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Effects of the Digital Jumper Cable on Silicon Sensors

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Abstract

The observed effects of the digital jumper cable on the level of noise read out from the sensor as well as some tests and possible solutions will be outlined.

1. *Introduction*

Through the testing of complete modules, it has become apparent that the digital jumper cables do contribute, at times, a significant amount of noise to the overall readout of the chip. Usually these effects can be seen on the readout of chip eight on a ten chip hybrid as this chip lies most closely to the digital jumper cable. See figure 1.1.

Outlined in the following sections will be definite ways to identify and troubleshoot the effects of the cable on the sensor readout. The manifestation of this effect will be described along with some tests to run in order to make a definitive identification of the source of the noise. Some possible solutions to the noise problem will then be outlined as well.

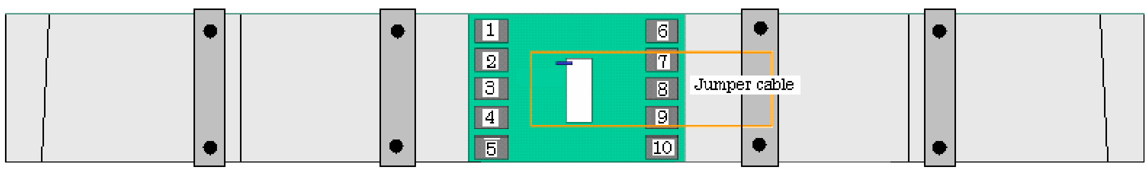

Fig. 1.1. Layout of a 20x20 module

2. *Observable Effects*

Though it may not be immediately apparent, there are some definite indications that an area of unusual noise is due to extra signal picked up from the digital jumper cable. Several of these indications correspond to other possible problems with the sensors, however, so it is necessary to run tests in order to make a positive identification of the source of the problem, and several of these effects should be found in conjunction before the digital jumper cable is considered the prime suspect of the noise problem.

There are several things to keep in mind when considering the digital jumper cable as the source of a readout noise problem. The effects of the cable are highly localized, so they would only be observed in the area where the digital jumper cable runs directly over the readout chip and sensor. This usually corresponds to chip eight on a ten chip hybrid. The effects on the level of noise usually correspond to an area of high noise and then an area of decreased noise. See figure 2.1. This effect cannot be isolated by masking or other sources. Biasing the module should not completely fix the problem. It should also be noted that the effect on the readout noise is inversely proportional to distance, it increases with decreased distance from the surface of the chip or sensor.

