Beam Transport to the "First Light" Dump

D. Douglas

Abstract

Beam transport to the first light dump is described.

Primary System Requirements

Initial operation of the IR FEL will be in a low power mode not using energy recovery. In this "first light" mode, all recirculation arc dipoles (from the first reverse bend on) will be unpowered; following the wiggler spent beam will be transported through the downstream matching telescope to a "first light dump". This transport is subject to the following requirements [1].

- Beam power deposition and heating constraints demand that the transport provide a spot of 1-2 cm x 1-2 cm, which will be rastered over an 8 cm x 8 cm area of the dump. This must hold for normalized beam emittances in the range of 5-20 mm-mrad (geometric emittances of 0.0625-0.25 mm-mrad at 42 MeV).
- The transport must have a full momentum acceptance of ~5% after the FEL.
- The transport must support various beam properties measurements, including a beam momentum spread measurement after the FEL and a transverse emittance measurement.

Beam Transport Requirements

The primary system requirements stated above can be met by enforcing the following beam transport system detailed requirements,

- The transport should extend straight ahead from the matching telescope. This will insure it is achromatic and will assist in achieving the desired 5% momentum acceptance.
- The beam spot size requirements stated above can be met by providing beam envelopes at the dump as indicated in Table 1, below. A "full" 4σ spot size of 1 cm can be provided for emittances ranging from 20 mm-mrad down to 5mm-mrad by varying the beam envelope function at the dump from 25 m up to 100 m. Note however that a 4σ spot size of 2 cm for the same emittances requires beam envelopes on the range of 100 m<β<400 m. These values are quite large and may prove error sensitive, unstable, and lead to poor uniformity in the beam distribution (there may be plumes or tails). We therefore will generate a 1 cm spot as a baseline, rely on rastering to reduce local beam power deposition, and push the spot size, if possible, based on operational experience. The system therefore should provide a "midrange" beam envelope at the dump of ~50 m.
- The required emittance measurement can be accomodated if multiple beam profiles can be measured at a single location with good resolution while varying an upstream quadrupole, or if at least three high-resolution profile measurements

can be made at undispersed locations through the transport system. Either method requires that the beam spot at the profile monitor be large enough that the relative error in measurement is small. Typical profile monitors give resolutions of order 25 μm; a good emittance measurement can therefore be achieved by performing the measurements at locations with spot sizes in excess of 250 μm. For the minimum normalized emittance of 5 mm-mrad, this indicates the beam envelope at a measurement point must be (at 42 MeV) at least 1 m [2].

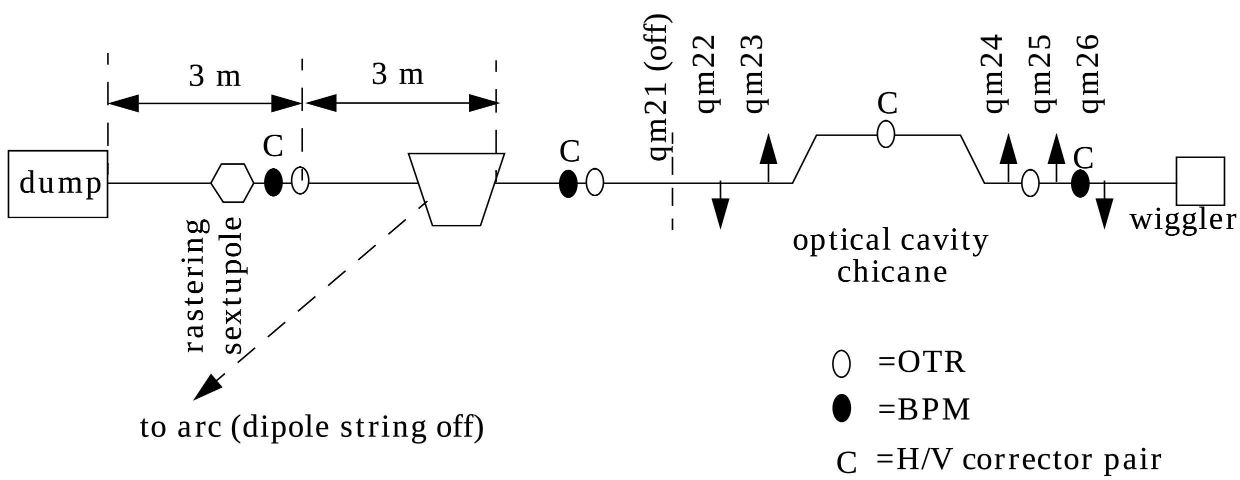
- The required momentum spread measurement can be performed in the optical cavity chicane embedded in the matching telescope. The chicane provides a dispersion of ~0.4 m; when the horizontal beam envelope at this point is made small (less than 1 m) the beam size is momentum spread dominated. For geometric emittances under 1/4 mm-mrad, a momentum spread resolution of order 10^{-3} can be achieved [3].

