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ADONE - THE FRASCATI 1.5 GeV ELECTRON POSITRON STORAGE RING

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STORAGE RING DATA

Particles stored			e^+, e^-
Maximum energy		(GeV)	1.5
Intensity, per beam		(part)	2×10^{11}
Storage time		(hrs)	~ 0.5
Crossing regions free for experiments			4
Luminosity at 1.5 GeV		(cm^{-2} hrs^{-1})	10^{33}
Magnet			
Focusing, type			AG, separated functions
Focusing, order			$0/2\ Q_F Q_D B Q_D Q_F\ 0/2$
Field index, n, in bending magnets			0.5
Field gradient in quadrupoles, at max energy		(Gs/cm)	380
Field, at injection in the magnets		(kGs)	2.4
Field, at max energy in the magnets		(kGs)	10
Orbit radius		(m)	5.00
Mean radius		(m)	16.71
Number of periods			12
Betatron wave numbers (variable)			3.1 ± 0.5
Closed orbit amplitudes for $(\Delta p/p) = 1\%$ and $Q_R = 3.2$		(cm) (cm)	1.91 max 0.96 min
Momentum compaction			6.12×10^{-2}
Damping time constants for betatron oscillations	inj. max energy	(msec) (msec)	800 11
Iron weight		(ton)	300
Copper weight		(ton)	30
Power, at 1.5 GeV		(kW)	800
Useful aperture:	width	(cm)	22
	height	(cm)	10
Injector			
Type			S-band linac
Injection energy, e^-		(MeV)	375
e^+		(MeV)	360
Injector current within 2% energy bin	e^-	(mA)	$\gtrsim 75$
	e^+	(mA)	$\gtrsim 0.3$
Injection repetition rate		(pps)	1.5 — 3
Vacuum system			
Design pressure		(torr)	10^{-9}
Pumps, type			getter ion
Pumps, number and size			24×500 lt/sec.
R.f. system			
Frequency		(Mc/sec)	8.58
Harmonic number			3
Accelerating cavities			2×2
Max voltage per turn		(kV)	200
Input power to r.f. cavities, max		(kW)	190
Power delivered to the beam, at 1.5 GeV		(kW)	18

