

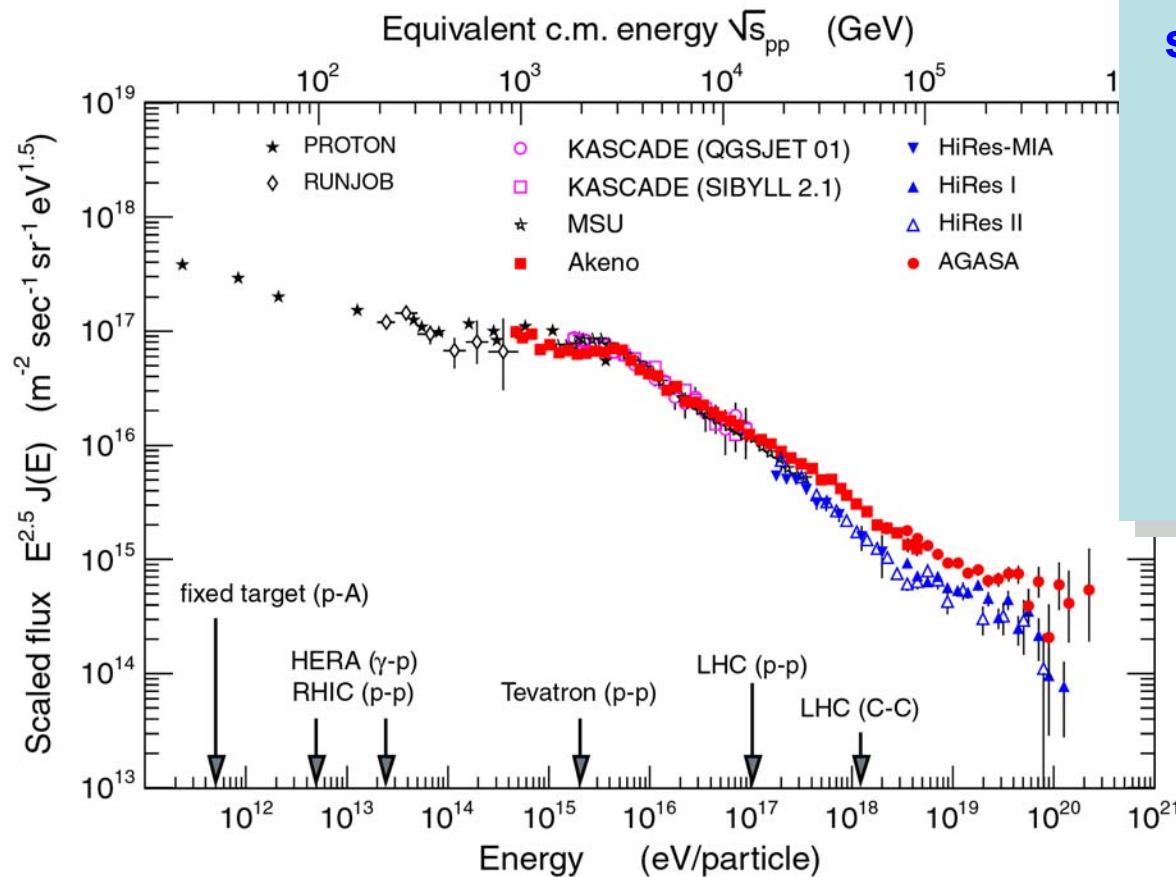
# NA49-future Astroparticle physics programme

## From Quarks to Cosmos

still an open question:

cosmic ray flux spectrum

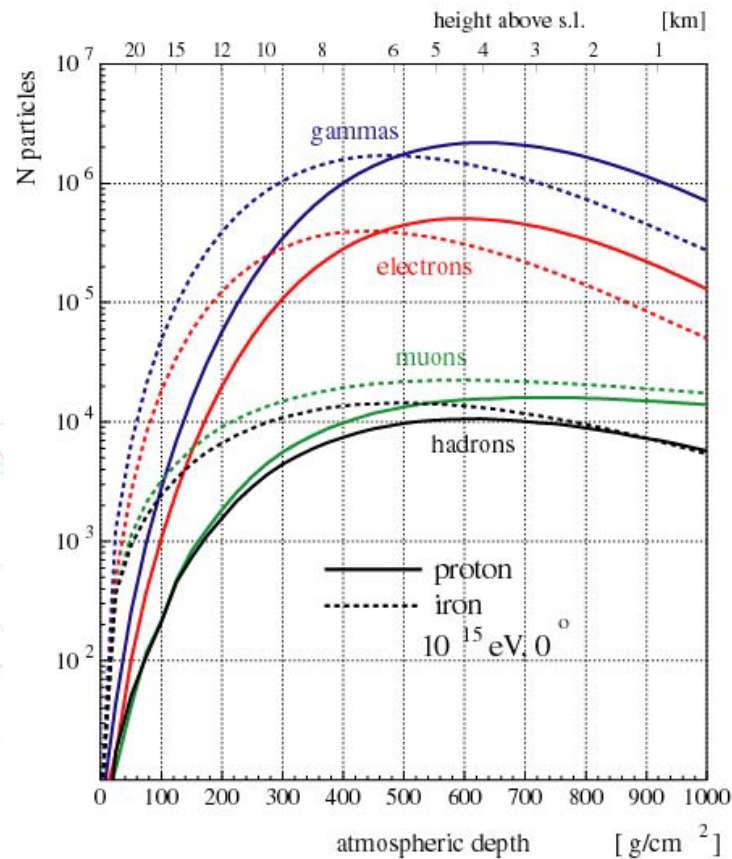
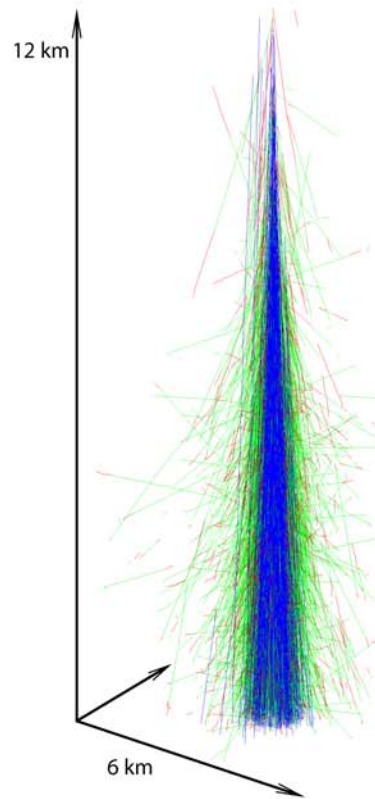
- sources
- acceleration
- transport
- highest energies ?



