Karlsruhe Institute of Technology

PADF-2. Data for ^{32,33,34,36}S, ^{50,51}V, ^{55}Mn, ^{59}Co, and ^{93}Nb

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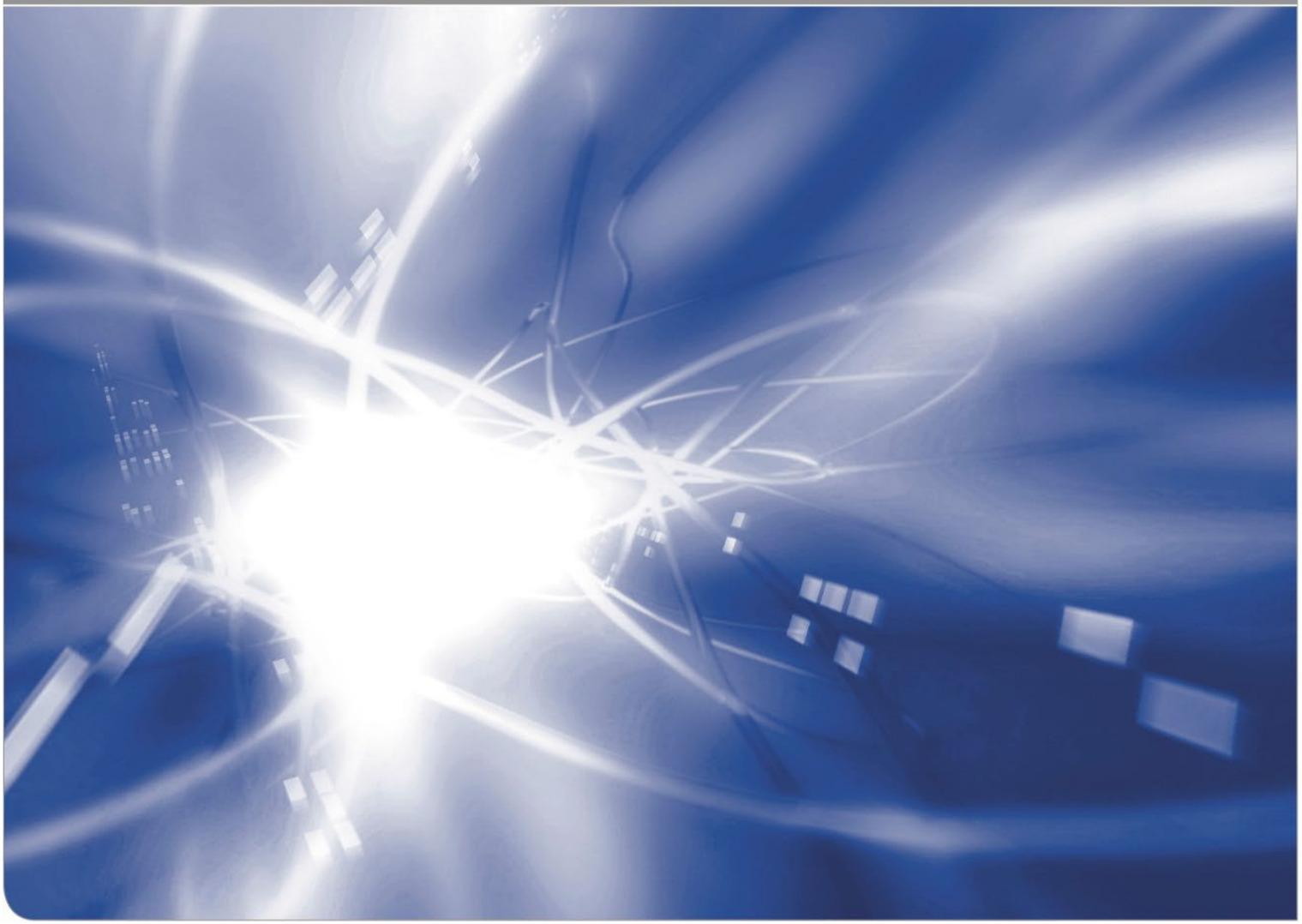

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Abstract

Cross-sections of nuclear reactions induced by protons by the irradiation of stable isotopes of sulfur, vanadium, manganese, cobalt, and niobium were obtained in the proton energy range from the reaction threshold up to 200 MeV. Obtaining the cross-sections involved calculations using various nuclear models and codes, analysis and use of experimental data.

The cross-sections were recorded using two different formats as separate files and as part of a general-purpose proton library JEFF-4.

The obtained files with only cross-sections can be downloaded from the https://t1p.de/3vzun website.

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1. Introduction

This work is a continuation of two others [1,2] devoted to the preparation of activation data files for proton induced reactions. This report describes the evaluation of cross-sections for stable isotopes of sulfur ^{32,33,34,36}S, vanadium ^{50,51}V, ^{55}Mn, ^{59}Co, and ^{93}Nb irradiated with protons at energies from reaction thresholds up to 200 MeV.

As in Refs. [1,2], the evaluation was performed using results of calculations with different models and computer codes, and experimental data.

The resulting files contain cross-sections of all observed reactions, provided and not provided by experimental data. It also concerns the total production cross-sections of neutrons, protons, deuterons, ^{3}He, α-particles, and heavy fragments.

The files were recorded in two different formats, in one case using the MF=10, MT=5 numbers [3] as in Refs. [1,2], in the other case the cross-sections were included in the JEFF-4 general-purpose files for protons, which also contain data obtained by other authors, as double differential cross-sections and others.

The files recorded with MF=10, MT=5 can be downloaded from Ref. [4] and data as part of JEFF-4 general-purpose files from Ref. [5].

The following Sections summarize the general principles of the use of experimental data, the results of calculations using different methods and codes, the evaluation of the cross-sections, the data file format, and results.

2. Experimental data

As in Refs. [1,2], the EXFOR data [6] recorded in C5 format [7] were used to prepare data for the subsequent evaluation. The experimental data shown in the Figures in the report are from Refs. [8-37], cited from the records of EXFOR. References to all data used in this work can be found in the obtained files [4].

In many cases, the information contained in the EXFOR files has been verified by analyzing data presented in published original papers describing the measurements. The most important issues were: is the compiled cross-section cumulative or independent; was the sum of isomer and ground state formation measured in the appropriate cases or only the ground state yield; is the observed deviation in the threshold energy region with the calculation results a possible consequence of the influence of impurities in the irradiated sample.

In the case where the measured cross-section is partial ("*PAR*"), an analysis was carried out to determine the possibility of using these data as a complete cross-section in a certain energy range. For this purpose, the results of calculations performed with the TALYS-2.0 code [38,39] and different models for the nuclear level density were applied.

All necessary available experimental information was used for the final evaluation of cross-section: data on individual and cumulative yields of individual isotopes, as well as independent and cumulative data for natural mixtures of isotopes. For a single reaction on a single isotope, the measured data for that specific reaction, if available, and the data extracted from the independent and cumulative data for the natural mixture of isotopes, if exist, were used. A special procedure was used for this purpose. In other words, data for natural mixture and/or cumulative data have never been used for simple comparison after evaluations performed for separate isotopes, but have always been applied directly as part of the information on the cross-section for this reaction.

For each reaction, experimental data obtained by different authors were further analysed for possible inclusion in the final data set used together with the calculation results for the evaluation of cross-section. In some cases, as for the reactions shown in Fig. 1, such a choice of data suitable for evaluation is of principal importance for the quality of the subsequently evaluated cross-section.

It is no secret that published experimental works do not always contain clear information about the presented results, for example, whether the cumulative or independent cross-section was measured. For this reason, the analysis of the data selected for evaluation also contains a certain amount of uncertainty. Fortunately, in some cases, the interpretation of a given measurement as cumulative does not change the cross-section value essentially, because the possible contribution of the precursors is relatively small. However, such a conclusion cannot be drawn solely from the analysis of a published article and requires verification through calculations, which, unfortunately, also contain some uncertainty.

Another important question is how much we can trust the measurements made in the 1950s and 1960s. Comparison with newer measurements, if they exist, sometimes shows a noticeable difference between the "old" and "new" measurements.

The answer to the question is difficult due to the lack of proper analysis of possible errors of the old measurement technique. In any case, in this paper, results of measurements made in the 50-60s are used with caution.

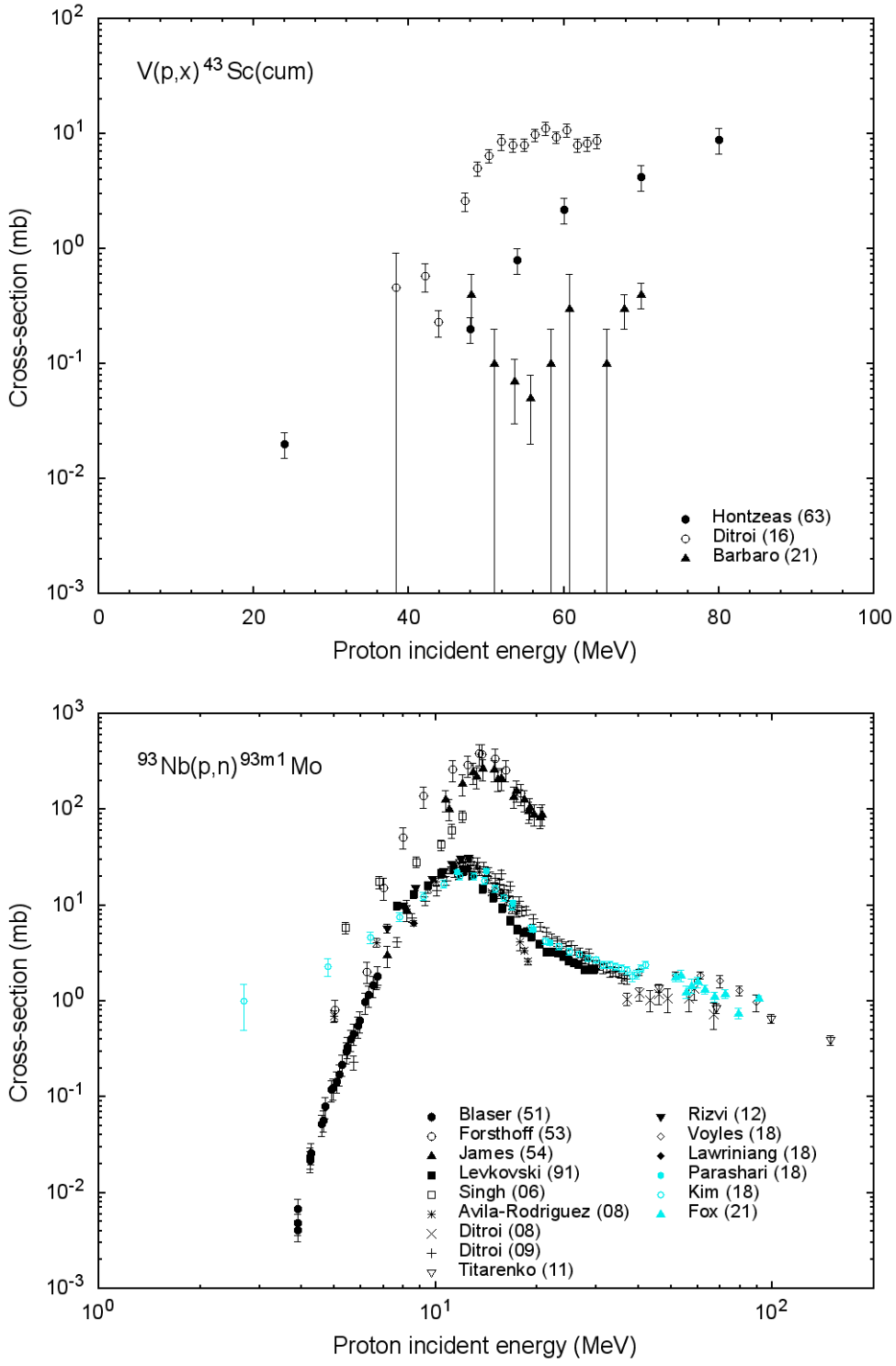

Fig.1 Examples of scatter of experimental data. See references in the text.

3. Calculation of cross-sections

The calculations were performed using current versions of the codes ALICE/ASH [40-42], CEM [43,44], PHITS [45,46], TALYS [38,39], and TALYS-G [47-49]. The calculations using TALYS-2.0 were carried out using various models describing the level density of excited states and corresponding to the input code parameters *ldmodel* equal *1, 2, 3,* and *5*. The optimal parameters of the models obtained by the authors [39] were applied by including the value "*fit y*" for the parameters *ldmodel* = *1, 2,* and *5* in the input data fille.

In general, for most reactions there is a fairly noticeable spread in the results of calculations using different codes and models. The examples are shown in Fig.2.

Sometimes the differences in the calculation results for a specific reaction are due to the lack of a mechanism for modelling a particular process, for example, the pre-compound emission of heavy clusters (A > 4), the Fermi break-up [51], and sometimes due to a simplified description of particle emission, for example, using the Weiskopf-Ewing model [50].

Such features were taken into account when estimating the reaction cross-section by assigning appropriate statistical weights to various results, including zeros weights corresponding to the complete exclusion of certain codes from consideration.

The assignment of such weights is always associated with uncertainty, except in certain cases. For example, it seems sensible that at relatively low primary proton energies, when calculating the yield of products with Z and A close to the target ones, the preference should be given to calculations using the TALYS code, Fig.3. It should be noted that even in this case, calculations using different models describing the nuclear level density sometimes give markedly different cross-section values. Preference for calculating the cross-sections of the yield of heavy fragments should probably be given to the ALICE/ASH code, Fig. 4.

At energies of 150-200 MeV, it seems reasonable to use equal weights for all models, unless of course the correct prediction of the cross-section is impossible due to the above-mentioned lack of a reaction modelling mechanism or for some other reason.

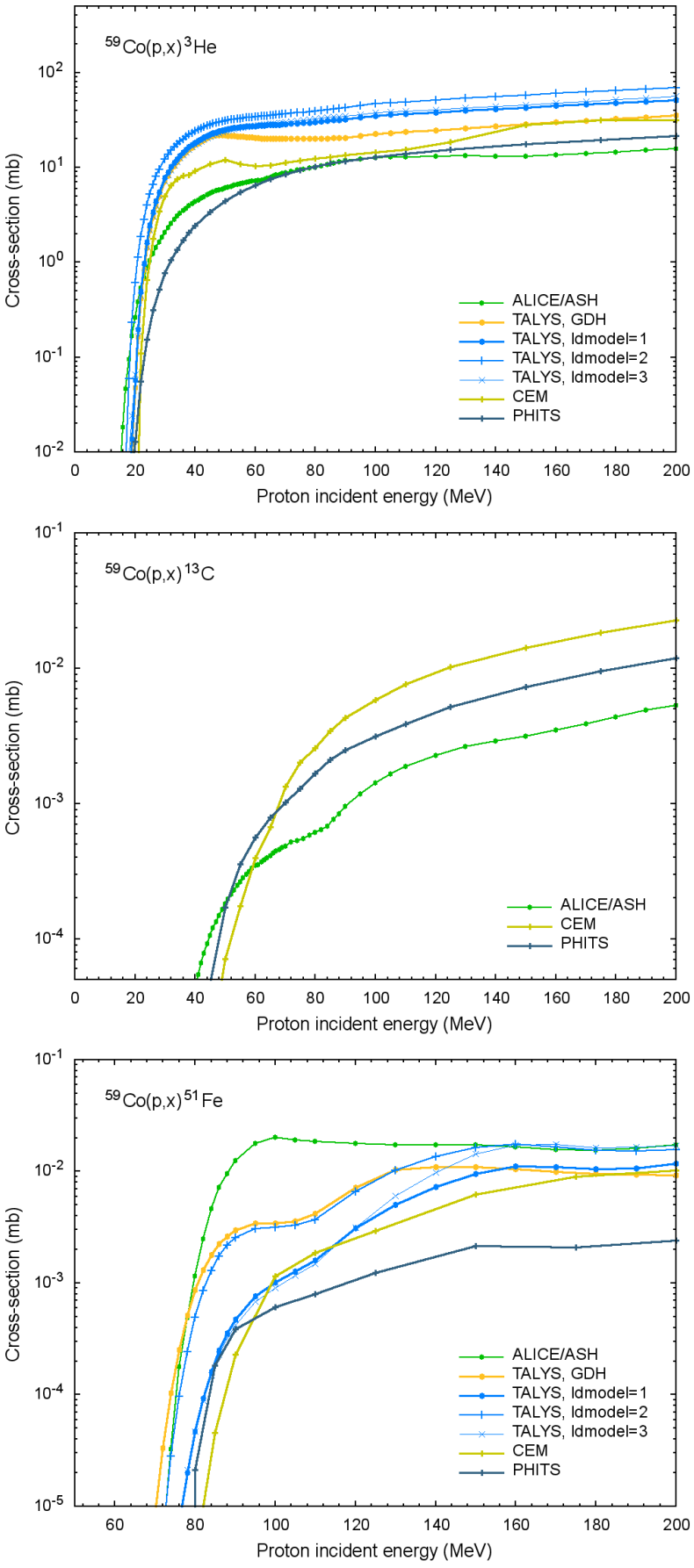

Fig.2 Examples of scatter of results of calculations.

Examples of the use of the weighted sum of cross-sections are shown in the Fig.5 and Fig.6. Figure 5 shows that the weighted averaged data are a rather reasonable preliminary estimate. In contrast, Fig. 6 shows that averaging the cross-sections does not solve the problem of consistency between the estimated cross-sections and measured data, at least for the production of ^{43}K.

In any case, the final evaluation was made using experimental data.

The cumulative cross-sections were calculated using the JEFF-3.3 data [52] and the SNT code [53].

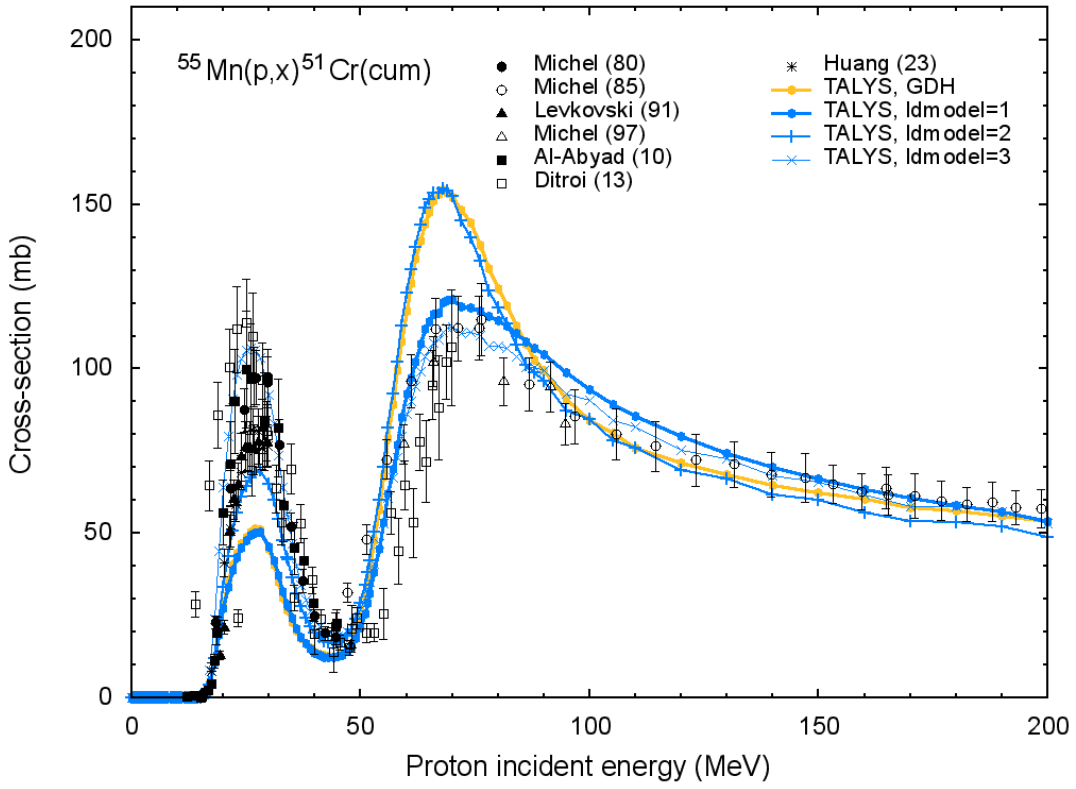

Fig.3 Example of calculations performed using TALYS-G, and TALYS-2.0 with the different models for nuclear level density. In the case of TALYS-G, the value of *ldmodel* is equal to *1.*

4. Evaluation of cross-sections

Evaluation of cross-sections, in the exact sense of the word, was performed both for reactions with measured cross-sections and for which experimental data were not available. In the latter case, the evaluation was carried out using results of calculations with different models and codes, as discussed in Section 3.

When experimental data were available in a limited energy region, the cross-sections were evaluated using these data and an estimate obtained from the calculation results.

For some reactions, sufficient experimental data were available to evaluate cross sections using primarily these data.

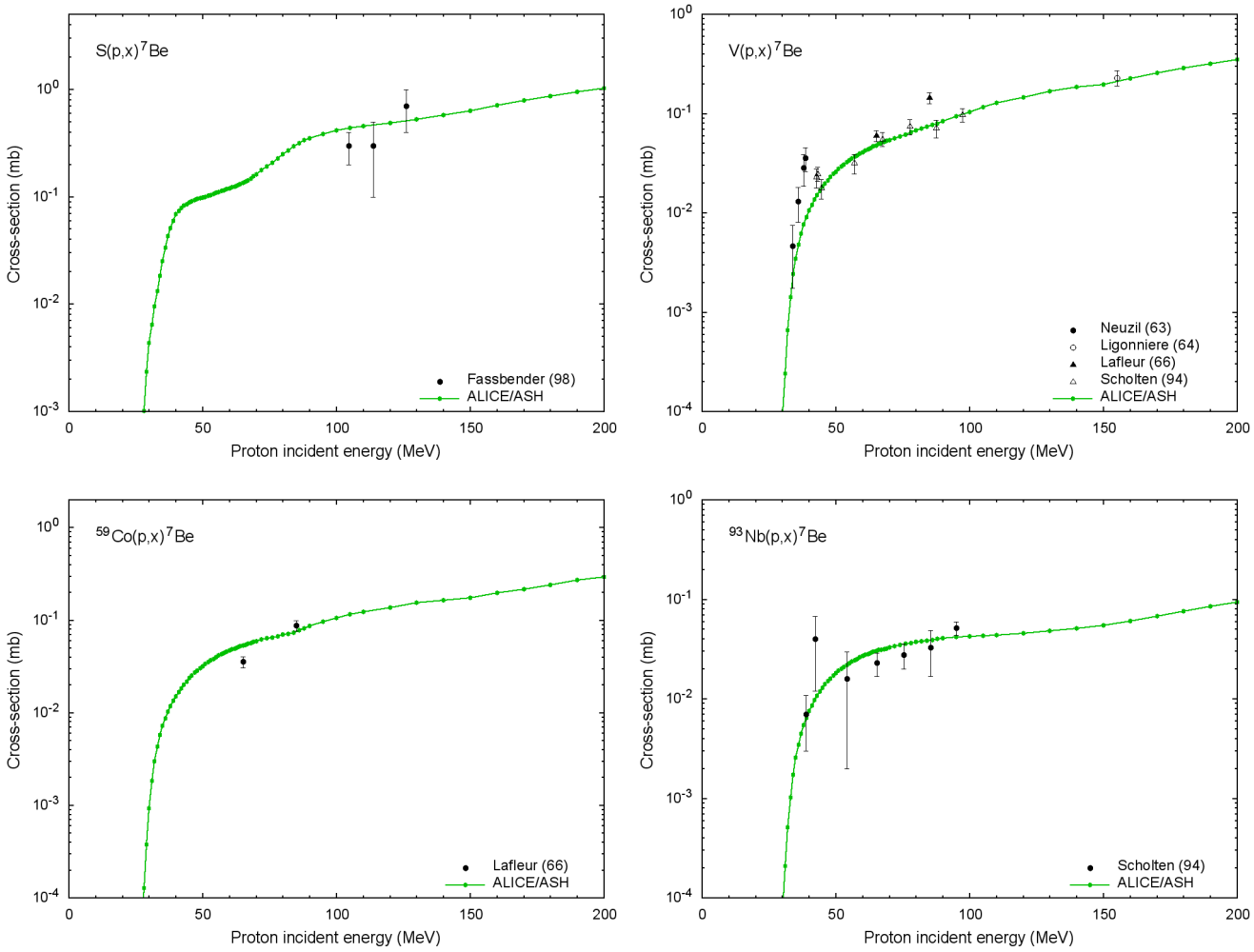

Fig.4 Examples of (p,^{7}Be) reaction cross-section calculated using ALICE/ASH code. Relatively good agreement is achieved by using the models of pre-equilibrium and equilibrium emission of fragments with A > 4.

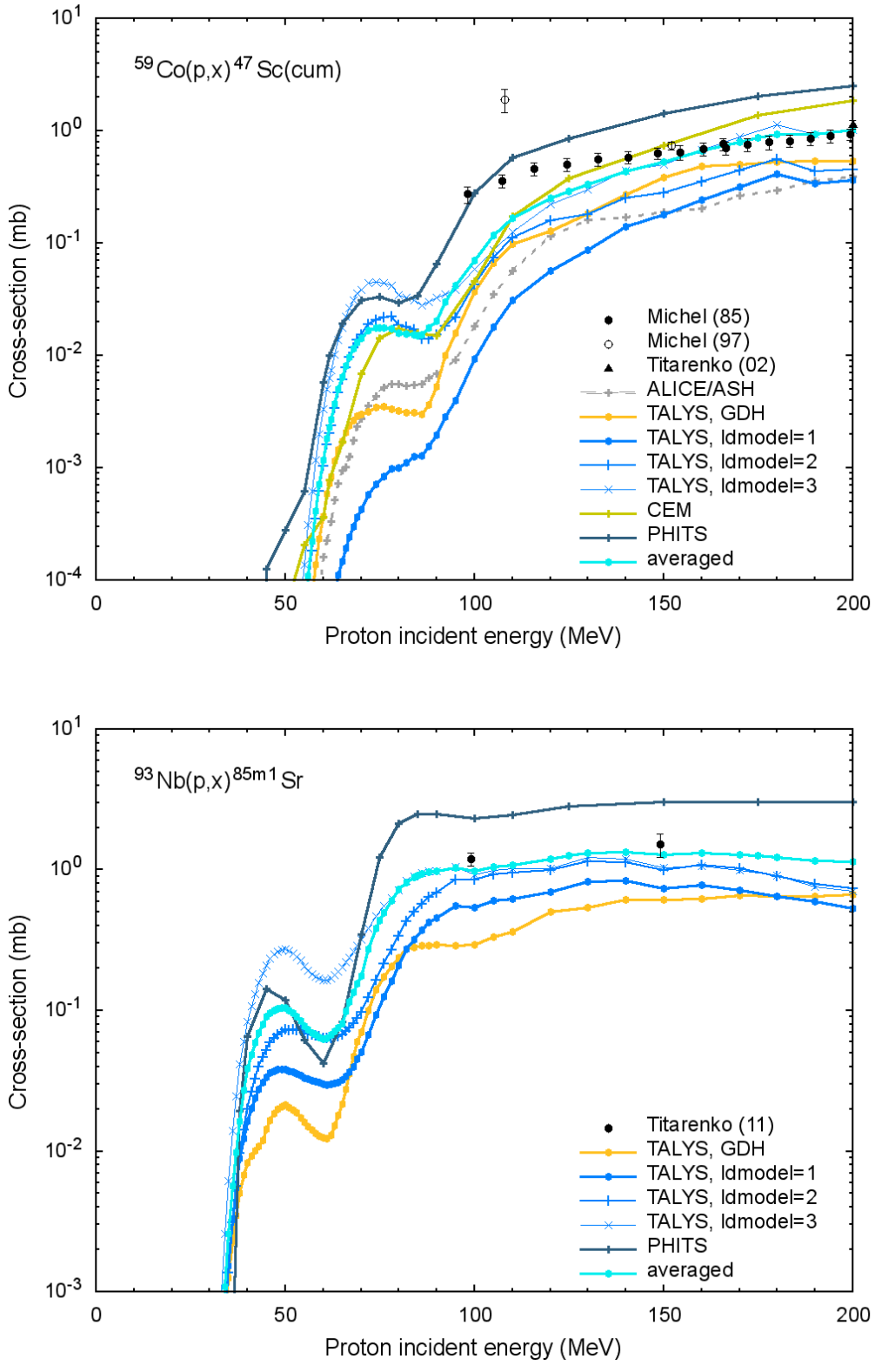

Fig.5 Examples of reactions for which the use of a weighted sum of the results of various calculations gives a rather reasonable approximation to experimental data. The final evaluated data for these reactions are shown in the Appendix, page A69 and A101.

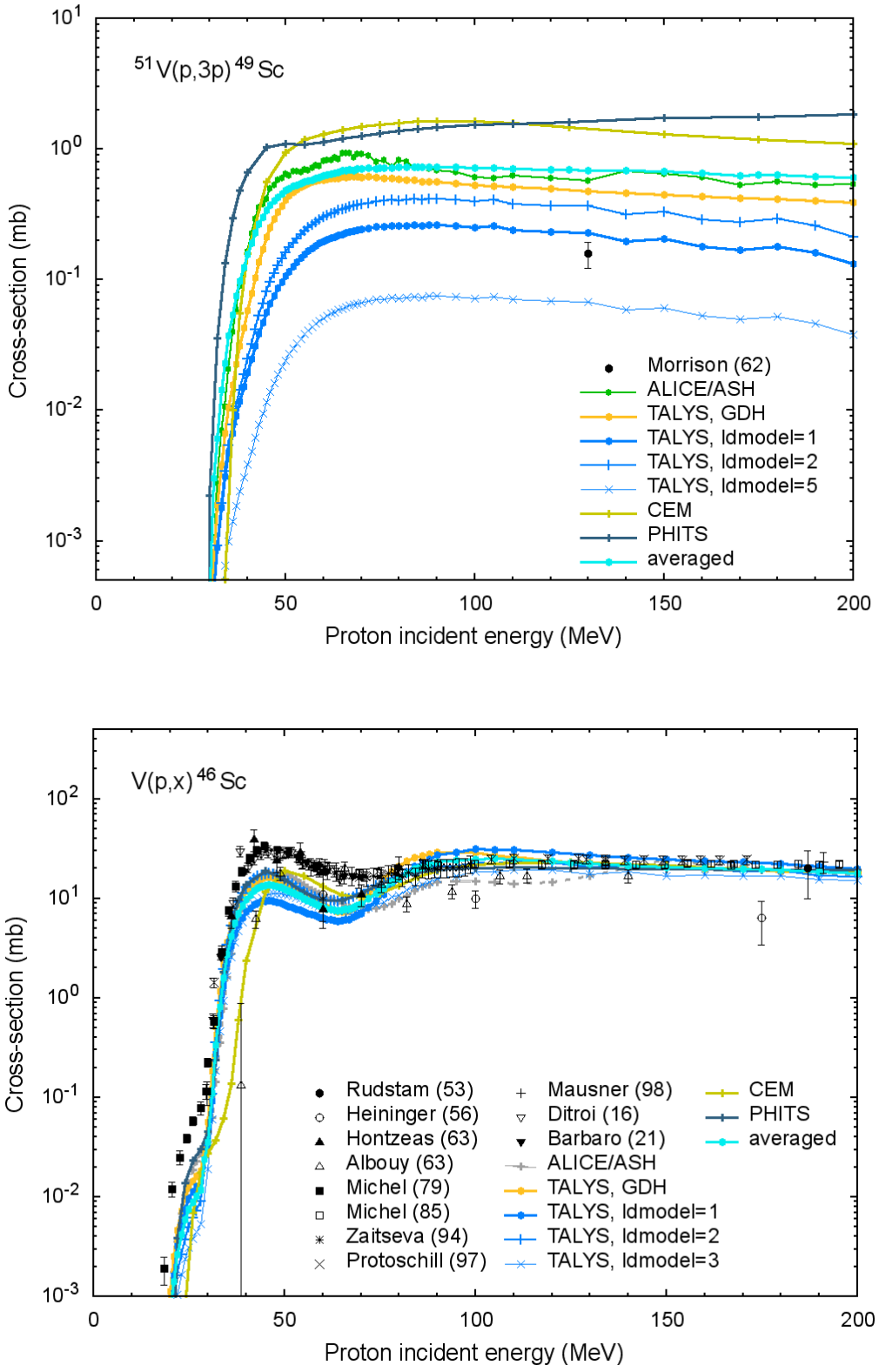

Fig.6 Examples of reactions for which the weighted sum of the results of calculations does not solve the problem of agreement with experiment. The final evaluated data for these reactions are given in the Appendix, page A26 and A36.

The recommended data [54,55] for beam monitor reactions were included in the new files, as in Refs. [1,2]. In addition, the cross-sections for the ^{93}Nb(p,x)^{90}Nb(cum) reaction were taken up to 100 MeV from Refs. [54,56]. It is planned to incorporate all recommended data [54] into PADF-2 in the near future. The progress can be followed in the generated files [4], where detailed information on the used data of other authors and experimental data is given in section MF=1, MT=451.

The example of evaluated data is shown in Fig.7.

A comparison of the evaluated and all available experimental data is given in the Appendix.

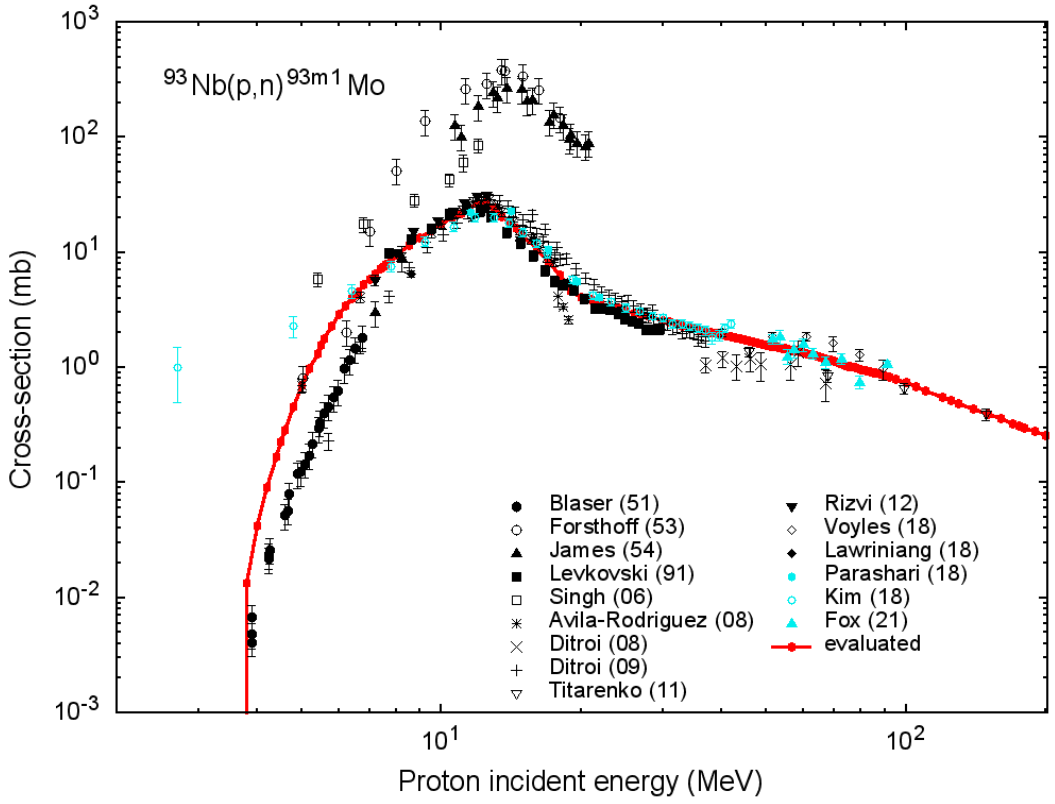

Fig.7 Example of evaluated reaction cross-section.

5. Format of the data files

The resulting files were written in two different formats using ENDF-6 rules [3]. In the first case, the files were recorded with MF=10 and MT=5, see Ref.[1] for details; in the second case, the files were integrated into general-purpose JEFF-4 files using MF=6 and MT=5 section.

6. Results

The cross-sections were obtained for proton induced reactions for stable isotopes of sulfur ^{32,33,34,36}S, vanadium ^{50,51}V, ^{55}Mn, ^{59}Co, and ^{93}Nb at energies up to 200 MeV.

The files contain cross-sections of all reactions occurring by emission of gammas, π-mesons, neutrons, hydrogen and helium isotopes, and fragments with A > 4.

The data obtained and recorded with MF=10, MT=5, together with the files prepared in Refs.[1,2], can be downloaded from Ref.[4].

The Appendix presents graphs of reaction cross-sections for which experimental data are available. First, data for individual isotopes of each element are presented, then data for the natural mixture, including independent and cumulative cross-sections. Reference to all measured data used in this work can be found in the files [4].

7. Conclusion

Proton-induced reaction cross-sections for stable isotopes of sulfur ^{32,33,34,36}S, vanadium ^{50,51}V, ^{55}Mn, ^{59}Co, and ^{93}Nb at energies up to 200 MeV have been evaluated.

The work involved calculations using various models and computer codes, as well as analysis of experimental data.

The resulting files, distributed under the name PADF-2, can be downloaded from Ref. [4] and the data as part of JEFF-4 general-purpose files from Ref. [5].

Acknowledgement

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A.Yu.Konobeyev, S.Kopecky, B.Kos, A.Krása, L.C.Leal, N.Leclaire, P.Leconte, Y.O.Lee, H.Leeb, O.Litaize, M.Majerle, J.I Márquez Damián, F.Michel-Sendis, R.W.Mills, B.Morillon, G.Noguère, M.Pecchia, S.Pelloni, P.Pereslavtsev, R.J.Perry, D.Rochman, A.Röhrmoser, P.Romain, P.Romojaro, D.Roubtsov, P.Sauvan, P.Schillebeeckx, K.H.Schmidt, O.Serot, S.Simakov, I.Sirakov, H.Sjöstrand, A.Stankovskiy, J.C.Sublet, P.Tamagno, A.Trkov, S. van der Marck, F.Álvarez-Velarde, R.Villari, T.C.Ware, K.Yokoyama, G.Žerovnik, The joint evaluated fission and fusion nuclear data library, JEFF-3.3, *Eur. Phys. J. A*, vol.56, p. 181 (2020)

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Appendix

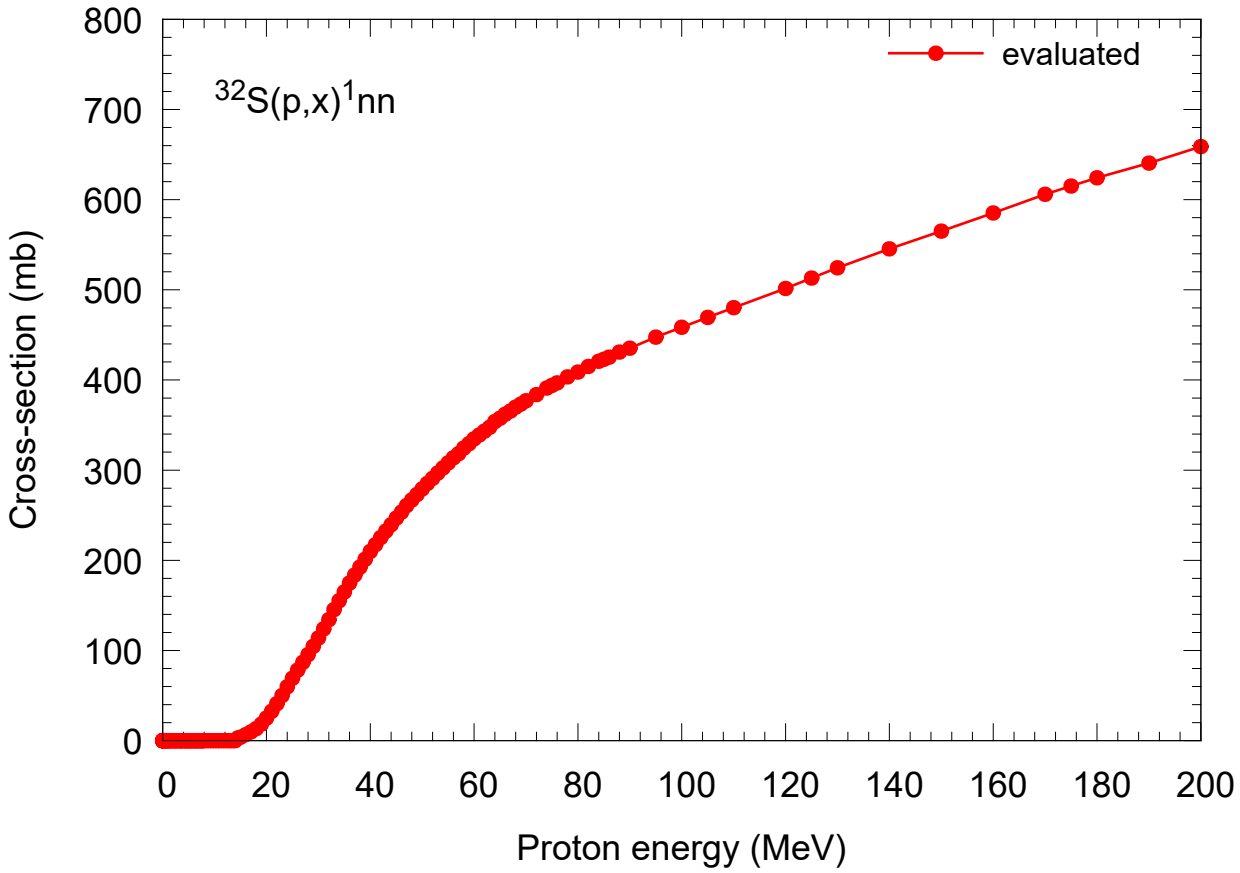
Sulfur

Vanadium

Manganese

Cobalt

Niobium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Proton energy (MeV)
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400
500
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700
800
0
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40
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80
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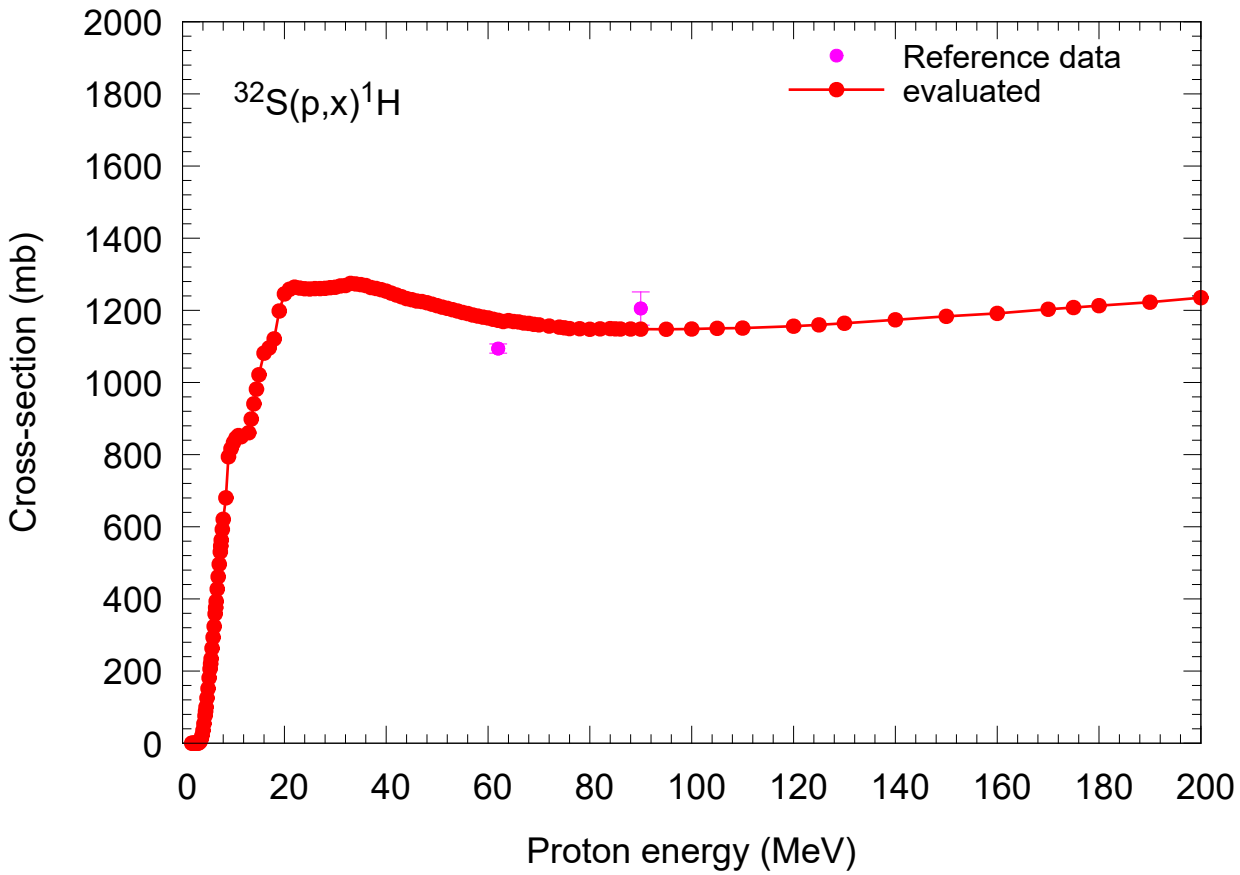
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Proton energy (MeV)
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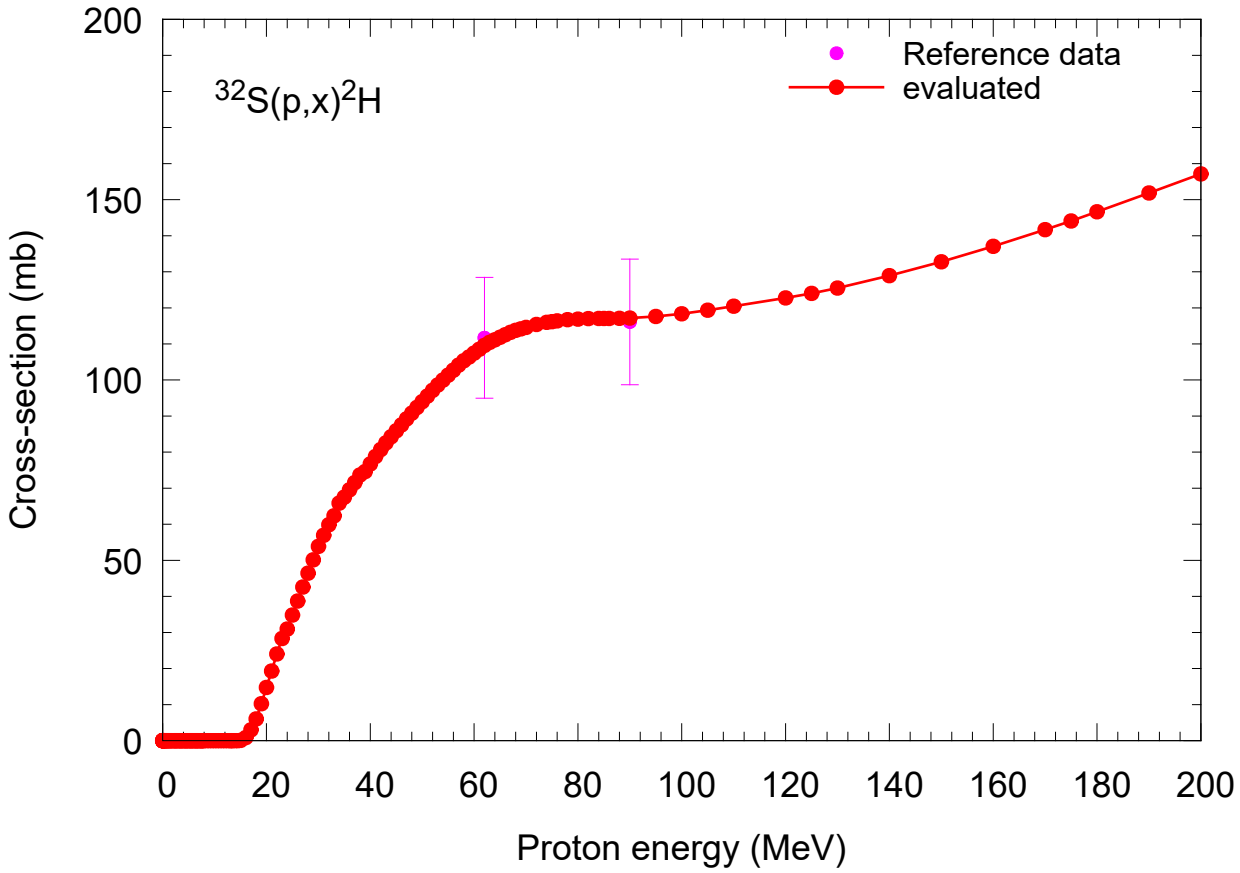
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Cross-section (mb)
Proton energy (MeV)
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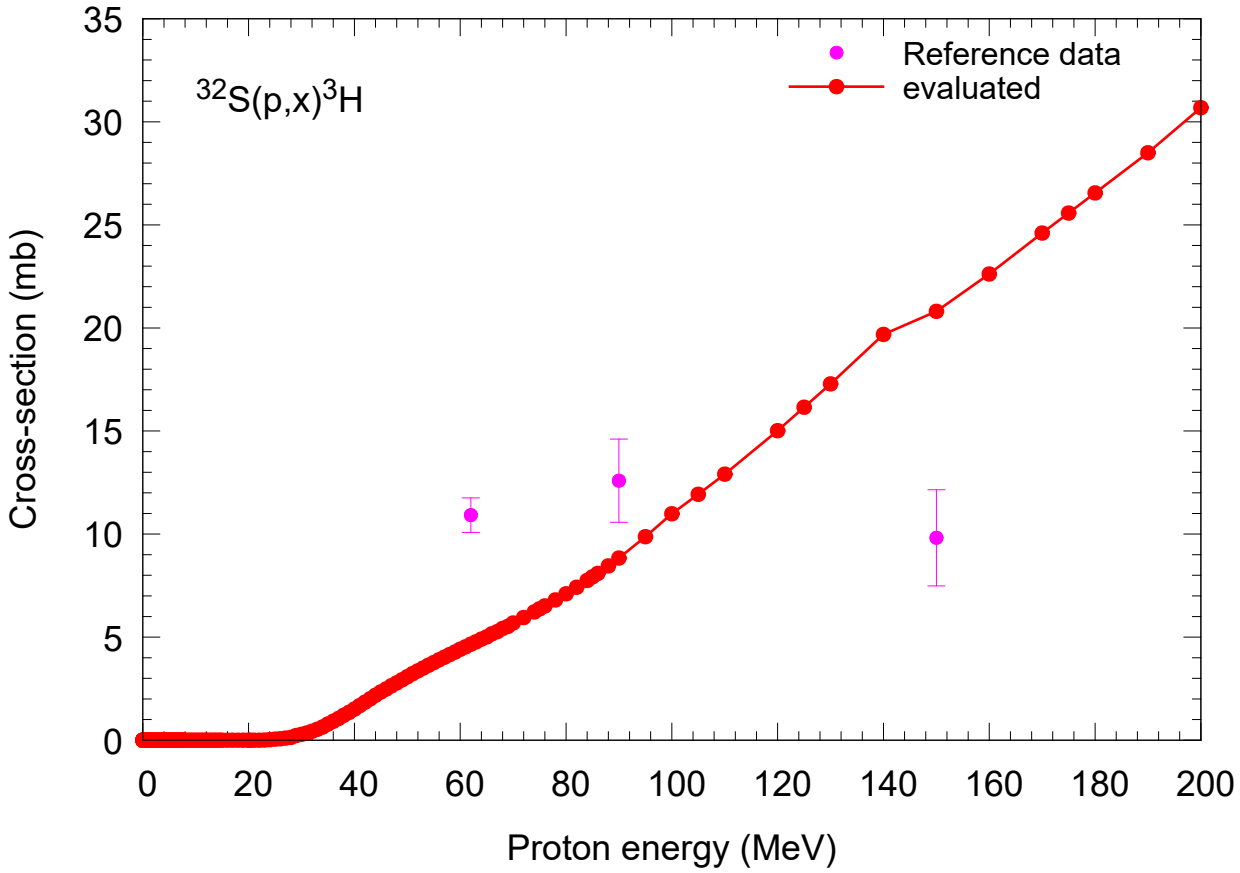
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Proton energy (MeV)
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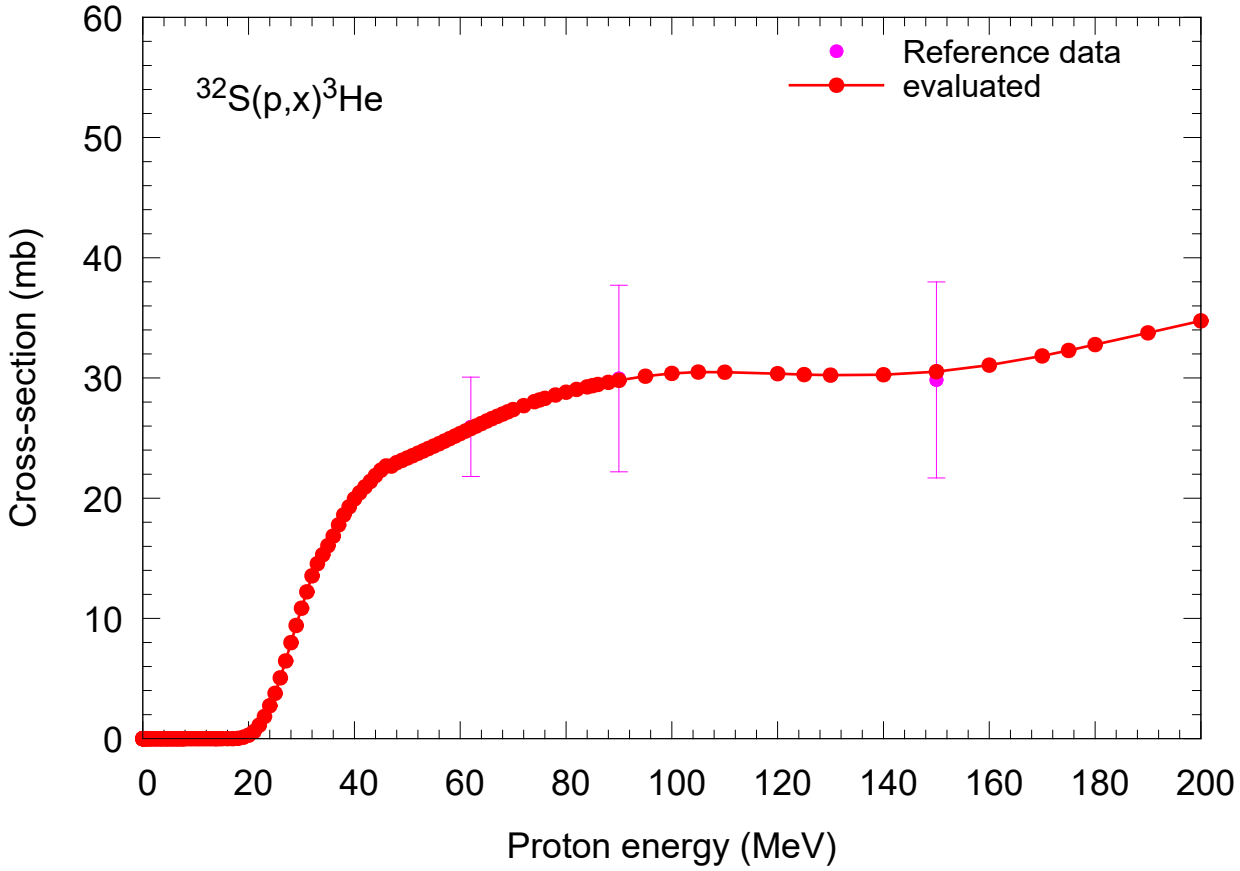
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Cross-section (mb)
Proton energy (MeV)
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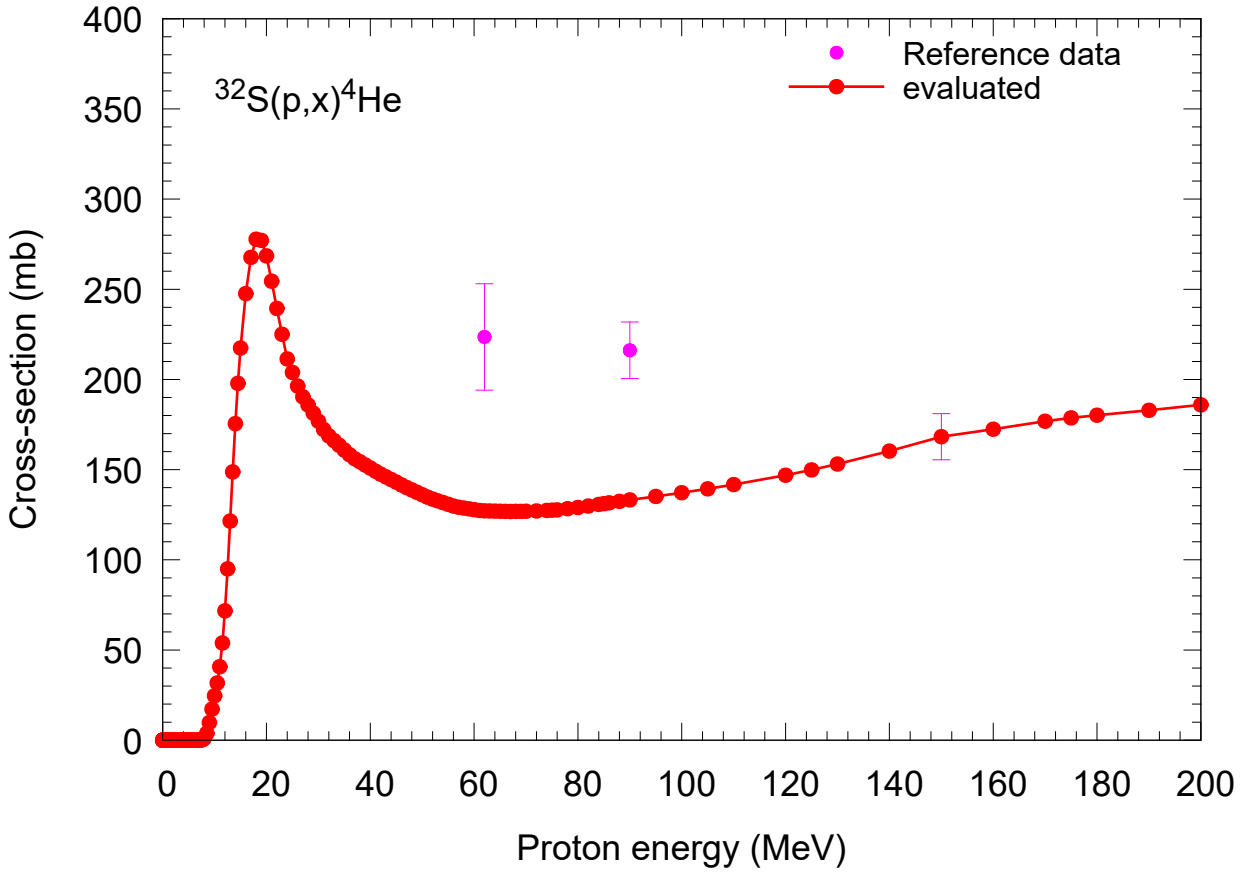
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Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
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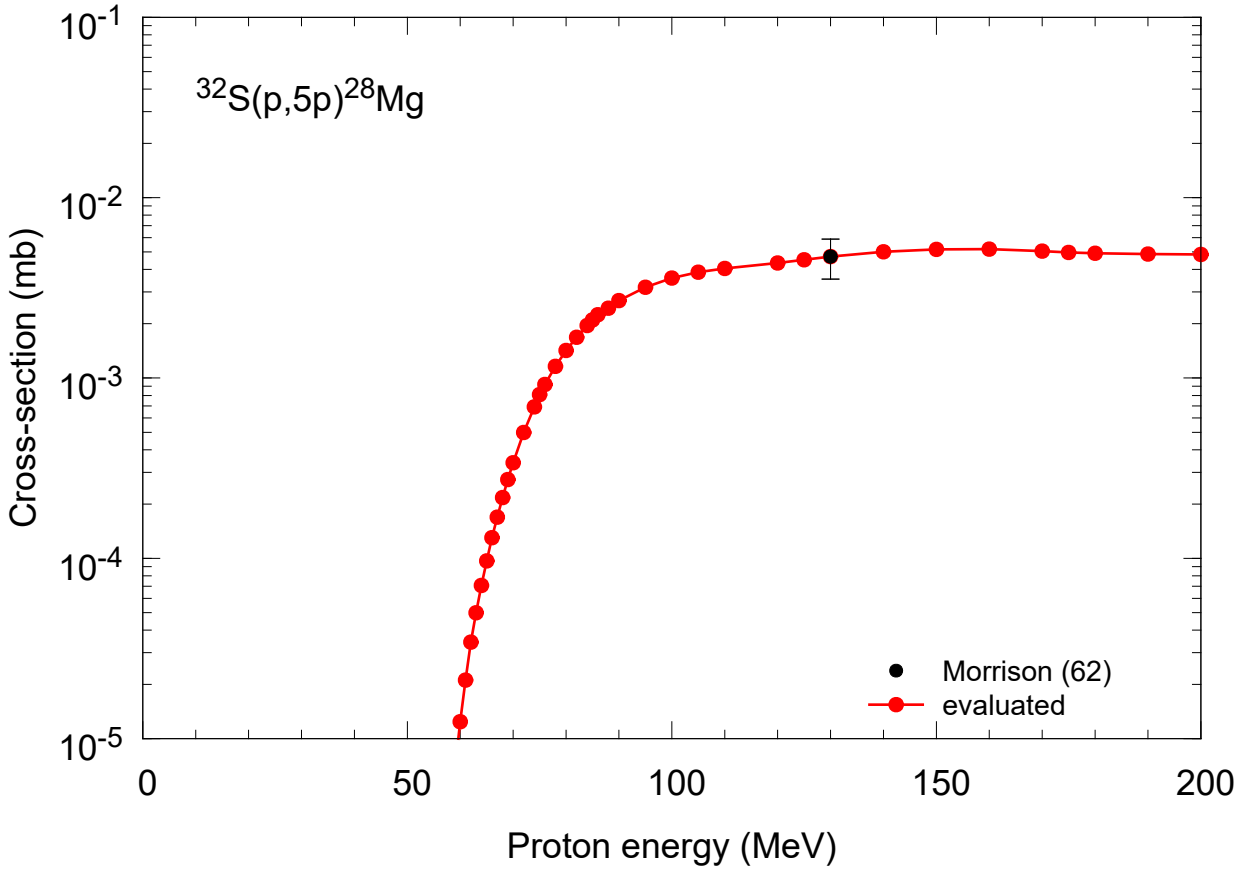
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10^{-3}
10^{-4}
10^{-5}
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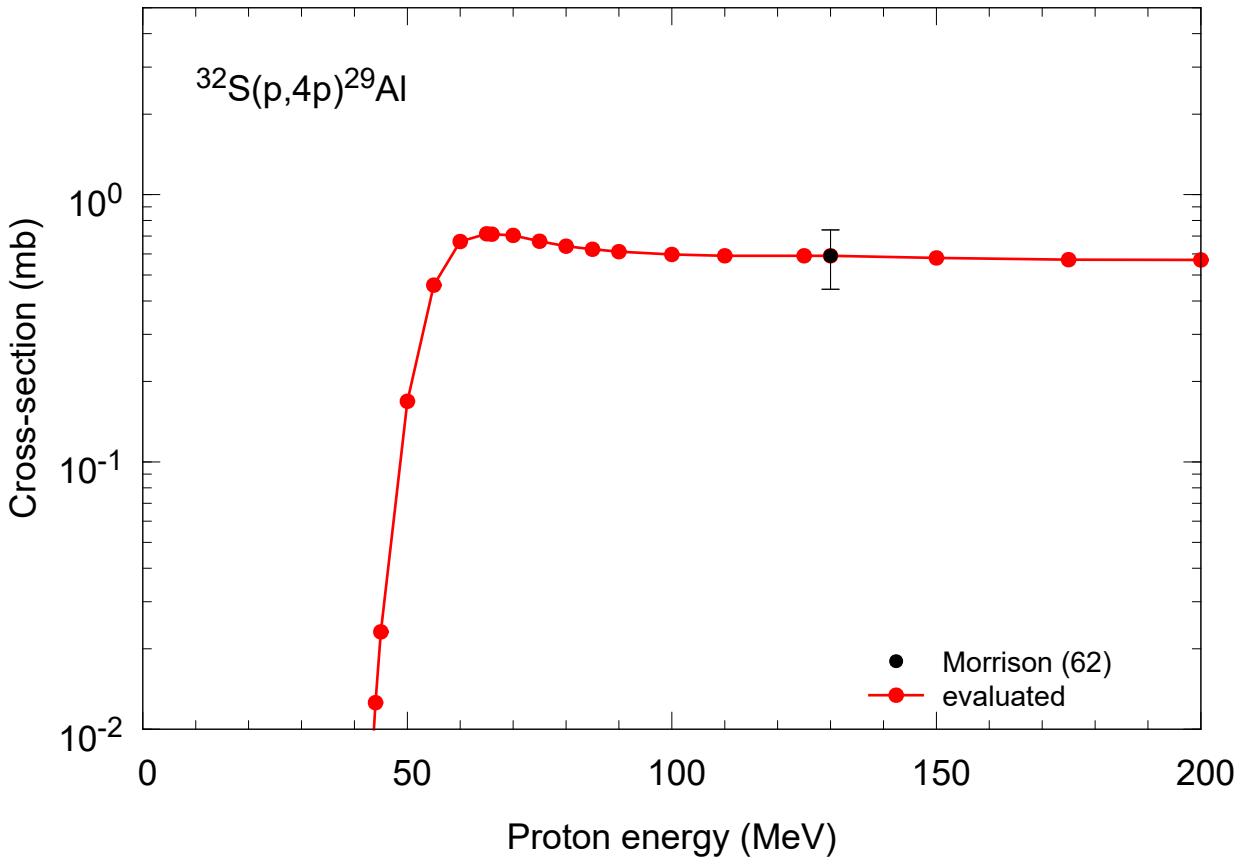
100
150
200
Proton energy (MeV)
Morrison (62)
evaluated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Cross-section (mb)
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10^{-2}
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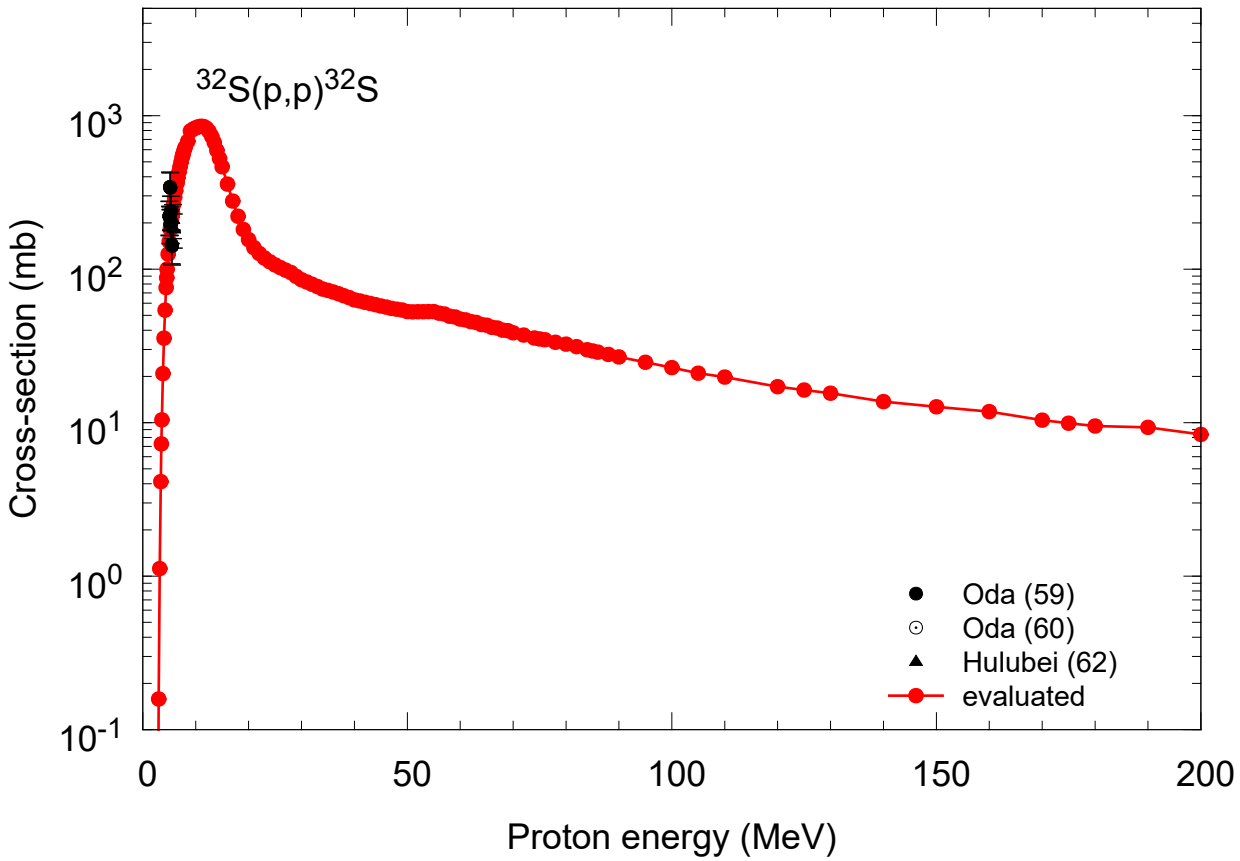
200
Proton energy (MeV)
Morrison (62)
evaluated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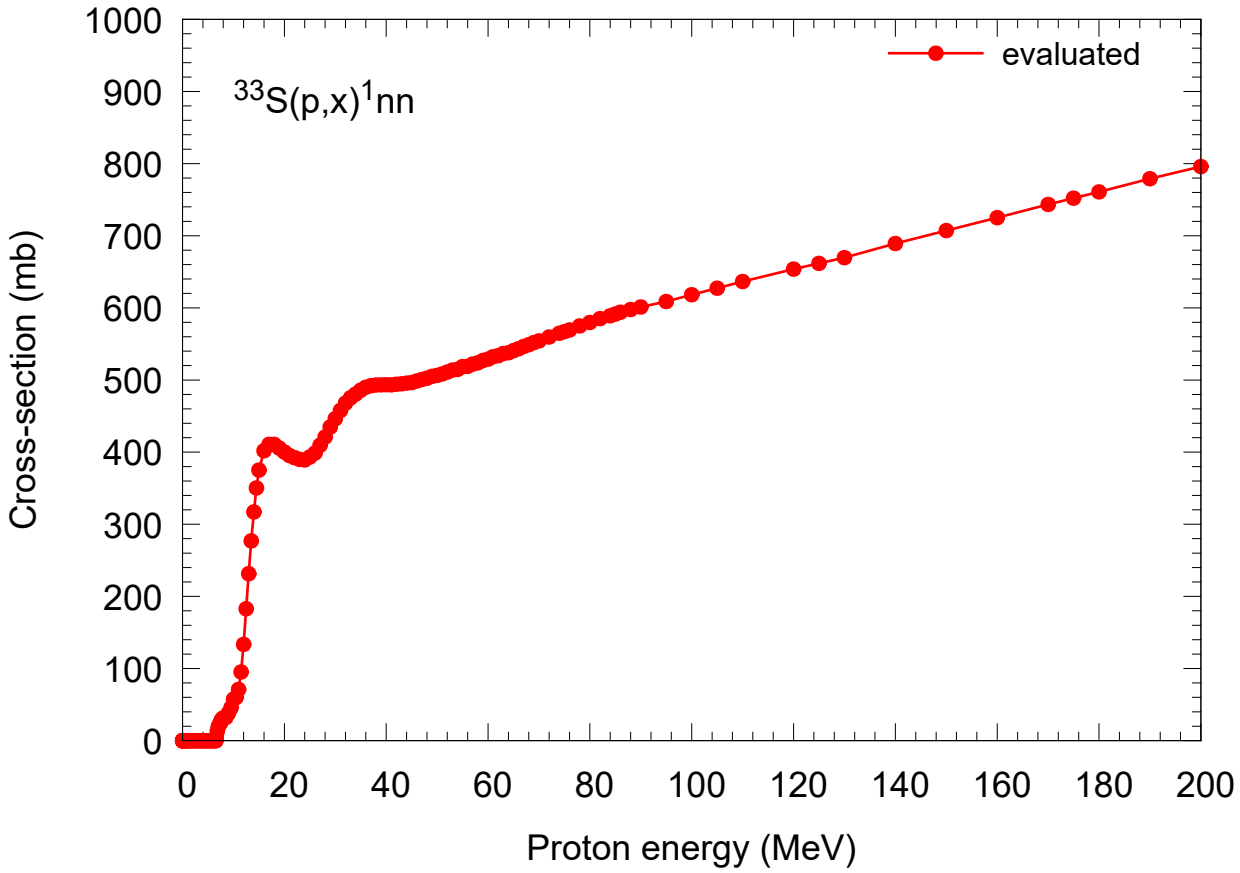
Cross-section (mb)
Proton energy (MeV)
Oda (59)
Oda (60)
Hulubei (62)
evaluated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Cross-section (mb)
Proton energy (MeV)
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900
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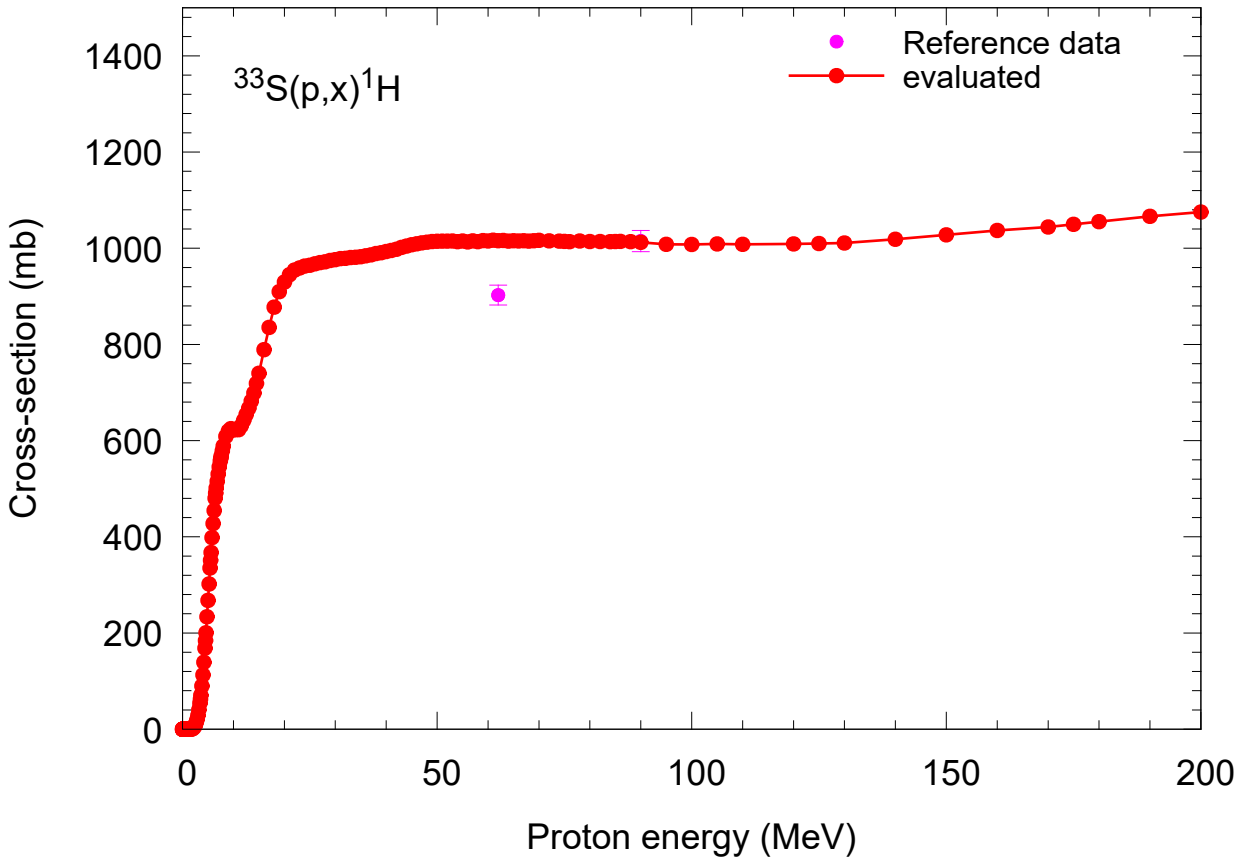
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evaluated
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Cross-section (mb)
Proton energy (MeV)
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1400
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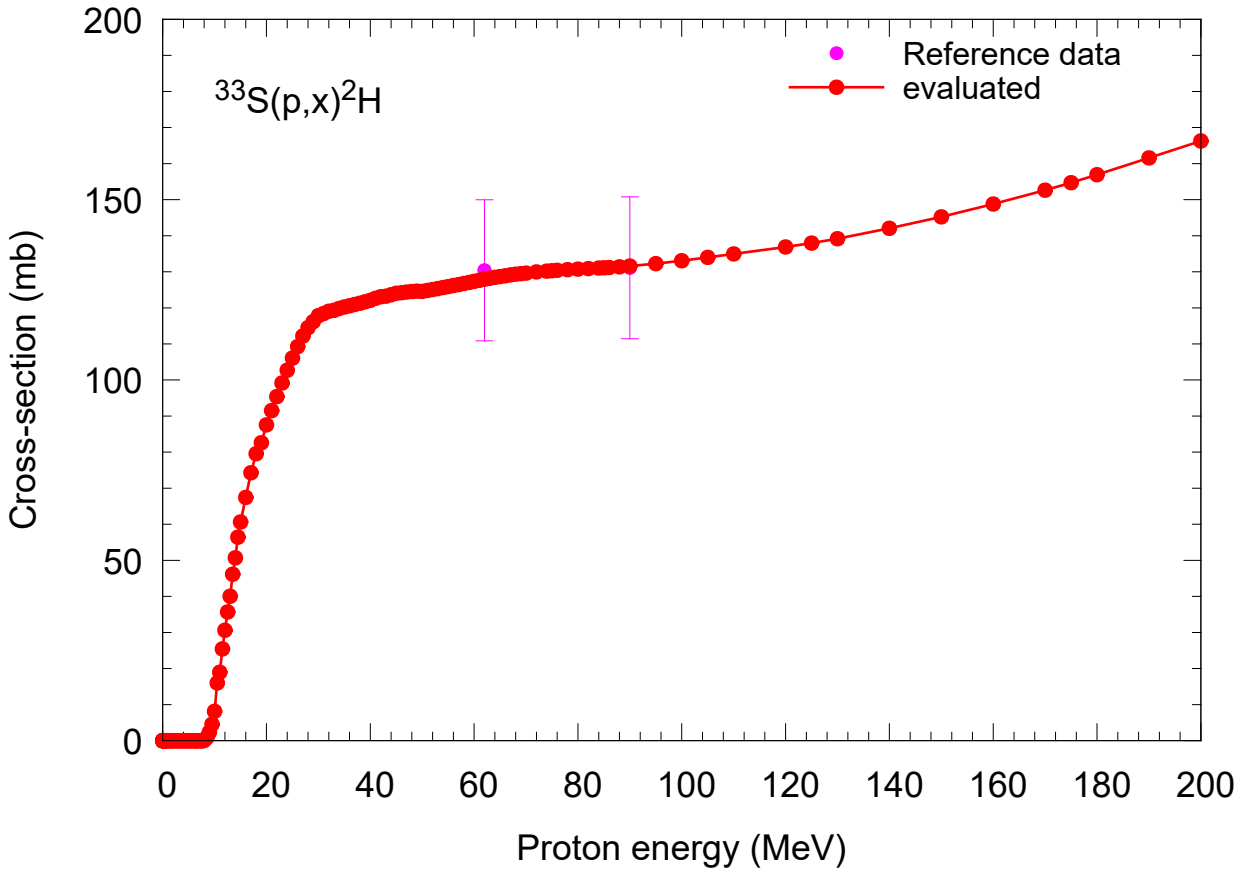
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evaluated
Cross-section (mb)
Proton energy (MeV)
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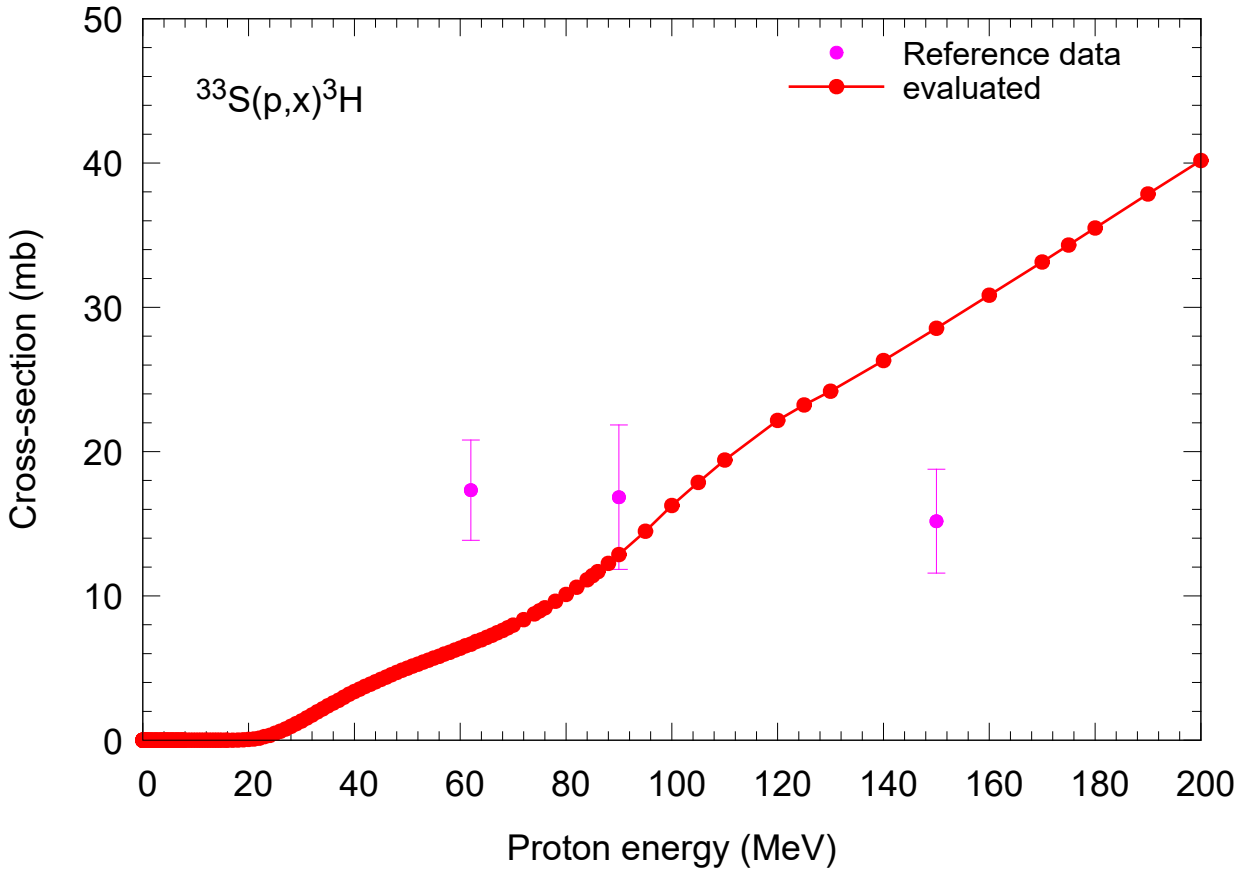
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Cross-section (mb)
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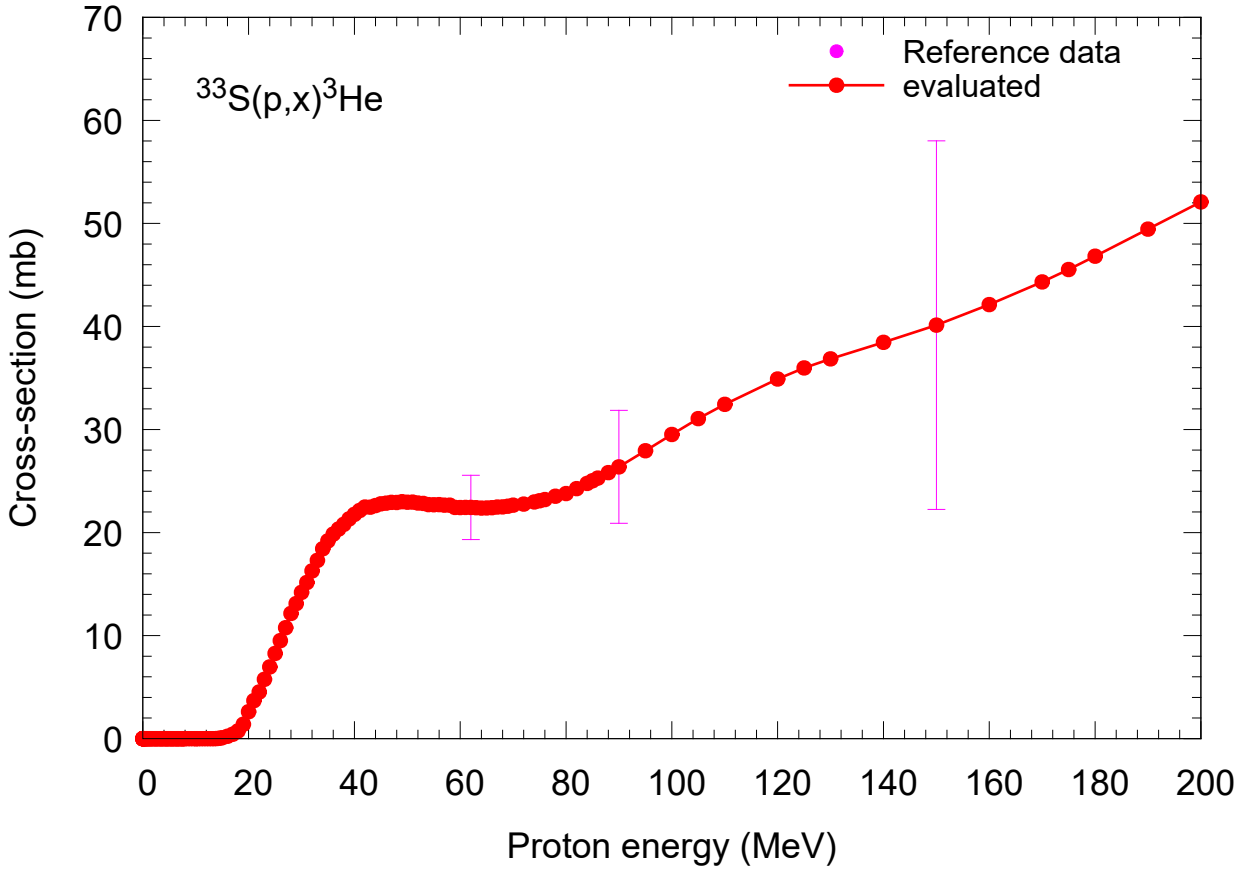
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Proton energy (MeV)
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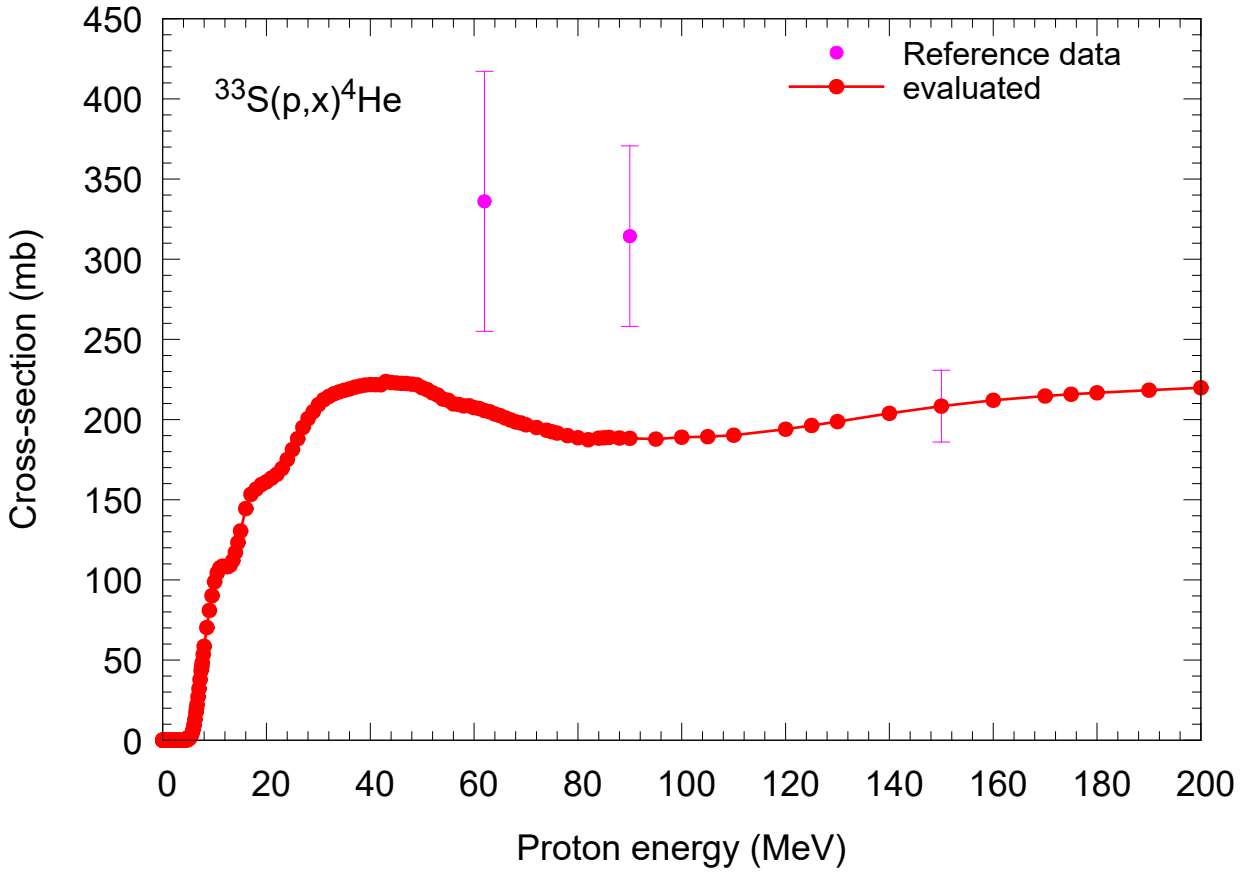
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Cross-section (mb)
Proton energy (MeV)
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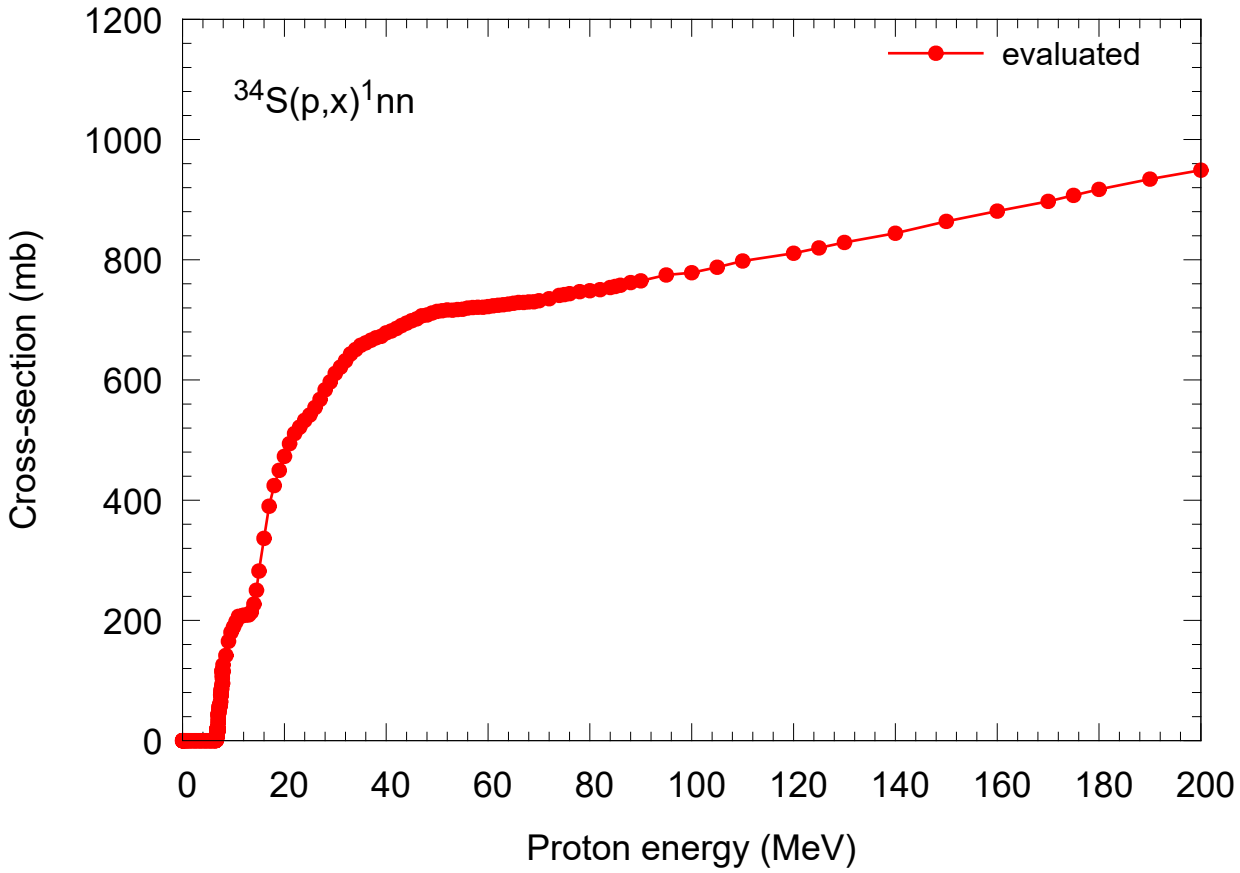
evaluated
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Cross-section (mb)
Proton energy (MeV)
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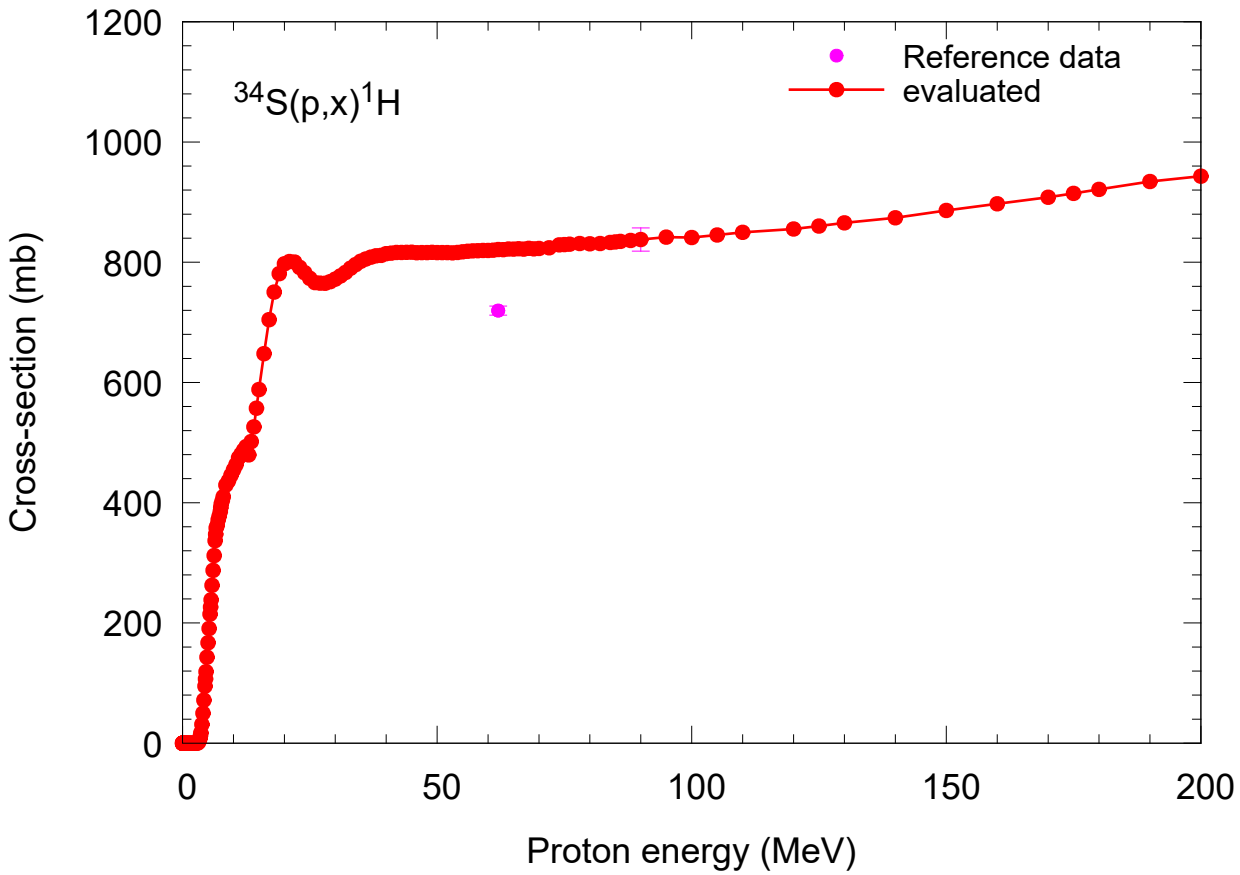
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Proton energy (MeV)
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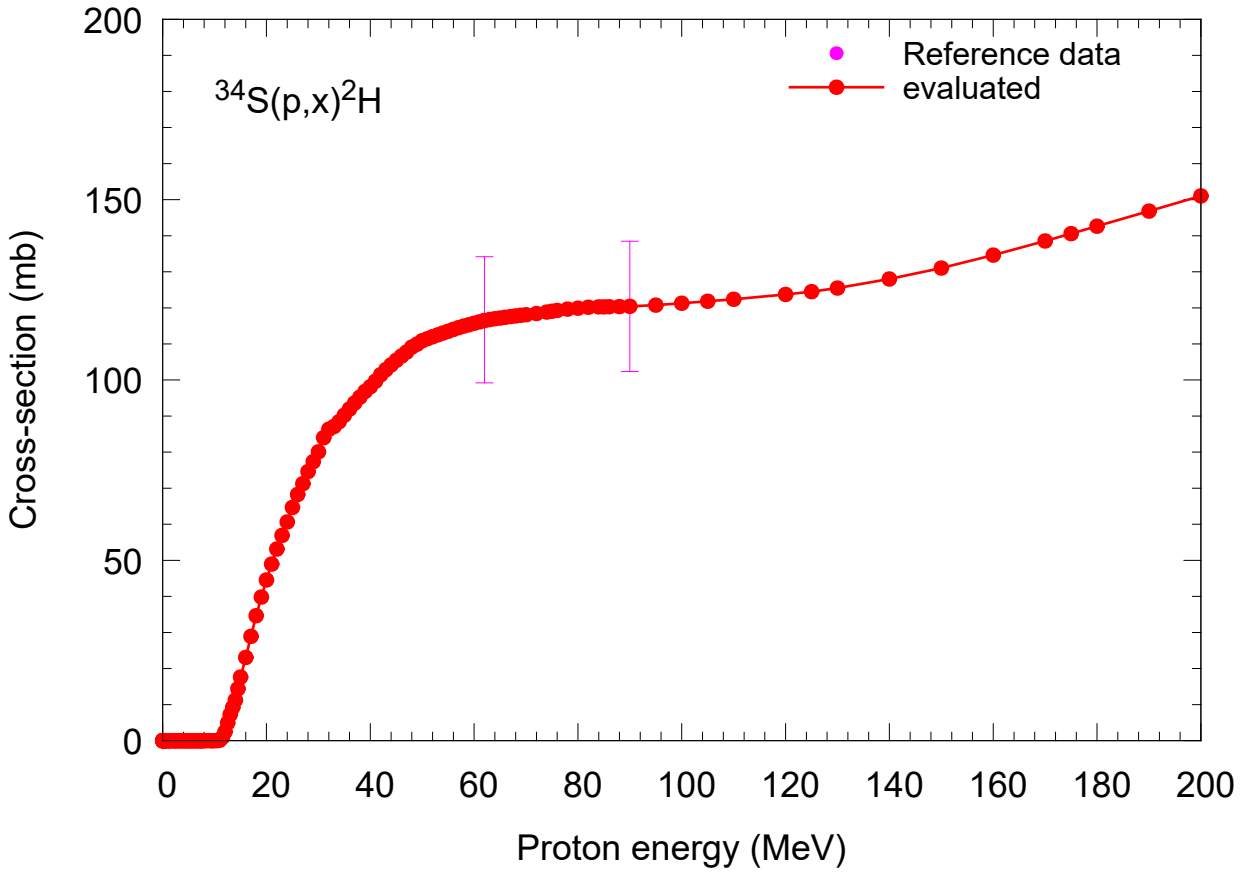
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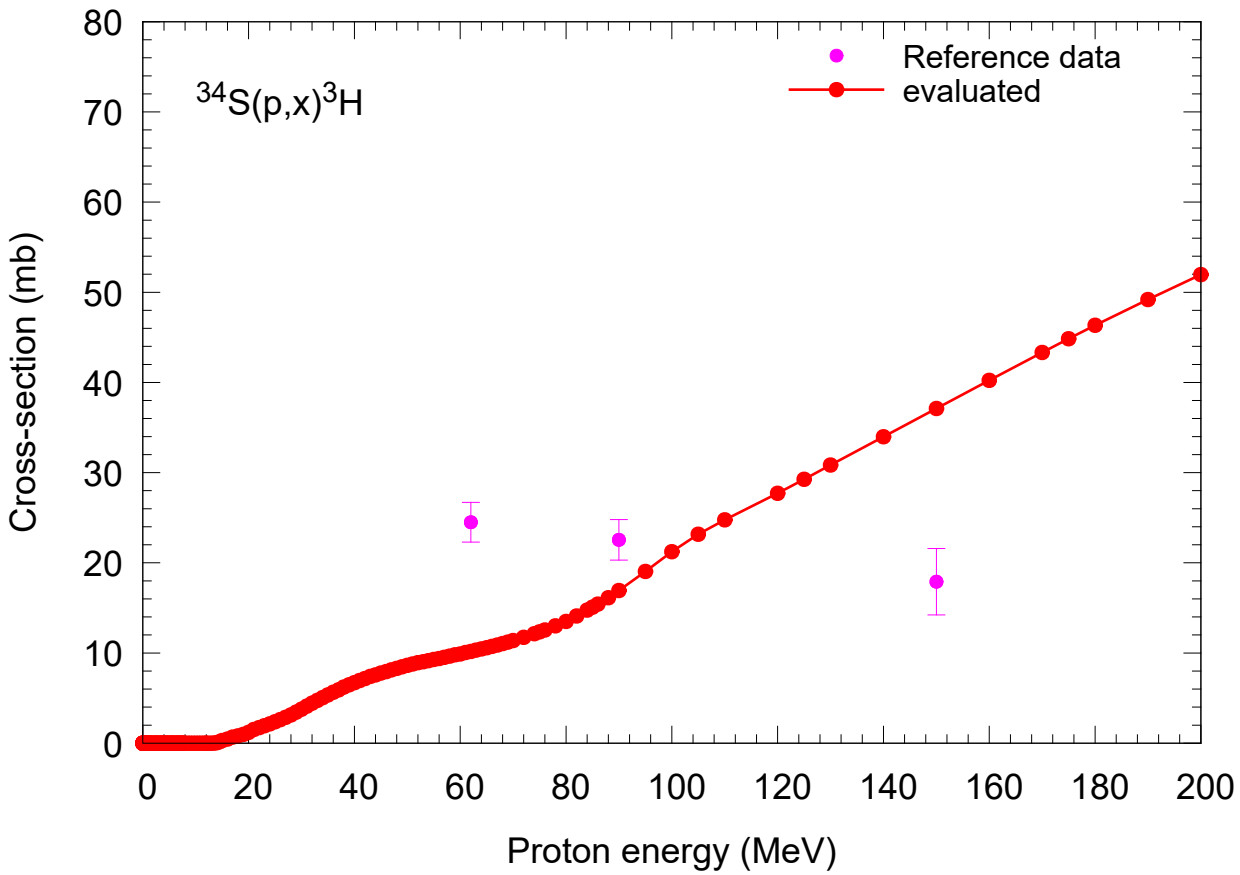
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Proton energy (MeV)
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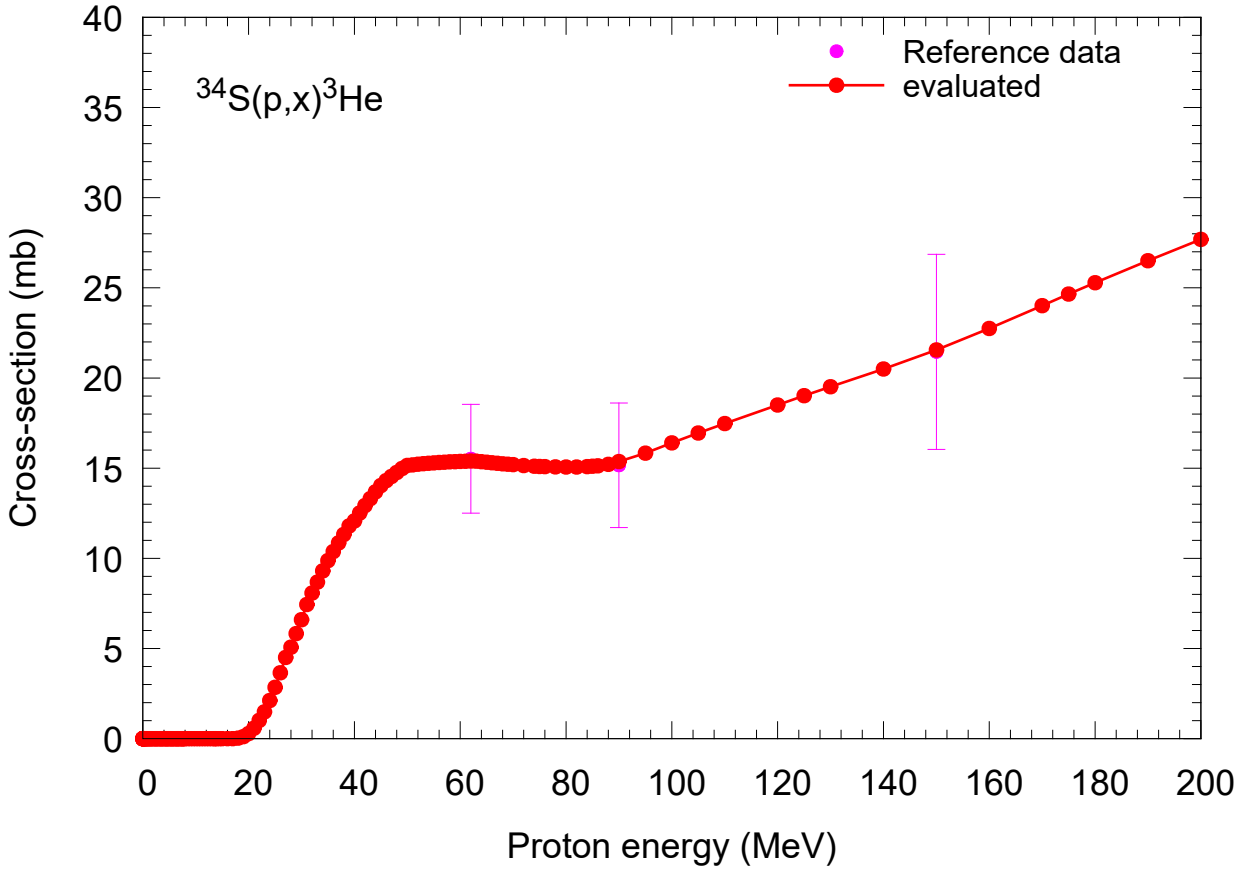
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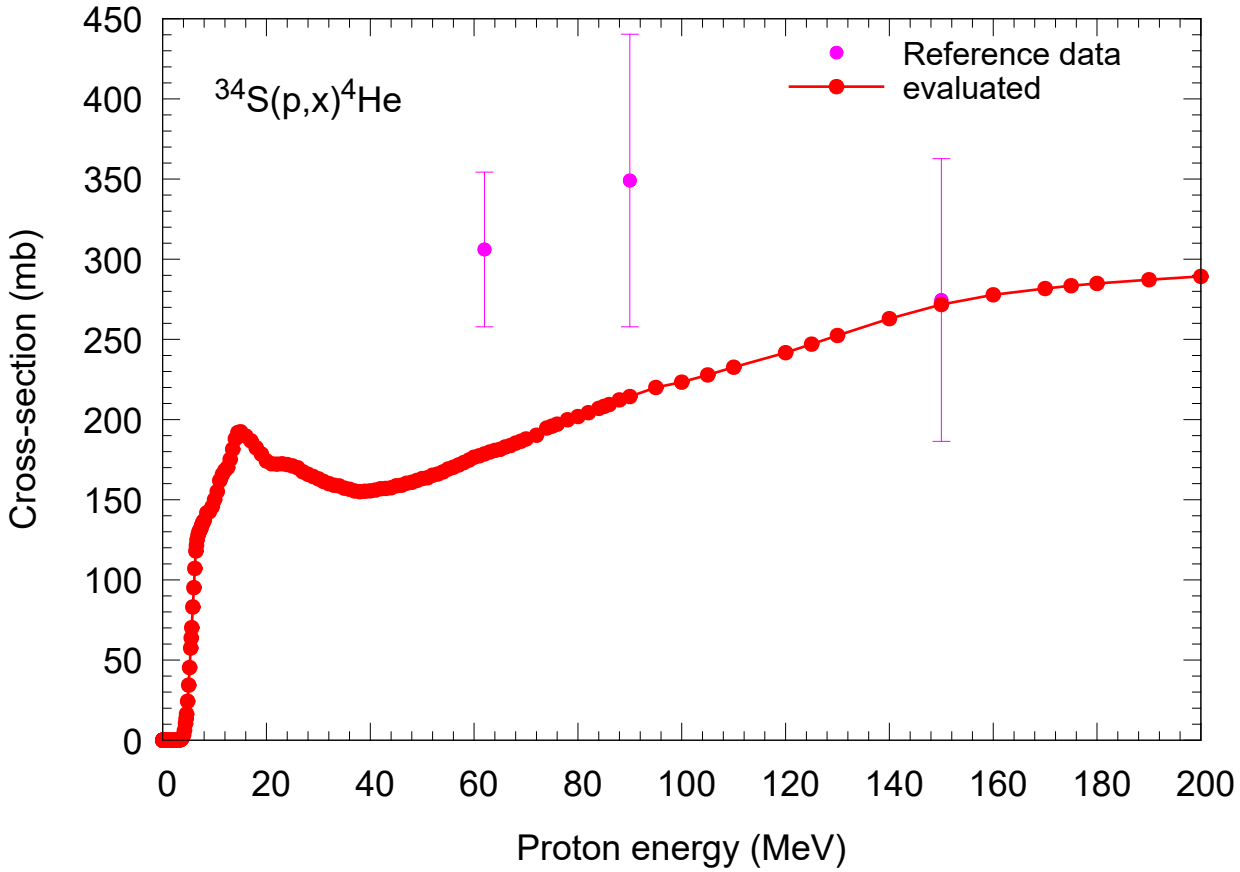
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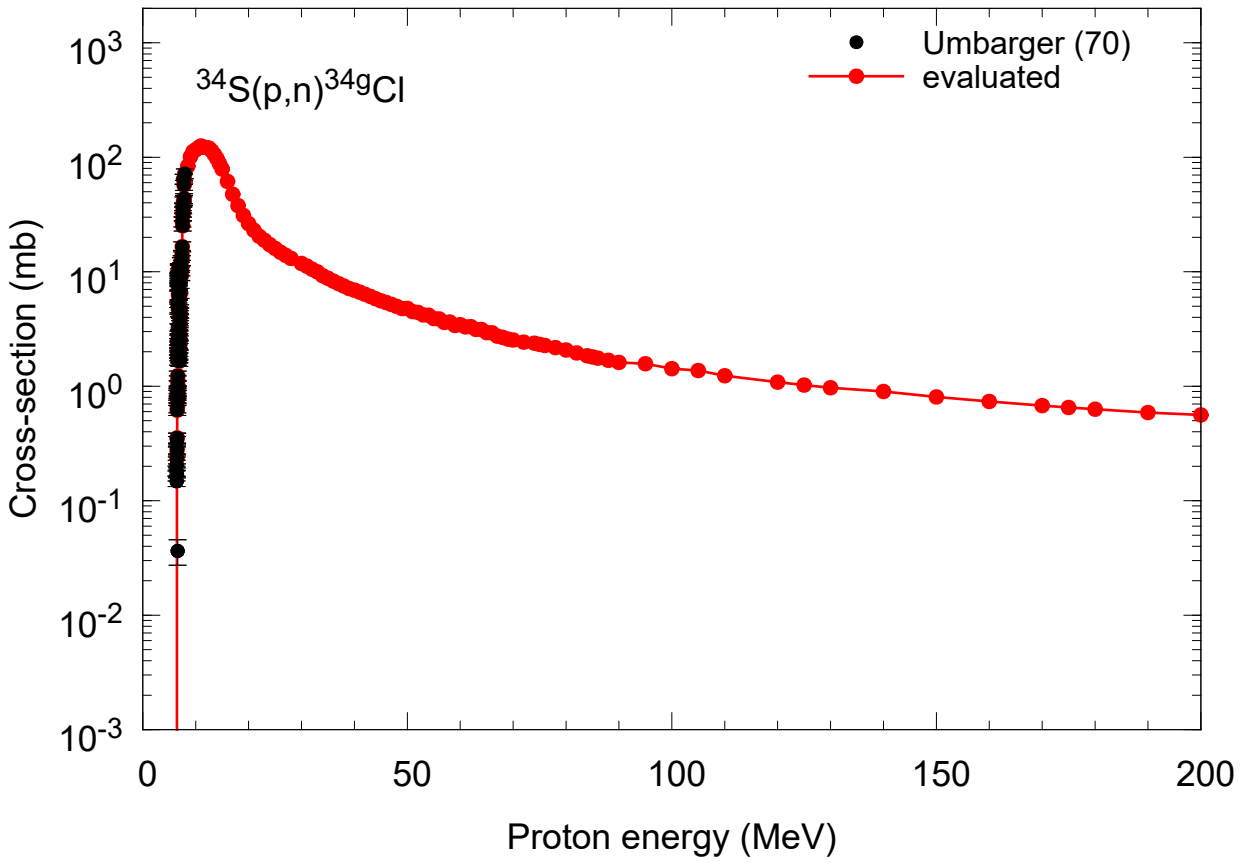
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Umbarger (70)
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Cross-section (mb)
Proton energy (MeV)
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10^{0}
10^{-1}
10^{-2}
10^{-3}
0
50
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150
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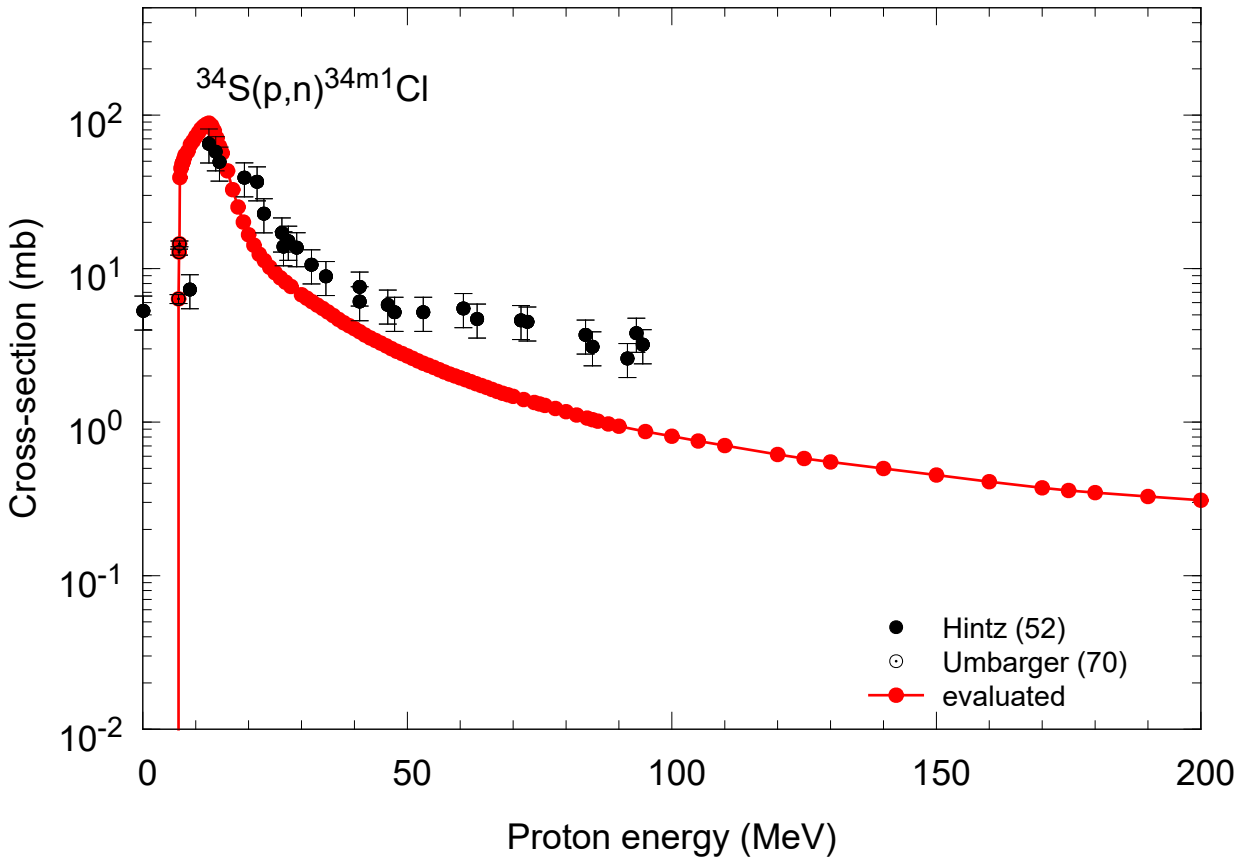
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Hintz (52)
Umbarger (70)
evaluated
Cross-section (mb)
Proton energy (MeV)
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10^{1}
10^{0}
10^{-1}
10^{-2}
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150
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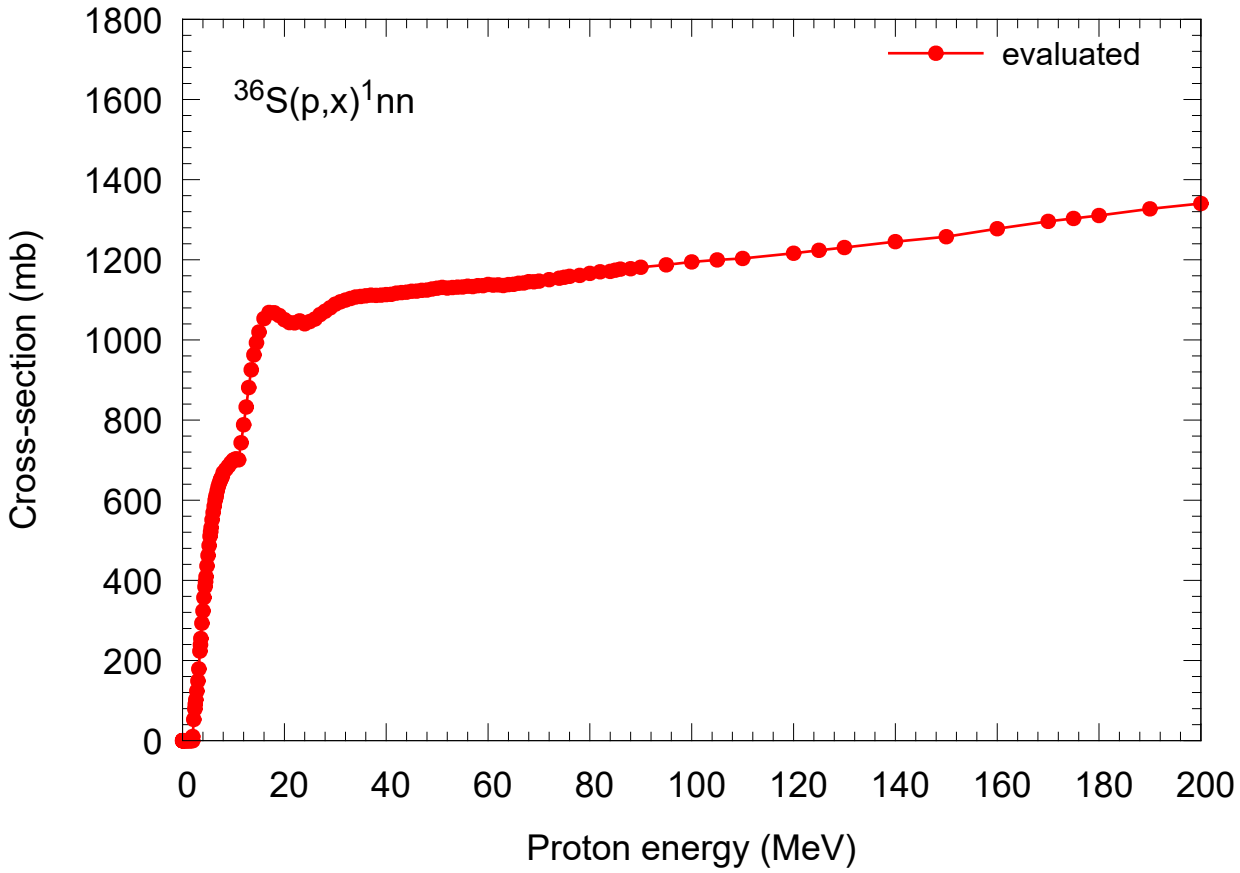
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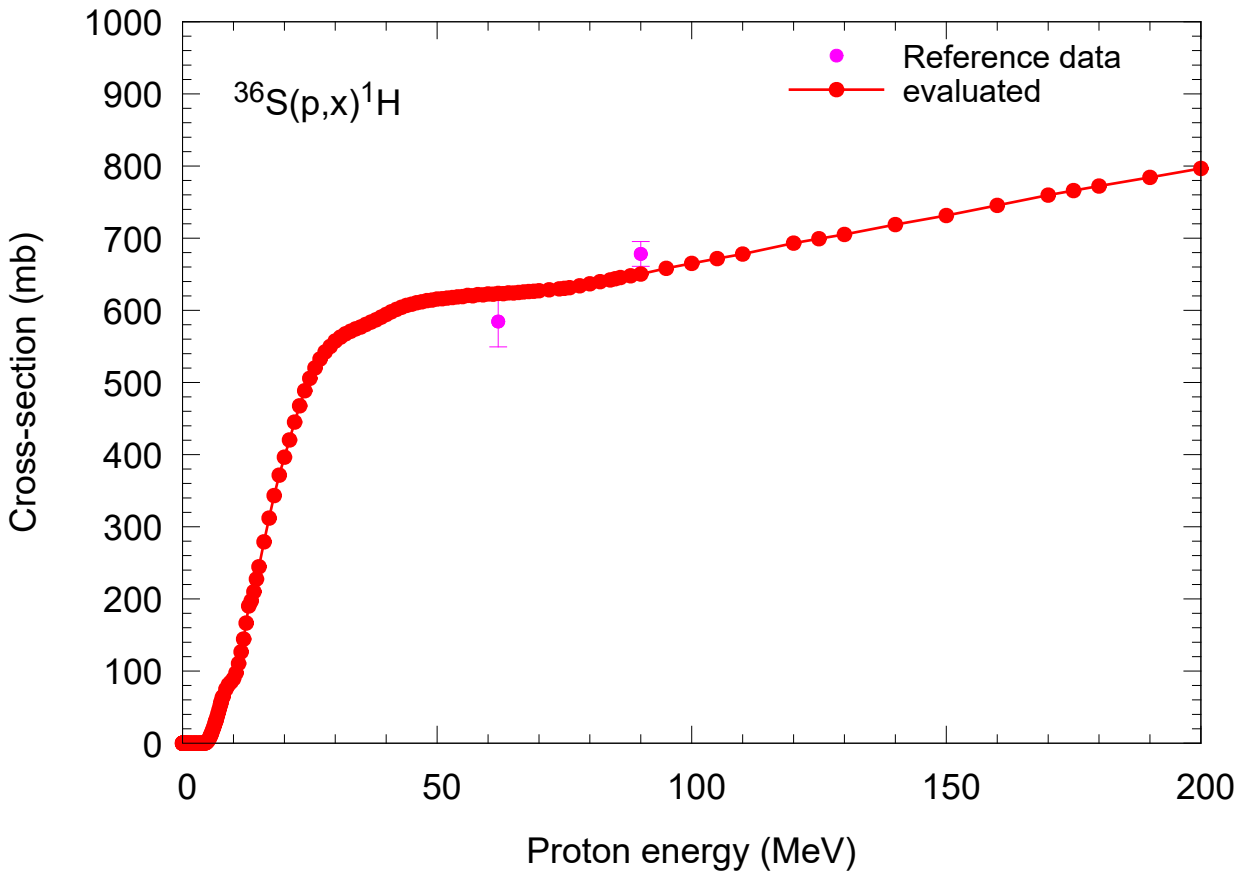
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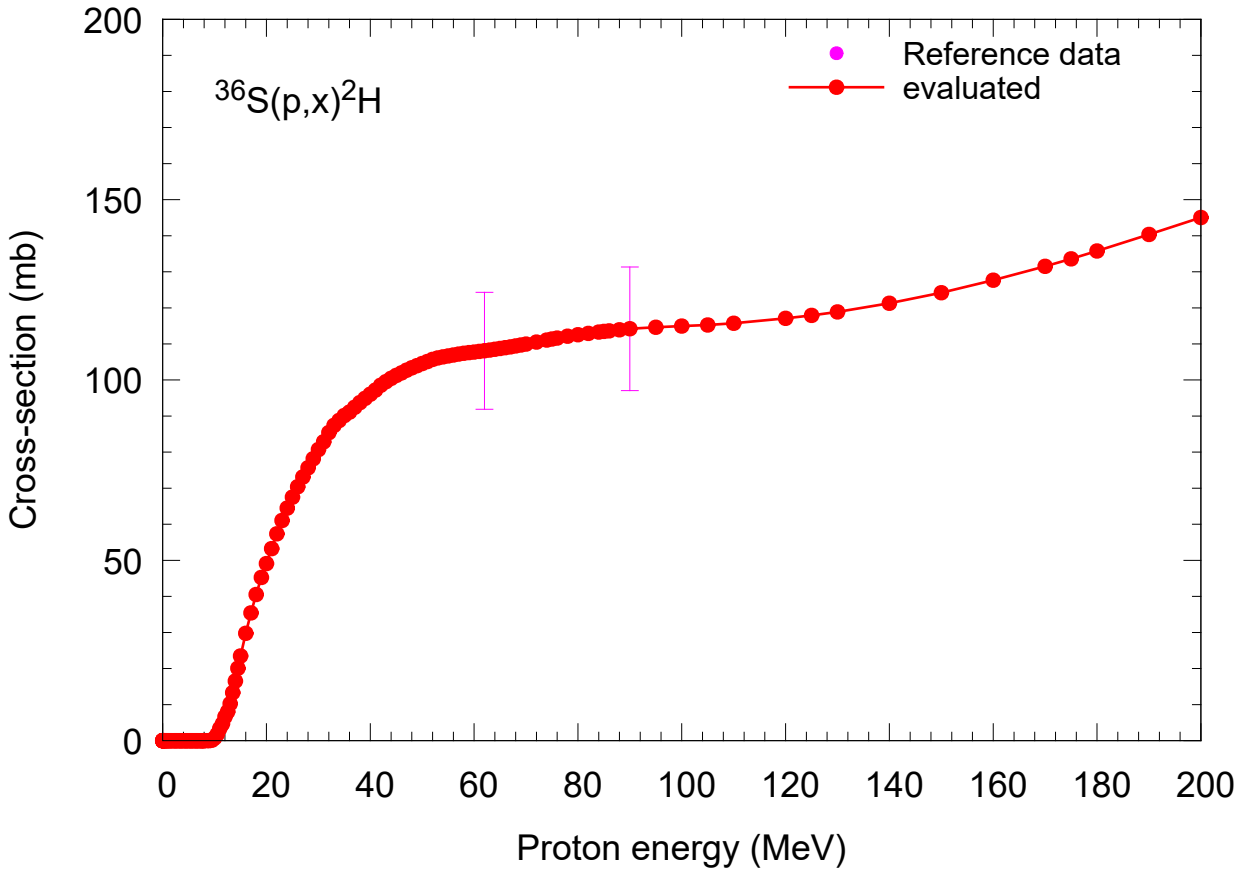
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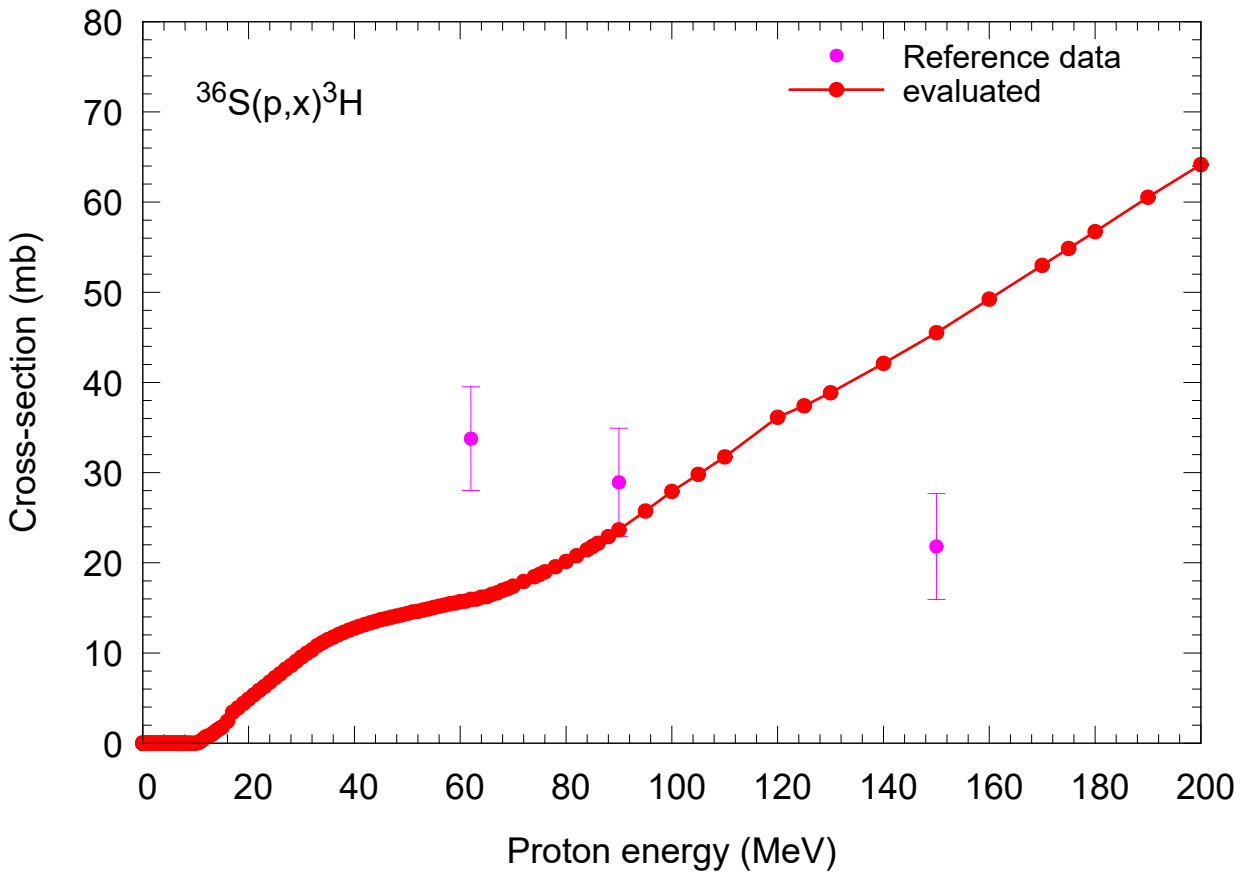
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Proton energy (MeV)
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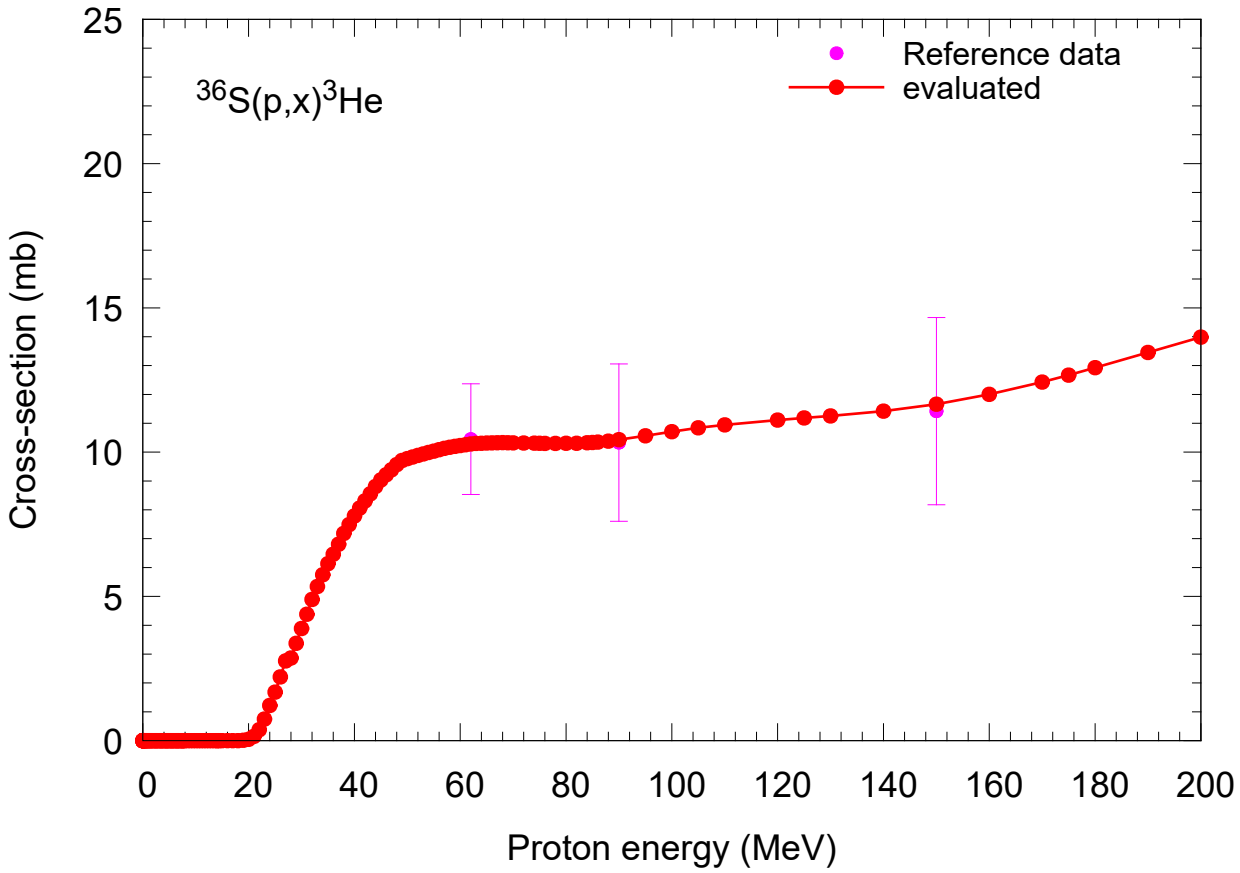
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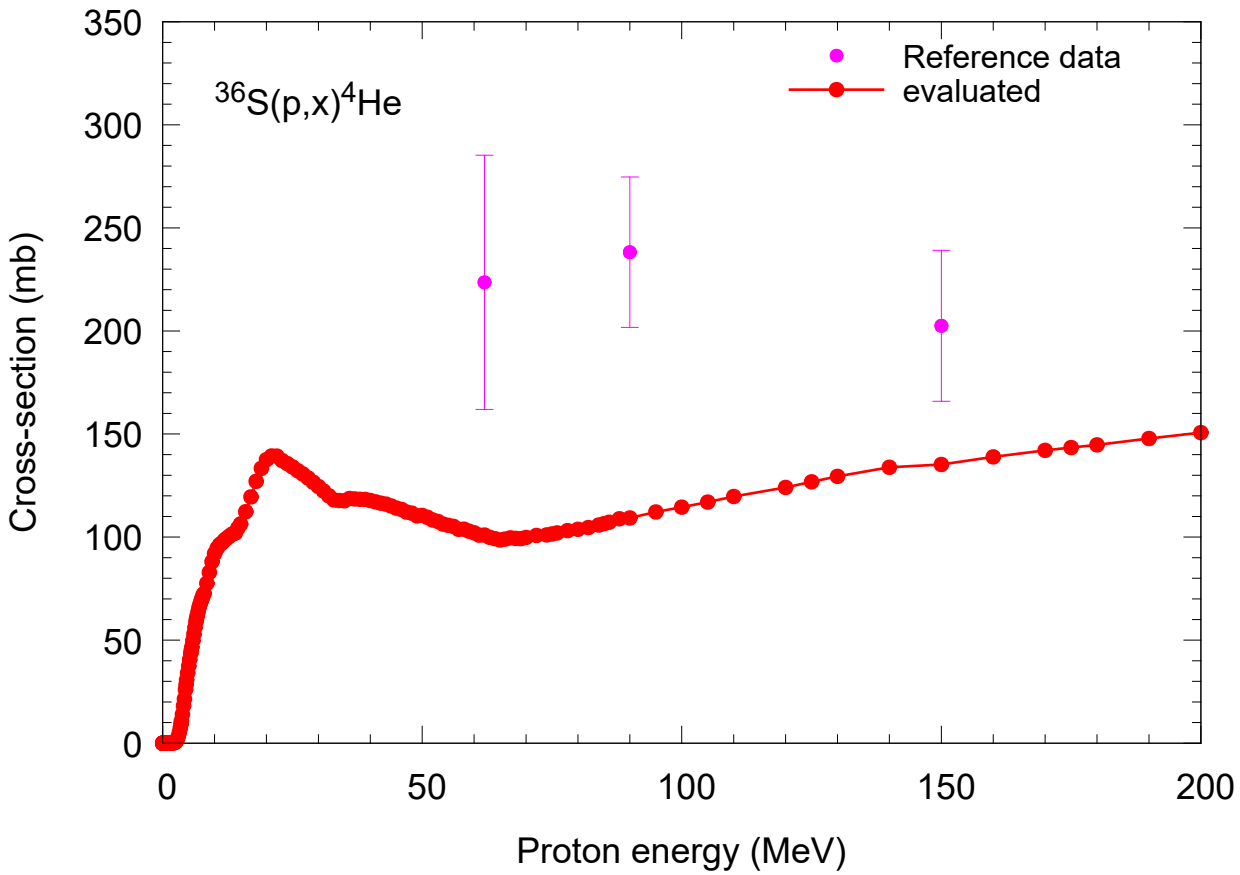
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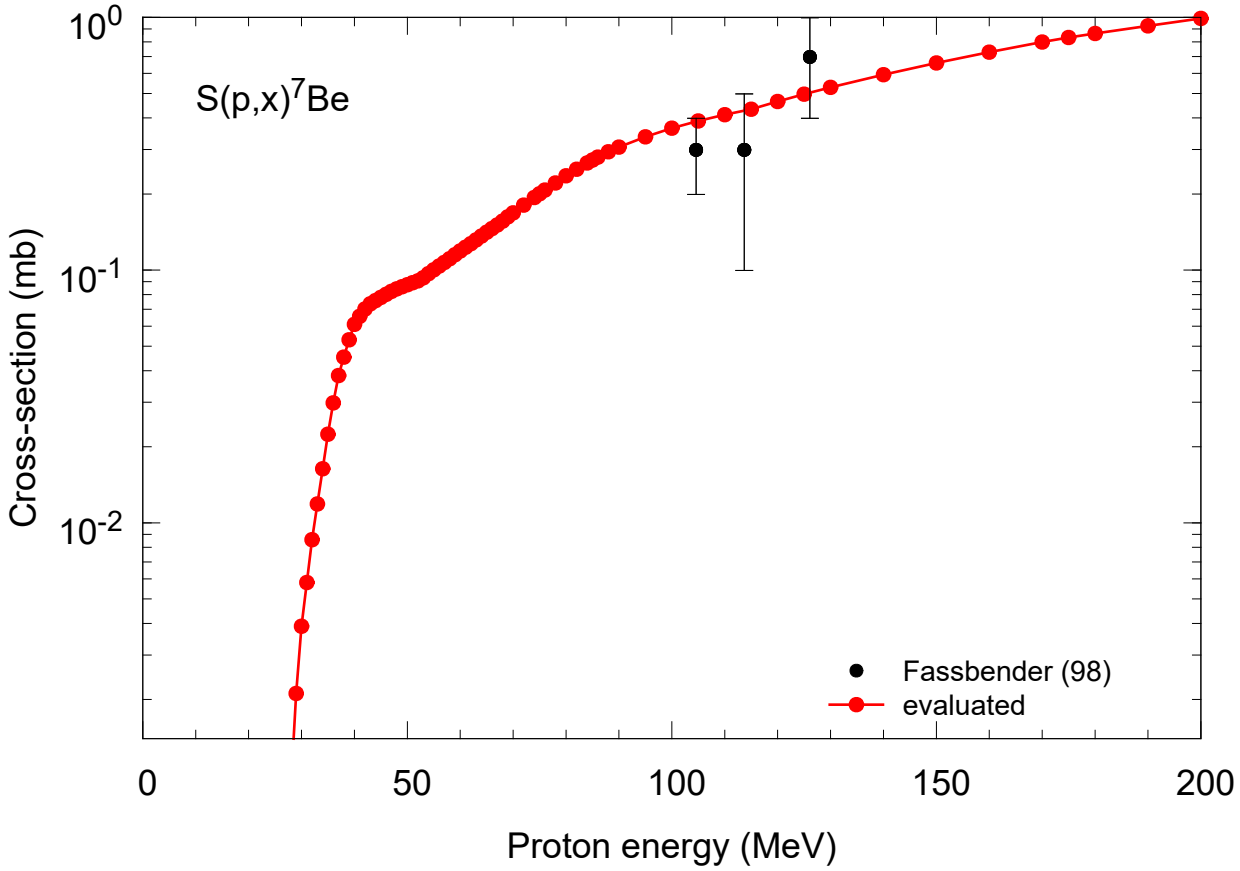
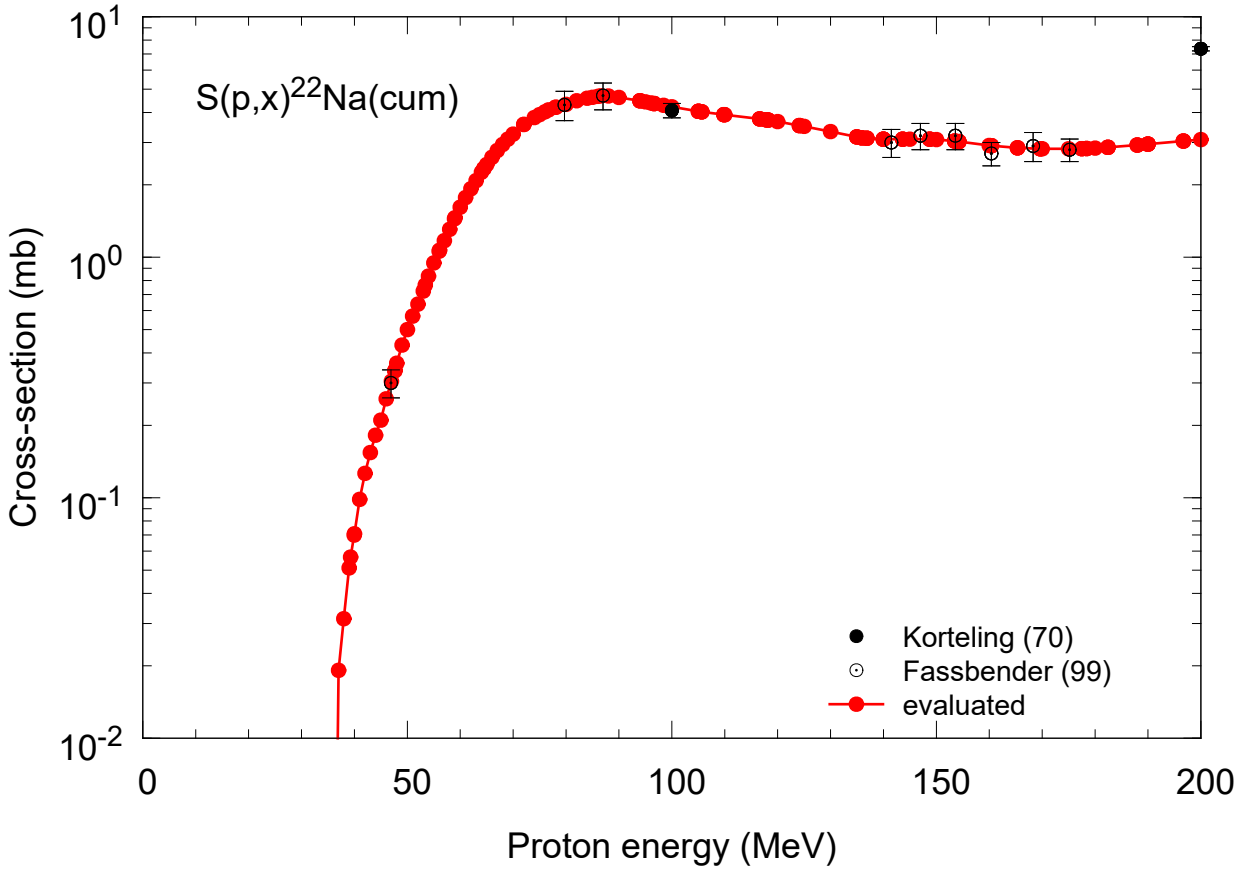
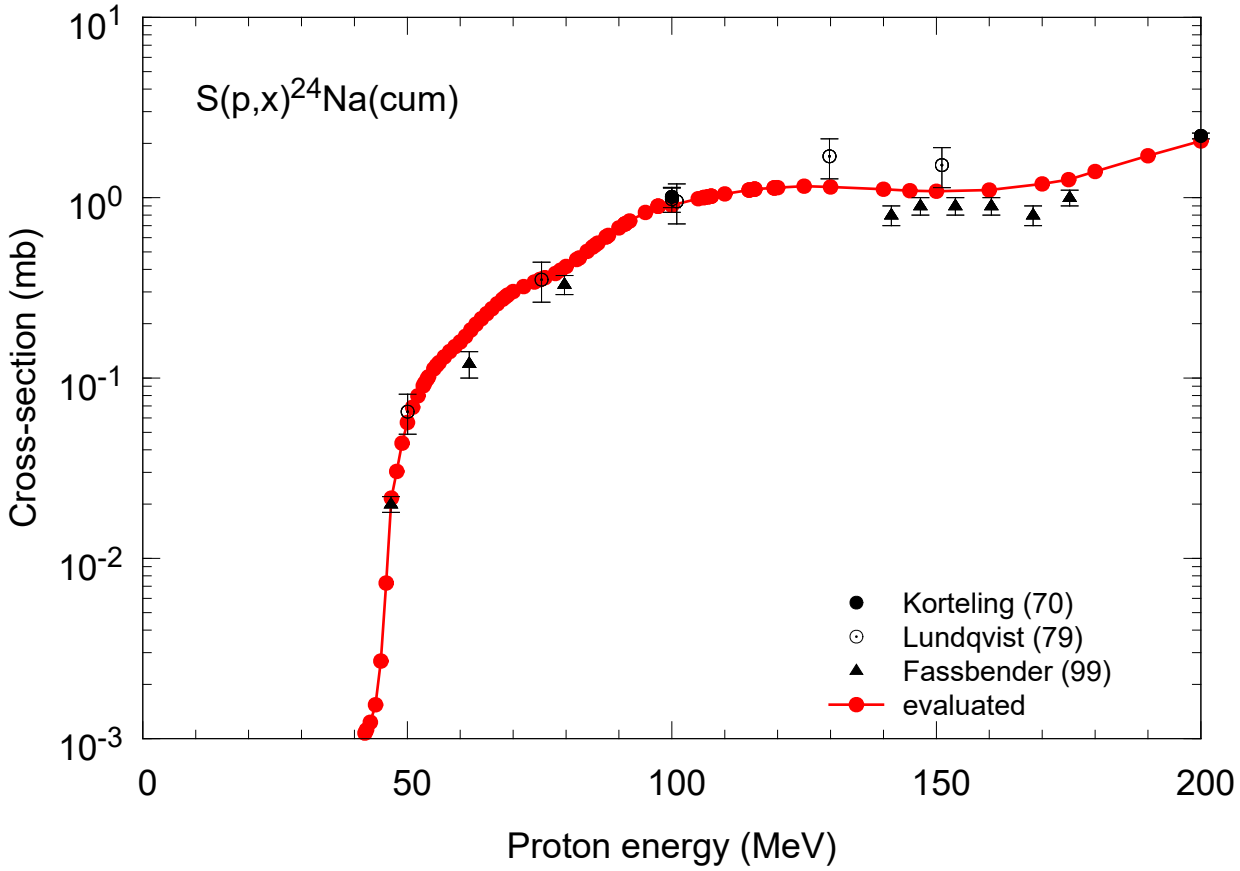

