Technical University Berlin

Telecommunication Networks Group

Bit Error Rate Measurements - Second Campaign, **longterm1** measurement

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Chapter 1

Introduction

In this report we partly document the results of a second measurement campaign, taken at the PTZ Berlin. The measurement campaign was divided into three different measurements, each taken on a separate day: the **longterm1** and **longterm2** measurements are closely related, while the **factorial** measurement serves different purposes. The results of the **longterm1** measurement are shown in this report along with some joint discussion of both the **longterm1** and **longterm2** measurements. The companion report [4] shows only the figures for the **longterm2** measurement. Some results of the **factorial** measurement are presented in [3].

This report and the companion reports [4] and [3] serve only the purpose of documentation. The topics are loosely coupled and by no means complete or self-contained. The overall discussion of the second measurement campaign and some further details can be found in an upcoming report, which should be read first [6],

The methodology and the measurement setup used for the second campaign is almost the same as for the first campaign, described in the companion report [5], however, the experience gained with the first campaign is also taken into account.

Chapter 2

Measurement and Evaluation Methodology

Basically we have used the same measurement setup and evaluation methodology as in [5]. To capture the packet loss behaviour, we apply the methodology developed for the bit error behaviour: for every trace we determine the *packet loss indicator sequence* by assigning a zero to received packets and a one to lost packets. In this way, we can use the burst definition given in [5] and talk about packet loss bursts (abbreviated as PLB) and packet loss free bursts (abbreviated as PLFB) in an analog manner. We can apply all methodology and tools developed for the bit error sequences to the packet loss indicator sequences.

Furthermore, we have introduced the following minor changes:

- We have changed the 1b8b coding as discussed in [5] from

  $$\begin{aligned} 0 &\mapsto 00000000 \\ 1 &\mapsto 00111100 \end{aligned}$$

  to

  $$\begin{aligned} 0 &\mapsto 11000011 \\ 1 &\mapsto 00111100. \end{aligned}$$

  The reasons for this are first to have the same number of transmitted zero and one bits, and second, to make the format more sensitive to bit shifts (as explained in [5]).

- Before actually starting the measurements, we have “warmed up” our equipment for half an hour and discarded the results.

- We have introduced a heuristics for detecting bit shifted packets: if the fraction of erroneous bits within a packet is more than 10%the packet is considered as bit shifted (an assessment of the quality of this heuristics can be found in an upcoming report [6]). Bit shifted packets are removed from the traces.

Chapter 3

Campaign 2: Produktionstechnisches Zentrum (PTZ), Berlin, August 28 - August 30, 2000

A second measurement campaign was undertaken from Aug. 28 to Aug. 30 2000, again in the PTZ Berlin[1]. We have investigated the same non-line-of-sight scenario as in [5], the setup is shown in Figure 3.1, the relative position of our setup within the PTZ building (having the ground plan of a circle) is shown in Figure 3.2. The five-axis milling machine was not active during the campaign, however, a huge portal crane, capable of moving 20 tons around, was actively moving for some hours on the first two days of the campaign. The EDM machine was active most of the time, except when changing the workpiece. Most of the other machines were not active. We have performed three different measurements (each on a separate day):

longterm1 : A long time measurement with fixed modulation type, fixed packet size and fixed interpacket time, using modem set 1. The measurement was done on Aug. 28, 2000, started at 10.40 AM and stopped at 15.00 PM. The portal crane was active most of the time.

[1]Definitions: a *measurement campaign* consists of one or more *measurements*. A measurement is distinguished from other measurement by its set of fixed and variable parameters and consists of a number of *traces*. A trace consists of a fixed number of packets, which are all transmitted with the same parameters (modulation type, packet size, gap time, and so forth).

longterm2 : The same measurement as before, with modem set 2. The measurement was done on Aug. 29, 2000, started at 9.28 AM and stopped at 13.50 PM. The portal crane was active most of the time.

factorial : The third measurement was basically the same as in the first campaign, however, with a slightly different set of variable and fixed parameters. The portal crane was not active during this measurement. The measurement was performed on Aug. 30, 2000.

On every day, we have started the measurements with half an hour of dummy measurements, in order to "warm up" the equipment. The results of these dummy measurements were discarded.

From the companion report [5] we know that stochastic models for the Harris/Intersil PRISM chipset in an industrial environment should take at least two phenomena into account: the loss of whole packets due to errors in the packets PHY header, and the bit error process in the remaining packets. The first two measurements are targeted to assess the packet loss process and the long term behaviour of the channel, while the **factorial** measurement is used for building bit error models.

3.1 Measurement Parameters

The **longterm1** and **longterm2** measurements are designed to find answers to the following questions (some of them came up during the first campaign):

- Are the phenomena observed (ghost packets, bit shifts, packet losses, non-uniform clustering of bit errors) due to the modem set actually used?
- Does the presence of scrambling influence the error rates, the bit error behaviour or the packet loss behaviour?
- What can be said about the long term packet loss behaviour?
- What can be said about the long term error rate behaviour?

