EUROPEAN AI FOR FUNDAMENTAL PHYSICS CONFERENCE
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Enhancing event discrimination in LEGEND-200 with transformer

Marta Babicz[1*], Yuri van der Burg[1], Laura Baudis[1]

[1]University of Zurich

[*]marta.babicz@uzh.ch

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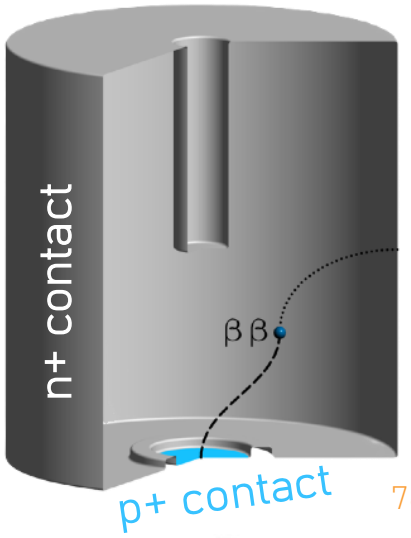
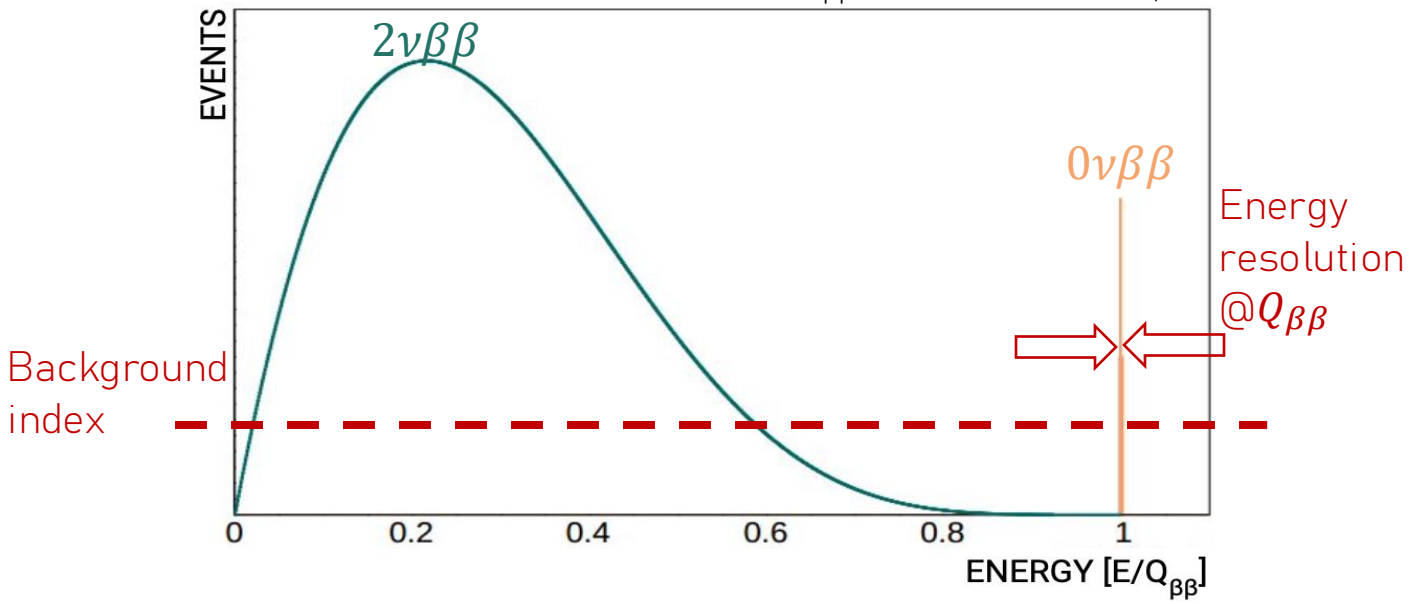
Searching for $0\nu\beta\beta$ with LEGEND



High-Purity Germanium detectors enriched in ^{76}Ge:

- source = detector → *high efficiency*
- High-purity → *low intrinsic background*
- Ge crystal → *outstanding energy resolution*
- Very good topological discrimination

