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E. PEREZ FERREIRA, M.A.J. MARISCOTTI, E. VENTURA, A. CEBALLOS, N. FAZZINI, A. FILEVICH, H. GONZÁLEZ, R. REQUEJO, R. RIBARICH, J.J. ROSSI, E. ACHTERBERG, D. CAMIN, J. NICOLAI and S. TAU
Departamento de Física, CNEA, Av. del Libertador 8250, 1429 Buenos Aires, Argentina

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THE ARGENTINE 20 MV TANDEM ACCELERATOR PROJECT

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Departamento de Física, CNEA, Av. del Libertador 8250, 1429 Buenos Aires, Argentina

A 20 MV tandem accelerator laboratory is currently under construction in Argentina. The facility is planned to be completed by the end of 1982.

1. Introduction

In 1976, the National Atomic Energy Comission (CNEA) of Argentina approved a proposal presented by its Department of Physics to build a major new facility for nuclear physics, the heart of which is a 20 MV electrostatic tandem accelerator. The project, known as the TANDAR project [1], later enlarged to accommodate also all the basic research activities of CNEA grouped under its Research Branch: the Department of Physics with its nuclear, solid-state and theoretical physics divisions; the Department of Reactor Chemistry with activities in the basic research of reactor technology; the Department of Radiobiology and the Department of Special Projects engaged primarily in the study of non-conventional forms of energy such as solar energy and nuclear fusion.

Because of the characteristics of this research centre, which will be similar to those of a National Laboratory, the facility will be located on 5 hectares of land in Buenos Aires, with easy access to national and international airports and main freeways. Thus linking it not only to universities and other research centres in Buenos Aires, but also to institutions in the rest of the country and the world.

When completed the research centre will hold conference facilities including a fully equipped auditorium for 500 people, dining facilities and guest rooms for visiting scientists. In addition, the main library of CNEA with one of the best technical collections of books and journals in Argentina will be built on this site.

The purpose of this paper is to present the first stage of the TANDAR project, namely that connected with the accelerator, pressure vessel, gas handling system and building. A brief outline of the proposed research activities with the accelerator is also given.

A schedule showing the main landmarks of this first stage is shown in fig. 1. At present the pressure vessel is being constructed and assembled in its final position, the accelerator is ready to be packed for shipping and all of the components for the gas handling system have been ordered, thus assisting our goal of achieving a beam on target by the middle of 1982.

2. Accelerator

The accelerator is a 20 MV straight through Pelletron accelerator built by National Electrostatic Corporation, Middleton, Wisconsin, U.S.A. according to CNEA specifications. The basic lay-out of the accelerator is shown in fig. 2.

2.1. Negative ion source and injector system

The negative ion source system consists of a high voltage cylinder and column with injector magnet, three interchangeable ion source modules, a vacuum system, power supplies and controls for the source modules. The high voltage cylinder and column is an electrostatically smooth cylinder, 132″ diameter, designed to support 300 kV negative dc voltage in clean, dry, atmospheric pressure air. It is supported from above and below by columns consisting of 8 metal bonded alumina ceramic support posts,

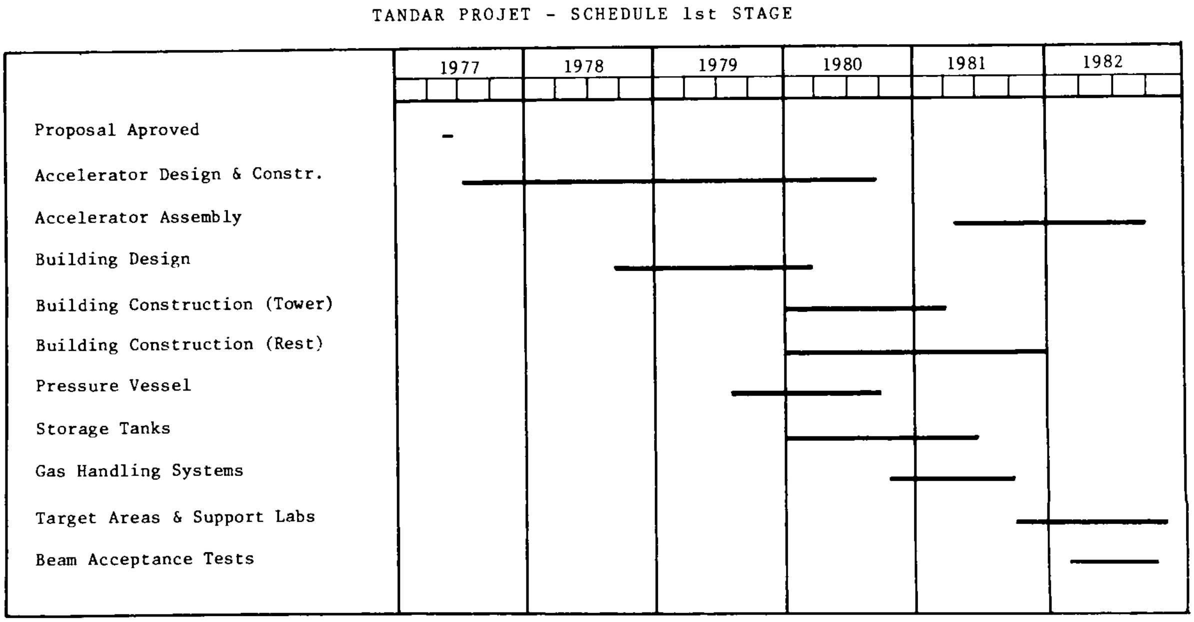

Fig. 1. Schedule for completion of first stage of the TANDAR project.

stainless steel hoops and aluminum castings. It is surrounded by a grounded safety screen which is interlocked so that entry into the high voltage region is not possible with the high voltage on. An insulating rotating shaft driven by a motor positioned below the lower column and driving an alternator inside the high voltage cylinder provides power for components at high voltage. Focusing elements, including a 90° $ME/Z^2 = 12$ double focusing magnet with a resolution of 1/150 placed before the 300 keV injector accelerator tube, are positioned inside of the high voltage cylinder.

