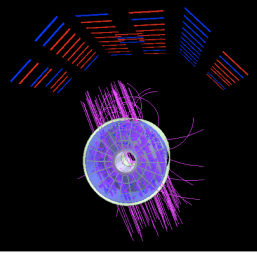
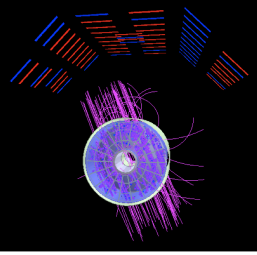


Detection of atmospheric muons with ALICE detectors

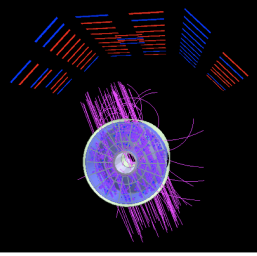
Frontier Detectors for Frontier physics
May 25th 2009

Mario Rodríguez Cahuantzi
FCFM - BUAP, Puebla, México
For the ALICE Collaboration

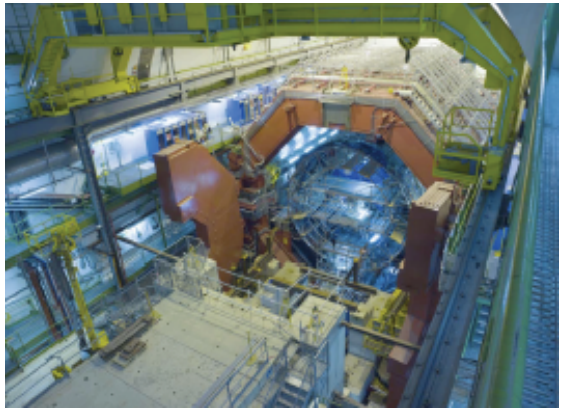


Outline

1. ALICE: A Large Ion Collider Experiment
   - General review
   - Tracking detectors
   - Triggers in ALICE
2. ACORDE: Cosmic Ray detector in ALICE
   - Design of ACORDE
   - Electronics of ACORDE
   - Reconstruction of Atmospheric muons with ACORDE + TPC
3. SPD Trigger in ALICE
   - SPD Trigger
   - Observed events with high number of tracks
   - Event rate estimation
4. Summary

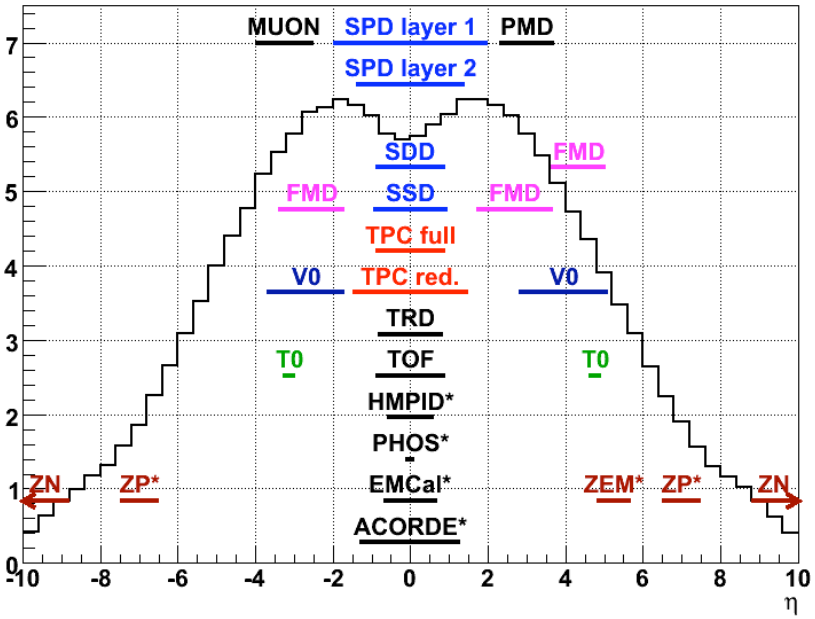


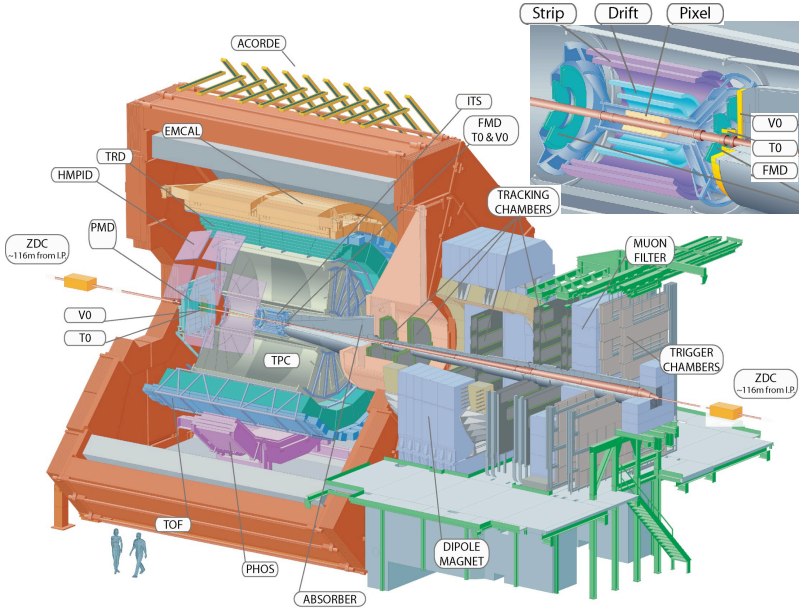
ALICE: A Large Ion Collider Experiment
General Review

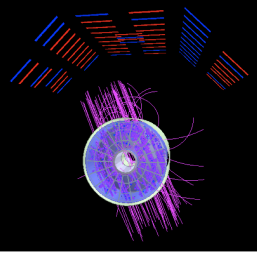


- The main purpose of the ALICE experiment is to study heavy ions collisions at the LHC-CERN.
- It will analyze strong interactions and quark gluon plasma at high values of density for temperature and energy.
- The atmospheric muons which energy is bigger or equal than 15 GeV can be detected by the ALICE detector.

