DAΦNE - 2021 Activity report

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1 Introduction

DAΦNE Activity during 2021 have been devoted to deliver data for the SIDDHARTA-2 experiment [1] in the so-called, SIDDHARTINO configuration [2]. The main purpose of the used setup is to certify and optimize DAΦNE working point in order to achieve the target signal over background ratio in the experimental apparatus [3]. The collider has been operated before the summer shutdown between January, 20th and July, 18th, with a planned stop of two weeks at the beginning of April to perform routine maintenance. A large fraction of this period has been used to fully characterize collision optics for both rings and to optimize beam dynamics in order to achieve the maximum stored current. A small running period of one month between November, 15th and December, 22nd allowed to verify effectiveness of the major maintenance and revamping intervention on all sub-systems realized during Summer/Fall shutdown.

2 Activity Report

Beam based measurements outlined non-negligible alignment errors for three chromatic sextupoles in the positron ring, which have been corrected thus eliminating tune shifts and horizontal dispersion distortion. Such alignment (mechanical and beam based), allowed to set the chromaticities of the two beams to the highest possible positive values, compatible with the smallest values of second order dispersion and second order chromaticity as well.

Crab-Waist Sextupoles have been aligned in the transverse plane relying, even then, on beam-based measurements in order to not perturb beam parameters as, for instance, the transverse beam dimensions as can be seen from Fig.1-Left. Machine studies finalized to non-linear optics tuning of the Crab-Waist configuration are still not completed.

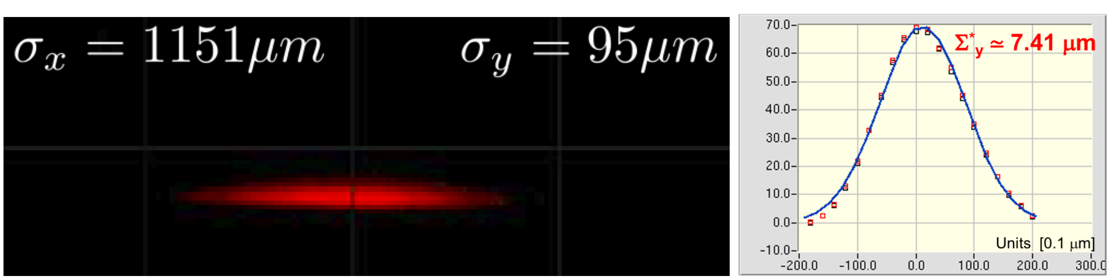

Figure 1: Letf: Electron beam profile as measured at the SLM, for a current of 500 mA stored in 100 bunches, after setting the Crab-Waist Sextupoles at 1/3 of the nominal strength. The beam vertical size is at the level of the diagnostics resolution. Right: Vertical beam-beam scan performed with single beam bremsstrahlung monitor.

After a systematic optimization of beam overlap, the Crab-Waist Sextupoles have been set at moderate strength, almost 1/3 of their nominal value. Then, the convoluted vertical size Σ^*_y of the interacting beams has been evaluated by scanning one beam through the other, at low current, while recording relative luminosity trend with single beam bremsstrahlung monitor, see Fig.1-Right. The vertical bunch size at the IP, σ_y, has been deduced with the assumption that the two beams have same sizes at the IP. The obtained σ_y is of the order of 5.2 μm, such value is consistent with the one evaluated by the Synchrotron Light Monitor, as well as the one computed on the basis of the nominal beam optics parameters.

Since vacuum behaviour has a relevant impact on beam dynamics dedicated beam conditioning runs, periodical sublimation, and beam scrubbing have been fundamental in progressing toward high intensity, stable, beam currents before starting the collision operations. e-cloud activity is quite evident looking at the measurements from vacuum gauges. In Fig.2-Left the vacuum rise as a function of the stored current is shown for different bunch patterns. The 40 bunches pattern, being the most harmful, in terms of e-cloud activity, has been adopted for scrubbing runs.

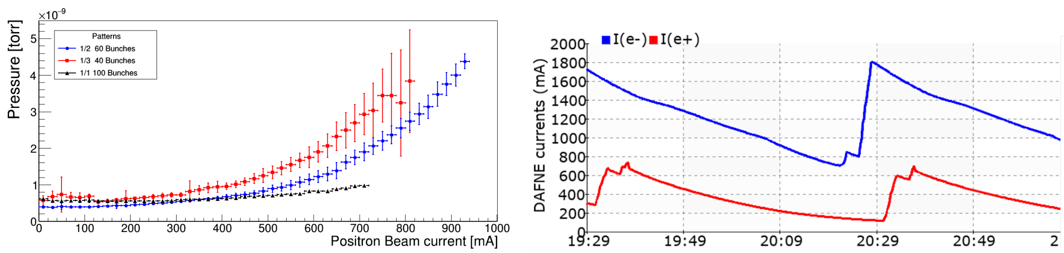

Figure 2: Left: Positron ring vacuum rise as a function of the stored current for different bunch patterns. Each series represent the average (markers) and RMS (bars) over several hours of running. Right: Maximum electron (blue) and positron (red) beam currents stored so far in the DAΦNE main rings.

