



# Study of Muon Decays in KM3NeT/ORCA6

Gogita Papalashvili



ANTARES/KM3NeT Collaboration Meeting  
Rome, Italy

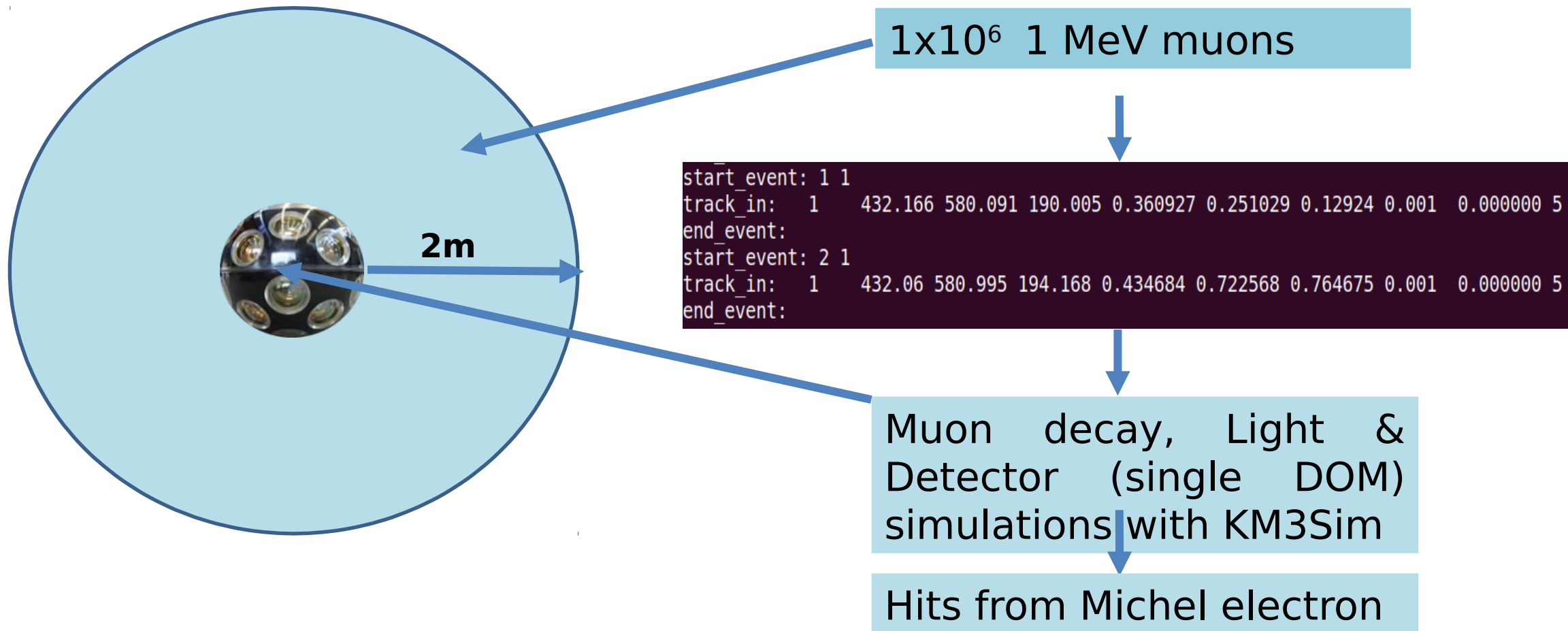
24 October 2022

Supported by the joint grant of  
Volkswagen Foundation and  
SRNSF (Ref. 93 562 & #04/48)

