THE STRASBOURG PROJECT. A 35 MV VIVITRON TANDEM

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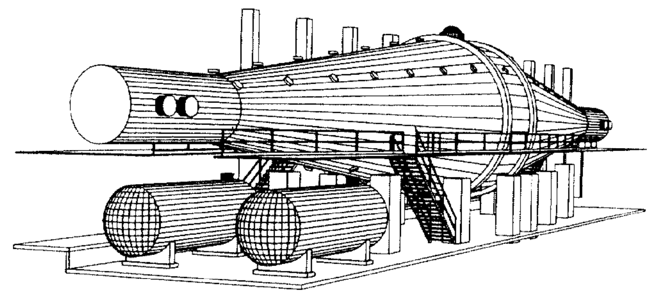
Abstract

The 35 MV Van de Graaff Tandem Accelerator called Vivitron is under construction. Voltage tests are expected in 1989 and final completion in 1990.

At the last international accelerator conference in Washington we reported the start of the construction of the Vivitron, a new 35 MV Tandem Van de Graaff. All decisions about the design have now been taken. The construction itself progresses straightforwardly. The voltage tests should be made in 1989, the machine will be completed and ready in 1990.



The Vivitron and the SF6 storage tanks.

1.General description and principles of construction

The Strasbourg machine is a 35 MV Van de Graaff Tandem accelerator whose design incorporates some new features and ideas. All the electrical characteristics are very conservative, especially for the accelerator tube, which is a standard inclined field tube, but the philosophy and some of the rules for building such an accelerator are new.

The tank is 51 m long and has 8.4 m in diameter in the center. On each side of the terminal electrode of 1.4 m diameter, there are 9 tube sections on each side (7 of 100" and 2 of half length). The column is assembled in an internal structure using epoxy-fiber glass insulating material. On each side of this structure there are 48 column electrodes. They act as large spark gaps. This column is attached onto and supported by the tank through insulated epoxy posts. These insulators together with the discrete electrodes constitute the mechanical structure of the machine. These electrodes assembled in 7 porticos are connected at the right place to dead sections. The charging system is a small belt running close to the tube at a speed of 10 m/s.

One of the new principles developed by M.Letournel comes from the intention to lower at any place the mean electrical field, to allow higher field but in an appropriate geometric configuration, where sparks can occur, and to have a lower field always with appropriate design, on places where weak parts should be protected. An other idea concerns the location of stored electrostatic energy which should be dissipated mainly outside the column and far away from the column or other sensitive components. The consequences are the introduction of discrete electrodes, the use of individed insulators and great care in the design of the geometry of the construction.

2. Discrete electrodes

The design consists of 7 sets of 7 electrodes at volt ages linearly distributed. One can show that the field in the whole space between column and tank wall becomes nearly constant. The field excursion is always low and the maximum stress magnification factor on the electrodes is of the order of 1.4.

Knowing that the electrostatic energy which is stored in the space between electrodes is proportional to the square of the field intensity, we see that the use of discrete electrodes allows a much more uniform distribution of the energy than in the previous situation. This is also the construction principle which allows smaller radial dimensions for the same voltage.

The principle of discrete electrodes has been applied on the MP Tandem of our laboratory. One set of electrodes at half potential enabled the voltage to be increased from 13 to 18 MV which is now the usual working voltage.

One can calculate that the stored electrical energy in the 35 MV Vivitron is about 400 kJ (by comparison a 13 MV classical Tandem stores 60 kJ). In the case of the Vivitron where the longitudinal field inside the column is 17 kV/cm on average, the stored energy in the column is only 1 part in 100 of the whole energy. This is a very favorable situation. On the other hand, in case of a spark, very often induced by the tube or the column, the design of the discrete electrodes hinders its propagation. The machine is like a set of machines one inside the other.

3) Insulators

The mechanical strength problems led us to use epoxy-fiber glass material for the column. We used these materials in large pieces in such a way to avoid using any metallic parts, like dividing electrodes. These metal parts would focus electrical field lines. Avoiding this, one can have better electrical behaviour.

