Software status

ENUBET Kick off meeting - Padova 24th July 2016

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Introduction

- The current software simulation Geant4 code is in SVN at the Lyon cluster.
- We are now using the “gdr neutrino” space and in principle we can continue like this however only people having already an account at Lyon can use it.
- If the collaboration gets larger and people without an account at lyon will need to use the code we could ask for a dedicated group enabling access to “external people”. Not immediate but normally it should be possible.

MC infos

- Based on the G4 ENUBET code at Lyon.
- 50 m instrumented decay tunnel (from -25 m to 25 m in Z).
- Events generated along the beam pipe using exponential decay of parent kaon.
- Events generated in ±12 cm in X and Y direction (transverse plane).
- We generate directly e^+,π^0 and π^+ and not the parent hadrons.
- All events were saved (also events to te beam dump) therefore the efficiencies take into account geometrical factor already.

Future improvements

- Simulate parent hadrons.
- Correlate events in time to study pile up.
- Discuss the output to make sure it is optimized for large productions.

Analysis strategy: event definition

- In real life we can not correlate information of cells too far in space-time due to pile up ⇒ we defined a **preliminary event builder**.
- **Detector naming**: we have a T0 layer which is the T0 doublet for the e^+/π^0 separation and 8 calorimeter layer (E0 to E7). E0 and E1 are the electromagnetic calorimeters. The transverse section is divided in 76 φ cells.
- An event is build according to the following steps:
  - We take the cell with the shortest time in the first electromagnetic layer (E0).
  - We consider cells time correlated i.e. Δt between [-2,2] ns for T0 layer and E0, [-2,3] ns for E1, [-2,15] ns for E2 and E3, and [-2,20] ns for E4 to E7.
  - We consider cells in the correct φ region (± 7 cells) corresponding to about ± 33 degrees.
  - The same Geant4 event is analysed many times (up to 20 to make sure to use all the cells) each time discarding the cells already used in previous loops.

