Development of the muon entrance trigger system for the PSI muEDM experiment

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Physical Motivation for muEDM

**Why EDM are interesting?**
- A search for new physics that is “background-free”, the complementarity to the LHC search
- Hint for the Beyond Standard model
  - Many BSM models predict large EDMs (SUSY, left-right symmetric models, and extended Higgs sectors [1])
  - Matter-antimatter asymmetry requires more CP Violation source
  - CP violation exists in the phase in the CKM matrix and the coefficient $\bar{\theta}$ in the SM strong interaction Lagrangian [1], but it’s insufficient
  - EDM means T violation, the new CPV source within CPT conservation
- The muon EDM of SM prediction is small ($|\mu| \lesssim 10^{-18}$ cm [2])
- Muon g-2 and EDM are connected in some BSMs [3,4]

![EDM Spin T = CP](image)

The best limit on the muEDM is provided by the BNL muon g-2[5]:

$$d_\mu = (0.0 \pm 0.9) \times 10^{-15} \text{cm}, \quad |d_\mu| < 1.8 \times 10^{-15} \text{cm} \quad (95\% \text{ C.L.})$$

**muEDM Muon Entrance Detector: Prototype**

Providing a timing signal for muon entrance into storage solenoid and a trigger signal to the pulsed magnetic kicker
To be sufficiently efficient while keeping at the minimum the multiple scattering of the detected muon

![Prototype](image)

5-10 mm thick scintillators
50-100 μm thin scintillators
muon trajectory

**R&D for fast electronics in progress**

Strict propagation delay for the electronics of the entrance detector

- DC-DC Up-Convert
- Pre-amp
- SIPP + pre-amp readout
- Discriminator

Testing of PCBs with individual components completed.
Finetuning PCB board with multiple components in progress

**Experimental devices and detectors**
- $\mu^+$ from Pion-decay → high polarization $p \approx 95\%$
- Injection through superconducting channel
- Fast scintillator triggers pulse
- Magnetic plus stops the longitudinal motion of $\mu^+$
- Weakly focusing field for storage
- Electrodes provide an electric field for frozen spin
- Pixelated detector for $e^+$ tracking

Frozen-spin approach, and asymmetry due to EDM measured
- Freeze $g-2$ by applying a radial $E$-field of $\sim a_g B c \beta^2$
- no anomalous precession in the storage plane: $\omega_0 = 0$
- EDM causes an increasing vertical polarization

References

1. Timothy Chupp et al., Rev.Mod.Phys. 91 (2019) 1, 015001

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Summary

1. We are developing an entrance detector composed of a gate detector and a telescope detector for the PSI muon EDM experiment
2. The strict propagation delay for the electronics of the entrance detector is not greater than 5 ns
3. The PCBs with individual components were completed, and finetuning at present
4. The UP-Convert and Preamp modules show stability and sufficiently good performance
5. The propagation delay was tested to 4–5 ns for the electronics prototype