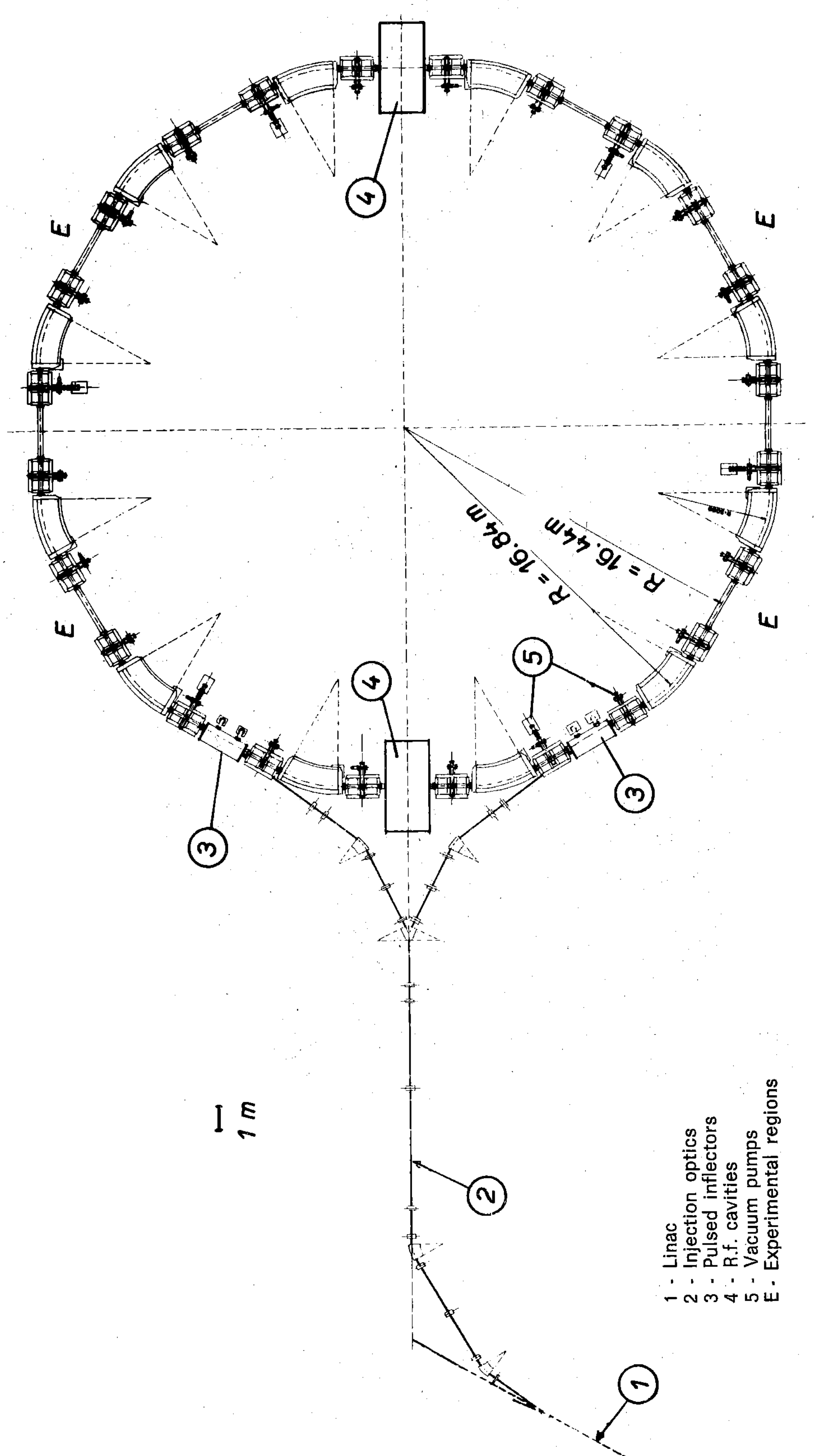


Fig. 1 - Storage ring lay-out.

STATUS REPORT

Introduction

Many of the technical features of this machine are given in the Proceedings of the 1963 Dubna Conference on High Energy Accelerators and will not be repeated here (1).

The ring is a strong focusing, separated function machine, with 12 equally long straight sections; the beam crossing can take place in six of them, and four of the six will be used for experiments, two for the r.f. cavities (see Fig. 1).

A vertical electric field all around the ring (besides sweeping off the ions produced in the residual gas) allows to get the beams to cross at an angle in the vertical plane; with the electric fields on, one can have either six crossing regions or only two, at the extremes of a diameter, or none.

Two different systems can be used to decrease the effective transverse charge density at the crossing: the angle crossing or the coupling of radial and vertical oscillations, by means of two rotated quadrupoles.

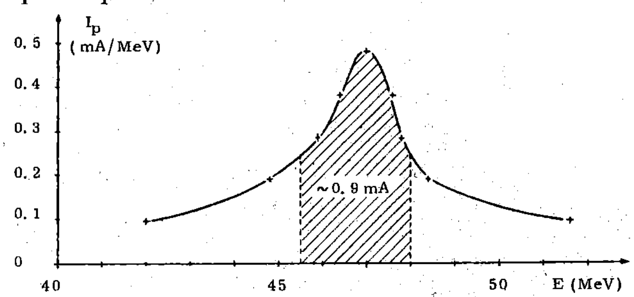


Fig. 2 - Positron energy spectrum at the end of section no. 5.
Positron current between 42 and 51.6 MeV: 1.9 mA peak. - Primary electron beam: energy 80 MeV, current 260 mA peak. - Pulse duration: 1.5 μsec. - Conversion coefficient: 7.3×10^{-3} e^+/e^-. - Energy resolution: 1%. - (March 10, 1965).

The resistive wall instabilities seem not to be too serious in Adone: there should be only one unstable mode at low energy, which will be stabilized with a feedback system: the rise time is such that the instabilitiv should disappear for energies higher than 850 MeV, as the damping time constant becomes shorter than the instability rise time. According to (20, 21) there is the possibility of having a stable mode of operation without feedback, filling only one bunch out of three per beam; this can be obtained easily with our injector.

The beam lifetime is limited mainly by scattering in the bunch, beam-beam bremsstrahlung and bremsstrahlung on the residual gas; typical values should be 5 to 10 hours, depending on the energy.

The filling time will be shorter than 30 minutes, including the time for changing from positron to electron acceleration in the linac.

Expected performance

The design figure for the luminosity at the maximum energy is 10^{33} $cm^{-2}\,hr^{-1}$. A simple scaling of the Stanford 500 MeV electron-electron ring first results gives for our machine a luminosity of $\sim 5 \times 10^{32}$ $cm^{-2}\,hr^{-1}$; we are therefore confident that it will be possible to obtain the design figure, and probably to go somewhat closer to the computed values (which range between 3 and 10×33^{33} $cm^{-2}\,hr^{-1}$);

Injector

The injector, an S-band linac, designed optimizing the positron operation, has been built by Varian Ass. (Palo Alto, Cal.) on our specifications (3, 5, 8).

