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RHIC Insertion Concepts

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Abstract

In this note, we analyzed several new concepts in the RHIC insertion design. We found that
(1) Lattice can be tuned to obtain a mini-β insertion. However, the required quadrupole **aperture** QX1 and QX2 may be too large, due to the crossing angle, to reach the gradient needed for the mini-β. To obtain a more realistic gradient achievable mini-insertion layout, we also solve the insertion matching with fixed gradient and determine the length of the mini-insertion common quadrupoles(see Appendix). It turns out that the available free experimental area becomes ±3.6m .
(2) A conventional or superferric magnet may be used to replace the BC1 as part of the detector system. This option requires an 8m X 1.76T field strength at 840Tm. The length of this BC1 precludes the possibility of mini β insertion in this configuration. Based on these two options, we concluded however that the lattice design is not the most effective way of reaching higher luminosity due to inherent nature of flexibility of operational modes. It is therefore more important to consider other options, such as improving the source, increasing the number of bunches, or stochastic cooling in order to control the growth of the beam due to the intrabeam Coulomb scattering.

I. Introduction

The users in the second RHIC workshop pointed out some of the following features may be important to the upgrade of the RHIC design:

(1) Higher intensity is helpful and important for certain experiments, while smaller diamond length is very important.
(2) The detector size is about ±6m derived from the workshop design.
(3) BC1 may be used as a spectroanalyzer.

These features indicate that several possible new concepts can be incorporated into the present IR design. Following table lists the parameters of IR design in the present configuration.

Free space	±10m	
BC1	3.3m @4.63T	20 cm coil i.d.
Drift(BC1-BC2)	5.3m	
BC2	4.4m @2.73T	10 cm coil i.d.
Crossing angles	0 mrad 7 mrad	
Operational β^*	6m @ 30 GeV/amu 3m @ 100 GeV/amu$^+$	

& $B\rho$ = 840 Tm

+ β^*=2m may be operable at 100GeV/amu.

Based on the demand of the user's group, there are a few possible considerations for the IR region to be discussed in the following. In section 2, we shall discuss the mini-β insertion, i.e. a pair of quadrupoles will be located between the interaction point and BC1 to reach an even smaller β^*. We discuss a more realistic mini-β insertion design in the appendix. In section 3, we analyze the option of using conventional magnet for BC1. This option may be important to experiments, which use BC1 as a spectroanalyzer. However this option excludes the possibility of a mini-β insertion.

II. Mini-β insertion in RHIC

To reach a highest intensity in the RHIC, a pair of quadrupoles located between BC1 and the experimental detector may be used to obtain a matched smaller beta functions for the interaction point. Figure 1 shows the present configuration of the IR region with the common quadrupoles for the mini-β insertion.

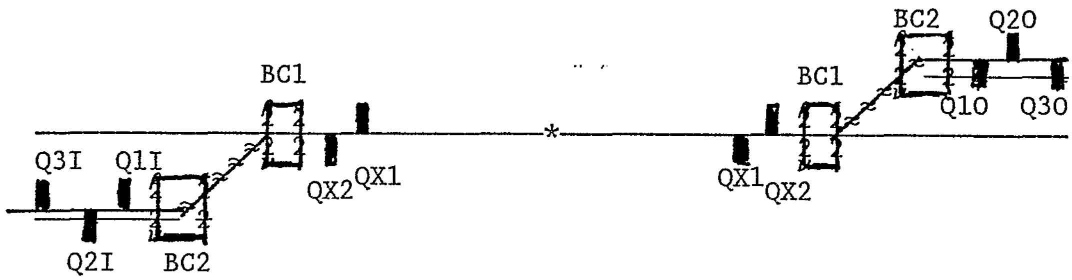

Fig.1 Geometric configuration of MINI insertion

In the norminal insertion, there is no common quadrupoles between BC1's. The distance between the BC1 and the interaction point is ±10 m free space for the expermental instrumentation. The mini-β insertion requires an extra-pairs of quadrupoles shown in Fig.1. The free space available becomes ±6.5 m. Table 1 lists the lattice properties in the insertion region for the mini-β insertion. The beam size requirement (6σ) is calculated for the normalized emittance of ϵ_N=33 π-mm-mrad and dp/p= $1.2\cdot10^{-3}$ at 100 GeV/amu for Au ion at 10 Hours of operation. Figure 2 shows the betatron function at straight section. Figs.3 and 4 show the beam size at the straight section for 100 GeV/amu and 30 GeV/amu respectively.

