# Design of a New Terminal Gas Stripper System

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# DESIGN OF A NEW TERMINAL GAS STRIPPER SYSTEM

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## ABSTRACT

A new terminal gas stripper, for the electrostatic FN tandem accelerator of the AMS system at the Nuclear Regulatory Authority in Argentina, is being designed at present. Most of the vacuum, electrical and electronic components are already available. The remote control of the system is being developed at LABI1). In order to construct the vacuum chamber, a collaboration with the LNLS2) is under consideration. The status of the project is presented.

## RESUMEN

En la actualidad se esta llevando a cabo el diseño de un nuevo intercambiador de carga gaseoso para el acelerador del sistema AMS, de la Autoridad Regulatoria Nuclear en Argentina. La casi totalidad de las componentes de vacío, eléctricas y electrónicas están ya disponibles. El sistema que controlará remotamente al intercambiador de cargas, esta siendo desarrollado por el LABI1). Al efecto de construir la cámara de vació del sistema, se esta considerando una posible colaboración con el LNLS2). Se describe estado presente del proyecto.

## 1. INTRODUCTION

Accelerator Mass Spectrometry (AMS) is an ultra-sensitive analytical technique that allow to identify and count rare atoms having abundance's as low as 1 in $10^{15}$ matrix atoms.

That capability has enable AMS to be successfully applied to the science of radiocarbon dating as well as to many other long lived radioisotopes that as chronometer or tracer, are at present actively applied in fields like biomedicine, geoscience, environmental science, extraterrestrial material, nuclear safeguards, etc.

The extreme sensitivity of this technique allow to use very small samples, just a few hundred micrograms may be enough. The atoms are extracted from the sample by sputtering them with positive cesium ions. The extracted negative ions, are pre-accelerated to tens of keV, to be mass analyzed and then injected into an electrostatic tandem accelerator. Once in the positive high voltage terminal of the accelerator (MV range), the ions pass through a gas or foil stripper where its charge is exchanged to positive and then further accelerated to ground potential. The charge state most efficiently produced is selected in the post-accelerator line, by mean of energy and momentum analyzers. Finally at the detection system the ions are individually counted, while being identified in mass, energy and atomic number.

The stripping process plays an additional and fundamental role in AMS: the charge changing collisions induce the breaking of the ions into their elemental constituents. This process known as Coulomb explosion enable the elimination of the molecular background.

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1) Laboratorio Abierto (LABI), Facultad de Ingeniería, Universidad Nacional de Buenos Aires, Argentina.
2) Laboratório Nacional de Luz Síncrotron, Campinas, São Paulo State, Brazil.

In order to improve precision and throughput, is very important in AMS, to use an efficient and long-lived stripper medium. Although this demand is better met with gas stripping than with foils, problems arise when the gas from the stripper canal goes into the accelerating tubes. A poor vacuum will significantly decrease the beam transmission due to multiple scattering and charge exchange with atoms of the residual vacuum.

In order to overcome this problem it is necessary to recirculate the gas leaked at the ends of the stripper canal. Since 1984, when for the first time a turbomolecular pump was used to recirculate the stripping gas at a tandem terminal [1] an increasing number of similar upgrading has been performed up to now [2-7].

It is the purpose of the present work to summarize the design of the future gas stripper system for the FN electrostatic tandem accelerator of our AMS dedicate facility.

## 2. THE DESIGN OF THE SYSTEM

Figure 1. is an schematic view of the future terminal gas stripper system. An important feature of the present design is the incorporation of a duct interconnecting the terminal ends of the accelerator tubes [3]. Two 20 l/s StarCell ion pump are attached on that high conductance in order to vacuum pump the terminal ends of the accelerator tubes.

