SAND2017-9439PE

PSD Quantification with Large Scintillators

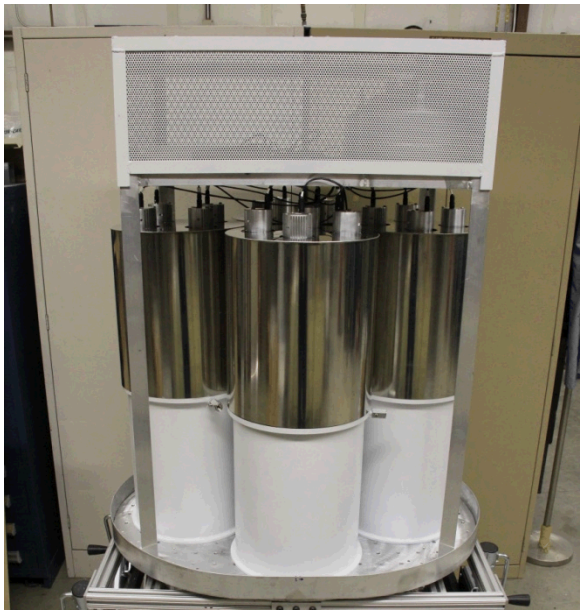
SNL/AWE Meeting

Nov. 16, 2016

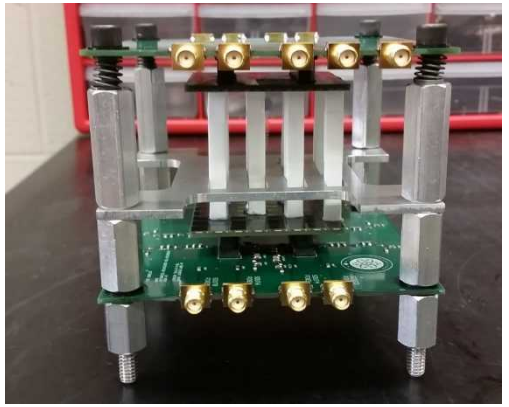
Motivation

- Large detectors with multiple (traditional) photo-detectors
- Compact detectors with new readouts (SiPM)
- Pixelated detectors
- How to combine information to maximize particle discrimination capability?

