INSTITUTE OF SPACE SCIENCE

Electromagnetic dissociation simulation with FLUKA

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Summary

- **FLUKA** a fully integrated particle physics MonteCarlo simulation code
- Electromagnetic dissociation using NIKFI - BR-2 emulsion
- Validation of FLUKA at high energy
- Comparation between FLUKA and Becquerel experimental data

a fully integrated particle physics MonteCarlo simulation code

FLUKA characteristics:

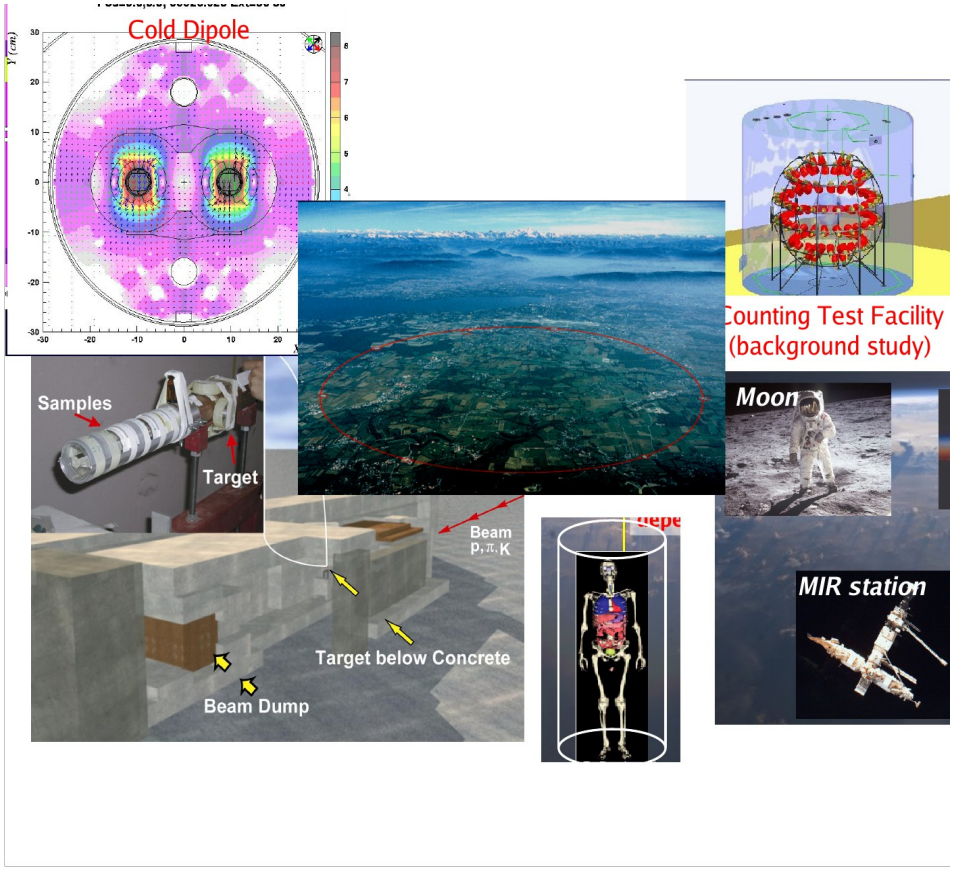
- is a Monte Carlo code writen in FORTRAN
- is a „Black Box" Physics code
- can simulate with high accuracy the interaction and propagation in matter of about 60 different particles and all the coresponding antiparticles;
- has the capability of particle transport and interaction with matter, such as:

Interaction	Energy	Model
hadron - hadron	5 GeV/c – 20 TeV/c	Dual Parton Model (DPM)
	< 5 GeV/C	Resonance production and decay model
hadron - nucleu	5 GeV/c – 20 TeV/c	Glauber-Gribov multiple scattering and GINC
	< 5 GeV/c	PEANUT model
nucleus - nucleus	> 5 Gev/A	DPMJET
	0.1 – 5 GeV/A	RQMD
	<0.1 GeV/A	Boltzman Master Equation (BME)

a fully integrated particle physics MonteCarlo simulation code

Aplications in:

· high energy experimental physics and engineering
· shielding
· detector and telescope design
· cosmic ray studies
· dosimetry
· medical physics
· radio-biology
· etc.



