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CERN - PS DIVISION

PS/ CA/ Note 99-13

INITIAL MEASUREMENTS OF THE VERTICAL BOOSTER TRANSFER MAGNETIC SEPTUM 10 (BTSMV 10)

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1. Introduction

In the frame work of the project "PS for LHC" the Booster energy was increased from 1 GeV to 1.4 GeV as from the run in 1999. Over the past few years already the ejection septa in the booster rings, a septum magnet in the transfer line to the PS (BTSMV 20), and the septum injection magnet in the PS ring have been modified to handle the increased beam energy. These new generation septum magnets have been constructed as pulsed current magnets, instead of DC current magnets as previously installed. During the shut down of January 1999 the Booster Transfer Vertical Septum Magnet 10, (referred to as BTSMV10) was replaced by a pulsed current version, capable of handling the increased beam energies. This report describes the initial tests of these magnets and their spares.

2. The layout of the BTSMV 10

The BTSMV 10 consists of two separate septum magnets and their respective vacuum tanks. BT1 SMV10 is the recombination septum in the Booster – PS transfer line, that recombines the 1st booster ring with the 2nd, and BT4 SMV10 is the recombination septum in the Booster – PS transfer line, that recombines the 4th booster ring with the 3rd. Previously one rectangular vacuum tank was used to house both septum magnets. Now two circular vacuum tanks are used to house each one septum magnet. In appendix 1 the layout of the septa magnets is shown as seen from the exterior of the accelerator rings. Each tank is also equipped with beam observation equipment on the down stream side of the magnets.

3. The measurements

Before installation the magnets were tested. In the final assembly the two tanks are stacked on top of each other and the two tanks have each the individual power supply. The transformer used for the tests was the same as used in the machine. A capacitor bank of 3 mF was used. This resulted in an approximate 3 half-sine pulse. Figure 1 shows circuit diagram.

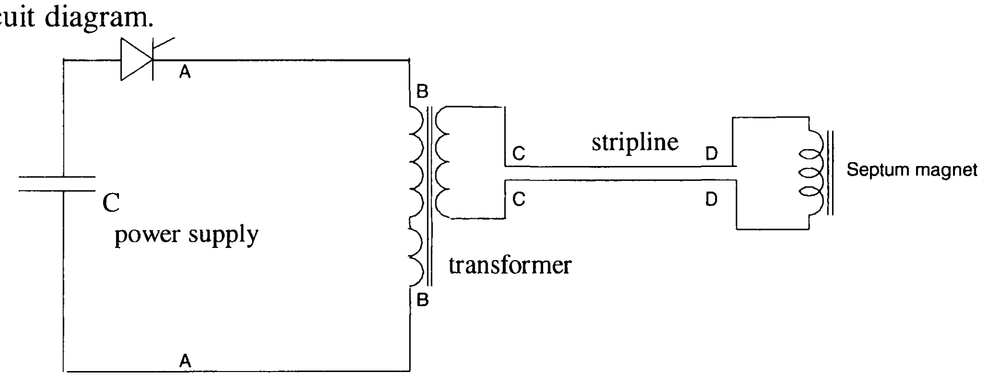


Figure 1: The circuit diagram

The circuit specifications were:

Capacitance C	3 mF
Transformer	12 : 1

The measurement equipment used was:

Impedance meter	H.P. Model
Current Transformer	Pearson Model 1423 (1 V/kA)
Digitizer	Tektronixs 7612D
Data handling	PC 486 running Labview
Scope (for current measurements)	H.P. Model 54601 A

3.1 Inductance measurements

Using the H.P. impedance meter the values of resistance and inductance was measured at point A in the circuit diagram. After measuring the total impedance, another measurement was taken when a short circuit was made at point D. This is at the feedthrough of the tank. This allows to derive the inductance of the magnet itself. Another measurement was taken with a short circuit where the horizontal stripline from the transformer joins the vertical stripline of the tanks. This measurement allows to derive the inductance and resistance of the magnet, including the flexible, and vertical striplines. Since the tanks BT4 SMV10 have slightly longer striplines, compared to the ones of BT1 SMV10, the measurements were done for each type. Table 1 reproduces the results.

Table 1: The impedances of BT1/BT4 SMV10

Impedance (μH)	BT1 SMV10	BT4 SMV10
No short	410.2	416.6
Short at end horizontal stripline	53.0	54.4
Short circuit at Feedtrhough	Not done	99.4
Derived magnet impedance	Not done	**2.20**
Derived magnet + striplines impedance	**2.48**	**2.52**

The theoretical value of the inductance per magnet is 2.2 μH (see appendix 2 for the theoretical pre-calculations of the magnet) so the measured value is as expected, taking into account the measurement tolerances.

