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THE DEVELOPMENT OF THE TANDAR PROJECT

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Summary

Progress on the installation of the Buenos Aires 20 MV Electrostatic Accelerator is proceeding at a rate consistent with its completion by 1982. About 90% of the civil engineering work on the accelerator tower is completed. The vessel has successfully passed pressure test up to 18 atm. Installation of the accelerator is due to start by the end of April 81. An outline of the research programme is also presented.

Introduction

In December 1977, the Department of Physics of the Atomic Energy Commission (CNEA) of Argentina signed a contract to purchase a large electrostatic tandem accelerator which will serve as the base of a new Research Laboratory that will include all the basic research activities currently performed at CNEA, such as nuclear, solid state and atomic physics, reactor chemistry, biology, solar energy, etc.

In this paper we would like to report on the progress done on the construction of the first stage of the program, namely that connected with the accelerator and related experimental research facilities. The general schedule for completion and operation of the accelerator as well as a summary of the planned initial research activities will also be presented.

A maquette showing a complete view of the planned facility is shown in Fig. 1.

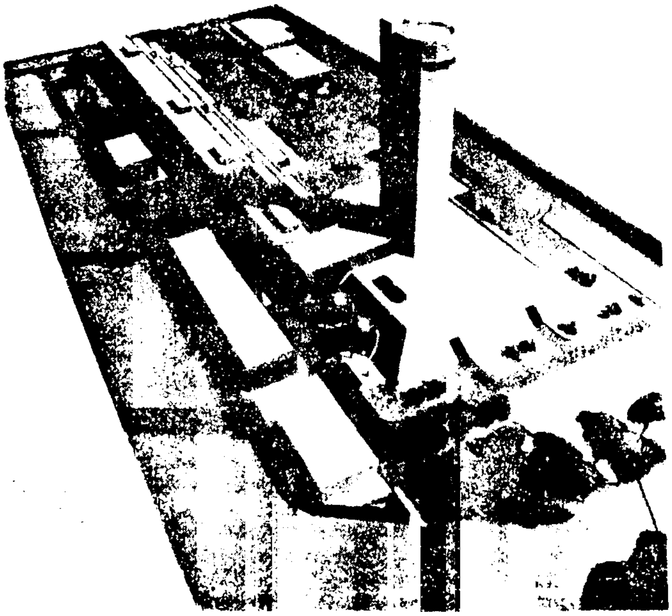

Fig. 1. Maquette showing a complete view of the Tandar Project.

Accelerator Design and Construction

The Accelerator is a 20 MV straight through pelletron tandem built by National Electrostatics Corporation (NEC), USA, according to CNEA specifications. Briefly, it consists of a modular column structure 2.15m in diameter and 34.8m high; modules are 60cm high. One major and three minor dead sections are included. The accelerator tubes are standard NEC units. Voltage grading is achieved with enclosed corona discharged tubes. Four pelletron chains are used to transport 400 μA of charge to the high voltage terminal.

The high voltage terminal, 2.44m in diameter and 4.88m high, houses an off-center quadrupole tripplet charge selector lens, gas and foilstripping systems and other standard equipment. Focusing elements are also placed in the first dead section. An additional stripping system is located in the first high energy dead section.

The machine will be controlled by means of a mixed system using light links and control rods. The implementation of the digital control system will use the CAMAC standard.

In addition to the accelerator itself NEC provides the injector system, including three interchangeable negative ion source modules as well as a pulsing and a bunching system. A 90° magnet of resolution $\Delta M/M = 1/150$ will be placed before the 300 kV injector acceleration stage. A 90° double focusing analyzer magnet with a mass energy product of $ME/Z^2 = 500$ manufactured by ANAC, New Zealand, will be used to mass analyze and bend the beams to the experimental areas. The magnet has an additional 15° port to bend heavy molecular beams into a target room below.

Table I shows the specifications contracted for acceptance of the accelerator.

Construction of the accelerator started in December 1977 and finished on schedule in September 1980. Ninety five percent of the machine is now in Argentina and only the control system remains to be delivered. Assembly of the accelerator starts in April 1981. It is scheduled to pass all acceptance tests within a period of fifteen months after assembly begins.

