Update on coincidences studies

F. Coccetti, M. Garbini, F. Noferini

CENTRO FERMI
Museo Storico della Fisica e
Centro Studi e Ricerche Enrico Fermi

INFN
Istituto Nazionale
di Fisica Nucleare

Outlines

- MC simulations: current status
- Writing paper: update
- Conclusions

MC

We are working to provide MC simulation following three steps

1. Creation of a large sample of showers (Fabrizio)
2. Simulation of the material in front of our detectors (Marco B. started to look into that)
3. Generation of DST as done for real data (+ some additional MC information)
   - Physics: Showers + Energy spectrum
   - Acceptance (also for mutliple-telescope scenarios)
   - Digitalization
   - Reconstruction (the same as for data)

MC sample

So far we did some test on an old set of Corsika shower generated at fixed energies (10^2 GeV, 10^3 GeV, 10^4 GeV, 10^5 GeV, 10^6 GeV, 10^7 GeV). The next results will refer to this set of data (accordingly to a $\cos^2(\theta)$-distribution).

In the meanwhile Fabrizio produced a set of showers with energy distributed continuously ($E^{-2.7}$ power law).

General strategy of simulations

1. Configuration: we define
   - A data period
   - A number of detectors and their displacements
   - The radius of the region where shower cores are generated (uniformly)
   - The energy range of the primaries
2. Loop on Cosmic Rays: depending on the radius and energy range the primary cosmic ray flux is computed. Then a loop to generate cosmic rays is performed.
   - The arrival time of each cosmic rays is generated randomly accordingly to the flux of CRs.
   - The event is processed and in case stored (see next slide)

Event simulation

Once the arrival time is assigned the event is processed in this way

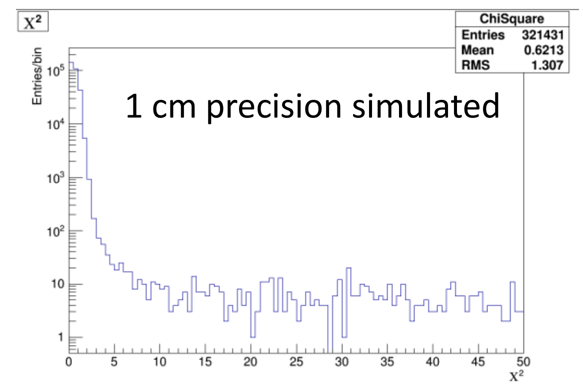
- A shower is taken accordingly to the energy distribution ($E^{-2.7}$)
- (x,y) of the core is assigned randomly
- The azimuthal angle of the primary is assigned randomly (θ of the original shower is kept!)
- Only muons are tracked
- If at least one muon is close enough to a telescope the event is processed, otherwise it is skipped (to save time)
  - All the secondary particle candidates are propagated through the material in front of the telescope (not yet in) and in case the produced particle are also propagated through the detector
- Particles are then propagated through the detector to produce hits.
- If all the 3 chambers of a telescope have at least one hit, the event is considered as «triggered» and then it is acquired
  - Tracks are reconstructed in the same way of real data
  - Event is stored as for real data in DST
  - The GPS time is assigned as primary_time + delay_time_of_secondary

N.B.|| If two telescopes were able to see the same event this will be visible in the DST!

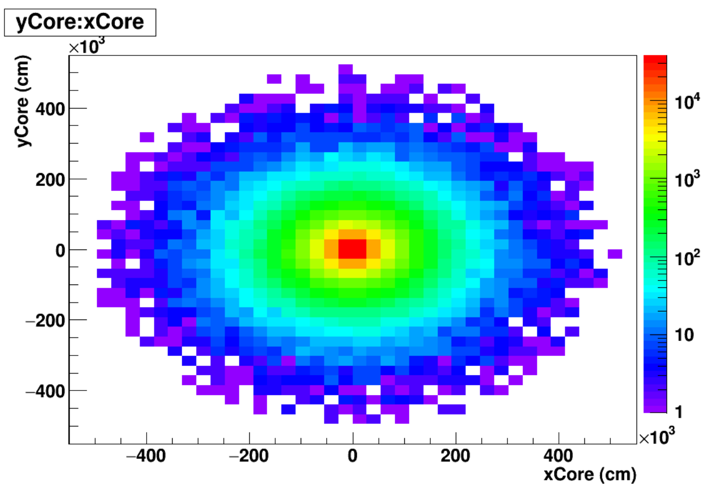
An example of the output

Results obtained for showers of 10^7 GeV:

