The FLUKA Code: a short introduction

An Introduction to FLUKA:
a Multipurpose Particle Interaction and Transport MC code

21st FLUKA Beginner's Course
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FLUKA

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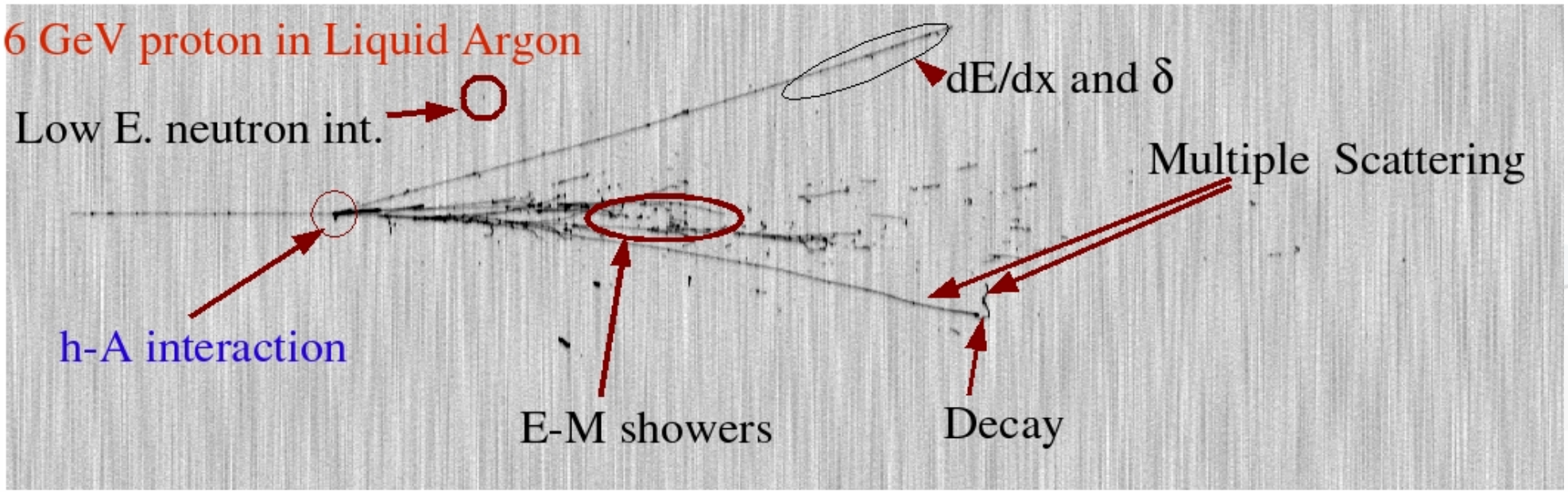

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http://www.fluka.org

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FLUKA short description:

- FLUKA is a general purpose tool for calculations of particle transport and interactions with matter
- All Hadrons (p, n, π, K,pbar, nbar, (anti)hyperons…) [0-10000 TeV]
- Electromagnetic (γ, $e^{+/-}$) and μ and ν [1 keV – 10000 TeV]
- Nucleus-nucleus [0-10000 TeV/n]
- Low energy neutrons (0-20 MeV, multigroup, ENDF…)
- Transport in magnetic field
- Combinatorial (boolean) and Voxel geometries
- Double capability to run either fully analogue and/or biased calculations
- On-line evolution of induced radioactivity and dose
- Radiation damage predictions (NIEL, DPA)
- User-friendly GUI interface thanks to the Flair interface

http://www.fluka.org

Particles transported by FLUKA:

FLUKA name	FLUKA number	Symbol	Common name	Standard PDG number (Particle Data Group) [142]
4-HELIUM (1)	-6	α	Alpha	—
3-HELIUM (1)	-5	^{3}He	Helium 3	—
TRITON (1)	-4	^{3}H	Triton	—
DEUTERON (1)	-3	^{2}H	Deuteron	—
HEAVYION (1)	-2	—	Generic Heavy Ion with Z > 2 (see command HI–PROPE)	—
OPTIPHOT	-1	—	Optical Photon	—
RAY (2)	0	—	Pseudoparticle	—
PROTON	1	p	Proton	2212
APROTON	2	$\bar{p}$	Antiproton	-2212
ELECTRON	3	e^-	Electron	11
POSITRON	4	e^+	Positron	-11
NEUTRIE	5	ν_e	Electron Neutrino	12
ANEUTRIE	6	$\bar{\nu}_e$	Electron Antineutrino	-12
PHOTON	7	γ	Photon	22
NEUTRON	8	n	Neutron	2112
ANEUTRON	9	$\bar{n}$	Antineutron	-2112
MUON+	10	μ^+	Positive Muon	-13
MUON-	11	μ^-	Negative Muon	13
KAONLONG	12	K^0_L	Kaon-zero long	130
PION+	13	π^+	Positive Pion	211
PION-	14	π^-	Negative Pion	-211
KAON+	15	K^+	Positive Kaon	321
KAON-	16	K^-	Negative Kaon	-321
LAMBDA	17	Λ	Lambda	3122
ALAMBDA	18	$\bar{\Lambda}$	Antilambda	-3122
KAONSHRT	19	K^0_S	Kaon-zero short	310
SIGMA-	20	Σ^-	Negative Sigma	3112
SIGMA+	21	Σ^+	Positive Sigma	3222
SIGMAZER	22	Σ^0	Sigma-zero	3212
PIZERO	23	π^0	Pion-zero	111
KAONZERO	24	K^0	Kaon-zero	311
AKAONZER	25	$\bar{K}^0$	Antikaon-zero	-311
Reserved	26	—	—	—
NEUTRIM	27	ν_μ	Muon Neutrino	14
ANEUTRIM	28	$\bar{\nu}_\mu$	Muon Antineutrino	-14
Blank	29	—	—	—

table continues

FLUKA name	FLUKA number	Symbol	Common name	Standard PDG (Particle Data
Reserved	30	—	—	—
ASIGMA-	31	$\bar{\Sigma}^-$	Antisigma-minus	-3222
ASIGMAZE	32	$\bar{\Sigma}^0$	Antisigma-zero	-3212
ASIGMA+	33	$\bar{\Sigma}^+$	Antisigma-plus	-3112
XSIZERO	34	Ξ^0	Xi-zero	3322
AXSIZERO	35	$\bar{\Xi}^0$	Antixi-zero	-3322
XSI-	36	Ξ^-	Negative Xi	3312
AXSI+	37	$\bar{\Xi}^+$	Positive Xi	-3312
OMEGA-	38	Ω^-	Omega-minus	3334
AOMEGA+	39	$\bar{\Omega}^+$	Antiomega	-3334
Reserved	40	—	—	—
TAU+	41	τ^+	Positive Tau	-15
TAU-	42	τ^-	Negative Tau	15
NEUTRIT	43	ν_τ	Tau Neutrino	16
ANEUTRIT	44	$\bar{\nu}_\tau$	Tau Antineutrino	-16
D+	45	D^+	D-plus	411
D-	46	D^-	D-minus	-411
D0	47	D^0	D-zero	421
DOBAR	48	$\bar{D}^0$	AntiD-zero	-421
DS+	49	D_s^+	D_s-plus	431
DS-	50	D_s^-	D_s-minus	-431
LAMBDAC+	51	Λ_c^+	Lambda$_c$-plus	4122
XSIC+	52	Ξ_c^+	Xi$_c$-plus	4232
XSIC0	53	Ξ_c^0	Xi$_c$-zero	4132
XSIPC+	54	$\Xi_c'^+$	Xi$'_c$-plus	4322
XSIPC0	55	$\Xi_c'^0$	Xi$'_c$-zero	4312
OMEGAC0	56	Ω_c^0	Omega$_c$-zero	4332
ALAMBDC-	57	$\bar{\Lambda}_c^-$	Antilambda$_c$-minus	-4122
AXSIC-	58	$\bar{\Xi}_c^-$	AntiXi$_c$-minus	-4232
AXSIC0	59	$\bar{\Xi}_c^0$	AntiXi$_c$-zero	-4132
AXSIPC-	60	$\bar{\Xi}_c'^-$	AntiXi$'_c$-minus	-4322
AXSIPC0	61	$\bar{\Xi}_c'^0$	AntiXi$'_c$-zero	-4312
AOMEGAC0	62	$\bar{\Omega}_c^0$	AntiOmega$_c$-zero	-4332
Reserved	63	—	—	—
Reserved	64	—	—	—

