

**CHARGED PARTICLE NUCLEAR DATA GROUP,  
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**Progress Report to the  
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## **General**

The Debrecen Nuclear Data Group is working within the Cyclotron Department of the Institute of Nuclear Research of the Hungarian Academy of Sciences (ATOMKI). The group is dealing with charged particle induced nuclear reaction cross section data measurement, compilation, evaluation and practical application in low and medium energy range. The experimental work and the compilations are carried out in international collaborations with different cyclotron laboratories (INC, FZ Jülich, Germany, VUB Brussels, Belgium, Turku PET Center, Finland, Tohoku University, Japan). We have also connections with theoretical groups in Russia, IPPE, Obninsk, and China, CNDC, Beijing.

## **Recent Progress**

We have continued the experimental determination of cross sections data and yield measurements for charged particle induced nuclear reactions, as well as the compilation and the critical comparison of several selected processes used for production of medically important radioisotopes, for monitoring charged particle beams and for thin layer activation measurements.

Since the last meeting first priority was given to the final preparation of the TECDOC of an evaluated Reference Database for medical isotope production and monitoring light charged particle beams. The work was co-ordinated by the Agency as a CRP under the title of "Development of reference charged particle cross section database for medical radioisotope production". In this final stage the manuscript was completed with all the figures and data tables. The database contains 22 monitor reactions to monitor the beam parameters of p, d,  $^3\text{He}$  and  $\alpha$  bombarding particles, 16 reactions to produce single gamma emitter diagnostic radioisotopes and 10 reactions for production of the most commonly used PET isotopes.

The project included 7 laboratories among them our group. The Debrecen group took a significant part in the CRP, regarding the compilation of the experimental data, the connected

new experiments and finally the preparation of the technical document. The manuscript was completed in the second half of the last year. An online version of the TECDOC also was created and placed on the IAEA Web server under the <http://www-nds.iaea.or.at/medical/> address. The web version still needs some final adjustments.

#### Further conclusion and remarks on the CRP

- A significant effort was done to produce the database, but in case of some reactions the quality of the result is still requires some adjusting.
- The program and the number of the evaluated reactions were too ambitious for the available limited time, therefore some corrections are needed at some parts of the database.
- In general, most cases the status of the experimental data of the charged particle induced reactions was poor. To produce more reliable recommended data set deep analysis of the available experimental data is required and/or additional experiment is still needed under a well-defined condition.
- In case of some reactions no recommended data was given. Further work is required.
- It was found that a significant part of the experimental data still not compiled in the EXFOR format.
- It was practically impossible to use the results of the model codes to produce recommended data.

#### Recommendation for additional work regarding the CRP:

- It is essential to collect new experimental data in case of several reactions.
- The quality of the recommended data can be improved significantly by a new evaluation process including the new experimental data gathered since the compilation process was closed.
- We recommend an immediate continuation of the evaluation process since at this time the correction of the presented results to get better quality data requires only moderate additional effort. After a longer period of time it is not a correction work anymore but a complete new evaluation that means much more effort and requires more manpower too.
- At this stage the correction process requires only limited number of participants. It would be enough the joint work of one experimental and one theoretical group.

#### **Compilation in EXFOR format**

The Debrecen CP Nuclear Data Group are collecting and compiling charged particle experimental cross section data measured in Debrecen and Jülich. In the last year this activity was temporary suspended, due to the overload by the program of CRP. After completing the Medical Isotope Reference Database, the compilation work was restarted again in this year. One TRANS was completed by this time. The missing works from Debrecen and Jülich will be compiled soon.

#### **Nuclear data services**

The group continue to distribute compiled experimental charged particle data at low a medium energies for special request, needed mainly on non-energy related applications (medical isotope production, TLA, etc).

### **Staff**

The staff consists of five physicists, working in different application areas at the Debrecen cyclotron. They can work only in-part time in different percentage on data compilations and other related work. The main problem is the lack of technical support, for data input and to check the compiled data.