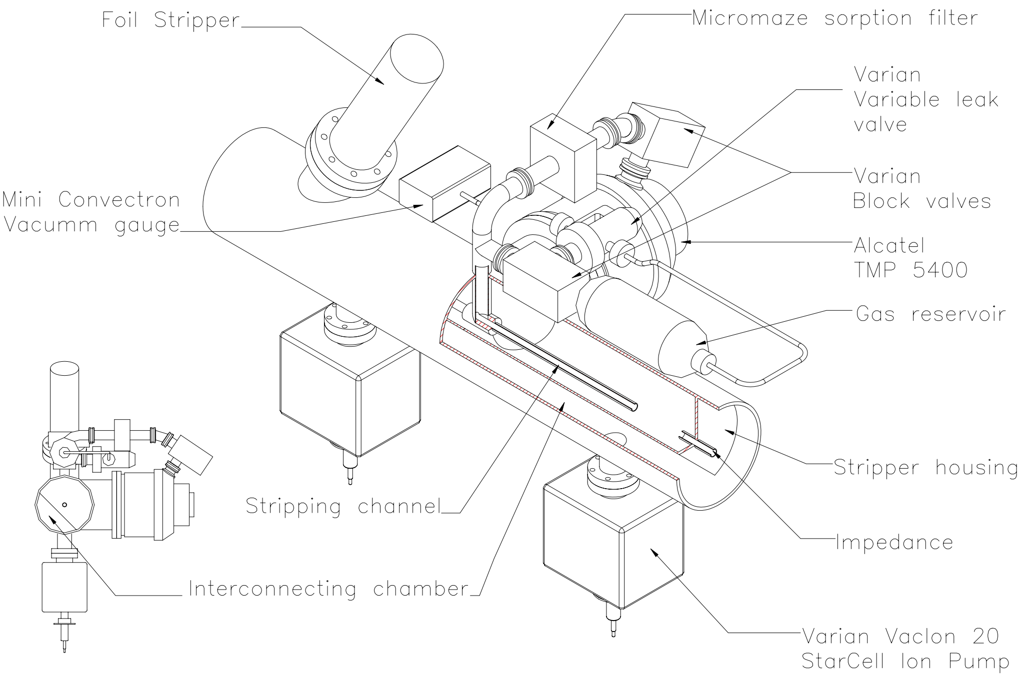

**Figure 1.** isometric view of the future Terminal Stripper System of the FN accelerator.

A 400 l/s turbo-molecular pump Alcatel TMP 5400, recirculates the gas leaked at the ends of the stripper canal. Two impedance’s tubes, at the entrance and exit of the high conductance stripper housing, limit the gas flow toward the accelerating tubes. The already mentioned ion pumps, evacuate most of the gas still leaked through the stripper housing impedance’s.

A Varian variable leak valve (up to 1x10$^{-10}$ Torr-litres per second regulation) control the gas injection into the stripper canal. This valve is mechanically driven by a servo motor not depicted in Figure 1. The pressure at the entrance of the stripper canal is monitored with a Mini-Convectron gauge module. A Micromaze sorption trap at the outlet of the turbo-pump reduces the partial pressure of hydrocarbons from the lubrication grease of the turbo-molecular pump. Two electromagnetic block valves at the exit of the leak valve and the turbo-pump respectively, allow to close the gas supply and exhaust, when the gas stripping is not under operation. The foil stripper magazine, placed at the high-energy end of the stripper canal, charge a maximum of 45 foils.

The length of the stripping canal and stripper housing impedance's are basically determined by the available space at the accelerator terminal. The determination of their diameter is a delicate compromise between the lowest admissible vacuum at the accelerating tubes and the beam losses produced by angular straggling at the stripper canal [8]. A calculation for uranium ions [9] suggest diameters not lower than 11 mm. In order to prevent an eventual over dimensioning of that diameter we plan to design a canal that can be easily replaced without affecting its alignment.

A high pressure chamber of 450 mm diameter by 1200 mm length is being prepared in order to perform the pressure test for the turbo pump, ion pumps, convectron gauge, and valves, at 16 Bar.

## 3. ELECTRICAL SYSTEM AND CONTROL

It is well known that when the terminal of a tandem accelerator suffer an abrupt discharge, strong voltage and current upsurges will destroy the unprotected electronic devices at the accelerator terminal. To overcome this problem we have followed the shielding criteria's already developed in other laboratories [2,4]. We have basically adopted the "double shielding" version applied at the 14UD tandem accelerator at ANU [4]. Figure 2. shows schematically the main electrical and electronic components of the future Stripper System. Two alternators provide the required energy for the system and a Control Block linked to a PC at ground, enable its control.

