Uncertainties and covariances for the recommended cross sections

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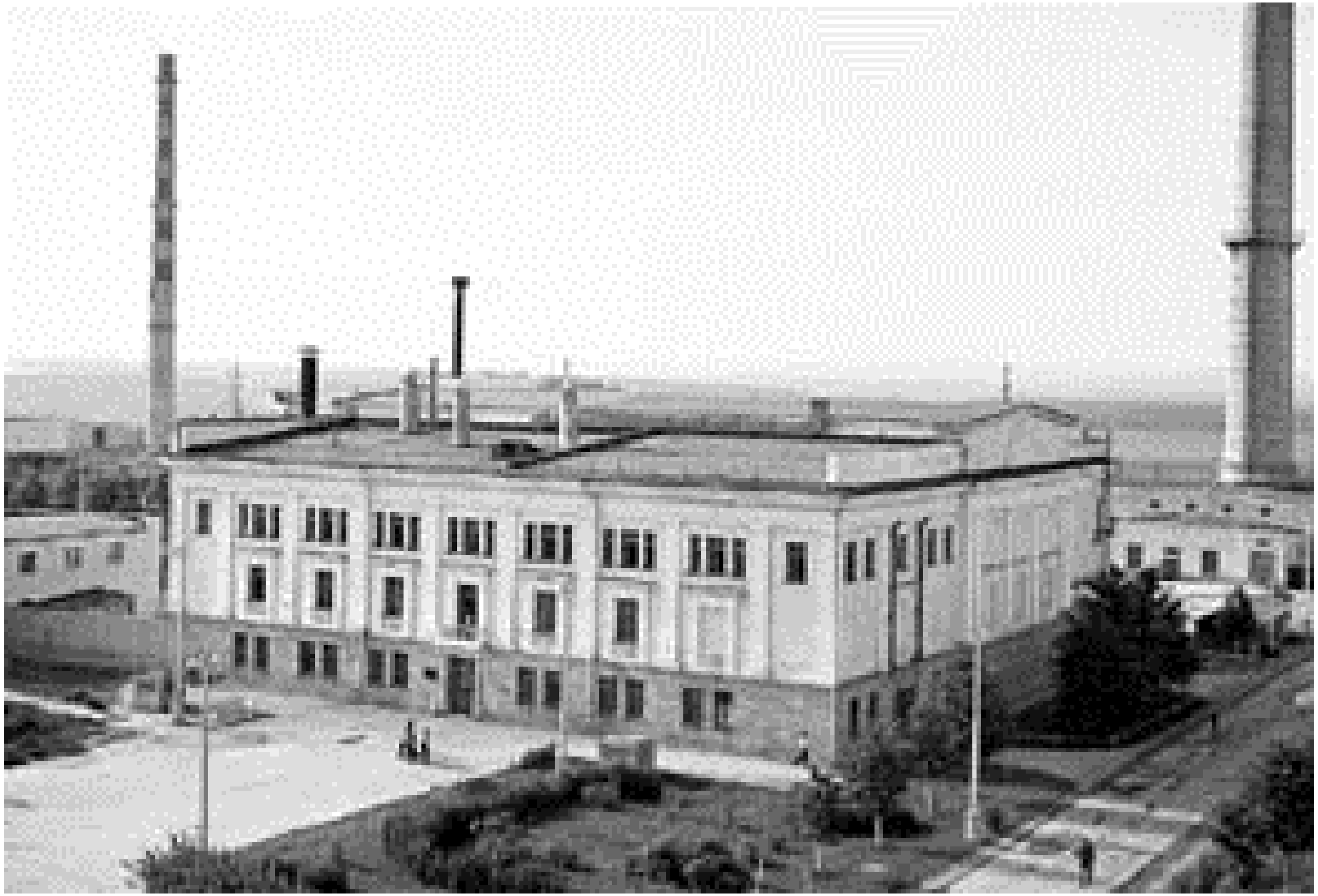
- Brief history of the IPPE;
- Statistical calculations of the reaction cross sections;
- Phenomenological systematics of the cross sections;
- Analysis of uncertainties and covariencies;
- High-energy data for protons (Ep>100 MeV).

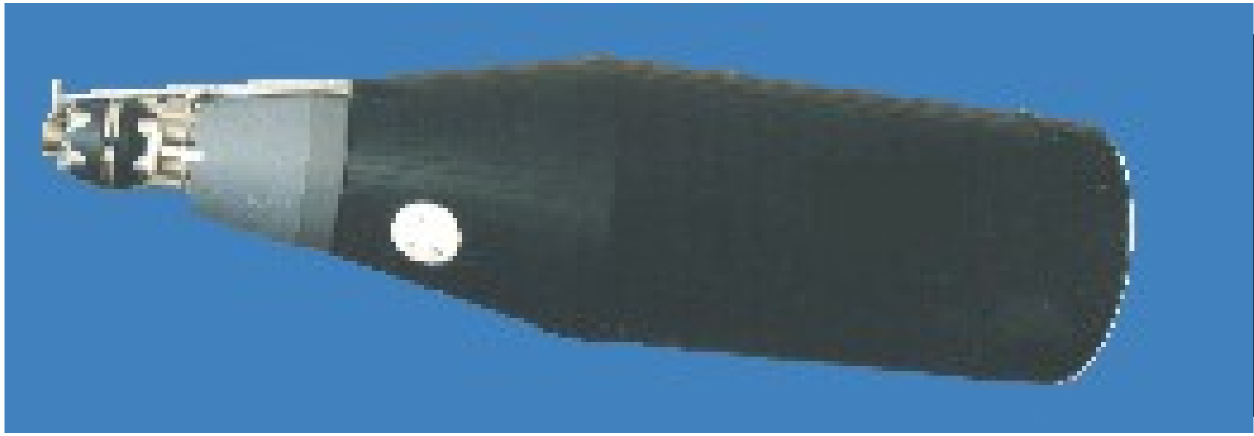
1st CRP Meeting on Nuclear Data for Charged-particle Monitor reactions and Medical Isotope Production, Vienna, 3-7 December 2012

The first in the world atomic power plant

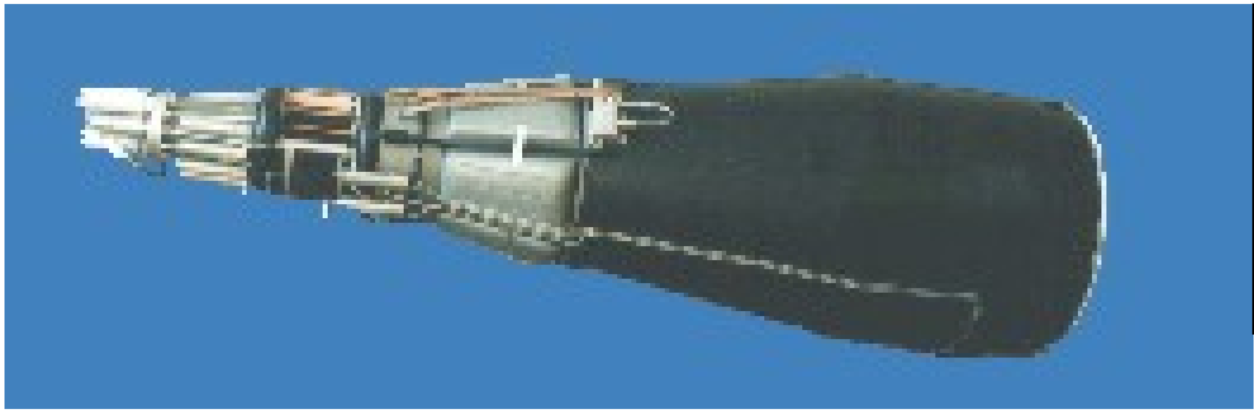


The plant with the electric-production power of 5MW was set in operation on June 27, 1954. It was shutdown on April 29, 2002 after 48 years of various mode operations without any nuclear accident. Now it is transforming to the historical museum.

Space power plants



The Buk space power-plant with a small-size fast reactor and a thermo-electrical transformer. More than 30 such plants operated on the Russian satellites of the "Cosmos" type.



The Topaz space power-plant with a small-size reactor on intermediate neutrons and a thermo-emission transformer. It was tested successfully on several satellites.

Nuclear submarines with the Pb-Bi coolant reactors

Development of the nuclear reactors with the Pb-Bi coolant was started at the IPPE from 1952 for the high-speed submarines. These submarines were included in the Guinness-record book as the fastest ones, but all of them are disassembled now. Nowadays a modified prototype of such reactor is considered as the advanced power plant satisfying the Generation-IV safety conditions.

