Extreme Energy Events
Science inside Schools

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Monte Carlo simulation chain of the **Extreme Energy Events** Project for **extensive air shower** detection

Fabrizio Coccetti for the **EEE Collaboration**

Centro Fermi - *Museo Storico della Fisica e Centro Studi e Ricerche "Enrico Fermi"*

SIF - 103° Congresso Nazionale

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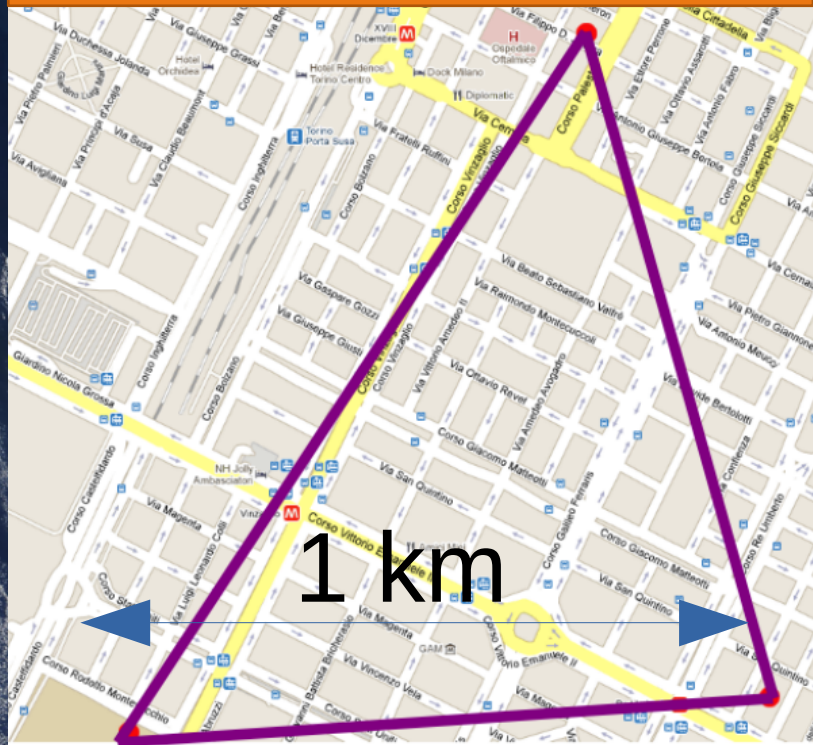
Extreme Energy Event Project

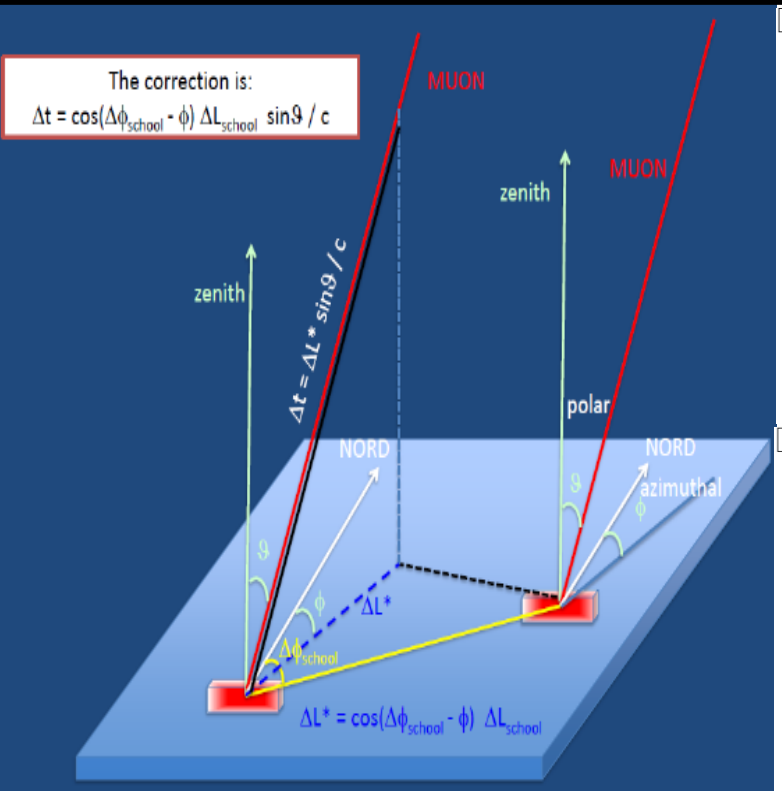
CENTRO FERMI
Enrico Fermi
MUSEO STORICO DELLA FISICA E CENTRO STUDI E RICERCHE ENRICO FERMI

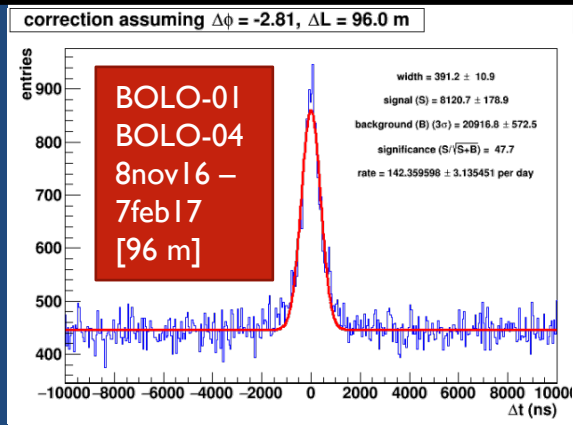
Extreme Energy Events
Science inside Schools

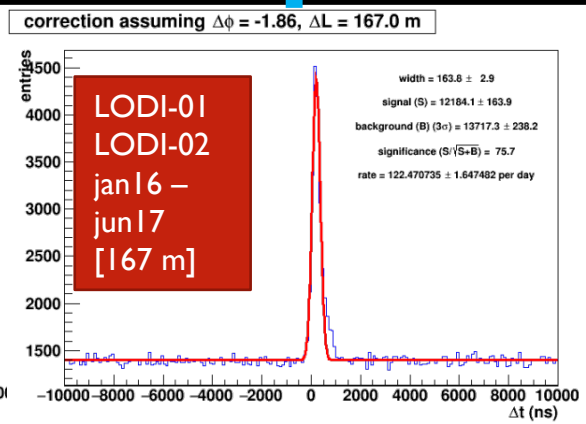
- 53 EEE Telescopes (increasing…)
- More than 100 High Schools involved
- Clusters of Telescopes all over Italy (and CERN)

