LASH:
Large Area Sensors for Hadron physics

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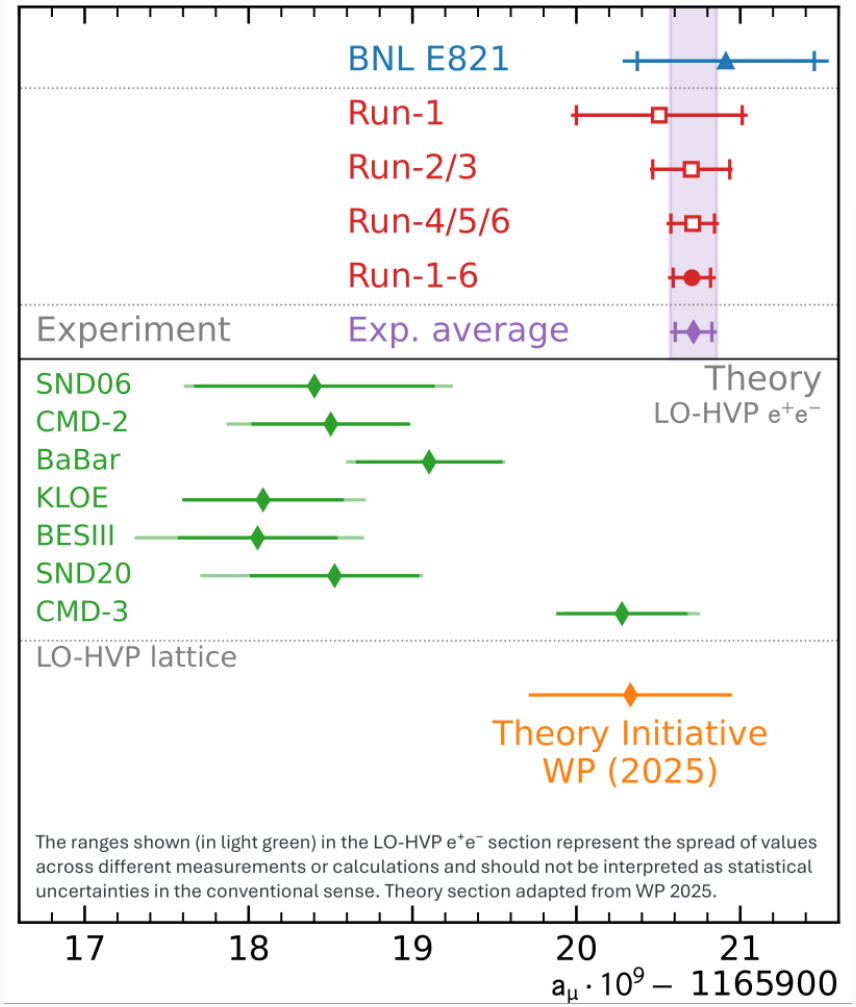
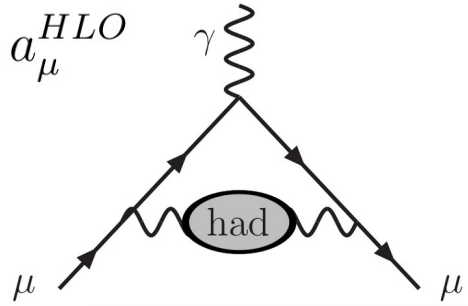
Nantes, 1-2 July 2025

Outline

- Motivation: the MUonE experiment at CERN
- The LASH project
- Budget requests and conclusions

Muon g-2: current status





Main source of uncertainty
of the theoretical prediction

Tensions in the evaluation of a_μ^{HLO}
using lattice QCD (WP2025)
or e^+e^- hadronic cross sections.

A clarification of the
theoretical prediction is needed

S. Corrodi, muon g-2 at Fermilab
run4-5-6 release talk (2025)

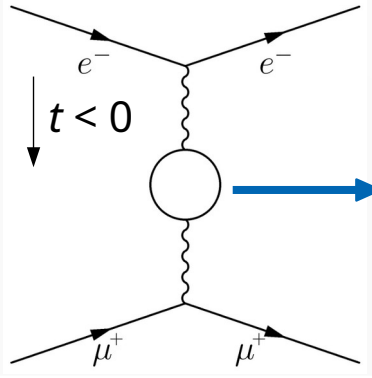
The MUonE experiment

New independent evaluation of a_μ^{HLO}, based on the measurement of $\Delta\alpha_{\mathrm{had}}(t)$: hadronic contribution to the running of the electromagnetic coupling constant