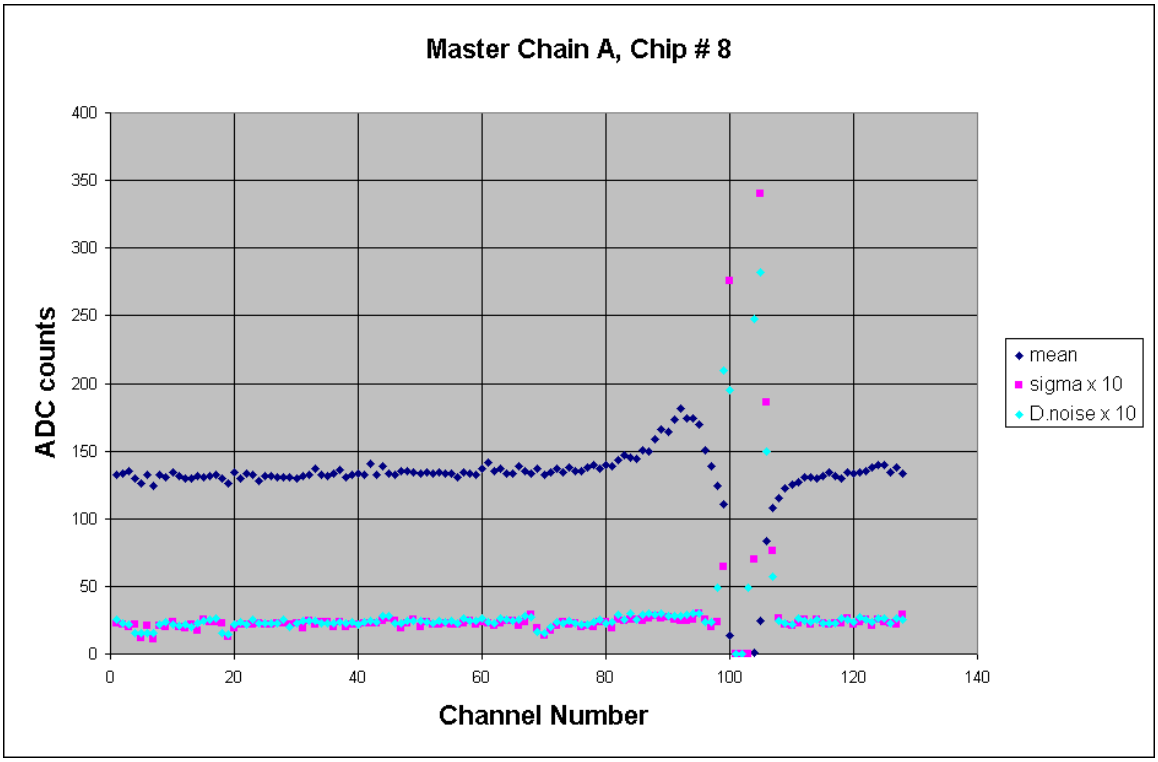

Fig. 2.1. Chip 8 on Hybrid 12 with an area of effected noise from a digital jumper cable

3. *Tests*

There are several tests that can be run once the digital jumper cable has been determined to be a possible cause of noise. These tests should conclusively show whether or not the jumper cable is the source of the problem. It is necessary to run these tests as many of the manifestations of a digital jumper cable problem correspond to other problems on the sensor or chip as well.

There are three main tests to be run. One is to see the relationship between the distance between the surface of the sensor and the cable itself and the noise level. The data collection mode can also be changed from *cal inject mode* to *data mode*. The value of the *pipeline* can also be changed to a different value than the *calpipe*. All of these tests are made to exploit the nature of the problem and will be explained further below.

A major factor in a noisy digital cable problem is distance to the surface of the sensor. By varying the distance of the cable to the surface of the sensor, fluctuations in the noise level should occur. The cable needs to be pretty close to the sensor in order to affect the readout noise. During a survey of how distance affects the noise readout, it was found that, moving the cable closer by 1 mm increments, the readout noise was not effected when the cable was held at 4 mm, 3 mm, and even as close as 2 mm above the surface of the sensor. See figures 3.1 – 3.4. At 1 mm from the surface, however, the beginnings of noise disruption were observed. See figure 3.5. Increased levels of noise due to the digital jumper cable have not been observed on 10x10 modules, but they have been observed on 20x20 modules. It is believed that the 10x10 modules do not have the length required to allow the digital jumper cable to bow to a level close enough to the surface of the sensor to disrupt the noise level whereas the 20x20 modules do. This emphasizes that the digital jumper cable must be close to the sensor, at least less than 2 mm away, in order to affect it.

Another test that can be used to determine if the problem is caused by the digital jumper cable is to switch from *cal injection mode* to *data mode* when collecting data. When doing a cal injection, one differential of the differential pair on the digital jumper cable makes a 0.4V transition in approximately two nanoseconds during the acquire mode in order to cause the SVX chip to self-inject a charge into its preamplifiers. The timing of this pulse is such that it will occur in the pipeline set to be digitized by the SVX. Even if no channels are selected to receive a charge injection when this pulse happens, evidence supports some charge injection occurs simply due to the pickup from the digital signal. See figure 3.6. By changing to *data mode*, this signal pulse is absent. When changing from *cal injection mode* to *data mode*, the extra readout noise should be eliminated, and if the digital jumper cable is to blame, the noise level should then appear to be normal.

The last test that can be used is to change the value of the *pipeline*. Through testing, it has been shown that the grouping of channels with unusual noise level corresponds to the area of the sensor that is approximately under this digital signal. If the SVX is downloaded to digitize charge in a different pipeline from that which the cal injection signal is pulsed, the possibility of picking up noise from this pulse will be eliminated. It is best to change the pipeline value by only one more or one less than the calpipe value. See figures 3.7 – 3.8.

