Update on effective volumes and energy reconstruction

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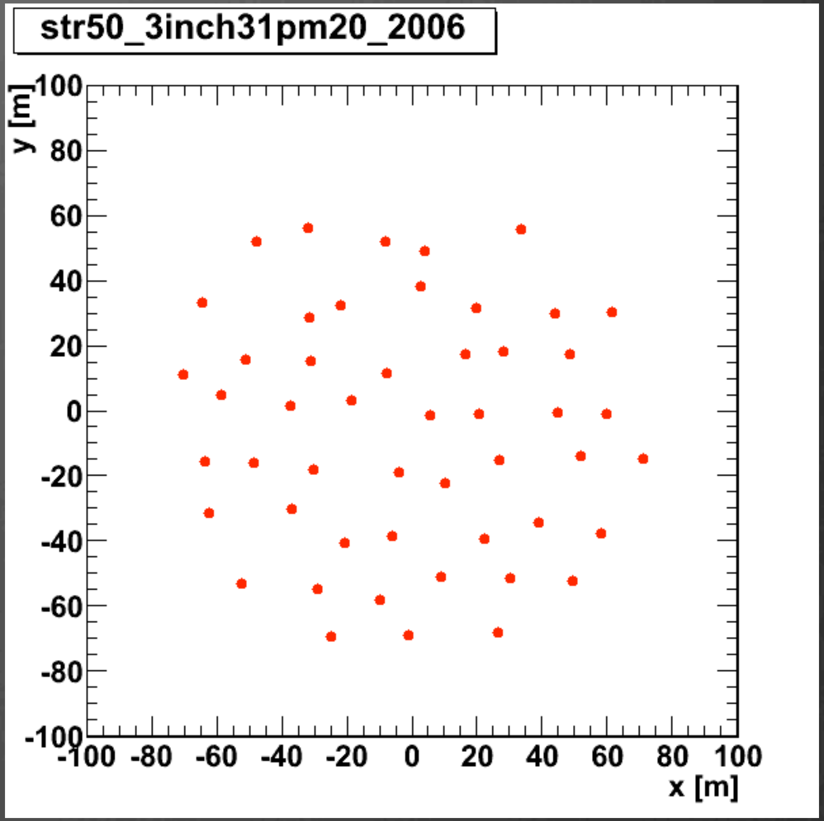
Detector layout

- ✓ 50 Strings
- ✓ OM=31 3”PMTs
- ✓ 20 OM in each string
- ✓ 6 m vertical distance between OM
- ✓ 20 m average distance between strings

Instrumented volume = 1.75 Mt



Simulation chain

GENDET
geometry

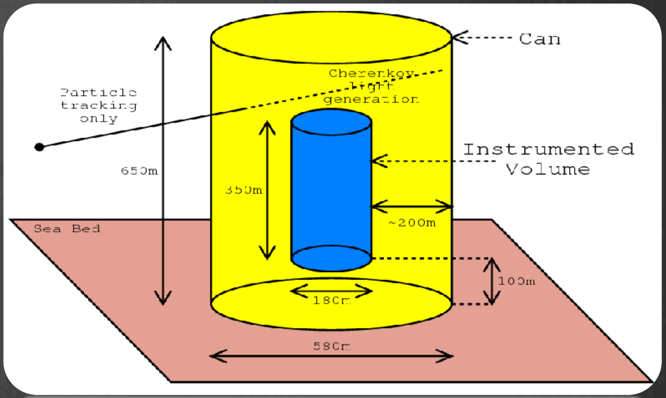
Genhen (v6r10 seawiet)
Neutrino generator

KM3 (v4r4)
Light & hits

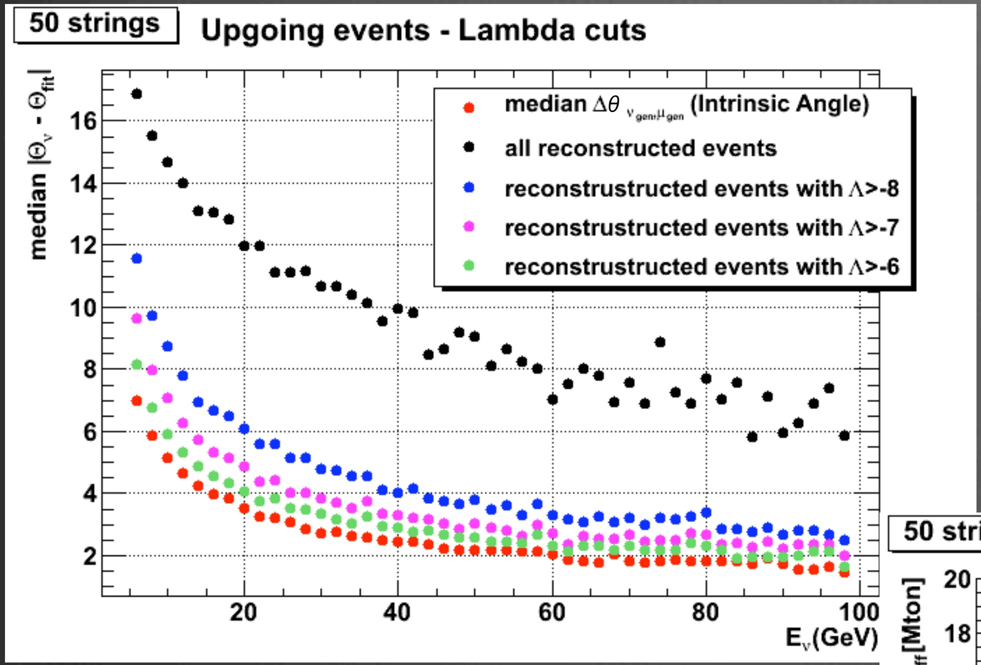
GEASIM
(v4r13seawiet)
Light & hits

MODK40
(v4r13seawiet)
^{40}K Background hits

RECO
Reconstruction code
(see my talk in the software session)

