Université Claude Bernard Lyon 1

# Minimum Spaning Trees with the SDHCAL

Gérald Grenier
IPN Lyon, Université Lyon 1

CALICE meeting, CERN May 19th 2011



UNIVERSITÉ DE LYON



IN2P3
Institut National de Physique Nucléaire et de Physique des Particules

# Hadronic showers

Hadronic showers contain electromagnetic ($e^-$, $\gamma$, $e^+$) particles and hadronic particles. Electromagnetic secondary particles creates local electromagnetic shower inside the hadronic shower.

Electron interaction length << hadron interaction length

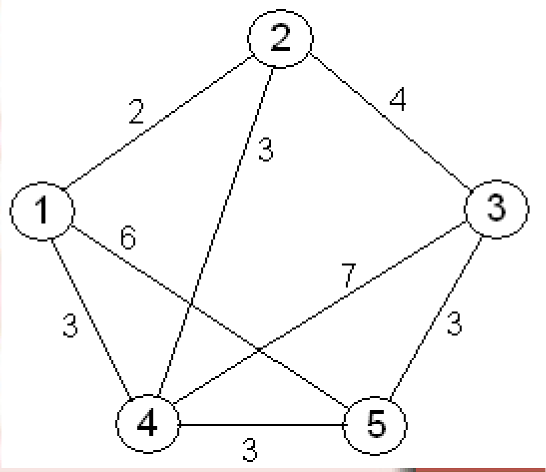
Electrons lose the same quantity of energy than hadrons in smaller volumes.

The density of shower particles and of deposited energy higher for electron thanfor hadron.

Higher density of calorimeter hits for electron than for hadron.

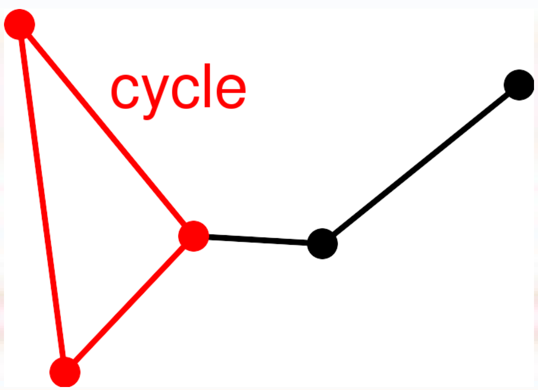
Distances between hits smaller for electrons.

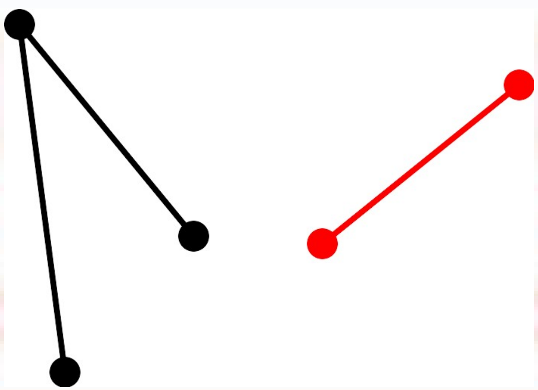
# Minimum Spaning Tree

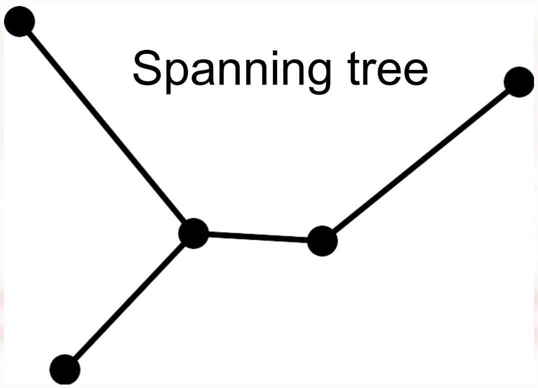



From the Travel Salesman problem :
Each circle (edge) is a city, cities are connected by links.
Number on each link is a weight representing distance, time or cost.
Problem : travel to each city minimising the total travel weight.