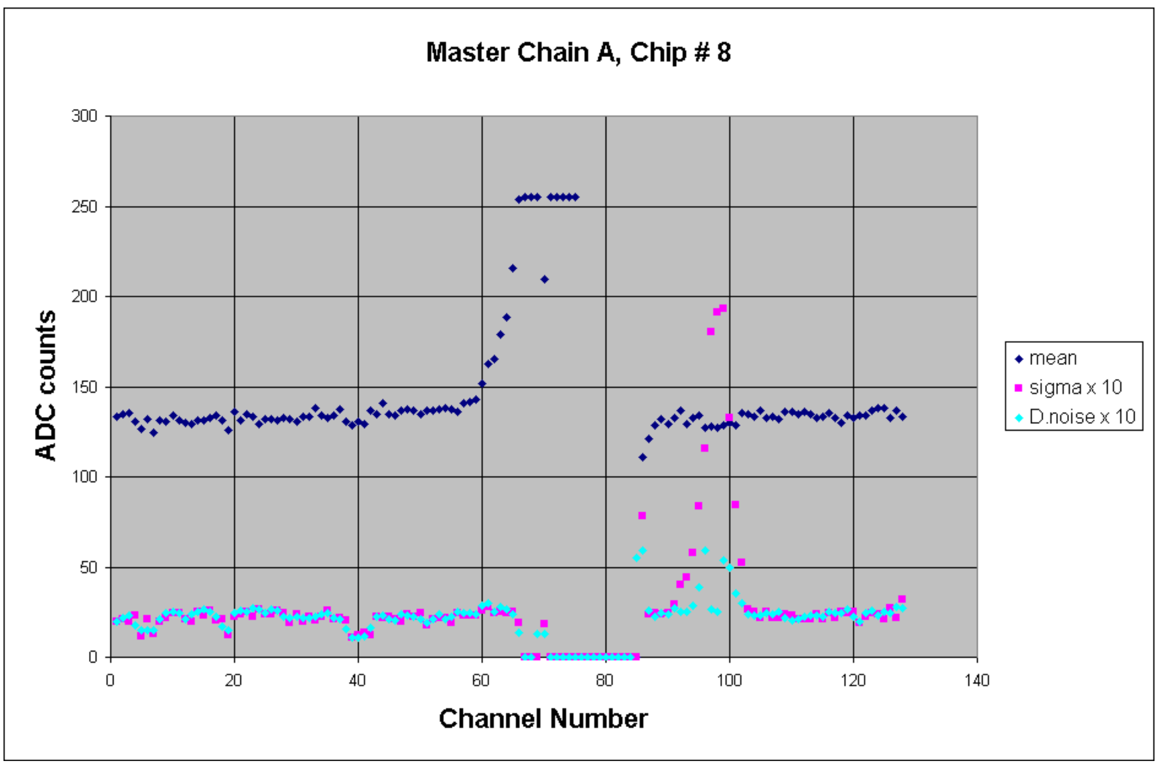

Fig. 3.1. Chip 8 on Hybrid 12 with the digital cable held very close

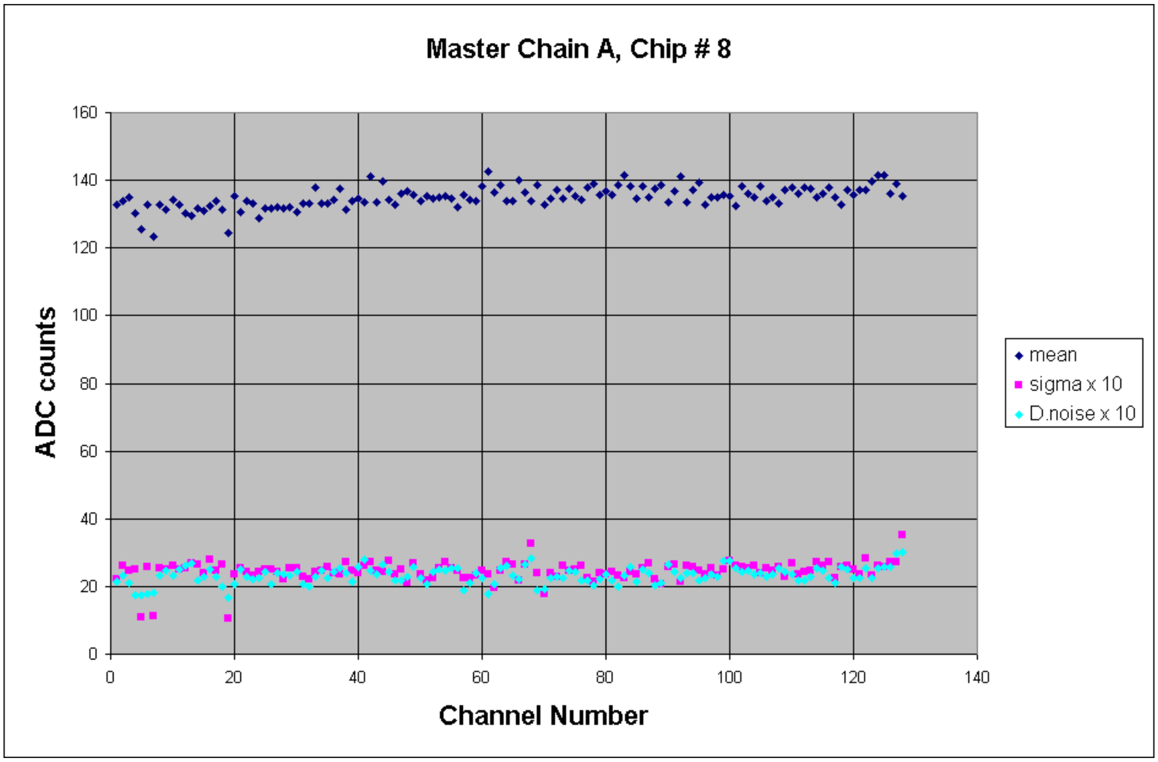

Fig. 3.2. Chip 8 on Hybrid 12 