The McGNASH Nuclear Reaction Code

Patrick Talou, Mark B. Chadwick, Phillip G. Young, Toshihiko Kawano

T-16, Nuclear Physics Group, Los Alamos National Laboratory

- Statistical/Preequilibrium Nuclear Reaction Code
- Projectiles: n,p,γ; Targets: A > 10 ;
  Incident energies: keV - 200 MeV
- Modern Version of the GNASH Code
- Improved Physics and Coding
- Simpler to Use, More Powerful and Easy to Upgrade

Statistical / Pre-equilibrium Nuclear Reaction Code

- Hauser-Feshbach Statistical Theory of the Compound Nucleus Decay.
- Pre-equilibrium stage described by Hybrid Monte Carlo approach [Blann, Chadwick]; DDHMS code [Chadwick].
- Width Fluctuation Correction Factors calculated with Moldauer, HRTW, and exact GOE models.
- Total and reaction cross sections calculated with the coupled-channels code ECIS96.
- Excitation of discrete inelastic levels calculated with ECIS.

Modern Coding in F95 Scientific Language, and Perl

- Perl driver code
- F95: Extensive modular programming
- Dynamic memory allocation
- Data structures & encapsulation
- Large place for comments
- Simple and compact input file (caution!)
- Default calculations with default parameters
- ENDF formatting with Perl routines

Physics Models in McGNASH (I)

- Statistical Hauser-Feshbach model; use of spin and angular momentum dependent transmission coefficients.
- ECIS96 coupled-channels code provides input for McGNASH: transmission coefficients, total and reaction cross section; discrete inelastic scattering cross sections and angular distributions.
- Gamma-ray strength function to describe Giant-Dipole Resonance: Generalized Lorentzian formalism of Kopecky-Uhl
- Direct-semidirect calculations by DSD code [Kawano]

Physics Models in McGNASH (II)

- Discrete level scheme matched to representation of the continuum by Constant-T + Fermi-gas level densities. Gilbert-Cameron-Ignatyuk formalism.
- Simple fission model: double-humped fission barriers; uncoupled oscillators; Hill-Wheeler formula; asymmetry enhancement parameter.
- Extensions of this model:
  - E. Lynn detailed study of fluctuations due to the coupling between the two wells;
  - P. Möller microscopic-macroscopic approach to study saddle points, level densities and fission paths.
  - Calculation of fission transmission coefficients for arbitrarily-shaped fission barriers (1D). Connection with IAEA-CRP on RIPL-3.

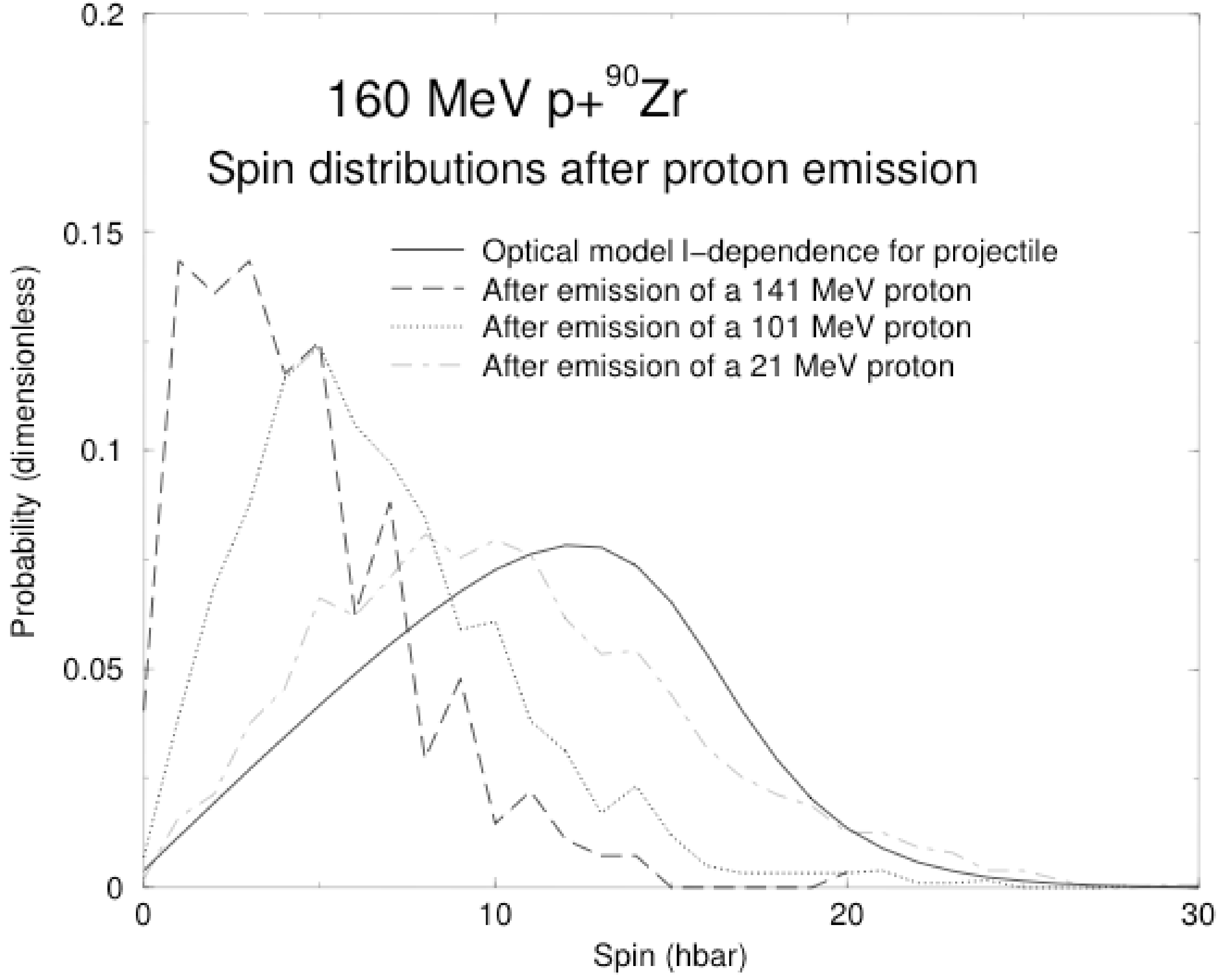
Physics Models in McGNASH (III)

