Dynamic temperature mapping of Nb$_3$Sn cavities provides new insight into quench:

1. First quench appears to be multipacting
2. Multiple quench sites present
3. Temperature jumps present ‘all over’ cavity

Niobium-3 Tin (Nb$_3$Sn) is the most promising alternative material to niobium for SRF cavities. Current Nb$_3$Sn cavities reach quality factors of $2 \cdot 10^{10}$ at 4.2 K, but are limited to 17-24 MV/m. Cornell University has recently developed a high-speed temperature mapping system that can examine cavity quench mechanisms in never before achieved ways. This provides a new window into the quench mechanism.

New electronics allow temperature maps to be taken at 50 kHz. This provides sufficient time resolution to record cavity quench.

Videos of the first quench show non-localized heating near the equator. This heating initiates across the entire band rather than spreading. This is potentially a multipacting quench.

Multipacting Quench:

- First quench appears to be multipacting
- Multiple quench sites present
- Temperature jumps present ‘all over’ cavity

Temperature ‘jumps’ were seen at many locations on the cavity.

Temperature Jumps

<table>
<thead>
<tr>
<th>Temperature vs Surface Fields</th>
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<tbody>
<tr>
<td>Temperature Jumps</td>
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<tr>
<td>Peak RF Field (mT)</td>
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</table>

Left: Previous work by D.L. Hall et al. found temperature jumps at the quench site of Nb$_3$Sn Cavities. Close to the quench field the temperature suddenly increased in a jump. While lowering the field inverse jumps occurred with hysteresis.

Top right: similar jumps were observed using dynamic temperature mapping.

Bottom right: These jumps were observed on 59 sensors. Not all jumps are independent—some are time-correlated and may be temperature spread. However, some jumps appear to spread up and down more than sideways.

A second localized quench site appears after the first quench. Quenches ‘ping-pong’ between sites and eventually settle on the second site.

Multiple Quench Sites

<table>
<thead>
<tr>
<th>Temperature as Cavity Energy Rises</th>
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<tr>
<td>Temperature Jump</td>
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The cavity is allowed to quench for 20 s and the temperature is recorded. The average temperature shows two quench sites.

The time data reveals that the quench site moves. Possibly from the processing of a multipactor.

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