CBC, Latches, and Response Time

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Background and Purpose

The purpose of this notepad is to see if increasing CBC latches can decrease CPU and non-idle wait time per buffer get.

Experimental Data

Below is all the experimental data. The experiment was run on a Dell single four-core CPU, Oracle 11.2G. According to "c /proc/version": Linux version 2.6.18-164.el5PAE (mockbuild@ca-build10.us.oracle.com) (gcc version 4.1.2 20080704 (Red H 4.1.2-46)) #1 SMP Thu Sep 3 02:28:20 EDT 2009. There was a tremendous CBC latch contention load, the OS was CPU bott necked at between 95% and 100% utilization and the CPU run queue between 5 and 12. For each sample set, 60 samples we collected each with an interval of 180 seconds. There was also a calm time of 4 seconds between each sample. When t number of latches was changed, the instance was (obviously) cycled, the number of latched and chains checked, the identic CBC load program restarted, and the system was allowed to stabelize for three minutes before the sample collection began.

The order of sample data is sample number, elapsed time (seconds), buffer gets (session logical reads), instance non-idle w time (sec), instance CPU consumption (sec), and DB time (sec).

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    180.310671, 80 069 747, 42.28, 698.47181, 1017.863295, 42, 180.213795, 78 757 549, 52.72, 691.781822,
    1026.405785, 43, 180.205013, 78 471 540, 41.94, 686.865577, 1018.031258, 44, 180.220742, 78 833 878,
    39.68, 689.10323, 1010.306641, 45, 180.216823, 79 311 659, 42.61, 696.85106, 1017.165998, 46,
    180.222645, 78 139 330, 48.2, 682.019311, 1024.72662, 47, 180.300793, 79 151 748, 45.23, 694.562408,
    1027.352977, 48, 180.391127, 80 263 981, 37.68, 709.803082, 1021.996977, 49, 180.216213, 79 511 533,
    39.75, 699.489653, 1021.453255, 50, 180.26257, 80 192 087, 35.03, 704.266935, 1014.044386,
    51, 180.226415, 77 640 118, 53.53, 682.391253, 1020.719593, 52, 180.219639, 78 170 028, 38.67,
    683.45009, 1015.789978, 53, 180.205745, 80 122 821, 36.84, 701.542341, 1012.073465, 54, 180.442426,
    78 606 558, 43.91, 688.565315, 1025.320524, 55, 180.263737, 79 545 331, 42.96, 700.608483, 1017.7414,
    56, 180.158263, 79 693 746, 38.29, 698.586795, 1016.721117, 57, 180.219271, 79 741 930, 39.84,
    694.916351, 1021.183241, 58, 180.21995, 79 116 284, 47.63, 695.084328, 1029.534948, 59, 180.210881,
    78 211 075, 48.08, 685.340806, 1023.055412, 60, 180.222937, 79 151 867, 43, 694.400432, 1011.485485};
```

Data Loading

All the data sets are contained in the above section.

In[10]:=

```
ssNum = 9;
sampleNum = 60;
ss[1] = ss256; latches[1] = 256;
ss[2]  = ss512; latches[2] = 512;
ss[3] = ss1024; latches[3] = 1024;
ss[4] = ss2048; latches[4] = 2048;
ss[5] = ss4096; latches[5] = 4096;
ss[6] = ss8192; latches[6] = 8192;
ss[7] = ss16384; latches[7] = 16 384;
ss[8] = ss32768; latches[8] = 32 768;
ss[9] = ss65536; latches[9] = 65 536;

ncols = 6;
sampleCol = 1;
elapsedTCol = 2;
lioCol = 3;
waitTCol = 4;
cpuTCol = 5;
dbtimeCol = 6;

Do[
  ssLio[ssidx] = {}; ssL[ssidx] = {}; ssSt[ssidx] = {}; ssQt[ssidx] = {}; ssRt[ssidx] = {};
  theSS = ss[ssidx];
  Table[
   elapsedT = theSS[[ncols sampleidx + elapsedTCol]];
   lioTot = theSS[[ncols sampleidx + lioCol]];
   cpuSecTot = theSS[[ncols sampleidx + cpuTCol]];
   waitSecTot = theSS[[ncols sampleidx + waitTCol]];

   λ = lioTot / (1000 elapsedT);
   St = (cpuSecTot 1000) / lioTot;
   Qt = (waitSecTot 1000) / lioTot;
   Rt = St + Qt;

   AppendTo[ssLio[ssidx], lioTot];
   AppendTo[ssL[ssidx], λ];
   AppendTo[ssSt[ssidx], St];
   AppendTo[ssQt[ssidx], Qt];
   AppendTo[ssRt[ssidx], Rt];

   , {sampleidx, 0, sampleNum - 1}
  ];
  , {ssidx, ssNum}
 ];
Length[ssLio[6]]
Take[ssLio[6], 5]
Mean[ssL[6]]
```

Out[29]= 60

Out[30]= {74 774 687, 74 174 241, 73 783 895, 73 859 573, 74 516 434}

Out[31]= 409.834

Basic Statistics

In this section I calculate the basic statistics, such as the mean and median. My objective is to ensure the data has been c lected and entered correctly and also to compare the two datasets to see if they appear to be different.

In[32]:=

```
myData = Table[
    {
     latches[ssidx], Mean[ssL[ssidx]], Mean[ssSt[ssidx]], Mean[ssQt[ssidx]], Mean[ssRt[ssidx]],
     Length[ssLio[ssidx]], N[StandardDeviation[ssL[ssidx]]], N[StandardDeviation[ssSt[ssidx]]],
     N[StandardDeviation[ssQt[ssidx]]], N[StandardDeviation[ssRt[ssidx]]]
    }, {ssidx, 1, ssNum}
   ];
toGrid = Prepend[myData,
    {"CBC\nlatches", "Avg L\n(lio/ms)", "Avg St\n(ms/lio)", "Avg Qt\n(ms/lio)", "Avg Rt\n(ms/lio)",
     "Samples", "Stdev L\n(lio/ms)", "Stdev St\n(ms/lio)", "Stdev Qt\n(ms/lio)", "Stdev Rt\n(ms/lio)"}];
Grid[
 toGrid,
 Frame →
  All]
```

Out[34]=

CBC latches	Avg L (lio/ms)	Avg St (ms/lio)	Avg Qt (ms/lio)	Avg Rt (ms/lio)	Samples	Stdev L (lio/ms)	Stdev St (ms/lio)	Stdev Qt (ms/lio)	Stdev Rt (ms/lio)
256	138.734	0.0284258	0.0288526	0.0572784	60	0.814778	0.000184135	0.000344842	0.000487636
512	210.418	0.0187991	0.0125996	0.0313987	60	1.55396	0.000152414	0.000233856	0.000352127
1024	287.358	0.0137272	0.00546732	0.0191945	60	2.32697	0.0000828219	0.000255526	0.000286022
2048	332.64	0.0118625	0.00464851	0.016511	60	10.0387	0.000398166	0.00123333	0.00160922
4096	387.139	0.0099953	0.0013012	0.0112965	60	3.1811	0.0000335773	0.0000978125	0.000103975
8192	409.834	0.00939936	0.000958364	0.0103577	60	4.13574	0.0000297841	0.0000911158	0.000086636
16 384	427.075	0.00897593	0.000731758	0.00970769	60	4.11008	0.0000380549	0.000064413	0.000066204
32 768	438.803	0.0087585	0.000533976	0.00929247	60	5.34519	0.0000263652	0.0000677016	0.0000638878
65 536	437.329	0.00875556	0.000544505	0.00930007	60	4.52967	0.0000322069	0.0000644969	0.0000645832

In this section I calculate the key parameters for understanding the impact of chaning the number of latches and chains. T columns heading are queuing theory centric, not Oracle-ease centric.

In[35]:=

