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STATUS OF DAΦNE: FROM KLOE-2 TO SIDDHARTA-2, EXPERIMENTS WITH CRAB-WAIST

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Abstract

DAΦNE, the Italian lepton collider, is running since more than a decade thanks to a radical revision of the approach used to deal with the beam-beam interaction: the *Crab-Waist* Collision Scheme. In this context, the collider has recently completed a long term activity program aimed at providing an unprecedented sample of data to the KLOE-2 detector, a large experimental apparatus including a high intensity axial field strongly perturbing ring optics and beam dynamics. The KLOE-2 run has been undertaken with the twofold intent of collecting data for rare decay and flavor physics studies, and testing the effectiveness of the new collision scheme in presence of a strongly perturbing experimental apparatus. The performances of the collider are reviewed and the limiting factors discussed along with the preparatory phase activities planned to secure a new collider run to the SIDDHARTA-2 experiment.

INTRODUCTION

The DAΦNE [1] accelerator complex consists of a double ring lepton collider working at the c.m. energy of the Φ-resonance (1.02 GeV) and an injection system. The collider includes two independent rings, each 97 m long. The two rings share an interaction region (IR), where the detector taking data, one at the time, is installed. Beam injection is performed on energy, also in topping-up mode during collisions as well, by a system including an S-band LINAC, 180 m long transfer lines and an accumulator damping ring. DAΦNE became operational in 2001, and it still is an attractive collider to perform relevant experiments aimed at understanding flavour physics. This has been possible thanks to a continuous effort finalized at increasing the collider performances, which culminated in 2009 with the realization of a new approach to the beam-beam interaction: the *Crab-Waist* (*CW*) Collision Scheme. The new approach to collisions is based on large Piwinski angle (ψ) and *CW* compensation of the beam-beam induced instabilities [2, 3, 4]. It was, implemented during the run dedicated to a tabletop experiment, SIDDHARTA, and allowed to increase the instantaneous luminosity by a factor three, paving the way to a new run dedicated to a revised KLOE detector: KLOE-2 [5], that, in view of a higher luminosity, extended its physics search programs. In fact, the upgraded KLOE-2 setup includes calorimeter devices close to the IR, as well as a cylindrical GEM detector, the Inner Tracker (IT) installed at a distance of 15 cm from the Interaction Point (IP). However, a long-term run finalized to deliver a large statistical sample of data can only be planned if all the collider subsystems perform in a highly reliable way. For this reason, in the first six months of 2013, before starting the data-delivery phase, the DAΦNE infrastructure underwent a general consolidation program [6]; exploiting the long planned shutdown foreseen to install the new detector layers. Still some activities were not completed at that time, due to delays in the spare parts procurement, thus they have been finalized during the data taking, profiting from the seasonal shutdowns.

The DAΦNE collider parameters are listed in Table 1.

Table 1: DAΦNE Beam Parameters

	DAΦNE native (2000÷2006)	DAΦNE CW Since 2007
Energy (MeV)	510	
β^*_y (cm)	1.8	0.85
β^*_x (cm)	160	23
σ^*_x (μm)	760	250
σ^*_y (μm) at low current	5.4	3.1
σ_z (cm)	2.5	1.5
Bunch spacing (ns)	2.7	
Damping times τ_E, τ_x (ms)	17.8/36.0	
Cros. angle $\theta_{cross}/2$ (mrad)	12.5	25
Piwinski angle ψ (mrad)	0.6	1.5
ε (mm mrad)	0.34	0.28
RF frequency [MHz]	368.26	368.667
Harmonic number	120	

Presently DAFNE, after having successfully completed the KLOE-2 run [7], is facing the preparatory phase propaedeutical to a new operation period aimed at delivering data to the SIDDHARTA-2 detector [8], an upgraded version of the old one. The new experimental apparatus aims at performing the first kaonic deuterium measurement by improving its measurement resolution which, in turn, requires to considerably reduce the signal background ratio increasing, at the same time, the signal rate. The

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SIDDHARTA-2 experimental program requires a sample of data of the order of 1 fb^{-1}. This target should be achieved in about a year of data taking.