The FLUKA Code design

- Based, as far as possible, on original and well-tested microscopic models
- Full cross-talk between all components:

  hadronic, electromagnetic, neutrons, muons, heavy ions
- It is a "condensed history" MC code, however with the possibility to use single instead of multiple scattering

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

- **The user does not need to choose a "physics list"**
- **The user has, however, the possibility to optimize CPU vs accuracy**

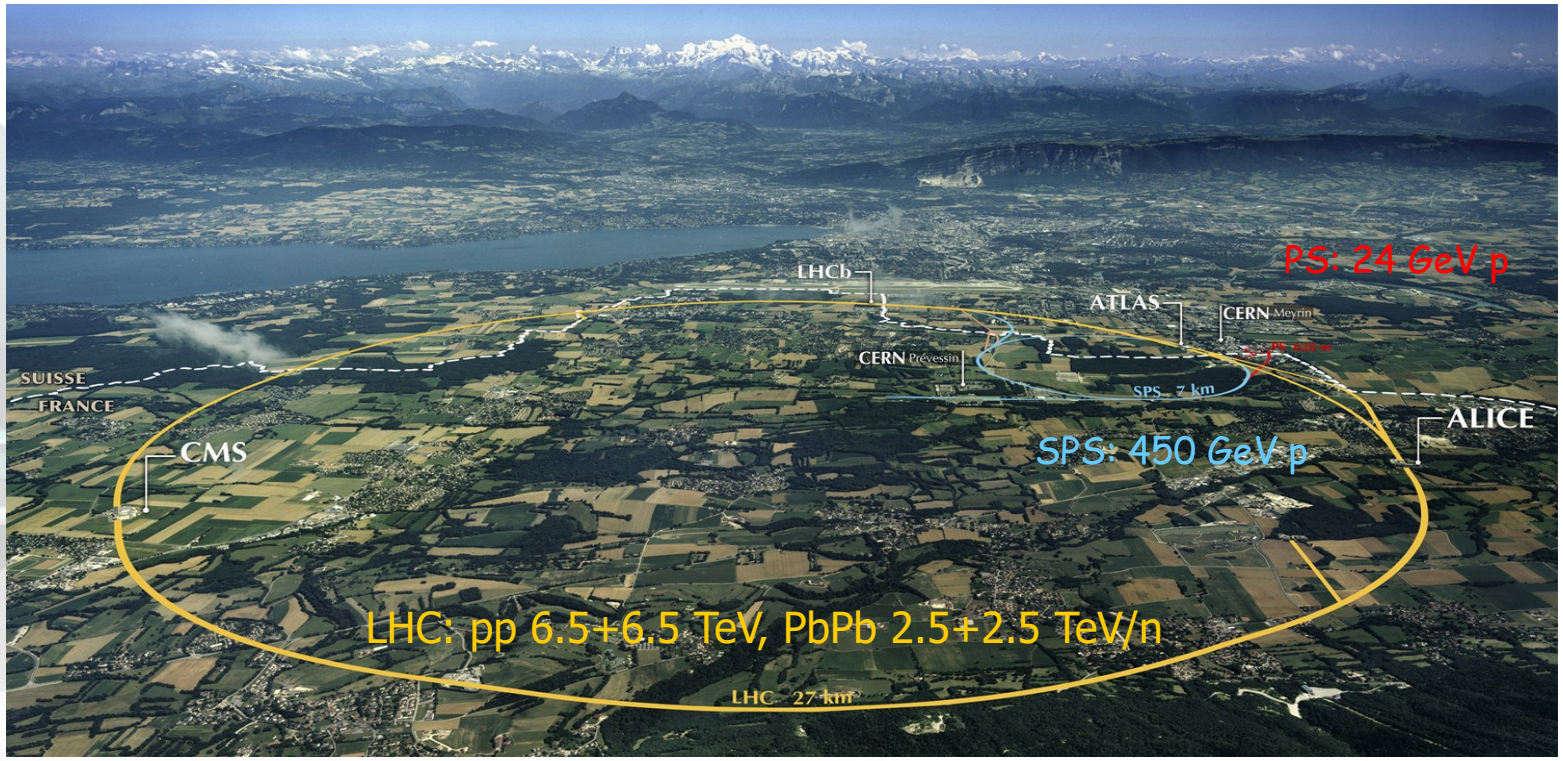
- Fluka provides powerful built-in scoring, tested and suited for most applications
  - **The user does not need to write external code to get results and statistics**

What can be done with FLUKA?

