



# Introduction to FLUKA

# Where we come from

- FLUKA was born in the 60's at **CERN** with [Johannes Ranft](#)
- It was further developed in the 70s and 80s in a collaboration between **Leipzig University**, **CERN** and **Helsinki University** for applications, e.g., at CERN's high energy accelerators, and in the 90s with **INFN**, among others for the design of SSC and LHC
- From 2003 until August 2019 maintained and developed under a **CERN & INFN** agreement
- From December 2019, new **CERN** distribution aiming to ensure FLUKA's long-term sustainability and capability to meet the evolving requirements of its user community, [welcoming contributions by both established FLUKA contributors as well as new partners within an international collaboration](#).
- Presently a joint development & management team based in the **CERN Accelerators and Technology Sector and Radiation Protection Group and at ELI-Beamlines (Prague)**, with contributors from the CERN Research and Computing Sector and JRC Geel, is in place.

# FLUKA.CERN distribution

<https://fluka.cern>



Release of FLUKA 4-0.1  
2020-08-24 - [Release](#)

FLUKA online training for beginners (Sept/Oct 2020)  
2020-08-01 - [Event](#)

Release of FLUKA 4.0 and Flair 3.1  
2020-06-30 - [Release](#)

FLUKA online training in autumn 2020  
2020-06-29 - [Event](#)

[more](#)

**FLUKA 4-0.1**, 2020-08-24

**Flair 3.1-2<sup>nd</sup>**, 2020-07-10

Registration problems? Enquiry about a commercial license? Enquiry about an institutional license for accessing the source code? Feedback to the website?

Use the [contact form](#).

**About FLUKA**

- Installing, Running and Runtime Errors**  
Category for questions related to installing and running FLUKA and Flair
- Flair**  
Category for questions related to the graphical user interface Flair
- Source Definition**  
Category for questions concerning built-in source options, like particle beams, hadron-fluxion options or hadronic sources
- Geometry and Materials**  
Category for material and geometry-related questions including topics like transformations and lattices
- Scoring and Biasing**  
Category for questions related to built-in scoring and biasing options
- Physics, Transport and Magnetic Fields**  
Category for physics-related questions, as well as questions on transport and magnetic field settings
- Advanced Features and User Routines**  
Category for questions on user routines and other advanced features
- Applications**  
Category for application-related questions, including topics such as medical physics and detector simulations

**User Forum**

**Download**

**Documentation**

**Flair Graphical User Interface**

**Courses and events**

## Version history:

FLUKA 2011-3 released on December 2019

**FLUKA 4-0** released on June 2020

FLUKA 4-0.1 released on August 2020

FLUKA 4-1 released on November 2020

FLUKA 4-1.1 released on February 2021












FLUKA 4-2 released on October 2021

FLUKA 4-2.1 released on December 2021

**FLUKA 4-2.2** released on **March 2022**

# A fresh reference

## New Capabilities of the FLUKA Multi-Purpose Code

 C. Ahdida<sup>1</sup>,  D. Bozzato<sup>1,2</sup>,  D. Calzolari<sup>1</sup>,  F. Cerutti<sup>1\*</sup>,  N. Charitonidis<sup>1</sup>,  A. Cimmino<sup>3</sup>,  A. Coronetti<sup>1,4</sup>,  G. L. D'Alessandro<sup>1</sup>,  A. Donadon Servelle<sup>1,5</sup>,  L. S. Esposito<sup>1</sup>,  R. Froeschl<sup>1</sup>,  R. García Alía<sup>1</sup>,  A. Gerbershagen<sup>1</sup>,  S. Gilardoni<sup>1</sup>,  D. Horváth<sup>3</sup>,  G. Hugo<sup>1</sup>,  A. Infantino<sup>1</sup>,  V. Kouskoura<sup>1</sup>,  A. Lechner<sup>1</sup>,  B. Lefebvre<sup>3</sup>,  G. Lerner<sup>1</sup>,  M. Magistris<sup>1</sup>,  A. Manousos<sup>1,6</sup>,  G. Moryc<sup>1</sup>,  F. Ogallar Ruiz<sup>1,7</sup>,  F. Pozzi<sup>1</sup>,  D. Prelicpean<sup>1,8</sup>,  S. Roesler<sup>1</sup>,  R. Rossi<sup>1</sup>,  M. Sabaté Gilarte<sup>1</sup>,  F. Salvat Pujol<sup>1</sup>,  P. Schoofs<sup>1</sup>,  V. Stránský<sup>3</sup>,  C. Theis<sup>1</sup>,  A. Tsinganis<sup>9</sup>,  R. Versaci<sup>3</sup>,  V. Vlachoudis<sup>1</sup>,  A. Waets<sup>4</sup> and  M. Witorski<sup>1</sup>

**ORIGINAL RESEARCH article**

Front. Phys., 27 January 2022 | <https://doi.org/10.3389/fphy.2021.788253>

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<sup>9</sup>European Commission, Joint Research Centre (JRC), Geel, Belgium

### TABLE OF CONTENTS

Abstract

1 Introduction

2 New Physics Developments

3 Flair, the FLUKA User Interface

4 Radiation to Electronics

5 Code Testing and Benchmarking

6 Outlook

Data Availability Statement

Author Contributions

Conflict of Interest

Publisher's Note

Acknowledgments

Footnotes

References

# Licensing Scheme

## Registration options

### FLUKA **Single User License Agreement**

Affiliates of institutes with a FLUKA **Institutional License Agreement**

CERN Staff members and Fellows

Affiliates of institutes which signed the FLUKA **Memorandum of Understanding**

Companies which purchased a FLUKA **Commercial License Agreement**

*Includes access to the*

**source code**

**development version**

- **Licenses are free** except for commercial use
- They are granted for **non-military use** only

