Wright Laboratory

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Effects of Time Resolution on Background Model for Neutrinoless Double Beta Decay

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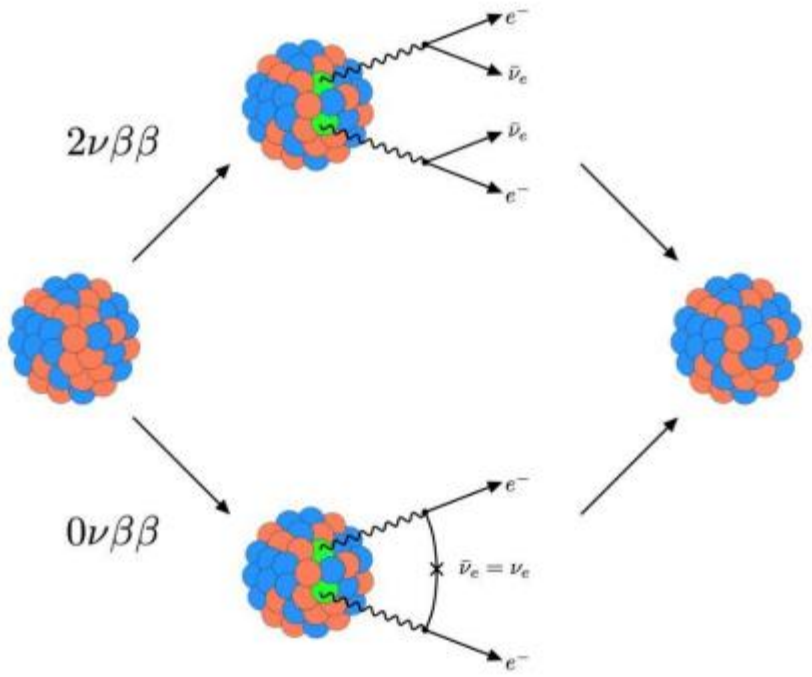
CUORE

CUPID

Neutrinoless Double Beta Decay

- Lepton number violation
  - Matter-antimatter asymmetry
- Forbidden
- Rare
  - $T_{1/2} \approx 10^{25}$ years



