Beam loss at Tevatron abort kicker prefire.

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The summaries of discussions:

1. A48 Collimator:

A) analysis shows that 200 rad CDF dose during April prefire was due to the collimator being too far from the beam and CDF was hit by 1 or 2 proton bunches (See Table 8 - 10);

B) the collimator is 3 mm closer to the beam now compared to the April prefire and those bunches (Table 8) would be intercepted if the prefire occurs today - in that case the estimated dose at CDF would be 10 rad or less.

Action items:

1. **halt replacement of 0.5 long collimator by 1.5 m long collimator;**
2. **consider benefits of options which will not require moving the pots:**

- **steel 0.7 m long A48 collimator or 0.5 m long tungsten collimator instead of existing steel collimator.**

  The stainless steel collimator length increase from 0.5 to 0.7 m effects reduction of losses by a factor of 3. A 0.5 m tungsten collimator is a factor of 7 more efficient compared to stainless steel collimator. See Table 6. The cheapest way to do this is to put a 10-mm thick tungsten plate at the existing 0.5 m steel spare collimator. A proton bunch position at the collimator A48 entrance depending on the possible bunch location with respect to the beginning of the antiproton kicker prefire and beam loss in the collimators A11, A48 and dipole magnets are shown in Figure 5.

- **fire the rest modules of kickers in nearest gap.**

  This option does not give any advantage compared to firing modules with $2\mu sec$ delay after kicker prefire. Up to twelve bunches are lost in two SC magnets behind AØ at antiproton kicker prefire in this case (See Table 7 and 8). This may damage SC magnets.

- **tilting the collimator by few mm.**

  There is no visible difference between losses at different alignment of A48 collimator. See Table 11.

All tables start from BØ IP (Path length=0.000 m) and end at BØ IP (Path length=6283.191 m). At the end of the table the charged particle flux is estimated in the silicon detector at R=5 cm, generated by particles lost at the collimator A48 (called "from A48") and at the separators and quadrupole triplet upstream of the BØ IP (called "from separ."), based on the data from Table 1. Very rough estimation of dose in the detector are done also based on the data from Table 1. The real particle flux is not equal to the sum of these two figures, because mostly losses at the separators and quadrupole triplet upstream of the BØ IP are produced by the particles outscattered from the A48 collimator (if collimator A48 is in a working position).

Table 1: RADIATION LOADS TO THE CDF SILICON AT BEAM LOSS IN THE BO IR. Results of MARS calculations of particle flux $F(1/cm^2)$ in the CDF silicon at BØ for a 10^8 proton beam loss on the ES separators or A48 collimator at several distances R from the beam axis. Charged particle flux was calculated, other values were scaled from previous results. Dose is proportional to F-charged and is below 1 rad in silicon in the considered ES-case, being somewhat higher at z=430 cm. Information from Rick: The 200 rad are measured in 4 ionization chambers with two chamber on the incoming proton side of CDF and two on the incoming antiproton side of CDF ($z = \pm 430\ cm$). Each pair of chambers are centered 12.4 cm from the center of the beam pipe in the horizontal plane. Each ion chamber is a cylinder 22.1 cm long and 6.4 cm in diameter.

Beam Loss = 10^8	Value	R = 5 cm	R = 10 cm	R = 20 cm	R = 50 cm
On ES	F-charged	3.3e+04	5.5e+03	3.3e+02	1.1e+02
	F-neutrons	2.0e+04	3.3e+03	2.0e+02	7.0e+01
	F-photons	3.3e+05	5.5e+04	3.3e+03	1.1e+03
On A48	F-charged	1.8e+03	240	18	6
	F-neutrons	1.1e+03	144	110	4
	F-photons	1.8e+04	2.4e+03	180	60

1 Abort kicker prefire at uniform longitudinal distribution of the beam

Proton beam loss at proton and antiproton kicker prefire, fire of only proton or antiproton kicker and both proton and antiproton kickers are shown in the Tables 2 - 5. A "uniform" longitudinal beam distribution along the ring was simulated via bunches spacing by 0.02 μsec between center. Intensity of accelerator is 10^9 *ppp* in the calculations. Each unit of kinetic energy loss in the tables corresponds to $4.76 \cdot 10^3$ particles lost in the accelerator.

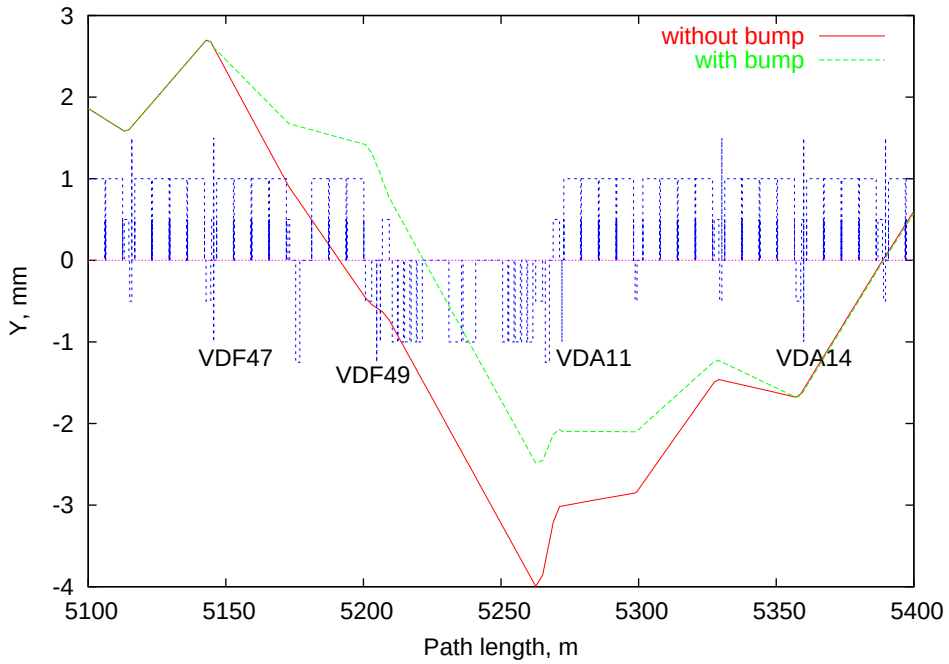

Figure 1: Proton orbit at collisions at AØ with and without vertical bump excited by dipole correctors VDF47 (+0.9417 kG-m), VDF49 (-0.9878 kG-m), VDA11 (+0.86895 kG-m) and VDA14 (+0.27115 kG-m).

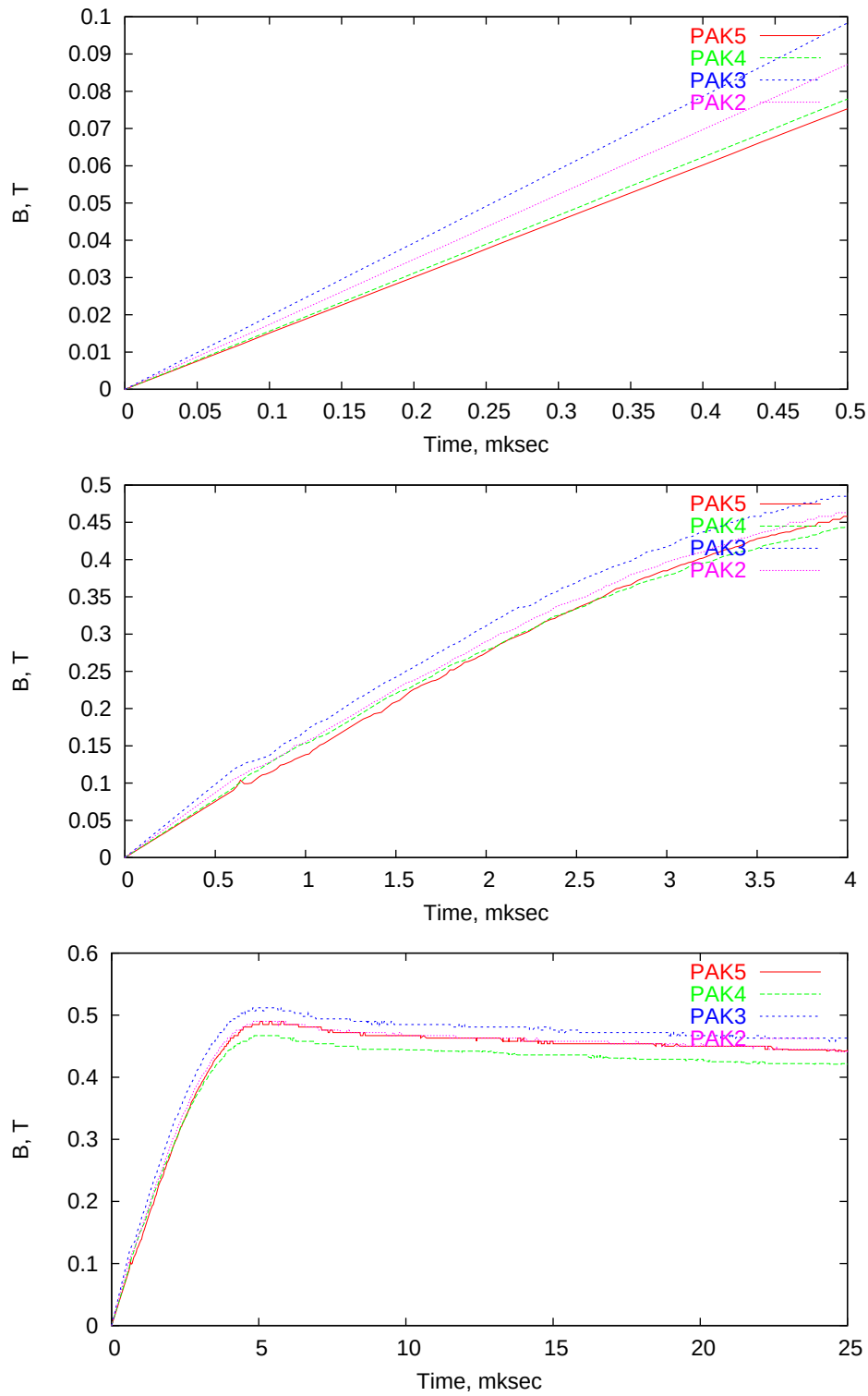

Figure 2: Proton kicker pulse (magnetic field): top - beginning, middle - raise time, bottom - during one turn.

