Muon neutrino disappearance

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OPERA Collaboration meeting
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Progress update

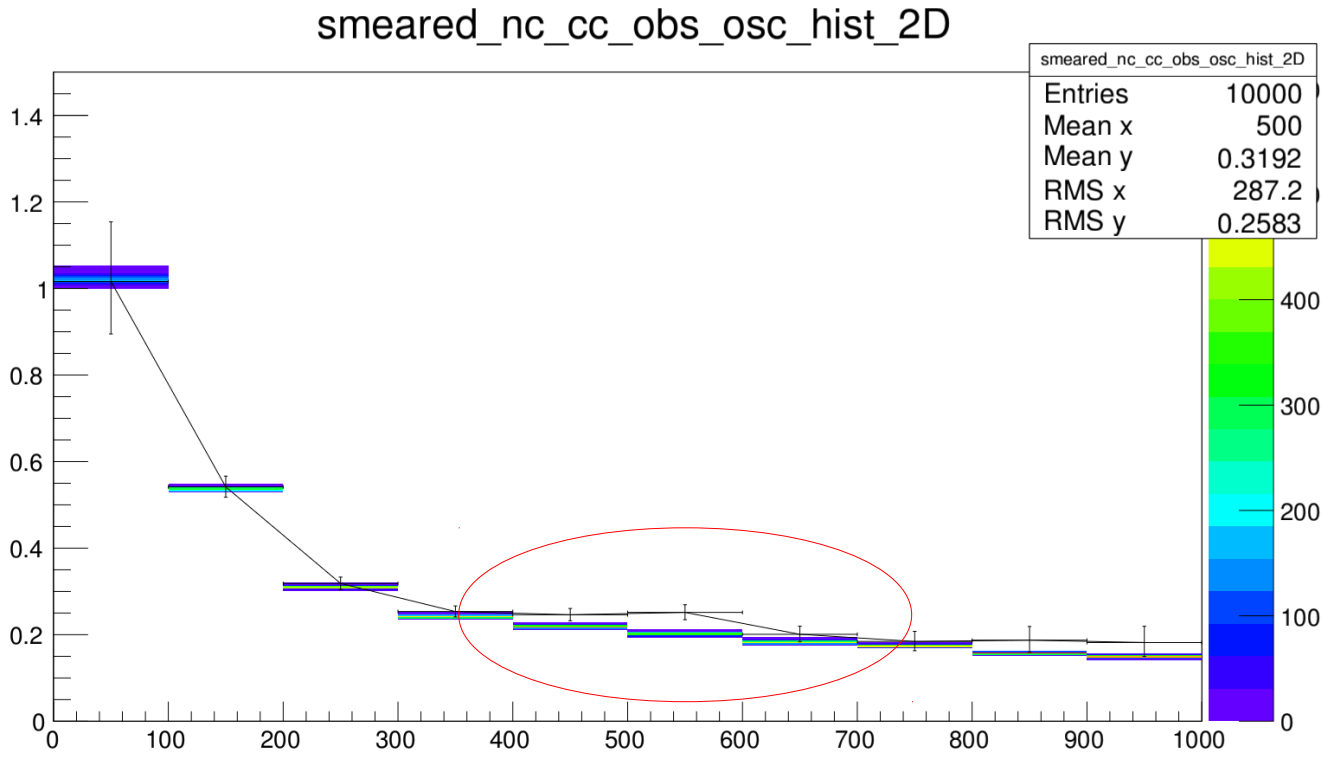
- Since the last collaboration meeting, new things are:
  - beam systematics study finished
  - sensitivity evaluation done
  - additional systematics removed (the bump)
  - construct proper statistical limits (started)

