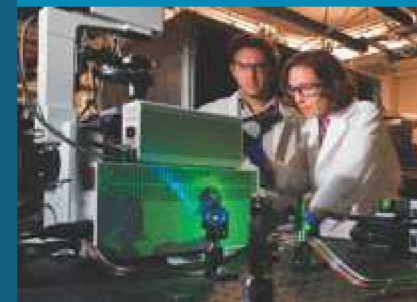
SAND2018-12907C

High Resolution Measurements of the Prompt Temporal Response of Fast Plastic Scintillators

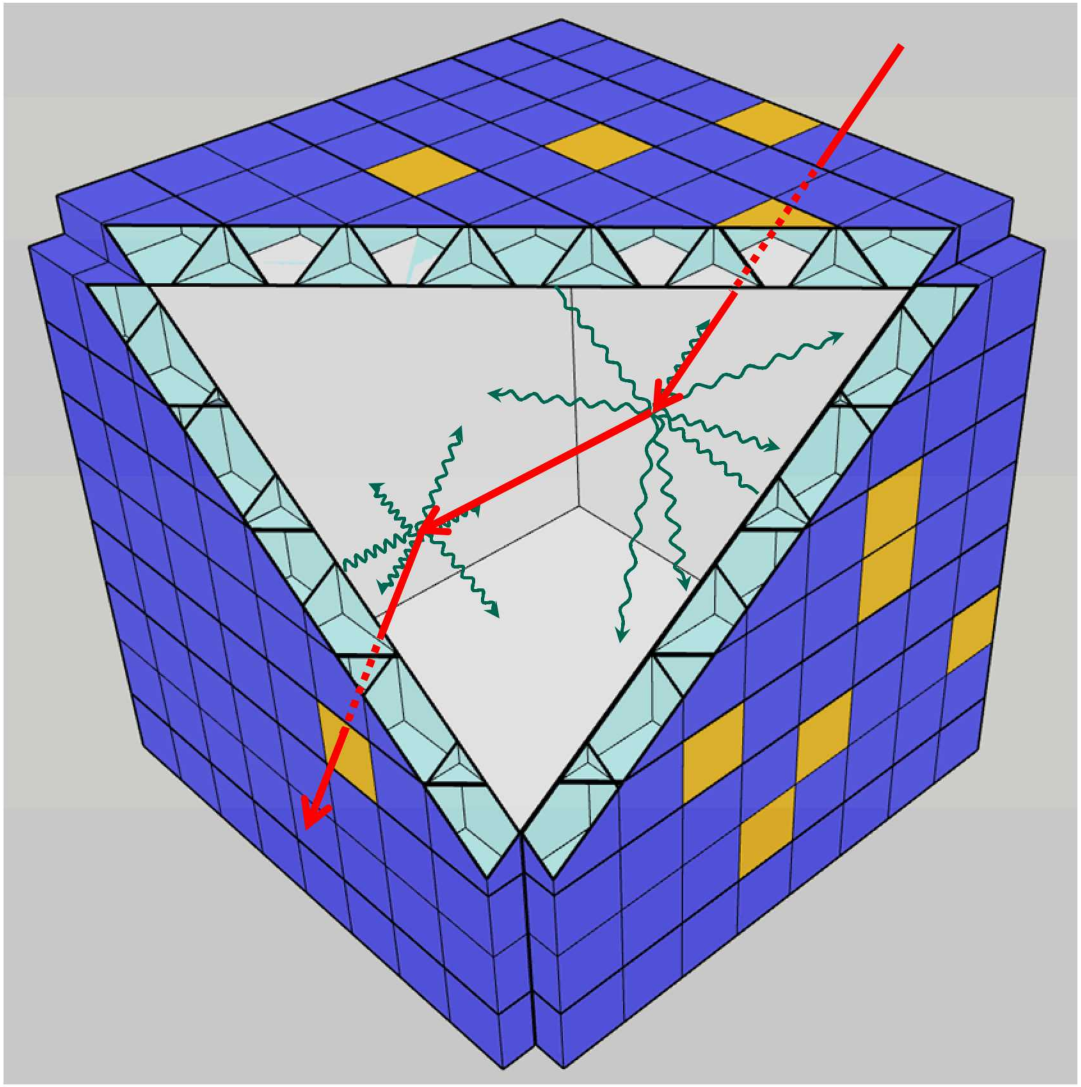


PRESENTED BY

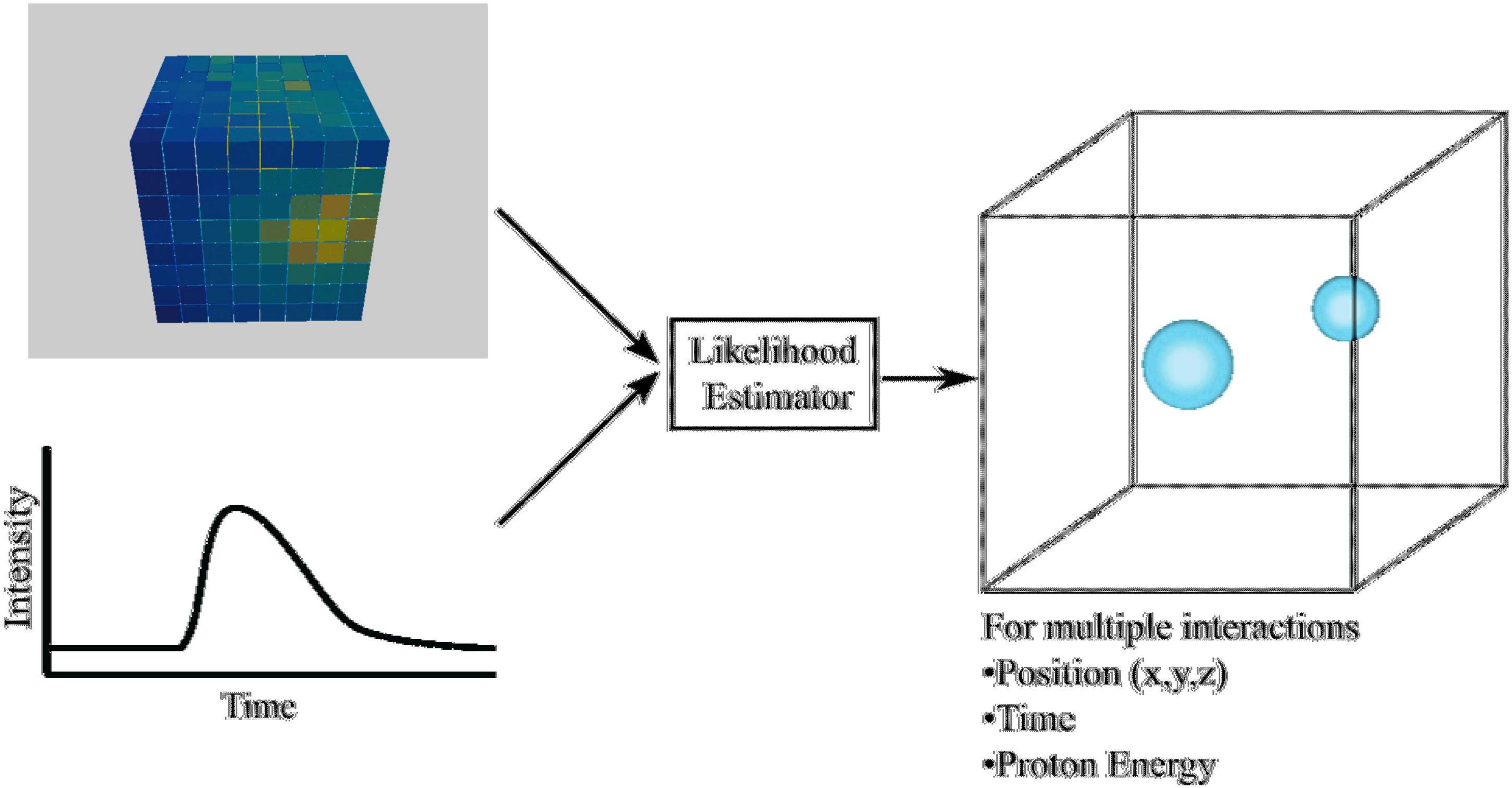
Joshua A. Brown

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

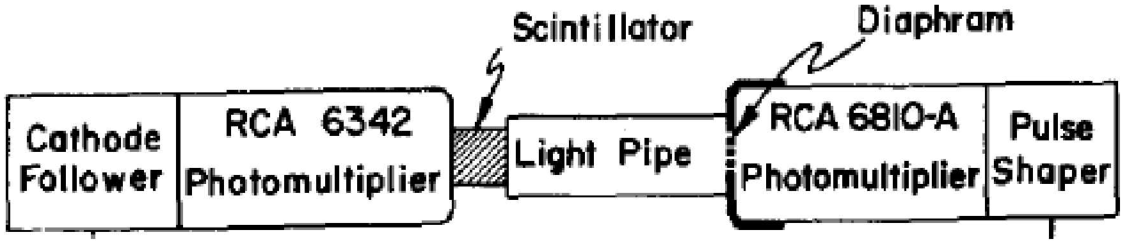
Why Measure Pulse Shapes?

