EXTENSION OF THE MUNICH HEAVY ION POSTACCELERATOR

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Abstract

The heavy ion postaccelerator at the Munich tandem laboratory with its new additional accelerator unit, its three-harmonic double drift buncher and its "emittance conserving" chopper is described.

Introduction

The linear rf-postaccelerator with a drift tube structure of the IH-type is operated in combination with the Munich MP-tandem at a resonance frequency around $f \approx 80$ MHz. It has been used for eight years in about 20% of the tandem beam times [1,2]. During this time there wasn't any failure.

In this contribution we report on our new accelerator unit. It is of the same type as the first booster, its resonance frequency is $2 \cdot f$ in order to rise the shunt impedance. A special synchronous particle-structure is used to accelerate heavy ions from typically $\beta \approx 0.07$ to $\beta \approx 0.11$ over a total postaccelerator-length of 8.5 m. Three magnetic quadrupole lenses are used, one in front of the first booster, one between the booster and one behind the second booster. The drift tubes contain no radial focussing elements. A high efficient buncher and a recently installed "emittance-conserving" chopper between tandem and postaccelerator have shown to be helpful for many experiments.

Chopper and buncher

To investigate short-lived activities in the nanosecond range it is important to have a very low background between the pulses, which are generated at the low-energy side of the tandem with a frequency of about 5 MHz. This background is eliminated by a chopper at the high energy side of the tandem. The chopper consists of two pairs of deflector plates which work at ~ 5 MHz and ~ 150 MHz[3]. This superposition of fields (fig. 3) reduces the deterioration of radial and longitudinal beam-emittance, which is normally caused by a simple 5 MHz-chopper.
More than 70% of an injected dc-beam is accepted by the postaccelerator with the help of the 3-harm. double drift buncher[4], which generates a rather smooth approach to the sawtooth voltage distribution over 76% of the period length (fig. 4). The rf-phase between buncher and postaccelerator can be kept very stable. This is especially important for our accelerator mass spectroscopy-experiments with microscopic beams. This means, that the problem of forming sharp pulses with the low energy pulse system and keeping the phase stable has been bypassed.

2f-SchweIN

Some typical numbers:
total length: 3m; eff. gap-voltage: 200 kV
rf-power: 45 kW; eff.shunt-impedance: 190 $\frac{M\Omega}{m}$

number of gaps: 26
resonance frequency: 140 MHz - 180 MHz

inner drifttube-diameter: 20 mm

The cross section of the tank and a top view on the middle part are shown in fig. 1a,b. The geometry of the tank and of the drifttubes is optimated to high shunt impedance. Because of the great gap/period-ratio $g/L \simeq 0.5$ and the small outer drifttube diameter of 28 mm, we have a gap field-distribution of the so-called long gap-type. This has two positive effects on the beamdynamic:
- The transit time factor in this geometry is nearly independent from the radius while in usual field-distributions the transit time factor for particles rises with the radius.
- The great g/L-ratio lowers the radial defocussing effect of the gaps (the drift length between the focussing force at the gap entrance and the defocussing force at the gap exit is long).

Beam dynamic+

To keep the radial defocussing effect of the gap-fields as low as possible we try to use a synchronous particle structure with $\varphi_s \simeq 0^\circ$:
The longitudinal beam transport of a pulse through a synchronous particle structure can be investigated by calculating the exit energy in dependence from injection phase and energy in the first gap of the postaccelerator. This 3-dim. matrix is shown in fig. 5 a-c for beam line positions I,II and III (fig. 2). The energies of the postaccelerated ions are plotted as contour-lines.
The calculation is done for a $^{58}Ni^{22+}$-beam with 0°-synchronous particle structures in both machines.

At the exit of the first booster, the synchronous particle is changed to get adaptation between the two boosters (fig. 6 a). From fig. 5a one can see that short linac-sections with 0°-synchronous particle structure have fine properties: particles which are injected into the booster with to high energy and to late relative to the synchronous particle have an exit energy very close to the synchronous particle; this may especially be helpful to accelerate a low β-high intensity-beam. Fig. 6 a-c show the exit energy/phase-region at positions I,II,III of a pulse whose injection energy/phase-region is defined by the dotted parallelogram in fig. 5 a-c.
Fig. 5c shows the pulse, formed by the 3-harm. double drift buncher and containing more than 70% of the tandem dc-beam (the poststripper foil is placed at the booster entrance). After the debuncher, the energy-spread is $\frac{\Delta E}{E} \lesssim 3 \cdot 10^{-3}$ (fig. 5c). The radial beam dynamic is calculated with the ray-tracing method. A linear approach on measured gap field distributions is used dividing each gap radially into 4, longitudinally into 5 sections. The maximum beam diameter in the 2f-SchweIN is expected to be less than 10 mm.

Flexibility of the postaccelerator

The function $\beta(z)$ along the beam-axis is defined by the resonance-frequency and the drift-tube-configuration. A possibility to change

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+ We design phases on the leading edge of the rf-wave (logitudinal stability) with a (-)-sign.