In order to address these questions, we find the following parameter settings convenient:

- We perform the same measurements with two different modem sets (the modem set 1 corresponds to the **longterm1** measurement, modem set 2 accordingly to the **longterm2** measurement). This allows to assess the dependency on the modem set actually used.

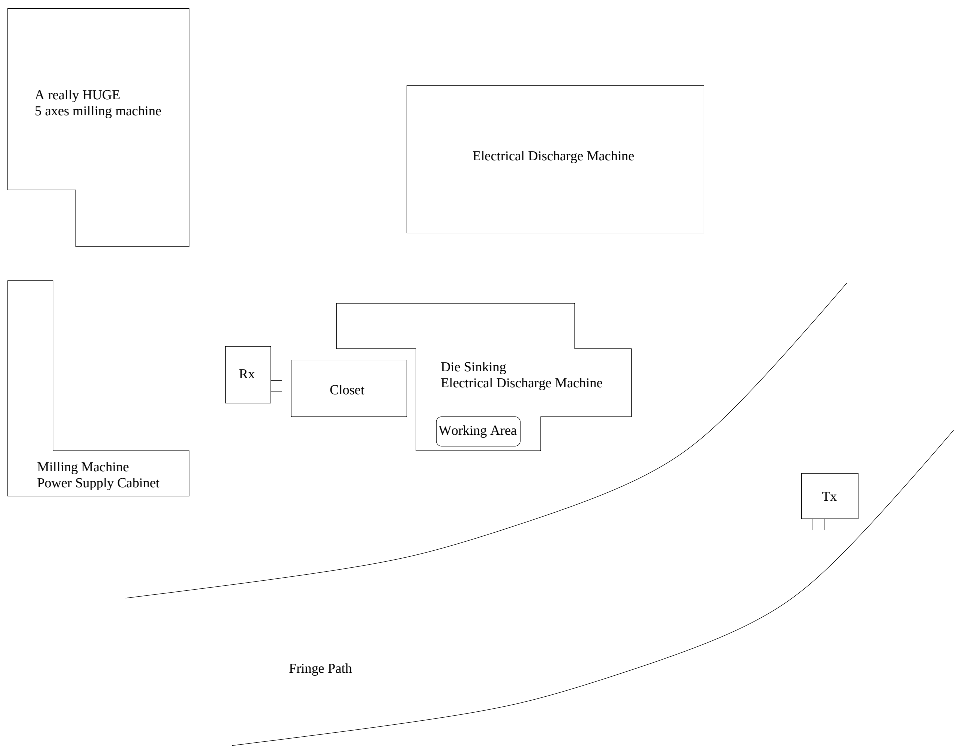


Figure 3.1: Setup of PTZ measurement

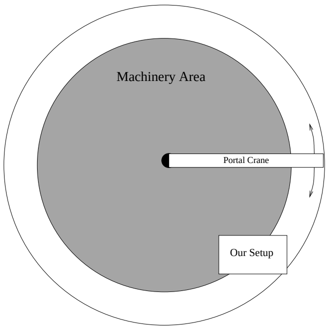


Figure 3.2: Position of our Setup within the Building

Parameter	**Value**
PreambleLength	128 bits
DiversityEnabled	True
SFD Threshold	152
Frequency	12
NumPackets	20000
Rx-Tx-Distance	$\approx$ 7-8 meter
CRCUsageEnabled	False
NumChunks	14
GapTime	1000 μsec
ModulationCode	2 MBit/s QPSK

Table 3.1: Fixed Parameters for **longterm1** and **longterm2** measurements

- To assess the long time behaviour and to allow a direct mapping to the time axis, we have chosen to keep the packet size and the gap times fixed and to perform many (90) measurements per parameter setting.
- The packet size chosen (14 chunks or 504 bytes) was a compromise between having many packets (and thus many traces and many data for investigating the packet loss process) and large-enough packets for making the clustering of bit errors at the beginning of packets visible.
- We have chosen to use the same setup and environment as in the first campaign, and to vary only the modem set and the scrambling mode used.

For the first two measurements **longterm1** and **longterm2** we have fixed all parameters, except the modem set used and the scrambling mode. The set of fixed parameters is shown in table 3.1, the variable parameters are summarized in table 3.2. For each combination of modem set and scrambling mode 90 traces are taken. Within each measurement the traces are numbered consecutively: for every measurement traces 1 to 90 are with *ScramblingEnabled* equals False, while traces 91 to 180 are with *ScramblingEnabled* equals True. So the trace numbers are displaying the time axis. With 90 traces a time duration of 2 hours and 10 minutes is covered. To our knowledge there were no active interferers.

Parameter	**Value**
ScramblingEnabled	True[2], False
Modem Set	modem set 1, modem set 2

Table 3.2: Variable Parameters for **longterm1** and **longterm2** measurements

3.2 Measurement Results

In this section we present the results of our measurements. We restrict ourselves mainly to the **longterm1** measurement, however, findings from the **longterm2** measurement are taken into account where appropriate.

