BREMGE

Monte Carlo generator of high energy electron-proton and electron-nucleus bremsstrahlung events

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1 Basic Facts

Version: BREMGE 1.0, from December 1991.

Computer type: IBM 3090 300S under MVS/XA operating system and VAX under VMS.

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Program size: 180 lines.

2 Introduction

In both experiments at HERA, H1 and ZEUS, fast luminosity monitoring will be based on measurement of the small angle electron-proton bremsstrahlung $ep \to e\gamma p$ event rates [1,2]. The bremsstrahlung of electrons on nuclei $eN \to e\gamma N$ of the rest gas atoms is expected to be the main source of background. Its contribution will be measured with those electron bunches which will traverse the interaction region alone, without proton bunch. Electron-proton bremsstrahlung events with low energy photons will be suppressed due to limited transverse beam sizes (an effect first observed at Novosibirsk [3]).

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BREMGE can generate e-p as well as e-N bremsstrahlung events. Optionally beam-size effect can be also included.

For electron-proton collisions the events are generated according to ultra-relativistic differential cross section calculated in the Born approximation and small angle approximation [4] . Higher order diagrams and inelastic ($ep \to e\gamma X$) contributions are well below 1% [5,6] and have been neglected. The energy transfer to a target (proton or nucleus), which is of the order of m_e^2/M_N, has been also neglected therefore the sum: $E_\gamma + E'$ always equals the energy E of primary electron.

For electron-nucleus bremsstrahlung events the screening of the nucleus field by atomic electrons according to the Thomas-Fermi-Moliere form factor [7] was taken into account. Beam-size effect is implemented in BREMGE by suppressing events with small momentum transfer (transversal to direction of primary electron) from proton, which corresponds to large impact parameter values - comparable with transverse beam sizes.

3 The structure of the generator

The generator was written as a FORTRAN 77 package containing the subroutine BREMGE and the blockdata LUBLDT. Generator parameters can be set by attaching in the main program to the following common block:

```
      COMMON/BREMPA/  PI, EMASS, PMASS, EEO, EPO, EGMIN,
     &                EGMAX, XEP, YEP, TGMAX, MODEBR, ZETGAS, FGEGP,
     &                EEOM, EHL, DSDUMA, DMIN, DMAX, DMIN2, DMAX2, DU3
```

where:

- PI - 3.14159...., EMASS - electron mass, PMASS - proton mass
- EE0 - electron beam energy, EP0 - proton beam energy
- EGMIN, EGMAX - photon energy interval
  $(0. < EGMIN < EGMAX < EE0 - EMASS)$
- XEP, YEP - transverse beam sizes defined as:
  XEP= $\sqrt{\sigma^2_{x,e} + \sigma^2_{x,p}}$, YEP= $\sqrt{\sigma^2_{y,e} + \sigma^2_{y,p}}$
- TGMAX - maximum photon angle $(0. < TGMAX << 1rad)$
- MODEBR - type of process:
  0 - e-p bremsstrahlung, no corrections
  1 - e-p bremsstrahlung+beam-size effect
  2 - e-gas (=e-nucleus) bremsstrahlung
- ZETGAS - Z of nucleus

The blockdata LUBLDT gives default values to the parameters. The units used are: GeV, radian, meter. The other variables in COMMON/BREMPA/ should not be touched by a user. The generator is initialized automatically during its first call and may be re-initialized any time by a call with EG=0.0.
A call of subroutine BREMGE:

```
CALL BREMGE(EG,TGX,TGY,EE,TEX,TEY)
```

returns values of its six arguments:

1. EG - photon energy
2. TGX - photon angle w.r.t. the primary electron, projected onto the horizontal plane (TGX = arctan(PGx/PGz))
3. TGY - photon angle w.r.t. the primary electron, projected onto the vertical plane (TGY = arctan(PGy/PGz))
4. EE - electron energy
5. TEX - electron angle w.r.t. the primary electron, projected onto the horizontal plane (TEX = arctan(PEx/PEz))
6. TEY - electron angle w.r.t. the primary electron, projected onto the vertical plane (TEY = arctan(PEy/PEz))

For MODEBR=1 all events suppressed by the beam-size effect are tagged by setting EE=0.0. Source of the generator is available as a F1PLUM.BREMGE.S(BREMGE) at the DESY mainframe IBM.