Phys. Lett. B 746 (2015), 325
Eur. Phys. J. C 77.3 (2017), 139
Letter of Intent CERN-SPSC-2019-026
Proposal MUonE Phase-1 CERN-SPSC-2024-015

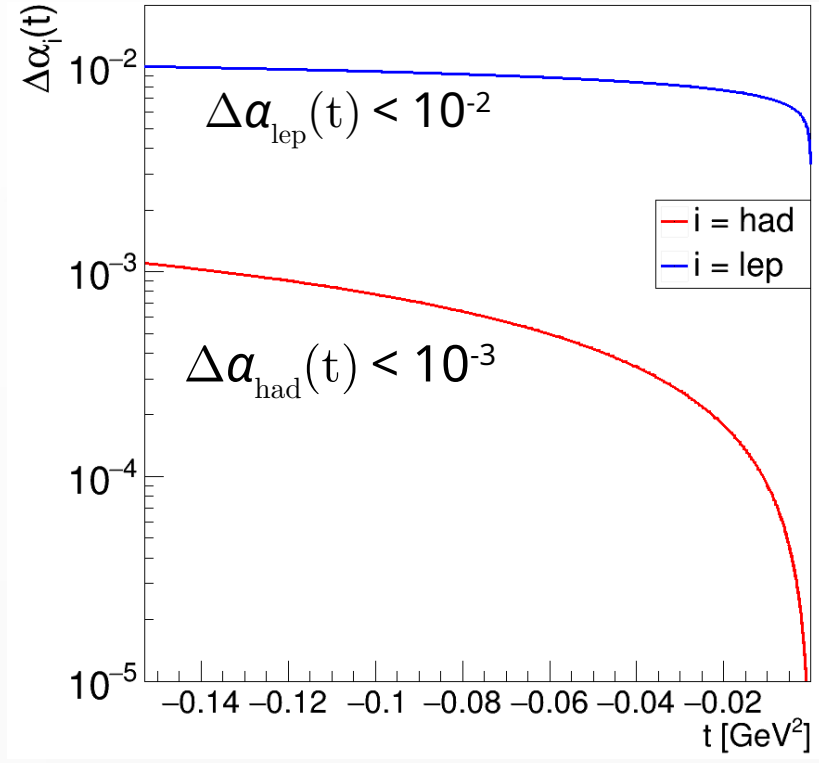
$$a_\mu^{HLO} = \frac{\alpha_0}{\pi} \int_0^1 dx(1-x)\Delta\alpha_{had}[t(x)] \qquad t(x) = \frac{x^2 m_\mu^2}{x-1} < 0$$

Extraction of $\Delta\alpha_{\mathrm{had}}(t)$ from the *shape* of the ***μe → μe*** differential cross section



+ radiative corrections

$$\Delta\alpha(t) = \Delta\alpha_{\mathrm{lep}}(t) + \Delta\alpha_{\mathrm{had}}(t) + \Delta\alpha_{\mathrm{top}}(t)$$



