Report on Tester Correlation Studies

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1 Scope

This document describes the correlation studies of different wafer testers.
The goal of these studies is to guarantee that a measured yield does not depend on the wafer tester used or differences in the tester electronics, but only on the chip quality.
Older yield studies of the ABCD3T chip were done at CERN. The electronics, which ran the tests and reads out the results, was not fast enough for series tests, as it took about 24 hours to test one wafer. Additionally the old electronics maximum frequency was 50 MHz, which turned out to be too low. It then was decided to develop a new test system which can test a wafer in a much shorter time and can run up to frequencies of 90 MHz. The probe stations itself were not changed but they differ for the testing sites (see Table 1.1).
The correlation studies were done between the old and the three new test systems.

Testing site	referred to as	Remark
CERN	old CERN	The only data with the old tester electronics.
CERN	CERN	Same probe station as old CERN, but with new readout electronics.
RAL	RAL	Only data with new tester electronics.
SCIPP	SCIPP	Only data with new tester electronics.

Table 1.1: Testing sites.

Two wafers (Table 1.2) of which old CERN data exists were tested with the new test system and compared. The setup for the old CERN does not exist any more.

Lot Number	Wafer Number	old CERN	CERN	RAL	SCIPP
Z37277	07	$\surd$	$\surd$	$\surd$	$\surd$
Z37277	15	$\surd$	$\surd$	$\surd$	$\surd$

Table 1.2: Wafers. $\surd$ shows if the wafer was tested at the corresponding site.

2 Description of Correlation Studies

To accept a chip as perfect it must pass three different tests: The analog, the digital and the power consumption test. These tests are described in this chapter. The combination of these three tests determine a chip yield.

2.1 Analog tests

In the analog part, the following studies were done:

- gain
- offset
- noise

For a precise description of the tests see [Bia01] and [Dab99].

2.2 Digital tests

To test the digital performance of a chip, the wafertester sends commands and bit patterns to the chip and compares the returned result with the expected result. The efficiency is the number of correct results divided by the number of executions of a test. The tester runs different programs, called test vectors (TV), six for the old tester, nine for the new tester. These tests are run with V_{dd} ranging from 3.3V to 4.1V in 0.1V steps and frequencies ranging from 40MHz to 90MHz in 10 MHz steps for the new testers. For a precise description of the testing procedure see [Bia01] and [Cio01]. The old CERN tester could only run up to 50MHz, therefore a comparison can only be done for 40MHz and 50MHz. The minimum V_{dd} of a TV at a given Frequency is the minimal V_{dd} at which the chip responds correctly to the given inputs, which is the number to be compared among the testers. A minimum V_{dd} of 0V means that the the chip did not operate correctly at any value of V_{dd}.
The TVs had to be changed from the old to the new system because the new tester runs the tests in hardware to achieve shorter test time and also because the TVs were further improved to receive better information about the digital performance of a chip. Therefore, a direct comparison of the new and the old TVs can not be done individually, but with the combaniton of all TVs which represents the digital yield. An exception is TV 0, which tests the configuration register. This test is almost the same on both systems, with the only difference that the new TV 0 tests the beamcounter as well.

2.3 Power consumption

The analog as well as the digital current is measured in slave and master mode (I_{cc} at $V_{cc} = 3.5V$ and I_{dd} at $V_{dd} = 4.0V$). For a precise description see [Bia01].

2.4 Yield

The yield is the most important number to be compared among the testers, since it represents the decision if a chip will be used. The yield incorporates digital, analog and power consumption tests. Any disagreement in one of these tests will result in a different yield.

3 Results

This section presents the analysis and results of the stability, analog, digital and power consumption measurements. Usually an example of one wafer is given as a scatterplot and the results of all wafers are shown in a histogram. The actual results of each part are also summarised in a table. The digital and total yield are only shown in a table.

3.1 Analog Results

This sections concerns the analog results of the new chip testing system at CERN, SCIPP, and RAL. The focus of this section is on the stability of consecutive analog measurements on the new systems (Section 3.1.1) and the direct comparison difference in the data between the new systems and the old CERN testing system (Section 3.1.2).

3.1.1 Stability

The stability of analog results for the SCIPP and RAL tester systems were varified by repeatedly measuring a single chip without resetting the system. The result were then compared

Tester System	Gain Deviation	Offset Deviation	Noise Deviation
SCIPP	1%	5%	7%
RAL	1%	8%	8%

Table 3.3: Summary of the tester stability. The deviation is a measurement of how much consecutive test runs vary from the first run.

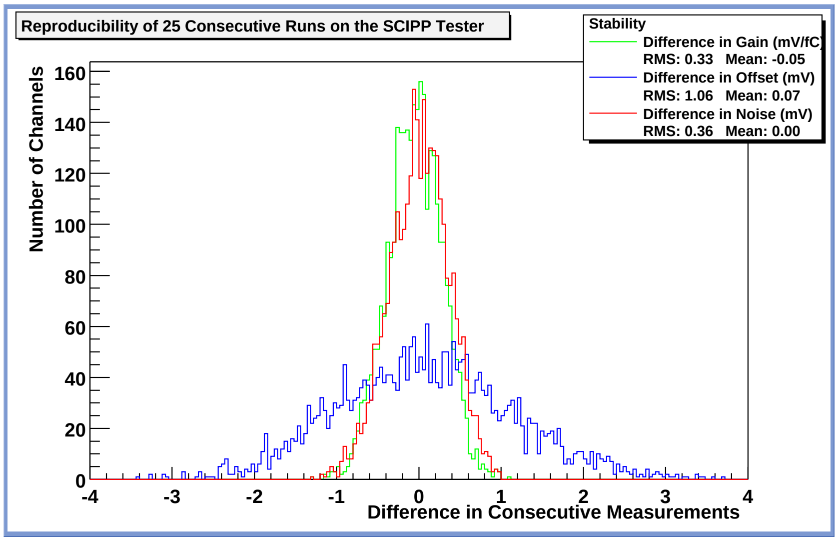

Figure 3.1: Analog reproducibility results for 25 consecutive measurements on the SCIPP tester system.

channel by channel for differences. Figure 3.1 and 3.2 show the distribution of the difference for the gain, offset, and noise of the 25 measurements used. Table 3.3 is a summary of the deviation between the first run of the tester and the other 24 consecutive runs.

3.1.2 Tester Comparison

The comparison between the old testing system at CERN and the new testing systems at CERN, SCIPP, and RAL was accomplished by directly comparing the analog measurements. The gain, noise, and offset values measured on the new testing systems were analyzed for their compatibility with the old CERN data.

Gain

In Figure 3.3 the gain measured on the SCIPP system and the old CERN system for a single chip from wafer 15 is displayed in a scatterplot format. This Figure is a typical example of the gains for these two systems. In general the SCIPP system measures slightly higher gains on average compared to the old CERN system. These differences are on the order of a 3% change over wafer 15 (Table 3.4).
The gain of a channel must be at least 50% of the mean gain to be accepted. The average difference in gain of the different test sites is about 3%, that means, that a channel with a gain that lies in the region around half the mean has the danger of passing on one site and failing on some other site. Fortunately, the chance of a channel having a value around half

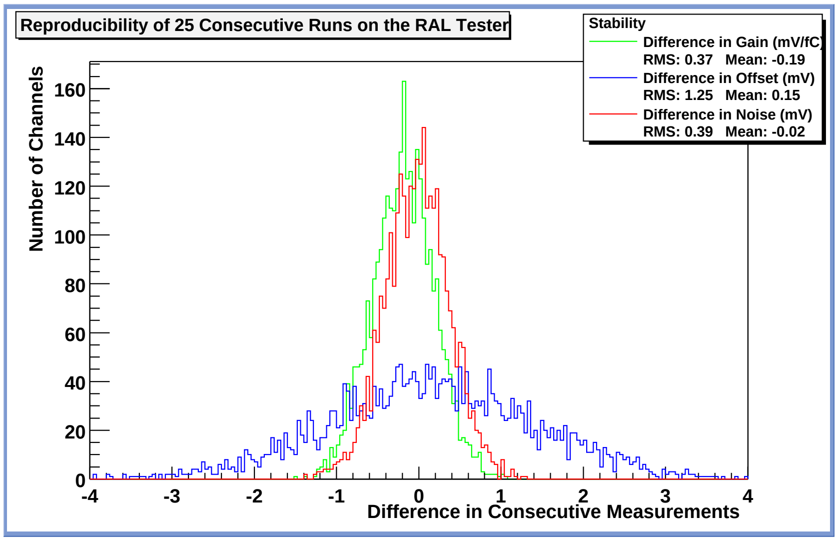

Figure 3.2: Analog reproducibility results for 25 consecutive measurements on the RAL tester system.

of the mean is very low. Of all channels tested on all wafers and testing sites, only one single channel was in a 3 RMS region of the half mean of the gain (Figure 3.5). The difference in the measured values of gain between the old CERN testing system and its new counter parts are plotted in Figures 3.4 and 3.6. These Figures were created by subtracting the old CERN data from the new data for each system respectively. The gain for each channel is typically between 50-60mV/fC. The gain comparisons showed deviations around 3%.

Offset

Figure 3.7 is a scatterplot of the typical offsets for the CERN and the old CERN systems for wafer 15, but since the offset values are much more dependant on fit quality than the gain, causing a wider distribution, it is hard to see any systematic trends from this plot. The trends of the comparison can be seen in figures 3.8 and 3.9. When these plots are compared to the average measured values of the offset there is a deviation between the new and old systems of around 20-30%.

Noise

All the new testers have less noise than the old CERN tester (Figure 3.11 and 3.12), especially the RAL and SCIPP tester are significantly quieter. A scatterplot of the noise for RAL and the old CERN system is shown in Figure 3.10. The comparison of difference in noise is shown in Figures 3.13 and 3.14. The deviation in the noise from new tester to old tester can vary due to the probe station involved, but this deviation is never greater than 20%. The CERN and old CERN tester comparison shows that when using the same probe station the new system is, on average, quieter than the old system by 10%. Table 3.4 is a summary of all of the data shown in the analog comparison Figures.

