FINAL FOCUS QUADRUPOLE FOR THE CRAB-WAIST TAU-CHARM FACTORY

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Abstract

In the crab-waist colliders design of the final focus region is a matter of primary importance. The paper describes analysis of final focus quadrupole design.

INTRODUCTION

A project of the tau-charm factory with the luminosity $\geq 1\cdot 10^{35}$ $cm^{-2}s^{-1}$ is now under development at BINP (Novosibirsk) [1]. To reach such luminosity a novel concept of the crab-waist collision is planned to be applied at the collider [2-3]. Main parameters of the factory are listed in Table 1 while its schematic view is shown in Fig.1.

Table 1: C-τ factory parameters

Energy	GeV	1.5-2.5
Beam current	A	1.36
Number of bunches		295
Hor.beta at IP, β^*_x	mm	20
Vert.beta at IP, β^*_z	mm	0.76
Hor.emittance, ε_x	nm·rad	10
Coupling, $\varepsilon_x/\varepsilon_z$	%	1
Bunch length	mm	1
Crossing angle	mrad	34
Tune shift parameter		0.13
Particles per bunch		$7\cdot 10^{10}$
Luminosity	$cm^{-2}s^{-1}$	$1\cdot 10^{35}$
Circumference	m	749.5

One of the most challenging tasks for such colliders is the final focus design and the final focus quadrupole development. In this paper we discuss the main parameters of the final focus quadrupoles and estimate their parameters.

FINAL FOCUS QUADRUPOLES

Requirements to the final focus design

Besides the parameters listed in Table 1 and needed to reach the luminosity of 10^{35} $cm^{-2}s^{-1}$, the final focus (FF) design should satisfy the following requirements [4]:

- No bend for incoming beam (SR background reduction)
- No longitudinal field integral over each FF lens
- Longitudinal field is compensated before the FF lens
- Interaction region length less than 100 m
- Proper betatron phase advance for the crab sextupoles
- Extremely low β^*_z and low β^*_x
- Extremely compact FF quadrupoles (because they are placed inside the detector) with rather high field quality

The main detector features are:

- The length of the vertex detector is 60 cm
- The first quadrupole should cover about 15-17° of the detector solid angle
- The length of the SC detector solenoid is ~4 m

FF design

The FF quadrupole design is defined primarily by the optical functions at the IP, the crossing angle and the transverse beam size at the IP. These parameters, together with the detector requirements, allow us to determine the quadrupole strength, length and position. Main parameters of the first FF doublets are listed in Table 2 while the beam trajectories and schematic view of the interaction region is shown in Fig.2.

FF quadrupoles

At the moment two approaches of the first single-aperture quadrupole QD0 are under consideration (a) superconducting iron free magnet and (b) superconducting magnet with iron yoke and variable (cone-like) aperture. The second two-aperture lens QF0 is actually two joined quadrupoles in a single cryostat. Both quadrupoles are shielded from the detector field by a solenoidal coil.

