Preliminary Test of Multi-layer Faraday Cup for Quality Assurance of Proton Beam Energy

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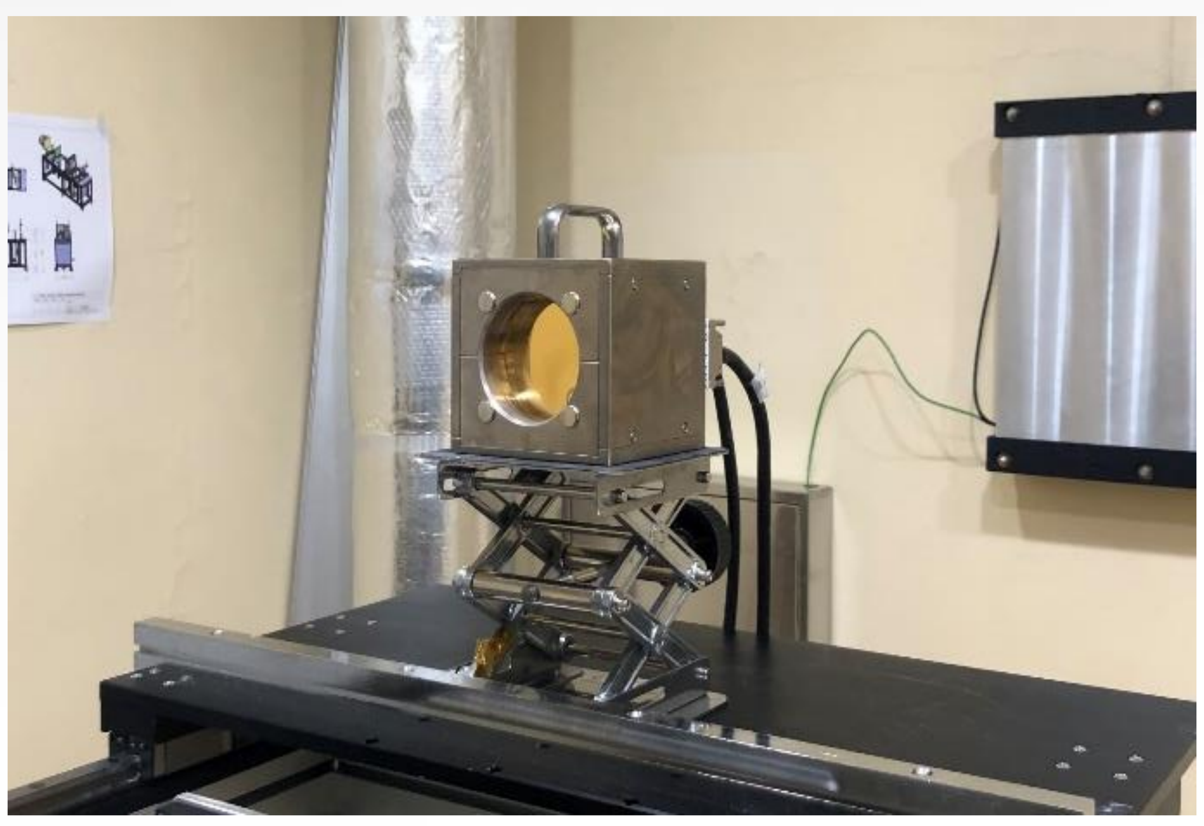
Motivation

- A KOMAC has operated 100-MeV proton linear accelerator since 2013.
- A quality assurance (QA) of proton beam energy is required to provide exact energy users want to know
- As a general method to estimate proton energy, the range in the wedge-shaped polycarbonate phantom was measured using radio-chromic film.
- A new beam energy QA system using multi-layer faraday cup (MLFC) was introduced for in-situ proton energy monitoring
- To confirm performance of MLFC for quality assurance, beam energy measurement test and data post-processing was conducted.