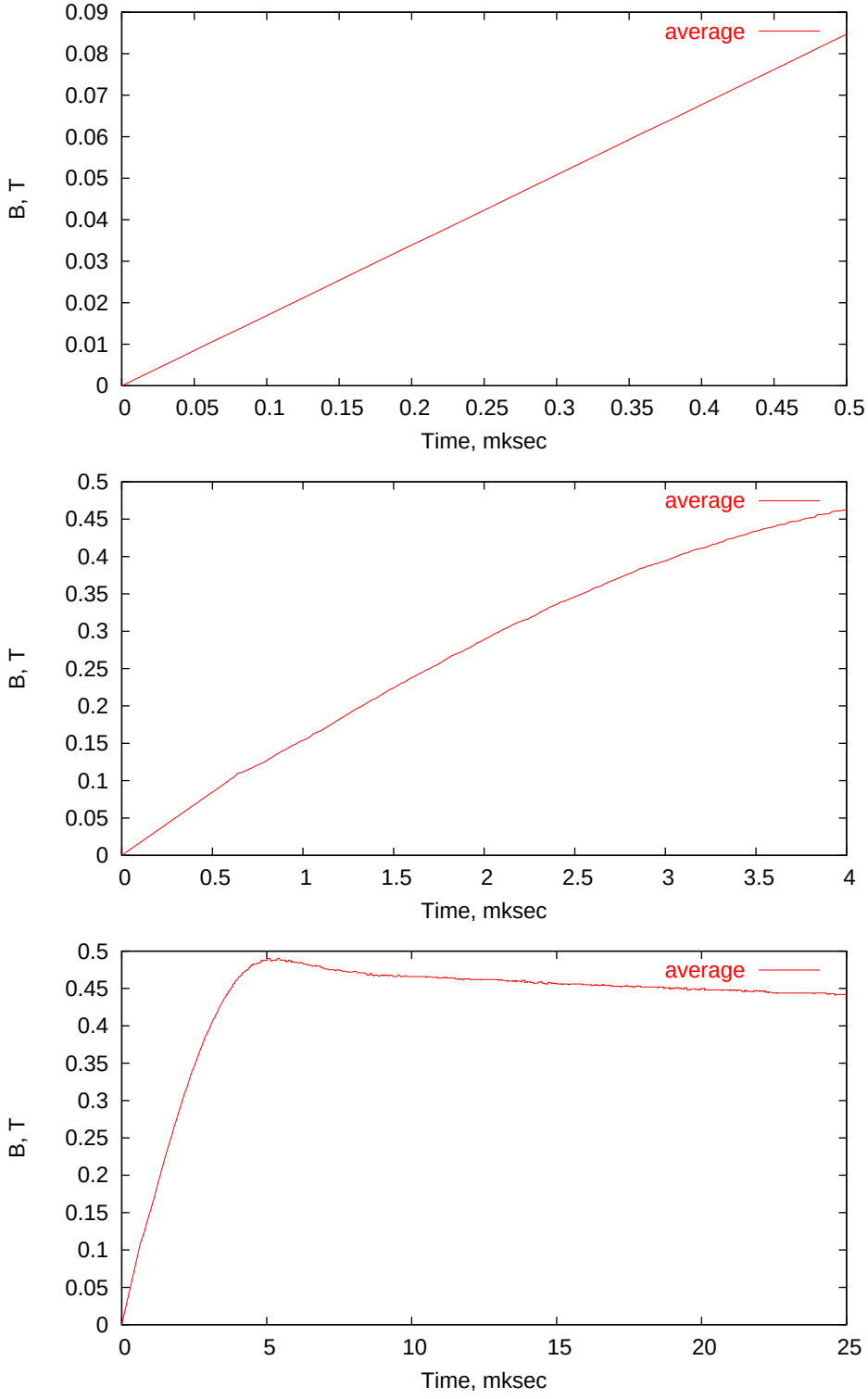

Figure 3: Proton kicker pulse (magnetic field) averaged over four modules: top - beginning, middle - raise time, bottom - during one turn.

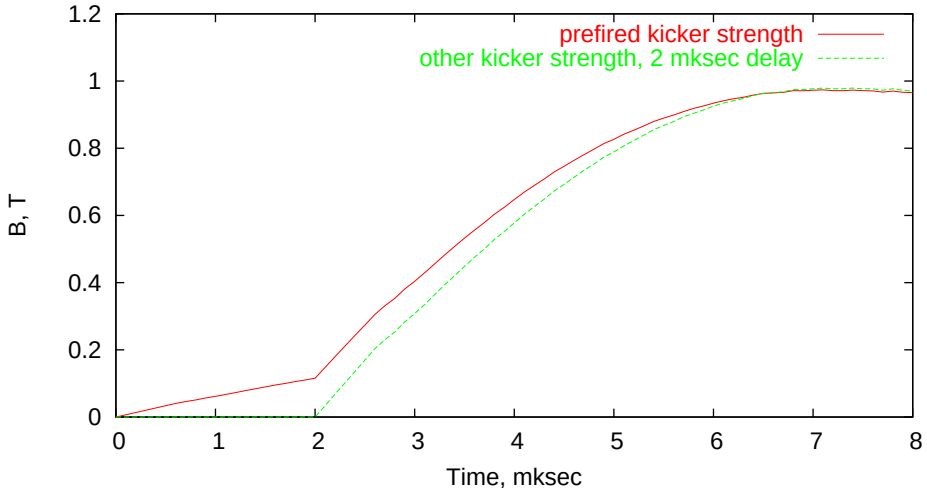

Figure 4: Proton kicker pulse (magnetic field) and antiproton kicker strength fired with 2 μsec after proton kicker prefire.

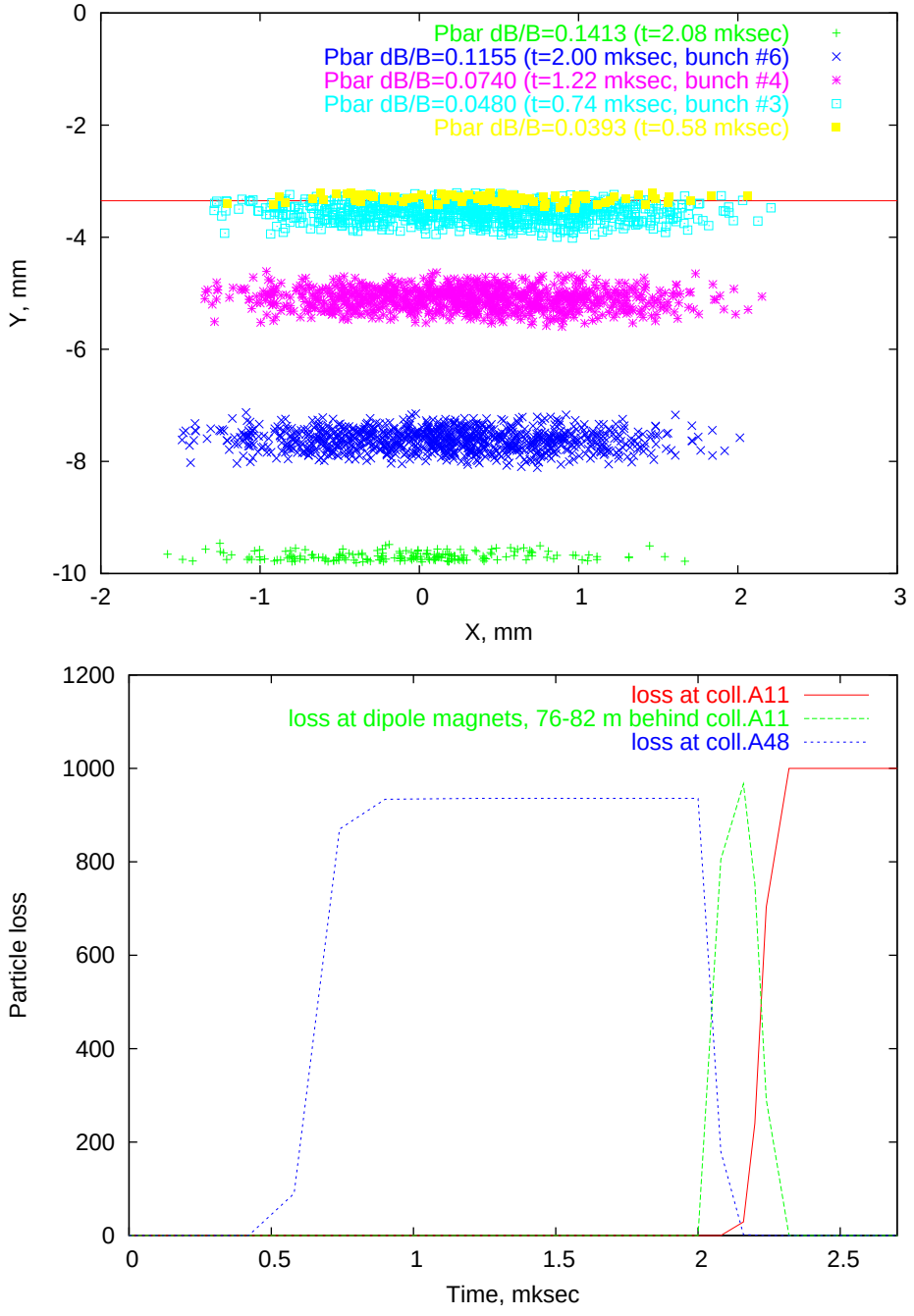

Figure 5: Proton bunch position at the collimator A48 entrance depending on the bunch location with respect to the beginning of the antiproton kicker prefire (top) and beam loss in the collimators A11, A48 and dipole magnets (bottom).

