

# Total prompt $\gamma$ -ray emission in fission

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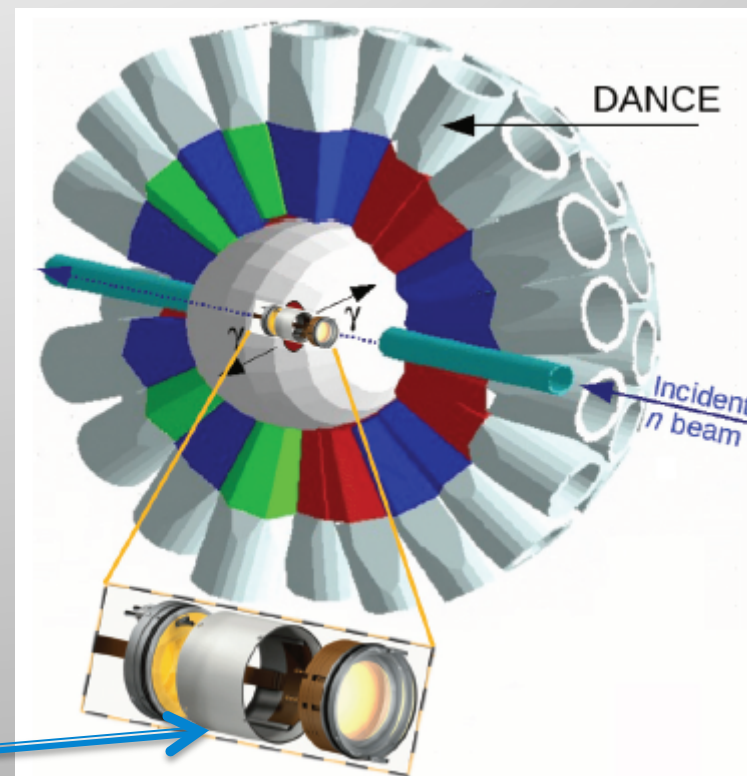
LLNL-PRES-701403

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# Experiments

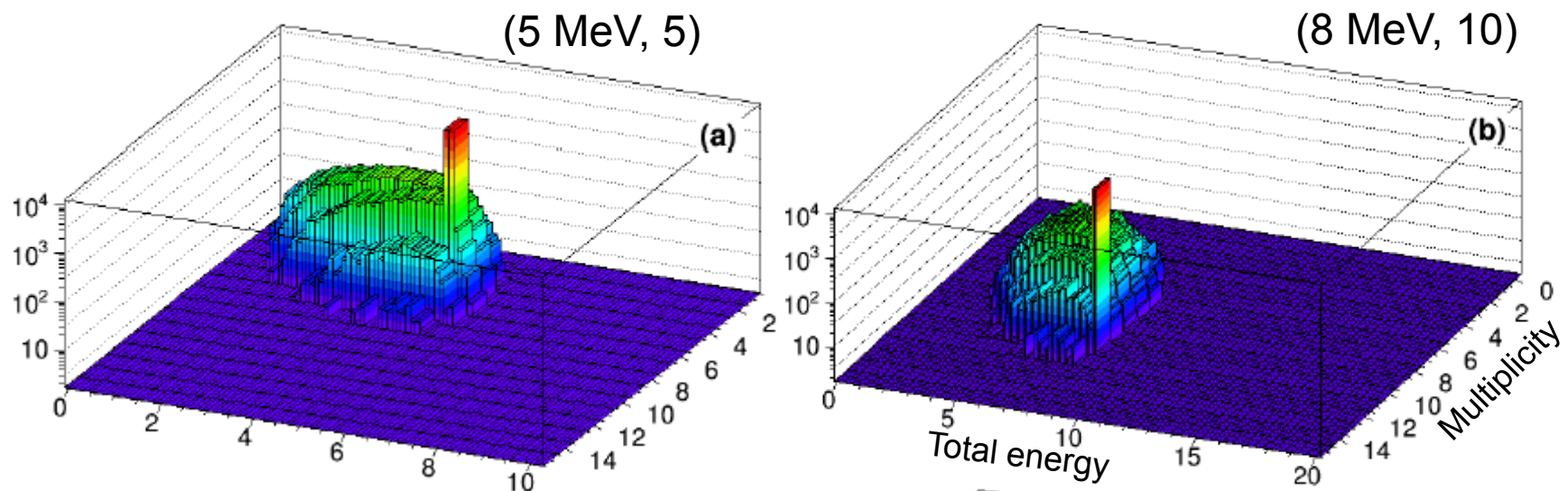
- Carried out at the Lujan Center of LANSCE using the DANCE array in conjunction with a parallel-plate avalanche counter (PPAC).
- Prompt  $\gamma$ 's detected by DANCE in coincident with the detection of fission fragments by PPAC for the neutron-induced fission of  $^{235}\text{U}$ ,  $^{239,241}\text{Pu}$  with  $E_n$  from thermal to  $\sim 100$  keV and the spontaneous fission of  $^{252}\text{Cf}$ .