Construction of the Pressure Vessel

The accelerator is enclosed in a cylindrical pressure vessel of 7.6m in diameter, 36.3m in height and a weight of 310 tons. The vessel has been made out of 38mm thick steel and designed to work at a maximun pressure of 10 Kg/cm^2. This is 2 Kg/cm^2 higher than the value specified by NEC to achieve 20 MV in the terminal, thus having the advantage of providing a tolerance for attempting voltages above 20 MV.

Due to its size the vessel has been partly fabricated on site except for the top and bottom hemispheres which were manufactured at the factory. The installation of the tank was initiated in June 80 after the building reached 13.9m, level at which the tank sits. After the bottom hemisphere with its support skirt attached to it was positioned, the tank was built by stacking up seven rings, each approximately 3.5m high, and welding them together. Finally the top hemisphere

TABLE 1

Beam Specifications for Acceptance of 20 UD Accelerator

Beam	Mode	Terminal Voltage		Current	Transmission
p	DC	5-20	MV	3 μA	75% (1)
α	DC	20	MV	1 μA	75% (1)
S	DC	10-20	MV	150-200nA(2)	15% (1)
I	DC	10-20	MV	50-100nA(2)	
Au	DC	20	MV	0.05 nA(3)	
p	<Pulsed 1ns FWHM 4.0MHz	6-13-20	MV	0.3-0.5-0.8 mA(3)	
I	<Pulsed 3ns FWHM 4.0MHz	6-13-20	MV	1-10-10mA(3)	

(1) Transmission defined as particle current of most probable charge states measured after analyzer magnet image slit divided by particle current measured at input Faraday cup multiplied by 100.
(2) Particle micro or nanoamperes of ions of the most probable charge state
(3) In the burst.

was mounted and welded in August.

After all the peripheral welding was finished (including a total of over 30 windows and five access doors: three on the side and one on each hemisphere) and the X-ray analyses showed satisfactory results, the tank was hydraulically tested with 1.5×10^6 m^3 of water at a pressure of 18 Kg/cm^2 to 21 Kg/cm^2. In addition it was pneumatically tested for leaks at a pressure of 5 Kg/cm^2. The tank was commissioned on October 20th, 1980. A picture showing the tank completed is shown in Fig. 2.

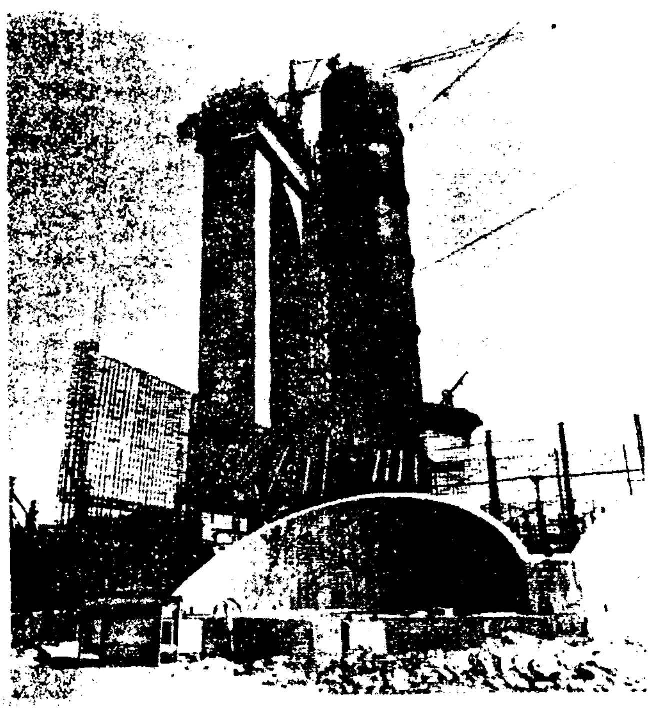

Fig. 2. Photograph showing the pressure vessel for the 20 MV accelerator.

The SF_6 Gas Transfer System

As described earlier[1], the SF_6 gas handling system is divided into two main sections: (1) The SF_6 transfer system and (2) The recirculation and purification system.