# User Support

## FLUKA User Forum

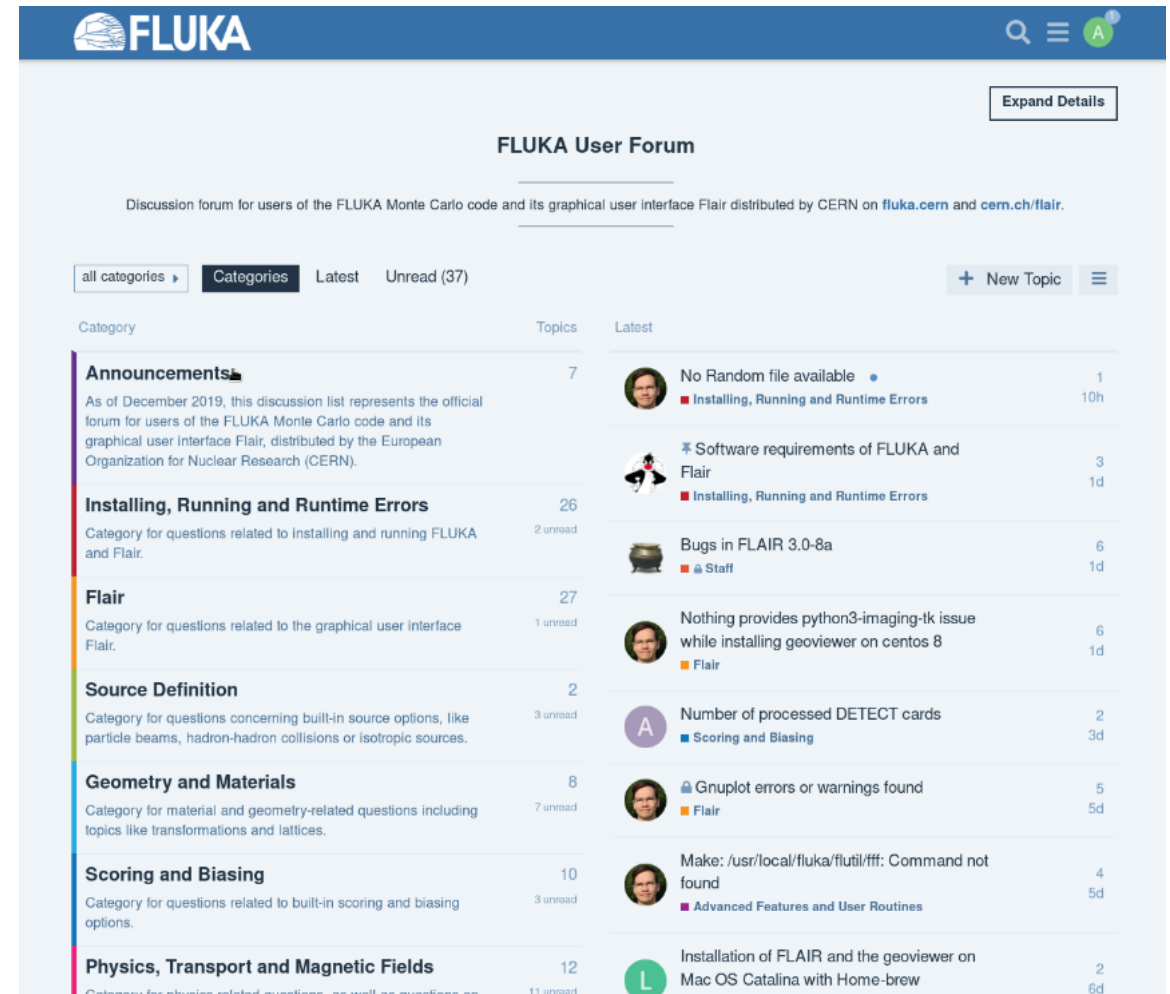
<https://cern.ch/fluka-forum>

**Note:** an independent one time registration is required to be able to participate

## FLUKA Training

Three Beginner Online Training courses were held 2020 and one in 2021.

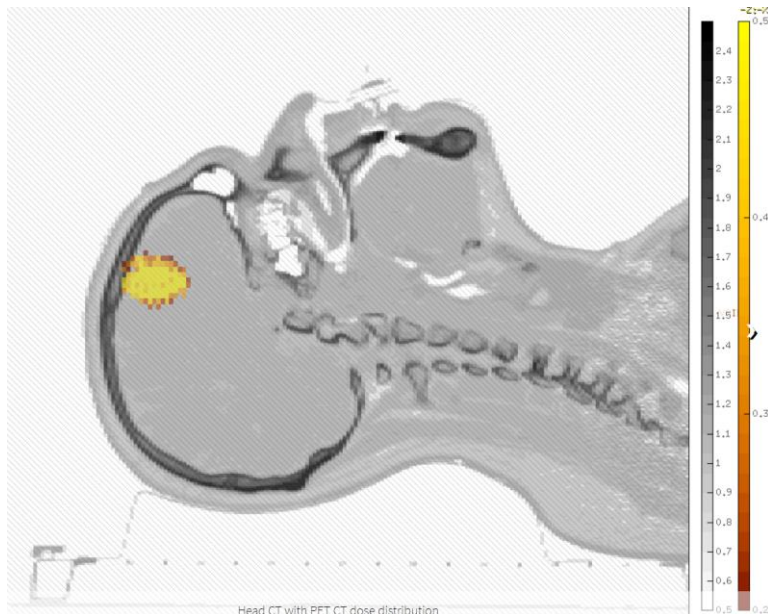
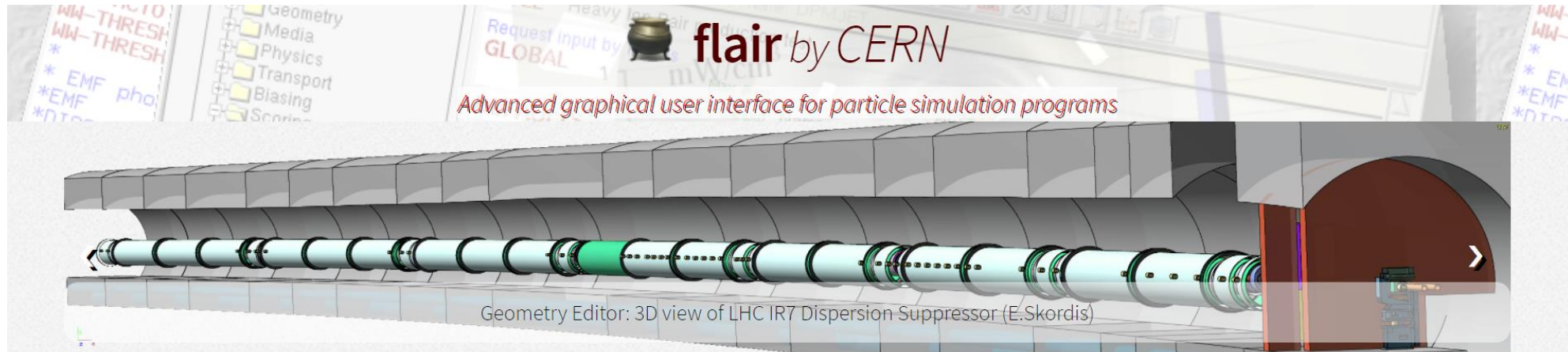
Advanced course planned for spring 2023 in the US.