S(p,x)7Be
Cross-section (mb)
Proton energy (MeV)
Fassbender (98)
evaluated


S(p,x)22Na(cum)
Cross-section (mb)
Proton energy (MeV)
Korteling (70)
Fassbender (99)
evaluated


S(p,x)24Na(cum)
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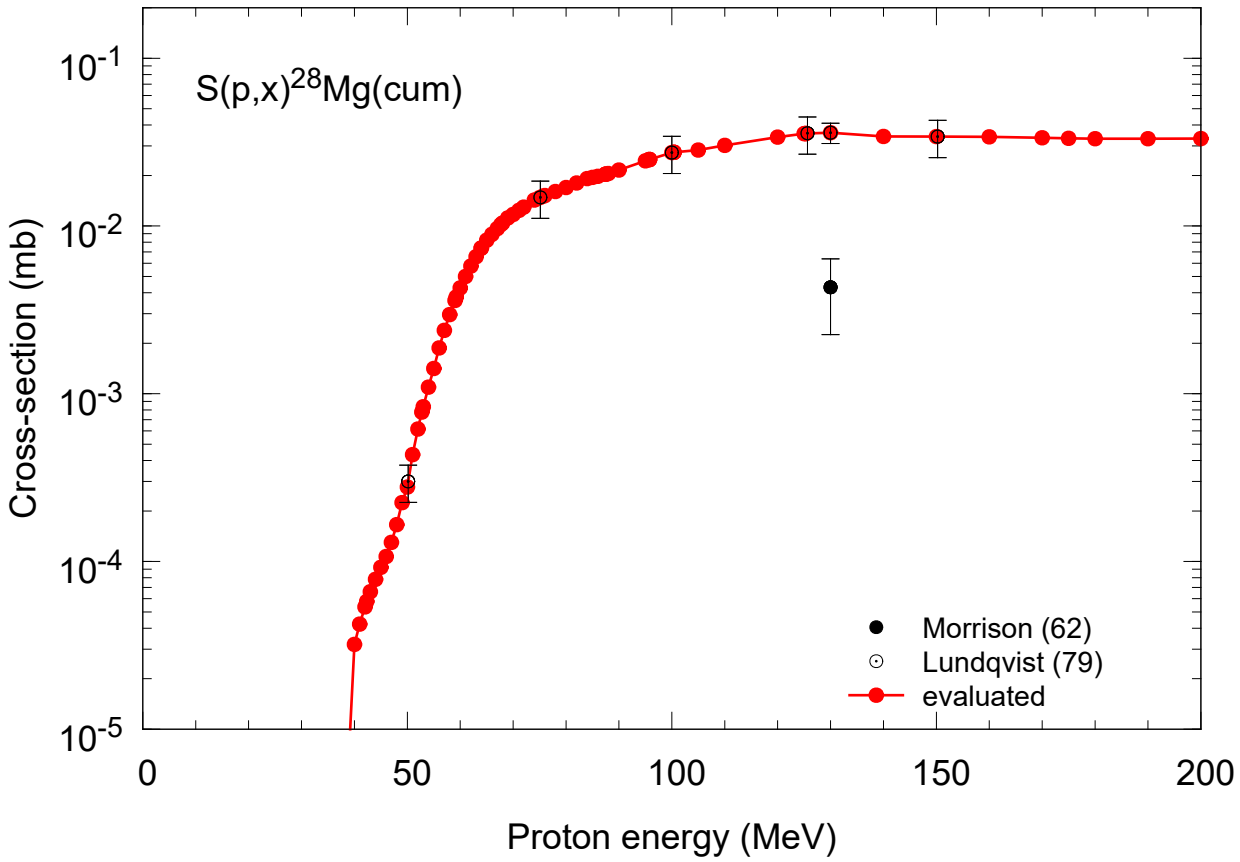
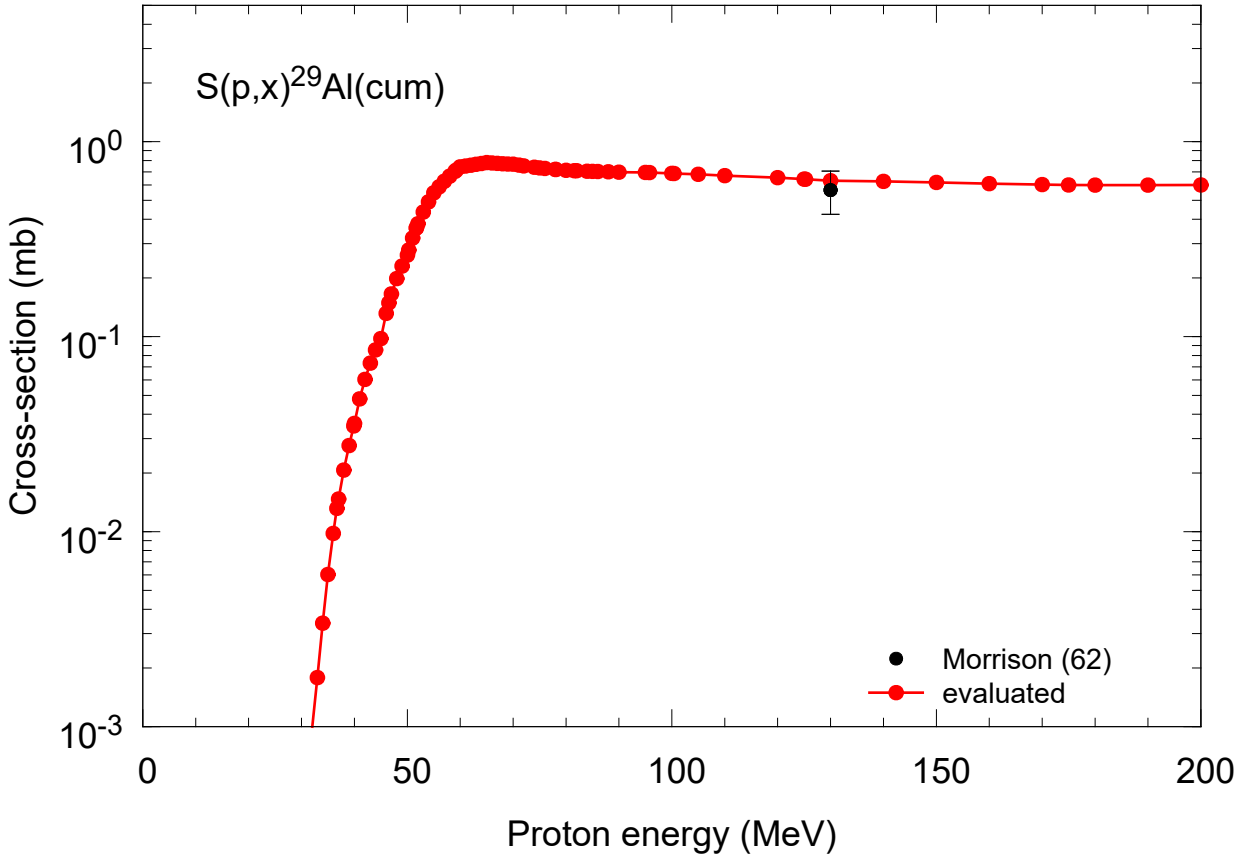
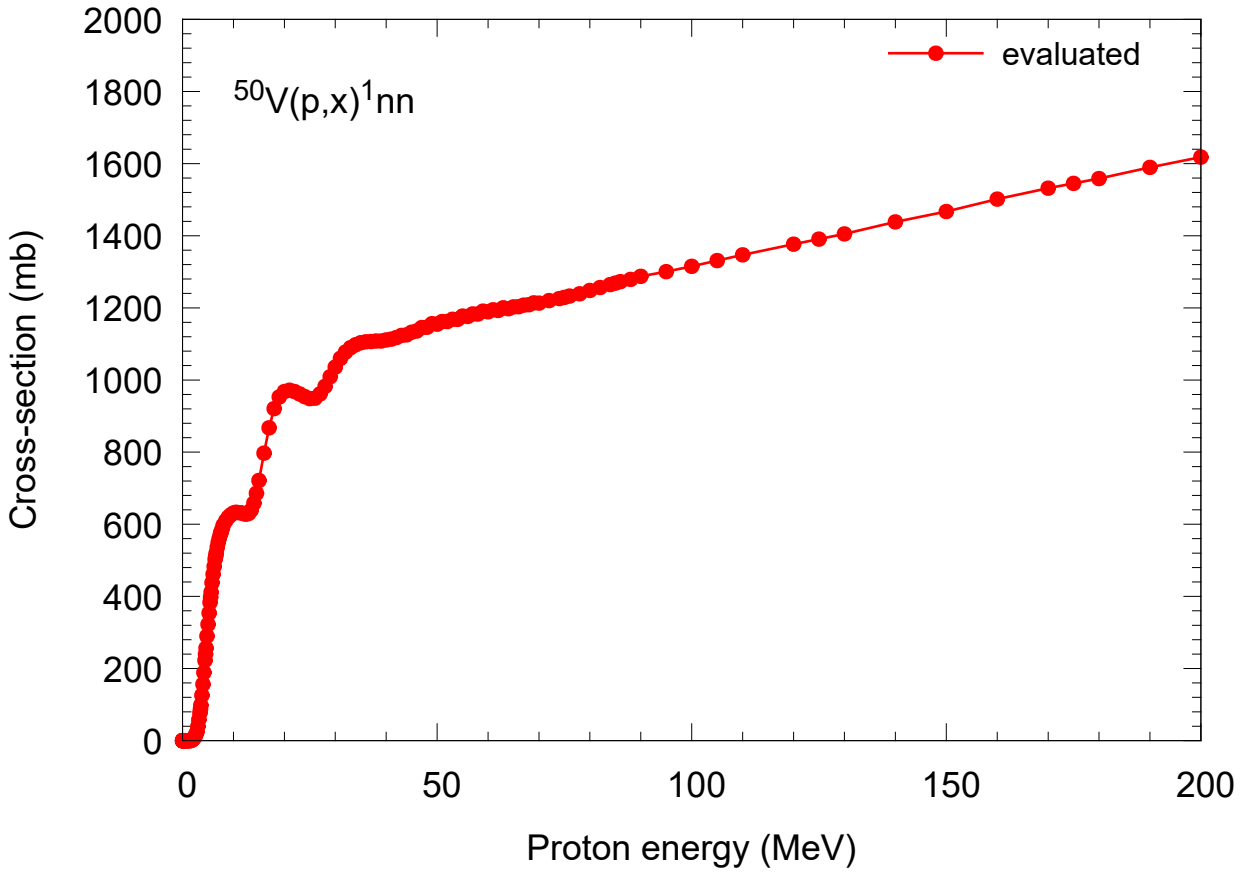
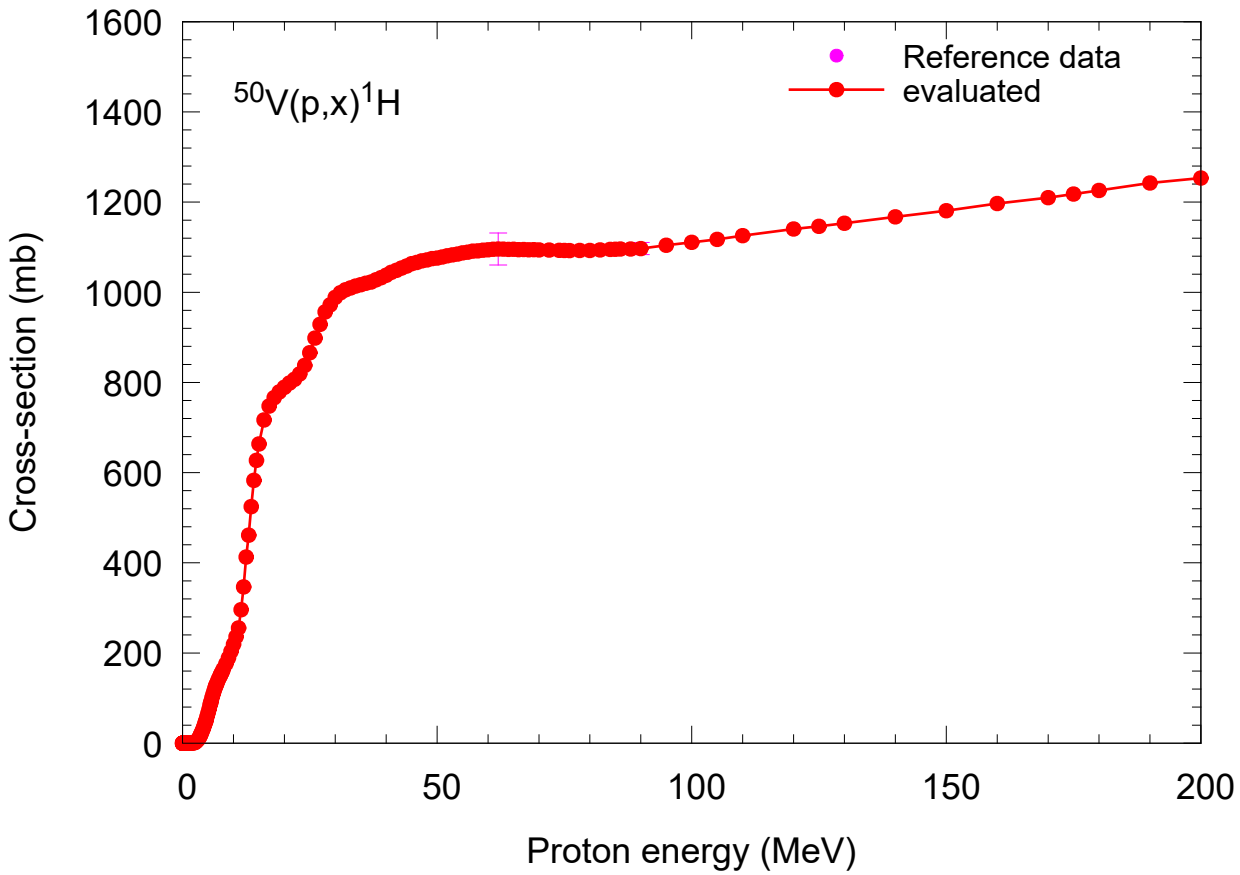
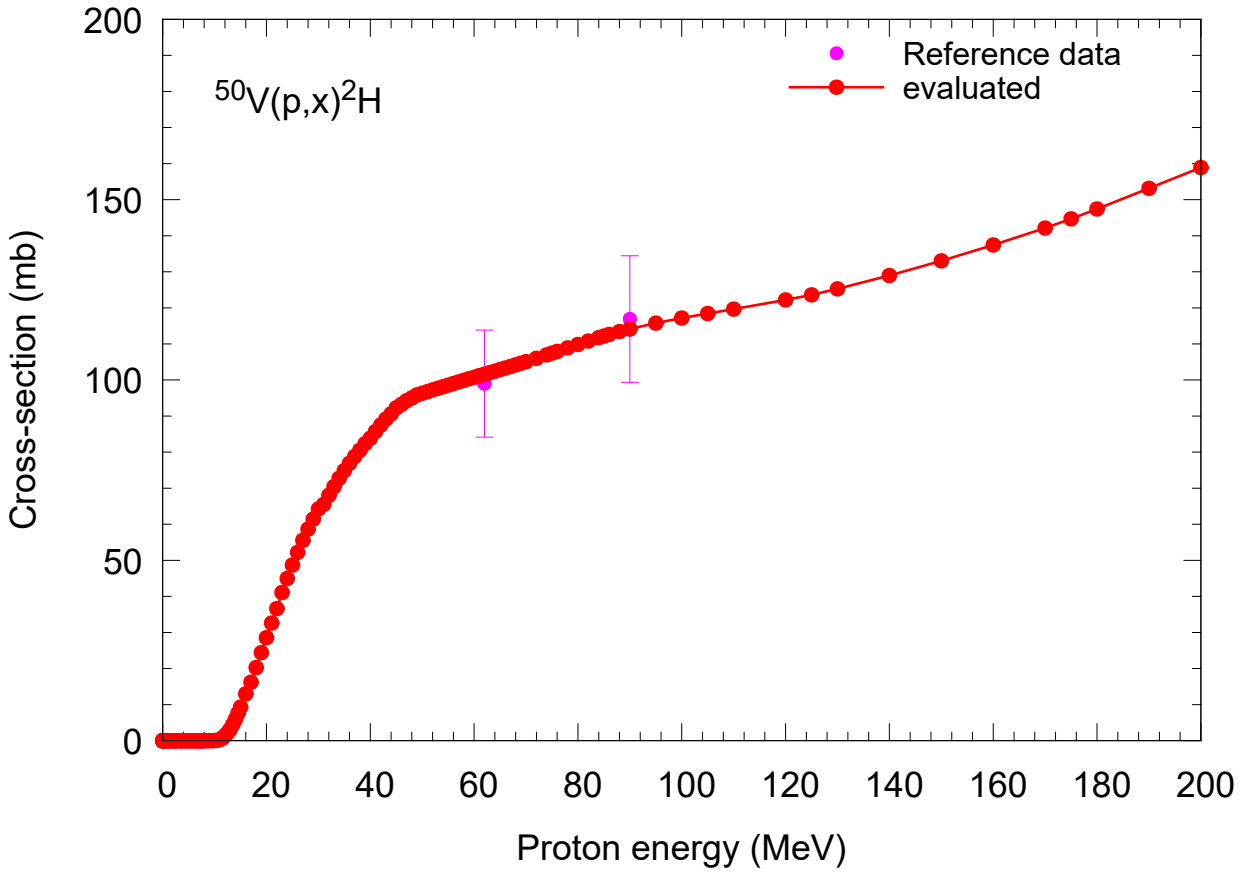
Proton energy (MeV)
Korteling (70)
Lundqvist (79)
Fassbender (99)
evaluated

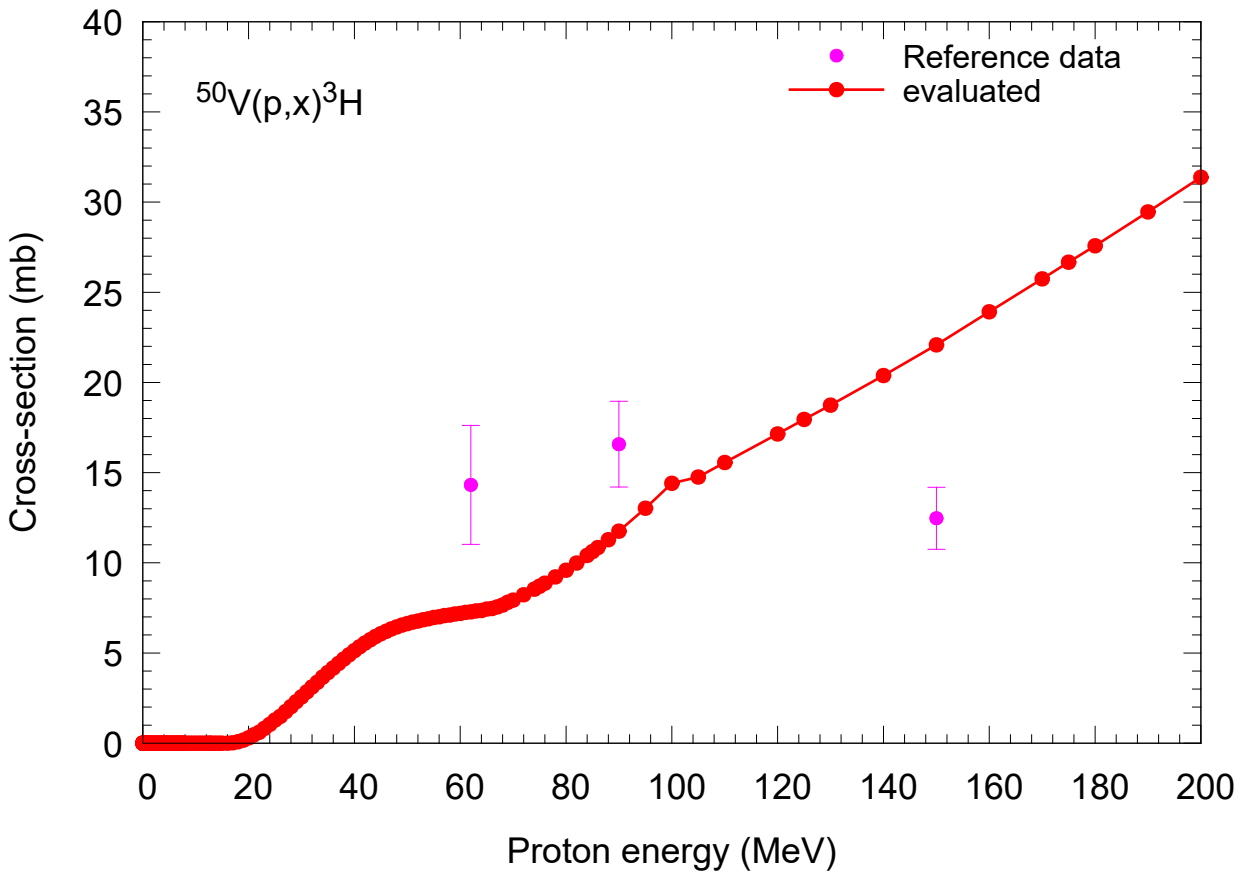

S(p,x)28Mg(cum)
Cross-section (mb)
Proton energy (MeV)
Morrison (62)
Lundqvist (79)
evaluated

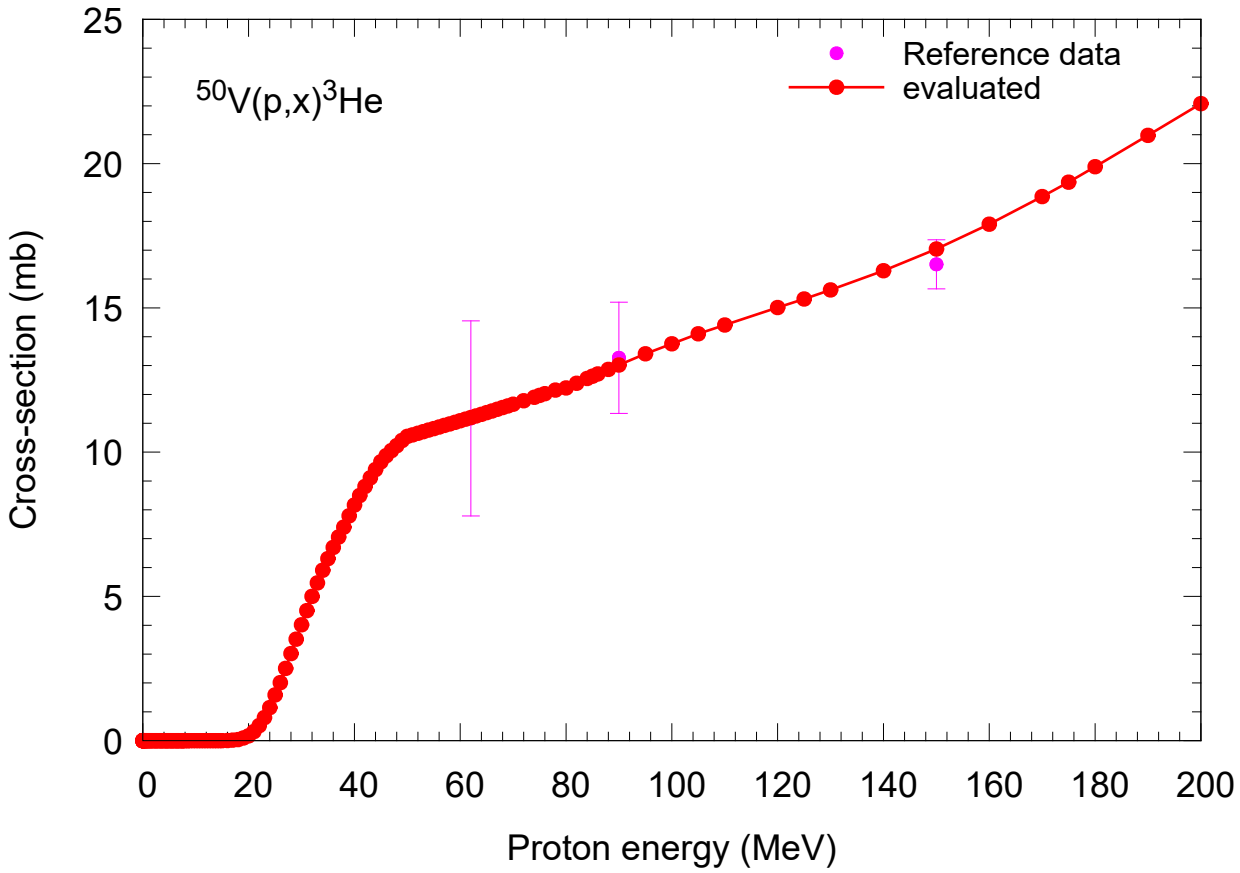

S(p,x)29Al(cum)
Cross-section (mb)
10^0
10^-1
10^-2
10^-3
0
50
100
150
200
Proton energy (MeV)
Morrison (62)
evaluated

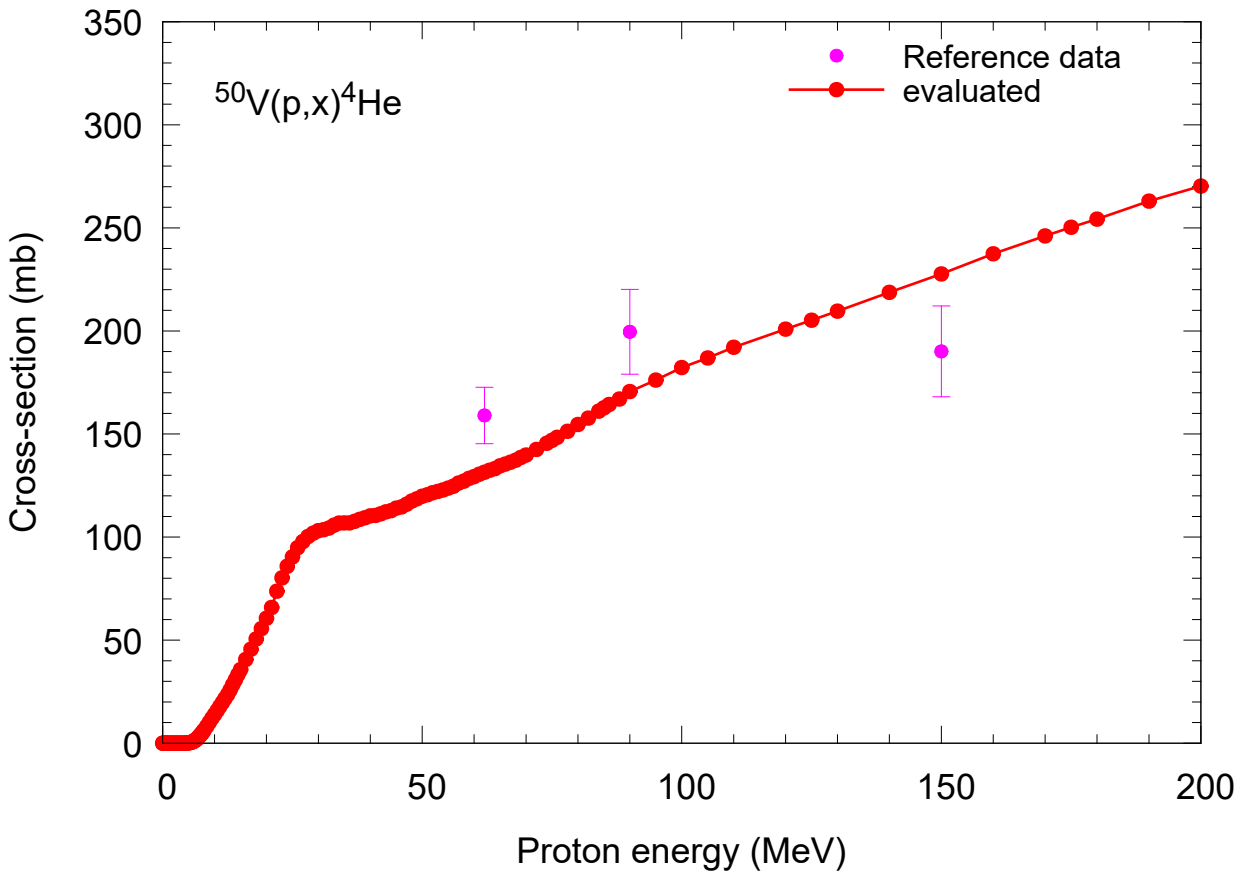

evaluated
^{50}V(p,x)^{1}nn
Cross-section (mb)
Proton energy (MeV)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
50
100
150
200

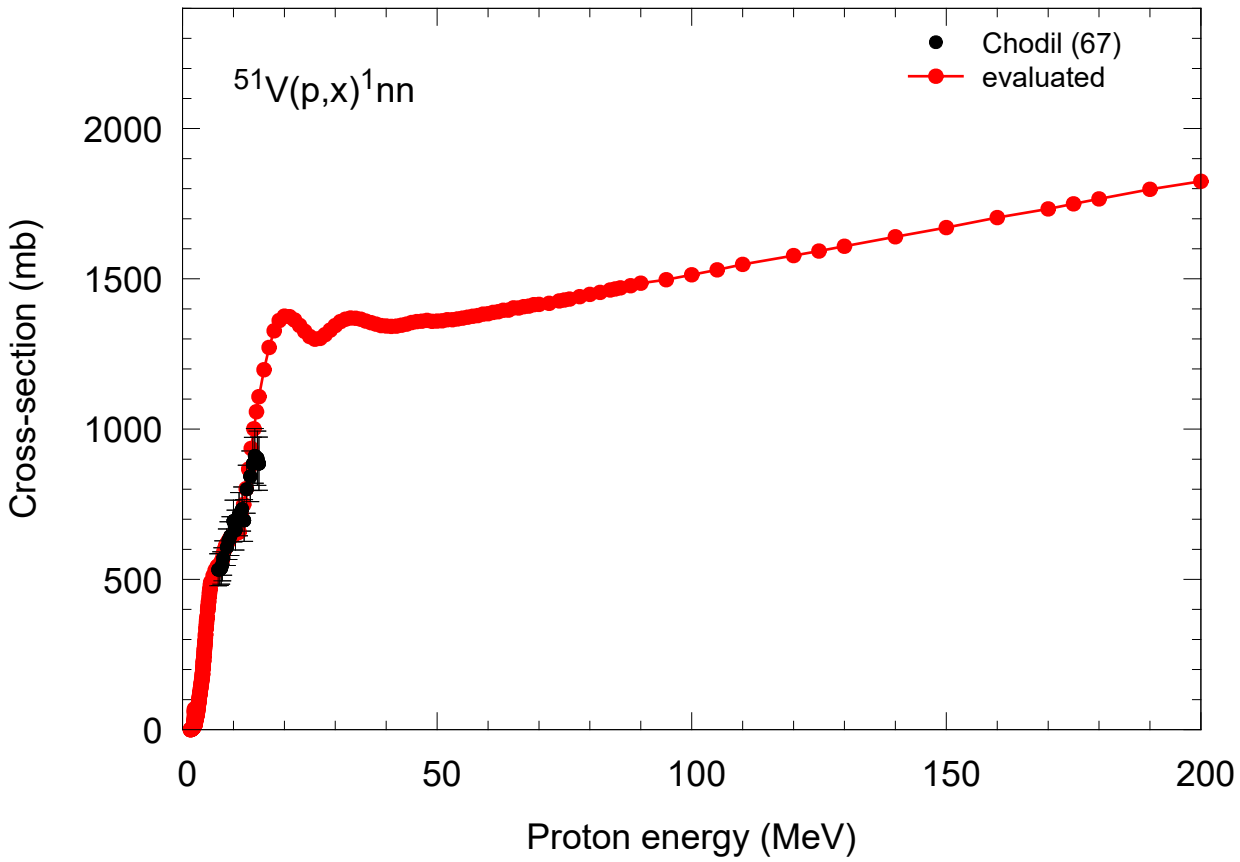

Reference data
evaluated
^{50}V(p,x)^{1}H
Cross-section (mb)
Proton energy (MeV)
0
200
400
600
800
1000
1200
1400
1600
0
50
100
150
200

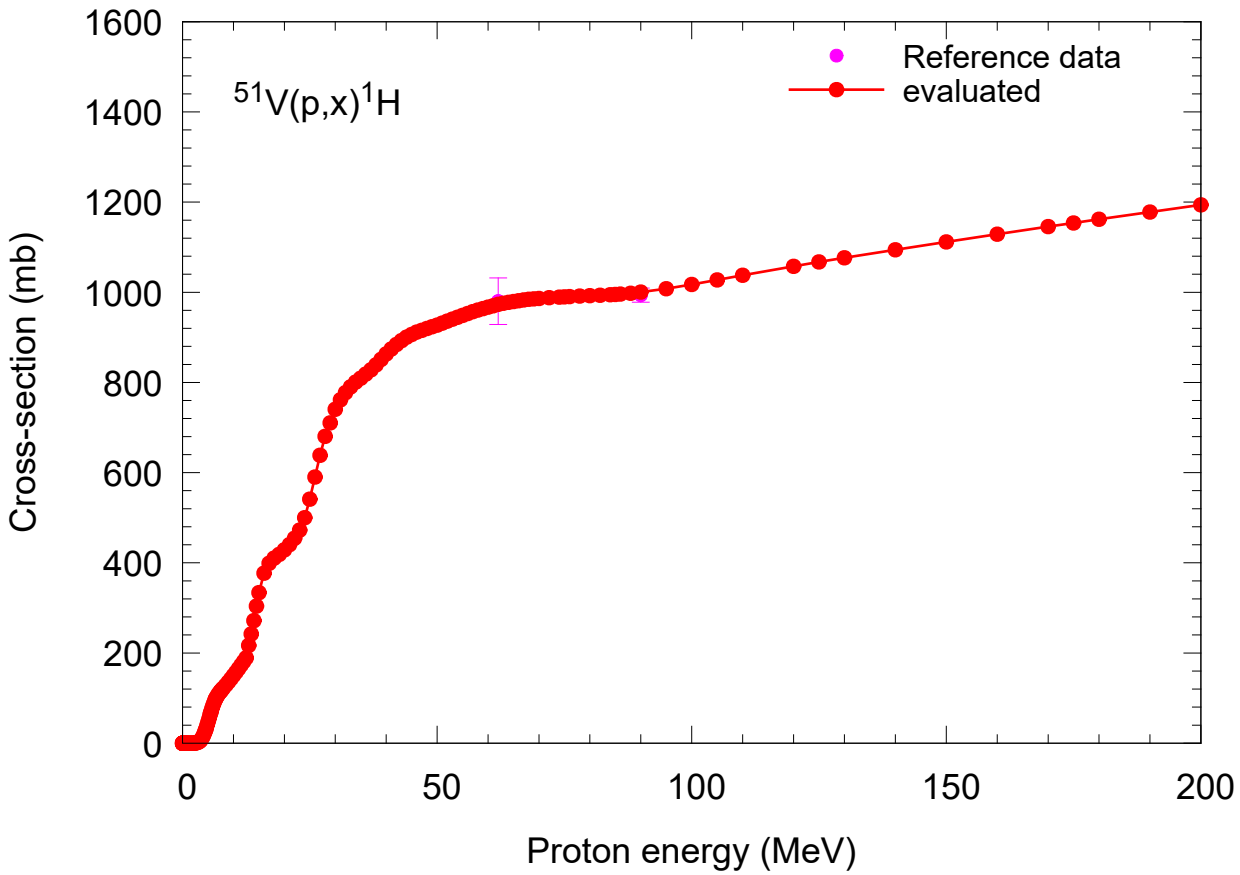

^{50}V(p,x)^{2}H
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
50
100
150
200
0
20
40
60
80
100
120
140
160
180
200

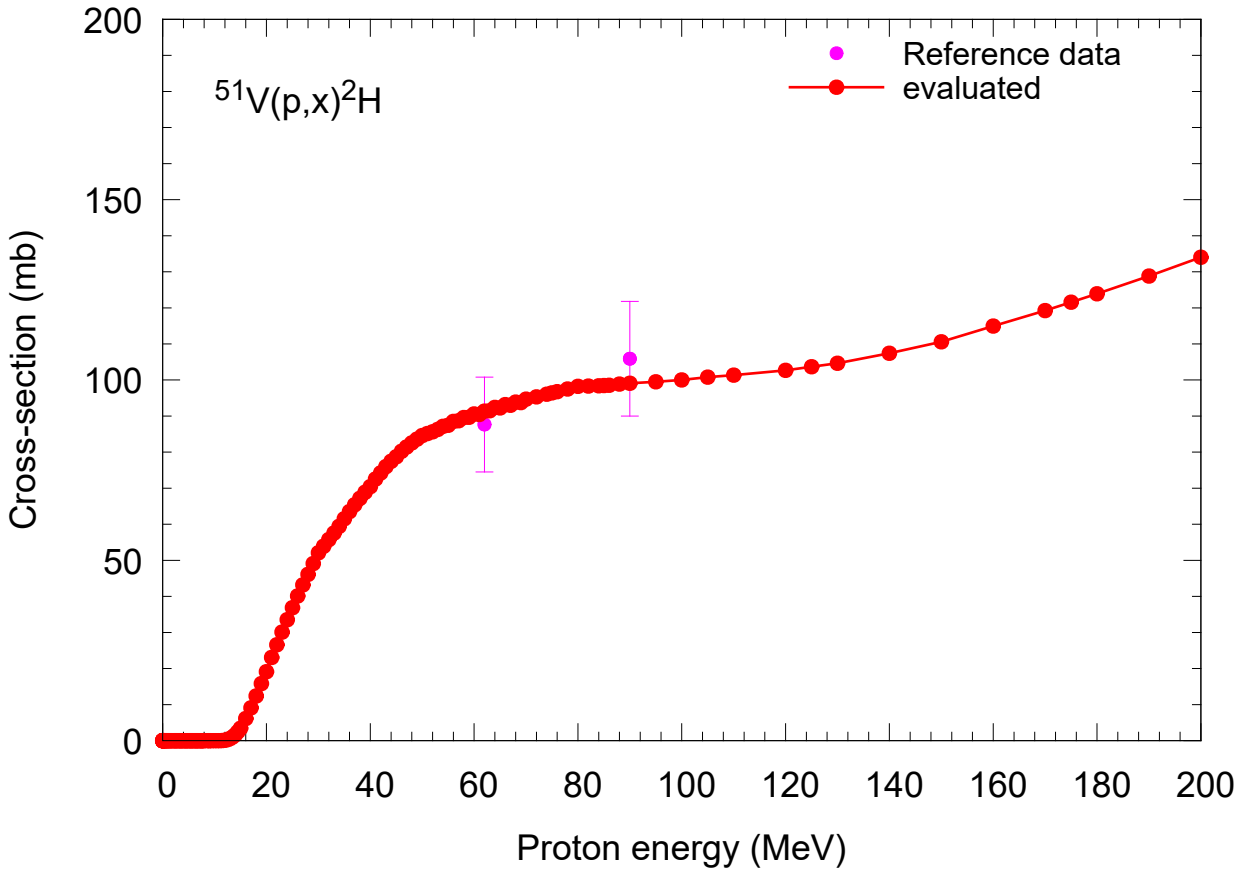

^{50}V(p,x)^{3}H
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100
120
140
160
180
200

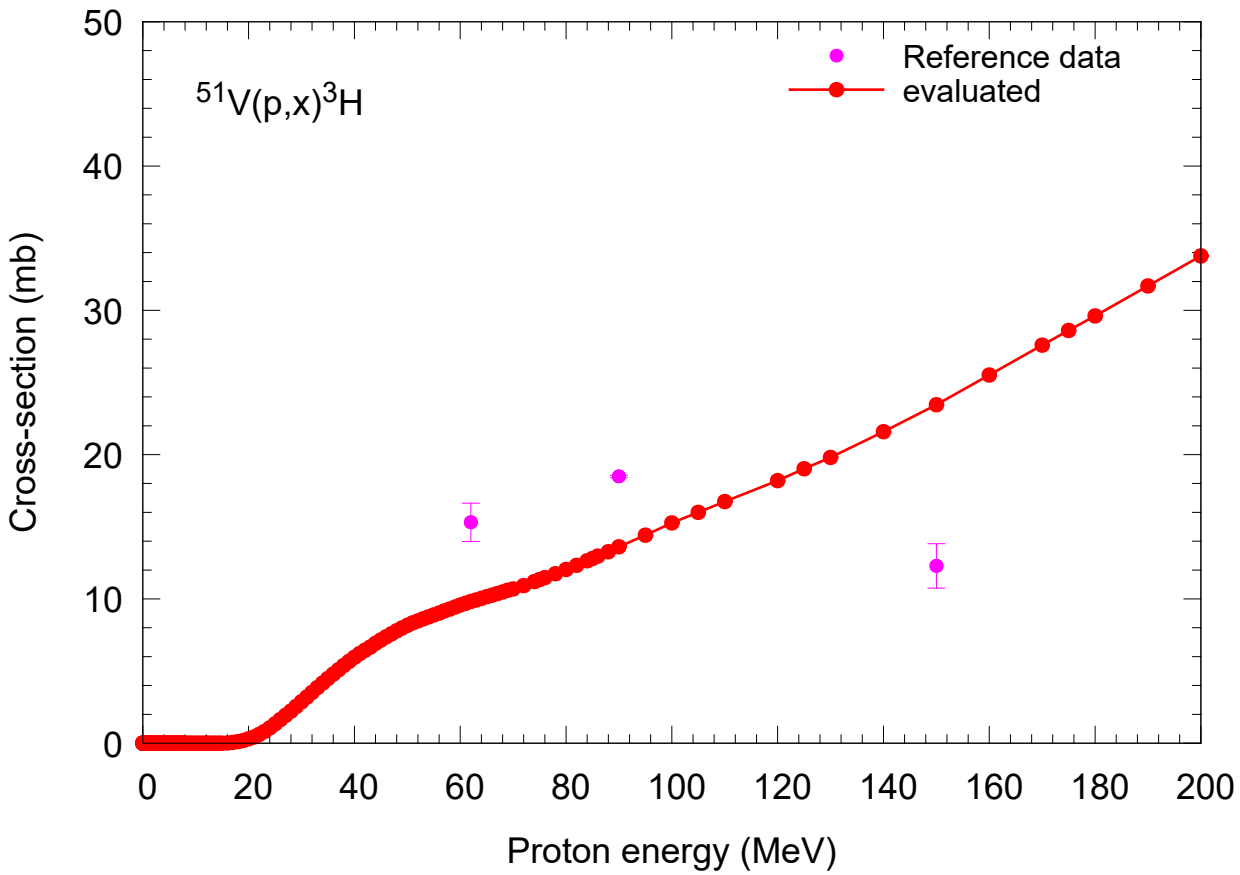

^{50}V(p,x)^{3}He
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
5
10
15
20
25
0
20
40
60
80
100
120
140
160
180
200

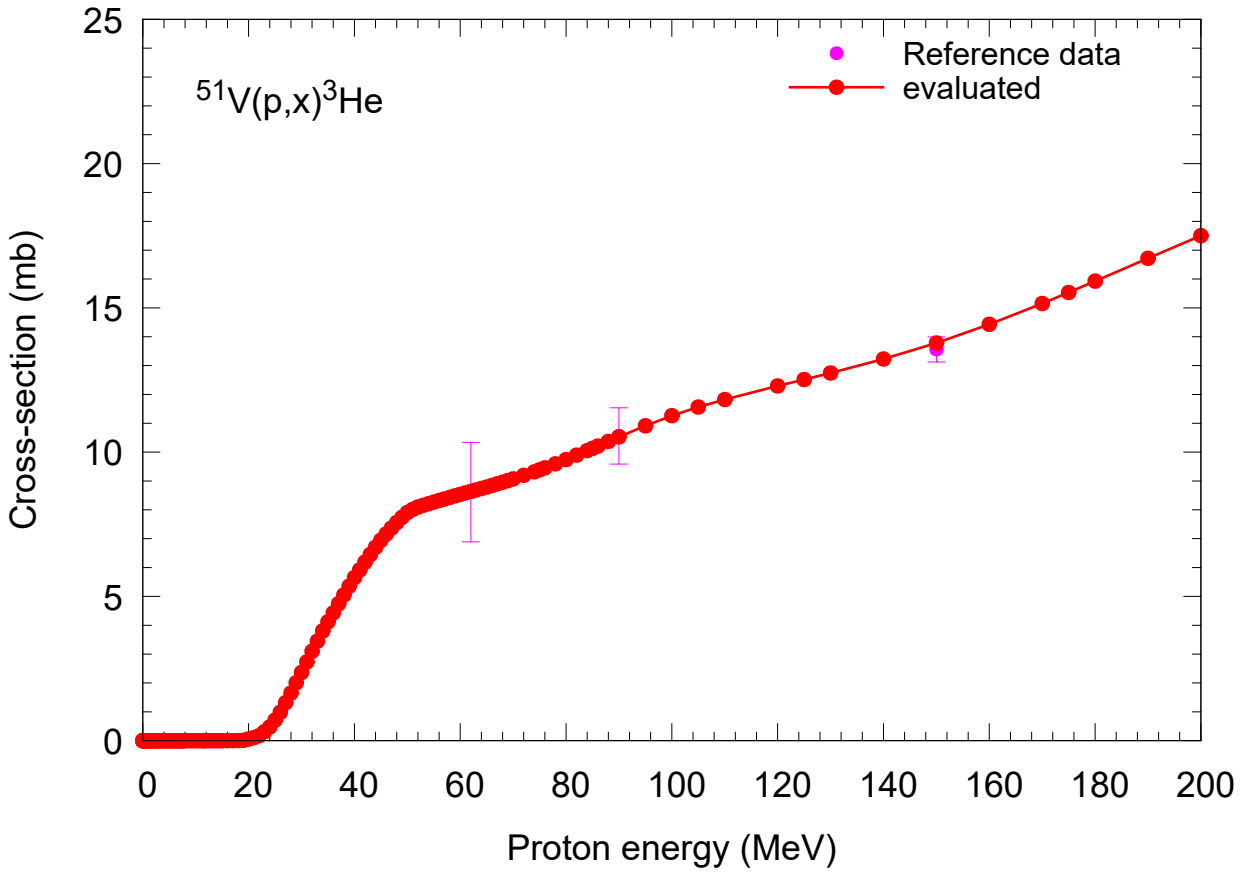

^{50}V(p,x)^{4}He
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
50
100
150
200
250
300
350
0
50
100
150
200

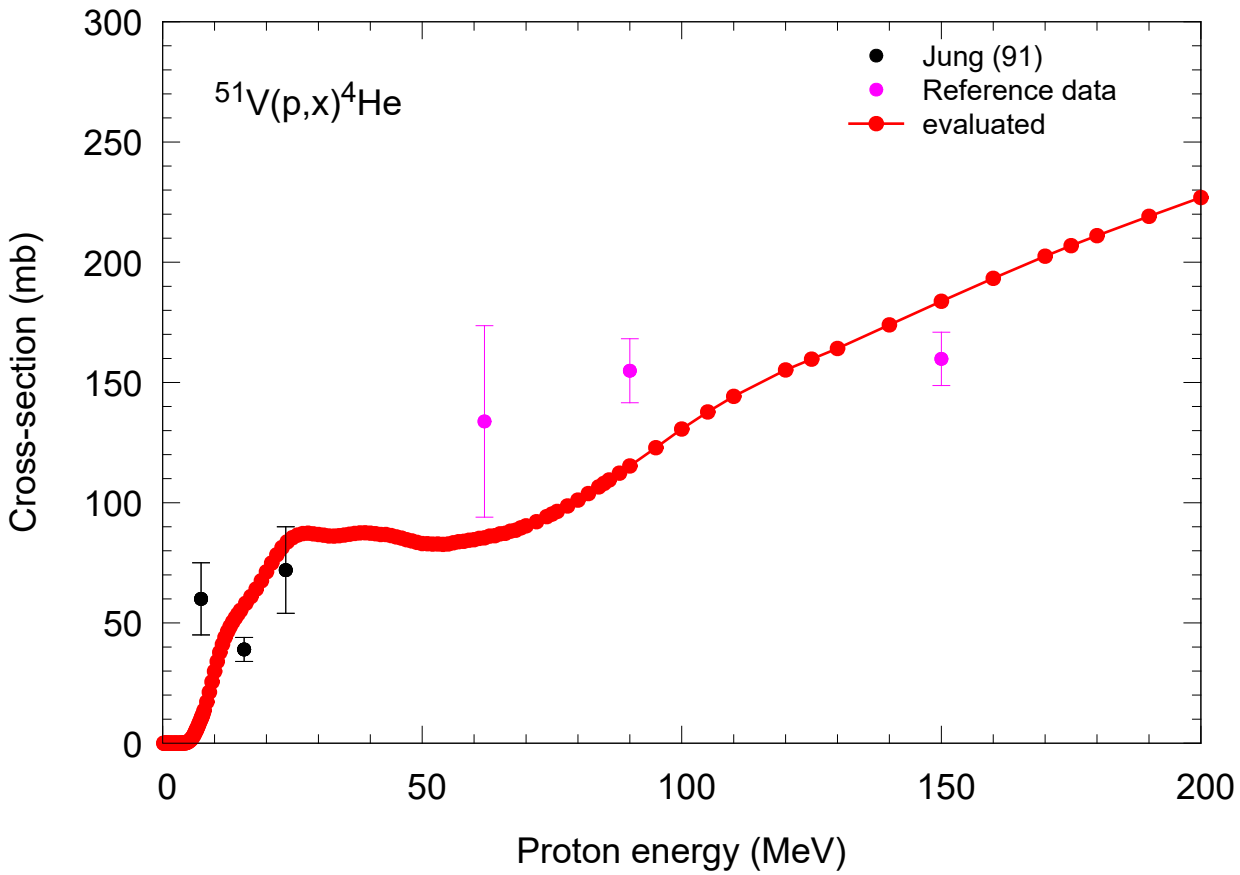

^{51}V(p,x)^{1}nn
Chodil (67)
evaluated
Cross-section (mb)
Proton energy (MeV)
0
500
1000
1500
2000
0
50
100
150
200

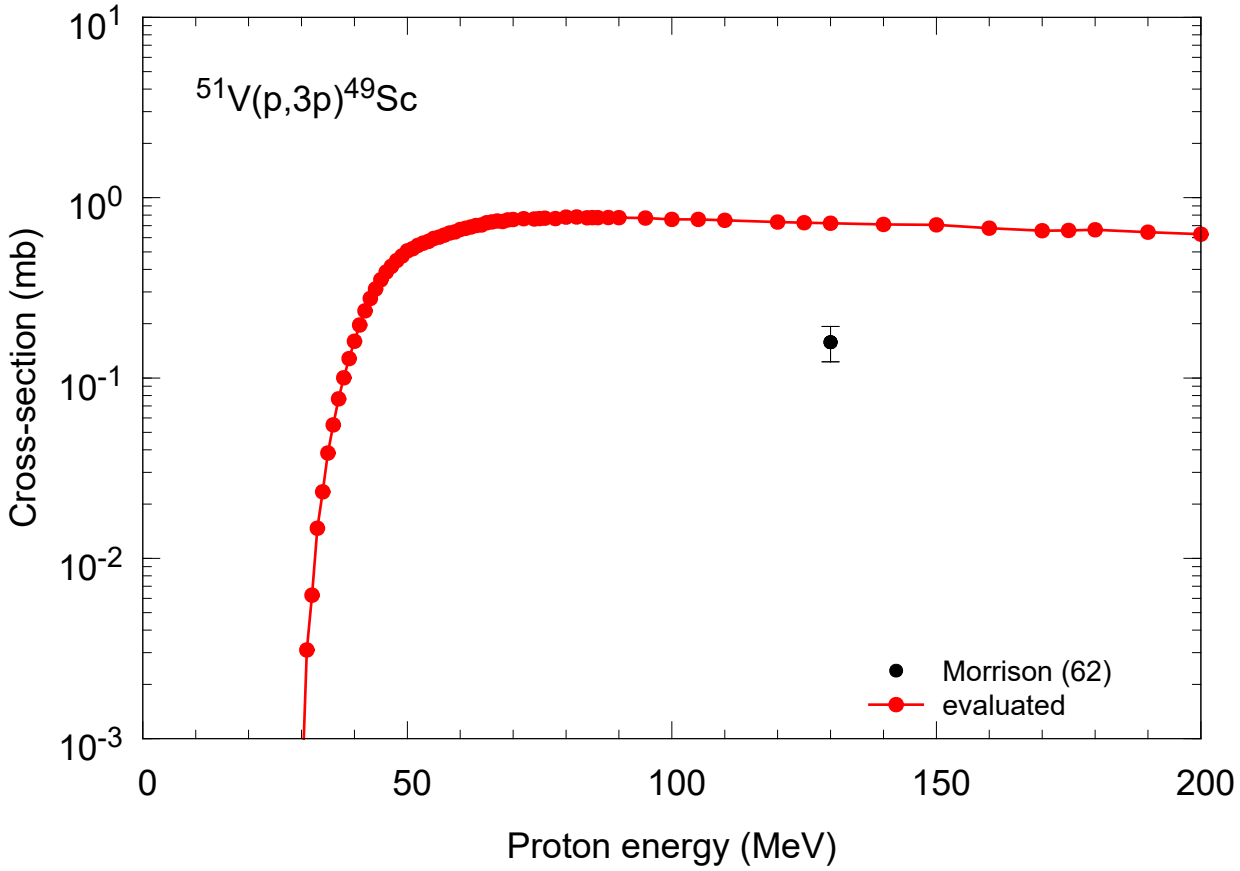

^{51}V(p,x)^{1}H
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
200
400
600
800
1000
1200
1400
1600
0
50
100
150
200

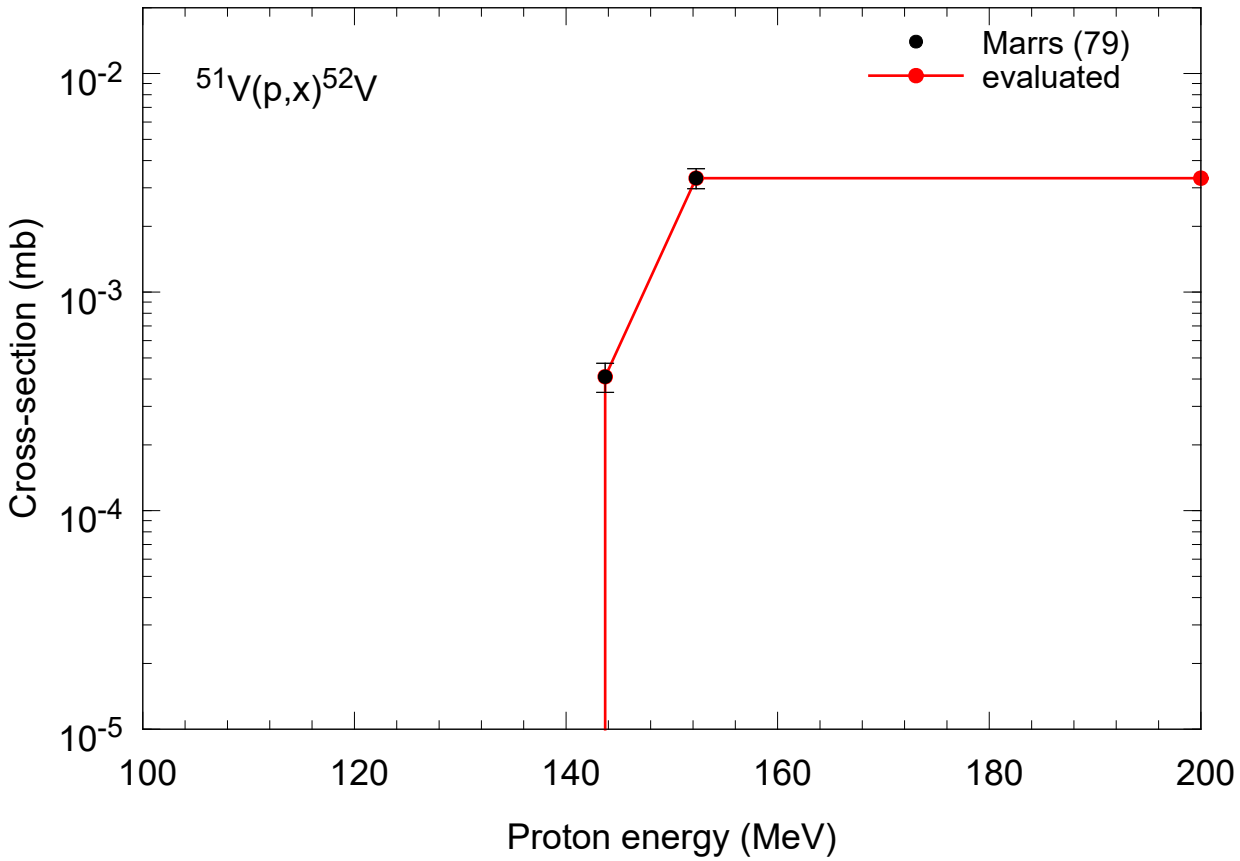

^{51}V(p,x)^{2}H
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
50
100
150
200
0
20
40
60
80
100
120
140
160
180
200

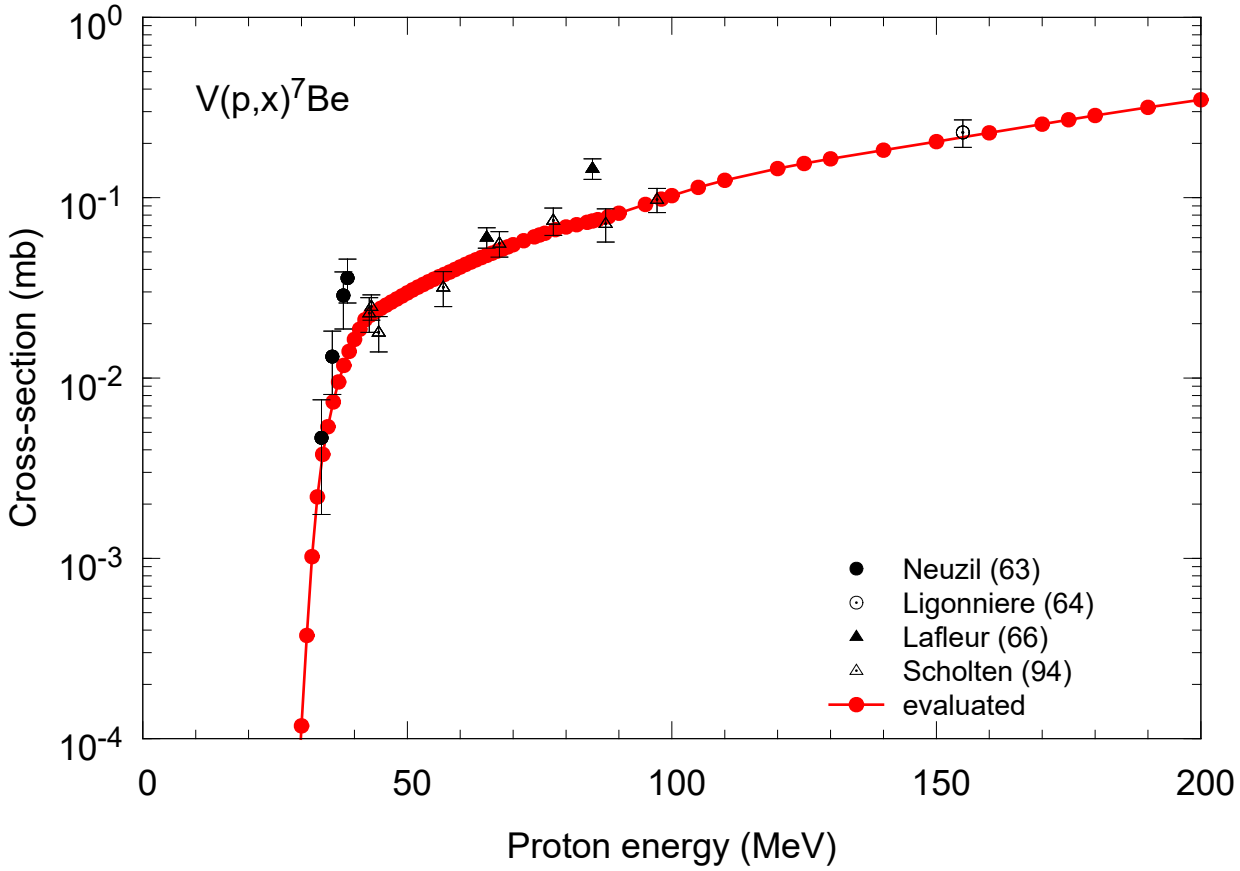

^{51}V(p,x)^{3}H
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
10
20
30
40
50
0
20
40
60
80
100
120
140
160
180
200

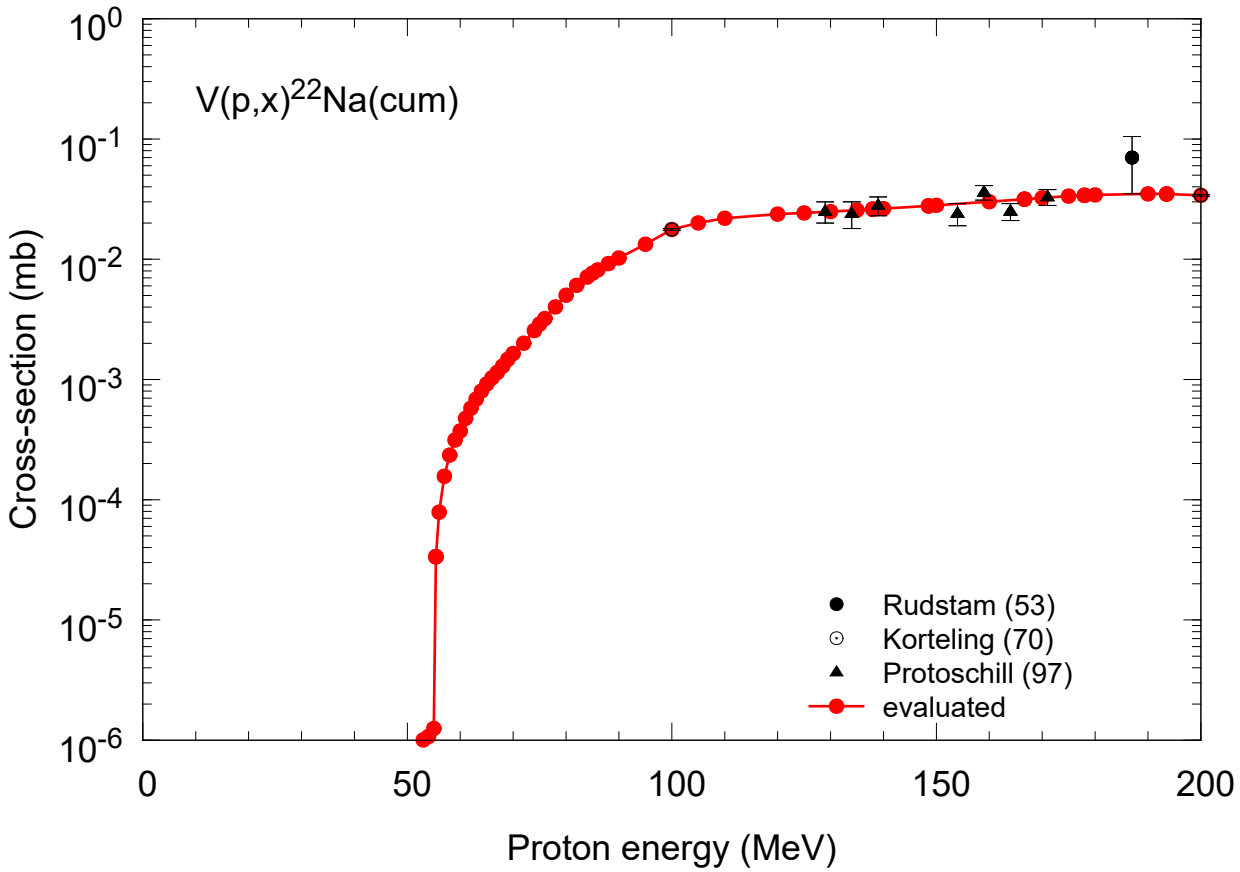

^{51}V(p,x)^{3}He
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
5
10
15
20
25
0
20
40
60
80
100
120
140
160
180
200