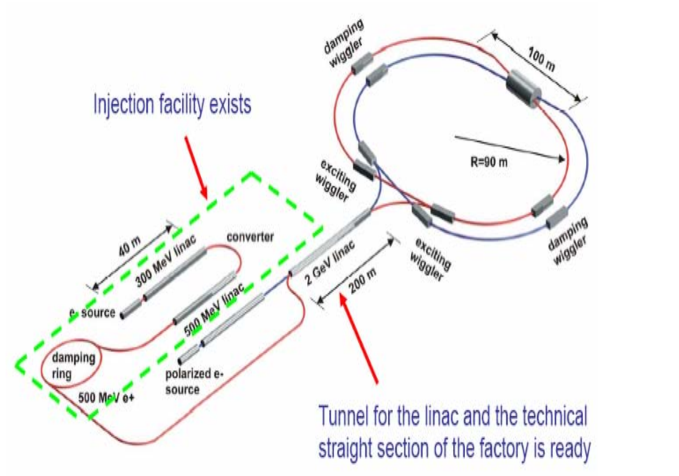

Fig.1: Schematic layout of C-τ factory (at the

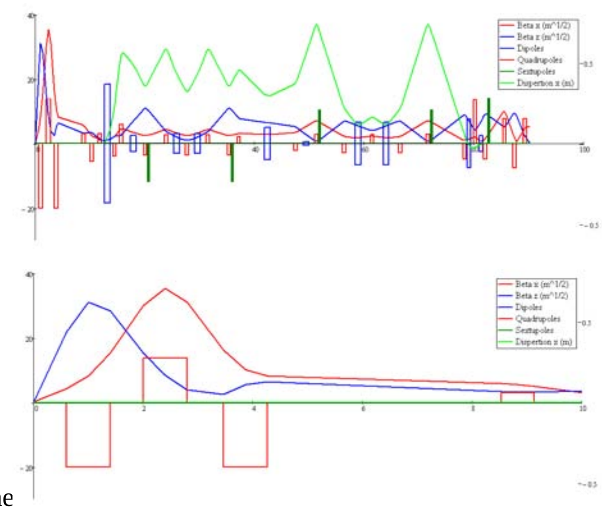

Table 2: FF quadrupoles parameters

Lens	Type	Inscribed radius, cm	Gradient, T/m	Tilt angle	Length, cm	Distance to IP, cm
QD0	Single-aperture superconducting	10	-21	4.8° for outgoing beam	80	60
QF0	Twin-aperture superconducting	5	15	0	80	200

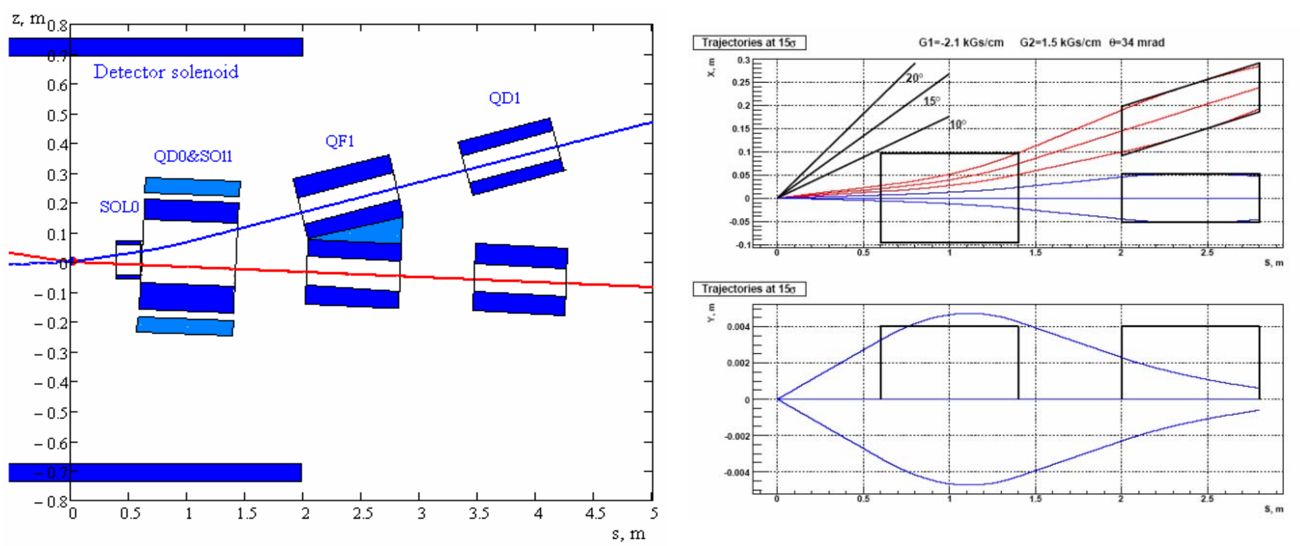

Fig 2 Schematic layout of Final Focus

QD0 quadrupole

We have failed to develop a conventional room-temperature quadrupole QD0 because of substantial overall dimensions of such a magnet. After some consideration we have decided to design the QD0 quadrupole as a superconducting magnet with cosine coils. BINP has the experience in the development of such magnets, which are simple in manufacturing and compact. As a drawback of this solution the requirement of the detector solenoid field shielding could be mentioned.

The QD0 coil consists of 6 layers and 3 sections with 126 turns, 96 turns and 36 turns in the sections from 1 to 3, respectively. For the field calculation we used a SC conductor of 0.9 mm ×1.9 mm (0.98 mm ×1.98 mm including insulation). For the gradient of 21 T/m, the nominal current is equal to 1.3 kA and the maximum value of magnetic field in the coils is 1.3 kA. The critical current for this type of the conductor is 1.6 kA at 4.2 K.

