HERA e⁻ injection with septum and kicker technology

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Abstract

The HERA e- injection works with two septum and 4 kicker magnets. Kickers on both sides of the septa guide the HERA beam during injection near the septa. Both beams come together in the HERA acceptance. Without the kickerbump the beam oscillations damp down. New injections into the packet or into another one are possible.

This report shows the injection scheme and the septa and kicker data.

1. Introduction

The injection scheme shown in Fig. 2 enables new and also re-injections with circulatory beams. Four kickers and two septa form the injection elements. All four kickers produce a 38 uS long half-wave pulse. With a balanced kicker bump the circulating beam is only moved transversally in the injection region. Both beams, the old one in the HERA and the new one which is to be injected are then located in the kicker bump in the acceptance region of HERA.

Using this flexible injection scheme and depending on HERA requirements, complete PETRA fillings, pilot bunches or even short bunch trains from PETRA can be filled at various points in HERA or they can also be filled in rows.

2. Points of injection on HERA

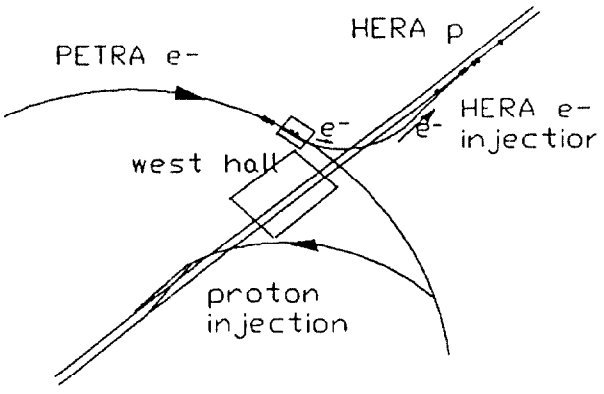
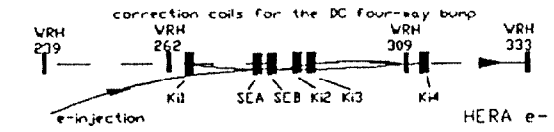


Fig.1

2.1 injection scheme



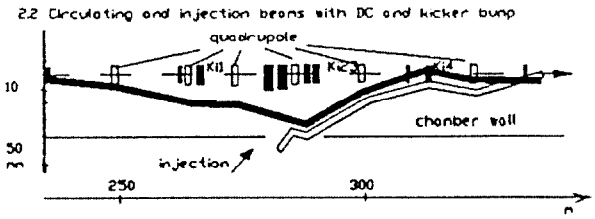


Fig.2

Circulating and injection beams at the septum output.

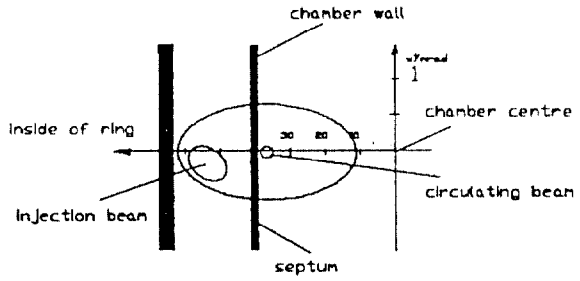


Fig.3

3. Injection data

E = 12 GeV/c

DC bump		WRH 239	WRH 262	WRH 309	WRH 333
I	A	-0,3452	-0,3162	-0.2529	-0,3461

Kicker		K1	K2	K3	K4
U	kV	+2,6	-1,5	-1,5	+2,6
I	kA	3,9	2,25	2,25	3,9
a	mrad	1,3	0,75	0,75	1,3

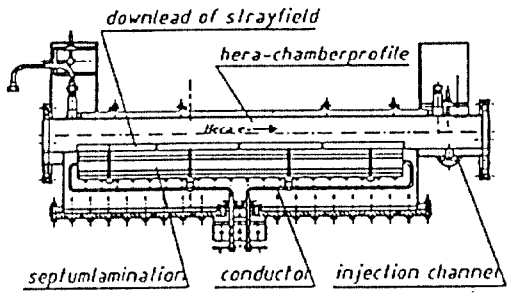
Septa		Septum A	Septum B
I	kA	9	5,5
a	mrad	19	11,8

4. The septum magnets
Messrs Ganske W1 and Rümmler MIN

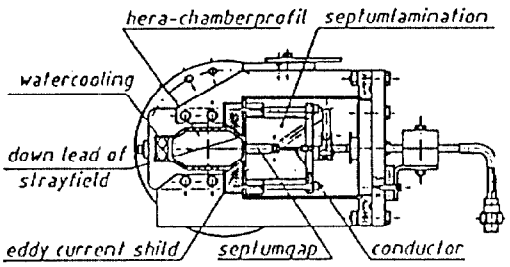
Data for both septa.

		Septum A	Septum B
E	GeV/C	14	14
Deflection	mrad	25,5	11,6
Length of iron	m	0,8	0,8
Gap	mm	25 x 10	25 x 10
Windings		1	1
current/field	kA/T	12/1,5	5,4/0,7
Busbar thickness	mm	10	3
Sinusoidal pulse	uS	880	440

The septum magnet



Top view Fig.3



Septum cross-section Fig.4

The profile of the HERA vacuum chamber can be seen in the cross-section. It is water-cooled due to the synchrotron and Compton radiation. The septum magnet panel assemblies, welded with bands, are located outside of the chamber but in a vacuum and clamped to the chamber. The septum guide leads through the gap and is insulated with Vespel against pulsed shocks.The eddy current shield was reinforced outside of the vacuum chamber against pulsed stray fields using copper parts.

Screening panels of magnetically permeable material in the vacuum chamber extract the residual stray field.