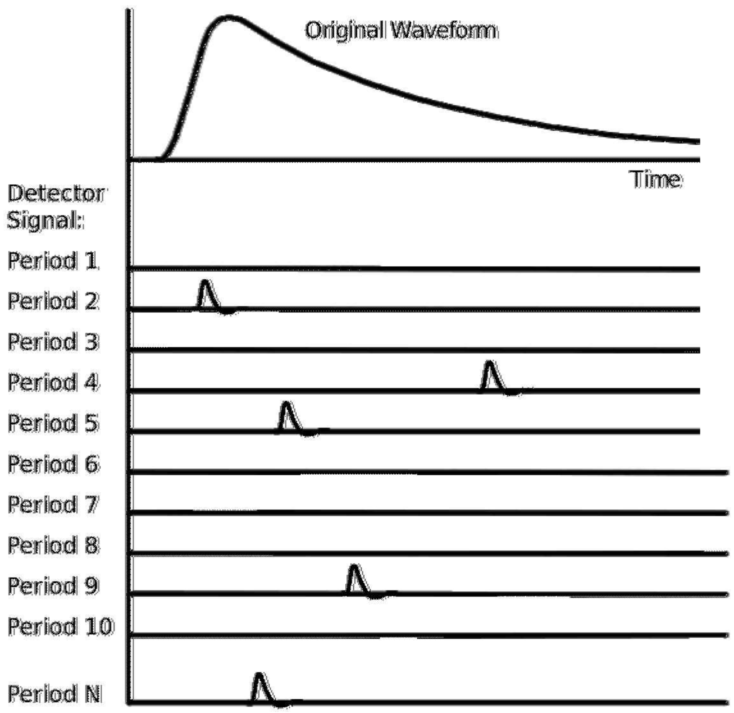


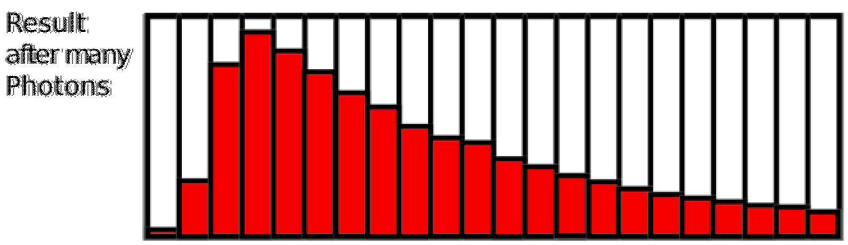
Why Measure Pulse Shapes?



Time Correlated Single Photon Counting







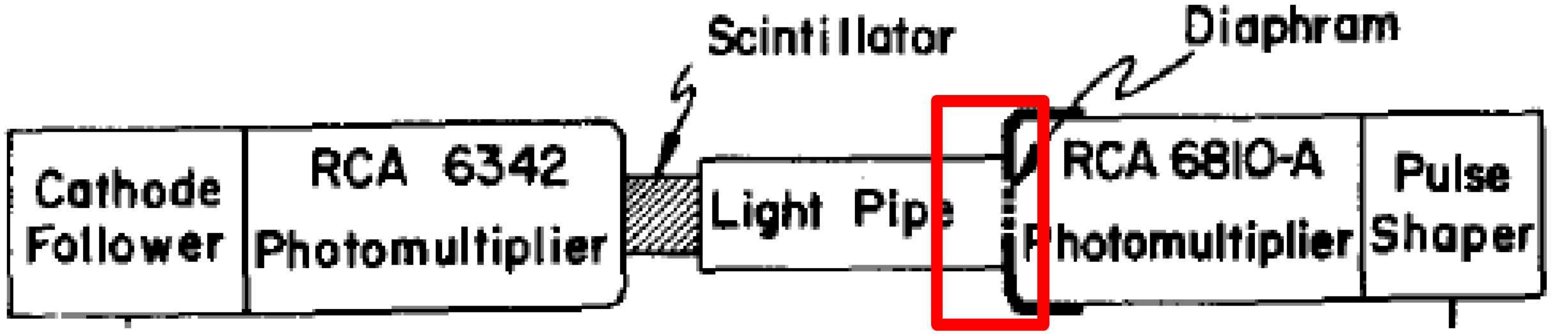
Principle of the TCSPC technique

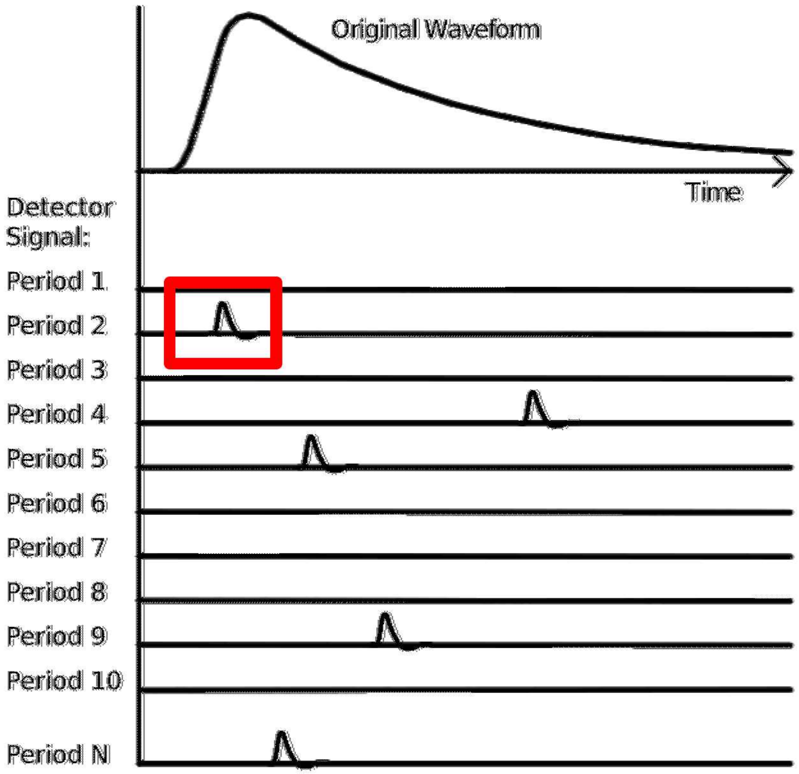
Measurement of the Time Dependence of Scintillation Intensity by a Delayed-Coincidence Method*