The screenshot shows the FLUKA User Forum interface. At the top, there is a blue header with the FLUKA logo and navigation icons. Below the header, the forum title "FLUKA User Forum" is displayed, along with a description: "Discussion forum for users of the FLUKA Monte Carlo code and its graphical user interface Flair distributed by CERN on fluka.cern and cern.ch/flair." There are buttons for "Expand Details", "all categories", "Categories", "Latest", "Unread (37)", and "+ New Topic". The main content area is divided into two columns: "Category" and "Latest". The "Category" column lists various topics with their respective counts and unread status. The "Latest" column shows a list of recent posts with user avatars, titles, and timestamps.

Category	Topics	Latest
<b>Announcements</b> As of December 2019, this discussion list represents the official forum for users of the FLUKA Monte Carlo code and its graphical user interface Flair, distributed by the European Organization for Nuclear Research (CERN).	7	
<b>Installing, Running and Runtime Errors</b> Category for questions related to installing and running FLUKA and Flair.	26 2 unread	No Random file available ■ Installing, Running and Runtime Errors 10h
<b>Flair</b> Category for questions related to the graphical user interface Flair.	27 1 unread	Software requirements of FLUKA and Flair ■ Installing, Running and Runtime Errors 3 1d
<b>Source Definition</b> Category for questions concerning built-in source options, like particle beams, hadron-hadron collisions or isotropic sources.	2 3 unread	Bugs in FLAIR 3.0-8a ■ Staff 6 1d
<b>Geometry and Materials</b> Category for material and geometry-related questions including topics like transformations and lattices.	8 7 unread	Nothing provides python3-imaging-tk issue while installing geoviewer on centos 8 ■ Flair 6 1d
<b>Scoring and Biasing</b> Category for questions related to built-in scoring and biasing options.	10 3 unread	Number of processed DETECT cards ■ Scoring and Biasing 2 3d
<b>Physics, Transport and Magnetic Fields</b> Category for physics-related questions. as well as questions on	12 11 unread	Gnuplot errors or warnings found ■ Flair 5 5d
		Make: /usr/local/fluka/flutil/fff: Command not found ■ Advanced Features and User Routines 4 5d
		Installation of FLAIR and the geoviewer on Mac OS Catalina with Home-brew ■ 2 6d

<https://flair.cern>



## Authors

authors: Vasilis Vlachoudis (lead author)  
Christian Theis  
Wioletta Kozłowska

## Current Version

- Latest version: 3.1-15.1
- Released on: *Fri 22-Oct-2021*
- Powered by python3, tkinter, gnuplot, pydicom

## Features

- modern and intuitive design
- Input editor for error free inputs
- Interactive geometry editor, photorealistic ray tracer and debugger
- run and monitor the simulation
- back-end for post-processing of results
- I/O of other simulation formats (MCNPX,GDML,...)
- Medical file importing, DICOM, RT-PLAN,DOSE,...
- extended material library