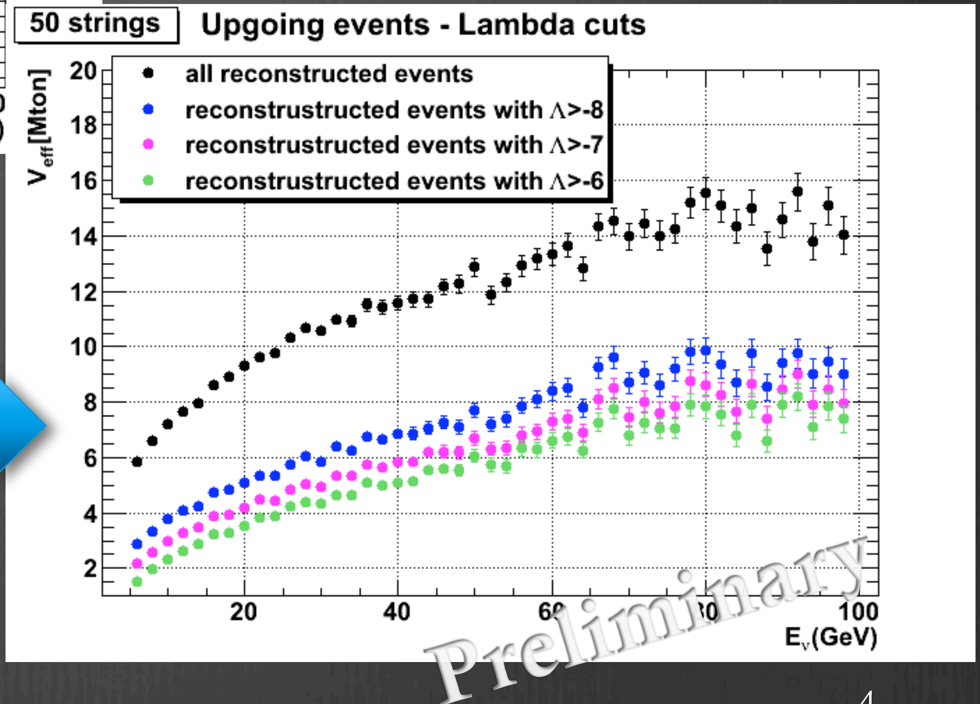


Effective volumes and angular error

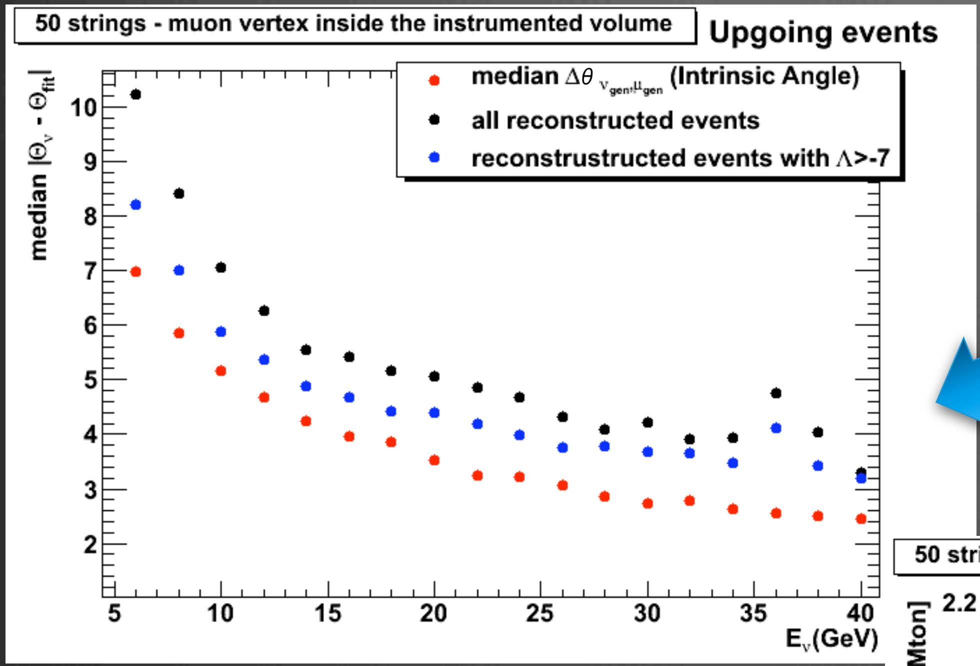


With more stringent cuts both the angular error and the effective volumes are reduced

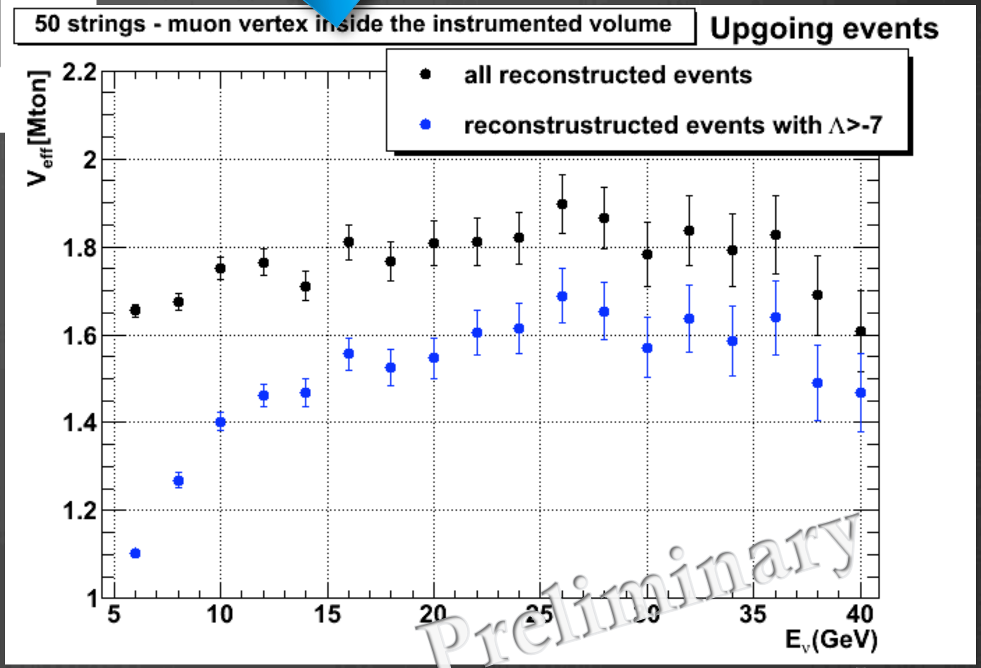
Only events generated inside the can volume (≈100 Mton)



Effective volumes and angular error

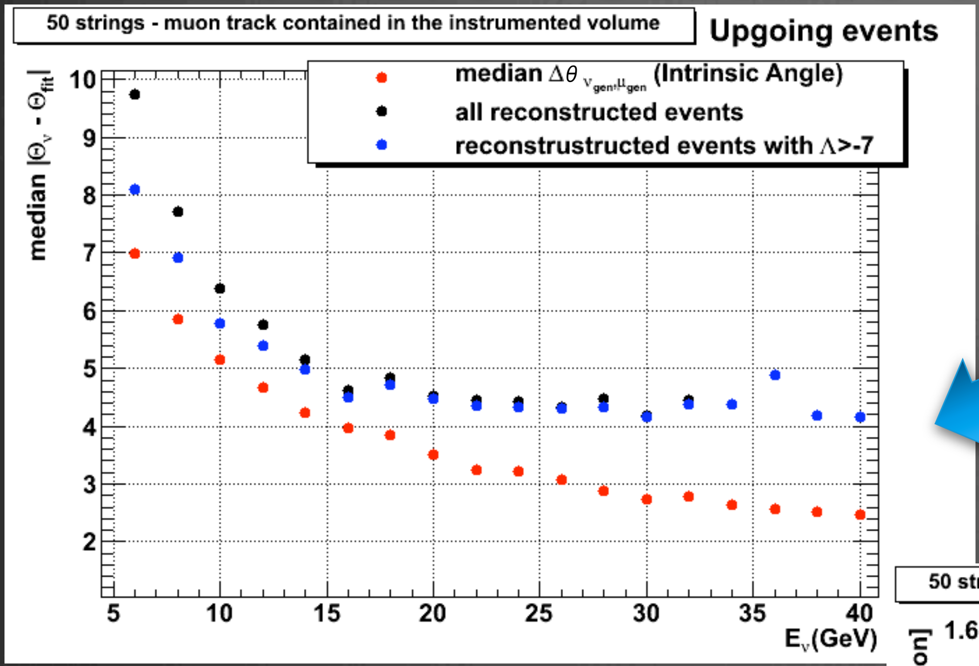


Only events with the muon vertex inside the instrumented volume

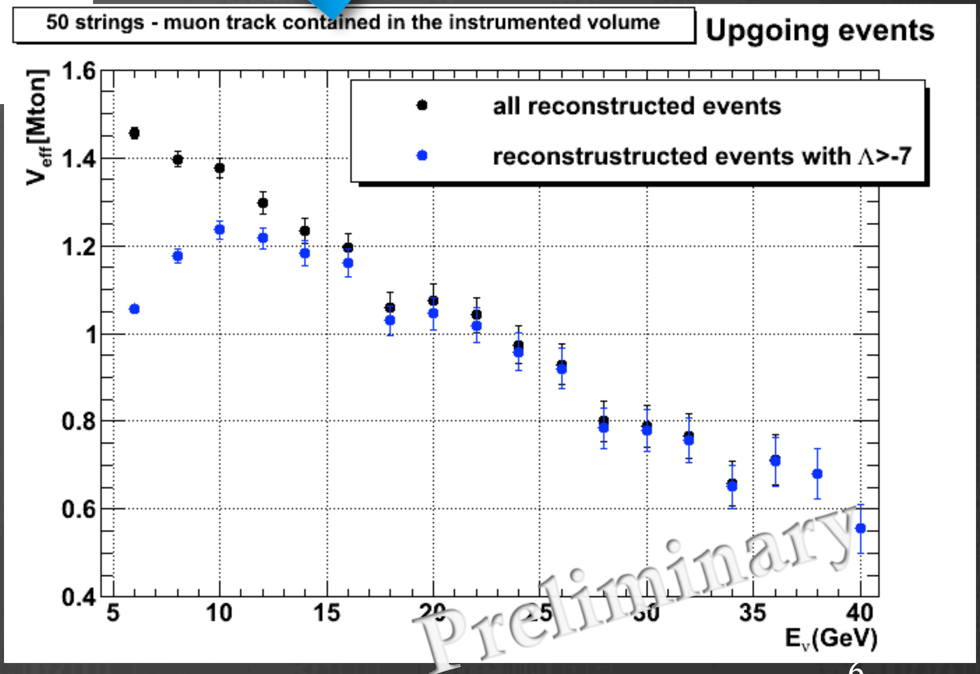


Public plots?

