

## IMPROVEMENT OF THE 400 KV LINAC ELECTRON SOURCE OF AmPS

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*Abstract*

The installation of the 900 MeV Amsterdam Pulse Stretcher (AmPS) is nearly completed and its commissioning will start spring 1992. The existing linac MEA will inject electrons in the AmPS ring. The linacs peak current will be increased from 20 to 80 mA. This requires the modification of the 400 kV low emittance gun which now will deliver a peak current of maximum 400 mA instead of 100 mA at a pulse width of 2.1  $\mu$ sec. The fourfold increase of the peak current is obtained by doubling both the gun perveance (new gun part) and the pulsed extractor voltage. After chopping and pre-bunching more than 80 mA will be available for acceleration in MEA. To obtain optimum beam quality over this increased current range the hot deck electronics, operating at -400 kV, has been exchanged by a state of the art fast high voltage FET switching supply. The increased space charge forces in the beam require stronger electrostatic focussing in the first electrostatic gap to define the beam diameter at the gun exit. This is accomplished with a 25 kV controlled power supply. A build in microprocessor, coupled to the local computer by optical fibers, is used to monitor and control the gun parameters. The 5kV gun extractor voltage pulse shape can be monitored by means of an analog fibre transducer with build in calibration. Finally, in order to improve the energy stability of the accelerated electrons a serial electron-tube stabilizer was added to the 400 kV DC power supply. A supply stability of  $2 \cdot 10^{-5}$  has been achieved.

## INTRODUCTION

For 3-turn injection in AmPS, MEA should deliver a 2.1  $\mu$ s pulsed beam at 400Hz, with a peak current of 80mA and taking into account a beamloss of 10% an extracted CW beam of 60  $\mu$ A should be available for the physics experiment.[1]

With an RF chopped bunch length of  $120^\circ$  and a corresponding transmitting efficiency through the chopper collimator of 20-24% a peak current of 400mA must be extracted from the 8mm diameter dipenser cathode button. For generation and handling of this fourfold increased beam current an important improvement of the hot deck electronic equipment combined with adaptations in the injector driftspace were necessary.

The increased radial space charge forces of the increased current in this HV injection system gave narrower restrictions to the correct tuning of the chopping parameters. To minimize the contribution of the chopper [2] on the resultant emittance it is possible to match the existing large diameter (7mm) chopping collimator while creating a relatively small waist at the chopper cavity. The beam diameter at lens1 should be maintained at about 7mm for both high and low peak current operation. To double the microperveance of the gun the distance and shape of the gun's focussing electrodes are changed. The cathode button

is still the same. The beam emittance will increase by about a factor of 1.5 for full current operation. The optimum tuning of the injector under high current condition is more critical than for low currents. Much attention is given to the short and longterm stability of the injector behaviour. For this reason all the input voltages delivered by the hot deck electronics and the 400kV ICT are stabilized. For fast diagnostic purpose all the input parameters can be monitored on line. A switchable beamviewer just in front of the chopper collimator gives visible information about the chopping action.

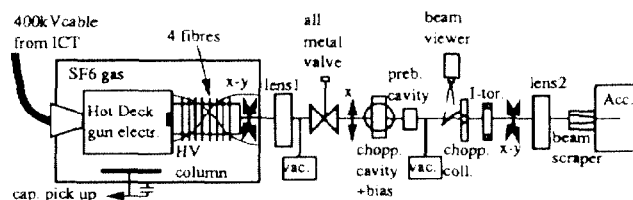


Fig.1 400kV Injector lay out

## INJECTOR MODIFICATIONS

Modifications of the injector drift space (fig.1).

