LouMU - Geant / Fast Simulation

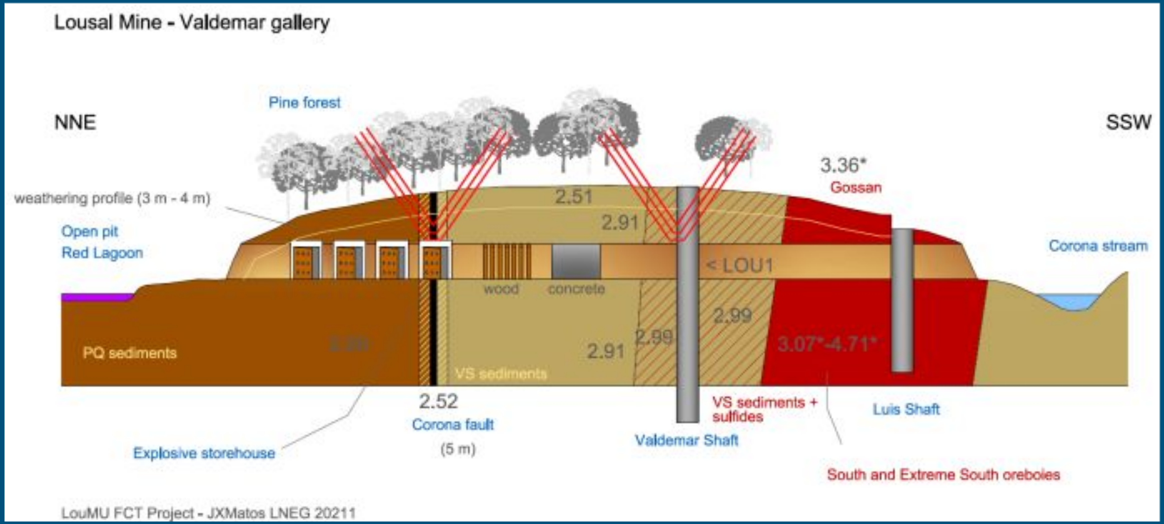
07/02/2023

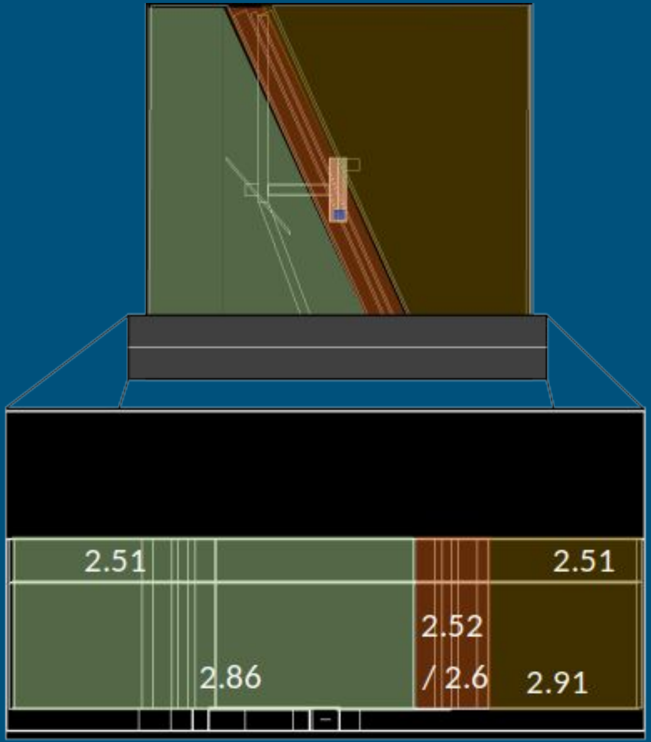
Lousal Mine

$$flux = \frac{18}{E \times \cos(\theta) + 145}\left(E + \frac{2.7}{\cos(\theta)}\right)^{-2.7}\frac{E+5}{E+5/\cos(\theta)}$$