```
myData = Table[
   {
    latches[ssidx],
    Mean[ssL[ssidx]], 100 * (Mean[ssL[ssidx]] - Mean[ssL[1]]) / Mean[ssL[1]],
    Mean[ssSt[ssidx]], 100 * (Mean[ssSt[ssidx]] - Mean[ssSt[1]]) / Mean[ssSt[1]],
    Mean[ssQt[ssidx]], 100 * (Mean[ssQt[ssidx]] - Mean[ssQt[1]]) / Mean[ssQt[1]],
    Mean[ssRt[ssidx]], 100 * (Mean[ssRt[ssidx]] - Mean[ssRt[1]]) / Mean[ssRt[1]],
    Length[ssLio[ssidx]]
   }, {ssidx, 1, ssNum}
  ];
toGrid = Prepend[myData, {"CBC\nlatches", "Avg L\n(lio/ms)", "%\nChange", "Avg St\n(ms/lio)",
    "%\nChange", "Avg Qt\n(ms/lio)", "%\nChange", "Avg Rt\n(ms/lio)", "%\nChange", "Samples"}];
Grid[
 toGrid,
 Frame →
  All]
```

Out[37]=

CBC latches	Avg L (lio/ms)	% Change	Avg St (ms/lio)	% Change	Avg Qt (ms/lio)	% Change	Avg Rt (ms/lio)	% Change	Samples
256	138.734	0.	0.0284258	0.	0.0288526	0.	0.0572784	0.	60
512	210.418	51.6705	0.0187991	-33.866	0.0125996	-56.3312	0.0313987	-45.1823	60
1024	287.358	107.129	0.0137272	-51.7086	0.00546732	-81.0509	0.0191945	-66.489	60
2048	332.64	139.769	0.0118625	-58.2686	0.00464851	-83.8888	0.016511	-71.1741	60
4096	387.139	179.052	0.0099953	-64.8372	0.0013012	-95.4902	0.0112965	-80.2779	60
8192	409.834	195.411	0.00939936	-66.9337	0.000958364	-96.6784	0.0103577	-81.9169	60
16 384	427.075	207.838	0.00897593	-68.4233	0.000731758	-97.4638	0.00970769	-83.0517	60
32 768	438.803	216.292	0.0087585	-69.1882	0.000533976	-98.1493	0.00929247	-83.7767	60
65 536	437.329	215.229	0.00875556	-69.1985	0.000544505	-98.1128	0.00930007	-83.7634	60

Sample Set Normality Tests

Before we can perform a standard t-test hypothesis tests on our data, we need to ensure it is normally distributed...because th is one of the underlying assumptions and requirements for properly performing a t-test.

Statistical and vIsual normality test

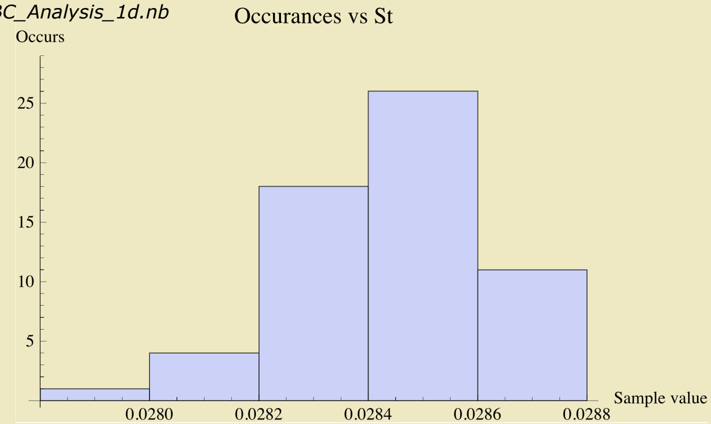
Our alpha will be 0.05, so if the distribution fit test results in a value greater than 0.05 then we can assume the data set is inde normally distributed.

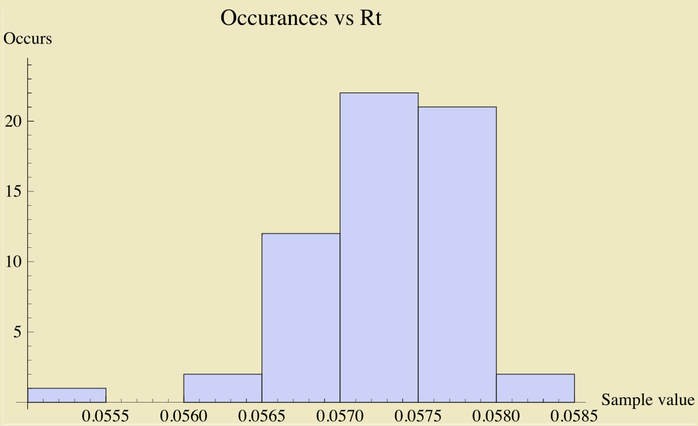
The first test is just to double check to make sure my thinking is correct. Since I creating a normal distribution based on a me and standard deviation (just happens to be based on the my sample set data), I would expect a p-value (the result) to grea exceed 0.05. Notice that the more samples I have created (the final number), the closer the p-value approaches 1.0.

In[38]:=

```
check = DistributionFitTest[
   RandomVariate[NormalDistribution[Mean[ssSt[1]], StandardDeviation[ssSt[1]]], 10 000]];
Do[
  pValueSt = DistributionFitTest[ssSt[i]];
  pValueRt = DistributionFitTest[ssRt[i]];
  Print["Sample set ", i, " with ",
   Length[ssSt[i]], " values. P-values: St=", pValueSt, " Rt=", pValueRt];
  st = Histogram[ssSt[i], PlotLabel → "Occurances vs St", AxesLabel → {"Sample value", "Occurs"}];
  rt = Histogram[ssRt[i], PlotLabel → "Occurances vs Rt", AxesLabel → {"Sample value", "Occurs"}];
  Print[st];
  Print[rt];
  Print["-----------------------------------------------"];
  , {i, 1, ssNum}
 ];
Print["This number should be much greater than 0.05: ", check, " If not try again by re-evaluating."];
```

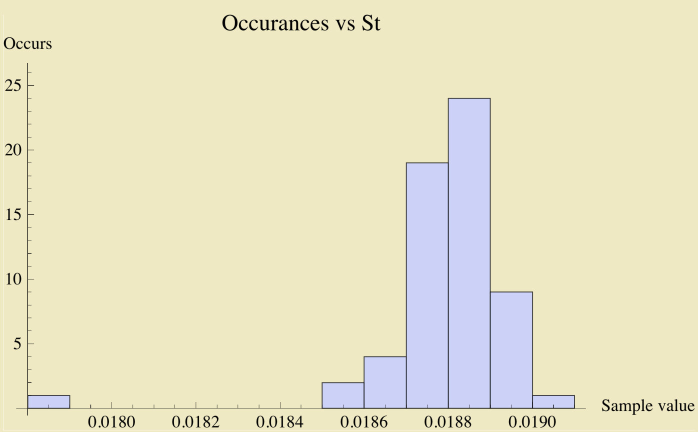
```
Sample set 1 with 60 values. P-values: St=0.0524528 Rt=0.306614
```

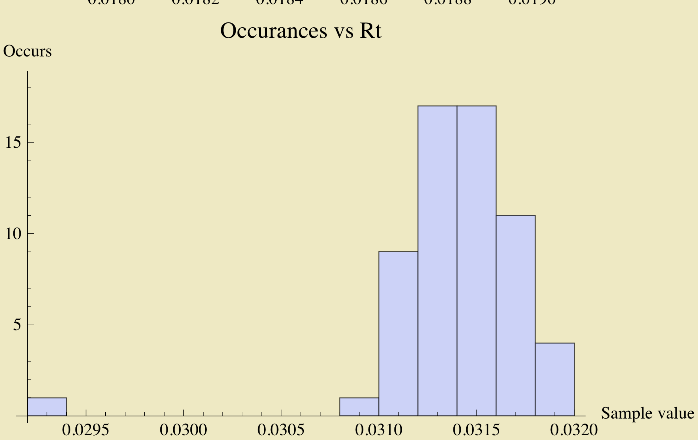





```
--------------------------------------------

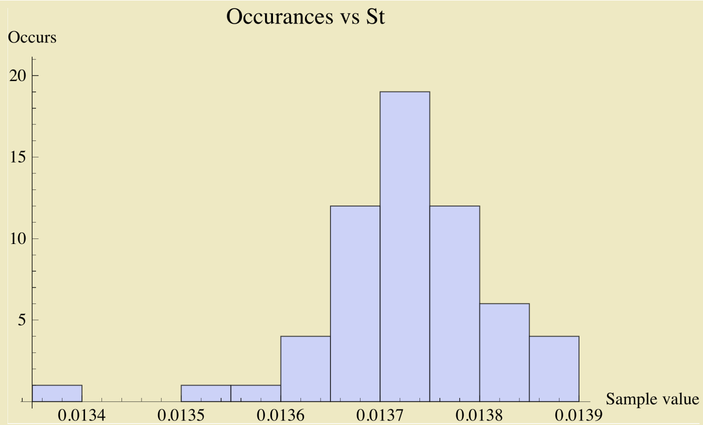
Sample set 2 with 60 values. P-values: St=1.27776 × 10^-6 Rt=0.0000163863
```

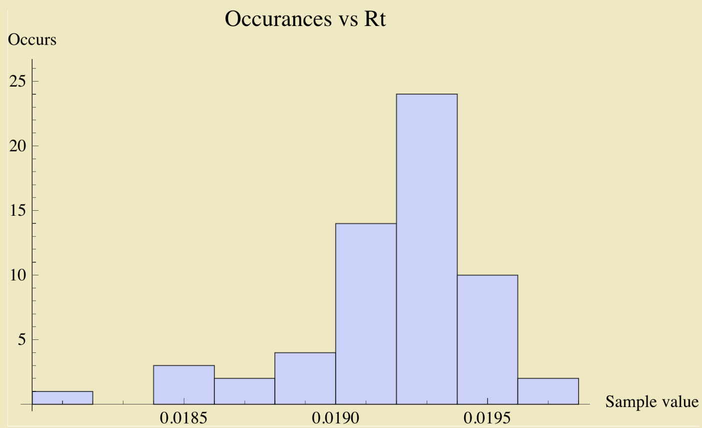





```
--------------------------------------------

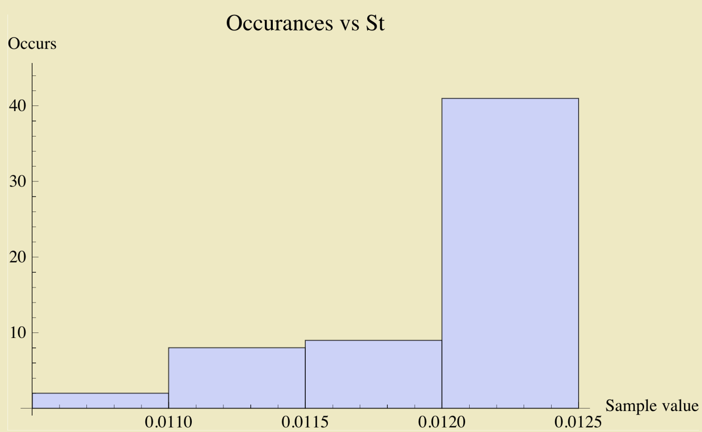
Sample set 3 with 60 values. P-values: St=0.164076 Rt=0.000232992
```

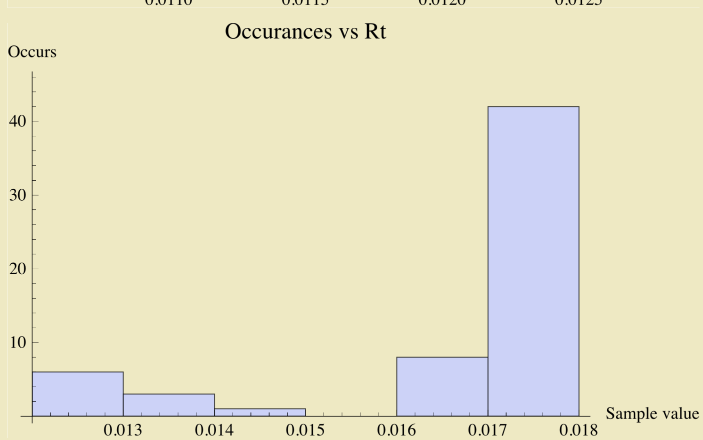