All layers are fed by the single power supply. Besides two last sections additionally have correction power supplies.

Results of the magnetic field simulation are shown in Table 3 and in Fig.3.

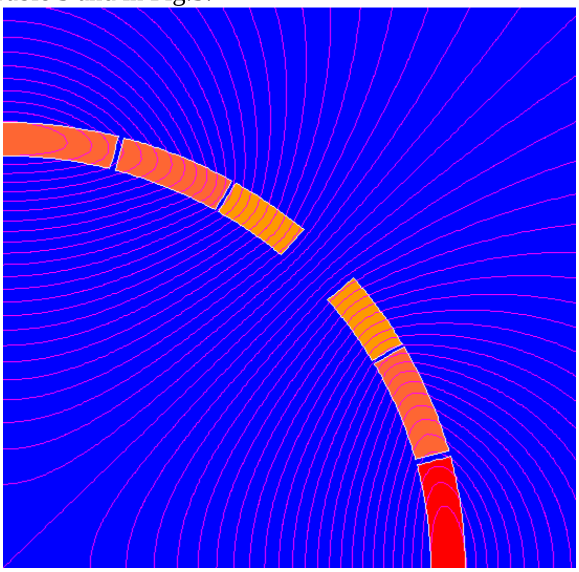

Fig.3 Current layers and flux lines for QD0 lens

Table 3 Harmonics field amplitude for QD0

Harm number	*B* (kG) at *R* = 10 cm	B (kG) at *R* = 1 cm
2	23.65	2.365
4	-8.50E-06	-1.00E-07
6	9.30E-05	1.00E-07
8	-2.15E-05	0.00E+00
10	-2.71E-04	-1.00E-07
12	6.00E-07	0.00E+00
14	5.59E-02	3.48E-05

QF0 quadrupole

QF0 is a twin-aperture magnet composed of two joined quadrupoles. Small vertical beam size as at the QF0 azimuth allows designing the quadrupole with rectangular aperture with large horizontal size and small vertical size as it is shown in Fig.4. Such a design provides a compact magnet with the required gradient and field quality. The field harmonic content for QF0 is presented in Table 4.

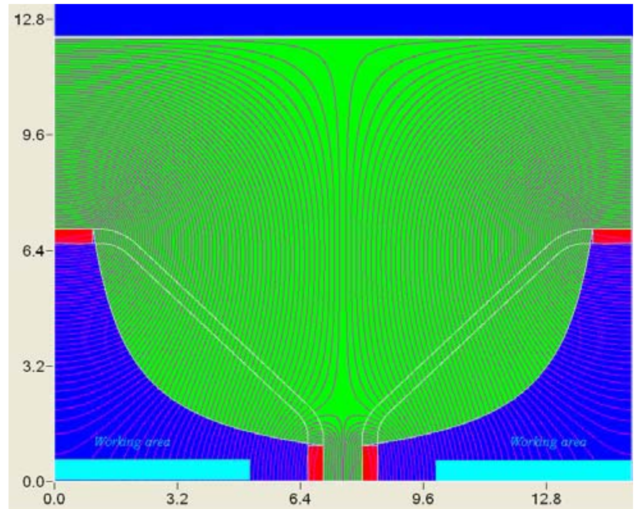

Fig.4 Working aperture and flux lines for QF0 quadrupole

Table 4 Harmonics field amplitude for QF0

Harm number	*B* (kG) at *R* = 10cm	*B* (kG) at *R* = 1 cm
2	-2.26	-0.902
4	-4.97E-05	-1.91E-05
6	1.24E-03	1.53E-03
8	-2.20E-06	-1.80E-05
10	-6.72E-05	-6.40E-03
12	1.20E-06	1.98E-03
14	1.94E-05	8.12E-01

CONCLUSIONS

Draft final focus quadrupoles design is considered and the quadrupoles parameters are chosen to fulfill characteristics of the tau-charm factory with the luminosity of 10^{35} $cm^{-2}s^{-1}$. Particular requirements of the final focus design and the detector are taken into consideration. Our plan is to continue the detailed 3D magnets study.

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