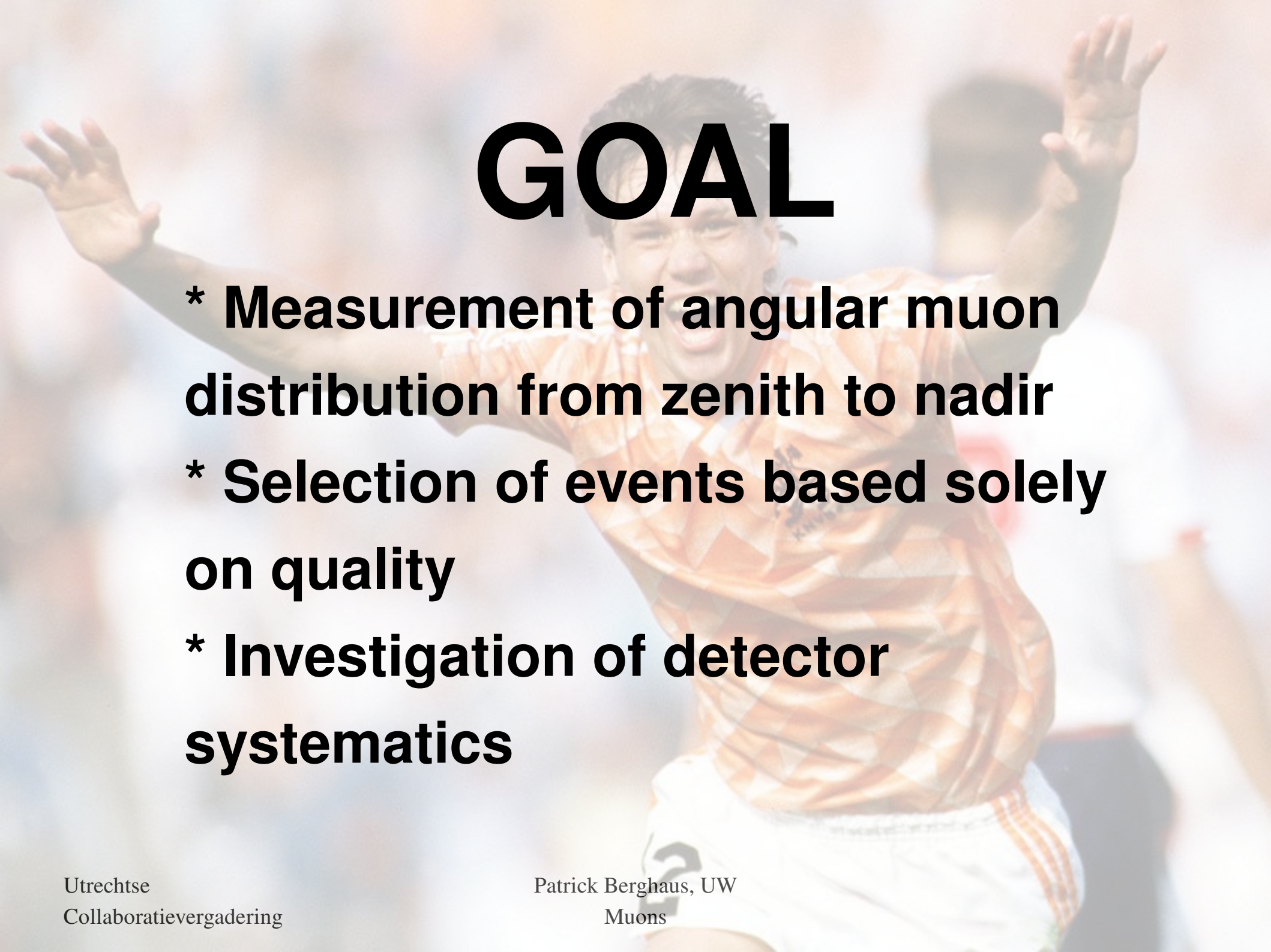
All-Sky Muon Measurement

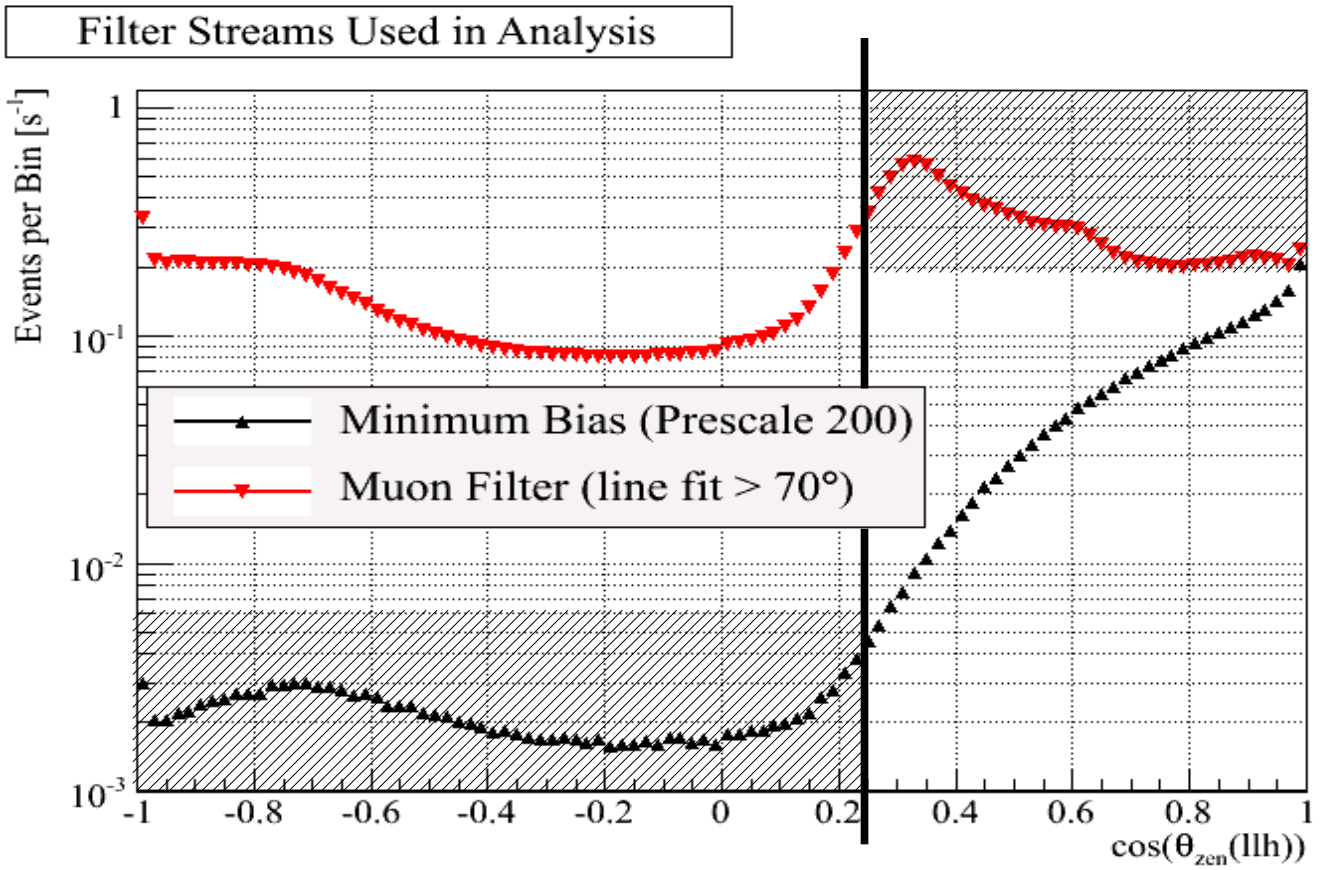
P. Berghaus and K. Rosenau



GOAL

* Measurement of angular muon distribution from zenith to nadir
* Selection of events based solely on quality
* Investigation of detector systematics

Filters



cos(θ$_{zen}$)=0.25 (78°)

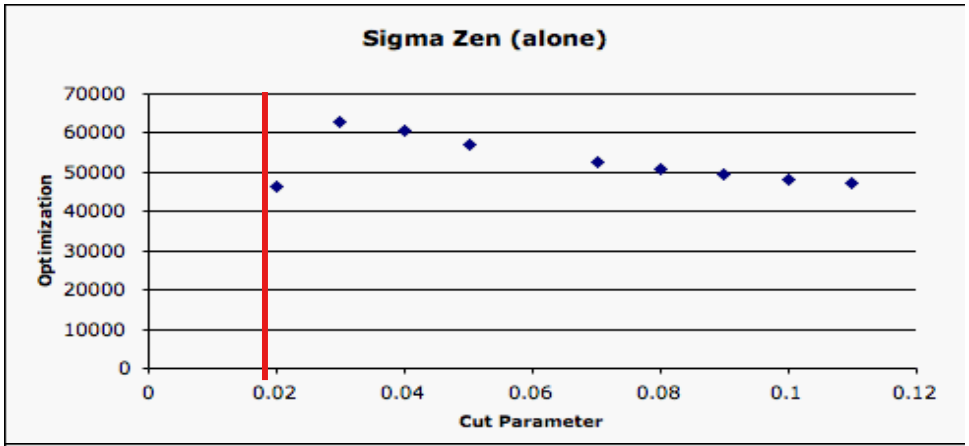
Minimum Bias Cuts

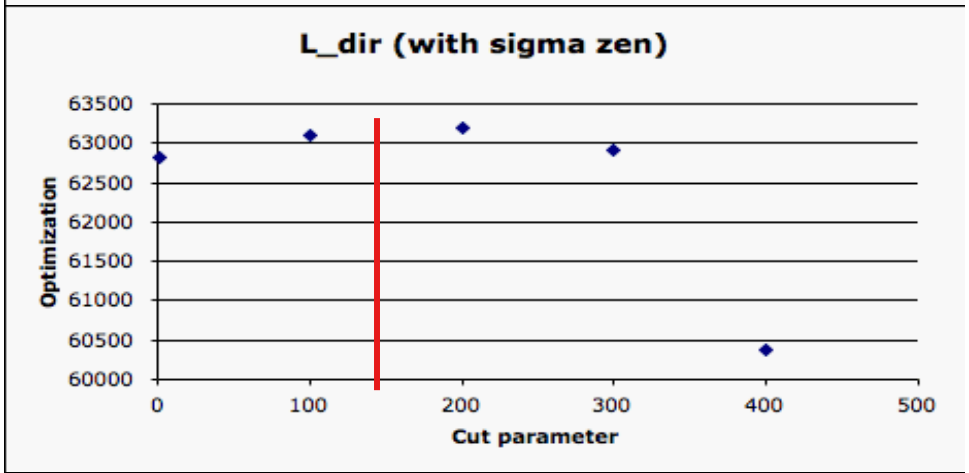
σ_{zen}

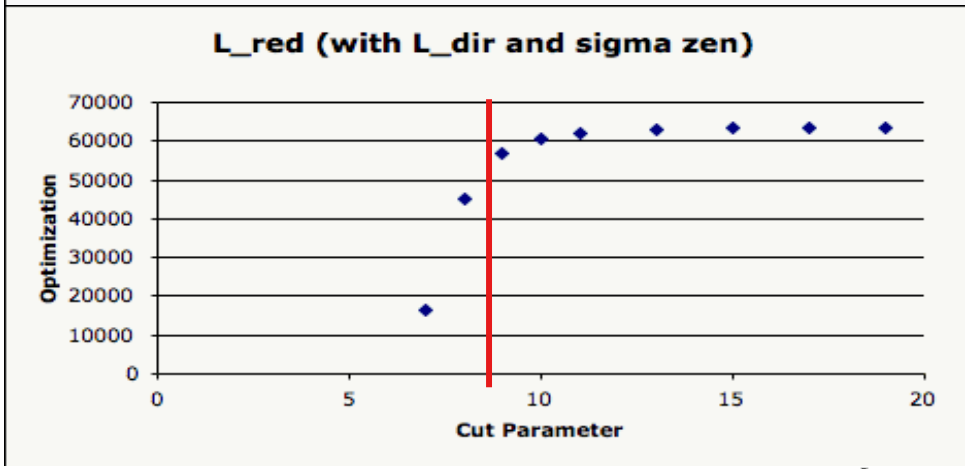
$$\frac{\sqrt{\epsilon_{cut}}}{\Delta\theta_{zen}(median)}$$