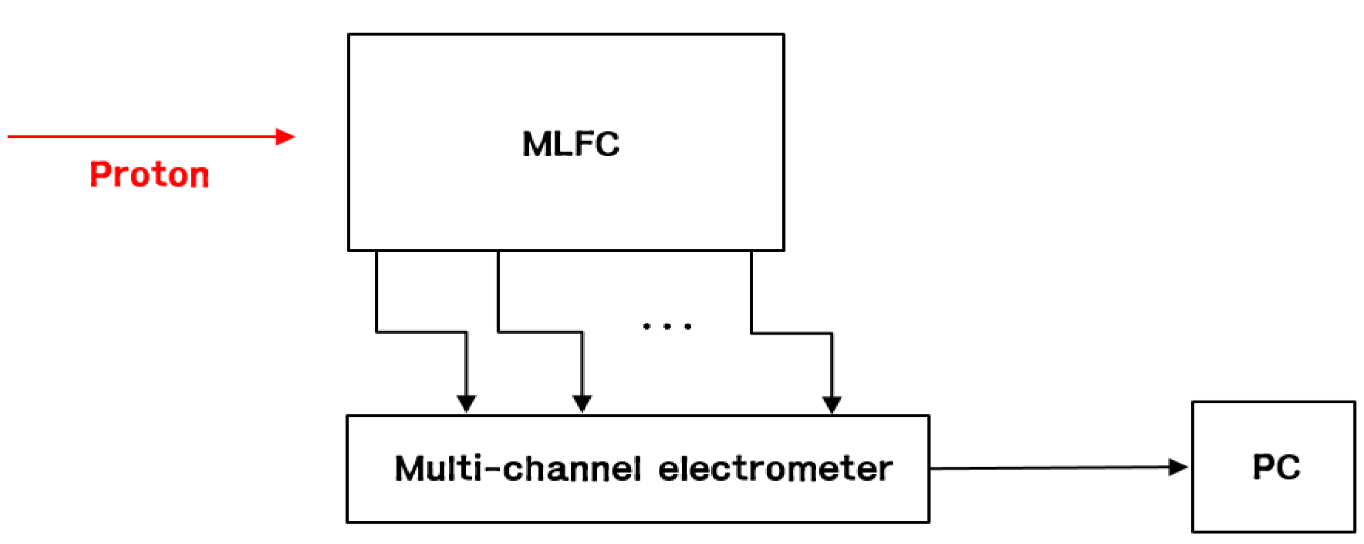
Proton Energy QA System

❑Multi-layer Faraday Cup (MLFC)



- Set up of the MLFC at the device under test (DUT)

- The MLFC (Pyramid, MLFC-128-125) is capable of measuring proton energy from 30 to 125 MeV.
- It consists of 128 copper clad FR4 with a thickness of 0.508 mm separated by 76 μm Kapton™ film
- A 128 channel electrometer (Pyramid, I128S) was used to integrate charge individually from each plate