Some examples

FLUKA at CERN

- Shielding, residual dose rates
- Energy deposition
  (quenching and damage)
- Radiation damage
  (electronics, insulation)
- Activation, waste disposal
- Shielding design
- Spallation source (nToF)
- Secondary beams
- Neutrino experiments

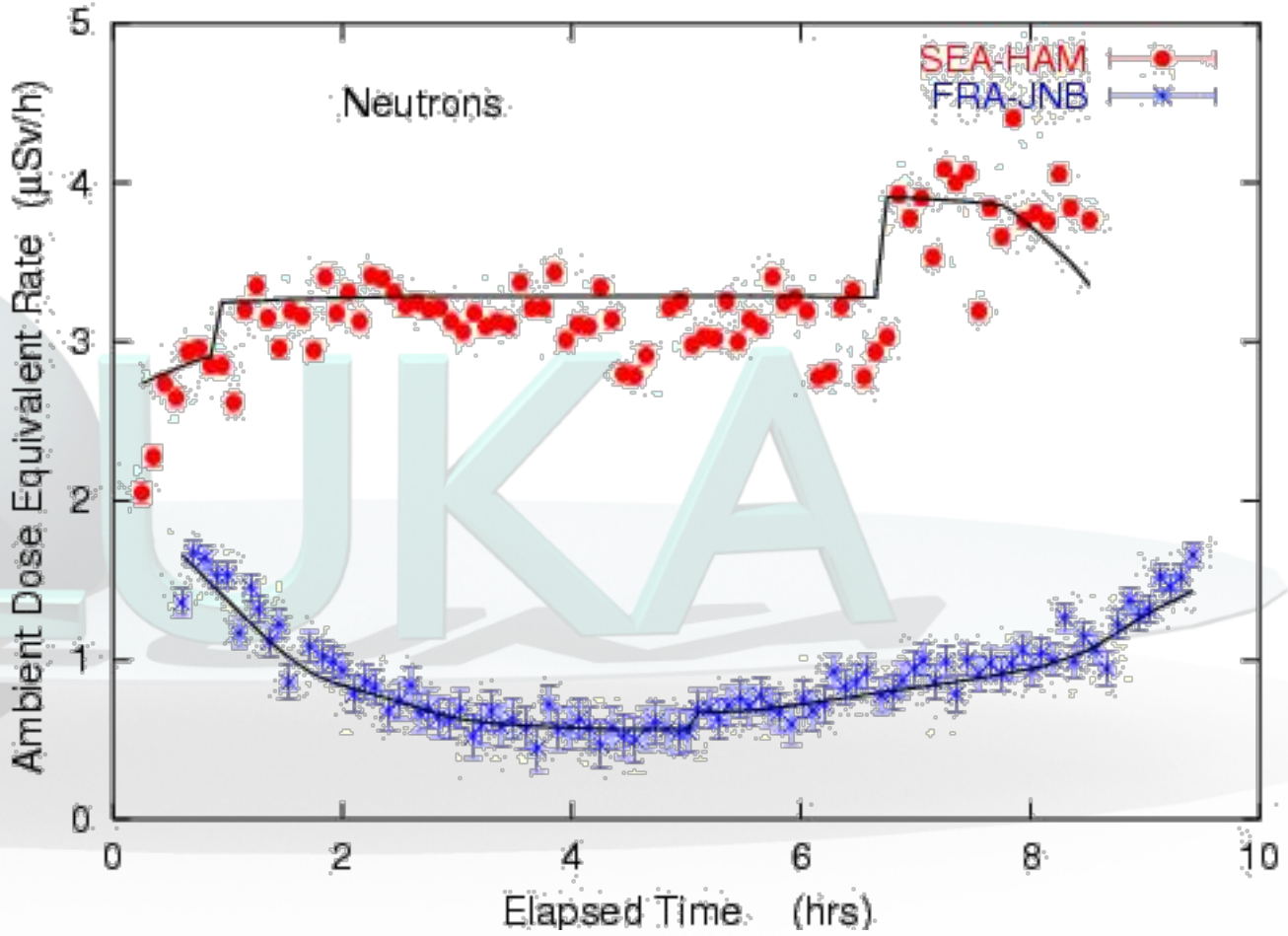


Dosimetry + cosmic rays

Complete simulation of cosmic rays interactions in the atmosphere
- Dedicated "cosmic" package available to users

