Physics I’ve done in the last two years

- Not very much…maybe 30% of my time was on physics?
- 70%: management (organization of the group, contact with Leverhulme, workshops, meetings, rectruitment, grants…)

Before I move to physics…

- 70% of time spent on non-physics is a lot…but I can only remember a couple of things (maybe) significant at the management level in the last two years…
- “Doing things is very frustrating because you put in a lot of effort and almost always you get nothing” (“fare le cose e’ molto frustrante perche’ si fa un mucchio di fatica e quasi sempre non si ottiene nulla”)

Moving to physics…

- Directly:
  - J-PARC high sensitivity study (proposal to increase the energy; work on 6 T magnet; management activity; talk at HEP-EPS2025)
  - RMCL2 (coordinate activities with Adrian, Andrzej and Yannick)
  - Supervising students (MUonE; KLOE)
  - Coordinating KLOE efforts
  - MUonE TR2025; contribution to the BMS
  - Papers/talks/proceedings
  - Organizing Events/Workshops

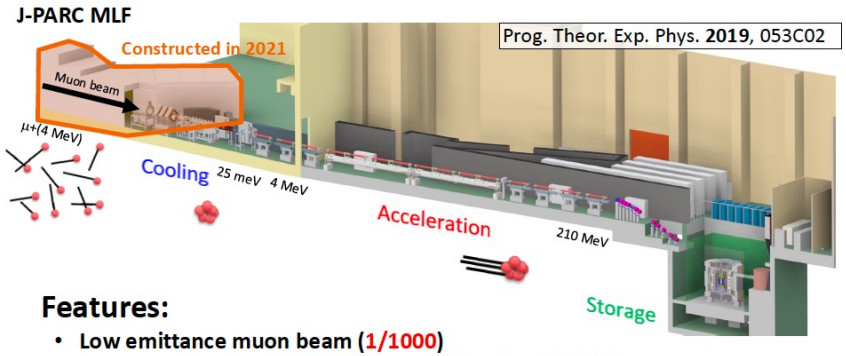
- Mostly Indirectly:
  - Meetings, meetings, meetings…

Few things I’m particularly proud/involved

- Contribution to the success of TR2025; BMS
- RMCL2
- Collaboration with Muon g-2 experiment at JPARC; sensitivity study

High Sensitivity Study for Muon g-2 @ JPARC:
All started with Mibe visit in Liverpool in October 2024

J-PARC muon *g*-2/EDM experiment 18



Features:

- Low emittance muon beam (1/1000)
- No strong focusing (1/1000) & good injection eff. (x10)
- Compact storage ring (1/20)

The only experiment to check FNAL/BNL *g*-2 results

Excellent sensitivity to **muon EDM** about **100 times** better than the previous limit (sensitivity : 1.5 E-21 ecm)

Visit of Tsutomu Mibe to Liverpool

G. Venanzoni – 7/10/24

GV -10/3/2025

An interesting observation…possibility to reach O(100ppb) by increasing the momentum to 450-600 MeV

Expected uncertainties

	Estimation
Total number of muons in the storage magnet	5.2×10^{12}
Total number of positrons	0.57×10^{12}
Effective analyzing power	0.42
Statistical uncertainty on ω_a [ppb]	450
Statistical uncertainty on ω_p [ppb]	100
Uuncertainties on a_μ [ppb]	460 (stat.)
	< 70 (syst.)
Uncertainties on EDM [10^{-21} e·cm]	1.4 (stat.)
	0.36 (syst.)

Prog. Theor. Exp. Phys. **2019**, 053C02 (2019)

Topics for discussion

- **muon g-2**
  - J-PARC muon g-2/EDM
    - silicon strip tracker (mechanical design of structure, assembly)
    - timing layer
    - timing calibration
    - options for higher energy (300 MeV/c → 600 MeV/c?), higher polarization (>50%?)
  - MUonE
    - precision alignment monitor, silicon strip tracker
- **muon EDM@PSI & J-PARC**
  - Injection
  - detector alignment
  - track reconstruction
- **Misc.**
  - KEK/J-PARC summer student program for undergraduate students
  - MPP2024, Shinji Ogawa (KEK, the leader of detector mechanics and assembly) will come to Liverpool in November.