https://arxiv.org/pdf/nucl-ex/0601019.pdf

Volume considered in the Geant simulation: 60m x 60m x 18m





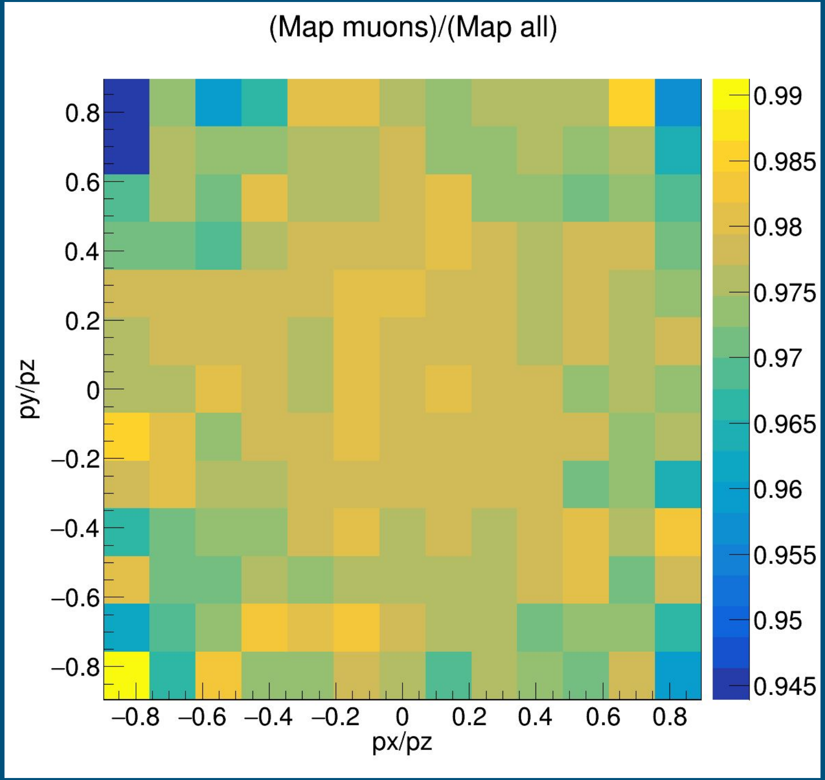
Geant

- Scattering (60m x 60m)
- Interaction with matter
- Electrons
- 5m radius around the detector

Fast Simulation

- No scattering (15,5m x 15,5m)
- No interaction with matter
- No electrons
- No “security” radius

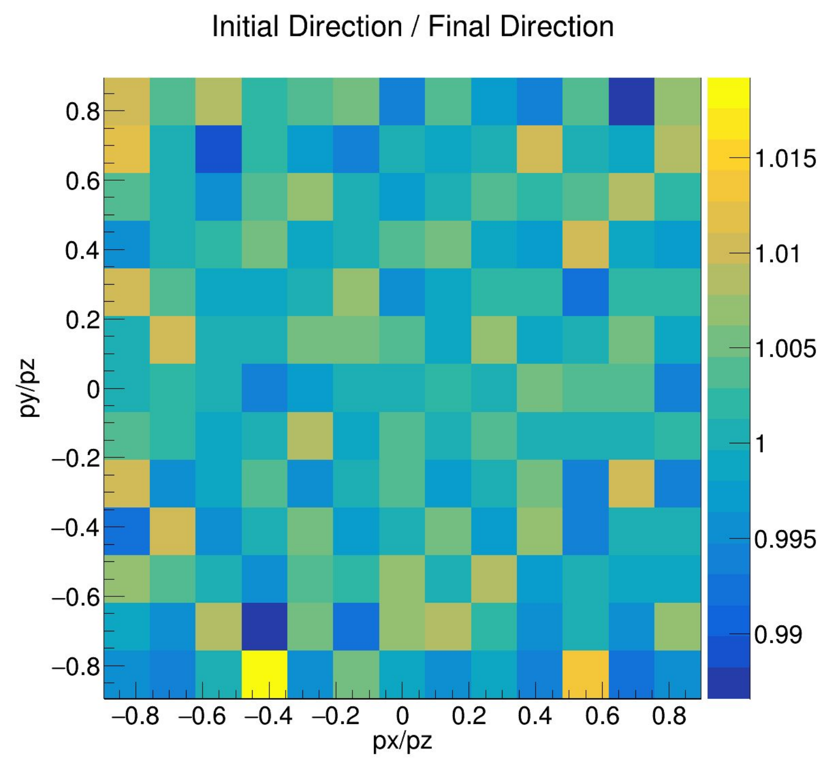
Electrons - 2,24% of the detected particles