*Wu et al., NIM Phys. Res. A 696, 78 (2012)*

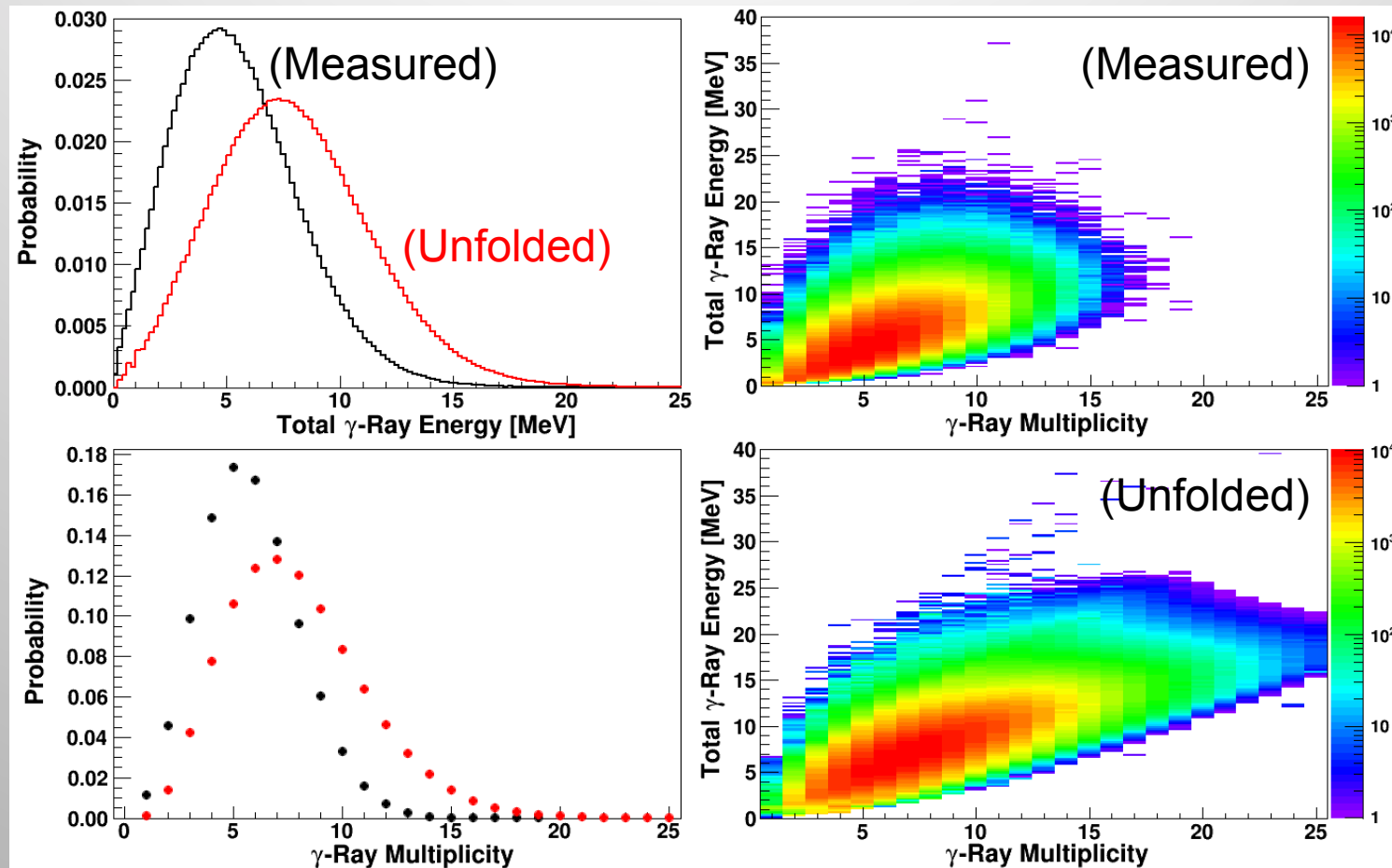
# Two-dimension unfolding: $E_{\text{tot}}$ vs $M$