Recent visitors (2008)

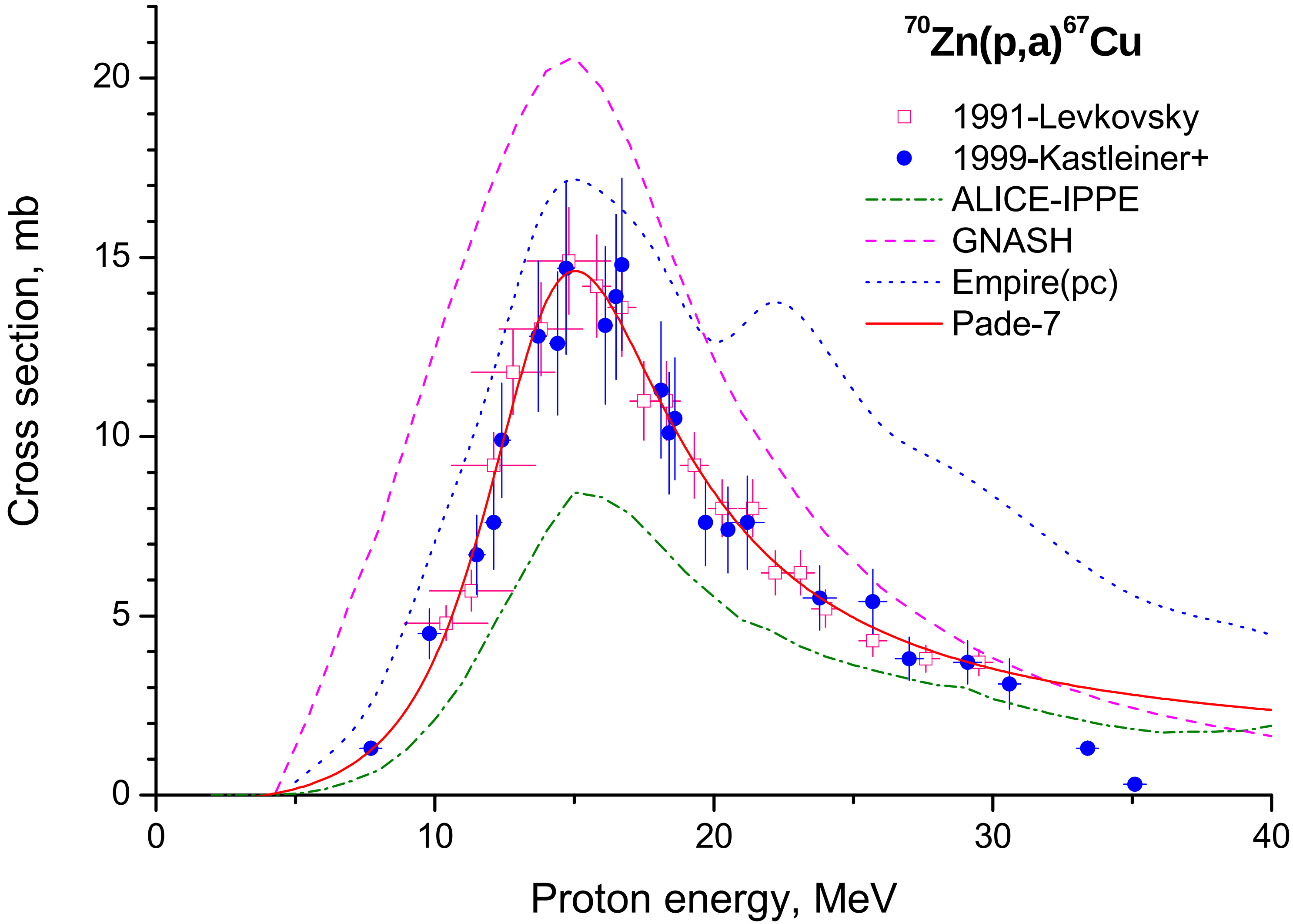
Some famous persons were extremely satisfied from visit to our Institute.

Scientific experience of the IPPE Theory Division and Russian Nuclear Data Center:

Works on the statistical theory of nuclear reactions, nuclear fission theory and level density systematics, evaluations of nuclear data for the Russian evaluated data libraries ADL-3, BROND-3, ROSFOND-2010 and the international libraries FENDL-2, RADL-1, RIPL-3, and FENDL-3.

Long term collaboration with experimental groups involved in the measurements of neutron and charged-particle reactions over the world.

Available experimental data and theoretical calculations for some important reactions



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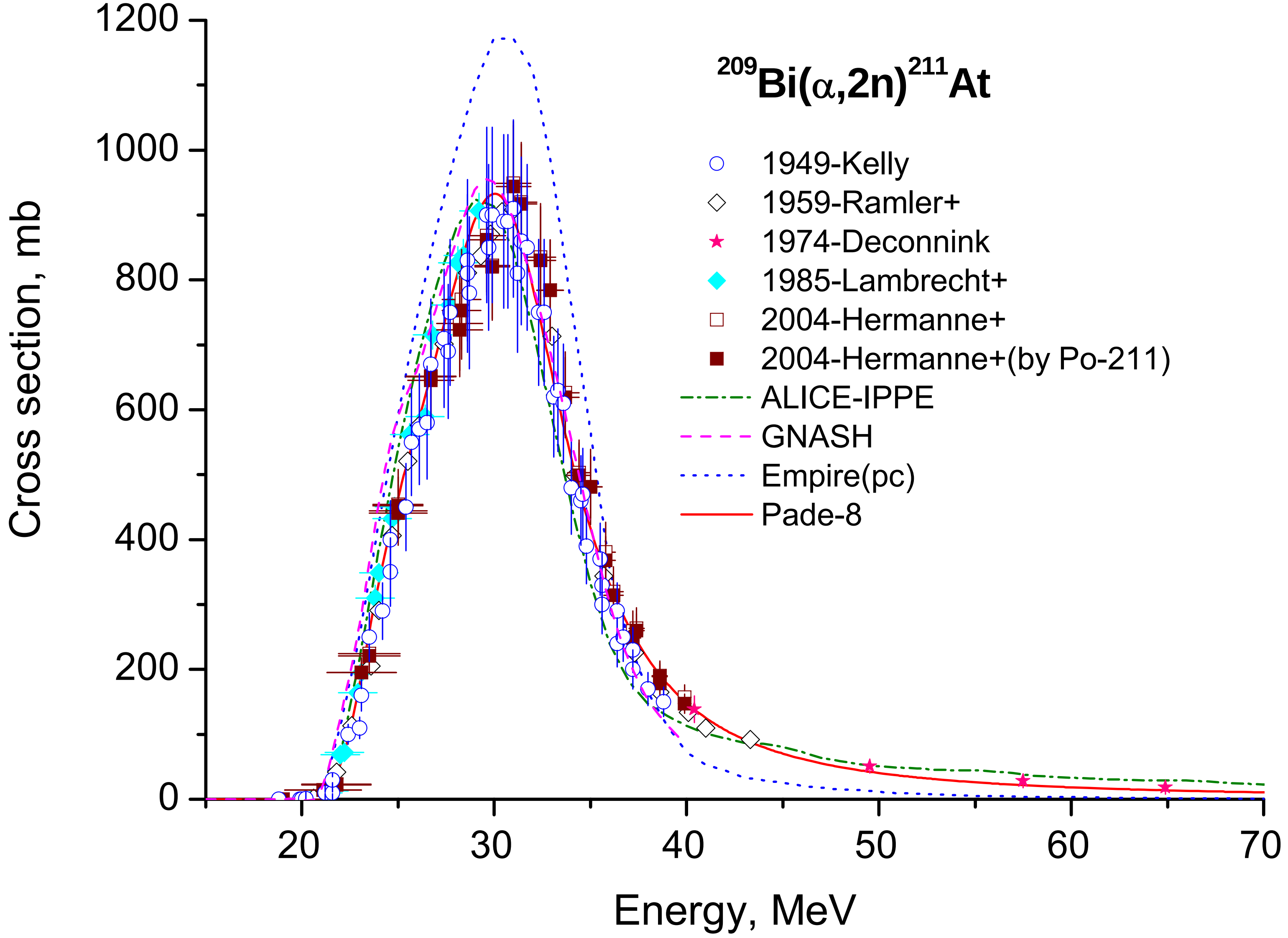
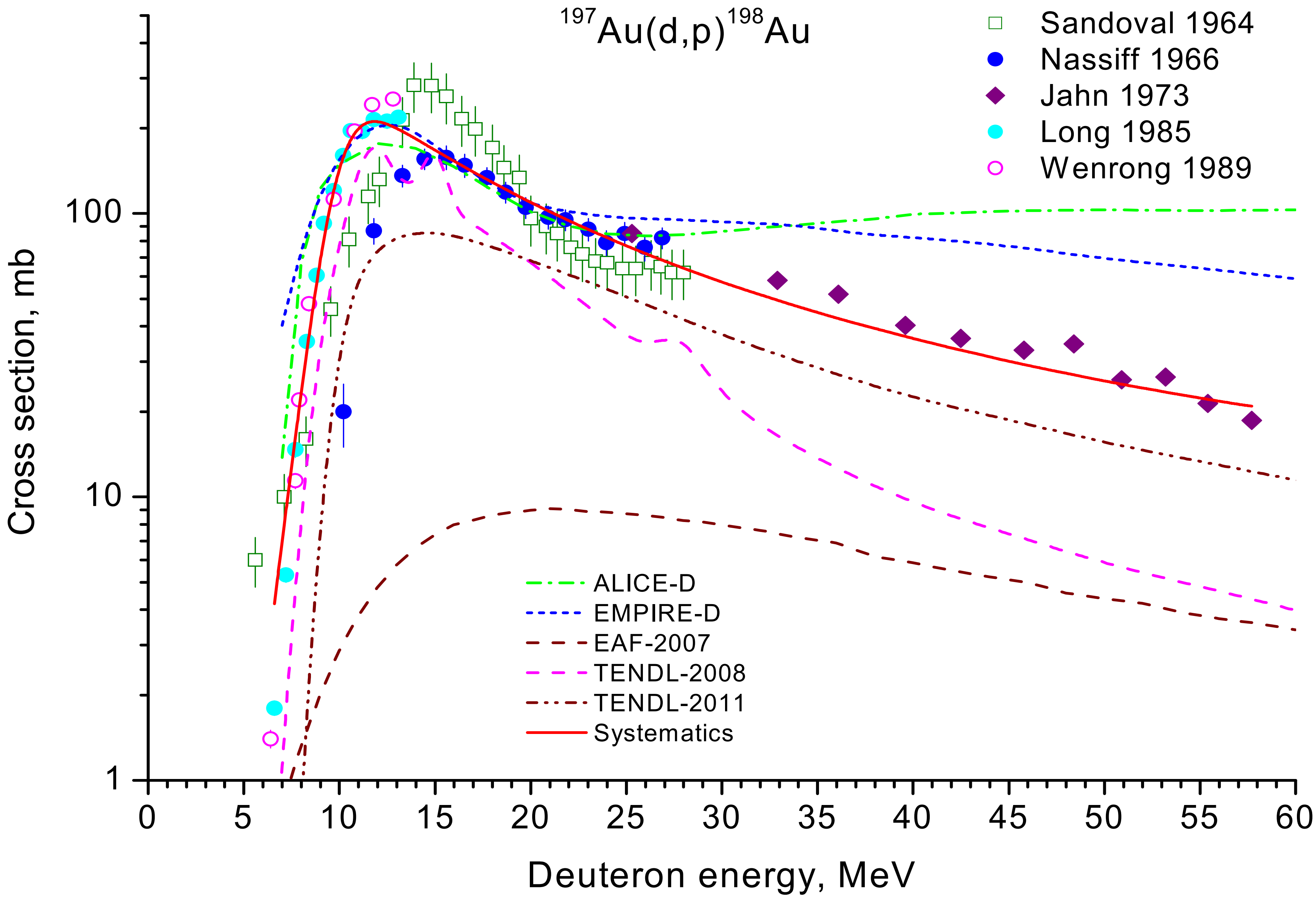