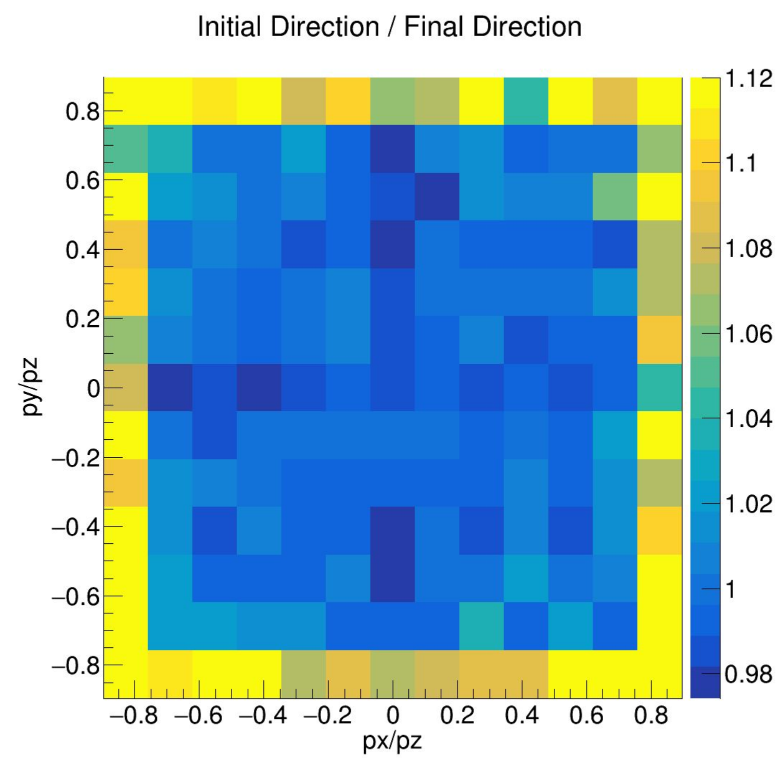
Map 12

Scattering

All muons Geant



Detected muons

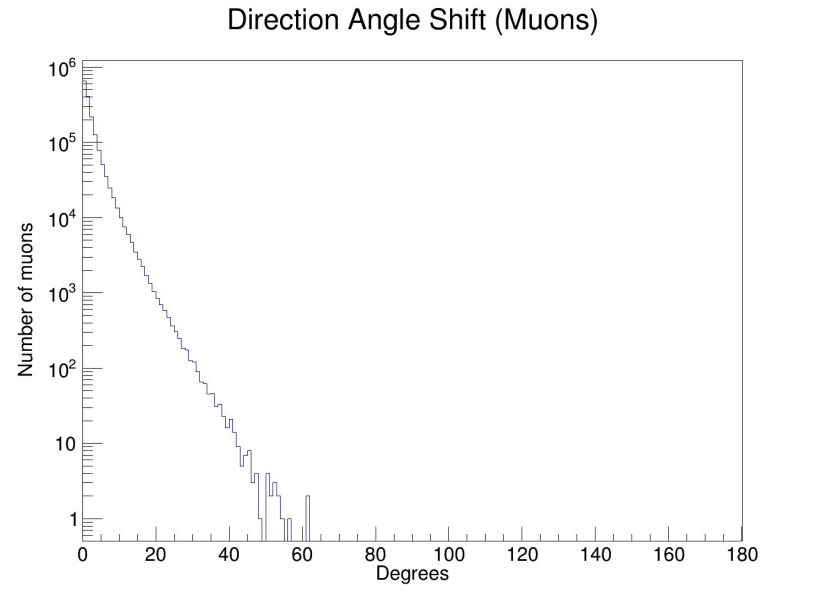


Direction Angle Shift

- The pads of the CorePix have an area of 3.8cm x 3.8cm.
- The current distance between planes is 33.5cm.

