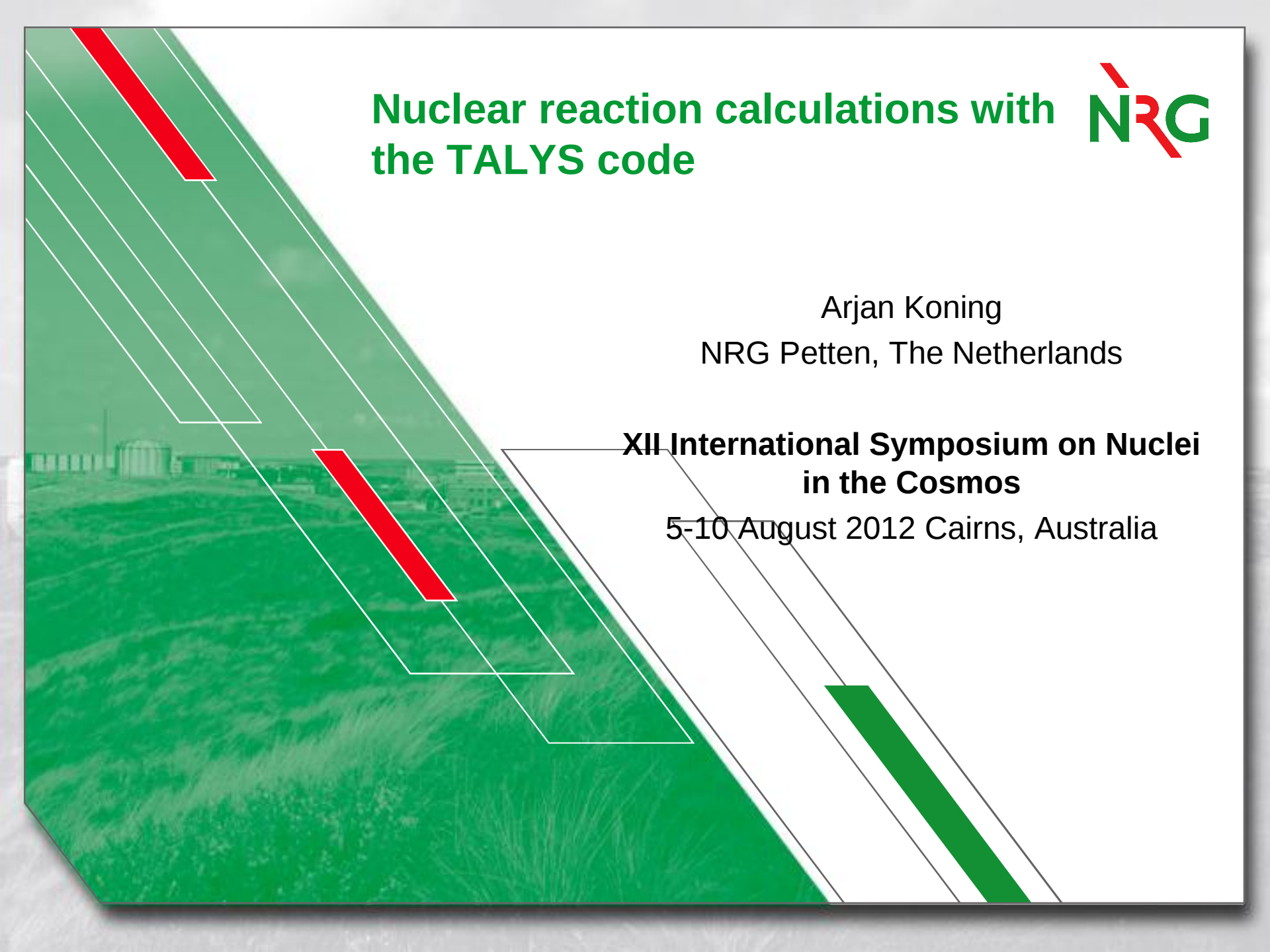




Nuclear reaction calculations with the TALYS code



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in the Cosmos**
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Contents

- TALYS
- New possibilities and developments in nuclear data evaluation
 - Reproducible calculation systems
 - Uncertainties and Total Monte Carlo
 - Protons: medical isotope production
- Conclusions

TALYS

- Nuclear model code by NRG Petten, CEA Bruyeres-le-Chatel, UL Bruxelles
- g,n,p,d,t,h,a induced reactions from 10^{-5} eV up to 250 MeV

