Towards the emulation of BLOB, a nuclear interaction model, with Deep Learning

L. Arsini[1,2], B. Caccia[3], A. Ciardiello[2], M. Colonna[4], R. Faccini[1,2], S. Giagu[1,2], P. Napolitani[5], F. Nicolanti[1,2], C. Mancini-Terracciano[1,2]

[1]Department of Physics, University of Rome "La Sapienza", Rome, Italy.
[2]INFN, Section of Rome, Rome, Italy
[3]Istituto Superiore di Sanità, Rome, Italy
[4]INFN, LNS, Catania, Italy
[5]IPN, CNRS/IN2P3, Orsay Cedex, France

Background: Nuclear interaction models are a key component in Monte Carlo (MC) simulations for Ion-therapy [1]. Geant4 [2] is one of the most widely used MC toolkit, also for Ion-therapy simulations. Despite the relevance of the applications, Geant4 models have severe limitations in reproducing the secondary yield measures in ion interactions below 100 MeV/n [3]. To mitigate such a shortcoming, we interfaced a model well suited to describe these reactions, namely the BLOB ("Boltzmann-Langevin One Body") model [4], with Geant4, obtaining promising results [5]. However, the BLOB computation time is too large (several minutes to simulate one interaction) for medical applications. Thus, we developed a generative Deep Learning algorithm to emulate BLOB [6]; interfacing it with Geant4 will allow one to have predictions as precise as using BLOB, without its computing overhead.

Material and Methods: BLOB is among the most advanced transport approaches used to handle the first stage of nuclear collisions at a few hundreds of MeV/n and below. The BLOB final output is a Probability Density Function (PDF) of having a nucleon in a position of the phase space. The physical final state, i.e.: the fragments and their properties and the nucleons emitted in the first stage of the interaction, is sampled from such a PDF. We trained a Deep Learning algorithm, in particular a Variational Auto-Encoder (VAE), to emulate the BLOB final states and interfaced it with Geant4.

Preliminary results: We will present the preliminary results obtained coupling the VAE decoder with the Geant4 de-excitation model for the simulation of the interaction of ^{12}C with a fixed ^{nat}C target. We ported the decoder in ONNX, to interface it with Geant4 in C++. The code will be soon released, jointly with a container to run it.

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