Neutrino energy reconstruction (continue)

Anatoli Butkevich (INR, Moscow)

Talk at the T2K 2km meeting, March 9, 2006

Outline

- Motivations
- Analysis and Results
- Conclusions

Motivations

Mean value of neutrino energy $\langle\varepsilon_\nu\rangle$ and its variance $\sigma(\varepsilon_\nu)$, can be estimated using a momentum distribution of nucleons $S(\mathbf{p}_m)$ in nucleus as follow

$$\langle\varepsilon_\nu\rangle = \int \varepsilon_\nu(\mathbf{p}_m) S(\mathbf{p}_m) d\mathbf{p}_m,$$

$$\langle\varepsilon_\nu^2\rangle = \int \varepsilon_\nu^2(\mathbf{p}_m) S(\mathbf{p}_m) d\mathbf{p}_m,$$

$$\sigma^2(\varepsilon_\nu) = \langle\varepsilon_\nu^2\rangle - \langle\varepsilon_\nu\rangle^2.$$

In framework of the Fermi gas model the nucleon momentum distribution can be written as

$$S(\mathbf{p}_m) = \frac{3}{4\pi p_F^3}, \quad \text{and} \quad \int S(\mathbf{p}_m) d\mathbf{p}_m = 1,$$

where p_F is the Fermi momentum.

