

PPAP Online Community Meeting

Impact Assessment

Non-accelerator flavour physics
Kaon and muon experiments

Kaon experiments: the context

UK has played and is playing a strong leadership role in **NA62** at CERN:

- UK is a founder member of NA62 (initially via an ERC grant for construction, **then included into STFC** for maintenance and exploitation). Membership fee follows a different model from LHC experiments.

Data taking in 2016-2018 and 2021-2026. Large leverage from STFC funding (EU-ERC, Royal Society).

- Long-standing leadership and responsibility of the kaon identification detector
- Crucial roles in the flagship analysis of $K^+ \rightarrow \pi^+ \nu \nu$: 5 sigma measurement published in 2025
- Long-standing leadership in data analysis and searches
- 1 of the 3 Spokespersons; current Deputy Spokesperson; previous Physics Coordinator; current Rare Decay Coordinator

NA62 will move to full data exploitation phase from 2027.

Strong theory support worldwide.

The Kaon community has internationally expanded, and UK has joined the **KOTO II** collaboration in Japan:

- UK is a founder member of KOTO II
- Current Co-Spokesperson is UK
- 1 out 3 physics coordinators is UK
- 3 out of 10 Working Group coordinators is UK

KOTO II (current) timeline: 2026-2028 Design, prototyping and TDR; construction and installation 2030-2034; “physics” beam from 2035.

Flavour physics, and maintaining a diverse programme has been highlighted as a priority in the EU Strategy

Kaon experiments: innovative technologies

Innovative technologies made by NA62 at that time (construction 2010-2015):

- first silicon detector to reach **O(100) picosecond** time resolution
- first silicon detector to demonstrate **micro-channel cooling**
- first **low-mass STRAW detector operating in vacuum**
- first H₂, **low-mass differential Cherenkov detector** with 70 ps time resolution

Requirements of time resolution of 100-50 ps, low-mass (including cooling) requirements are ubiquitous for future experiments

For example, STRAWs will be used in COMET, and are a candidate for ALLEGRO at FCC

Relatively small detector means short construction phase, i.e. more time for prototyping innovative solutions. Small-scale experiments have often synergetic technical requirements.

Small-scale experiments represent an agile testbench for demonstrating innovative technologies, with prototypes being used for immediate physics return.

KOTO II plans to follow the same path: intensive use of AI in pattern recognition, challenging low-mass requirements and neutron environment.

Excellent training ground for young researchers, taking variety of responsibility roles at an earlier stage.

UK Muon programme: STFC supported experiments

A strong programme was developed following initial STFC support for the FNAL g-2 experiment

FNAL g-2

- Strong UK contribution to detector construction and operation and physics programme
- large leverage from STFC funding (Fellowships, Leverhulme funding, ...)
- Many leadership positions including two UK based spokespersons (Mark Lancaster, Graziano Venanzoni) and many leading roles for ECRs
- Legacy g-2 results (124 ppb) measurement that will stand for many years. Still $>5\sigma$ discrepancy to dispersive theory predictions)
- World best limit Muon EDM still to come

Mu2e and Mu3e charged-lepton flavour violation experiments

- Strong UK participation on detector construction and physics preparations
- First physics in 2026/2027 with discovery sensitivity from the moment of switch-on
- Ultimately factor $\sim 10^4$ sensitivity improvement in respective CLFV channels
- Current CG PDRA losses just before just before switch-on.

UK Muon programme: other activities and future opportunities

CLFV experiments:

- smaller UK involvements: COMET, MEG-2, (MEG-3), ..
- Mu2e-II and Mu3e-II upgrade programmes in early 2030s

g-2 legacy programme:

- Worldwide theory effort with strong UK participation to resolve dispersive to lattice discrepancy
- Strong UK participation in MUonE muon-electron scattering experiment at CERN (independent measure of the hadronic vacuum polarisation)
- Exploration of next-generation g-2 measurements (JPARC, HIAF, ..)
- Deployment of the storage-ring approach to measure electric dipole moments (Muon EDM at PSI and proton EDM at BNL)

UK Muon programme: innovative technologies

Technical innovations:

- low-mass straw detectors in vacuum (g-2 tracker)
- High precision field mapping for storage ring magnetic and electric moments (g-2)
- High purity Germanium target monitor in collaboration with UK NP community (Mu2e-STM)
- High-rate low mass HV-MAPS tracking array (Mu3e pixel tracker)
- Ultra low mass ($\sim 0.1\%X_0$) tracker mechanics (Mu3e pixel tracker)
- Triggerless data acquisition chain based on commercial FPGA and GPU technology (Mu3e)
- Ultra-low CTE composite tracker mechanics (MUonE beam-monitor & tracker)
- High precision electro-static deflectors (proton EDM)

Key point on UK technical capacity: (in the context of the loss of the LHCb 2030+ and EIC projects)

- UK technical leadership in the development and construction the muon experiments relied critically on the expertise and infrastructure capacity developed through extensive development and construction.
- At the same time these and similar smaller/medium experiments provide an ideal environment for the development of new (sometimes more risky) approaches and to sustain and develop expertise and capacity.
- Without a pipeline of large and small projects, the UK's unique strength in detector development and construction is in danger**
→ in prioritisation great care is needed to ensure we retain a basis for regrowth (or re-orientation).

Impact chain: IF medium-sized non-collider flavour experiments were to be terminated completely

Immediate impact

Loss of UK involvement in exciting physics programme; loss of programme continuity; uncertainty for early-career researchers and technical staff. Drastic loss of diversity in the programme.

Capacity impact

Loss of a long-standing national community, with thus far an excellent international reputation.

Combined with the disappearance of two major IF construction projects (LHCb/EIC) facing critical cliff edge for detector development and construction capacity after completion ATLAS/CMS upgrades.

Drastic loss of agility to respond to future opportunities, making it hard to adjust to landscape changes and potential discoveries.

Strategic impact

Loss of a powerful training ground and skills pipeline.

Loss of strategic technological testbench.

Reputational impact

UK leadership in an area where it is regarded as an exemplar is severely weakened.

Much harder to leverage the programme internationally causing damage to international collaborators.

Recovery cost

Rebuilding the community later would require significantly more time and investment than sustaining it at a low level

High-level narrative:

Non-accelerator flavour experiments of medium size illustrates how interruption of a successful programme can rapidly erase strategic gains.

The absence of programme continuity (even at a low level) will lead to loss of momentum, dispersal of trained people, loss of established leadership and international influence.

Most importantly, will cause the loss of an agile tool for technology innovation and skilled-force training.

These effects are difficult and costly to reverse.