The Mu2e experiment at Fermilab

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Summary. — The Mu2e experiment searches for the neutrino-less muon to electron conversion in the field of a nucleus, which is a charged lepton flavor violating process. The goal of the experiment is to reach a single event sensitivity of 2.8×10^{-17}, setting an upper limit on the muon conversion rate at 6.7×10^{-17}. This corresponds to a four order of magnitude improvement with respect to the existing limits.

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1. – Charged Lepton Flavor Violation and Mu2e Physics

The Mu2e experiment at Fermilab will search for the charged lepton flavor violating (CLFV) process of muon to electron conversion in an aluminum nucleus field, $\mu + N(Z,A) \to e + N(Z,A)$ [1]. No CLFV interactions have been observed experimentally yet.

Lepton flavor violation for neutral leptons, proved by several experiments of the last decades, implies that also CLFV is possible even in the Standard Model (SM), but with a rate not-detectable by current experiments. Indeed, in the SM, even considering diagrams with neutrinos oscillation, the expected rate is negligible ($\sim 10^{-54}$). So, observation of these processes should be a crucial evidence of new physics beyond the SM.

The current best experimental limit on $\mu - e$ conversion has been set by SINDRUM II experiment [2]. Mu2e intends to improve its result by four orders of magnitude, constraining the ratio, $R_{\mu e}$, between the conversion rate and the number of muon captures by Al nucleus:

$$R_{\mu e} = \frac{\mu^- \, N(Z,A) \to e^- \, N(Z,A)}{\mu^- \, N(Z,A) \to \nu_\mu \, N(Z-1,A)} < 6 \times 10^{-17} \,, \text{at } 90\% \,\text{C.L.}$$

with a single event sensitivity of 2.7×10^{-17}

2. – The Mu2e apparatus

The signature of this neutrinoless conversion process is a monoenergetic electron, with an energy slightly lower than the muon rest mass, ~ 104.96 MeV. In order to achieve our goal on the $R_{\mu e}$ measurement, a very intense muon beam ($\sim 10^{10}$ Hz) has to stop on an aluminum target and a precise momentum analysis has to be performed. The beam must also have a pulsed structure to discriminate the prompt beam-induced background.
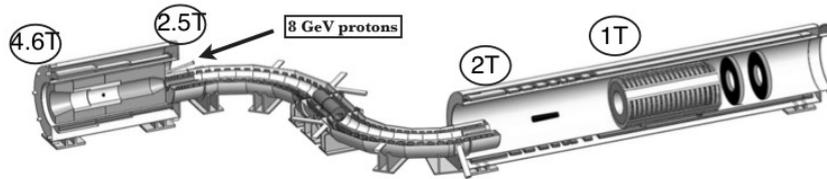

Fig. 1. – Experimental layout of Mu2e. The Cosmic ray veto is not shown.

The Mu2e experiment [1] is composed by three main superconducting solenoid magnets (Fig. 1). The first is the production solenoid (PS), where an intense 8 GeV bunched proton beam strikes a tungsten target producing mostly pions. Its graded magnetic field (from 4.6 T to 2.5 T) collects most of the produced charged particles and moves them through the second magnet, the transport solenoid (TS). The TS transfers and selects negative low-momentum muons towards the last detector solenoid (DS), trough a system of collimators. Its "S" shape prevents that neutral particles produced in the PS reach the last solenoid. The DS houses the muon stopping Al targets and the detection system devoted to identify and analyze the conversion electrons (CEs). The Al targets reside in a graded field region (from 2 T to a 1 T), in this way electrons emitted upstream are reflected downstream through the detectors, whose acceptance is optimizes to collect $\sim$100 MeV/c tracks. The detector consists of a tracker made by 18 stations of straw tubes, with a resolution of $\sim$ 120 keV/c for 100 MeV/c momentum, followed by a pure CsI crystal electromagnetic calorimeter, which allows particle identification and rejection of background. In particular, energy (with a resolution around 5%, at 100 MeV) and timing (with a resolution better than 500 ps) measurements from the calorimeter provide critical information for efficient separation of electrons and muons in the detector.

A Cosmic Ray Veto system surrounds the DS on three sides (the ground is not covered) and extends up to the midpoint of the TS.It is designed to reduce the number of expected cosmic induced background events to 0.05 events during the entire running period (three years).

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REFERENCES

[1] L. Bartoszek, et al., *Mu2e Technical Design Report, arXiv:1501.05241*
[2] W. Bertl et al, *A search for $\mu - e$ conversion in muonic gold*, The European Physical Journal C - Particles and Fields, **47(2)** (2006) 337-346