Institut de Physique Nucléaire Orsay

A. THE FACILITY

A.1 The nuclear data research infrastructure of the tandem ALTO facility

The Orsay Tandem Van de Graaff accelerator, manufactured by High Voltage Engineering Corporation (HVEC), is of the MP type (figure 1). Its nominal voltage is 15 MV and it is usually operated up to 14.5 MV. Stable ion beams range from protons to gold (see table 1). "Cluster-beams" and microdroplets are also routinely delivered, but at lower voltage (10 MV) in order to prevent any microdischarge contamination during the accelerating process.

Recently, the ALTO infrastructure (**A**ccélérateur **L**inéaire auprès du **T**andem d'**O**rsay) has completed this Tandem facility. It consists on a 50 MeV electron beam linear accelerator, producing neutron-rich low energy beams by photo-fission. These beams will be sent in several of the already existing experimental areas of the Tandem.

Seven beam lines were available for experiments before the construction of ALTO (figure 2). One beam line is devoted to industrial irradiation and another to cluster physics. Light, non-permanent experimental devices are used in any of three experimental areas. Two areas are equipped with permanent spectroscopic analysers such as the high-resolution "Split-Pole" magnetic spectrometer and the ISOL line PARRNe (**P**roduction d'**A**tomes **R**adioactifs **R**iches en **Ne**utrons).

Fig. 1: The IPNO MP-Tandem accelerator.

The beam time delivered by the machine depends mainly on the number of shift operators. Presently, the MP-Tandem operates 24 hours per day, 5 days per week, delivering some 3850 hours of beam per year. Adjustment and tuning of the beams are done by 7 shift-operators (with two operators per shift required by safety rules) and one student for assistance during the night shifts. A typical beam energy adjustment takes about 15 minutes. A change of beam particles (i.e. ion species) requires one hour if the same ion source can be used. Some delicate cluster-beams need an entire day for optimisation.