A Minimum Spanning Tree (MST) is a
- Tree : graph that has no cycle
- Spanning : all edges are connected
- Minimal : the sum of weights is minimal



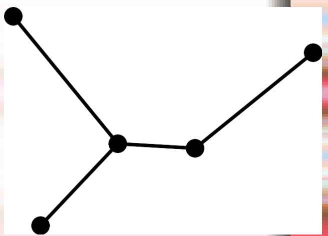





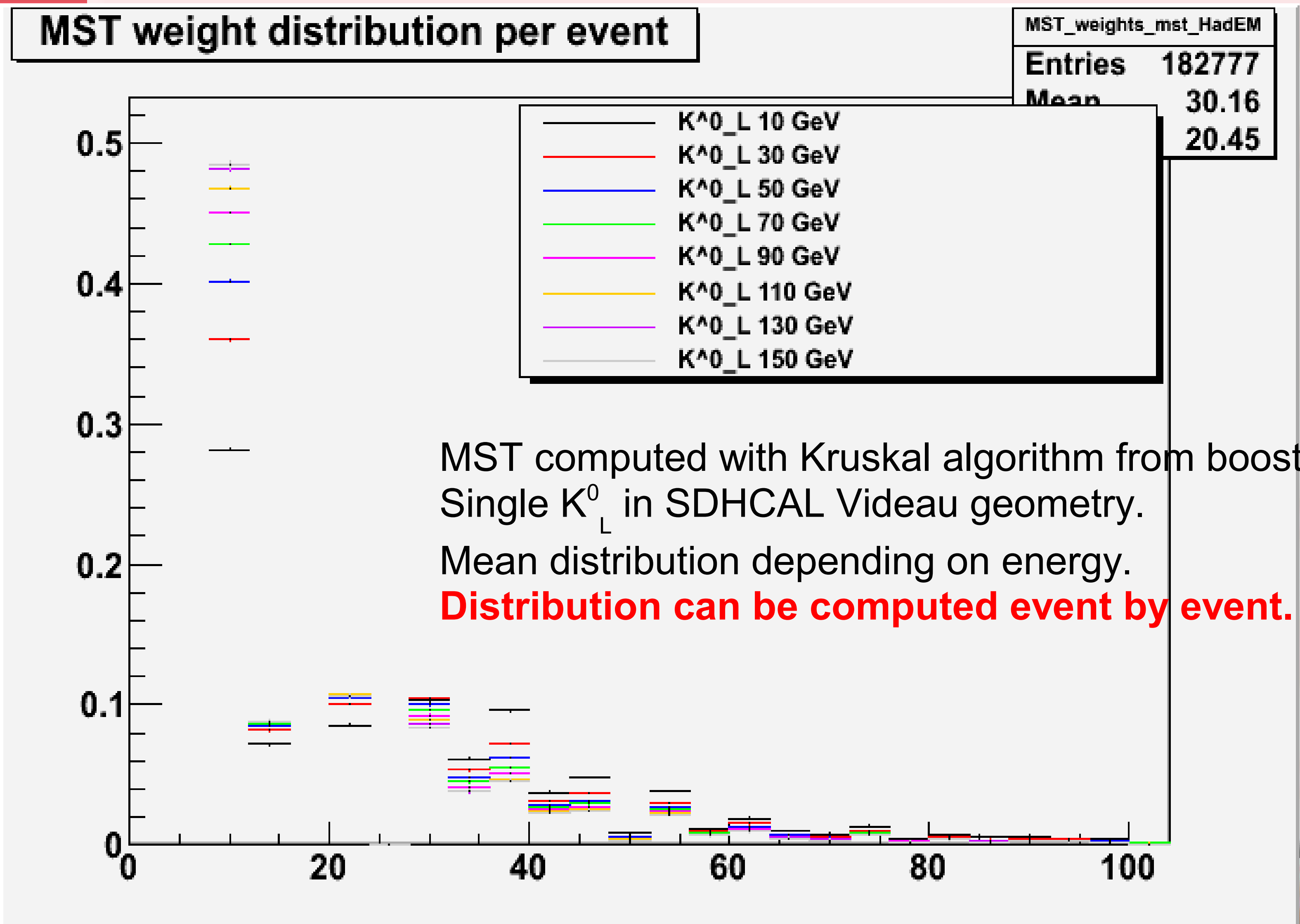

Apply MST to a graph with calorimeter hits as edges.

# MST geometrical distance

Apply MST to a graph with calorimeter hits as edges. Simplest exemple, use geometrical distance as weight between edges.



- Higher density of calorimeter hits for electron than for hadron.
- Distances between hits smaller for electrons.
- More electron in shower, more small weights in the corresponding MST



