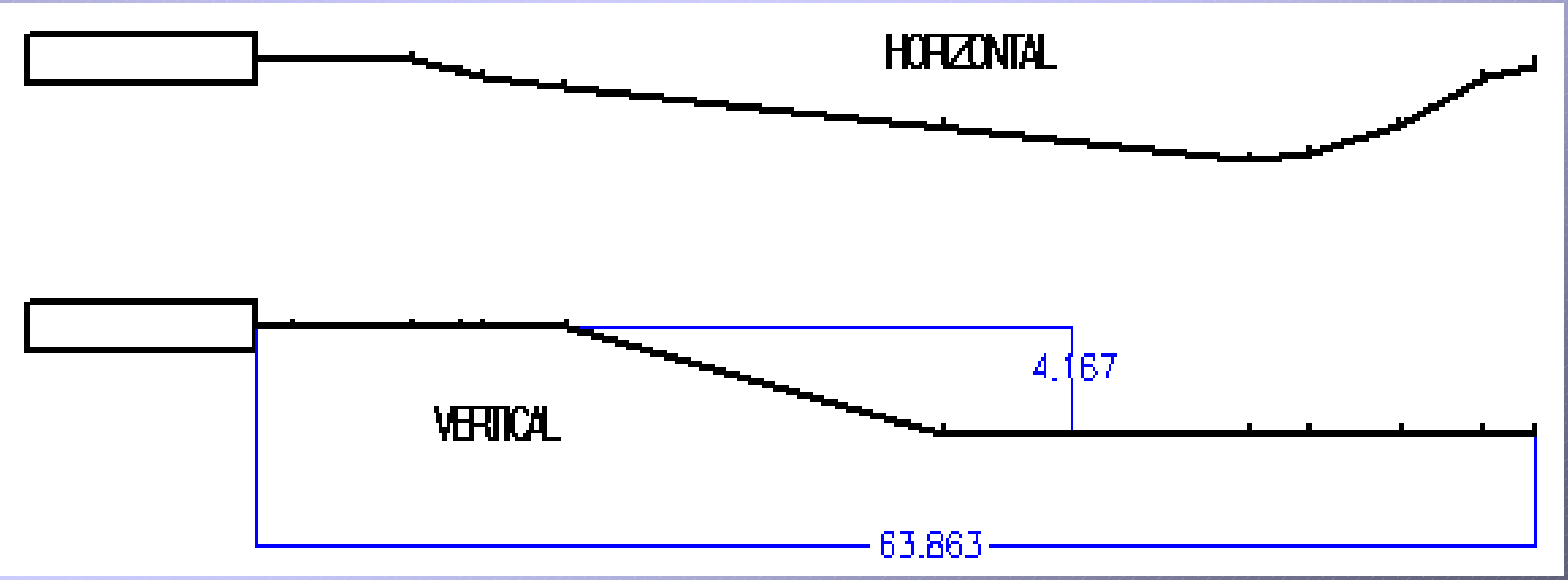
400 MeV Transport and Injection

Jim Lackey

Dec 2004

400 MeV Parameters

Nominal Energy	401 MeV
dp/p	0.1%
Current (typ)	37 mA
Emittance	< 10 pi-mm-mR



Beam Line Elements

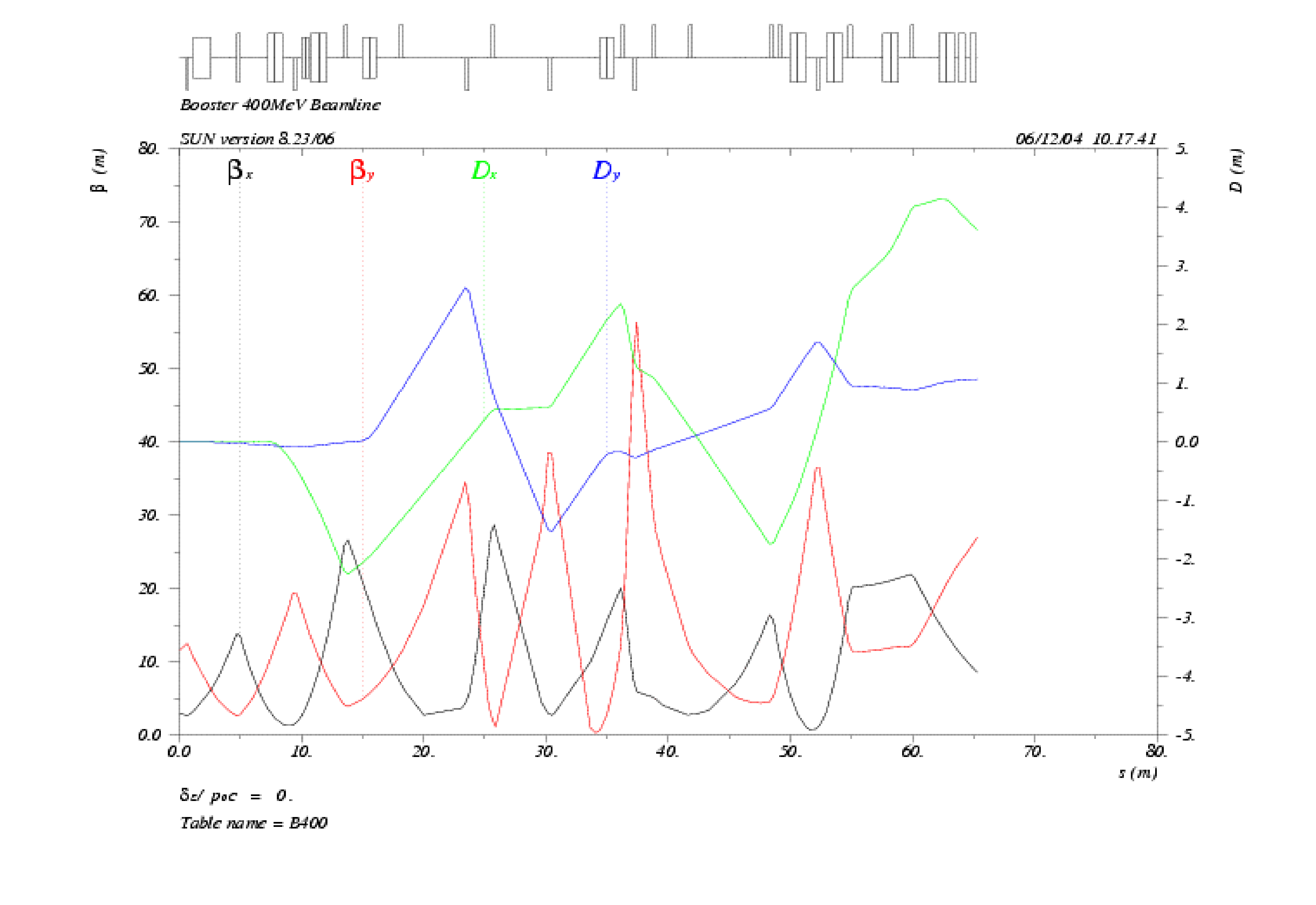
