DAFNE-TF Workshop
Book of abstracts

Laboratori Nazionali di Frascati - INFN
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⋆ editor of this booklet

submitted to:
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Workshop

Proposal for Using DAFNE as Pulse Stretcher for the Linac Positron Beam

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Abstract

A proposal of converting the DAΦNE positron ring as a high duty cycle pulse stretcher for the linac beam for producing a high-intensity (up to 10^{10}), high-quality positron beam (with energy up to 500 MeV) for HEP experiments, mainly, but not only, motivated by light dark-particles searches, is presented. A list of the required modifications of the DAΦNE positron transfer line and main ring are presented. A dedicate lattice for the ring has been designed and tracking of the positrons injected in the ring has been performed to optimize the extraction parameters and give an estimate of the extracted beam characteristics.

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Proposal of an experimental test at DAFNE for LEMMA

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Abstract

We propose an experimental test at DAFNE of the positron-ring-plus-target scheme foreseen in the positron driven Low EMittance Muon Accelerator (LEMMA) . This test would be a validation and an experimental benchmarking of the beam dynamics particle tracking studies on-going for LEMMA. This talk could cover the proposal of the test at DAFNE with goals and requirements for different targets, i.e. material and thickness. The development of the existent diagnostic needed to test the behaviour of the circulating beam would be described together with the turn-by-turn measurement systems of charge, lifetime and transverse size. Measurements on the temperature and thermo-mechanical stress on the target are also under study. The talk would be based on the studies discussed in the recent article: doi:10.1088/1742-6596/1067/2/022013

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DAFNE-TF as FCC-ee Demonstrator

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Abstract

Many features of DAFNE will render it a unique test facility for demonstrating and exploring key concepts of the proposed future FCC-ee collider, and for optimising the FCC-ee design. The particular DAFNE-TF features of interest for FCC-ee include the following:

(1) high beam currents, with significant bunch charge;

(2) availability of high-current positron beams;

(3) crab-waist collisions;

(4) low-beta insertion with detector;

(5) lepton injector including linac, positron source, and damping ring.

Novel coherent beam-beam instabilities, anomalous emittance blow up, advanced feedback systems, high-current operation and HOM damping of novel RF cavities, various types of beam diagnostics, machine background sources, aspects of electron-cloud and ion effects, and numerous other FCC-ee concepts and prototypes can all be tested at DAFNE-TF.

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QCD with strangeness: the first measurement of the 1s state of kaonic helium isotopes (KAHEL)

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Abstract

The KAHEL collaboration proposes to perform the first measurement of the kaonic helium-3 and helium-4 exotic atom X-ray transitions to the fundamental level. Light kaonic atoms are the ideal framework to study the physics of the strong interaction, since their lowest-lying energy levels are shifted and broadened, with respect to electromagnetic calculated values, due to the presence of the strong interaction between the antikaon and nucleus.SIDDHARTA has measured the 1s level shift and width for kaonic hydrogen and SIDDHARTA-2 is going to measure them for kaonic deuterium. For the kaonic helium atoms X-ray transitions to the 2p level of kaonic helium-3 and helium-4 have been measure by SIDDHARTA (Phys.Lett. B681 (2009) 310, 85 citations; Phys.Lett. B697 (2011) 199, 48 citations).

The measurement of the kaonic helium transitions to the 1s is very challenging, due to the extremely small yield expected for a kaon to reach the 1s ground state and to a broader ground state level, as compared to the kaonic hydrogen and deuterium.

KAHEL will take advantage of the unique quality kaon beam delivered by the DAFNE Test Facility and make use of the SDD detectors of SIDDHARTA-2 in coincidence with new Cadmium-Zinc- Telluride (CZT) semiconductor detectors, developed in the framework of the ASTRA European project (WP within STRONG-2020 European project). The SDDs will detect the L-transitions to the 2p state in kaonic helium and the CZT detectors will measure, in coincidence, the K-transition X-rays to the 1s state.

The KAHEL setup will make use of the SIDDHARTA- 2 apparatus in which the diameter of the target cell will be increased to make space for additional rows of CZT detectors in-between the SDDs. The exit window will also be covered by CZT detectors. The solid angle, compared to that of SIDDHARTA-2, will be increased by 75%. We propose to perform the first KAHEL measurement immediately after SIDDHARTA-2 kaonic deuterium, to take advantage of the machine optimization and the optimized setup.The preliminary MCarlo simulations show that for a luminosity of about 100-200 pb^{-1} (one month of data taking) one can have a first measurement of kaonic helium-4 transition to 1s level.

KAHEL proponents:

- LNF-INFN; SMI-Vienna;
- Univ. Jagiellonian, Krakow;
- Univ Zagreb;
- IFIN-HH, Bucharest;
- IMEM CNR Parma;
- INFN and Politecnico di Milano;
- RIKEN, Japan

Funding from participating institutes and STRONG-2020 project.

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GeKA: Precision measurement of X and gamma-ray transitions in selected Kaonic Atoms with High Purity Germanium detectors

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Abstract

GeKa proposes to measure X and gamma-ray transitions in a series of selected kaonic atoms in order to deliver fundamental experimental information for: resolve the potential of the interaction of kaons with nuclear matter and its dependency on density; contribute to the development of chiral theories by delivering interactions of kaons with nuclei; feasibility/measurement of kaon mass to solve the puzzle of kaon mass; contribute to the Equation of State for neutron stars.The measurements will be done with High Purity Germanium detectors, which will be tested in measurements of kaonic X-ray transitions in solid targets (carbon and/or lead) during the SIDDHARTA-2 run. The HPGe detectors are special detectors optimized to work at high rates on a collider; they have a transistor reset preamplifier and can handle much higher rates than HPGe with a RC preamplifier. The HPGe detectors can measure X-rays and gamma rays with energies above 40 keV and up to 30 MeV.

