

# Electromagnetic showers energy estimation

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# Outline

- Last results with Frank shower tool
- First results with my new shower tool
- A new MC production
- Efficiency calculation in numu-nue analysis

# MC Sample - OpRelease 4.0

**Sample of 1000 nue beam produced by Elisabetta**

**Sample of 1000 monochromatic electron produced by FB**

**MC samples without background**

- Processed through OpEmuIO
- Processed through OpEmuRec packages : CS, Scanback, Link, Alignment, Track & Shower by using all plates available in the brick
- All packages up to OpEmuRec Track are taken from the release \$GROUP\_DIR/soft/OpRelease4.0\_emulsion\_march2011/
- OpEmuRec Shower is released here :  
/sps/opera/scratch/flbrunet/analysis/OpRelease\_2011-04-04\_OKwithShower/4.0/OpEmuRec/

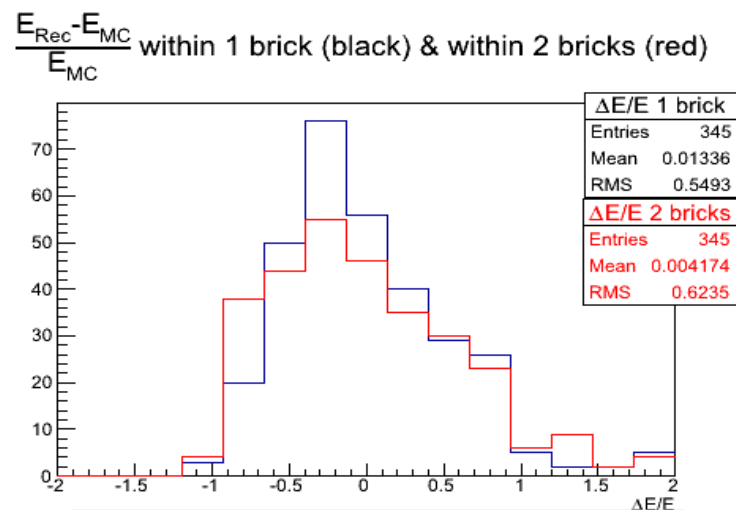
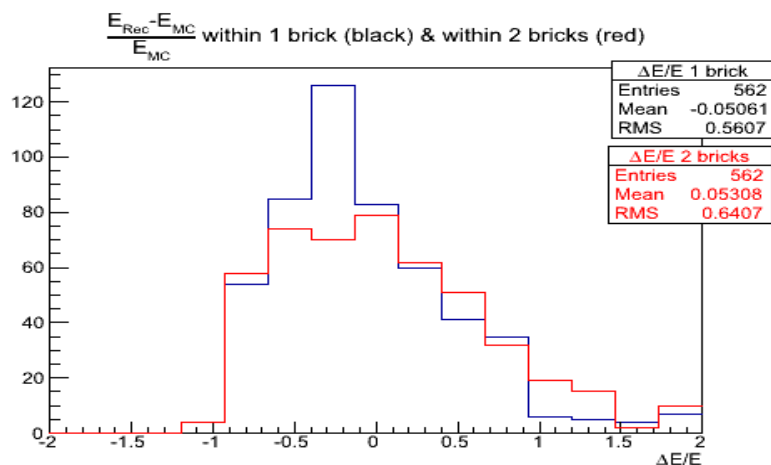
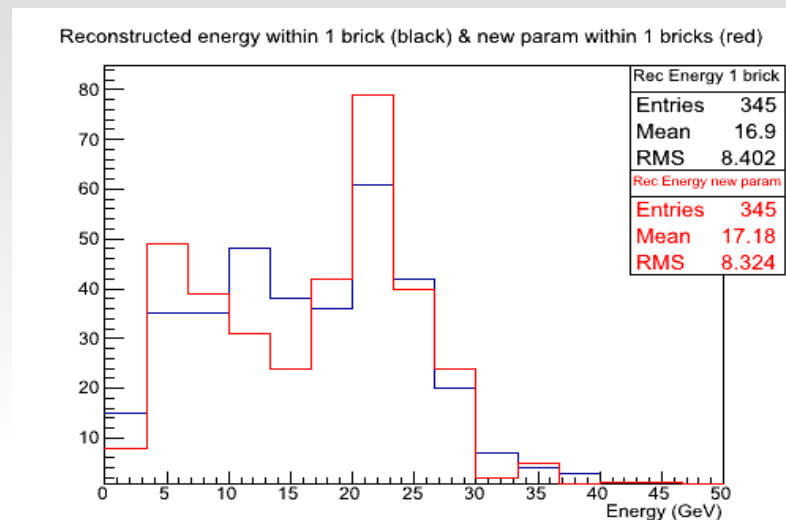
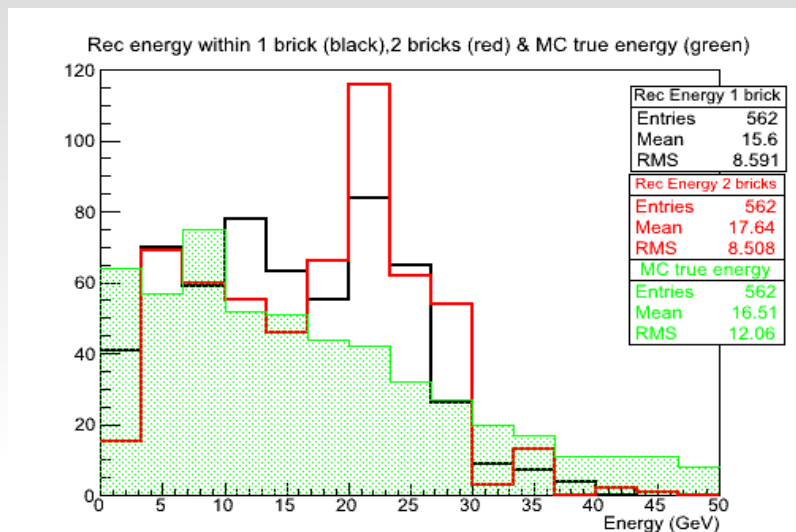
**FEDRA RELEASE (1210)**  
**OPEMUREC(v3)/OPRELEASE(4.0)**

