DAΦNE UPGRADE: A NEW MAGNETIC AND MECHANICAL LAYOUT

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Abstract

The DAΦNE Φ-Factory upgrade, foreseen for the SIDDHARTA detector run in 2007, requires a new magnetic and mechanical layout to exploit the "large Piwinski angle" and "crab waist" concepts [1]. New permanent quadrupole magnets and aluminium vacuum chamber with thin window have been designed for the new interaction region, with the aim to reuse as far as possible the present magnetic and vacuum chamber components. A vacuum chamber of novel design will allow separating the beams at the second interaction region. The new layout together the new hardware components are presented.

INTRODUCTION

The SIDDHARTA experiment will be ready to be installed in DAΦNE by fall 2007. A new Interaction Region (IR) suitable to exploit the "large crossing angle" and "crab waist" concepts has been designed and is under construction. This new scheme for luminosity increase in e^+e^- colliders, first presented at the 2nd Frascati Workshop on SuperB-Factory, March 2006 [2], is compatible with the SIDDHARTA setup. A combination of large crossing angle, together with very small beam sizes at the IP, and the "crab vertical waist", is expected to give the possibility of reaching a luminosity of the order of 10^{33} cm^{-2} s^{-1}, with small modifications to the machine and beam currents similar to those reached during the KLOE run.

DAΦNE UPGRADE GENERAL LAYOUT

The need to have a very small β_y and a large crossing angle requires two new IR geometries. Defocusing and focusing (QD, QF) quadrupoles on both sides of the interaction point (IP) will provide the necessary beam focusing and beam separation. Further trajectory separation will be provided by two small dipole correctors upstream and downstream the quadrupole doublets. Other three quadrupoles will be used to match the betatron functions in the arcs. In this scheme there will be no need for the presently used splitter dipoles. The general layout of DAΦNE upgrade is shown in figure 1.

IR1 Magnetic and mechanical layout

The total crossing angle at the IP1 will be 50 mrad (25 mrad per beam). The low-β section quadrupoles near the IP are of permanent magnet (PM) type.

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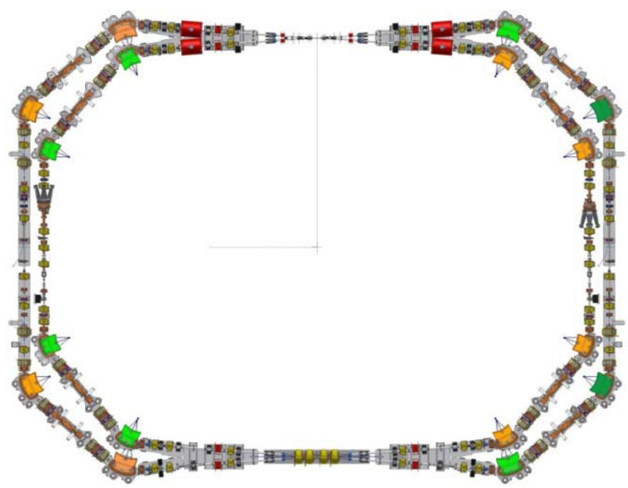

Figure 1: DAΦNE upgrade general layout.

A set of two QD and four QF is required. Their characteristics have been studied and a summary of them is given in table 2. A close-up of the near IP1 region is shown in figure 2.

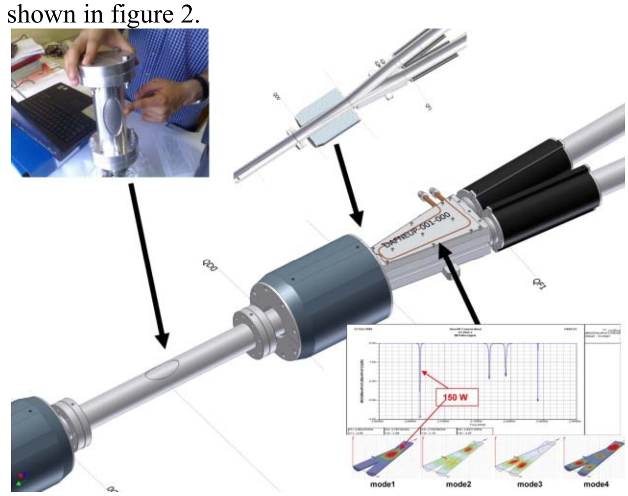

Figure 2: IP1 low-β permanent magnet and thin chamber.

Four corrector dipoles will be used with deflection of 9.5 mrad to match the inlet and outlet arc chamber flanges. Sextupoles for the crab waist are placed at 9.3 m from the IP1. Bending dipoles facing the IRs will be rotated and the field adjusted according to table 1.

