Fast-track simulations in XENONnT

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Bundesministerium
für Bildung
und Forschung

XENON

UNI FREIBURG

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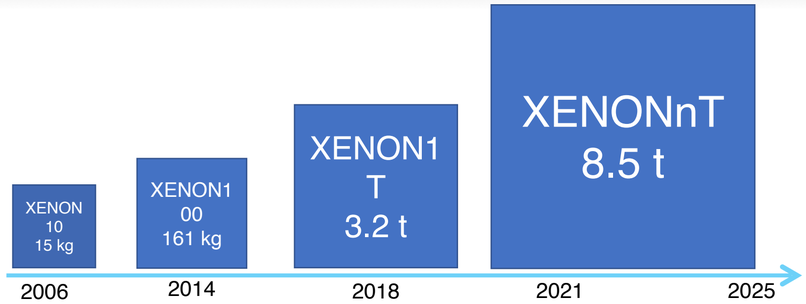
That’s me

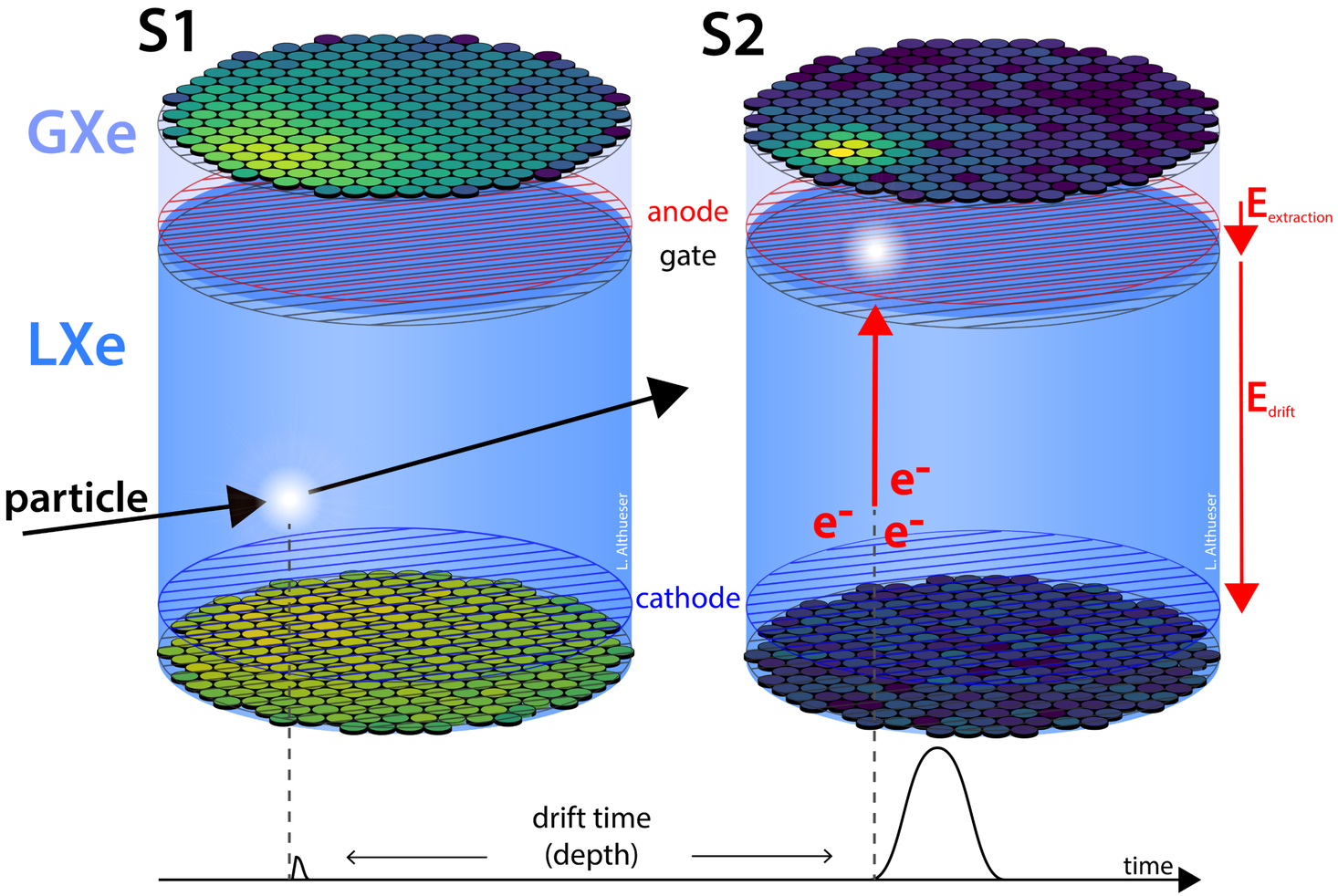
- Jaron Grigat
- Phd student since 2 years @ Uni Freiburg
- Group of Prof. Marc Schumann
- Also part of the XENON collaboration