Table 2: Proton beam loss at proton (third column) and antiproton (4-th column) kicker prefire with "uniform" longitudinal beam distribution along the ring. Bunches are located with distance of 0.02 μsec between center. Collimator A11 is at $Y = -9.5\ mm$ ($7.5\sigma_y$) and A48 is at $Y = -3.35\ mm$ ($15\sigma_y$) from the beam pipe center. Intensity of accelerator is 10^9 ppp. Each unit of kinetic energy loss corresponds to $4.76 \cdot 10^3$ particles lost.

path length	element number	kinetic energy loss prot.kick.prefire	kinetic energy loss antiprot.kick.prefire	element	aperture hor.	aperture vert.	element length	name
m		GeV/Pc			mm	mm	m	
18.621	15		5.9893	quadrupole	34.30	34.30	0.8763	DTRIPB
21.974	16	13.9746	75.8361	quadrupole	34.30	34.30	3.3528	CB0Q2D
31.477	30	21.9597	57.8351	separator	38.10	25.00	2.5718	B11VESE
93.159	94		0.9645	quadrupole	34.30	34.30	1.6789	HQUADF
107.961	112		0.9762	quadrupole	34.30	34.30	0.1397	DBENDEN
114.222	115	0.9680	1.9430	dipole	31.50	31.50	6.1214	BEND
114.362	117			dipole	34.30	34.30	0.1397	DBENDEN
120.623	120	0.9762		dipole	31.50	31.50	6.1214	BEND
122.903	125			quadrupole	34.30	34.30	1.6789	HQUADD
123.880	128	0.9873		quadrupole	34.30	34.30	0.6350	CBQ7
131.164	133	1.9917	1.9844	dipole	31.50	31.50	6.1214	BEND
131.304	135		0.9877	dipole	34.30	34.30	0.1397	DBENDEN
137.565	138		1.9913	dipole	31.50	31.50	6.1214	BEND
143.966	143	1.9852	1.9966	dipole	31.50	31.50	6.1214	BEND
150.366	148	1.9967	3.9879	dipole	31.50	31.50	6.1214	BEND
190.651	193	0.9953	0.9934	dipole	31.50	31.50	6.1214	BEND
197.052	198	0.9948		dipole	31.50	31.50	6.1214	BEND
203.453	203	0.9982	0.9974	dipole	31.50	31.50	6.1214	BEND
209.853	208	1.9958	2.9941	dipole	31.50	31.50	6.1214	BEND
217.408	222	3.9915	6.9829	separator	25.00	38.10	2.5718	B17HESE
316.025	320		0.9980	dipole	31.50	31.50	6.1214	BEND
322.426	325			dipole	31.50	31.50	6.1214	BEND
328.827	330	0.9983	0.9979	dipole	31.50	31.50	6.1214	BEND
1316.538	1303	1.9973		dipole	31.50	31.50	6.1214	BEND
1958.092	1958		0.9983	dipole	31.50	31.50	6.1214	BEND
1964.493	1963	1.9976	1.9964	dipole	31.50	31.50	6.1214	BEND
1970.894	1968	1.9971		dipole	31.50	31.50	6.1214	BEND
2064.856	2091	9.9843	1.9968	separator	25.00	38.10	2.5718	C49HESE
2076.651	2111			quadrupole	34.30	34.30	0.8763	DTRIPB
2116.370	2140			quadrupole	34.30	34.30	3.3528	CD0Q2D
2318.215	2366	62.8815	23.9535	collimator	20.00	20.00	1.5000	coD172
3109.904	3187	2.9961		collimator	20.00	20.00	0.0050	colD49
3122.833	3212	0.0000		collimator	20.00	20.00	0.0025	colE01
3124.328	3213	6.9880	4.9919	collimator	20.00	20.00	1.4950	colE01
3162.666	3247	4.9912	4.9920	collimator	20.00	20.00	1.5000	colE02
3164.520	3253	10.9849	6.9886	collimator	20.00	20.00	1.5000	colE03
3184.393	3285			dipole	31.50	31.50	6.1214	BEND
3206.493	3310			quadrupole	34.30	34.30	0.4064	DPACKU2
4407.219	4515	29.9589	88.9108	collimator	20.00	20.00	1.5000	coF172
4630.192	4748		0.9984	dipole	31.50	31.50	6.1214	BEND
5176.877	5313	5.9911	112.8853	collimator	20.00	20.00	1.5000	colF48
5204.866	5341	14.9858		collimator	20.00	20.00	0.0050	colF49
5235.636	5375	60520.1464	47794.1299	AØdump	28.00	28.00	4.5593	DA0PAB
5240.772	5381	4638.6456	4554.7236	AØdump	28.00	28.00	4.5593	DA0PBAB
5252.494	5385	1299.7799	1076.9890	pbar kicker	22.00	22.00	1.8923	DA0KICK
5252.799	5386	122.8846	123.8837	pbar kicker	22.00	22.00	0.3048	D12IN
5254.692	5387	774.2732	701.3416	pbar kicker	22.00	22.00	1.8923	DA0KICK
5255.149	5388	182.8284	150.8584	pbar kicker	22.00	22.00	0.4572	D18IN
5257.041	5389	1017.0453	1042.0218	pbar kicker	22.00	22.00	1.8923	DA0KICK
5257.498	5390	263.7524	323.6961	pbar kicker	22.00	22.00	0.4572	D18IN
5259.391	5391	904.1513	1206.8671	pbar kicker	22.00	22.00	1.8923	DA0KICK
5259.695	5392	109.8968	156.8528	pbar kicker	22.00	22.00	0.3048	D12IN
5261.588	5393	642.3970	949.1091	pbar kicker	22.00	22.00	1.8923	DA0KICK
5262.403	5394	252.7627	401.6230	pbar kicker	22.00	22.00	0.8150	DA0SP12
5267.588	5401	5874.4855	5497.8391	collimator	20.00	20.00	1.5000	collA11
5285.358	5423	0.7597		dipole	31.50	31.50	6.1214	BEND
5285.498	5425	0.7306		dipole	34.30	34.30	0.1397	DBENDEN
5291.759	5428	5.5399	0.7239	dipole	31.50	31.50	6.1214	BEND
5298.160	5433	0.8767		dipole	31.50	31.50	6.1214	BEND
5307.670	5447	0.9635		dipole	31.50	31.50	6.1214	BEND
5314.210	5454			dipole	34.30	34.30	0.1397	DBENDEN
5320.471	5457			dipole	31.50	31.50	6.1214	BEND
5337.413	5477		13.9861	dipole	31.50	31.50	6.1214	BEND
5343.814	5482	0.9961	399.6240	dipole	31.50	31.50	6.1214	BEND
5350.215	5487		604.4322	dipole	31.50	31.50	6.1214	BEND
5356.616	5492	0.9985	479.5498	dipole	31.50	31.50	6.1214	BEND
6159.828	6309	0.9988		dipole	34.30	34.30	0.1397	DBENDEN
6189.431	6335			dipole	31.50	31.50	6.1214	BEND
6223.390	6378	3038.1312	13479.3465	collimator	30.00	30.00	0.5000	collA48
6241.148	6406	1.5666	15.3491	dipole	31.50	31.50	6.1214	BEND
6241.287	6408	1.7543	7.4206	dipole	34.30	34.30	0.1397	DBENDEN
6241.427	6409		0.7761	dipole	34.30	34.30	0.1397	DBENDEN
6247.548	6411	22.5162	67.8199	dipole	31.50	31.50	6.1214	BEND
6247.688	6413	0.9986	8.9081	dipole	34.30	34.30	0.1397	DBENDEN
6247.856	6414		0.8863	quadrupole	34.30	34.30	0.1675	DLB6
6249.257	6415	0.8377	3.4339	quadrupole	34.30	34.30	1.4018	CB0Q1D
6250.044	6417	2.7908	1.7302	quadrupole	34.30	34.30	0.5063	DLB4
6250.580	6419	1.7833	2.7423	dipole	34.30	34.30	0.5357	DLB3
6250.809	6420	0.8867	3.9337	quadrupole	34.30	34.30	0.2286	DLB2
6250.964	6421	0.9982	1.9714	quadrupole	34.30	34.30	0.1556	DLB1
6254.285	6427	10.1969	9.3888	separator	25.00	38.10	2.5718	A49HESE
6257.044	6429	1.9681	294.1076	separator	38.10	25.00	2.5718	A49VESE
6259.803	6431	0.9990	34.8370	separator	38.10	25.00	2.5718	A49VESE
6260.124	6432		0.9301	separator	38.10	38.10	0.3208	DSEPEND
6261.080	6438	0.9163		separator	38.10	38.10	0.4445	FCAN
6264.569	6441	0.9428	9.7413	quadrupole	34.30	34.30	3.3528	CB0Q2F
6265.446	6442	2.9878	63.8625	quadrupole	34.30	34.30	0.8763	DTRIPB
6281.641	6453		0.9397	str. sect.	14.60	14.60	0.2280	DB0C
from A48		2.6e+2 $part/cm^2$	1.2e+3 $part/cm^2$					
from separ.		3.1e+1 $part/cm^2$	6.5e+2 $part/cm^2$					
detector		<0.007 rad	<0.032 rad					

Table 3: Proton beam loss at fire of both proton and antiproton kickers with "uniform" longitudinal beam distribution along the ring (bunches are located with distance of 0.02 μsec between center). Third column - collimator A11 is at $Y = -11.5\ mm$ and A48 is retracted from the beam pipe; 4-th column - collimator A11 is at $Y = -9.5\ mm$ and A48 is retracted from the beam pipe; 5-th column - collimator A11 is at $Y = -9.5\ mm$ ($7.5\sigma_y$) and A48 is at $Y = -3.35\ mm$ ($15\sigma_y$) from the beam pipe center. Intensity of accelerator is 10^9 ppp. Each unit of kinetic energy loss corresponds to $4.76 \cdot 10^3$ particles lost.