with cable held 4 mm away from the surface of the sensor

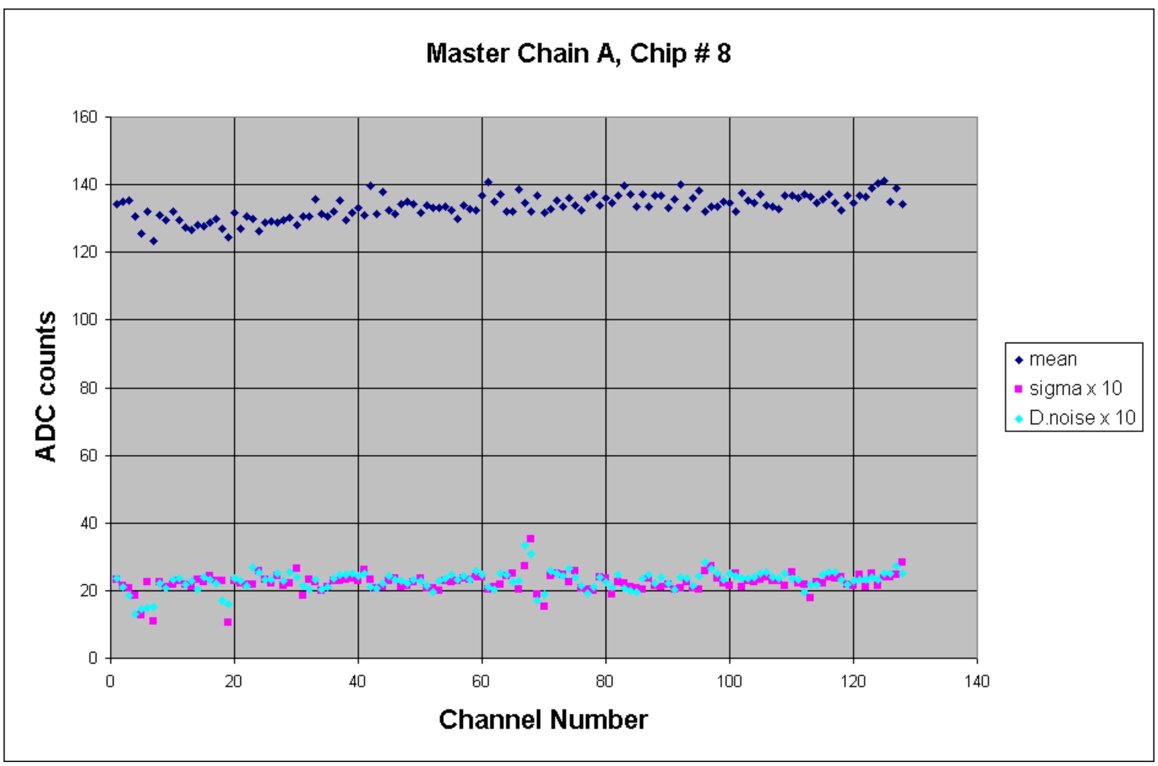

Fig. 3.3. Chip 8 on Hybrid 12 with the cable held 3 mm above the surface of the sensor

