THE AMSTERDAM PULSE STRETCHER PROJECT (AmPS).

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SUMMARY

To obtain electron beams with a high duty factor a stretcher and storage ring will be added to the existing Medium Energy Accelerator (MEA) facility. The ring will operate at energies between 250 and 900 MeV and with circulating currents up to 200 mA. The storage mode will be used for internal target physics.

INTRODUCTION

The present 500 MeV, 1% duty factor electron linac facility MEA [1] has been in continuous operation since 1980. MEA is primarily used for electron scattering experiments of the (e,e'p) type. Coincidence measurements are an essential part of these experiments. The real/random ratio of coincidences is proportional to the duty factor (d.f.). To enhance the efficiency of the experiments a proposal was submitted in 1984 to increase the d.f. to > 90 % by adding a pulse stretcher to the facility [2]. End of 1987 this proposal has been approved by the funding agencies. Meanwhile it was decided to use the ring in a storage mode as well to allow experiments with internal targets (IT). To achieve an acceptable luminosity currents up to 200 mA will have to be stored. In addition to these requirements the maximum energy has been increased as well. To reduce the costs of the project the circumference of the ring was reduced from the original 280 m to 212 m. In order to maintain an acceptable extracted current on target the maximum peak current of the linac had to be increased to 80 mA assuming a 3 turn injection. A comparison of the present and future modes is made in Table 1.

BASIC RING DESIGN

LAYOUT: Fig.1 shows the layout of the ring and the experimental areas. Existing vaults will accomodate 100 m of the ring. For the remaining 112 m a new tunnel will be built. Part of the tunnel will be combined with a new experimental hall for internal target physics.

Table 1. Comparison of main beam parameters on target, present mode and in stretcher & storage mode.

		Present	Stretcher	Storage
E min	[MeV]	75	250	300
E max @ î= 80 mA	[MeV]	550	700	900
E max @ î=0	[MeV]	580	910	910
Linac pulse	[μsec]	40	2.1	2.1
Rep. rate	[Hz]	300	400	-
Beam d.f.	[%]	1.2	>90	100
Peak î MEA	[mA]	10	80	10
Target <I>	[μA]	>100	67	200000

LATTICE: the ring is designed with a four fold symmetric lattice [3]. Each curve is a double achromat and consists of 8 dipoles, 8 quadrupoles and 8 sextupoles. The curves are connected by dispersion free straight sections each with a length of 32 m. The internal target, the RF cavities (one for each mode) and the injection and extraction septa are all located in straight

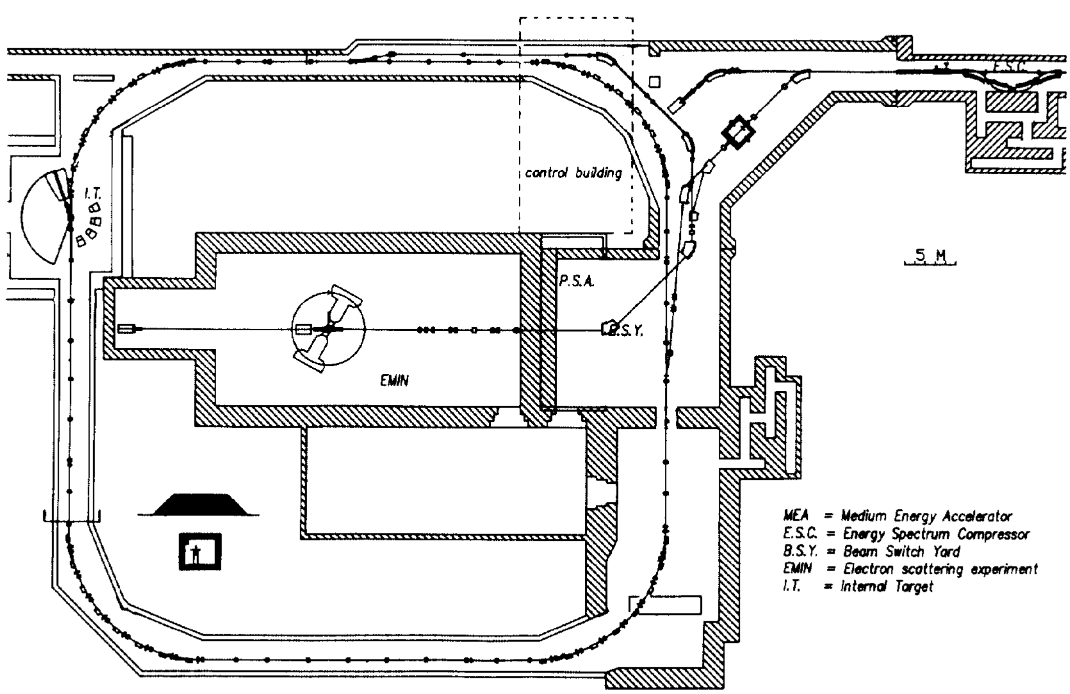

Fig.1 Layout of the ring; also shown are the end of the linac with the energy spectrum compressor (ESC), the beam switch yard (BSY), the electron scattering end station (EMIN) and the internal target hall (IT). The walls of the existing buildings are hatched.

