Analysis of first KM3NeT/ORCA data

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ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG

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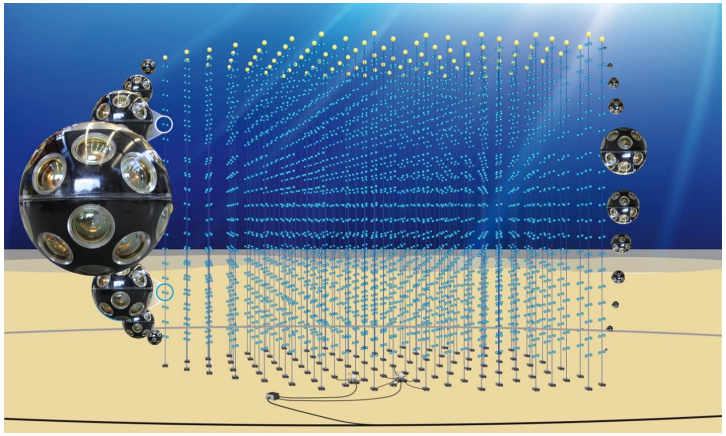
Overview

- **KM3NeT**: Water Cherenkov detector in the Mediterranean Sea
- Detector is split up and deployed at two sites:
  - → ARCA Astroparticle research
  - → **ORCA** Neutrino oscillation research
    8 Mton instrumented mass
- Current project status:
  - → Deployment for Phase-1 (7 DUs)
  - → Four detection units (DU) installed and taking data

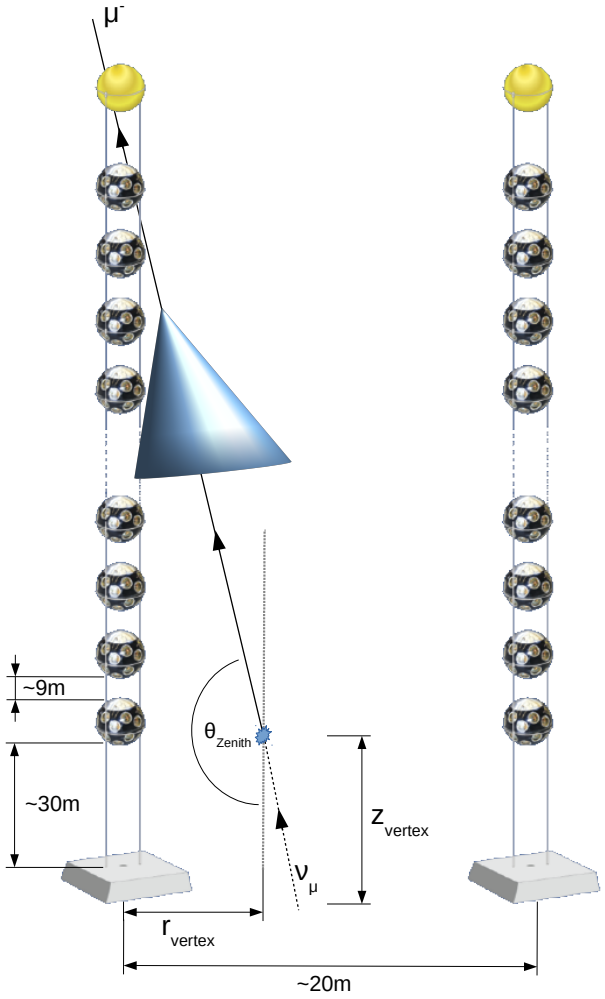
⇒ First data available → **Data Analysis**



Artist impression of the KM3NeT detector

Detection Unit & Reconstruction

- **Detection Unit:**
  18 DOMs, 31 photomultipliers each
- **Dataset Livetime** 1 DU $\rightarrow$ 82 days
  2 DUs $\rightarrow$ 17 days
- **Event Reconstruction:**
  $\rightarrow$ Maximum likelihood method for track hypothesis using PDFs generated from Monte-Carlo simulations
- **Task:**
  $\rightarrow$ Search for neutrino candidates requires dedicated event selection



