FLUKA practical workshop

iThemba LABS
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Introduction

- I will take inspiration form the the 17th FLUKA course

- you can download the slides of the FLUKA course from https://www.fluka.org/fluka.php?id=secured_intro

- you can download these slides from www.roma1.infn.it/~mancinit/

Monte Carlo methods

- It is a mathematical approach using a sequence of random numbers to solve a problem

- Random quantities (e.g. the average value of mm of rain)

- Deterministic problems (definite integral?)

Monte Carlo methods

- Comte de Buffon (1777): needle tossing experiment to calculate the π;

- Laplace (1886): random points in a rectangle to calculate π;

- Fermi (1930): random approach to calculate the properties of the newly discovered neutron;

- Manhattan project (40's): simulations during the initial developments of thermonuclear weapons;

- Von Neumann and Ulam coined the term 'Monte Carlo' (1949);

- Exponential growth of the electronic computers (40's-60's);

- Berger (1963): first complete coupled electron-photon transportation code 'ETRAN'.

FLUKA

- Developed and maintained under an INFN-CERN agreement Copyright 1989-2015 CERN and INFN

- more than 8'000 users

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FLUKA applications

- Cosmic ray physics

- Neutrino physics

- Accelerator design (n_ToF, CNGS, LHC systems)

- Particle physics: calorimetry, tracking and detector simulation

- Shielding design

- Dosimetry and radioprotection

- Radiation damage

- Space radiation

- Hadrontherapy…

The History

The beginning:

1962: Johannes Ranft (Leipzig) and Hans Geibel (CERN): Monte Carlo for high-energy proton beams

The name:

1970: study of event-by-event fluctuations in a NaI calorimeter (FLUktuierende KAskade)

Early 70's to ≈1987: J. Ranft and coworkers (Leipzig University) with contributions from Helsinki University of Technology (J. Routti, P. Aarnio) and CERN (G.R. Stevenson, A. Fassò)

Link with EGS4 in 1986, later abandoned

The modern code: some dates

Since 1989: mostly INFN Milan (A. Ferrari, P.R. Sala): little or no remnants of older versions. Link with the past: J. Ranft and A. Fassò

1990: LAHET / MCNPX: high-energy hadronic FLUKA generator *No further update*

1993: G-FLUKA (the FLUKA hadronic package in GEANT3). *No further update*

1998: FLUGG, interface to GEANT4 geometry

2000: grant from NASA to develop heavy ion interactions and transport

2001: the INFN FLUKA Project

2003: official CERN-INFN collaboration to develop, maintain and distribute FLUKA

➔ *FLUKA is NOT a toolkit! Its physical models are fully integrated*

The Physics Content of FLUKA

- ➢ **60 different particles + Heavy Ions**
  - Nucleus-nucleus interactions from Coulomb barrier up to 10000 TeV/n
  - Electron and μ interactions 1 keV – 10000 TeV
  - Photon interactions 100 eV - 10000 TeV
  - Hadron-hadron and hadron-nucleus interactions 0–10000 TeV
  - Neutrino interactions
  - Charged particle transport including all relevant processes
  - Transport in magnetic fields
  - Neutron multigroup transport and interactions 0 – 20 MeV
  - Analog calculations, or with variance reduction

The FLUKA license (it is not GPL):

- Standard download: **binary library + user routines**.
  - FLUKA can be used freely for scientific and academic purposes, ad-hoc agreement for commercial purposes
  - It cannot be used for weapon related applications
  - It is not permitted to redistribute the code (single user, single site)
  - Users can add their own scoring, sources, etc. through a wide set of user routines, provided they do not modify the physics
  - Relevant references for each FLUKA version can be found in the documentation
- It is possible, by explicit signing of license, to download the **source** for researchers of scientific/academic Institutions.
  - FLUKA can neither be copied into other codes (not even partially), nor translated into another language without permission.
  - The user cannot publish results with modified code, unless explicit authorization is granted in advance.
- For **commercial use**, trial version (limited in time and random seeds) available. Commercial license to be negotiated.

