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The Mu2e experiment at Fermilab

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Summary. — The Mu2e experiment searches the muon coherent conversion into an electron in the electric field of a nucleus. This represents an example of Charged Lepton Flavor Violation process. Mu2e will set a limit on the conversion rate $R_{\mu e} < 6 \times 10^{-17}$ (@ 90% C.L.) improving the current limit by four orders of magnitude.

1. – The Mu2e experiment and the search of CLFV

Mu2e is a proposed experiment, hosted in the Muon Campus of the Fermi National Accelerator Laboratory (FNAL) in Batavia, United States, that proposes to measure the ratio between the rate of the neutrinoless conversion of muons into electrons in the field of a nucleus and the rate of ordinary muon capture on the nucleus [1]:

$$R_{\mu e} = \frac{\Gamma\left(\mu^- N \rightarrow e^- N\right)}{\Gamma\left(\mu^- N \rightarrow \text{all captures}\right)}. \tag{1}$$

The signature of this process is a mono-energetic electron with an energy nearly equivalent to the muon rest mass. Mu2e should collect 7.52×10^{17} stopped muons in three years of running, with the goal of improving the result of previous generation experiments (SINDRUM II) by a factor of 10^4. The conversion process belongs to the Charge Lepton Flavour Violating (CLFV) family that is forbidden in the Standard Model (SM). In the last decades, several experiments proved the existence of the lepton flavor violation in the neutral sector. Considering the minimal extension of the Standard Model (SM), by including diagrams with neutrinos oscillation, the CLFV rate are still not detectable (BR $\sim 10^{-54}$). New physics beyond SM allows to predict rates (BR $= 10^{-15}$–10^{-17}) that could be accessible with Mu2e.

As shown in fig. 1 the layout of the experiment shows a typical S-shape: the entire system is surrounded by the Superconducting Solenoid Magnet System. In order to limit backgrounds from muons that might stop on gas atoms and to reduce the contribution of multiple scattering for low-momentum particles, the inner bore of the solenoids is evacuated to 10^{-4} Torr. The solenoids are organized into 3 sub-systems: Production

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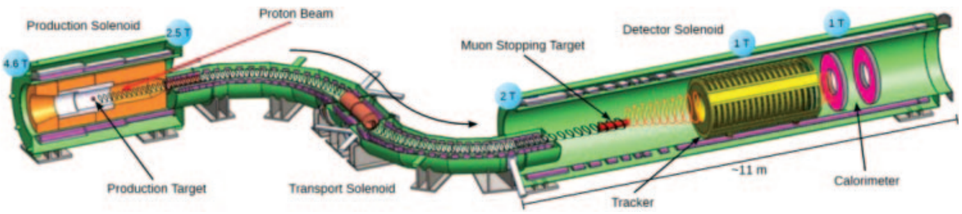

Fig. 1. – Schematic view of the experimental apparatus.

Solenoid (PS), Transport Solenoid (TS) and Detector Solenoid (DS). The 8 GeV proton beam enters the PS and hits the production target. The reaction products with a selected charge are transported through the S-shaped TS, which is long enough to allow the decay of almost all hadrons and allows to suppress line-of-sight particles. The resulting negative muon beam enters the DS and hits the aluminum stopping target: the muons can then be either captured by the atoms and decay (40%) or captured by the nucleus (60%) or converted into electrons. Electrons momentum and energy from Decay In Orbit (DIO) and Conversion Electrons (CE) events are measured by the cylindrical-shape tracker and by the two-disks calorimeters, respectively. Outside the PS, an extinction monitor is used to measure the number of protons between two subsequent proton pulses. The Detector Solenoid is surrounded by a cosmic-ray veto system. Outside the DS, a stopping target monitor is used to measure the total number of muon captures. In order to achieve the designed event sensitivity, the produced muon beam must meet strict requirements: i) High rate: a larger number of stopped muons is essential to improve previous experiments results. ii) Pulsed structure: in order to suppress the prompt background, the muons hitting the stopping target should be distributed in a narrow time burst (< 200 ns), each one separated by the other by intervals of $\sim 1.5\,\mu$s (larger than the muonic aluminum lifetime). Mu2e will take data 670 ns after the injection bursts, to let the prompt background to subside. The data taking time window will then close 925 ns afterwards, just before the arrival of the next bunch. iii) Extinction: extinction is fundamental to suppress background generated by unwanted beams between pulses. iv) A high-precision detector for momentum reconstruction.

The tracker is made of 20736 drift straw tubes placed transverse to the axis of the DS and organized in 18 stations. Each station is rotated by 60° with respect to the following one. The calorimeter design consists in 1346 undoped CsI crystals located downstream of the tracker, arranged in two disks and, positioned at a distance of half-wavelength of a typical conversion electron. The crystals have squared faces with dimensions of $(34 \times 34)\,\text{mm}^2$ and are 200 mm long. Each crystal is readout by two 2×3 arrays of individual $6 \times 6\,\text{mm}^2$ UV-extended Silicon Photomultipliers (SiPMs). The solid-state photodetectors are necessary due to the presence of the high magnetic field.

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REFERENCES

[1] Bartoszek L. *et al.*, *Mu2e Technical Design Report*, arXiv:1501.05241.