From 2004, a model, based on Weizsäcker-Williams aproximation, for electromagnetic dissociation of ions in ion-ion interactions has been implemented.

Electromagnetic dissociation using NIKFI – BR - 2 emulsion at relativistic energies

High sensitivity of NIKFI – BR-2 about 30 grains per 100 μm for the minimum ionizing particles.

NIKFI-BR-2 emulsion composition:

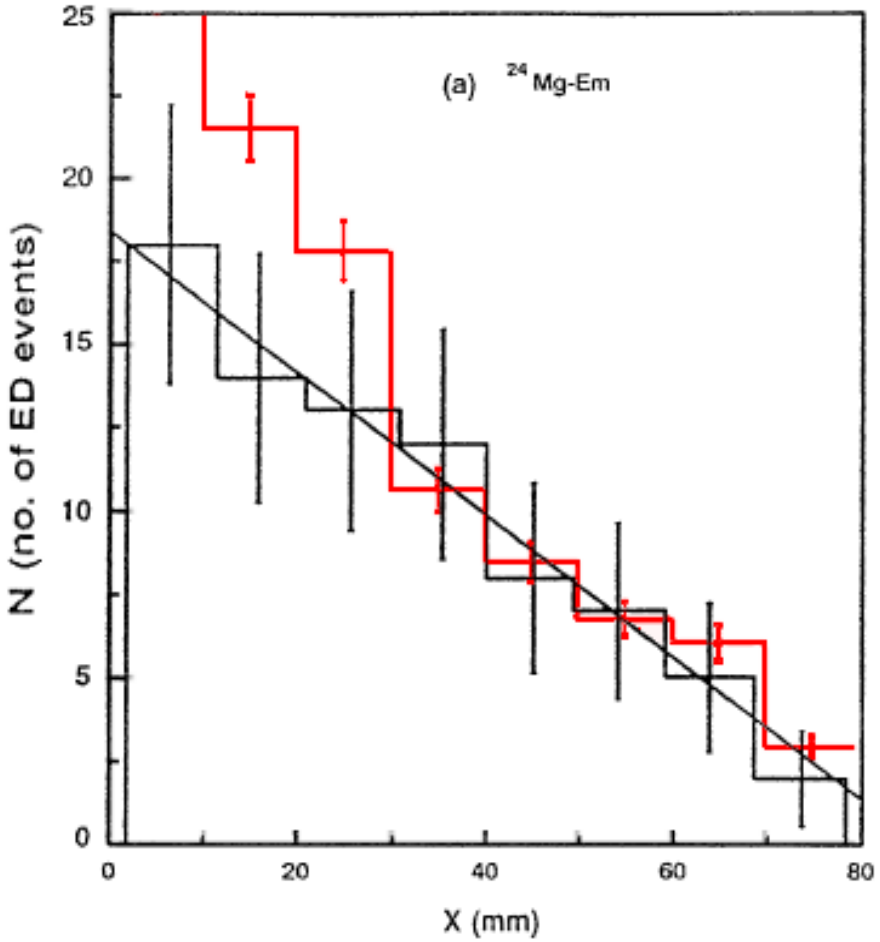
Element	$^{1}H_{1}$	$^{12}C_{6}$	$^{14}N_{7}$	$^{16}O_{8}$	$^{32}S_{16}$	$^{80}Br_{35}$	$^{108}Ag_{47}$	$^{127}I_{53}$
No. of atoms $\times 10^{22}/cm^{3}$	2.930	1.390	0.370	1.060	0.004	1.020	1.020	0.003

FLUKA definition of NIKFI – BR-2 emulsion

```
MATERIAL         16.0     32.06      2.07      26.0                    SULFUR
MATERIAL         35.0    79.904     3.123      27.0                    BROMINE
MATERIAL         53.0 126.9045      4.79      28.0                    IODINE
MATERIAL                            7.79      29.0                    EMULSION
COMPOUND        +2.93      +3.0     +1.39      +6.0     +0.37     +7.0 EMULSION
COMPOUND        +1.06      +8.0     +1.02     +13.0     +0.004   +26.0 EMULSION
COMPOUND        +1.02     +27.0    +0.003     +28.0                    EMULSION
```

- highest spatial resolution;
- important to characterize the projectile fragmentation;
- describe the statistical and nonstatistical nature of the decay and for heavy-ion reactions can be useful in measuring the excitation energy distribution which provides information about the electromagnetic excitation mechanism.