Effective volumes and angular error



Only events with the muon track full contained in the instrumented volume



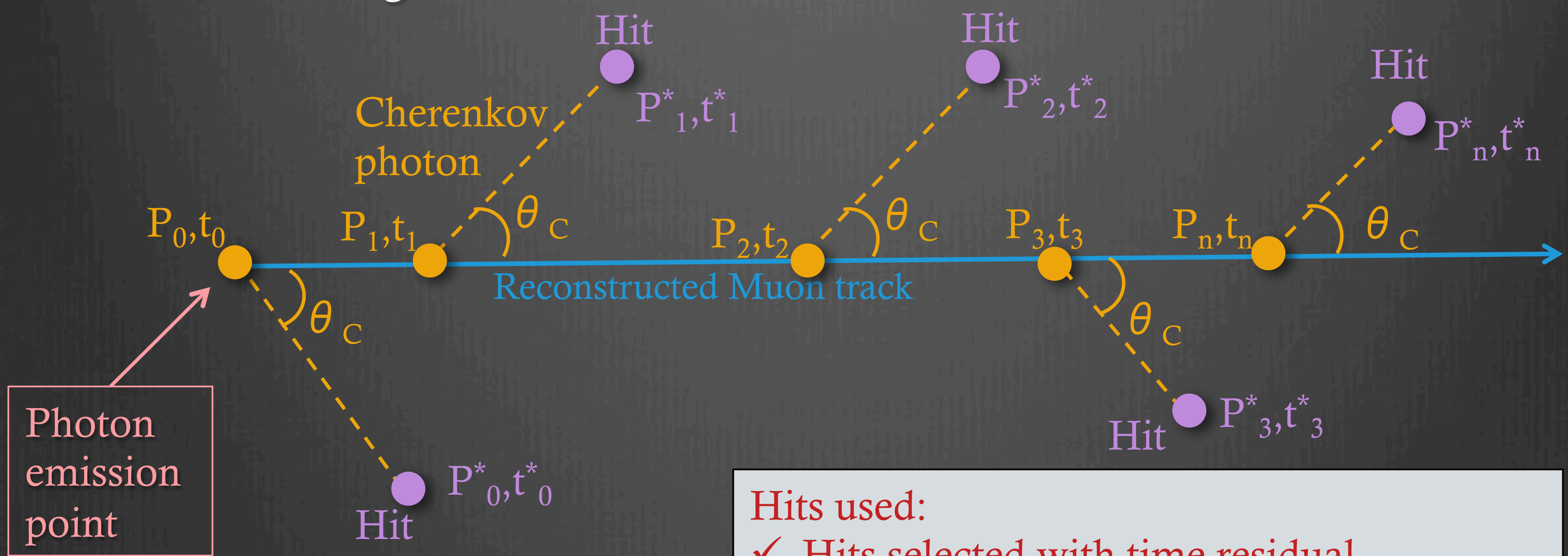
Probably this condition is too stringent: considering the high absorption length of light in water, an energy estimate will be possible even if the track goes outside the detector

Muon Track length estimate

- Results presented in Catania too optimistic: I used unwittingly info about the vertex from the MC truth!
- New procedure described in the following slides:
  - ✓ First estimate of the muon track length based on the hits projection on the track ➔ track length overestimated because of hits from hadronic shower
  - ✓ Study of the hadronic shower
  - ✓ Attempt to calculate the vertex from hadronic shower

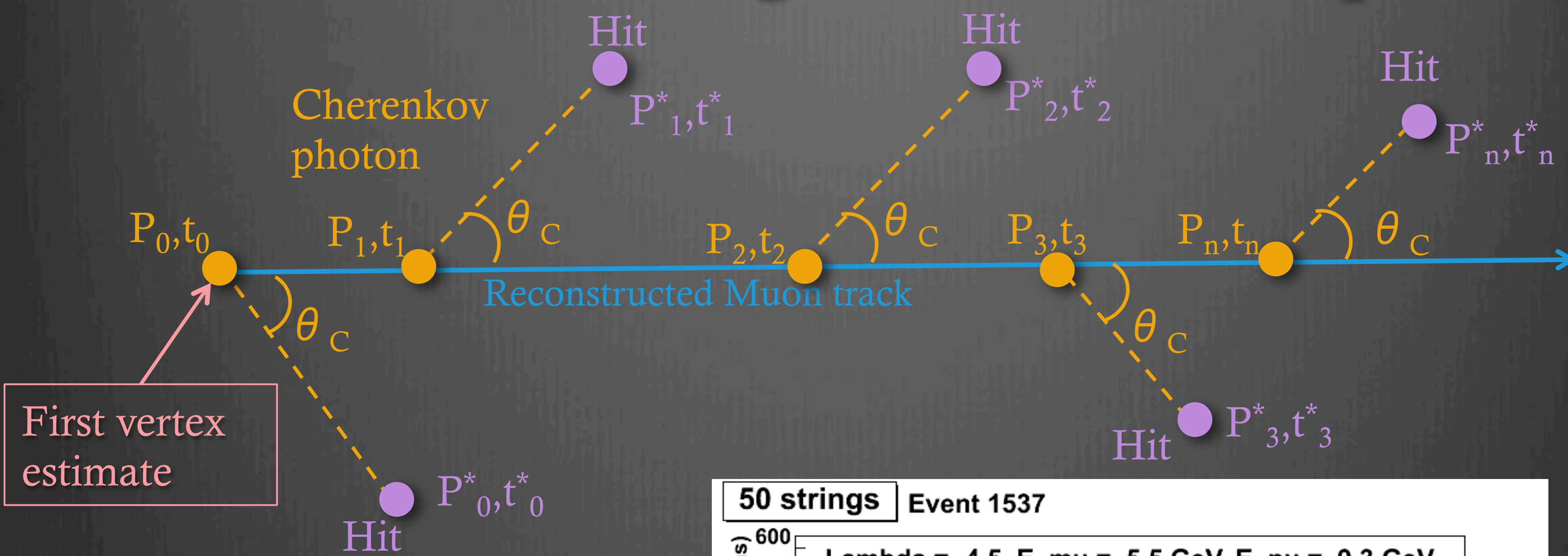
Muon Track length estimate – part I

- From the position P^*_i and the time t^*_i of each hit, the photon emission point P_i and the emission time t_i can be calculated
- The distance between the first point P_0 and the last point P_n is an estimate of the muon track length

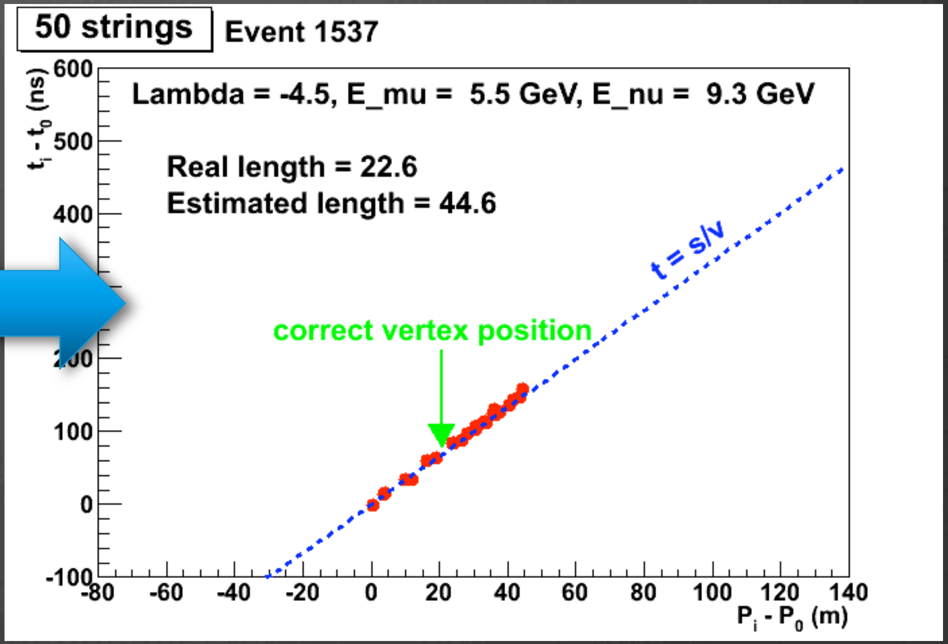


Hits used:
- ✓ Hits selected with time residual $-10ns < \Delta t_{res} < 10ns$
- ✓ High density of points P_i along the track required (1Point/2meter)