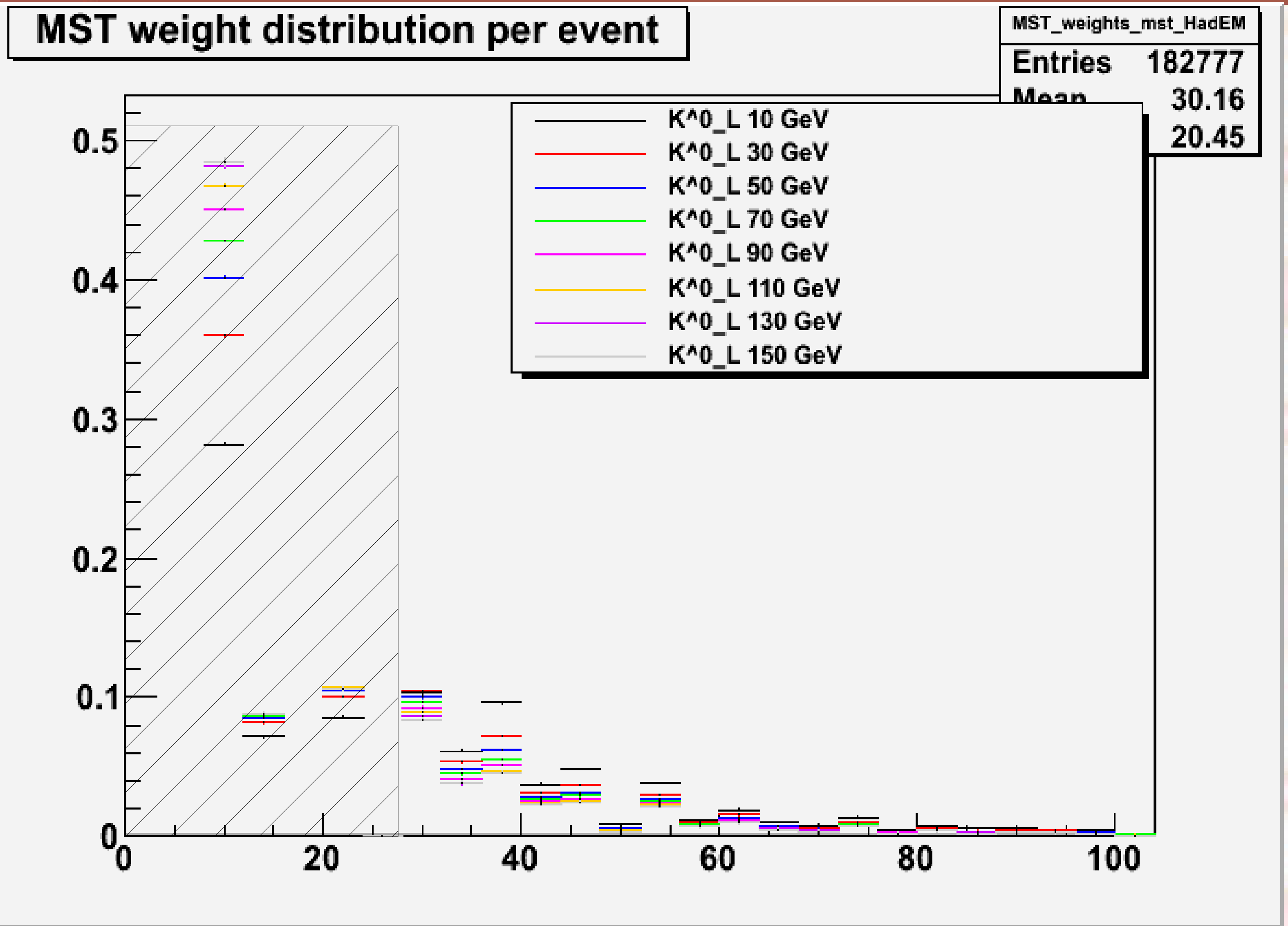

MST computed with Kruskal algorithm from boost C++ library.

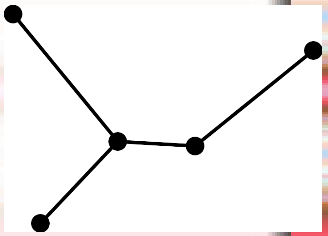
Single $K^0_L$ in SDHCAL Videau geometry.

Mean distribution depending on energy.

**Distribution can be computed event by event.**

# MST geometrical distance

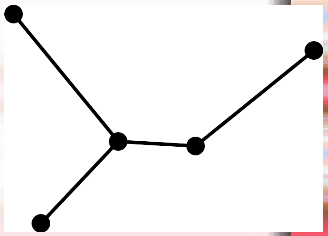


More electron in shower, more small weights in the corresponding MST, fraction of the weight distribution in lower bins higher

**Can derive a variable by integrating the weight distribution in a given range.**

# MST parameters



Variables related on minimum spanning tree can be varied by

•During MST computation by changing the weight distribution :

