JUNO OSIRIS ONLINE TRIGGER

XIX International Workshop on Neutrino Telescopes

Parallel Flash talk

22.02.2021 I RUNXUAN LIU[1,2], on behalf of the JUNO collaboration

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Plenary talk about *JUNO* by Donglian Xu on Thursday 16:15

More about OSIRIS: parallel flash talk by Tobias Sterr, *JUNO OSIRIS Calibration Systems* on Thursday, 11:40

The OSIRIS Detector

A pre-detector of JUNO

- Decay of radioactive isotopes in the liquid scintillator can mimic neutrino signal events.
- OSIRIS (Online Scintillator Internal Radioactivity Investigation System) will monitor the liquid scintillator during the filling of JUNO.

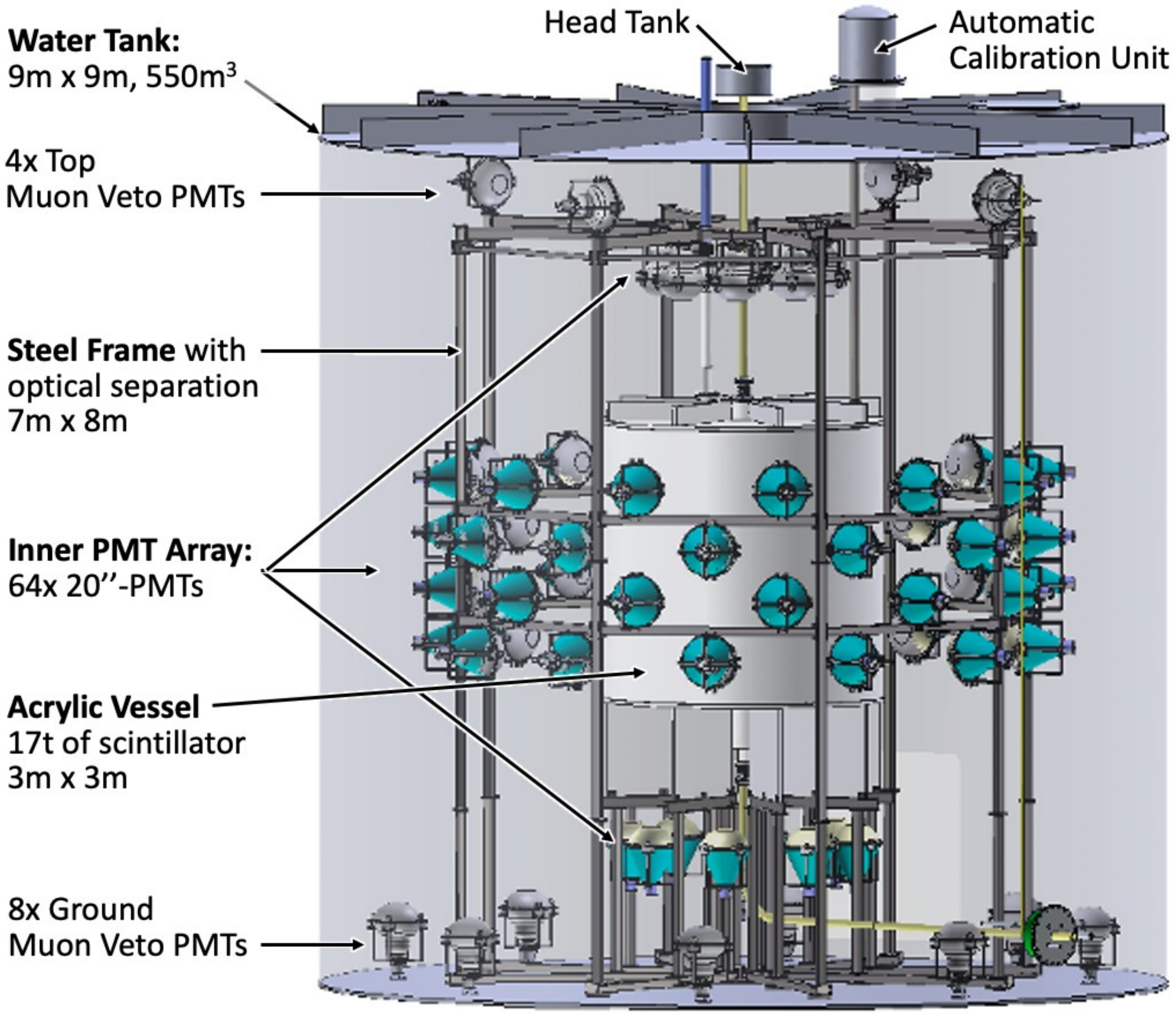
  OSIRIS has:
- Inner detector:

  - 18 tons of scintillator

  - 64 20''- iPMTs
- Muon Veto:

  - Water cherenkov detector

  - 12 20''- iPMTs

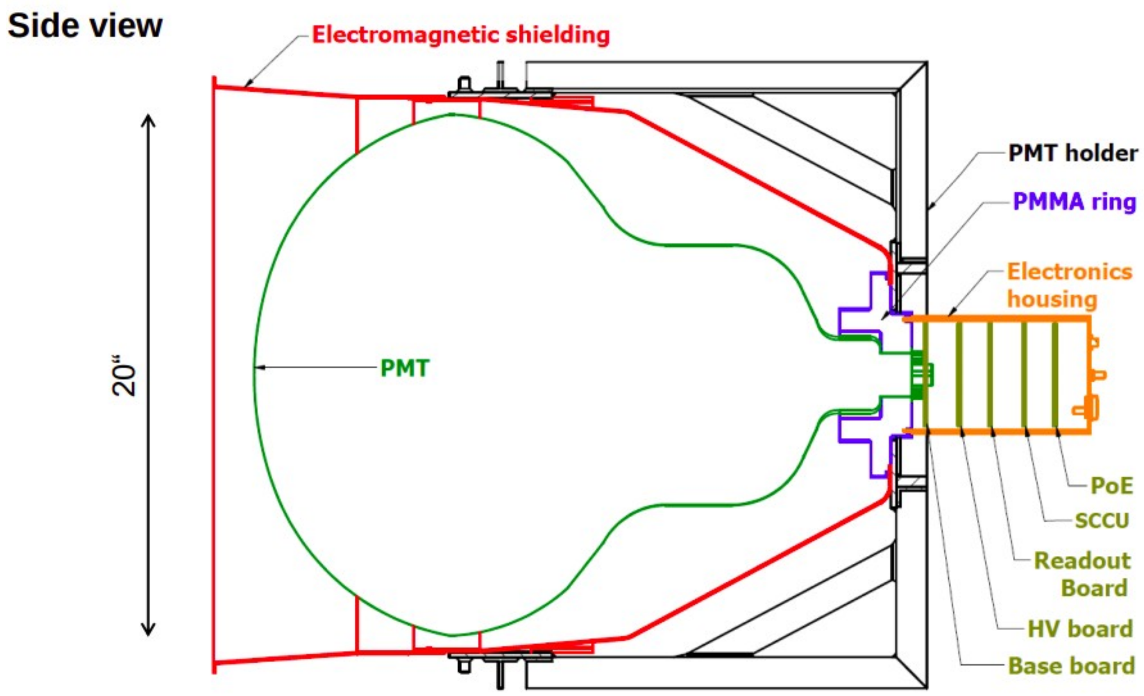


iPMTs of OSIRIS

- Idea of iPMT (intelligent PMT):

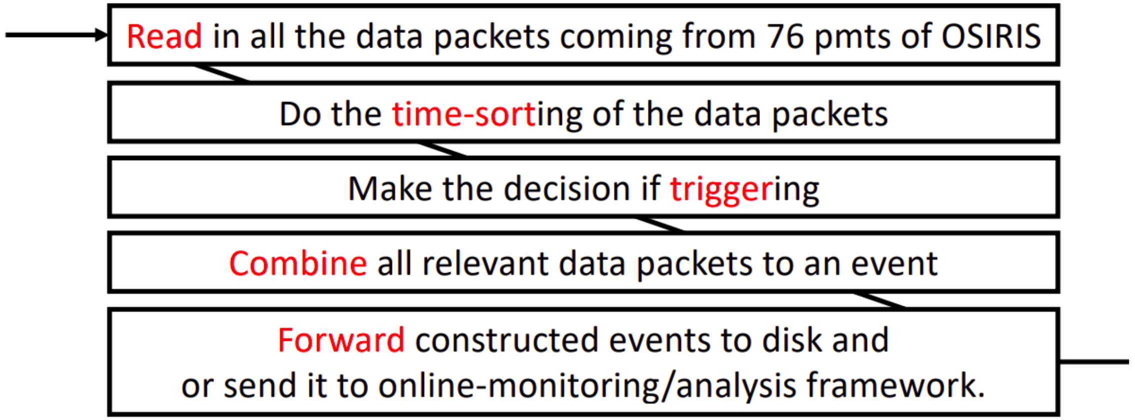
  combines the PMT and the required electronics into a single device.
- This design permits digitization of the signals directly at the PMT base.