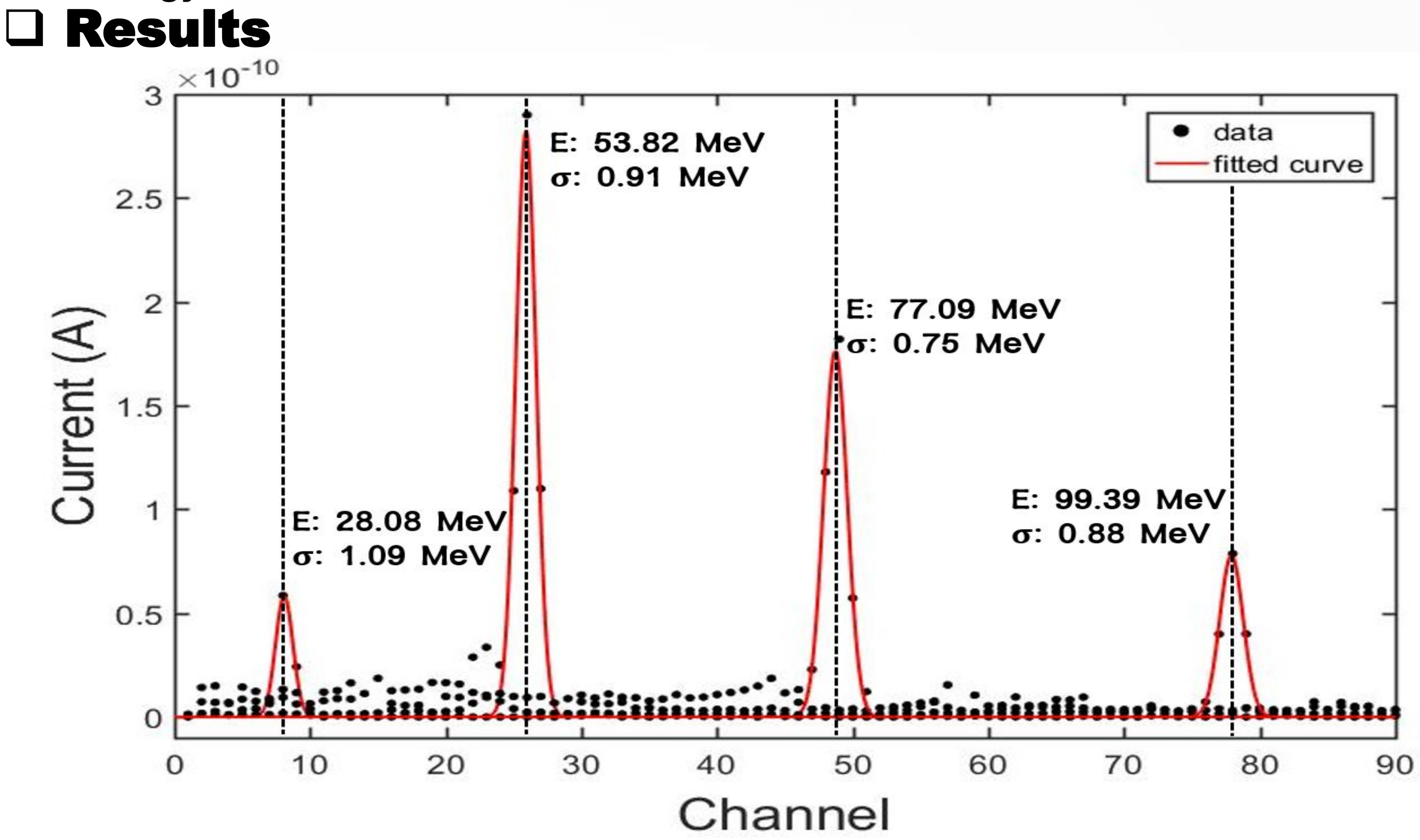
- Overall configuration of proton energy QA system

Proton Energy Measurement Test

❑ Test conditions

- Irradiation facility: TR102
- Flux: 10^6~10^7 #/(cm^2·pulse)
- Initial beamline energy: 33, 57, 80, 102 MeV
- Energy measurement at DUT