path length	element number	kinetic energy loss A11(-11.5mm) A48(retracted)	kinetic energy loss A11(-9.5mm) A48(retracted)	kinetic energy loss A11(-9.5mm) A48(-3.35mm)	element	aperture hor.	aperture vert.	element length	name
m		GeV/Pc				mm	mm	m	
18.621	15	10.9897	10.9897		quadrupole	34.30	34.30	0.8763	DTRIPB
21.974	16	259.7562	260.7549	15.9670	quadrupole	34.30	34.30	3.3528	CB0Q2D
31.477	30	229.7843	229.7843	7.9855	separator	38.10	25.00	2.5718	B11VESE
95.020	101			0.9697	quadrupole	34.30	34.30	0.3810	CB0QT6F
143.966	143			0.9982	dipole	31.50	31.50	6.1214	BEND
150.366	148			0.9977	dipole	31.50	31.50	6.1214	BEND
197.052	198			0.9944	dipole	31.50	31.50	6.1214	BEND
203.453	203			0.9981	dipole	31.50	31.50	6.1214	BEND
217.408	222			0.9981	separator	25.00	38.10	2.5718	B17HESE
316.025	320			0.9964	dipole	31.50	31.50	6.1214	BEND
1964.493	1963			0.9983	dipole	31.50	31.50	6.1214	BEND
2064.856	2091			1.9969	separator	25.00	38.10	2.5718	C49HESE
2318.215	2366	0.9985		5.9881	collimator	20.00	20.00	1.5000	coD172
3124.328	3213			1.9935	collimator	20.00	20.00	1.4950	colE01
3164.520	3253			0.9985	collimator	20.00	20.00	1.5000	colE03
4407.219	4515			4.9919	collimator	20.00	20.00	1.5000	coF172
5176.877	5313	119.8875	119.8875	1.9970	collimator	20.00	20.00	1.5000	colF48
5235.636	5375	62538.2934	62463.3637	62405.4190	AØdump	28.00	28.00	4.5593	DA0PAB
5240.772	5381	4487.7865	4510.7649	4534.7432	AØdump	28.00	28.00	4.5593	DA0PBAB
5252.494	5385	1068.9965	1137.9318	1113.9543	pbar kicker	22.00	22.00	1.8923	DA0KICK
5252.799	5386	119.8875	120.8865	107.8987	pbar kicker	22.00	22.00	0.3048	D12IN
5254.692	5387	734.3107	688.3538	713.3304	pbar kicker	22.00	22.00	1.8923	DA0KICK
5255.149	5388	139.8687	158.8509	174.8359	pbar kicker	22.00	22.00	0.4572	D18IN
5257.041	5389	934.1227	931.1255	885.1691	pbar kicker	22.00	22.00	1.8923	DA0KICK
5257.498	5390	296.7215	262.7534	301.7168	pbar kicker	22.00	22.00	0.4572	D18IN
5259.391	5391	1042.0218	1101.9656	1047.0172	pbar kicker	22.00	22.00	1.8923	DA0KICK
5259.695	5392	142.8659	146.8621	167.8424	pbar kicker	22.00	22.00	0.3048	D12IN
5261.588	5393	814.2357	843.2085	824.2263	pbar kicker	22.00	22.00	1.8923	DA0KICK
5262.403	5394	308.7102	310.7083	326.6933	pbar kicker	22.00	22.00	0.8150	DA0SP12
5267.588	5401	4639.6447	5384.9451	5405.9254	collimator	20.00	20.00	1.5000	collA11
5320.471	5457		0.9735		dipole	31.50	31.50	6.1214	BEND
5343.814	5482	7.9925			dipole	31.50	31.50	6.1214	BEND
5350.215	5487	170.8373	0.9986	0.9981	dipole	31.50	31.50	6.1214	BEND
5356.616	5492	348.6721	30.9708	25.9755	dipole	31.50	31.50	6.1214	BEND
5832.510	5977	15.9850		0.9991	dipole	31.50	31.50	6.1214	BEND
6223.390	6378			1773.3332	collimator	30.00	30.00	0.5000	collA48
6241.148	6406			3.2608	dipole	31.50	31.50	6.1214	BEND
6241.287	6408			0.7567	quadrupole	34.30	34.30	0.1397	DBENDEN
6247.548	6411	91.9137	34.9672	9.3483	dipole	31.50	31.50	6.1214	BEND
6247.688	6413	0.9980		0.9443	quadrupole	34.30	34.30	0.1397	DBENDEN
6249.538	6416	0.9976			quadrupole	34.30	34.30	0.2805	DLB5
6250.044	6417		0.9987		quadrupole	34.30	34.30	0.5063	DLB4
6250.580	6419			0.9983	dipole	34.30	34.30	0.5357	DLB3
6250.809	6420	15.9844	0.9991		quadrupole	34.30	34.30	0.2286	DLB2
6250.964	6421	10.9897	3.9960		quadrupole	34.30	34.30	0.1556	DLB1
6254.285	6427	0.9982			separator	25.00	38.10	2.5718	A49HESE
6257.044	6429	1073.9917	871.1811	30.8837	separator	38.10	25.00	2.5718	A49VESE
6259.803	6431	117.8893	117.8893	7.9853	separator	38.10	25.00	2.5718	A49VESE
6264.569	6441			0.9591	quadrupole	34.30	34.30	3.3528	CB0Q2F
6265.446	6442	178.8321	178.8321	5.9852	quadrupole	34.30	34.30	0.8763	DTRIPB
6281.641	6453			0.9290	str. sect.	14.60	14.60	0.2280	DB0C
from A48		0.0 $part/cm^2$	0.0 $part/cm^2$	1.5e+2 $part/cm^2$					
from separ. detector		2.1e+3 $part/cm^2$ <0.065 rad	1.8e+3 $part/cm^2$ <0.056 rad	7.4e+1 $part/cm^2$ <0.004 rad					

Table 4: Proton beam loss at fire of only proton kickers with "uniform" longitudinal beam distribution along the ring (bunches are located with distance of 0.02 μsec between center). Third column - collimator A11 is at $Y = -13.5\ mm$ and A48 is retracted from the beam pipe; 4-th column - collimator A11 is at $Y = -9.5\ mm$ and A48 is retracted from the beam pipe; 5-th column - collimator A11 is at $Y = -9.5\ mm$ ($7.5\sigma_y$) and A48 is at $Y = -3.35\ mm$ ($15\sigma_y$) from the beam pipe center. Intensity of accelerator is 10^9 ppp. Each unit of kinetic energy loss corresponds to $4.76 \cdot 10^3$ particles lost.

path length	element number	kinetic energy loss A11(-13.5mm) A48(retracted)	A11(-9.5mm) A48(retracted)	A11(-9.5mm) A48(-3.35mm)	element	aperture hor.	aperture vert.	element length	name
m		GeV/Pc				mm	mm	m	
18.621	15	4.9947			quadrupole	34.30	34.30	0.8763	DTRIPB
21.974	16	230.7825		1.9967	quadrupole	34.30	34.30	3.3528	CB0Q2D
31.477	30	610.4252	5.9944	4.9924	separator	38.10	25.00	2.5718	B11VESE
131.164	133			1.9864	dipole	31.50	31.50	6.1214	BEND
150.366	148			1.9868	dipole	31.50	31.50	6.1214	BEND
262.939	263			0.9928	dipole	31.50	31.50	6.1214	BEND
1964.493	1963			0.9981	dipole	31.50	31.50	6.1214	BEND
2064.856	2091			1.9968	separator	25.00	38.10	2.5718	C49HESE
2318.215	2366	344.6740		8.9825	collimator	20.00	20.00	1.5000	coD172
2336.272	2392	1.4523			quadrupole	34.30	34.30	1.6789	HQUADD
2344.534	2401	0.8298			dipole	31.50	31.50	6.1214	BEND
2350.935	2406	0.9251			dipole	31.50	31.50	6.1214	BEND
2476.309	2533	0.9945			dipole	31.50	31.50	6.1214	BEND
3083.420	3156	0.9957			separator	25.00	38.10	2.5718	D48HESE
3124.328	3213	0.9982		0.9982	collimator	20.00	20.00	1.4950	colE01
3162.666	3247	664.3757	68.9348	1.9965	collimator	20.00	20.00	1.5000	colE02
3164.520	3253		2.9964	1.9976	collimator	20.00	20.00	1.5000	colE03
3197.194	3295	1.6597			dipole	31.50	31.50	6.1214	BEND
4407.219	4515	2.9961		0.9990	collimator	20.00	20.00	1.5000	coF172
5176.877	5313	13.9866	17.9827	1.9971	collimator	20.00	20.00	1.5000	colF48
5200.126	5330	0.7518			dipole	31.50	31.50	6.1214	BEND
5204.866	5341	11.9886	2.9972	3.9961	collimator	20.00	20.00	0.0050	colF49
5235.636	5375	64925.7883	64848.1224	64321.6158	AØdump	28.00	28.00	4.5593	DA0PAB
5240.772	5381	4512.7638	4464.8088	4476.7976	AØdump	28.00	28.00	4.5593	DA0PBAB
5252.494	5385	1079.9862	1114.9534	1103.9637	pbar kicker	22.00	22.00	1.8923	DA0KICK
5252.799	5386	132.8753	128.8790	118.8884	pbar kicker	22.00	22.00	0.3048	D12IN
5254.692	5387	704.3388	705.3379	764.2826	pbar kicker	22.00	22.00	1.8923	DA0KICK
5255.149	5388	159.8499	164.8453	158.8509	pbar kicker	22.00	22.00	0.4572	D18IN
5257.041	5389	678.3632	631.4073	619.4185	pbar kicker	22.00	22.00	1.8923	DA0KICK
5257.498	5390	133.8743	149.8593	151.8574	pbar kicker	22.00	22.00	0.4572	D18IN
5259.391	5391	603.4335	616.4214	580.4551	pbar kicker	22.00	22.00	1.8923	DA0KICK
5259.695	5392	88.9165	94.9109	100.9053	pbar kicker	22.00	22.00	0.3048	D12IN
5261.588	5393	573.4617	555.4786	533.4992	pbar kicker	22.00	22.00	1.8923	DA0KICK
5262.403	5394	227.7862	253.7618	220.7927	pbar kicker	22.00	22.00	0.8150	DA0SP12
5267.588	5401	4196.0611	6086.2867	6165.2126	collimator	20.00	20.00	1.5000	collA11
5285.358	5423		0.7141		dipole	31.50	31.50	6.1214	BEND
5291.759	5428	1.5770		0.8854	dipole	31.50	31.50	6.1214	BEND
5298.160	5433	0.8788			dipole	31.50	31.50	6.1214	BEND
5299.408	5438		0.9301		quadrupole	34.30	34.30	0.6477	HQUAD5D
5307.670	5447	0.9398			dipole	31.50	31.50	6.1214	BEND
5343.814	5482		0.9934		dipole	31.50	31.50	6.1214	BEND
5350.215	5487	0.9971			dipole	31.50	31.50	6.1214	BEND
5356.616	5492	0.9989	0.9980		dipole	31.50	31.50	6.1214	BEND
5360.896	5505		0.9861		quadrupole	34.30	34.30	0.5175	DPACKOU
6223.390	6378			565.4669	collimator	30.00	30.00	0.5000	collA48
6234.887	6403	0.9988			quadrupole	34.30	34.30	0.1397	DBENDEN
6241.148	6406			0.7492	dipole	31.50	31.50	6.1214	BEND
6247.548	6411	0.9987		1.5142	dipole	31.50	31.50	6.1214	BEND
6257.044	6429	3.9955	4.9932	1.9651	separator	38.10	25.00	2.5718	A49VESE
6259.803	6431		0.9990		separator	38.10	25.00	2.5718	A49VESE
6265.446	6442	0.9991		0.9979	quadrupole	34.30	34.30	0.8763	DTRIPB
from A48		0.0 $part/cm^2$	0.0 $part/cm^2$	4.8e+1 $part/cm^2$					
from separ.		7.8 $part/cm^2$	9.4 $part/cm^2$	4.7 $part/cm^2$					
detector		<0.0003 rad	<0.0003 rad	<0.001 rad					