- each PMT has readout windows of 240 ns with 120 samples,
- the correspond time stamps and waveforms are sent continuously over network.



Trigger Logics

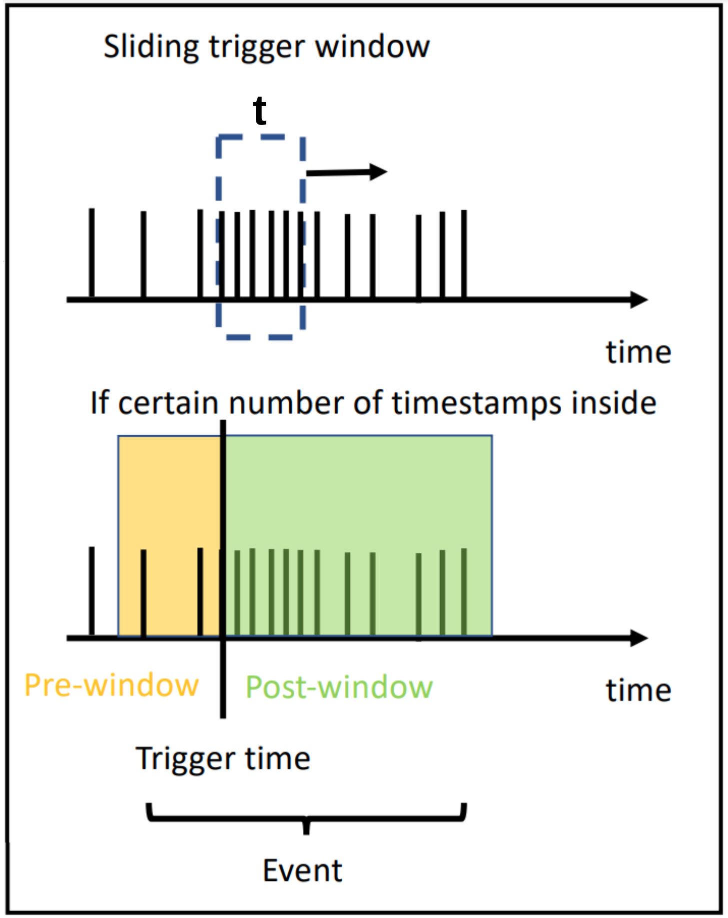
- Self-triggering:



- Coincidence trigger:
  - search for excess over **n** hits in trigger window time **t**
  - Event contains all PMT readout windows from:

    a pre-time before the trigger time

    to a post-time after the trigger time



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Dark-noise-only Trigger Rate