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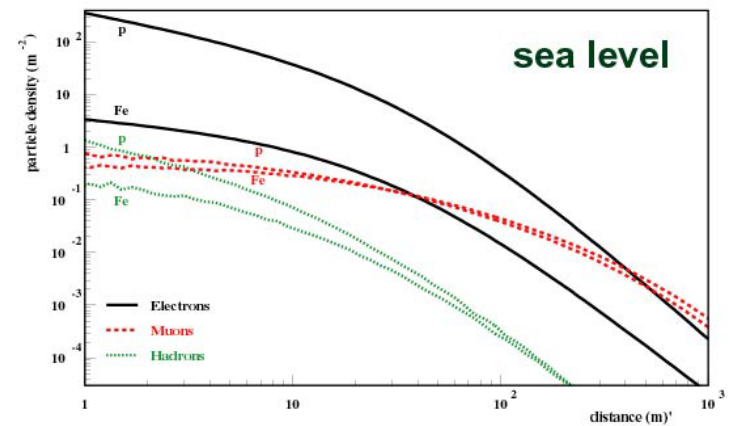
# Astroparticle physics programme

## Air shower measurements



No direct measurements for  $E_0 > 10^{14}$  eV  
 → Air shower measurements

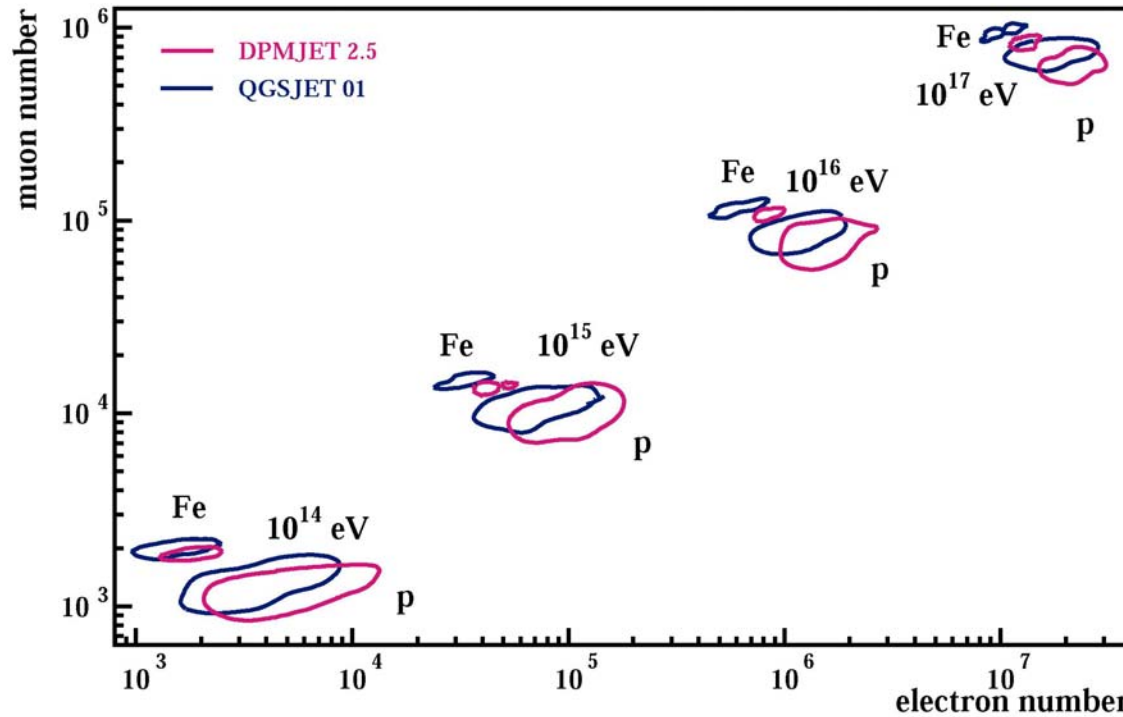
Air shower development:  
 → longitudinal distribution  
 → lateral distribution



