Development of 8-Stripline BPM for Measurement of Momentum Spread of Electron Beam at Injector Test Facility of Pohang Accelerator Laboratory

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Chang-Kyu Sung[1], Moses Chung[1], Seong-Yeol Kim[1], BokKyun Shin[1], Inhyuk Nam[2] and Changbum Kim[2]

[1] Ulsan National Institute of Science and Technology, Ulsan, Korea
[2] Pohang Accelerator Laboratory, PAL, Pohang, Korea

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Abstract

A stripline beam position monitor has been developed with 8 feedthroughs in order to nondestructively measure the momentum spread of an beam. The beam momentum spread causes the variation of transverse beam width at a dispersive section and can be detected by the multipole moment based analysis of the beam-induced electromagnetic field. The feasibility of such a device will be tested with electron beam generated in the beamline of Injector Test Facility (ITF) at Pohang Accelerator Laboratory (PAL). The experimental preparation with electron beam test will be presented and the future plan for an application to bunch compressors at X-ray Free Electron Laser (XFEL) of PAL will be followed

• *Multipole Moment Analysis for Reconstruction of Momentum Spread*

- *Quadrupole moment & Momentum Spread*

$$\sigma_x^2 - \sigma_y^2 = \beta_x\epsilon_x - \beta_y\epsilon_y + D_x^2\langle(\Delta P_x/P_0)^2\rangle$$

- ✓ σ_x σ_y: RMS beam size in X and Y axis
- ✓ $\beta_{x,y}$, $\epsilon_{x,y}$: beta function and RMS emittance
- ✓ D_x: Dispersion function
- ✓ $\langle(\Delta P_x/P_0)^2\rangle$: RMS momentum spread

- *Multipole Moment Analysis*

$$J = \frac{I_0}{2\pi r}\left[1 + \frac{2\rho}{r}\cos(\theta-\phi) + \frac{2\rho^2}{r^2}\cos(2\theta-2\phi) + 2\frac{\sigma_x^2-\sigma_y^2}{r^2}\cos(2\theta+2\alpha)\right]$$

- ✓ J, I_0: current density on electrode and beam current
- ✓ ρ, ϕ: beam centroid
- ✓ r, θ: electrode position
- ✓ α: skew angle of transverse beam distribution

• *Feasibility Simulation for Reconstruction of Momentum Spread from Quadrupole Moment*

- ➢ Electron beam travels the dipole magnet with different RMS momentum spread
- ➢ The propagation of electron beam through dipole magnet is simulated with the beam dynamics code, Elegant
- ➢ Using the multipole-moment analysis, the RMS momentum spread is reconstructed from the quadrupole moment after the dipole magnet
- ➢ The simulation results give good agreements between the initial and reconstruction within 1 % of RMS momentum spread