IMPROVEMENTS DURING KLOE-2 RUN

The run for the KLOE-2 detector has been possible thanks to the DAΦNE general consolidation program undertaken during the first half of 2013. The main commissioning phase started by the end of January 2014.

Despite several unpredictable failures in the water and power supply networks serving the laboratories, exceptional weather conditions and even earthquakes the collider uptime all along the 40 months of operations has been, in average, of the order of 75%.

It is worth noticing that the DAΦNE uptime is defined as the fraction of time in which the collider has been delivering a luminosity suitable for acquisition, e.g. greater than $0.1 \bullet 10^{32}$ cm^{-2}s^{-1}.

Operations have been interspersed with several relevant mending activities.

In November 2015, the flow rate of the water cooling the wiggler magnets has been halved in order to prevent holes formation in the magnet coils and damages to hoses. In spring 2016 the water cooling circuit serving: KLOE power supply, the electronics of the new detector layers, and the IR vacuum chamber has been deeply revised in order to improve its efficiency and disentangle the temperature of the water flowing in the IR beam pipe circuit from the one circulating in the new detector layers. During summer 2016 the compressor of the cryogenic plant, that had been running well beyond the specification, has been replaced in order to assure stable and reliable operations till the completion of the run.

The control system procedure dealing with the commutation of the injection system has been optimized, from both hardware and software points of view, in order to setup the magnet configuration for the opposite beam injection in less than 100 seconds.

One of the most relevant criticalities of the machine was the availability of the RF klystrons powering the main ring cavities. The CW 150 kW 368 M Hz tube TH2145, formerly produced by Thomson/THALES, is no longer in production. LNF own a total of 4 tubes delivered between 1994 and 1998, 2 of them used to power the e$^-$ and e$^+$ ring cavities, and 2 stored as spares. In February 2015, the klystron powering the e$^-$ ring cavity had to be replaced. Moreover, during the KLOE-2 run it has been necessary to substitute an electronic phase shifter in electron ring LLRF. The device failure caused the cavity RF phase, and consequently the beam, to shift slowly and randomly by about 10 degrees during operations. Thus, a dedicated longitudinal beam position diagnostics was implemented, at first to identify the problem and, after the cause was identified and fixed, to monitor the beam relative arrival time at the IP. A vacuum leakage in a sputter ion pump near the IR has been fixed in situ, avoiding harmful vacuum vent in the IR vacuum chamber common to both beams.

TUNING COLLISIONS

DAΦNE and KLOE-2 restarted operations by January 2014 with a commissioning phase aimed at optimizing beam orbit, setting up the *CW* optics, correcting transverse betatron coupling, and timing the 6-independent bunch by bunch feedbacks, 3 in each ring, which are fundamental in order to maintain stable high current operations and, in the e$^+$ ring, to keep under control the *e-cloud* induced instabilities. This time has also been efficiently used to test the new machine equipment and to recover optimal dynamic vacuum.

The first working points selected for collisions was: $\nu_x^- = 5.098$, $\nu_y^- = 5.164$ and $\nu_x^+ = 5.1023$, $\nu_y^+ = 5.139$, which, confirming *LIFETRAC* [9] simulations, allowed to achieve rather higher luminosity, $L = 1.8 \bullet 10^{32}$ cm^{-2}s^{-1} with respect to the preliminary KLOE test run. Unfortunately in that configuration the background on the detector endcaps and the current driven by the drift chamber were non compatible with efficient data taking.

The number of colliding bunches were progressively increased in the range of 93 ÷ 108 maintaining almost the same total current; thus reducing the Touschek contribution to the background as well as the impact of the microwave instability threshold.