The former, designed in Argentina, is an entirely oil free system featuring gas storage as opposed to liquid storage as is usual in systems of this size. Its main components are two trains of Leybold-Heraeus Roots vaccum pumps and two large 450 HP Norwalk Compressors. Civil work for the gas handling plant is near completion. Piping installation has already started. Welding of these pipes will be 100% X-rayed and flushing will take care of slug and dust. The system is designed to complete a one-way cicle in 15 hours.

The main components for the recirculation and purification system such as turbocompressors, dryers, filters, etc., are provided by NEC and are ready for assembly. According to the present schedule, the test of the entire system should take place by September.

Storage Tanks

Two spherical containers are used to store the SF_6 gas. Each sphere has a diameter of 10m and a volume of 520 m^3. They are rated for a maximun working pressure of 23 Kg/cm^3 at a temperature of 80 °C.

The spheres were conformed at the factory and assembled on site. In addition to the hydraulic and pneumatic pressure test they were also vaccum tested. The spheres were successfully commissioned on March 31, 1980 and are ready to receive the first charge of SF_6 gas which will take place in April 1980.

Accelerator Building

The accelerator building constitutes the first and most important stage in the construction plan of the new research laboratory which, as mentioned in the Introduction, will be dedicated to CNEA's basic research activities.

The accelerator itself is enclosed by a 12 sided vertical structure serviced by an adjacent auxiliary tower both over 70m high. The latter will accomodate a 5 ton freight elevator, a fast elevator, a stairway and separator is presently used to mass-analyze the different products of a deuteron-induced fission reaction on U. The separator will be upgraded and moved to the new target room built to locate the ion source. In addition to the present gas ion source, a new non gaseous fission source has been built and set in operation, thus broadening the possibilities of the system. At the new laboratory a further enhancement will be possible with the use of heavy ion projectiles.

On-line γ-ray spectroscopy

This is a general purpose "gamma line". It proved fruitful in our present installation at the Buenos Aires Synchrociclotron with alpha and deuteron beams of 55 and 27 MeV respectively, and there is a group activelly involved with on-line γ-ray spectroscopy. In the new facility the γ and particle decay of high spin states of nuclei will be studied following their population through compound nucleus reactions. In order to populate these high spin states it is necessary not only to provide the required excitation energy but also a large amount of angular momentum to the compound nucleus. Heavy ion reactions are particularly convenient for these processes, both from energy and angular momentum considerations. The beam line will be provided with a versatile set of reaction chambers for γ-γ coincidence and singles measurements, for timing using the pulsing system and angular distributions of γ-rays. Nuclear magnetic moments and lifetimes using the plunger technique will also be measured. In addition a special chamber for measuring on-line conversion electrons will be built.

Heavy Ion Scattering

The machine will probably be used to a large extent with heavy ions although in principle any ion can be accelerated. Various proposals for a heavy ion scattering facilities were considered. It was finally decide to build a reaction chamber, based on the design used at the Weizzmann Institute.

The chamber consists of a cylindrical main body with a sliding steel foil to allow rotation of the chamber and two independently rotatable arms for angular distributions measurements.

A number of interesting features have been incorporated to the design of this chamber such as the possibility of using the kinematic method or a combination of binary angular distributions with the fragments time of flight.

Some development on HI detection has been made, specially in the fast detection of fragments by thin-foil scintillators. Intensive tests of home made HI solid state detectors are being carried out.

Light Ion Scattering

A general purpose, high quality, scattering chamber has been ordered from General Ionex Co. The chamber will be installed in experimental room B (see Fig. 4) to avoid interference with HI work carried out in room C.

The schedule for installation of this chamber was planned so as to have it ready for early work on machine acceptance tests and beam energy calibrations.

Magnetic Spectrometer

The purchase of a magnetic split-pole spectrometer has been appoved. Ample space has been reserved in room B for this importance piece of equipment.

Non Nuclear Physics

Beam time will be made available to the uses and two beam lines are currently being planned for this purpose: One for the study of radiation effects in biological medias and another for atomic physics studies.

