VLVnT workshop
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Comparison of different km3 designs using Antares tools

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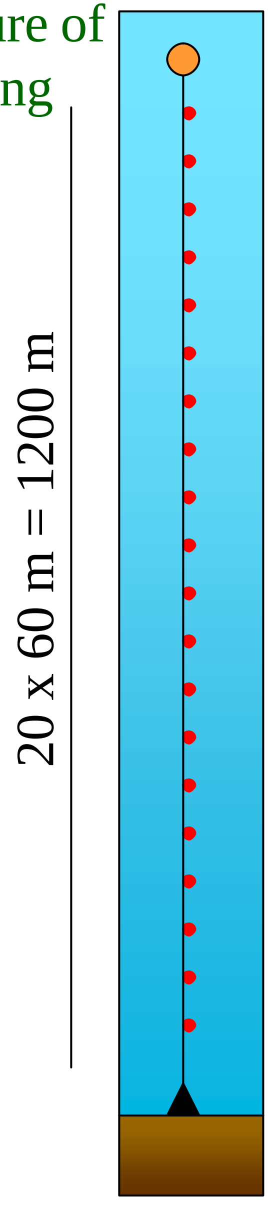
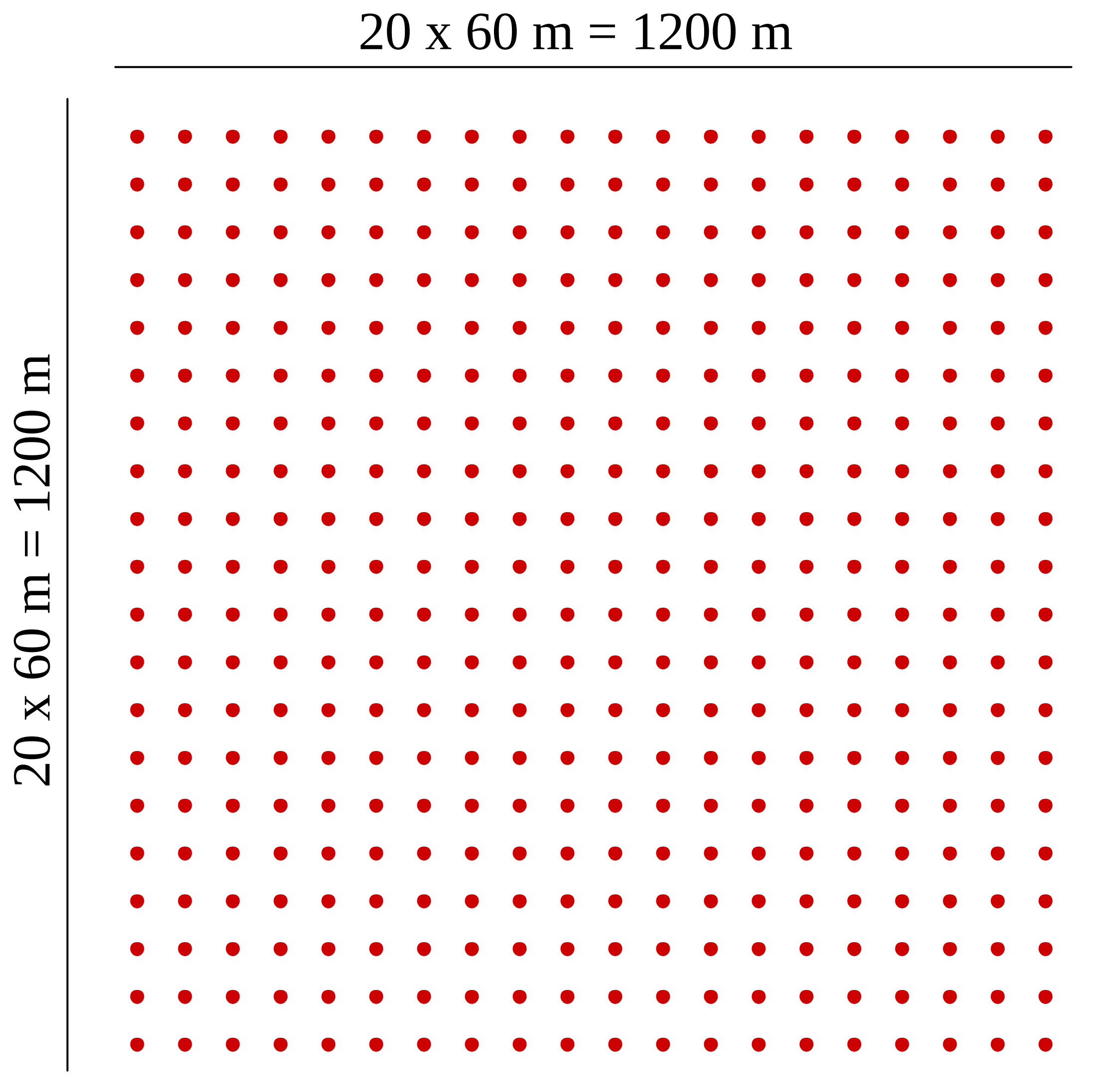
- Three kinds of detector geometry
- Incoming muons within 1 .. 1000 TeV energy range
- Detector efficiency and angular resolution obtained with the Antares tools

A large homogeneous KM3 detector (8000 PMTs)