Summary of the analysis

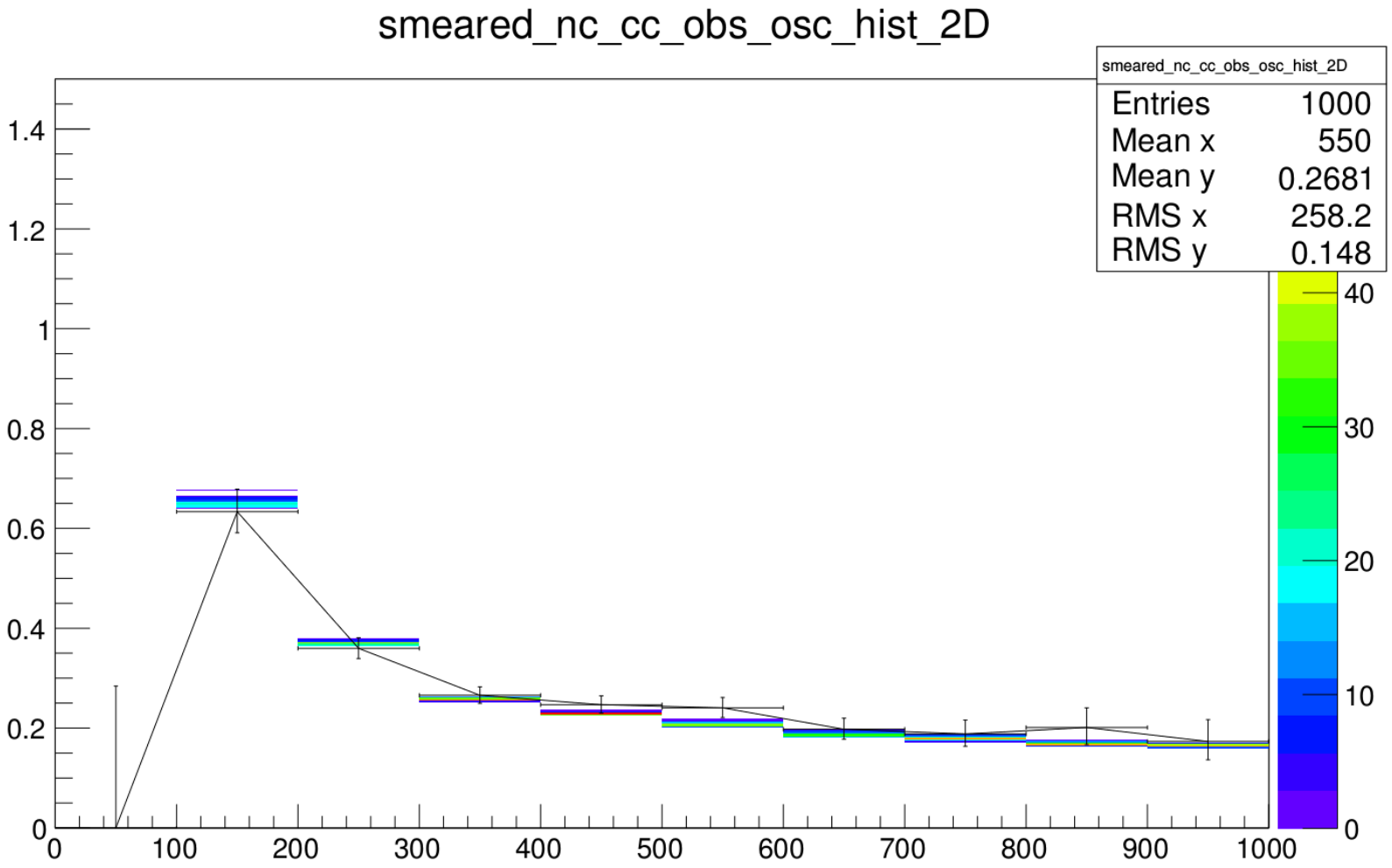
- Use only ELEDET data
- Make NC-like and CC-like event selection
- Construct NC-like/CC-like ratio histogram
- Fit MC to data using Dm_32^2 as a free parameter using bayesian likelihood
  - new and improved high statistics MC was created for this purpose
- Note – this is not purely disappearance analysis, we need to add tau appearance in our model to have consistency between MC and data
  - and the fit is significantly different if we turn off the tau appearance
  - maybe the better name would be “Oscillation analysis using ELEDET data”