3.2 Magnetic measurements

Using a power supply based on the circuit as shown in figure 2, with a pulse repetition rate of approximately 4.5 seconds, a series of measurements were recorded in order to determine the magnetic field in the gap and the fringe fields. The field in the gap was measured to determine the actual punctual values as well as the integrated field ($\int Bdl$) from which the equivalent magnetic length of the magnet was calculated.

The measurements we taken with the Tektronics digitizer and transferred to a PC running a Labview application as described in Cern Note PS/PA/95-13. In appendix 3 the results of all magnetic measurements are shown.

The gap field

As the result of the B field and integrated B field measurements in the gap, the magnetic equivalent length was derived at different currents. Table 2 shows the minimum and maximum measured for each magnet.. The equivalent magnetic length of all the magnets is 996 mm with a measurement error of ±3 mm mainly due to the alignment error of the measurement coils. A three dimensional finite element calculation predicted 1003 mm, so the measured value is lower than expected. The poor model used to calculate the magnet in TOSCA, necessary to avoid a too big amount of elements could explain this. The model used for the finite element calculation follows the general outlines as described in CERN Note PS / CA / 97 – 27.

Table 2: Resume of magnetic equivalent lengths as measured at different currents for each magnet

Magnet coil number	**Lowest measurement (mm)**	**Highest measurement (mm)**
3	**994**	**998**
4	**994**	**999**
5	**993**	**997**
6	**995**	**997**

The fringe field

Also the integrated fringe field, the field next to the septum conductor outside the gap, has been measured. The results are reproduced in appendix 3, and in figure 2 the relative integrated fringe field with respect to the gap field at 27.2 kA (necessary for 1.4 GeV operation) is illustrated as function of the distance to the septum. No great variation between the magnets can be observed, and at 55 mm the fringe field level drops below 1/1000 of the gap field.

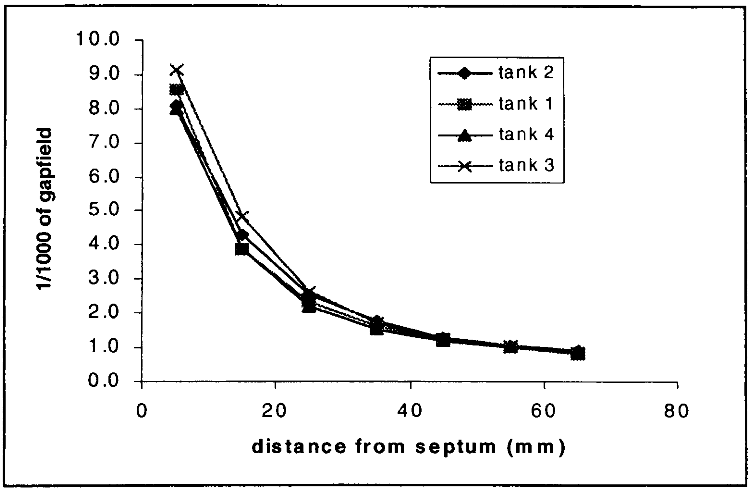


Figure 2: The relative fringe field at 27.2 kA for the BTSMV10 magnets as installed in the Booster Transfer line in January 1999

The end field

For completeness also the end field was measured for the different magnets. The end field is measured in the middle of the gap, starting at the magnet extremity moving outwards, into the air. The leak field measured over there, is taken into account when doing the integrated gap field measurement, but was measured punctually for verification purposes. The results are tabulated in appendix 3.

3.3 Miscellaneous

In appendix 4 the identification of the coils, tanks and feedthroughs is well indicated for future reference. Also the water flow is mentioned as measured at 12 bar.

To support the last magnetic steel lamination at the extremities, next to the cross over conductors, all BTSMV 10 magnets have a 1.5 mm stainless steel non magnetic lamination at these ends installed, to prevent movement of the last magnetic gap lamination due to the pulsing magnetic fields. Also Vespel clamping plates are installed to provide additional support to this stainless steel lamination. The layout of this mechanical support is of identical layout as the one described in note CERN PS / CA / Note 98 – 11 for the modified SMH 16.

For the record also the water flow tests for all coil manufactured, have been included in appendix 5. The first two coils (20.01 and 20.02) have been used for magnet BTSMV 20 and its spare. Coils 3 to 6 have been used on the magnets for BTSMV 10. What can be noticed is that there is no wide spread in flow rate at a given pressure between the various coils. The measured flow is 10% lower than of the calculated flow rate, due to approximations concerning bends in the water circuits in the calculation. However this can still be considered as largely sufficient, given the relatively low RMS power losses in the coil.