# Contents

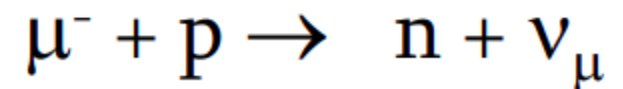
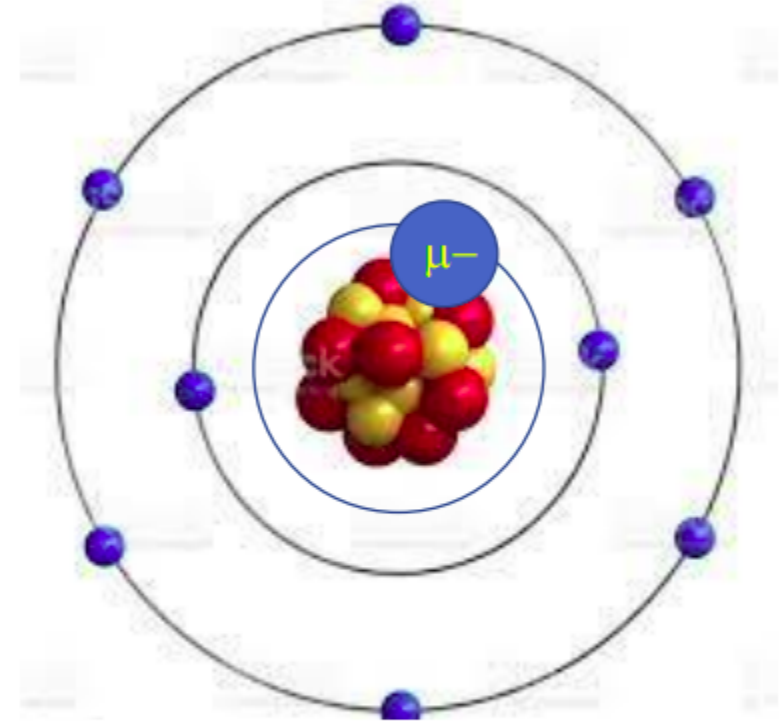
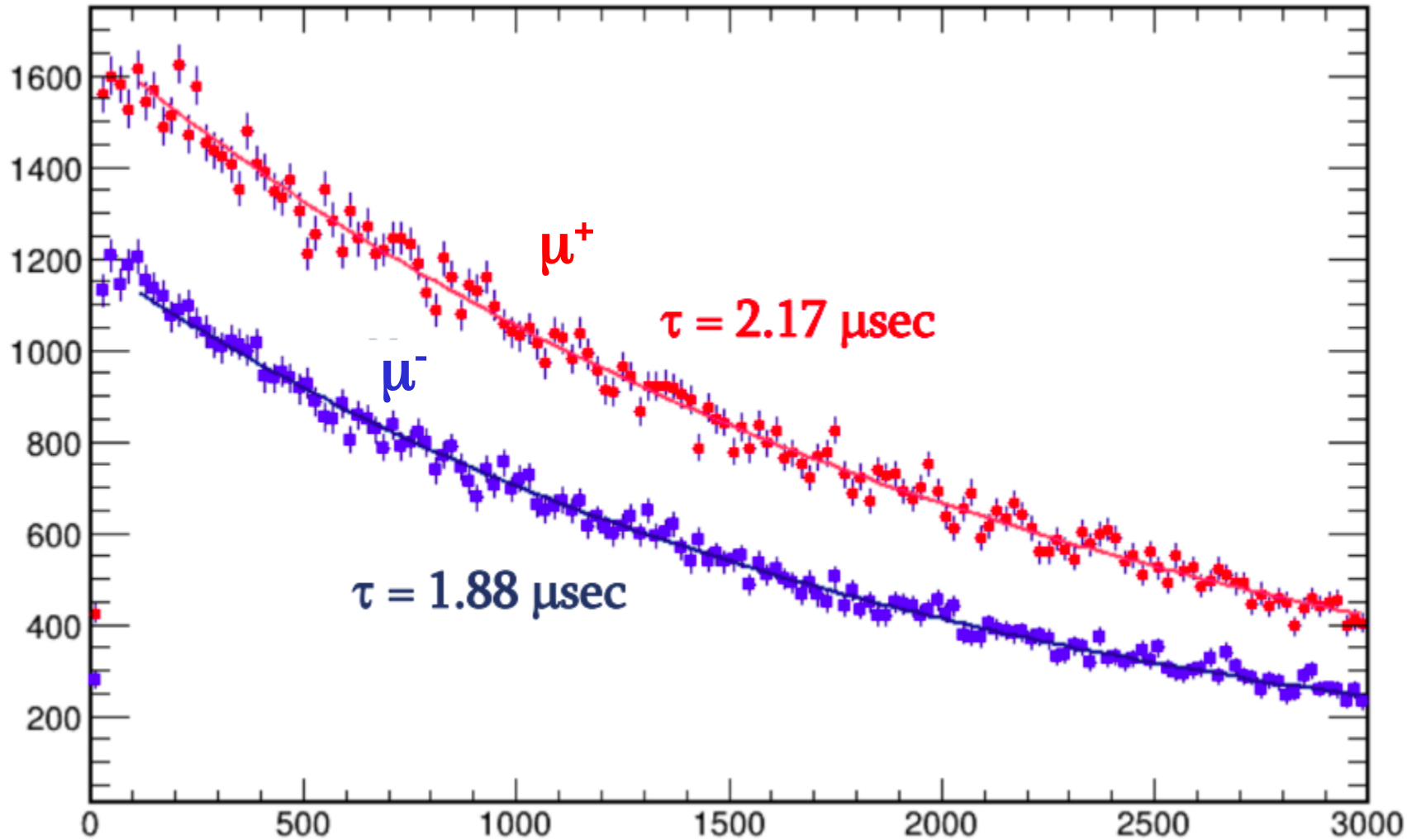
- ▶ Introduction
  - muon decays in KM3NeT/Antares
- ▶ Michel electron signal in KM3NeT
- ▶ Backgrounds for Michel electron:
  - deep sea optical background -  $^{40}\text{K}$  decays; bio luminescence
  - Cherenkov light from stopping muons
  - PMT afterpulses
- ▶ Summary and outlook

