Development of a new Particle Flow reconstruction algorithm based on Deep Learning techniques for a Dual readout calorimeter with timing

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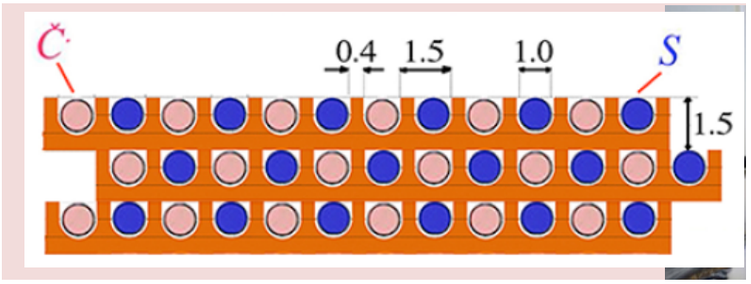
The project

- use Passive (Pb, Cu)/fiber calorimeter with different fibers sensitive to scintillation light and Cerenkov light



- profit of different speed of light particles (electrons) with respect to heavy particle (pions, protons and kaons) in hadronic shower, producing different cerenkov radiation) to determine the electromagnetic and the hadronic components of the shower

- use this information to correct EM/hadronic statistical fluctuations to improve the hadronic calorimeter resolution

Caveats:

- electromagnetic calorimeter cannot be put before the hadronic one without spoiling the EM/hadronic balance and then the resolution gain

- typically readout is with fibers inclined respect to the radial direction with readout on the back of the module, misses longitudinal segmentation

- Single Particle ID is very difficult in these conditions, Particle Flow algorithms, based on single particle ID are not easy to apply (at FCC/CEPC needs particle flow to achieve the best possible jet energy resolution)

Arrival time of the light could be used to provide the longitudinal position of the energy deposits.
Use the richness of the available informations: Scintillating vs. Cerenkov signal amplitudes, fiber position, arrival time, to make particle PID using a Neural Network algorithm.

Use identified particles as input to a Neural Network based jet reconstruction algorithm.

Participating institutes: INFN: LNF, Milano, Padova, Pavia, Roma 1, Roma Tre
CERN
University of Sussex

Representatives: Biagio Di Micco - INFN
Sofia Vallecorsa - CERN
Iacopo Vivarelli - University of Sussex

Original request: 100 PMs total - 33 EU
Present proposal: 30 PMs total -10 EU

The project has been cut by 1/3.

How we can compensate:

1. increase co-funding fraction (ie. reducing institution involvement by less than 1/3)
2. use EU funds where the manpower is cheaper (typically Italy)
3. use institutional funds for traveling of manpower to other institutions for relatively long periods
4. co-fund the project with funds from institutions (INFN RD-FA project for example)

Person power:

INFN 1.6 FTE CERN 0.2 FTE Sussex 0.2 FTE

Total 2 FTE, corresponding to 72 PM in 3 years

Original proposed project development

1. the integration of a GEANT4 simulation of the dual-readout calorimeter with timing information with the Pythia8 and Herwig++ MC for the simulation of jets in the calorimeter; the embedding of this calorimeter inside a full or fast simulation of the drift chamber, the silicon tracker and the muon detector;
2. the development of a neural-network based particle flow algorithm that returns a collection of particle candidate to be as input to the Particle Flow (PF) algorithm;
3. the development of a neural-network PF algorithms for the full reconstruction of gluons and light-quark jets and the optimisation of their energy response;
4. development of neural-network algorithms for the recalibration of b- and c- quark jets;
5. validation of the performances of the items above for different time resolution of the calorimeter, from a realistic 100 ps achievable with modern sensor technologies, to more aggressive 30 ps.

Descoped project + integration in Pandora (present funding)

Item 1. will be provided by the RDFA collaboration (can be used as an input to this project), the geometry can be simplified to Fast Track (only parameterisation) + Full Geant Caolrimeter (muon ID can also be fast simulated, without real geometry implementation)

Items 2. and 3. are kept as core deliverables of this project, in a first test PID from 2 can be put as input directly in Pandora layer after Particle Flow Objects are built.

4. is dropped

5. is part of the project

6. integration in Pandora should come mainly from other tasks (4.1b), start collaborating from the beginning to be sure that the code is easily integrable using PandoraSDK for example while the code is developed.

Descoped project (extra funding up to 100k)

- NN can be applied also to jet clustering and calibrations as an addition to the Pandora algorithm (try to use PID probabilities instead of flags to use as inputs to NN algorithms for final jet reconstruction and calibration)