Atmospheric Neutrinos Detected with the First KM3NeT Detection Units of ARCA and ORCA

R. Coniglione, J. Hofestädt*, A. Sinopoulou, E. Tzamariudaki, D. Zaborov
on behalf of the KM3NeT Collaboration
ICRC 2019, Madison, USA, 26th July 2019

ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG

KM3NeT collaboration: ARCA & ORCA

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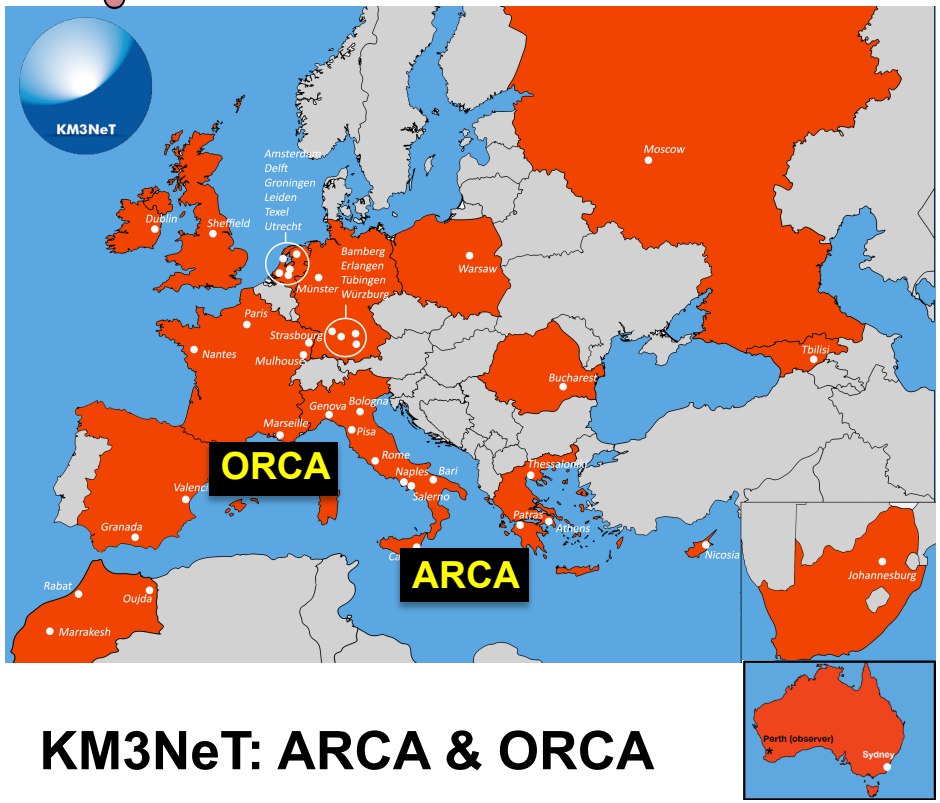
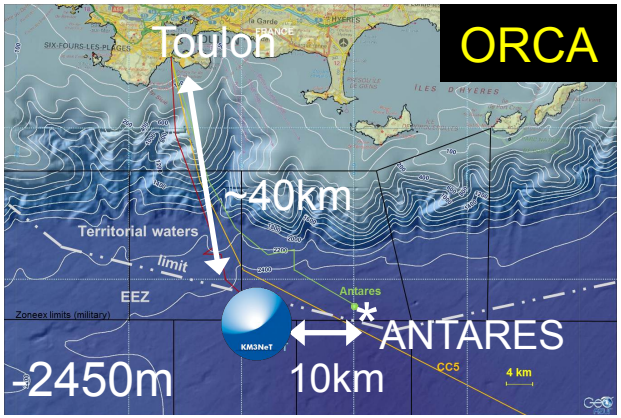
☞ Highlight talk
R. Coniglone, Tue 11.30





ORCA: Oscillation **R**esearch with **C**osmics in the **A**byss

ARCA: Astroparticle **R**esearch with **C**osmics in the **A**byss

KM3NeT: ARCA & ORCA

ARCA → TeV-PeV neutrino astronomy

ORCA → neutrino mass ordering with few-GeV atmospheric neutrinos

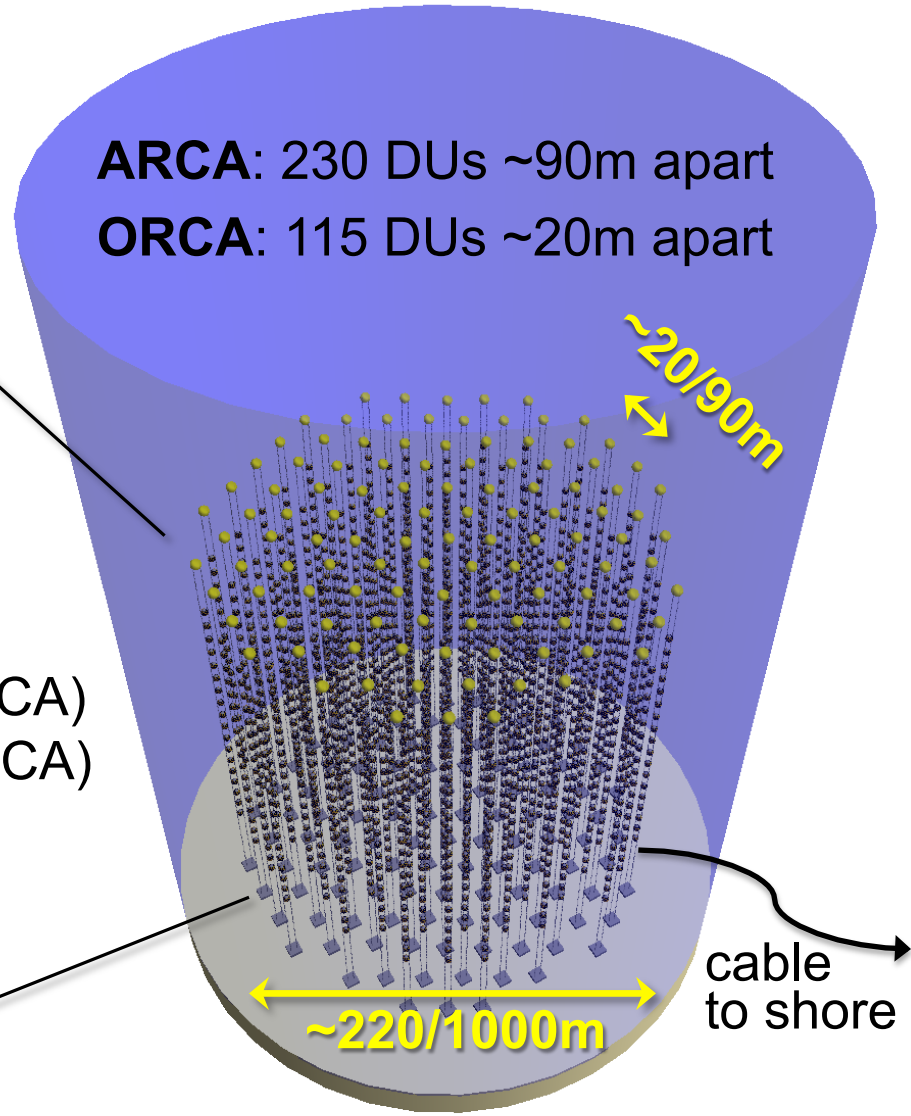
ARCA & ORCA detectors

Digital Optical Module (DOM)

31 x 3”-PMTs
(19↓, 12↑)

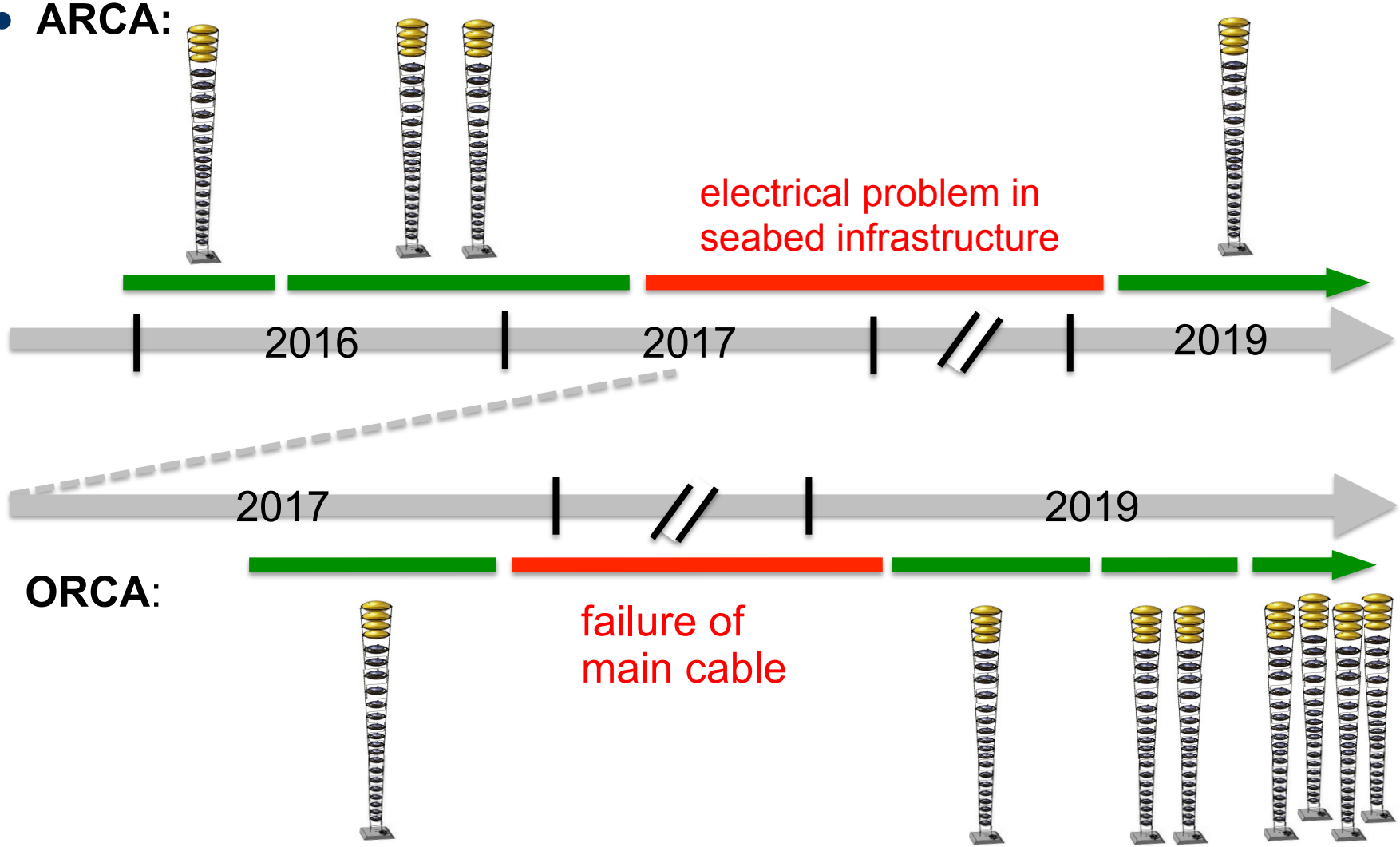
Detection Unit (DU)