• Quads	17
• Ver Dipoles	3
• Hor Dipoles	4
• Electrostatic Chopper	1
• Lambertson	1
• DC Septum	1
• Length	~ 65 M

Diagnostics

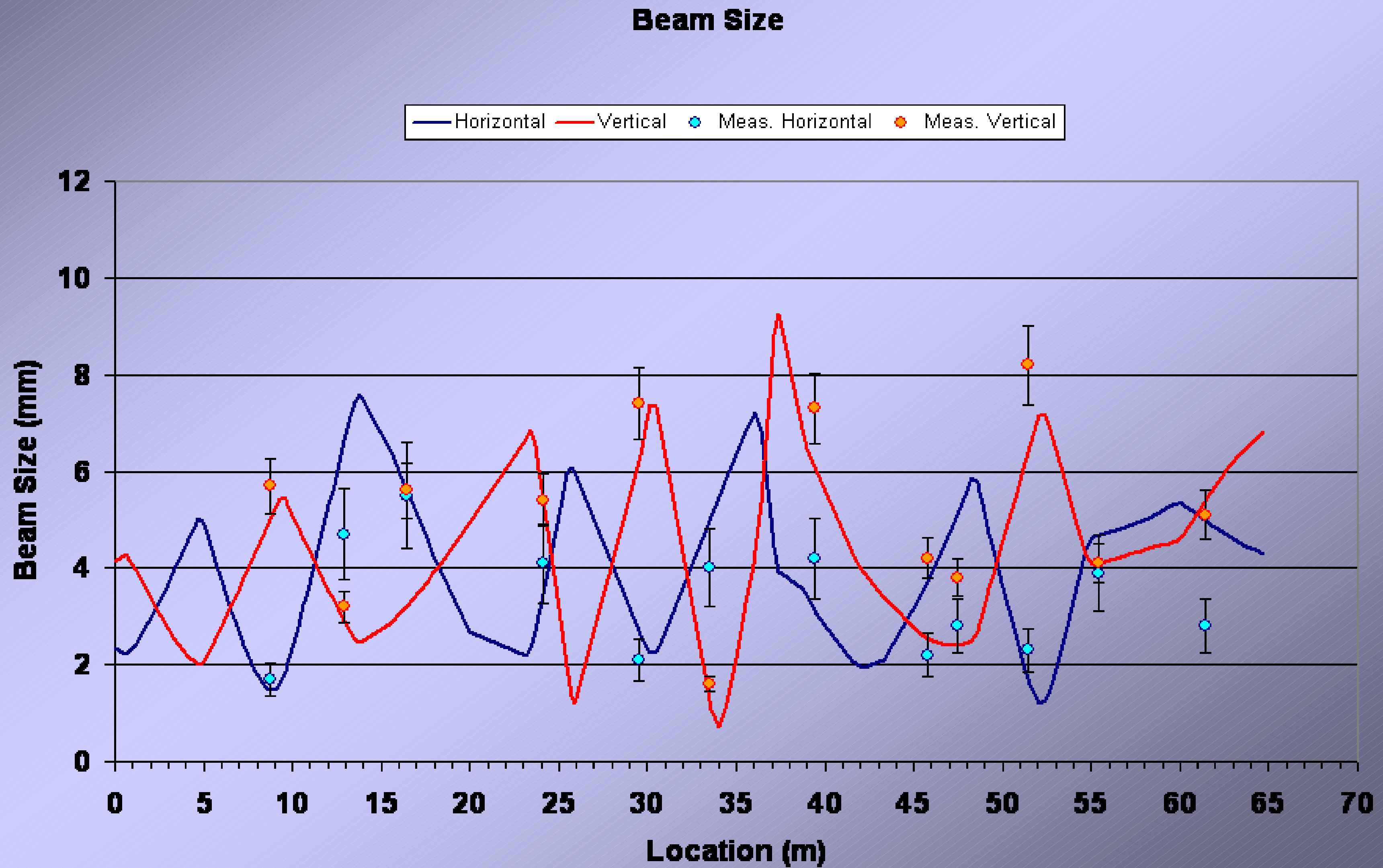
• Multiwires	12
• Ver BPMs	20
• Hor BPMs	20
• BLMs	15