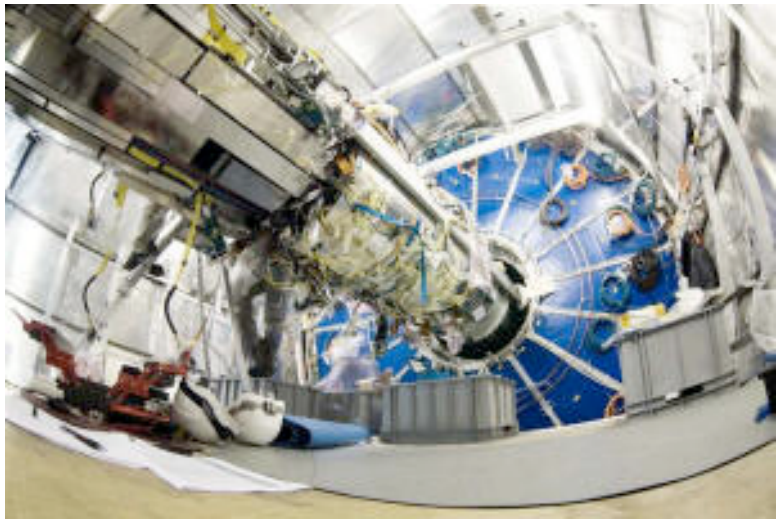
Charged Particle Acceptance

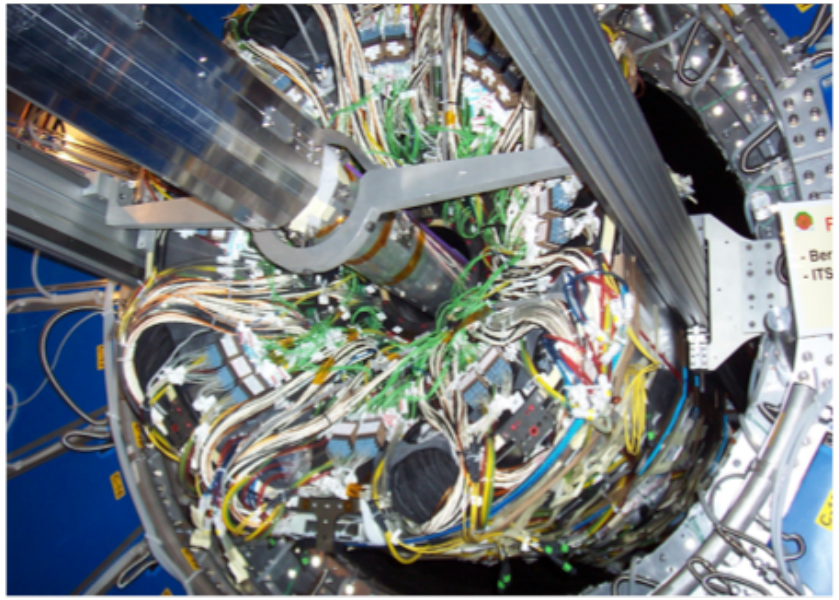




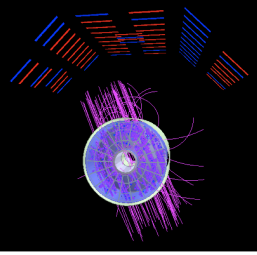


The ITS will locate the primary vertex



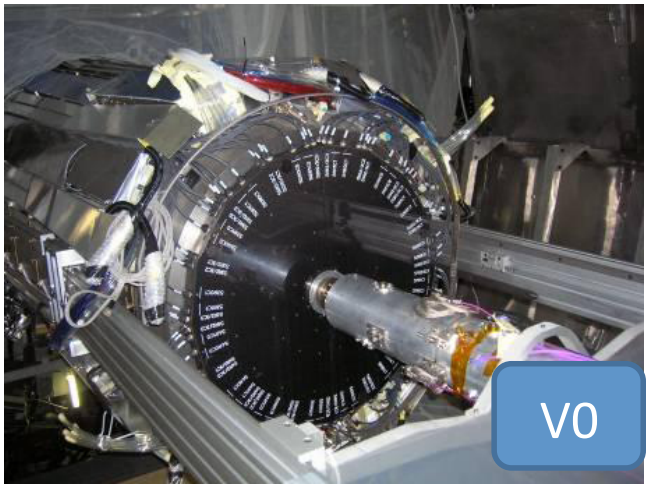


The TPC is used to track charged particles in $|\eta| < 0.9$

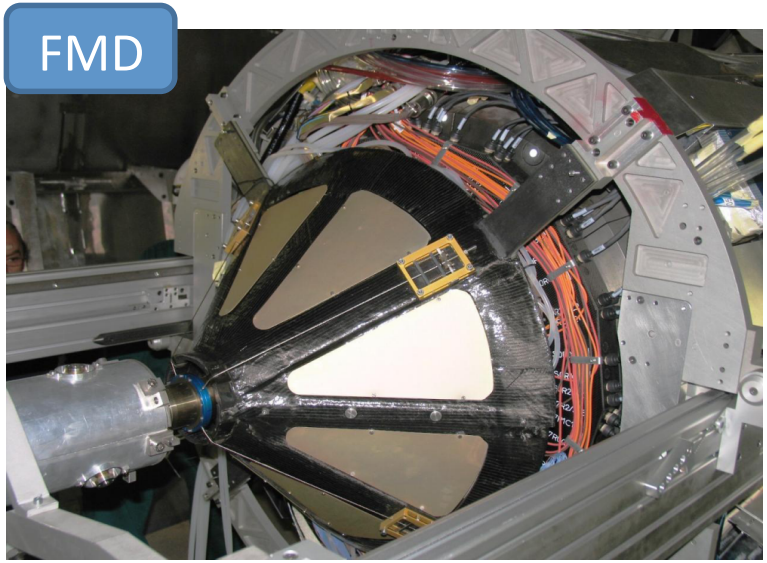


ALICE: A Large Ion Collider Experiment
Trigger detectors

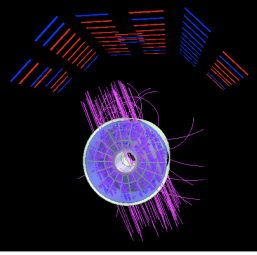
Minimum bias trigger



Provides multiplicity information over $-3.4 < \eta < -1.7$ and $1.7 < \eta < 5$



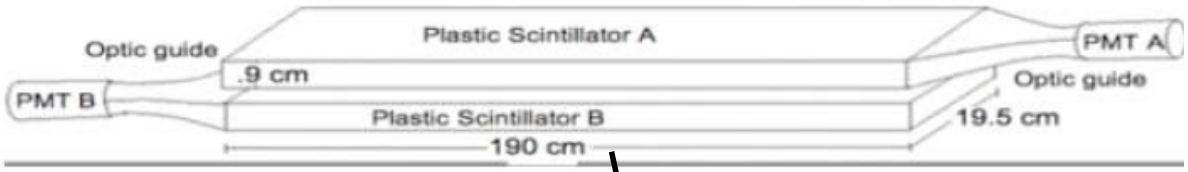
Cosmic ray trigger of ALICE

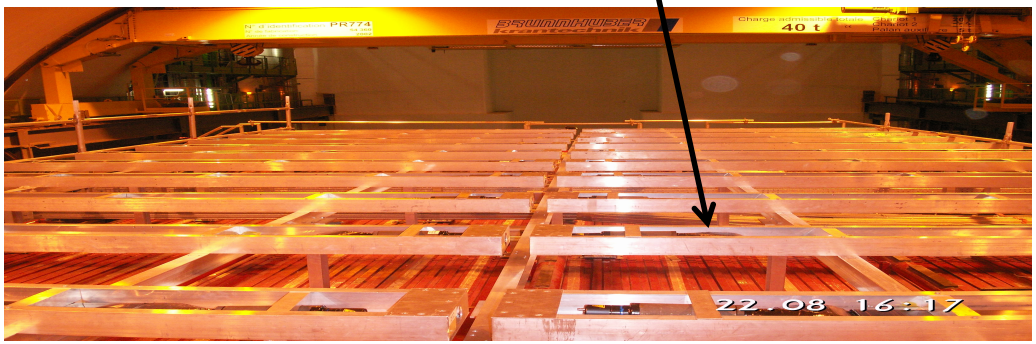


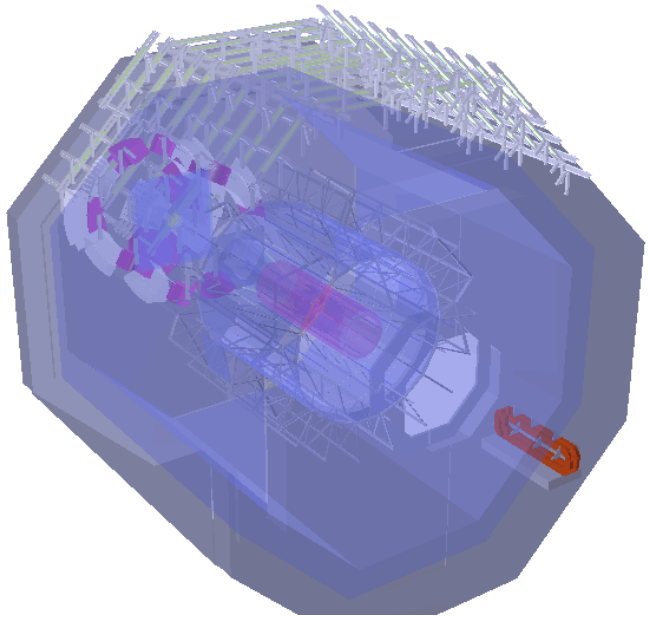
ACORDE: Cosmic Ray detector in ALICE
Design of ACORDE