Table 1: Required beam envelopes for various emittances and spot sizes

β	normalized/geometric (42 MeV) emittance	
full (4σ) spot size	5/0.0625 mm-mrad	20/0.25 mm-mrad
1 cm	100 m	25 m
2 cm	400 m	100 m

Design Details

Figure 1: Conceptual Design of Transport to First Light Dump



The above requirements are met by the conceptual design shown in Figure 1. The beam is transported straight from the downstream matching telescope, through the deactivated first reverse bend, approximately 6 m to the dump. The second matching telescope is retuned (using qm22 through qm62 only; qm21 is deactivated) to provide

$\beta_{x,y} = 2$ m, $\alpha_{x,y} = -1$ in both x and y at the OTR downstream of qm21. This choice of beam envelope functions and layout insures the following:

1. As the OTR is ~2 m downstream of qm22, the spot size provided by $\beta_{x,y} = 2$ m, $\alpha_{x,y} = -1$ is the minimum that will be encountered at the OTR for *any* setting of qm22 [4]. For the 5 mm-mrad normalized emittance, the minimum rms spot size at 42 MeV will be ~350 μm; at 75 MeV it will be ~250 μm. The beam spot at the OTR can then be simultaniously and symmetrically varied in both planes by varying qm22. This provides the required emittance measurement.
2. The relatively tightly focussed beam near the OTR downstream of qm21 diverges to a relatively large spot with $\beta_{x,y} = 50$ m at the dump. For the 5 mm-mrad normalized emittance, the minimum full (4σ) spot size at 42 MeV will then be ~7 mm, and can be enlarged at will simply by varying qm22.
3. As the optical cavity chicane dipoles focus vertically, the horizontal beam envelope is naturally small (less than 1 m) at the dispersed point of the wiggler to dump transport. The momentum spread measurement is then readily provided by using a wide-chamber OTR present in the optical cavity chicane.
4. A rastering sextupole is provided midway between the reverse bend and the dump. This should provide adequate distance to raster the beam over the desired 8 cm x 8 cm area of the dump face.
5. An OTR and BPM are provided upstream of the rastering sextupole to give setup steering, and beam stability diagnostic information during operation. An adjacent corrector pair is provided for beam steering. The OTR can be used in conjection with upstream OTRs (near qm22, in the optical cavity chicane, and between qm24 and qm25) to provide emittance measurement data, either for regular operation or to supplement the OTR/qm22 measurement described above.

Appendix I provides a DIMAD “`hardware layout`” tabulation of beamline elements in machine coordinates. Beamline parameters and performance are discussed below.

Performance

The performance of the machine from cryomodule to wiggler and wiggler to reinjection point has been discussed in detail elsewhere [5]. Here, we restrict attention to the performance of the wiggler to first light dump transport. Figure 2 provides a plot of beam envelope functions from wiggler to first light dump. It shows that the beam is well confined through the transport, diverging in size only at the dump.

Table 2 presents second order matrix elements for the wiggler to dump transport. All values are modest in magnitude, indicating acceptance of the full 5% momentum spread and full emittance. Behavior and sensitivities are expected to be similar to those in the wiggler to reinjection transport [6].

Figure 3 displays results of a momentum scan of properties at the first light dump over a ±3 % momentum range. All properties are well behaved.

Figure 2: Beam envelope functions from wiggler center to first light dump

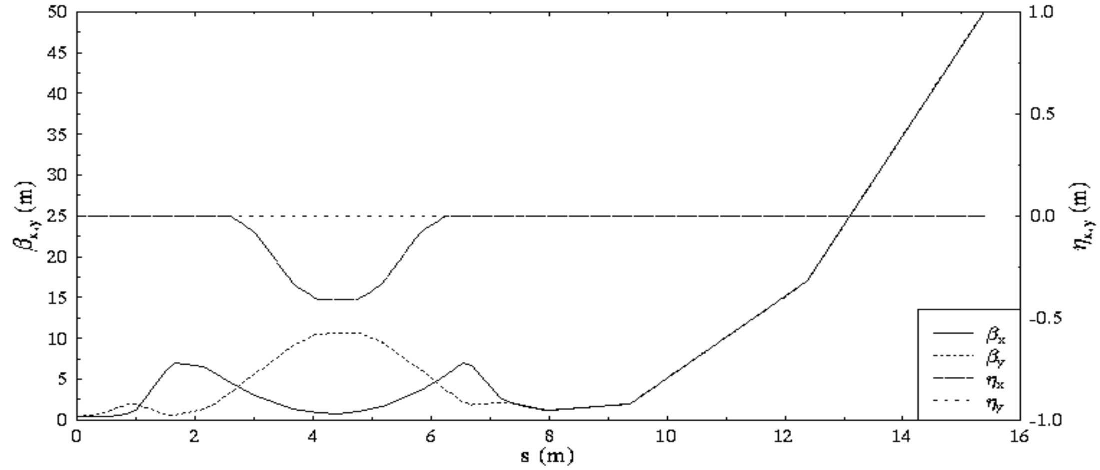


Table 2: Second Order Transport Matrix Elements from Wiggler Center to First Light Dump

