the HERA rest gas
    0.015     !  HLUMI    expected HERA luminosity in nb-1*sec-1 units
    0.000     !  TILTH    e-beam tilt angle in horizontal plane [rad]
    0.000     !  TILTV    e-beam tilt angle in vertical   plane [rad]
    3.0       !  PEL      min energy of scattered electrons [GeV]
   24.0       !  PER      max energy of scattered electrons [GeV]
    0.0       !  TETL     min scattering angle [rad]
    0.002     !  TETR     max scattering angle [rad]
*
*                global trajectory offset:
*
    0.0       !  XOFF     x-offset [cm]
    0.0       !  YOFF     y-offset [cm]
    0.0       !  ZOFF     z-offset [cm]
*
GGRP  0 /     ! Generator general run parameters
*             ! ===============================
```

```
  930417      !  ISEED    seed for random generator initialization
       0      !  IEXP     Experiment number
       1      !  IRUN     Run number
      11      !  LEPIN    Lepton type: 11 => e-,  -11 => e+
     -26.7    !  PLBEAM   Lepton beam momentum, GeV (signed)
     820.0    !  PPBEAM   Proton beam energy, GeV (signed, along z)
*
*--------------------------------------------------------------------*
*
LSIM  0 /      ! Steering parameters for LSIM module
*                ==================================
          0    ! IFSIM  = -1   don't simulate acceptance/response
               !           0        simulate
               !           1        simulate and create output banks
*
   0.0   0.0   ! x0[cm],  y0[cm]  -  offset of the PD center w.r.t. IP
   0.01  0.10  ! a,b   for ET     -  sigma(E)/E = a + b/sqrt(E)
   0.01  0.17  ! a,b   for PD     -  sigma(E)/E = a + b/sqrt(E)
*
POFF
*
*-------------------------------------------------------------------*
*
LGAL  0 /  ! Luminosity Monitor Geometry mAgnet Elements Layout
*            #=================#=========#=============#=====
        3  !  = Lenght of subheader
       21  !  = # of modules
   930225  !  = YYMMDD of creation
        8  !  = # of words in module description
*
* #     Name     S       v-ang     w-ang     v-pos      w-pos
*               (cm)     (rad)     (rad)     (cm)       (cm)
*
  1 '   DRIFT'  580.    0.0          0.0     0.56535    0.0    ! e-beamline
  2 '   QL-11'  680.   -0.00036765   0.0     0.52859    0.0    !
  3 '   DRIFT'  710.   -0.00073529   0.0     0.50378    0.0    !
  4 '   QK-11'  786.   -0.00101471   0.0     0.42466    0.0    !
  5 '   DRIFT'  826.   -0.00129412   0.0    -0.77217    0.0    !
  6 '   QC-12'  926.   -0.00166176   0.0    -0.93835    0.0    !
  7 '   DRIFT'  948.   -0.00202941   0.0    -0.39900    0.0    !
  8 '   QC-12' 1048.   -0.00202941   0.0    -0.60194    0.0    !
  9 '   DRIFT' 1070.   -0.00202941   0.0    -0.64600    0.0    !
 10 '   QC-12' 1170.   -0.00202941   0.0    -0.84894    0.0    !
 11 '   DRIFT' 1220.   -0.00202941   0.0     0.34512    0.0    !
 12 '   QB-13' 1400.   -0.00269118   0.0    -0.13929    0.0    !
 13 '   DRIFT' 1440.   -0.00335294   0.0    -0.27288    0.0    !
 14 '   QB-13' 1620.   -0.00401470   0.0    -0.99552    0.0    !
 15 '   DRIFT' 1667.2  -0.00467647   0.0     1.40000    0.0    !
 16 '   BH-04' 2003.   -0.00467647   0.0     0.30000    0.0    !
 17 '   DRIFT' 2041.   -0.00733823   0.0     0.30000    0.0    !
 18 '   BH-04' 2376.8  -0.00733823   0.0    -1.90000    0.0    !
 19 '   D-PIP' 2397.   -0.01000000   0.0   -12.45000    0.0    !
 20 '   D-WIN' 2730.   -0.01000000   0.0   -22.40000    0.0    !
*                                                              !
 21 '   D-ETD' 3340.   -0.01000000   0.0   -33.40000    0.0    ! Feb-1993
*
LGAA 0/  ! Luminosity Monitor Geometry Element's Apertures
*          #=================#=================#========
        2  !  = Lenght of header
       21  !  = # of modules
   930225  !  = YYMMDD of creation
*
* L  #   Shape   VM(cm)  WM(cm)  DV(cm)  DW(cm)
*-------------------------------------------------------------------
  4  1   'ELIP'    4.0     2.5                         !  QL-11
  4  2   'ELIP'    4.0     2.5                         !
  4  3   'ELIP'    4.0     2.7                         !  QK-11
  4  4   'ELIP'    4.0     2.7                         !
  4  5   'ELIP'    4.1     2.9                         !  QC-12
  4  6   'ELIP'    4.1     2.9                         !
  4  7   'ELIP'    4.1     3.1                         !  QC-12
  4  8   'ELIP'    4.1     3.1                         !
```

```
  4  9   'ELIP'    4.2     3.3                          !  QC-12
  4 10   'ELIP'    4.2     3.3                          !
  4 11   'ELIP'    4.2     3.5                          !  QB-13
  4 12   'ELIP'    4.2     3.5                          !
  4 13   'ELIP'    4.3     3.7                          !  QB-13
  4 14   'ELIP'    4.3     3.7                          !
  4 15   'RECT'    9.6     4.6                          !  BH-04
  4 16   'RECT'   12.1     4.6                          !
  4 17   'RECT'   12.1     4.6                          !
  4 18   'RECT'   15.7     4.6                          !
*----------------------------------------------------------------------
  4 19   'RECT'    6.45    4.0                          !  exit channel
*----------------------------------------------------------------------
  4 20   'ELIP'    6.9     6.9                          !  e-window
  4 21   'RECT'    7.7     7.7                          !  Detector (ET)
*----------------------------------------------------------------------
ENDQ
```

Appendix

An example job below illustrates the use of the 'non-modular' version of the package, for the reason of speed (1200 enents per second compared to 600 for the CALL H1LUMI case).