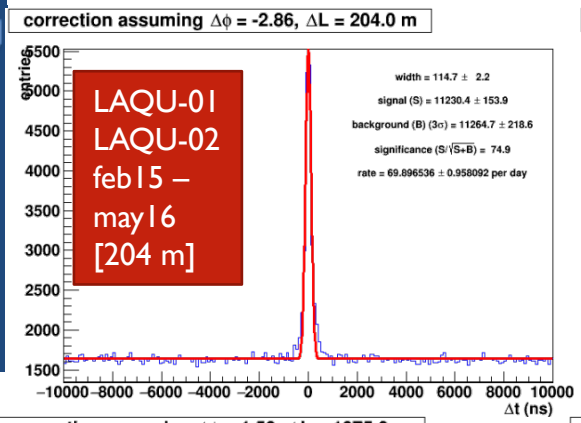


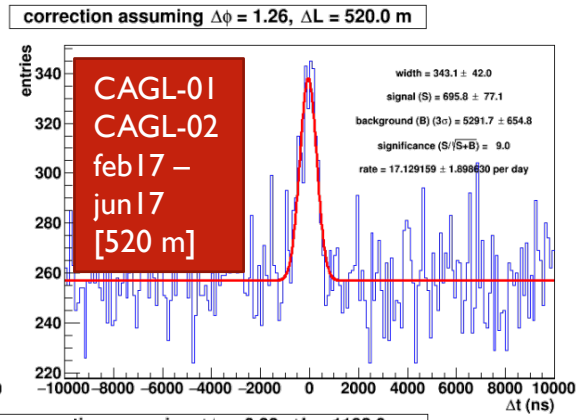
EAS Analysis: Coincidences between Telescopes