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# Energy reconstruction : nue beam

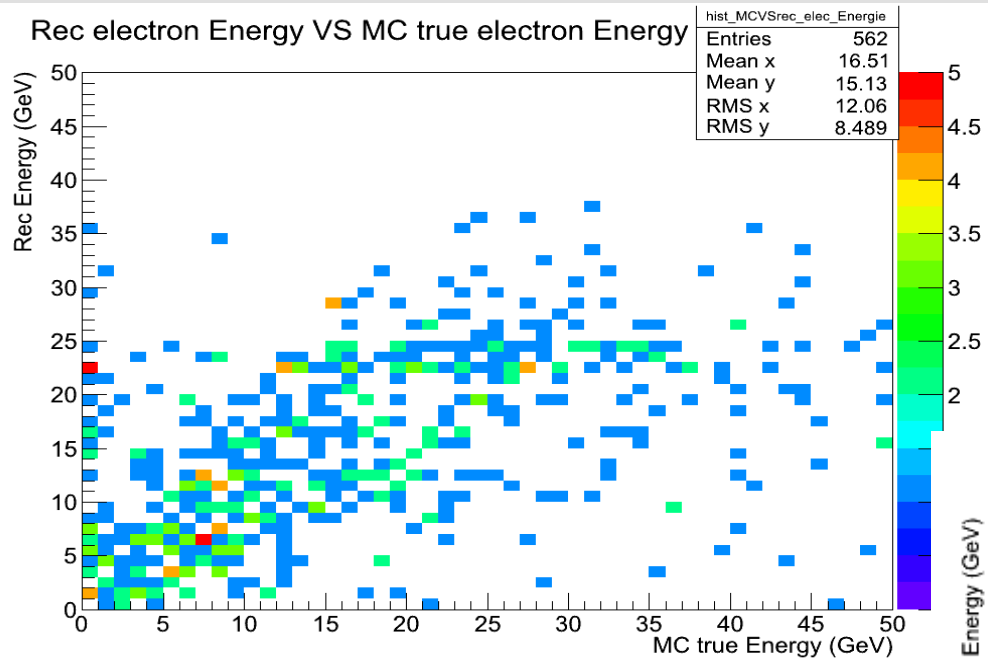
Goal : comparison with a sample containing only 1-brick fully contained showers