$^{76}Ge \rightarrow {}^{76}Se + 2e^-$, $Q_{\beta\beta}$ = 2039 keV, $T_{1/2}>10^{26}$yr



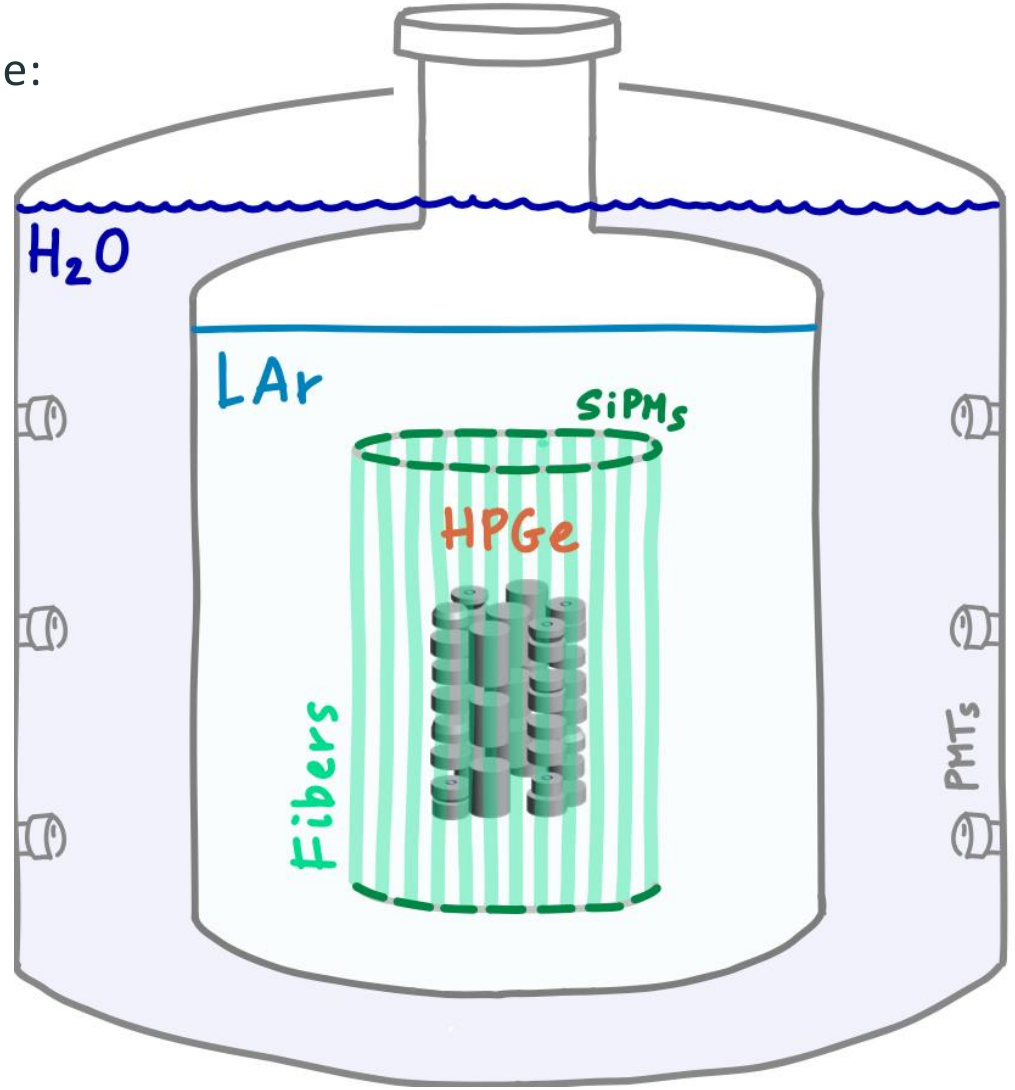
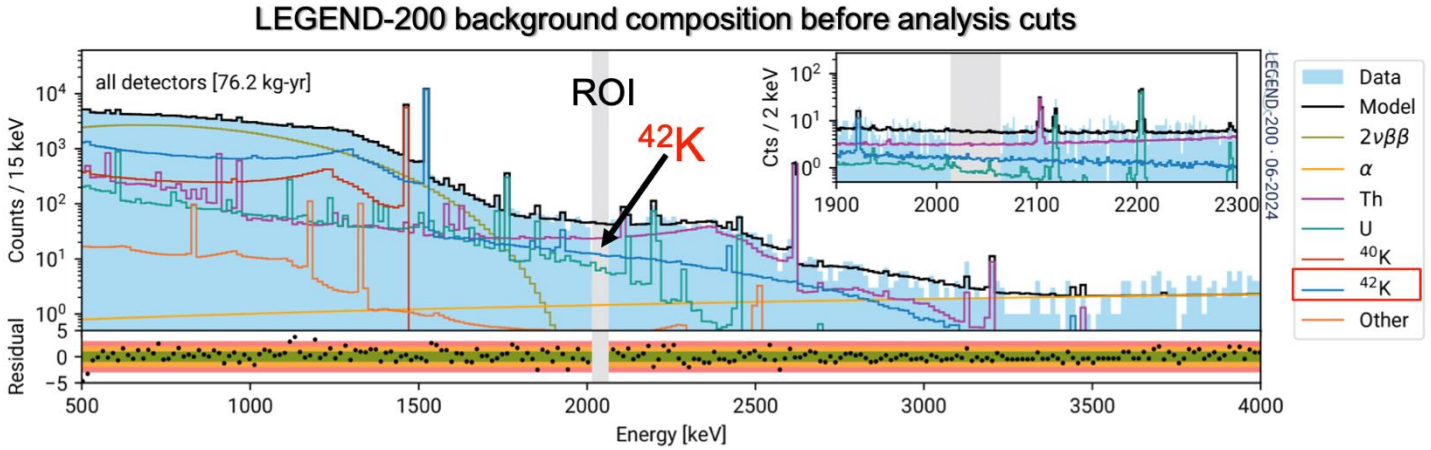