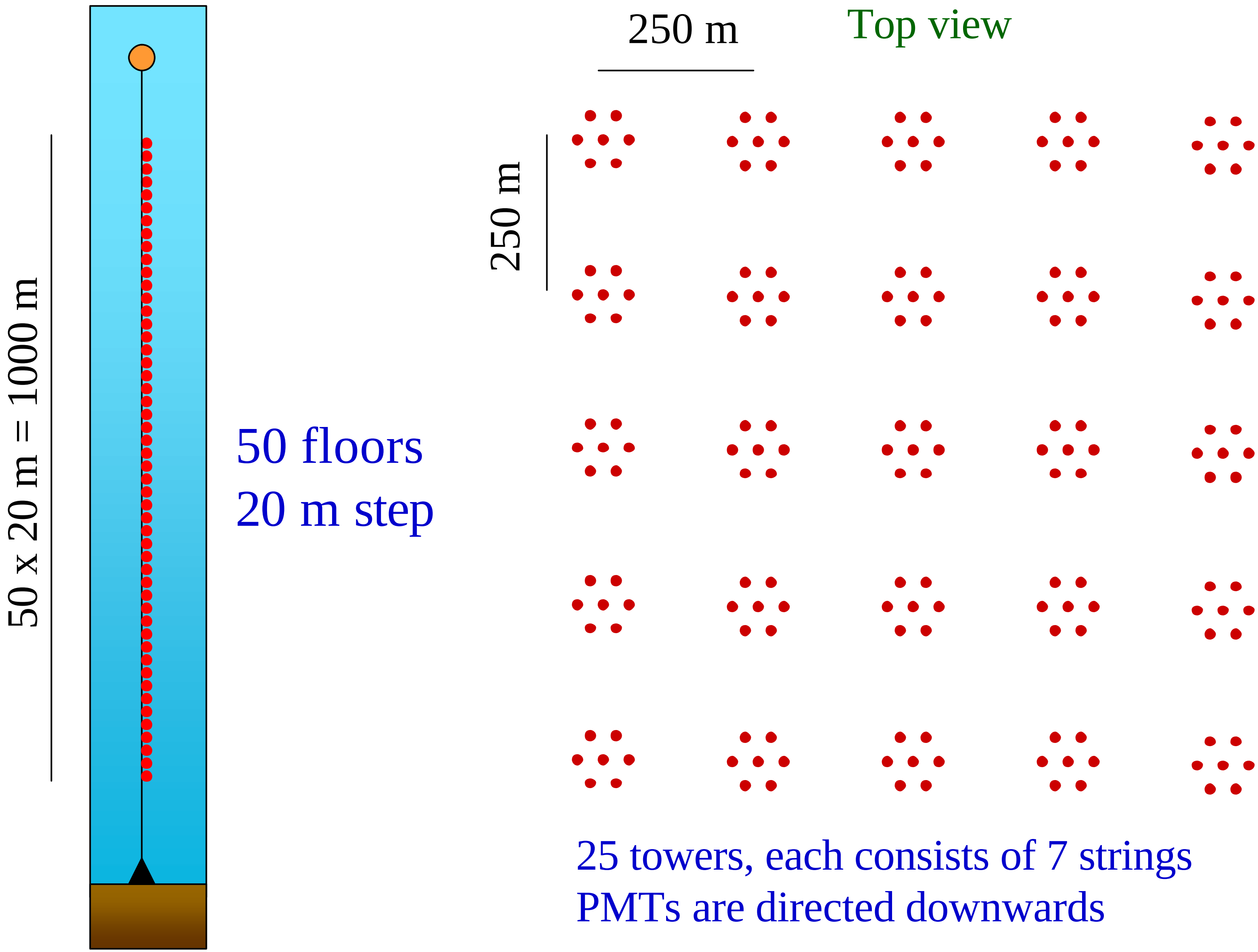
Structure of the string





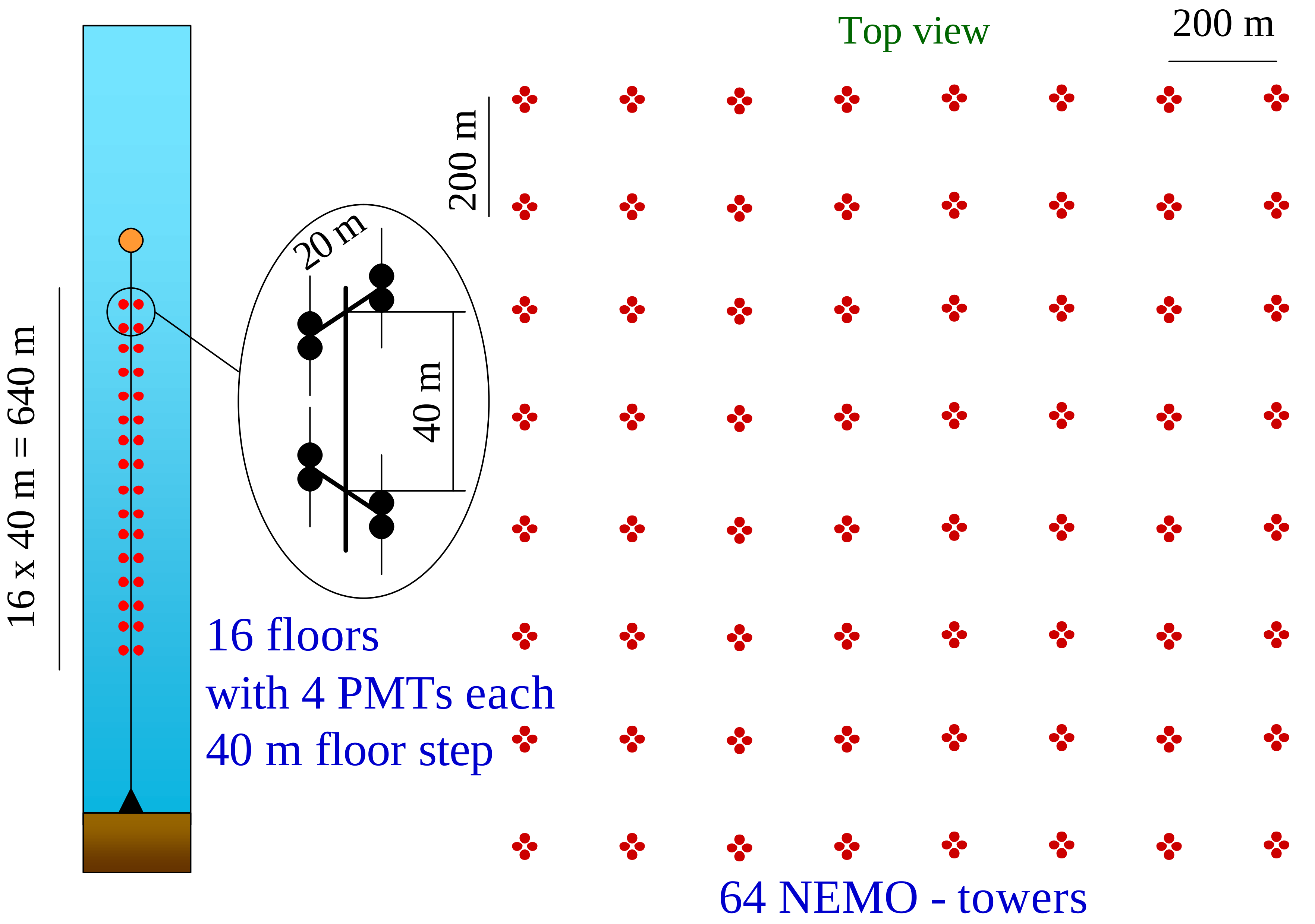
homogeneous lattice 20 x 20 x 20 downward-looking 10 “ photomultiplier tubes

A large NESTOR – like detector (8750 PMTs)



25 towers, each consists of 7 strings
PMTs are directed downwards

A large NEMO – like detector (4096 PMTs)



Detector geometries: Common features

Set 1:

PMTs: 10 inch

Characterestics from Antares Hamamatsu R7820 used (eff. Area = 0.44 cm^2, angular response, QE)

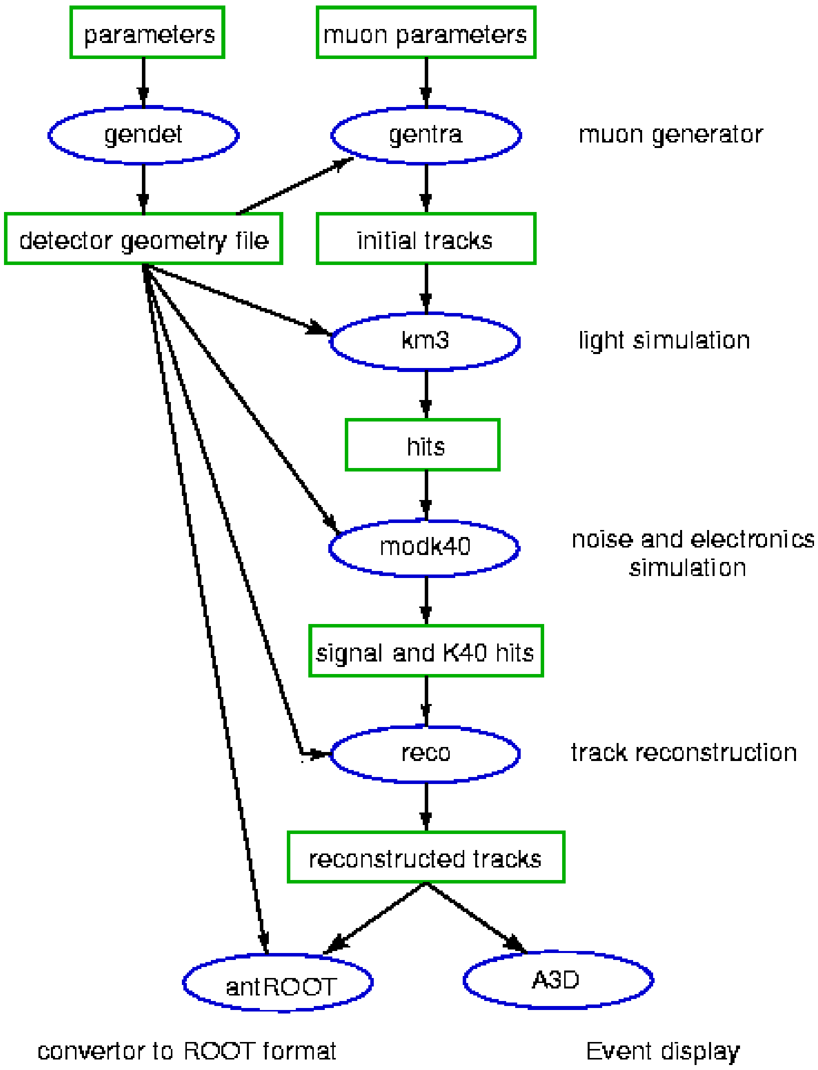
Set 2:

15 inch PMTs: same characteristics but eff. Area = $(15/10)^2$

No PMT multipletts used

i.e. Tight coincidences between close PMTs not possible replaced by high pulse condition (above 2.5 , 3.5 pe)

Event Sample



Energy range: 1TeV - 1PeV
Spectrum: 1/E (flat in log(E))
lower hemisphere isotropic
Surface drawing
km3 with partic-0.0075
60 (135) kHz noise light
Simplified digitisation
(2 ARS 25nsec integration)

recov4r2 with AartStrategy

Analysis antroot and a3d

Program modifications

Most of the code was easily scalable for use with 1km^3 detector

Some parameters in include files had to be changed like:
(km3.inc, phomul.inc)
max. number of PMTs, clusters, strings

Patch work in km3 to allow use of 15 inch PMT without creating new diffusion tables

Reco: modification of Select and Filter routines to
adapt to high pulse condition and absence of coincidences
(2.5 pe for 10 inch PMT, 3.5pe for 15inch PMT)

Modified causality filter

Usual filter:

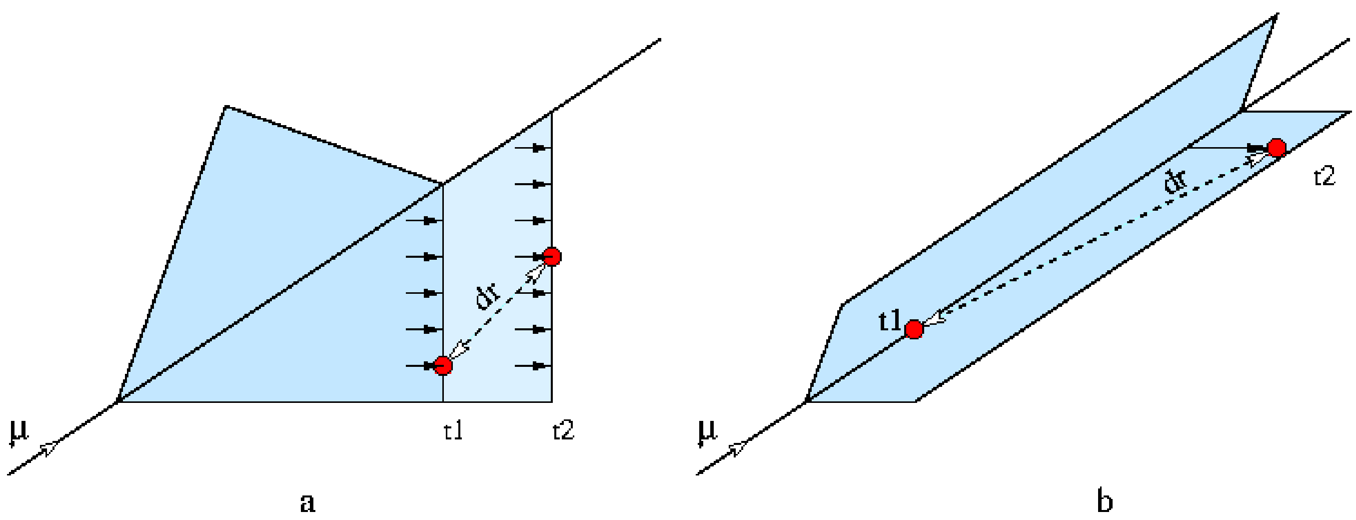
$abs(dt) < dr/v_{light}$

Plane wave approximation
dr << x (photon travel path)

Large detectors (new condition):