Experimental data for the $^{197}Au(d,p)^{198g}Au$ cross section in comparison with various calculations



Phenomenological systematics

The analytical function for the description of experimental data was accepted in the following form:

$$\sigma(E) = \frac{a_1}{1 + \exp(\frac{b-E}{c})}[a_2 \exp(-E/d_1) + (1-a_2)\exp(-E/d_2)]$$

where the factor before the square brackets defines the low-energy increasing part of the (d,p) cross section and the terms in the square brackets characterize the decreasing part.

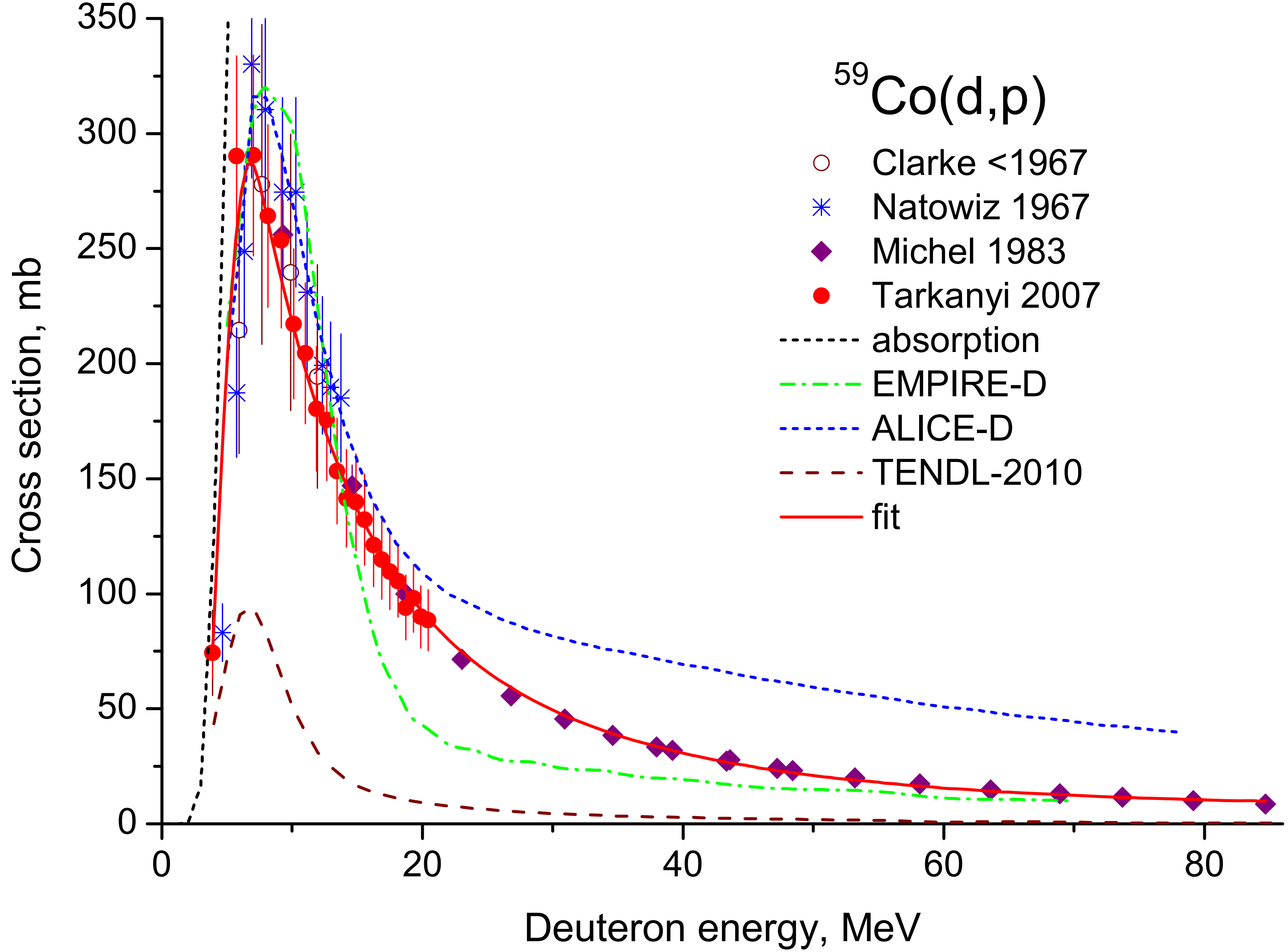
The parameter *b* determines the effective threshold of the (d,p) reaction and it should be close to the height of the Coulomb barrier