L_{dir}

$logL_{red}$

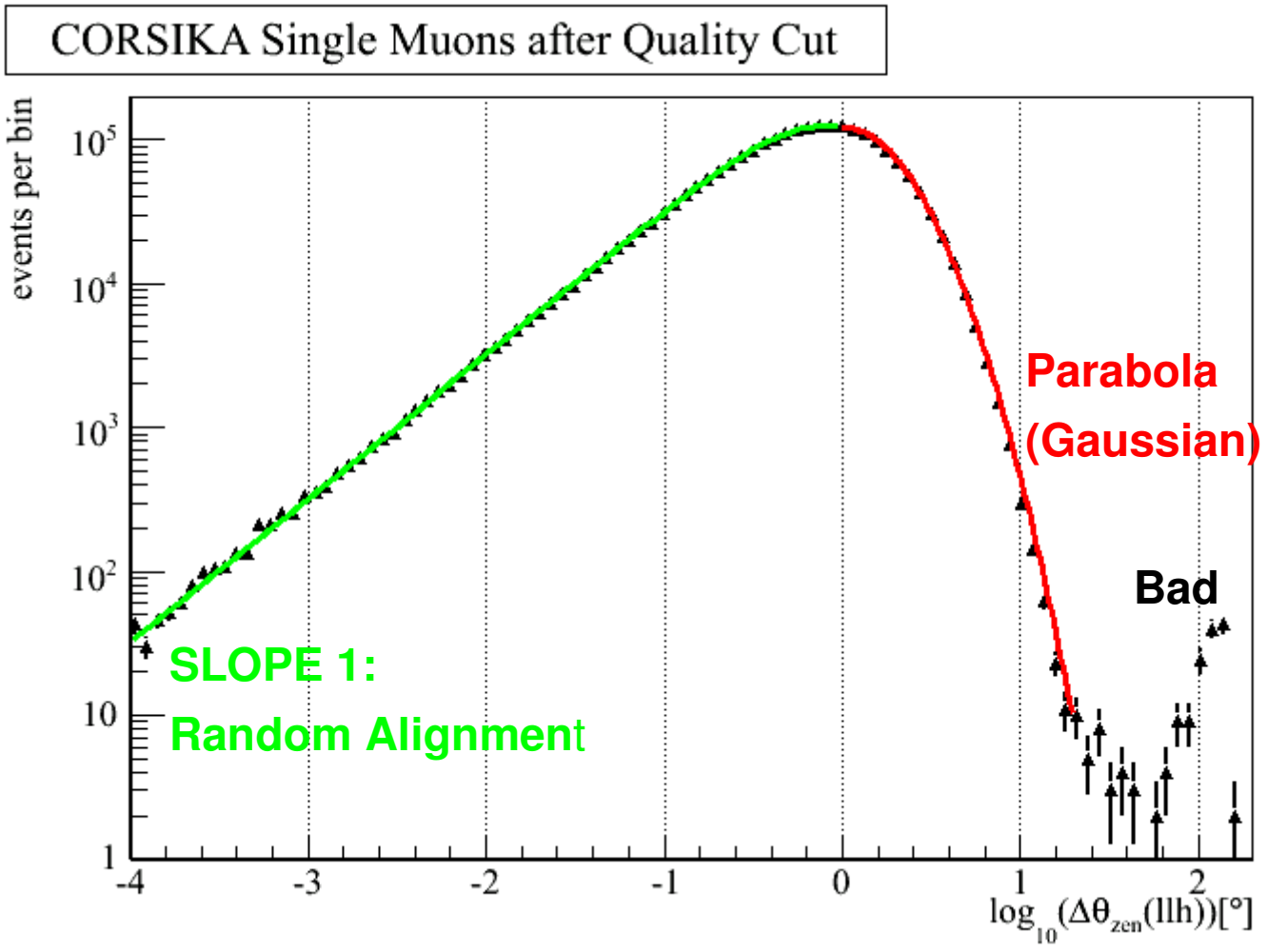




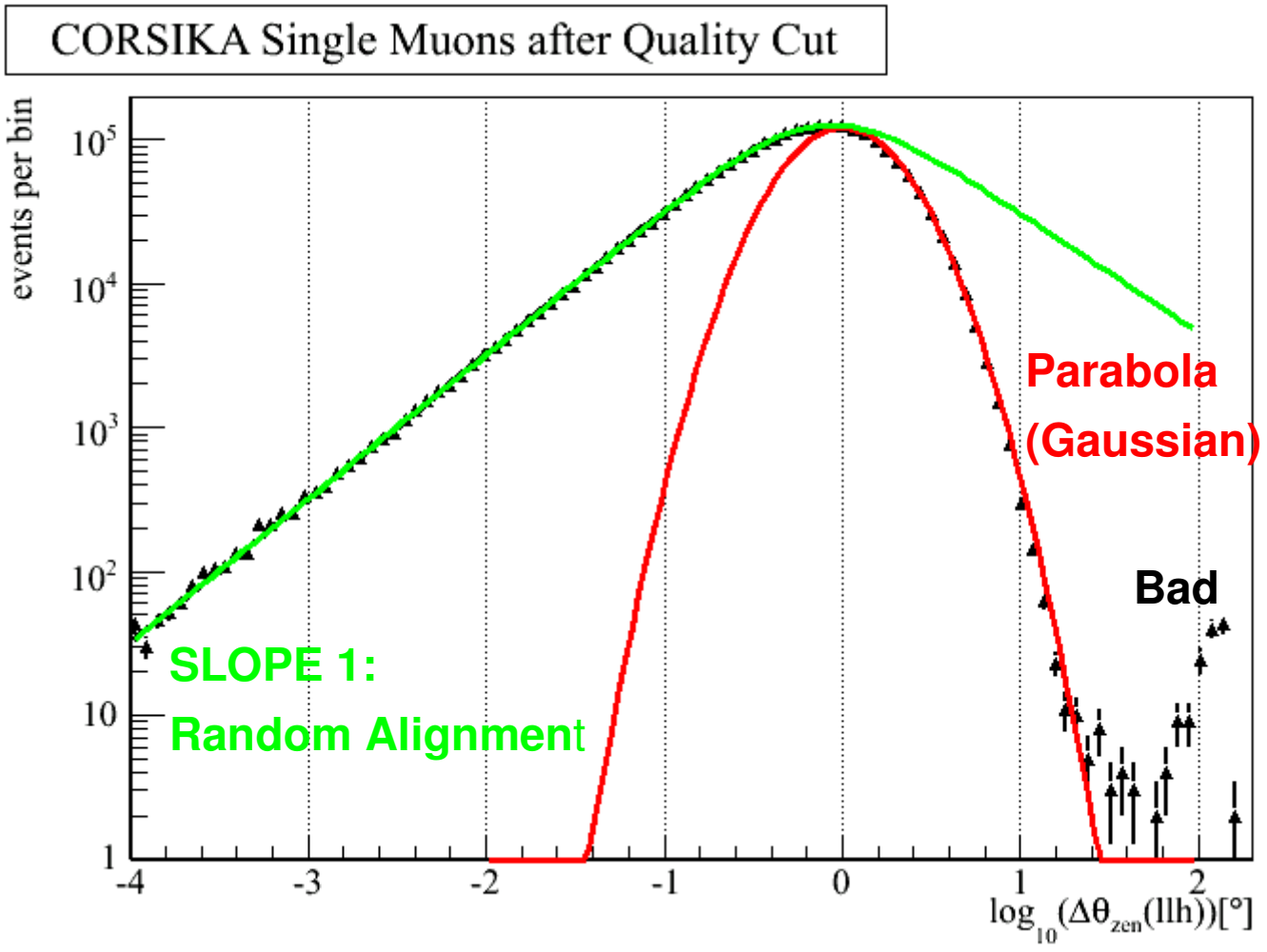


$L_{llh,red}$

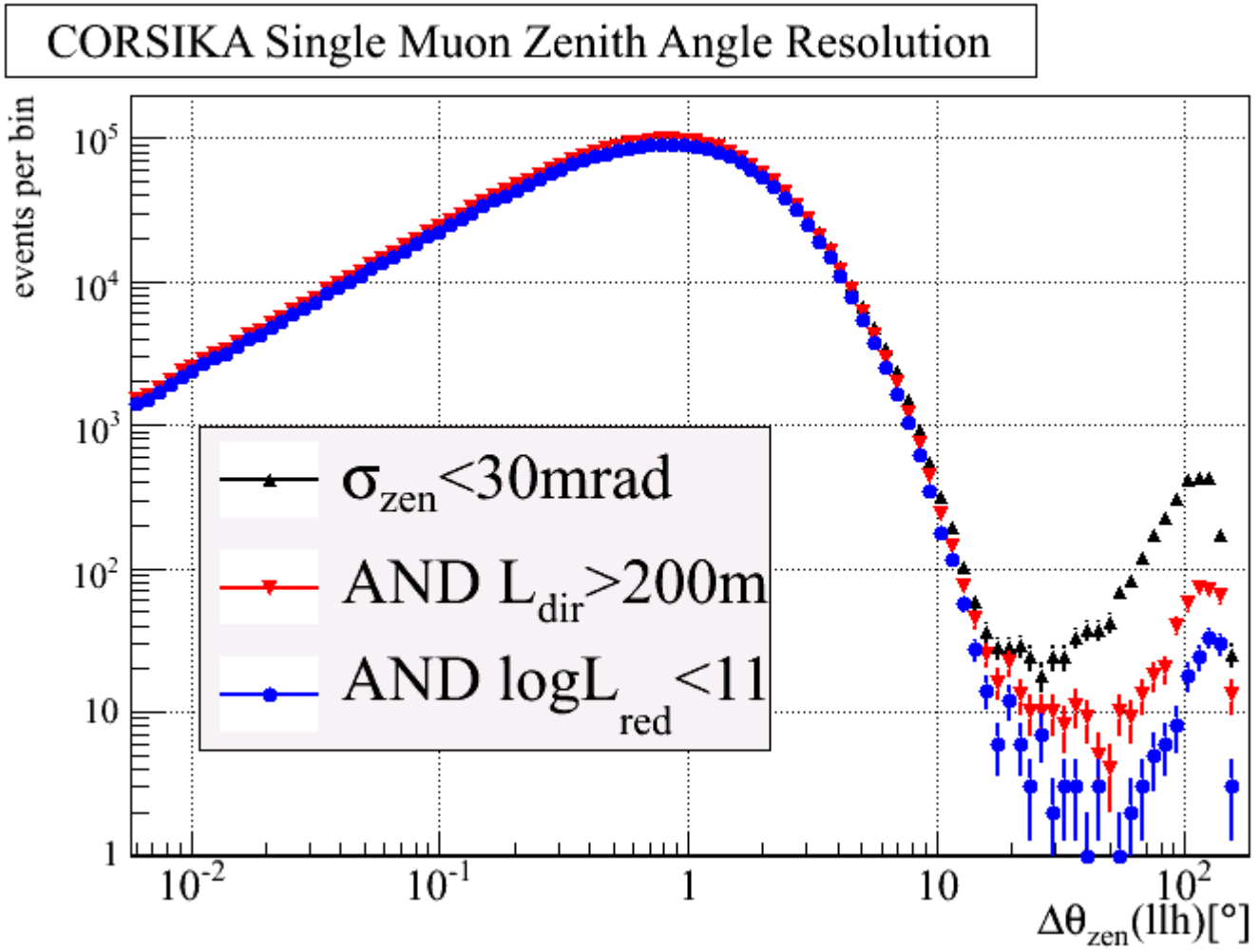
Zenith Angle Resolution



Zenith Angle Resolution

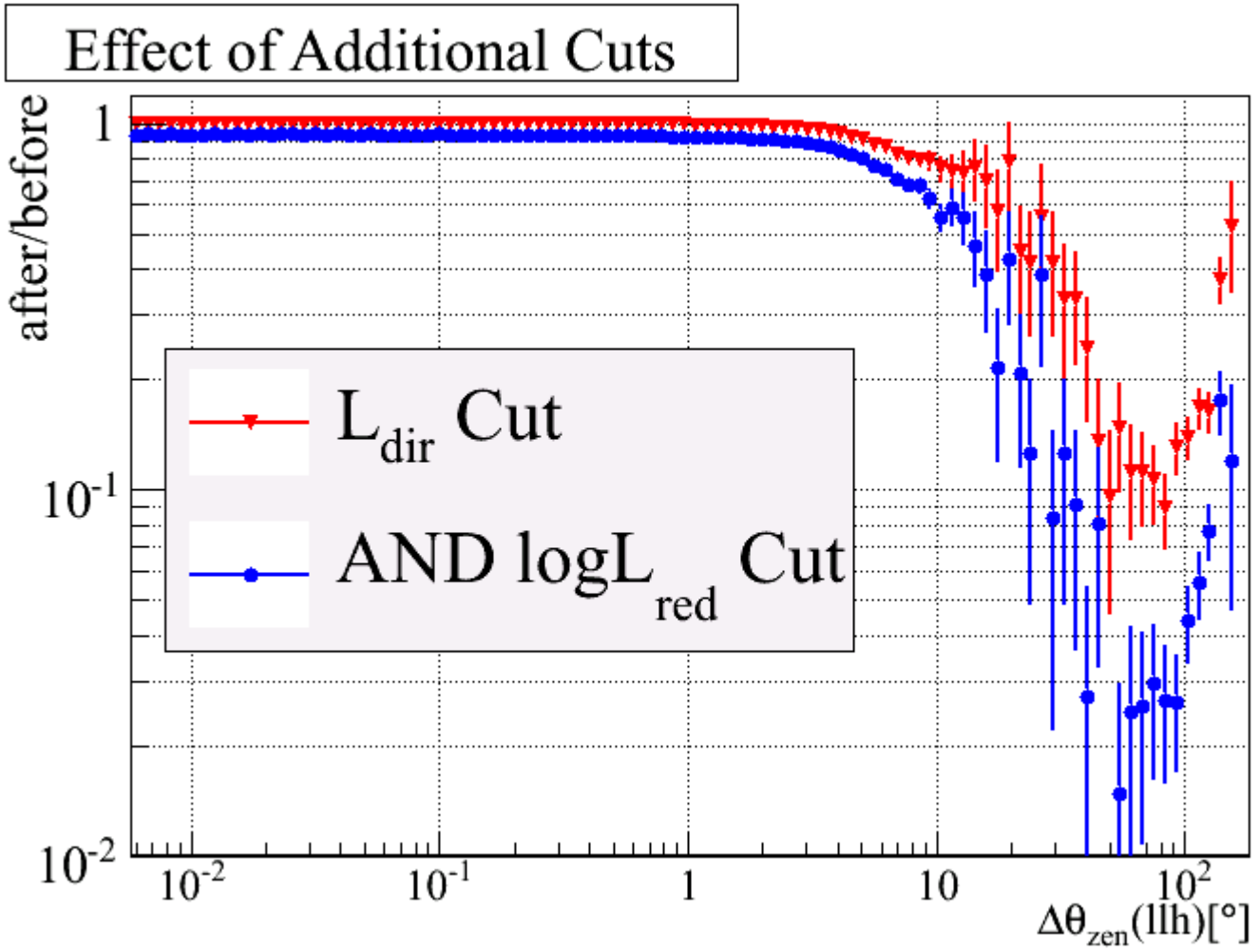


Misreconstructed Tracks

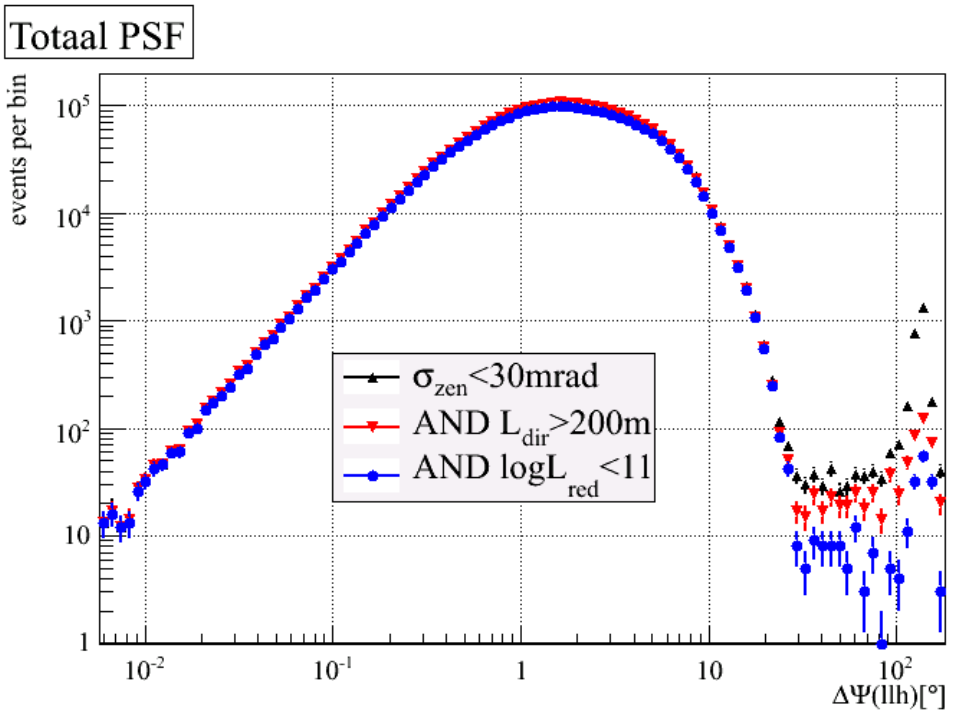


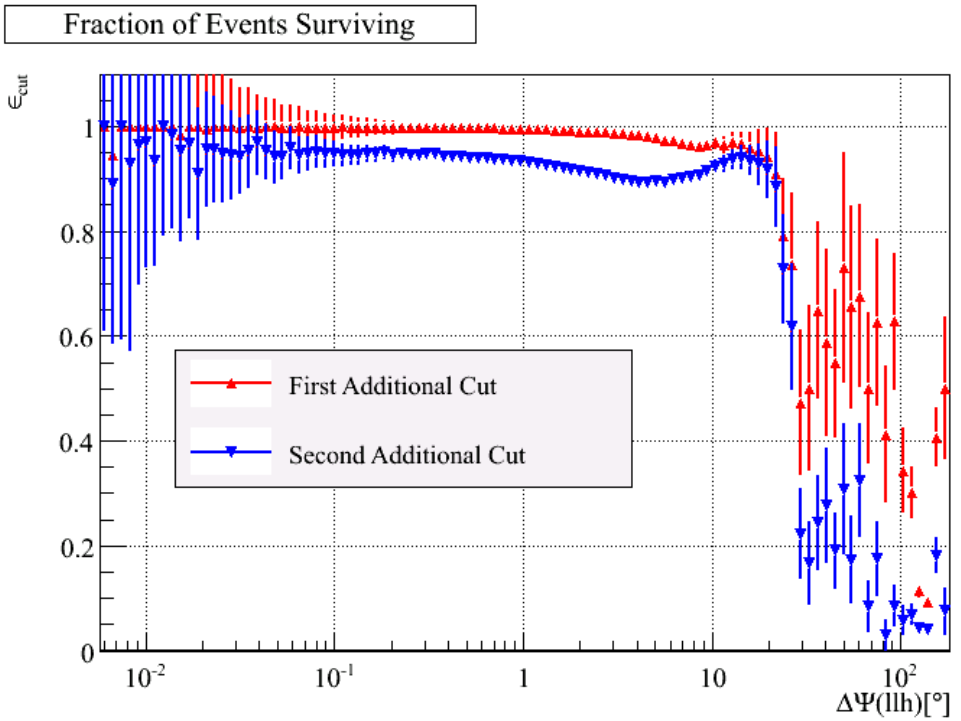
Reduction

