Optimization of Monitor Detector

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Outline

- Motivations
- Monitor Detector
- Monitor detector with Anti-counter
- Conclusions

Motivations

To study the left-right neutrino flux asymmetry in energy range above 1GeV monitor detectors at the 280m hall are need. As follows from Maxim's evaluations of the electron appearance BG events due to NC and CC ν_μ interactions the left-right flux asymmetry should be measured at least up to energy $\sim$ 1.6 GeV (CC ν_μ interactions).

Constraint

Due to space constraint in underground lab size of the monitor detector (MD) should be below 1.5 $\times$ 1.5 $\times$ 1.8 m and total weight of the MD not more than 10 tons

Estimations

In order to measure muon energy upto 1.6 GeV the total thickness of the MD must be ≈ 1000 g/cm^2. In this case muons produced in the upstream planes can stop in the detector.

Range of muons with energy 0.2 GeV in iron is ~ 110 g/cm^2 and follow such muons can hit 5 planes with thickness 2.5cm (iron) + 1cm (scintillator).

To increase a probability of high energy muon production and detection the thick steel planes should be at the beginning of the detector, and to detect low energy muons downstream planes should be thin.

Expected number of CC interaction/year/100t @ 2km in water is N(2km)=179056. Expected number of CC interaction in iron @ 280m can be estimated as N(280m)=$(2km/280m)^2 \times (N/A)_{iron}/(N/A)_{oxygen} \times N(2km)$, where N is a number of neutrons and A is atomic number. Then

N(280m)$\simeq$ 97872/year/ton @ 280m in iron.

