Monte Carlo Analysis of Multiplicity Measurements for the Characterization of Fissile Materials

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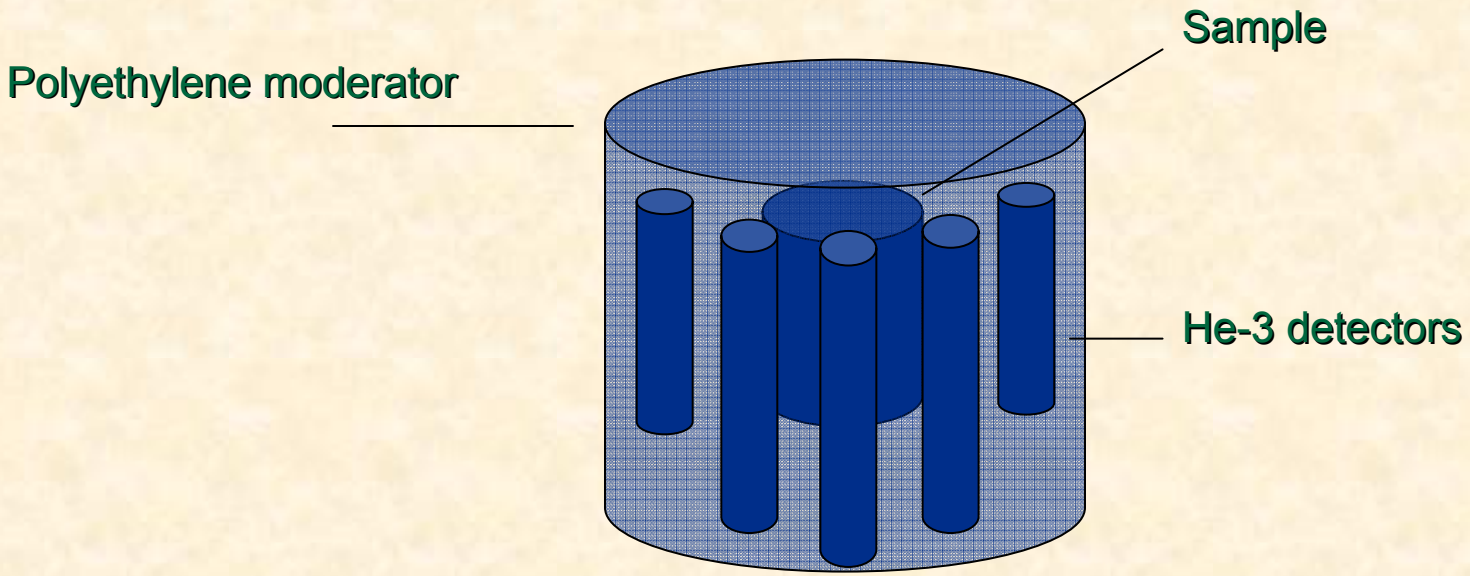
Outline

- Traditional Multiplicity Counters
- Use of Organic Scintillators for Multiplicity Counting
- Experimental Configuration and Results
- Monte Carlo Modeling
- Transport Equation Derivation
- Conclusions

Traditional Multiplicity Counters

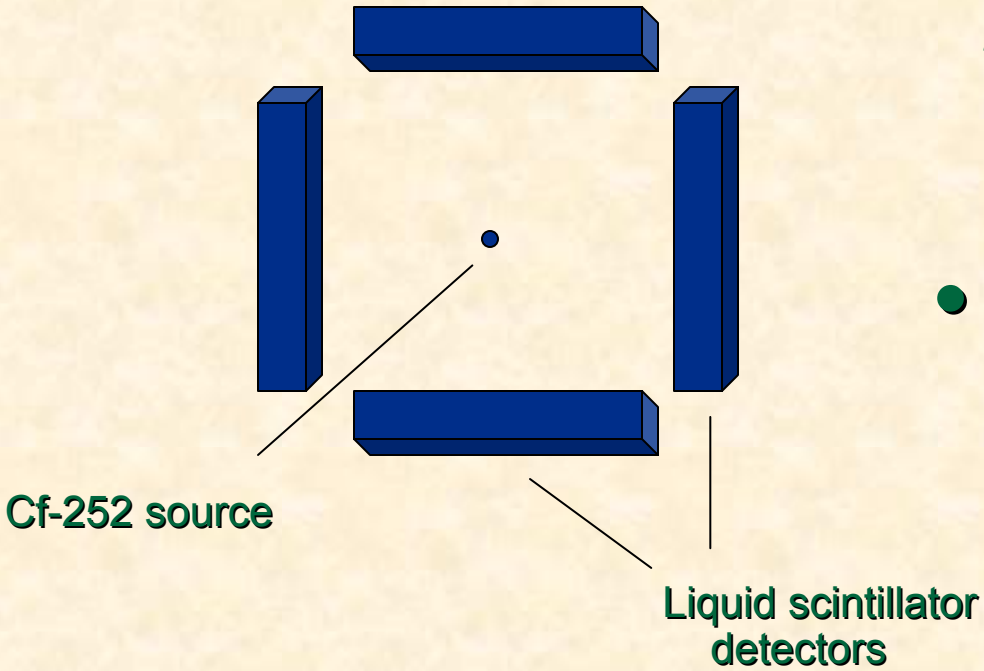
- Make use of He-3 detectors to detect neutrons
- Have a die-away time of ~60 microseconds