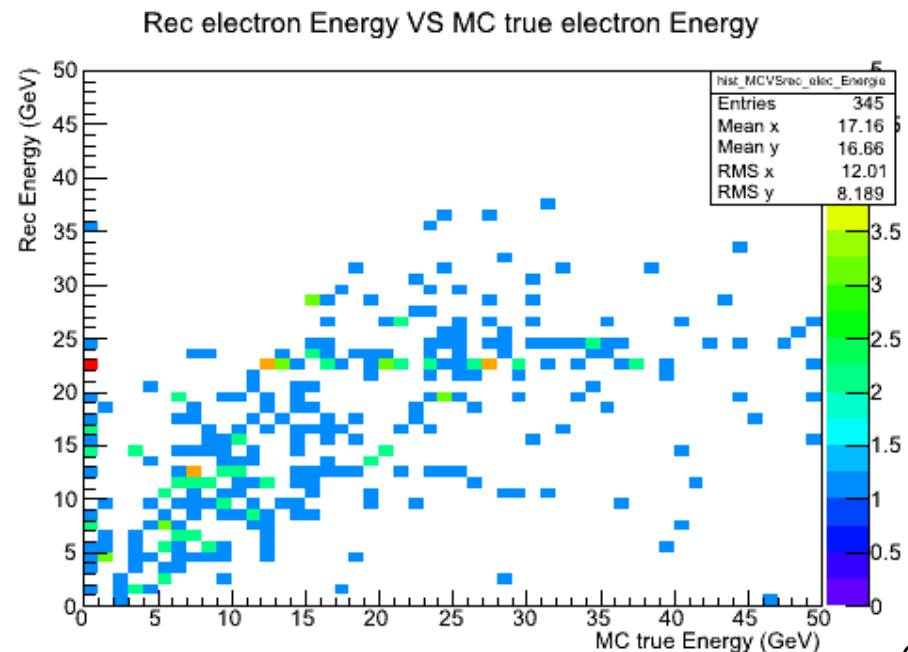
**FULLY CONTAINED**

# Energy reconstruction : nue beam

Goal : comparison with a sample containing only 1-brick fully contained showers



**FULLY CONTAINED**



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# New tool status

- 3 meetings in the former weeks to understand the result shown just before
- Different checks have been made in order to stabilise the output of the energy estimation unsuccessfully
- It has been decided to build a new tool to estimate the energy
- A new tool is being built : a **first test** a low statistics and discrete energy works & some ideas came up in the EWG
- Need a large statistics sample : **new MC production**
- In the meantime Frank try to understand the differences between his tool and mine