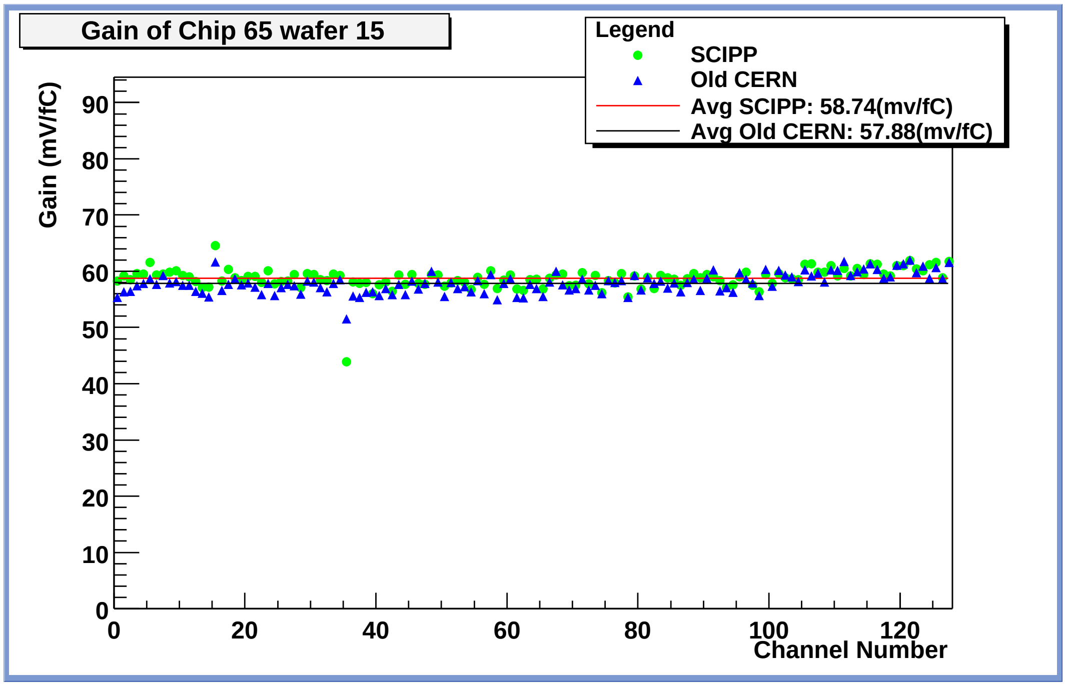

Figure 3.3: SCIPP and old CERN gain scatterplot for chip 65 on W15.

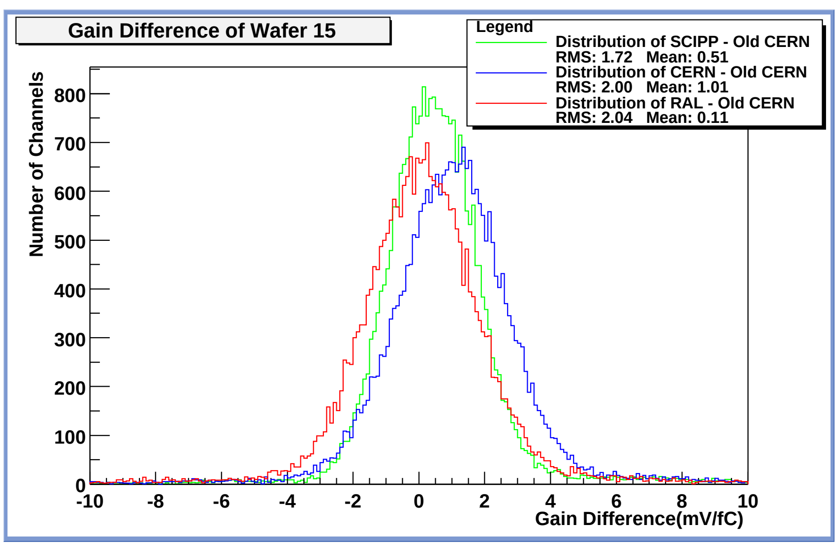

Figure 3.4: Histogram of the channel by channel difference between measured gains of W15. Results from the old CERN tester are subtracted from the new testers.

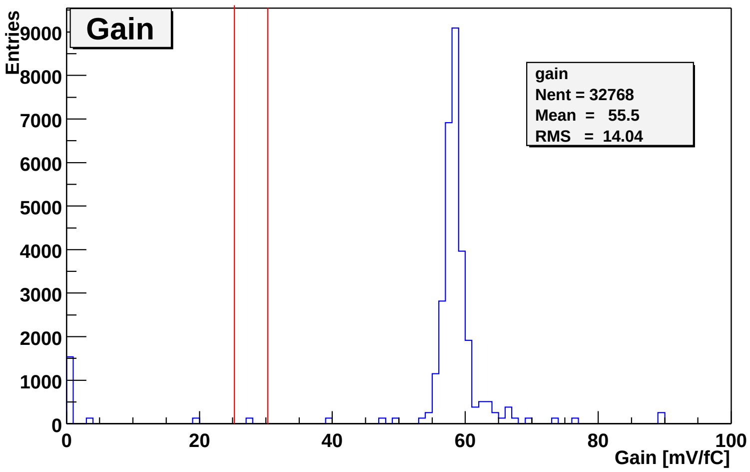

Figure 3.5: Gain Distribution for Wafer 15 on SCIPP. The mean value of the gain is $55.5mv/fC$. Only one channel is in the 3 σ region (red lines) of the cut (the gain of a channel must be greater than 50% of the mean chip gain).

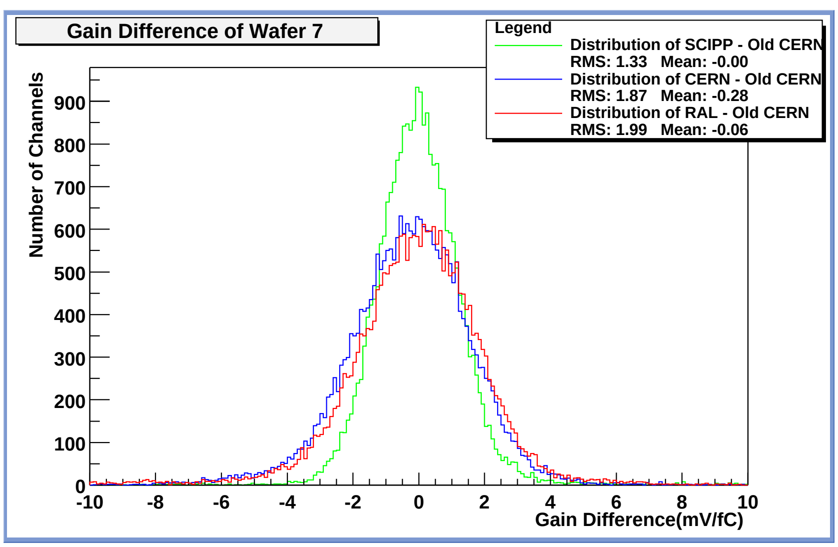

Figure 3.6: Difference between measured gains of W07.

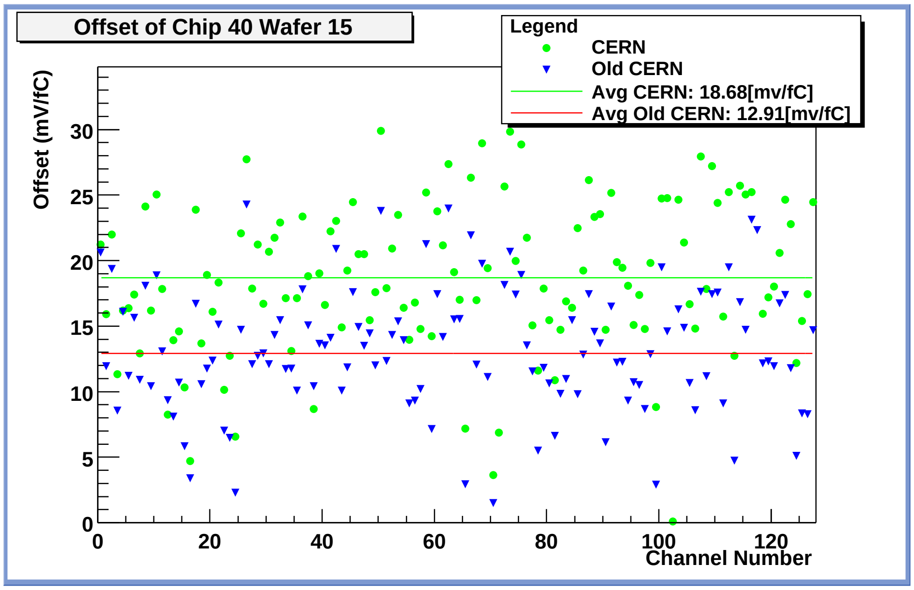

Figure 3.7: Old CERN and CERN scatterplot for chip 40 on W15.

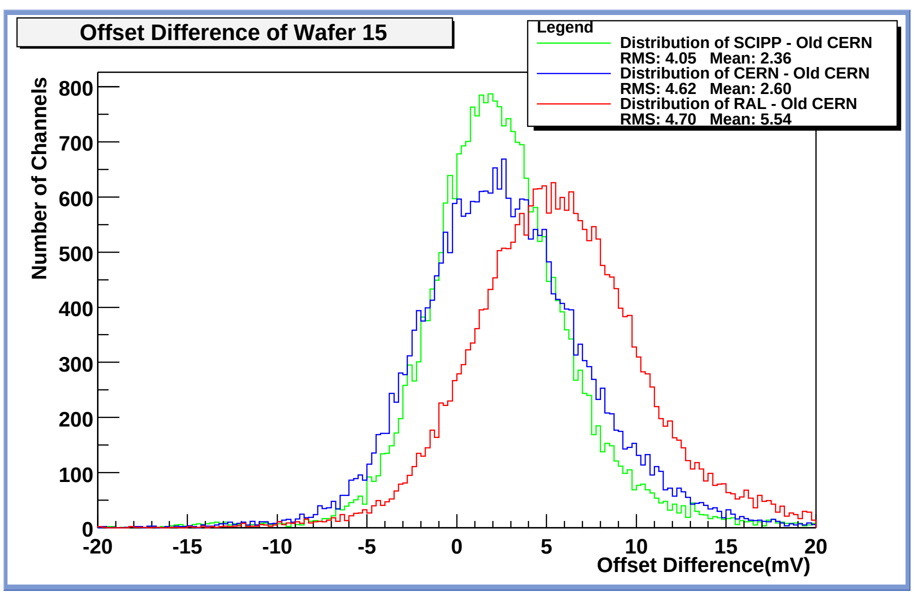

Figure 3.8: Histogram of the channel by channel difference between measured offsets of W15. Results from the old CERN tester are subtracted from the new testers.

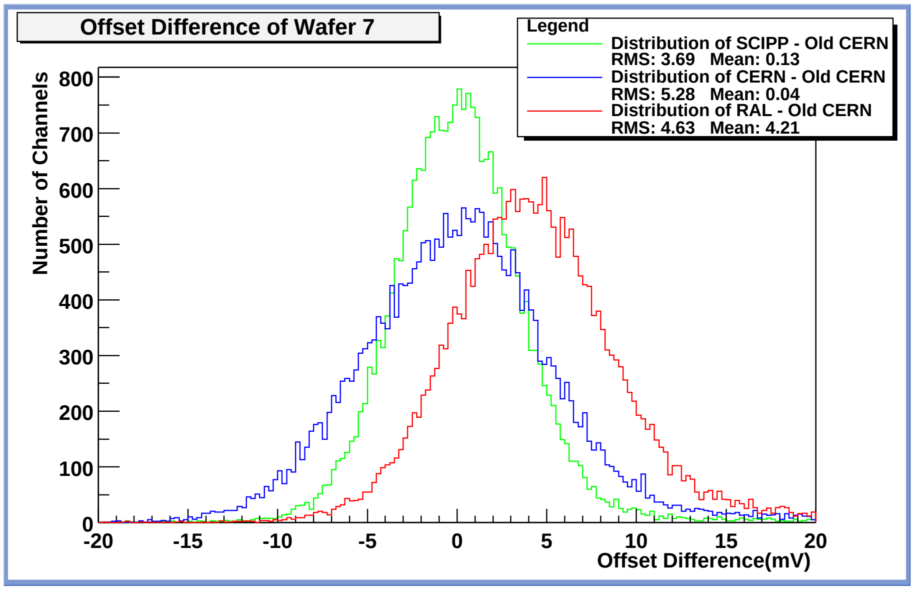

Figure 3.9: Difference between measured offsets of W07.