Credit: CUPID collaboration

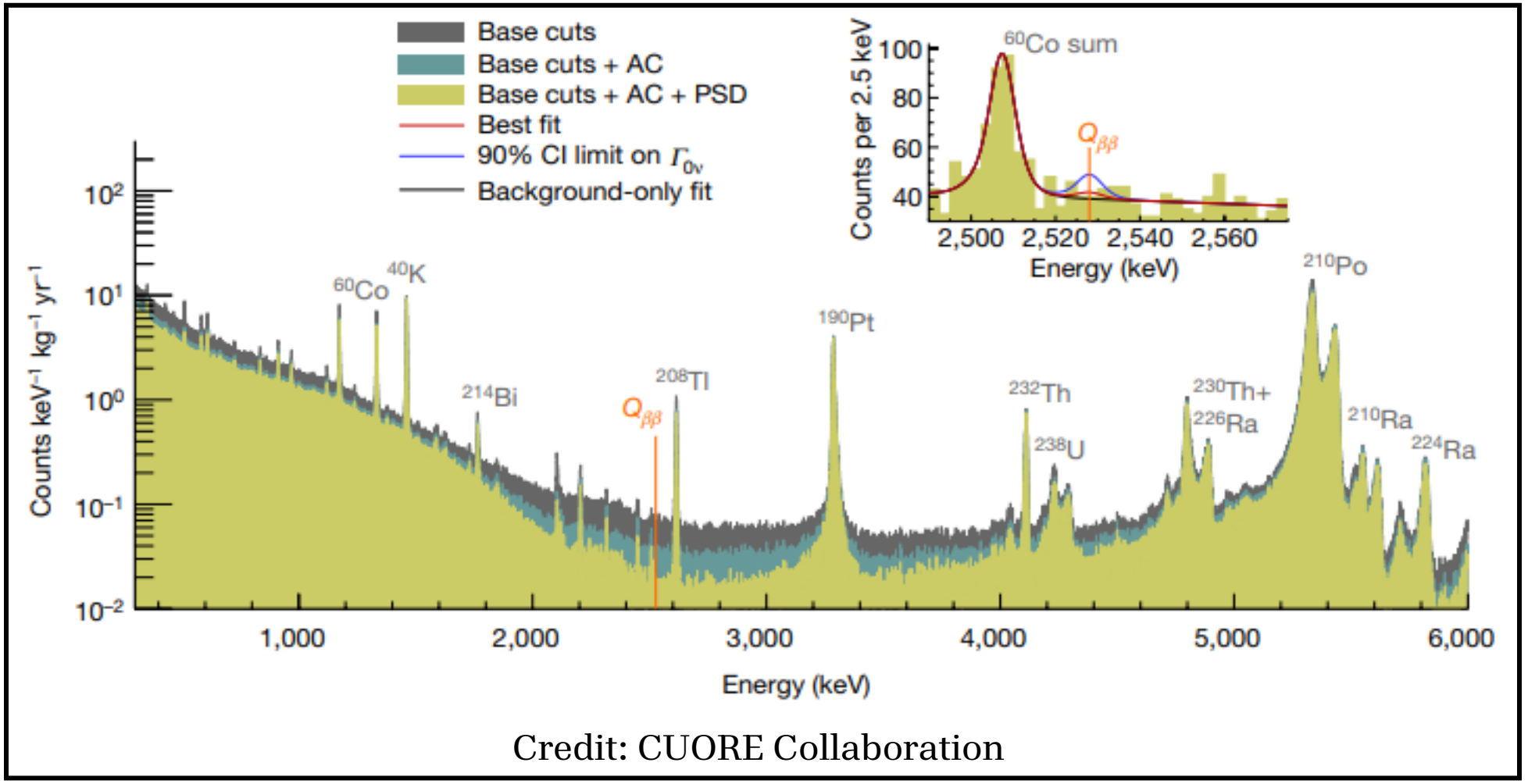
CUORE

- Bolometry experiment
  - Each crystal is made of decay source (~30%)
  - Germanium thermistor reads thermal energy as voltage
- What data do we have?
  - 988 channels of voltage over time
  - Derivative trigger picks out peaks

Event Multiplicity

- Suppose an event produces two particles shooting off in opposite directions (a very common occurrence):
  - We get lucky, and they are both detected, albeit in different crystals
  - We would like to know that they have the same origin, i.e., were produced by one event happening at a certain energy
  - How do we know?
    - Perhaps pick out events in the data stream and cluster them together in accordance with a set of criteria
    - We call such events **coincident**
    - The event above has **multiplicity 2**
      - Were it to be detected in 3 crystals, it would have multiplicity 3, etc.