Line Optics

F. Garcia



Beam Size



Beam Size
Horizontal
Vertical
Meas. Horizontal
Meas. Vertical
Beam Size (mm)
Location (m)
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70

Linac Phase Space

C. Johnstone
1994

Table I. Evolution of Linac phase space at exit of Module 7

Date	β_x	α_x	β_y	α_y	ε_x	ε_y
design	1.9397	0.	9.0271	0.	6.0	6.0
27-Sep-93						
data set #1	2.3316	2.6364	6.5462	-2.3642	8.704	3.639
data set #2	1.3260	.5743	-----	------	10.014	------
1-Oct-93	2.0937	1.9108	9.7877	-3.3407	9.492	8.104
19-Oct-93						
fit to 4 data	1.0239	0.5325	8.2889	-2.9183	6.671	3.820
sets	2.4575	0.9480	10.9197	-3.4286	6.491	6.966
	2.6913	1.1657	poor fit	poor fit	4.258	poor fit
	2.0095	1.0496	11.0472	-2.6364	6.458	4.709
24-Nov-93	1.8615	.8952	8.6654	-3.7955	7.6243	6.876
30-Nov-93	1.2785	.3933	8.1358	-3.0424	7.397	7.665
16-Nov-94	2.2131	0.8553	7.5119	-2.5103	6.608	7.433
21-Nov-94	1.9803	0.8220	7.7129	-2.7807	9.105	6.224
1-Dec-94						
wking tune	2.8871	1.4168	9.0281	-3.4750	6.849	7.481
new tune	3.2900	1.2630	9.0299	-3.1455	8.061	8.193
14-Dec-94						
new tune	2.2659	.9454	7.7121	-2.8336	7.276	5.777

In initial fits to the data, the ratio of the conversion factor for the Loma Linda-style quadrupoles to that for 200-MeV quadrupoles was found to be consistent among the various data sets, yielding a value of .952 +/- .012. Only the most recent data sets--Nov24, 1993-Dec 14, 1994 were included, even though earlier data also confirmed this value. This ratio was then applied in a subsequent analysis to constrain one of the two floating normalizations. Both normalizations

Booster Phase Space

C. Johnstone

1994

phase space calculated for the Dec 1st tunes, in particular the vertical values, could not be used to describe beamline profiles measured on neighboring dates (albeit different operational states). On the other hand, the reverse condition did hold--the Dec 1st profiles and tunes were adequately reproduced by solutions found for the other data sets. The Dec 1st solutions are considered nonphysical; artifacts of the minimization approach and the errors discussed at length above.

