# Solar Neutrino Detection via Charged Current Interactions at the Kilotonne Scale

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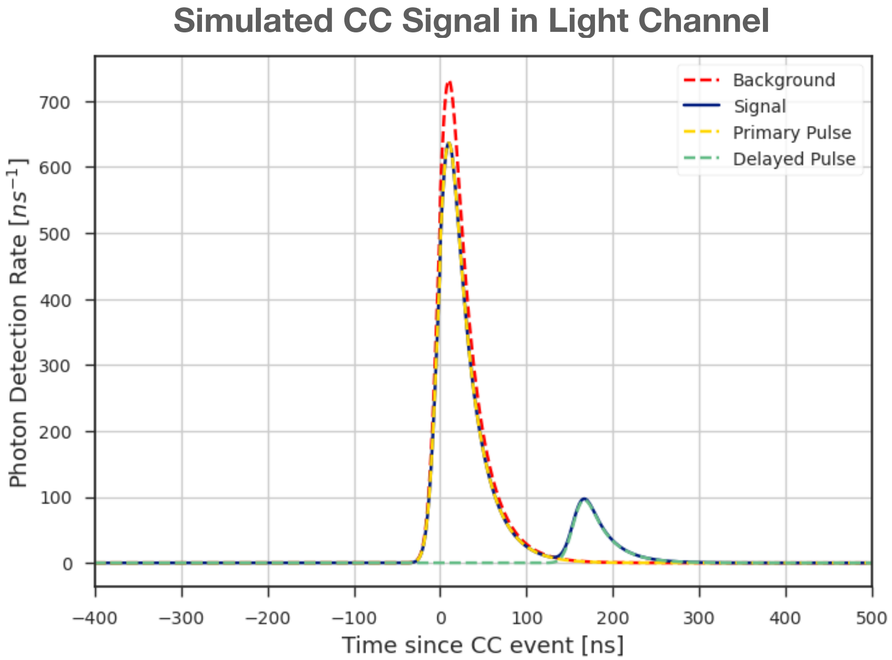
# Charge Current (CC) Interactions

- $\nu_e + {}^{136}Xe \rightarrow {}^{136}Cs^* + e^-$ provide an exciting method for solar neutrino detection in xenon detectors

- Displays aspects of both traditional radiochemical and liquid scintillator detectors

  - Time delayed coincident signal gives exceptional background rejection

  - Ionization and scintillation of Xe allows for direct energy spectrum measurements