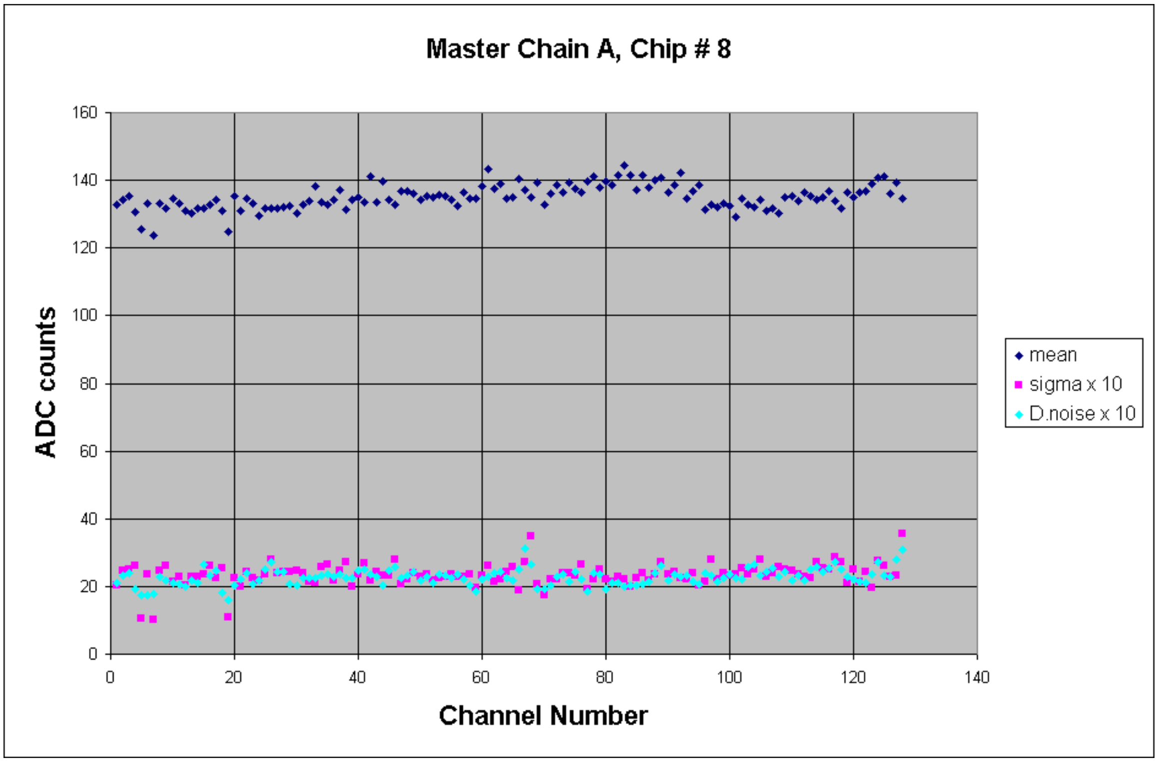

Fig. 3.4. Chip 8 on Hybrid 12 with the cable held 2 mm away from the surface of the sensor