Muon Track length estimate – part I



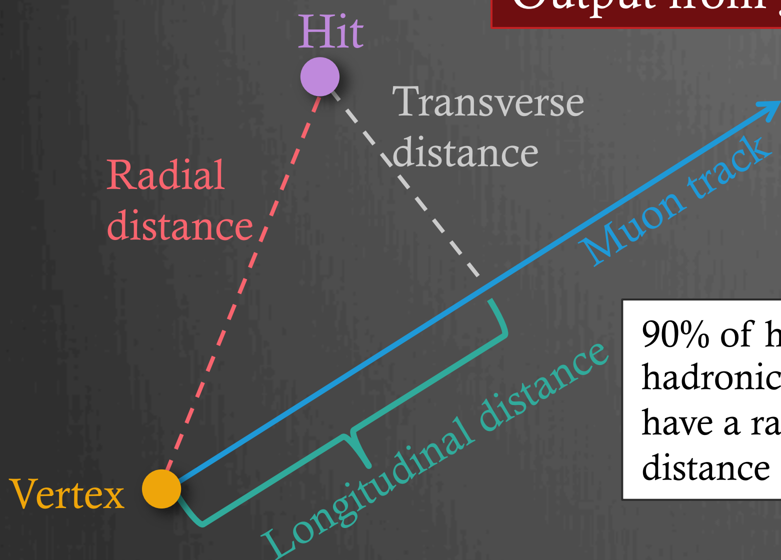
Track length often overestimated because of hits from hadronic shower



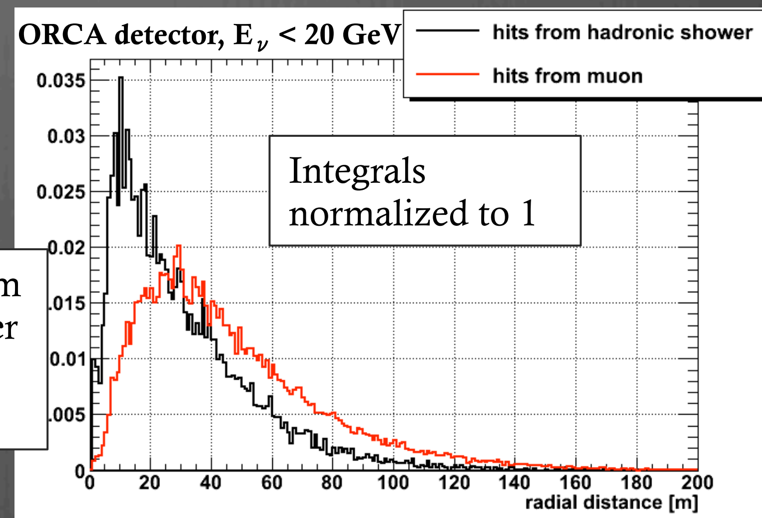
A different vertex estimate in needed

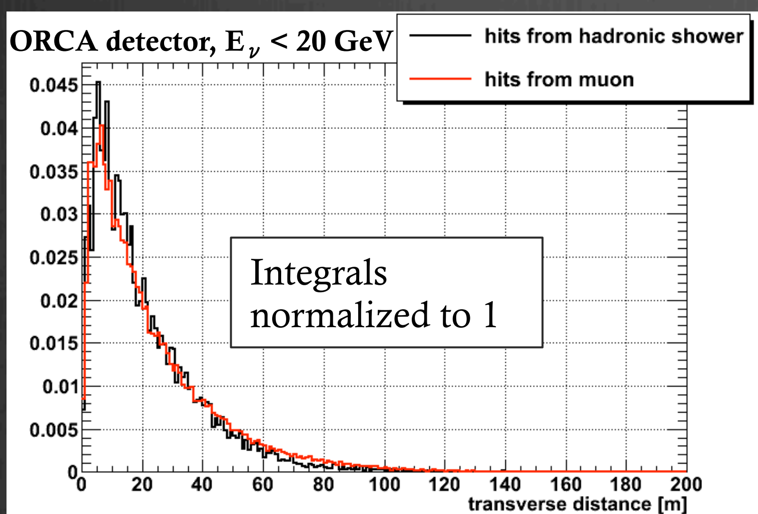
Hadronic shower analysis

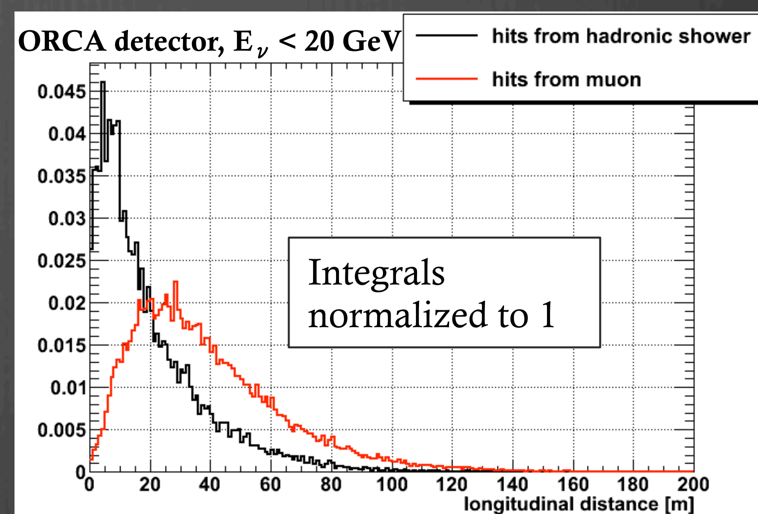
Output from geasim ➔ no ^{40}K background



90% of hits from hadronic shower have a radial distance <60m







Preliminary

Hadronic shower analysis

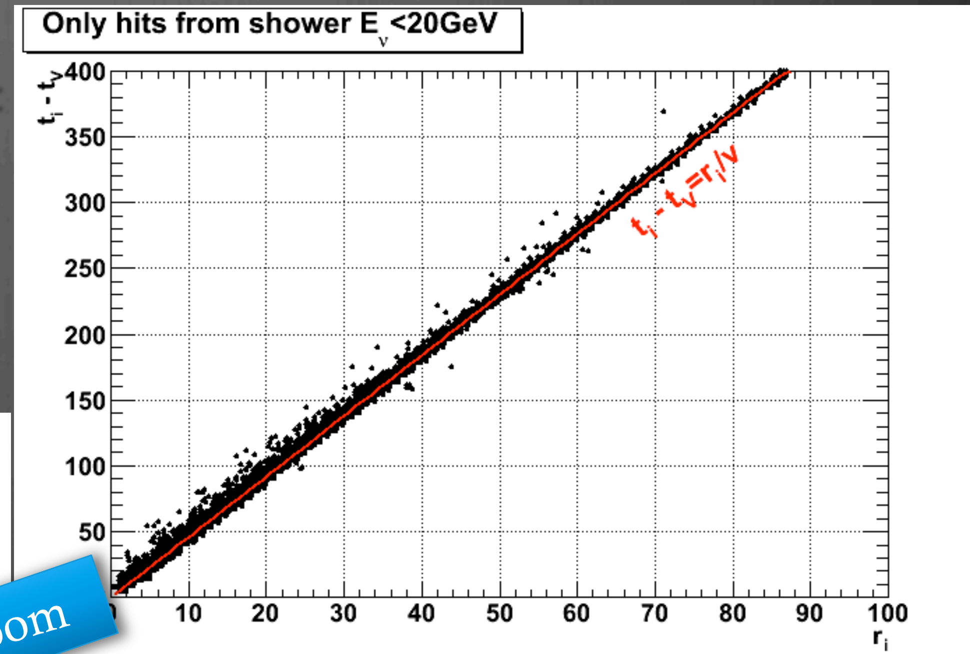
Output from geasim ➔ no ^{40}K background

Assuming the evolution of the shower as a spherical wave, each hit time should be:

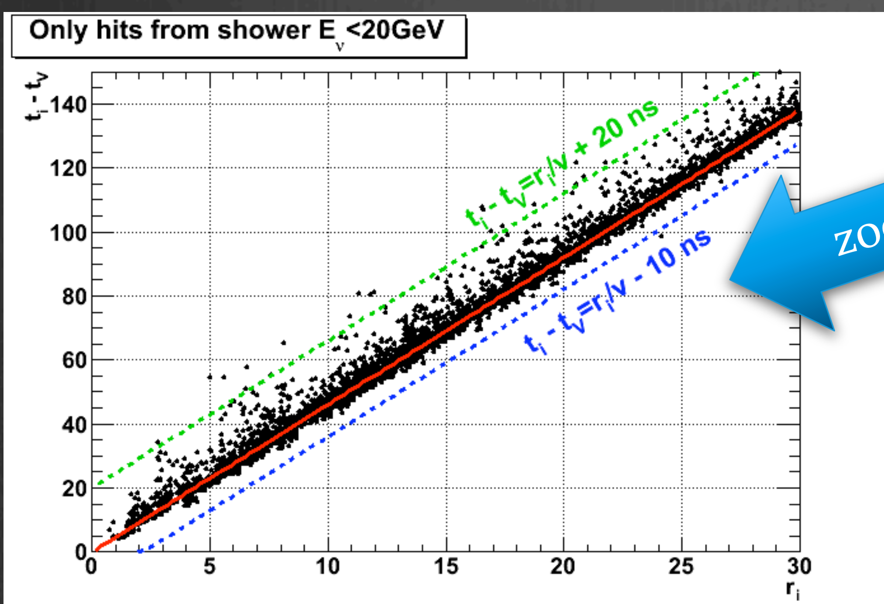
$t_i = t_{vertex} + r_i/v$

Radial distance hit-vertex

light speed in water



zoom



Defining a "time residual" as

Δt = recorded – expected time

$= t_i - (t_V + r_i/v)$,

99% of hits from shower have

$-10\text{ns} < \Delta t < 20\text{ns}$

Preliminary

Hadronic shower vertex

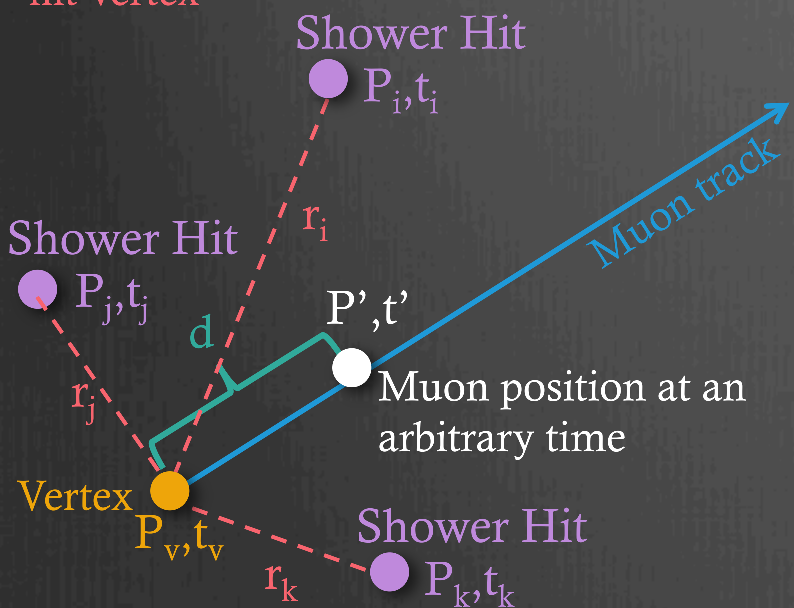
Assuming the evolution of the shower as a spherical wave, each hit time should be:

$t_i = t_{vertex} + r_i/v$

Radial distance hit-vertex

light speed in water

From this equation an estimate of the vertex position can be calculated expressing r_i and t_{vertex} as a function of the distance along the track between the vertex and the position P' of the muon at an arbitrary time t'



If vx, vy, vz are the director cosines of the muon track and P'=(x',y',z')

$x_v = x' - d*vx$

$y_v = y' - d*vy$

$z_v = z' - d*vz$

$t_v = t' - d/c$

d can be calculated analytically for each hit solving a quadratic equation: 2 solution

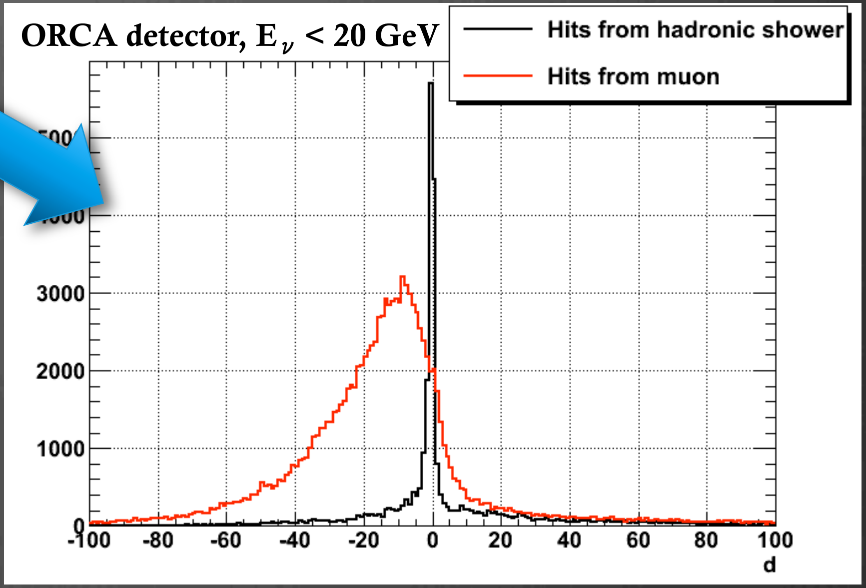
Preliminary

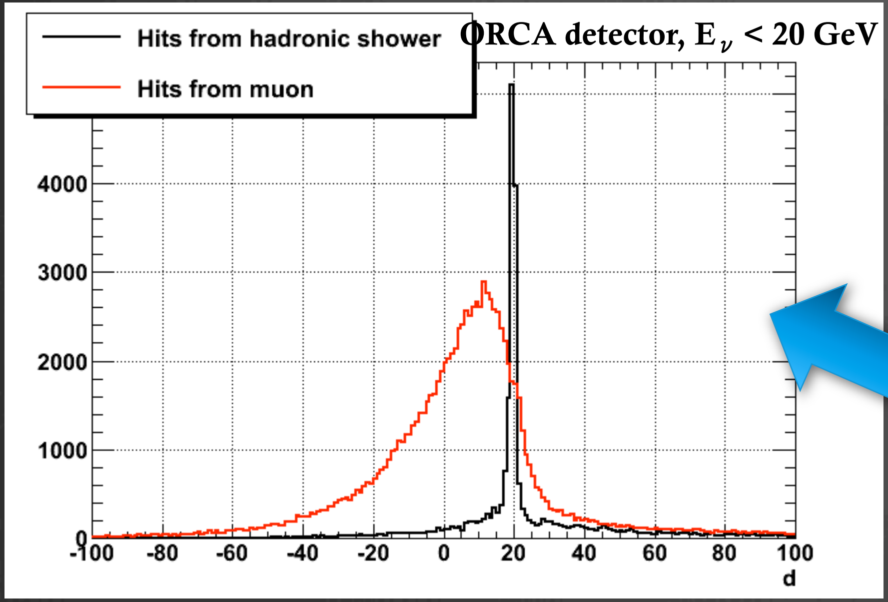
Hadronic shower vertex

Output from geasim ➔ no ^{40}K background

To test the calculation of d described before, I used as reference the real muon track

Test I: P'= real vertex ➔ d should be = 0





Test II: P'= real vertex moved of 20 m along the muon track ➔ d should be = 20

Preliminary

Vertex + track length estimate

- Same procedure applied to the reconstructed track with all hits
- Find a peak in the d distribution is complicated because you have a sum of hits from shower + hits from muon + hits from ^{40}K
- When the peak is not clear I try to clean my hit list using what I learnt about the radial and temporal distribution from the MC truth
- Vertex estimate is possible with this method only for 30% of events that have the muon track contained in the instrumented volume and that permit a first estimation of the muon track length with the projected hits ($5GeV<E_{\nu}<20GeV$)
- If this method fails, I use the first vertex estimate described before from the first photon emission point
- The track length is estimated as the distance between the estimated vertex and the last photon emission point accepted

