Bridging Monte-Carlo worlds: A new framework for accelerators simulations

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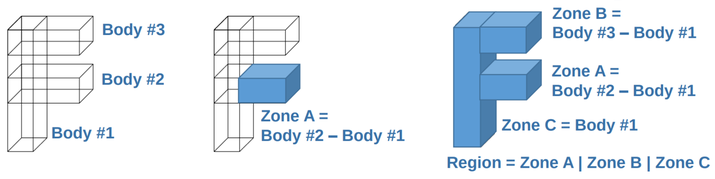
The PhD thesis can be divided in two parts: **Development** and **BLM benchmarking simulations**.
The **development stage** consists of creating the new code, preliminary called «Moira»,
a Geant4 application that provides to the user a FLUKA experience with the Geant4 toolkit.
The **simulations stage** involves using the new framework to perform BLM benchmarking studies in the LHC accelerator. The SY-STI-BMI group does these type of simulations mainly in points of the LHC were the radiation is high and these results are crucial to avoid damages in the accelerator.
Thus, the plan is to perform BLM benchmarking simulations of LHC sections and CERN facilities until the new code reaches a situation of development and confidence that allows to do any simulation executed by BMI.

Development: Moira - The New Framework

FLUKA-Geant4 Bridge

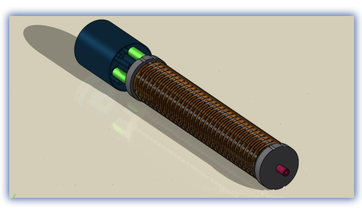
Combinatorial Geometry



- Moira: Hybrid G4 ”application” that provides FLUKA experience using the Geant4 toolkit:
  - Geometry description equivalent to FLUKA (Combinatorial Geometry)
  - Two ASCII files as input files:
    - For Geometry: Textgeom (+ extension)
    - For the rest of components: UI commands via macro file
  - Fully integrated with Flair (built in + own commands)

Simulations: BLM Benchmarking

Beam Loss Monitoring (BLM) system



- Series of ionization chambers utilized for accelerator machine protection
- In the LHC, there are approx. 3600 of these chambers at critical loss locations
- The losses measured by the BLMs are integrated and compared to defined thresholds.
  It defines if the beam should be abort or not.

BLM Benchmarking

- In a particle accelerator, beam losses affect in several ways the collider equipment and operation
- Studies are crucial to assess the losses effects and develop mitigation strategies
- BLM benchmarking is one of the studies performed by BMI. (FLUKA simulations)
- BLM calculation: Estimate results that would be obtain in a real run. Results used to compare with experimental data, or to predict the radiation layout in a future run (e.g. HL-LHC, FCC)

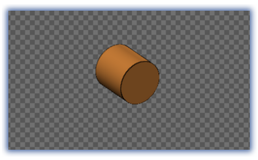
State of the Art: Moira Status

+Geometry

- Analog FLUKA geometry:
  BODIES ⇔ FLUKA BODIES
  CELL ⇔ FLUKA REGION
  G4Zone ⇔ FLUKA ZONE
- A Moira External Navigator performs the tracking in G4Zone
- .moira file as an input

```
// Default identity rotation matrix
:ROTM __IDENT__ 0 0 0

//
// Cylindrical target
:BODY target RCC 0.0 0.0 0.0 0.0 0.0 100.0 50.0
// Void sphere
:VOLU void ORB 1000.0 G4_Galactic
// Void around
:CELL VOID void G4_Galactic +void -target
// Target volume
:CELL TARGET void G4_Cu +target
```



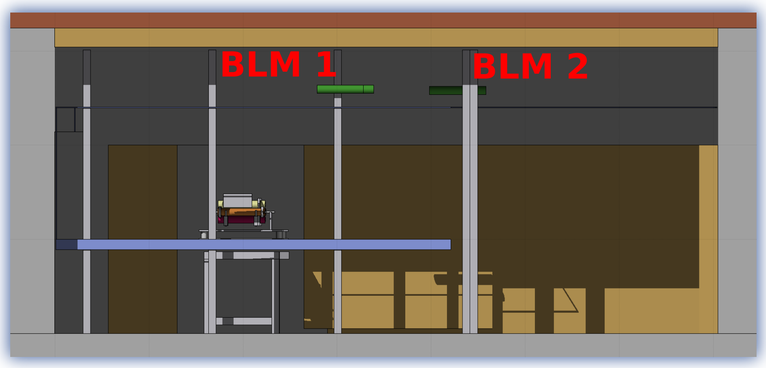
+Everything -Geometry

- Physics:
  Physics lists: Set of many physics constructors
- Scoring: Mesh scoring, Track length, boundary crossing, particle track visualization
- Biasing: Importance, Weight Window, Leading particle (EM, hadronic)
- Magnetic Fields: Multipoles, 2D/3D interpolated fields, userdefined

Flair

- Input Editor
- Inspecting the files and progress of a run
- Merging all output data files to combine the statistics
- Some basic plotting (geometry, mesh, 1D and 2D distributions)
- **Partial conversion of a FLUKA input file to Moira**

First results: CHARM Facility



The aim of the CHARM facility is to have a flexible and dedicated place for the testing of electronics and systems.

	FLUKA Dose [Gray/primary]	Moira Dose [Gray/primary]
BLM 1	$55.85 \pm 2.04 \times 10^{-15}$	$43.05 \pm 1.34 \times 10^{-15}$
BLM 2	$33.68 \pm 1.48 \times 10^{-15}$	$250.1 \pm 8.9 \times 10^{-16}$

Road Map

- Test in simple cases, with different beams, the scoring, physics models, biasing, thresholds, etc
- Advance with more and more complicated cases like sections of the tunnel
- Complete tunnel and realistic beam losses, obtaining BLM outputs
- Compare results with FLUKA and experimental measurements
- Improve convergence with the use of biasing techniques