GV – Muon meeting 7/10/2024

$$\frac{\delta\omega_a}{\omega_a} = \frac{1}{\omega_a \gamma \tau P}\sqrt{\frac{2}{NA^2}}$$

$$\omega_a = a\frac{qB}{m}$$

If p (=300 MeV) → 2 p (=600 MeV):
- B → 2 B → ωa → 2 ωa
- γ→ 1.9 γ

→ A factor 3.8 statistical gain:
450 ppb → **119 ppb** (=450/3.8)

If Polarization (50%) → 2 P (=100%):
- additional factor 2:
- 119 ppb –> **60 ppb** (=230/2)

- TOT: possible factor 7.6 stat gain

https://indico.ph.liv.ac.uk/event/1764/contributions/8713/attachments/3957/5595/visita_mibe.pdf

GV -10/3/2025

Soon confirmed by Mibe

Towards higher precision measurements of muon g-2 and EDM at J-PARC

Tsutomu Mibe (KEK)

December 18, 2024

1 Introduction

The J-PARC muon $g-2$/EDM experiment [1] aims to measure the $g-2$ and EDM of muon with precision 1.5×10^{-21} e-cm, respectively. The FNAL $g-2$ experiment has already obtained results with 200 ppb level a precision will be around 100 ppb level. An experiment at PSI plans to reach the EDM sensitivity in the order of with the novel spin frozen method to enhance the EDM sensitivity. It is desired to have higher precision for b well as EDM beyond the current precision.

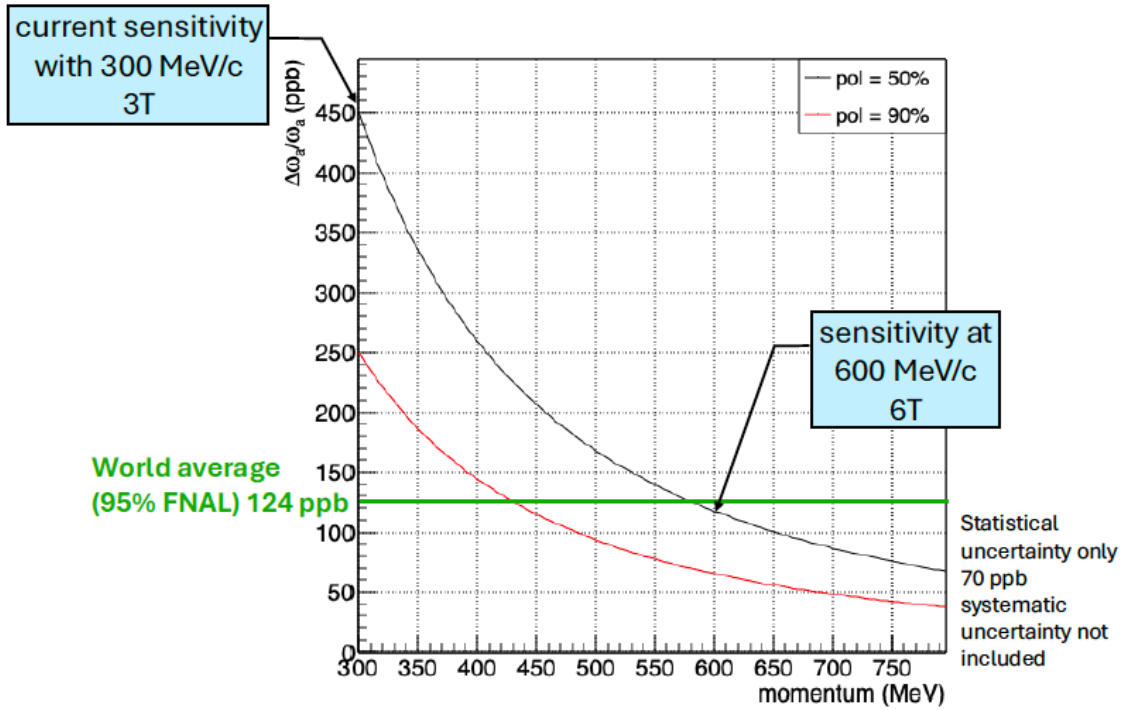
The statistical precision of the anomalous spin precession angular frequency ω_a is determined as