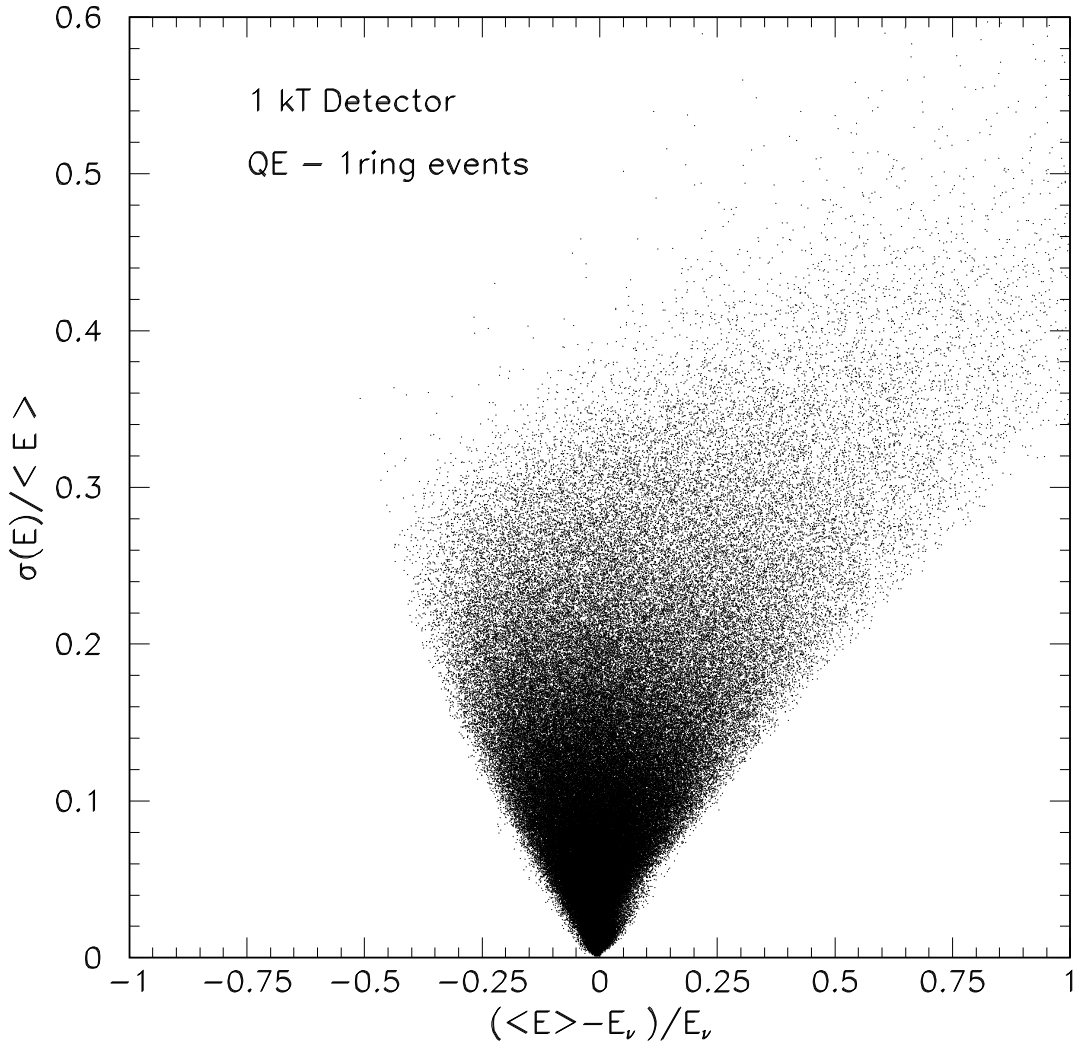
' Averaged energy' method

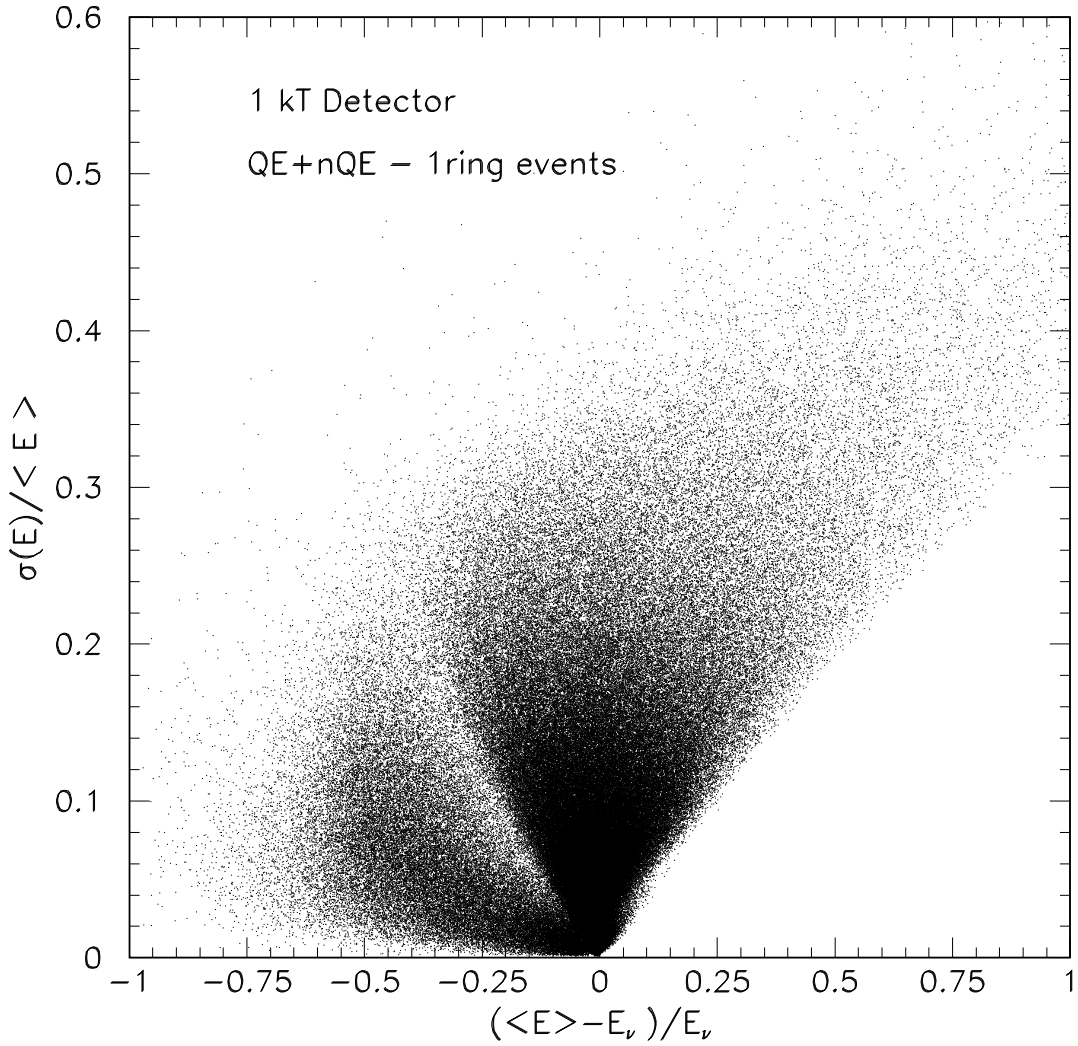
For each event the mean value of neutrino energy $\langle\varepsilon_\nu\rangle$, its variance $\sigma(\varepsilon_\nu)$, and parameter $R = \sigma(\varepsilon_\nu)/\langle\varepsilon_\nu\rangle$ are estimated.

