Statistical approach to muography as a non-destructive testing technique for industry problem solving

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Muons systems

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Outline

- Introduction
- Muons and muography
- Statistical basis of the algorithm
  - Probability density functions
  - Kernel density estimation
  - Monte-Carlo simulations
  - Likelihood minimization
- The algorithm
- Results obtained
- Conclusions

Section I
General introduction

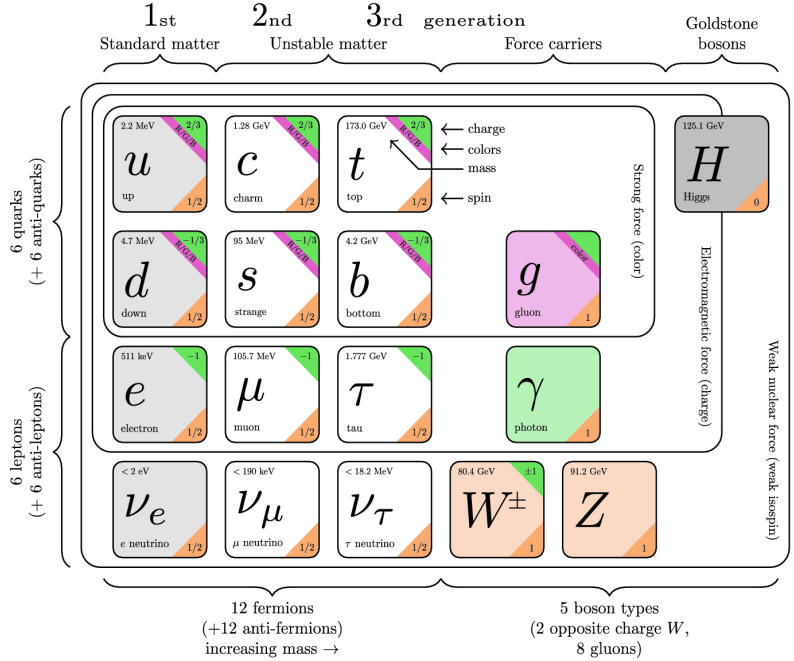
Main goal of this work

Develop a new framework allowing to perform a muography experiment to characterize the inner properties of physical objects using data science and advanced statistical models.

Particle physics and muons

The Standard Model **describes the fundamental particles** existing and their interactions:

- Introduced in the 1970s and still considered to be valid, but probably incomplete
- Simple in concept but extremely precise
- Lots of successful predictions made over the years, such as the existence of the top quark and the Higgs boson



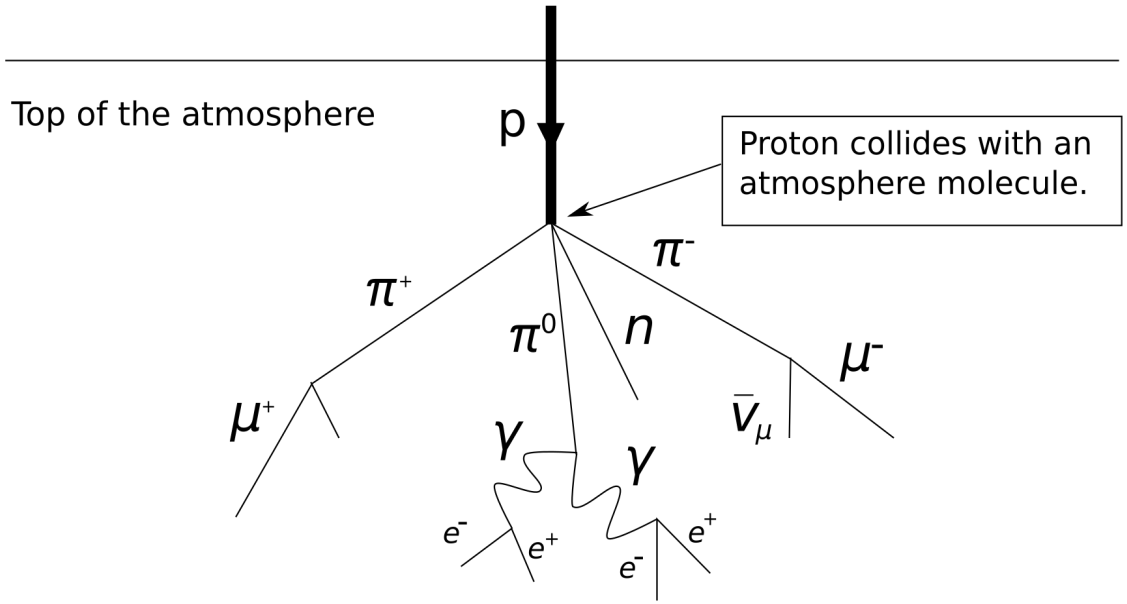
Muons

- Muons μ^- are one of the 12 fundamental particles existing
- They have a relatively small interaction cross-section with ordinary matter, allowing them to cross material without being stopped, making them interesting.

Cosmic rays

Comic rays are a **constant flux of high energy particles** reaching the Earth:

- Mostly made out of protons and atomic nuclei
- Trigger a decay chain by interacting with the atmosphere, producing muons
- Muons are not stable ($\tau \simeq 2.2\mu$s) but relativity can make them live long enough to reach the ground $\rightarrow$ 10.000 cosmic muons are observed per m^2 and per minute at sea level.



Interaction with matter

Muon tomography

Experimental setup

Statistical basis

Probability density functions

Kernel density estimation

Monte-Carlo simulations

Maximum likelihood estimation

General idea

MuonState

Surfaces and Volumes

Cylinders and pipes

Propagator

Likelihood

Generator validation

Pipes geometries

Kernel density functions

Likelihood curves

Conclusion

Future improvements

Thank you
for your attention!

Any questions?