Monitor Detector

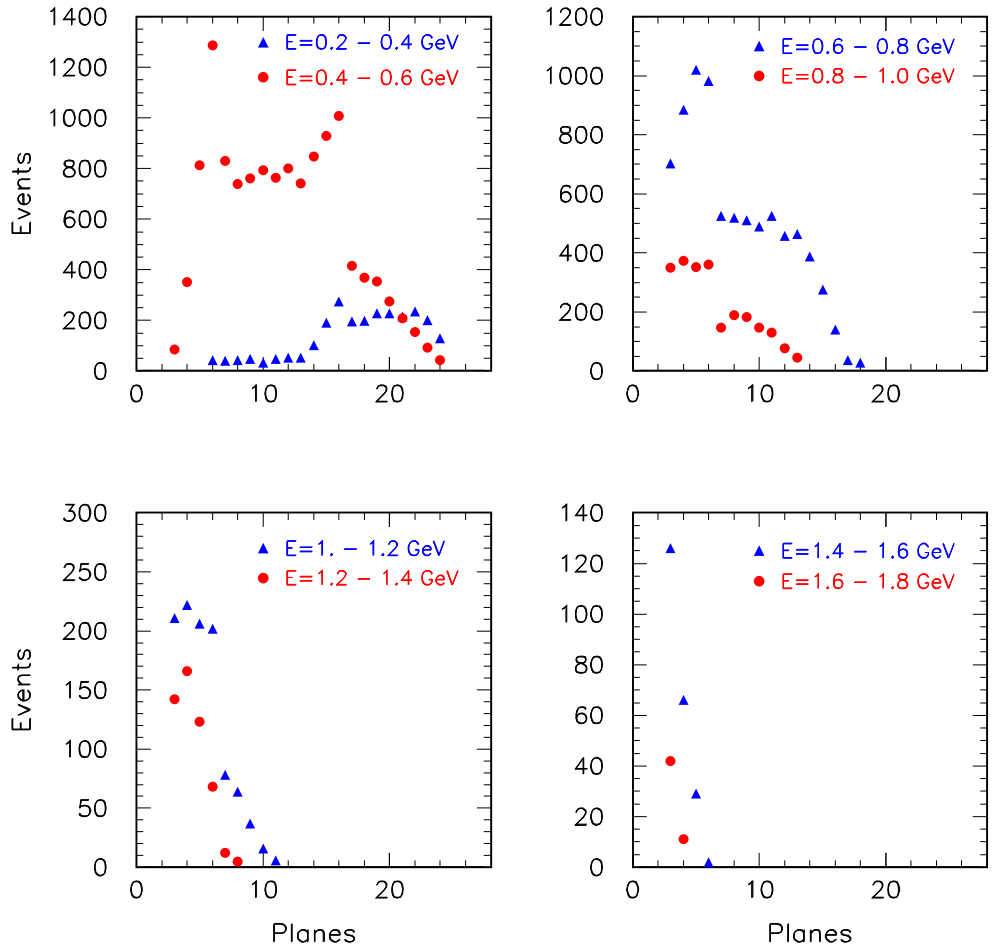
Overall Design

The MD consists of 26 steel planes, each followed by a scintillator plane. Two additional scintillator planes (veto) are placed before the first steel plane at the distance 2 cm. The size of the MD is $0.96 \times 0.96 \times 1.78$ m. The first four upstream steel plates are 10 cm thick, the next ten layers are 5 cm thick and the downstream twelve are 2.5 cm. A center-to-center spacing between upstream four steel planes is 12.1 cm, with 7.1 cm between the next ten planes and 4.6 cm between the downstream twelve planes.

The total MD thickness (including scintillator) of $\approx$940 g/cm^2 corresponds to muon energy of $\approx$1.5 GeV. Fiducial volume of the MD includes 23 upstream steel planes and its mass is 8.41 tons, total weight of the detector is 8.99 tons.

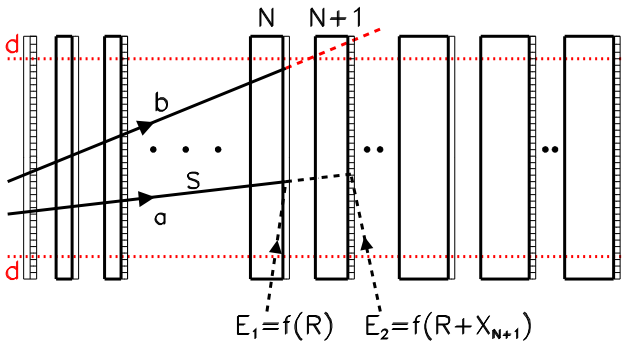
Statistic: 179975 CC ν_μ interaction in FV

Distributions of stopping muon vertex positions along the detector that hit at least 4 planes



Cut

- No the first and the last hit planes
- Number of hit planes ≥ 4
- The reconstructed track is extrapolated to the next scintillator plane. If an intercept is at distance less than d=7 cm from the edge of the plane, this event is identified with through going muon and excluded from the following analysis.