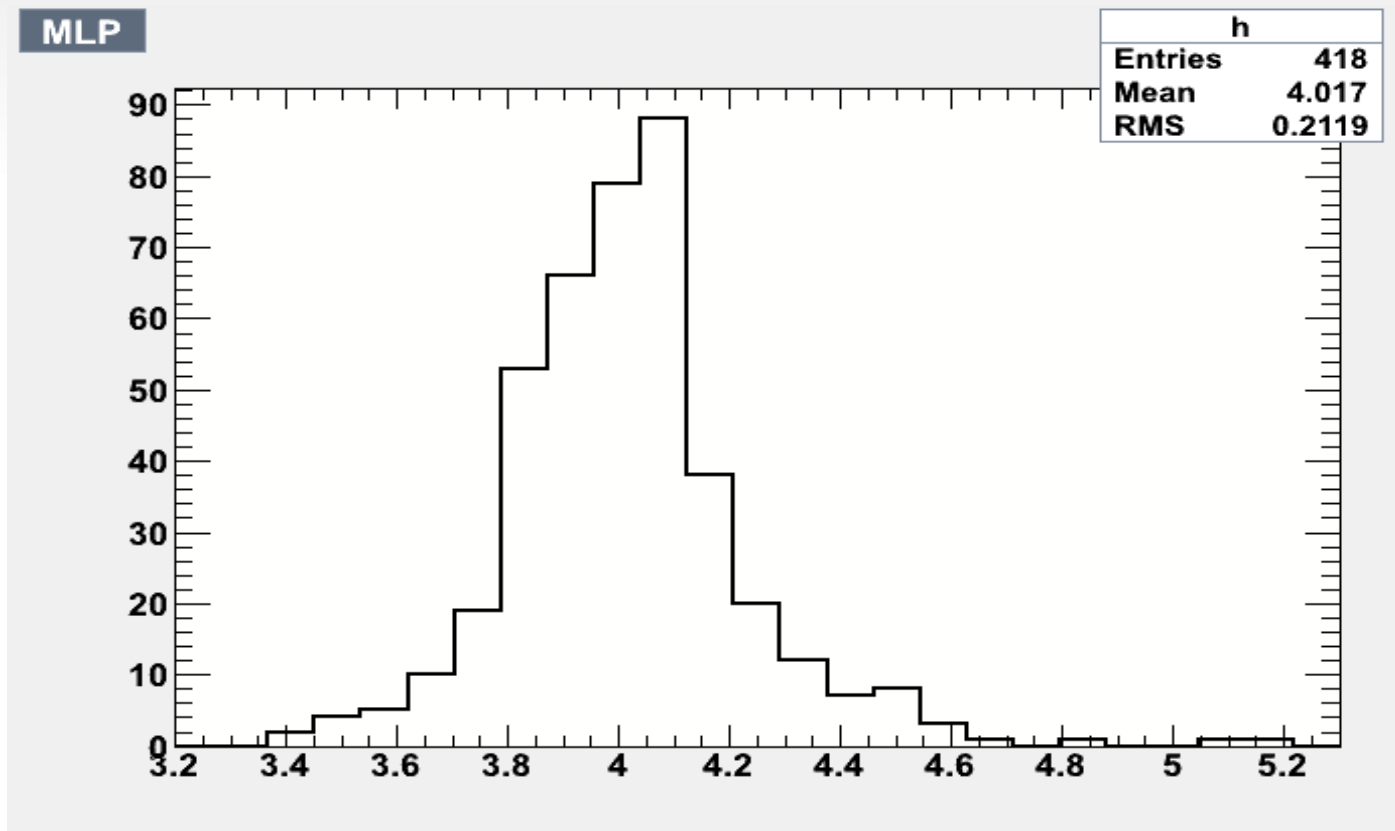
# First attempt

Electron Energy estimation : New training of the neural network in the shower reconstruction tool

- Framework of the NN : TMVA : MLP class
- MC sample to train & test the new NN : OpRelease 4 (Geant 3, OpEmuIO, OpEmuRec) → sample 4 GeV electron interacting randomly in the brick (incoming angle :  $[-0.5, 0.5]$  rd)
- MC sample statistics : 1k (NN check)
- Input variables : BT multiplicity, Plate extension, longitudinal profile (10 plates → coupling bins by 2 = 5 variables)