4. Conclusions

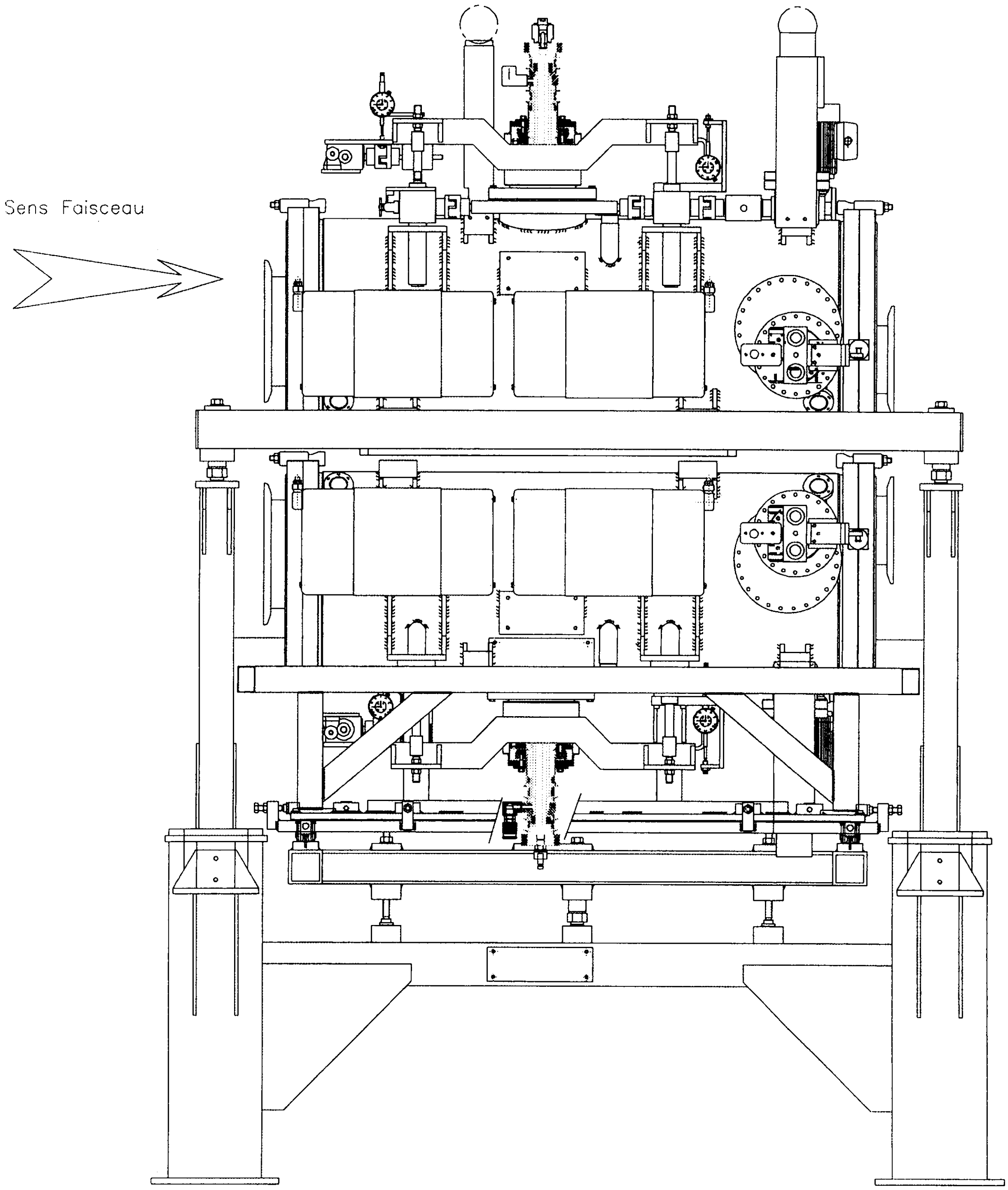
The BTSMV10 magnets have been tested before installation in the Booster – PS Transfer line in January 1999. The magnetic equivalent length was found to be 996 ± 3 mm, which is 7 mm shorter than the calculated length. This could be explained by a poor model used for the calculations. This was necessary to keep the number of elements of the model low enough to be handled by the computer. Compared to measurements done on BTSMV 20, a magnet of the same type, a 2 mm lower magnetic length was found, but this difference is within the error margin.

The fringe field was measured as well. The integrated fringe field for a typical magnet is 1 ‰ of the integrated gap field at 55 mm from the septum conductor. At 5 mm from the septum blade the integrated fringe field is typically 8 ‰ of the integrated gap field. This is considered as sufficiently low, given the magnets use in a beam transfer line.

