WEPP007

BEAM PROFILE MEASUREMENT USING HELIUM GAS LIGHT EMISSION AND BEPM FOR SUPERHEAVY ELEMENT SEARCH EXPERIMENT

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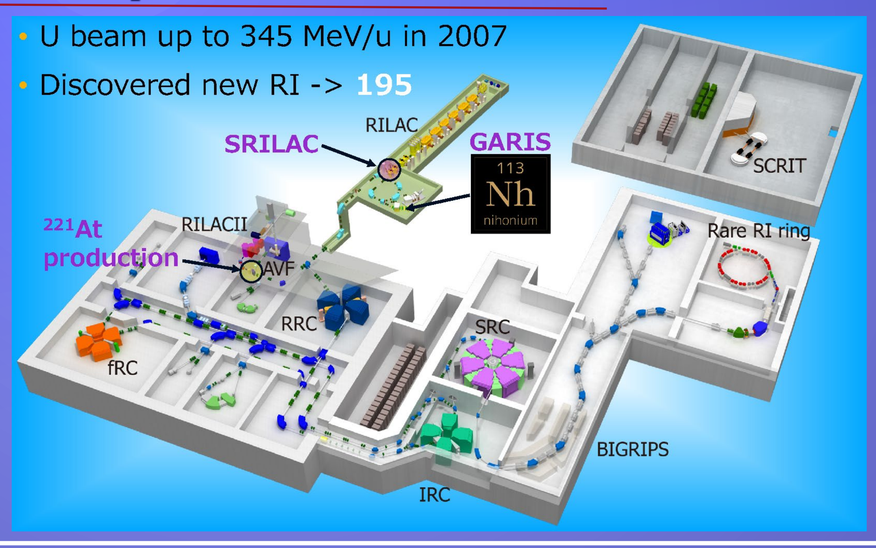
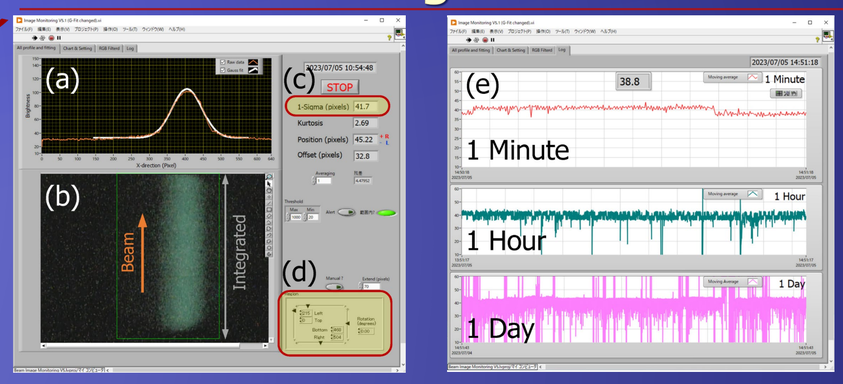
Abstract

The newly constructed superconducting linear accelerator (SRILAC) is now in operation with the aim of discovering new superheavy elements and advancing the production of medical radiation isotopes. Because it is crucial to extend the durability of the expensive Cm target for as long as possible, these experiments require the accelerated V beam to be sufficiently widened. To this end, a helium gas light emission monitor (HeLM) has been introduced to measure the beam profile. Because He gas flows within the target chamber, by capturing the light emitted from He gas with a CCD camera, the beam profile can be obtained nondestructively and continuously.

Bird's-eye View of the RIBF



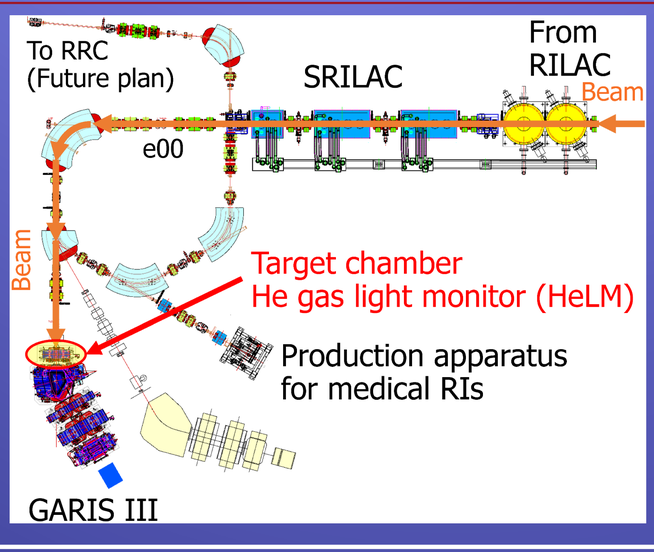
Front Panels Programmed with LabVIEW



(a) Result of integrating the brightness and a Gaussian fit 1σ
(b) Image of He gas emission
(c) Gaussian fit 1σ and the deviation from the center
(d) Setting panel for the fitting region
(e) Record of the Gaussian fit 1σ

