Study of the impact of magnetic field uncertainties on physics parameters of the Mu2e experiment

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The Mu2e Experiment

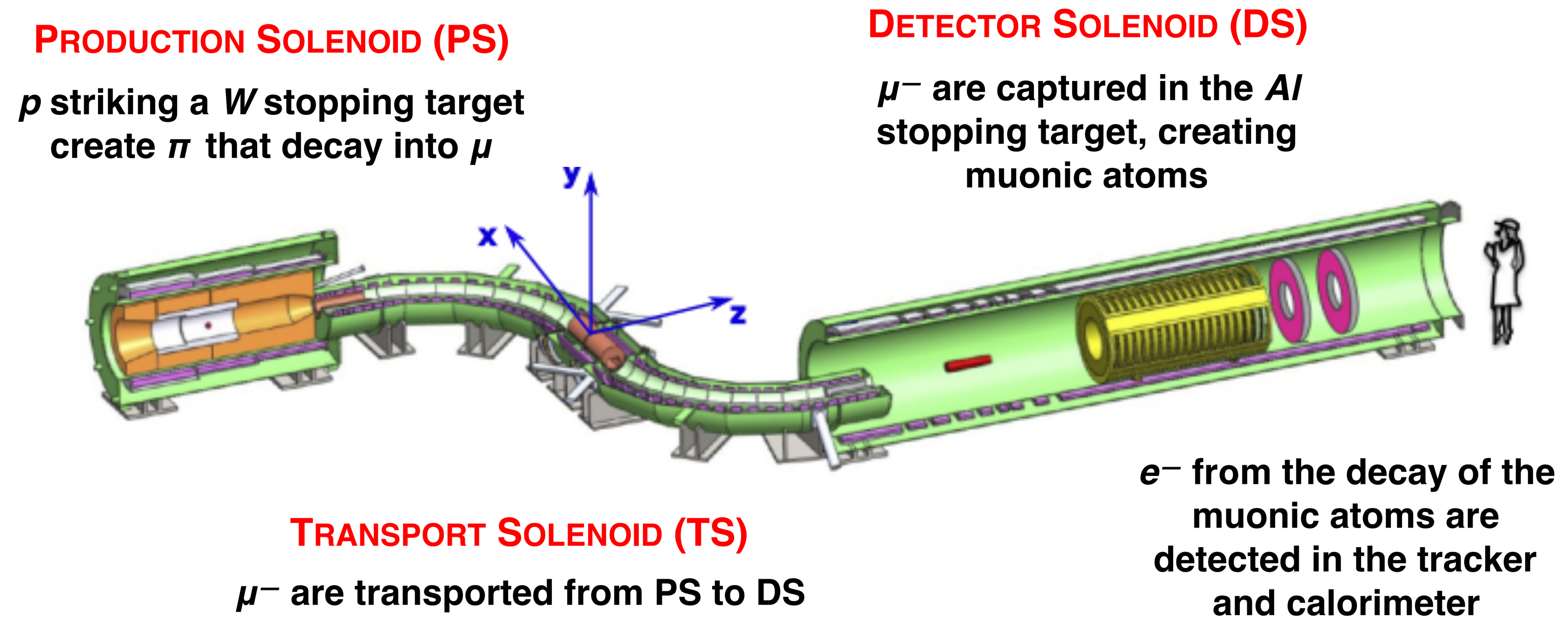
Search for Charged Lepton Flavor Violation (CLFV) via the coherent conversion:

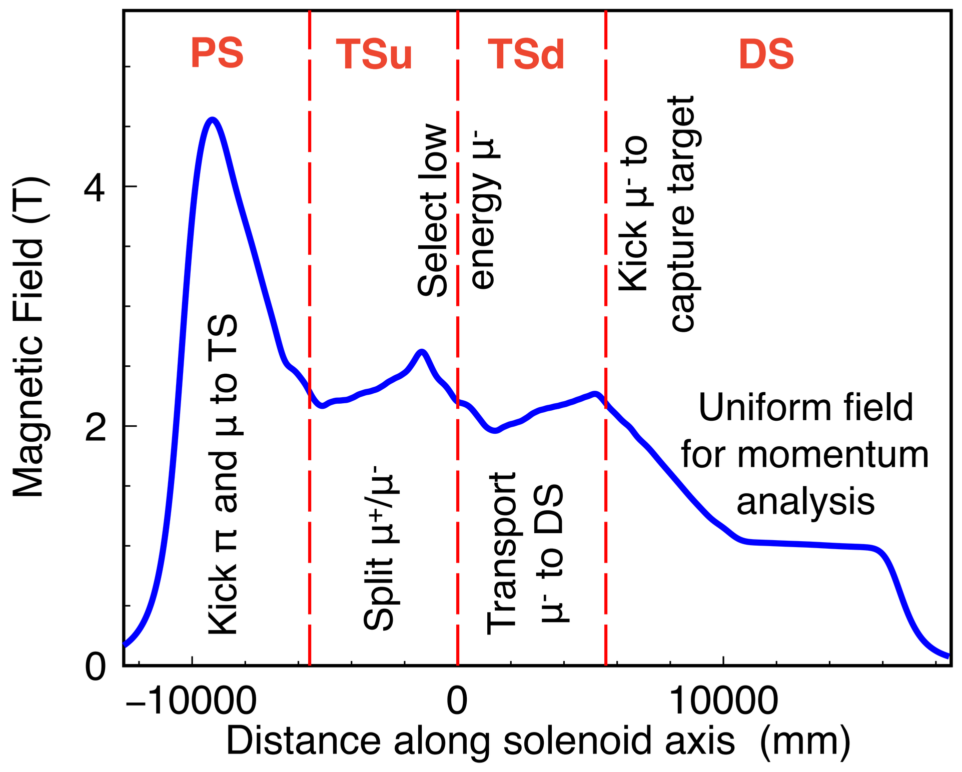
$$\mu^- + {}^{27}_{13}\mathrm{Al} \rightarrow {}^{27}_{13}\mathrm{Al} + e^-$$

Signature of physics beyond the Standard Model

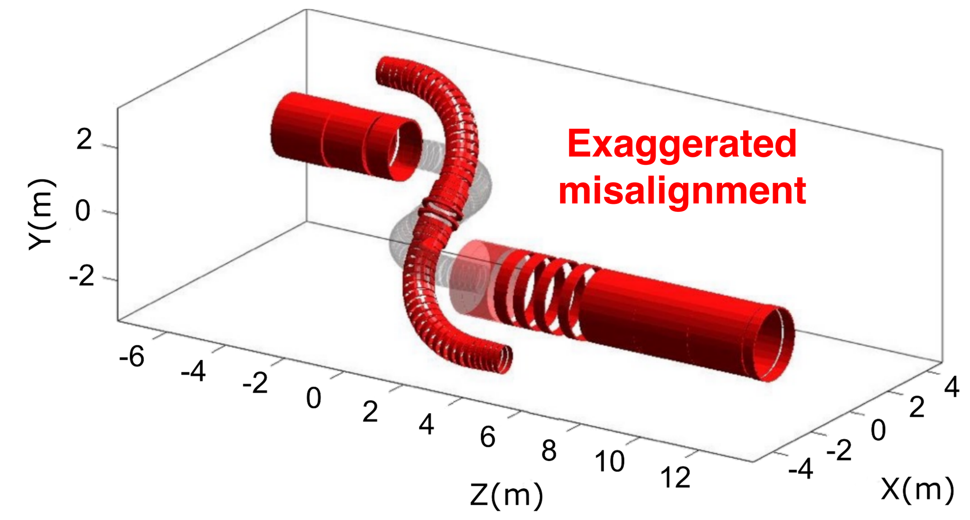
Quantitative signal of the search:

$$R_{\mu e} = \frac{\Gamma(\mu^- + {}^{27}_{13}\mathrm{Al} \rightarrow e^- + {}^{27}_{13}\mathrm{Al})}{\Gamma(\mu^- + {}^{27}_{13}\mathrm{Al} \rightarrow \nu_\mu + {}^{27}_{12}\mathrm{Al})} = 2.87 \times 10^{-17}$$