~36m (ARCA)
~9m (ORCA)



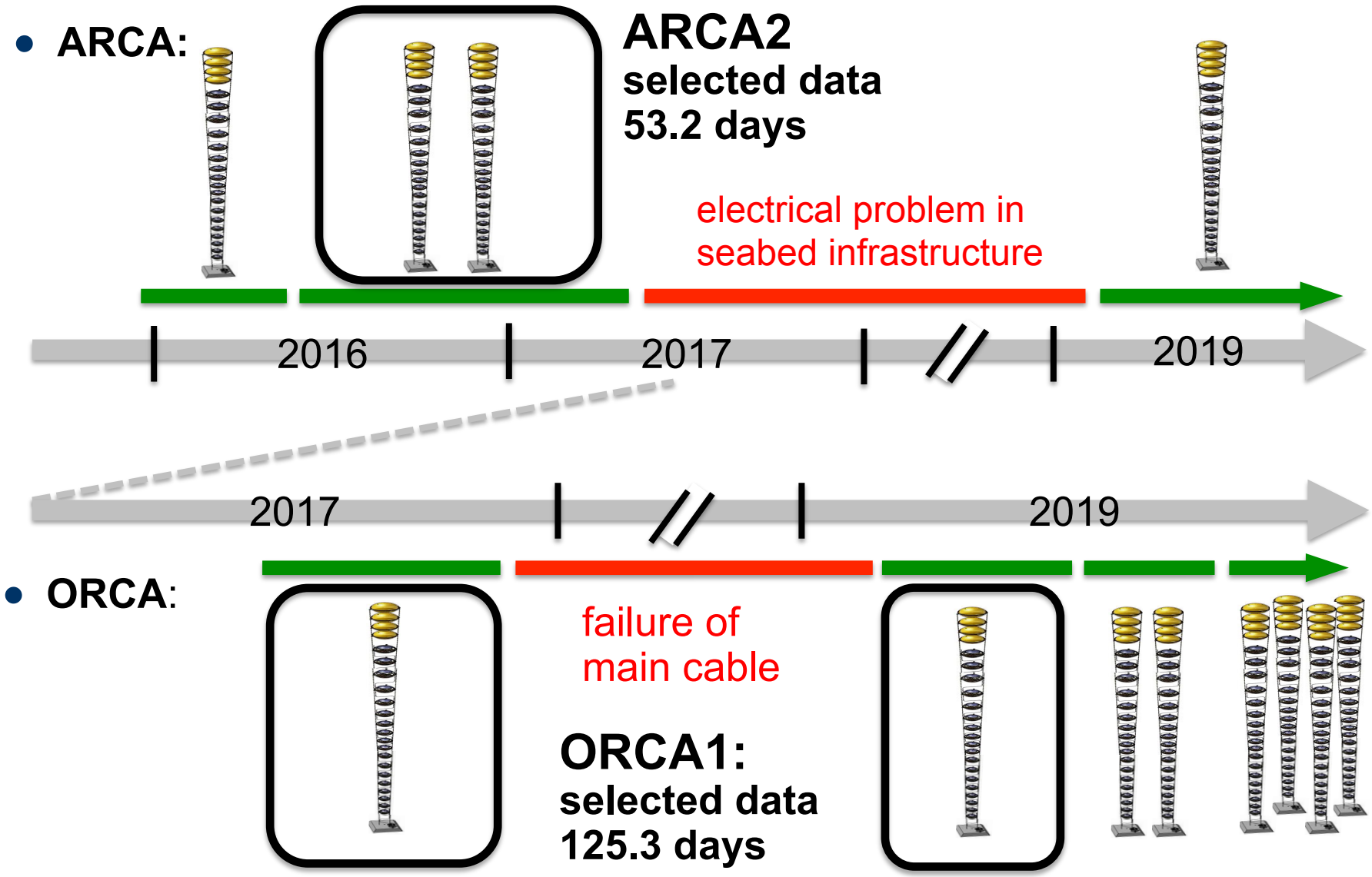
Detector construction status

- **ARCA:**



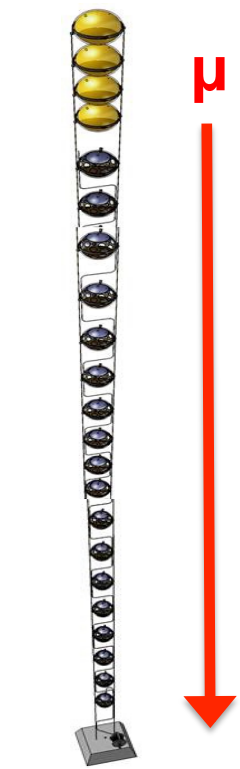
- **ORCA**:

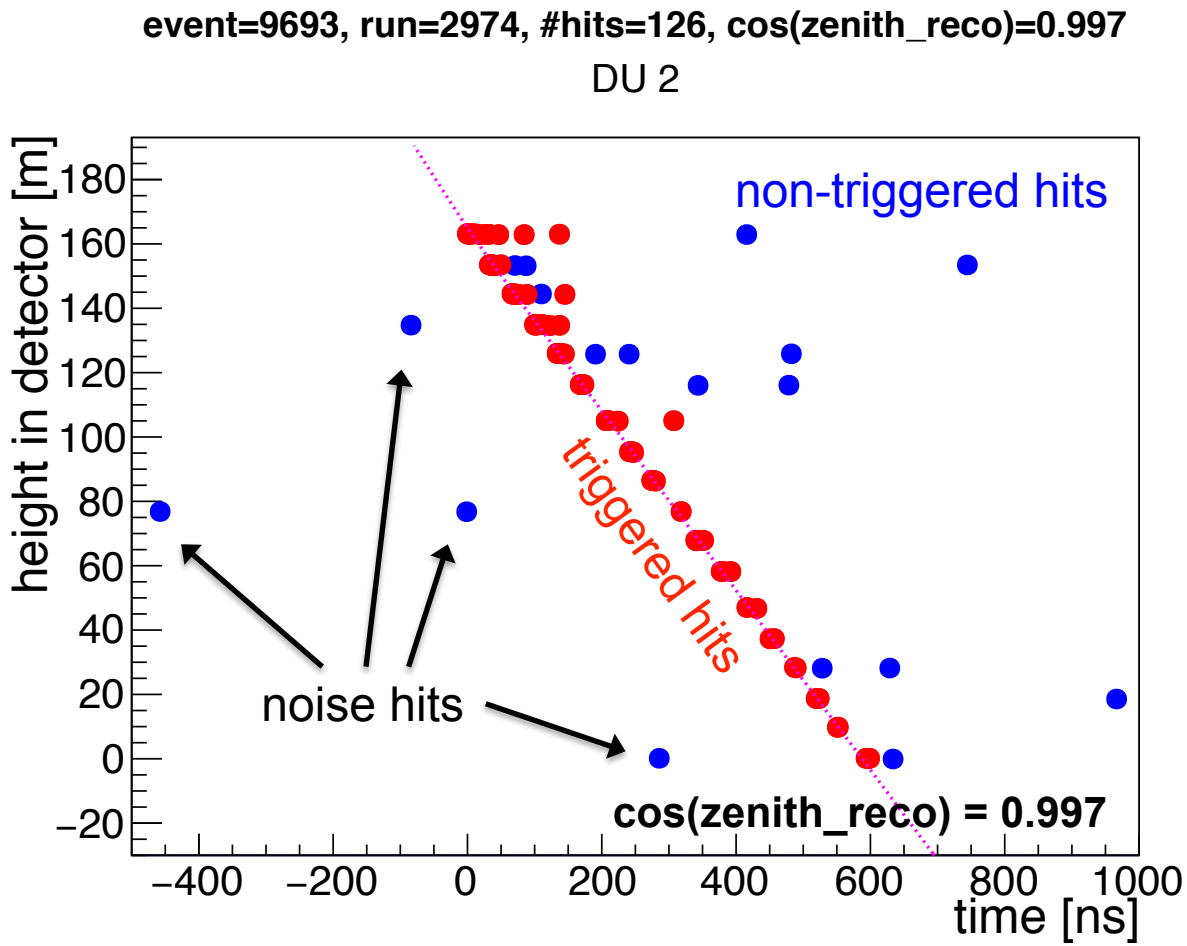
Detector construction status



Recorded data and event reconstruction

- Example: **down-going atmospheric muon** passing close to DU





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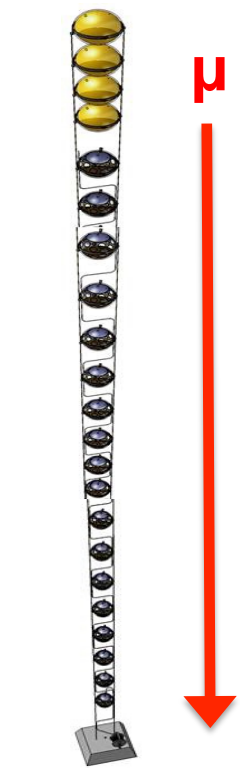
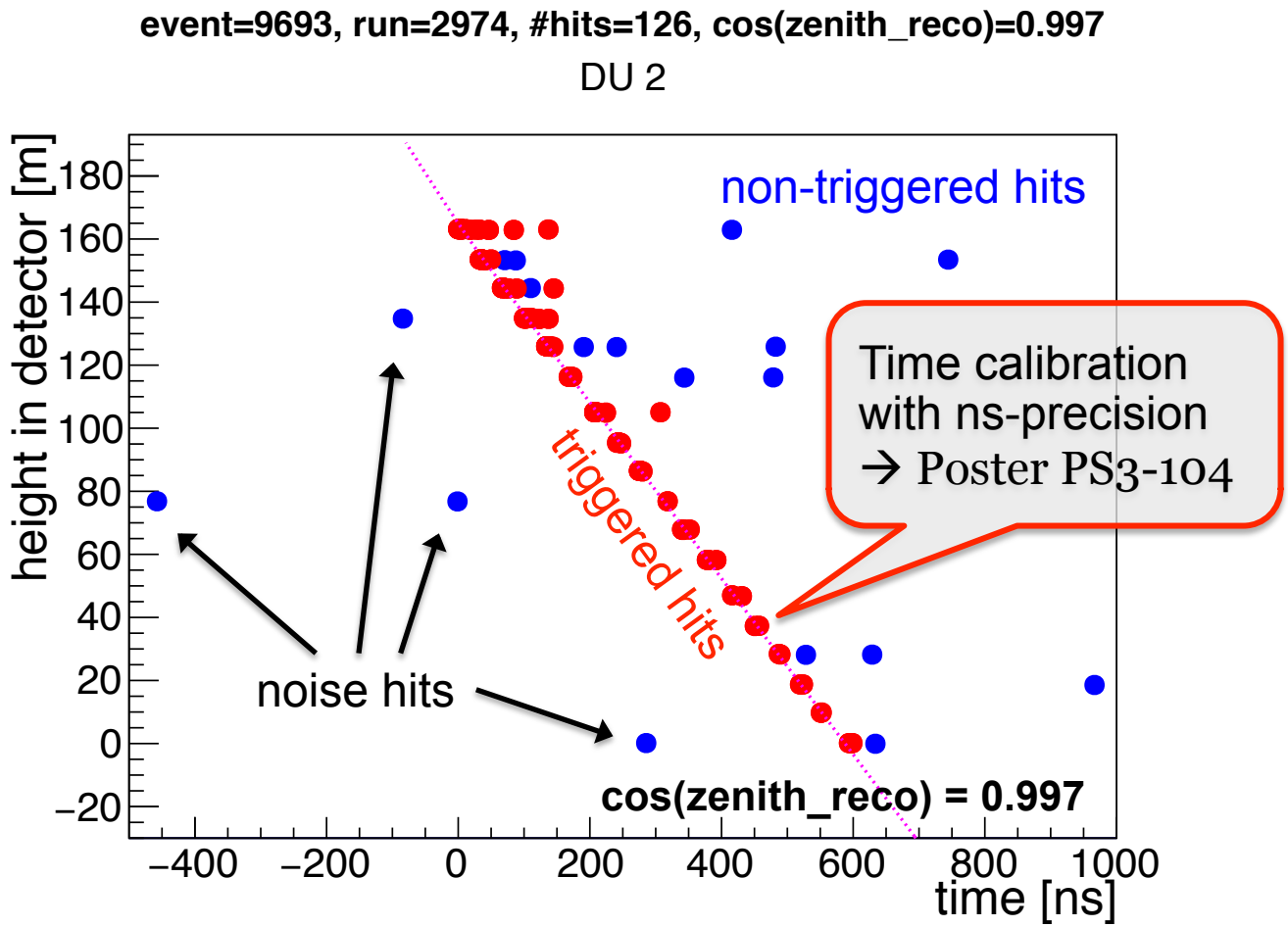
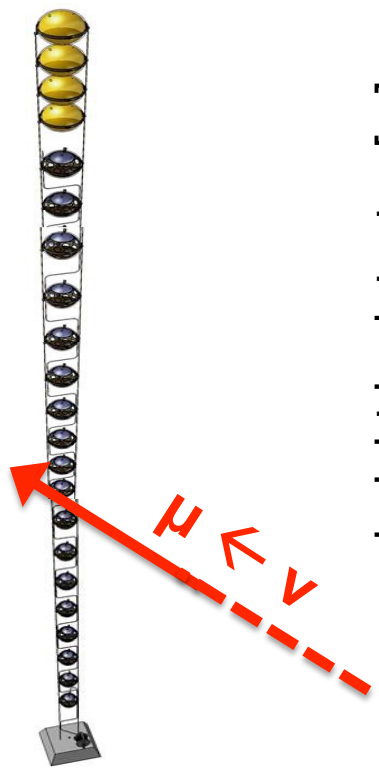




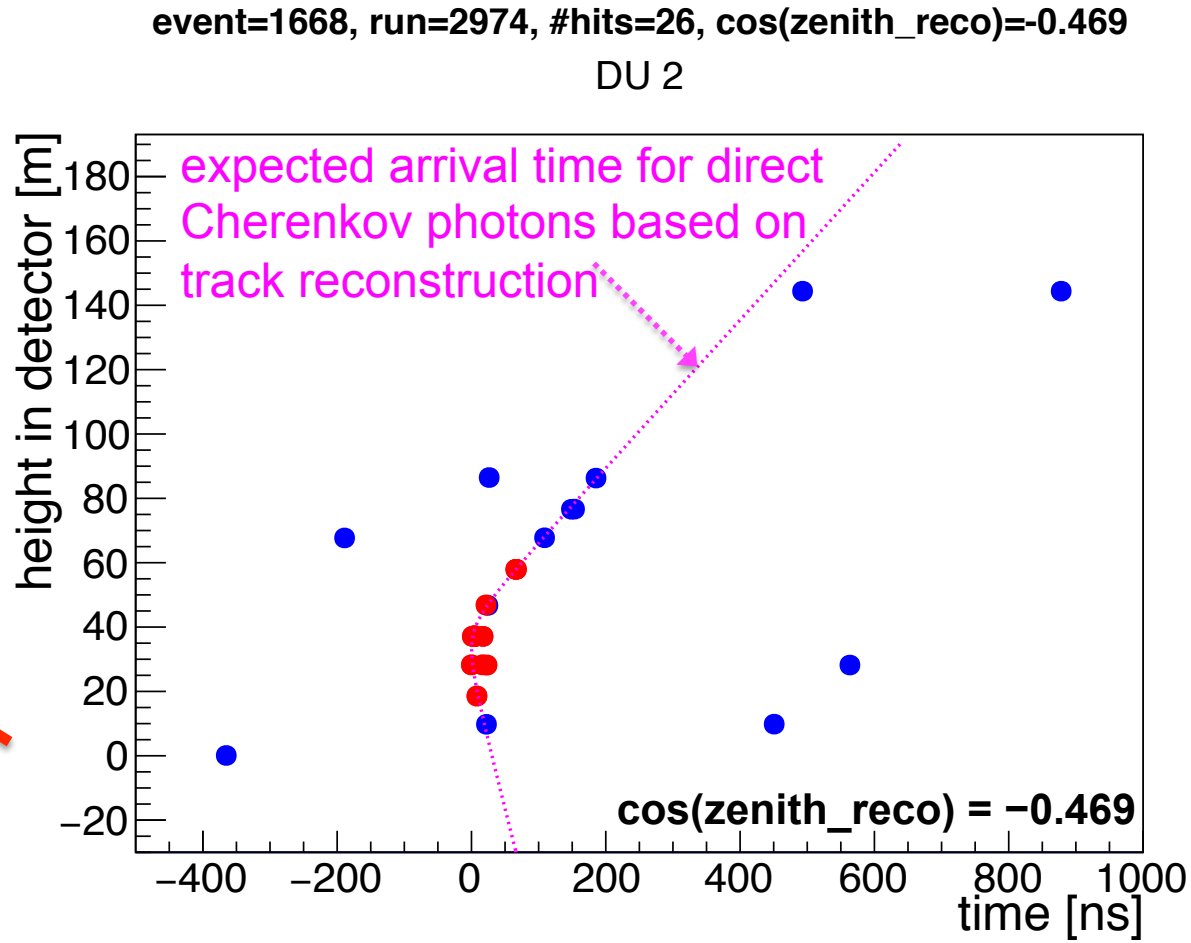
- Most detected photons arrive ‘on-time’ due to the large scattering length in deep-sea water

Recorded data and event reconstruction

- Example: **up-going neutrino candidate**



ORCA1



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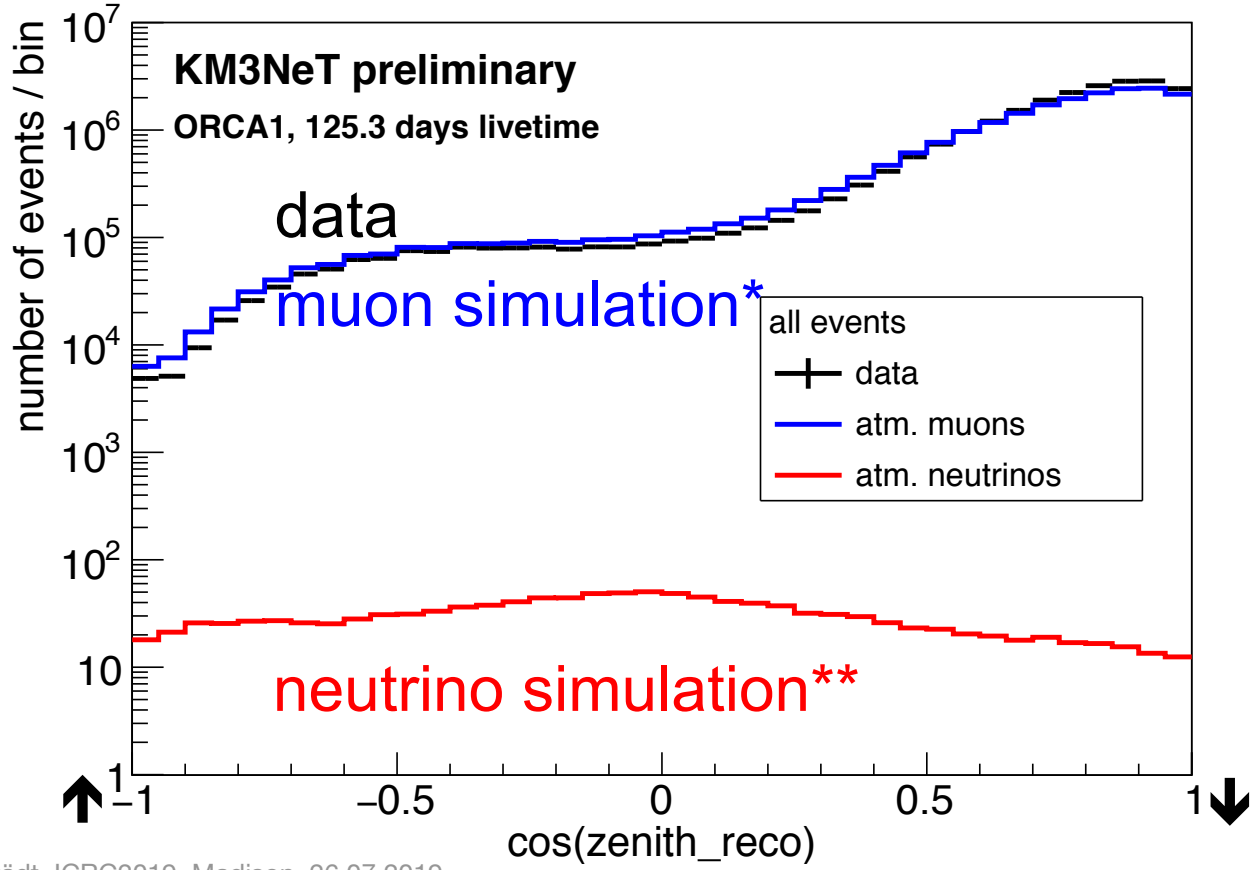
Atmospheric neutrinos and muon background