2.2. Pulsing system

A pulsing system designed to produce nanosecond bursts of particles after acceleration is located at the low energy entrance to the machine. The system can be used for light and heavy ions. It consists of a beam chopper and retrace eliminator, a travelling wave deflector, light ion buncher, and heavy ion buncher. The acceptance specifications of the system are listed in table 1.

2.3. Accelerator

The accelerator is based on the designs and ideas that have been described by R. Herb and collaborators elsewhere [2]. Its voltage characteristics are:

voltage rating = 5–20 MV
voltage stability = ± 2 kV
voltage ripple = ± 500 V

The column structure is built in 60 cm high modules consisting of 10 cm thick horizontal cast aluminium bulkheads supported by 6 circumferentially located column posts of the type used in previous NEC designs. It has a diameter of 2.15 m and a length of 34.84 m including the high voltage terminal.

One major and three minor dead sections are used in the design. The acceleration tubes are of the standard NEC design. Voltage grading for each acceleration tube and the column structure are provided by two enclosed corona discharge tubes. Two independent groups of two pelletron chains are used to transport 400 μA of charge to the high voltage terminal. Power for various components within the column structure will be provided by two rotating shafts.

The high voltage terminal is 2.44 m in diameter and 4.88 m high. A displaced element electrostatic quadrupole triplet charge selector along with a variable selector aperture and high energy tube matching lens are placed to separate

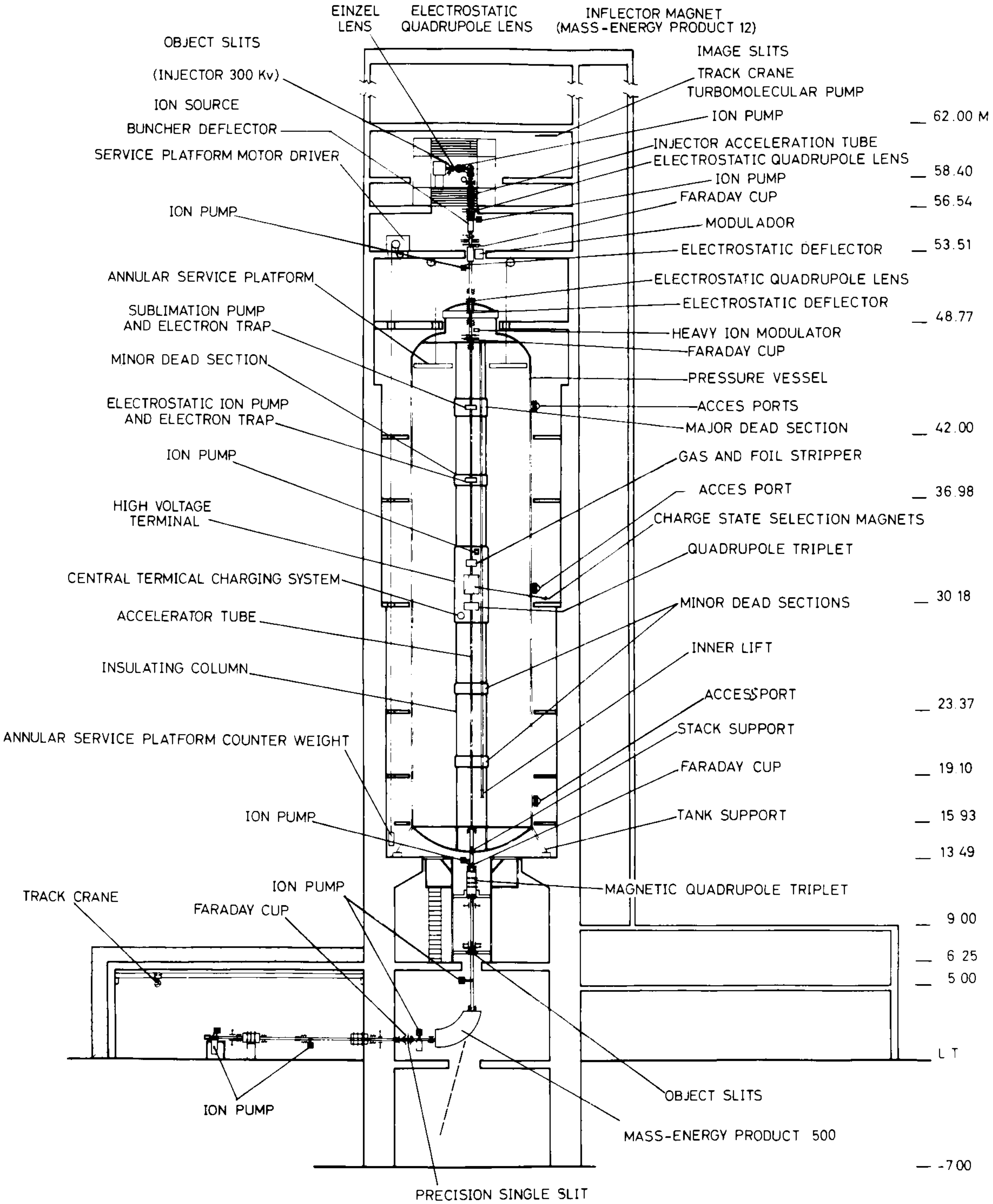

Fig. 2. Basic lay-out of the 20 MV pelletron accelerator and related equipment. The numbers on the right are height in meters.