Simulated and reconstracted (1-ring) neutrino events in 1 kT detector were used.

Statistics: QE 1-ring events - 183249; QE+nQE 1-ring events - 236205

Scattered plots R as a function of $(\langle\varepsilon_\nu\rangle - \varepsilon_\nu)/\varepsilon_\nu$ are shown.


1 kT Detector
QE − 1ring events
σ(E)/< E >
(<E>−E$_\nu$)/E$_\nu$
0.6
0.5
0.4
0.3
0.2
0.1
0
−1
−0.75
−0.5
−0.25
0
0.25
0.5
0.75
1


1 kT Detector
QE+nQE − 1ring events
σ(E)/< E >
(<E>−E$_\nu$)/E$_\nu$
0.6
0.5
0.4
0.3
0.2
0.1
0
−1
−0.75
−0.5
−0.25
0
0.25
0.5
0.75
1

Cuts

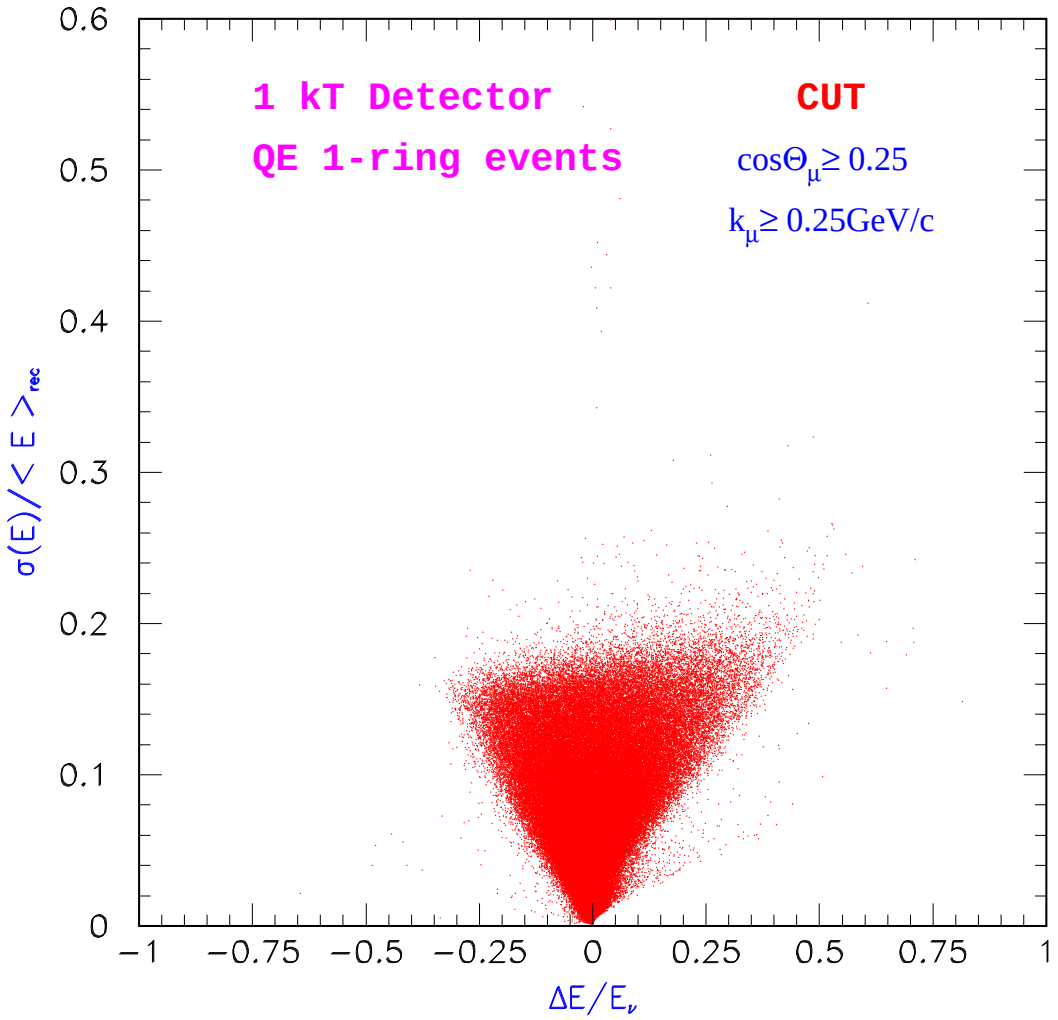
Old cut: $R \leq 0.2$
QE 1-ring events. Efficiency=$N_{cut}/N_{w.cut} = 0.825$
QE+nQE 1-ring events. Efficiency=0.856