Analysis Details & Event Selection Cuts

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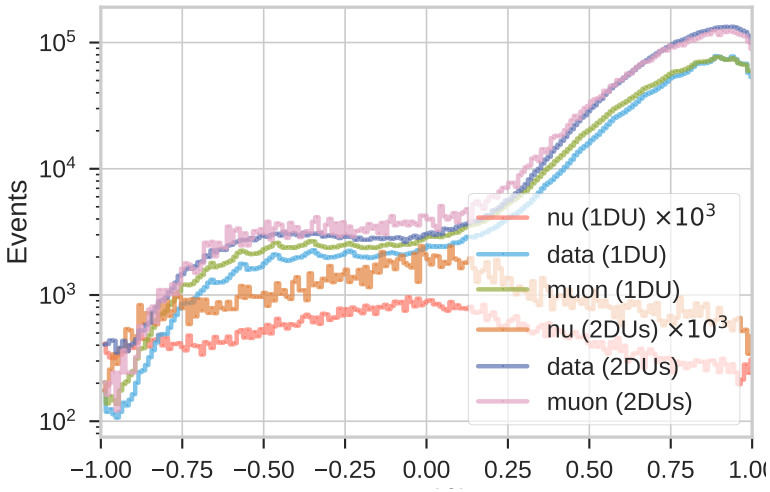
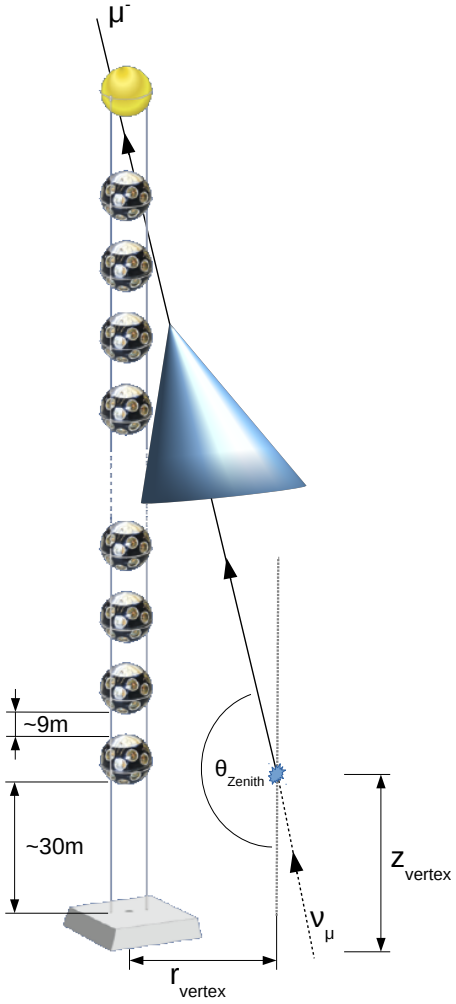
Reconstructed Events

- **Problem:**
  - → Event rate dominated by atmospheric down-going muons
  - → Rate of 'up-going', i.e. mis-reconstructed, muon events still $\sim 10^4$ higher than actual neutrino event rate
- **up-going** events → Neutrino events

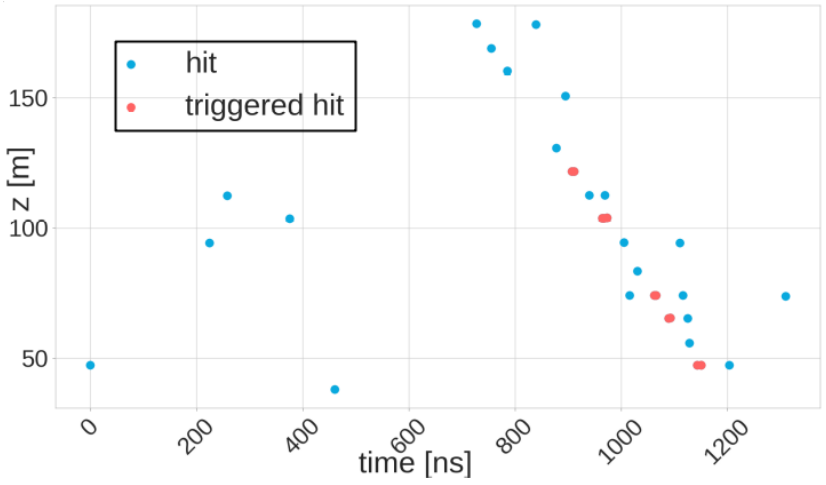


Zenith distribution of all reconstructed events

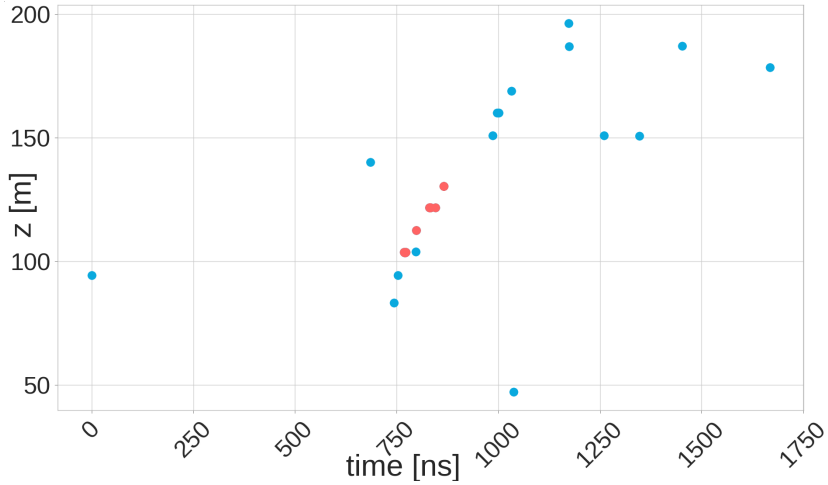


Event Topology

- **Event trigger:**
  large clusters of causally connected detected photons at the PMTs (hit)
- Search for hit patterns of up-going events
- Identification of (spacial) characteristics for event selection