In comparison with the norminal insertion at the same maximum β function of 400 m, we would expect an enhancement factor of 3.13/2.06 $\approx$ 1.5 to the luminosity in comparison with the standardard insertion. This enhancement factor can be increased up to 2, i.e. the β^* is tuned to 1.5 m, where the betatron function at BC2 becomes about the size of 350m. Assuming a 10cm coil i.d. for BC2, the beta-value of 350m has reach the dynamical aperture limit for BC2. Thus the enhancement factor of 1.5 to 2 can be obtained by the mini-β insertion layout. Table 2 lists also the ratio of the beam size to the magnet coil aperture. The ratio measure the magnitude of nonlinearity experienced by the beam.

Tracking study indicates that 2 out 6 interaction points can be operated at β^*= 3m without the mini-β insertion at *30 GeV/amu*. At 30 GeV/amu, the ratio at Q2 and Q3 is about 0.75. If the tracking result is correct, then the mini-β insertion can also be operated at 30 GeV/amu with β^*= 2 m. At this β^* value, beam size ratio at BC2 is also about 0.75. It is however clear that the mini-β insertion can not give an enhancement factor of 2 at 30 GeV because of the aperture limitation at BC2.

Table 1. Betatron function in the interaction region.

ELEMENTS	S(m)	β_x(m)	$6\sigma_x$(mm)[&]	β_y(m)	$6\sigma_y$(mm)[&]	$\bar{X}_p$(m)	RATIO[+]
Q4I	60.29	25.38	7.90	29.16	7.60	-0.11	.12
Q4I	60.89	26.41	8.01	30.56	7.78	-0.11	
D34I	105.84	400.45	29.41	161.78	17.90	0.17	
Q3I	106.40	400.18	29.42	167.79	18.23	0.18	.46
Q3I	106.97	384.12	28.83	180.80	18.92	0.17	
D23I	112.53	186.71	20.24	384.69	27.60	0.14	
Q2I	113.74	169.78	19.34	399.06	28.11	0.14	.43
Q2I	114.95	187.51	20.37	337.97	25.87	0.15	
D12I	116.23	227.81	22.50	246.63	22.10	0.17	
Q1I	116.98	242.68	23.24	209.45	20.36	0.18	.36
Q1I	117.73	236.90	22.99	192.35	19.52	0.18	
D013	118.73	215.89	21.97	181.39	18.95	0.18	
BC2I	123.13	135.12	17.30	137.07	16.47	0.13	.44
D012	128.43	63.14	11.42	92.21	13.51	0.03	
BC1I	131.73	32.31	8.02	68.96	11.68	0.00	
DX2	132.33	27.86	7.44	65.12	11.36	0.00	
QX2I	132.83	25.88	7.17	58.53	10.77	0.00	
DX1	134.73	24.30	6.95	27.32	7.35	0.00	
QX1I	135.23	22.50	6.69	22.52	6.68	0.00	
DX0	141.73	2.07	2.03	2.07	2.02	0.00	
CR	141.73	2.07	2.03	2.07	2.02	0.00	
DX0	148.23	22.51	6.68	22.52	6.68	-0.00	
QX1O	148.73	27.30	7.36	24.32	6.94	-0.00	
DX1	150.63	58.49	10.77	25.90	7.16	-0.00	
QX2O	151.13	65.05	11.36	27.89	7.43	-0.00	
DX2	151.73	68.84	11.69	32.37	8.01	-0.00	
BC1O	155.03	91.75	13.71	63.41	11.20	-0.03	
D012	160.33	136.07	17.35	135.80	16.40	-0.13	
BC2O	164.73	179.86	20.16	217.01	20.73	-0.18	.42
D013	165.73	190.70	20.75	238.13	21.71	-0.18	
Q1O	166.48	207.62	21.65	243.94	21.98	-0.19	
Q1O	167.23	244.44	23.48	229.00	21.29	-0.21	.36
D12O	168.51	334.90	27.47	188.51	19.32	-0.24	
Q2O	169.72	395.40	29.84	170.69	18.38	-0.26	
Q2O	170.93	381.15	29.29	187.70	19.28	-0.25	.46
D23O	176.50	179.20	20.05	386.03	27.65	-0.17	
Q3O	177.06	166.30	19.31	402.16	28.22	-0.16	
Q3O	177.62	160.35	18.96	402.43	28.23	-0.16	.44
D34O	222.57	30.60	7.86	26.56	7.25	0.01	
Q4O	223.17	29.20	7.69	25.53	7.11	0.01	
Q4O	223.76	26.35	7.32	25.92	7.16	0.01	.12