CUORE Spectrum

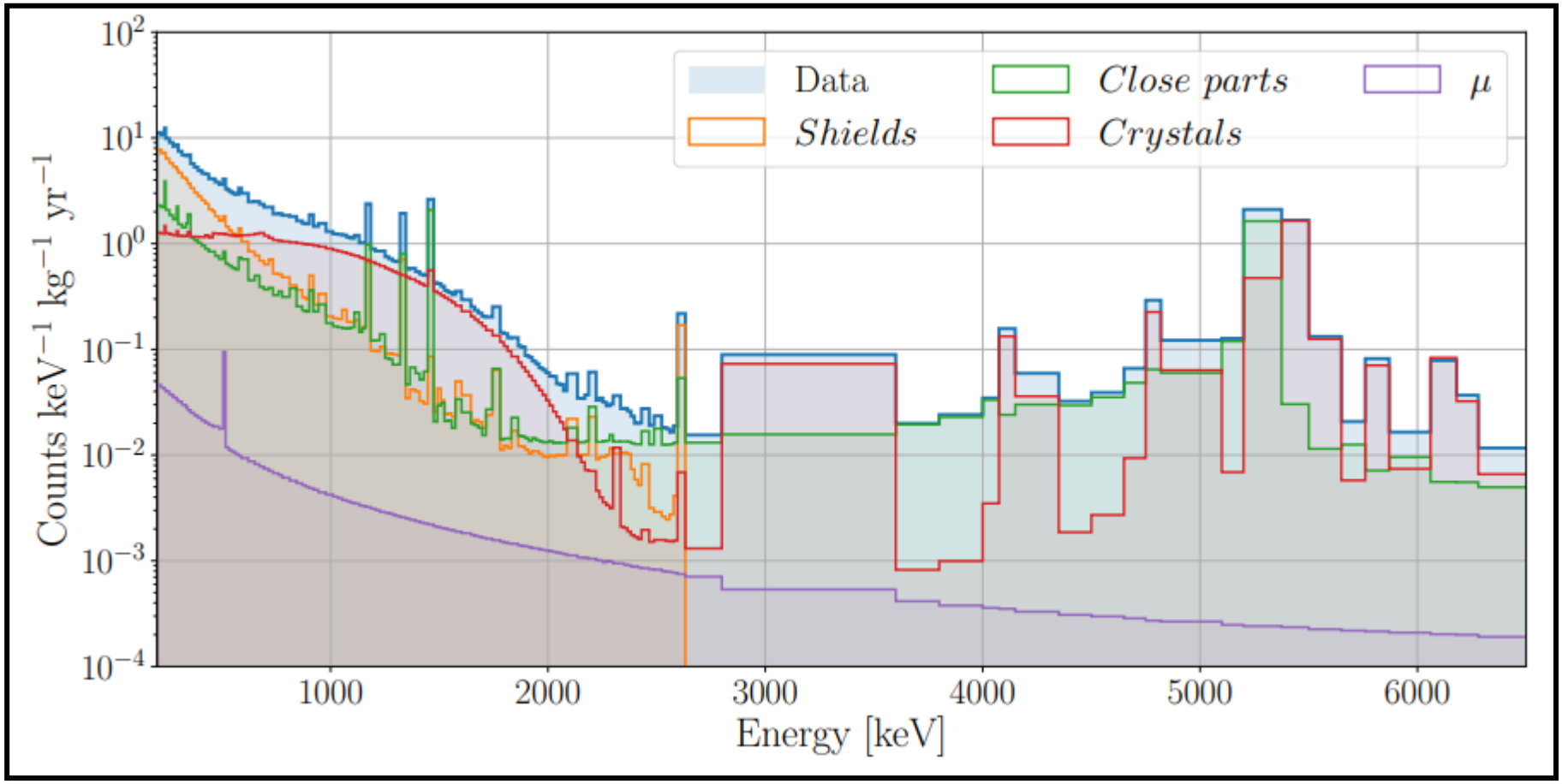


Credit: CUORE Collaboration

We have not found $0\nu\beta\beta$

- Why?
  - Doesn’t exist?
    - Maybe, but can we be sure?
  - Background too noisy?
    - This is an extremely rare event. Could be buried under background. Half-life higher than expected?