The new detector layers installed around the beam pipe posed new tight requirements on cooling and background control. The working temperature of the water cooling system serving the IR had to be set to a lower value in order to cope with the heat loading due to the circulating beams and to the IT electronic equipment. As a consequence, the permanent magnet defocusing quadrupoles of the low-β were operating at a temperature around 18 °C, 6 °C below the one in the magnet specifications. Differently from the past the criterion for acceptable background level was set by the discharge threshold on the innermost IT layer, instead of the counting rate on the detector endcaps and the current amplitude measured by the different drift chamber sectors.

Thereafter, a new working point was adopted for the e$^-$ ring [10] having: $\nu_x^- = 5.135$, $\nu_y^- = 5.17$.

The new configuration provided: improved injection efficiency, 20% lower background due to the e$^-$ beam, and about 10 % higher luminosity. The background reduction was very relevant for the KLOE-2 data taking, it had a very positive impact on the accidental counting rate as well as on the event size, which are a main issue in terms of data storage. Moreover the background optimization was propaedeutical to switch on the IT acquisition.

The operational frequency of the RF cavities of the main rings was tuned relying on the experimental evaluation of the energy acceptance, which was clearly asymmetric with respect to the nominal frequency set point. In the e$^+$ ring, for instance, the energy acceptance, A_E, was in the range -75 kHz $\leq A_E \leq 25$ kHz. Lowering the RF frequency by 4 kHz, provided improved performances such as: lower background on the detector, less harmful reduction of the e$^-$ beam lifetime at high current while injecting the e$^+$ one,

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smoother injections, and stable and reproducible luminosity trends.

In general, it is worth reminding that machine studies and developments have been limited to very few aspects in favour of the experiment's data taking.

BEAM DYNAMICS ISSUES

The maximum e^- current accumulated during operations has been $I^- \sim 1.7$ A, stored in 98 consecutive bunches. However, at regime in collision, only currents in the range 1.4 ÷ 1.5 A have been injected. The quality of the e^- beam depended heavily on the mitigation of the effect induced by the ions of the residual vacuum, such effect is counteracted by leaving a suitable empty gap in the batch. The width of such gap is a compromise between opposite requirements posed by e^- beam dynamics and high luminosity. It depends greatly on the vacuum condition which improve with the stored beam dose. In fact, the best results in terms of luminosity have been achieved, by the second half of the run, through collisions of 106 consecutive bunches.

Concerning the e^+ current, it is strongly dominated by the *e-cloud* effects [11] which are mitigated by using solenoidal winding around the beam pipe, clearing electrodes (ECEs), and feedback systems. ECEs were installed during the shutdown for the KLOE detector roll-in. At that time 4 and 8 devices were inserted inside wiggler and dipole vacuum chambers respectively, in order to mitigate the *e-cloud* formation. DAΦNE has been the first collider to operate with, and thanks to the ECEs. They have been fundamental, especially at the beginning of the operations when the vacuum level in the ring was not optimal yet. At that stage, a careful tuning of each stripline polarization voltage has been done in order to avoid sudden variation in the e^+ beam orbit. Then, progressively during the data taking, several ECEs had to be switched off due to faulty behaviour. The KLOE-2 run finished with only 2 ECEs fully operative, but, at that point, the benefits coming from the scrubbing process helped in keeping the *e-cloud* instabilities under control, as confirmed by comparing the pressure rise in the arcs of the e^+ ring for the two periods with 80% and only 2 ECE working properly. A conclusive explanation of the process leading the largest part of the ECEs to exhibit a faulty behaviour, after having worked for some time, is under way since it requires to extract and analyse in detail the striplines concerned. During the whole KLOE-2 run the maximum current stored in the e^+ beam has been of the order of $I^+ \sim 1.2$ A, although, at regime in collision, a current $I^+ > 0.95$ has been rarely injected; a value somewhat lower than the one achieved during the previous DAΦNE's run periods.

