Atmospheric μ data vs MC with KM3NeT detectors & prompt μ analysis

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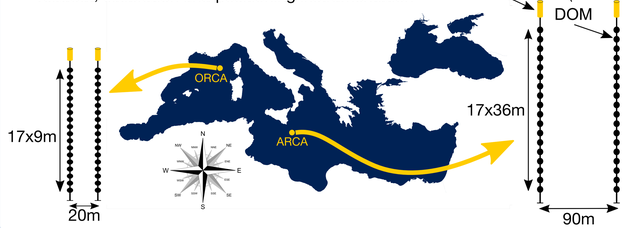
#1 KM3NeT

KM3NeT - neutrino telescope research infrastructure in the Mediterranean Sea [1]

Two detectors:
- ARCA (astroparticle physics, 3.5 km underwater)
- ORCA (oscillation physics, 2.5 km underwater)

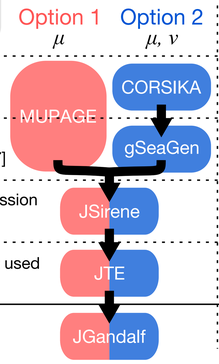
Structure:
- vertical detection units (DUs)
- each DU: 18 digital optical modules (DOMs)
- every DOM: 31 3" photomultiplier tubes (PMTs) plus readout, calibration and positioning instrumentation



#2 Muon simulation

parameters used for data vs MC:

MUPAGE		CORSIKA	
max multiplicity:	100	hadronic model:	SIBYLL-2.3c [2]
muon energy:	E > 10 GeV	CR flux model:	GST3 [3]
		primary energy:	$10^3 < E < 10^9$ GeV
		gen. showers:	$2.5 \cdot 10^9$



CORSIKA - full air shower MC [4]
MUPAGE - parametrized code [5,6]

gSeaGen - transports muon bundles to the detector with a 3D propagator [7]

JSirene - simulates the Cherenkov light emission and detection by the DOMs

JTE - applies the same trigger algorithms as used for real data

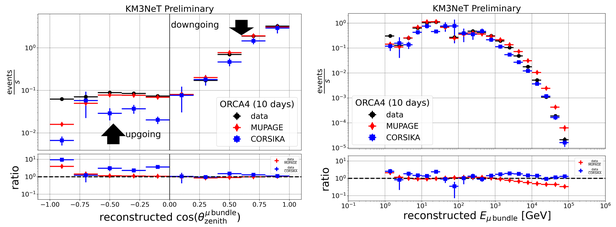
JGandalf - muon track reconstruction

#3 data vs MC

What is plotted	Errors	Stage
Atmospheric μ bundle distributions	Only statistical	reconstructed

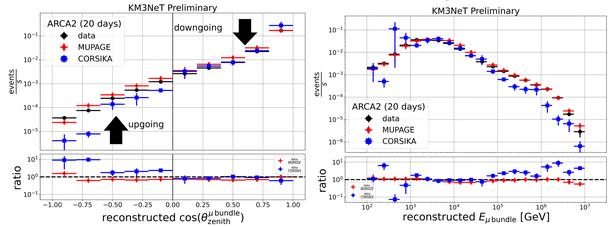
ORCA4 (ORCA with 4 DUs)

data/MUPAGE: livetime = 10d — CORSIKA: $2.5 \cdot 10^9$ generated showers

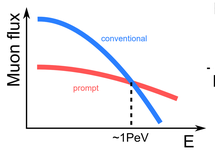


ARCA2 (ARCA with 2 DUs)

data/MUPAGE: livetime = 20d — CORSIKA: $2.5 \cdot 10^9$ generated showers



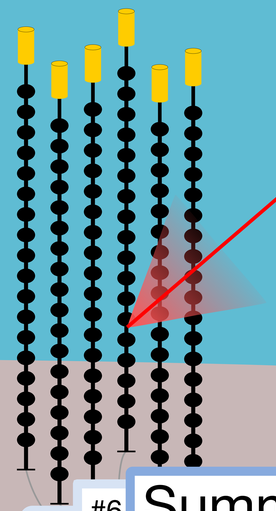
#4 Prompt μ intro



Flux categories:
- conventional – μ, ν mostly from π and K decays
- prompt – μ, ν mostly from heavy hadron decays

Definitions for muon bundles:
- SIG = bundles with ≥1 prompt muons
- BGD = bundles with 0 prompt muons
- TOTAL = SIG + BGD

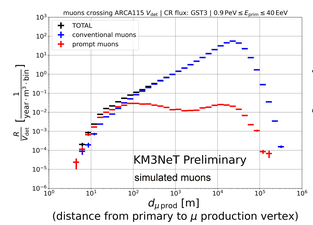
Color coding for MUPAGE and CORSIKA has nothing to do with prompt and conv!



#5 Prompt μ results

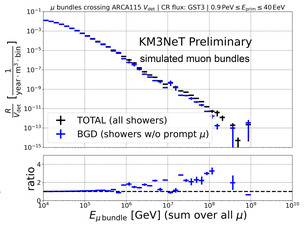
ARCA115 (ARCA with 115 DUs)

Stage: detector — CORSIKA: $5.3 \cdot 10^6$ generated showers, SIBYLL-2.3d [8]



(distance from primary to μ production vertex)

control plot (see drawing above)



expected excess due to prompt

#6 Summary

data vs MC:
- data and MC simulations are consistent
- systematic uncertainties to be added
- analysis for ARCA6 and ORCA6 is ongoing

prompt muon analysis:
- first results encouraging
- next steps: reco stage, sensitivities, comparison with IceCube [9]

References:

1) S. Adrian-Martinez et al. (the KM3NeT Collaboration), Journal of Physics G: Nuclear and Particle Physics, 43 (2016) 084001
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3) T. K. Gaisser et al., Front.Phys. 8 (2013) 748
4) D. Heck et al., FZKA-6019 (1998)
5) M. Ambrosio et al. (the MACRO Collaboration), Phys.Rev.D 56
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7) S. Aiello et al. (the KM3NeT Collaboration), Comput. Phys. Commun. 256, 107477 (2020)
8) F. Riehn et al., Phys. Rev. D 102, 063002 (2020)
9) M. G. Aartsen et al. (the IceCube Collaboration), Astropart.Phys. 78 (2016) 1-27
10) Wikimedia Commons contributors, https://commons.wikimedia.org/w/index.php?title=File:Brosen_windrose.svg&oldid=510510534, 10.11.2020

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