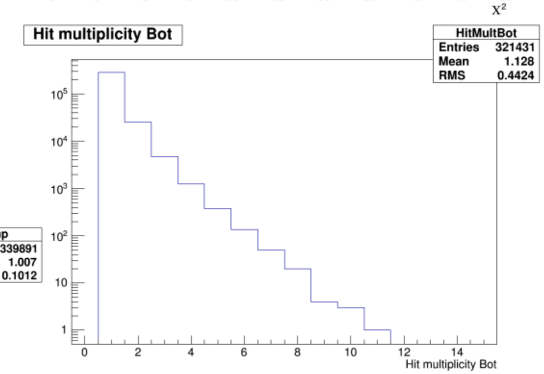
- 320k events stored in one telescope for a period of 940 days (it is still not the real rate because we need to tune better the simulation)

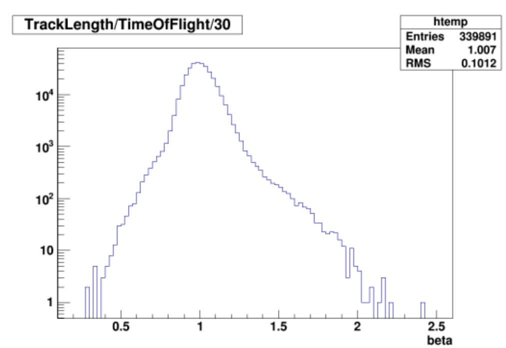


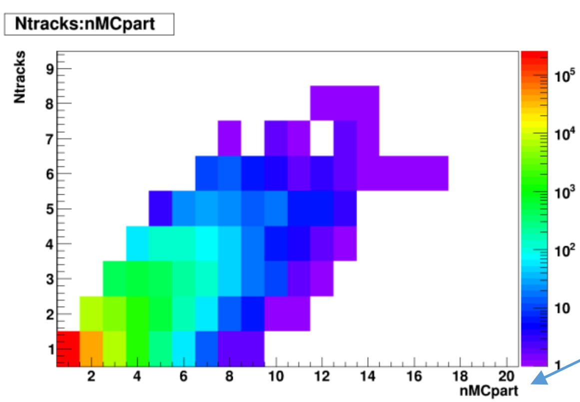
1 cm precision simulated



Core distribution for triggered events (generated core distribution is uniform within a radius of 5 km)