The gap between the column, discrete electrodes and tank wall has a mean field of 100 kV/cm. To hold the column and discrete electrodes, specially designed insulators were necessary. We used those designed by C. Cooke. In a coaxial geometry the field around these posts is lowered near the end and larger between. If one compares the field versus the radius we observe higher field values far from the insulator than in the vicinity. So this type of design is very suitable for a coaxial geometry, or a non uniform geometry. The type of posts made of epoxy charged with alumina has been extensively tested in our CN machine. We found that well mounted posts behave very well. We observed that with our geometry sparks do not give significant damage. 248 posts are used in the Vivitron structure.

4. Performances of the Vivitron

Depending on the choice of stripper (gas, foil or a combinaison of the two of them) the energy goes from 15 to 20 MeV/A for the lightest ions and to 5 MeV/A for the heaviest. The expected intensity reaches 10^{12} pps for light ions but only a few 10^{9} pps for the heavy ions. The beam properties are those usual with Tandems.

5) Present status

At the present time the activities of the Vivitron group has to do mainly with the construction of the accelerator and with the different technological aspects of this work. But we made also an important effort with more fundamental problems like those concerned with the particle beam. The photograph shows the present status of the construction. Most of the parts concerning the structure and necessary for the preliminary voltage tests have been delivered or ordered. The gas transfer system is under construction. We think that all preliminary technical work will be ready in May 1989, where the electrical tests can start. The accelerator tube has been ordered and should be completely delivered end of 1989. The first beam can be expected for 1990.

Special attention has to be given to the computer control system, mainly concerning the equipment and data transmitting system located inside the tank. The problems have to do with the electromagnetic perturbations following eventual sparks and the very little space available.

An extensive series of measurements has been made to obtain better kwowledge of the tank deformation under pressure and to determine the final design of the mechanical structure.

The Vivitron will use a belt as charging system. This device is very well known but will be used here with a greater length than usual. We built a mechanical test bench for the design of the mechanical aspects of the belt system.

We are making electrical and mechanical tests on all delivered insulating posts. These tests also allow us to understand better the behaviour of these insulators.

A few other original developments have to be reported. Concerning the beam we made emittance measurements with the ion source injector of the MP. As an example we show here the experimental emittance picture obtained with a sputtering source (type 860). The beam was ^{16}O, the measured emittance was 3,4 π.mm.mrad$\sqrt{\text{MeV}}$.

On the other hand we performed non linear calculations for the negative ion sputter source. Space charge aberrations and general focusing properties were investigated. The comparison with experiment shows good agreement.

Extensive calculations were also made concerning the transmission of the beam through the accelerator tube, which is of the inclined field type with a special design for the first element. The knowledge of this part of the machine determines the final design of the injector and the charge selector situated at the high voltage terminal.

One remaining aspect of the transmission is the charge exchange and consecutive intensity loss in the residual gas of the machine tube. Extensive measurements have been made using the MP Tandem accelerator. It has been shown that with an appropriate vacuum ($0{,}4.10^{7}$ torr at the entrance of the LE tube) the transmission of the ions, like C, S or Ni, reaches ≈90%, and also that the beam losses occur mainly in the the injector beam line. So with a foil stripper, with a better vacuum in the whole tube, the transmission is best in the low energy side, but less good in the high energy side, because of angular and energy straggling in the 5 mg/cm^2 foil. With a gas stripper in the actual situation of the MP Tandem it was the inverse, better transmission in the high energy side (less straggling) but the more important charge exchange on the low energy side is due to a poorer vacuum. This work goes on for different other masses and energies and should give us all needed indications for the final design of the vacuum system.

We continue our fundamental and design work and expect to be ready for an optimal running when the machine will be in operation, presently in 1990.

