Survey Control Network Maintenance and Coordinate Update Strategy at the RAON Heavy-Ion Accelerator

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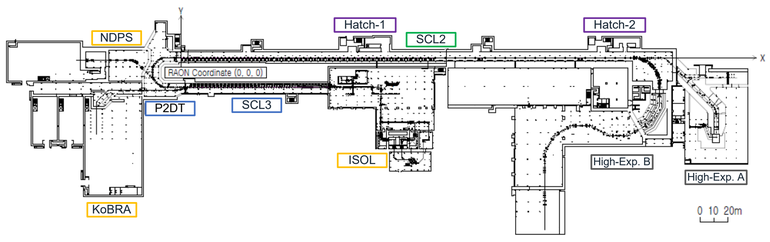
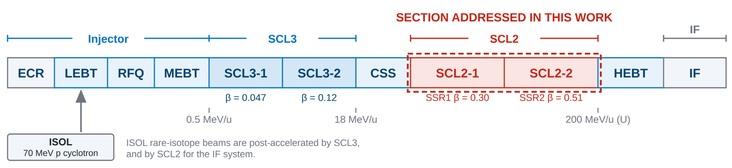
Scope This poster reviews the establishment, periodic monitoring, and current status of the survey control network at RAON. Component-level alignment assessment and realignment are presented in a companion poster (WEP05).

1 RAON at a Glance (Heavy-Ion Accelerator complex in Korea)

RAON is Korea's rare-isotope accelerator facility, operated by IRIS/IBS in Daejeon.
The total beamline length of RAON is approximately **1.3 km**, and the survey control network for its precision alignment consists of approximately **700 floor monuments** and **500 wall monuments**.





SCL3
Low-energy SC Linac: commissioned and used for beam operation since 2023.

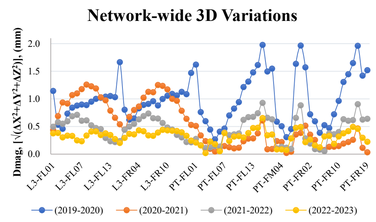
SCL2
High-energy SC Linac:
tunnel and cryogenic distribution exist,
but cryomodules remain under development and are not installed.

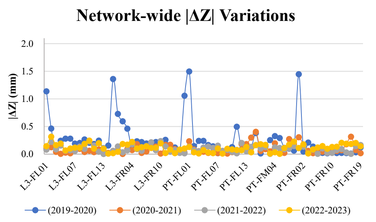
Operational areas
Beam operation for ISOL, SCL3, NDPS, KoBRA, etc.
→ controlled access during scheduled shutdown period for maintenance

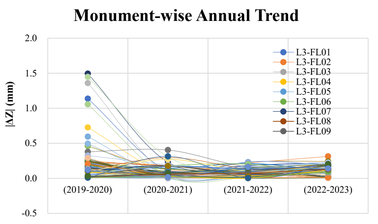
Why SCL2 now?
No beam operation and no installed cryomodules
→ flexible (free) access for repeated in-house trials.

2 Periodic Monitoring for Survey Control Network

SCL3 monitoring (2019–2023) shows early structural movement followed by a clear stabilization trend.







2019 (Initial Network Establishment)
- Monuments installed, starting in SCL3
- Survey control network established

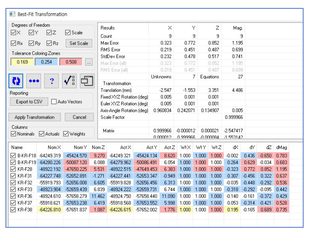
2020–2023 (Periodic Monitoring)
- Annual remeasurement; coordinate changes and long-term structural movement tracked

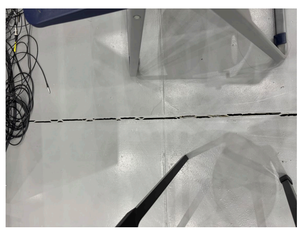
Observed Trend
- Structural movement gradually decreased >3 years after construction completion
- Clear trend toward stabilization
- But, approximately 0.2–0.3 mm epoch-to-epoch changes remain in parts of the network