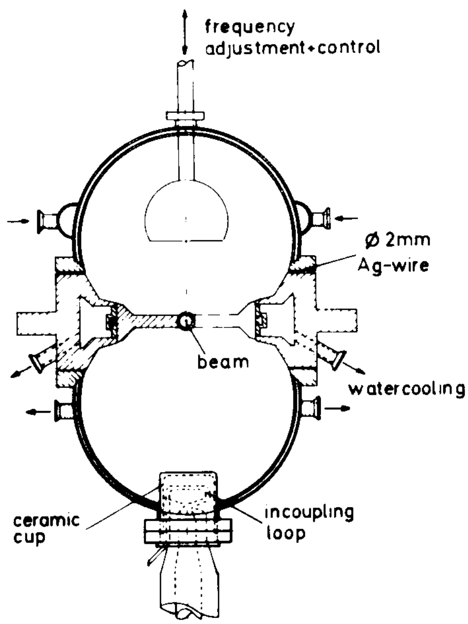

Fig. 1a: Cross section 2f-booster.

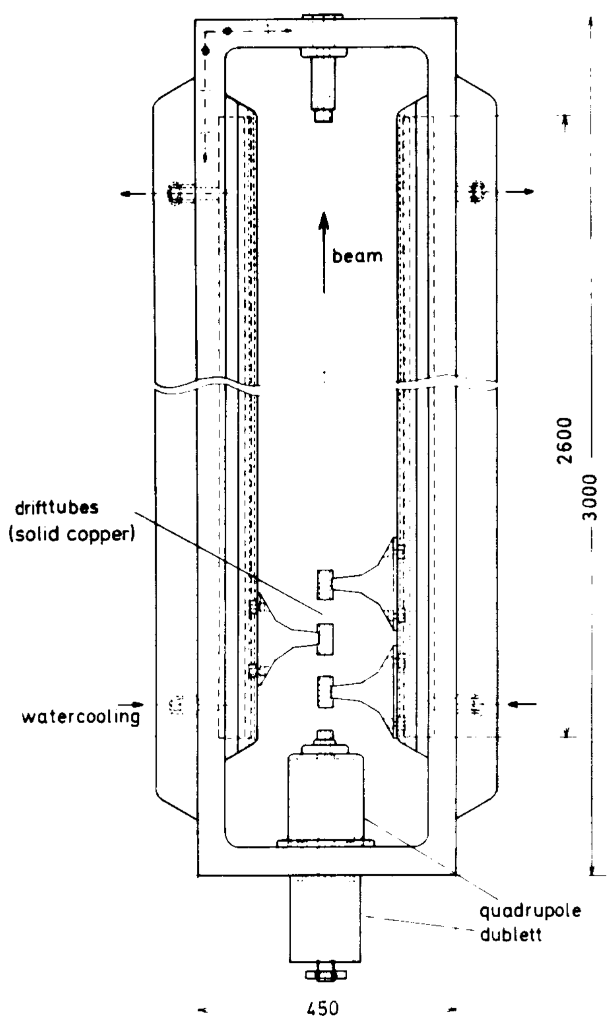

Fig. 1b: Top view on middle part 2f-booster.

ß(z) into const·ß(z) is to change the resonance-frequency by moving big plungers (fig. 1a). Changing both resonance-frequency and ß-profile can be achieved by moving the drifttubes. For example, if the average period length of the structure is shortened by 10%, the resonance-frequency is lowered by typically 5-10% because of the capacity increase between adjacent drifttubes (dependent on the drifttube geometry).
It seems to be possible to construct a middle part for our booster type, where the drifttubes can be shifted without opening the tank.

References

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3. to be published in Nucl. Instr. and Meth.
4. U. Ratzinger, R. Geier, W. Schollmeier, S. Gustavsson and E. Nolte: Nucl. Instr. and Meth. 205 (1983) 381