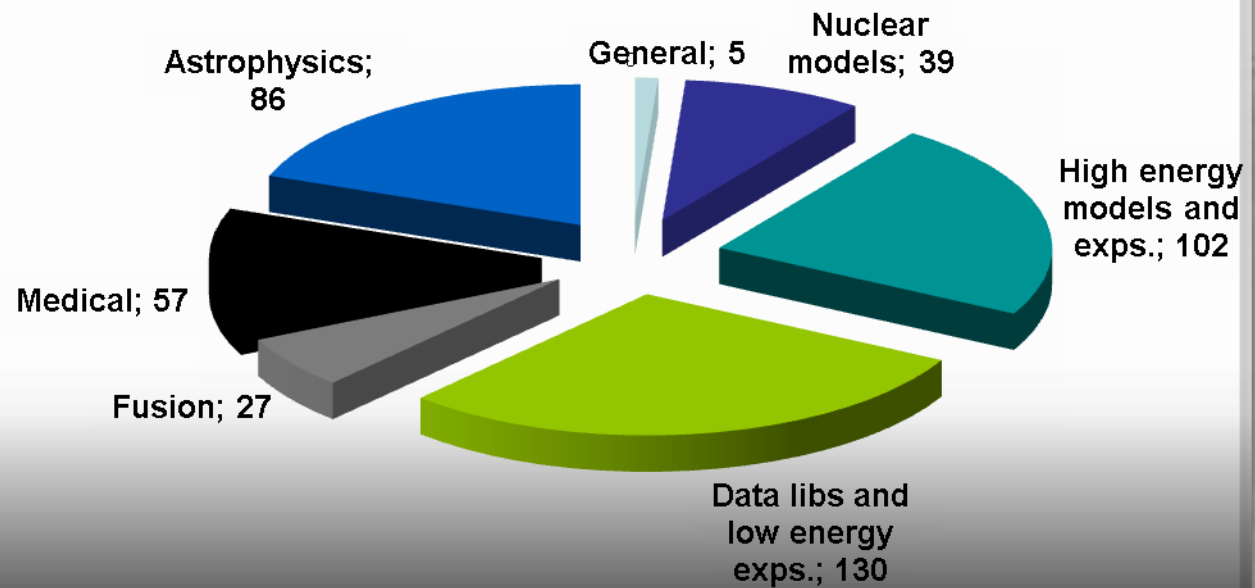
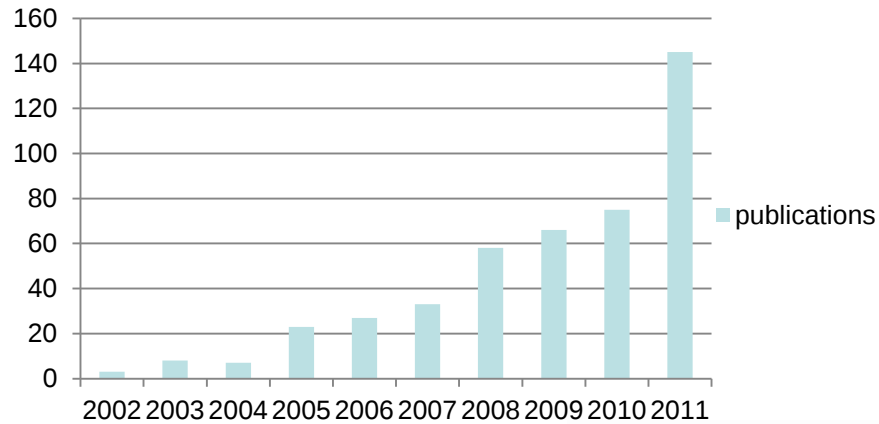
Release:

- www.talys.eu
- Latest official version, TALYS-1.4, released december 23, 2011.
- Estimated 400-500 users, > 400 publications

