

Status Report of the NFS collaboration

TITLE of the Project: Neutrons For Science (NFS)

Spokespersons (maximum 3) with one corresponding spokesperson:

Xavier Ledoux, CEA/DIF F-91297 Arpajon, 01 69 26 57 05

Stanislav Simakov, FZK, Karlsruhe

Contact person at GANIL:

F. Rejmund

Members of the Collaboration:

X. Ledoux, E. Bauge, G. Belier, T. Caillaud, A. Chatillon, T. Ethvignot, T. Granier, O. Landoas, B. Rossé, J. Taïeb, I. Thfoin, C. Varignon, CEA/DIF, Arpajon, France

S. Andriamonje, D. Doré, F. Gunsing, S. Panebianco, D. Ridikas, A. Takibaev, CEA/DSM/IRFU/SPhN, Saclay, France

V. Blideanu, CEA/DSM/IRFU/Senac, Saclay, France

M. Aïche, G. Barreau, S. Czajkowski, B. Jurado, CENBG, Gradignan, France

G. Ban, F. R. Lecolley, J. F. Lecolley, J. L. Lecouey, N. Marie, J. C. Steckmeyer, LPC, Caen, France

P. Baumann, P. Dessagne, M. Kerveno, G. Rudolf, IPHC, Strasbourg, France

P. Bem, NPI, Řež, Czech Republic

J. Blomgren, S. Pomp, DNR, Uppsala, Sweden

U. Fischer, S. P. Simakov, M. Majerle, FZK, Karlsruhe, Germany

B. Jacquot, F. Rejmund, GANIL, Caen, France

M. Avrigeanu, V. Avrigeanu, C. Borcea, F. Negoita, M. Petrascu, NIPNE, Bucharest, Romania

S. Oberstedt, A.J.M. Plompen, JRC/IRMM, Geel, Belgium

O. Shcherbakov, PNPI, Gatchina, Russia

M. Fallot, L. Giot, Subatech, Nantes, France

A. G. Smith, I. Tsekhanovich, Department of Physics and Astronomy, University of Manchester, Manchester, UK

O. Serot, CEA/DEN, Cadarache, France

L. Perrot, L. Tassan-Got, IPNO, Orsay, France

E. Balanzat, S. Bouffard, S. Guillous, J. M. Ramillon, CIMAP, Caen, France

A. Oberstedt, Örebro University, Örebro, Sweden

J.C. Sublet, UKAEA, United Kingdom

I Beam line design

Some progresses have been performed in the integration of the ion beam line in the converter room. The arrangement has to take into account the optical elements (quadruples focusing, steerer, beam profile set-up...), the neutrons-production-converter, the irradiation box and the CIRIS2 set-up. Downstream we find some shielding and the clearing magnet used to remove the primary beam at 0°. The design of the converter is under study. A preliminary scheme is given on Figure 1.

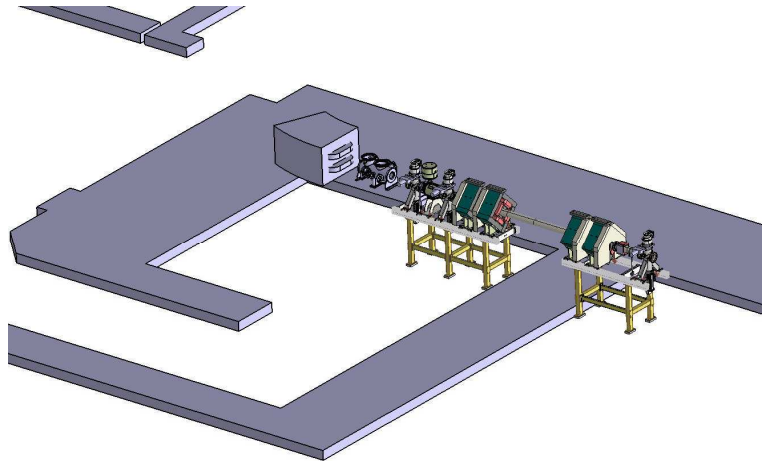


Figure 1: Beam line integration in the converter room.

Four quadrupoles (see Figure 1) are able to produce beam with transverse size in agreement with the requirements ($X_{RMS}=Y_{RMS}=4\text{mm}$). After the last quadrupole, the beam divergence is low (around 1mrad). These properties are achieved for all beam species (deuterons, protons, heavy ions) at various available energies. Transverses beam size and misalignments can be measured using two beam profile detectors.

