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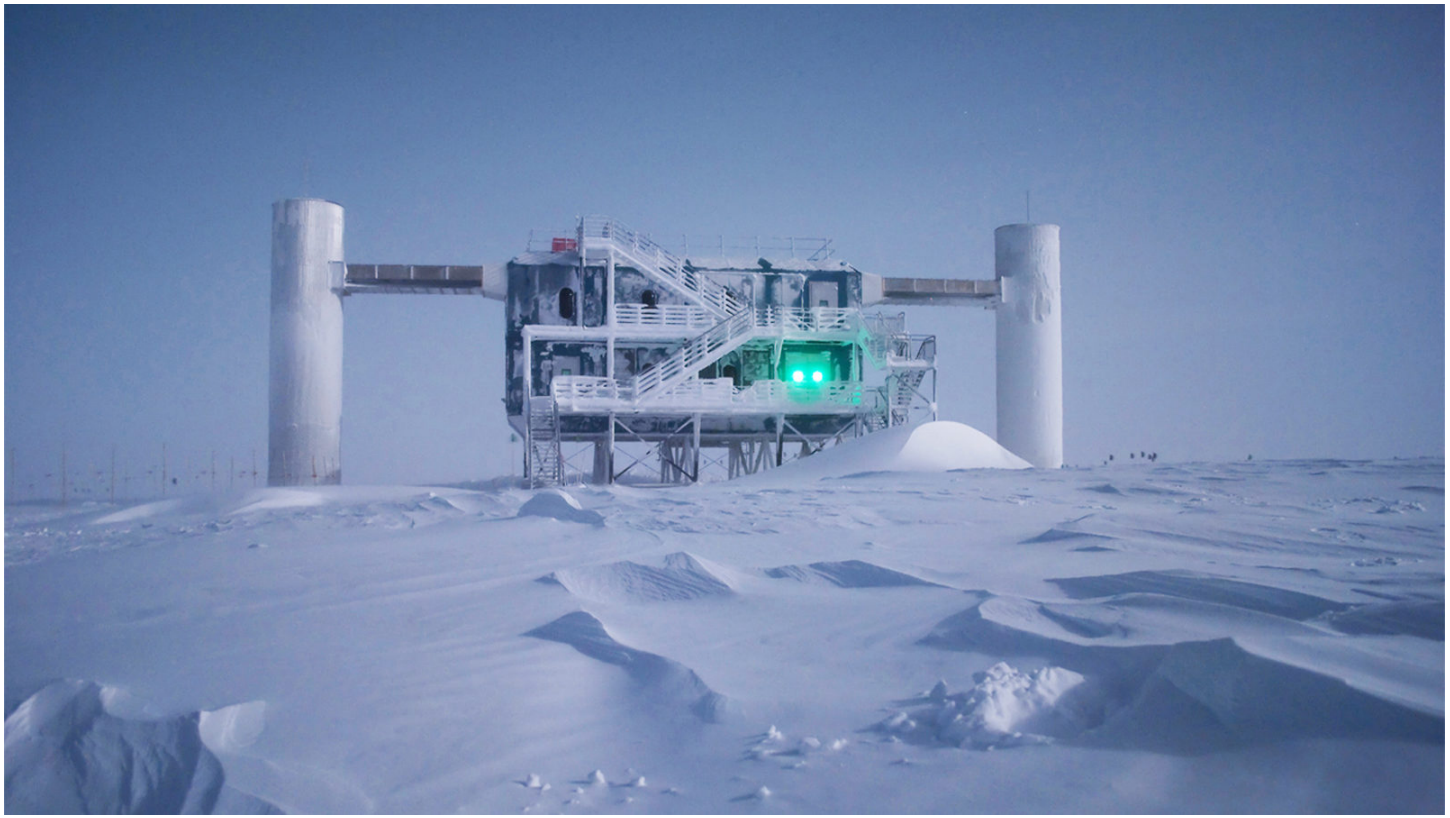