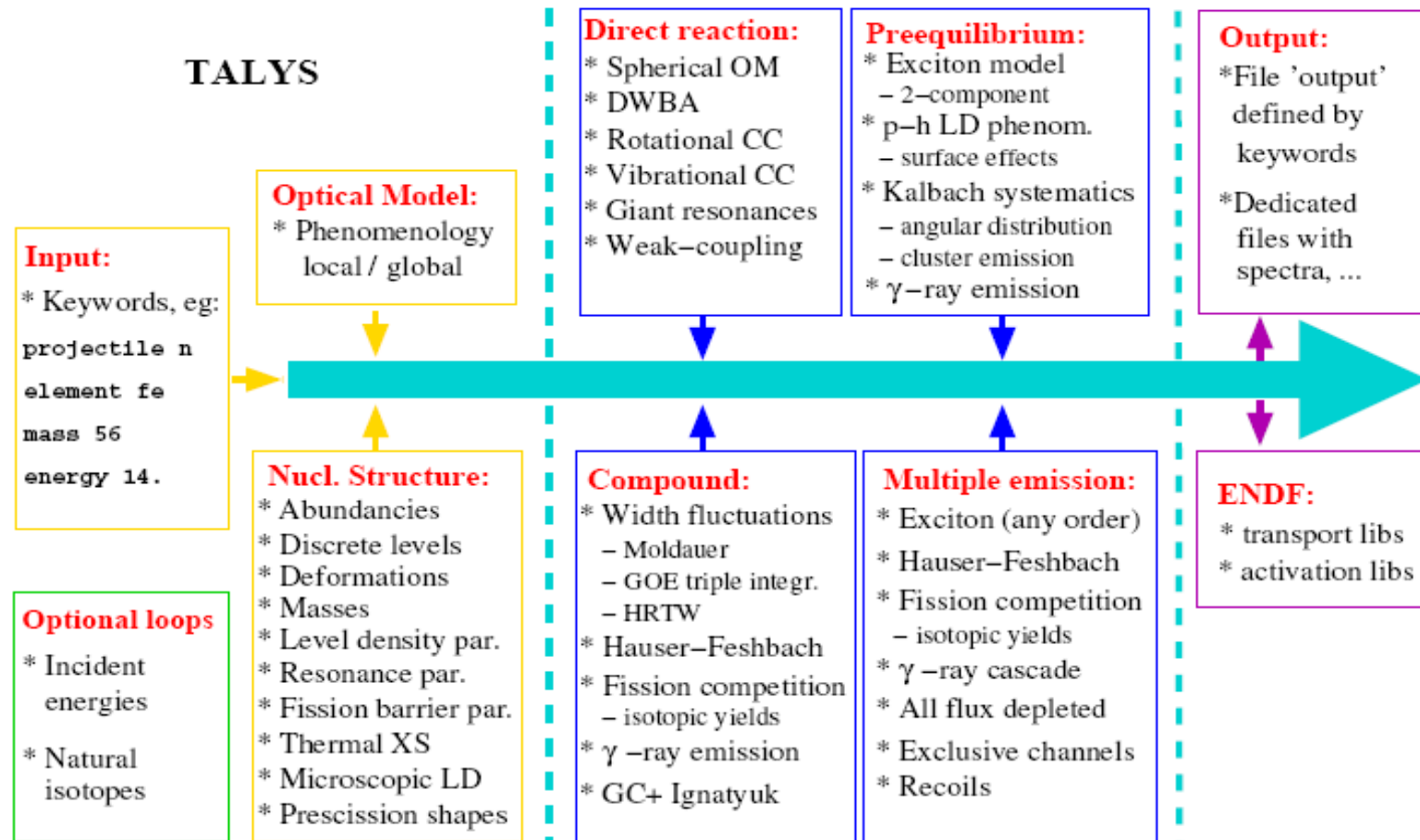
Software issues:

- TALYS is ready to be used by persons other than the authors
- Very flexible:
 - 4-line idiot-proof input (element, mass, projectile, energy), but also...
 - > 250 keywords to change models, parameters, level of output, etc.
- 300 page manual, 20 widely varying sample cases
- Readable modular programming (extensions by others is relatively easy)
- Very robust, thanks to dripline-to-dripline and random input testing

TALYS publications



TALYS code scheme



TALYS physics

General use:

- TALYS can be used for
 - In-depth single nuclide/reaction analyses
 - Global multi-nuclide calculations

Complete output:

- Total, partial and residual production cross sections, (Double)-differential spectra, Angular distributions per discrete level, Fission yields, Recoils, Isomeric production, Astrophysical reaction rates
Gamma production, etc,

Recent accomplishment: option to use all optical, level density, fission and pre-equilibrium models phenomenologically (Woods-Saxon, Fermi gas, Hill-Wheeler, exciton) or microscopically (Hartree-Fock-Bogolyubov-based, by Hilaire, Goriely, Bauge)