Same as Fraction

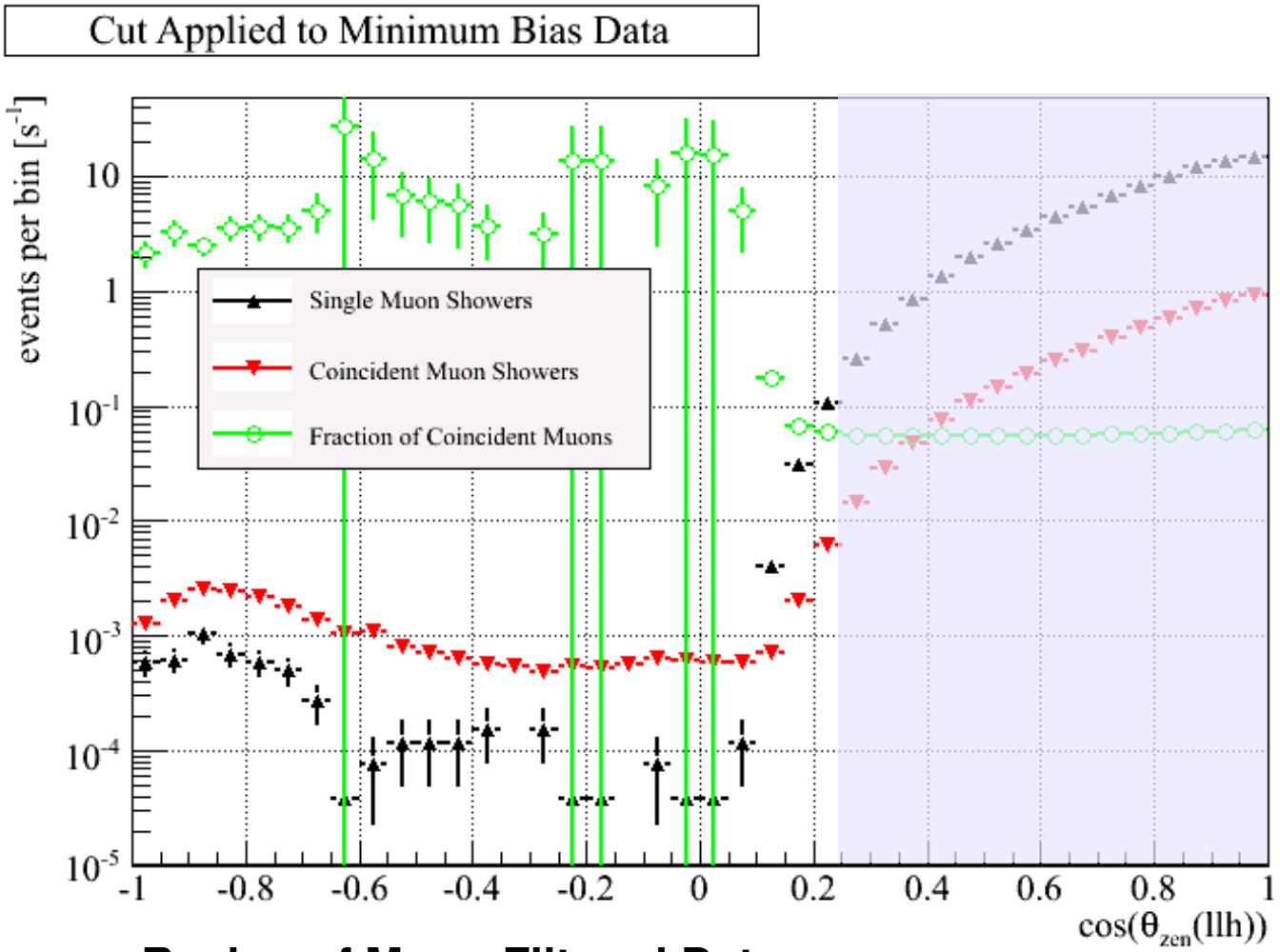


PSF


Totaal PSF
events per bin
10^5
10^4
10^3
10^2
10
1
10^{-2}
10^{-1}
1
10
10^2
ΔΨ(llh)[°]
σ_{zen}<30mrad
AND L_{dir}>200m
AND $logL_{red}$<11

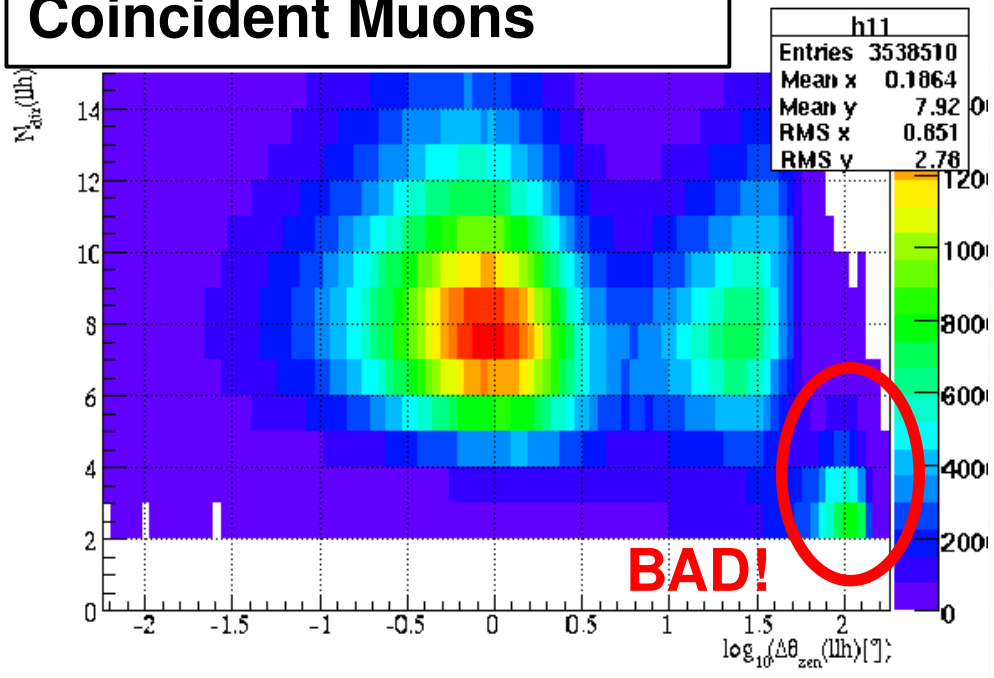

Fraction of Events Surviving
ϵ_{cut}
1
0.8
0.6
0.4
0.2
0
10^{-2}
10^{-1}
1
10
10^2
ΔΨ(llh)[°]
First Additional Cut
Second Additional Cut