Validation of FLUKA at high energy

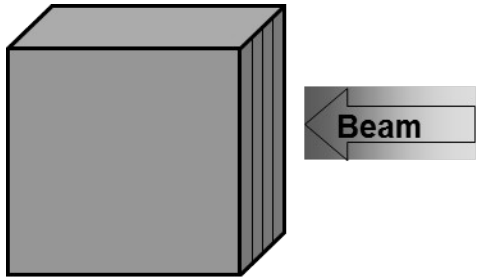


Comparation of FLUKA with experimental data at 3.7 A GeV

Red line – FLUKA; Black line – M.A. Jilany Nuclear Physics A 705 (2002) 477-493.

Comparation between FLUKA and Becquerel experimental data

Stacks composed of NIKFI-BR-2 nuclear emulsion pellicles were exposed horizontally, so:



Beam	^{16}O	^{22}Ne	^{28}Si	^{32}S	^{56}Fe
Energy (A GeV)	3.7	3.2	3.7	3.7	1

FLUKA run and analysis options:

```
PHYSICS         3.0       0.0       0.0       0.0       0.0       0.0EM-DISSO
PHYSICS         3.0                                                   EVAPORAT
PHYSICS         1.0                                                   COALESCE
PHYSICS         1.0                                                   DECAY
```

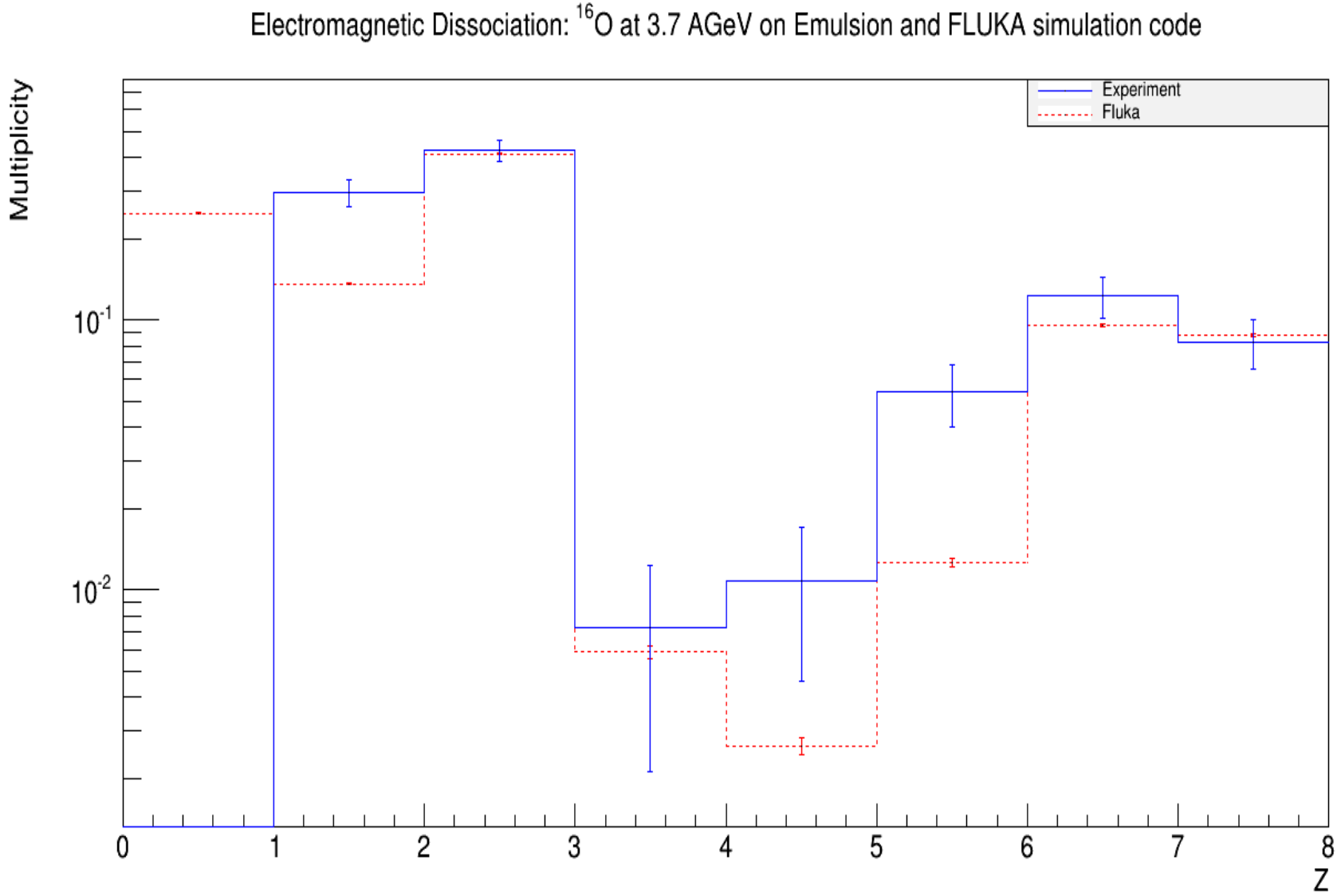
```
 Flags indicating the event interaction type:                          *
                                                                       *
       LELEVT  =  Elastic interaction                                  *
       LINEVT  =  Inelastic interaction                                *
       LDECAY  =  Particle decay                                       *
       LDLTRY  =  Delta ray production (Moller and Bhabha included)    *
       LPAIRP  =  Pair production                                      *
       LBRMSP  =  Bremmsstrahlung                                      *
       LANNRS  =  Annihilation at rest                                 *
       LANNFL  =  Annihilation in flight                               *
       LPHOEL  =  Photoelectric effect                                 *
       LCMPTN  =  Compton effect                                       *
       LCOHSC  =  Rayleigh scattering                                  *
       LLENSC  =  Low energy neutron scattering                        *
       LOPPSC  =  Optical photon scattering                            *
       LELDIS  =  Electromagnetic dissociation                         *
       LRDCAY  =  Radiactive decay                                     *
                                                                       *
```

