INVESTIGATE EXOTIC HIGH-ENERGY PHYSICS SCENARIOS IN AIR SHOWERS WITH CORSIKA 8

Internship M2/Mag3

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Internship done at KIT in Karlsruhe (100% remote) from May 2020 to September 2020 included.

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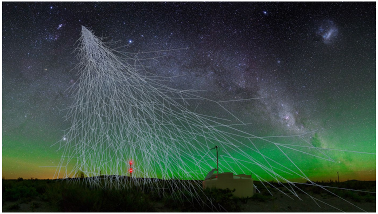
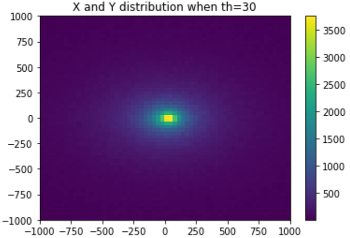
The physics of high scattering boson cascade

Air shower : Cosmic ray entering the atmosphere yielding to a multitude of scattered particles decaying more and more.





- Cosmic rays reach 1e14 to 1e19 eV
  LHC is 1e13eV as a comparison
- Bad side : Not controled
- Use CORSIKA to simulate showers
- Air shower is a tool to test "higgsplosion" theory

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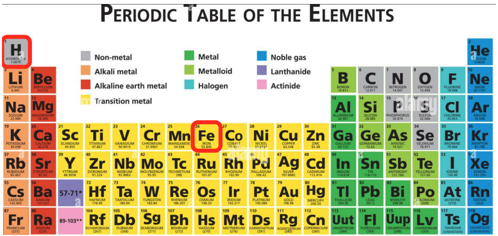
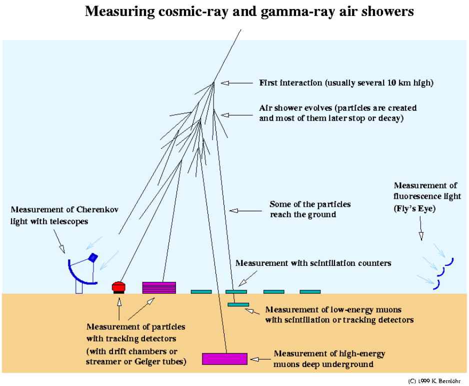
"In" parameters

- Particle type : Hadron (lighter than ${}^{56}_{26}Fe$)



- Energy (1e14-1e19eV)
- Angle (0=zenit)
- Physical model of computation (Sybill)

"Out" parameters



- Study the evolution of the shower across the air (X_{max})
- Study the particle hitting the ground. (more precise but past is lost) particle type, energy, position

Contents

Standard air showers simulations

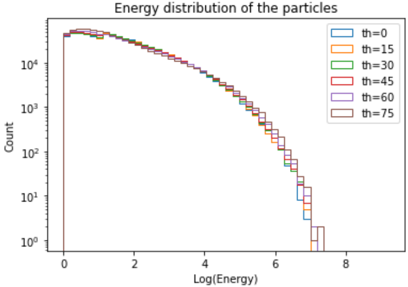
Goal of this section:

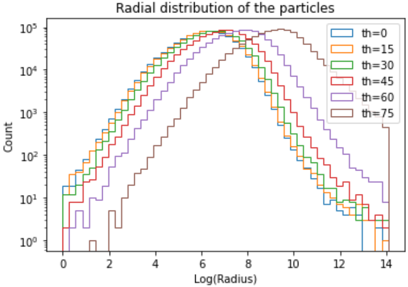
- Setting a ground
- Verify the transition CORSIKA 7 to 8

Own research

Looking for any original result

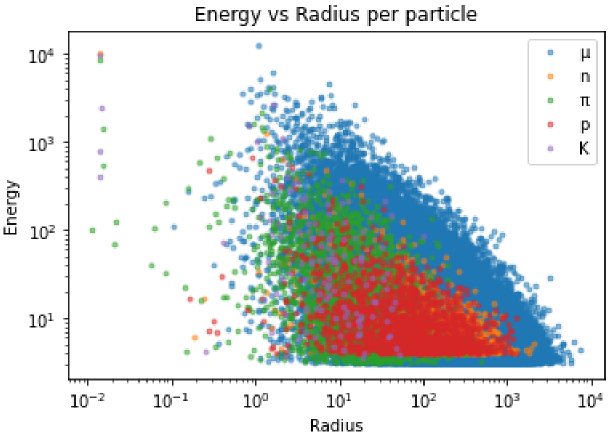
Looking for a way to deduce the "in" parameters by only looking at the ground.





