# A 4π array for the inelastic scattering study

Workshop for applied nuclear data activities

January 24, 2019

Ching-Yen Wu

Lawrence Livermore National Laboratory

LLNL-PRES-766456

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

# Neutron inelastic scattering on actinides

- **Proposed approach**
  - Highly segmented $4\pi$ $\gamma$-ray calorimeter with capability of neutron detection
  - Dual Mode scintillator: $Tl_2{}^6LiYCl_6$ ($\geq$ 95% $^6Li$, 75.8% $^{35}Cl$, $\rho$ = 4.5 g/cm$^2$)
    - $\gamma$-ray energy resolution better than 4% and the efficiency better than NaI
    - Neutron energy resolution better than 10% and the efficiency $>$ 80% for thermal neutrons
  - Closed pack structure possible because both $\gamma$ and neutron energies are measured directly
- **Existing $4\pi$ $\gamma$-ray arrays**
  - DANCE at LANL
    - Excellent $\gamma$-ray calorimeter with low sensitivity to neutrons
    - A total of 162 $BaF_2$ crystals with four different shapes, a regular hexagon (12), three irregular pentagons (60 + 60 + 30)
    - Efficiency ~ 84 – 88% and peak-to-total ~ 55% remain nearly constant for the $\gamma$ energy between 150 keV and 10 MeV
  - Gammapshere
    - A highly segmented $\gamma$ array of high energy resolution
    - A total of 122 locations with four different shapes, a regular pentagon (12), three irregular hexagons (60 + 30 + 20)

# Characterization of TLYC scintillator and initial exploration of 4π array

- **Current status and future plan**
  - A 1” x 1” crystal was ordered in FY19 for measuring
    - γ response with standard γ calibration sources
    - Timing, γ-neutron separation, pulse shape … with a $^{252}$Cf fission PPAC in LLNL
    - Simulations on the γ response using GEANT4 and the neutron response by MCNP
    - Optimization achieved by comparing to measurements
  - A shaped crystal of 3” x 3” will be ordered in FY20
    - Neutron response using a monoenergetic neutron source at Ohio University
  - Simulations on a 4π array
    - Total efficiency and the peak-to-total ratio for γ as a function of energy
    - Total efficiency and the multiple scattering for neutron as a function of energy
  - A new design of fission PPAC to minimize the complicated background originated from various foils and improve the separation between fission and α