

Commissioning of Linear IFMIF Prototype Accelerator (LIPAc) RFQ and RF system towards high current and high duty operation

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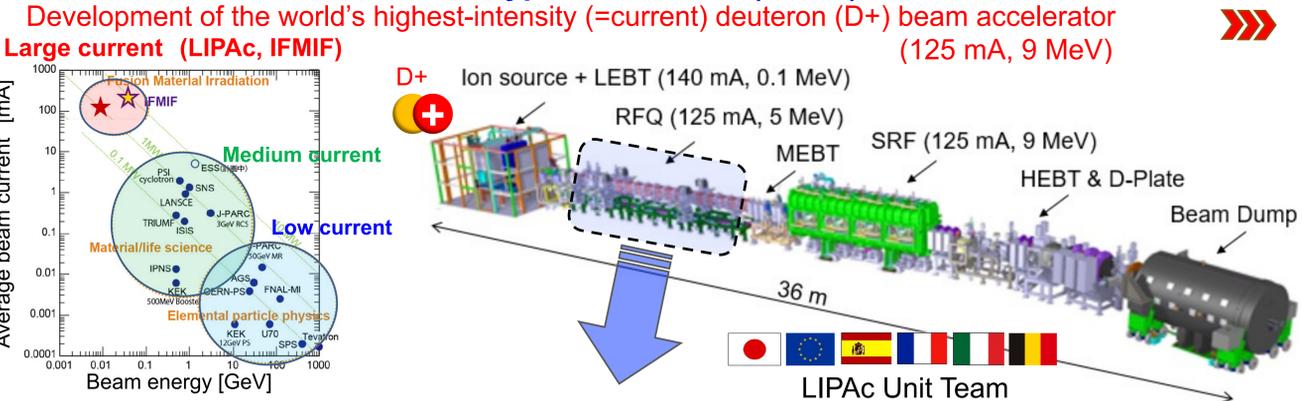
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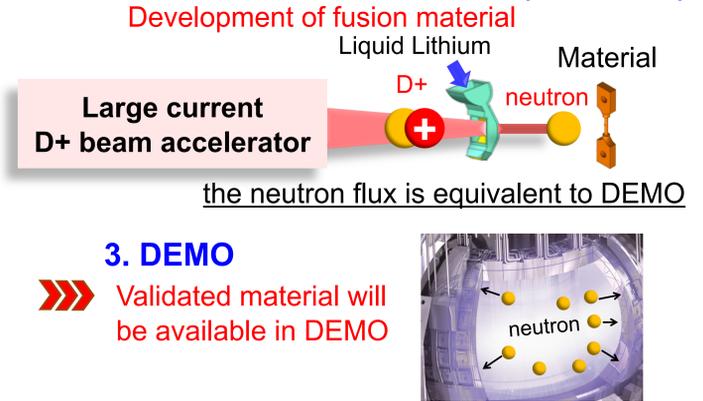
Introduction

The construction of the Linear IFMIF Prototype Accelerator (LIPAc) is ongoing in Rokkasho Fusion Institute of QST under the Broader Approach Agreement in the field of fusion energy research between Japan and EURATOM. The aim of LIPAc is to accelerate the deuteron beam up to 9 MeV at 125 mA in CW in order to validate the engineering design of the low energy section of the 40 MeV International Fusion Materials Irradiation Facility (IFMIF) accelerator.

1. Linear IFMIF Prototype Accelerator (LIPAc)



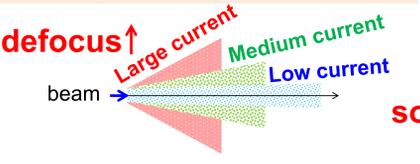
2. Accelerator driven neutron source (IFMIF etc.)