MUonE kinematic range

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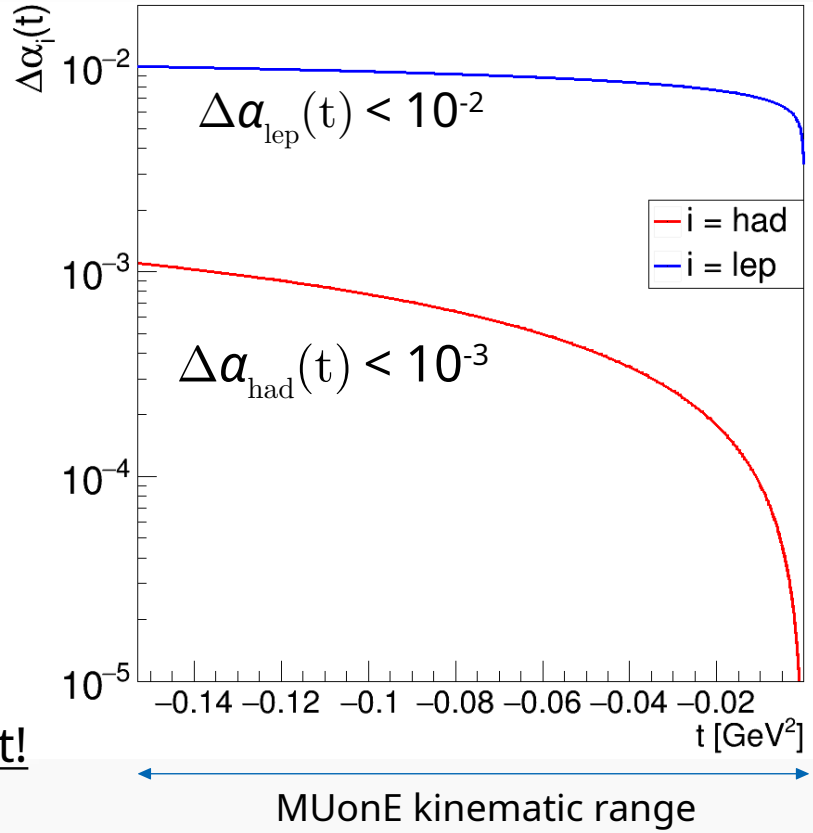
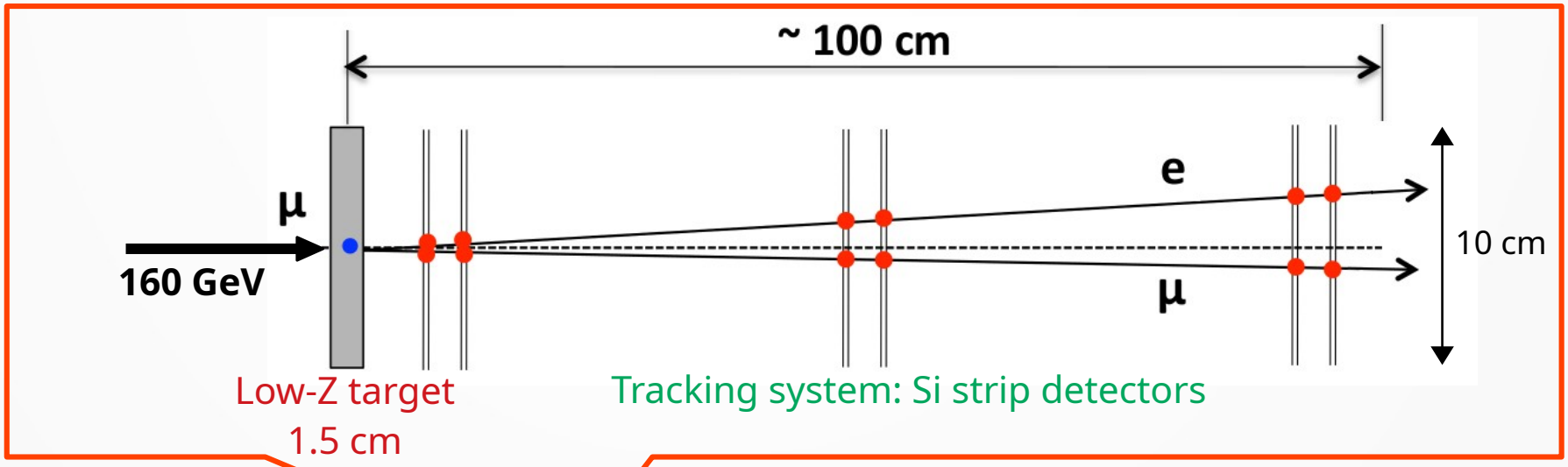
To be competitive with the latest evaluations:
error($\Delta\alpha_{\mathrm{had}}(t)$) ~1% = 10^{-5}

Challenging control of the systematic effects:
10ppm in the signal region.
An unprecedented level for a fixed target experiment!

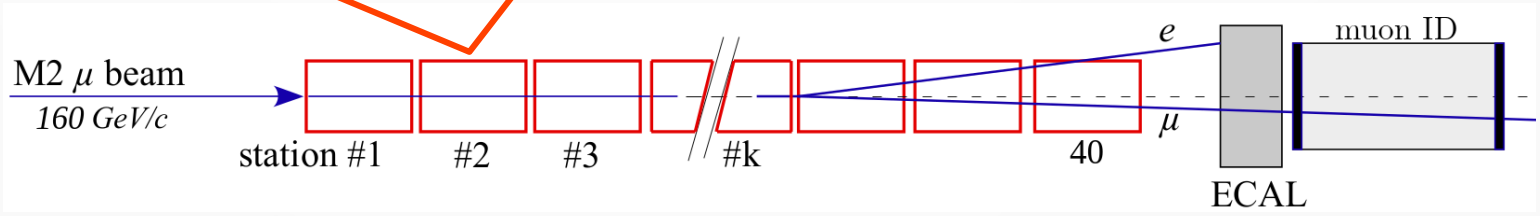


The MUonE experiment

Fixed target experiment at CERN SPS (M2 beam line)