# Microscopic process modeling for macroscopic quantity assessment

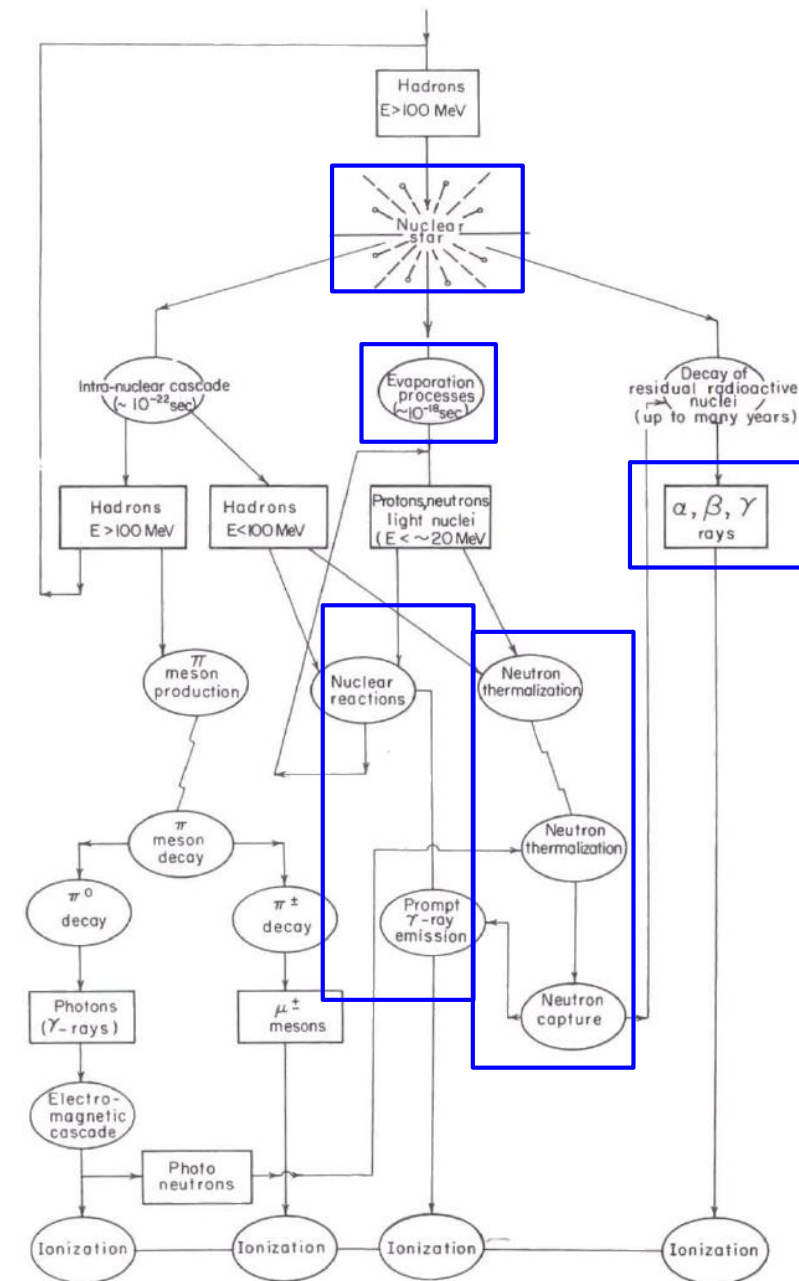
A (hadronic) shower implies a lot of different physics processes, touching a very broad energy [time-space] scale

Its description relies on the organic integration of diverse **theories and models**, and requires as essential pieces of **information**:

- reaction cross sections
- exclusive fragment production
- nuclide structure and decay data
- evaluated quantities of neutron induced reactions

Monte Carlo simulation is an effective way to calculate **macroscopic quantities** (such as energy deposition, dpa, particle fluence, activation and residual dose rate) with an accuracy reflecting the quality of the critical processes implementation

Multipurpose widespread codes are available: FLUKA, GEANT4, MARS, MCNP, PHITS, ...





# FLUKA capabilities

- hadron-hadron and hadron-nucleus interactions
- nucleus-nucleus interactions (including deuterons!)
- photon interactions (>100 eV)
- electron interactions (> 1 keV; including electronuclear)
- muon interactions (including photonuclear)
- neutrino interactions
- low energy (<20 MeV) neutron interactions and transport
- particle decay
- ionization and multiple (single) scattering (including all ions down to 250 eV/u)
- coherent effects in crystals (channelling)
- magnetic field, and electric field in vacuum
- combinatorial geometry and lattice capabilities
- voxel geometry and DICOM importing
- analogue or biased treatment
- on-line buildup and evolution of induced radioactivity and dose
- built-in scoring of several quantities (including DPA and dose equivalent)

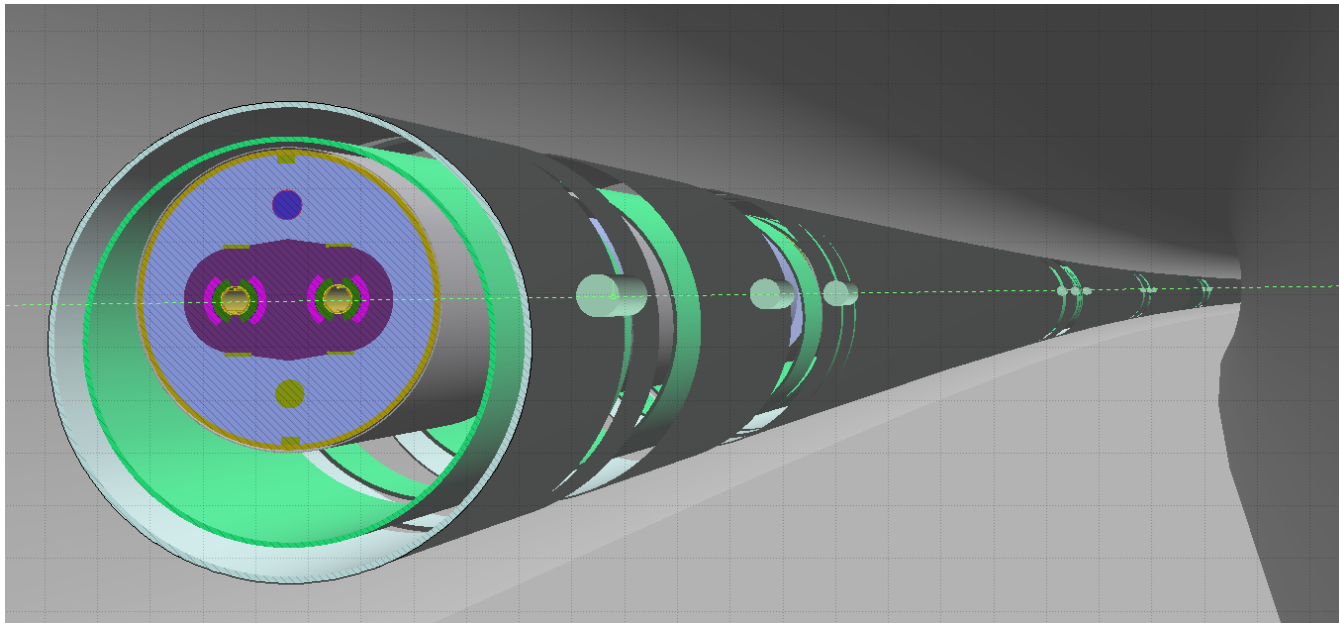
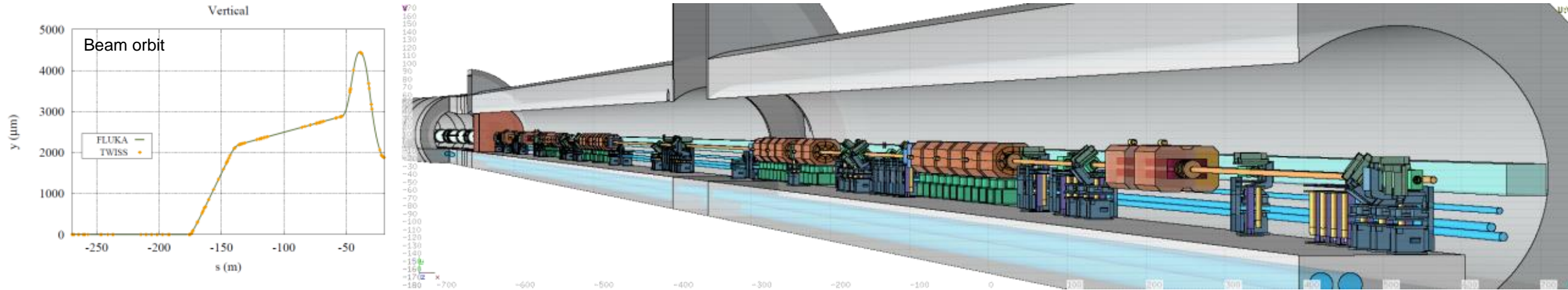
In support of a  
**wide range of applications**