```
-------------------------------------------

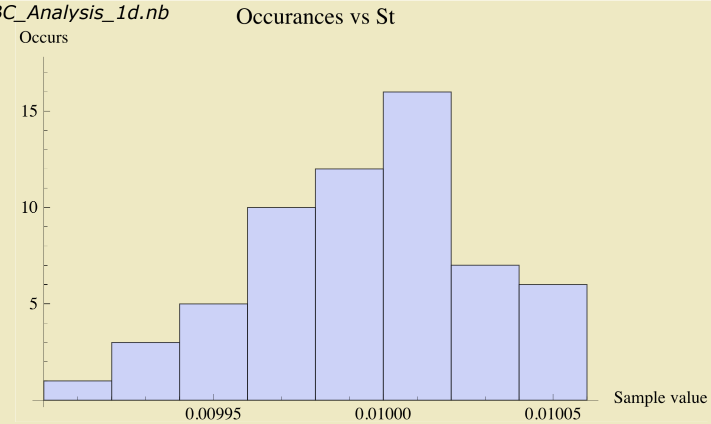
Sample set 4 with 60 values. P-values: St=0. Rt=0.
```

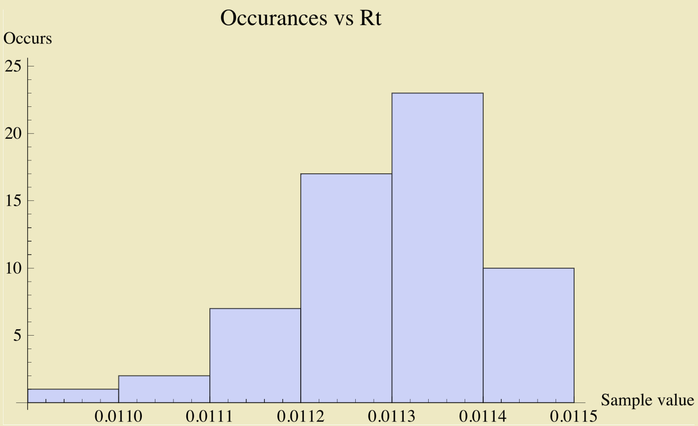





```
-------------------------------------------

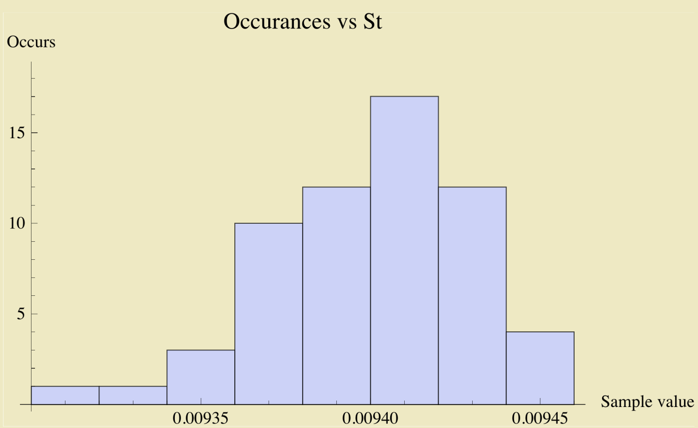
Sample set 5 with 60 values. P-values: St=0.903748 Rt=0.107277
```

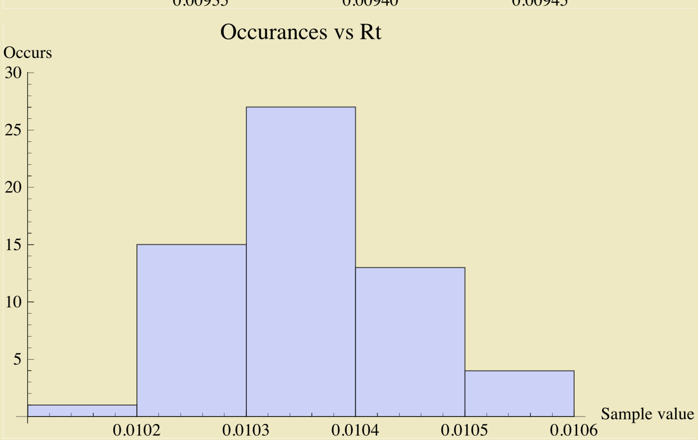





```
------------------------------------------

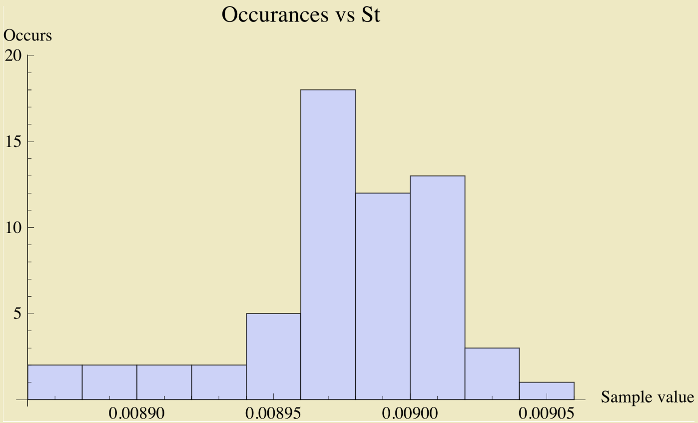
Sample set 6 with 60 values. P-values: St=0.189813 Rt=0.81928
```

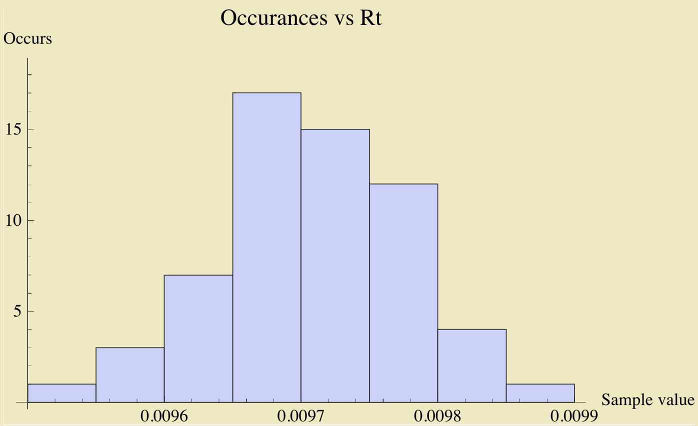





```
------------------------------------------

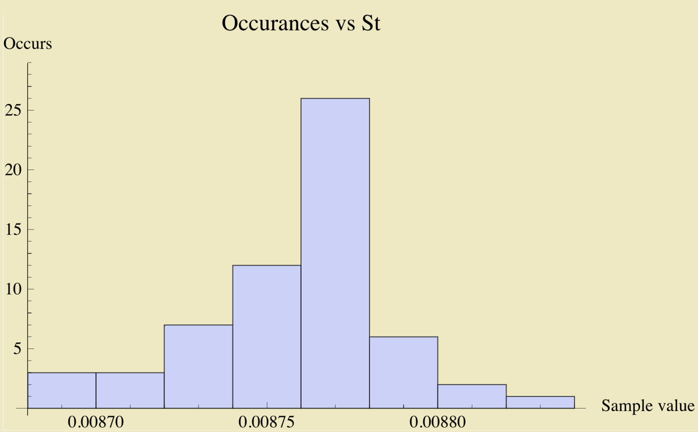
Sample set 7 with 60 values. P-values: St=0.00510801 Rt=0.628153
```

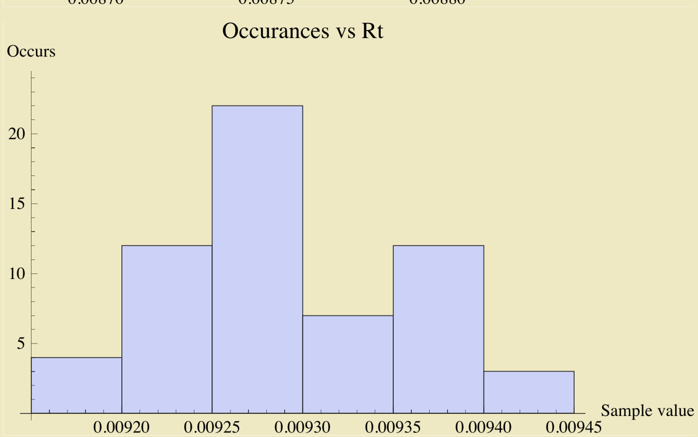





```
-------------------------------------------

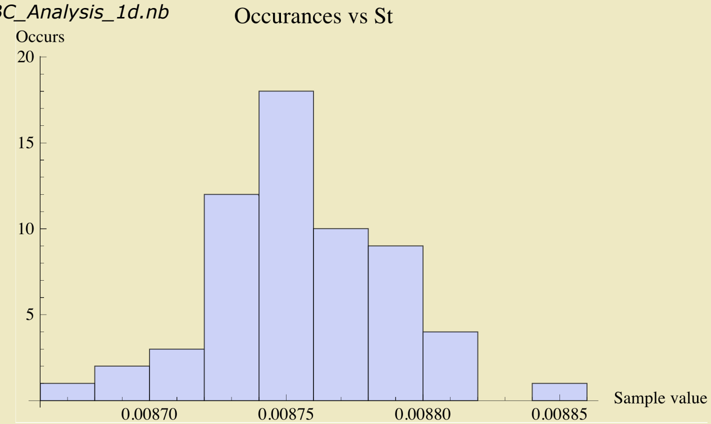
Sample set 8 with 60 values. P-values: St=0.0137613 Rt=0.141916
```

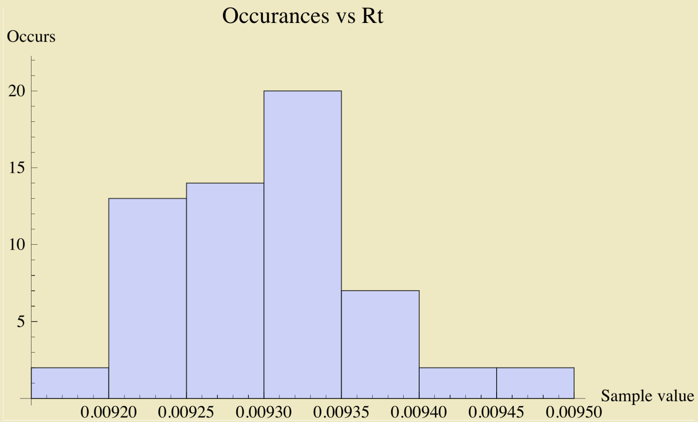





