Status of the MIND simulation and Analysis

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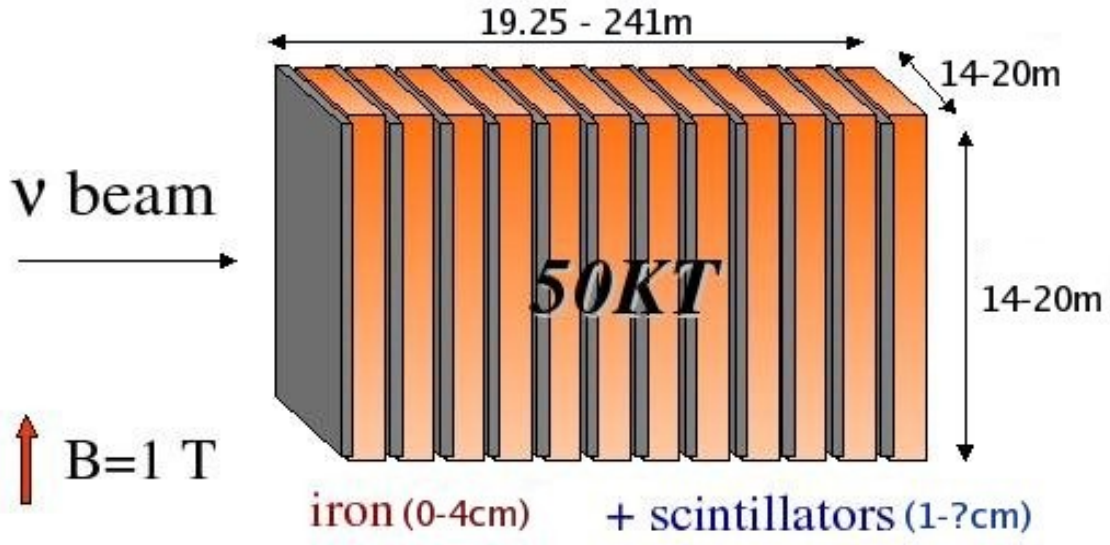
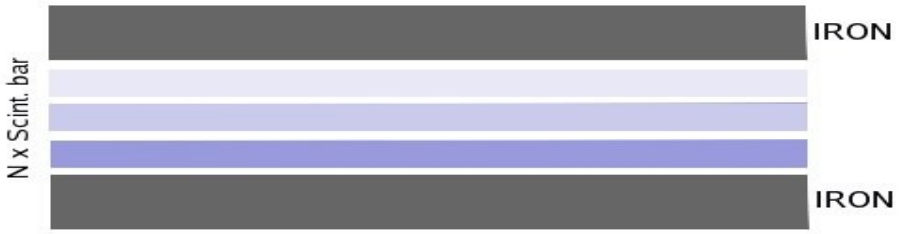
- MIND
- Update on the reconstruction analysis
  - Optimisation of efficiency and backgrounds using cuts and likelihoods
  - Shower reconstruction
- Geant4 MIND
- Summary of status

The Detector

Baseline Detector for golden channel measurement at the neutrino factory





Simulation work package to optimise geometry and analysis

Muon Extraction

- Events with at least 5 hits.
- Two possible methods are then employed to extract a muon candidate from the event:

Method 1 *Events with at least the final 5 hits alone in their plane*

1) Free hits used to form a trajectory and seed.
2) Accept hit according to lowest χ^2 in each plane
3) Remaining hits considered as hadronic activity.

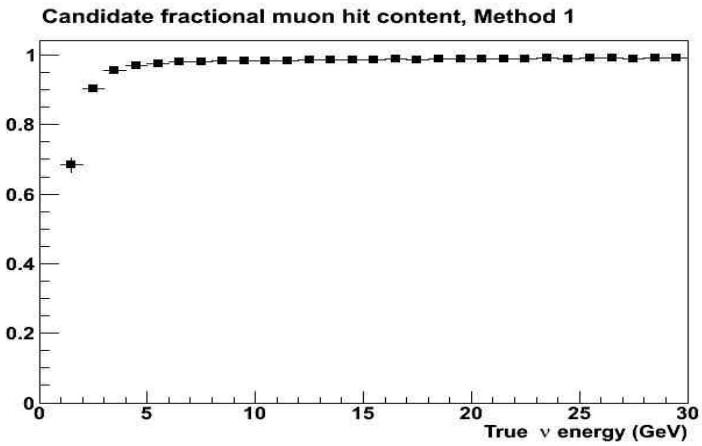
Muon Extraction 2

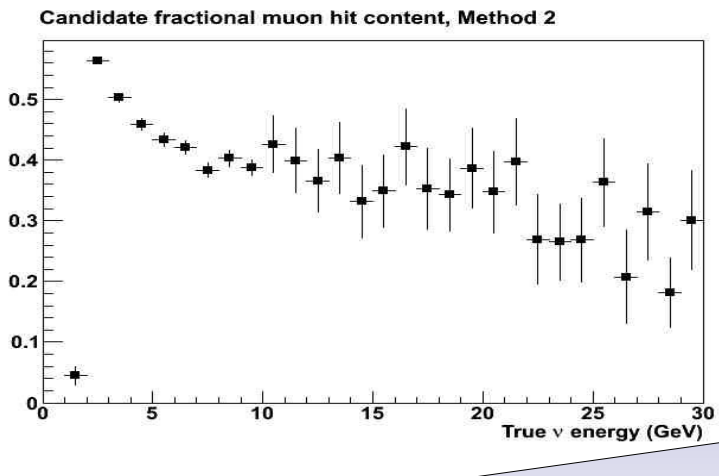
Method 2 *Cellular Automaton for more complex events*

1) Build all possible combinations of one hit per plane according to a neighbour criterion.