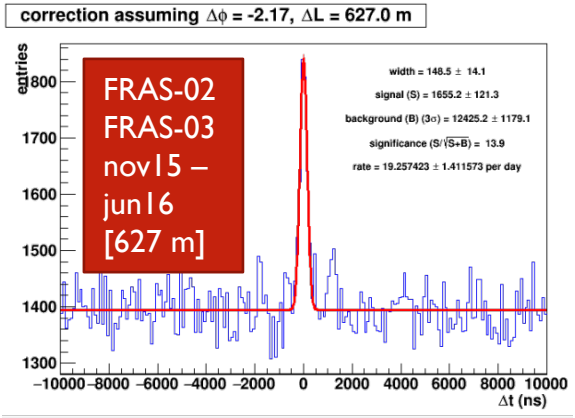


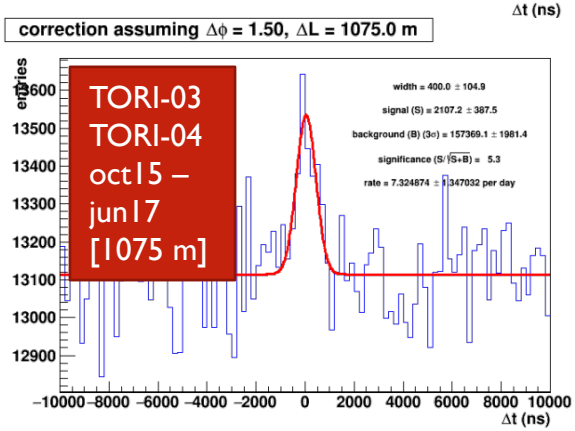


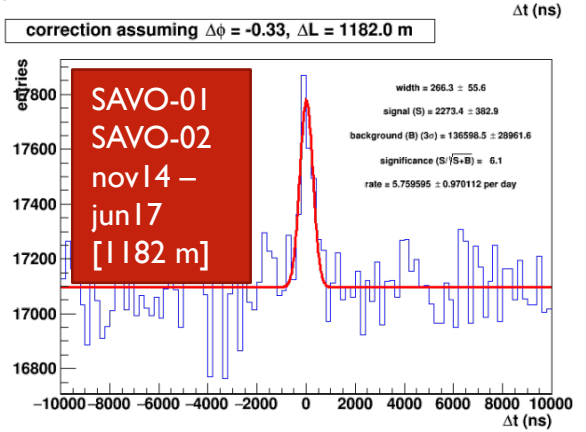




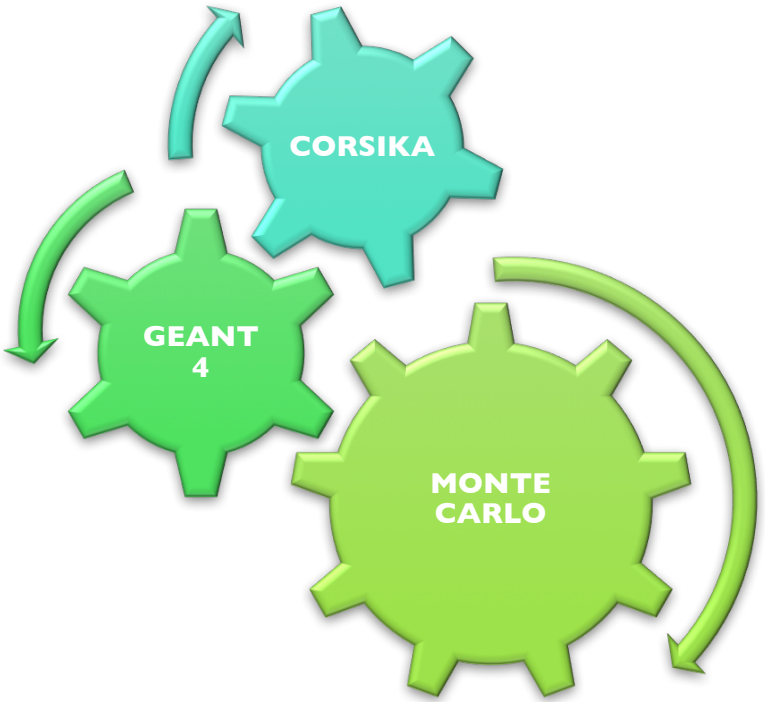








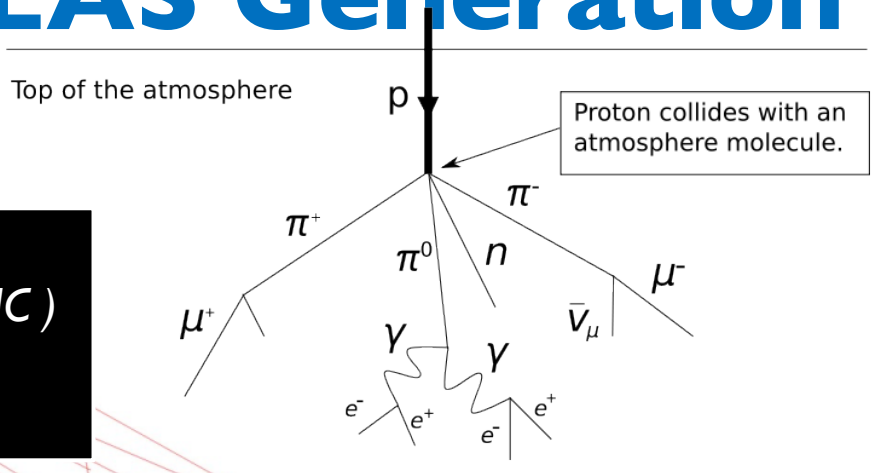
The Chain



SIMULATION CHAIN

- EAS Generation
- CR Flux and EEE Telescopes
- Buildings and Detectors Characterization

EAS Generation



High-energy Hadronic Interactions:
EPOS *(reproduces heavy ion data from RHIC and LHC)*
Low-energy Hadronic Interactions: **FLUKA**
Electromagnetic Interactions: **EGS4**

- Proton, 10^6 GeV,
- θ = 45 deg
- xz-projection
- red = electrons, positrons, gammas
- green = muons
- blue = hadrons

CORSIKA (COsmic Ray SImulations for KAscade)
www.ikp.kit.edu/corsika

e3sim

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centrofermi / e3sim

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Simulation software for EEE

Add topics

github.com/centrofermi/e3sim

Edit

29 commits 1 branch 0 releases 1 contributor GPL-3.0

Branch: master New pull request Create new file Upload files Find file Clone or download

coccetti Multithread Latest commit 8ce548b on 2 Aug 2016

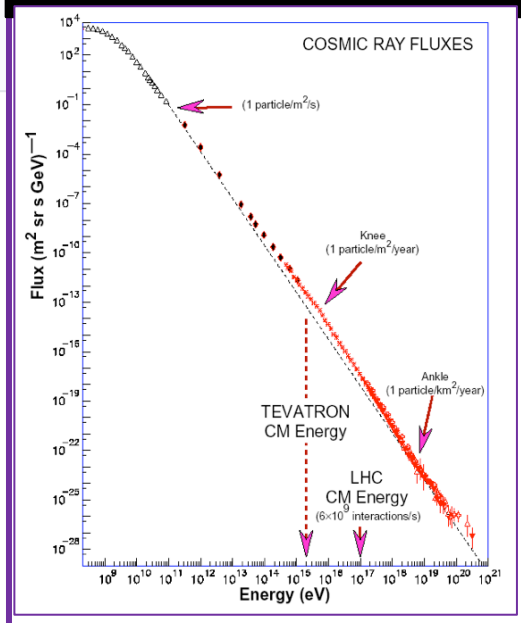
app	Multithread	a year ago
config	Adding automatic email report	a year ago
macros	Updating Root macros	2 years ago
plot	Now it is almost possible to generate showers with options	2 years ago
tasks	Added energy range production	a year ago
.gitignore	Adding automatic email report	a year ago
LICENSE	Let's start this sim	2 years ago
MANIFEST	Let's start this sim	2 years ago
README	Now we are able to change easily architecture and machine	2 years ago
README.md	Now we are able to change easily architecture and machine	2 years ago
__init__.py	Now we are able to change easily architecture and machine	2 years ago
clean_pyc.sh	Let's start this sim	2 years ago

README.md

e3sim

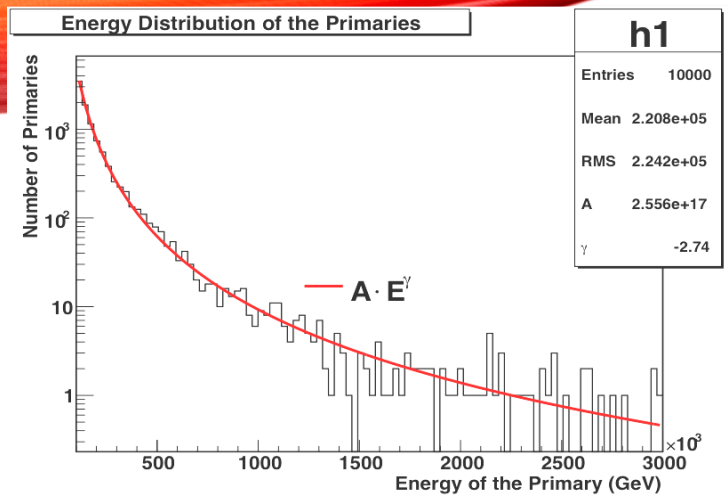
e3sim is a python package written to perform simulations for the (Extreme Energy Events) EEE experiment.