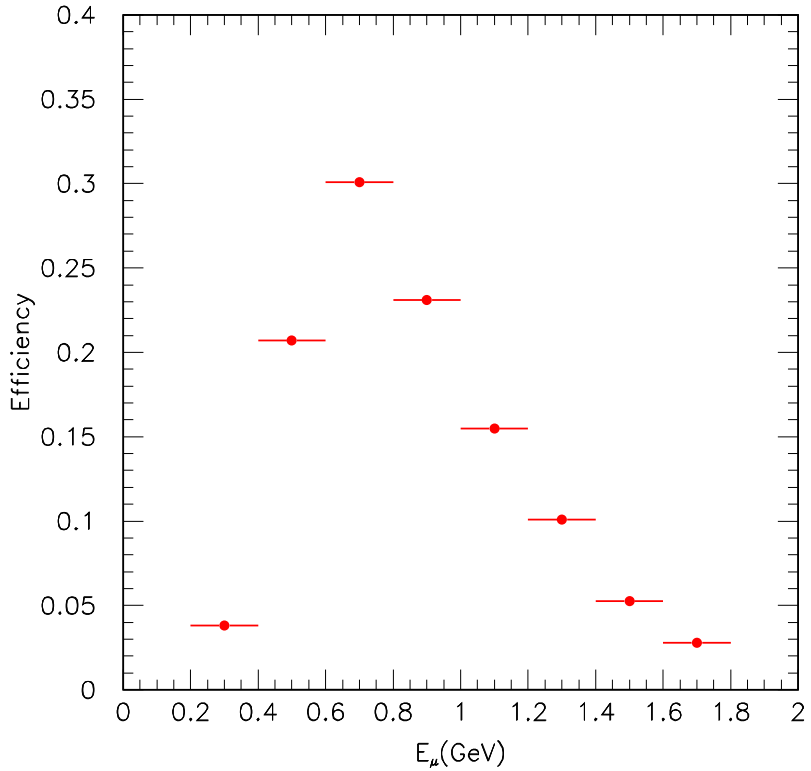


Result

Efficiency of through going cut ε=0.977

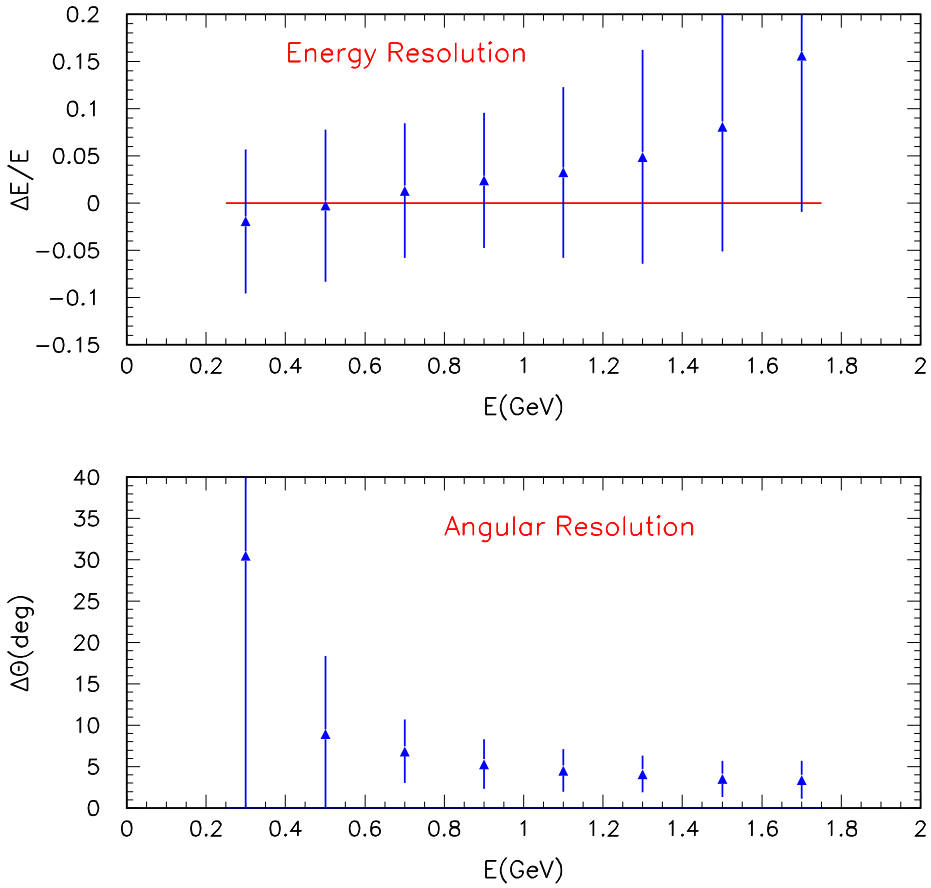
77% of stopping muons lived after cut

Efficiency of the monitor detector as a function of total muon energy



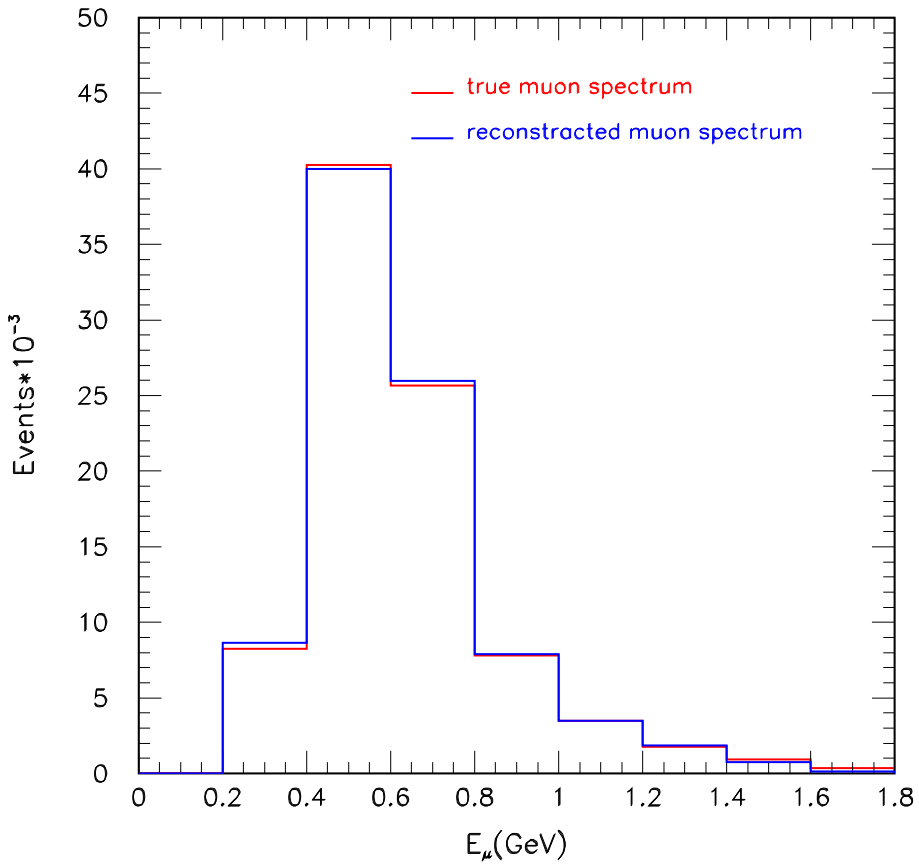
Integral efficiency of the detector is $\simeq 0.12$.

