

MTV Student Virtual Research Symposium



Event-by-Event Correlations of Total Photon Energy and Neutron Multiplicity in Spontaneous Fission of $^{252}\text{Cf}(\text{sf})$

June 9, 2020

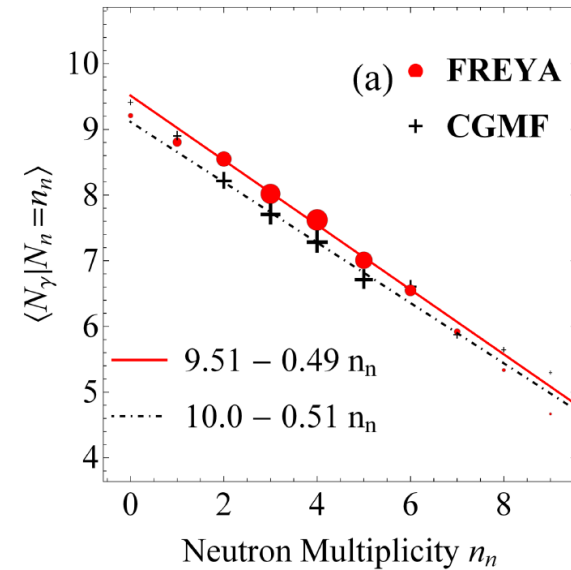
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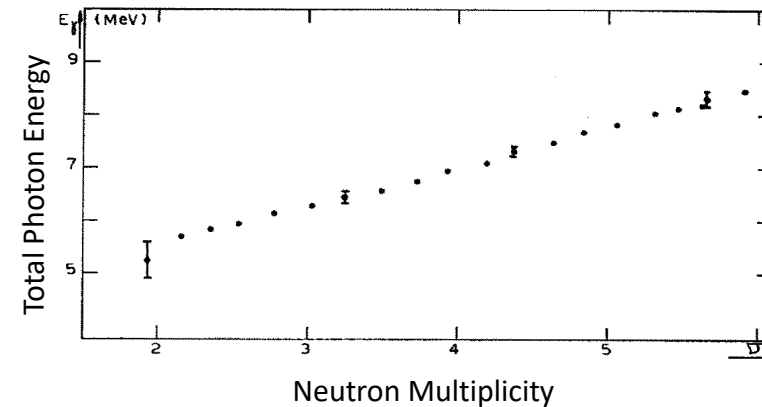


Introduction and Motivation

- Since its discovery in late 1930s, fission has advanced fields of science and engineering, but still has many mysteries
- Event-by-event Analysis
 - Focus on photon and neutron multiplicities
- Fragment Analysis
 - Focus on neutron multiplicities and photon energy
- This work combines the focuses and creates correlation between the two
 - Use the detected correlations to find emitted



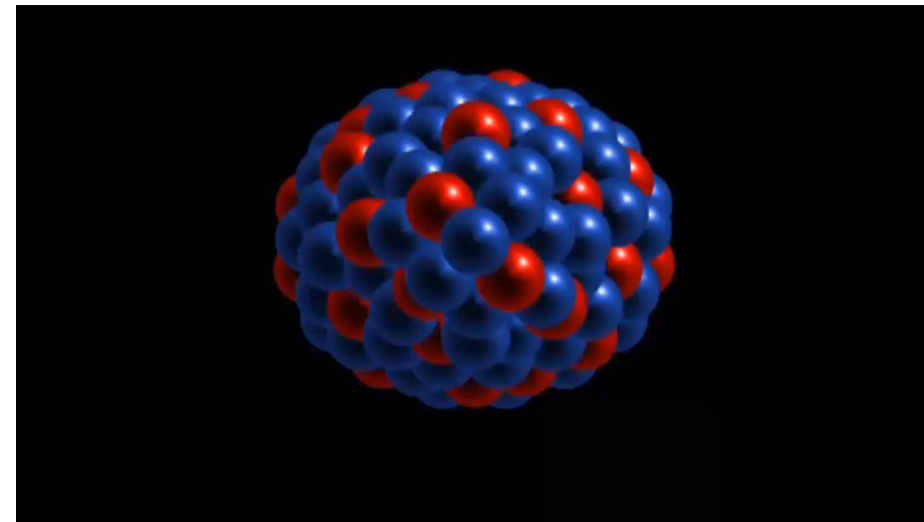
Marin, S., et al. "Event-by-event neutron–photon multiplicity correlations in $^{252}\text{Cf}(\text{sf})$ ", Nucl. Instrum. Methods Phys. Res. A 968 (2020) 163907



