The analysis strategy for the measurement of the electron flux with CALET on the International Space Station

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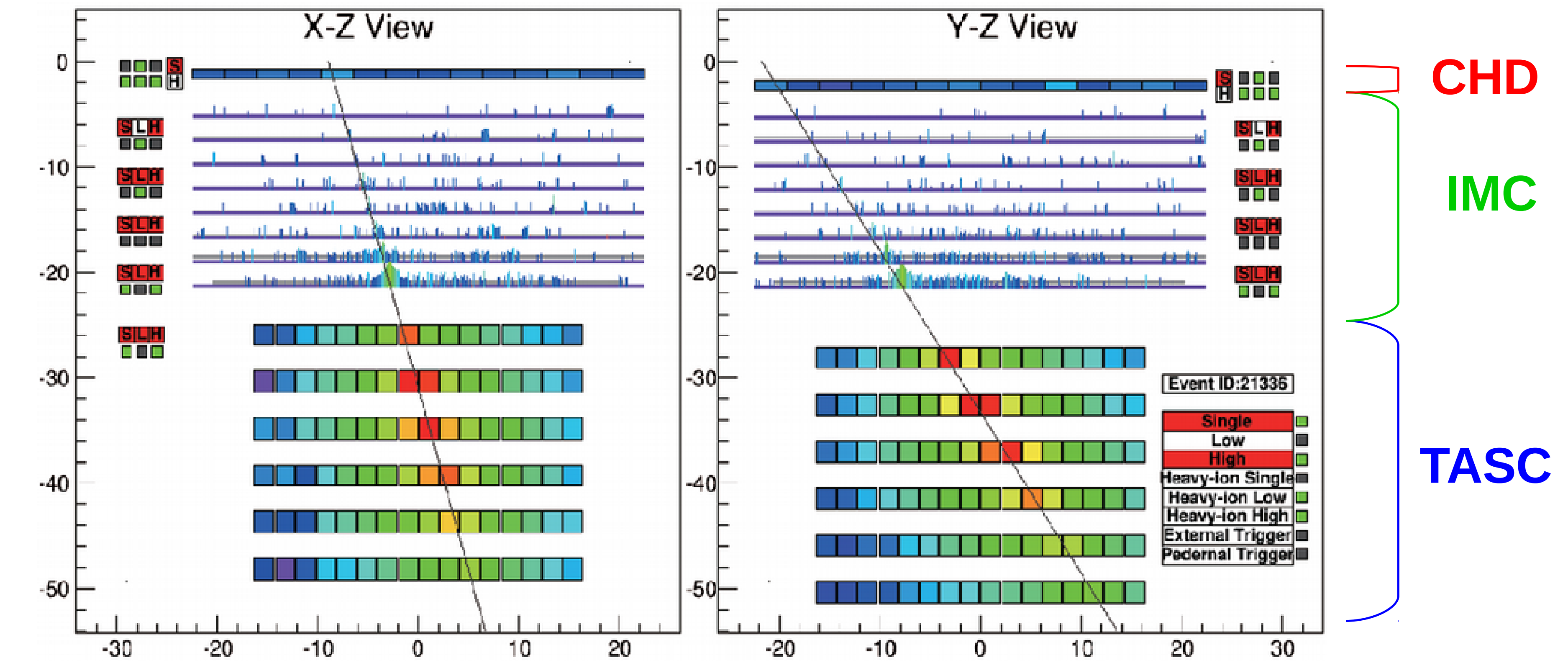
The CALET experiment

The CALorimetric Electron Telescope (CALET), operating on board the International Space Station since October 2015, is an experiment dedicated to high-energy astroparticle physics. The primary scientific goal of the experiment is the measurement of the electron+positron flux up to the multi-TeV region. This is possible thanks to the excellent detector performances, having a geometrical factor of 0.1 m²sr, an electromagnetic shower energy resolution of 2% and a proton rejection factor of 10^5. These performances are obtained by an accurate design of the CALET calorimeter, made by a CHarge Detector (CHD), an IMaging Calorimeter (IMC) and a Total AbSorption Calorimeter (TASC).