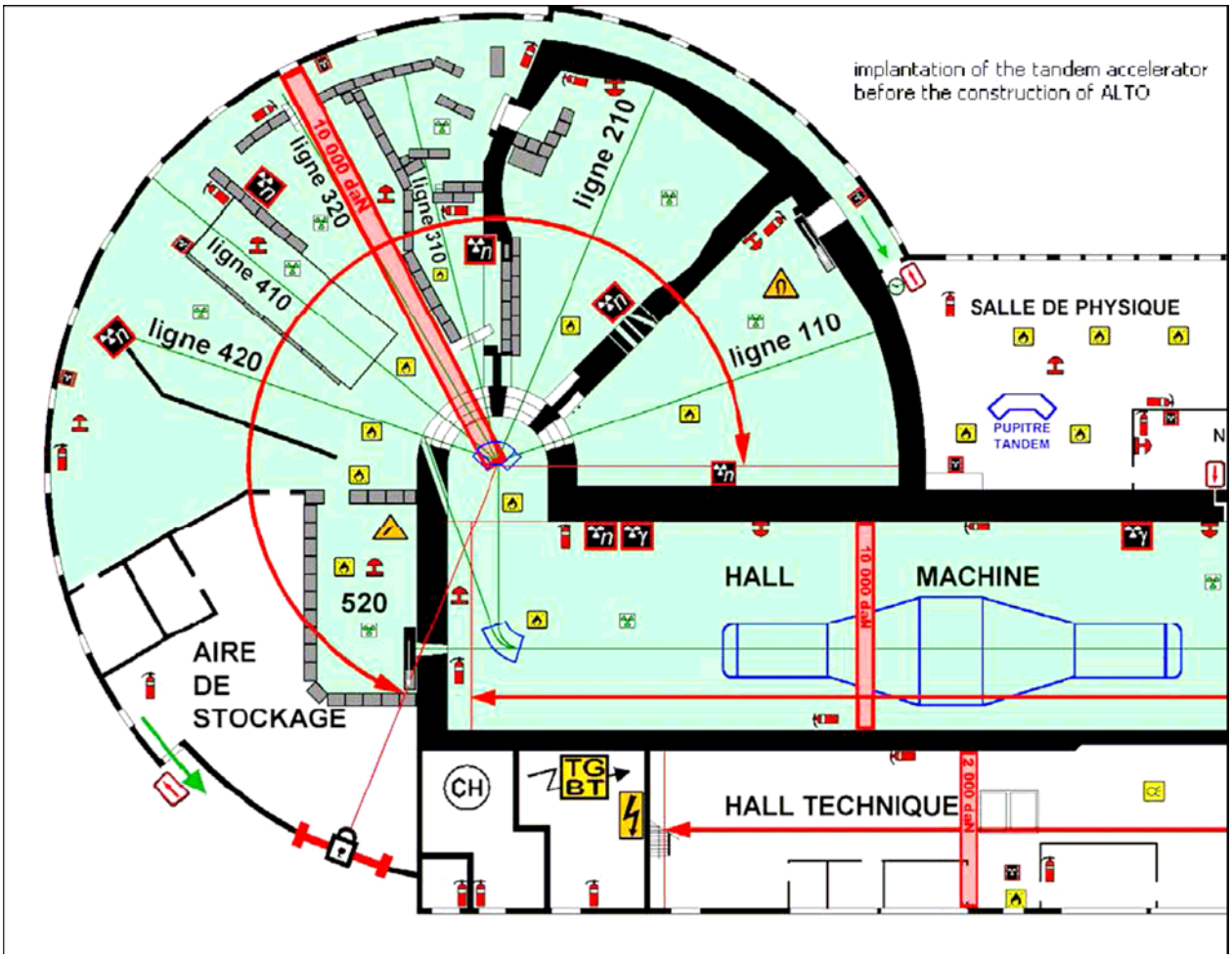

Fig 2: The beam lines and experimental areas of the Tandem accelerator.

The ion species already developed at the Tandem accelerator are indicated in the following table:

Injected ion species	Injected intensity (µA)	Energy (MeV)	Intensity analysed (pps x 10^{10})
^{1}H	2.5	25	600
^{2}H	1.6	29	113
^{4}He	1.9	36	900
^{6}Li	0.07	50	1.8
^{7}Li	0.09	56	13
^{9}Be	0.0025	62	0.56
^{11}B	0.0042	77	4.3
^{12}C	0.92	69	94
^{13}C	1.8	70	2.6
^{14}C	0.11	72	15
^{16}O	4	90	100
^{19}F	0.2	104	3.3
^{24}Mg	0.06	130	6
^{27}Al	0.18	120	8
^{28}Si	0.14	150	0.063
^{32}S	0.75	154	29
^{34}S	0.09	130	5.6
^{35}Cl	0.2	154	10

^{40}Ga	0.12	168	37
^{48}Ti	0.014	210	1.2
^{56}Fe	0.0025	99	0.032
^{58}Ni	0.18	182	6.8
^{81}Br	1.5	217	2.2
^{127}I	0.5	297	0.5
^{197}Au	0.2	172	0.045

A.2 Quality of research

The Tandem/Alto facility is traditionally devoted to nuclear structure studies. Fusion/evaporation reactions are currently used to populate and study high-spin states in the n-rich nuclei region, such as, for example, ^{59}Mn, ^{60}Mn, or ^{57}Cr. Moreover, the diversity and intensity of beams of neutron rich fission products that are presently available at the PARRNe mass separator have allowed to open up important nuclear structure studies close to N=50. Besides the physics interest of this region, such a study is to be considered as a full scale feasibility test of the physics programme of the very low energy part of the SPIRAL-2 project and soon will be continued in a significant way at ALTO. This program is completed by various type of experiment such as study of cluster in nuclei, nuclear astrophysics studies, biological effects of particle irradiations at cellular level, as well as ion-surface interaction and atomic physic with "cluster beams": for instance, fullerenes beams (C_{60n+} at 50 MeV) as well as heavy gold cluster beams up to $Au_{100,400}^{2+}$ at 20 MeV are available since 1993. Finally, radiation damage are currently studied by some industrial partners in various field such as electronic, space research, telecommunication, avionics, medical imaging, high energy physics and nuclear power plants.

Besides the possibility of an neutron irradiation experimental array (PARNNe and ALTO facilities produces a huge amount of neutrons which could be used for irradiation purposes), the relatively high voltage availability of the Tandem allows to make original measurements of fission and capture cross sections, using reaction transfer technique. This method is very powerful, especially when it is quite impossible (due to activity, and/or to the availability of raw material) to have radioactive target of minor actinide. This kind of technique has already been used by the CENBG group, for transmutation of highly radioactive nuclear waste purpose. The method consists of measuring the fission probability of a "compound nucleus" $^{A}Z^{*}$ formed in the transfer reaction (^{3}He,X) where X=p,d,t,α, versus its excitation energy. Excitation energy of the fissionning nuclei is determined by the measurement of the transfer partner (X), and the fission cross section is the product of the measured probability of fission of $^{A}Z^{*}$, by the calculated cross section of the formation of the "compound nucleus" in direct neutron reaction ^{A-1}Z target.