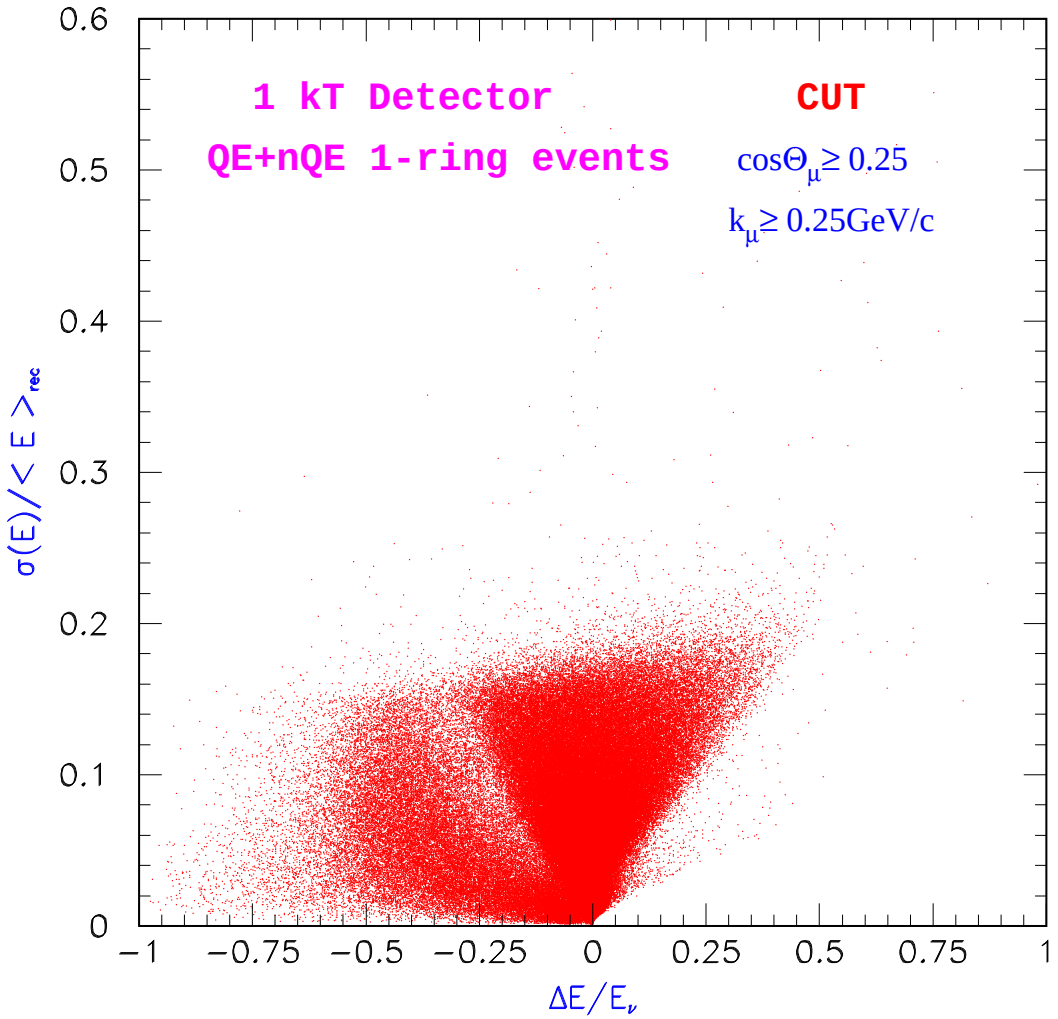
In the case of QE 1-ring events energy resolution was increased up to 8-12% in the energy range $E_\nu \leq 2$ GeV