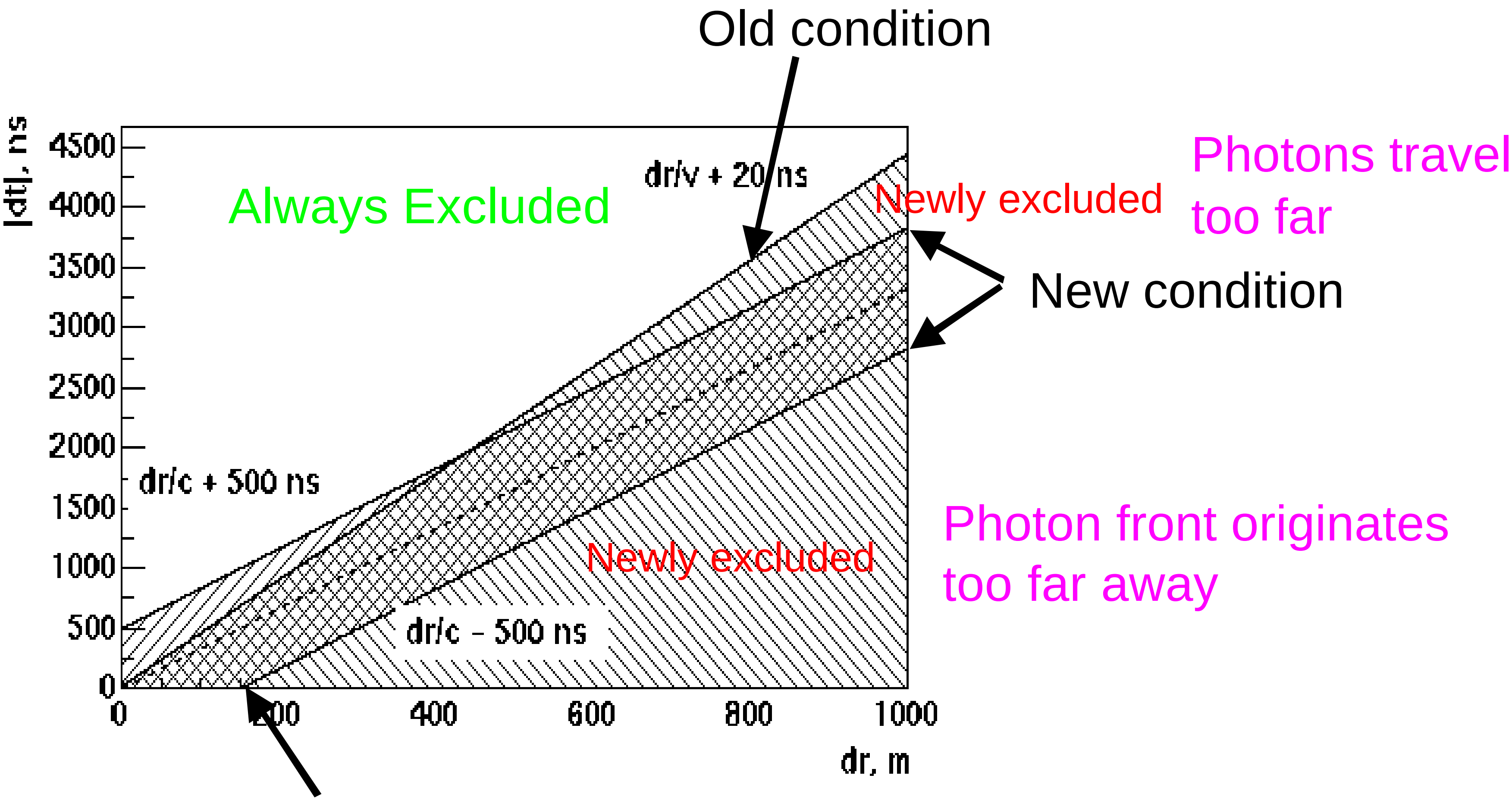
$abs[abs(dt)-dr/c_{light}] < 500nsec$

Approximation x << dr
(hits close to muon track,
takes into account absorption)