The XENON experiment



- Long tradition of building world-leading detectors for direct dark matter search (WIMPs)
- Many other science channels (e.g. solar axions, 0νββ, …)

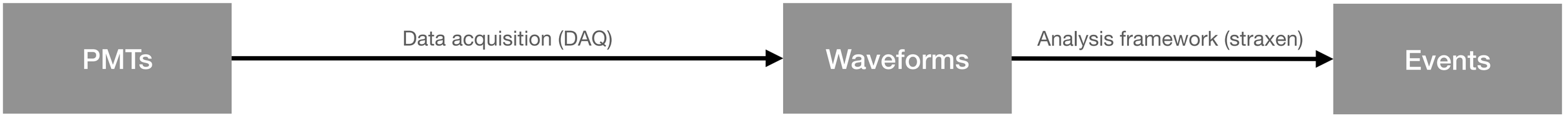
Dual-phase time projection chamber (TPC)



Combination of S1 and S2 signals allows for:

- 3D Position reconstruction
- Energy reconstruction
- discrimination between electronic and nuclear recoils

Data processing chain



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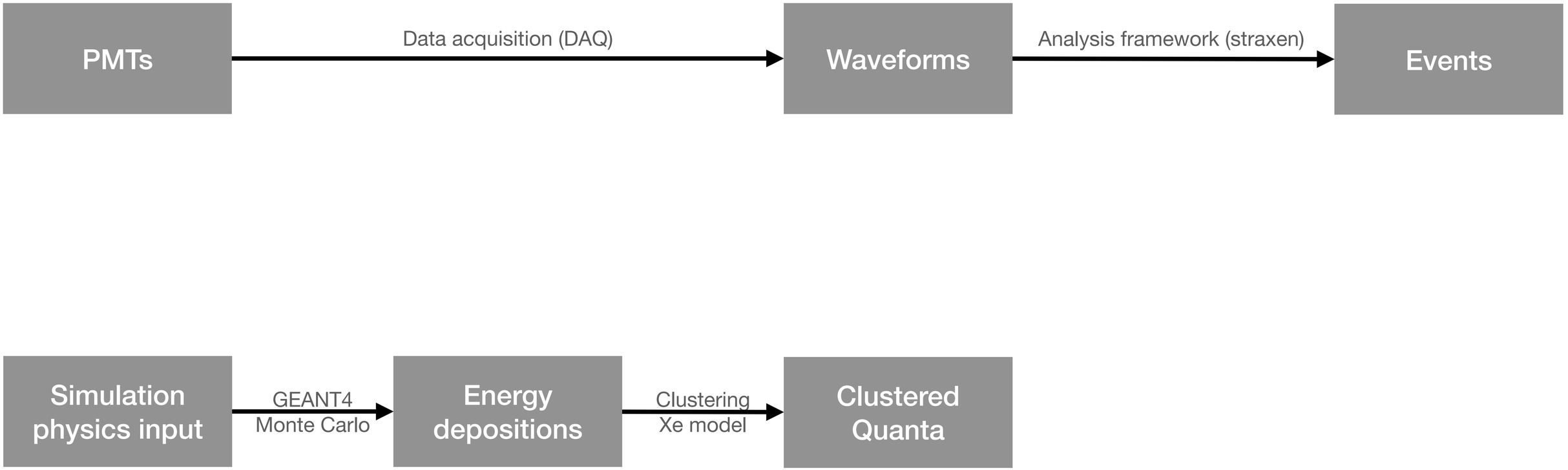
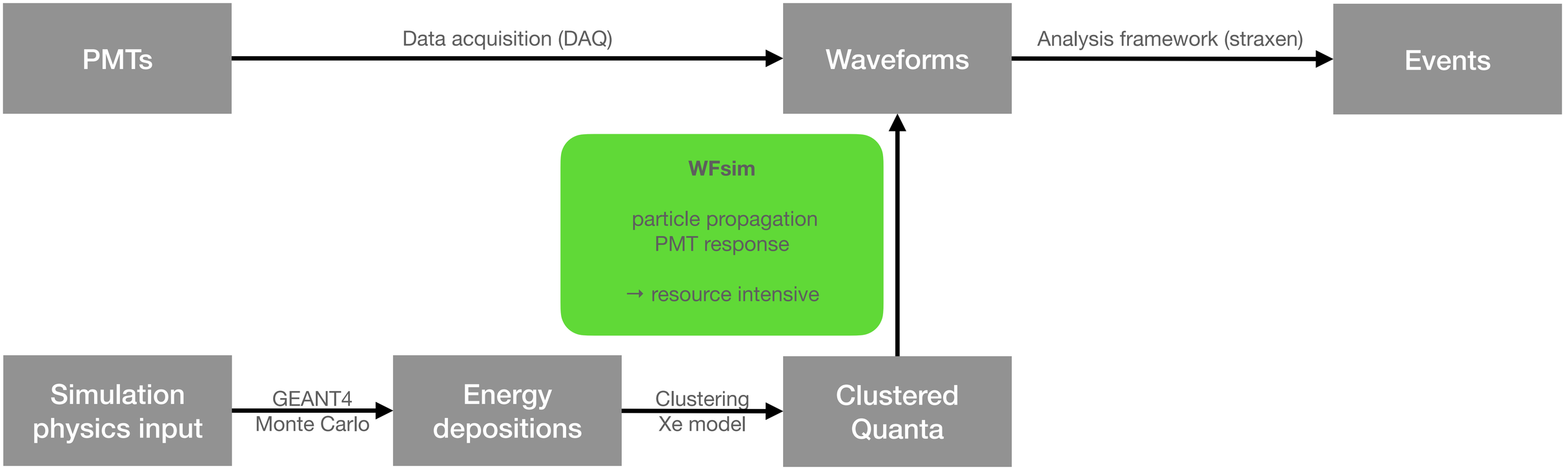