charge states after stripping. Electrostatic steering plates, gas and foil stripping systems and getter-ion pumps are also mounted in the terminal. Focusing elements including a quadrupole triplet lens are also placed in the first dead section. An additional stripping system is located in the first high energy dead section.

In order to increase the reliability keeping at

Table 1
Beam specifications for acceptance of 20 UD accelerator

Beam	Mode	Terminal voltage (MV)	Current	Transmission (%)
p	dc	5–20	3 μA	75[a]
α	dc	20	1 μA	75[a]
S	dc	10–20	150–200 nA[b]	15[a]
I	dc	10–20	50–100 nA[b]	
Au	dc	20	50 nA[b]	
p	pulsed <1 ns fwhm 4.0 MHz	6–13–20	0.3–0.5–0.8 mA[c]	
I	pulsed <3 ns fwhm 4.0 MHz	6–13–20	1–10–10 mA[c]	

[a] Transmission is defined as the particle current of the most probable charge state measured after the analyzer image slit divided by the particle current measured at the input Faraday cup multiplied by 100. For example, 15% transmission for sulphur at 20 MV would mean when using a foil that no more than 1.33 μA measured current must be injected into the accelerator to achieve a measured current of 2.0 μA of 220 MeV sulphur at the analyzer magnet image slit position, where S^{+10} is the most probable charge state for foil stripping at 20 MV.
[b] Particle micro or nanoamperes of ions of the most probable charge state.
[c] In the burst.

the same time its precision and expansion capabilities, 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. Two PDP-11/23 computers, one acting as backup, will be used to communicate with the system.

Service for the column structure and contents of the high voltage terminal will be performed from two movable service platforms. The large annular platform will be located in the space between the column and pressure vessel. A small platform will move vertically within the column allowing easy access to the interior of the column structure and high voltage terminal.

2.4. *Analyzer magnet*

The 90° analyzer magnet is a double focusing unit with a mass-energy product of $ME/Z^2 = 500$ manufactured by Auckland Nuclear Accessory Co. Ltd., Auckland, New Zealand. It has a bending radius of 2.0 m, a maximum magnetic field in the gap of 16 kG, contoured, uniformly saturating poles and image and object distances of 6.1 m. It is supported on a rotatable base so as to be able to align it to each of the experimental beam lines.

In addition to the 90° exit port there is a 0° port and a 15° port. The latter port has been designed to mass analyze heavy molecular beams, which cannot be bent through 90°.

3. Pressure vessel

The accelerator is enclosed in a cylindrically shaped pressure vessel, 7.6 m in diameter and 36.3 m in height filled with 100% pure sulphur hexafluoride (SF_6) as insulating gas. The vessel is made of steel 38 mm thick designed to work at a maximum of 10 kg/cm^2 absolute pressure. This is 2 kg/cm^2 above the operating pressure specified by NEC to achieve 20 MV in the terminal, thus giving the advantage of not being severely tank limited in reaching voltages above 20 MV.

Due to its size, the vessel will be fabricated at the site, and one of the features in the choice of its maximum working pressure is the avoidance of a difficult and expensive on site stress-relief treatment.

Access for normal accelerator service operations will be provided by five ports in the tank. Access to the annular service platform takes place through three side manways. Another port, located on top of the vessel, will be used for ventilation (together with the bottom port), and for lowering heavy objects to the annular service platform. For assembly of the column structure and major service operations a large port is provided on top of the vessel. In addition there are many smaller openings dealing with the requirements for viewing windows, cable entries, light links, probes, etc.

The tank will be supported by a skirt which will have the capability of realigning the vessel if necessary. This skirt is designed to carry the weight of the tank plus the weight of 1500 m^3 of water during the hydraulic test. The overall weight of the pressure vessel (without gas) is 310 metric ton.

4. SF_6 gas handling system

The gas handling system can be divided into two main sections: (1) the SF_6 transfer system and (2) the recirculation and purification system. The former was designed jointly by CNEA and TECHINT, a large Argentinian engineering firm contracted by CNEA. The latter is a NEC design.

4.1. SF_6 transfer system

The main features of this system are that it makes use of gas storage, as opposed to liquid storage used in all other plants of this size and that it is an oil-free system. A study made by CNEA in this respect showed that both liquid and gas storage systems are equivalent in price when operating costs over a 10 year period are taken into account. Gas storage was chosen since it has the advantages of being a simpler, more reliable and versatile system.

The main components of the system are the vacuum pumps, the compressors, the charging system and the storage tanks. A block diagram of the system is shown in fig. 3.

Vacuum pumps: There are two groups of pumps. They have been purchased from Leybold Heraeus, West Germany. Each group is composed of the following five pumps:

2 × WAU 2000 (7.5 kW);
1 × RAV 1000 (18.5 kW);
1 × RAV 1000 (15 kW);
1 × RAV 250 G (7.5 kW).