& The beam size is calculated at 100 GeV/amu at 10 Hours operation.
+ RATIO = BEAM SIZE(6σ) / Magnet Coil Inner Radius

Figure 5 shows the betatron function in the entire insertion region. The phase advance per insertion is increased by $0.05\cdot 2\pi$. The tune of the machine can be readjusted by the phase advance of arc cells. Table 2 lists the quadrupole strength requirement in the mini-β insertion. For 0 degree crossing, the aperture requirement for magnets X1 and X2 is 60 mm coil i.d. for a 10 hours 30 GeV/amu operation. If the mini-β insertion is only intended for 100 GeV/amu operation, the SSC 40 mm coil i.d. magnet may be used. To incorporated with the crossing angle up to 7 mrad, The coil i.d. requirement of magnet X2 becomes 130 mm for 100 GeV/amu operation or 160 mm for 30 GeV/amu operation. The gradient requirement is about 190 T/m for a .5 m long magnet. I can imagine the difficulty of this magnet. As a reference, The 130mm coil i.d. magnets of Q1-Q4 require a gradient of 57 T/m.

Table 2. quadrupole strength for mini-β IR

	LQ(m)	inner $K(m^{-1})$	outer $K(m^{-1})$
X1	0.5000	0.1217	0.1217
X2	0.5000	0.1127	0.1133
G1	1.5107	0.1170	0.1170
G2	2.4209	0.1626	0.1625
G3	1.1225	0.0703	0.0703
G4	0.8327	0.0628	0.0632
G5	1.2531	0.1127	0.1128
G6	1.1916	0.1201	0.1201
G7	1.6037	0.1354	0.1353
G8	1.4168	0.1179	0.1179
G9	1.0344	0.0843	0.0843

From the ratio of table 1, it is clear that RHIC may be operated at higher β function at Q2 and Q3. Recent tracking calculations[3] indicate that RHIC may be operated at $\beta^* = 2$ m, where $\beta_{max} \simeq 625$ m. This gives beam size to the magnet coil i.d. ratio of 0.6 for Q2 and Q3. In this case, the natural chromaticity becomes -70. Thus the sextupoles need extra 23% of strength to correct the chromaticity. If only two-family of sextupoles are needed in the chromatic correction, the 23% of extra strength is included in the sextupole design. This require further studies.

Based on the above assumption that β^*=2m is operable, the mini-β insertion can give 50% increase in luminosity. Thus we can expect to have a factor of 2 in luminosity from this operational mode.

III. Conventional magnet for BC1

If the experimental set up requires only ±6m of free space, it is interesting to use the conventional or superferric magnet for the BC1 suggested by G. Cottingham. In this case the magnet can be used easier for the dual purposes of beam crossing dipole as well as spectroanalyzer. Fig. 6 show the crossing geometry in this configuration. The following table gives relevant parameters.

Free space	±7 m	
BC1	8 m @1.76T&	10"X2"
Drift(BC1-BC2)	4 m	
BC2	4 m @2.69T	10 cm coil i.d.
Crossing angles	0 mrad 9 mrad	
Operational β^*	6m @ 30 GeV/amu	
	3m @ 100 GeV/amu+	

& $B\rho$ = 840 Tm

+ β^*=2m may be operable at 100GeV/amu.

As we have mentioned earlier, this insertion layout excludes the possibility of mini-β insertion. However it gain a very important feature of customizing the BC1 for experimental purposes.

IV. Conclusion.

We have analyzed serveral possible features of different insertion layout(see table 3). We found that the mini-β insertion can only give enhancement factor of 1.5 2 in the luminosity. This is largely determined by the BC2 aperture. On the other hand, RHIC may be operated at $\beta^* = 2$m at 100 GeV/amu without the mini-β insertion. With the mini-β insertion, RHIC may be operated at 1 1.5 m of β^*. Thus the luminosity may be a factor of 2 3 in comparison with that of the RHIC proposal. Magnets X1 and X2 may be difficult to be manufactured due to the large crossing angle requirement.

Table 3. Performance comparison between Norminal & MINI insertion

	Norminal Insertion		MINI Insertion	
Energy(GeV/amu)	30	100	30	100
Operable β^*(m)	3	2	2^+	1.5^+
Maximum β(m)	400	625	400	625
Performance limitation	Q2-Q3	Q2-Q3	BC2,QX1,QX2,Q2-Q3	

+ See the discussion for the difficulty in BX1-BX2

On the other hand, when the luminosity is not a critical issue, an conventional or superferric BC1 magnet is very attractive option as well. In this case, the luminosity can not be increased by mini-β insertion. However $\beta^* = 2$m may still be operable.