Muon Multiplicities in IceCube

School for Astroparticle Physics, Obertrubach, 7. Oct. 2017

Philipp Hoffmann

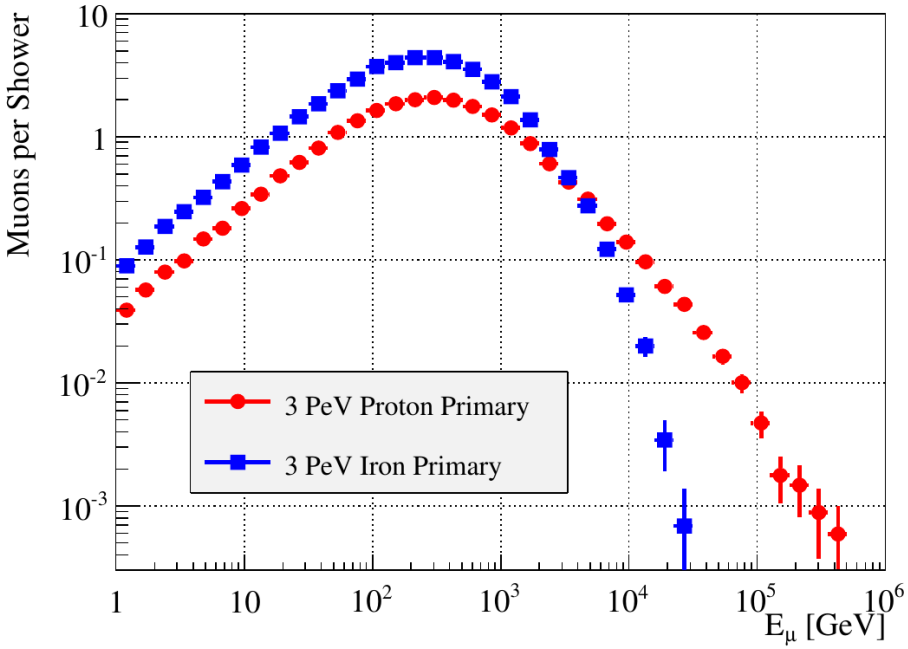
Why Muon Multiplicities?

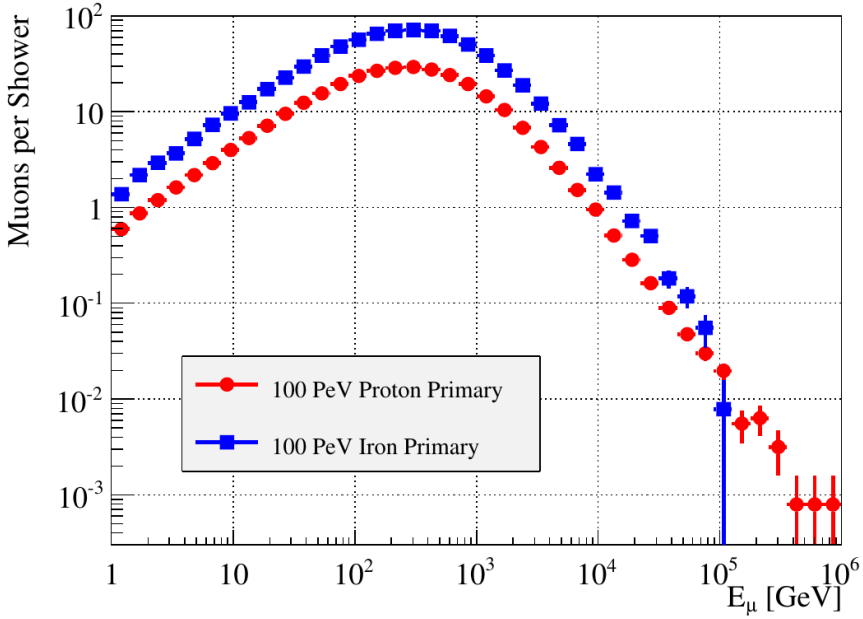
- IceCube sees muons from cosmic ray showers
- Number of muons in shower depends on e.g. type of cosmic ray