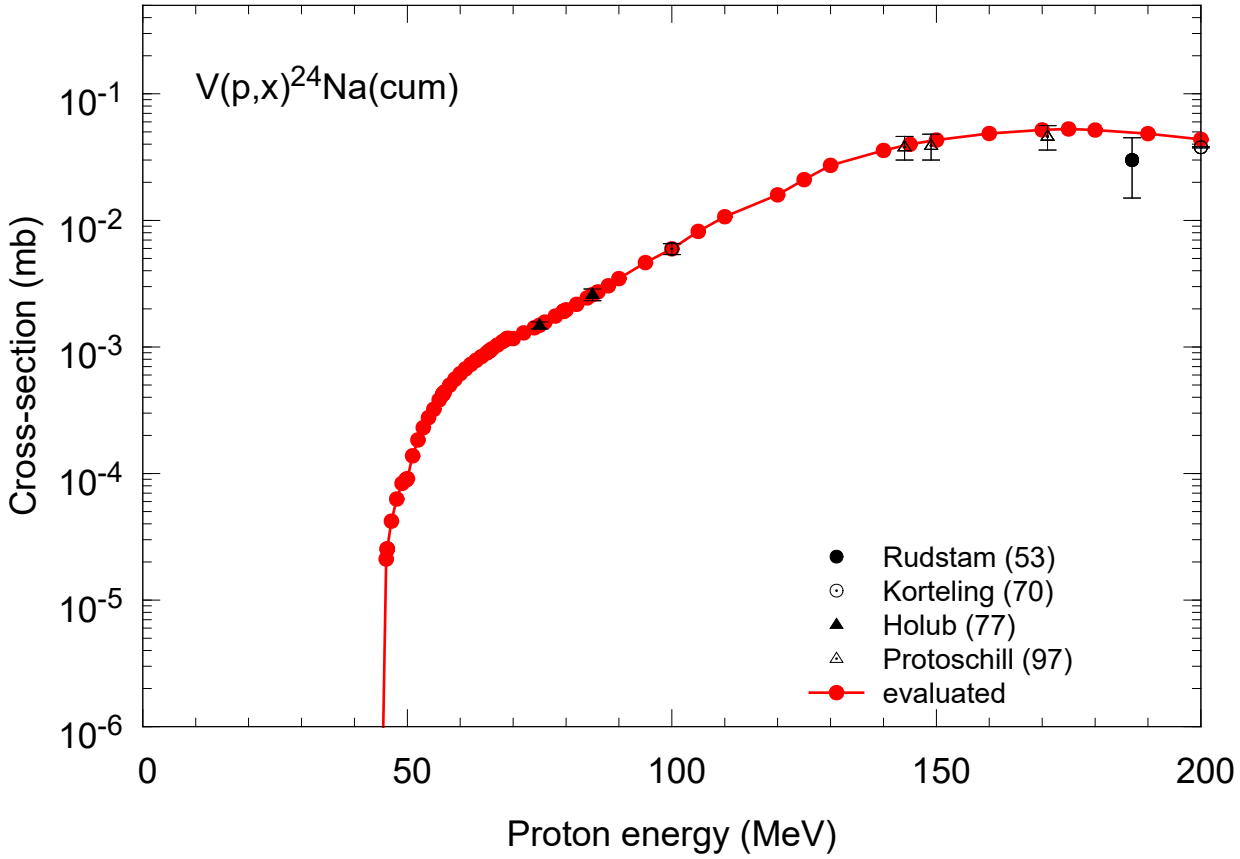

^{51}V(p,x)^{4}He
Jung (91)
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
50
100
150
200
250
300
0
50
100
150
200

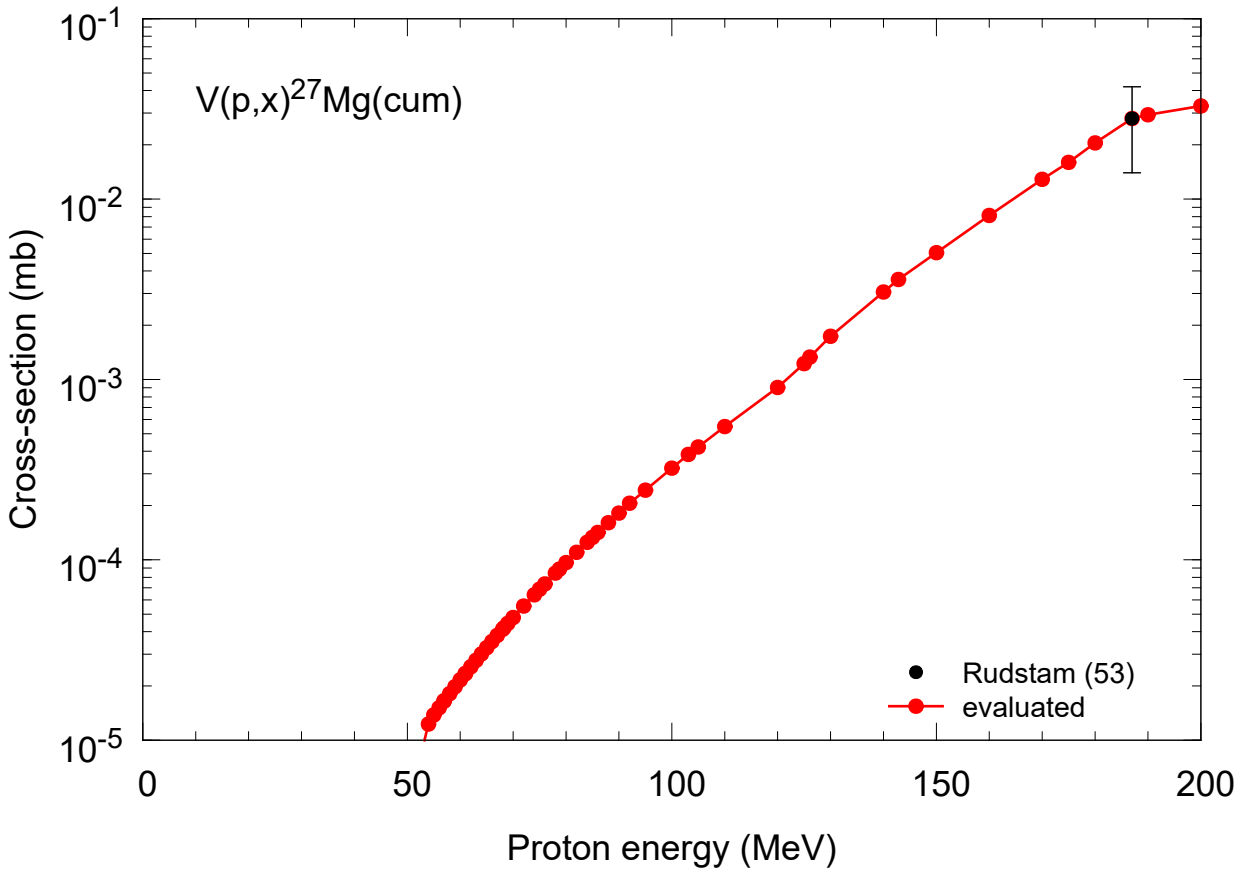

^{51}V(p,3p)^{49}Sc
Cross-section (mb)
Proton energy (MeV)
Morrison (62)
evaluated

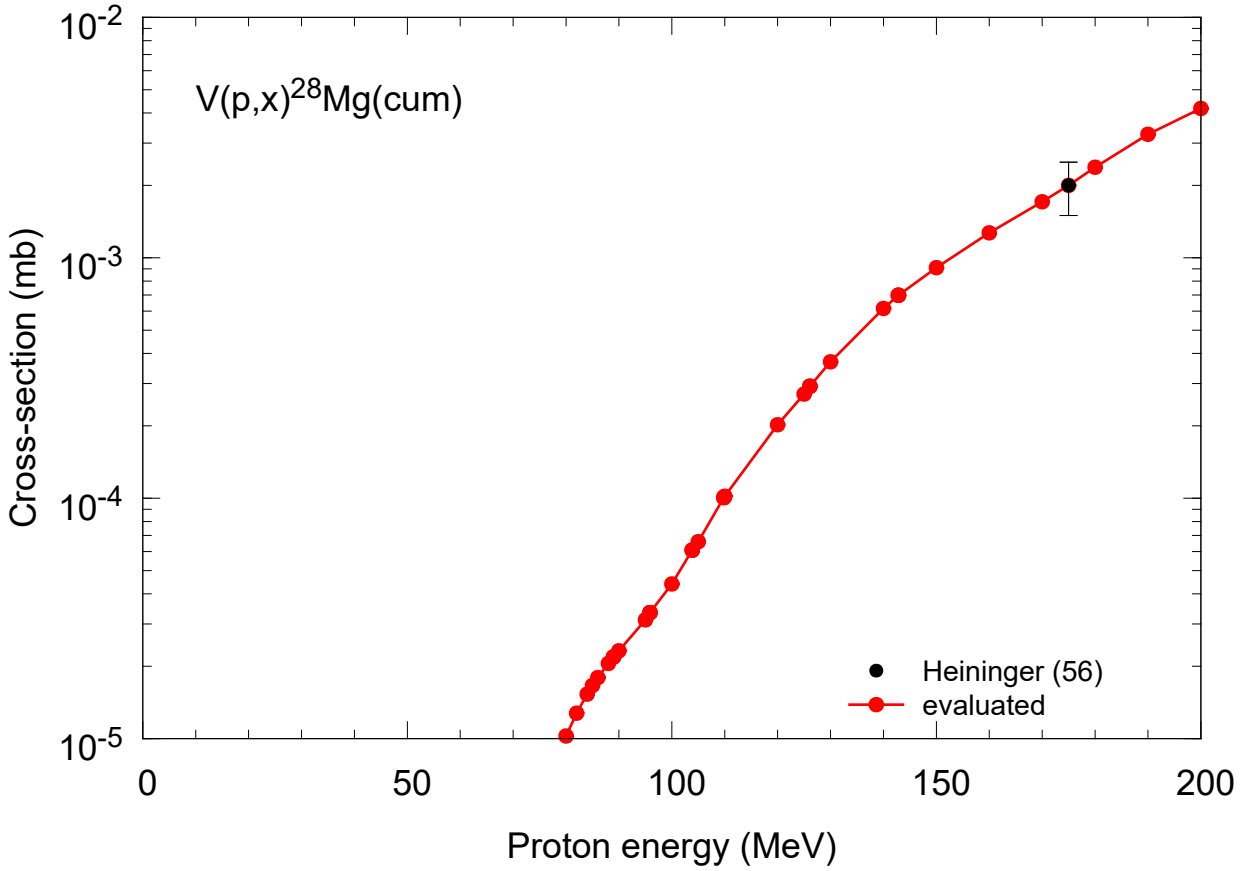

^{51}V(p,x)^{52}V
Cross-section (mb)
Proton energy (MeV)
Marrs (79)
evaluated

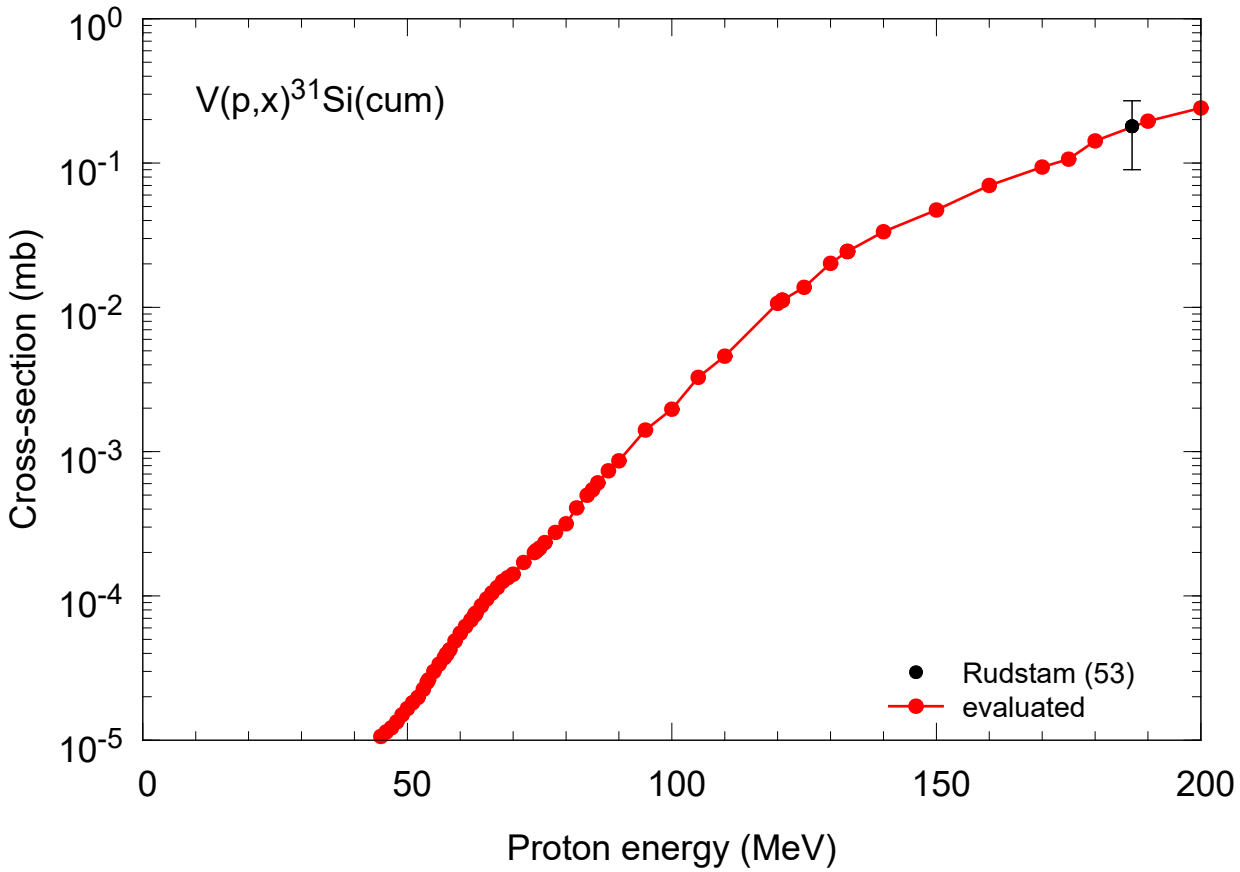

V(p,x)7Be
Cross-section (mb)
Proton energy (MeV)
Neuzil (63)
Ligonniere (64)
Lafleur (66)
Scholten (94)
evaluated

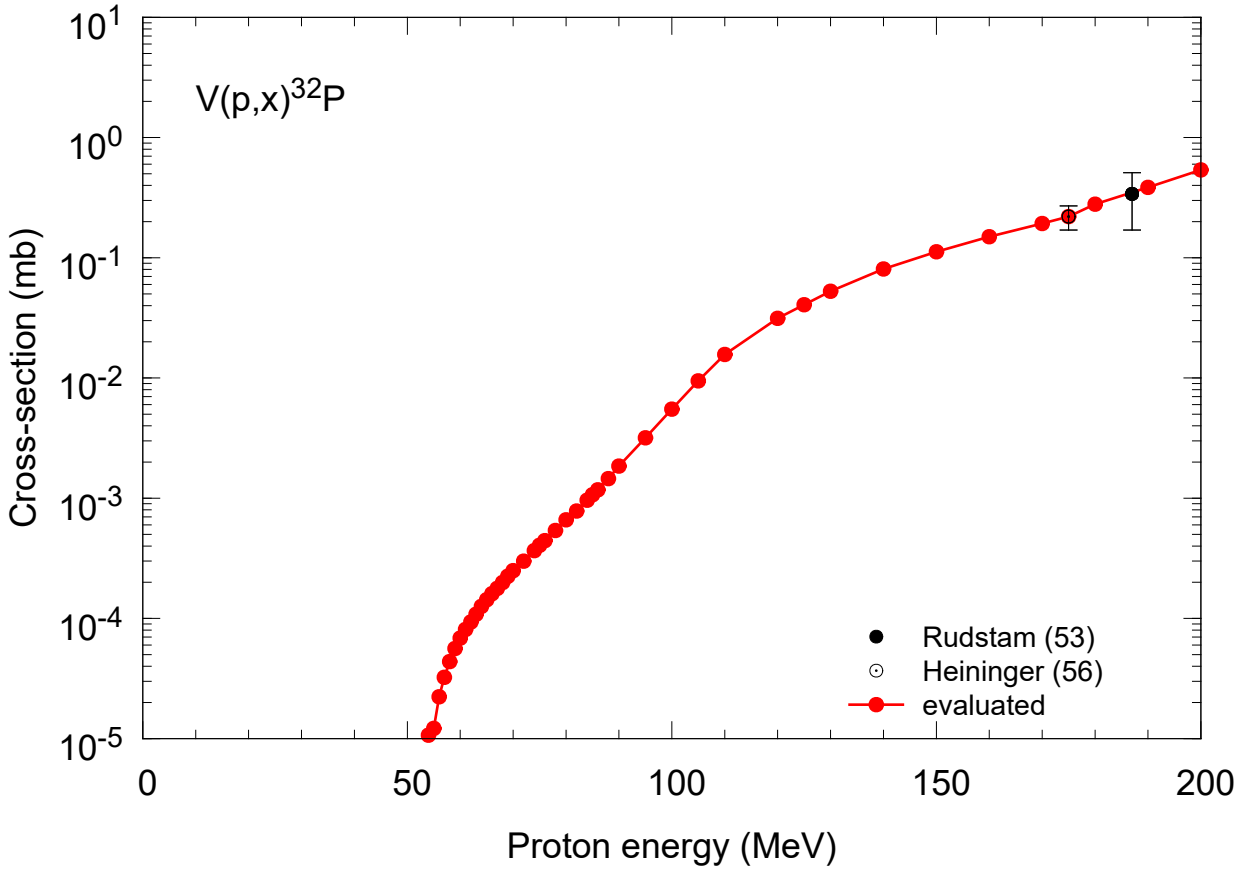

V(p,x)22Na(cum)
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Korteling (70)
Protoschill (97)
evaluated

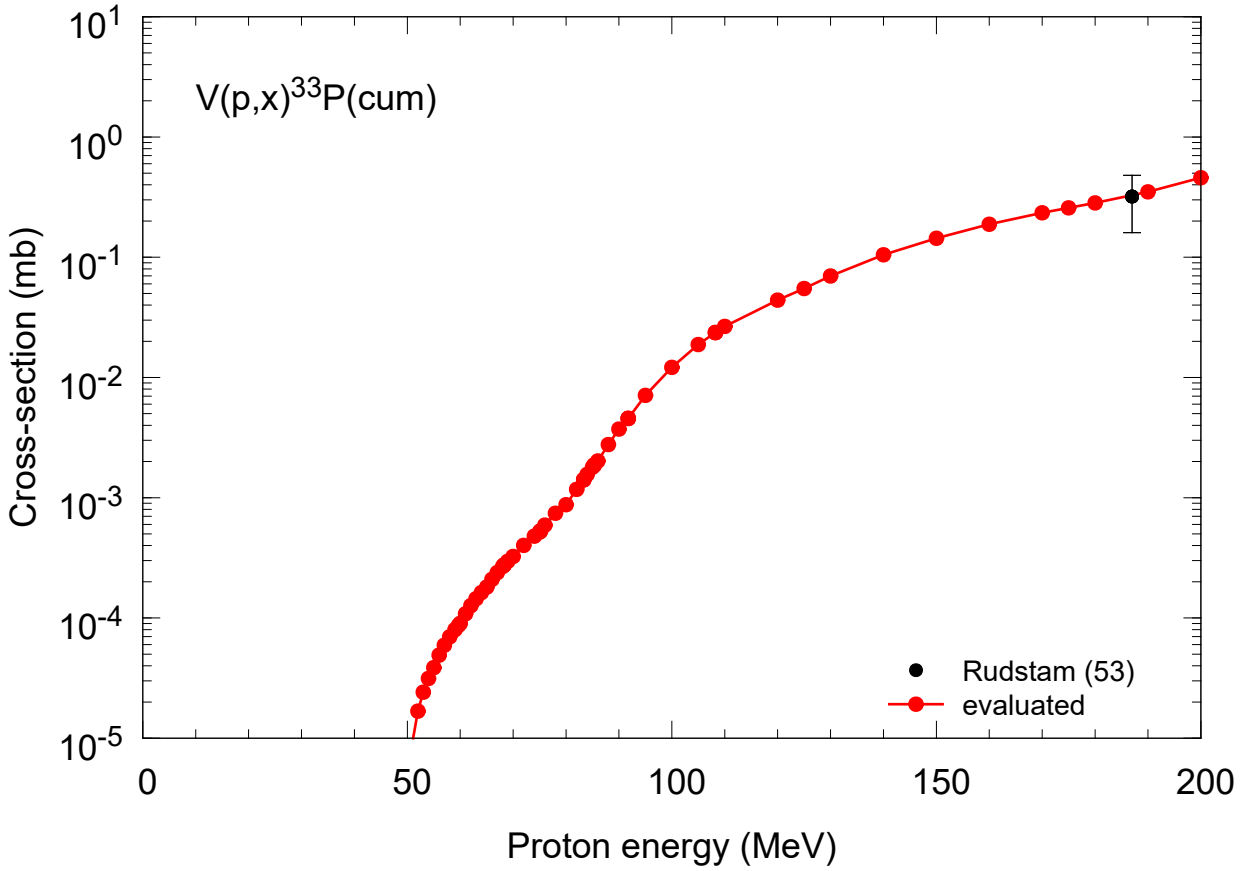

V(p,x)24Na(cum)
Cross-section (mb)
10-1
10-2
10-3
10-4
10-5
10-6
0
50
100
150
200
Proton energy (MeV)
Rudstam (53)
Korteling (70)
Holub (77)
Protoschill (97)
evaluated

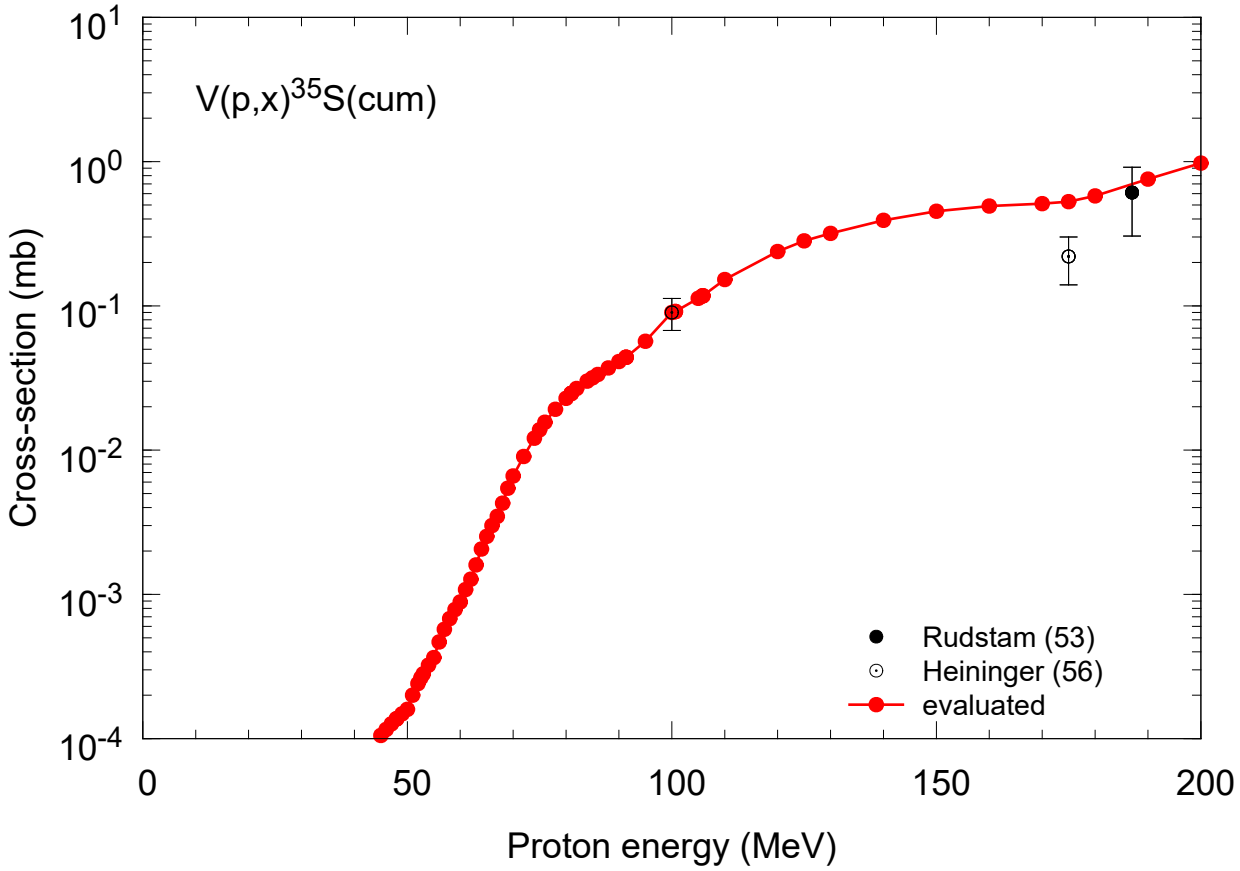

V(p,x)27Mg(cum)
Cross-section (mb)
10-1
10-2
10-3
10-4
10-5
0
50
100
150
200
Proton energy (MeV)
Rudstam (53)
evaluated

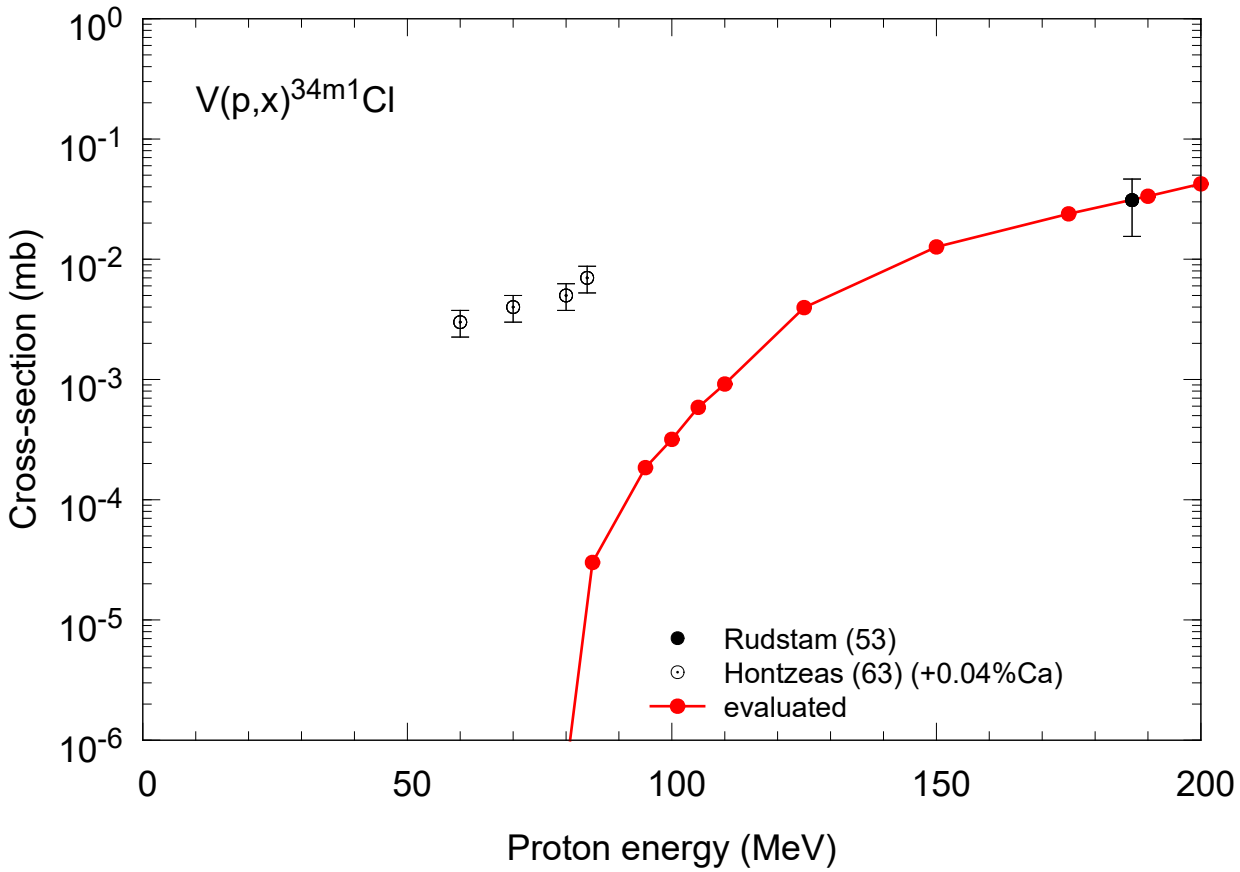

V(p,x)28Mg(cum)
Cross-section (mb)
10-2
10-3
10-4
10-5
0
50
100
150
200
Proton energy (MeV)
Heininger (56)
evaluated

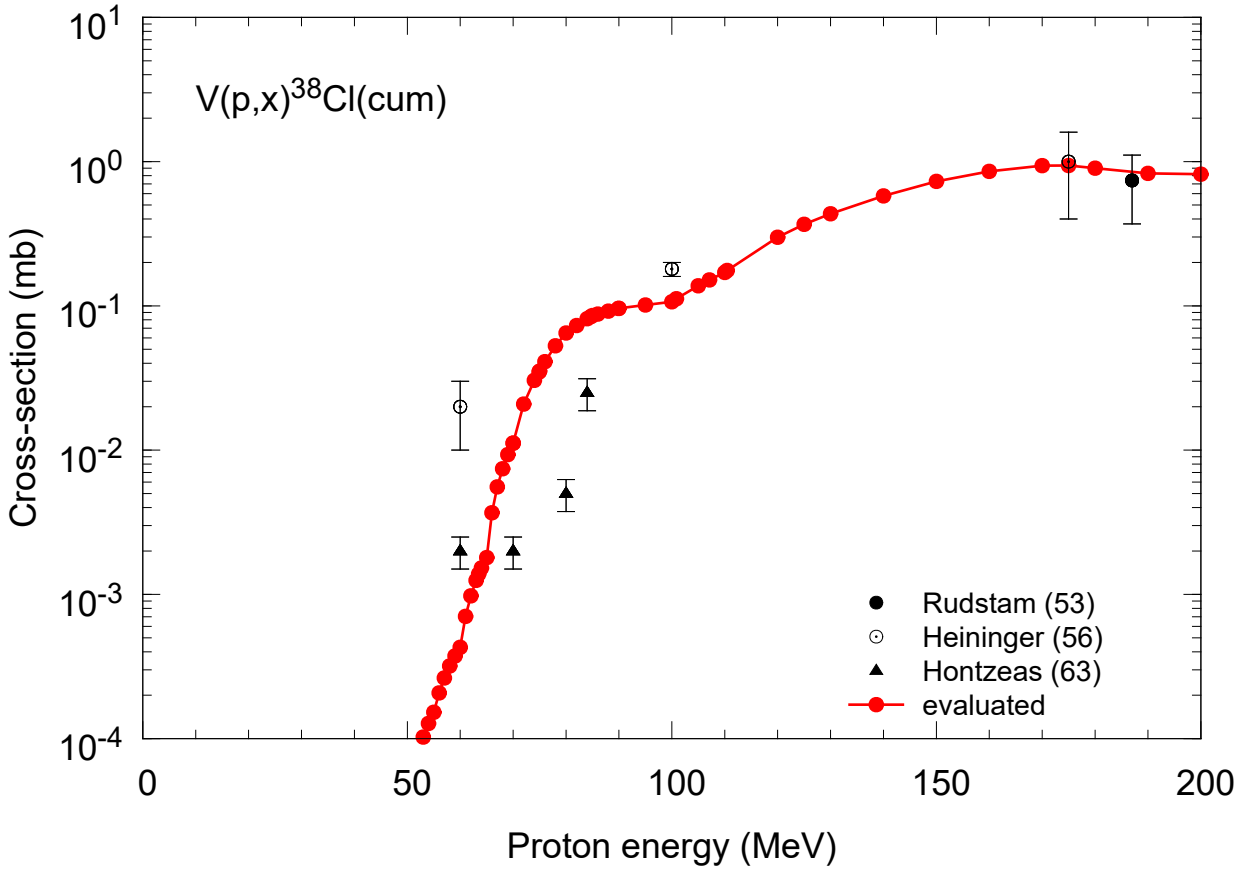

V(p,x)31Si(cum)
Cross-section (mb)
100
10-1
10-2
10-3
10-4
10-5
0
50
100
150
200
Proton energy (MeV)
Rudstam (53)
evaluated

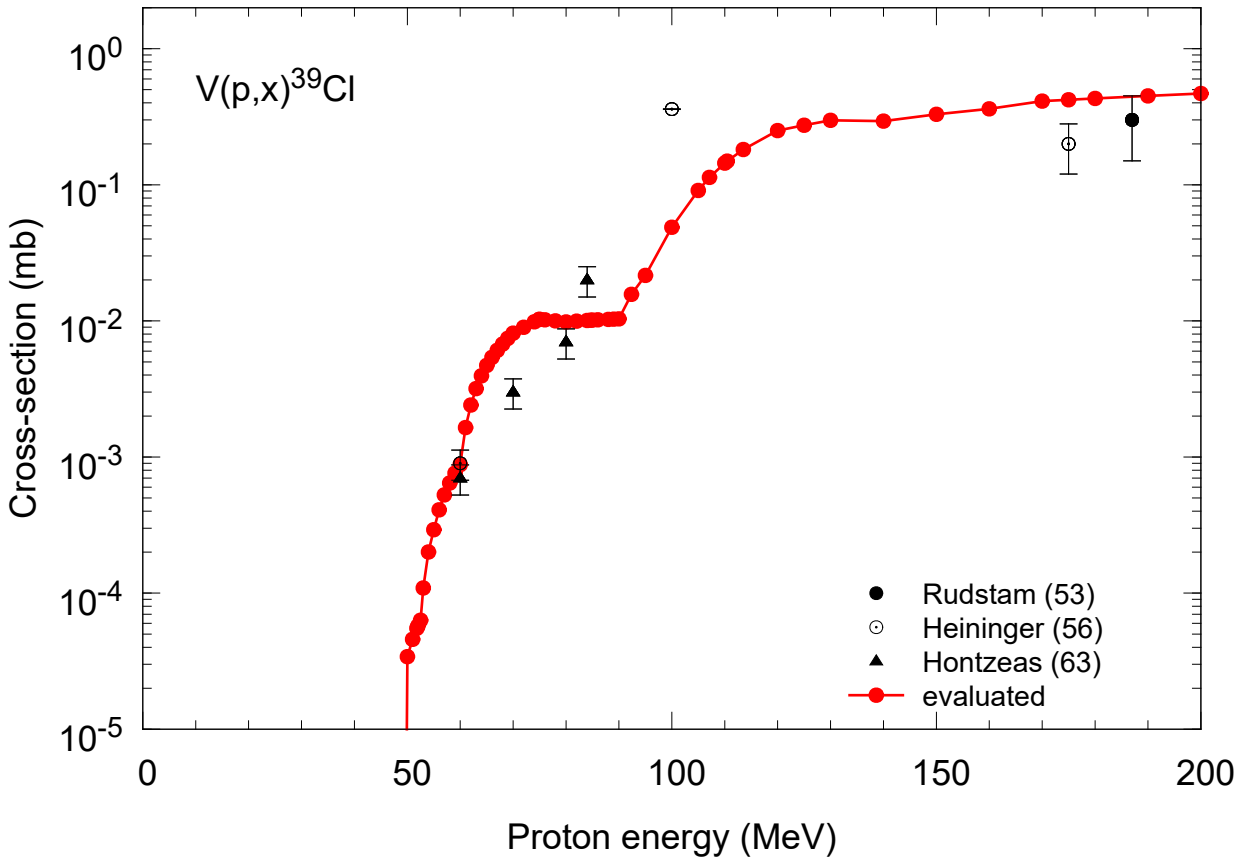

V(p,x)32P
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Heininger (56)
evaluated

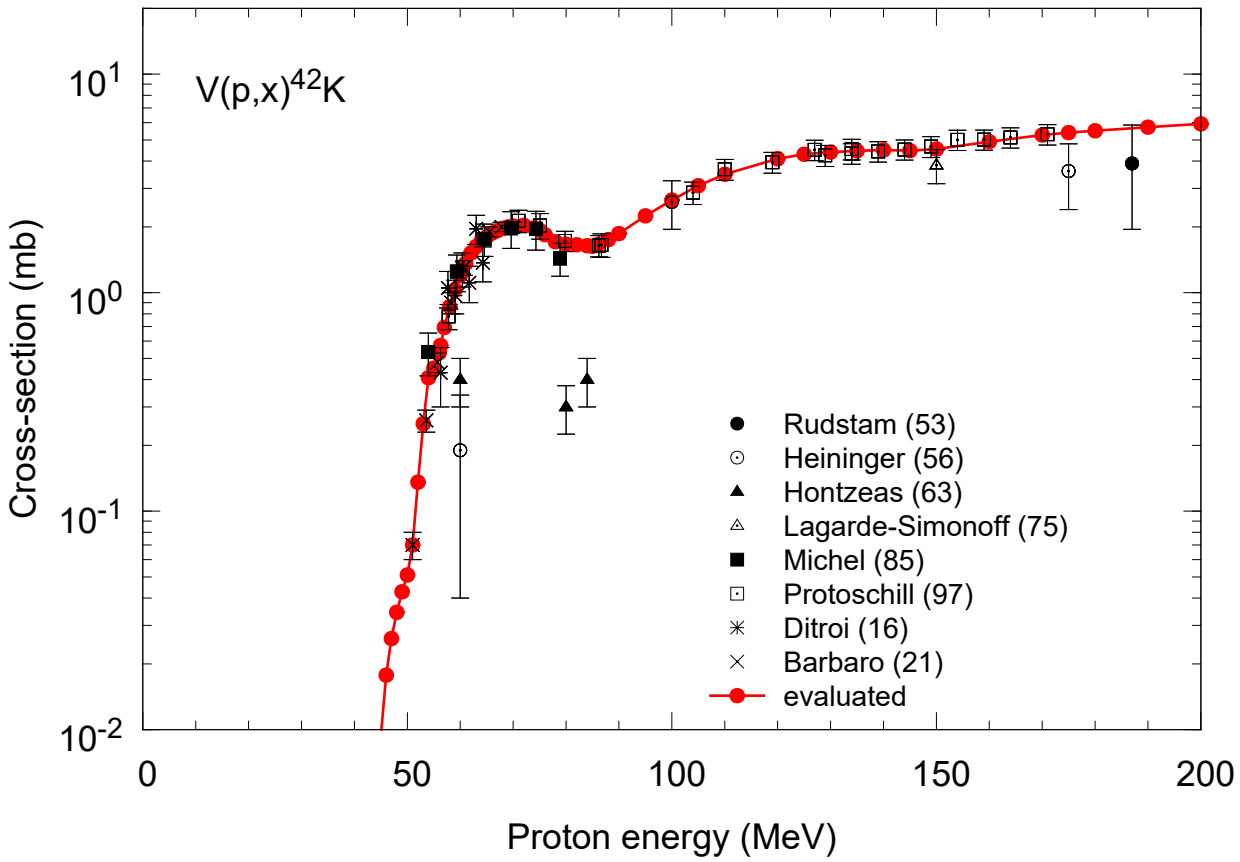

V(p,x)33P(cum)
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
evaluated

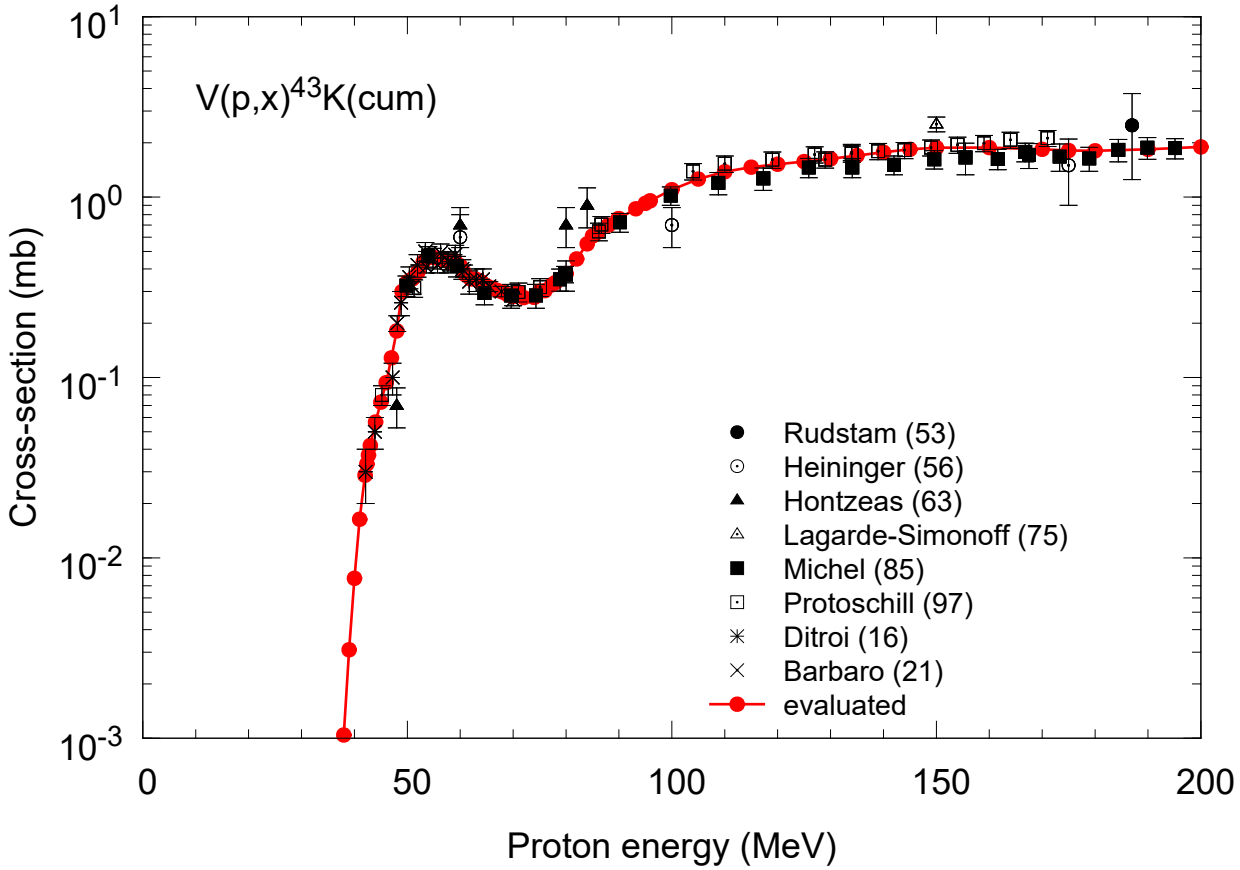

V(p,x)35S(cum)
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Heininger (56)
evaluated

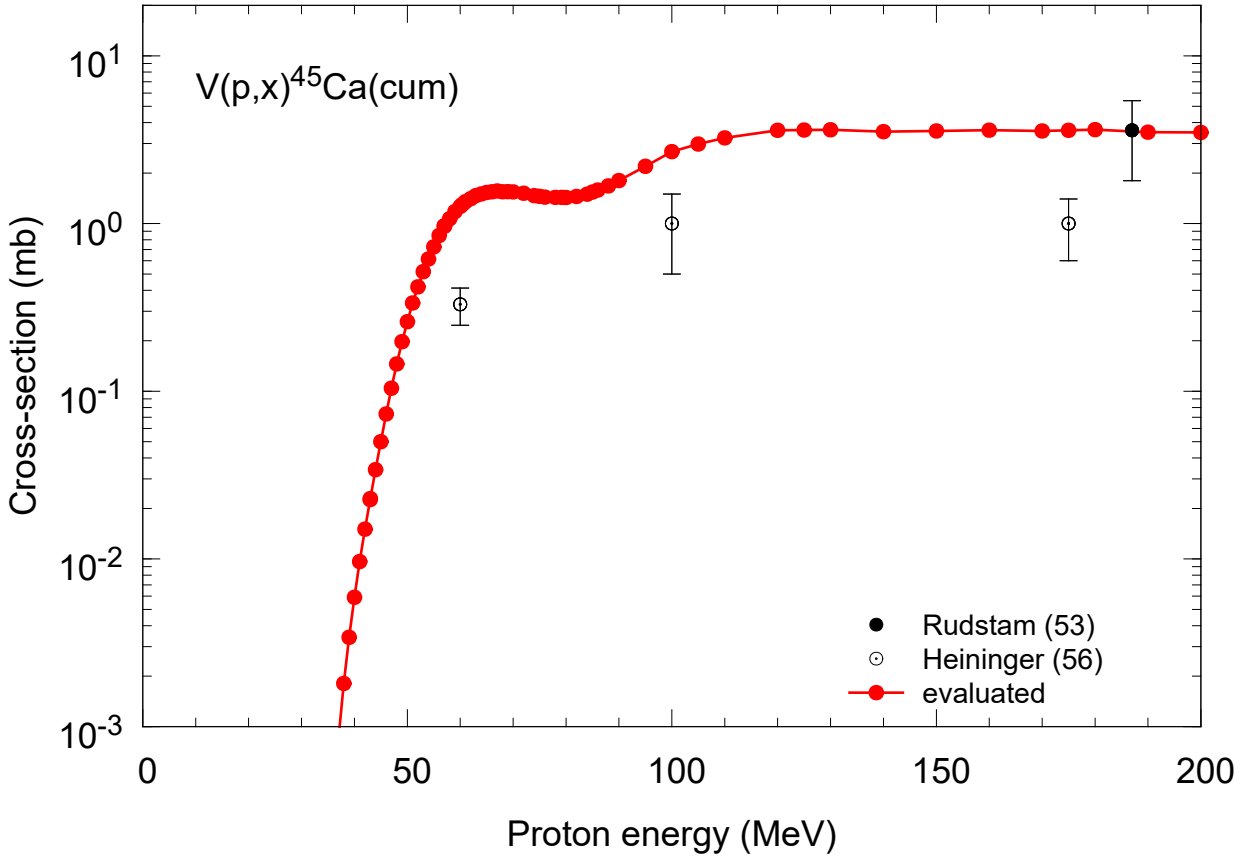

V(p,x)34m1Cl
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Hontzeas (63) (+0.04%Ca)
evaluated

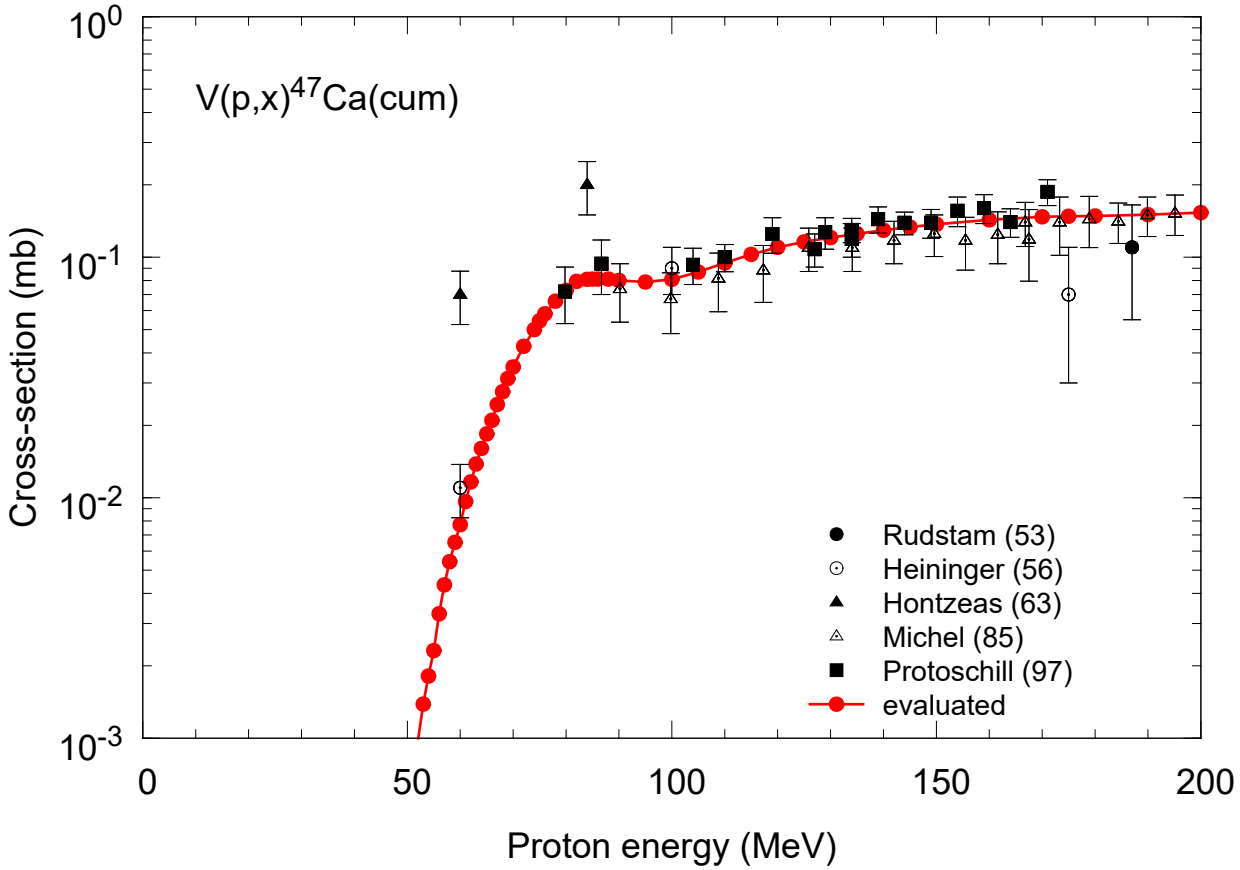

V(p,x)38Cl(cum)
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Heininger (56)
Hontzeas (63)
evaluated

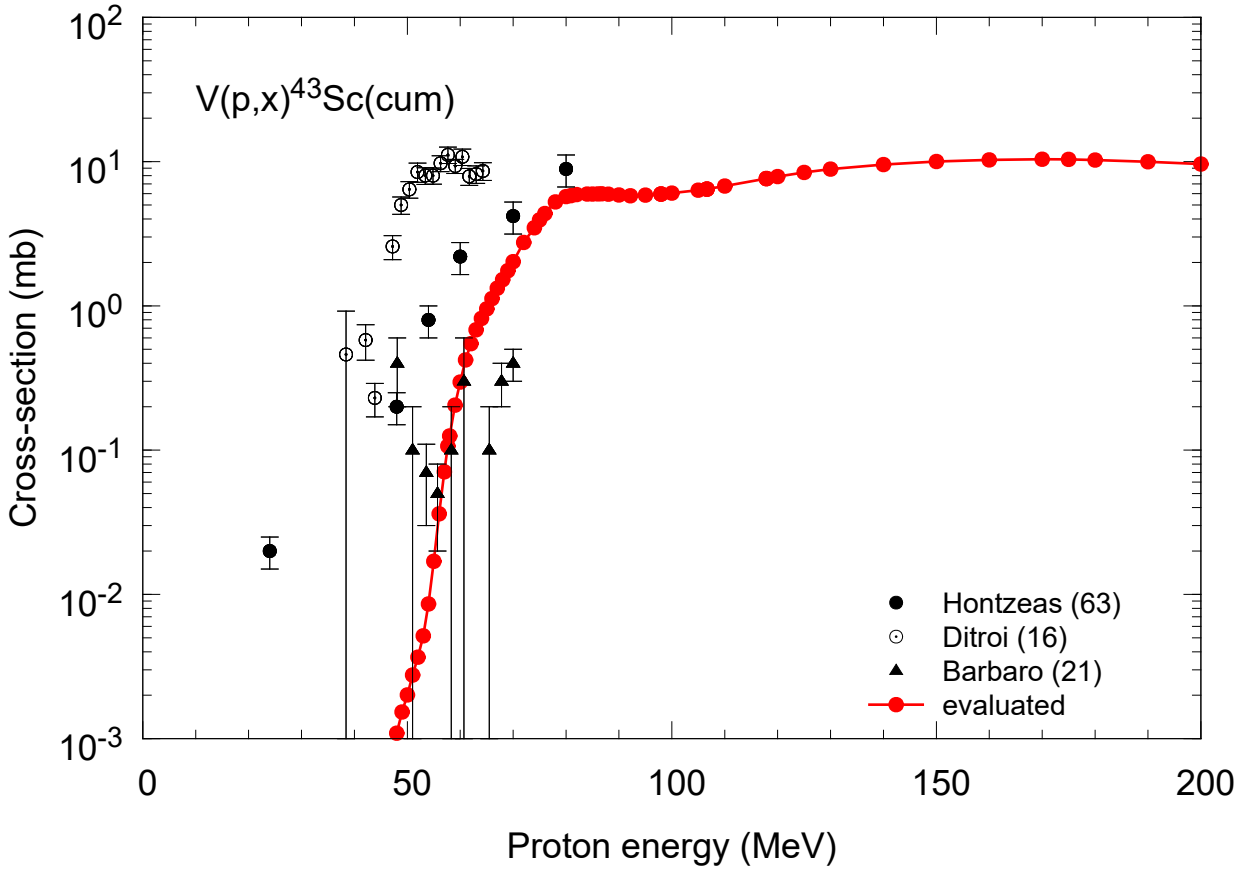

V(p,x)39Cl
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Heininger (56)
Hontzeas (63)
evaluated

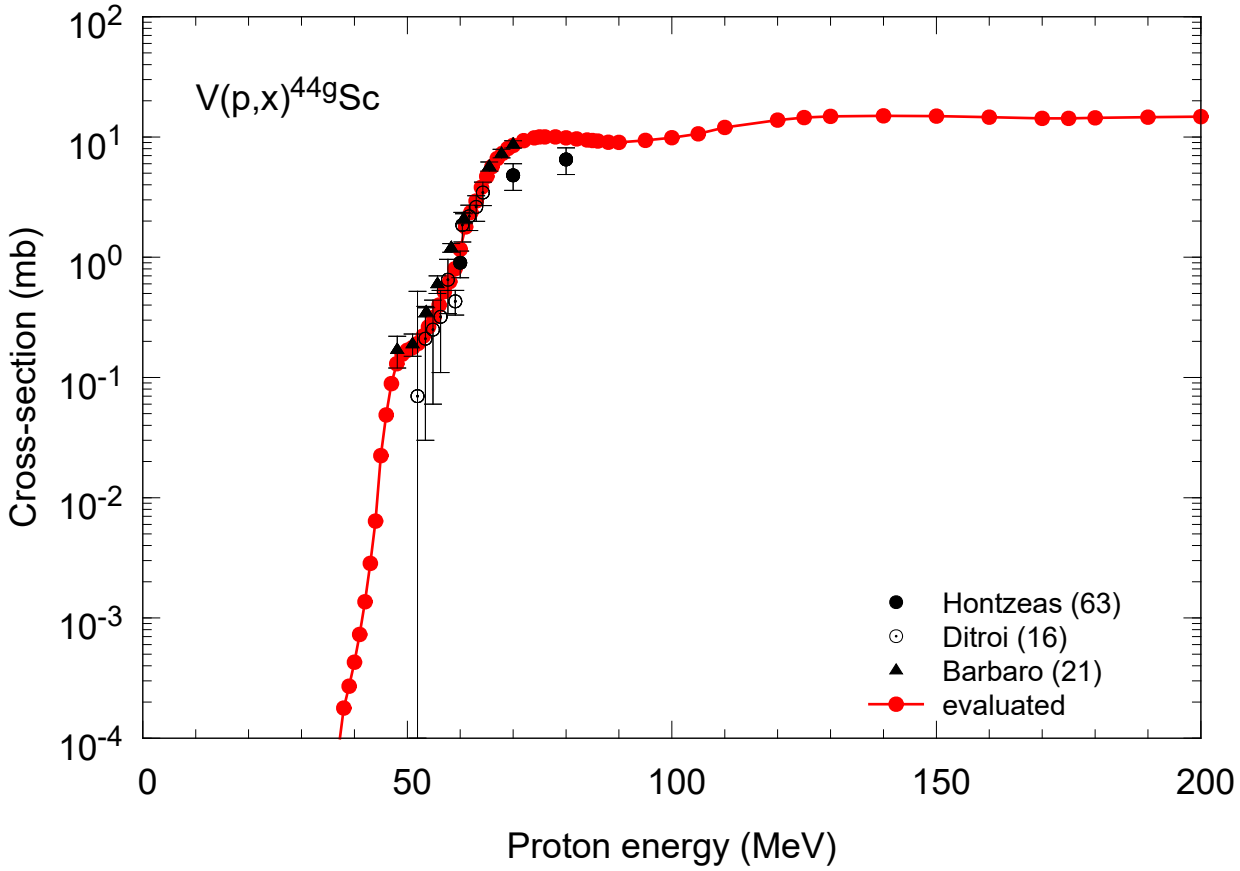

V(p,x)42K
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Heininger (56)
Hontzeas (63)
Lagarde-Simonoff (75)
Michel (85)
Protoschill (97)
Ditroi (16)
Barbaro (21)
evaluated

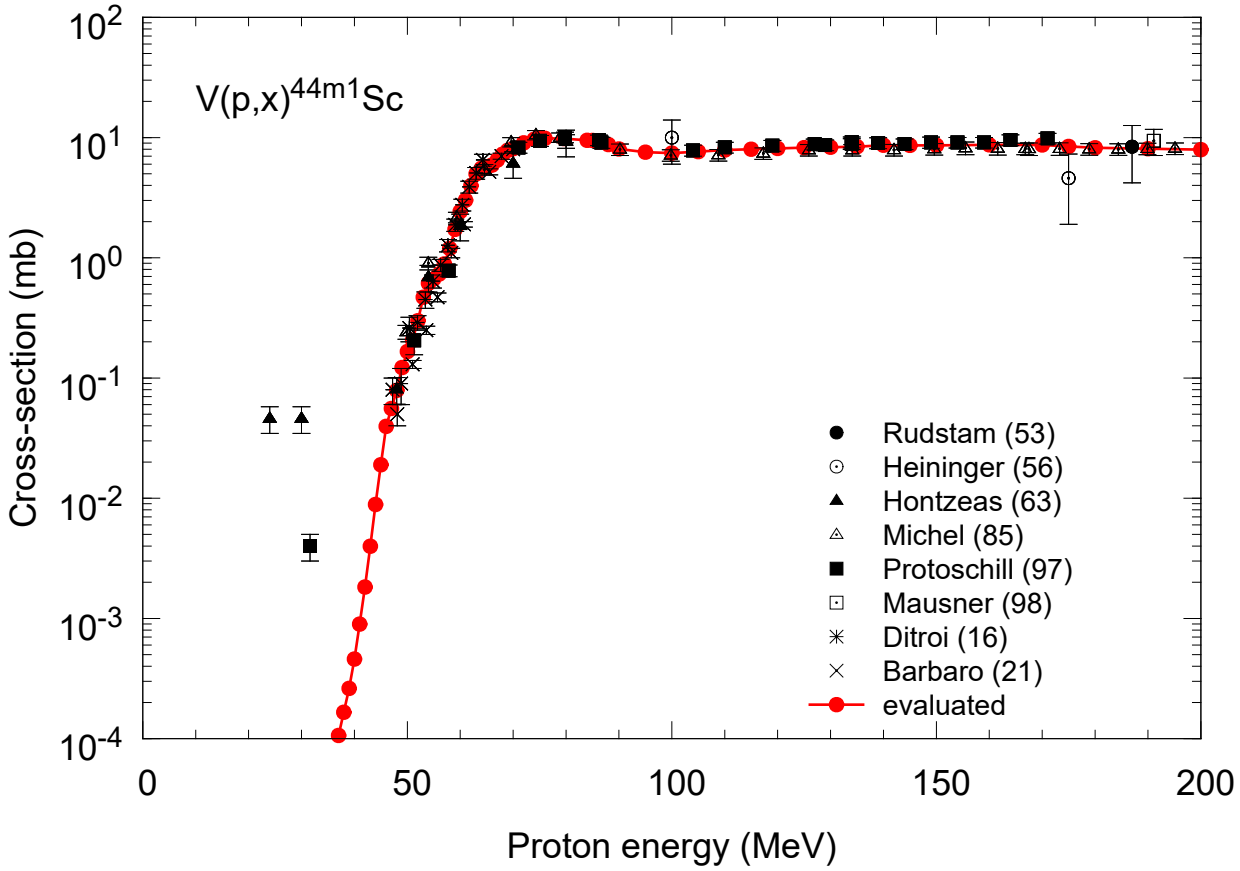

V(p,x)43K(cum)
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Heininger (56)
Hontzeas (63)
Lagarde-Simonoff (75)
Michel (85)
Protoschill (97)
Ditroi (16)
Barbaro (21)
evaluated

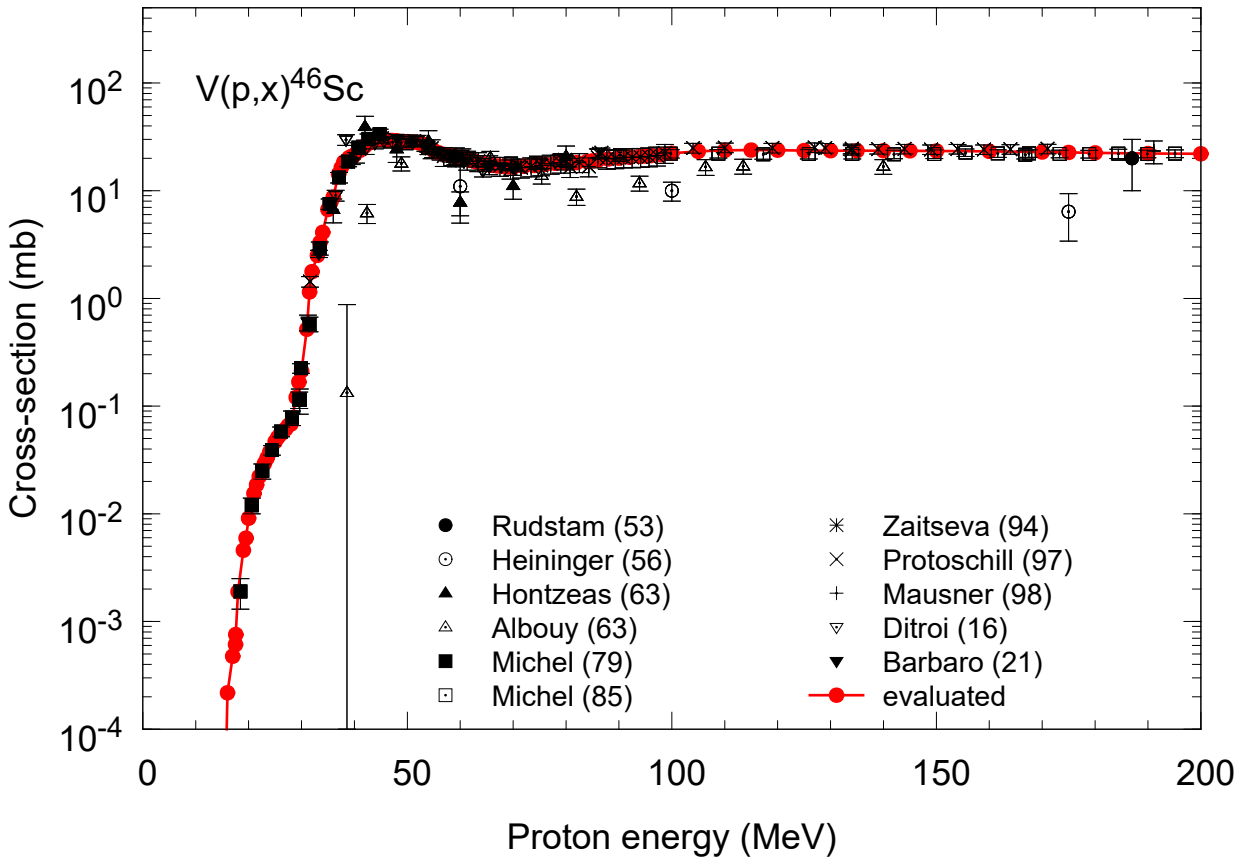

V(p,x)45Ca(cum)
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Heininger (56)
evaluated

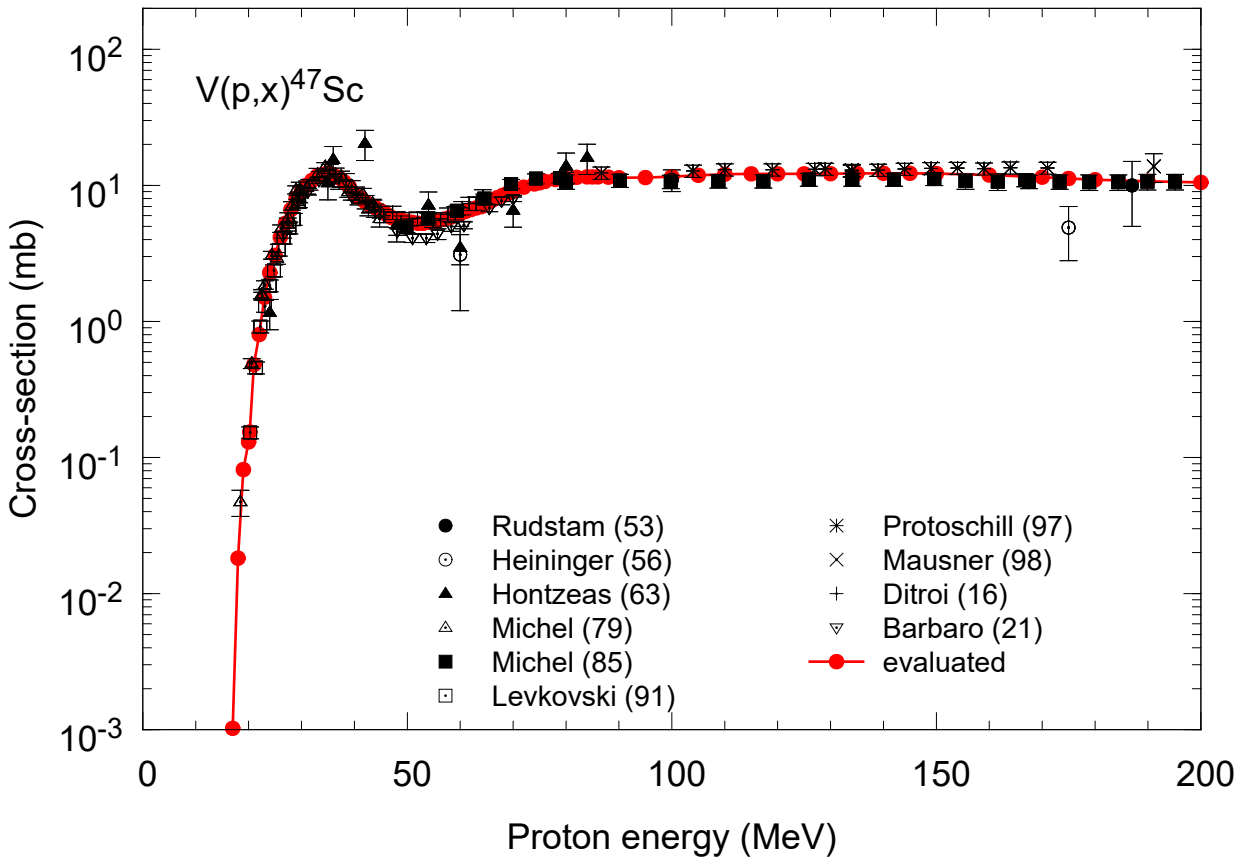

V(p,x)47Ca(cum)
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Heininger (56)
Hontzeas (63)
Michel (85)
Protoschill (97)
evaluated

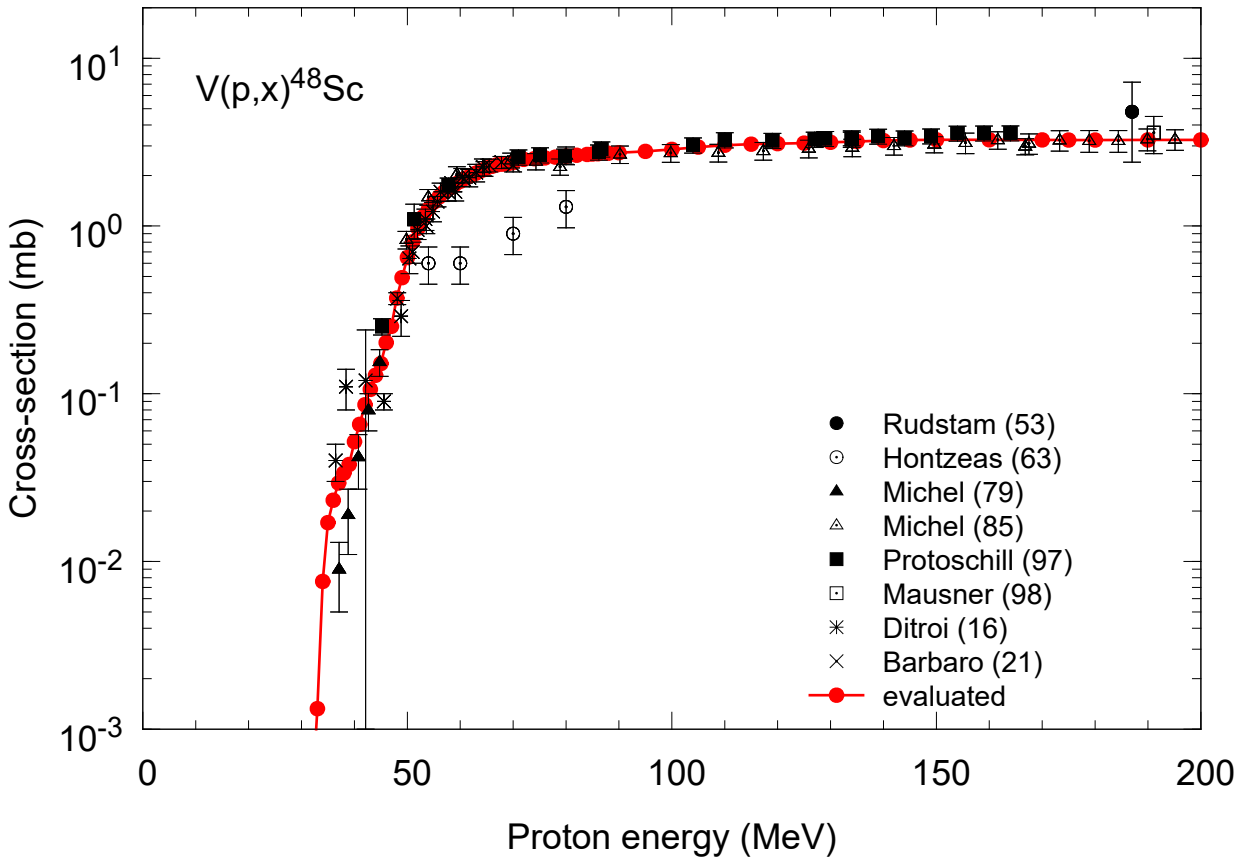

V(p,x)43Sc(cum)
Cross-section (mb)
Proton energy (MeV)
Hontzeas (63)
Ditroi (16)
Barbaro (21)
evaluated

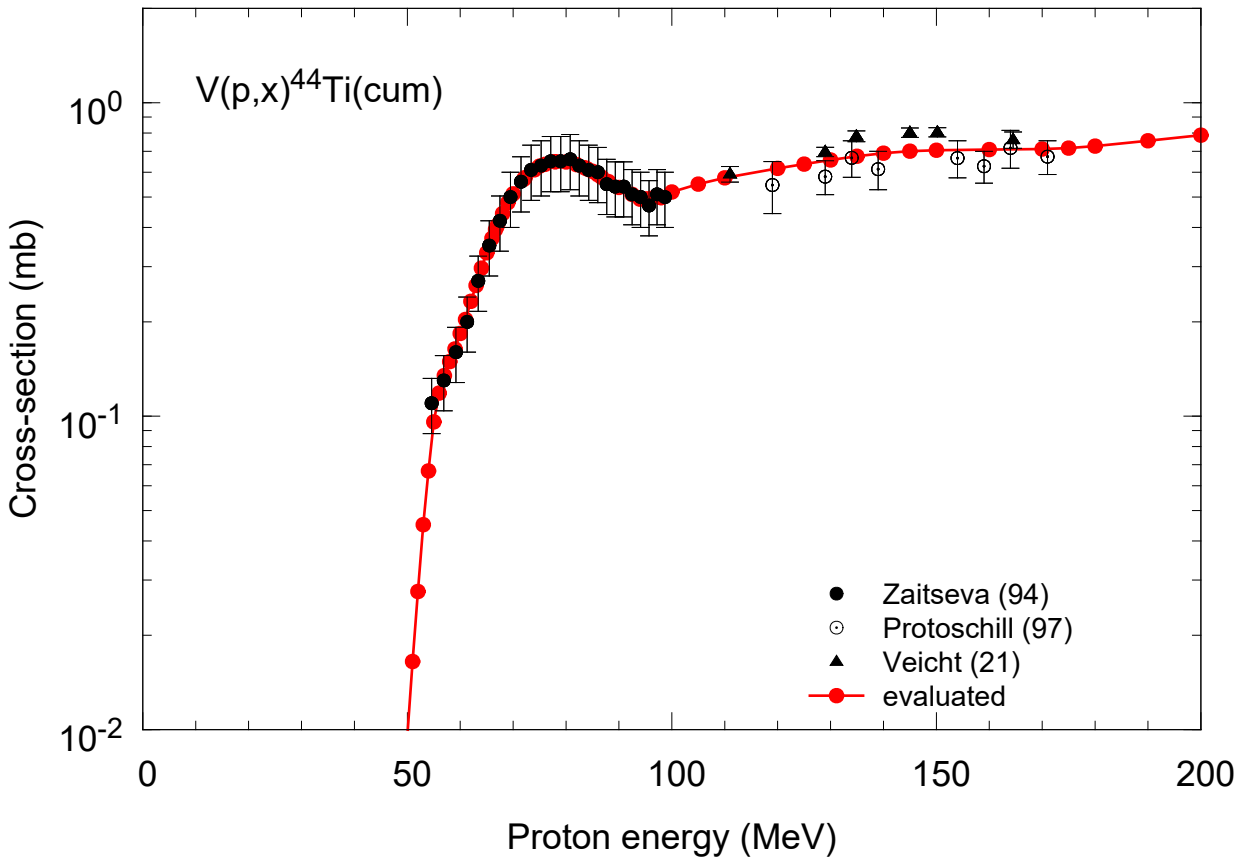

V(p,x)44gSc
Cross-section (mb)
Proton energy (MeV)
Hontzeas (63)
Ditroi (16)
Barbaro (21)
evaluated

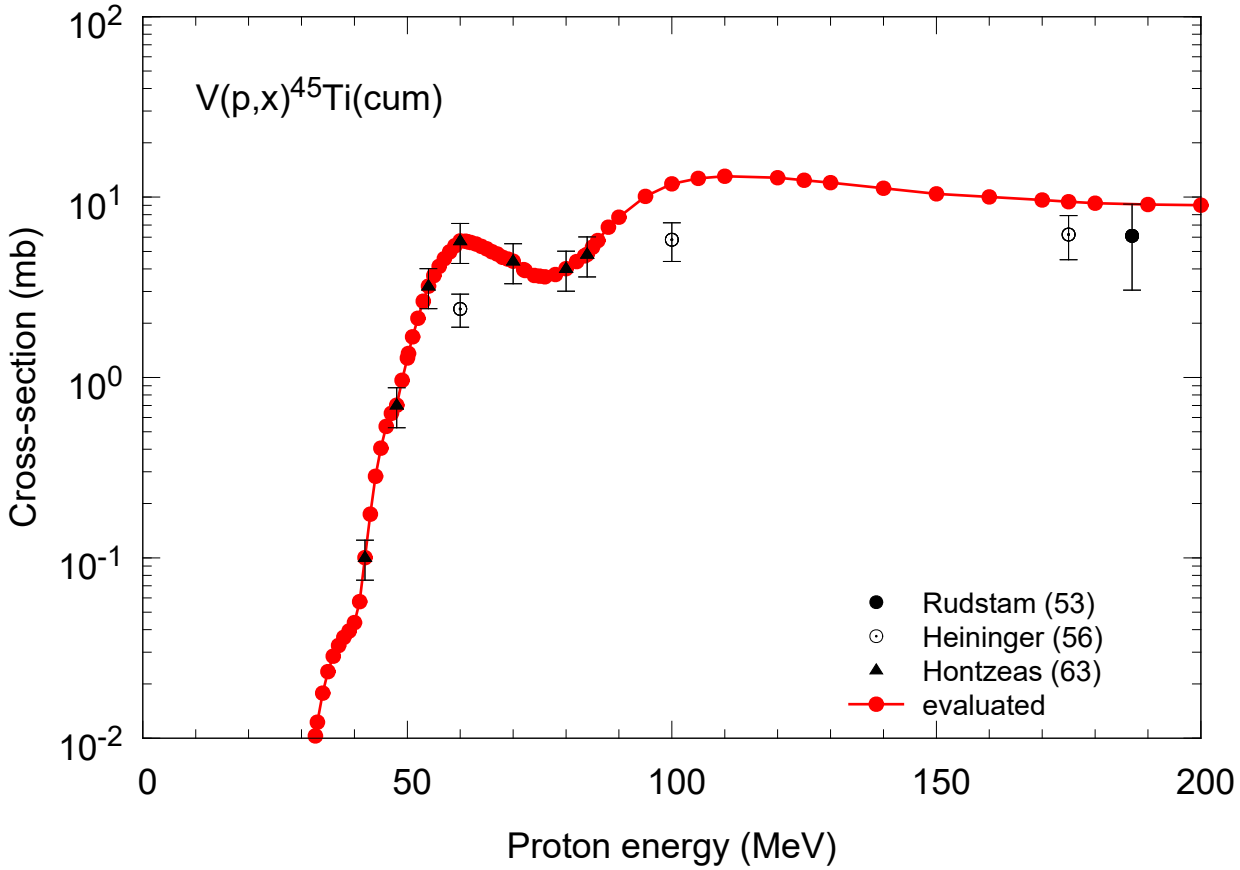

V(p,x)44m1Sc
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Heininger (56)
Hontzeas (63)
Michel (85)
Protoschill (97)
Mausner (98)
Ditroi (16)
Barbaro (21)
evaluated

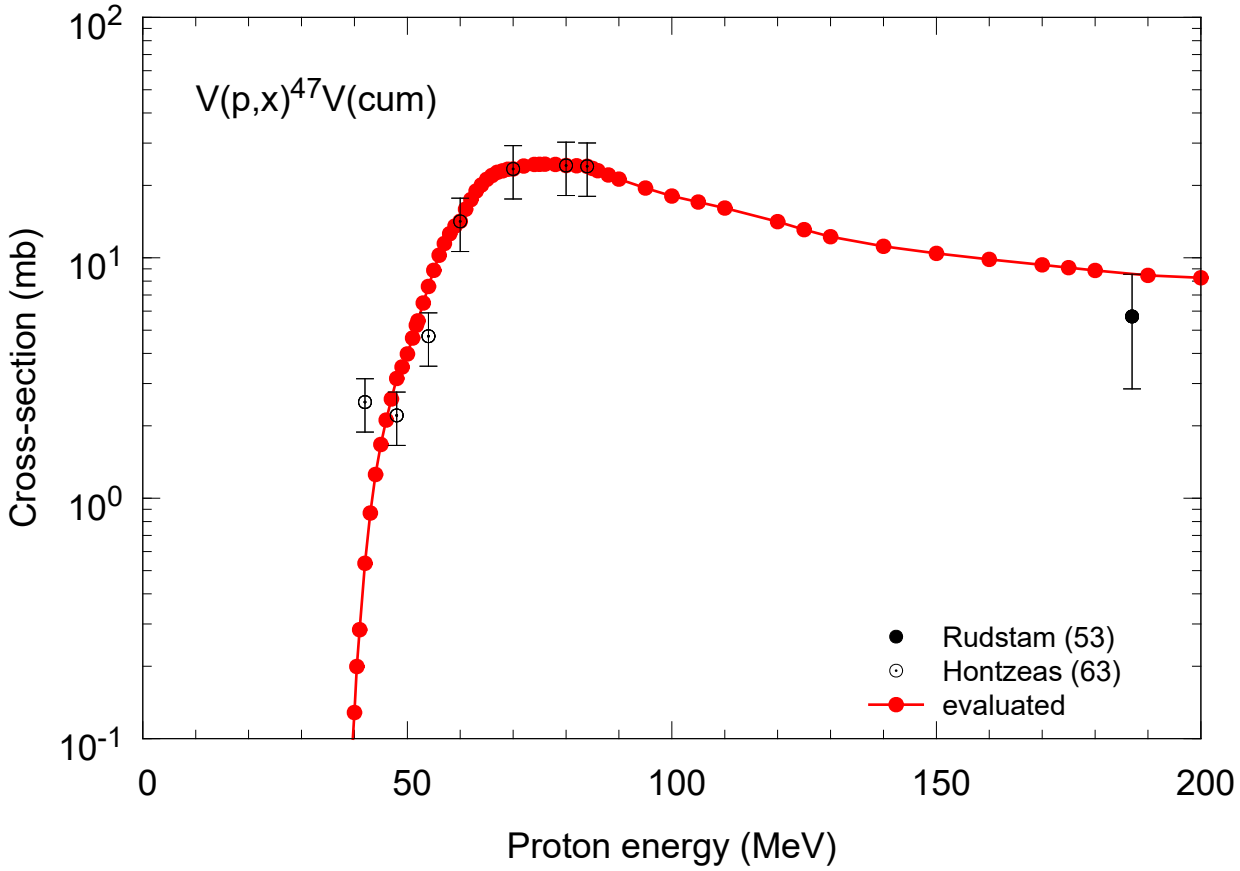

V(p,x)46Sc
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Heininger (56)
Hontzeas (63)
Albouy (63)
Michel (79)
Michel (85)
Zaitseva (94)
Protoschill (97)
Mausner (98)
Ditroi (16)
Barbaro (21)
evaluated

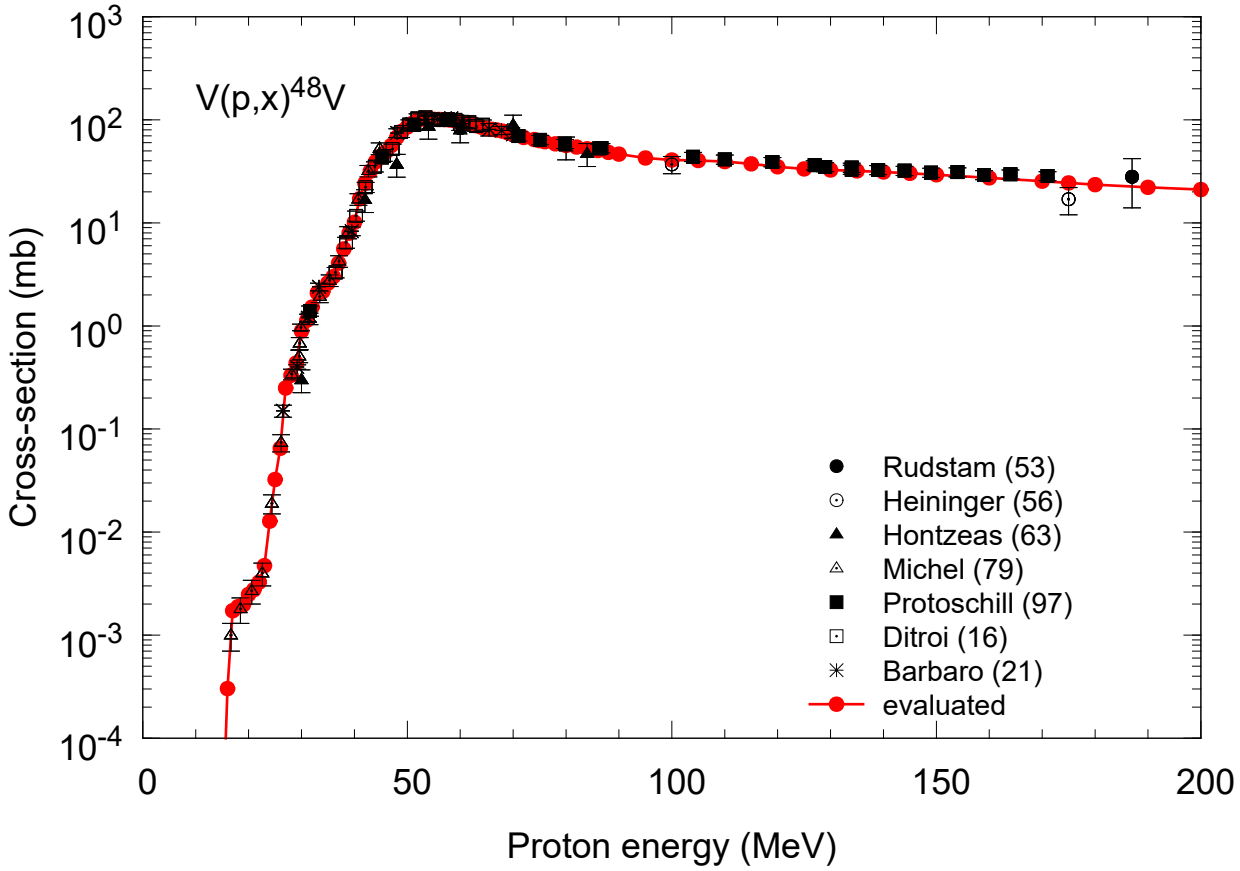

V(p,x)47Sc
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Heininger (56)
Hontzeas (63)
Michel (79)
Michel (85)
Levkovski (91)
Protoschill (97)
Mausner (98)
Ditroi (16)
Barbaro (21)
evaluated

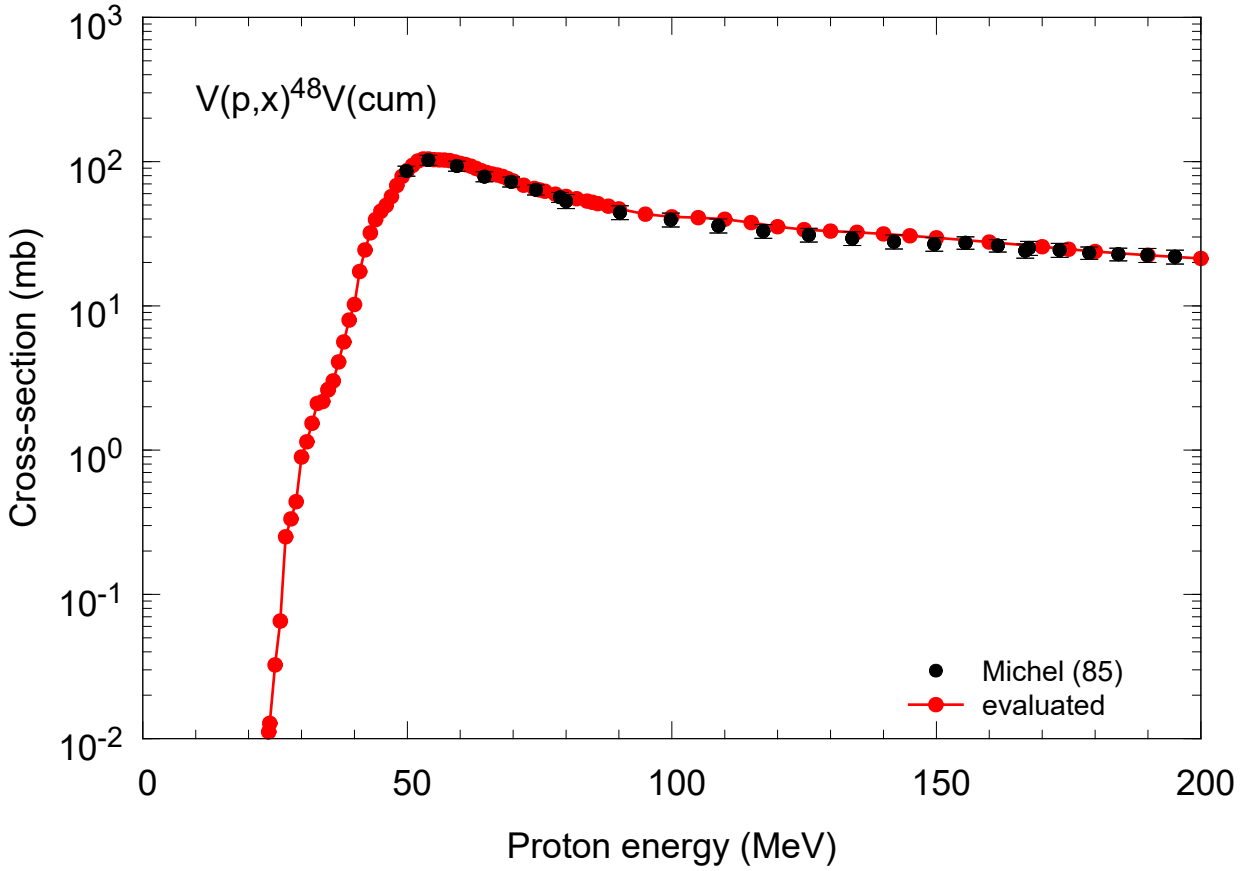

V(p,x)48Sc
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Hontzeas (63)
Michel (79)
Michel (85)
Protoschill (97)
Mausner (98)
Ditroi (16)
Barbaro (21)
evaluated

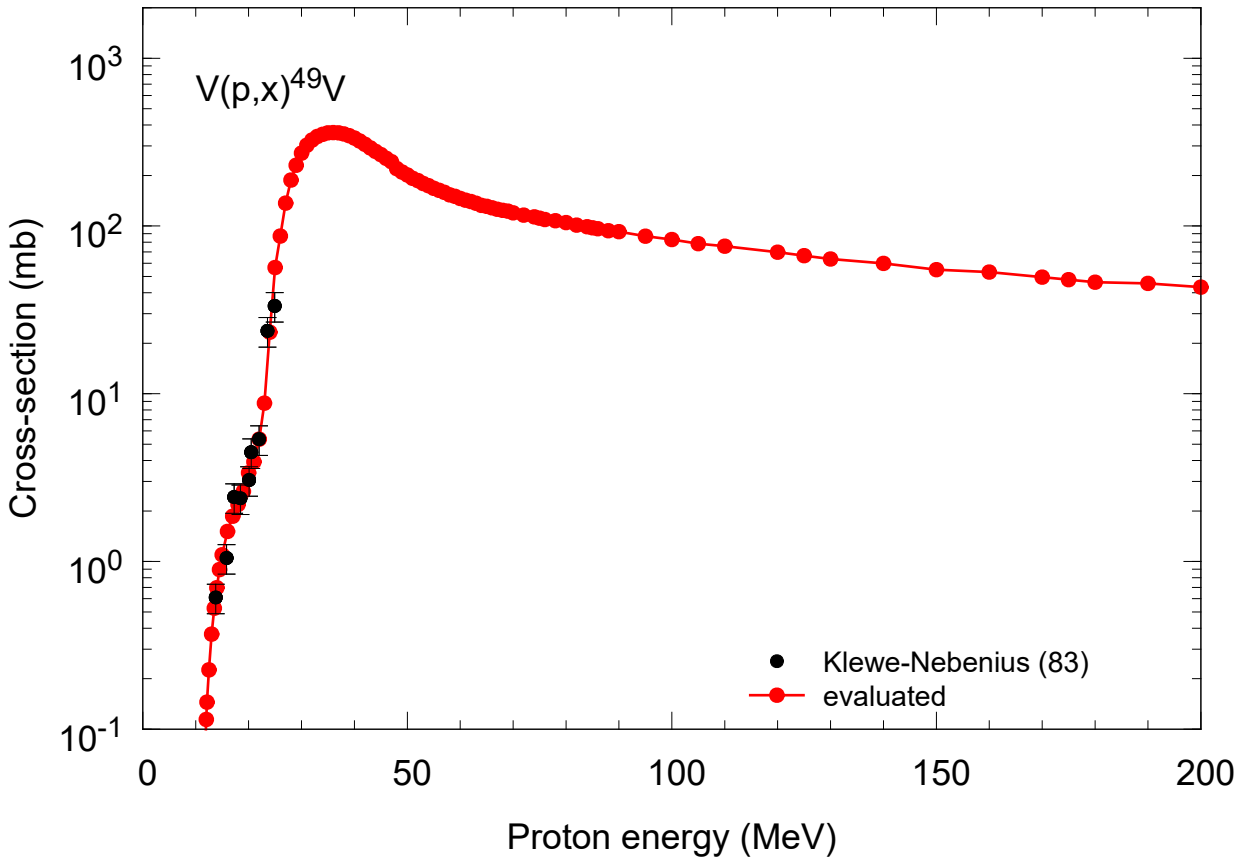

V(p,x)44Ti(cum)
Cross-section (mb)
Proton energy (MeV)
Zaitseva (94)
Protoschill (97)
Veicht (21)
evaluated

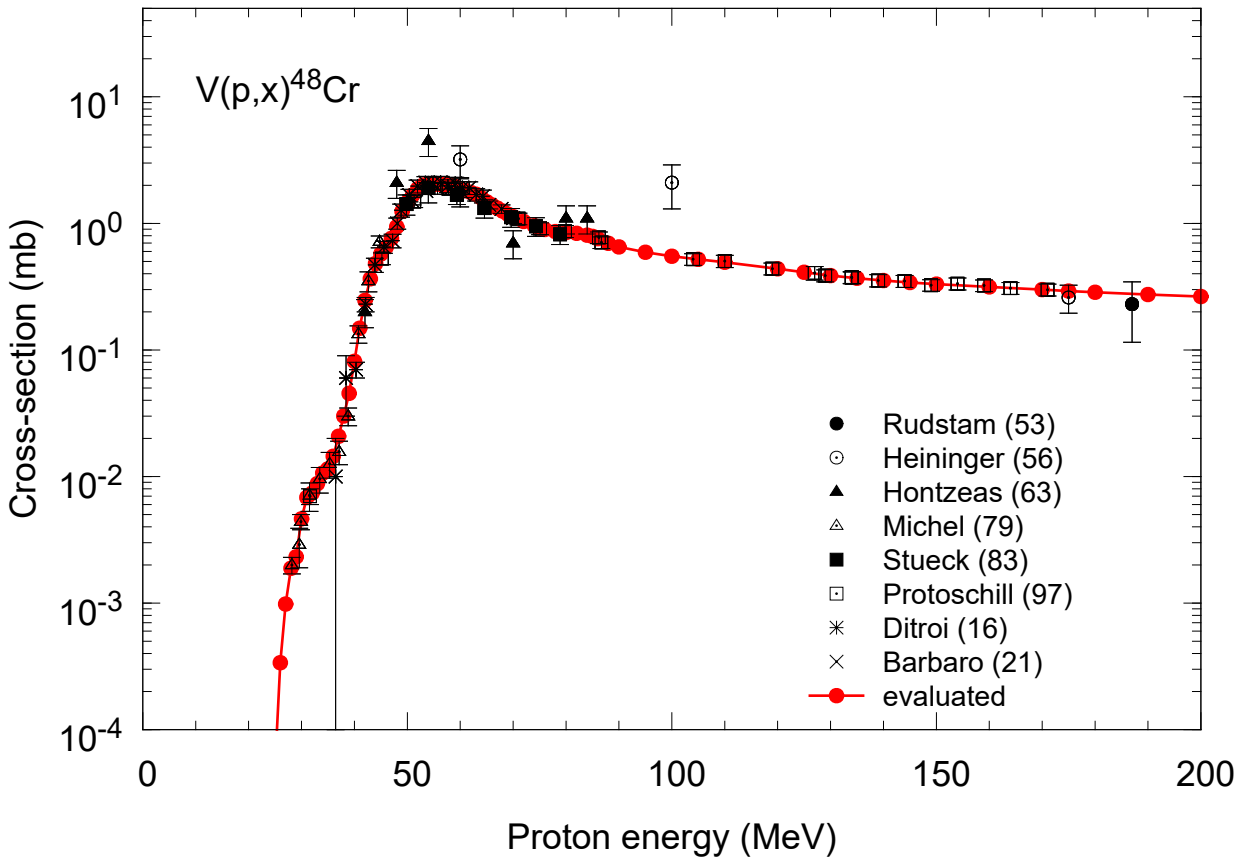

V(p,x)45Ti(cum)
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Heininger (56)
Hontzeas (63)
evaluated

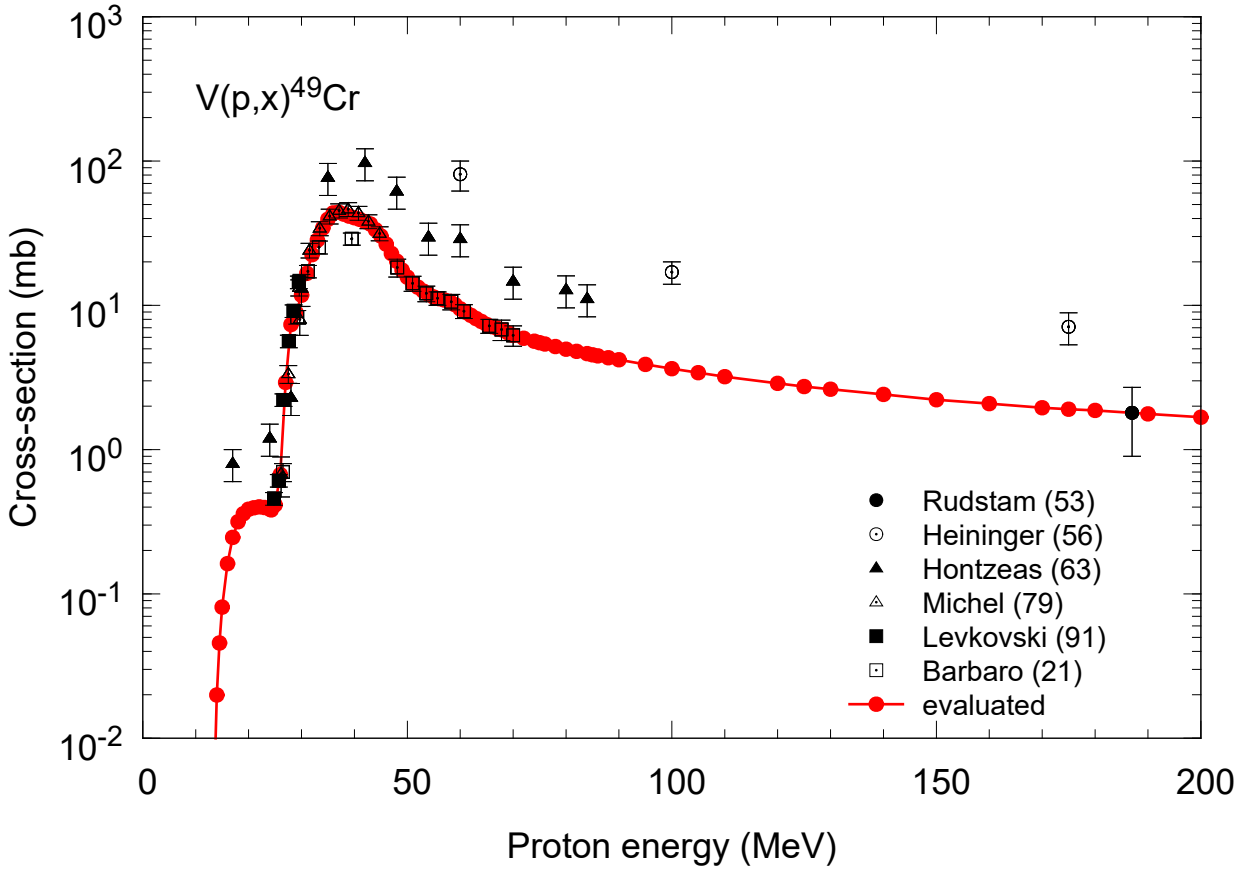

V(p,x)47V(cum)
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Hontzeas (63)
evaluated

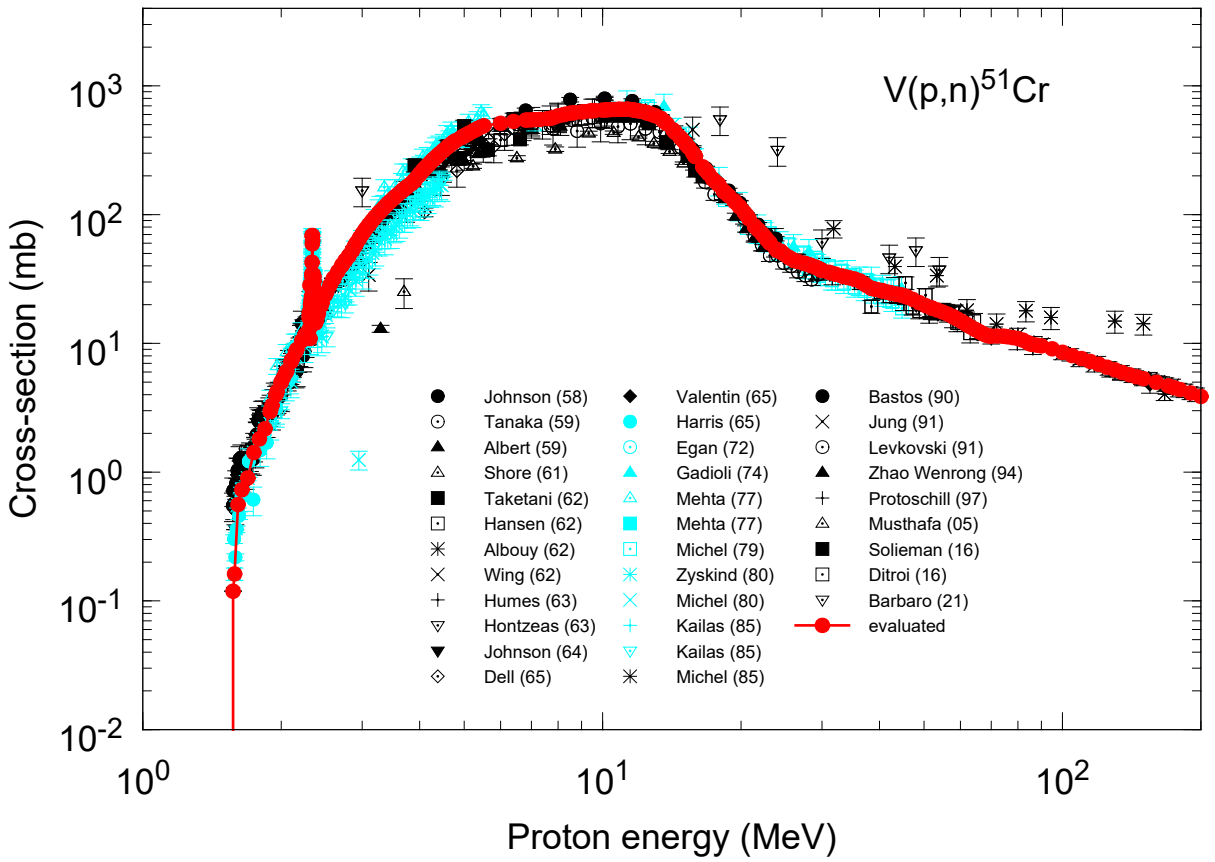

V(p,x)48V
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Heininger (56)
Hontzeas (63)
Michel (79)
Protoschill (97)
Ditroi (16)
Barbaro (21)
evaluated