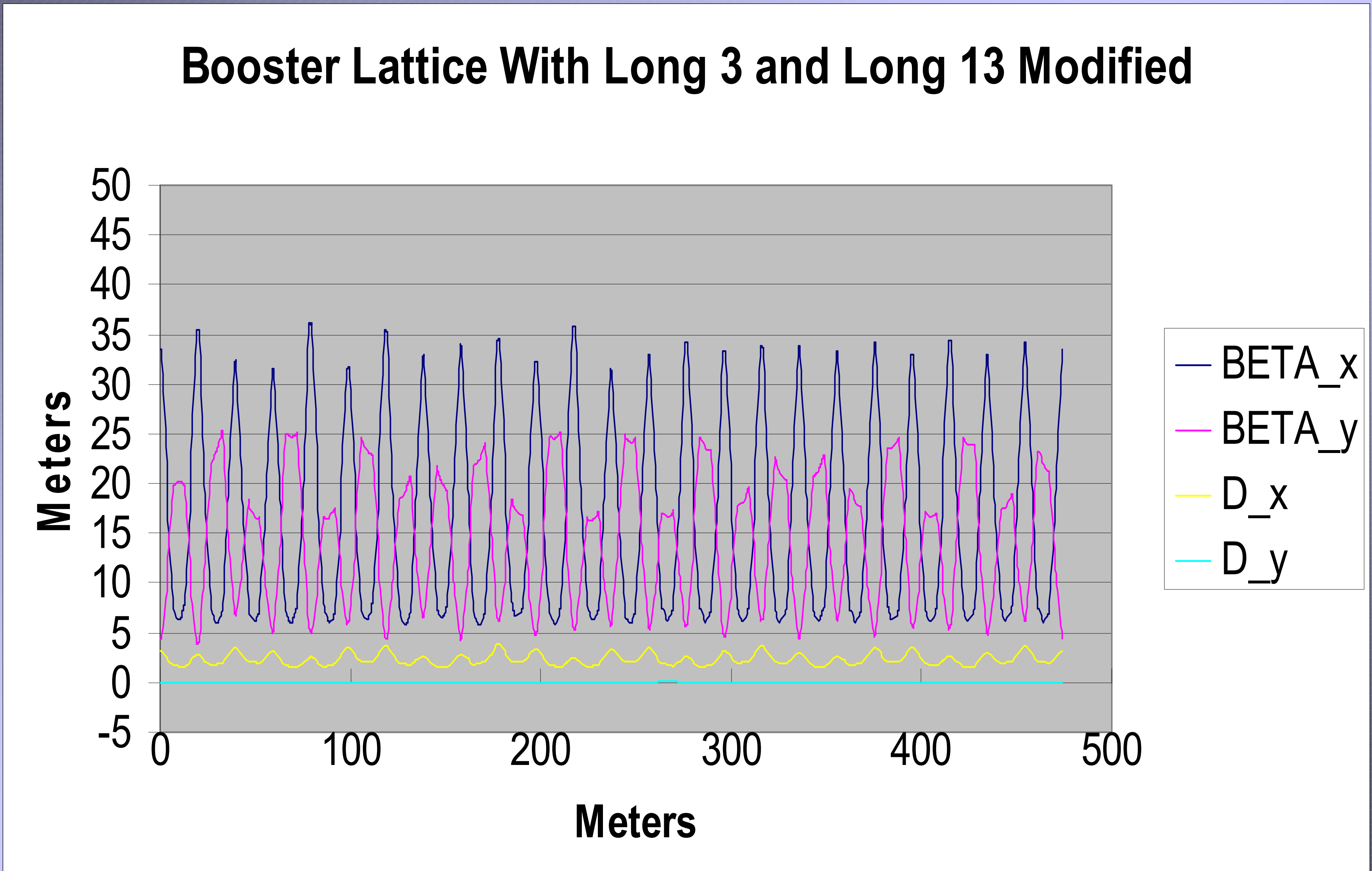
Of course, once the input phase space is known, the output phase space can be calculated. The output phase space delivered by the 400-MeV transfer line is of interest because it represents the phase space of beam injected into the Booster Synchrotron. Since, during commissioning, the Linac FODO cell lattice was tuned and retuned, the phase space match to the Booster was impacted as a matter of course. Tracking the Linac phase space, then, also samples the phase space at Booster injection, which, in turn, affects Booster beam characteristics. The consequences of Linac tuning, that is the quality of the lattice match, are noted in Table III.

Table III. Phase space measured at Booster injection point after retune of Linac lattice

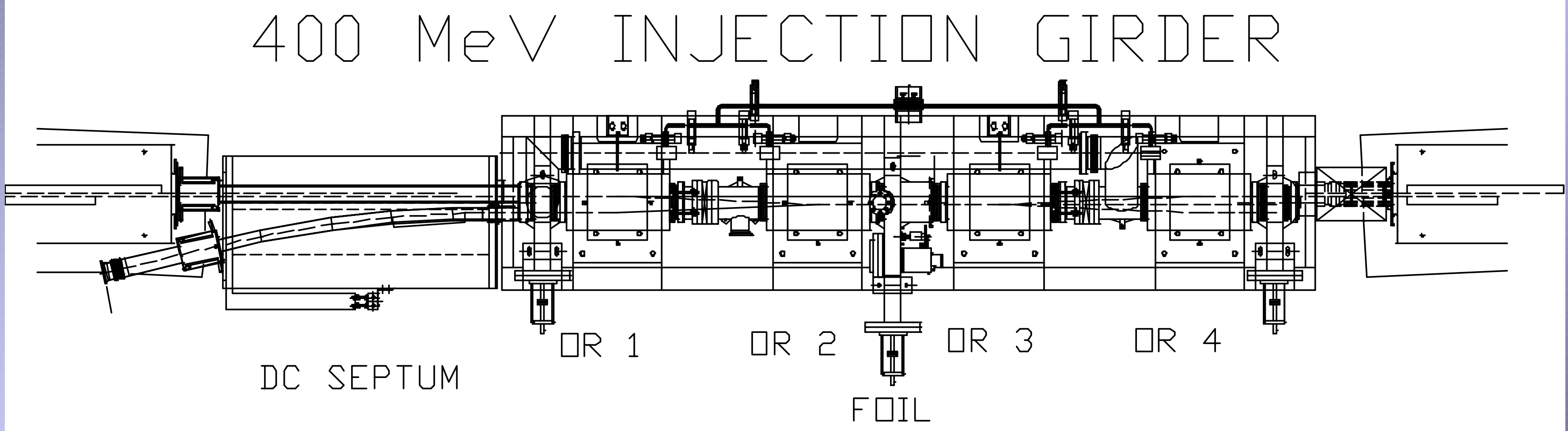
Date	β_x	α_x	β_y	α_y	D_x	D_y
Booster design lattice	6.1218	0.	20.0067	0.	-1.840	0.
1-Oct-93	2.6067	.2757	25.8904	-0.4372	-1.879	.1759
24-Nov-93	8.5663	.1728	18.9275	.0188	-1.984	.3136
30-Nov-93	4.0070	.2706	27.8330	-.8366	-1.7723	1.3019
16-Nov-94	3.1794	-0.2084	24.1614	-1.4407	-1.693	0.507
1-Dec-94 working tune	4.3426	-.4130.	17.5466	-1.0986	-1.513	0.800