Using FLUKA

Platform: Linux with **g77** (in 32bit mode)
and **gfortran** (on 64bit machines)

Work in progress: Mac OSX with gfortran

The code may be compiled/run only using operating systems, compilers (and associated) options tested and approved by the development team

Standard Input:

- Command/options driven by "data cards" (ascii file) .
  Graphical interface is available!!!!

- Standard Geometry ("Combinatorial geometry"): input by "data cards"

Standard Output and Scoring:
- Apparently limited but highly flexible and powerful
- Output processing and plotting interface available

The FLUKA mailing lists

- fluka-users@fluka.org

  Users are automatically subscribed here when registering on the web site. It is used to communicate the availability of new versions, patches, etc.

- fluka-discuss@fluka.org

  Users are encouraged to subscribe at registration time, but can uncheck the relevant box. It is used to have user-user and user-expert communication about problems, bugs, general inquiries about the code and its physics content

  users are strongly encouraged to keep this subscription

"Per me si va ne la città dolente,
per me si va ne l'etterno dolore,
per me si va tra la perduta gente.

Giustizia mosse il mio alto fattore:
fecemi la divina potestate,
la somma sapienza e 'l primo amore;

dinanzi a me non fuor cose create
se non etterne, e io etterno duro.
Lasciate ogne speranza, o voi ch'intrate."

–Dante Alighieri,
Divine Comedy - Canto III (Gate of Hell)
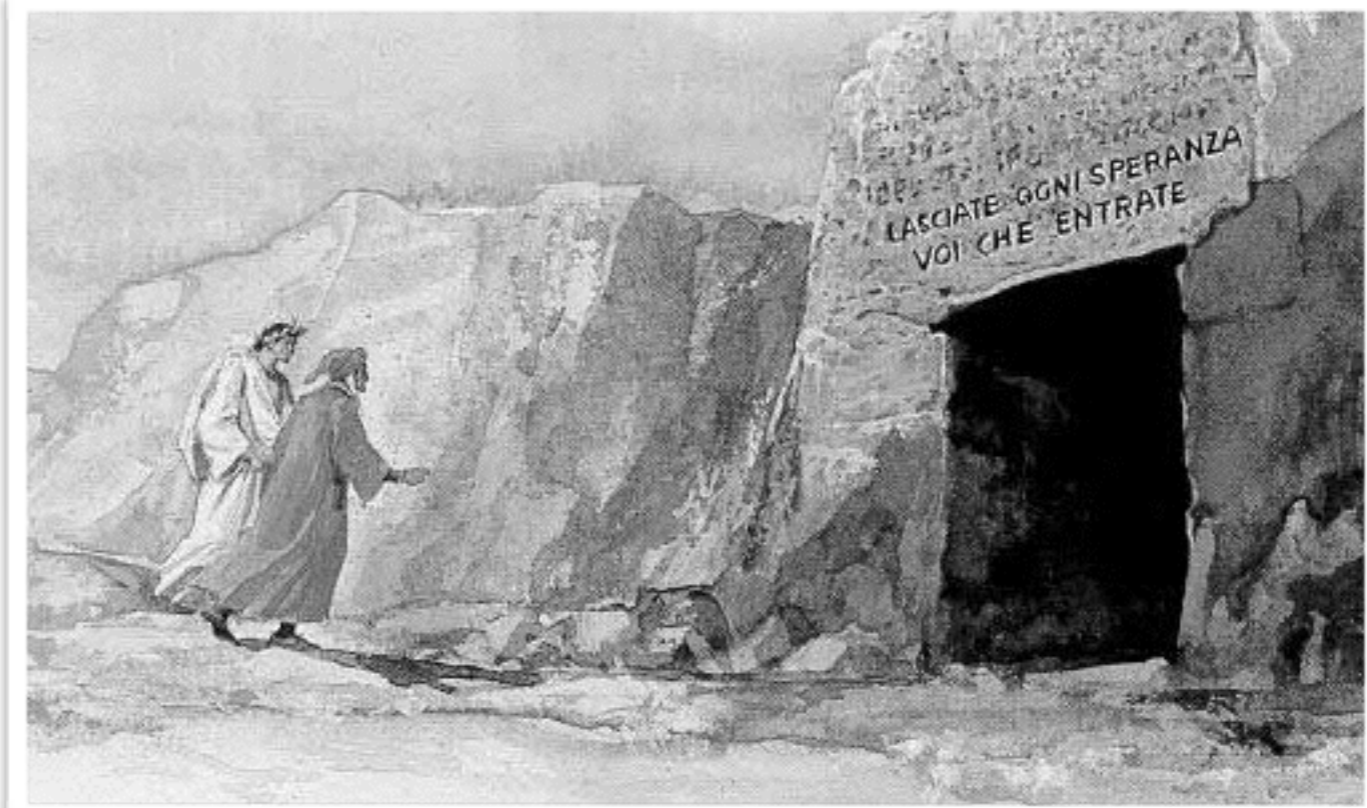
Abandon all hope, ye who enter here.