TEI-1D

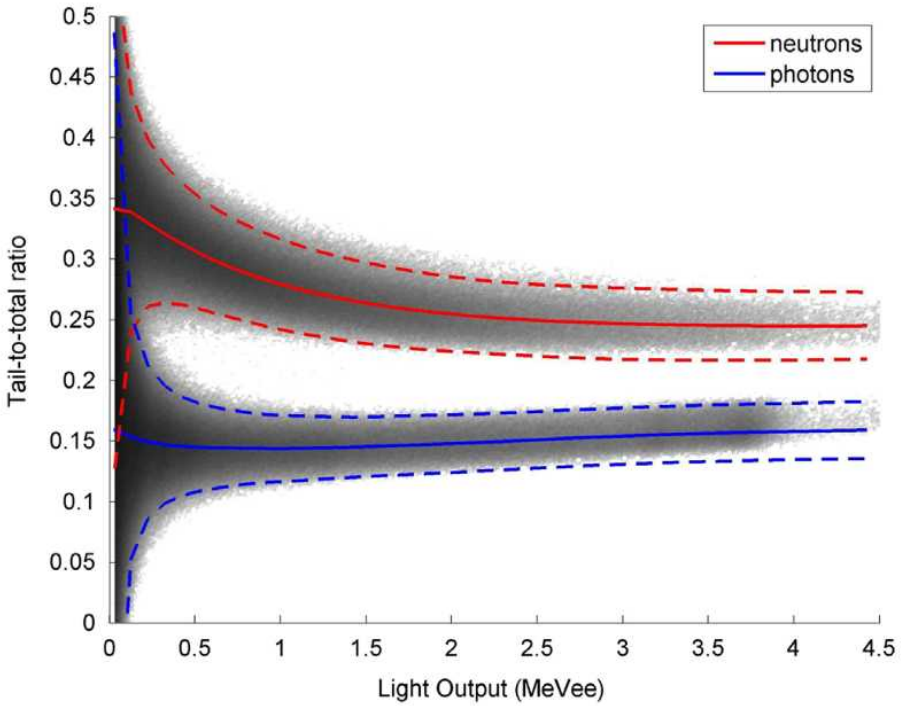


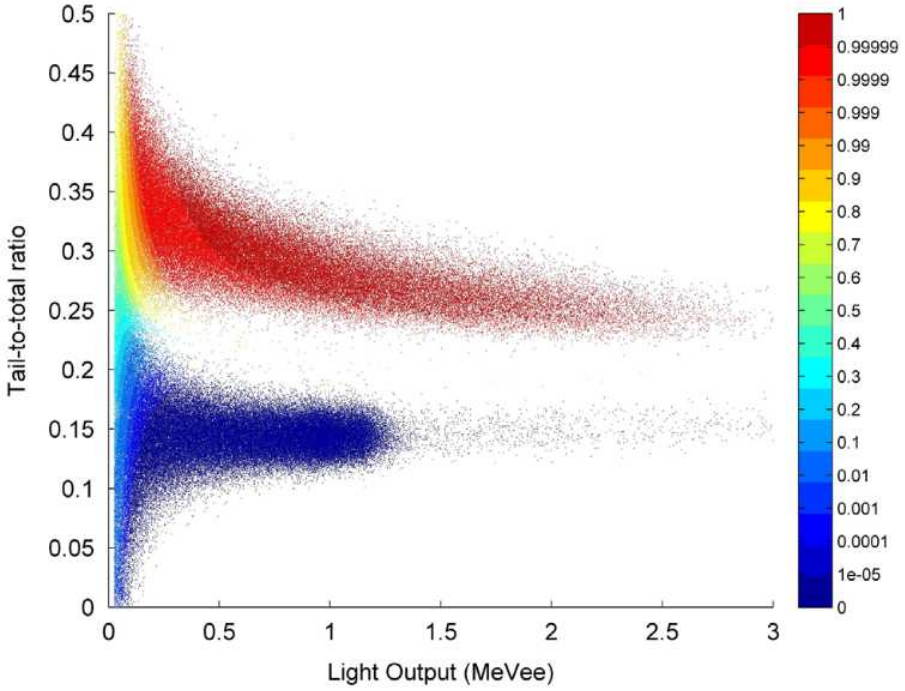
Stilbene Pillar Array



Bayesian Framework for PSD

"Application of Bays' theorem for pulse shape discrimination" NIMA A795 (2015) 318-324