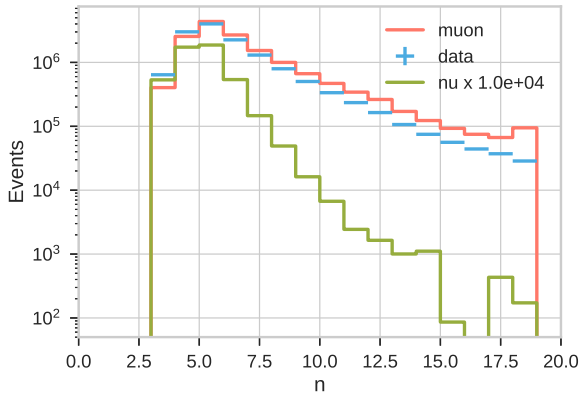
Simulated atmospheric muon event



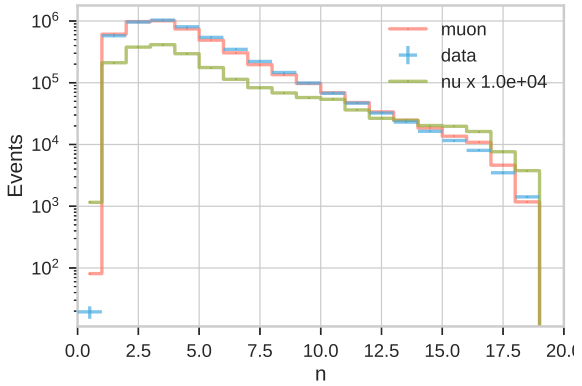
Simulated neutrino event

Data / Monte-Carlo comparison

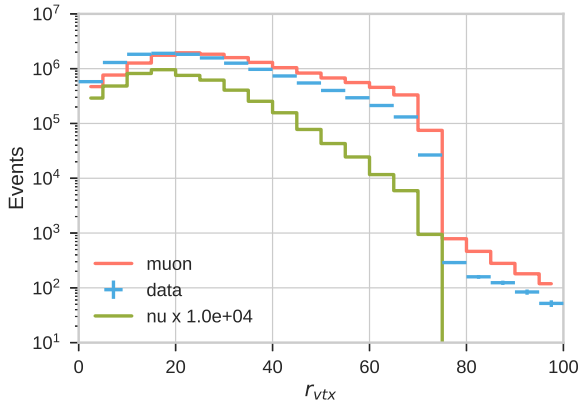
- Data is in good agreement with Monte-Carlo simulations



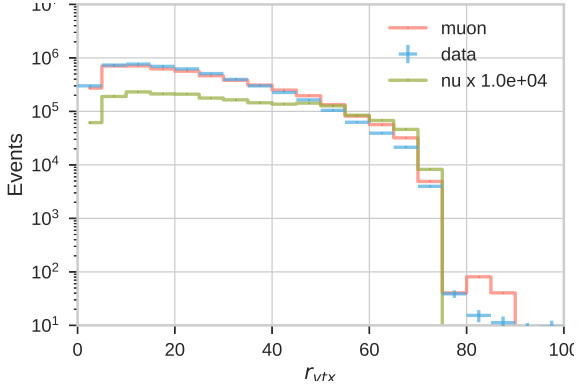
Number of triggered DOMs (1 DU)



Number of triggered DOMs (2 DUs)



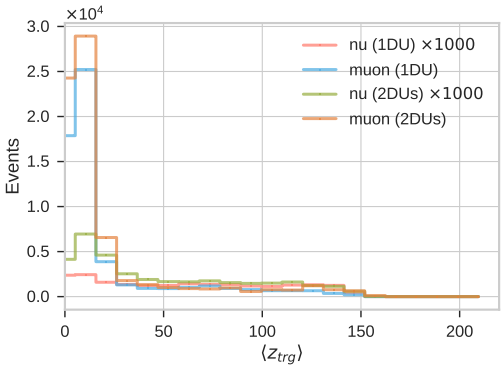
Radial vertex distance (1 DU)



Radial vertex distance (2 DUs)

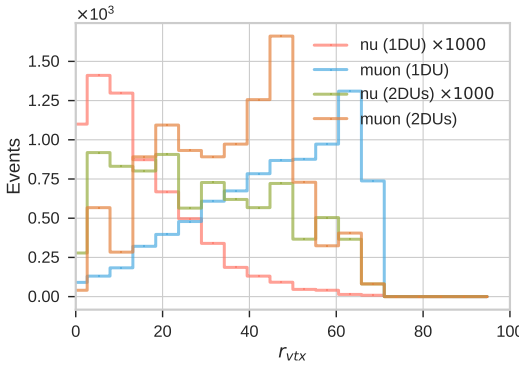
Geometrical Cuts

- Require reconstructed tracks close to the DU(s)
- Horizontal muon tracks below the DU(s) create (also) up-going patterns