→ Explore how multiplicity is seen in IceCube

→ Estimate multiplicity to find more physics

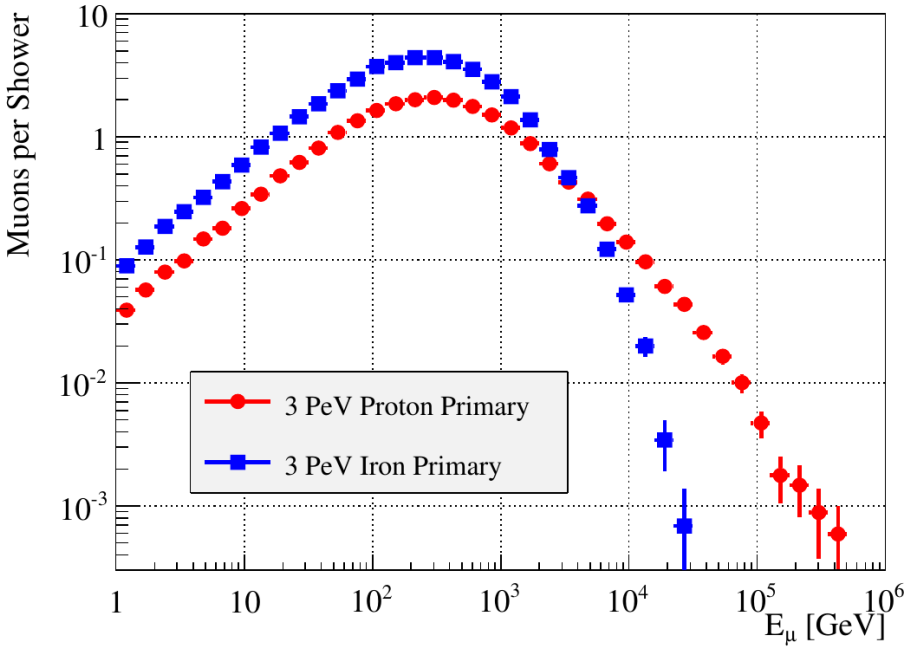
Consequences of Primary Composition and Energy

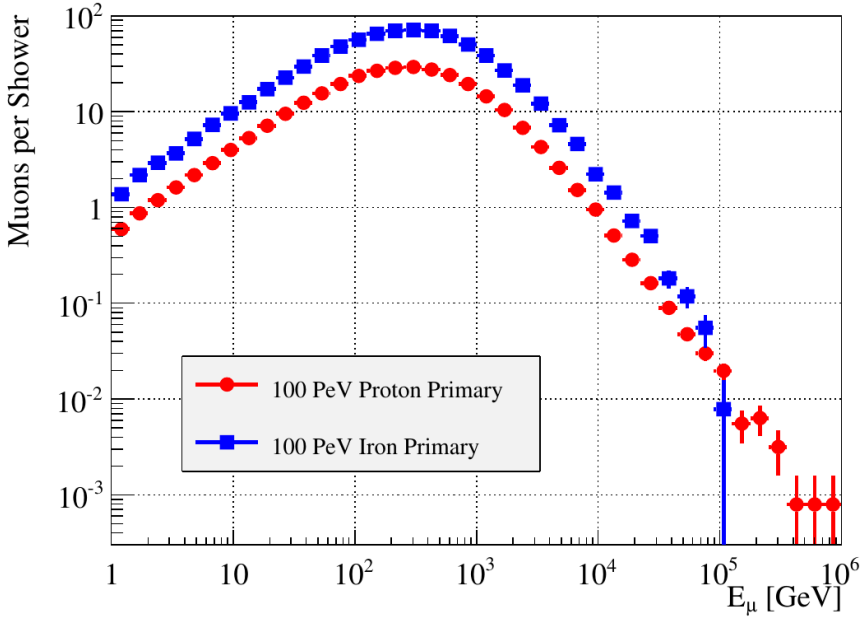




[1]