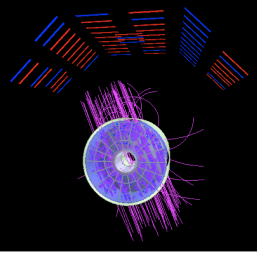
ACORDE is used to:

- Generate a fast signal of level zero that has been used for alignment and calibration of the inner central detectors in ALICE.
- Trigger events of atmospheric muons and identify those with high multiplicity.



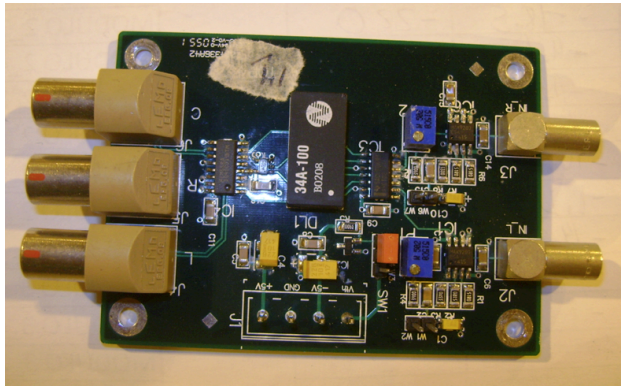




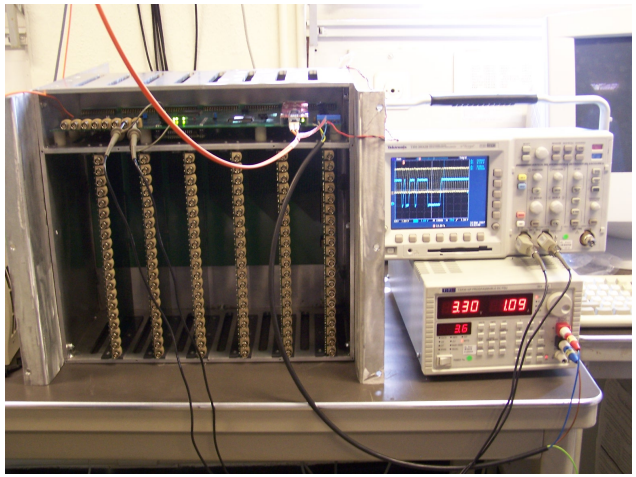


ACORDE: Cosmic Ray detector in ALICE
Electronic of ACORDE

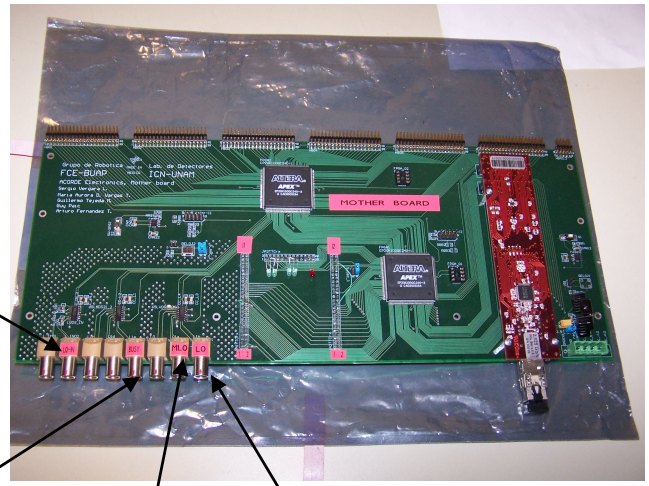
60 FEE cards



60 Path Panel cards



Mother board



L0 from the LTU

BUSY

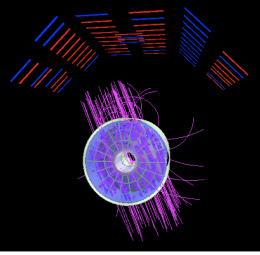
ML0

L0

DAQ
- Installed and working.

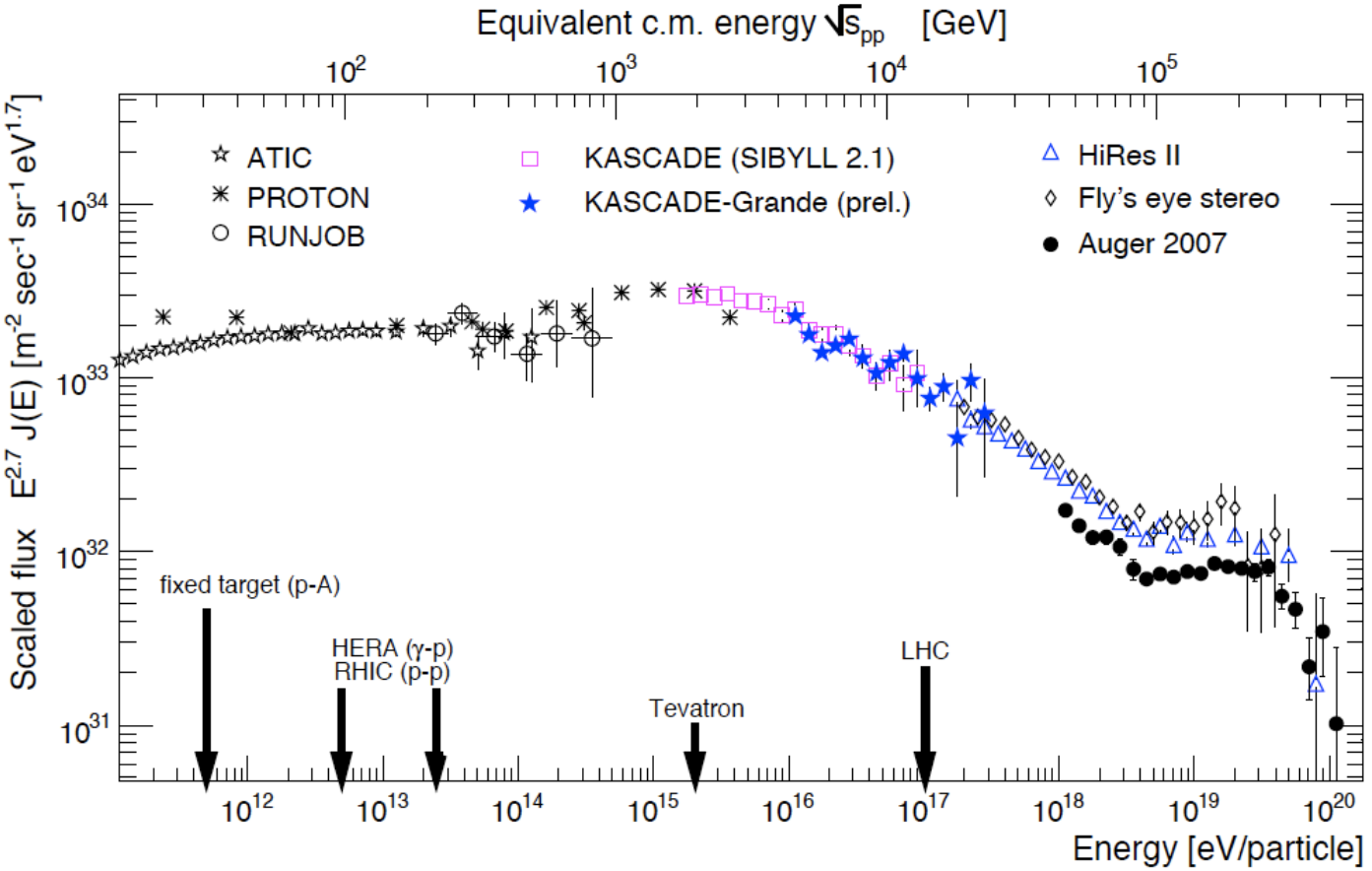
ECS.
- Installed and working.

