JLAB-TN-05-075

Optics of QDD Spectrometer

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1. Constraints of optical optimization

This study aims several points in SHMS optics design:

- The total optical length should be shorter than 18 m
- The minimum scattering angle should be about 5^0
- The gradient of first quad should be less than 0.6 Tesla/cm
- The combined function element should not be used
- Overlap in phase space should be avoided
- Quad dominant optics should be changed to dipole mode

2. Specification of QDD

Optical length	15.73 m
Bending angle	18.32^o
Focusing mode	point-to-point in both planes
Maximum rigidity	400 kG m
Maximum central momentum	12 GeV/c
Minimum scattering angle	5.5^o
Maximum target length	30 cm
Vertical acceptance	± 55 mr
Horizontal acceptance	± 12 mr
Maximum solid angle	2 msr
Momentum acceptance	± 20%
Momentum resolution	10^{-3}
Dispersion	2.86 cm/%
D/M	0.09
Vertical magnification	3.16
Horizontal magnification	0.24
Focal plane angle	1.77^o
Length of quad	1.89 m
Physical aperture of quad	± 10 cm, ± 30 cm
Nominal gradient at 12 GeV/c	5.6 Tesla/m
Length of D_1, D_2	1.6 m
Bending angle of D_1, D_2	9.16^o
Rotation α/β of D_1	-60^o / 53.27^o
Rotation α/β of D_2	60^o / 60^o
Nominal field of $D_{1,2}$	4 Tesla