$$\frac{\Delta\omega_a}{\omega_a} = \frac{1}{\omega_a \gamma\tau P}\sqrt{\frac{2}{NA^2}}$$

where key parameters are given int Table 1.

In the past, We considered options to improve the degree of spin polarization of muon [2] and intensi beam [3]. On top of these options, new possibilities were proposed to increase beam energy and magnetic fiel of discussion with Prof. G. Venanzoni and his colleagues during my visit to University of Liverpool in Oct Figure 1 shows expected improvement of $g-2$ precision as a function of the beam momentum. Here we a magnetic field is scaled up linearly with higher momentum. For example, two times higher momentum ($p =$ ($B = 6$ T), precision becomes 120 ppb which is comparable to the Fermilab final precision. With the impr polarization to 90 %, the precision goes down beyond the Fermilab to 70 ppb. After my visit to Liverpo follow-up discussion on these possibilities with the core members in the collaboration.

This document briefly summarizes these possibilities and potential challenges. Note that all discussio below are private considerations.



600 MeV with 50% (75%) polarization → ~120 (80) ppb statistical error

Competitive (even better) than Fermilab.

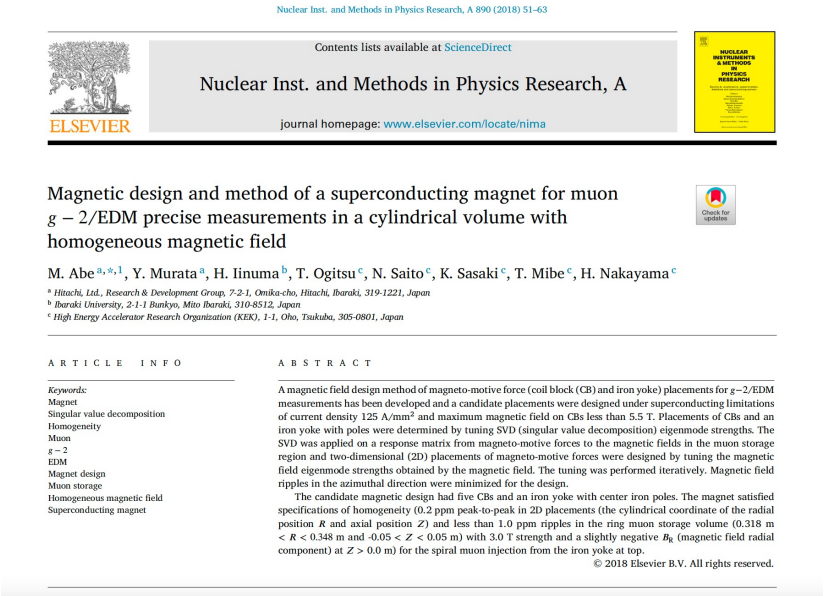
It reequires upgrade of linac, magnet (6T) (and muon laser for polarization)

- At the beginning of 2025 I started contacting the following companies:
  - AGS Superconductors Magnets Systems (https://www.asgsuperconductors.com/magnets-systems) (IT)
  - Oxford Instruments (UK)
  - Tesla Engineering (http://www.tesla.co.uk/magnet/index.html) (UK)
  - Scientific Magnetics (https://www.scientificmagnetics.co.uk/) (UK)
  - SigmaPhi (https://www.sigmaphi.fr/en/produits/magnets/aimants-supraconducteurs/) (FR/CH/Japan)