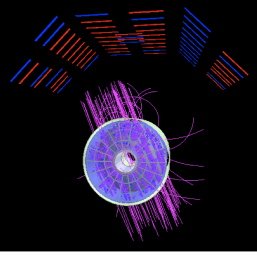
LTUproxi.
- Installed and working.



ACORDE: Cosmic Ray detector in ALICE
Reconstruction of atmospheric muons with ACORDE+TPC

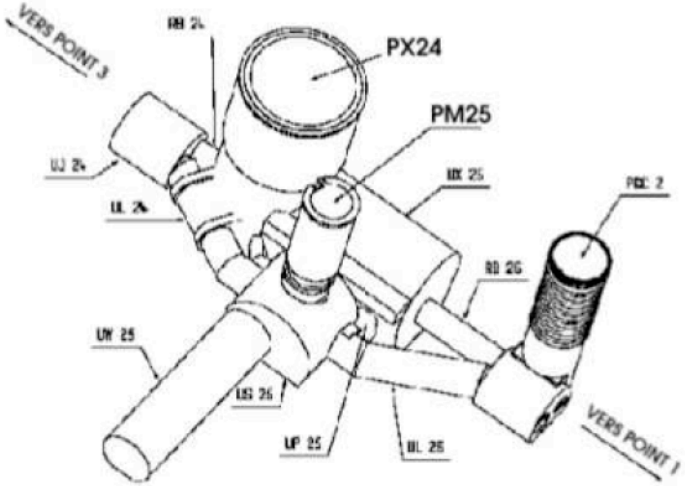
The multiplicity of high energy secondary muons has a further dependency of the primary cosmic ray composition and energy.

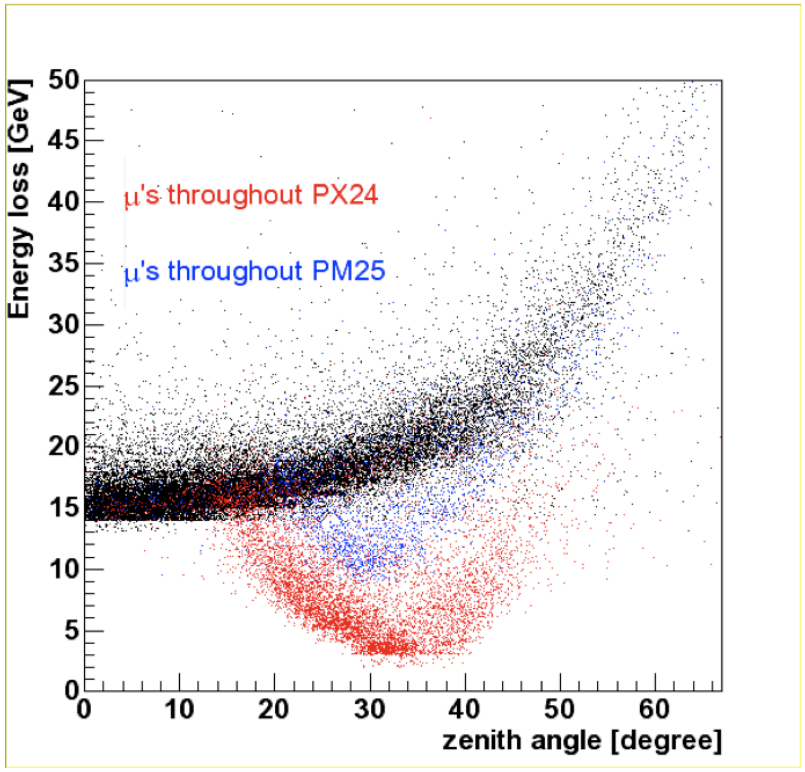


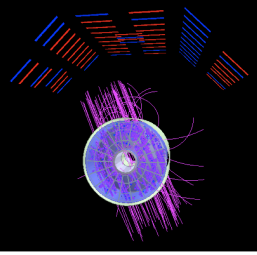


ACORDE: Cosmic Ray detector in ALICE
Reconstruction of atmospheric muons with ACORDE+TPC

The enviorenment of ALICE
Significant effects exist due to the material between the surface and equipment that include energy loss and dispersion between muons.



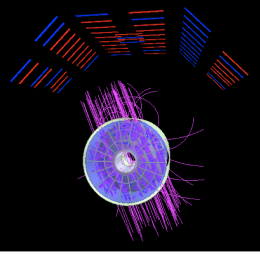




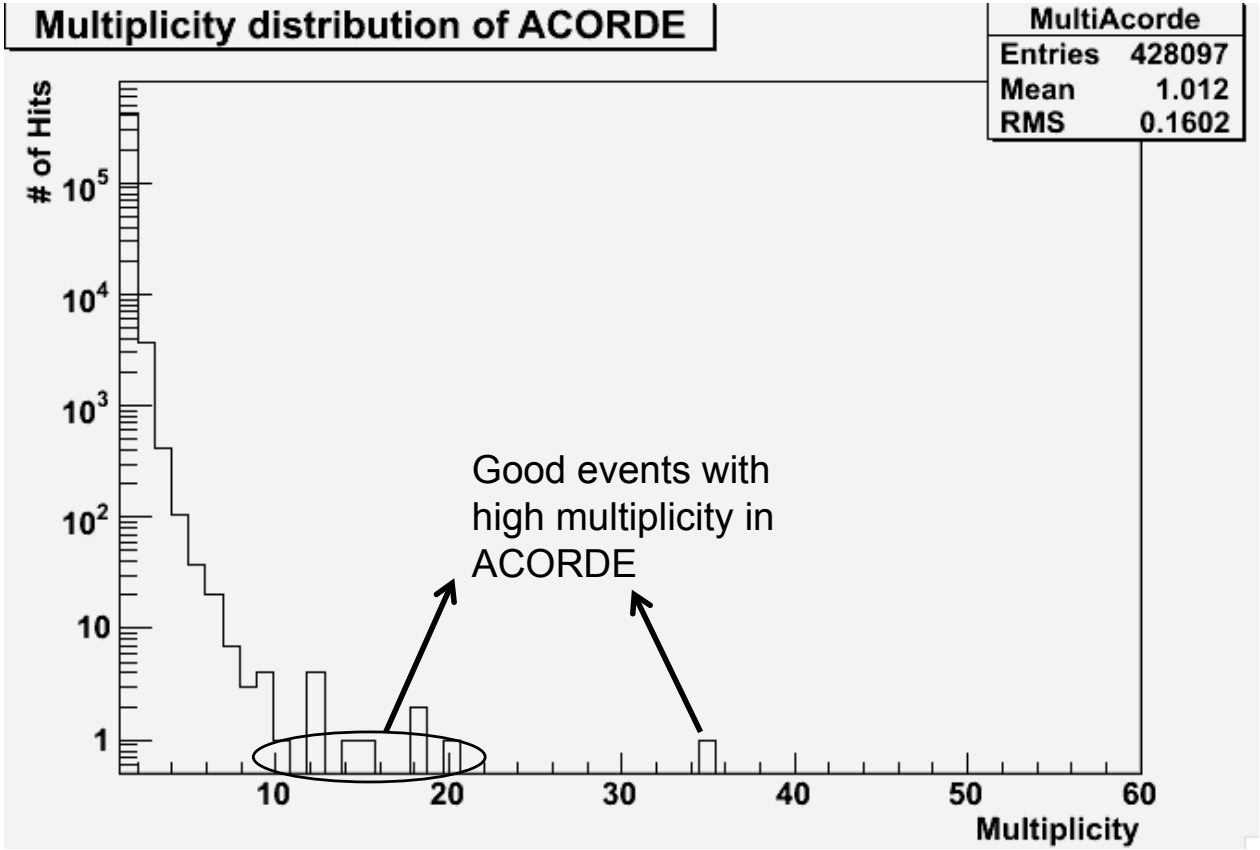
ACORDE: Cosmic Ray detector in ALICE
Reconstruction of atmospheric muons with ACORDE+TPC