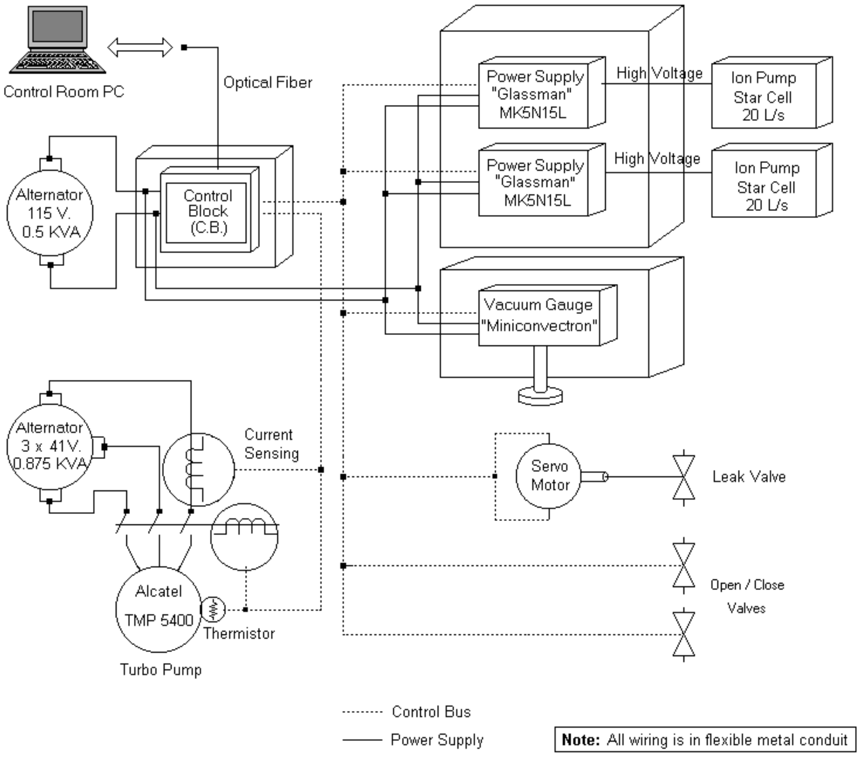

**Figure 2**. Block diagram of he main electrical and electronic components of the Stripper System. Its spark and RF Shielding is represented with boxes enclosing the electronic components.

The electronic devices are shielded within single copper boxes, while the Control Block is double shielded. Its outer box communicate with the other boxes through flexible metallic conduits. That is, the Control Block, the electronic devices and the wiring between them, remains within a common shielded environment.

In the next subsections the various component of the system are described in some detail.

### 3.1 The AC Generators

The two generators are of permanent magnet type and the same brand, “Georator”. The 115V - 400Hz single-phase alternator, is the original from the accelerator and provide the energy to all electronic and electrical components. The second alternator was rebuilt to provide the three-phase 41 V, 400 Hz required by the motor of the turbomolecular pump. Both generators are mechanically motorized by the high and low energy Pelletron chain respectively.

### 3.2 The Control Block and its Optical Link

The Control Block (CB) is basically composed by a micro-controller plus adequate interfaces communicating with the controlled devices. This unit enclose also the main DC power supply required by the electric and electronic devices of the whole system.

