

PROPOSAL update

Jan Soedingrekso, Jean-Marco Alameddine

October 19, 2020

Technische Universität Dortmund

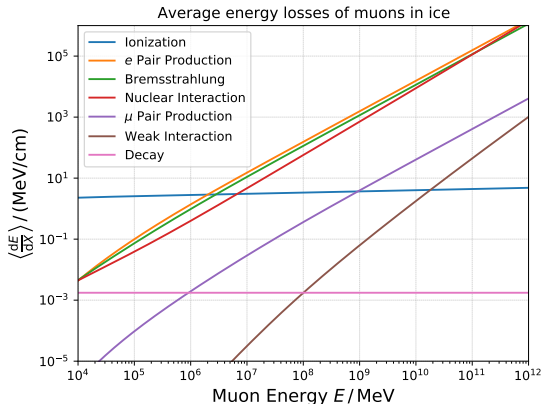
PRopagator with Optimal Precision and Optimal Speed for All Leptons

- Successor of MMC (Muon Monte Carlo)
- Monte-Carlo Simulation of Muons and Taus
- svn code <http://code.icecube.wisc.edu/svn/meta-projects/combo/trunk/PROPOSAL/>
- github code (current development) <https://github.com/tudo-astroparticlephysics/PROPOSAL/>

Contributors (regarding svn commits):

- | | | |
|-------------------|--------------------------|--------------------|
| ■ Alex Olivas | ■ Don La Dieu | ■ Jacob van Santen |
| ■ Christian Haack | ■ Erik Ganster | ■ Kevin Meagher |
| ■ Chris Weaver | ■ Jan Soedingrekso | ■ Kotoyo Hoshina |
| ■ Claudio Kopper | ■ Jan-Hendrik Koehne | ■ Nathan Whitehorn |
| ■ David Schultz | ■ Juan Carlos Diaz-Velez | ■ Tomasz Fuchs |

- Calculating energy losses of muons/taus
 - including all four dominant processes
 - and additional effects such as LPM
 - optional: Inclusion of rare, subdominant processes
- Calculating decay products
- Returns a vector of interaction and decay secondaries which can be further processed in the simulation chain



Continuous and Stochastic Losses

- Interaction are characterized by their relative energy loss v
- PROPOSAL differentiates continuous energy losses and stochastic energy losses:

$$v < v_{\text{cut}} \\ \text{continuous}$$

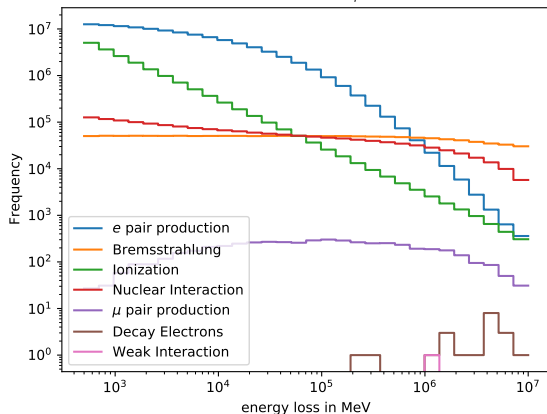
$$v > v_{\text{cut}} \\ \text{stochastic}$$

with

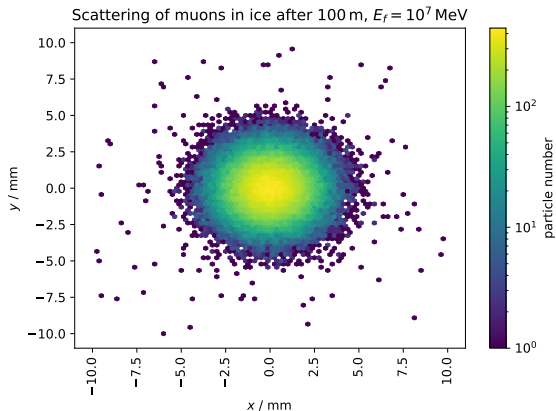
$$v_{\text{cut}} = \min [e_{\text{cut}}/E, v'_{\text{cut}}]$$

- Vary values for e_{cut} and v'_{cut} to adjust precision (for example with respect to the detector volume)

Stochastic losses of 10^7 muons with $E_i = 10^7$ MeV in 100 m of ice



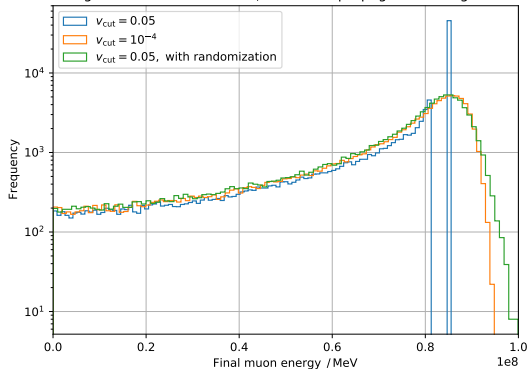
Multiple scattering (Molière, Highland)



Continuous Randomization

→ add Gaussian fluctuations to continuous energy losses

Final energies of 10^5 muons with $E_f = 10^8$ MeV propagated through 1 km of ice



Using PROPOSAL in IceCube

- PROPOSAL callable via the `I3PropagatorServicePROPOSAL`:
 - `propagator = icecube.PROPOSAL.I3PropagatorServicePROPOSAL(
config_file, slice_tracks, ...)`
 - `config_file`: path to json configuration file
 - `slice_tracks`: whether to output continuous energy losses
- **Configuration file** includes information on the propagation environment, including ...
 - Sector geometries, medium, energy cuts and precision options
 - Path to interpolation tables (for IceCube: `"$I3_TESTDATA/PROPOSAL/resources/tables"`)
 - additional parameters e.g. cross section parametrization

Recently fixed Issues

- update ionization constant for ice r182227
- taus were decaying ν_{μ} instead of ν_{τ} r179732
- decay products in wrong direction r179098 #2413
- create decay products outside the detector for secondary muons propagating inside r179009 #2412
- numerically instable Keallen function r179002 #2397

Current developments

- Simulation of electromagnetic shower components in CORSIKA 8 using PROPOSAL
 - e^- , e^+ and high-energy γ propagation has been improved/included in PROPOSAL
 - Recently: First production of CORSIKA 8 showers using PROPOSAL
- Restructurations of the code structure
 - Modularization of Propagator routine
 - Performance improvements for interpolation tables

Future developments

- Merge current developments into PROPOSAL master branch
- Create a separate repository for the PROPOSAL-IceCube interface
- Neutrino propagation
- Finalize CORSIKA 8 interface (long-term task)

Links:

- [PROPOSAL master on GitHub](#)
- [PROPOSAL issues on GitHub](#)
- [Current PROPOSAL development branch](#)
- [PROPOSAL in CORSIKA 8](#)