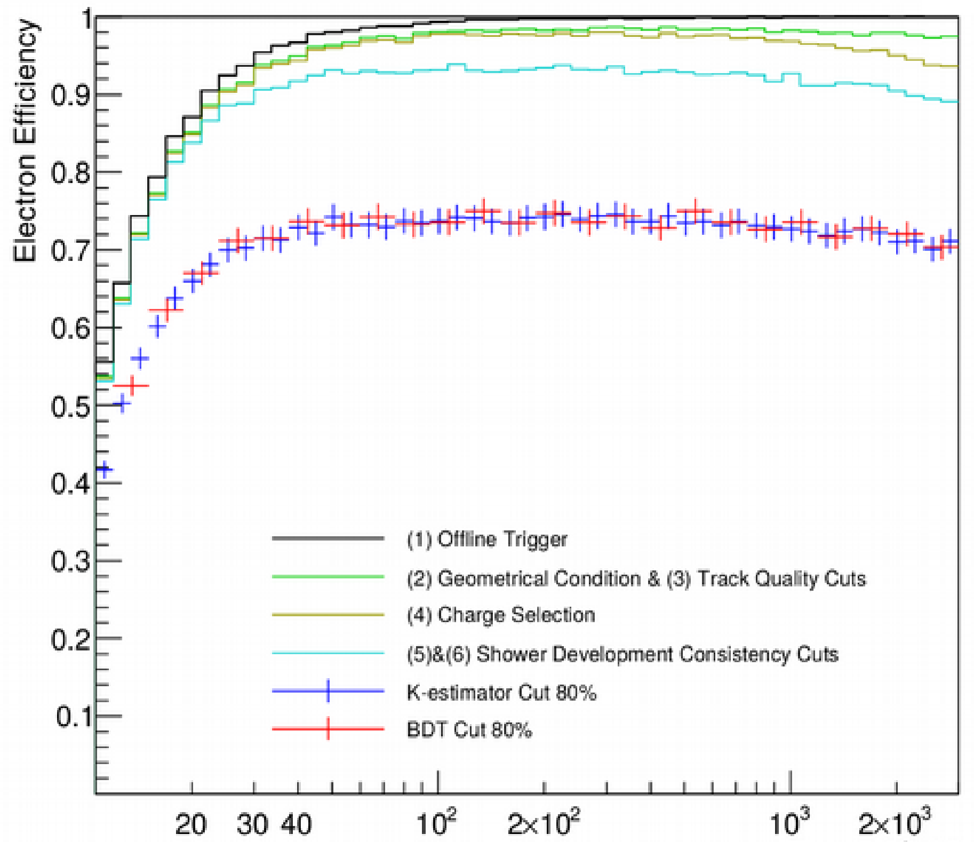


(a) Selections

Group of selections in the order they are applied:

`(1)Offline trigger confirmation` - select a flat region in the efficiency curve of the trigger discriminators

`(2)Geometrical condition` - select tracks inside acceptance



`(3)Track quality` - ensure an accurate track reconstruction

`(4)Charge selection` - remove contamination from He and nuclei

`(5)Longitudinal shower likelihood` - suppress contamination from proton

`(6)Lateral shower concentration` - suppress contamination from proton and events outside acceptance

Analysis strategy

The electron analysis strategy is divided in two main steps:

(a) a group of selections to obtain a well reconstructed sample of electron candidates, removing contamination from events outside acceptance and particles with charge Z>1

- ◆ Above 30 GeV, selection efficiency is higher than 95% for electrons and smaller than 1% for protons

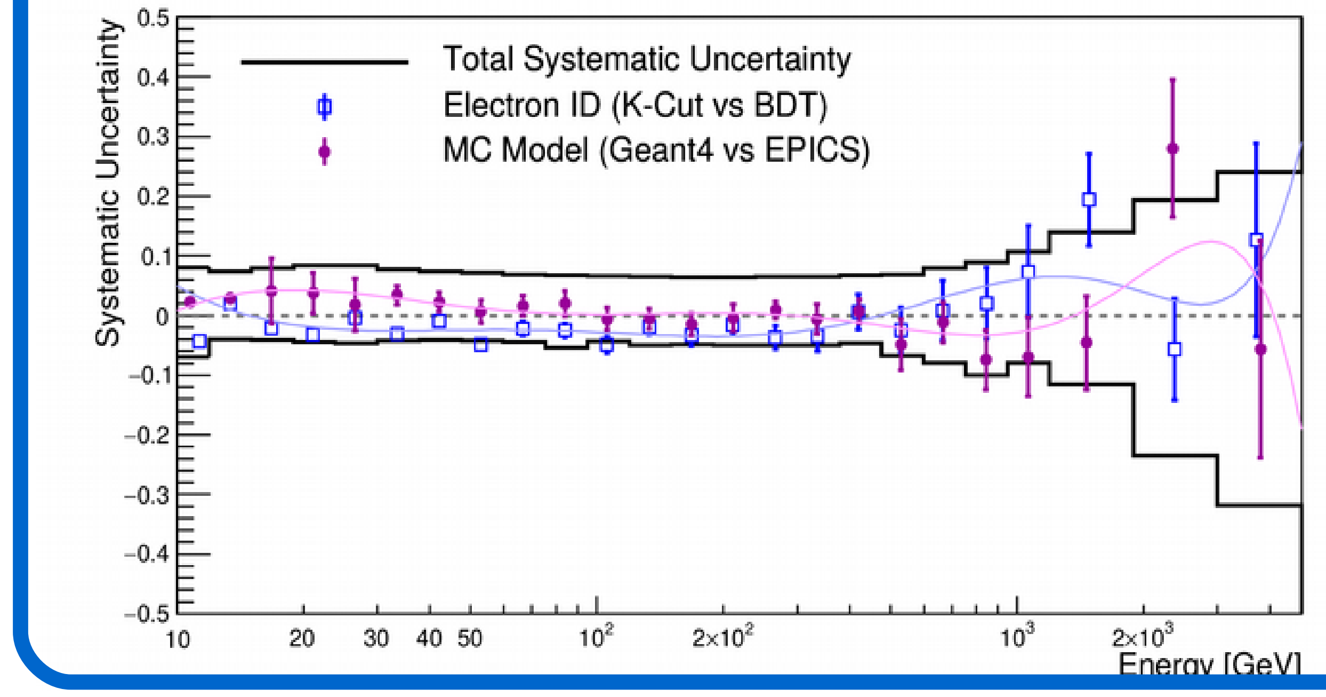
(b) a proton rejection cut to further suppress the contaminating proton background (necessary since, in cosmic rays, protons are more abundant than electrons by a factor 100-1000)