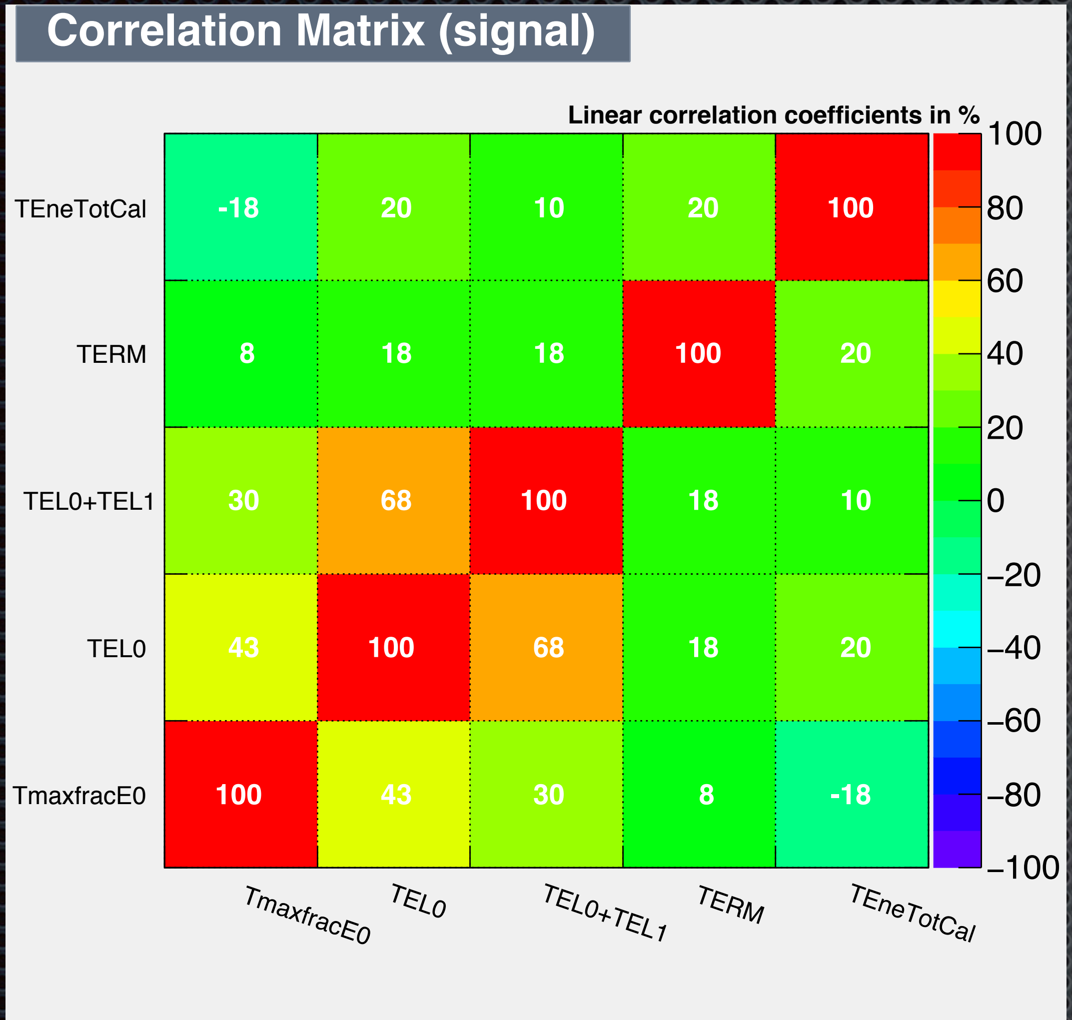
Analysis strategy: PID

- For each event we performed an analysis to separate e^+, π^0 and π^+.
- The analysis is carried out in 2 steps:
    - First a e^+/π^+ separation based on Neural Network.
    - Then a second analysis is performed to reject π^0 based on sequential cuts.

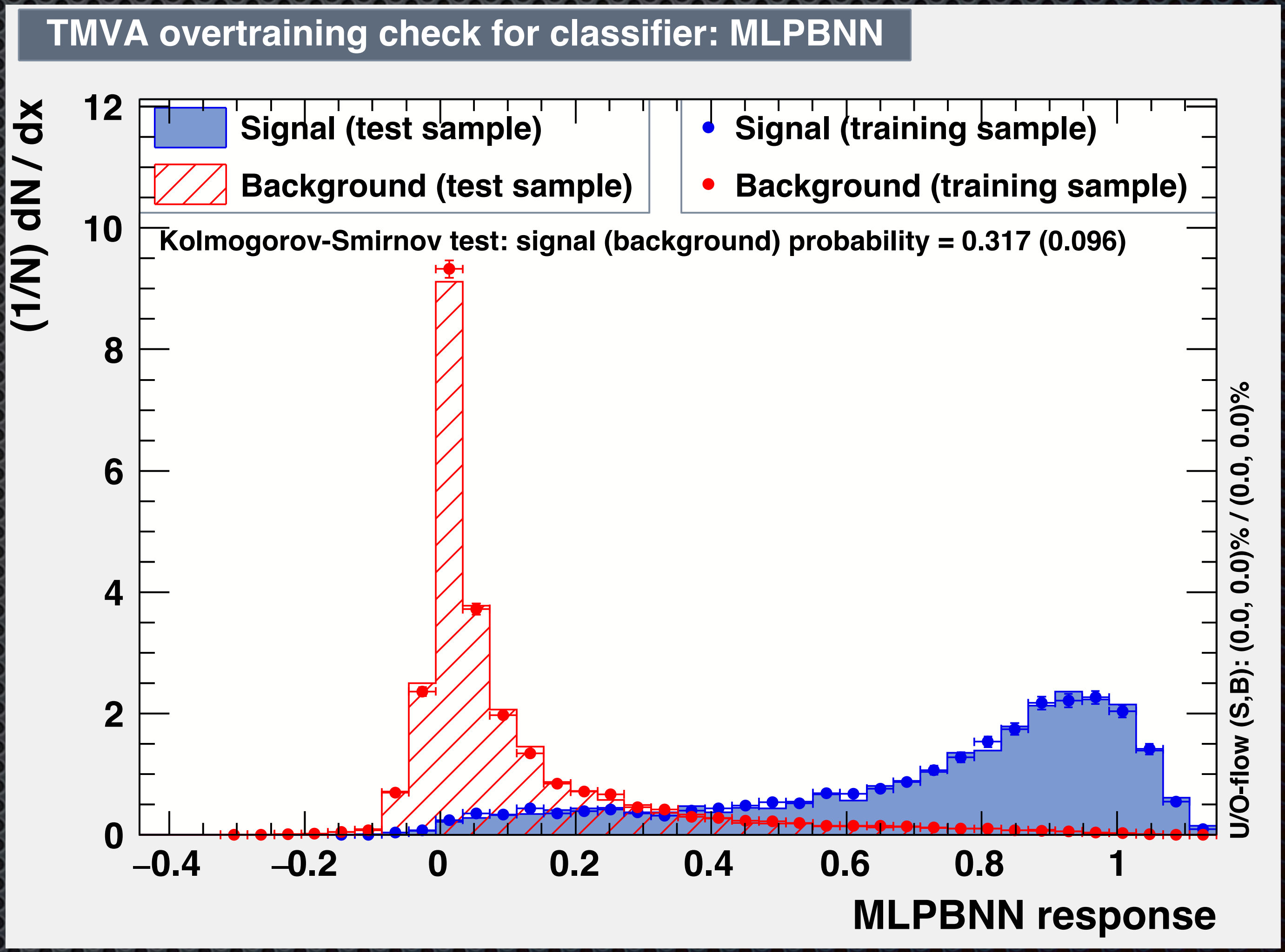
NN for e^+/π^+ separation (1)