More info on the EEE experiment at: http://www.centrofermi.it/eee



- Python package
- **Drives Corsika Simulations:**
  - Hadronic Models
  - PID Primary
  - E, Theta, Phi
  - Magnetic Field
  - Energy Cuts
- Output: ROOT files
- Open source (availabe on github)

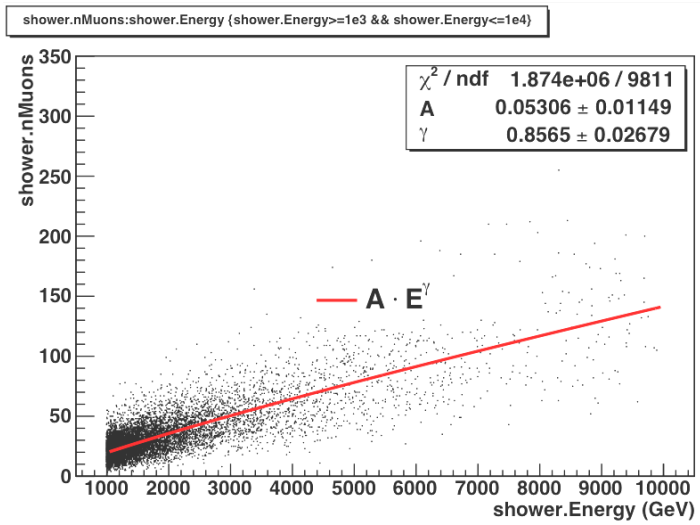
EAS Generation



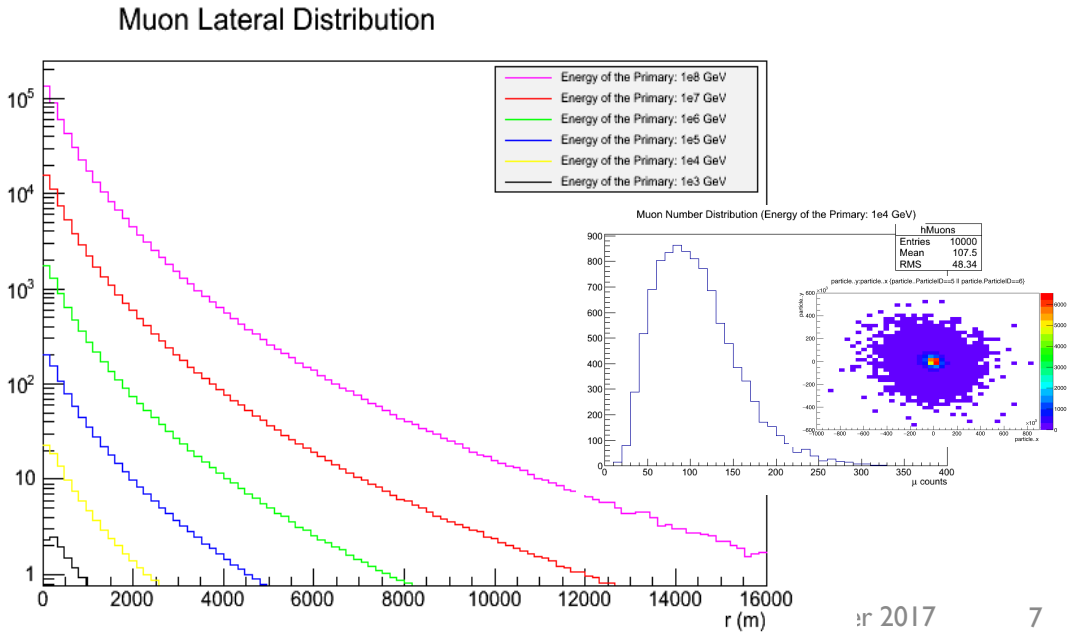
$$\Phi(E) \sim 1.6 \cdot 10^4 / E^{\gamma} \quad (m^2 s^{-1})$$

Catalogue (to date): ~**100000** showers (increasing). Hosted at CNAF (Bologna).

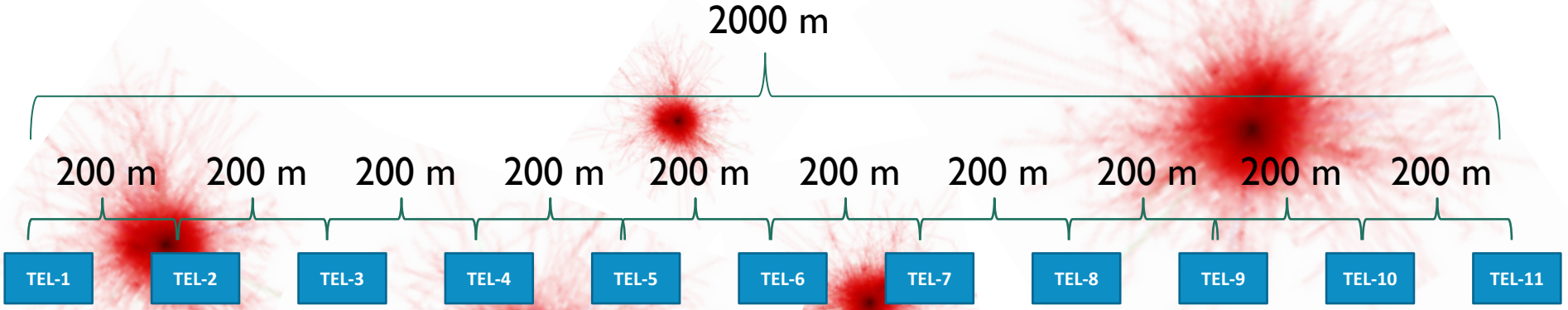
- 10^3 GeV < E < 10^7 GeV
- Theta [0, 70]
- Phi [0, 360]
- PID Primary: p
- EPOS – FLUKA – EGS4