- Only iterative Bayesian method available.
- Each grid point in the response matrix is a two-dimension matrix of the same dimension.
  - Simulated numerically using GEANT4.
  - Resulting  $\sim 3,300$  such matrices, out of 5,000 grids, for the response matrix.
  - A single factor varied for each matrix varied during the iteration.



# Two-dimension unfolding: $E_{\text{tot}}$ vs $M$

$^{239}\text{Pu}(n,f)$  [?]



A. Chyzh et al., PRC 90, 014602 (2014)



# Comparison of mean value of $E_{\alpha,tot}$

| Isotope           | 2-D  | Ref. 1 | ENDF/B-VII.1 | Ref. 2   | Refs. 3, 4, 5 |
|-------------------|------|--------|--------------|----------|---------------|
| $^{235}\text{U}$  | 8.35 |        | 6.60         | 6.53(20) | 6.92(9)       |
| $^{239}\text{Pu}$ | 7.94 | 7.46   | 6.74         | 6.78(10) |               |
| $^{241}\text{Pu}$ | 8.01 |        | 7.26         |          | 6.41(6)       |
| $^{252}\text{Cf}$ | 8.52 |        |              | 6.95(30) | 6.64(8)       |

- $E_{\alpha,tot}$ 's are consistently ~ 20% higher than all previous and the most recent measured values, derived from  $E_{\alpha,tot} = E_{\alpha} + M_{\alpha}$ .
- It agrees within 6% of that from an independent analysis of the same DANCE data for  $^{239}\text{Pu}$ , carried out by Ullmann et al. [1] assuming a very general parameterized correlation between  $E_{\alpha}$  and  $M_{\alpha}$ .
- This raises serious concern on the derivation of  $E_{\alpha,tot}$  without the consideration of the correlation between  $E_{\alpha}$  and  $M_{\alpha}$ .

# Summary

- Systematics of the prompt  $\gamma$  emission for the neutron-induced fission of  $^{235}\text{U}$ ,  $^{239,241}\text{Pu}$ , and the spontaneous fission of  $^{252}\text{Cf}$  has been studied using DANCE.
- The prompt  $E_{\gamma,\text{tot}}$  vs  $M_{\gamma}$  was derived and unfolded to determine the physical spectrum.
- The  $E_{\gamma,\text{tot}}$  and  $M_{\gamma}$  distributions, projected from the 2-D spectrum, were measured for the first time and the  $\langle E_{\gamma,\text{tot}} \rangle$  is about 20% higher than previous and recent measured values using a single  $\gamma$ -ray detector for all fissile nuclei studied.
  - It could account for a significant fraction of 28% that is the underestimated  $\gamma$  heating from existing data.