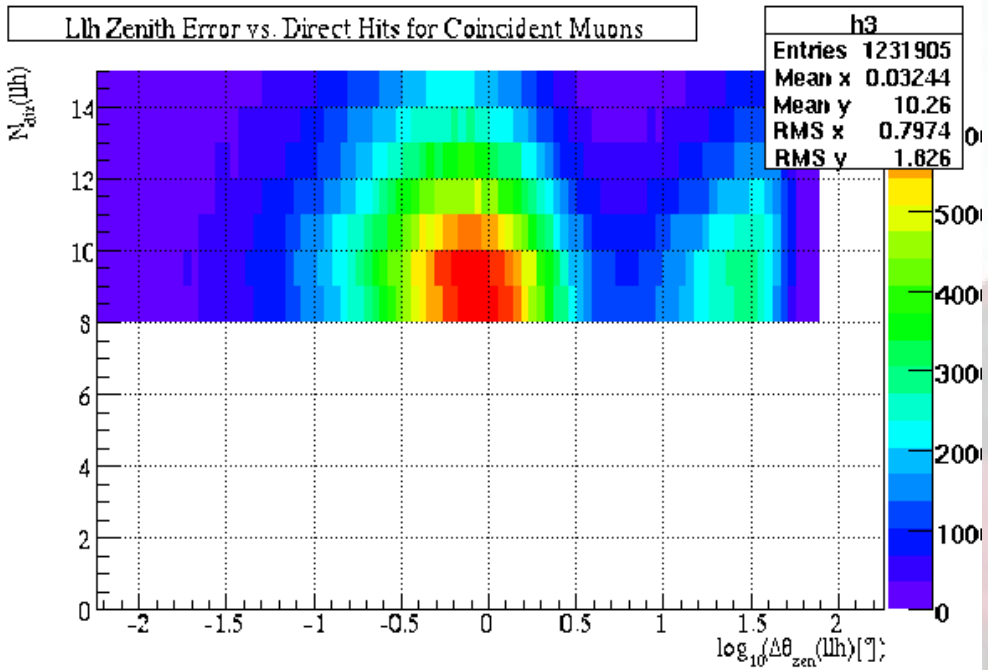
After First Cut



Region of Muon-Filtered Data

Coincident Muons





Muon Filter Cuts

$\log L_{red} < 9$

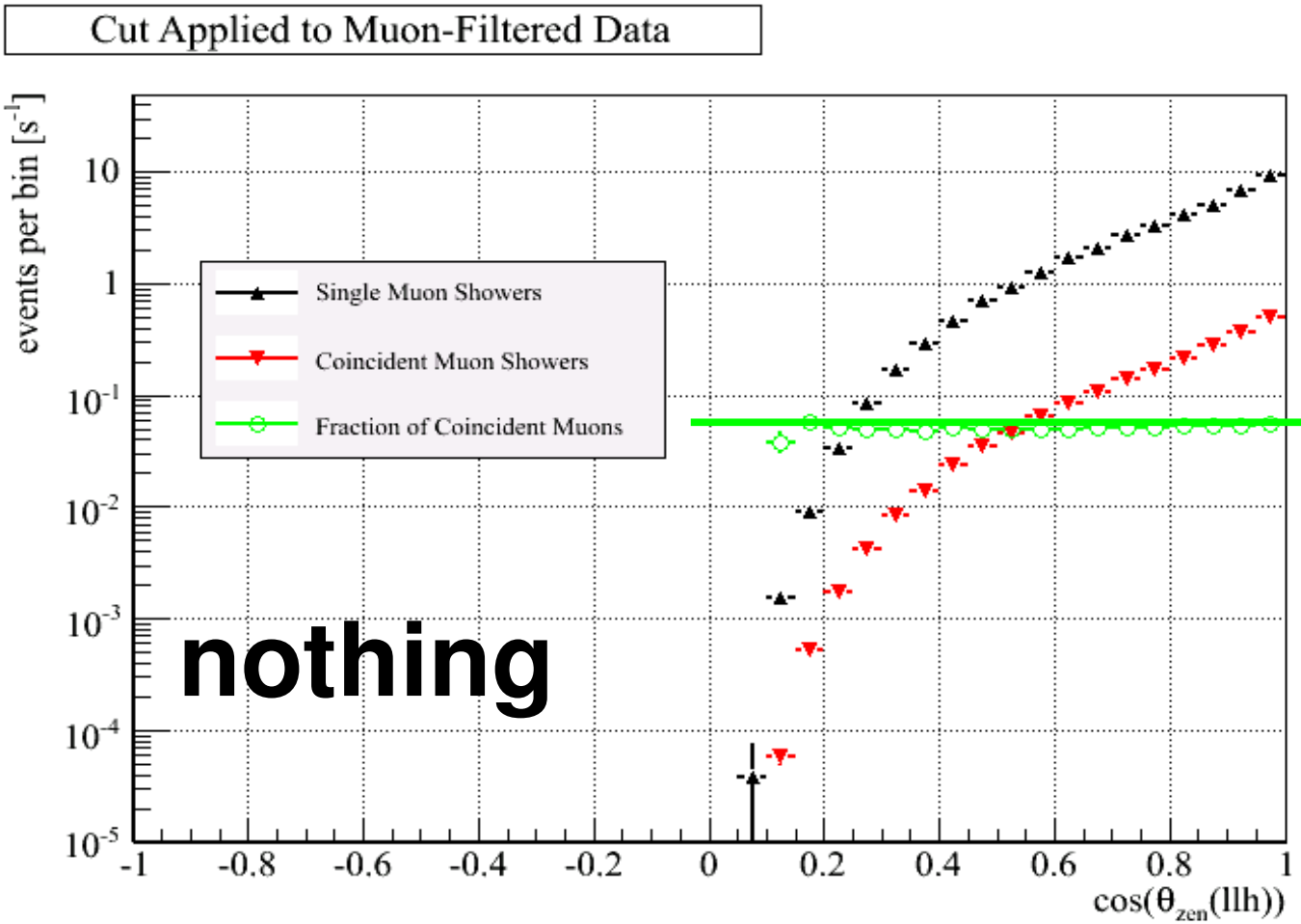
$\Psi_{subtracks} < .7\text{rad}$

$.15\text{m/ns} < v_{LF} < .40\text{m/ns}$

$-.4 < Smooth_{all} < .4$

$N_{dir}(75\text{ns}) < 7$

Final Cut Level

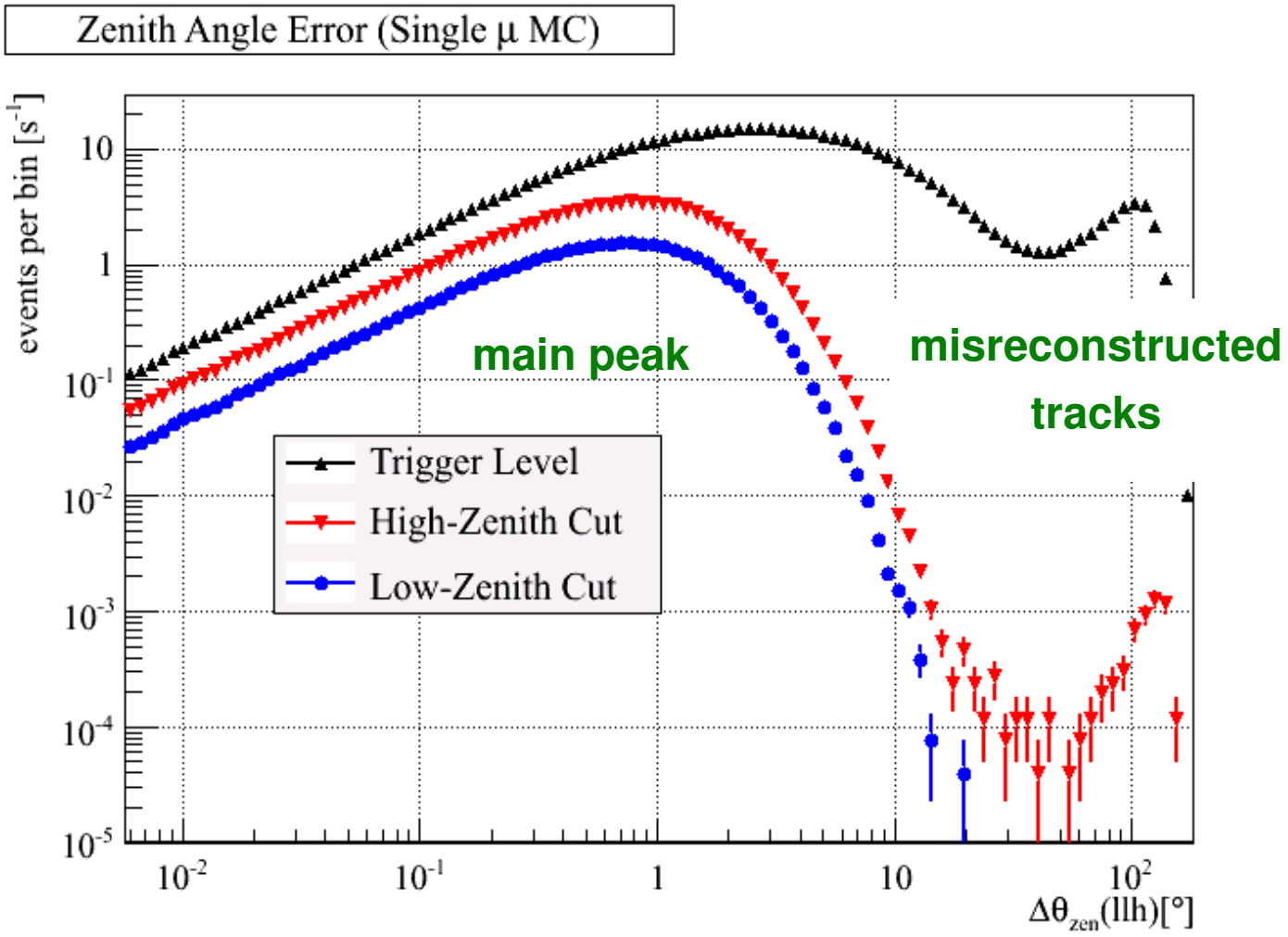


Coincident

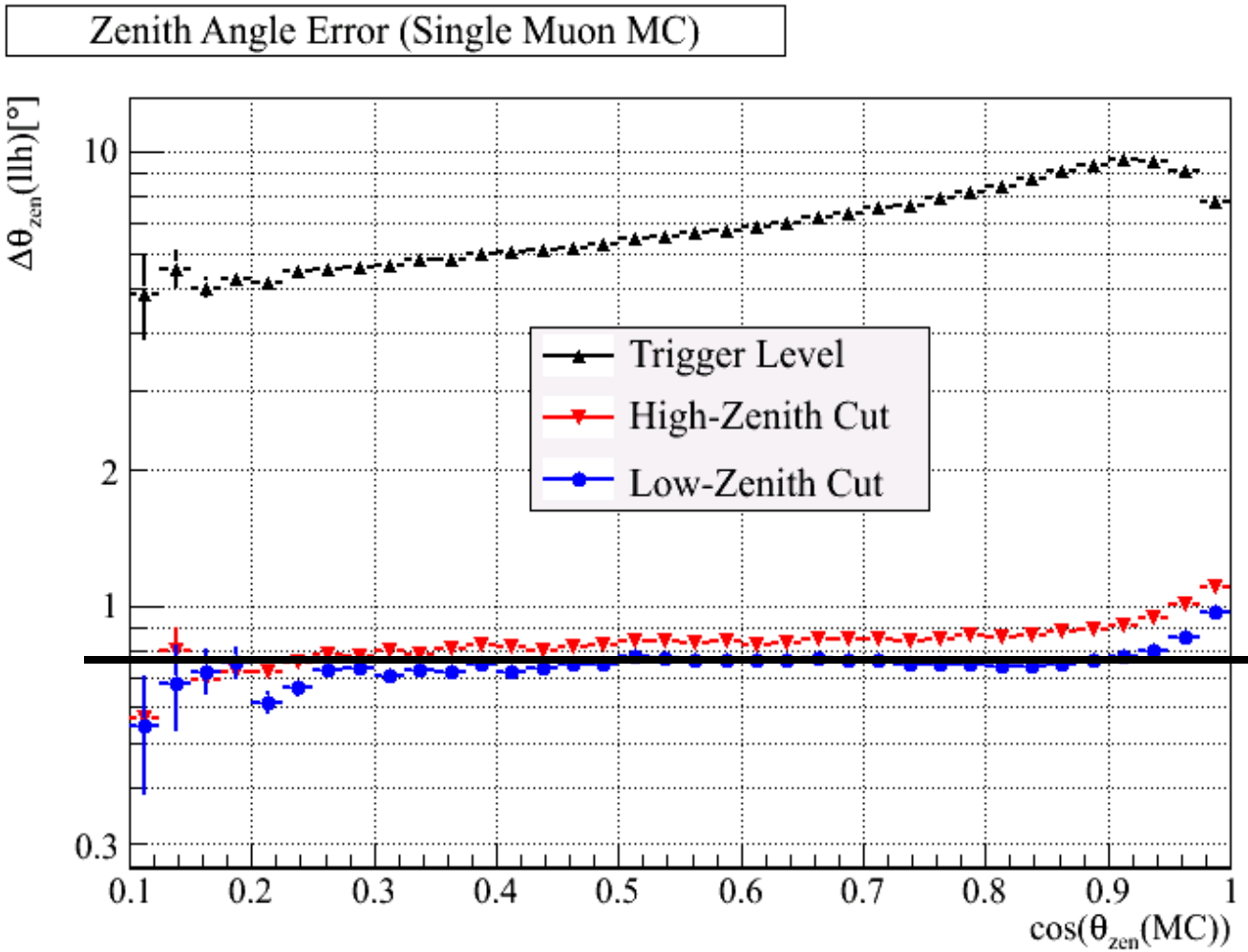