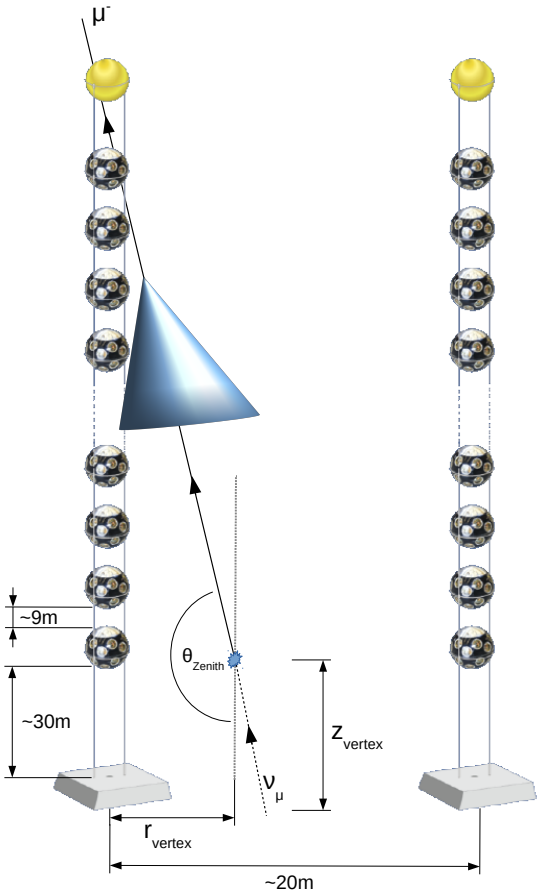
Mean height of tiggered hits

Cut: $\langle z_{\text{trg}} \rangle > 40\,\text{m}$



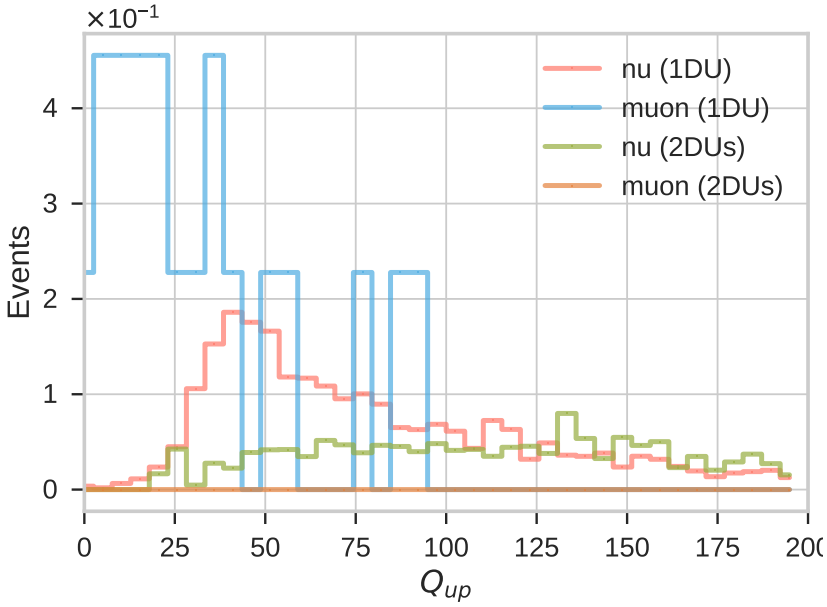
Radial distance of the reco. vertex

Cut: $r_{\text{vtx}} < 20\,\text{m}$



Likelihood / Reconstruction Cuts

- Check likelihood value of best up-going solution
- **Other cuts:**
  - → Likelihood value difference between best up- and down-going solution
- **Possible improvements:**
  - → Use likelihood value normalised to number of degrees of freedom