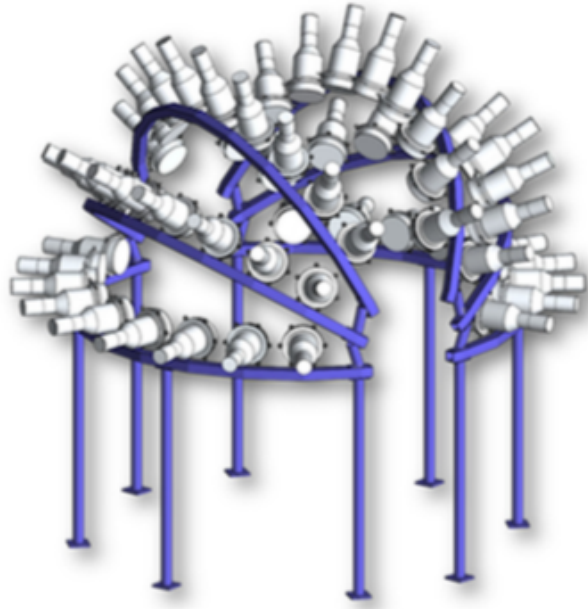
Nifenecker, H., et al. "Gamma-Neutron Competition in the De-Excitation Mechanism of the Fission Fragments of ^{252}Cf ." *Nuclear Physics A*, vol. 189, no. 2, 1972, 285–304.

Mission Relevance

- Fundamental science research is important for mission
- Advance nuclear nonproliferation capabilities
- Accuracy of nuclear data is a limiting factor for new technological developments