Data processing chain



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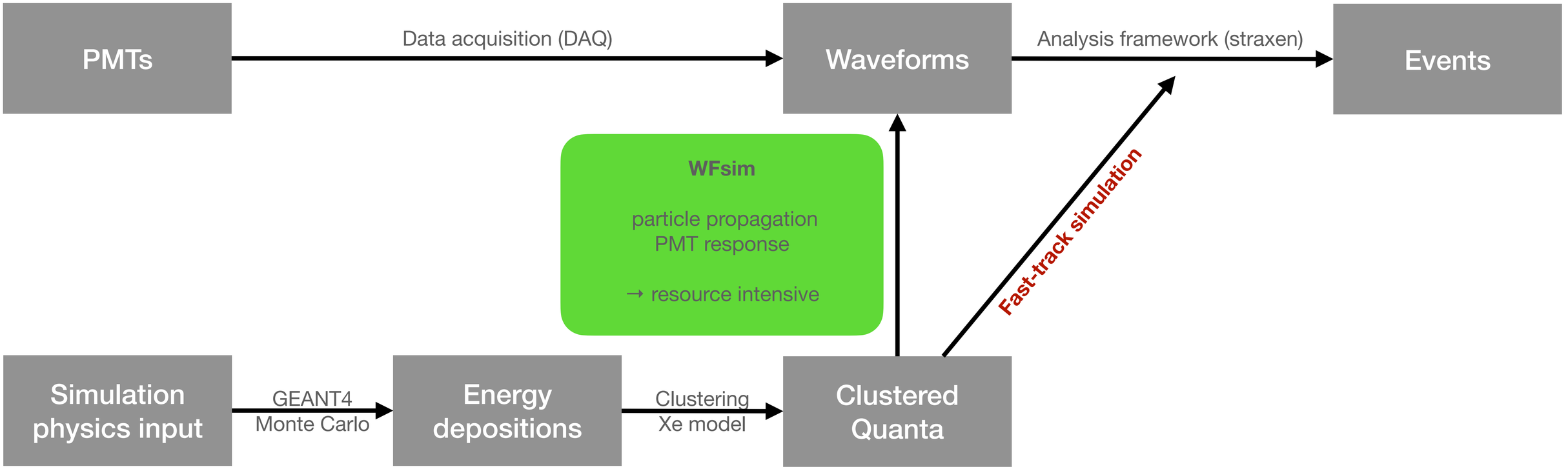
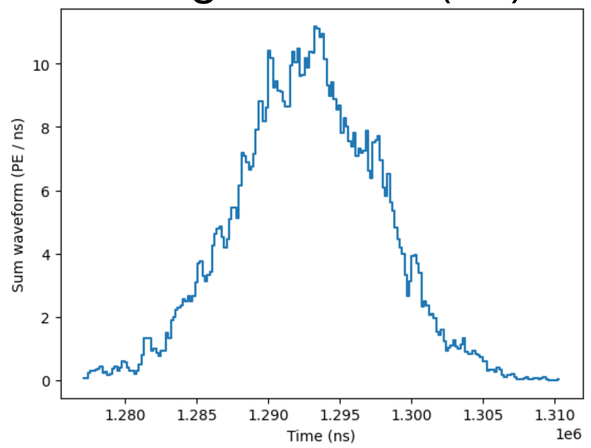