The bump

- There is a bump in the NC-like/CC-like ratio plot which pushes the value of Dm^2 up
- After a lot of trial and error, we have found the origin of the bump
  - it's created by the events which happened in the first ~ 10 brick walls upstream of the spectrometer
  - when these events are filtered out, the bump is gone (and is quite prominent in the inverse filter)
  - the fit is quite better



No bump


smeared_nc_cc_obs_osc_hist_2D
smeared_nc_cc_obs_osc_hist_2D
Entries 1000
Mean x 550
Mean y 0.2681
RMS x 258.2
RMS y 0.148
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
600
700
800
900
1000
40
30
20
10
0

New global cut

- We accept events that:
  - Have triggered the detector
  - Brick Finding flag is OK
  - OpCarac event type is “CONTAINED”
  - Total deposited photoelectrons is >= 600
    - used to be >= 400
  - First BF brick in the wall <= 20
    - reduces the bump
  - Either classified as NC-like or CC-like

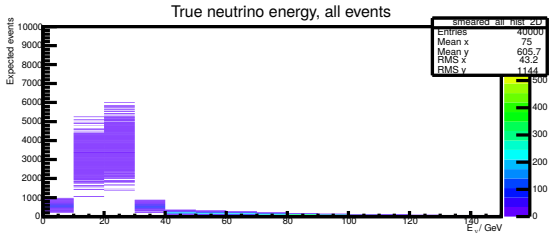
NC-like/CC-like selection

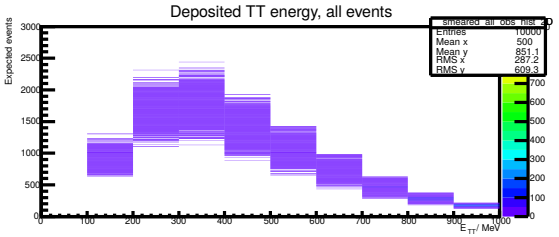
- Event is CC-like if:
  - Reco number of mu tracks != 0
  - Spectrometer bending topology == true
    - at least one digit in both arms of a single spectrometer
  - Reco “good” muon momentum reconstructed and is < 0
    - exclude positive muons
- Event is NC-like if:
  - Reco number of mu tracks == 0
  - Spectrometer bending topology == false
  - Reco “good” muon momentum NOT reconstructed
    - this one is actually obsolete

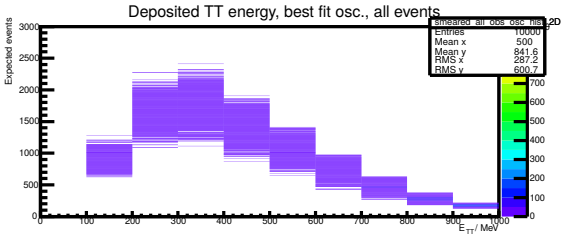
Beam systematics study

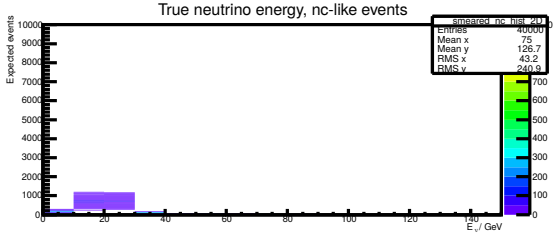
- Measure of systematics coming from the uncertainty in interacting neutrino spectrum
- This should include systematics coming from
  - beam flux uncertainty
  - neutrino cross sections
- Produced in the following way:
  - load real data
  - smear interacting flux by 20% in each bin
    - used bin size 10 GeV in true MC energy
  - fit data to smeared MC
  - fill the histogram with best fit value
  - repeat 1000 times