- We used the MLP (multi layer perceptron) approach.
- In addition a cut at 15 MeV on the total visible energy is applied.
- The NN is based on 5 variables:
  - maxfracE0 which is the energy of the most energetic cell in E0 divided by the total visible energy in all layers (excluded T0).
  - EL0 which is the energy of all the cells in E0 divided by the total visible energy in all layers (excluded T0).
  - EL1 which is the energy of all the cells in E1 divided by the total visible energy in all layers (excluded T0).
  - ERM which is the energy of all the cells in a range of ±1 with respect to the initial φ cell (for all layer excluded T0) divided by the total visible energy in all layers (excluded T0). This should correspond roughly to the energy in the Moliere radius.
  - EneTotCal which is the total visible energy in all layers (excluded T0).

NN for e^+/π^+ separation (2)



Correlation between variables

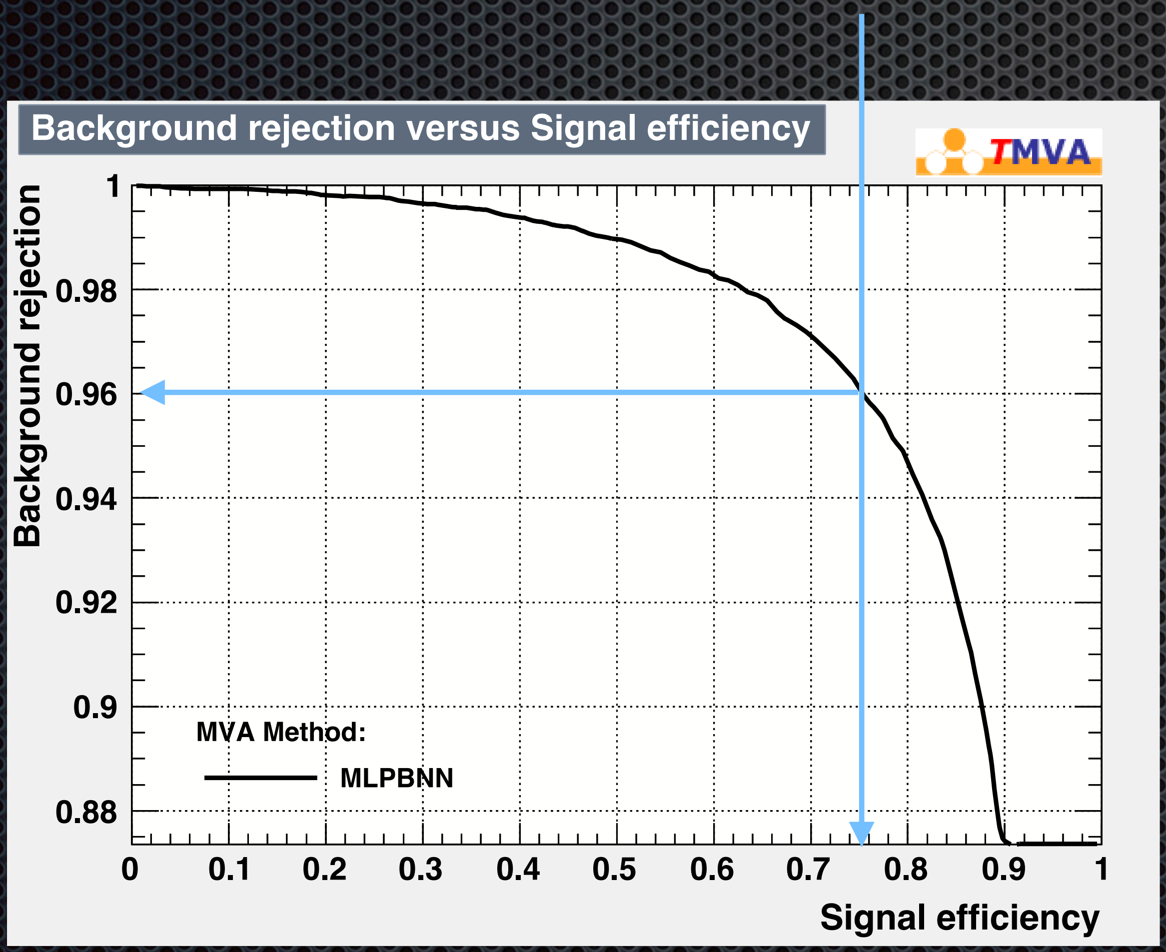


NN output

NN for e^+/π^+ separation (3)

