PILOT-BUNCH AND LONG-PULSE EJECTION (t=7.6 μs) WITH STRIPE KICKERS: OUT OF PETRA FOR THE PATH TO HERA

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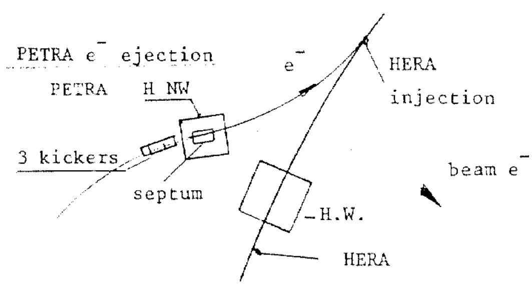
Abstract

The idea of stripe kickers is to have kicker chambers which lead the RF as in a vacuum chamber. Stripe kickers as line kickers are very suitable for rectangular ejection pulses, both short and long. Double-ended thyratrons drive the kickers in both polarities to eject electrons or positrons.
This report describes the kickers and their PFN-pulsers and how they work for PETRA.

Fig. 1: The ejection point in PETRA



PETRA e- and p Ejektion (Kicker and Pulser)

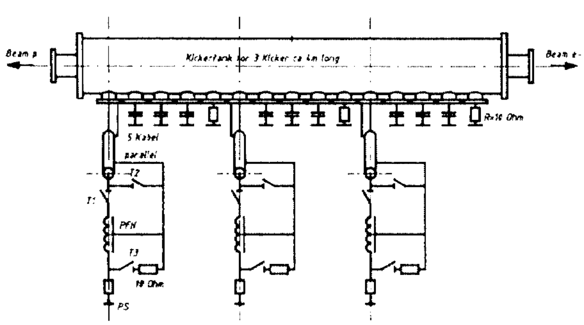


Fig. 2: Kicker and pulser scheme

The Kicker and Pulser Scheme

Three kickers lie in a vacuum tank that is bolted together. The kickers have the same electrical effect as a delay line for a 10-Ohm characteristic impedance. One PFN pulser drives each kicker. Long pulses (t=7.8 μs) are switched by the main thyratron (T1). Thyratron T2 can be used to reflect the pulse current out of the PFN and thus shorten it up to the pilot pulse. By means of T3, the reflected pulse is routed into the discharge resistor at the input of the PFN.

System Data

1. Ejection energy 14 GeV

2. Protective stripes in the kicker between the beam and ferrite decouple the beam and the kickers from undesirable interaction and warming of the ferrite.

3. For rectangular pulses for ejection of the entire PETRA bunch series, kickers, pulsers and PFN's are designed for the same characteristic impedance (as low as possible). It must, however, be possible to achieve rectangular pulses with rising flanks that are steep enough. The voltage at the kicker and pulser is selected so that the thyratrons in the pulser can be operated without oil insulation and the cable and so that the PFN's are economical. A characteristic impedance of 10 Ohm for kickers, pulsers and PFN's is the minimum value. A low characteristic impedance requires a long delay for the pulse in the kicker and thus a longer fill time or switch-on time. The kicker must be divided into thirds and driven by three single PFN pulsers.

4. The pulsers are PFN-driven in order to obtain a straight top for the rectangular pulse. Cables as drivers cause declining (skew) tops for pulses longer than 3 μs through line losses in the cable.

5. Pulser polarity reversal for the e- or p ejection
Line pulsers do not tolerate any additional unwanted inductances caused by switches. Double cathode thyratrons prevent this occurring. The polarity of the power supplies is reversed. PFN pulses and kickers must be proof against bipolar high-tension, however.

6. Pilot pulse ejection
Pilot-bunch and short-pulse ejection for both polarities require further pulser equipment. Since the PETRA filling from DESY2 cycles are collected and accelerated, no particles must be lost in the storage mode. By using ejected pilot bunches out of the bunch chain, the transport path and HERA injection can be tested without interfering with PETRA filling. The ejection method was tested successfully for HERA filling.

7. Conditions for kicker design
a Stripe kickers for kickers and beam decoupling
b Ferrite kickers for field guidance
c Ferrite insulation using ceramics as flashover protection
d Synchrotron beam absorber with water cooling
e Kicker structure as line lickers (L-C)
f L-C element of the kicker with external capacitances

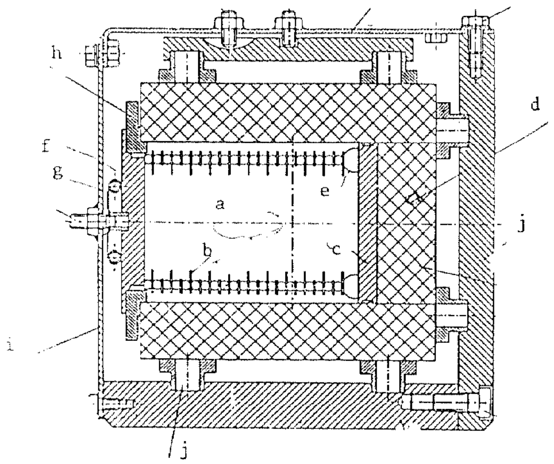


Fig. 3: Cross-section of the kicker

Description of the Kicker Diagram (Fig. 3)

a. The beam current in the kicker
b. The protective stripe in the kicker
c. The current conductor
d. C-yoke of the kicker, made of ferrite
e. Ceramic insulation
f. Absorber for the synchrotron light
g. Water cooling of the absorber
h. Ceramic insulation
i. Clamping plate for holding the stripes
j. Kicker frame