Own research

Parameters distribution depending on the particle type



- Used Log scale to spread out the bundle
- Looking for any kind of emerging phenomenon
- Energy Threshold (Chosen by CORSIKA team)

Own research

Parameters distribution depending on the particle type

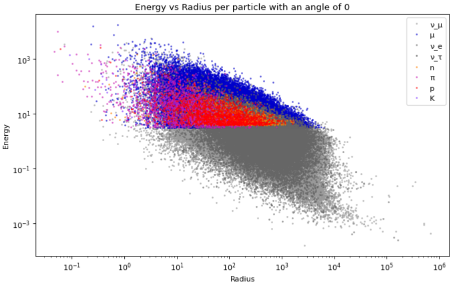


Figure: θ=0

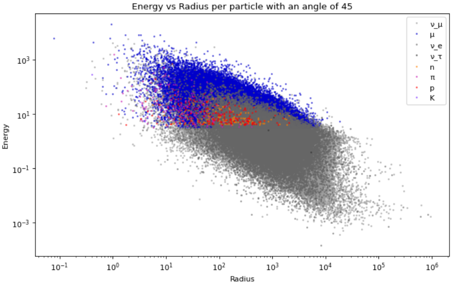


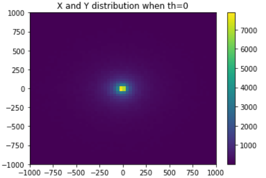
Figure: θ=45

Wider angle $\Rightarrow$ Longer travel in the atmosphere

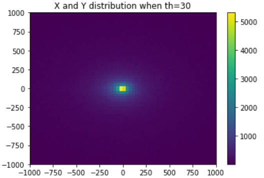
Less n,p,K,π

Constant ν, μ

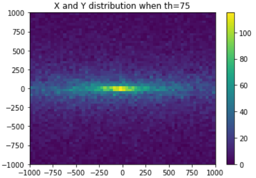
Spacial distribution of the particles



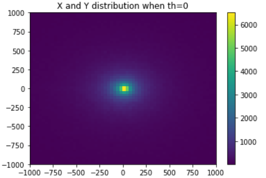
(a) $\theta = 0$



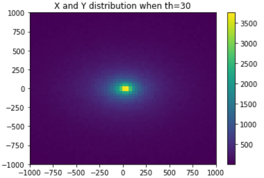
(b) $\theta = 30$



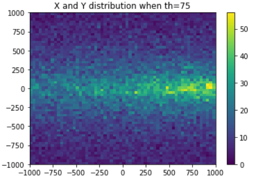
(c) $\theta = 75$



(a) $\theta = 0$



(b) $\theta = 30$

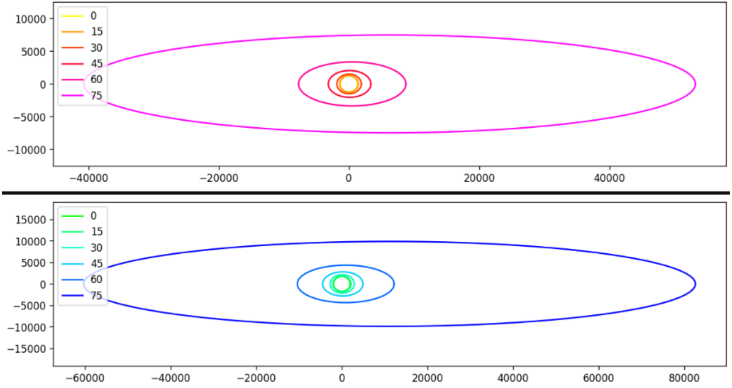


(c) $\theta = 75$

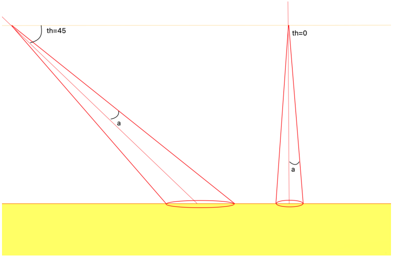
Top : Proton | Bottom : Iron

Spacial distribution of the particles

Parameters of the ellipse are such that 90% of the particles are in.