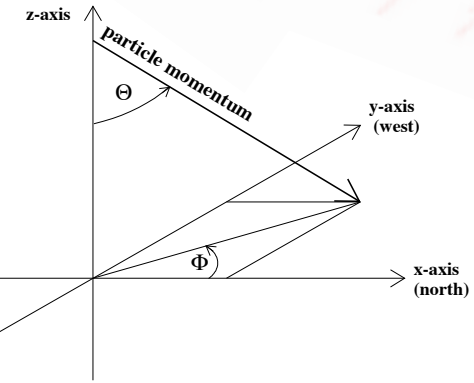


$$N_{\mu} \sim A \cdot E^{\gamma}, \ \gamma \in [0.78, 0.86]$$

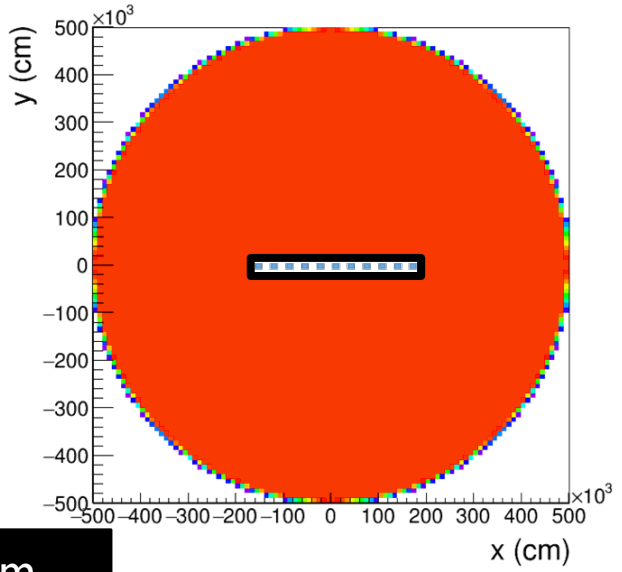


Simulation setup





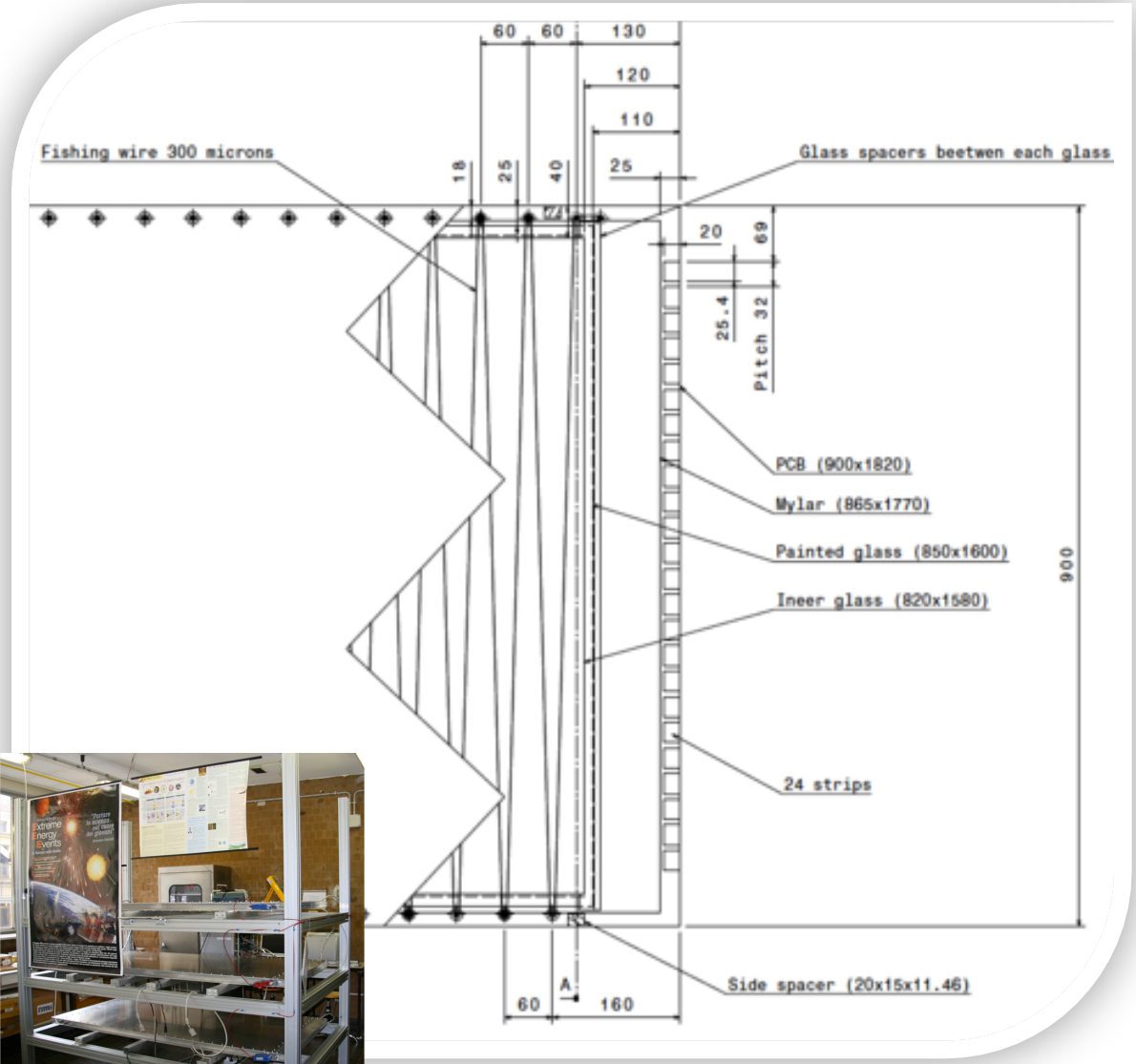
- CR Flux (20 days)
- E, θ, ϕ
- Core position (x, y)
- CPU: 16 cores, 120 hrs

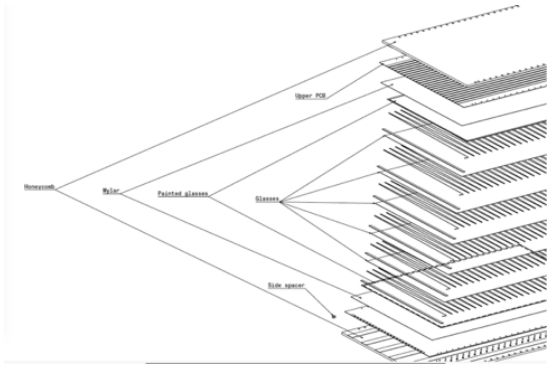


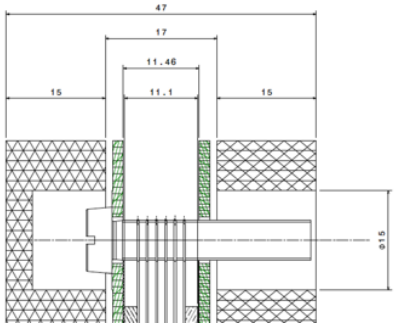
11 telescopes 200m spaced. Pair distances from 200m to 2000m.
Statistics for 200 m → 10 pairs → 200 days