- Pre-equilibrium stage: Hybrid Monte Carlo model [Blann, Chadwick] using a F90 version of the DDHMS code [Chadwick]
- Width Fluctuation correction factors, three models:
  - Moldauer
  - HRTW
  - Exact GOE

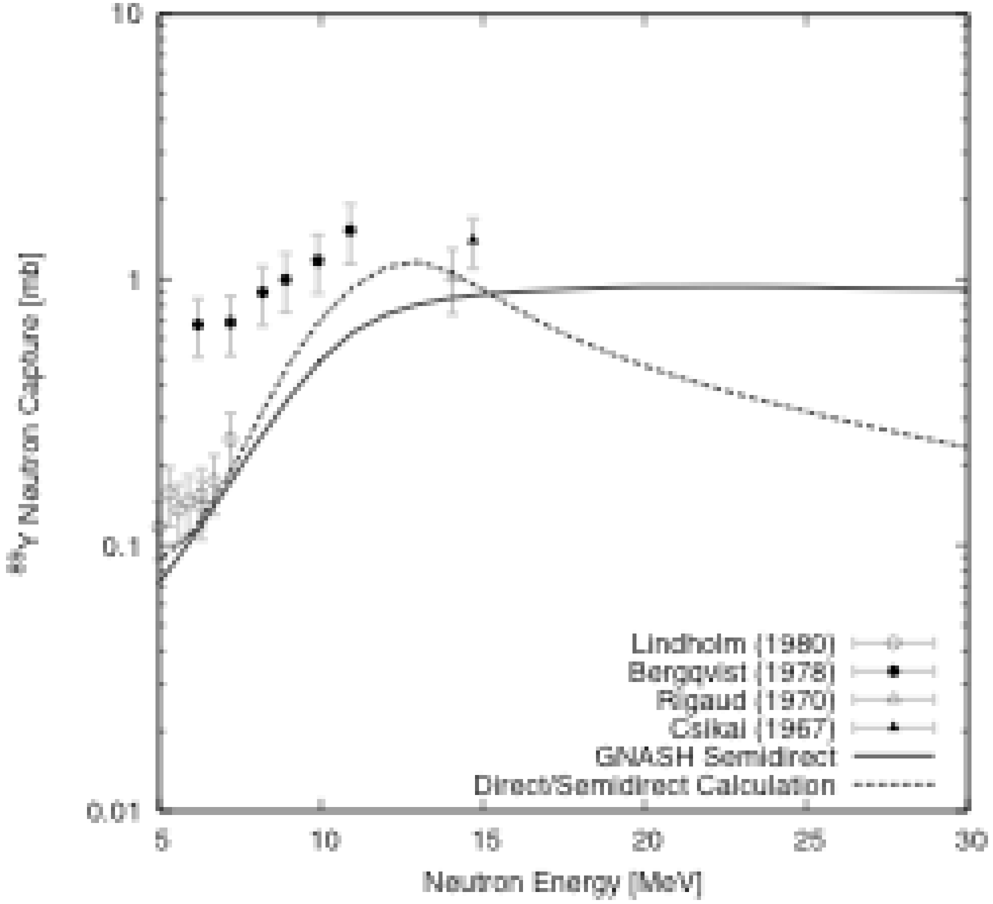
Physics Models in McGNASH- Extensions

- Prediction of fission fragments yields (Möller or Brosa model calculations)
- Link with Monte Carlo simulations of FF statistical decay (Lemaire et al., ND2004)
- Link with KALMAN code (Kawano) to produce covariance matrices from nuclear model calculations.