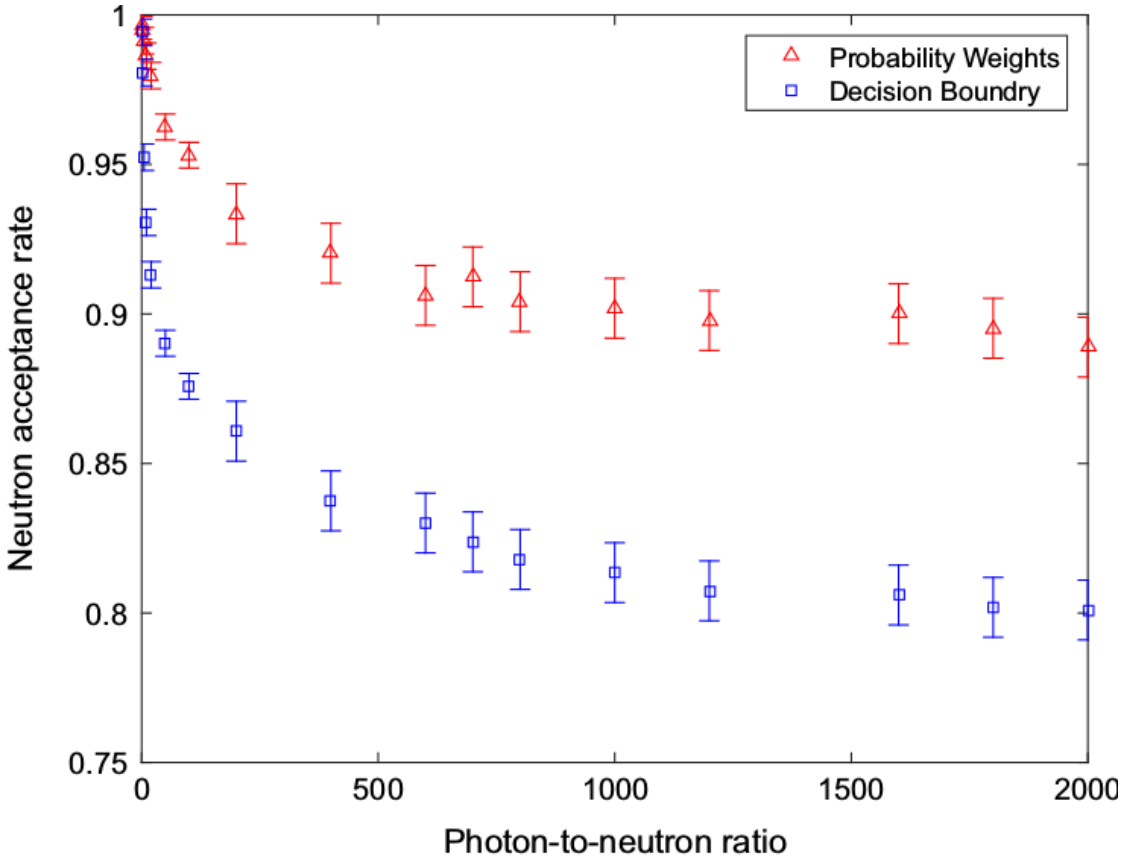
Gaussian Fit for gammas/neutrons

$$f(s) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(s-\mu)^2}{2\sigma^2}\right)$$

Gamma probability: $$P(\gamma \mid s) = \frac{f_\gamma(s) R_{\gamma/n}}{f_\gamma(s) R_{\gamma/n} + f_n(s)}$$

Neutron probability: $$P(n \mid s) = \frac{f_n(s)}{f_\gamma(s) R_{\gamma/n} + f_n(s)}$$

Comparison With Decision Boundary



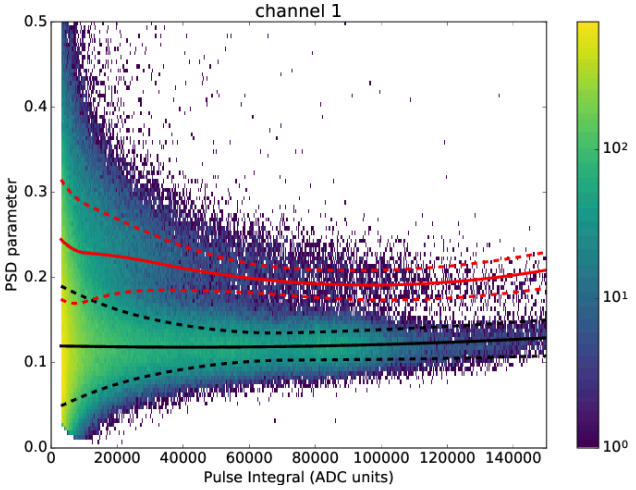
Step 1:

$$N_\gamma = \sum_{s \in E_i} P(\gamma \mid s)$$

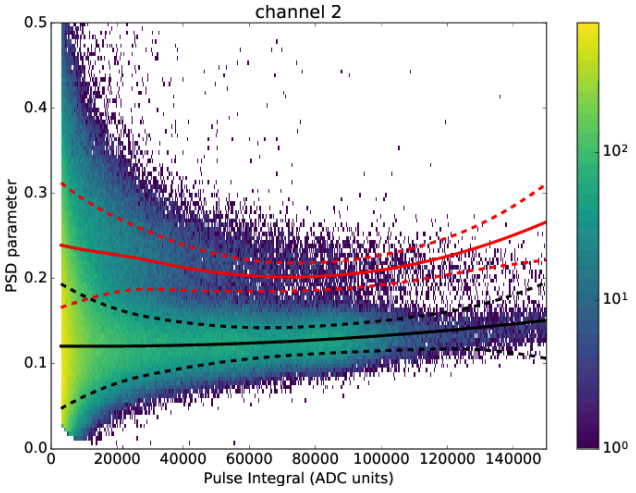
$$N_n = \sum_{s \in E_i} P(n \mid s)$$

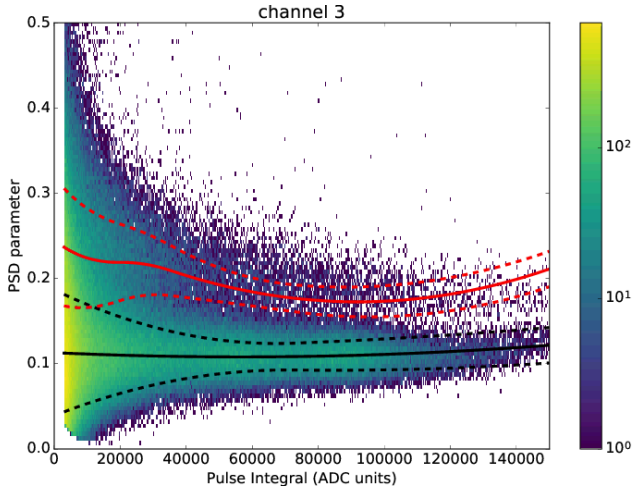
Step 2: $R_{\gamma/n} = \frac{N_\gamma}{N_n}$

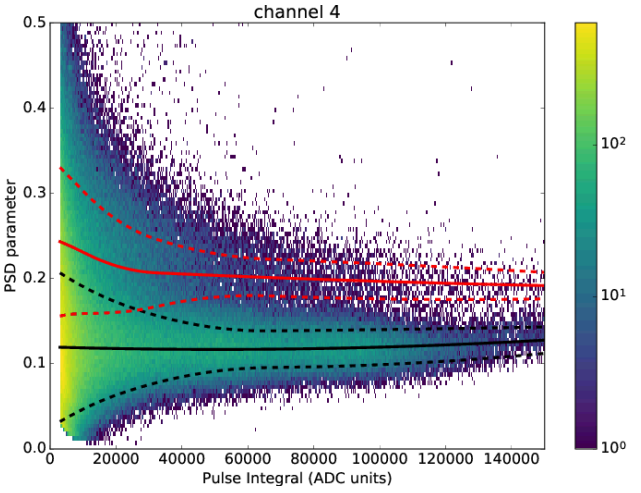
Multiple Readouts



$$\hat{P}_n(E) = \frac{\prod_{p=0}^{4} \mathcal{L}_{n,p}(E_p)}{\prod_{p=0}^{4} \mathcal{L}_{n,p}(E_p) + \prod_{p=0}^{4} R_p(E_p)\mathcal{L}_{\gamma,p}(E_p) + \mathcal{L}_O},$$







Quantification

- **Problem:** Lack of neutron pure source.
- Solution: Time-of-flight

Fig. 1. Setup of the two detectors with Am–Be source in position.

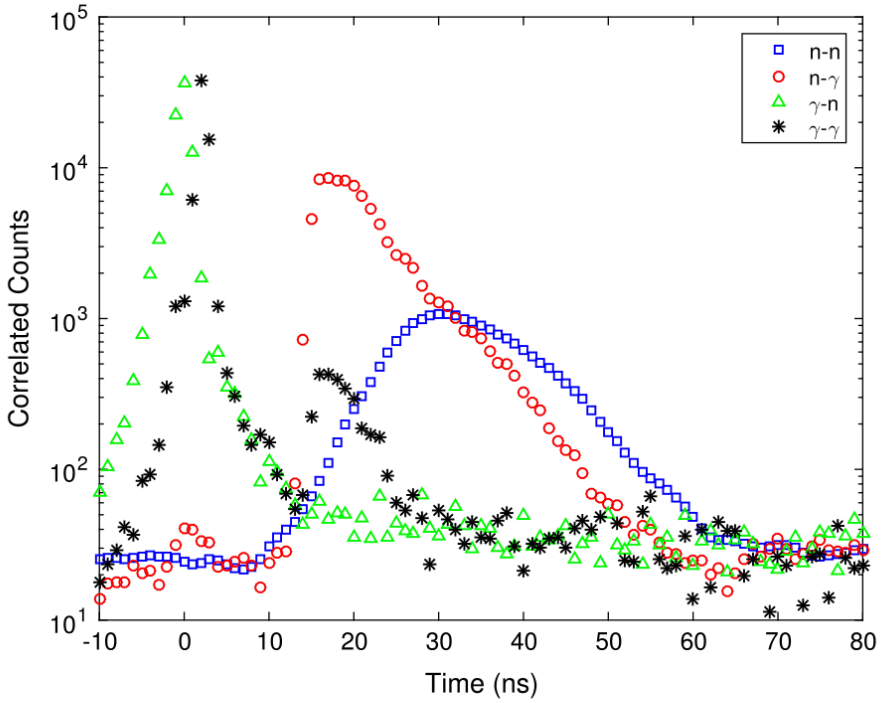


Fig. 3. Timing distribution of correlated counts between two liquid scintillator detectors using and Am–Be source. The minimum correlation probability threshold was 99% to minimize appearance of misclassified correlations.