All of these are Roots pumps, the RAV ones modified to work against atmospheric pressure. This allows the system to be free from oil contamination. The pumps will be supplied with their own control system, and its noise during operation will be reduced to 85 dB using silencers and acoustic cases. The accelerator pump-down time for SF_6, combining the capabilities of the two groups of pumps, is less than 5 h to get from 1 atm to 1 Torr inside the tank.

Compressors: Two identical Norwalk compressors with non-lubricated cylinders will be used. They are rated for a maximum discharge pressure of 21 kg/cm^2, having a variable suction pressure of 1–10 atm, and a piston displacement of 540 CFM. Each compressor requires up to 175 HP of electrical power and 50 GPM of cooling water for the inter and after coolers. Another small compressor will be used to recirculate leaks into the main compressors.

Charging system: This consists of a manifold where the SF_6 containers will be connected. A heater is located between this manifold and the storage tanks in order to compensate the temperature drop caused by the expansion of the gas. In addition, there is a by-pass which connects the charging system with the small "leak compressor" having a maximum discharge pressure of 21 kg/cm^2 to the storage tanks. The first step of the gas charging procedure can be accomplished without using this compressor. After equalizing the pressure between storage tanks and containers, the small compressor is used.

Storage tanks: Two spherical containers will be used for the storage of the SF_6 gas. Each sphere has a diameter of 10 m and a volume of 520 m^3. They are rated for a maximum working pressure of 23 kg/cm^3 absolute. The spheres are made of steel 31 mm thick with a design temperature range of 28–80°C.

4.2. Recirculation and purification system

Drawings and components of the recirculation system for purification and refrigeration of the dielectric gas were contracted from NEC. A block diagram is shown in fig. 4.

The system has two turbo-compressors, which circulate a continuous supply of gas through alumina absorption beds. These dryers remove the moisture present in the gas in addition to the

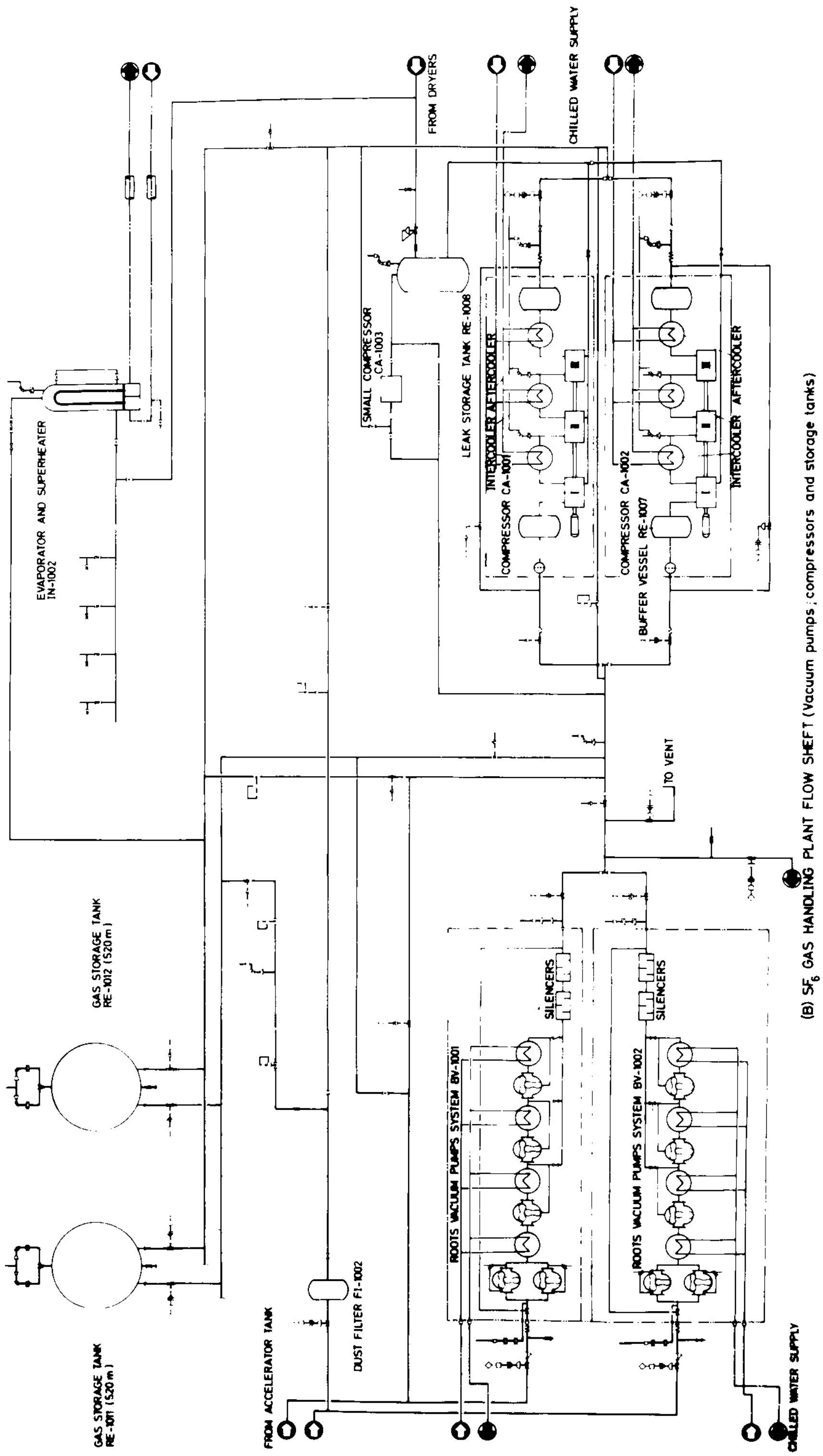

Fig. 3. Block diagram of the SF_6 transfer system.