Fission and capture cross section of ^{233}Pa has already been measured using a ^{232}Th target and an experiment on Cm isotopes is planned at the Tandem/ALTO facility. Such a program is complementary to direct measurements and should be developed for all isotopes of interest for which it is too difficult to obtain targets. Moreover, radiochemistry activities are being developed at the Tandem/ALTO facility. They consist on ion irradiations on materials which are candidates for nuclear waste confinement, in order to simulate self irradiation. It is then possible to determine parameters like critical dose of amorphization, to study the consequences on physical and chemical properties of the material, such as mechanical resistance, dissolution rate… Radiolysis, and diffusion of Helium and fission products can also be studied with such irradiations.

B MANAGEMENT OF THE ACCESS PROVIDED

B.1 User access to the infrastructure

Beam time is allocated annually by an Experiment Committee. Some exceptions may also be considered during the year, in which case there is a call for a special Committee session.
The experiment proposed in the frame of EFNUDAT must be presented at the Tandem/ALTO PAC after the EFNUDAT agreement. The Tandem/ALTO PAC will take into account the EFNUDAT recommendations and will especially examine the technical feasibility of the experiment.
The beam is delivered free of charge to users from academic and scientific institutes. Industrial services are based on specific contracts.
The co-ordination of users and machine planning is achieved through links between the various spokespersons and the physicist responsible for Tandem co-ordination. The institute management supervises the administrative and practical use of the facility (i.e. safety rules, access badges for controlled areas, radioprotection and logging).
The Tandem/ALTO facility can provide two weeks of beam time for the concerned community.
Accomodation:
7 rooms in the Tandem/ALTO building. Near by hotel in Orsay
Transportation:
Public transportation (RER B). Both Paris Airports directly reachable by the RER B

B.2 Scientific, technical and logistic support

B.2.1 Scientific environment

The "Institut de Physique Nucléaire" of Orsay is a multi-disciplinary research institute and an internationally recognised centre of excellence. The institute covers a great variety of scientific disciplines

- Nuclear Structure
- Nuclear physics for energy nuclear waste management and environment
- Hadronic physics
- Nucleus Nucleus collision
- Atomic physics
- Heavy ion plasma and cluster
- Radiochemistry and cycle of nuclear waste
- Detectors and imaging for biology and medicine
- Theory group
- Astroparticles

B.2.2 Technical and logistic support

The Tandem ALTO team is available for installation, alignment, adjustment and training. There are also mechanical, electronics and data processing services. Libraries exist at the laboratory and at the university.

B.2.3 Training

First-time users will be given a detailed facility-specific training, including detailed instructions on safety rules and, if needed, the use of the measurement techniques applied at our facility. They may also participate in seminars and lectures organised on site.

C EUROPEAN ADDED VALUE: European interest in the infrastructure

C.1 Community interest in the infrastructure

C.1.1 International users in the past

Tandem/ALTO produced heavy ion beams for experiments during 3850 hours per year. The accelerator was running continuously in shift-work operation Monday to Friday. The following table lists the users of the Tandem/ALTO facility over the last three years.

Institution	Town	Country
Nuclear Structure		
IPN	Orsay	France
Centre de spectrométrie de masse et de spectrométrie nucléaire (CSNSM)	Orsay	France
Centre d'étude nucléaire de Bordeaux Gradignan (CENBG)	Bordeaux	France
Centre Energie Atomique (CEA) DAPNIA, SPHn	Saclay	France
Centre Energie Atomique (CEA) DAM/SPM	Bruyères le Châtel	France
National Accelerator Centre (NAC) - now called iThemba Labs	Somerset West	South Africa
Ac. Science	Sofia	Bulgaria
USTHB	Alger	Algeria
Isolde, CERN	Geneva	Switzerland
JINR	Dubna	Russia
GANIL	Caen	France
INFN - LNS	Catania	Italy
Giessen University	Giessen	Germany
Laboratorio Nationale di Legnaro	Legnaro	Italy
University of Birmingham	Birmingham	UK
University of Warsaw	Warsaw	Poland
Radiochemistry		
IPN	Orsay	France
Nice University Sophia Antipolis	Nice	France
Clusters and Atomic Physics		
IPN	Orsay	France
Ecole Polytechnique	Palaiseau	France
Institut Electronique Fondamentale (IEF)	Orsay	France
Laboratoire des collisions atomiques et moléculaires (LCAM)	Orsay	France
IPN Lyon	Villeurbanne	France
Groupe de Physique de Solides (GPS)	Paris	France
Institute for Electronic Materials	Varsovie	Poland
GSI	Darmstadt	Germany
JAERI	Tokai Mura	Japan
Institute of Modern Physics	Lanzhou	China
THU	Darmstadt	Germany
Kholpin Radium Institute	St Petersburg	Russia
Kurchatov Institute	Moscow	Russia
Niels Bohr Institute	Copenhagen	Denmark
Industrial Companies		
ALCATEL ESPACE	MHS SA TEMIC	
ALTEN	SODERN	
C E R T /ONERA	THOMSON	
C N E S	TIMA/CNRS	