The phase space calculations were often performed in response to poor accelerator performance, with corrective operational responses being required based on the information given in Table III. For

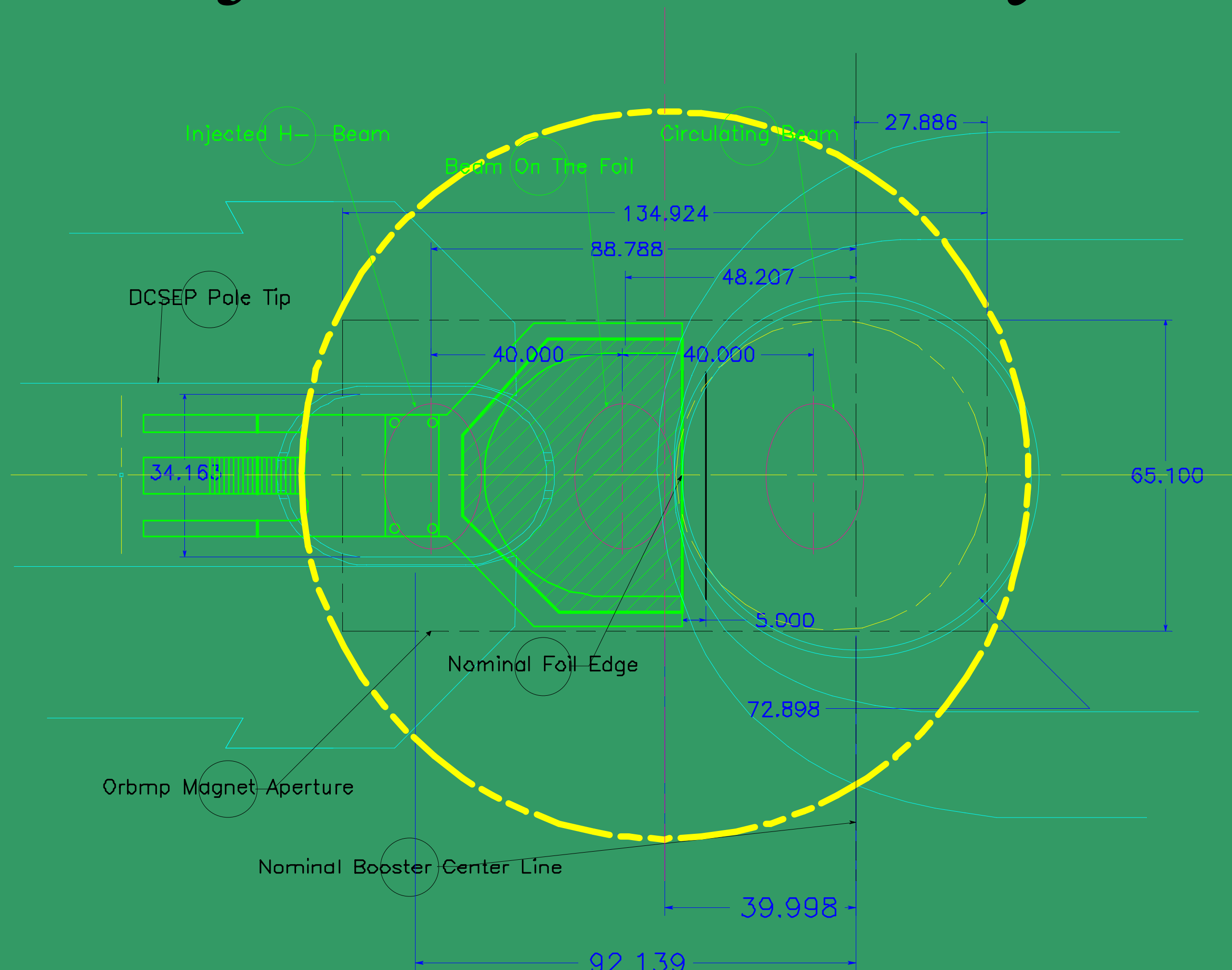
Transverse Matching ???



