Energy Calibration for the SND@LHC Calorimeter

Filippo Mei (INFN and University of Bologna)
on behalf of the SND@LHC Collaboration

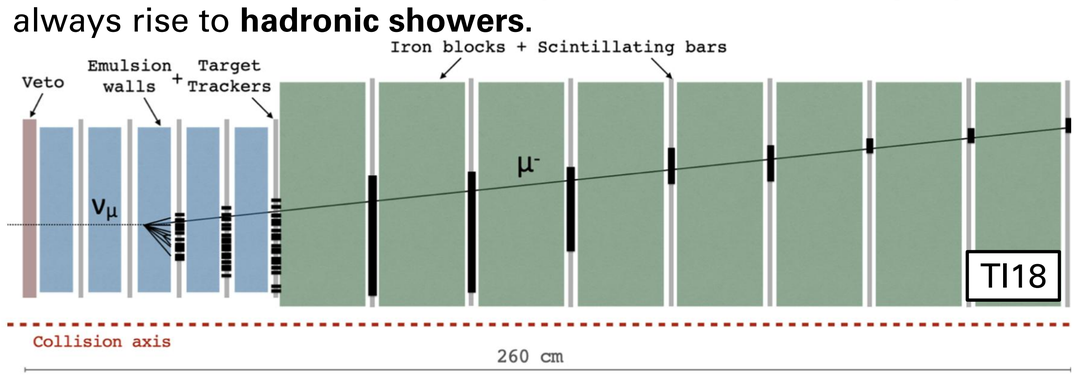
2025 European Physical Society Conference on High Energy Physics

Scattering and Neutrino Detector at the LHC

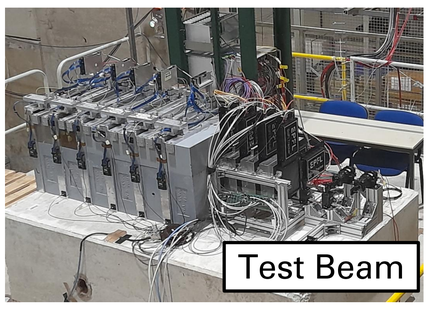
Istituto Nazionale di Fisica Nucleare, Sezione di Bologna

Motivation

Neutrinos of any flavor interacting in the SND@LHC target give always rise to **hadronic showers**.



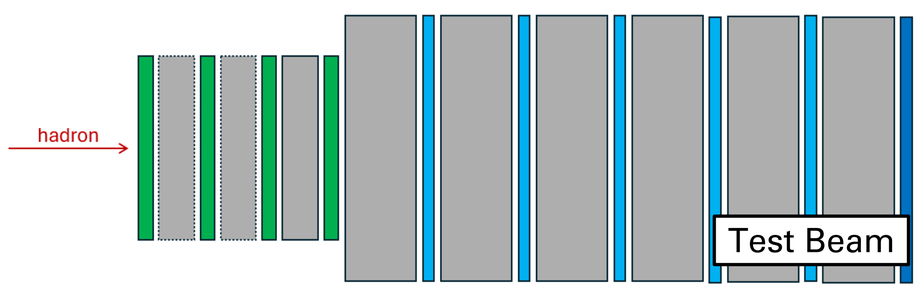
To calibrate the measurement of hadronic showers, a replica of the SND@LHC detector was exposed to hadron beams of different energies in the H8 test beam line of the CERN North area [1].



Test beam setup

The setup consisted of:
→ 4 **scintillating fibres** (**SciFi**) modules, interleaved by 0.5 λ_{int} thick iron blocks;
→ 5 **upstream** modules (**US**), made of horizontal 6 cm thick scintillating bars, interleaved by 1 λ_{int} thick iron blocks;
→ 1 **downstream** module (**DS**), made of 1 cm thick scintillating bars.