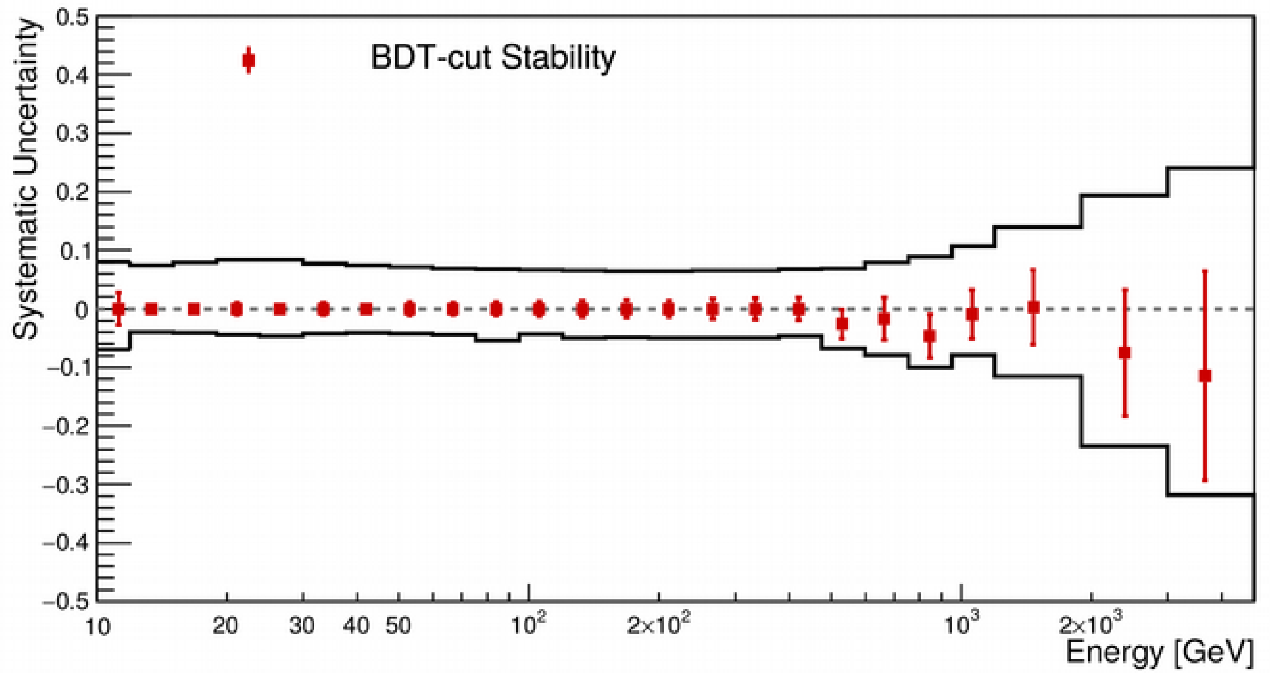
- The residual proton contamination (<5 % for E < 1 TeV and <20% for E > 1 TeV [<10% for the optimized BDT analysis using 13 parameters]) is subtracted from the final measurement