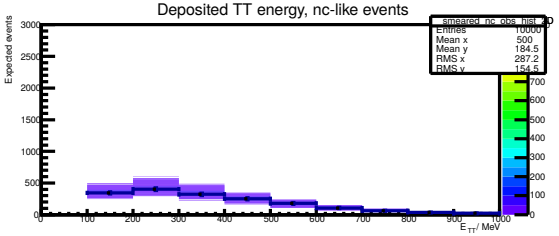
Decreasing beam systematics

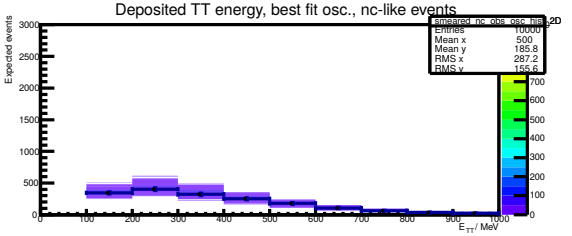


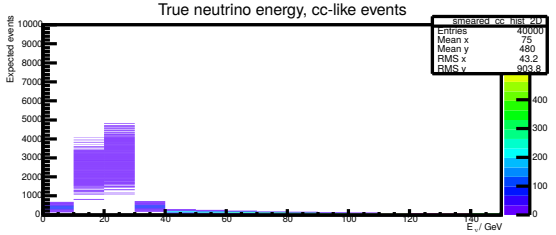


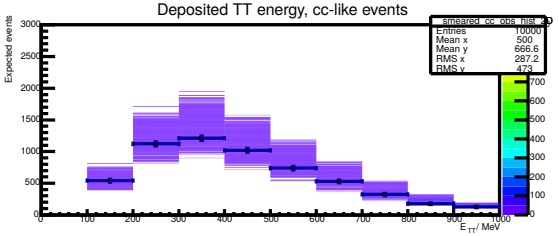


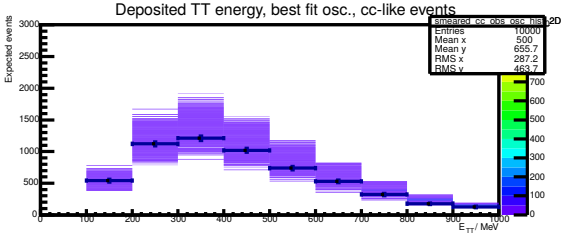


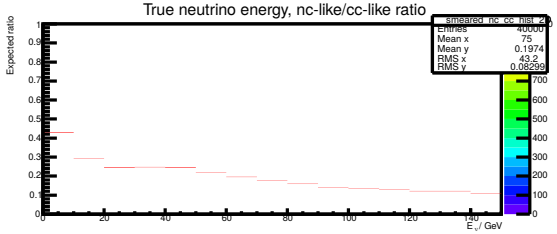


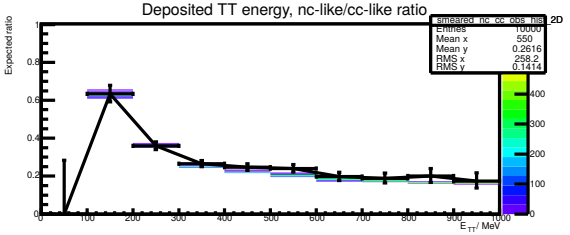