The inductance measurements show a value of 2.2 μH per tank as measured from the feedthrough. This measured value is slightly lower than what could be expected theoretically. This is likely due to the use of less suitable measurement equipment.

Appendix 1. Layout of BTSMV10.

BT4 SMV10, in the top tank, BT1 SMV10 in the lower tank



Appendix 2. Magnet characteristics for proton operation

- Magnet pre calculations for 800 MeV protons
- Magnet pre calculations for 1.0 GeV protons
- Magnet pre calculations for 1.4 GeV protons

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PREDETERMINATION SEPTUM MAGNETIQUE — SMCALC.XLS — **PW prot:jb**

BT SMV 10 version pulsee

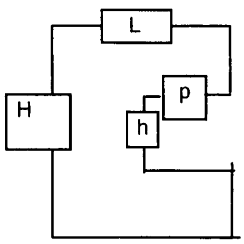
particularités

DONNEES

particules electrons : e protons : p	**p**	
quant.mouvt : MV Energie cin. : EC	**ec**	
Energie cinétique Ec =	**0.8**	GeV
Déflexion requise	**79.3**	mrad
Epaisseur du septum	**5**	mm
Hauteur du Gap	**60.4**	mm
Profondeur du Gap	**116**	mm
Longueur magnetique equivalent	**996**	mm
Espace de glissement	0	m
Monospire donc	**1**	spire
Epaisseur cond. retour	8.8	mm
Hauteur de conducteur retour	60.4	mm
Résistivité du cuivre (1.72E-2	0.0172	mO.mm
module d'Elasticité (12500	12500	daN/mm2
Forme de l'impulsion		
DC , 1/2 sinus : S , trapèze : T	**S**	
1/2 période de l'impulsion	**3.1**	ms
Période de récurence (cycle tot.	**1.2**	s
taux de répétition de l'impulsion de courant		
Systeme de refroidissement		
pression différentielle	**12**	bar
nombre du circuits	**2**	
septum		
forme element de refroidissement	**rec**	
Cote horizontal	**5**	mm
Cote vertical	**30.2**	mm
forme du passage d'eau	**circ**	
Diametre trou	**2**	mm
conducteur retour		
forme element de refroidissement	**rec**	
Cote horizontal (mm)	**8.8**	mm
Cote vertical (mm)	**30.2**	mm
forme du passage d'eau	**rec**	
Cote horizontal	**3.6**	mm
Cote vertical	**2.2**	mm
Matiere		
maximum admissible champ dans le f	**0.58**	T

RESULTATS PROTONS

Masse au repos mo	0.94	Gev/c2
Energie cinétique	**0.8000**	GeV
Quantité de mouvement	**1.4642**	Gev/c
beta	0.8415	
gamma	1.8511	
beta*gamma	1.5577	
Déplact. après espace de gliss	**39.4914**	mm
Champ intégré B*L	**0.387**	T.m
Induction dans le Gap	**0.389**	T
Champ magn. H=B/uo	3.09E+05	A/m
Courant nécessaire	**18678**	A
Valeur efficace du courant	671	A
densité de courant eff.	**2.27**	A/mm2
Résistance de l'aimant	**0.104**	mOhms
Inductance de l'aimant	**2.26**	uH
Puissance dissipée	**0.047**	kW
Energie stockée	394	J



	116	p en mm
	60.4	h en mm
	193.7	L en mm
	215.8	H en mm
Débit d'eau total	**4.32**	l/min
Débit dans chaque spire	2.16	l/min
vitesse de l'eau dans septum	11.47	m/s
dT total d'eau	0.17	K
Force septum /cond fond	**361.47**	daN
Flèche max . septum (appui	0.008	mm
moment flech.max. (appui	2.74	mm*daN
contrainte maxi <5 (appui	0.66	daN/mm2
Masse culasse (sans poutre	**249**	**kg**
section cond. septum	295.7168147	mm2
Section refroidissement septur	6.283185307	mm2

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PREDETERMINATION SEPTUM MAGNETIQUE SMCALC.XLS **PW prot:jb**