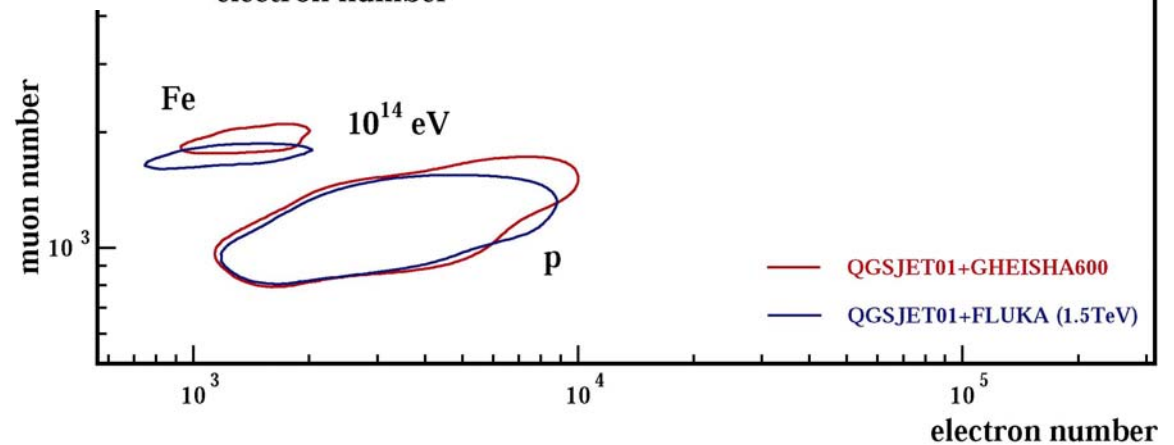
# Astroparticle physics programme

## Shower observables

**Energy and mass sensitive observables:  
Electron and muon  
particle numbers**

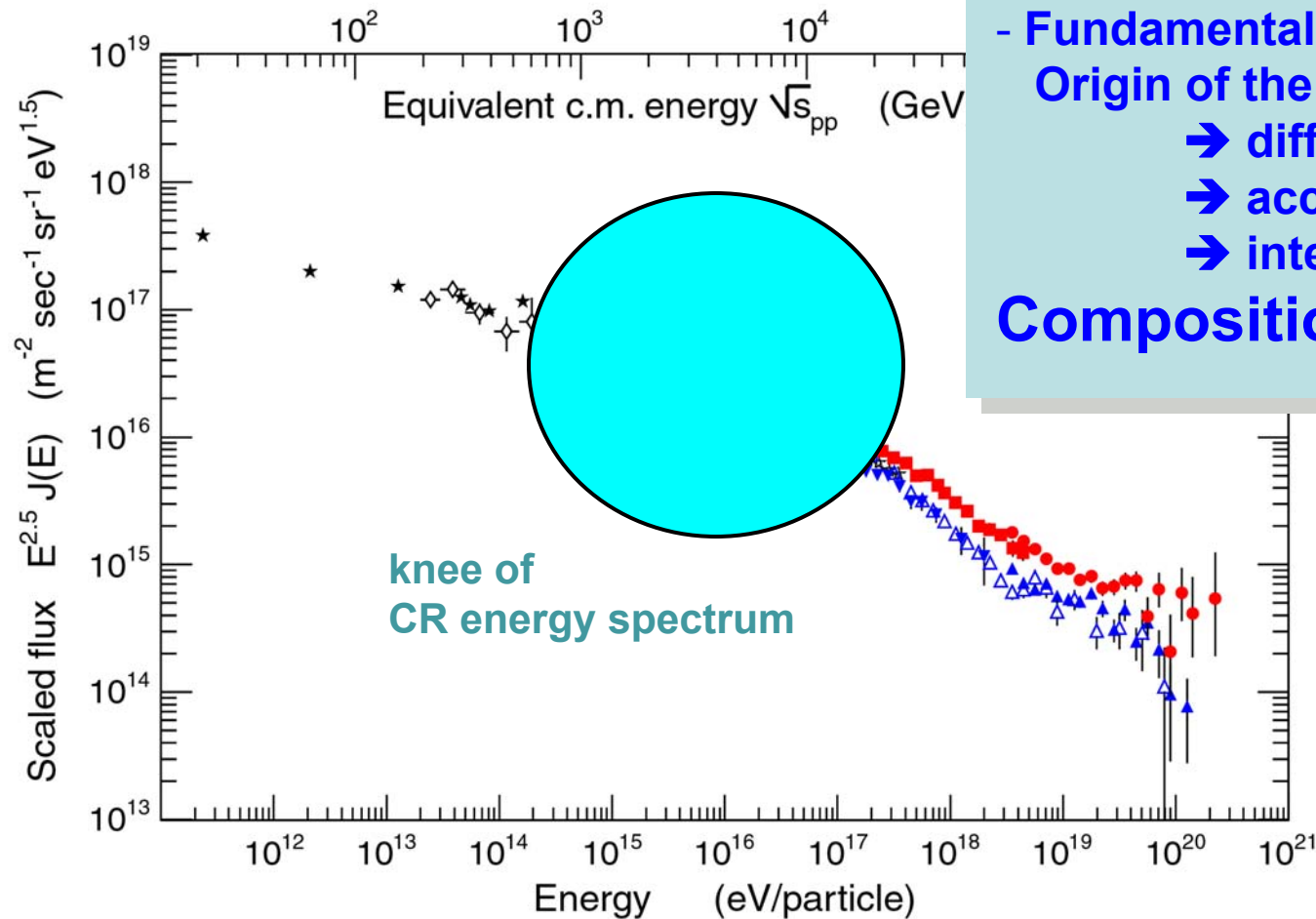


**electron number vs. muon number  
for various primary energies  
and different hadronic interaction  
models**



## Astroparticle physics programme

### Problem of the knee



- The knee: approx  $3 \cdot 10^{15}$  eV

- Fundamental question:

Origin of the knee?