L. M. Bollinger and G. E. Thomas
Argonne National Laboratory, Argonne, Illinois

(Received January 13, 1961; and in final form, April 11, 1961)

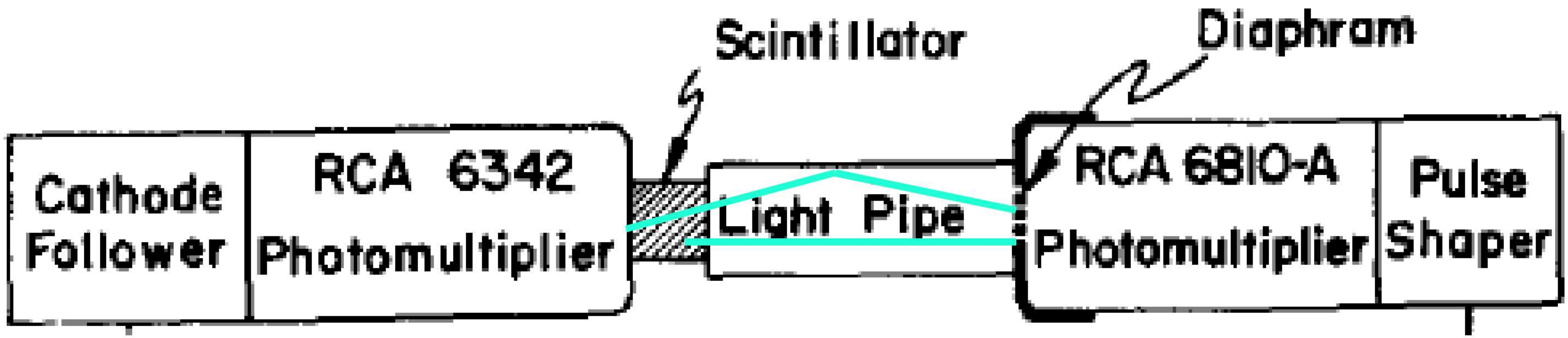
Temporal Resolution of the Single Photon Counter





- Generally set by the characteristics of the photomultiplier used
- Held as the dominant source of uncertainty in classical setups

Optical Path Length Variance

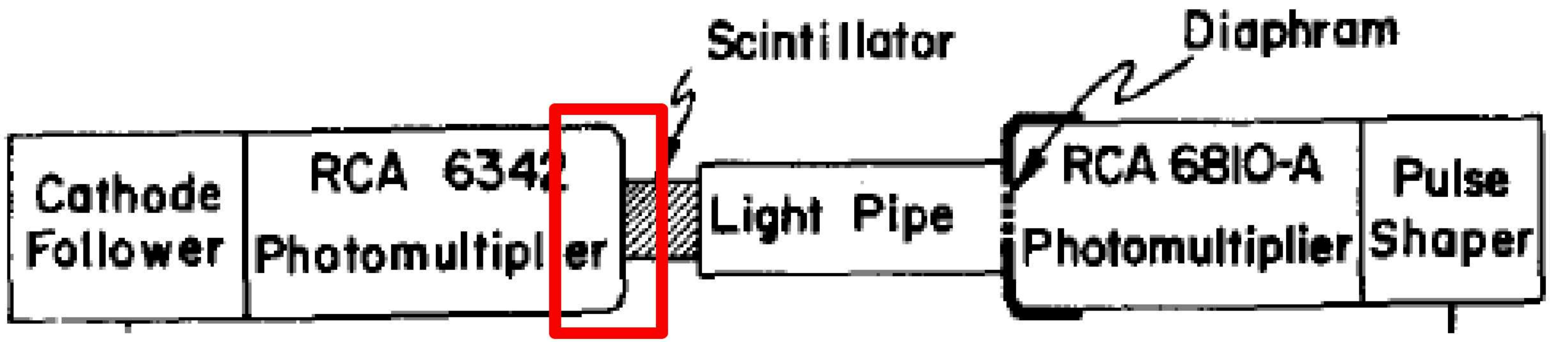


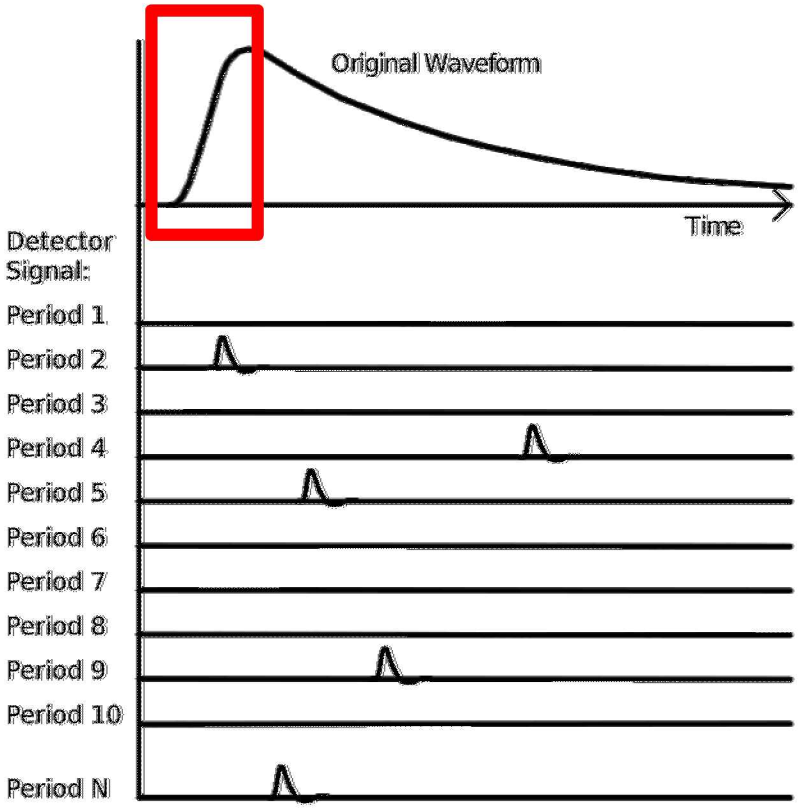
- Dependent on the geometry employed
- Dependent on scintillator size
- Potentially includes effects due to absorption and re-emission

Measurement of the Time Dependence of Scintillation Intensity by a Delayed-Coincidence Method*

L. M. Bollinger and G. E. Thomas
Argonne National Laboratory, Argonne, Illinois
(Received January 13, 1961; and in final form, April 11, 1961)

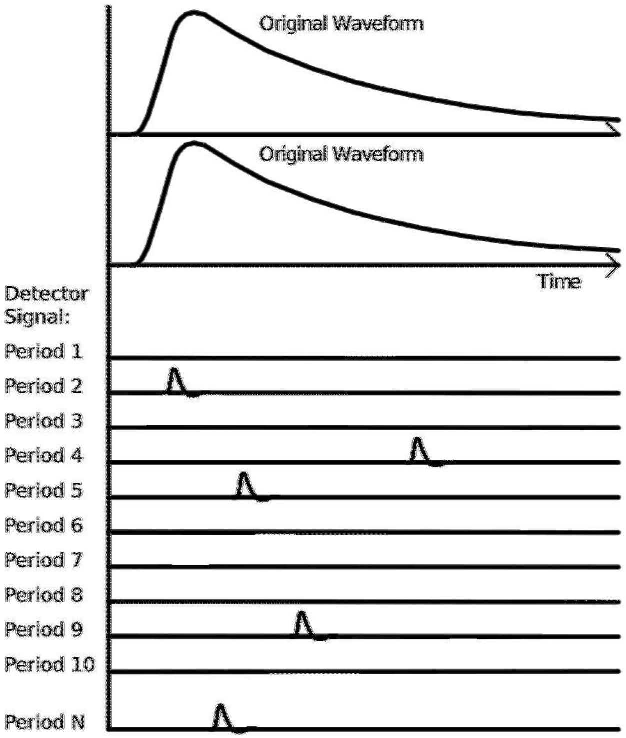
Temporal Resolution of the Pulse Start Time (T0)