$$R_{13} = \arctan\left(\frac{3.8}{33.5 * 2}\right) = 3.25\ Degrees$$

$$R_{12} = \arctan\left(\frac{3.8}{33.5}\right) = 6.47\ Degrees$$

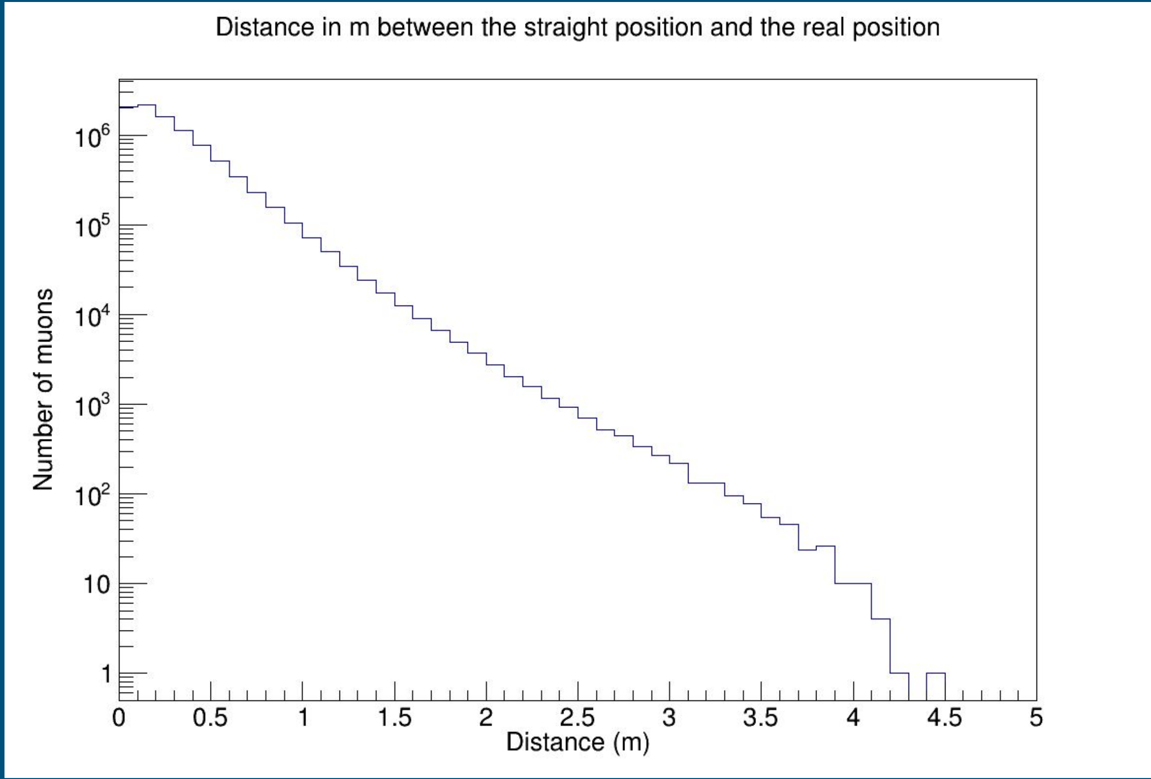


Detected muons

- 21,24% of the muons have a direction angle shift superior to 3.25 Degrees .
- 7,14% of the muons have a direction angle shift superior to 6.47 Degrees .

5m radius

All muons Geant



Fast Simulation

$$flux = \frac{18}{E \times \cos(\theta) + 145} \left(E + \frac{2.7}{\cos(\theta)} \right)^{-2.7} \frac{E + 5}{E + 5/\cos(\theta)}$$

https://arxiv.org/pdf/nucl-ex/0601019.pdf

1 Muon flux

https://arxiv.org/pdf/nucl-ex/0601019.pdf

$$\frac{dI(\theta, \varphi, p)}{dp} = \frac{18}{p \times \cos(\theta) + 145} \left(p + \frac{2.7}{\cos(\theta)} \right)^{-2.7} \frac{p + 5}{p + 5/\cos(\theta)} \tag{1}$$

Units: $cm^{-2}\ s^{-1}\ sr^{-1}$
Muon momentum p in the interval $1 \leq p \leq 10^5$ GeV/c.
The muon's mass is 105.7 MeV/c^2. We are considering c = 1, so:

$$E = \sqrt{p^2 + m^2} \tag{2}$$

If we have momentum of 1 GeV:

$$E = \sqrt{1 + 0.1057^2} \approx 1.0056 \tag{3}$$

$$\frac{E - p}{E} \approx 0.6\% \tag{4}$$

For bigger values of p, this percentage will be even lower, so we can neglect the mass and have $E = p$.

$$\frac{dI}{dE} = \frac{18}{E \times \cos(\theta) + 145} \left(E + \frac{2.7}{\cos(\theta)} \right)^{-2.7} \frac{E + 5}{E + 5/\cos(\theta)} \tag{5}$$

We now want to write this as a function of $E' = E \times \cos(\theta)$.