2) A single trajectory is selected by cutting those with low number of hits, high fit χ^2 and selecting the most viable remaining.

3) All other hits are cast as hadronic activity.

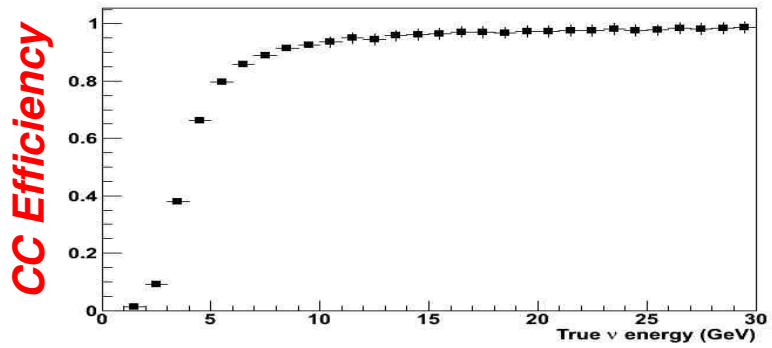


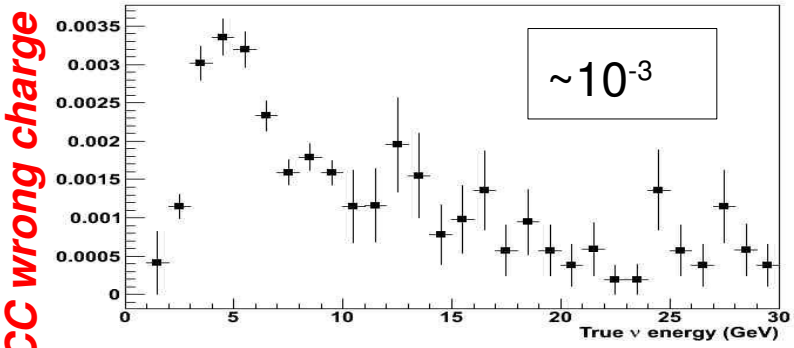


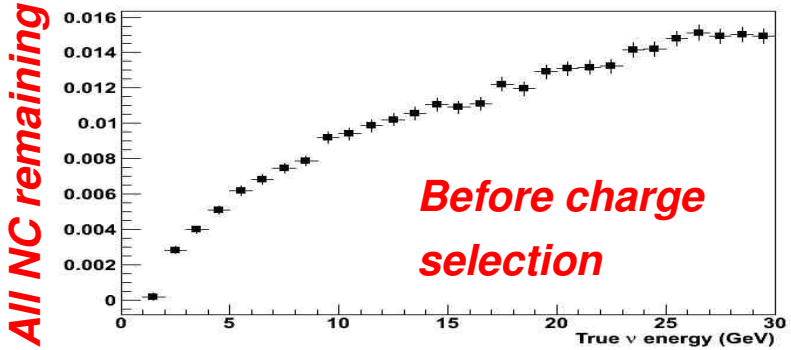
Track quality cuts

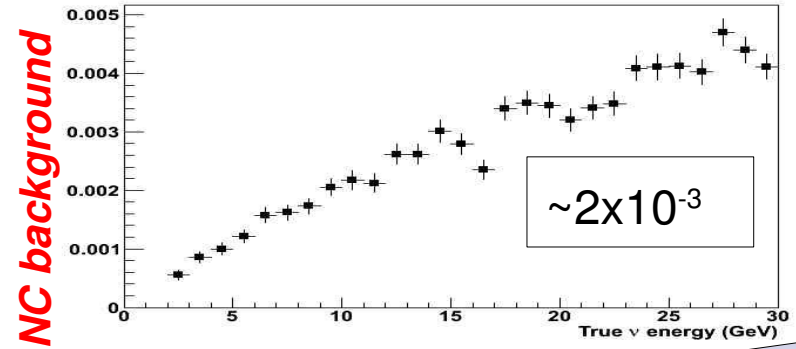
Track quality cuts include:

- Online cut requiring at least 6 hits in candidate for fit.
- $|\sigma_{q/p}/(q/p)| < 0.7$
- χ^2 probability > 0.999.