# $\mu$ Decay simulations with KM3Sim



# $\mu$ Decay simulations with KM3Sim

Hit time = First hit time of the event



D.F. Measday,  
Physics Reports 354 (2001) 243  
12

# Simulations with ROOT and JPP

$2.9 \times 10^5$  Muons stopping inside detector volume obtained from 1000 atm muon v7.1 production files ( $\sim 1.6 \times 10^7$  events  $\sim 24$  days)

decays with ROOT TGenPhaseSpace with corresponding mean lifetime

```
start_event: 170 1
track_in: 1 407.1350055811927 730.082423503678 470.7 0.11690043655418146 -0.36210766479199624 -0.9247769066279332 121.26509797460454 0.000 5
track_in: 2 456.50757201525073 577.1472825990655 80.12310734649577 0.8456182058434933 0.5822953211609274 0.7748345015570521 0.02323166110484152 3564.9489058938298 2
end_event:
```

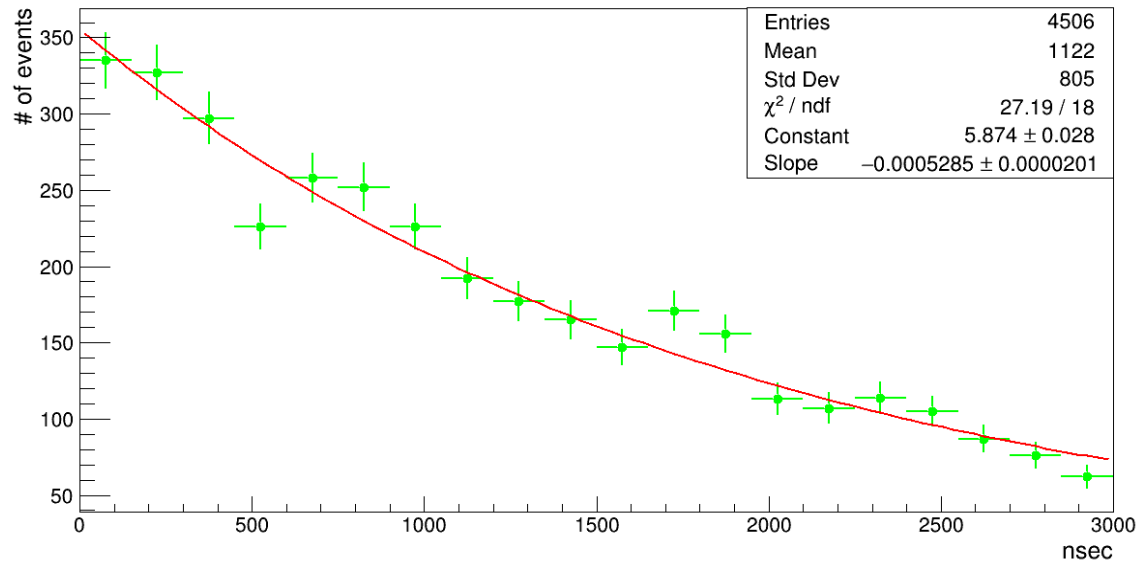
Light & ORCA6 Detector simulations with JSirene  
**(including Michel electrons)**