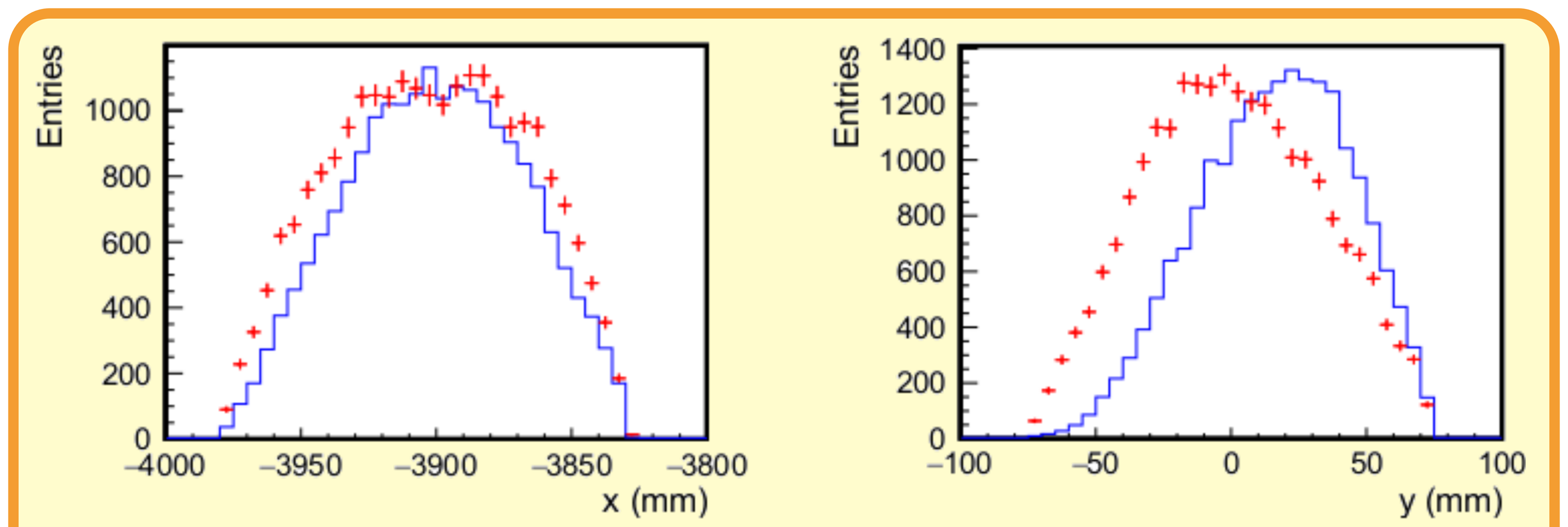


The cooldown to cryogenic temperature could misalign the solenoids, especially TS because of its complicated geometry.