$$weight = n_{tr} d_{tr} + n_l d_l$$

$d_{tr}$ : distance between hits perpendicular to SDHCAL layers

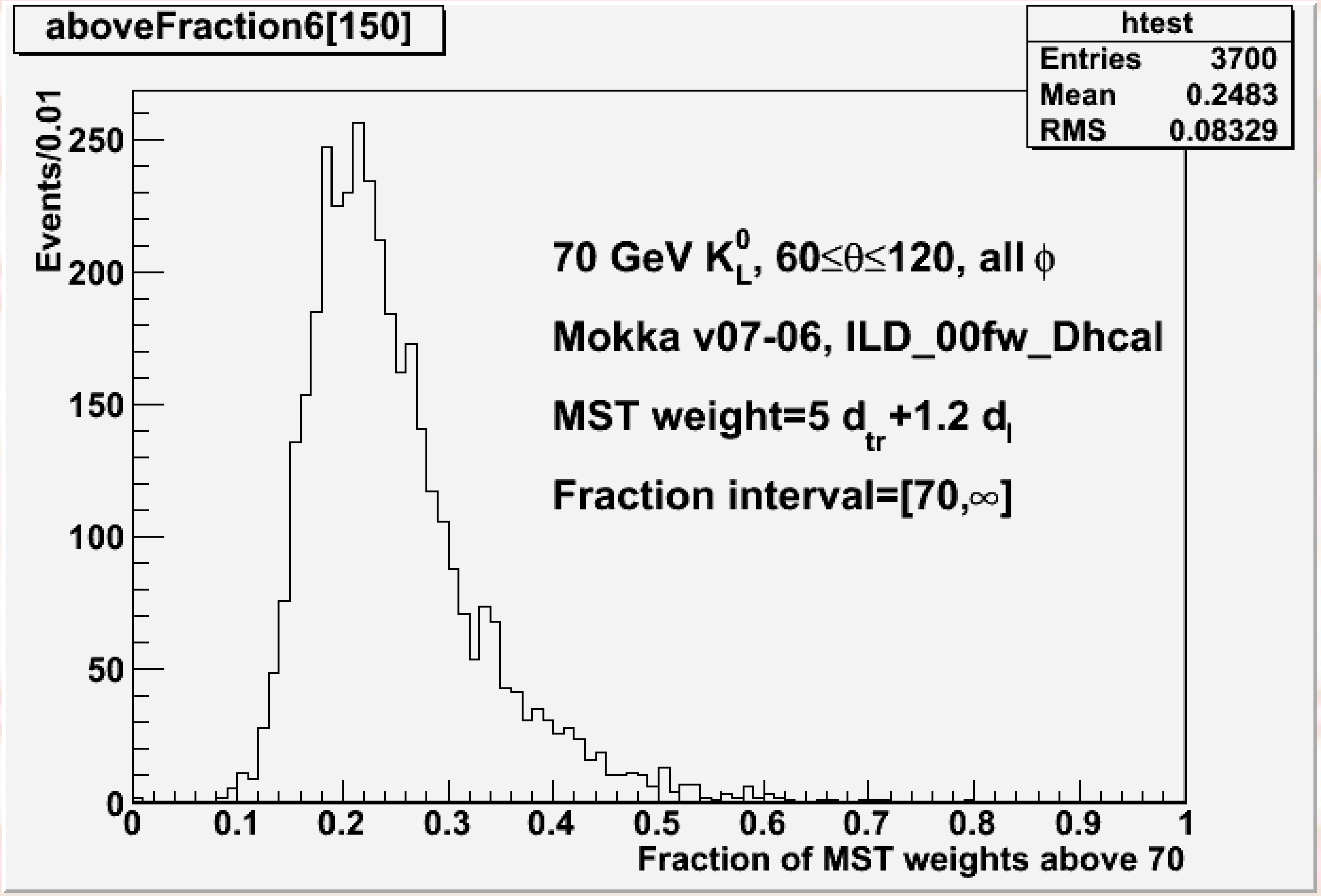
$d_l$ : distance between hits parallel to SDHCAL layers

$n_{tr}$ and $n_l$ are factors : varied from 0.2 to 5 by step of 0.2

•After the MST computation by changing the range in which to perform the integration of the MST weights distribution (normalised to 1).

