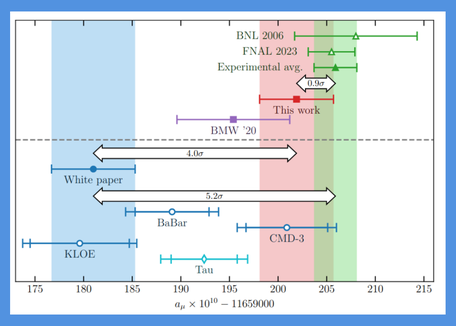
Muon linac for the J-PARC muon g-2/EDM experiment

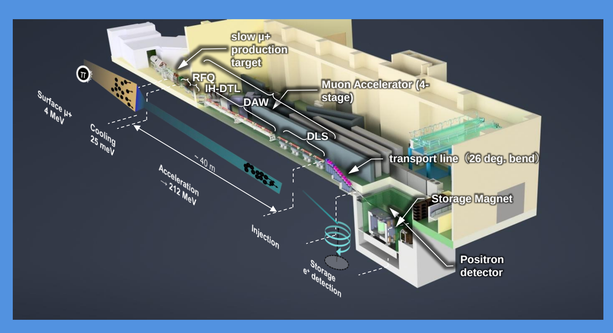
KEK, Accelerator Lab., Masashi Otani
on behalf of E34 muon linac group

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. 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, current status of the developments of will be presented.

Introduction

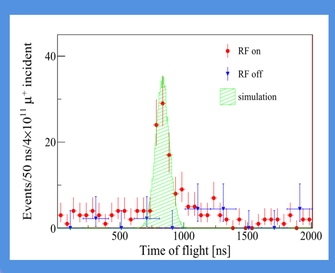
- Verification of the measured value of the muon anomalous magnetic (g-2) is an urgent issue [1, 2].
- J-PARC E34 experiment [3] aims to measure muon g-2 with completely different way than previous experiments using unprecedented low-emittance muon beam.

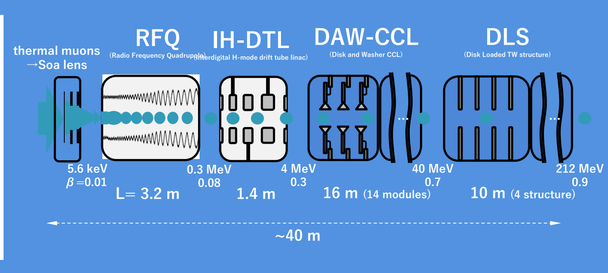




Muon linac overview

- Low-emittance beam realized by acceleration of thermal muon.
- Less emittance growth & loss is required to the linac to satisfy the requirement.
- First muon acceleration had been realized by an RFQ [4-8].
- Linac dedicated muon has been developed based on this proven technology.

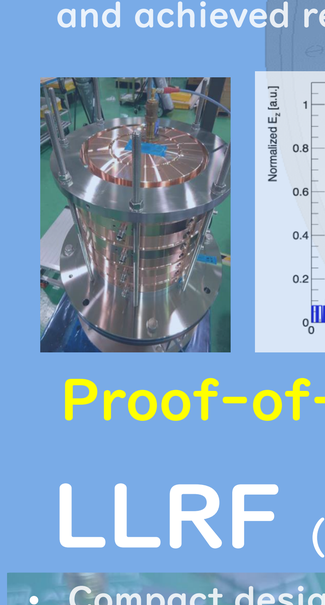


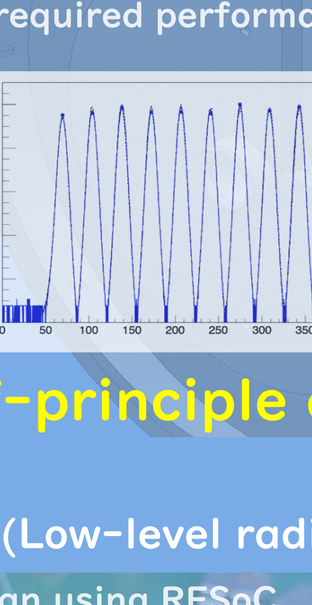


Energy [MeV]	212
intensity [/s]	10^6
repetition [Hz]	25
Pulse [ns]	10
norm. ε_t [π mm mrad]	1.5
Δp [%]	0.1

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.





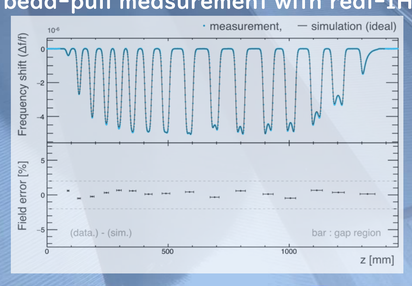
	H^-	μ
Particle mass (MeV/c^2)	939	106
Intervane voltage (kV)	83	9.3
Power dissipation (kW)	330	4.2
Input energy (keV)	50	5.6
Output energy (MeV)	3	0.3

Ready for acceleration

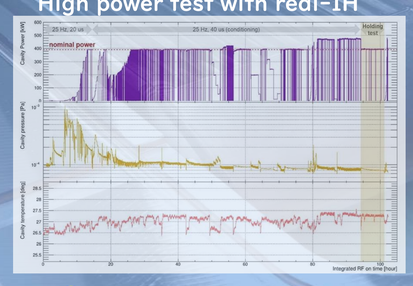
IH-DTL (Interdigital H-mode drift tube linac)

- 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 and fabricated based on the experiences with the proto-type. H-power operation was demonstrated.