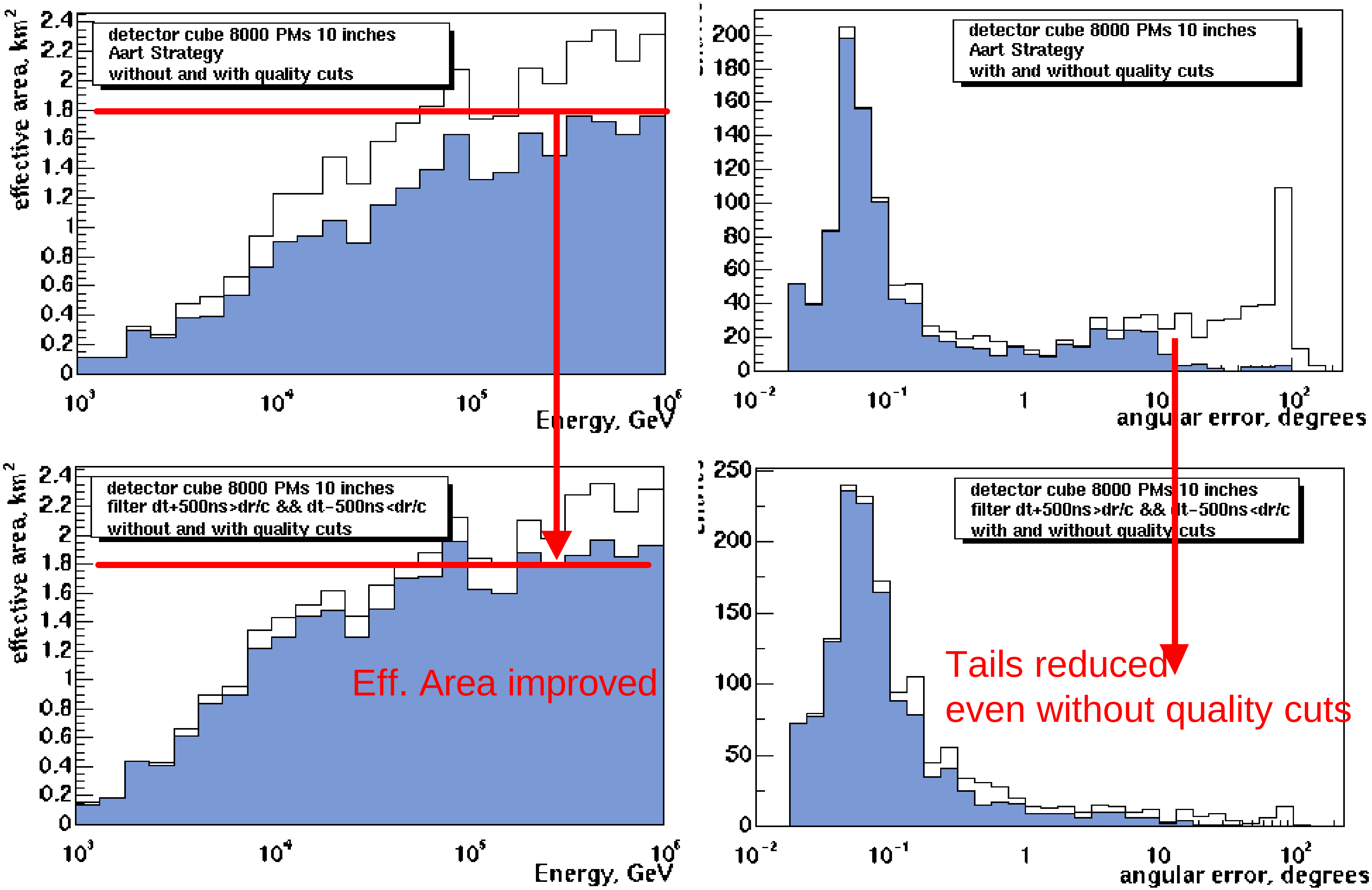
Modified causality filter

Logical AND between both conditions

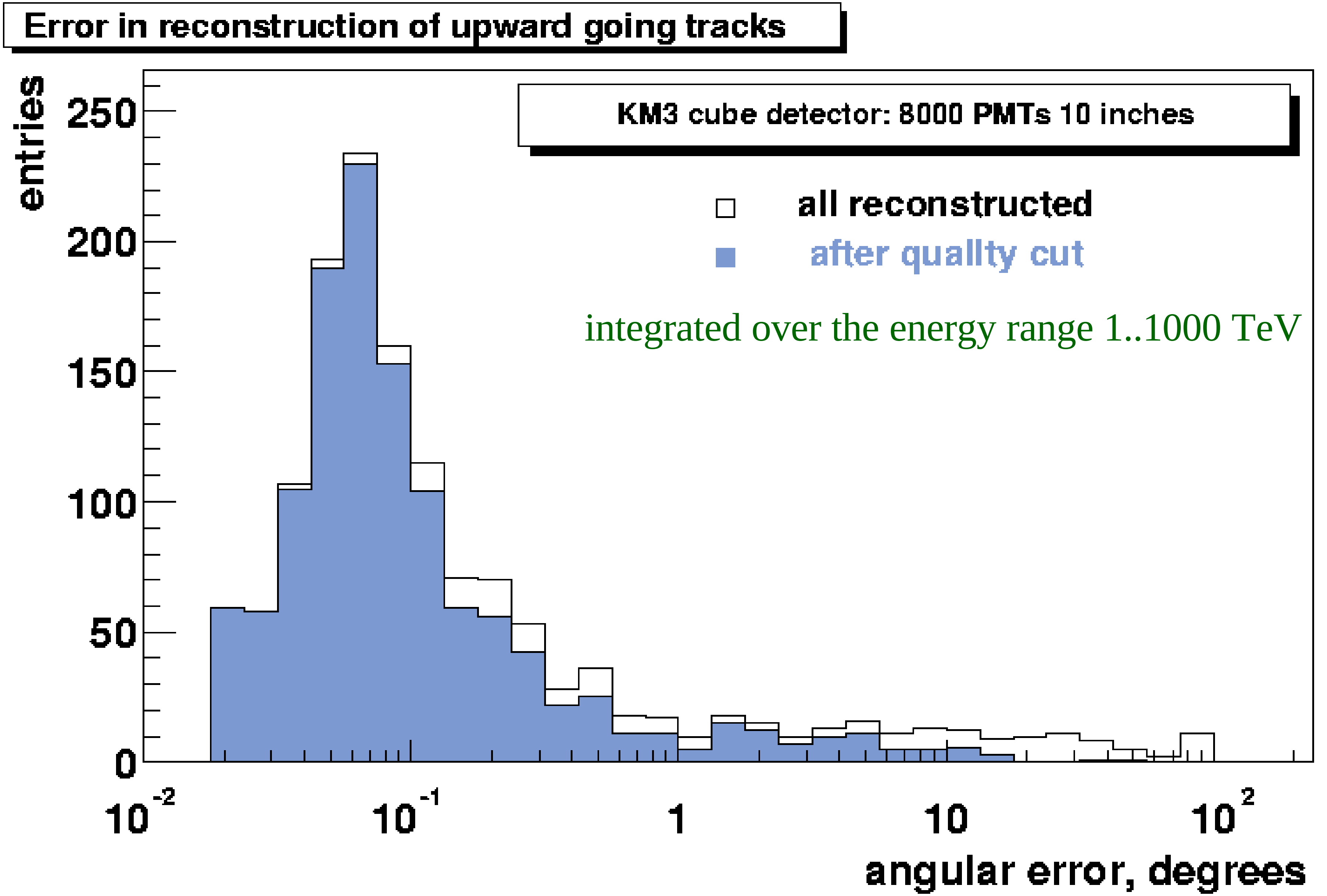


Effective for dr > 150m, probably negligible for $0.1km^2$ detector

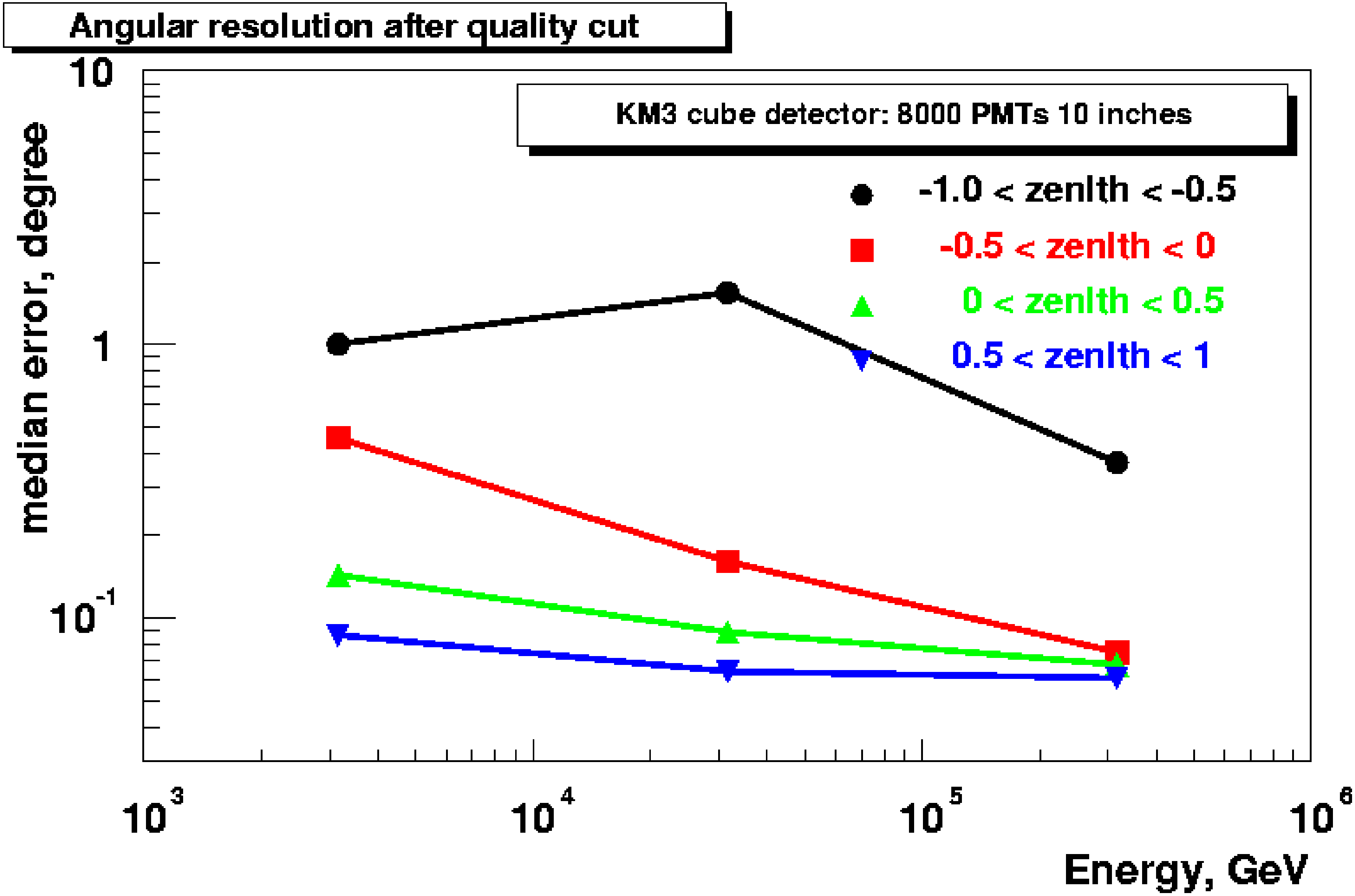
Effect of new causality filter



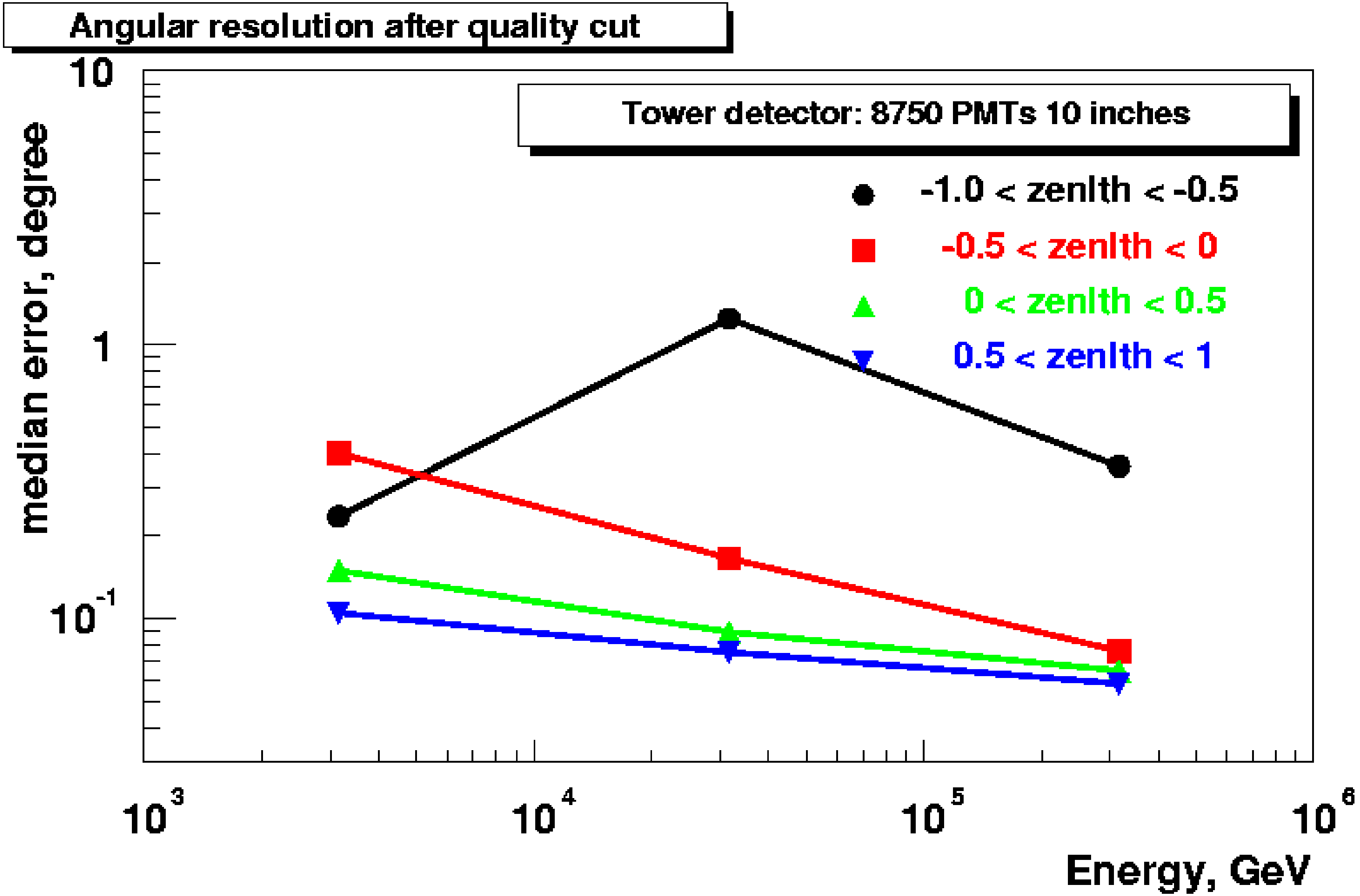
Angular error distribution with the homogeneous detector