Process Variables
HeLM Controller General LAN ⟷ Proxy Server ⟷ EPICS LAN

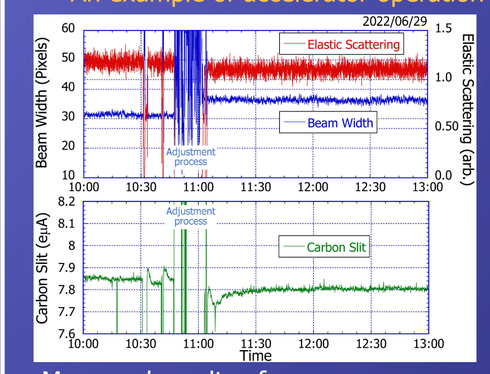
RILAC, SLIRAC and GARIS III



- RILAC
  RIKEN Heavy-ion Linac
- SRILAC
  Upgraded Superconducting Linac
- GARIS III
  Gas-filled Recoil Ion Separator

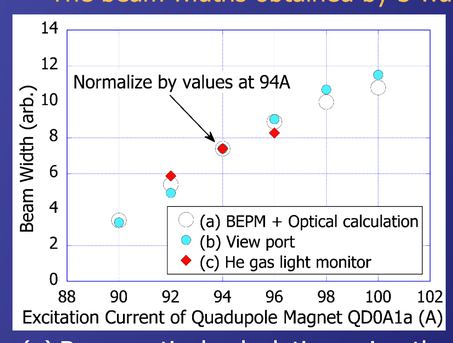
Measured Results

- An example of accelerator operation



Measured results of
(a) Elastic scattering (red line)
(b) Beam width by the HeLM (blue line)
(c) Carbon slit current (green line)

- The beam widths obtained by 3 ways



(a) Beam optical calculation using the quadrupole moments measured by the BEPMs
(b) Target spot on the fluorescent target observed through the view port
(c) Measurement result taken with the HeLM

Target Chamber for GARIS III and HeLM

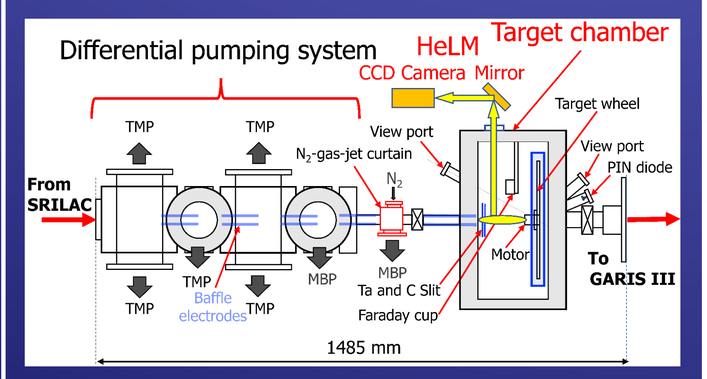
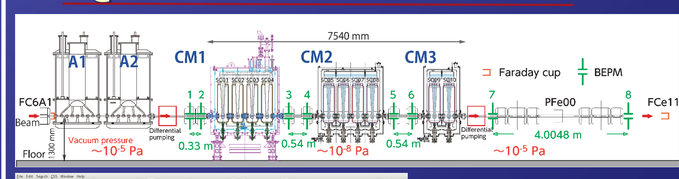
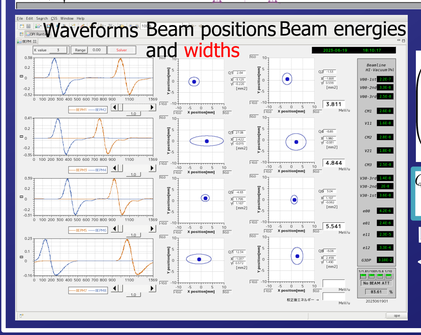