Model of airplane geometry
Response of dosimeters

Dose to aircrew on commercial flights , depending on route



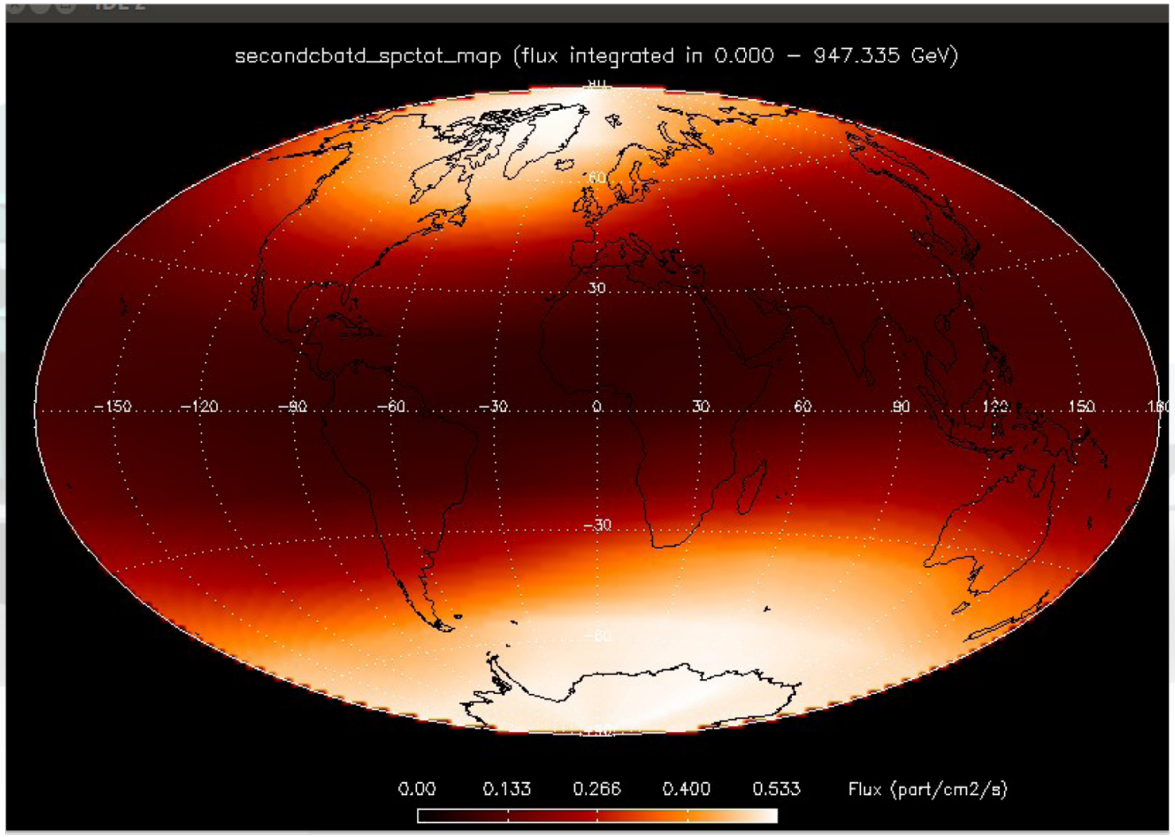
Ambient dose equivalent from neutrons at solar maximum on commercial flights from Seattle to Hamburg and from Frankfurt to Johannesburg.