4 Performance

The generator has been tested with long runs (up to 10^7 events). It is fast; one e-p event (MODEBR=0,1) takes about 0.3 msec of CPU time on the IBM 3090. The generation of e-gas events (MODEBR=2) is about 15 - 20 times slower.

Fig.1 shows that theoretical shapes of photon spectrum [7,8] and angular distribution [9] are very well reproduced using BREMGE for ep (MODEBR=0) and eN (MODEBR=2, ZETGAS=4.) events.

To compare MC and theoretical [10] predictions of the beam-size effect at HERA we have plotted in Fig.2 the ratio $(\frac{d\sigma}{dE_\gamma}^{uncorr} - \frac{d\sigma}{dE_\gamma}^{corr})/\frac{d\sigma}{dE_\gamma}^{uncorr}$ as a function of the bremsstrahlung photon energy E_γ. The comparison reveals a systematic difference between MC and theory; one possible source of it is the use of the Born approximation in BREMGE instead of quasi-classical approach applied in [10] and will be further studied in the near future.

Bremsstrahlung 30 x 820 GeV MC events

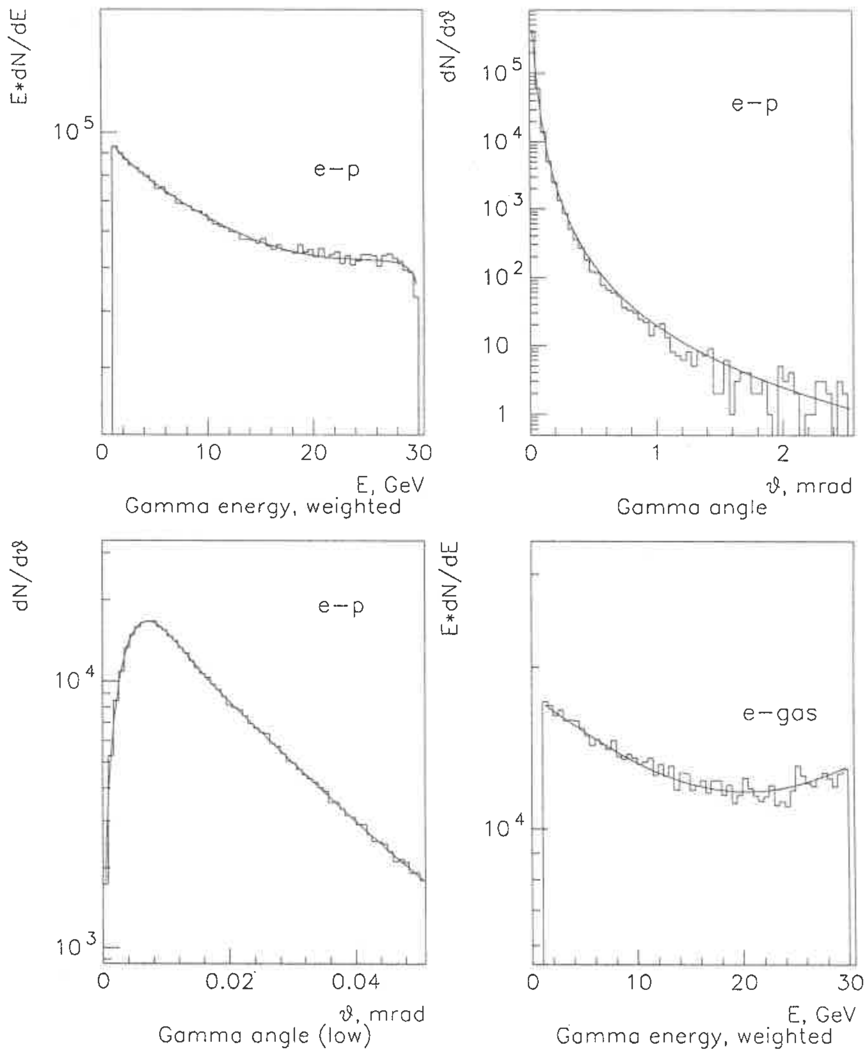

Figure 1: BREMGE performance - comparison of MC and theoretical distributions.