BT SMV 10 version pulsee

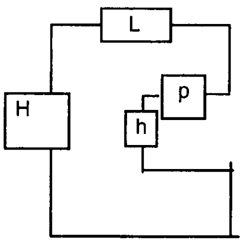
particularités

DONNEES

particules electrons : e protons : p	**p**	
quant.mouvt : MV Energie cin. : EC	**ec**	
Energie cinétique Ec =	1	GeV
Déflexion requise	**79.3**	mrad
Epaisseur du septum	**5**	mm
Hauteur du Gap	**60.4**	mm
Profondeur du Gap	**116**	mm
Longueur magnetique equivalent	**996**	mm
Espace de glissement	0	m
Monospire donc	**1**	spire
Epaisseur cond. retour	8.8	mm
Hauteur de conducteur retour	60.4	mm
Résistivité du cuivre (1.72E-2	0.0172	mO.mm
module d'Elasticité (12500	12500	daN/mm2
Forme de l'impulsion		
DC , 1/2 sinus : S , trapèze : T	**S**	
1/2 période de l'impulsion	**3.1**	ms
Période de récurence (cycle tot.	**1.2**	s
taux de répétition de l'impulsion de courant		
Systeme de refroidissement		
pression différentielle	**12**	bar
nombre du circuits	**2**	
septum		
forme element de refroidissement	**rec**	
Cote horizontal	**5**	mm
Cote vertical	**30.2**	mm
forme du passage d'eau	**circ**	
Diametre trou	**2**	mm
conducteur retour		
forme element de refroidissement	**rec**	
Cote horizontal (mm)	**8.8**	mm
Cote vertical (mm)	**30.2**	mm
forme du passage d'eau	**rec**	
Cote horizontal	**3.6**	mm
Cote vertical	**2.2**	mm
Matiere		
maximum admissible champ dans le f	**0.67**	T

RESULTATS **PROTONS**

Masse au repos mo	0.94	Gev/c2
Energie cinétique	**1.0000**	GeV
Quantité de mouvement	**1.6971**	Gev/c
beta	0.8748	
gamma	2.0638	
beta*gamma	1.8054	
Déplact. après espace de gliss	**39.4914**	mm
Champ intégré B*L	**0.449**	T.m
Induction dans le Gap	**0.450**	T
Champ magn. H=B/uo	3.58E+05	A/m
Courant nécessaire	**21648**	A
Valeur efficace du courant	778	A
densité de courant eff.	**2.63**	A/mm2
Résistance de l'aimant	**0.104**	mOhms
Inductance de l'aimant	**2.26**	uH
Puissance dissipée	**0.063**	kW
Energie stockée	529	J



116	p en mm
60.4	h en mm
194.0	L en mm
216.4	H en mm

Débit d'eau total	**4.32**	l/min
Débit dans chaque spire	2.16	l/min
vitesse de l'eau dans septum	11.47	m/s
dT total d'eau	0.22	K
Force septum /cond fond	**485.55**	daN
Flèche max . septum (appui	0.011	mm
moment flech.max. (appui	3.68	mm*daN
contrainte maxi <5 (appui	0.88	daN/mm2
Masse culasse (sans poutre	**250**	**kg**
section cond. septum	295.7168147	mm2
Section refroidissement septur	6.283185307	mm2

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Modifie R, L pour monospire, hydraulique revise 2/8/94 J. Borburgh

PREDETERMINATION SEPTUM MAGNETIQUE SMCALC.XLS **PW prot:jb**

BT SMV 10 version pulsee

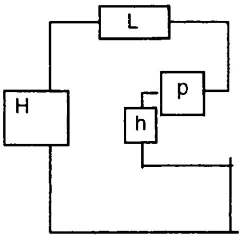
particularités

DONNEES

particules electrons : e protons : p	**p**	
quant.mouvt : MV Energie cin. : EC	**ec**	
Energie cinétique Ec =	**1.4**	GeV
Déflexion requise	**79.3**	mrad
Epaisseur du septum	**5**	mm
Hauteur du Gap	**60.4**	mm
Profondeur du Gap	**116**	mm
Longueur magnetique equivalent	**996**	mm
Espace de glissement	0	m
Monospire donc	**1**	spire
Epaisseur cond. retour	8.8	mm
Hauteur de conducteur retour	60.4	mm
Résistivité du cuivre (1.72E-2	0.0172	mO.mm
module d'Elasticité (12500	12500	daN/mm2
Forme de l'impulsion		
DC , 1/2 sinus : S , trapèze : T	**S**	
1/2 période de l'impulsion	**3.1**	ms
Période de récurence (cycle tot.	**1.2**	s
taux de répétition de l'impulsion de courant		
Systeme de refroidissement		
pression différentielle	**12**	bar
nombre du circuits	**2**	
septum		
forme element de refroidissement	**rec**	
Cote horizontal	**5**	mm
Cote vertical	**30.2**	mm
forme du passage d'eau	**circ**	
Diametre trou	**2**	mm
conducteur retour		
forme element de refroidissement	**rec**	
Cote horizontal (mm)	**8.8**	mm
Cote vertical (mm)	**30.2**	mm
forme du passage d'eau	**rec**	
Cote horizontal	**3.6**	mm
Cote vertical	**2.2**	mm
Matiere		
maximum admissible champ dans le f	**0.85**	T

