Belgrade meeting notes

A meeting of the E&T RAW Collaboration was organised by Stevan Jokic in the Vinca Institute near Belgrade from August 30 to September 3, 2010.

Participants:
Stevan Jokic (Vinca Institute, Republic of Serbia)
Sergej Tyutyunnikov (VBLEHP, JINR, Russia)
Mikhail Kadykov (VBLEHP, JINR, Russia)
Valeri Chilap (CPTP Atomenergomash, Moscow, Russia)
Metaxia Manolopulou (Aristotle University, Thessaloniki, Greece)
Marcin Szuta (IAE, Swierk, Poland)
Orlin Yordanov (INRNE, Sofia, Bulgaria)
Ondrej Svoboda (INP, Rez, Czech Republic)
Wolfram Westmeier (Dr. Westmeier GmbH, Germany)

Unfortunately Maria Zamani-Valasiadou (Aristotle University, Thessaloniki, Greece), Reza Hashemi-Nehhad (University of Sydney, Australia) and our colleagues from Belarus could not attend the meeting for various reasons.

General remarks:
The meeting in Vinca Institute was extremely well organised: Accomodation was arranged in a central hotel in the old city of Belgrade and fast and effective transportation to and from Vinca was available in morning and afternoon. In the Vinca institute there were optimal meeting facilities with continuous supply of tea/coffee/juice/sweets as well as lunch facilities. A carefully selected social programme and excursion to the University of Novi Sad, as well as personal support in every case of problems was provided. We wish to thank Stevan a lot for the unbelievably good organisation and arrangements that he achieved to set up on very short notice.

Opening notes:
In his opening notes W. Westmeier reminded the group that we are very very sorry that Micha Krivopustov cannot take part in this meeting – he was “father” of experiments and meetings – we will remember him as a super colleague and organiser.
However, when the good team Malakhov/Krivopustov was replaced by the new team Tyutyunikov/Kadykov there was no break, no difference, no problem. All preparation work and the experiment in November 2009 went smoothly and well, the organisation for the experiment was perfect, there were no problems. Thank you!

We are facing the new EZHIK (means “hedgehog”) target, details of which we should know and we should prepare for experiments to be made!
We are sorry that Valeri Chilap had to come alone to Belgrade without Walter Furman – however, he will surely succeed in explaining to us what is EZHIK. In fact, the two envisaged EZHIK targets will be our Collaboration’s main targets for future work. We now have five targets of different application and complexity: GAMMA-2, GAMMA-3, E+T, EZHIK(Pb) and EZHIK(U).

Wolfram stressed that his dream is a strong Collaboration that can ask for something and which moves something. His dream is a Collaboration where various tasks are taken over by different groups and where there are no repeats of identical experiments. Having a large

variety of targets available we are able to tackle all aspects of transmutation research with our Collaboration. We are actually a very strong team of scientists who have a unique set of experimenting facilities at hand and who are looked upon enviously by other groups. Thus, we shall even improve our experience and produce first-class reference and benchmark data on neutron spectra and integral reaction probabilities. These data are key ingredients to the development of all transmutation facilities and model codes – we can measure them and we will continue to do so!

First of all we must understand what can every participating group really do, where is a group good at? That's why we have gathered here and give talks on our work. We will find out strong points of every group and make use of their strength, accordingly. Everybody shall do what he can do best.

We also must think of new experiments that help us to increase our knowledge, especially in the field of determination of the neutron spectrum – that must be our main focus in the future: How many neutrons of what energy are where?

Our Collaboration is the only group measuring integral data for Transmutation on a large scale. Thus, automatically we are the only ones who can really compare experimental results with calculations! We have the data. We are unique! We must make that clear to the public and to our financiers!

We have already succeeded to introduce GAMMA-2, E+T and GAMMA-3 into a Coordinated Research Project of IAEA and these targets are now acknowledged as "IAEA benchmark targets".

We must think how we can make the generation of papers even more efficient. It would be good if every group contributes their results from the last experiment within 6 to 8 months to Mikhail who will write the frame of a new paper. Every group can then fill that frame with their own information and a complete paper about an experiment may be available within a year thereafter.

