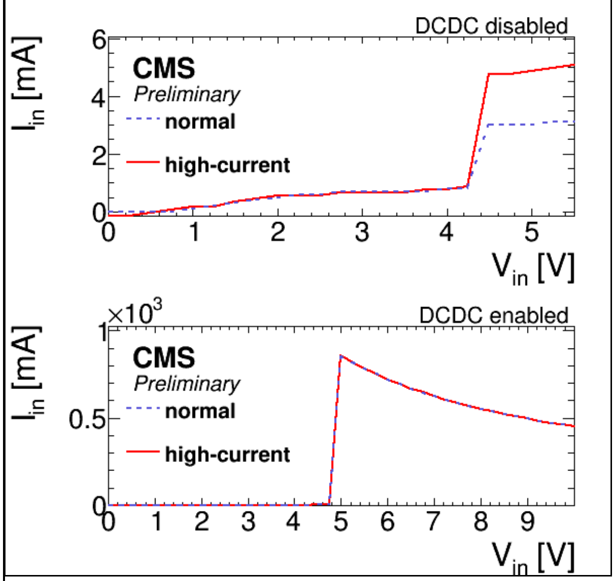
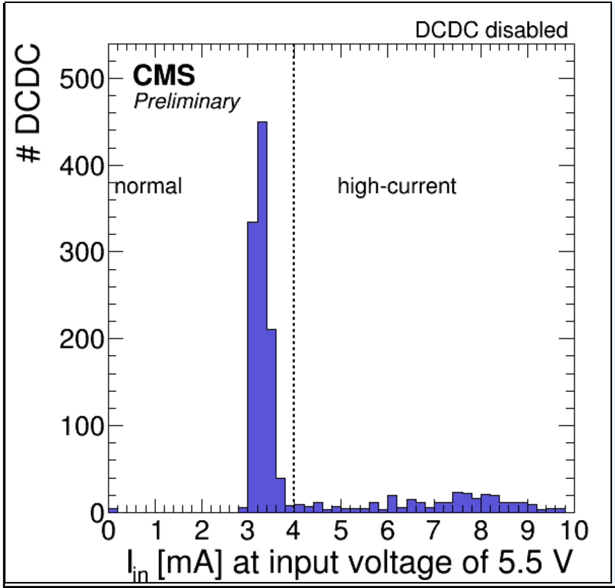
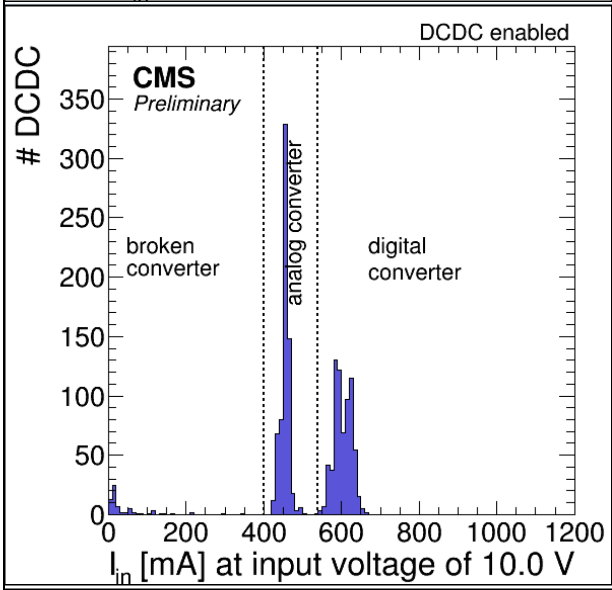
In October 2017 DCDC converters in the CMS Pixel started failing. At the end of 2017 data taking 5% of the DCDCs did not provide power to the modules. In the YETS the Pixel was extracted and the DCDC converters were examined. During the YETS examination 30% of the DCDC where found to have a higher current than expected. The preliminary findings were reported at the ACES conference After this report additional findings suggest a failure mechanism that is only present in a radiated DCDC ASIC. In the disabled state one of the radiated transistors has a leakage current, which is amplified by the circuit and not drained. This stress can then either break the DCDC ASIC or make it a high current DCDC. In the enabled state the current is drained.

