



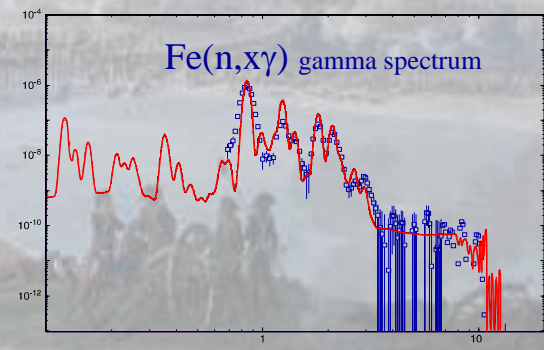
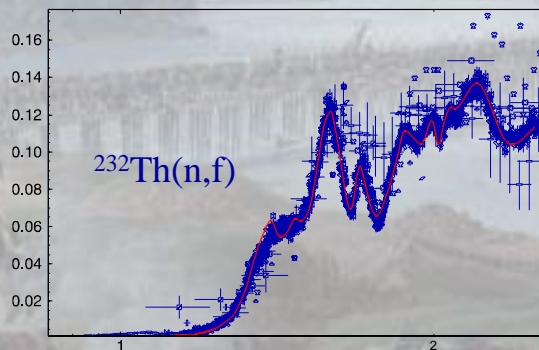
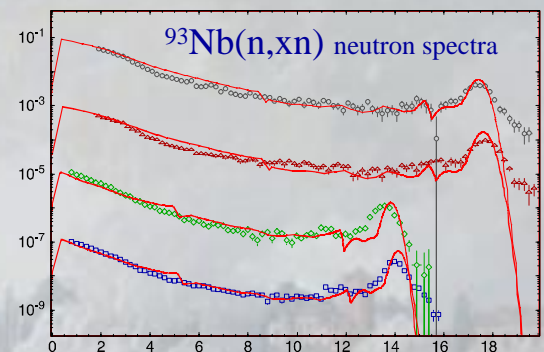
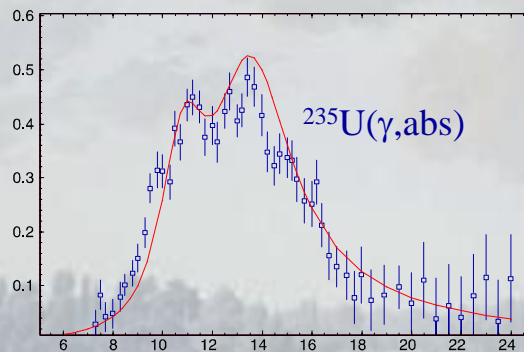
# EMPIRE-2.19 (Lodi\*)

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Easy to use software package for comprehensive modeling of nuclear reactions using various theoretical formalisms. Consists of a number of FORTRAN codes, input parameter libraries, and experimental data library (EXFOR/CSISRS) operated through the Graphic User Interface (GUI).

## New features in 2.19

- Multi-modal fission with multi-hump barriers
- Photonuclear reactions
- Reactions on excited targets
- Exact treatment of exclusive spectra
- Improved algorithm for recoil spectra
- Suite of gamma-ray strength functions from RIPL-2
- Exciton model with cluster emission (Iwamoto-Harada)



\* It was at the battle for the bridge of Lodi (May 10, 1796) that Napoleon Bonaparte proved himself to his men and won the nickname 'The Little Corporal'

# Nuclear Reaction Code EMPIRE-2.19 (Lodi)

## Availability

Version 2.19 planned for release by the NNDC by the end of 2004.

Version 2.18 available from:

- [www.nndc.bnl.gov/empire](http://www.nndc.bnl.gov/empire)
  - [www.nds.iaea.org/empire](http://www.nds.iaea.org/empire)
- EMPIRE-2.18 on CD-ROM:
- [www.nds.iaea.org/cd-catalog.html](http://www.nds.iaea.org/cd-catalog.html)

## Features

- Broad range of energies (from above the resonance region up to a few hundreds of MeV)
- Projectile: nucleons, nuclei (HI), and **photons\***
- **Reactions on excited targets**
- **Exact treatment of exclusive spectra**
- **Improved algorithm for recoils**
- ENDF-6 formatting
- **Automatic MySQL retrieval of experimental data from the updated EXFOR library**
- Automatic plotting of experimental and calculated excitation functions, angular distributions and double differential cross sections
- GUI assisted interactive comparison plots; overlying different calculations/evaluations (**photon production included**)
- Easy operation through **Graphic User Interface (GUI)**

## Reaction mechanisms

- Spherical Optical Model
- Coupled Channels (CC) and DWBA
- Simplified CC for HI fusion
- **Multi-hump and multi-modal fission formalism**
- TUL Multistep Direct
- NVWY Multistep Compound with gamma emission
- Second-chance preequilibrium emission
- Exciton Model
- **Iwamoto-Harada for preequilibrium cluster emission**
- Monte Carlo preequilibrium
- HRTW for widths fluctuations
- Hauser-Feshbach model with full gamma-cascade and dynamical deformation effects



## Parameters

- nuclear masses (Nix-Moller and Audi95)
- ground state deformations (Nix-Moller)
- optical model parameters (RIPL-2)
- discrete levels and decay schemes (RIPL-2)
- level densities (including HF-BCS from RIPL-2)
- fission barriers (**RIPL-2**, BARFIT)
- moments of inertia (MOMFIT)
- gamma-ray strength functions (**RIPL-2**)

## Outputs

- Total, elastic and reaction cross sections
- Cumulative residue production cross sections
- Multi-chance, **multi-modal** fission cross sections
- Elastic and inelastic angular distributions
- Double-differential cross sections for inelastic scattering
- Particle and gamma-spectra
- Cross sections for discrete gamma transitions
- Population of discrete levels (isomeric ratios)
- Recoil spectra (**emission and excitation energy correlations taken into account**)

## Incorporated codes

- **ECIS-03** coupled channels by J. Raynal
- **SCAT2** spherical optical model by O. Bersillon
- **CCFUS** simplified coupled channels calculation of HI fusion cross section by C.H. Dasso and S. Landowne
- **ORION+TRISTAN** TUL approach to Multistep Direct by H. Lense
- **DDHMS** Monte Carlo preequilibrium by M. Chadwick
- **DEGAS** exciton model by E. Betak and P. Oblozinsky
- **BARMOM** fission barriers and moments of inertia by A. Sierk

\*) red indicates new or modified features in 2.19