3.2.1 Judging the Measurement Equipment

In this section we discuss the findings related to the behaviour of our measurement equipment. An important question posed in the first measurement campaign was, if some phenomena occured are specific only for the radio modems actually used.

Therefore, it is important to check whether these phenomena (bit shifted packets, ghost packets, non-uniform-clustering of bit errors) occur in both the **longterm1** and **longterm2** measurements, since these are performed with different modem sets, but with otherwise completely identical parameters.

Ghost Packets and Missized Packets

As a *missized packet* we denote a packet, which has not the correct size (as given by *NumChunks* times the size of a chunk). We distinguish between too short (or *truncated*) packets and too long (or *oversized*) packets. Since there was no interferer present (e.g. an IEEE 802.11 access point producing beacon packets) it is reasonable to assume that these packets are produced by errors in the transmission channel or radio hardware. The detection of missized packets is based on the packet size information passed by the Rx module. The notion of ghost packets refer to a packet of correct length, which, however, contains at least one chunk with an already consumed sequence number (and thus is an old packet). This can occur when a currently received packet is streamed into a receiver buffer which was already used and the reception is truncated prematurily.

In figure 3.3 we show the rates of *ghost packets*, *oversized packets* and *truncated packets* (subsumed under the notion of *missized packets*) vs. the trace number for the **longterm1**

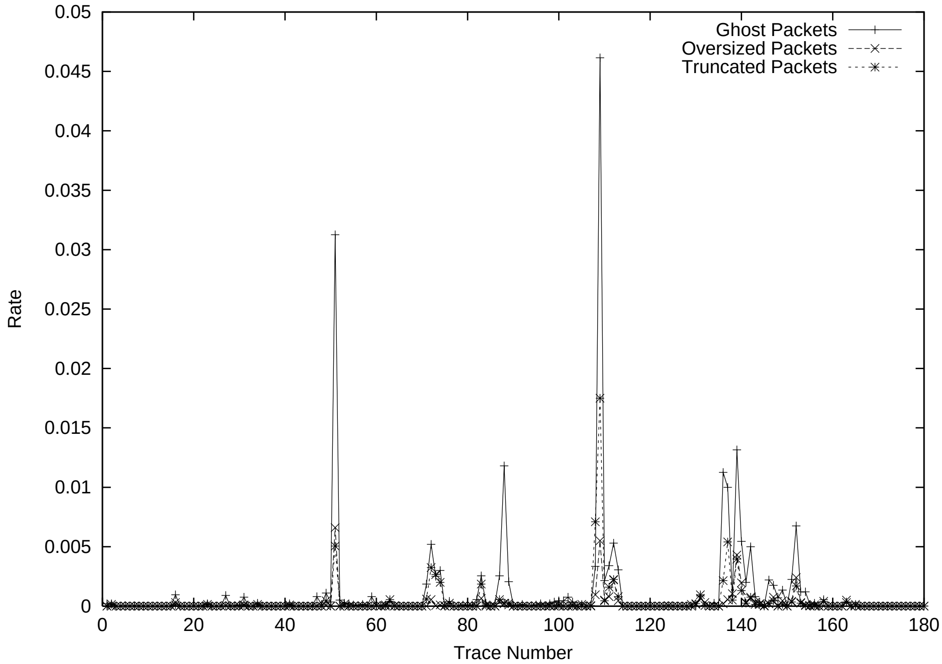


Figure 3.3: Rates of ghost packets, oversized packets and truncated packets vs. trace number for **longterm1** measurement

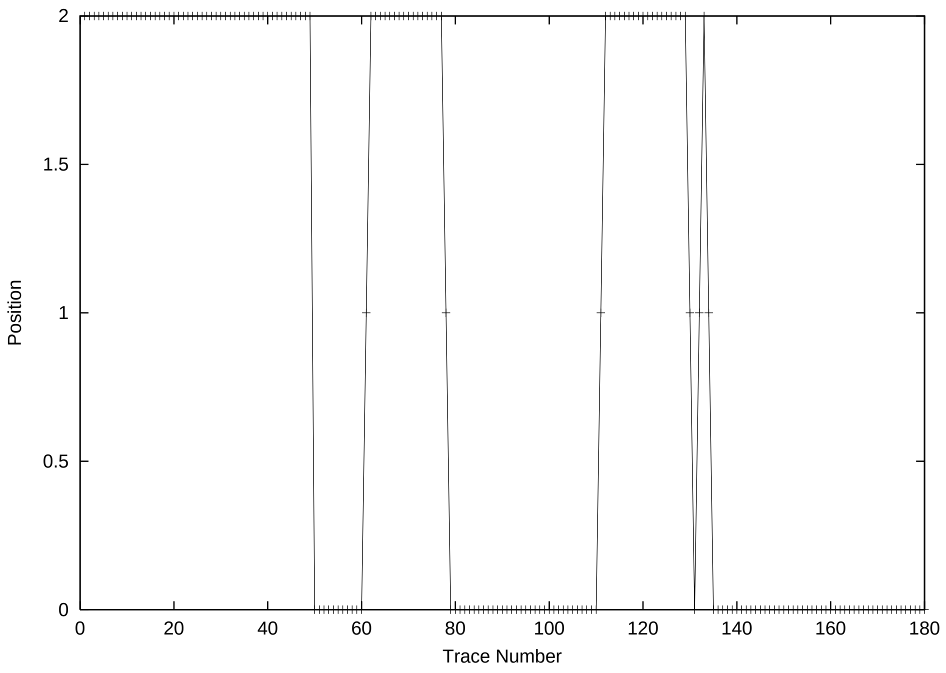


Figure 3.4: Position of portal crane (0=close proximity, 1=short distance, 2=longer distance) for **longterm1** measurement