This material shows the results of the investigations during the YETS. First the characterization of the DCDC is shown and then the distribution of the DCDCs in the detector. The Pixel DCDC are used to provide the low voltage to the analog and the digital part of the modules, therefore the DCDCs have different output voltages 2.4-2.5V for the analog and 3.0 - 3.3V for the digital voltage.

Classification based on I-V curve measurement

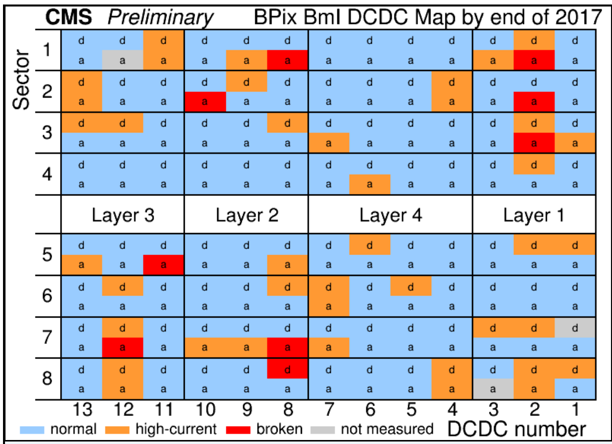
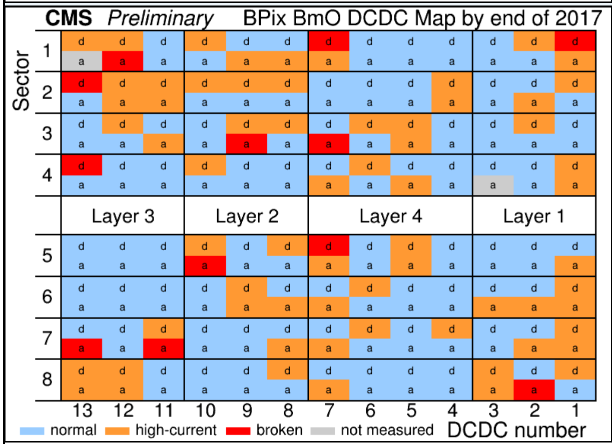
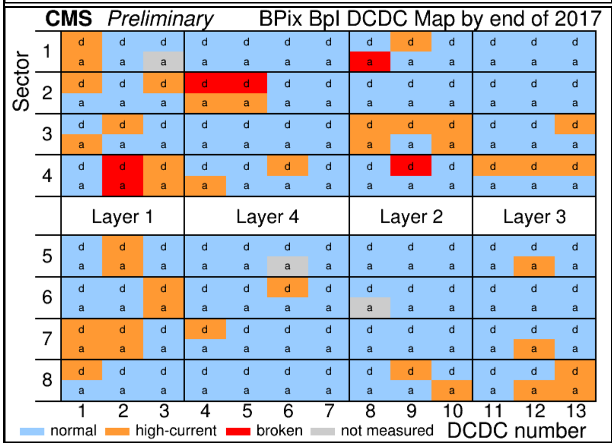
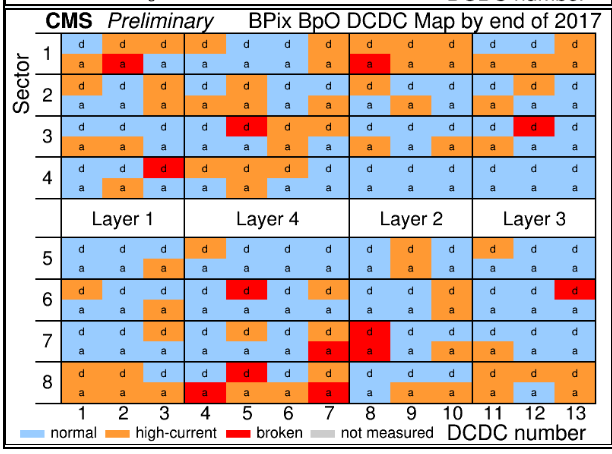
Figure in png format	other formats	Description
	.eps .pdf	Two tests are performed to classify the DCDC converters as either working normally, having high-current or being broken. The first test is the disable test, where the DCDC converter is disabled and the input voltage is scanned from 0 V to 5.5 V (upper plot). The second test is the enable test, where the DCDC is enabled and a load of 1.5A is connected. The input voltage is then scanned from 0 V to 10 V. There is a difference in the behavior between a high-current DCDC and a normal working DCDC in the disabled test, while the converters show the same behavior in the enable test. A DCDC converter is considered as having high-current, when the input current at 5.5V is larger than 4mA. The behavior of a broken DCDC converter is not shown. A DCDC converter is considered broken, when the input current at 10V in the enabled test is less than 400mA.
	.eps .pdf	The input current of the DCDC converters that were extracted from the detector after the 2017 run. The current was measured at an input voltage of 5.5V while the DCDC is disabled. DCDCs with an input current less than 4mA are considered as working normally. DCDCs with an input current greater than 4mA are considered as high-current.