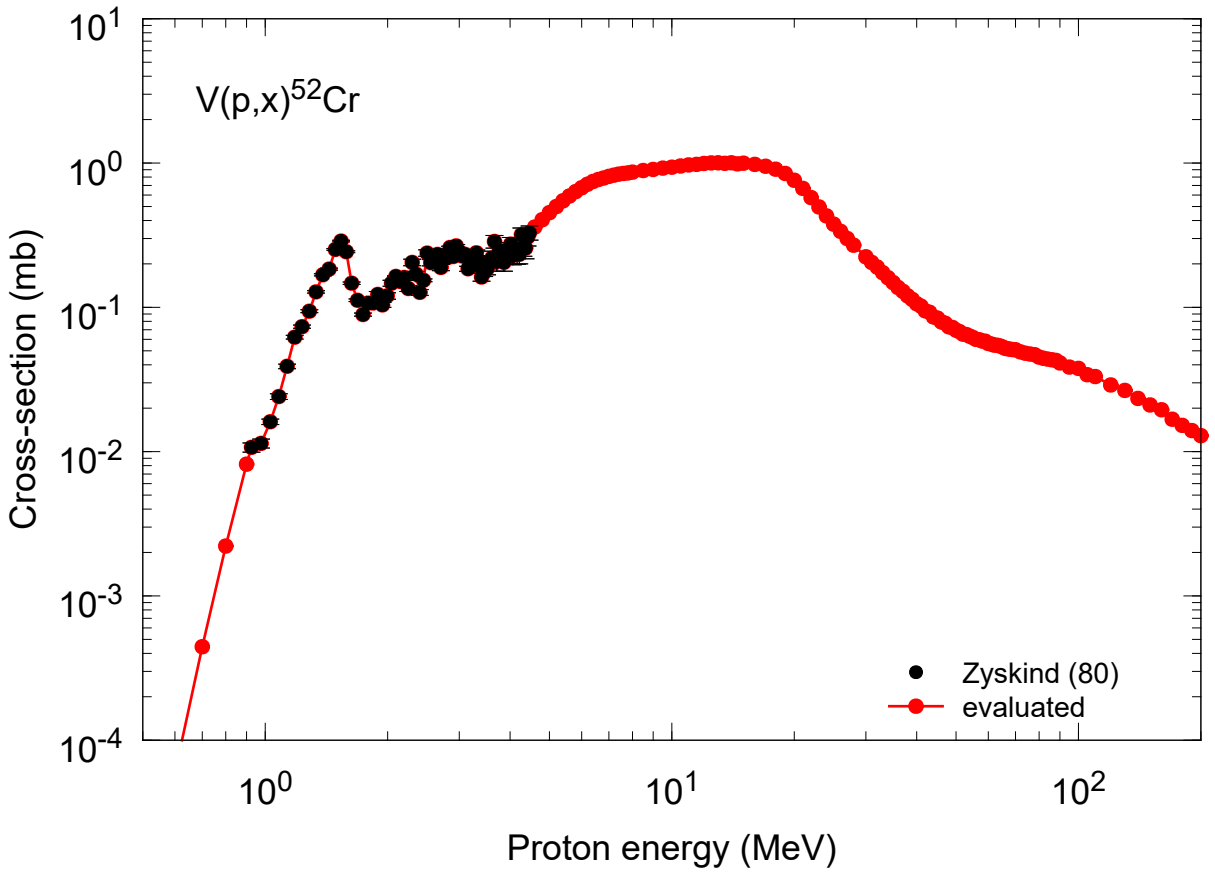

V(p,x)48V(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (85)
evaluated

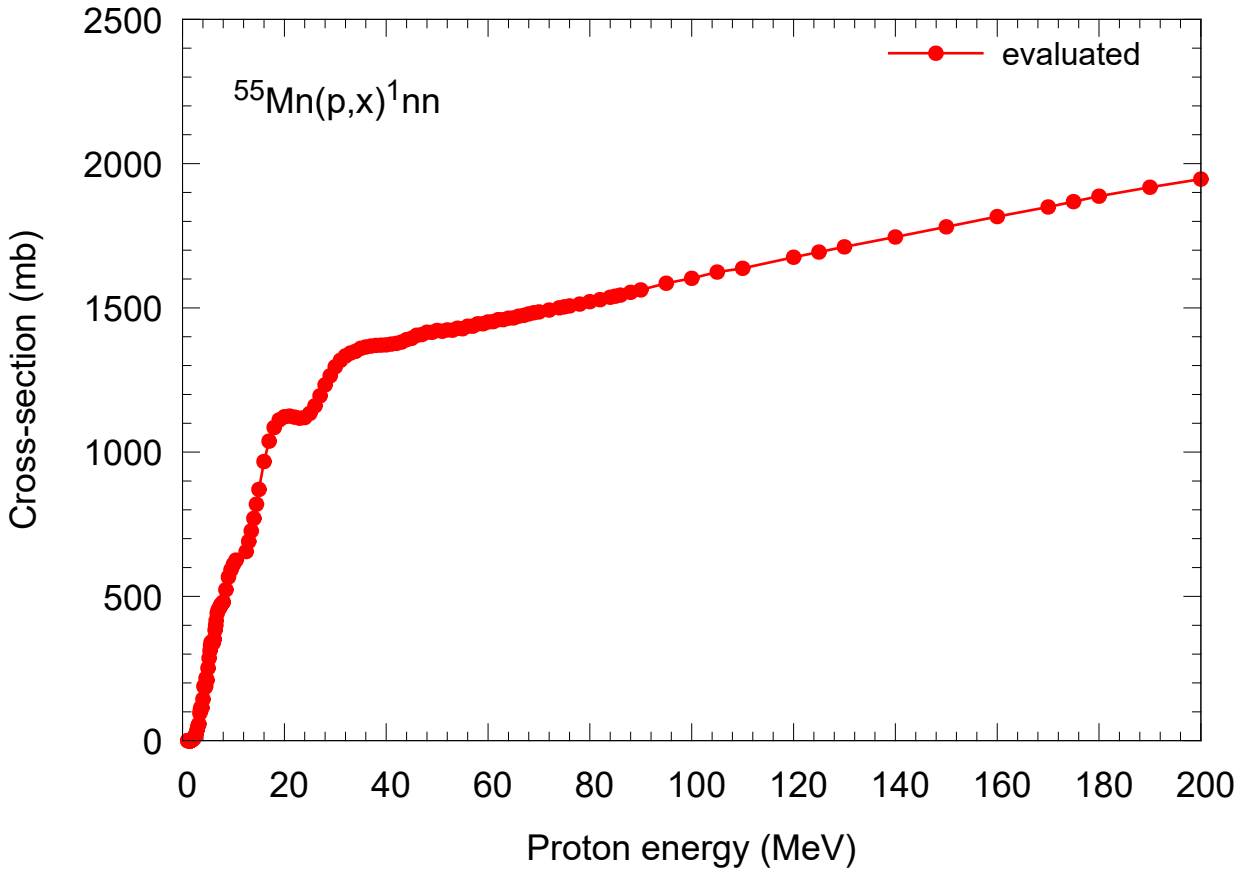

V(p,x)49V
Cross-section (mb)
Proton energy (MeV)
Klewe-Nebenius (83)
evaluated

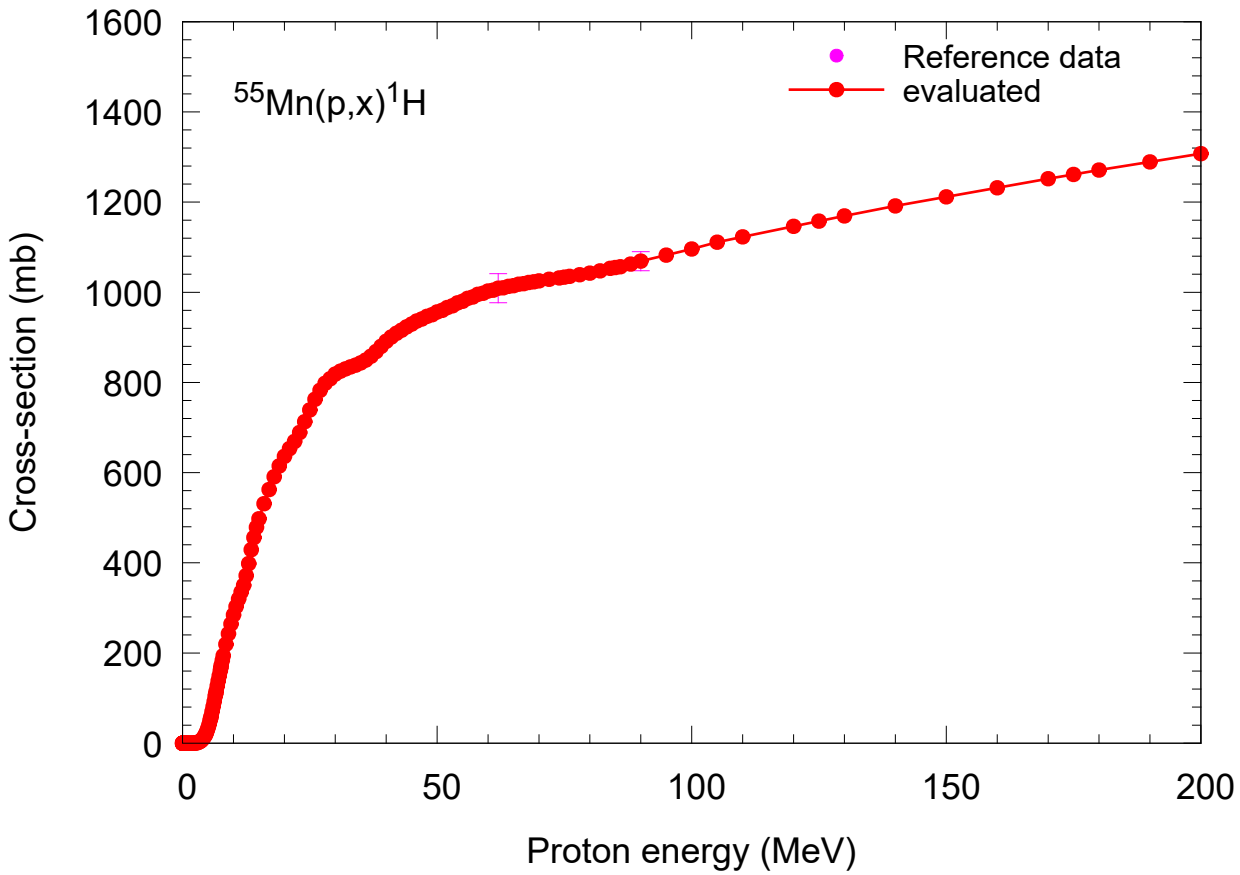

V(p,x)48Cr
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Heininger (56)
Hontzeas (63)
Michel (79)
Stueck (83)
Protoschill (97)
Ditroi (16)
Barbaro (21)
evaluated

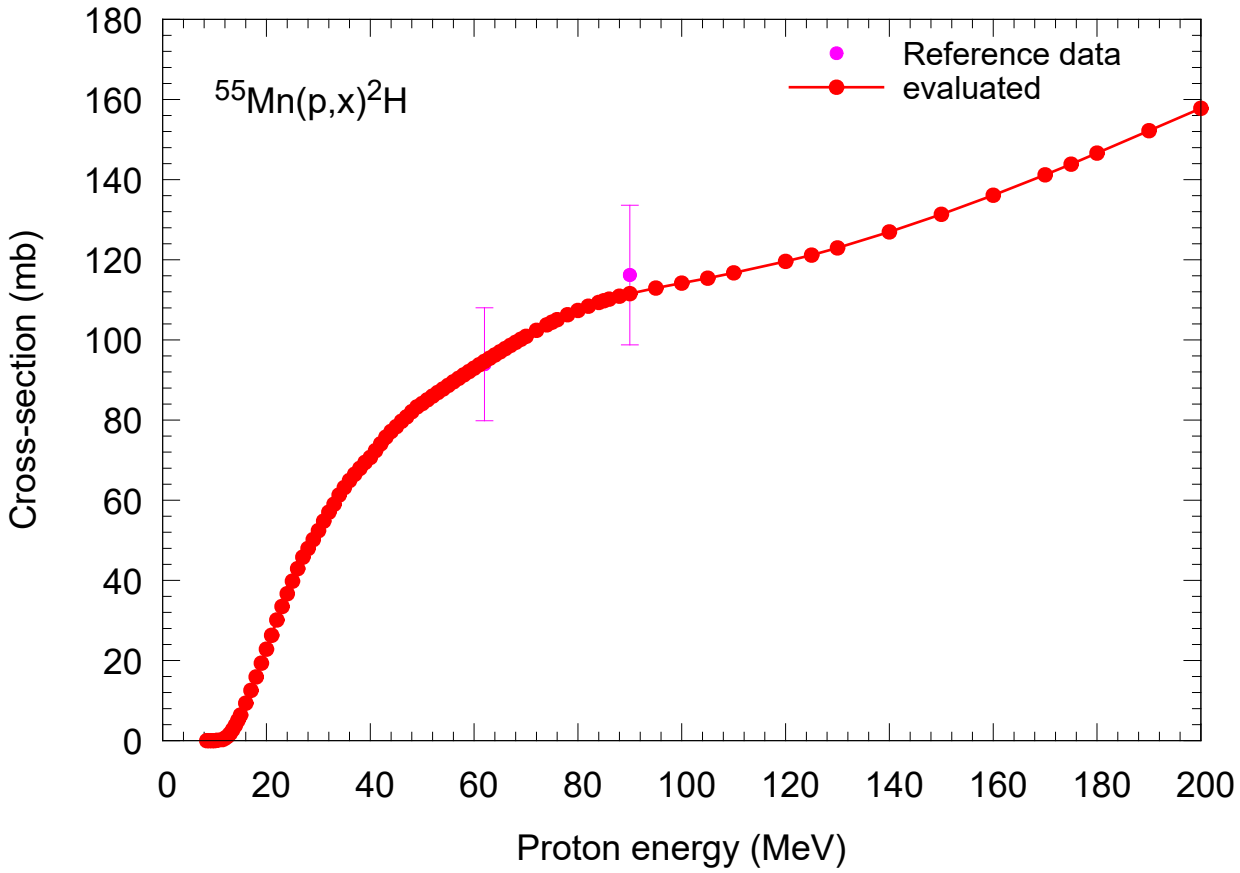

V(p,x)49Cr
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Heininger (56)
Hontzeas (63)
Michel (79)
Levkovski (91)
Barbaro (21)
evaluated

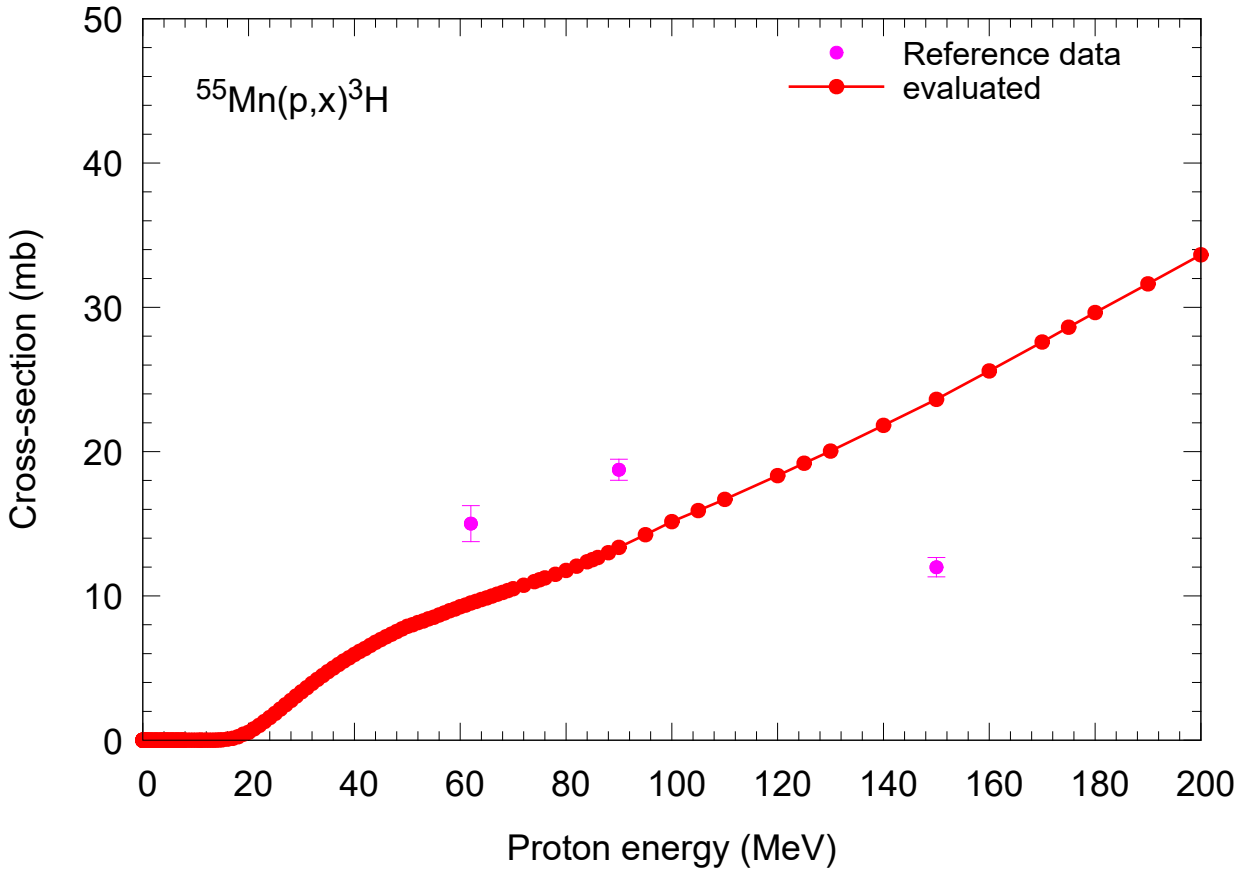

V(p,n)51Cr
Cross-section (mb)
Proton energy (MeV)
Johnson (58)
Tanaka (59)
Albert (59)
Shore (61)
Taketani (62)
Hansen (62)
Albouy (62)
Wing (62)
Humes (63)
Hontzeas (63)
Johnson (64)
Dell (65)
Valentin (65)
Harris (65)
Egan (72)
Gadioli (74)
Mehta (77)
Mehta (77)
Michel (79)
Zyskind (80)
Michel (80)
Kailas (85)
Kailas (85)
Michel (85)
Bastos (90)
Jung (91)
Levkovski (91)
Zhao Wenrong (94)
Protoschill (97)
Musthafa (05)
Solieman (16)
Ditroi (16)
Barbaro (21)
evaluated

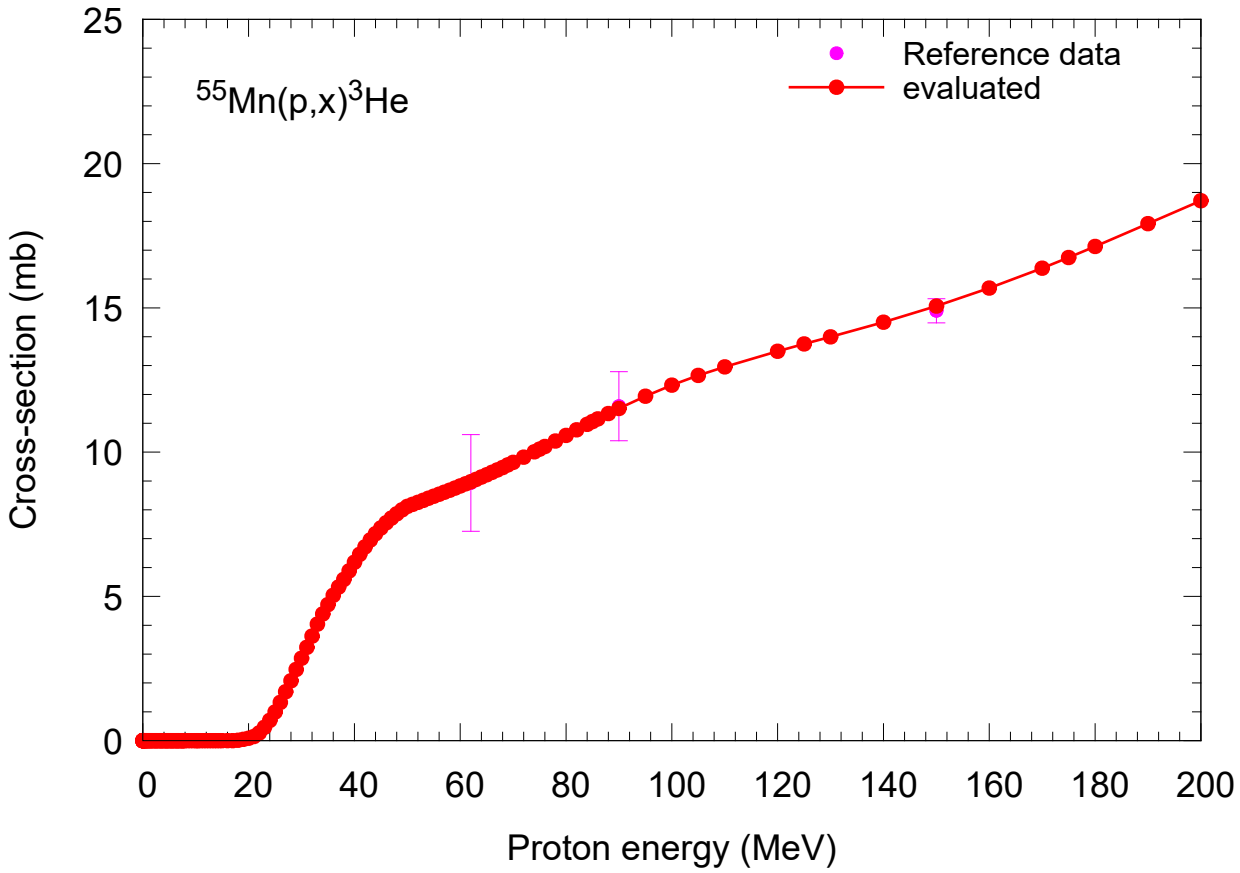

V(p,x)52Cr
Cross-section (mb)
Proton energy (MeV)
Zyskind (80)
evaluated

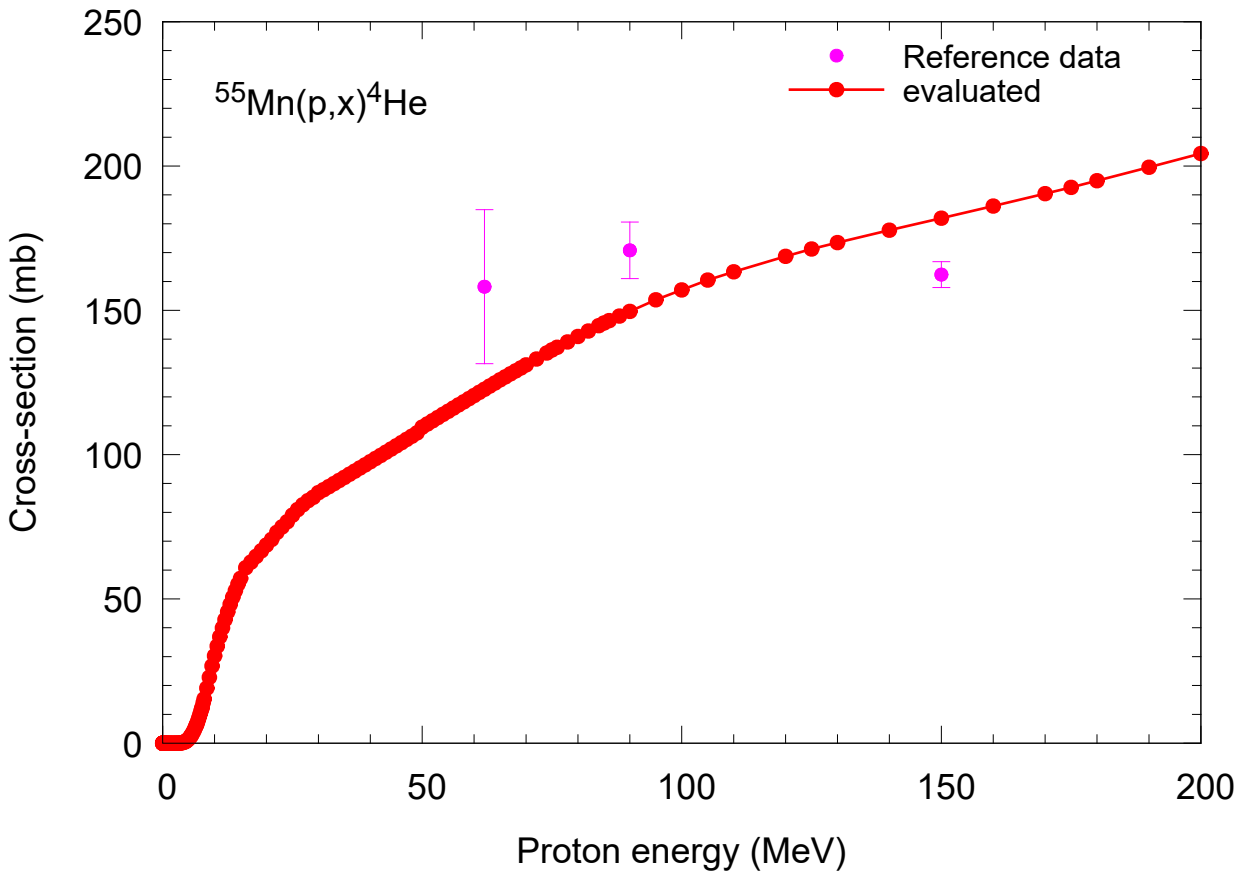

evaluated
^{55}Mn(p,x)^{1}nn
Cross-section (mb)
Proton energy (MeV)
0
500
1000
1500
2000
2500
0
20
40
60
80
100
120
140
160
180
200

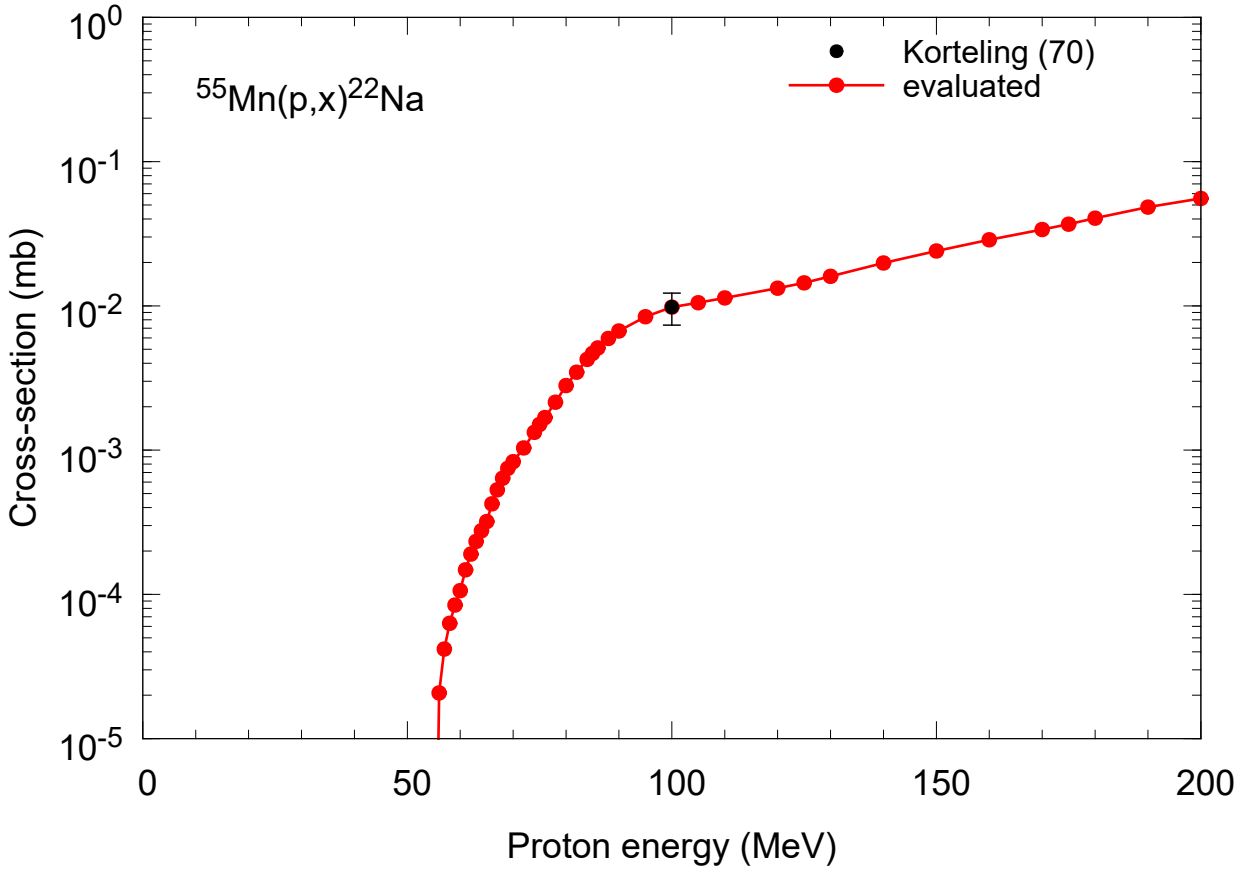

Reference data
evaluated
^{55}Mn(p,x)^{1}H
Cross-section (mb)
Proton energy (MeV)
0
200
400
600
800
1000
1200
1400
1600
0
50
100
150
200

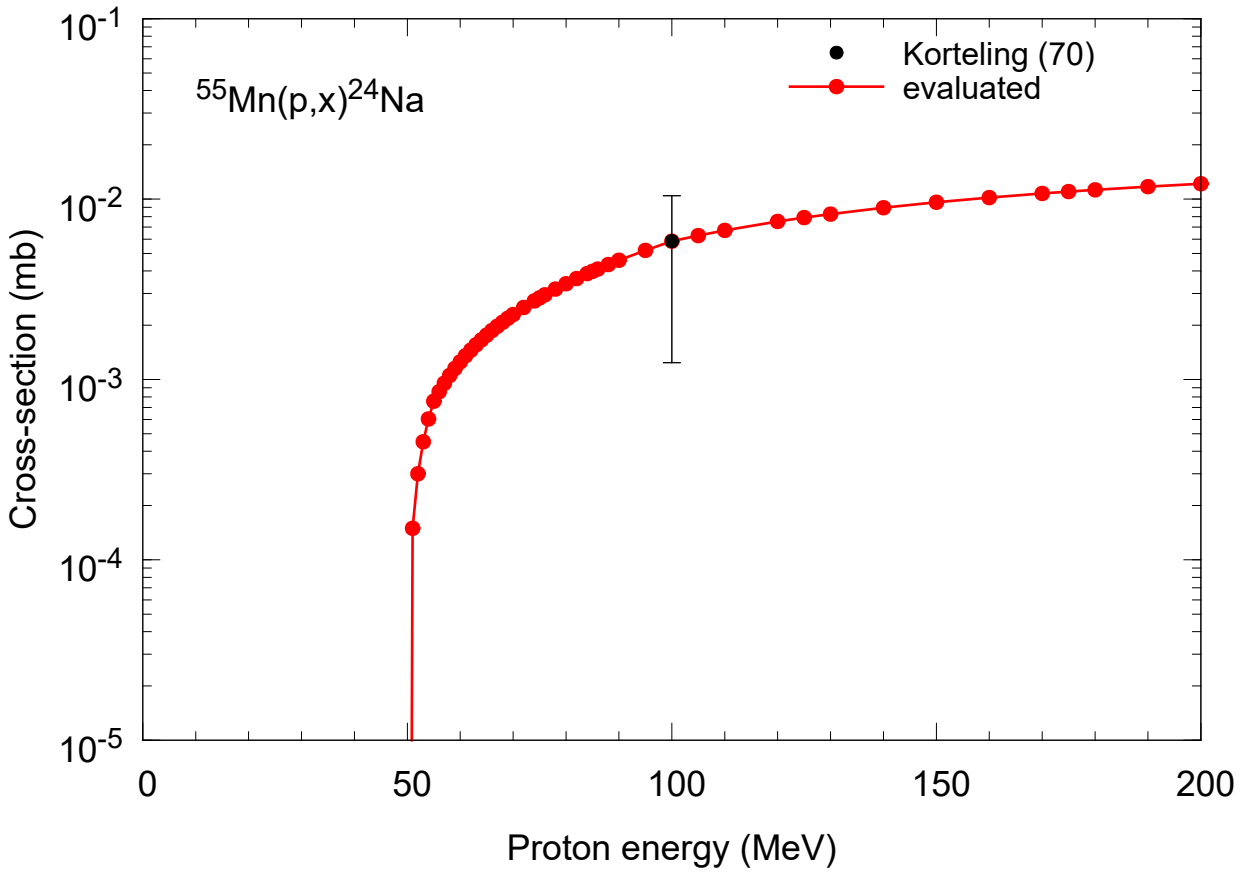

^{55}Mn(p,x)^{2}H
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
20
40
60
80
100
120
140
160
180
200

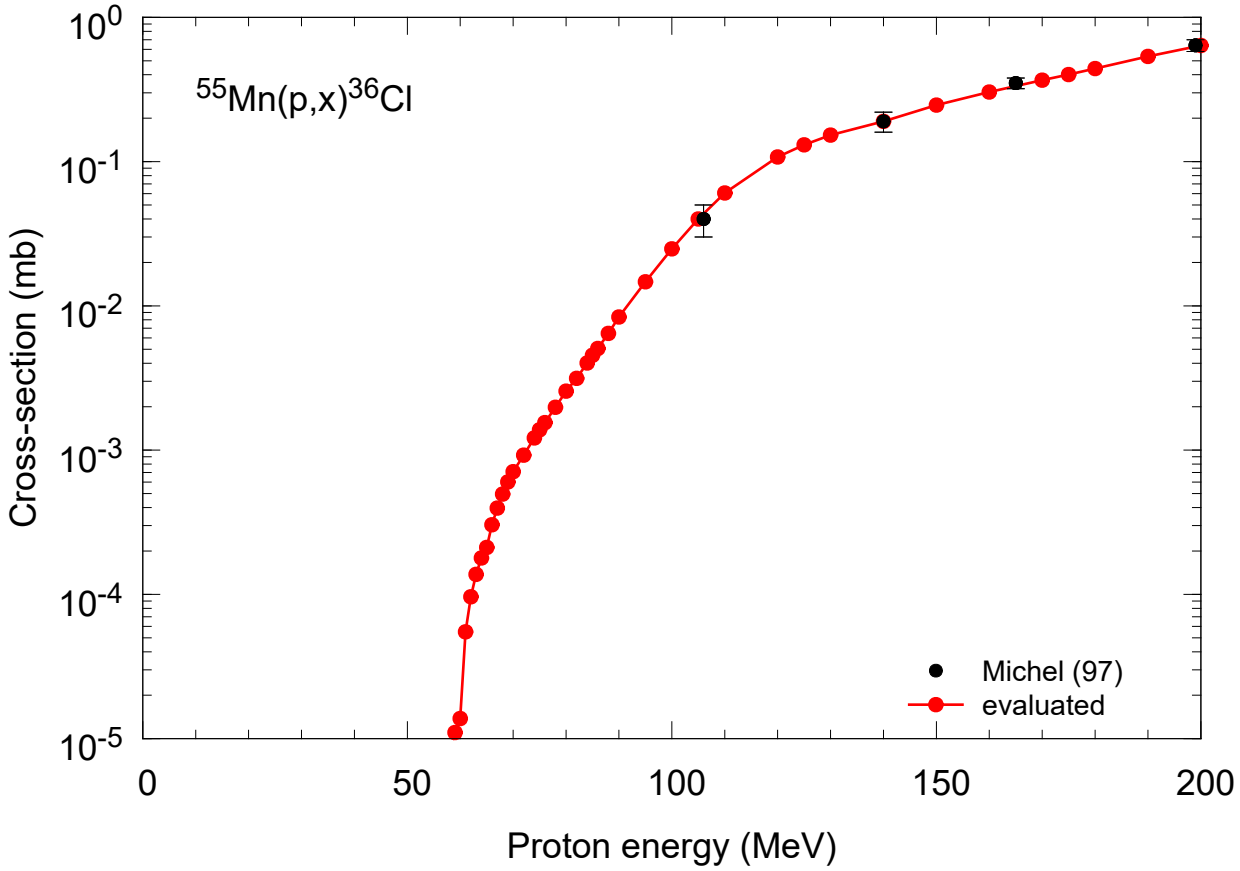

^{55}Mn(p,x)^{3}H
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
10
20
30
40
50
60
80
100
120
140
160
180
200

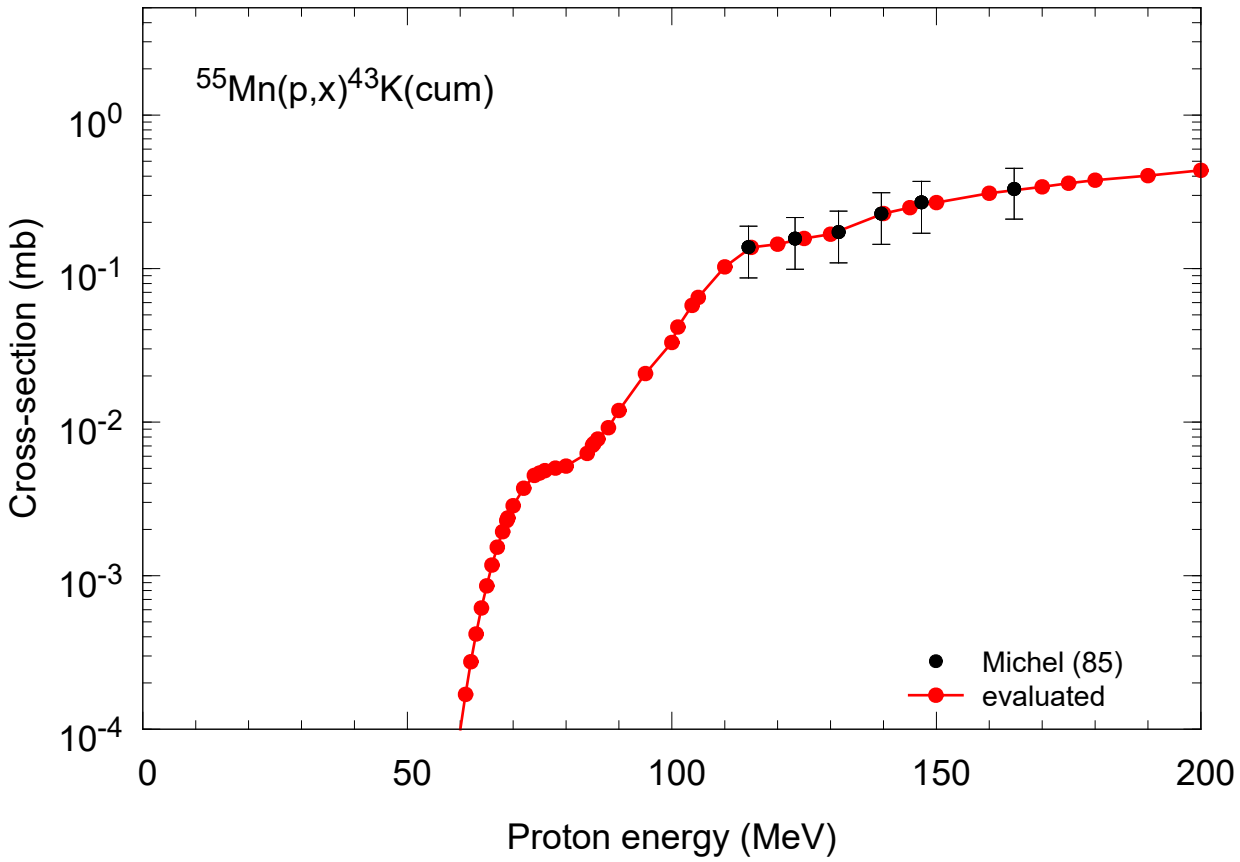

^{55}Mn(p,x)^{3}He
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
5
10
15
20
25
0
20
40
60
80
100
120
140
160
180
200

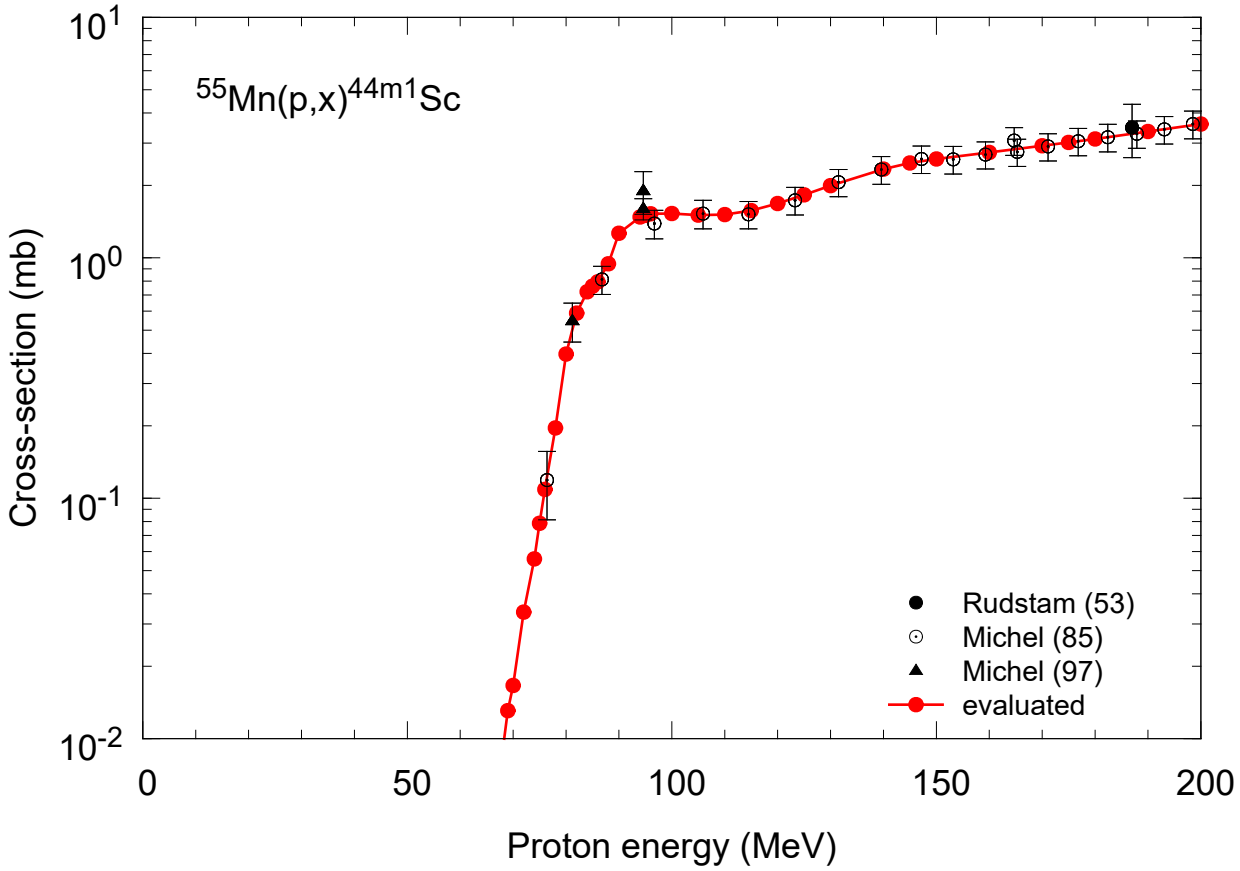

^{55}Mn(p,x)^{4}He
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
50
100
150
200
250
0
50
100
150
200

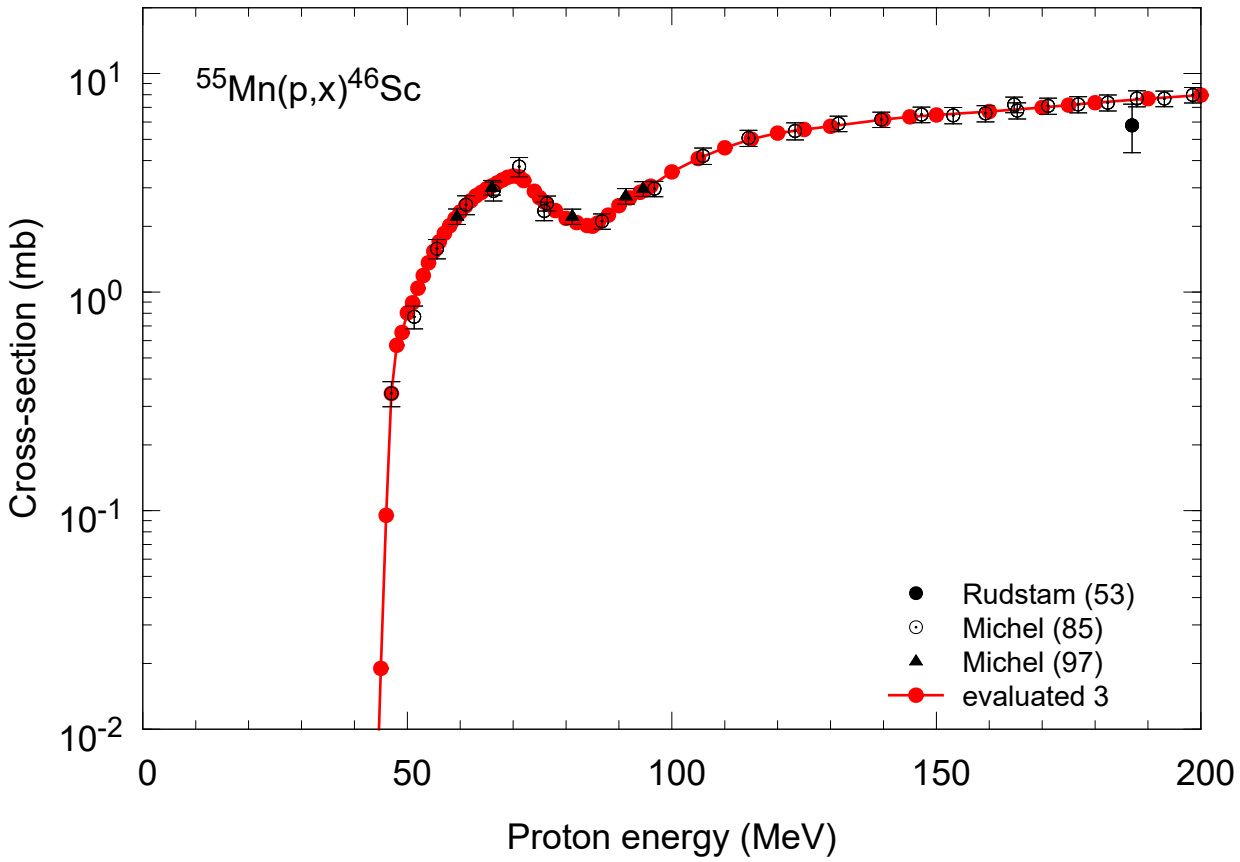

^{55}Mn(p,x)^{22}Na
Korteling (70)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
50
100
150
200

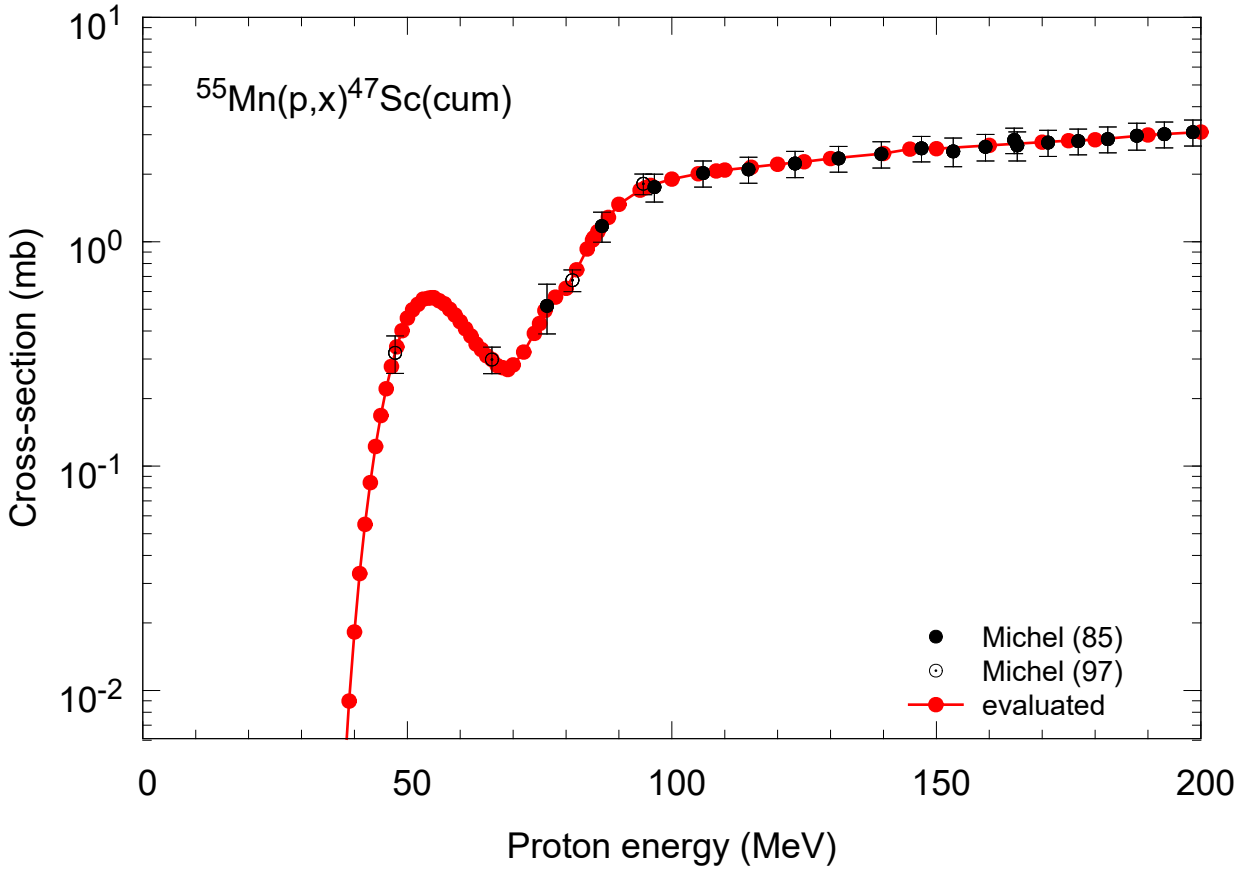

^{55}Mn(p,x)^{24}Na
Korteling (70)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
50
100
150
200

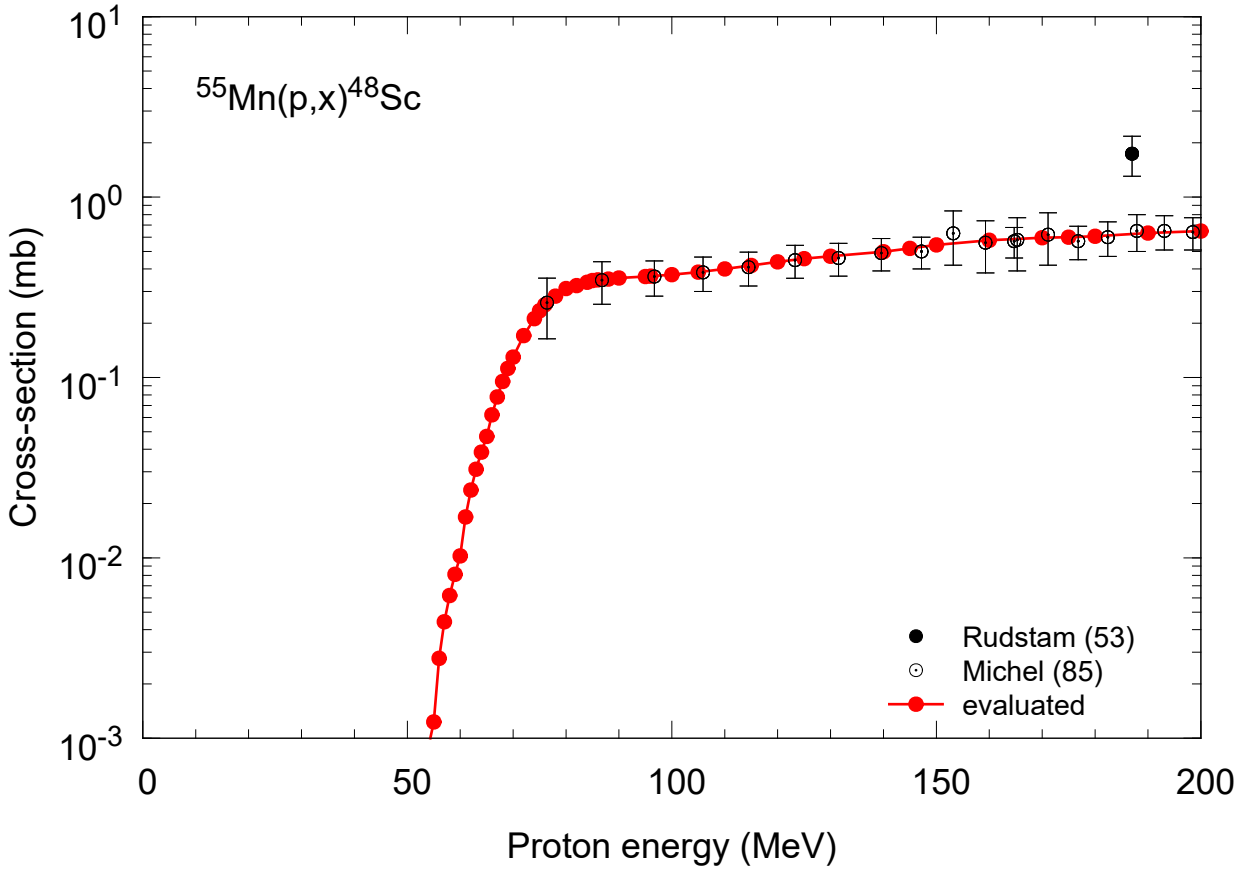

^{55}Mn(p,x)^{36}Cl
Cross-section (mb)
Proton energy (MeV)
Michel (97)
evaluated

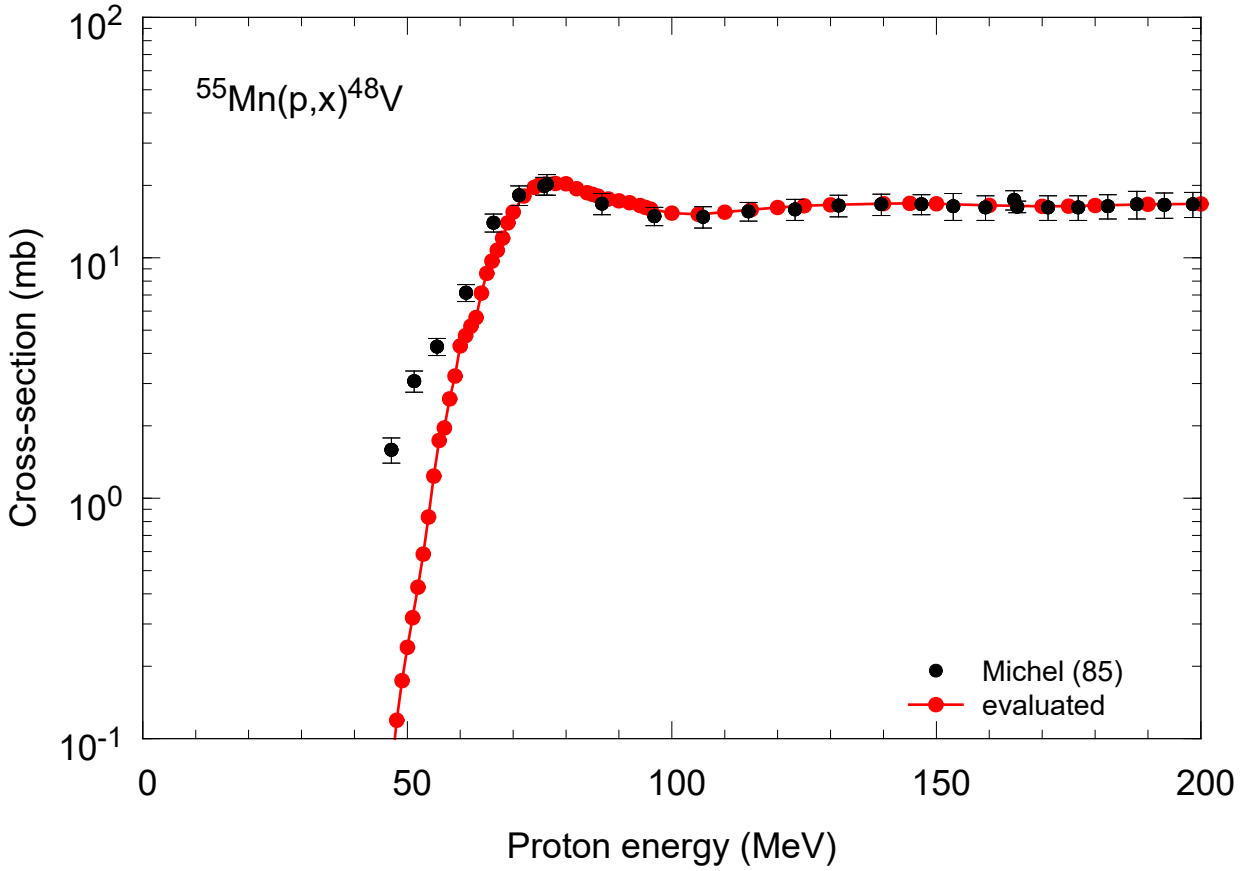

^{55}Mn(p,x)^{43}K(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (85)
evaluated

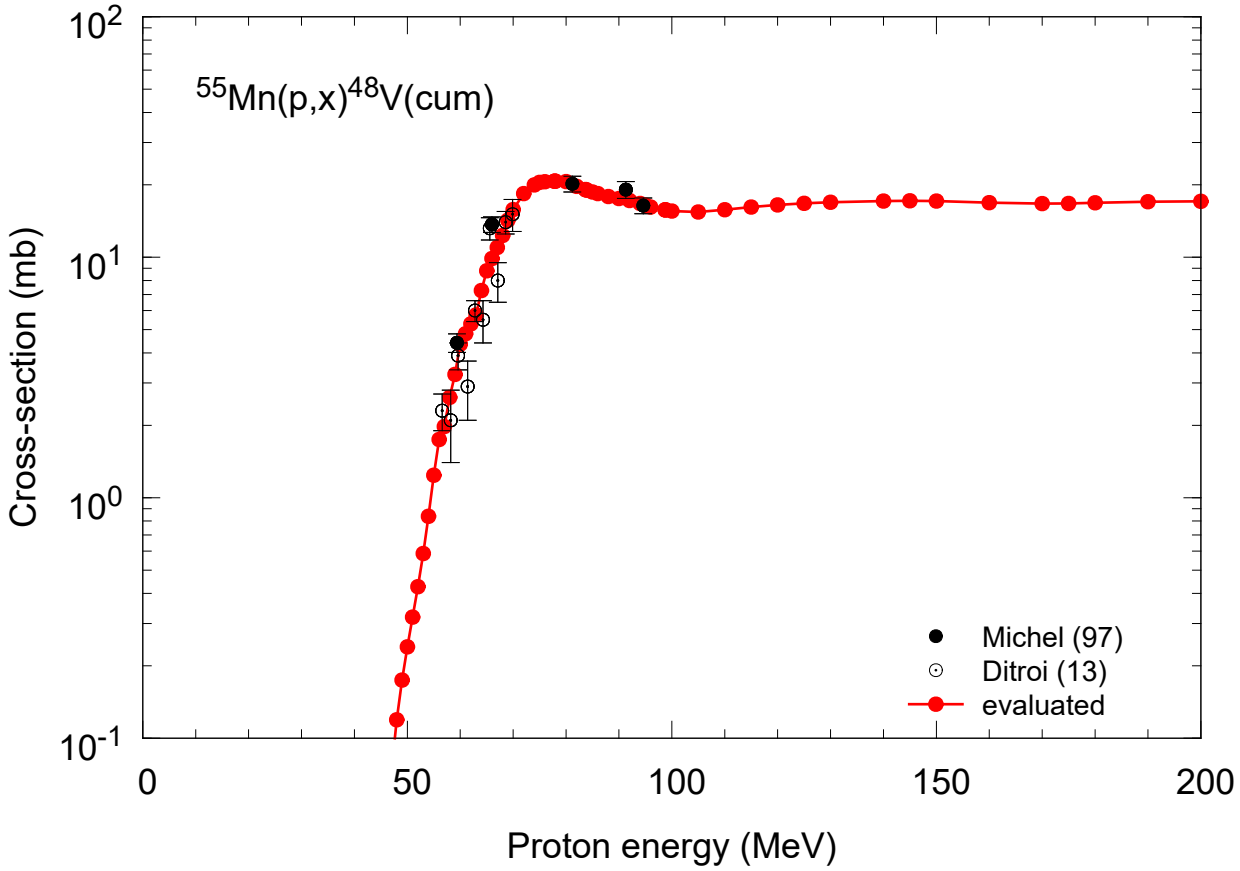

^{55}Mn(p,x)^{44m1}Sc
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Michel (85)
Michel (97)
evaluated

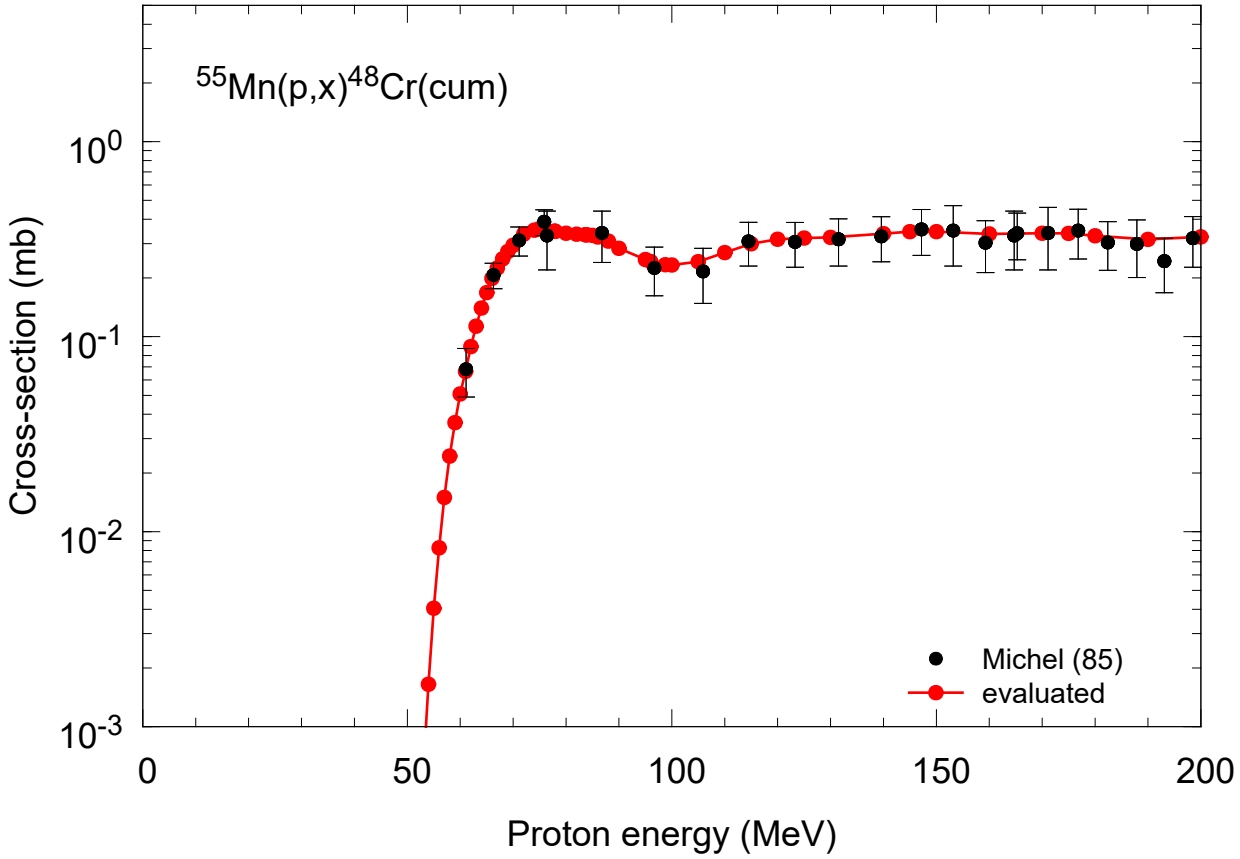

^{55}Mn(p,x)^{46}Sc
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Michel (85)
Michel (97)
evaluated 3

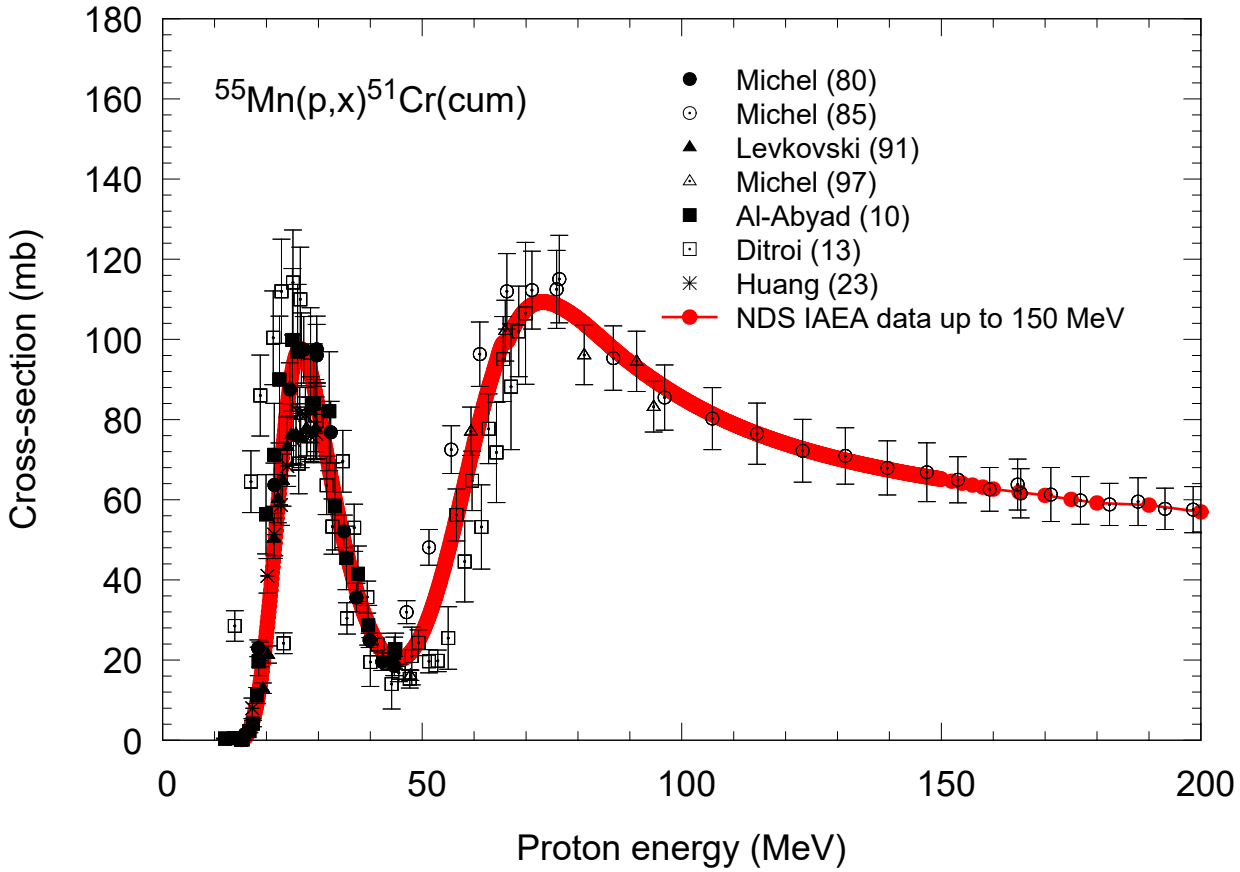

^{55}Mn(p,x)^{47}Sc(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (85)
Michel (97)
evaluated

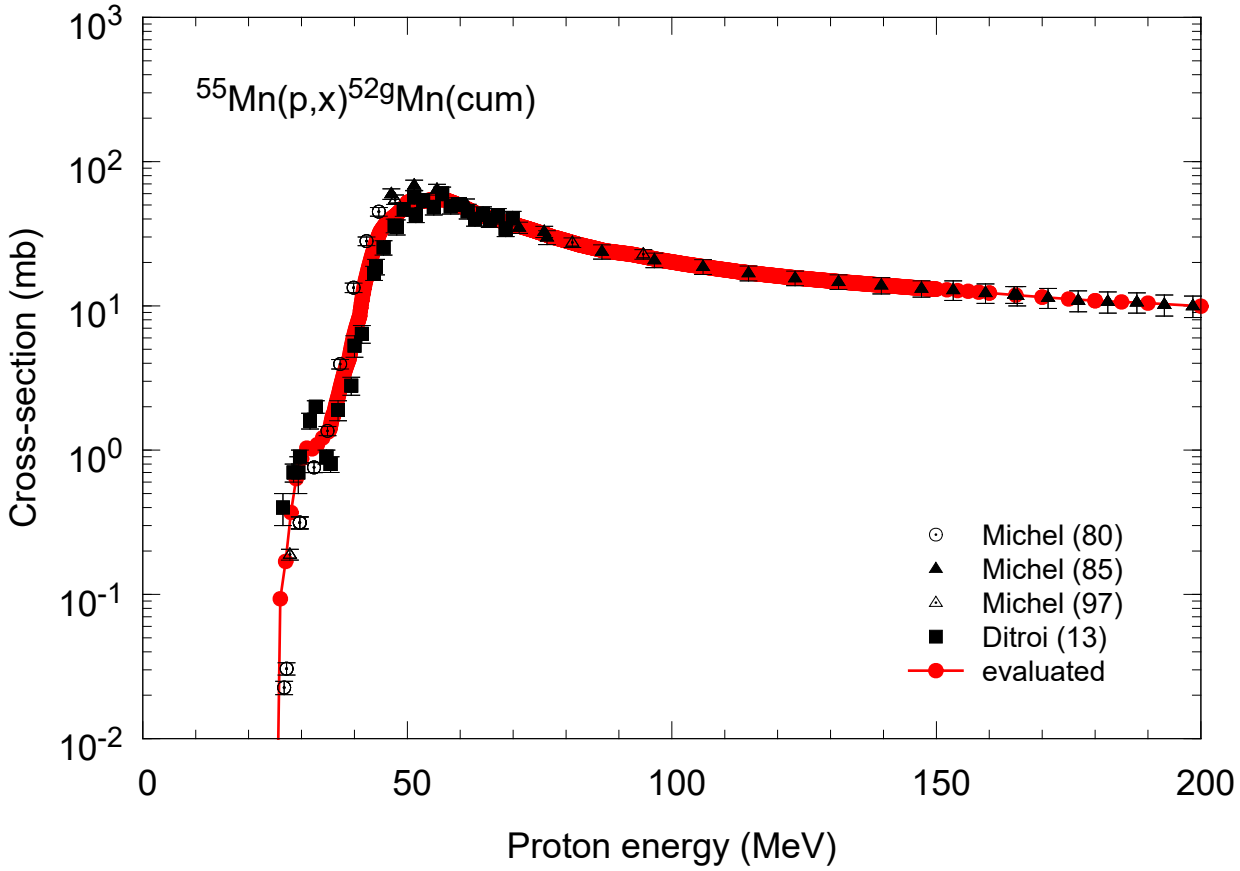

^{55}Mn(p,x)^{48}Sc
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Michel (85)
evaluated

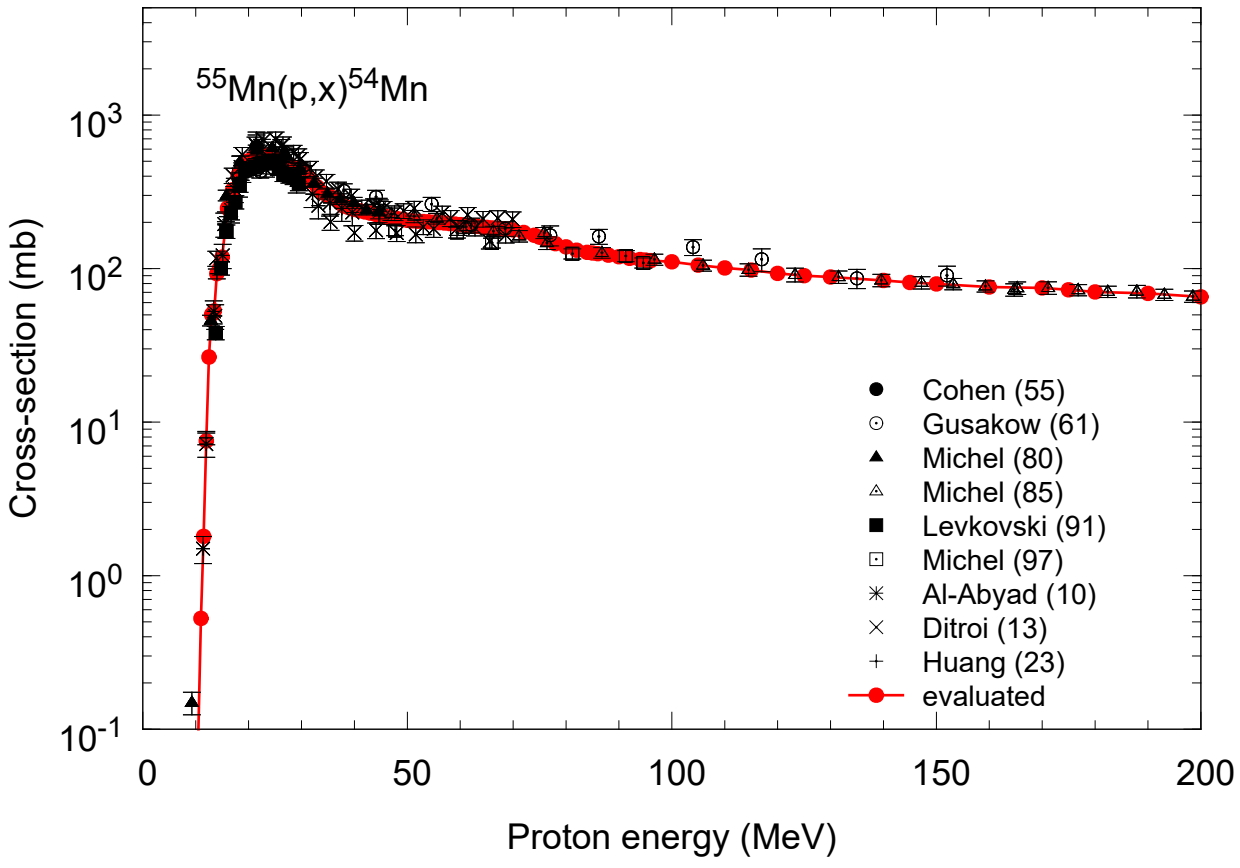

^{55}Mn(p,x)^{48}V
Cross-section (mb)
Proton energy (MeV)
Michel (85)
evaluated

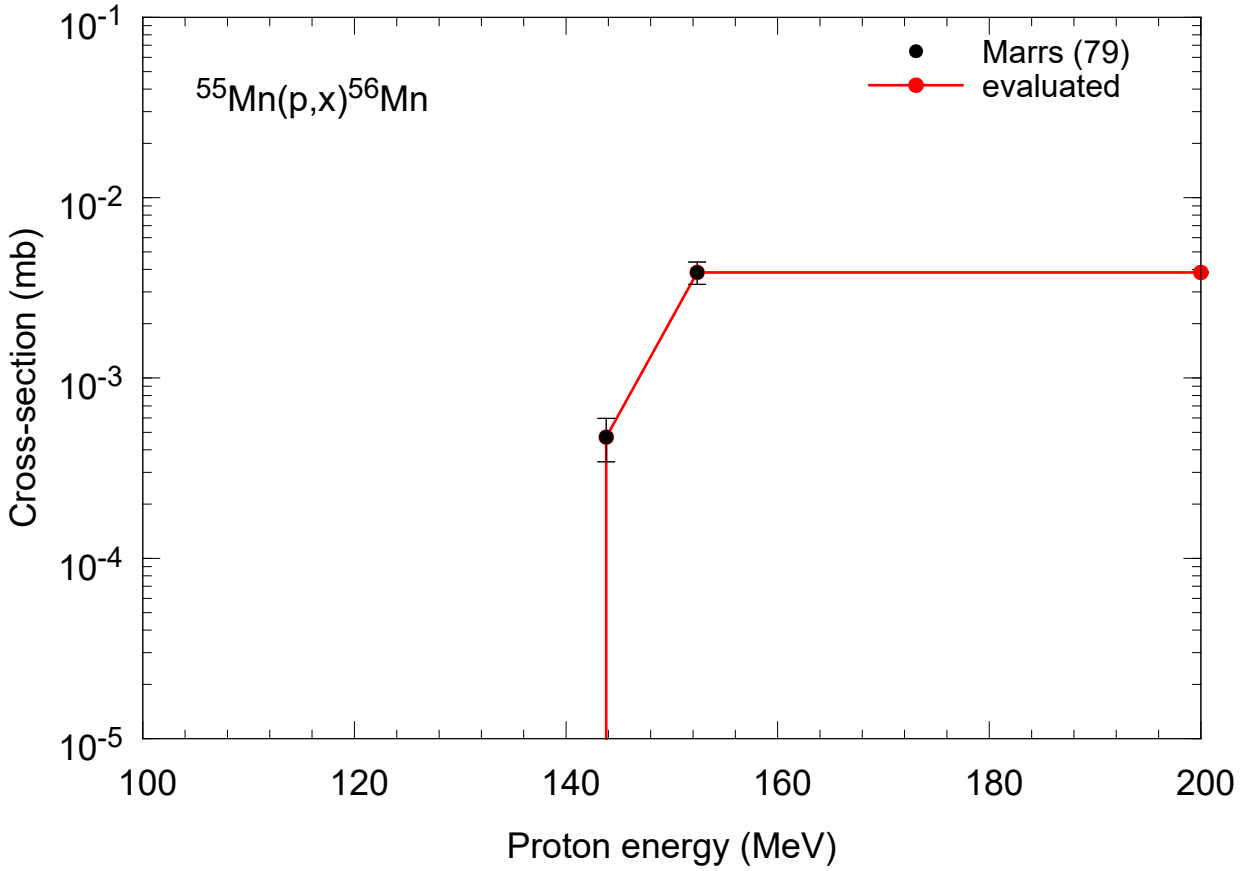

^{55}Mn(p,x)^{48}V(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (97)
Ditroi (13)
evaluated

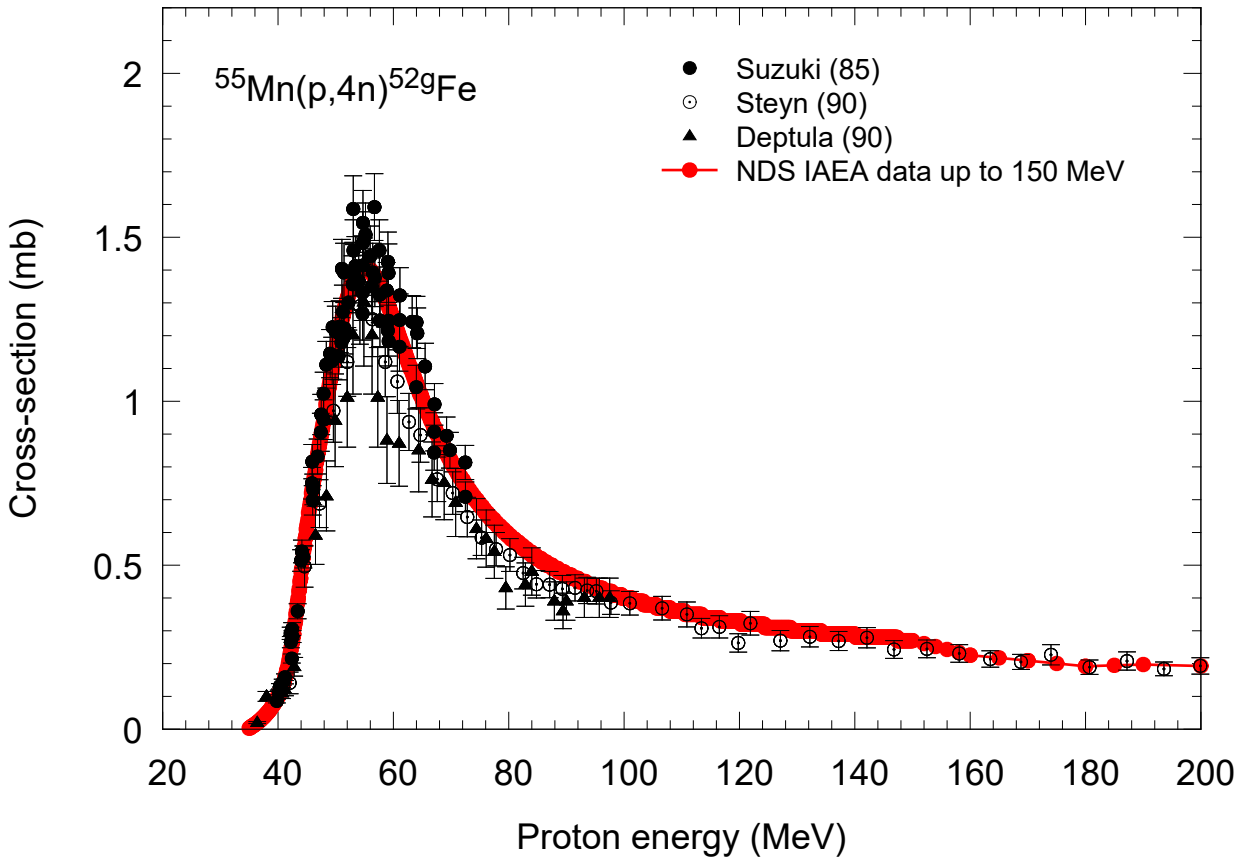

^{55}Mn(p,x)^{48}Cr(cum)
Cross-section (mb)
10^{0}
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200
Proton energy (MeV)
Michel (85)
evaluated

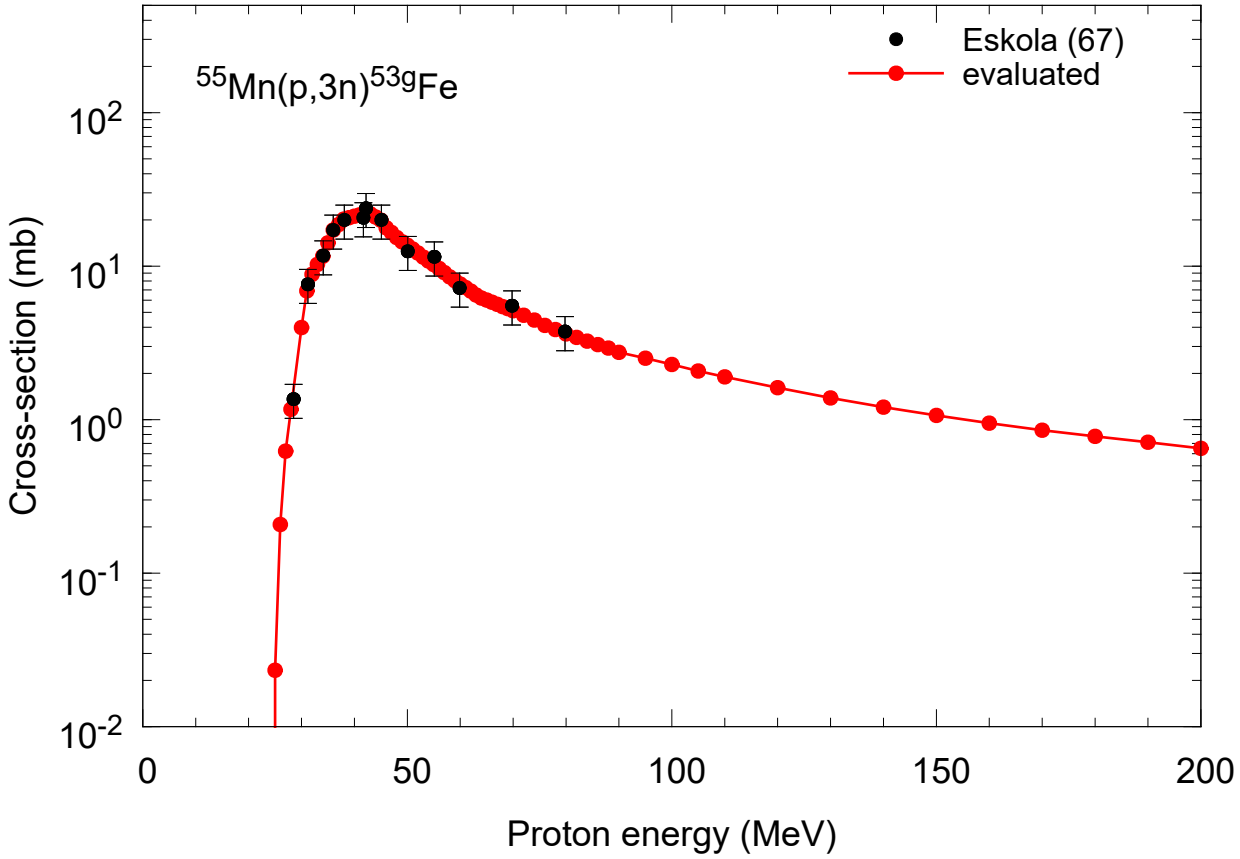

^{55}Mn(p,x)^{51}Cr(cum)
Cross-section (mb)
180
160
140
120
100
80
60
40
20
0
0
50
100
150
200
Proton energy (MeV)
Michel (80)
Michel (85)
Levkovski (91)
Michel (97)
Al-Abyad (10)
Ditroi (13)
Huang (23)
NDS IAEA data up to 150 MeV

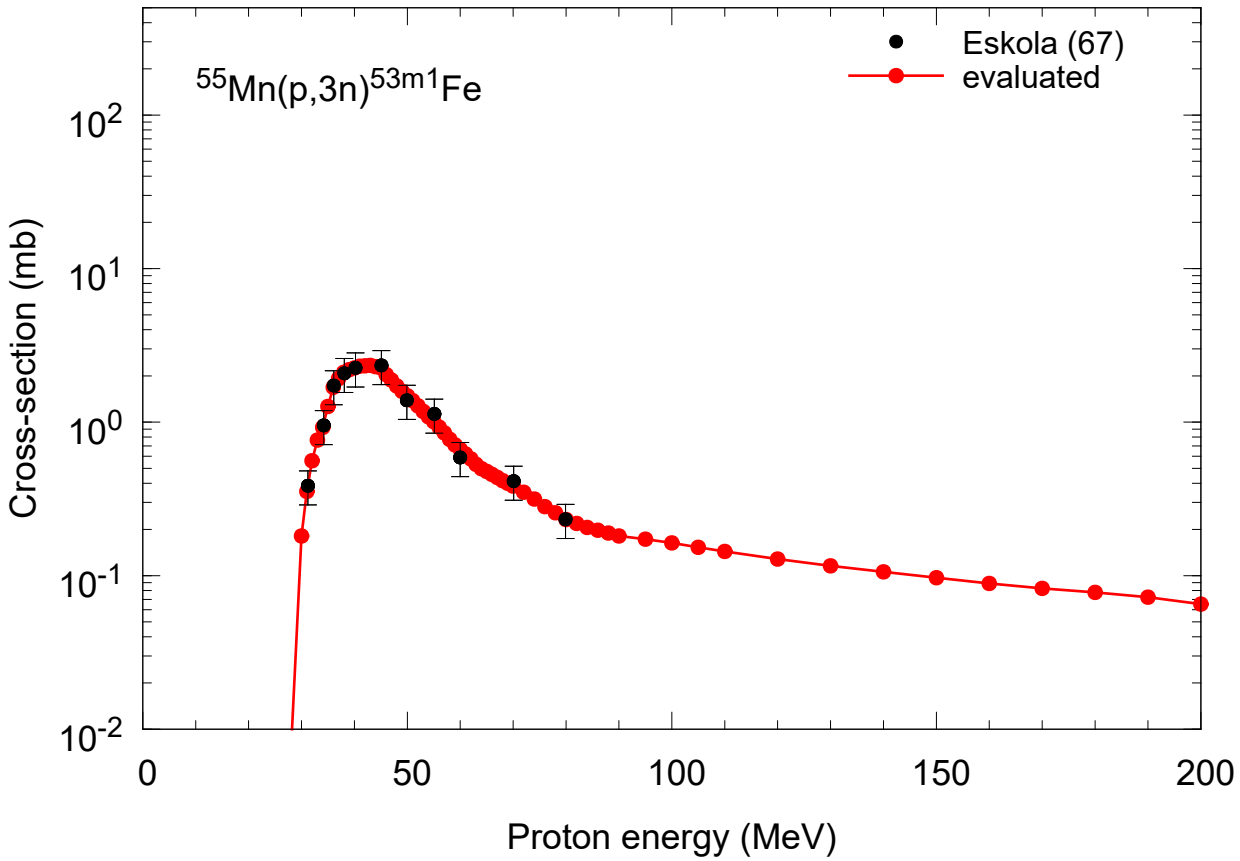

^{55}Mn(p,x)^{52g}Mn(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (80)
Michel (85)
Michel (97)
Ditroi (13)
evaluated

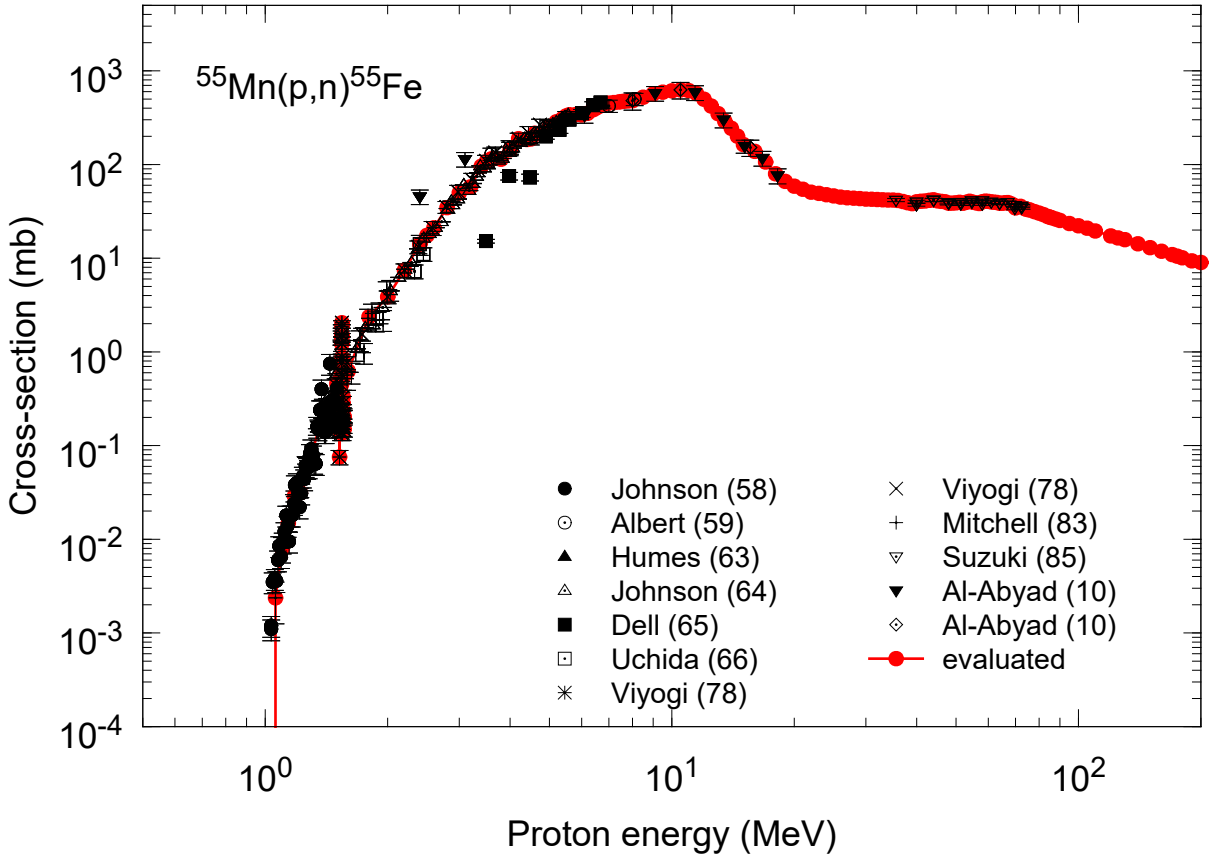

^{55}Mn(p,x)^{54}Mn
Cross-section (mb)
Proton energy (MeV)
Cohen (55)
Gusakow (61)
Michel (80)
Michel (85)
Levkovski (91)
Michel (97)
Al-Abyad (10)
Ditroi (13)
Huang (23)
evaluated

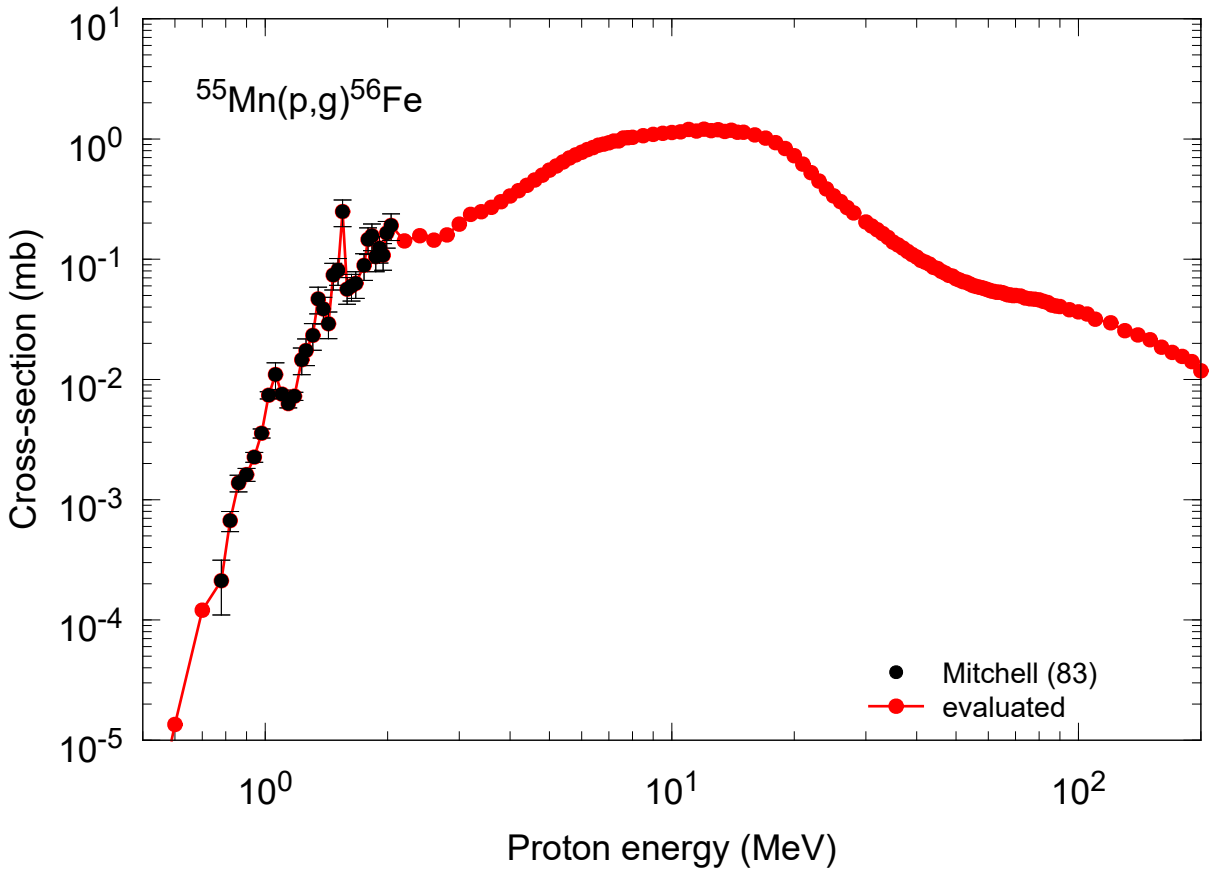

^{55}Mn(p,x)^{56}Mn
Marrs (79)
evaluated
Cross-section (mb)
Proton energy (MeV)

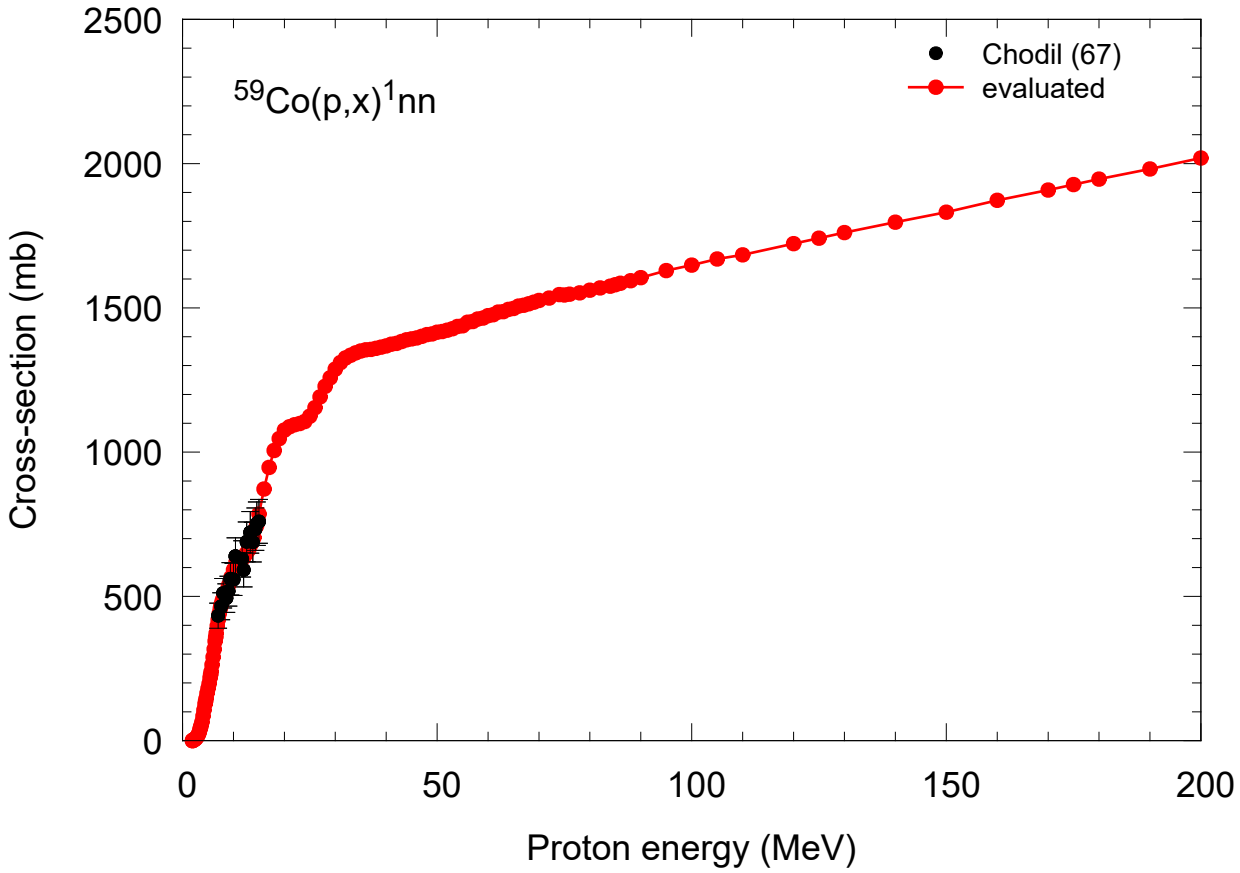

^{55}Mn(p,4n)^{52g}Fe
Suzuki (85)
Steyn (90)
Deptula (90)
NDS IAEA data up to 150 MeV
Cross-section (mb)
Proton energy (MeV)

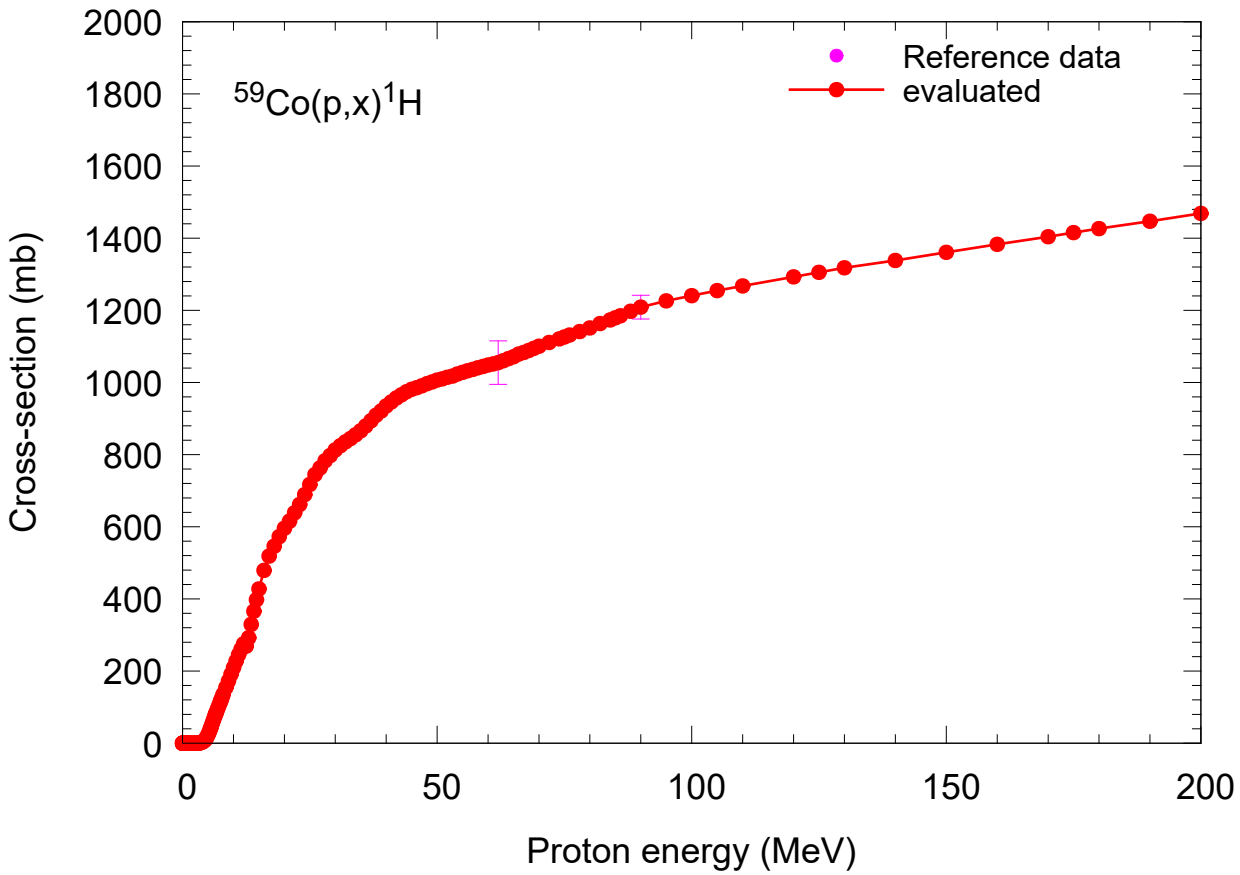

^{55}Mn(p,3n)^{53g}Fe
Eskola (67)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
0
50
100
150
200

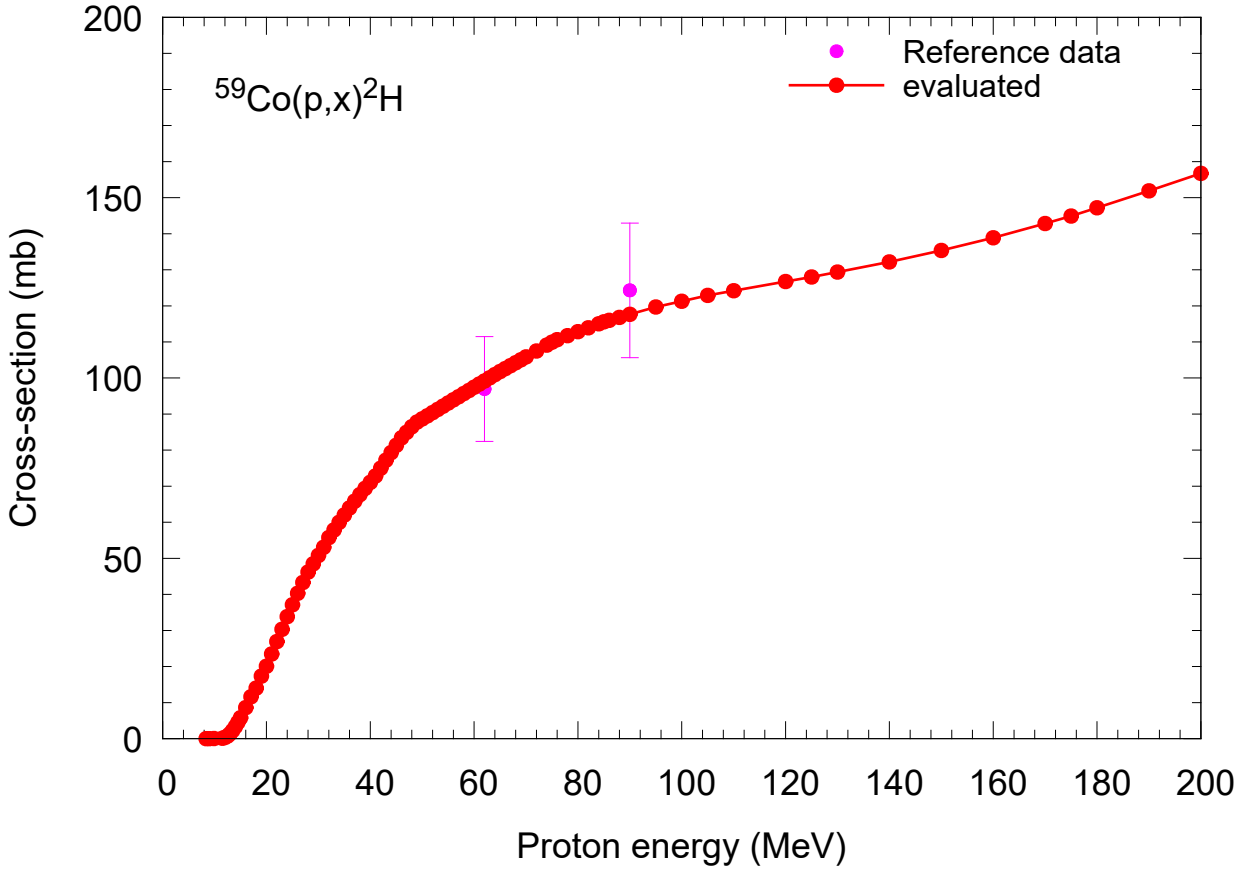

^{55}Mn(p,3n)^{53m1}Fe
Eskola (67)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
0
50
100
150
200

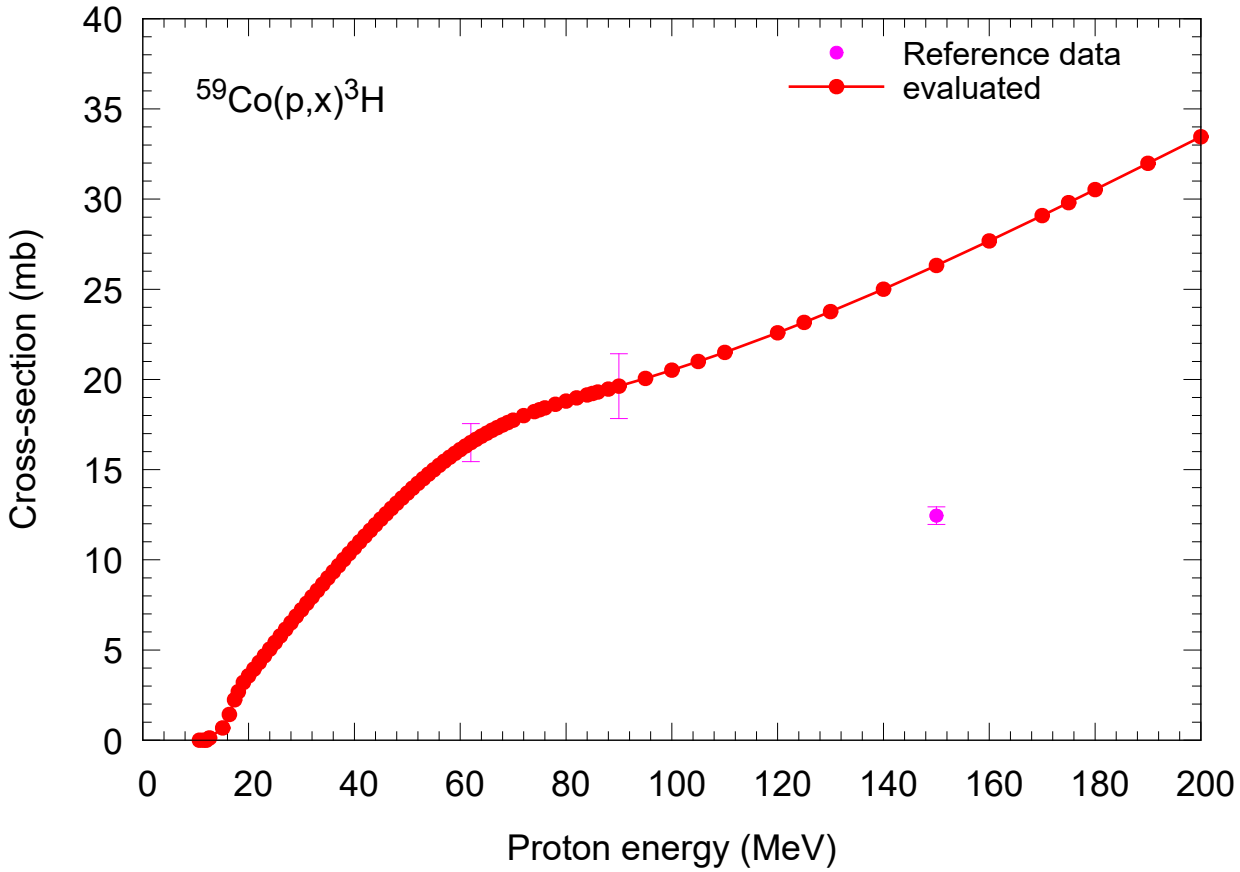

^{55}Mn(p,n)^{55}Fe
Cross-section (mb)
Proton energy (MeV)
Johnson (58)
Albert (59)
Humes (63)
Johnson (64)
Dell (65)
Uchida (66)
Viyogi (78)
Viyogi (78)
Mitchell (83)
Suzuki (85)
Al-Abyad (10)
Al-Abyad (10)
evaluated

