Improved muon decay simulation with Geant4 and McMule (A. Gurgone et al.)

- The **MEG II experiment** searches for $\mu^+ \to e^+\gamma$ with a sensitivity of $6 \cdot 10^{-14}$.
- The physics programme can be extended with the search for **axion-like particles** in muon decays: $\mu^+ \to e^+X$, $\mu^+ \to e^+X\gamma$ or $\mu^+ \to e^+(X \to \gamma\gamma)$.
- The only signature of $\boldsymbol{\mu^+ \to e^+X}$ is a monochromatic positron close to the kinematic endpoint of the $\boldsymbol{\mu^+ \to e^+\nu_e\bar{\nu}_\mu}$ background ($E_e \simeq 52.83$ MeV).
  $\hookrightarrow$ The hunt for such an elusive signal requires exhaustive MC simulations.
- Implementation of a new **positron event generator** based on **McMule**, a framework for the computation of radiative corrections for low-energy processes with leptons.
  $\hookrightarrow$ $\mu^+ \to e^+X$ at NLO and $\mu^+ \to e^+\nu_e\bar{\nu}_\mu$ at NNLO + NLL.
  $\hookrightarrow$ Best theory error on the positron energy spectrum achieved so far.
- Simulation of event reconstruction with the MEG II **positron spectrometer**.
- Feasibility study of searching for $\mu^+ \to e^+X$ for different masses ad couplings.
  $\hookrightarrow$ Preliminary results show a **competitive sensitivity** around $10^{-5} \div 10^{-6}$.
- The new event generator is fundamental to improve the sensitivity at the endpoint, where the higher-order corrections are enhanced by the emission of soft photons.
- A rigorous control of the **systematic effects** on the positron energy reconstruction is required to avoid signal biases $\to$ New calibration tools in development.