Background and event reconstruction is done with JPP

# Muon decay reconstructions

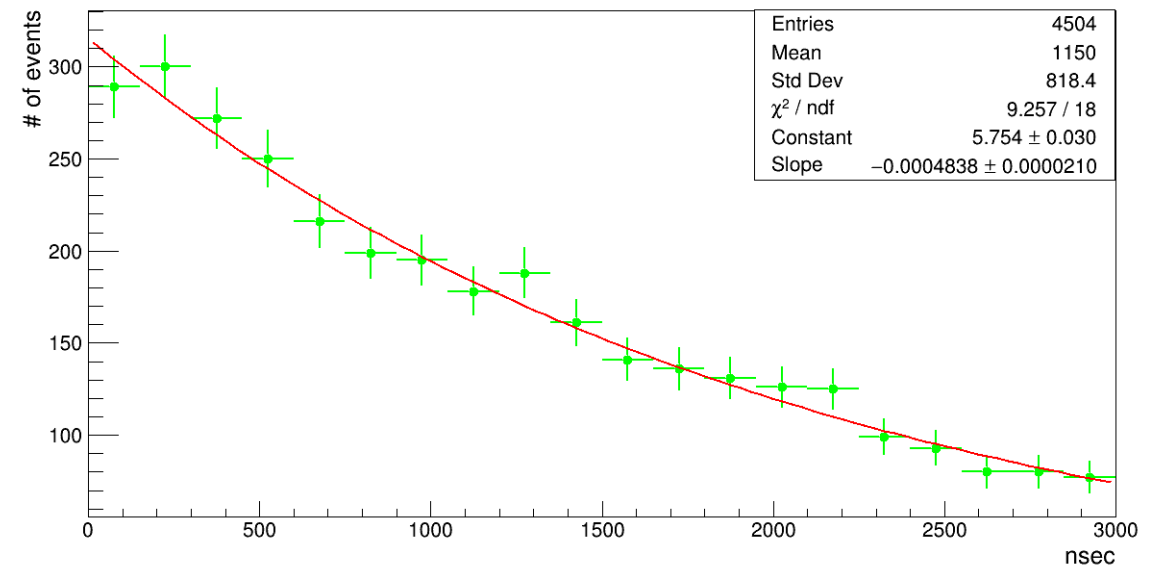
Reconstructed decay with closest DOM for muons and antimuons from MC hits