=

Single

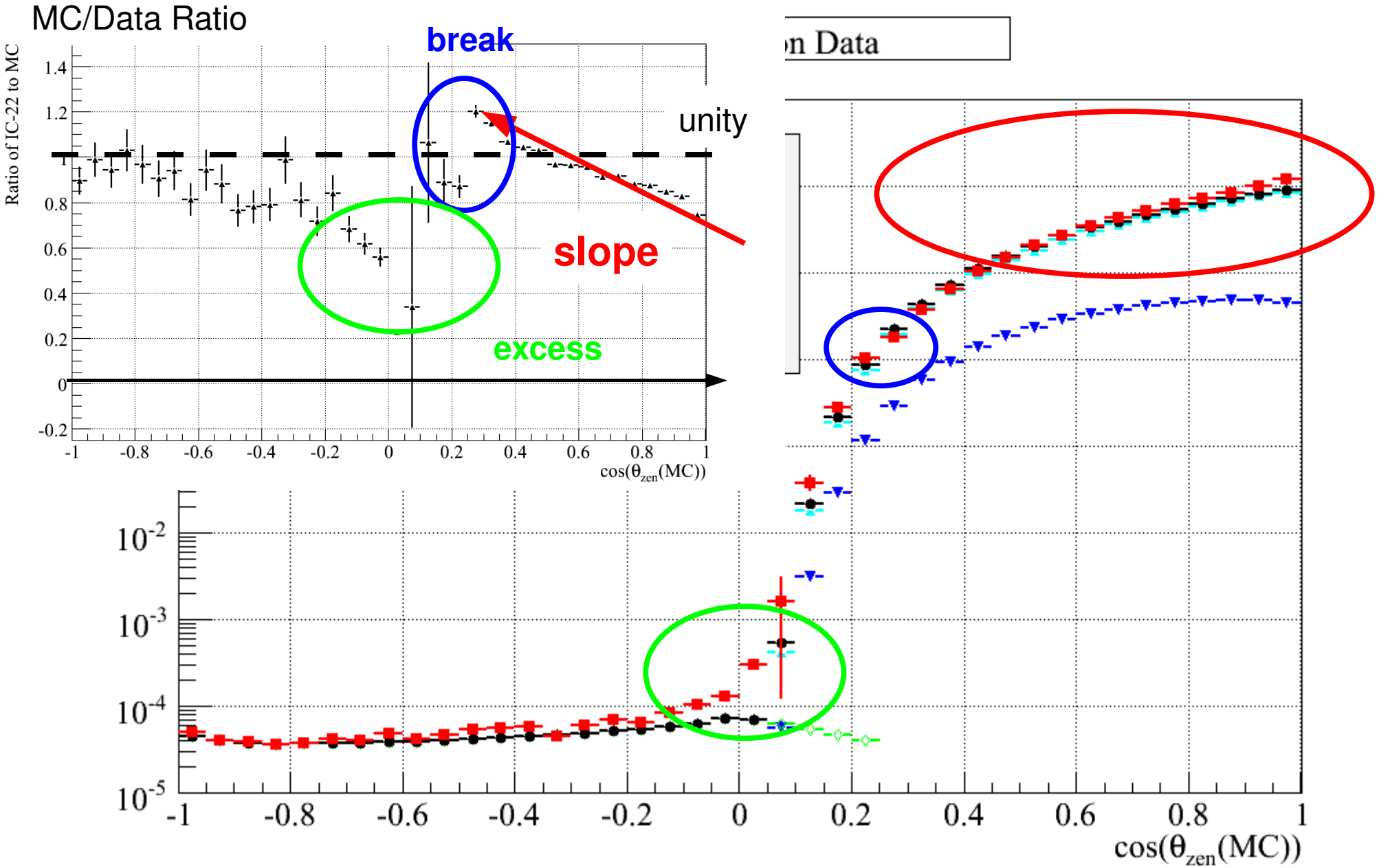
Zenith Angle Resolution

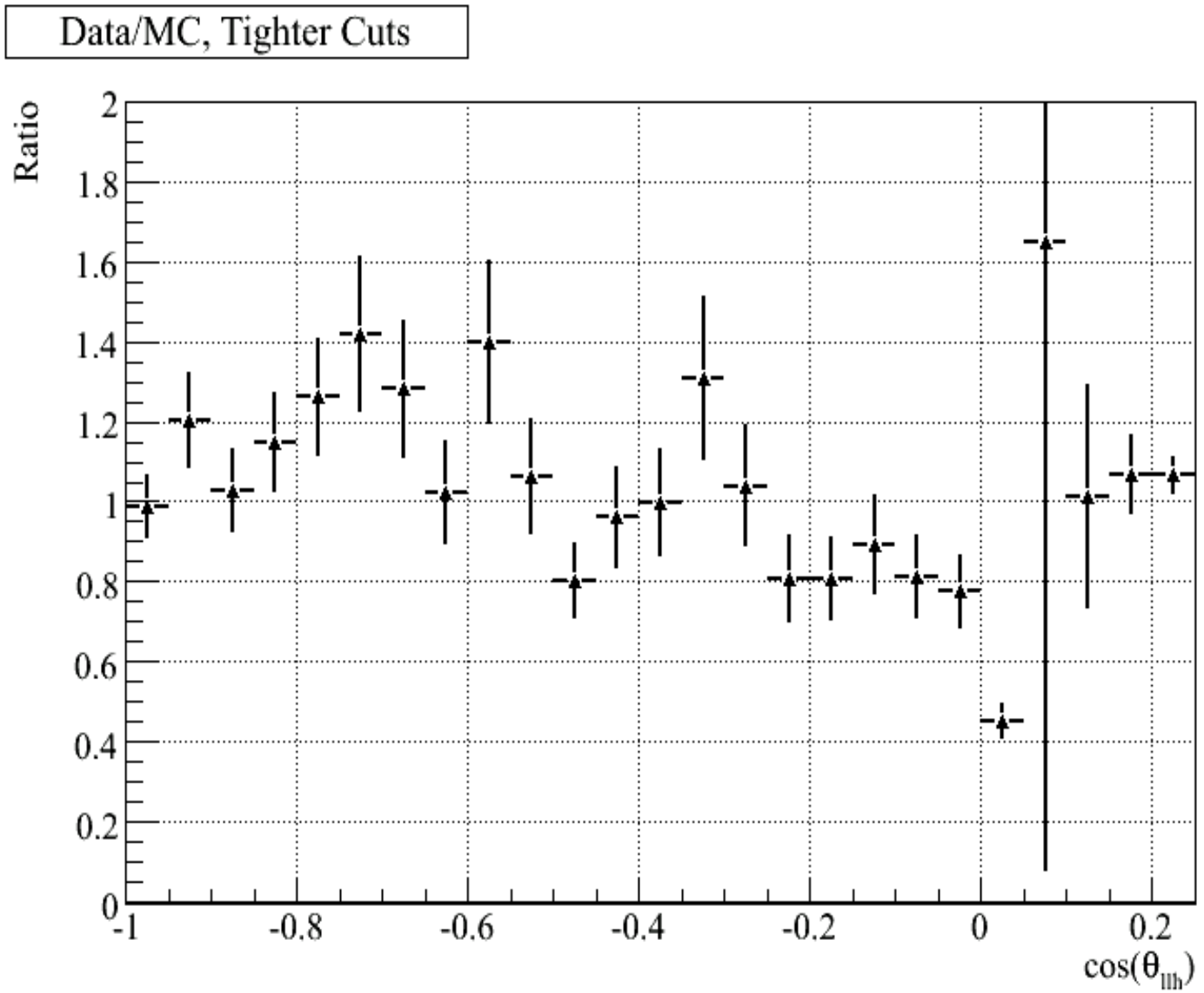


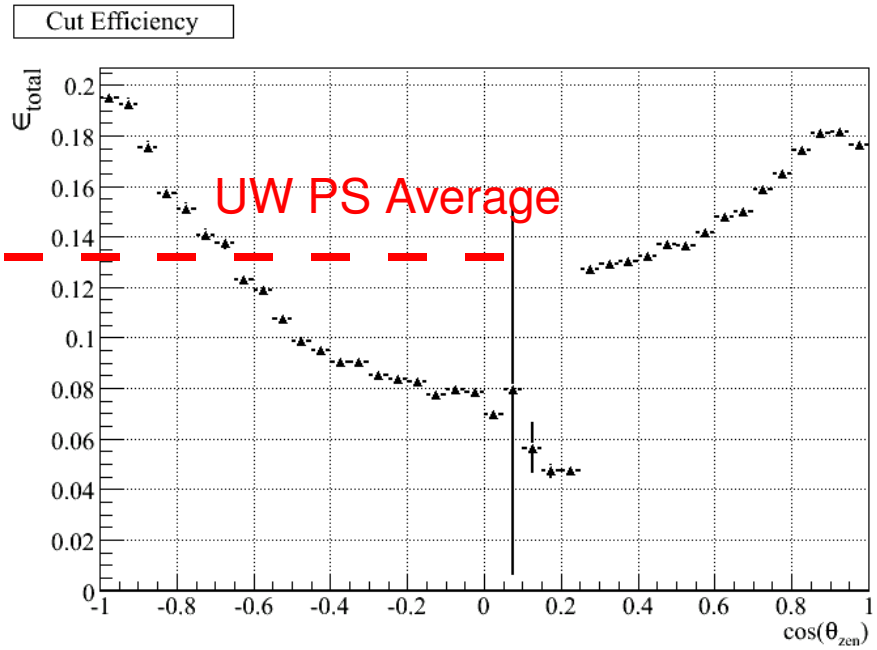
Zenith Angle Resolution

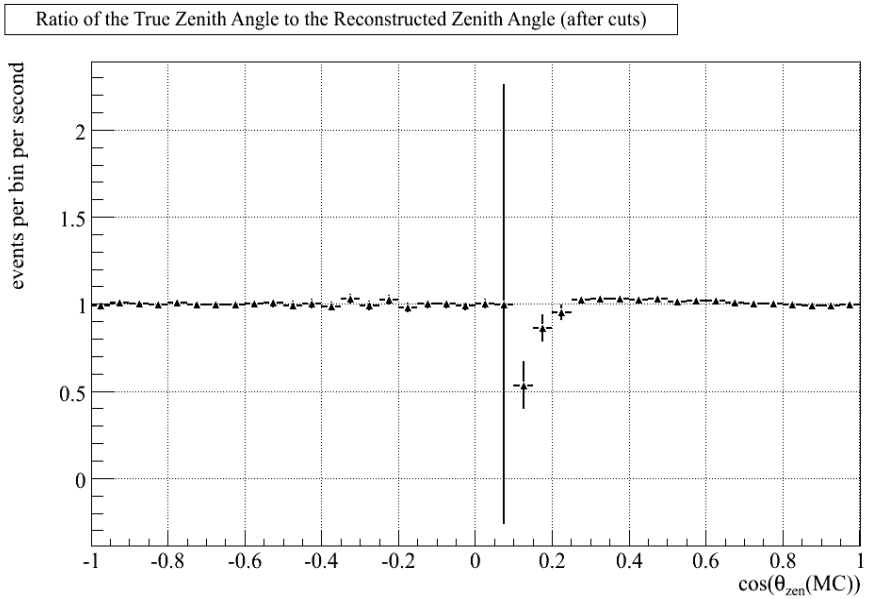


0.7-0.8°


MC/Data Ratio
break
unity
slope
excess
Ratio of IC-22 to MC
cos(θzen(MC))
n Data
cos(θzen(MC))


Data/MC, Tighter Cuts
Ratio
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
cos(θ_llh)