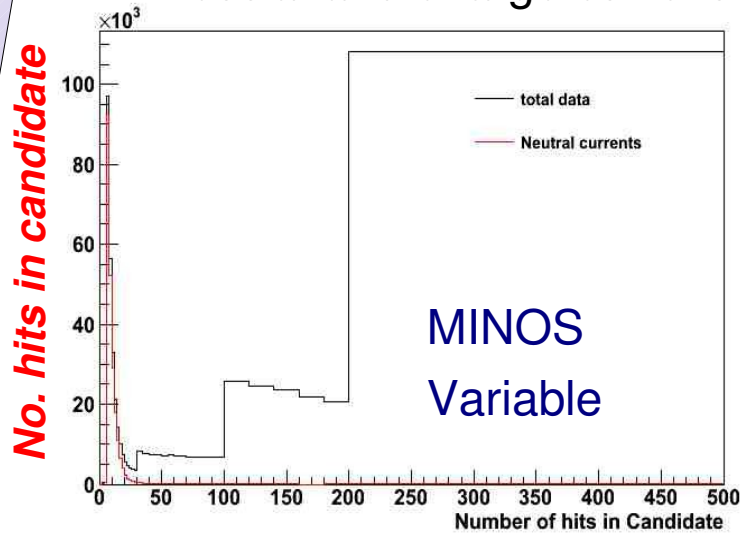


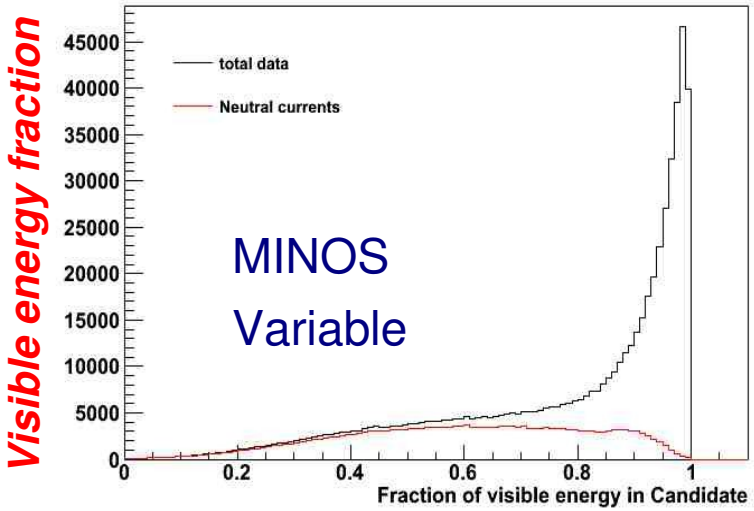


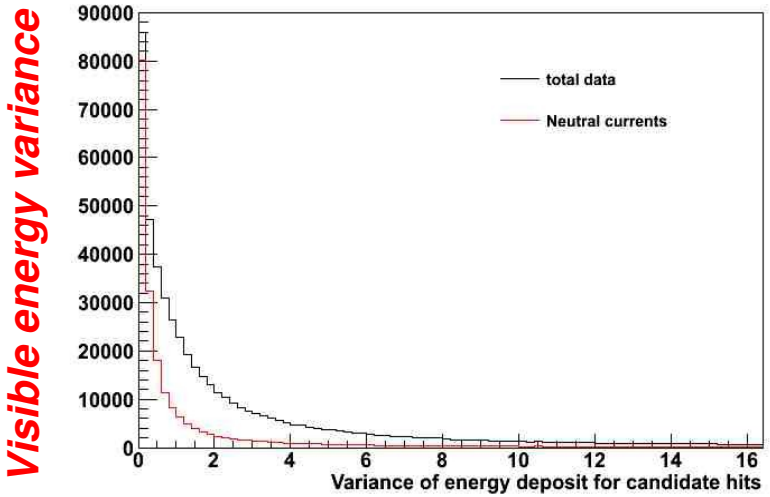


Likelihood Method for NC rejection

Three main parameters chosen to separate neutral and charge current interactions



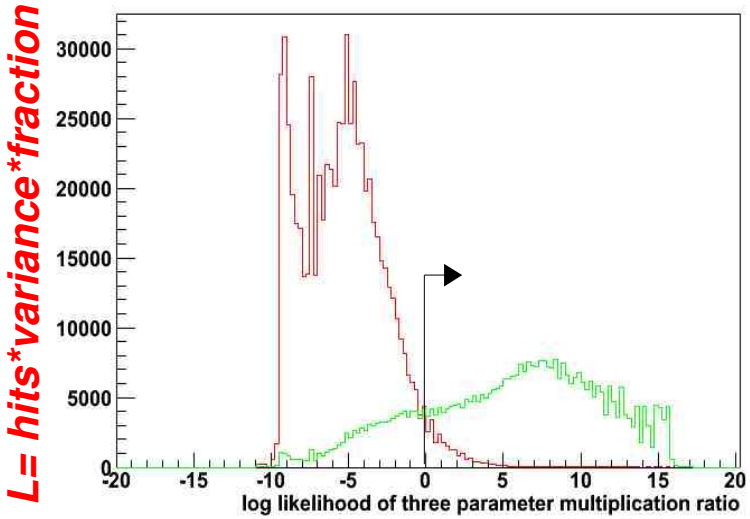


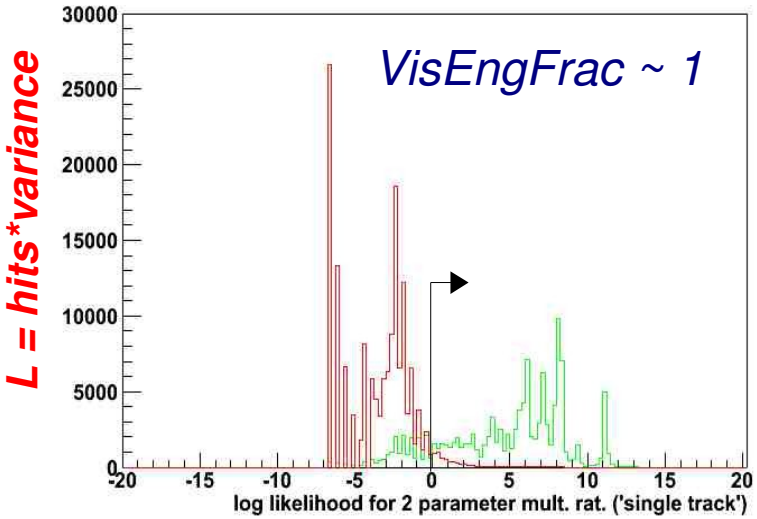


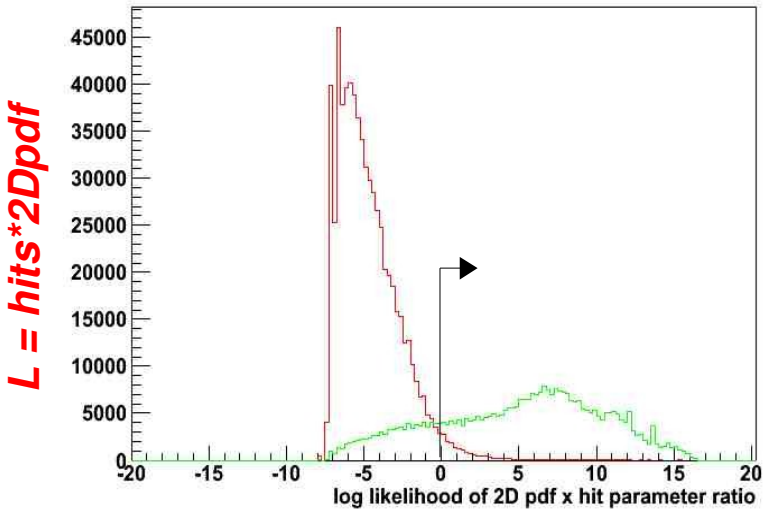
Candidates with > 99.9% of the visible energy considered with separate pdf for hits and variance only.

Distribution of log likelihood ratio

VisEngFrac < 1







Log likelihood:

$$\log\left(\frac{L_{CC}}{L_{NC}}\right)$$

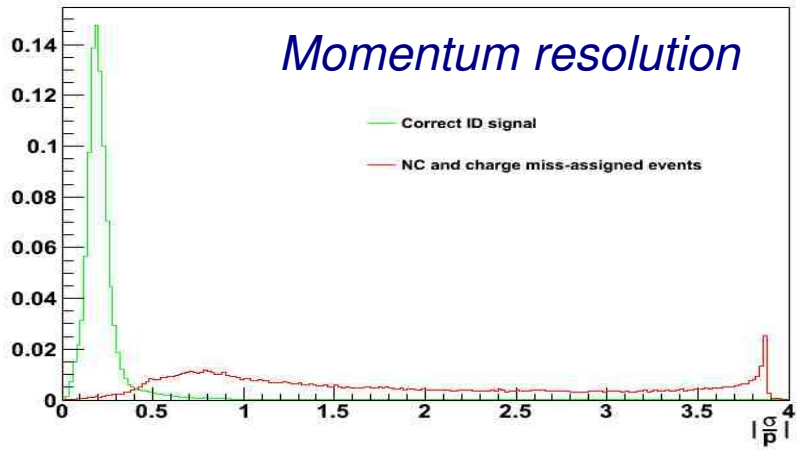
Analysis methods

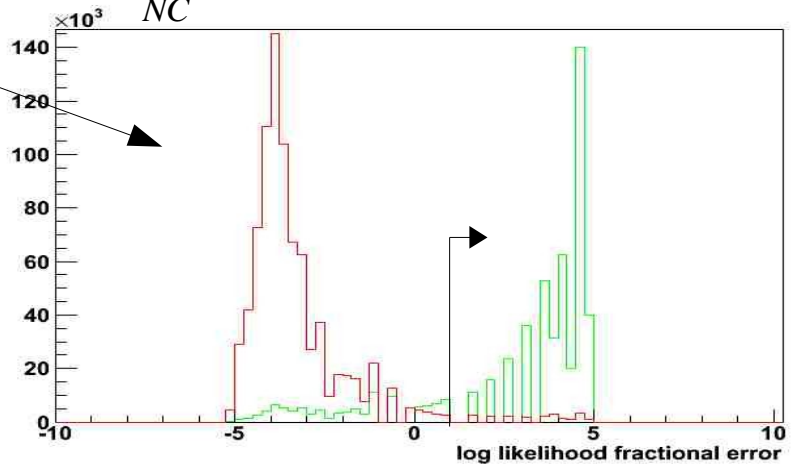
Standard Method

Apply track quality cuts and $\log\left(\frac{L_{CC}}{L_{NC}}\right) > 0$

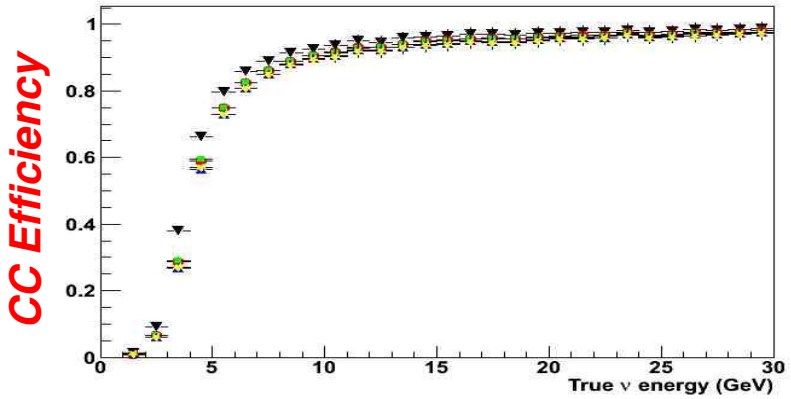
Alternate Method

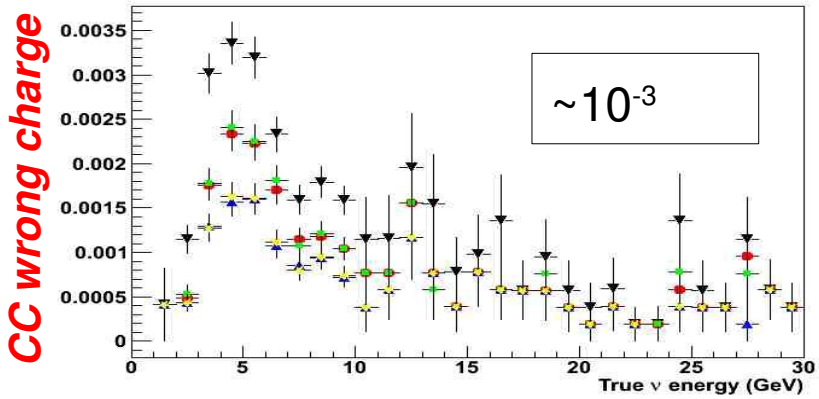
$\log\left(\frac{L_{CC\ correct\ charge}}{L_{all\ wrong\ charge}}\right) > 1.0$ and $\log\left(\frac{L_{CC}}{L_{NC}}\right) > 0$

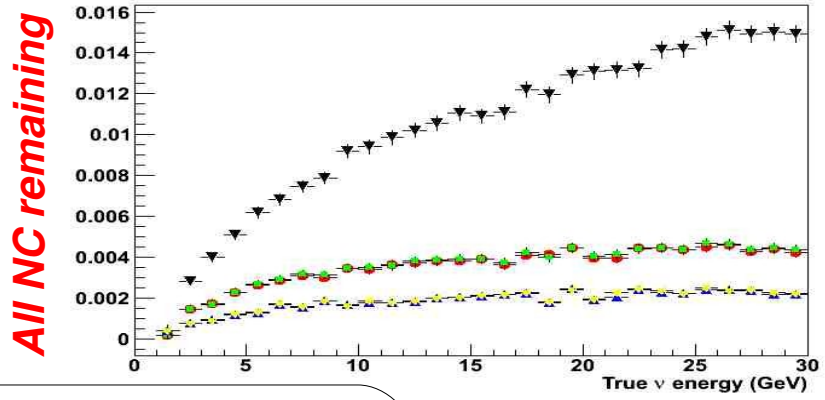


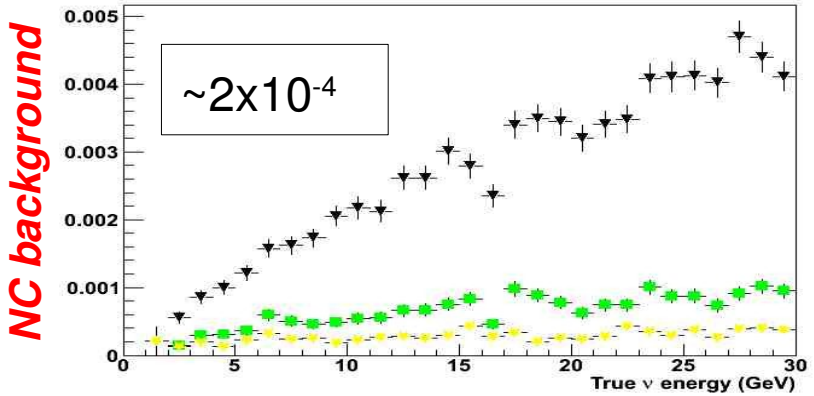


Summary of Efficiencies









- Quality cuts
- Quality cuts and 1D*1D*1D
- Quality cuts and 2D*1D
- Quality like. and 1D*1D*1D
- Quality like. and 2D*1D

Reconstructed energy

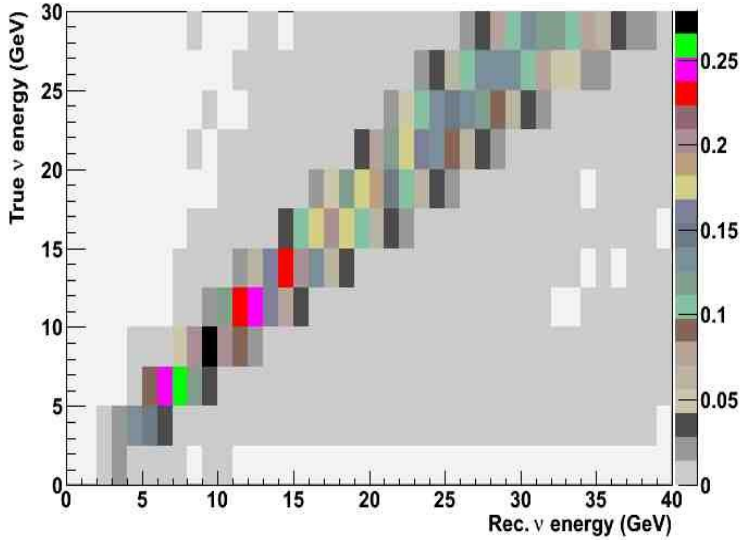
Hadron Shower energy smeared according to MINOS CalDet:

$$\frac{\sigma}{E} = \frac{0.55}{\sqrt{E}} + 0.03$$

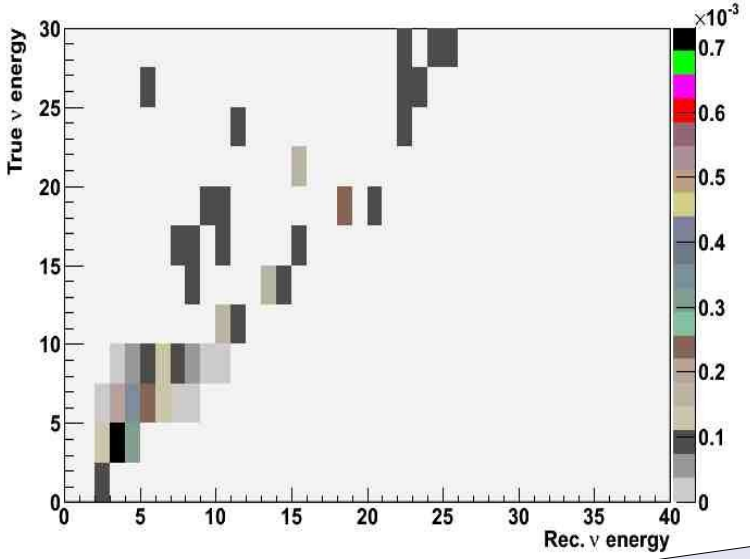
Neutrino energy then reconstructed as:

$$E_\nu = E_\mu + E_{hads}$$

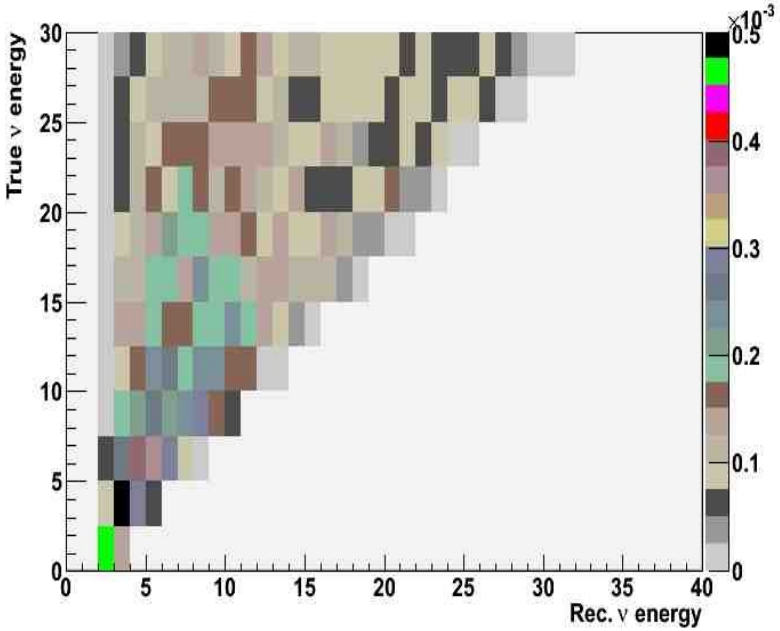
CC Efficiency



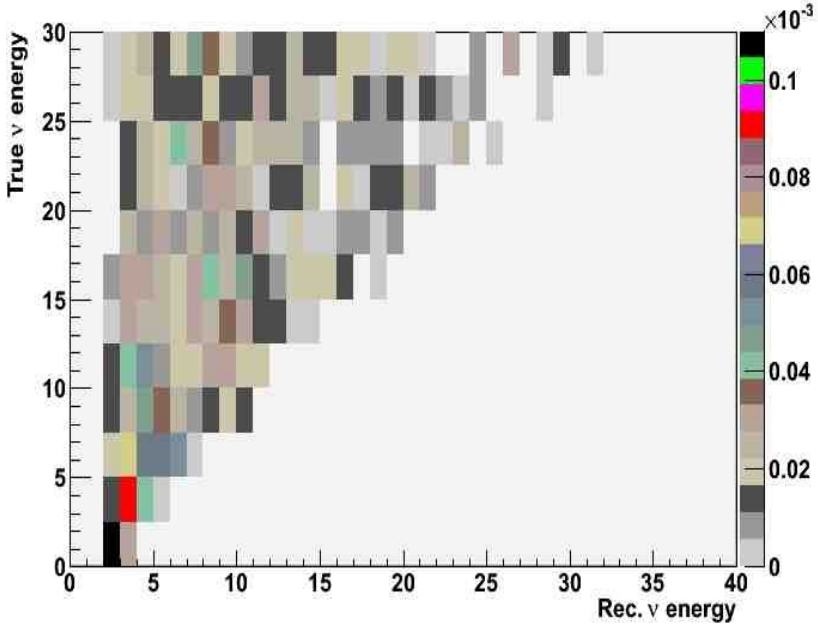
CC wrong charge



Reconstructed energy, NC



All NC remaining

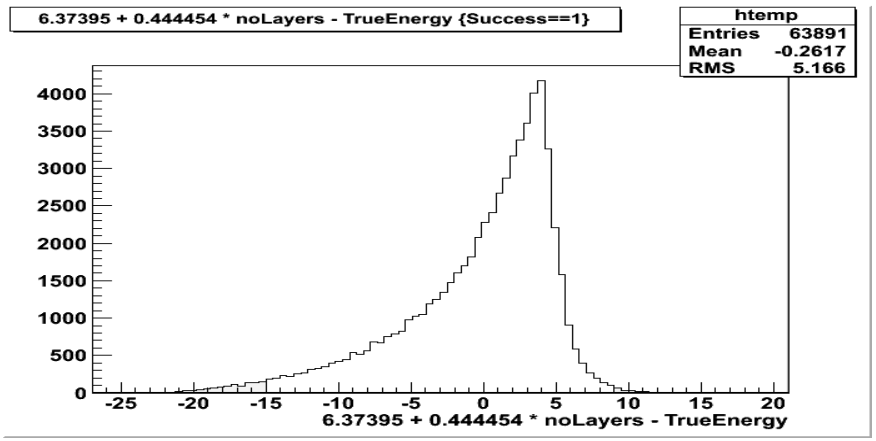


NC background

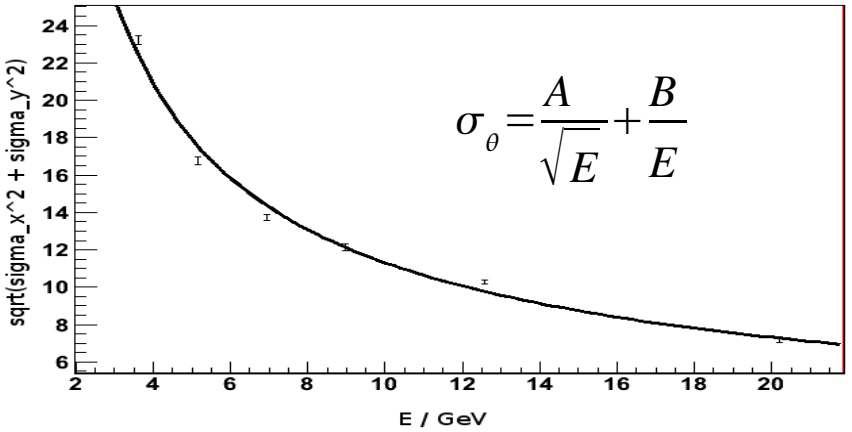
Shower reconstruction

Shower reconstruction in infancy:

- Investigation of MINOS and alternative methods underway