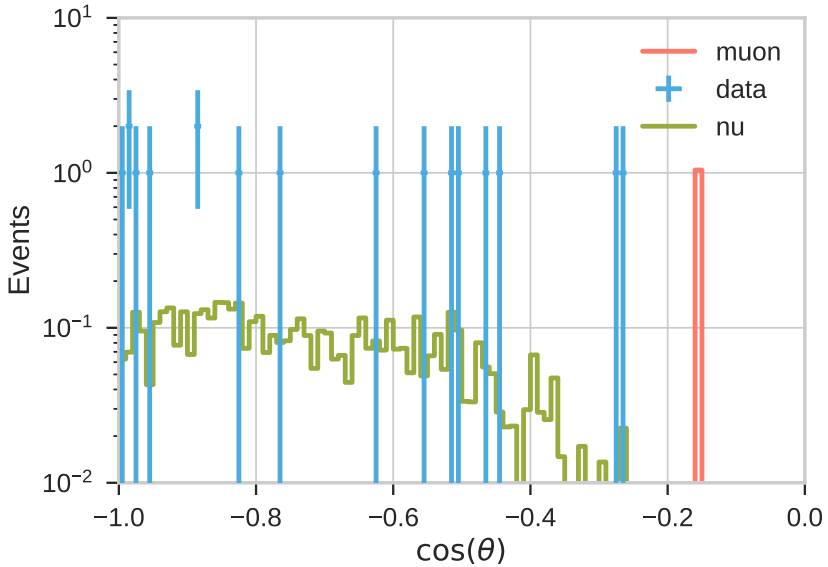


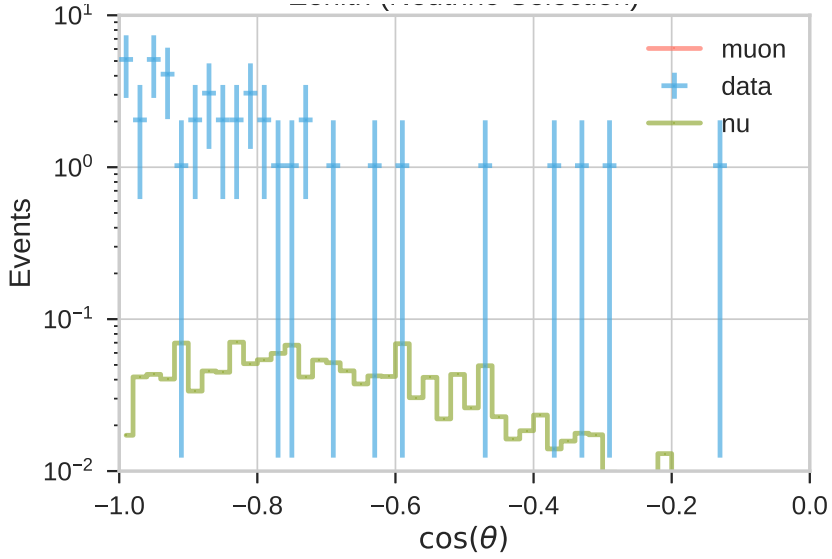
Likelihood of best up-going solution

Cut: $Q_{\text{up}} > 40$

Resulting Zenith Distribution

Analysis	Initial events	ν Candidates (MC)	Mis-reco. muons in MC	Rate
1DU	1.4×10^7	17(5.2)	1	0.2 / day
2DU	5.0×10^6	43(1.4)	0	2.5 / day
2DU (min. muons)	5.0×10^6	81(5.22)	0	4.8 / day





Final Remarks / Outlook

- Event reconstruction with one/two DUs
  → **Neutrino identification possible**
  → Features for Sparking PMTs and Bioluminesence effects needed
- **No blinding** → Main goal: **understanding the detector**
  ⇒ Focus on geometrical cuts
- **Current status:**
  → **Preliminary Results**
  → Start from other ongoing collaboration analysis (cross-check)
  → **Most promising:** Arrival time residual w.r.t. reco. hypothesis
- **Outlook:**
  → Use also the four installed DUs
  → Development of (new) cut features on-going

Thank you for your attention!