FIRST ORDER MATRIX

.7107136E+01	.3513701E+01	.3486451E-15	-.3267405E-15	.0000000E+00	-.1931790E-15
.8460082E+00	.5589621E+00	.7704239E-16	-.4629544E-16	.0000000E+00	-.2477364E-16
-.4610530E-16	-.3391100E-15	.9096499E+01	-.2076879E+01	.0000000E+00	.5796010E-14
.2089247E-16	-.4223681E-16	.1356585E+01	-.1997980E+00	.0000000E+00	.8958438E-15
.1110223E-15	.1110223E-15	.2862630E-15	.6367737E-15	.1000000E+01	-.2794636E+00
.0000000E+00	.0000000E+00	.0000000E+00	.0000000E+00	.0000000E+00	.1000000E+01

SECOND ORDER TERMS

.2072357E-14	-.3424473E-14	.2589035E-14	-.7253962E-02	.0000000E+00	.5241805E+02
	.7384481E-15	-.1335324E-14	-.1194615E-02	.0000000E+00	-.5552709E+02
		.7351865E+00	.4181686E+01	.0000000E+00	-.9304442E-14
			-.5609404E+00	.0000000E+00	.4261455E-14
				.0000000E+00	.0000000E+00
					.5948936E-15
.2727417E-15	-.4630880E-15	.3217615E-15	-.1066210E-02	.0000000E+00	.7515117E+01
	.1166332E-15	-.1735965E-15	-.9881708E-04	.0000000E+00	-.7016919E+01
		-.4851043E-01	.5769536E+00	.0000000E+00	-.1392731E-14
			-.7364496E-01	.0000000E+00	.5185543E-15
				.0000000E+00	.0000000E+00
					.6428899E-16
.6553058E-02	-.2804883E-02	-.1100572E+01	-.2791812E+00	.0000000E+00	-.5394634E-14
	-.1457854E-02	.5248145E+01	-.3548781E+00	.0000000E+00	.5908156E-14
		.5680784E-14	-.3739771E-13	.0000000E+00	-.5232242E+02
			-.1515744E-13	.0000000E+00	-.1154629E+02
				.0000000E+00	.0000000E+00
					-.3572329E-13
.9772750E-03	-.4182997E-03	-.3759785E+00	.2003368E-01	.0000000E+00	-.7324122E-15
	-.2174136E-03	.6534106E+00	-.8683647E-01	.0000000E+00	.6046249E-15
		.7463560E-15	-.4664881E-14	.0000000E+00	-.3621408E+01
			-.2009621E-14	.0000000E+00	-.2044326E+01
				.0000000E+00	.0000000E+00
					-.2517161E-14
.7538778E+01	.7879056E-01	.9158066E-15	-.2714650E-15	.0000000E+00	.2330991E-15
	.4173104E+01	.4170039E-16	-.2626968E-15	.0000000E+00	-.2477326E-15
		.2518336E+02	-.5748404E+01	.0000000E+00	.3379873E-13
			.1176764E+01	.0000000E+00	-.4045993E-14
				.0000000E+00	.0000000E+00
					.4460317E+00