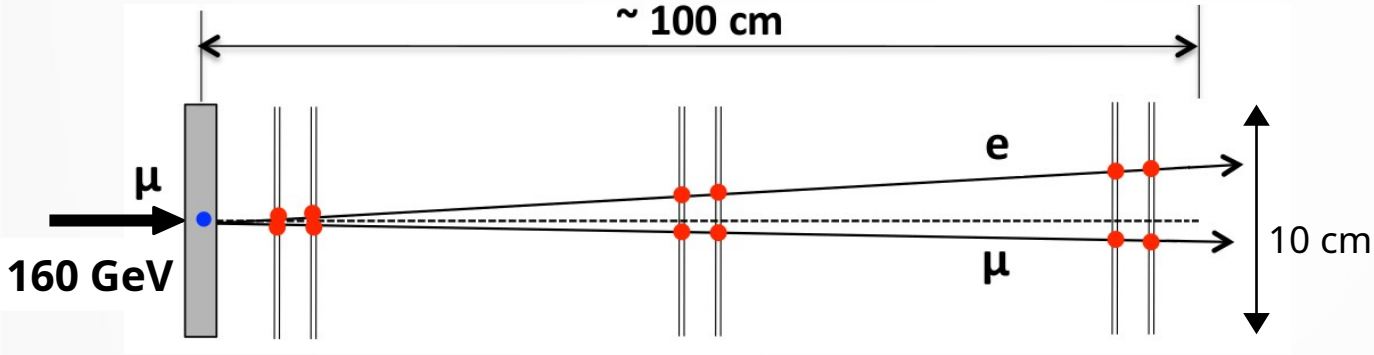


BMS ....



After CERN Long Shutdown 3 (2027-29): full apparatus with 40 stations

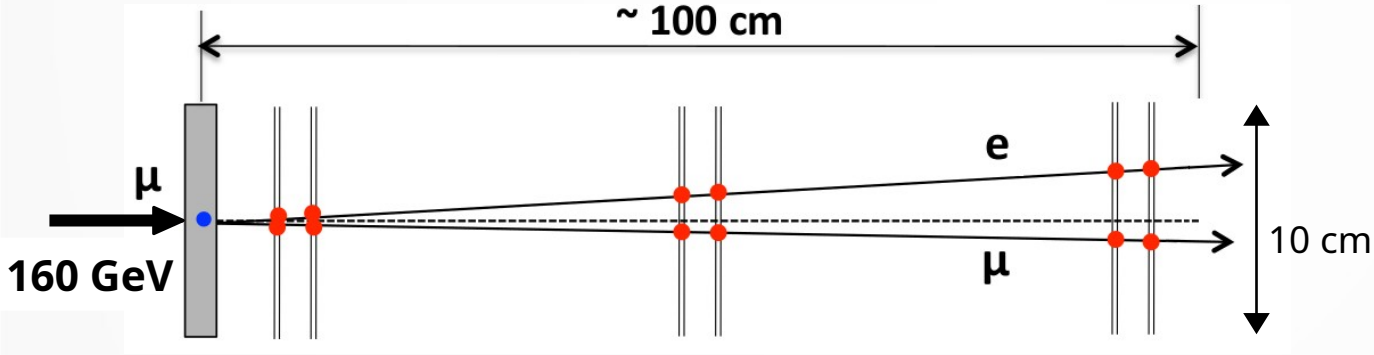
The ideal tracking station for MUonE: wishlist



- Boosted kinematics:
  $\theta_\mu < 5$ mrad, $\theta_e < 32$ mrad
  Full acceptance with
  10x10 cm^2 Si sensors

Detector characteristics	Hardware design
Low material budget	Thin Si sensors (< 300 μm)
Resolve events with small μ-e opening angle (signal region)	Excellent hit resolution (~5 μm)
Uniform detector response	High tracking efficiency uniformity
Asynchronous beam, ~50 MHz	DAQ operating at 40 MHz
Mechanical stability < 10 μm	0-CTE mechanical structure