Hoping that VBLHEP's projections of NUCLOTRON availablity will come true, we will use the NUCLOTRON as best we can. It should be planned that in the near future we shall have 2, maybe 3, runs per year?

It is also a key task in the future that many Diploma and PhD students can be interested in our work. The amount of data to be expected will be paramount and we should give as many students as possible the chance to enhance their qualification through work on transmutation.

There is a lot to do – let's start it now

<u>Startup news:</u>
Valeri Chilap will present another new target named "Kwinta" which is already in use and which will be available to the Collaboration in the irradiation scheduled for November / December 2010.

There is interest from France (represented by Sylvie Leroy) in our work and our results. WW emphasises that other collaborators are cordially welcome to participate and to experiment with us, however, we are not workers and data-producers for other freeloading users. We had

once tried to get financial support from EU money (FP6, where Sylvie Leroy was actually participating) but we were refused.

The new project E&T RAW from which we have the text (and which is also available as JINR preprint E1-2010-61) is approved by the PAC of JINR. In fact, there is a "tema" concerned with applied work which carries the name of this project. Thus we are now officially acknowledged in Dubna and we do no longer have to "hide" under another project when beamtime is requested. This is a major achievement brought forward by Sergej Tyutyunnikov and Mikhail Kadykov.

Sergej proposes that the Collaboration should contemplate about the question where one can source money for spectrometric equipment. The cooperation with the Laboratory of Nuclear Problems (Adam laboratory) is not very stable and one may have to fear loss of measuring power when Dr. Adam will retire. The Czech group should try to secure the fate of Czech equipment and maybe arrange transfer into a "spectrometry laboratory" which shall be installed at VBLHEP. Sergej shall try to identify rooms in building 205 that can be used for such spectrometry lab. Some 4-5 rooms on ground level should be available for the lab: 3 rooms for detectors with lead castles, 1 room for shielded preparation and storage of samples, and one room for personal amenities (sitting, sleeping, tea pots etc.)

Sergej requests that the Collaboration (WW as the coordinator) shall write a letter to the JINR directorate presenting the successful history of the Collaboration, mentioning that our targets are accepted IAEA benchmark targets and emphasising the remarkable publication record of our work, in which we request support for acquisition of 4 additional HPGe spectrometers with lead castles for our research. It should be highlighted that our Collaboration has now six spallation-transmutation targets for every kind of applied experiments for that subject. This pool of experimental facilities is unique and it allows JINR to take over clear leadership in experiments measuring integral transmutation data. These data are urgently needed by the international transmutation community, as had already been emphasised during the EU PARTRA Workshop in Karlsruhe 2 years ago, as well as during other EU-sponsored meetings in Brussels and Prague.

Presentations of focus of work:

Wolfram Westmeier explained scientific and technical premises for measuring the absolute beam intensity on target using the $^{27}Al(p,3pn)^{24}Na$ reaction. With the help of one experimental data point, the excitation function for this reaction can also serve for cross-section determination in deuteron induced reactions.
Measurements of low-energy neutron density distributions in, on and around targets have revealed interesting insight into the neutronics of the targets. Integral data for transmutation probabilities (B-values) indicate that long-lived radioactive waste is most effectively (in terms of cost per neutron) destroyed with spallation neutrons produced by protons having around 800 keV kinetic energy. However, there is indication that deuterons may be more effective projectiles than protons.
There is indication that the narrow distribution of neutrons around the spallation target may be directed into a forward cone. This feature shall be investigated in upcoming experiments with the GAMMA-3 target.
The German contribution to the work of the Collaboration will continually focus on systematics of low-energy neutron induced transmutation data.

Metaxia Manolopoulou explained details of the Greek He-3 detectors, including calibration in Braunschweig. The detector is proven to see neutrons up to approx. 7 MeV. There was no full energy peak registered from 7.2 MeV neutrons. Although a very complicated spectrum is registered from just mono-energetic primary neutrons the Greek group can now successfully unfold (without prior knowledge of the shape of the expected neutron spectrum) an experimental spectrum from the He-3 detector and find the primary neutron spectrum. For good and sensible resolution a counting rate <2000 cps is required in the He-3 detector.