Image credit: L. Pertoldi

Background Suppression Strategies

L1000 background index: $<10^{-5}$ cts/(keV·kg·yr) at ROI [1]



Main challenge:

- surface events dominate if Underground Liquid Argon (UGLAr) is unavailable [1]
- these events mimic signal-like pulses

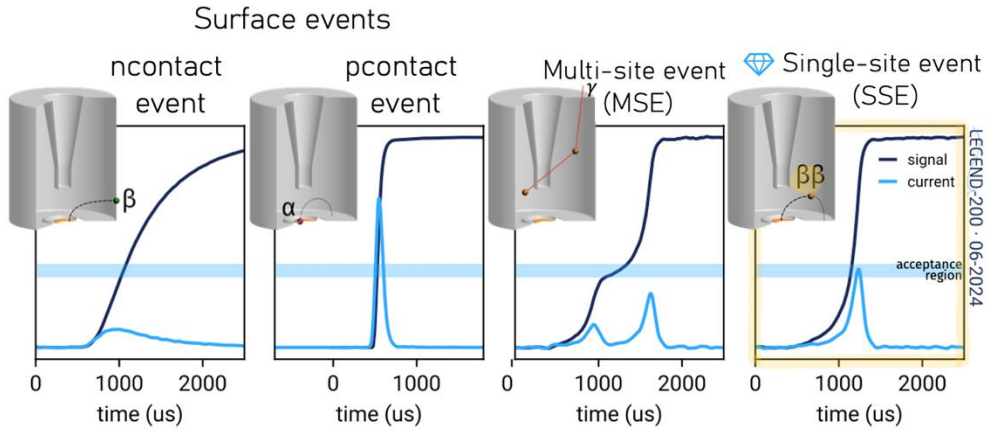
Mitigation strategy:

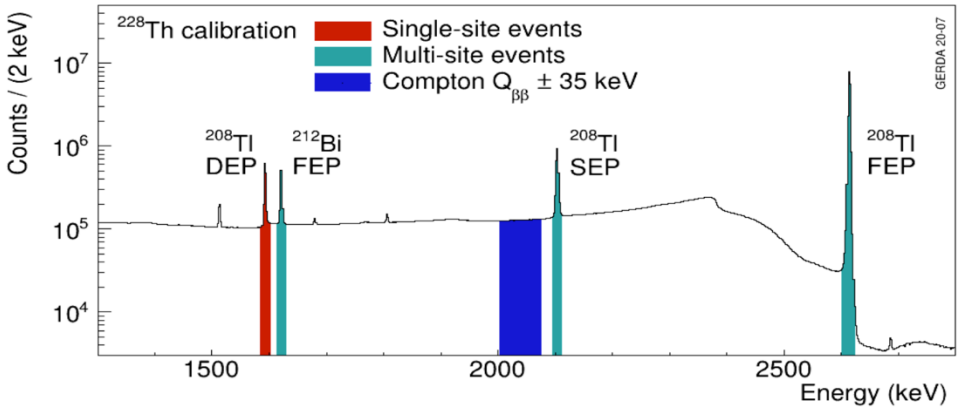
- AI-based pulse-shape classification

Data Limitation:

- Few labelled surface events in real LEGEND-200 data
- Requires **robust models** + **data-efficient training**

Ionizing events in HPGe detectors produce four main pulse shapes. The 0νββ signal is expected to be single-site bulk event:



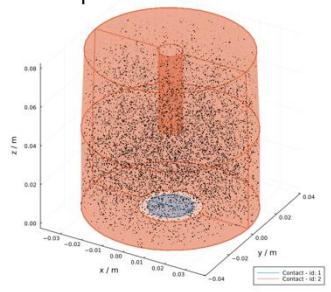


[1] LEGEND Collaboration, *LEGEND-1000 Preconceptual Design Report*, arXiv:2107.11462 [physics.ins-det], 2021.