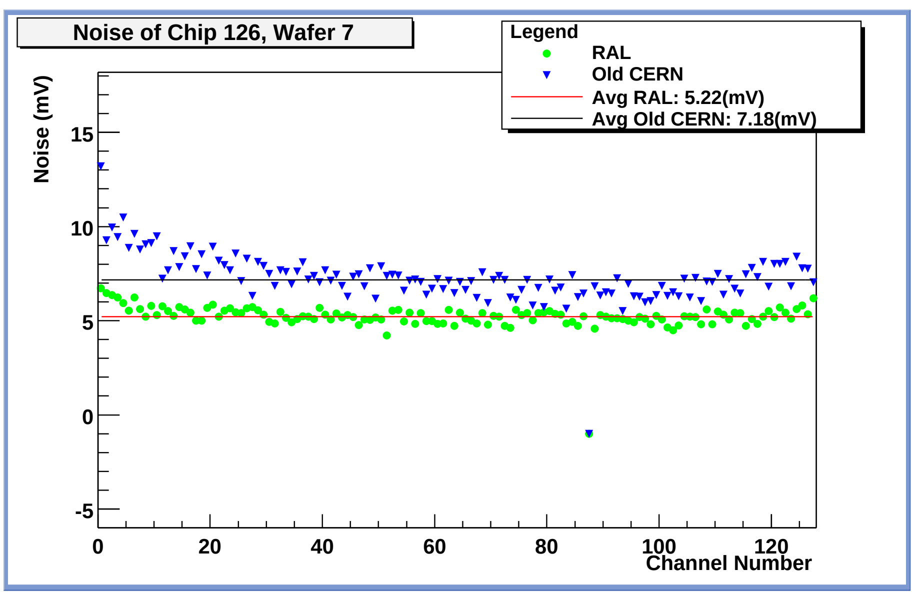

Figure 3.10: RAL - old CERN scatterplot for chip 126 W07.

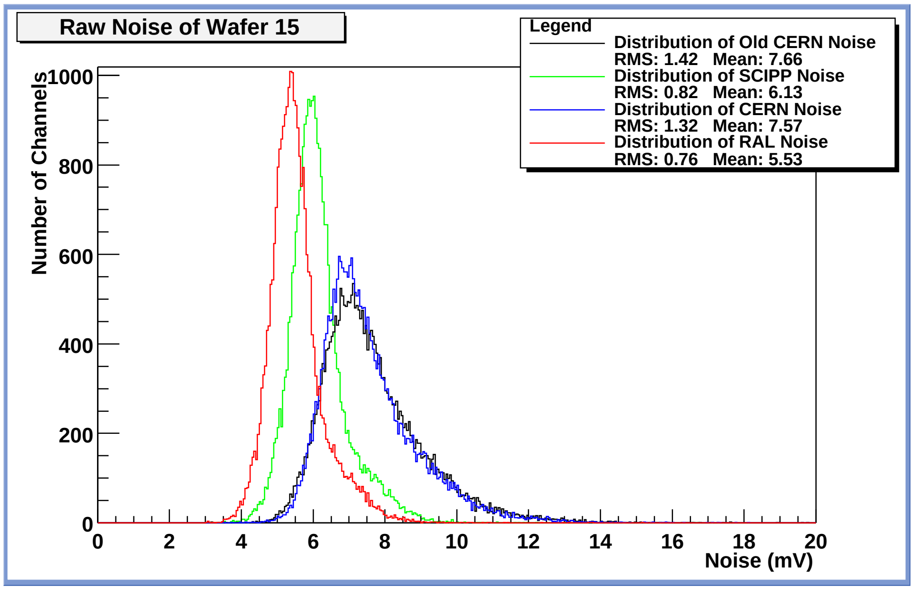

Figure 3.11: Noise of each tester for W15.

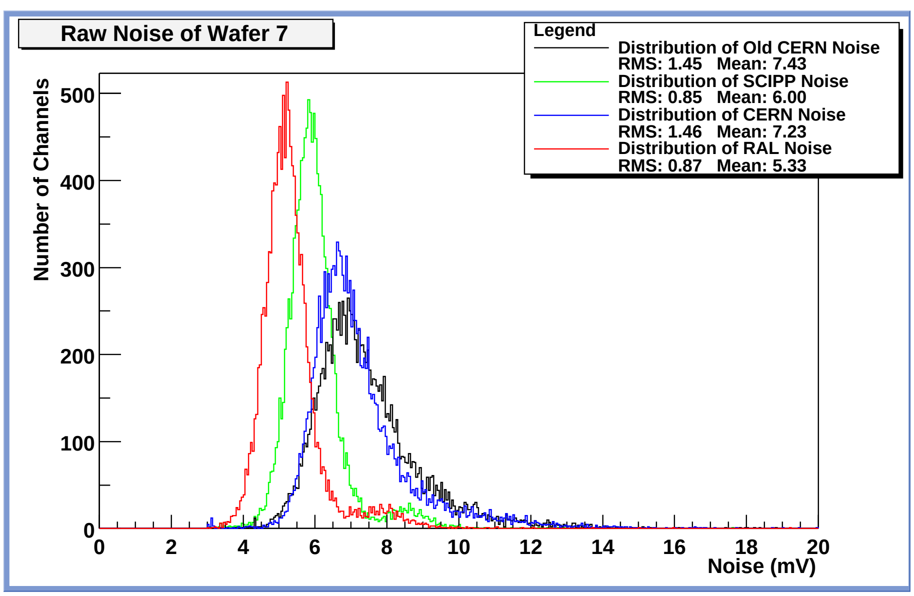

Figure 3.12: Noise of each tester for W07.

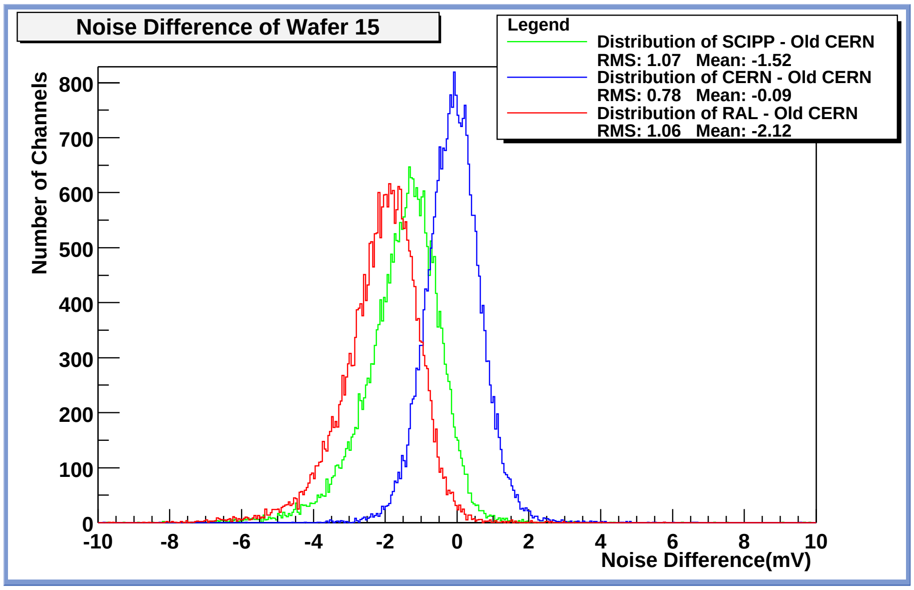

Figure 3.13: Difference in noise for W15. The original CERN data was subtracted from the new data.

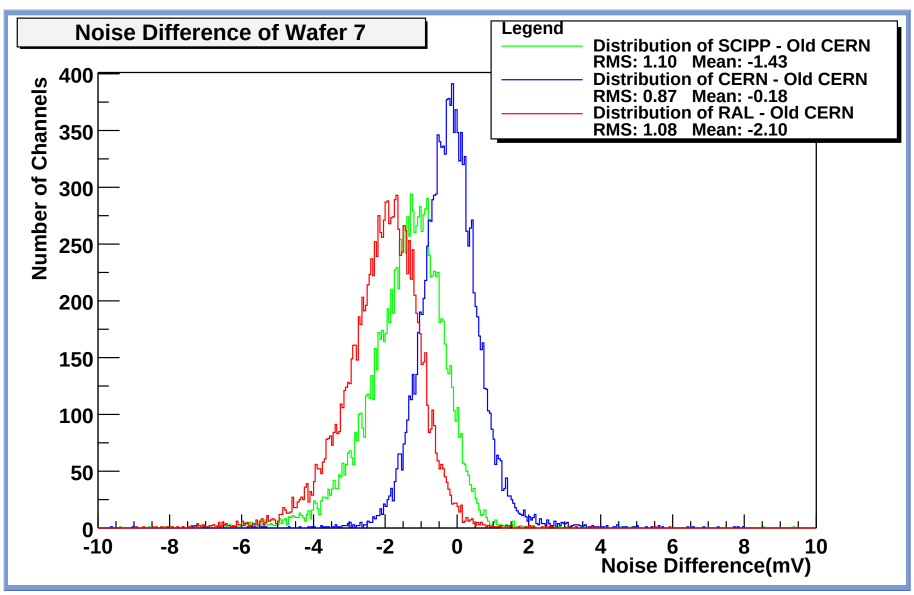

Figure 3.14: Difference in noise for W07.

Wafer	Tester System	Mean Difference of Gain	Standard Deviation of Gain	Mean Difference of Offset	Standard Deviation of Offset	Mean Difference of Noise	Standard Deviation of Noise	Average System Noise
		(mV/fC)	(mV/fC)	(mV)	(mV)	(mV)	(mV)	(mV)
Z37277 W15	CERN	1.01	2.00(3.3%)	2.60	4.62(30%)	-0.09	0.78(10%)	7.57
	SCIPP	0.51	1.72(3.0%)	2.36	4.05(27%)	-1.52	1.07(17%)	6.13
	RAL	0.11	2.04(3.5%)	5.54	4.70(26%)	-2.12	1.06(19%)	5.53
	Old CERN							7.66
Z37277 W7	CERN	-0.28	1.87(3.3%)	0.04	5.28(35%)	-0.18	0.87(11%)	7.23
	SCIPP	0.00	1.33(2.3%)	0.13	3.69(24%)	-1.43	1.10(17%)	6.00
	RAL	-0.06	1.99(3.4%)	4.63	4.21(21%)	-2.10	1.08(19%)	5.33
	Old CERN							7.23

Table 3.4: Summary of the analog comparison. In all cases the original CERN data sets were subtracted from the new data sets