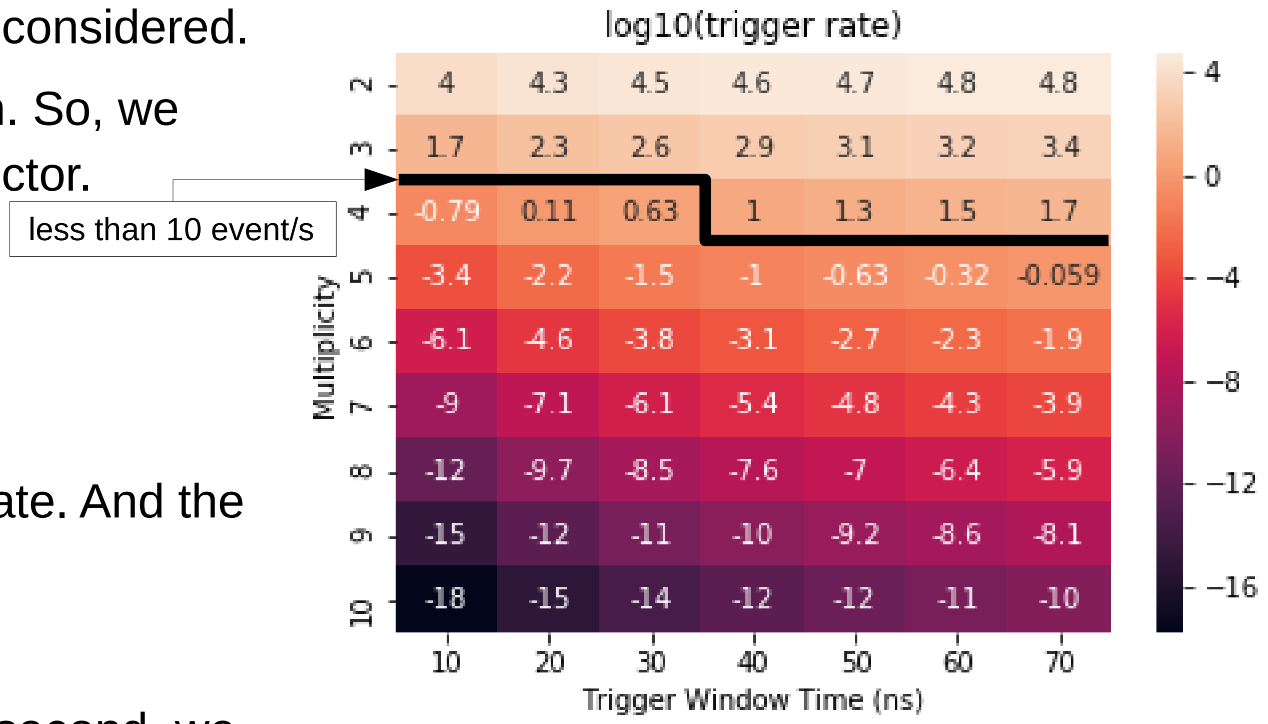
- To avoid high frequency of noise triggers, the trigger rate by dark noise pulses needs to be considered.
- 64 inner PMTs have dark rates of 15,900 s^{-1} each. So, we have 1 dark hit per microsecond in the inner detector.
- The trigger probability is:

$$\mathbb{P}(n,t) = \binom{63}{n-1} p(0;t)^{63-n+1} \, (1 - p(0;t))^{n-1}$$

where t is the trigger time window, f is the dark rate. And the probability of getting no dark hits in t is:

$$p(0;t) = (ft)^0 \cdot e^{-ft} = e^{-ft}$$

- For less than 10 dark noise triggered events per second, we need the multiplicity **n >= 4**.