*MUPAGE
**Honda model

	ORCA1	ARCA2
Atmo. muons*:	~2Hz	~0.2Hz
Atmo. neutrinos**:	~10/day	~1/day

- Zenith-angle distribution for ORCA1 for all events before event selection



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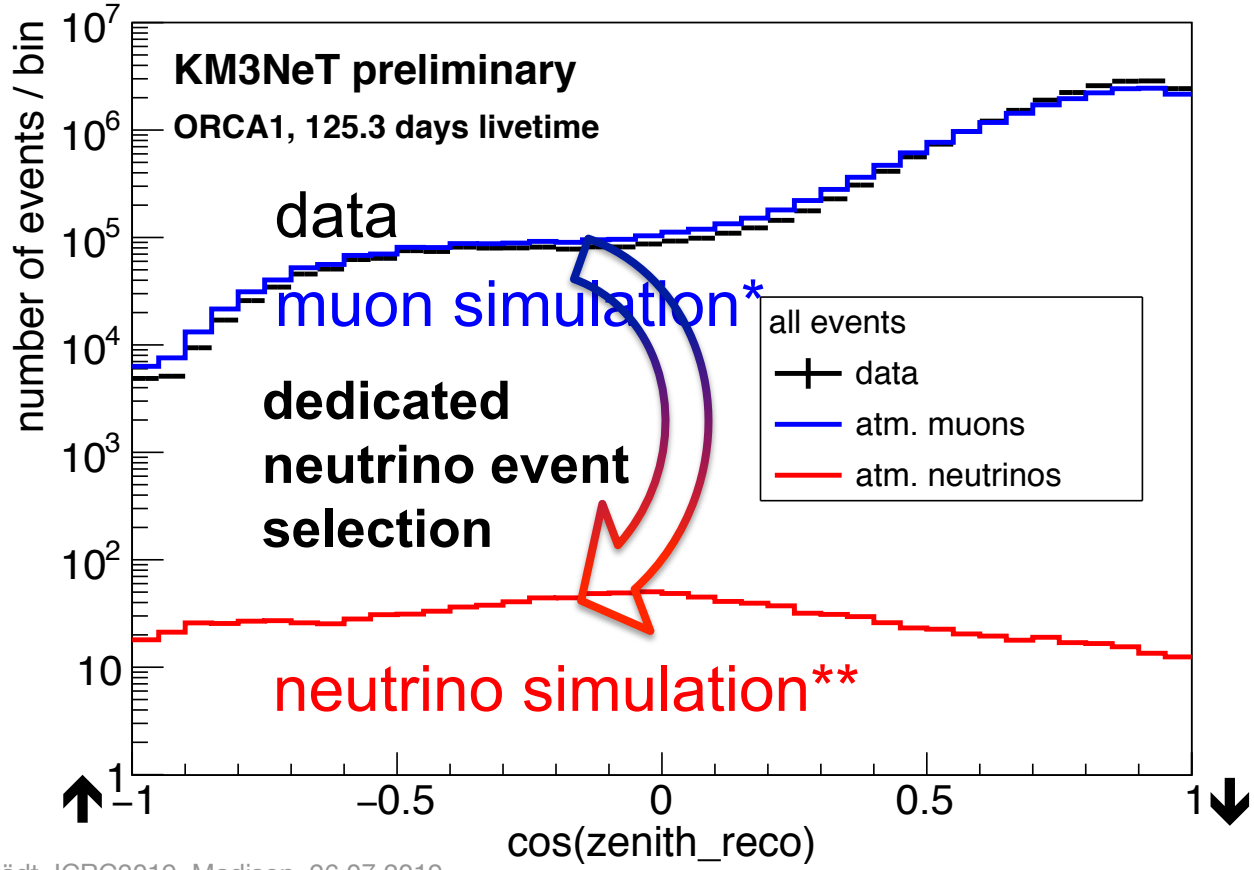
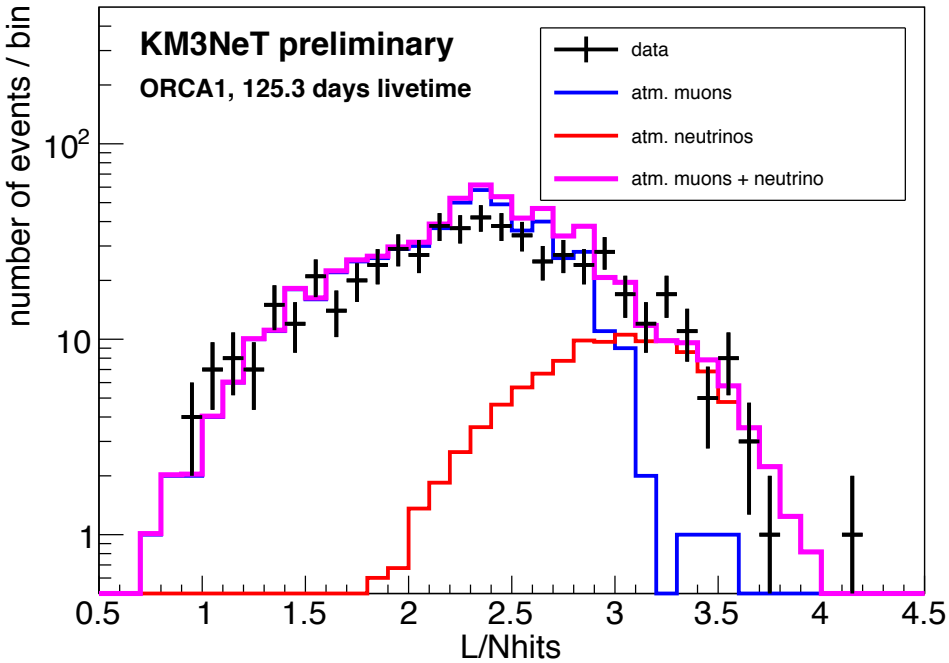


ORCA1: Data-MC comparison

- Reconstruction quality for intermediate event selection →
- Good data-MC agreement for muon-dominated as well as neutrino-dominated regime



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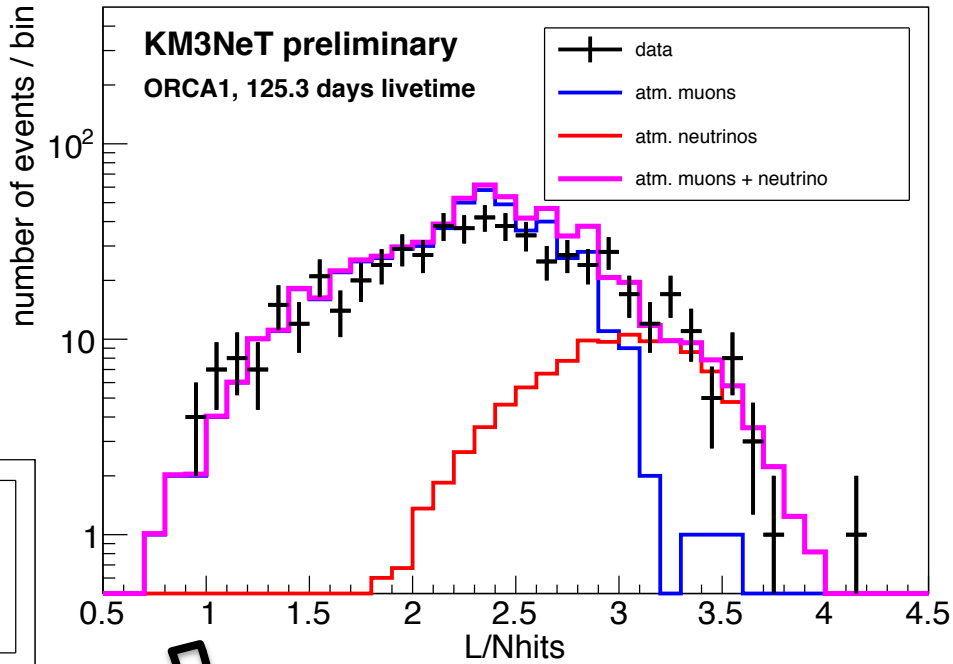