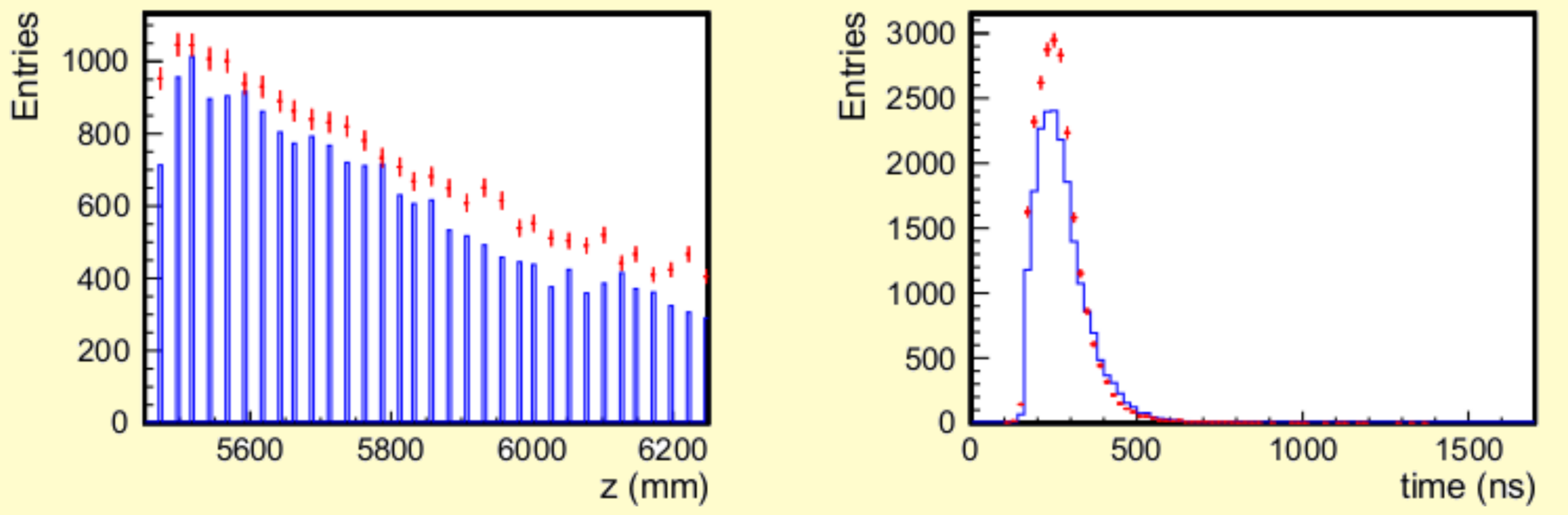


Misaligned solenoids introduce systematic uncertainties in the magnetic field → Determine the effects of the TS misalignments on the physics parameters of the experiment

Hard to measure the TS field because of mechanical constraints → Need of a way to test the TS field without measuring it

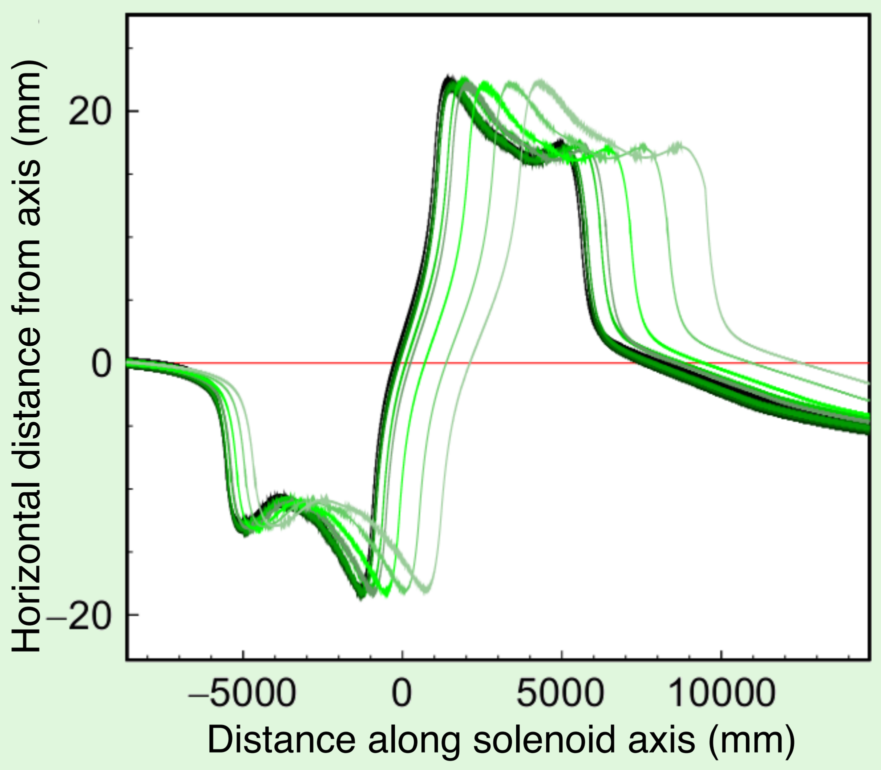


Stopped π− distributions for exaggerated misalignment (blue histograms).