Comparation between
FLUKA and Becquerel experimental data

```
      IF (LTRACK.EQ.1.and.MREG.EQ.3.and.iflag.eq.0) THEN
         IF(idp.eq.13) THEN
          xpos = XSCO
          ypos = YSCO
          zpos = ZSCO
          pjtrack=JTRACK
          pmreg=MREG
          psecondary=NP+NPHEAV
*         write(*,*)"================== Nr. Event ======================",
     & Nrevent

      do 10 ip = 1, NP
*       write(*,*)" --- KPart = ",KPART(ip)
.......
          ID=KPART(ip)..........
          IF (ID.gt.-6) THEN
          ID=KPART(ip)
          EKIN=TKI(ip)
          MASS=AM(ID)
          CHARGE=ICHRGE(ID)
          BARNR=IBARCH(ID)
          ELSE
          ID=KHEAVY(ip)
          EKIN=TKHEAV(ip)
          MASS=AMNHEA(ID)
          CHARGE=ICHEAV(ID)
          BARNR=IBHEAV(ID)
          ENDIF

<------->   IMP=PLR(ip)
          cosx = CXR(ip)
          cosy = CYR(ip)
          cosz = CZR(ip)
.........
         IF(KPART(ip).lt.-6.and.NPHEAV.gt.0) THEN
         GO TO 10
         ENDIF

         CALL treefill(pjtrack,pmreg,psecondary,idp,ID,
     &   MASS,EKIN,IMP,ICHRGE(ID),
     &   IBARCH(ID),cosx,cosy,cosz,xpos,ypos,zpos,
     &   ATRACK,Nrevent)
```

```
      do 20 ip = 1, NPHEAV
*       write(*,*)" --- ID Ions= ",KHEAVY(ip)
......
          ID=KHEAVY(ip)
          EKIN=TKHEAV(ip)
.....
          MASS=AMNHEA(ID)
          CHARGE=ICHEAV(ID)
          BARNR=IBHEAV(ID)
..........
          IMP=PHEAVY(ip)
          cosx = TXFLK(ip)
          cosy = TYFLK(ip)
          cosz = TZFLK(ip)..........
..........
         CALL treefill(pjtrack,pmreg,psecondary,idp,ID,
     &   MASS,EKIN,IMP,ICHEAV(ID),
     &   IBHEAV(ID),cosx,cosy,cosz,xpos,ypos,zpos,
     &   ATRACK,Nrevent)
*         write(*,*)"ID primary = ",JTRACK," \--/ ID secondary = ",ID,
*     &   " \--/ Charge = ",CHARGE," \--/ Barionic = ",BARNR,
*     &   " \--/ Ekin = ",EKIN
20    continue
```