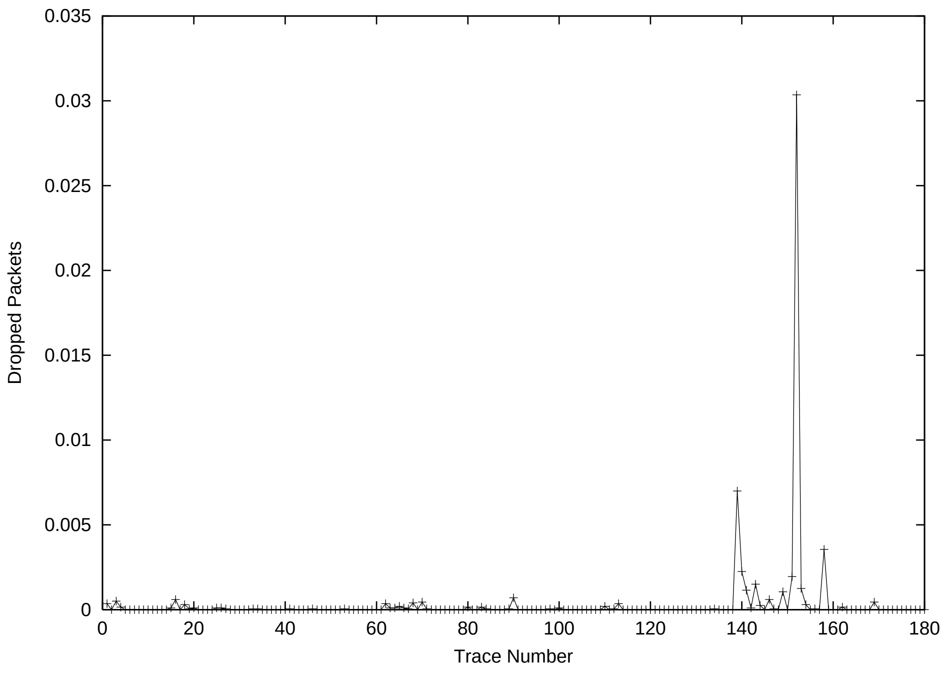


Figure 3.5: Rate of packets dropped due to more than 10% erroneous bits vs. trace number for **longterm1** measurement

measurement. Furthermore we show in figure 3.4 the position of the portal crane with respect to the measurement setup.

For the **longterm1** measurement it can be observed that the rate of truncated packets closely follows the rate of ghost packets, they seem to be strongly correlated, especially the peaks show up at the same traces. Both rates have their peaks at those traces, where the portal crane makes transitions from position 0 (closest to measurement equipment) to position 2 (more than 10 meters away from measurement equipment), i.e. where the derivative of the "portal crane function" is nonvanishing. Furthermore both rates show a significant variability for those traces, where the portal crane is in position 0 (traces 50 to 60 and 80 to 110). A possible explanation of this behaviour is that the portal cranes motors create strong magnetic fields, which disturb the receiver. In almost every case the rate of ghost packets (maximum: $\approx$ 4.7 %) is higher than the rate of truncated packets (maximum: $\approx$ 1.7%). The rate of oversized packets also has its highest values when the portal crane is in position 0, however, the peaks do not follow that closely those of the ghost packets rates (maximum: $\approx$ 1.1%). If the portal crane is at position 2 (more than 10 meters away), the rates of ghost packets and missized packets are always below 1%.

For the **longterm2** measurement things look slightly different: although in general the ghost packets have the highest rates (maximum: $\approx$ 5.5%), for some traces, e.g. trace 42, the rate of truncated packets (maximum: $\approx$ 3.7%) is significantly higher than the rate of ghost packets. However, again both rates seem to be strongly correlated. For traces 135 to 145 the oversized packets rate (maximum: $\approx$ 4.5%) is also larger than the ghost packets rate. We can also observe that when the portal crane is close (position 0), all rates are strongly varying, and the rates are low when the crane is away (position 2), except for traces 1 to 15. For this measurement there seems to be no clear relationship between peaks of the three rates and the transients of the portal crane function.

It is important to note that ghost packets and missized packets occur also in the **factorial** measurement and especially for the BPSK traces, see [3], and thus do not depend on the modulation type (or the need to switch the modulation type at the beginning of the data part of the packet). Furthermore there are only few ghost packets, but much more truncated and oversized packets.