- Better understanding with G4 simulation.



Energy reconstruction



Direction reconstruction

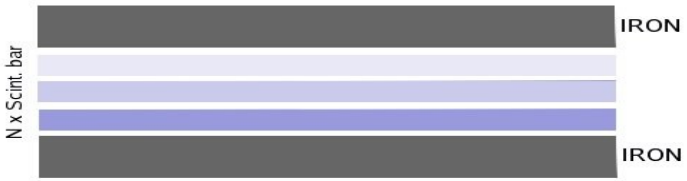
MINDG4

Event Generation

Nuance:

- Two text files, one for each material.
- Read according to nucleon proportion or material requested

Geometry



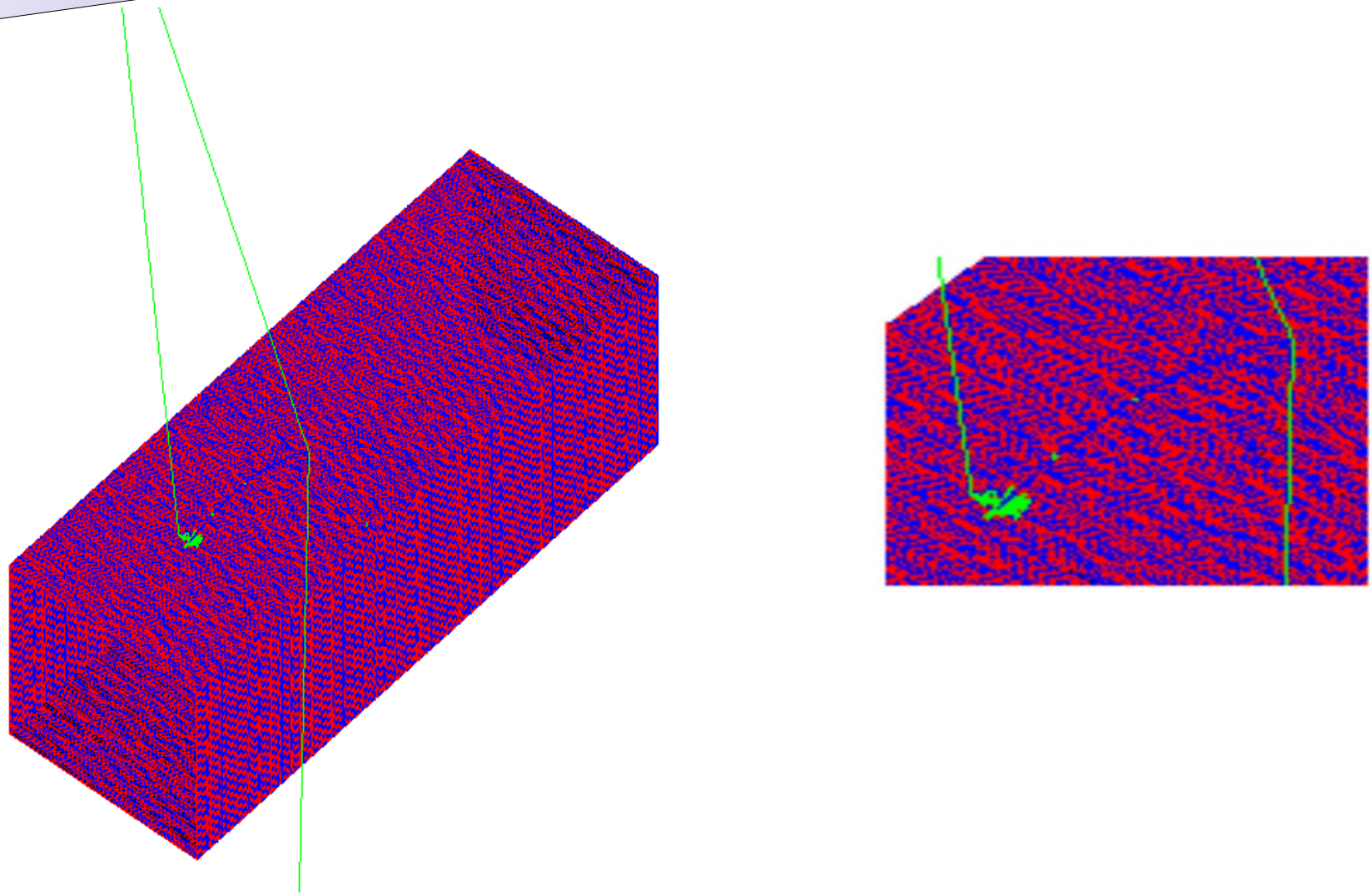
Repeated piece to fill volume:

- Iron of requested length.
- Requested number of scintillator planes.
- Scintillator of requested length
- Air gaps between each plane and piece

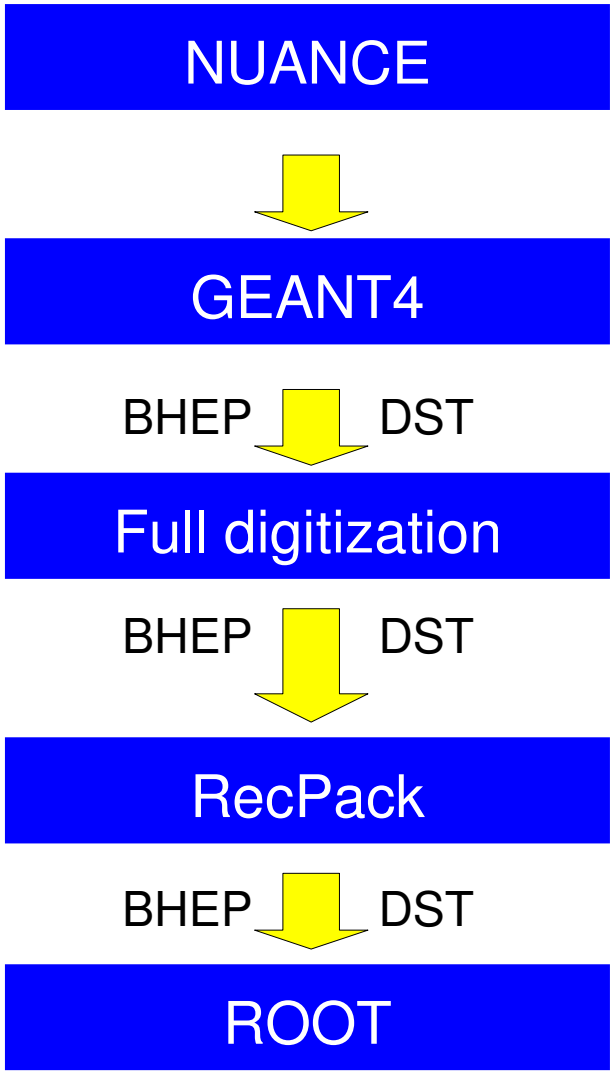
Physics

Modular Physics list QGSP_BERT 3.3

- Production cut at min. 3cm
- Min. Kin. Eng. 100MeV



Summary of software status



Understood, possibility of other generators

At debugging stage: optimisation of cuts to increase speed

Simple smear for now, ultimately use full scintillator bar simulation

Analysis method understood, tune and optimise in the G4 era.

Work completed and plan

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<tr><td>1</td><td rowspan="3">DIS</td><td rowspan="3">old segmentation</td><td rowspan="2">G3</td><td rowspan="2">smearing</td><td>smearing</td></tr>
<tr><td>2</td><td rowspan="3">PR and new analysis</td></tr>
<tr><td>3</td><td rowspan="5">G4</td><td rowspan="3">some clustering + smearing</td></tr>
<tr><td>4</td><td rowspan="4">DIS+QEL+RES</td><td rowspan="2">MINOS seg</td><td>Compare with MINOS MC and data</td></tr>
<tr><td>5</td><td rowspan="3">Improve analysis</td></tr>
<tr><td>6</td><td>Optimise seg</td><td rowspan="2">Full digitisation</td></tr>
<tr><td>7</td><td></td></tr>
</table>

**Step 5 important for credibility of simulation