Comparation between FLUKA and Becquerel experimental data



Nuclear diffraction dissociation of ^{16}O, ^{22}Ne, ^{28}Si, ^{32}S, ^{56}Fe at 1–3.7 A GeV in nuclear emulsion – 2013 –
A. T. Neagu, E Firu and M Haiduc - - *J. Phys. G: Nucl. Part. Phys.* 40 035102

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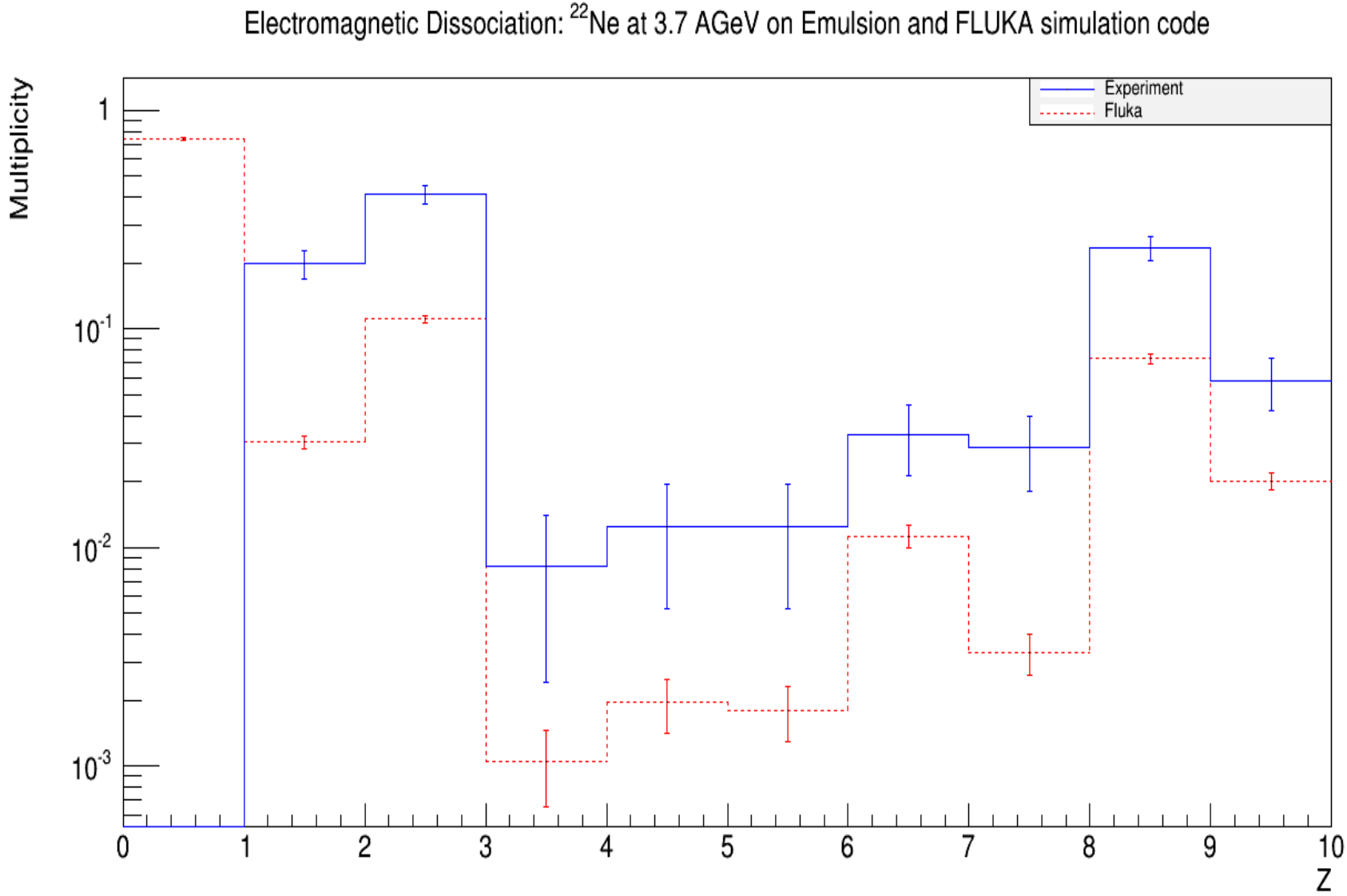