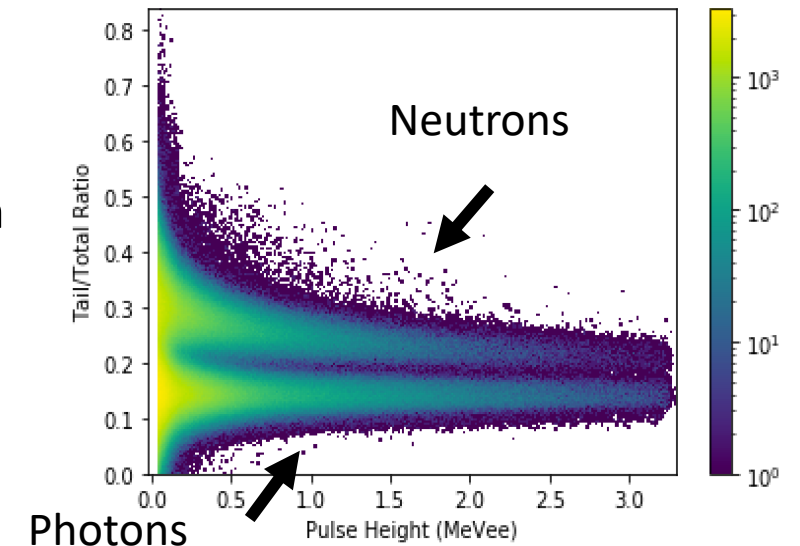


Technical Approach



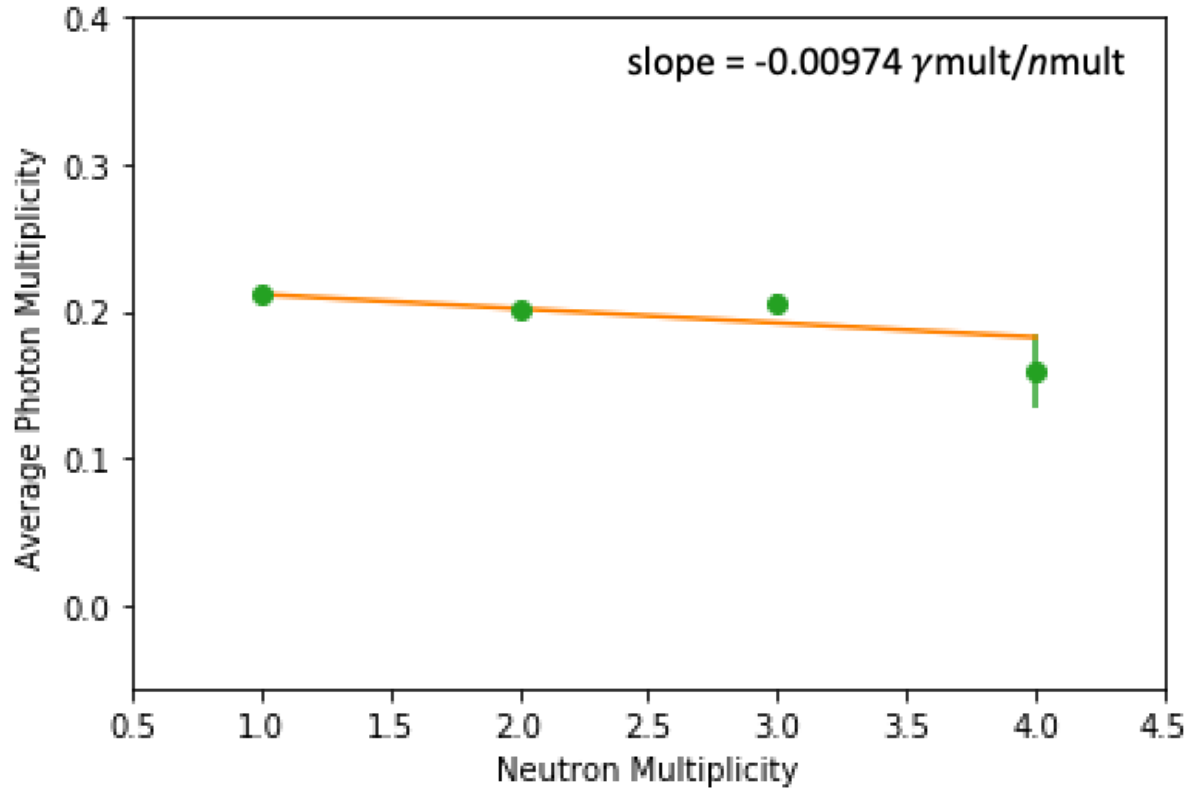
LANL Chi-Nu detector holder with 45 17.78 cm by 5.08 cm EJ-309 detectors. ORNL fission chamber placed inside the center hemisphere.

- Measure correlations between neutrons and photons emitted during the spontaneous fission of ^{252}Cf
- Flight path approximately 100 cm from detectors to chamber, 100 keVee threshold
- Organic scintillators simultaneously measure neutrons and photons
 - Pulse shape discrimination (PSD) used to discriminate neutrons and photons