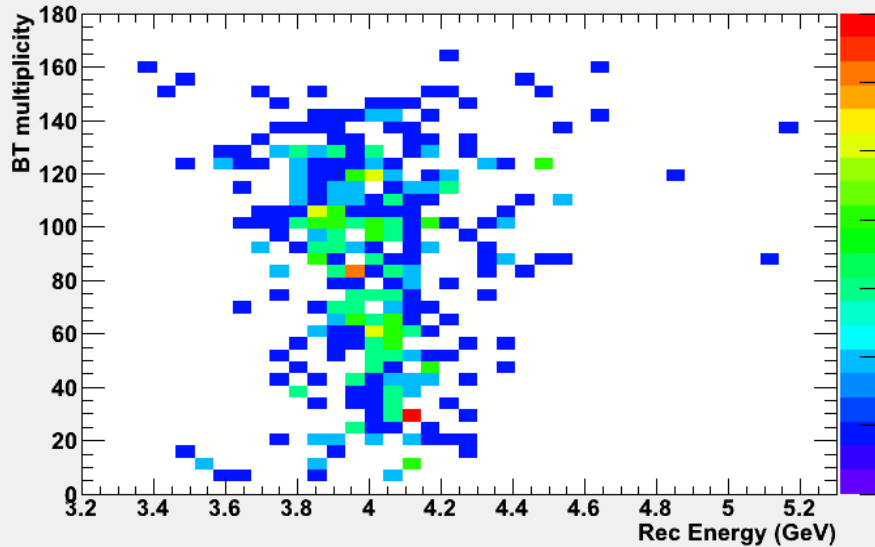
# First attempt : MLP results

- With the MLP class, the energy reconstructed on the test sample is good.
- But non-gaussian shape of the energy distribution → variables ?