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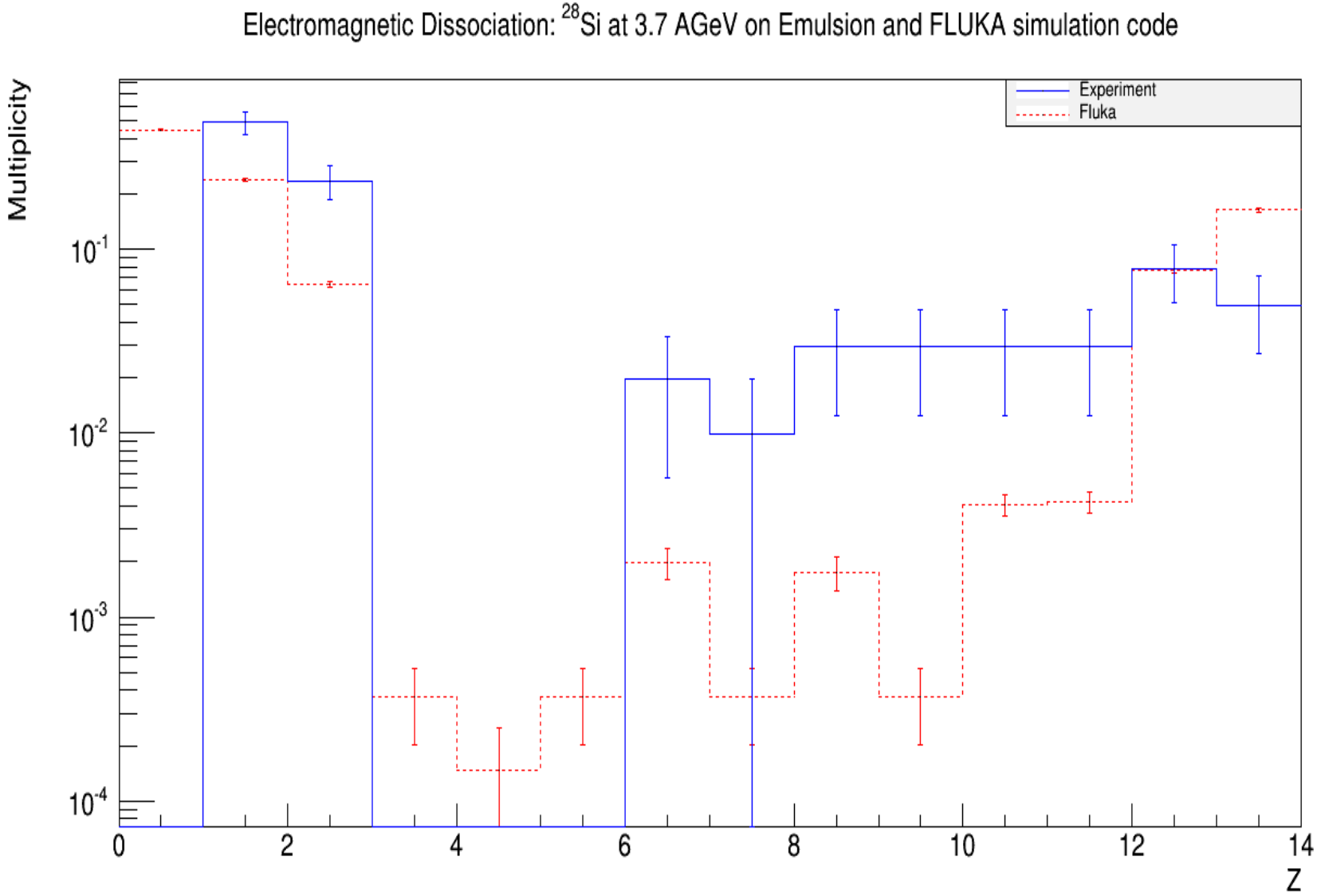