→ diffusion

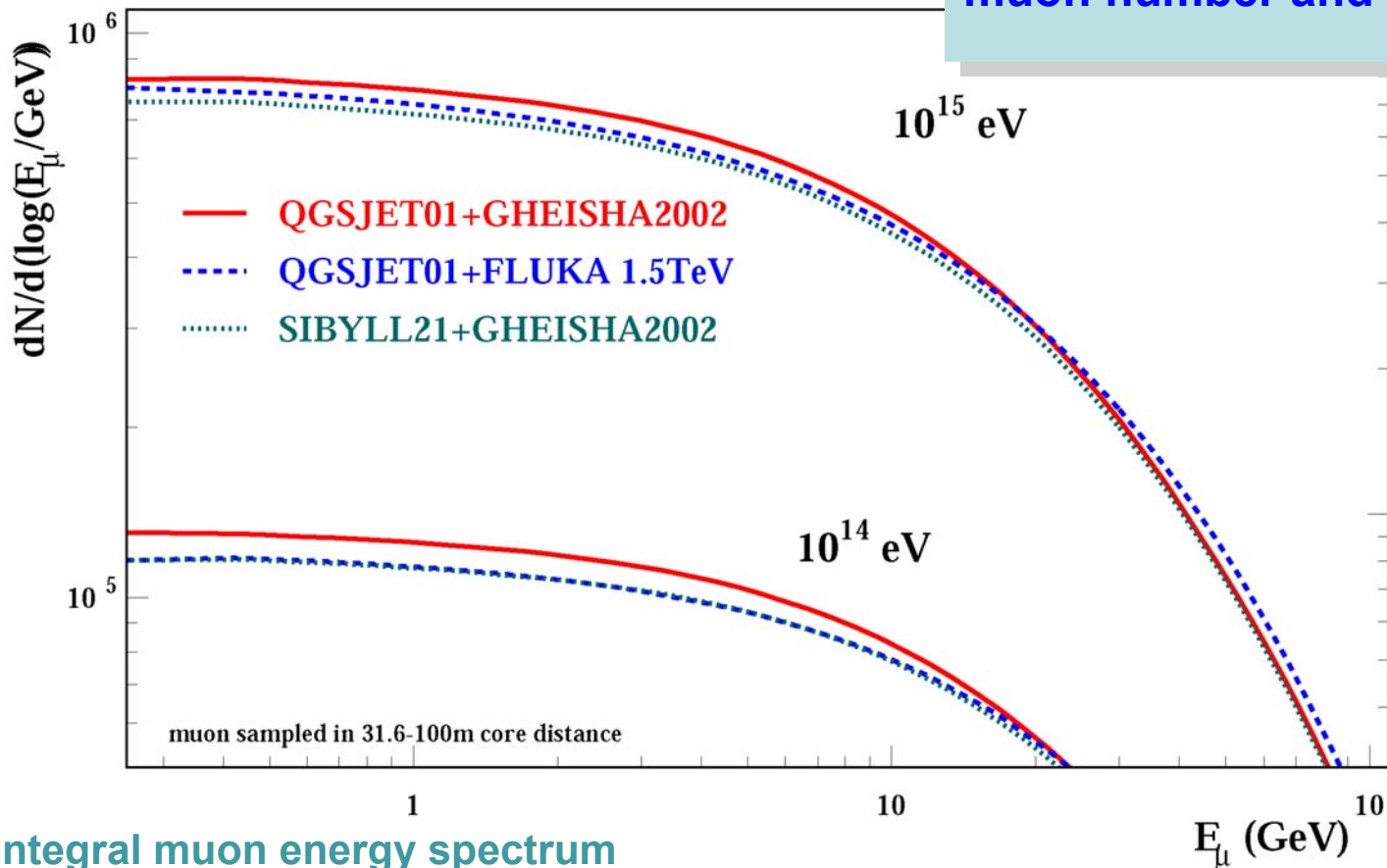
→ acceleration

→ interaction

Composition of cosmic rays

## Astroparticle physics programme Muon distribution

**Composition of cosmic rays  
needs to understand  
muon number and muon density !**

