



Contribution ID: 100

Type: **Oral contribution**

Design and Optimization of a Heavy-Ion-Driven GeV Muon Beamline at HIAF

Tuesday, September 1, 2026 2:25 PM (25 minutes)

The large acceptance and high magnetic rigidity of the High Energy Fragment Separator (HFRS) at HIAF provide a promising opportunity to develop a tunable GeV-scale muon beam using a heavy-ion-driven production target. We present a stage-by-stage optimization of the existing HFRS optics using G4beamline simulations and a differential evolution algorithm. The objective function accounts for useful muon yield within the required momentum acceptance, pion decay along the beamline, particle contamination, phase-space quality, and downstream transmission. Particular attention is paid to avoiding local improvements that result in particle losses in subsequent beamline sections. The optimized performance is evaluated against the original HFRS optics, with the aim of maximizing the final usable muon flux while maintaining acceptable beam purity and transport quality. This work provides a systematic approach to adapting an existing high-rigidity fragment separator for high-energy muon production, purification, and transport.

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Session Classification: WG3+WG4 — Muon Sources & Beams

Track Classification: WG3: Accelerator Physics