		
	.eps .pdf	The input current of the DCDC converters that were extracted from the detector after the 2017 run. The current was measured at an input voltage of 10V while the DCDC is enabled. A clear separation between the broken DCDC converters (input current less than 400 mA), the working analog converters (input current between 400 and 540 mA) and the working digital converters (input current greater 540 mA) is observed. While a DCDC converter is enabled no difference between the normal behavior and the high-current behavior is visible in this distribution.

Maps with DCDC classifications after run 2017

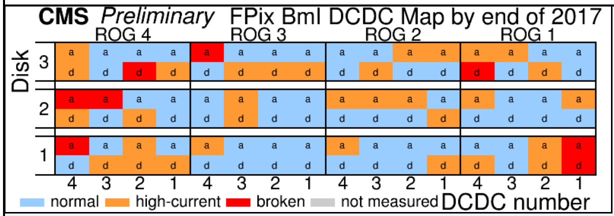
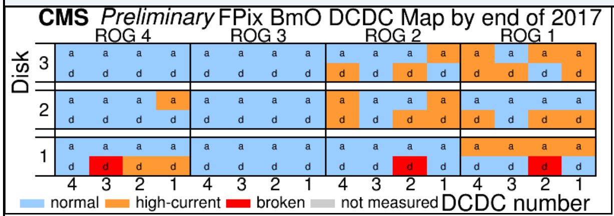
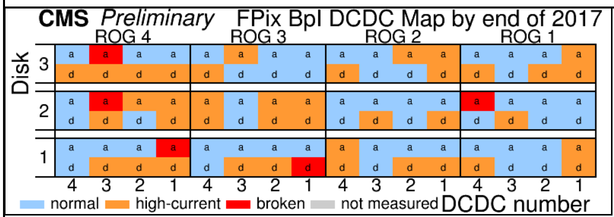
Pixel Barrel

<table>
<tr><th>Figure in png format</th><th>other formats</th><th>Description</th></tr>
<tr><td>
<table>
<tr><th>Quadrant</th><th>normal behavior</th><th>high-current</th><th>broken</th><th>not measured</th></tr>
<tr><td>BPix BmI</td><td>155</td><td>41</td><td>9</td><td>3</td></tr>
<tr><td>BPix BmO</td><td>129</td><td>65</td><td>12</td><td>2</td></tr>
<tr><td>BPix BpI</td><td>159</td><td>40</td><td>6</td><td>3</td></tr>
<tr><td>BPix BpO</td><td>126</td><td>69</td><td>13</td><td>0</td></tr>
<tr><td>BPix All</td><td>569</td><td>215</td><td>40</td><td>8</td></tr>
</table>
</td><td>.pdf</td><td>Summary of the characterization of the 2017 DCDC converters for the barrel pixel detector. The number of normal behaving, high-current and broken DCDC converters is given for each half-cylinder separately and for the total barrel pixel detector. The defects of DCDCs are randomly distributed.</td></tr>
</table>