The University of Zagreb group has two suitable HPGe detector setups which will be employed in the measurements and can provide required trigger scintillation detectors for HPGE detectors. GeKA plans to perform a series of measurements with the following targets: Carbon, Selenium, Zirconium, Tantalum and lead, which are the targets proposed by the theoreticians with whom we are collaborating. For each target we plan to take data for about 100 pb^{-1} and these data can be taken in differet data taking periods.

We also plan to do a study of a run with liquid hydrogen target to measure the monochromatic gamma ray delivered from kaon absorption on proton with direct formation of the $\Lambda(1405)$ to understand the structure of this resonance there are two conflicting theories predicting gamma energy as being 5 or 27 MeV. Also for this measurement we need an integrated luminosity in the range of 100 pb^{-1}. We mention that the measurements of kaonic atoms in solid targets will also deliver the charged kaon mass, which badly needs a new measurement (in PDG there are two 5 keV precision measurements, 60 keV apart); the charged kaon mass enters in all measurements relying on its values (CTP tests, standard model and beyond standard model...).

GeKA proponents:

- Univ Zagreb;
- LNF-INFN;
- SMI-Vienna;
- Univ. Jagiellonian, Krakow;
- RIKEN, Japan.

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Low-energy kaon-nucleon scattering

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Abstract

The KNscat collaboration proposes to realise unique measurements of low-energy kaon-nucleon elastic and inelasting scattering processes at kaon momenta below 100 MeV/c, where there are no data available. The low-energy antikaon nucleon system is of special interest in particle and nuclear physics, as well as in astrophysics, since the rather large mass of the strange quark allows testing chiral SU(3) symmetry in QCD and also to obtain information for the Equation of State for neutron stars. The existence of the $\Lambda(1405)$ resonance just 25 MeV below the Kp threshold makes the loop-wise expansion of chiral perturbation theory inapplicable and therefore, non-perturbative coupled-channel techniques, based on driving terms of the chiral SU(3) effective Lagrangian, have been proven to be successful in dealing with this problem. In this approach the $\Lambda(1405)$ is generated dynamically as a superposition of an I=0 Kp quasi bound state and a resonance in the $\pi\Sigma$ channel. High-precision threshold data will set important constraints for such theoretical approaches.

The present knowledge of total and differential cross sections of low-energy kaon-nucleon reactions is very limited. Below 150 MeV/c there is a desert - the experimental data are very few and with large errors and practically no data exist below 100 MeV/c. Beside the study of kaonic atoms [1], which allows the extraction of the kaon-nucleon scattering lengths at threshold, precise cross section measurements at low momenta, very close to threshold, are an additional important input for theoretical models [2].

The DAFNE ϕ-factory at LNF is the world leading facility for low-energy kaons, producing charged kaons in the momentum range 115 140 MeV/c and is therefore ideally suited to study low-energy kaon scattering.

Measuring the particle resulting from the scattering processes on various targets (starting with hydrogen and helium) with low momenta represents a big experimental challenge. Therefore, we will develop in the framework of the EU programme Horizon 2020, project STRONG2020, an active Time Projection Chamber (TPC), which will allow to study the kaon interaction directly in the TPC, without additional material. Scintillator tiles, read out with Silicon Photomultiplier [3], will surround the TPC [4]. In addition, to study also non-elastic channels it is necessary to detect neutrons as well as gammas. A new detector concept is under study.

Proponents:

- SMI-Vienna,
- LNF-INFN,
- TU-Mnchen;
- Mainz Univ.,
- Jagellionian Univ.,
- IFIN-HH Bucharest.

References:
[1] M. Bazzi et al., Phys. Lett. B 704 (2011) 113
[2] B. Borasoy, R. Niler, W. Weise, Phys. Rev. Lett. 96 (2006) 199201
[3] M. Tchler et. al, PSAS 2018, IOP Conference Series, to be published
[4] L. Fabbietti et al., NIMA 628 (2011) 204.

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Proposal for DAΦNE-TF to Probe Future Collider Optics Challenges

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Abstract

DAΦNE is planned to operate as a test facilty (TF) of physics and innovative technologies for accelerators by 2020. With the DAΦNE-TF various optics challenges of future colliders such as the High Energy Large Hadron Collider (HE-LHC) can be studied. The HE-LHC is a proposed future circular collider in the same tunnel as the existing Large Hadron Collider (LHC) at CERN, but with a centre of mass energy of about 27 TeV. In the following, HE-LHC challenges which can be tested at the DAΦNE-TF are described.

The HE-LHC optics foresees currently a minimum β^* of about 15 cm. This small betatron function at the interaction point requires a well-designed final focus system (FFS), which can withstand outstanding high betatron amplitudes, which lead to beam stay clear and chromaticity challenges. The current HE-LHC optics parameters result in a L^*/β^* ratio (which is an approximation of the FFS chromaticity) of about 153.3. This relation found in the HE-LHC design distinguishes from the current DAΦNE operation parameters by two order of magnitudes in the horizontal plane, and by a factor 5 in the vertical plane. Nevertheless, it is possible to reproduce the FFS challenges in the HE-LHC more accurately by testing an optics at the DAΦNE-TF with a β_y^* of about 0.002 m. As a results L^*/β_y^* becomes 147 which is nearly identical to the HE-LHC. Such optics requires pushed DAΦNE-TF optics parameters.

To summarise, the DAΦNE-TF offers great opportunities to reproduce FFS challenges of the HE-LHC. It has to be noticed that it is possible to test issues of other future linear colliders if β_y^* can be reduced in total by a factor 500. With the ability of reproducing challenges of possible future colliders, especially the HE-LHC, the DAΦNE-TF is qualified as a framework for testing a great variety of optics issues.