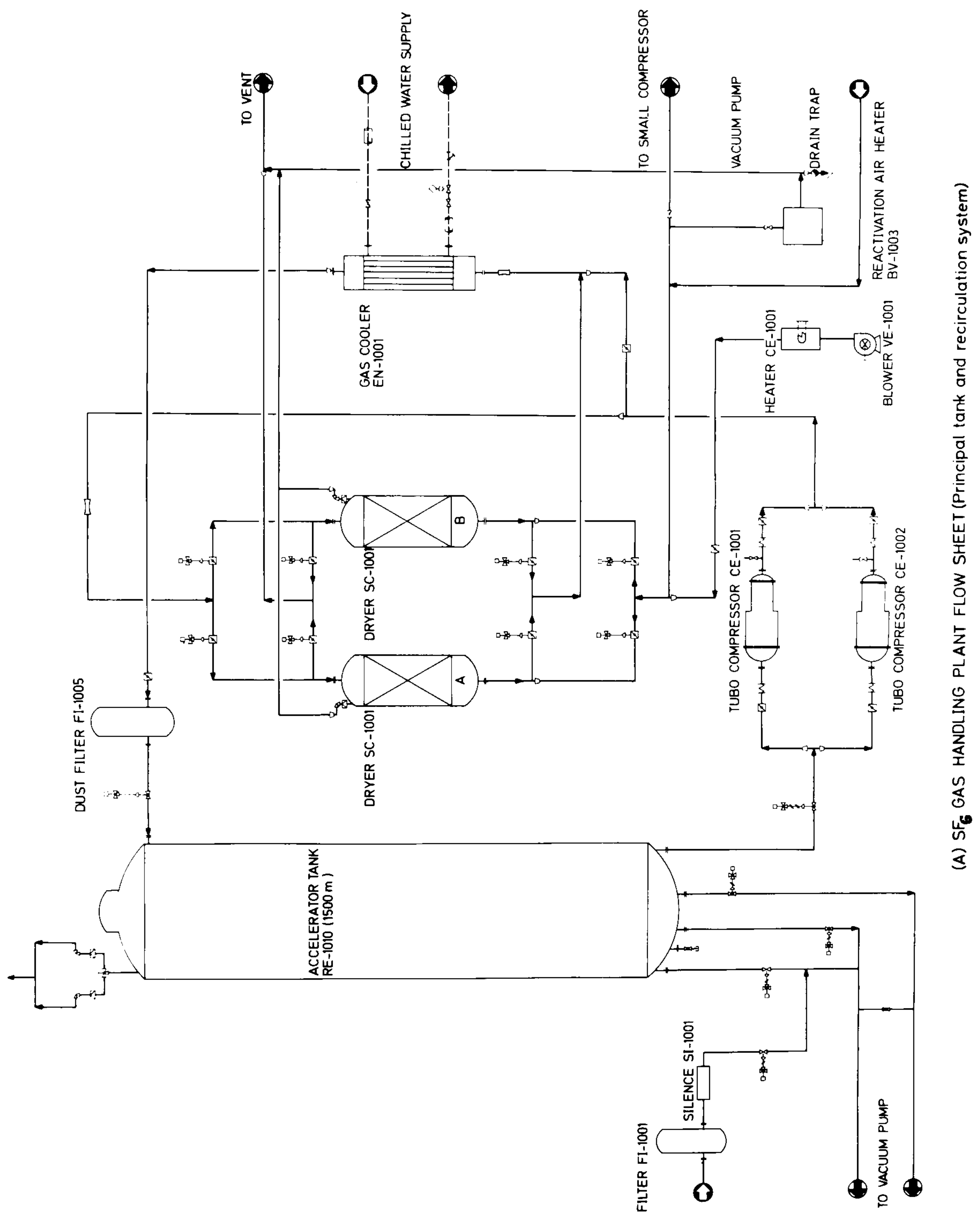

Fig. 4. Block diagram of the SF_6 recirculation and purification system.

gas breakdown products. Before reinjection into the tank, the gas is cooled in a water-cooled heat exchanger in order to remove the heat produced by the electrical components inside the tank. Finally, the gas is filtered before being passed back into the tank. The system has been designed with two dryers: while one is in operation, the other can be reactivated by a hot air current at 400°C.

5. The buildings

The design of all the buildings for the TANDAR project was contracted with TECHINT following the requirements imposed by NEC and CNEA. The goal in the architectural design was to emerge with an overall functional and aesthetically pleasant laboratory at a reasonable cost. Again we will limit ourselves to a description of the first stage only.

5.1. Accelerator building

The most prominent feature of this building is the tower structure that houses the accelerator. It consists basically of a dodecagonal base 15 m in (outer) diameter and 73 m in height. The design took into consideration the stability of the accelerator during periods of intense wind and solar heat gain. It has also been designed with the appropriate concrete thickness to shield it from radiation produced when beams of protons and deuterons are accelerated to the maximum energy. In addition to the accelerator, space is also provided for the ion sources, injector and 90° analyzer magnet. Finally, a conference room has been included at the top of the structure.