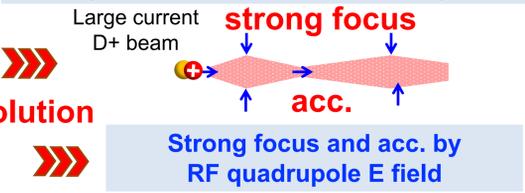
3. DEMO

Validated material will be available in DEMO

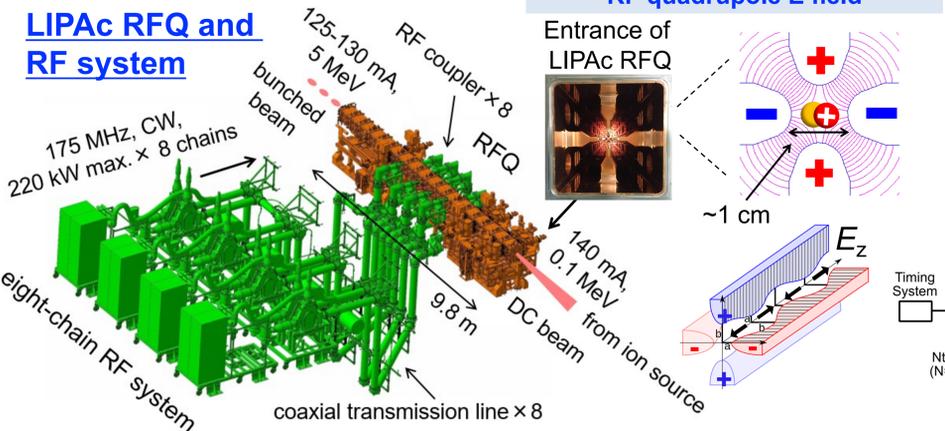
Difficulty of the large beam current



Strong focus and acceleration by RFQ

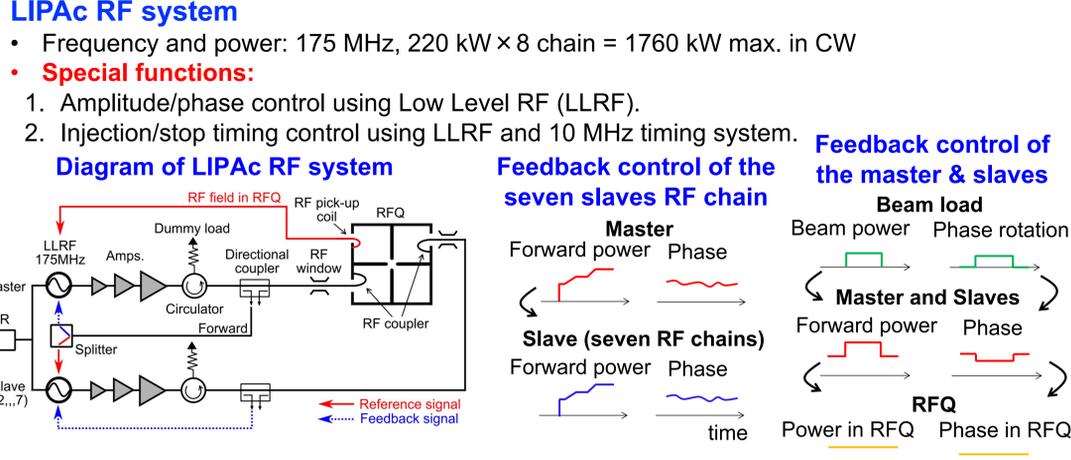


LIPAc RFQ and RF system



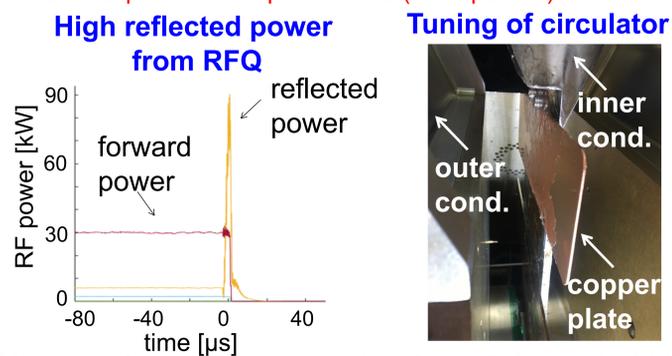
175 MHz LIPAc RFQ and RF system

- LIPAc RFQ**
- Resonance frequency: ~175 MHz. It is adjustable by changing the cooling water temperature.
 - Beam acceleration: CW, 0.1 to 5.0 MeV, 125 mA, ~90% transmission ratio.
 - Requirement of RF power: wall loss ~ 560 kW, beam loading ~ 625 kW = ~1200 kW in total.
- LIPAc RF system**
- Frequency and power: 175 MHz, 220 kW x 8 chain = 1760 kW max. in CW
 - Special functions:**
 - Amplitude/phase control using Low Level RF (LLRF).
 - Injection/stop timing control using LLRF and 10 MHz timing system.

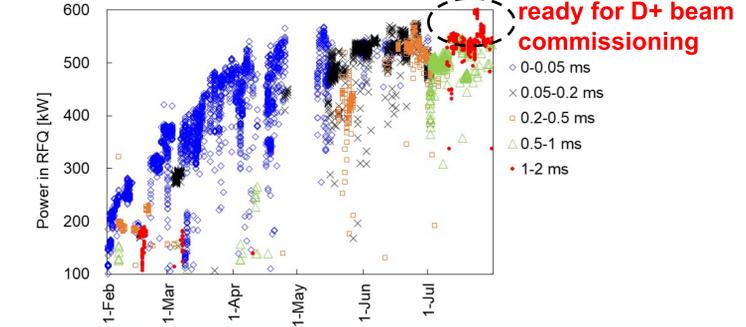


RF conditioning of RFQ

- High reflected power from RFQ was observed (a factor of 3-8 larger than that of the forward power). For reducing the reflected power to the tetrode, an isolation of the circulator was tuned onsite using a copper plate.
- A High Voltage Power supply of the anode was tuned for the short pulse width (20 μs to CW) and high repetition rate operation (~100 Hz)
- The RF conditioning of RFQ successfully achieved to the nominal power in the pulse mode (1 ms per 1 s).