$$\frac{dE'}{dE} = \cos(\theta) \iff \frac{1}{dE} = \frac{\cos(\theta)}{dE'} \tag{6}$$

$$\frac{dI}{dE} = \frac{18}{E \times \cos(\theta) + 145} (E \times \cos(\theta) + 2.7)^{-2.7} (\cos(\theta))^{2.7} \frac{E \times \cos(\theta) + 5\cos(\theta)}{E \times \cos(\theta) + 5} \tag{7}$$

$$\frac{dI}{dE'} = \frac{1}{\cos(\theta)} \frac{18}{E' + 145} (E' + 2.7)^{-2.7} (\cos(\theta))^{2.7} \frac{E' + 5\cos(\theta)}{E' + 5} \tag{8}$$

$$\frac{dI}{dE'} = \frac{18}{E' + 145} (E' + 2.7)^{-2.7} \frac{E' + 5\cos(\theta)}{E' + 5} (\cos(\theta))^{1.7} \tag{9}$$

$$\frac{dI}{dE'} = \frac{18}{E' + 145} (E' + 2.7)^{-2.7} \left(\frac{E' \times (\cos(\theta))^{1.7}}{E' + 5} + \frac{5(\cos(\theta))^{2.7}}{E' + 5} \right) \tag{10}$$

We have concluded that the function can be written as:

$$\frac{dI}{dE'} = F_1(E')\ G_1(\cos(\theta)) + F_2(E')\ G_2(\cos(\theta)) \tag{11}$$