Consequences of Primary Composition and Energy

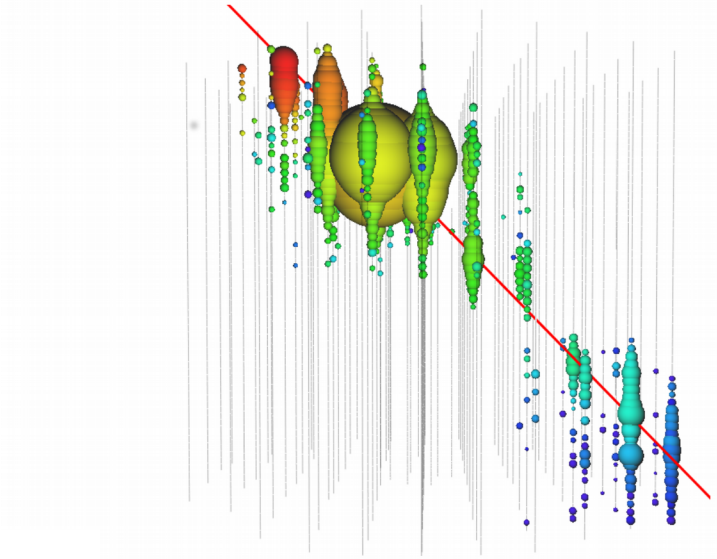


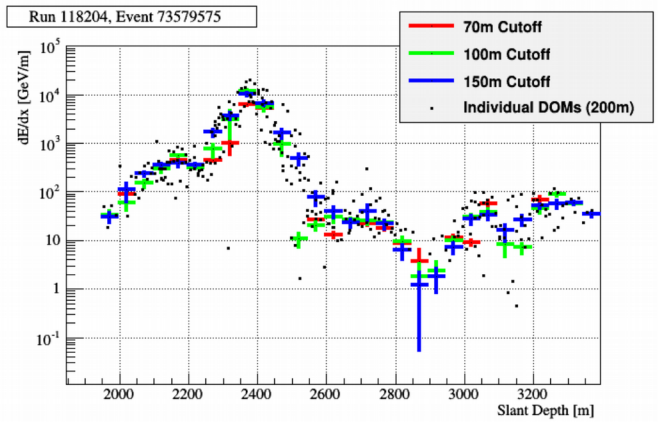


[1]

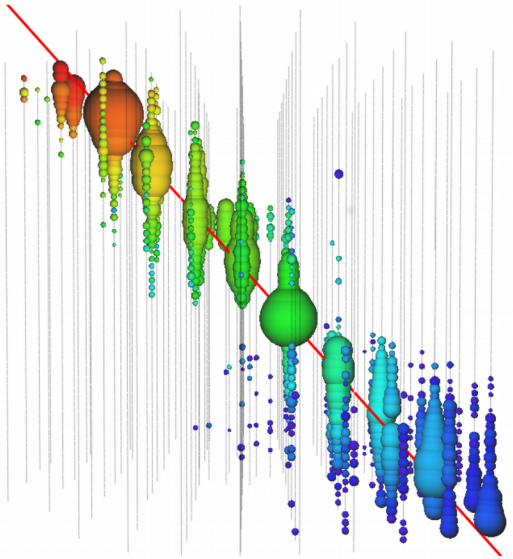
$$N_\mu \propto E_{\text{prim}}^{\alpha} \cdot A^{1-\alpha}$$