- ✓ Accelerator design
- ✓ Particle physics
- ✓ Cosmic ray physics
- ✓ Neutrino physics
- ✓ Medical applications

- ✓ Radiation protection (shielding design, activation)
- ✓ Dosimetry
- ✓ Radiation damage
- ✓ Radiation to electronics effects
- ✓ ADS systems, waste transmutation
- ✓ Neutronics

# Some examples

# Accelerator geometries



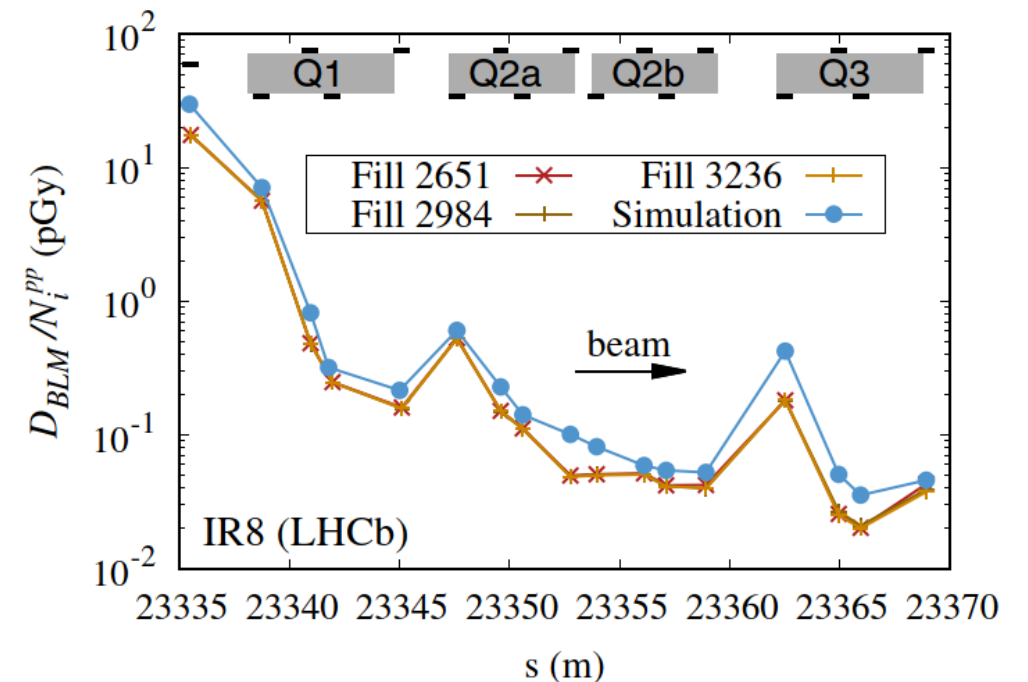
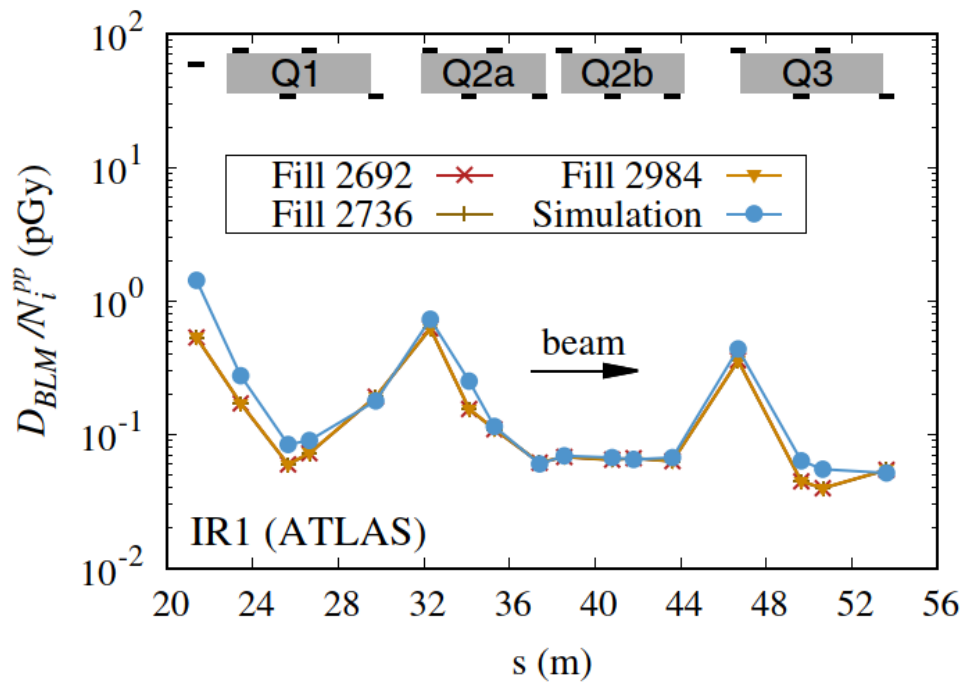
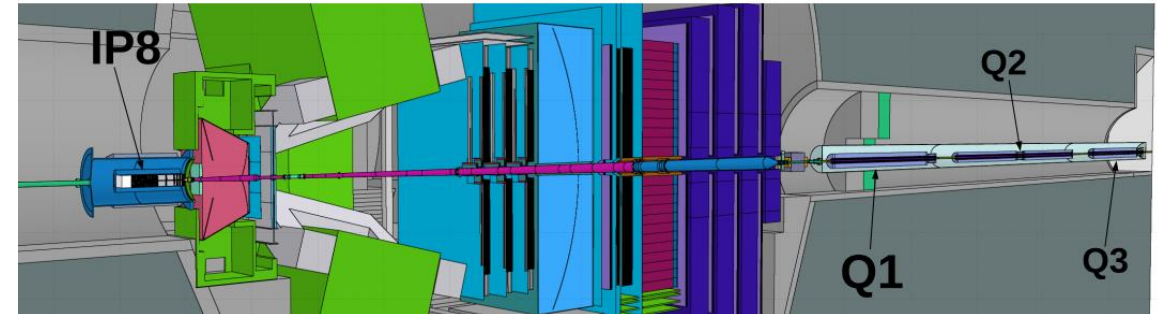
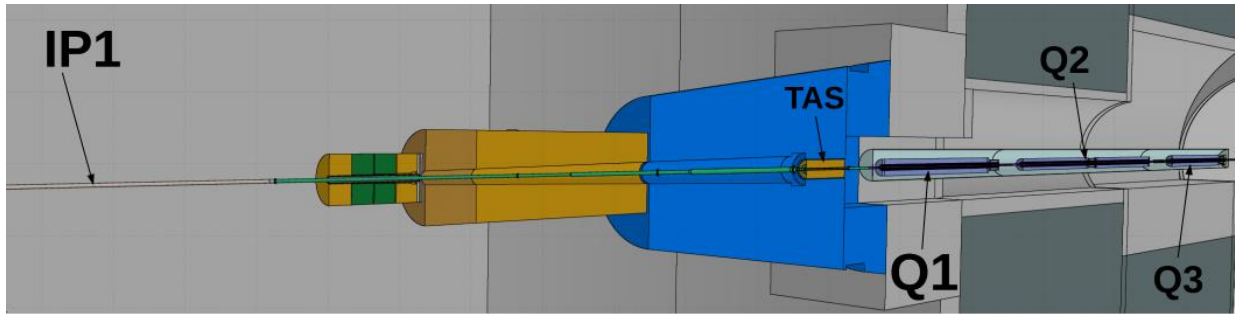
From DETAILED MODELS OF ACCELERATOR COMPONENTS WITH ASSOCIATED SCORING and the ELEMENT SEQUENCE AND RESPECTIVE MAGNETIC STRENGTHS, as given IN THE MACHINE OPTICS (TWISS) FILES, the **AUTOMATIC CONSTRUCTION OF COMPLEX BEAM LINES**, including collimator settings and element displacement (BLMs), is achievable, profiting from roto-translation directives and replication (lattice) capabilities.