If we define

$$f(E') = \frac{18}{E' + 145} (E' + 2.7)^{-2.7} \tag{12}$$

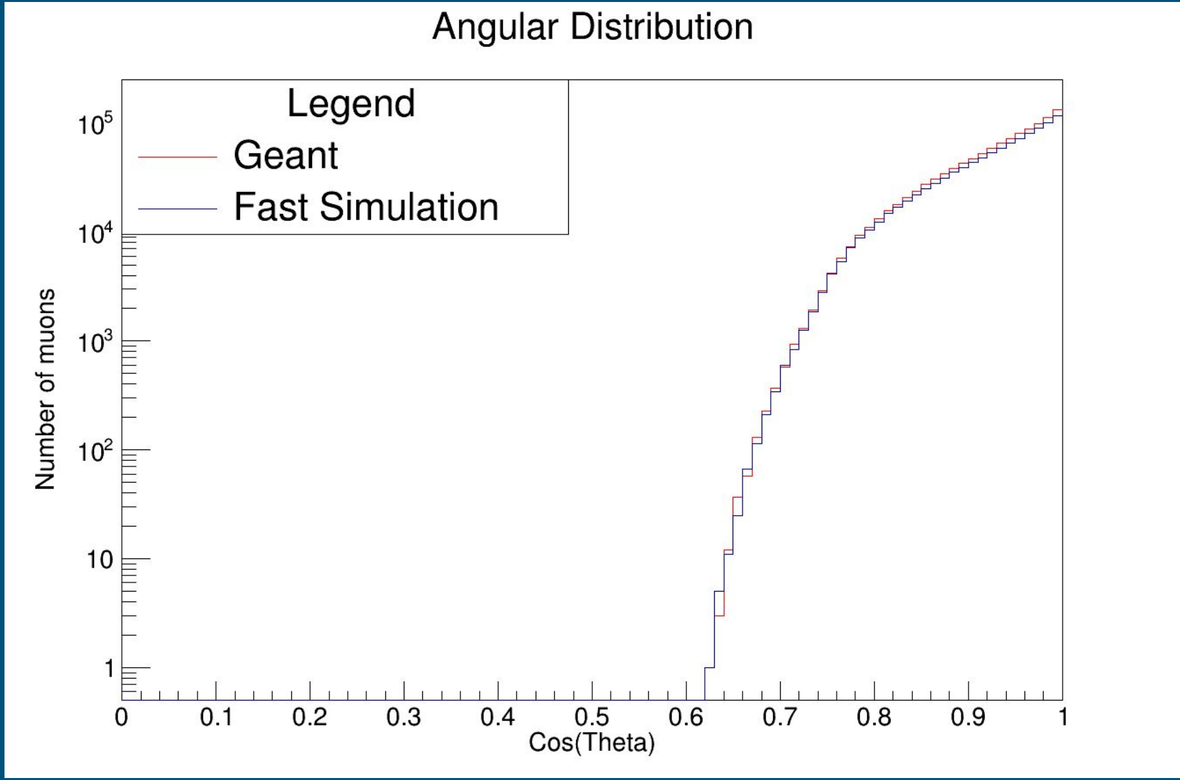
we can write

$$F_1(E') = f(E') \frac{5}{E' + 5} \tag{13}$$

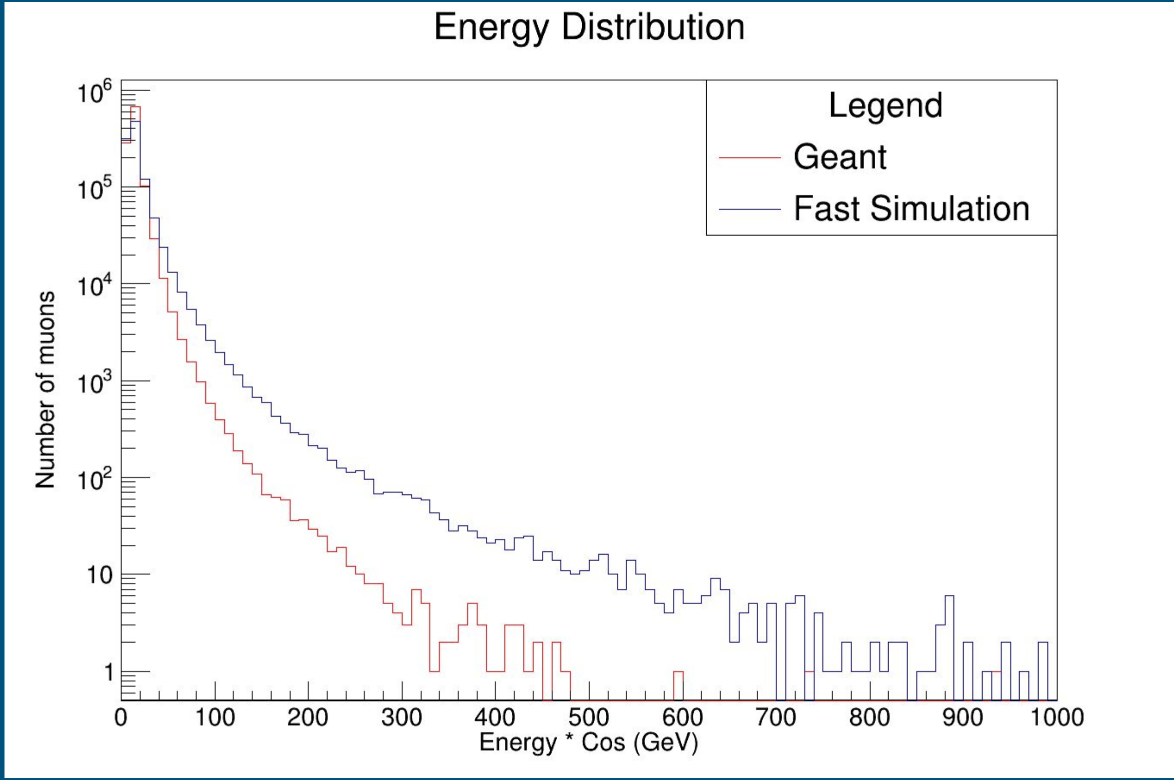
$$F_2(E') = f(E') \frac{E'}{E' + 5} \tag{14}$$

The vertical muon flux is $F_1(E') + F_2(E') = f(E')$.