New cuts

$$k_\mu \geq 0.25 GeV/c$$
$$\cos\theta \geq 0.25$$

QE 1-ring events. Efficiency=0.738
QE+nQE 1-ring events. Efficiency=0.766


1 kT Detector
QE 1-ring events
CUT
cosΘμ≥ 0.25
kμ≥ 0.25GeV/c
σ(E)/< E >rec
ΔE/Eν
0.6
0.5
0.4
0.3
0.2
0.1
0
−1
−0.75
−0.5
−0.25
0
0.25
0.5
0.75
1


1 kT Detector
QE+nQE 1-ring events
CUT
cosΘ$_\mu$≥ 0.25
k$_\mu$≥ 0.25GeV/c
σ(E)/< E >$_{rec}$
ΔE/E$_\nu$
0.6
0.5
0.4
0.3
0.2
0.1
0
−1
−0.75
−0.5
−0.25
0
0.25
0.5
0.75
1

Results

The well known formula

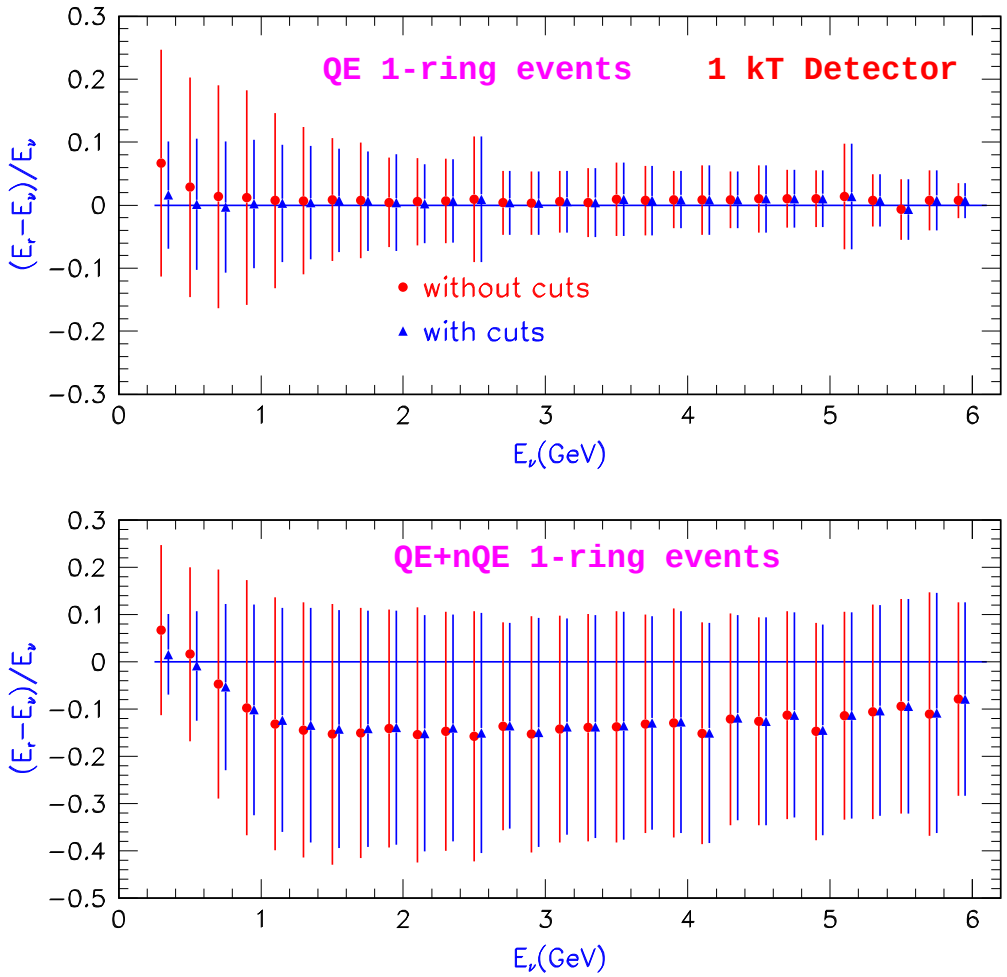
$$\varepsilon_\nu = \frac{(M-\epsilon_b)\varepsilon_\mu + (2M\epsilon_b - m_\mu^2 - \epsilon_b^2)/2}{(M-\epsilon_b) - \varepsilon_\mu + k_\mu \cos\theta}$$