Besides the above mentioned options, there are a few other concepts:

(1) Move BC1-BC2 unit forward 3m so that the first quadrupole is located at 21m instead of 24m in the present configuration. The luminosity in this case is increased only 20%.

(2) Move BC1-BC2 unit backward so that a set of triplet to obtain the small β^*. This option has a few drawback as well.
   a. The triplet are common quadrupoles for colliding beams. Thus they can not be used for the unequal species. The luminosity for the unequal species collision will be low.
   b. The BC1 would encounter large β function and require even larger magnet paerture.
   c. Aperture limitation for the crossing angle is even larger.

Because of these limitations, the later options are not studied further.

Based on the present study, we conclude that the lattice may not be the best option for higher luminosity operation in RHIC. It would more fruitful to study the following problems,

- Source improvement
- feasibility of increasing the number of bunches
- Stochastic cooling feasibility

Appendix:

To obtain a realistic mini-insertion quadrupoles, we shall assume a constant transfer function of having $B'/B = 19.325\ m^{-1}$ similar to the RHIC regular quadrupoles and then search for a solution of mini-β insertion with allowable quadrupole length. The length of these mini-β quadrupoles are LQX1=1.5925m and LQX2= 1.3117 m. The free insertion space becomes ± 3.6 m or 7.2 m . In this configuration, the lattice can be tuned to 1.5m without much impact on the beam size in the insertion region. The quadrupole strength is given in table A.1 and the lattice function is given in Table A.2.

Table A.1 Quadrupole strength(m^{-1}) in the MINI insertion
LQX1= 1.5925m LQX2= 1.3117 m

β^*(m)	2		1.5	
Quads	Inner	Outer	Inner	Outer
K1	1.0000	0.9990	1.4098	1.4099
K2	1.0000	1.0063	1.3478	1.3464
G1	1.0243	1.0240	1.0443	1.0436
G2	0.8382	0.8376	0.8075	0.8076
G3	0.7338	0.7331	0.6871	0.6869
G4	0.9219	0.9266	0.9429	0.9445
G5	1.1333	1.1358	1.1666	1.1699
G6	1.2838	1.2849	1.4632	1.4634
G7	1.0625	1.0636	1.0766	1.0766
G8	1.0254	1.0259	1.0342	1.0338
G9	1.0275	1.0286	1.0343	1.0304

+ The length of quadrupoles Q1-Q9 are obtained via. the standard insertion layout.

The essential problem in the mini-insertion scheme is the mini-quadrupole paerture vs. the crossing angle problem. At 5 mrad angle crossing, the required aperture becomes 42mm PLUS the required beam size of 44 mm at β^*= 1.5m and 38 mm at β^*= 2m. Thus the coil i.d. of these magnet should be 130 mm or larger. At 7 mrad crossing angle, the aperture requirement of QX2 would be 160mm coil i.d.. In the above calculation we have assumed,

B' = 56.0 T/m for Q1-Q4 with coil i.d. of 130mm.
B' = 66.7 T/m for other quadrupoles.

Therefore the length of QX2 may require even longer due to the obtainable gradient.