```
-------------------------------------------

Sample set 9 with 60 values. P-values: St=0.897632 Rt=0.207335
```






```
-------------------------------------------

This number should be much greater than 0.05: 0.887174 If not try again by re-evaluating.
```

Sample Comparison Tests (when normality exists)

Assuming our samples **are normally distributed**, now it's time to see if they are significantly different. If so, then we kno changing the number of latches and chains indeed makes a significant performance difference...at least statistically.

The null hypothesis is; there is no real difference between our samples sets. We need to statistically prove that any difference the result of randomness; like we just happened to pick poor set of samples and it makes their difference look much worse thar really is.

A t-test will produce a statistic p. The p value is a probability, with a value ranging from zero to one. It is the answer to this que tion: If the populations really have the same mean overall, what is the probability that random sampling would lead to a differen between sample means larger than observed?

For example, if the p value is 0.03 we can say a random sampling from identical populations would lead to a difference smal than you observed in 97% of the experiments and larger than you observed in 3% of the experiments.

Said another way, suppose I have a single sample set and I copy it, resultling in two identical sample sets. Now suppose v perform a significance test on these two identical sample sets. The resuting p-value will be 1.0 because they are exactly t same. We are essentially doing the same thing here except we have to different sample sets... but we still want to see if th "like" each other..and in our case we hope they are NOT the like each other, which means the p-value will low... below our cut value of 0.05.

For our analysis we choose alpha of 0.05. To accept that our two samples are statistically similar the p value would need to less than 0.05 (our alpha).

Good reference about the P-Value and significance testing: http://www.graphpad.com/articles/pvalue.htm

Here we go (assuming our samples are normally distributed):

1. Our P value threshold is 0.05, which is our alpha.
2. The null hypothesis is the two populations have the same mean. (Remember we have to sample sets, which not the popu tion.)
3. Do the statistical test to compute the P value.
4. Compare the result P value to our threshold alpha value. If the P value is less then our threshold, we will reject the null hypoth sis and say the difference between our samples is significant. However, if the P value is greater than the threshold, we cann reject the null hypothesis and any difference between our samples are not statistically significant.

In[41]:=

```
Do[
  pValueSt = TTest[{ssSt[i], ssSt[i + 1]}];
  Print["St: (", Length[ssSt[i]],
   " values) pvalue between sample set ", i, " and ", i + 1, " is ", pValueSt];
  pValueRt = TTest[{ssRt[i], ssRt[i + 1]}];
  Print["Rt: (", Length[ssRt[i]],
   " values) pvalue between sample set ", i, " and ", i + 1, " is ", pValueRt];
  ,
  {i, 1, ssNum - 1}
 ];
```

TTest::nortst : At least one of the p-values in $\{0.0524528, 1.27776\times10^{-6}\}$, resulting from a test for normality, is below 0.025`. The tests in {T} require that the data is normally distributed. ≫

St: (60 values) pvalue between sample set 1 and 2 is 5.44313×10^{-169}

TTest::nortst : At least one of the p-values in {0.306614, 0.0000163863}, resulting from a test for normality, is below 0.025`. The tests in {T} require that the data is normally distributed. ≫

Rt: (60 values) pvalue between sample set 1 and 2 is 1.01951×10^{-163}

TTest::nortst : At least one of the p-values in $\{1.27776\times10^{-6}, 0.164076\}$, resulting from a test for normality, is below 0.025`. The tests in {T} require that the data is normally distributed. ≫

General::stop : Further output of TTest::nortst will be suppressed during this calculation. ≫

St: (60 values) pvalue between sample set 2 and 3 is 1.42298×10^{-157}

Rt: (60 values) pvalue between sample set 2 and 3 is 2.58161×10^{-153}

St: (60 values) pvalue between sample set 3 and 4 is 7.01882×10^{-44}

Rt: (60 values) pvalue between sample set 3 and 4 is 7.30389×10^{-24}

St: (60 values) pvalue between sample set 4 and 5 is 2.18046×10^{-42}

Rt: (60 values) pvalue between sample set 4 and 5 is 2.68525×10^{-33}

St: (60 values) pvalue between sample set 5 and 6 is 2.42795×10^{-117}

Rt: (60 values) pvalue between sample set 5 and 6 is 8.36543×10^{-85}

St: (60 values) pvalue between sample set 6 and 7 is 2.11358×10^{-96}

Rt: (60 values) pvalue between sample set 6 and 7 is 5.07128×10^{-74}

St: (60 values) pvalue between sample set 7 and 8 is 2.37165×10^{-61}

Rt: (60 values) pvalue between sample set 7 and 8 is 4.21973×10^{-64}

St: (60 values) pvalue between sample set 8 and 9 is 0.585614

Rt: (60 values) pvalue between sample set 8 and 9 is 0.518692

If the above T-Test results (p value) are less then our threshold we can say there is a significant difference between the t sample sets.

Sample Comparison Tests (when normality does NOT exist)

If our sample sets are **not normally distributed,** we can not perform a simple t-test. We can perform what are called locati tests. I did some research on significance testing when non-normal distributions exists. I found a very nice reference:

The paragraph below (which is from the reference above) is a key reference to what we're doing here:

...the need is evident for statistical procedures that enable us to process data of "low quality," from small samples, on variabl about which nothing is known (concerning their distribution). Specifically, nonparametric methods were developed to be used cases when the researcher knows nothing about the parameters of the variable of interest in the population (hence the nar nonparametric). In more technical terms, nonparametric methods do not rely on the estimation of parameters (such as the me or the standard deviation) describing the distribution of the variable of interest in the population. Therefore, these methods a also sometimes (and more appropriately) called parameter-free methods or distribution-free methods.

Being that I'm not a statistician but still need to determine if these sample sets are significant different, I let *Mathematica* det mine the appropriate test. Notice that one of the above mentioned tests will probably be the test *Mathematica* chooses.

Note: If we run our normally distributed data through this analysis (speically, the "LocationEquivalenceTest"), *Mathematica* shou detect this and use a more appropriate significant test, like a t-test.

Here we go with the hypothesis testing (assuming our sample sets are not normally distributed):

1. Our P value threshold is 0.05, which is our alpha.
2. The null hypotheses is the two populations have the same mean. (Remember we have to sample sets, which is not the popu tion.)
3. Do the statistical test to compute the P value.
4. Compare the result P value to our threshold alpha value. If the P value is less then our threshold, we will reject the null hypoth sis and say the difference between our samples is significant. (Which is what I'm hoping to see.) However, if the P value greater than the threshold, we cannot reject the null hypothesis and any difference between our samples are not statistica significant; randomness, picked the "wrong" samples, etc.

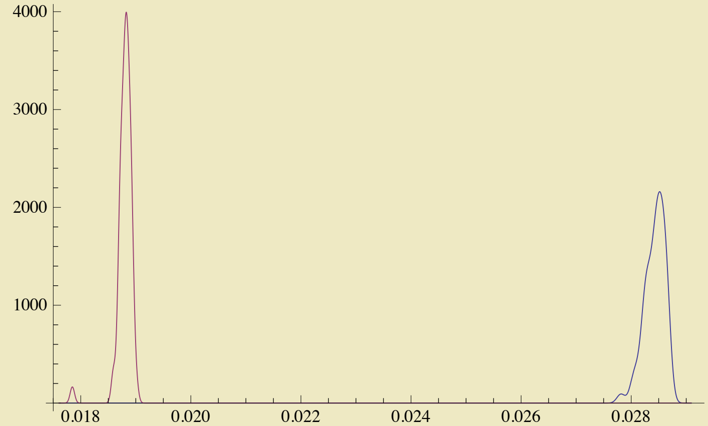
In[42]:=