In Figure 3.5 we show the number of dropped packets, i.e., those packets removed from the trace because they are considered to be bit shifted. This removal is based on a heuristic, which considers each packet with more than 10%wrong bits as bit shifted. It can be seen that the rates of dropped packets are comparably low, only for trace 152 it reaches $\approx$ 3%.

To summarize, the important observations are:

- Ghost packets and missized packets occur with both modem sets.
- The rates are correlated to the position and movement of the portal crane, likely due to strong magnetic fields. If the crane is close, one can observe high rates and variation in the rates.
- For both measurements the rates of ghost packets and missized packets are smaller than 5.5%.
- There seems to be no dependency on the modulation type.
- None of the effects is clearly dominating the others.

Position of Bit Errors

In tables 3.3, 3.4, and 3.5 we show the error position histograms for all traces, where the mean bit error rate (MBER) E_k exceeds a threshold of 10^{-5}.

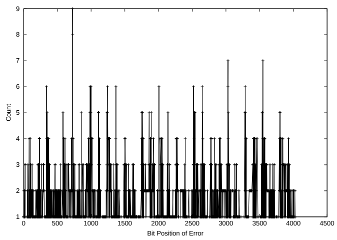
Most traces of the **longterm1** measurement show a pronounced spike between indices 200 and 250, regardless of the scrambling mode. The same holds for the **longterm2** measurement. However, especially during **longterm2** a number of 18 traces (20 to 38) do not show this peak, even if they have higher bit error rates of around 10^{-3} , thus the presence of this peak seems to be "seasonal". In the **factorial** measurement this peak is almost always present for BPSK and QPSK traces without scrambling, for BPSK and QPSK traces with scrambling this effect shows up sometimes, but is often overshadowed by an 128 bit pattern discussed below. In traces with 5.5 MBit/s CCK or 11 MBit/s CCK this peak is not visible. The important points of the "position 250 peak" are:

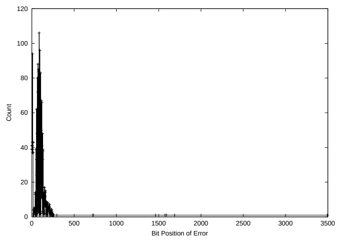
- The peak at 250 occurs in most cases for BPSK and QPSK modulation, regardless of the scrambling mode. For the CCK modes it cannot be observed, thus it depends on the modulation type.
- It occurs for both modem sets.

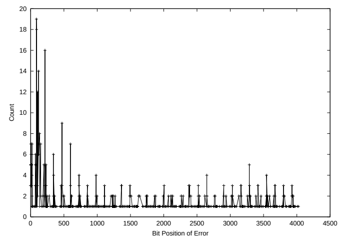
Another pattern which occurs frequently is the "128 bit spikes pattern" ("spikes pattern" for short). Example traces from **longterm1** showing this pattern are 111, 112, 113, 138 and 139. The period of this pattern is 128, as taken by inspection from traces 113 and 139. In the **longterm2** measurement this pattern occurs e.g. in traces 17, 62, 68, 101, 106 and 107, thus in traces with and without scrambling. However, it is our impression that this pattern shows up more clearly in traces with scrambling. Up to now we have no satisfactorily explanation for this pattern. The important points for the "spike pattern" are:

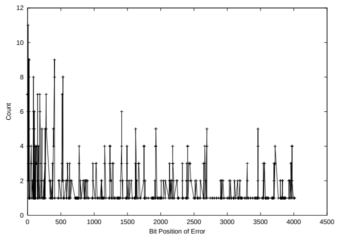
- It occurs for both modem sets.
- It occurs with and without scrambling (for modem set 1 it was not observed for traces without scrambling), but seems to be more pronounced if scrambling is enabled.

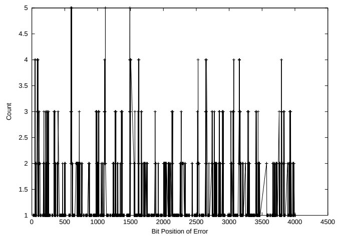
For some **longterm1** traces with scrambling the number of errors per bit position tends to increase towards higher indices (e.g. traces 143, 152). From inspection this behaviour is due to bit shifts occuring in the mid of packets.