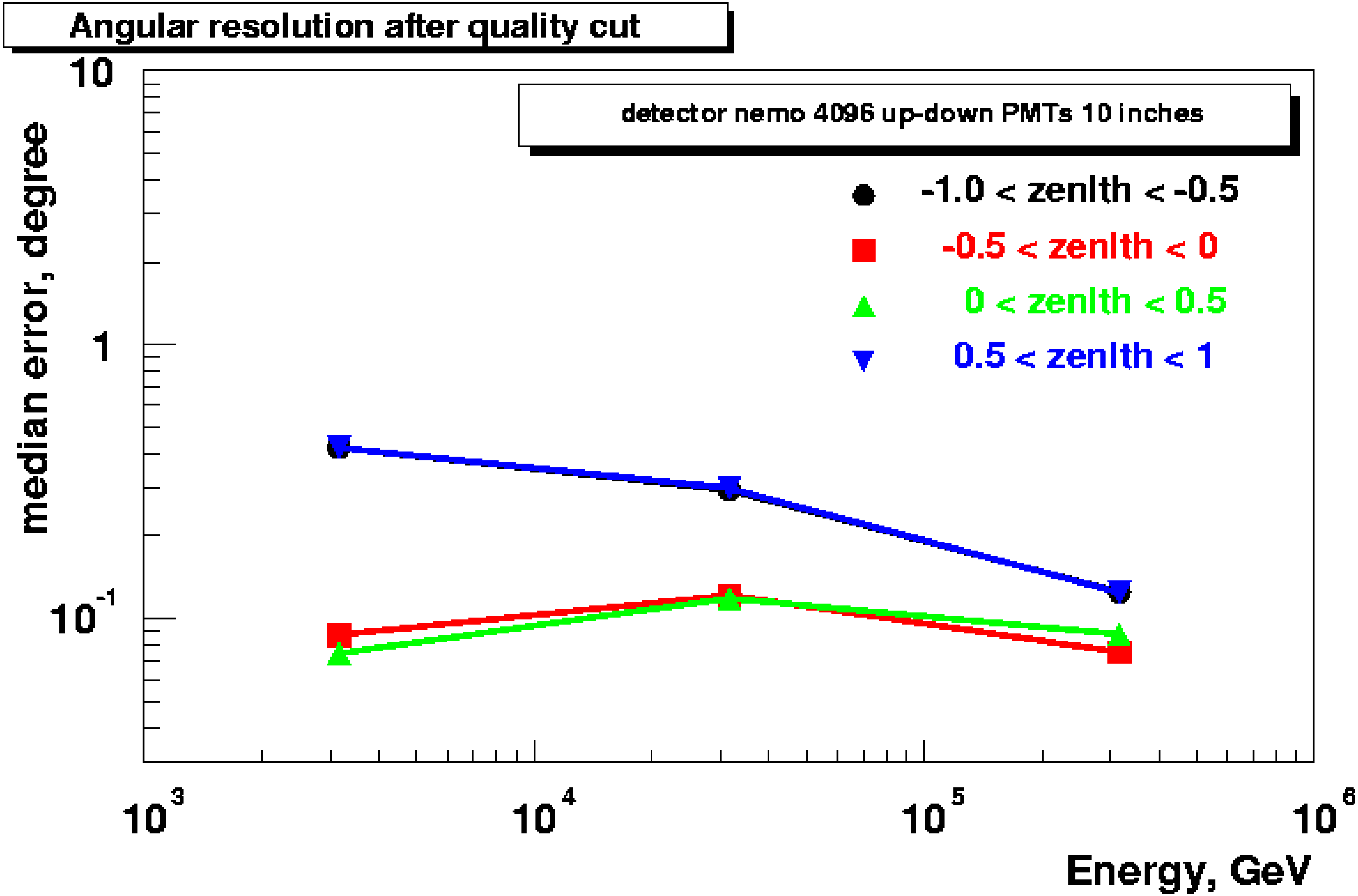
Angular resolution of the homogeneous detector



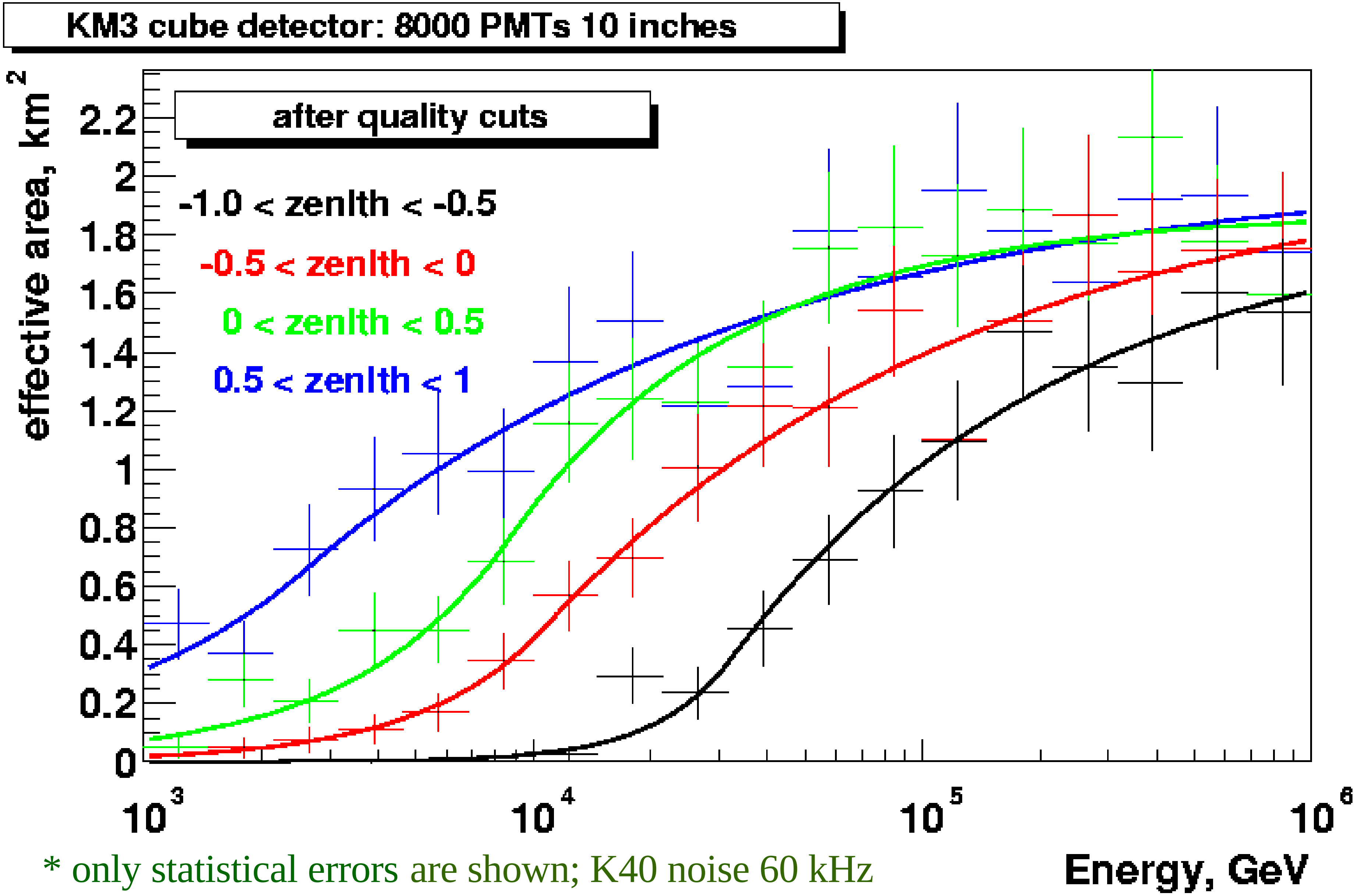
Angular resolution of the NESTOR-like detector