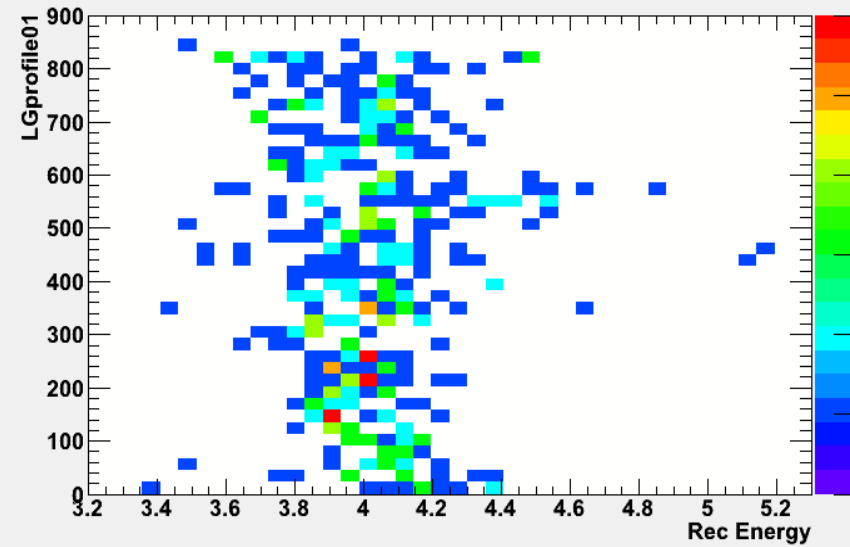


# First attempt : MLP results

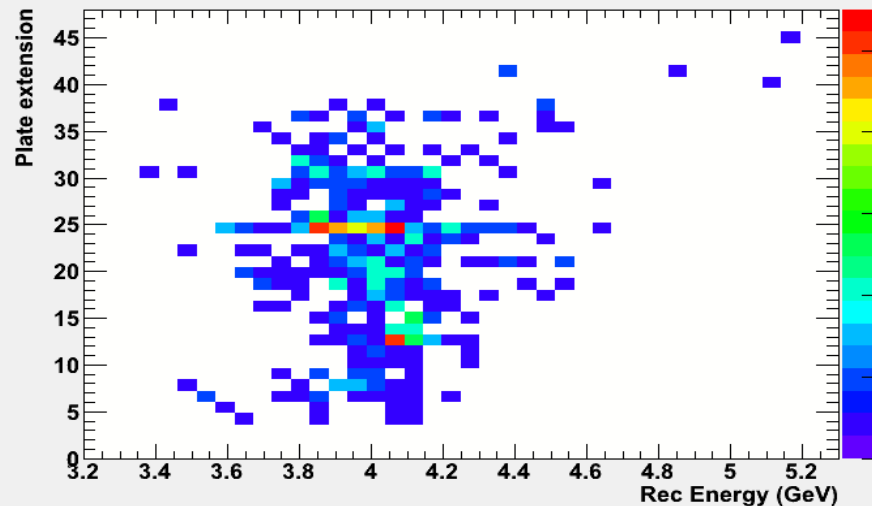
BTmultiplicity:MLP



LGprofile01:MLP

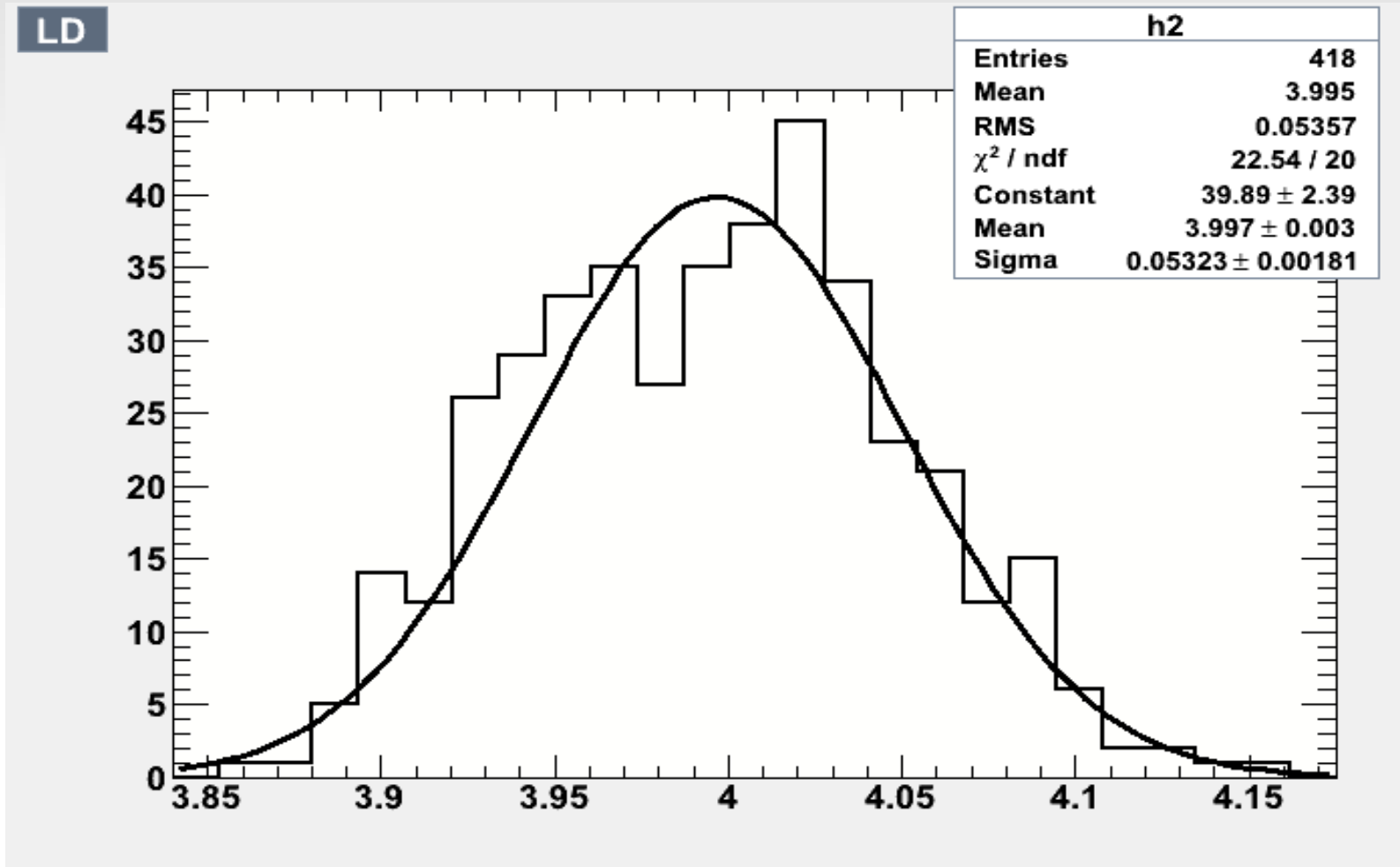


PLextension:MLP



# First attempt : LD results

- Another method : Linear regression
- But non-gaussian shape of the energy distribution → variables ?