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Backup

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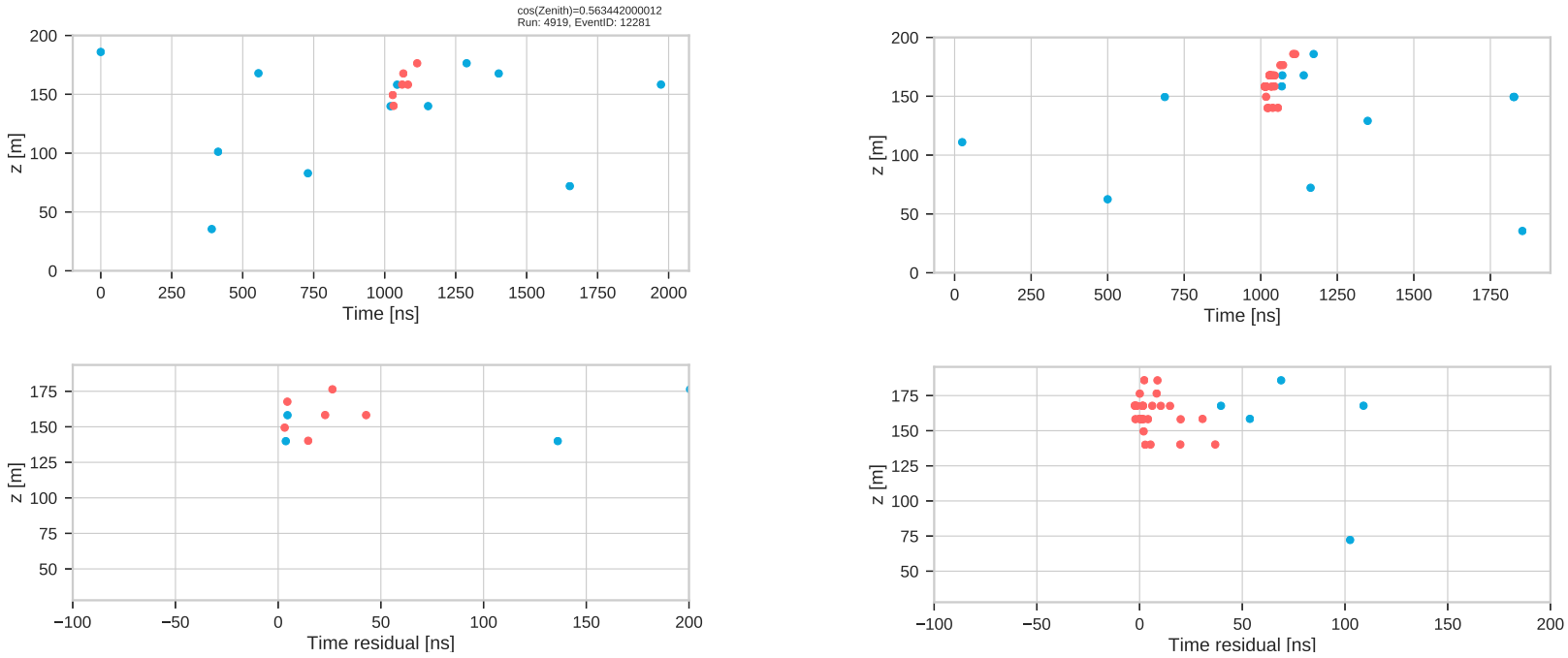
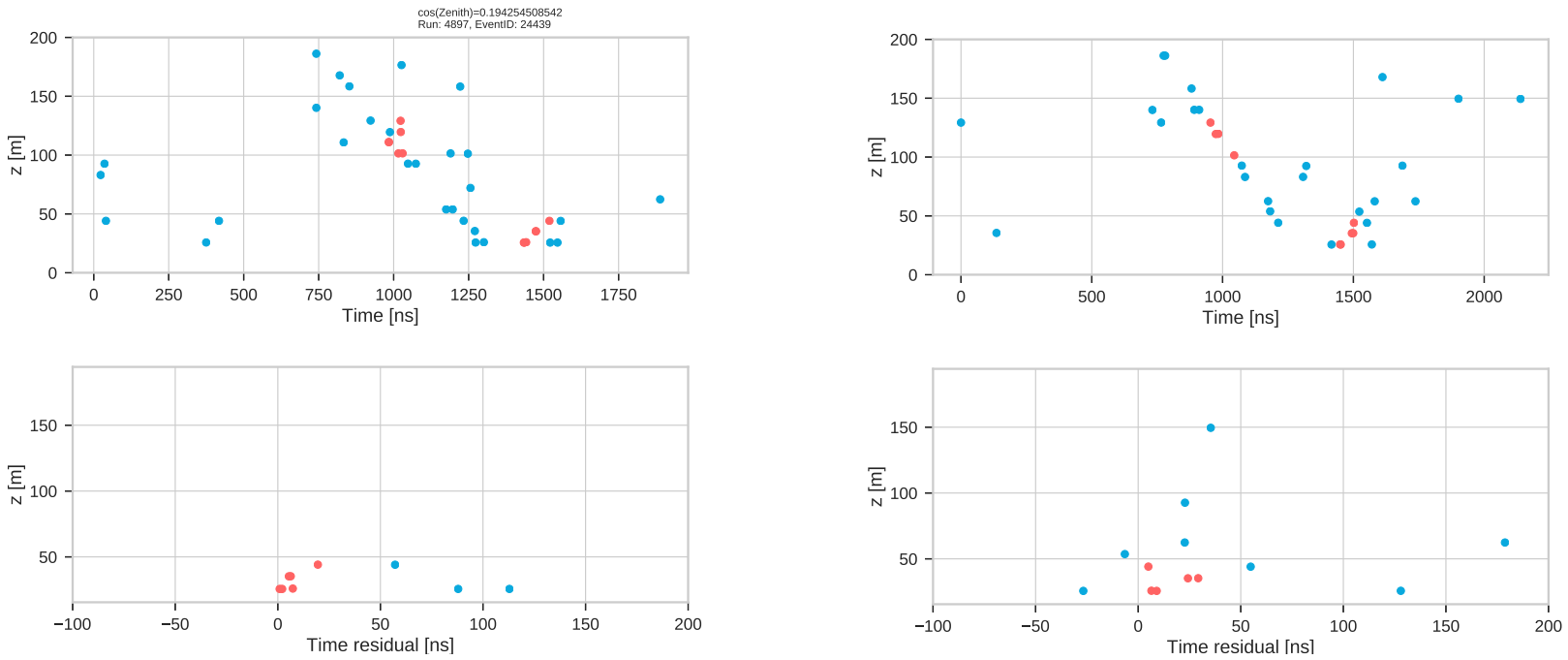
Neutrino Candidate