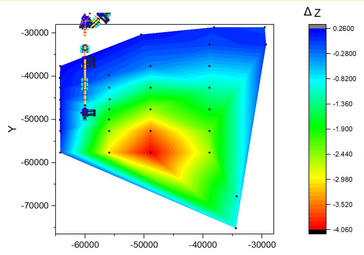
Maintenance Policy
- Network coordinates do not constitute a permanent as-built set
- Periodic re-observation reflects long-term structural and monument movement

3 Local Network Update in the Low-Energy Experimental Area during a Short Shutdown

Background
- 2025 Summer: beamline alignment check + reference marker installation for target positioning
- Coordinate changes in part of the control network → possible structural movement







Approach - local 3D update, two measurement schemes tested against the conventional method
- (A) Laser tracker only
- (B) Laser tracker + Total station, added because each station in (A) saw only nearby monuments, leaving the network weakly constrained globally
- Driver: network maintenance limited to a short shutdown between user beam experiments

	Time	Instrumentation	Uncertainty
Conventional (LT + Digital Leveling)	—	—	Reference
(A) Laser tracker only	Shorter ✔	Simplified ✔	Higher ✗
(B) Laser tracker + Total station	No gain ✗	No gain ✗	≈ (A) ✗

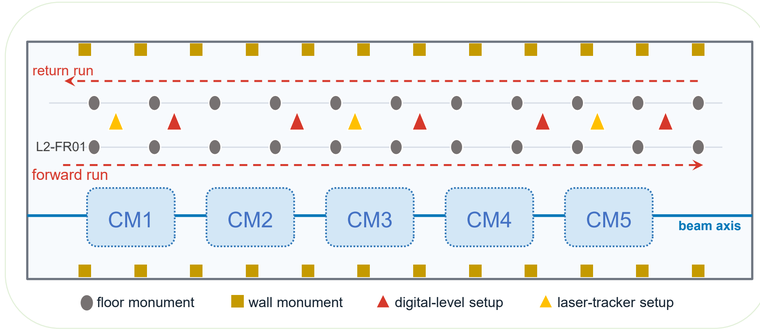
Findings
- (A): faster and simpler, but accuracy below the conventional LT+DL method
- (B): added total station recovered neither accuracy nor efficiency
- Reproducibility not verifiable from a single limited campaign

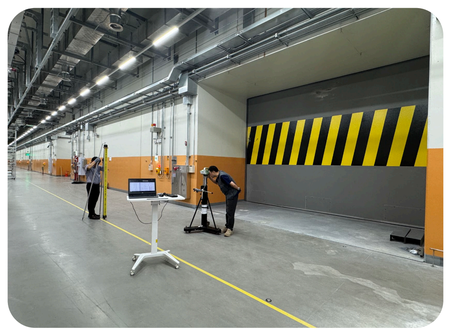
Implication
- Neither scheme replaces the conventional method
- Still needed: a fast method preserving accuracy, with redundancy for reproducibility
- Next step: trial of local network update by conventional method in the SCL2 area (free access), using in-house team and techniques

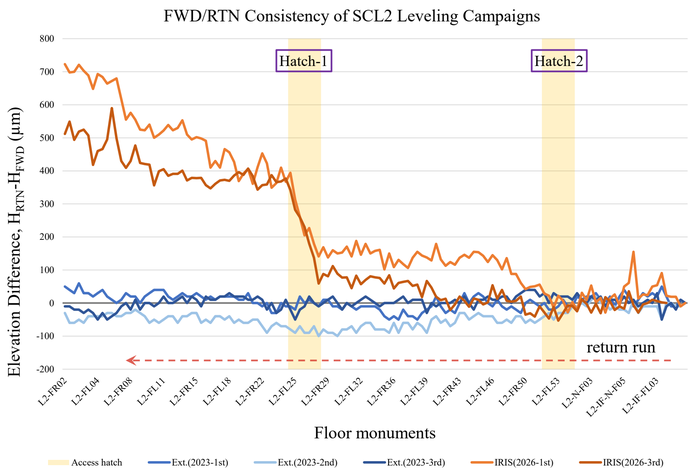
4 Trial of Local Network Update by Conventional Method