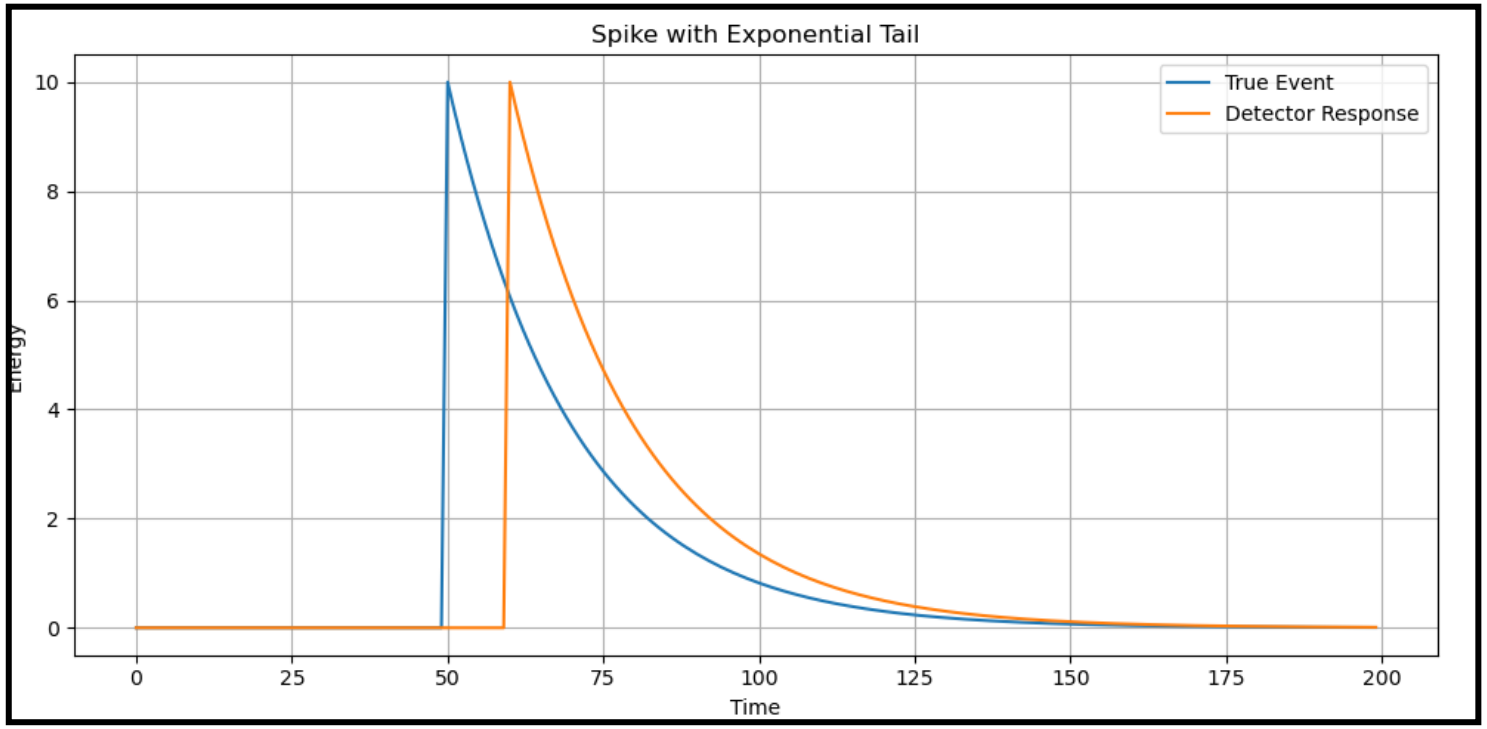
CUORE Background Model



Decomposition of CUORE data by source location
Credit: CUORE collaboration

Time Resolution

- We cannot know exactly when an event happens
- Crystals may respond differently
- Detector response is independent of the underlying physics