## LINE BUILDER

[A. Mereghetti et al.,  
IPAC2012, WEPPD071, 2687]

# Beam loss description at the LHC

[A. Lechner et al.,  
Phys. Rev. AB 22 (2019) 071003]



# Activation benchmarking

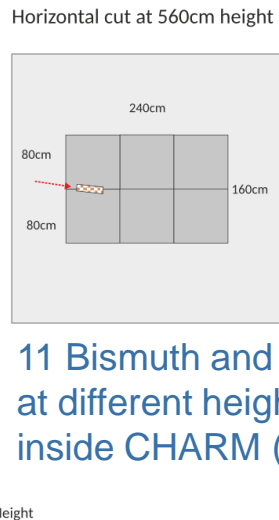
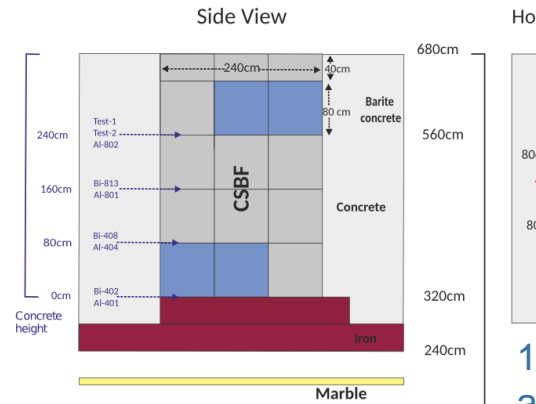
@ CERN SHIELDING BENCHMARK FACILITY (24 GeV/c p)

[E. Iliopoulou and R. Froeschl]

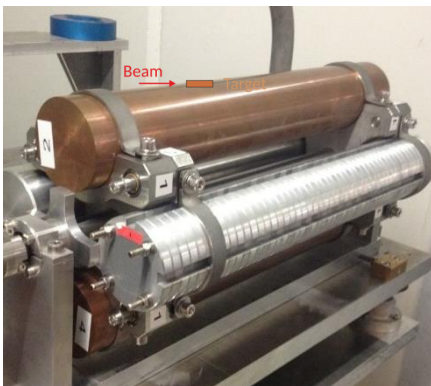
Situated laterally above the CHARM target

for deep shielding penetration studies (Detector calibration, Detector inter-comparison, Activation)