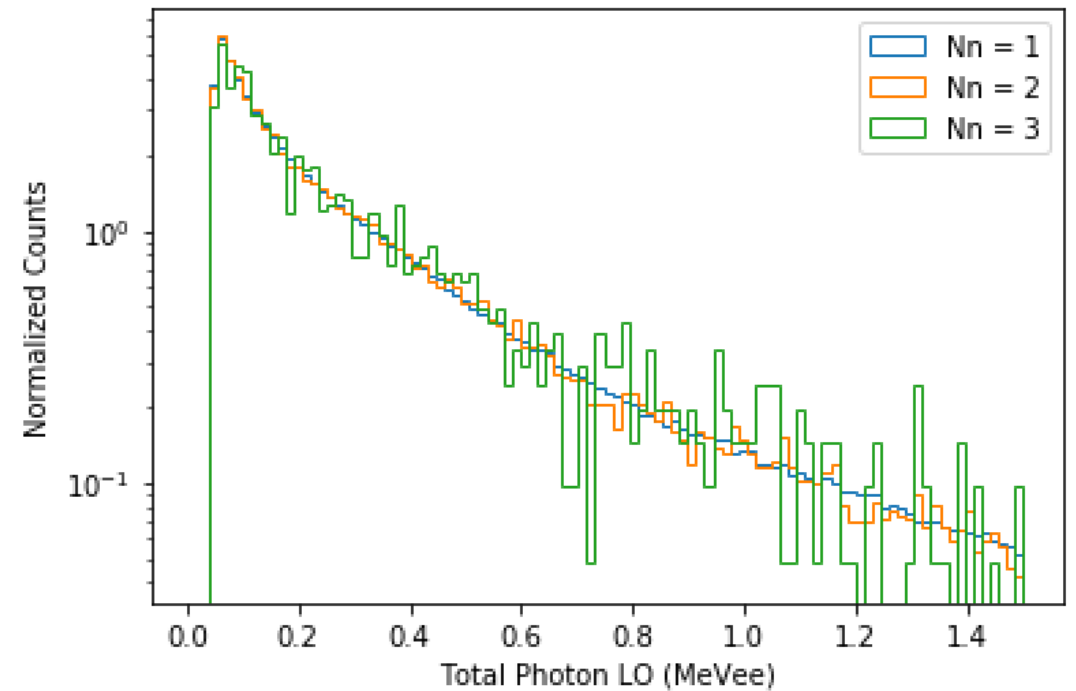
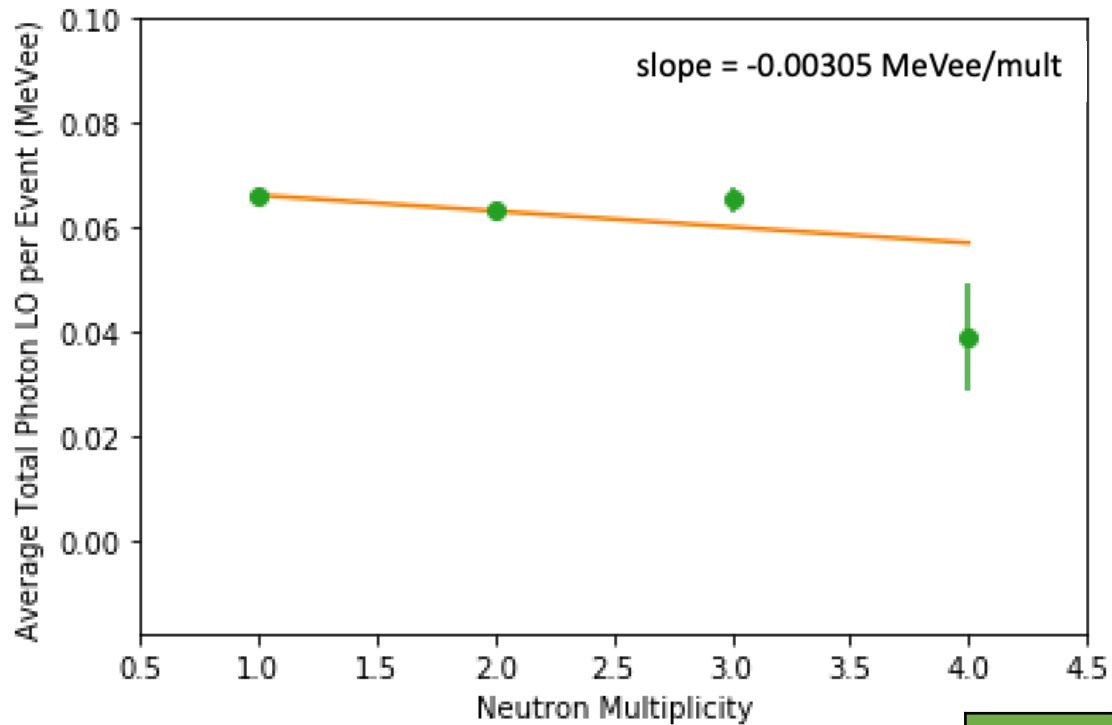
Marcath, M., et al., "Measured and simulated $^{252}\text{Cf}(\text{sf})$ prompt neutron-photon competition," Phys. Review C 97, 044622, 2018

Results



- Linear polynomial fit with counts as weights
- Standard error of mean
- Anticorrelation of photon and neutron emission, consistent with predicted with models