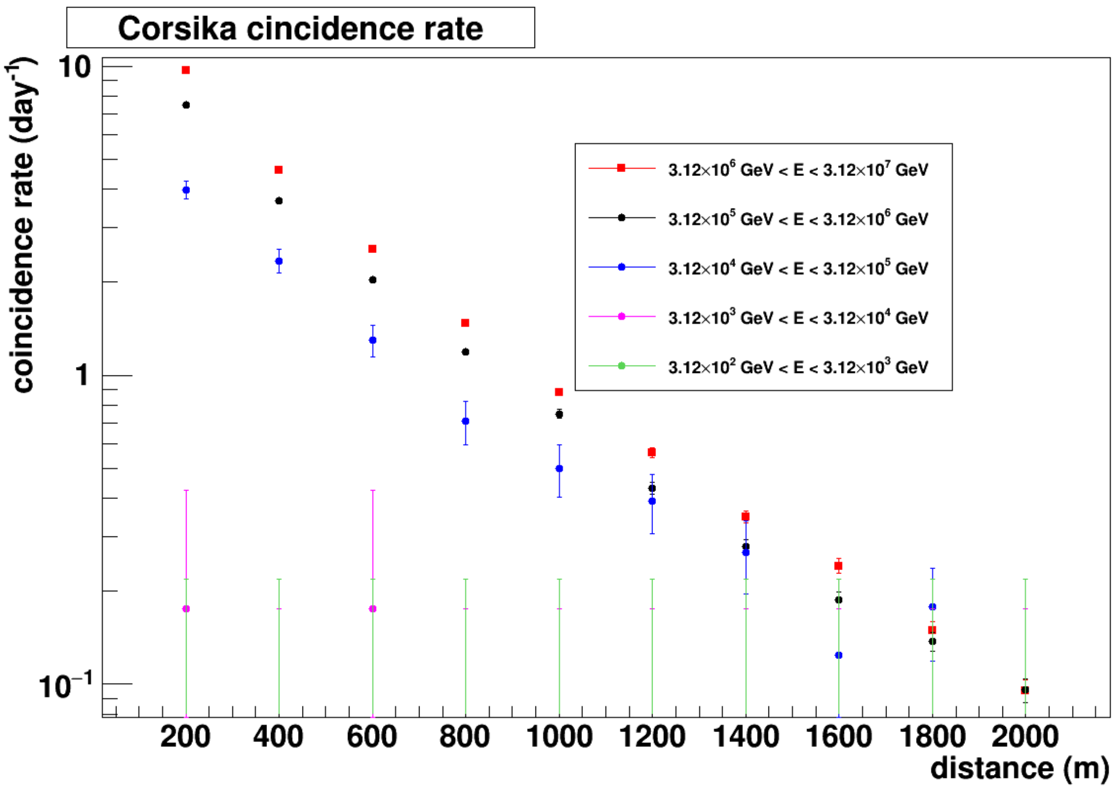






At least one hit in a chamber

Simulation of coincidences

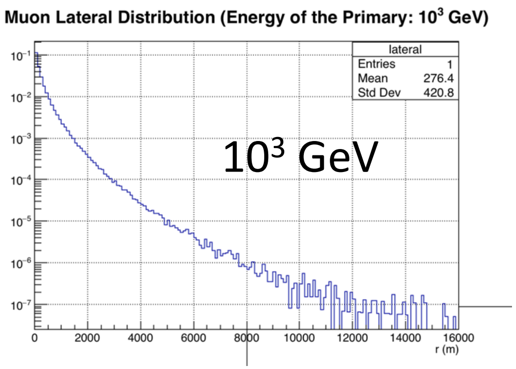


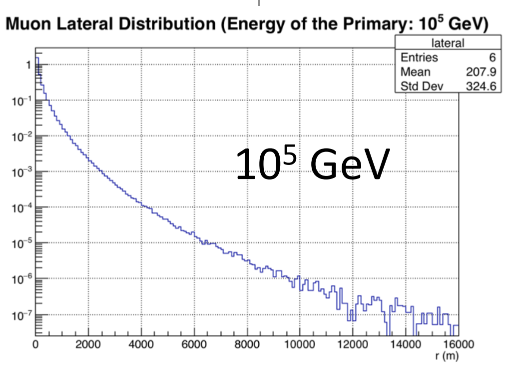
A preliminary study shows that the trend of coincidences vs distance is slightly dependent on the energy of the primary.

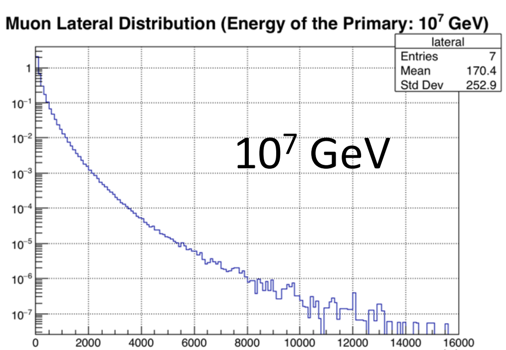
This happens because the lateral distributions are very similar (except for the normalization value). See next slide.