CONAE	TRAD
DELTA TECHNOLOGIES	ASTRIUM
INFODUC	INFODUC
MATRA MARCONI SPACE	HIREX

C.2 Expected impact

C.2.1 Impact on use of infrastructure

Additional 360 data-taking hours per year will be available for external users. As a consequence, the workload of the local staff will be increased. Nevertheless, the integration of our accelerator to the transnational access program is for the IPN Orsay a unique opportunity to increase and strengthen our scientific knowledge and technical capabilities. New ideas, new contacts and a diversification of the scientific domain and techniques will create around the Tandem/ALTO pole a fertile and innovative environment.

C.2.2 Impact on Europe's scientific community in general

Nuclear research has always been a subject with a large European dimension. Key theoretical and experimental elements have originated in Europe. In the neutron physics domain Tandem/ALTO will be a unique instrument, of the highest quality and performance in Europe. Integration of Tandem/ALTO into the consortium of EFNUDAT and securing open non-restricted transnational access to the facility will:

- Improve significantly the availability of resources for nuclear data research in Europe. TANDEM/ALTO is an essential instrument for the nuclear data community working in the areas of radioactive waste management and other activities in the field of nuclear technologies.
- Help integrating European research efforts in a lasting way by fostering long-term collaborations and co-ordinating European nuclear data research laboratories by planning of joint experiments and setting research priorities.
- Support the New Member States and Candidate Countries in their integration into an enlarged area by creating effective links.
- Provide unique training and mobility opportunities to young visiting researchers and technicians, an important aspect in view of the declining number of nuclear science specialists in Europe.

Special actions will be taken, mainly with respect to young researchers from the Candidate Countries, deprived from similar 'on-the-job' training opportunities. The multi-disciplinary training component will also receive particular attention.

C.3 Attracting potential new users

The research possibilities at all EFNUDAT facilities together will be advertised internationally in a common and systematic way, using different modern methods and media. In addition the publicity within the framework of NUDAME will also refer to the EFNUDAT Transnational Access programme.

D ACCESS OFFERED BY THE INFRASTRUCTURE

D.1 Annual implementation plan

The implementation plan covers project duration of 48 months. If the proposal can be accepted a reasonable estimate is that we can offer each year 240 hours. The average duration of an experiment is estimated to be one week for preparation and one week for the experiment, so that

researchers will spend 14 days at the infrastructure. For a visiting experimental group, access will be financed for 2 users.

D.2 Activities connected with access

Access offered to the external users will include user training, scientific and technical support during the experiment, office services, computers and administrative, logistic and security backing.

D.2.1 Training

All starting projects at Tandem/ALTO are submitted to a specific procedure for hazard identification and risk assessment. Special training sessions are organized for newcomers on health and safety at work, including radiation protection issues for activities in controlled areas. In addition, new users will be given a detailed facility-specific newcomers training. If needed, first-time users will get all training they need to get acquainted with the novel measurement techniques applied at our facility.

D.2.2 Scientific and technical support

The scientific coordinator of the Tandem/ALTO facility will be in charge of the external users during their whole measurement period. He will introduce the users to all facility aspects. He functions as a liaison with the machine operators and with the administration and technical service of the IPN Orsay.
The use of radioactive samples and/or chemically hazardous materials should be clearly stated in the proposal. For more details, please contact the safety responsible: Yves Adès (ades@ipno.in2p3.fr).

D.2.2 Administrative and logistic support

Users will get access to all the services offered by the Tandem/ALTO facility (telephone, fax, internet services) and meeting rooms, library and canteen. The Administration Service of the IPN Orsay can be contacted for administrative or personal problems, such as lodging, contacts with local administration and hospitals.

D.2.3 Travel and subsistence costs

Justified and approved travel costs for users traveling to the infrastructure and to user meetings will be reimbursed, together with their subsistence costs.
The calculation of the expected cost of the reimbursement for travel and subsistence is based on 3 additional experiments per year. A typical experiment has duration of 2 weeks performed by 2 researchers. They will stay during 14 days at TANDEM/ALTO. The unit cost for subsistence is estimated at 100 Euro/person-day. The unit cost for travel is quoted at an average of 350 Euro/person.