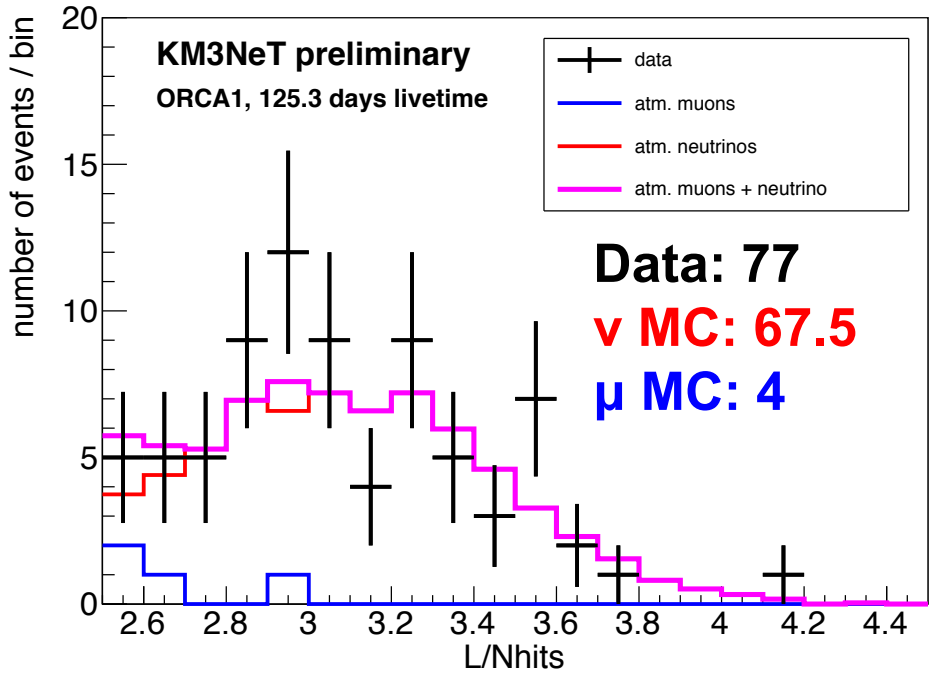

Final event selection

ORCA1: Data-MC comparison

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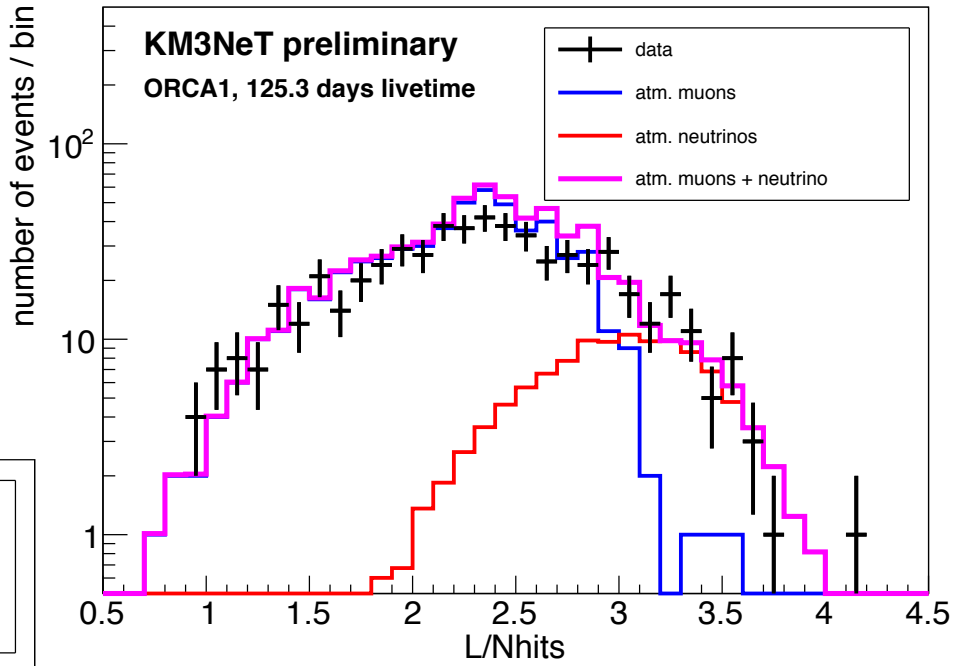
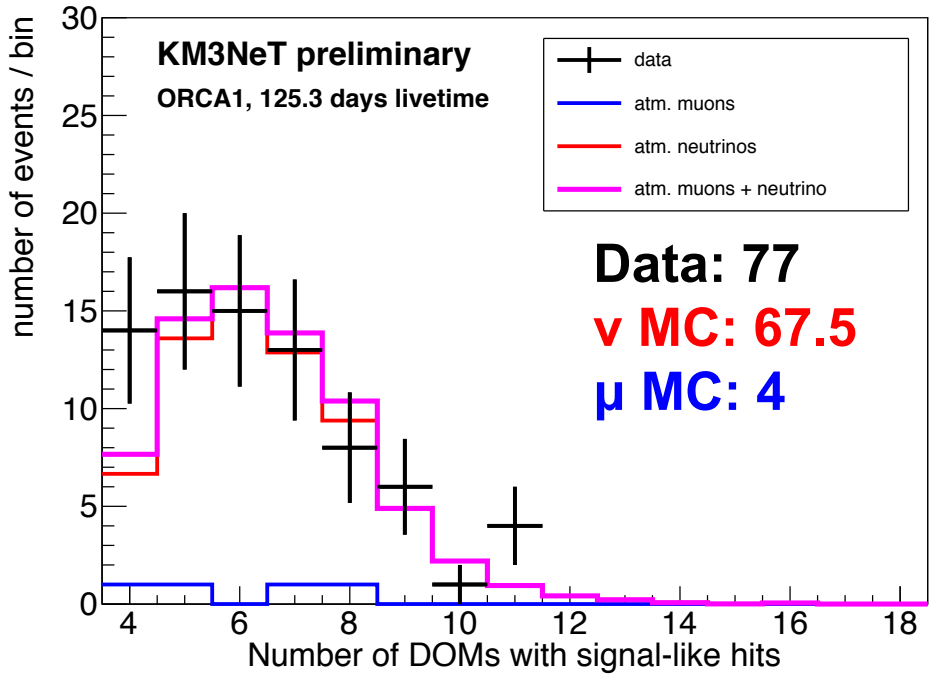
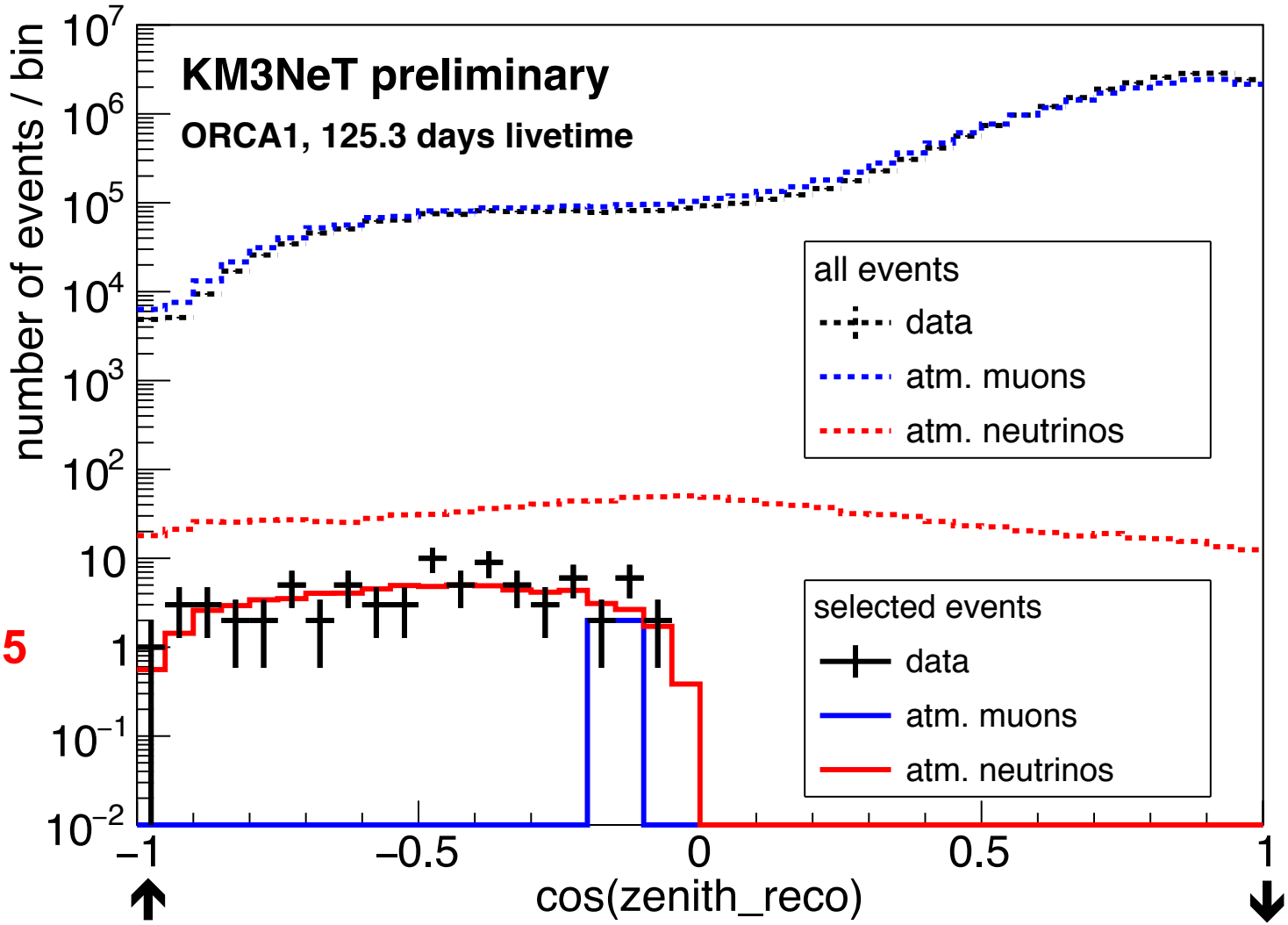