In a low energy machine as DAΦNE, operating with beams having long damping times, high current performances significantly depend on bunch by bunch feedback systems. The maximum currents stored so far are 1800 mA for the electron beam and 900 mA for the positron one, see Fig.2-Right. These beam currents was obtained by adjusting the timing parameters and feedback setup (FIR filter parameters) of the iGp Signal processors [4]. The maximum achievable electron beam current is limited by injection efficiency, beam lifetime, and by the onset of longitudinal instabilities. The maximum positrons beam current is limited by mode-0 instabilities and longitudinal quadrupole instabilities. The first one shows a clear dependence on the RF-Cavity feedbacks tuning, while the latter is going to be cured by a special technique [5] developed at DAΦNE consisting in detuning the QPSK modulation in the feedback back-end in order to damp dipole and quadrupole beam motions at the same time.

The !CHAOS framework [6] have been largely used to acquire, monitor and online process the data coming from DAΦNE, in fact the collision luminosity measurement has been the first real test-bench for the in-house developed "general purpose" control system [7]. The low angle detector collecting Bhabha scattering events is fully controlled and acquired within !CHAOS environment thus providing real time absolute luminosity measurement trough online processing of the data collected. During this year, the data display and correlation with other DAΦNE parameters (e.g. beam current, vacuum, beam size, betatron tunes) using the tools available within the !CHAOS services ecosystem have been released. Information coming from the experiment (e.g. background couters, kaon flux) have been also integrated in order to allow better tuning of the collider. In Fig. 3-Left the observed rate of coincidence is shown as a function of the calculated geometrical luminosity: a good linearity is observed as expected. In Fig. 3-Right a comparison between concurrent luminosity measurements is shown: the geometrical luminosity evaluation

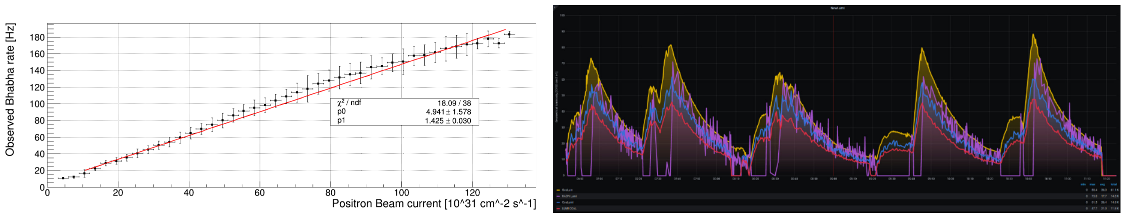

Figure 3: Left: Observed coincindece rate versus geometrical luminosity during collisions. The geometrical luminosity is evaluated taking into account measured beam sizes and hourglass. Right: Luminosity measurement comparison: geometrical luminosity (yellow) is compared with DAFNE luminometer (blue and red) and SIDDHARTA-2 kaon monitor (purple). DAFNE luminometer measurement differs by energy calibration that results in higher (blue) or lower (red) effective threshold for event selection. A substantial agreement between DAFNE and SIDDHARTA-2 evaluation is observed.

is compared with measurements coming from DAΦNE monitor and from SIDDHARTA-2 Kaon monitor indipendent system.

According to the SIDDHARTINO experiment purpose, dedicated beam time has been allocated to improve kaon counting rate in the apparatus with respect to the machine induced background counting rate. The experiment released dedicated measurements coming from central apparatus and kaon monitor system that allows to monitor in real time the background behaviour. In Fig. 4-Left the first step of the optimization is show. The observed difference between the average value at the beginning and at the end of the considered period is related to the installation of further passive lead shielding to minimize the machine background flux impinging in the bottom section of the experiment. Further improvements come from collider tuning (e.g. betatron tunes, cromaticity correction, transverse feedback tune-up) allowed to reach a quite stable situation, as shown in Fig. 4-right, that was kept between June, 1st and July, 18th to deliver around 80 pb^{-1} to the experiment.

Figure 4: Left: KAON/SDD rate as a function of the time. The large difference observed in the average value at the beginning wit respect to the end of the showed period is associated with the installation of additional lead shielding. Right: Standard condition of the experiment counters during the SIDDARTINO data acquisition period.

During Summer/Fall shutdown a major maintenance campaign has been performed on several subsystems:

WIGGLER : survey of the cooling pipes to avoid leakage from water hoses performed;

LINAC : new high voltage power supply for Modulator C installed, UFS Upgrade, slits and flags maintained, vacuum pipe and bellows in the positron converter section replaced, quadrupole cooling system revised;

Control System : virtual machine for the new main ring orbit acquisition system installed, new Hunter-Dog under !CHAOS framework has been realized, new fully automatized procedure to restart VME based equipment's realized;

Vacuum : new adapter for electrical feed-through for the damping ring injection kickers have been designed and installed, damaged electrovalves in LINAC tunnels have been replaced, electron RF cavity and electron scrapers chamber leakage sealed;

Magnets : all power supply that exhibits some fault during Spring run have been maintained;

Radio Frequency : klystron filament power supply has been replaced.

3 Conclusions

Crab-Waist Optics has been extensively characterized and assures a reliable control on beam parameters. Beam Dynamics limitations are kept under control to store the beam currents required in this phase of the collider activity.

SIDDHARTINO test run has been successfully completed. The experiment has recorder $54pb^{-1}$ of data from June 1st to July 18th. Since the beginning of the SIDDHARTINO run machine background has been reduced by a factor of 2. DAΦNE Luminosity monitor provides increasingly reliable measurements, and enhanced diagnostics tools. Peak Luminosity measured so far is about $0.8 \times 10^{32} cm^{-2} s^{-1}$, at intermediate currents, several possible limiting factors have been identified and will be addressed in the next run. An extensive program of consolidation and upgrade has been completed during the summer shutdown.

References

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