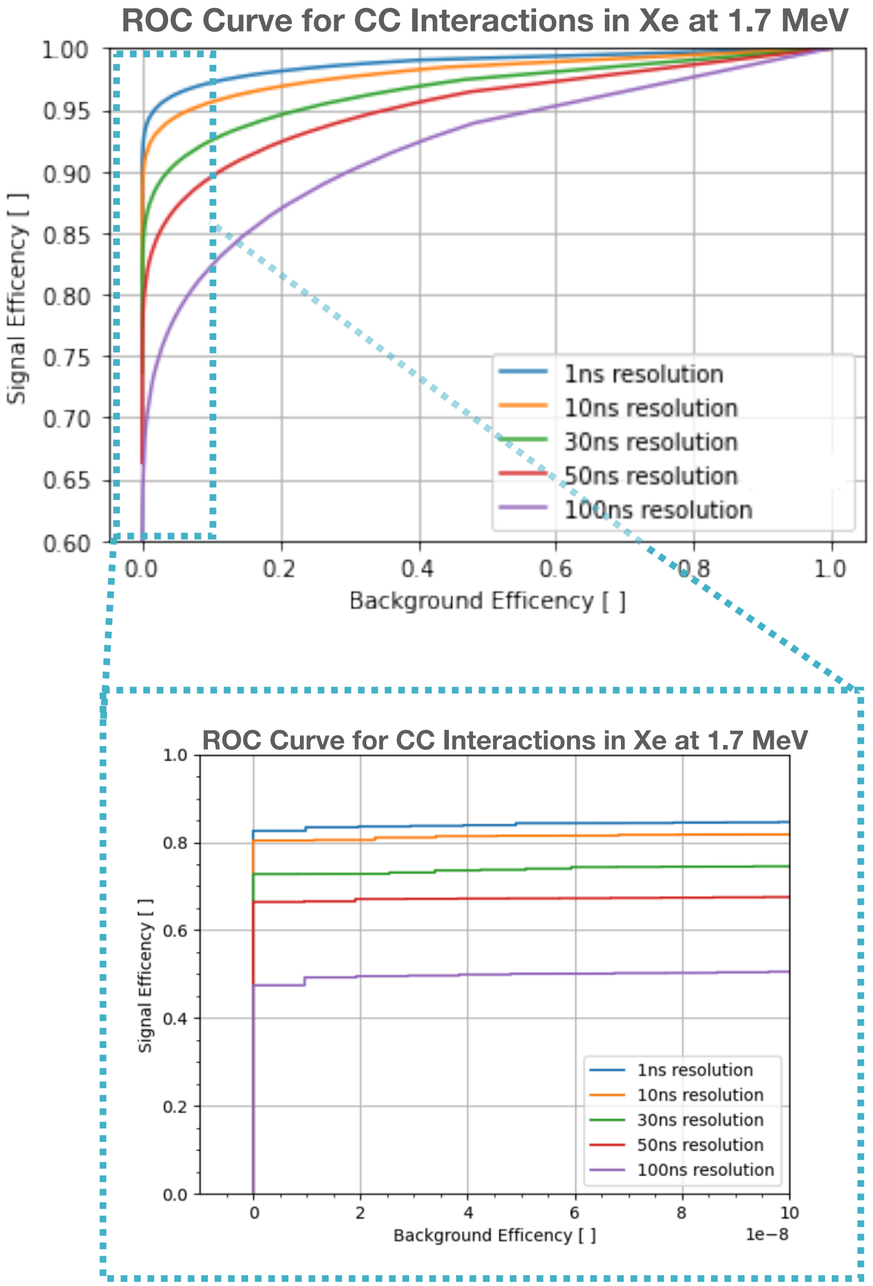




Figures provided by Brian Lenardo

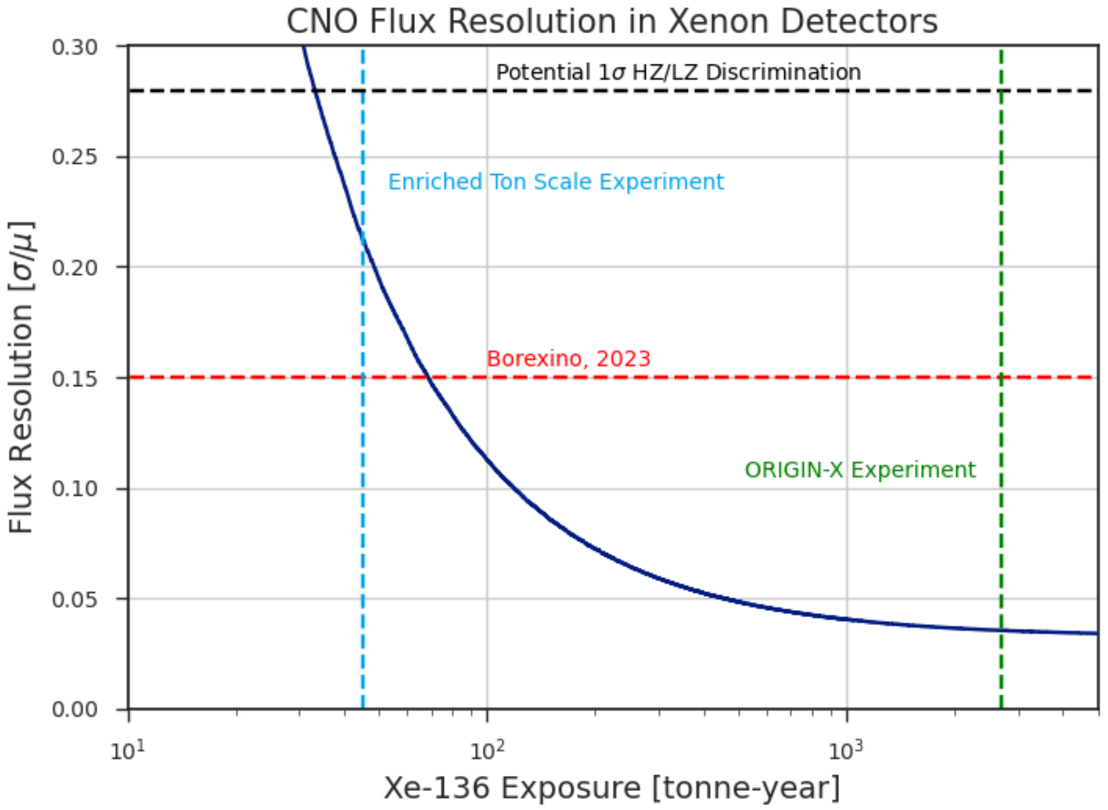
# Signal and Background Efficiency

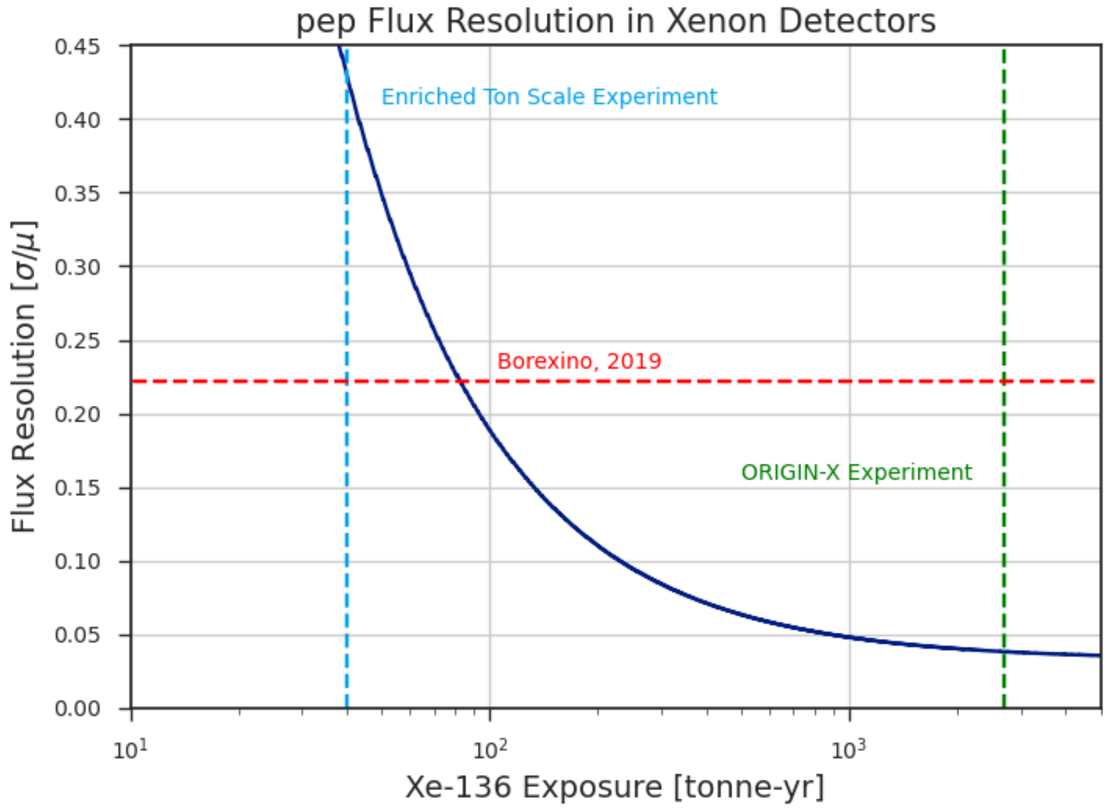
- Ability to discriminate between initial and final pulse depends on timing resolution of detector
- Precise ROC curves for a specific detector will depend on unique detector characteristics
  - Photon travel time, external crosstalk, etc.
- Next generation kilotonne scale experiments might expect for CC solar neutrino studies:
  - Background discrimination ~$\mathcal{O}(10^{-8})$
  - Signal efficiencies ~$\mathcal{O}(0.7)$
- Will most likely be at or close to background free