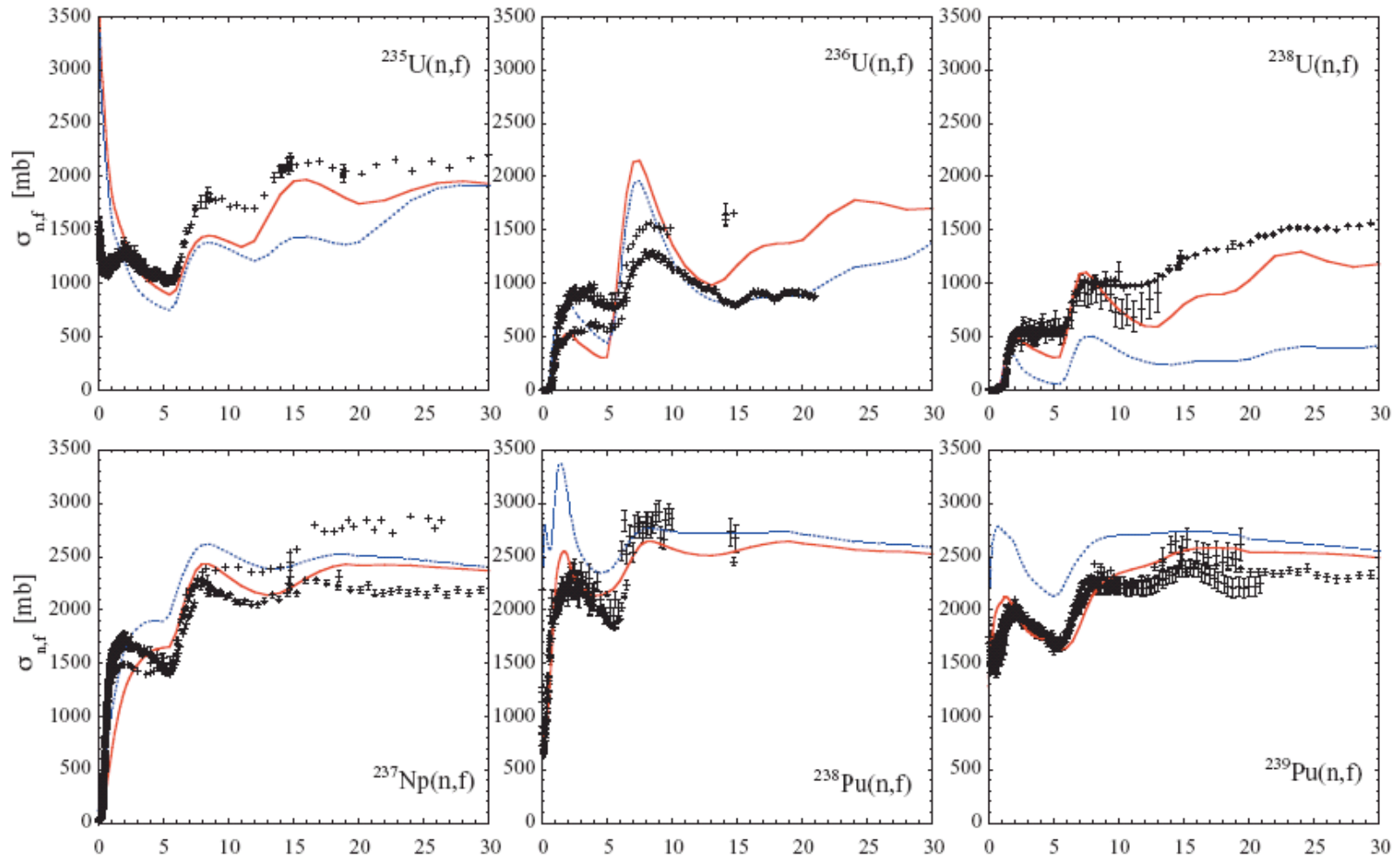
Typical calculation times

Numbers based on a single Intel Xeon X5472 3.0 GHz processor

Time needed to get all cross sections, level densities, spectra, angular distributions. gamma production etc.:

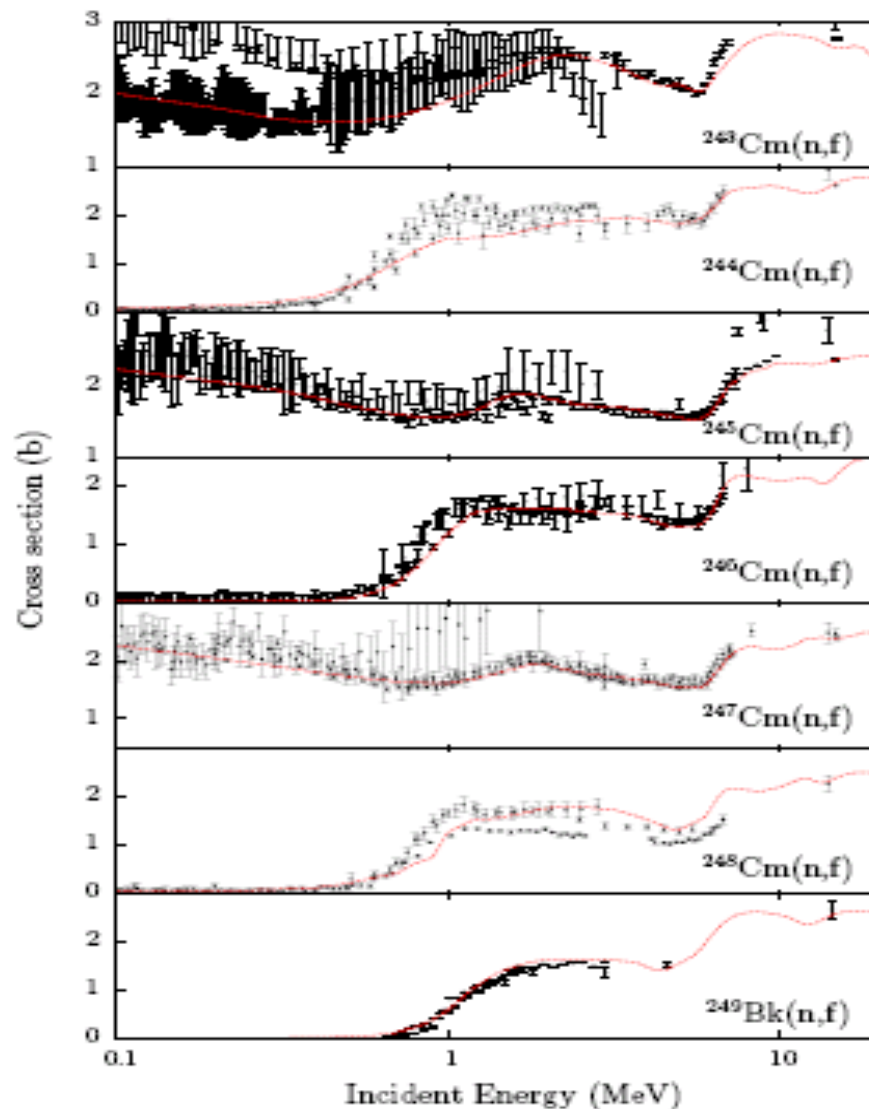
- 14 MeV neutron on non-deformed target: 3 sec.
- 60 incident energies between 0 and 20 MeV:
1 min. (Al-27) to 4 min. (Pb-208) to 10 min. (U-238)
- 100 incident energies between 0 and 200 MeV:
20 min. (Al-27) to 3 hours (U-238)
- 60 incident energies between 0 and 20 MeV for all 2430 nuclides, stable or with $t > 1$ sec: about 200 hours
- To obtain credible Monte Carlo based covariance data: multiply the above numbers by 50-500.