- Installation of the high current gun. Microperveance 1.4 instead of .7 delivered by Haimson Research Corporation.
- Exchange of the O-ring vacuum valve by an all metal type; because of the increased current under space charged limited condition any source to poison the cathode surface should be avoided.
- Increased strength of lens1 to fulfill the condition of creating a small waist (1mm) inside the chopper cavity. The chopper cavity with its bias coils is situated halfway between lens1 and the chopper collimator. The strength is increased by insertion of a yoke with smaller diameter.
- Installation of large diameter air bias coils around the TM110 chopper deflection cavity to minimize optical aberrations. The former small diameter chopper bias coils were situated just in front of the chopper cavity.
- Installation of a retractable tv screen in front of the chopper collimator for diagnostic information about the chopper.
- Exchange of the cavity type current intensity monitor just behind the chopper collimator by an absolute toroid current monitor, to measure the maximum available peak current for acceleration by MEA and the chopper beam transmission efficiency. Lens2 defines the actual current at the entrance of the accelerator.

Modifications of the electronic hardware (fig.2).

- Variation of the voltage in the first electrostatic acceleration gap to get the correct focussing strength for a certain peak current from the cathode. The voltage between the first

electrostatic acceleration gap defines the strength of this electrical lens and can be changed by adjusting the resistor value. Because optimization of the beam properties for the whole current dynamic range must be possible a remote controlled HV power supply is used for this task.

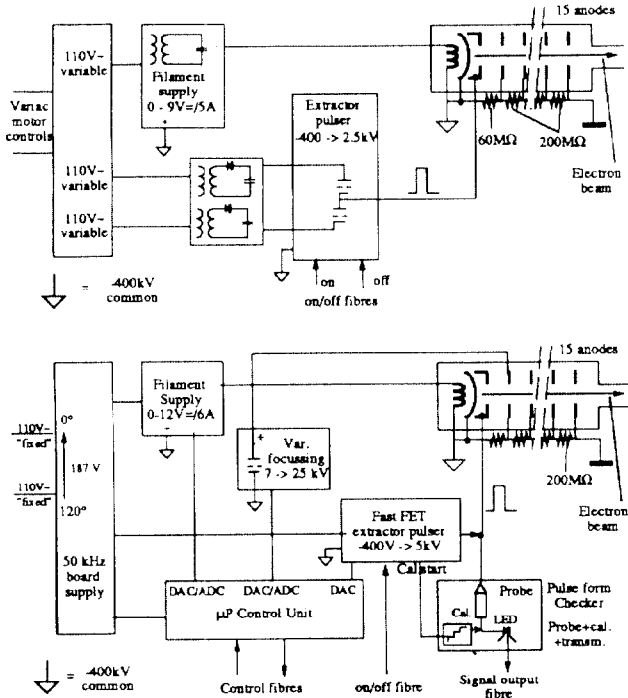


Fig.2 Hot deck gun electronics former (upper) and new (lower) lay out

- Improved extractor switching electronics for a pulse height of 5kV with 50ns rise- and falltime and a stability of  $1.10^{-3}$  which results in a cathode current stability of  $1.5 \cdot 10^{-3}$ . The fast rise time is requested for better current start definition, which is needed, for beamtransient compensation by the use of spreaded timing of the RF in the 12 accelerator stations of MEA. With the present beam pulse length of 2.1 µs at a peakcurrent of 80mA, the MEA beamloading factor of 2.6MeV/mA and a beamfilltime of 1.25µs, most of the electrons in the beam are subjected to transient beamloading.
- Continuous analog measurement of the extractor pulshape with added calibration signal for accurate level setting; this information is transmitted to earth level by an analog fibre transducer with 10MHz bandwidth.
- µprocessor contol unit at the -400kV level coupled with two fibres for communication with a PC by bitbus protocol; all the gun input parameters are set, read out and watched by this system.
- The former thick fibers are exchanged by new thin (1mm diam.) fibers of which the strength members and coating is removed. The fibers are wrapped around the HV column (1.5turn) making contact with the anodes. Since this modification 5 years ago no fibre was damaged.
- Installation of a capacitive pick up electrode in the 400kV injector tank to measure the ripple and transients ( $f > 10\text{Hz}$ ) of the -400kV steady state level.