Use of Organic Scintillators for Multiplicity Counting

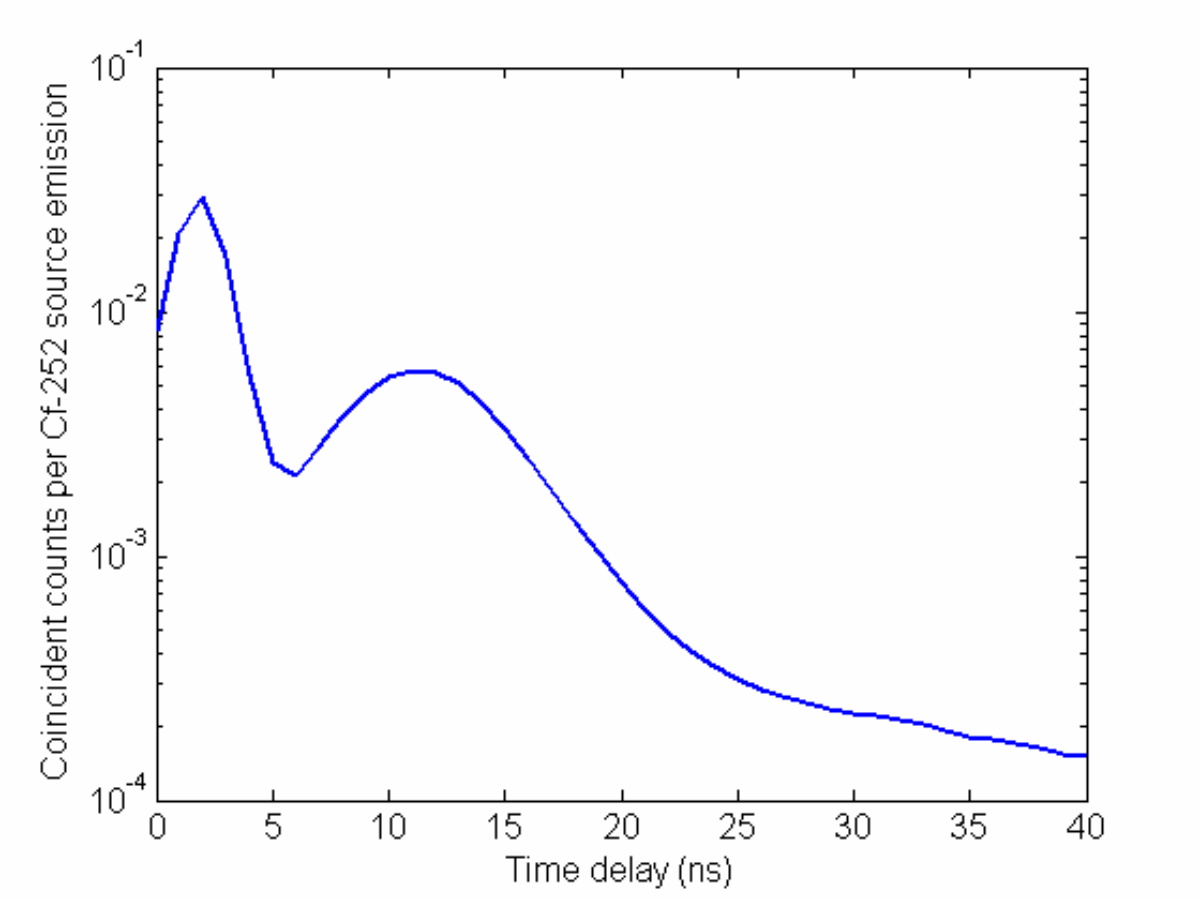
- Detect fast neutrons and gamma rays
- Have a die-away time of a few tens of ns
- Do not require bulky moderator