# Prospects

Electron Energy estimation : New training of the neural network in the shower reconstruction tool

- Framework of the NN : TMVA → MLP class or other methods (LD)
- 
- MC sample to train & test the new NN : OpRelease 4 (Geant 3, OpEmuIO, OpEmuRec)
- MC sample statistics : 1k → 10k (NN more checks) then 50k (CCAGE needed) using fully contained in one brick showers ?
- Input variables : BT multiplicity, Plate extension, longitudinal profile (depend on Energy & angle) (as described in the 1st attempt) OR fitted shower model

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# New MC production

Electron Energy estimation : New training of the neural network in the shower reconstruction tool

- MC sample statistics : 50k electrons – [0,30]GeV [-500,+500]mrad incoming angle
- Before Christmas vacation, I asked for a restricted batch queue in ccage with larger amount of memory available (8Gb) & an extended disk space to store MC production (5Tb)
- Elisabetta has provided a restricted queue for me (16Gb) and a folder in the official production space to store the MC production (new space available in ccage 9Tb)
- Production started on Tuesday (17th january) → 10k electrons OpEmulO step done
  - I had to split the 10k events into 2 subsamples of 5k because of OpDigit (new problem?)

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# Toward paper

MC studies

Efficiency calculation

- location efficiency
- electron ID

Signal/Noise estimation

kinematical cuts

- electron energy reconstruction
- neutrino energy reconstruction

Data: nue candidates with all valuables

Shower reco volume, primary track info, TT info

Physics messages and plots.

# Final Efficiency calculation

```

-----
|| Total || OpCarac | Brick finding | CS | Scanback | Vertex ||
-----
|| 1.00000 || 0.7720000 | 0.521000000000000 | 0.50 | 0.44100000 | 0.340000 ||
-----

```

|                       | OpCarac                | BF                     | CS                     | SB<br>( $p_l < 55 \& 5p_{lvt}$<br>x) | VTX(at least<br>2trks, $p_l < 55$ ) |
|-----------------------|------------------------|------------------------|------------------------|--------------------------------------|-------------------------------------|
| <b><i>NueOsc*</i></b> | <b>0.856±0.0</b><br>38 | <b>0.541±0.0</b><br>35 | <b>0.523±0.0</b><br>35 | <b>0.438±0.0</b><br>31               | <b>0.403±0.0</b><br>30              |

Umut

Code developments :

- A modified OpNtpWriter to include Shower information (using STL std::vector)
- A code to compute efficiency from outputs of modOpNtpWriter on all channels (nue oscillated, nue beam, nueQE, numuNC, tau → e, tau → e QE)
- Next step is to implement CS electron trigger and estimate its efficiency

# Final Efficiency calculation

|                | OpCarac     | BF          | CS          | SB<br>(pl<55&5plvtx) | VTX(at least<br>2trks,pl<55) | VTX+singlestop |
|----------------|-------------|-------------|-------------|----------------------|------------------------------|----------------|
| <i>NueOsc*</i> | 0.856±0.038 | 0.541±0.035 | 0.523±0.035 | 0.438±0.031          | 0.403±0.030                  | 0.460±0.032    |