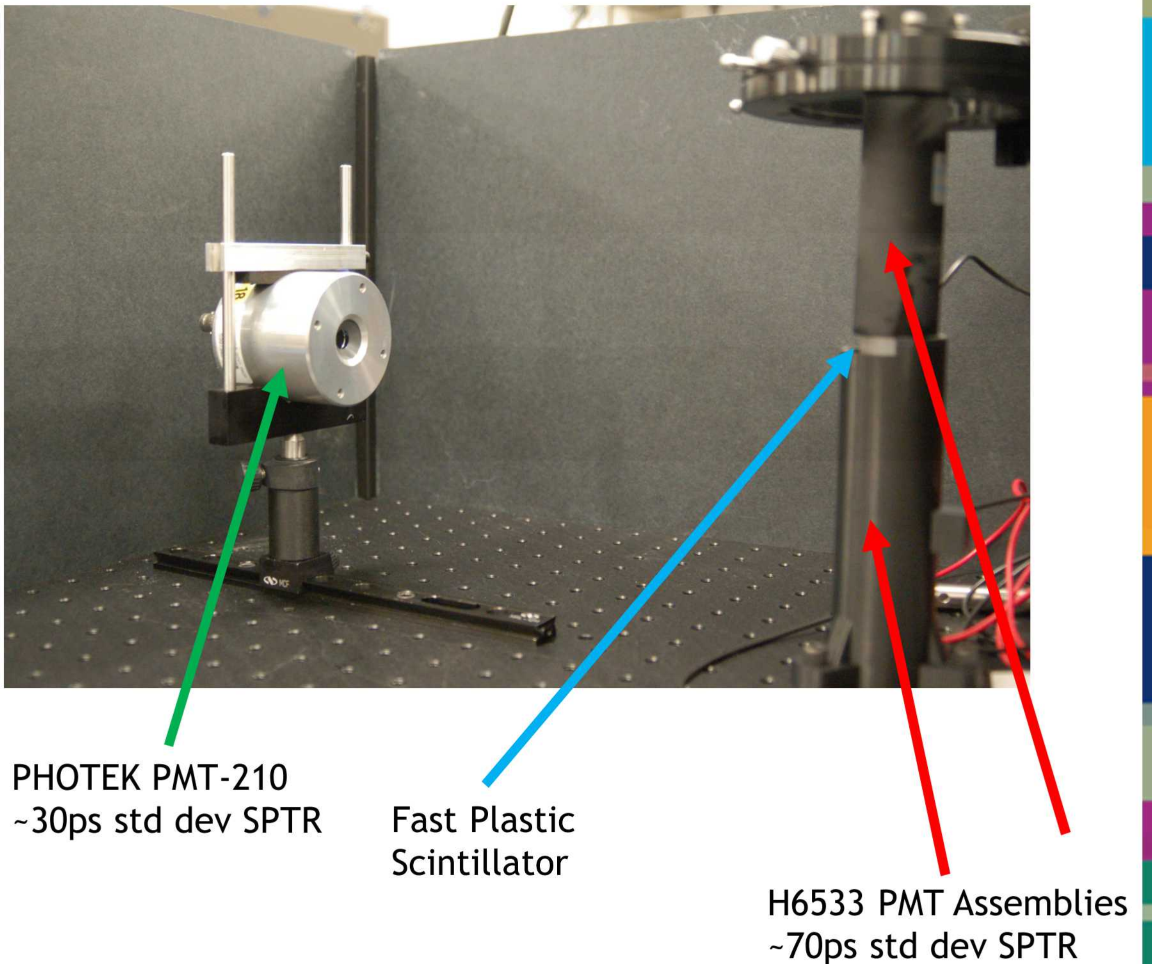




- Dependent on Number of photons collected
- Dependent on photomultiplier used
- Dependent on scintillator size
- Dependent on scintillator rise time
- Generally thought of as small due to the large number of photons collected

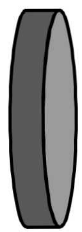
Time Correlated Single Photon Counting
(A Modern Interpretation)