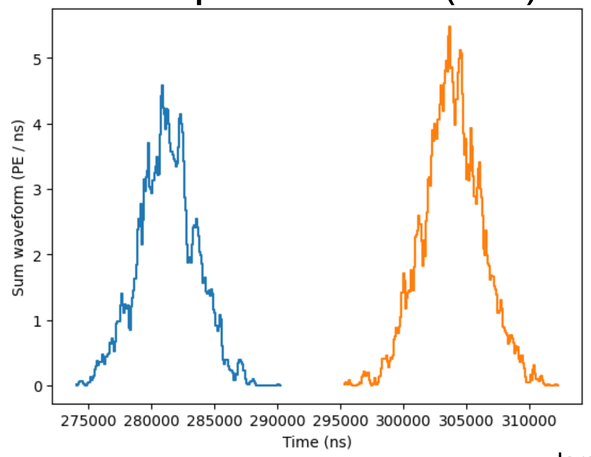
Multi-scatter discrimination

- We differentiate between events with a single scatter (SS) and events with multiple energy depositions (MS)
- Understanding the detectors efficiency to differentiate between SS & MS events is crucial for all science channels

Single Scatter (SS)

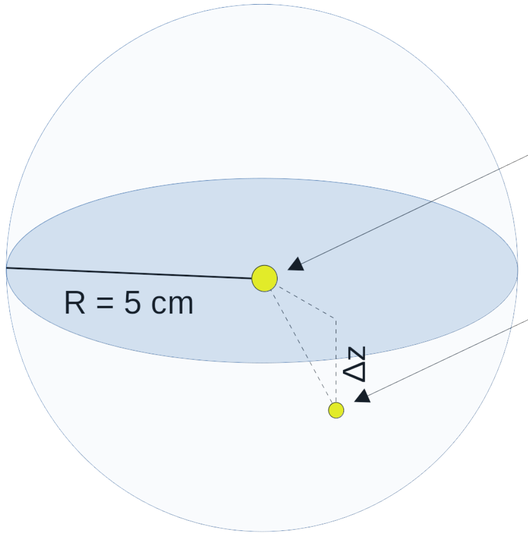


Multiple Scatter (MS)



General idea

- Simulate Waveforms of events with two S2s (WFsim)
- Check if both signals are reconstructed as individual peaks
- Identify parameters that influence separation efficiency
- Define function that predicts separation based on these parameters



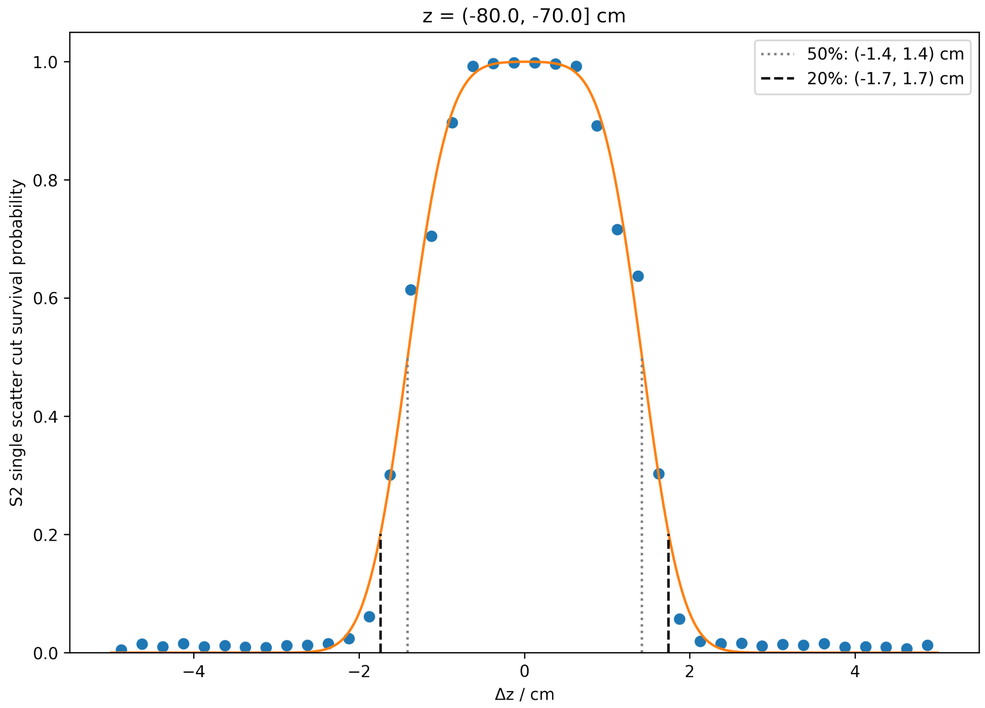
1. Generate S1 & S2a:
   - homogeneously in TPC
   - E ∈ [1, 300] keV_{ER}