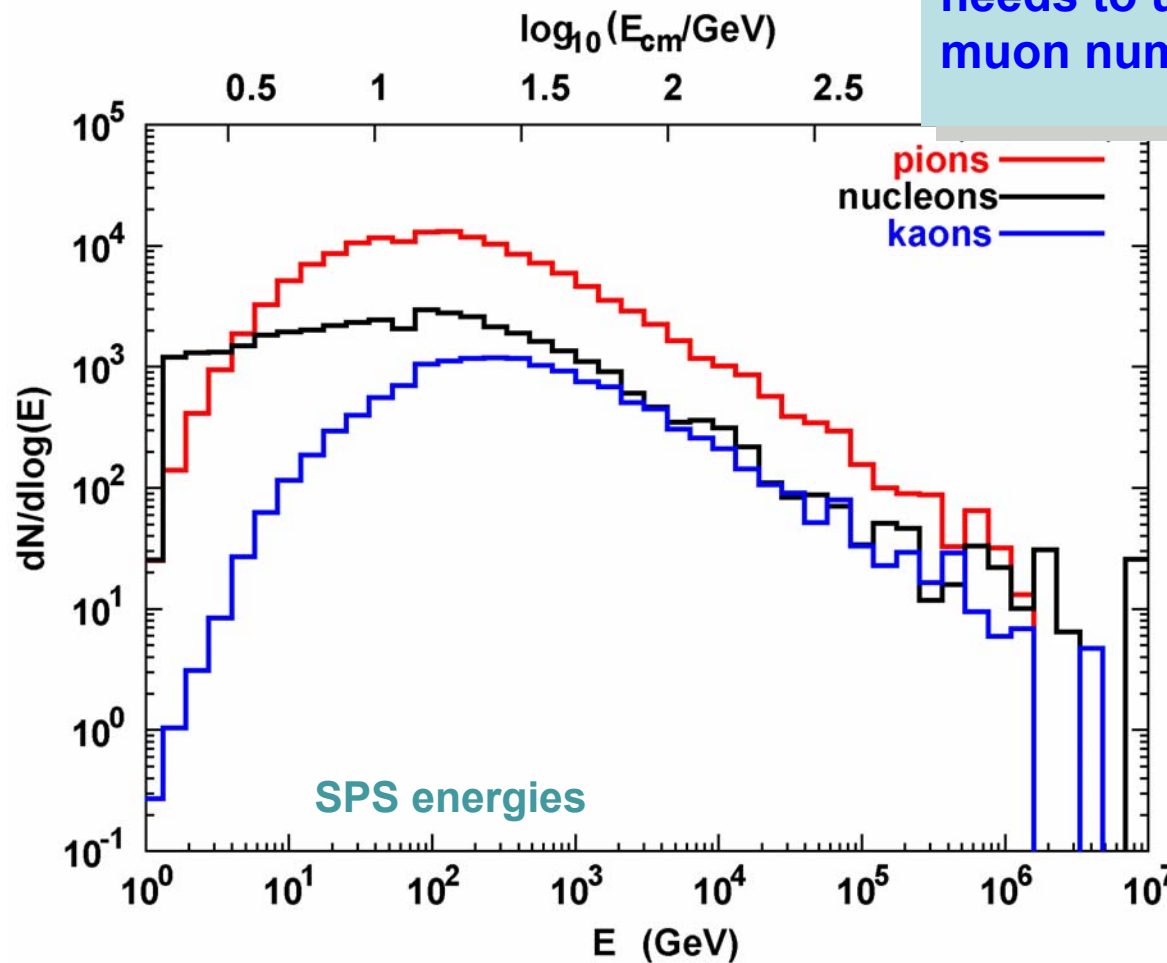


**integral muon energy spectrum  
in air showers for different primary energies**

# Astroparticle physics programme

## Muon distribution

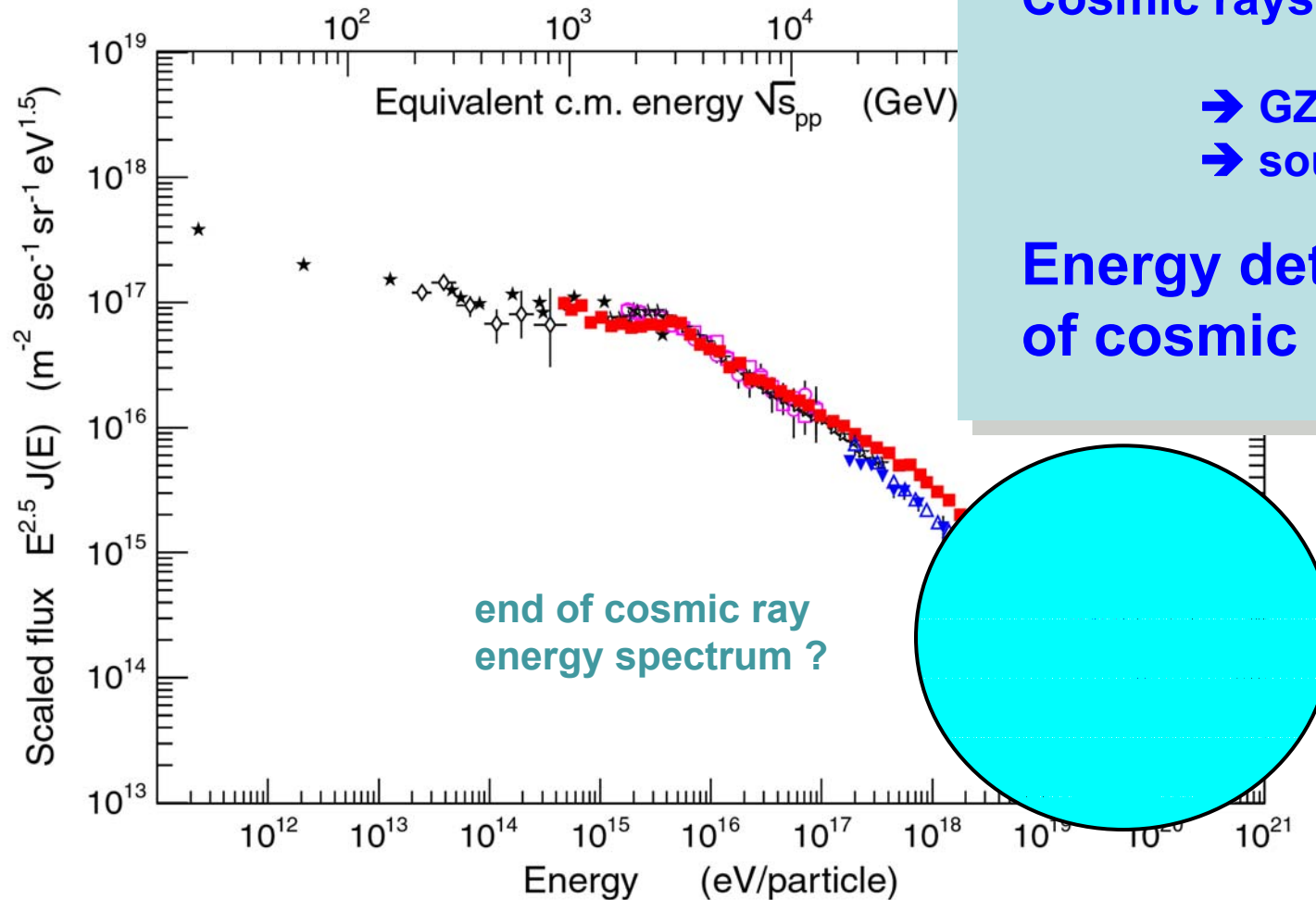
**Composition of cosmic rays  
needs to understand  
muon number and muon density !**



energy  $E$   
 of parent particles  $h$   
 in air showers  
 for detectable muons  
 $(h + x \rightarrow \pi + x$   
 $\pi \rightarrow \mu + x)$