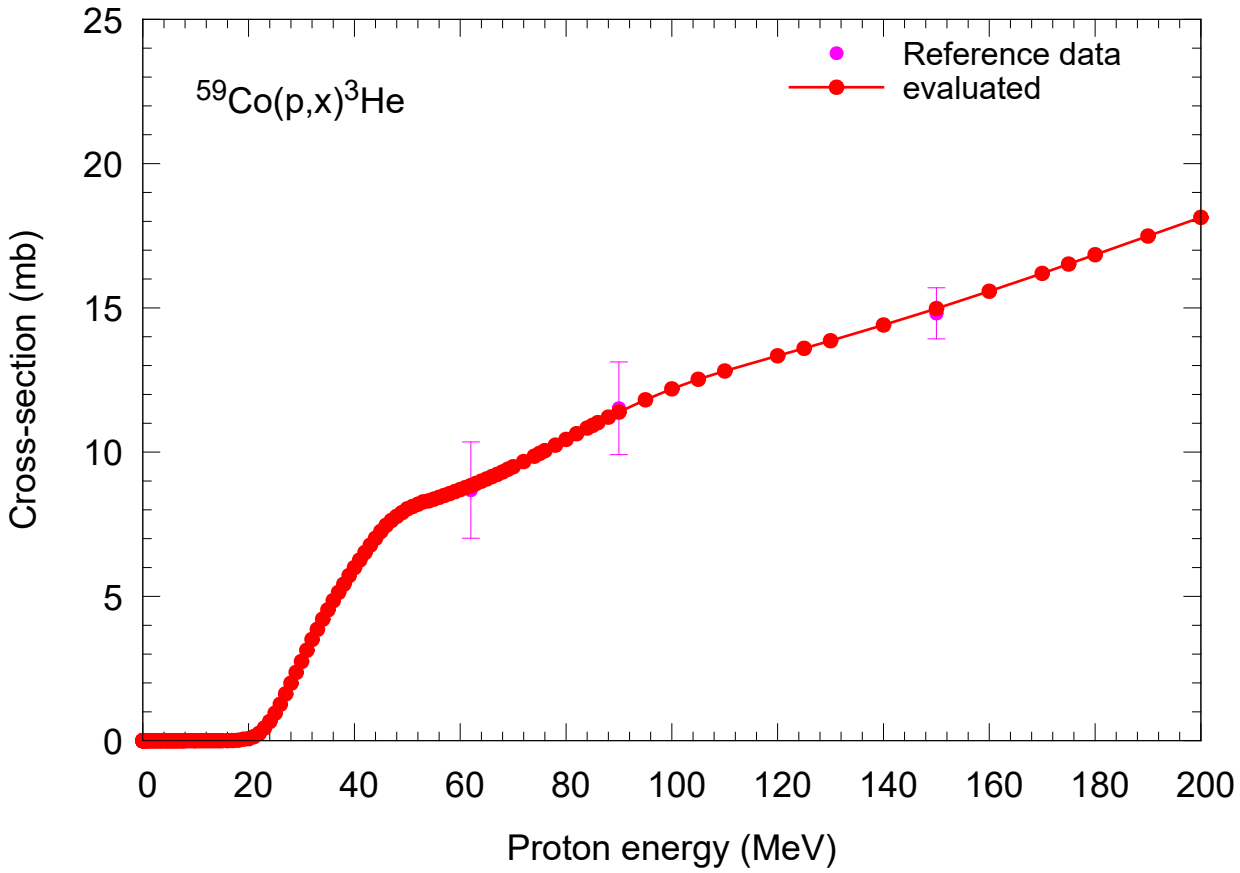

^{55}Mn(p,g)^{56}Fe
Cross-section (mb)
Proton energy (MeV)
Mitchell (83)
evaluated

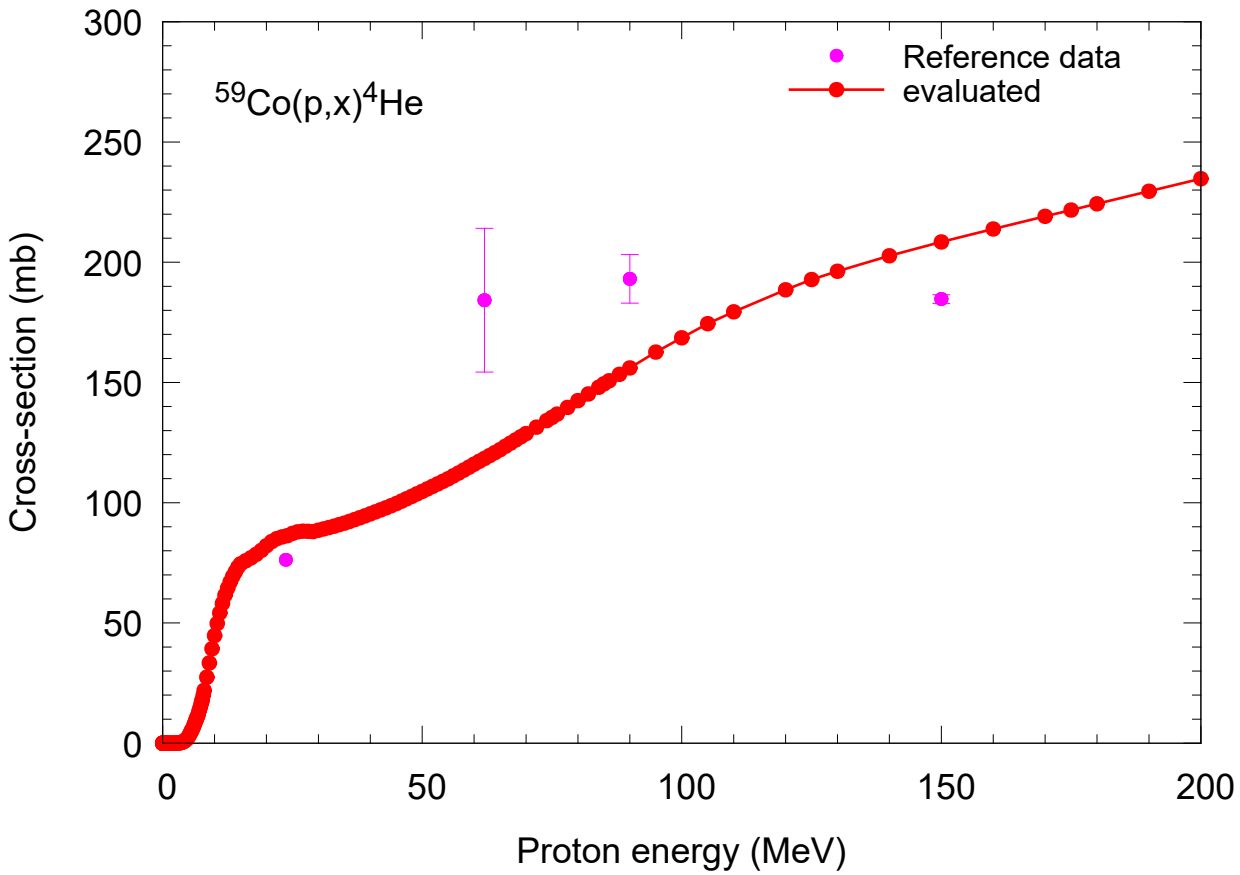

^{59}Co(p,x)^{1}nn
Chodil (67)
evaluated
Cross-section (mb)
Proton energy (MeV)
0
500
1000
1500
2000
2500
0
50
100
150
200

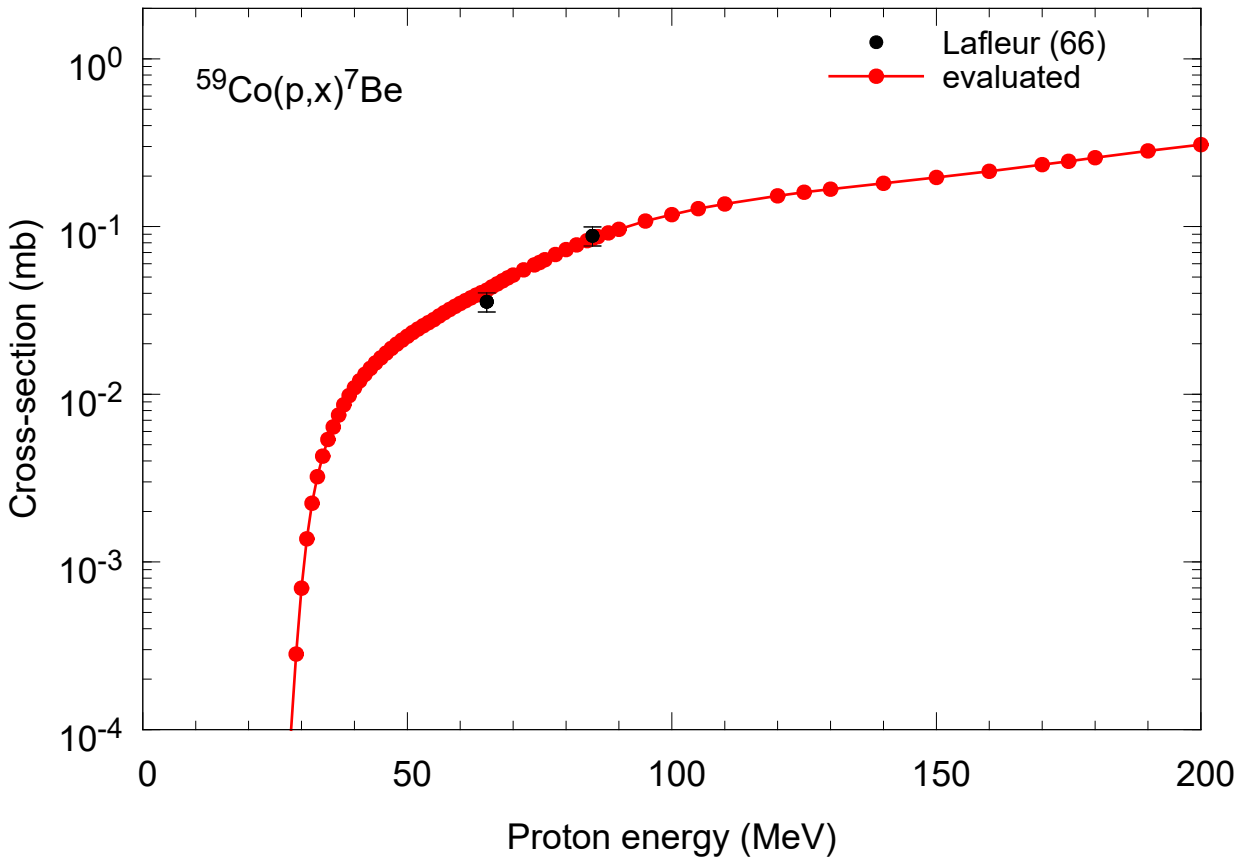

^{59}Co(p,x)^{1}H
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
50
100
150
200

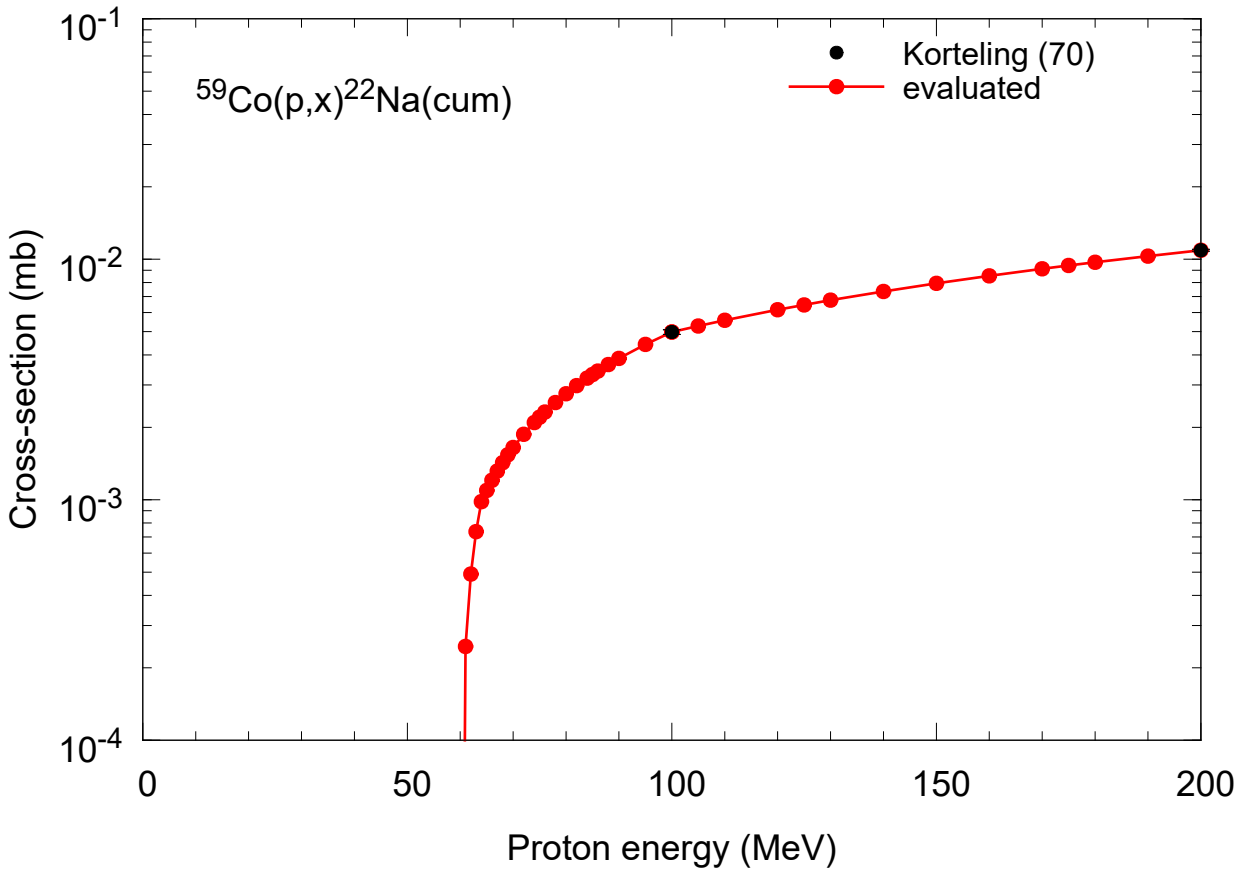

^{59}Co(p,x)^{2}H
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
50
100
150
200
0
20
40
60
80
100
120
140
160
180
200

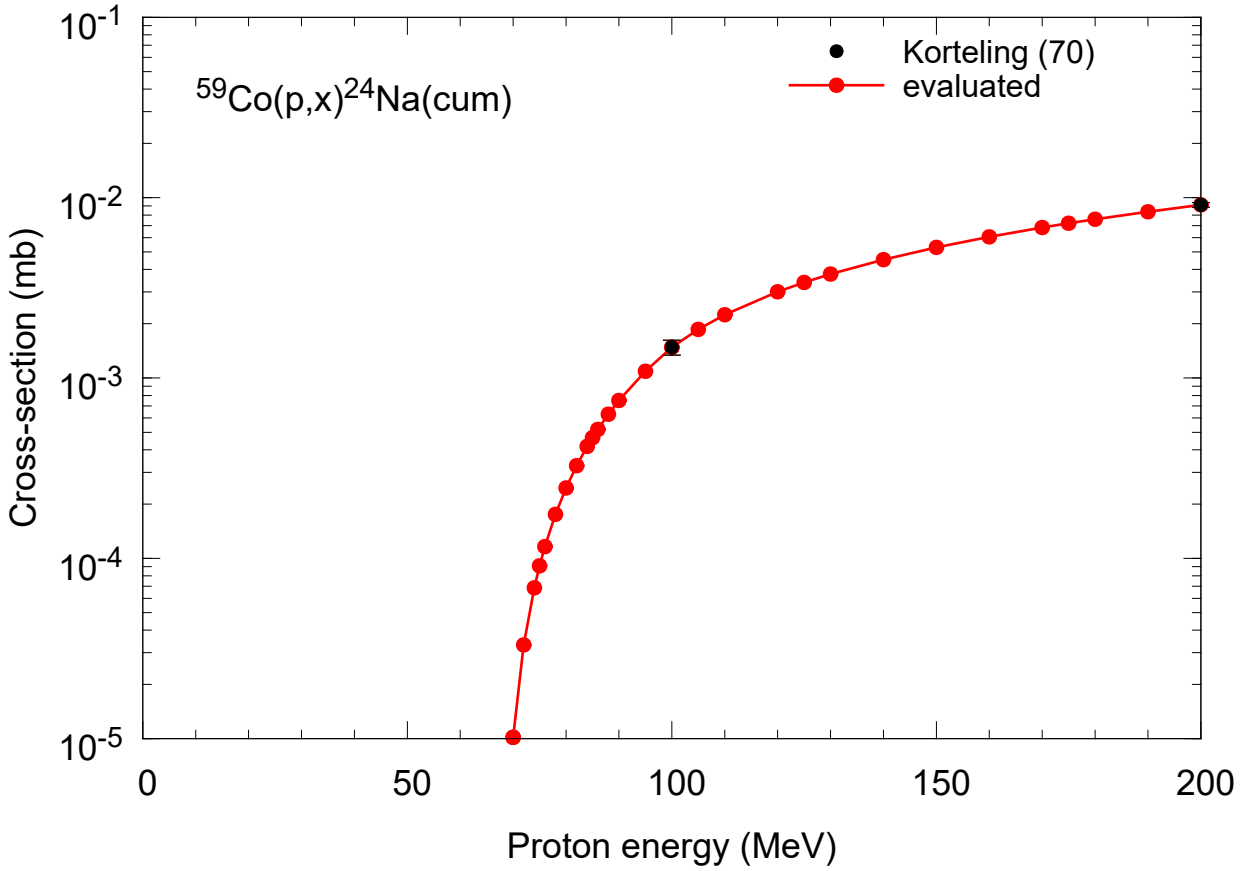

^{59}Co(p,x)^{3}H
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100
120
140
160
180
200

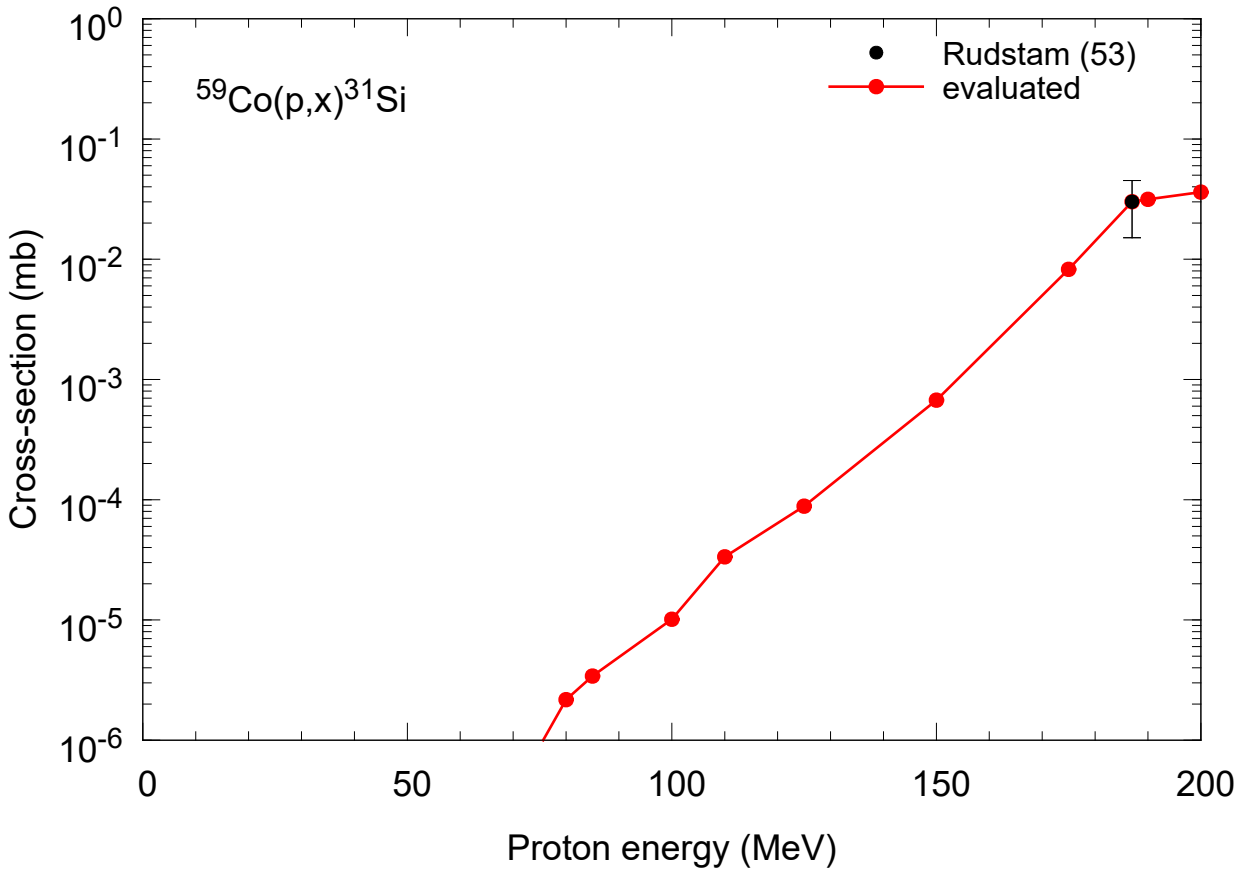

^{59}Co(p,x)^{3}He
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
5
10
15
20
25
0
20
40
60
80
100
120
140
160
180
200

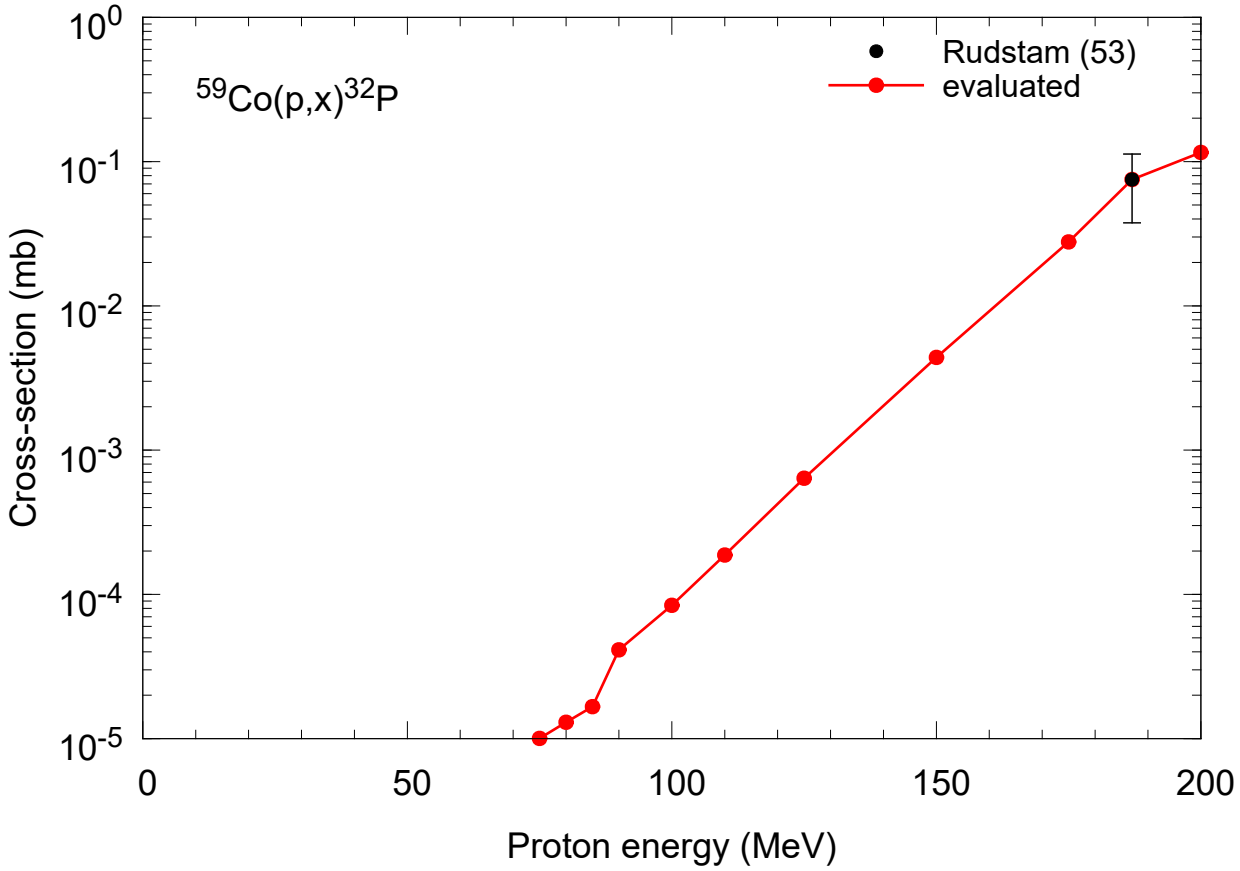

^{59}Co(p,x)^{4}He
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
50
100
150
200
250
300
0
50
100
150
200

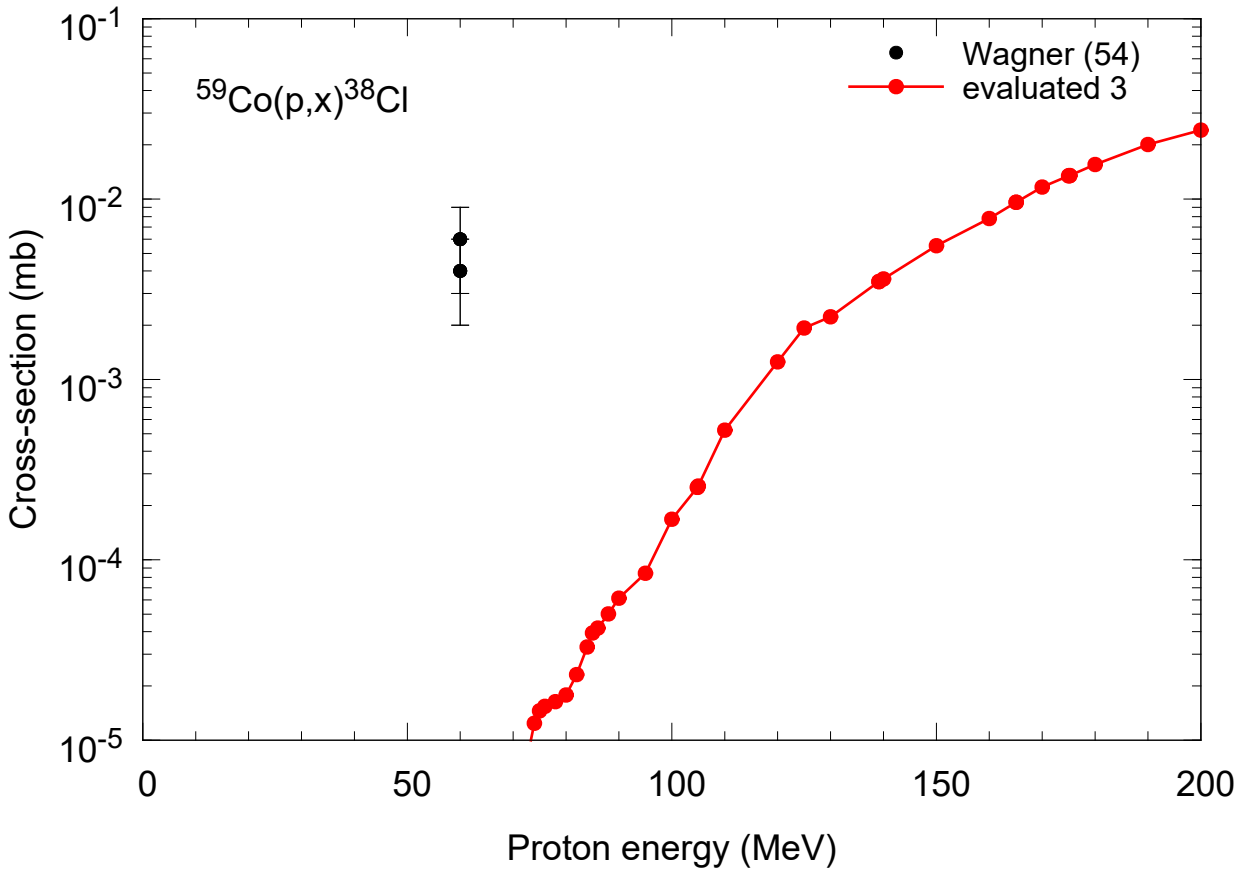

^{59}Co(p,x)^{7}Be
Lafleur (66)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
50
100
150
200

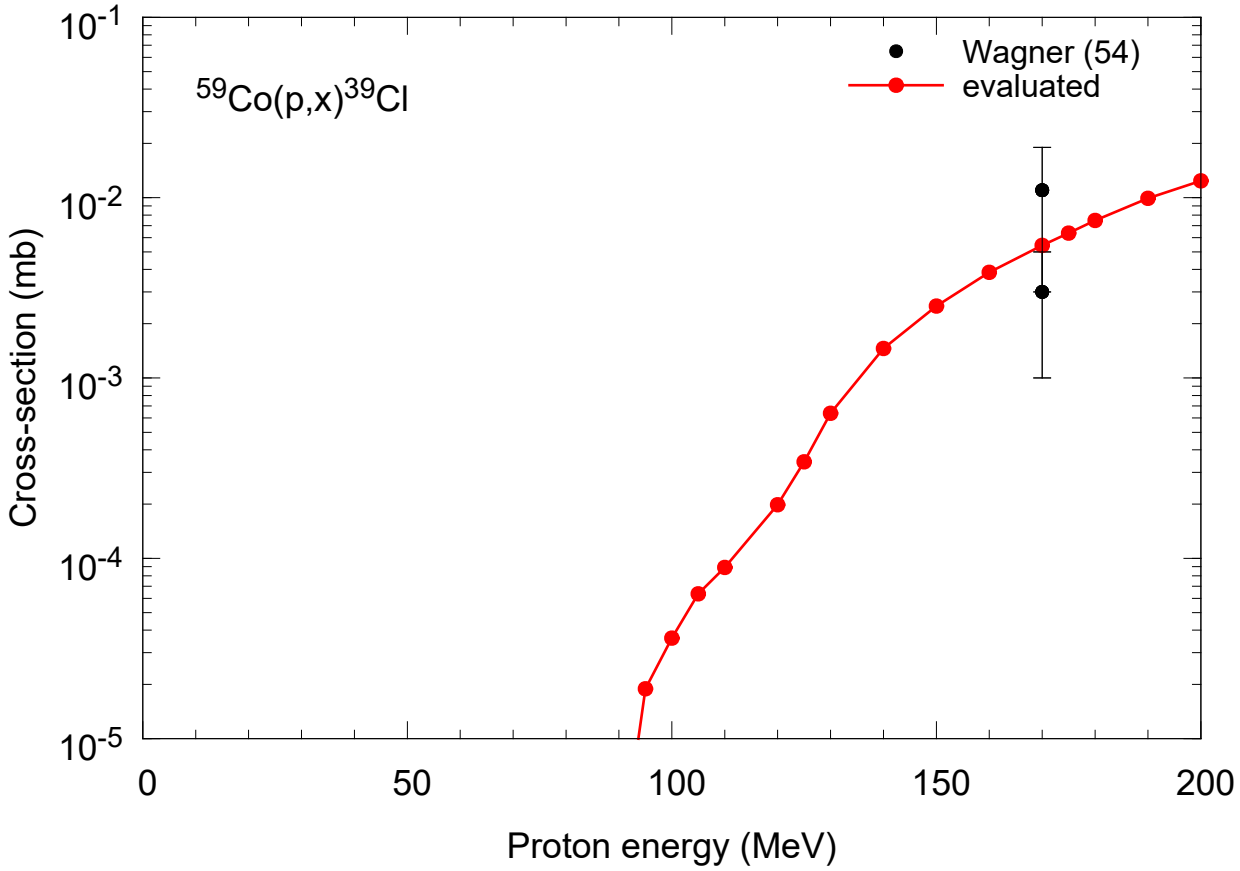

^{59}Co(p,x)^{22}Na(cum)
Korteling (70)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
50
100
150
200

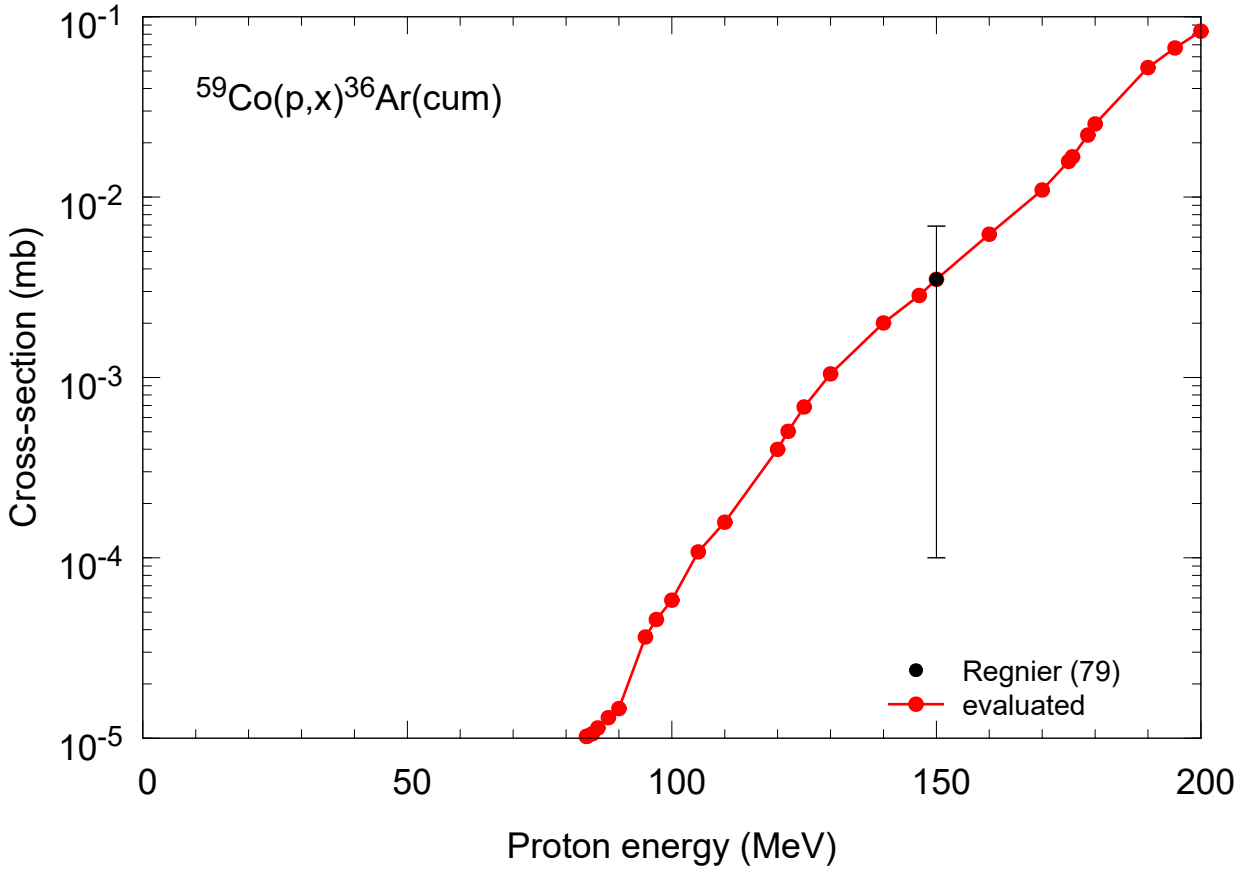

^{59}Co(p,x)^{24}Na(cum)
Korteling (70)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
50
100
150
200

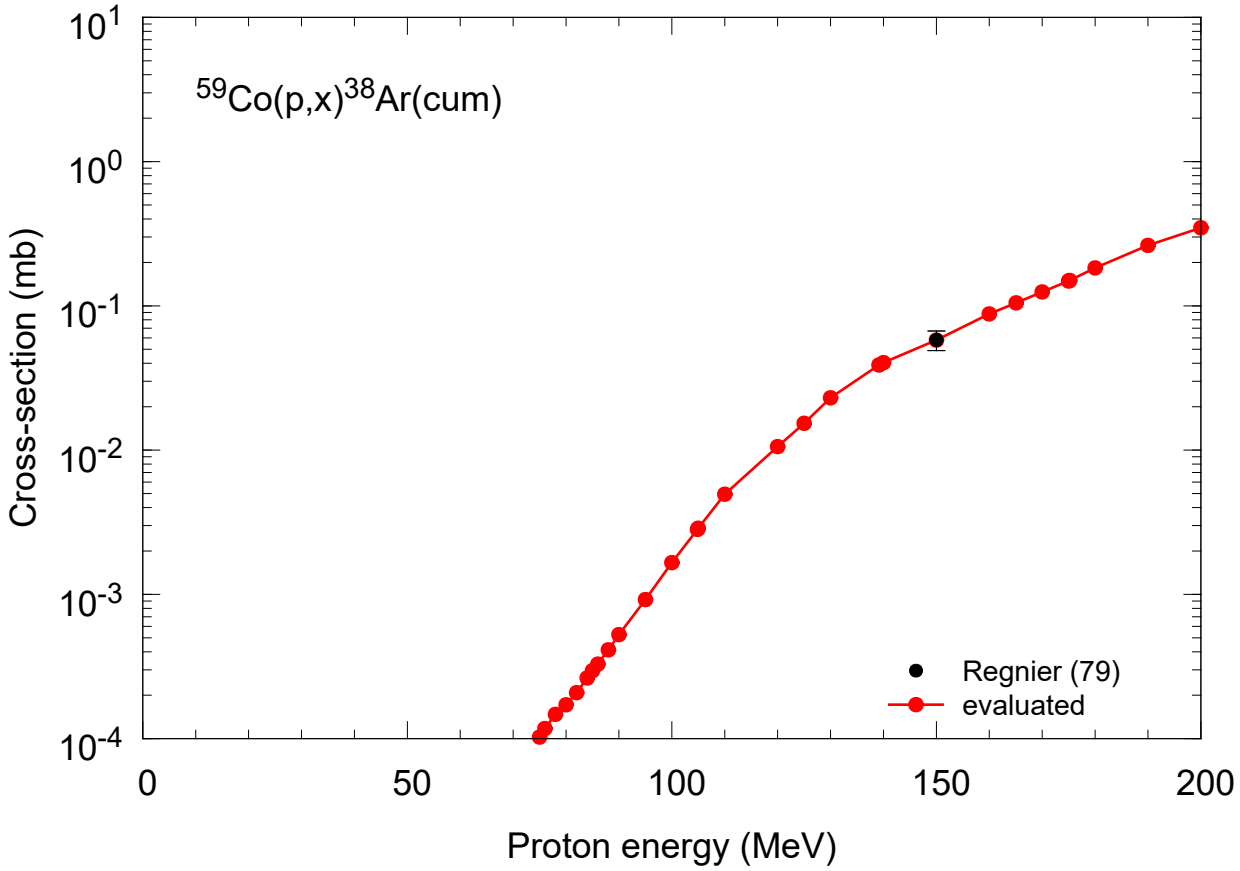

^{59}Co(p,x)^{31}Si
Rudstam (53)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
0
50
100
150
200

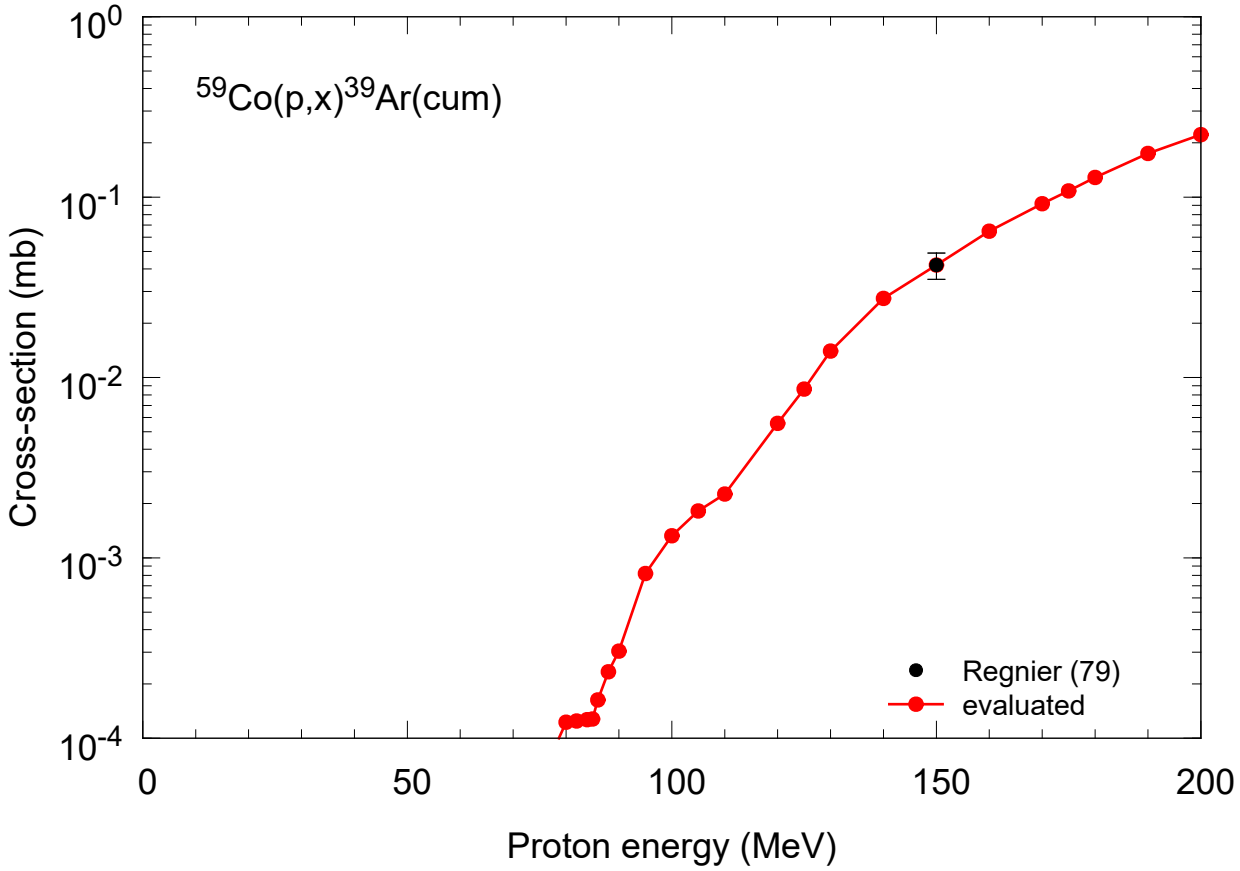

^{59}Co(p,x)^{32}P
Rudstam (53)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
50
100
150
200

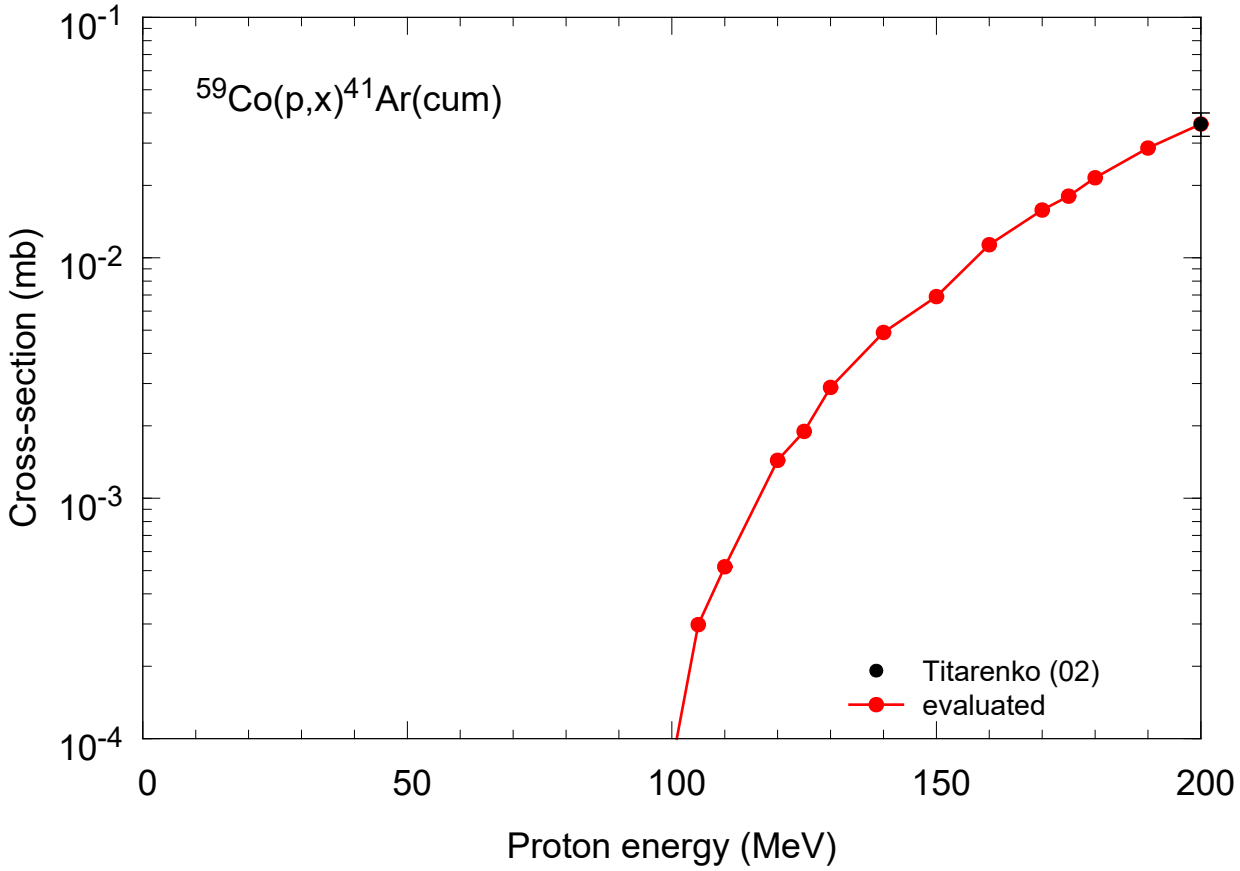

^{59}Co(p,x)^{38}Cl
Wagner (54)
evaluated 3
Cross-section (mb)
Proton energy (MeV)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
50
100
150
200

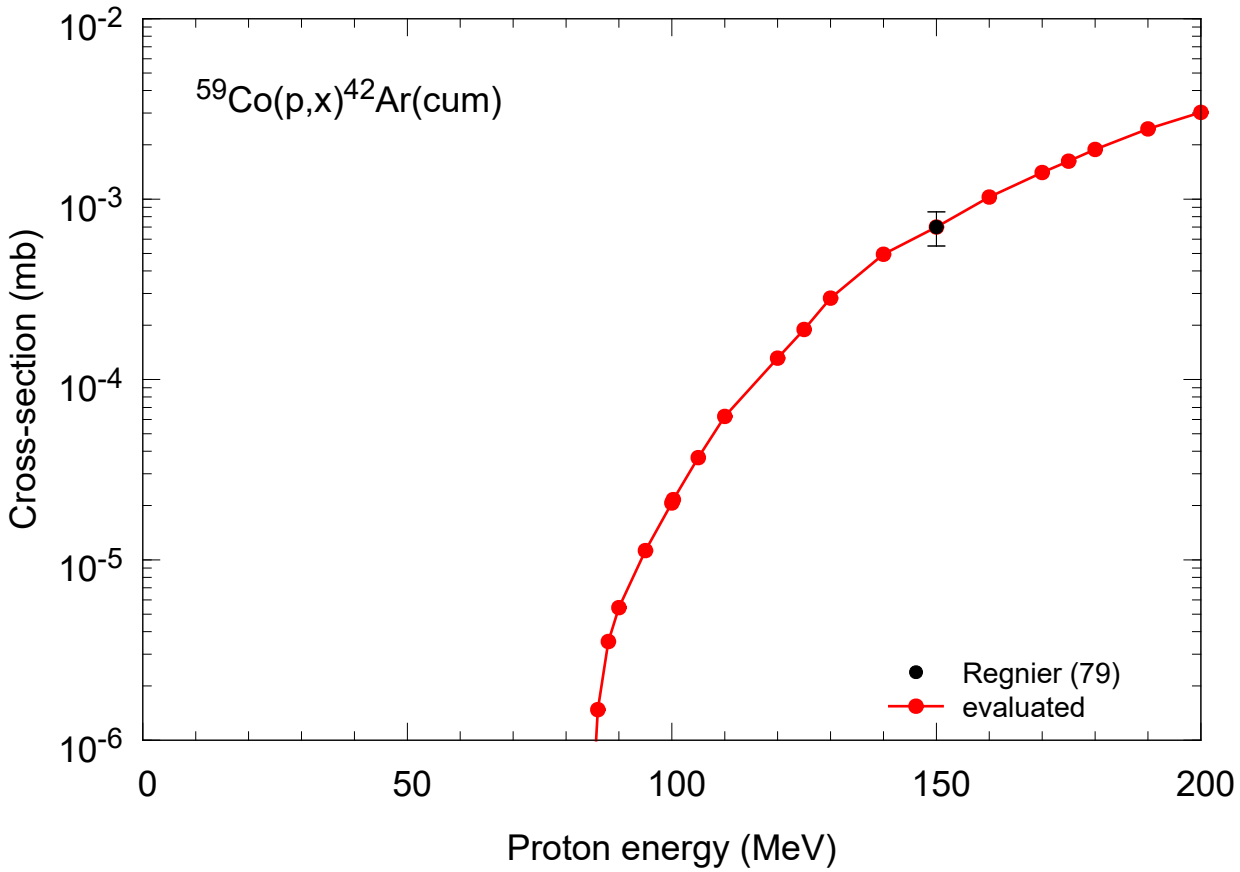

^{59}Co(p,x)^{39}Cl
Wagner (54)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
50
100
150
200

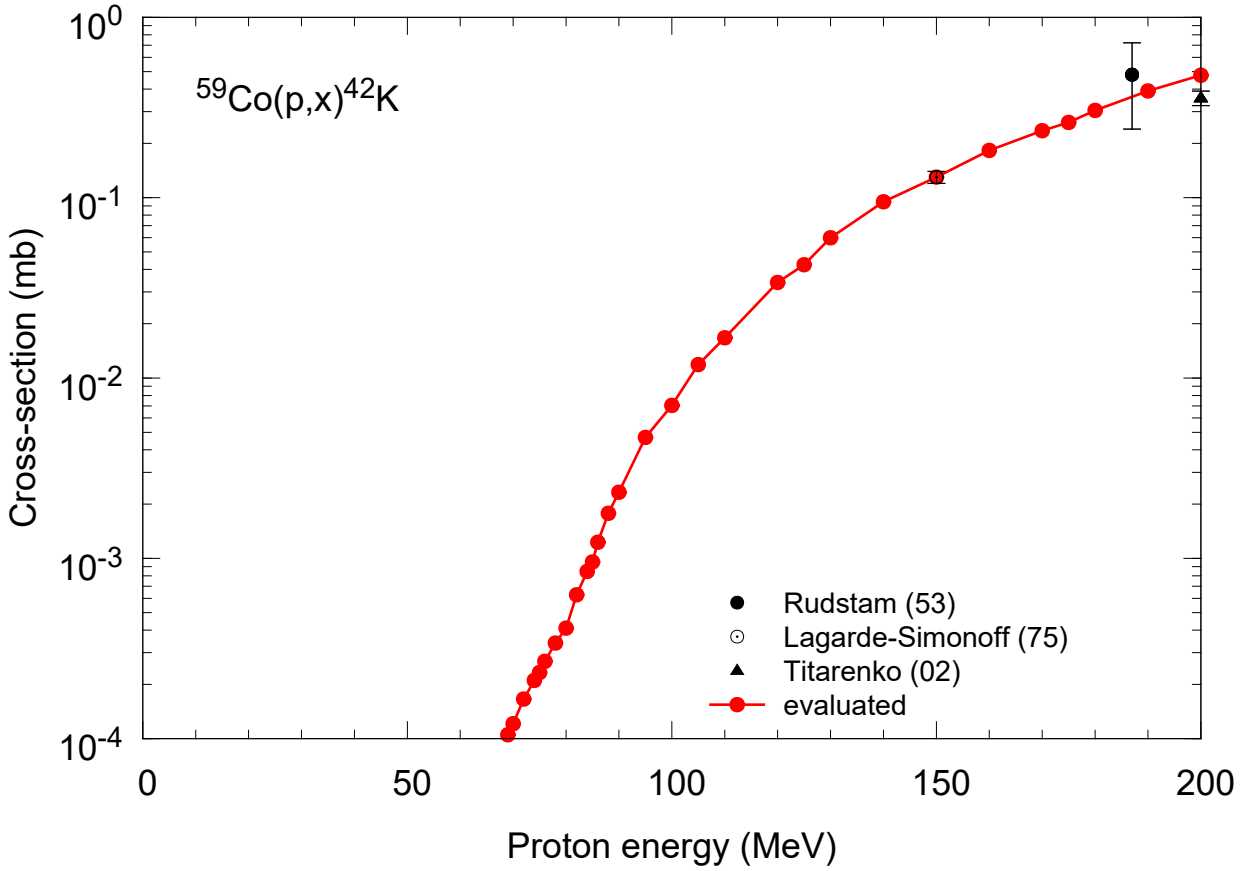

^{59}Co(p,x)^{36}Ar(cum)
Regnier (79)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
50
100
150
200

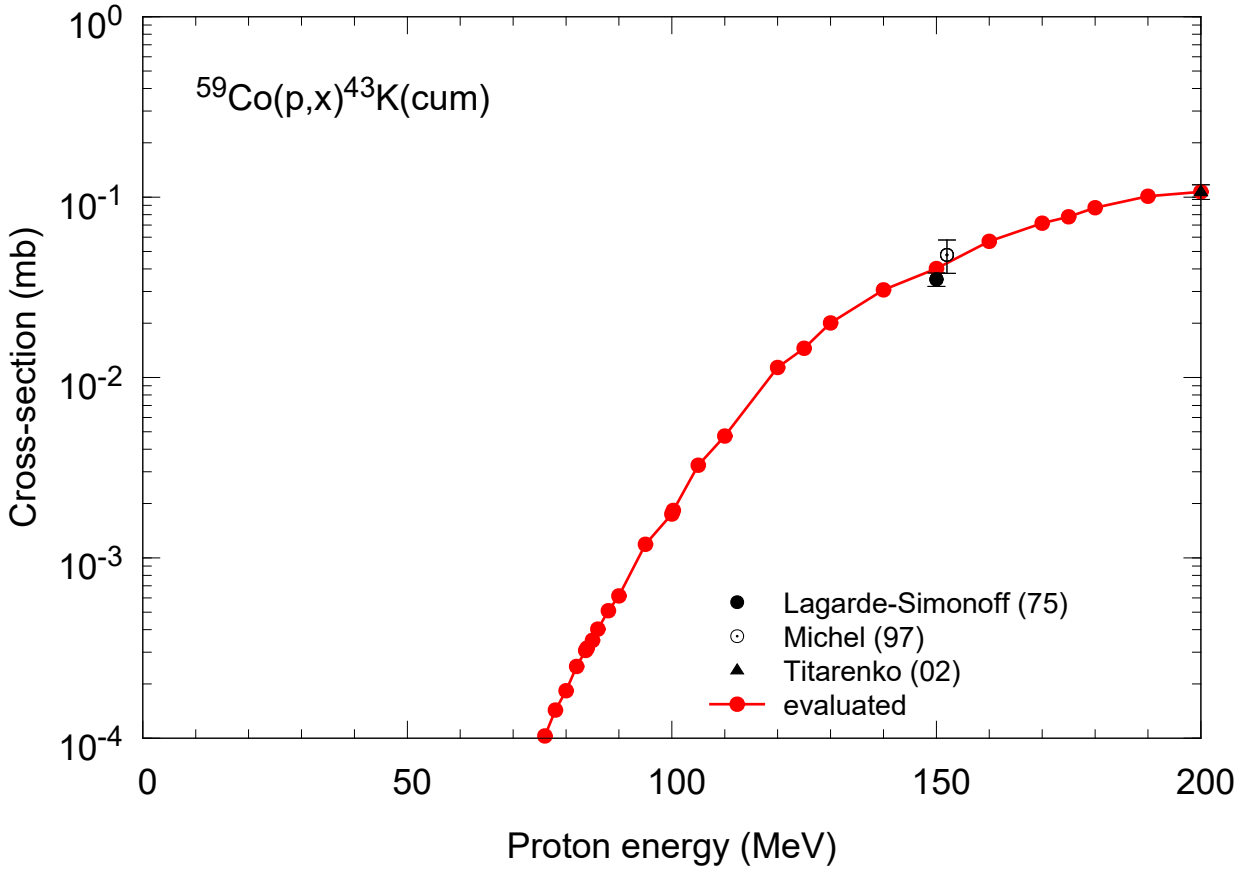

59Co(p,x)38Ar(cum)
Cross-section (mb)
Proton energy (MeV)
Regnier (79)
evaluated

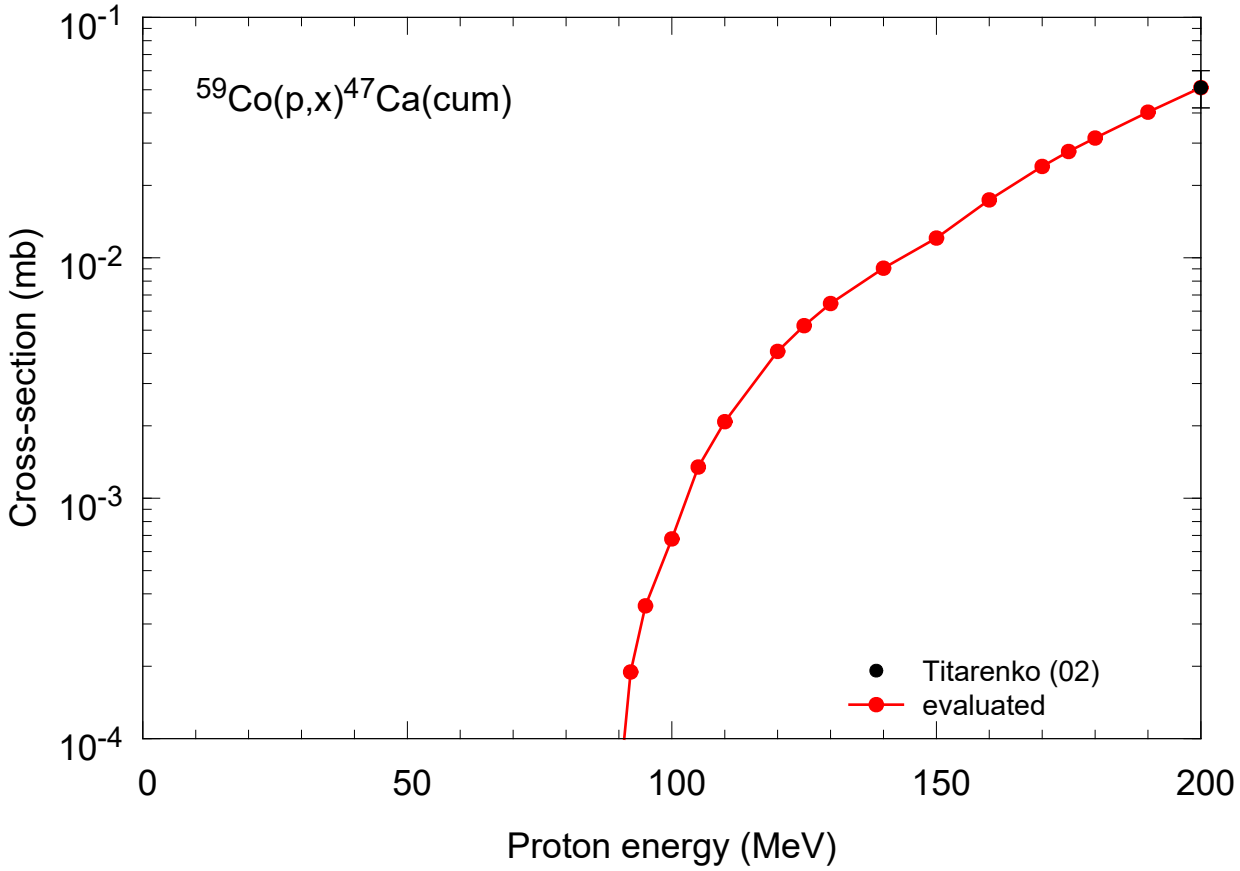

59Co(p,x)39Ar(cum)
Cross-section (mb)
Proton energy (MeV)
Regnier (79)
evaluated

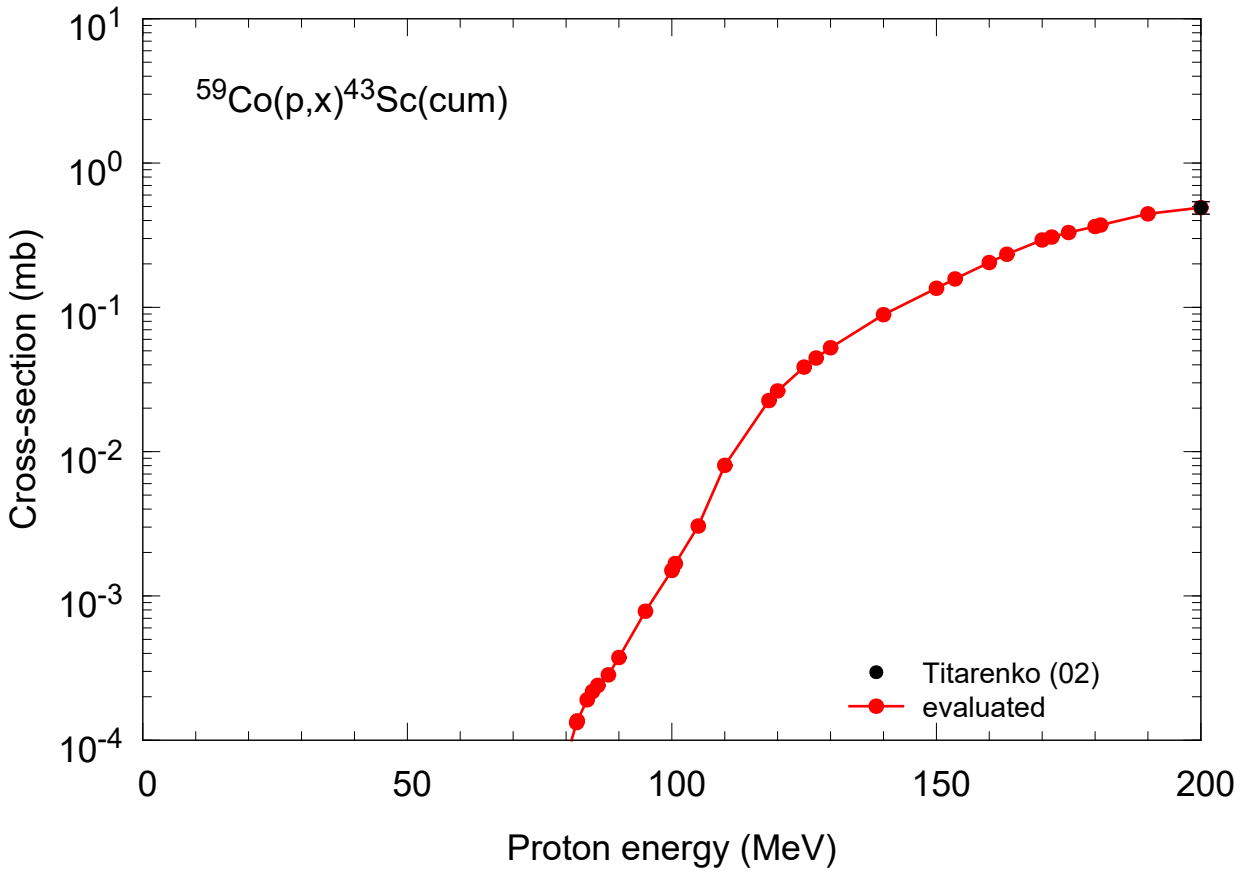

^{59}Co(p,x)^{41}Ar(cum)
Cross-section (mb)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
50
100
150
200
Proton energy (MeV)
Titarenko (02)
evaluated

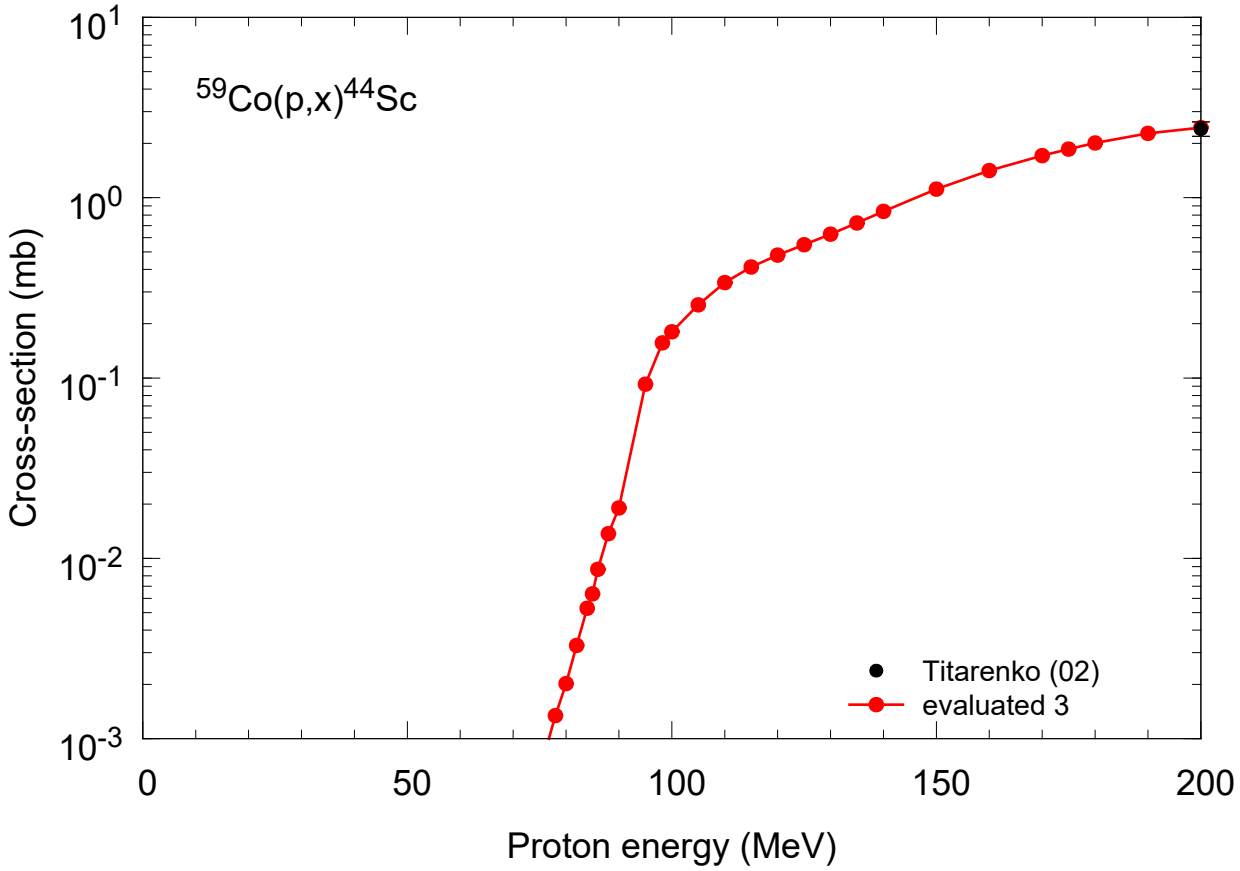

^{59}Co(p,x)^{42}Ar(cum)
Cross-section (mb)
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
0
50
100
150
200
Proton energy (MeV)
Regnier (79)
evaluated

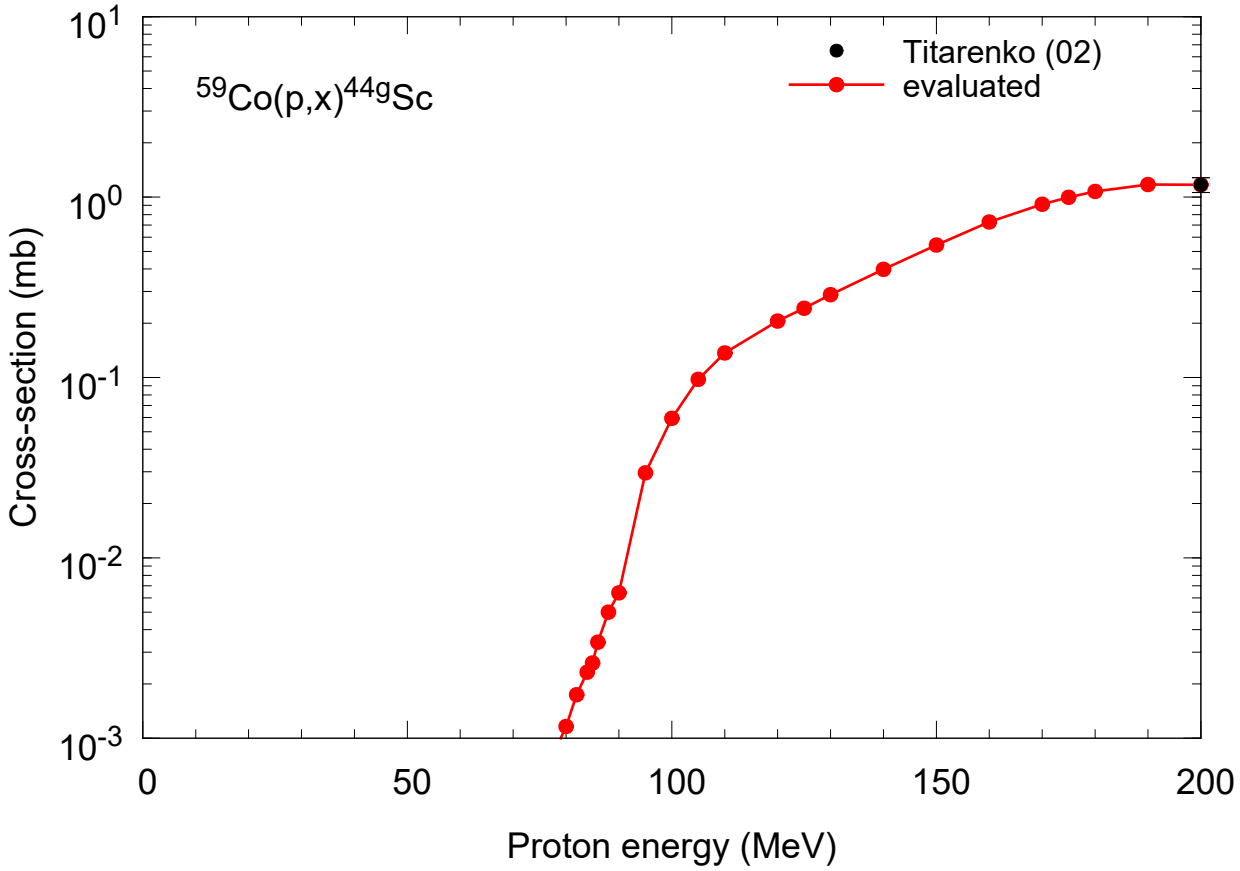

^{59}Co(p,x)^{42}K
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Lagarde-Simonoff (75)
Titarenko (02)
evaluated

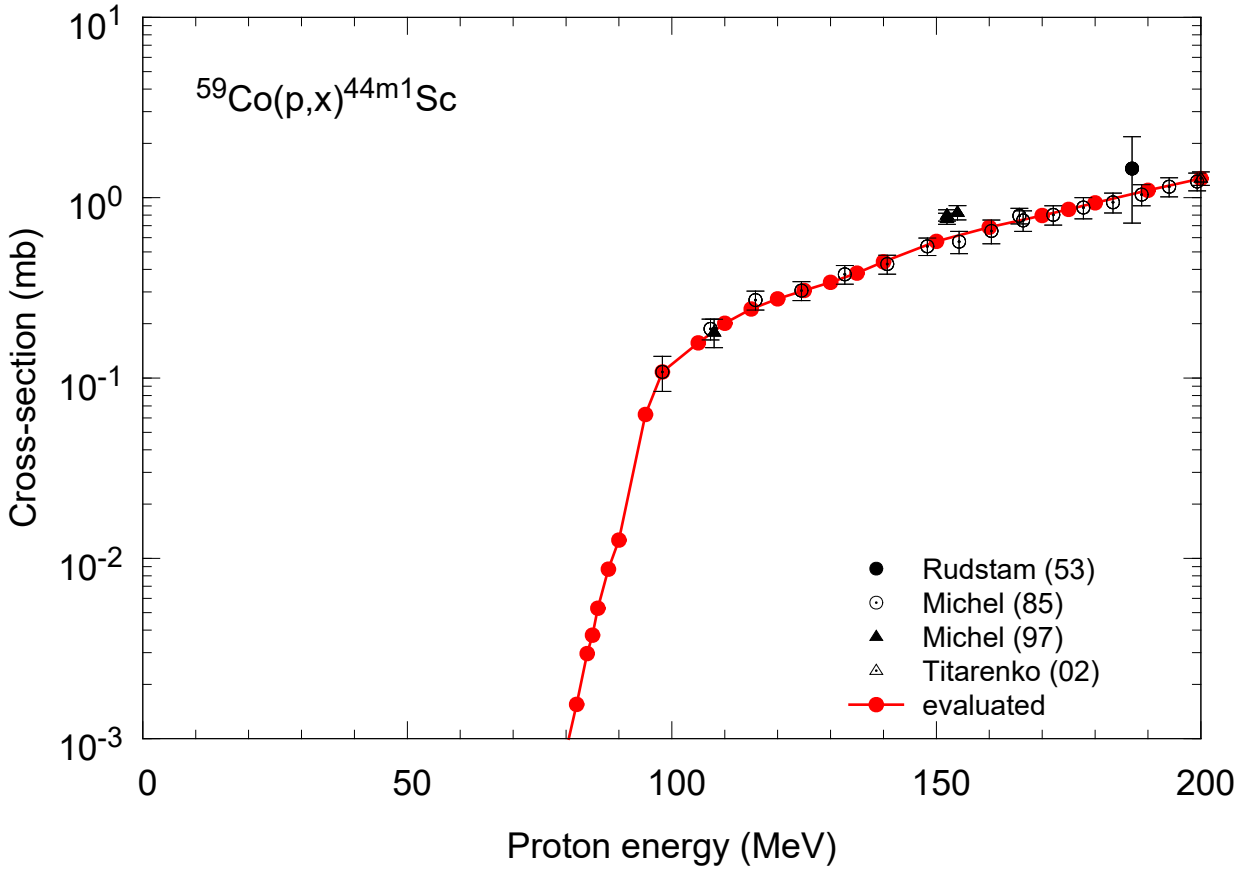

^{59}Co(p,x)^{43}K(cum)
Cross-section (mb)
Proton energy (MeV)
Lagarde-Simonoff (75)
Michel (97)
Titarenko (02)
evaluated

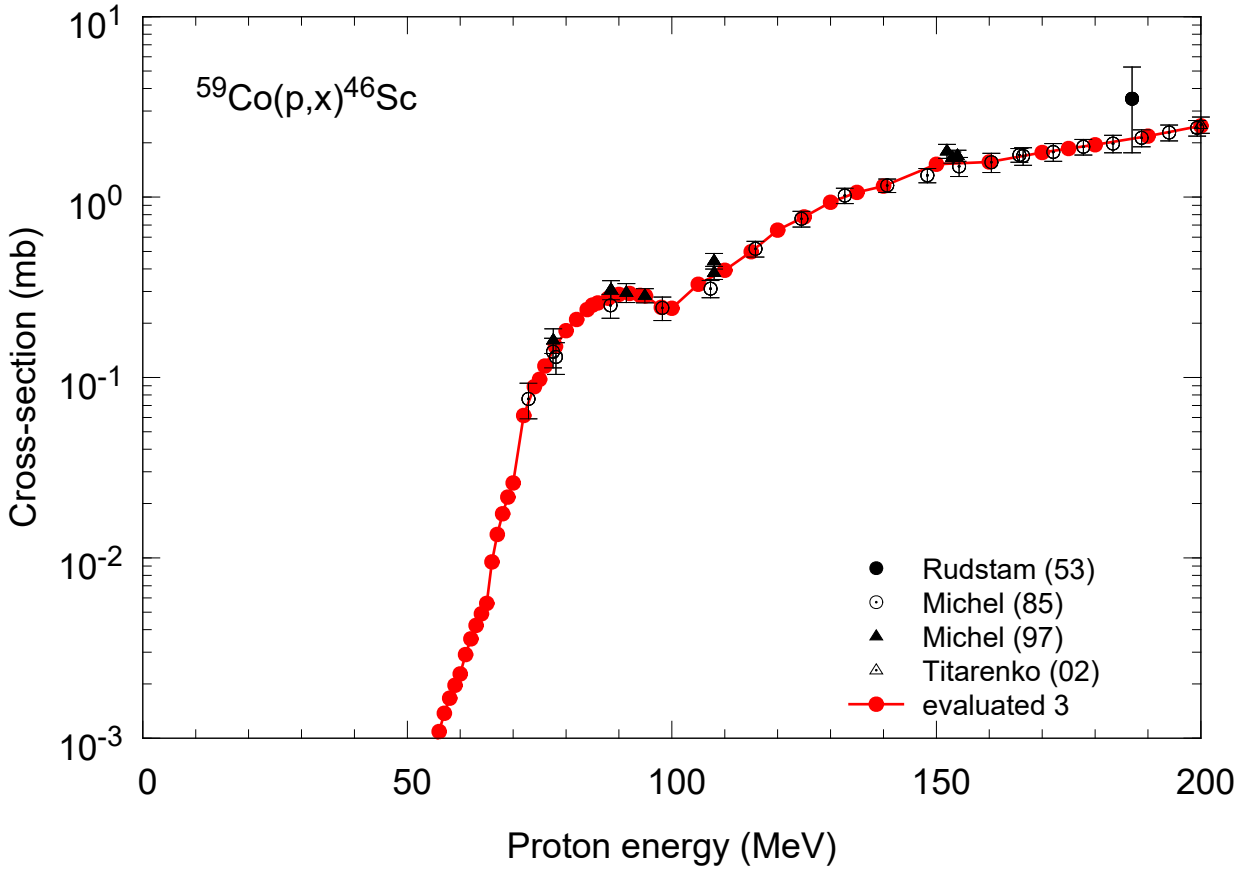

^{59}Co(p,x)^{47}Ca(cum)
Cross-section (mb)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
50
100
150
200
Proton energy (MeV)
Titarenko (02)
evaluated

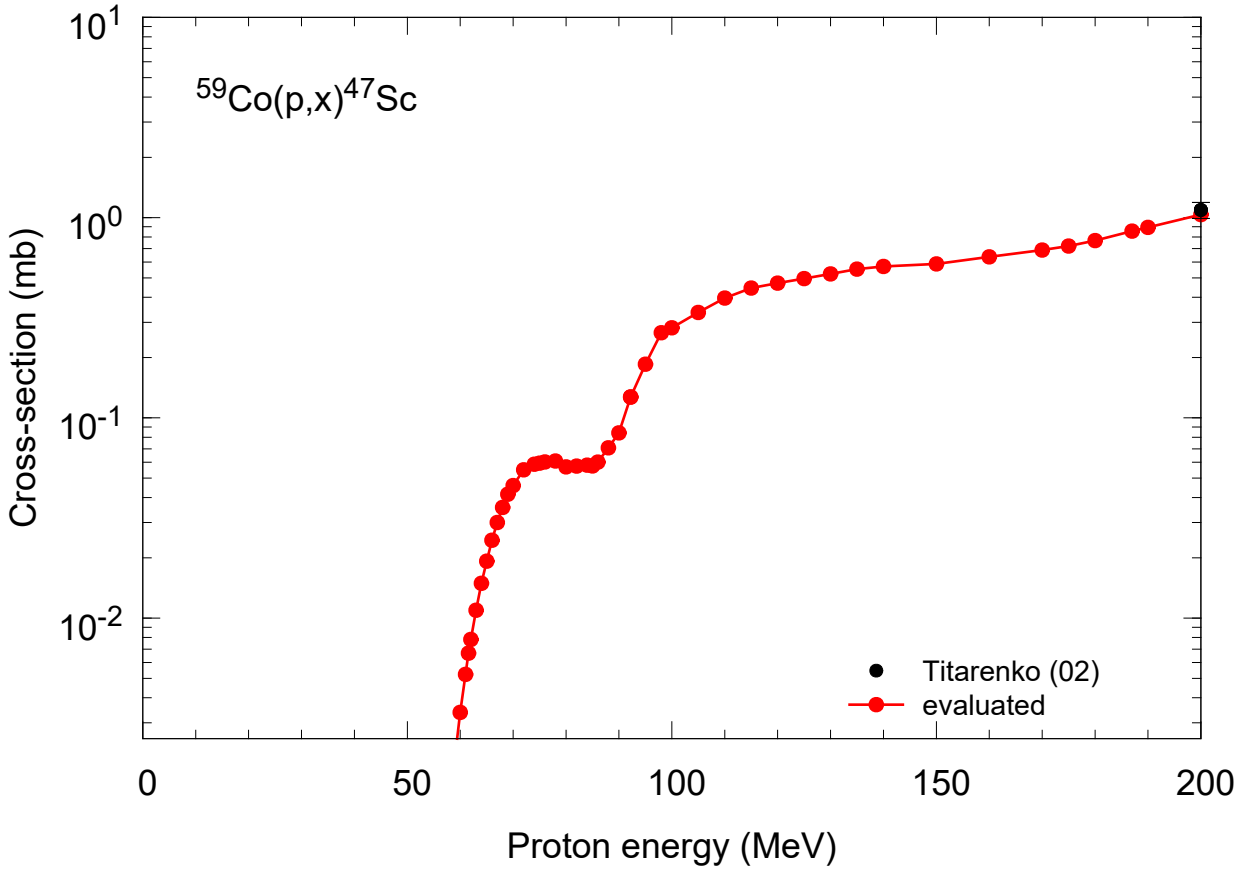

^{59}Co(p,x)^{43}Sc(cum)
Cross-section (mb)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
50
100
150
200
Proton energy (MeV)
Titarenko (02)
evaluated

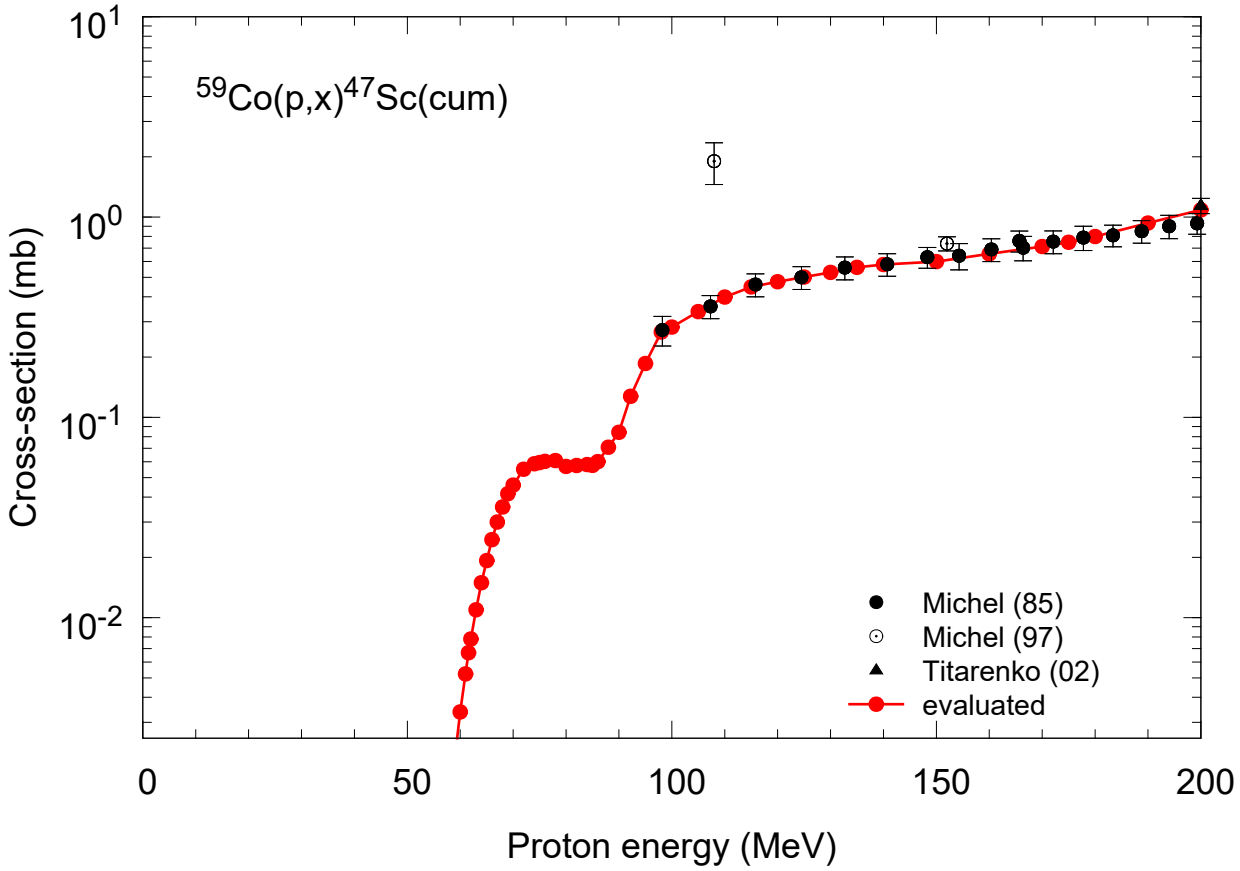

^{59}Co(p,x)^{44}Sc
Titarenko (02)
evaluated 3
Cross-section (mb)
Proton energy (MeV)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200

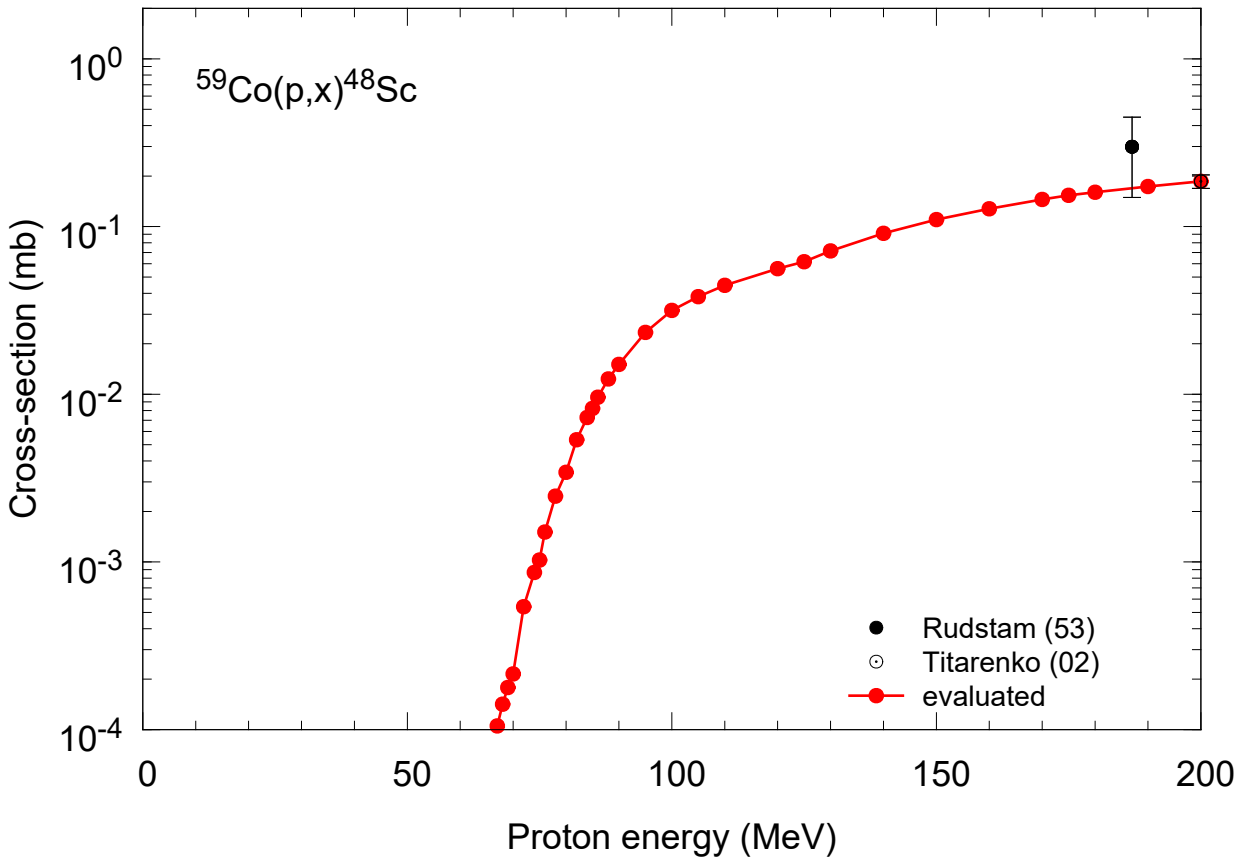

^{59}Co(p,x)^{44g}Sc
Titarenko (02)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200

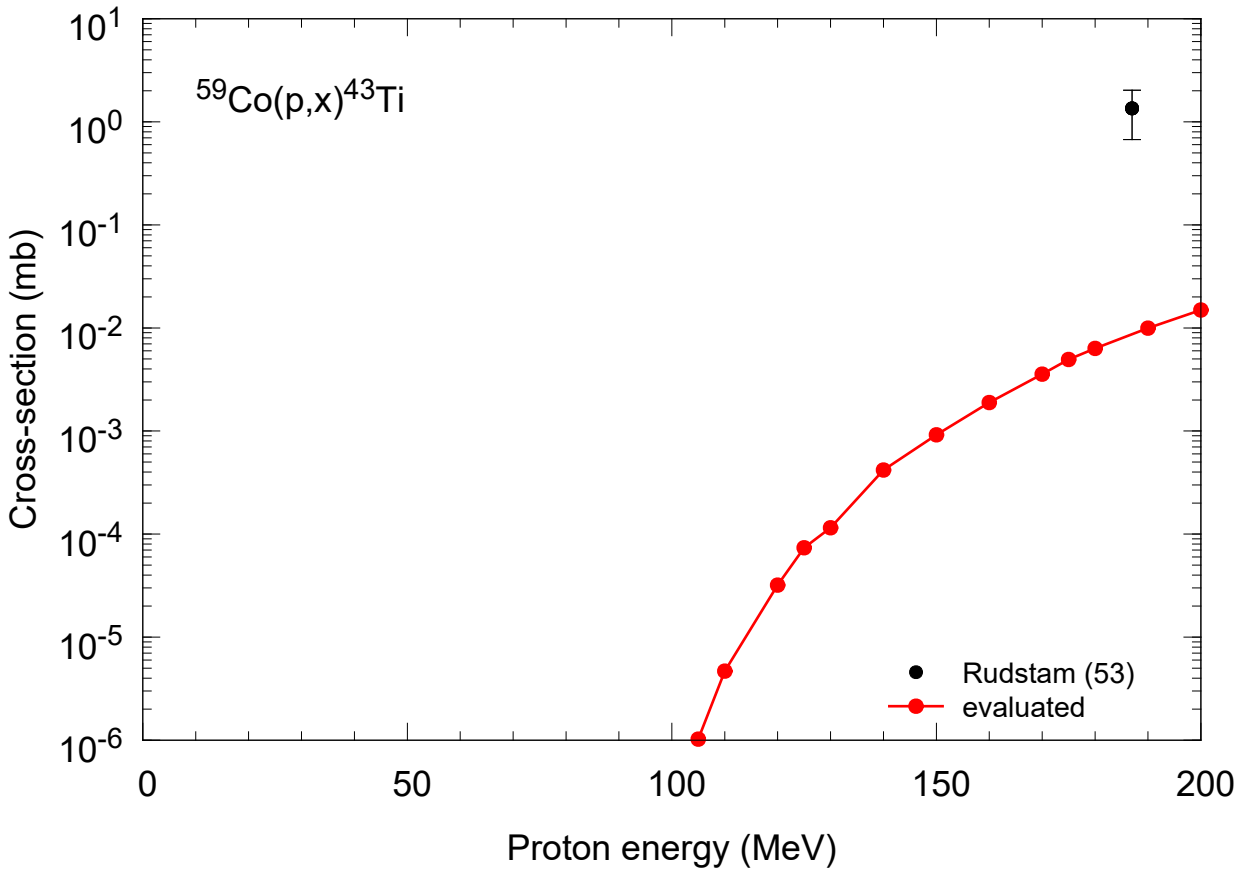

^{59}Co(p,x)^{44m1}Sc
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Michel (85)
Michel (97)
Titarenko (02)
evaluated

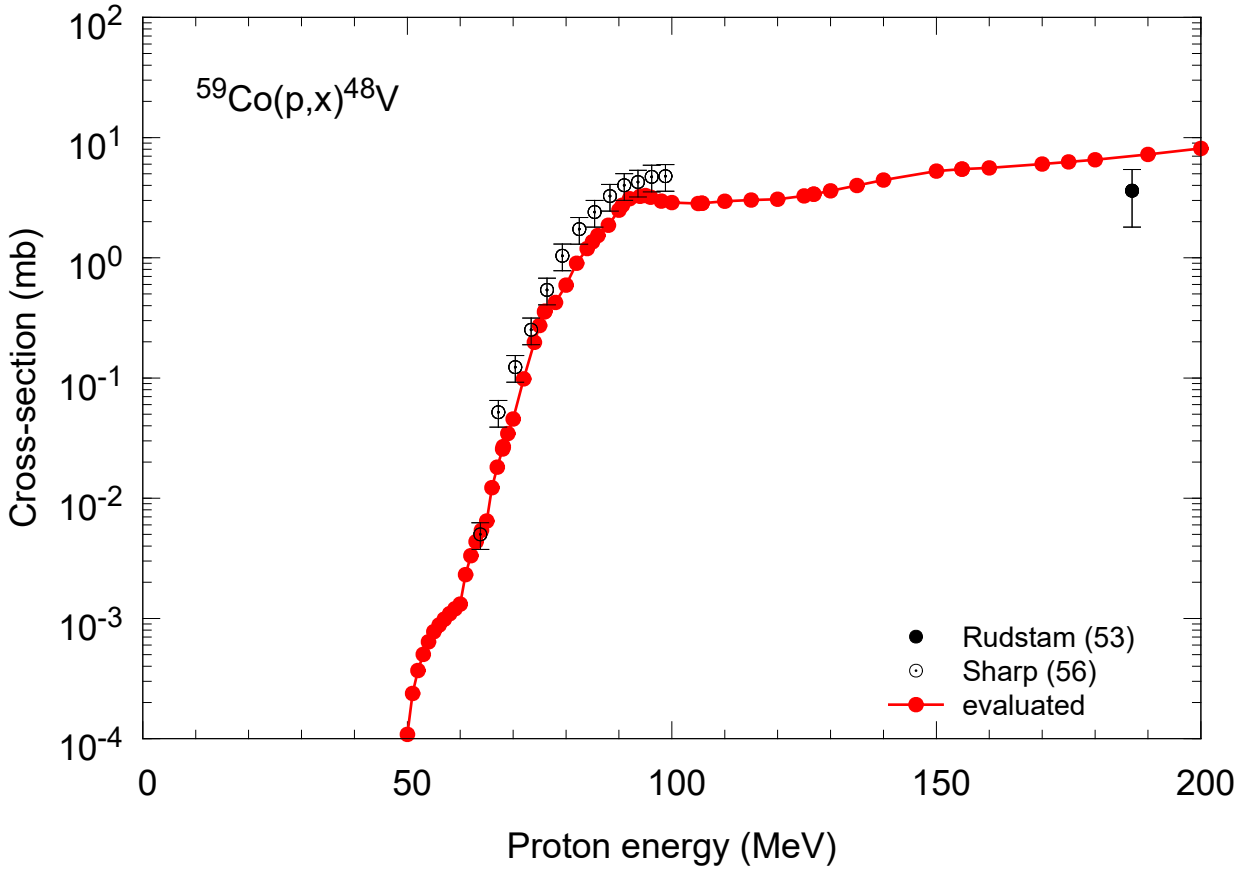

^{59}Co(p,x)^{46}Sc
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Michel (85)
Michel (97)
Titarenko (02)
evaluated 3

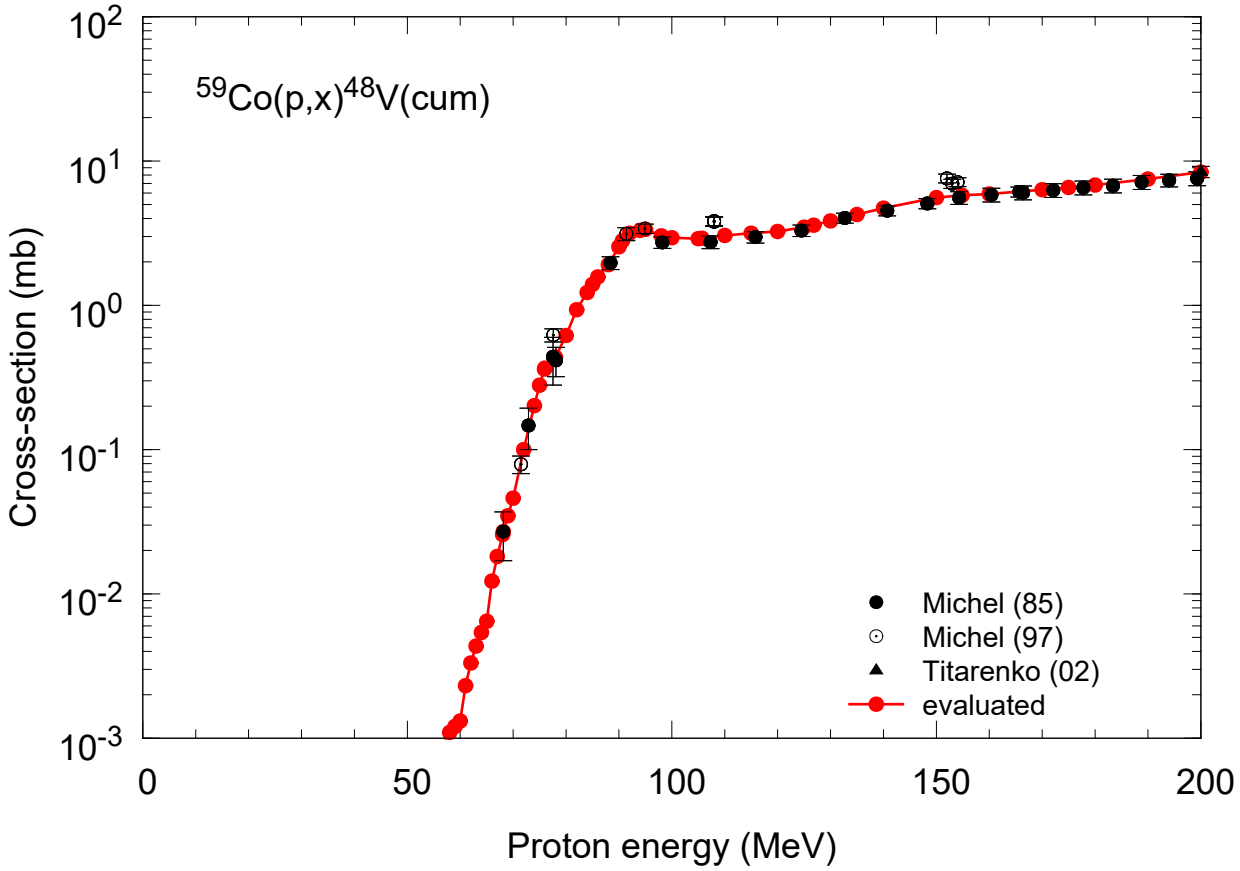

^{59}Co(p,x)^{47}Sc
Cross-section (mb)
10^{1}
10^{0}
10^{-1}
10^{-2}
0
50
100
150
200
Proton energy (MeV)
Titarenko (02)
evaluated

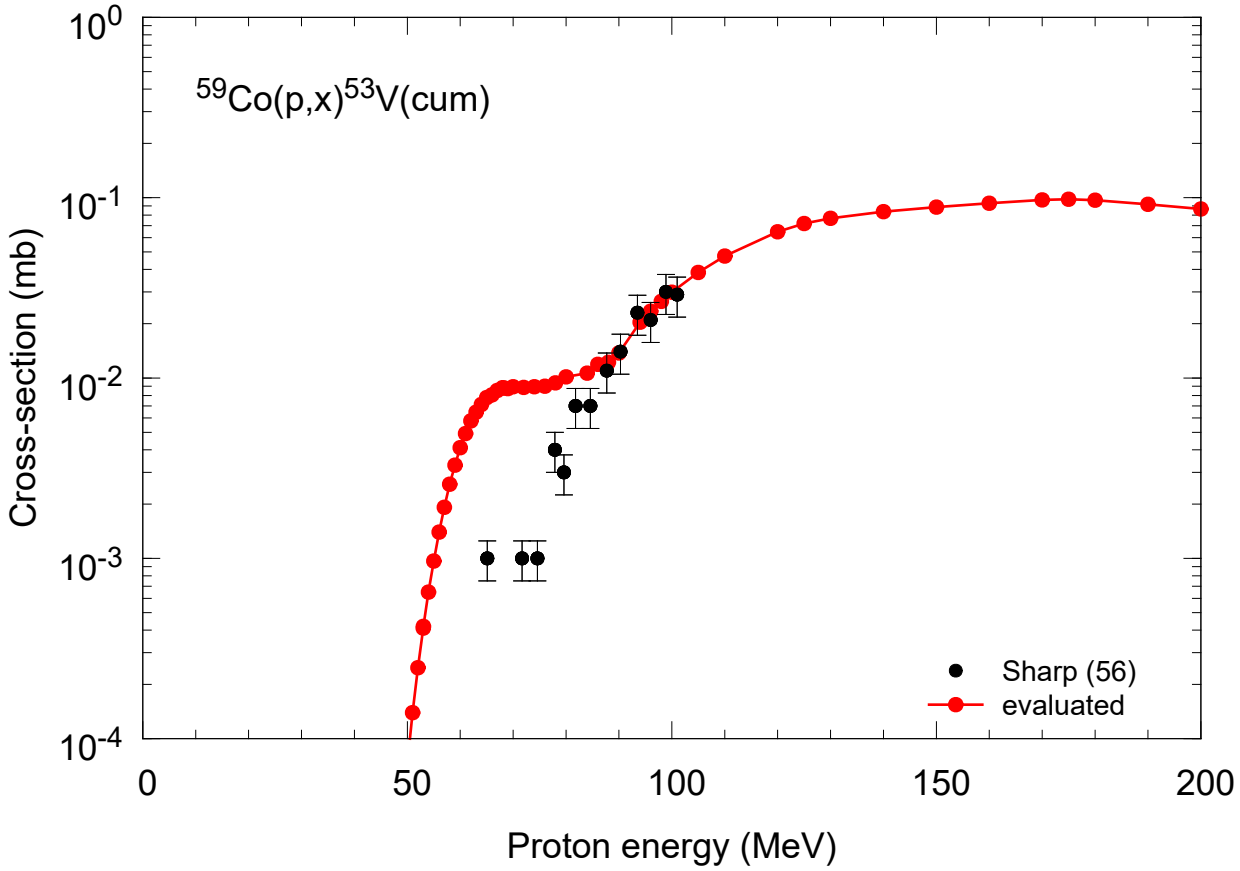

^{59}Co(p,x)^{47}Sc(cum)
Cross-section (mb)
10^{1}
10^{0}
10^{-1}
10^{-2}
0
50
100
150
200
Proton energy (MeV)
Michel (85)
Michel (97)
Titarenko (02)
evaluated

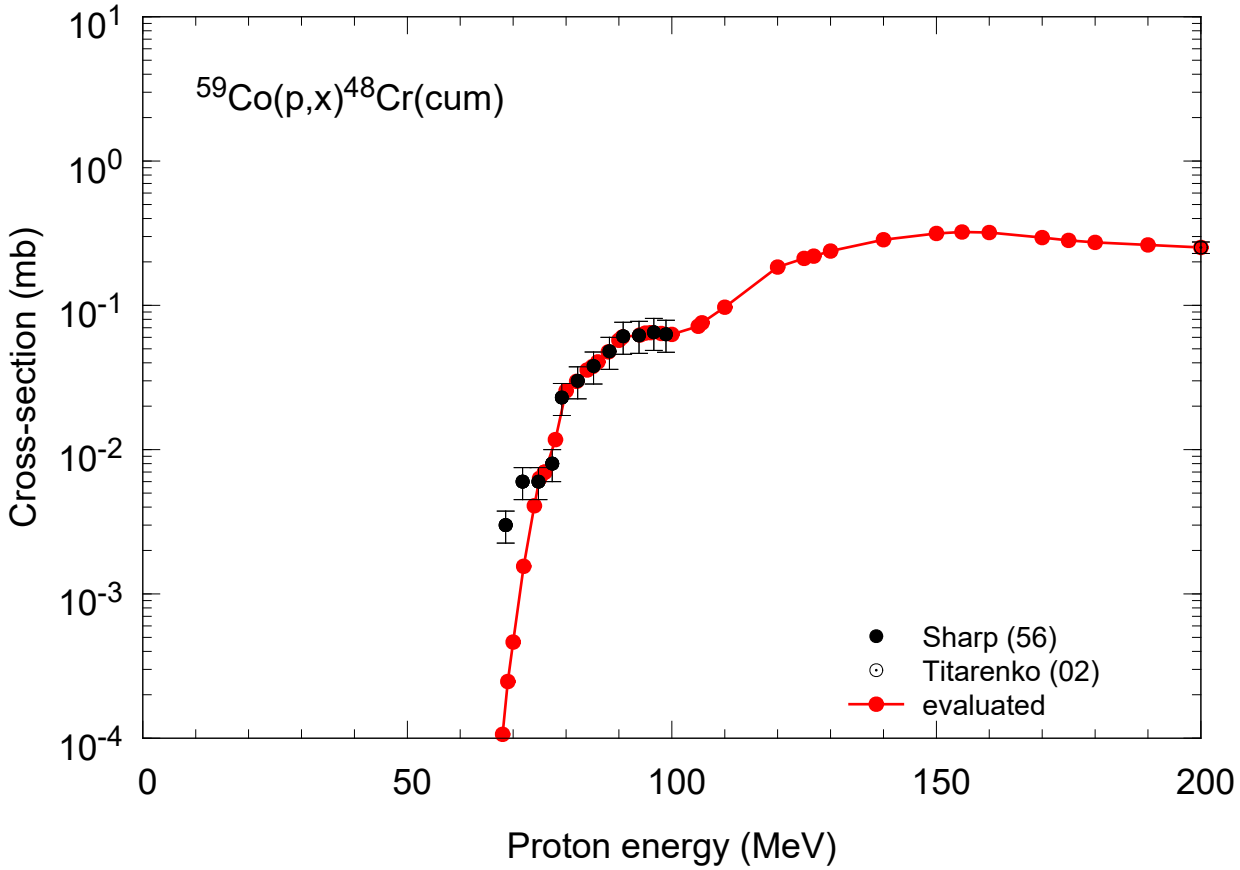

59Co(p,x)48Sc
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Titarenko (02)
evaluated