Table 1: Specifications of the lens, CCD camera and video server

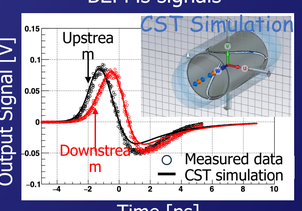
	Lens for CCD camera
CCTV* Lens	For 1/3 or 1/4 inch sensor
Focus	Focal length 6-60 mm (variable)
Iris	Manual F1.6
	CCD camera
Sensor	Sony307 1/3 inch CMOS
Video resolution	Pal/NTSC 1920 × 1080
Electrical shutter	1/50 ~1/10,000 sec
	Video server
Model No.	AXIS Q7404
Chanel number	4
Video compression	H.264 MPEG-4 Part 10/AVC Motion JPEG
Resolution	720 × 480 ~176 × 120
Frame rate	30 frames/s
Processor	ARTPEC-3 × 4
Memory	Main 128MB × 4, Flush128MB × 4
CCTV*	Closed Circuit Television

Beam Envelope Measurements Using Q-moment of BEPMs





BEPMs signals



$$Q = M\sigma$$

$$\begin{pmatrix} Q_1 \\ Q_2 \\ \vdots \\ Q_8 \end{pmatrix} = \begin{pmatrix} M_x(1|0)^2_{11}, -2M_x(1|0)_{11}M_x(1|0)_{12}, M_x(1|0)^2_{12}, -M_y(1|0)^2_{11}, \cdots \\ M_x(2|0)^2_{11}, -2M_x(2|0)_{11}M_x(2|0)_{12}, M_x(2|0)^2_{12}, -M_y(2|0)^2_{11}, \cdots \\ \vdots \\ M_x(8|0)^2_{11}, -2M_x(8|0)_{11}M_x(8|0)_{12}, M_x(8|0)^2_{12}, -M_y(8|0)^2_{11}, \cdots \end{pmatrix} \begin{pmatrix} \epsilon_x\beta(0)_x \\ \epsilon_x\alpha(0)_x \\ \epsilon_x\gamma(0)_x \\ \epsilon_y\beta(0)_y \\ \epsilon_y\alpha(0)_y \\ \epsilon_y\gamma(0)_y \end{pmatrix}$$

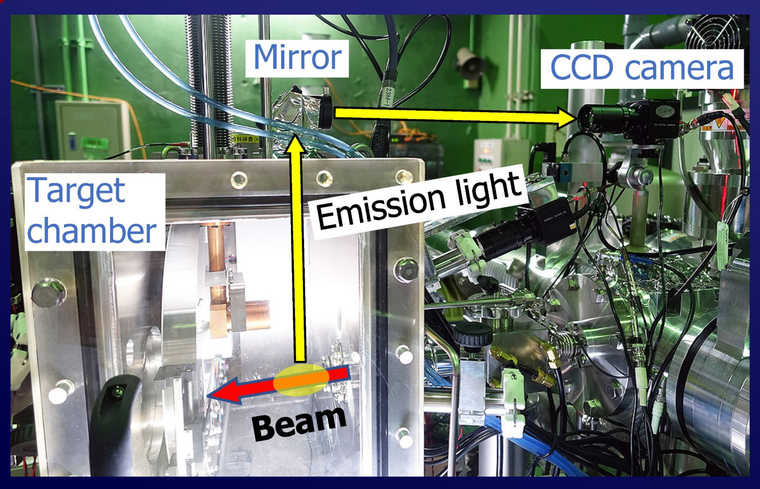
$$Q = \sigma_x^2 - \sigma_y^2 = k_q(V_L + V_R - V_U - V_D)/(V_L + V_R + V_U + V_D) - < x >^2 - < y >^2$$

$V_{L,R,U,D}$: Voltage measured by BEPM
$<x>$, $<y>$: Beam position measured by BEPM

$$\sigma = (M^t M)^{-1} M^t Q$$

T. Nishi et al., SRF2023, MOPMB086.

Target Chamber and HeLM



- Extremely high radiation environment
- To minimize deterioration,
- Emitted light is reflected by a mirror, and
- Reflected light is received by the CCD camera
- However, the CCD camera needs to be replaced every two months

Conclusion

- Beam profile is obtained nondestructively and continuously with a CCD camera by observing the light emitted when the beam passes through the helium gas in the target chamber.
- Handled through programming in LabVIEW and the analyzed data are integrated into an EPICS control system.
- A method to estimate the beam envelope has been recently developed by leveraging the measured quadrupole moments with BEPMs and incorporating calculations of the transfer matrix.
- Synergistic use of HeLM and BEPM allows us to accurately control the beam size at the Cm target.

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