Access to the main tower is through another smaller service tower adjacent to it. One freight elevator and one fast passenger elevator provide the means of conveniently transporting equipment and personnel to the different levels. Fig. 5 shows a vertical cross section of the accelerator building.

5.2. Experimental areas

Experimental areas were assigned the utmost importance by the research physicists. The main considerations that went into the design were (1) size and shape, (2) number of rooms and (3) access. The layout has been arranged in a way to keep as much area as possible available around the base of the accelerator for beam lines, allowing at the same time easy access from the control, data handling and service areas.

The experimental area occupies approximately a 270° sector. The final design, shown in fig. 6, consists of two, all-purpose, shielded (partly by concrete and partly by an earth embankment) rectangular rooms approximately 22 × 23 m in size, occupying a 180° sector of the floor area. These rooms have the possibility of being equipped with overhead cranes if necessary. Two access doors, with removable concrete blocks, directly connect these areas with an outside road, providing the necessary entrance space for future heavy equipment such as a magnetic spectrometer.

A heavily shielded area for high radiation experiments is also available. This room has been planned to accommodate part of the on-line electromagnetic isotope separator facility. In addition there are two unshielded experimental areas for off-line use, these can be later shielded and equipped for on-line work.

Finally there is an experimental room in the basement directly below the 90° analyzer magnet. It has been designed for studies with heavy molecular beams focused through the 15° port of the magnet.

5.3. Plant areas and support laboratories

The control and data handling facilities are located in the ground level with direct access to experimental areas, gas handling plant and tower entrance. It has been designed so that the area can be easily divided into separate functional compartments.

The gas handling plant is located on two levels (ground and first floor) so as to locate the vacuum pumps as close to the tank as possible. Due to its noisy operation the plant has been acoustically separated from the rest of the building.

The upper floor accommodates the support laboratories needed in connection with the accelerator activities: electronics, ion source development, target preparation, detectors and health physics. Office space is provided

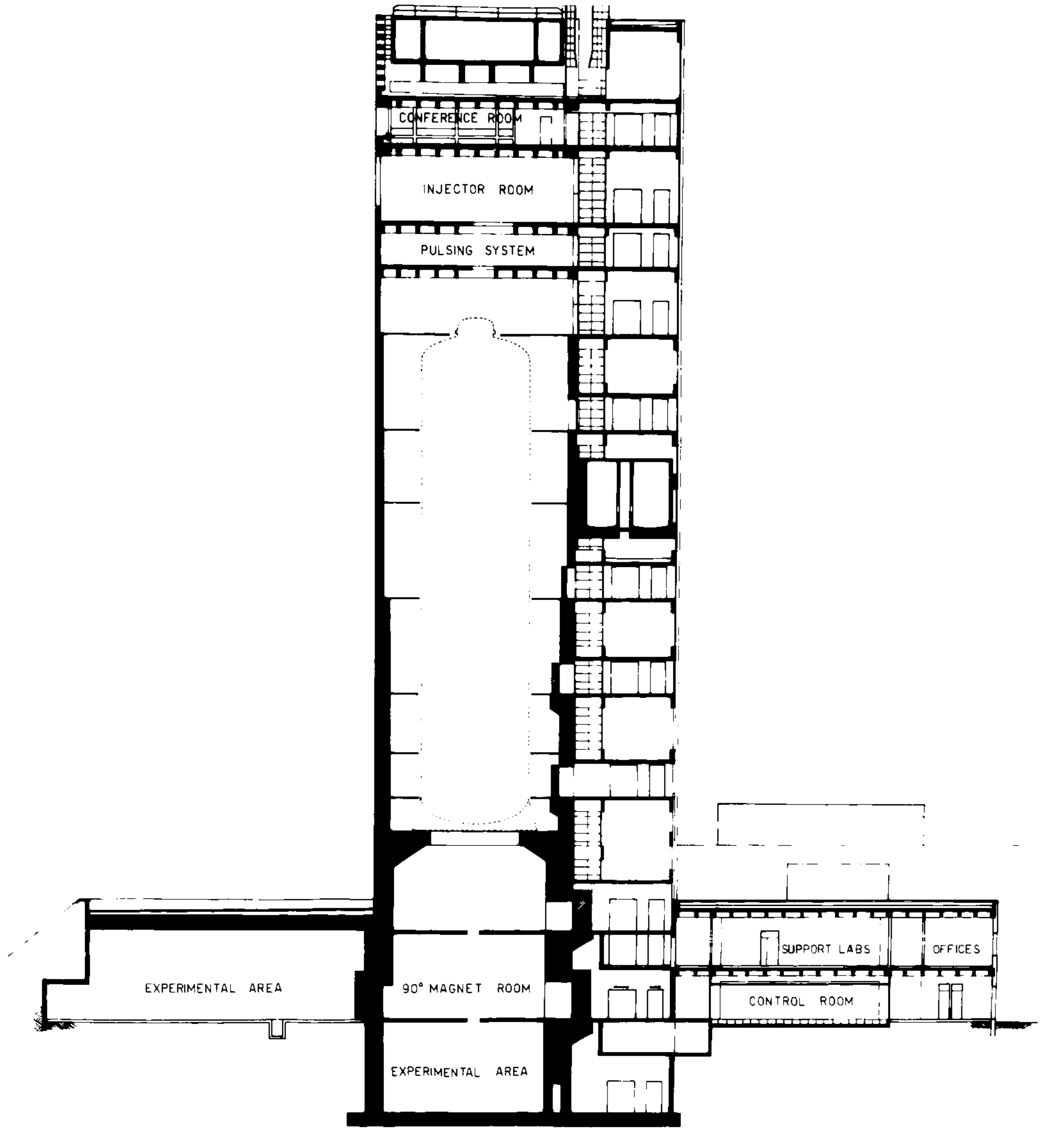

Fig. 5. Vertical cross section of the accelerator building.