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WiKAMP: Investigation of single and multinucleon processes of antikaons in nuclei by simultaneous measurements of upper and lower levels transition widths of kaonic atoms with ultra-high energy resolution detectors

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Abstract

The WiKAMP (Widhts of Kaonic Atoms Measurements with high Precision) collaboration proposes to use newly developed X-ray detector systems, with energy resolutions at the level of eV for energies going from 1 to 100 keV, to perform measurements of X-rays emitted in transitions between various levels of several kaonic atoms, aiming to extract their widths with unprecedented precision.

The simultaneous measurement of the widths of the radiative transitions occurring from upper and lower levels from the same (kaonic) element, will provide important information on the antikaon-nucleon potential (light atoms) and on the single and multi-nucleon processes of antikaons in nuclei (medium and heavy atoms), fundamental to understand the non-perturbative QCD with strangeness.

Such measurements, in particular for the transitions towards n¿1 levels, are very challenging due to the relatively small influence of the strong interaction leading to very small widths of few eV; thus, the capability to detect X-rays with ultra-high resolution is mandatory.

As an additional benefit, the determination of the high n transition energies with a precision below 1 eV will allow the extraction of the charged kaon mass with a precision of few keV.

Recently, impressive results have been obtained by the HEATES collaboration, in particular in the E62 experiment at JPARC, measuring the X-ray emitted in the $3d \rightarrow 2p$ levels transitions of K3He and K4He with few eV resolution, using Transition Edge Sensors (TES). Also, promising results have been obtained by the VOXES collaboration at LNF-INFN, which measured X-rays in the range of 2-20 keV with few eV resolution using a VonHamos spectrometer based on Highly Annealed Pyrolitic Graphite bent crystals.

The complementarity of these two emerging techniques is the key ingredient of WiKAMP. WiKAMP will make use of the already existing TES of the E62 experiment and of an optimized version of the existing VOXES spectrometer.

Preliminary MCarlo simulations show that for a total integrated luminosity of about 300-400 pb^{-1} (in 3-4 different data taking periods) several kaonic atom widths can be measured with a precision below 1 eV.

WiKAMP proponents and funders are:

- LNF-INFN;
- RIKEN, Japan;
- SMI-Vienna;
- Univ. Jagiellonian, Krakow;
- Univ Zagreb;
- IFIN-HH, Bucharest.

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Possible NEG coating studies on DAFNE TF

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Abstract

Various technological solution used inside the beam vacuum chamber of accelerators should not solve one problem introducing another one. ASTeC team is developing in-vacuum technologies for beach chamber that address multiple problems. A non-evaporable getter (NEG) coating of accelerator beam chamber was initially invented as a vacuum solution. It allows to reach specified vacuum even in a very confined space and narrow (5-20 mm) beam chambers. It is also an ideal solution to with a fast ion instability in negatively charged machines and an ion induced pressure instability in positively charged machines.

Later it was show that NEG coating can be deposited with a surface structure allowing to reduce SEY

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DAFNE-TA as a Beam Diagnostic and Instability Control Test Facility

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Abstract

This proposal covers 4 ideas, which can be expanded in scope as the workshop offers ideas and opportunities.

(1) New high-gain transverse instability feedback control methods for large rings or extremely high growth rates The existing control schemes in common use have limitations from noise in the pickup and processing as well as group delay limits from the processing techniques which look problematic for future machines such as FCC. We propose to develop new processing methods that use multiple pickups (at unique betatron phases) to lower the noise and calculate high-gain correction signals in a single turn of latency. The goals would be both the development of low-noise processing as well as new algorithms for computation. We propose trying these methods out with DAFNE-TA and quantifying the performance limits of existing and new methods in a careful way, resulting in publications and demonstration technology that can guide new technology efforts. The scale of this can be modest (mostly built on the existing processing at DAFNE with judicious use of available pickups, revised firmware) or if resources allow technology development a complete new architecture and technology platform could be developed and evaluated at DAFNE-TA, with potential application to demonstrations at other facilities.

(2) Benchmarking and Characterization of novel Tune and Beam Diagnostics from instability feedback data processing streams. The experience using closed-loop noise spectra and other methods to characterize beam tune and other properties (such as collision induced beam-beam tune shifts) can be formally expanded to incorporate driven methods with special chirps and spectrally tailored excitations and control filters. This effort would use the DAFNE-TA ma-

chine to compare methods from a suite of analysis and operational tools, carefully benchmark these to establish regions of applicability, determine sources of systematic errors, and to characterize achievable error bars. The goal is to provide more consistent, and possibly novel beam diagnostics.

(3) Development of a hands-on Beam Instrumentation and Feedback school for training the next generation of Accelerator Scientists and Engineers Various UPSAS, CERN, and Asian accelerator schools have tried to cover this topic. We think a resident school, with both lectures and hands-on experience with the beam and signals would be a more extensive training opportunity. This sort of 2 4 week in residence school would bring the students to readiness to understand and utilize modern control methods, it could also allow skills in the design of pickups and kickers, coding of algorithms, development on FPGA platforms, etc. We think having a group of expert instructors with live beam exercises, the opportunity to have lab sessions with hardware, kickers, RF components, etc. is the best way to build a new generation of experts for this area. This school could be twice yearly, or yearly, or even could be a several month in residence fellowship training opportunity with resident instructors and mentors.

(4) Development and Evaluation of novel wideband Beam Kicker structures The recent experience developing intra-bunch instability methods has led to ideas for novel wideband kicker structures as well as demonstration hardware installed at the SPS. The scaling of this approach to future hadron machines such as HL-LHC or FCC machines requires new kickers at higher frequencies. We want to investigate the use of DAFNE-TA as a test bed for these new kickers, as the relatively long bunch length at DAFNE (and possible new optics with longer bunch lengths) may be consistent with test opportunities. The effort should explore all the options in the original Kicker Design Report (http://www.slac.stanford.edu/cgi-wrap/getdoc/slac-r-1037.pdf), and as consistent with the allowed impedance budget at DAFNE a wideband kicker could be designed, fabricated and commissioned for test with real beams.