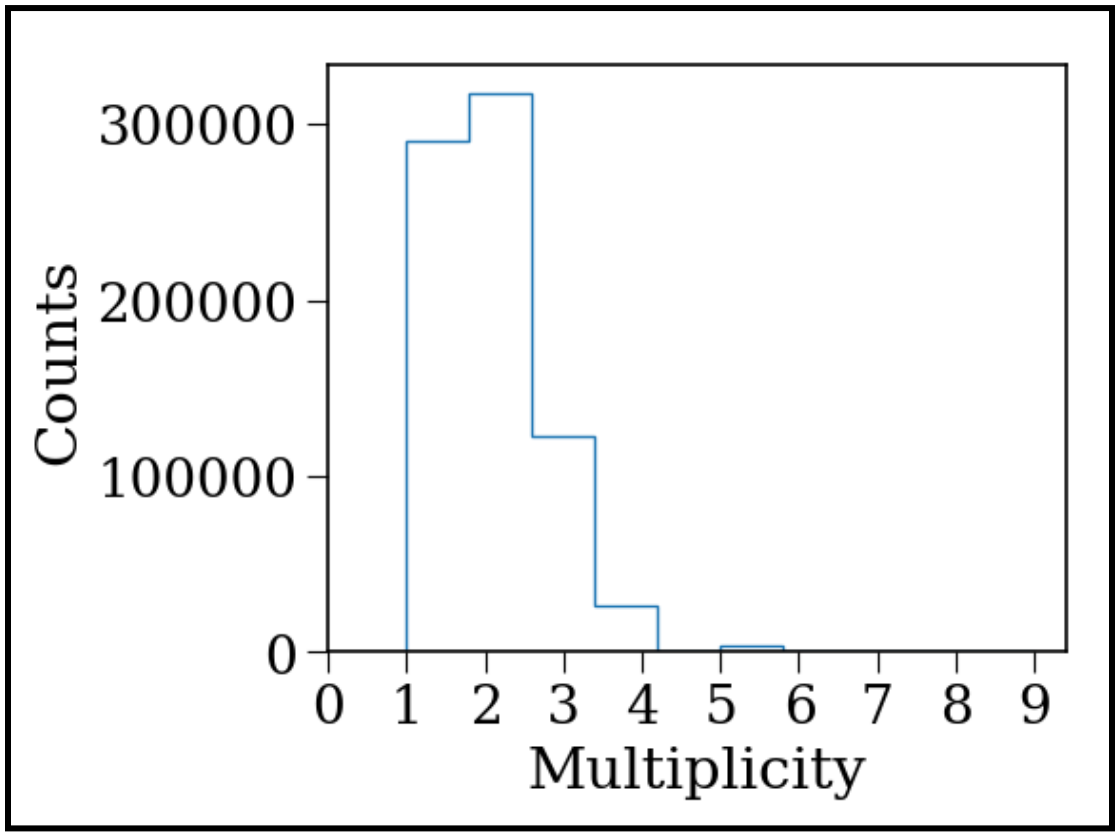


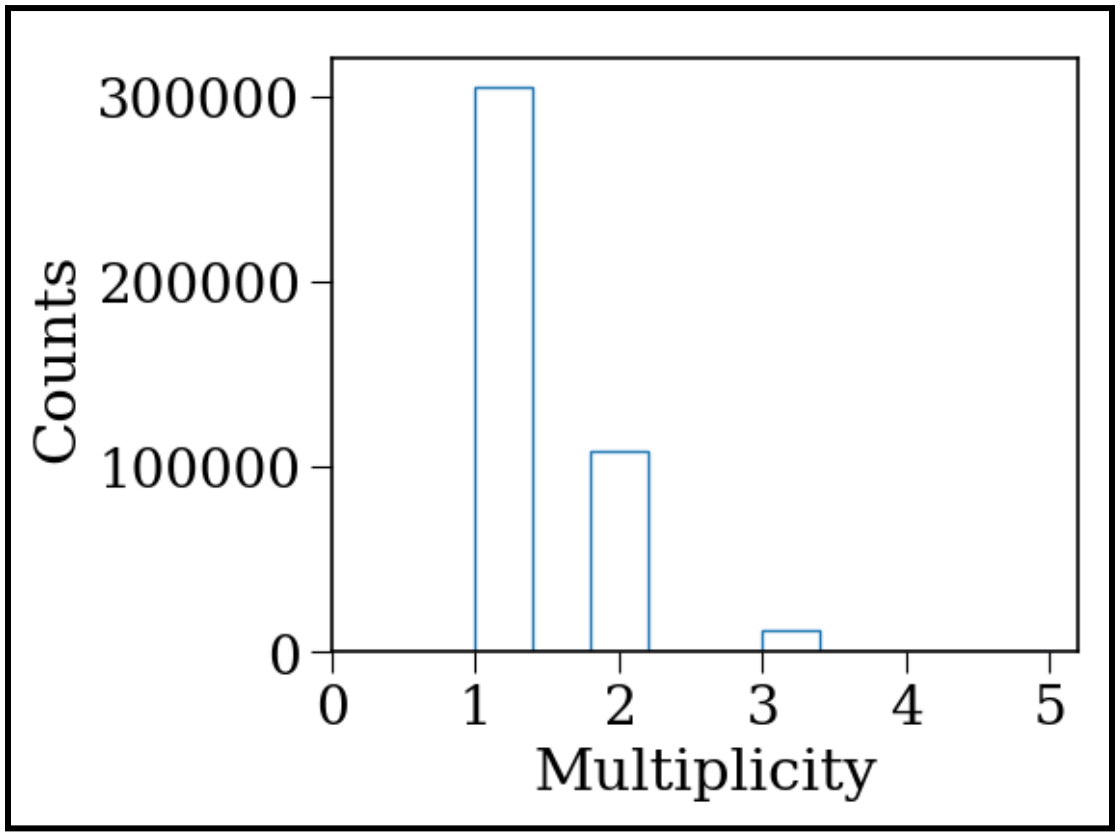
Multiplicity and Time Resolution

- One event creates two particles
- Detected as two events
- Have different energies