$$b = \frac{e^2 Z}{r_{eff} A^{1/3}}$$

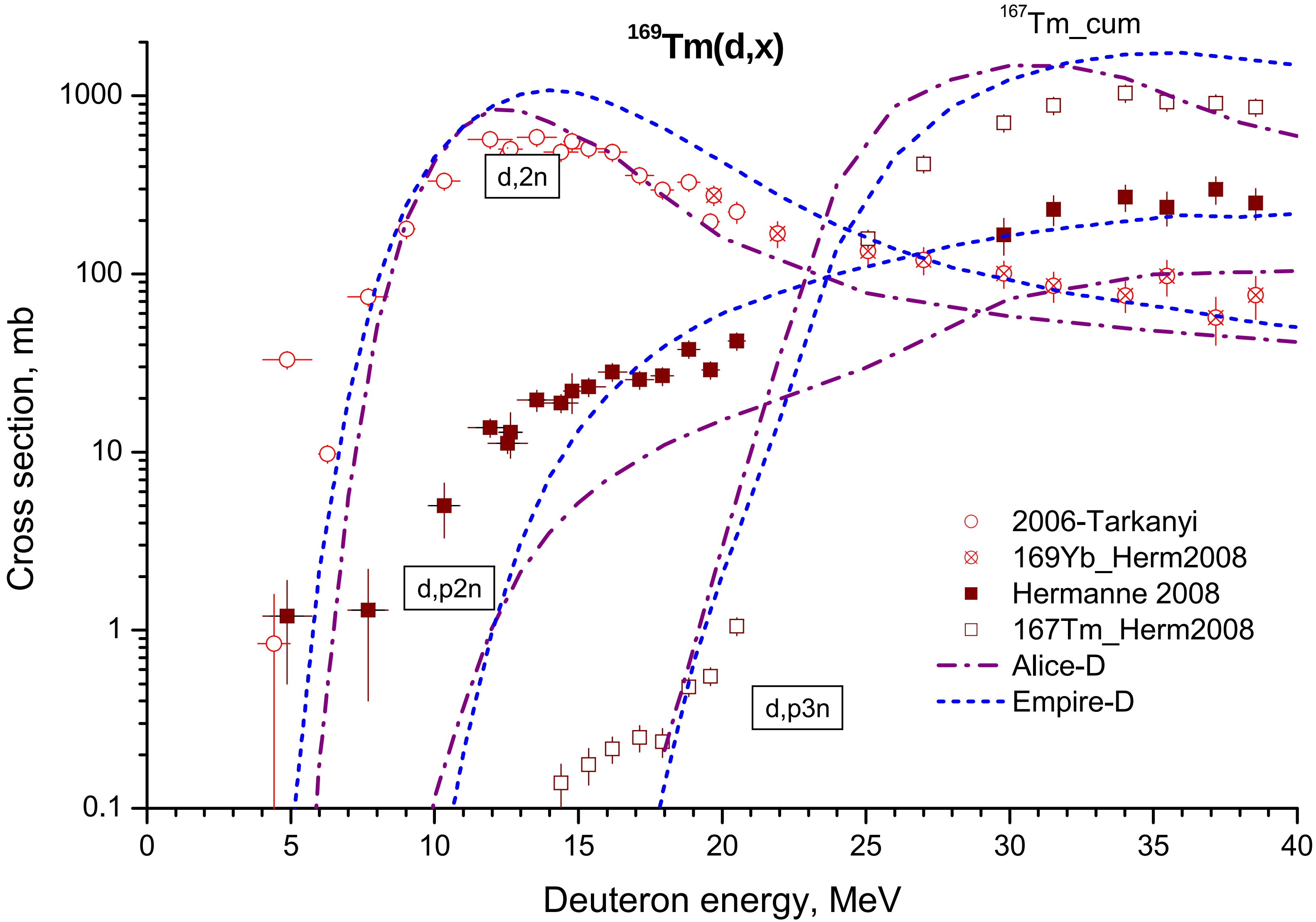
The mean value of the radius parameter estimated from the experimental data analysis is r_{eff}=1.985±0.045 fm.

b.

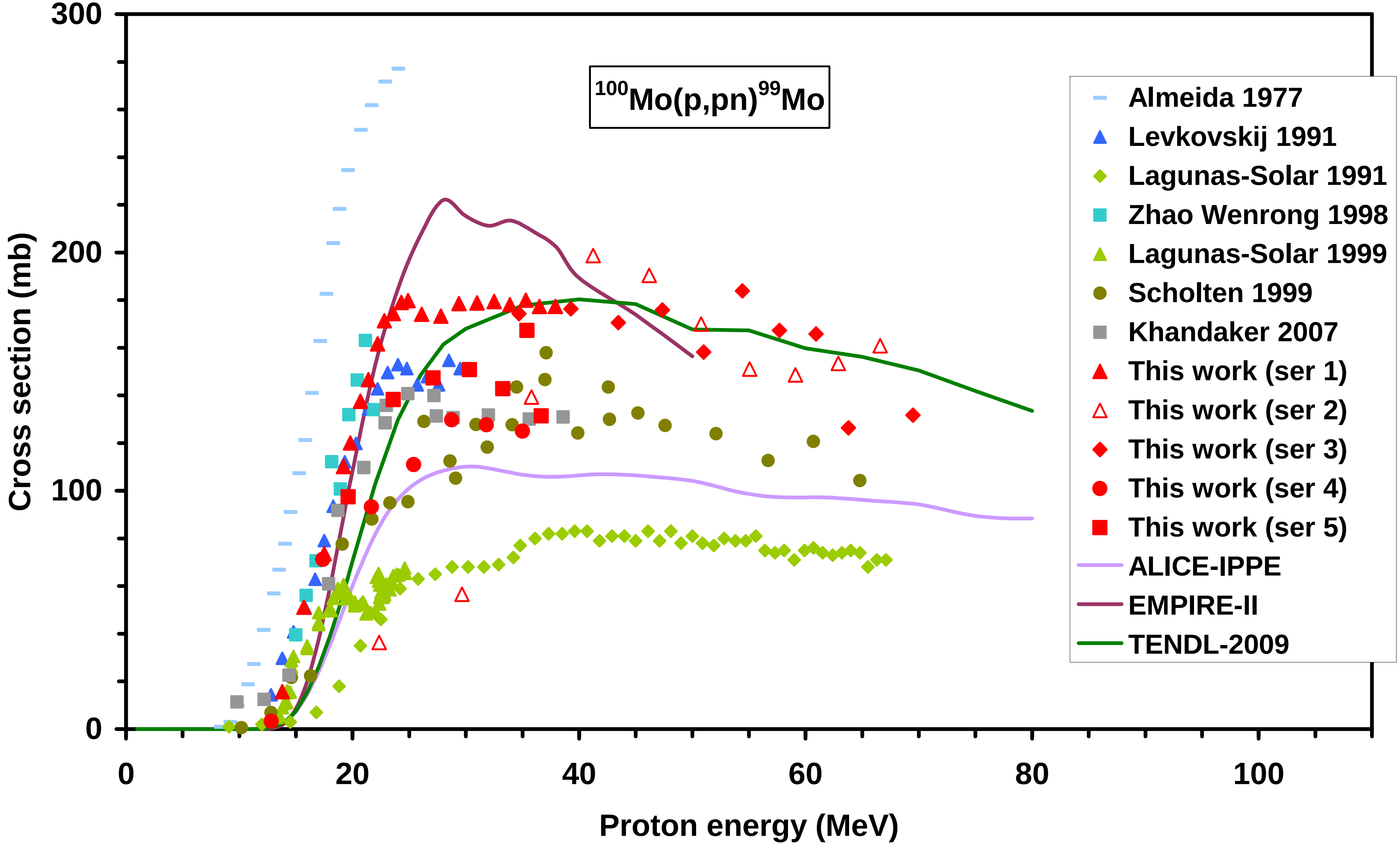
Experimental data for the ^{59}Co(d,p) reaction compared with various calculations



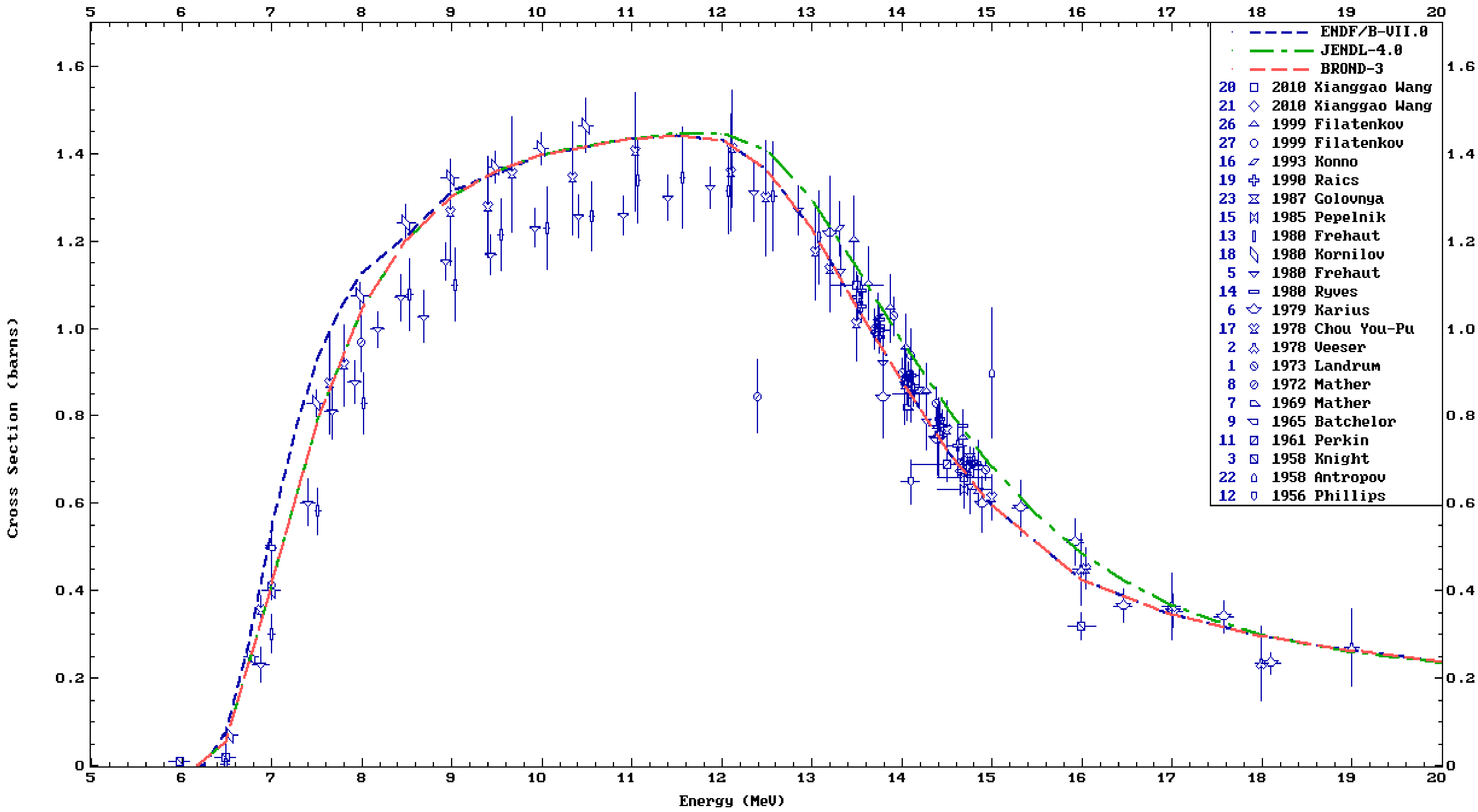
Analysis of the ^{169}Tm(d,x) cross sections