← Number of DOMs with signal-like hits for final event selection

- Good data-MC agreement

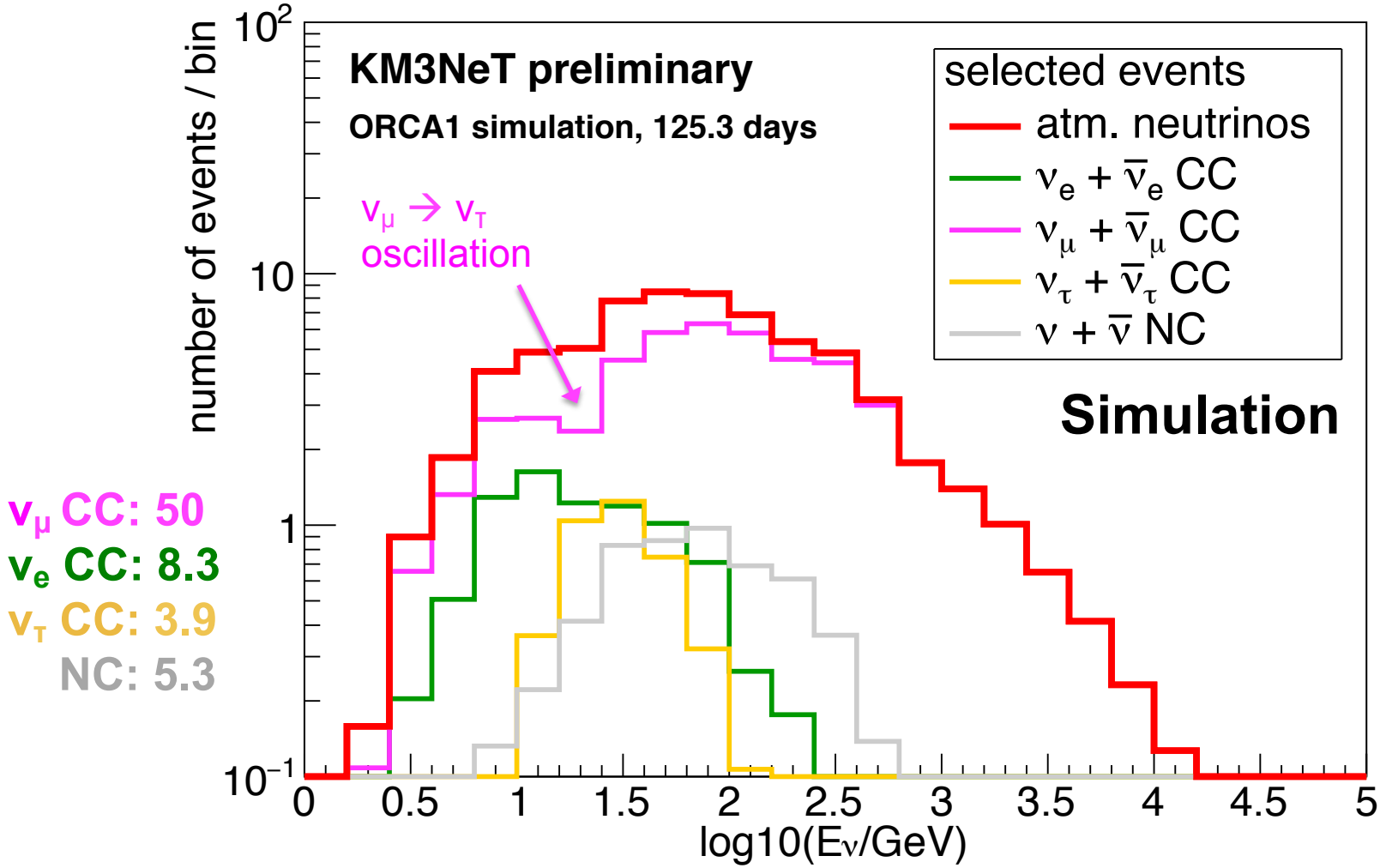
ORCA1: Reconstructed zenith angle



Data: 77
ν MC: 67.5
μ MC: 4

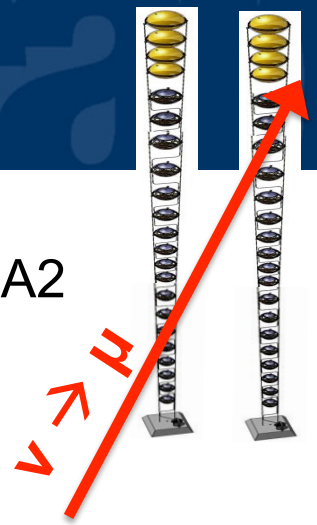
ORCA1: True neutrino energy

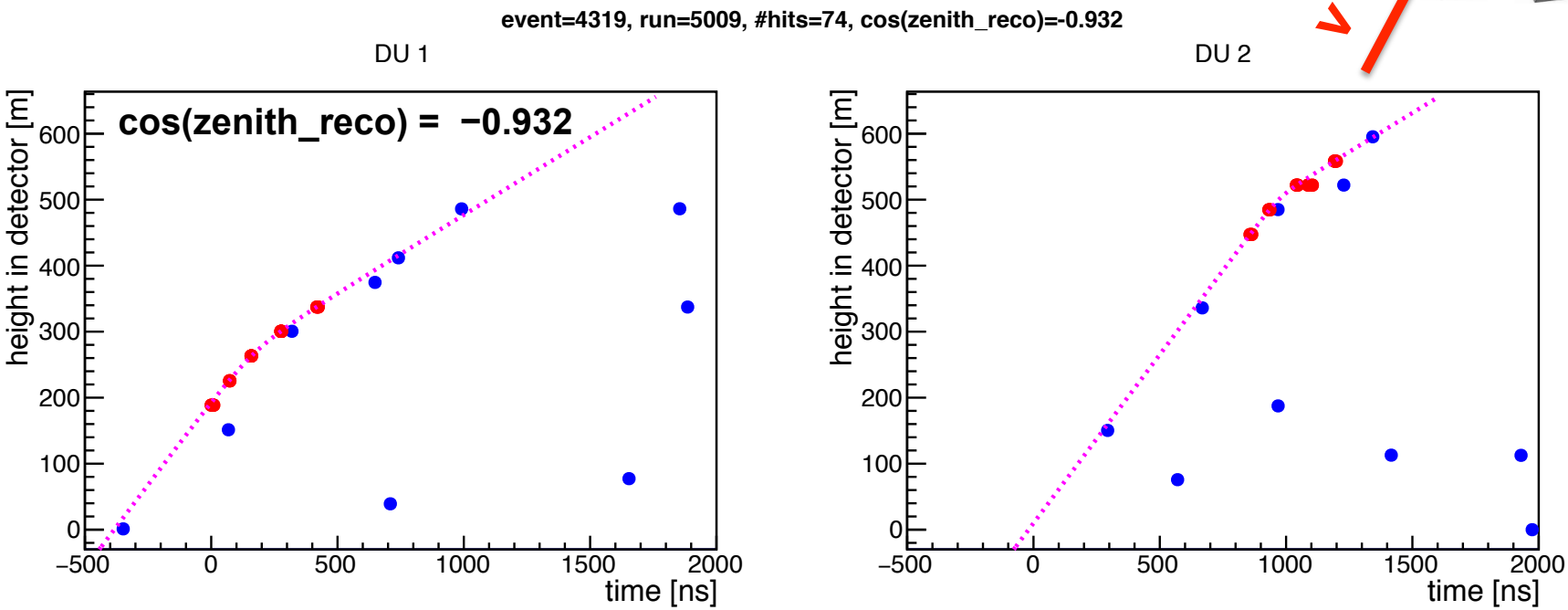
- Detection threshold: ~few GeV



ARCA2
53.2 days of selected data

- Up-going neutrino candidate visible on both DUs of ARCA2





ARCA2: Reconstructed zenith angle

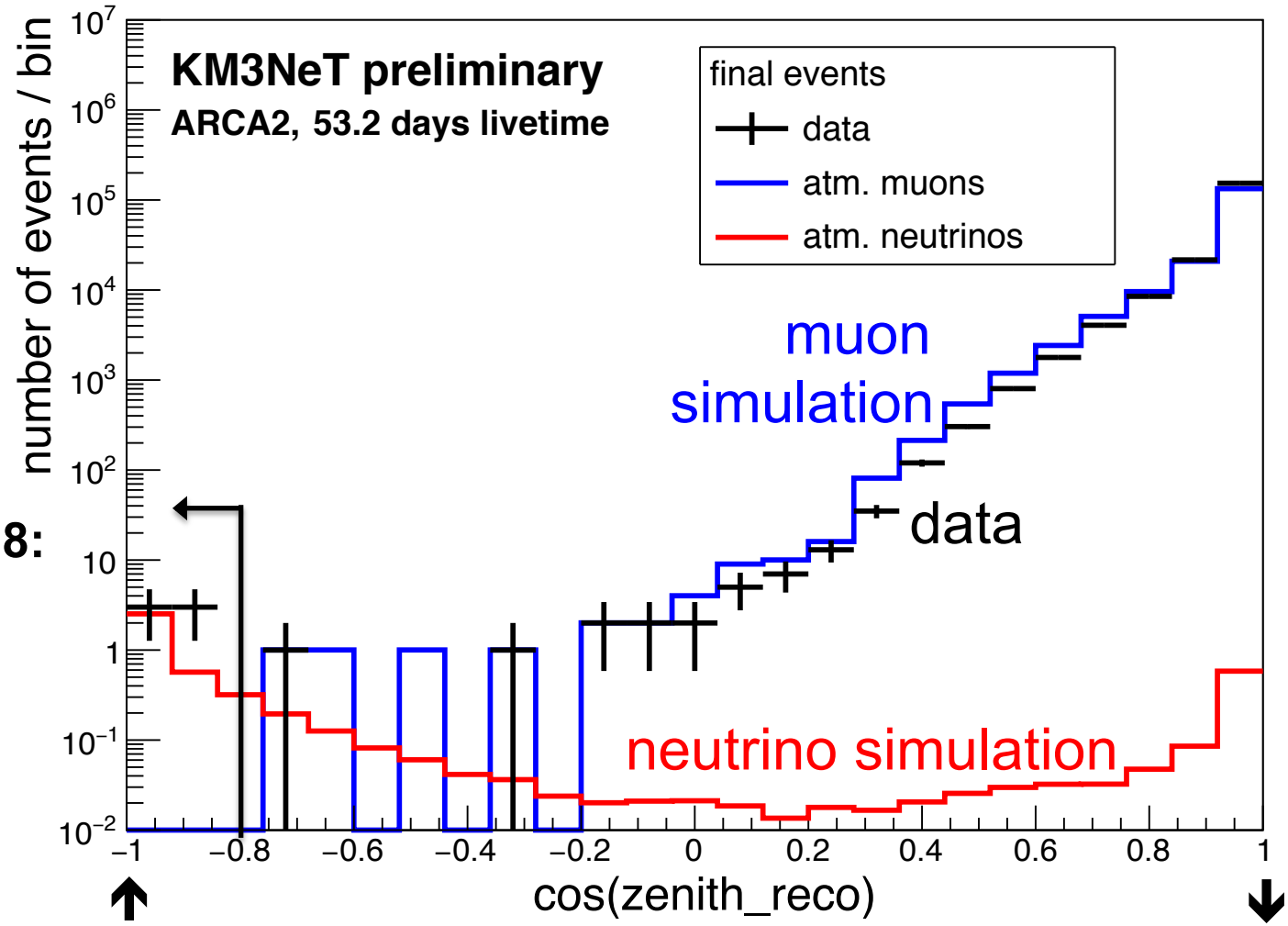
- Similar analysis for ARCA2, but more challenging due to sparser instrumentation → detection threshold at higher energy