and cuts

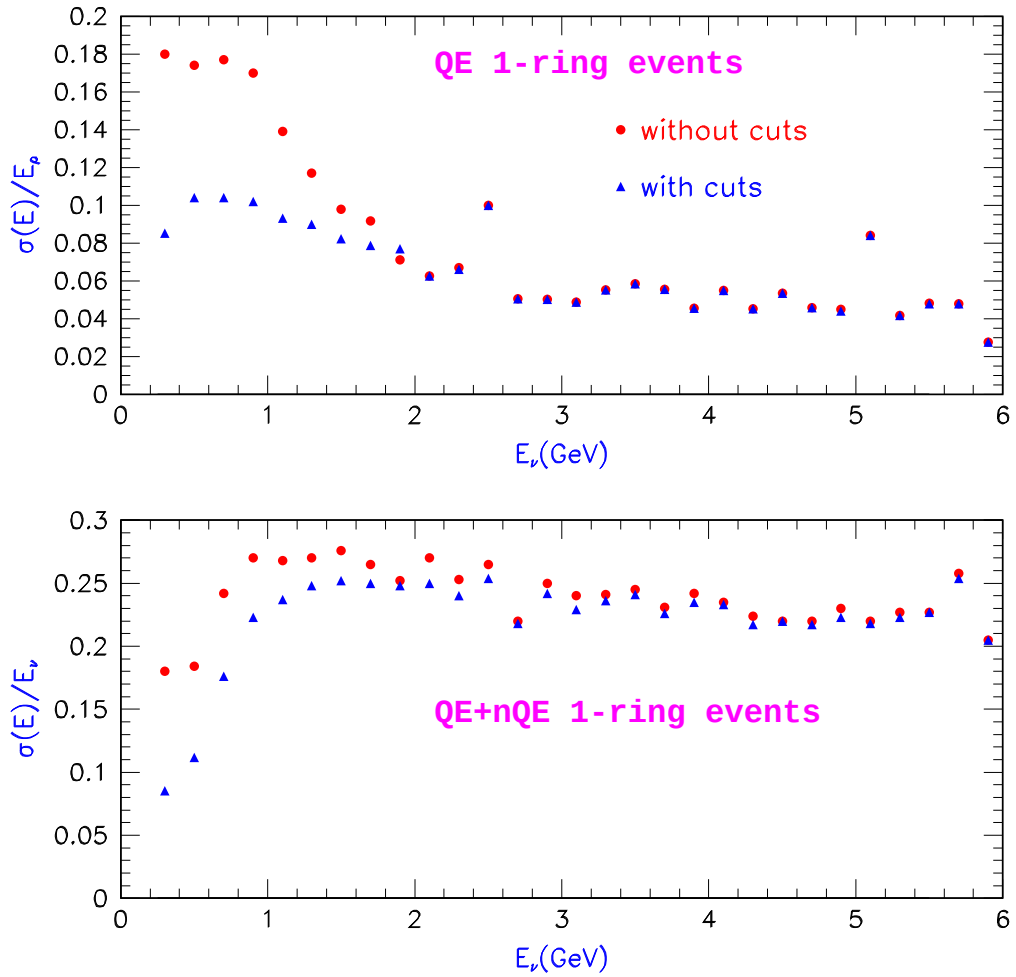
$$k_\mu \geq 0.25 GeV/c$$
$$\cos\theta \geq 0.25$$