Due to the characteristics of the ACORDE trigger system in ALICE, we have considerate the following studies in cosmic ray:

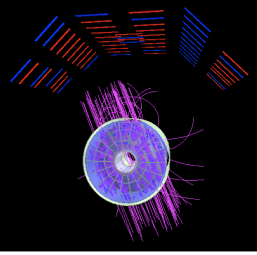
- Multi-muon Distribution
- Multi-muon Direction
- Measurements of vertical/horizontal rate
- Single muon energy spectrum and $\mu+/\mu-$ ratio;
- Muon energy in muon bundle events.



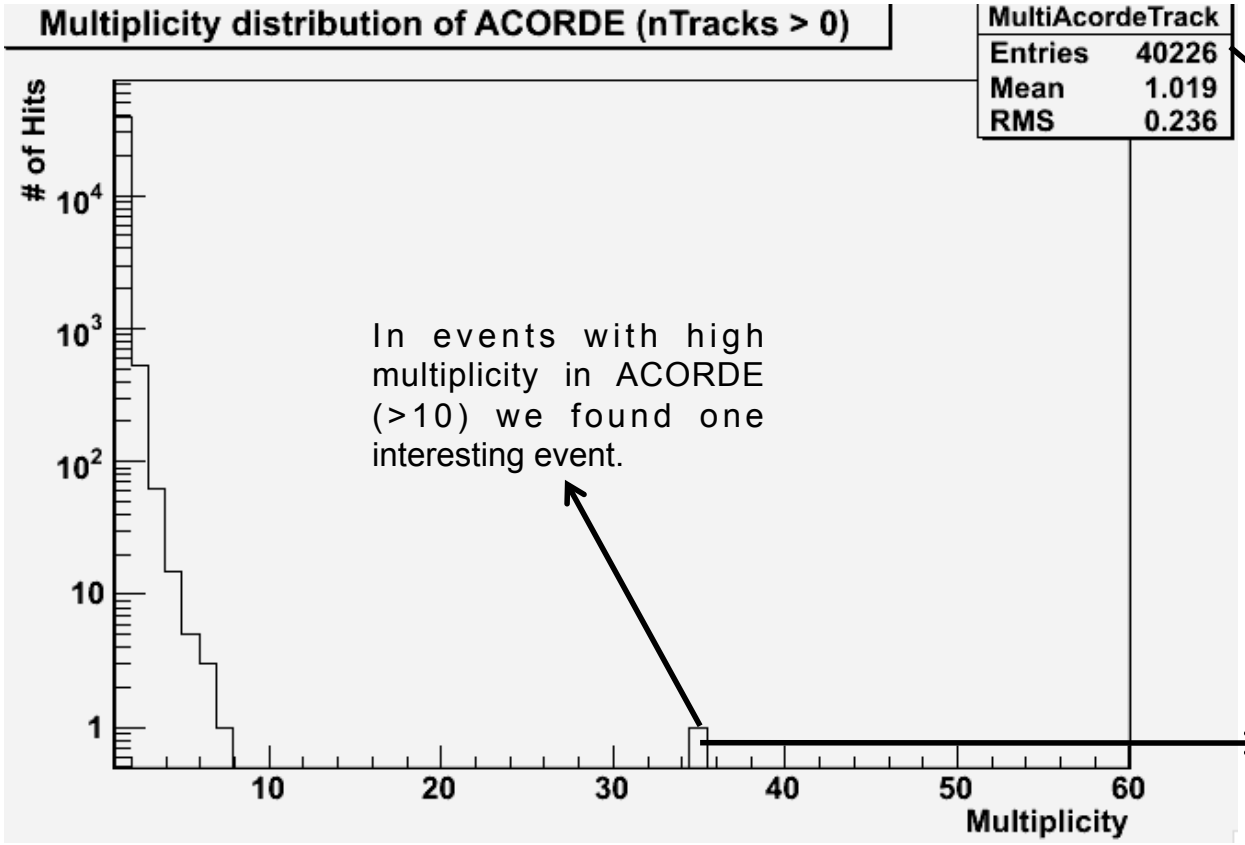
ACORDE: Cosmic Ray detector in ALICE
Reconstruction of atmospheric muons with ACORDE+TPC



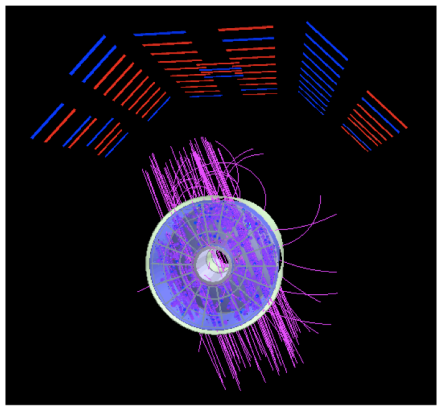
We can see events with ACORDE's multiplicity bigger than 7. Also one with 35 !!!

