Overview of SAMMY

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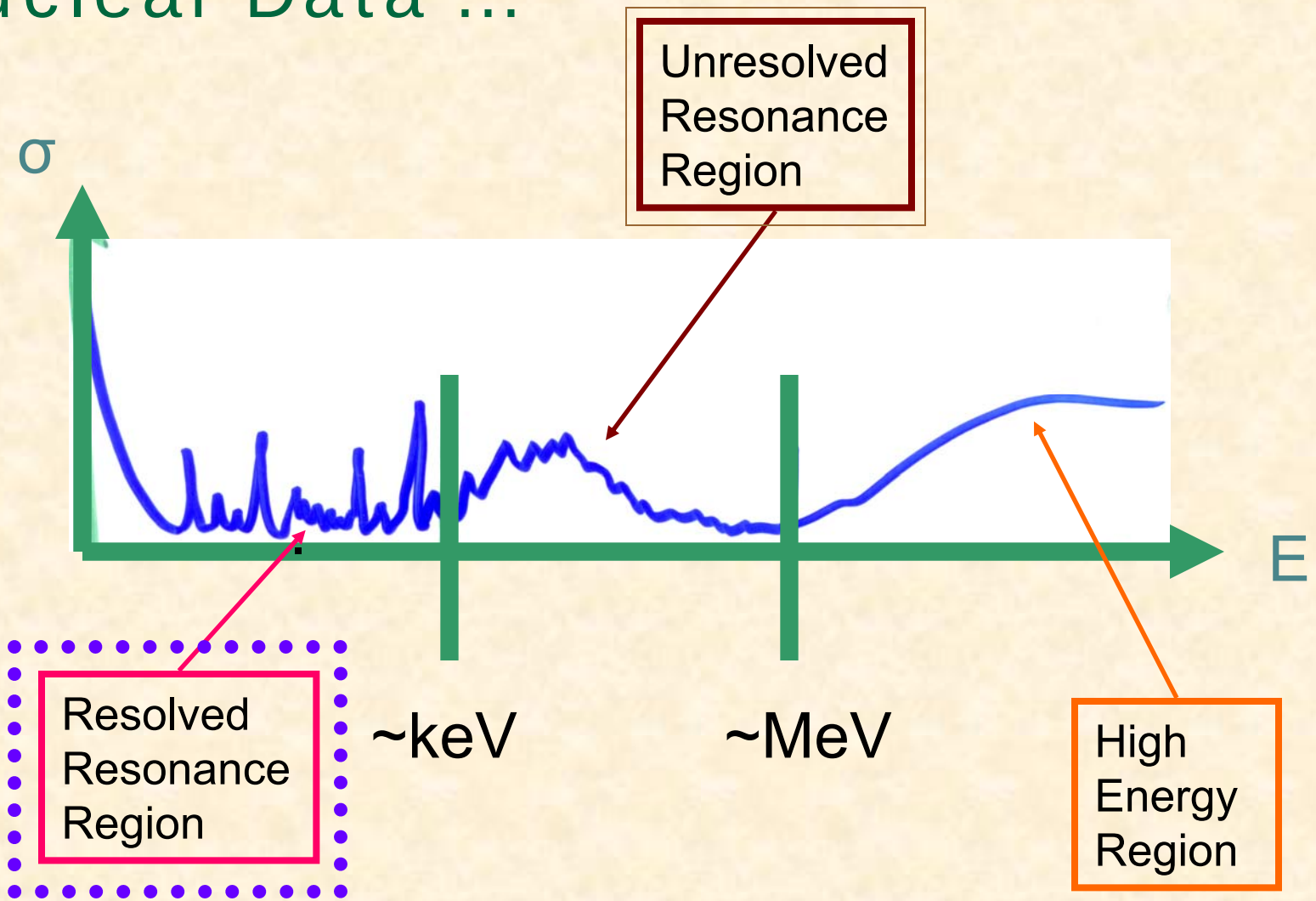
Nuclear Data ...