bead-pull measurement with real-IH



High power test with real-IH

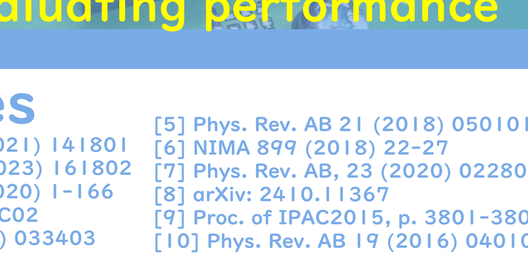


f_0 [MHz]	324
W_{in} [MeV]	0.337
W_{out} [MeV]	4.26
Cavity length [m]	1.32
# of cells	16
Bore radius [mm]	11.4
synch. phase [deg.]	-44 ~ 48
Max. E_0 [MV/m]	10
ZTT [MΩ/m]	68
Max. surface field [MV/m]	35.6 (2.0 E_k)
Power [kW]	310

Ready for acceleration

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

- Designed to cover wide range of velocity (β=0.3-0.7) [12].
- The Al cold model was fabricated and tested to confirm the design.
- The 1st accelerator tank was fabricated and achieved required performance.



f_0 [MHz]	1296
W_{in} [MeV]	4.26
W_{out} [MeV]	41.4
Length [m]	16.15
# of tanks	14
# of modules	3
# of tanks / module	4, 5, 5
# of cells / tank	11
Bore radius [mm]	12
Sync. phase [deg]	-30
E_0 [MV/m]	5.6
ZTT [MΩ/m]	18.6 ~ 62.7
Max. field [MV/m]	28.9 (0.9 E_k)
Max. power / tank[kW]	420

Proof-of-principle completed.

DLS (disk-loaded structure)

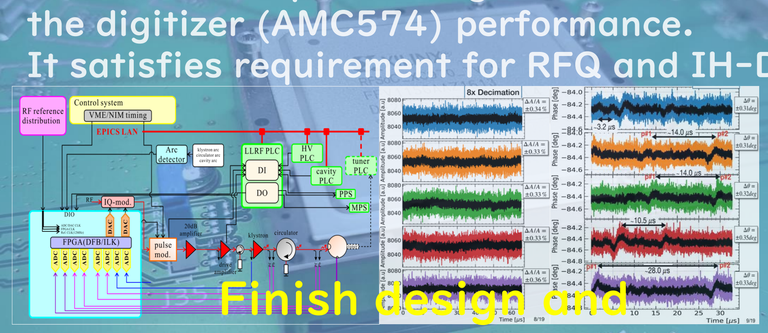
- Establish muon-dedicated design scheme (β=0.7-0.9) and finished quasi-constant gradient design [13].
- Proto-type cells and bridge couplers were fabricated and achieved required performance.

f_0 [MHz]	2592
W_{in} [MeV]	41.4
W_{out} [MeV]	212.4
Section length [m]	9.8
# of acc. tubes	4
# of regular cells / tube	63, 63, 60, 60
Iris aperture [mm]	22.6 ~ 26.4
Synch. phase [deg.]	-13
Max. E_0 [MV/m]	21
Z [MΩ/m]	32.2 ~ 57.0
Max. power* / tube [MW]	40

Proof-of-principle completed.

LLRF (Low-level radiofrequency)

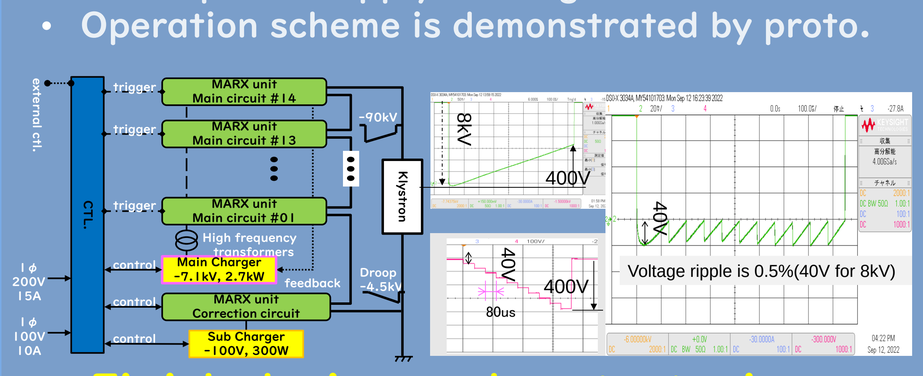
- Compact design using RFSoC
- Finished conceptual design and evaluated the digitizer (AMC574) performance. It satisfies requirement for RFQ and IH-DTL



Finish design and evaluating performance

Modulator PS

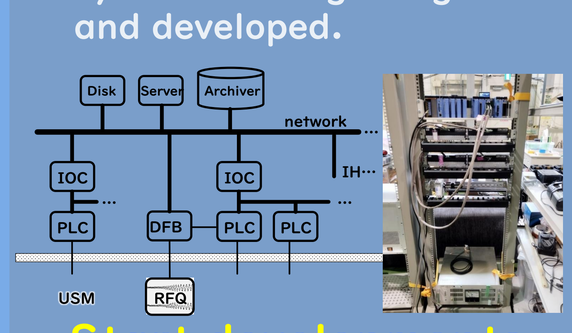
- MARX power supply is designed for IH-DTL
- Operation scheme is demonstrated by proto.



Finish design and proto-typing

Control

- EPICS-based control system is being designed and developed.



Start developments

References

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This work is supported by JSPS KAKENHI (Grant Numbers 25800164, 15H03666, 15H05742, 16H03987, 16J07784, 18H03707, 18J22129, 19J21763, 20J21440, 20H05625, 21K18630, 21H05088, 22H00141), JST FOREST Program (Grant Number JPMJFR2120), the natural science grant of the Mitsubishi Foundation, a project commissioned by the New Energy and Industrial Technology Development Organization (NEDO).