Laser muon sources : concepts and challenges

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Muons, standard constituents of elementary particle model with the mass of 207 times electron mass, are available nowdays in cosmic radiation or can be produced by accelerators [1]. The progress in laser technolology - availability of high-intensity and highrep systems [2] , inspires the study of their potential production as tertiary particles in laser-matter interaction. There exists several posibilities how to achieve this goal :

<table>
<tr><td rowspan="5">Direct muon production processe (electromagnetic processes)</td><td colspan="2">Electron / photon driven systems</td><td rowspan="2">High-energy complex particle sources</td></tr>
<tr><td>1.1 Electron-electron collisions</td><td>1.2 Electron-nucleus collision</td></tr>
<tr><td colspan="2">Photon-driven systems</td><td rowspan="2">Weak pure lepton sources</td></tr>
<tr><td>2.1 Photon-photon collisions</td><td>2.2 Photon-electron collision</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="3">Muon production via pion decay (nuclear processes)</td><td colspan="2">Proton / ion driven systems</td><td rowspan="2">Medium energy sources</td></tr>
<tr><td>3.1 Flying pion decay</td><td>3.2 Stopped pion decay (surface muons)</td></tr>
<tr><td colspan="3"></td></tr>
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In this contribution, results of a suitability study in this area considering concrete ELI Beamlines systems (HELL, ELIMAIA, P3) will be presented. Main attention will be given to the processes 2.1, 2.2 and 3.2. The first calculation of the proces 1.2 [3] evidently overestimates the muon yield in a real experiment. Detection and parameter measurement of muons in this process should be the first task for the experiment, results from the study [4] are not convicing. The most effective process, alowing the development of applicable muon source could be the mechanism 3.2. Nevertheless, its possibility supposes the availabilty of a laser-driven proton / ion beam with energy of several hundred MeV. The energy of this order is necessery also for oncological applications, the progress in this intensively studied area will pave also the route for laser muonics. Proposal of an applicable source based on the process 3.2 wil be presented. Some potential applications of laser-based muon beams will be mentioned.

References

[1] Nagamine K.: Proc. Jpn. Acad., Ser. B 92 (2016), 265 * [2] ELI Beamlines, https://www.eli-beams.eu * [3] Titov A. I. et al.: Phys. Rev. STAB 12 (2009), 111301 * [4] Dreesen W. et al.: DOE/NV/25946 - 2262 (2014).