Calibrating the Scintillation Timing in SNO+ using In-Situ Backgrounds

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On Behalf of the SNO+ Collaboration
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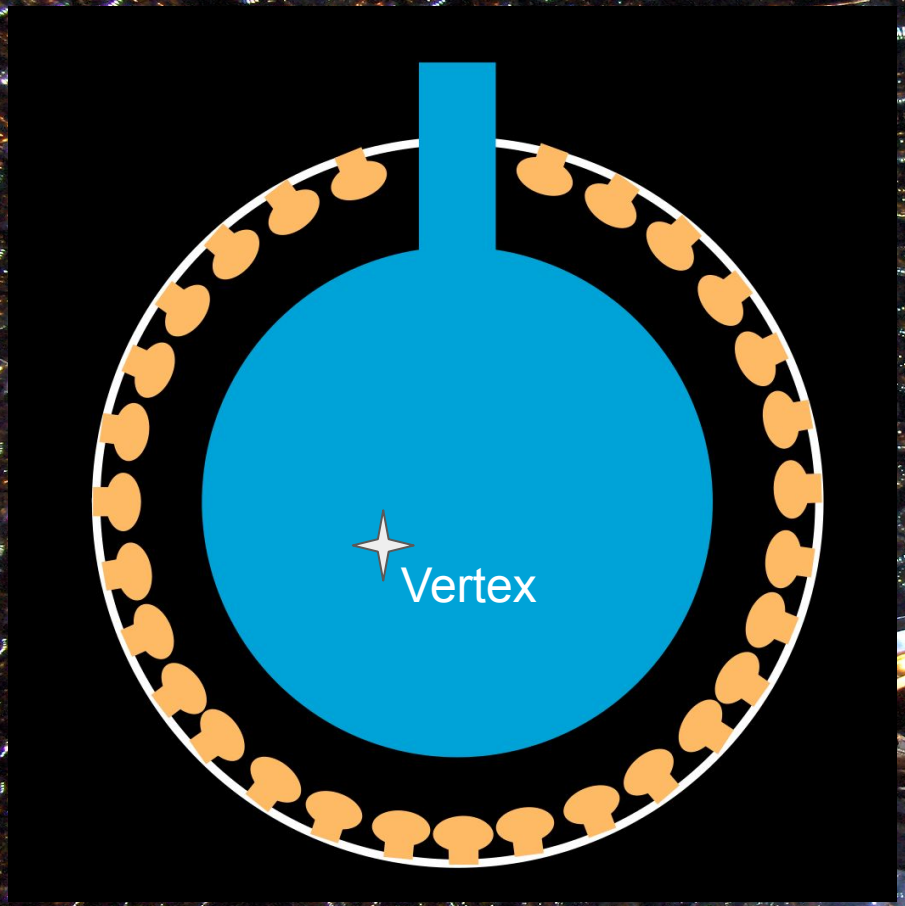
Emission Time Profiles in Liquid Scintillator