Angular resolution of the NEMO-like detector

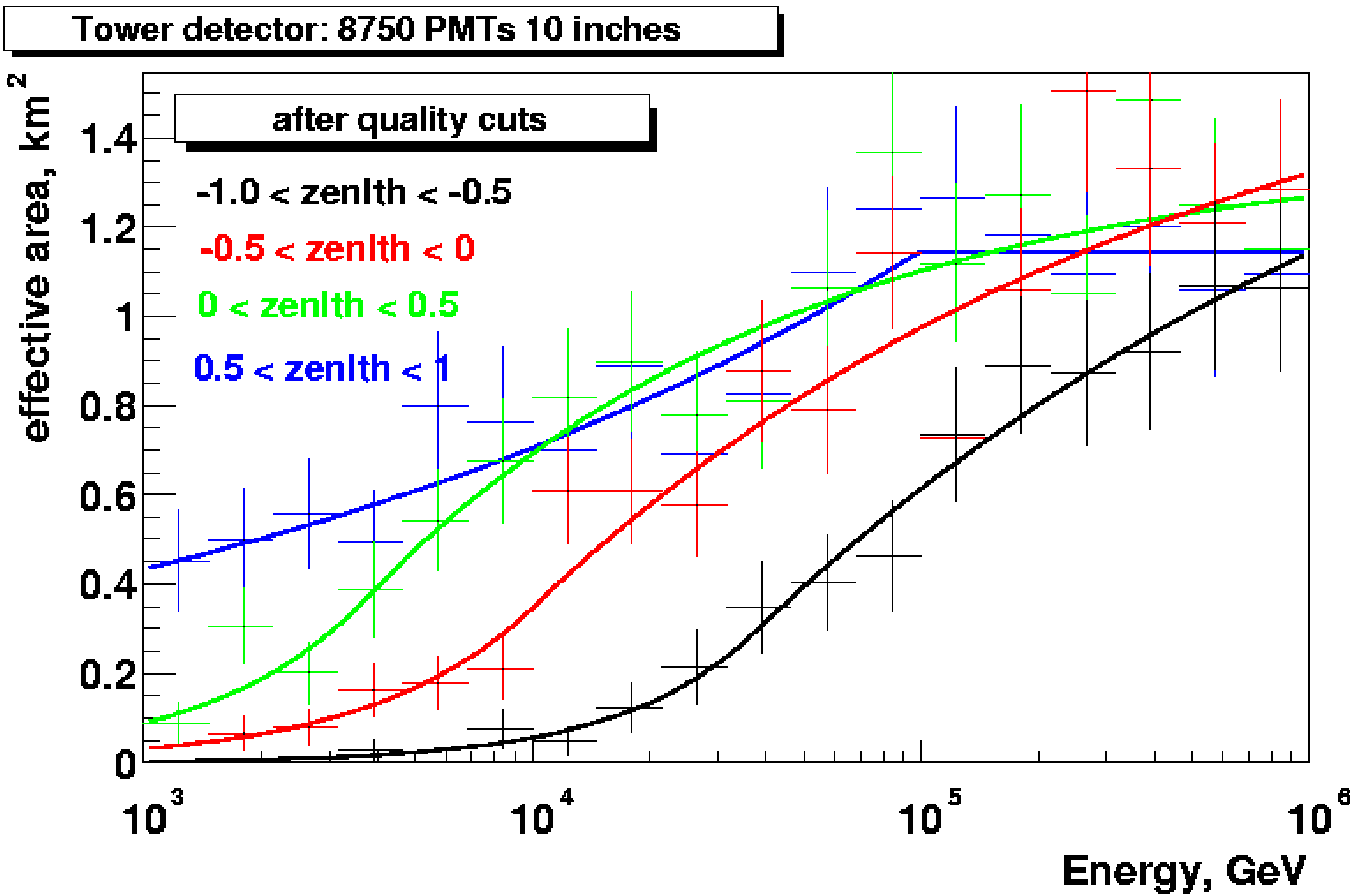


Effective area of the homogeneous detector for muons

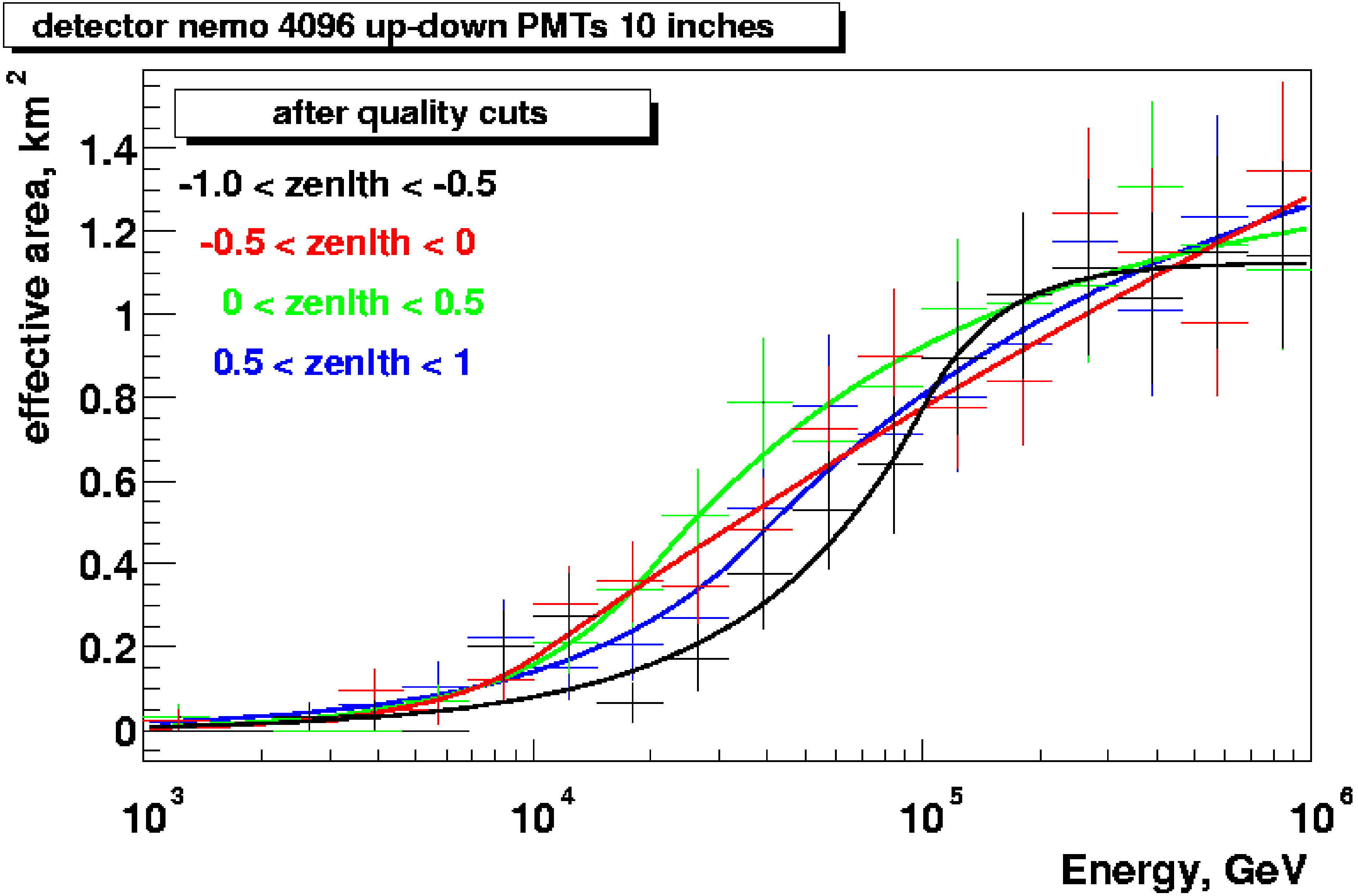


* only statistical errors are shown; K40 noise 60 kHz

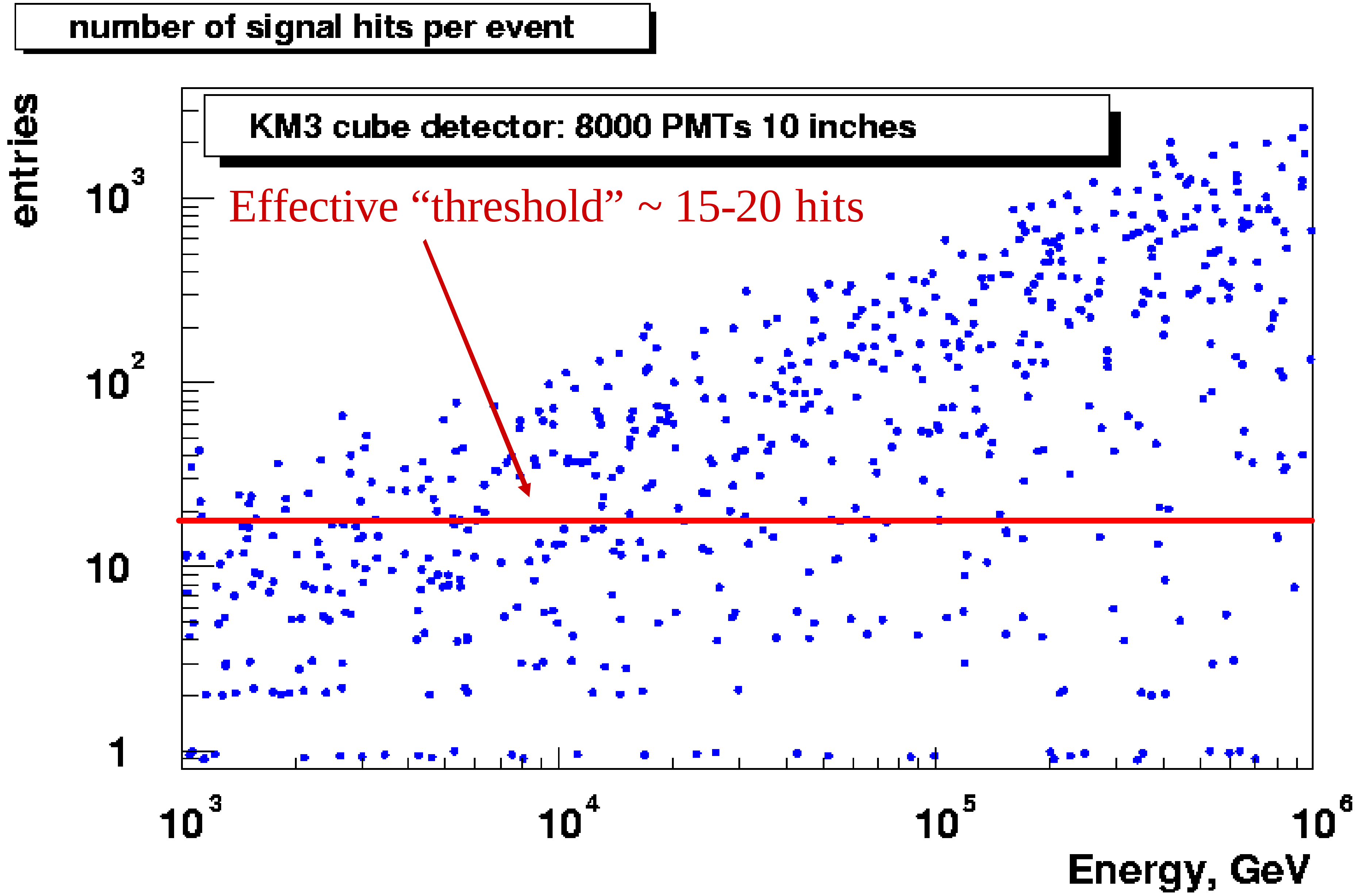
Effective area of the NESTOR-like detector for muons