Collaborators:

- John Fox
- Dmitry Teytelman
- Wolfgang Hofle
- Makoto Tobiyama
- Themis Mastorides
- A. Drago
- S. Gallo

and others from LNF.

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Study of e-cloud mitigation efficiency with LASE surfaces at DAFNE TF

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Abstract

The secondary electron emission (SEE) can cause an electron cloud build-up inducing an increase in beam instability, beam losses, emittance growth, vacuum pressure increase, a reduction in the beam lifetime, or, it can lead to additional heat loads on a cryogenic vacuum chamber. In the past few years we have established that Laser Ablation Surface Engineering (LASE) is a very effective way of producing surfaces which have Secondary Electron yields (SEY) ¿1. These can be achieved with a variety of laser pulse durations from nano- to pico seconds. The effect of such engineered surface on SEE reduction for copper has been successfully demonstrated by monitoring the electron cloud current in a dipole magnet in the SPS accelerator at CERN and similar test to determine Photon Stimulated Desorption (PSD) of such surfaces is currently being run at KARA. Unfortunately the features (i.e. moderately deep grooves and nano-particulates) that help to reduce the SEY also produce undesirable effects such as an increase in surface impedance and loose particulates. For reducing the depth of the surface altered layer femtosecond laser pulses has recently been used which generate wave-length-scale surface structures with directionality and periodicity, known as laser-induced periodic surface structure (LIPSS). The reduction in SEY in most cases so far has been less effective, but a few laser processing parameters have produced reasonable SEY values (less than 1 for primary electron energy below 400 eV).

It is important to note that the efficiency of ecloud mitigation with LASE surfaces recently investigated with a proton beam at SPS demonstrated the case of SEY driven e-cloud, as there was practically no synchrotron radiation. Ongoing experiment at KARA will report photon stimulated desorption from LASE. The

advantage of experiments at the DAFNE TF would be a complex study of ecloud build up in presence of photo-electrons and photon stimulated pressure increase. Thus, unlike the earlier experiment, three main sources of electrons ecloud will be present. Furthermore, this will provide an opportunity to measure the correlation between four input parameters required for modelling future machines: PSD, ESD, PEY and SEY.

It will be a good opportunity to test and optimise such laser engineered surfaces in comparison to other coating such as amorphous carbon and NEG.

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Dafne-Light synchrotron radiation facility: status and perspectives

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Abstract

In the DAFNE electron storage ring, a 0.51 GeV e^+e^- collider, a routinely circulating current over 1.5 A provides a very high photon flux in the energy range going from the IR to soft x-rays. Due to this unique characteristic DAFNE is used in dedicated and in parasitic mode as a synchrotron radiation source.

DAFNE-Light is the INFN-LNF synchrotron radiation facility where three beamlines are already operational and open to users (IR, softX and UV), two are under commissioning (X-UV) and a new white branch line is under construction.

The DAFNE-Light facility is mainly dedicated to materials characterization for fundamental research and technology transfer. Twice a year, call for proposals are open to EU, Italian and other external Users coming from Universities or Research Centers. Measurements from the IR to the soft X-ray region concerning different application fields as life science, chemistry, material science, cultural heritage and space applications are currently performed.

The DAFNE-Light facility is involved in different EU projects like OPEN SESAME, CALIPSOplus and ATTRACT, in a MoU with CERN and in the INFN CHNet cultural heritage network (ADAMO project), as well as a MAECI bilateral project on graphene and a CSN5 large scale project for the development of a laser THz source.

A short description of the DAFNE-Light facility together with some recent scientific results and more details about the present and future projects will be given.

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Dark sector experiments and test-beam facility based on the slow extraction of a positron beam from the DAΦNE ring

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Abstract

The PADME experiment, running at DAFNE BTF with a 550 MeV secondary positron beam, is designed for searching a new light boson invisibly decaying into particles of a dark sector in fixed-target annihilations: $e^+e^- \to A'\gamma$. The main limitation comes from the pulse length: in order not to over-veto due to the pile-up in the detectors, the intensity should be lower than 100 particles/ns. Due to SLED compression the primary electron beam from the linac has a maximum length of 200 ns: at 50 Hz, this gives a rate on target of 1 MHz. PADME@BTF thus requires 10^7 s in order to reach its benchmark of 10^{13} positron on target, i.e. a sensitivity of 10^{-3} in the coupling of A' to the photon, up to a mass of 24 MeV/c^2. Recently, a facility (POSEYDON) based on the stretching of the positron beam of the linac by using one of the rings of DAFNE was proposed, using 1/3 resonant extraction inspired by the ALFA project for ADONE and EROS ring in Saskatchewan. The physics potential of PADME@POSEYDON, assuming a positron beam of 510 MeV, energy spread and emittance suitable for PADME is discussed, together with modifications to the experiment: for a length of 0.2 ms a gain of 3 orders of magnitude is expected. The realization of the extraction line from the point of view of infrastructure, time schedule and costs is discussed, as well as operation costs assuming a less than 3 months running for PADME@POSEYDON. A further possibility is the non-resonant, ultra-slow extraction using channeling phenomena in crystals (DUSE), from the halo of the circulating positron beam. Even though a lower efficiency with respect to the resonant extraction is expected, the continuous time structure allows reaching virtually zero-background for PADME@DUSE, further improving the physics potential

wrt POSEYDON. The modifications to the setup and operational aspects are discussed also for this option. An extracted, high-duty-cycle positron beam would be also useful for at least 3 kinds of applications: test-beam with low-rate long-pulse particles beam; irradiation for total dose studies *e.g.* for testing devices for space applications; studies of channeling phenomena with positron. Such a facility would also profit of the possibility of modulating the energy, which ca be relatively easily implemented building a BTF-like beam attenuation and selection system. The modifications to the transfer lines and main ring, as well as the calculation of the lattice of the ring and the optimization of the extraction parameters are presented in a separate contribution (S. Guiducci).