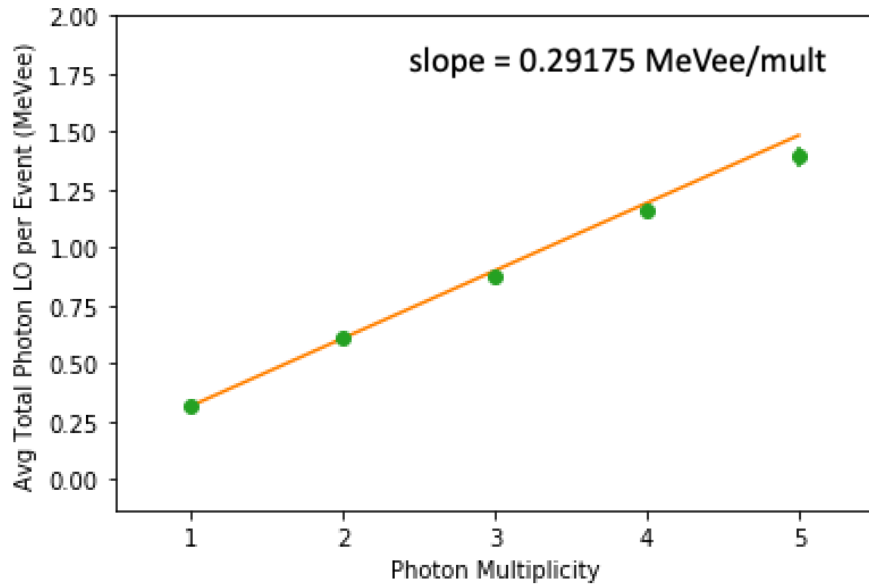
Neutron Mult.	Photon Mult.
1	0.2113 +/- 0.0002
2	0.2015 +/- 0.0003
3	0.2061 +/- 0.0010
4	0.1588 +/- 0.0255



- The average total photon light output per event for a given neutron multiplicity
- Linear polynomial fit with counts as weights
- Standard error of mean
- Slight decrease in slope

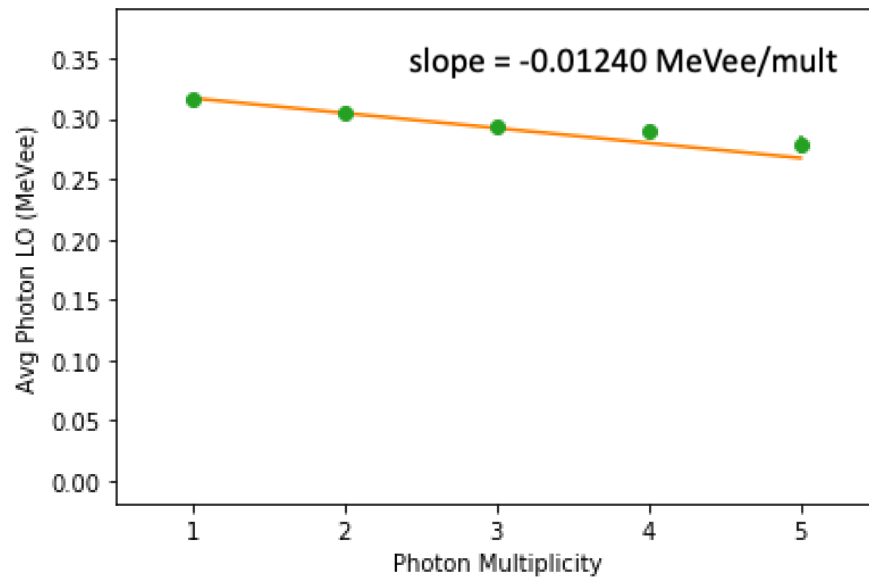
Neutron Mult.	Avg. Photon Total LO (MeVee)
1	0.0662 +/- 0.0001
2	0.0631 +/- 0.0005
3	0.0654 +/- 0.0026
4	0.0390 +/- 0.0103

- LO spectra for photons as function of neutron multiplicity



Photon Mult.	Avg. Total LO (MeVee)
1	0.3170 +/- 0.0002
2	0.6092 +/- 0.0007
3	0.8781 +/- 0.0035
4	1.1618 +/- 0.0104
5	1.3923 +/- 0.0416