Neutron/Gamma Recovery

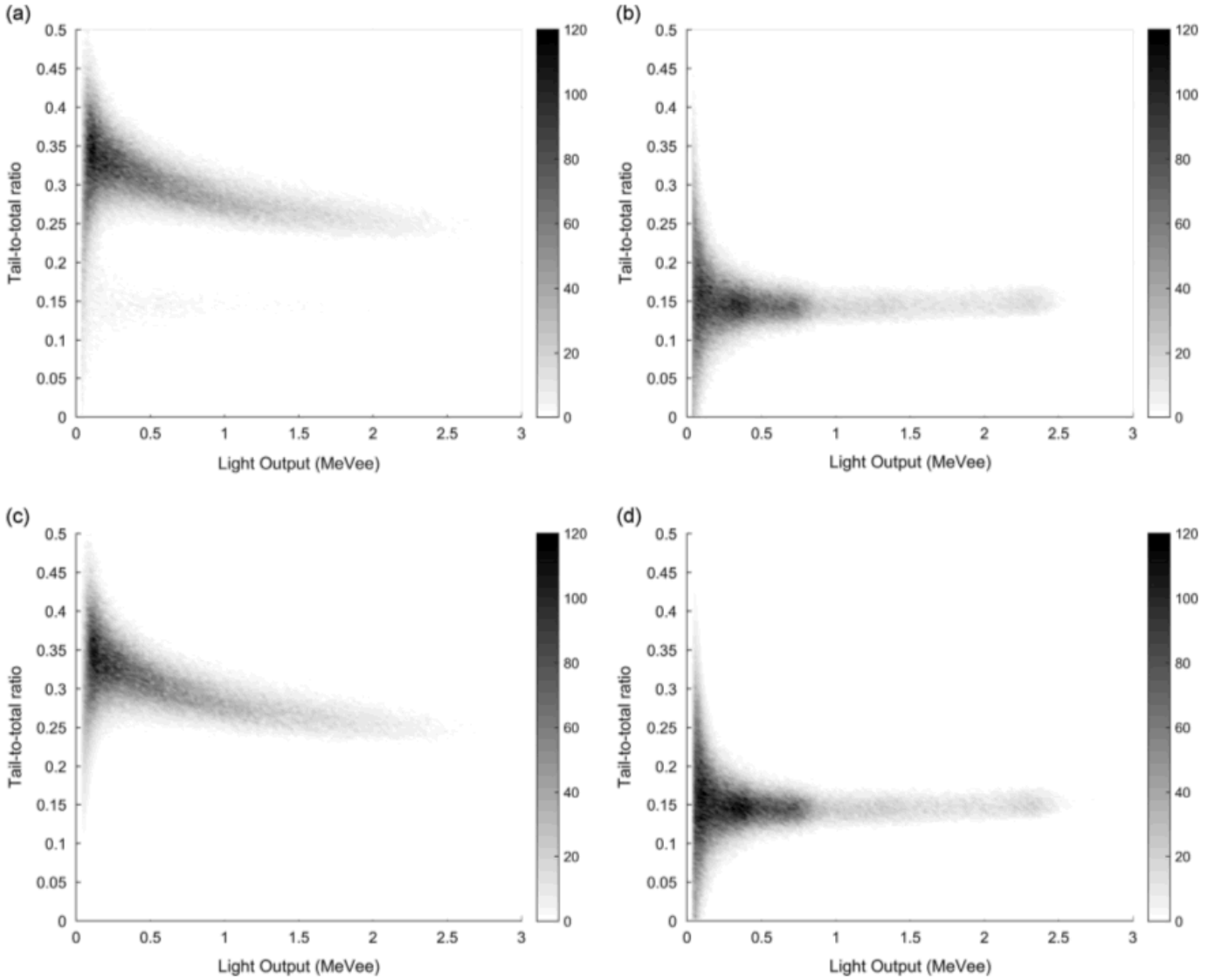


Fig. 5. The distribution of time-tagged neutrons and ^{232}Th photons before and after mixing in a 1:1 ratio. (a) Neutrons before. (b) Photons before. (c) Neutrons after. (d) Photons after.