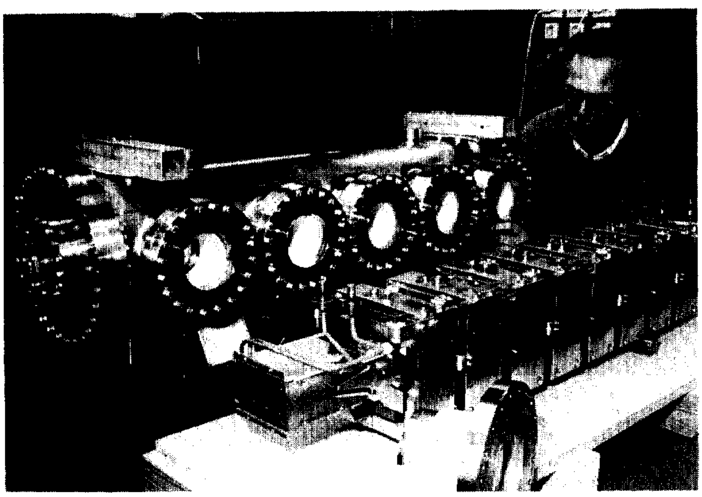


Fig. 4: Kicker magnet

Notes on the Kicker Design

Three identical kickers lie in a kicker tank that is bolted together. Each kicker is connected from outside via five large vacuum-sealed ceramic cable glands that are high-tension proof (see Figs. 4 and 5). Gland 1 connects the kicker to the five parallel cables of the pulsers. The fifth gland connects the coaxial 10-Ohm absorber to the kicker. The central glands connect the external capacitors of the L-C elements, since it is hardly possible to obtain high-tension-proof plate capacitors for a characteristic impedance of 10 Ohm in the kicker. Particular care must be taken with the power connections through the ferrite casing of the kicker, due to its unwanted inductances. Flat, high conductors without magnetic shunt, or even a short-circuit over the ferrite, are particularly important.

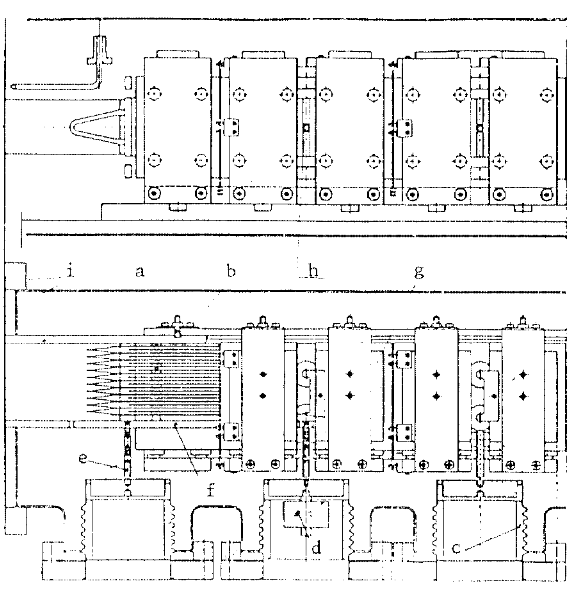


Fig. 5: Kicker magnet seen from above

Top View of the Kickers (see Fig. 5)

a. Kicker chamber. At the tank end, the kicker chamber is bolted to the vacuum chamber and sealed with a compression flange. This yields a smooth kicker connection without aperture gap or reflections for the wall currents of the beam. The outer chamber wall is a copper rail leading through the kicker and acts as an absorber for synchrotron radiation and, at the same time, as a good conductor for the RF wall currents through the kicker.
b. At the top and bottom, parallel stripes decouple the kicker and the beam. The stripes fastened to the input and output of the kicker run in the opposite direction next to each other. Their capacitive coupling leads the RF currents of the beam and closes the chamber. As measurements have shown, the kicker field is hardly distorted and the constant field of the rectangular pulse is not distorted at all.
c. Ceramic gland, high-tension proof
d. External capacitor of the L-C element
e. Kicker connection with short paths
f. Conductors in the kicker
g. Ferrite plates of the kicker's C-yoke
h. Connection gland for the external capacitors.
i. Kicker tank as round tube