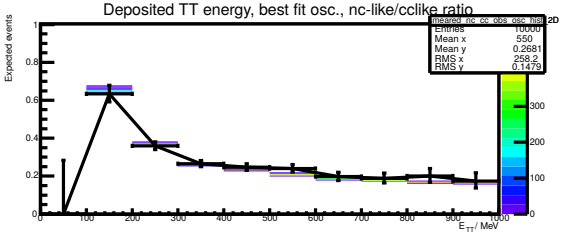








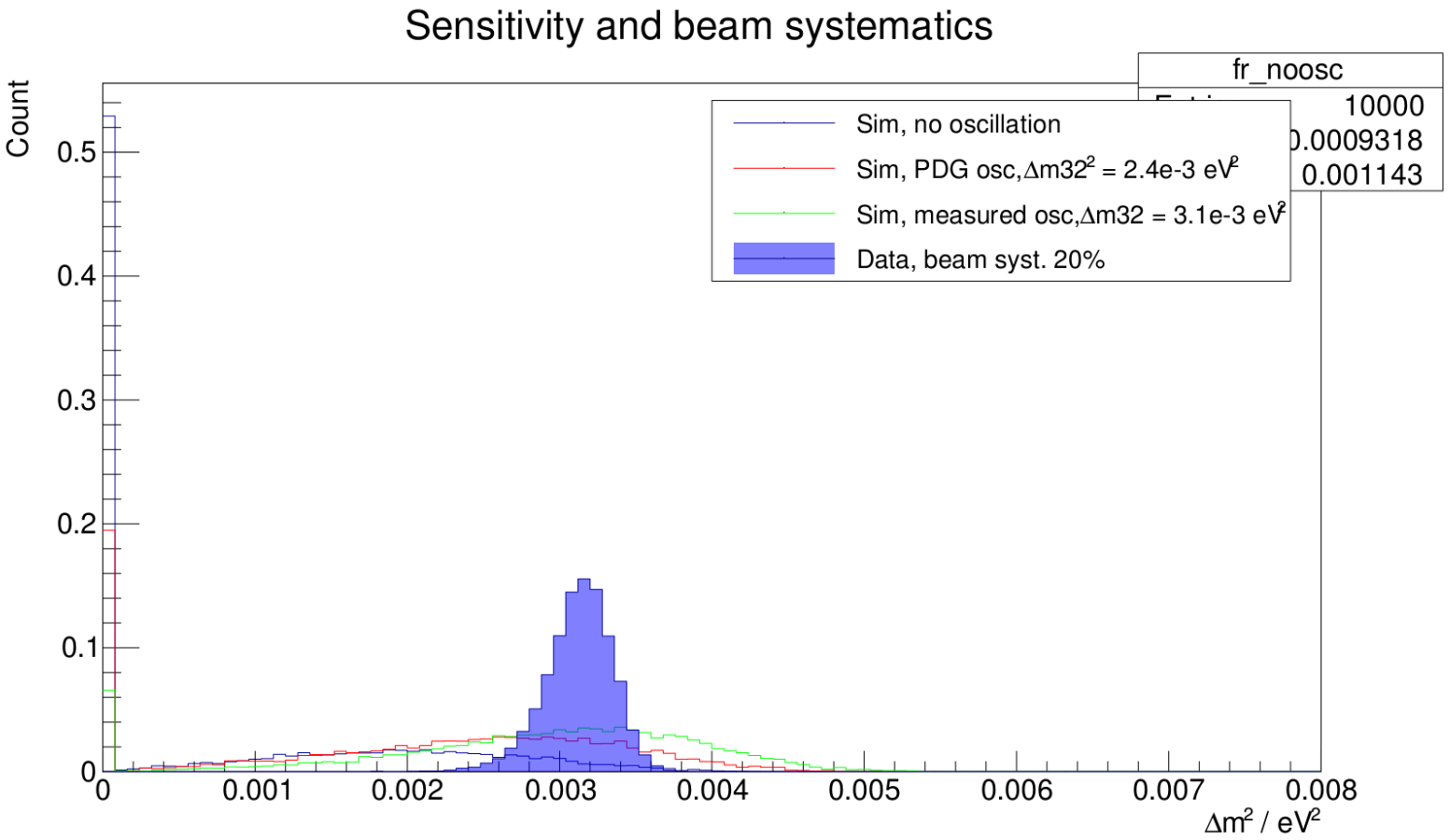




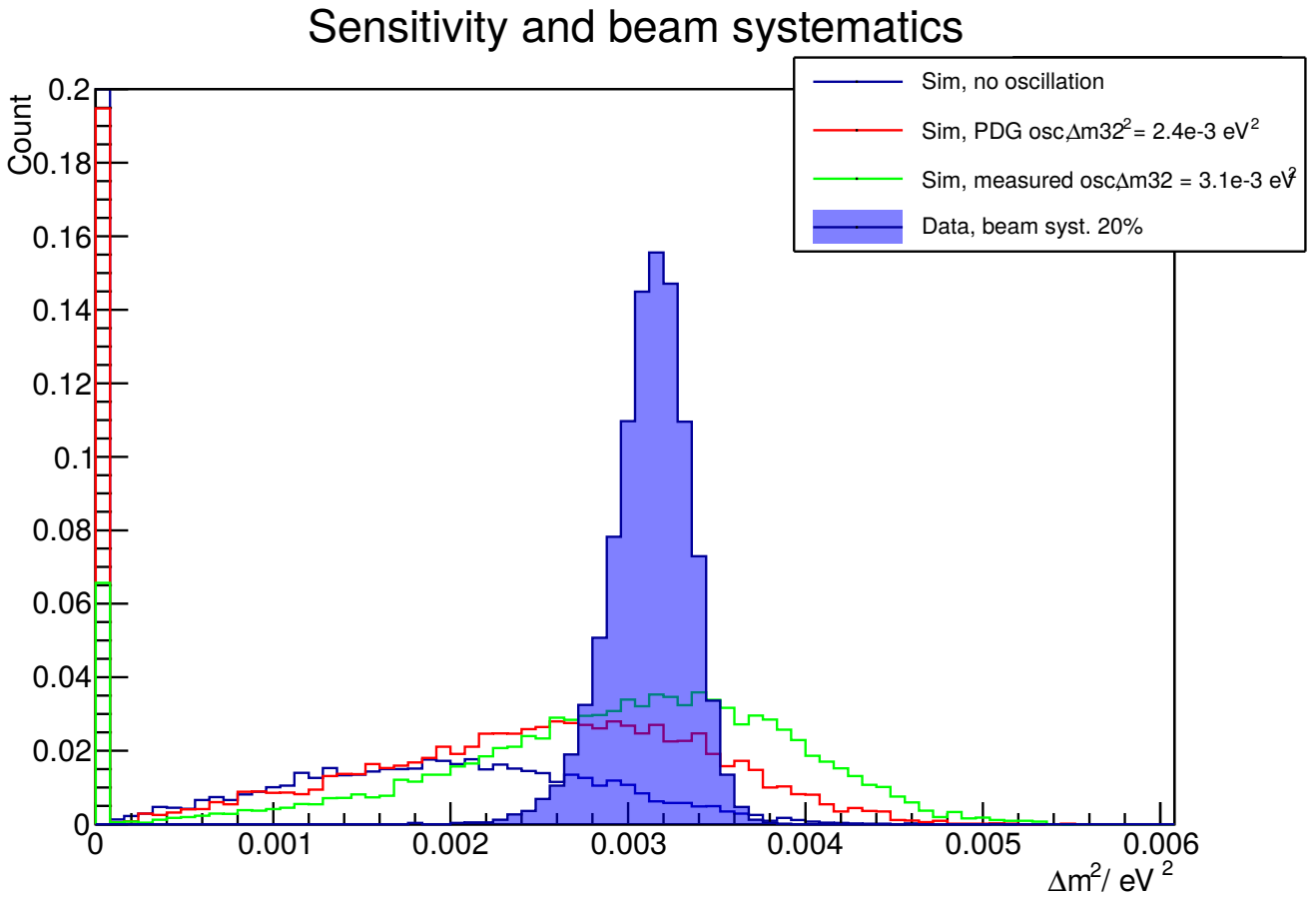
Sensitivity evaluation

- Done using MC pseudo-experiments, produced like this:
  - simulate a data sample from MC
    - number of events close to what we have in data
    - a probability of choosing particular event is proportional to it's oscillated MC weight
  - preform a fit on the simulated data
  - fill the histogram with best fit value
  - repeat 1000 times
- This was done for three different values of dm_32^2
  - zero – no oscillation
  - 2.4e-3 eV^2 – PDG value
  - 3.1e-3 eV^2 – our current best-fit value