INJECTION



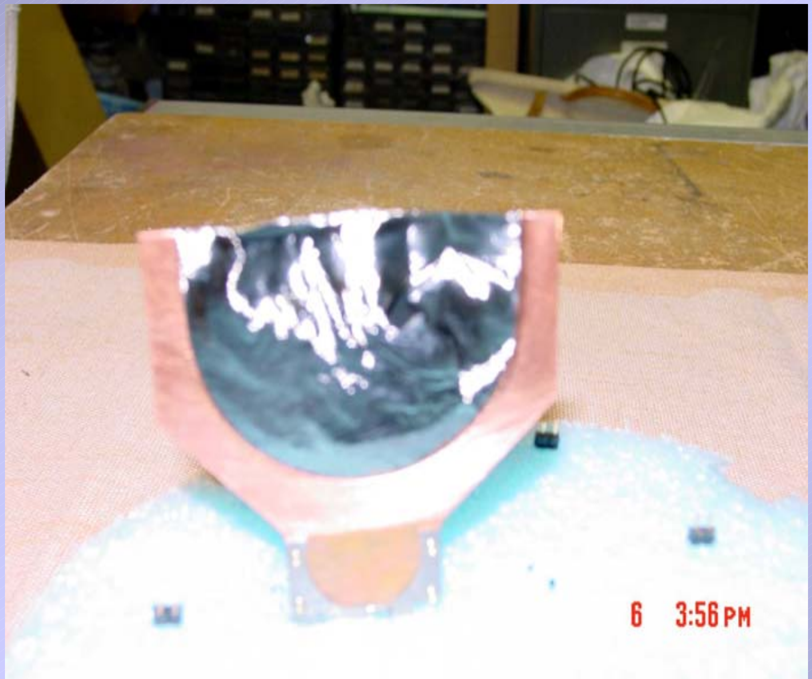
Injection Girder Layout



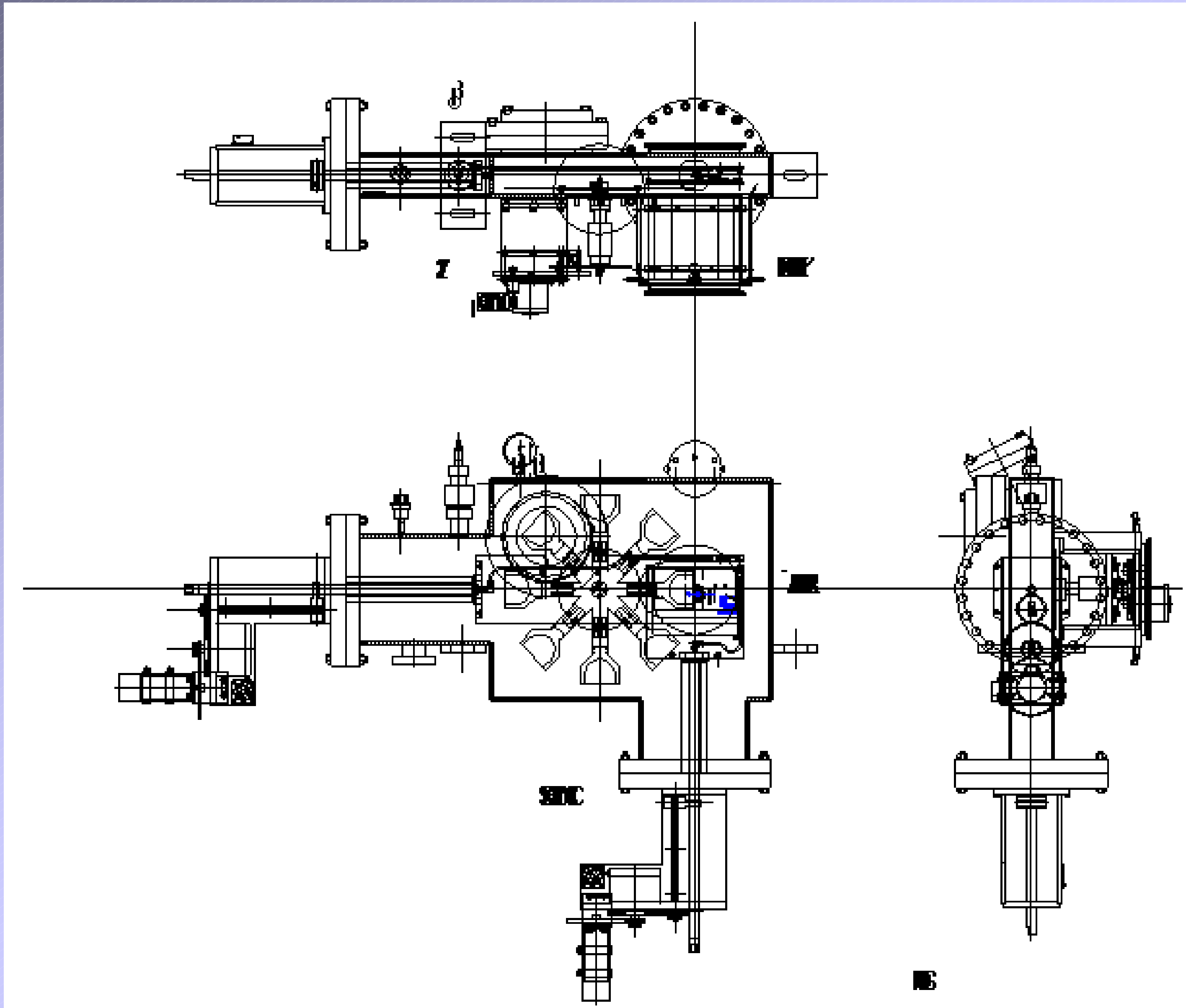
Injection Girder Transverse Layout. ie. Where the nominal Beam and apertures are:::

FOILS

- Density > 300 ug/cm^2
- Lifetime Years ????
- Beam induced failures (200MeV) 0 [see below]
- Beam induced failures (400MeV) 0