Marcin Szuta explained their methods of neutron field quantification using Y-samples and identifying various (n,xn) products. Thus they can determine average neutron densities in various energy ranges (e.g.: 11-20 MeV / 20-31 MeV / 32-100 MeV). For the purpose of "cleanness" of the neutron spectrum they wish to measure the neutron field around a bare Pb-target.

Orlin Yordanov explained their investigation of nuclide production in ^{nat}Pb. The group also makes calculations, using n,p and d as projectiles. It seems that the MCNPX program does not correctly reproduce the experimental product distributions.

Ondreij Svoboda presented their measurements and calculations of product cross sections from (n,xn) and other reactions. Cross-section calculations using the Fredholm Equation (i.e. the integral over energy of the neutron spectrum times the excitation function) are made, where TALYS program is used for calculation of the excitation function; results of TALYS are reliable. The MC simulation (normalized to one data point) is >20% off.
The Czech group can offer MCNPX computer power and calculation time, as well as net-space for information from the Collaboration.
There is a significant discrepancy in the experimental deuteron beam intensity from the latest experiment with 4 GeV deuterons on the E+T target. Whereas the Czech group measured $(1.985\pm0.019)*10^{13}$ deuterons in F3 the result from the German group is $(1.398\pm0.148)*10^{13}$ deuterons. No apparent reason for the discrepancy could be identified. The Czech result seems to be supported by measurement using other foil, whereas the German result is in line with earlier measurements of beam transmission from the Nuclotron to F3. It is highly desirable to resolve this discrepancy.

Both speakers, Ondreij Svoboda and Orlin Yordanov, stressed that there is a severe shortage of detectors for sample measurement. Moreover, it is highly desirable to have the detectors available close to the irradiation position, in order to make cooling times as short as possible and thus to allow measurement of short-lived products. It is anticipated that (n,10n) products from some reactions can be measured if the time between EOB and SOC can be very short (<5 minutes?).

Sergej Tyutyunnikov presented the scientific programme of the NUCLOTRON for the immediate future. It is anticipated that beam particles up to Z=42 (Mo) shall be available with energies up to 5.2 GeV/u. Intensities shall be upgraded in 2010 by a factor of 8, and 50-fold enhancement of intensity is envisaged for 2011. On the long run it is planned to accelerate particles up to U in the Nuclotron. From 2012 on much effort and hardware will go into development and manufacture of a new cryogenic system.

It may well be that from 2011 on there will be proton beams again available from the Nuclotron; for the time being the light particle beam is only deuterons.