Neutron/Gamma Recovery

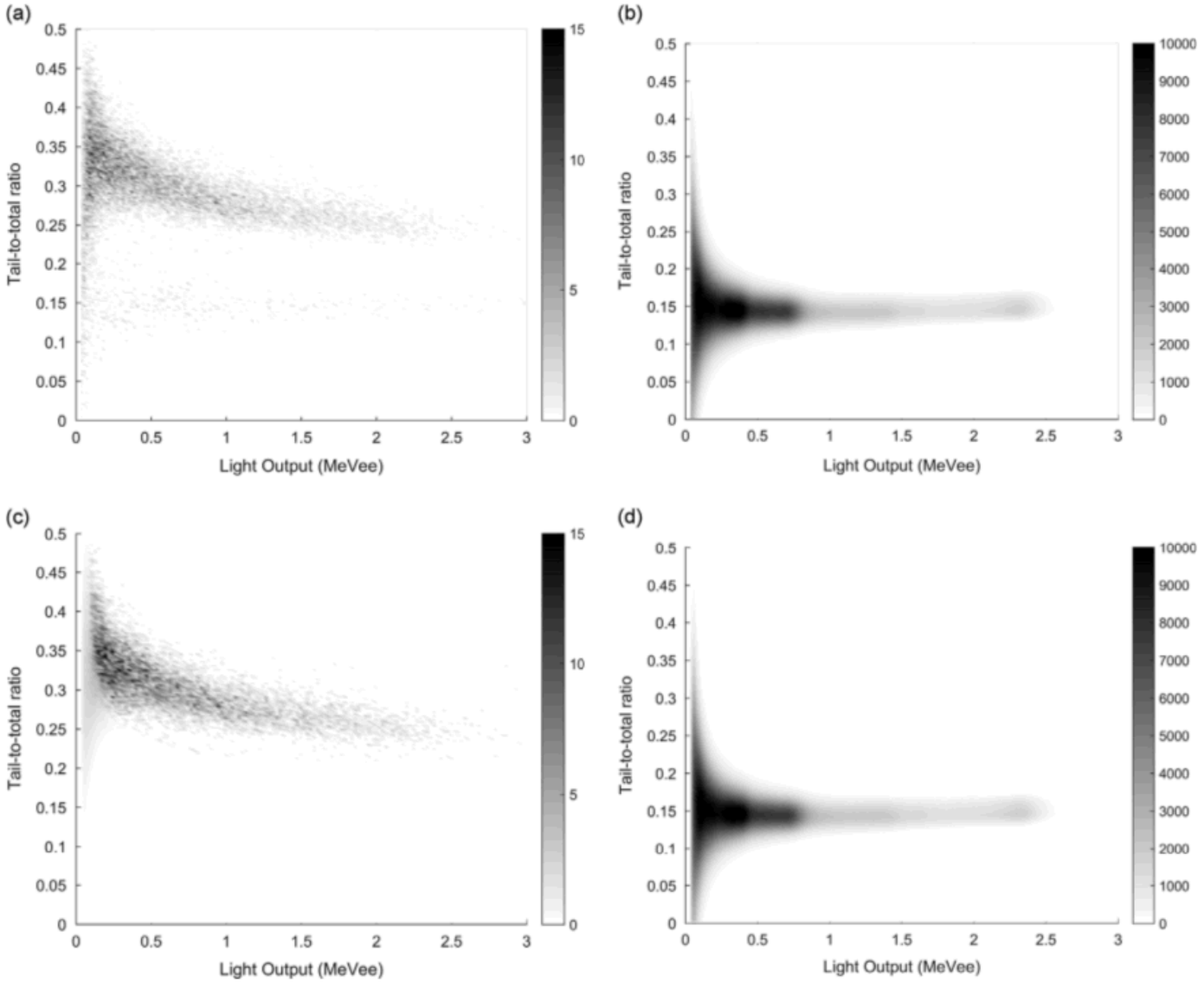


Fig. 6. The distribution of time-tagged neutrons and ^{232}Th photons before and after mixing in a 1000:1 ratio. (a) Neutrons before. (b) Photons before. (c) Neutrons after. (d) Photons after.