Table A.2 MINI INSERTION lattice properties

		β^* = 2m				β^* = 1.5m			
NAME	S	QX	BX	QY	BY	QX	BX	QY	BY
	-141.73	0.00	50.22	0.00	8.49	0.00	50.22	0.00	8.49
"Q9I	-141.73	0.00	50.22	0.00	8.49	0.00	50.22	0.00	8.49
Q9I	-141.30	0.00	49.46	0.01	8.65	0.00	49.45	0.01	8.65
D89I	-120.88	0.16	12.21	0.15	77.48	0.16	12.08	0.15	77.63
Q8I	-120.20	0.17	12.61	0.15	78.66	0.17	12.49	0.15	78.78
"Q8I	-120.20	0.17	12.61	0.15	78.66	0.17	12.49	0.15	78.78
Q8I	-119.52	0.17	14.08	0.16	74.03	0.18	13.97	0.16	74.08
D78I	-114.15	0.21	37.16	0.17	27.64	0.21	37.21	0.17	27.17
Q7I	-113.36	0.22	39.62	0.18	24.11	0.22	39.68	0.18	23.61
"Q7I	-113.36	0.22	39.62	0.18	24.11	0.22	39.68	0.18	23.61
Q7I	-112.56	0.22	37.97	0.18	23.33	0.22	37.98	0.18	22.79
I672	-111.46	0.22	33.10	0.19	24.08	0.23	33.01	0.19	23.47
BS2	-102.01	0.32	7.84	0.24	35.19	0.33	7.48	0.25	33.96
I671	-100.16	0.37	6.37	0.25	38.35	0.37	6.08	0.26	37.01
Q6I	-99.58	0.38	6.36	0.26	38.09	0.39	6.12	0.26	36.59
"Q6I	-99.58	0.38	6.36	0.26	38.09	0.39	6.12	0.26	36.59
Q6I	-99.01	0.39	6.89	0.26	35.34	0.40	6.75	0.26	33.45
I562	-96.01	0.44	13.13	0.28	18.19	0.45	13.97	0.28	14.84
BS1I	-91.50	0.48	29.96	0.36	4.35	0.49	33.32	0.42	2.41
I561	-89.24	0.49	41.77	0.47	2.83	0.49	46.87	0.57	3.25
Q5I	-88.67	0.49	43.81	0.50	3.11	0.50	49.20	0.59	4.31
"Q5I	-88.67	0.49	43.81	0.50	3.11	0.50	49.20	0.59	4.31
Q5I	-88.11	0.50	43.40	0.53	3.80	0.50	48.69	0.61	5.98
D45I	-81.47	0.53	27.13	0.63	34.18	0.53	29.38	0.67	61.47
Q4I	-80.86	0.53	26.68	0.63	37.93	0.53	28.76	0.67	67.90
"Q4I	-80.86	0.53	26.68	0.63	37.93	0.53	28.76	0.67	67.90
Q4I	-80.25	0.53	27.74	0.63	39.74	0.53	29.81	0.67	70.72
D34I	-35.48	0.60	397.63	0.73	164.06	0.60	397.42	0.73	177.66
Q3I	-34.91	0.60	397.82	0.73	169.66	0.60	397.98	0.73	182.74
"Q3I	-34.91	0.60	397.82	0.73	169.66	0.60	397.98	0.73	182.74
Q3I	-34.34	0.60	383.22	0.73	181.91	0.60	384.67	0.73	194.47
D23I	-28.38	0.61	189.08	0.73	386.63	0.60	203.20	0.74	388.68
Q2I	-27.17	0.61	174.94	0.73	397.80	0.60	191.18	0.74	397.95
"Q2I	-27.17	0.61	174.94	0.73	397.80	0.60	191.18	0.74	397.95
Q2I	-25.96	0.61	196.13	0.73	334.78	0.61	216.37	0.74	335.70
D12I	-24.50	0.61	247.79	0.73	231.02	0.61	274.92	0.74	233.80
Q1I	-23.75	0.61	264.73	0.73	194.35	0.61	294.19	0.74	198.11
"Q1I	-23.75	0.61	264.73	0.73	194.35	0.61	294.19	0.74	198.11
Q1I	-23.00	0.61	257.84	0.73	177.52	0.61	286.47	0.74	182.78
D013	-22.00	0.61	233.46	0.74	166.73	0.61	258.97	0.74	174.36
BC2I	-17.60	0.62	140.67	0.74	123.39	0.61	154.54	0.75	139.74
D012	-12.30	0.63	60.22	0.75	80.16	0.62	64.59	0.75	103.42
BC1I	-9.00	0.64	27.44	0.76	58.17	0.63	28.40	0.76	83.74
DX2	-8.40	0.64	22.90	0.76	54.59	0.64	23.45	0.76	80.41
QX2I	-7.09	0.65	16.95	0.76	40.73	0.65	17.73	0.76	60.31
DX1	-5.19	0.67	13.10	0.77	18.26	0.67	15.35	0.77	24.36
QX1I	-3.60	0.70	8.50	0.80	8.50	0.68	10.15	0.79	10.15
DX0	0.00	0.87	1.99	0.96	1.99	0.87	1.50	0.98	1.50
"CR	0.00	0.87	1.99	0.96	1.99	0.87	1.50	0.98	1.50