cos(zenith)<-0.8:

data: 6

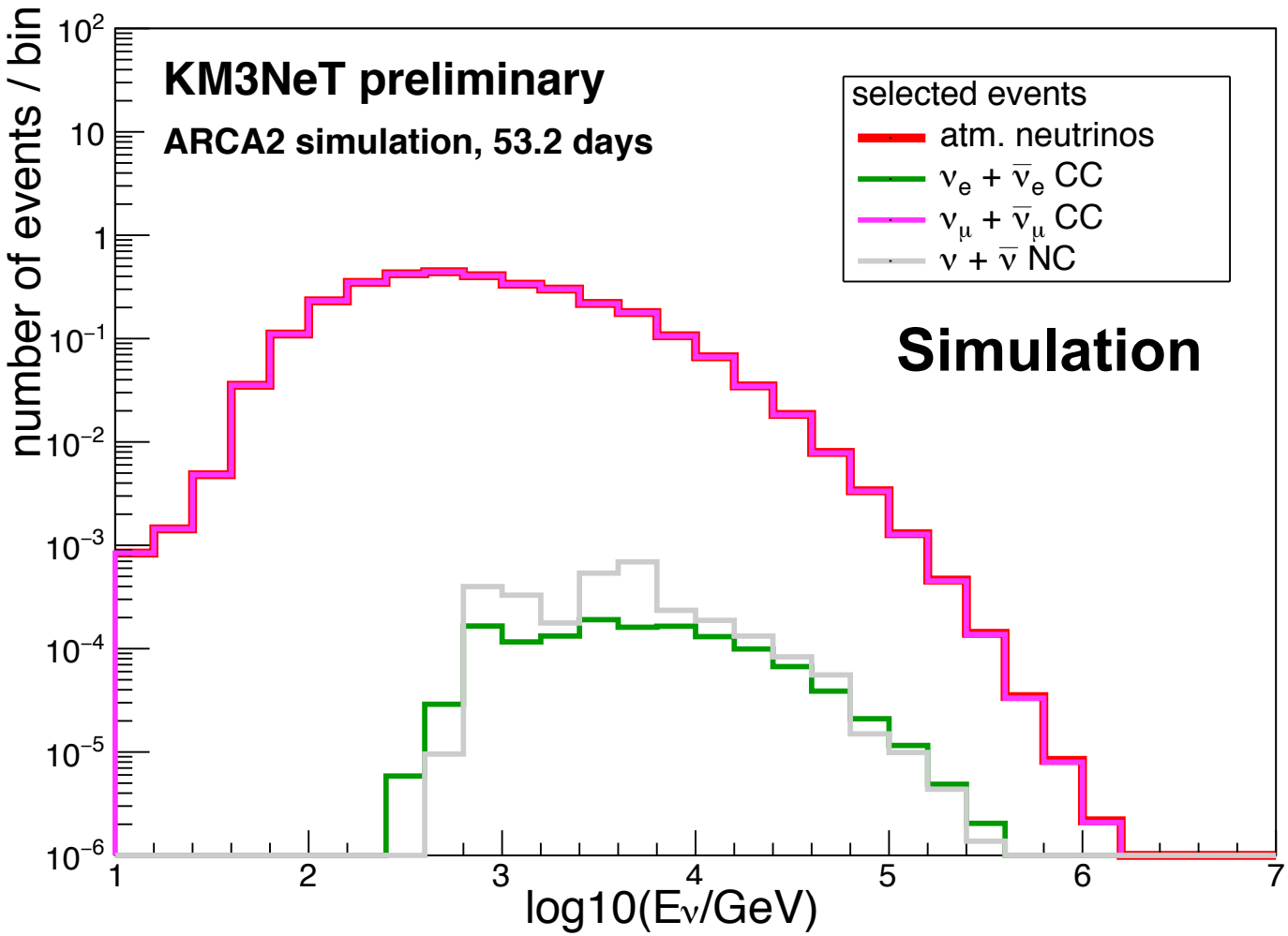
ν MC: 3.3

μ MC: 0



ARCA2: True neutrino energy

- Detection threshold: ~100GeV for ν_μ

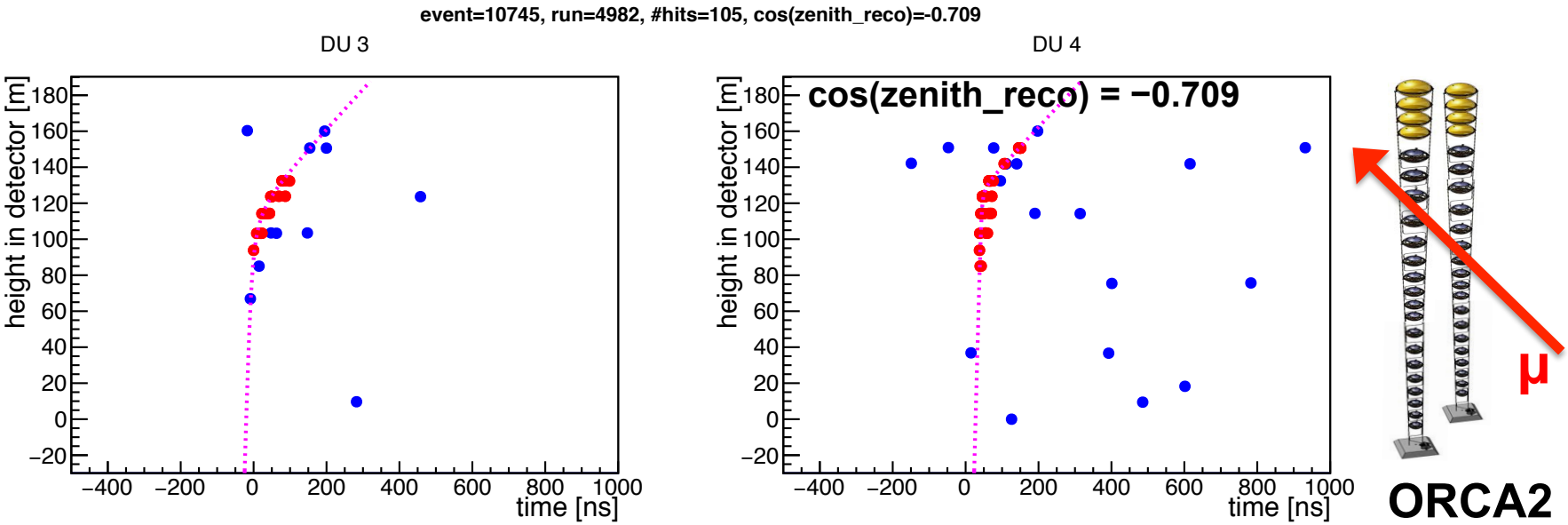


ν_μ CC: 3.3
ν_e CC: ~0
NC: ~0

Conclusions and outlook

- First neutrinos detected with ~1% of full ARCA and ORCA detectors
- Good data-MC agreement → verifies detector understanding and detector calibration

- Data analysis of multi-DU ORCA ongoing; first neutrino candidates



- Outlook: two further ORCA DUs will be deployed soon → 6DUs
  → will allow first oscillation results

☞ talk B. Strandberg, Mon 13.45

Thank you for your attention !

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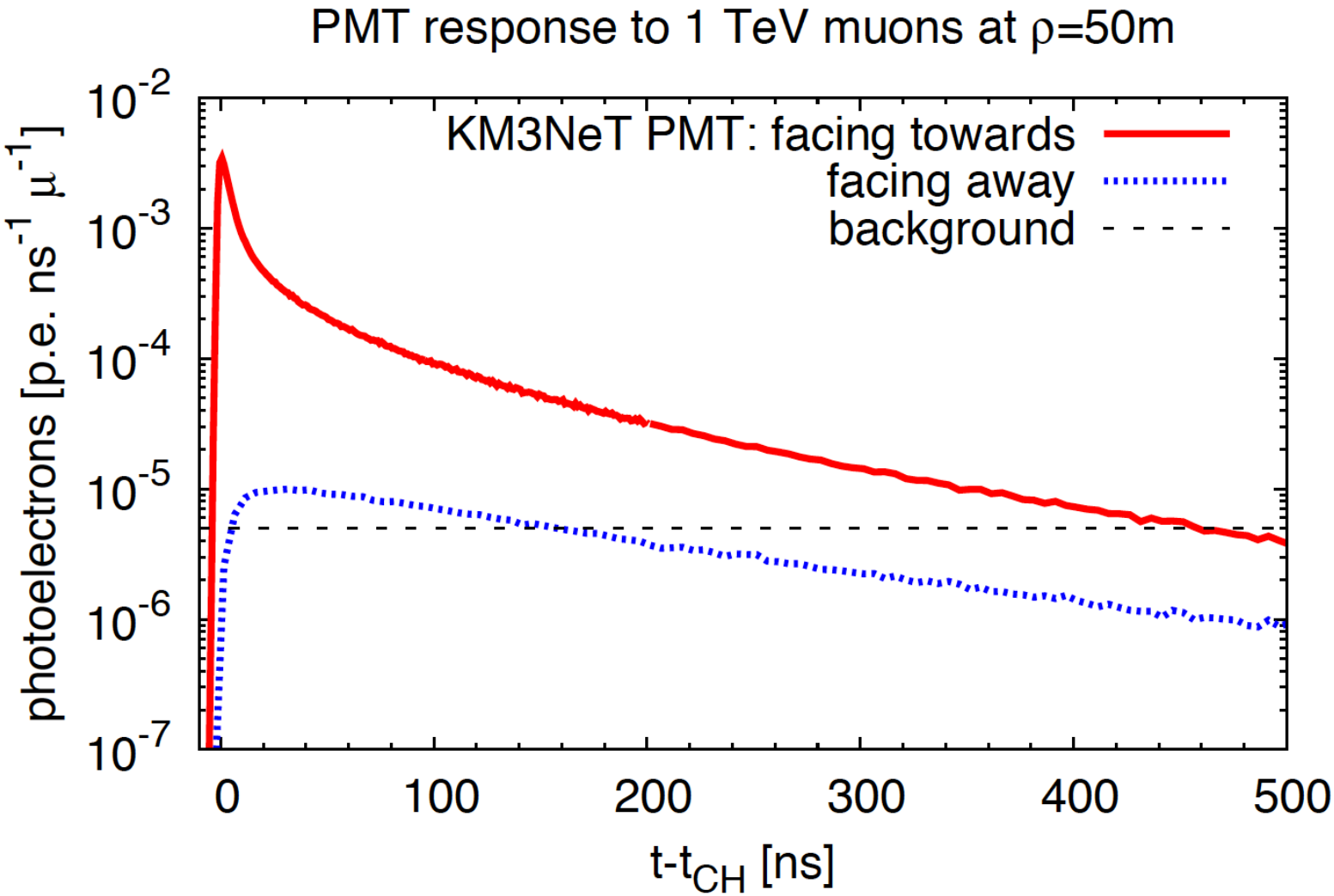
Time residual distribution