- Average total photon light output per fission event as a function of photon multiplicity
- As photon multiplicity increases, total photon LO increases, as expected because more photons = larger sum of LO

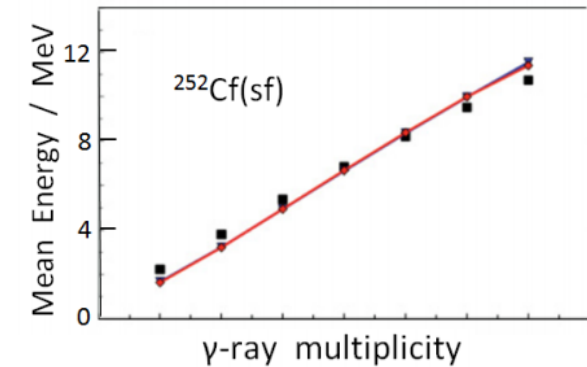
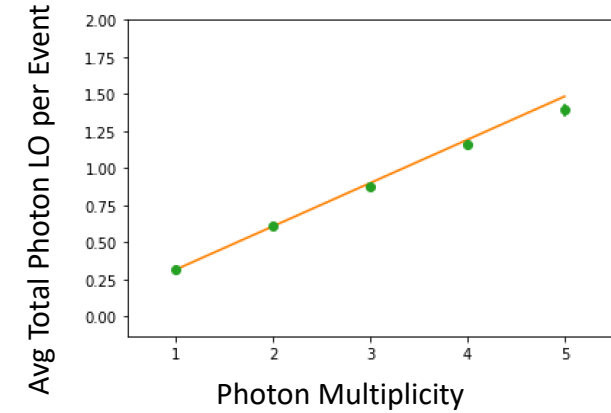


Photon Mult.	Avg. LO (MeVee)
1	0.3170 +/- 0.0002
2	0.3046 +/- 0.0003
3	0.2927 +/- 0.0008
4	0.2904 +/- 0.0026
5	0.2785 +/- 0.0083

- Average photon LO per photon in a single event as a function of photon multiplicity
- When an event has a certain photon multiplicity, value is the average LO that a single gamma in that event will have

Expected Impact

- Accomplish transition from event-by-event analysis to fragment analysis
- Better understanding of fundamental fission research
- Accuracy of nuclear data
- Use this work as basis for related neutron-photon emission



F. Gönnerwein, Neutron and Gamma Emission in Fission, University of Tübingen / Germany , 2014

MTV Impact

- Completed 1st year of PhD
 - MTV Funding
 - Opportunities to present/attend conferences and workshops
- Collaboration with national labs
 - LANL, ORNL