```
Do[
  StHist = SmoothHistogram[{ssSt[i], ssSt[i + 1]}];
  StTest1 = MannWhitneyTest[{ssSt[i], ssSt[i + 1]}];
  StTest2 = LocationEquivalenceTest[{ssSt[i], ssSt[i + 1]}, {"TestDataTable", "AutomaticTest"}];
  Print["St: (", Length[ssSt[i]], " values) Between sample ",
   i, " and ", i + 1, ". Test1=", StTest1, " Test2=", StTest2];
  Print[StHist];
  Print["-----------------------------------------------------"];
  QtHist = SmoothHistogram[{ssQt[i], ssQt[i + 1]}];
  QtTest1 = MannWhitneyTest[{ssQt[i], ssQt[i + 1]}];
  QtTest2 = LocationEquivalenceTest[{ssQt[i], ssQt[i + 1]}, {"TestDataTable", "AutomaticTest"}];
  Print["Qt: (", Length[ssQt[i]], " values) Between sample ",
   i, " and ", i + 1, ". Test1=", QtTest1, " Test2=", QtTest2];
  Print[QtHist];
  Print["-----------------------------------------------------"];
  RtHist = SmoothHistogram[{ssRt[i], ssRt[i + 1]}];
  RtTest1 = MannWhitneyTest[{ssRt[i], ssRt[i + 1]}];
  RtTest2 = LocationEquivalenceTest[{ssRt[i], ssRt[i + 1]}, {"TestDataTable", "AutomaticTest"}];
  Print["Rt: (", Length[ssRt[i]], " values) Between sample ",
   i, " and ", i + 1, ". Test1=", RtTest1, " Test2=", RtTest2];
  Print[RtHist];
  Print[
   "------------------------------------------------------------------------------------"
  , {i, 1, ssNum - 1}
 ];
```

St: (60 values) Between sample 1 and 2. Test1= 3.55657×10^{-21} Test2={

	Statistic	P-Value
Kruskal-Wallis	89.2562	2.50875×10^{-37}

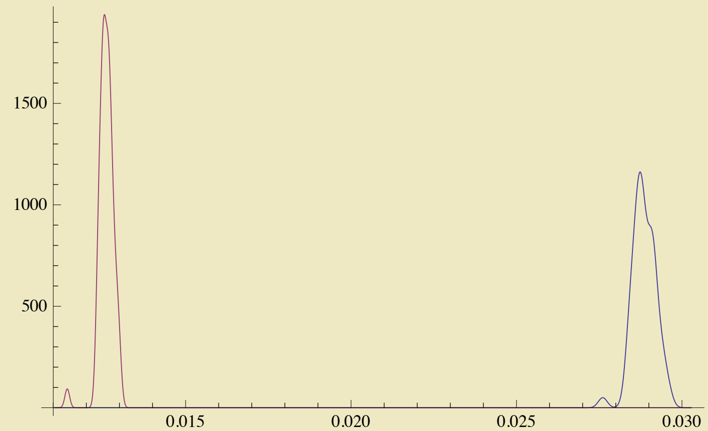
, KruskalWallis}



Qt: (60 values) Between sample 1 and 2. Test1=3.55657×10^{-21} Test2={

	Statistic	P-Value
K-Sample T	91297.5	2.54811×10^{-172}

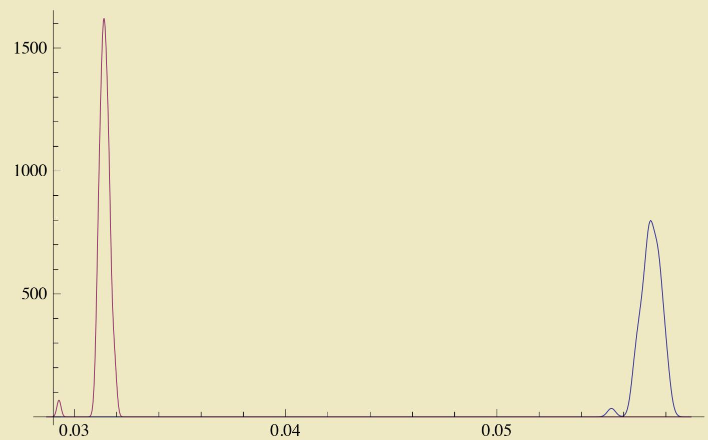
, KSampleT}



Rt: (60 values) Between sample 1 and 2. Test1=
3.55657×10^{-21} Test2={

	Statistic	P-Value
Kruskal-Wallis	89.2562	2.50875×10^{-37}

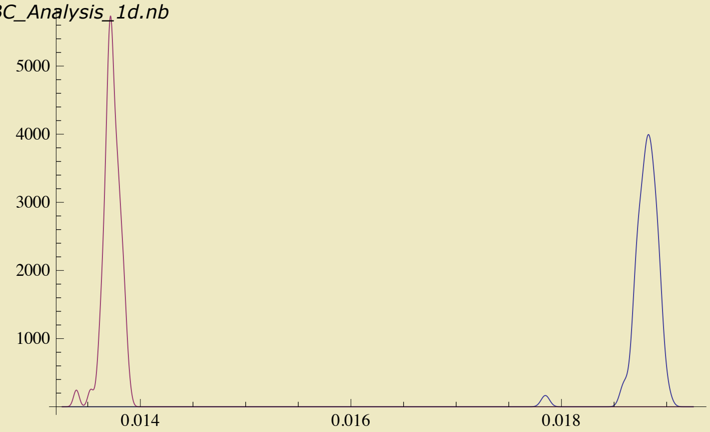
, KruskalWallis}



St: (60 values) Between sample 2 and 3. Test1=
3.55657×10^{-21} Test2={

	Statistic	P-Value
Kruskal-Wallis	89.2562	2.50875×10^{-37}

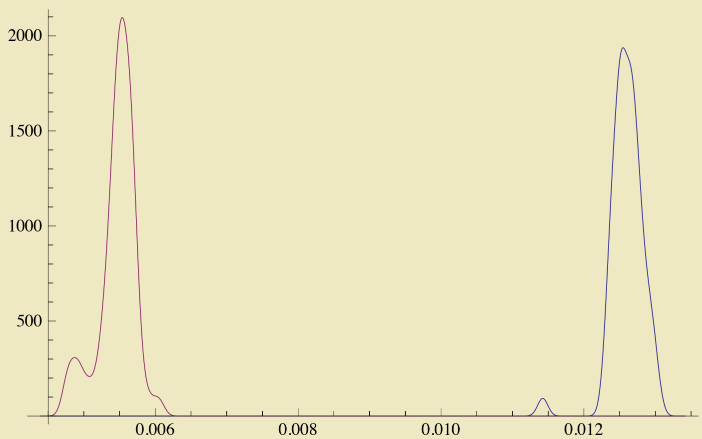
, KruskalWallis}



Qt: (60 values) Between sample 2 and 3. Test1= 3.55657×10^{-21} Test2={

	Statistic	P-Value
Kruskal-Wallis	89.2562	2.50875×10^{-37}

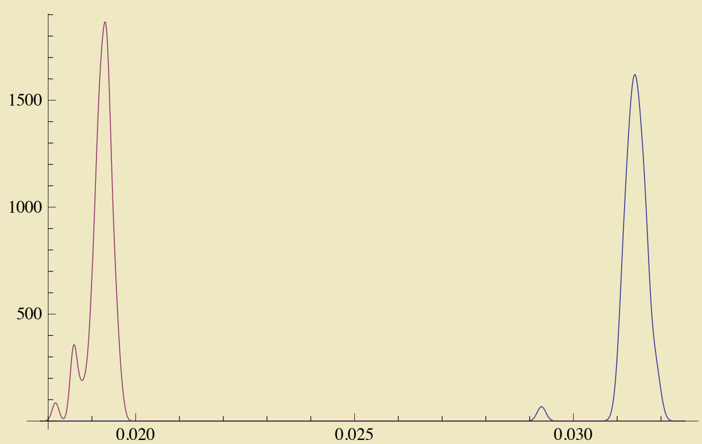
, KruskalWallis}



Rt: (60 values) Between sample 2 and 3. Test1= 3.55657×10^{-21} Test2={

	Statistic	P-Value
Kruskal-Wallis	89.2562	2.50875×10^{-37}

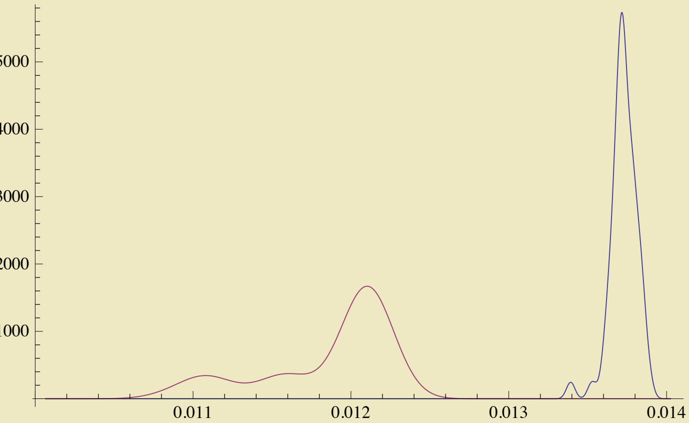
, KruskalWallis}



St: (60 values) Between sample 3 and 4. Test1= 3.55657×10^{-21} Test2={

	Statistic	P-Value
Kruskal-Wallis	89.2562	2.50875×10^{-37}

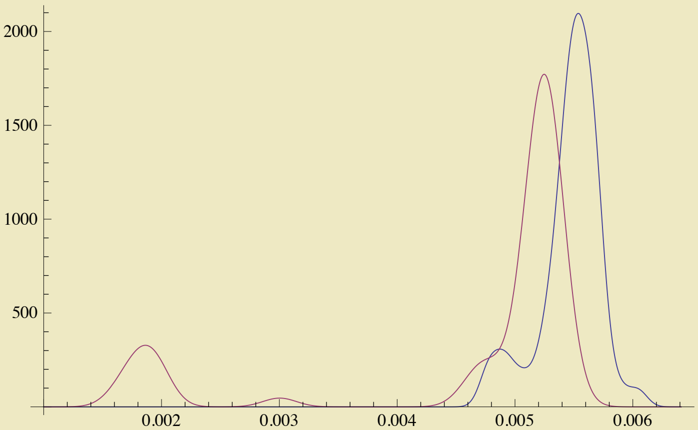
, KruskalWallis}



Qt: (60 values) Between sample 3 and 4. Test1=
2.59347×10^{-13} Test2={

	Statistic	P-Value
Kruskal-Wallis	53.5327	5.27721×10^{-17}

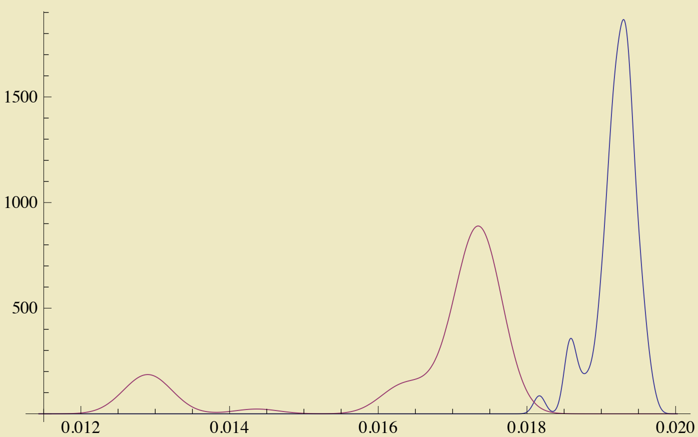
, KruskalWallis}



Rt: (60 values) Between sample 3 and 4. Test1=
3.55657×10^{-21} Test2={

	Statistic	P-Value
Kruskal-Wallis	89.2562	2.50875×10^{-37}

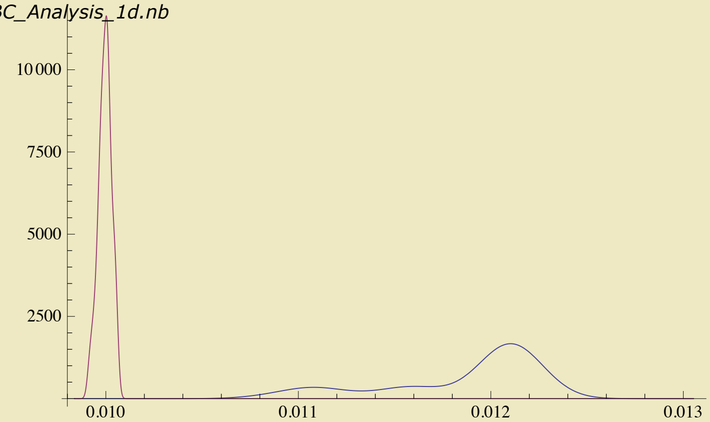
, KruskalWallis}



St: (60 values) Between sample 4 and 5. Test1=
3.55657×10^{-21} Test2={

	Statistic	P-Value
Kruskal-Wallis	89.2562	2.50875×10^{-37}

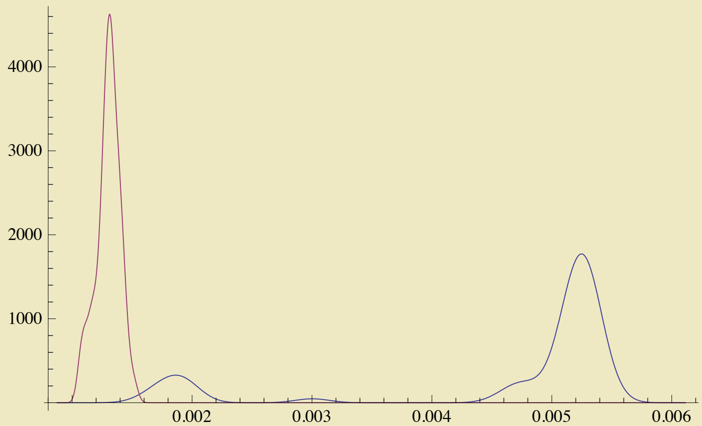
, KruskalWallis}



Qt: (60 values) Between sample 4 and 5. Test1= 3.55657×10^{-21} Test2={

	Statistic	P-Value
Kruskal-Wallis	89.2562	2.50875×10^{-37}

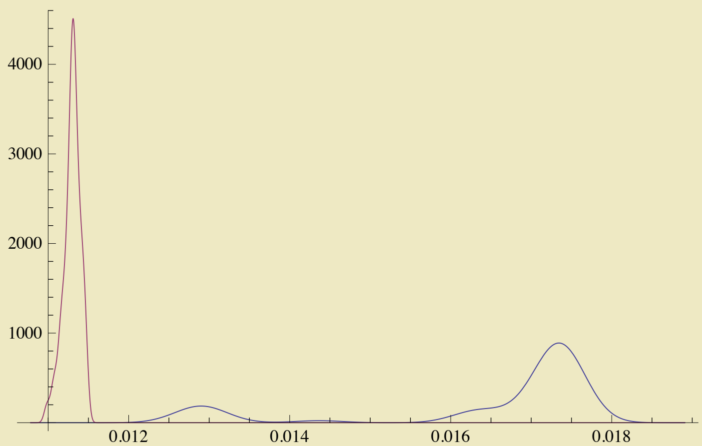
, KruskalWallis}



Rt: (60 values) Between sample 4 and 5. Test1= 3.55657×10^{-21} Test2={

	Statistic	P-Value
Kruskal-Wallis	89.2562	2.50875×10^{-37}

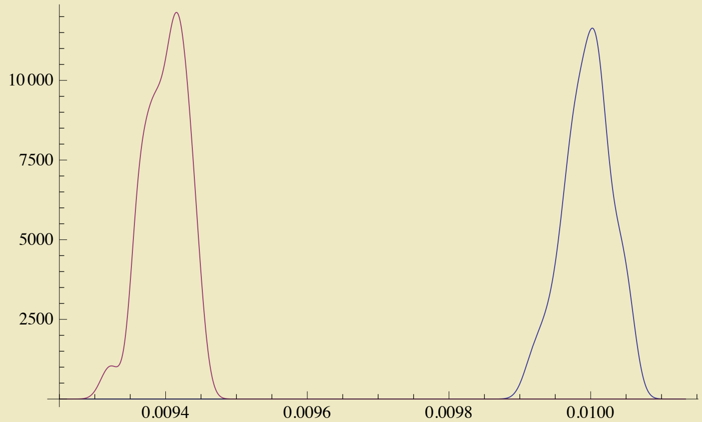
, KruskalWallis}



St: (60 values) Between sample 5 and 6. Test1=3.55657×10^{-21} Test2={

	Statistic	P-Value
K-Sample T	10577.7	2.42795×10^{-117}

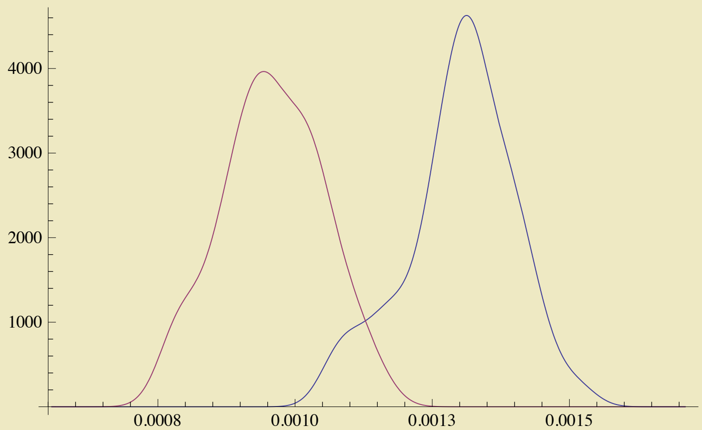
, KSampleT}



Qt: (60 values) Between sample 5 and 6. Test1=1.06416×10^{-20} Test2={

	Statistic	P-Value
K-Sample T	394.658	1.91438×10^{-39}

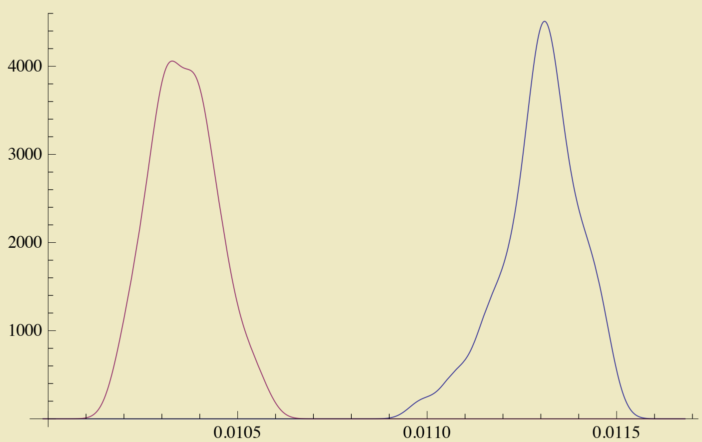
, KSampleT}



Rt: (60 values) Between sample 5 and 6. Test1=3.55657×10^{-21} Test2={

	Statistic	P-Value
K-Sample T	2886.92	8.36543×10^{-85}

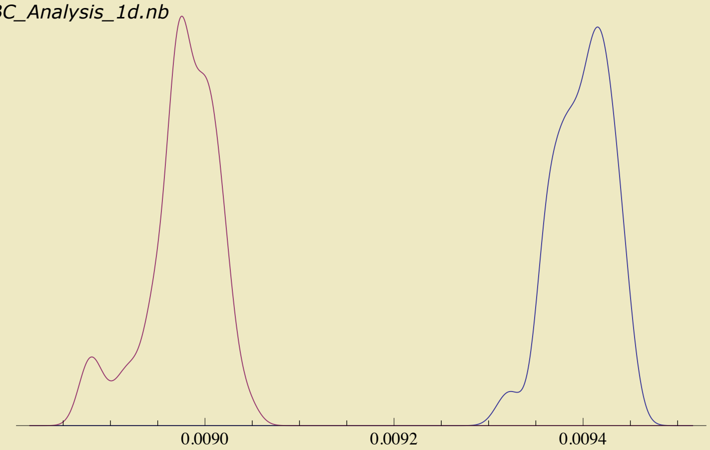
, KSampleT}



St: (60 values) Between sample 6 and 7. Test1=
3.55657×10^{-21} Test2={

	Statistic	P-Value
Kruskal-Wallis	89.2562	2.50875×10^{-37}

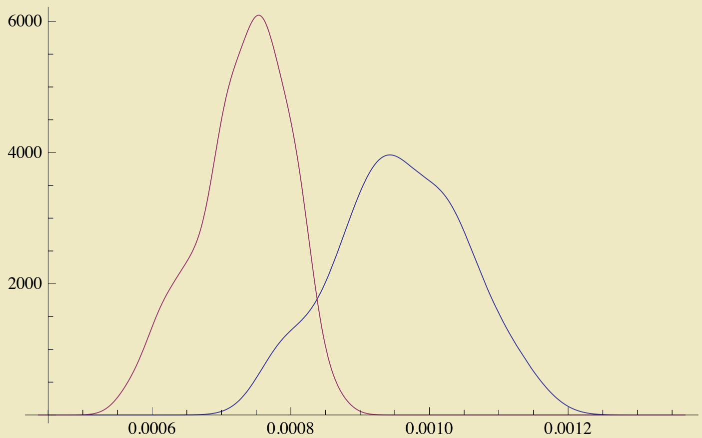
, KruskalWallis}



Qt: (60 values) Between sample 6 and 7. Test1=8.72542×10^{-20} Test2={

	Statistic	P-Value
K-Sample T	247.449	9.60099×10^{-31}

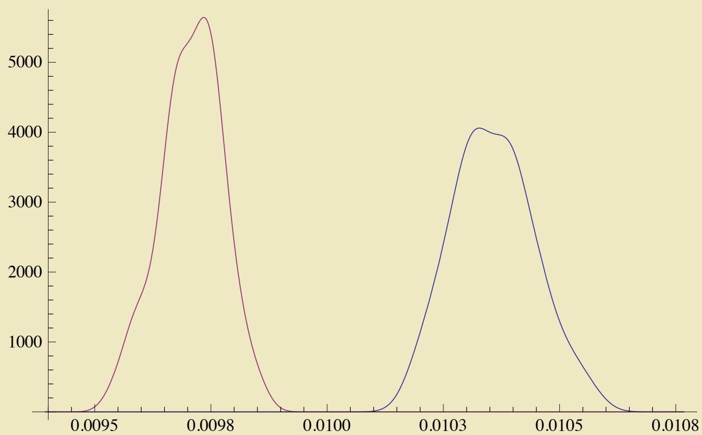
, KSampleT}



Rt: (60 values) Between sample 6 and 7. Test1=3.55657×10^{-21} Test2={

	Statistic	P-Value
K-Sample T	2132.45	2.15619×10^{-77}

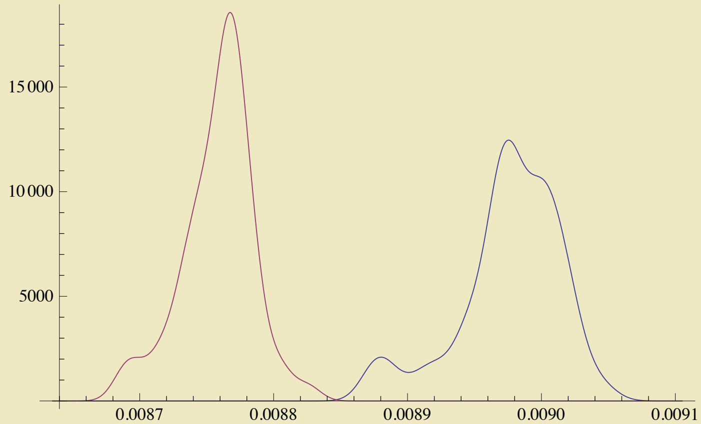
, KSampleT}



St: (60 values) Between sample 7 and 8. Test1=
3.55657×10^{-21} Test2={

	Statistic	P-Value
Kruskal-Wallis	89.2562	2.50875×10^{-37}

, KruskalWallis}

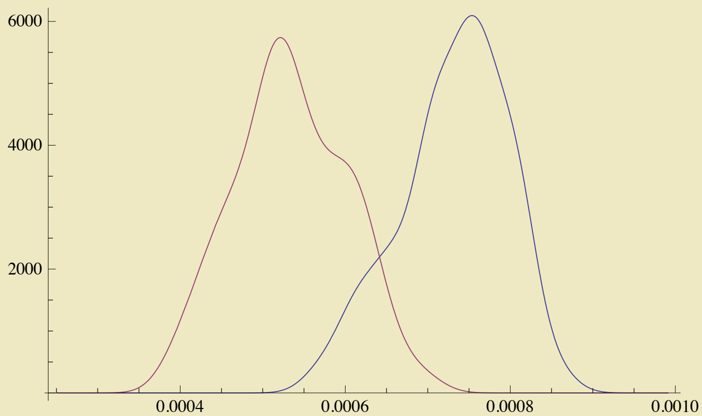