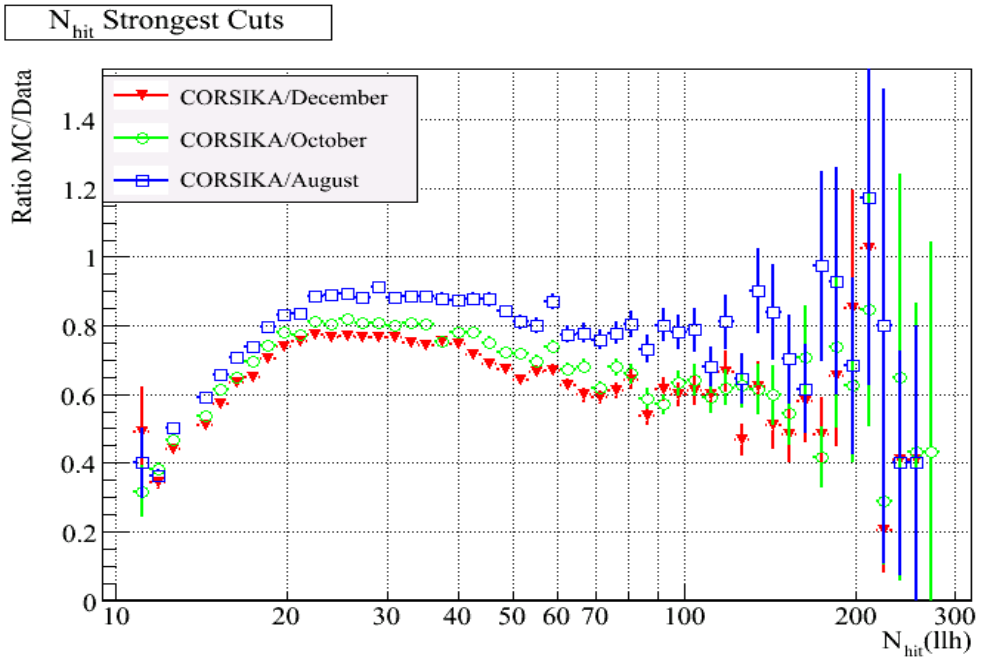


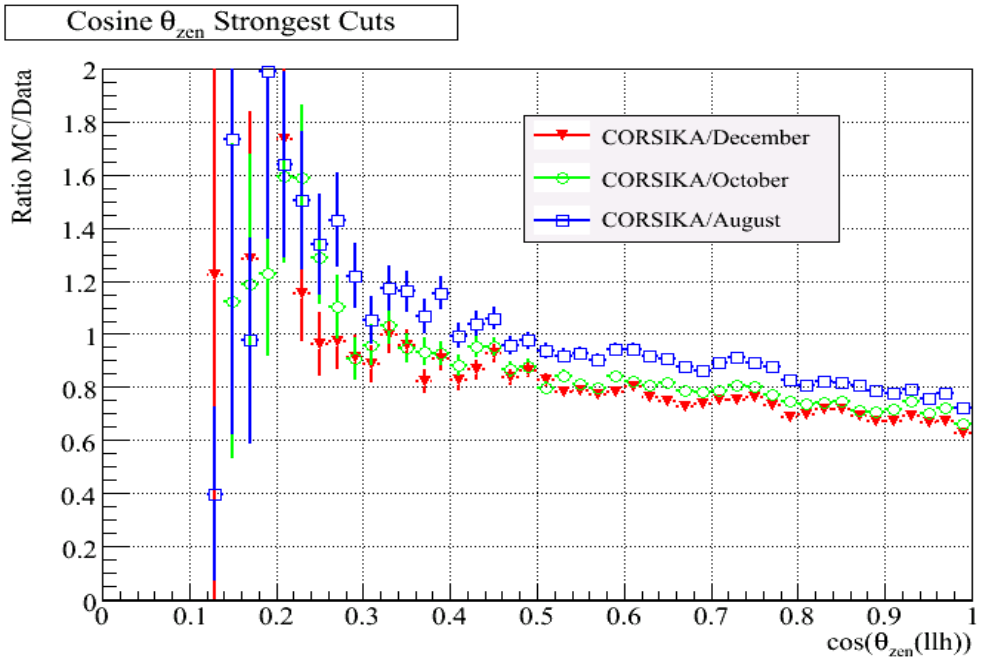


Efficiency

True over Reco Angle

Minimum Bias Strongest Cuts

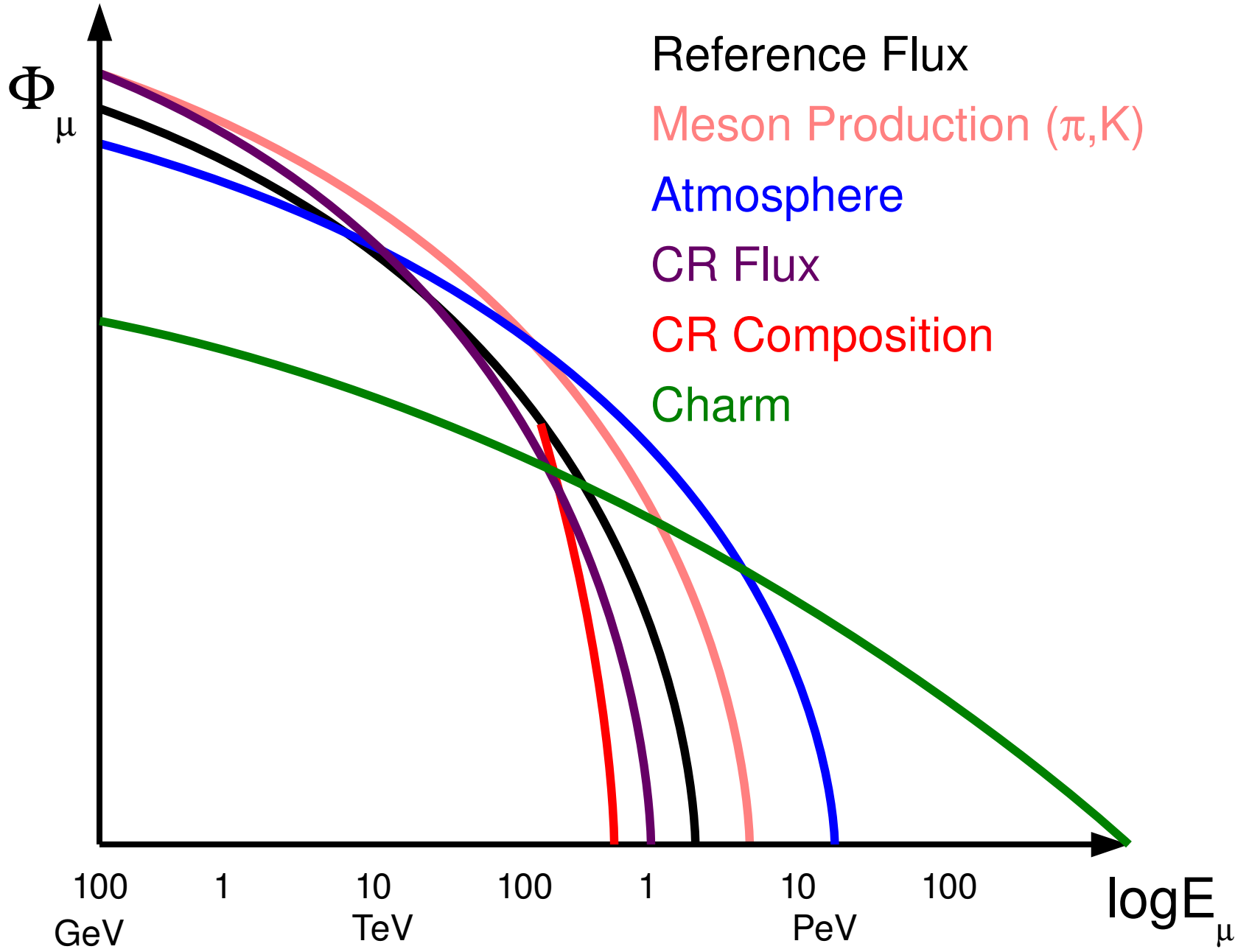




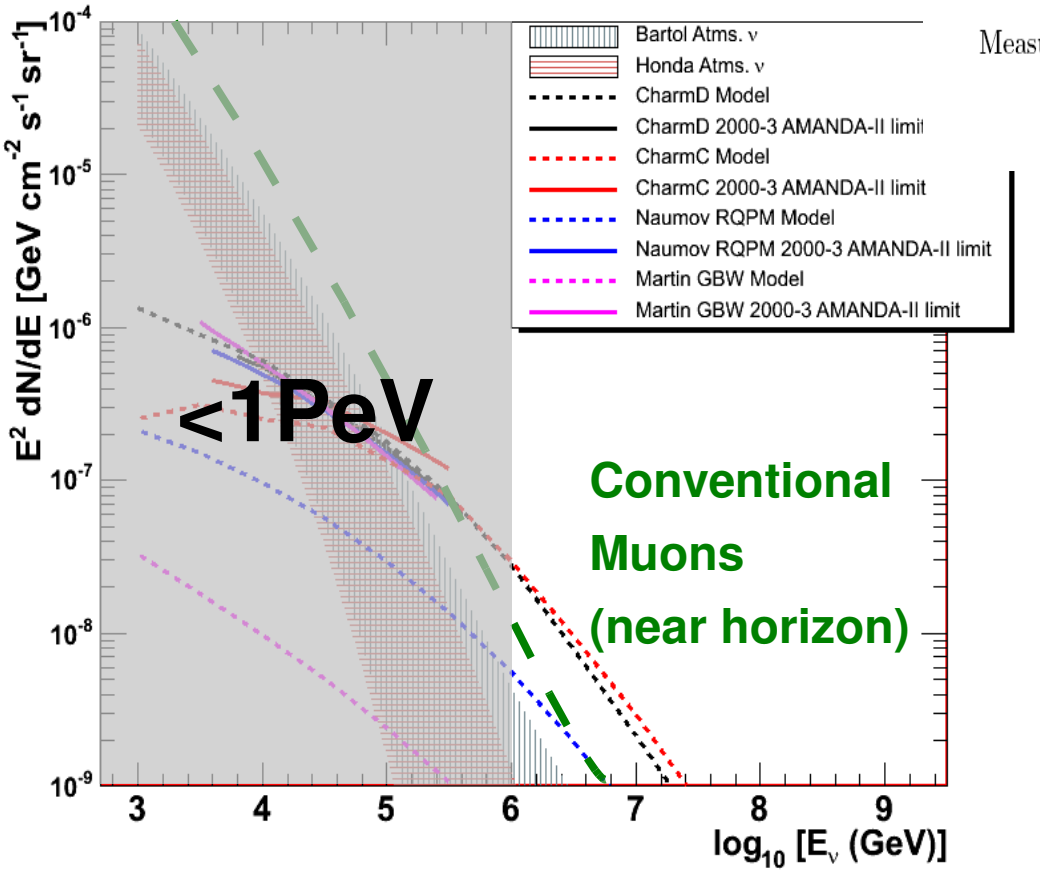
N_{hits}

cosθ

Physics?


Φ μ
Reference Flux
Meson Production (π,K)
Atmosphere
CR Flux
CR Composition
Charm
100
GeV
1
10
TeV
100
1
10
PeV
100
logE μ

Prompt Muons



UCLA/02/TEP/23, CWRU-P13-02, NSF-ITP-02-97

Measuring the prompt atmospheric neutrino flux with down-going muons in neutrino telescopes

Graciela Gelmini[1], Paolo Gondolo[2], and Gabriele Varieschi[3]

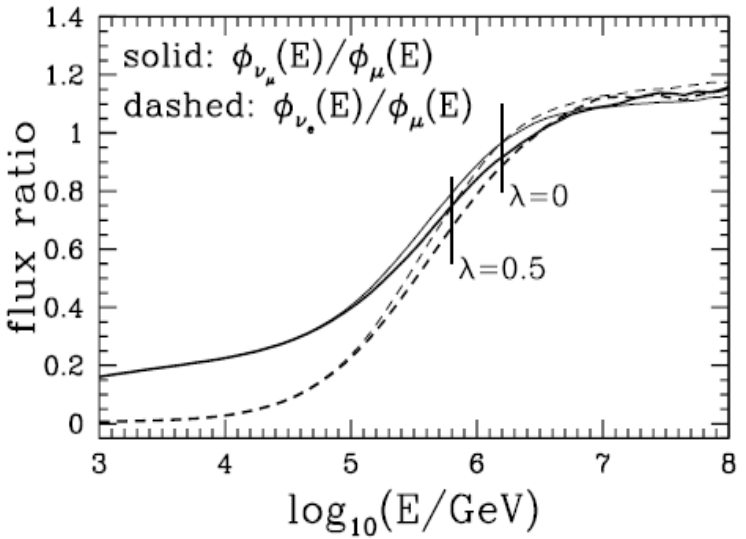
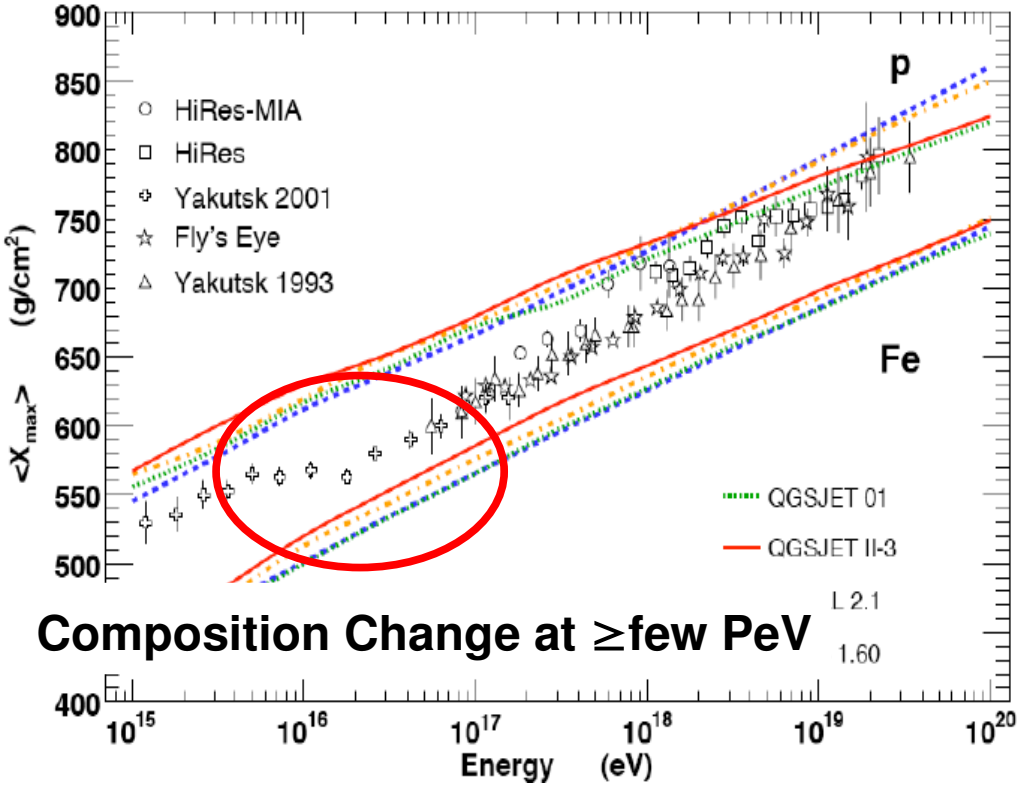


FIG. 4. Total neutrino-over-muon ratio as a function of lepton energy. Vertical marks denote the crossing energy from conventional to prompt muons.

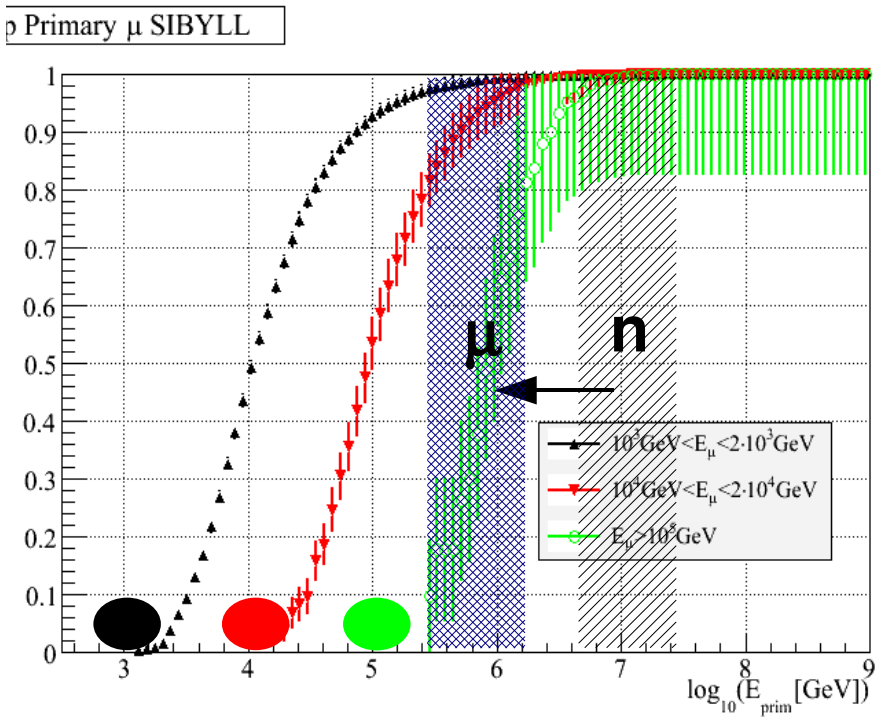
CR Composition

$\overline{E}_{prim,nucleon} \; ! \; / E_{\mu} \leq 10$

(T.K.Gaisser, "CR&Part.Phys.")