Field and stray fields on the septum

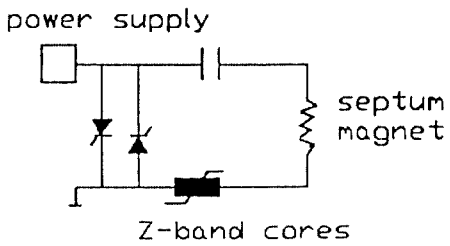
The stray field on the septum guide is below 1% and decreases rapidly with increasing distance from the guide.

The injection process is not impaired by the stray field, particularly as the kicker bump only displaces the beam 10 uS nearer to the septum.

4.1 Septum pulser

Fast septum pulsers are required in the septum system with the eddy current shield in order that the eddy current shield becomes effective. Full or half-wave sinusoidal pulses of t= 240 uS were selected and checked by measurement. An oscillating pulser is in operation for each septum.

Pulser circuit diagram
Rümmler und Strahlendorf



5.Kicker magnets
Kicker magnet without tank

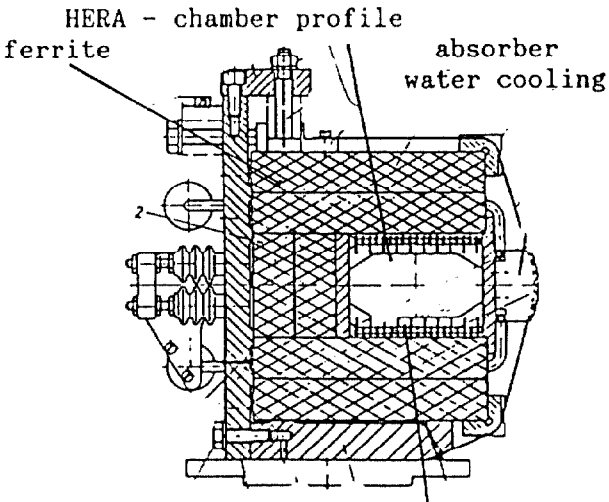
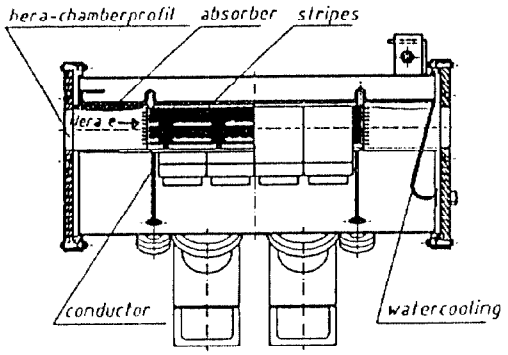


Fig. 5



Kicker plan view Fig.6

New stripe kickers were used for the injection.

Ferrite kickers in the HERA electron ring must be protected against heating by mirrored currents.

The external chamber wall of the kicker, which is metal, passes right through the kicker, guides the RF without reflection and also blocks off the synchrotron radiation.

V2A stripes above and below in the kicker gap are joined to the chamber alternatively to the left and right. Their capacitances to one another close the chamber to protect the kicker ferrite from the beam fields. For the kicker field, the stripe capacitances are in series so that the kicker field does not meet any short-circuit winding.

Kicker pulser Mr. Gödecke

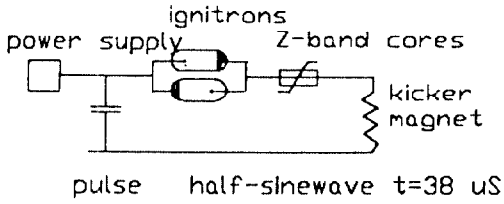
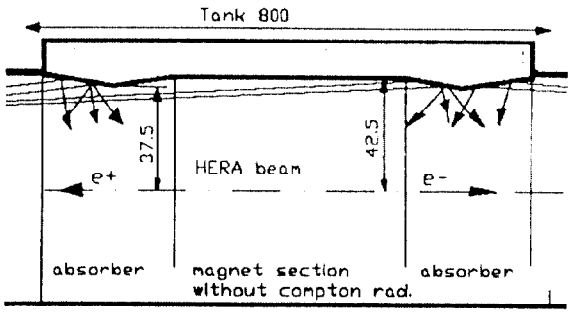


Fig.7

Kicker data:

E	GeV/c	14
Deflection	mrad	1,3
Magnet length	m	0,4
Ferrite gap	mm	80 x 65 (94 x 65)
Free gap	mm	80 x 40 (94 x 40)
Half sinewave pulse		t = 38 uS
Voltage	kV	2,6
Current pulse	kA	3.9

5.1 Synchrotron and Compton radiation in the HERA kicker magnets



Kicker top view

Fig.8

Power loss in the kicker magnets

$$P = \frac{1.41 \times 10^{-4} \times E(GeV) \times I(A) \times da}{r}$$

da is the aperture angle for the synchrotron radiation in the shadow of the kicker for remotely located dipole magnets.

E(GeV)	Beam energy
I	Machine current
x_k	Distance of the kicker from the dipol

Data sets					
E	GeV	26 e-,	50 e-,	26 e+,	50 e+
r	m	304	304	304	304
da	mrad	0.571	0.571	0.74	0.74
x_k	m	4	4	3	3
Kicker	m	0.5	0.5	0.5	0.5
I	mAmp	58	6	58	6
P	Watt	701	1000	910	1280

Operating experience
The injection works perfectly.

Acknowledgment:

We would particularly like to thank Messrs Bialowons, Brinkmann and Rossbach for many measurement sessions on the injection with the complete HERA e-.

Professor Voss also deserves a special mention for his helpful ideas during the design of the injection elements.