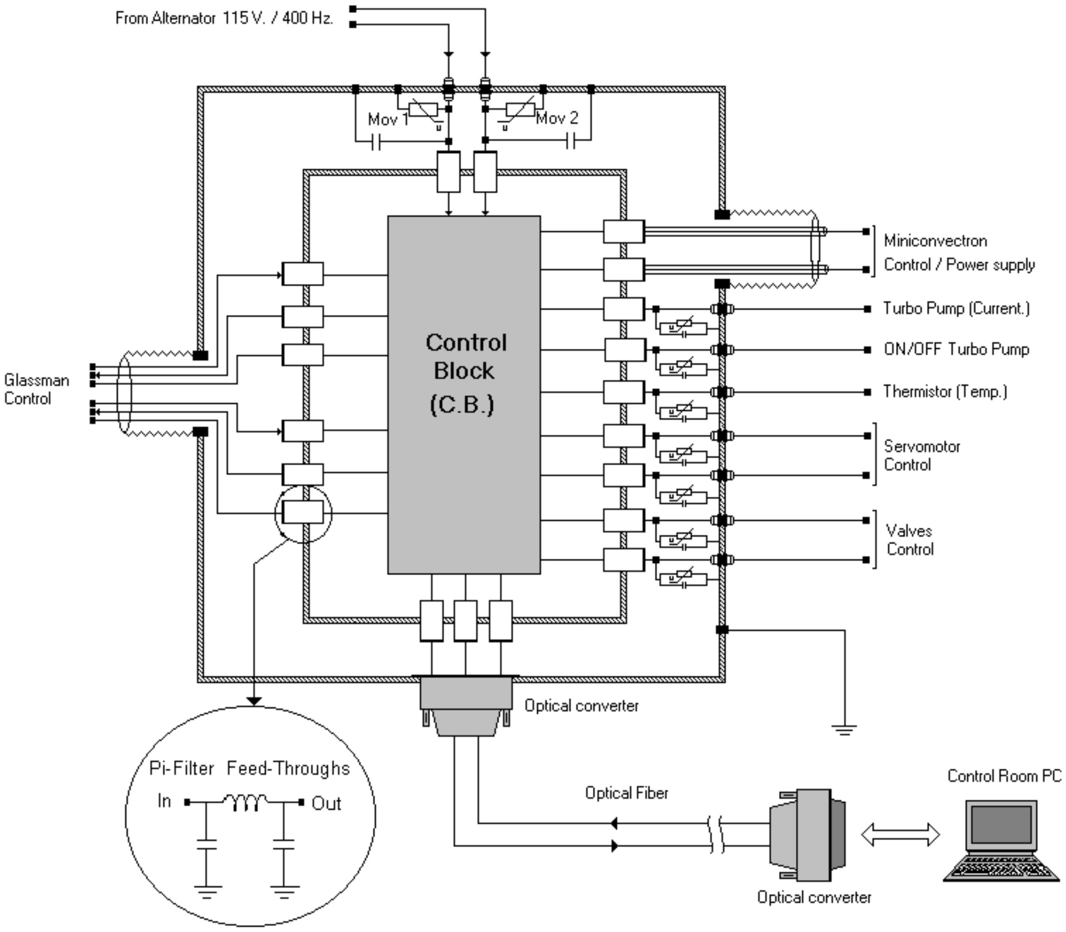

**Figure 3.** Spark and RF shielding of the Control Block
and details of the wiring through the metal shielding cabinets

As shown in Figure 3. the CB unit is doubly shielded. The external wiring penetrate the outer cabinet via BNC connectors with attached varistors and capacitors, in order to divert the sparks to ground. The inner cabinet is penetrated with Pi-Filter feed-through to filter the HF noise.

The CB couple to an optical fiber pair through an auto-powered optical interface converter. This converter is plugged on a DB25 connector installed on the outer cabinet. At the groundside the optical fibers couples to the control room PC also through an optical interface converter. The CPU communicates with the PC on the basis of the RS232 protocol.

### 3.3 The Power Supplies for the ion pumps

The high voltage for the two Star Cell Ion Pumps is provided, as shown in Figure 2, by Glassman power supplies. In order to protect their active electronics, the two power supplies are allocated inside a shielding metallic cabinet. The connections and shielding details are shown in Figure 4. The wiring from the alternator penetrate the shielding through BNC connectors having attached varistors and capacitors to ground, for spark protection. The wiring from the Control Block are multipairs twisted and shielded arriving within flexible metal conduits. The high voltage from the Glassman's is applied with RG59 coaxial cables enclosed within a flexible metallic conduit. The coaxial cable is grounded only at the power supply end. The central wire of these RG59 have spark gaps on the load end. Following criteria's applied at ANU [4], additional spark hardening is added inside the Glassman power supplies

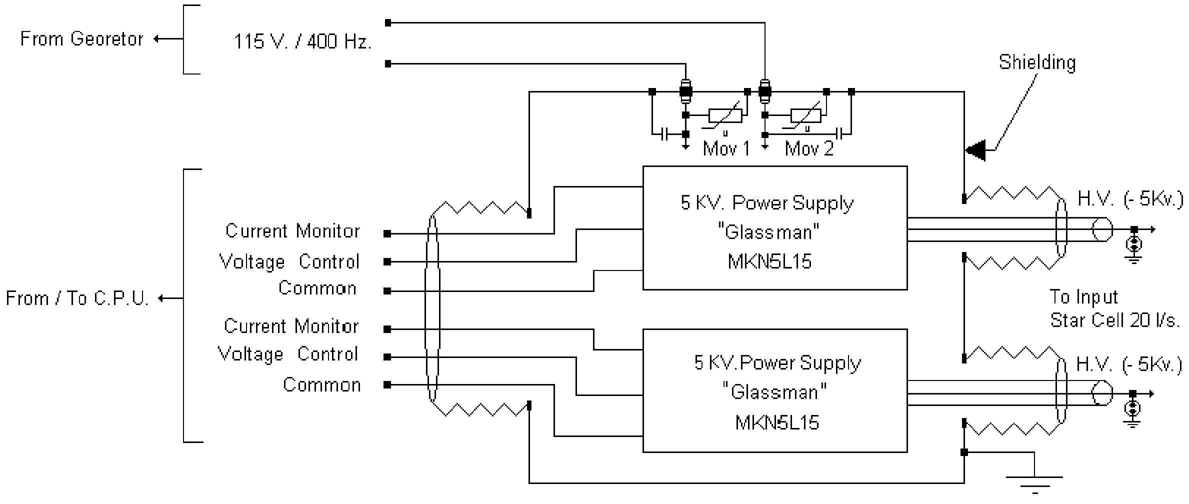

**Figure 4.** Shielding an connection details of the Gassman power supplies

### 3.4 Pressure measurement at the stripper canal

The gas pressure at the stripper canal is monitored with convectron gauge having its electronic within an stand-alone module, see Figure 2. The module is allocated inside a shielding metallic cabinet. The connections and shielding details are according to those described for the Glassman power supplies in subsection 3.3.