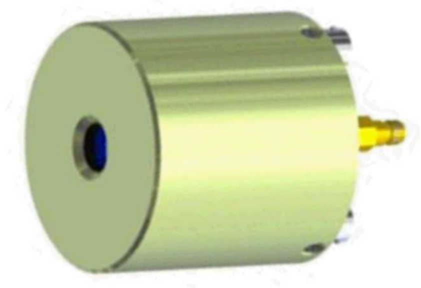


Single Photon Time Resolution

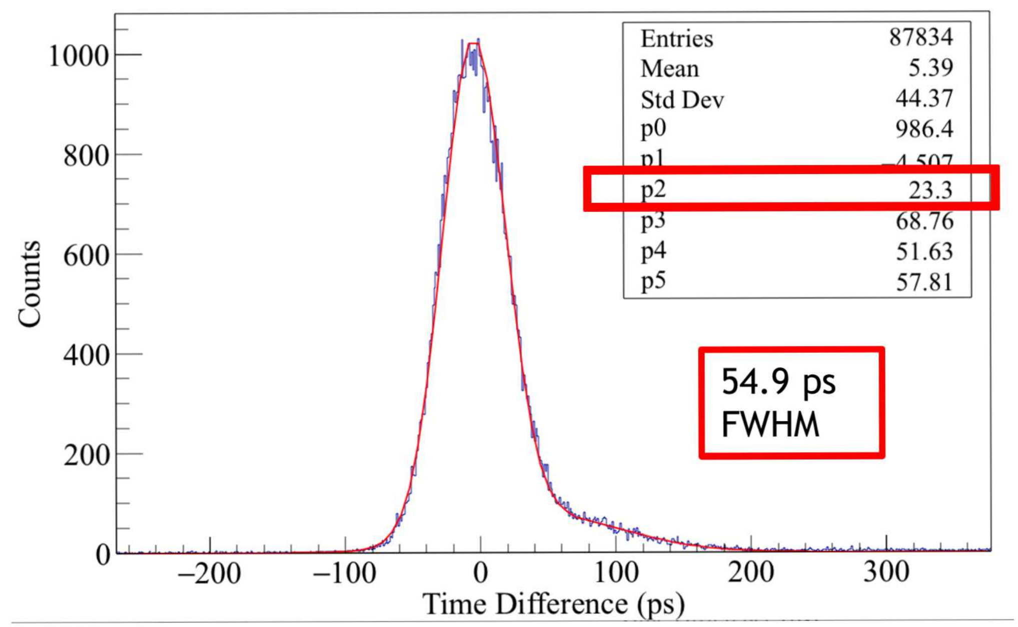
Uncertainty Quantification



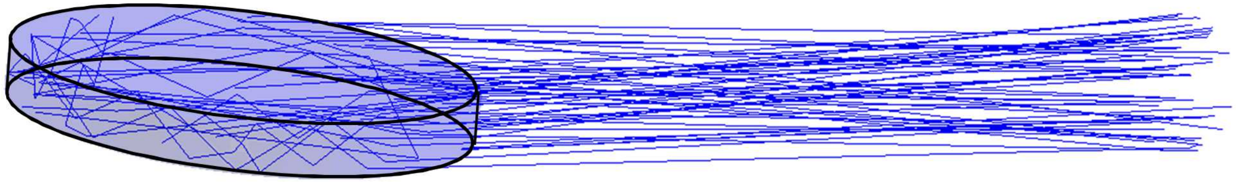
Attenuation
~40dB

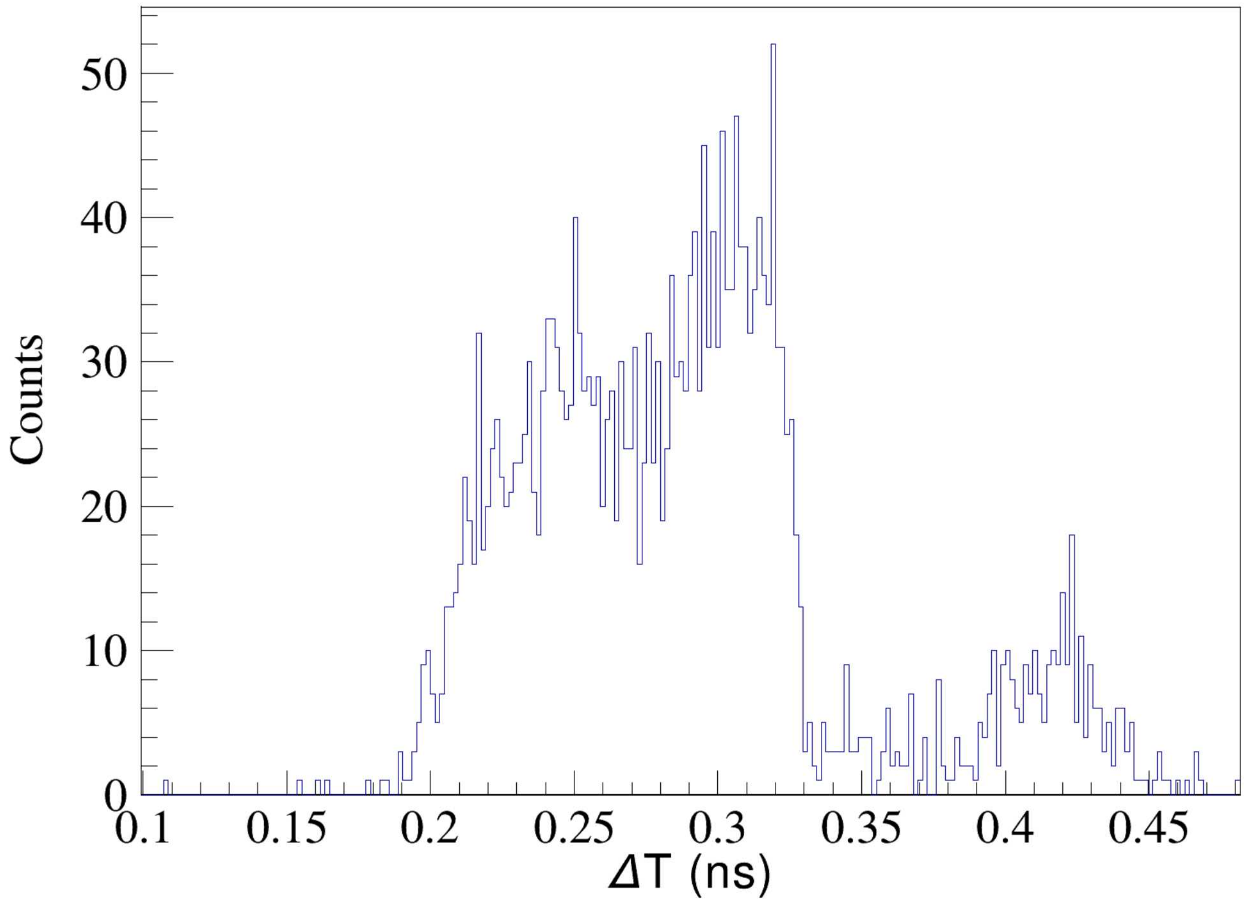