The ideal tracking station for MUonE: wishlist



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LASH

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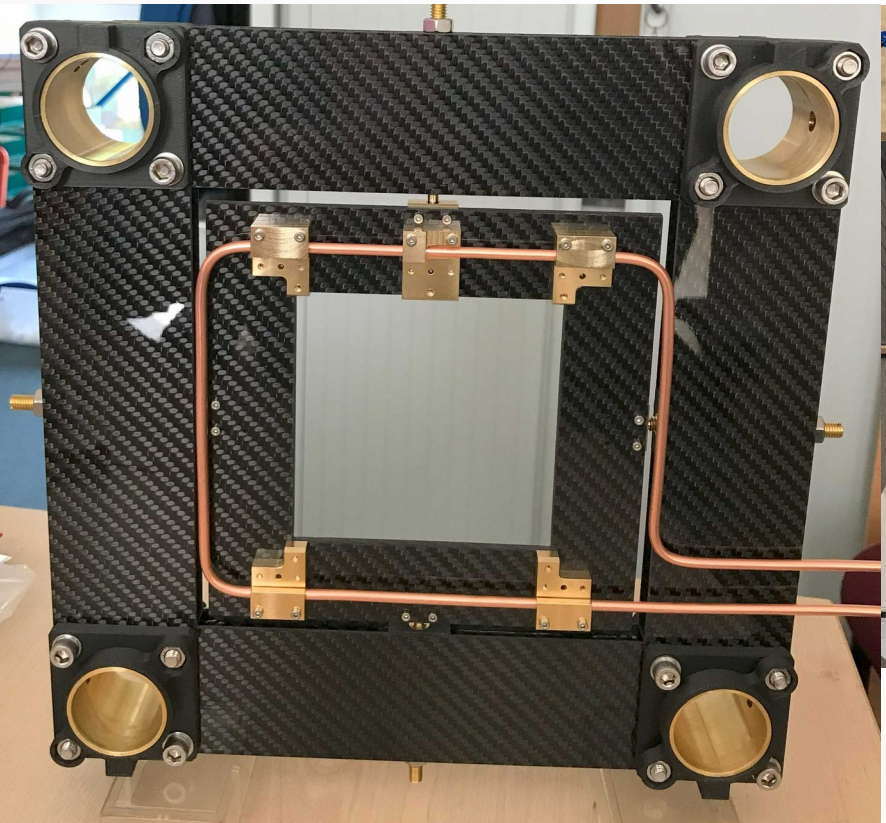
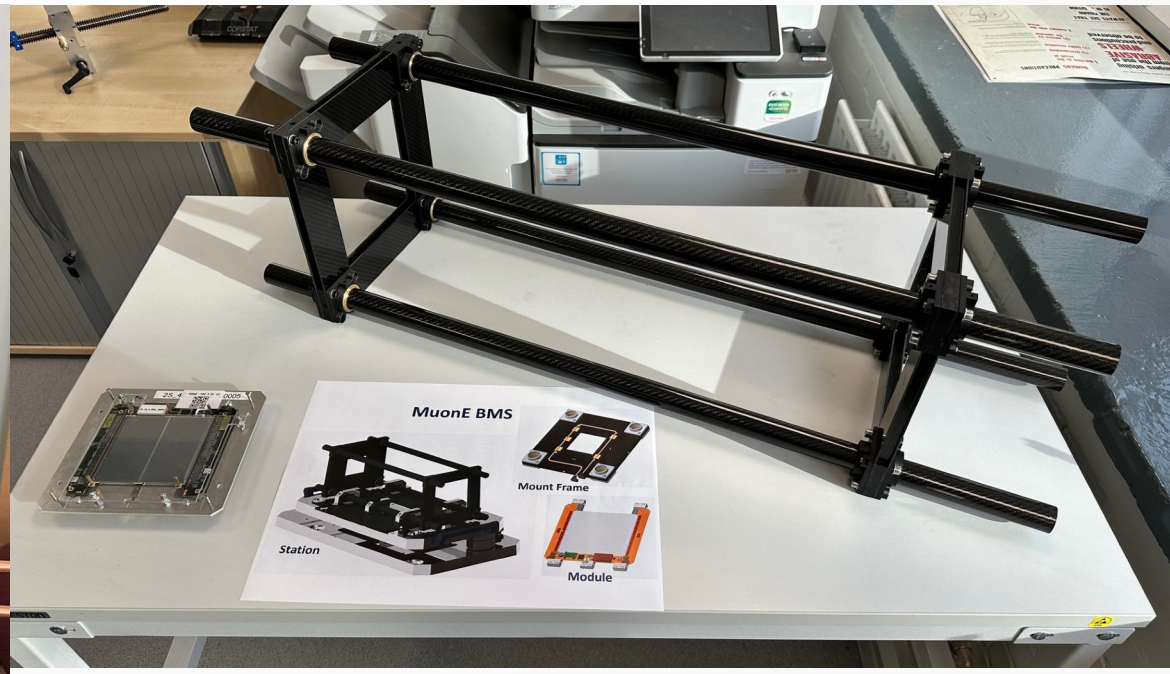
Excellent hit resolution (~5 μm)
High tracking efficiency uniformity
DAQ operating at 40 MHz
0-CTE mechanical structure