# Flux Measurements

- An ORIGIN-X Experiment could make most the precise measurements of low energy solar neutrino fluxes yet



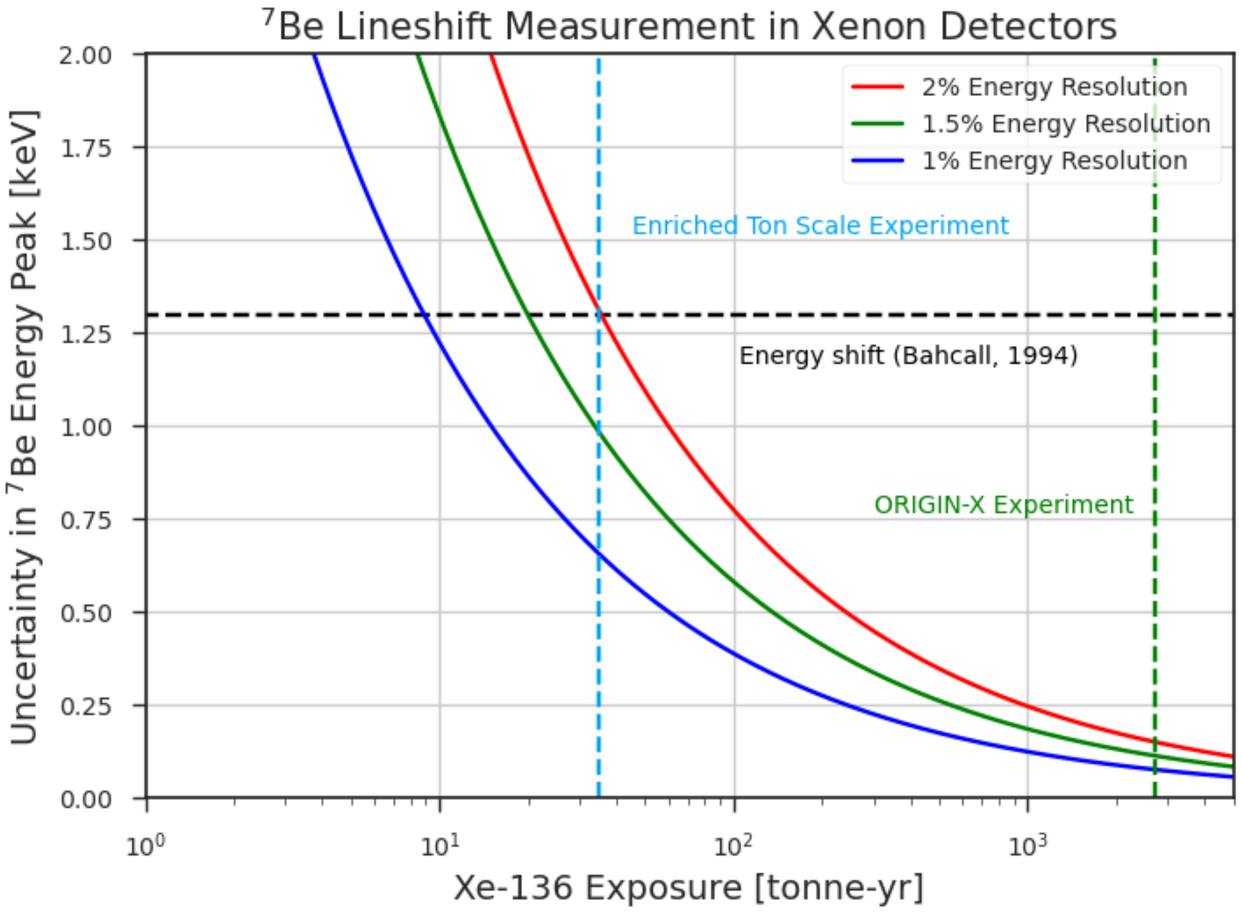

- <5% resolution after 10 years of data taking for both CNO and pep
- Could potentially provide high significance answer to the so-called Solar Metallicity problem

# $^{7}Be$ Lineshift Measurements

- Solar $^{7}Be$ is predicted to have a shifted (~1.2 keV) and distorted neutrino energy spectrum compared to lab $^{7}Be$

