Multiple interactions in a Neutron Monitor

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Introduction

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  - 18NM64 + 2 unleaded tubes
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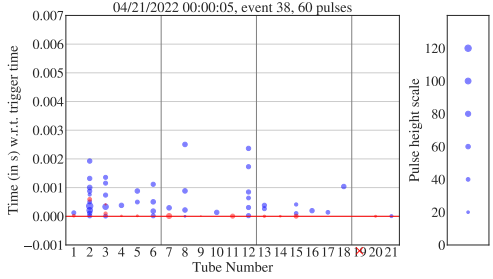

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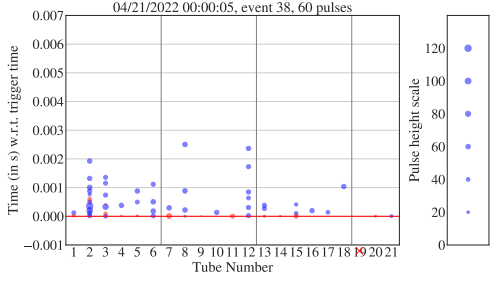
  - Very energetic secondary particle (SP)?
  - Coincidence between SP?



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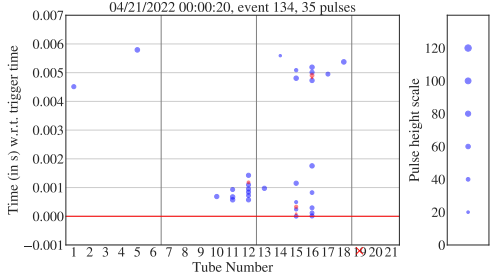

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- What produces these large events?
  - Air shower core?
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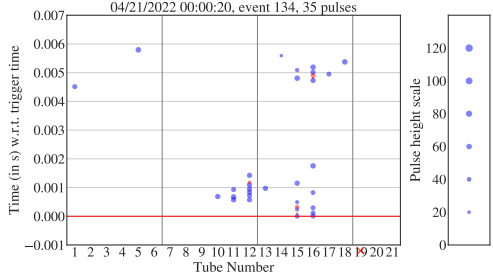
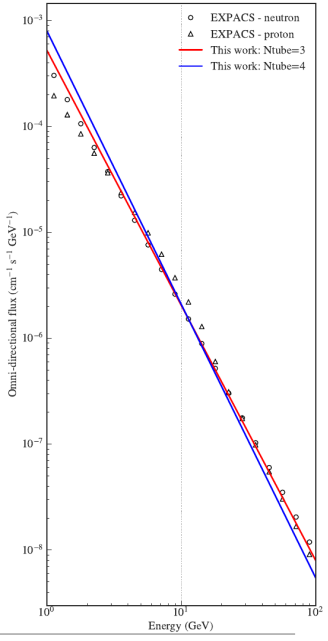
  - Coincidence between SP?
- Can we identify the source of an event?
- Can we use these events (or a subset) to evaluate the spectrum at rigidities above the cutoff?



Preliminary results from Evenson et al. [2021]

- Event selection
  - 7 pulses or more
  - Contained (no hit in the edge tubes)
  - Compact (hits in adjacent tubes)
  - 3 tubes or 4 tubes
- Monte-Carlo Simulation
  - Neutron only
  - Incident angle: 0-45°
  - Energy: 1-100 GeV
- Analysis
  - Fit of the distributions of the number pulses
  - Neutron energy spectrum: Power law
- Conclusions
  - Promising results for a simple analysis
  - Energy range of the simulation should be extended
  - Extend the analysis to smaller events

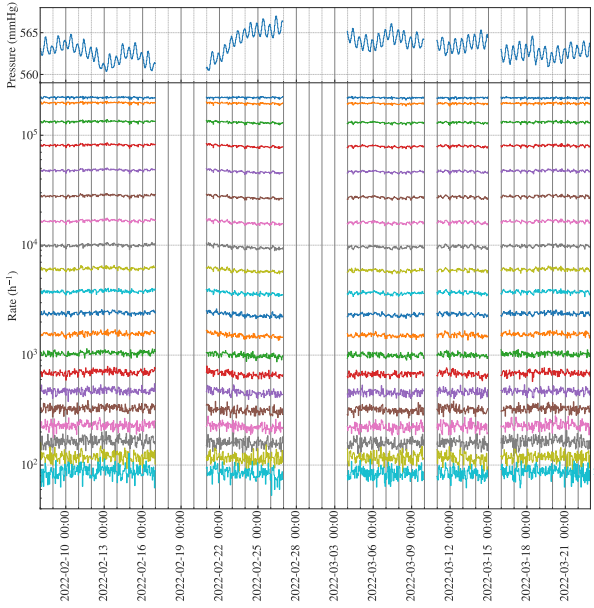


Problematic

- High rate: ∼610 counts/second
- All pulses/events can't be recorded: too much disk space
  - How small could an event be?
  - How do we select the events?
- How long should the trigger time window be?
  - A long time window provides the full information of the multiple interactions in the detector
  - BUT we want to limit coincidences of multiple small events that could mimic larger events
  - HOWEVER we don't want to split long and large events in multiple smaller events

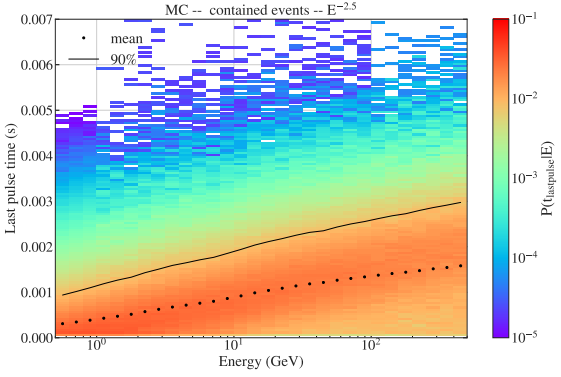
Decimation of small events with a high rate

- Every event with more than 20 pulses is recorded
- A gradual decimation based on the number of pulses per event has been implemented for the smaller events
- The decimation factor ranges from O(1000) to O(1) for events with 1 pulses to 20 pulses respectively
- Hourly rates of the smaller events are recorded
- A pressure dependence is observed for each rate



Trigger time window

- Simulated neutrons: 0.5-500 GeV
- The duration of the interactions in the NM increases with the energy
- A 7 ms time window records the most information but induces a large rate due to chance coincidences
- A 2 ms time window reduces the contamination from chance coincidences but split/duplicate large events
- The determination of the duration of the time window depends on the smallest event allowed. More systematic tests are needed to optimize the recorded data set



Conclusion

- We aim to extend the measurements provided by the neutron monitors
- Recent developments allow us to record detailed information about timing and position for events with multiple interactions in a neutron monitor
- Hourly count rates of events with multiple pulses are now recorded
  - The individual energy responses need to be determined
  - Their sensitivity to atmospheric properties (pressure, humidity) needs to be determined
- Detailed information of multiple-hit events are now recorded down to small events. To reduce the contributions of duplicated/splitted events and multiple coincidences, more work is needed on the determination of:
  - Trigger time window
  - Event selection
  - Decimation factors
- To be continued!

References

Paul Evenson, John Clem, Pierre-Simon Mangeard, Waraporn Nuntiyakul, David Ruffolo, Alejandro Sáiz, Achara Seripienlert, and Surujhdeo Seunarine. Multiple particle detection in a neutron monitor. *PoS*, ICRC2021:1240, 2021. doi: 10.22323/1.395.1240.