GEMC / GEANT4
framework to simulate the passage of particles through matter

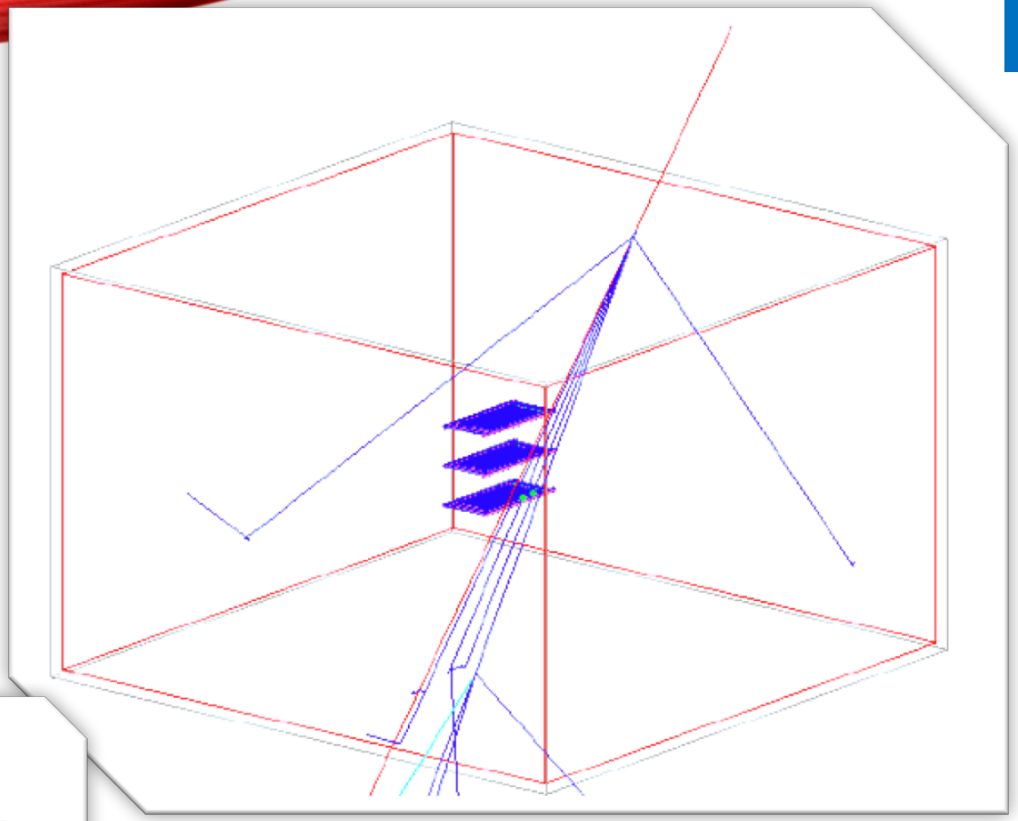
MRPC simulation: geometry

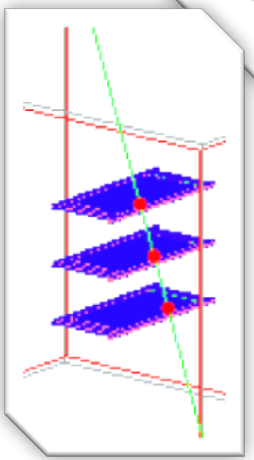


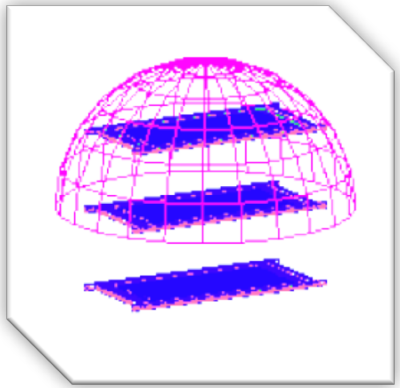


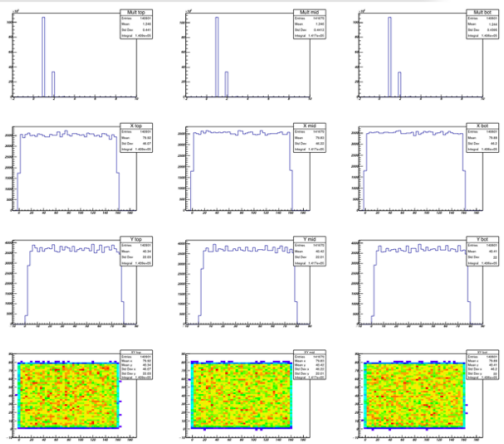


Walls, Celings, Buildings…



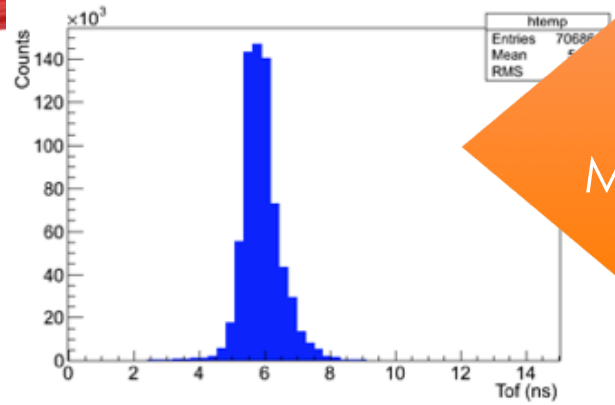






- EEE Telescopes are housed in High Schools.
- The location of each Lab is different (you may have Telescopes close to the roof of the school, or Telescopes in underground…).
- Effect of the walls.
- Asymmetric buildings.