Beam currents were affected by longitudinal quadrupole oscillations. This instability has been controlled by a special technique [12] implemented at DAΦNE in the synchrotron (dipole) feedback system. This is done by detuning the Quadrature Phase Shift Keying (QPSK) modulation in the feedback back end for damping both dipole and quadrupole beam motions. Also the environmental RF and DC noise coming from pickups, and leading to undesirable vertical beam size growth, was minimized by installing a low noise front end, designed in collaboration with SuperKEK Team, for the vertical feedback.

In general beam dynamics has been affected by the several new components installed on the two rings during the preparatory phase for the KLOE-2 run [13, 14]. In fact the new kicker developed for the transverse horizontal positron feedback has also been used for the horizontal electron feedback, and as beam dumper. This adds a new kicker per ring in the opposite section with respect to the IR. The IP vacuum chamber has been replaced with a new section having a slightly different mechanical design. The rectangular vacuum chambers of the collimators close to the IP, the most effective ones, have been replaced with some chambers of reduced volume in order to increase the blade insertion length. The four wigglers installed in each ring have been modified in order to reduce the higher order multipoles of the magnetic field [15], and removing a purpose built sextupole component, which was efficiently used to implement a smooth and distributed chromaticity control.

LUMINOSITY PERFORMANCES

Luminosity in DAΦNE is evaluated by using different approaches. A fast γ monitor measures the photons emitted at small angle (~1 mrad) in the e^+e^- inelastic scattering, by means of two detectors aligned along the direction of each beam from the IP. They are used for relative luminosity measurements only, during collision optimization. The absolute luminosity measurement is provided by the experimental detector. Another dedicated tool based on the direct signals of CCALT, one of the new KLOE-2 layers, provides bunch by bunch luminosity measurements [16].

The data taking for the KLOE-2 detector has been organized in four runs, as shown in Fig. 1. For each run milestones have been agreed upon, in order to grant to the experiment a total integrated delivered luminosity of the order of 6 fb^{-1}, after 40 months of operations.

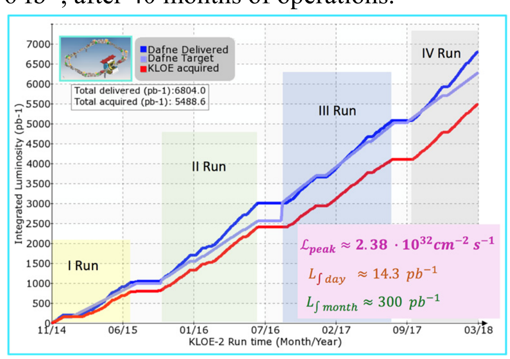

Figure 1: KLOE-2 data taking summary.

Trends in integrated luminosity show how the agreed milestones have been achieved for each data taking period, and often even exceeded. By the end of operations, the DAΦNE collider has been able to provide a total integrated luminosity of the order of $L_{\int del} \sim 6.8$ fb^{-1}, of which $L_{\int acq} \sim 5.5$ fb^{-1} has been stored on disk by the experiment.

The maximum instantaneous luminosity measured has been $L_{peak} \sim 2.38 \cdot 10^{32}$ $cm^{-2}s^{-1}$ which is the highest luminosity ever measured by KLOE. Such a result could, without

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any doubt, only be achieved thanks to an effective integration of the *CW* Collision Scheme with the experimental apparatus that strongly perturbs machine optics and beam dynamics [17]. The peak luminosity achieved day by day as a function of the day number since the beginning of operations is reported in Fig. 2 for *CW* and conventional collisions, red and blue dots respectively. *CW* provides a 59% increase in terms of peak luminosity, as highlighted by comparing data taken by the same detector with the same accuracy.

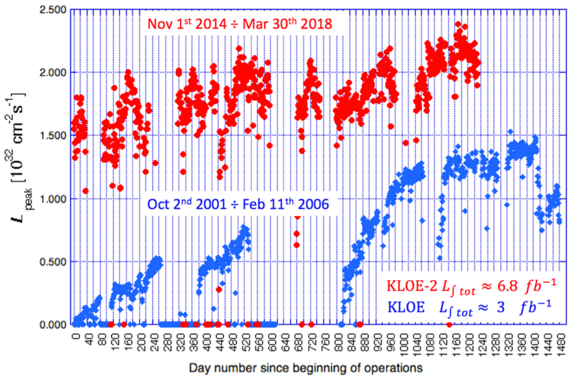

Figure 2: Instantaneous luminosity trend.