Installing FLUKA

How to download and install FLUKA

Two ways of downloading the FLUKA software:

- From the FLUKA website http://www.fluka.org
- From NEA databank http://www.nea.fr through the liaison officer from your institute

It is mandatory to be registered as FLUKA user.
Follow the link:

http://www.fluka.org/download.html

After registration (or using your user-id and password) you can proceed in downloading the latest official release version.

The currently available distribution files are:

fluka20*XX.YY*-linuxAA.tar.gz (for g77 compiler, 32 bit mode)

fluka20*XX.YY*-linux-gfor64bitAA.tar.gz (for gfortran compiler, 64 bits)

fluka-20*XX.YY*.i686.rpm (rpm, 32 bit)

fluka-20*XX.YY*.x86_64.rpm (rpm, 64 bit)

Some hint

- g77 is nowadays deprecated in almost all the linux distributions

- use a 64bit linux distribution and gfortran

- fortran >= 4.6 is required

- the package you should download is: fluka2011.2c-linux-gfor64bitAA.tar.gz

- in the next slides I assume a debian based 64bit linux distribution

My way to installing FLUKA

- sudo apt-get update

- sudo apt-get install gfortran emacs python-imaging python-imaging-tk python-imaging-tk python-pil python-pil.imagetk python-numpy python-dicom gnuplot gnuplot-x11 libpython-dev python-dev libx11-dev tk-dev

- echo "export FLUFOR=gfortran" >> ~/.bashrc
  echo "export FLUPRO=~/fluka" >> ~/.bashrc
  echo "export FLUKA=\$FLUPRO" >> ~/.bashrc
  echo "export PATH=\$PATH:~/flair" >> ~/.bashrc
  echo "alias ll='ls -ltrh'" >> ~/.bashrc

- source ~/.bashrc

My way of installing FLUKA

- mkdir fluka

- cd fluka

- wget --user fuid-xxxx --password mypswd https://www.fluka.org/packages/fluka2011.2c-linux-gfor64bitAA.tar.gz

- tar -zxvf fluka2011.2c-linux-gfor64bitAA.tar.gz

- make

Installing flair

- mkdir flair

- wget http://www.fluka.org/flair/install.sh

- chmod +x install.sh

- ./install.sh install flair

- rm install.sh

Using the script

- You can try my script, it should install FLUKA, flair and all the dependencies

- Signup on www.fluka.org

- wget www.roma1.infn.it/~mancinit/installflukaflair.sh

- edit it with your FLUKA username and password

- sh installflukaflair.sh

Documentation

- FM.pdf in the FLUKA directory/ It's the current version of the manual

- CERN-2005-10.pdf official reference for FLUKA
  (not up to date)

- online version (not up to date)

- F1 from flair or type fm in the terminal

- at a further stage the FAQ available at:
  http://www.fluka.org/fluka.php?id=faq&mm2=3

- at a further stage the archive of fluka-discuss:
  http://www.fluka.org/MailingList.html

A way to "Go FLUKA" - **FLUPIX**

Besides the current FLUKA distribution you also got the current version of FLUPIX distributed on your USB stick.