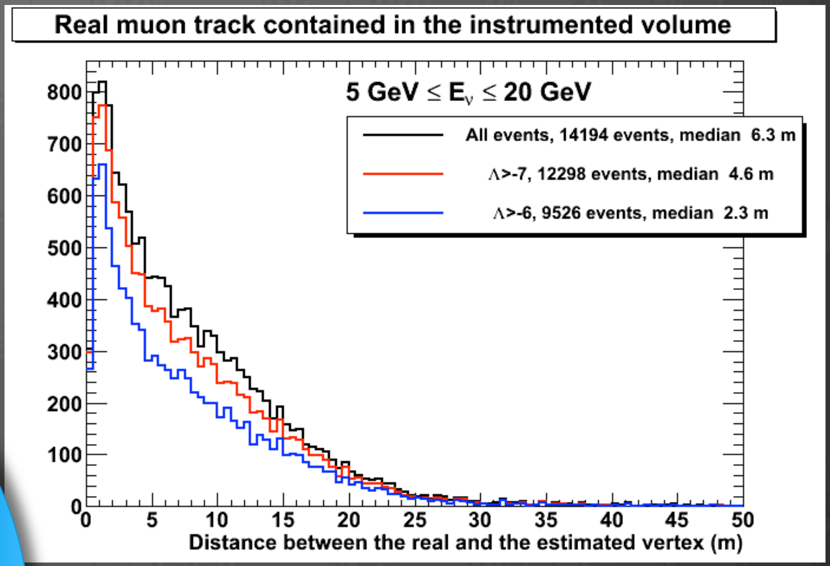
Preliminary

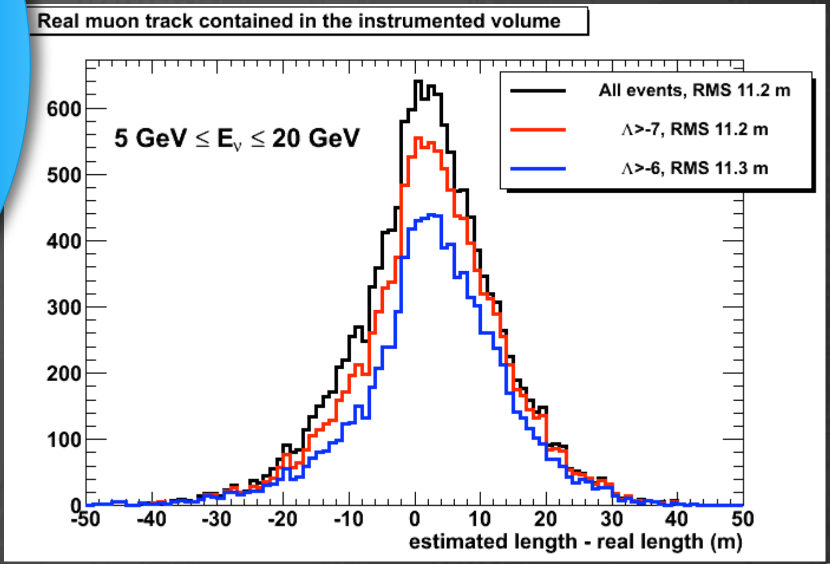
Results: vertex + track length estimate

Events generated with 5GeV<E_ν<20GeV and the real muon track fully contained in the instrumented volume:

- N_{gen} =16380 events generated with at least 5 signal hits
- N_{rec} = 15397 reconstructed events
- 14149 events permit the track length estimate (L>0)
- 12298 events permit the track length estimate and have Λ>-7
- 9526 events permit the track length estimate and have Λ>-6

	% w.r.t. Nrec
L>0	92%
L>0 && Λ>-7	80%
L>0 && Λ>-6	62%



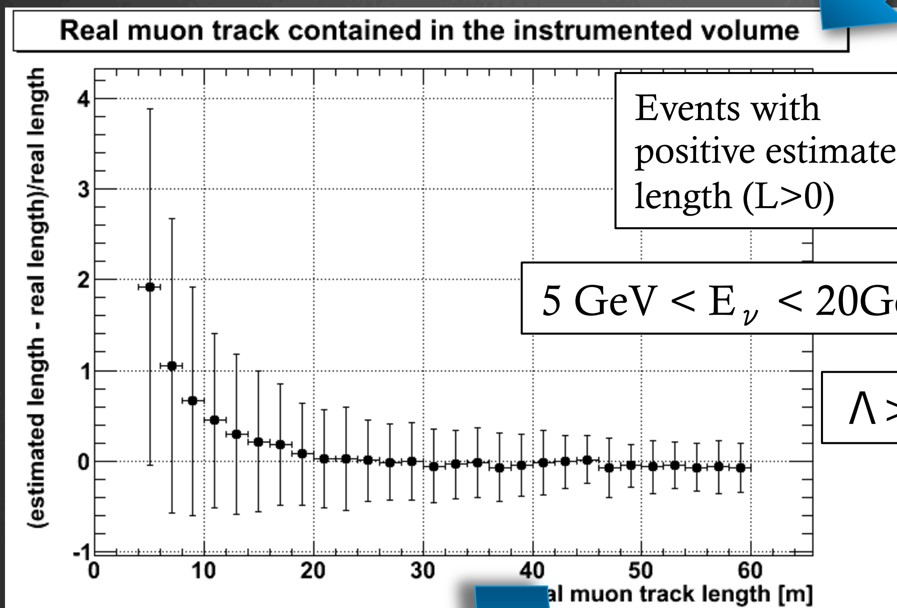


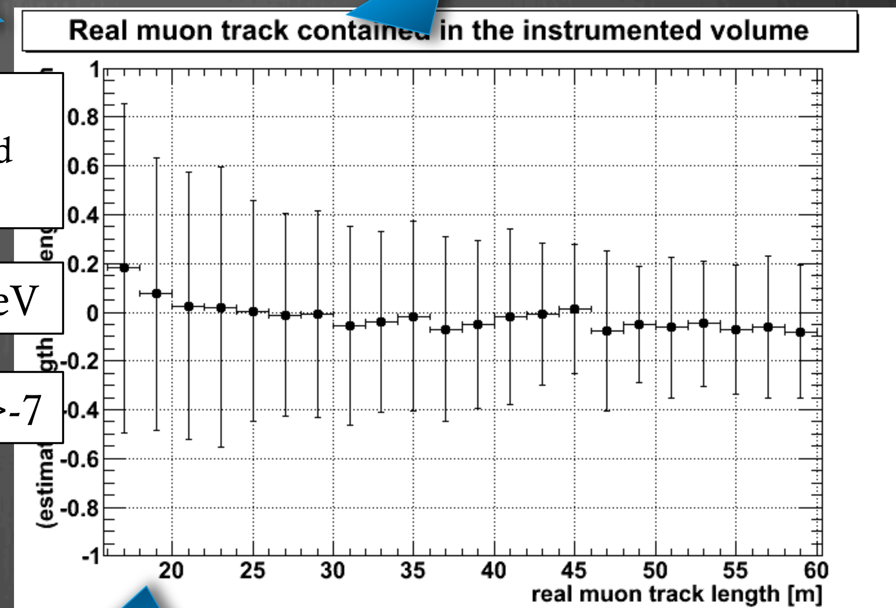
Preliminary

Muon Track length estimate

Only events with E_ν<20GeV and the muon track fully contained in the instrumented volume (1.75 Mton)

- Horizontal errors: only to highlight each bin range
- Vertical errors: standard deviation from the mean value