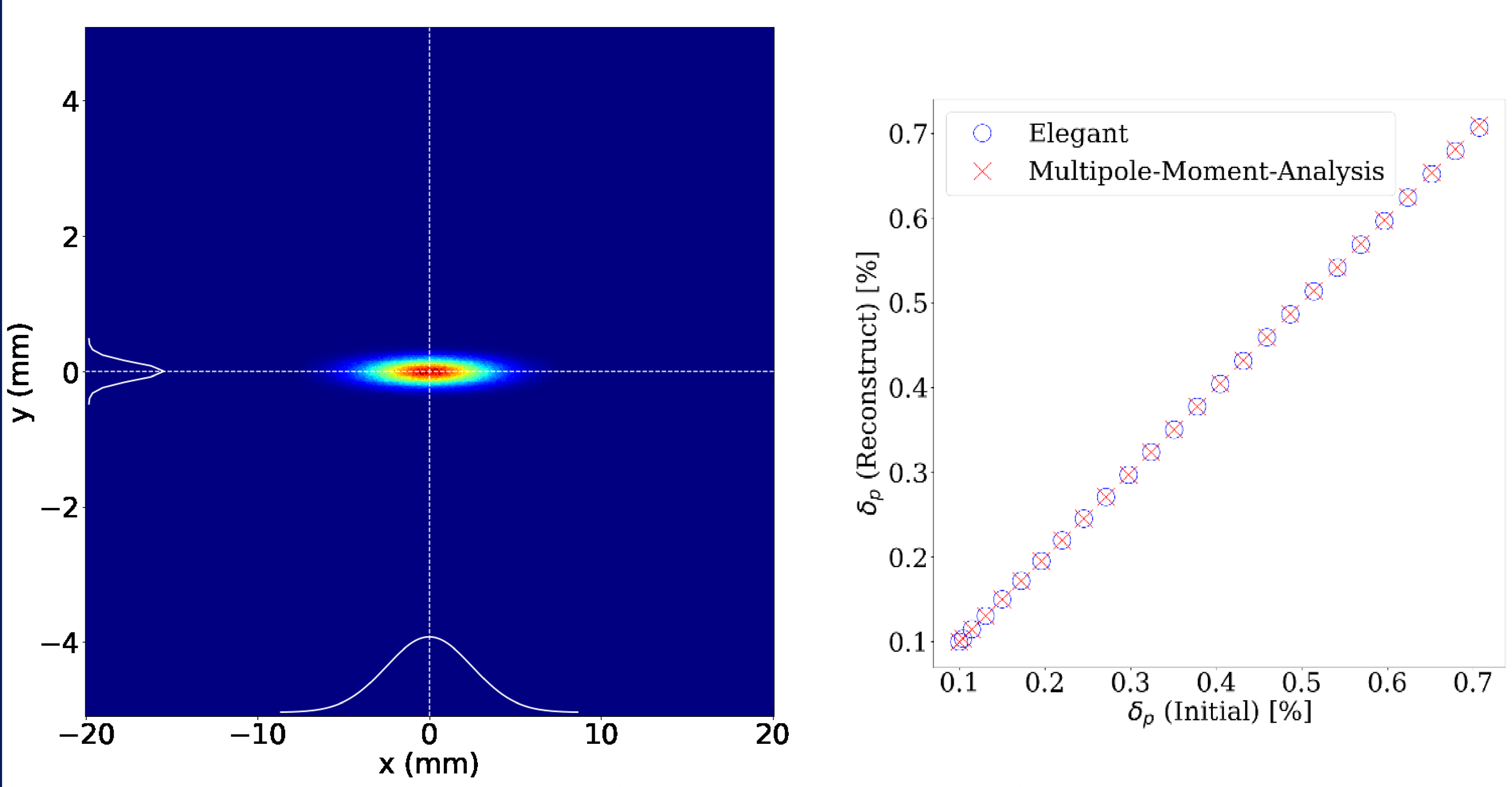

Fig.3. Simulation results for reconstruction of RMS momentum spread from the quadrupole moment with the beam dynamics code Elegant