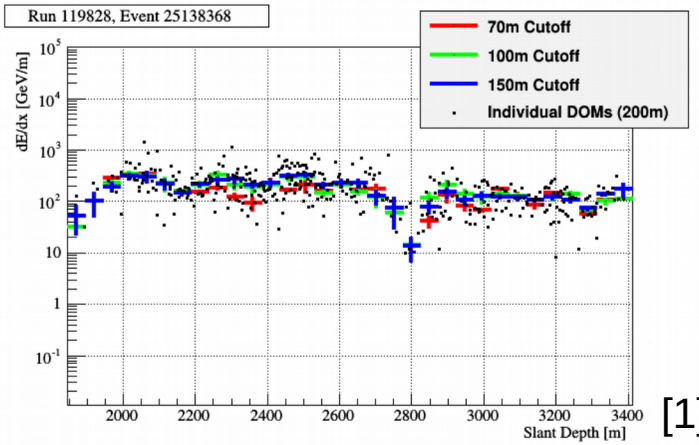
Events: Leading





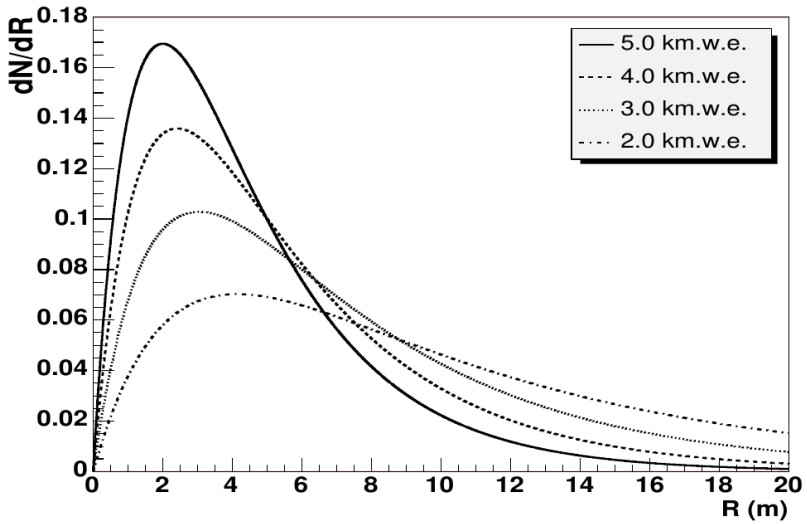
Bundle

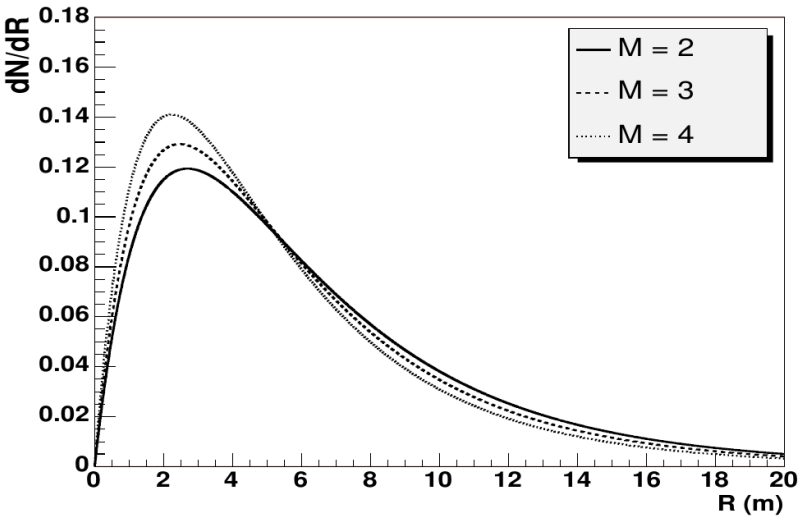




[1]

One Problem for IceCube: Resolving Muons in a Bundle

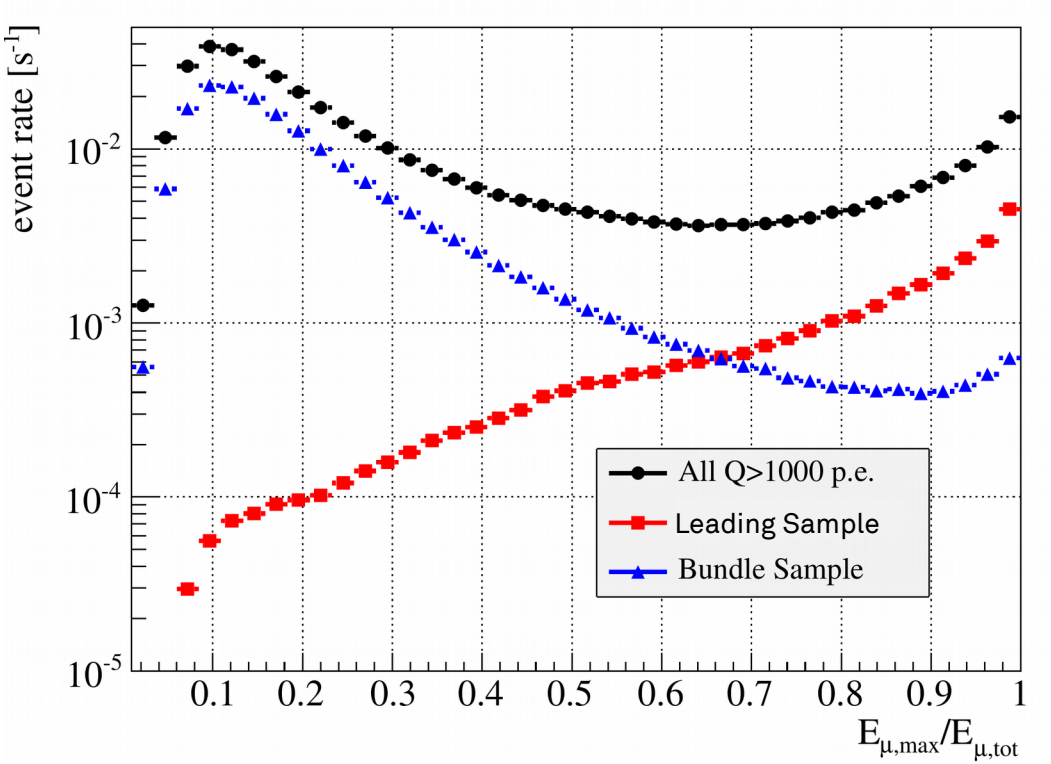




[3]

	Module density	Area
IceCube	100/km²	1km²
Alice (LHC)	1000/m²	100m²

How common are bundles?