```
--------------------------------------------------------
```

`Qt: (60 values) Between sample 7 and 8. Test1=`1.28345×10^{-19} `Test2=`{

	Statistic	P-Value
K-Sample T	268.772	3.34004×10^{-32}

`, KSampleT`}

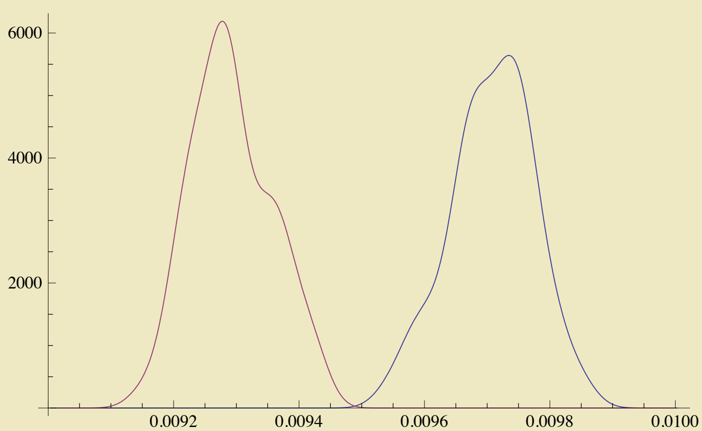