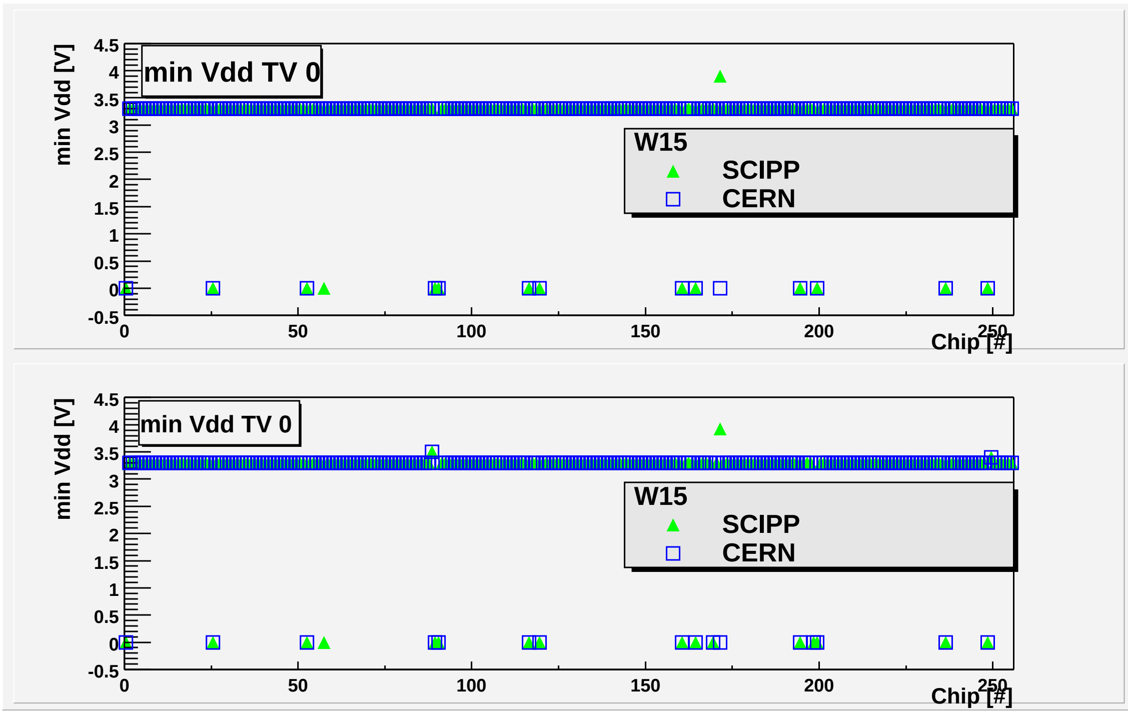

Figure 3.15: Minimum V_{dd} for TV 0 scatterplot for the CERN and SCIPP tester of Wafer 15. See Table 3.5 for the results printed.

3.2 Digital Results

The comparison of the digital TV for the new testers agree very well (Figure 3.15). Only TV 4 shows differences from SCIPP to the other new test sites (Figure 3.16). These differences are due to the fact that TV 4 is sensitive to noise in the analogue part of the chip. Improvement has already been achieved and some more work to reduce this sensitivity will eliminate the problem. The rest of the graphs comparing the new sites look the same, having very satisfying results, and will be omitted.

The comparison between the old CERN and the new testers for the configuration register test, which corresponds roughly to TV 0 is shown in Figure 3.17. Unfortunately not even this TV is exactly the same on the old and the new system, which explains the differences in results.

The combination of all TV gives the digital yield. The results can be found in Table 3.16.

Min V_{dd} at 40MHz			
Chip Nr.	CERN	SCIPP	Diff.
58	3.3	0	3.3
172	3.3	3.9	0.6
Chips failed	15	15	2
Min V_{dd} at 50MHz			
Chip Nr.	CERN	SCIPP	Diff.
58	3.3	0	3.3
172	3.3	3.9	0.6
Chips passed	15	15	2

Table 3.5: List of all chips having a difference in minimum V_{dd} for TV 0 CERN - SCIPP of Wafer 15. The tests at CERN were done before the tests at SCIPP. By the time the wafer arrived at SCIPP, chip 58 was dead. This agrees with following testing at RAL. Therefore chip 58 now gives no result, i.e. 0.

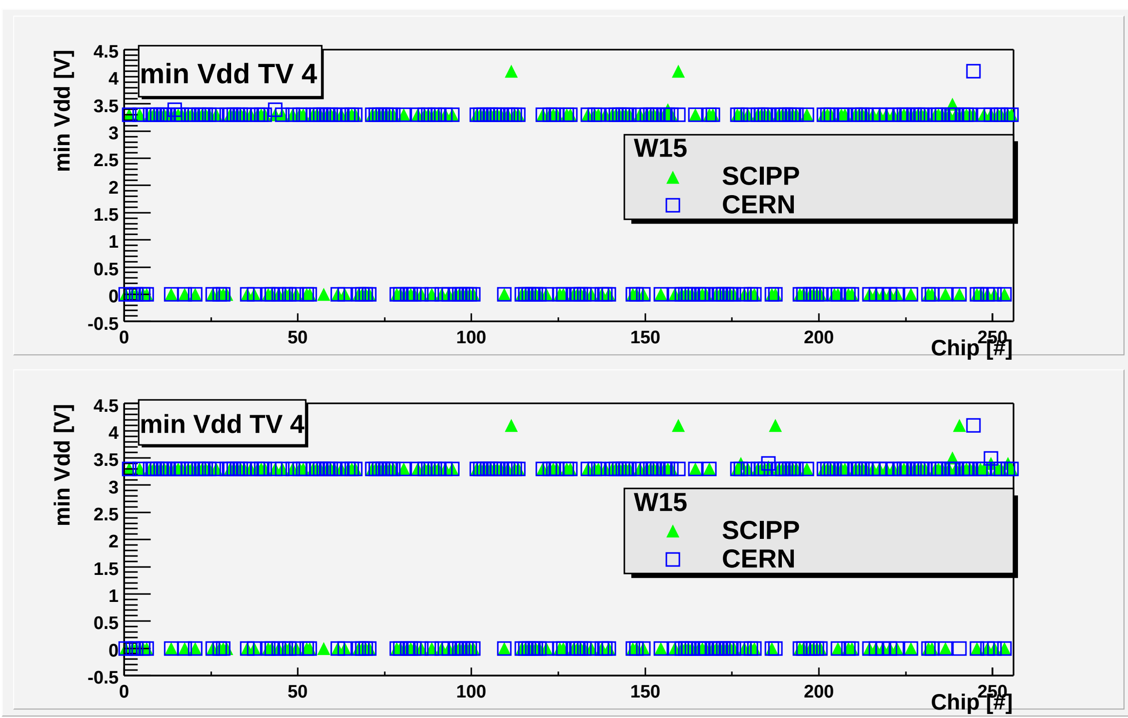

Figure 3.16: Minimum V_{dd} scatterplot for improved TV 4 for the CERN and SCIPP tester of Wafer 15. See Table 3.6 for the results printed.

Min V_{dd} at 40MHz			
Nr.	SCIPP	CERN	Diff.
14	3.3	3.4	-0.1
43	3.3	3.4	-0.1
111	4.1	3.3	0.8
156	3.4	3.3	0.1
159	4.1	3.3	0.8
238	3.5	3.3	0.2
244	3.3	4.1	-0.8
Min V_{dd} at 50MHz			
Nr.	SCIPP	CERN	Diff.
111	4.1	3.3	0.8
159	4.1	3.3	0.8
177	3.4	3.3	0.1
185	3.3	3.4	-0.1
238	3.5	3.3	0.2
244	3.3	4.1	-0.8
249	3.4	3.5	-0.1
254	3.4	3.3	0.1

Table 3.6: List of all chips having a difference in minimum V_{dd} for TV 4 CERN - SCIPP of Wafer 15.

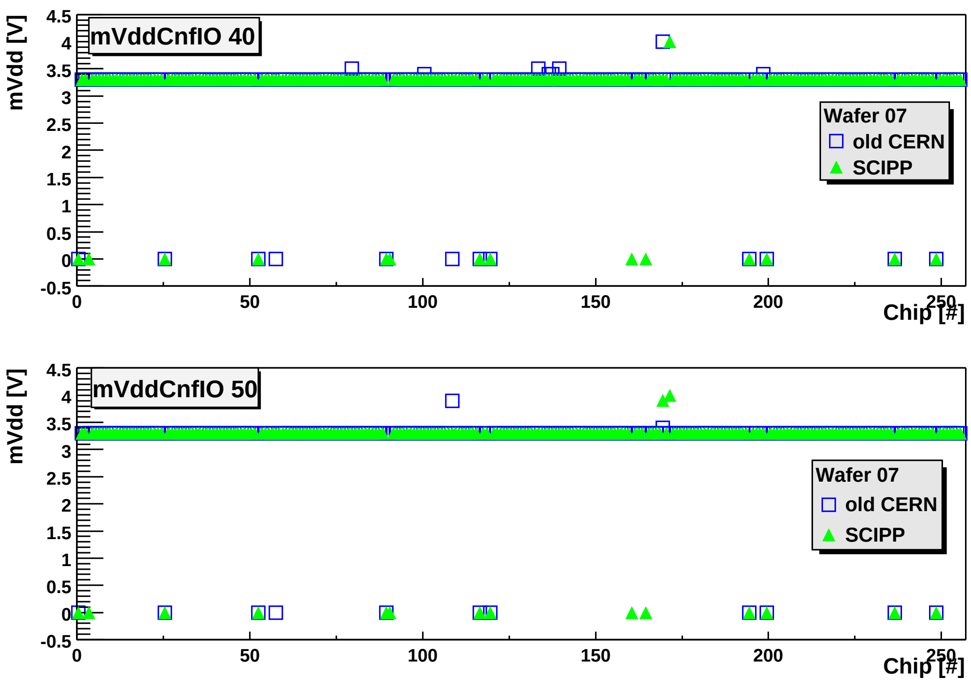

Figure 3.17: Minimum V_{dd} for CnfIO ($\simeq$ TV 0) scatterplot for old CERN and SCIPP tester of Wafer 07. See Table 3.7 for the results printed.

Min V_{dd} at 40MHz			
Chip Nr.	old CERN	SCIPP	Diff.
3	3.3	0	3.3
57	0	3.3	-3.3
79	3.5	3.3	0.2
90	3.3	0	3.3
100	3.4	3.3	0.1
108	0	3.3	-3.3
133	3.5	3.3	0.2
136	3.4	3.3	0.1
137	3.4	3.3	0.1
139	3.5	3.3	0.2
160	3.3	0	3.3
164	3.3	0	3.3
169	4	3.3	0.7
171	3.3	4	-0.7
198	3.4	3.3	0.1
Chips failed	12	14	6
Min V_{dd} at 50MHz			
Chip Nr.	old CERN	SCIPP	Diff.
3	3.3	0	3.3
57	0	3.3	-3.3
90	3.3	0	3.3
108	3.9	3.3	0.6
160	3.3	0	3.3
164	3.3	0	3.3
169	3.4	3.9	-0.51
171	3.3	4	-0.7
Chips passed	11	14	5

Table 3.7: List of all chips having a difference in minimum V_{dd} for CnfIO ($\simeq$ TV 0) old CERN - SCIPP for Wafer 07.