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Beam shaping and ultra-slow extraction based on crystal channeling

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Abstract

A particle beam crossing a bent crystal can be deflected or partially focused, depending on a number of parameters, both of the beam (mainly charge sign and energy) and of the crystal (crystal axis or plane, radius of curvature and thickness), as a result of the particles being trapped in the channeling regime.

In particular, parasitic non-resonant beam extraction based on the use of a bent crystal would produce a quasi-continuous beam, that is a very interesting feature for low pile-up experiments, as - for instance - fixed-target dark sector searches. While for hadron beams ultra-slow extraction by bent crystals has been recently studied at the CERN SPS also in view of future applications at the LHC, this has been much less explored in the case of electron and positron beams.

Positive and negative particles behave differently in the crystalline potential. DAFNE in that sense becomes quasi-unique facility providing simultaneously the possibility to perform dedicated studies for channeling related phenomena. In particular, studies on positrons at the energy range of the DAFNE machine are very limited. Studying the different channeling phenomena in the halo of the positron ring at 0.5 GeV would provide a powerful tool to test a number of beam manipulation options.

A goniometer located in the vacuum of one of the DAFNE rings, complemented by beam tracking diagnostics, would provide a general-purpose facility to test a wide range of channeling phenomena, with a modest investment and possibly with a high degree of synergy with other experiments aimed to study targets with a electron/positron beam.

Finally, it would be possible to design and realize an extraction septum and an extraction channel, positioned at a suitable phase-advance with respect to the crystal setup aimed at producing an extracted beam for possible users. In the case of positrons, such an extracted beam facility (DAFNE Ultra-Slow Extraction or DUSE) would be already competitive for fundamental physics applications, largely extending the sensitivity of fixed-target positron annihilation dark sector searches, as the PADME experiment at the Frascati BTF.

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Beam-Beam effects and impedance effects for the FCC-hh and HE-LHC design studies.

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Abstract

Future hadron colliders under study at the Future Circular Collider collaboration plan to collide for the first time protons at energies of 13 and 50 TeV for the High Energy Large Hadron Collider (HE-LHC) and the Future Circular Collider hadron-hadron (FCC-hh), respectively. For the first time the effect of radiation damping become important for the proton dynamics and therefore it has to be included in the beam dynamics models. Present models of the electromagnetic interactions between the two colliding beams (so called beam-beam effects) for the Large Hadron Collider do not cover these effects since they are negligible. Due to the higher energies foreseen radiation damping becomes important and has to be modelled and the relevant experience and knowledge should be acquired. Beam-beam models from the LHC will have to be up-dated to take into account such effects (*i.e.* synchrotron radiation, quantum excitations). The benchmark of the numerical models with the DAFNE collider data represents an important and unique opportunity.

The beam-beam parameter for such future colliders is now limited to maximum 0.03. The study of any possible extension or limitation of such value would be a fundamental input to the design.

We would like to propose to study the beam-beam effects for different radiation damping time scales to acquire data for the benchmark of the beam-beam models for the FCC-hh and the HE-LHC options. A list of studies to be performed is:

- Study the beam-beam effects for different radiation damping and for different beam-beam parameters. With and without beam-beam long-range encounters to understand differences and identify scaling laws where possible.

- Study the coupling of beam-beam coherent modes to the machine impedance modes. This coupling has been observed in one single dedicated experiment at the LHC for the case of one single beam-beam interaction. The extension to beam-beam long-range effects is still to be addressed.
- Effects of a finite crossing angle on the particle dynamics would also provide an important data sample for code benchmarking together with the exploration of the parameter space.
- DAFNE collider could represent a unique opportunity to collect data to train a model using machine-learning techniques to describe the collider performances in terms of losses and luminosity production. The model could be tested for predicting the performances and would represent an important data sample to possibly compare to LHC models under study at EPFL and CERN.

This opportunity is a unique possibility to transmit to students and post-doc of the FCC collaboration the knowledge and experience of beam-beam effects accumulated at DAFNE over the many years of operation of the collider. This will represent an extremely valuable training for the future generation of accelerator physicist that will be working on the design of the FCC-hh and HE-LHC collective effects.

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UV-VIS investigation of analogue of planetary environments at DAFNE-L

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Abstract

Space missions, as JWST and ARIEL (ESA M-Class Mission) or ground based instruments like SPHERE@VLT, GPI@GEMINI and HIRES@ELT, have been proposed and built to measure the exoplanetary atmospheric transmission, reflection and emission spectra over a wide wavelength range. Exoplanets are unique objects in astronomy because they have local counterparts the Solar System planets available for comparative planetology studies but also outsider case like Super Earths. In our own system, proto-planets evolution was flanked by an active prebiotic chemistry that brought to the emergency of life on the Earth. The search for life signature requires as first step the knowledge of planet atmospheres, main objective of future exoplanetary space explorations. In particular, it is important to know in detail the optical characteristics of gases in the typical physical conditions of the planetary atmospheres and how those characteristics could be affected by radiation driven photochemical and bio-chemical reaction. Insights in this direction can be achieved from laboratory studies of simulated planetary atmosphere of different pressure and temperature conditions under the effects of radiation sources, used as proxies of different bands of the stellar emission.

The radiation sources should be of different kinds in order to reproduce in the laboratory the radiation environment where the planet and its atmosphere are. Important is high energy radiation and its interaction with the planetary atmosphere. We propose to setup a specific experiment at the UV-VIS beamline at DAΦNE-L combining the UV-VIS and IR radiations to study the modification of different gas mixtures simulating super earths atmospheres under the action of extremophile bacteria and irradiation of high energy radiation.

