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The Mu2e experiment at Fermilab: μ N→ e N

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Summary. — Lepton flavor violation in the neutrino mixing is so far a fact. This means that also charged-lepton-flavor-violation (cLFV) must exists. Mu2e searches for a particular process, the neutrino-less conversion of muons into electrons in the field of an aluminum nucleus. The sensitivity expected for Mu2eis $\sim 10^{-17}$, which represents an improvement of a factor of 10^3-10^4 over existing limits. If no conversion events will be seen, it will set an upper limit on the conversion rate of $R_{\mu e} < 6 \times 10^{-17}$ 90% C.L. Mu2e collaboration has received CD1 approval in 2012 and will start data taking in 2019.

1. – Mu2e physics

The particular process searched by the Mu2e experiment is the coherent conversion of a muon in to an electron in the field of an aluminum nucleus. The dynamic of this process is the same of a two-body-decay, resulting in a mono-energetic electron with the recoil of the atomic nucleus with no neutrinos in the final state. The electron from conversion (CE) has an energy of the muon rest mass minus corrections for the nucleus recoil and the binding energy of the muon ($E_{\mathrm{ce}} = 104.967$ MeV). In the standard model, including finite neutrino masses, $R_{\mu e}$ is expected to be much smaller than the current experimental limits ($\sim 10^{-54}$). This leaves large opportunities for the observation of new physics beyond the standard model, because several models predict $R_{\mu e}$ few orders of magnitude below the current experimental limit [2].

2. – Physics backgrounds

The search of muon conversion in the Mu2e experiment is affected by four main background sources: **Radiative Pion capture** (RPC), **prompt beam related particles**, **cosmic induced** background and **decay-in-orbit electrons** (DIO).

RPC ($\tau \sim 200$ ns) is given by the negative pions stopped in the targets. The kinematic endpoint is near the pion rest mass energy with a broad distribution that peaks at about 110 MeV.

Prompt beam related background consists of e^-, π^-, $\bar{p}$, K^-.. which can either decay or interact producing an e^- mimicking the conversion electron. Mu2e uses pulsed bunches with a period of 1700 ns. This beam structure allows the selection of a "time window" which avoid the contamination by these two kind of backgrounds (PRC and prompt beam related).

Cosmic-ray muons hitting the muon stopping target and other materials in the detector region can produce delta rays that may have the right energy and may fall within the detector acceptance, so producing conversion-like background events. Cosmic ray muons can also decay, producing electrons that could mimic a conversion e^-, or they can be scattered in the detector region and be trapped by the magnetic bottle.

An electron from muon DIO [2] can have an energy close to that of a CE, in fact the energy spectrum of electrons from muon DIO falls rapidly near the endpoint ($E_{\text{endpoint}} = E_{\text{ce}}$), approximately as $(E_{\text{endpoint}} - E_e)^5$.

3. – Experimental set-up

The Mu2e experiment is composed by three main magnet systems (see fig. (1)): the first is the Production Solenoid (PS), where an 8 GeV/c proton beam strikes a tungsten target, producing mostly charged pions which are then collected (by means of a graded magnetic field) in the second magnetic system, the Transport Solenoid (TS). The TS

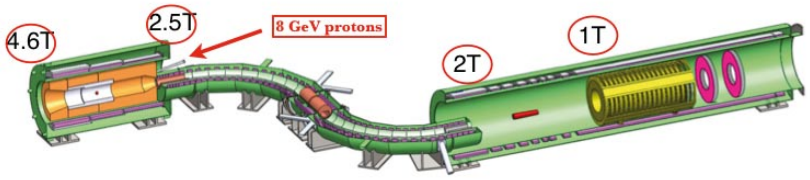

Fig. 1. – Mu2e experimental layout

is devoted to move and select only negative low-momentum muons (from pion decay) through the last solenoid, the Detector Solenoid (DS); to perform this selection the TS has been designed with inside a system of collimators and filters. The S shape of the transport solenoid allows also to avoid all the neutral particles generated in the PS to reach the detector region. The DS is the last stage where the muon beam arrives. It houses the muon stopping targets and the detection system devoted to identify and analyze the conversion electrons. The targets resides in a graded field region that varies from 2 to a 1 T, so that electrons emitted upstream (towards the DS entrance) are reflected downstream throw the detectors region. Downstream the targets a proton absorber, made of high density polyethylene is located in order to reduce the proton flux (produced in nuclear reactions) to the tracker. The tracking system consists of 18 straw tubes stations designed for maximizing the acceptance for the conversion electrons; it is the main detector of the experiment and it is expected to have a resolution (@ 100 MeV/c) $\sim$ 100 keV/c. The second detector is a crystal electromagnetic calorimeter (EMC). It consists of two disks separated by $\sim$ 75 cm (1/2 wavelength of the signal electron helix). Each disk contains $\sim$ 900 LYSO crystals 3 x 3 x 11 cm^3, which are read out by two large area APD's. The EMC supplies energy, position and timing informations on tracks and it also provides a muon rejection of a factor $\sim 10^2 - 10^3$ and its good timing can help pattern recognition of the tracker.

REFERENCES

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