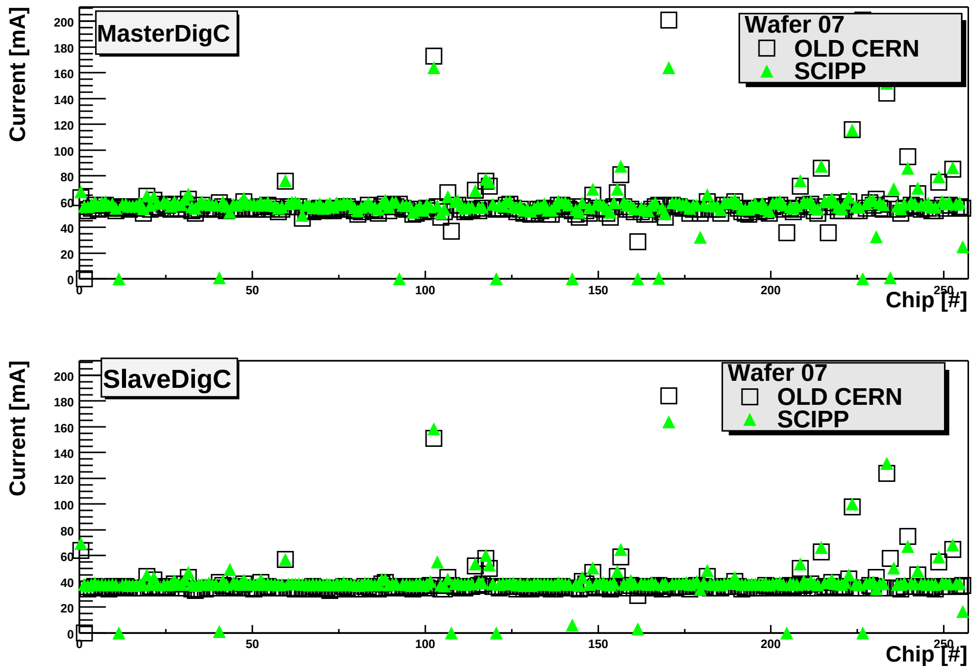

Figure 3.18: I_{dd} scatterplot as master or slave for old CERN and SCIPP tester of Wafer 07.

3.3 Power Consumption

The analog (I_{cc}) and digital (I_{dd}) current of each chip is measured, while the analog line is set to $V_{cc} = 3.5V$ and the digital line to $V_{dd} = 4.0V$. During this test the chip receives triggers at a rate of 100kHz with an occupancy of 3%. For details see [Bia01].
A scatterplot of the current is shown for Wafer 07 on the old CERN and SCIPP tester (Figure 3.18 and 3.27) and the old CERN and RAL tester (Figure 3.19 and 3.26).
Histograms of the currents are shown for all Wafers and Testing sites (Figure 3.20 to 3.21 and 3.28 to 3.29) and the results are listed in Figure 3.8 and 3.9, respectively 3.12 and 3.13.
Differences of the currents are shown in Figure 3.22 to 3.25 and 3.30 to 3.33 and the results are listed in Figure 3.10 and 3.11, resp. 3.14 and 3.15.
For the Digital current, the old CERN, CERN and SCIPP tester show a good agreement in slave and master mode of the chip. The RAL tester has a systematic shift to higher I_{dd} of about 10% for all digital measurements.
For the analog current, the old CERN, CERN and RAL tester agree nicely. The SCIPP tester shows smaller I_{cc} for the chips in master and slave mode of about 10%.
This discrepancy in I_{dd}, respectively I_{cc}, is most likely due to an incorrect calibration of the tester ADC which will be corrected, but has no impact on the measured yield (compare 3.4), because the requirement for passing parts is a cut of I_{dd} (I_{cc}) in comparison to the average digital (analog) current of a wafer, which receives the same systematic shift.

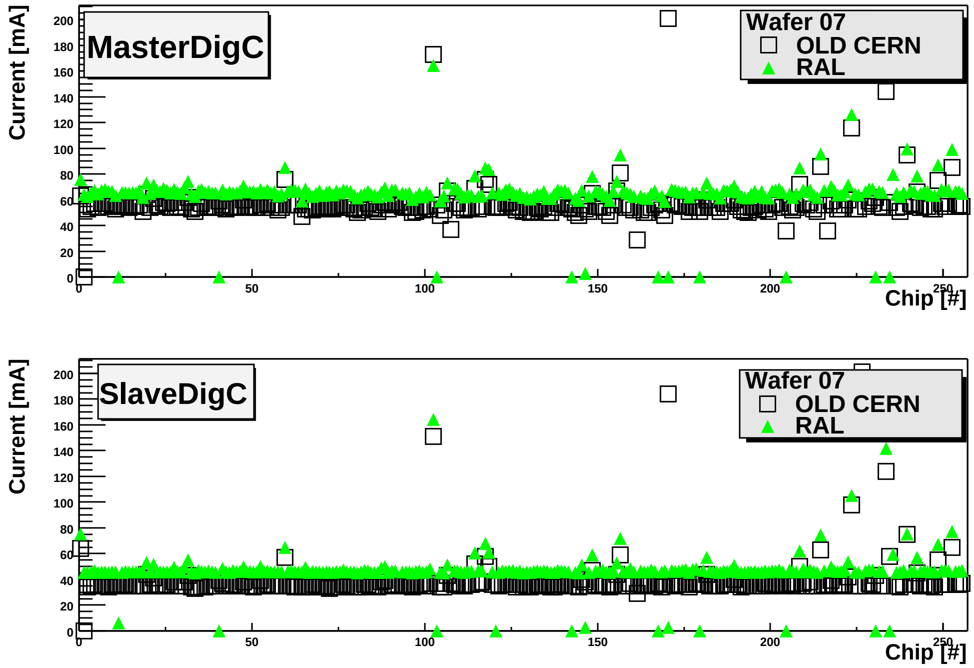

Figure 3.19: I_{dd} scatterplot as master or slave for old CERN and RAL tester of Wafer 07.

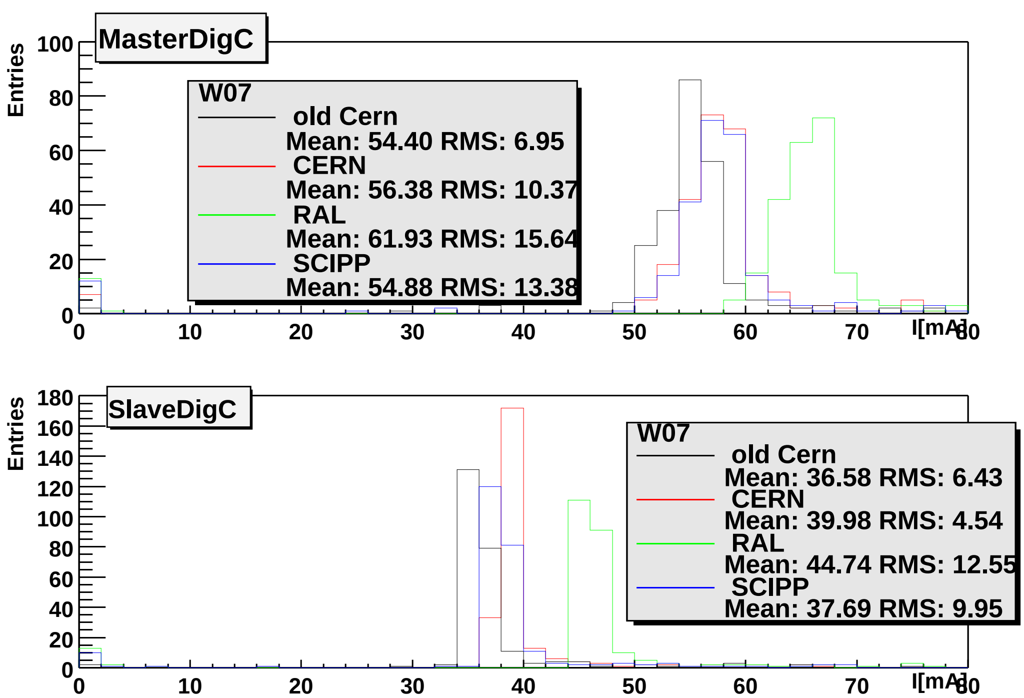

Figure 3.20: Histogram of I_{dd} as slave or master for all testers on Wafer 07.

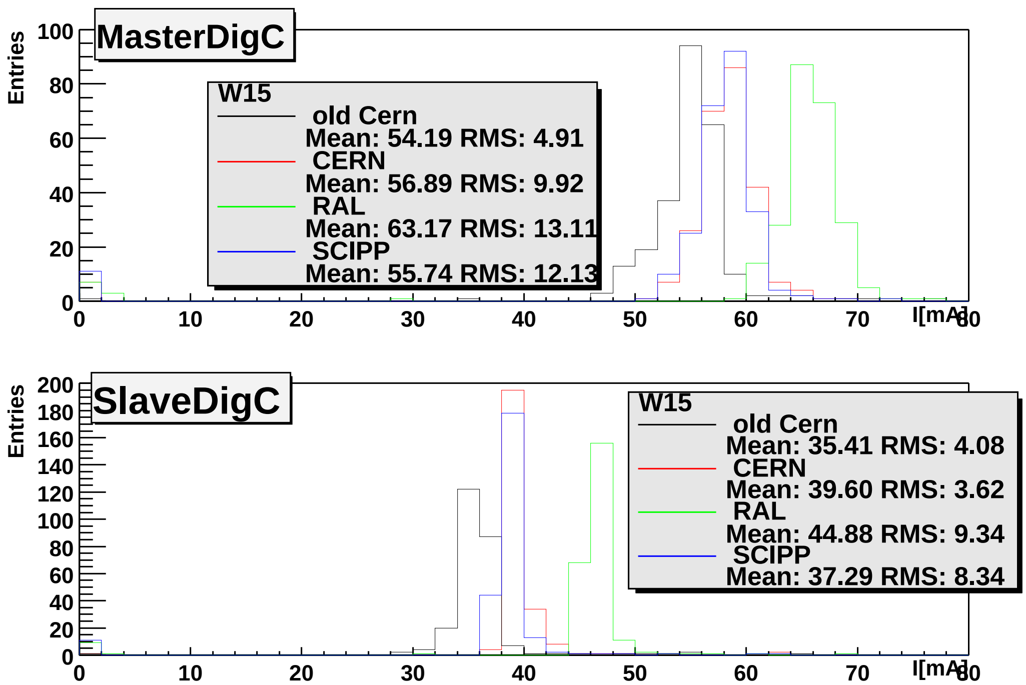

Figure 3.21: Histogram of I_{dd} as slave or master for all testers on Wafer 15.

Master Digital Current I_{cc} [mA]				
	Wafer 07		Wafer 15	
	Mean	RMS	Mean	RMS
old CERN	54.40	6.95	54.19	4.91
CERN	56.38	10.37	56.89	9.92
RAL	67.93	15.64	63.17	13.11
SCIPP	54.88	13.38	55.74	12.13

Table 3.8: I_{dd} in master mode.

Slave Digital Current I_{cc} [mA]				
	Wafer 07		Wafer 15	
	Mean	RMS	Mean	RMS
old CERN	36.58	6.43	35.41	4.08
CERN	39.98	4.54	39.60	3.62
RAL	44.74	12.55	44.88	9.34
SCIPP	37.69	9.95	37.29	8.34

Table 3.9: I_{dd} in slave mode.