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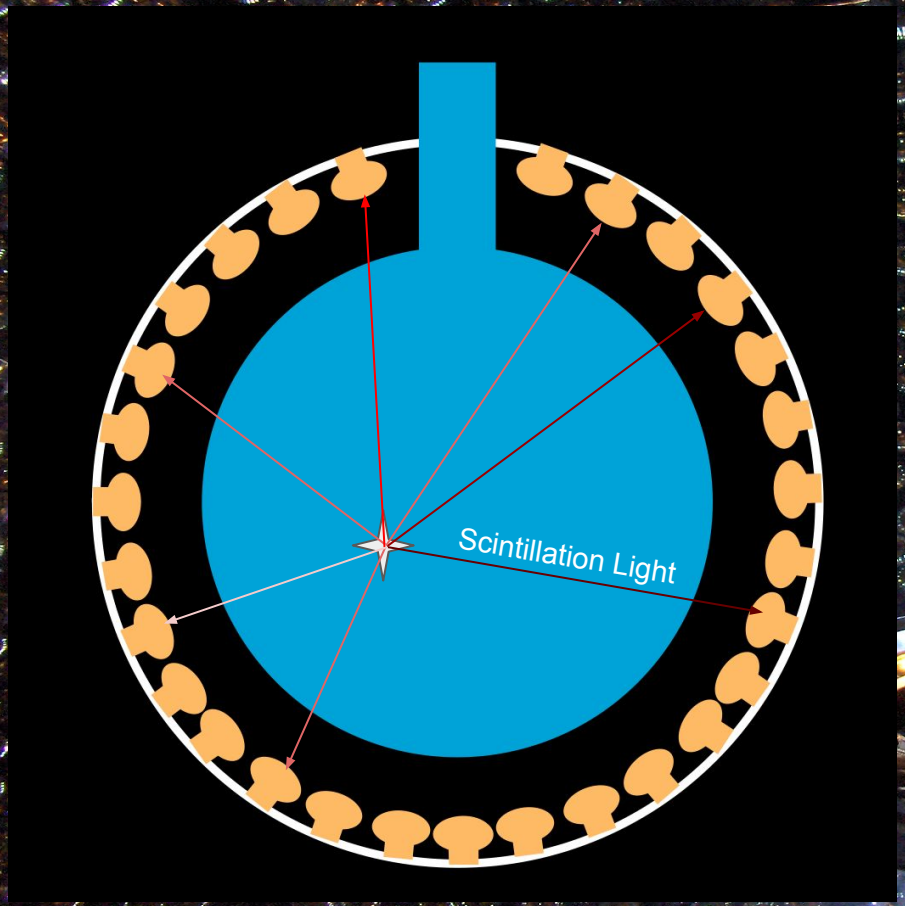

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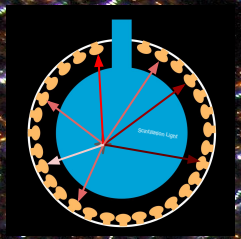