Energy and angular resolution of the MD



Direction of short tracks is determined with accuracy $\Delta\theta \pm 180°$.

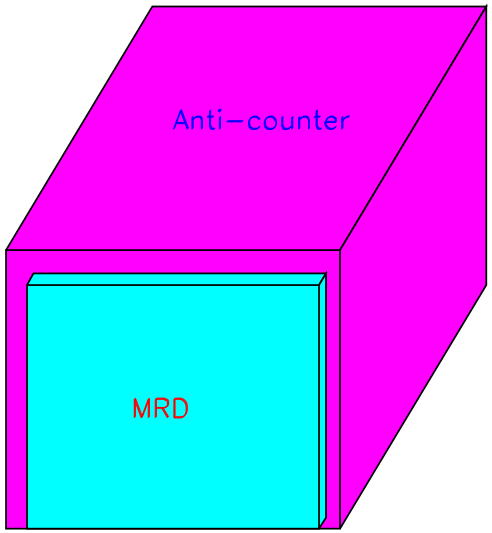
True and reconstructed energy distribution of events detected by the MD



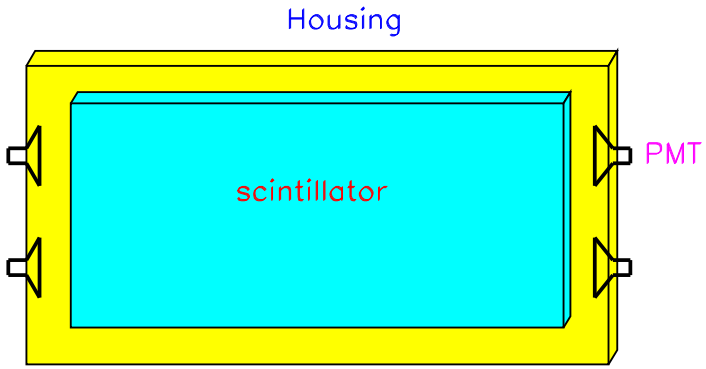
Total number of reconstructed events is $\approx 88700/\text{year}$.