The LASH project

- Demonstrate 0-CTE mechanical support using customised CF composites. A prototype will be tested on beam by the end of July.





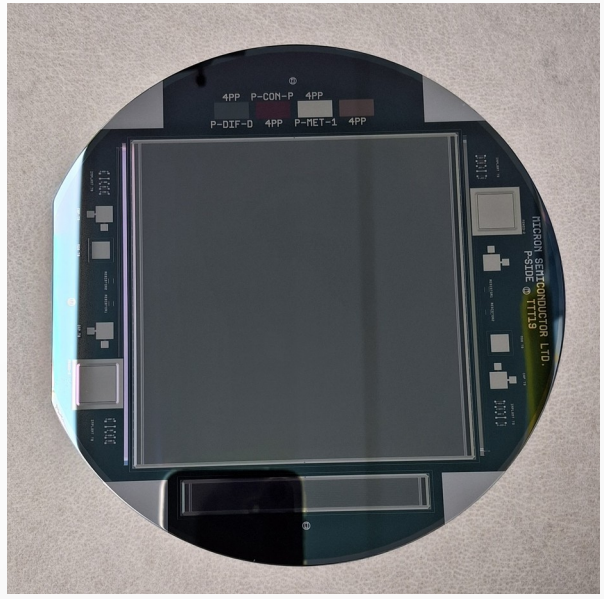
The LASH project

- Demonstrate 0-CTE mechanical support using customised CF composites.
  A prototype will be tested on beam by the end of July.

- Test fine pitch (25um) 10x10cm^2 Si sensors (Micron Semiconductor).
  Prototypes already purchased,
  expected delivery by the end of July.

- Build a complete LASH tracking station
  using existing ASICS (LHCb/CMS).
  Requires development of a custom
  hybrid/flex to interface ASICS and Si sensors.

- Demonstrate DAQ at 40MHz
  and evaluate efficiency and tracking performance.



The LASH project

- **4 years project**, building on existing developments and substantial team expertise: low risk and high reward project.

Participanting insitutions:

- University of Liverpool
  - Si sensors
  - DAQ
  - Mechanics
  - Hybrids + flex
- University of Rome, La Sapienza
  - Si sensors

Transnactional access infrastructures:

- CERN
  - Test the LASH system on beam
- FBK
  - Hybrids + flex

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- Phase2: **F**urther than **LASH** (not part of this funding request):
  - Build and test custom ASIC for LASH sensor + next generation hybrid/flex (UoL + FBK)
  - Develop DAQ to operate up to 120 MHz
  - Test in the LASH system

Conclusions and budget requests

- MUonE aims to provide an independent evaluation of a_μ^{HLO}, contributing to shed light on the muon g-2 puzzle.

> *"This must be complemented by new experimental efforts with completely different systematics, such as the MUonE experiment, aimed at measuring the LO HVP contribution, as well as an independent direct measurement of a_μ, which is the goal of the E34 experiment at J-PARC. The interplay of all these approaches, various experimental techniques and theoretical methods, may yield profound insights in the future, both regarding improved precision in the SM prediction and the potential role of physics beyond the SM."*
>
> Muon g-2 Theory Initiative, 2025 White Paper, Conclusions and Outlook

- The LASH project aims to develop and test an advanced tracking system that meets the challenging requirements of MUonE.
- **Budget requests:**
  - 4 years-engineer to contribute to the development and testing of the LASH system: 320 k€.
  - Travels between nodes: 40 k€.
  - Consumables (sensors, laboratory usage, maintanance): 40 k€.
  - **Total**: 400 k€.