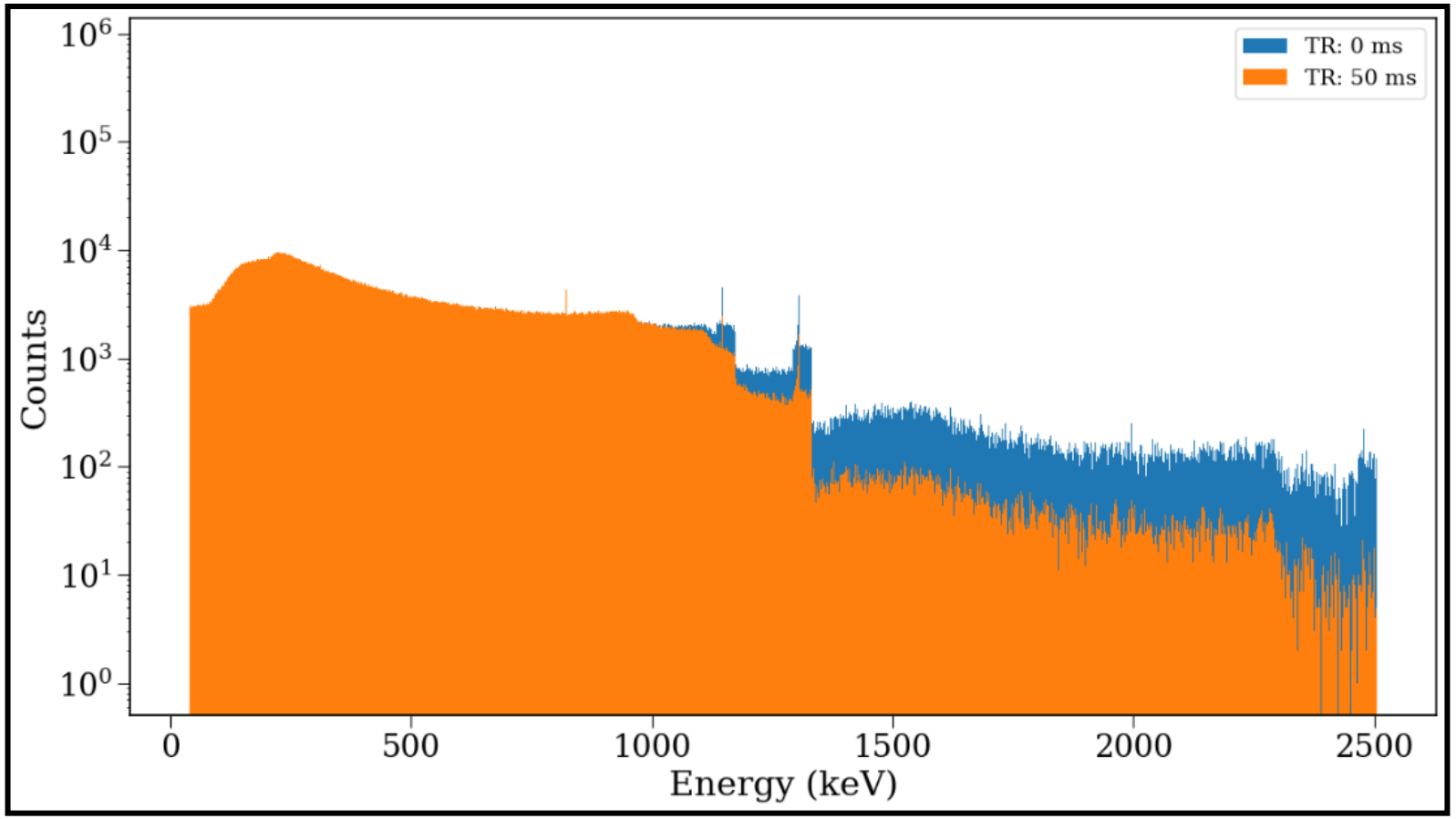
Effects on the Spectrum

- Time resolution affects the spectrum

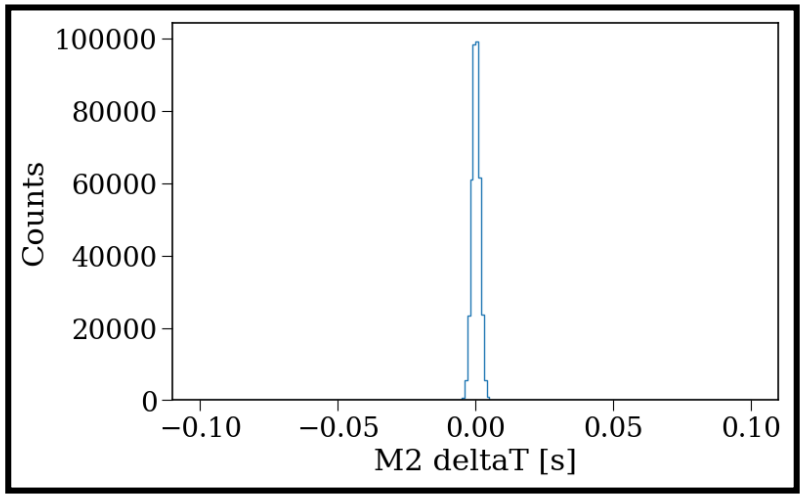




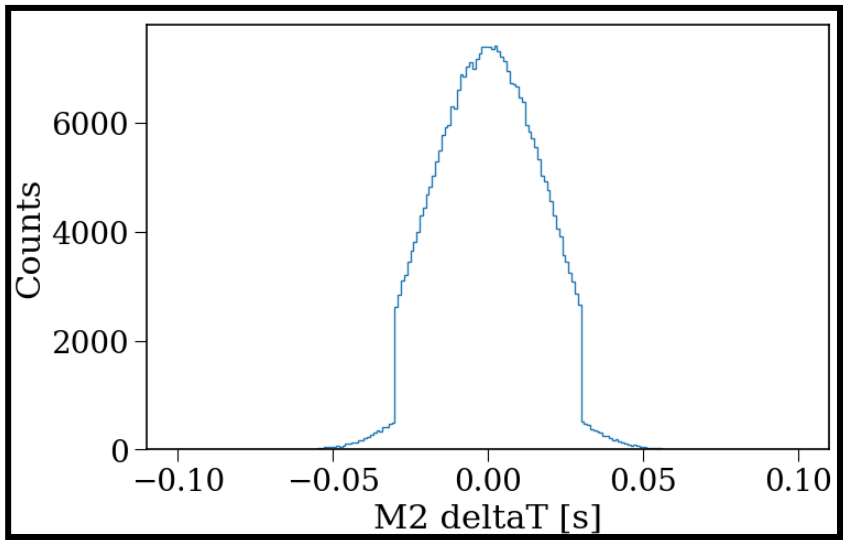
Effects on the Spectrum



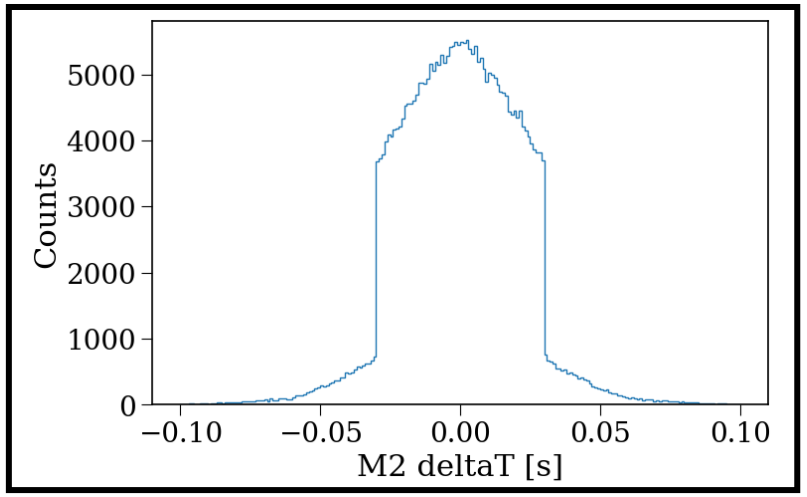
What is the correct time resolution?



TR: 1 ms
RC: 150 mm



TR: 30 ms
RC: 150 mm



TR: 30 ms
No RC

Future Work

- Create deltaT distribution using live data
- Evaluate time resolution model
- Present results at DNP 2025 CEU

Acknowledgements

Thanks to Ridge Liu, Dr. Tyler Johnson, Dr. Karsten Heeger and Dr. Thomas Gutierrez for their mentorship.

Thanks to the CUORE and CUPID collaborations and NSF-PHY-1913374 and NSF-PHY-2412377

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