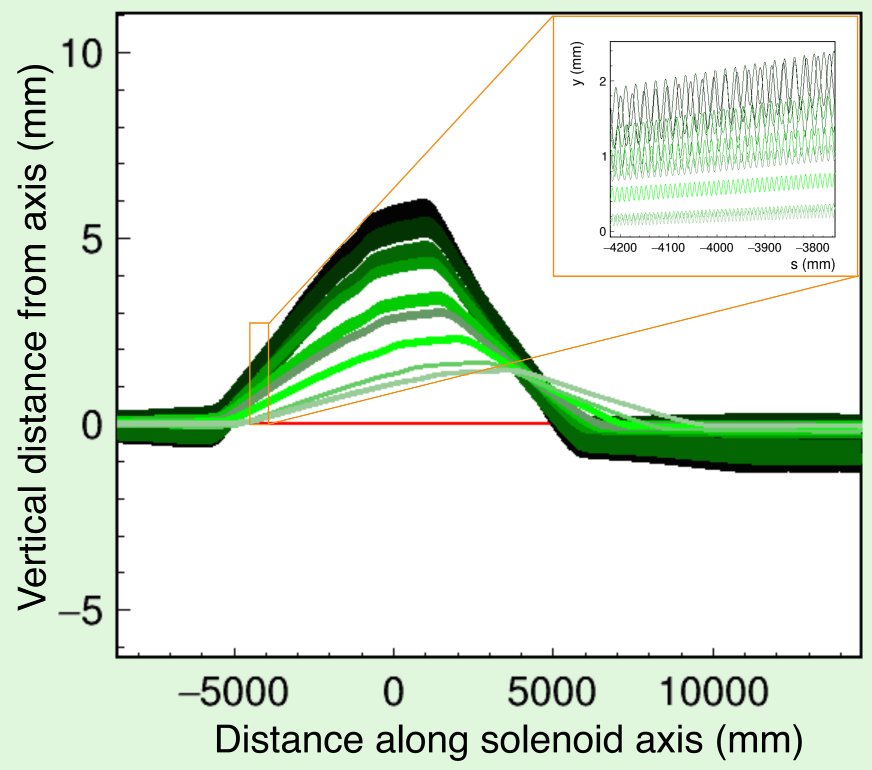


The distributions of μ^- and π^- stopped at the Al target depend on the TS field. The yield from muonic atom decays, producing either signal or *decay in flight* background, and the π^- radiative capture background are therefore subject to field uncertainties from TS misalignments.

