UPGRADING THE ENERGY OF THE SACLAY ELECTRON LINAC

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The maximum energy of the ALS has been recently raised from 600 MeV at 1 % duty cycle to 720 MeV at 0.6 % duty cycle for electron scattering experiments (600 MeV for positron beams). The peak power of 13 out of the 15 klystrons of the linac has been raised from 4 MW to 6 MW with the same efficiency, by boosting the high voltage from 120 kV to above 140 kV without drastic changes in the modulator electronics.

The magnetic field in the magnets of the beam switchyard has been raised from 12 000 gauss to 15 000 gauss without changing the coils nor the power supply, by reducing the gap from 80 mm to 66 mm. The pole pieces have been redesigned and their profile optimized to reduce the leakage flux and to give a field homogeneity of $\pm 2 \times 10^{-4}$ over a distance of $\pm$ 30 mm from the central trajectory which is needed for high resolution electron spectroscopy.

The TV 2013 klystrons have been used until now at peak power of 2 MW and 4 MW for beam duty cycle of 2 % and 1 %. In both cases the average RF power is 60 kW.

Recent measurements have shown that the efficiency of the klystrons, which is maximum at 4 MW, decreases slowly if the peak power is raised up to 6 MW (fig. 1).

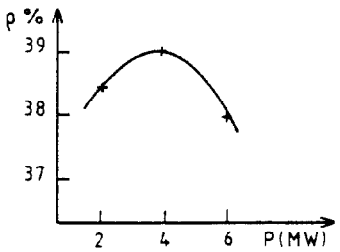

Fig. 1 - Efficiency of the TV 2013 klystron.

For the operation at 6 MW, we have found an optimum profile for the magnetic focusing by measuring the temperature rise on the 5 cavities and minimizing the beam interception. All the focusing power supplies have been redesigned.

The other problem with the new mode of operation of the klystrons was the X-radiation level in the klystron gallery. The lead protection has been reinforced.

The electrical characteristics of the klystron are given in table 1

Table 1

Characteristics of the klystron

P(MW)	2	4	6
V(kV)	92	120	150
I(A)	60	90	115

The principle of operation of the modulators is given on fig. 2. The two switch tubes are capable of switching a peak current of 400 A each. To raise the high voltage from 120 kV to 150 kV, without changing the DC high voltage we have changed the pulse transformer ratio from 4.6 to 5.3. The peak current of the two switch tubes in parallel is then 600 A which is below the maximum value. In all these operations the maximum average power remains constant, by reducing the duty cycle.

The flatness of the RF pulse is one of the most important parameters for obtaining a narrow energy spectrum

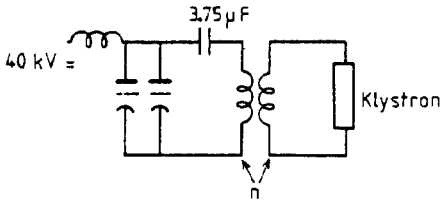

Fig. 2 - Principle of operation of the modulator.

with long beam pulses (10 to 20 μs); we have verified that this parameter has remained at a good value. The energy spectrum measured at 700 MeV with a beam pulse of 12 μs was of the same order than the spectra obtained before the change : half of the beam within $\Delta E/E = 10^{-3}$, for an average current of 20 μA.

The present characteristics of the ALS are given in table 2.

Table 2

Duty cycle	2 %	1 %	0.6 %
	1000 c/s 20 μs	1000 c/s 10 μs	500 c/s 12 μs
Max. energy (e^-)	460 MeV	600 MeV	720 MeV
(e^+)		480 MeV	600 MeV

The magnets of the beam handling system were redesigned with the constraint of keeping the same coils and the same power supply. The gap had been set at 80 mm at the beginning because of uncertainties on the beam emittance and it has been possible to reduce it to 66 mm, thus raising the field from 12 000 gauss to 15 000 gauss for the same number of ampere-turns. The optics of the beam switchyard is a critical parameter for the overall resolution in the electron spectroscopy experiments. The homogeneity of the magnetic field had to be better than $\pm 2 \times 10^{-4}$ over a distance of $\pm$ 30 mm from the central trajectory for all energies. The profile of the pole pieces and the correcting shims were computed ; two computer codes were used : MAGNET and TRIM, which gave very similar results only if the mesh size is taken very small. Fig. 3 gives a result of computation of field homogeneity. Measurements show very good agreement with these results. A measurement of the overall resolution obtained with the energy loss spectrometer gave a figure of 10^{-4} for an energy of 670 MeV.

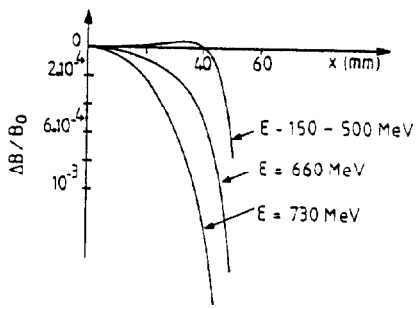

Fig. 3

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