3. The TRANSPORT input deck file of QDD

```
'QDD spectrometer, 30 cm target, 2 msr, 09/20/05, Tursday'
0
ORDER                                                  '2-nd';
PLOT   L, XBEAM, YBEAM, R12, R34, R16, R52              ;
BEAM      0.01   55.   1.44   12.   0.   10.   12.    'BEAM';
DRIFT     4.64                                         'DRF1';
QUAD      1.89      13.77682      25.                  'Q001' ;
DRIFT     1.00                                         'DRF2';
ROTAT     -60.                                         'ROT1';
BEND      1.6           40.             0.             'D001';
ROTAT     53.26939                                     'ROT2';
DRIFT     1.00                                         'DRF3';
ROTAT     60.                                          'ROT3';
BEND      1.6           40.             0.             'D002';
ROTAT     60.                                          'ROT4';
DRIFT     4.0                                          'DRF4';
-FIT      -1.       2.      0.      0.0001             'FIT1';
-FIT      -3.       4.      0.      0.0001             'FIT2';
-FIT      -5.       2.     -0.1     0.0001             'FIT3';
PRINT      4.                                             ;
SENTINEL
SENTINEL
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*) $\Delta\theta$ = 55 mr, $\Delta\varphi$ = 12 mr, $\rightarrow$ $\Delta\Omega = \pi\,\Delta\theta\,\Delta\varphi$ = 2 msr

**) L_{target} = 30 cm, at 5.5^{o} and 4.64 m away from target, Δy = 1.44 cm

4. Envelope output file of QDD ($\Delta p/p = \pm 10\%$)

LENGTH	XBEAM	YBEAM	R12	R34	R16	R52
0.00000	0.01000	1.44000	0.00000	0.00000	0.00000	0.00000
4.64000	25.52000	5.75119	0.46400	0.46400	0.00000	0.00000
6.53000	29.06901	9.62573	0.52839	0.78772	0.00000	0.00000
7.53000	27.18751	12.73043	0.49372	1.04421	0.00000	0.00000
9.13000	16.72419	21.24984	0.29603	1.74377	0.12764	-0.06327
10.13000	12.78998	23.70482	0.20922	1.94749	0.30394	-0.06327
11.73000	13.04773	21.07589	0.12594	1.73408	0.79240	-0.09012
15.73000	34.96133	4.57166	0.00000	0.00000	2.86247	-0.09012
20.73000	65.70344	28.70680	-0.15742	-2.16760	5.45005	-0.09012

5. Output table of first order matrix element

-3.17624	0.00000	0.00000	0.00000	0.00000	2.86247
-5.51983	-0.31484	0.00000	0.00000	0.00000	5.17516
0.00000	0.00000	-0.23067	0.00000	0.00000	0.00000
0.00000	0.00000	-6.24872	-4.33519	0.00000	0.00000
0.06372	-0.09012	0.00000	0.00000	1.00000	-0.09123
0.00000	0.00000	0.00000	0.00000	0.00000	1.00000

6. Large solid angle mode

   This tune could be carried out by either move entire spectrometer as a rigid body towards target by 2.32 m or insert a septum magnet between target and the quad. The two methods are equivalent in optics.

   Condition: momentum p_0 = 12 GeV/c,
   dipole magnet as the same as original QDD (4 Tesla)
   retune the quad to get final focusing

   Results: $\Delta\Omega$ = 4 msr (110 mr, 12 mr)
   $G_{12\ Gev/c}$ = 8.76 Tesla/m (6.05 Tesla/m for present Q_1)

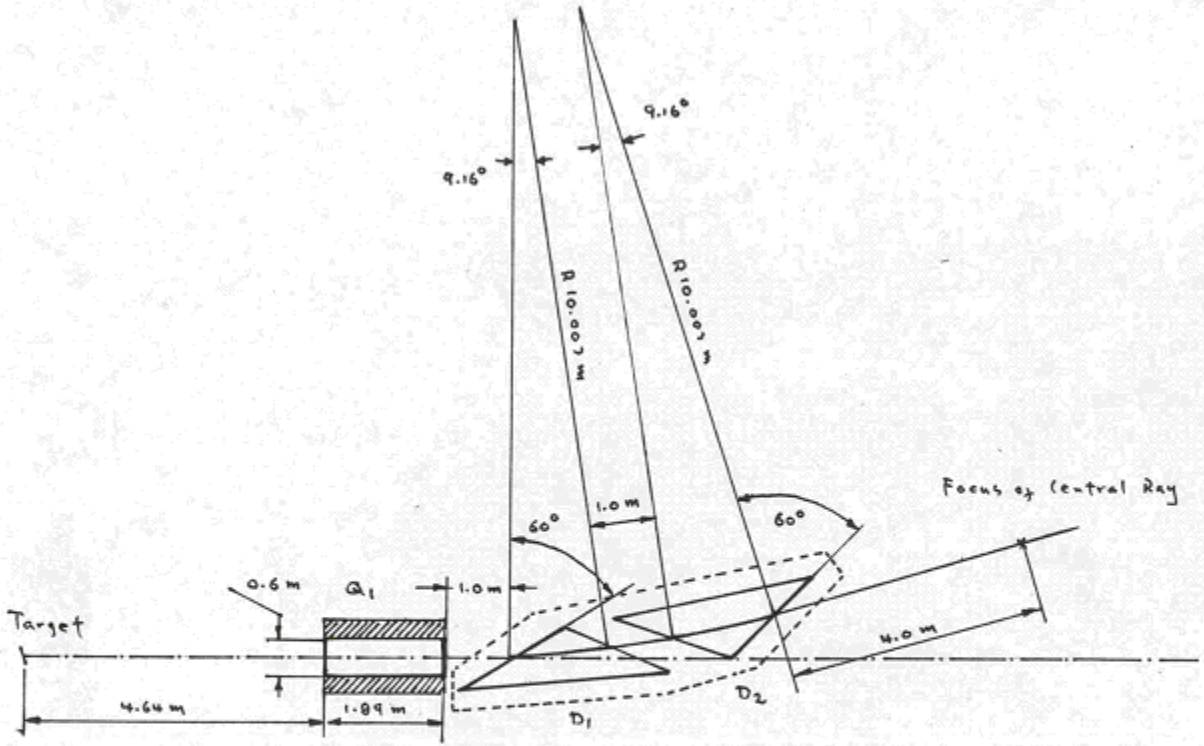
-5.37173	0.00000	0.00000	0.00000	0.00000	2.86247
-8.94317	-0.18616	0.00000	0.00000	0.00000	5.17516
0.00000	0.00000	0.01476	0.13391	0.00000	0.00000
0.00000	0.00000	-7.84004	-3.37571	0.00000	0.00000
0.22000	-0.05329	0.00000	0.00000	1.00000	-0.09123
0.00000	0.00000	0.00000	0.00000	0.00000	1.00000

7. Comparison of QQQD and QDD

Configuration	QQQD	QDD
Total optical length in	18.5	15.73
Maximum Q_1 gradient in T/m	8.7	5.6
Maximum target length in cm	15	30
Minimum scattering angle in ^{0}	5.5 (notch)	5.5
Dispersion (cm/%)	1.8	2.86
D/M	-0.12	-0.09
x/x	-1.5	- 3.17
y/y	-1.05	- 0.23
Quad length in m	> 1.89	1.89
Dipole length in m	3.2	2x1.6
Focal plane tilt in ^{o}	7.6	1.77
P_0 in large solid angle tune (GeV/c)	8.5	12
Solid angle	4.4	4.0
Special component	CF dipole	-

8. Remarks

   This study is to try to find a reasonable solution for SHMS design based on TRANSPORT second order optics and engineering availability. The frame work is easy to change, modify, and to add other constraints.



12 Gev/c setting

$B_0(Q_1) = 1.377$ Tesla

$G_0(Q_1) = 5.6$ T/m

$B_0(D_1/D_2) = 4$ Tesla

QDD GEOMETRY

Total linear length ≈ 15.5 m