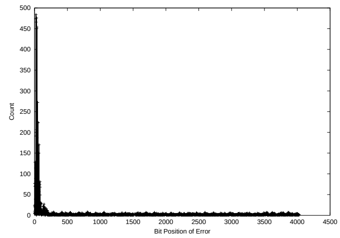

Trace 16, $E_k = 0.000042$

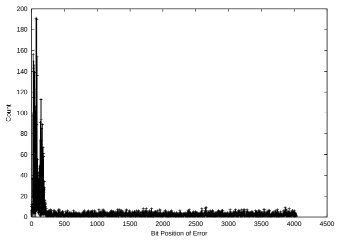

Trace 51, $E_k = 0.000066$

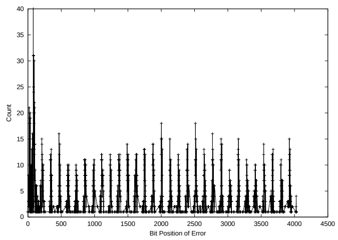

Trace 72, $E_k = 0.000011$

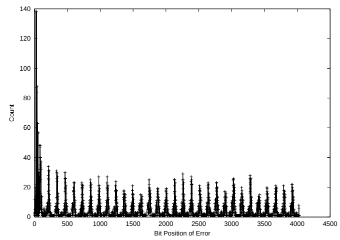

Trace 83, $E_k = 0.000016$

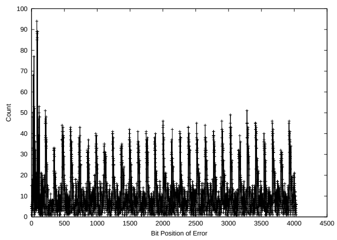

Trace 100, $E_k = 0.000025$

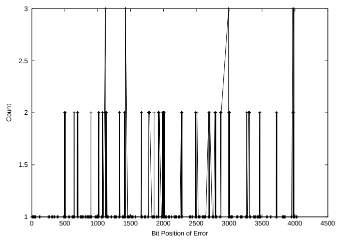

Trace 109, $E_k = 0.000191$

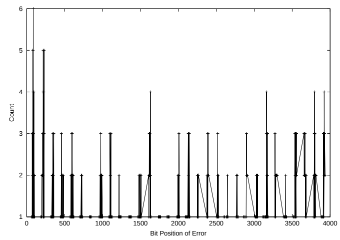

Trace 110, $E_k = 0.000190$

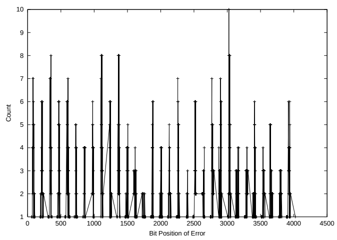

Trace 111, $E_k = 0.000088$

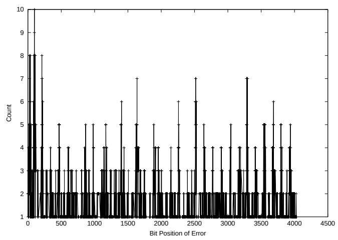

Trace 112, $E_k = 0.000201$


Trace 113, $E_k = 0.000587$


Trace 114, $E_k = 0.000010$


Trace 129, $E_k = 0.000010$


Trace 130, $E_k = 0.000024$


Trace 131, $E_k = 0.000045$

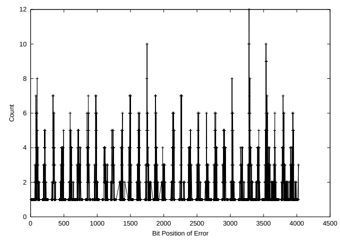
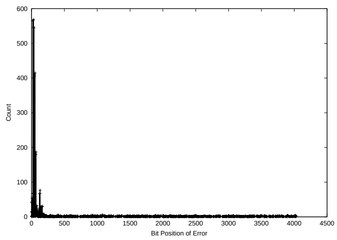
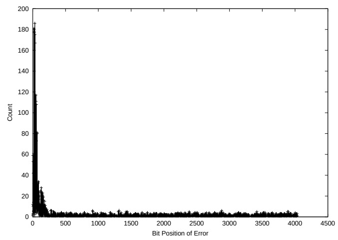

Trace 134, $E_k = 0.000046$

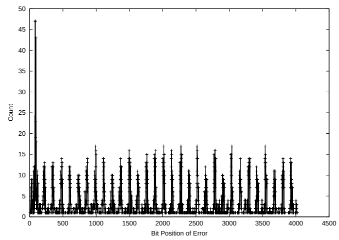
Table 3.3: Positions of Bit Errors, Traces 16 to 134 for **longterm1** measurement