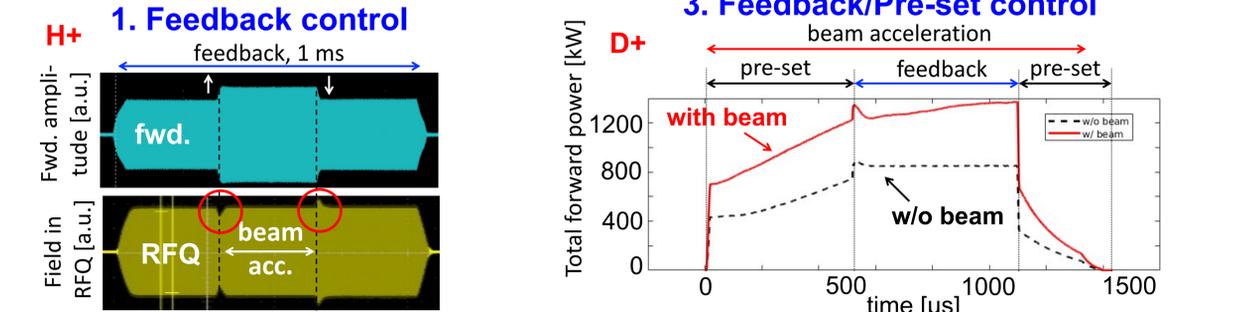


History of the RF conditioning from Feb. - Jul., 2019

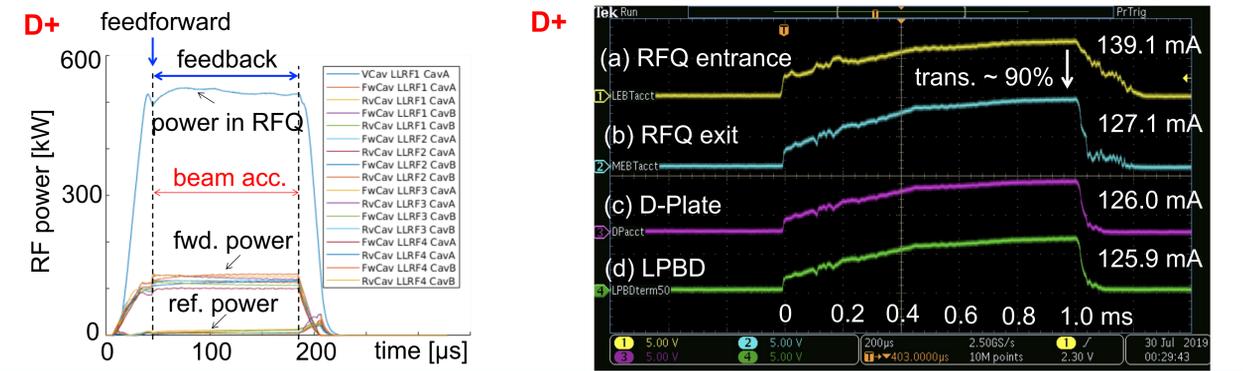


H+/D+ beam commissioning of RFQ and RF system

- H+** 1. The feedback control stably maintained the RF field in RFQ, but there was about 15% (about 28% in power) of drop and rise of the field in transients with 54 H+ beam acceleration.
- D+** 2. The feedback/feedforward control and RF injection/stop timing control improved the rise/drop of the power in RFQ. It was about +/- 5% in power with 52 D+ beam. The controls was tested up to 70 mA D+ beam.
- D+** 3. The feedback/pre-set control and RF injection/stop timing control resulted in accelerating over 125 mA D+ beam despite the unstable beam from the ion source. The beam energy was 5 MeV and trans. ratio was about 90% as the design.



2. Feedback/Feedforward control 3. Achievement of 125 mA D+ beam acceleration



Summary

The commissioning of the RFQ and RF system for the LIPAc was performed in the pulsed operation mode up to 1 ms per 1 s, and the deuteron beam with 125 mA was successfully accelerated up to 5 MeV. The RF power reflection at the RF breakdown events of the RFQ during the RF conditioning (3-8 times larger than the forward power) was overcome by tuning the circulators and upgrading the dummy loads of the RF system. The LLRF functionality was validated with the deuteron beam at the nominal beam current in the pulsed operation mode. In addition, the performance of the RFQ indicated a good agreement with its design: 5 MeV of beam acceleration, 90% of beam transmission at 125 mA, and the major beam loss occurring at the bunching section of the RFQ.

Reference in FEC2020

TECH/4, 14 May 2021: P. Cara
"IFMIF/EVEDA Project: Achievements and Outlooks beyond 2020"

P8-823, 14 May 2021: K. Kondo
"Neutron production measurement in the 125 mA 5 MeV deuteron beam commissioning of Linear IFMIF Prototype Accelerator (LIPAc) RFQ"