Gradient Team Plans

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Gradient Team Members

- Team members are:
  - Rama Bachimanchi, Ken Baggett, Rhonda Barbosa, Jay Benesch, Mike Drury, Bob Legg, Mike McCaughan, Clyde Mounts, Robert Norton and Tom Powers
- Auxiliaries:

  Trent Allison, Krystina Serafini
- Stakeholders
  - Jonathan Creel, Arne Freyberger, Andrew Hutton, Andrew Kimber, Will Oren, Tony Reilly

- The team has solicited help from experts on the various aspects of the problem.

Gradient Team Charter

"The CEBAF superconducting cavities and associated RF systems must provide 1.1 GeV per linac with a total trip rate less than 5 trips/hour while operating within the cooling capacities of the CHL1 and CHL2. At the time the Team is being chartered, these specifications are barely being met, and previous operating experience shows that trip rates increase with time. This creates an urgent need to get the best possible performance out of the installed systems, now and for the future.

The goal of the Team is to evaluate every aspect of the cryomodule-RF-cryogenics system and optimize the system parameters to maximize the available gradient and minimize the trip rate at the nominal energy of 12 GeV."

Overview of Prioritization Method Used

- Each expert on the team contributed to the set of issues that need to be evaluated to optimize the accelerator gradient "system".
  - Over 70 issues identified

- Needed a way to organize the list into prioritized plans of action.
  - Wanted to understand:
    - Issues grouped into Themes
    - Goals for each theme
    - Objectives (costs and benefits) assigned and evaluated

Grouping of Issues

- Identified Themes for Improvement:
  - Gradient
  - Trip Rate
  - Recovery Time
  - Cryo Stability
  - Maintenance
- The team worked to develop potential solutions for each theme
- Two stages of rankings used for prioritization:
  - Costs and Benefits - Traditional approach using cost, labor, risks, and rewards
  - Weights - Using the Analytic Hierarchy Process (AHP)
  - https://jlabdoc.jlab.org/docushare/dsweb/View/Collection-28424

Plans: RF

- C50 Super-MOPS ™ – prototype this summer, full production and installation after test
  - Recover gradient from C50 modules presently limited by heater power
- C100 individual electric heater modifications - prototype this summer, full production and installation after test
  - Precise and rapid resistive heat response to cavity RF transitions
  - Prevents helium bath perturbations that increases recovery times
- Optimize Klystron and 2.5W amp distribution in C20 and C50s
  - Leave no "gradient on the table"
- Training for C100 operation, recovery and diagnostics
  - "Every operator a Clyde"

Plans: LLRF

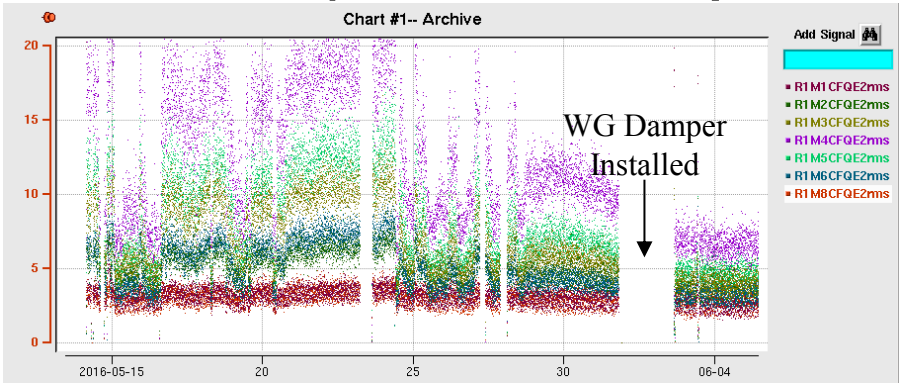
- Continued LLRF Improvements
  - Prevent full string trips – Done
  - Improved large microphonic detune and quench detection and handling algorithms
  - Integrate fast individual heaters to improve cavity cryo stability and reduce recovery times substantially – prototype this summer
  - Piezoelectric tuners to reduce mechanical tuner actions - prototype this summer
  - C100 Fault Logger/Viewer – ready in October, *really*
    - Improved fault identification
    - Metric for "goodness" of firmware versions
  - Additional waveforms and collection modes

Plans: SRF

- Drury Plans for this summer
  - 1L11, 2L25 and 2L26 insulating vacuums checked/repaired
  - 1L12 cryomodule removal and C50-12 installation/commissioning
  - 1L08-40 Waveguide Vacuum
  - 2L09-1, 1L22-7 Tuner Checkout
  - 2L08 Warm window and IR detector replacement
  - All modules above will need varying levels of SRF HPRF checkout
- C100 He Processing – prototype this summer
  - 1L23 (C100 Test Bed)
    - Gas Desorption Cryocycle w RGA Monitoring
    - Investigate procedural changes to mitigate potential performance in C100 cavities

Plans: SRF (cont.)

- C100 Microphonics Mitigation – Prototypes this summer
  - Waveguide motion dampers on 1L22 (C100-3)



1L22 Cavity RMS Frequency Error

  - SRF Microphonics Team formed to address problem
    - Production quality waveguide braces/dampers and tuner dampers will be installed in 2L23 and 2L24 so that they can be optimized using low power measurements.
- Field Emission – Instrumentation in place by mid-July
  - SSG will install the ion chambers in tunnel to measure radiation vs C100 gradient

Plans: Software

- Cryogenic heat management for Cryomodules – Status this session
  - Specification detailing how heat should be managed in cryomodules passed to Cryogenic Heat Load Management Team for inclusion in their overall plan.
  - Only ask for desired results; leave the implementation details to Cryogenics so heat management is an integrated plan.

Plans: OPS

- Raise C20/50 drive highs back to known supported gradients by the cavities - this SSAD
  - This pushes back against derating done too aggressively and places cavities back at drive highs/max gradients.
- Characterize and Optimize C20/50 RF cavities – FY '17
  - This ATLis will clearly identify the limitations of those cavities which have been derated for nebulous/unclear reasons.

Plans: Future

- Develop algorithm to optimize gradient setpoint for C20, 50 and 100's
  - Based on trips, gradient and field emission (?)
- Mechanically damp microphonics on cryomodules
  - Maximum GSETs for Generator Driven Resonance (GDR) should be the same as for Self Excited Loop (SEL).
- Develop Q0 and total heat load measurement technique controlling heaters and Valves, and monitoring liquid levels and pressure
  - Fold back to LEM for heat management.
- Develop complete slice simulation of acceleration system
  - LLRF Model (FCC, Firmware, HPA, Coupler, cavity and probe) to allow firmware to be tested – FY '17 ?

Issues and Open Questions

- Less than Complete Understanding of C100 behaviors
  - All Fault modes are not yet well understood
  - Cavities quench after hours of stable operation at a given gradient
- How will field emission radiation effect linacs long term?
  - Reliability of equipment and materials will be effected
  - Vacuum deterioration and valve closures?
- Even with 10 new klystrons on order, only have 2.5% spares
  - 25 to 30 now in system have mod anode current (out of spec)
- What is the best gradient payoff for our procurement dollars?
  - Mechanical Microphonics dampeners? Unproven in all C100s
  - C75? Expensive, still in development
  - C100 Individual Electric heaters? Limited gradient gain