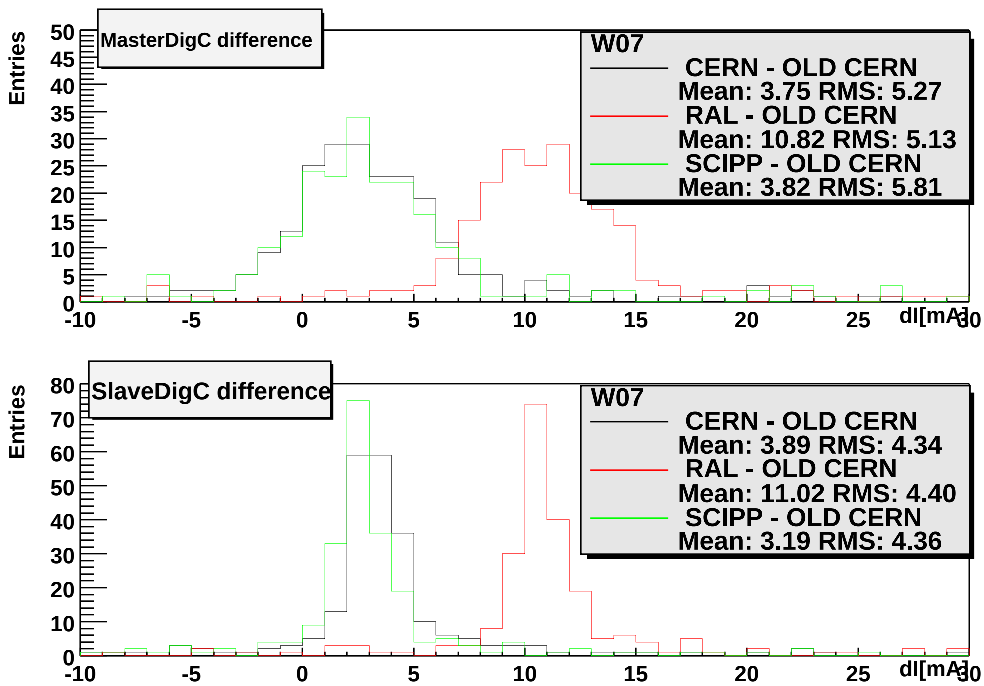

Figure 3.22: Histogram ΔI_{dd} of each new tester to the old CERN tester for Wafer 07.

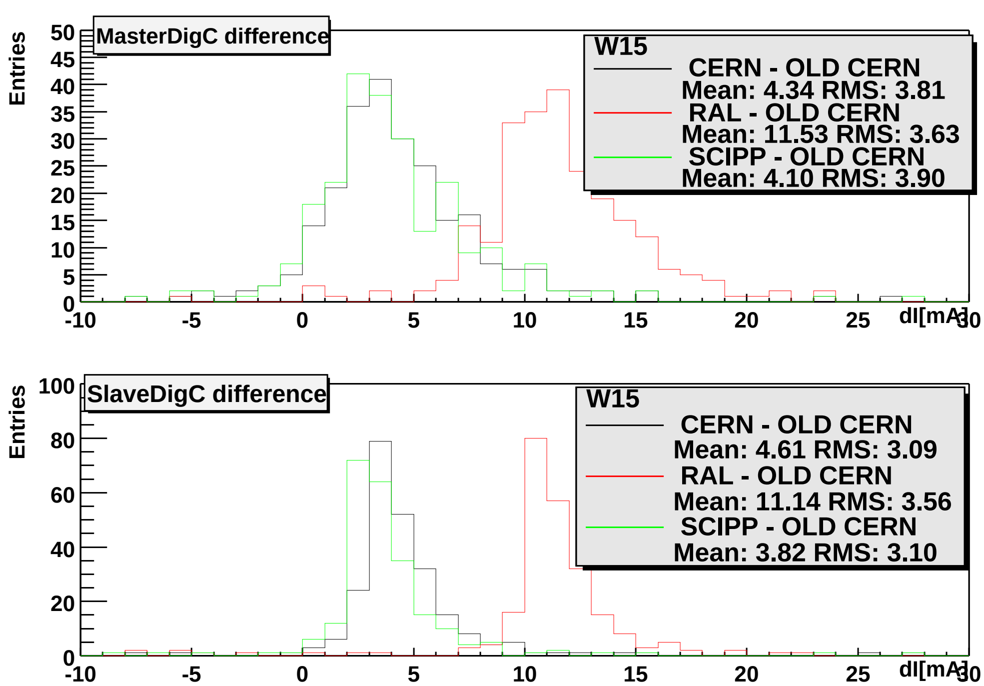

Figure 3.23: Histogram ΔI_{dd} of each new tester to the old CERN tester for Wafer 15.

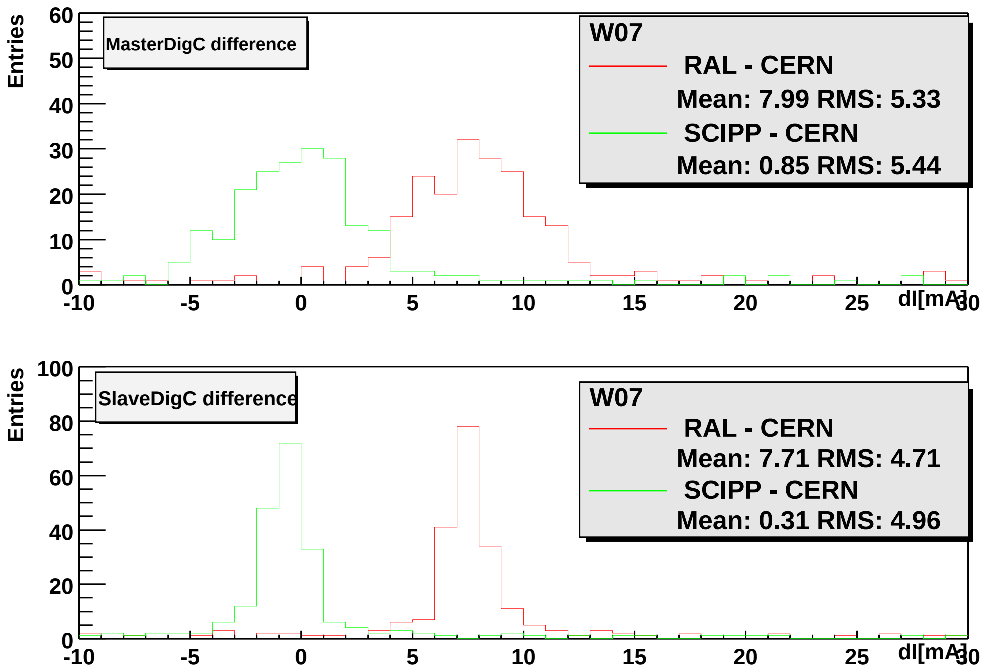

Figure 3.24: Histogram ΔI_{dd} the RAL, CERN and SCIPP tester for Wafer 07.

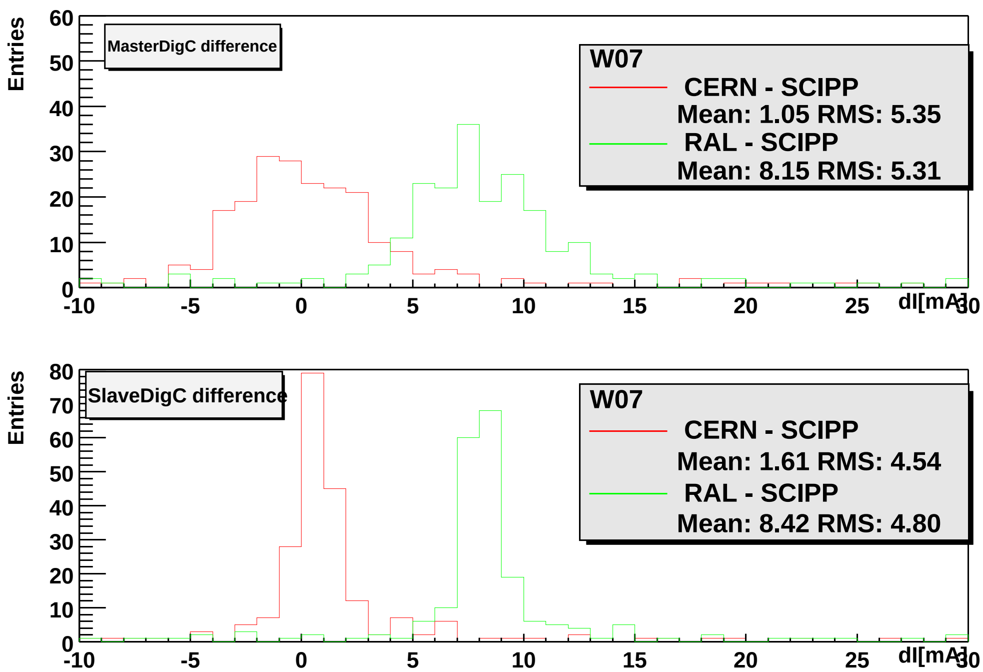

Figure 3.25: Histogram ΔI_{dd} the RAL, CERN and SCIPP tester for Wafer 07.

Difference of digital current I_{cc} in master mode for Wafer 07 [mA]								
	- old CERN		- CERN		- RAL		- SCIPP	
	Mean	RMS	Mean	RMS	Mean	RMS	Mean	RMS
old CERN	-	-						
CERN	3.75	5.27	-	-			1.05	5.35
RAL	10.82	5.13	7.99	5.33	-	-	8.15	5.31
SCIPP	3.82	5.81	0.85	5.44			-	-

Table 3.10: ΔI_{dd} in master Mode for Wafer 07.

Difference of digital current I_{cc} in slave mode for Wafer 07 [mA]								
	- old CERN		- CERN		- RAL		- SCIPP	
	Mean	RMS	Mean	RMS	Mean	RMS	Mean	RMS
old CERN	-	-						
CERN	3.89	4.34	-	-			1.61	4.54
RAL	11.02	4.40	7.71	4.71	-	-	8.42	4.80
SCIPP	3.19	4.36	0.31	4.96			-	-

Table 3.11: ΔI_{dd} in slave Mode for Wafer 07.

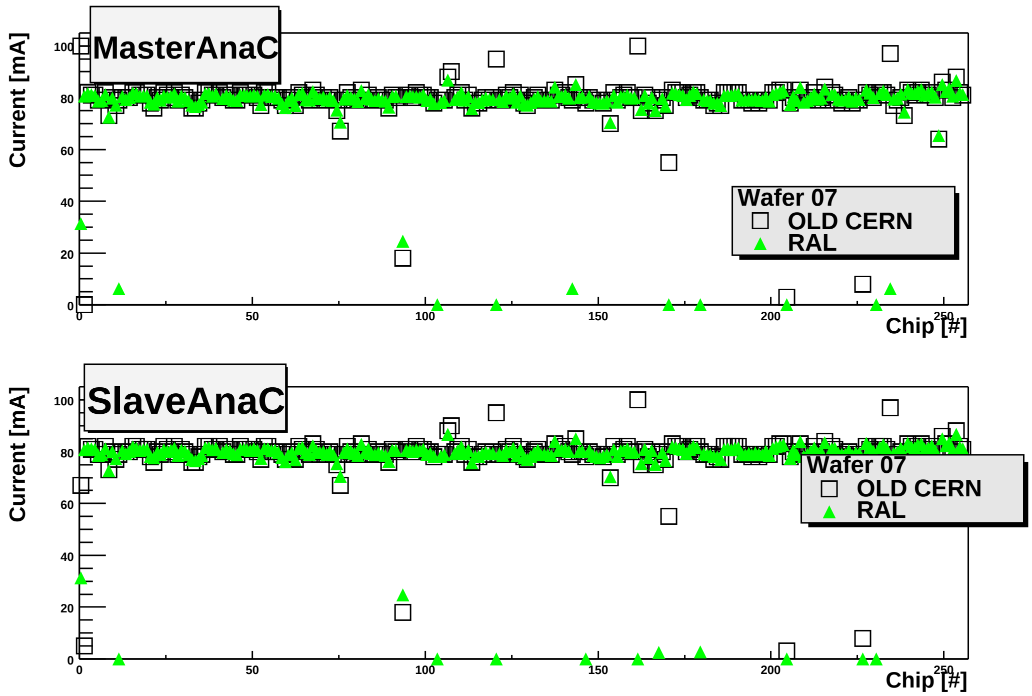

Figure 3.26: I_{cc} scatterplot as master or slave for old CERN and RAL tester of Wafer 07.

