Expected depletion voltages for barrel and forward modules, at the upper bound of expected fluence and an access scenario of 2 days at 20 °C and 14 days at 17 °C every year (ref: Inner detector TDR)

2 x 10^{14} n_{eq}/cm^2
Thermal runaway measurement

- Barrel module

- With proton-irradiated detectors at $3 \times 10^{14} \text{ p/cm}^2$

- Kapton hybrid with Be bridges

- The coolant temperature was at -10 °C due to the capability of cooling unit

- At the SCT operation of -15 °C and the runaway point will be extended near to the 500 volts
Thermal module test with irradiated sensors

$3 \times 10^{14}$ protons/cm$^2$

Temperature at point 1 [°C]

- $T_{cool} = -10°C$
- $+10.7°C$
- $+0.8°C$
- $-2.2°C$

Voltage on sensors
Thermo-distortion measurement

- Thermal runaway module with irradiated detectors, and Kapton hybrid with Be bridges

- Although the module distortion was elastic, there was a rather large distortion, 36 fringes, i.e., 9 microns, over 20% change of the power in the hybrid

- The above distortion was plausibly caused by the (rotation-)offset of the top and the bottom hybrids
60% → 80% x 4.7 W hybrid (coolant -16°C)
Kapton hybrid development

- Low-mass solution by replacing BeO ceramics with Be (or Carbon material)

- First full-size prototype was fabricated

- Testing of the hybrid and the ABCD chips are being underway
<table>
<thead>
<tr>
<th>Chip</th>
<th>Gain [mV/fC]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>73.9</td>
</tr>
<tr>
<td>2</td>
<td>77.1</td>
</tr>
</tbody>
</table>

$\text{y} = 0.00029887 + 0.013525x \quad R = 0.99973$

$\text{y} = -0.003695 + 0.012968x \quad R = 0.9997$