Description of the problem to be solved

- What do we have?
  - Raw data as counts per time-channel
  - Many thousands of pairs of numbers
- What do we want?
  - Cross sections as a function of energy
  - Parameterized in terms of resonance energies, widths, and quantum numbers

How do we accomplish this?

- Perform the experiment
- Reduce the data
  - (counts => cross section, time-of-flight => energy)
- Generate covariance matrix for data
- Estimate prior values for parameters
- Estimate prior covariance matrix for parameters
- Analyze the data using multilevel multi-channel R-matrix code (e.g. SAMMY)

In these notes we concentrate on the analysis, but will also talk about the other steps.

SAMMY Overview

- Purpose: analyze time-of-flight cross-section data in the resonance region
  - resolved
  - unresolved
- (Other codes are used to analyze experimental data in high-energy region)

SAMMY Overview, continued:

I. Physics for Resolved-Resonance Region

- *Incident particles:* neutron, proton, alpha, ...
- *Target:* one type of nuclide, or many (multiple isotopes, chemical compounds, contaminants)
- *Types of data:*
  - total, elastic, capture, fission, inelastic, other reactions
    - Coulomb or not
  - angular distributions for elastic cross sections
  - certain types of integral data

I. Physics for Resolved-Resonance Region, continued

- *Theoretical cross sections:* Reich-Moore approximation to multilevel multichannel R-matrix theory
- *Corrections for experimental effects:*
  - Four versions of Doppler broadening
  - six types of resolution broadening
  - self-shielding and multiple scattering
  - several types of normalization & broadening
  - etc.
- *Fitting procedure:* Bayes' method

SAMMY Overview, continued:

II. Pre- & Post- Processors (RRR)

- ***Prepare input "from scratch":***
  1. Determine appropriate quantum numbers using SAMQUA
     - Written by O. Bouland, R. Babut, and N.M. Larson
  2. Estimate resonance parameter values (energies and widths) from experimental data via code RSAP
     - Written by R. O. Sayer
  3. Use program SUGGEL to suggest appropriate quantum numbers for a resonance
     - Written by S. Y. Oh and L.C. Leal
- ***Start from existing resonance parameters:***
  1. Use values from Evaluated Nuclear Data Files
     - SAMMY reads ENDF File 2 format

II. Pre- & Post- Processors (RRR) continued

- ***ENDF Format:*** report results in ENDF File-2,3,32,33 formats
- ***Statistics:*** statistical properties for resonance parameters
- ***Averaging:*** two methods to calculate multigroup cross sections (including associated covariances)
- ***Astrophysics:*** stellar averages as a function of temperature

SAMMY Overview, continued:

III. Physics for Unresolved-Resonance Region

SAMMY's treatment is based on Fritz Froehner's FITACS code

- *Incident particles:* neutron
- *Target:* one type of nuclide
- *Types of data:* total, capture, fission, inelastic
- *Theoretical cross sections:* Hauser-Feshbach for total, Moldauer's prescription for partial cross sections
- *Corrections for experimental effects:* energy-dependent normalization
- *Fitting procedure:* Bayes' method

SAMMY Overview, continued:
IV. Code Details

- *Origin:* ~1978, ORELA rewrite of MULTI code
  - (written by G. Auchampaugh at LANL)
- *Language:* FORTRAN 77 (moving towards FORTRAN 90)
- *Size:* ~ 130,000 lines of code
- *Structure:*
  - 42 semi-autonomous segments
  - 16 auxiliary codes
  - plotting packages (forodf, rsap, ...)
- *Platforms:*
  - Unix (IBM, Dec, Sun, ...)
  - VMS (DEC)
  - Linux
  - PC Windows

IV. Code Details, continued

- *Input:* User-friendly (gradually becoming friendlier)
- *Documentation:*
  - 411-page users' manual, pdf ← 470-page (so far) for next version
  - many other publications
  - web sites
- *Quality Control:* 161 test cases [>1600 individual SAMMY runs]
- *Experience:* two decades of successful analyses of a large number of experimental data sets ranging from light to heavy nuclei
- *Instruction:* tutorial exercises for novice users; workshops