throughout these levels, its designation being mainly for accelerator-related personnel. Figs. 6 and 7 show layouts of these two levels. Finally, a separate building, across the street from the main accelerator building, will house the main shop and storage area.

6. Initial research activities

Due to its versatility, the 20 MV tandem accelerator allows a very broad range of research activities. Here we will only present a brief outline of the initial programme.

Although a total of 15 different beam lines could in principle be installed, only six of them will be initially assembled. These beam lines will be equipped with all the necessary beam handling and beam diagnostic devices to focus a beam on target.

Four initial experimental facilities for nuclear physics research are planned. These are (1) various multi-purpose correlation tables for gamma ray spectroscopy following nuclear reac-

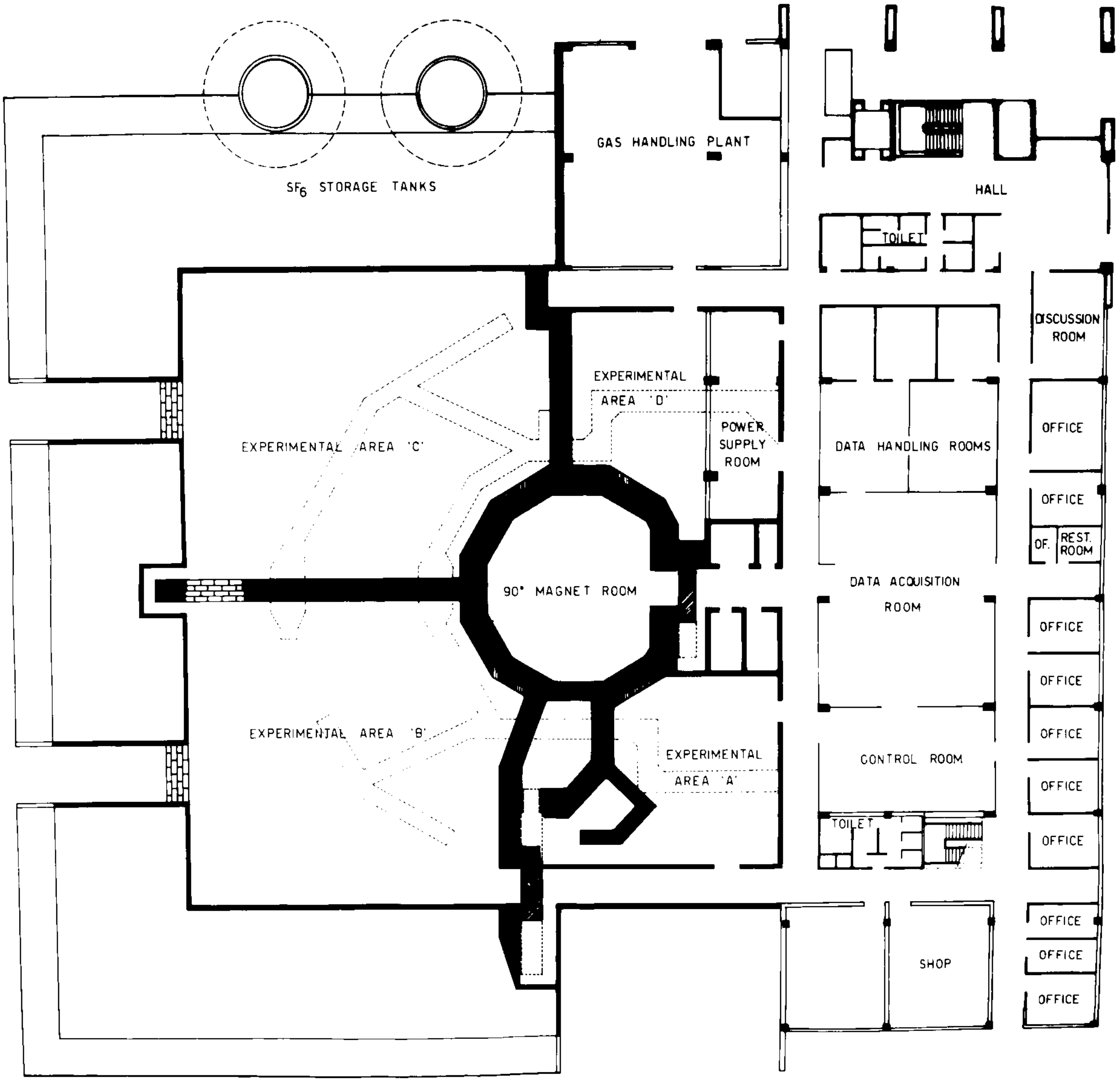

Fig. 6. Lay-out of the ground floor level. This floor accommodates primarily the experimental areas, control and computer rooms and part of the gas handling plant.

tions; (2) an on-line electromagnetic isotope separator; (3) an all purpose scattering chamber mainly for light ions and (4) a heavy ion scattering chamber. Facilities (1) and (2) are presently operating at CNEA and will be moved to the new laboratory in due course. Plans to purchase a magnetic spectrometer have also been discussed and are presently subject to budget considerations.