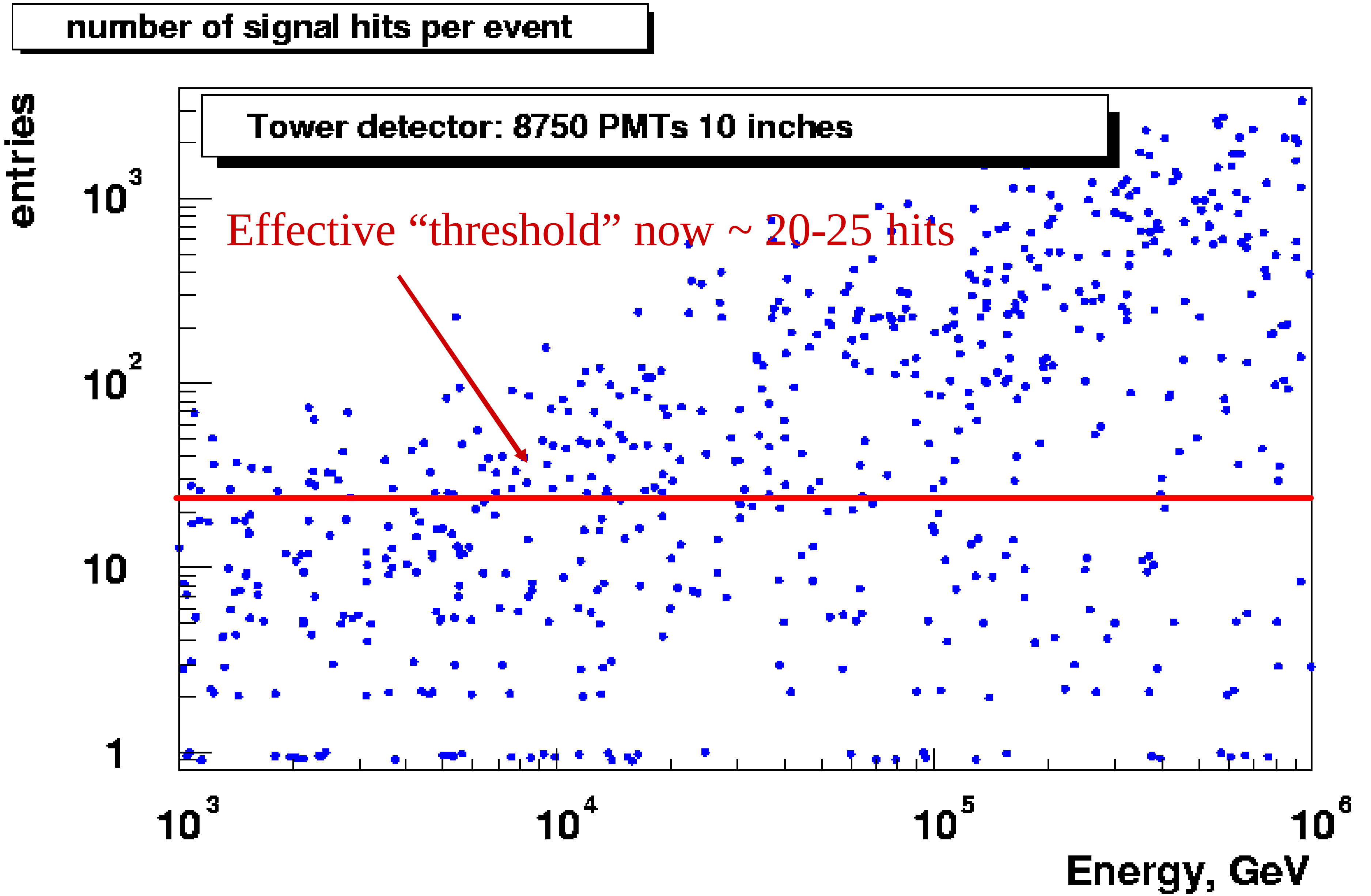
Effective area of the NEMO-like detector for muons



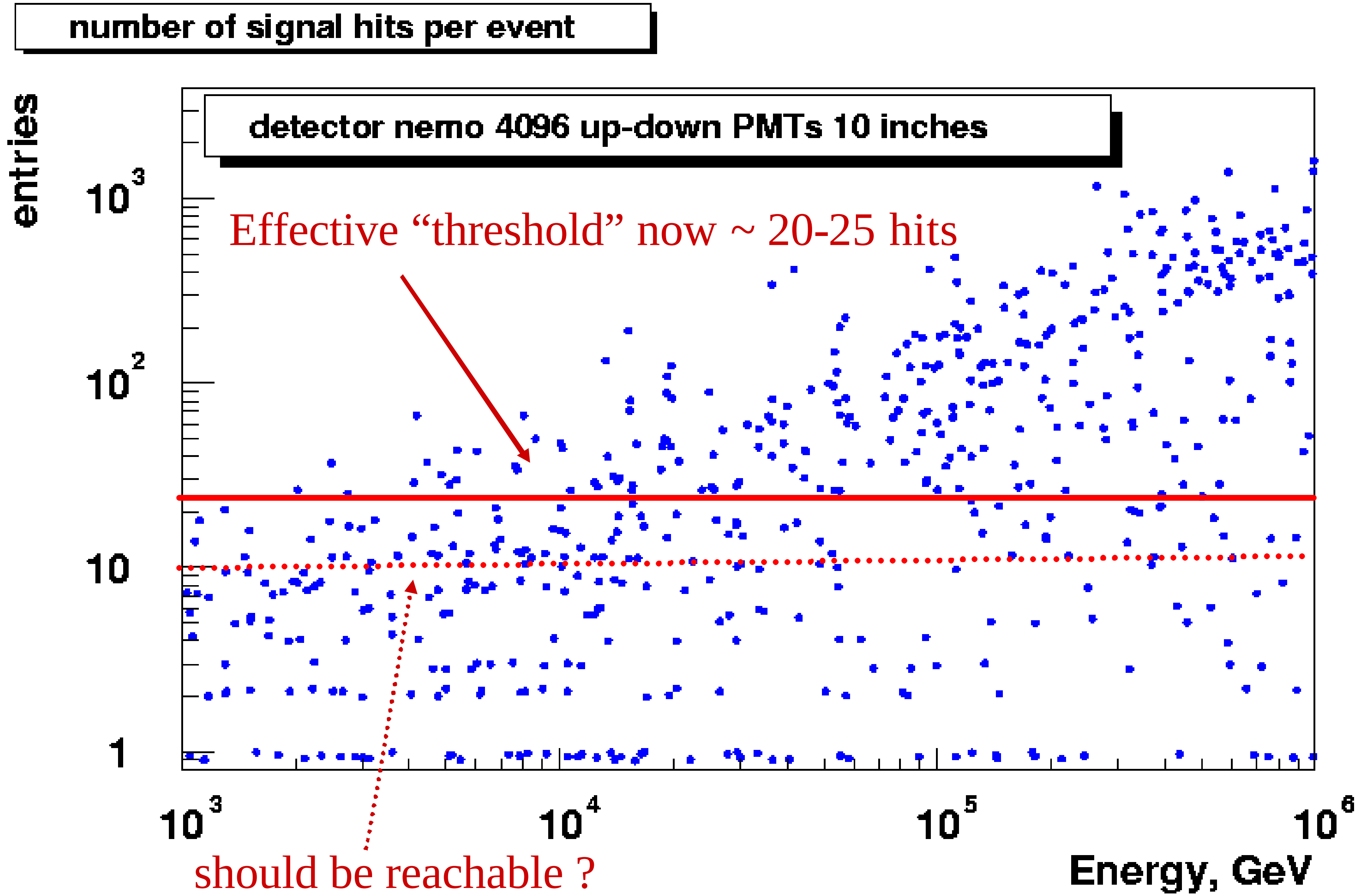
Homogeneous geometry: number of detected hits vs. muon energy



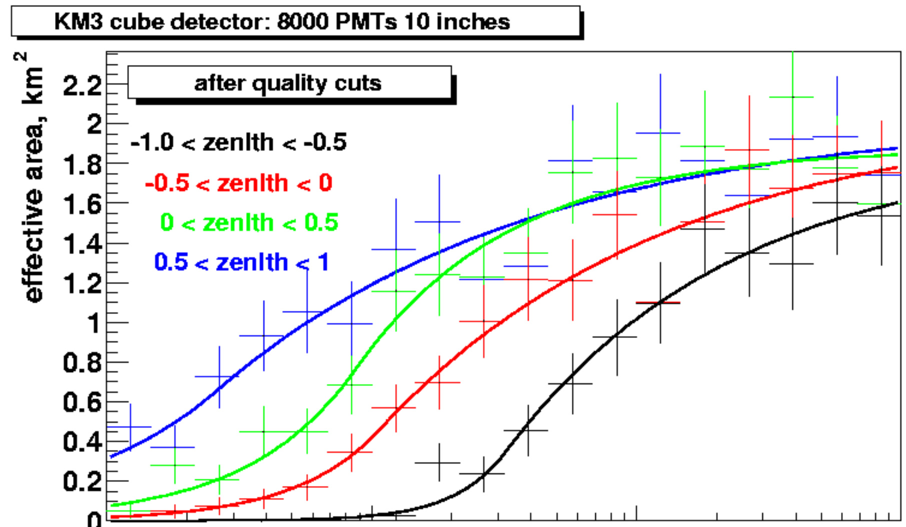
NESTOR-like geometry: number of detected hits vs. muon energy