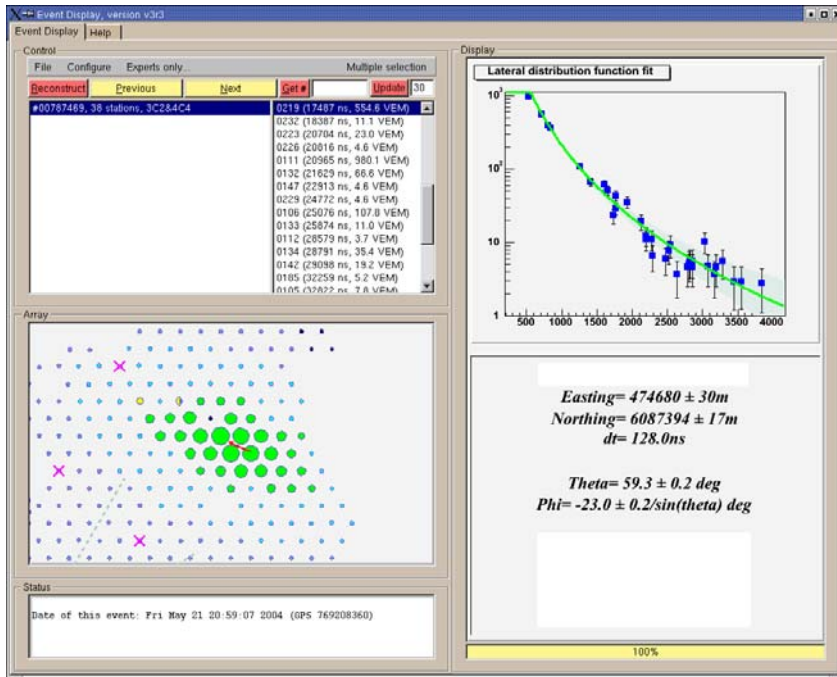
# Astroparticle physics programme

## Problem of highest energy



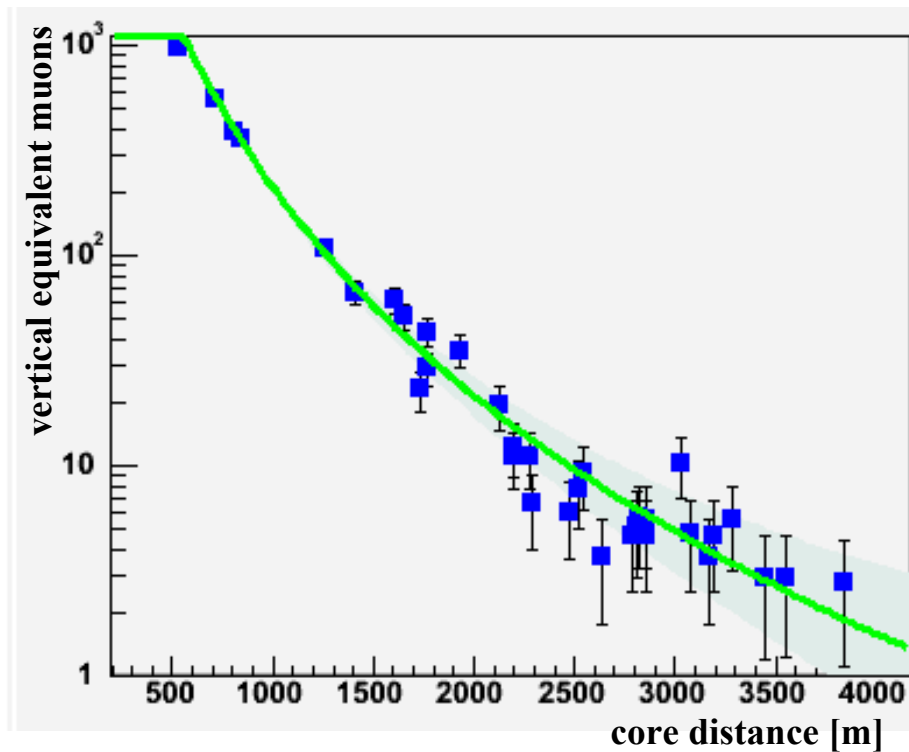
# Astroparticle physics programme

## Highest energy event



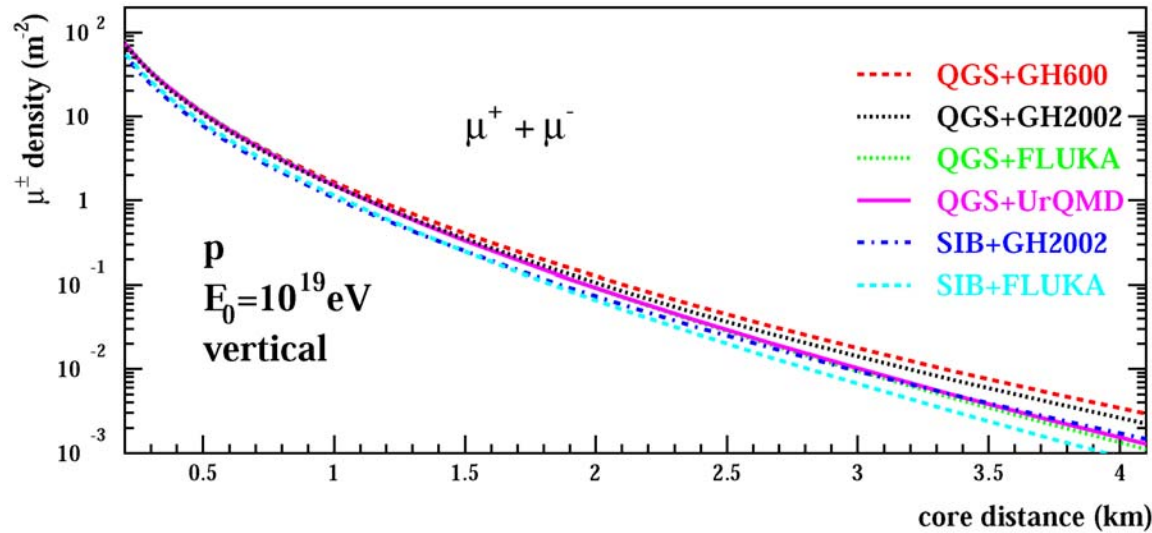
highest energy event  
 measured by the  
 Pierre Auger Experiment