Data Adquisition System

The data adquisition system for the TANDAR Project has been planned so as to provide both a maximun of flexibility in the hardware implementation of the different functions to be accomplished, and a simplification of the task of software development. For the conventional computing components we have purchased a DEC VAX 11/780 as main processor, with a DEC PDP 11/34 as front-end processor, interconnected through a full duplex 1 Mbaud link. The PDP-11 will provide the link between the system and a GT-43 display processor, a Versatex 1200A printer/plotter, and the CAMAC subsystem which will handle the actual interaction with the experimenta. A CAMAC compatible experimental controller interface in presently in the design stage. This interface will allow the setup of the logical relations desired between the different detector output by a combination of hardware and software components. It will also handle the formatting of the accepted data as well as the setup of files for the display of raw and/or partially evaluated data as for example singles spectra gated coincidence spectra, E-DE plots , etc

External Users

The facility will be opened to external users, both from other argentine institutions and from abroad. Criteria traditionally applied in most other international laboratories will be adopted, such as the formation of special committee to deal with external users.

A file of interested institutions to partipate in this programme will be opened in the near future.

Schedule

The schedule for the installation of the 20 MV accelerator in shown in Fig. 5. It can be seen that the difference between the schedule planned in 1977 and

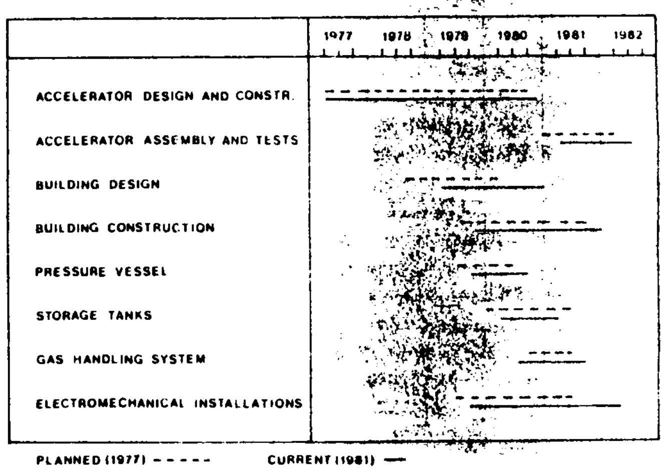

Fig. 5. Schedule for completion of the first stage of the Tandar Project

the current one is small. It has been our aim all along to meet our original timetable as much as possible and considerable effort has been put in this respect. In view of the work done so far we are optimist that we will be able to start research activities by 1982.

References

1. E.P.Ferreira et al., Nucl.Instr. and Meth. Vol. 184 (1981).

service conduit. A picture showing both towers is shown in Fig. 3.

Most of the concrete work on the two towers was made employing the sliding form technique. This method allowed for a substantial time saving. The towers were built separately in about 25 days each of non-stop cement pouring routine. The auxiliary tower was built first while the tank, which was already assembled and positioned in its specially reinforced base at 13.49m above ground, was undergoing pressure tests. By the end of October 1980 the auxiliary tower was completed and the installation on the sliding form structure for the main tower at 13.49 was started. In this case the sliding technique was used up to 62.00m corresponding to the injector roof level. The upper levels (i.e., seminar room and water reservoir) are presently being built in the conventional way.

Between the bottom and the top of the pressure vessel there are seven metallic platforms. Five of them have direct access from the auxiliary tower. Of these, three correspond to levels with manway ports: one at the first dead section in the high energy column where a second stripper will be installed and the remaining one at the tank's top at 48.77m. At this level there is an additional vertical manway port. Most of the accelerator components will be hoisted up from the outside and brought into the tower through an opening at this level.

The experimental areas, shown in the layout of Fig. 4, are at ground level surrounding the tower almost 270°. Target areas A and D are designed for low activities so that they are nearer the control room and other normally occupied working places such as offices and laboratories.