Table 5: Proton beam loss at fire of only antiproton kickers with "uniform" longitudinal beam distribution along the ring (bunches are located with distance of 0.02 μsec between center). Collimator A11 is at $Y = -9.5\ mm$ ($7.5\sigma_y$) and A48 is at $Y = -3.35\ mm$ ($15\sigma_y$) from the beam pipe center. Intensity of accelerator is 10^9 ppp. Each unit of kinetic energy loss corresponds to $4.76 \cdot 10^3$ particles lost.

path length	element number	kinetic energy loss A11(-9.5mm) A48(-3.35mm)	element	aperture hor.	aperture vert.	element length	name
m		GeV/Pc		mm	mm	m	
18.621	15	0.9706	quadrupole	34.30	34.30	0.8763	DTRIPB
21.974	16	13.9726	quadrupole	34.30	34.30	3.3528	CB0Q2D
31.477	30	8.9805	separator	38.10	25.00	2.5718	B11VESE
93.159	94	0.9528	quadrupole	34.30	34.30	1.6789	HQUADF
101.421	105	0.9737	dipole	31.50	31.50	6.1214	BEND
150.366	148	0.9981	dipole	31.50	31.50	6.1214	BEND
197.052	198	0.9934	dipole	31.50	31.50	6.1214	BEND
203.453	203	0.9982	dipole	31.50	31.50	6.1214	BEND
217.408	222	0.9983	separator	25.00	38.10	2.5718	B17HESE
1970.894	1968	0.9970	dipole	31.50	31.50	6.1214	BEND
2064.856	2091	0.9979	separator	25.00	38.10	2.5718	C49HESE
2318.215	2366	1.9962	collimator	20.00	20.00	1.5000	coD172
3162.666	3247	0.9980	collimator	20.00	20.00	1.5000	colE02
3164.520	3253	0.9983	collimator	20.00	20.00	1.5000	colE03
4407.219	4515	13.9852	collimator	20.00	20.00	1.5000	coF172
5176.877	5313	17.9813	collimator	20.00	20.00	1.5000	colF48
5267.588	5401	63346.5356	collimator	20.00	20.00	1.5000	collA11
5278.958	5418	1.7359	dipole	31.50	31.50	6.1214	BEND
5285.358	5423	8.5049	dipole	31.50	31.50	6.1214	BEND
5285.498	5425	3.0626	dipole	34.30	34.30	0.1397	DBENDEN
5285.638	5426	0.7786	dipole	34.30	34.30	0.1397	DBENDEN
5291.759	5428	161.1035	dipole	31.50	31.50	6.1214	BEND
5298.160	5433	1939.7210	dipole	31.50	31.50	6.1214	BEND
5307.670	5447	1643.4495	dipole	31.50	31.50	6.1214	BEND
5314.071	5452	872.1752	dipole	31.50	31.50	6.1214	BEND
5320.471	5457	717.3265	dipole	31.50	31.50	6.1214	BEND
5326.872	5462	628.4099	dipole	31.50	31.50	6.1214	BEND
5330.228	5470	144.8640	dipole	34.30	34.30	0.7620	TQFA4
5330.635	5472	207.8049	dipole	34.30	34.30	0.4064	DPACKU2
5331.152	5474	259.7562	dipole	34.30	34.30	0.5175	DPACKOU
5331.292	5475	64.9390	dipole	34.30	34.30	0.1397	DBENDEN
5337.413	5477	3398.8095	dipole	31.50	31.50	6.1214	BEND
5343.814	5482	1743.3633	dipole	31.50	31.50	6.1214	BEND
5350.215	5487	900.1548	dipole	31.50	31.50	6.1214	BEND
5356.616	5492	673.3679	dipole	31.50	31.50	6.1214	BEND
6223.390	6378	3005.1790	collimator	30.00	30.00	0.5000	collA48
6234.747	6401	0.7529	dipole	31.50	31.50	6.1214	BEND
6241.148	6406	4.6303	dipole	31.50	31.50	6.1214	BEND
6241.287	6408	2.2625	quadrupole	34.30	34.30	0.1397	DBENDEN
6247.548	6411	34.7245	dipole	31.50	31.50	6.1214	BEND
6247.688	6413	2.6343	quadrupole	34.30	34.30	0.1397	DBENDEN
6250.044	6417	2.8187	quadrupole	34.30	34.30	0.5063	DLB4
6250.964	6421	1.9797	quadrupole	34.30	34.30	0.1556	DLB1
6257.044	6429	59.8664	separator	38.10	25.00	2.5718	A49VESE
6259.803	6431	4.9890	separator	38.10	25.00	2.5718	A49VESE
6264.569	6441	0.9290	quadrupole	34.30	34.30	3.3528	CB0Q2F
6265.446	6442	11.9760	quadrupole	34.30	34.30	0.8763	DTRIPB
6282.607	6454	0.9470	str. sect.	13.10	13.10	0.9660	DB0B
from A48		2.6e+2 $part/cm^2$					
from separ. detector		1.2e+2 $part/cm^2$ <0.013 rad					

2 Abort kicker prefire at normal operation

Proton beam loss at proton and antiproton kicker prefire are shown in the Tables 6 - 11 for normal operation with bunch spacing of 0.4 μsec between center. Intensity of accelerator is 10^{13} ppp in the calculations. Each unit of kinetic energy loss in the tables corresponds to $2.8 \cdot 10^8$ particles lost in the accelerator.

Table 6: Proton beam loss at antiproton kicker prefire with 0.5 m long steel (third column), 0.7 m long steel (4-th column) and 0.5 m long tungsten (5-th column) A48 collimator. Intensity of accelerator is 10^{13} *ppp*. Each unit of kinetic energy loss corresponds to $2.8 \cdot 10^8$ particles lost. The stainless steel collimator length increase from 0.5 to 0.7 m effects reduction of losses by a factor of 3. A 0.5 m tungsten collimator is a factor of seven more effective compared to stainless steel collimator.

path length	element number	kinetic energy loss 0.5m,steel	0.7m,steel	0.5m,tungsten	element	aperture hor.	vert.	element length	name
m		GeV/Pc				mm	mm	m	
18.621	15	0.9984	1.9954		quadrupole	34.30	34.30	0.8763	DTRIPB
21.974	16	35.9303	5.9884	4.9855	quadrupole	34.30	34.30	3.3528	CB0Q2D
31.477	30	17.9457	3.9920	0.9966	separator	38.10	25.00	2.5718	B11VESE
91.019	91		0.9548		dipole	34.30	34.30	0.1397	DBENDEN
123.880	128			0.9859	quadrupole	34.30	34.30	0.6350	CBQ7
131.164	133	0.9984			dipole	31.50	31.50	6.1214	BEND
150.367	148	0.9983		0.9967	dipole	31.50	31.50	6.1214	BEND
197.052	198	0.9959			dipole	31.50	31.50	6.1214	BEND
203.453	203			1.9925	dipole	31.50	31.50	6.1214	BEND
209.853	208			1.9928	dipole	31.50	31.50	6.1214	BEND
217.408	222	0.9984			separator	25.00	38.10	2.5718	B17HESE
322.426	325	0.9965	0.9978		dipole	31.50	31.50	6.1214	BEND
1316.538	1303		0.9981		dipole	31.50	31.50	6.1214	BEND
1958.092	1958	0.9976			dipole	31.50	31.50	6.1214	BEND
1964.493	1963	0.9983			dipole	31.50	31.50	6.1214	BEND
1970.894	1968		0.9973		dipole	31.50	31.50	6.1214	BEND
2064.856	2091	1.9964			separator	25.00	38.10	2.5718	C49HESE
2116.370	2140		0.9981		quadrupole	34.30	34.30	3.3528	CD0Q2D
2318.215	2366	5.9871	2.9930	2.9920	collimator	20.00	20.00	1.5000	coD172
3124.328	3213		0.9978	0.9982	collimator	20.00	20.00	1.4950	colE01
3162.666	3247	0.9986			collimator	20.00	20.00	1.5000	colE02
3164.520	3253	1.9962		0.9984	collimator	20.00	20.00	1.5000	colE03
4407.219	4515	3.9933			collimator	20.00	20.00	1.5000	coF172
5176.877	5313	4.9934	1.9977	1.9979	collimator	20.00	20.00	1.5000	colF48
5235.636	5375	23950.5165	23950.5174	23962.5057	AØdump	28.00	28.00	4.5593	DA0PAB
5240.772	5381	1028.0350	1026.0368	1015.0472	AØdump	28.00	28.00	4.5593	DA0PBAB
5252.494	5385	54.9484	65.9381	68.9353	pbar kicker	22.00	22.00	1.8923	DA0KICK
5252.799	5386	39.9625	40.9615	31.9700	pbar kicker	22.00	22.00	0.3048	D12IN
5254.692	5387	427.5986	421.6042	428.5977	pbar kicker	22.00	22.00	1.8923	DA0KICK
5255.149	5388	112.8940	121.8856	128.8790	pbar kicker	22.00	22.00	0.4572	D18IN
5257.041	5389	360.6614	347.6736	339.6811	pbar kicker	22.00	22.00	1.8923	DA0KICK
5257.498	5390	2.9972	0.9991	0.9991	pbar kicker	22.00	22.00	0.4572	D18IN
5259.695	5392	2.9972	2.9972		pbar kicker	22.00	22.00	0.3048	D12IN
5261.588	5393	309.7093	326.6933	341.6793	pbar kicker	22.00	22.00	1.8923	DA0KICK
5262.403	5394	311.7074	278.7383	313.7055	pbar kicker	22.00	22.00	0.8150	DA0SP12
5267.588	5401	1373.7105	1389.6955	1342.7396	collimator	20.00	20.00	1.5000	collA11
6223.390	6378	3722.5056	3911.3284	3950.2918	collimator	30.00	30.00	0.5000	collA48
6241.148	6406	7.4052	3.1172		dipole	31.50	31.50	6.1214	BEND
6241.287	6408	1.4898	1.5124		dipole	34.30	34.30	0.1397	DBENDEN
6247.548	6411	26.0169	5.5406	2.5436	dipole	31.50	31.50	6.1214	BEND
6247.688	6413	0.8383		0.8634	dipole	34.30	34.30	0.1397	DBENDEN
6247.856	6414			0.8752	dipole	34.30	34.30	0.1675	DLB6
6249.257	6415		1.8630	0.9139	dipole	34.30	34.30	1.4018	CB0Q1D
6250.044	6417	0.9048	0.9197		dipole	34.30	34.30	0.5063	DLB4
6250.580	6419	0.9983			dipole	34.30	34.30	0.5357	DLB3
6250.809	6420			0.9976	dipole	34.30	34.30	0.2286	DLB2
6254.285	6427	2.8589	0.9257		separator	25.00	38.10	2.5718	A49HESE
6257.044	6429	105.5577	38.9068	13.9400	separator	38.10	25.00	2.5718	A49VESE
6259.803	6431	8.9795	2.9936	0.9977	separator	38.10	25.00	2.5718	A49VESE
6260.124	6432	0.9458			separator	38.10	38.10	0.3208	DSEPEND
6261.080	6438	0.9485			separator	38.10	38.10	0.4445	FCAN
6264.569	6441	1.9452			quadrupole	34.30	34.30	3.3528	CB0Q2F
6265.446	6442	22.9578	2.9941	3.9869	quadrupole	34.30	34.30	0.8763	DTRIPB
6281.641	6453	0.9318			str. sect.	14.60	14.60	0.2280	DB0C
from A48		1.9e+7 $part/cm^2$	2.0e+7 $part/cm^2$	2.0e+7 $part/cm^2$					
from separat.		1.3e+7 $part/cm^2$	4.2e+6 $part/cm^2$	1.8e+6 $part/cm^2$					
detector		<900 rad	<700 rad	<640 rad					