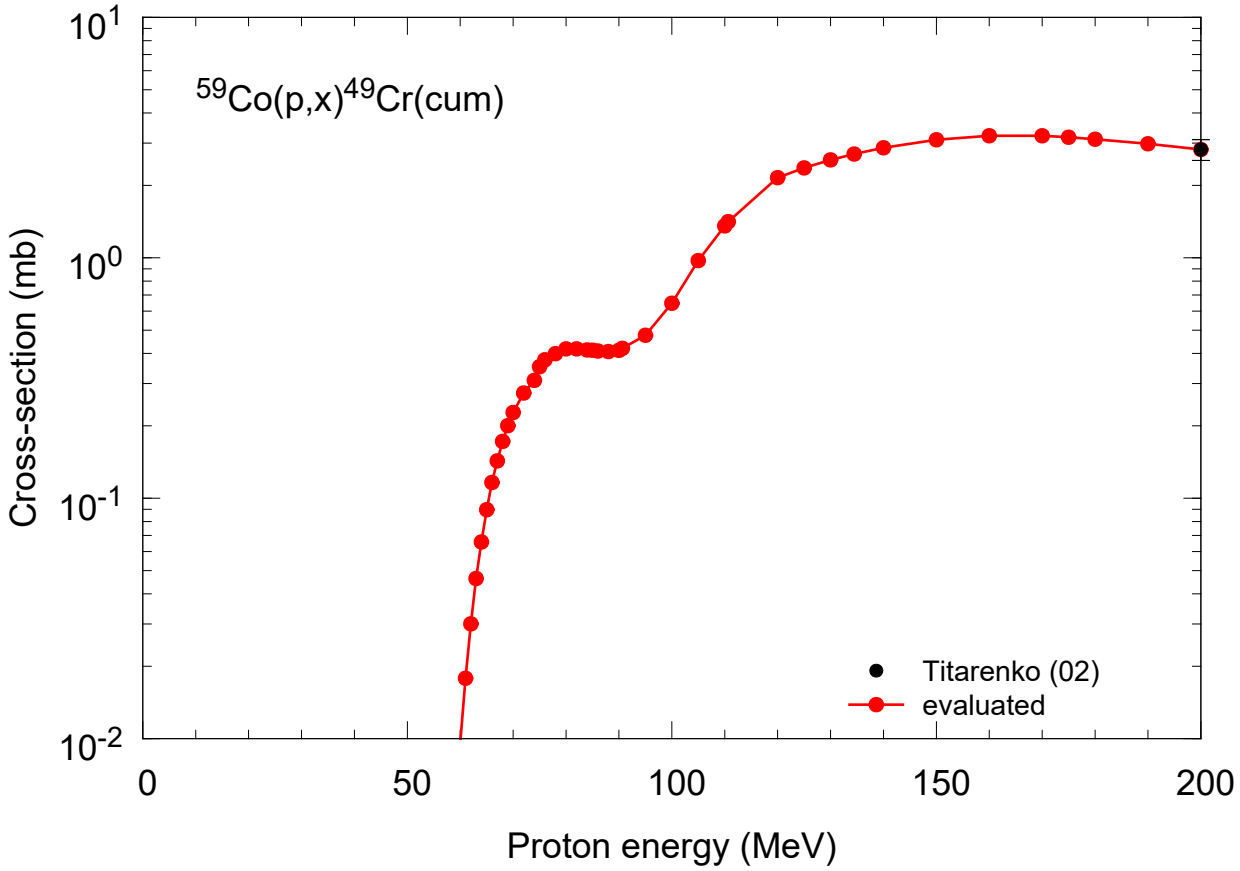

59Co(p,x)43Ti
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
evaluated

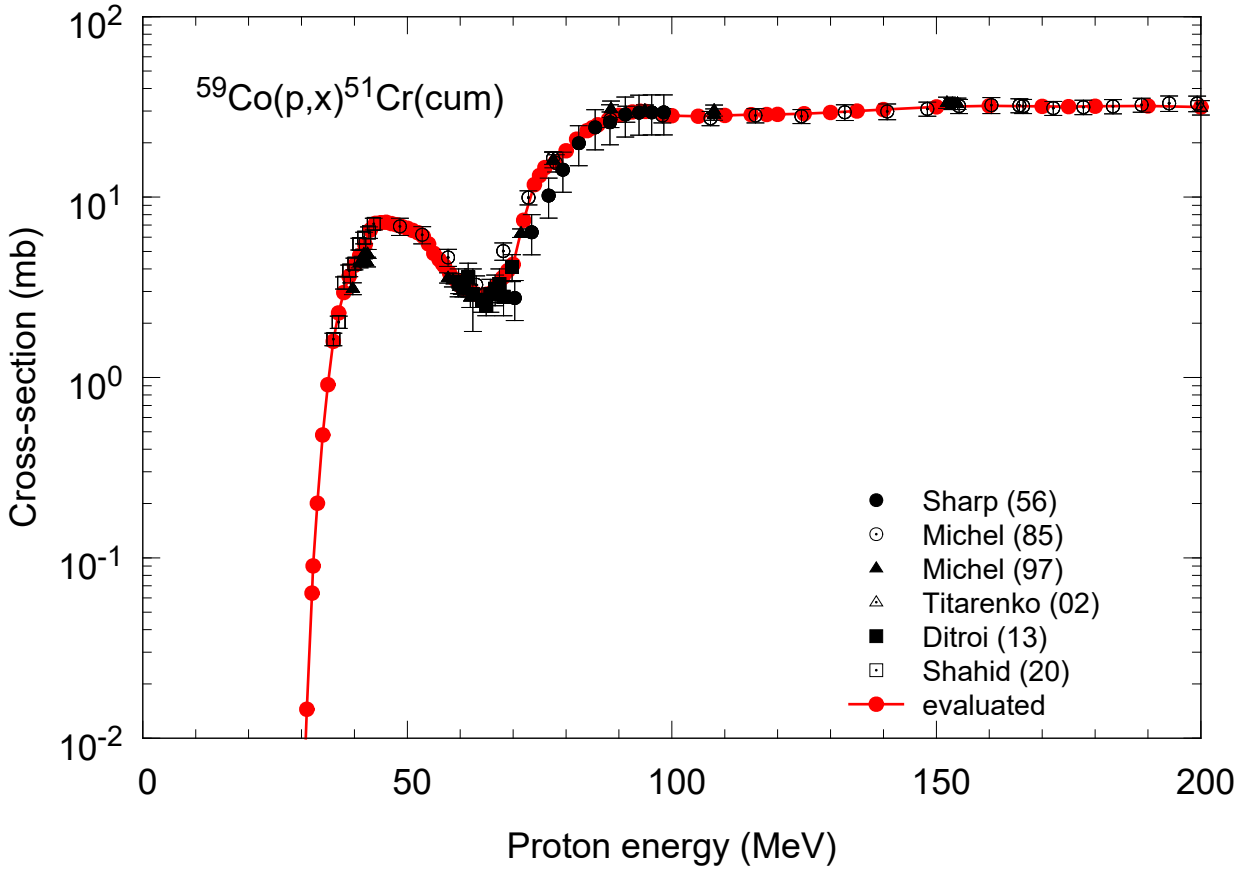

^{59}Co(p,x)^{48}V
Cross-section (mb)
Proton energy (MeV)
Rudstam (53)
Sharp (56)
evaluated

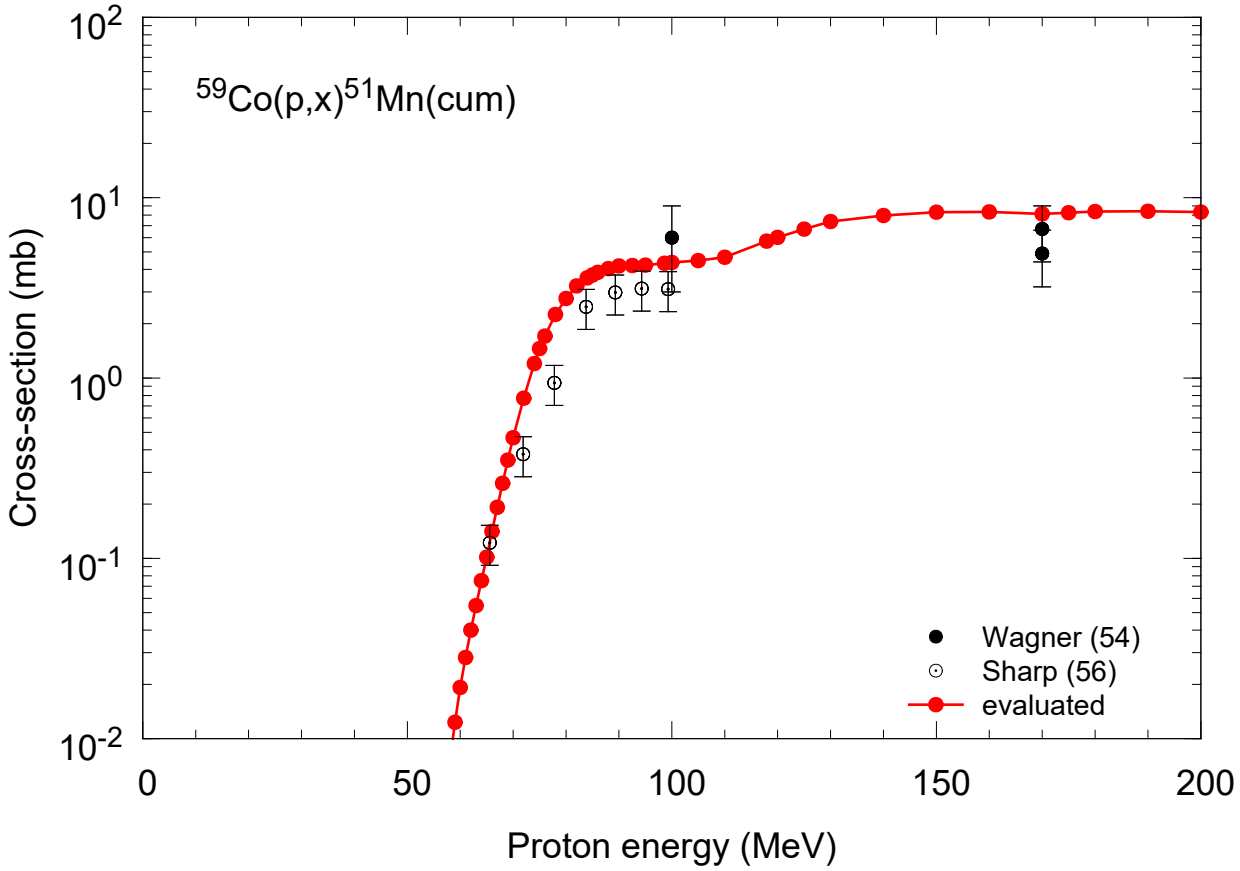

^{59}Co(p,x)^{48}V(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (85)
Michel (97)
Titarenko (02)
evaluated

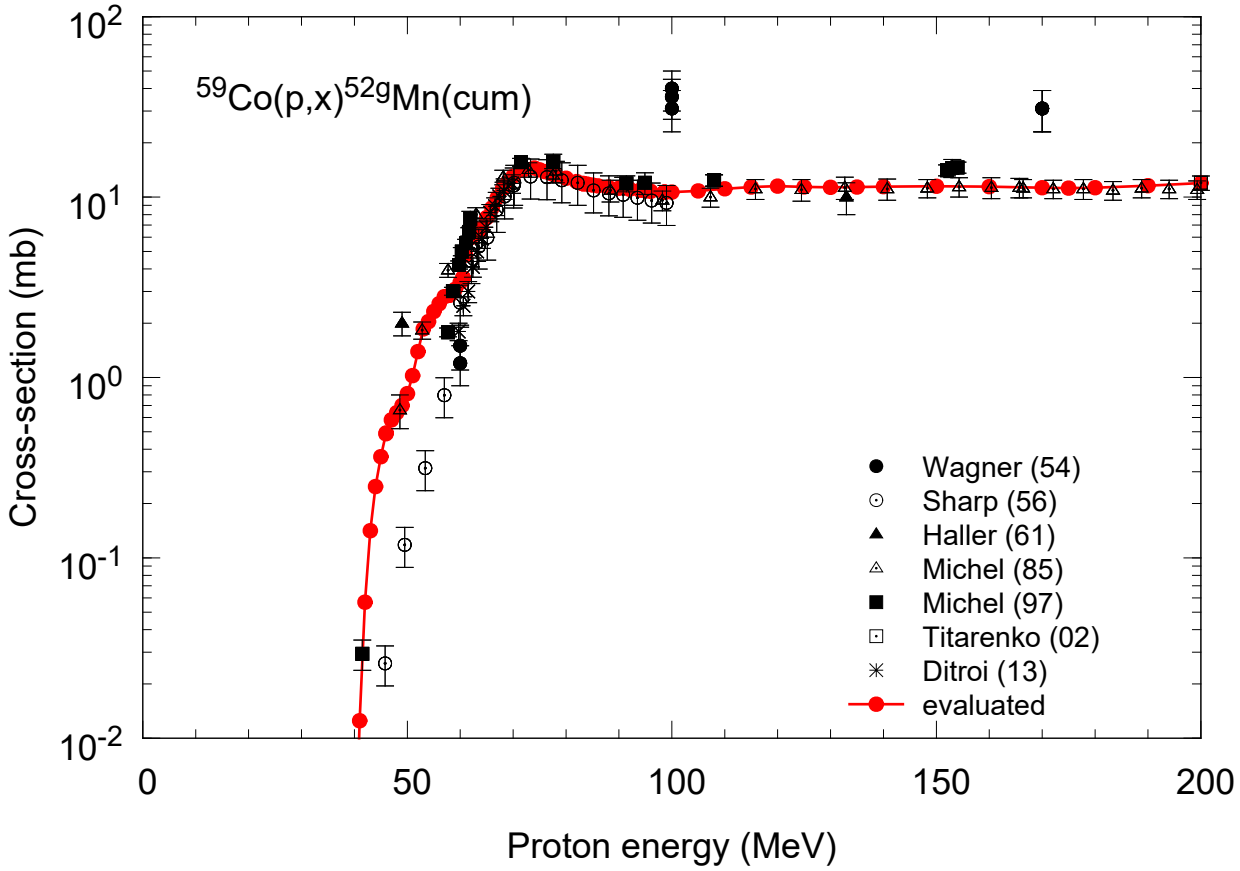

^{59}Co(p,x)^{53}V(cum)
Cross-section (mb)
Proton energy (MeV)
Sharp (56)
evaluated

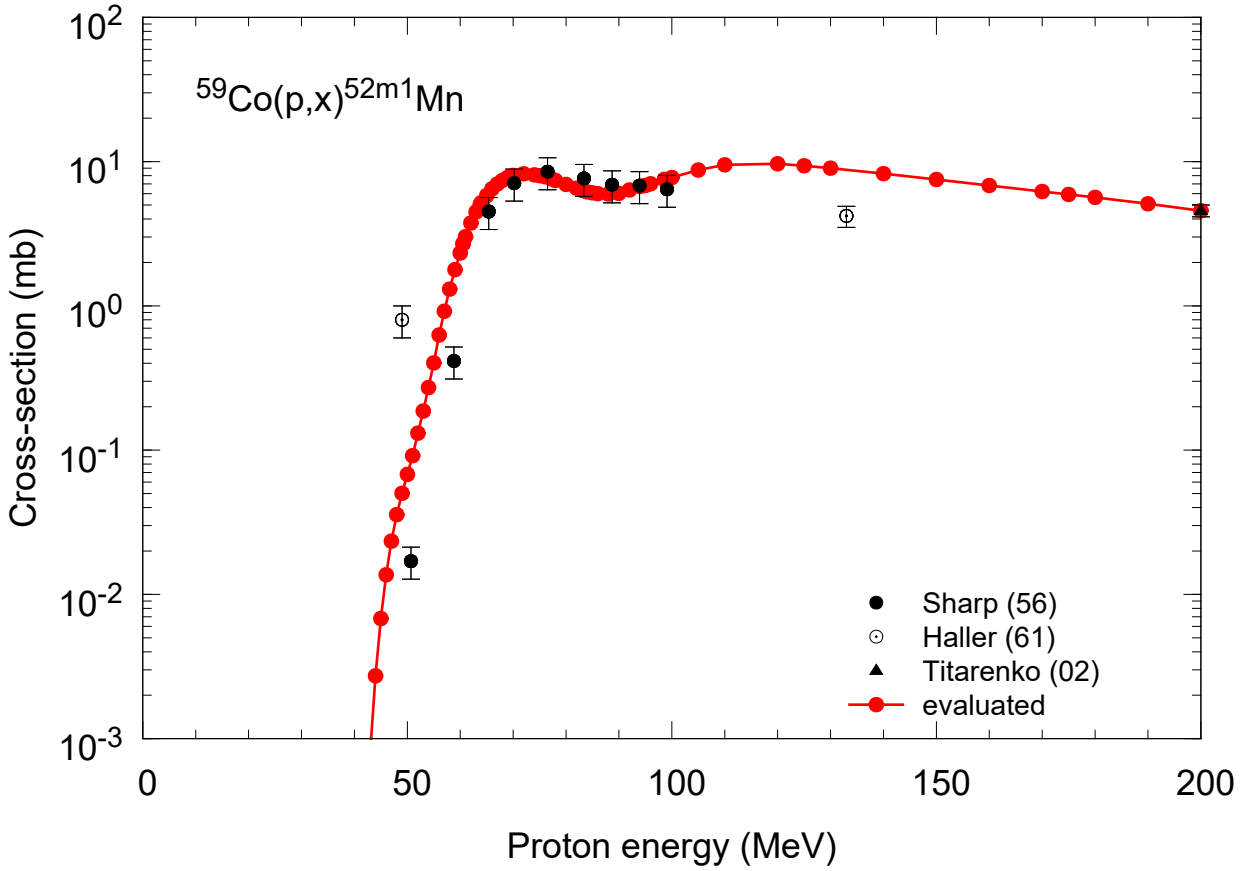

^{59}Co(p,x)^{48}Cr(cum)
Cross-section (mb)
Proton energy (MeV)
Sharp (56)
Titarenko (02)
evaluated

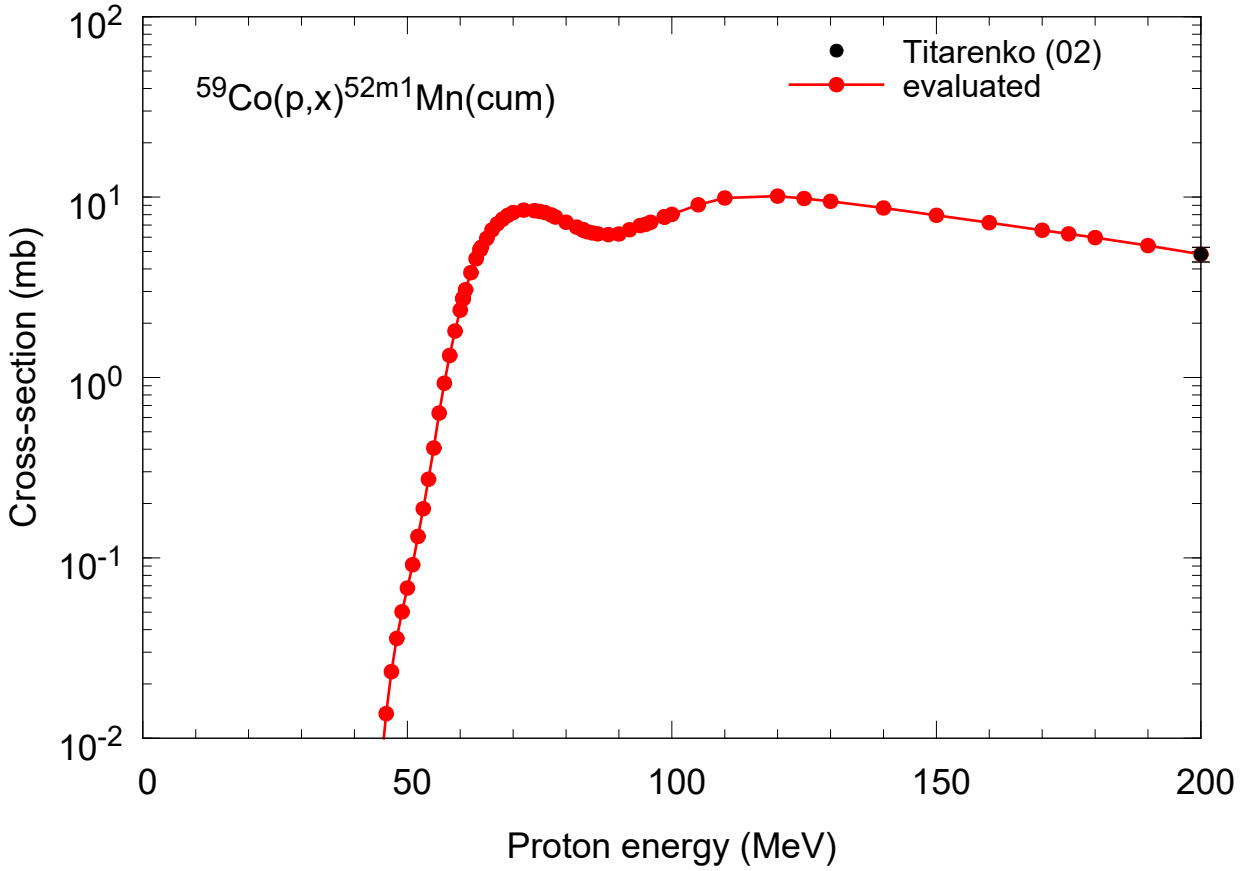

^{59}Co(p,x)^{49}Cr(cum)
Cross-section (mb)
Proton energy (MeV)
Titarenko (02)
evaluated

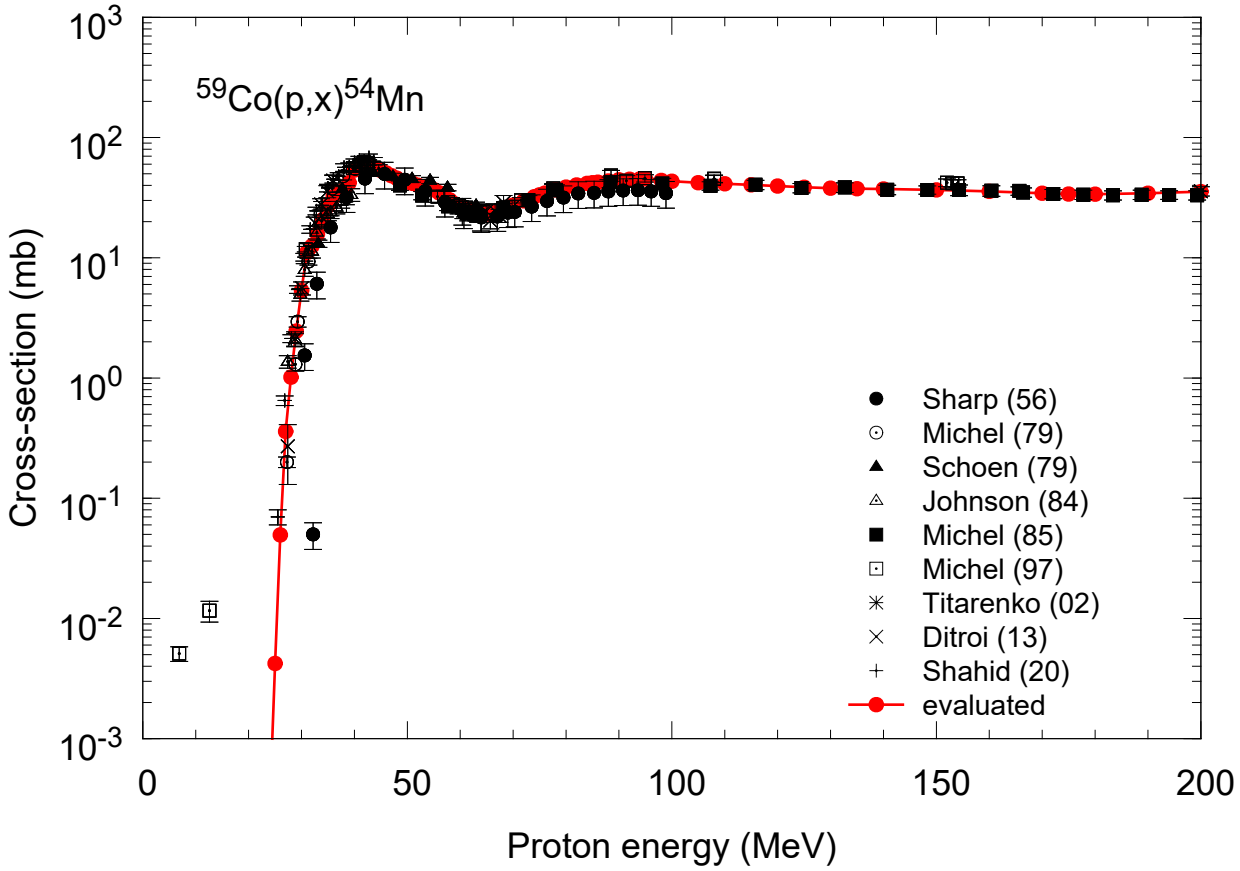

^{59}Co(p,x)^{51}Cr(cum)
Cross-section (mb)
Proton energy (MeV)
Sharp (56)
Michel (85)
Michel (97)
Titarenko (02)
Ditroi (13)
Shahid (20)
evaluated

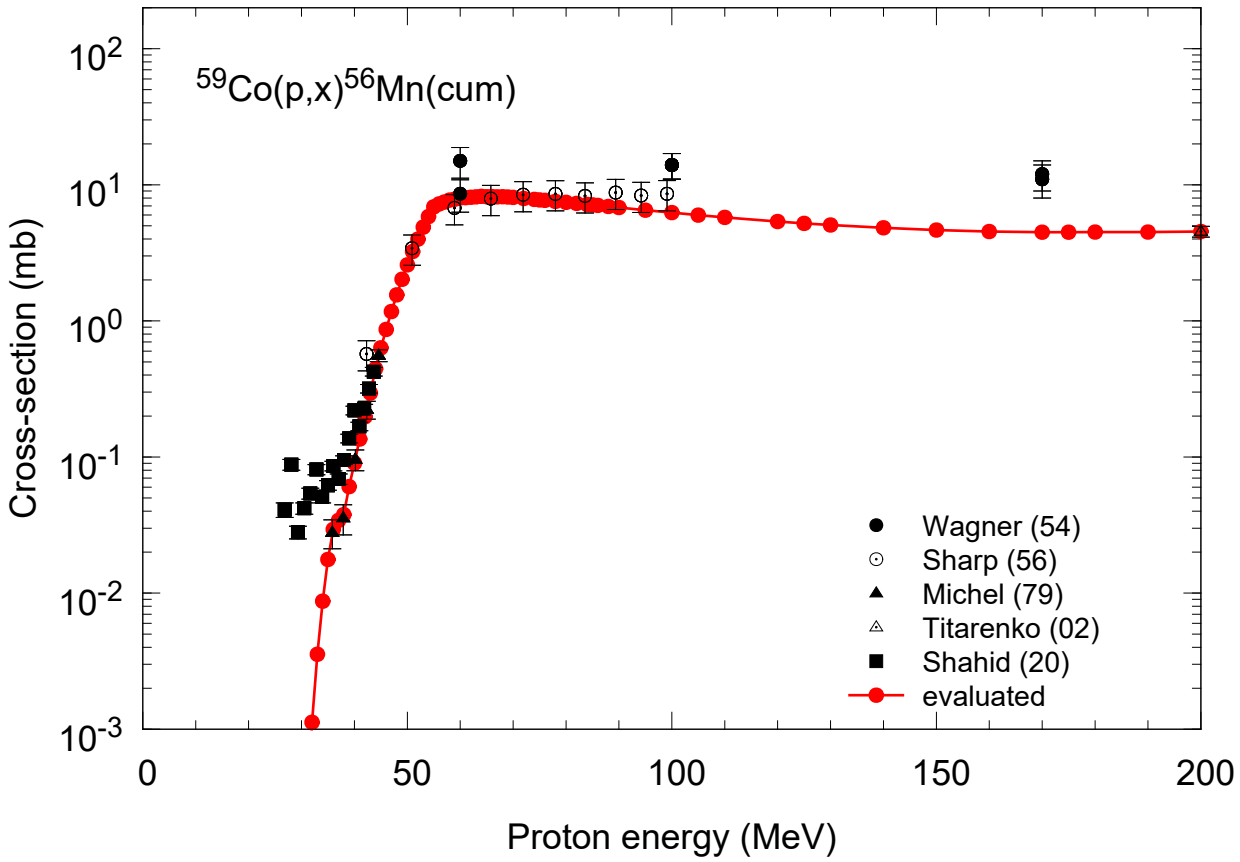

^{59}Co(p,x)^{51}Mn(cum)
Cross-section (mb)
Proton energy (MeV)
Wagner (54)
Sharp (56)
evaluated

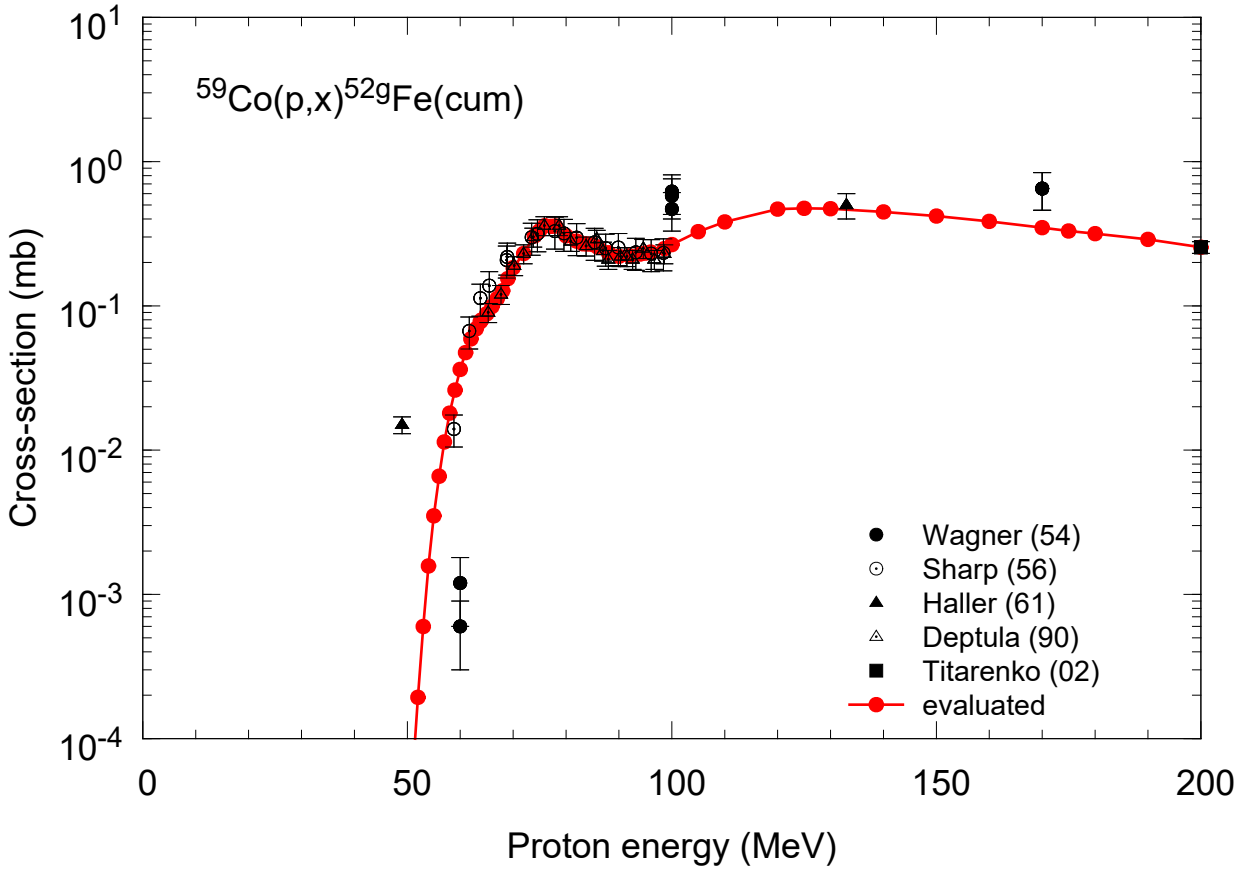

^{59}Co(p,x)^{52g}Mn(cum)
Cross-section (mb)
Proton energy (MeV)
Wagner (54)
Sharp (56)
Haller (61)
Michel (85)
Michel (97)
Titarenko (02)
Ditroi (13)
evaluated

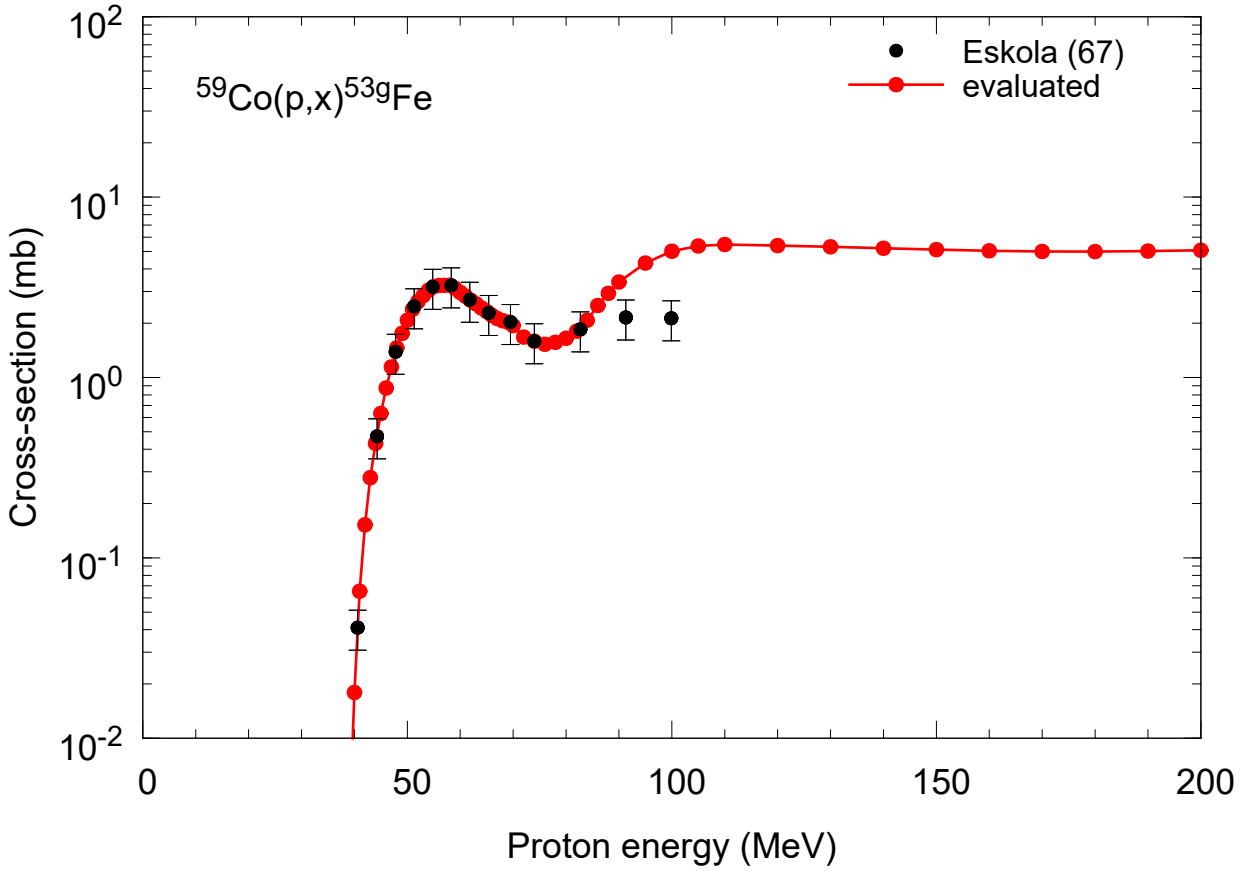

^{59}Co(p,x)^{52m1}Mn
Cross-section (mb)
Proton energy (MeV)
Sharp (56)
Haller (61)
Titarenko (02)
evaluated

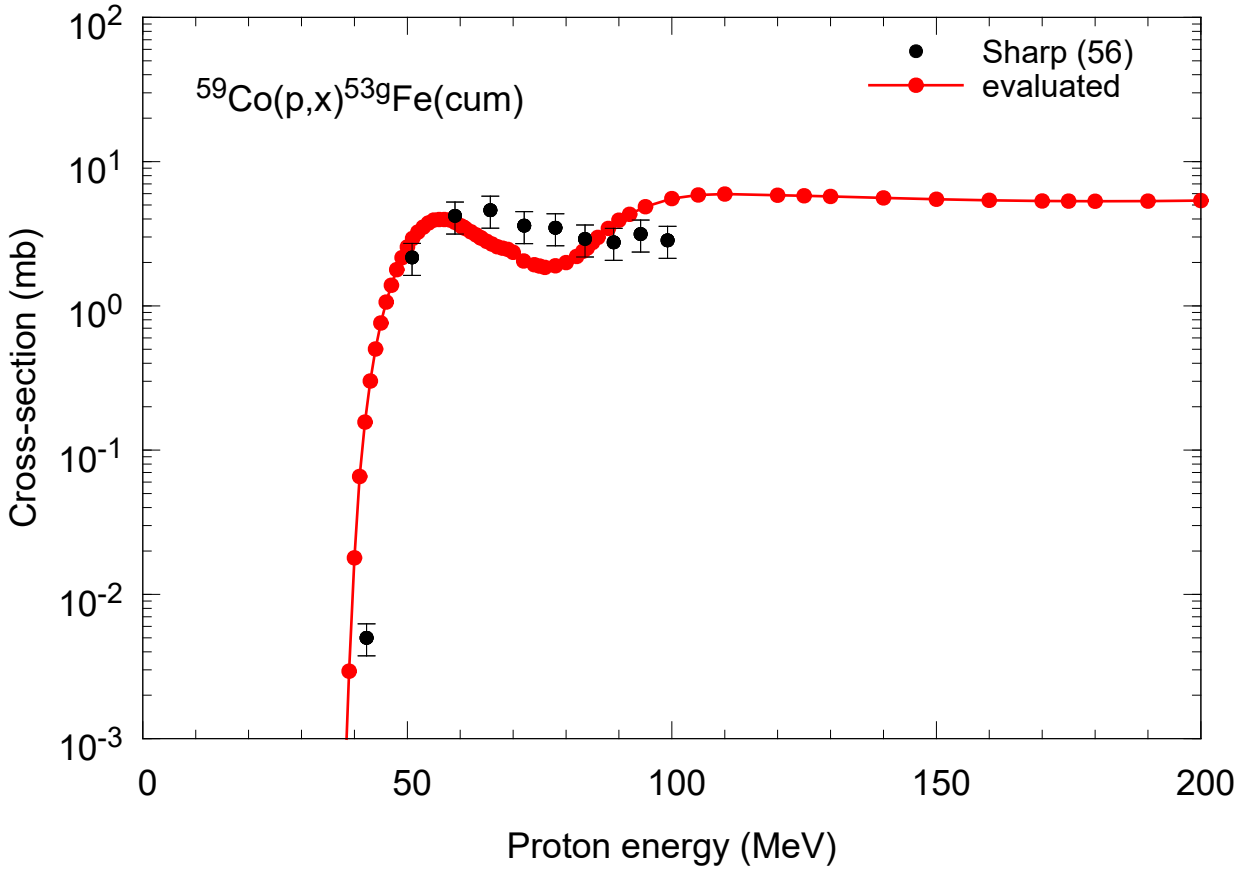

^{59}Co(p,x)^{52m1}Mn(cum)
Cross-section (mb)
Proton energy (MeV)
Titarenko (02)
evaluated

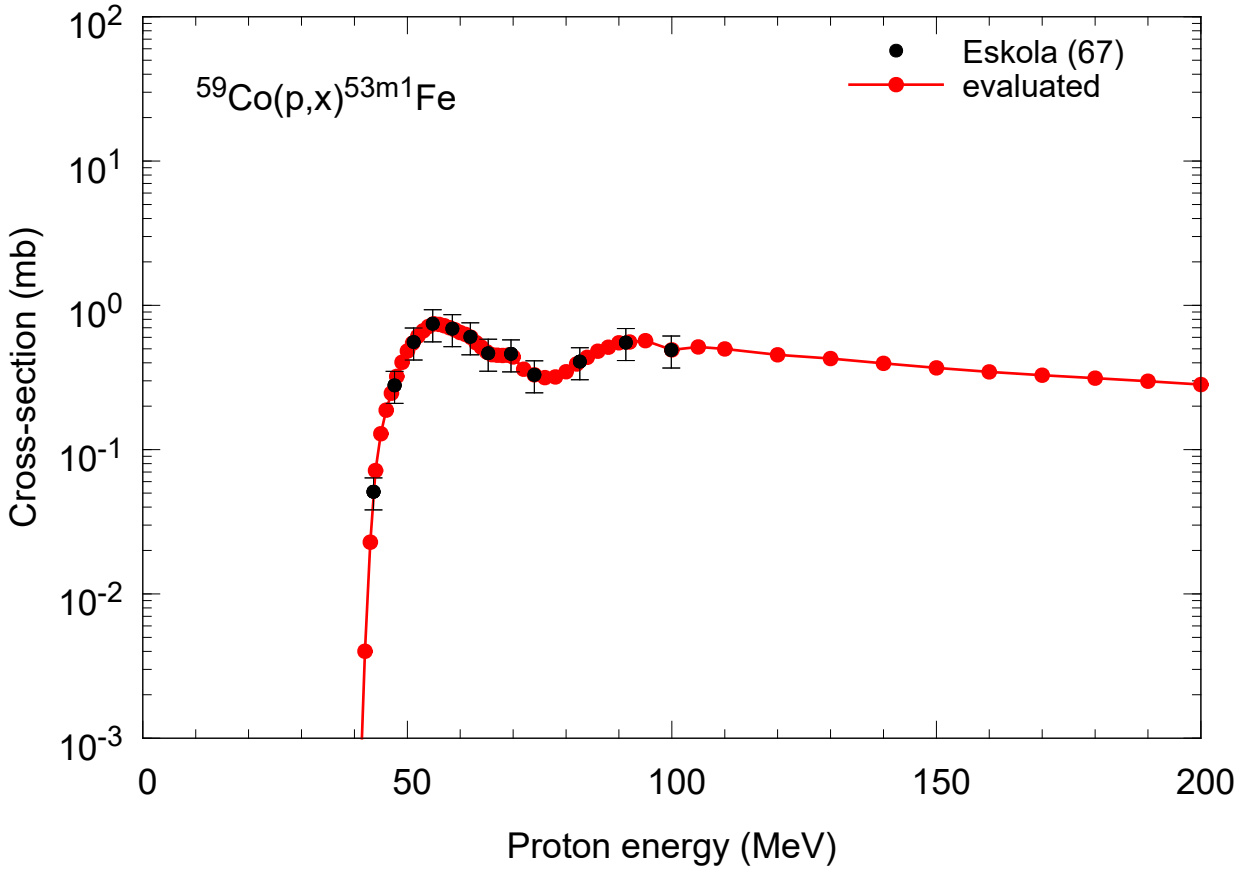

^{59}Co(p,x)^{54}Mn
Cross-section (mb)
Proton energy (MeV)
Sharp (56)
Michel (79)
Schoen (79)
Johnson (84)
Michel (85)
Michel (97)
Titarenko (02)
Ditroi (13)
Shahid (20)
evaluated

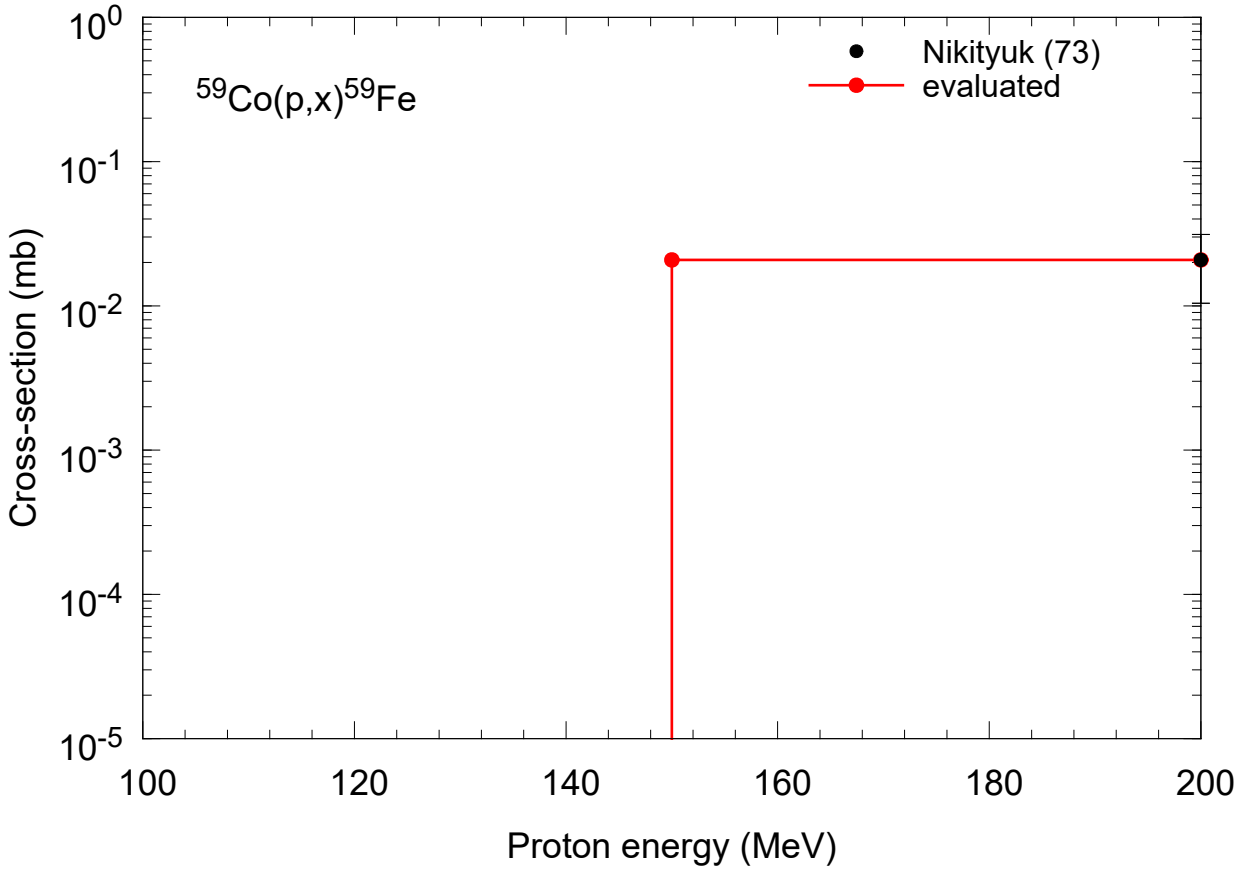

^{59}Co(p,x)^{56}Mn(cum)
Cross-section (mb)
Proton energy (MeV)
Wagner (54)
Sharp (56)
Michel (79)
Titarenko (02)
Shahid (20)
evaluated

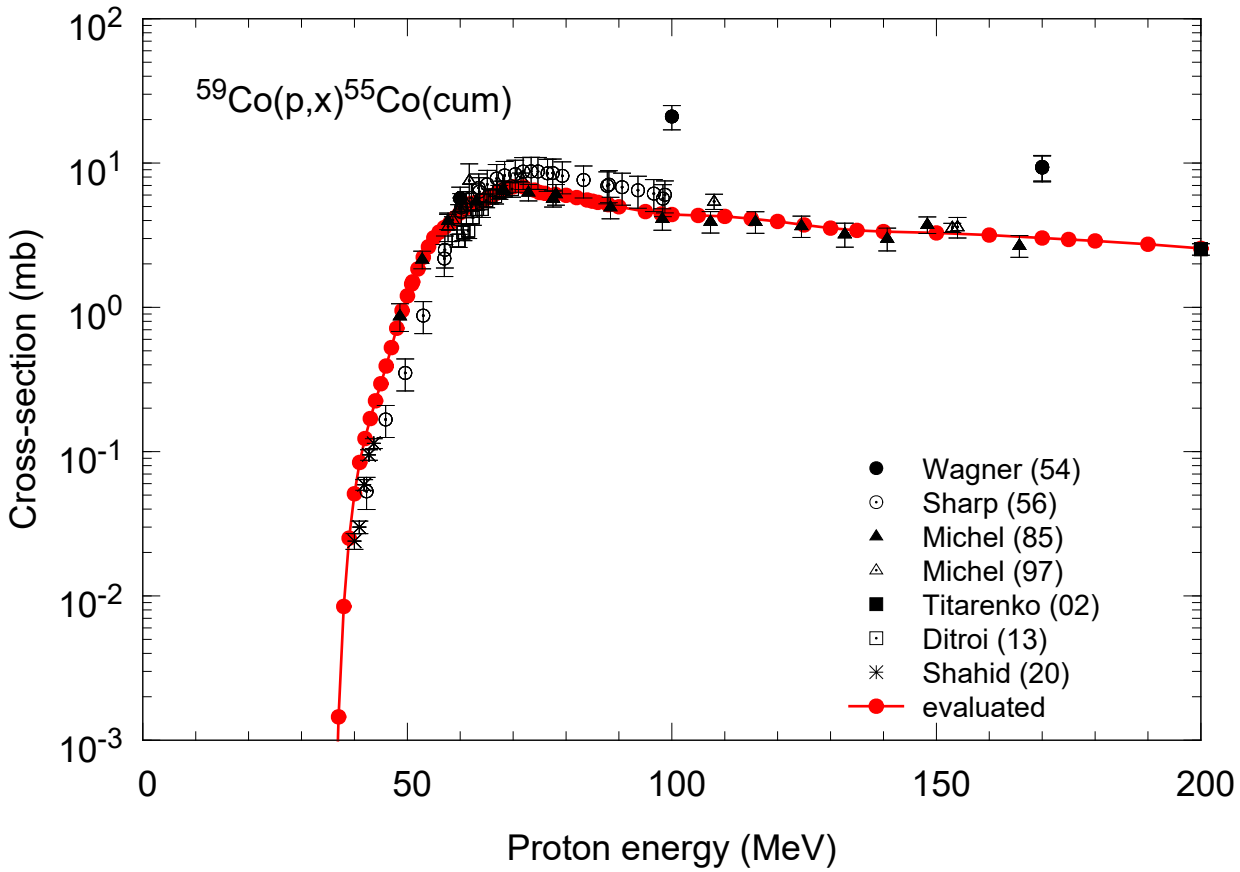

^{59}Co(p,x)^{52g}Fe(cum)
Cross-section (mb)
Proton energy (MeV)
Wagner (54)
Sharp (56)
Haller (61)
Deptula (90)
Titarenko (02)
evaluated

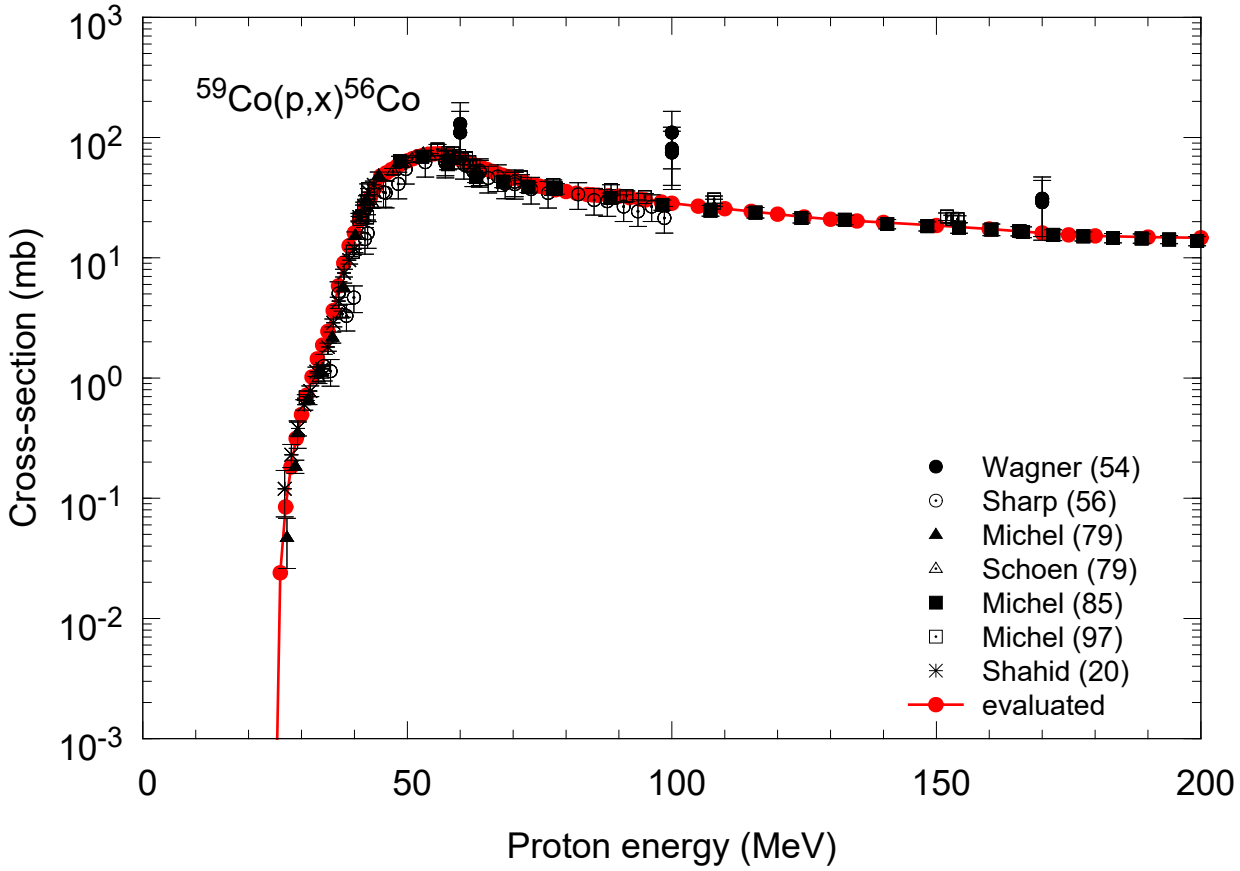

^{59}Co(p,x)^{53g}Fe
Cross-section (mb)
Proton energy (MeV)
Eskola (67)
evaluated

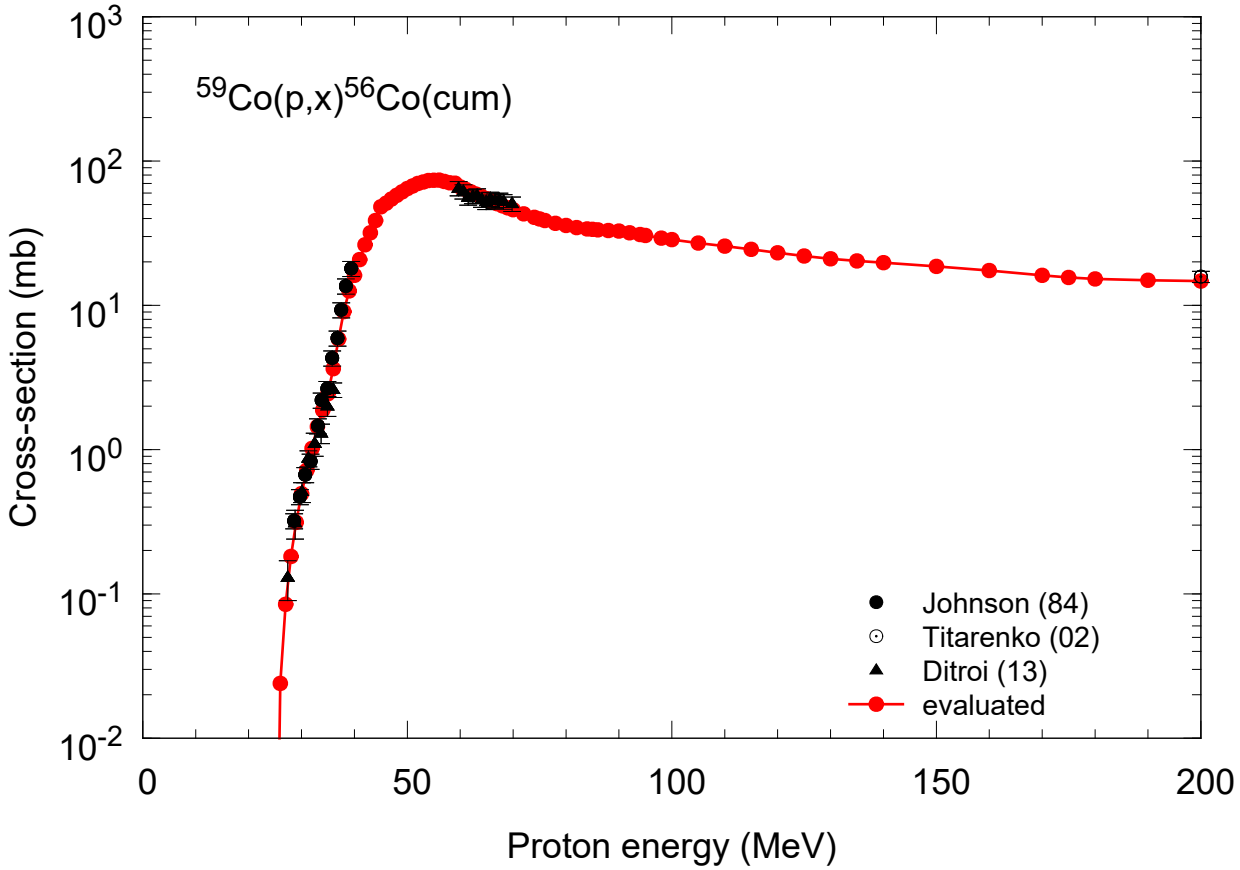

^{59}Co(p,x)^{53g}Fe(cum)
Sharp (56)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200

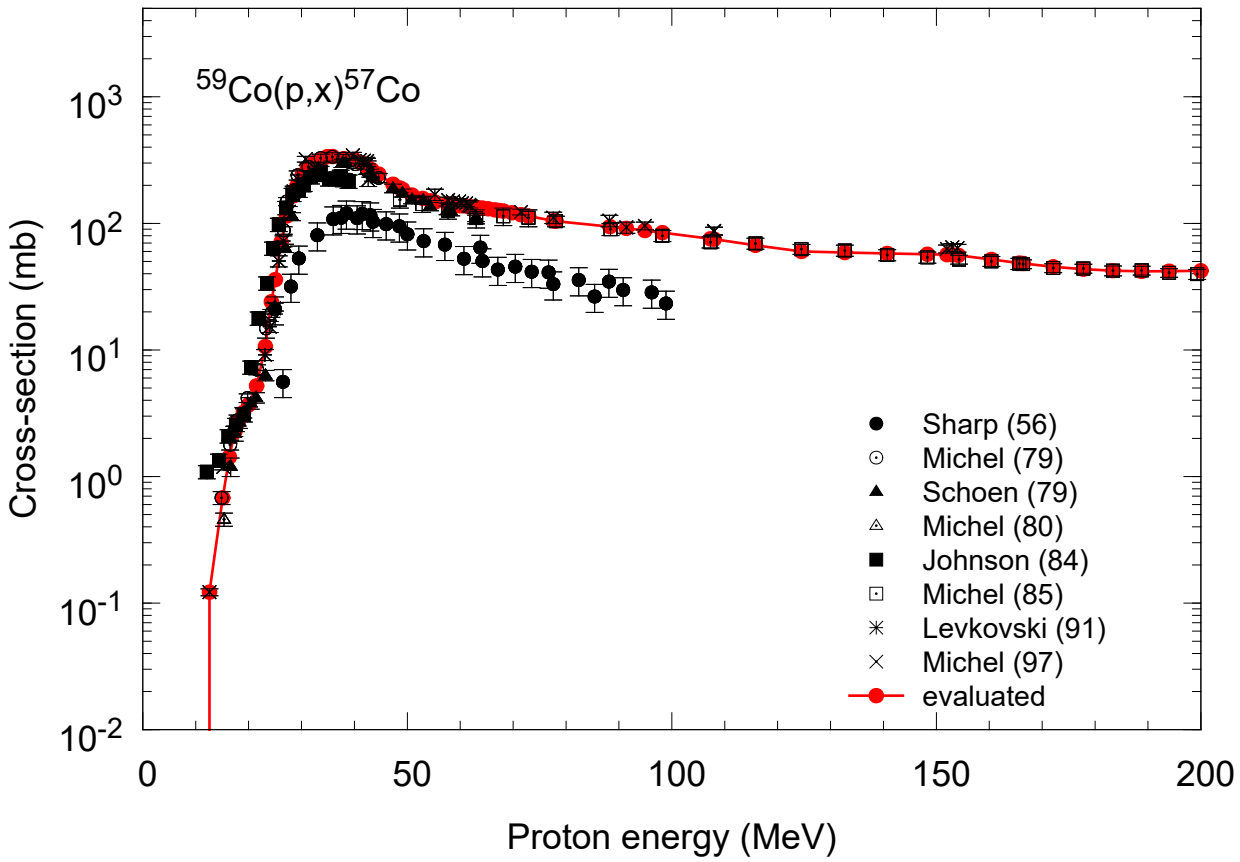

^{59}Co(p,x)^{53m1}Fe
Eskola (67)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200

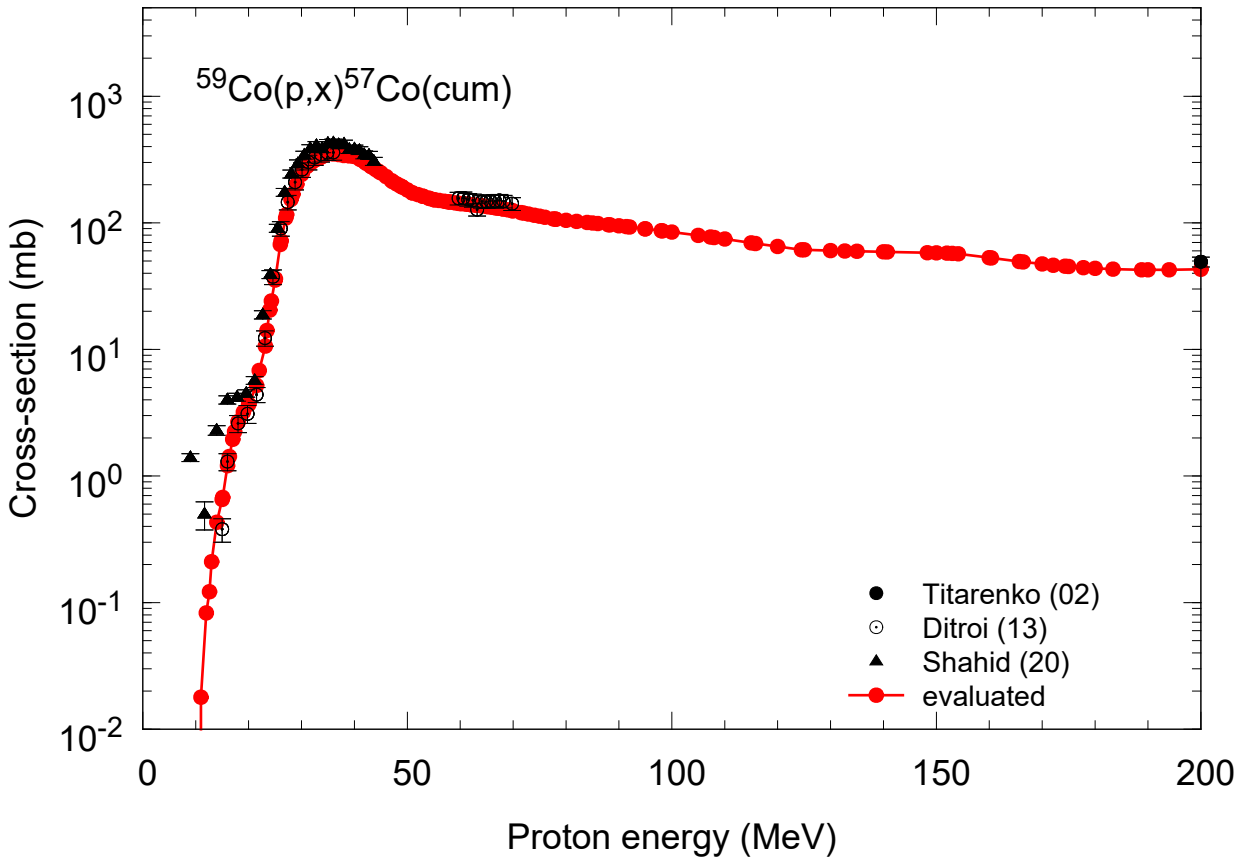

^{59}Co(p,x)^{59}Fe
Nikityuk (73)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
100
120
140
160
180
200

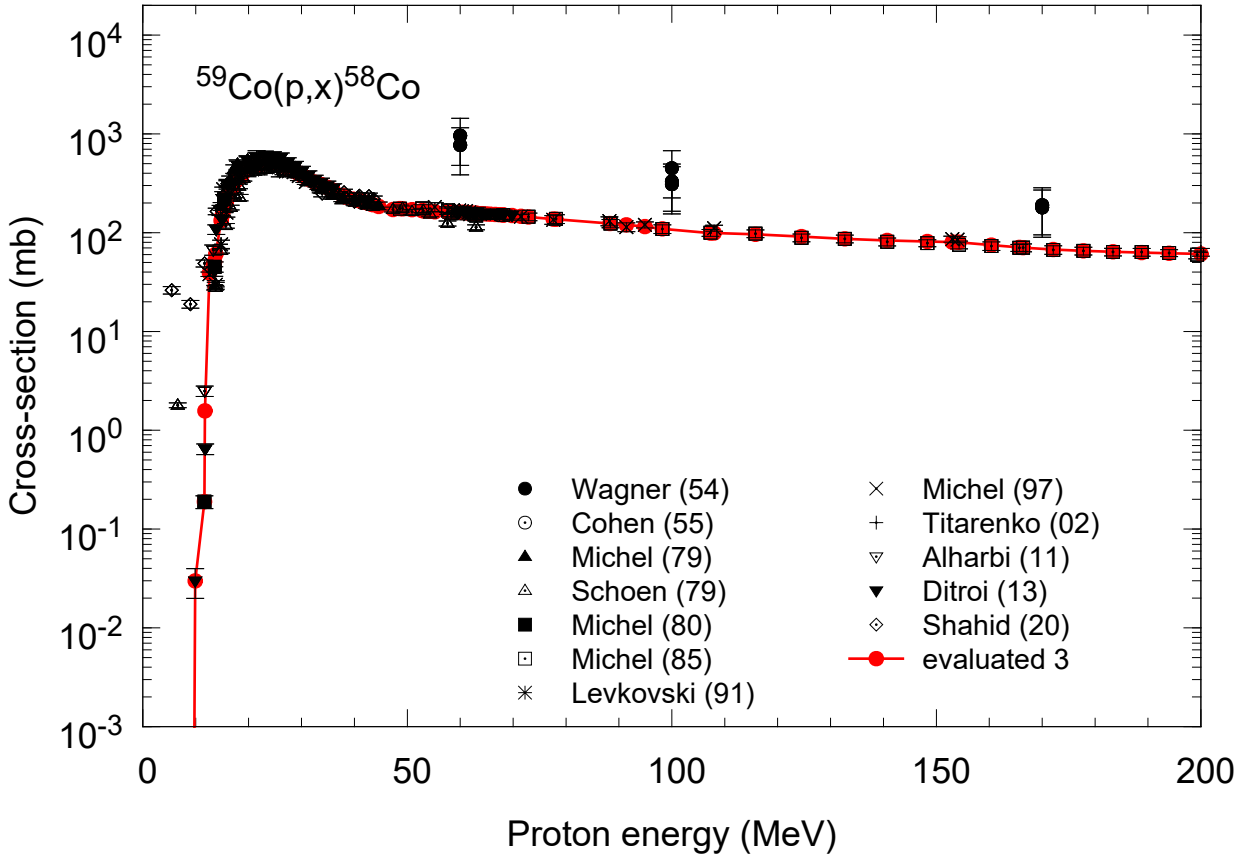

^{59}Co(p,x)^{55}Co(cum)
Wagner (54)
Sharp (56)
Michel (85)
Michel (97)
Titarenko (02)
Ditroi (13)
Shahid (20)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200

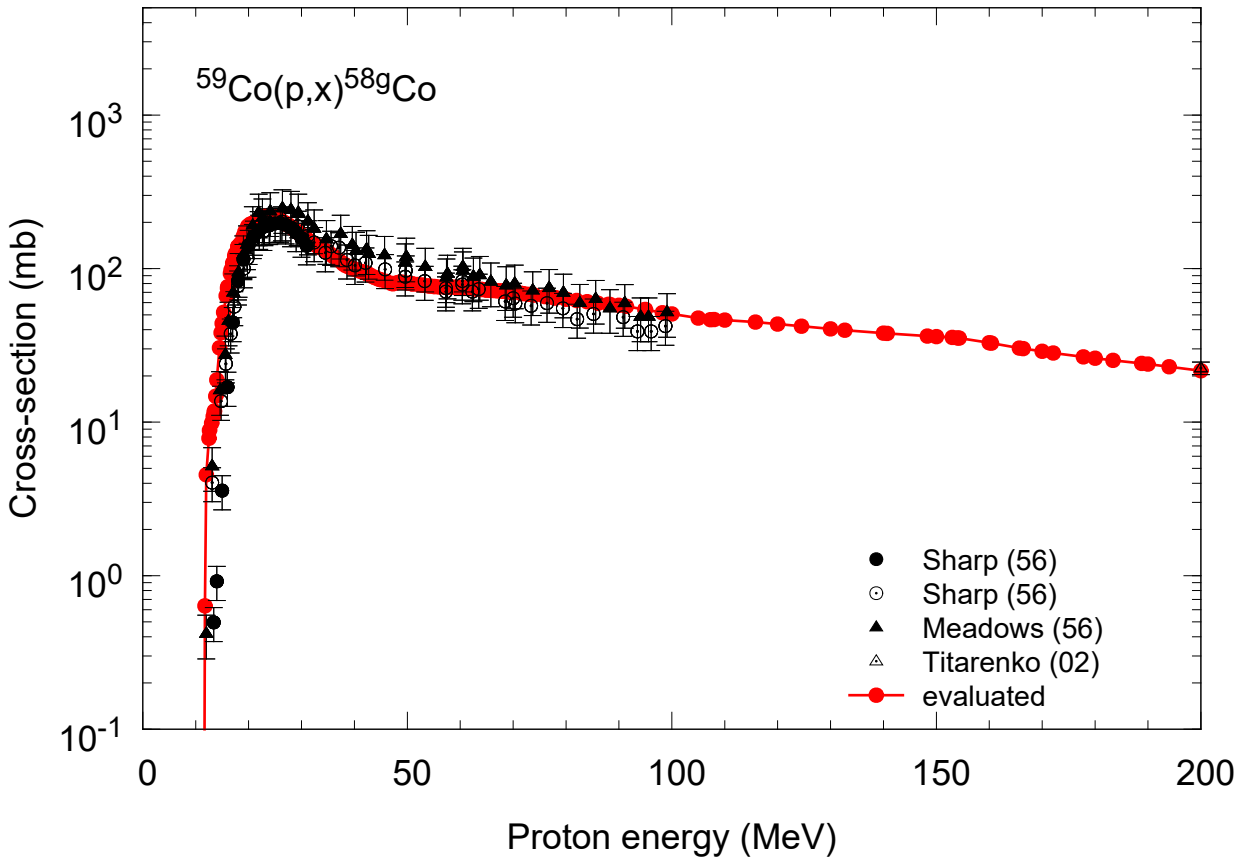

^{59}Co(p,x)^{56}Co
Cross-section (mb)
Proton energy (MeV)
Wagner (54)
Sharp (56)
Michel (79)
Schoen (79)
Michel (85)
Michel (97)
Shahid (20)
evaluated

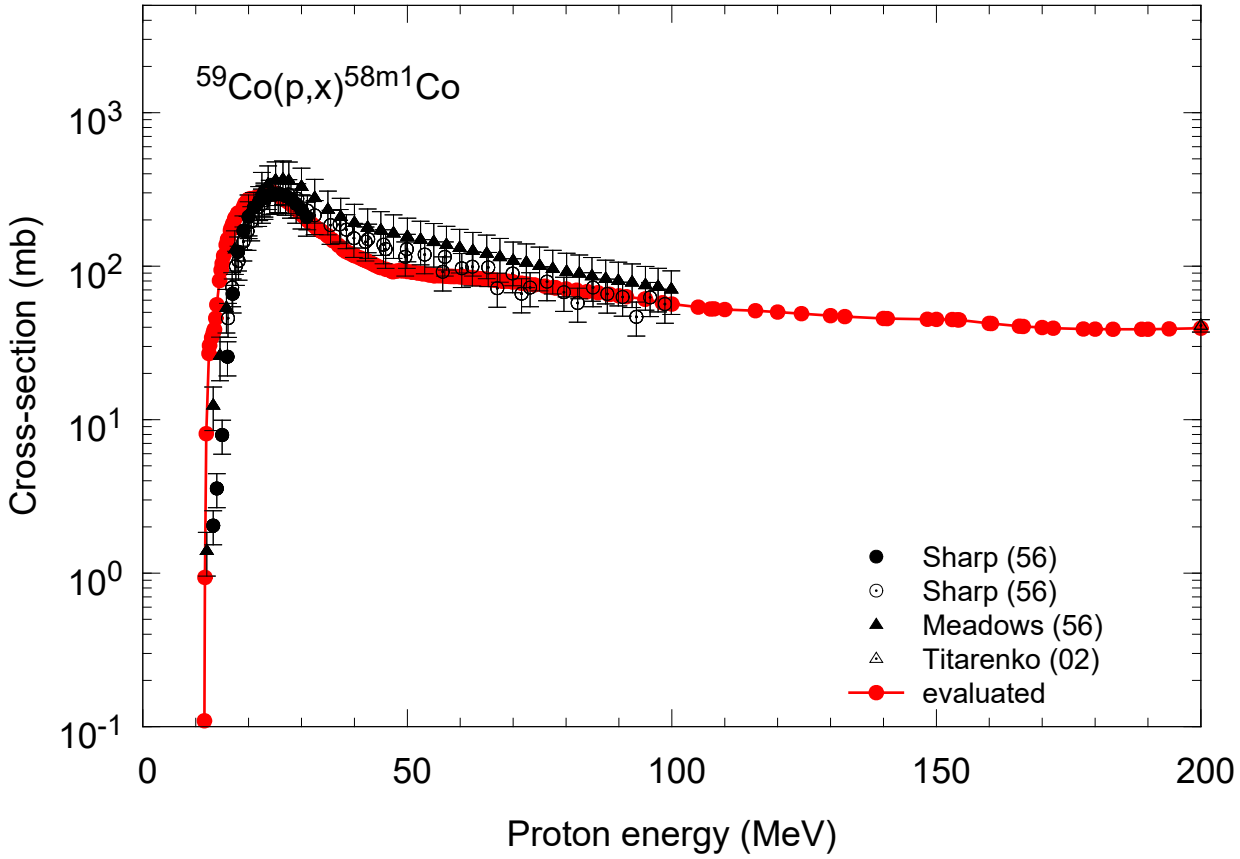

^{59}Co(p,x)^{56}Co(cum)
Cross-section (mb)
Proton energy (MeV)
Johnson (84)
Titarenko (02)
Ditroi (13)
evaluated

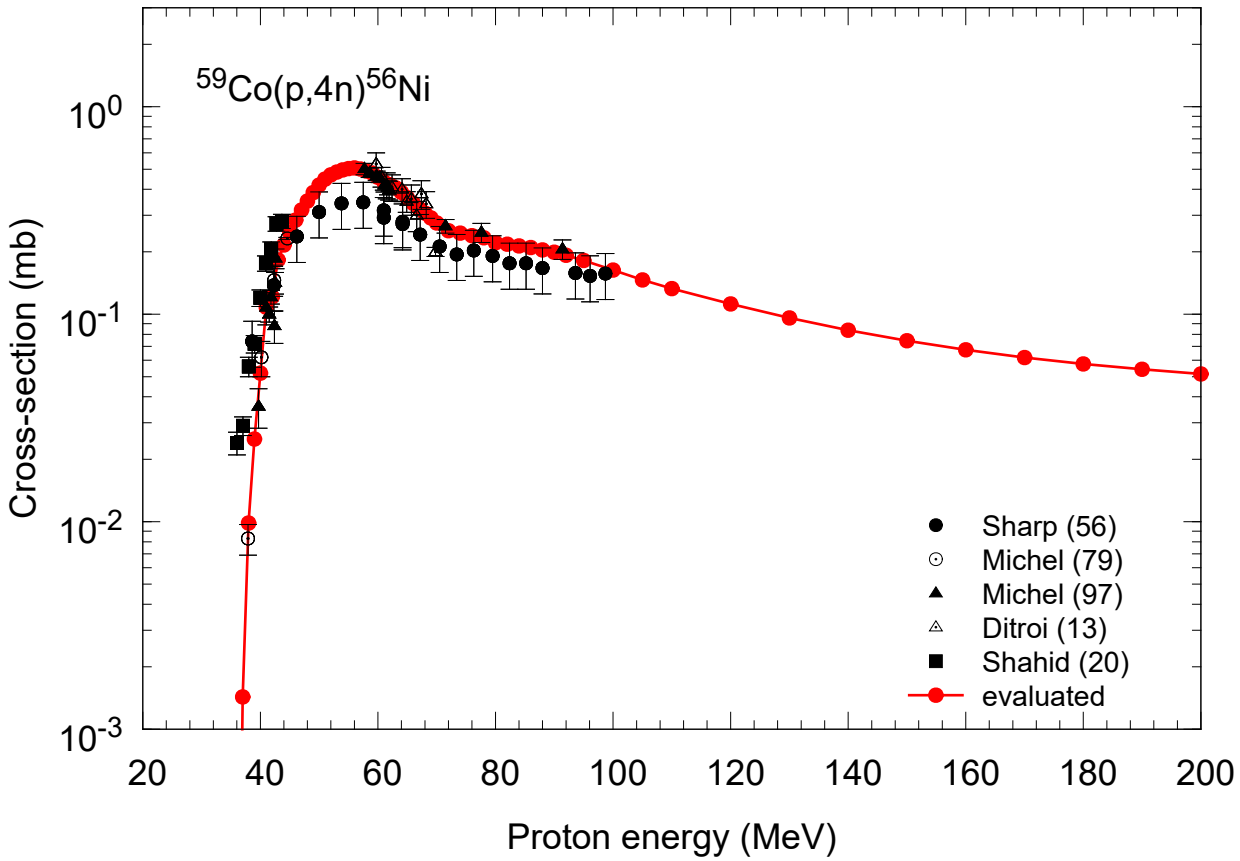

59Co(p,x)57Co
Cross-section (mb)
Proton energy (MeV)
Sharp (56)
Michel (79)
Schoen (79)
Michel (80)
Johnson (84)
Michel (85)
Levkovski (91)
Michel (97)
evaluated

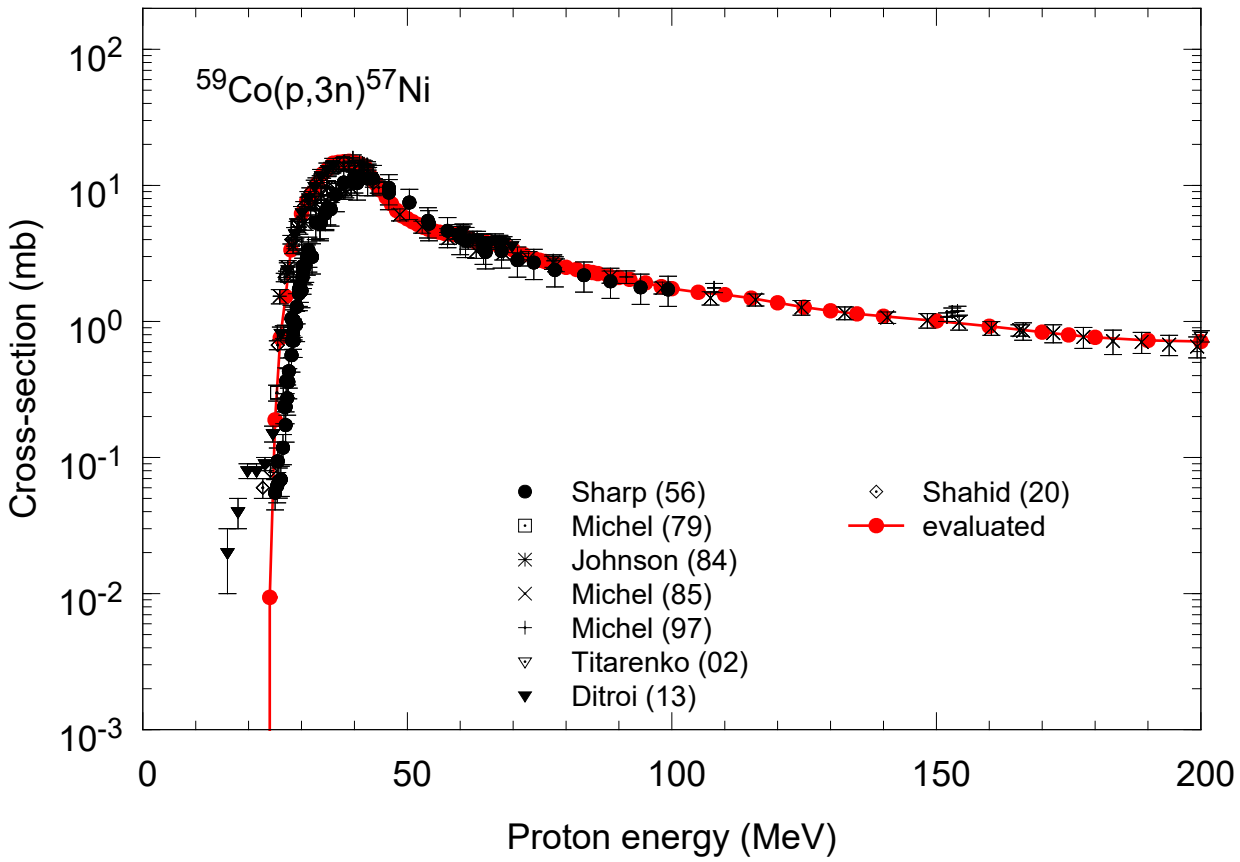

59Co(p,x)57Co(cum)
Cross-section (mb)
Proton energy (MeV)
Titarenko (02)
Ditroi (13)
Shahid (20)
evaluated

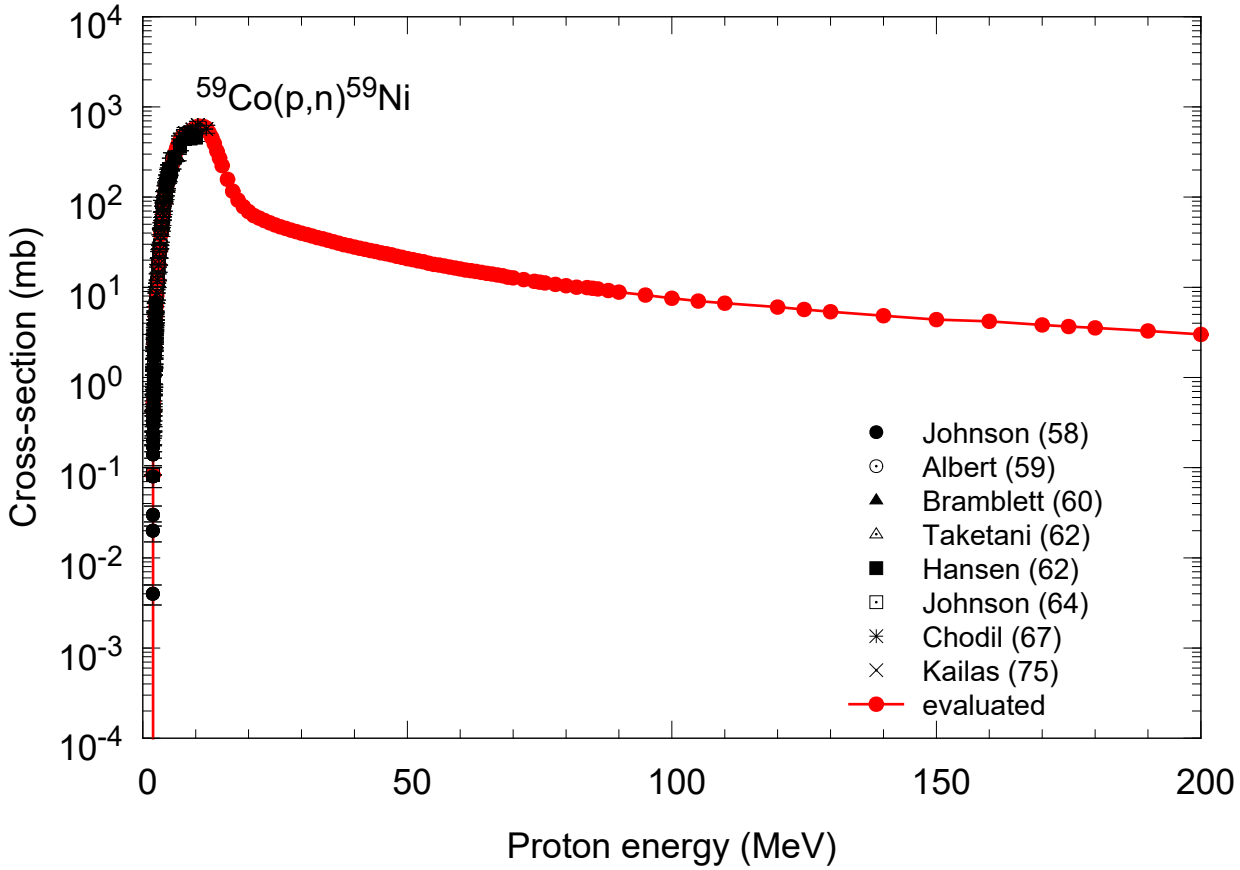

^{59}Co(p,x)^{58}Co
Cross-section (mb)
Proton energy (MeV)
Wagner (54)
Cohen (55)
Michel (79)
Schoen (79)
Michel (80)
Michel (85)
Levkovski (91)
Michel (97)
Titarenko (02)
Alharbi (11)
Ditroi (13)
Shahid (20)
evaluated 3

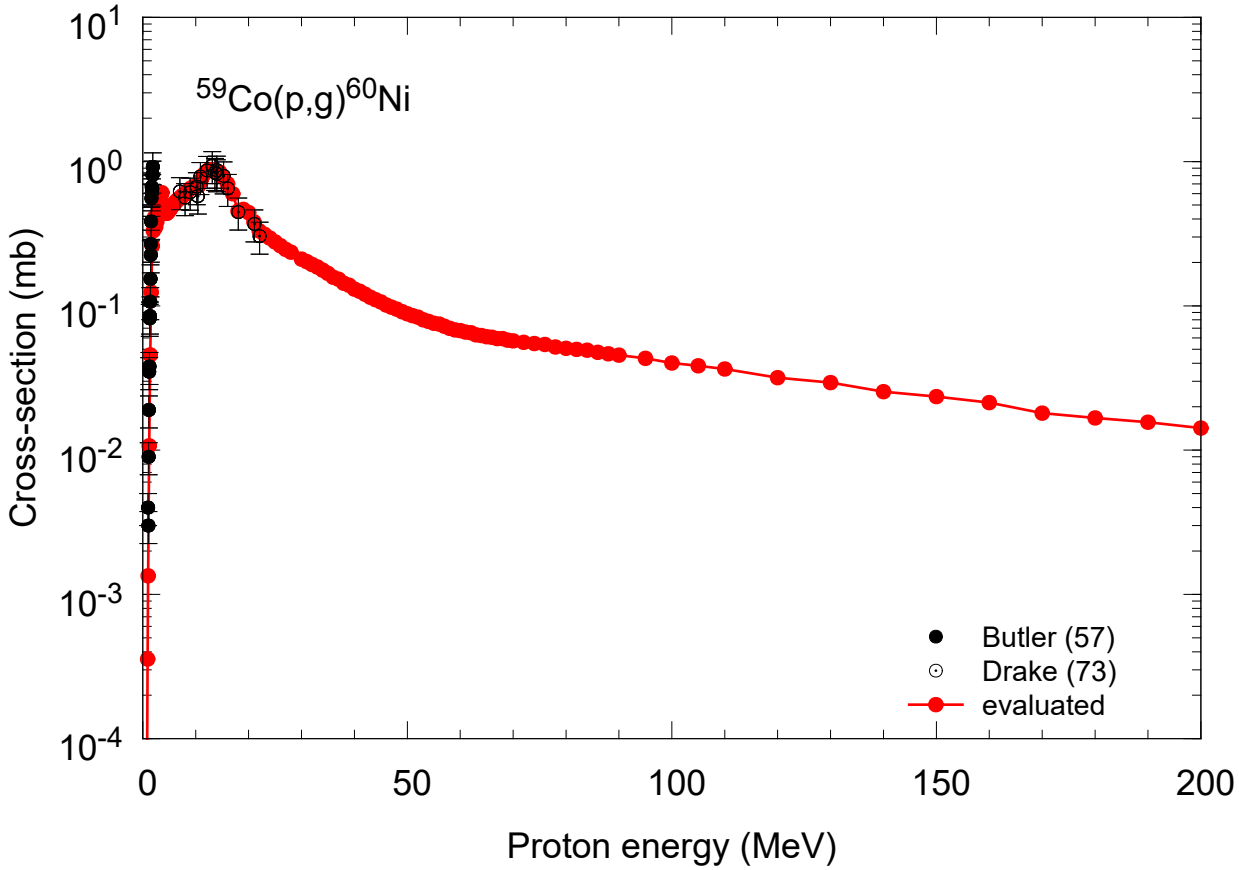

^{59}Co(p,x)^{58g}Co
Cross-section (mb)
Proton energy (MeV)
Sharp (56)
Sharp (56)
Meadows (56)
Titarenko (02)
evaluated

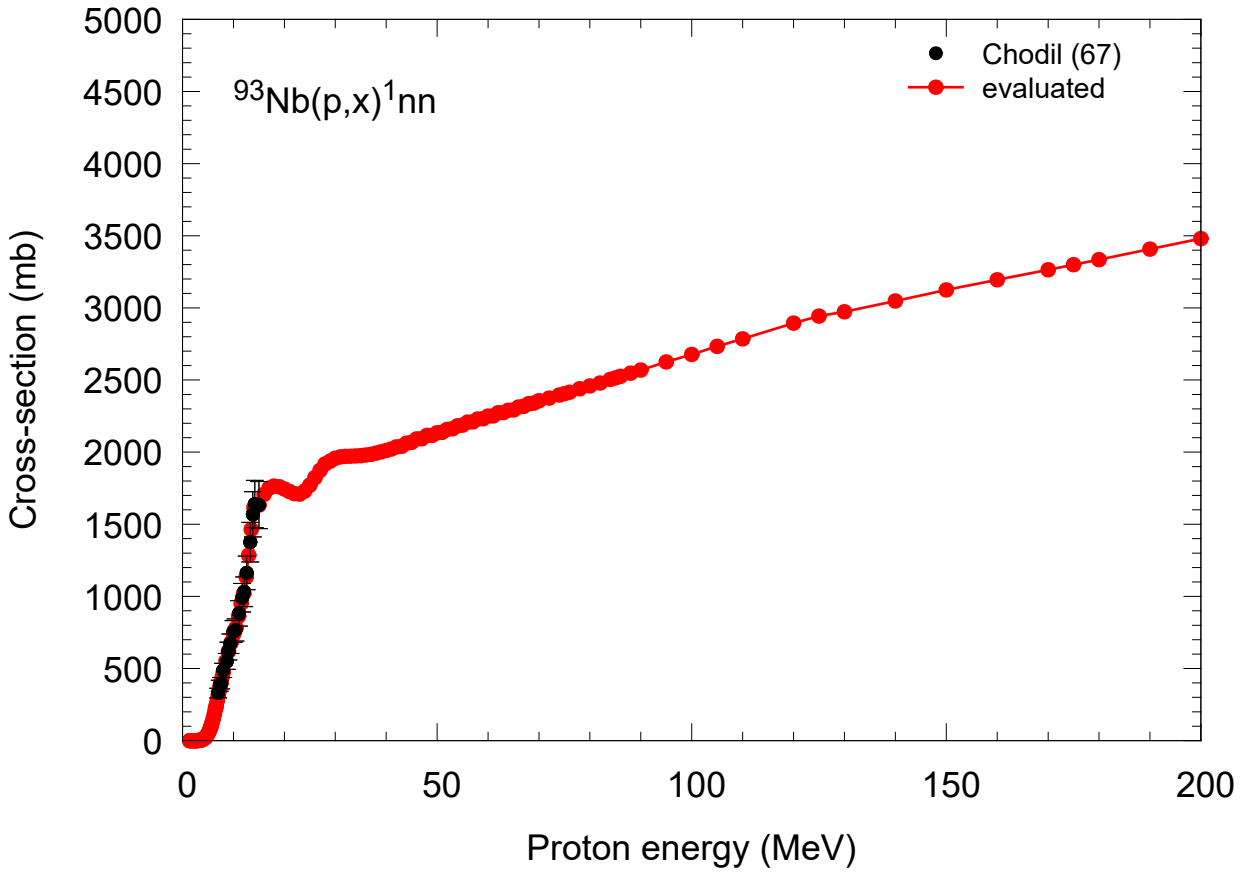

^{59}Co(p,x)^{58m1}Co
Cross-section (mb)
Proton energy (MeV)
Sharp (56)
Sharp (56)
Meadows (56)
Titarenko (02)
evaluated

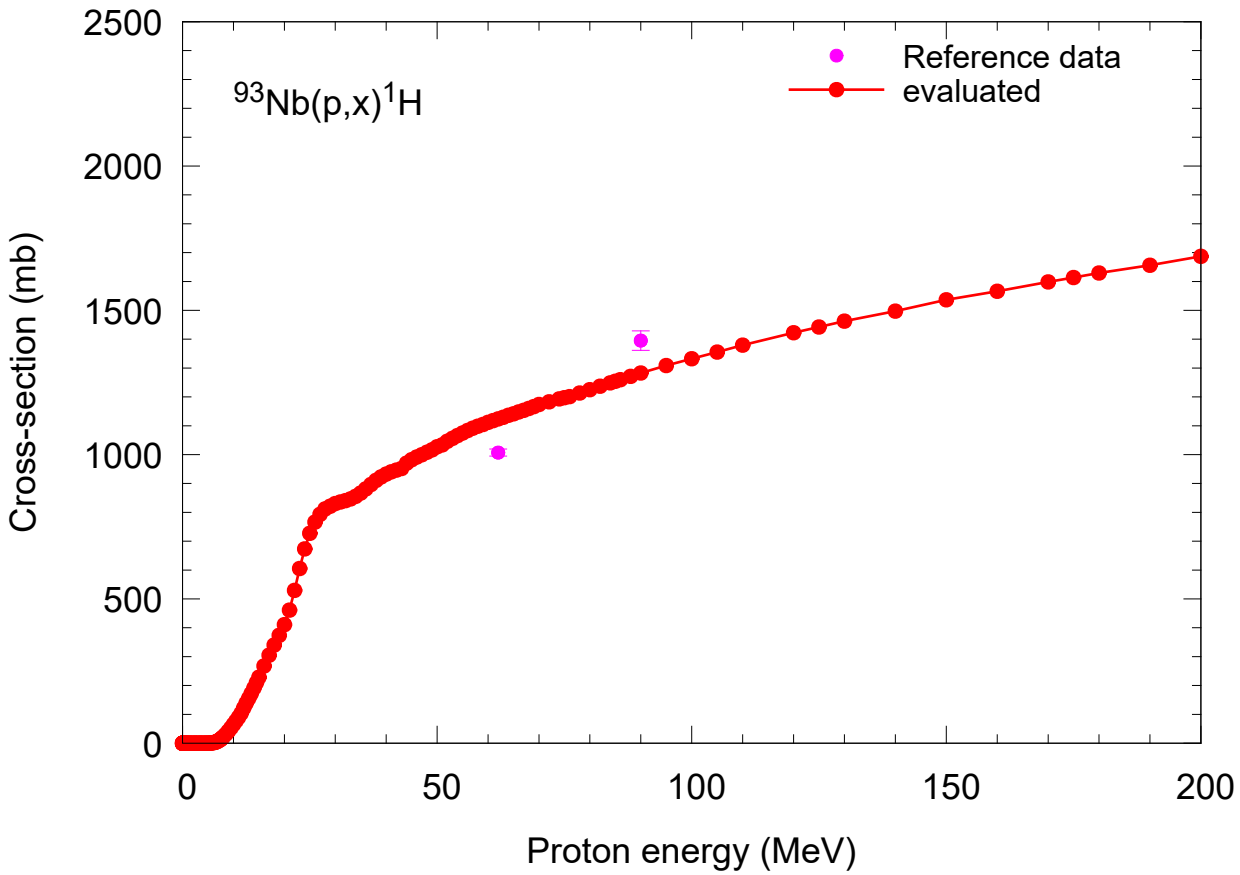

^{59}Co(p,4n)^{56}Ni
Cross-section (mb)
Proton energy (MeV)
Sharp (56)
Michel (79)
Michel (97)
Ditroi (13)
Shahid (20)
evaluated

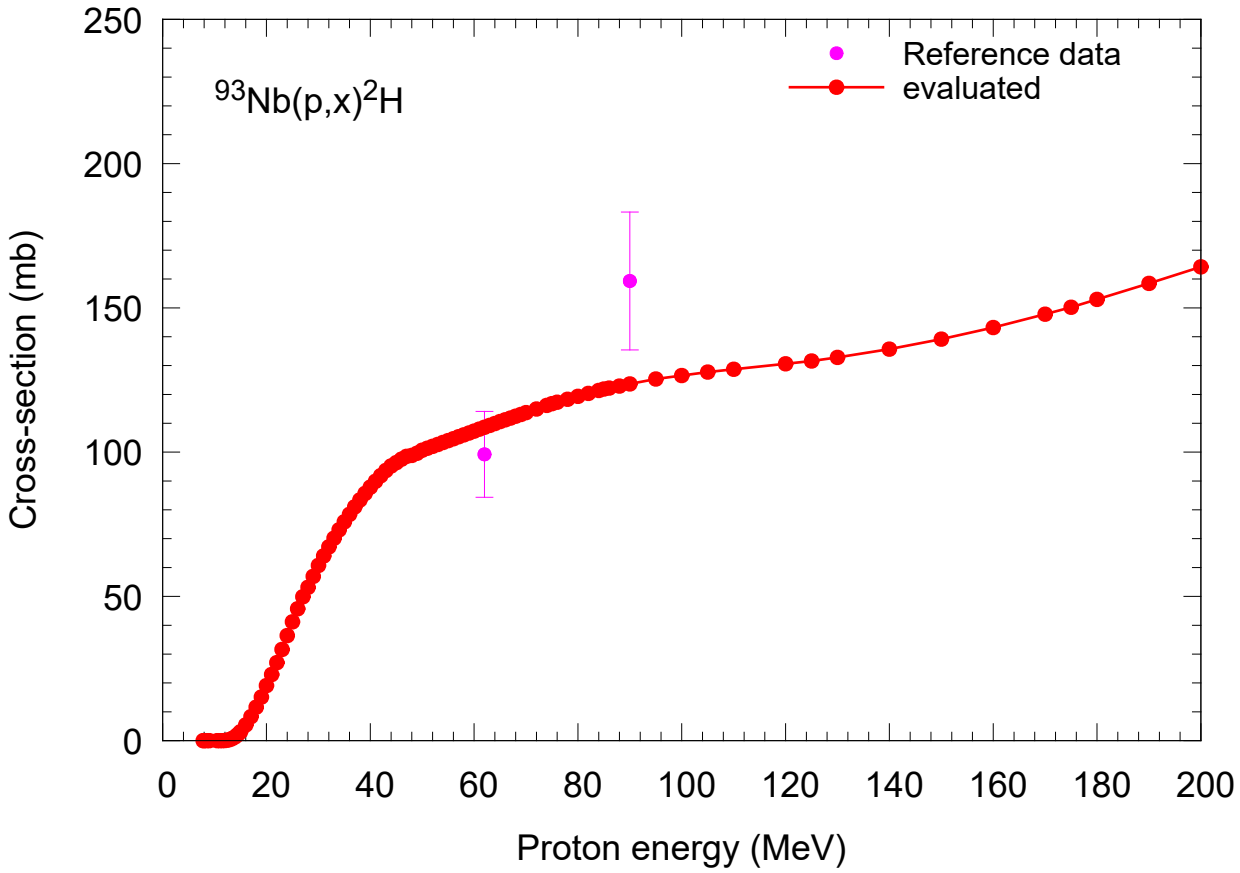

59Co(p,3n)57Ni
Cross-section (mb)
Proton energy (MeV)
Sharp (56)
Michel (79)
Johnson (84)
Michel (85)
Michel (97)
Titarenko (02)
Ditroi (13)
Shahid (20)
evaluated

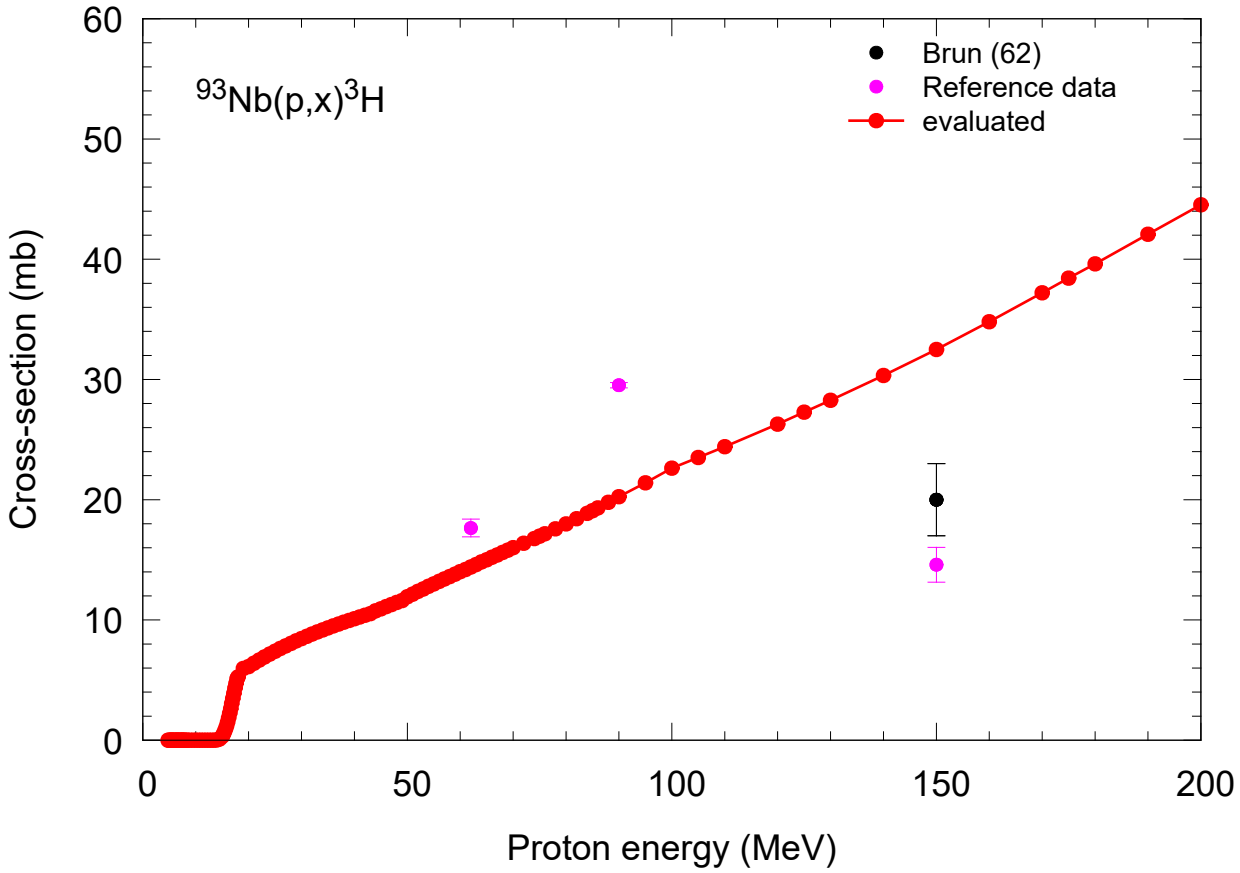

59Co(p,n)59Ni
Cross-section (mb)
Proton energy (MeV)
Johnson (58)
Albert (59)
Bramblett (60)
Taketani (62)
Hansen (62)
Johnson (64)
Chodil (67)
Kailas (75)
evaluated