Still, the instantaneous luminosity trend exhibits an evident positive slope, regardless the lack of suitable time and manpower for dedicated extended machine studies. Furthermore, a rather promising instantaneous luminosity, L ~ $3 \cdot 10^{31}$ cm^{-2}s^{-1}, has been measured with 10 colliding bunches, see Fig. 3, in order to minimize the impact of *e-cloud* and multibunch effects.

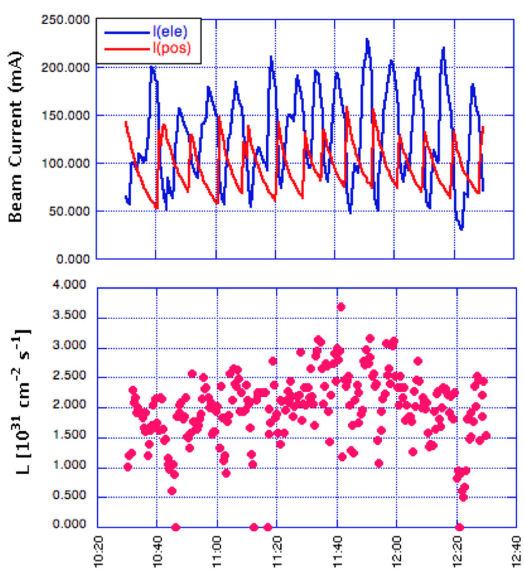

Figure 3: Ten bunches collisions.

The impact of *CW* on the luminosity gain is also clearly highlighted by comparing the luminosity performance as a function of the beam currents product for data acquired by the KLOE detector before, and after implementing the *CW* Collision Scheme.

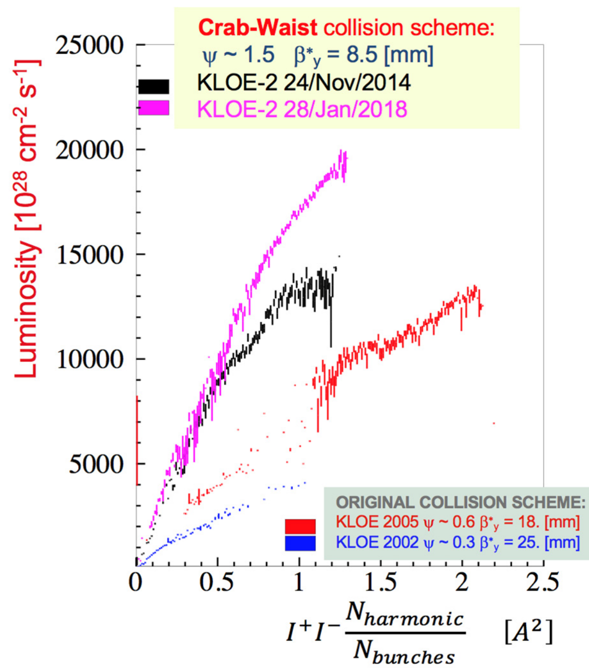

Figure 4: Luminosity as a function of the beam currents product normalized per number of interacting bunches, before (blue and red curves) and after (black and pink curves) implementing ng the *CW* Collision Scheme.

Already in 2005 increasing the Piwinski angle and the beam focusing at the IP allowed a consistent improvement in terms of luminosity, see red plot in Fig. 4. Then, after implementing a new IR based on *CW*, such luminosity gain became remarkable, mainly at low currents, even before any extensive collider optimization, see the black plot in Fig. 4. Eventually, after a comprehensive machine tuning, luminosity growth extended up to high currents, without showing any sign of saturation, see pink plot in Fig. 4.