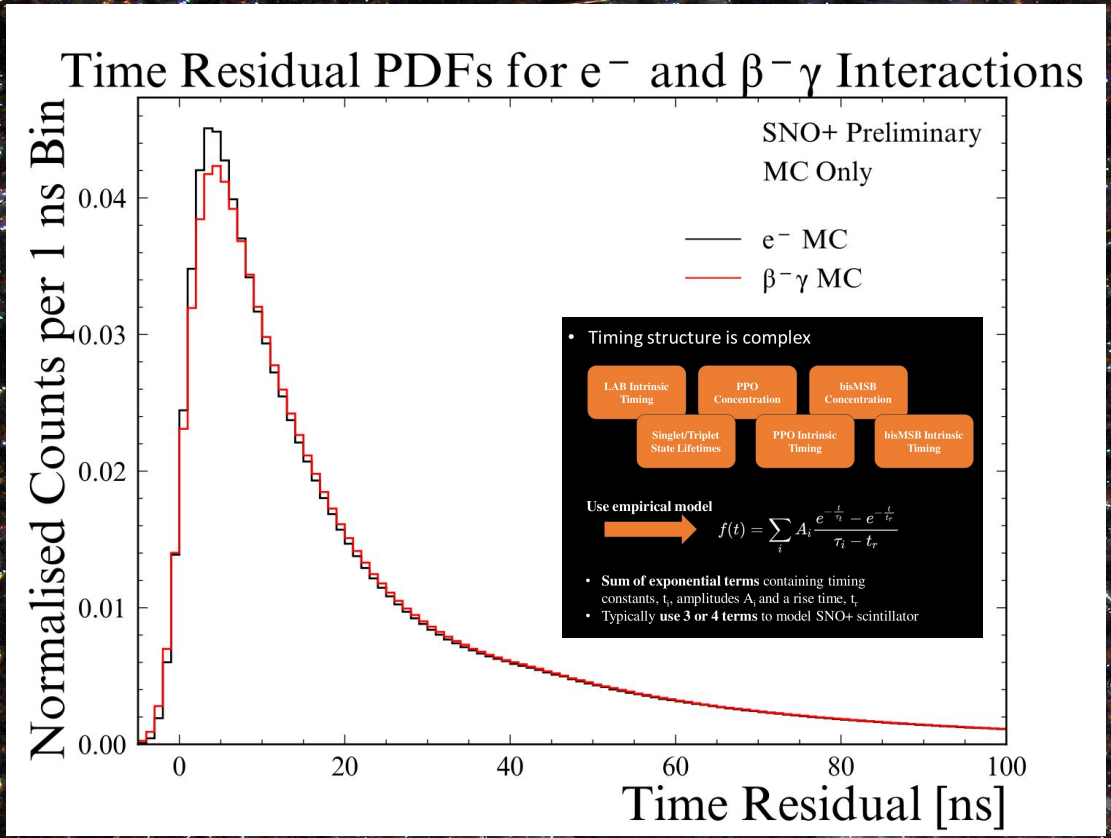

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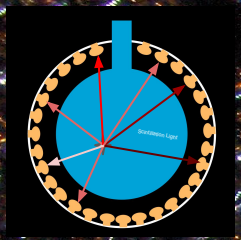


- Timing structure is complex

LAB Intrinsic Timing | **PPO Concentration** | **bisMSB Concentration**

Singlet/Triplet State Lifetimes | **PPO Intrinsic Timing** | **bisMSB Intrinsic Timing**

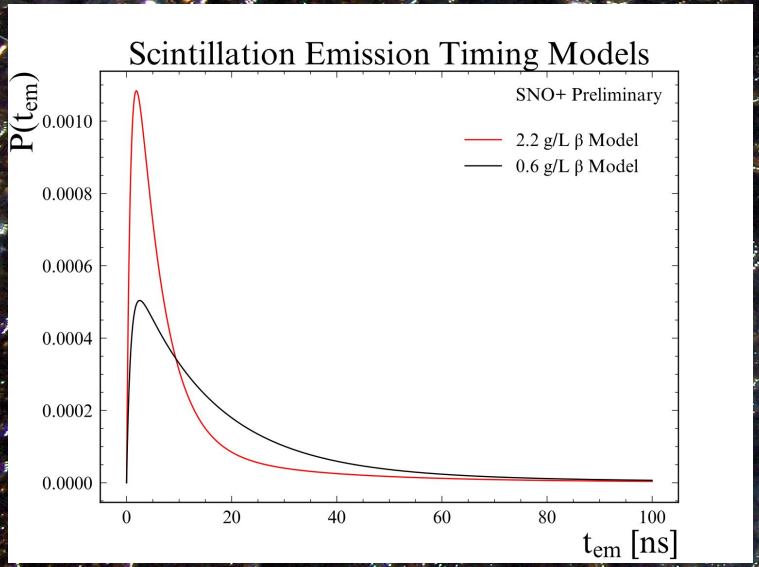
Use empirical model

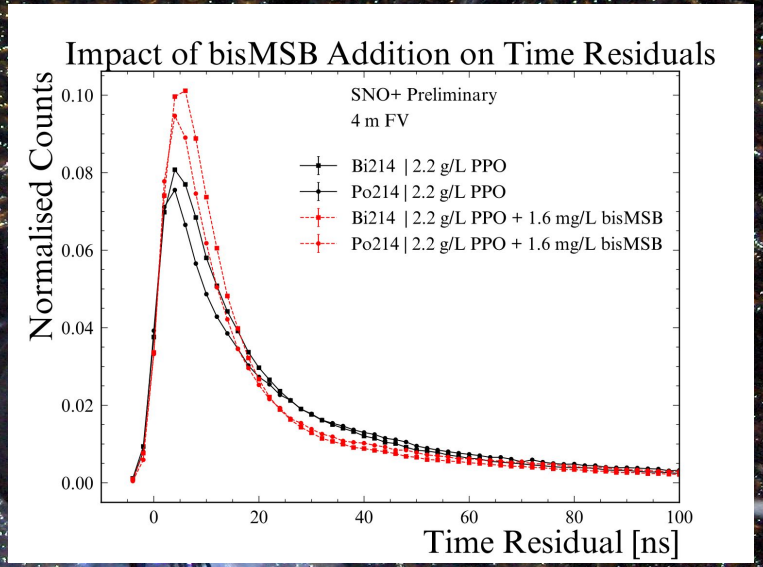
$$f(t) = \sum_i A_i \frac{e^{-\frac{t}{\tau_i}} - e^{-\frac{t}{t_r}}}{\tau_i - t_r}$$

- **Sum of exponential terms** containing timing constants, t_i, amplitudes A_i and a rise time, t_r
- Typically **use 3 or 4 terms** to model SNO+ scintillator

Challenge: Timing Profiles across SNO+ Phases

LAB + 0.6 g/L PPO	LAB + 2.2 g/L PPO	LAB + 2.2 g/L PPO + ~ 1.6 mg/L bisMSB





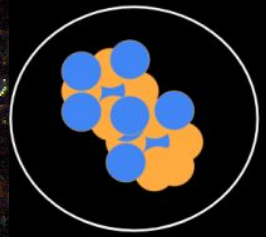
How do we Calibrate ?!