Spacial distribution of the particles



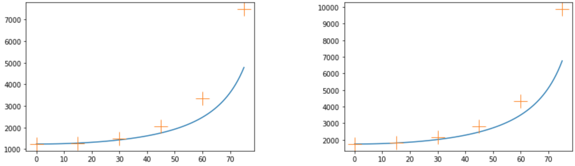


Figure: Expected ellipse width[1] (blue line) versus actual ellipse width (Orange crosses). Proton showers on the left, iron shower on the right

[1]Same result for length, but data were lost

What is X_{max}

Study of the shower before impact

- Time-dependent evolution (no)
- Altitude dependence (no)
- Interaction Depth $g.cm^{-2}$ (yes)

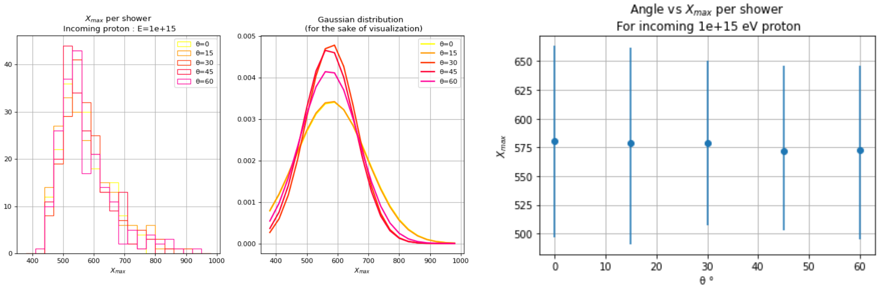
$$X = \int \rho dr$$

Starts at 0 when outside the atmosphere, and grows as the altitude goes down.
One important parameter[2] : X_{max}.

[2]The value of X when the amount of muon produced is at the maximum

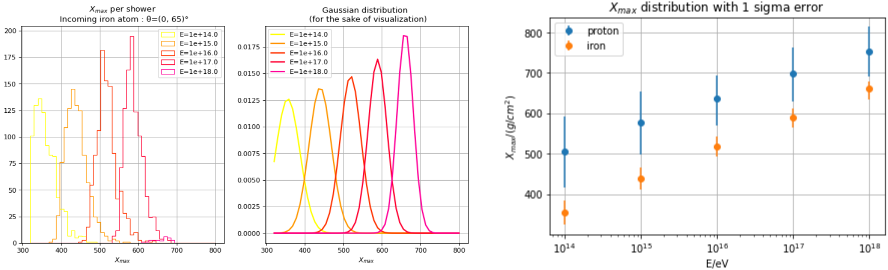
How X_{max} evolves depending on the input parameters