PMT-210 Single Photon Time Resolution

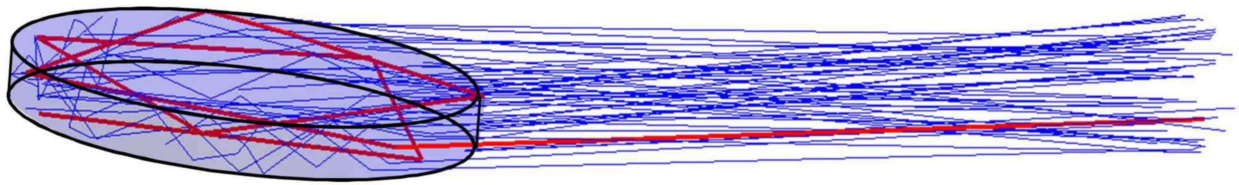


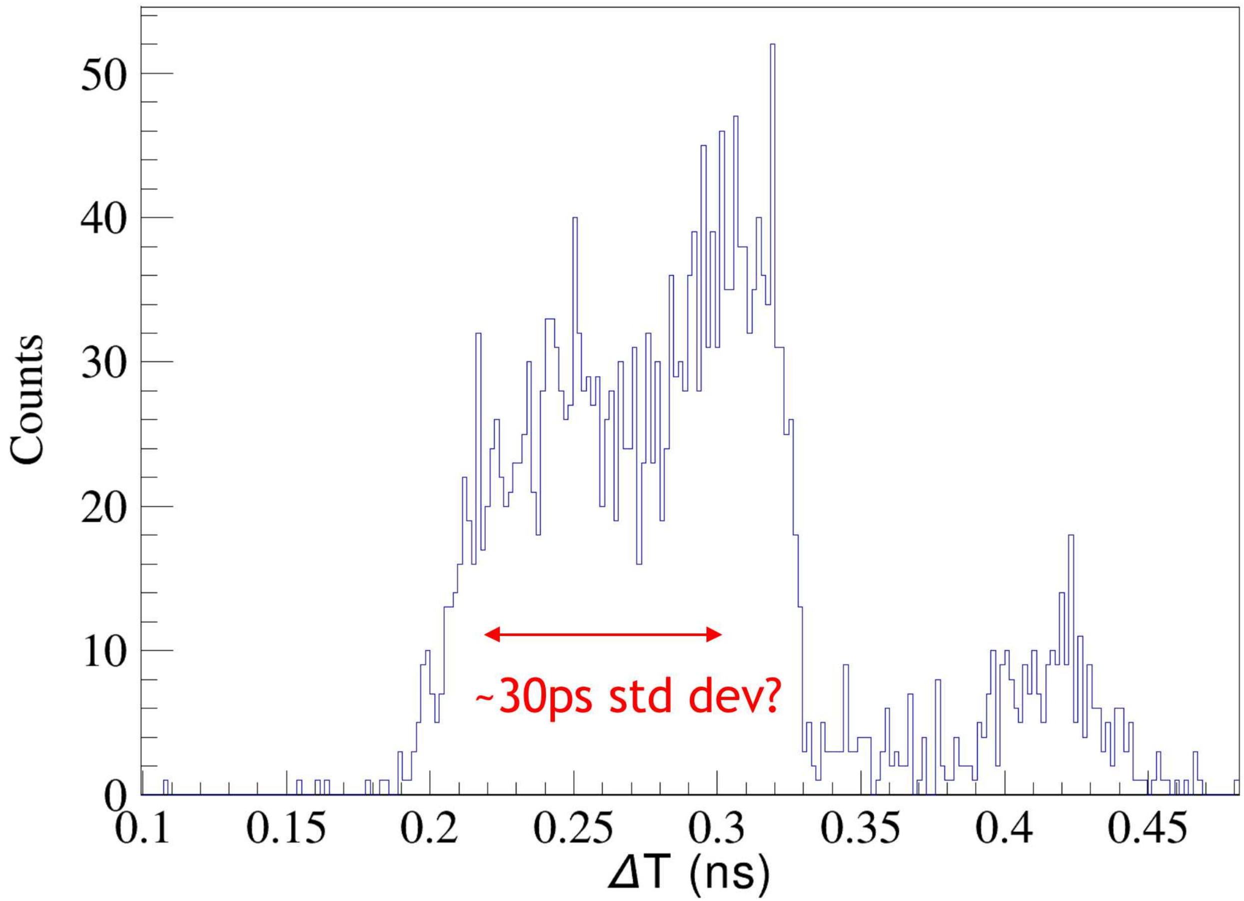
Optical Path Length Variance



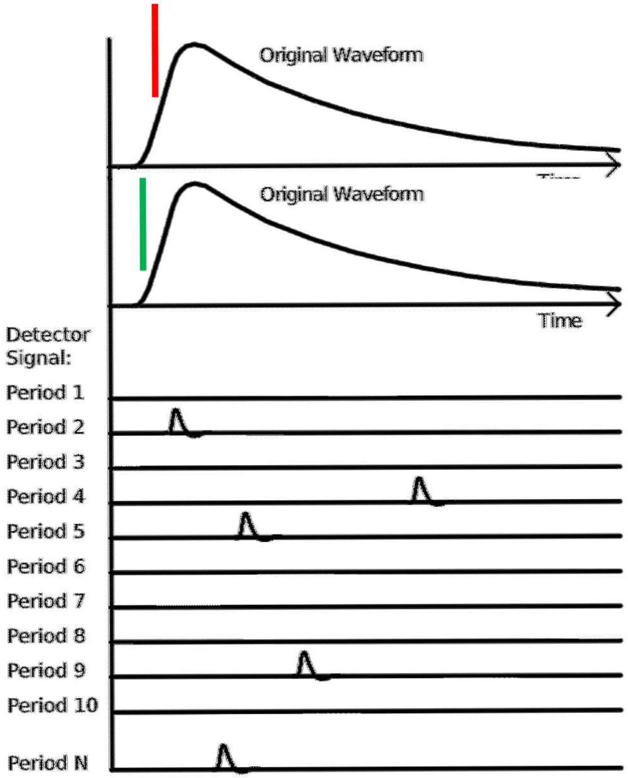


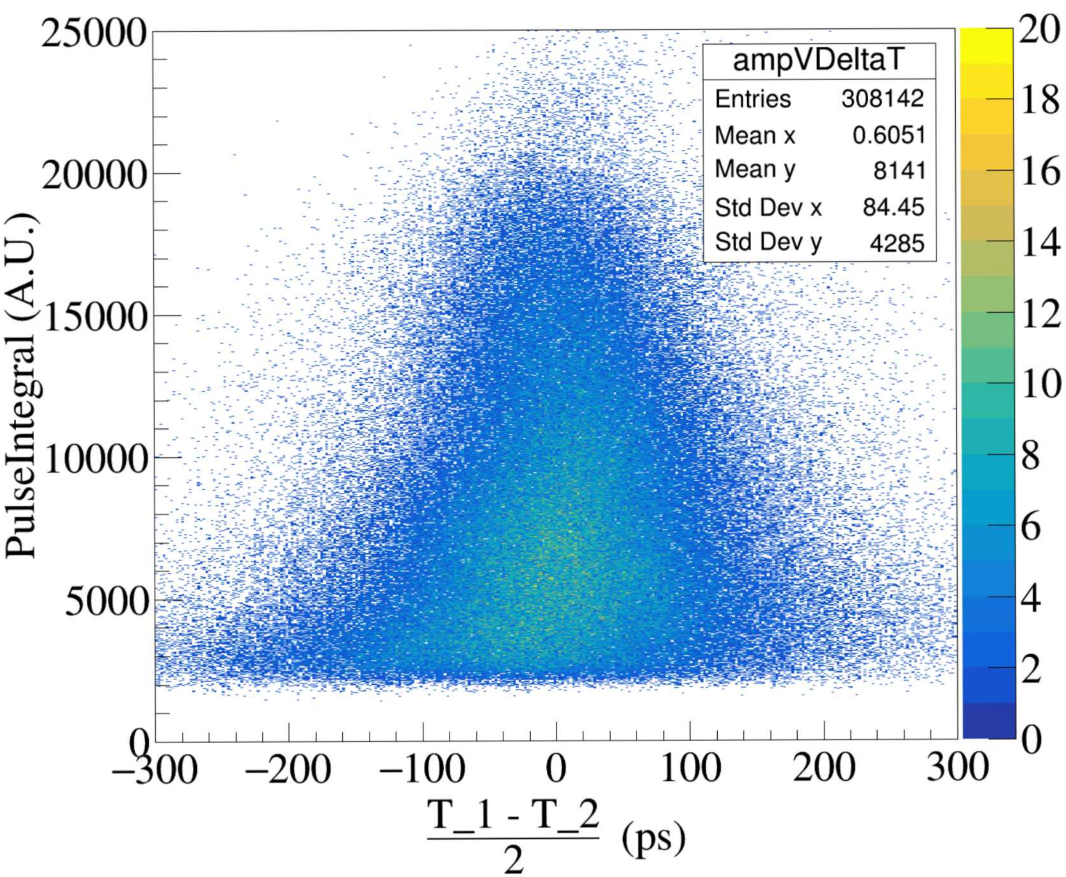
Optical Path Length Variance