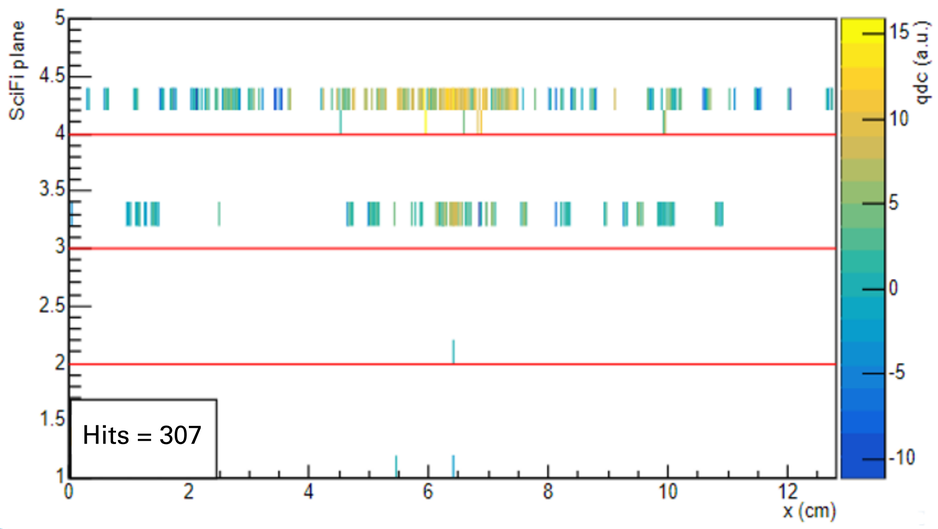
Data were collected with different configuration, with 1, 2 or 3 iron blocks in between the SciFi modules, to study the behavior of the calorimeters as a function of the position of the shower origin.



Data were collected with:
→ π^+ at 100 – 140 – 180 GeV
→ π^- at 240 – 300 GeV

Shower tagging

The most upstream SciFi station satisfying the **shower tagging** requirement marks the start of the shower.
The shower tagging algorithm looks for at least 36 hits within a sliding window 128 channels wide, in both X and Y SciFi planes independently. This tagging algorithm resulted consistent across different runs, energies, number of blocks in the target.
Only events tagged as showers are considered for energy calibration.



Calibration

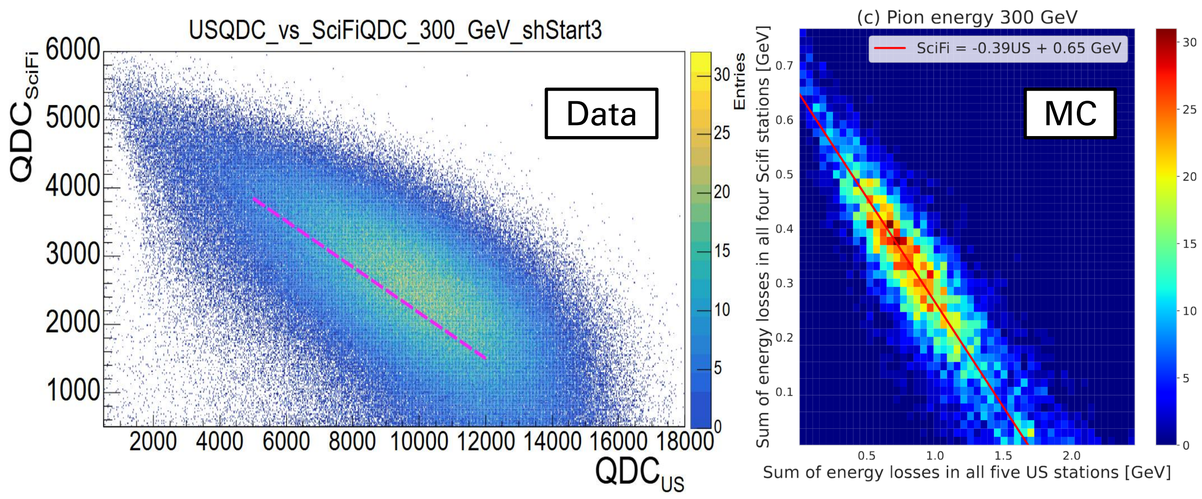
Event by event the relevant quantities are:
→ start of shower given by the shower tagging;
→ Integral charge signal (QDC) of in time SciFi hits (**QDC_{SciFi}**);
→ QDC sum of in time US hits (**QDC_{US}**).