Monitor Detector with Anti-counter

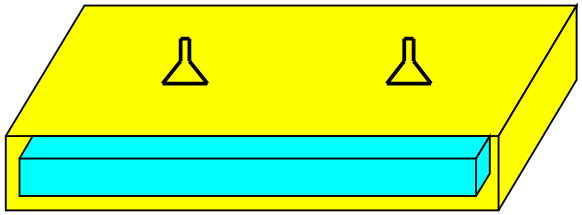
Veto of the MD consists of the two first and the last scintillator planes of the MRD and Anti-counter (AC) i.e. additional scintillator planes that can be placed around of the MD .



Possible design of the AC scintillator planes.



Size of scintillator 5cm x 96cm x 178cm

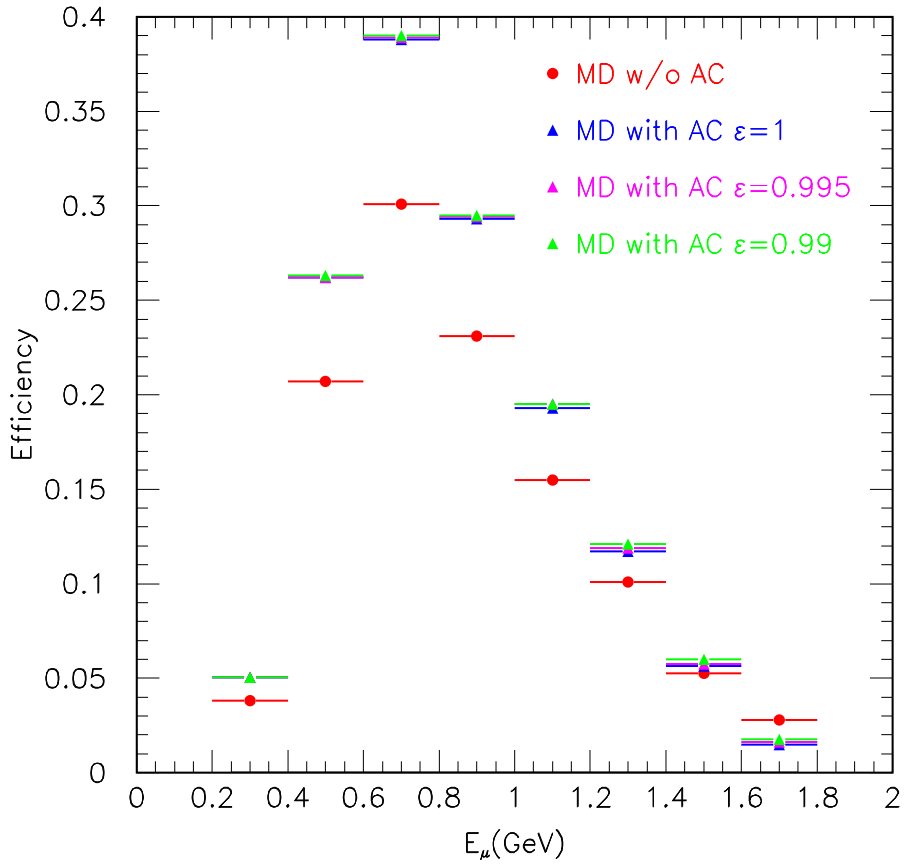


Cut

- No hit veto planes
- Number of hit planes ≥ 4

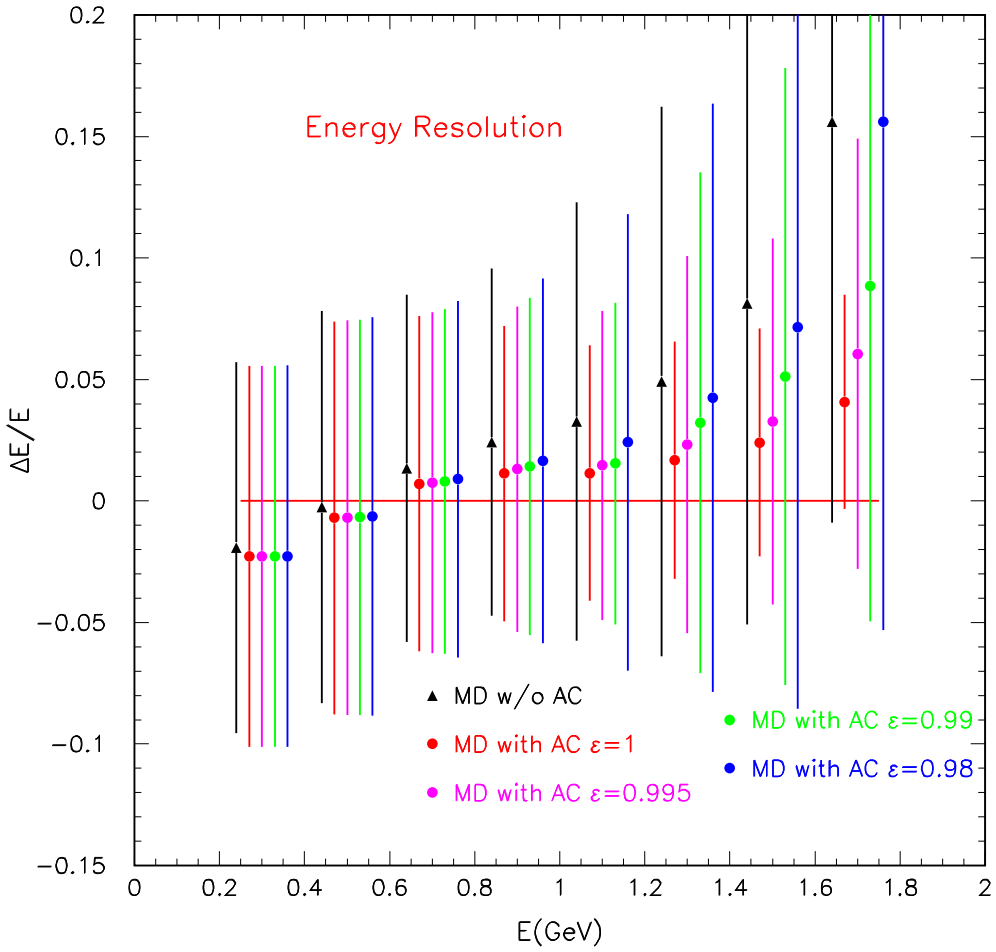
Efficiency of the AC: ε = (Number of detected through going muons)/(Total number of through going muons).

Efficiency of the MD with Anti-counter as a function of total muon energy.



Integral efficiency of the MD with the AC (ε=0.995) is $\simeq$ 0.15 and number of reconstructed events is $\simeq$ 113200/year

Energy resolution of the MD with the AC



Conclusion

The main parameters and characteristics of the left-right monitor detector have been evaluated using the muon vector generated in 2km WC detector. The preliminary results can be summarized as follows

- Integral efficiency of the detector is $\sim 0.12 \div 0.15$. Expected number of reconstructed events is $\sim 88700 \div 113200$/year.
- Energy acceptance is $E_\mu \simeq 0.2 \div 1.6$ GeV with resolution $\langle \Delta E/E \rangle = 2 \div 8\%$. The energy resolution can be improve $(1 \div 4\%)$ if the Anti-counter with efficiency ≥ 0.995 will be used.

Next step

- Generation of CC and NC ν_μ interactions in iron using neutrino spectrum @ 280m.

- Generation of the detector response to full CC and NC events (not only muon).
- Tracking algorithm and muon track reconstruction

Questions

- Possible effects of magnetic field near ND280 (low energy muon track, PMTs)
- Correlated with spill radiation background (efficiency of the veto)