Table 7: Proton beam loss at proton (third column) and antiproton (4-th column) kicker prefire for kicker modules fire with $7.2\mu sec$ delay after prefire (waiting of the abort gap). Bunches are located with distance of 0.4 μsec between center. Collimator A11 is at $Y = -9.5\ mm\ (7.5\sigma_y)$ and A48 is at $Y = -3.35\ mm\ (15\sigma_y)$ from the beam pipe center. Intensity of accelerator is 10^{13} ppp. Each unit of kinetic energy loss corresponds to $2.8 \cdot 10^8$ particles lost. Ten - twelve bunches are lost in the SC magnets behind AØ at antiproton kicker prefire. This may damage SC magnets.

path length	element number	kinetic energy loss prot.kick.prefire	kinetic energy loss antiprot.kick.prefire	element	aperture hor.	aperture vert.	element length	name
m		GeV/Pc			mm	mm	m	
18.621	15		2.9932	quadrupole	34.30	34.30	0.8763	DTRIPB
21.974	16	2.9940	31.9096	quadrupole	34.30	34.30	3.3528	CB0Q2D
31.477	30	2.9927	13.9731	separator	38.10	25.00	2.5718	B11VESE
101.561	107		0.9697	dipole	34.30	34.30	0.1397	DBENDEN
131.164	133		0.9912	dipole	31.50	31.50	6.1214	BEND
143.966	143	1.9957	0.9967	dipole	31.50	31.50	6.1214	BEND
150.367	148	2.9930		dipole	31.50	31.50	6.1214	BEND
190.651	193		0.9944	dipole	31.50	31.50	6.1214	BEND
197.052	198		1.9895	dipole	31.50	31.50	6.1214	BEND
203.453	203		0.9981	dipole	31.50	31.50	6.1214	BEND
209.853	208	0.9961	0.9972	dipole	31.50	31.50	6.1214	BEND
217.408	222	2.9941		separator	25.00	38.10	2.5718	B17HESE
309.625	315		0.9977	dipole	31.50	31.50	6.1214	BEND
316.025	320		0.9964	dipole	31.50	31.50	6.1214	BEND
1316.538	1303		0.9982	dipole	31.50	31.50	6.1214	BEND
1970.894	1968		0.9982	dipole	31.50	31.50	6.1214	BEND
2064.856	2091	5.9903		separator	25.00	38.10	2.5718	C49HESE
2318.215	2366	12.9772	8.9823	collimator	20.00	20.00	1.5000	coD172
3162.666	3247	1.9966	2.9947	collimator	20.00	20.00	1.5000	colE02
3164.520	3253	1.9967	1.9965	collimator	20.00	20.00	1.5000	colE03
4407.219	4515	3.9948	1.9963	collimator	20.00	20.00	1.5000	coF172
5176.877	5313	4.9932	2.9956	collimator	20.00	20.00	1.5000	colF48
5204.866	5341	0.9991		collimator	20.00	20.00	0.0050	colF49
5235.636	5375	14345.5244	10959.7117	AØdump	28.00	28.00	4.5593	DA0PAB
5240.772	5381	1150.9196	1031.0322	AØdump	28.00	28.00	4.5593	DA0PBAB
5252.494	5385	540.4926	64.9390	pbar kicker	22.00	22.00	1.8923	DA0KICK
5252.799	5386	94.9109	37.9644	pbar kicker	22.00	22.00	0.3048	D12IN
5254.692	5387	268.7477	421.6042	pbar kicker	22.00	22.00	1.8923	DA0KICK
5255.149	5388	10.9897	119.8875	pbar kicker	22.00	22.00	0.4572	D18IN
5257.041	5389	4.9953	350.6708	pbar kicker	22.00	22.00	1.8923	DA0KICK
5257.498	5390	7.9925	3.9962	pbar kicker	22.00	22.00	0.4572	D18IN
5259.391	5391	212.8002	0.9991	pbar kicker	22.00	22.00	1.8923	DA0KICK
5259.695	5392	71.9325	6.9934	pbar kicker	22.00	22.00	0.3048	D12IN
5261.588	5393	515.5161	471.5573	pbar kicker	22.00	22.00	1.8923	DA0KICK
5262.403	5394	114.8921	299.7187	pbar kicker	22.00	22.00	0.8150	DA0SP12
5267.588	5401	13591.2417	1218.8558	collimator	20.00	20.00	1.5000	collA11
5285.358	5423	0.7653		dipole	31.50	31.50	6.1214	BEND
5291.759	5428	4.2217		dipole	31.50	31.50	6.1214	BEND
5298.160	5433	1.7498		dipole	31.50	31.50	6.1214	BEND
5350.215	5487		9740.8561	dipole	31.50	31.50	6.1214	BEND
5356.616	5492		1696.4076	dipole	31.50	31.50	6.1214	BEND
5439.445	5578	0.9953		dipole	31.50	31.50	6.1214	BEND
6223.390	6378	962.0916	5250.0717	collimator	30.00	30.00	0.5000	collA48
6234.747	6401		0.7529	dipole	31.50	31.50	6.1214	BEND
6241.148	6406	0.7020	10.9823	dipole	31.50	31.50	6.1214	BEND
6241.287	6408		3.8709	dipole	34.30	34.30	0.1397	DBENDEN
6247.548	6411	6.8394	55.6656	dipole	31.50	31.50	6.1214	BEND
6247.688	6413	0.9953	5.3726	dipole	34.30	34.30	0.1397	DBENDEN
6249.257	6415	2.7060	1.7973	dipole	34.30	34.30	1.4018	CB0Q1D
6250.580	6419		0.9983	dipole	34.30	34.30	0.5357	DLB3
6250.809	6420		2.9922	dipole	34.30	34.30	0.2286	DLB2
6254.285	6427	0.9298	0.9286	separator	25.00	38.10	2.5718	A49HESE
6257.044	6429	2.9932	100.7572	separator	38.10	25.00	2.5718	A49VESE
6259.803	6431		11.8775	separator	38.10	25.00	2.5718	A49VESE
6264.569	6441	0.9192	1.9400	quadrupole	34.30	34.30	3.3528	CB0Q2F
6265.446	6442	0.9819	7.9585	quadrupole	34.30	34.30	0.8763	DTRIPB
6281.641	6453		0.9290	str. sect.	14.60	14.60	0.2280	DB0C
from A48		4.8e+6 $part/cm^2$	2.6e+7 $part/cm^2$					
from separ.		5.5e+5 $part/cm^2$	1.2e+7 $part/cm^2$					
detector		<150 rad	<1100 rad					

Table 8: Proton beam loss at proton (third column) and antiproton (4-th column) kicker prefire for kicker modules fire with $2\mu sec$ delay after prefire. Bunches are located with distance of 0.4 μsec between center. Collimator A11 is at $Y = -9.5\ mm$ ($7.5\sigma_y$) and A48 is at $Y = -3.35\ mm$ ($15\sigma_y$) from the beam pipe center. Intensity of accelerator is 10^{13} ppp. Each unit of kinetic energy loss corresponds to $2.8 \cdot 10^8$ particles lost.