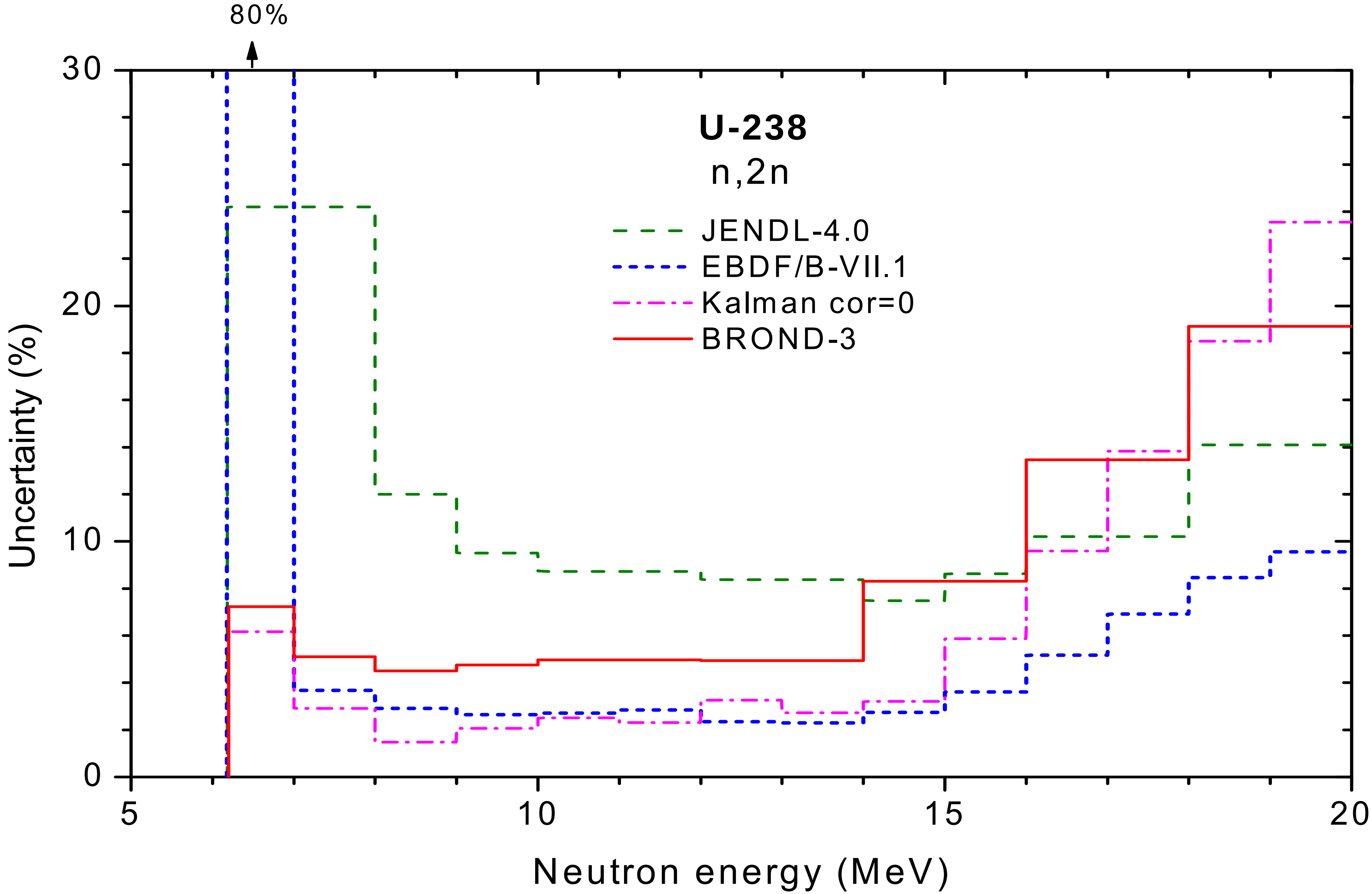
Available experimental data and theoretical calculations for some important reactions



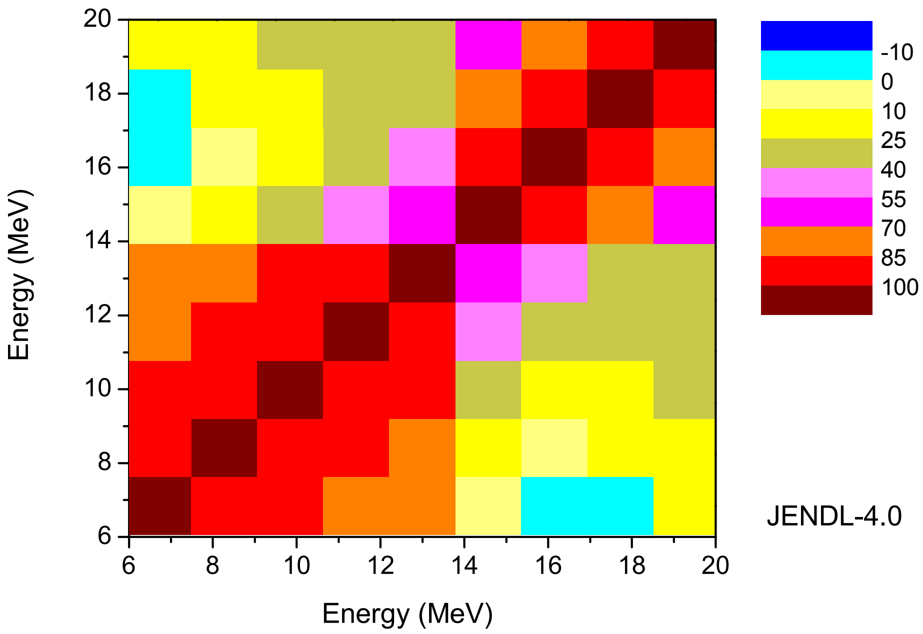
Available experimental data and evaluations for the $^{238}U(n,2n)$ cross section