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sections (IT and RF at locations with small beta functions;injection and extraction at locations where the beta's are large). A list of machine parameters is presented in table 2.

Table 2. List of important machine parameters of AmPS.

Ring circumference	211.618	m
Revolutionfrequency	1.417	MHz
Beta function (maximum)	22.5	m
Beta function (minimum)	2.0	m
Dispersion function (maximum)	2.7	m
Momentum compaction factor	0.027	
Tune in stretcher mode		
horizontal	7.637	
vertical	7.22	
Tune in storage mode		
horizontal	7.61	
vertical	7.15	
Chromaticity in stretcher mode		
horizontal	-15.0	
vertical	+ 0.2	
Chromaticity in storage mode		
horizontal	+ 0.2	
vertical	+ 0.2	
RF frequency (stretcher)	2.856	GHz
harmonic number	2016	
Synchrotron radiation @.9GeV		
energy loss/turn	17.59	keV
emitted power @ 0.2 A	3.52	kW
critical energy	0.49	keV

Damping times [msec],Touschek lifetimes [hr]

Energy [MeV]	300	600	900
Damping time			
transversal	1944	243	72
longitudinal	977	122	36
Touchek lifetime	0.3	1.3	11.6

(100 % coupling, I=200 mA, RF=130 kV)

INJECTION: 3 turn injection is foreseen; 2 fast electrostatic kickers deflect the closed orbit during injection. A d.c. injection septum will be used. In storage mode at energies > 700 MeV, because of beam loading (2.5 MeV/mA) in the linac, injection will require tens of pulses to achieve a circulating current of 200 mA. Third integer resonance extraction will be used [3].

STORAGE MODE: in this mode a thin dust or gas jet target will interact with the circulating beam. Target densities as high as 1 E 17 atoms/cm 2 will be used. Lifetimes of the beam have been calculated taking into account the effects of Bremsstrahlung, single and multiple scattering and Møller scattering: for a hydrogen target the 1/e lifetime at 900 MeV & 1 E 17 atoms/cm^2 is 30 sec, at 300 MeV & 1 E 16 atoms/cm^2 it is 90 sec. [4]

To be sure that currents up to 200 mA can be stored the current thresholds for the single and coupled longitudinal bunch instability as well as the transversal instability are studied at present. First calculations show that stable operation should be possible with the chosen lattice. A separate RF cavity with a frequency < 500 MHz is planned for the storage mode.

RING HARDWARE

MAGNETS: all d.c. ring magnets are laminated both because of cost considerations and to improve their reproduceability. They can be split into 2 halves to ease the installation of the vacuum chambers. The coils of the ring dipoles are made of aluminium tape and they will be cooled indirectly. It is not yet sure of this type of coil can also be used for the quadrupoles and sextupoles. The dipoles and families of quadrupoles and sextupoles will be powered in series. Kickers and septa are still in an early design stage; special attention is given to an RF compatible design. Some specifications of magnets and septa are given in table 3.

Table 3. Specifications of ring magnets and septa.
D : dipole, Qc : quadrupole curved section
Qs : quadrupole straight section,S : sextupole

Magnet type		D	Qc	Qs	S
Quantity		32	32	36	32
Field @ 1 GeV	[T]	1	0.33	0.33	0.024
Gap/aperture	[mm]	50	75	110	75
Homogeneity/	[.01 %]	1.5	-	-	-
Harmonic content	[%]	-	0.1	0.1	0.1
Length	[mm]	647	212	297	212

Kickers:	electrostatic, length 1.6 m, 2 mrad deflect., flat pulseduring 2.1 µsec, fall time < 70 nsec, deflection voltage @ 1 GeV :+ & - 25 kV
Septum :	injection: d.c., septum thickness 2 mm, 20mrad deflection, field @ 1 GeV 0.167 T
Septum :	extraction: electrostatic wire septum, wire thickness 0.1 mm, gap 20 mm, length 2 m, 5 mrad deflection, voltage @ 1 GeV 55 kV.

VACUUM & MECHANICAL CONSTRUCTIONS: the required pressure is determined by the quantum lifetime in storage mode. Considering the decay of the beam intensity in the presence of an internal target (a few minutes) a quantum lifetime of one hour should be adequate. The vacuum system will be designed for a pressure (with beam) of 1 E -6 Pa. The vacuum chambers and beam pipes will be made of stainless steel 316 LN. This choice has been made mainly because of the low manufacturing costs and the low initial pressure (especially when vacuum fired) when compared to aluminium [5]. The need for in situ bake out is still being investigated. Ion getter pumps will be used with a total capacity of 4000 liter/sec. All vacuum components will be designed with a smooth bore; RF shields will be fitted in bellows, pump outs, etc. Ring components, including magnets, will be pre-installed and pre-aligned on girders. Fig.2. shows a girder layout.