• *Fabrication of 8-Stripline BPM Device*

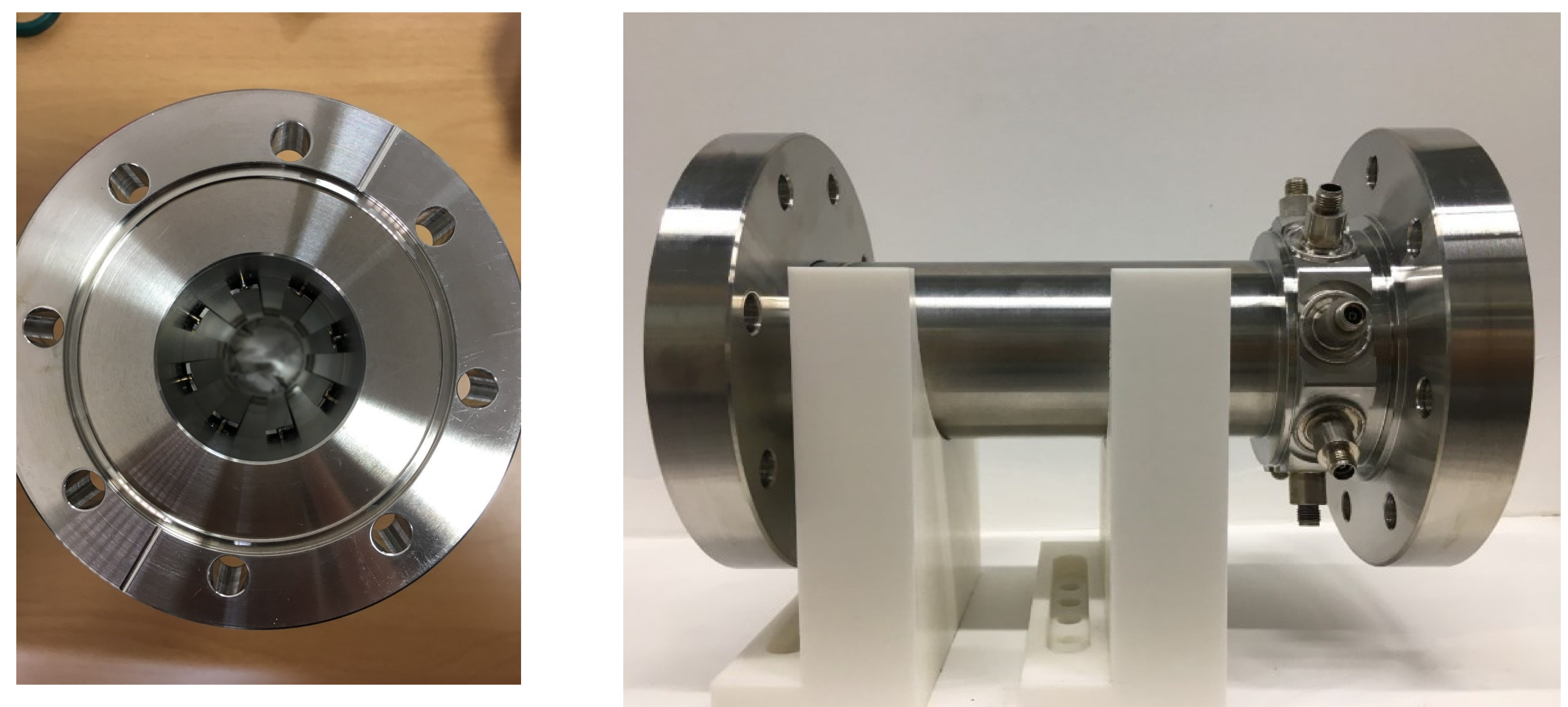

Fig.1. 8-Stripline BPM device fabricated with SUS316

• *Bench Test for Position and Skew Angle Resolution*

- ➢ Limitation of specification of test stand on mechanical resolution
- ➢ Position resolution: ~ 1 mm
- ➢ Skew angle resolution: 1 degree
- ➢ More tests including a resolution of quadrupole moment will be done with electron beam at Injector Test Facility of PAL