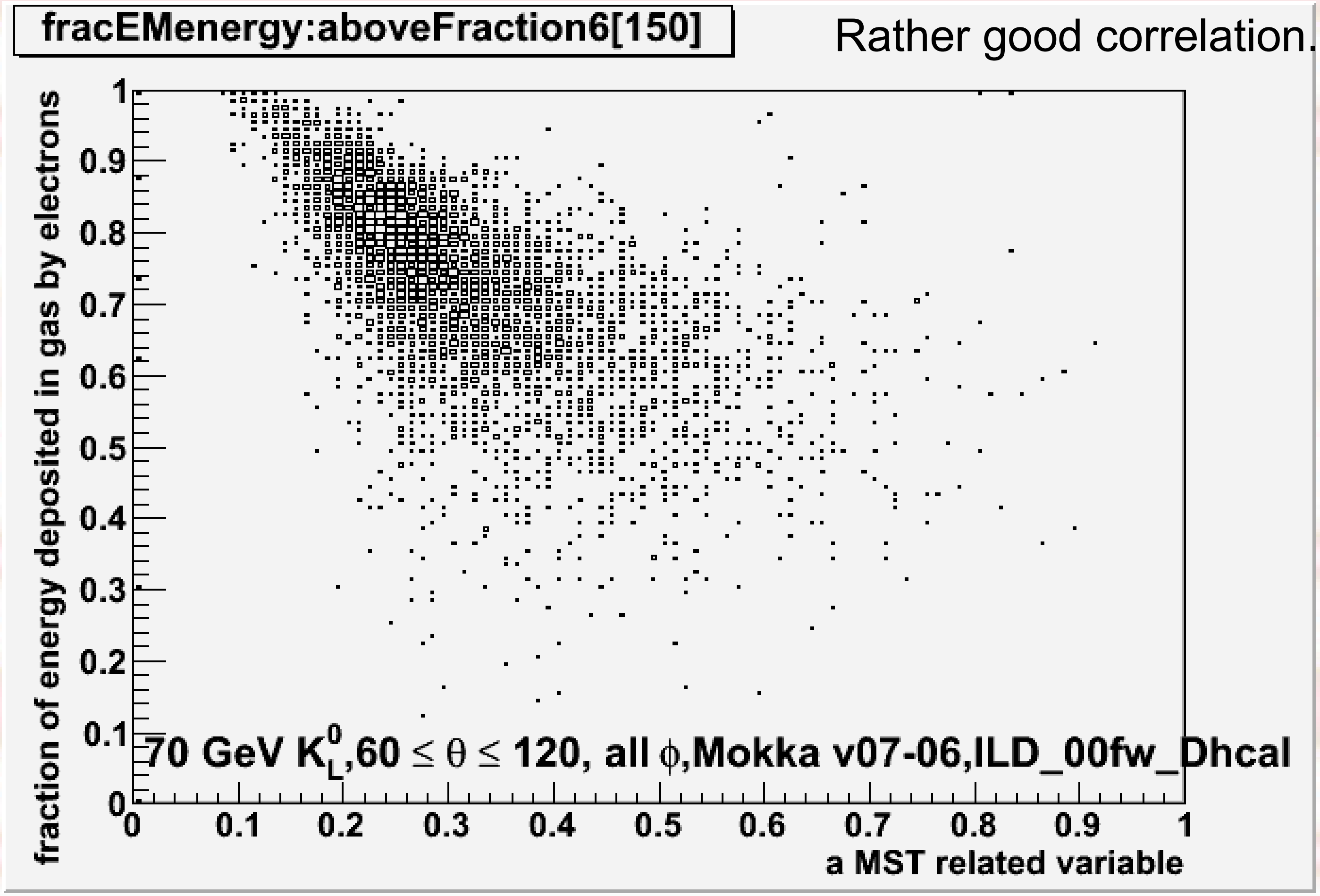
Have tried 28 different interval of integration.

# A MST related distribution



# Correlation with fraction of energy

Use Mokka LCIO output to estimate the fraction of electromagnetic energy in the shower on an event by event basis.
Compute the ratio of deposited energy in the GRPC gas by e+/e- in all SDHCAL calorimeter hits over the total deposited energy in all SDHCAL calorimeter hits.




Rather good correlation.