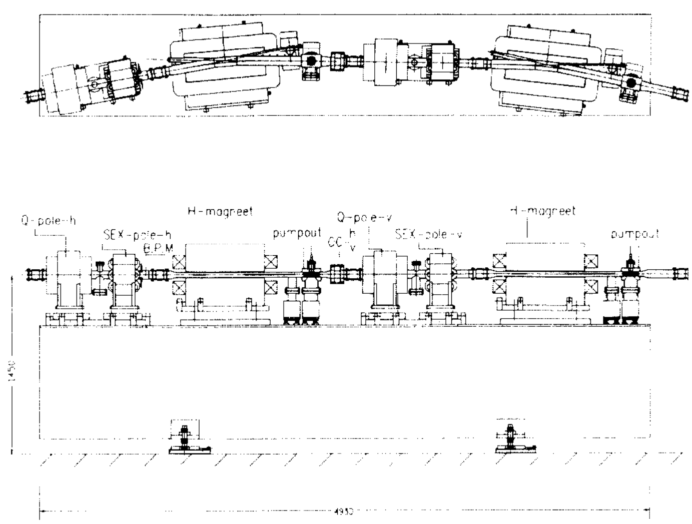

Fig.2. Part of curved section showing 2 dipoles, 2 quadrupoles and 2 sextupoles on the supporting girder

RF SYSTEM: in stretcher mode a cavity operating at the linac frequency of 2856 MHz will be used; this frequency was choosen to minimize the capture loss at injection. At 850 MeV the required RF voltage is 95 kV. Proper extraction control can be achieved by amplitude and phase modulation of the RF. A slow wave cavity structure enables this because of its broadband behaviour. Several CW klystrons are commercially available to power the cavity structure.

In storage mode a high overvoltage is required to insure a reasonable quantum lifetime; since for a given bucket size the RF power scales roughly to the harmonic number, it pays to lower the frequency. Until now operation at 476 MHz with a standing wave cavity is assumed. At 900 MeV an RF voltage of 110 kV will then be required.

DIAGNOSTICS: an overview of planned monitors is given in table 4.

Table 4. Listing of ring monitors and their resolution.

Parameter	qty	type	resolution
position	32	stripline	0.1 mm @ I > 1 mA
	8	synchr.radiation	1 mm
	8	screen	1 mm
profile		flying wire	<0.1 mm
current	1	d.c.transformer	0.1 mA; 10 kHz
	1	stripline	0.1 mA; 0.1 GHz
dE/E	2	synchr.radiation	0.03%
tune	1	kicker+FFT	3 E -4

LINAC MODIFICATIONS

Both peak current and maximum energy of the present linac have to be increased to 80 mA and 900 MeV respectively. The present low values for the emittance should remain unaffected. To that purpose the injector and the RF modulator stations will be modified; an energy spectrum compressor (ESC) added to the linac to restore the deteriorated energy spectrum.

INJECTOR: HRC[6] redesigned the injector. It appeared feasible to increase the current fivefold without a significant deterioration of the emittance; this could be achieved with only minor changes of the optical components.

MODULATORS: raising the energy to 900 MeV requires an increase in RF power from 60 to 130 MW. Therefore the present 5 MW 2.5 % RF d.f. klystrons will be replaced by a tube which can deliver 10-20 MW at 0.15 % RF d.f.[7].

This tube will initially operate at a 10 MW RF output level. The video power will be obtained from the present pulse forming network modules by conecting them in parallel instead of in series [7].

BEAM BREAK UP: studies by HRC [6] indicate that beam break up will not be a problem for peak currents up to 80 mA assuming the previously mentioned 10 MW RF power levels.

ESC: the peak current increase will cause an increase of the energy spread from 0.3 % to about 1 % . This value is beyond the acceptance of the ring so an ESC has to be implemented. A full description of the ESC system is given in [8].

BSY: the BSY should be able to handle electron energies of 900 MeV instead of the present 550 MeV. The system has been redesigned while preserving its excellent optical quality [9]. All quadrupoles can be re-used. The dipole magnets will all be replaced.

TIMESCHEDULE, MANPOWER AND BUDGET.

The realization of the project is scheduled to take 4 years. Civil engineering, the implementation of the ESC and the upgrade of the BSY will be completed early 1990. Ordering and manufacturing of major systems will start mid-1989. Installation and subsystem tests are foreseen in 1990/1991. Early 1992 commissioning of the ring in stretcher mode should start. The IT will be implemented afterwards.

During the construction of the ring,operation of the present MEA facility will be reduced to 50 % .

The manpower estimate amounts to 140 effective manyears. NIKHEF's technical staff consists of 100 scientists, engineers and technicians. The total budget for the project is 26.5 M DFl incl. VAT (~M $ 12.6).

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