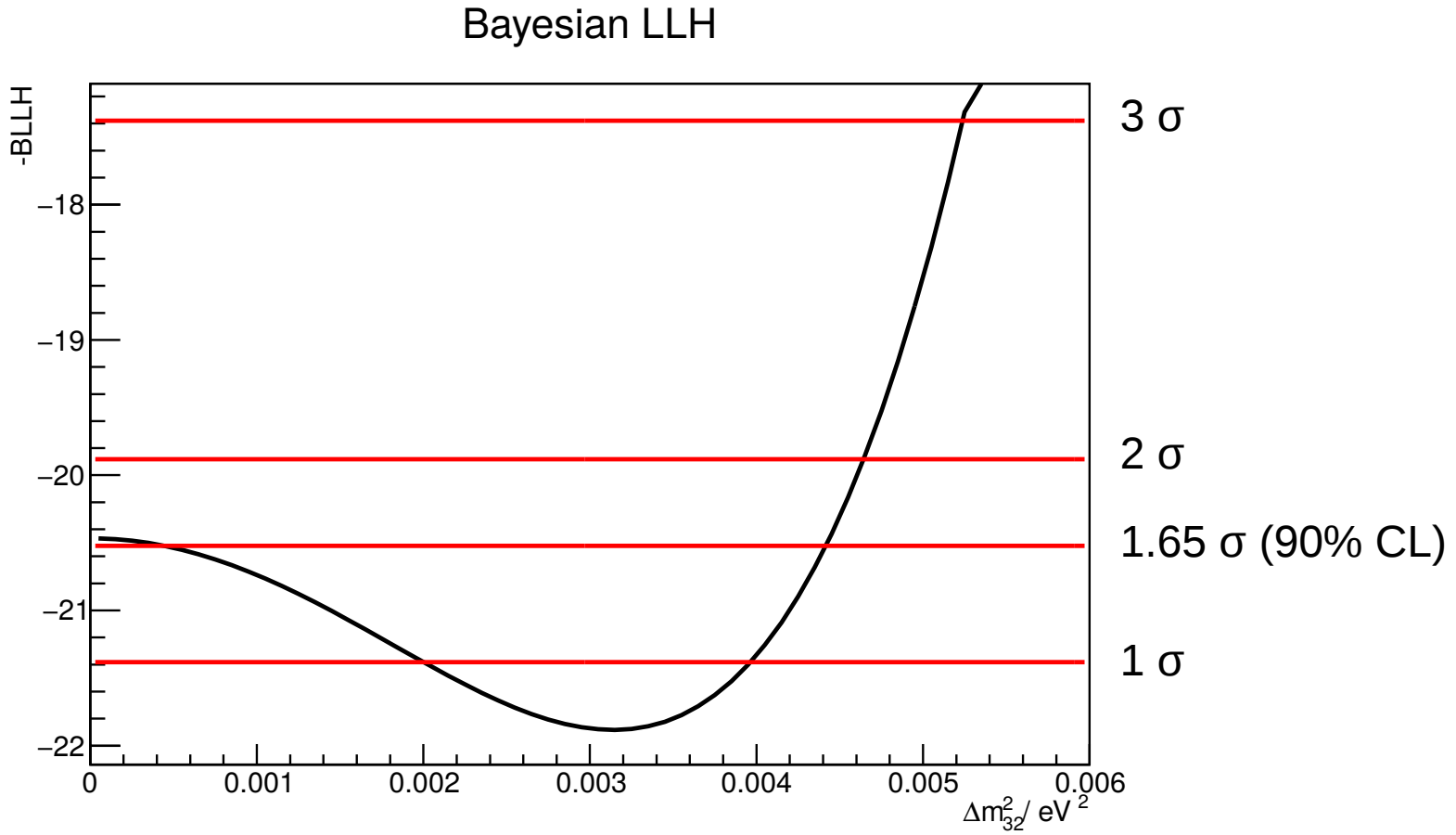
Sensitivity evaluation



Sensitivity evaluation

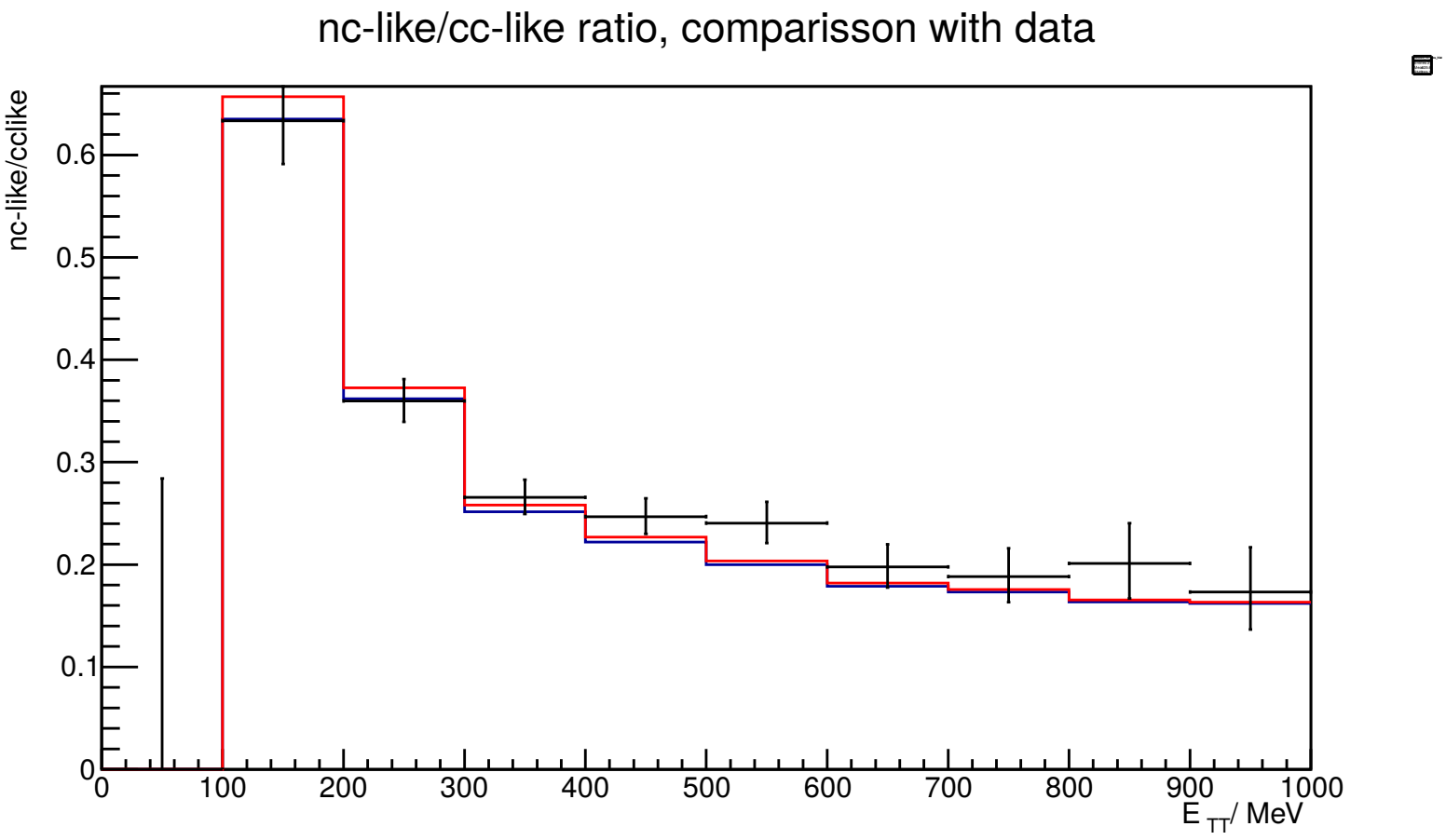


Bayesian LLH fit (no beam systematics)



best_fit=3.14126e-3 eV^2
1 σ CL = (2.00561, 3.96327)e-3 eV^2
90% CL = (0.453137, 4.41695)e-3 eV^2

Fit result, data space



Conclusions

- It seems that, in the end, OPERA can't exclude the null oscillation hypothesis using the ELEDET data by more than 1 sigma
- To conclude this analysis, I propose:
  - freeze this data sample
  - construct the upper limit and 1 σ CL

The end