Valeri Chilap presented progress with the new targets that will be available for experiments of the Collaboration.
Three new targets (see below) are the core of application for a project that was submitted to the PAC of JINR and which was finally accepted. The title of the project submitted by the E&T RAW COLLABORATION is "Study of deep subcritical electronuclear systems and feasibility of their application for energy production and radioactive waste transmutation". The project was accepted for the years 2011 to 2013 and it was embedded into an applied topic of JINR work (a "tema") which carries the same title. The tema covers applied work of E&T RAW as well as work for radio-carbon therapy. There is already a website under construction that will provide information about our E&T RAW work (http://e-t.jinr.ru).
One of three new targets named "QUINTA" exists already and it was used for an experiment before. The target consists of three segments of approx. 100 kg of natural uranium each. The U is encapsulated in Al-rods identical to the E+T blanket and the construction is identical to E+T. There are 61 rods in one segment. An 8-fold energy release in the U was measured for beam particles having energies between 1 GeV and 4 GeV. Further experiments are foreseen with QUINTA in the run Nov/Dec 2010 and thereafter. For gamma radiation protection purposes the QUINTA target is surrounded by a Pb-shield weighing approx. 2.1 tons. Experimenting space in and on QUINTA is definitively available, although the space between sections is very limited. Due to the heavy Pb-shielding of the target, recovery of samples that are irradiated between the U-sections or directly on top of the U is very delayed after an experiment. However, there is ample sample space on the surfaces of the Pb-shield where recovery after irradiation is fast and simple. Decay times after irradiations of QUINTA were about 10 minutes in former experiments with 1 GeV and 4 GeV deuterons. It is planned to irradiate QUINTA with deuterons of 2 GeV, 4 GeV and as high energy as possible in the Nov/Dec run.
The LNP will make spectrometric measurements of neutrons around QUINTA using Stilbene detectors.
After completion of experiments with the GAMMA-3 target the graphite from GAMMA-3 will be used around QUINTA and later around the EZHIK targets. There will be various EZHIK targets with and without a graphite reflector.
The EZHIK ('Joshik', meaning hedgehog) targets will be an asymmetric uranium target of approx. 3 tons of U that can be surrounded by different reflectors and/or shielding. The first version of EZHIK will be an asymmetric lead target having the same geometry as the U-target. EZHIK(Pb) will serve for the development of experimenting techniques and gathering of experience.
It is highly recommended that all participants of the Collaboration shall design their future experiments to be proposed for the KWINTA and EZHIK targets.

Miscellaneous:
After presentations of ongoing work and planned targets several details for the upcoming run in November/December 2010 and other topics were discussed:

- For the next run it is anticipated that the GAMMA-3 target shall be irradiated with 4 GeV deuterons. The wishlist of experiments shall please be sent to Mikhail Kadykov (and W. Westmeier) for preparations and coordination.
- After the GAMMA-3 irradiation it is planned to irradiate the QUINTA target with 3 energies deuterons (2 GeV, 4 GeV, as high as possible). The wishlist of

experiments shall please be sent to Mikhail Kadykov (and W. Westmeier) for preparations and coordination. Irradiation times and integrated beam intensities are not yet defined. It would be good if the waiting time between irradiations of GAMMA-3 and QUINTA could be around 3-4 days.

- The beamtime planning gremium should be asked to provide irradiation times for GAMMA-3 and QUINTA so that irradiation of QUINTA finishes around December 10, 2010 at the latest.
- The Collaboration (WW) shall write a letter to the JINR directorate asking for support in providing more detectors to the Collaboration for the upcoming experiment. One should also provide two additional detectors from LNP. Moreover a request shall be written for four new HPGe detectors for the E&T RAW Collaboration. It is planned to set up a "detector laboratory" in building 205 that provides space for detectors, samples, calibration material and users in separate rooms as appropriate. The laboratory should provide very fast access after a run in order to allow measurement of nuclides having short halflives. Facilities for effective and loss-free handling of liquid nitrogen shall also be available in the detector laboratory.
- A big meeting of the E&T RAW Collaboration shall be planned for the year 2011. There is a "School of High-Energy Physics" in Belarus in 2011 which may serve as the host for such meeting. Sergej Tyutyunnikov will try to arrange that a session during this School shall be devoted to our work and that we can take advantage of the facilities of the conference. The timeframe for the meeting is probably around July/August 2011.
- Wolfram agrees to take over the job of the external Coordinator for activities of the Collaboration.
- Former publications of the Collaboration can be published in the E&T RAW website http://e-t.jinr.ru for external reference. All members of the Collaboration are asked to provide their transmutation papers as .PDF files to Mikhail Kadykov who will include them in the website.

Acknowledgements

Highly interesting visits to the TESLA museum in Belgrade as well as the spectrometry laboratory of the University of Novi Sad were part of the scientific programme of the Collaboration Meeting in Belgrade. The social programme was extremely well organized by Stevan Jokic, comprising of a boatride on the Sava, conference dinner in local style in the old city of Belgrade and private lunch invitation to his home.
We cordially wish to thank Stevan for plenty of work that he must have spent for us, and for a lot of expenses that were well invested into the success of the meeting.

W. Westmeier
Ebsdorfergrund-Mölln
September 20, 2010