- Stabilization of the -400kV steady state level to  $1.10^{-4}$  under full load condition. This stabilization is done at the ground level of the -400kV Isolated Core Transformer power supply by means of a tube in series with 4kV of control range.

The modification and extention of the hot deck was so drastic that adaption of the existing hot deck hardware could not be implemented because of the lack of space. Another point of attention was the total weight(23kg) of the hot deck equipment which is mounted at the beginning of the HV column. This hot deck part is hanging on the ceramic HV column. After 15 years of operation a sag of 2mm and several small cracks in the HV column influenced the decision for a total new design with half the weight of the former one.

SOME ELECTRONIC DETAILS

50KHz board supply

The line voltage from the two 110V, 50Hz and 120° phase shifted coupled transformers at the -400kV level in the ICT is transported by wires in the central conductor of the -400kV coaxial cable to the injector vessel. The AC voltage is immediatly converted to DC by rectifying and filtering. This voltage is then chopped by a 50kHz balanced transistor chopper. All the hot deck electronic equipment, such as extractor pulser, filament power, control circuit power and gas circulation fan's are fed by this 50kHz system by means of isolated secondary windings on the central 50kHz supply transformer and by local rectifying, filtering and stabilization circuits. Much attention was given to the adequate screening of this board supply. Smart mechanical constructions were developed to allow fast exchange of parts in case of a failure

Extractor pulser

The heart of the extractor pulser consists of deck1 to deck8. (Fig.3). The principle is a Marx generator. In rest all the B-switches(FET's) are closed and all the A-switches are opened.

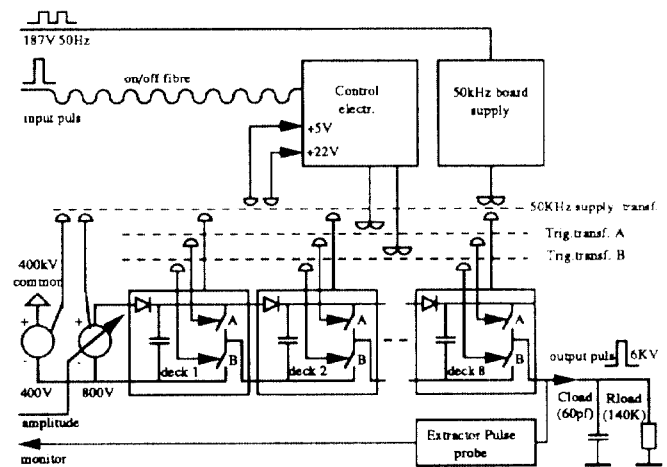


Fig.3 Extractor pulser principle

The rest level of -400V is connected to the output port via all the closed B-switches. The capacitors of decks 1 to 8 are now in parallel connected to the 800V controlled powersupply and are loaded to this level. To create a HV pulse form first of all

the B-switches are opened and after that the A-switches are closed. The diodes prevent the discharge of the capacitors. On the output of the pulser the sum of all the capacitor voltages is delivered. The switches on the decks are controlled by isolated (6kV) trigger transformers A and B. It is important to minimize the parasitic capacity between the decks and the common to optimize the switch speed. The extractor pulse shape will be measured by the already mentioned system.