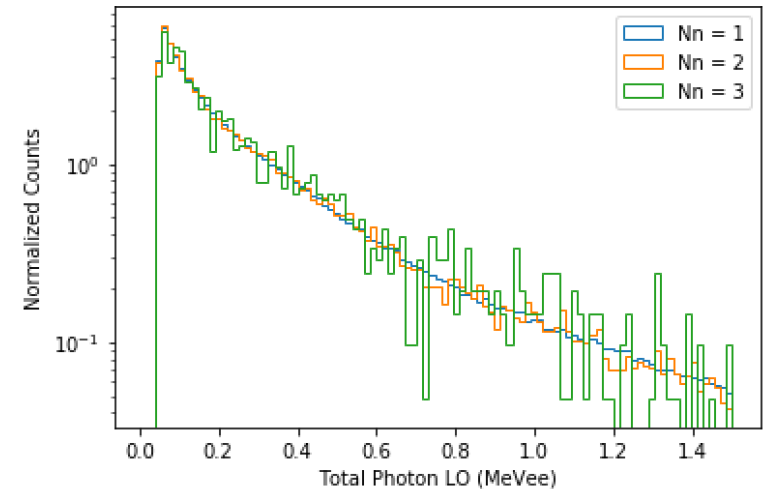
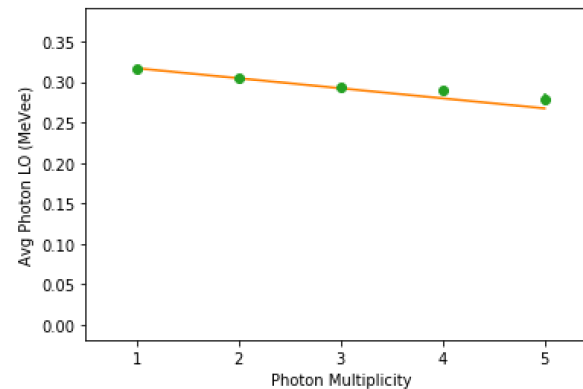
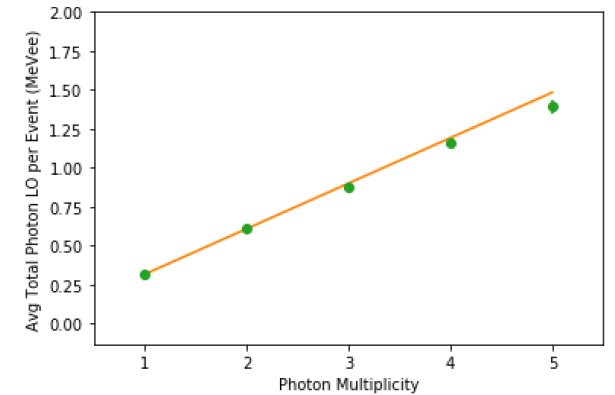
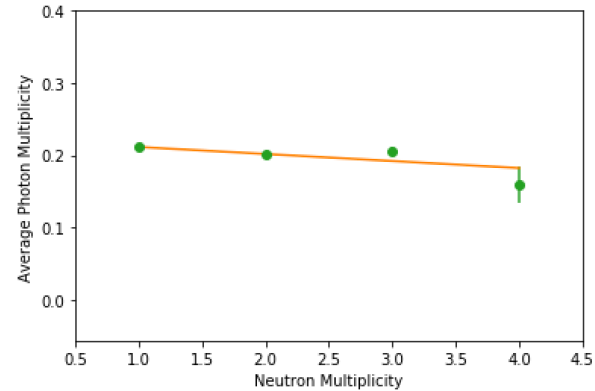


MTV 2020 Workshop



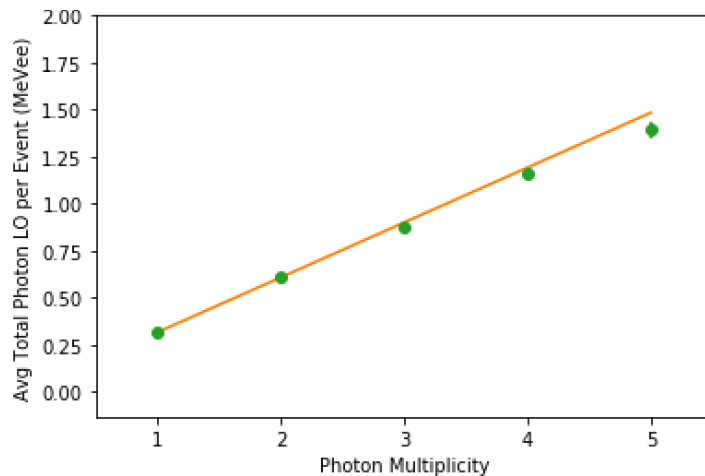
Conclusion

- Created correlations for event-by-event and fragment analysis
 - Anticorrelation
 - γ multiplicity and n multiplicity
 - γ energy vs n multiplicity
 - γ energy per γ vs γ multiplicity
 - Positive correlation
 - γ energy per event vs γ multiplicity
- LO spectra for n multiplicities of 1 and 2 almost indistinguishable

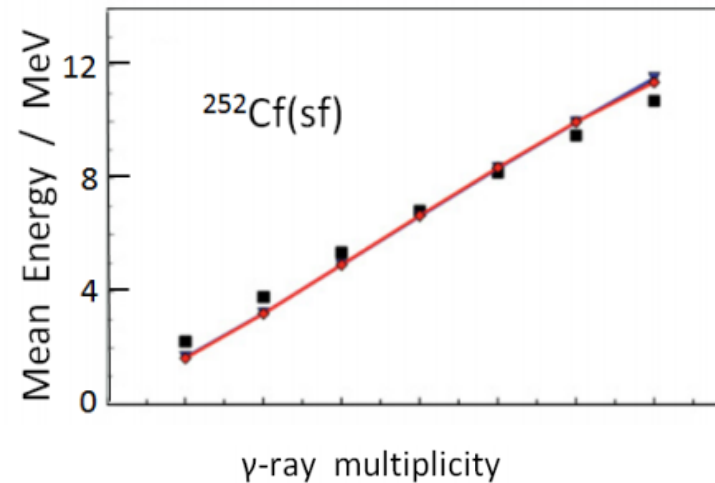


Next Steps

- Unfold results and determine correlated neutron-photon emission
- MCNP Simulation
- In progress publication