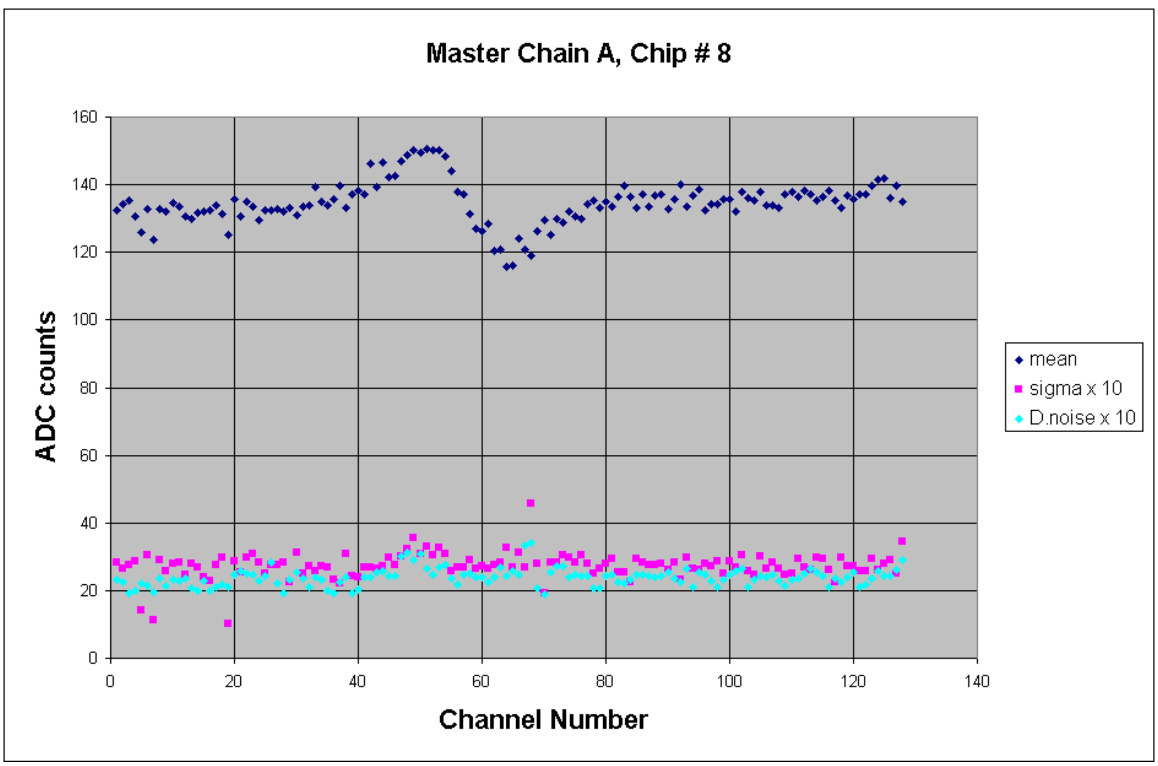

Fig. 3.5. Chip 8 on Hybrid 12 with the cable held 1 mm away from the surface of the sensor