Master Analog Current I_{cc} [mA]				
	Wafer 07		Wafer 15	
	Mean	RMS	Mean	RMS
old CERN	79.81	2.93	80.36	2.95
CERN	78.21	2.78	79.48	2.94
RAL	79.80	2.24	80.00	3.23
SCIPP	73.13	2.80	74.05	2.48

Table 3.12: I_{cc} in master mode.

Slave Analog Current I_{cc} [mA]				
	Wafer 07		Wafer 15	
	Mean	RMS	Mean	RMS
old CERN	79.76	3.03	80.38	2.96
CERN	78.23	2.79	79.50	2.94
RAL	79.83	2.24	80.06	3.29
SCIPP	73.03	3.14	74.06	2.50

Table 3.13: I_{cc} in slave mode.

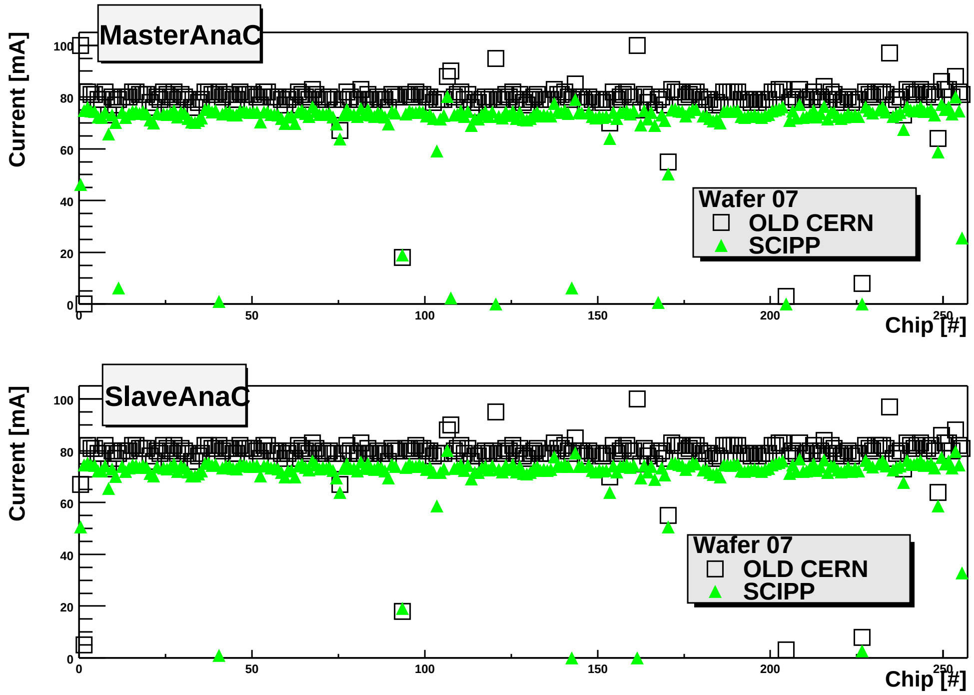

Figure 3.27: I_{cc} scatterplot as master or slave for old CERN and SCIPP tester of Wafer 07.

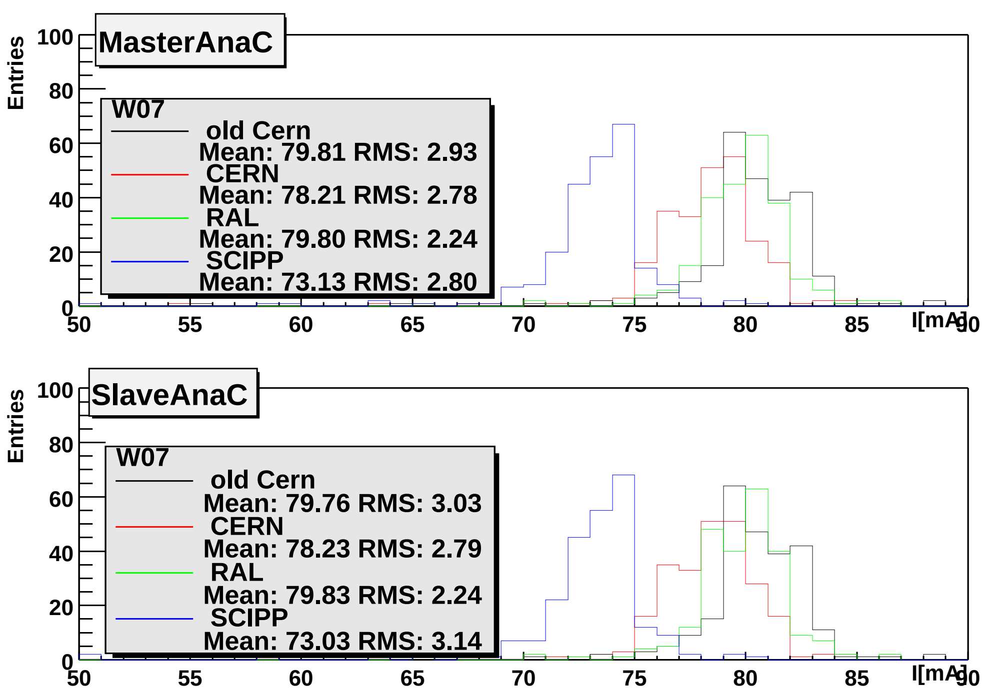

Figure 3.28: Histogram of I_{cc} as slave or master for all testers on Wafer 07.

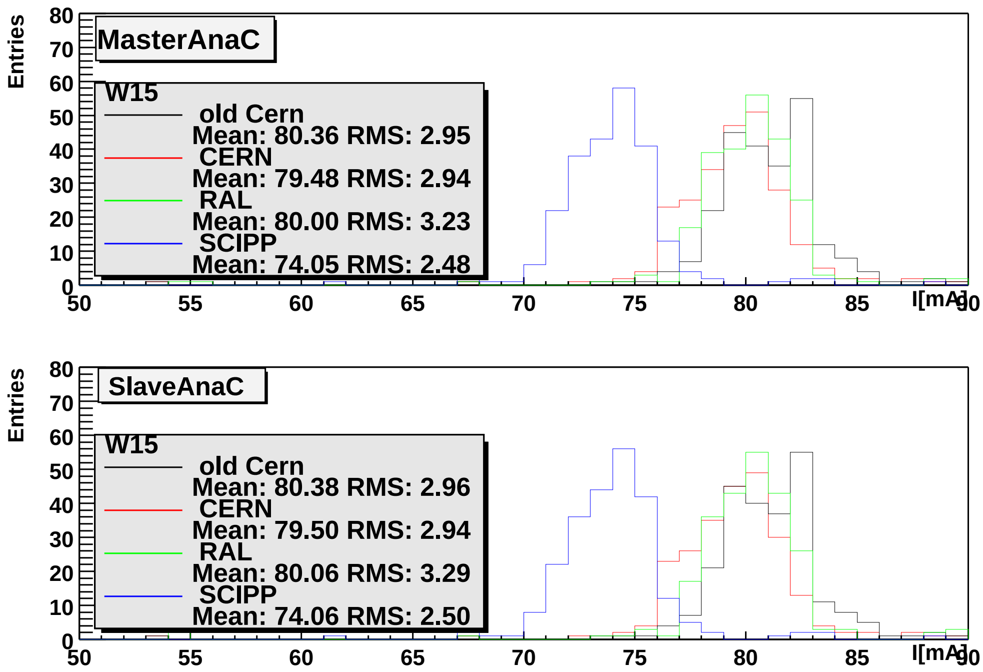

Figure 3.29: Histogram of I_{cc} as slave or master for all testers on Wafer 15.

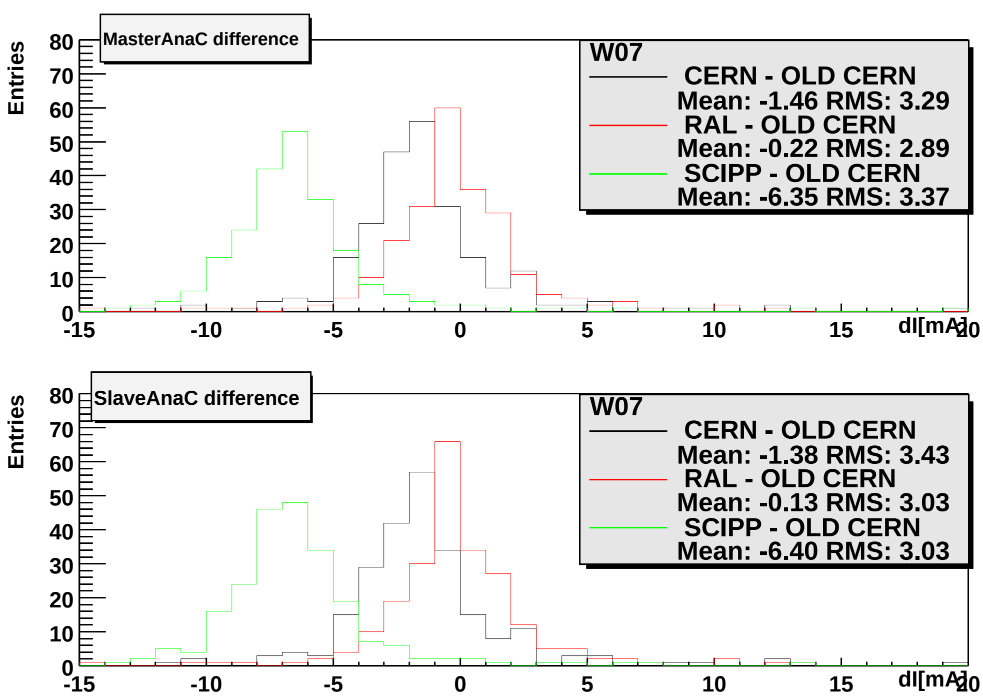

Figure 3.30: Histogram ΔI_{cc} of each new tester to the old CERN tester for Wafer 07.