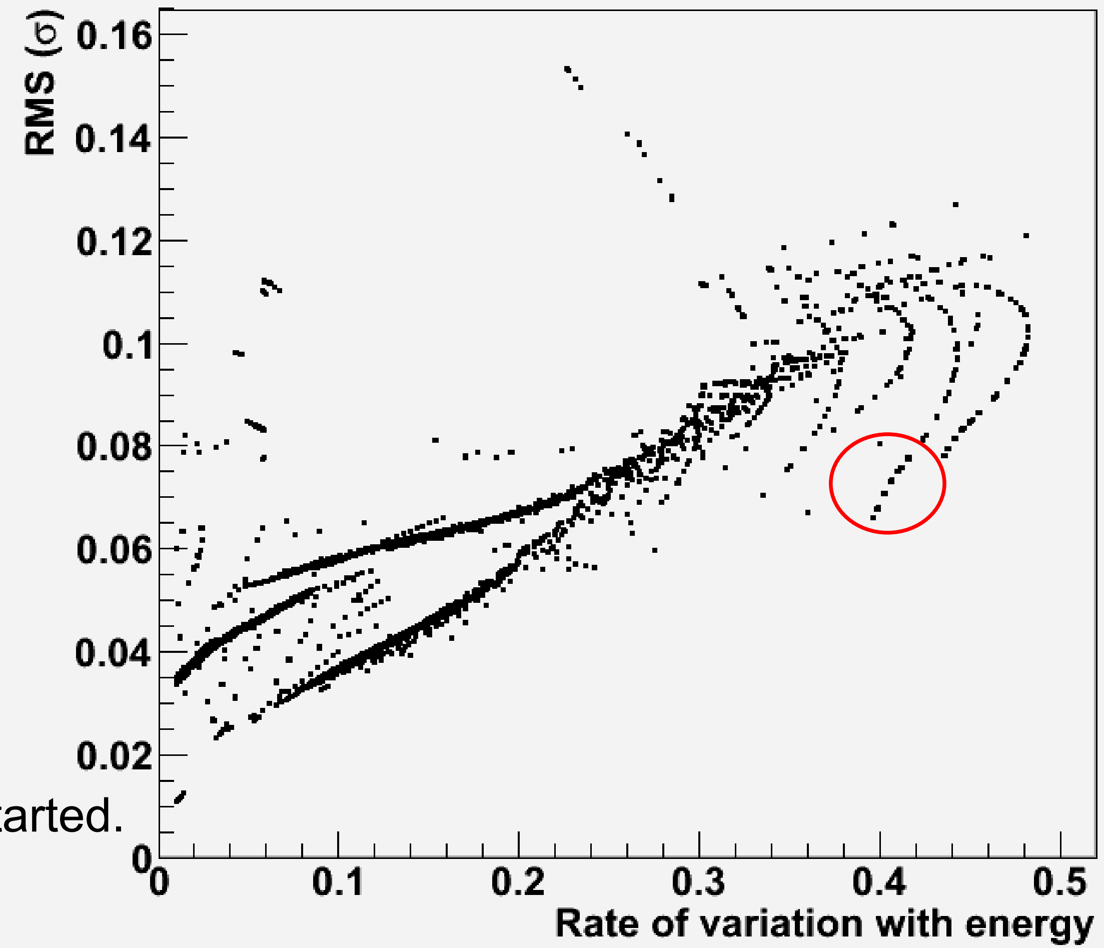
# Choice of MST variables

Up to now, have tried various MST weight parameters $n_{tr}$ and $n_l$ with various integral range for MST weight fraction distributions.

To pick up a set of variables to contribute as an energy estimator, choose the ones that :

- Vary the most with $K^0_L$ energy
- Has smaller standard deviation

Usually, the 2 conditions go opposite




Selected MST variables so far :

$n_l$=0.2, $n_{tr}$=4 to 5,

fraction integral=[70,∞] or [100,∞]

First attempt to see how energy resolution changes by including MST variable in Neural Network have just started.

# A note on tools

The MST computation are done within a Marlin Processor.

The tools to choose which MST variables are the most promising are currently under development.

The MST computation can also be included as part of the Pandora PFA algorithm (a bit of coding will be necessary).

# Conclusion

- Use of Minimum Spanning Tree to derive variables to help improve the energy reconstruction/resolution.
- The idea is that, MST variable can give a clue on the fraction of electromagnetic energy inside a shower.
- MST can also be used to help perform PID.

Ways to improve :

- Use threshold information in the MST weight (electromagnetic portion of the shower has denser energy deposition, hence more hits above higher thresholds)
- Use first Hough transform to identify hadron tracks in the calorimeter and remove intermediate hits along the Hough tracks before computing the MST.

I would like to thanks undergraduate students trainees who have contributed to this study :  Guillaume Garcia, Daniel Förster, Loïc Cousin.