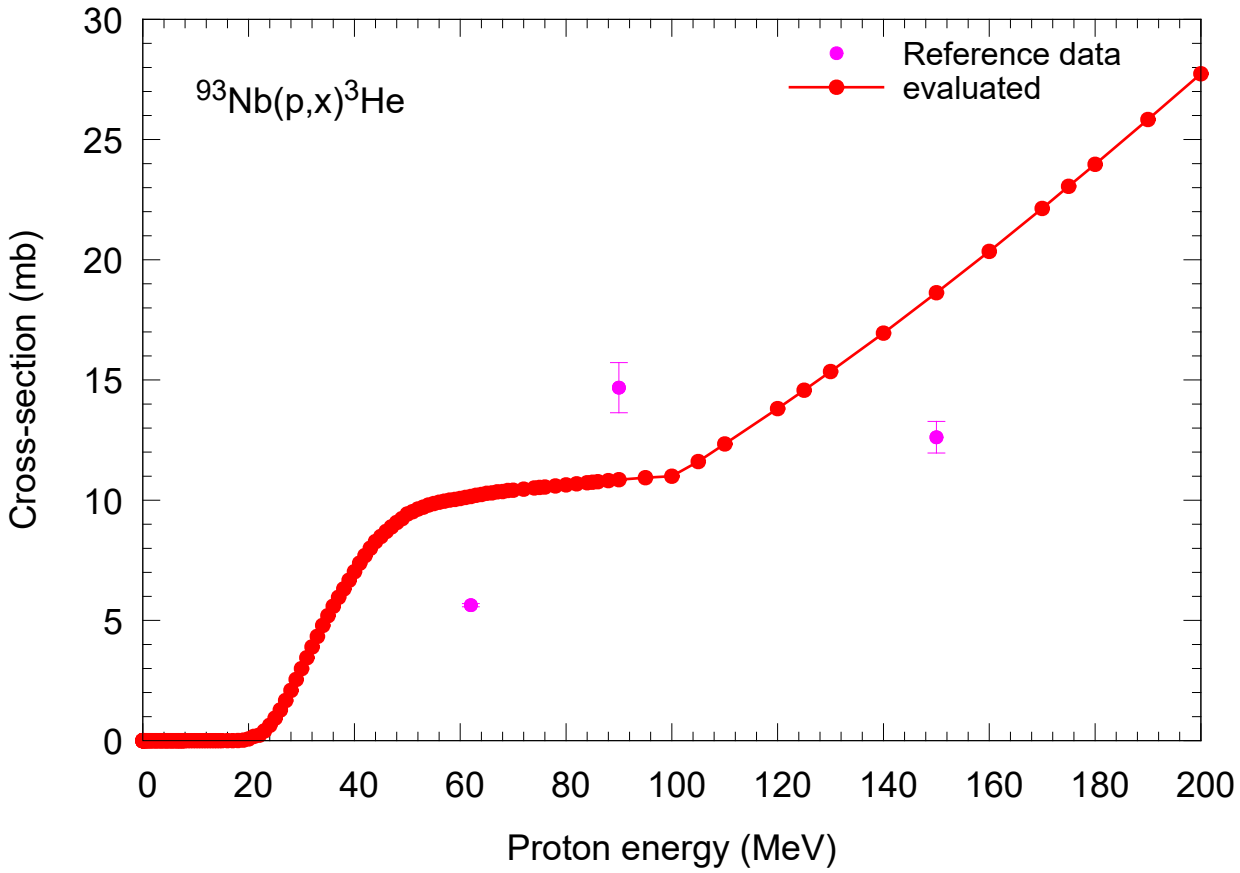

^{59}Co(p,g)^{60}Ni
Cross-section (mb)
Proton energy (MeV)
Butler (57)
Drake (73)
evaluated

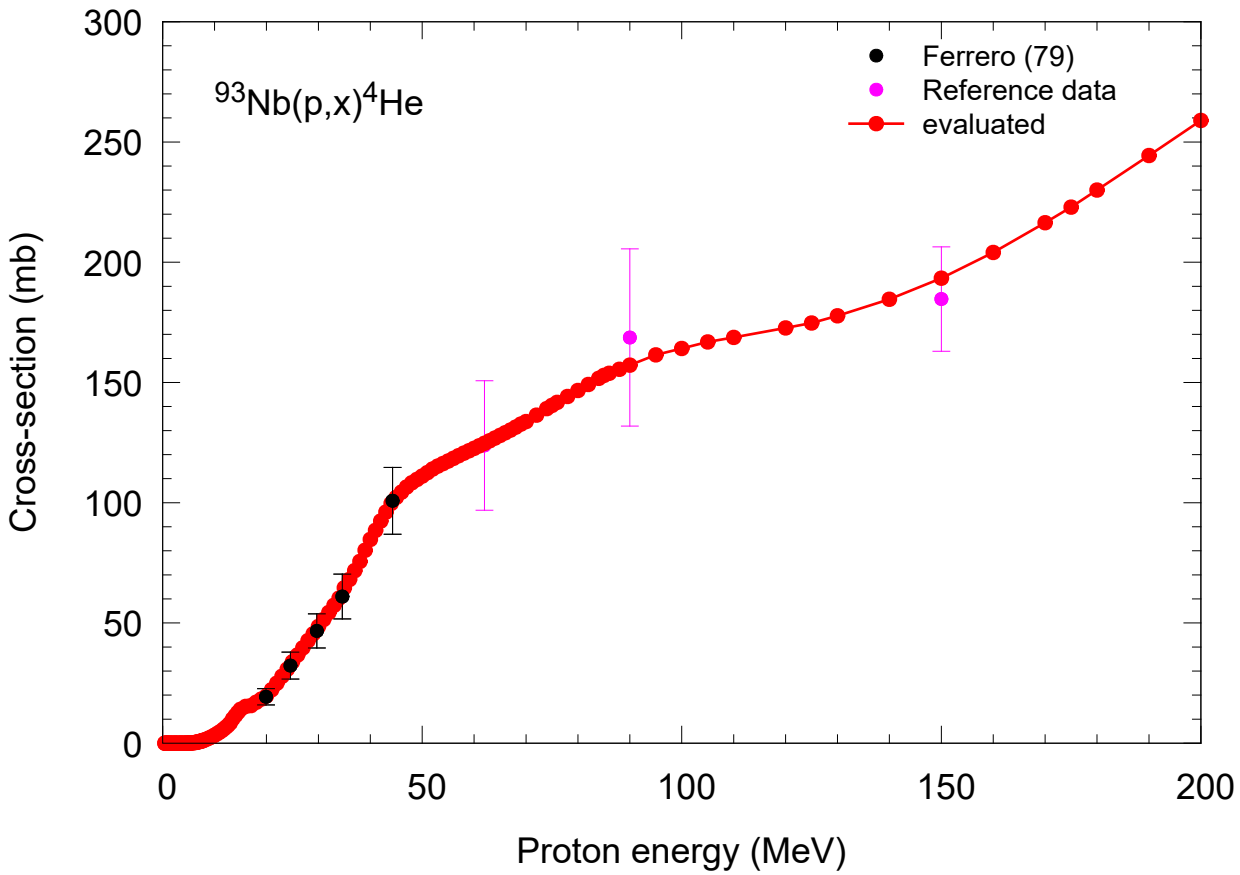

^{93}Nb(p,x)^{1}nn
Chodil (67)
evaluated
Cross-section (mb)
Proton energy (MeV)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
0
50
100
150
200

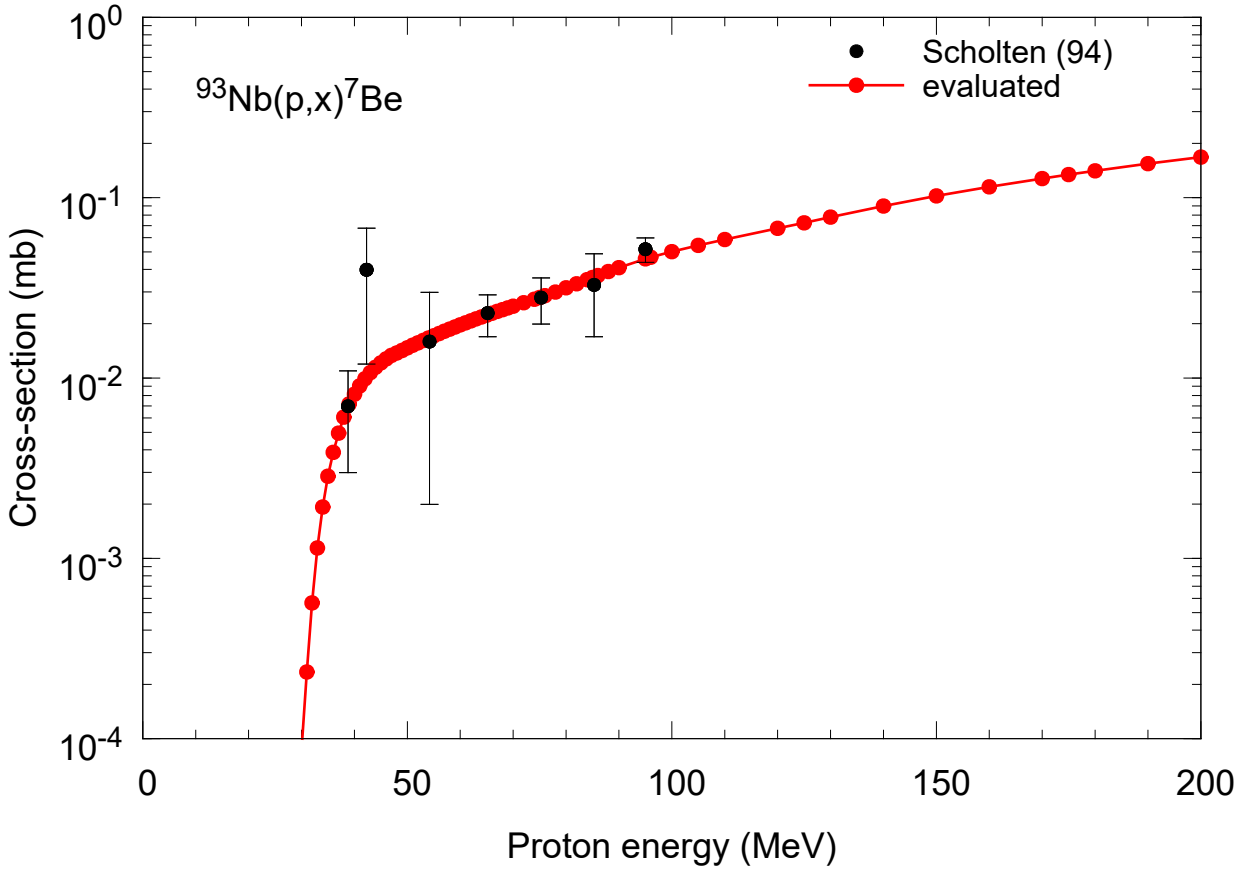

^{93}Nb(p,x)^{1}H
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
500
1000
1500
2000
2500
0
50
100
150
200

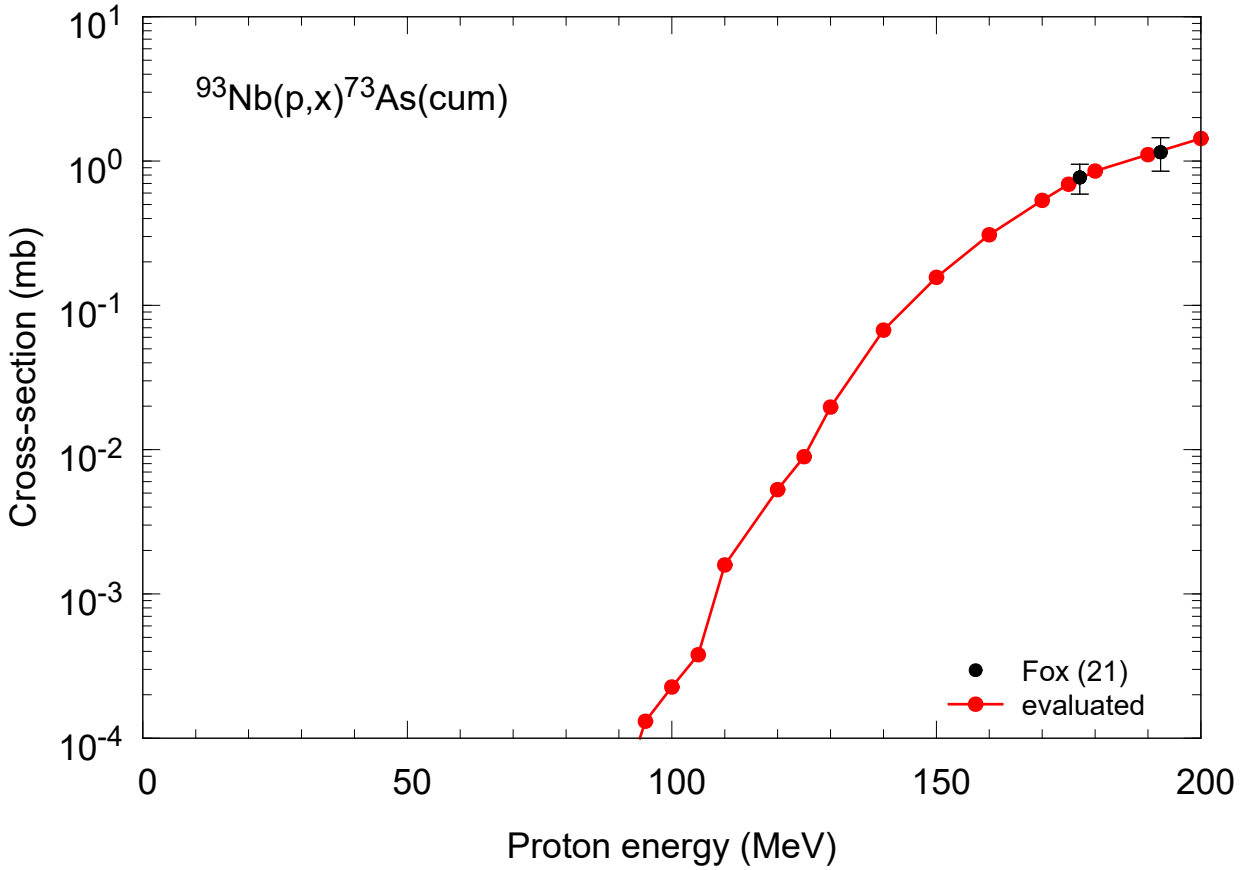

^{93}Nb(p,x)^{2}H
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
50
100
150
200
250
0
20
40
60
80
100
120
140
160
180
200

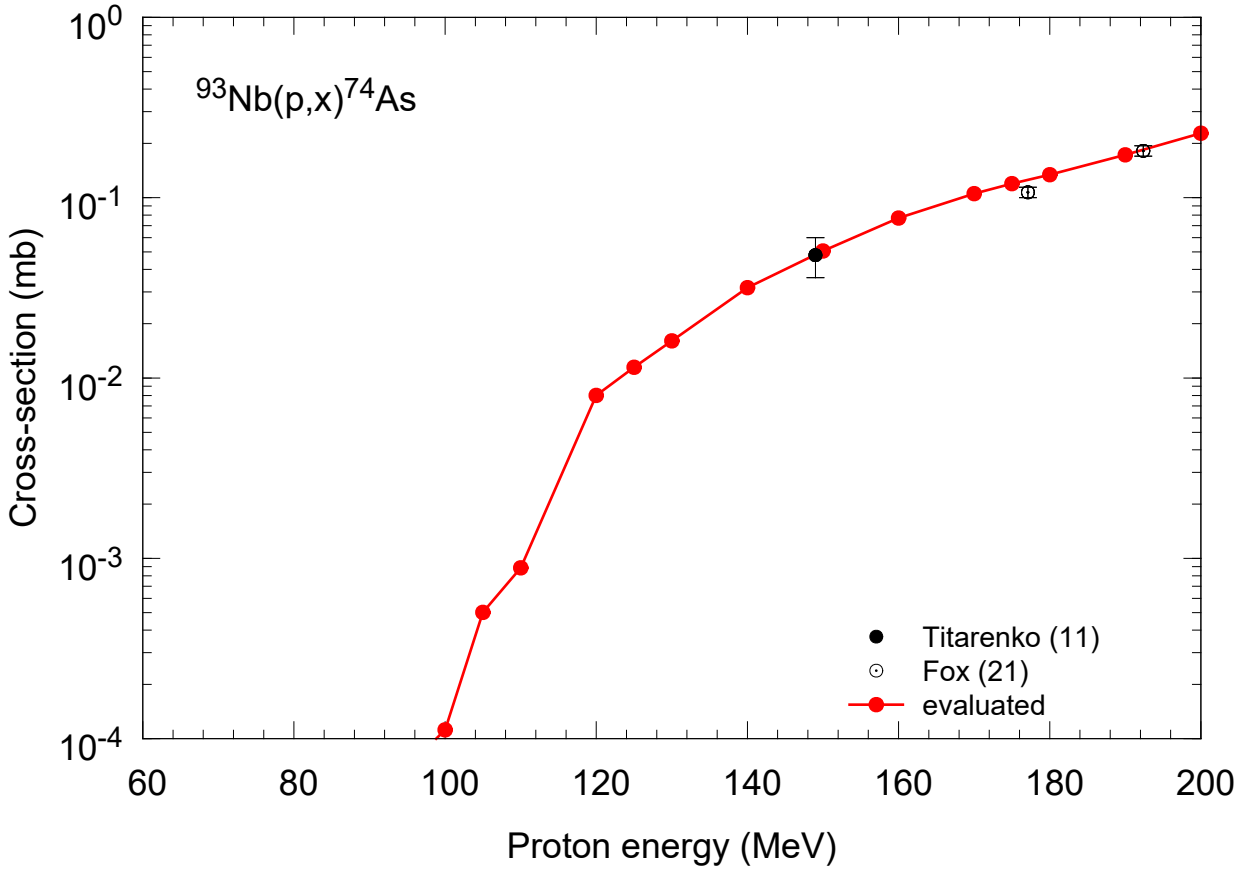

^{93}Nb(p,x)^{3}H
Brun (62)
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
10
20
30
40
50
60
0
50
100
150
200

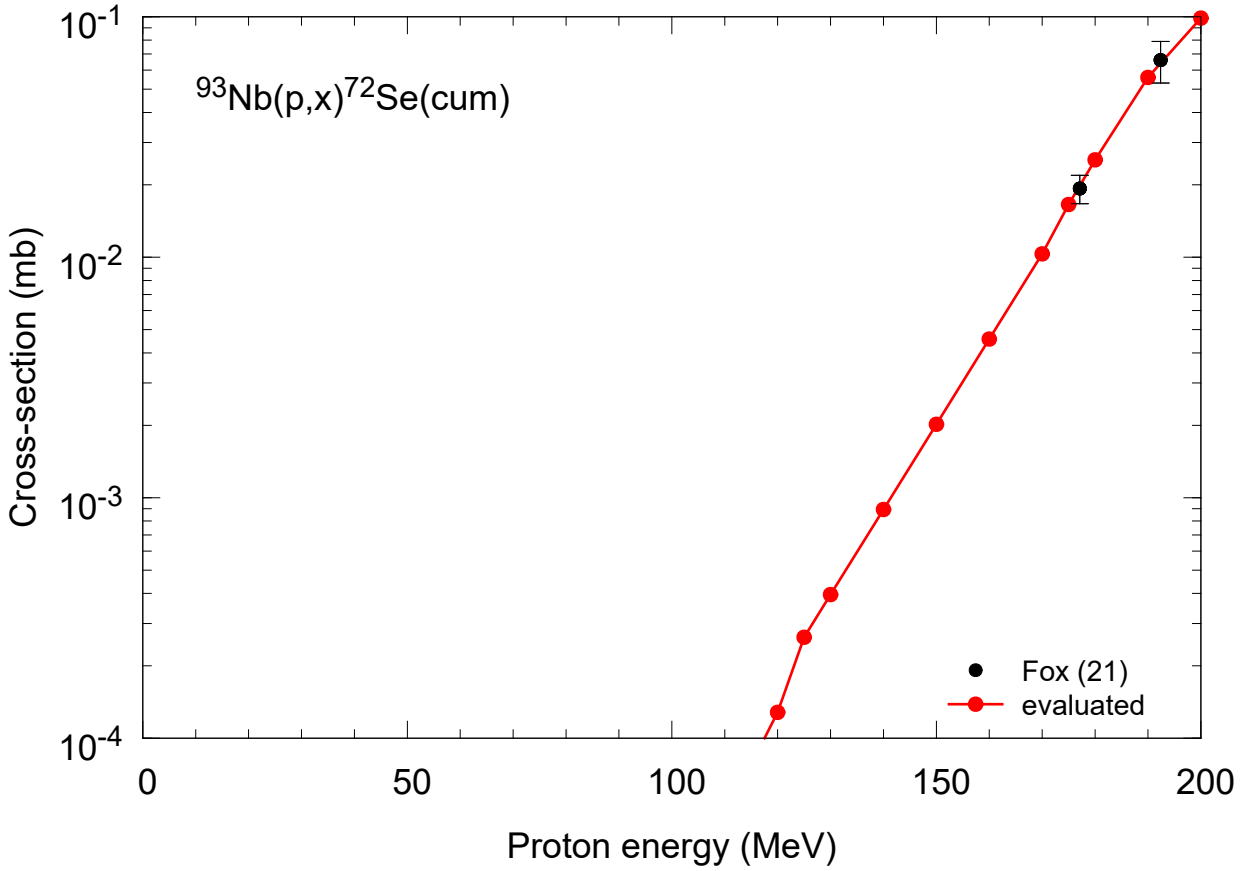

^{93}Nb(p,x)^{3}He
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
5
10
15
20
25
30
0
20
40
60
80
100
120
140
160
180
200

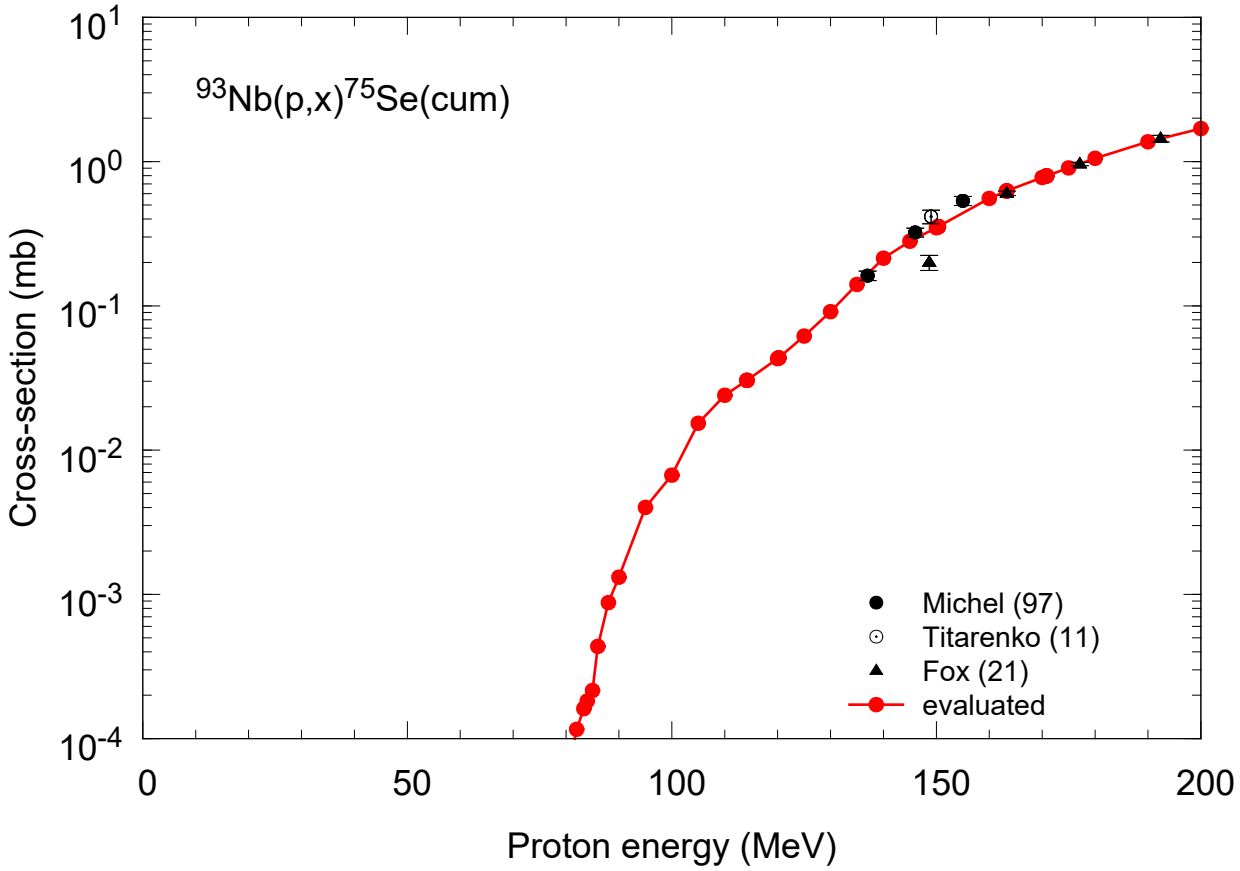

^{93}Nb(p,x)^{4}He
Ferrero (79)
Reference data
evaluated
Cross-section (mb)
Proton energy (MeV)
0
50
100
150
200
250
300
0
50
100
150
200

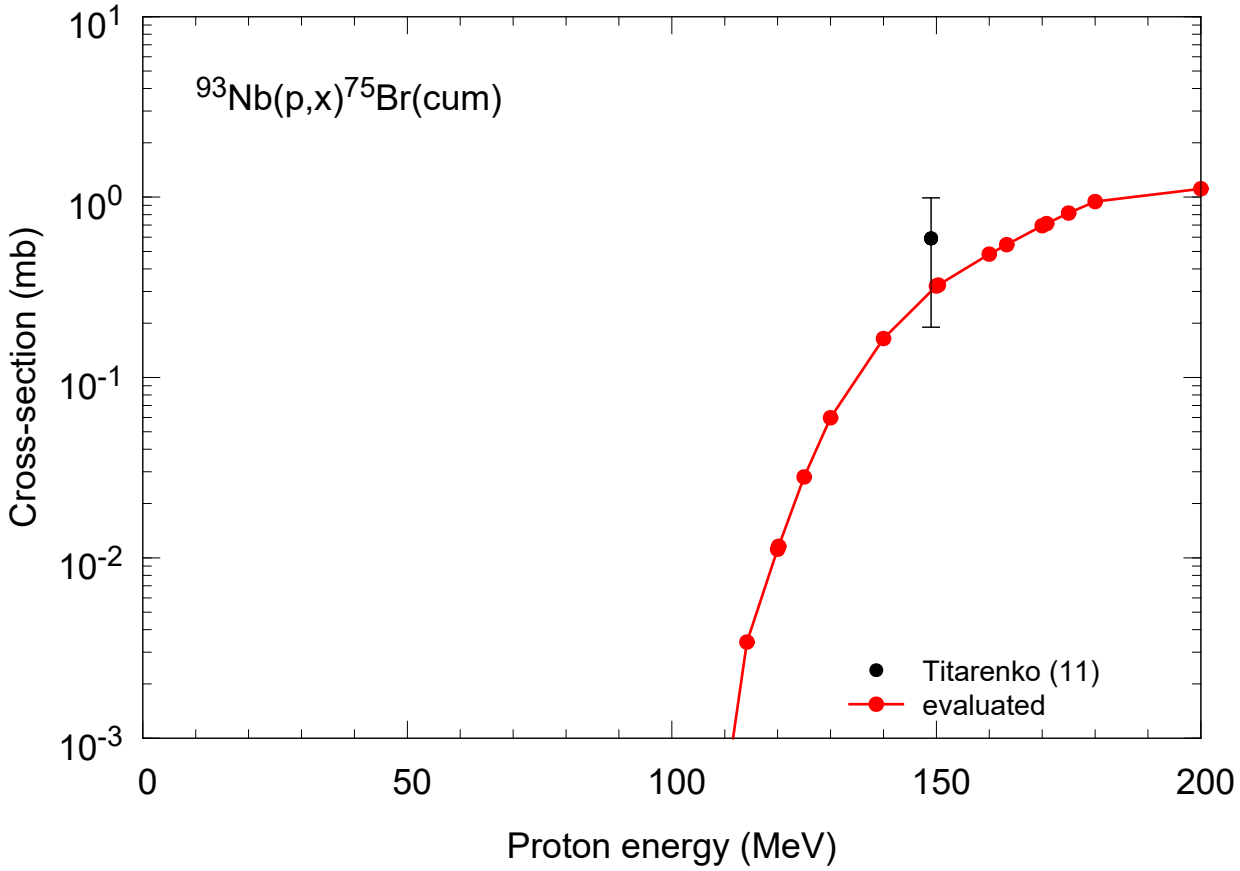

^{93}Nb(p,x)^{7}Be
Scholten (94)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
50
100
150
200

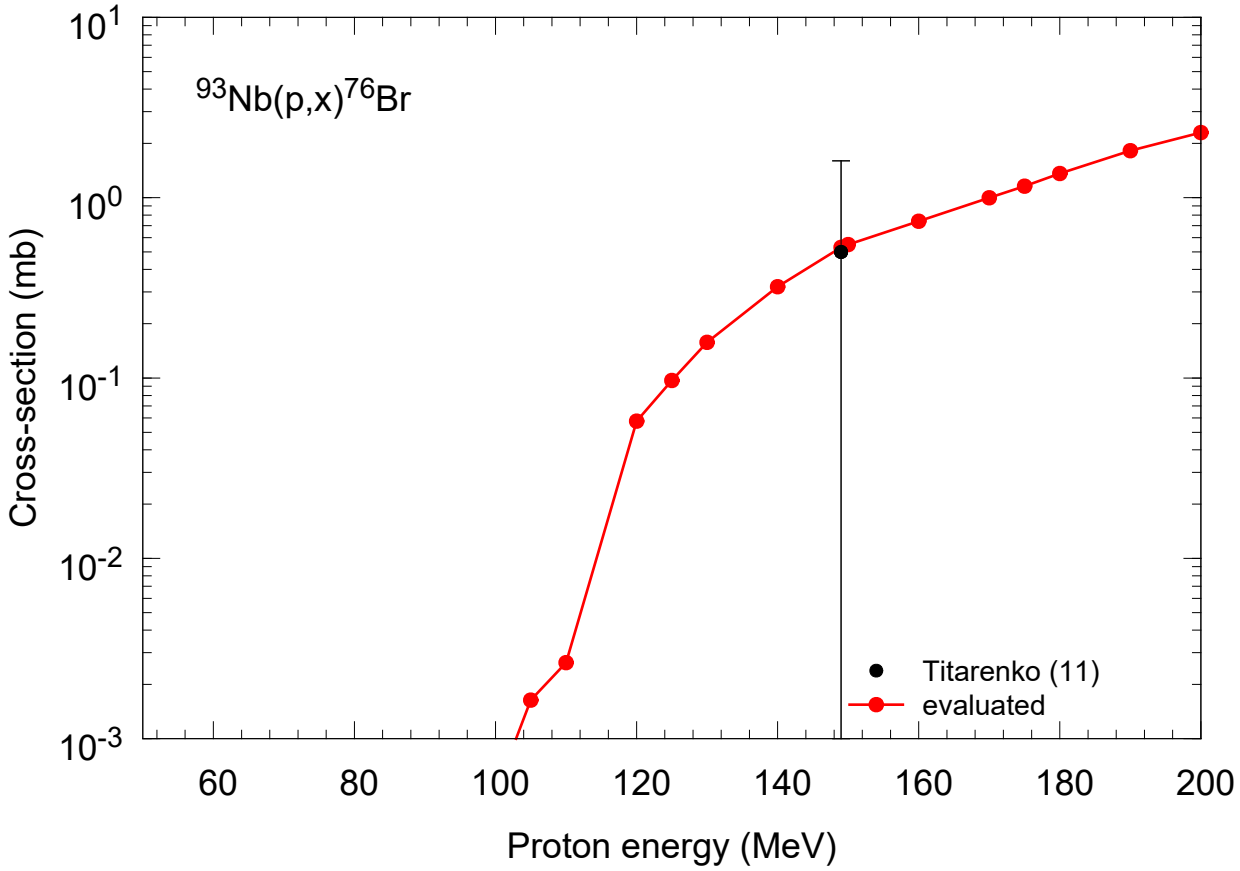

^{93}Nb(p,x)^{73}As(cum)
Fox (21)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
50
100
150
200

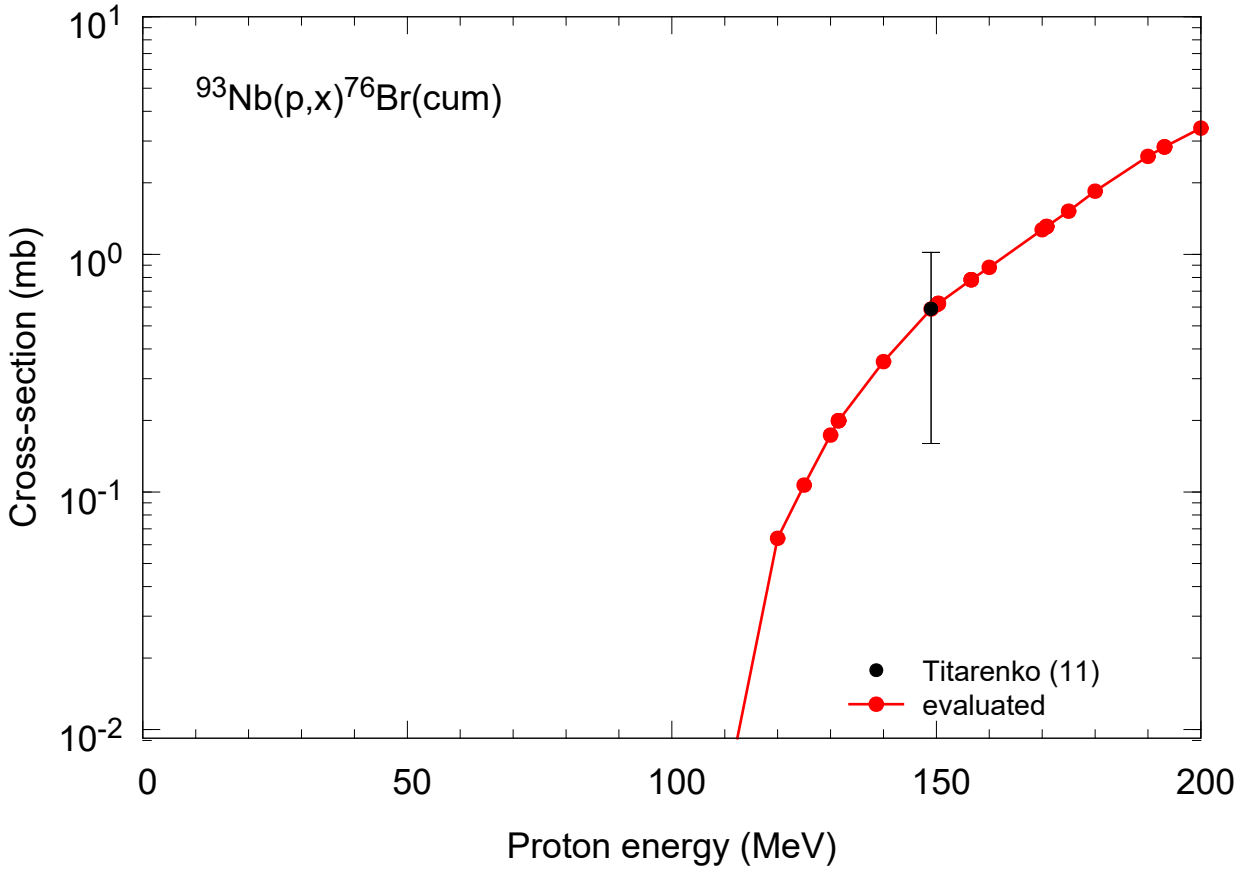

^{93}Nb(p,x)^{74}As
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
Fox (21)
evaluated

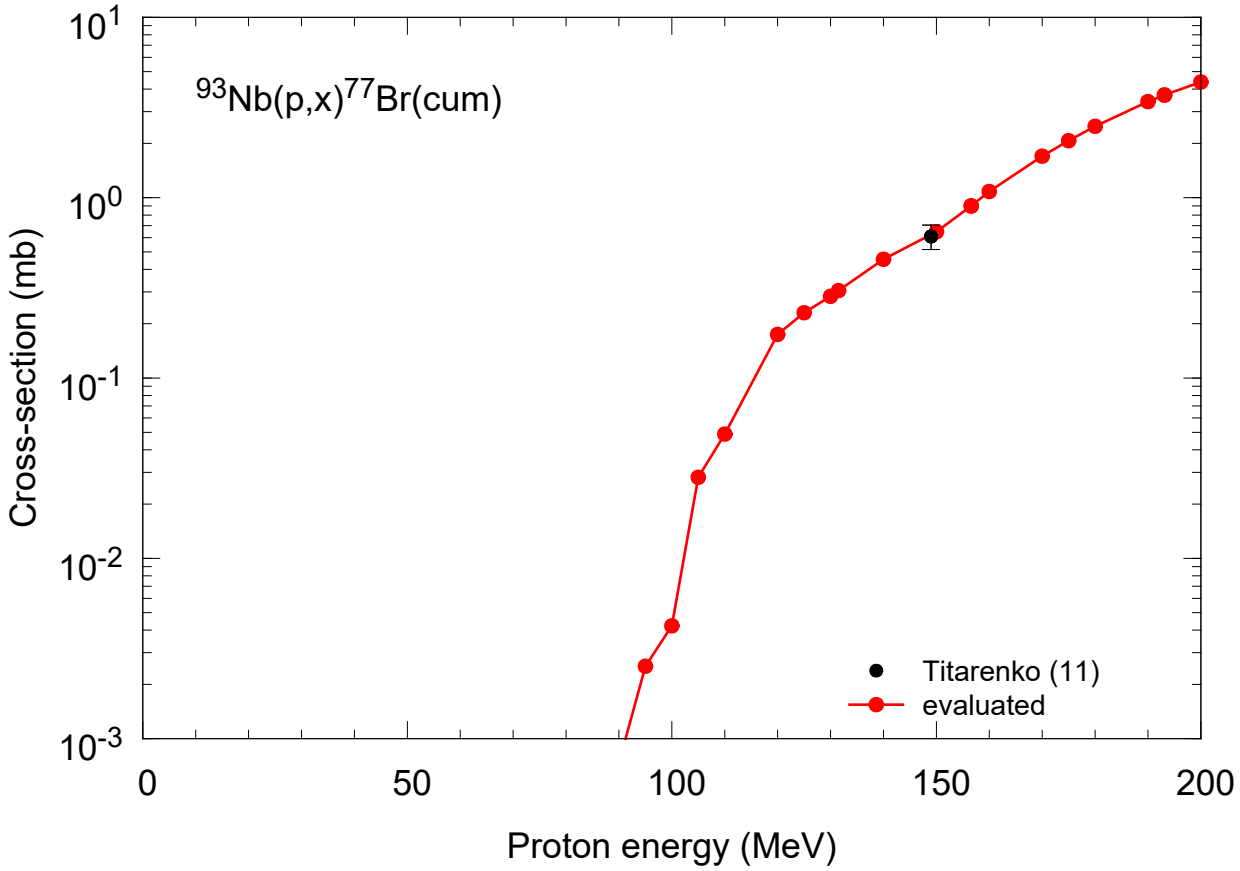

^{93}Nb(p,x)^{72}Se(cum)
Cross-section (mb)
Proton energy (MeV)
Fox (21)
evaluated

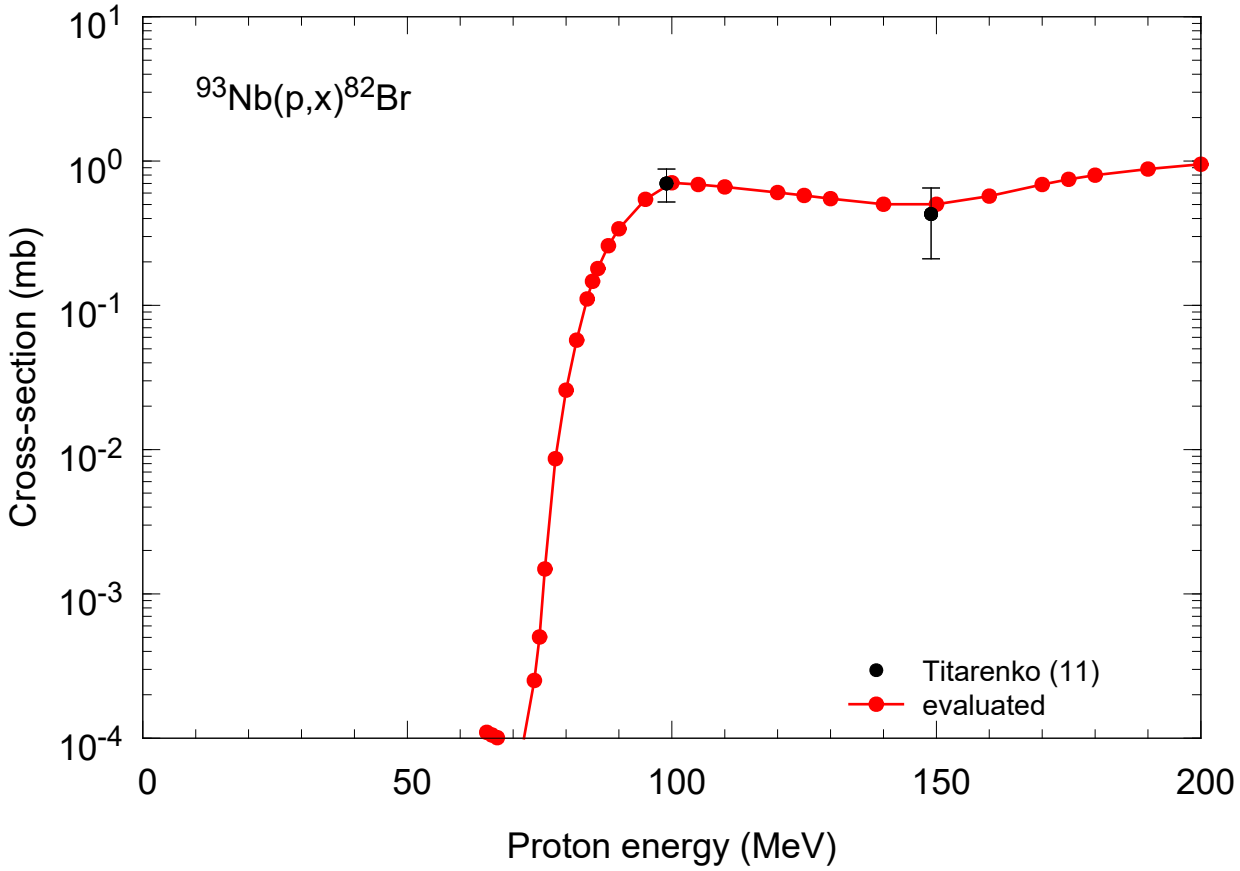

^{93}Nb(p,x)^{75}Se(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (97)
Titarenko (11)
Fox (21)
evaluated

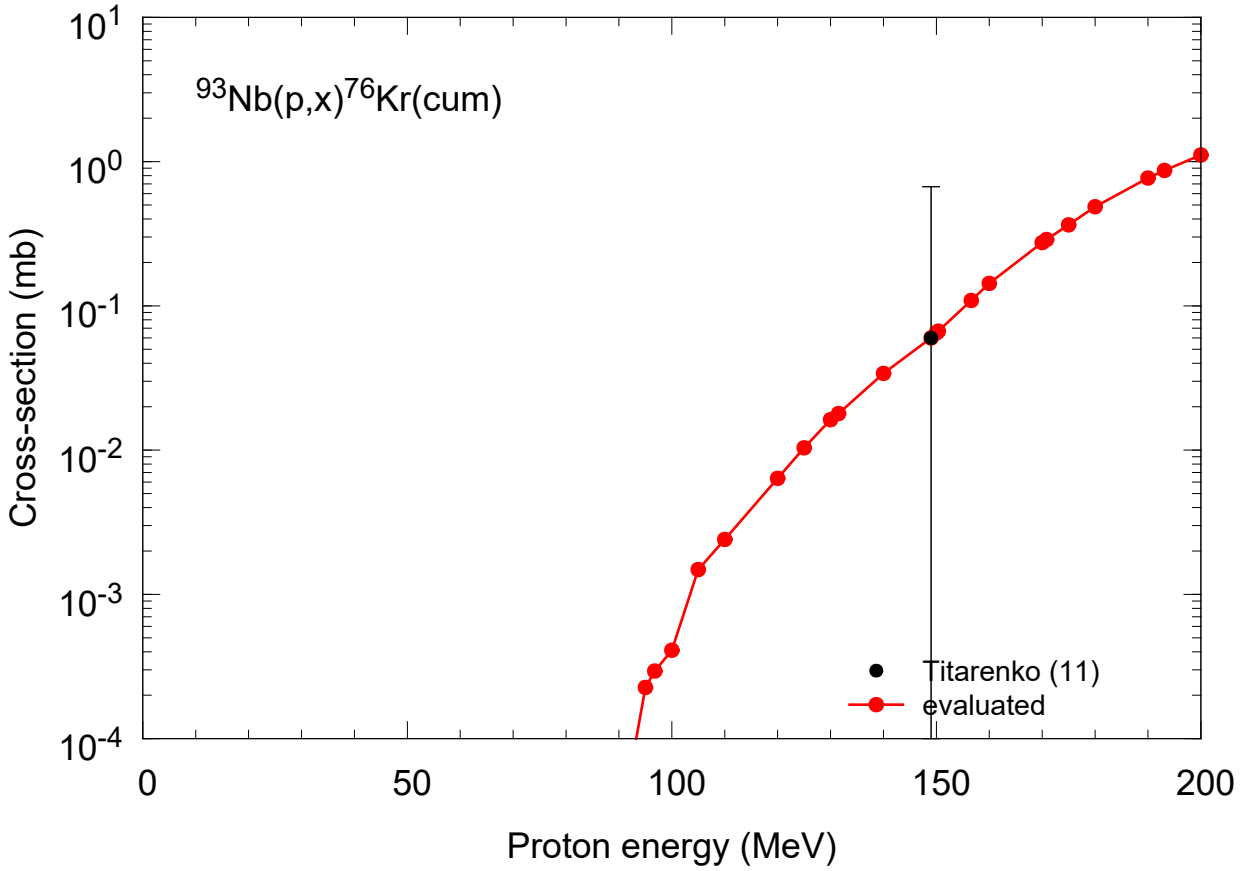

^{93}Nb(p,x)^{75}Br(cum)
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
evaluated

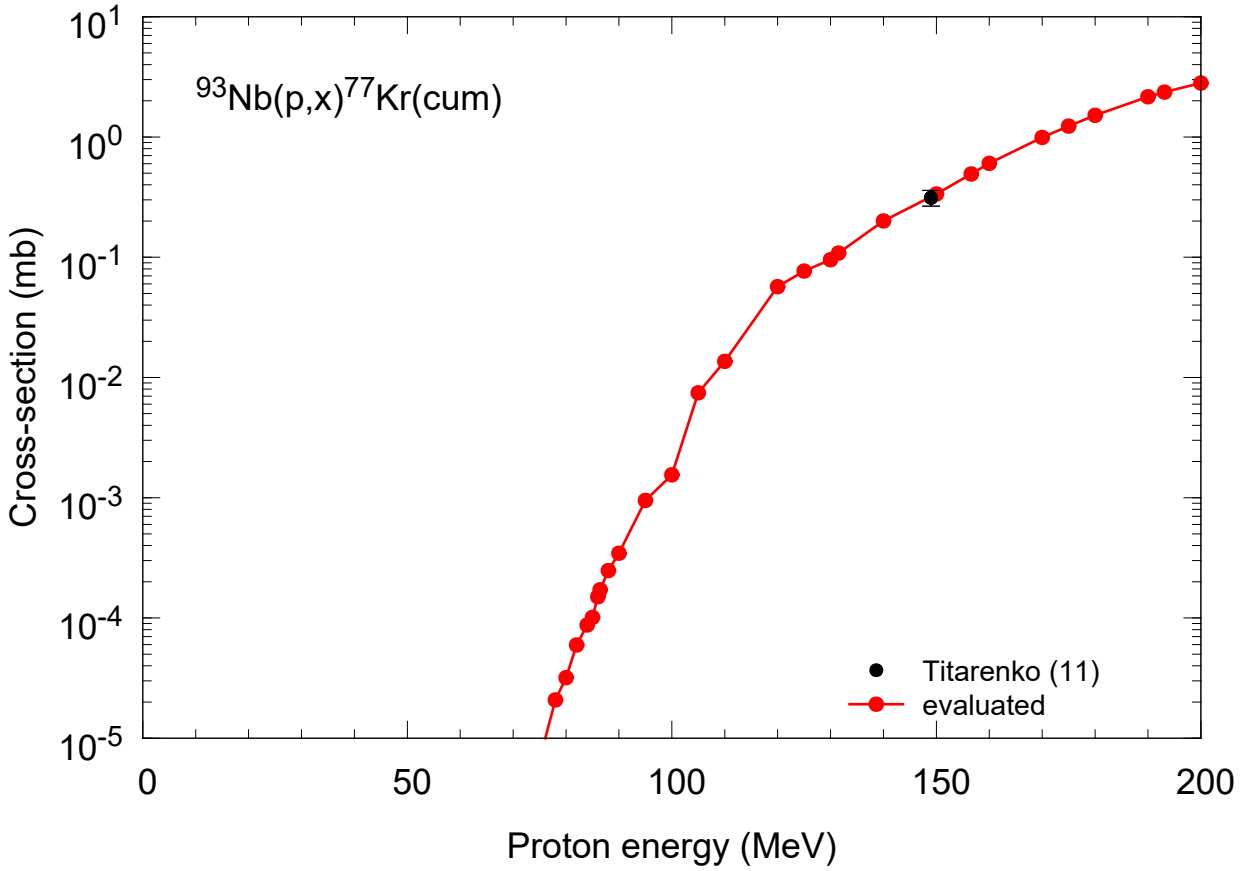

^{93}Nb(p,x)^{76}Br
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
evaluated

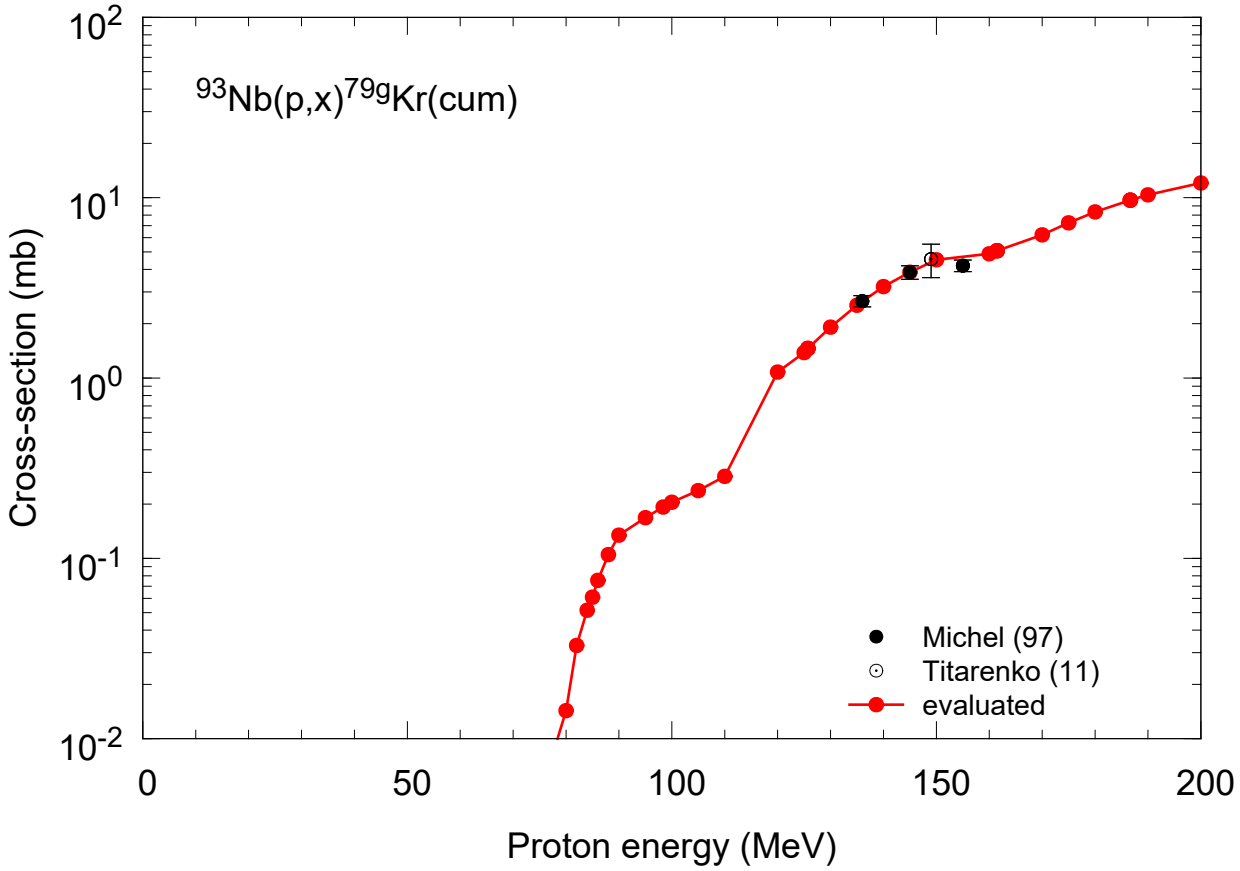

^{93}Nb(p,x)^{76}Br(cum)
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
evaluated

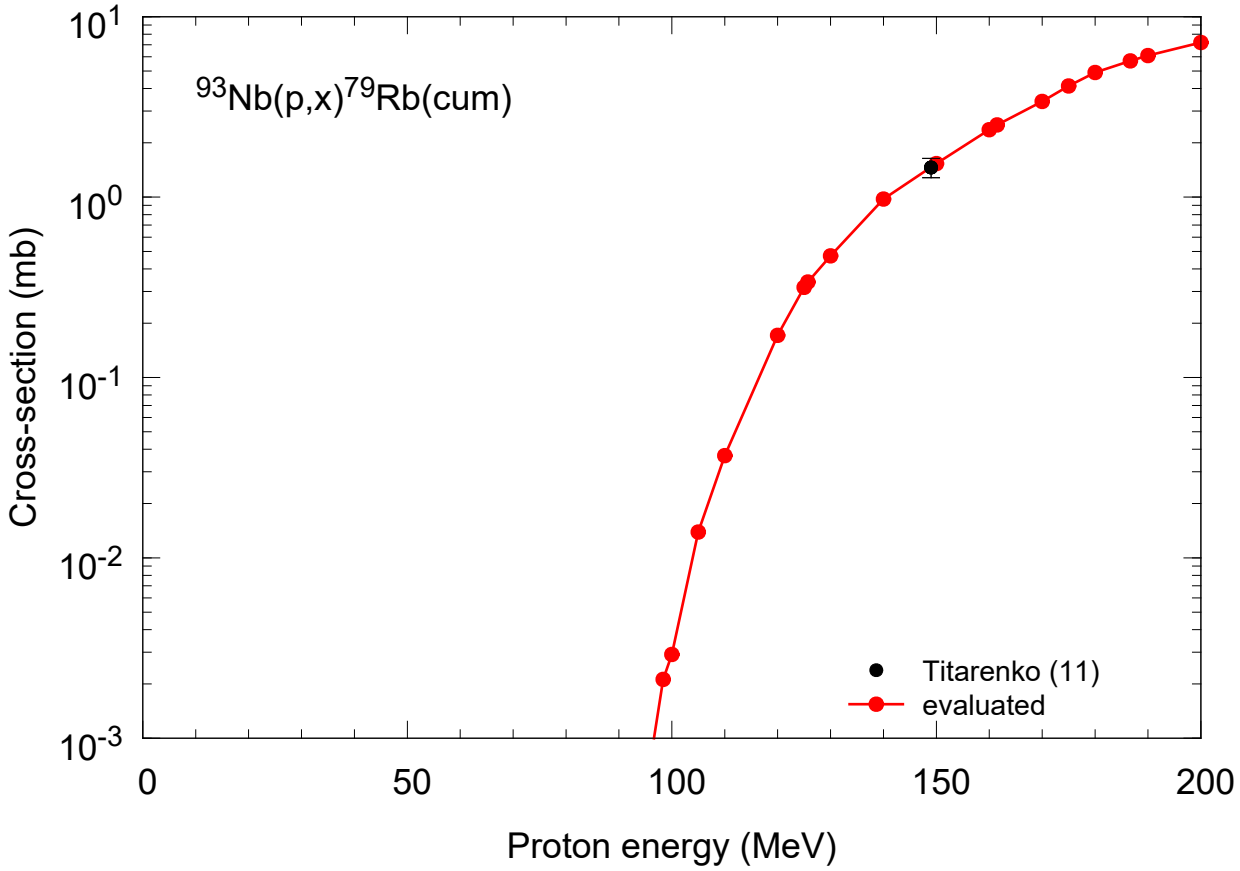

^{93}Nb(p,x)^{77}Br(cum)
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
evaluated

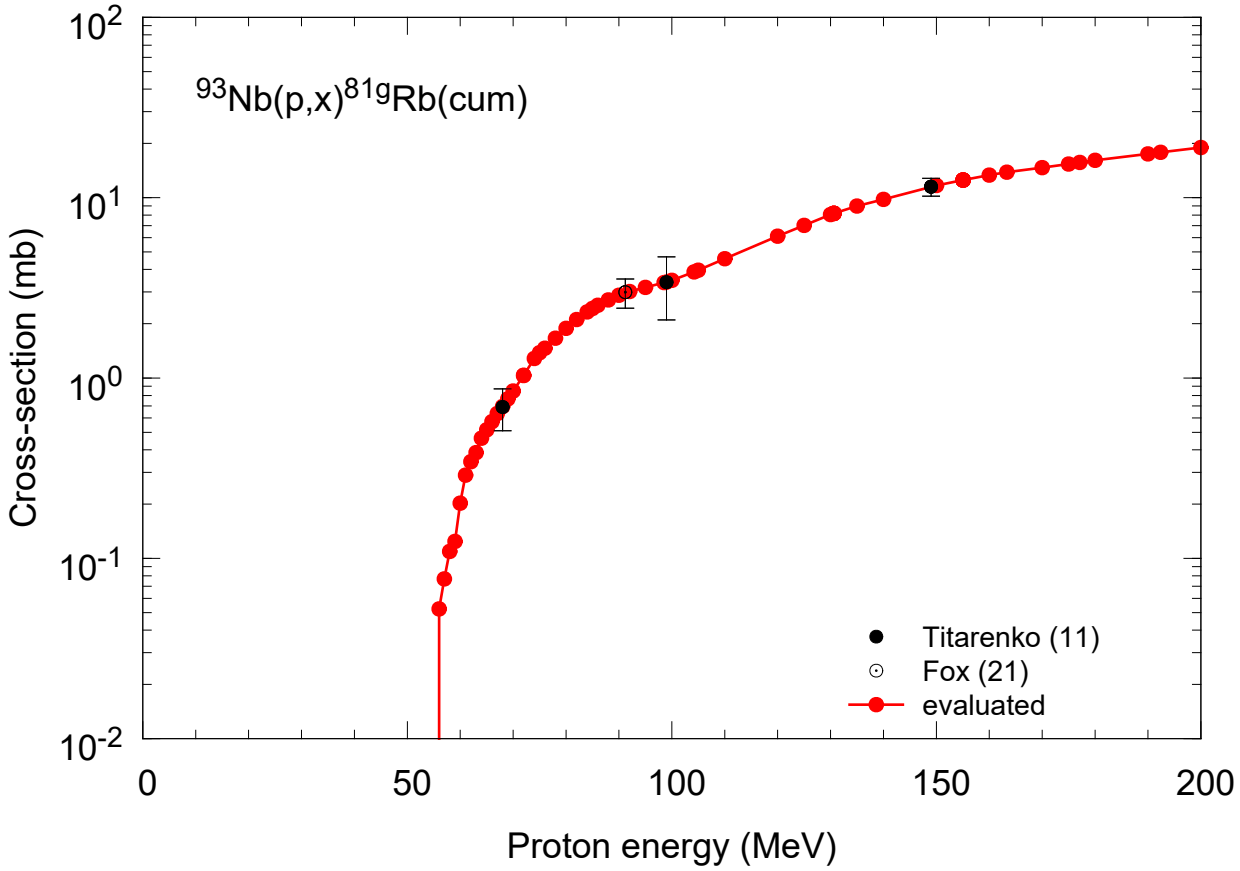

^{93}Nb(p,x)^{82}Br
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
evaluated

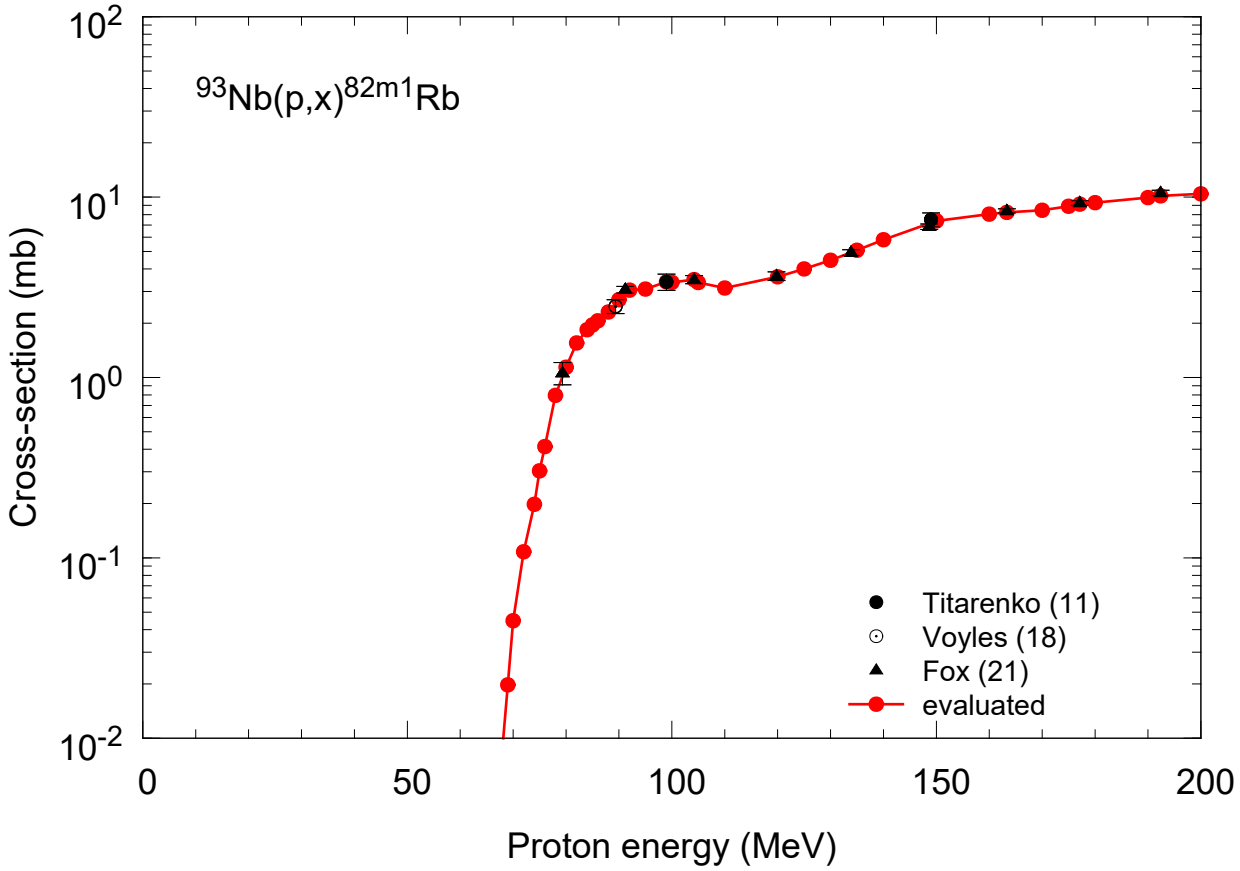

^{93}Nb(p,x)^{76}Kr(cum)
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
evaluated

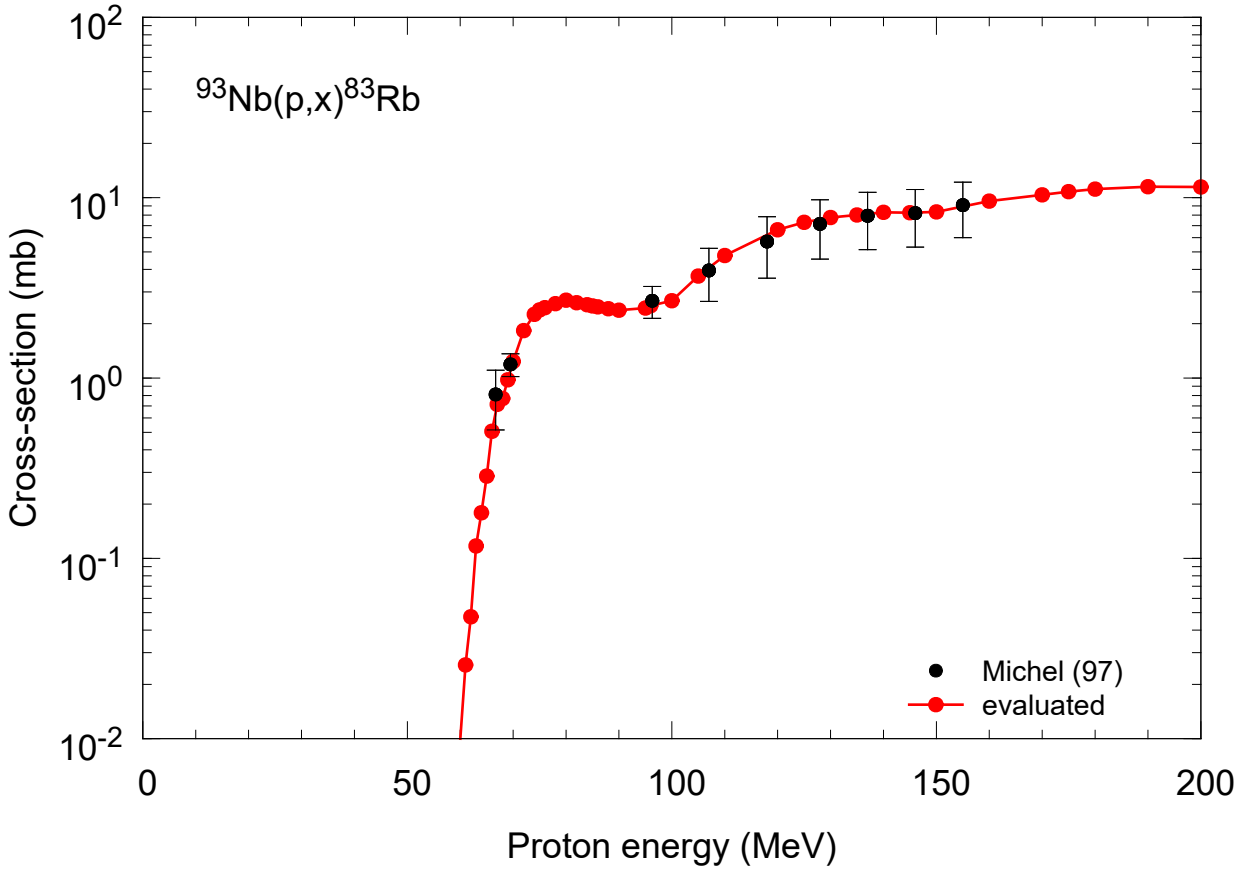

^{93}Nb(p,x)^{77}Kr(cum)
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
evaluated

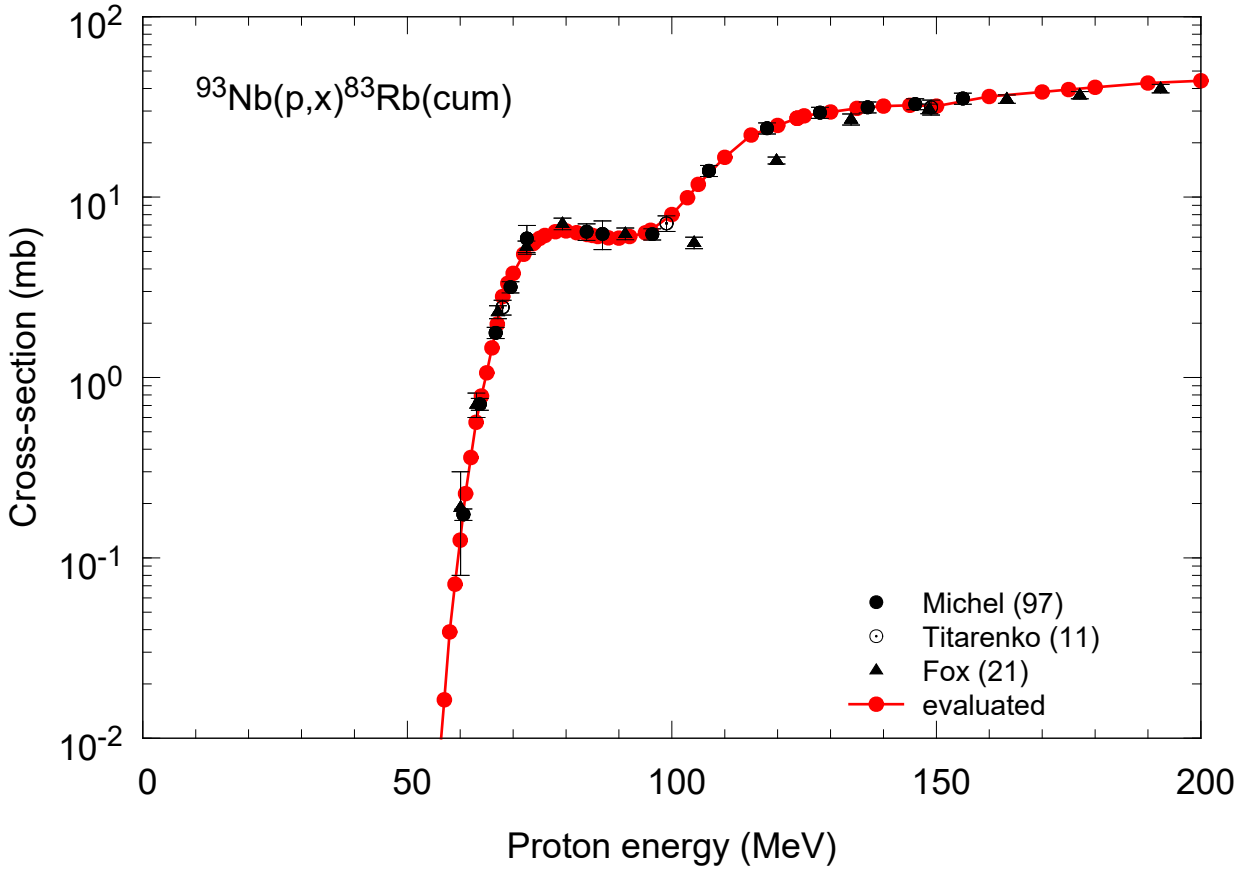

^{93}Nb(p,x)^{79g}Kr(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (97)
Titarenko (11)
evaluated

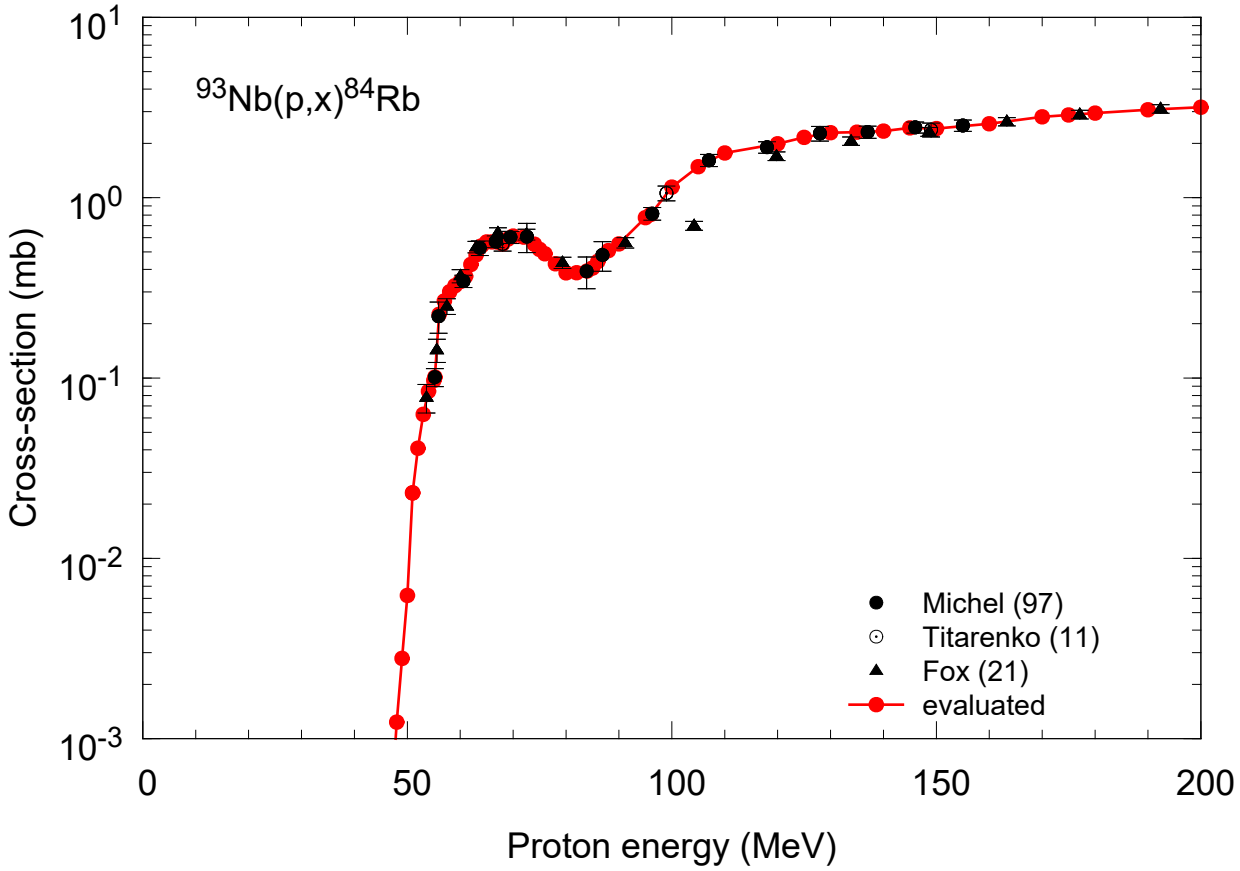

^{93}Nb(p,x)^{79}Rb(cum)
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
evaluated

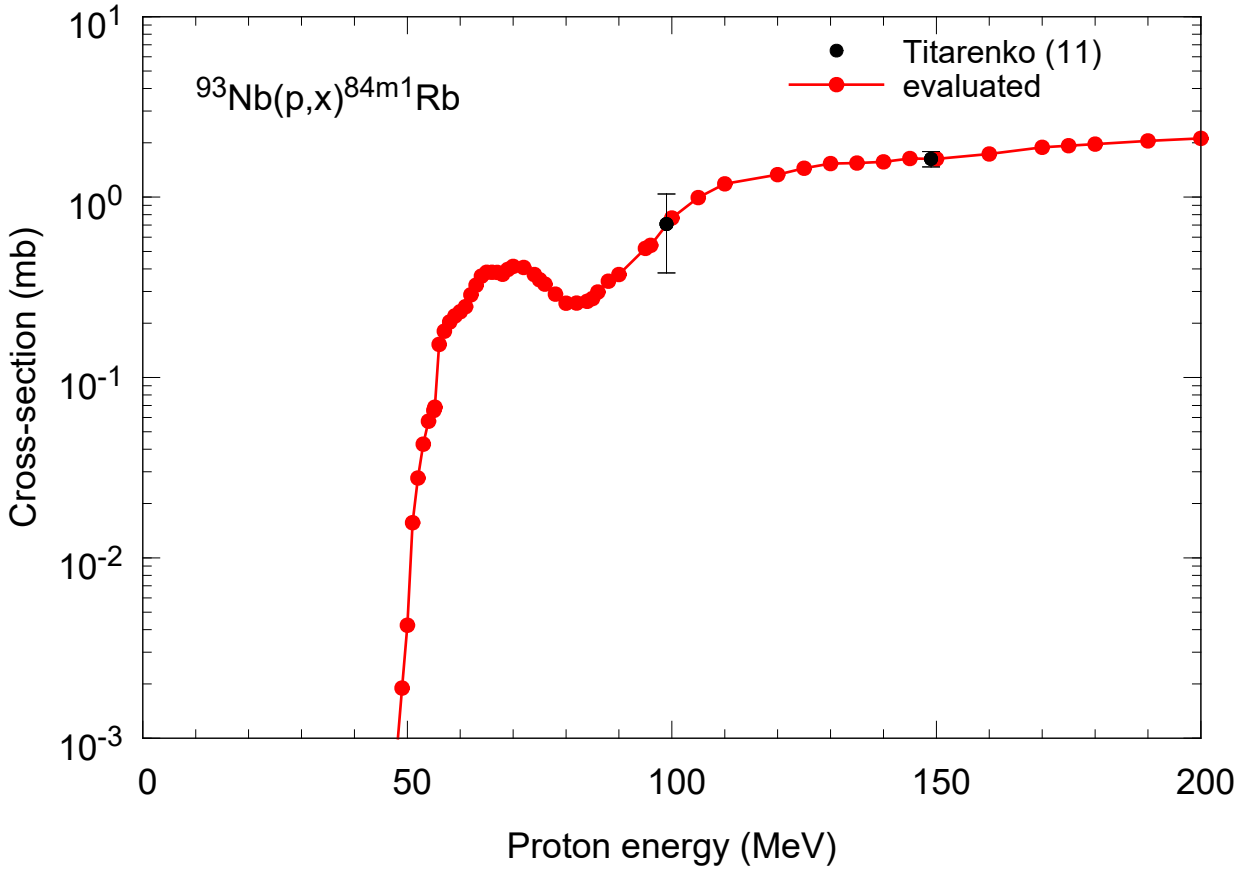

^{93}Nb(p,x)^{81g}Rb(cum)
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
Fox (21)
evaluated

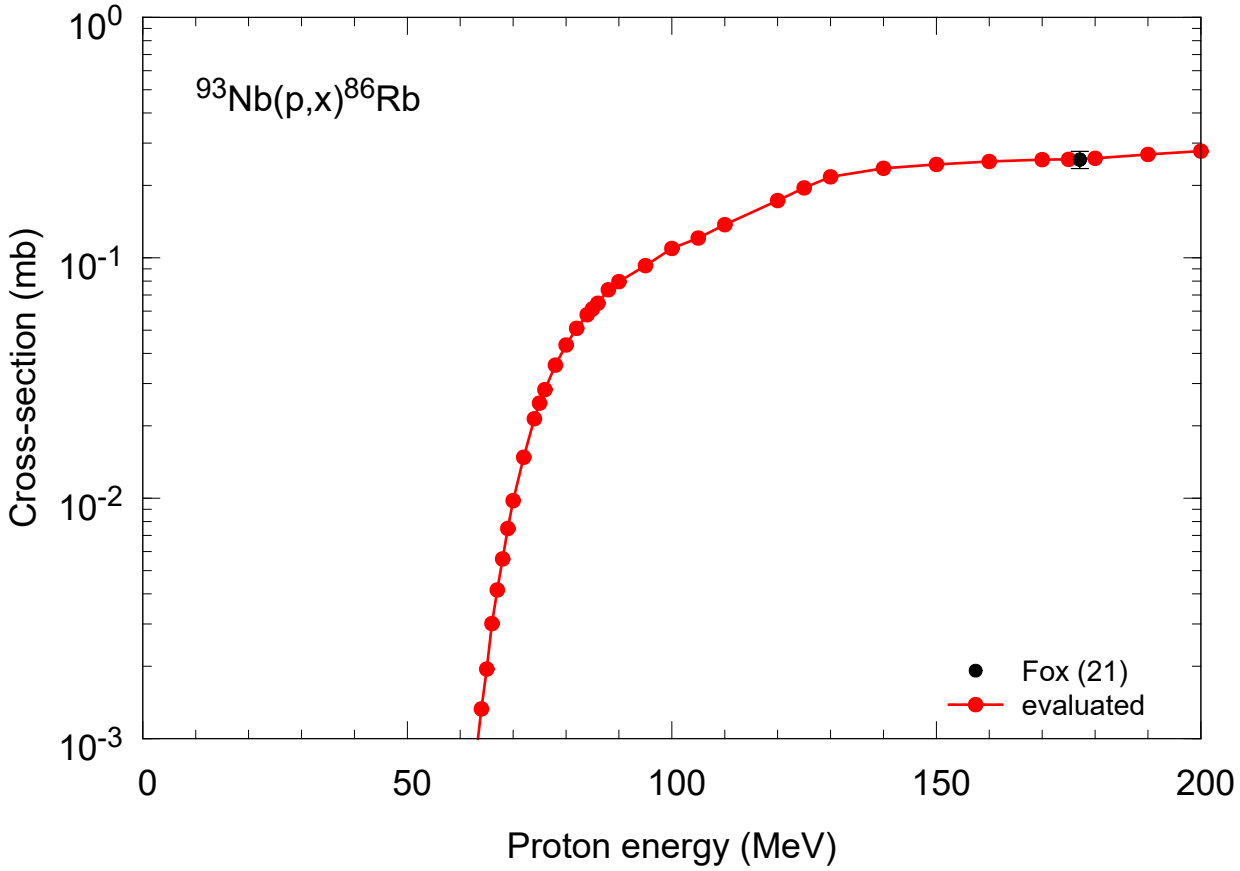

^{93}Nb(p,x)^{82m1}Rb
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
Voyles (18)
Fox (21)
evaluated

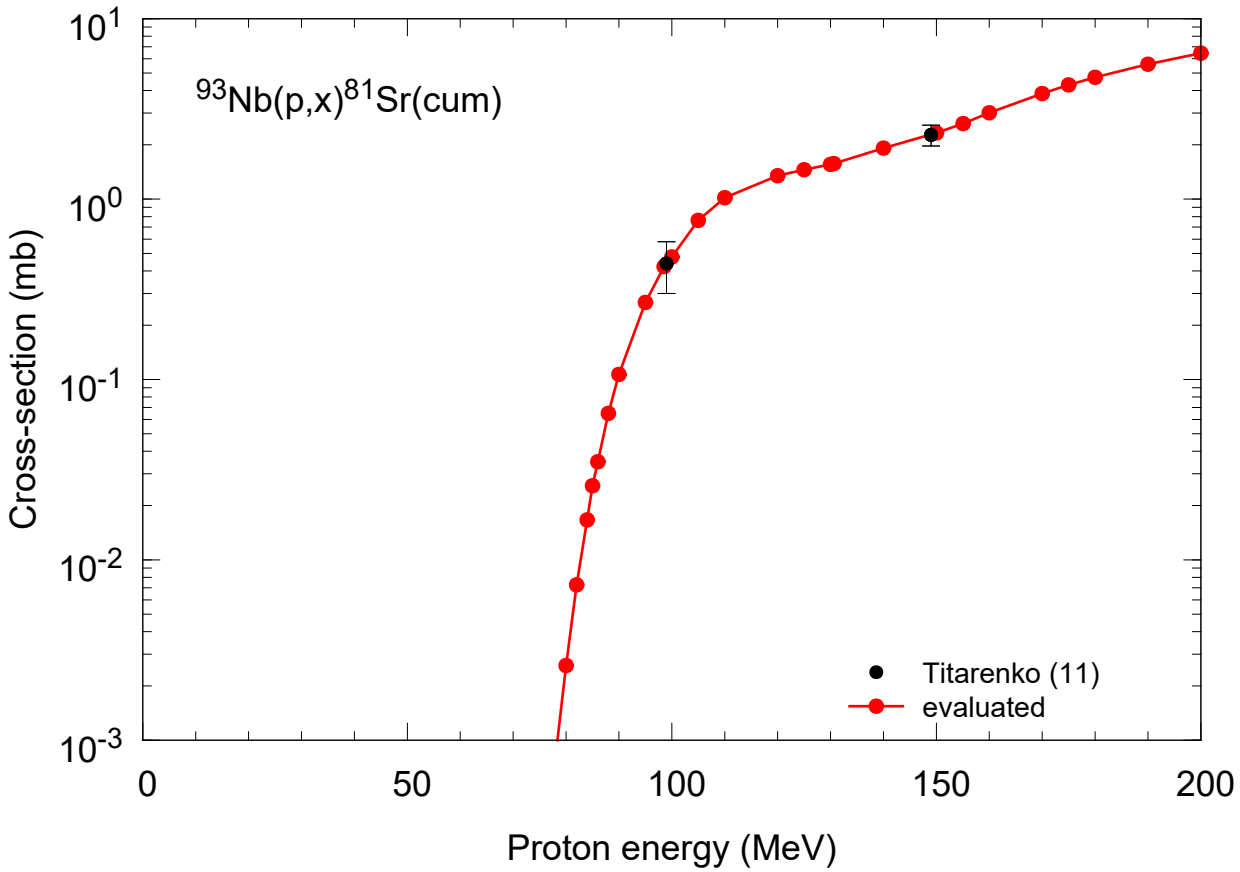

^{93}Nb(p,x)^{83}Rb
Cross-section (mb)
Proton energy (MeV)
Michel (97)
evaluated

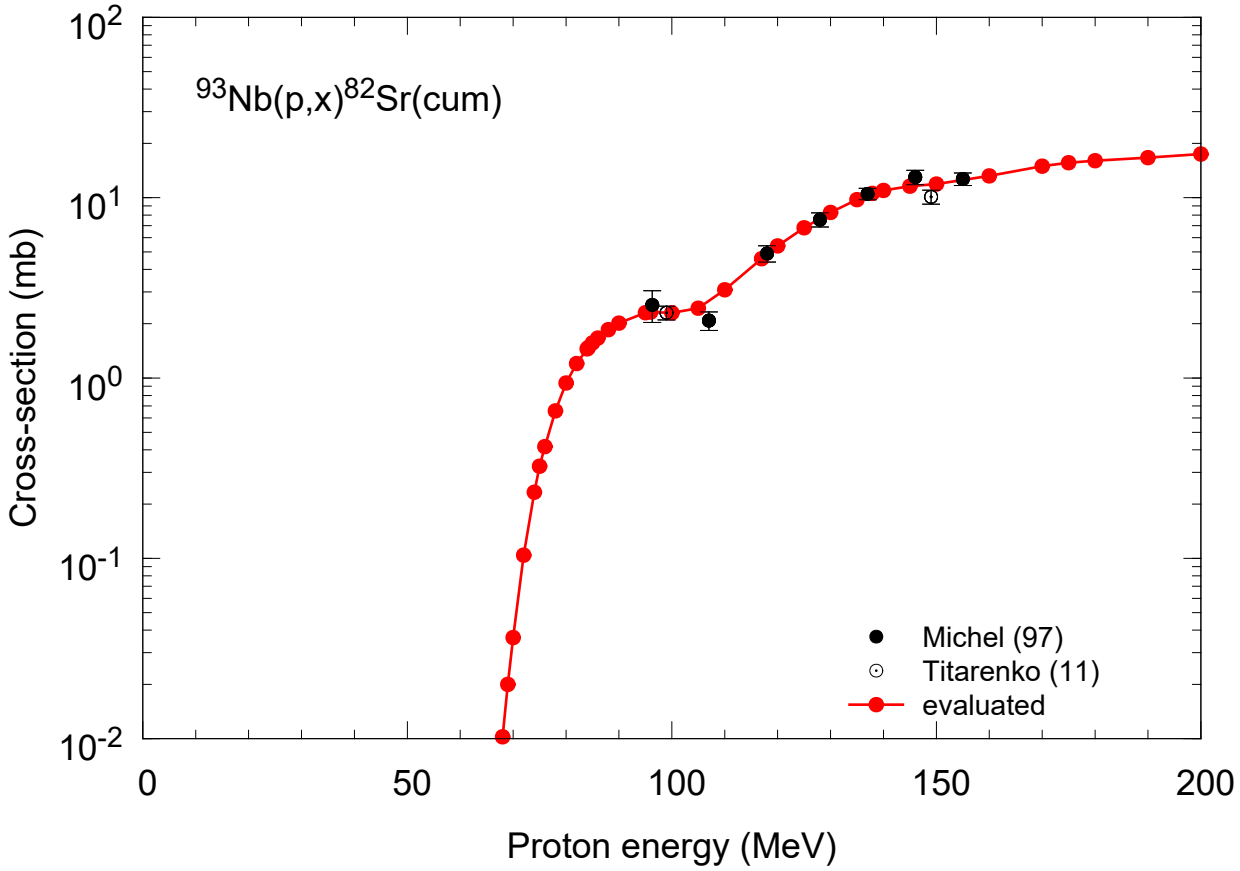

^{93}Nb(p,x)^{83}Rb(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (97)
Titarenko (11)
Fox (21)
evaluated

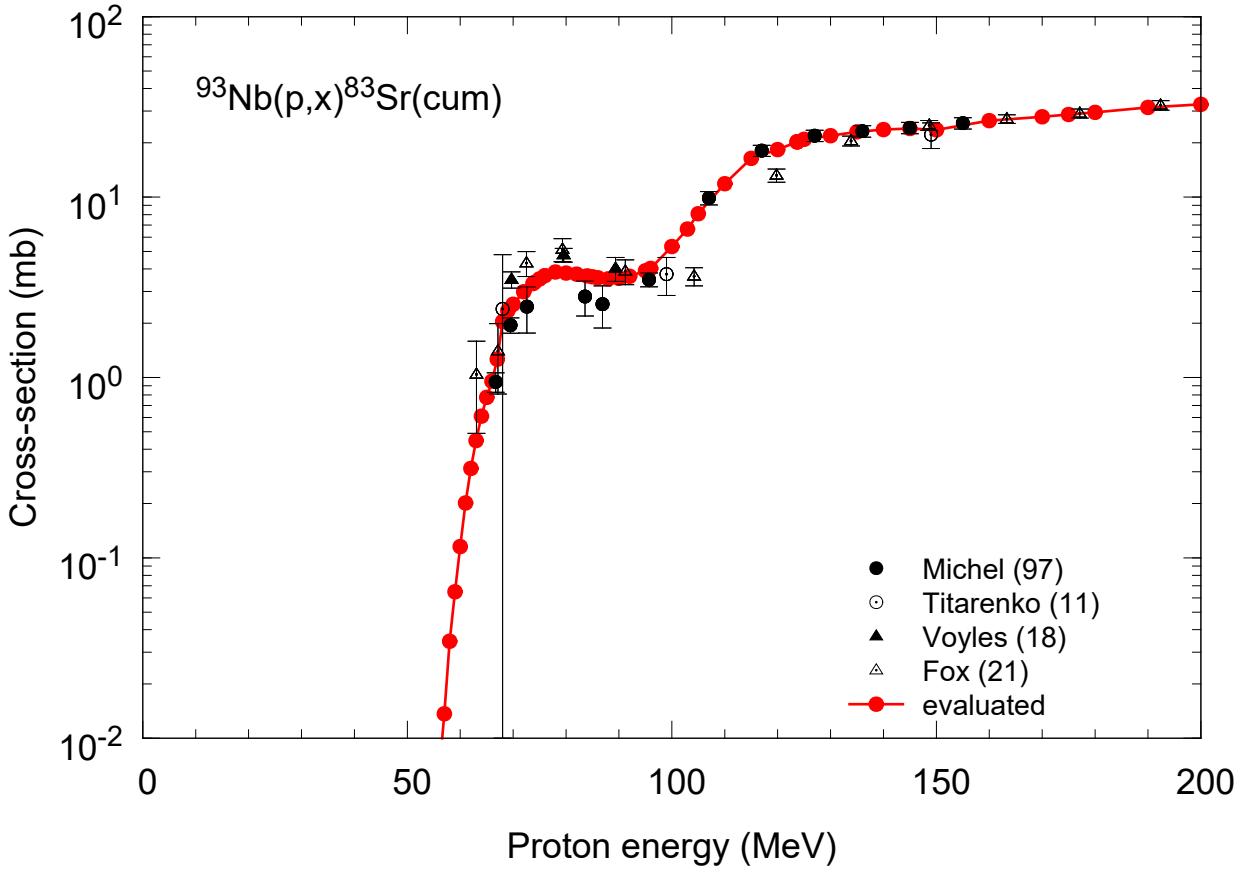

^{93}Nb(p,x)^{84}Rb
Cross-section (mb)
Proton energy (MeV)
Michel (97)
Titarenko (11)
Fox (21)
evaluated

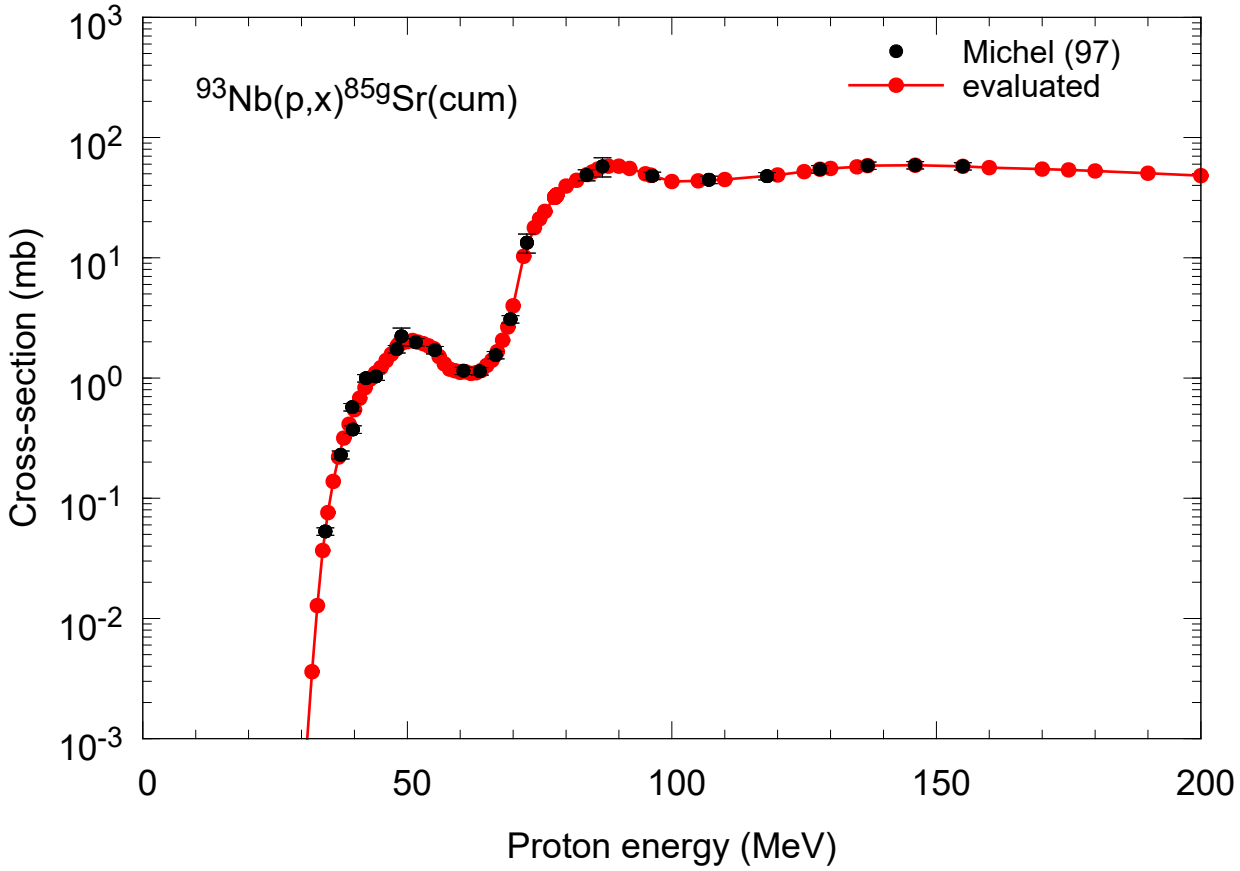

^{93}Nb(p,x)^{84m1}Rb
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
evaluated

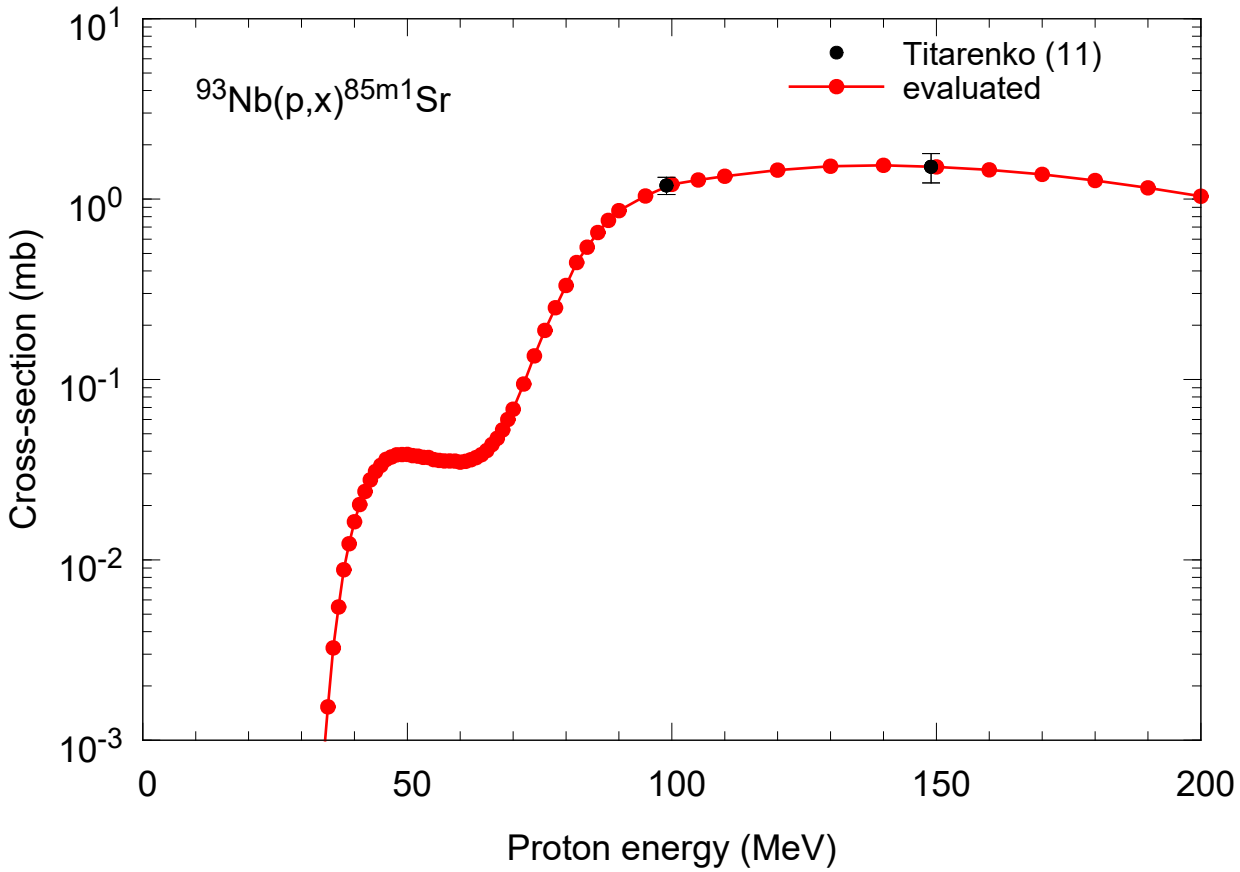

^{93}Nb(p,x)^{86}Rb
Cross-section (mb)
Proton energy (MeV)
Fox (21)
evaluated

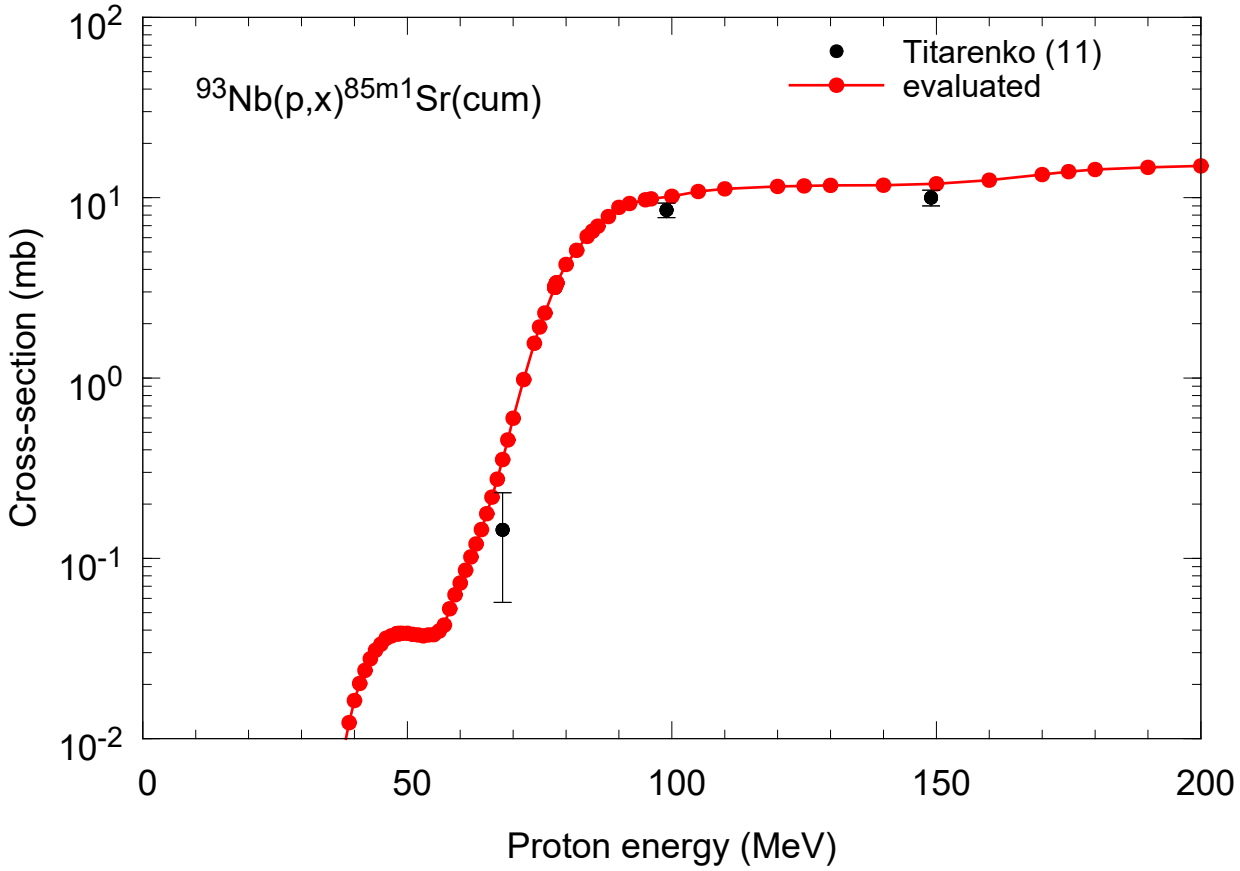

^{93}Nb(p,x)^{81}Sr(cum)
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
evaluated

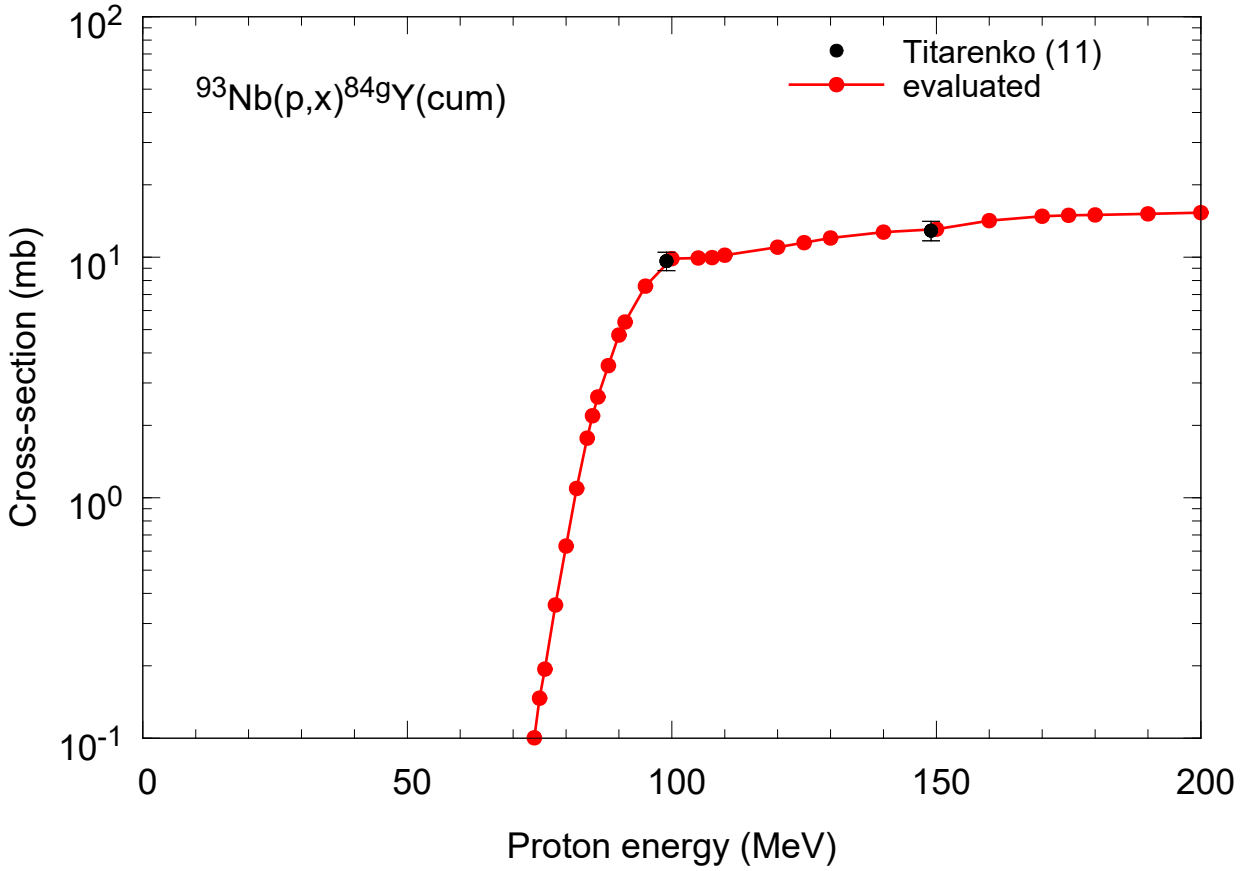

^{93}Nb(p,x)^{82}Sr(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (97)
Titarenko (11)
evaluated