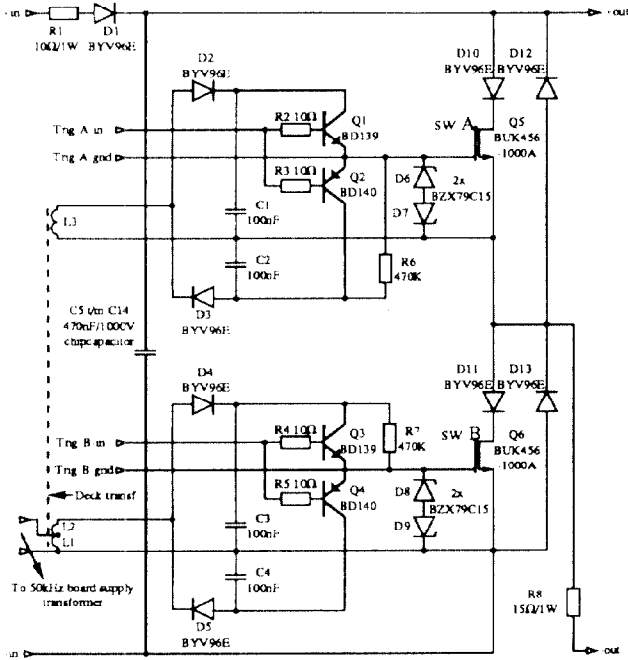


Fig.4 Single deck pulse circuit

In Fig.4 the scheme of one deck module with its components is shown. Switch A and B are driven by push/pull circuits. The primary power is delivered by the 50kHz board supply. The timing and length of the trigger signals for the decks are very crucial.

In Fig. 5 a photograph shows the total new design of the hot deck electronics mounted at the beginning of the HV column.

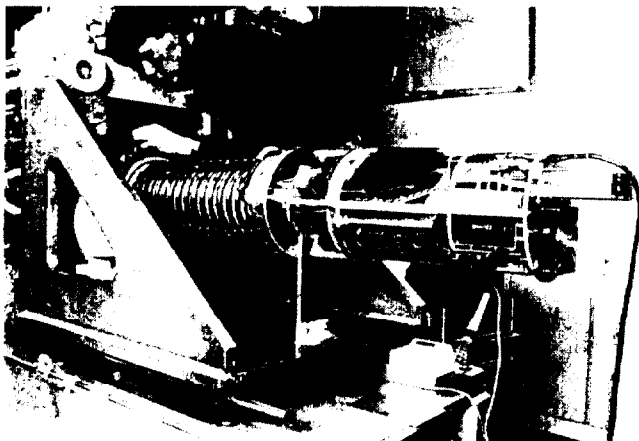


Fig.5 HV Column with hot deck electronics

-400kV stabilization

In the past the -400kV steady state level during the start up of

MEA shows changes >1000V caused by respectively the line voltage stabilizer (400V,10Hz), the stepping transformer control transients (800V,1sec) and the action of the beam safety control device (120V,10Hz). As mentioned earlier the tuning of the injector and MEA with respect to its energy spectrum and corresponding transmission is more critical for high peak currents. The voltage stability should be better than  $1 \cdot 10^{-4}$  under all beamloading conditions to make this influence negligible. The max. sawtooth ripple at full loaded condition is <100V. Fig. 6 shows the stabilization control scheme.

The series tube only controls the steady state level for frequency changes below 50Hz. The tube control takes care of the stepping transformer control. If the control voltage over the series tube passes a certain lower value the stepping transformer will be activated to increase one step. The reversed action will occur if the control voltage exceeds a certain value. The reference signal is a 16 bits DAC with a stability of  $1 \cdot 10^{-6}$ . Level control from 0 to -400kV can be done by hand or remote. After installation of this system measurements show a stability of  $1 \cdot 10^{-4}$  under full range load conditions. The stability is  $1 \cdot 10^{-5}$  at constant loading.

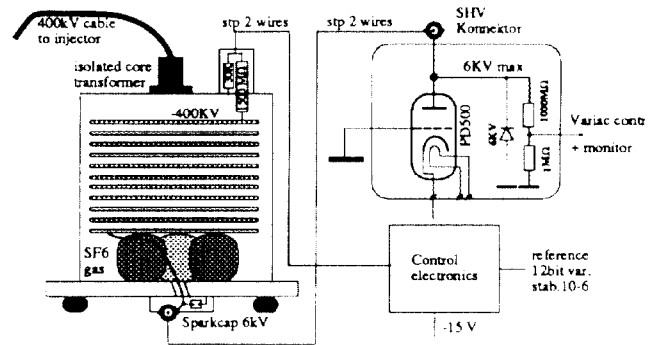


Fig.6 400kV stabilization circuit

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