TALYS: Microscopic fission



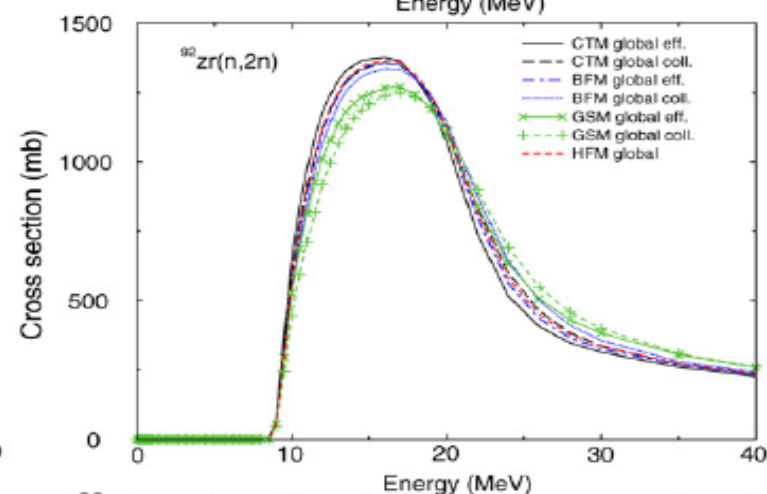
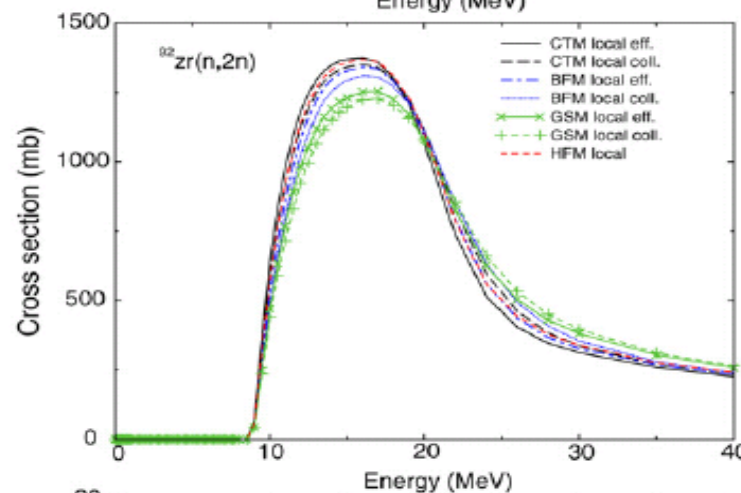
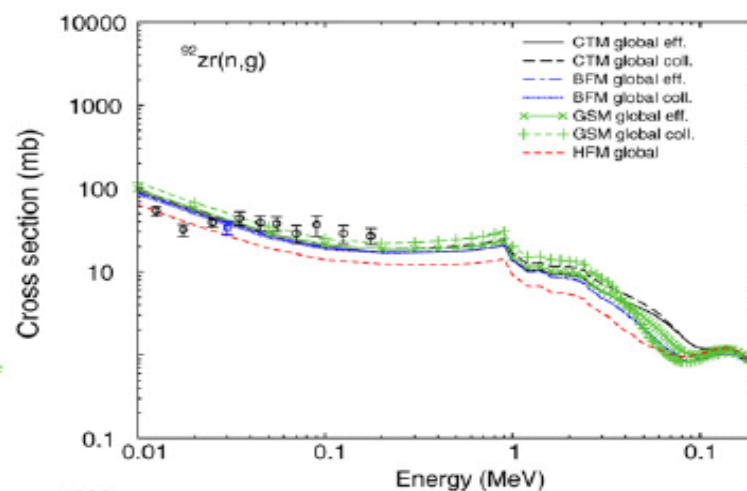
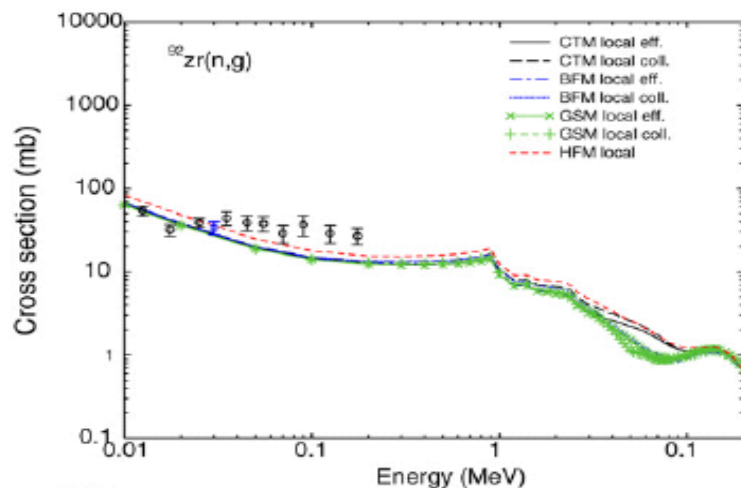
S. Goriely, S. Hilaire, A.J. Koning, M. Sin and R. Capote, Phys Rev C79, 024612 (2009)