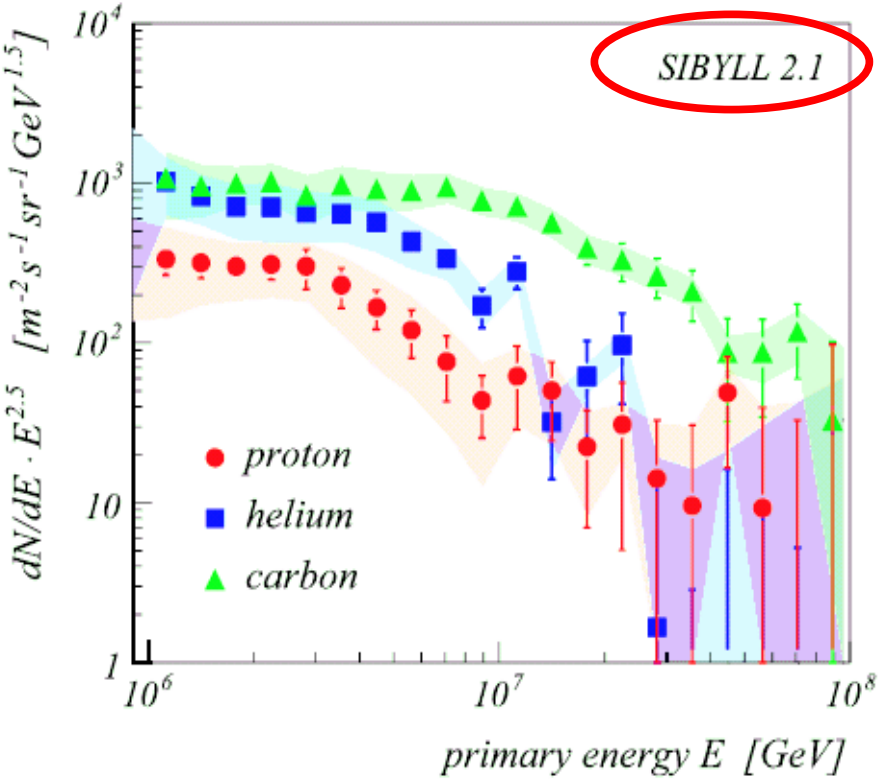
Composition Change at ≥few PeV

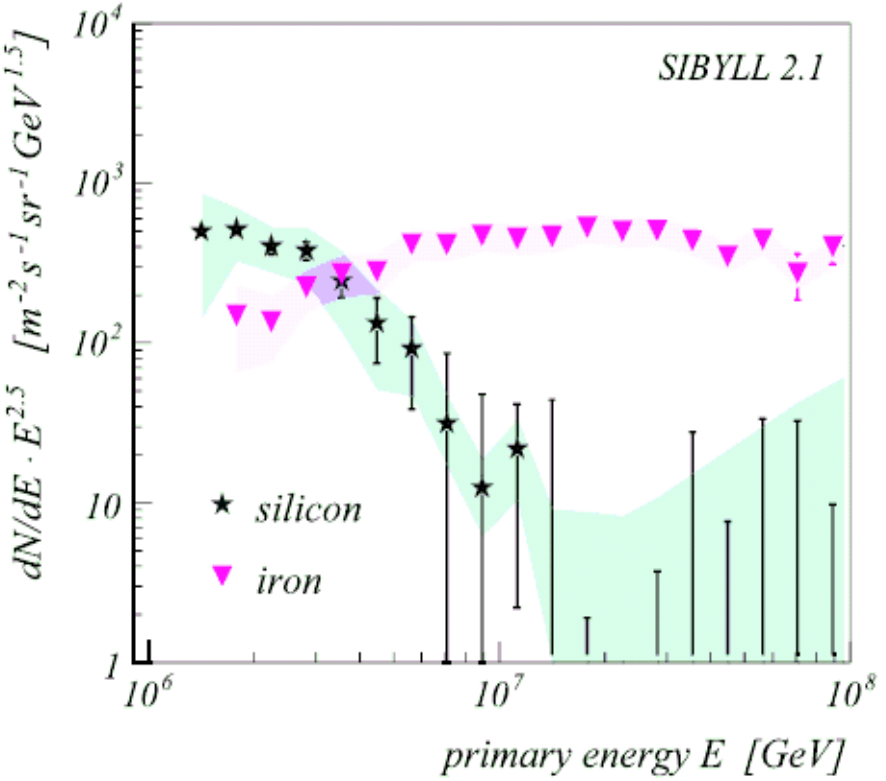


Same Energy Region as Charm!