Detected



Emitted

F. Gönnerwein, Neutron and Gamma Emission in Fission, University of Tübingen / Germany, 2014

Acknowledgements



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Extras Slides

- Misclassification of photons as neutrons around 1% After background is subtracted in the time region from fission to 10 ns after the fission, only photon detections are expected and all neutron detections in that region were considered misclassified photons.



History	Type	Channel	Time	Energy
2	2	37	3.56827	0.360737
4	1	5	35.9547	0.924753
4	2	39	-0.93493	0.0893921
4	2	40	4.59548	0.168584
200	2	6	3.52879	0.474986
200	2	10	3.09888	0.576526

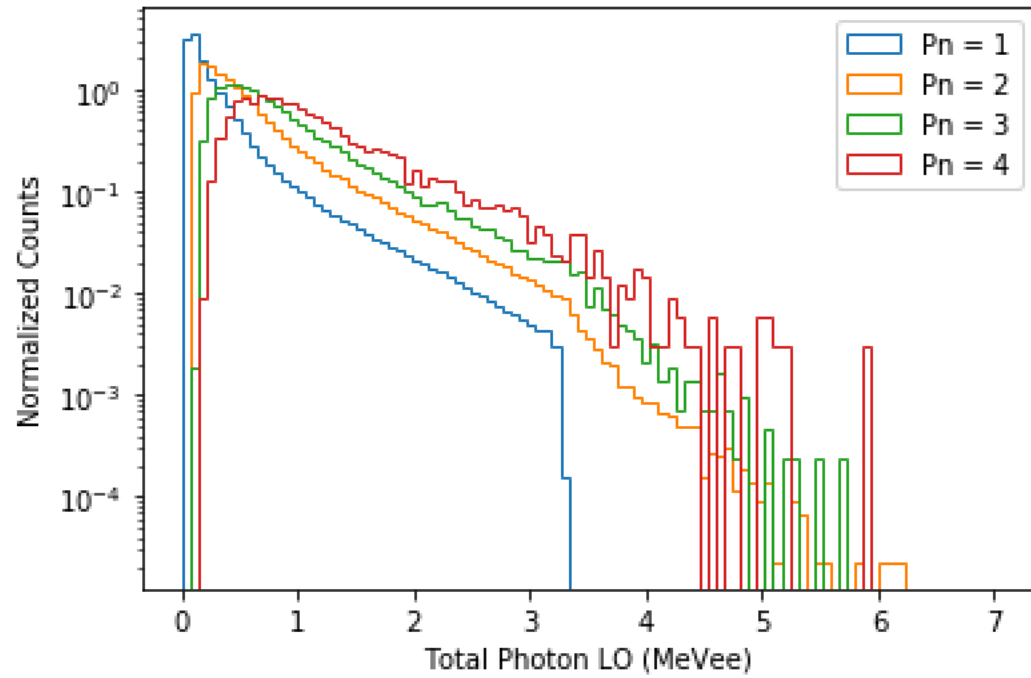
History = event
 Type: 1 = neutron
 2 = gamma
 Energy = Light Output
 in MeVee

- Looking at event 4, have 1 neutron and 2 photons
- Sum is ~0.258 MeVee, averaging 0.128 MeVee per photon

- Looking at event 200, also photon multiplicity 2
- Sum ~ 1.05 MeVee, averaging 0.526 MeVee per photon

Photon Multiplicity = 2		
Event	Total Photon LO per Event (MeVee)	Photon LO per Photon (MeVee)
4	0.258	0.128
200	1.05	0.526





- LO spectra for photons as function of photon multiplicity