2. Generate S2b:
   - homogeneously distributed in sphere (R = 5 cm) around primary interaction site
   - $N_e(S2_b) \in [0.1, 0.9]\ N_e(S2_a)$

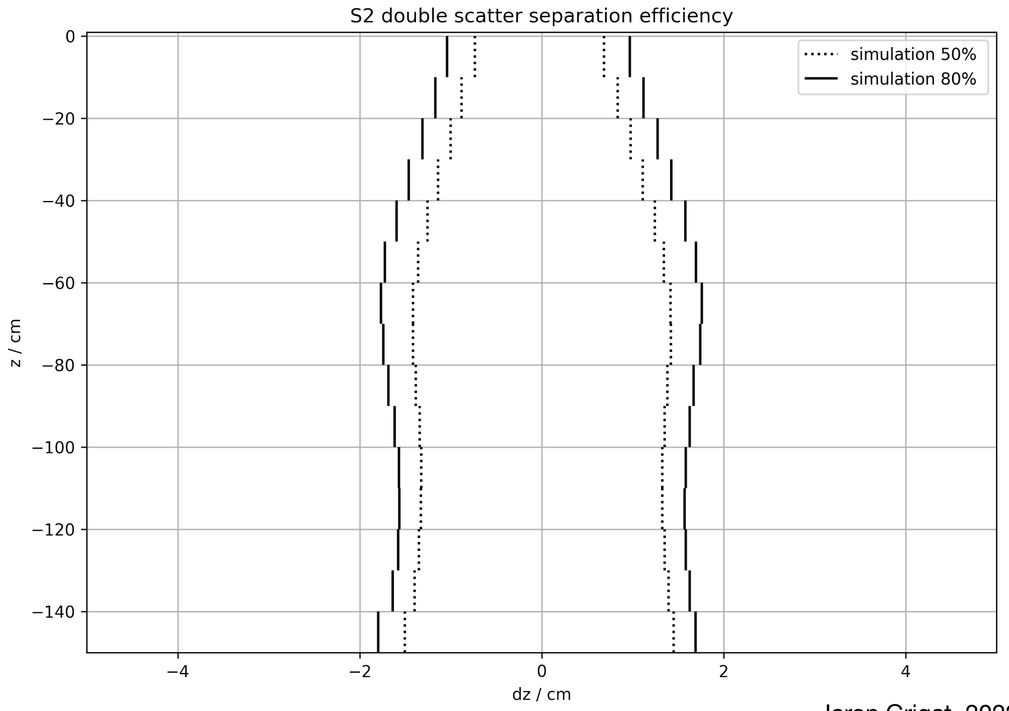
Data analysis

We can for example look at the MS-discrimination power as a function of the depth-difference of the two S2s (Δz)

For one slice in depth (z):