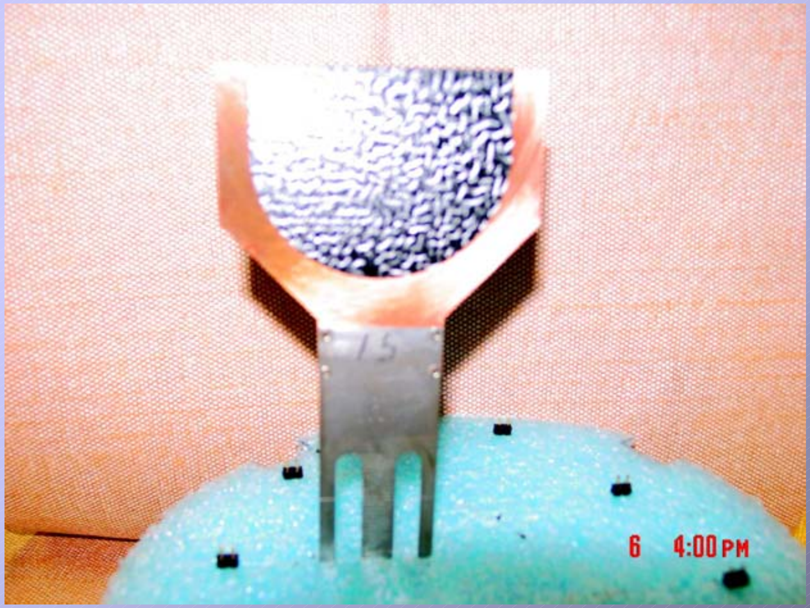
FOIL CHANGER



400 MeV Foils

- A 260 ug/cm^2 foil
  for experimental use.