360cm of concrete and barite concrete  
plus 80cm of cast iron



11 Bismuth and Aluminum samples  
at different heights in CSBF and also  
inside CHARM (@ -80cm)

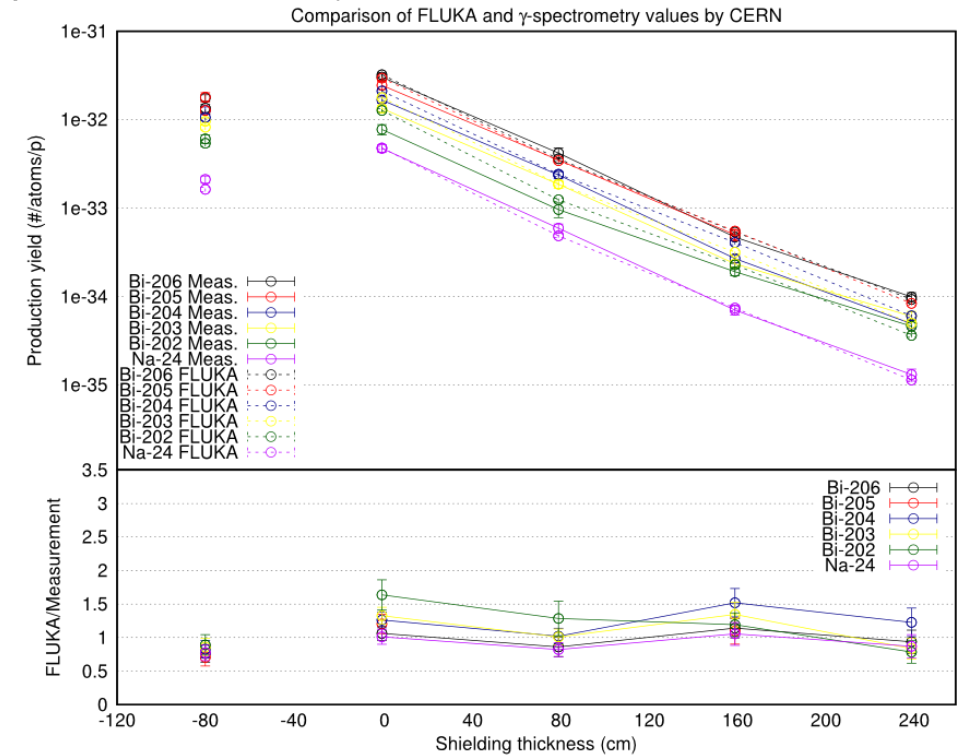


@ CHARM (CERN High energy AcceleRator Mixed field facility,

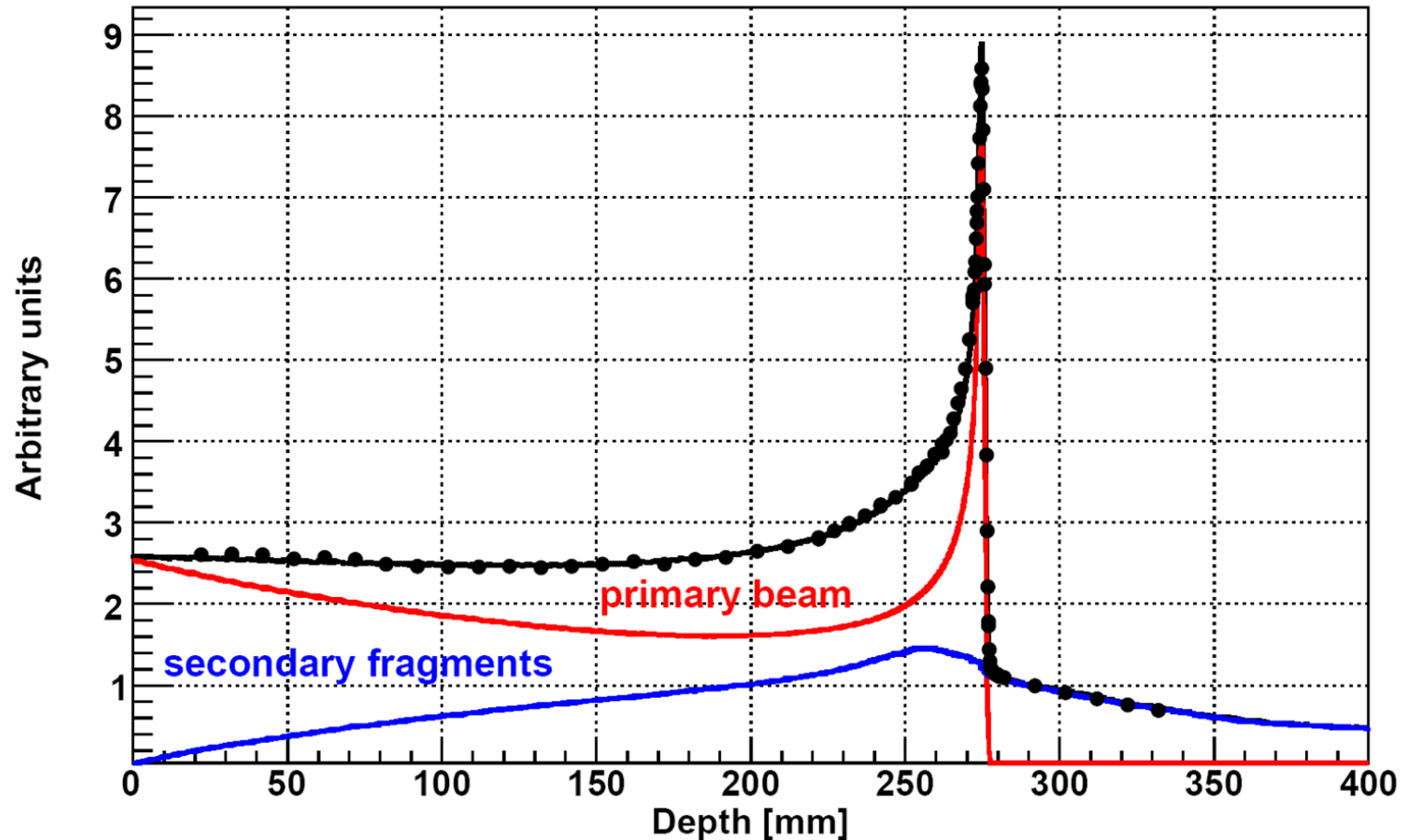
to study radiation effects on electronic components)