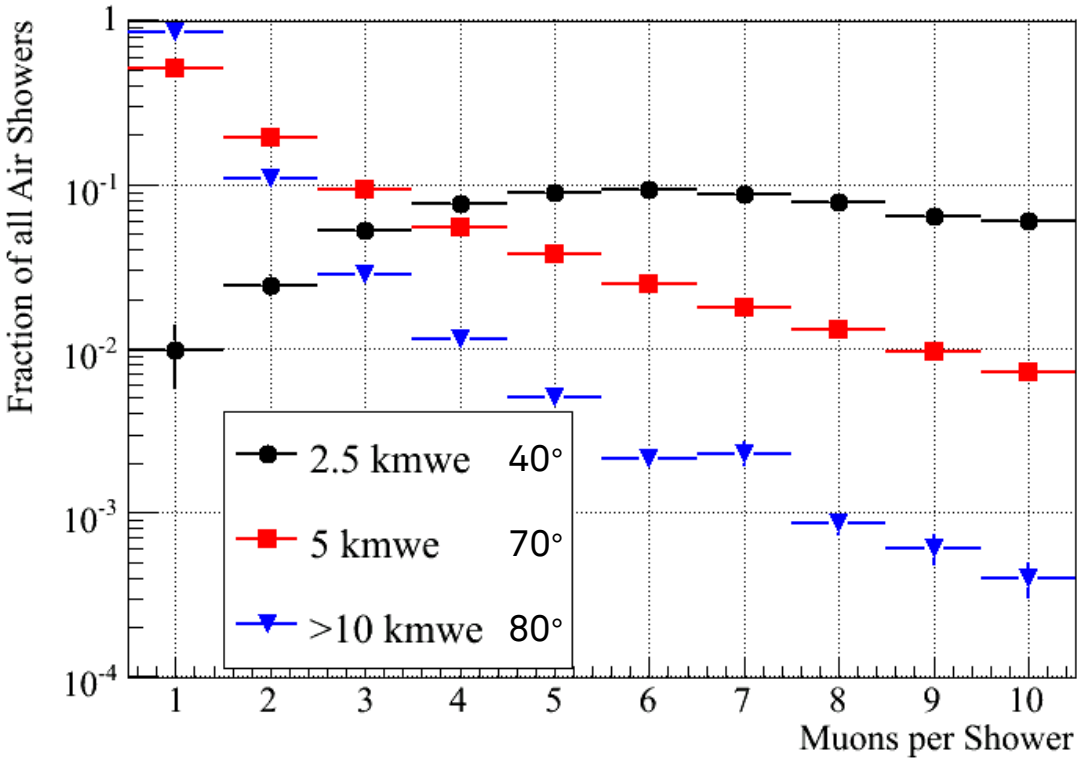
[1]

- Most bright events are high in multiplicity
- High/Low multiplicity can be reduced:

Selection	Effect
All $Q_{tot} > 1,000$ p.e.	n/a
$\cos\ \theta_{zen} > 0.3$	low N_μ
L_{dir} >600 m	high N_μ
$q_{max}/Q_{tot} < 0.3$	low N_μ
$d_{mpe,cod} < 425$ m	high N_μ

[1]

Multiplicity is zenith dependent



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[2]