A VAX 11/780 computer with a half Mbyte memory (to be expanded to 2 Mbytes) has already been delivered by Digital Corp. The data acquisition system will be based on this computer and software development has been initiated.

As well as nuclear physics, research in atomic and solid state physics is actively being planned. In addition some applied research will also be carried out in areas as diverse as metallurgy and radio-biology.

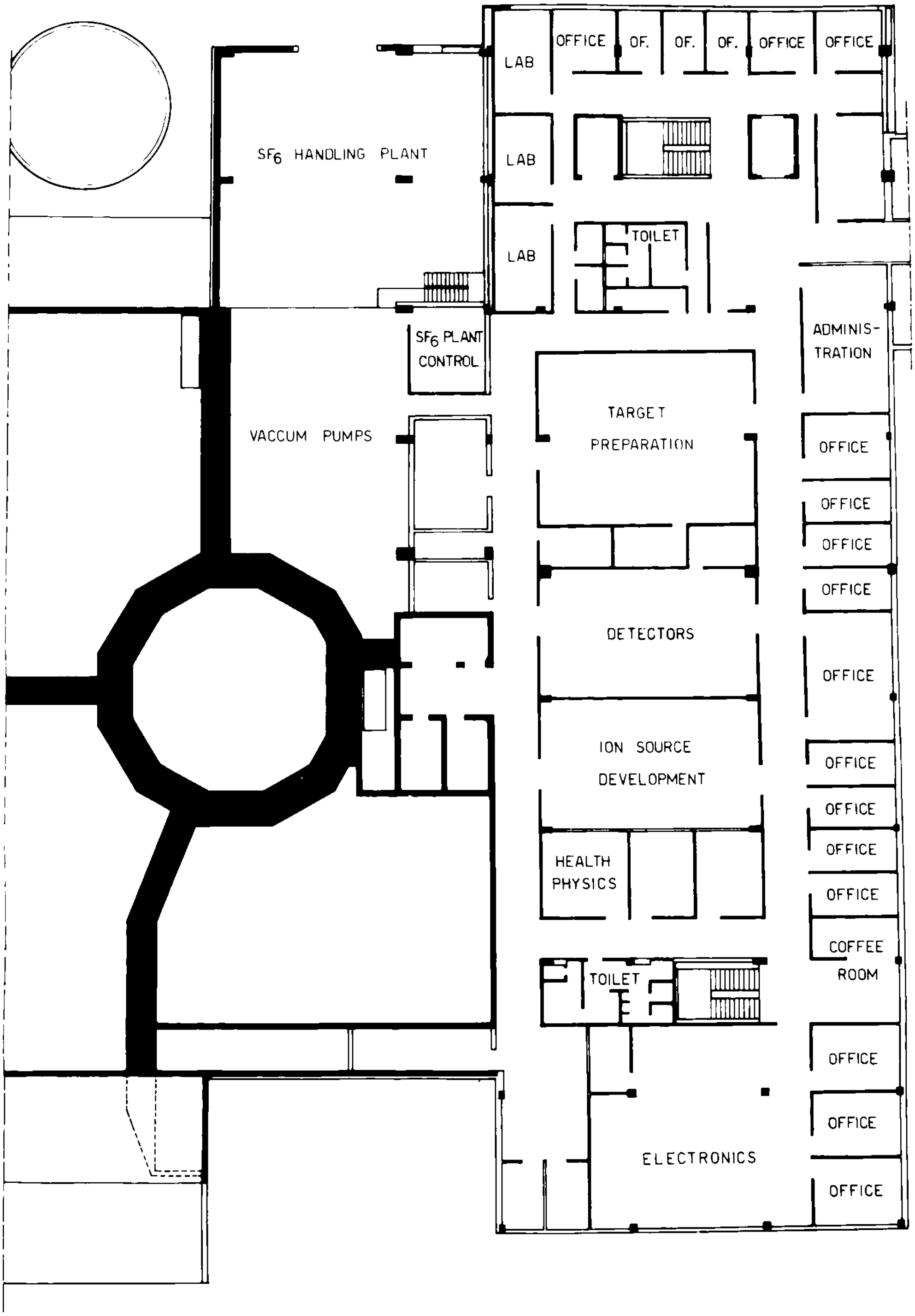

Fig. 7. Lay-out of first floor level. This floor accommodates primarily the support laboratories, the rest of the gas handling plant and offices for accelerator related personnel.

7. Conclusion

The TANDAR project, a project to install a 20 MV electrostatic accelerator in Argentina has been described. When completed it will be the largest facility of its type in Latin America, and one of the largest in the world. We hope the project will create an active place of research, attractive to physicists from all institutions within our country and beyond. In view of the work done so far, we are also optimistic that research activities will begin by the end of 1982.

We would like to thank all the members of this Department who have collaborated on many specific details of this project. We are also deeply indebted to Dr. Peter Thieberger for his generous and prolific advice during various stages of this project.

References

[1] The word TANDAR stands for the contraction of TANDem ARgentino.

[2] R.G. Herb, Nucl. Instr. and Methods 122 (1974) 267 and ref. therein.