path length	element number	kinetic energy loss prot.kick.prefire	kinetic energy loss antiprot.kick.prefire	element	aperture hor.	aperture vert.	element length	name
m		GeV/Pc			mm	mm	m	
18.621	15		2.9932	quadrupole	34.30	34.30	0.8763	DTRIPB
21.974	16	2.9940	31.9096	quadrupole	34.30	34.30	3.3528	CB0Q2D
31.477	30	2.9927	13.9731	separator	38.10	25.00	2.5718	B11VESE
101.561	107		0.9697	dipole	34.30	34.30	0.1397	DBENDEN
131.164	133		0.9912	dipole	31.50	31.50	6.1214	BEND
143.966	143	1.9957	0.9967	dipole	31.50	31.50	6.1214	BEND
150.367	148	2.9930		dipole	31.50	31.50	6.1214	BEND
190.651	193		0.9944	dipole	31.50	31.50	6.1214	BEND
197.052	198		1.9895	dipole	31.50	31.50	6.1214	BEND
203.453	203		0.9981	dipole	31.50	31.50	6.1214	BEND
209.853	208	0.9961	0.9972	dipole	31.50	31.50	6.1214	BEND
309.625	315		0.9977	dipole	31.50	31.50	6.1214	BEND
316.025	320		0.9964	dipole	31.50	31.50	6.1214	BEND
217.408	222	2.9941		separator	25.00	38.10	2.5718	B17HESE
1316.538	1303		0.9982	dipole	31.50	31.50	6.1214	BEND
1970.894	1968		0.9982	dipole	31.50	31.50	6.1214	BEND
2064.856	2091	4.9919		separator	25.00	38.10	2.5718	C49HESE
2318.215	2366	12.9772	8.9823	collimator	20.00	20.00	1.5000	coD172
3162.666	3247	1.9966	2.9947	collimator	20.00	20.00	1.5000	colE02
3164.520	3253	1.9967	1.9965	collimator	20.00	20.00	1.5000	colE03
4407.219	4515	3.9948	1.9963	collimator	20.00	20.00	1.5000	coF172
5176.877	5313	4.9932	2.9956	collimator	20.00	20.00	1.5000	colF48
5204.866	5341	0.9991		collimator	20.00	20.00	0.0050	colF49
5235.636	5375	27193.4654	23955.5124	AØdump	28.00	28.00	4.5593	DA0PAB
5240.772	5381	1194.8784	1023.0397	AØdump	28.00	28.00	4.5593	DA0PBAB
5252.494	5385	15.9850	75.9287	pbar kicker	22.00	22.00	1.8923	DA0KICK
5252.799	5386	11.9887	31.9700	pbar kicker	22.00	22.00	0.3048	D12IN
5254.692	5387	240.7740	418.6070	pbar kicker	22.00	22.00	1.8923	DA0KICK
5255.149	5388	83.9212	126.8809	pbar kicker	22.00	22.00	0.4572	D18IN
5257.041	5389	562.4720	343.6774	pbar kicker	22.00	22.00	1.8923	DA0KICK
5257.498	5390	62.9409	1.9981	pbar kicker	22.00	22.00	0.4572	D18IN
5259.391	5391	30.9709		pbar kicker	22.00	22.00	1.8923	DA0KICK
5259.695	5392		3.9962	pbar kicker	22.00	22.00	0.3048	D12IN
5261.588	5393		348.6727	pbar kicker	22.00	22.00	1.8923	DA0KICK
5262.403	5394	2.9972	305.7130	pbar kicker	22.00	22.00	0.8150	DA0SP12
5267.588	5401	1597.5004	1339.7424	collimator	20.00	20.00	1.5000	collA11
5291.759	5428	3.4018		dipole	31.50	31.50	6.1214	BEND
5298.160	5433	0.8509		dipole	31.50	31.50	6.1214	BEND
5439.445	5578	0.9953		dipole	31.50	31.50	6.1214	BEND
6223.390	6378	900.1506	3773.4578	collimator	30.00	30.00	0.5000	collA48
6234.747	6401		0.7529	dipole	31.50	31.50	6.1214	BEND"
6241.148	6406	0.7020	4.6564	dipole	31.50	31.50	6.1214	BEND
6241.287	6408		1.4599	dipole	34.30	34.30	0.1397	DBENDEN
6247.548	6411	6.8394	16.3615	dipole	31.50	31.50	6.1214	BEND
6247.688	6413	0.9985	4.4400	dipole	34.30	34.30	0.1397	DBENDEN
6249.257	6415	2.7060	1.7973	quadrupole	34.30	34.30	1.4018	CB0Q1D
6250.580	6419		0.9983	quadrupole	34.30	34.30	0.5357	DLB3
6250.809	6420		0.9961	quadrupole	34.30	34.30	0.2286	DLB2
6254.285	6427	0.9298	0.9286	separator	25.00	38.10	2.5718	A49HESE
6257.044	6429	1.9959	81.7971	separator	38.10	25.00	2.5718	A49VESE
6259.803	6431		10.9758	separator	38.10	25.00	2.5718	A49VESE
6264.569	6441	0.9192	1.9400	quadrupole	34.30	34.30	3.3528	CB0Q2F
6265.446	6442	0.9819	6.9879	quadrupole	34.30	34.30	0.8763	DTRIPB
6281.641	6453		0.9290	str. sect.	14.60	14.60	0.2280	DB0C
from A48		4.5e+6 $part/cm^2$	1.9e+7 $part/cm^2$					
from separ.		4.6e+5 $part/cm^2$	9.7e+6 $part/cm^2$					
detector		<800 rad	<800 rad					

Table 9: Proton beam loss at proton (third column) and antiproton (4-th column) kicker prefire for kicker modules fire with $2\mu sec$ delay after prefire. Bunches are located with distance of 0.4 μsec between center. Collimator A11 is at $Y = -9.5\ mm$ ($7.5\sigma_y$) and A48 is at $Y = -4.35\ mm$ ($15\sigma_y$) from the beam pipe center. Intensity of accelerator is 10^{13} ppp. Each unit of kinetic energy loss corresponds to $2.8 \cdot 10^8$ particles lost. Losses in the separator downstream of BØ are pretty big at antiproton kicker prefire.

path length	element number	kinetic energy loss prot.kick.prefire	kinetic energy loss antiprot.kick.prefire	element	aperture hor.	aperture vert.	element length	name
m		GeV/Pc			mm	mm	m	
21.974	16		34.9396	quadrupole	34.30	34.30	3.3528	CB0Q2D
31.477	30	0.9990	794.2310	separator	38.10	25.00	2.5718	B11VESE
95.020	101		0.9697	quadrupole	34.30	34.30	0.3810	CB0QT6F
120.763	122		0.9912	dipole	34.30	34.30	0.1397	DBENDEN
143.966	143	0.9972		dipole	31.50	31.50	6.1214	BEND
1964.493	1963		0.9983	dipole	31.50	31.50	6.1214	BEND
2318.215	2366	0.9987	1.9953	collimator	20.00	20.00	1.5000	coD172
3162.666	3247	66.9367		collimator	20.00	20.00	1.5000	colE02
3164.520	3253	1.9977		collimator	20.00	20.00	1.5000	colE03
4407.219	4515	0.9989	2.9972	collimator	20.00	20.00	1.5000	coF172
5176.877	5313	38.9626	186.8240	collimator	20.00	20.00	1.5000	colF48
5203.017	5336	0.8521		quadrupole	34.30	34.30	2.2908	HQUAD4D
5203.189	5337		0.9434	quadrupole	34.30	34.30	0.1718	DQOUT
5204.866	5341	1.9978		collimator	20.00	20.00	0.0050	colF49
5235.636	5375	28063.6518	23962.5060	AØdump	28.00	28.00	4.5593	DA0PAB
5240.772	5381	1139.9299	1017.0453	AØdump	28.00	28.00	4.5593	DA0PBAB
5252.494	5385	35.9662	65.9381	pbar kicker	22.00	22.00	1.8923	DA0KICK
5252.799	5386	12.9878	35.9662	pbar kicker	22.00	22.00	0.3048	D12IN
5254.692	5387	259.7562	427.5986	pbar kicker	22.00	22.00	1.8923	DA0KICK
5255.149	5388	102.9034	126.8809	pbar kicker	22.00	22.00	0.4572	D18IN
5257.041	5389	526.5058	340.6802	pbar kicker	22.00	22.00	1.8923	DA0KICK
5257.498	5390	53.9494	1.9981	pbar kicker	22.00	22.00	0.4572	D18IN
5259.391	5391	28.9728		pbar kicker	22.00	22.00	1.8923	DA0KICK
5259.695	5392		3.9962	pbar kicker	22.00	22.00	0.3048	D12IN
5261.588	5393		315.7036	pbar kicker	22.00	22.00	1.8923	DA0KICK
5262.403	5394	2.9972	313.7055	pbar kicker	22.00	22.00	0.8150	DA0SP12
5267.588	5401	1600.4976	1364.7189	collimator	20.00	20.00	1.5000	collA11
5285.358	5423	0.7057		dipole	31.50	31.50	6.1214	BEND
5291.759	5428	3.3499		dipole	31.50	31.50	6.1214	BEND
5802.767	5947	0.9985		dipole	31.50	31.50	6.1214	BEND
6223.390	6378	18.9788	2842.3319	collimator	30.00	30.00	0.5000	collA48
6241.148	6406		1.5686	dipole	31.50	31.50	6.1214	BEND
6241.287	6408		1.4402	dipole	34.30	34.30	0.1397	DBENDEN
6247.548	6411		11.2321	dipole	31.50	31.50	6.1214	BEND
6247.688	6413		2.5148	dipole	34.30	34.30	0.1397	DBENDEN
6250.580	6419		0.9982	dipole	34.30	34.30	0.5357	DLB3
6250.964	6421		0.9980	dipole	34.30	34.30	0.1556	DLB1
6257.044	6429	1.9953	78.7637	separator	38.10	25.00	2.5718	A49VESE
6259.803	6431		8.9397	separator	38.10	25.00	2.5718	A49VESE
6265.446	6442		13.9699	quadrupole	34.30	34.30	0.8763	DTRIPB
6281.641	6453		0.9290	str. sect.	14.60	14.60	0.2280	DB0C
from A48		9.6e+4 $part/cm^2$	1.4e+7 $part/cm^2$					
from separ.		1.8e+5 $part/cm^2$	9.5e+6 $part/cm^2$					
detector		<8 rad	<680 rad					

Table 10: Proton beam loss at proton (third column) and antiproton (4-th column) kicker prefire for kicker modules fire with $2\mu sec$ delay after prefire. Bunches are located with distance of 0.4 μsec between center. Collimator A11 is at $Y = -9.5\ mm$ ($7.5\sigma_y$) and A48 is at $Y = -5.35\ mm$ ($15\sigma_y$) from the beam pipe center. Intensity of accelerator is 10^{13} ppp. Each unit of kinetic energy loss corresponds to $2.8 \cdot 10^8$ particles lost. Losses in the separators and low-β quadrupoles upstream and downstream of BØ are very big at antiproton kicker prefire.