Experimental Configuration

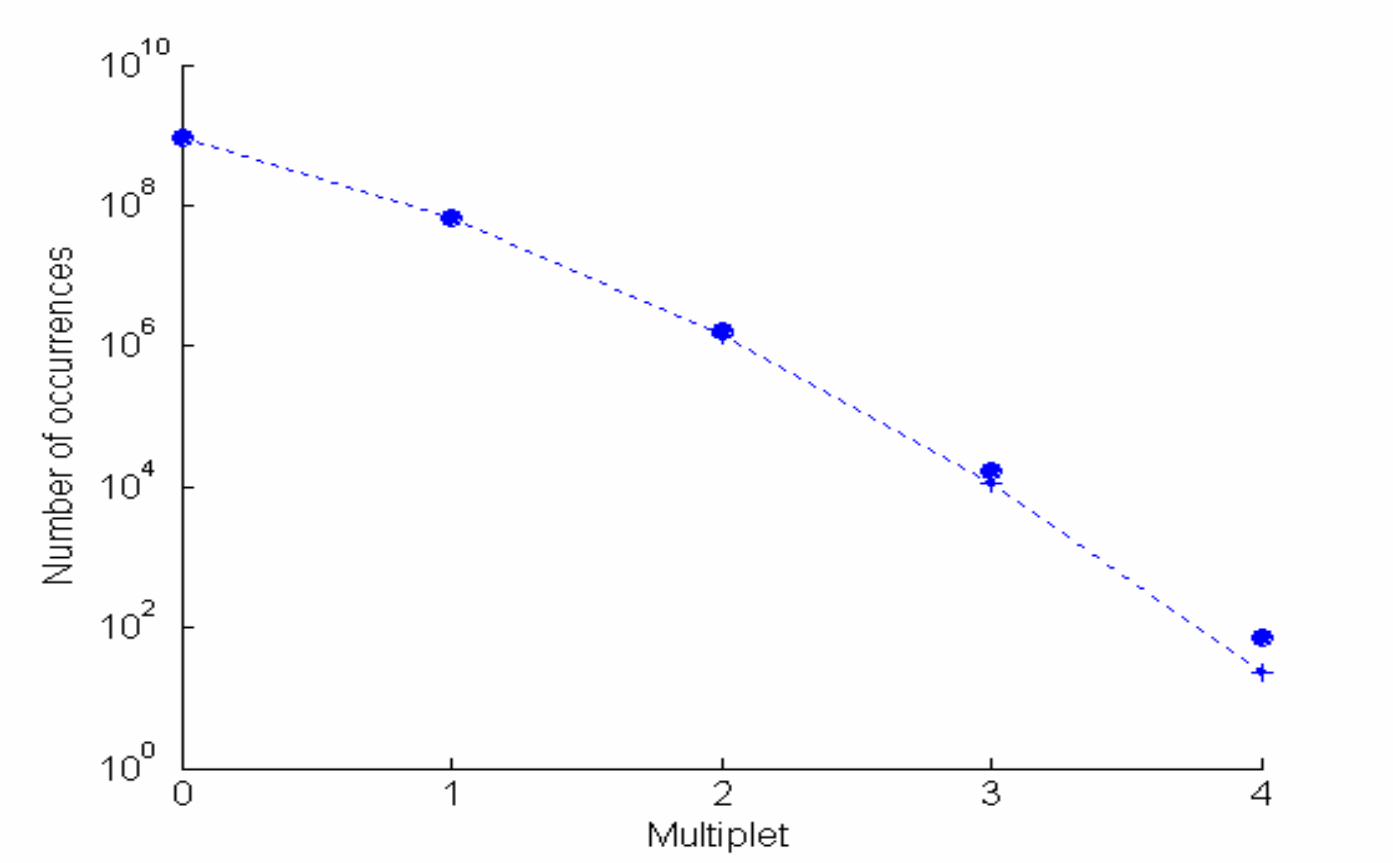


- 4 liquid scintillators 25 by 25 by 8 cm
- Cf-252 source placed at the center of the assembly

Results: source-detector correlation



Results: Multiplets



Monte Carlo Modeling

- MCNP-PoliMi for the simulation of the response of organic scintillators
- Post-processing code to calculate source triggered, detector triggered and random multiplets

Transport Equation Derivation

$$p(n,m) = p_f(n)p_\gamma(m)$$

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- Post-processing code to calculate source triggered, detector triggered and random multiplets

$$P(N,M,t+dt) = P(N-1,M,t)Sdt + P(N+1,M,t)\lambda_c(N+1)dt +$$
$$+P(N,M+1,t)\lambda_\gamma(M+1)dt + \sum_{n,m} P(N-n+1,M-m,t)\lambda_f(N-n+1)g(n,m)dt +$$
$$+[1-(S+N\lambda_c+\lambda_f+\lambda_\gamma)dt]P(N,M,t)$$

Transport Equation Derivation

Conservation of probability

$$P(N,M,t)$$

Can be expressed as the sum of the following terms

$$P(N-1,M,t)Sdt$$

$$\sum_{m,n} P(N-n+1,M-m,t)\lambda_f(N-n+1)g(n,m)dt$$

$$P(N+1,M,t)\lambda_c(N+1)dt$$

$$P(N,M+1,t)\lambda_\gamma(M+1)dt$$

$$\left[1-\left\{N(\lambda_c+\lambda_f)+M(\lambda_\gamma)\right\}\right]dtP(N,M,t)$$

Conclusions

- Organic scintillators for the measurement multiplicity: neutron and gamma ray
- We showed the results from some preliminary measurements and simulations
- We are developing a stochastic model to describe these processes