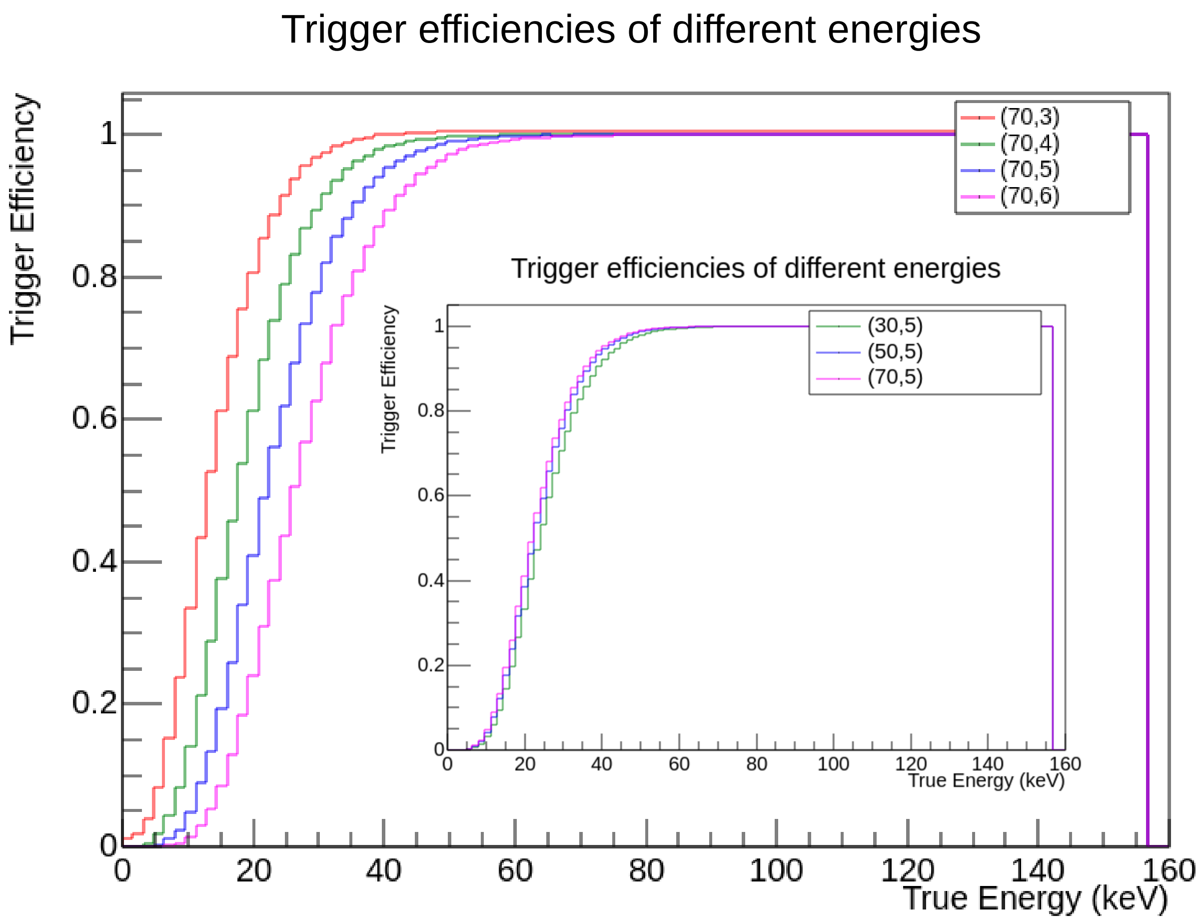


^{14}C Beta-decay Trigger Rate

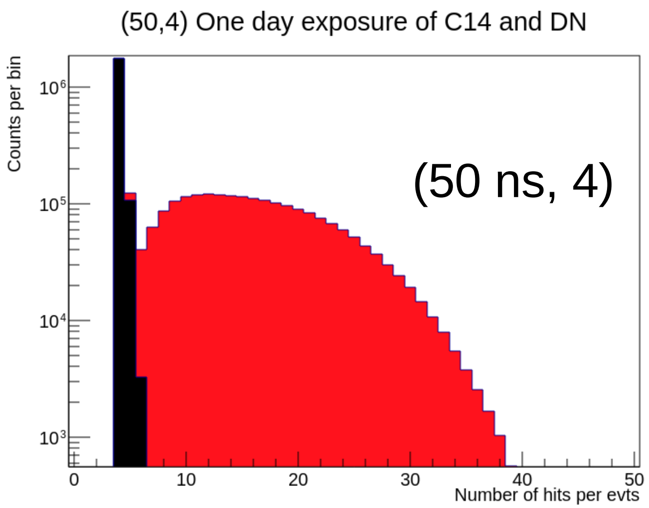
- OSIRIS will determine ^{14}C concentration of the JUNO liquid scintillator.
- The ^{14}C event rate for the whole detector is expected to be 30.0 Bq.
- To have a lower energy threshold, we need:

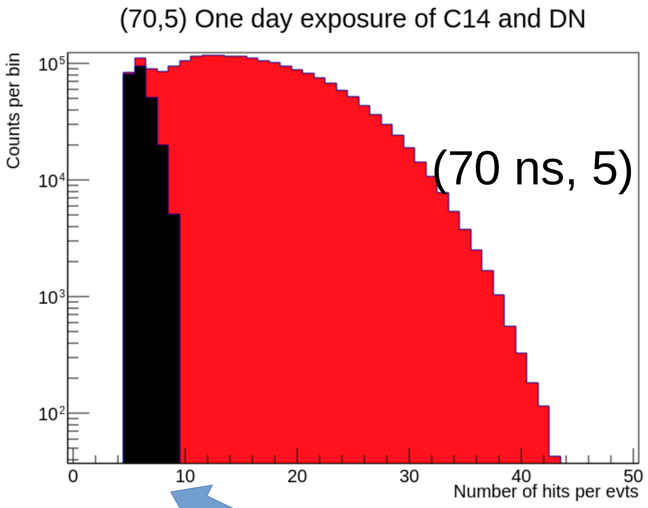
  lower multiplicity and longer trigger window.
- For a fixed **n**, changing of **t** does not contribute much to our trigger efficiency.