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Workshop

Intense crystal-based hard-X and gamma sources with the DAΦNE beam

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Abstract

In the 60^s, Diambrini Palazzi et al. discovered at the Frascati synchrotron the increase of the Bremsstrahlung in oriented crystals due to an effect called Coherent Bremsstrahlung (CB). CB is the enhancement that occurs in normal bremsstrahlung inside a crystal when the momentum transfer from the electron/positron to the atom matches a reciprocal lattice vector. It is currently used in many laboratories, where GeV electron beams are available (MAMI, JLAB, ELSA and Max Lab) to produce intense monochromatic and linearly polarized -beams for photo-nuclear research.

When the electron/positron velocity is nearly parallel to a crystal axis or plane its trajectory can be forced in an oscillatory motion within the potential well formed by neighbouring axes or planes. This channeling condition leads to a specific e.m. radiation emission, named Channeling Radiation (CR), which is a bit softer but more intense than CB. With the 0.5 GeV DAΦNE beam an intense CR around 1 MeV is expected. For comparison, hundreds keV X-rays as synchrotron radiation require a few-GeV electron beam.

Even if CR possesses a strong potential due to its high-intensity, it is not currently exploited for applications due to the spoiling contribution of dechanneling, that

limits the radiation intensity and monochromaticity. Indeed channeled electrons move close to atomic nuclei with high probability to be ejected from the crystal channel. Since the dechanneling probability is much lower for positive particles and DAΦNE is one of the few facilities worldwide providing e+, this open the way for the realization of an intense CR source at LNF.

Moreover, intense e.m. radiation can be generated in periodically bent crystals (Crystalline Undulators-CU), in which the nearly sinusoidal motion of charged particles causes the generation of X-ray ($\sim$100 keV at DAΦNE) with high monochromaticity. The existence of CU radiation was recently proved using a 855 MeV electrons at MAMI, but with poor intensity. The usage of a e+ beam could lead for the first time to the generation of intense CU radiation.

In conclusion, the production of highly-polarized hard X or radiation using the interaction of e-/e+ with crystals, both based on the CB, and on novel techniques as CR and CU can be explored. This source can be exploited for technology, medicine and basic sciences with a great advantage over Inverse Compton since it does not require a short-pulse powerful laser, i.e. much lower cost at a comparable photon energy and intensity.

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Crab Waist at the Maximum Performance

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Abstract

Look for a possibility to test crab waist again at DAFNE to verify its maximum performance. In the previous tests have shown its validness, however, they have not achieved the beam-beam parameter as high as desired and predicted, gsim 0.1. We would like to look how this can be done at DAFNE-TF.

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DAΦNE Crystal Radiations Based Applications

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Abstract

Interaction of different kinds of radiations (electromagnetic one and charged beams) with a matter has been studying since scientific community started to operate with the penetrating radiations. Hence, at present this branch of science is not a new one. However, interest to the problem of radiations interaction with solids does not fall down. Practically in all accelerator centres there are groups/laboratories specialising in those tasks.

Among different research branches, studies on coherent phenomena of the beams passage through the solids attract attention of physicists due to the possibility of getting strong radiation fluxes in various spectrum intervals, from optical frequencies via soft/hard x-rays up to -rays. In order to obtain quasi monochromatic photon beams of high intensities, it has been proved that, instead of radiation by moderate energies electrons or positrons in amorphous, it is more reasonable to use the following radiation processes in mono- or polycrystals or in specially fabricated nanostructures: a) coherent bremsstrahlung for production of photon beams of MeV energies (that is necessary, for instance, for various nuclear reactions); b) transition radiation - for 1-5 keV photons (for lithographic applications); c) channeling radiation - for 1-100 keV photons (for material science, chemistry, biology and

medicine); d) large angle channeling radiation, i.e. Cherenkov radiation at channeling for 1-10 eV photons (powerful Cherenkov ultraviolet radiation); e) parametric x-ray radiation - for very monochromatic 1-50 keV beams (for beam diagnostics, x-ray applications in elemental and CT studies).

In this report we propose to establish a dedicated facility within the DAΦNE layout for studying various crystal related radiations from the point of view of their applications for investigation of the beams and physical phenomena as well. Keeping in mind the fact that DAΦNE can provide simultaneously in time and space low-emittance electron and positron beams of several hundred MeV energy, experiments to reveal new features of the beams interaction in crystals becomes very promising for both basic studies and diagnostics applications. Additional to some innovations in well studied branch, the proposed applications based on the use of small crystals might have very promising future as extremely low-cost tool.

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Workshop

DAFNE as a test bench for innovative vacuum equipment and surface treatments

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Abstract

DAFNE offers a unique opportunity to test vacuum components and surface modifications with beams. Thanks to its flexible beam parameters, a large spectrum of applications can be covered and a multitude of experiments could be conceived.

A typical example is the study of photon interaction with surfaces exposed to synchrotron radiation. Indeed, DAFNE may provide photons, in either a large or narrow spectrum of energy, that can be focused on samples or distributed along metre-long vacuum vessels. In the framework of HL-LHC and FCC, CERN's Technology Department has a running collaboration with INFN on this theme.

The effect of specific surface treatments on electron multipacting can be measured with positively charged beams. In that respect, DAFNE would be the ideal test bench to assess surface modifications and validate new concepts for electron pickups and other sensors.

New designs and materials could be tested for impedance reduction at different temperatures with beams having distinct characteristics.

In addition to the exceptional beam quality of DAFNE, LNF is equipped with key infrastructures, e.g. cryogenic facilities, and provides the expertise of skilled technical and scientific colleagues; both are essential for the success of those experiments.