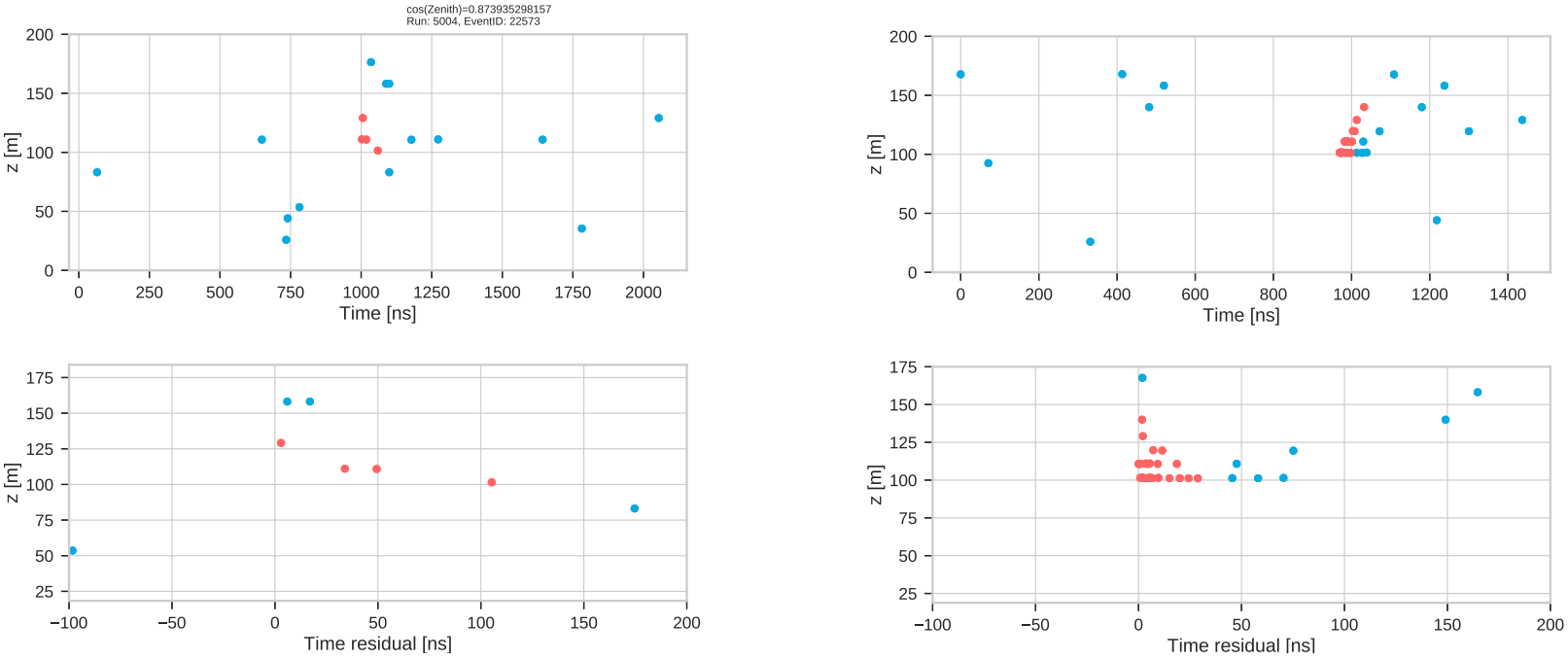
Run: 4919, EventId: 12281, $\cos(\Theta) = 0.56$

Reconstuction Hit Selection



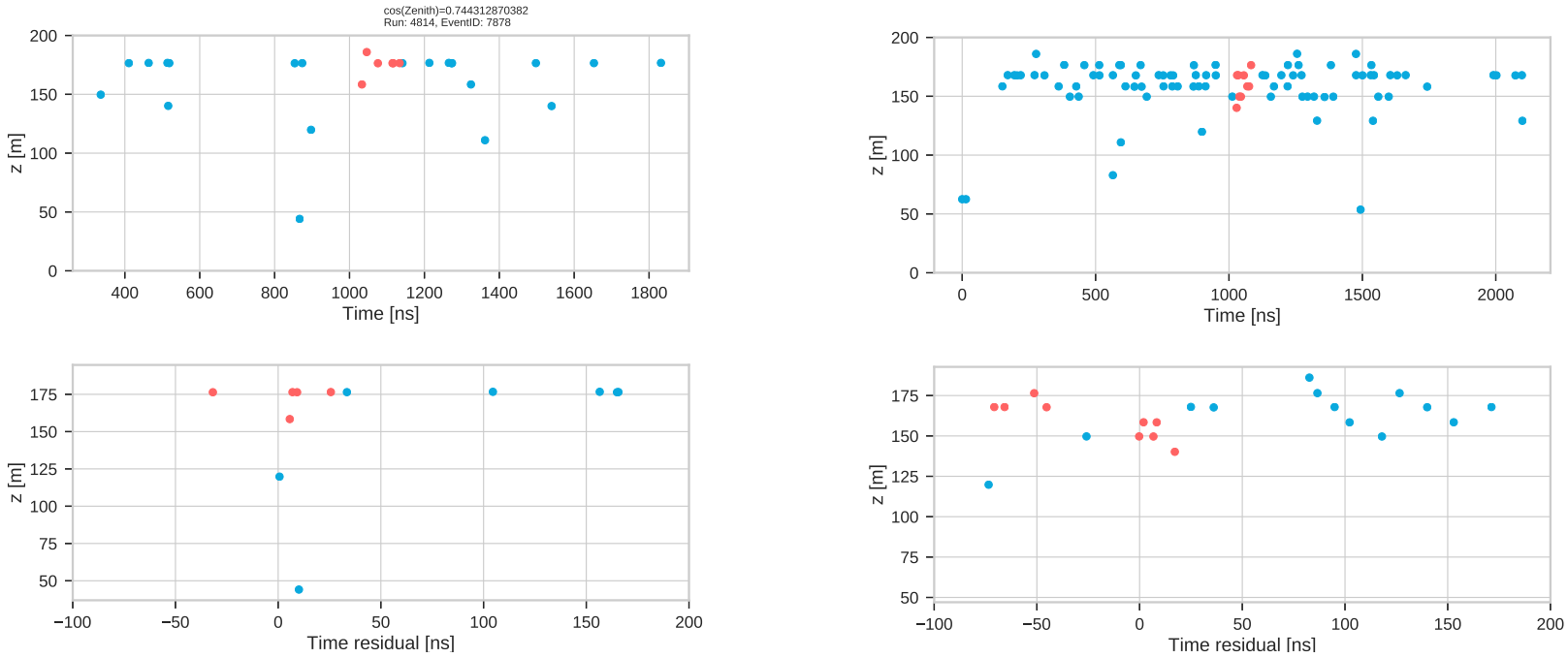
Run: 4897, EventId: 24439, $\cos(\Theta) = 0.19$