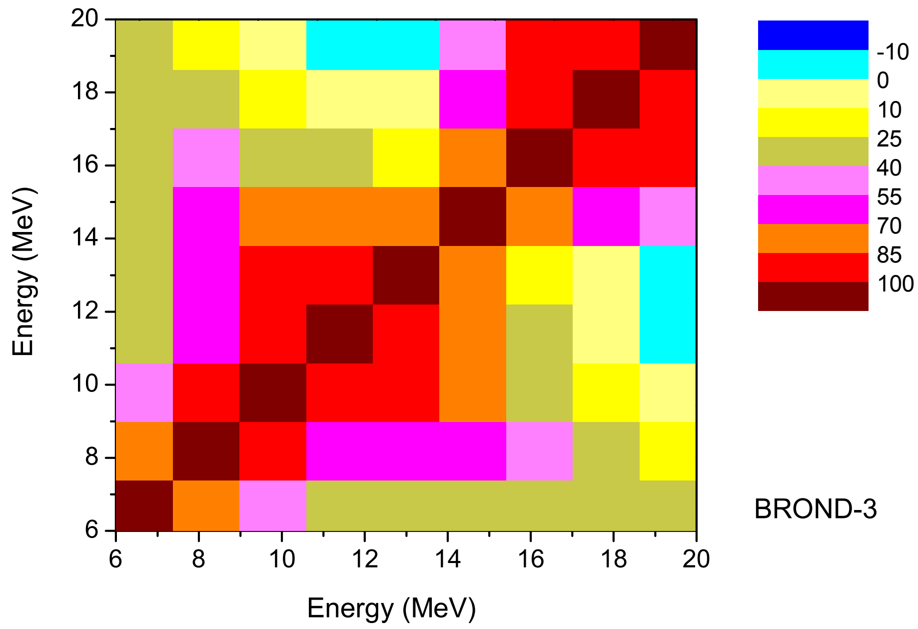


Uncertainties of the $^{238}U(n,2n)$ cross-section evaluations

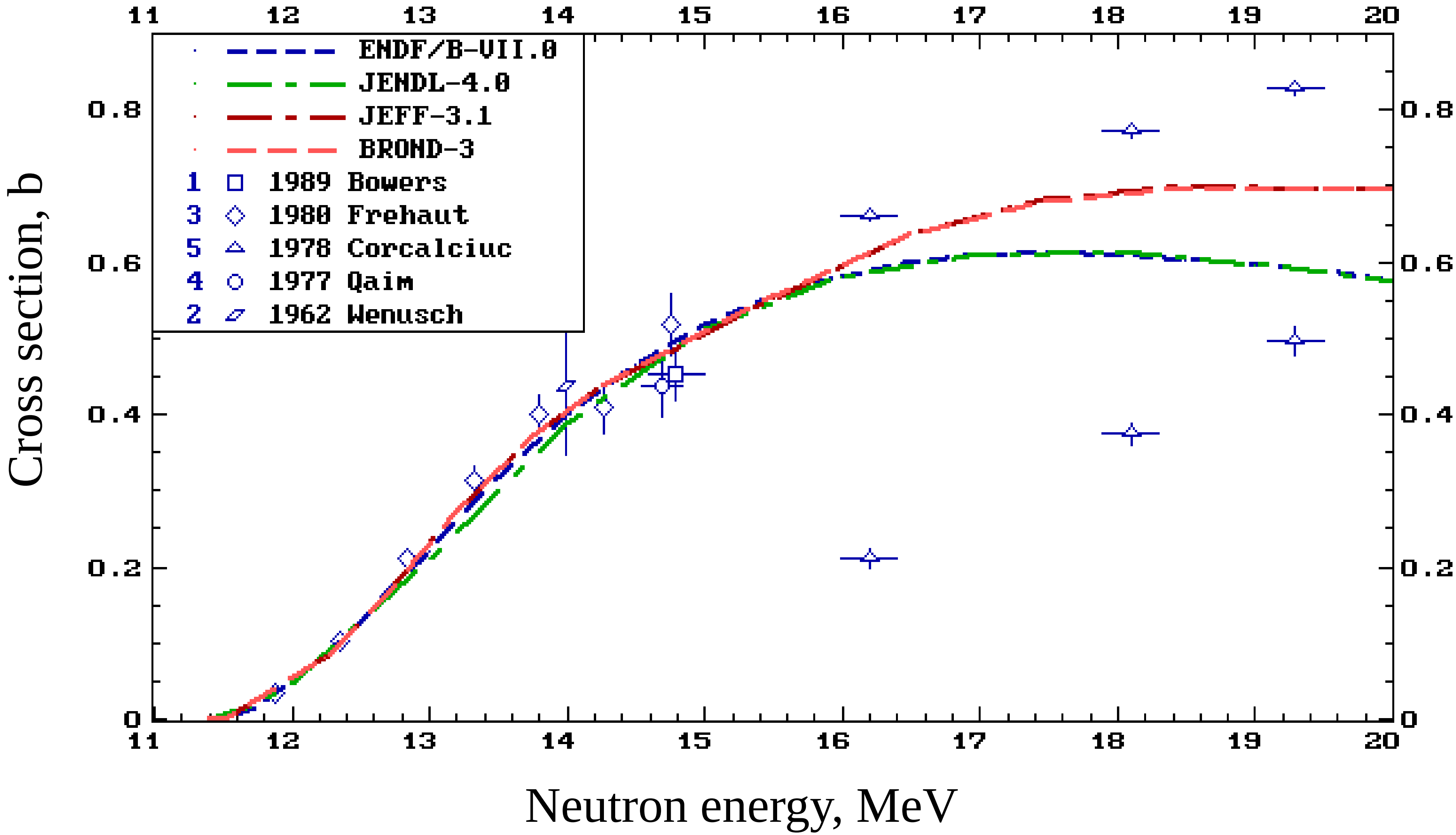


Covariances for the ^{238}U(n,2n) cross-section evaluations

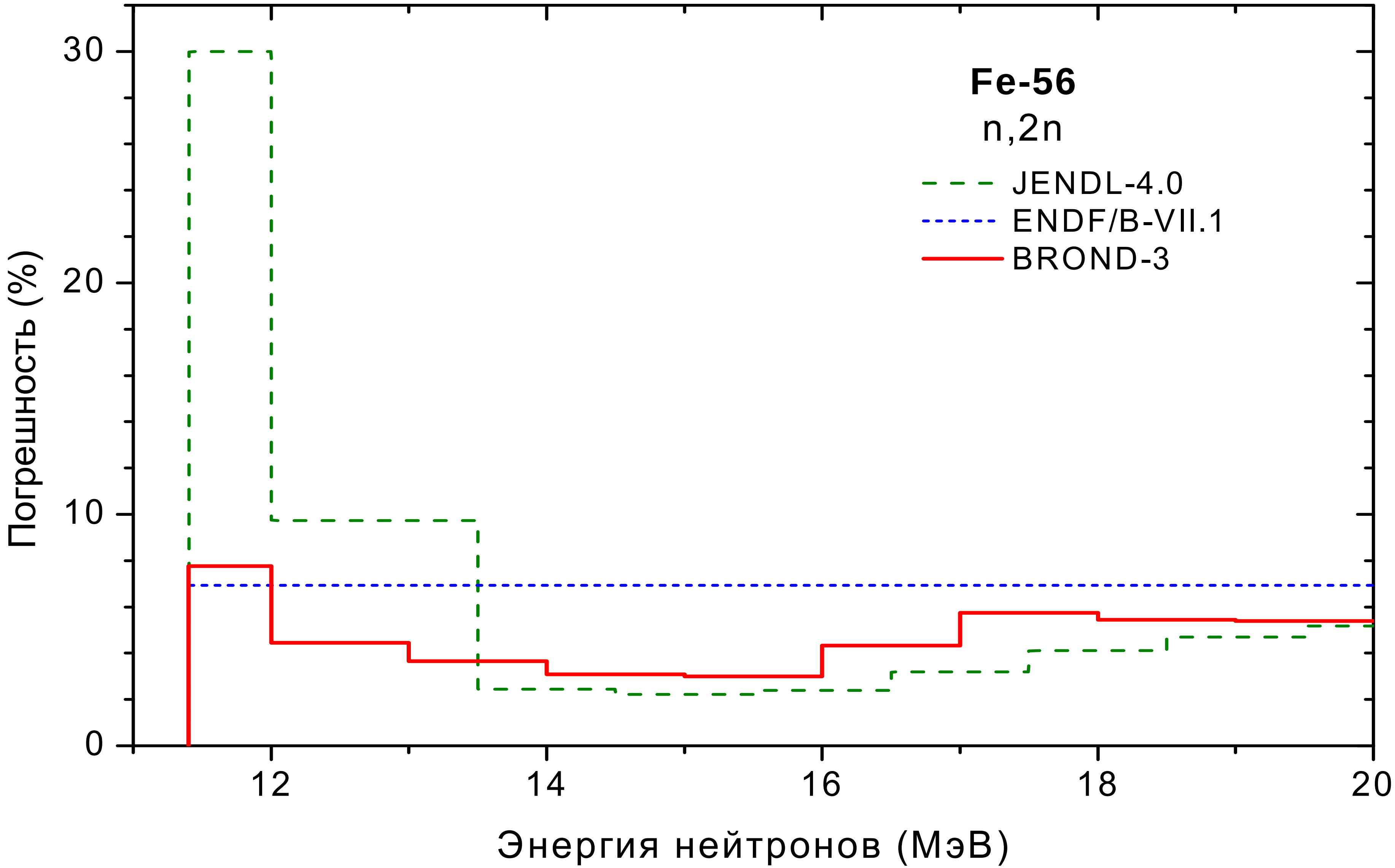




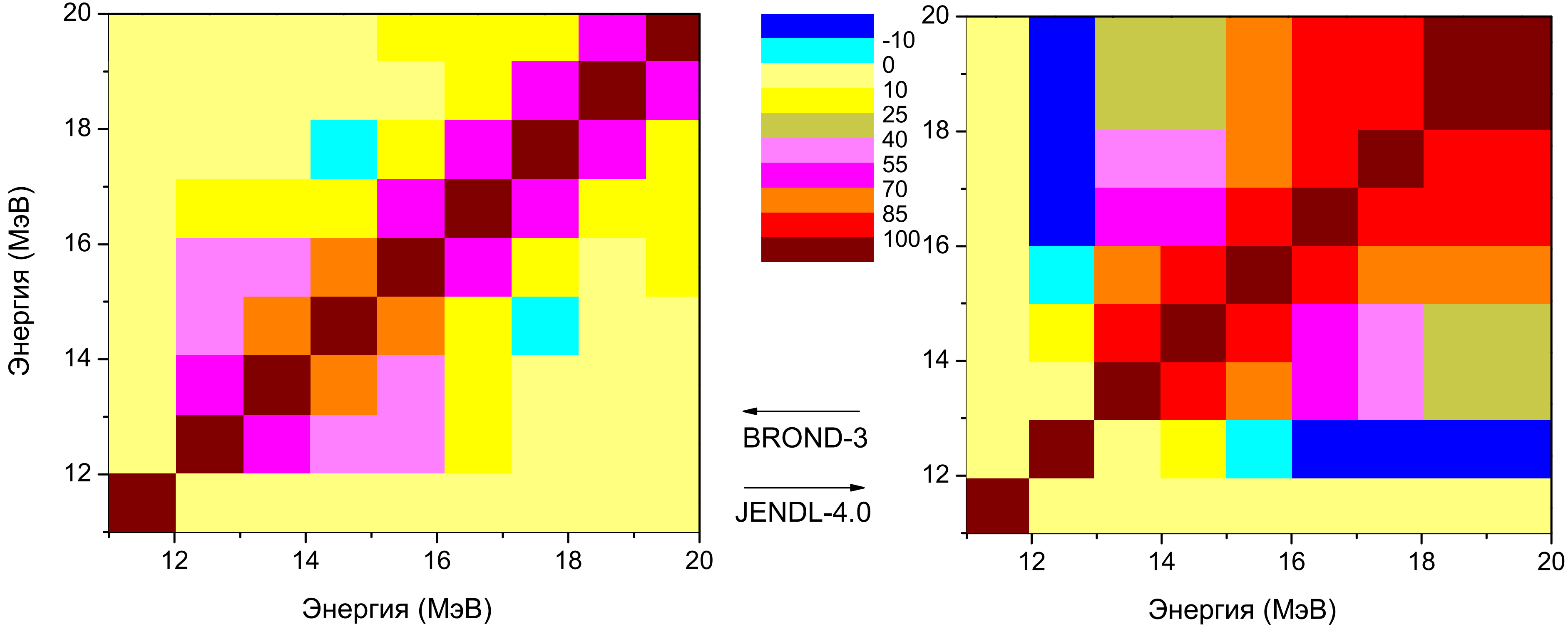
