OPERATION EXPERIENCE OF THE SUPERCONDUCTING LINAC AT RIBF

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Abstract
After beam commissioning of the RIKEN superconducting linac (SRILAC) based on 10 SC-QWRs (73 MHz, C.W.) in the end of FY2019, SRILAC got into a user service phase. Argon and vanadium beams were accelerated to the energy from 4.2 to 6.3 MeV/u. The beam power reached 1 kW. In this phase one of the most important issues for superconducting cavity is how to preserve the original performance, such as acceleration gradient, field emission level and so on. In this paper operation history and monitoring of FE for each cavity are reported.

1. Overview of RILAC Upgrade at RIKEN
- The RIKEN Heavy-Ion Linac (RILAC) upgrade was performed to allow it to further investigate super-heavy elements.
- The new element Nb was synthesized by bombarding a 208Pb target with an intense 70Zn+ beam with an energy of 5 MeV/u accelerated by the RILAC, which was upgraded by adding a booster linac comprising six DTLS.
- The Superconducting RILAC (SRILAC) was introduced by replacing the latter 4 DTLS of the booster linac so that ions (A/q=6) are accelerated to 6.5 MeV/u. (14 MV upgrade)
  - Construction:2016–2019
  - First cool down:October 2019
  - First beam acceleration test: 40A13+ 6.2 MeV/u in January 2020

2. Superconducting Linac Booster SRILAC
- Three Cryomodules host 10 SC-QWRs.
- 4.5 K, 73 MHz, CW, independent isolation vacuum
  *How to preserve the cavity performance?*
- All metal angle valves (VAT) are installed at the both end of CMs.
- The number of opening/closing times is being recorded.
- RT Quadrupole magnets and non-destructive diagnostics are installed in the MEBT (installed utilizing a local clean booth).
- Beam losses are being minimized keeping vacuum pressure of MEBT (V0, V1, V2, V3) below 1x10^-7 Pa.
- Three-stage differential pumping systems (DPS) are introduced to prevent gas flow from existing RT section.
- Non-destructive beam diagnostics have been adopted (BEPM).

3. Operation History (2020 - 2021)
- Average beam power reached 1 kW.
- 51+13+ beams with an energy from 4.2 MeV/u to 6.3 MeV/u were delivered.
- FE measurements were made after cool-down(1-48).
- In October 2020, a vacuum leakage from the RF window of the number 6 power coupler occurred under user operation.

4. Field Emission
- FE measurement was made for the fist time before opening the gate-valves.
- Field emission was observed for most of all cavities.
- 1: Vacuum leakage of SC05 PC did not give serious damage to SC06. 07, 08.
- 5: There found no significant increase of FE levels after beam operation.
- 6: After vacuum leakage of SC06 coupler FE levels of CM2 increased.
- 8: SC05, SC06 cavities were successfully recovered.
- FE levels became worse.
  SC06 quenches at 1.2 MV gap voltage.
  SC07 had sudden drop of gap voltage at 450 kV.
  Cleaning of cavities is needed for recovery of performance.
  DPS looks work well. There are no change in FE of SC10.

5. Summary
- RIKEN Superconducting Linac (SRILAC) got into the user service phase.
- Beam loss was being minimized so as not to get serious degradation of SC-QWRs.
- Beam delivery did not give serious damage to SC-QWRs.
- Vacuum leakage of SC06 PC brought significant degradation to CM2.
- Beam service will be continued monitoring FE of SC-QWRs.

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