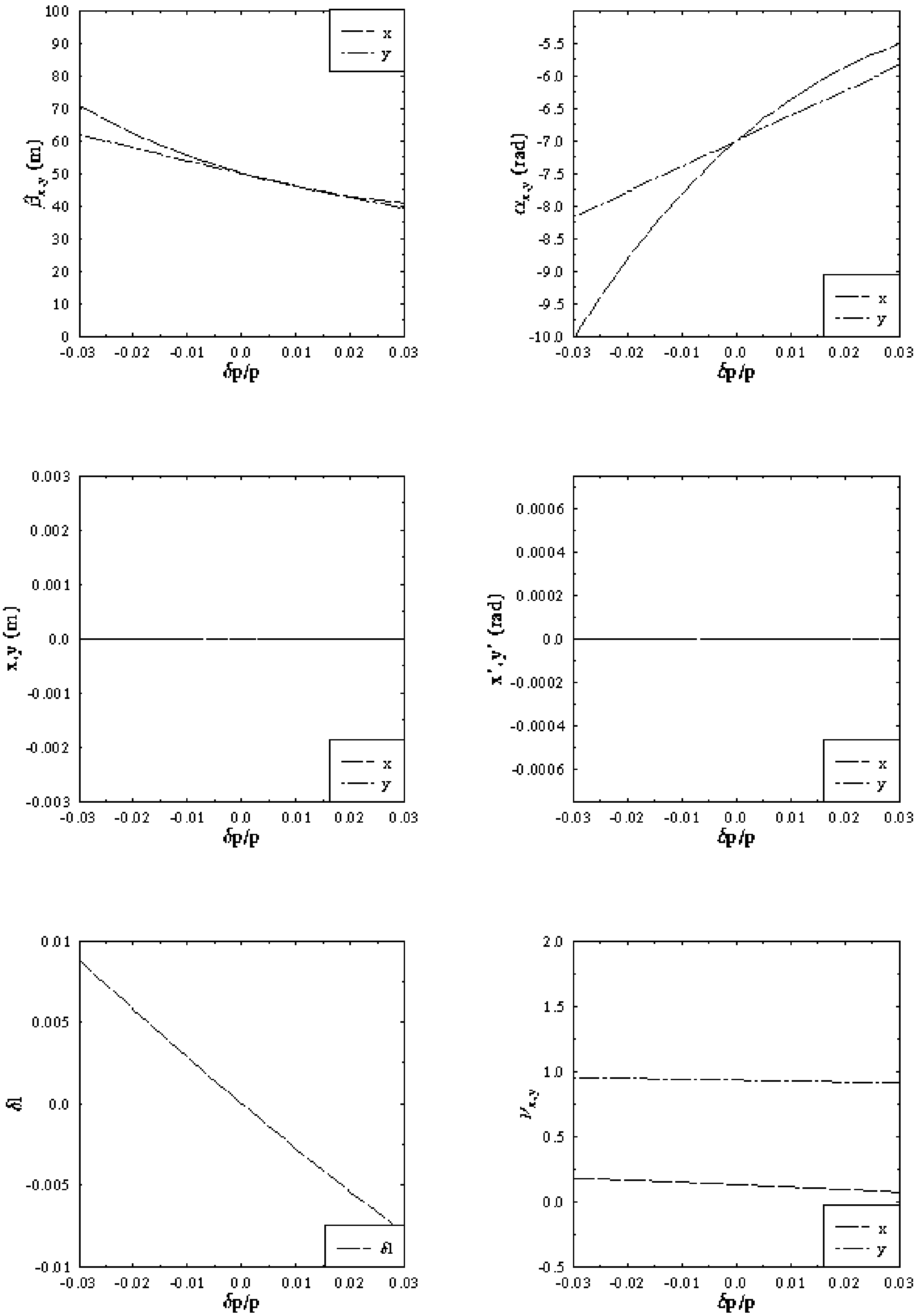


Figure 3: Momentum scan of beam and beamline properties at first light dump

The DIMAD "`line geometric aberrations`" operation was used to check the effect of amplitude dependences in the transport. At ten times the nominal 42 MeV geometric emittance of 0.16 mm-mrad (13 mm-mrad normalized), the phase space distortions $\Delta\varepsilon_{x,y}/\varepsilon_{x,y}$ are less than 0.5% over a full momentum range of $\pm 3\%$. No phase space distortion is visible in plots of the image phase space at any of several momentum offsets, as shown in Figure 4.

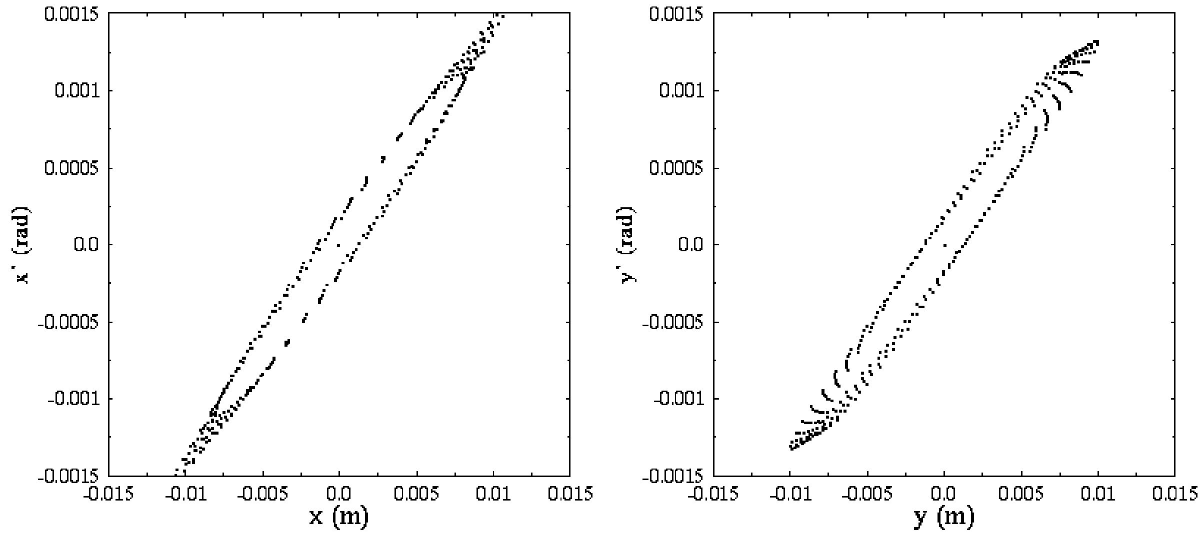


Figure 4: Image phase spaces at dump for initially matched ellipses at 10 times the nominal 0.16 mm-mrad emittance and seven momentum offsets of -3%, -2%, ... 3%.

