Physics and Simulation for CALICE Experiment

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Plan

1. **Muon calibration**
2. **Noise and noise term in the calorimeter energy resolution**
3. **SiPM nonlinearity and its correction**
4. **Beam properties and particle selection, beam multiplicity, purity, energy accuracy, backgrounds**
5. **Calibration of calorimeter energy scale**
6. **Simple analysis**
7. **Deep shower analysis**
8. **Simulation**
9. **Comparison**

Muon calibration

1. Establish event selection for muon runs
2. Develop of muon track finding procedure
3. Fit of energy distribution deposited by muon
4. Find a deviations of energy distribution shapes
5. Establish a possible procedure to find a “bad” channels
6. Cross–check of the obtained coefficients
7. Find coefficients stability and its temperature and HV dependences
8. Find influence of muon miscalibration on the calorimeter energy resolution and its constant term

Noise and noise term in the calorimeter energy resolution

Correct noise estimation cannot be done without knowledge of muon coefficients

1. **Pedestal stability estimation**
2. **Find a noise estimation using pedestal runs**
3. **Find a noise estimation using muon runs**
4. **Noise spectrum analysis**
5. **Analysis of the noise at channel by channel level**
6. **Development of procedures of suppression of noisy channels for simple and deep analysis (can be different)**

$\sigma(E) = A \times \sqrt{E} + C$ **Coefficient C can be found using noise estimation and it can be compared with the same coefficient but taken from energy resolution fitting.**

SiPM nonlinearity and its correction

1. Find gain for each channel, its stability and temperature dependence
2. Develop of inter-calibration procedure and find its accuracy
3. Find a stability of the obtained parameters of SiPM nonlinearity correction
4. Development of the correction procedures (can be several)
5. Cross–check of the different SiPM amplitude corrections
6. Analysis of influence of SiPM amplitude correction on the shape of the calorimeter response function
7. Influence of the SiPM response correction accuracy on the calorimeter energy resolution and its constant term
8. Estimation of each SiPM response in pixels per MIP, its stability and accuracy

Beam properties and particle selection,

beam multiplicity, purity and energy accuracy

- Establish the procedures of event selection for different types of particles in the beam mixture
- Prove of the chosen procedures
- Analyze the beam containment for different runs and beam–line states/files; it will include analysis of drift chambers and Cherenkov signal as well as veto and trigger counters
- Find the influence of beam purity after event/particle selection on the final parameters of analysis of calorimeter data
- Analyze the beam background, it can be companion particle, gamma background at the front or at the side of the calorimeter, or ...

Calibration of calorimeter energy scale

Correct energy calibration cannot be done without knowledge about the beam purity and its containment.

1. **Establish the calibration coefficients to transfer amplitude in MIPs into GeV scale for all calorimeter parts**
2. **Cross–check of obtained coefficients for all energies and all particle types using deep analysis**

Simple analysis

Correct analysis cannot be done without knowledge about of all above.

For all energies and all particle types

- **Find shape of calorimeter response function**
- **Find longitudinal and transversal energy density distributions**
- **Find e/π ratio for all calorimeter parts**
- **Find distributions of hits number**
- **Find calorimeter energy resolution**
- **Plot energy in ECAL versus energy in HCAL+TCMT and similar**
- **Plot energy resolution versus reconstructed energy**

Deep analysis

- **Decomposition of hadronic shower into number of energy deposition types (muon–like, hadron–like, electromagnetic and neutron signal)**
- **Distribution of each type of deposited energy in the calorimeter volume as in terms of energy as in terms of hit number**
- **All possible cross–correlations between that types of energy deposition**
- **Cross–correlation of binding energy with all types, as well as for particular event as for the set of events at the same energy, as for the set of different beam energies**
- **Building of hadronic shower model using obtained cross–correlations**
- **Develop a procedure for software energy correction**
- **Find the calorimeter energy resolution using the software energy correction**

Simulation

- **GEANT3: several hadron interaction models (GHEISHA, FLUKA, CALOR with its three intranuclear cascade models and MICAP as low energy neutron transport code)**
- **GEANT4: several physics lists, including HP – low energy neutron transport code**
- **FLUKA: several physics options, including LOW-NEUT option**
- **MCNPX: with its several and very modern intranuclear cascade models**
- **All programs should have the geometry and materials description as similar as it is possible**
- **All programs should have the same cuts and thresholds for the transport codes as close as it is possible**
- **Simulation might include the digitization step with full chain of simulation of the SiPM response**

Comparison

Comparison of all above with simulated events