"CR	0.00	0.87	1.99	0.96	1.99	0.87	1.50	0.98	1.50
DX0	3.60	1.04	8.50	1.13	8.50	1.06	10.15	1.16	10.15
QX10	5.19	1.06	18.25	1.16	13.11	1.08	24.36	1.18	15.35
DX1	7.09	1.07	40.72	1.18	16.96	1.08	60.31	1.20	17.72
QX20	8.40	1.07	54.52	1.19	22.93	1.09	80.42	1.21	23.44
DX2	9.00	1.07	58.06	1.19	27.49	1.09	83.72	1.21	28.39
BC10	12.30	1.08	79.72	1.21	60.49	1.09	103.50	1.23	64.55
D012	17.60	1.09	122.41	1.21	141.39	1.10	140.12	1.24	154.27
BC20	22.00	1.10	165.21	1.22	234.68	1.10	175.07	1.24	258.36
D013	23.00	1.10	175.87	1.22	259.17	1.11	183.59	1.24	285.75
Q10	23.75	1.10	192.52	1.22	266.09	1.11	199.03	1.24	293.43
"Q10	23.75	1.10	192.52	1.22	266.09	1.11	199.03	1.24	293.43
Q10	24.50	1.10	228.81	1.22	249.07	1.11	234.91	1.24	274.21
D120	25.96	1.10	331.50	1.22	197.15	1.11	337.34	1.24	215.81
Q20	27.17	1.10	393.87	1.22	175.85	1.11	399.93	1.24	190.70
"Q20	27.17	1.10	393.87	1.22	175.85	1.11	399.93	1.24	190.70
Q20	28.38	1.10	382.83	1.22	190.02	1.11	390.63	1.24	202.70
D230	34.34	1.10	180.30	1.23	384.85	1.11	195.52	1.25	383.80
Q30	34.91	1.10	168.17	1.23	399.50	1.11	183.72	1.25	397.09
"Q30	34.91	1.10	168.17	1.23	399.50	1.11	183.72	1.25	397.09
Q30	35.48	1.10	162.63	1.23	399.31	1.11	178.63	1.25	396.55
D340	80.25	1.20	39.97	1.30	28.03	1.18	71.17	1.31	30.08
Q40	80.86	1.20	38.16	1.30	26.96	1.18	68.32	1.32	29.04
"Q40	80.86	1.20	38.16	1.30	26.96	1.18	68.32	1.32	29.04
Q40	81.47	1.20	34.39	1.30	27.43	1.18	61.84	1.32	29.68
D450	88.09	1.30	3.82	1.33	44.04	1.24	6.02	1.35	49.34
Q50	88.66	1.33	3.11	1.34	44.47	1.25	4.33	1.35	49.87
"Q50	88.66	1.33	3.11	1.34	44.47	1.25	4.33	1.35	49.87
Q50	89.22	1.36	2.83	1.34	42.40	1.28	3.26	1.35	47.51
O561	91.50	1.47	4.33	1.35	30.32	1.43	2.41	1.36	33.66
BS10	96.01	1.56	18.21	1.38	13.24	1.57	14.93	1.39	14.04
O562	99.02	1.57	35.53	1.44	6.86	1.59	33.81	1.44	6.70
Q60	99.60	1.58	38.30	1.45	6.31	1.59	36.98	1.46	6.05
"Q60	99.60	1.58	38.30	1.45	6.31	1.59	36.98	1.46	6.05
Q60	100.17	1.58	38.56	1.46	6.31	1.59	37.40	1.47	6.00
O671	102.05	1.59	35.34	1.51	7.76	1.60	34.27	1.52	7.38
BS2	111.50	1.64	24.13	1.61	32.90	1.65	23.57	1.62	32.89
O672	112.62	1.65	23.36	1.61	37.84	1.66	22.86	1.63	37.94
Q70	113.41	1.65	24.14	1.62	39.49	1.67	23.67	1.63	39.66
"Q70	113.41	1.65	24.14	1.62	39.49	1.67	23.67	1.63	39.66
Q70	114.20	1.66	27.68	1.62	37.03	1.67	27.23	1.64	37.20
D780	119.57	1.68	74.15	1.66	14.04	1.69	74.10	1.67	14.02
Q80	120.25	1.68	78.78	1.67	12.57	1.69	78.80	1.68	12.54
"Q80	120.25	1.68	78.78	1.67	12.57	1.69	78.80	1.68	12.54
Q80	120.93	1.68	77.60	1.67	12.17	1.69	77.64	1.69	12.14
D890	141.35	1.82	8.62	1.83	49.62	1.84	8.62	1.85	49.62
Q90	141.78	1.83	8.46	1.83	50.39	1.85	8.46	1.85	50.39
"Q90	141.78	1.83	8.46	1.83	50.39	1.85	8.46	1.85	50.39