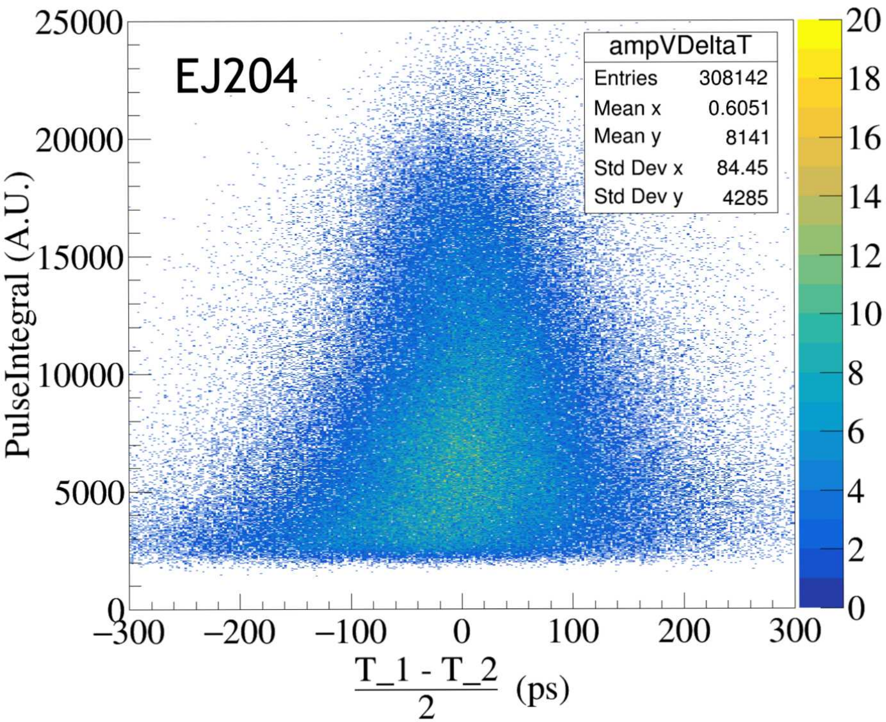


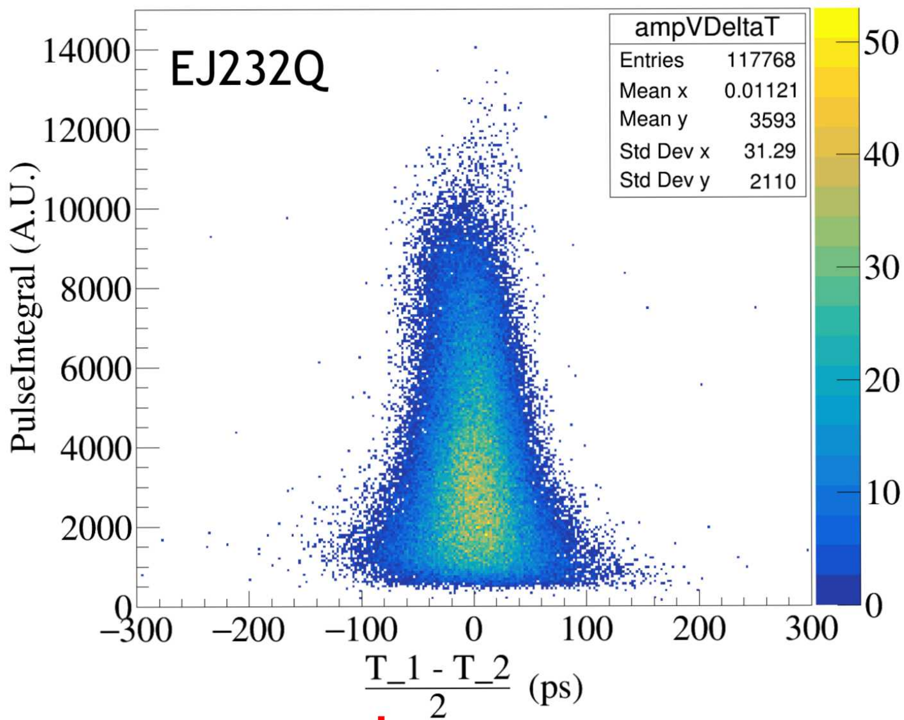
Pulse Start Time Uncertainty (T0)

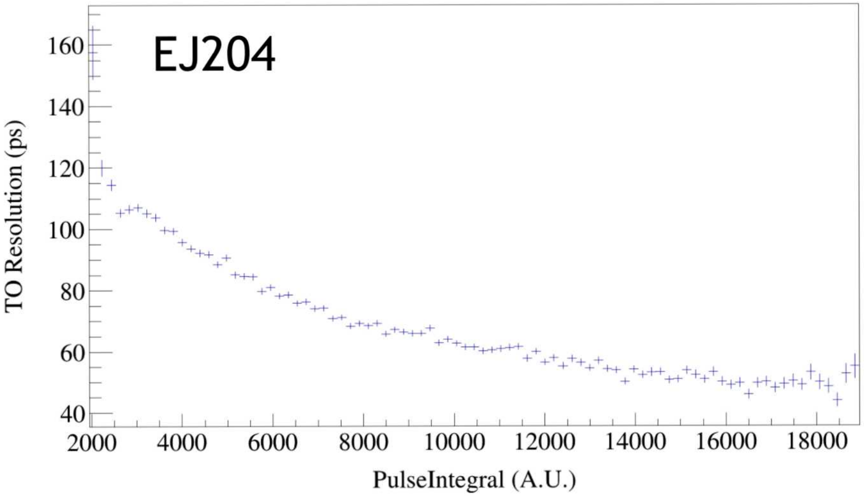


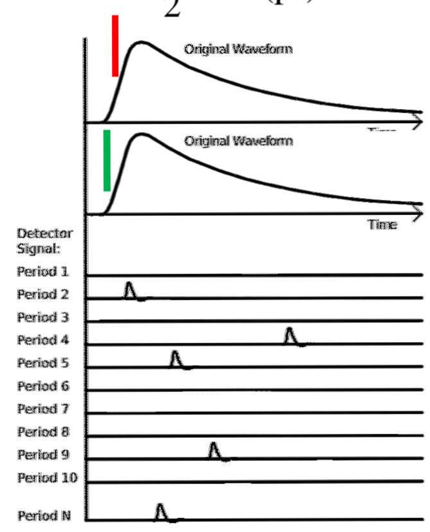


Pulse Start Time Uncertainty (T0)