TALYS: Phenomenological fission



requires “in-depth” evaluation and adjustment of fission barrier parameters, level density parameters (a , T , shell corr.) for ground state and fission barriers, radiative widths, and pre-equilibrium parameters

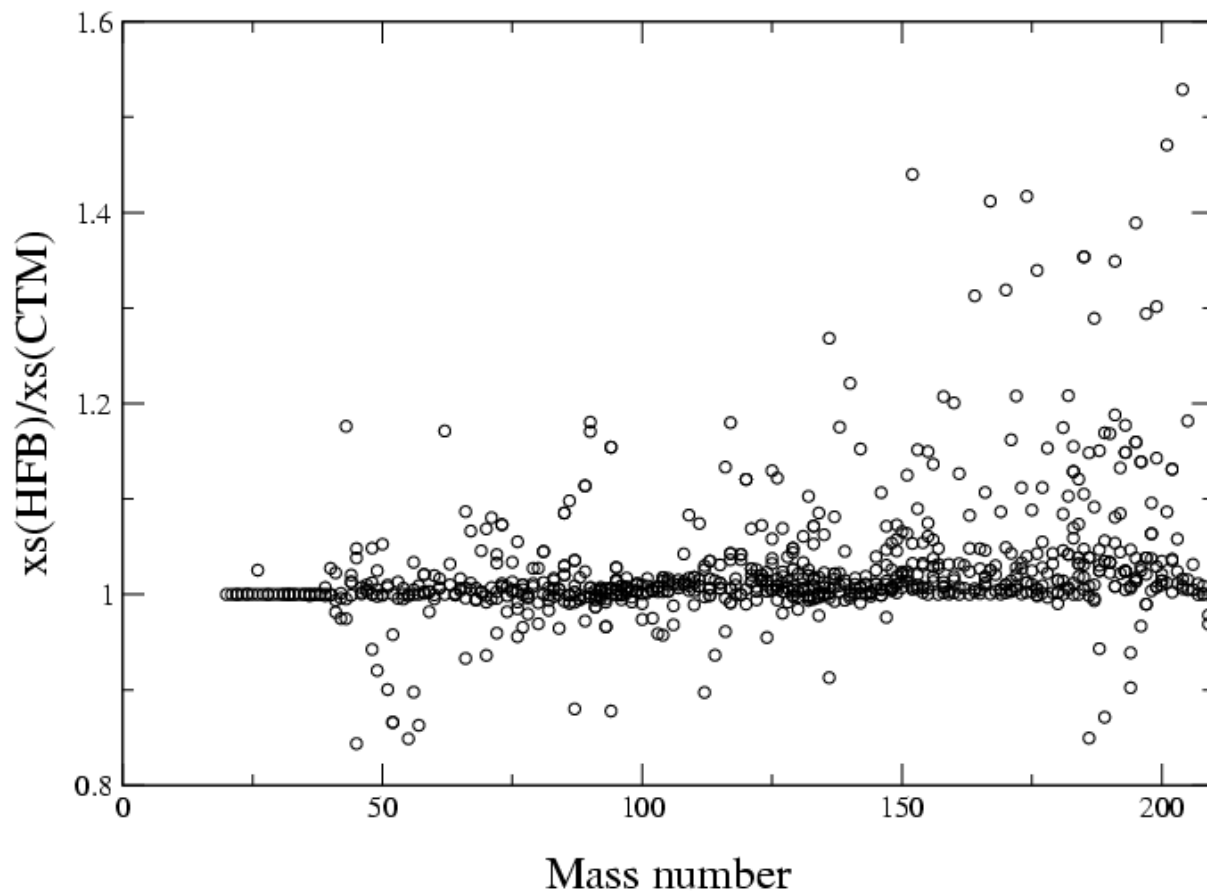
Level density models: cross sections



A.J. Koning, S. Hilaire and S. Goriely, Nucl. Phys. A810, 13-76 (2008)

Trends for level densities: HFB (Goriely-Hilaire) vs constant temperature model

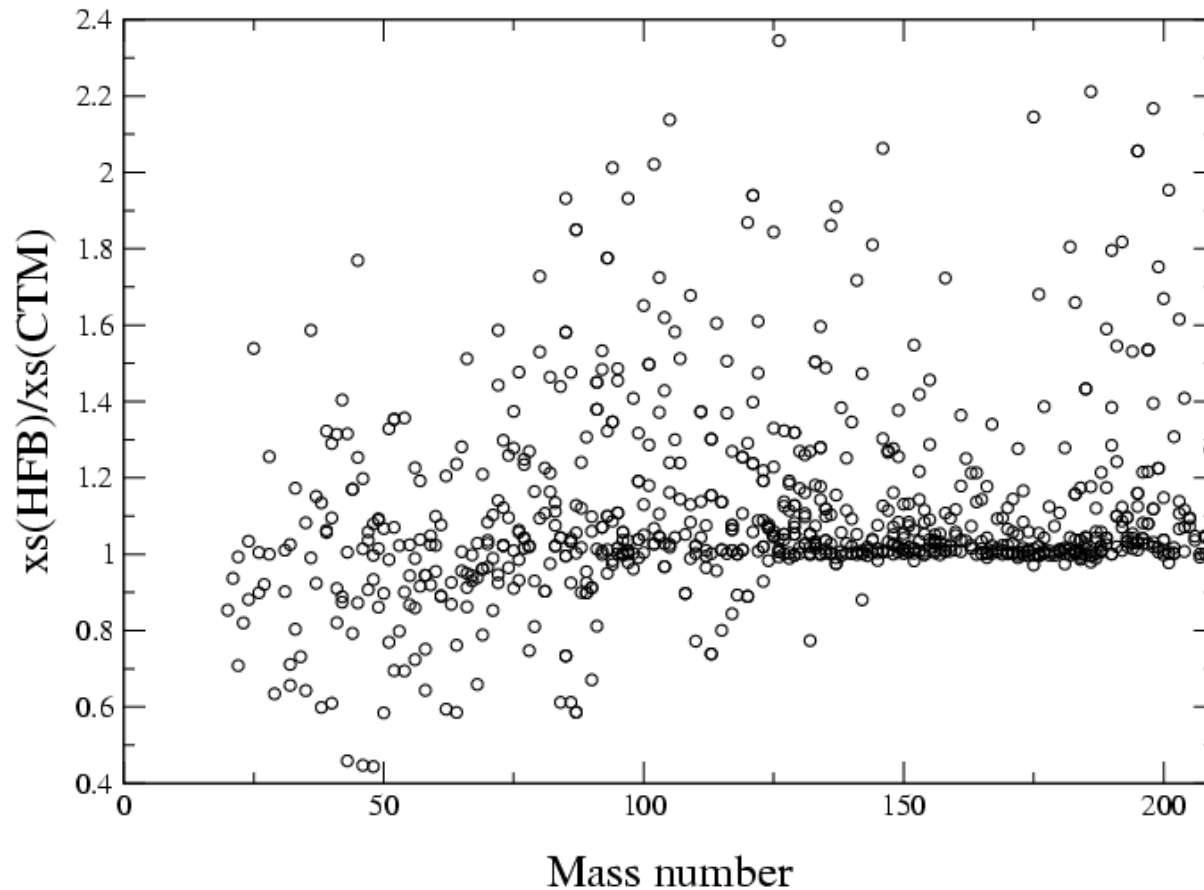
Inelastic neutron c.s. at 4 MeV: HFB l.d. vs. CTM l.d.
(1100 nuclides)



