# Muon linac for the muon g-2/EDM experiment at J-PARC

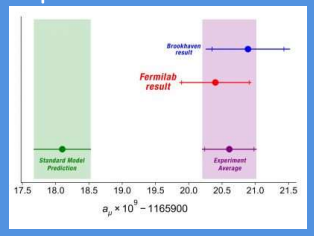
Masashi Otani (KEK/J-PARC)
on behalf of the E34 muon linac group

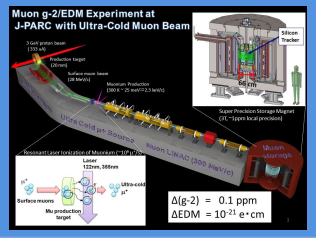
## Abstract

The muon g-2/EDM experiment at J-PARC (E34) aims to measure muon g-2 and EDM with unprecedented low-emittance muon beam realized by acceleration of thermal muons. Thanks to its low emittance, it can measure muon g-2 in a completely different way than FNAL or BNL. The muon linac accelerates muons from thermal energy (25 meV) to 212 MeV with electro-static extraction and four different radio-frequency cavity: RFQ, IH-DTL, DAW-CCL, and DLS. We succeeded in accelerating muons using the radio-frequency accelerator for the first time, and are now fabricating actual acceleration cavities. In this poster, demonstration of first muon acceleration and current status of the fabrication will be presented.

## Introduction

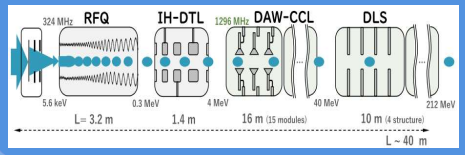
- The anomaly of the muon g-2 [1, 2] should be investigated to get a clue for new physics.
- J-PARC E34 experiment [3] aims to measure muon g-2 with completely different way than FNAL and BNL using unprecedented low-emittance muon beam.




## Muon linac overview

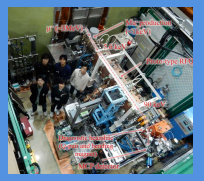
- The low-emittance muon beam realized by acceleration of thermal muon.
- Less emittance growth & loss is required to the linac to satisfy the requirement.
- One of the milestones was the demonstration of muon acceleration, which had never been demonstrated before.

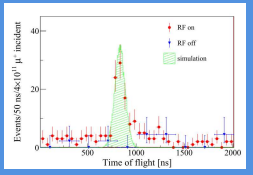


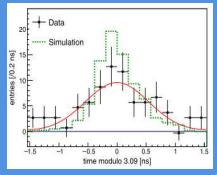

| | |
|---|---|
| Energy [MeV] | 212 |
| intensity [/s] | $10^6$ |
| repetition [Hz] | 25 |
| Pulse [ns] | 10 |
| norm. ε [π mm mrad] | 1.5 |
| Δp [%] | 0.1 |

## First muon acceleration

- The muon cooling with formation of the negative muonium was developed for the demonstration [4].
- First muon acceleration using radio-frequency accelerator was demonstrated using proto-RFQ [5].
- The accelerated muon profile and bunch width were measured using the beam monitors [6, 7, 8].

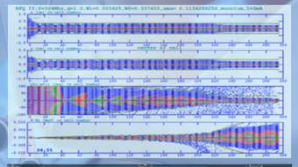


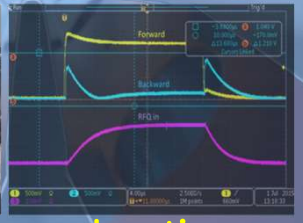



## RFQ
(Radio-frequency quadrupole)

- The J-PARC H⁻ linac spare will be used.
- Muon acceleration is confirmed by the simulation [9].
- High power test was done and ready for acceleration.

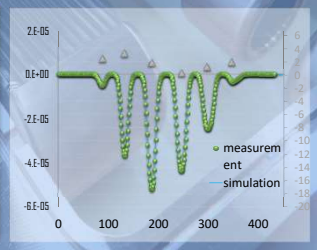





**Ready for acceleration**

## IH-DTL
(Interdigital H-mode drift tube linac)

- Designed using the alternative phase focusing scheme, to realize higher efficiency [10].
- The fabrication scheme and performance were confirmed with proto-type [11].
- The real IH-DTL was designed based on the experiences with the proto-type and is being fabricated.

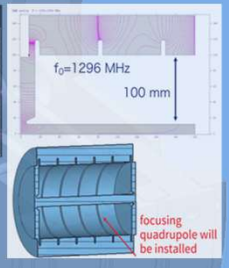



**Fabricated in 2021**

## DAW-CCL
(Disk and washer coupled-cell linac)

- Designed to cover wide range of velocity ($\beta$=0.3-0.7) [12].
- The Al cold model was fabricated and tested to confirm the design.
- Detail design for real DAW-CCL, such as bridge coupler etc., is being done.


| | sim. | meas. |
|---|---|---|
| freq. [GHz] | 1.318 | 1.323 |
| $Q_0$ | 9254 | 8766 |

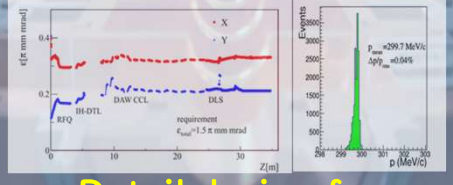



**First module is fabricated in 2021-2022**

## DLS
(disk-loaded structure)

- Finish basic design [13].
  Detailed design for the production of the actual machine is underway.
- Emittance and loss satisfies the requirement.

| | Soa | RFQ | IH-DTL | DAW-CCL | DLS |
|---|---|---|---|---|---|
| Transmission | 87 | 95 | 100 | 100 | 100 |
| Decay loss | 17 | 19 | 1 | 4 | 1 |
| $\varepsilon_x$ [π mm mrad, rms, normalized] | 0.38 | 0.30 | 0.32 | 0.32 | 0.33 |
| $\varepsilon_y$ [π mm mrad, rms, normalized] | 0.11 | 0.17 | 0.20 | 0.21 | 0.21 |




**Detail design for fabrication is ready in 2021-2022**

## Acknowledgement

This work is supported by JSPS KAKENHI Grant Numbers JP25800164, JP15H03666, JP15H05742, JP16H03987, JP16J07784, JP18H03707, JP18J22129, JP19J21763, JP20J21440, and JP20H05625.

## References

[1] Phys. Rev. D 73 (2006) 072003
[2] Phys. Rev. Lett. 126 (2021) 141801
[3] PTEP 2019 (2019) 053C02
[4] Phys. Rev. AB 24 (2021) 033403
[5] Phys. Rev. AB 21 (2018) 050101
[6] NIMA 899 (2018) 22-27
[7] J. Phys. Conf. Ser. 1067 (2018) 052012
[8] Phys. Rev. AB, 23 (2020) 022804
[9] Proc. of IPAC2015, p. 3801-3803
[10] Phys. Rev. AB 19 (2016) 040101
[11] J. Phys. Conf. Ser. 1350 (2019) 012054
[12] J. Phys. Conf. Ser. 1350 (2019) 012097
[13] J. Phys. Conf. Ser. 875 (2017) 012054