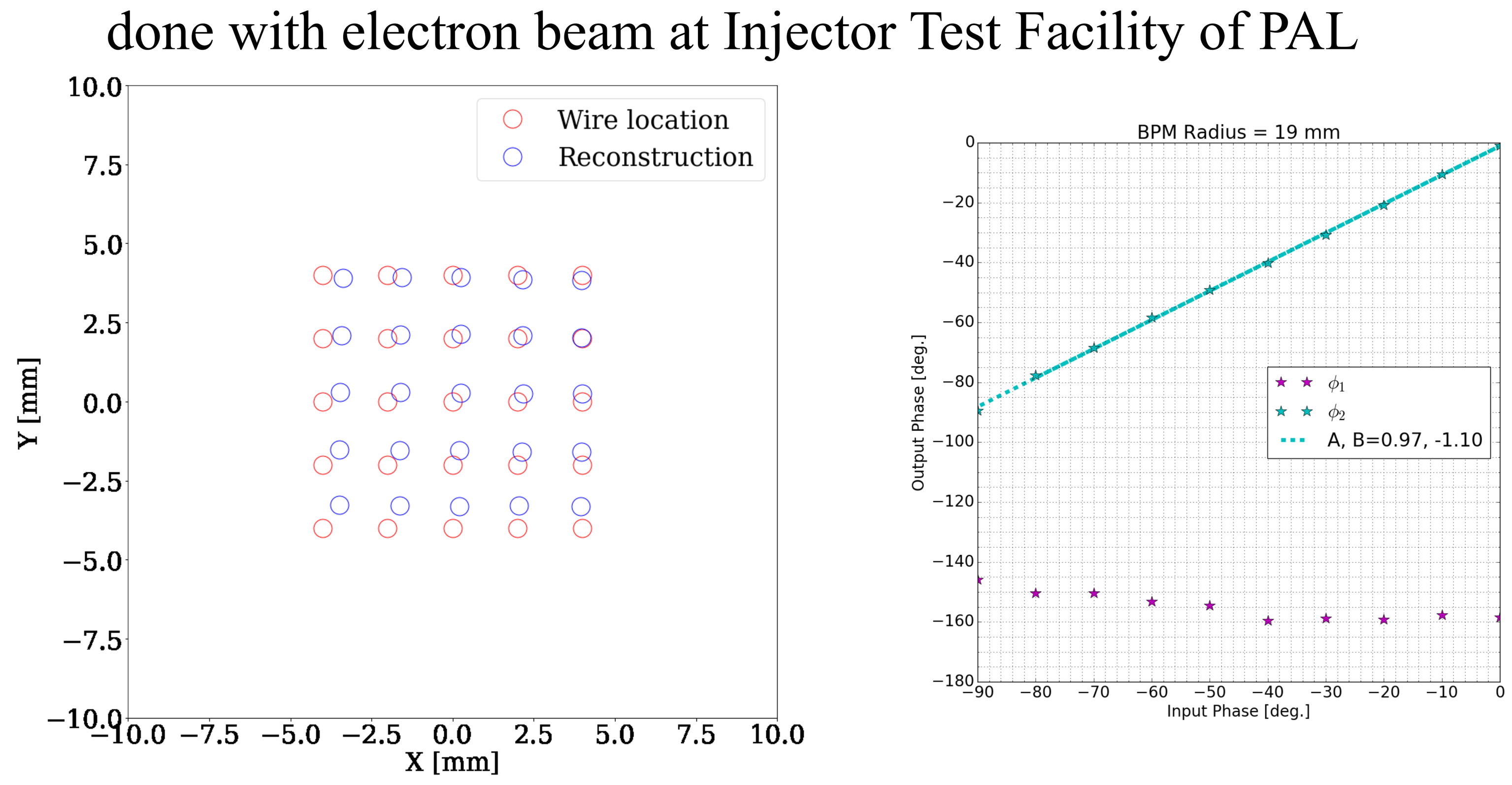

Fig.2. Test results for position and skew angle of beam

• *Experimental Preparation at Injector Test Facility of PAL*

- ➢ Injector Test Facility (ITF) of PAL consists of photocathode RF gun (2.856 GHz), solenoid magnets to compensate space-charge effects , a booster cavity (accelerates up to 70 MeV), deflecting cavity, dipole and quadrupole magnets
- ➢ The 8-stripline BPM is implemented behind of dipole magnet at the end of the line

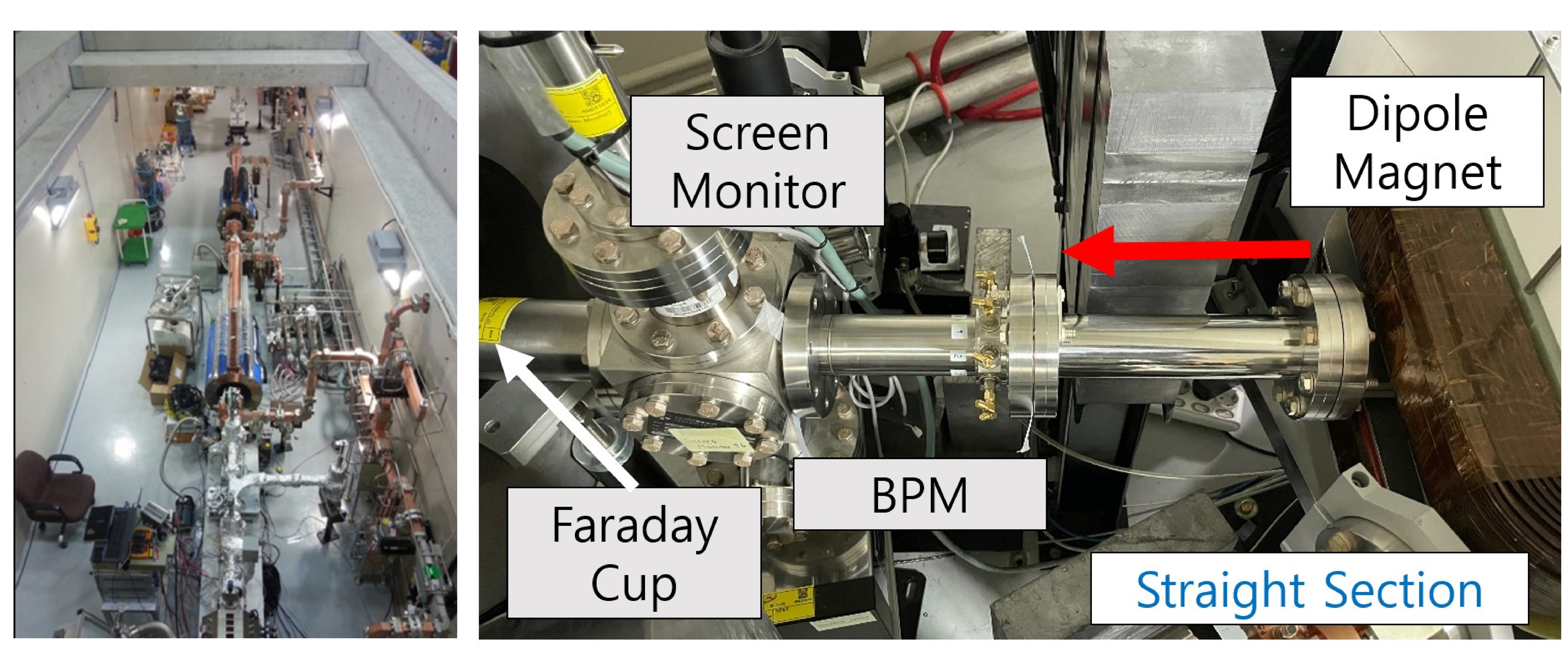

Fig.4. Beamline of PAL-ITF and the implemented 8-stripline BPM at the behind of dipole magnet