RESULTATS **PROTONS**

Masse au repos mo	0.94	Gev/c2
Energie cinétique	**1.4000**	GeV
Quantité de mouvement	**2.1429**	Gev/c
beta	0.9158	
gamma	2.4894	
beta*gamma	2.2797	
Déplact. après espace de gliss	**39.4914**	mm
Champ intégré B*L	**0.566**	T.m
Induction dans le Gap	**0.569**	T
Champ magn. H=B/uo	4.53E+05	A/m
Courant nécessaire	**27335**	A
Valeur efficace du courant	982	A
densité de courant eff.	**3.32**	A/mm2
Résistance de l'aimant	**0.104**	mOhms
Inductance de l'aimant	**2.26**	uH
Puissance dissipée	**0.100**	kW
Energie stockée	844	J



	116	p en mm
	60.4	h en mm
	193.6	L en mm
	215.6	H en mm
Débit d'eau total	**4.32**	l/min
Débit dans chaque spire	2.16	l/min
vitesse de l'eau dans septum	11.47	m/s
dT total d'eau	0.36	K
Force septum /cond fond	**774.18**	daN
Flèche max . septum (appui	0.017	mm
moment flech.max. (appui	5.87	mm*daN
contrainte maxi <5 (appui	1.41	daN/mm2
Masse culasse (sans poutre	**248**	**kg**
section cond. septum	295.7168147	mm2
Section refroidissement septur	6.283185307	mm2

Appendix 3. Magnetic measurement results

- Magnetic measurements in the gap
- Magnetic measurements of the fringe field
- Magnetic measurements of the end field

BTSMV 10 Gap Measurements

coil 1:	diameter 5 mm	0.03693 m2
coil 2	l=1300 mm	0.05769 m2/m

BT4 1/12/98 tank2

I (kA)	V.s	B(mT)	Vs	Bdl(mT.m)	Leq (mm)
	coil 1		coil 2		
17.2	1.27E-02	342.7	1.98E-02	342.3	999
18.6	1.37E-02	370.2	2.13E-02	369.8	999
19.9	1.46E-02	395.0	2.27E-02	393.0	995
21.6	1.60E-02	433.2	2.48E-02	430.4	994
25.1	1.87E-02	506.7	2.91E-02	503.7	994
27.2	2.03E-02	548.2	3.14E-02	545.0	994

BT1 9/12/98 tank1

17.2	1.28E-02	346	1.99E-02	344.1	995
18.6	1.38E-02	374	2.15E-02	371.9	994
19.9	1.48E-02	399.9	2.30E-02	399	998
21.6	1.61E-02	434.5	2.49E-02	432.3	995
25.1	1.88E-02	510.1	2.93E-02	507.4	995
27.2	2.03E-02	550.8	3.16E-02	547.5	994

BT4 23/3/99 tank4

17.2	1.28E-02	346.2	1.98E-02	344.4	995
18.6	1.38E-02	372.9	2.15E-02	371.8	997
19.9	1.48E-02	400.6	2.30E-02	398.9	996
21.6	1.61E-02	436.1	2.51E-02	434.4	996
25.1	1.88E-02	510.1	2.93E-02	507.5	995
27.2	2.04E-02	551.8	3.17E-02	549.1	995

BT1 4/5/99 tank3

17.2	1.28E-02	346.3	1.98E-02	343.8	993
18.6	1.38E-02	373.9	2.14E-02	371.6	994
19.9	1.49E-02	402.4	2.31E-02	400.1	994
21.6	1.62E-02	438.9	2.52E-02	437.5	997
25.1	1.89E-02	511.4	2.93E-02	508	993
27.2	2.05E-02	554.9	3.18E-02	551.2	993

BTSMV 10 End field measurements

coil 1: diameter 5 mm 0.03693 m2

BT4 1/12/98 tank2

distance of center of coil to outside endplate in mm	V.s	B (mT)	V.s	B (mT)
	1.0 GeV (21.6 kA)		**1.4GeV (27.2 kA)**	
0	6.71E-04	18.16	8.85E-04	23.90
10	3.40E-04	9.20	4.37E-04	11.82
20	1.92E-04	5.21	2.44E-04	6.62
30	1.17E-04	3.18	1.51E-04	4.09
40	7.53E-05	2.04	1.00E-04	2.72
50	5.25E-05	1.42	6.80E-05	1.84
60	3.70E-05	1.00	4.74E-05	1.28
70	2.80E-05	0.76	3.67E-05	0.99
80	2.14E-05	0.58	2.79E-05	0.75