Trends for level densities: HFB vs CTM

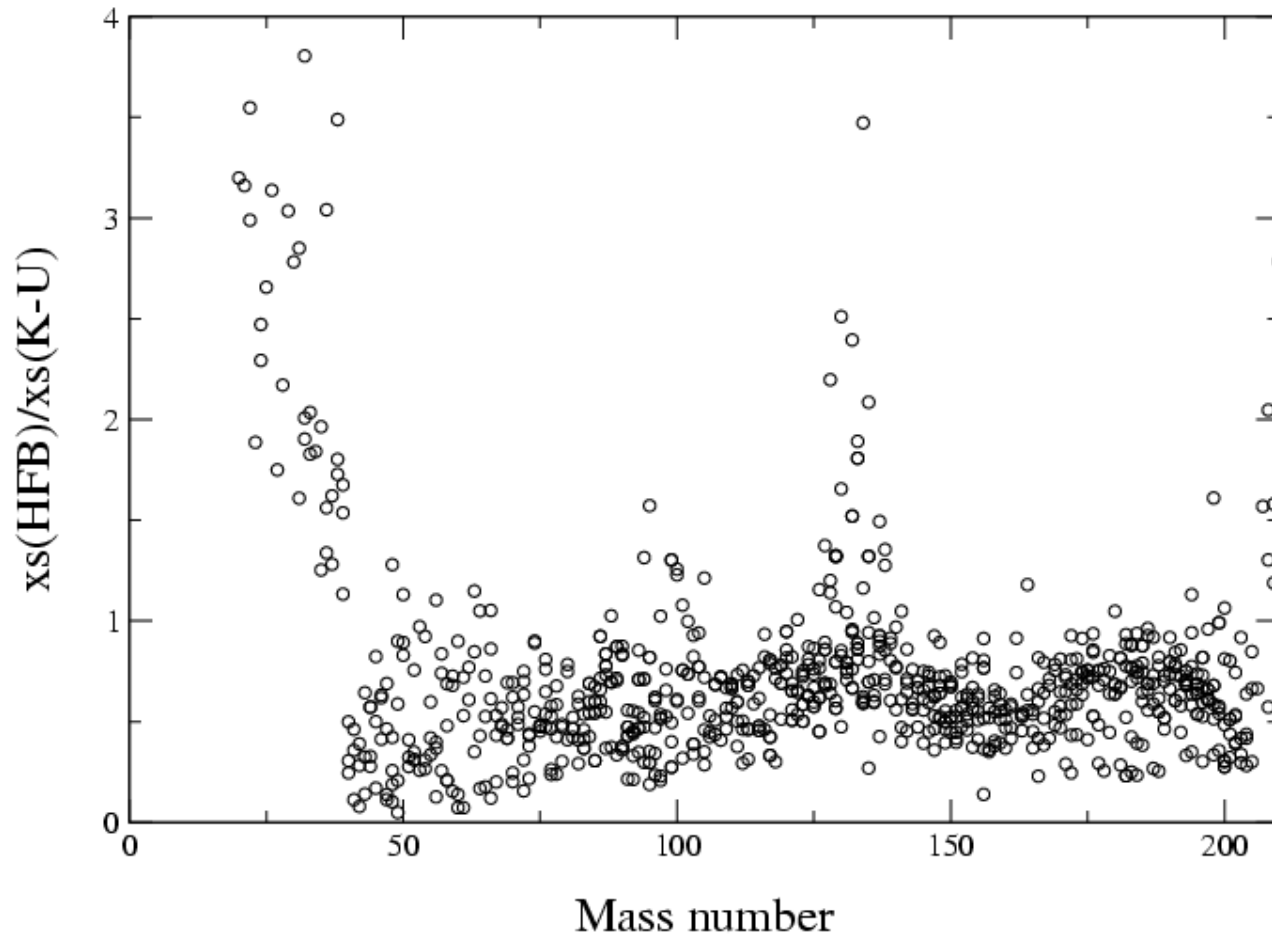
(n,p) c.s. at 14 MeV: HFB l.d. vs. CTM l.d.

(1100 nuclides)



Trends for gamma-ray strength functions

Capture c.s. at 100 keV: HFB vs. Kopecky-Uhl strength f.
(1100 nuclides)



Conclusions

- TALYS (www.talys.eu) is
 - a user-friendly nuclear model code for reactions involving all light particles up to 200 MeV,
 - used, and validated, by a worldwide community,
 - competitive at all energies
 - Used to analyze nuclear reaction experiments
 - Capable of producing complete nuclear reaction data sets of reasonable to good quality for all kinds of applications