**Energy of cosmic rays**  
 -Signal density lateral distribution  
 -muon number dominated

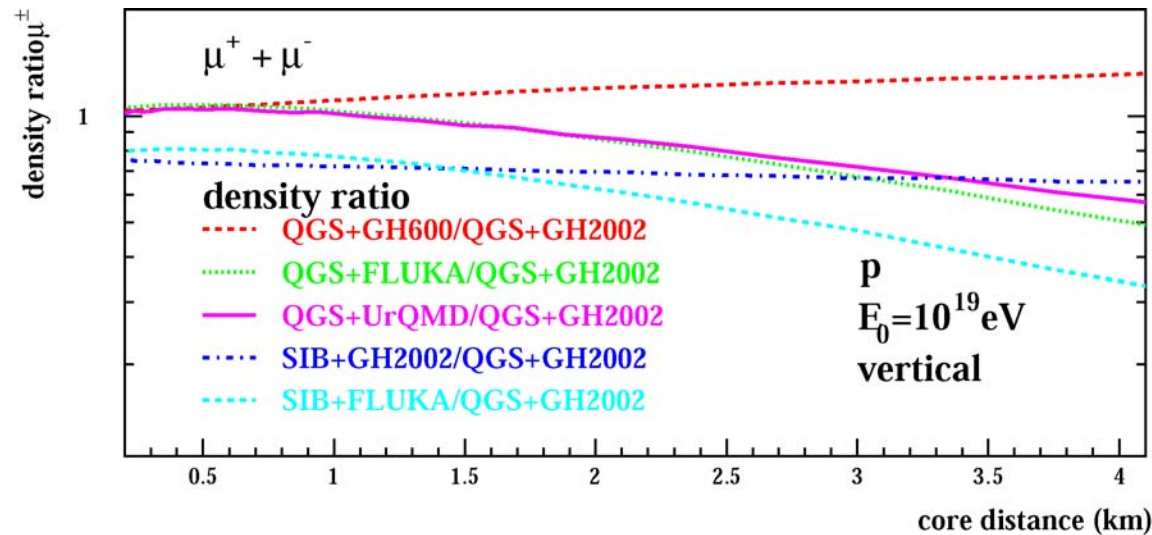




## Astroparticle physics programme Muon lateral distribution



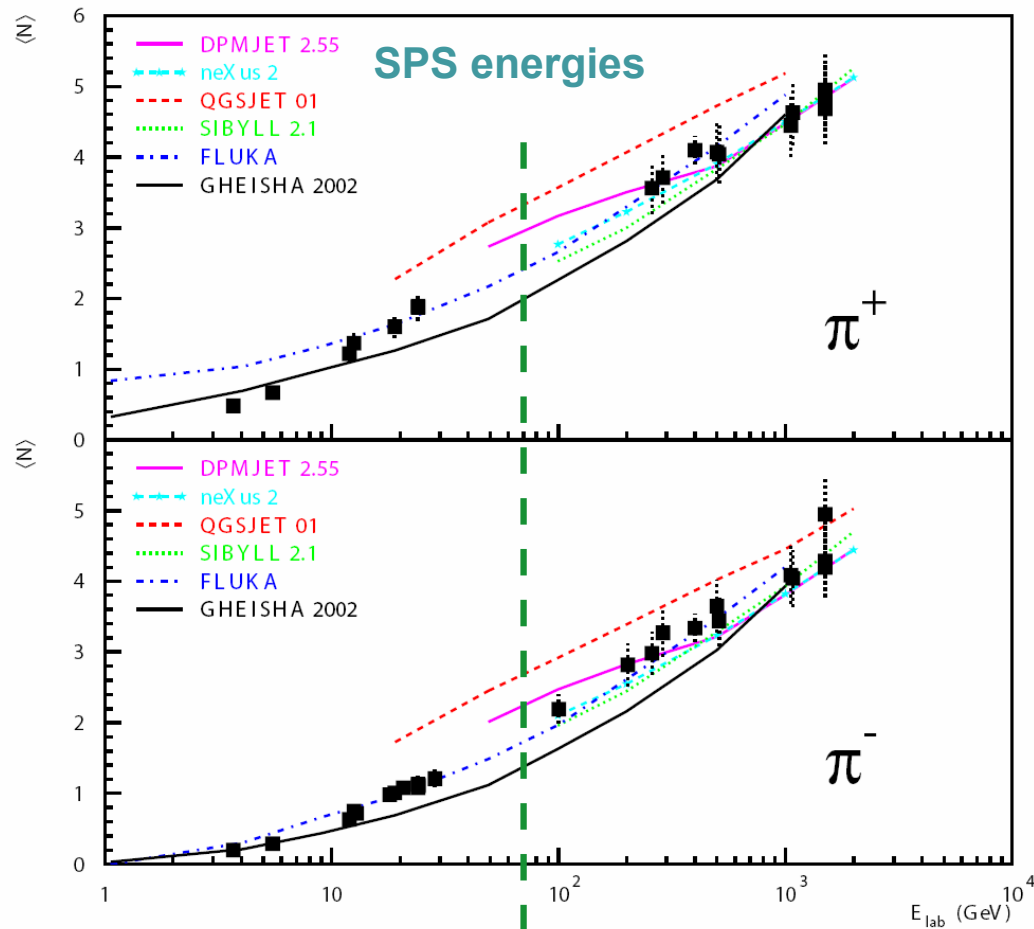
Energy of  
cosmic rays  
-muon lateral density



muon lateral density  
distributions as predicted  
by hadronic interaction  
models

# Astroparticle physics programme

## Reactions to be measured



**NA49-future:**  
 Pion spectra and multiplicities in  
 p-Air  
 $\pi$ -Air  
 p-p  
 p-C  
 C-C  
 at SPS energies

needed for  
 understanding  
 the whole cosmic ray  
 flux spectrum

default transition energy of low and high energy interaction models in CORSIKA

pion multiplicity for p-p interactions (Eichten et al.) compared to simulations