Solid lines: FLUKA simulation

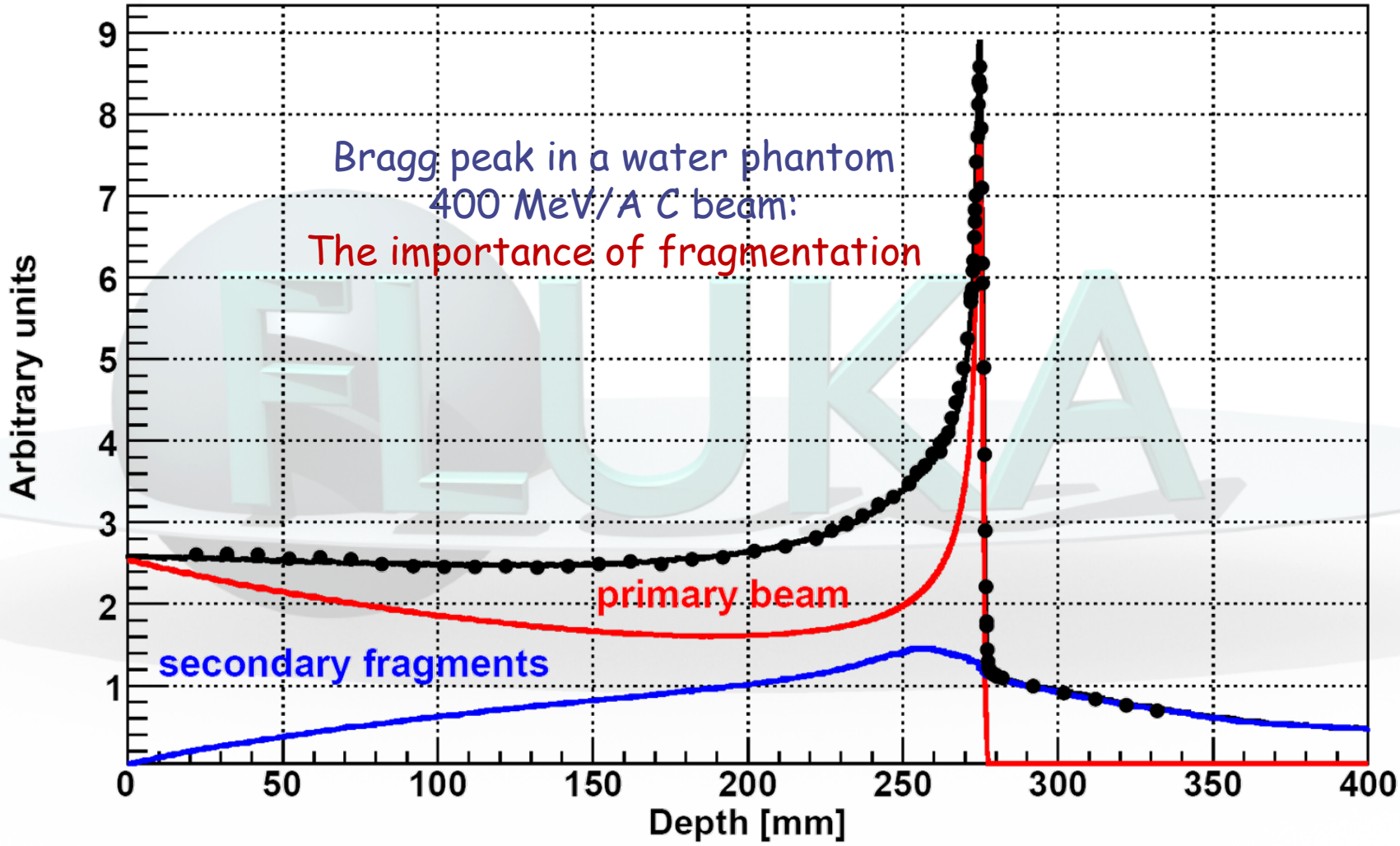
Roesler et al., Rad. Prot. Dosim. 98, 367 (2002)

The neutron albedo from GCR's at 400 km altitude*

*In collaboration with CEA-Saclay



Medical physics : Radiotherapy



Exp. Data (points) from Haettner et al, Rad. Prot. Dos. 2006
Simulation: A. Mairani PhD Thesis, 2007, Nuovo Cimento C, 31, 2008

The FLUKA course: an Introduction

This course is intended to provide users with the basic (and possibly more than basic!) knowledge of:

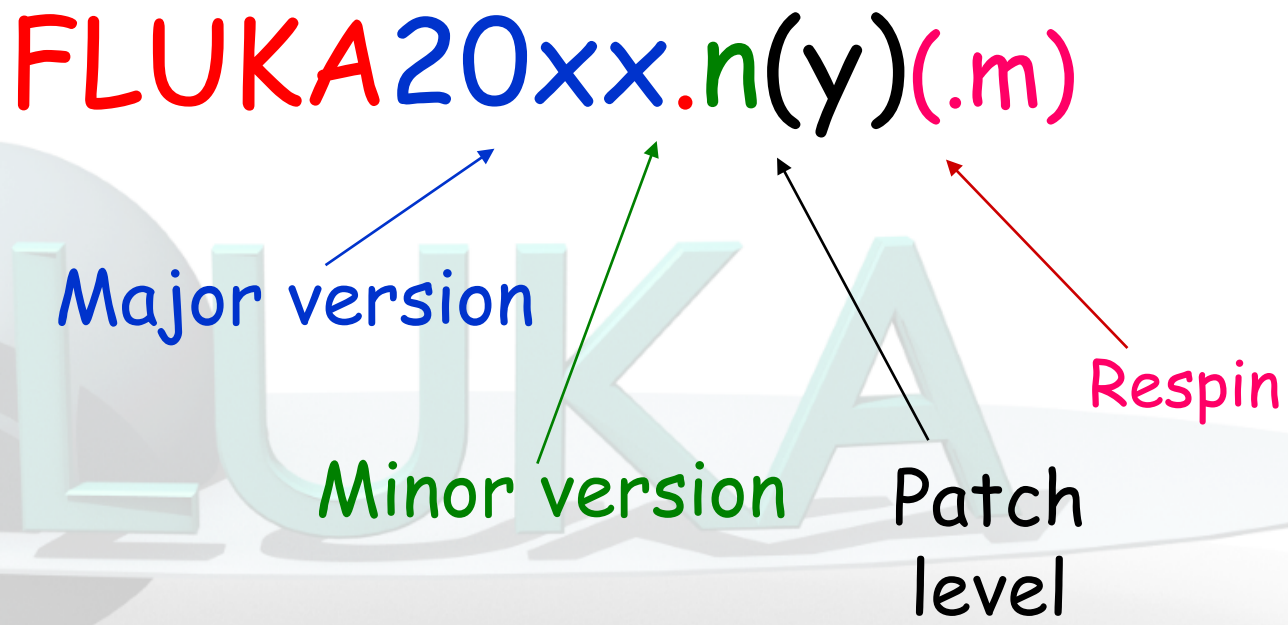
a) The most relevant FLUKA instructions and options
b) The physics models adopted in FLUKA
c) The different scoring options embedded in FLUKA
d) The different running options
e) The tools to plot results
f) The right approach to the existing documentation
g) The procedures to overcome difficulties and problems and related debugging tools
h) etc. etc.

Possible problems

- People here are not all at the same level of FLUKA knowledge. There are those who already have some experience, maybe not negligible.
- However we need to start from scratch.
- We apologize to the experienced people and beg them to be patient: it's not excluded a priori that they can learn something new also concerning the very basic elements!
- FLUKA is written in fortran. No knowledge of fortran or other languages is needed in this course, however some of the terminology used might be derived from fortran. If this happens and gives problems, please ask!
- FLUKA runs in a Linux environment. A basic knowledge of most common Linux commands is required, as well as the capability to use a text editor (emacs, vi, gedit..). If some of you has troubles with this, please tell us

A glimpse of FLUKA

The FLUKA version



In this course we are using FLUKA2011.2x.6

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 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
- For **commercial use**, trial version (limited in time and random seeds) available. Commercial license to be negotiated with CERN & INFN.

Please register on www.fluka.org .....and read the license!

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

Using FLUKA

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

Disclaimer

- A good FLUKA user is **not** one that **only** masters technically the program
- BUT a user that:
  - Indeed masters technically the code;
  - Know its limitations and capabilities;
  - Can tune the simulation to the specific requirements and needs of the problem under study;

  but most of all
  - Has a critical judgment on the results
- Therefore in this course we will equally focus on:
  - The technical aspects of the code
    [building your input, geometry, scoring, biasing, extracting results…]

  as well as
  - The underlying physics and MC techniques

The course team

- Teachers, please introduce yourself

The students

- Students, please introduce yourself, with a word on your application field

Thanks for your attention!