```
--------------------------------------------------------
```

`Rt: (60 values) Between sample 7 and 8. Test1=`3.55657×10^{-21} `Test2=`{

	Statistic	P-Value
K-Sample T	1222.07	4.21973×10^{-64}

`, KSampleT`}

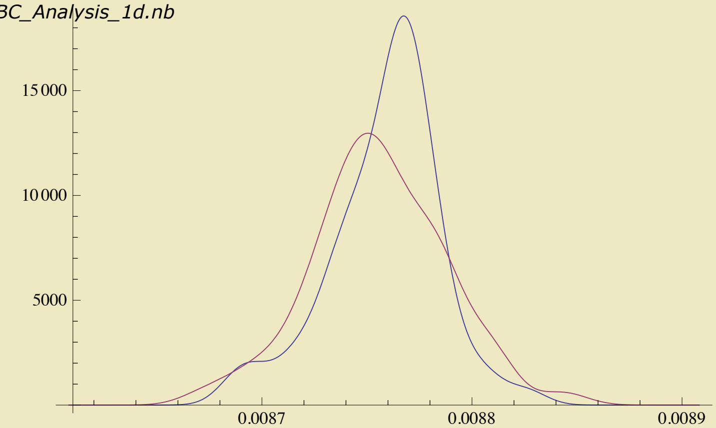



```
-----------------------------------------------------------------------------------------------------
```

`St: (60 values) Between sample 8 and 9. Test1=0.408429 Test2=`{

	Statistic	P-Value
Kruskal-Wallis	0.687713	0.409235

`, KruskalWallis`}

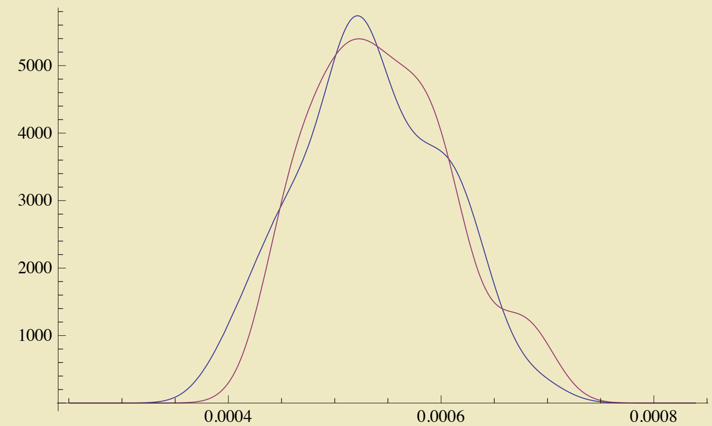



```
-------------------------------------------------------
```

```
Qt: (60 values) Between sample 8 and 9. Test1=0.496695 Test2={
```

	Statistic	P-Value
K-Sample T	0.760787	0.384854

```
, KSampleT}
```

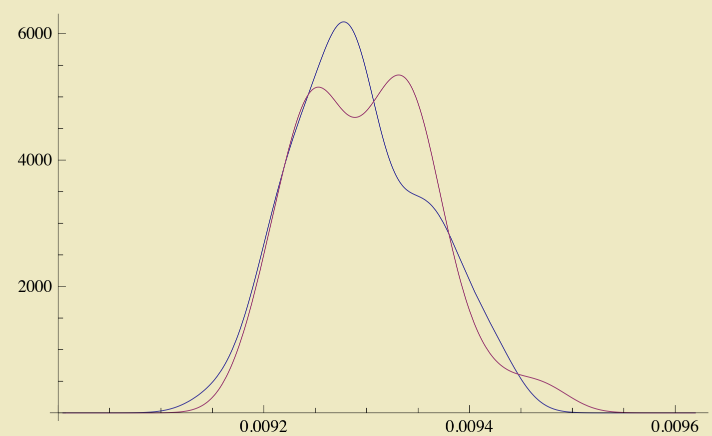



```
-------------------------------------------------------
```

```
Rt: (60 values) Between sample 8 and 9. Test1=0.64605 Test2={
```

	Statistic	P-Value
K-Sample T	0.419003	0.518692

```
, KSampleT}
```




```
---------------------------------------------------------------------------------------------------
```

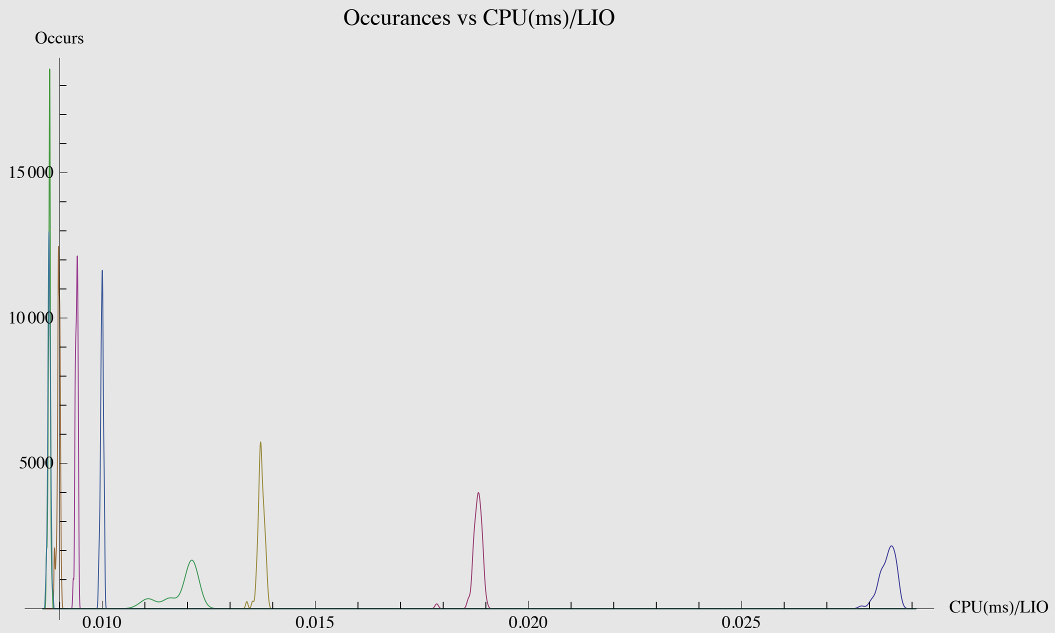
Visually Comparing All Samples

I also wanted to get a nice visual picture of my sample sets...together. Sometimes I include all the sample sets and sometime don't. It's just based on what I want to convey. Sometimes you get a more appropriate view if all the data is not included. That remove ssSt[9] for example.

In[43]:=