Figure 5 presents results of simulated emittance measurements for limiting cases with normalized emittances of 5 mm-mrad and 20 mm-mrad (42 MeV geometric emittances of 0.0625 mm-mrad and 0.25 mm-mrad). The simulation tracked beam sigma matrices from the wiggler to the OTR between qm21 and the reverse bend, thereby evaluating propagated spot sizes at the OTR for various excitations of qm22.

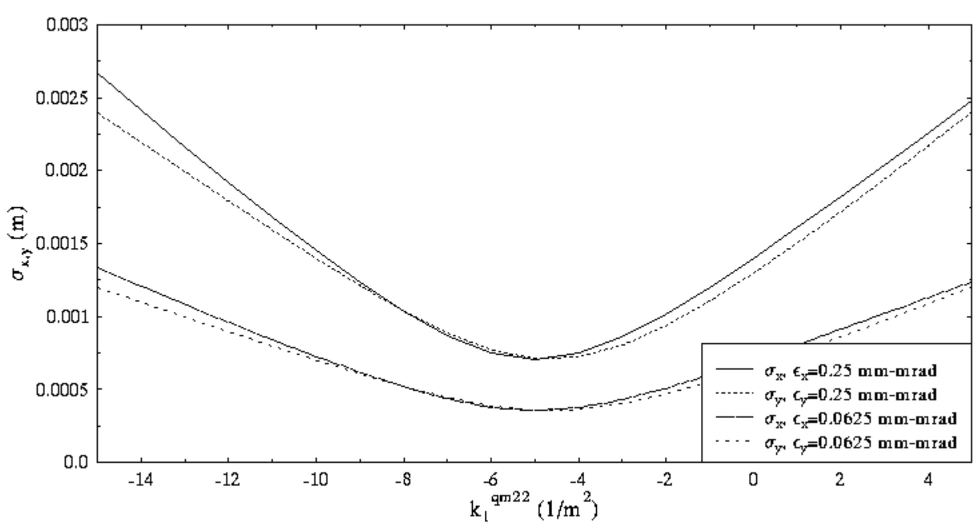


Figure 5: Data from simulated emittance measurement.

The plot shows the propagated spot size as a function of qm22 excitation; these data can be analysed to provide the initial emittance. The minimum spot size is clearly in excess of 300 μm and the spot size changes by at least a factor of 3 as the quadrupole is varied, indicating good resolution will be possible.

Figure 6 shows similarly derived spot size data at the dump as a function of qm22 excitation. This variability indicates we may operationally reduce beam power density on the dump by setting the size to the largest value tolerated by beam loss and stability constraints.

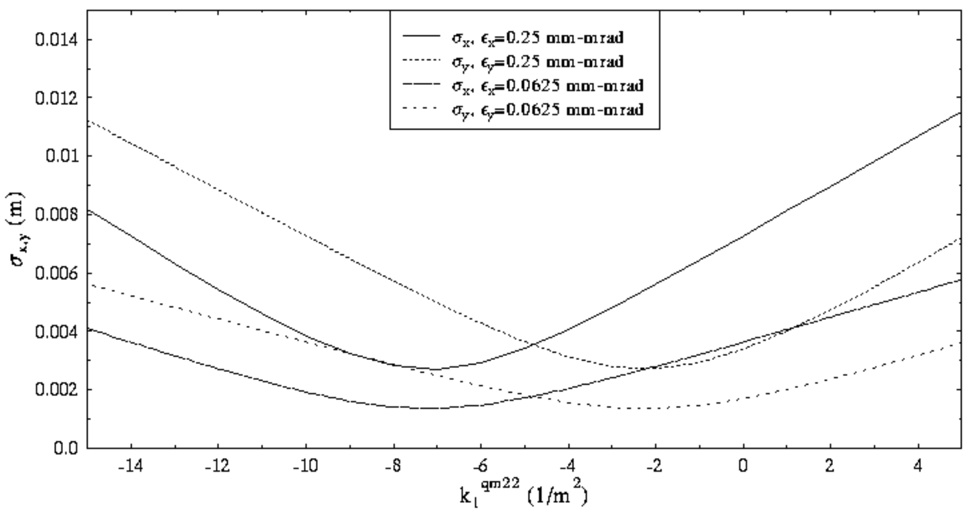


Figure 6: RMS spot sizes at dump as function of qm22 excitation.