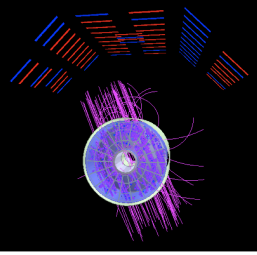


ACORDE: Cosmic Ray detector in ALICE
Reconstruction of atmospheric muons with ACORDE+TPC

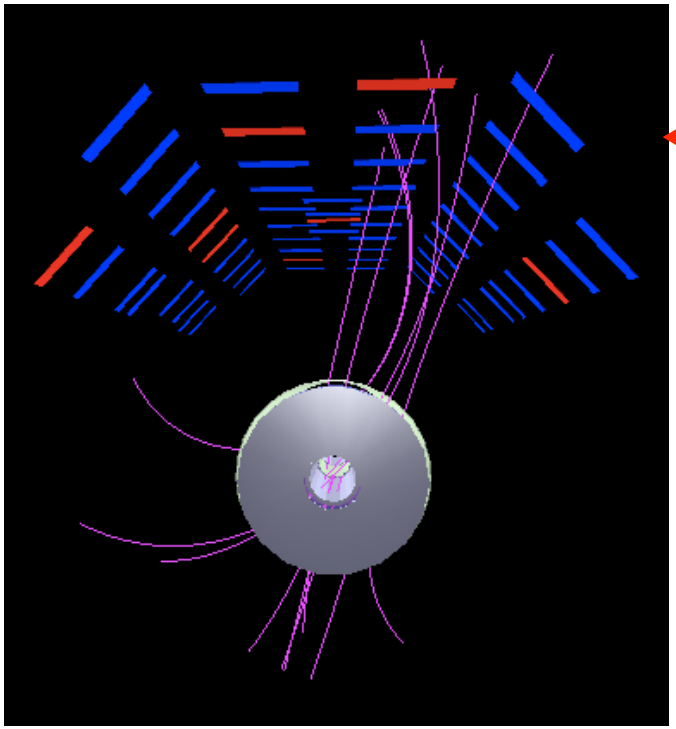


From the total information triggered by ACORDE that we have in ESD, only in the 9.40 % we found at least one track.



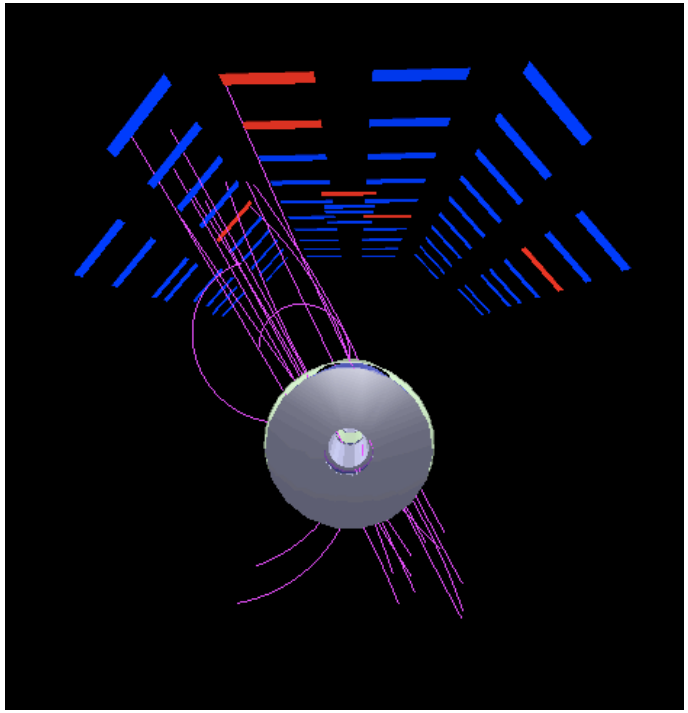


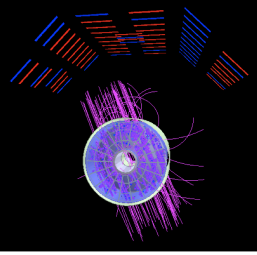
ACORDE: Cosmic Ray detector in ALICE
Reconstruction of atmospheric muons with ACORDE+TPC



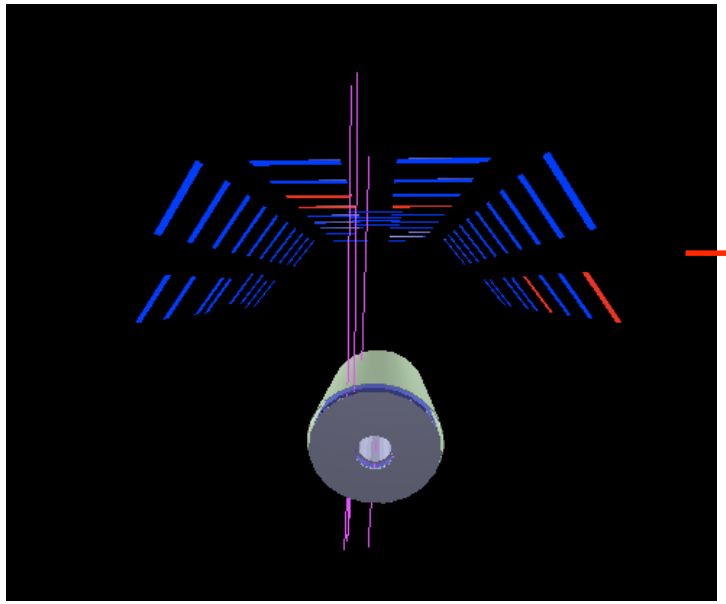
Run: 62102, Chunk: 570, # of Event: 5405,
Acorde Multiplicity: 8, # of tracks: 16

Run: 62102, Chunk: 280, # of Event: 9694,
Acorde Multiplicity: 6, # of tracks: 26



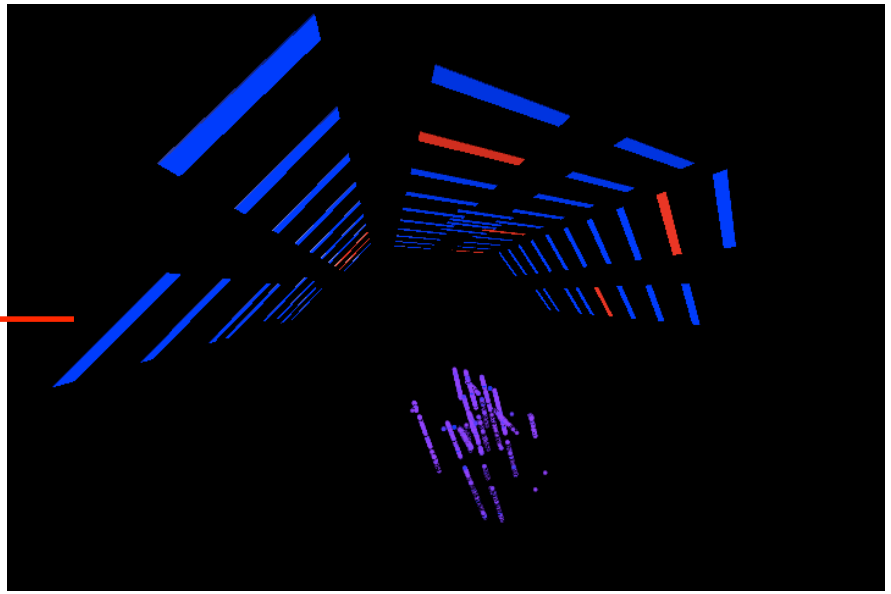


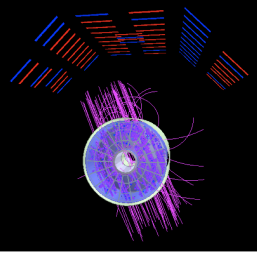
ACORDE: Cosmic Ray detector in ALICE
Reconstruction of atmospheric muons with ACORDE+TPC