```
      PROGRAM  H1FLUS
*=====================================================================
*
*     Fast H1 LUMI system simulation using:
*
*     LGEN    generator module (former LGENER)
*     LSIM    fast simulation "module".
*
*     Warning:  module steering is removed  and FSEQR/FSEQW
*               are substituted for the reason of speed.
*
*     S.Levonian   Moscow   Sep-87   first version of LGENER
*                           Mar-93   combine LGENER with tracking and
*                                    detector resolution functions
*=====================================================================
*
+SEQ, LLSTEE, LLCGEN, LLOUT, LLOOK.
+SEQ, BOSMDL.
      PARAMETER    (NDBCS=10000)
      REAL         RW(NDBCS)
      COMMON /BCS/ IW(NDBCS)
      EQUIVALENCE  (IW(1),RW(1))
      CHARACTER    LIST*1
*
*                            initialize BOS
      CALL BOS(IW,NDBCS)
*                            read steering cards and banks
      CALL FPARMR(5)
      CALL BREADC
*                            define output look file
      IND=IW(NAMIND('LOOK'))
      IF(IND.GT.0) THEN
         FILE=' '
         NB=IW(IND)
         DO 1 I=1,NB
    1    FILE(4*I-3:4*I)=CHAINT(IW(IND+I))
         NCF=LENB(FILE)
      ELSE
         NCF=0
      ENDIF
*                            define number of events to be generated
      NPRINT = 0
      IND=IW(NAMIND('NEVE'))
      IF(IND.GT.0) THEN
         NEV = IW(IND+1)
```

```
        IF(IW(IND).GE.2) NPRINT=IW(IND+2)
      ELSE
         NEV = 9 999 999
      ENDIF
      BEGJOB=.TRUE.
      ENDJOB=.FALSE.
      LIST  ='E'
*
*--------------------------- event processing loop -------------------
*
      DO 10 IEV=1,NEV+1
        IF(IEV.GT.1)   BEGJOB=.FALSE.
        IF(IEV.GT.NEV) ENDJOB=.TRUE.
        CALL FQCOND('TIME',LRET)
        IF(LRET.GT.0) THEN
           WRITE(*,*) ' Time limit reached'
           ENDJOB=.TRUE.
        ENDIF
        IF(ENDJOB) LIST='0'
*                             generate one event
        C A L L   L G E N (0)
*                             simulate lumi system for this event
        C A L L   L S I M
*                             analyse result and fill LOOK figures
        C A L L   L U S E R

        IF(IFOUT) THEN
           IF(LIST.EQ.'E') CALL FWBOSK(IW,LIST,'RUNEVENT',IRUN,IEV,0)
           CALL FWBOS(IW,LUN,LIST,IERR)
           CALL BDROP(IW,'E')
           CALL BGARB(IW)
        ENDIF
        IF(ENDJOB) GOTO 100
   10 CONTINUE

*--------------------------- final statistics ------------------------
  100 IF(IFOUT) THEN
         CALL BOSTA
         CALL FPSTAT
      ENDIF
      STOP
      END
```

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Figure Captions

Figure 1: LGEN results for the $ep \to ep\gamma$ events at 26.7×820 GeV collision energy: a) y and b,c) angular distributions for the photons. MC - histograms, theory (1) and (3) - solid curves. The effect of the angular divergence in the beam is shown by the dotted curves.

Figure 2: LGEN results for the low Q^2 scattered electrons at 26.7×820 GeV collision energy. The effect of the angular divergence in the beam is shown by the dotted histogram.

Figure 3: The layout of the H1 luminosity system. Axes show the H1 coordinate system convention.

Figure 4: Schematic view of the e- and γ-channel apertures as implemented in LSIM (only $-z < 40$ m part is shown). The dashed lines limit a 0.45 mrad acceptance cone of the H1 photon detector. The solid curve indicates the electron reference trajectory.

Figure 5: LSIM simulation results for the $ep \to ep\gamma$ events at the nominal beam conditions (a-f) and for the e-beam tilt of $\theta_x = 0.2$ mrad, $\theta_y = -0.2$ mrad (h). Solid and dashed histograms in (g) correspond to the nominal and 'tilted' e-beam. The photon beam spot in fig. (h) is cut by the limitations in the γ-aperture.

Figure 6: Low Q^2 scattered electrons accepted by the Electron Tagger. The solid lines and the scatter plots correspond to the nominal beam conditions. The dashed curve in fig. (h) shows the ET acceptance in case of the e-beam tilt of $\theta_x = 0.2$ mrad, $\theta_y = -0.2$ mrad. Fig. (c) corresponds to the fig. 2b but for the accepted electrons.

Figure 7: The systematic error in the acceptance calculation as a function of the possible error δx in the ET position measurements. Solid and dashed lines in (a) correspond to the bremsstrahlung and photoproduction events respectively. The contribution to the absolute normalization error for the e-tagged events (b) is small due to the partial compensation.