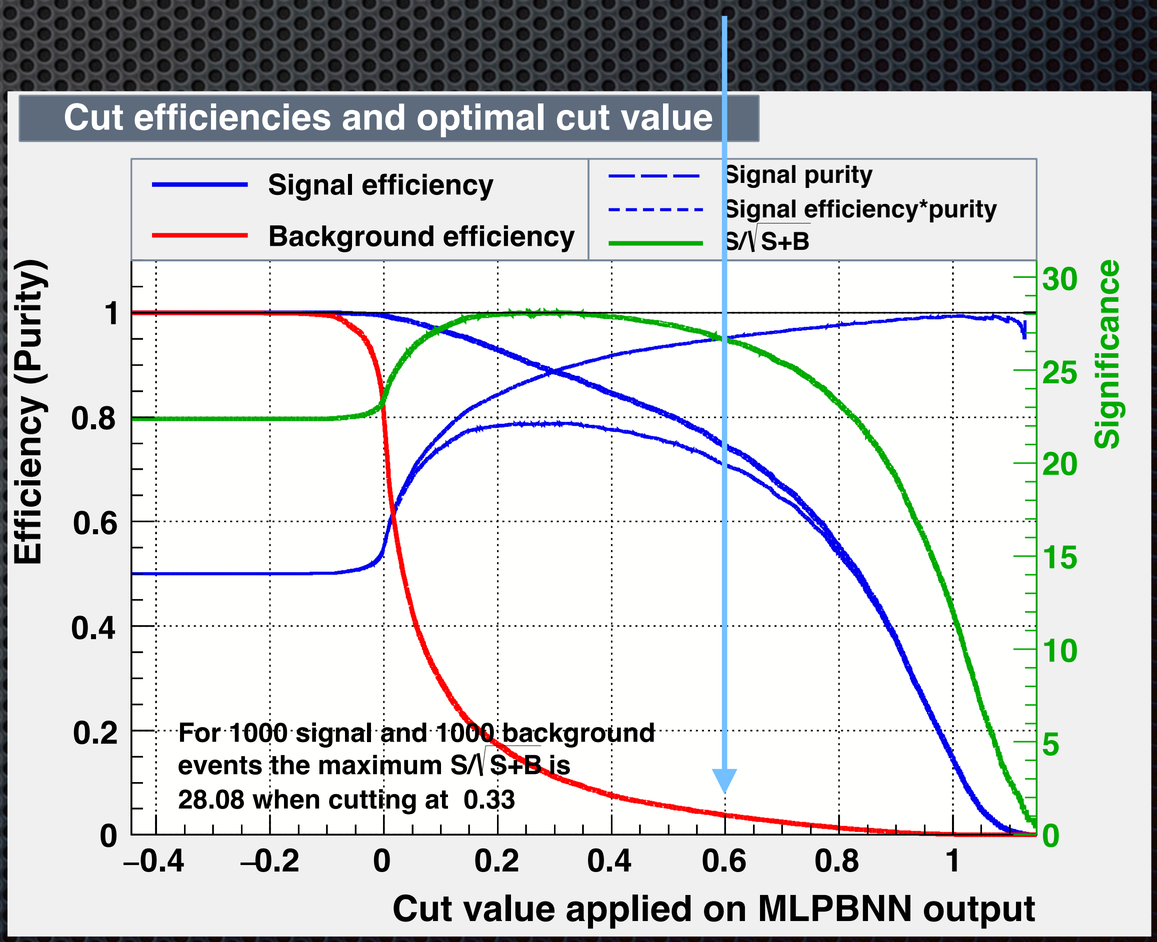
- We want to have π^+ below 3%. However the second step of the analysis for π^0 reduction will also reduce π^+.
- We choose therefore a cut at 0.6 which gives a signal efficiency of 75% and BG efficiency at 4%.

Selected cut



Signal Vs BG efficiency

Selected cut



Efficiency Vs NN cut

Discrimination e^+/π^0

- The discrimination between positron and π^0 relies mostly on the T0 layer.
- We considering the T0 cells in the good time interval [-2,2] ns as explained before with respect to the reference E0 cell of the event.
- We identify the first T0 doublet along the beamline and look at the energy deposited in each layer of the doublet.
- We ask for an energy between [0.65,1.7] MeV in each layer for the first 3 layers.
- In addition we ask that the missed number of T0 doublet between the first one and the position of the E0 cell is 1 at the most.

Summary results

- Note that the efficiency higher than 100% is due to the fact that it is computed on the number of MC events but in particular for π^0 we have double events due to the two gammas hitting different region of the beampipe.

Sample	Intrinsic ϵ (events not in beam dump)	ϵ after NN (ϵ due to NN)	ϵ after π^0 rejection (ϵ due to π^0 rejection)
e^+	90.70%	68.67% (75.71%)	49.04% (71.41%)
π^+	85.65%	7.68% (8.97%)	2.9% (37.76%)
π^0	95.06%	111.49% (117.28%)	1.21% (1.03%)

Conclusions

- We have a full MC working for preliminary results.
- A major upgrade is foreseen after summer (profit from new Post doc manpower).
- The results are conservative since a better reconstruction of the shower direction could be used for a more powerful reduction of π^0 events looking at T0 upstream.
- Nonetheless the results are not far from the first ones obtained in the first paper by Andrea, Lucio and Francesco (59% signal efficiency for 2.2% π^+ contamination but without π^0 reduction).