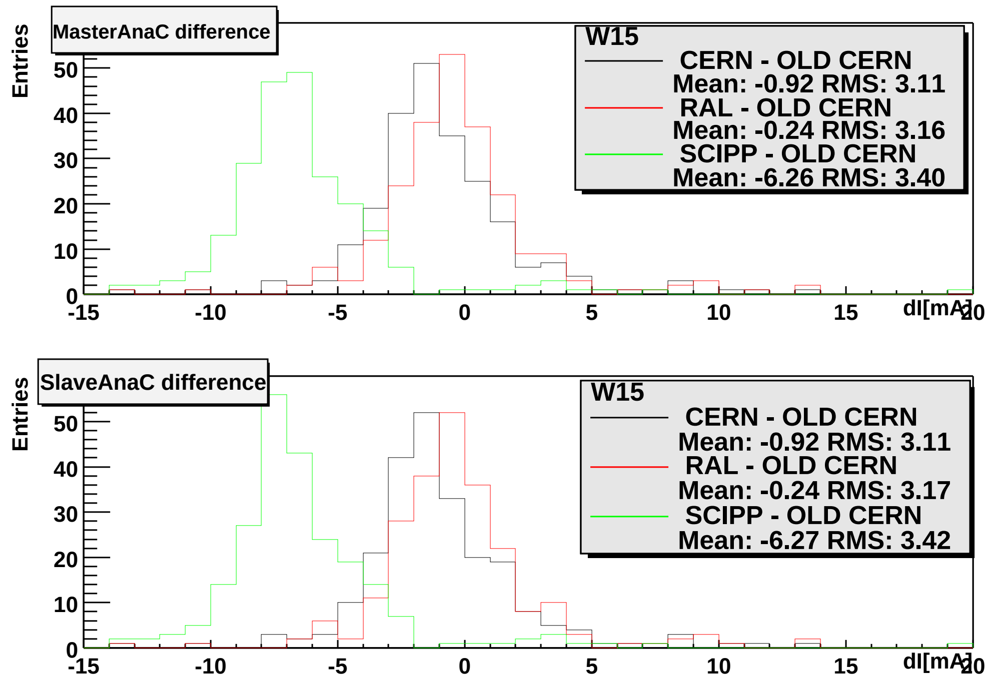

Figure 3.31: Histogram ΔI_{cc} of each new tester to the old CERN tester for Wafer 15.

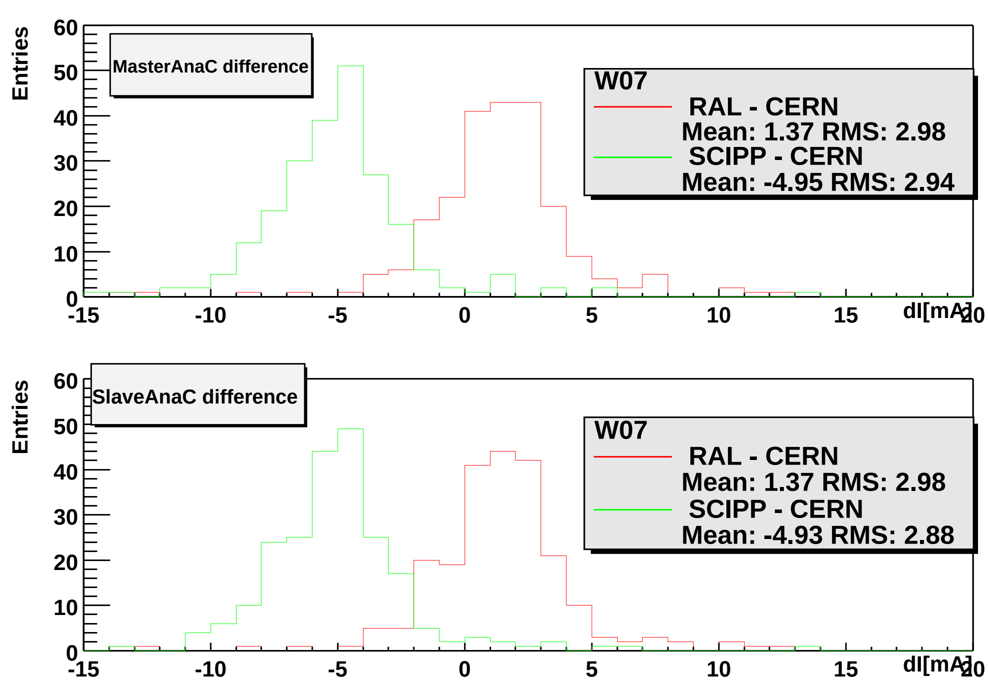

Figure 3.32: Histogram ΔI_{cc} the RAL, CERN and SCIPP tester for Wafer 07.

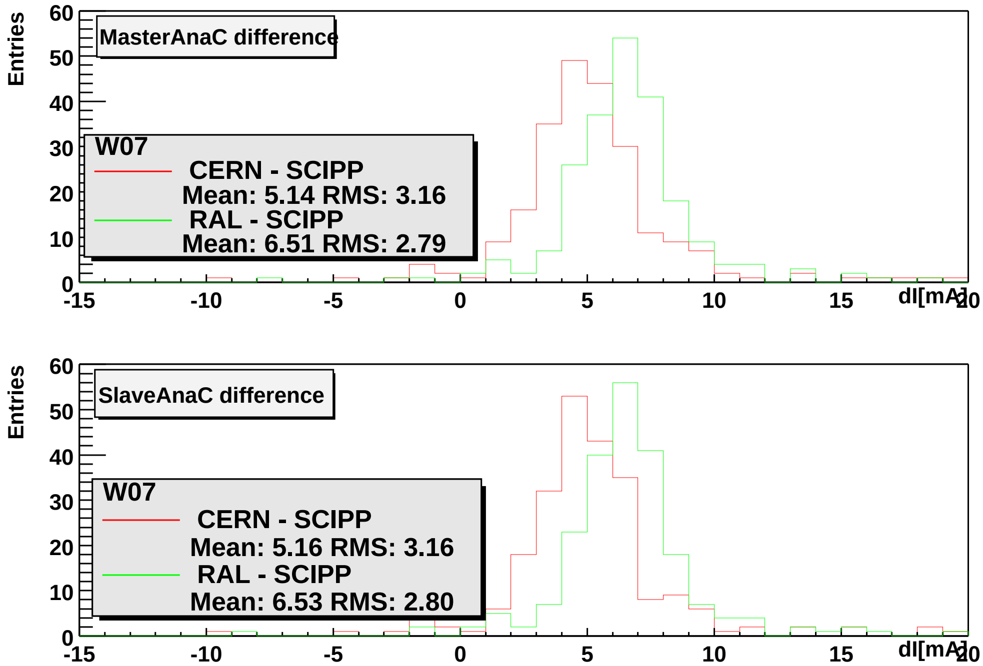

Figure 3.33: Histogram ΔI_{cc} the RAL, CERN and SCIPP tester for Wafer 07.

Difference of analog current I_{cc} in master mode for Wafer 07 [mA]								
	- old CERN		- CERN		- RAL		- SCIPP	
	Mean	RMS	Mean	RMS	Mean	RMS	Mean	RMS
old CERN	-	-						
CERN	-1.46	3.29	-	-			5.14	3.16
RAL	-0.22	2.89	1.37	2.98	-	-	6.51	2.79
SCIPP	-6.35	3.37	-4.95	2.94			-	-

Table 3.14: ΔI_{cc} in master Mode for Wafer 07.

Difference of analog current I_{cc} in slave mode for Wafer 07 [mA]								
	- old CERN		- CERN		- RAL		- SCIPP	
	Mean	RMS	Mean	RMS	Mean	RMS	Mean	RMS
old CERN	-	-						
CERN	-0.92	3.11	-	-			5.16	3.16
RAL	-0.24	3.17	1.37	2.98	-	-	6.53	2.80
SCIPP	-6.27	3.42	-4.93	2.88			-	-

Table 3.15: ΔI_{cc} in slave Mode for Wafer 07.

3.4 Yield

The total yield is the most important number to describe the comparison between the testers as it incorporates the analog, digital and power consumption tests. Table 3.16 shows the yield for all testers and wafers.
The digital yield is slightly lower by a maximum of 6% for the new testers, primarily because of the new test vectors. The agreement for old tester to the new testers is as low as 88%, but all three new testers agree within 94%.
The agreement for the total yield (i.e. perfect yield) is at least 99% for the three new testers and the minimum agreement for the old tester to the new tester is about 98%.

Lot Wafer	Raw Yield or Comparison	Tester or Context	Perfect Yield	1 Dead Channel	2 Dead Channels	Digital Perfect Yield
Z37277A W07	Yield	SCIPP	15 (5.86%)	22 (8.59%)	18 (7.03%)	92 (35.94%)
		old CERN	20 (7.81%)	23 (8.98%)	17 (6.64%)	108 (42.19%)
		CERN	17 (6.64%)	22 (8.59%)	18 (7.03%)	96 (37.50%)
		RAL	15 (5.86%)	21 (8.20%)	18 (7.03%)	95 (37.11%)
	CERN SCIPP	Agree	254 (99.22%)	254 (99.22%)	256 (100.00%)	242 (94.53%)
	CERN old CERN	Agree	251 (98.05%)	243 (94.92%)	249 (97.27%)	238 (92.97%)
	CERN RAL	Agree	254 (99.22%)	253 (98.83%)	254 (99.22%)	243 (94.92%)
	SCIPP old CERN	Agree	249 (97.27%)	241 (94.14%)	249 (97.27%)	236 (92.19%)
	SCIPP RAL	Agree	254 (99.22%)	253 (98.83%)	254 (99.22%)	239 (93.36%)
	old CERN RAL	Agree	249 (97.27%)	240 (93.75%)	247 (96.48%)	239 (93.36%)
Z37277 W15	Yield	SCIPP	17 (6.64%)	15 (5.86%)	16 (6.25%)	114 (44.53%)
		old CERN	16 (6.25%)	17 (6.64%)	16 (6.25%)	117 (45.70%)
		CERN	17 (6.64%)	15 (5.86%)	16 (6.25%)	114 (44.53%)
		RAL	16 (6.25%)	11 (4.30%)	15 (5.86%)	111 (43.36%)
	CERN SCIPP	Agree	256 (100.00%)	252 (98.44%)	249 (97.27%)	241 (94.14%)
	CERN old CERN	Agree	255 (99.61%)	250 (97.66%)	248 (96.88%)	229 (89.45%
	CERN RAL	Agree	255 (99.61%)	252 (98.44%)	251 (98.05%)	243 (94.92%)
	SCIPP old CERN	Agree	255 (99.61%)	252 (98.44%)	247 (96.48%)	226 (88.28%)
	SCIPP RAL	Agree	255 (99.61%)	252 (98.44%)	254 (99.22%)	244 (95.31%)
	old CERN RAL	Agree	254 (99.22%)	250 (97.66%)	247 (96.48%)	232 (90.62%)

Table 3.16: Yield results. 'Agree' shows the absolute number of chips that pass or fail the test on both sites. In parentheses is the ratio in percent of this number to the total number of chips on the given wafer.

4 Conclusion

The comparison of the different sites shows that they give similar results within the fluctuations on the analog and the power consumption part, except I_{cc} for SCIPP and I_{dd} for RAL, which should be easy to fix and does not have an influence on the derived yield.
The new test sites have a good agreement on the digital part as well, but the comparison to the old CERN tester is difficult due to the changes in the TVs. The result for the yield comparison for perfect chips seems to be quite acceptable.

5 Future Work

- The miscalibration of the RAL and SCIPP current measurements has to be corrected.
- The cause for some chips to fail TV4 more frequently on the SCIPP tester needs to be resolved.
- The statistics will be improved by adding the remaining three reference wafers to the comparison once the their testing is completed at all three sites.

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8 References

References

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