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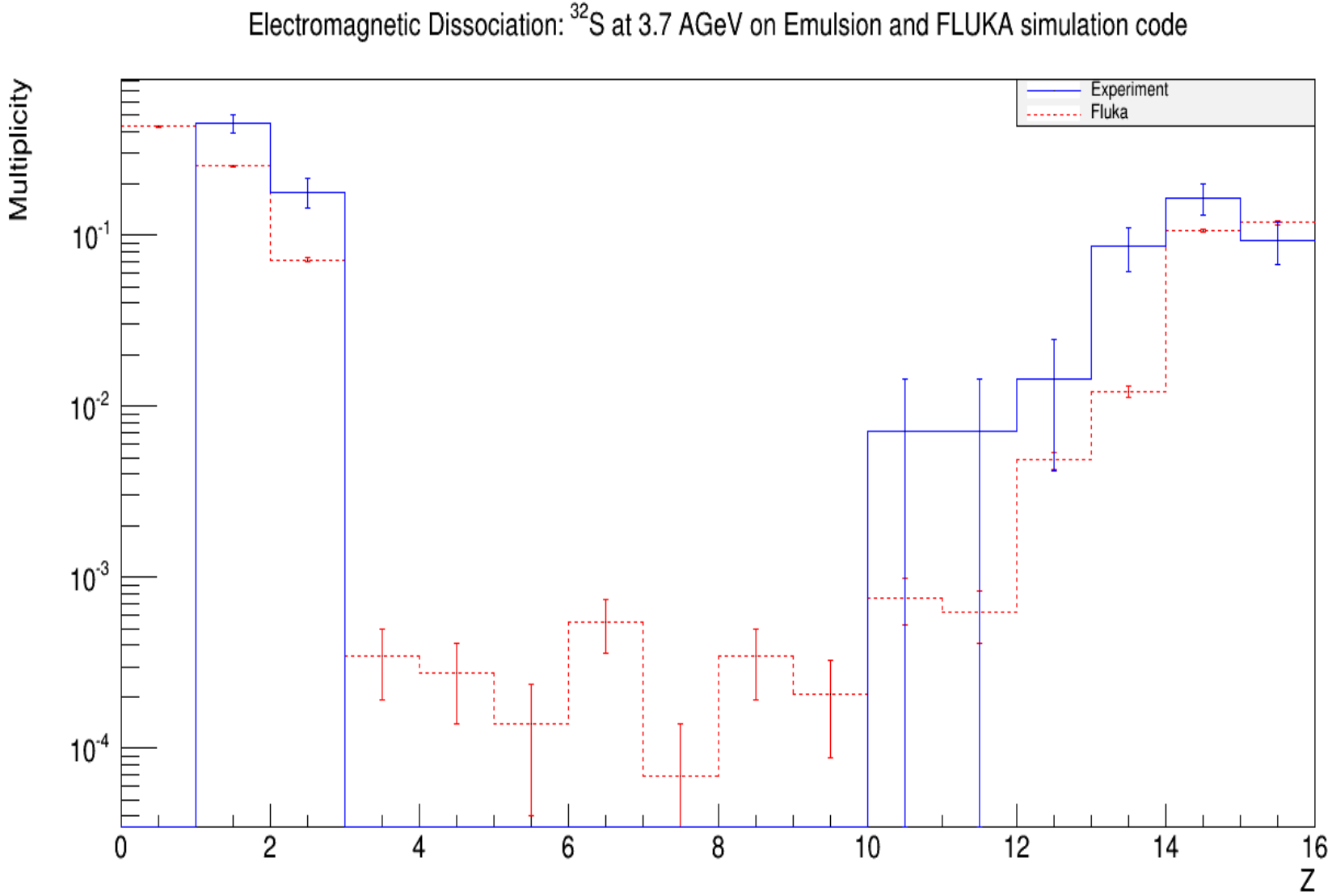