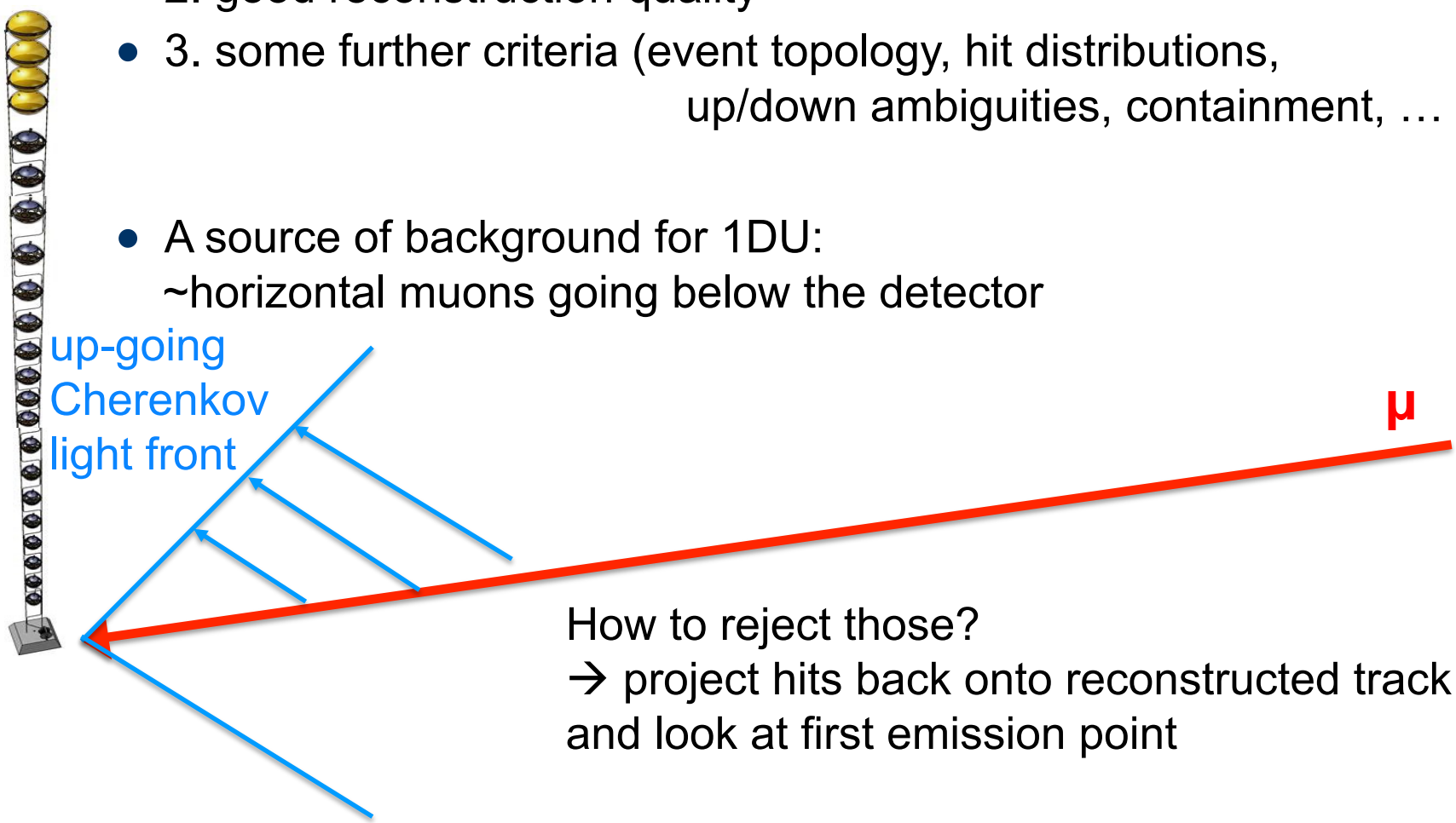
- Sharply peaked time distribution → favourable for direction reconstruction



Atmo. muon rejection & neutrino selection

- 1. reconstructed as up-going
- 2. good reconstruction quality
- 3. some further criteria (event topology, hit distributions, up/down ambiguities, containment, …)

- A source of background for 1DU:
  ~horizontal muons going below the detector



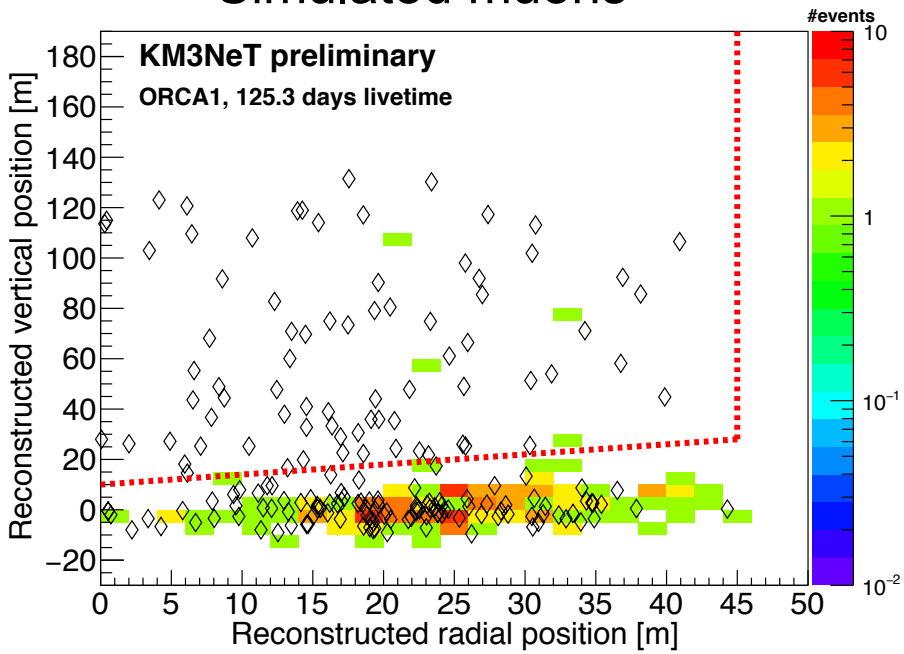
How to reject those?
→ project hits back onto reconstructed track and look at first emission point

ORCA1: 'Containment'

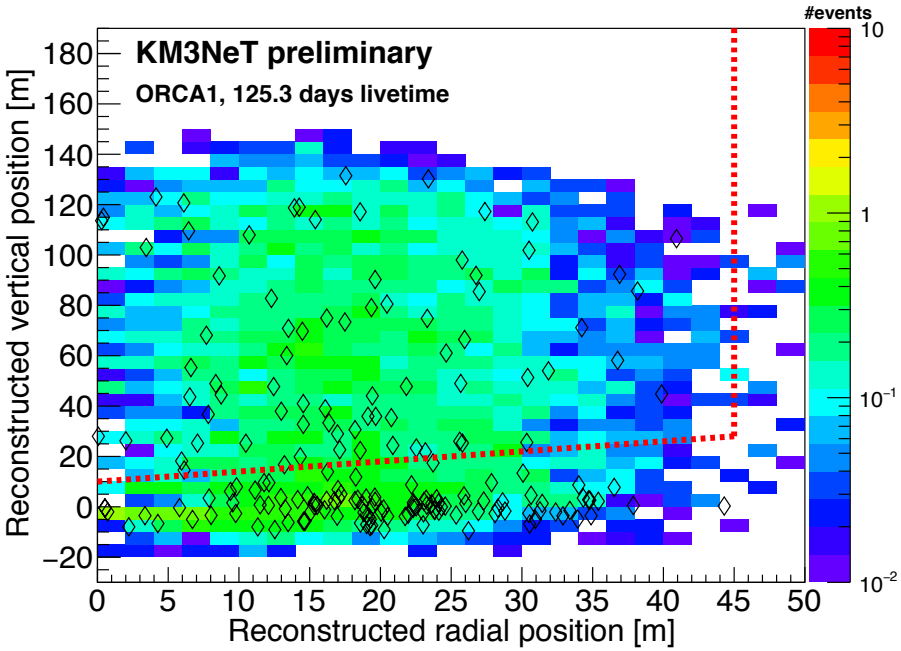
- Reconstructed first photon emission point: radial and vertical position

data

Simulated muons



Simulated neutrinos



- → muons below detector; neutrinos more equally distributed
- → 'containment' is possible with a single DU
- Data agrees with MC expectation