Superconducting Linac Turn On Strategy and Activities

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Overall scope and strategy

- **Prepare all cavities, cryomodules and related systems for beam operation**
- **Priorities**
  - Make sure that minimal performance is GUARANTEED
  - Make sure that reliable, extended operation is GUARANTEED
  - Absolutely prevent damage to components, especially internal to cryomodules and vacuum systems
- **Strategy**
  - Perform thorough pre-operational checkout tests ahead of cooldown and ahead of high power operation
  - Understand cavity and component behavior ahead of time and proceed cautiously
    - Interlocks are for things we don't understand or are too fast to react to, not for testing system performance

Cooldown and testing plans

- All cryomodule systems and signals will have been checked out all the way through the controls system before cooldown
  - Repairing things after cooldown require long and costly procedures
- Thorough RF calibrations pay off in beam time
  - Waveguide couplers and internal cables
- Cooldown will occur in batches (6 module initially, then 3 or 6 depending on availability)
  - For 2.1 K operation batches are necessary (minimum heat load, necessity to cycle to atmospheric operation for U-tube insertion)
  - For 4.2 K operation, cryomodules could be cooled one at a time. Operating at 4.2 K may provide lower operating costs for extended periods of testing

Cold, low power testing

- Verify all vacuum, RF, arc, temperature, level etc. interlocks before they are needed.
- Measure cavities fundamental frequencies and tuner operability
- Perform final RF calibrations and verify power level consistency from all RF ports (Measure Q_{ext} for: Fundamental Power Coupler, field probe, HOM filters)
- Establish operating and administrative limits on power and fields achievable in the cavities during initial turn on and later for extended operation.

High power operation

- Follow the specified coupler processing/cavity turn on sequence
  - Short pulses, low repetition rates: monitor vacuum levels, do not push power too soon
    - Irreversible damage to couplers and/or cavities may occur
  - Increase pulse lengths, power levels, fields, repetition rates and add RF control as systems allow
    - Monitor vacuum, temperatures, power levels from all ports
  - React to interlocks by stopping operation and understanding the reasons for interlock trips. DO NOT blindly reset interlocks.
- Find appropriate operating conditions (nominal fields first) and optimize operating parameters for extended tests

Set up vs. extended operation

- If the 4.2 K experience in setting up minimal parameters in M03 during the 4.2 K test holds, then it would take a relatively short time (few shifts) to process and set up a set of cavities (as many as are available for testing)
- Teams of cavity experts, LLRF experts and Accelerator Physics/Operations observers/trainees will set up cavities.
- Setting up will occur on evening (mostly) and night (if needed) shifts during the week, so that if system malfunctions are detected, they can be corrected during the following day during access to the tunnel.
- If no major problems are encountered, set up may require only one or two evening shift work per set of cryomodules
- Extended operation of the cryomodules already set up can be performed by Operations crews during the weekend, with expert personnel on call

Proposed teams

- Processing/cavity experts
  - Kang, Deibele, Vassioutchenko, Campisi……
- LLRF experts
  - Champion, Ma, Piller, Crofford……
- Accelerator Physics
  - Jeon, Galambos, Henderson, Cousineau, Chu, …...
- Operations
  - Chief Operators
- Support from and feedback to:
  - Installation
  - Cryogenics
  - High power RF
  - Modulator
  - Vacuum
  - Operations

Responsibilities

- Processing/Cavity experts
  - Determine appropriate operating parameters within safety margins and supervise additional technical personnel to maintain parameters within those limits
  - Follow cooldown, low power measurements. Acquire, review documentation and maintain logbook information about the cavities and processes
- LLRF experts
  - Provide support in setting up RF systems for cavity measurements and for LLRF control parameters
  - Follow instructions of cavity expert and help collect and interpret data
- Accelerator Physics
  - Acquire expertise about cavity performance and limitations with an eye toward future beam operation

Cryomodule test duration: planned vs. actual

M03 run at 4.2 K

Coupler processing	1 day/cavity	0.05 days
Learning system operation	1 day	0.5 days
Learning stable operation parameters	3 days	0.5 days
Two cavity operation (times 3)	1 day	0.1 days
Three cavity operation	3 days	0.1 days
Exploring limits	3 days	1 day
Miscellaneous issues	1 week	1 day

Planning for SC linac testing

- After installation and pre-operational checkout the following activities are planned, with the corresponding allocated time (sets of cryomodules can be cooled down simultaneously):
  - Cooldown to 4.2 K and 2.1 K: 3 days/set
  - Low power testing and calibrations 3 days/CM
  - High power testing 7 days/CM

Testing timeline

- Dec 15, 04 — CM M3-M8 ready for testing
- Jan 15, 05 — CM M9-M11 and H1-H3 ready for testing
- Jan 31, 05 — complete testing on M3-M11 and preliminary tests on H1-H3
- Feb 1, 05 — PPS reconfiguration. No high power tests possible. Concentrate on installation and low power tests
- Mar 1, 05 — Resume high power testing, H4-H6 ready for testing. 3 wks testing.
- Apr 1, 05 — H7-H9 ready for testing. 3 wks testing.
- Apr 15, 05 — M1-M2 ready for testing. 2 wks testing
- May 1, 05 — H10-H12 ready for testing. 3 wks testing
- June 1, 05 — All CM tested