At NFS experimental area, three types of experiments will be performed. Feasibility to a unique chamber is under study in order to produce neutrons via the Be or Li target. This chamber would also be used for sample irradiation (for ion induced reactions) and the CIRIS2 disposal.

In case of neutrons production by ${}^7\text{Li}(p,n)$ reaction, it is necessary to remove from 0° line the primary protons beam slowed-down in the thin Lithium target. This feature is achieved using a magnetic dipole located at 800mm after the target (order size distance). Basic characteristics of this dipole are : radius 900mm, maximum magnetic field 1T, angle 20° , magnetic length is around 300mm and gap up to 80mm. In these conditions, central trajectory of the proton beam is deviate to 50mm after the dipole in the horizontal plane. A beam dump is required to stop the pulsed primary beam. It is important to control the beam current in the beam-stop for security aspects. Dipole and Beam-dump must be design in a way to be sure that no associated background neutrons go through the neutrons beam pipe.

All detailed of the design of this room will be provided during 2010.

II. Collimator and facility design

The collimator design (see status report of 2009 September) was pursued further. The study is based on neutron transport calculations performed with the MCNPX code. First, only the proton on ${}^7\text{Li}$ reaction has been taken into account. A new source of neutrons produced by 40 MeV d + Be reactions has been modeled. The shielding efficiency as well as the effect of the scattering of neutrons in air have been studied. Calculations were then performed to evaluate the background in the TOF hall with respect to the building maps.

II.1. 40 MeV d + Be neutrons source

A white spectrum of neutrons is produced by deuteron irradiation of a thick (about 1 cm) beryllium

target. Due to the absence of nuclear data tables and reliable interaction models, the d + Be neutron source was constructed from the data available in scientific literature. The source thus obtained is compared with p + Li source in Figure 2.

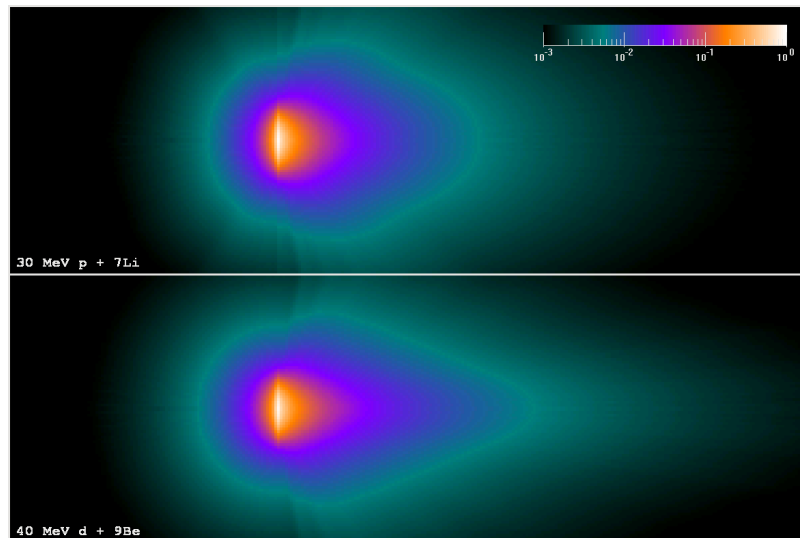


Figure 2: Comparison of neutron production by p + Li (up) and d + Be (down) reactions

The main drawbacks of this model are: 1) the constructed source does not provide information about neutron spatial distribution: neutron beam spatial profile could be very different from initial deuteron beam profile due to large thickness of the target; 2) contribution of low energy neutrons (< 2 MeV) is found to be overestimated due to the nature of data interpolation. Therefore, the d + Be neutron source described above should be compared with and validated by nuclear data tables.

In parallel the collaborators from FZK have build a neutron source produced by d+C and d + Be reactions by using a modified version of the McDeLi subroutine. This source will be used in the future simulations.

II.2. Neutron scattering inside the TOF hall

The previous studies show that the collimator with a conically shaped collimation channel seems very efficient and neutron background produced is quite low. The effect of air in the time-of-flight hall has been investigated. It appears clearly that the neutron scattering in air will generate considerable background in the area (see Figure 3). Total neutron background becomes about 1 order of magnitude higher at large distances (> 20 m) from collimator exit.

Due to this background the use of a vacuum pipe along the beam axis was studied. Figure 4 shows that the background is strongly reduced. Therefore, a set of cylindrical tubes under primary vacuum will be necessary from the collimator exit to the neutron beam dump. This set-up can be interrupted to place a target or an experiment set-up in air with each beam pipe being closed by thin beam windows.