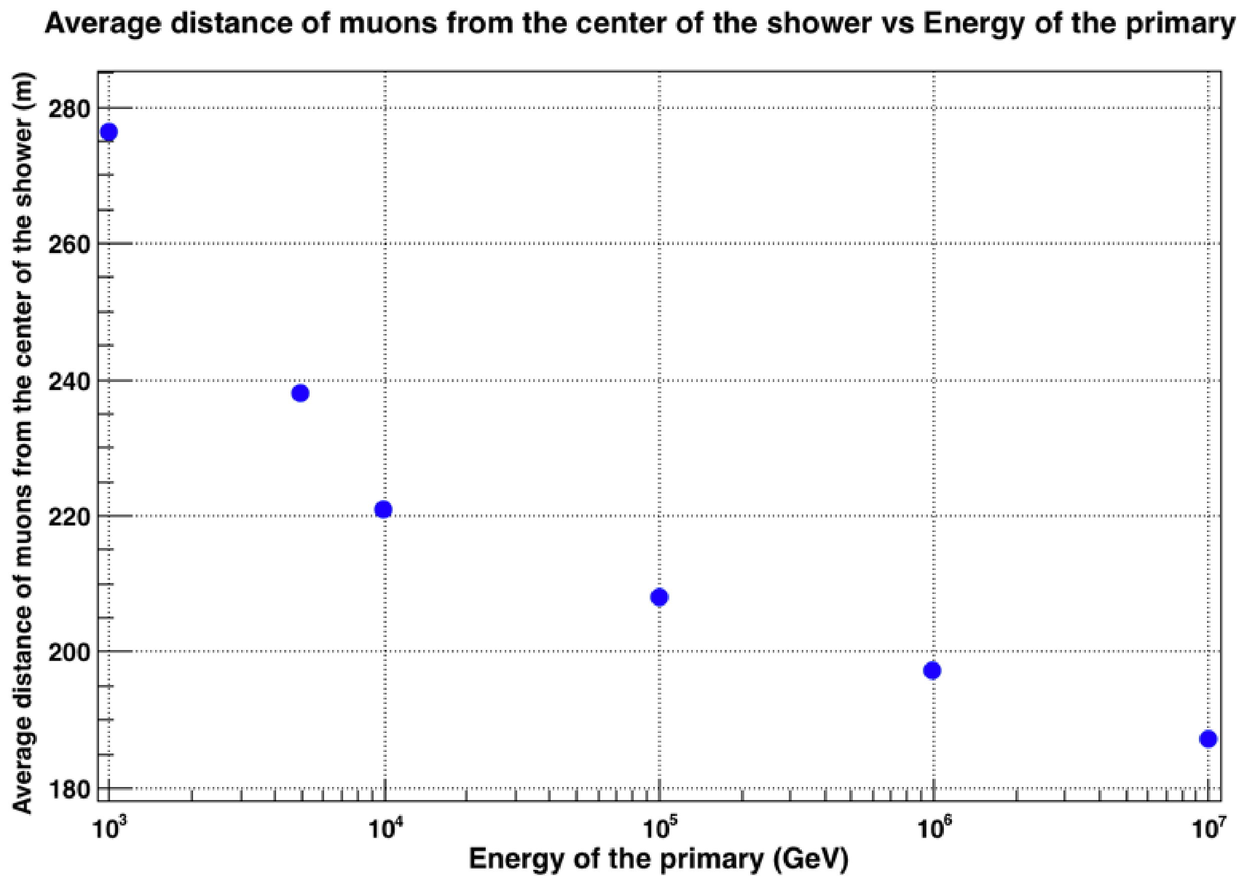
Our conclusion is that it is not possible to extract any information on the energy distribution from this kind of plot.