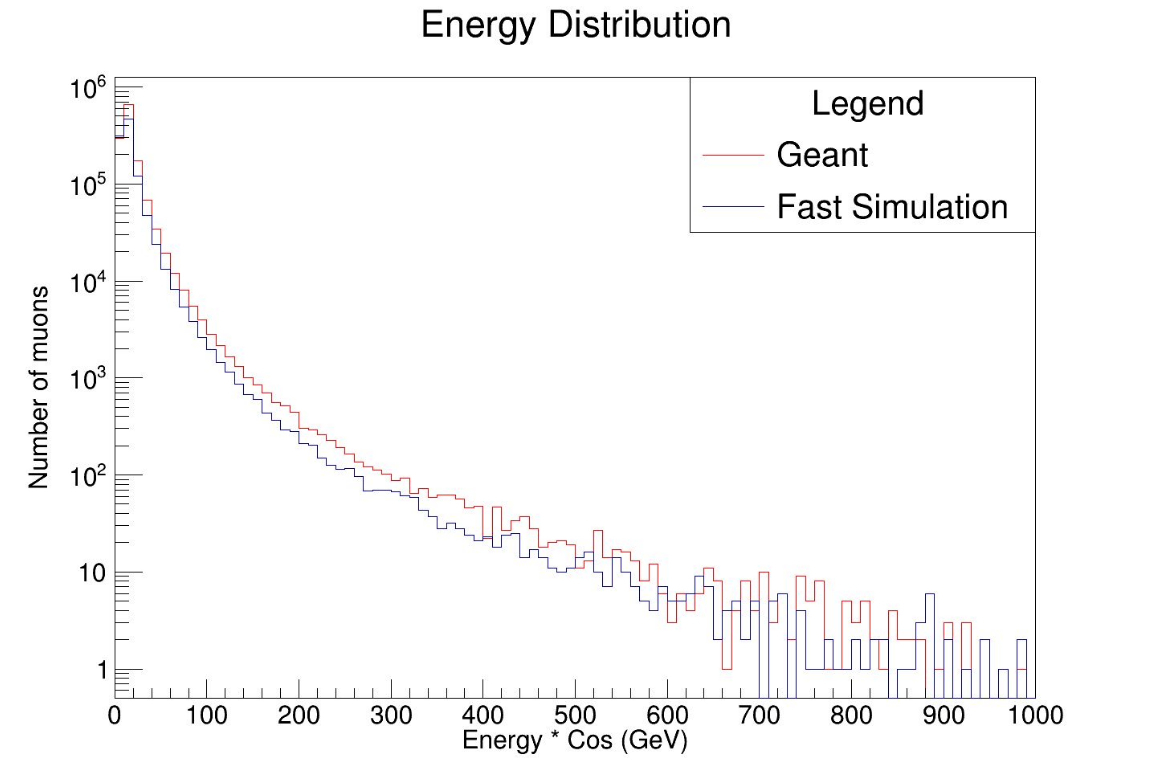
Angular distribution



Energy Distribution 1.0

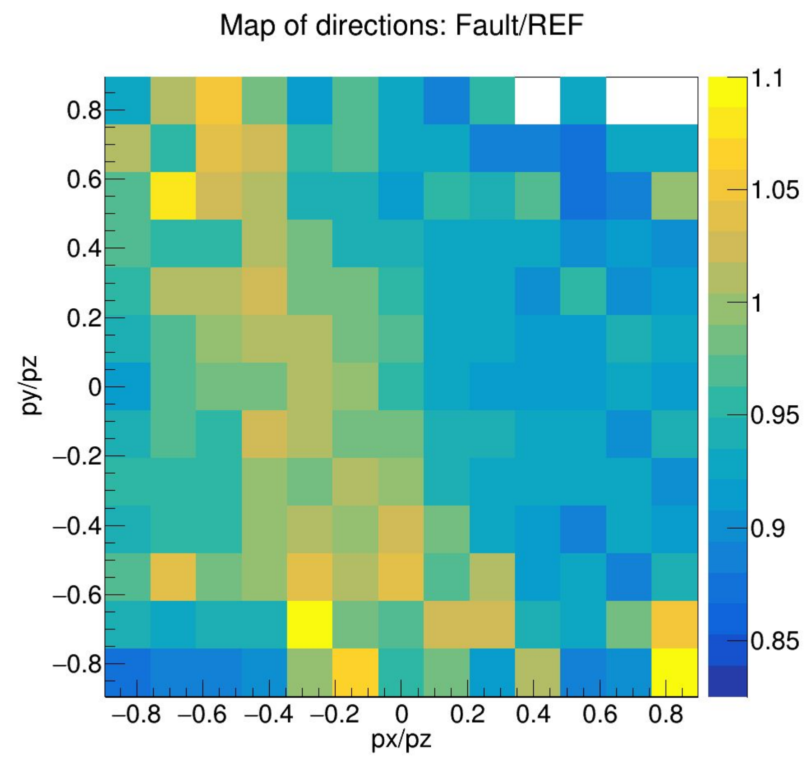


Energy Distribution 2.0



Geant

Map 12



Map of directions: Fault/REF
py/pz
px/pz
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−0.8 −0.6 −0.4 −0.2 0 0.2 0.4 0.6 0.8
1.1
1.05
1
0.95
0.9
0.85

Fast Simulation

Map 12