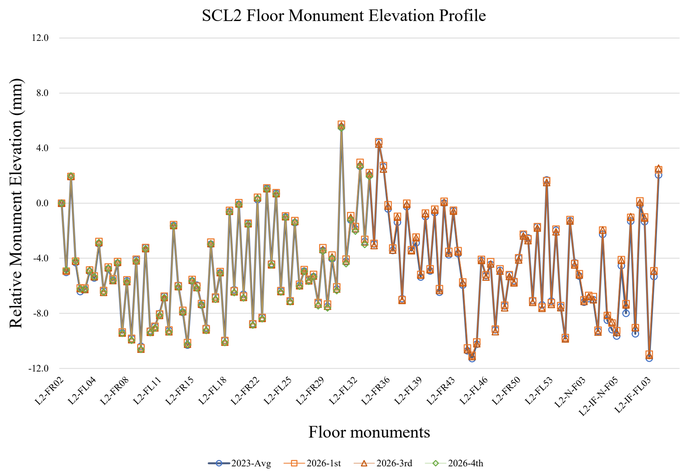
SCL2 as a Controlled Testbed
- Wall and floor monuments already installed
- Measured in several campaigns by a specialized external metrology contractor
- Earlier coordinates comparatively stable between campaigns
- In-house team can reproduce the procedure and quantify capability before issuing an update

LS15 digital leveling (Z) → **AT960LR** tracker (X,Y) → **USMN** global fit → **Release** validated (X,Y,Z)
Ongoing









2026 Digital Leveling Campaigns
- **1st campaign (May 2026)**
  Full SCL2, multi-day; step-like increase near the access hatch and overall elevation shift; closure error: 723 μm
- **LS15 calibration (Jun. 2026)**
  Calibrated by Leica Geosystems before subsequent campaigns
- **2nd campaign (Jul. 2026)**
  Multi-day, incomplete; same step-like increase near the access hatch
- **3rd campaign (Aug. 2026)**
  Full SCL2 in 2 days (FWD/RTN on separate days); same hatch-area increase and overall shift; closure error: 512 μm
- **4th campaign (Aug. 2026)**
  Half of SCL2 in 1 day, HVAC off (strong airflow); hatch-area increase remained, while overall shift was slightly reduced
- **Further study**
  Optimization of instrument setup locations to avoid the access hatch
  Vibration study in the tunnel to assess its influence on leveling measurement

- RTN-run elevation minus FWD-run elevation, in survey-route order (FWD runs left→right, RTN returns right→left).
- All three 2023 campaigns remain comparatively stable around zero. In 2026 the difference builds up from the turning point towards the start, reaching the closure errors
- The 2026 1st and 3rd campaigns show a reproducible step-like shift near the access hatch.
- The 2026 campaigns reproduce the 2023 elevation pattern, with an overall positive offset.

5 Summary

1. The RAON survey control network, established in 2019, was annually monitored and updated by a specialized external metrology contractor through 2023.
2. Changes in survey control network coordinates were detected in part of an area under beam operation, requiring a local coordinate update. A simplified in-house approach was tried under limited access time, but did not achieve the required accuracy and repeatability.
3. In SCL2, digital leveling was reproduced by the in-house team, but large FWD–RTN discrepancies/closure errors and a recurring step-like shift near the equipment access hatch are still unresolved.
4. Nevertheless, the 2026 elevation profiles closely reproduce the 2023 spatial pattern, confirming that the floor has not changed appreciably, which is what makes SCL2 a valid controlled testbed.
5. Further investigations will include an SCL2 tunnel vibration study and optimization of digital-level setup locations away from the access-hatch area.
6. Following digital leveling, laser-tracker measurements for horizontal coordinates are planned. The station layout will be optimized with SA MP beforehand, using an extended overlapping stationing so that adjacent stations share as many monuments as possible.
7. Collaboration with experienced accelerator alignment and metrology group is welcome.

RAON Alignment and Survey Group

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