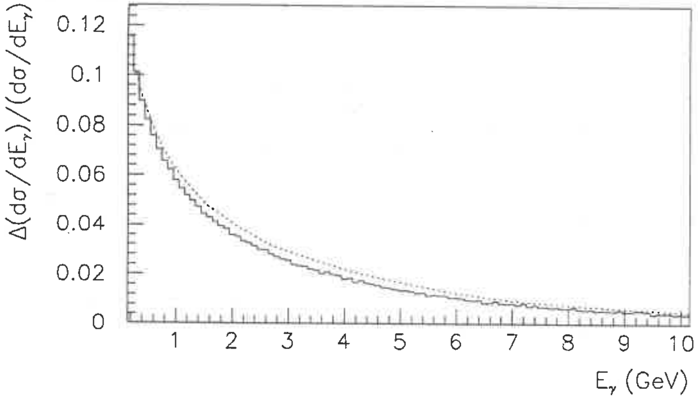

Figure 2: Beam-size effect at HERA. MC: solid line, theory: dotted line.

5 References

1 ZEUS collaboration, The ZEUS Detector, Technical Proposal; DESY internal report, (March 1986).

2 Technical Proposal for the H1 Detector. H1 Collaboration; DESY internal report, (March 1986). 1

3 A.E. Blinov et al., Phys. Lett. 113B (1982) 423.

4 V.B.Berestetskii, E.M.Lifshitz and L.P.Pitaevskii, "Quantum Electrodynamics", Pergamon Press, 1971.

5 M.van der Horst, Theoretical Calculations for Electron - Proton Scattering, Ph.D. thesis, University of Amsterdam (1990); K.J.F.Gaemers and M.van der Horst, Nucl.Phys. B316 (1989) 269; M. van der Horst, Nucl. Phys. B347 (1990) 149; M. van der Horst, Phys. Lett. B244 (1990) 107.

6 A.A. Akhundov et al., DESY 90-130.

7 Yung-Su Tsai, Rev. of Mod. Phys. 46 (1974) 815.

8 H.Bethe and W.Heitler, Proc. Roy. Soc. A146 (1934) 83.

9 R.L.Gluckstern and M.H.Hull,Jr., Phys. Rev. 90 (1953) 1030.

10 G.L.Kotkin et al., Z. Phys. C39 (1988) 61.

Quasi-real QED Compton Monte-Carlo

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Abstract: An unweighted Monte-Carlo of quasi-real QED Compton events obtained in head-on e-p collisions is described. This means the generation of events involving a final state with one electron and one photon, almost coplanar, observed inside the detector at finite angles.

1 Short overview

1. Program : Compton 2.00 (Dec. 1991)
2. Author : A. Courau Contact person: T.Carli [1]
3. Program size : 3500 lines
4. Input file : Steering [2]
5. Computer type : IBM
6. Installation : DESY-IBM at H01RTC.COM200.CMZ
7. Program called : JETSET 7.3
8. Initial QED radiation included
9. Hadronic mass generated but final hadronic states not treated

2 Definitions , remarks and physics purpose

Considering the reaction $e^- p^+ \rightarrow e^- + \gamma + X$ corresponding to the diagram of fig (1) one gets a priori :

$$d\sigma = \frac{dq_1}{q_1{}^2 - m_e{}^2} \frac{dq_2}{q_2{}^2} \tag{1}$$

The cross-section is largely dominated by $q_1{}^2$ and $q_2{}^2$ close to zero. This configuration (the so-called **Bremsstrahlung**) leads to a large counting rate, but only in a specific detector at low angles, since the outgoing electron and photon, as well as the hadronic system, go closely along the beam axis. Looking for particles at finite angles inside the main detector requires at le ast that one of the two q^2 takes finite values not too close to zero. One has to consider two different configurations :

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[2] Can be found in the CMZ file.