Error sensitivities should not differ from those dicussed elsewhere [7]. The tolerance on the remnant field of the first reverse bend when the arc dipole string is switched out is of particular interest. Proceeding as in [7], we find that steering and focussing errors are acceptable if the bend remnant field is limited to order of 1 gauss [8]. This can be achieved with a standardized dipole (with a trim coil or bipolar supply) and a Hall probe in the dipole body (as in the CEBA 0L08 spectrometer dipole).

Comments

This transport supports multiple operational modes. As noted above, emittance measurements can be supported using either single-quad/single profile monitor or multiple profile monitor methods. Moreover, the single-quad/single profile monitor method can be applied in multiple locations. The OTR between the downstream matching telescope and first reverse bend can be used, as described above. Alternately, one can set up the emittance measurement at the OTR between the first reverse bend and the dump. Doing so will increase the minimum spot size at the monitor, thereby improving resolution, while reducing the spot size/beam envelopes on the dump. This may prove useful should the emittance prove either very small or very large. In the former case, the improvement in resolution is beneficial; in the latter case, the reduction of spot size/beam envelopes at the dump may help reduce losses during measurement. One may in such a case even contemplate a measurement of beam emittance during FEL operation, provided a means of monitoring spot size on the dump can be provided (see Figure 6), or if beam interception by the OTR is limited enough to allow insertion during lasing.

Note that this latter limitation holds in the optical cavity chicane as well - if an OTR is to be used to measure beam size at the dispersed location after lasing, it must not intercept a significant fraction of the beam. If such interception cannot be limited, an SLM monitor must be installed on one of the outboard dipoles of the optical cavity chicane to allow monitoring of momentum spread during FEL operation.

Acknowledgements

I would like to thank Court Bohn, Erich Feldl, Bob Legg, Peter Kloeppel, and George Neil for a discussion on 21 October 1996, which defined the design requirements. I would like to thank Geoff Krafft for a useful discussion on the emittance measurement, during which the (perhaps insane) idea of measuring the emittance of the spent electron beam arose.

References

[1] C.L. Bohn, first light dump beam transport requirements memorandum generated following meeting of G. Neil, C. Bohn, R. Legg, P. Kloeppel, E. Feldl and D. Douglas on 21 October 1996.

[2] The minimum beam envelope is defined by $\beta > \sigma^2_{min}/\varepsilon_{min}$.

[3] With a 1/4 mm-mrad geometric emittance (20 mm-mrad normalized) the betatron spot size at a point with a 1 m beam envelope will be 0.5 mm, consistent with the dispersive spot size of 0.4 mm corresponding to a 10^{-3} momentum bite at a point of 0.4 m dispersion.

[4] D. Douglas, “An Observation Point for Measurement of the 45 MeV Emittance in the Front End Test”, CEBAF-TN-90-265, 12 October 1990.

[5] D. Douglas, “IR FEL Driver Accelerator Design”, CEBAF-TN-90-050, 27 September 1996; D. Douglas, “Simulation of Alignment and Powering Errors in the IR FEL Driver Beam Transport System”, CEBAF-TN-96-055, 18 October 1996.

[6] *ibid*.

[7] D. Douglas, “Error Estimates for the IR FEL Transport System”, CEBAF-TN-96-035, 15 July 1996; D. Douglas, “Simulation of Alignment and Powering Errors in the IR FEL Driver Beam Transport System”, CEBAF-TN-96-055, 18 October 1996.

[8] D. Douglas, unpublished response to inquiry by R. Legg.

Appendix I: Machine Layout

THE SXYZ COORDINATES,AZIMUTH,ELEVATION AND ROLL ANGLES ARE :