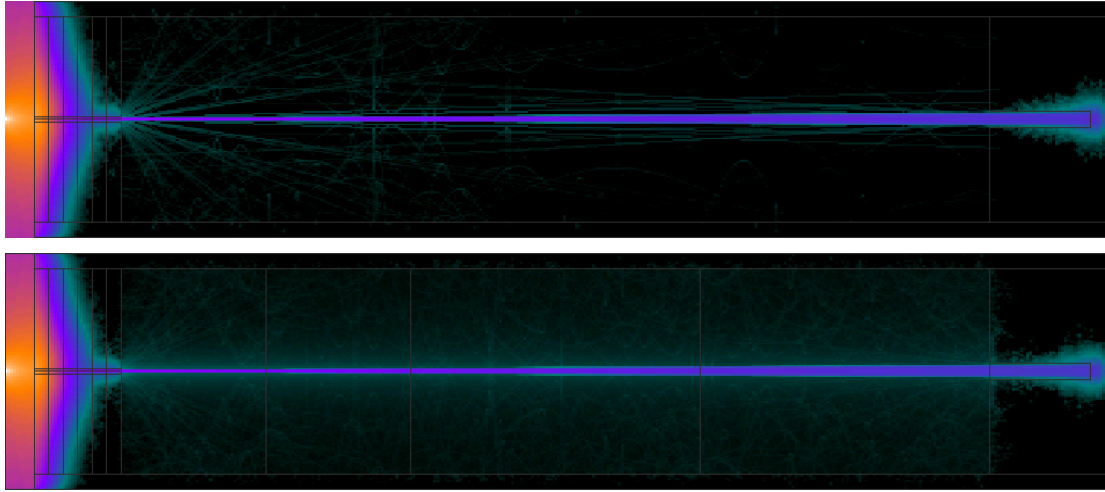


Figure 3: Comparison of neutron background inside the TOF hall without (up) and with air (down)

The collimator design and the air scattering effect were performed with a simplified geometry (see Figure 3). A realistic simulation (taking into account the converter room and the TOF area) was realized to evaluate the neutron background. The results presented on Figure 4 show that the background level in the TOF hall is limited. However, the facility design will be modified by the addition of nuclear ventilation shaft between the converter room and the TOF area. Additional calculations (not presented here) show that the shafts can be an important neutron background source and their design should be carefully optimized.

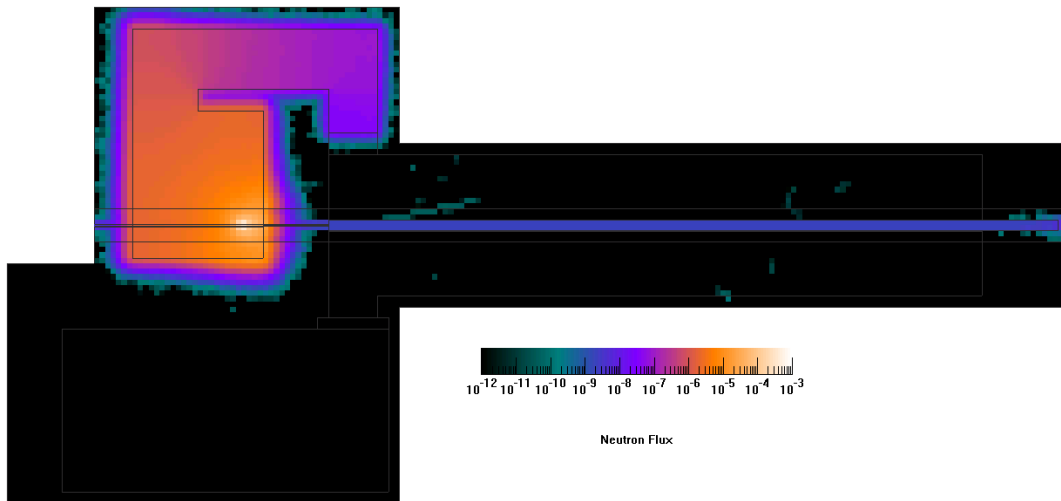


Figure 4: Total neutron flux in NFS rooms

III Future plan

The exchanges with the building designers will continue in order to reduce as low as possible the impact of the ventilation shaft on the neutron background in the TOF area. The design of the NFS process components (beam line, converter, beam dump...) will be pursued.