Table 1: Bending Dipoles Adjustment

Dipole name	Rotation angle (deg)	Bending radius(mm)
Sector Long	+2.19	1528.11
Sector Short	-2.19	1269.76

1-4244-0917-9/07/$25.00

Other elements just after the doublets (quadrupoles, sextupoles and correctors) are those already in place; only their positions have to be rearranged. Figure 3 shows a drawing of half the modified (top) and old (bottom) IR1.

Table 2: low-β PM quadrupoles specifications

Designation	**QD**	**QF**
Quantity	2	4
Minimum clear inner radius (mm)	33	30
PM inner radius (mm)	34	30.5
Maximum outer radius (mm)	100	45
Magnetic length (mm)	230	240
REM physical length (mm)	230	240
Maximum mechanical length (mm)	240	250
Nominal gradient (T/m)	29.2	12.6
Integrated gradient (T)	6.7	3.0
Good field region radius (mm)	20	20
Integrated field quality |dB/B|	5.00E-04	5.00E-04
REM stabilization temperature (°C)	150	150
Magnet material type	SmCo2:17	SmCo2:17
Magnet construction	2 halves	2 halves

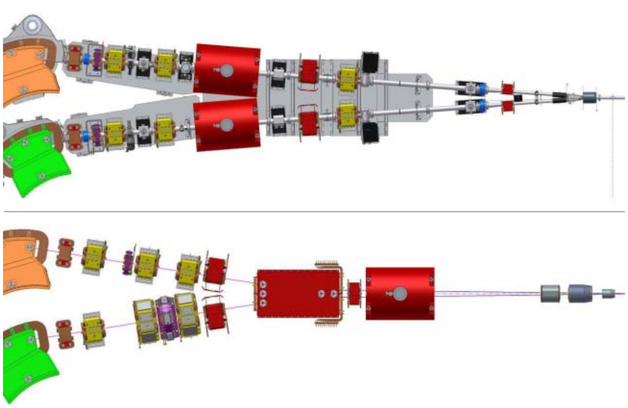

Figure 3: View of the new (top) and old (bottom) IR1 region (half).

Solenoid compensator magnets (the red cylinders in figure 3) will not be installed for the SIDDHARTA experiment because there is no detector solenoid at the IP but the new layout already foresees the possibility to reinstall KLOE or FINUDA in the future. Most vacuum chambers and pumps will be reused. The beam pipe around IP1 and in the two QDs will be common to the two beams and will start to bifurcate just before the QFs. For the SIDDHARTA experiment, which will be installed on the IP1, a new aluminium alloy (AL6082T6) chamber has been designed with two thin windows (0.3mm ±0.02 thickness) in the top and bottom sides (see figure 2). A prototype has been built and a mechanical and vacuum test performed. In the Y-chamber junction, in the worst possible scenario, when one of the powerful beam spectrum lines (at RF frequency harmonics) is in full coupling with this mode, the power loss will not exceed 200 W. Despite such a power seems to be manageable, we still decided to cool the chamber as shown in figure 2. This additional cooling will play a double role: to eliminate heating due to the high order modes (HOM), if necessary, and to shift the mode frequency with respect to the dangerous power spectrum lines, thus reducing the heating itself. Horizontal collimators are placed at 8 m from the IP.

IR2 Magnetic and Mechanical Layout

Similar modifications were made in the second interaction region, where the beams will not experience a low-beta insertion and will be vertically separated in order to avoid collisions. A layout of half IR2 is presented in figure 4, the original layout was very similar to the old IR1 section shown in figure 3. The magnet layout is almost the same as IR1 with the exception of sextupoles for crab waist, not present here and four large aperture quadrupoles in IP2. A new design of the central IR2 beam pipe, where the two beams are vertically separated, is shown in figure 5. The two vacuum chambers are completely separated and the cross section is “half moon” like.

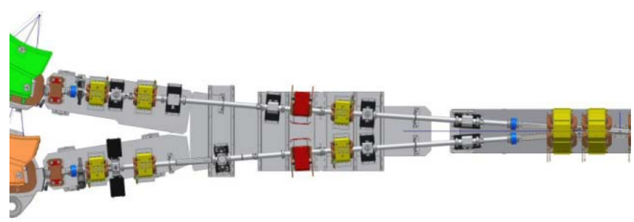

Figure 4: View of the modified IR2 region (half).

Figure 5: View of the IP2 beam pipe.

NEW Shielded Bellows

In order to keep the beam coupling impedance low, attention has been paid in designing the Y-shaped vacuum chamber as above described, but also the number of bellows has been reduced to the minimum necessary to compensate the thermal strain and mechanical misalignment. In each crossing region only 4 bellows per beam have been used [3]. The technology of copper-beryllium strips has been adopted minimizing the cost and maximizing the shielding performance. The working axial stroke is ±7 mm and the radial offset ±3 mm. See figure 6 where a section view of the bellows is shown.