#	NAME	S	X	Y	Z	THETA	PHI	PSI	ALPHA	
1	DDPB	1.00000	.00000	.00000	1.00000	.00000	.00000	.00000	.00000	R
2	PM	1.00000	.00000	.00000	1.00000	.00000	.00000	.00000	.00000	R
3	CH	1.00000	.00000	.00000	1.00000	.00000	.00000	.00000	.00000	R
4	CV	1.00000	.00000	.00000	1.00000	.00000	.00000	.00000	.00000	R
5	DA1	1.53410	.00000	.00000	1.53410	.00000	.00000	.00000	.00000	R
6	AC11	2.23410	.00000	.00000	2.23410	.00000	.00000	.00000	.00000	R
7	DA2	2.28410	.00000	.00000	2.28410	.00000	.00000	.00000	.00000	R
8	AC12	2.98410	.00000	.00000	2.98410	.00000	.00000	.00000	.00000	R
9	DA3	3.44470	.00000	.00000	3.44470	.00000	.00000	.00000	.00000	R
10	AC13	4.14470	.00000	.00000	4.14470	.00000	.00000	.00000	.00000	R
11	DA2	4.19470	.00000	.00000	4.19470	.00000	.00000	.00000	.00000	R
12	AC14	4.89470	.00000	.00000	4.89470	.00000	.00000	.00000	.00000	R
13	DA3	5.35530	.00000	.00000	5.35530	.00000	.00000	.00000	.00000	R
14	AC15	6.05530	.00000	.00000	6.05530	.00000	.00000	.00000	.00000	R
15	DA2	6.10530	.00000	.00000	6.10530	.00000	.00000	.00000	.00000	R
16	AC16	6.80530	.00000	.00000	6.80530	.00000	.00000	.00000	.00000	R
17	DA3	7.26590	.00000	.00000	7.26590	.00000	.00000	.00000	.00000	R
18	AC17	7.96590	.00000	.00000	7.96590	.00000	.00000	.00000	.00000	R
19	DA2	8.01590	.00000	.00000	8.01590	.00000	.00000	.00000	.00000	R
20	AC18	8.71590	.00000	.00000	8.71590	.00000	.00000	.00000	.00000	R
21	DA1	9.25000	.00000	.00000	9.25000	.00000	.00000	.00000	.00000	R
22	FIXU	9.25000	.00000	.00000	9.25000	.00000	.00000	.00000	.00000	R
23	PM	9.25000	.00000	.00000	9.25000	.00000	.00000	.00000	.00000	R
24	CH	9.25000	.00000	.00000	9.25000	.00000	.00000	.00000	.00000	R
25	CV	9.25000	.00000	.00000	9.25000	.00000	.00000	.00000	.00000	R
26	DDPA	10.25000	.00000	.00000	10.25000	.00000	.00000	.00000	.00000	R
27	DI1	10.73963	.00000	.00000	10.73963	.00000	.00000	.00000	.00000	R
28	DBUMP1	10.95483	-.00953	.00000	10.95454	-5.07536	.00000	.00000	.00000	R
29	DI2	11.41216	-.04998	.00000	11.41009	-5.07536	.00000	.00000	.00000	R
30	DBUMP2	11.84255	-.04998	.00000	11.83992	5.07536	.00000	.00000	.00000	R
31	DI2	12.29989	-.00953	.00000	12.29546	5.07536	.00000	.00000	.00000	R
32	DBUMP3	12.51508	.00000	.00000	12.51037	.00000	.00000	.00000	.00000	R
33	DI1	13.00471	.00000	.00000	13.00000	.00000	.00000	.00000	.00000	R
34	QM11	13.15471	.00000	.00000	13.15000	.00000	.00000	.00000	.00000	R
35	DM1A	13.65471	.00000	.00000	13.65000	.00000	.00000	.00000	.00000	R
36	QM12	13.80471	.00000	.00000	13.80000	.00000	.00000	.00000	.00000	R
37	DM1A	14.30471	.00000	.00000	14.30000	.00000	.00000	.00000	.00000	R
38	QM13	14.45471	.00000	.00000	14.45000	.00000	.00000	.00000	.00000	R
39	DB1	14.75471	.00000	.00000	14.75000	.00000	.00000	.00000	.00000	R
40	BBUMP1	15.16481	.07814	.00000	15.15000	22.10700	.00000	.00000	.00000	R
41	DB2	15.81242	.32186	.00000	15.75000	22.10700	.00000	.00000	.00000	R
42	BBUMP2	16.22252	.40000	.00000	16.15000	.00000	.00000	.00000	.00000	R
43	DB3	16.57252	.40000	.00000	16.50000	.00000	.00000	.00000	.00000	R
44	PM	16.57252	.40000	.00000	16.50000	.00000	.00000	.00000	.00000	R
45	CH	16.57252	.40000	.00000	16.50000	.00000	.00000	.00000	.00000	R
46	CV	16.57252	.40000	.00000	16.50000	.00000	.00000	.00000	.00000	R
47	DB3	16.92252	.40000	.00000	16.85000	.00000	.00000	.00000	.00000	R
48	MIRROR	16.92252	.40000	.00000	16.85000	.00000	.00000	.00000	.00000	R
49	BBUMP3	17.33262	.32186	.00000	17.25000	-22.10700	.00000	.00000	.00000	R
50	DB2	17.98023	.07814	.00000	17.85000	-22.10700	.00000	.00000	.00000	R
51	BBUMP4	18.39033	.00000	.00000	18.25000	.00000	.00000	.00000	.00000	R
52	DB1	18.69033	.00000	.00000	18.55000	.00000	.00000	.00000	.00000	R
53	QM14	18.84033	.00000	.00000	18.70000	.00000	.00000	.00000	.00000	R
54	PM	18.84033	.00000	.00000	18.70000	.00000	.00000	.00000	.00000	R
55	DM1B	19.34033	.00000	.00000	19.20000	.00000	.00000	.00000	.00000	R
56	QM15	19.49033	.00000	.00000	19.35000	.00000	.00000	.00000	.00000	R
57	PM	19.49033	.00000	.00000	19.35000	.00000	.00000	.00000	.00000	R
58	CH	19.49033	.00000	.00000	19.35000	.00000	.00000	.00000	.00000	R
59	CV	19.49033	.00000	.00000	19.35000	.00000	.00000	.00000	.00000	R
60	DM1B	19.99033	.00000	.00000	19.85000	.00000	.00000	.00000	.00000	R
61	QM16	20.14033	.00000	.00000	20.00000	.00000	.00000	.00000	.00000	R
62	DWD	20.45033	.00000	.00000	20.31000	.00000	.00000	.00000	.00000	R
63	PM	20.45033	.00000	.00000	20.31000	.00000	.00000	.00000	.00000	R
64	BWPA	20.45708	.00000	-.00005	20.31675	.00000	-.81987	.00000	.00000	R

several lines of wiggler stuff...