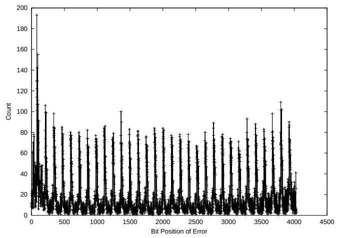
Trace 136, $E_k = 0.000114$



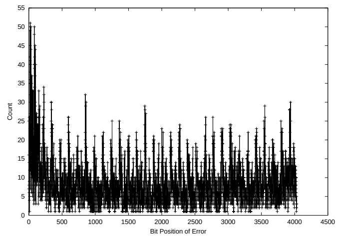
Trace 137, $E_k = 0.000087$



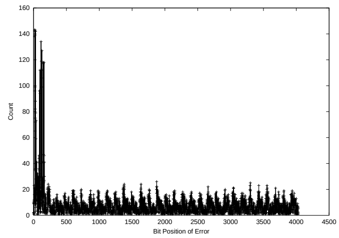
Trace 138, $E_k = 0.000117$



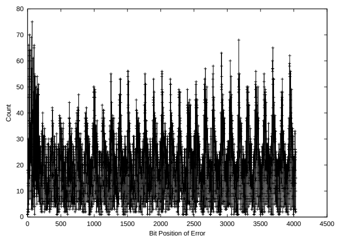
Trace 139, $E_k = 0.001027$



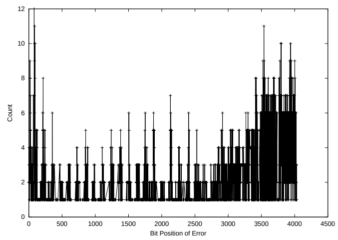
Trace 140, $E_k = 0.000444$



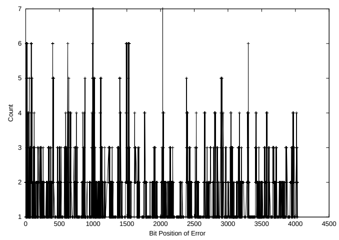
Trace 141, $E_k = 0.000382$



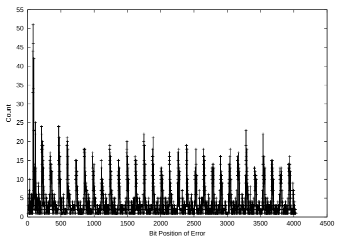
Trace 142, $E_k = 0.001052$



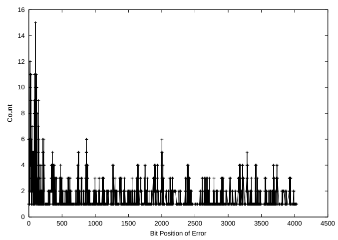
Trace 143, $E_k = 0.000063$



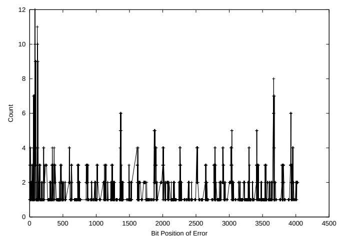
Trace 144, $E_k = 0.000040$



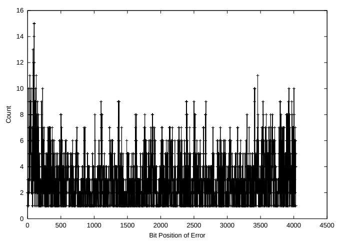
Trace 146, $E_k = 0.000179$



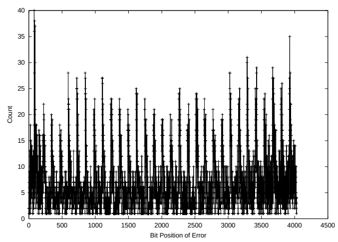
Trace 147, $E_k = 0.000044$



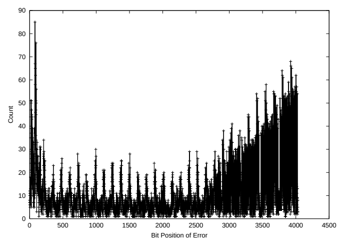
Trace 148, $E_k = 0.000029$



Trace 149, $E_k = 0.000131$

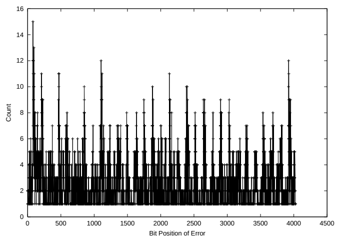


Trace 151, $E_k = 0.000360$

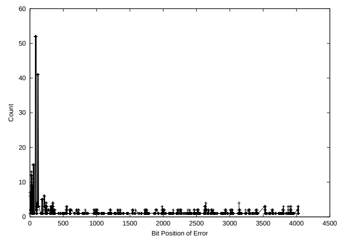


Trace 152, $E_k = 0.000583$

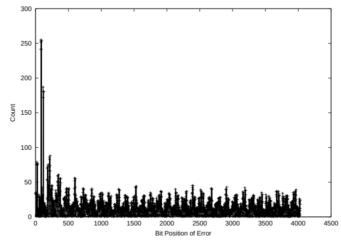
Table 3.4: Positions of Bit Errors, Traces 136 to 152 for **longterm1** measurement



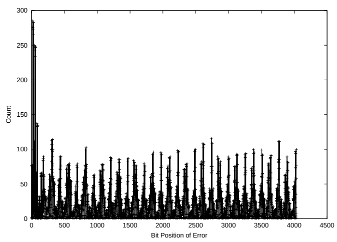
Trace 153, $E_k = 0.000107$



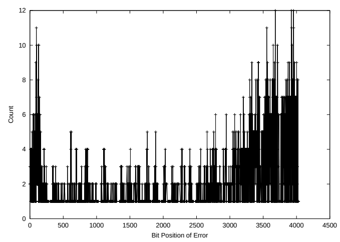
Trace 155, $E_k = 0.000029$



Trace 156, $E_k = 0.000693$



Trace 157, $E_k = 0.001038$



Trace 158, $E_k = 0.000062$

Table 3.5: Positions of Bit Errors, Traces 153 to 158 for **longterm1** measurement

3.2.2 First Order Statistics

In this section we present the main first order statistics. We focus on the packet loss behaviour and not on the bit error behaviour.