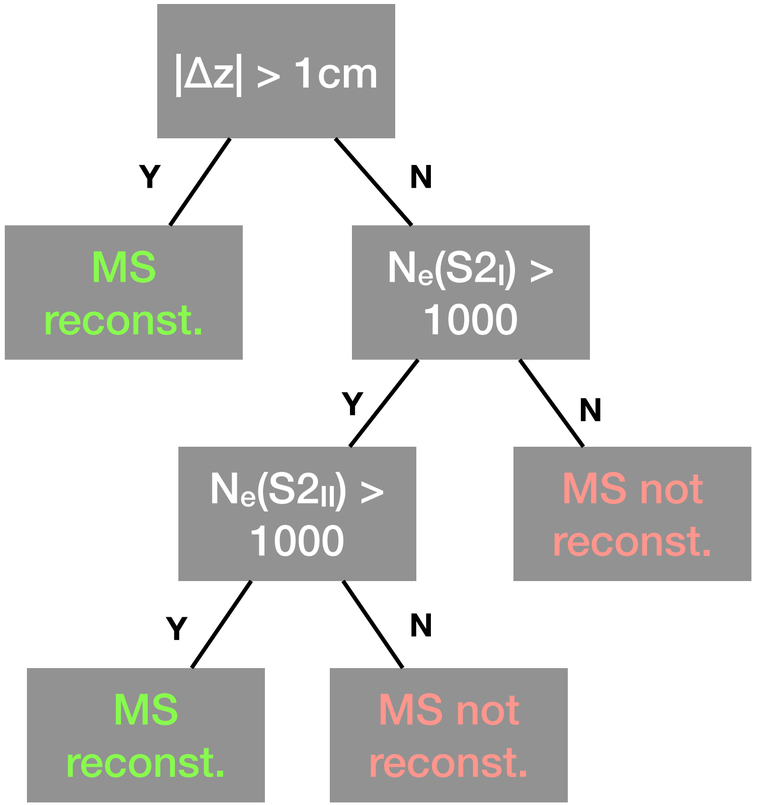


In the entire detector:



Machine learning

- We identified 4 main parameters that influence S2-separation: z, Δz, $N_e(S2_I)$, $N_e(S2_{II})$
- Since the functional correlation between those is not trivial, we plan on using Machine Learning techniques
- Classification Decision Tree: supervised learning approach to predict outcome based on set of inputs
- Use simulated events to train tree



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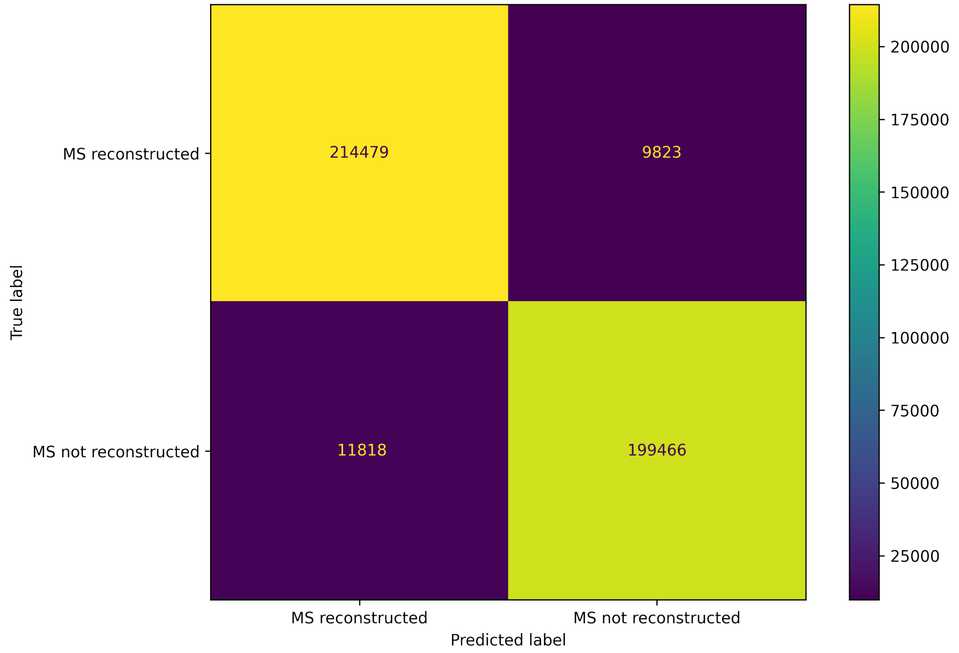

Already 95% accurate!

Conclusions

- We are currently building a fast, effective simulator for XENONnT, that will be used in the analysis of many science channels of the experiment (e.g. double-beta decay, nucleon disappearance, …)
- Machine learning techniques prove to be very fast and accurate in predicting multi-scatter resolution given a small set of inputs
- Ongoing work focuses on improving the decision tree further

Further information

XENON

xenonnt.org

xenon_experiment

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