- $(E_r - E_\nu)/E_\nu$ vs E_ν.
- $\sigma(E_\nu)/E_\nu$ vs E_ν.
- Efficiency=$N_{cut}/N_{w.cut}$

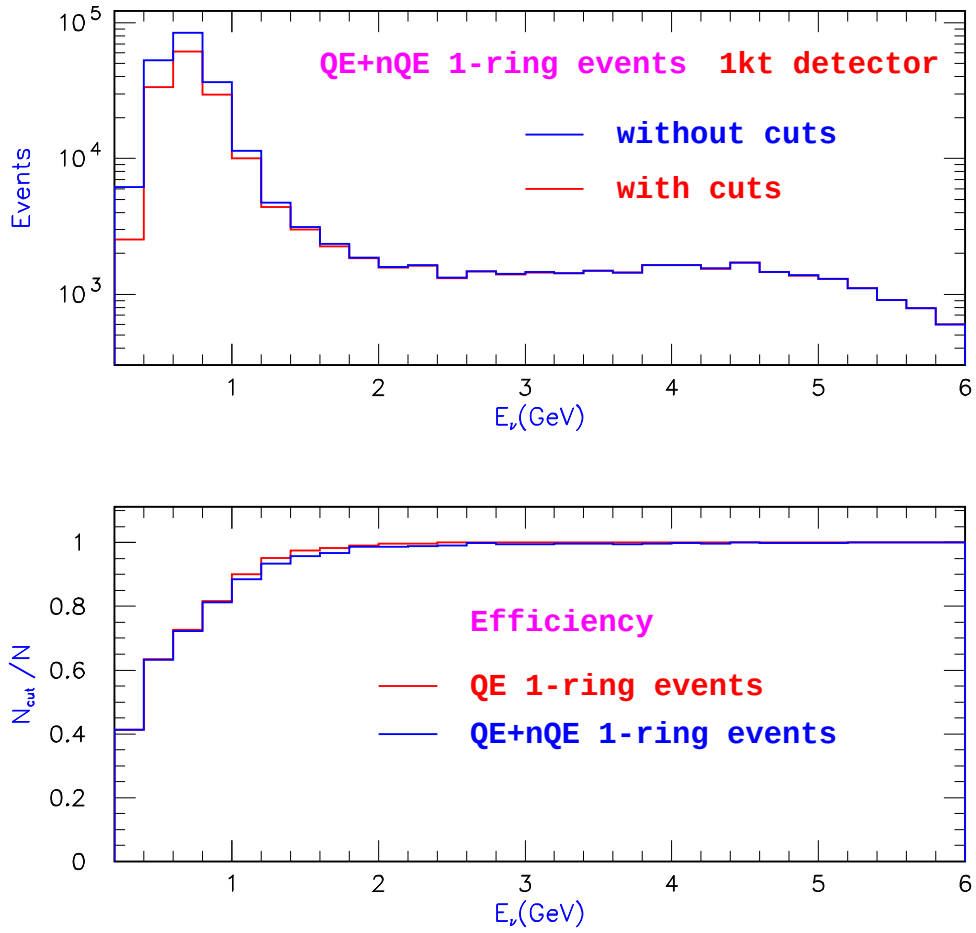
$(E_r - E_\nu)/E_\nu$ vs E_ν.



$\sigma(E_\nu)/E_\nu$ vs E_ν.



Efficiency=$N_{cut}/N_{w.cut}$



Summary

- The simple cuts which improve neutrino energy resolution were presented.
- Energy resolution of QE 1-ring events increases up to 8-10% in the energy range $E_\nu \leq 2$ GeV
- Energy resolution of QE+nQE 1-ring events increases up to 20% in the energy range $E_\nu \leq 1$ GeV