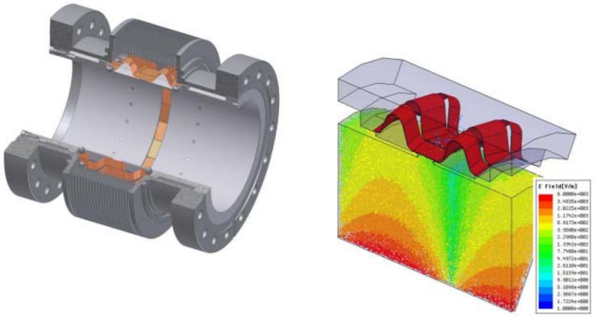

Figure 6: Copper-Beryllium Strip Shielded Bellows.

NEW Fast Injection Kickers

The design of the new kickers [4] is based on a tapered strip with rectangular vacuum chamber cross section, see figure 7, in order to simultaneously:

- improve the deflecting field quality obtaining a uniform horizontal deflection as a function of the transverse coordinate
- reduce the beam coupling impedance by means of the tapered transition between the beam pipe and the kicker structure
- have a uniform beam pipe cross section between the dipole region and the kickers region. This also reduces the total beam coupling impedance of the machine
- obtain a better matching between the generator and the kicker structure at high frequency. This can avoid multiple reflections of the deflecting pulse in the kicker structure that can perturb the stored bunches. Moreover it can allow extracting all the power released to the HOM of the structure by the beam

The 50kV feed-through has been tested successfully and the delivery of the first one is expected by the end of June.

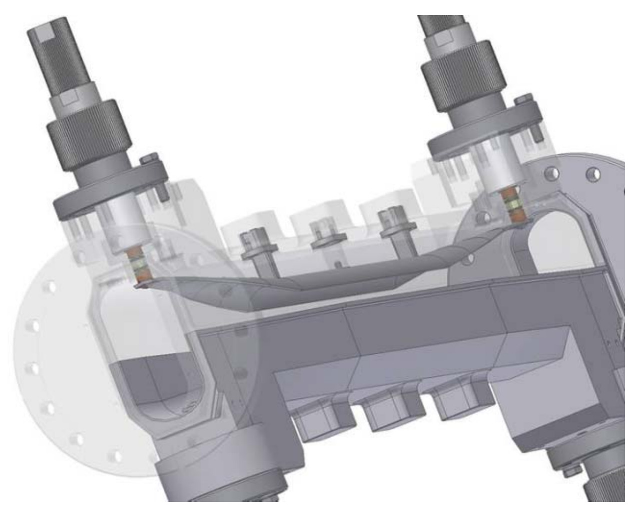

Figure 7: Mechanical drawing of the new fast kicker.

SIDDHARTA SETUP

The new IP1 for the SIDDHARTA experiment, compatible with the large crossing angle and crab waist option [5], is represented in figure 8. The experimental detector is visible in the top side and the two calorimeters to measure the machine luminosity from Bhabha events. The machine luminosity monitor is actually composed by three different devices: small angle Bhabha tile calorimeter composed by 20 sectors (30 degrees each) made of alternating lead and scintillating tiles, covering a vertical acceptance between 17.5 and 27 degrees; a GEM tracker placed in front of the tile calorimeters allowing a redundant measurements of Bhabha events to prevent background; a single bremsstrahlung gamma detector [6].

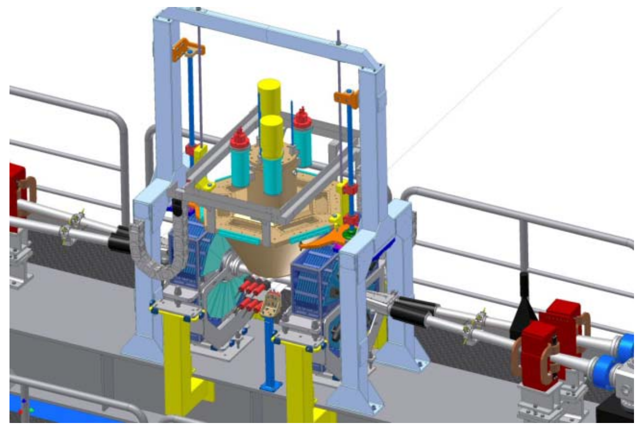

Figure 8: IP1 with SIDDHARTA installed.

CONCLUSIONS

The DAΦNE upgrade design compatible with the large crossing angle and crab waist option has been completed. All new components are under construction and the decommissioning of the old DAΦNE IRs started on mid June. New IRs components installation will start in few weeks. We expect to commission the machine by the end of October and give data to the SIDDHARTA experiment by the end of 2007. The compatibility of the DAΦNE upgrade with the KLOE and FINUDA detectors has also been foreseen.

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