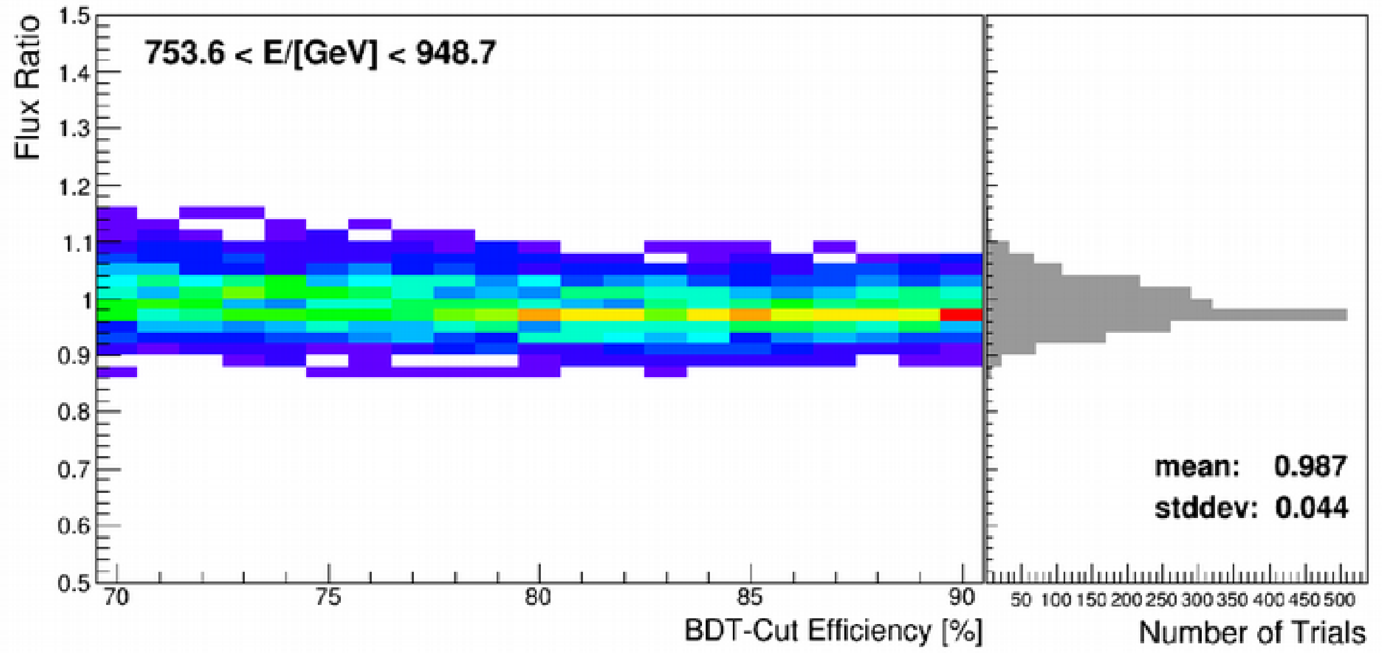
Systematic Uncertainties

Systematic uncertainties can be divided in two groups:

- Normalization uncertainties, *i.e.* detector acceptance, longterm stability, radiation environment, and live time, for a total of 3.2%
- Energy-dependent uncertainties, *i.e.* trigger efficiency, track reconstruction, charge selection, MC dependence, and BDT stability







(b) Proton rejection - single cut

Exploiting the different longitudinal and lateral development of the electromagnetic and hadronic showers, protons can be rejected using a single cut based on $K = \log_{10}(F_E) + 0.5 \times R_E$ [cm]:

- F_E is the fraction of energy deposited in the last TASC layer respect to the total energy deposited in TASC
- R_E is the second moment of the lateral energy-deposit distribution in the TASC first layer computed with respect to the shower axis

(b) Proton rejection - MVA cut

To further suppress the proton background, a multivariate algorithm based on Boosted Decision Tree (BDT) is used. BDT estimator is built employing 9 variables: F_E, R_E, variables from longitudinal fit in IMC (p_0, p_1 and goodness of fit) and in TASC (shower maximum α/b, attenuation constant b, 5% shower depth, goodness of fit)

Longitudinal Fit in IMC

$$\frac{dE}{dt} = e^{p_0 + p_1 t}$$

Longitudinal Fit in TASC

$$\frac{dE}{dt} = E_0 \frac{b^{(\alpha+1)}}{\Gamma(\alpha+1)} t^{\alpha} e^{-bt}$$

All these variables were chosen considering their e/p discrimination power and their level of data/MC agreement. After a careful optimization of the algorithm we opted for a BDT made of 100 trees with a depth of 20. This detailed study leads to very stable performances at all energies, except above 1 TeV due to the limited statistics. In an optimized BDT analysis that is currently under study at high energies, 4 additional variables are used to build the BDT estimator: lateral shower concentration, maximum ratio between adjacent IMC layers, ratio between 7th and 8th IMC layers, and CHD sum.