❑ Results



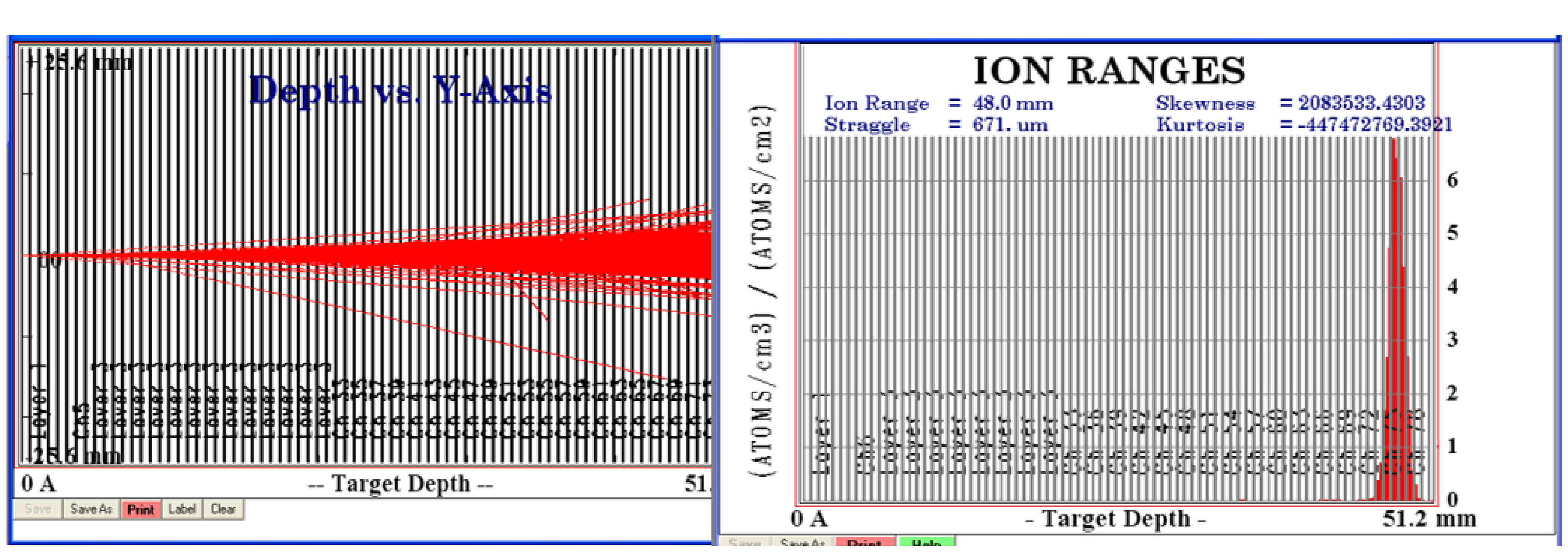
- Four kinds of initial beamline energy was extracted and passed through the beam window and the air causing energy loss.
- A few data on both sides of the peak channel were used for calculation of centroid and fitting

Beam line energy (MeV)	Measured peak width (MeV)	Range straggling (MeV)	Actual energy spread (MeV)	ΔE/E (%)
33	1.09	0.2	1.08	3.84
57	0.91	0.53	0.83	1.54
80	0.75	0.7	0.27	0.35
102	0.88	0.73	0.5	0.5

- The measurement and calculation (SRIM) results show good agreement within 1%

Beam Energy Spread

- For testing for space radiation effect to electronics, the proton beams should be monoenergetic or near monoenergetic (ΔE/E<5%).
- The peak widths in the MLFC spectrum are the convolution of longitudinal range straggling component and the actual energy spread of the beam expressed as $\sigma^2_{MEA} = \sigma^2 + \sigma^2_{STR,MLFC}$



- SRIM simulation can provide the longitudinal straggling in the geometry of MLFC.
- Acutal energy spread can be obtained bt de-convolution of the longitudinal range straggling in the MLFC from measured peak widths in the MLFC
- As ΔE/E, actual energy spread divided by measured energy, falls within 5% for all kinds of energy, it can be concluded that it satisfies the recommended condition for space radiation effect test

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Conclusion

- A comparison of measured energy with calculated energy using SRIM simulation shows good agreement within 1%
- Actual energy spread is obtained by de-convolution of the longitudinal range straggling from measured peak widths in the MLFC.
- ΔE/E within 5% satisfies the recommended condition for space radiation effect test.
- It is expected that MLFC will simplify the QA process and improve the accuracy of the proton energy measurement.

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