DDHMS Calculation: 160 MeV p+^{90}Zr



Direct-Semidirect calculation: ^{89}Y

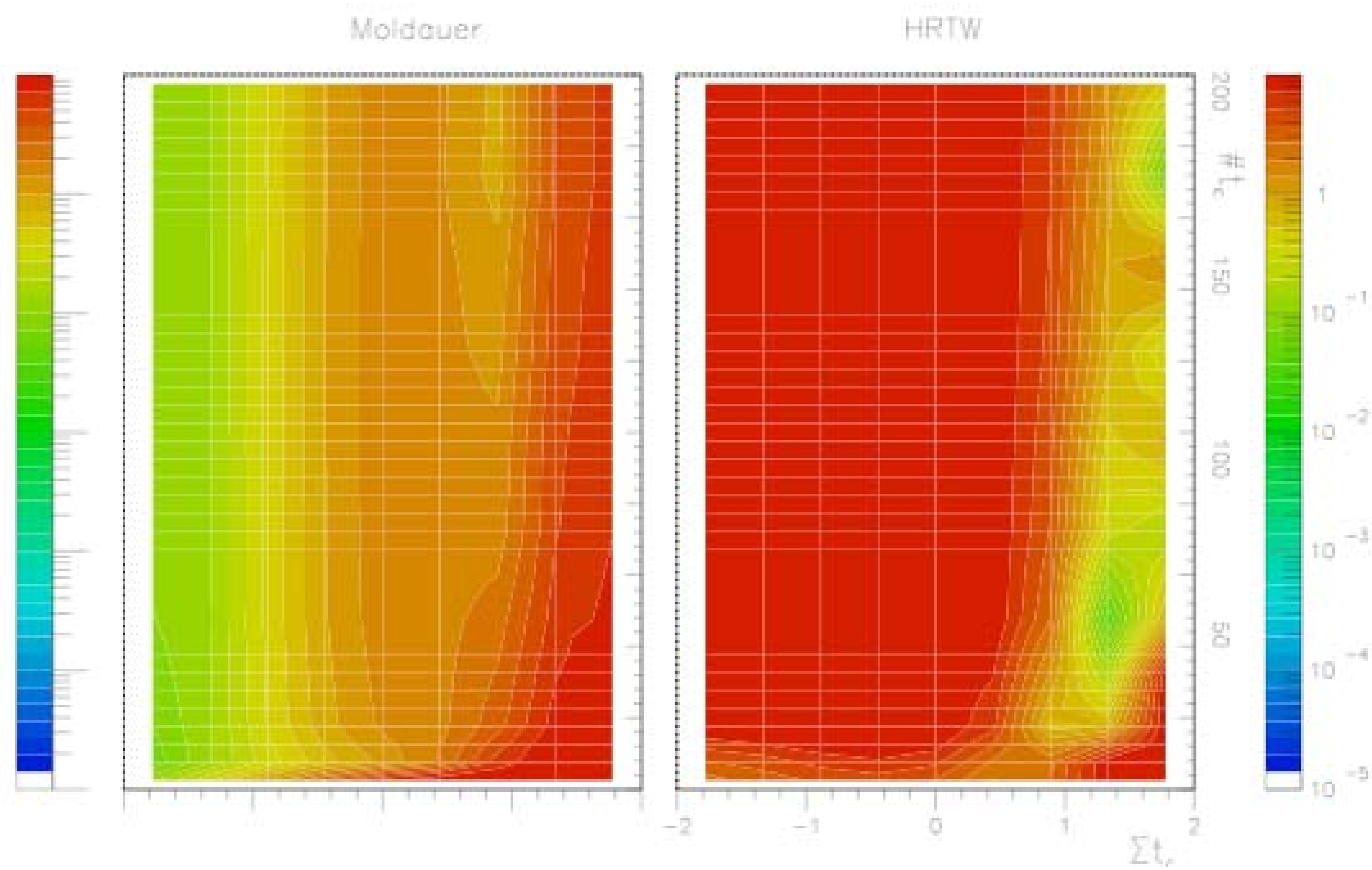


Width Fluctuation Correction Factors (I)

- Three models included
  - Moldauer *Phys. Rev. C 14, 764 (1976)*
  - HRTW *Ann. Phys. (N.Y.) 90, 403 (1975)*
  - Exact GOE *Ann. Phys. 168, 368 (1986)*
- Fast and Optimized algorithm for computing the exact GOE triple integral
- Fortran 90 module submitted to the ModLib collaboration (will be part of the first release of the ModLib library- end of 2004)
- GNASH cannot calculate these factors internally, but relies on an external code (COMNUC) to compute them in an approximate way.

Width Fluctuation Correction Factors (II)

Comparison between HRTW / Moldauer vs. exact GOE



First Public Release late 2005 !!