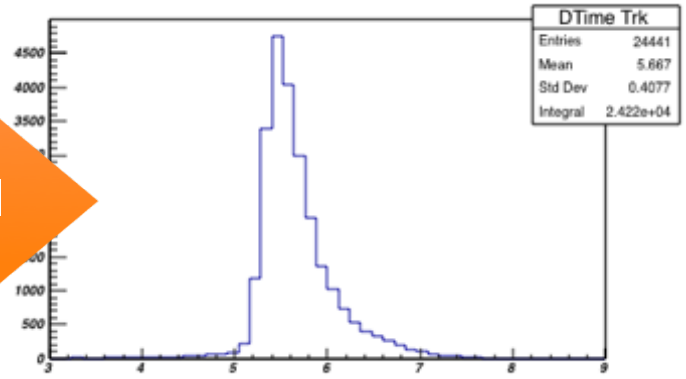
GEMC / GEANT 4

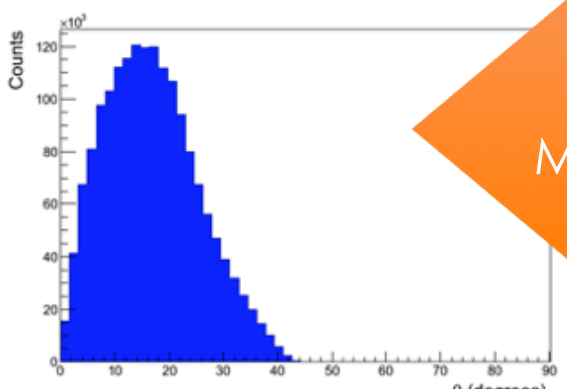


DATI MISURATI

SIMULAZIONI

ToF

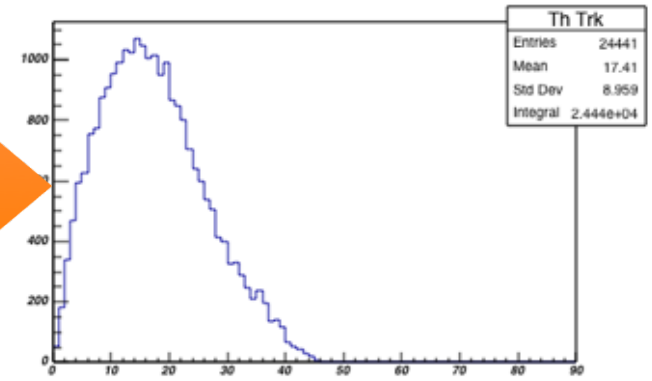


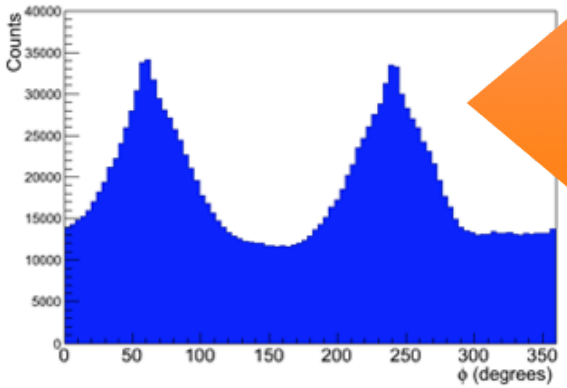


DATI MISURATI

SIMULAZIONI

Theta

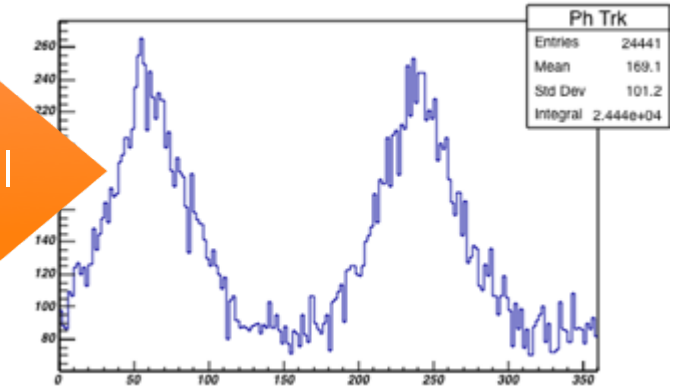




DATI MISURATI

SIMULAZIONI

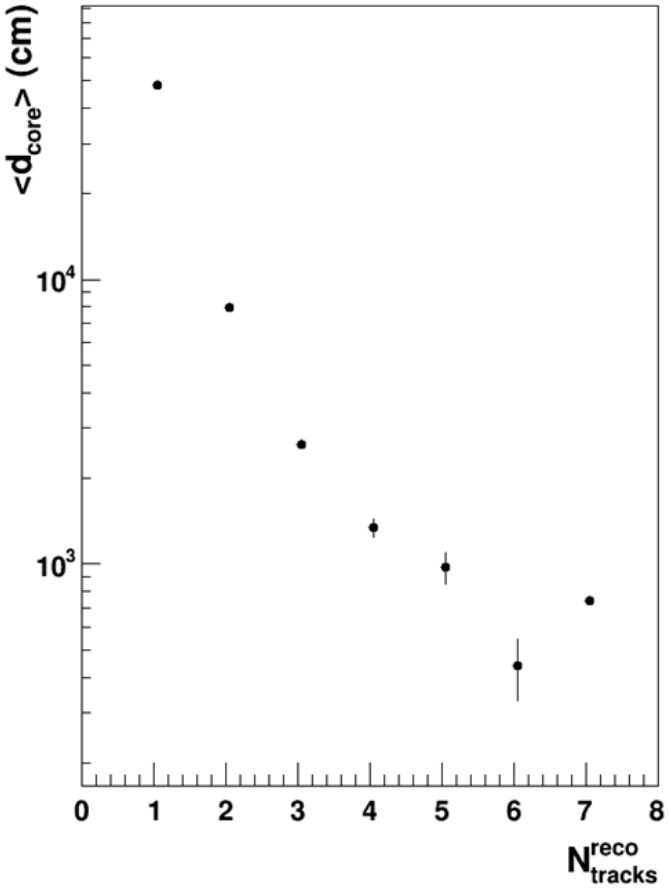
Phi



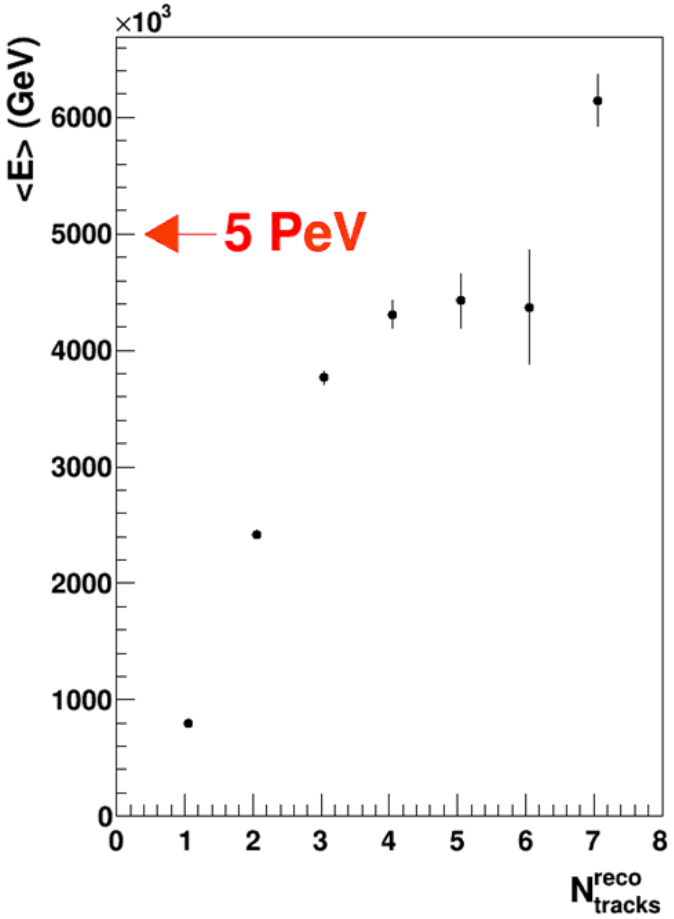