BT1 9/12/98 tank1

0	6.163E-04	16.69	8.573E-04	23.21
10	3.260E-04	8.83	4.294E-04	11.63
20	1.840E-04	4.98	2.451E-04	6.64
30	1.147E-04	3.11	1.516E-04	4.11
40	7.525E-05	2.04	9.931E-05	2.69
50	5.170E-05	1.40	6.807E-05	1.84
60	3.731E-05	1.01	4.891E-05	1.32
70	2.700E-05	0.73	3.487E-05	0.94
80	1.997E-05	0.54	2.634E-05	0.71

BT4 24/3/99 tank4

0	3.136E-04	19.32	9.081E-04	24.59
10	3.681E-04	9.97	4.692E-04	12.71
20	2.040E-04	5.52	2.703E-04	7.32
30	1.274E-04	3.45	1.630E-04	4.41
40	8.350E-05	2.26	1.080E-04	2.93
50	5.831E-05	1.57	7.595E-05	2.06
60	4.171E-05	1.13	5.514E-05	1.47
70	3.047E-05	0.83	3.941E-05	1.07
80	2.354E-05	0.64	3.063E-05	0.83

BT1 4/5/99 tank3

0	7.325E-04	19.84	8.835E-04	23.92
10	3.634E-04	9.84	4.655E-04	12.60
20	2.046E-04	5.54	2.664E-04	7.21
30	1.268E-04	3.43	1.625E-04	4.40
40	8.233E-05	2.23	1.057E-04	2.86
50	5.592E-05	1.51	7.308E-05	1.98
60	3.977E-05	1.08	5.148E-05	1.39
70	2.903E-05	0.79	3.755E-05	1.02
80	2.125E-05	0.57	2.797E-05	0.76

BTSMV 10 Integrated Fringe field measurements

coil 2	l=1300 mm	0.05769 m2/m
coil 3	l=1.3 m	0.058077 m2/m

BT4 1/12/98 tank2

distance to septum (mm)	V.s	B.dl (mT.m)	1/1000	V.s	B.dl (mT.m)	1/1000	
	1.0 GeV (21.6 kA)			1.4GeV (27.2 kA)			
5	1.99E-04	3.445	8.0	2.54E-04	4.4	8.1	coil 2
15	1.13E-04	1.957	4.5	1.36E-04	2.359	4.3	coil 2
25	6.03E-05	1.044	2.4	7.93E-05	1.374	2.5	coil 2
35	4.06E-05	0.7045	1.6	5.50E-05	0.9533	1.7	coil 2
45	2.86E-05	0.4959	1.2	4.01E-05	0.6951	1.3	coil 2
55	2.36E-05	0.4048	0.9	3.36E-05	0.5819	1.1	coil 2
65	2.00E-05	0.346	0.8	2.87E-05	0.4967	0.9	coil 2

BT1 9/12/98 tank1

5	2.15E-04	3.725	8.6	2.703E-04	4.685	8.6	coil 2
15	1.08E-04	1.877	4.3	1.231E-04	2.133	3.9	coil 2
25	5.63E-05	0.9753	2.3	7.341E-05	1.273	2.3	coil 2
35	3.63E-05	0.6284	1.5	5.166E-05	0.8954	1.6	coil 2
45	2.73E-05	0.4737	1.1	3.915E-05	0.6787	1.2	coil 2
55	2.24E-05	0.389	0.9	3.166E-05	0.5487	1.0	coil 2
65	1.94E-05	0.3369	0.8	2.640E-05	0.4576	0.8	coil 2

BT4 24/3/99 tank4

5	1.95E-04	3.378	7.8	2.529E-04	4.384	8.0	coil 2
15	9.59E-05	1.662	3.8	1.222E-04	2.119	3.9	coil 2
25	5.20E-05	0.901	2.1	6.977E-05	1.209	2.2	coil 2
35	3.53E-05	0.6127	1.4	4.859E-05	0.8423	1.5	coil 2
45	2.78E-05	0.4813	1.1	3.830E-05	0.6639	1.2	coil 2
55	2.31E-05	0.4	0.9	3.248E-05	5.63E-01	1.0	coil 2
65	2.07E-05	0.3591	0.8	2.825E-05	0.4896	0.9	coil 2

BT1 4/5/99 TANK3

5	2.31E-04	3.976	9.2	2.912E-04	5.014	9.2	Coil 3
15	1.25E-04	2.154	5.0	1.543E-04	2.657	4.9	Coil 3
25	6.50E-05	1.12	2.6	8.382E-05	1.443	2.6	Coil 3
35	4.06E-05	0.699	1.6	5.548E-05	0.9553	1.7	Coil 3
45	2.98E-05	0.5136	1.2	4.031E-05	0.694	1.3	Coil 3
55	2.36E-05	0.4065	0.9	3.273E-05	0.5636	1.0	Coil 3
65	2.02E-05	0.3477	0.8	2.753E-05	0.474	0.9	Coil 3