124	PM	20.99035	.00000	.00000	20.85000	.00000	.00000	.00000	.00000	R
125	START	20.99035	.00000	.00000	20.85000	.00000	.00000	.00000	.00000	R

several more lines of wiggler stuff...

186	PM	21.53037	.00000	.00000	21.39000	.00000	.00000	.00000	.00000	R
187	DWD	21.84037	.00000	.00000	21.70000	.00000	.00000	.00000	.00000	R
188	QM26	21.99037	.00000	.00000	21.85000	.00000	.00000	.00000	.00000	R
189	DM1B	22.49037	.00000	.00000	22.35000	.00000	.00000	.00000	.00000	R
190	PM	22.49037	.00000	.00000	22.35000	.00000	.00000	.00000	.00000	R
191	CH	22.49037	.00000	.00000	22.35000	.00000	.00000	.00000	.00000	R

192	CV	22.49037	.00000	.00000	22.35000	.00000	.00000	.00000	.00000	R
193	QM25	22.64037	.00000	.00000	22.50000	.00000	.00000	.00000	.00000	R
194	DM1B	23.14037	.00000	.00000	23.00000	.00000	.00000	.00000	.00000	R
195	PM	23.14037	.00000	.00000	23.00000	.00000	.00000	.00000	.00000	R
196	QM24	23.29037	.00000	.00000	23.15000	.00000	.00000	.00000	.00000	R
197	DB1	23.59037	.00000	.00000	23.45000	.00000	.00000	.00000	.00000	R
198	BBUMP4	24.00047	.07814	.00000	23.85000	22.10700	.00000	.00000	.00000	R
199	DB2	24.64808	.32186	.00000	24.45000	22.10700	.00000	.00000	.00000	R
200	BBUMP3	25.05818	.40000	.00000	24.85000	.00000	.00000	.00000	.00000	R
201	MIRROR	25.05818	.40000	.00000	24.85000	.00000	.00000	.00000	.00000	R
202	DB3	25.40818	.40000	.00000	25.20000	.00000	.00000	.00000	.00000	R
203	PM	25.40818	.40000	.00000	25.20000	.00000	.00000	.00000	.00000	R
204	CH	25.40818	.40000	.00000	25.20000	.00000	.00000	.00000	.00000	R
205	CV	25.40818	.40000	.00000	25.20000	.00000	.00000	.00000	.00000	R
206	DB3	25.75818	.40000	.00000	25.55000	.00000	.00000	.00000	.00000	R
207	BBUMP2	26.16828	.32186	.00000	25.95000	-22.10700	.00000	.00000	.00000	R
208	DB2	26.81589	.07814	.00000	26.55000	-22.10700	.00000	.00000	.00000	R
209	BBUMP4	27.22599	.00000	.00000	26.95000	.00000	.00000	.00000	.00000	R
210	DB1	27.52599	.00000	.00000	27.25000	.00000	.00000	.00000	.00000	R
211	QM23	27.67599	.00000	.00000	27.40000	.00000	.00000	.00000	.00000	R
212	DM1A	28.17599	.00000	.00000	27.90000	.00000	.00000	.00000	.00000	R
213	QM22	28.32599	.00000	.00000	28.05000	.00000	.00000	.00000	.00000	R
214	DM1A	28.82599	.00000	.00000	28.55000	.00000	.00000	.00000	.00000	R
215	QM21	28.97599	.00000	.00000	28.70000	.00000	.00000	.00000	.00000	R
216	CV	28.97599	.00000	.00000	28.70000	.00000	.00000	.00000	.00000	R
217	D0	30.36729	.00000	.00000	30.09130	.00000	.00000	.00000	.00000	R
218	PM	30.36729	.00000	.00000	30.09130	.00000	.00000	.00000	.00000	R
219	OTR	30.36729	.00000	.00000	30.09130	.00000	.00000	.00000	.00000	R
220	CH	30.36729	.00000	.00000	30.09130	.00000	.00000	.00000	.00000	R
221	FLD	33.36729	.00000	.00000	33.09130	.00000	.00000	.00000	.00000	R
222	OTR2	33.36729	.00000	.00000	33.09130	.00000	.00000	.00000	.00000	R
223	FLD	36.36729	.00000	.00000	36.09130	.00000	.00000	.00000	.00000	R