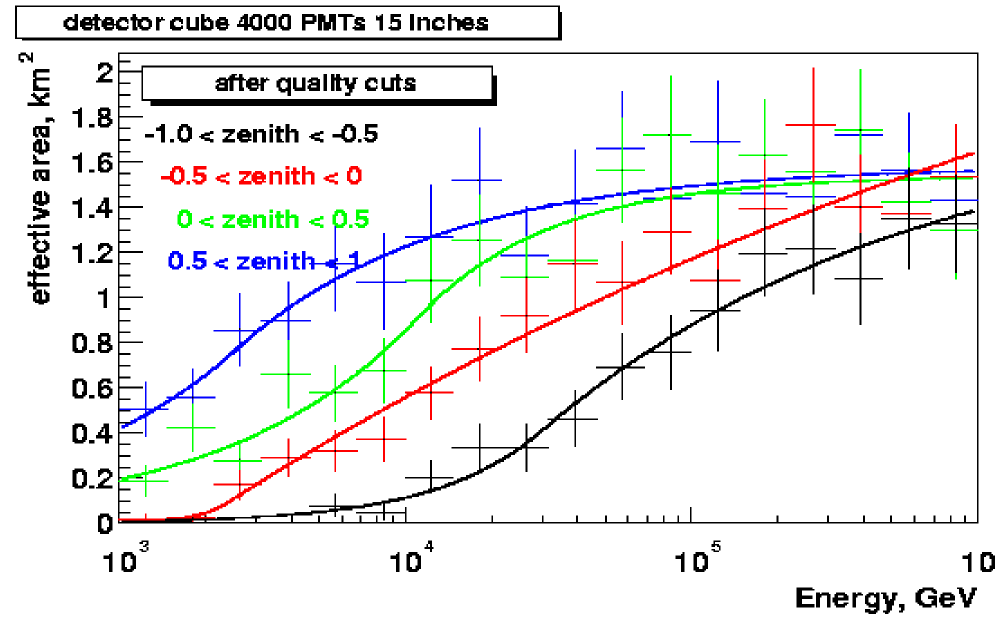


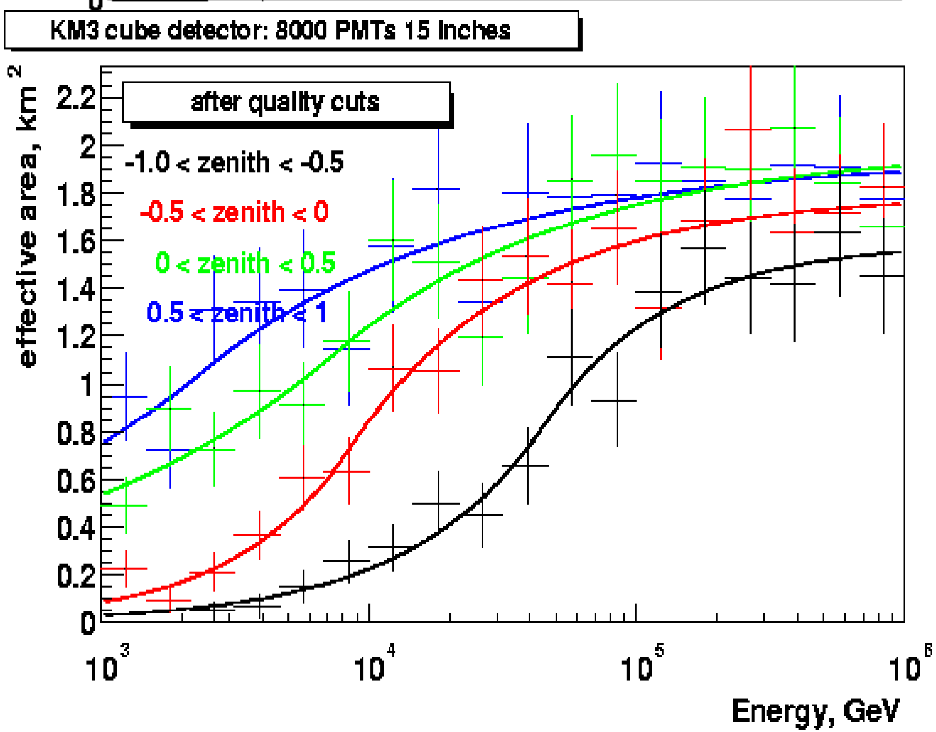
NEMO geometry: number of detected hits vs. muon energy



Effective area dependence on PMT size



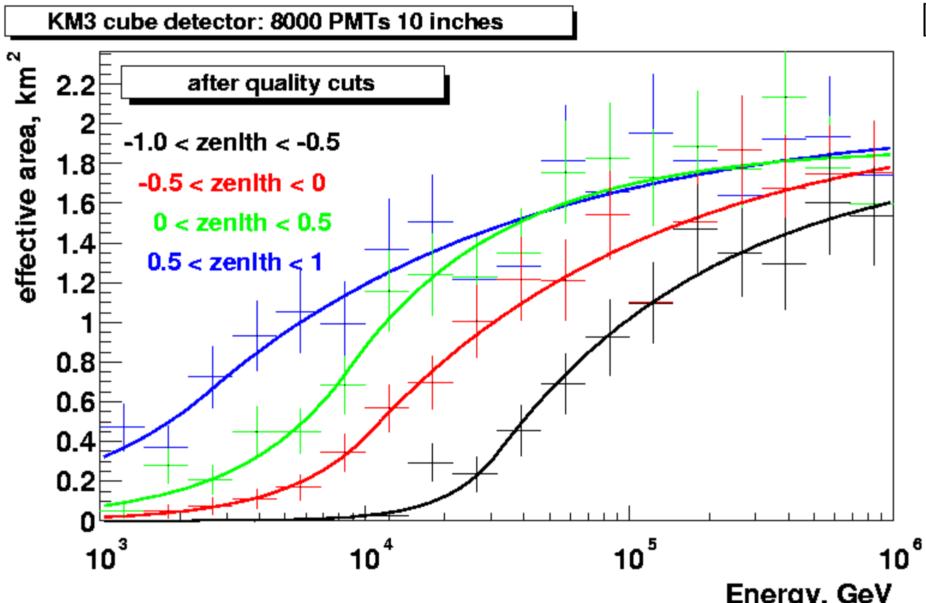


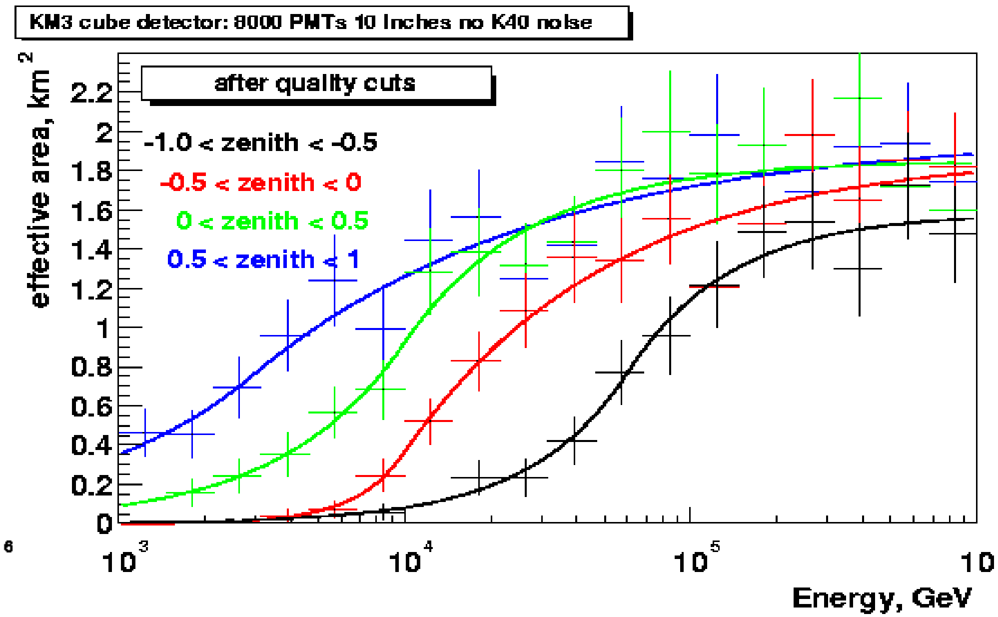


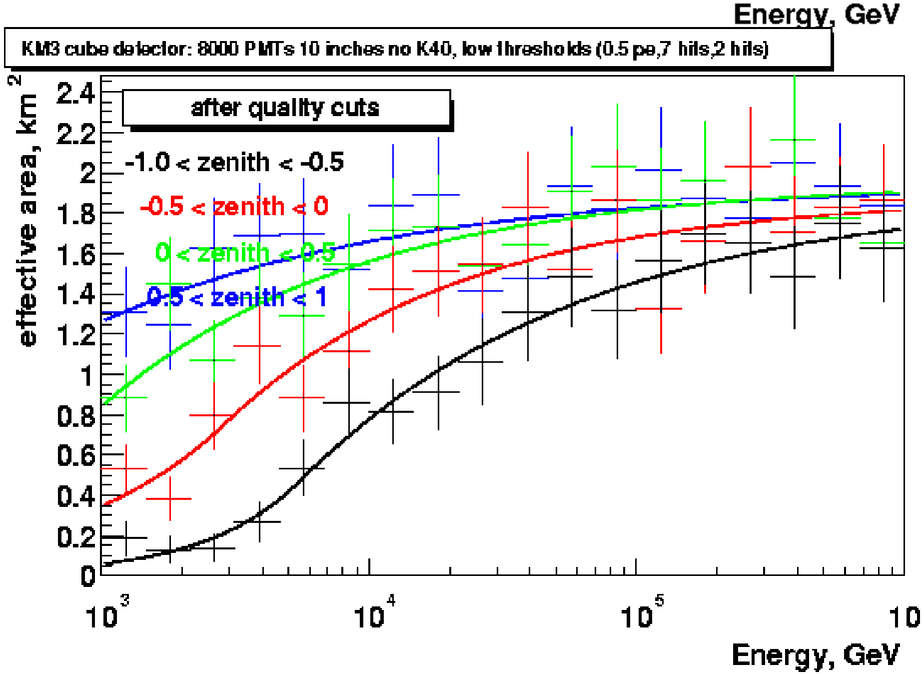
At low energies dependence on total photocathode area

At high energies dependence on PMT number

Effective area dependence on noise







Used reconstruction filters noise hits effectively

At low energies lowering thresholds with low noise improves performance

Conclusions

- Monte-Carlo simulation of Cherenkov light production and muon track reconstruction have been performed using Antares tools.
- The homogeneous geometry demonstrates high detector efficiency starting from 1 TeV.
- Effective area reached with the NESTOR-like geometry is smaller than obtained with the homogeneous geometry.
- The NEMO-like detector has a significantly smaller effective area than the homogeneous configuration mainly due to its lower PMT density.
- All the geometries show angular resolution in muon track reconstruction of about 0.1 degree or better.
- High requirements of the reconstruction software for the number of hits, especially with non-homogeneous detectors, have been discovered and require further investigations.