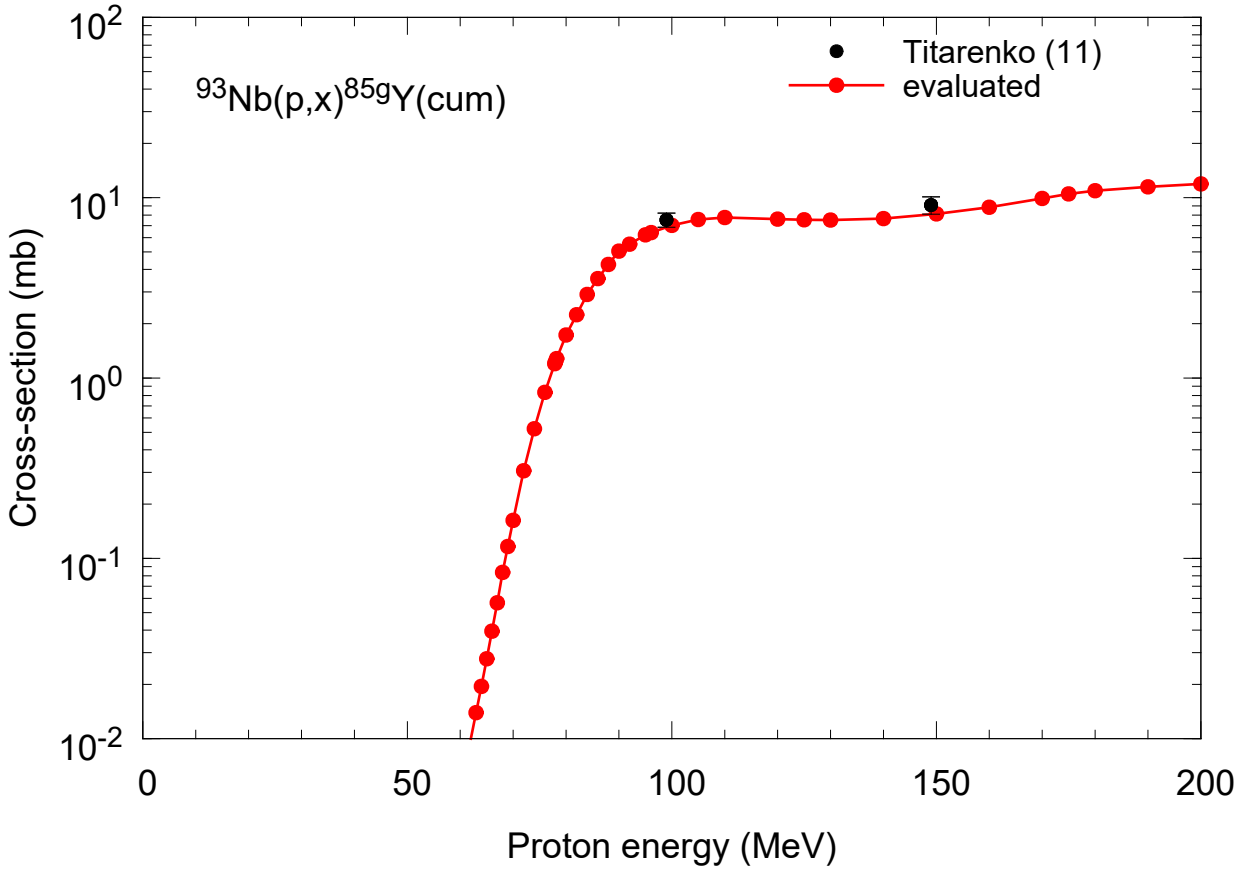

^{93}Nb(p,x)^{83}Sr(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (97)
Titarenko (11)
Voyles (18)
Fox (21)
evaluated

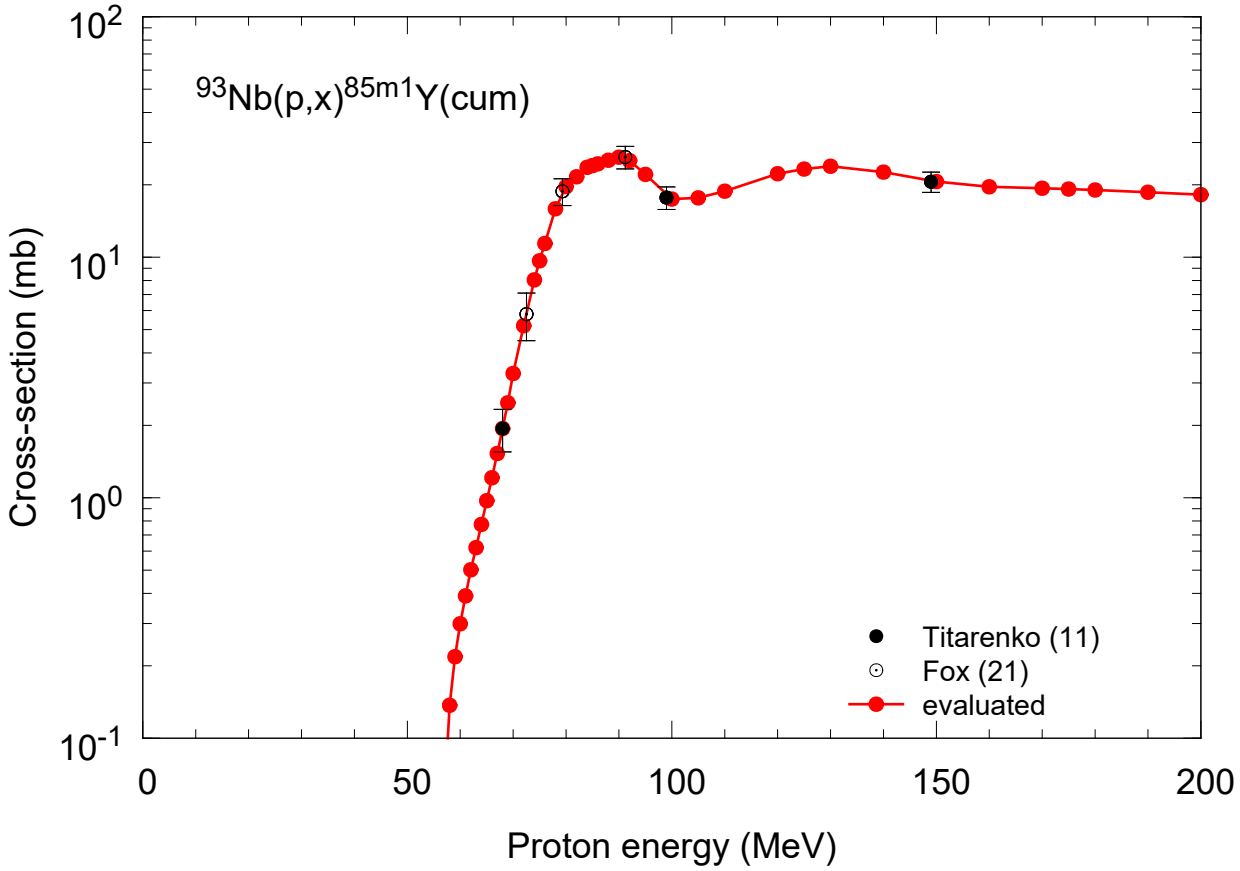

^{93}Nb(p,x)^{85g}Sr(cum)
Michel (97)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200

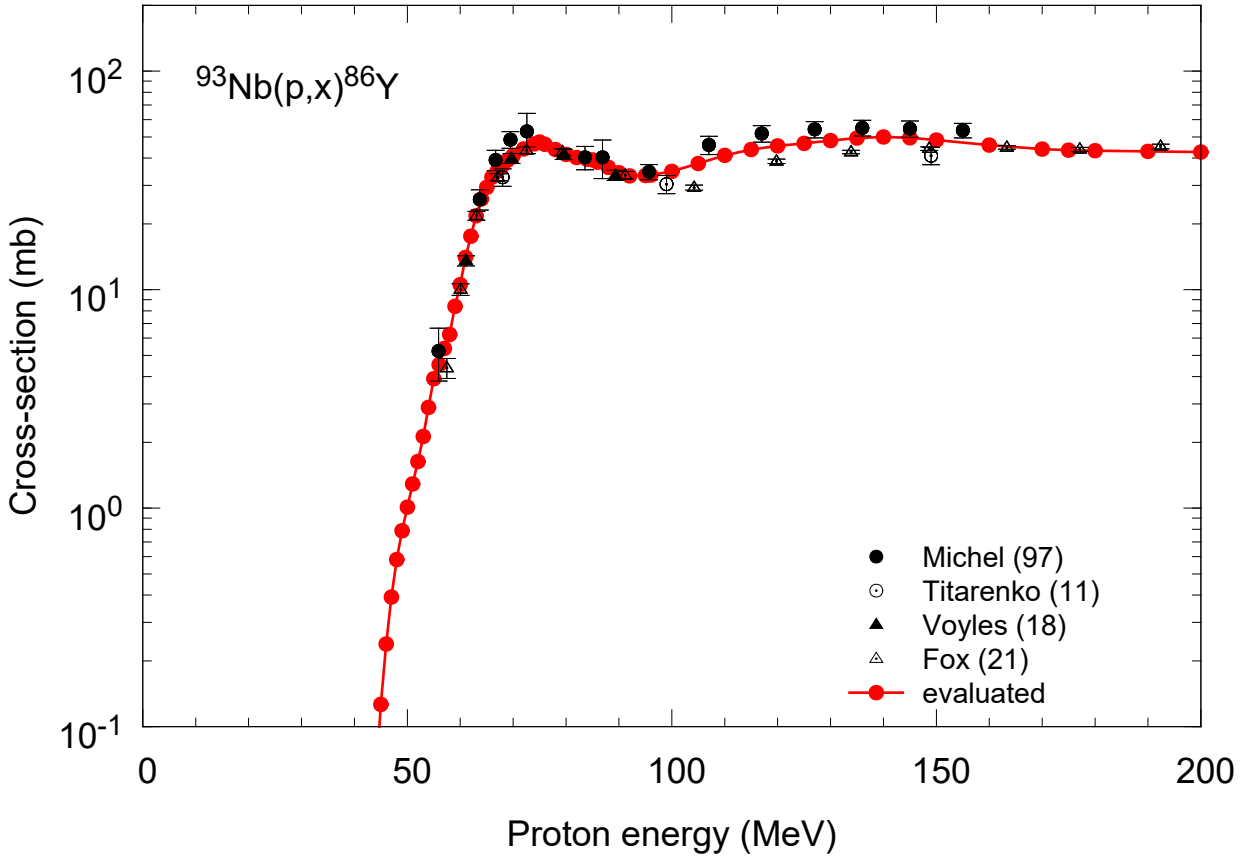

^{93}Nb(p,x)^{85m1}Sr
Titarenko (11)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200

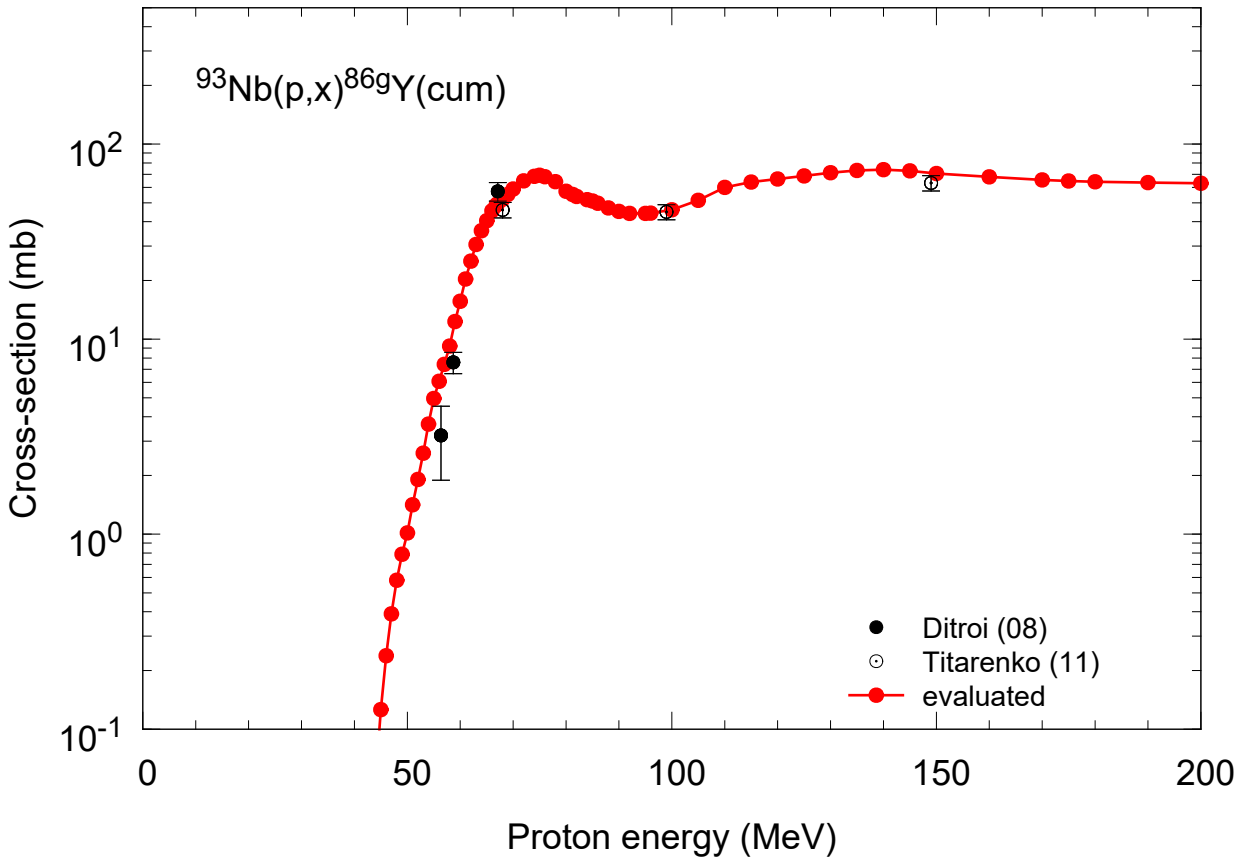

^{93}Nb(p,x)^{85m1}Sr(cum)
Titarenko (11)
evaluated
Cross-section (mb)
Proton energy (MeV)

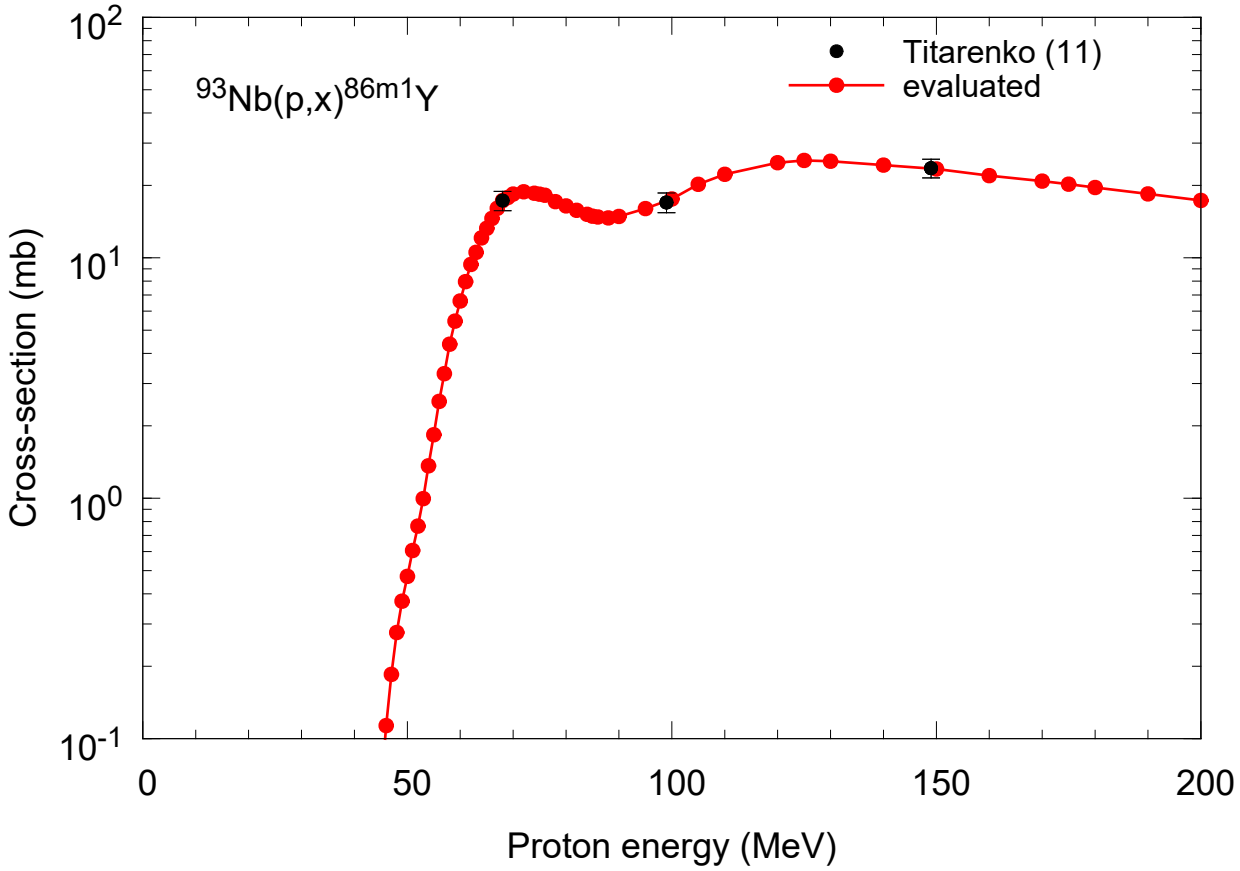

^{93}Nb(p,x)^{84g}Y(cum)
Titarenko (11)
evaluated
Cross-section (mb)
Proton energy (MeV)

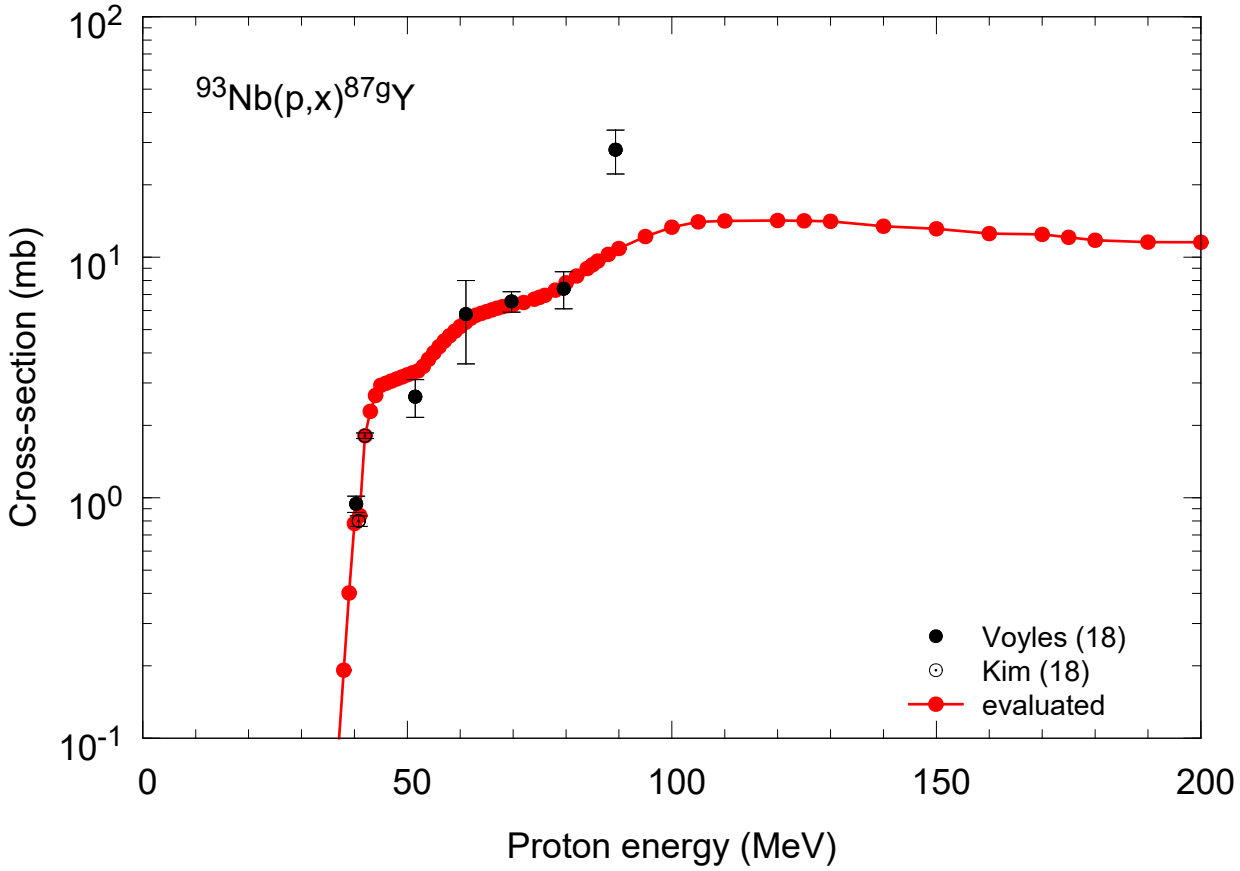

^{93}Nb(p,x)^{85g}Y(cum)
Titarenko (11)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
0
50
100
150
200

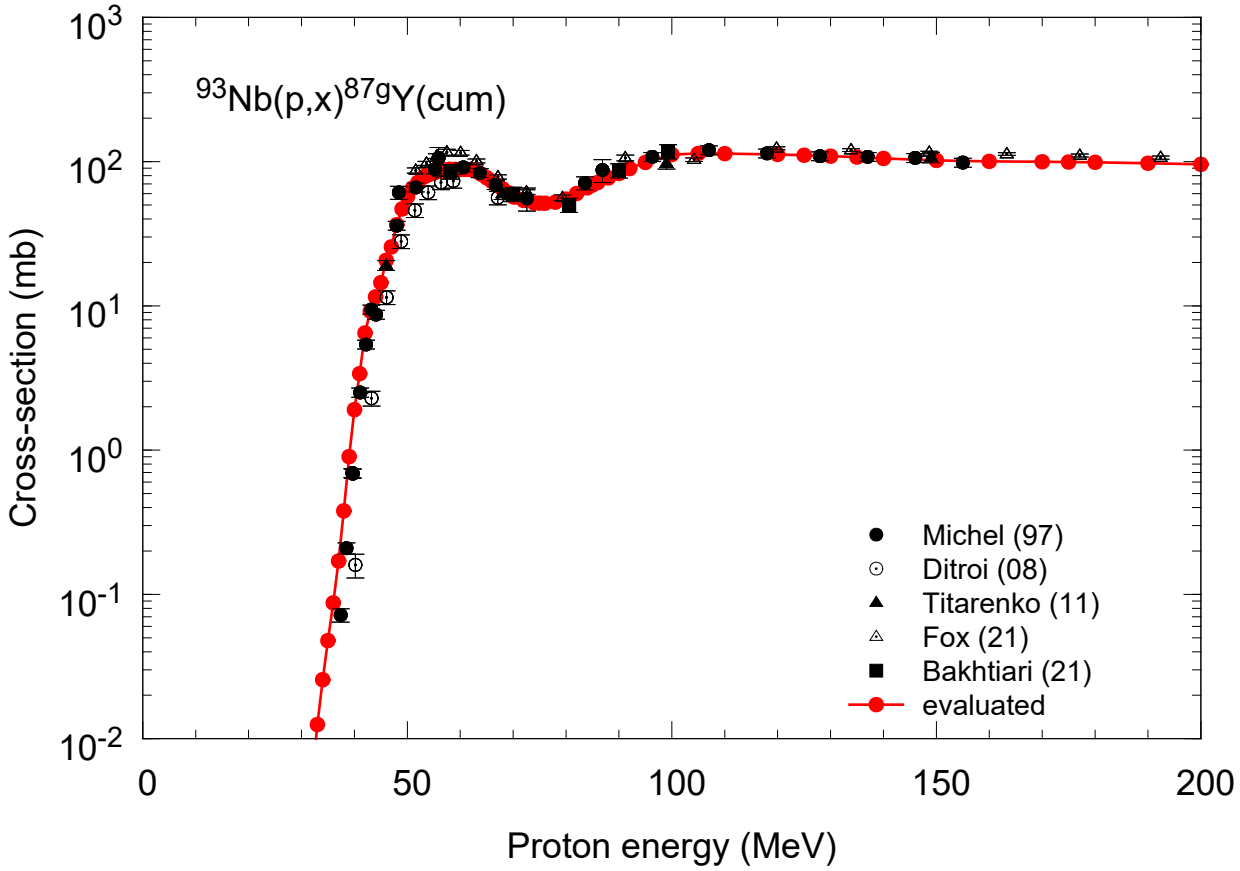

^{93}Nb(p,x)^{85m1}Y(cum)
Titarenko (11)
Fox (21)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{2}
10^{1}
10^{0}
10^{-1}
0
50
100
150
200

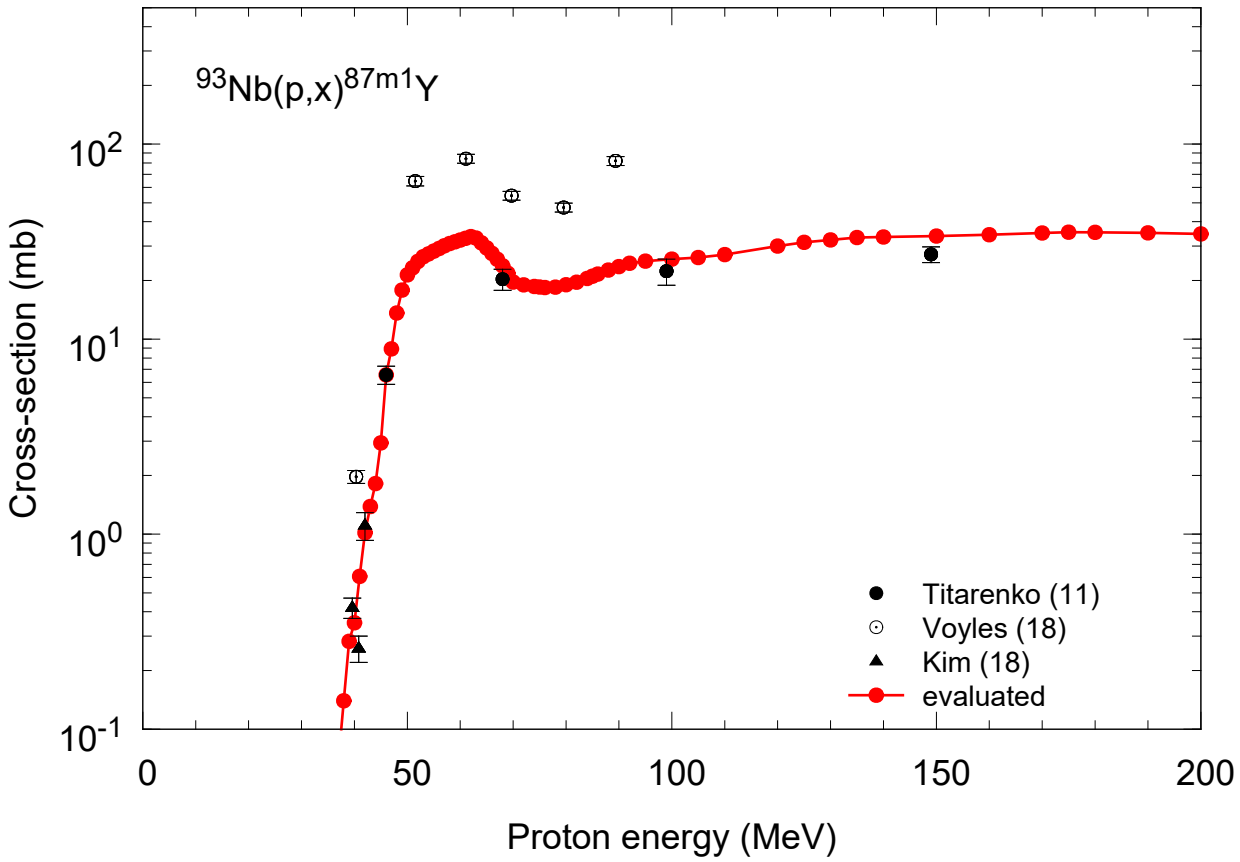

^{93}Nb(p,x)^{86}Y
Cross-section (mb)
Proton energy (MeV)
Michel (97)
Titarenko (11)
Voyles (18)
Fox (21)
evaluated

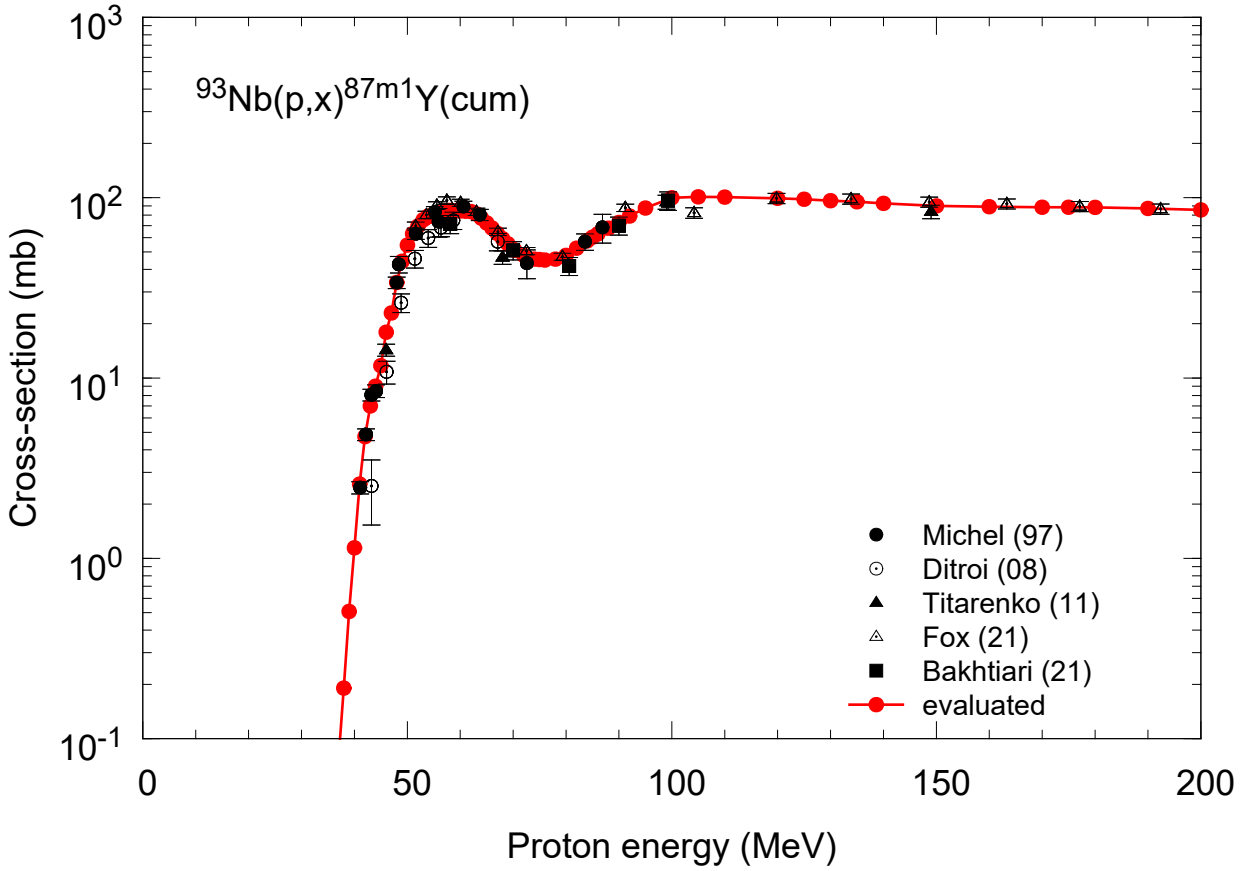

^{93}Nb(p,x)^{86g}Y(cum)
Cross-section (mb)
Proton energy (MeV)
Ditroi (08)
Titarenko (11)
evaluated

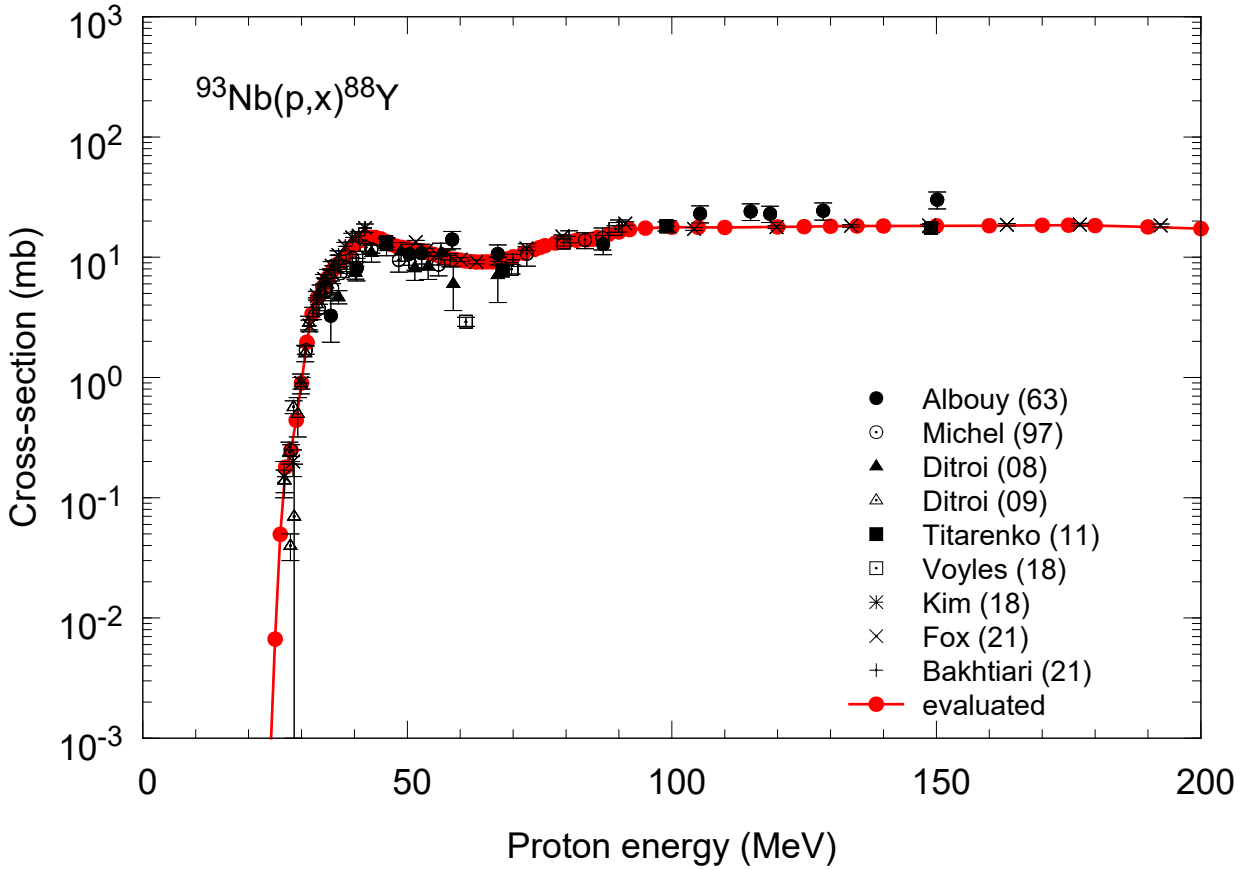

^{93}Nb(p,x)^{86m1}Y
Titarenko (11)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^2
10^1
10^0
10^{-1}
0
50
100
150
200

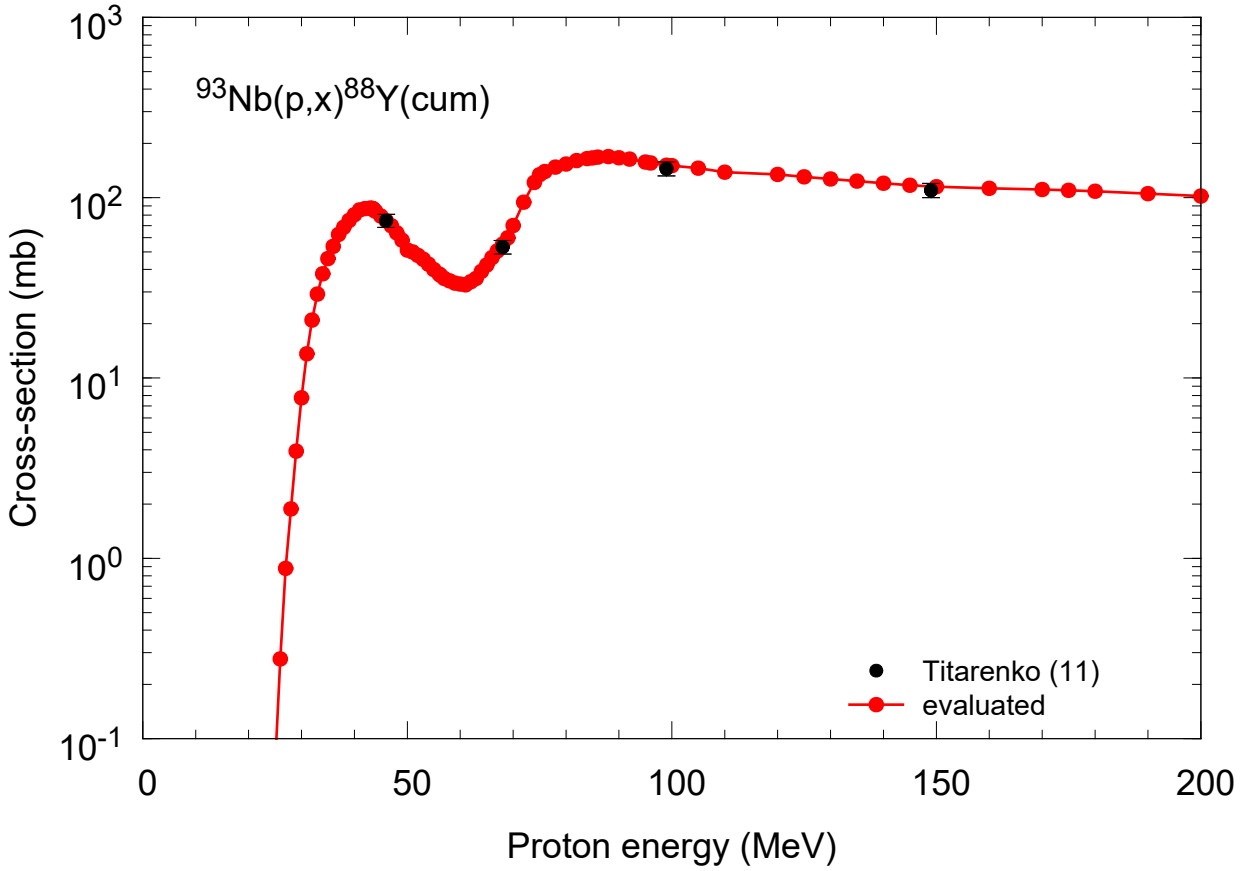

^{93}Nb(p,x)^{87g}Y
Voyles (18)
Kim (18)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^2
10^1
10^0
10^{-1}
0
50
100
150
200

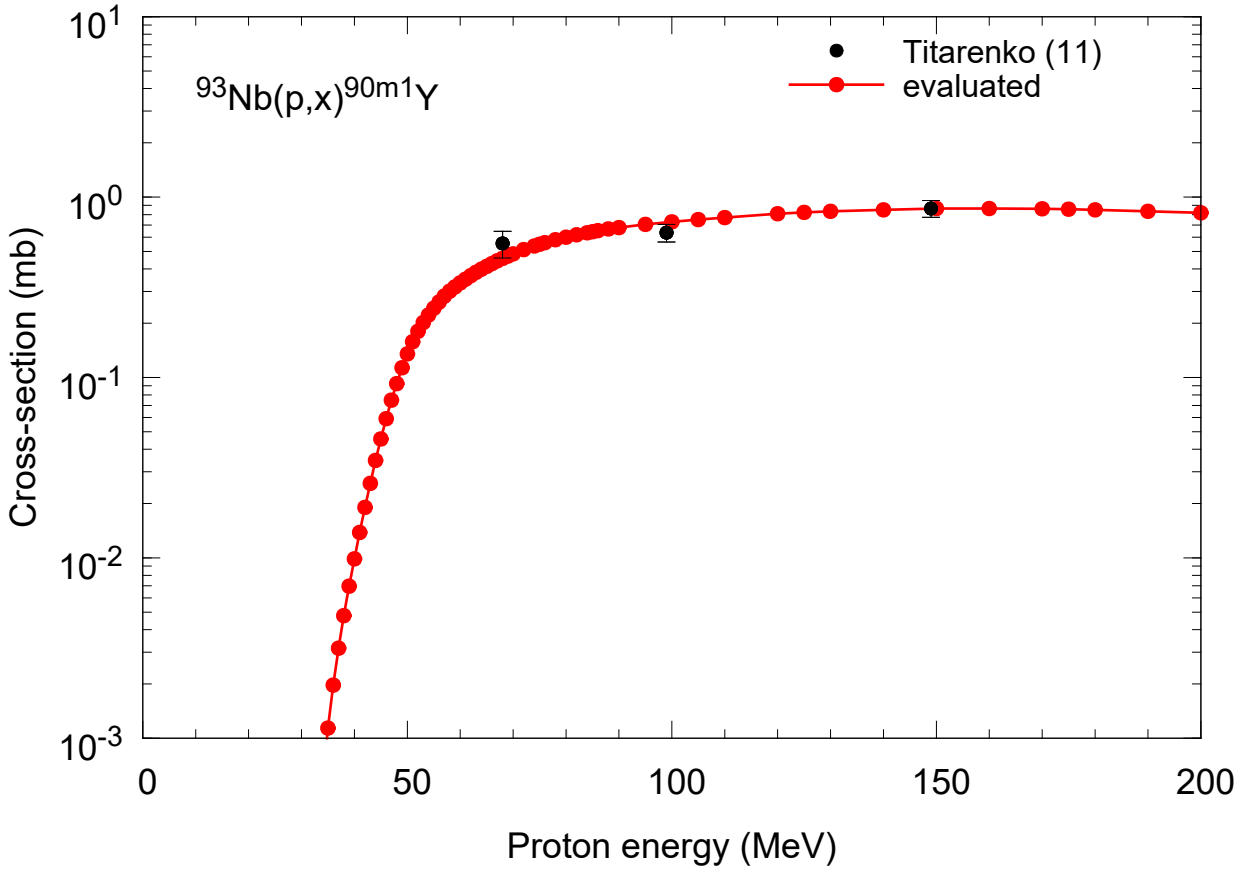

^{93}Nb(p,x)^{87g}Y(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (97)
Ditroi (08)
Titarenko (11)
Fox (21)
Bakhtiari (21)
evaluated

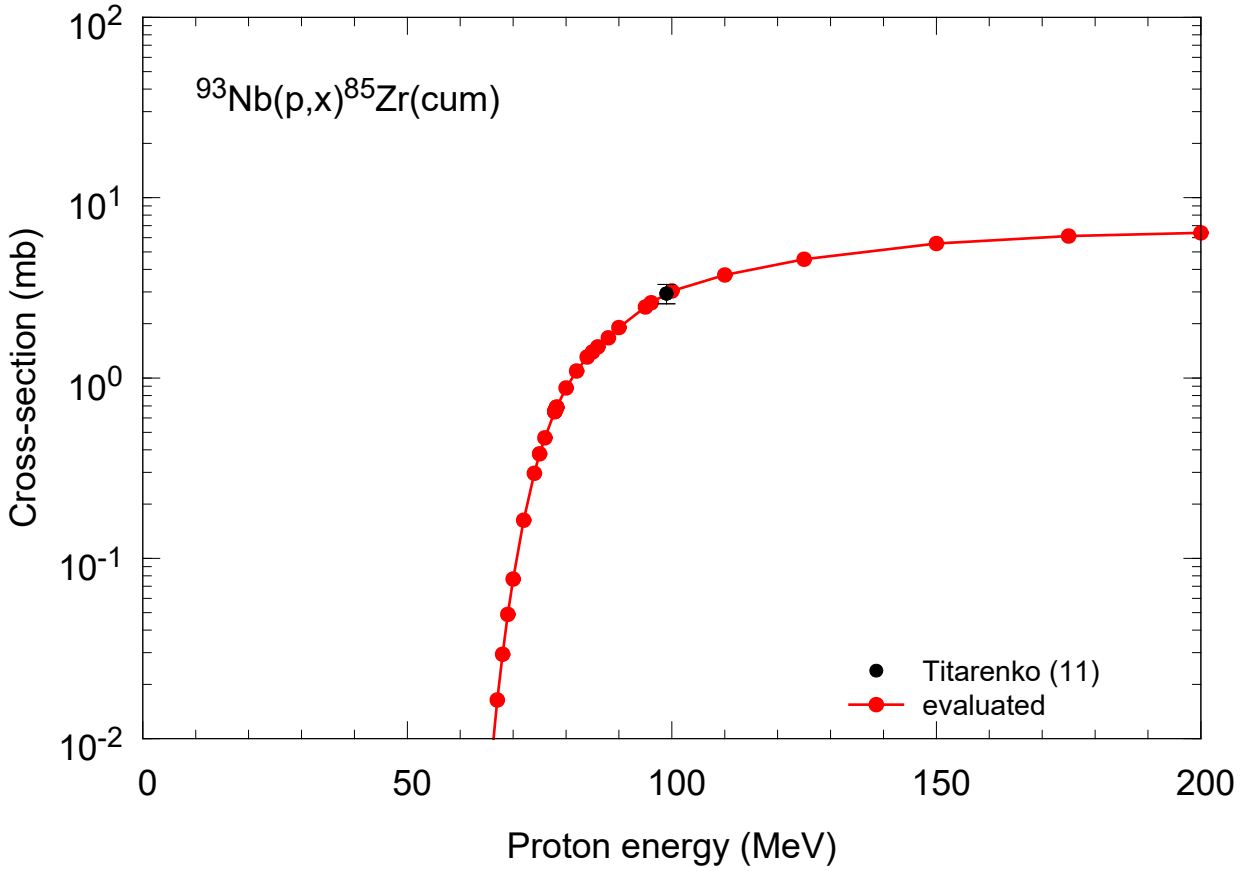

^{93}Nb(p,x)^{87m1}Y
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
Voyles (18)
Kim (18)
evaluated

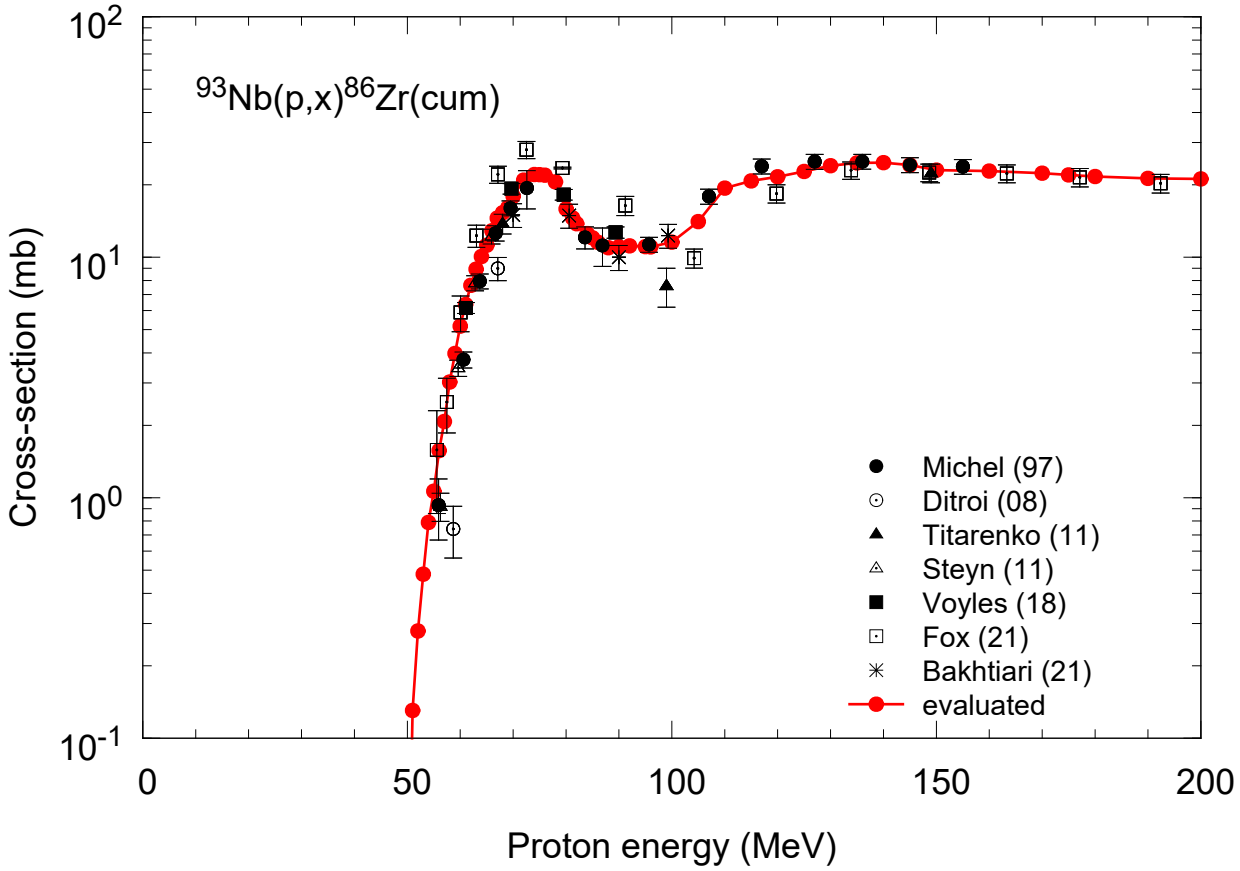

^{93}Nb(p,x)^{87m1}Y(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (97)
Ditroi (08)
Titarenko (11)
Fox (21)
Bakhtiari (21)
evaluated

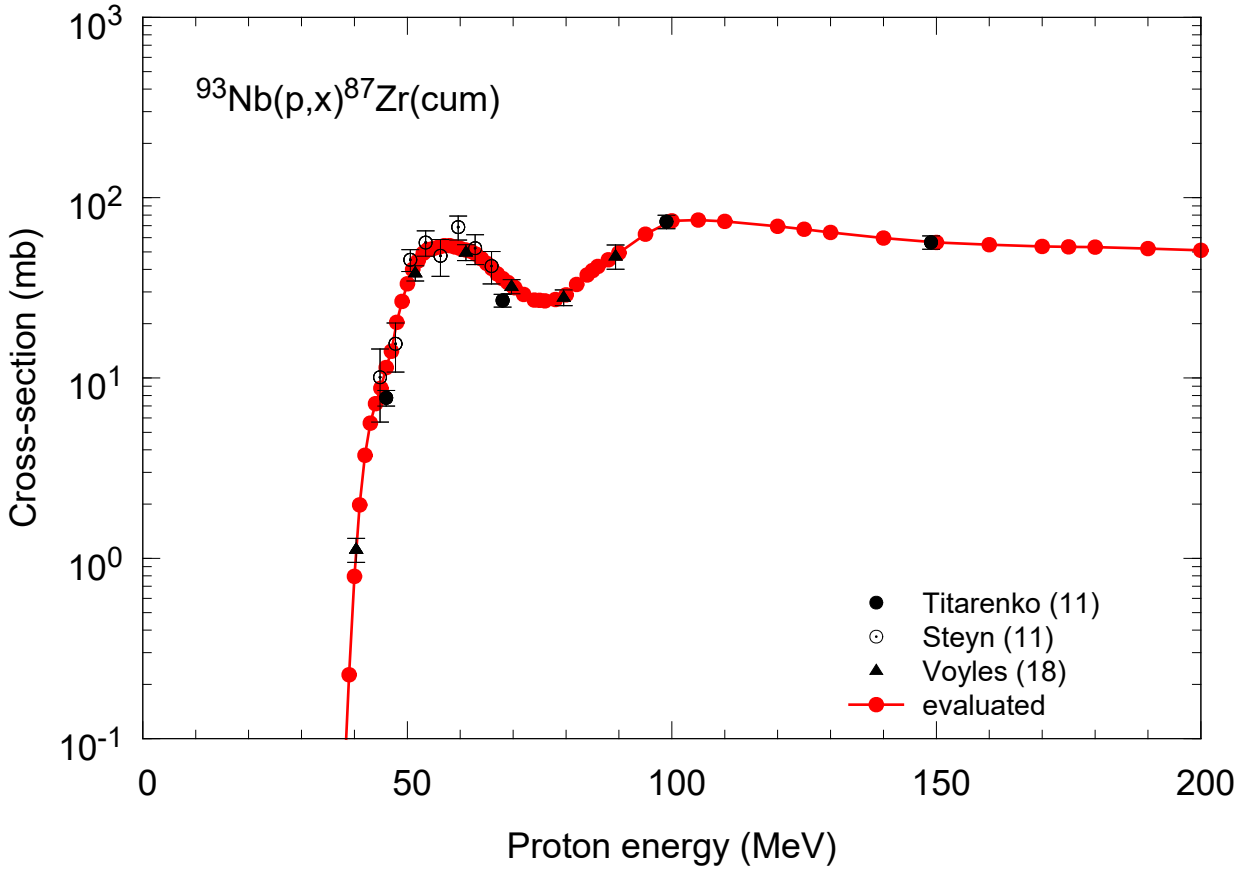

^{93}Nb(p,x)^{88}Y
Cross-section (mb)
Proton energy (MeV)
Albouy (63)
Michel (97)
Ditroi (08)
Ditroi (09)
Titarenko (11)
Voyles (18)
Kim (18)
Fox (21)
Bakhtiari (21)
evaluated

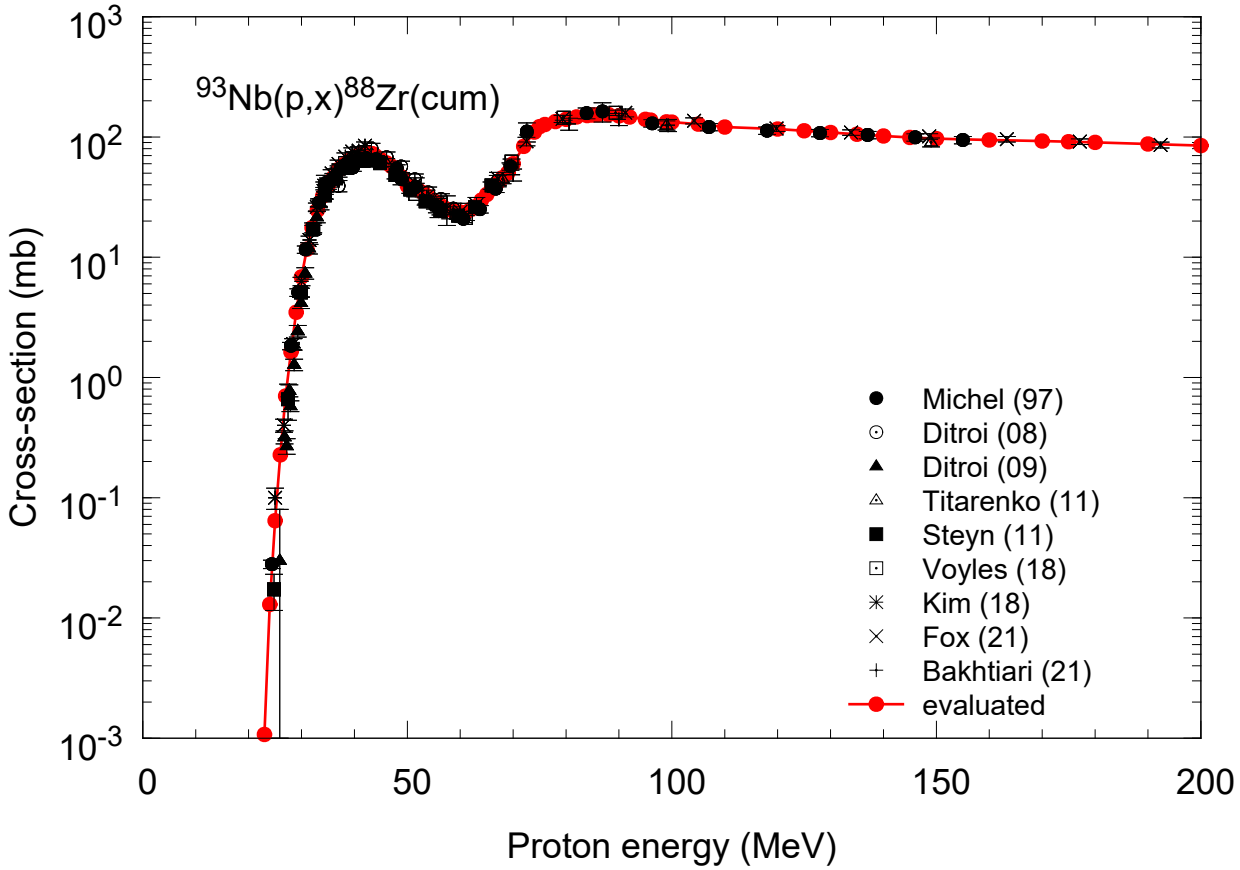

^{93}Nb(p,x)^{88}Y(cum)
Titarenko (11)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^3
10^2
10^1
10^0
10^{-1}
0
50
100
150
200

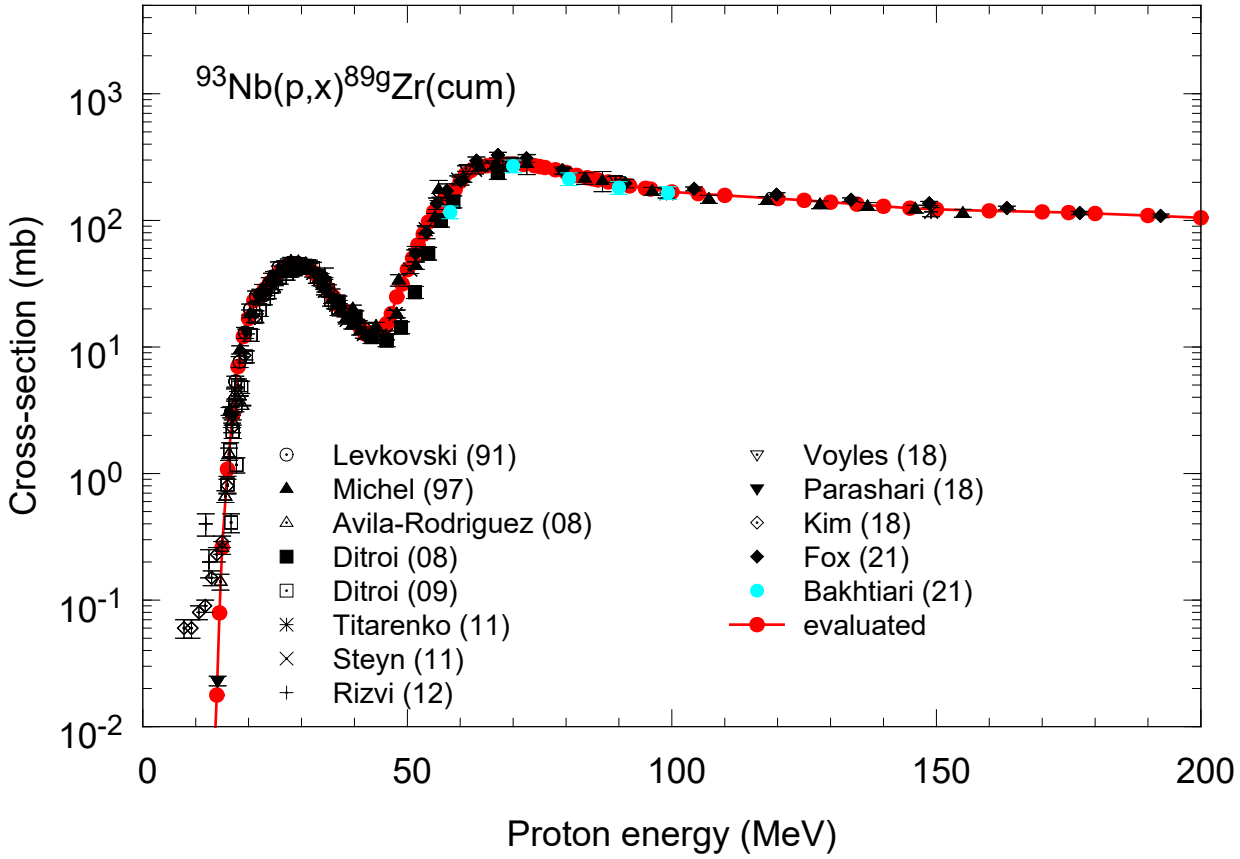

^{93}Nb(p,x)^{90m1}Y
Titarenko (11)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200

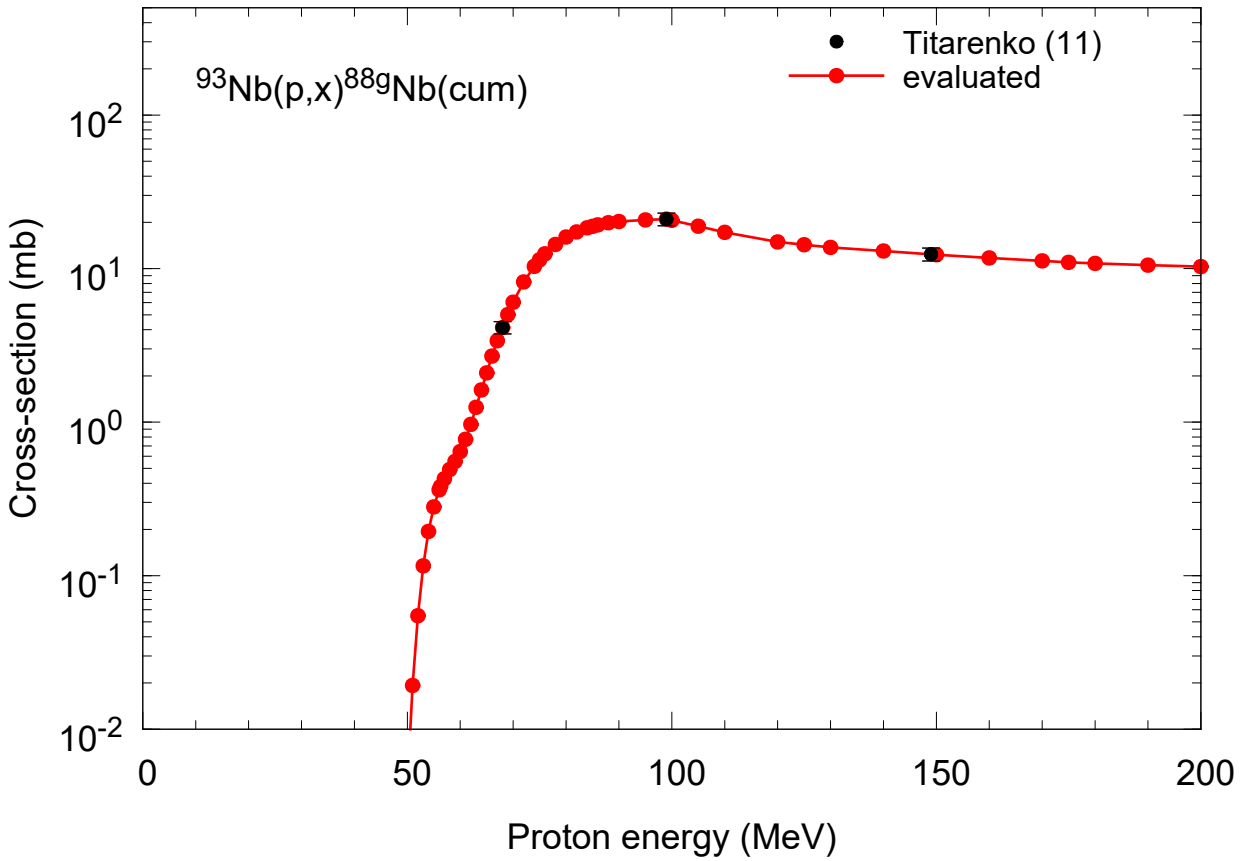

^{93}Nb(p,x)^{85}Zr(cum)
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
evaluated

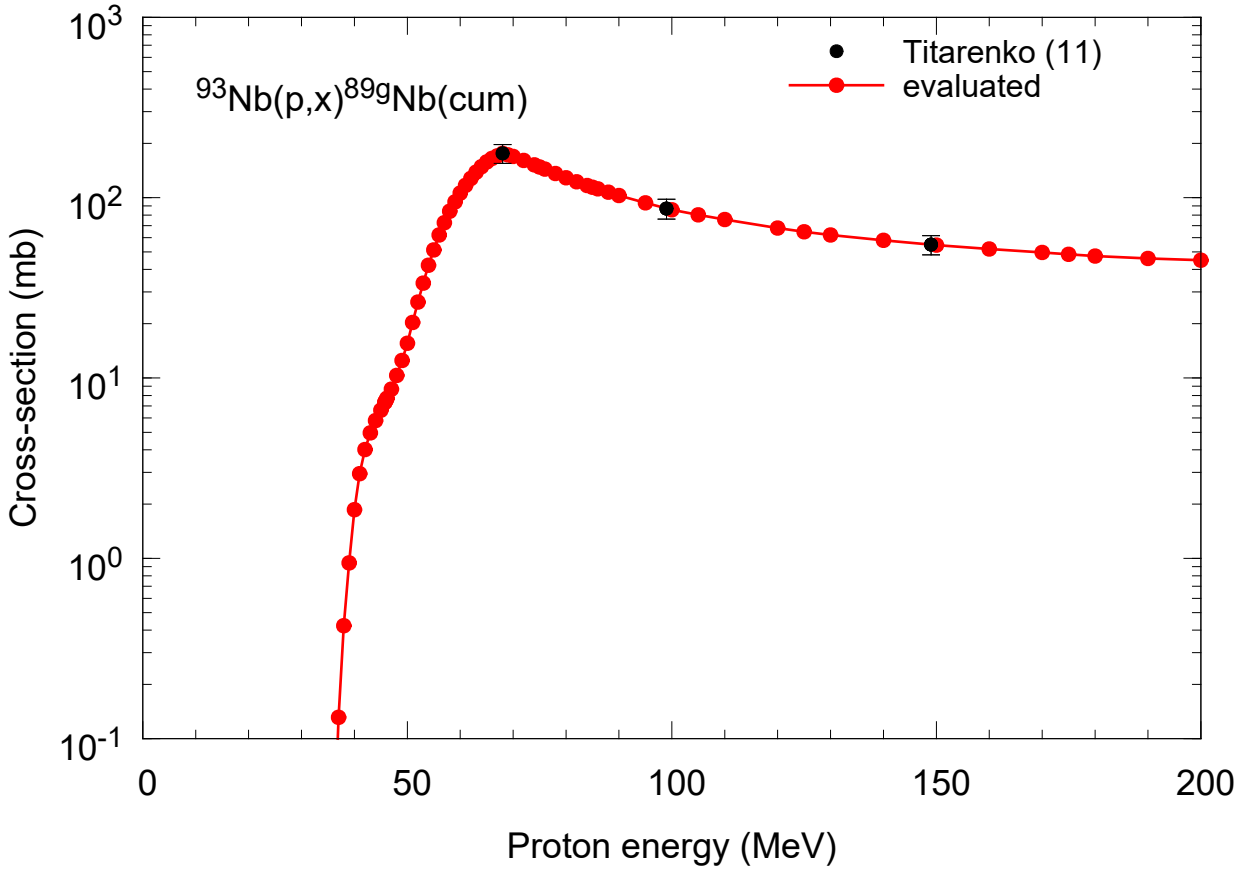

^{93}Nb(p,x)^{86}Zr(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (97)
Ditroi (08)
Titarenko (11)
Steyn (11)
Voyles (18)
Fox (21)
Bakhtiari (21)
evaluated

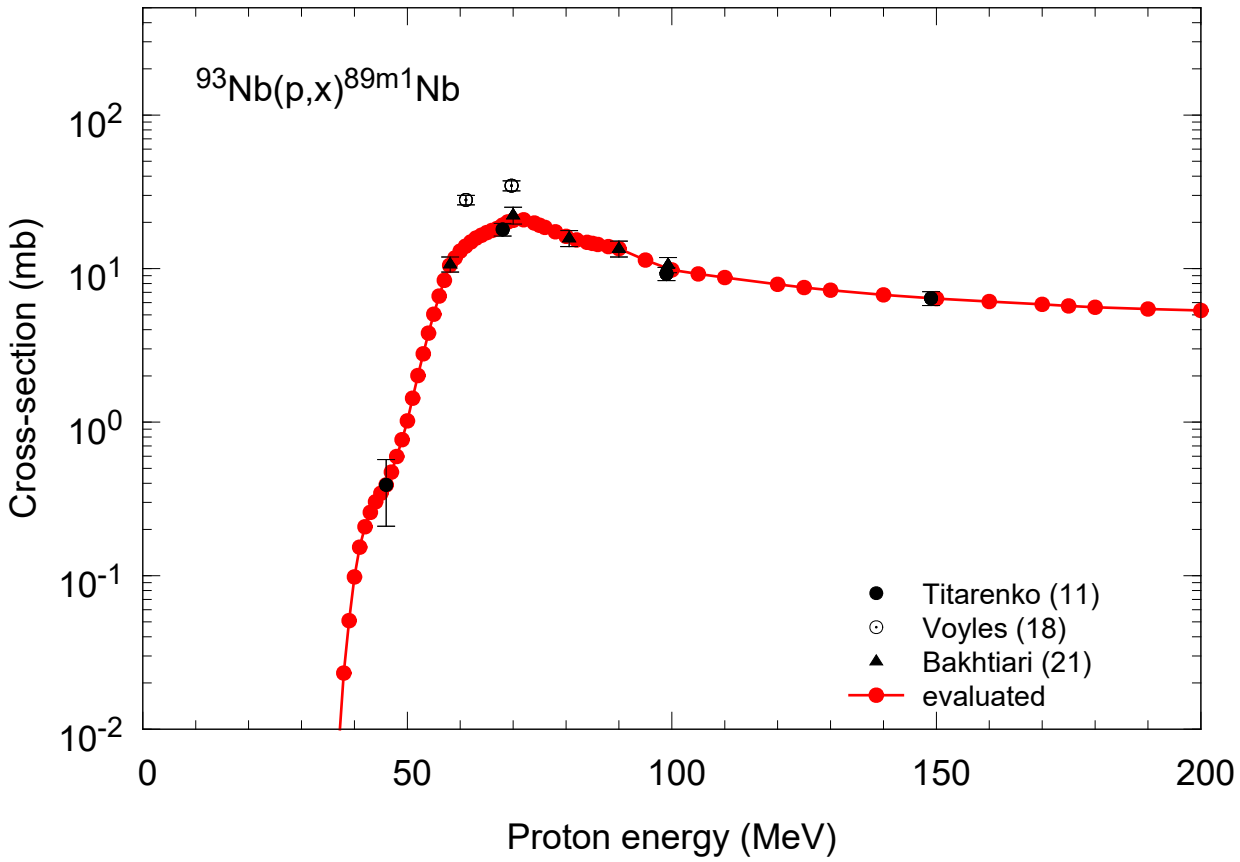

^{93}Nb(p,x)^{87}Zr(cum)
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
Steyn (11)
Voyles (18)
evaluated

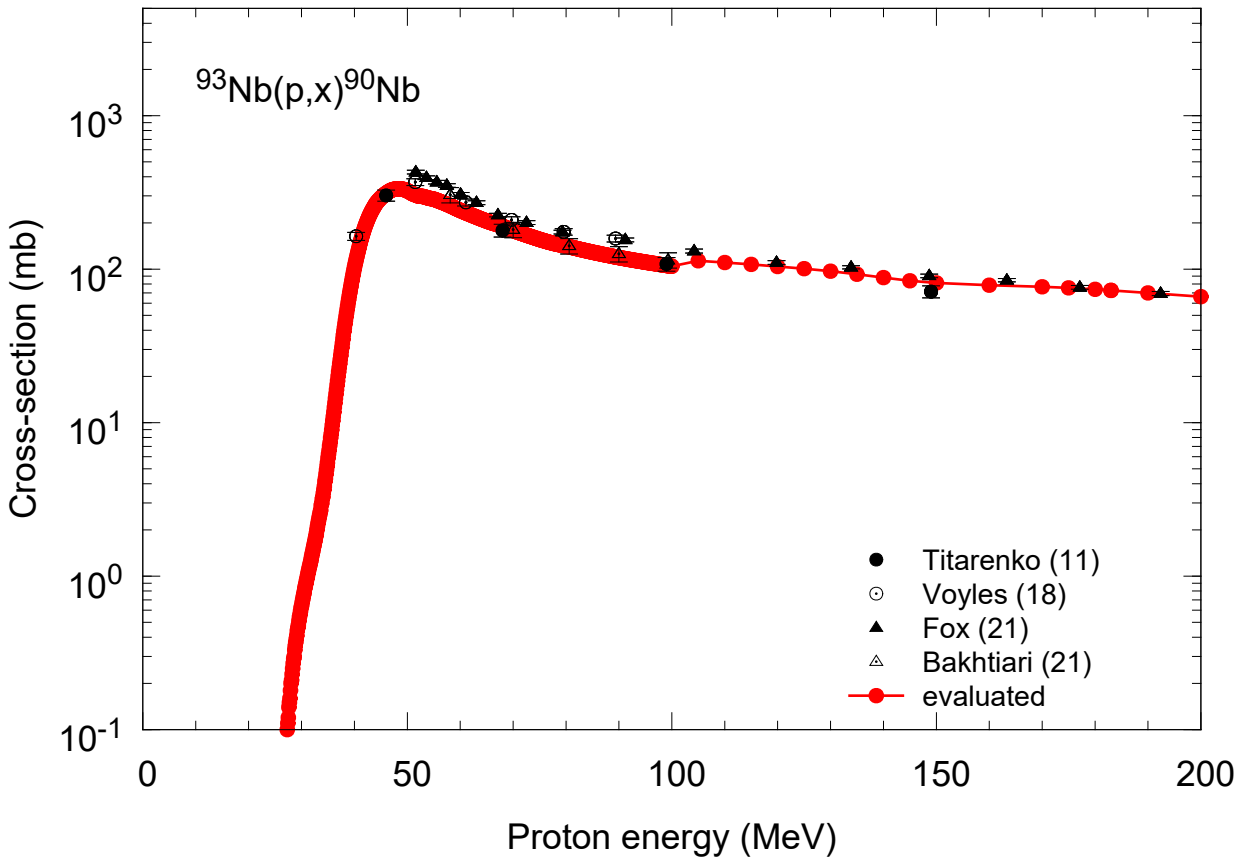

^{93}Nb(p,x)^{88}Zr(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (97)
Ditroi (08)
Ditroi (09)
Titarenko (11)
Steyn (11)
Voyles (18)
Kim (18)
Fox (21)
Bakhtiari (21)
evaluated

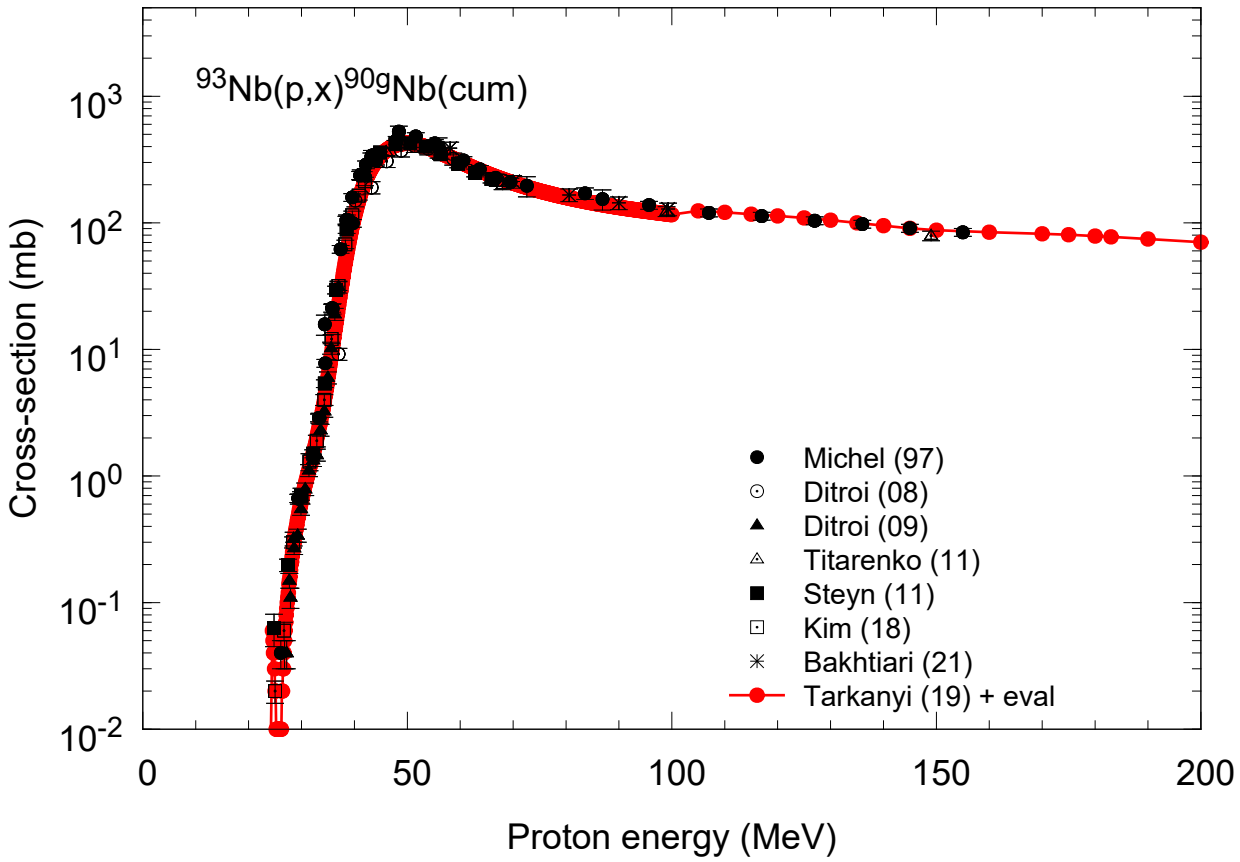

^{93}Nb(p,x)^{89g}Zr(cum)
Cross-section (mb)
Proton energy (MeV)
Levkovski (91)
Michel (97)
Avila-Rodriguez (08)
Ditroi (08)
Ditroi (09)
Titarenko (11)
Steyn (11)
Rizvi (12)
Voyles (18)
Parashari (18)
Kim (18)
Fox (21)
Bakhtiari (21)
evaluated

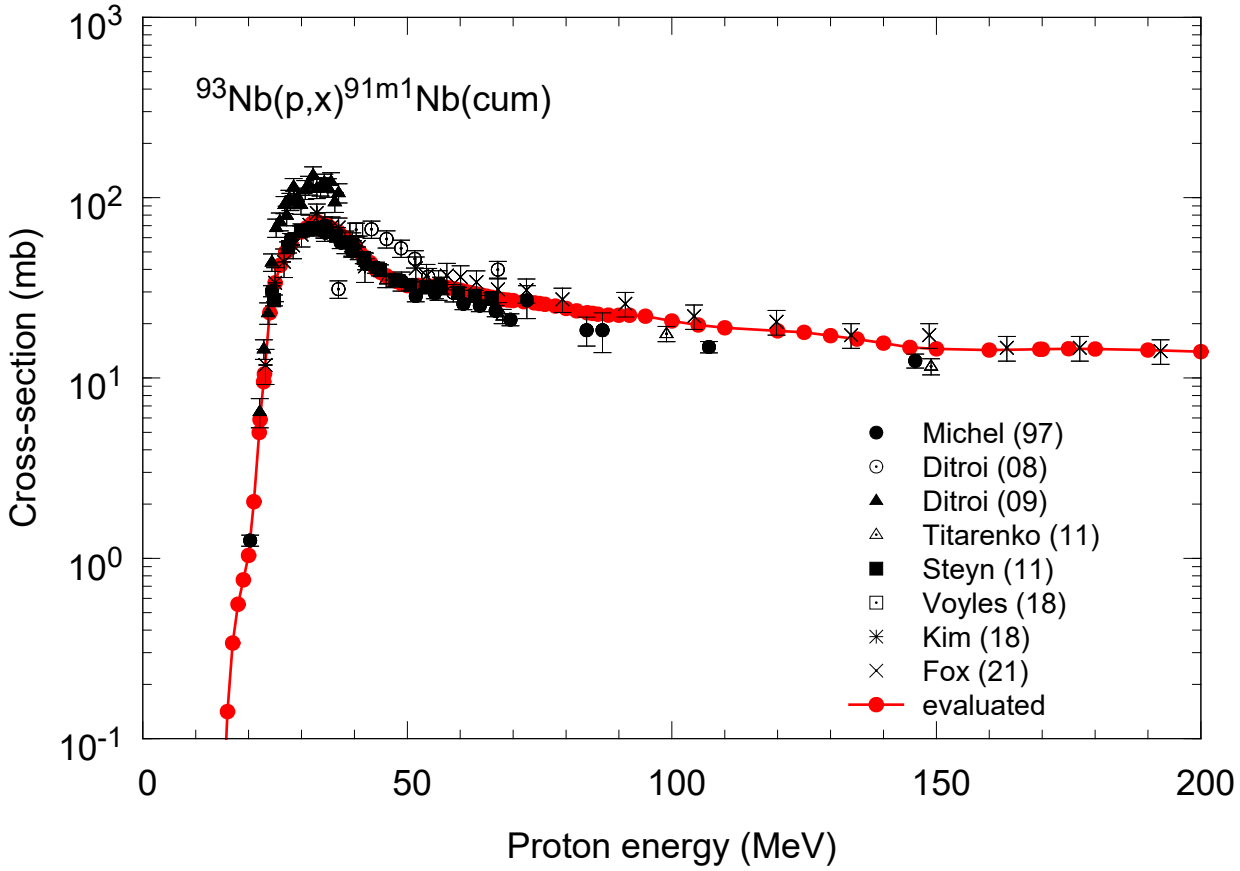

^{93}Nb(p,x)^{88g}Nb(cum)
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
evaluated

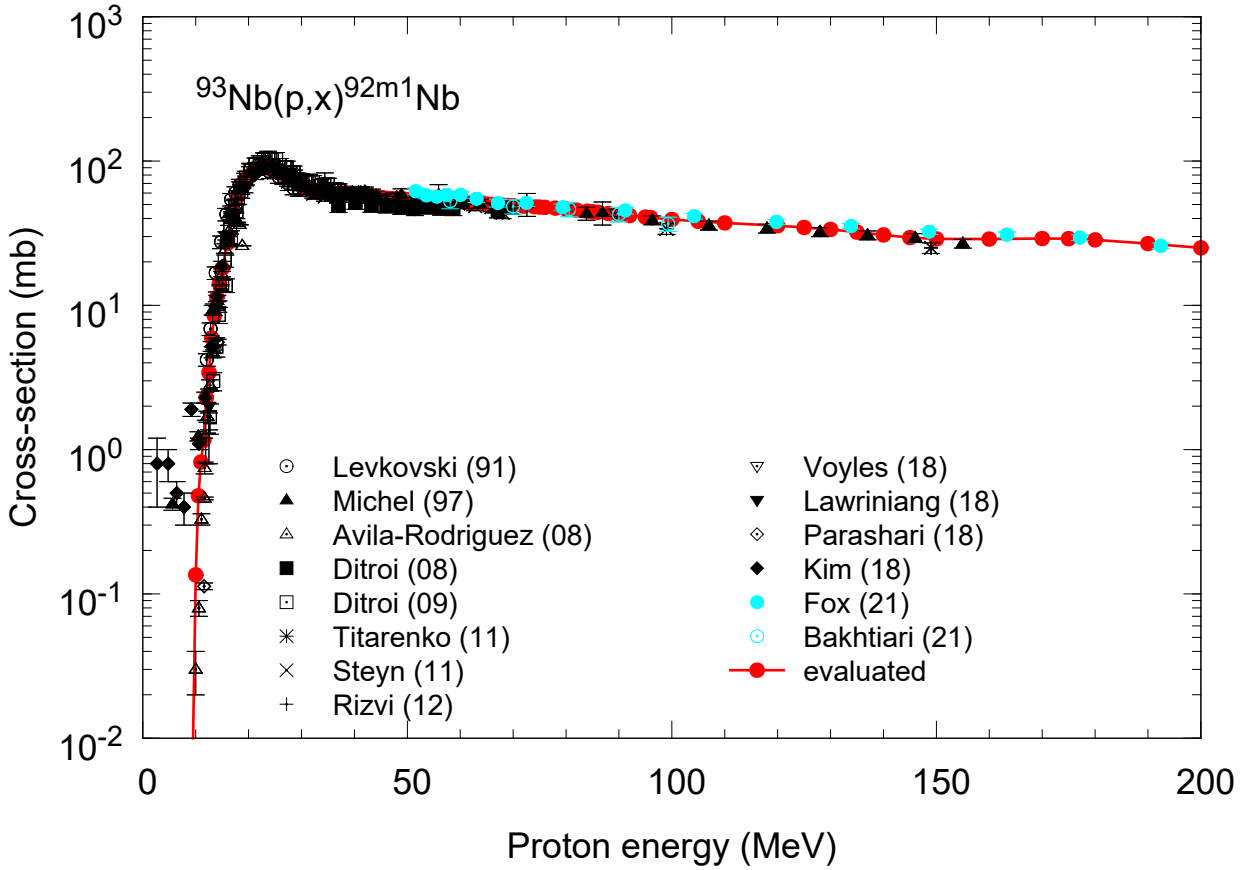

^{93}Nb(p,x)^{89g}Nb(cum)
Titarenko (11)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
0
50
100
150
200

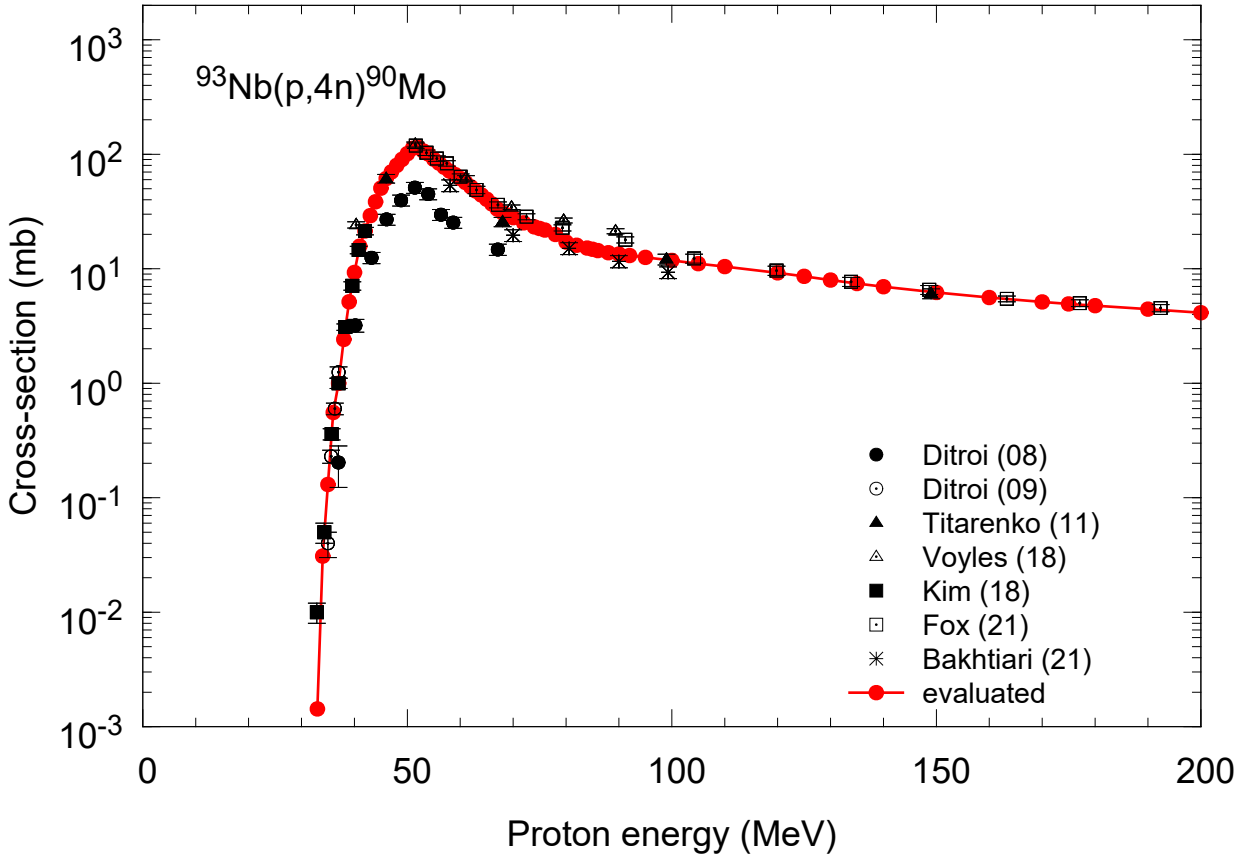

^{93}Nb(p,x)^{89m1}Nb
Titarenko (11)
Voyles (18)
Bakhtiari (21)
evaluated
Cross-section (mb)
Proton energy (MeV)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
0
50
100
150
200

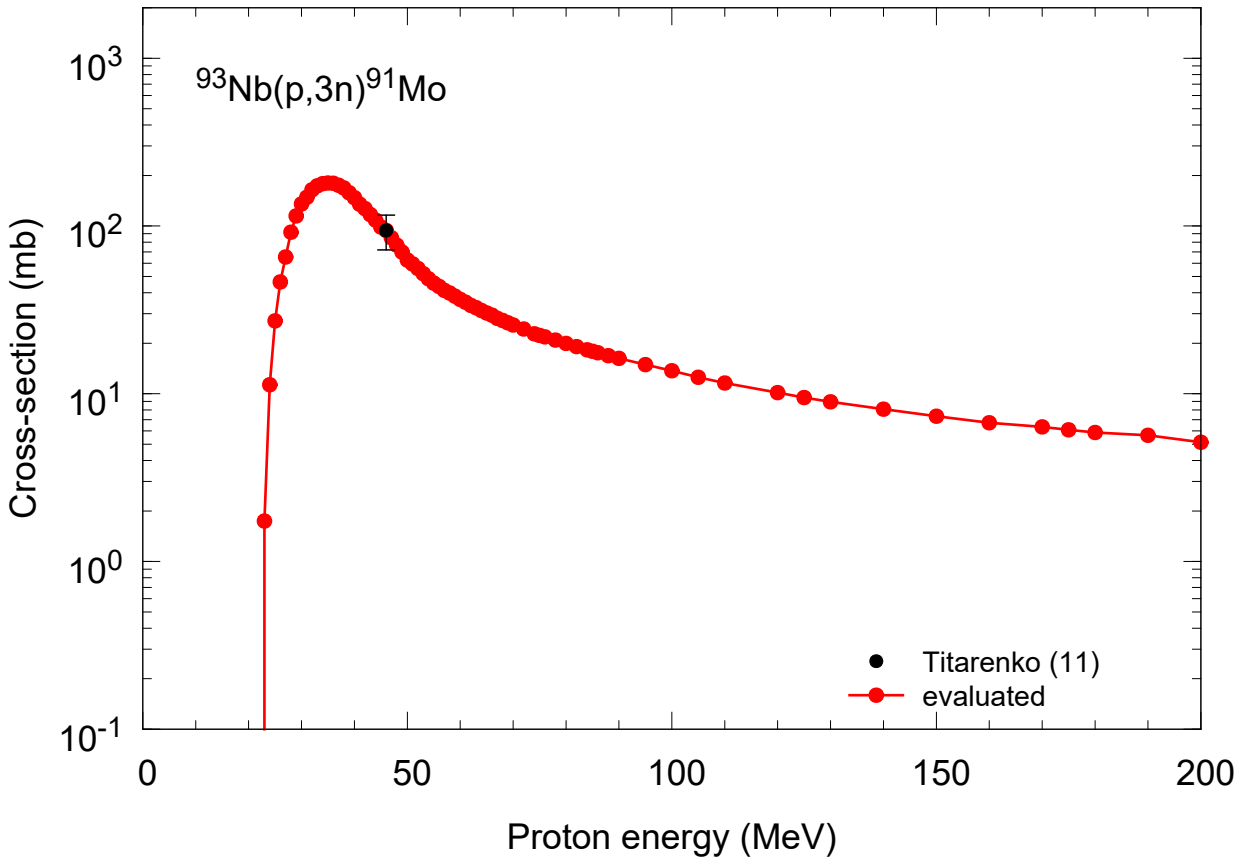

^{93}Nb(p,x)^{90}Nb
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
Voyles (18)
Fox (21)
Bakhtiari (21)
evaluated

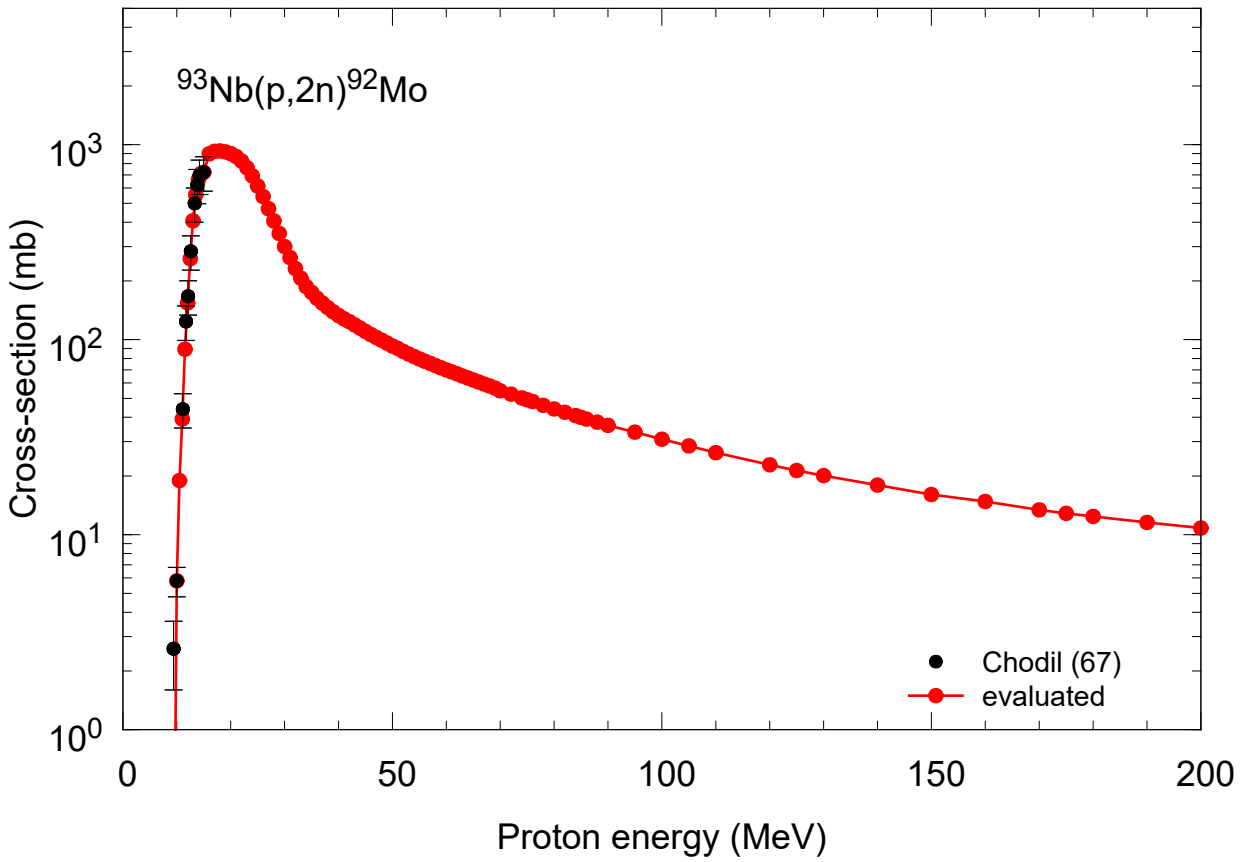

^{93}Nb(p,x)^{90g}Nb(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (97)
Ditroi (08)
Ditroi (09)
Titarenko (11)
Steyn (11)
Kim (18)
Bakhtiari (21)
Tarkanyi (19) + eval

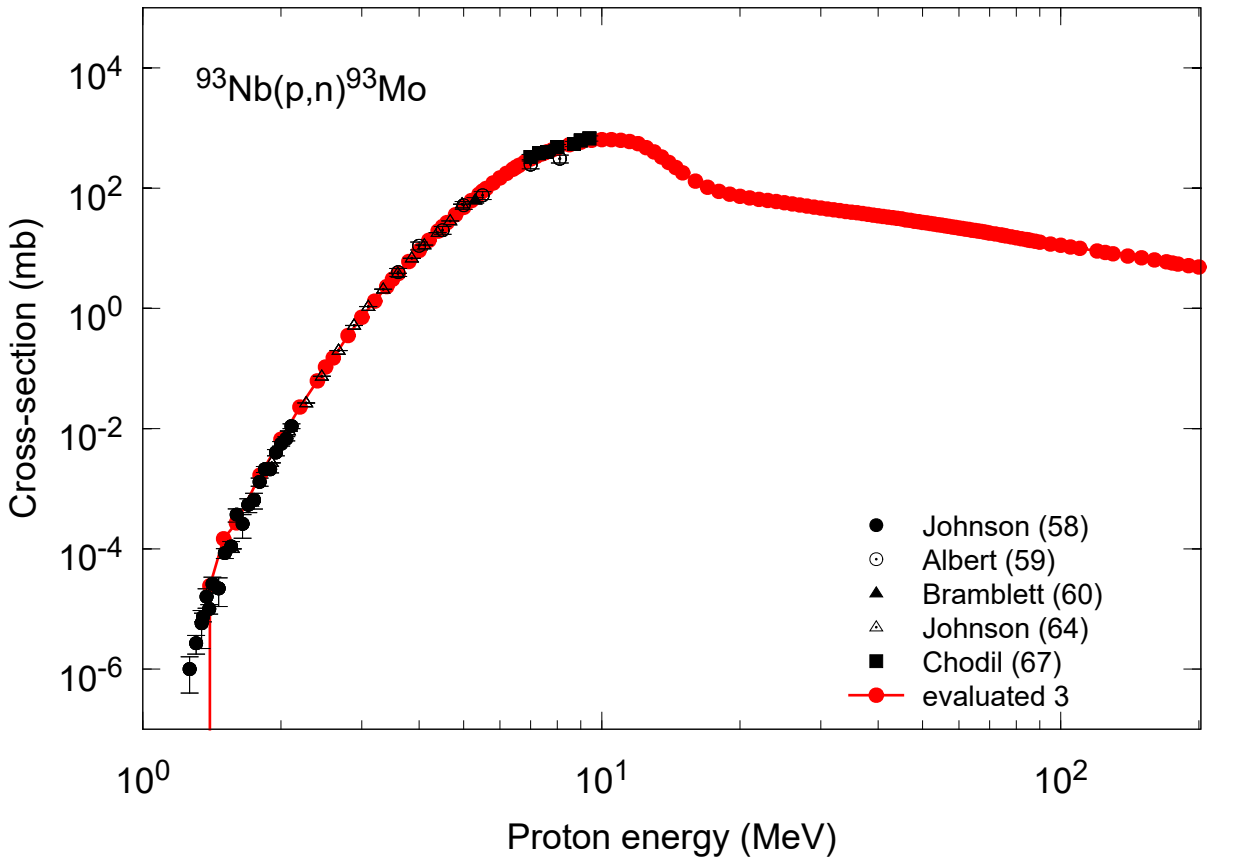

^{93}Nb(p,x)^{91m1}Nb(cum)
Cross-section (mb)
Proton energy (MeV)
Michel (97)
Ditroi (08)
Ditroi (09)
Titarenko (11)
Steyn (11)
Voyles (18)
Kim (18)
Fox (21)
evaluated

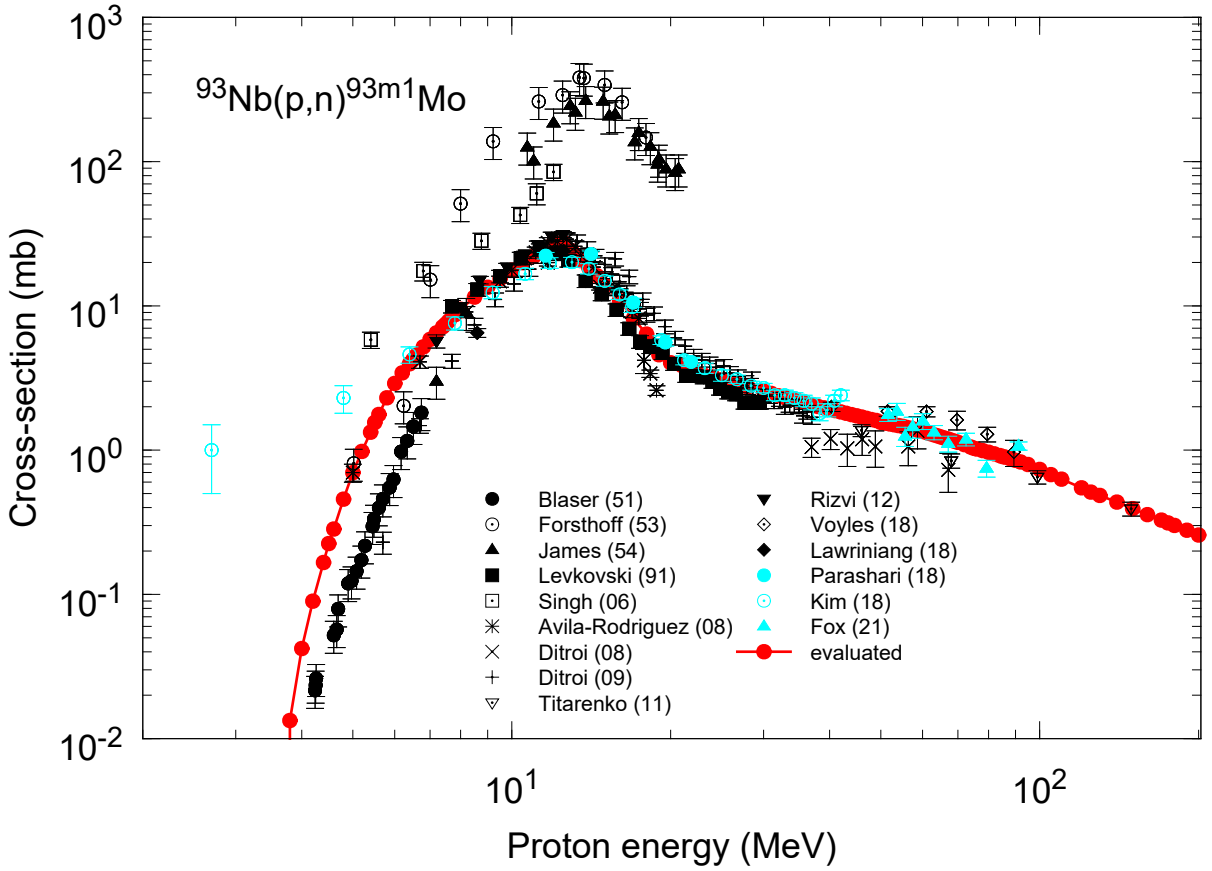

^{93}Nb(p,x)^{92m1}Nb
Cross-section (mb)
Proton energy (MeV)
Levkovski (91)
Michel (97)
Avila-Rodriguez (08)
Ditroi (08)
Ditroi (09)
Titarenko (11)
Steyn (11)
Rizvi (12)
Voyles (18)
Lawriniang (18)
Parashari (18)
Kim (18)
Fox (21)
Bakhtiari (21)
evaluated

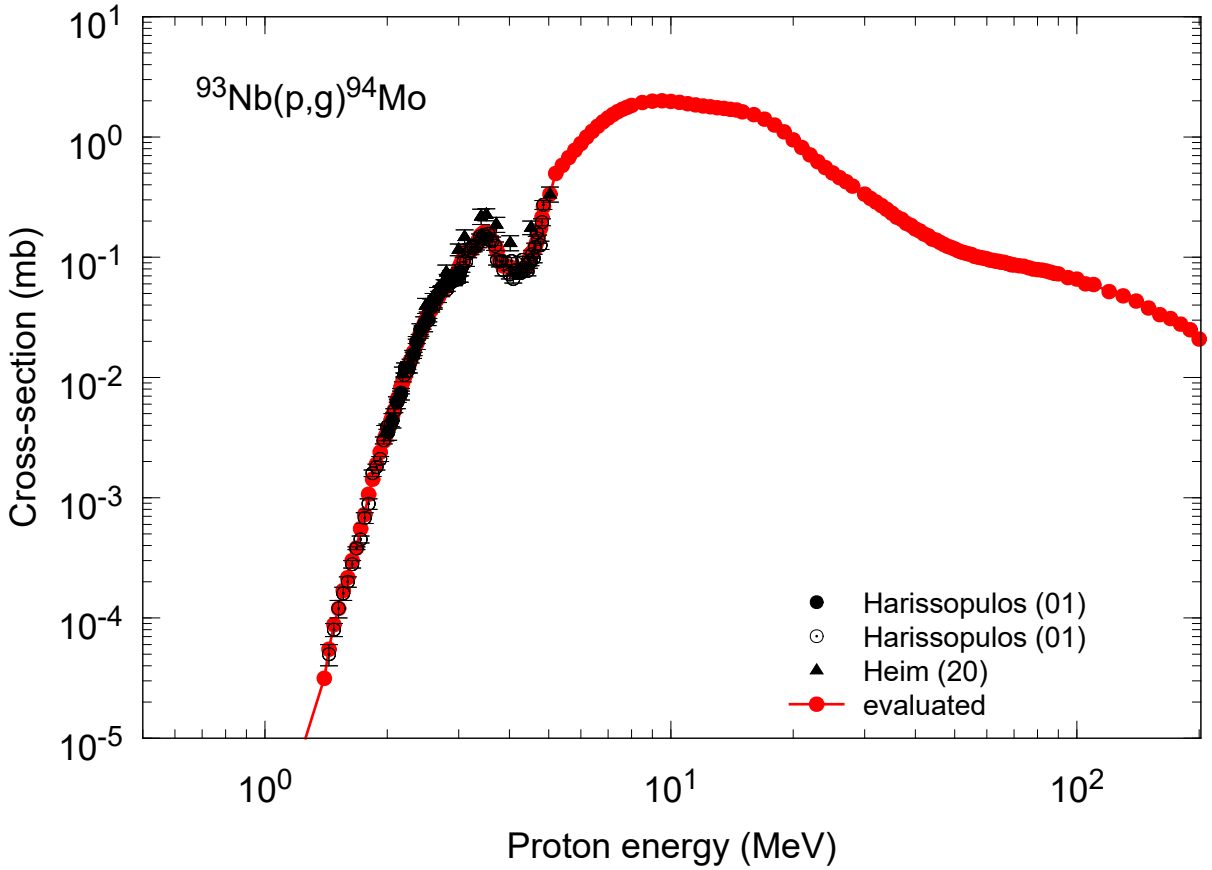

^{93}Nb(p,4n)^{90}Mo
Cross-section (mb)
Proton energy (MeV)
Ditroi (08)
Ditroi (09)
Titarenko (11)
Voyles (18)
Kim (18)
Fox (21)
Bakhtiari (21)
evaluated


^{93}Nb(p,3n)^{91}Mo
Cross-section (mb)
Proton energy (MeV)
Titarenko (11)
evaluated


^{93}Nb(p,2n)^{92}Mo
Cross-section (mb)
Proton energy (MeV)
Chodil (67)
evaluated


^{93}Nb(p,n)^{93}Mo
Cross-section (mb)
Proton energy (MeV)
Johnson (58)
Albert (59)
Bramblett (60)
Johnson (64)
Chodil (67)
evaluated 3


^{93}Nb(p,n)^{93m1}Mo
Cross-section (mb)
Proton energy (MeV)
Blaser (51)
Forsthoff (53)
James (54)
Levkovski (91)
Singh (06)
Avila-Rodriguez (08)
Ditroi (08)
Ditroi (09)
Titarenko (11)
Rizvi (12)
Voyles (18)
Lawriniang (18)
Parashari (18)
Kim (18)
Fox (21)
evaluated


^{93}Nb(p,g)^{94}Mo
Cross-section (mb)
Proton energy (MeV)
Harissopulos (01)
Harissopulos (01)
Heim (20)
evaluated

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