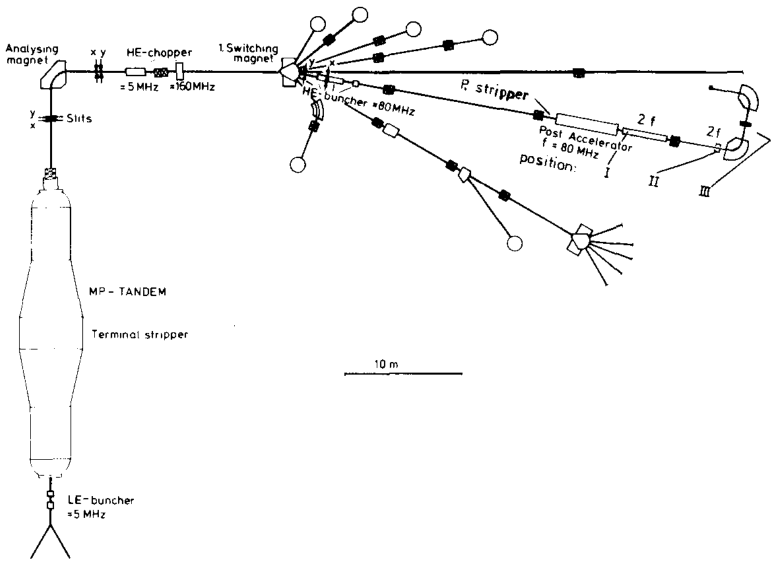

Fig. 2: Beamline system

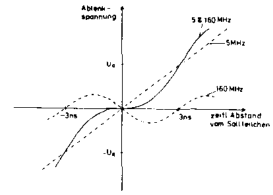

Fig. 3: Chopper

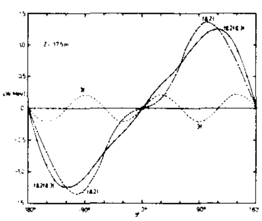

Fig. 4: Buncher

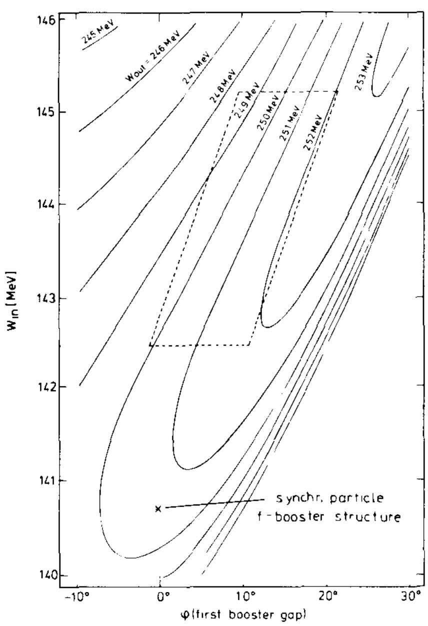

Fig. 5 a)

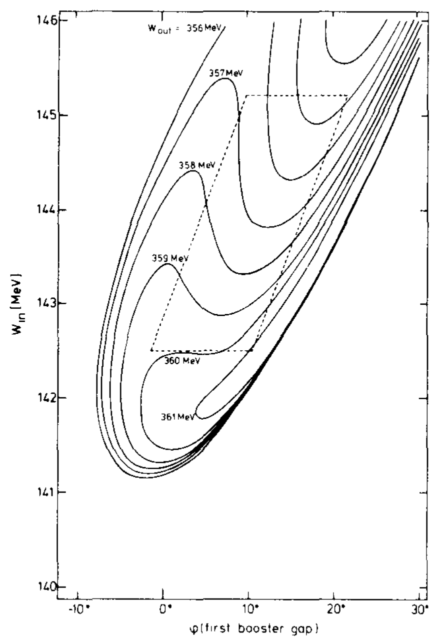

Fig. 5 b)

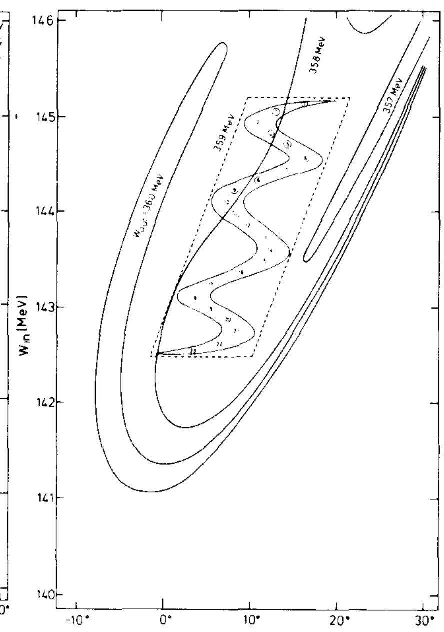

Fig. 5 c)

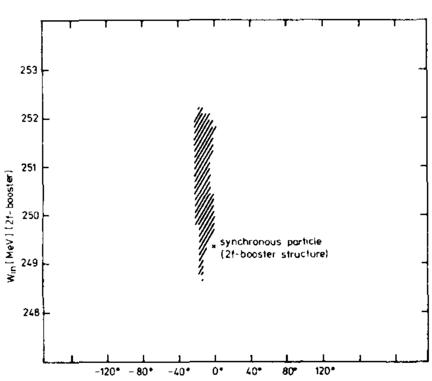

Fig. 6 a)

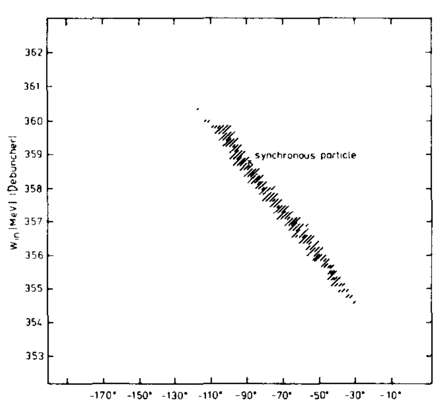

Fig. 6 b)

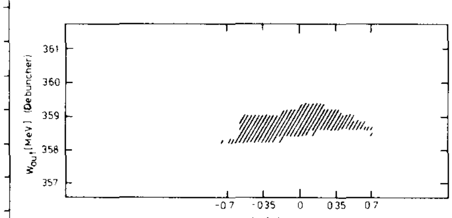

Fig. 6 c)