Summary

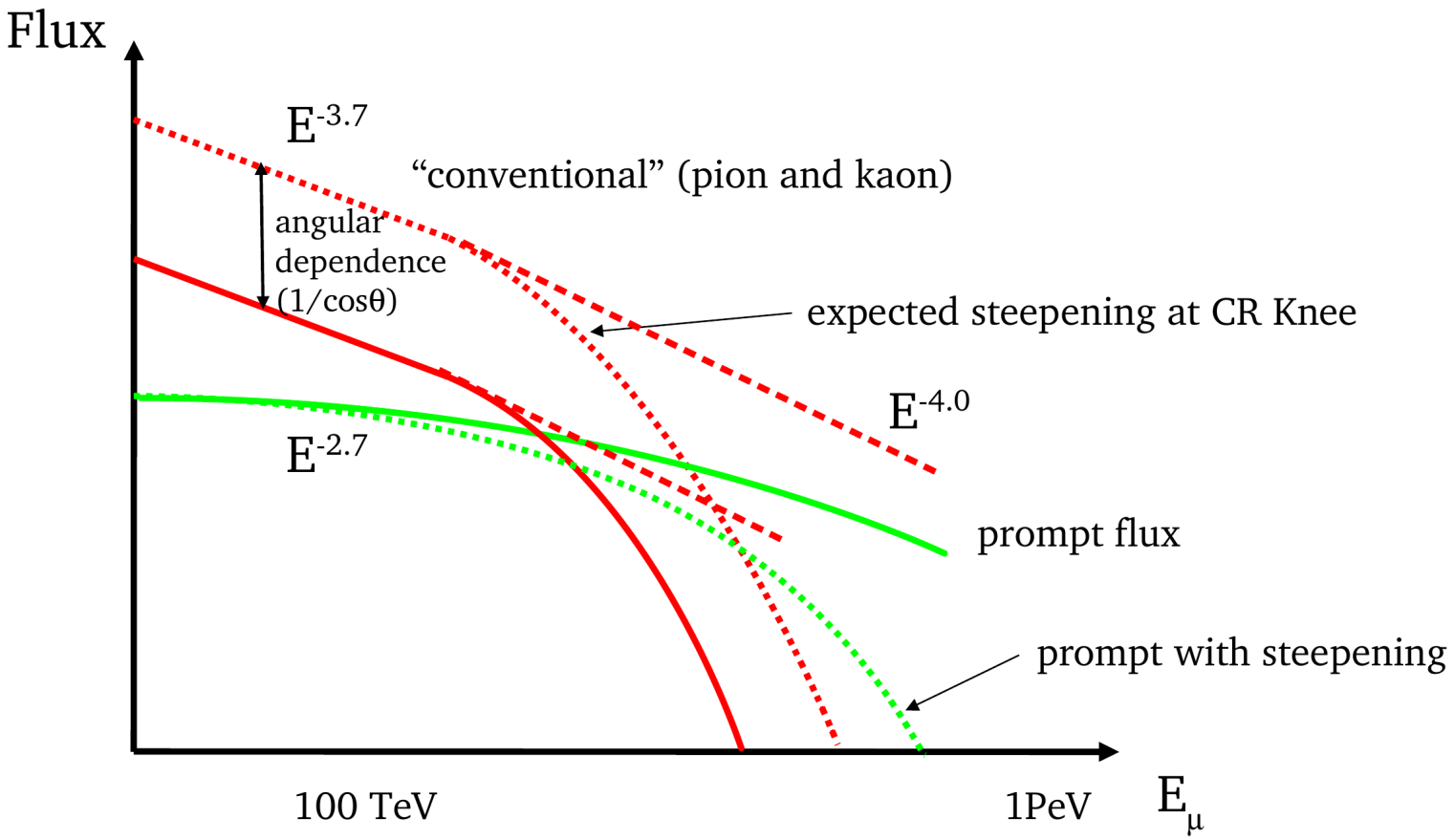
- Most important dependencies of N_μ:
  - Zenith/Depth
  - q_{max} / Q_{tot}
  - Primary energy
  - Primary weigth
- Can‘t see single muons in bundles with IceCube‘s resolution
- But: compared to other detectors much higher energy showers

Sources

- [1] Aartsen, (2016). Characterization of the atmospheric muon flux in IceCube. Astroparticle Physics, 78, 1–27. doi.org/10.1016/j.astropartphys.2016.01.006, p.11, p.12, p.13, p.14
- [2] Berghaus, P. (2009). Muons in IceCube. Nuclear Physics B - Proceedings Supplements, 196, 261–266. doi.org/10.1016/j.nuclphysbps.2009.09.050, p.4
- [3]Becherini et. al. (2005). A parameterisation of single and multiple muons in the deep water or ice, 1–25. doi.org/10.1016/j.astropartphys.2005.10.005 ,p.17, p.18

Backup

Prompt spectrum



[1]