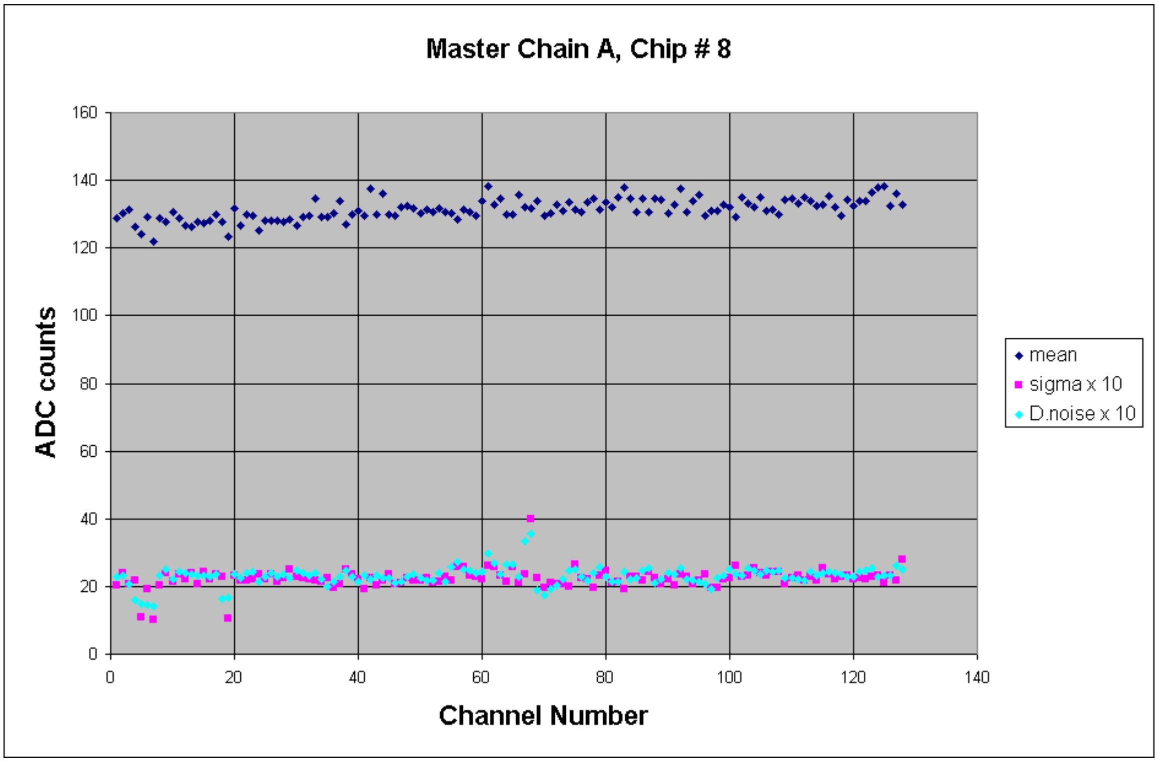

Fig. 3.6. Chip 8 on Hybrid 12 readout in data mode

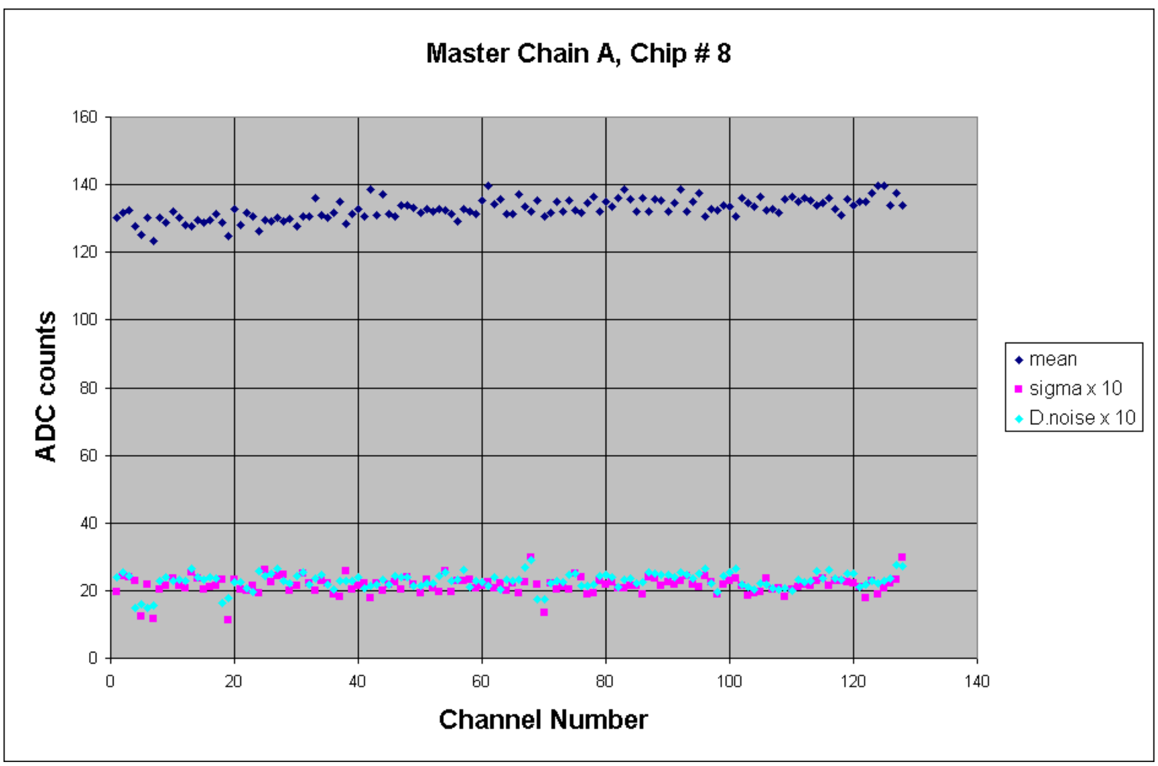

Fig. 3.7. Chip 8 on Hybrid 12 with a pipeline value of 7 and a calpipe value of 8