Sparking PMT



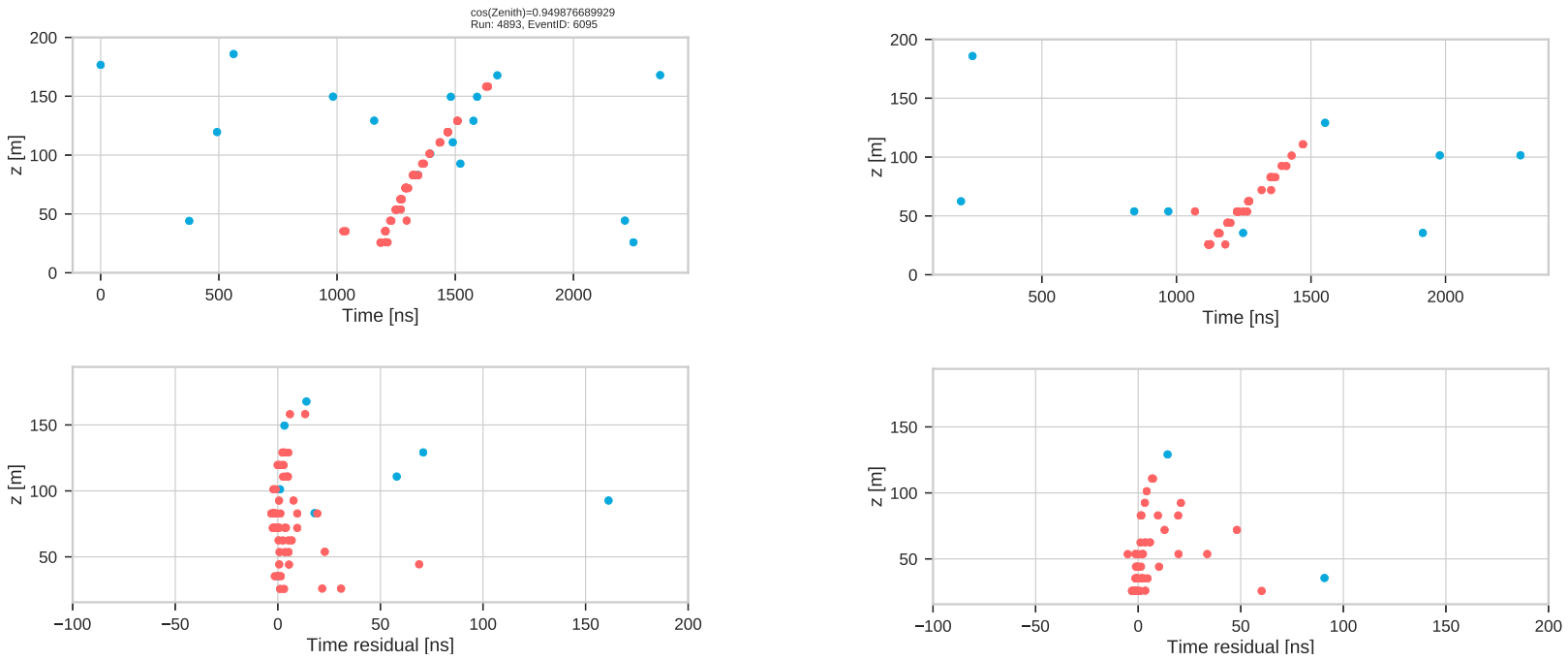
Run: 5004, EventId: 22573, $\cos(\Theta) = 0.87$

Bioluminesence



Run: 4814, EventId: 7878, $\cos(\Theta) = 0.74$

Misreconstructed muon candidate



Run: 4893, EventId: 6095, $\cos(\Theta) = 0.95$