Appendix 4. Magnet numbers, coil and feedthrough identification

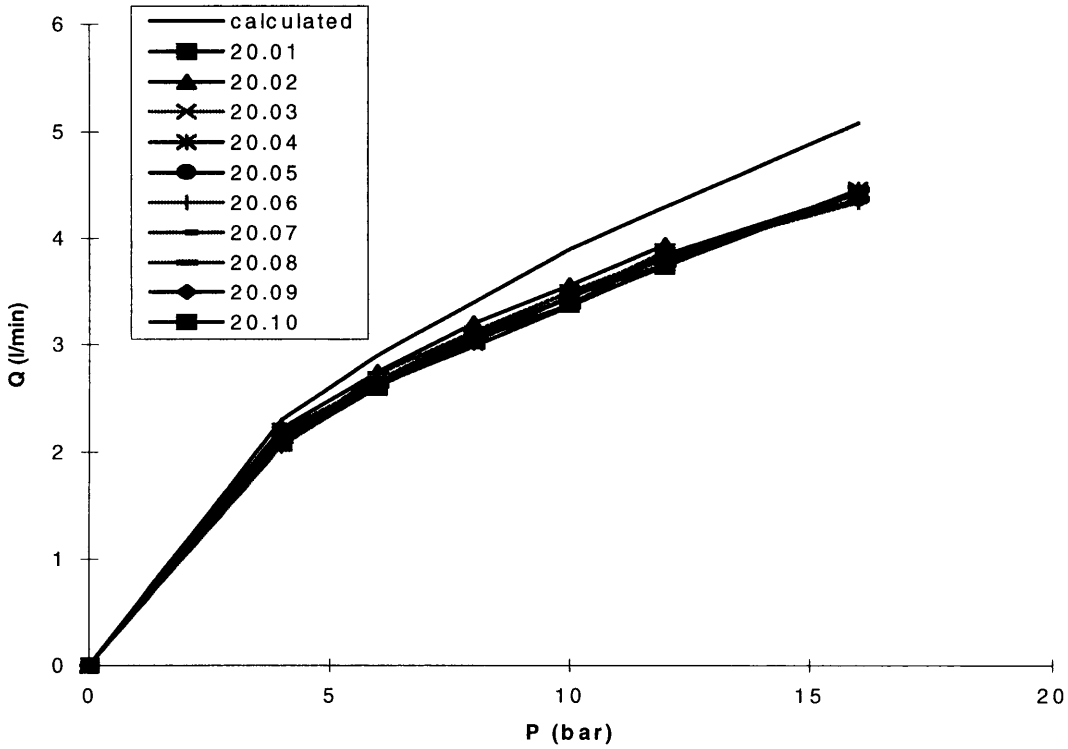
tank	magnet	coil	feedthrough	Type	
2	4	4?	PH08	BT4	installed in Booster transfer line 1999
1	3	3	PH09	BT1	installed in Booster transfer line 1999
3	3?	6	PH10	BT4	spare
4	1?	5	PH11	BT1	spare

Water flow: 3.72 l/min. at 12 bar ΔP

Appendix 5. Water flow measurements of the individual coils.

BTSMV 10/20 water flow measurements of individual coils.

P (bar)	calculated Q (l/min)	smv20.01 Q (l/min) 18/10/96	20.02 Q (l/min) 21/10/96	20.03 Q (l/min) 16/9/97	20.04 Q (l/min) 10/2/98	20.05 Q (l/min) 10/2/98	20.06 Q (l/min) 10/2/98	20.07 Q (l/min) 10/2/98	20.08 Q (l/min) 30/4/98	20.09 Q (l/min) 30/4//98	20.10 Q (l/min) 30/4/98
0	0	0	0	0	0	0	0	0	0	0	0
4	2.3	2.2	2.22	2.12	2.08	2.11	2.06	2.1	2.1	2.16	2.08
6	2.9	2.65	2.74	2.66	2.64	2.67	2.62	2.62	2.72	2.64	2.6
8	3.4	3.08	3.2	3.1	3.02	3.04	3.09	2.98	3.12	3.08	3.04
10	3.9	3.45	3.56	3.5	3.46	3.38	3.44	3.36	3.5	3.44	3.38
12	4.3	3.88	3.94	3.8	3.76	3.84	3.84	3.76	3.84	3.85	3.74
16	5.09			4.44	4.47	4.38	4.35	4.47	4.38	4.44	4.44



Distribution

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