Input  $\tau = 1879\text{ns}$   
Output  $\tau = 1892\text{ns}$



Muon

Input  $\tau = 2197\text{ns}$   
Output  $\tau = 2067\text{ns}$



Antimuon

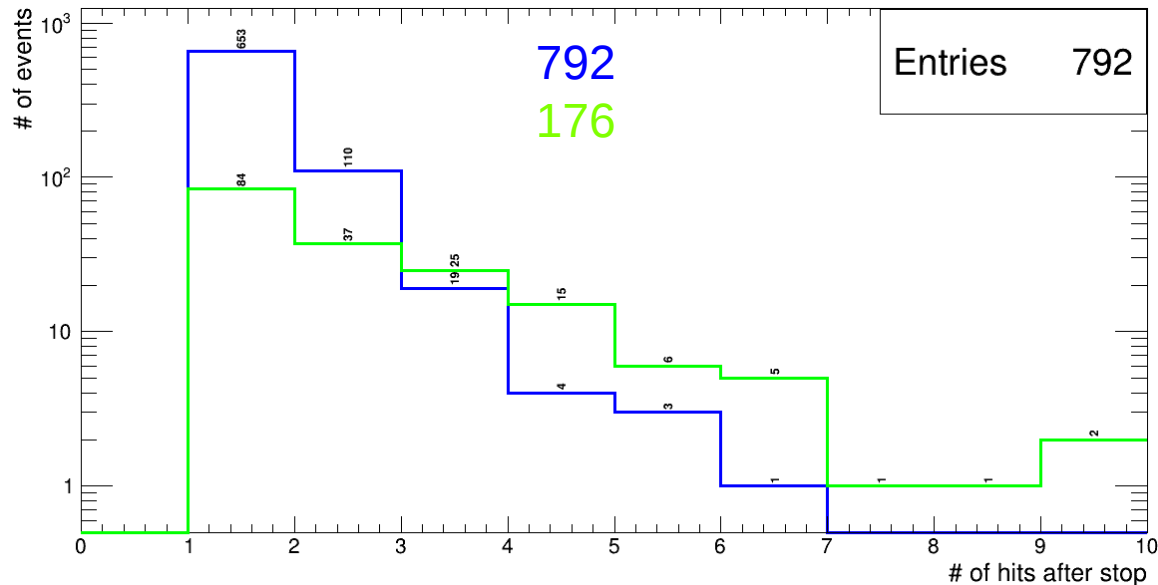
# Muon decay signal multiplicities

## MC Statistics:

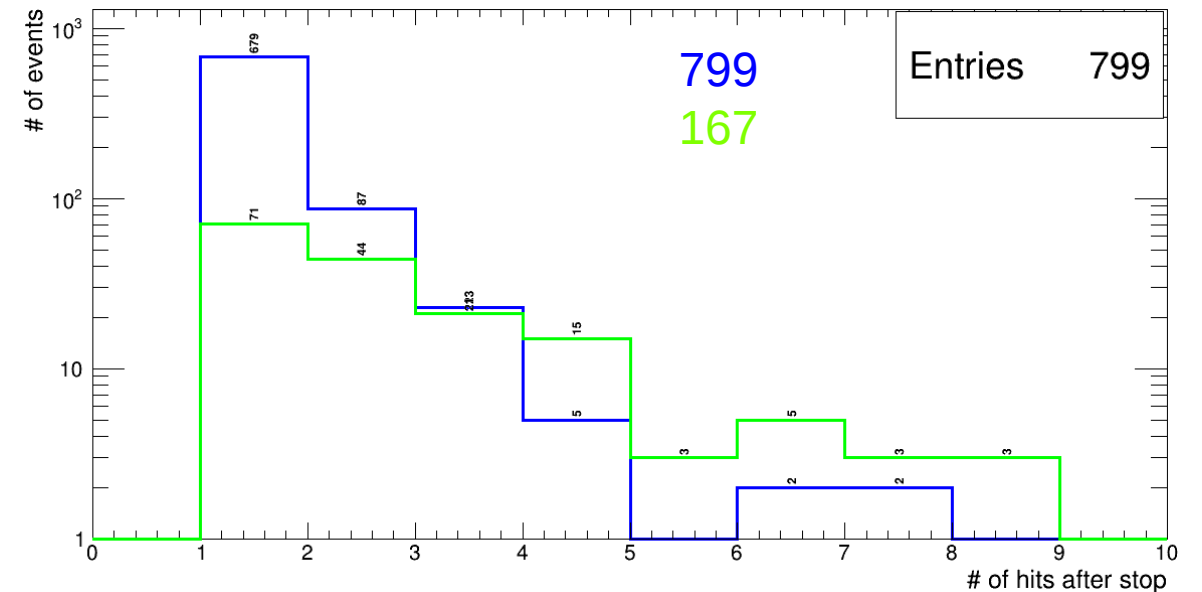
$2.9 \times 10^5$  Muons stopping inside detector volume obtained from 1000 atm muon v7.1 production files ( $\sim 1.6 \times 10^7$  events  $\sim 24$  days)

