The MAGIX experiment dark photon searches

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The current experimental setup of the Institute for Nuclear Physics at the Johannes Gutenberg University in Mainz[1], will soon be extended by a new accelerator called MESA[1] [2]. This machine is a three-orbit polarized electron recirculator designed for a maximum current of 1 mA, which can be operated in two modes: in the *extracted beam mode* the electrons are extracted after the third orbit at an energy of 155 MeV and delivered to the P2 experiment[3], dedicated to the precision measurement of the weak mixing angle. In the *energy recovery mode* the beam is extracted at the end of the second orbit at 105 MeV and diverted on an external loop, which hosts the interaction point of the **MAGIX** experiment[2]. After interacting the beam is injected again in the recirculator orbits in the decelerating phase of the accelerator so that its energy can be almost completely recovered and reused for the following bunches.

MAGIX is currently under development and is designed to be a versatile experiment to perform precision measurements at energy scales between 10 and 100 MeV. The current baseline design is composed of a gas target and a set of two identical magnetic spectrometers with GEM-based [4] trackers in the focal-planes and the possibility to integrate further detectors in the scattering chamber and in the forward direction. All of those components are currently undergoing an extensive R&D phase to obtain the required performance parameters. In particular, the target should be able to deliver a gas jet with a density of the order of $10^{19}\,\mathrm{g/cm^2}$ which will allow to reach luminosity of the order of $10^{35}\,\mathrm{cm^{-2}s^{-1}}$. The focal plane detectors will achieve a position resolution of $50\,\mu$m, corresponding to a relative momentum resolution of the order of $\frac{\delta p}{p} \approx 10^{-4}$ on a sensitive surface of $120 \times 30\,\mathrm{cm}^2$.

[1] Mainz Energy-recovering Superconductive accelerator

[2] http://magix.kph.uni-mainz.de/index.html

The versatility of **MAGIX** will allow us to perform high-precision measurements in several fields ranging from hadronic structure and few-body physics, with a particular focus on the form-factors of light nuclei, to the high-precision measurement of nuclear cross-sections and the search for new exotic particles focussing, in particular, on the search for dark photons [5].

In the case of a dark photon decaying back into detectable Standard Model particles, which, at the energy available, can only be electrons and positrons, we are going to use the two spectrometers to measure the invariant mass of the electron-positron pair produced scattering the MESA beam on a heavy nuclear target. The presence of peaks in that invariant mass distribution would unambiguously signal the presence of an invisible, massive mediator. A first estimate allows us to project a sensitivity in the mass range between 10 and 60 MeV down to effective couplings $\epsilon > 5 \cdot 10^{-5}$.

In the case of the invisible decays an accurate estimate of the projected sensitivity is current being evaluated. In that type of scenario we will scatter the incoming beam on a hydrogen target and completely reconstruct the vertex kinematics by measuring the momenta of both the scattered electron and recoil proton. From a preliminary analysis **MAGIX** will be able to look for possible invisible decays in the same mass range as for the previous case while the coupling sensitivity is currently under study, mostly dependant on the detection efficiency of the recoil proton.

Finally, not directly correlated to **MAGIX** but at the same accelerator, we are also investigating the possibility for a beam-dump experiment, which will be placed behind the beam-dump of the P2 experiment, taking advantage of $\approx 10^{23}$ electrons planned to be delivered on that target during the first few years of activity of that experiment. This beam-dump experiment aims to detect dark sector particles produced during the electron showers in the beam dump. An estimate of the potential sensitivity of such an experiment is currently ongoing.

References

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