Holder is 400 MeV style



Injection Modification
New Magnet Design

- Cooled for High Rep Rates
- Stronger
- Better Fields

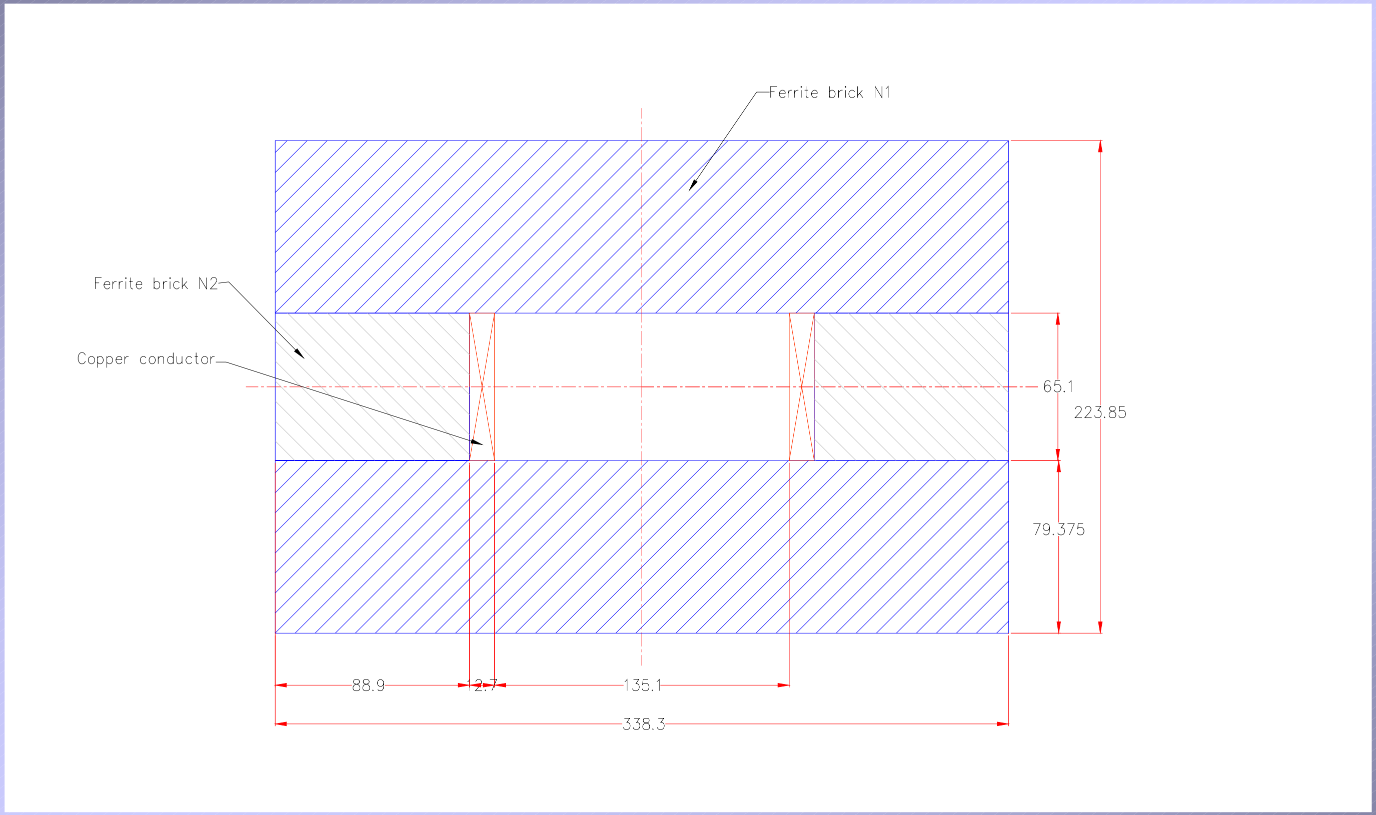
ORBUMP Magnetic Design

V.S. Kashikhin, Review April 5, 2004

Magnetic field	0.28 T
Yoke length	0.522 m
Max current	15000 A
Air gap ampere-turns	14927 A
Stored energy	154 J
Inductance	1.4 uH
Pulse length	110 μs
Frequency	15 Hz
Duty factor	0.2 %
Power AC losses	300 W
Air gap	65.1 mm, parallel with accuracy 0.05 mm
Yoke material	Ni-Zn Ferrite, B_m=0.41 T- 0.46 T, $\rho=10^7$ Ω-cm,
Conductor	Copper

New Magnet Parameters

Fig.1. Magnet cross section



dB/B

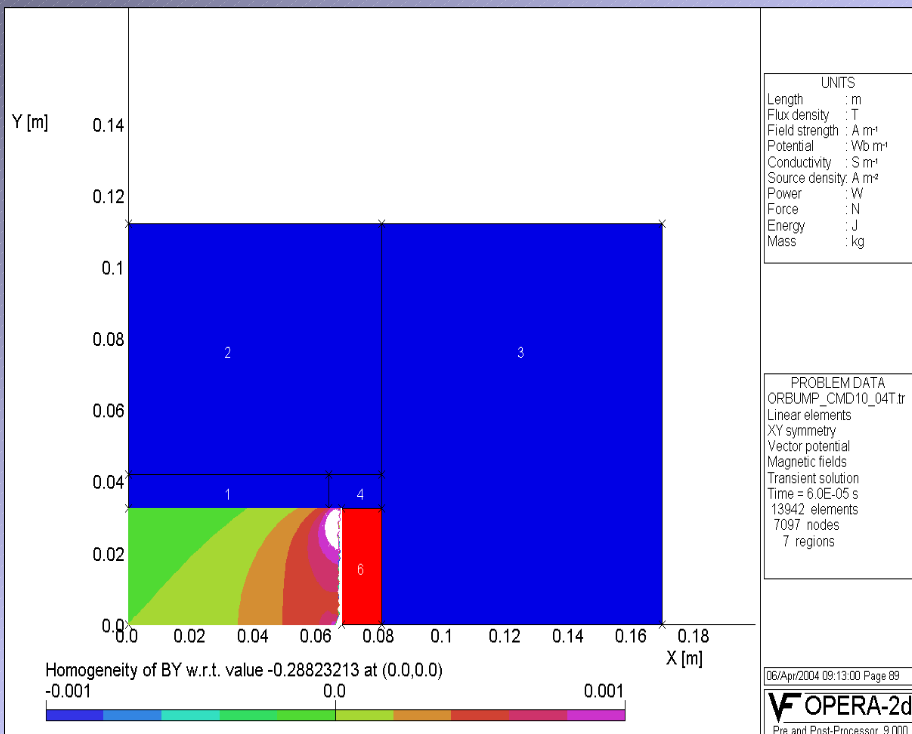
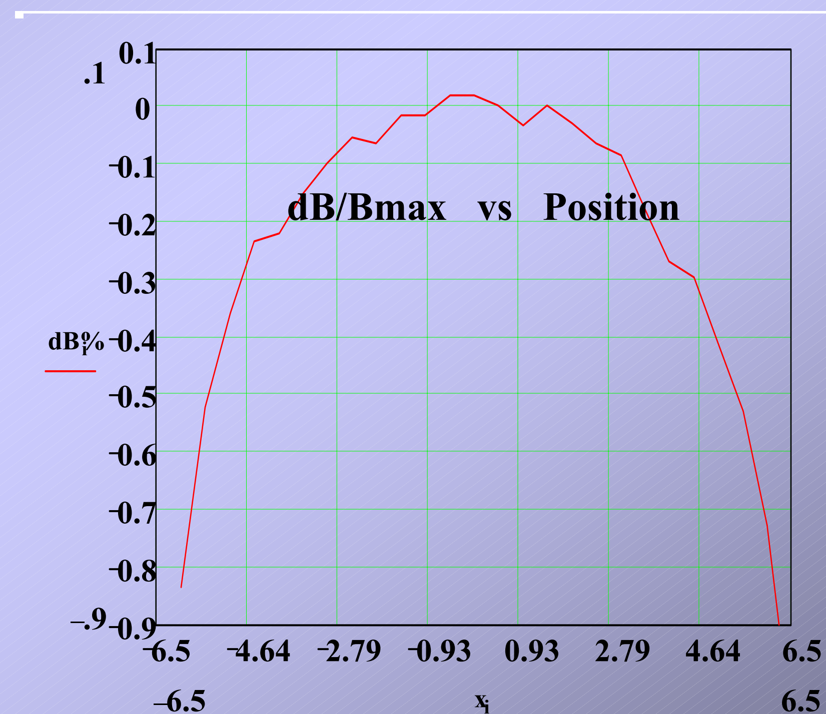


Fig. 9. Flux density at 15 kA with CMD10 Sample 1 measurements. Bo=0.288 T



Present Magnet Field Typical

New Injection Layout