	.eps .pdf	Overview of the DCDC converter classification after the 2017 run for the half-cylinder in minus direction wrt. the beam on the inner side (BmI) of the barrel pixel detector. The coordinates correspond to the position of the DCDC converter in the detector during the run. Analog DCDC converter are marked with an a , digital DCDC converter are marked with a d . The defects of DCDCs are randomly distributed.
	.eps .pdf	Overview of the DCDC converter classification after the 2017 run for the half-cylinder in minus direction wrt. the beam on the outer side (BmO) of the barrel pixel detector. The coordinates correspond to the position of the DCDC converter in the detector during the run. Analog DCDC converter are marked with an a , digital DCDC converter are marked with a d . The defects of DCDCs are randomly distributed.
	.eps .pdf	Overview of the DCDC converter classification after the 2017 run for the half-cylinder in plus direction wrt. the beam on the inner side (BpI) of the barrel pixel detector. The coordinates correspond to the position of the DCDC converter in the detector during the run. Analog DCDC converter are marked with an a , digital DCDC converter are marked with a d . The defects of DCDCs are randomly distributed.
	.eps .pdf	Overview of the DCDC converter classification after the 2017 run for the half-cylinder in plus direction wrt. the beam on the outer side (BpO) of the barrel pixel detector. The coordinates correspond to the position of the DCDC converter in the supply tube in the detector. Analog DCDC converter are marked with an a , digital DCDC converter are marked with a d . The defects of DCDCs are randomly distributed.

Pixel Forward

Figure in png format	other	Description

<table>
<tr><th></th><th>formats</th><th></th></tr>
<tr><td>
<table>
<tr><th>Quadrant</th><th>normal behavior</th><th>high-current</th><th>broken</th><th>not measured</th></tr>
<tr><td>FPix BmI</td><td>56</td><td>32</td><td>8</td><td>0</td></tr>
<tr><td>FPix BmO</td><td>69</td><td>24</td><td>3</td><td>0</td></tr>
<tr><td>FPix BpI</td><td>52</td><td>39</td><td>5</td><td>0</td></tr>
<tr><td>FPix BpO</td><td>64</td><td>23</td><td>9</td><td>0</td></tr>
<tr><td>FPix All</td><td>241</td><td>118</td><td>25</td><td>0</td></tr>
</table>
</td><td>.pdf</td><td>Summary of the characterization of the 2017 DCDC converters for the forward pixel detector. The number of normal behaving, high-current and broken DCDC converters is given for each half-cylinder separately and for the total forward pixel detector. The defects of DCDCs are randomly distributed.</td></tr>
<tr><td>
</td><td>.eps .pdf</td><td>Overview of the DCDC converter classification after the 2017 run for the half-cylinder in minus direction wrt. the beam on the inner side (BmI) of the forward pixel detector. The converters are grouped into readout groups (ROG) and the coordinates correspond to the position in the detector. Analog DCDC converter are marked with an a , digital DCDC converter are marked with a d . The defects of DCDCs are randomly distributed.</td></tr>
<tr><td>
</td><td>.eps .pdf</td><td>Overview of the DCDC converter classification after the 2017 run for the half-cylinder in minus direction wrt. the beam on the outer side (BmO) of the forward pixel detector. The coordinates correspond to the position of the DCDC converter in the detector during the run. Analog DCDC converter are marked with an a , digital DCDC converter are marked with a d . The defects of DCDCs are randomly distributed.</td></tr>
<tr><td>
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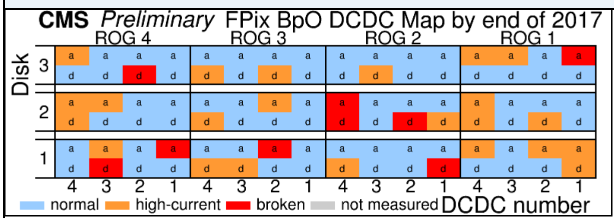
<tr><td>
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-- BenediktVormwald - 2018-08-17

This topic: CMSPublic > CMSPixelOperationPlots2018DCDCCharacterization
Topic revision: r14 - 2020-02-10 - BenediktVormwald