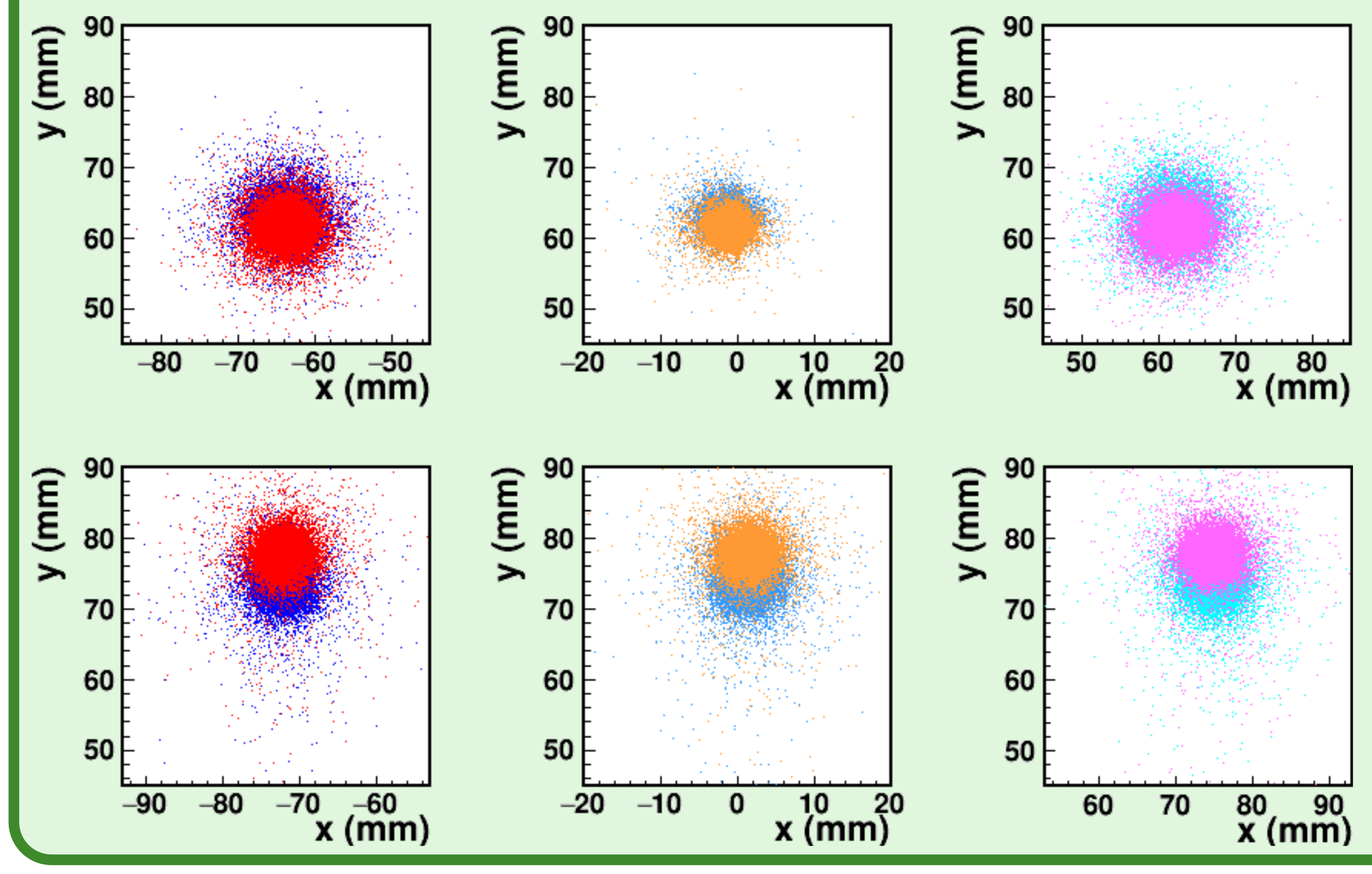
High energy e^- coming with the muon beam can scatter off the Al target into the tracker and create background. The distribution of e^- arriving at the Al target depends on the TS field, thus this background carries uncertainties from TS misalignment.



Low momentum e^- trajectories across the Mu2e beamline. Thicker lines correspond to higher momentum e^-.



The TS field can be tested using low energy e^-, for example from a collimated β^- source. The emitted e^- spiral around the field lines with a small pitch and Larmor radius and thus trace the field lines. With a moderate resolution detector, like a fiber tracker, the e^- can be detected and provide information about TS misalignments.



Beam profiles from a collimated β^- source in the beginning (top) and in the end (bottom) of TS for 3 locations of the source in the x-z plane near the production target. Detector hits of e^- from a simulation using misaligned TS are drawn on top of detector hits from a simulation using perfectly aligned TS.

Conclusions

Simulation studies show that the μ^- and π^- distributions are insensitive to realistic TS misalignments and that the beam e^- background is small (< 5×10^{-4} at 90% C.L.). The test of TS using low energy e^- is very efficient in detecting TS misalignments.

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[1]http://mu2e.fnal.gov/collaboration.shtml

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