As far as the integrated luminosity is concerned, the *CW* collisions at DAΦNE have been able to more than double the integrated delivered luminosity, in fact 3 fb^{-1} only had been delivered with the nominal collision scheme, in almost the same period of previous operations. Remarkable performances have been achieved also in terms of delivered daily and monthly integrated luminosities, which have been of the order of $L_{\int day}$ ~ 14.3 pb^{-1} and $L_{\int month}$ ~ 300 pb^{-1} respectively. It is worth noticing that the best delivered monthly luminosity has been obtained in 26 days of activity only, see Fig. 5. Furthermore, the maximum daily integrated luminosity is comparable with the highest ever achieved at DAΦNE, $L_{\int day}$ ~ 15 pb^{-1}, occasionally measured [18] during the test of the *CW* collision scheme with the SIDDHARTA experiment. Last, but not least, the aforementioned record luminosities have been achieved despite maximum currents in collision were somewhat lower than the ones used during the past DAΦNE runs. Such current reduction can be estimated to be of the order of 30% and 20% for the electron and the positron beam respectively.

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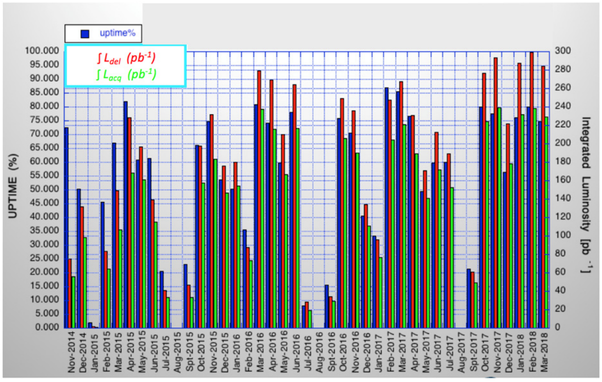

Figure 5: Month by month performances.

SIDDHARTA-2 PREPARATORY PHASE

Interaction Region

Several well founded considerations led us to install the SIDDHARTA-2 apparatus in place of KLOE-2 one that, as a consequence, must be moved back into its hangar.

Regardless, the IR hosting the SIDDHARTA-2 detector is based on the *CW* Collision Scheme too, it is deeply different from the one used to deliver data to the KLOE-2 experiment. The only components that could be reused were the Permanent Magnet Quadrupoles, PMQs, of the low-β which, however, should be extracted from the inner side of the apparatus requiring considerable time and manpower. The decision to build new PMQs gave us a useful opportunity to speed up the installation procedure and to improve design aspects of the low-β quadrupoles as well.

Low-β Quadrupoles

The low-β insertion of the SIDDHARTA-2 IR requires six magnets: two defocusing quadrupoles, PMQDs, common for the two beams, and four focusing magnets, PMQFs, one for each branch of the IR.

The new PMQs, shown in Fig. 6, have been designed in collaboration with the ESRF magnet group with the intent to improve: good field region, gradient uniformity, aperture, and mechanical assembly. The last aspect has special relevance for the PMQFs which are installed very close to each other, see Fig. 7. Bore radius is one of the main issues in order to provide a proper stay clear aperture for the beams and reduce background on the detector. A larger horizontal aperture is very relevant mainly for the PMQDs, in which colliding beams trajectories passes of axis.

The new PMQs are Halbach type magnets made of SmCo2:17, some of their more relevant parameters are shown in Table 2 along with the corresponding beam pipe apertures.

PMQDs consist of 2 rings of permanent magnet wedges, as in Fig. 6, the inner blocks are arranged according a fixed elliptical symmetry, while the outermost ones are disposed with circular symmetry and can be moved radially to shim the gradient strength and its inhomogeneities.