The hadronic shower energy is estimated by:

$$E = k \times QDC_{SciFi} + \alpha \times QDC_{US}$$

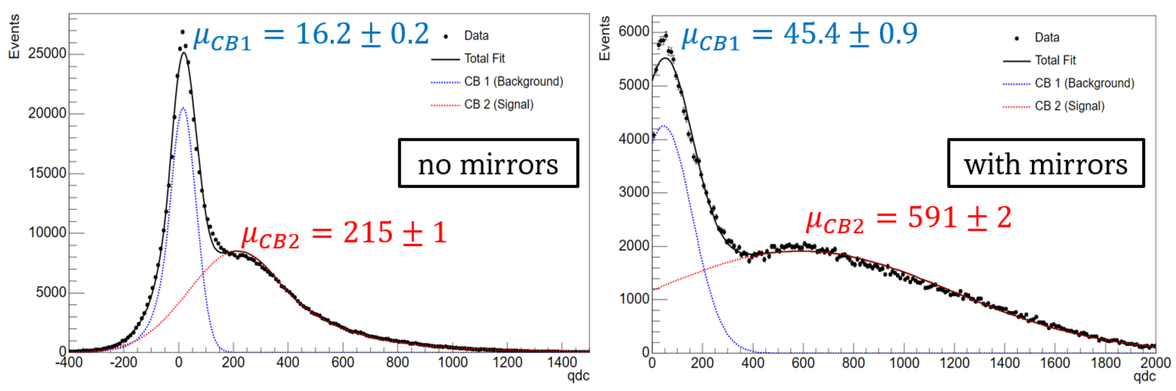
where E is the hadron energy, **k** and **α** two calibration constants to be determined. Calibration data is split into samples representing all 15 combinations of beam energy and start of shower. For each sample **Principal Component Analysis** is used to determine k and α.

This relation has been also confirmed by Monte Carlo simulations.



Showers starting late in the target (SciFi4) tend to cause signal saturation in the first US station and need ad-hoc calibration constants.

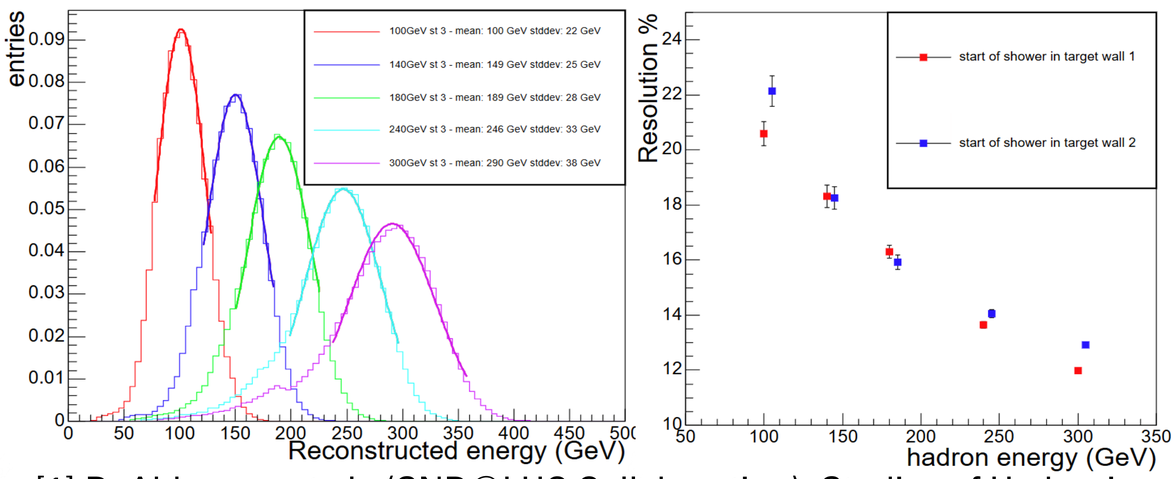
Since SciFi modules used in test beam have mirrors on the non-readout side, that are not present in the SND@LHC detector, a correction for the different QDC_{SciFi} yield is needed.



The QDC_{SciFi} correction factor (~ 2.6) is consistent between MIPs and hadrons.

Energy resolution

The reconstructed energy for showers starting in SciFi2 and SciFi3 is consistent across the whole energy range. For showers starting in SciFi4 it is underestimated at higher energies.
The **energy resolution ranges from 12% to 22%.**



[1] D. Abbaneo, et al., (SND@LHC Collaboration), Studies of Hadronic showers in SND@LHC, https://arxiv.org/abs/2504.01716