KASCADE Composition

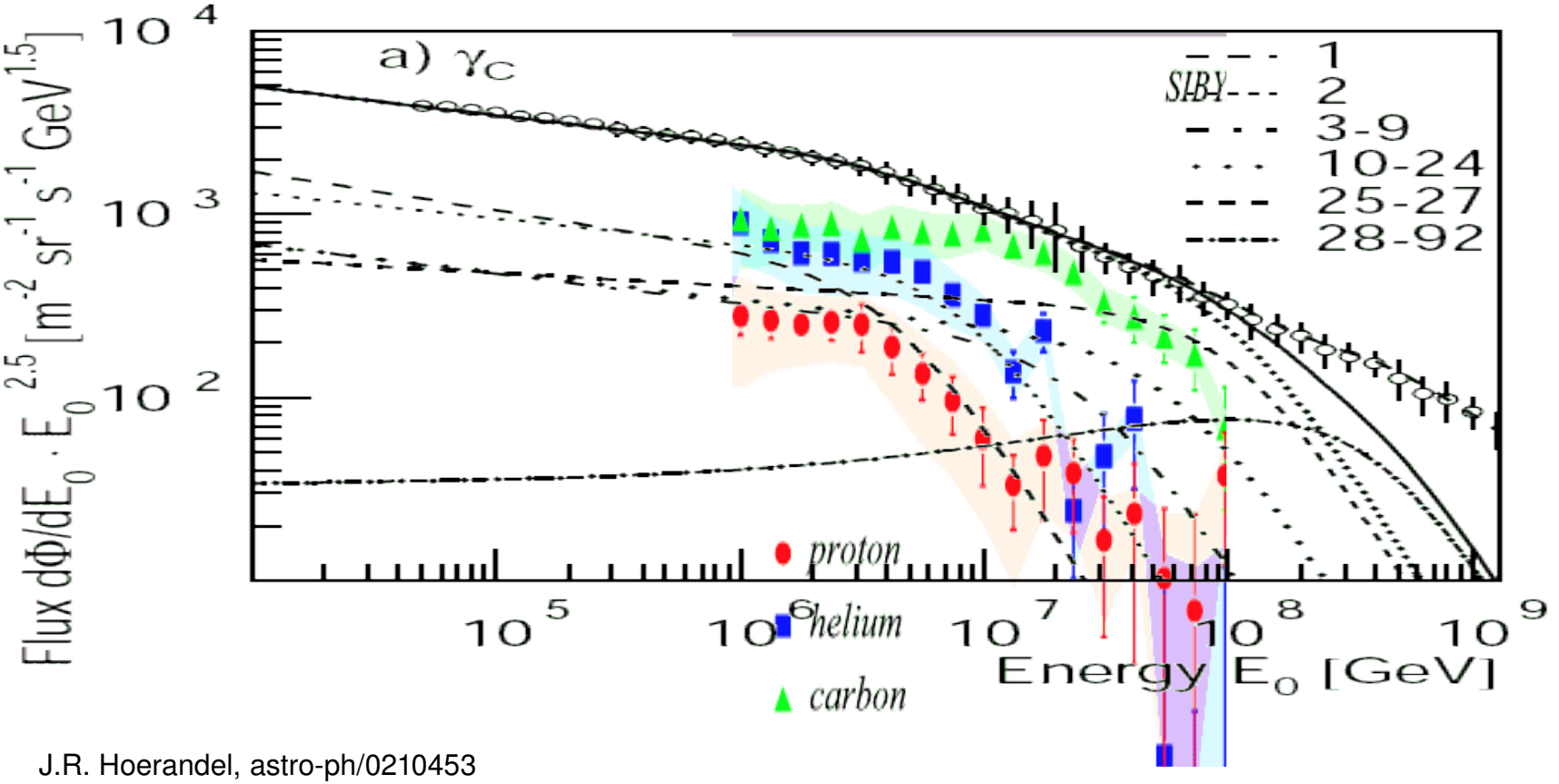
model-dependent





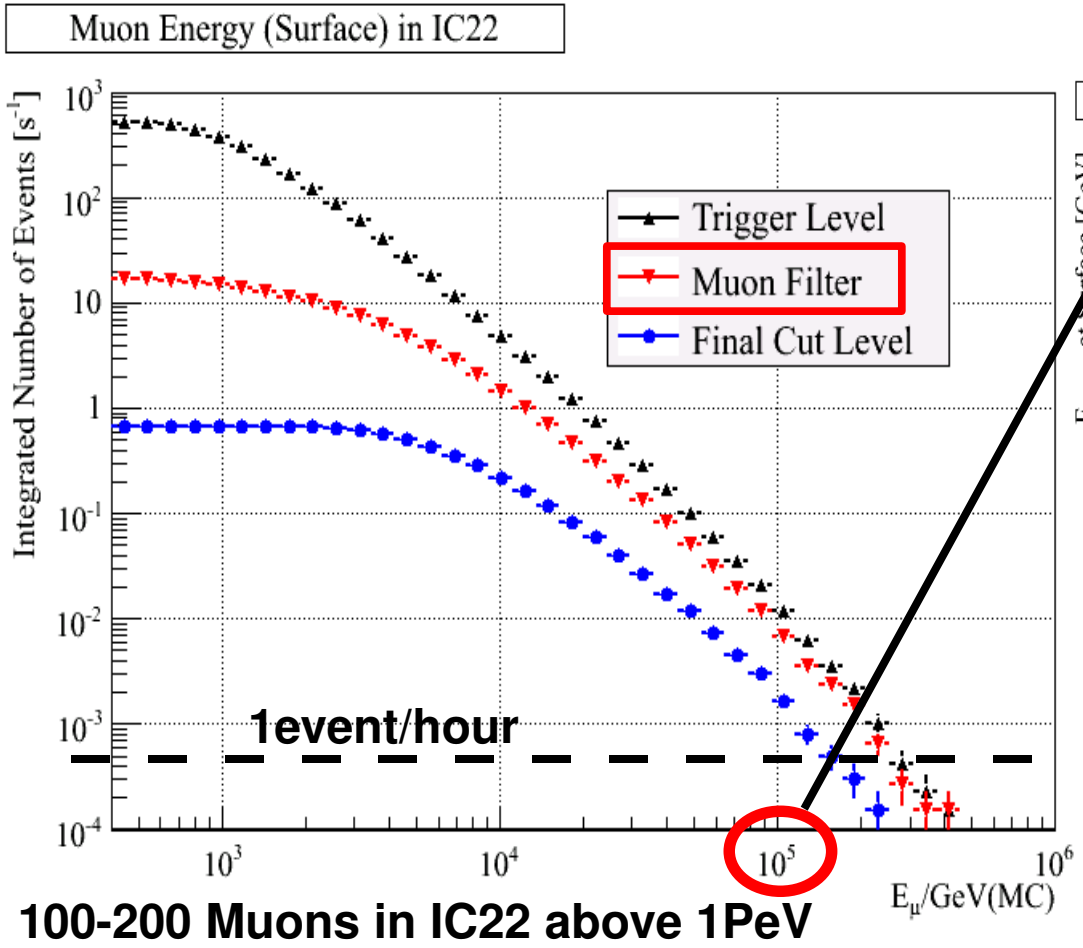
astro-ph/0505413

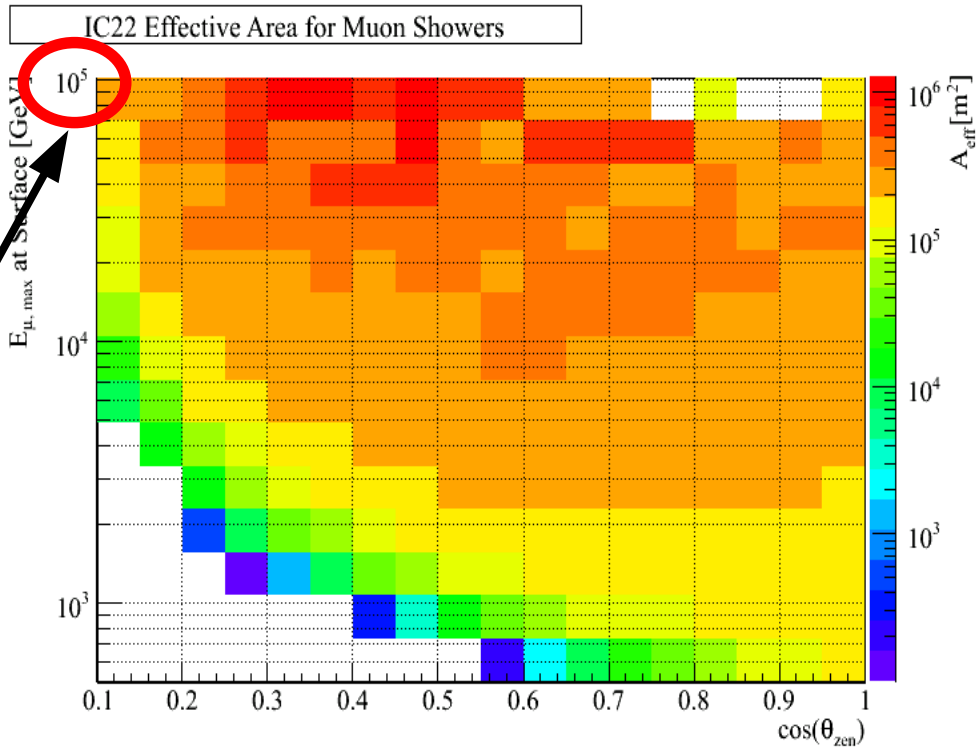
“Poly-Gonato” Model



J.R. Hoerandel, astro-ph/0210453

IceCube Muon Rates





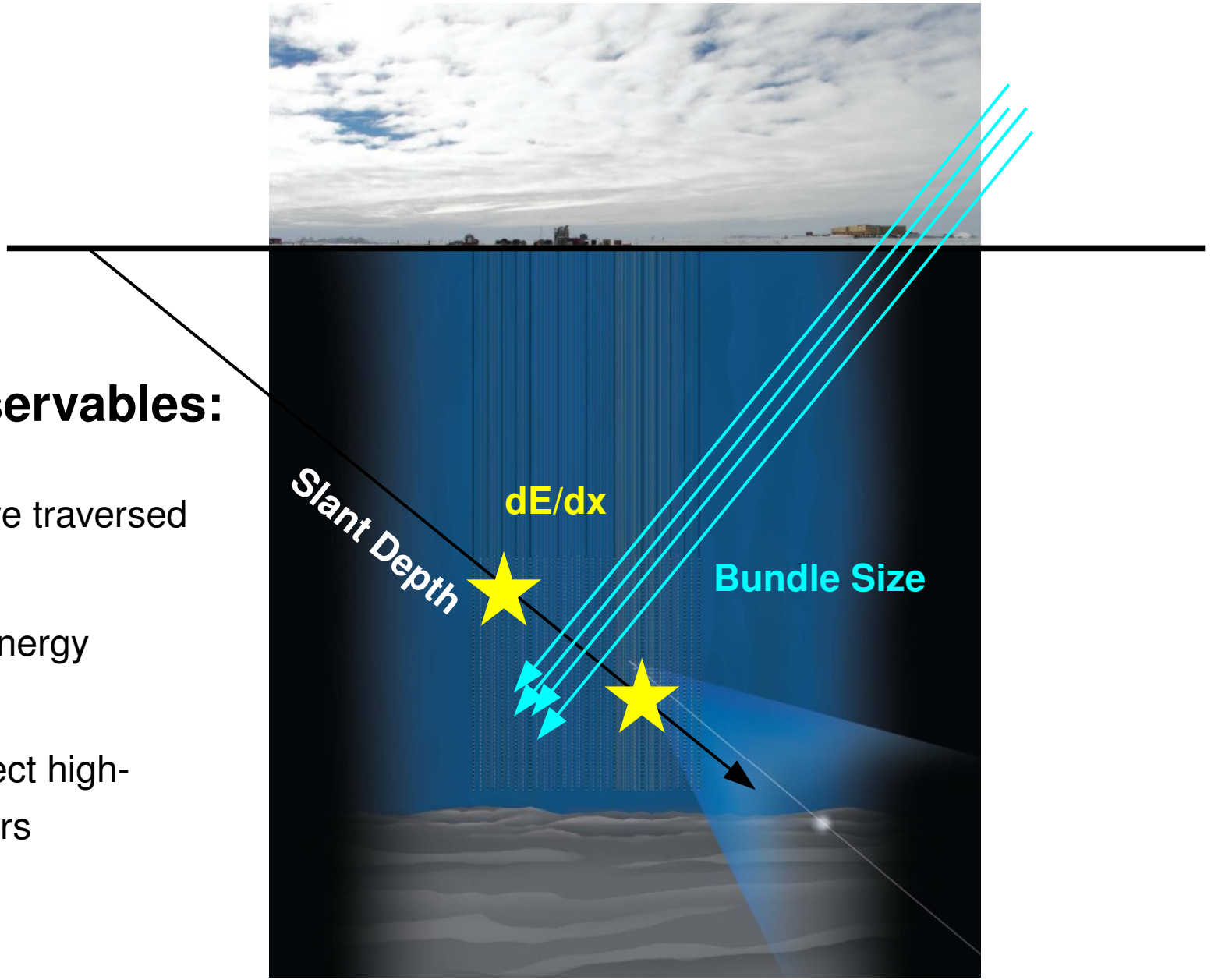
100-200 Muons in IC22 above 1PeV

Essential Observables:

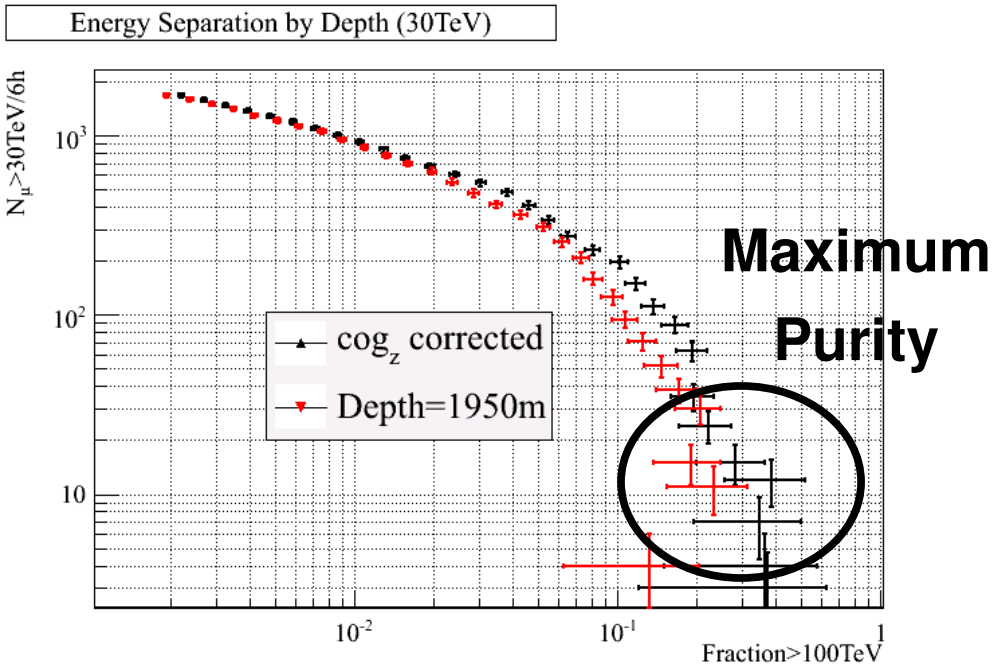
Slant Depth: mwe traversed

dE/dx: shower energy

Bundle Size: reject high-multiplicity showers

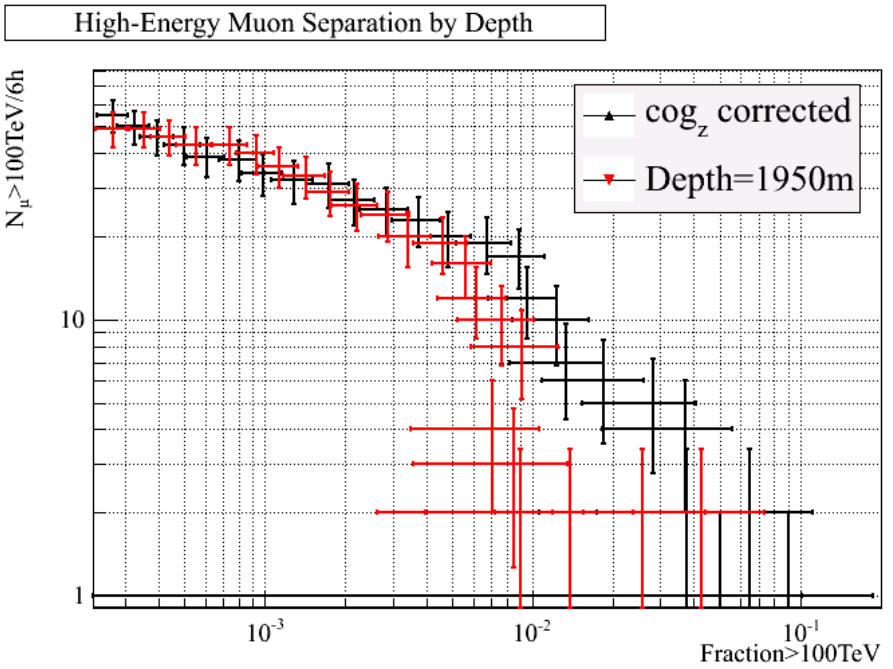


Separation by Slant Depth



Maximum Purity

30TeV



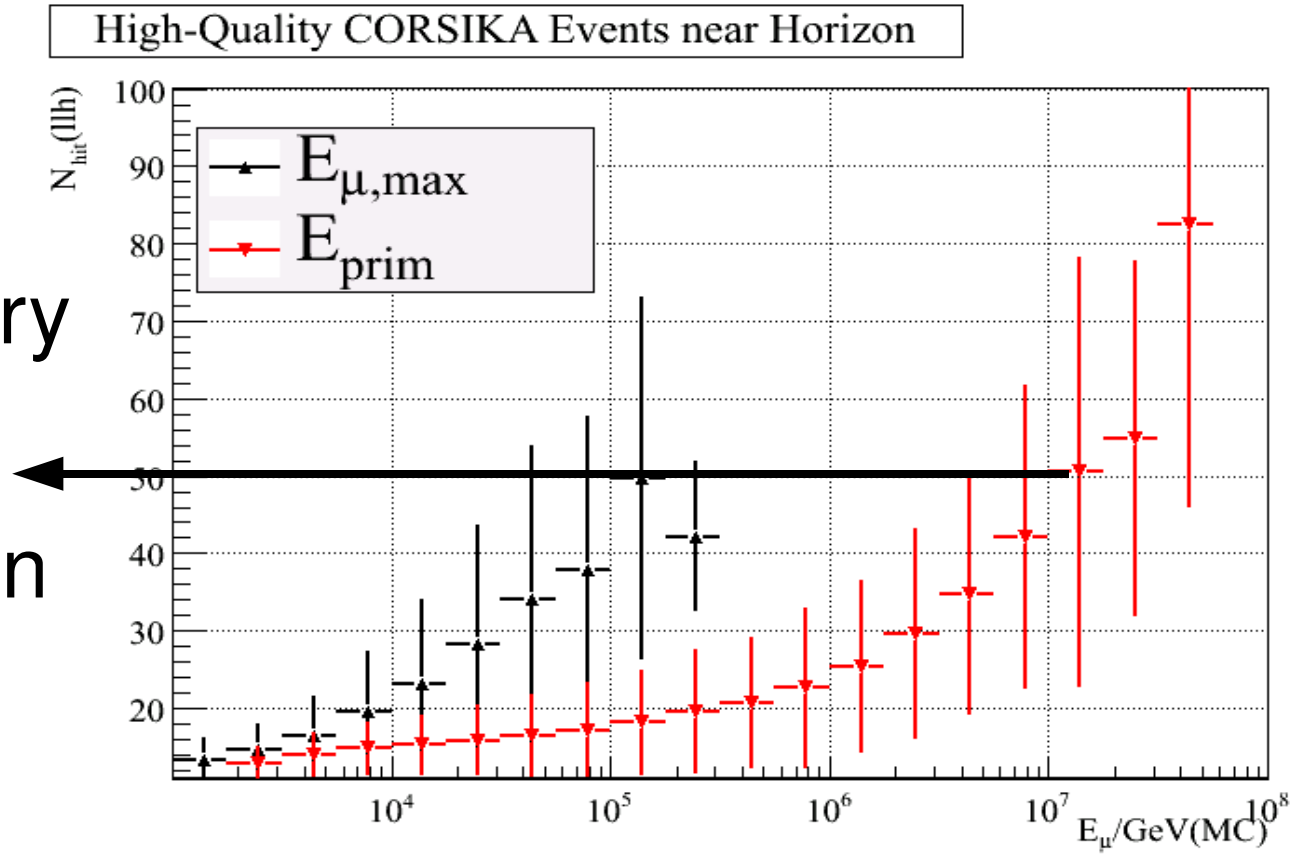
100TeV

Separation by Energy

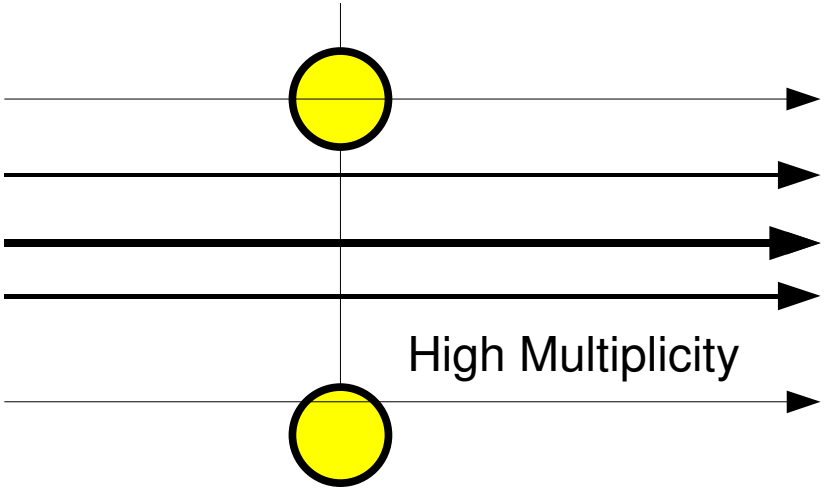
10PeV Primary

=

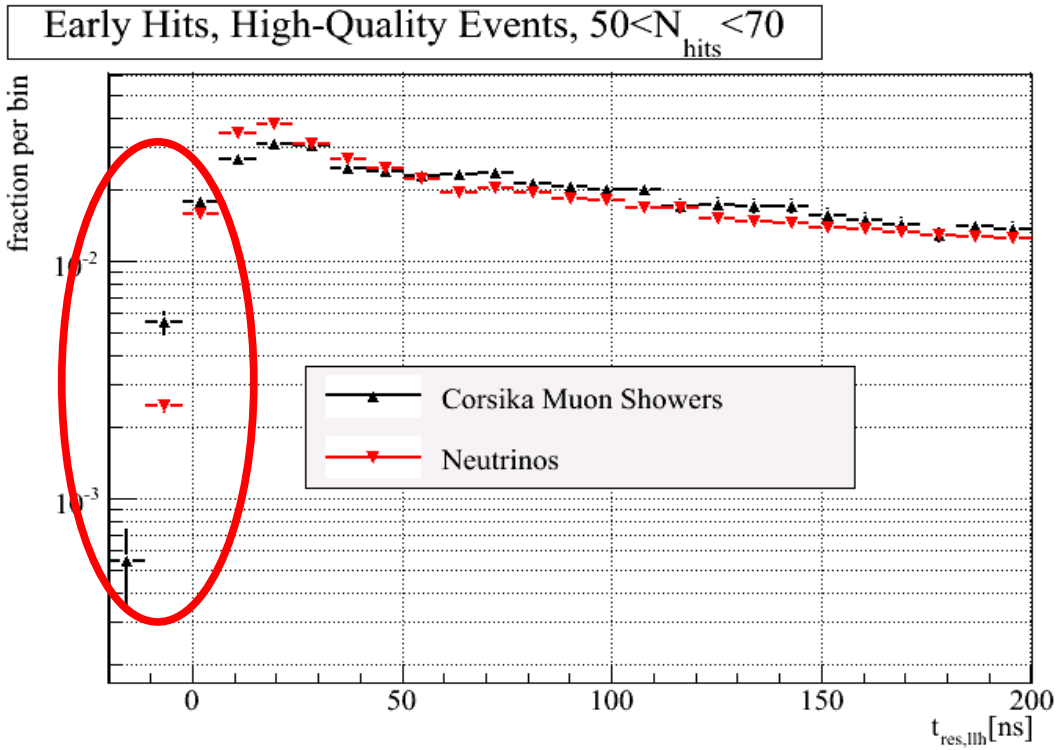
100TeV muon



Separation by Early Hits



Showers produce more early hits!



Next Steps

* Photonics/Ice!
* CORSIKA near horizon
* High-E Muon Analysis