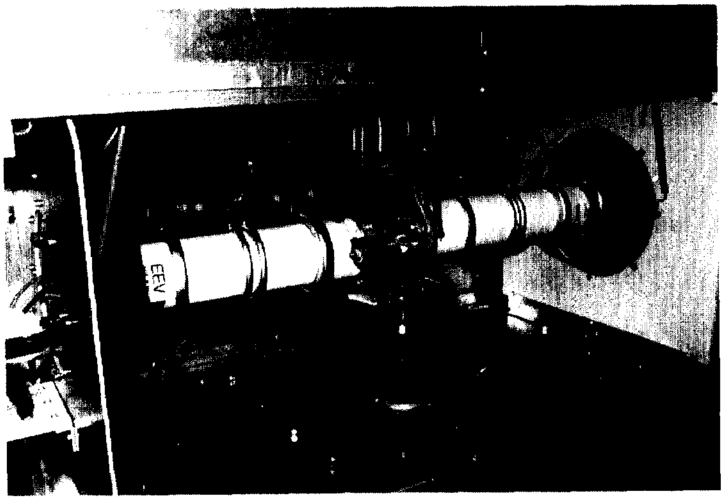


Fig. 6 Kickerpulser

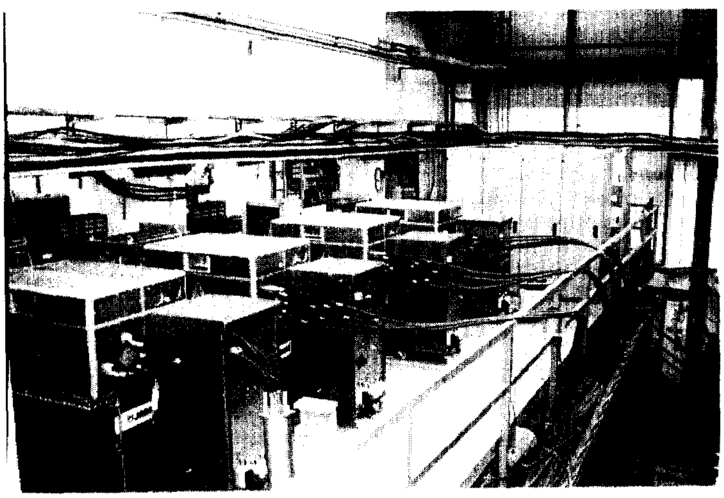


Fig.7 Kickerpulsers in the hall

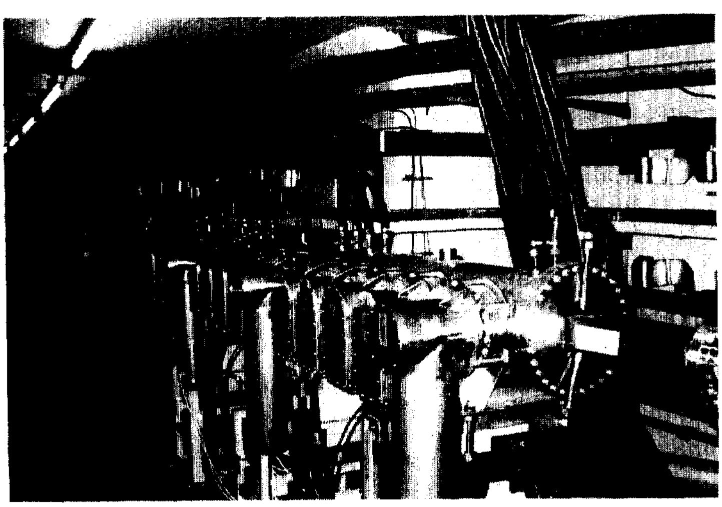


Fig.8 Ejectionkickers in PETRA

<u>Data of the Kicker Magnet</u>

Energy	GeV	14
Deflection	mrad	3 x 0.4
No. of units	n	3
Ferrite length	mm	750
Ferrite gap height	mm	65,6
Chamber gap height	mm	40
Chamber gap width	mm	90
Magnetic field	mt	26
Kicker type	Stripe kicker	
Kicker field filling time	ns	150
Current	kA	1.391
Pulse duration	μs	7.6
Pilot pulse	Yes	
Impedance	Ohm	10
PFN	Ohm	10
Voltage at kicker	kV	14
Voltage at PFN	kV	28
Voltage (ps)	kV	35
Thyratrons (double-ended)	CX 1154 B	
Polarity	Changeable	

<u>In the kicker pulsers (see Fig. 6)</u>, the two thyratrons (CX 1168 B), T1 and T2, are visible as in Fig. 2. The right-hand thyratron (T1) leads to the kicker in the PETRA tunnel via 120 m of cable. By means of the left-hand thyratron T2, the pulse is cut to length. The connection to the delay line is brought in from underneath.

<u>The kicker pulsers in the hall (Fig. 7)</u>
Four pulsers with power supplies can be seen. In order to be able to switch over quickly at night, four pulsers are available for three kickers. Thyratron changes can therefore be made the following day without interfering with the operation of the machines.

<u>The three kickers in PETRA (see Fig. 8)</u>
One can see the three hanging absorbers and the connection boxes of the external capacitors at the kickers. Coming down from the ceiling, there are the parallel connection cables from the pulsers to the kickers.

References:

[1] J. Rümmler, DESY: New Stripe Kickers in the Injection Chain of HERA.

[2] J. Rümmler, DESY: Fast Pulsed Converters (CAS Report).

[3] Prof. Voss: Consultations on Kicker Design.