References for the Vivitron

- Proc. 3rd Int. Conf. Electrostatic AcceleratorTechnology, Oak Ridge, 1981
- Particle Accelerator Conf., Santa Fe, 1983
- Rapport CRN-VIV-12, septembre 1983
- Proc. 4th Int, Conf. Electrostatic Accelerator Technology, Buenos Aires, 1985
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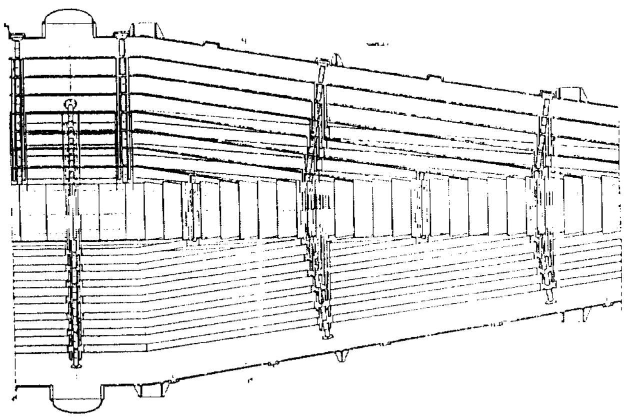
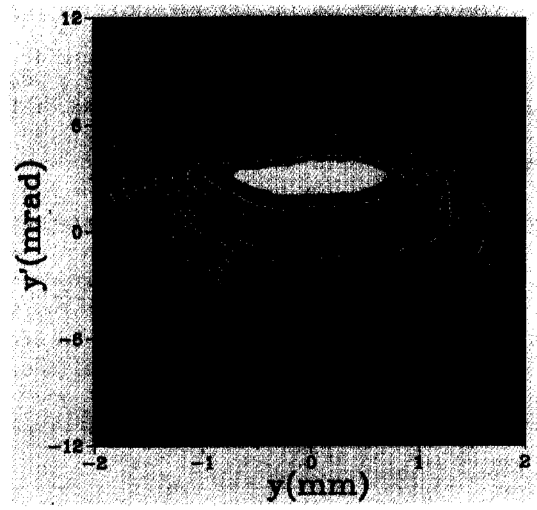
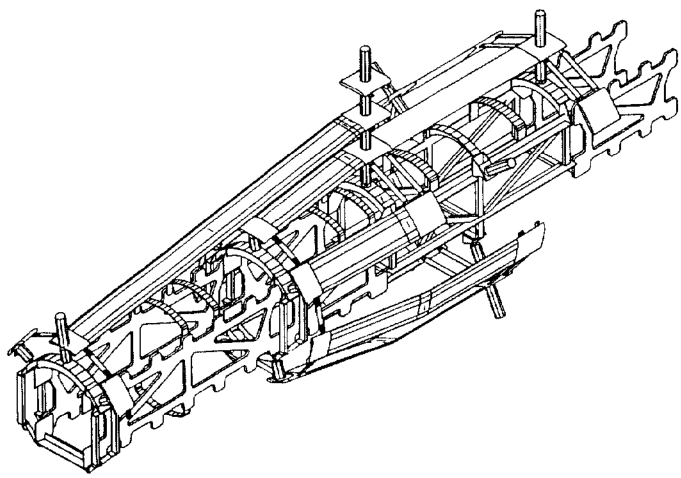
- Congrès de la SFP 1987, Jour. de Phys. Appl., to be published



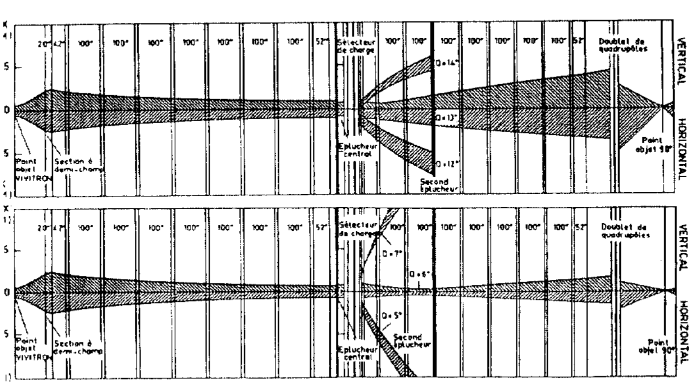
Drawing of the Vivitron structure.



Emittance of a ^{16}O beam delivered by the sputtering source (type 860).



Drawing of the Vivitron structure. Region of the terminal.



Beam enveloppes between source and analysing magnet :

at the top - $V_{terminal}$ = 20 MV
A ~130 , Q = 12^+ , 13^+ and 14^{+4}

at the bottom - $V_{terminal}$ = 35 MV
A ~12 , Q = 5^+ , 6^+ and 7^+

Construction of the Vivitron. The discrete electrodes.