```
SmoothHistogram[{ssSt[1], ssSt[2], ssSt[3], ssSt[4], ssSt[5], ssSt[6], ssSt[7], ssSt[8], ssSt[9]},
 PlotLabel → "Occurances vs CPU(ms)/LIO", AxesLabel → {"CPU(ms)/LIO", "Occurs"}]
```

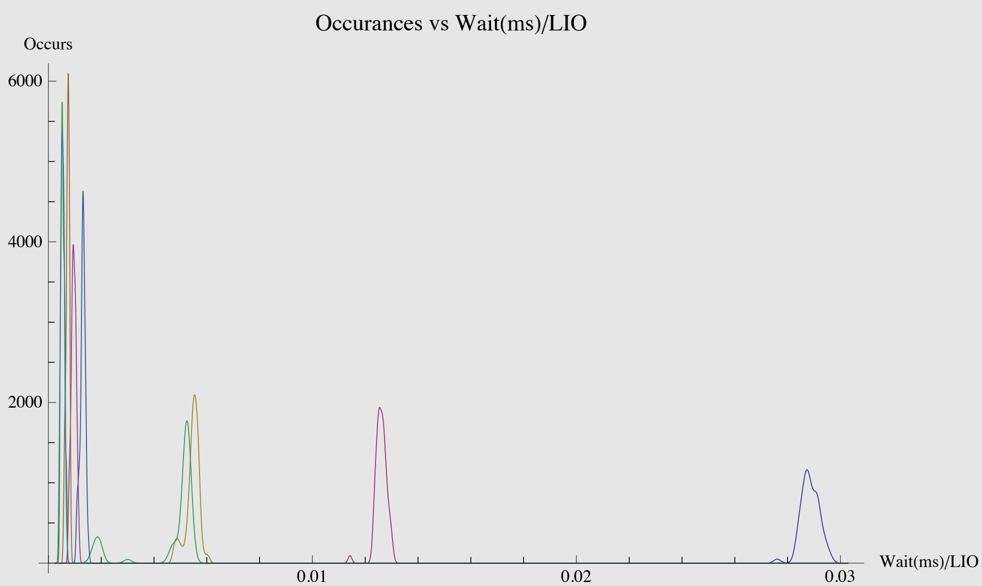
Out[43]=



In[44]:=

```
SmoothHistogram[{ssQt[1], ssQt[2], ssQt[3], ssQt[4], ssQt[5], ssQt[6], ssQt[7], ssQt[8], ssQt[9]},
 PlotLabel → "Occurances vs Wait(ms)/LIO", AxesLabel → {"Wait(ms)/LIO", "Occurs"}]
```

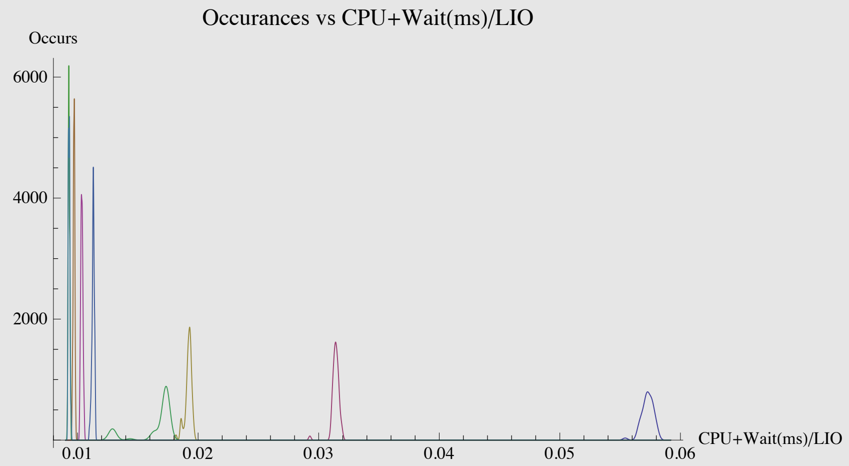
Out[44]=



In[45]:=

```
SmoothHistogram[{ssRt[1], ssRt[2], ssRt[3], ssRt[4], ssRt[5], ssRt[6], ssRt[7], ssRt[8], ssRt[9]},
 PlotLabel → "Occurances vs CPU+Wait(ms)/LIO", AxesLabel → {"CPU+Wait(ms)/LIO", "Occurs"}]
```

Out[45]=



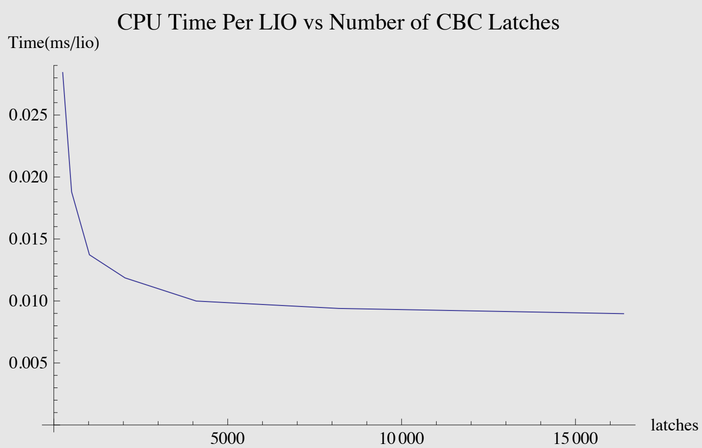
Important Graphics

I also wanted to get a nice visual picture of my sample sets...together. Sometimes I include all the sample sets and sometime don't... settting the leaveOut variable easily controls this. It's just based on what I want to convey.

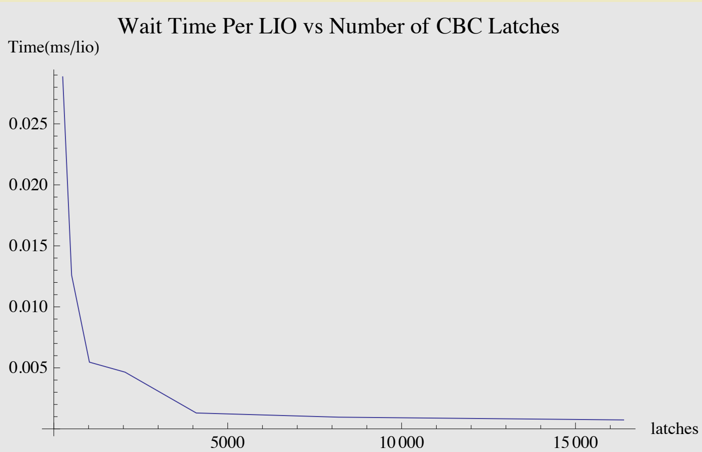
In[46]:=

```
leaveOut = 2;
St = Table[
    {latches[i], Mean[ssSt[i]]}
    , {i, ssNum - leaveOut}
  ];
Qt = Table[
    {latches[i], Mean[ssQt[i]]}
    , {i, ssNum - leaveOut}
  ];
Rt = Table[
    {latches[i], Mean[ssSt[i]] + Mean[ssQt[i]]}
    , {i, ssNum - leaveOut}
  ];
ListPlot[St, AxesOrigin → {0, 0}, PlotStyle -> PointSize[Large], Joined → True,
 AxesLabel → {"latches", "Time(ms/lio)"}, PlotLabel → "CPU Time Per LIO vs Number of CBC Latches"]
ListPlot[Qt, AxesOrigin → {0, 0}, PlotStyle -> PointSize[Large], Joined → True,
 AxesLabel → {"latches", "Time(ms/lio)"}, PlotLabel → "Wait Time Per LIO vs Number of CBC Latches"]
ListPlot[{St, Rt}, AxesOrigin → {0, 0}, PlotStyle -> PointSize[Large], Joined → True,
 AxesLabel → {"latches", "Time(ms/lio)"}, PlotLabel → "CPU+Wait Time Per LIO vs Number of CBC Latches"]
```

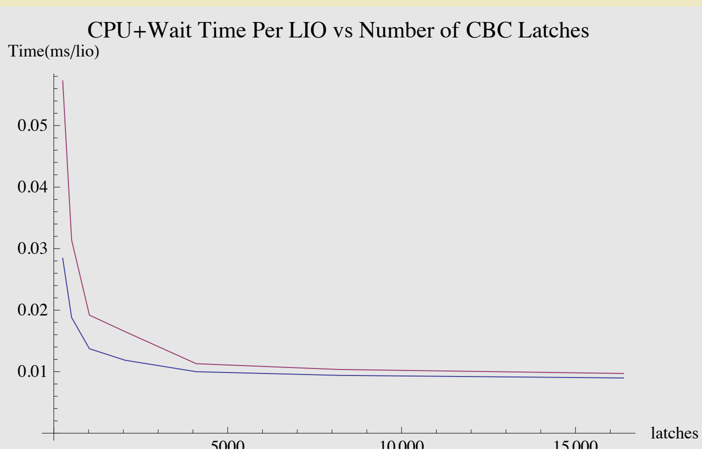
Out[50]=



Out[51]=



Out[52]=



In[53]:=

```
leaveOut = 2;
ListPlot[
 Table[
  {{latches[i], Mean[ssSt[i]]},
   {latches[i], Mean[ssSt[i]] + Mean[ssQt[i]]}
  }
  , {i, ssNum - leaveOut}
 ], AxesOrigin → {0, 0}, PlotStyle -> PointSize[Large], Joined → True, AxesLabel → {"latches", "Time(ms)"}
]
```

Out[54]=