$5 \times 10^{11}$  protons/pulse, 350ms pulse length, max. average beam intensity  $6.6 \times 10^{10}$  p/s

three 50cm long 8cm diameter targets: Copper, Aluminum, Aluminum with holes



# Medical physics: radiotherapy



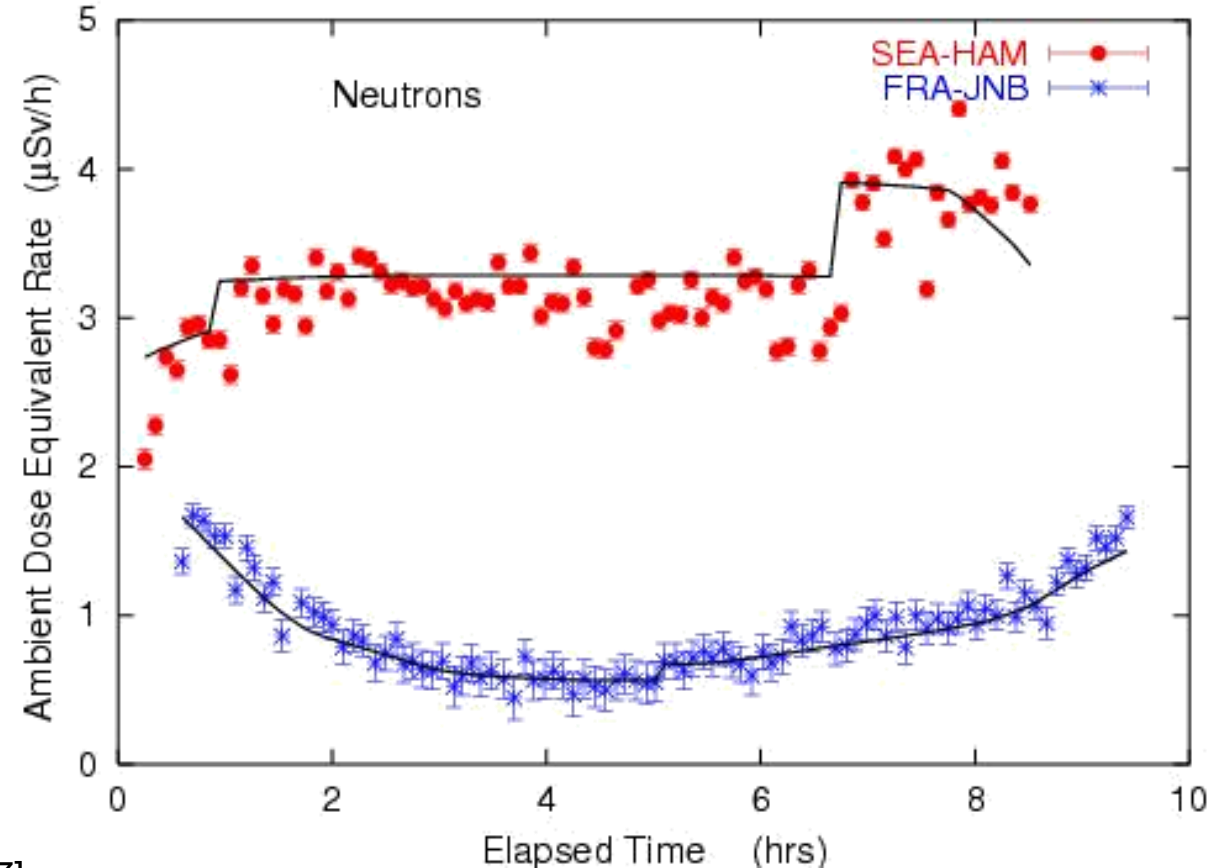
Bragg peak in a water phantom  
400 MeV/A C beam:  
The importance of fragmentation

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

# Dosimetry and cosmic rays

- Complete simulation of cosmic rays interactions in the atmosphere, by means of a dedicated CR package available to users
- Model of airplane geometry
- Response of dosimeters

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



[Solid lines: FLUKA simulation  
S. Roesler et al.,  
Rad. Prot. Dosim. 98 (2002) 367]

# Program of this course



# Schedule of the week

**Monday**




**Tuesday**

**Wednesday**

**Thursday**

**Friday**

	8	9	10	11	12	13	14	15	16	17	18
Monday	Introduction	Teachers/ participants Introduction	Coffee	Monte Carlo Basics	Basic Input / Introduction to Flair	Lunch	Basic Input / Flair 1st run	Geometry I	Coffee	Geometry I	
Tuesday	Geometry Editor	Geometry Editor	Coffee	Materials	Materials	Lunch	Scoring I : Intro & USBIN	Scoring I : Intro & USBIN	Coffee	Simple source & preprocessor	Simple source & preprocessor
Wednesday	EM & Thresholds	EM & Thresholds	Coffee	Scoring II : diff. spec.	Scoring II : diff. spec.	Lunch	Intermediate use of Flair	EM fields	Coffee	EM fields	Standard output and errors
Thursday	Interactions	Biasing	Coffee	Biasing	Geom II	Lunch	Geometry II	Source routines	Coffee	Source routines	
Friday	Activation and Scoring III	Activation and Scoring III	Coffee	Wrap Up Exercise		Lunch	Course Evaluation	Advanced Sources	Advanced topics	Coffee	

	Lecture
	Exercise
	Pause

Many thanks to **ULB**: Marie-Mo VAEYENS, Nicolas PAULY, Pierre-Etienne LABEAU, Cedric HERNALSTEENS