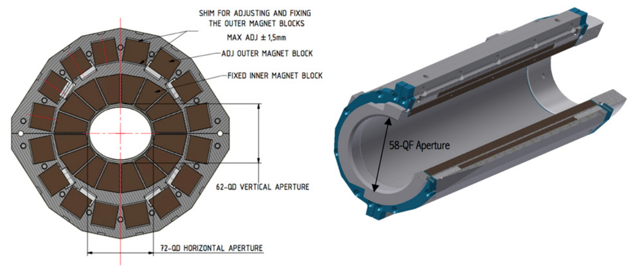

Figure 6: PMQD mechanical cross section (left), and PMQF 3-quarter section (right).

PMQFs are based on 2 concentric cylinders of PM wedges having different lengths, see Fig. 6, also in this configuration the PM blocks of the outer cylinder can be moved radially for shimming purpose.

Table 2: PMQ and Beam Pipe Parameters

	PMQD	PMQF
Beam Pipe Aperture H-V (mm) at IP (I row) and at Y (II row) side	57 69 - 55	54
Inner Apert. With Case H-V (mm)	72 - 62	58
Outer Diameter H-V (mm)	238 - 220	95.6
Mech. Length Inner-Outer (mm)	220	168 - 240
Nominal Gradient (T/m)	29.2	12.6
Integrated Gradient (T)	6.7	3.0
Good Field Region (mm)	±20	±20
Integrated Field Quality |dB/B|	5.00E-4	5.00E-4
Magnet Assembly	2 halves	2 halves

Aluminium casing has been designed relying on a comprehensive analysis of the magnetic forces among the different PM wedges, and paying attention to installation requirements as well. The new PMQD vacuum chamber has a tapered design allowing to match the elliptical quadrupole aperture, on the side of the Y-shape beam pipe, and the IR circular one at the entrance of the common vacuum chamber, as shown in Fig. 7.

IR Vacuum Chamber

The vacuum chamber of the low-β section have been designed in order to fit with the new quadrupole apertures, paying great attention to the impedance budget of the new structure.

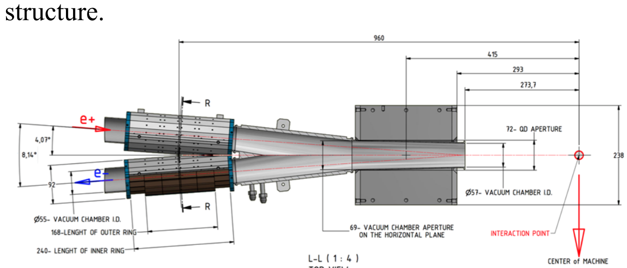

Figure 7: Half IR mechanical assembly, top view.

In a collider composed of two separate rings having a common IR it is unavoidable to create electromagnetic Higher Order Modes (HOM) in the area where the vacuum beam pipes of the two rings merge in the common beam pipe (Y-shape chamber) [19, 20].

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The numerical simulations with HFSS [21] have revealed the existence of two HOMs trapped in the Y-chamber of the new SIDDHARTA-2 IR at frequencies of 1.863 MHz and 2.299 MHz respectively. These modes are rather weak to create any dangerous multi-bunch instability that can be always controlled by the powerful feedback systems of DAΦNE. However, despite these are the TE-like modes, there are non-negligible longitudinal fields along the beam trajectory contributing into the longitudinal beam coupling impedance. Since the mode frequencies are rather close to the beam power spectrum lines there is a high probability of power loss enhancement in multi-bunch operations. For example, the first mode frequency is very close to the 5th harmonic of the RF frequency at 1.843 MHz. In the worst scenario of the full coupling of the spectrum line with the mode frequency the released power is estimated to be of the order of 0.5 kW. In order to avoid excessive overheating of the Y-chamber, and a resulting vacuum pressure rise in the vicinity of IR, it has been decided to apply cooling pipes on the top of the chamber. The simulations with ANSYS [22] have confirmed that the chamber temperature is kept under control in that case. Moreover, the temperature variation can also help in shifting the mode frequency with respect to the spectrum line thus providing another safety knob.