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Workshop

Crystal high quality positrons extraction from the DAΦNE accelerator ring

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Abstract

We propose to implement, test and operate the extraction assisted by bent crystal of a positron beam from one of the Frascati DAΦNE collider rings. The proposal is supported by the UA9 Collaboration that will provide know-how and some of the technical solution required.

The aim is to obtain a high-quality spill of low energy spread (¡ 10-3) and emittance (¡ 10-6 m*rad). The high value of the duty-cycle, expected in a non-resonant, crystal based extraction scheme, should also guarantee a very flat extracted flux and strong reduction of the background and of the pile-up in the experiments using it. The most common approach to extract from a circular accelerator is to use a resonant technique, creating an unstable region in the phase space and then driving the tune towards the resonant value, in order to gradually eject particles along the unstable separatrix of the phase-space. The proposed scenario, instead, is based on two ingredients. The halo population surrounding the circulating beam is steadily sustained by injecting some transverse or longitudinal random noise properly tuned. A bent-crystals properly oriented intercepts the diffusive halo and kicks it thanks to a coherent deflection of the incoming particles through the inter-planar potential. This non-resonant technique, already successfully used and still developed in hadron accelerators, in particular at CERN, i.e. in RD22 from 1990 to 1997 and in UA9 in 2018, will provide a continuous multi-turn extraction with high-efficiency and a better spill quality a simpler and cheaper way than non-resonant extraction. At the same time, crystals can support the resonant approach strongly contributing to extract particles towards the extraction septum, realizing a crystal-resonant hybrid extraction. This can be achieved by exploiting the deflection of positrons

due to channeling effect in bent crystals, or using them like ”mirrors” to reflect positrons by the so called ”Volume-reflection” process, thanks to the electrostatic potential generated by the coherent atomic structure. This can allow getting a better control of the extraction duration and a more collimated extracted beam. In 2013 positrons deflection by the ”Multi-volume-reflection” in 5 silicon bent crystals in a row has been performed at the BTF, obtaining very encouraging results. In fact, the DAΦNE LINAC 100 MeV positron beam has been deflected by 5 mrad with an efficiency of 30%, proving the real possibility to deflect positrons with an angle and an efficiency compatible with the DAΦNE ring extraction requirements. A further possibility, more effective and challenging, is to extract the beam using only one bent crystal in which the particles will be deflected directly by the channeling effect realized between lattice planes. In 2006 at the BTF 480 MeV positrons were deflected by 10 mrad by a bent silicon crystal only 1 mm thick along the beam direction, proving the principle. This more sophisticated approach reduces the interactions of the particles with the crystal itself, ensuring a more clean extraction process. Furthermore the deflection efficiency can be boosted exploiting multi-turn interactions of the circulating particles with the crystal, hence achieving the extraction of almost the whole beam. The solid expertise developed in the UA9 framework can provide the knowhow as well as the technological support for crystal angular actuators and beam monitoring detectors. In addition to providing an extracted beam with unprecedented features, this project is scientifically interesting per se: indeed no crystal-assisted extraction of positrons has been used so far.

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Workshop

The KIT accelerator test facilities: Karlsruhe Research Accelerator KARA, short-pulse linac FLUTE, and Magnet Characterization Facilities

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Abstract

The Institute of Beam Physics and Technology (IBPT) operates at KIT the infrastructures KARA, FLUTE, and Magnet Characterization Facilities. KIT's storage ring facility consisting of 2.5-GeV electron storage ring KARA, 53-MeV microtron and 500-MeV booster synchrotron as injectors, is operated as a synchrotron light source and, one third of the time and up to 50 operation days per year, as an accelerator test facility. A running refurbishment program supports the test facility mission of KIT's storage ring facility to host advanced accelerator physics and technology experiments and novel operation schemes, including novel methods such as machine learning. The current experiments are embedded in national programs of BMBF-funded research and within EU programs ARIES and EuroCirCol. KARA provides a wide range of beam energies from 0.5 to 2.5 GeV, bunch lengths from 50 ps down to a few ps, and a world-wide unique sensor network of turn-by-turn, bunch-by-bunch advanced laser-based electro-optical and detector diagnostics, as well for THz CSR. KARA's synchrotron radiation ranging from the THz range to hard X-rays is used by various independent KIT institutes and their collaborators, within the EuroCirCol project and for development of advanced diagnostics. Within EuroCirCol the envisioned 3 prototypes of the very first 2 meters of the 100-km FCC-hh vacuum beam pipe are already tested, providing a wealth of data to progress on the beam screen design and to cross the LHC energy frontier. FLUTE

consists of fs chirped laser-driven photo-injector, linac, and compressor for bunch lengths in the range of 3 to 300 fs at 41 MeV. The FLUTE accelerator test facility provides low energy electron beams since May 2018. The first accelerator physics experiment is installed to make use of FLUTE's few MeV electrons. Low-alpha, thus low momentum-compaction factor operation is routinely used at KARA for more than a decade for studies of micro-bunching instabilities and development of MHz-rate phase space tomography. The low-alpha scheme is currently considered in several synchrotrons as their next storage ring projects to provide ultra-low beam emittance. Within ARIES at KARA, based on a more of a decade experience in experiments and simulation theory, the lattice optics, low-alpha and negative low-alpha modes, and injection schemes have been investigated aggressively with the concrete scope of enabling these modes for future particle accelerators.

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Workshop

A tagged polarized gamma-ray facility in the medium-energy range as calibration tool for detectors in gamma-ray astrophysics.