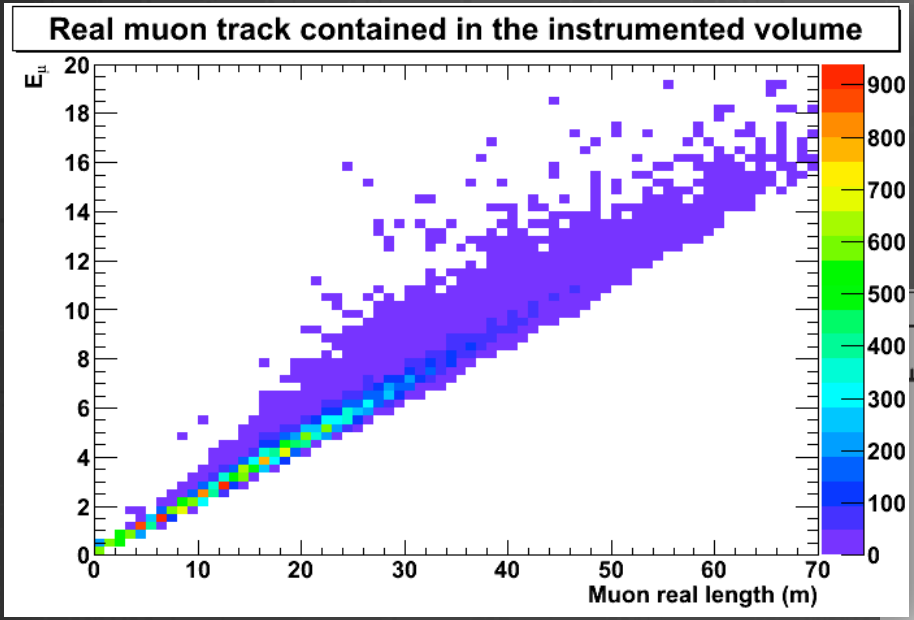


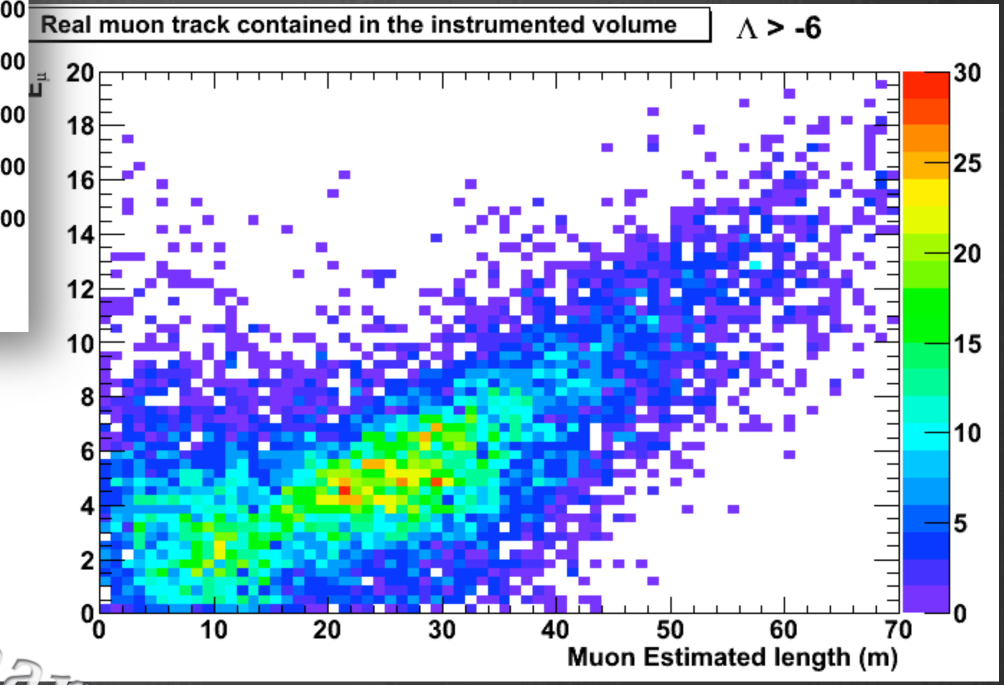
zoom

Preliminary

Muon Track length estimate

Only events with E_ν<20GeV and the muon track fully contained in the instrumented volume (1.75 Mton)



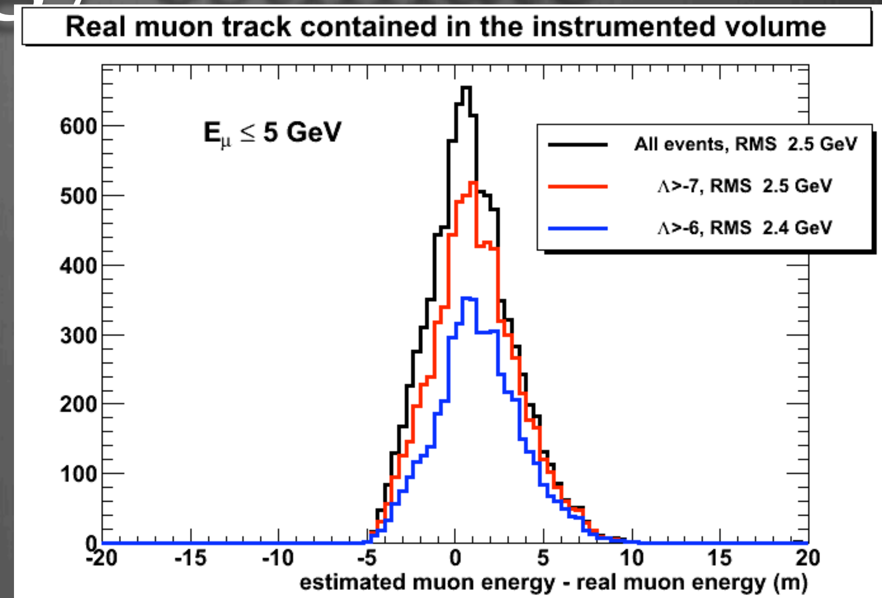


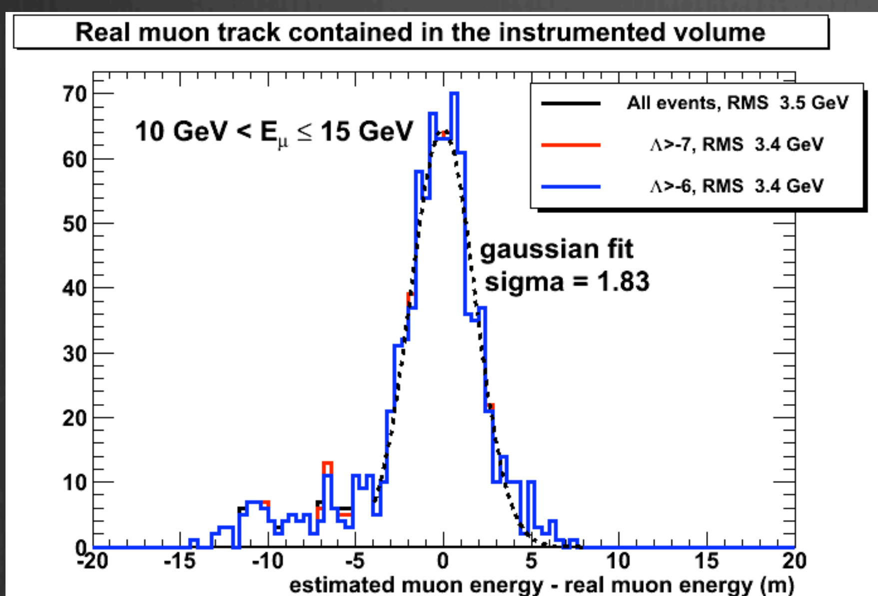
Preliminary

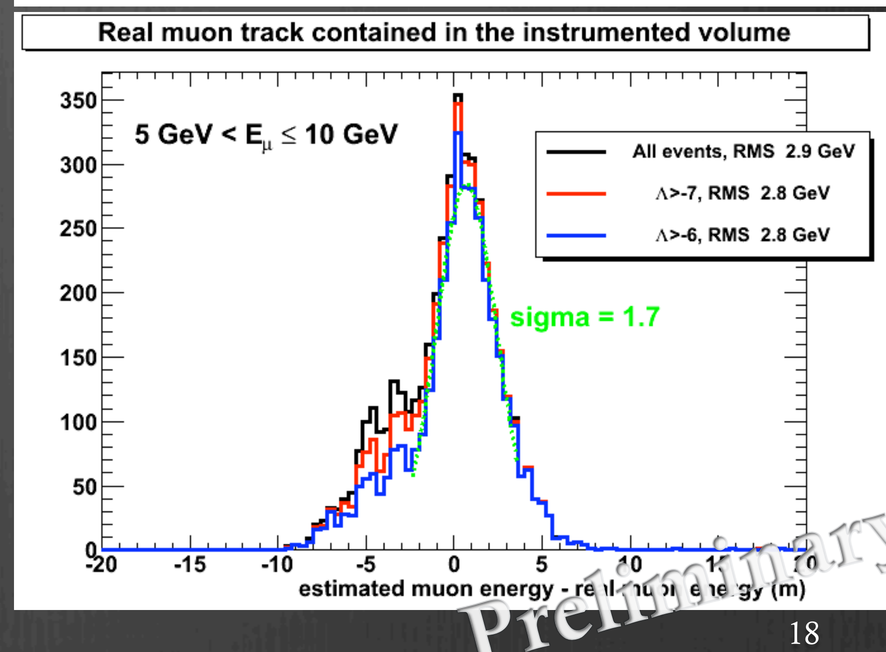
Muon energy estimate

Only events with E_ν<20GeV and the muon track fully contained in the instrumented volume (1.75 Mton)