Luminosity Measurements

In order to ensure fast absolute luminosity measurement, the IR will be equipped with several independent diagnostic tools.

The main luminosity measurement will rely on the small angle Crystal CALorimeters with Time measurement, CCALT [23], that was part of the KLOE-2 detector, in order to measure the Bhabha scattering events at small angle. The CCALT consists of two identical crystal calorimeters installed in front of each PMQD. This detector has been efficiently used, during the KLOE-2 run, to implement an absolute instantaneous luminosity measurement with an accuracy of the order of 5 ÷ 1 0% depending on repetition rate and threshold settings [16].

The CCALT luminosity measurement has been successfully cross-checked with the more accurate one provided by KLOE-2 apparatus. Moreover the diagnostics time resolution has proven to be suitable to implement bunch by bunch luminosity measurement.

The two High Energy Tagger (HET) [24] stations, also inherited from the KLOE-2 apparatus, will be used to detect Bhabha scattering at very low angle. The HET plastic scintillators allow to measure the arrival time and the distance from the nominal trajectory of the scattered particles. The two HET stations can measure the instantaneous luminosity independently using single-arm event rate determination with a good accuracy of the order of 5%. A third diagnostics based on gamma bremsstrahlung proportional counter will be installed as well. This detector, thanks to the very high rates, can be efficiently used as real time tool during machine luminosity optimization. However, it cannot provide a reliable absolute luminosity measurement since it is heavily affected by beam losses due to interaction with the residual gas, Touschek effect, and low angle scattered particles generated along the IR.

Subsystems Revamping

In view of the SIDDHARTA-2 physics run many other subsystems and machine components are going to be revamped [25].

Mechanical structures supporting and giving access to the IR must be reviewed in order to be compliant with the new experimental apparatus and with the present safety standards. Several vacuum components will be replaced. New sputter ion pumps will substitute for faulty devices and for the NEG ones previously installed in the IR.

A general checkup of more than 500 power supplies has been already completed. Each power supply has been tested in all its components with special attention to the cooling units and to the DCCT calibration.

The capacitor banks of the power supplies powering the two pulsed dipoles, the more sophisticated magnets of the Transfer Lines, have been replaced with new components.

Each capacitor bank is composed by 50 capacitors and the total capacity amount is about 7 mF.

The Power Supplies, PSs, of the correctors (short and long type) both in the positrons and in the electrons rings are going to be substituted with new equipment. The new PSs have accuracy and resolution improved by more than a factor 10 with respect to the old devices. This last aspect is of extreme importance in order to guarantee reproducible and stable beam trajectory during operations.

The two dump kickers, one in each ring, previously installed in the section opposite to the IR are going to be replaced by a straight beam pipe in the e^- ring, and by a new feedback kicker in the e^+ one in order to implement an additional horizontal feedback system. The latter is intended for doubling the total power available for the horizontal feedback in order to keep under control the *e-cloud* induced instability. In fact the *e-cloud* detrimental effects are espected to be more harmful due to the new Al vacuum chambers installed in the IR, and to the dramatic reduction of the properly working ECEs.

CONCLUSION

DAΦNE has just concluded the run for the KLOE-2 experiment achieving unprecedented results in terms of luminosity. This has been possible thanks to an effective integration of the *Crab-Waist* Collision Scheme with the high field detector solenoid.

The *Crab-Waist* Collision Scheme has proven to be a viable approach to increase luminosity in circular colliders even in presence of an experimental apparatus strongly perturbing beam dynamics. Definitely good news for all the new machines and projects around the world that have adopted *Crab-Waist* as their main design concept.

A comprehensive work program has been defined, and is under way to prepare the run for the SIDDHARTA-2 experiment at DAΦNE. Several aspects of the collider and many subsystems have been upgraded in order to grant the highest performances in terms of luminosity and the lowest background contamination on the acquired data.

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The run for SIDDHARTA-2 will be the very last physics run of DAΦNE as a collider; thereafter the accelerator complex will most likely be converted to a test facility.

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