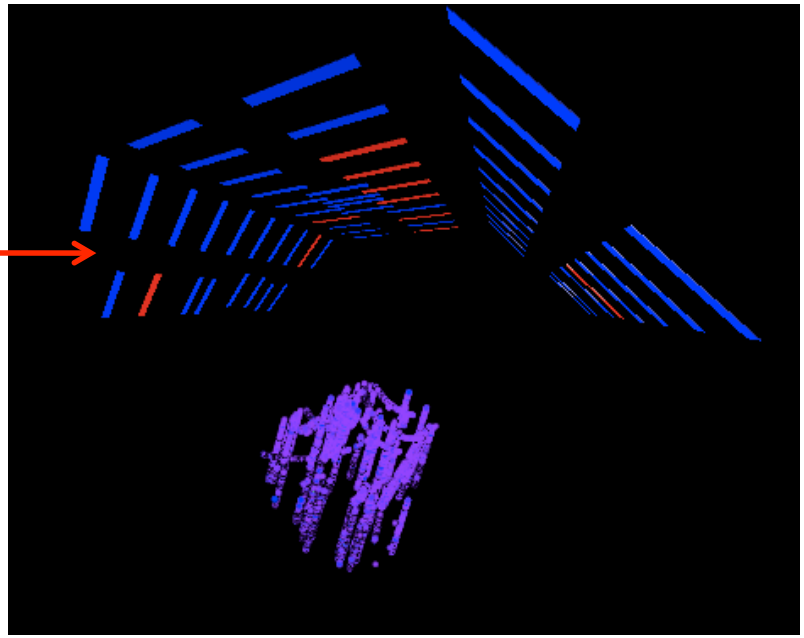
Run: 62084, Chunk: 60, # of Event: 3493,
Acorde Multiplicity: 5, # of tracks: 8

Run: 62084, Chunk: 80, # of Event: 3470,
Acorde Multiplicity: 7, # of tracks: 15

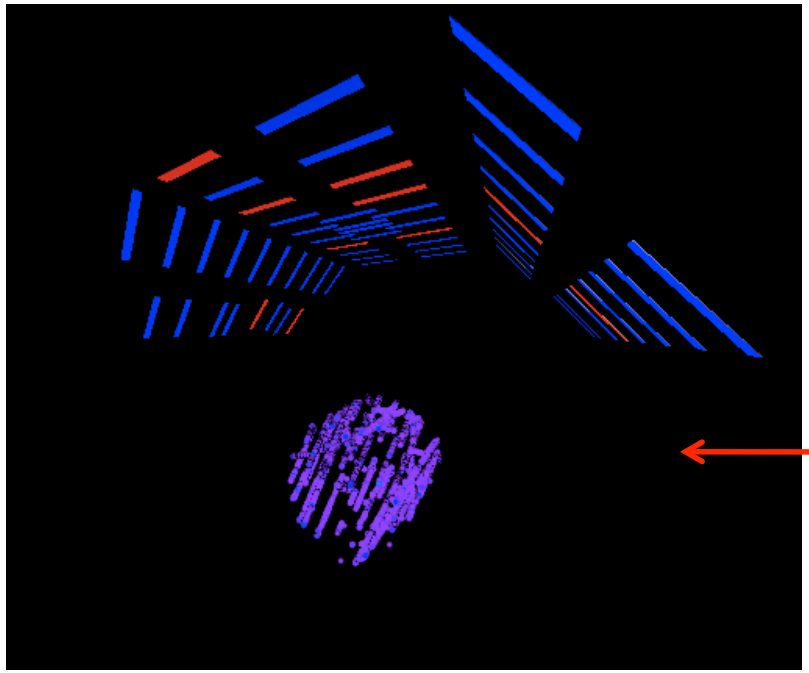




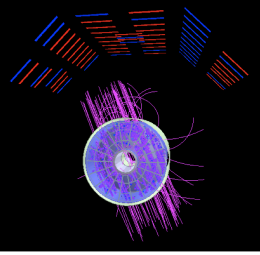
ACORDE: Cosmic Ray detector in ALICE
Reconstruction of atmospheric muons with ACORDE+TPC



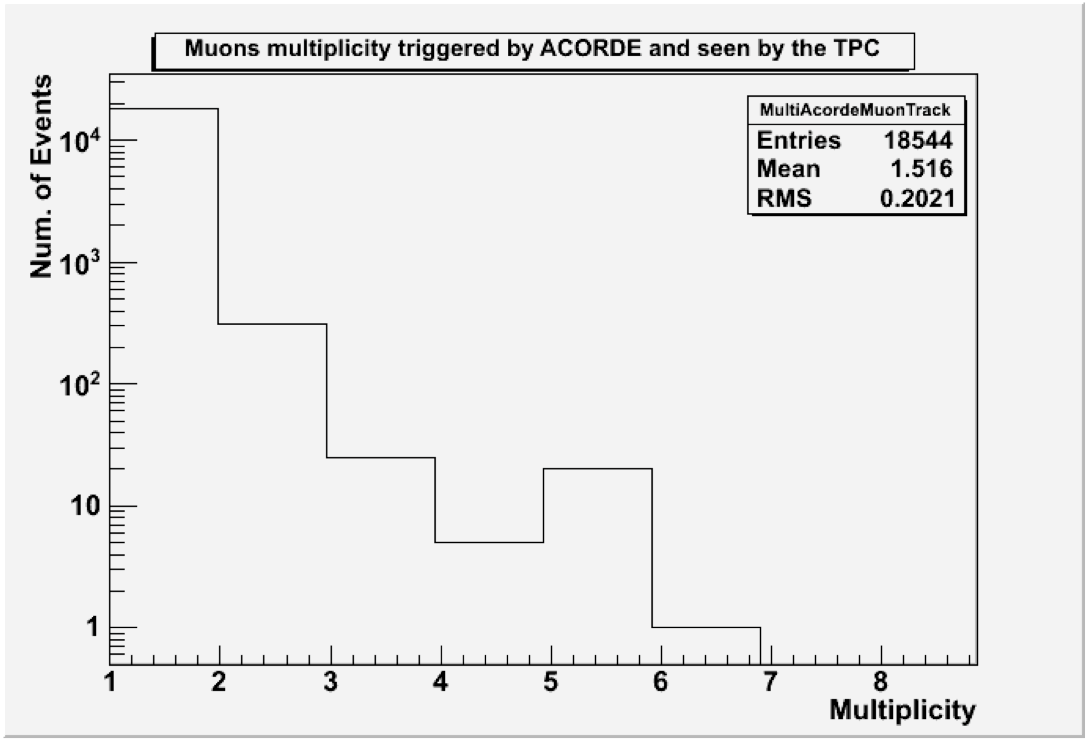
Run: 62084, Chunk: 960, # of Event: 1831,
Acorde Multiplicity: 9, # of tracks: 59



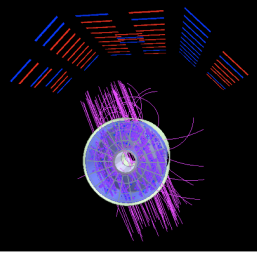
Run: 62084, Chunk: 310, # of Event: 6137,
Acorde Multiplicity: 10, # of tracks: 41



ACORDE: Cosmic Ray detector in ALICE
Reconstruction of atmospheric muons with ACORDE+TPC