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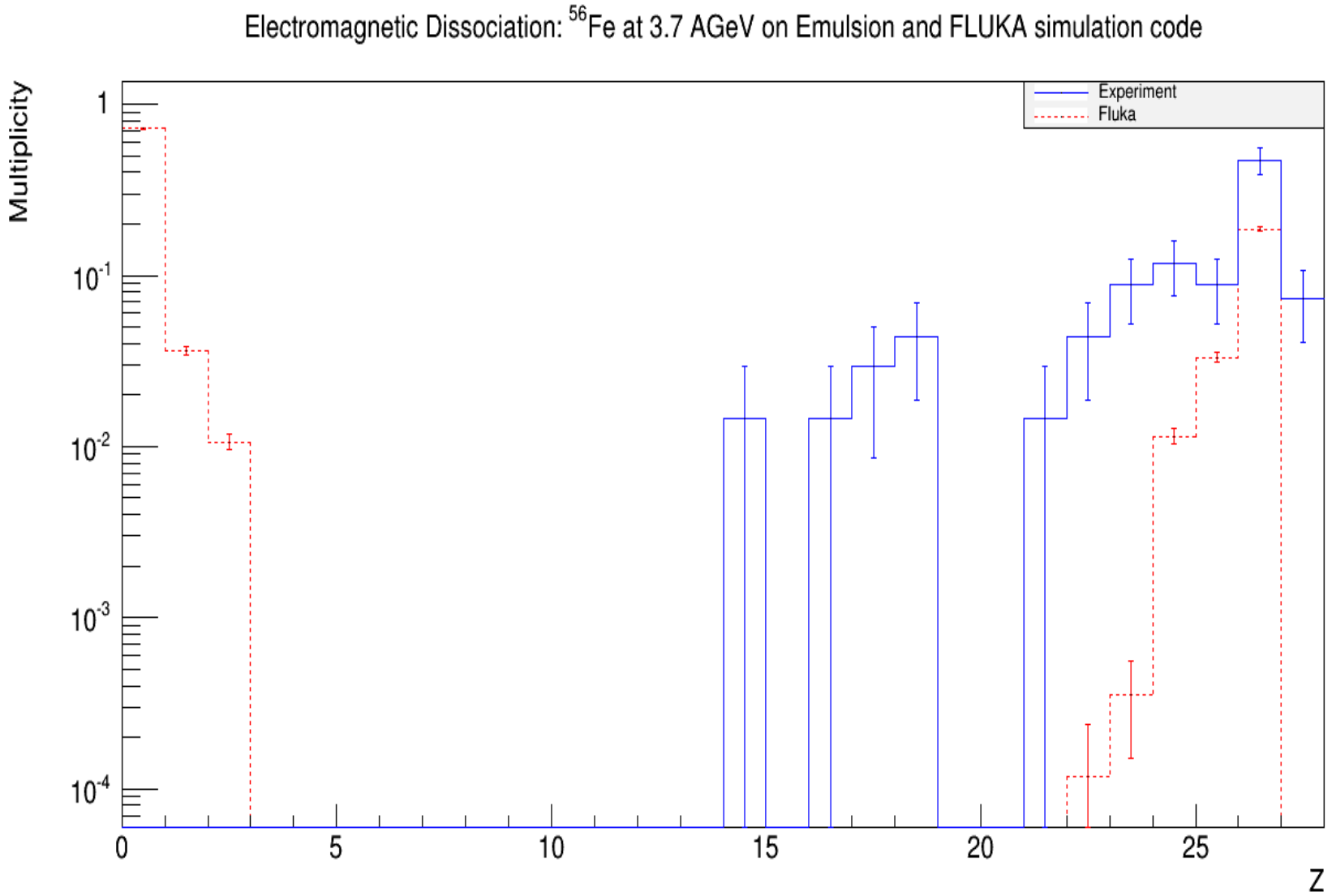

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Thank you for attention!