Reco events  
MC events

Muon + electron



Antimon + positron

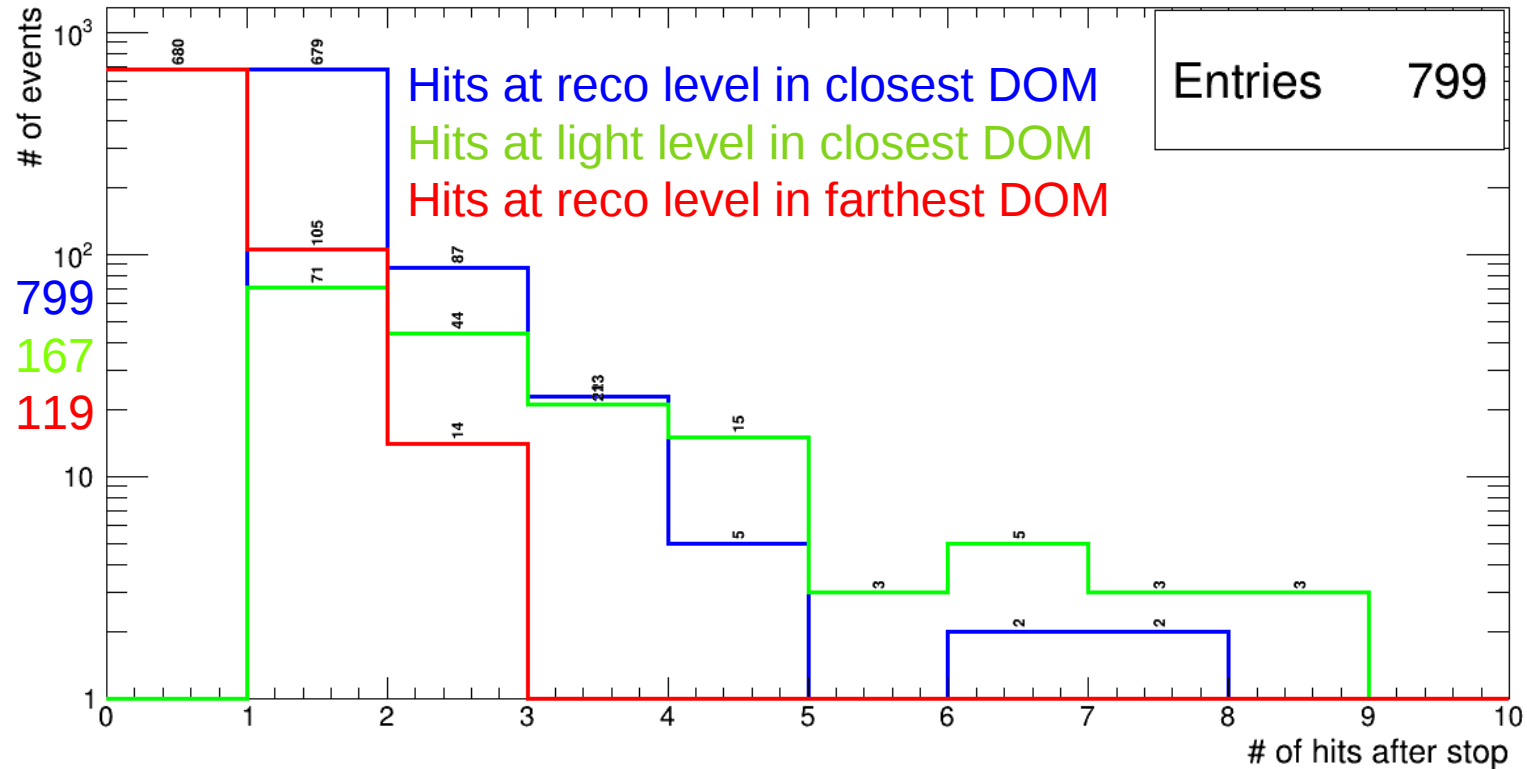


For the multiplicity=1 background hits are dominating

Next slides are focused on  $\mu^+$

# Muon decay signal multiplicities

Antimon + positron

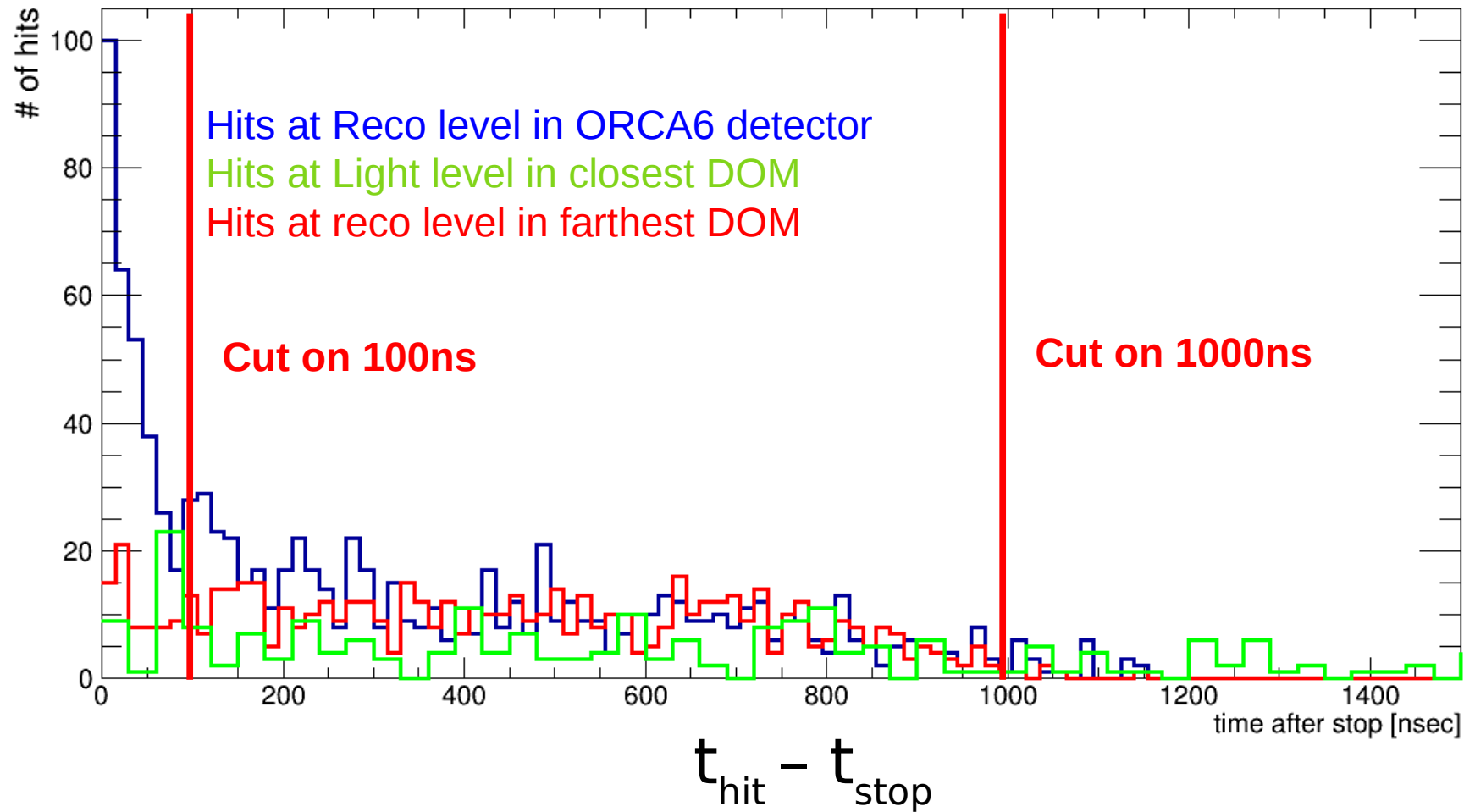


**For the multiplicity=1 background hits are dominating**



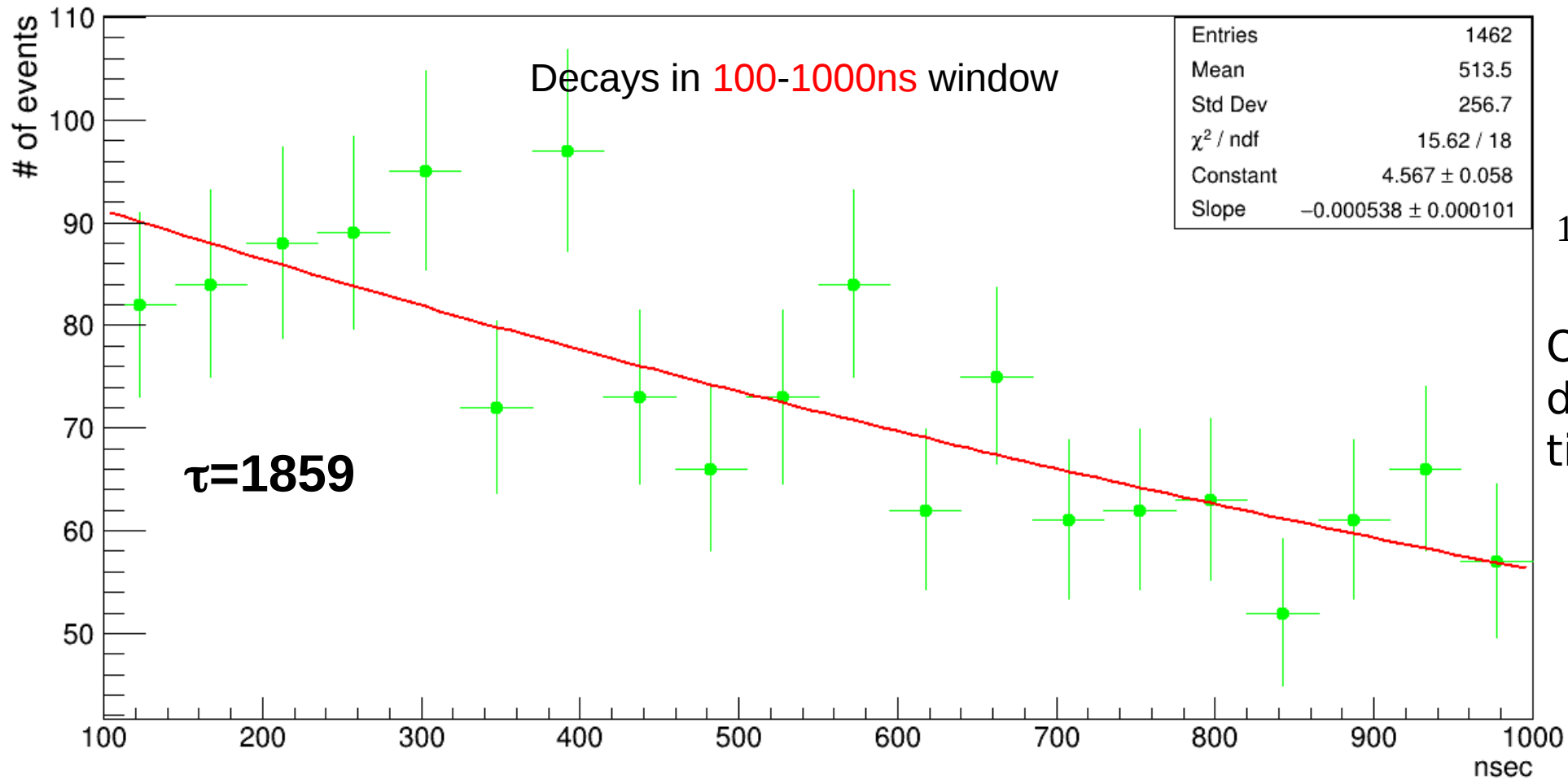
# Muon decay time window

Hit times after the muon stops



# Muon decay reconstructions

Reconstructed antimuon decay times from MC hits in **100-1000ns** time window



$$1 - e^{(-1/2.2)} - 1 - e^{(-0.1/2.2)} = 0.32$$

Only ~32% of muons decay in 100-1000ns time window

# Summary and Outlook

- ▶ Muon decays were simulated with ROOT
- ▶ Michel electron light simulations were included in JSirene
- ▶ Reconstruction of muon decay times with KM3NeT/ORCA6 MC is done
- ▶ Background suppression methods are under investigations
- ▶ Further studies of muon decay parameters and backgrounds from MC
- ▶ Optimization of the cuts
- ▶ Searches for decays in the data