- Because of their relatively unique energy resolution capabilities large scale xenon detectors might provide an opportunity to measure this shift

  - Could make significant improvement over current measurement



# Potential $^8B$ Measurements

- CC interactions can also provide a new channel for measuring $^8B$ solar neutrinos in large scale xenon detectors
  - In addition to standard CE$\nu$NS channel
- Flavor dependent and flavor agnostic detection method in the same detector
- Requires separate analysis method since higher energy neutrinos may not necessarily pass through delayed Cs states
  - *See Sam Hedge's talk (next) for information about CC interactions at high energy scales*

# Summary

- CC interactions provide an interesting and exciting method for solar neutrino detection in large scale xenon experiments
  - Combining the background discrimination power of radiochemical experiments with the energy measurements of liquid scintillator detectors
- Capable of making ~3% resolution measurements of CNO and pep solar neutrino fluxes
  - Could help answer the solar metallicity problem
- Could improve $^{7}Be$ lineshift measurements by several orders of magnitude
- Still potential for many other additional studies as well

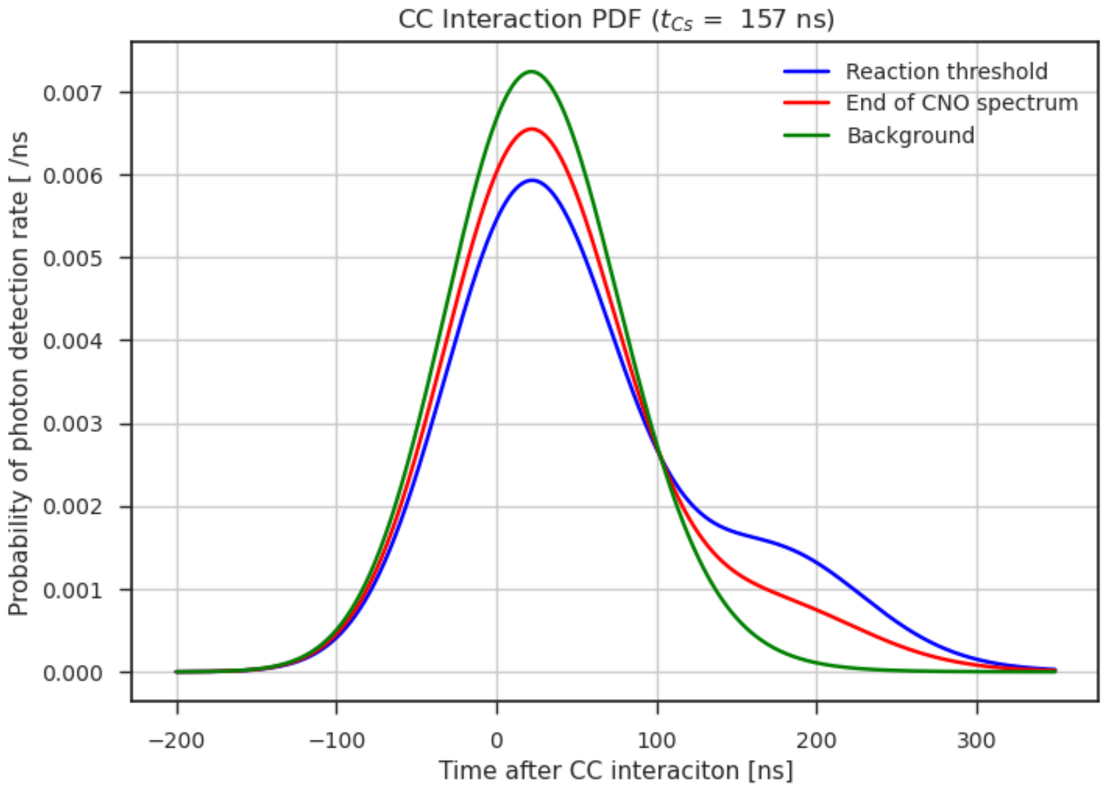
# Thank you!