Available experimental data and evaluations for the $^{56}Fe(n,2n)$ cross-section



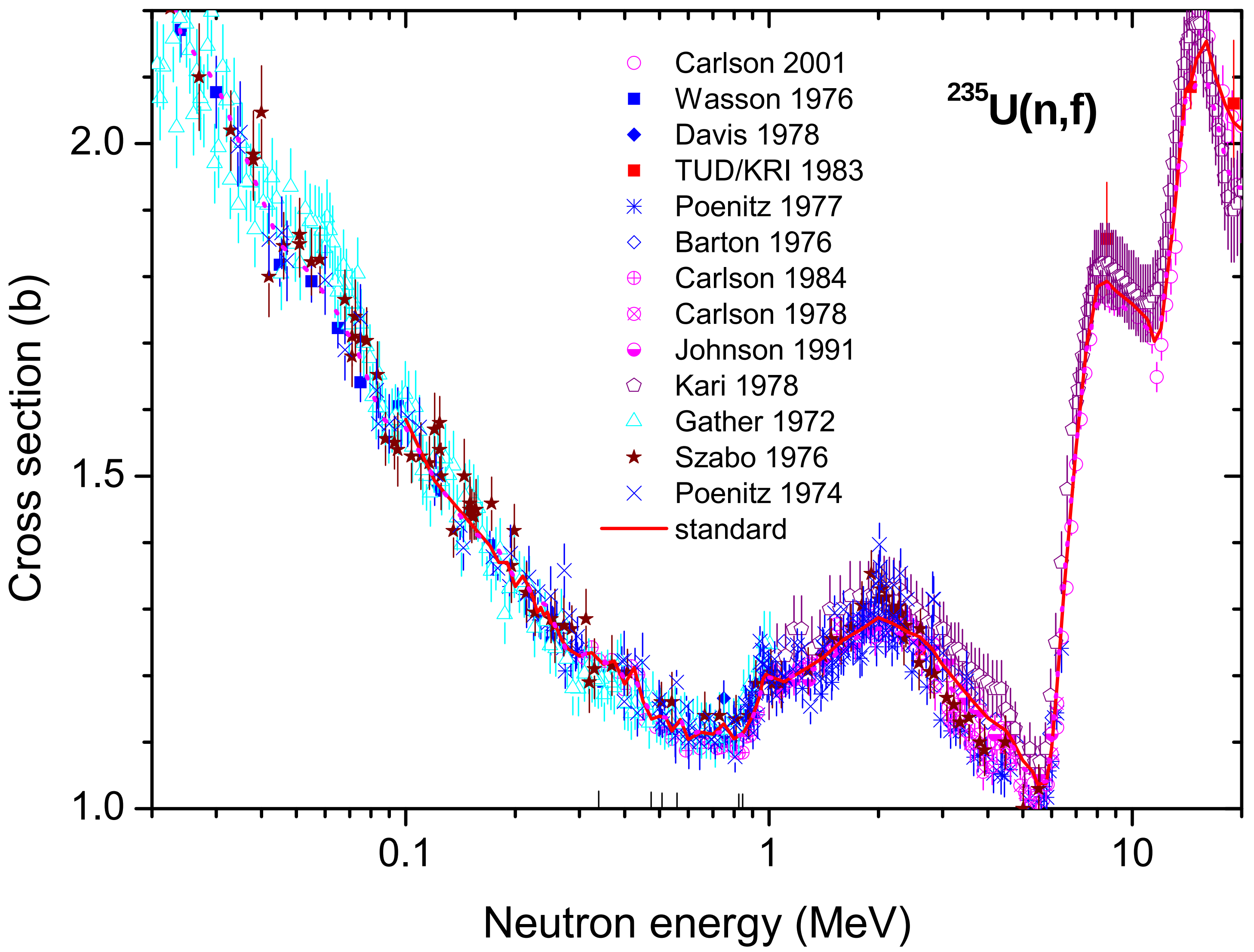
Uncertainties of the $^{56}Fe(n,2n)$ cross-section evaluations



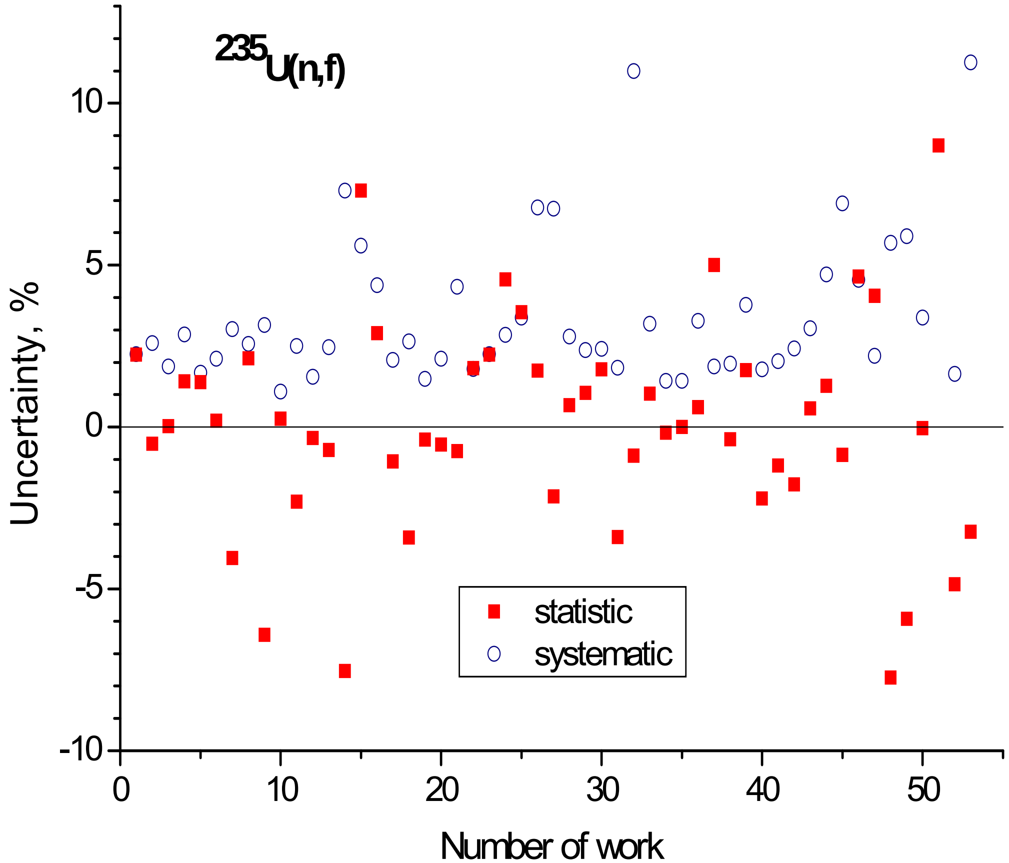
Covariances for the ^{56}Fe(n,2n) cross-section evaluations