I asked for a **feasibility study** for a 6T magnet with very high homogeneity (< 1ppm), based on the "Magnetic Resonance Imaging (MRI)-type solenoid storage" design magnet, described in NIMA 890 (2108) 51

The feasibility study could proceed in two stages:

- A high-level assessment indicating whether such a solenoid is feasible, along with rough estimates of time and cost.
- A more detailed analysis requiring a technical feasibility study (CDR) with information about the cost and timeframe required to carry out this study.



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Magnetic design and method of a superconducting magnet for muon $g-2$/EDM precise measurements in a cylindrical volume with homogeneous magnetic field

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ABSTRACT

A magnetic field design method of magneto-motive force (coil block (CB) and iron yoke) placements for $g-2$/EDM measurements has been developed and a candidate placements were designed under superconducting limitations of current density 125 A/mm^2 and maximum magnetic field on CBs less than 5.5 T. Placements of CBs and an iron yoke with poles were determined by tuning SVD (singular value decomposition) eigenmode strengths. The SVD was applied on a response matrix from magneto-motive forces to the magnetic fields in the muon storage region and two-dimensional (2D) placements of magneto-motive forces were designed by tuning the magnetic field eigenmode strengths obtained by the magnetic field. The tuning was performed iteratively. Magnetic field ripples in the azimuthal direction were minimized for the design.

The candidate magnetic design had five CBs and an iron yoke with center iron poles. The magnet satisfied specifications of homogeneity (0.2 ppm peak-to-peak in 2D placements (the cylindrical coordinate of the radial position R and axial position Z) and less than 1.0 ppm ripples in the ring muon storage volume (0.318 m < R < 0.348 m and -0.05 < Z < 0.05 m) with 3.0 T strength and a slightly negative B_R (magnetic field radial component) at Z > 0.0 m) for the spiral muon injection from the iron yoke at top.

I got replies from:

- ASG Superconductors Magnets Systems – replied: interested. They can provide a feasibility study in O(6 months)
- Oxford Instruments (UK) – replied: Not their product
- Tesla Engineering - replied: asked few more questions – waiting for their reply
- Scientific Magnetics – not yet replied
- SigmaPhi – not yet replied replied

- *Interaction/collaboration with ASG for a feasibility study of the magnet.*

ASG SUPERCONDUCTORS TODAY

≈200 people

3 Production Plants:
2 Genova, La Spezia

2 Branches:
USA, UK

4 Strategic Business Units:

- Big Science
- Materials
- Medical
- Industry & Energy





Setup of the High Sensitivity Study Group (Summer 2025)

Initial members:

Graziano Venanzoni (Chair), Tsutomu Mibe

B-field and Injection : Shinji Ogawa, Ken'ichi Sasaki, Ce Zhang, Graziano Venanzoni (on behalf of ASG)

Acceleration: Masashi Otani, Elia Bottalico

High-Pol: Shusei Kamioka, Jonathan Tinsley

Mandate:

Investigate potential / feasibility for higher sensitivity measurements

Establish pros and cons

Estimation of possible costs

Write a document (report)

Timeschedule:

June 2026 to complete the studies; December 2026 to distribute (internally) the report. In case of success the report can be the base for an addendum/upgrade of the proposal

One thing I’m particularly proud

- The Leverhulme group (people)

- I believe the setup of this group has been my main contribution to physics in the past year.

Within the next decade: what I would hope for

- More (personal) involvement on KLOE analysis of 2π
- NNLO MC generators for 2π → We have great theorists!
- MUonE measurement of a_μ^{HVP} at few permil → new idea (?)
- Measurement of a_μ at J-PARC at O(100) ppb → We need a lot of luck
- Clarification of the muon g-2 puzzle? (who is going to bet?)

THANKS!!!