Angle



How X_{max} evolves depending on the input parameters

Energy

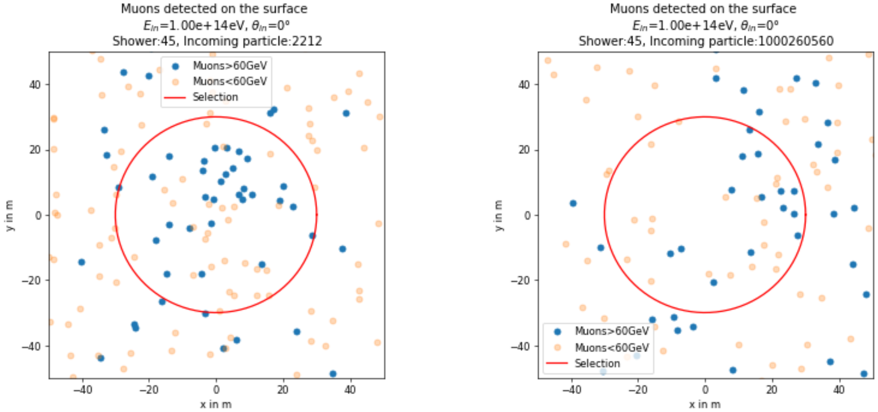


Focus on the muon production

Study of the shower on the ground

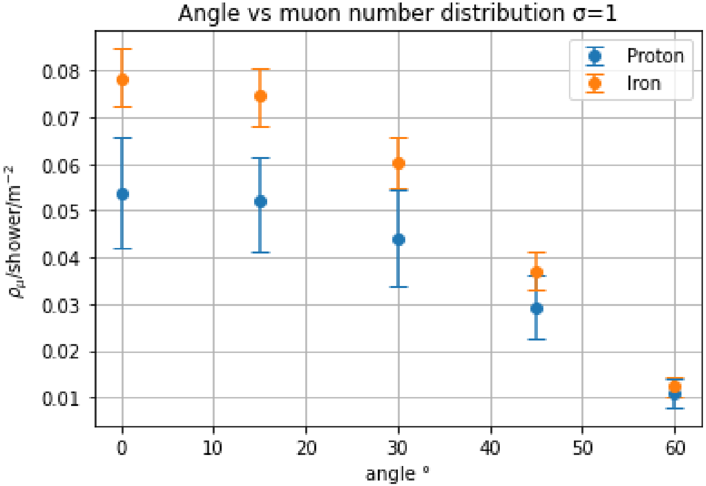
The amount of muon per shower : good indicator to compare standard showers and high boson scattering theory showers.
Introduction of the Muon Bundle.

The Muon Bundle

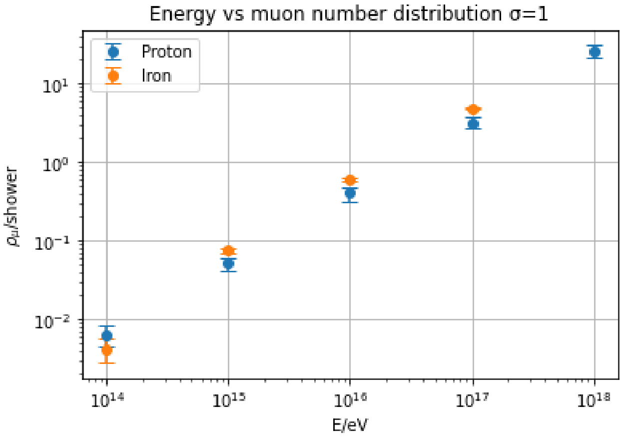


Two examples of muon bundle selection.
Threshold : $E_\mu > 60 GeV$, Radius<30m

Angle dependency



Energy dependency



- Linear behavior
- No Iron data at E=1e18eV
- Small inaccuracy at E=1e14eV

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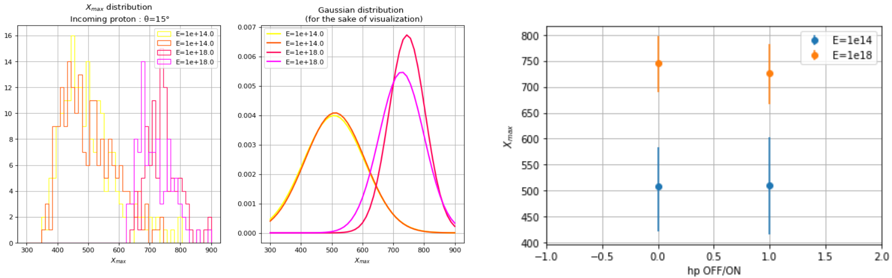
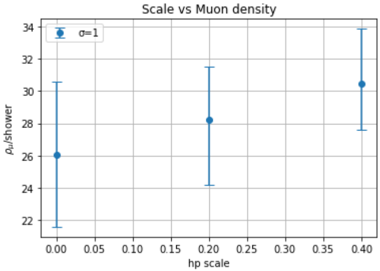
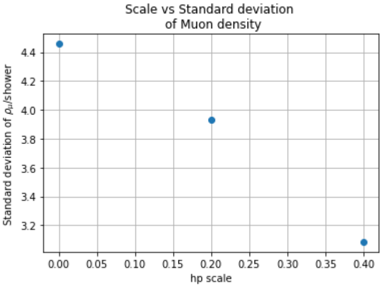
High scattering boson cascade simulation



High scattering boson cascade simulation

Muon Bundle





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Conclusion

The cosmic rays showers studies are a very important field of particle physics that one must not neglect.

I did not have the time to compare my result properly with experimental data.

This internship showed me a new way to study particle physics that I had never considered before.

Bad side : Remote. (SSH problems, communication problems)

Thank you for your attention.