Lateral distributions and Average distance of muons





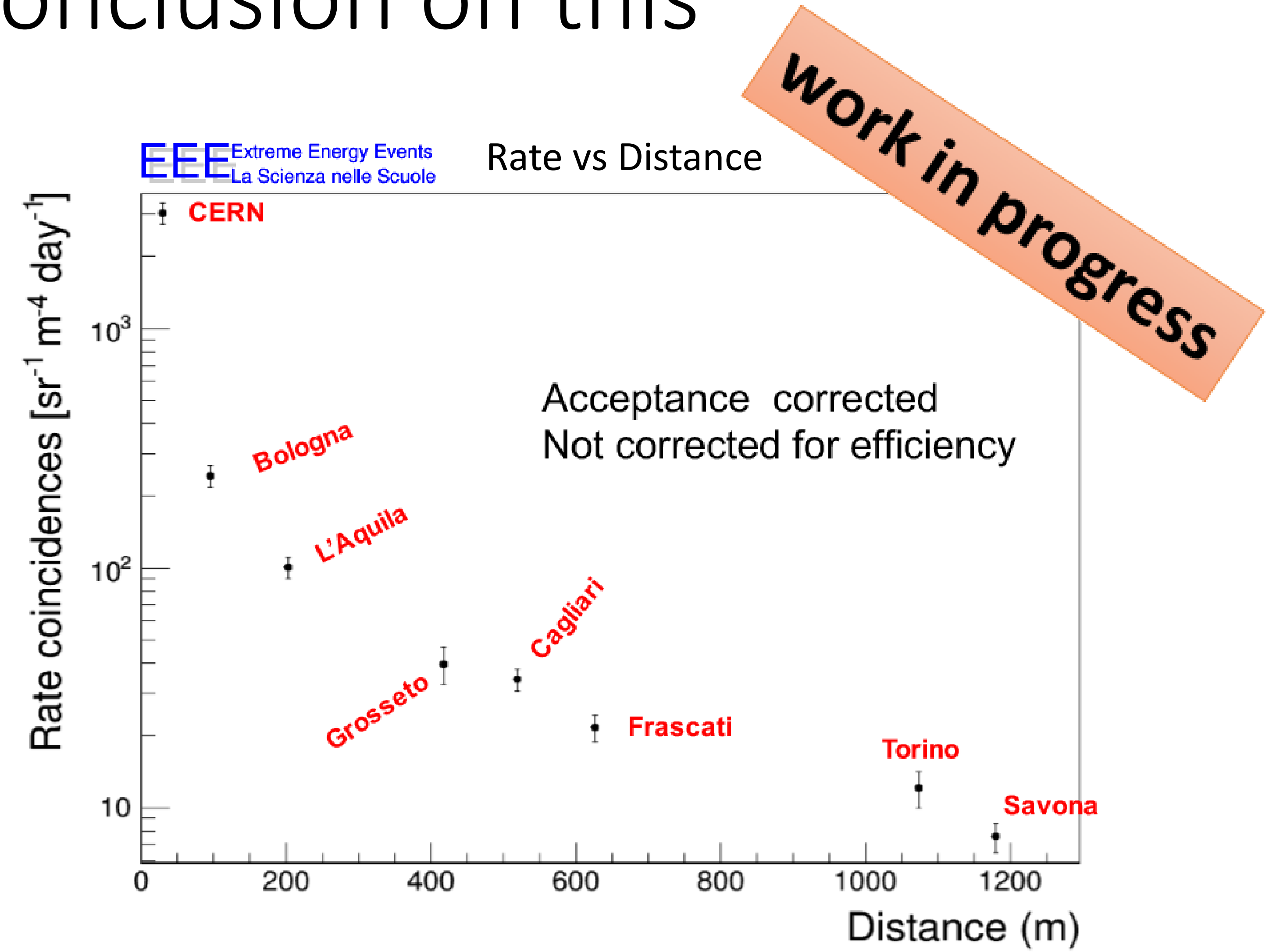




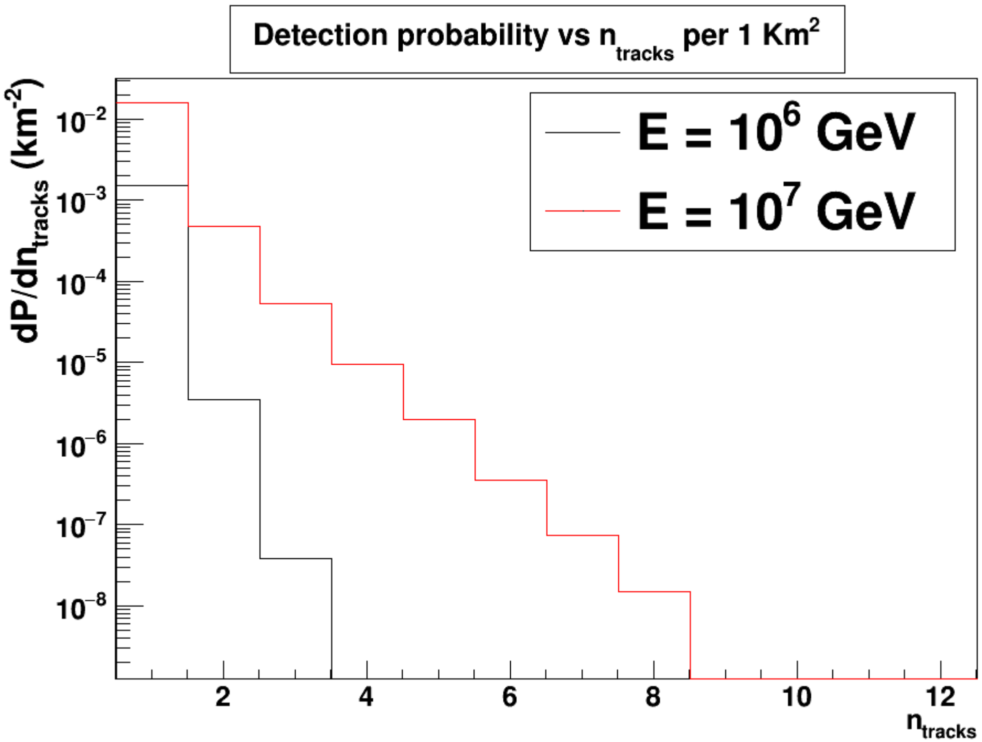
Next time: results with the new set of showers with energy distributed continuously !!

Main conclusion on this

This plot doesn't allow to get information on the energy spectrum. Only a comparison with Corsika simulation can be done.



Track multiplicity



A first look to track multiplicity seems encouraging.
Shower with different energies have a very different track multiplicity distribution.

But…

… the effect of material in front of our detector has to be taken into account!

Our comment: even if this is not a study related to coincidences we have to keep in mind that.

Paper

M. Garbini (writer) & L. Perasso (reviewer)

Started with standard EEE Project Introduction & Detector Description using NUOVO CIMENTO Template.
Internal meeting next week to define the structure on the basis of the results.

The EEE Project: results on time correlation between telescopes

Preliminary Title

1. – Introduction

The EEE Project [?] is an experiment designed to study the "Extreme Energy Events" class of cosmic rays. It is a very large ground array of muon tracking telescopes (figure 1, left), made of three large area ($\simeq 2\ m^2$) Multigap Resistive Plate Chambers (MRPCs) 50 cm apart, installed inside Italian High Schools and INFN Units or Laboratories. The telescopes are distributed across the whole Italian territory over an area of about $10^5\ km^2$ organised in town cluster or single sites (figure 1, right).

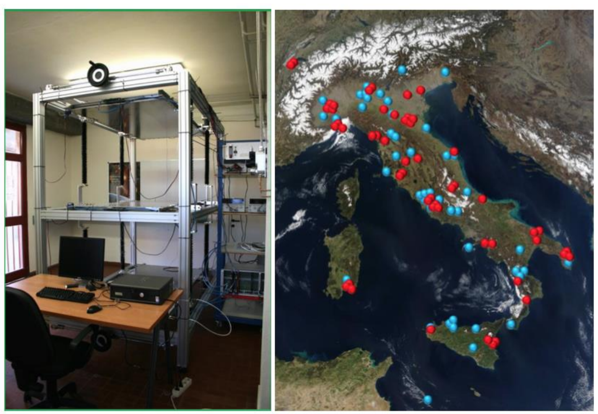


Fig. 1. – Left: the EEE Project Muon Tracking telescope. Right: map of EEE telescope distriburion in Italy; red circles mark the towns in which EEE telescopes are installed. The blue ones to schools participating in the EEE Project even without hosting a detector.

2. – Detector design

The single tracking telescope of the EEE Project is composed by 3 Multi-gap Resistive Plate Chambers (MRPCs) spaced of 0.5 m, one over the other as in Fig. 1 (left). These MRPCs are a wider and cheaper version of the detector developed for the Time-Of-Flight (TOF) group of the ALICE experiment at LHC [?]. Each MRPC ($80 \times 160\ cm^2$), is a stack of resistive glass plates, transparent to the avalanches generated inside the gas gaps: the signal induced on the pick up electrodes results as the sum over all the gaps providing high gain. The detector operated at about 18 kV shows efficiency close to 100%′ (qui si potrebbe mettere refernza a paper performances).