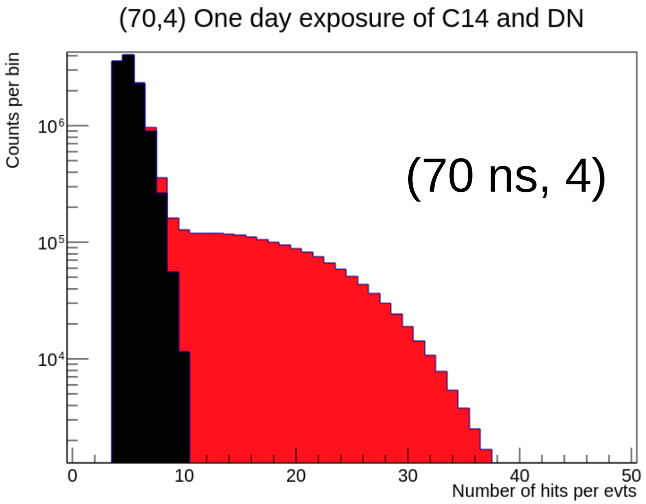
- Applying (**t**, **n**) = (70 ns, 5), we have:
- event rates of **22.5 s^{-1}** for ^{14}C and **2.9 s^{-1}** for dark noise in the event builder.
- **Trigger efficiency** reaches **90%** at **36.0 keV**.



Proportions Of Triggered ^{14}C And Dark Events







Acceptable

- Above showing distributions of number of hits for certain pairs of trigger conditions in one day of exposure.
- Multiplicity = 4 introduces large dark noise event contribution in low bins.
- Shrinking time window from 70 ns to 50 ns doesn't give much improvement.
- **(70 ns, 5) is much better than the others.**

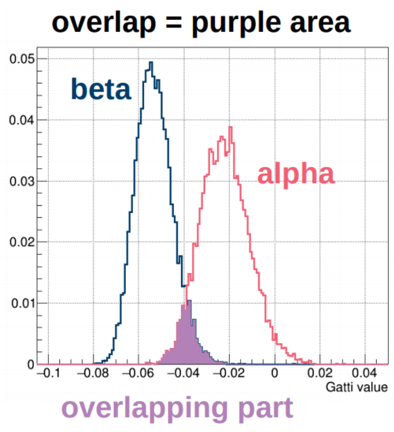
Pre-time And Post-time Optimization Discussion

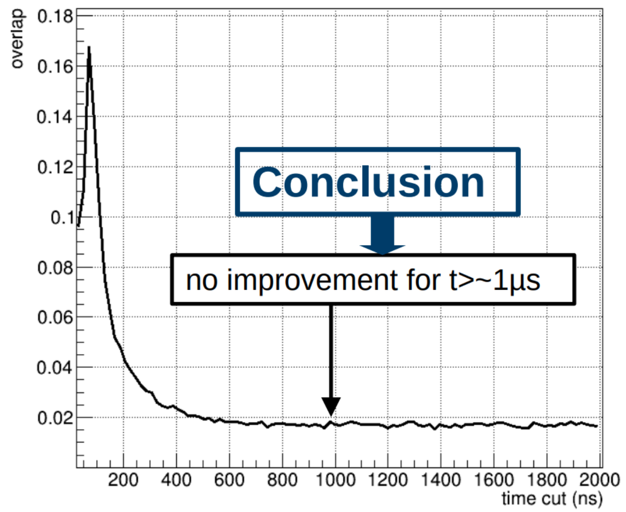
Determination of pre-time and post-time

Post-time:

- Simulated α/β events are applied in pulse shape discrimination study based on Gatti parameter.
- Separation of these two distributions can quantify the discrimination power.
- Time cut of more than 1000 ns does not give any better discrimination power.
- Hence post-time needs to be 1000 ns.

Definition:





Pre-time (under evaluation)**:**

- Idea: ^{85}Kr has two decay branches:

  1) 99.5%: β-decay with Q = 687 keV;

  2) 0.5%: β-decay with Q = 173 keV followed by a gamma decay with Q = 514 keV (τ = 2060 ns).
- Idea: measure ^{85}Kr with the minor branch coincidence -> backward search in the pre-window.

Conclusion

- Trigger window and multiplicity are decided to be: **(t, n) = (70 ns, 5)**
- This is optimal trade-off between:

  maintaining a low dark noise event rate and a low energy threshold for detecting ^{14}C events.
- We will achieve event rates of **22.5 s^{-1}** for ^{14}C and **2.9 s^{-1}** for dark noise in the event builder.
- Trigger efficiency will reaches **90%** at **36.0 keV**.

- Event duration:

  Pre-window: investigate backward-tagging of ^{85}Kr

  Post-window: optimize on α/β discrimination

Thank you for your attention!