Energy vs multi-track events in a single telescope

Preliminary Results

Average core distance from telescope (Corsika, 220 days)



Average energy (Corsika, 220 days)

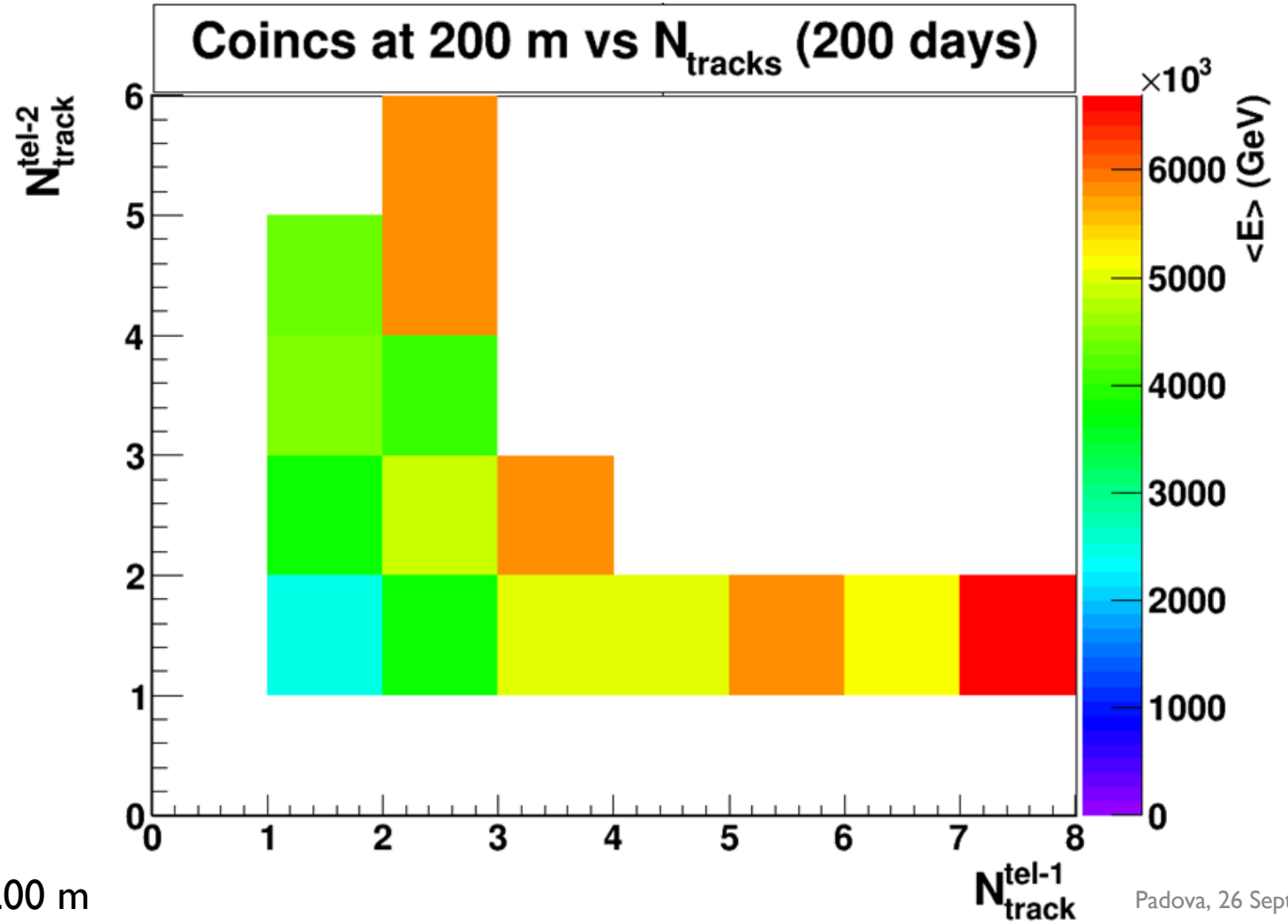


Track density has a **strong dependence on the energy** of the primary cosmic ray.

D = 200 m

Combining coincidences and multi-track

Preliminary Results



D = 200 m

Rate of Coincidences vs distance between telescopes

Preliminary Results