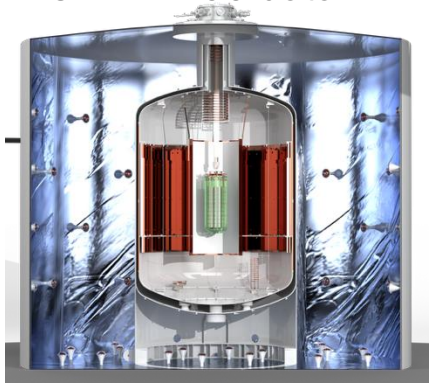
ML-based pulse shape discrimination

Transformer + Domain adaptation

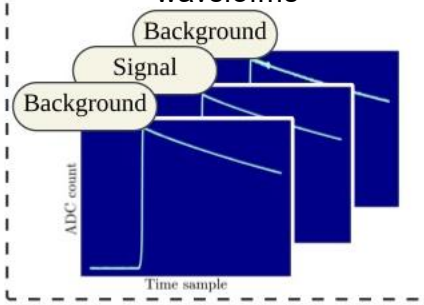
Pulse Shape Simulation



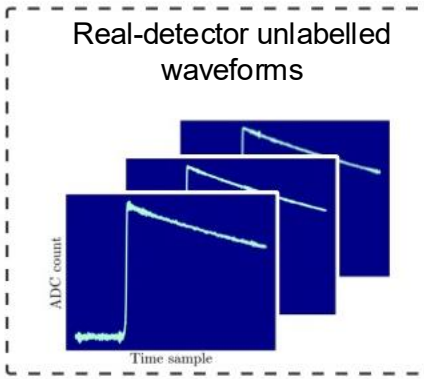
LEGEND-200 data



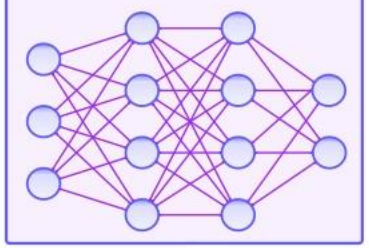
Simulated labelled waveforms



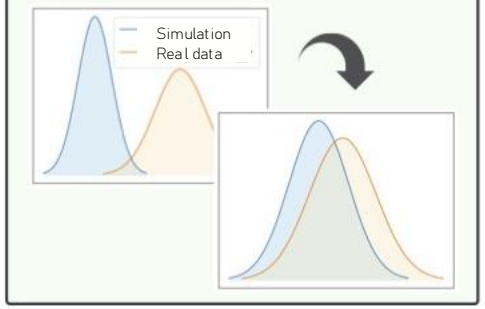
Real-detector unlabelled waveforms



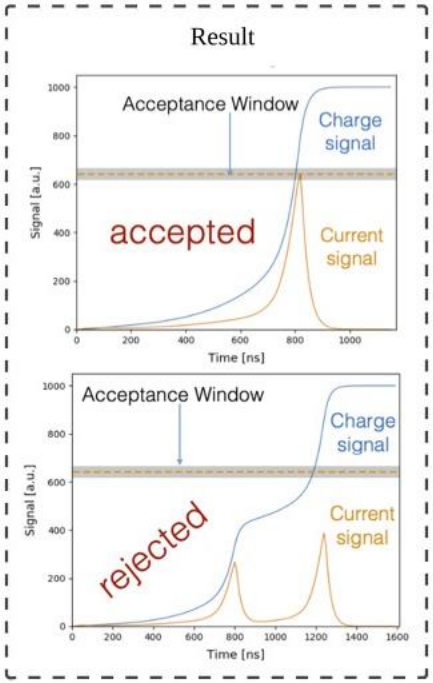
Transformer network



Domain adaptation

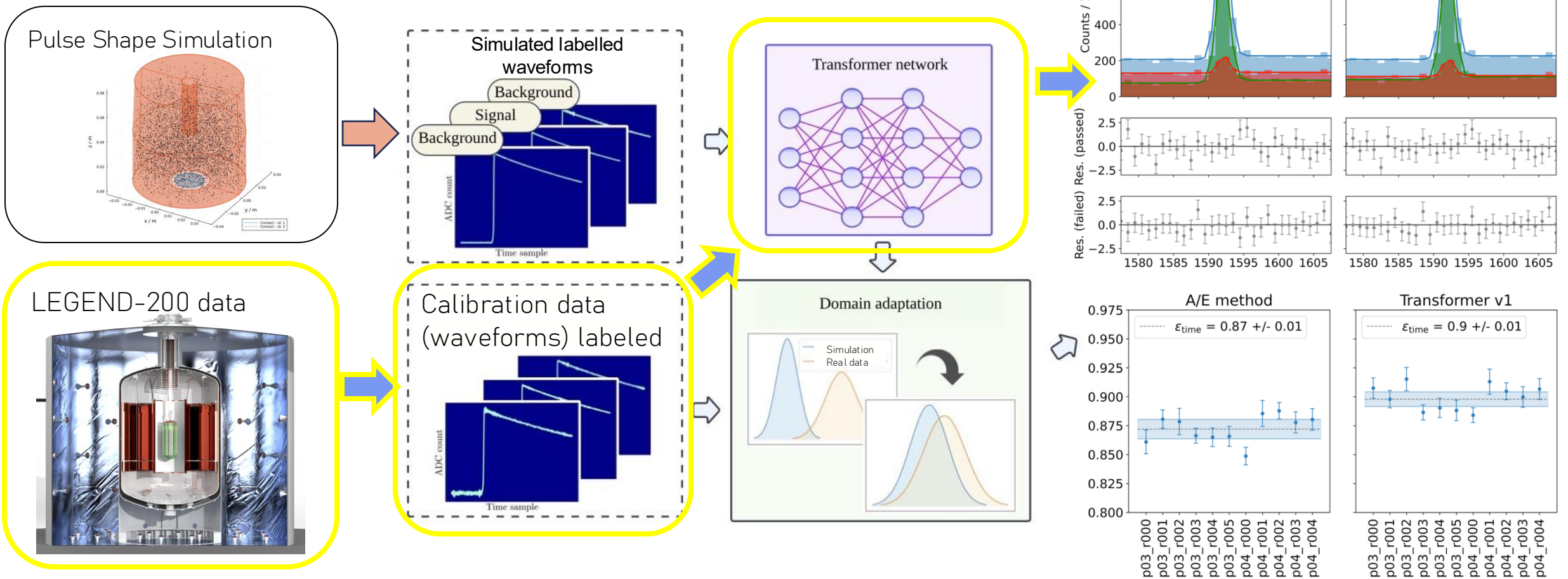


Result



ML-based pulse shape discrimination

Transformer + Domain adaptation



Compared to the traditional A/E method, transformers show higher average efficiency and similar or better temporal stability, validating their potential for deployment in LEGEND-200.