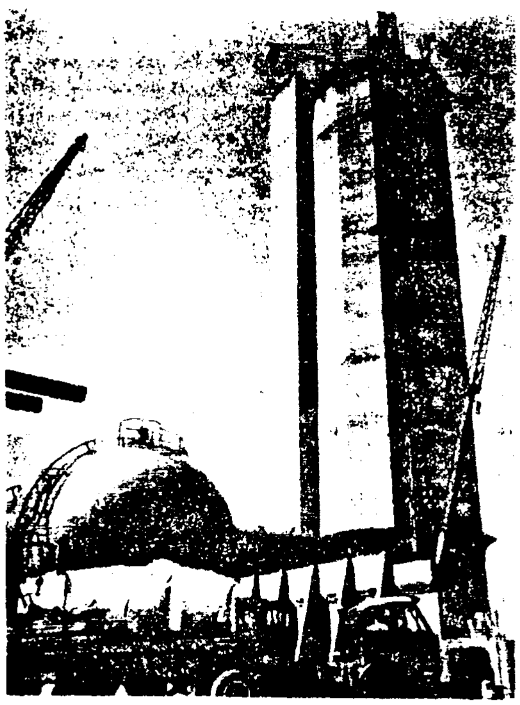

Fig. 3. View of the accelerator tower

Area A will be used for the spectroscopy of mass-separated fission products and therefore includes a specially shielded vault for the target. Areas B and C are shielded and are intended for conventional work. Area B will contain a magnetic spectrometer and an all purpose scattering chamber, while area C will contain a heavy ion scattering chamber, a gamma ray spectroscopy facility and an atomic physics beam line. Holes through the wall separating the experimental areas and the 90° analyzing magnet room were made every 5° so that other beam lines for external users and future programs can easily be added.

The shielding of the accelerator building was calculated so that permissible radiation levels for general public were not exceeded. The calculations were based on 40 MeV proton and deuteron beams, 20 μAmp, maximun current assuming they will be used 16% of the total time. This calculation yielded a minimum thickness of 1.60m, ordinary concrete at ground level. Nevertheless the tower wall was built 2m thick below 13.49m, gradually disminishing its thickness with height.

The outside shielding of areas B and C is achieved with an earth mound 4.5m thick at half height. Truck entrances for each of these areas are planned, which will be blocked with removable concrete bricks.

The layout of the ground floor is shown in Fig. 4. Besides the tower and experimental areas, other two important sections of the building are the control, data handling and computer room and the gas handling plant. Both have specially designed floors.

Below ground there are tunnels connecting the experimental areas with the tower and control room without loss of shielding effectiveness. In addition there is target room 7.00m below the zero level designed for work with low-charge heavy beams coming out of the analyzing magnet 15° port.

The second floor provides additional office and laboratory space for ion source development, target manufacture, strippers, detectors, electronics, etc.

A third floor occuping a fourth of the surface area with also be constructed to provide for additional office space.

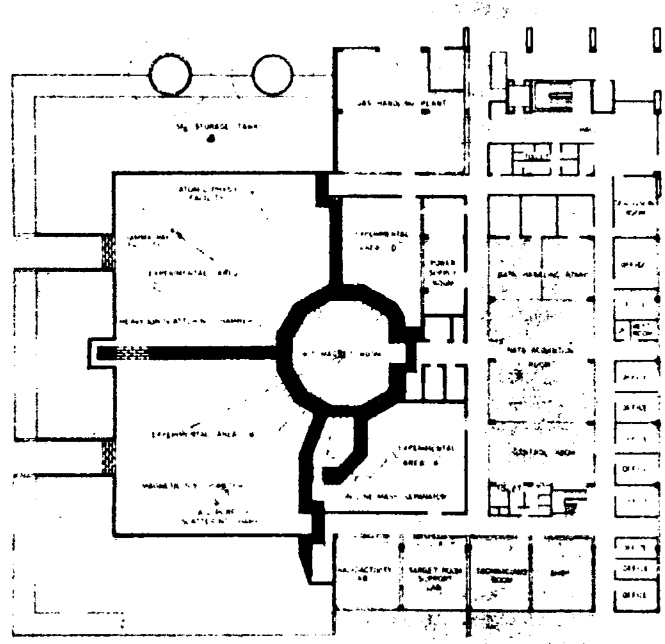

Fig. 4. Lay-ouy of experimental and ground floor area

Experimental Lines

The new accelerator can accomodate a large number of active experimental lines. Six are planned to be initially set up. The choice of these partially follows historical reasons, giving continuity to our present research programme.

On line isotope separator facility

In this facility a home built, on-line isotope