### 3.5 The Turbomolecular Pump

As indicated in Figure 2, the Alcatel TMP 5400 turbomolecular pump is directly powered by the three-phase 41V, 400Hz, "Georator" alternator. The power supplied to the motor of the turbo is sensed with a current transformer. The ac current of the transformer is converted to digital and sent to the Control Block, that will switch off the turbo pump if a pre-established limit is overpass. The data is also sent to the external PC and displayed on the screen.

The turbomolecular pump can be remotely switched on and off by a relay controlled via the Control Block. The wiring for this relay is a shielded and twisted pair of cables.

The temperature of the turbo pump is monitored by a thermistor thermally coupled to its body. The signal from the thermistor is sent to the Control Block via an A/D converter. The turbo pump is switch off if a pre-established maximum temperature is overpass. Data is also sent to the external PC and displayed on the screen.

The wiring connecting the current transformer and the thermistor with the Control Block are coaxial cables that penetrate the double shielding of the Control Block as described in subsection 3.2.

### 3.6 Servomotor Controlling the Gas Leak Valve

The servomotor actuating the Gas Leak Valve is remotely controlled via the Control Block, see Figure 2. An interface supply the working voltage. This voltage is provided in both polarities, in order to drive the motor in clock and counter-clockwise mode respectively, to open or close the valve. The wiring for this motor is a pair of cables twisted and shielded.

### 3.7 Electromagnetic Valves

Two electromagnetic block valves are remotely closed when the gas stripping in not in operation see Figure 2. An interface at the Control Block supplies the voltage required to activate the normally closed valve.

## 4. PRESENT STATUS OF THE PROJECT

A mechanical and electrical design for the future terminal gas stripper system has being completed. Most of the vacuum, electrical and electronic components are already available, under purchasing process or being designed or constructed. The next table summarizes the equipment already available:

| **Already available** | **Description** |
|---|---|
| Turbo molecular Pump | Alcatel TMP-5400-160 |
| Alternator, 115 V, 400 Hz | Georator, model 36-003 |
| Alternator, 41 V, 3-phases, 400 Hz | Georator, model 36-003, rebuilt to 3 phases |
| Micromaze Sorption Trap | Kurt J. Lesker model MMA-102-2QF |
| Variable Leak valve, Sapphire-sealed | Varian, Model 951-5100 |
| Optical interface converter | Hirschman, model OZDV-2451G |
| Optical interface converter | Hirschman, model OZDV-2471G |
| Gas reservoir | From accelerator |
| Personal Computer | Industrial Computer 610 Advantech |

The equipment under purchasing is:

| Under purchasing | Description |
|---|---|
| Mini-Convectron gauge module | Granville-Phillips series 275851-EU |
| Two High Voltage power supply 5 kV | Glassman MK5N15L |
| Two Ion pumps of 20 l/sec | Varian, VacIon Plus 20, model StarCell |

The components under design or building are:

| Under design or building | Description |
|---|---|
| Servomotor to control the Leak Valve | In construction at our Laboratory |
| Shielding Cabinets | In design at our Laboratory |
| Stripper Foils Changer | In design and at our Laboratory |
| High Pressure Test Chamber | Designed and in construction at our Laboratory |

Equipment to be purchased:

| Component |
|---|
| Two Varian Electromagnetic Block Valve, direct acting, 24 DCV, normally closed |
| Minor components to be defined in the final design of the stripper chamber |

## 5. CONCLUSIONS

In the frame of a future improvement of the transmission, precision and sensitivity of our AMS facility a new Terminal Gas Stripper System has been designed.

A technical collaboration with the National Sincroton Light Laboratory (LNLS) [10] is at present under consideration in order to perform the critical design review of the project and the detailed engineering and construction of the Vacuum Chamber of the System.

The design and construction of the Control Block and optical link that will enable to remotely control the system from a PC at ground, is been performed at the Open Laboratory of the National University of Buenos Aires [11].

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