

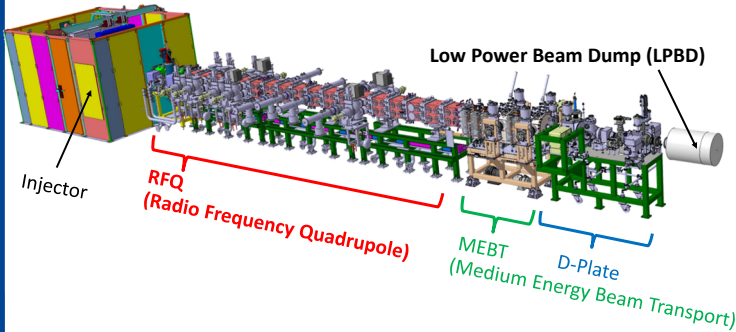
# Neutron production measurement in the 125 mA 5 MeV deuteron beam commissioning of Linear IFMIF Prototype Accelerator (LIPAc) RFQ

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## INTRODUCTION

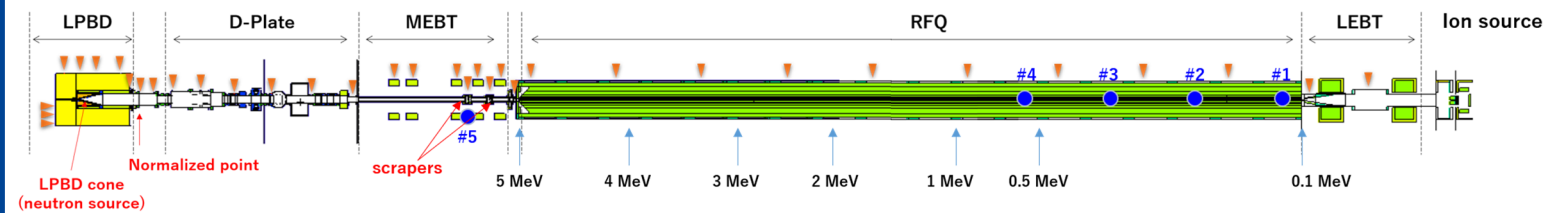


The commissioning of the **Linear IFMIF Prototype Accelerator (LIPAc)** has been progressed significantly in Rokkasho, Japan. The acceleration of a deuteron beam of 125-mA peak current up to 5 MeV (1 ms, 1 Hz pulsed beam) was succeeded for the first time on 24th July 2019. In LIPAc, it is highly important to minimize any beam loss at high energy to avoid activation or damage on accelerator components. The present study aimed to evaluate the amount of beam loss by measuring quantitatively neutrons generated during the experiment in order to verify the design concept of LIPAc to localize and control the loss.

## METHOD

- ▼ : Ni foils
- : <sup>3</sup>He proportional counter

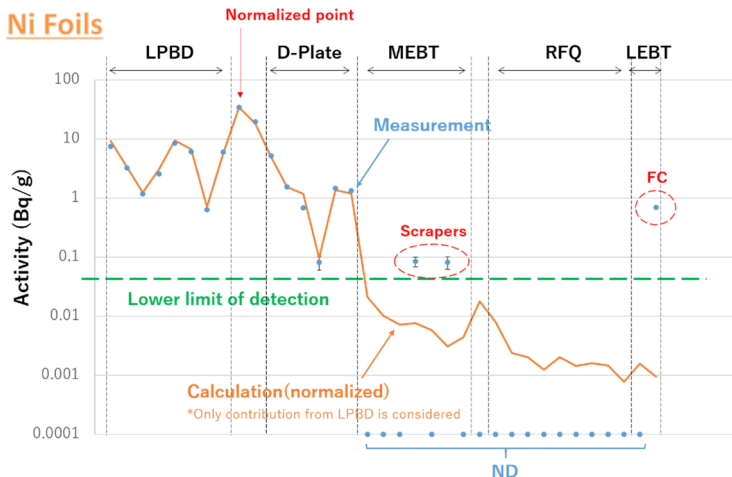
- 35 Ni foils (10 mm-φ, 1 mm thickness) were placed in different locations along the accelerator as indicated, and the activity produced through the <sup>58</sup>Ni(n,p)<sup>58m</sup>+gCo reaction, which is sensitive to neutrons with the energy more than about 2 MeV, was measured with a HPGe detector.
- Five <sup>3</sup>He proportional counters were placed on RFQ to detect a trace of small neutron productions.



- Neutron transport calculation was performed with MCNP5-1.60.
- Only the neutron production on LPBD was considered. The angle-energy correlated distribution of neutrons emitted from d-Al reaction on LPBD was given based on the experimental data measured at Kyushu University, Japan [1].

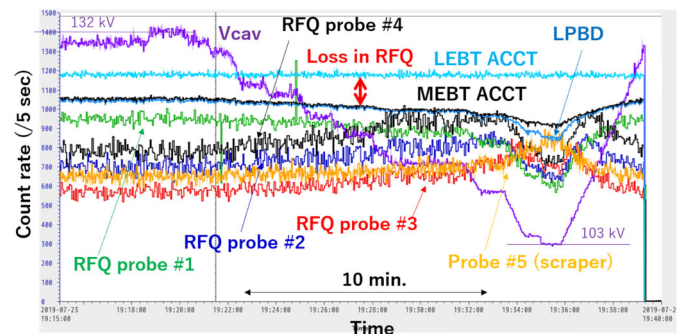
[1] HIRABAYASHI, K., et al., Prog. Nucl. Sci. Technol., 3 (2012) 60-64.

## RESULTS AND DISCUSSIONS



- Overall agreement with the measured and calculated (normalized) distributions are very well excepts at a few points with intentional loss, i.e., two MEBT scrapers and the last point in LEBT, which is close to FC.
- No significant activation was observed for 9 foils on RFQ.
- No significant contributions from unexpected beam loss.

## <sup>3</sup>He detectors



- When the cavity voltage (V<sub>cav</sub>) of RFQ was decreased from nominal 132 kV, LPBD current was decreasing, nevertheless the neutron production measured with the probe #4 was gradually increasing, and then the probe #3 was also increasing.
- Most probably the increase of the probes #3 and #4 counts are attributed to the increasing beam loss in the bunching section of the RFQ cavity (<0.5 MeV), and that was successfully detected.
- This behavior is in accordance with the prediction by the RFQ design and the beam dynamics simulation. [2, 3]

[2] COMUNIAN, M., et al., MOPSO31 (Proc. IPAC2011, 2011).

[3] NGHIEM, P.A.P., et al., Nucl. Instrum. Meth. Phys Res. A, 654 21 (2011) 63-71.

## CONCLUSION

- In LIPAc RFQ commissioning, unpredicted beam loss was not significant after the beam was accelerated to 5 MeV.
- No trace of the beam loss at the high energy section of the LIPAc RFQ was observed, while only the loss at the MEBT scrapers and LEBT FC were clearly identified as expected.
- Difference between the RFQ input and output was made at the bunching section as designed and the beam loss was well controlled.
- LIPAc RFQ and MEBT are working very well as predicted by the design calculation, and their concept is successful.

## Reference in FEC2020

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

P8-830, 14 May 2021: T. Shinya  
"Commissioning of Linear IFMIF Prototype Accelerator (LIPAc) RFQ and RF system towards high current and high duty operation"