**Glenn Richardson 10/26/23**

https://www.quantamagazine.org/neutrinos-linked-with-cosmic-source-for-the-first-time-20180712/

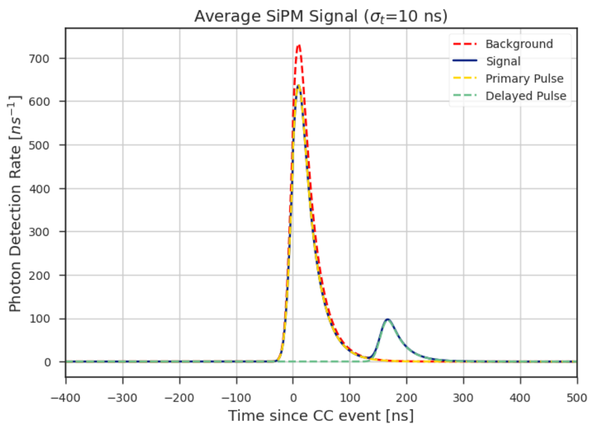
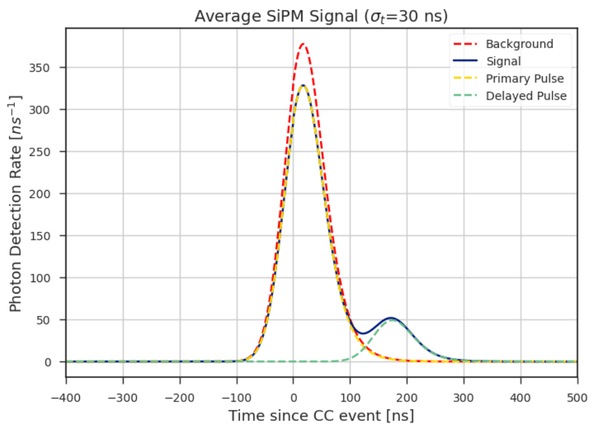
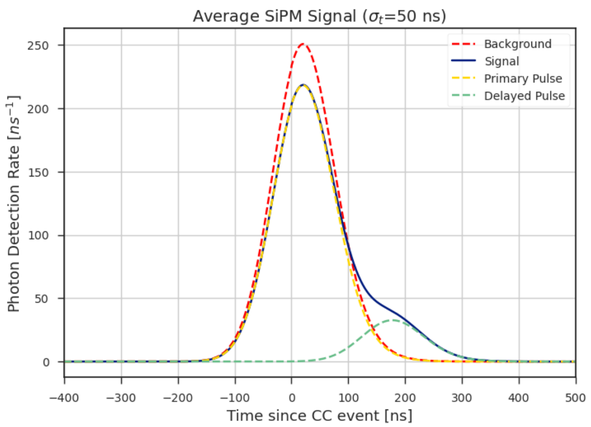
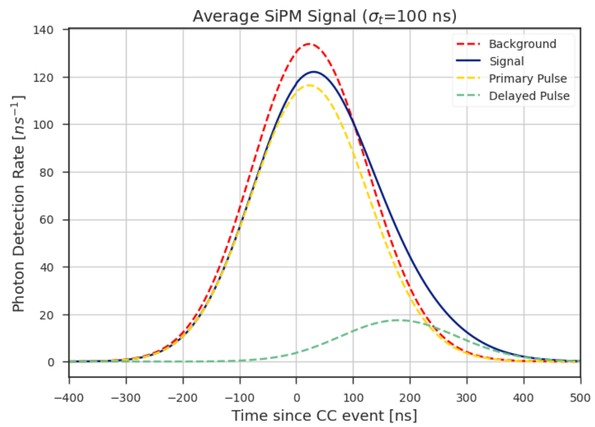
# Low energy signals

- At lower neutrino energies the initial CC pulse will become of comparable size to the delayed transition pulse
  - This makes it easier to discern the secondary pulse hidden within the tail of the prompt pulse
- Overall, this means signal efficiencies scale inversely with neutron energy
  - Though this will depend on specific detector characteristics



# Effect of Timing Resolution on Signals

$\tau_{Cs} = 157$ ns (Average Signal)

| 10 ns Resolution | 30 ns Resolution | 50 ns Resolution | 100 ns Resolution |
|---|---|---|---|
|  |  |  |  |



- Detector timing resolution affects our ability to separate the pulses
  - Can strongly affect background rejection