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Abstract

The study of the gamma-ray polarization is of great interest for high-energy astrophysics, for example gamma-ray polarization can distinguish between emission processes such as synchrotron radiation and other production mechanisms. Nevertheless it is a major technical challenge because of the difficulty of designing detectors adequate to the measurement of the photon polarization in the pair-creation regime at medium-energy (∼50-200 MeV), due to the almost collinear production of the pair particles that makes extremely difficult to identify the production plane of the pair because of multiple scattering in the detector itself. The distribution of the azimutal angle of the production planes is sensitive to the polarization plane of the gamma-rays. One of the preconditions for an efficient design of those detector is the availability of tagged gamma-ray beams with controlled polarization at variable energy. Beams of polarized gamma-rays can be obtained exploting a laser beam of polarized light shot against a beam of accelerated electrons/positrons or relying on Bremstrahlung from an extracted beam of polarized electrons/positrons. The facility should include not only the system for generating polarized gamma-rays but also a system for tagging the photon and determining the photon energy. This system must be carefully calibrated and can be very useful even in absence of polarization. Finally, the beam average polarization must be measured and monitored with a dedicated gamma-ray polarimeter. This polarimeter can be quite long and with low efficiency, that allows the use of low-density gaseous detectors for minimizing the multiple scattering. With this infrastructure it will be possible to study the overall efficiency, the energy resolution and the efficiency in measuring the polarization of detectors designed to operate in space-based experiments.

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Using DAFNE to study the physics of the $e^{\pm}$ beam interaction with vacuum devices

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Abstract

DAFNE is an excellent machine to study the interaction of electron and positron beams with vacuum chambers. In particular it could contribute to a deeper understanding of the beam heat load contribution to the cold bore, essential for the successful performance of circular colliders using superconducting magnets.

A beam heat load to superconducting magnets higher than predicted could cause a lower magnetic field seen by the beam, and therefore a lower center of mass energy for the collisions, up to a complete failure of the machine in case of a quench of a superconducting magnet (zero magnetic field). The measurements of the beam heat load on a cold bore are also essential to benchmark: different kind of simulations of beam heat load due to synchrotron radiation, impedance, and electron cloud. Insight on impedance, and electron cloud, which often causes harmful beam instabilities, can produce relevant improvement in terms of beam currents, and in turn of luminosity.

Studies on vacuum chambers for the successful performance of cryogenic insertion devices in low emittance light sources are also possible. In a first stage COLDDIAG, a cold vacuum chamber for diagnostics, developed by KIT in collaboration with CERN, DLS, Frascati National Laboratory, Rome University La Sapienza, STFC Daresbury Laboratory, STFC Rutherford Appleton Laboratory, University of Manchester, Cockcroft Institute of Science and Technology and Lund University MAX-lab, could be installed. COLDDIAG, fabricated by Biflinger Noell GmbH, was installed for one year in the Diamond Light Source. It is equipped with heaters and temperature sensors, retarding field analysers, pressure gauges, residual gauge analysers as well as by a solenoid with an on axis field of 10 mT in the middle of the magnet.

Within the EuroCirCol project, a dedicated BEam Screen Testbench EXperiment (BESTEX) setup has been developed in a collaboration between ALBA, CERN, LNF, and KIT which aims at testing a novel beam screen for the future hadron-hadron circular collider (FCC-hh). BESTEX should determine the photo-desorption yield, synchrotron radiation heat loads and photo-electrons generation inside the beam screen prototype. BESTEX is presently installed, and successfully acquiring data, in one of the frontends of the KIT accelerator test facility KARA. Up to now only samples at room temperature have been tested. Recently, a feasibility study of a cryogenic vacuum chamber test set up equipped with different diagnostics to measure the pressure, gas content, low energy electrons formation, as well as the heat load produced by a positively charged beam, has been approved by the German Ministry of Research and Education. The test set up should be flexible to exchange cold bores with different geometries and surfaces and be adaptable in different accelerator exposed to charged beams as well as to synchrotron radiation. In this context an upgraded BESTEX test chamber that could also be tested with electron and, what is more important, with positron beams at DAFNE.

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DAFNE Compton ring for ultra high flux photons in the 100 KeV-1 MeV range

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Abstract

Hard X rays and gamma ray sources with high flux and spectral densities are the main requirements for material science and industrial applications or nuclear physics experiments. The presentation is focused on a proposal of experiment of photons production using Compton collisions between the electron beam and a high average power laser pulse. The calculations show that the resulting beam source has extremely interesting and unique properties in terms of spectral density, energy spread and flux of photons in the range between 100 keV and 9 MeV. The energy of the beam depends on the adopted laser wavelength and can be tuned changing the energy of the electron ring. The main parameters are presented and the perturbation on the transverse and longitudinal electron beam dynamics is discussed. A preliminary accelerator layout to allow experiments with the beam is finally presented.

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Optimization of laser-plasma accelerators as injectors for storage rings

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Abstract

Typical electron storage rings use a combination of linac and booster as an injector and represent a substantial capital investment in a facility for construction, operation and maintenance. A compact laser-plasma injector could be a convenient replacement for this injector with sufficient development of the stability and reliability of the LPA. Unattactive features of LPAs, such as energy spread, are not a problem as long as the energy spread fits within the energy acceptance of the storage ring. Furthermore, LPAs may provide some interesting features for on-axis (or near on-axis) injection for multibend achromat lattices. Below I list some pros/challenges for this project at DAFNE. Pros:

- The energy of LPAs reaches from 0.1-1 GeV with conventional TW laser or 1-6 GeV with large laser ∼PW, a good match with existing storage ring energies.
- The rep rate for typical storage ring injectors is about 1-10 Hz, a good match with typical LPAs.
- The size of the LPA injector saves significant space and potentially cost vs a traditional linac/booster storage ring injector
- The LPA injector could be located, in principle, inside the storage ring vacuum chamber, allowing topoff injection for MBA rings
- INFN Frascati has strong expertise in storage rings and LPAs!

Challenges:

- The energy spread of the LPA beam must be less than the energy acceptance of the ring, typically 2-4%.
- The mean shot-shot energy stability must be stable.
- short bunches must be stretched for injection
- Reliability must be ¿99%.