## OSCILLATED NUE

|                 |         |                    |                    |      |            |          |  |
|-----------------|---------|--------------------|--------------------|------|------------|----------|--|
| Efficiency type | Total   | OpCarac (NC+C)     | Brick finding      | CS   | Scanback   | Vertex   |  |
| Cumulative      | 1.00000 | 0.7720000000000000 | 0.5210000000000000 | 0.50 | 0.44100000 | 0.340000 |  |
| Relative        | 1.00000 | 0.7720000000000000 | 0.6748704663212    | 0.96 | 0.88376754 | 0.770975 |  |

|               |             |             |             |             |             |             |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <i>NueDIS</i> | 0.901±0.009 | 0.618±0.015 | 0.616±0.015 | 0.577±0.016 | 0.550±0.016 | 0.584±0.016 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|

## NUE BEAM

|                 |         |                     |                 |      |            |          |  |
|-----------------|---------|---------------------|-----------------|------|------------|----------|--|
| Efficiency type | Total   | OpCarac (NC+C)      | Brick finding   | CS   | Scanback   | Vertex   |  |
| Cumulative      | 1.00000 | 0.49349349349349349 | 0.3423423423423 | 0.34 | 0.32332332 | 0.286286 |  |

|              |             |             |             |             |             |             |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <i>NueQE</i> | 0.852±0.011 | 0.608±0.015 | 0.596±0.016 | 0.530±0.016 | 0.446±0.016 | 0.535±0.016 |
|--------------|-------------|-------------|-------------|-------------|-------------|-------------|

## NUEQE

|                 |         |                    |                    |      |            |          |  |
|-----------------|---------|--------------------|--------------------|------|------------|----------|--|
| Efficiency type | Total   | OpCarac (NC+C)     | Brick finding      | CS   | Scanback   | Vertex   |  |
| Cumulative      | 1.00000 | 0.8410000000000000 | 0.6000000000000000 | 0.59 | 0.52500000 | 0.437000 |  |
| Relative        | 1.00000 | 0.8410000000000000 | 0.7134363852556    | 0.98 | 0.89285714 | 0.832381 |  |

# Final Efficiency calculation (2)

|                   | OpCarac     | BF          | CS          | SB<br>(pl<55&5plvtx) | VTX(at least<br>2trks,pl<55) | VTX+singlestop |
|-------------------|-------------|-------------|-------------|----------------------|------------------------------|----------------|
| <i>Tau-e DIS*</i> | 0.875±0.009 | 0.576±0.014 | 0.541±0.014 | 0.442±0.014          | 0.336±0.012                  | 0.455±0.014    |

TAUE

```

Efficiency type || Total || OpCarac (NC+C) | Brick finding | CS | Scanback | Vertex ||
Cumulative      ||1.00000||0.520251157222671|0.000000000000|0.0010.0000000010.00000011

```

|                  |             |             |             |             |  |  |
|------------------|-------------|-------------|-------------|-------------|--|--|
| <i>Tau-e QE*</i> | 0.748±0.013 | 0.498±0.014 | 0.411±0.014 | 0.268±0.012 |  |  |
|------------------|-------------|-------------|-------------|-------------|--|--|

TAUEQE

```

Efficiency type || Total || OpCarac (NC+C) | Brick finding | CS | Scanback | Vertex ||
Cumulative      ||1.00000||0.787000000000000|0.000000000000|0.0010.0000000010.00000011

```

|               |             |             |             |             |             |             |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <i>NumuNC</i> | 0.826±0.007 | 0.465±0.009 | 0.397±0.009 | 0.331±0.009 | 0.258±0.008 | 0.342±0.009 |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|

NUMUNC

```

Efficiency type || Total || OpCarac (NC+C) | Brick finding | CS | Scanback | Vertex ||
Cumulative      ||1.00000||0.57085695231744|0.2964321440480|0.17|0.14504835|0.091030||
Relative        ||1.00000||0.57085695231744|0.510275700034610.5010.8317300610.62758611

```

# Outlook

## 1/ Electron Energy estimation

- a/ production of new MC sample
- b/ build a new tool to estimate the energy of showers
- c/ Calibration of shower tool with electron data
- d/ Data analysis : comparison of my result with the one already produced by scanning labs

2/ numu  $\rightarrow$  nue analysis : final efficiency calculation (including kinematical selection once the new shower tool will be ready)

Backup slides