### **Planned new measurements to complete the available charged particle data**

In collaboration with other laboratories we participate in a systematic study and measurements of CP cross sections data in low and medium energy range. The reactions are selected on the basis of the every day practice and requirements of the collaborating laboratories, and on the problems arising during compilation and evaluation of the available data. We plan to investigate the following processes and areas:

- Production of radioisotopes for medical diagnostic.
- Production of radioisotopes for therapy.
- Commonly used reactions for thin layer activation technique.
- Intercomparison of commonly used monitor reactions.
- Confirmation of the experimental data measured by Levkovski.
- We continue to work on the problems related to the Reference Database for medical isotope production and monitoring light charged particle beams.
- As part of the CRP all the references included in the project will be reviewed again to select the works still are not compiled in EXFOR format.
- We continue to compile new entries in EXFOR from the papers published by the INC, Forschungszentrum Jülich, Jülich, Germany, and Institute of Nuclear Research, Debrecen, Hungary.

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## Publications of 2000-2001

The new experimental cross section and yield data measured by our group were published in different papers and presented at different conferences. Here we give the list of publications appeared in the last two years. Several other works are under preparation for presentation at conferences will be held this year or for publication in a scientific journal.

**S. Takács**, F. Szelecsényi, F. Tárkányi, M. Sonck, A. Hermanne, Yu. Shubin, A. Dityuk, M.G. Mustafa and Zhuang Youxiang: *New cross-sections and intercomparison of deuteron monitor reactions on Al, Ti, Fe, Ni and Cu.*  
NIM B 174 (2001) 235-258

F. Szelecsényi, F. Tárkányi, **S. Takács**, A. Hermanne, M. Sonck, Yu. Shubin, M.G. Mustafa and Zhuang Youxiang: *Excitation function for the  $^{nat}\text{Ti}(p,x)^{48}\text{V}$  nuclear process: Evaluation and new measurement for practical applications*  
NIM B 174 (2001) 47-64

F. Szelecsényi, **S. Takács**, F. Tárkányi, M. Sonck, A. Hermanne: *New cross section data on  $^{nat}\text{Ti}(p,x)^{48}\text{V}$  nuclear process: Monitoring of proton beam and production of  $^{48}\text{V}$ .*  
Synthesis and applications of isotopically labelled compounds. Vol. 7.: Proceedings of the Seventh International Symposium, Dresden, Germany, 18-22 June 2000. Eds: Ulrich Pleiss and Rolf Voges. Chichester, etc., John Wiley and Sons, Ltd. (2001)45.

A. Hermanne, M. Sonck, **S. Takács**, and F. Tárkányi: *Monitoring of proton beams: a practical application of an Evaluated Charged Particle Database.* NIM B (accepted)

F. Ditrói, F. Tárkányi, M.A. Ali, L. Andó, S-J. Heselius, Yu. Shubin, Zhuang Youxiang, M.G. Mustafa: *Investigation of  $^3\text{He}$ -induced reactions on natural Ti for nuclear analytical and radionuclid production purposes.*, NIM B 168 (2000) 337-346.

F. Tárkányi, F. Szelecsényi, **S. Takács**, A. Hermanne, M. Sonck, A. Thielemans, M.G. Mustafa, Yu. Shubin N. and Z. Youxiang: *New experimental data, compilation and evaluation for the  $^{nat}\text{Cu}(\mathbf{a},x)^{66}\text{Ga}$ ,  $^{nat}\text{Cu}(\mathbf{a},x)^{67}\text{Ga}$  and  $^{nat}\text{Cu}(\mathbf{a},x)^{65}\text{Zn}$  monitor.*  
NIM B 168 (2000)144-168

A. Hermanne, M. Sonck, **S. Takács**, F. Tárkányi: *Experimental study of excitation functions for some reactions induced by deuterons (10-50 MeV) on natural Fe and Ti.*  
NIM B 161 (2000) 178-185.

R. Dóczi, **S. Takács**, F. Tárkányi, B. Scholten, S.M. Qaim: *Possibility of production of  $^{81}\text{Rb}$  via the  $^{80}\text{Kr}(d,n)$  reaction at a small cyclotron.* Radiochimica Acta 88 (2000)135.