FLUPIX

(FLUka in knopPIX)

© Vasilis.Vlachoudis@cern.ch 2008

FLUPIX is a Fedora (originally **KNOPPIX**, www.knoppix.org) based version of the Live CD, with pre-installed FLUKA and flair and all the necessary tools in for performing FLUKA runs.

FLUPIX can run from a CD/DVD, bootable USB or through any virtual machine from any host operating system (Ms Windows, Mac OS, Linux, Solaris etc.). FLUPIX includes all the additions of VirtualBox (www.virtualbox.org) a free and open source Virtual machine supported by Sun, that provides easy installation and high performance.

FLUKA input

- FLUKA is driven by the user almost completely by means of an input file (.inp) which contains directives issued in the form of
DATA CARDS

- It is strongly recommended that for every exercise you create a subdirectory i.e., ex1, ex2, ex3 where all the necessary input and output file will be stored

Ex1

- cd

- mkdir ex1

- cd ex1

- wget www.roma1.infn.it/~mancinit/ex1.inp

Test the installation

- echo $FLUPRO

- cd ~/ex1/

- $FLUPRO/flutil/rfluka -N0 -M1 ex1

N of previous cycle (default 0)

inc file name (without extension)

N of cycles (default 5)

Warning!

- Do not put spaces in the path of the files…
  (like ~/Documents/ex 1/)

What rfluka does:

It creates a temporary subdirectory: $PWD/fluka_nnnn
($PWD means the current directory)
where nnnn is the system process-id assigned to FLUKA.
There all necessary assignments are defined and output files
are written.

elasct.bin	$\rightarrow$ $FLUPRO/elasct.bin
fluodt.dat	$\rightarrow$ $FLUPRO/fluodt.dat
fort.1	$\rightarrow$ ../ranex_1001
fort.11	$\rightarrow$ ex_1001.out
fort.12	$\rightarrow$ libec_thihecufealw_10t.pemf
fort.15	$\rightarrow$ ex_1001.err
fort.16	$\rightarrow$ "geometry scratch"
fort.2	$\rightarrow$ ranex_1002
neuxsc.bin	$\rightarrow$ $FLUPRO/neuxsc-ind_260.bin
nuclear.bin	$\rightarrow$ $FLUPRO/nuclear.bin
sigmapi.bin	$\rightarrow$ $FLUPRO/sigmapi.bin
xnloan.dat	$\rightarrow$ $FLUPRO/xnloan.dat

At the end of the FLUKA run:

If everything is OK the temporary directory disappears
And the relevant results are copied in the start directory:

Removing links

by default you have ex100n.log, ex100n.out, ex100n.err
(n=cycle) and ranex100m (seed for cycle m = n+1)

Removing temporary files

Saving output and random number seed

Saving additional files from scoring requested by the user
> Moving fort.33 to /home/username/work/ex1/ex1001_fort.33
> Moving fort.47 to /home/username/work/ex1/ex1001_fort.47
> Moving fort.48 to /home/username/work/ex1/ex1001_fort.48
> Moving fort.49 to /home/username/work/ex1/ex1001_fort.49
> Moving fort.50 to /home/username/work/ex1/ex1001_fort.50

End of FLUKA run

Checking FLUKA during the run

Look in the temporary directory:
a) Initialization phase ends when the *.err file is created.
b) Inside *.err file and (at the end of *.out file) the progress in the number of events is given in the line immediately following the one which starts by "NEXT SEEDS":

```
NEXT SEEDS:  C8888D      0      0      0      0      0 33B49B1      0      0      0
        1              9              9          0.0000000E+00       1.0000000E+30
0
 NEXT SEEDS:  C88894      0      0      0      0      0 33B49B1      0      0      0
        2              8              8          5.0010681E-03       1.0000000E+30
0
 NEXT SEEDS:  C8889A      0      0      0      0      0 33B49B1      0      0      0
        3              7              7          3.3340454E-03       1.0000000E+30
0
      ..
```

EVENTS ALREADY COMPLETED

EVENTS TO BE COMPLETED

AVERAGE CPU TIME CONSUMED PER EVENT