^{238}U Chain

^{214}Bi: **Prompt Candidate**
99.98 % β^-/γ decay
Q_{val} 3.27 MeV

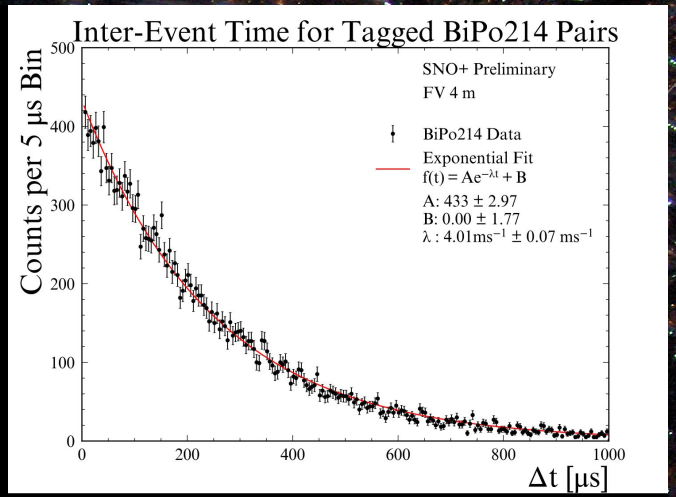
^{214}Po: **Delayed Candidate**
λ 4.22 ms^{-1}
α decay 7.83 MeV

^{210}Pb



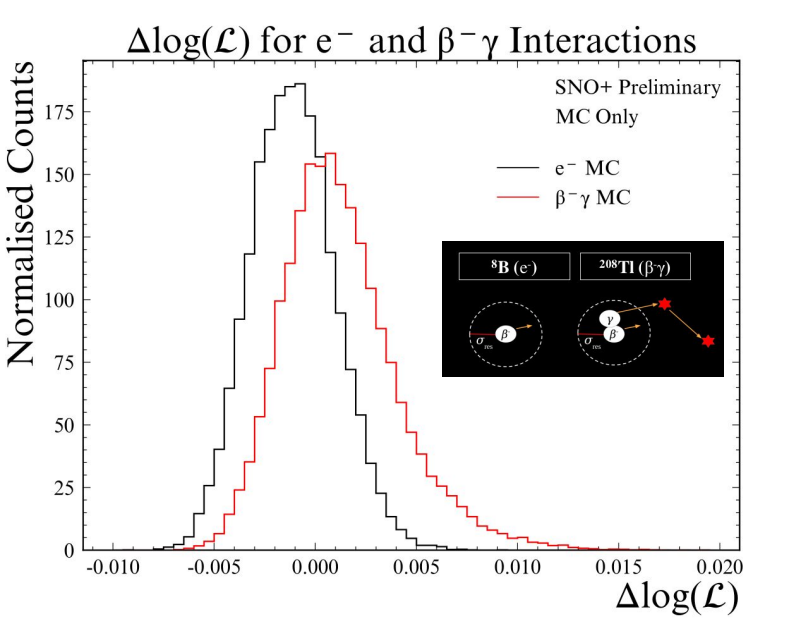
Tagged ^{214}Bi-^{214}Po Coincident Pair

- Bi-Po 214 tagged with coincidence method
- Provides pure sample of alpha and beta/gamma events
- In-situ calibration does not compromise radiopurity of detector



Prompt Energy Cut → Inter-event dR and dT cuts → Delayed Energy Cut

Using Timing Profiles for Event Discrimination in SNO+



- Energy deposition over broader area (e.g. gamma) leads to broader emission time distributions than single-site electrons
- Well calibrated emissions times allow us to statistically separate multi-site and single-site events
- E.g. ^{208}Tl (electron + gamma) vs ^{8}B solar (electron)