Five of the twelve sections have been satisfactorily tested; the positron production and acceleration up to 45 MeV is in good agreement with the expectation.

The total peak positron current obtained at 47 MeV, in a 10 MeV band, has been 1.9 mA (50% of which in 2.5 MeV band), with a primary electron beam of 260 mA at 80 MeV, as shown in Fig. 2; this gives a conversion coefficient equal to $\sim 7 \times 10^{-3}$.

The relative energy spread at the final energy should not increase more than a factor 1.5 as compared to that measured at 47 MeV: it means that we should get about 150 μA peak current in 1% energy bin.

Figure 3 shows the electron beam energy spectrum at the end of the 5th section: 75% of the current is in a 1% energy bin.

The linac is now being installed in Frascati (see Fig. 4); the beam tests are expected to begin in October.

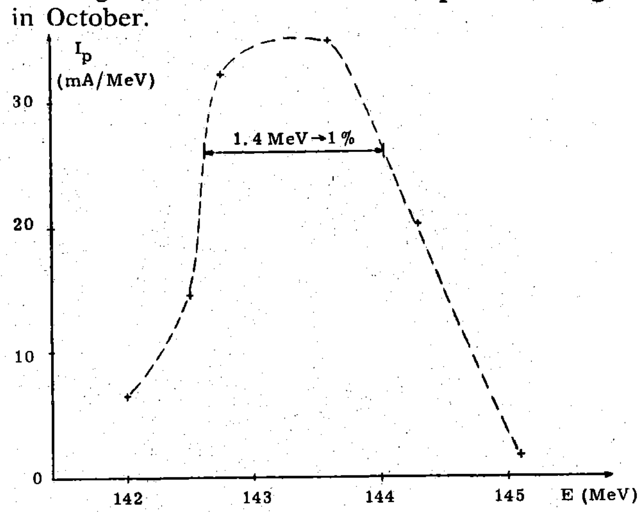


Fig. 3 - Electron energy spectrum at the end of section no. 5.
Total direct current: 60 mA. - Current in 1% energy bin: 45 mA. - Pulse duration: 1.6 μsec. - Energy resolution: 1%. (March 9, 1965).

Injection optics

The beam transport system from the linac to the ring has been designed; the construction will start soon, and it is axpected to be completed in six months (March-April 1966).

Pulsed inflector

The pulsed inflector structure has been changed: it is now a fourwire non-matched structure (16); the schematic of the system is shown in Fig. 5. This solution has the advantages of lower voltage (70 kV) and pulse length adjustement; the pulse decay time (100% to 10%) is ~ 150 nsec. A full scale prototype under vacuum will be tested in October.

A second inflection system is being studied; it has a "septum" inflector and time-dependent orbit perturbations along the ring. According to the computations this system improves the injection rate by a factor between 2 and 3 (17); the injection parameters are less critical, because the vertical acceptance is limited by the vacuum chamber, not by the inflector structure.

We intend to begin the operation with the pulsed inflector, and to test the septum system on the ring afterwards.

Magnet and magnet power supply

The twelve bending magnets and the 48 quadrupoles have been ordered to Rade Končar (Zagreb, Jugoslavia) in May 1964 and the delivery will be completed in May 1966. A quadrupole prototype has been built and is being tested; the prototype of the bending magnet will be ready during September.

The iron sheets, 2 mm thick, are punched with an accuracy of ± 0.02 mm and cemented with epoxyresin.

The total iron weight is 300 tons; the copper weight is 30 tons.

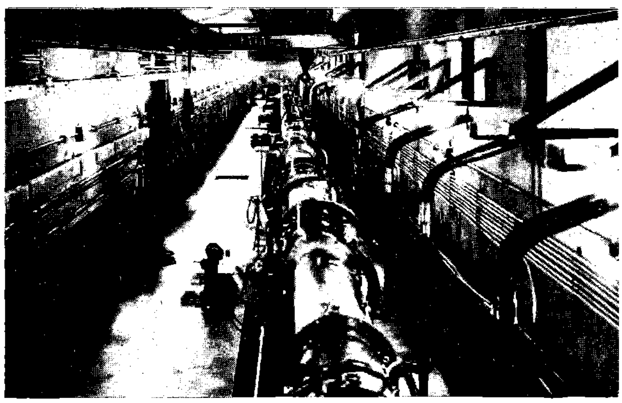


Fig. 4 - Linac tunnel (August 24, 1965).