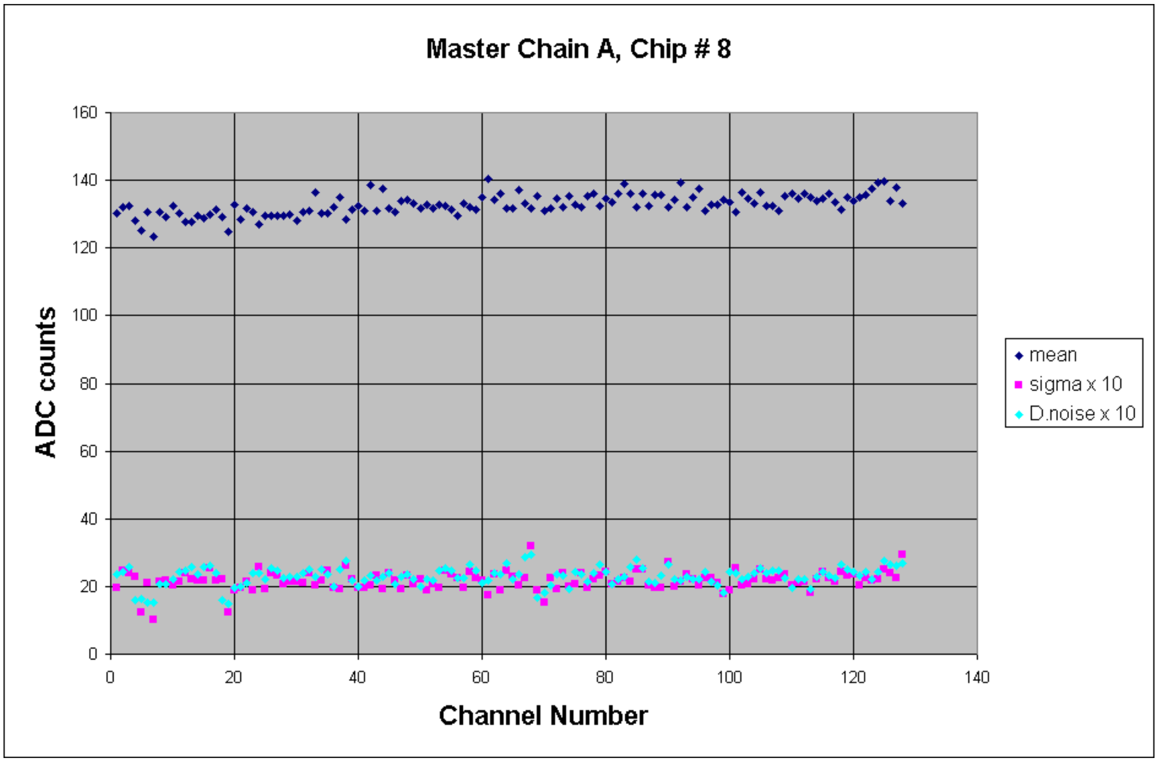

Fig. 3.7. Chip 8 on Hybrid 12 with a pipeline value of 9 and a calpipe value of 8

4. Solutions

All of the various tests run worked to mask the excess noise on the sensor readout and thusly represent possible solutions to the digital jumper cable noise problem. It would not be practical to never do a cal injection test, so running the sensor in data mode alone seems not to be a viable option. Also, changing the pipeline value to a different value than the calpipe value does not facilitate the collection of data from cal injections either. Therefore, the only tested observation left to exploit is that of distance. If the distance of the cable from the surface of the sensor is increased, the excess noise will not be read out, and the readout parameters will not have to be changed in order to run the sensor. In the present stave design, it is thought that the distance between the digital jumper cable and the surface of the sensor is 2.9 mm. This lies within the 2 mm or more from the sensor surface buffer distance determined through previous tests. However, the digital jumper cables can bow to a lower level if not properly held from the surface of the sensor, so special care should be taken to prevent this from happening. If the cables show a tendency to sag too close to the surface of the sensor, measures will need to be taken to restrain the cable. This could be accomplished by adding some buffer on the inside that would lie between the cable and the surface of the sensor while not requiring the lid of the sensor be raised. This is possible as all of the tests run on the sensor during the distance trials were done with pieces of foam acting as buffers while the lid to the stave remained closed. Extra shielding added to the digital jumper cable on the side that comes into close contact with the sensor is also a viable and quite promising solution. If another solution could be found that would not require the changing of any readout parameters or the stave or digital jumper cable layout, it would be highly encouraged.

5. Conclusion

The digital jumper cable has been shown to affect the readout noise of the sensor, in some cases significantly. Though it is mostly a localized problem, its overall effect on the performance of the sensors needs to be evaluated. There are a few things that can be done to circumvent the problem; however, maintaining a distance between the cable and the sensor of at least 2 mm seems the most straightforward and practical. Other solutions may be found that do not require the changing of some of the readout parameters or of the design of the stave and are highly encouraged. The problem seems to only affect the 20x20 modules, and should be addressed thoroughly. For a schematic of the digital jumper cable, see the layout on the D∅ website at http://d0server1.fnal.gov/projects/run2b/Silicon/Readout/JumperCable/dj_section_27nov01.pdf