path length	element number	kinetic energy loss prot.kick.prefire	kinetic energy loss antiprot.kick.prefire	element	aperture hor.	aperture vert.	element length	name
m		GeV/Pc			mm	mm	m	
18.621	15		33.9507	quadrupole	34.30	34.30	0.8763	DTRIPB
21.974	16		236.7654	quadrupole	34.30	34.30	3.3528	CB0Q2D
31.477	30	2.9968	792.2437	separator	38.10	25.00	2.5718	B11VESE
1964.493	1963		0.9983	dipole	31.50	31.50	6.1214	BEND
3162.666	3247	80.9232		collimator	20.00	20.00	1.5000	colE02
3164.520	3253	1.9977		collimator	20.00	20.00	1.5000	colE03
3197.194	3295	1.5576		dipole	31.50	31.50	6.1214	BEND
4407.219	4515	0.9988	2.9972	collimator	20.00	20.00	1.5000	coF172
5176.877	5313	34.9672	186.8240	collimator	20.00	20.00	1.5000	colF48
5200.126	5330	0.8444		dipole	31.50	31.50	6.1214	BEND
5203.189	5337		0.9434	quadrupole	34.30	34.30	0.1718	DQOUT
5204.866	5341	0.9991		collimator	20.00	20.00	0.0050	colF49
5235.636	5375	28033.6794	23954.5135	AØdump	28.00	28.00	4.5593	DA0PAB
5240.772	5381	1174.8971	1025.0378	AØdump	28.00	28.00	4.5593	DA0PBAB
5252.494	5385	30.9709	65.9381	pbar kicker	22.00	22.00	1.8923	DA0KICK
5252.799	5386	7.9925	41.9606	pbar kicker	22.00	22.00	0.3048	D12IN
5254.692	5387	237.7768	427.5986	pbar kicker	22.00	22.00	1.8923	DA0KICK
5255.149	5388	112.8940	123.8837	pbar kicker	22.00	22.00	0.4572	D18IN
5257.041	5389	537.4954	335.6849	pbar kicker	22.00	22.00	1.8923	DA0KICK
5257.498	5390	63.9400	3.9962	pbar kicker	22.00	22.00	0.4572	D18IN
5259.391	5391	25.9756		pbar kicker	22.00	22.00	1.8923	DA0KICK
5259.695	5392		1.9981	pbar kicker	22.00	22.00	0.3048	D12IN
5261.588	5393		341.6793	pbar kicker	22.00	22.00	1.8923	DA0KICK
5262.403	5394	1.9981	299.7187	pbar kicker	22.00	22.00	0.8150	DA0SP12
5267.588	5401	1601.4967	1354.7283	collimator	20.00	20.00	1.5000	collA11
5285.358	5423	0.7057		dipole	31.50	31.50	6.1214	BEND
5291.759	5428	3.3499		dipole	31.50	31.50	6.1214	BEND
5802.767	5947	0.9985		dipole	31.50	31.50	6.1214	BEND
6223.390	6378	5.9925	2099.0296	collimator	30.00	30.00	0.5000	collA48
6241.148	6406		3.3004	dipole	31.50	31.50	6.1214	BEND
6241.287	6408		1.4572	dipole	34.30	34.30	0.1397	DBENDEN
6247.548	6411		11.5544	dipole	31.50	31.50	6.1214	BEND
6247.688	6413		0.8918	dipole	34.30	34.30	0.1397	DBENDEN
6249.257	6415		0.8912	quadrupole	34.30	34.30	1.4018	CB0Q1D"
6250.044	6417		0.9983	dipole	34.30	34.30	0.5063	DLB4
6250.580	6419		3.9882	dipole	34.30	34.30	0.5357	DLB3
6250.809	6420		1.8808	dipole	34.30	34.30	0.2286	DLB2
6257.044	6429	2.9927	88.7368	separator	38.10	25.00	2.5718	A49VESE
6259.803	6431		22.9728	separator	38.10	25.00	2.5718	A49VESE
6264.569	6441		1.9680	quadrupole	34.30	34.30	3.3528	CB0Q2F
6265.446	6442		496.5138	quadrupole	34.30	34.30	0.8763	DTRIPB
6281.641	6453		0.9290	str. sect.	14.60	14.60	0.2280	DB0C
from A48		3.0e+4 $part/cm^2$	1.1e+7 $part/cm^2$					
from separ.		2.8e+5 $part/cm^2$	5.6e+7 $part/cm^2$					
detector		<9 rad	<2000 rad					

Table 11: Proton beam loss at antiproton kicker prefire with 0.5 m long steel A48 collimator placed parallel (third column), at -0.54 *mrad* (4-th column) and -1.08 *mrad* (5-th column) with respect to the beam pipe axes. Angle of -0.54 *mrad* corresponds to the trajectory of bunch lost at the separator. There is no visible difference between losses at different alignment of A48 collimator. Intensity of accelerator is 10^{13} *ppp*. Each unit of kinetic energy loss corresponds to $2.8 \cdot 10^8$ particles lost.

path length	element number	kinetic energy loss 0.00 mrad	-0.54 mrad	-1.08 mrad	element	aperture hor.	vert.	element length	name
m		GeV/Pc				mm	mm	m	
18.621	15	0.9984	1.9959		quadrupole	34.30	34.30	0.8763	"DTRIPB"
21.974	16	35.9303	37.9200	34.9174	quadrupole	34.30	34.30	3.3528	"CB0Q2D"
31.477	30	17.9457	16.9541	18.9681	separator	38.10	25.00	2.5718	B11VESE
131.164	133	0.9984			dipole	31.50	31.50	6.1214	BEND
150.367	148	0.9983		1.9967	dipole	31.50	31.50	6.1214	BEND
197.052	198	0.9959			dipole	31.50	31.50	6.1214	BEND
203.453	203		2.9916	0.9982	dipole	31.50	31.50	6.1214	BEND
209.853	208		0.9984		dipole	31.50	31.50	6.1214	BEND
217.408	222	0.9984	0.9965		separator	25.00	38.10	2.5718	B17HESE
322.426	325	0.9965	0.9965		dipole	31.50	31.50	6.1214	BEND
328.827	330			0.9984	dipole	31.50	31.50	6.1214	BEND
1316.538	1303		0.9981		dipole	31.50	31.50	6.1214	BEND
1958.092	1958	0.9976		0.9976	dipole	31.50	31.50	6.1214	BEND
1964.493	1963	0.9983	0.9983	0.9983	dipole	31.50	31.50	6.1214	BEND
1970.894	1968		0.9978	0.9989	dipole	31.50	31.50	6.1214	BEND
2064.856	2091	1.9964	0.9983	1.9969	separator	25.00	38.10	2.5718	C49HESE
2318.215	2366	5.9871	11.9765	8.9802	collimator	20.00	20.00	1.5000	coD172
3124.328	3213		0.9982	1.9967	collimator	20.00	20.00	1.4950	colE01
3162.666	3247	0.9986	0.9984	1.9965	collimator	20.00	20.00	1.5000	colE02
3164.520	3253	1.9962	0.9981	0.9980	collimator	20.00	20.00	1.5000	colE03
4407.219	4515	3.9933	4.9917	6.9884	collimator	20.00	20.00	1.5000	coF172
5176.877	5313	4.9934	3.9940	7.9874	collimator	20.00	20.00	1.5000	colF48
5235.636	5375	23950.5165	23953.5144	23954.5136	AØdump	28.00	28.00	4.5593	DA0PAB
5240.772	5381	1028.0350	1024.0387	1022.0406	AØdump	28.00	28.00	4.5593	DA0PBAB
5252.494	5385	54.9484	63.9400	66.9372	pbar kicker	22.00	22.00	1.8923	DA0KICK
5252.799	5386	39.9625	39.9625	54.9484	pbar kicker	22.00	22.00	0.3048	D12IN
5254.692	5387	427.5986	429.5967	420.6052	pbar kicker	22.00	22.00	1.8923	DA0KICK
5255.149	5388	112.8940	115.8912	106.8997	pbar kicker	22.00	22.00	0.4572	D18IN
5257.041	5389	360.6614	346.6746	348.6727	pbar kicker	22.00	22.00	1.8923	DA0KICK
5257.498	5390	2.9972	2.9972	0.9991	pbar kicker	22.00	22.00	0.4572	D18IN
5259.695	5392	2.9972	3.9962	1.9981	pbar kicker	22.00	22.00	0.3048	D12IN
5261.588	5393	309.7093	356.6652	309.7093	pbar kicker	22.00	22.00	1.8923	DA0KICK
5262.403	5394	311.7074	311.7074	310.7083	pbar kicker	22.00	22.00	0.8150	DA0SP12
5267.588	5401	1373.7105	1325.7555	1375.7086	collimator	20.00	20.00	1.5000	collA11
6223.390	6378	3722.5056	3716.5113	3711.5160	collimator	30.00	30.00	0.5000	collA48
6241.148	6406	7.4052	7.5893	5.7878	dipole	31.50	31.50	6.1214	BEND
6241.287	6408	1.4898	1.5548	0.8195	dipole	34.30	34.30	0.1397	DBENDEN
6247.548	6411	26.0169	23.2261	30.0580	dipole	31.50	31.50	6.1214	BEND
6247.688	6413	0.8383	0.8383	0.8383	dipole	34.30	34.30	0.1397	DBENDEN
6249.257	6415		0.9761	1.9705	dipole	34.30	34.30	1.4018	CB0Q1D
6249.538	6416		0.9944		dipole	34.30	34.30	0.2805	DLB5
6250.044	6417	0.9048	0.9962	0.9048	dipole	34.30	34.30	0.5063	DLB4
6250.580	6419	0.9983	1.9018	1.9967	dipole	34.30	34.30	0.5357	DLB3
6250.964	6421			0.9962	dipole	34.30	34.30	0.1556	DLB1
6254.285	6427	2.8589	3.6843		separator	25.00	38.10	2.5718	A49HESE
6257.044	6429	105.5577	106.5572	104.5153	separator	38.10	25.00	2.5718	A49VESE
6259.803	6431	8.9795	14.9230	13.9765	separator	38.10	25.00	2.5718	A49VESE
6260.124	6432	0.9458			separator	38.10	38.10	0.3208	DSEPEND
6261.080	6438	0.9485			separator	38.10	38.10	0.4445	FCAN"
6264.569	6441	1.9452	0.9485	3.8919	quadrupole	34.30	34.30	3.3528	CB0Q2F
6265.446	6442	22.9578	16.9628	18.9572	quadrupole	34.30	34.30	0.8763	DTRIPB
6281.641	6453	0.9318		0.9325	str. sect.	14.60	14.60	0.2280	DB0C
from A48		1.9e+7 $part/cm^2$	1.9e+7 $part/cm^2$	1.9e+7 $part/cm^2$					
from separat.		1.3e+7 $part/cm^2$	1.3e+7 $part/cm^2$	1.3e+6 $part/cm^2$					
detector		<900 rad	<900 rad	<900 rad					