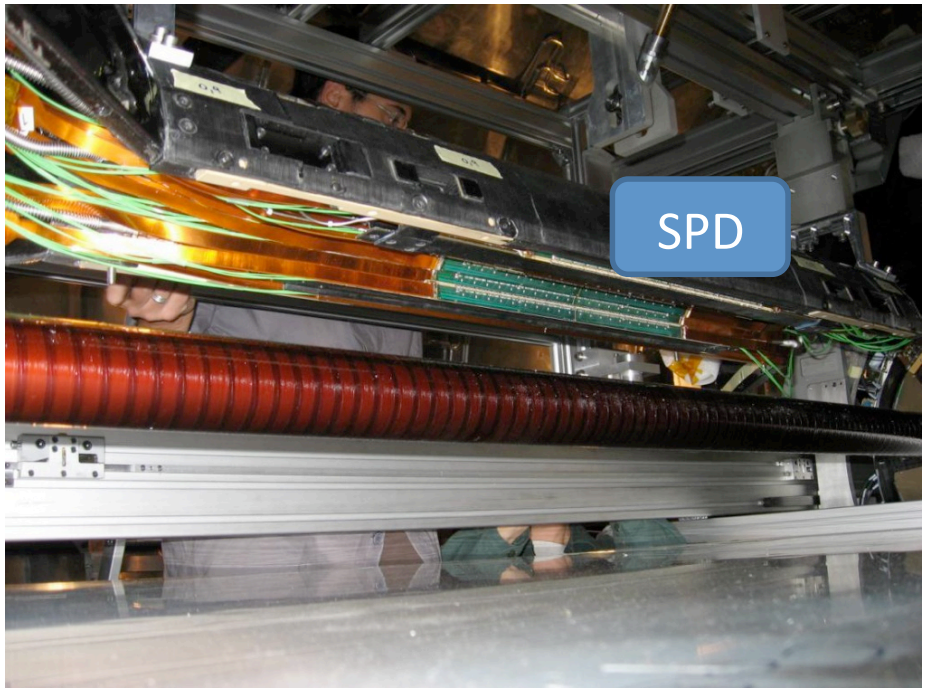


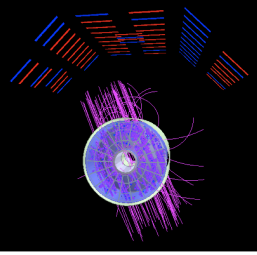
In principle, we can have a preliminar result for the multiplicity of muons triggered by ACORDE that reachs the ALICE site.



SPD Trigger in ALICE: Trigger

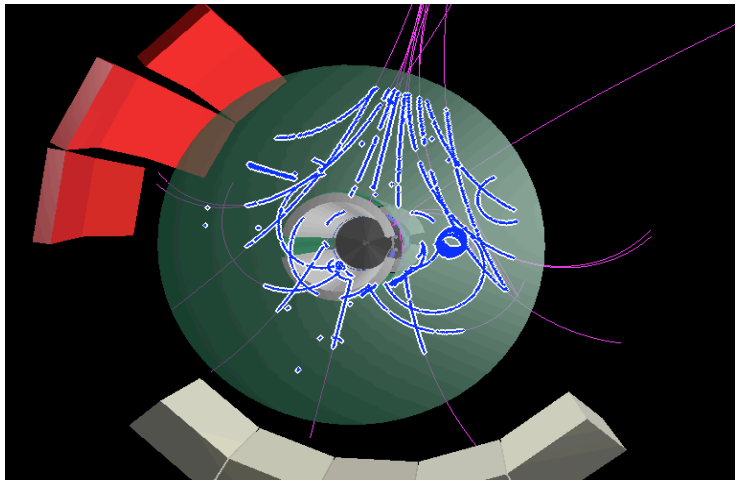
SPD (Silicon Pixel Detector) forms the first two layers of the Inner Tracking System. It has been used to trigger on single muon or high energy muons interacting with the magnet's iron.

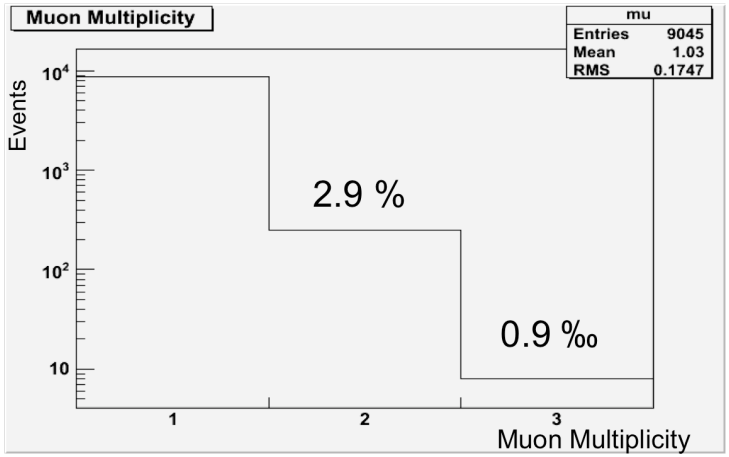




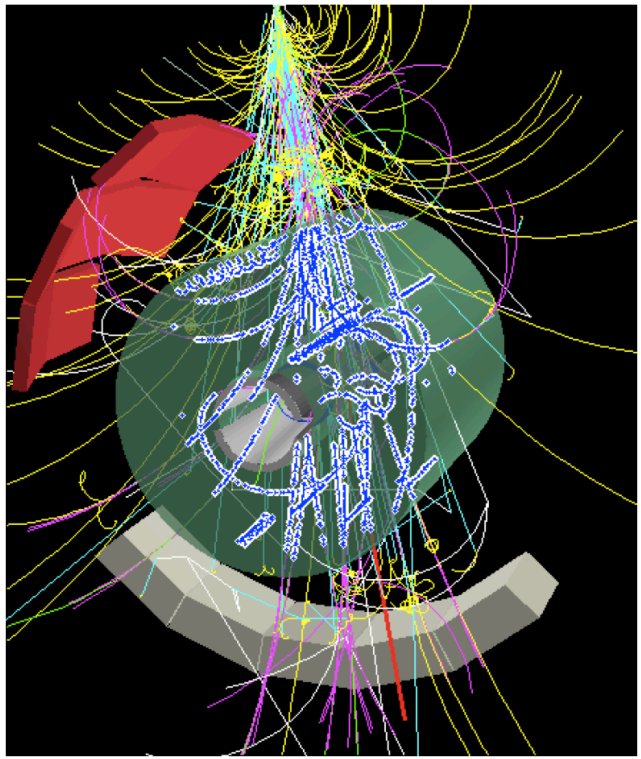
SPD Trigger in ALICE: Observed events with high number of tracks

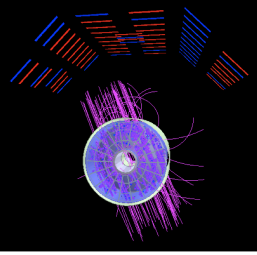
Real Data taken with the SPD trigger





The yellow tracks are positrons and electrons while in green gamma rays are shown. In violet are shown the charged particles reconstructed from the TPC clusters



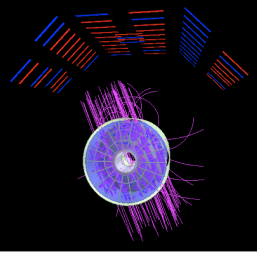


SPD Trigger in ALICE: Event rate estimation

- 200 photonuclear events $\longrightarrow$ ~ 60 10^6 events
- In ALICE: μ rate ~ 7 ev/m^2 s
  - measured with scintillators below magnet
- 60 M events require ~ 6.0 10^5 s ≃ 166 hrs = 7 days

So, we add to the possibles studies:

Muon interactions with iron



Summary

- We found around 1 interesting event triggered by ACORDE per hour.
- Around the 10% of ACORDE's trigger have at least an ESD track.
- Using the ACORDE's multiplicity we can find events with high multiplicity of tracks from cosmics events.
- Nuclear interactions of high energy muons seem interesting.
- Collecting a good starting sample seem feasible in quite a short time.