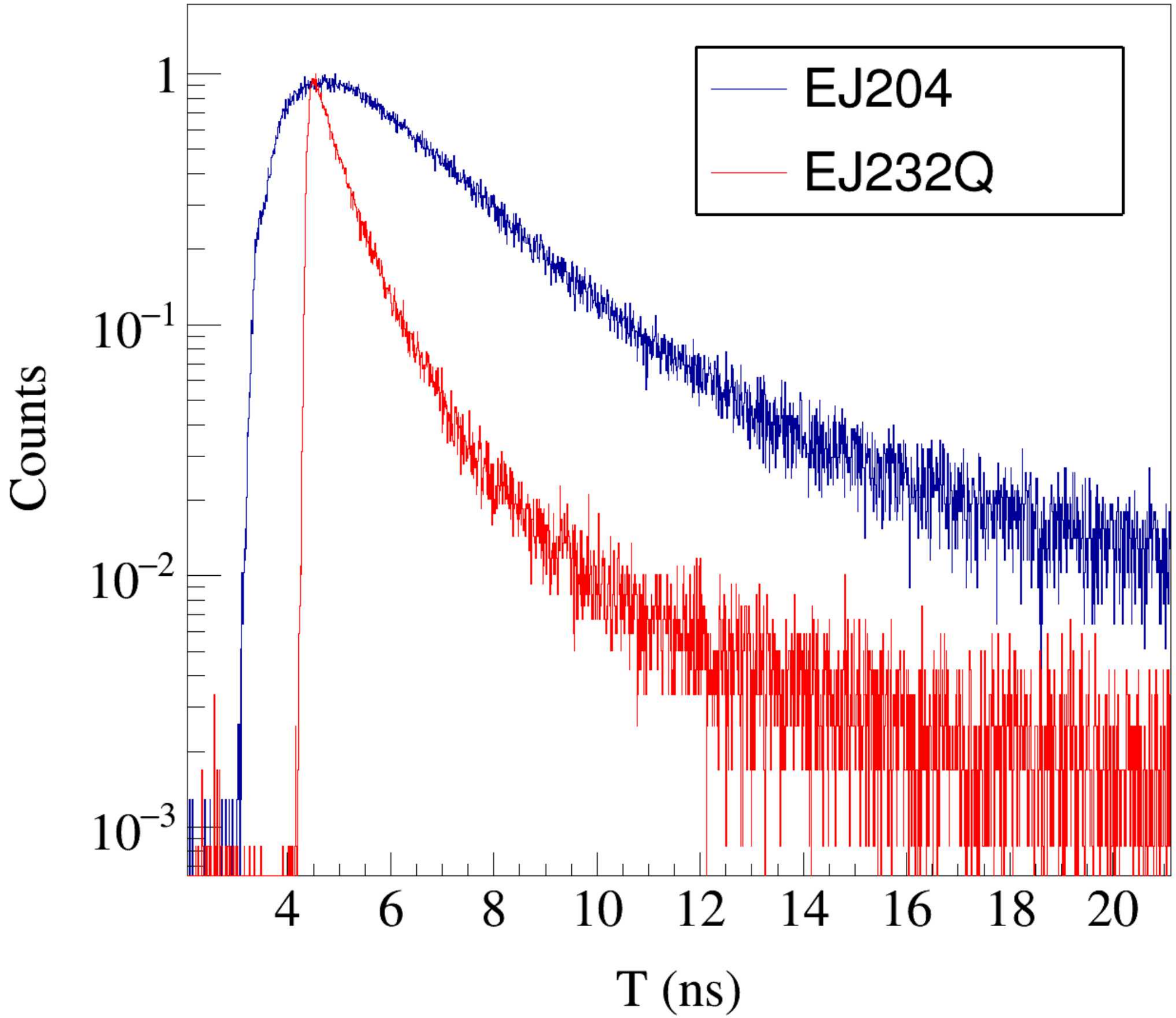








Pulse Shapes

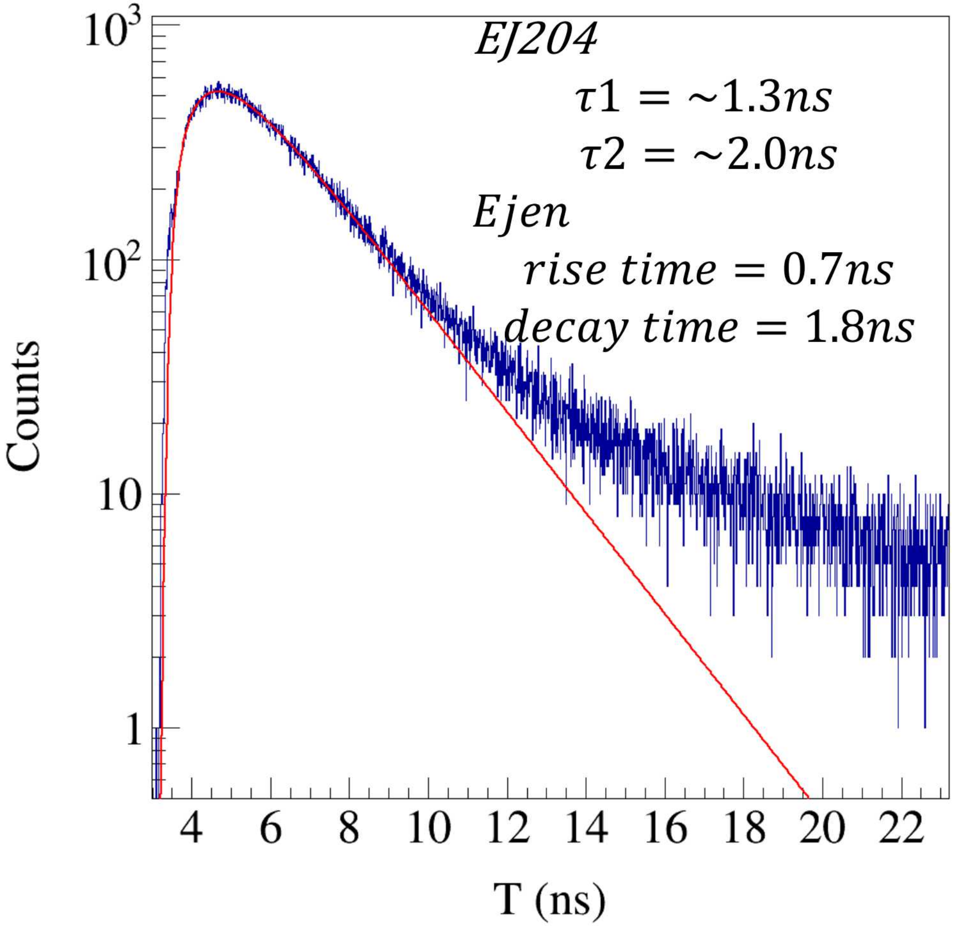


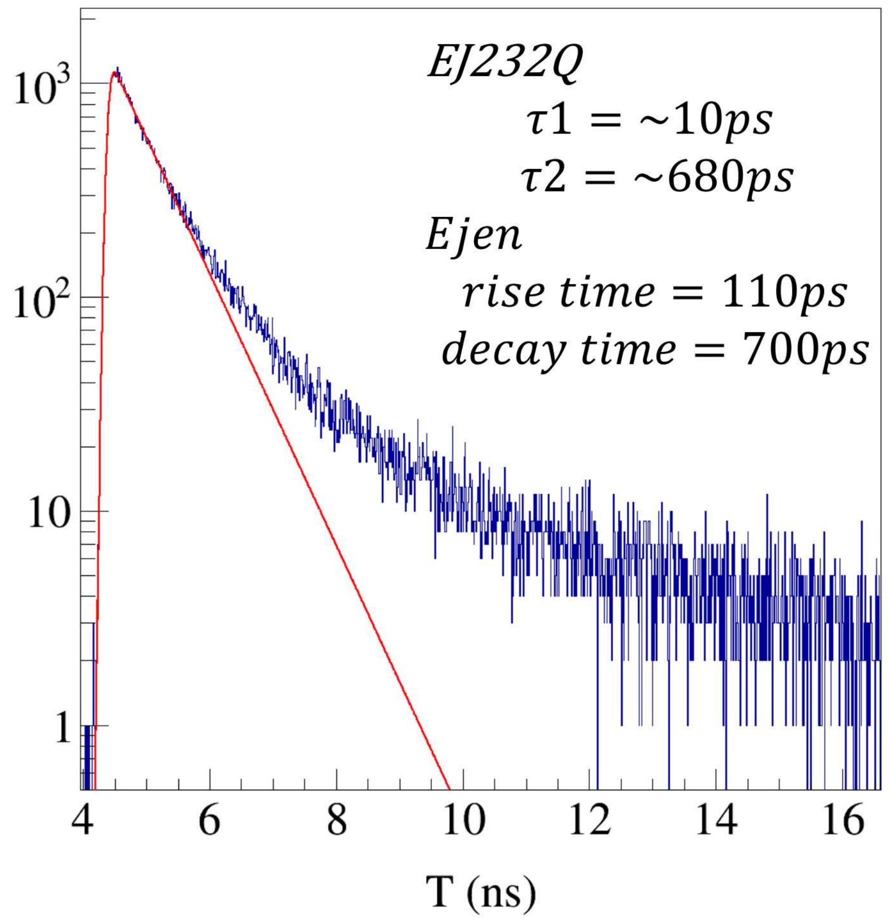
Model Comparison

$$I(\tau 1, \tau 2, t) = \frac{(\tau 1 + \tau 2)}{\tau 2^2} e^{-\frac{t}{\tau 2}} \left(1 - e^{-\frac{t}{\tau 1}}\right) \theta(t)$$

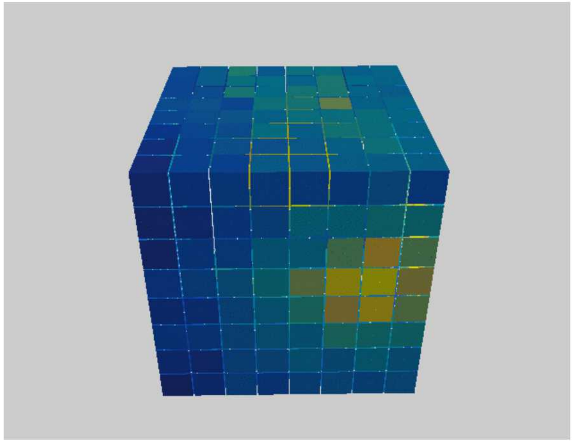
$$F = IRF(t) * I(\tau 1, \tau 2, t)$$

- IRF is considered a normal distribution with standard deviation equal to the quadrature sum of the outlined uncertainties





Summary and Outlook



- A pulse shape measurement capability has been established with the resolution needed to provide inputs for the likelihood reconstruction algorithms of the Single Volume Scatter Camera
- Mixed source results were presented for two samples

Open Questions

- Neutron and Gamma-ray Pulse Shape Differences
  - Time of flight gated experiments are currently being analyzed
- Optical Path Length Variance
  - Realism needs to be added to the current Geant model to get a better handle on this uncertainty
- Can T0 resolution be improved with more sophisticated timing algorithms?
- Incorporation of delayed light?