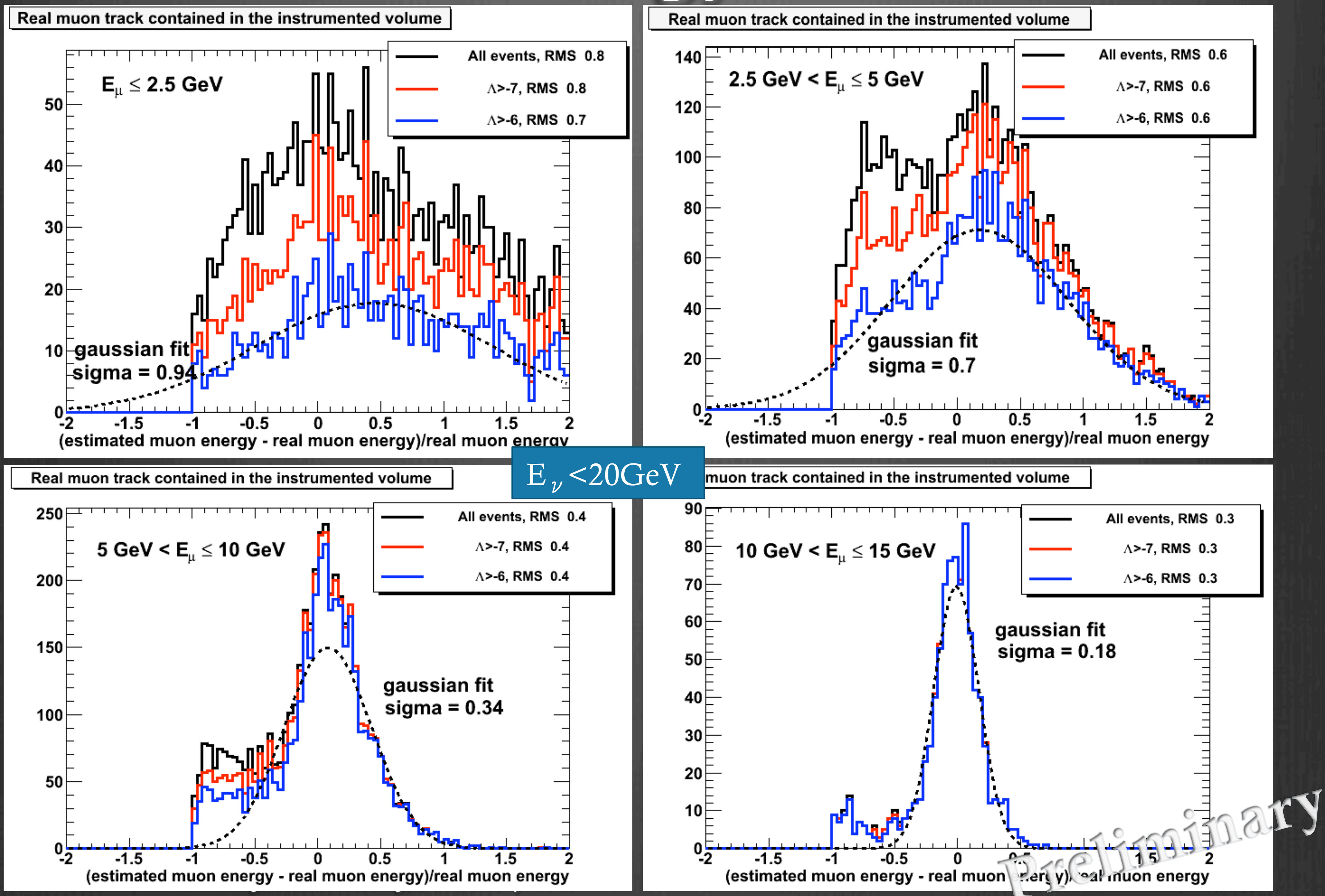
Muon energy calculated from the track length







Muon energy estimate

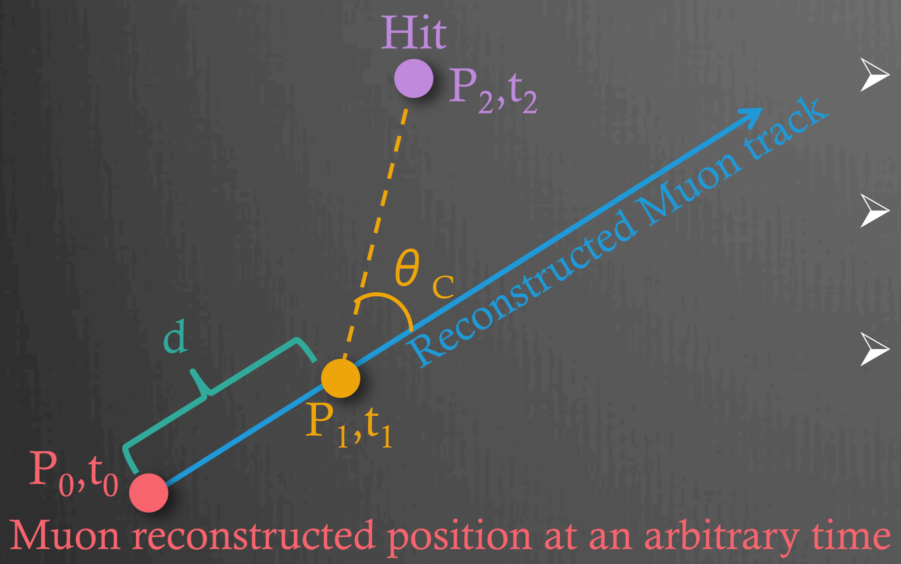


Outlook

- Improvement on the interaction vertex estimate using a minimization instead of the analytical solution
- Try to estimate the shower energy
- Containment conditions and veto
- Simulations with genie

Backup slides

Old Muon Energy Reconstruction

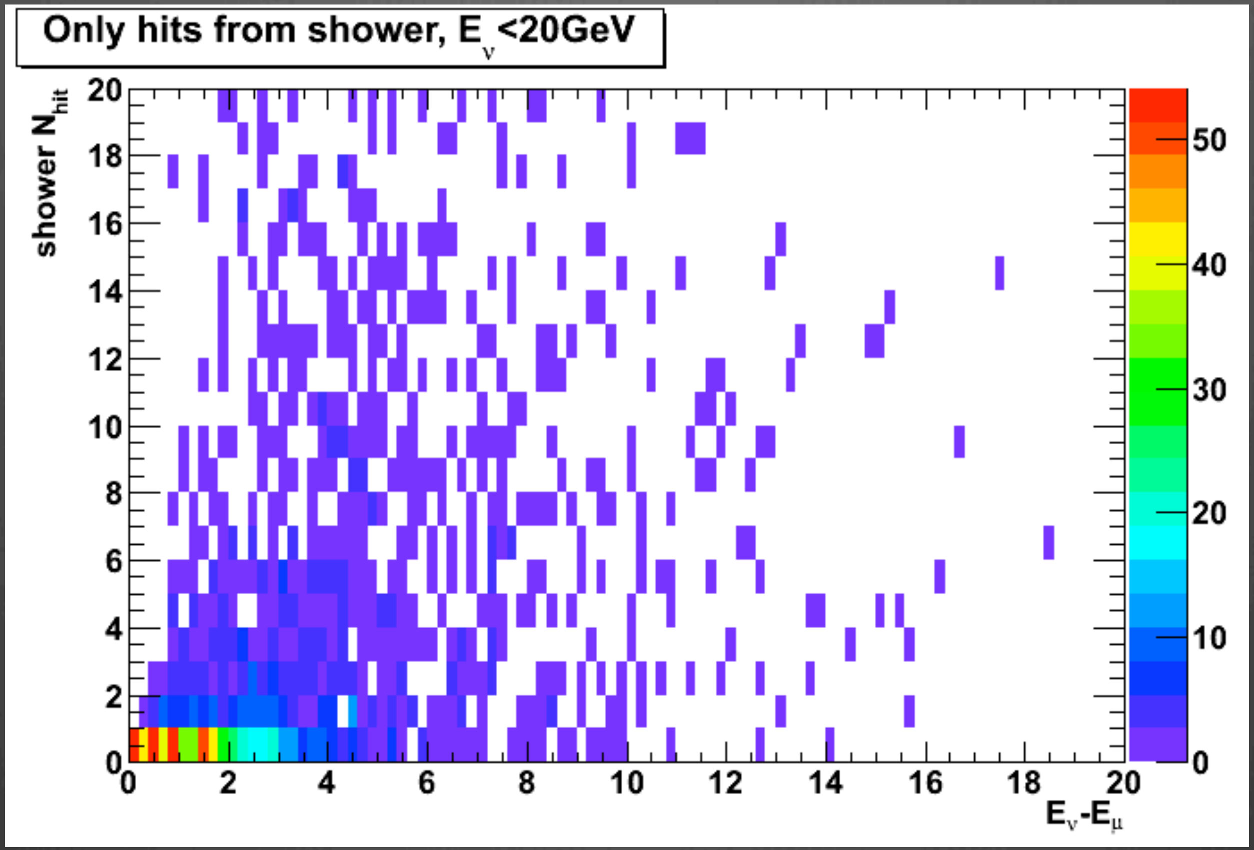


- For each hit, P_1 and t_1 can be calculated from P_2 and t_2
- The relation between d and t = (t_1-t_0) should be d/t = muon speed = c
- Maximum value of $d=P_1-P_0$ can be used to estimate the muon track length

ATTENTION: In my first calculation I've used P_0 as an estimate of the vertex position but it's not correct!
The track reconstruction gives the position P_0 at an arbitrary time $t_0=0$ and in the simulation t=0 is the interaction time so P_0 is a good estimate of the vertex position only in the simulation!

The vertex position can be estimated from the first P_1 or from the distribution of the hits in the hadronic shower.

Preliminary


Only hits from shower, E<20GeV
shower N
20
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
18
20
E-E
50
40
30
20
10
0