Available experimental data for the $^{235}U(n,f)$ cross section

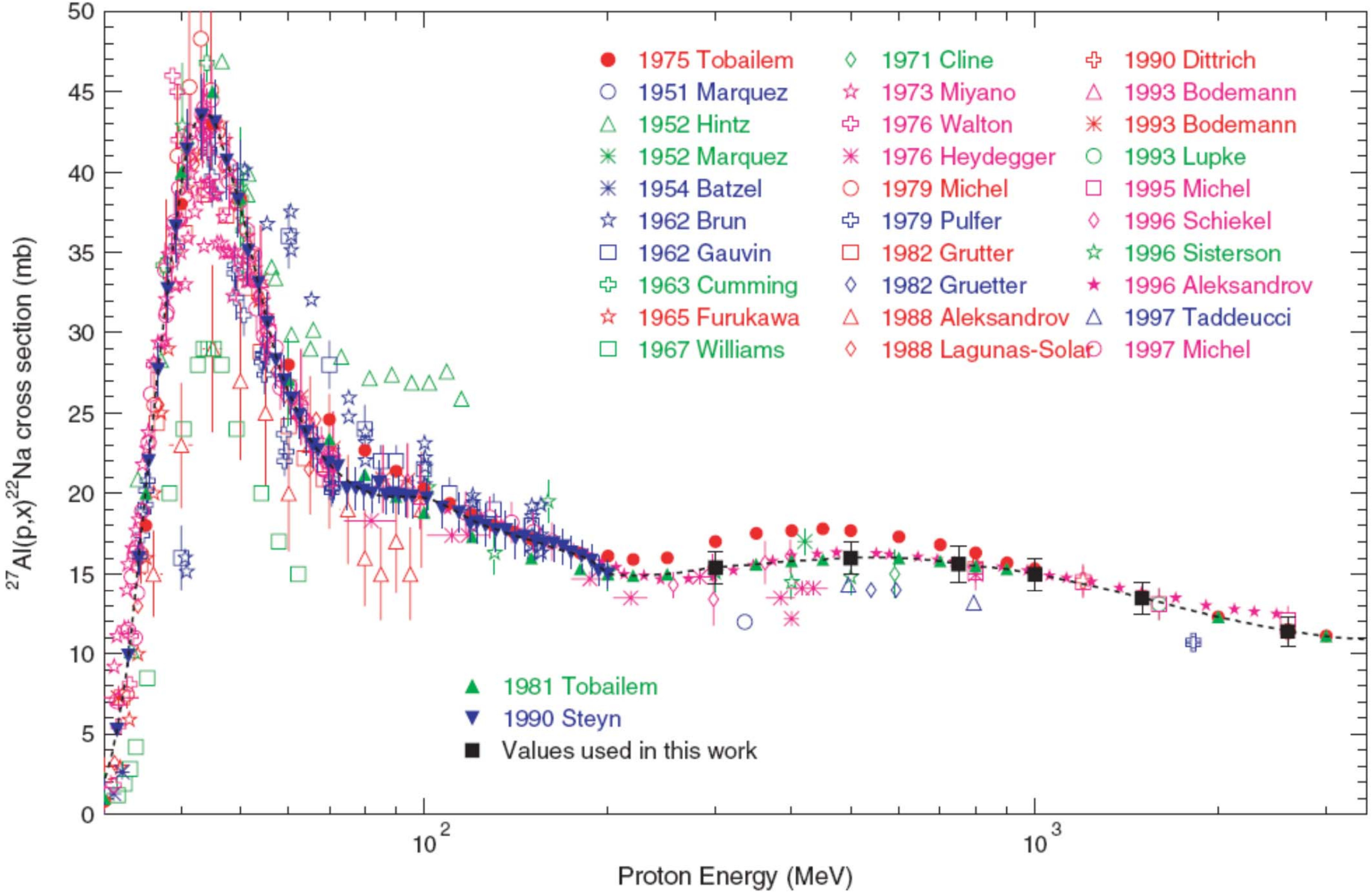


The unrecognized error-estimation method

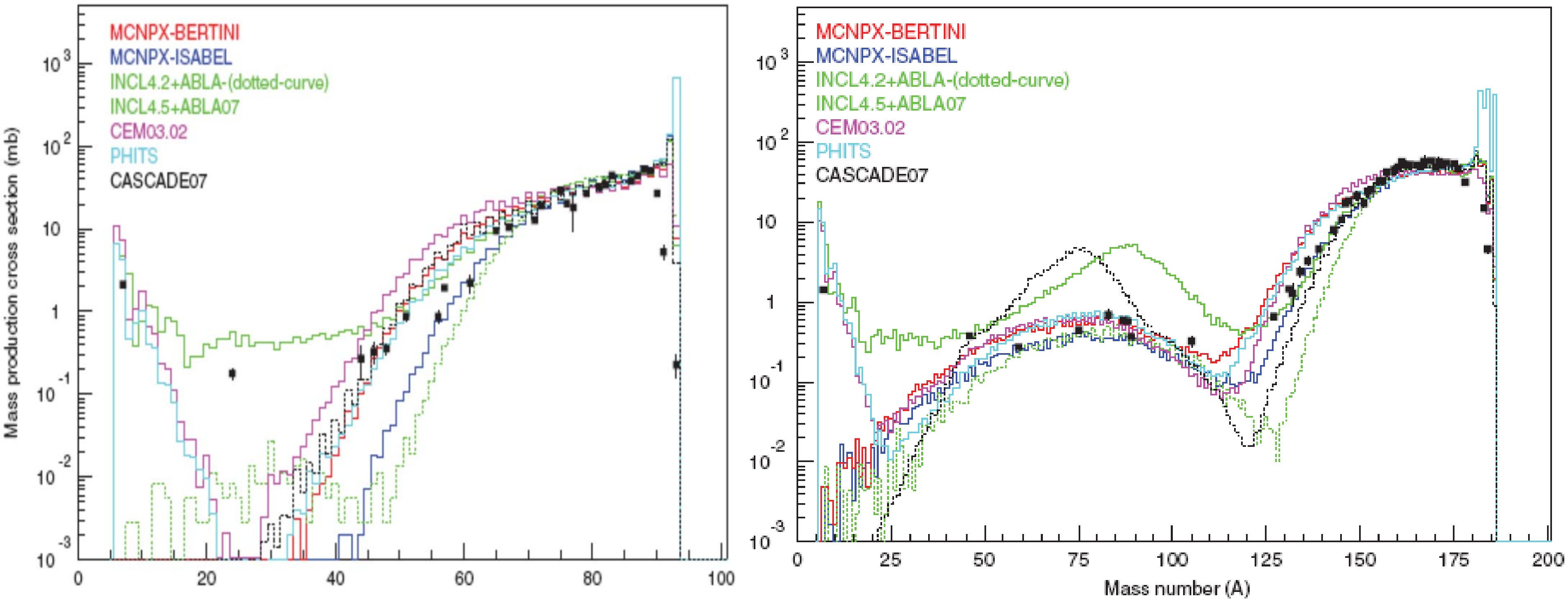


i) The total amount of works considered is 107 (about 10 thousands exp. points), 53 works are left after selection.
ii) All data are fitted by the optimal Pade parameterization.
iii) A distribution of each work data around a shifted individual description estimates an average statistical error of this work.
iv) A shift of individual data set concerning the common fitted curve estimates a systematic error of the work.
v) A width of the systematic error distribution estimates a general uncertainty of all data.

$^{27}Al(p, x)\,^{22}Na$ cross section for the 25–3000 MeV energy range used at the ITEP activation measurements /Phys. Rev., C **78**, 034611 (2008)/



Calculated mass distributions of product yields for the targets of ^{93}Nb (left plot) and ^{nat}W (right one) irradiated with 0.8-GeV protons compared with the measured cumulative and supracumulative yields./Phys. Rev., C84, 064612 (2011)/



Conclusion:

•Large amounts of new experimental data on the charged-particle induced reactions have been obtained during the last decade. These data allow revising many previous recommendations on the monitor reaction cross sections and the isotope production yields.

•The theoretical model parameters assuring an optimal description of experimental data were obtained for the most of nuclei used at practical applications.

•New methods of uncertainties estimations developed at IPPE allow performing a reasonable evaluation of uncertainties and covariances for recommended cross sections. The reasonable covariance matrices are the extremely important component of the present-day requests on the recommended nuclear data.