The field in the bending magnet gap is 10 kGs at 1.5 GeV; the typical quadrupole gradient, at the same energy, 380 Gs/cm.

The magnetic structure and its power supply allow 10% increase in the maximum energy up to 1.65 GeV.

The power supply is made of three DC generators using solid state controlled rectifiers. Total power at 1.5 GeV is 800 kW. The maximum field derivative allowed by the power supply is 10 kGs/sec (referred to the magnetic field in the bending magnet gap).

The power supply is being built by Soc. E. Marelli (Milan) and will be delivered in March 1966.

Vacuum system

The vacuum chamber has been ordered recently to SIAI-Lerici (Milan) and will be delivered in March 1966.

It will be evacuated by 24 getter ion pumps, 500 lt/sec each; the order for them will be placed in September. A combination of molecular pumps and sorption pumps will be used for roughing and during the vacuum chamber outgassing.

In a prototype sector after an operation cycle similar to the final installation, a residual gas pressure of 4×10^{-11} torr has been obtained.

The pumping speed has been determined taking into account the gas desorption due to the synchrotron light (9); the operating pressure at full intensity should lower than 10^{-9} torr.

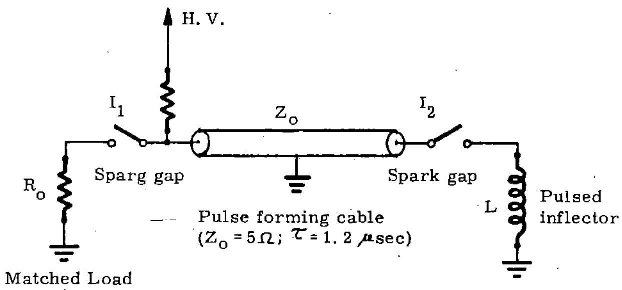


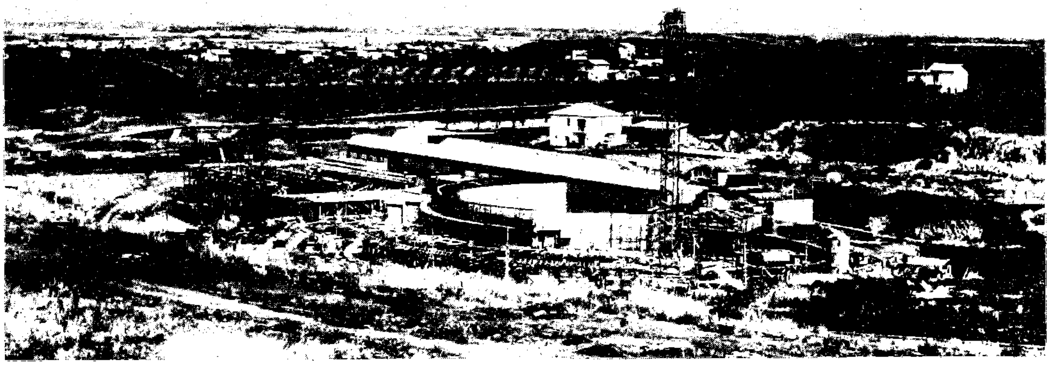
Fig. 5

R.f. system

In two diametrically opposed straight sections are placed the four r.f. cavities, two in each section, of the re-entrant single gap type. The maximum voltage per gap is 50 kV, giving therefore a total voltage per turn equal to 200 kV.

Each of the four final amplifiers can deliver to the cavity 47 kW of r.f. power; the power required by the cavity (without beam) at 50 kV is 6 kW, and the power delivered to the beam (at 1.5 GeV) is 4.5 kW per cavity.

Fig. 6 - Storage ring site. Behind the ring building is the linac modulator hall (August 24, 1965).



The margin in the available power allows to operate the cavities partially out of turn.

The four cavities have a system for automatic phasing and a separate voltage control; both the phase and the voltage must be kept constant within quite stringent limits (± 5° and ± 5%) to keep stable the azimuthal position where the centers of mass of the bunches cross in time (± 10 cm at 1.5 GeV).

A prototype cavity, with its power amplifier, has been built and is under test; in a second model cavity we are testing the ceramic insulating pipes, separating the vacuum system from the accelerating cavities.

Buildings

The situation of the buildings is shown in Fig. 6. The ring building and the power supply hall will be completed in February 1966.

Expected operation schedule

The installation of the parts in the ring hall will start in March 1966; the first beam tests in the ring are expected to take in the fall 1966.

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