In figure 3.6 we show the percentage of lost packets vs. the trace number. In figure 3.7 we show the mean bit error rates vs. the trace number (refer to figure 3.8 for a non-logarithmic scaling), where clearly only the bit errors in received packets are taken into account. For lost packets we cannot make any statement, so they are not considered.[3] After applying the indicator sequence methodology developed in [5] to the sequence of received packets (marked as zero) and lost packets (marked as one), and therefore creating *packet loss indicator sequences*, we can talk about packet loss bursts (abbreviated as PLB) and packet loss free bursts (abbreviated as PLFB) in an analog manner. In figure 3.9 we show the mean length of PLBs vs. the trace number (for burst order $k_0 = 1$), while in figure 3.10 we show the mean length of PLFBs. In figures 3.11 and 3.12 the corresponding coefficients of variation are shown. We have considered only those traces with a packet loss rate of at least 10^{-3}. In tables 3.7, 3.8, 3.9, 3.10, 3.11, 3.12, 3.13, and 3.14 we show the probability distribution of the PLB lengths separately for every trace, while in tables 3.15, 3.16, 3.17, 3.18, 3.19, 3.20, 3.21, and 3.22 we show the distribution function of the PLFB lengths. Furthermore in figure 3.13 we show the maximum values of the autocovariance function for the sequence of PLB lengths and PLFB lengths, respectively. The following observations are important:

- If the portal crane is close, the packet loss rates can be very high and show much variation. For some traces more than 80% of the packets are lost. If the portal crane is away, packet loss rates are low. As discussed in [5], packet losses occur likely due to failing preamble acquisition.
- The mean PLB length from figure 3.9 seems to be correlated to the packet loss rate. The coefficient of variation of the PLB length (figure 3.11) is strongly varying over time and is sometimes larger than ten.
- Almost all PLB length distributions for $k_0 = 1$ show a regularly decaying behaviour, indicating that most packet loss bursts are shorter than five packets, with single packet losses being the most often occurring event. However, very long bursts occur.
- For the PLFB length distributions the behaviour is more diverse:

[3] For the mean BER statistics and the lost packet statistics we have removed ghost packets, missized packets and bit shifted packets from consideration.

	longterm1	**longterm2**
mean PLR	0.065215	0.033454
mean PLB length	3.546146	1.458691
CoV PLB length	17.194991	1.269700
max. PLB length	14936	179
mean PLFB length	50.829559	42.143444
CoV PLFB length	20.174408	21.386316
max. PLFB length	101158	108548

Table 3.6: First order packet burst statistics for **longterm1** and **longterm2** measurements (CoV = coefficient of variation, PLR = packet loss rate, PLB = packet loss burst, PLFB = packet loss free burst)

  - Not surprising, for traces with high packet loss rates (say, greater than 20%) the distributions have their main mass on short lengths, however, there is no clear relationship between the overall packet loss rate and the mass concentrated on the first 20 burst length values. These can be different even for high packet loss rates. We conclude from this, and supported by the coefficients of variation from figures 3.11 and 3.12 that the variability of the PLFB lengths and thus their distribution is time-varying.
  - For traces with packet loss rates in the range of 1% to 10% the main mass is also in the first 20 lengths, however, independently from the packet loss rate, the mass on burst length one varies from 20% (trace 55) to more than 70% (trace 81).

- For many traces the PLB lengths and PLFB lengths exhibit a substantial amount of correlation, as can be seen from figure 3.13. However, the presence of correlation is varying with the trace number.

In addition to inspecting the packet loss indicator sequence separately for each trace, we have formed the *compound packet loss indicator sequence* or *compound sequence* for short, where the packet loss indicator sequences of all traces are concatenated. In this sequence ghost packets, dropped packets and missized packets are treated as lost packets. The summary statistics about PLB lengths and PLFB lengths for the compound sequence are shown in Table 3.6.

In figure 3.14 we show for burst order $k_0 = 1$ the probability distribution function of PLB lengths for the compound sequence, while in figure 3.15 we show the distribution function of

PLFB lengths for the compound trace. In figure 3.16 we show the autocovariance function for the sequence of PLB lengths, while in figure 3.17 we show the corresponding information for the PLFBs. We can make the following important observations:

- The **longterm1** measurement was much more distorted in terms of packet loss rate than the **longterm2** measurement. The packet loss bursts for **longterm1** are also longer and much more variable than for **longterm2**. However, likely the increased level of distortion cannot be attributed to the modem set used, since the same modem set was used in the **factorial** measurement, where the packet loss rates are very low (no trace exceeds a rate of 0.08, see [3]).
- The coefficient of variation of the PLFB lengths is very large for both the **longterm1** and **longterm2** compound sequences. The coefficient of variation of the PLB lengths differ significantly, the **longterm2** measurement has a strong tendency to single packet losses.
- The histograms and distributions of PLB lengths and PLFB lengths for both measurements look pretty regular. Furthermore, for the **longterm1** measurement, from the autocovariance functions shown we can see that the PLB lengths are nearly uncorrelated, while for PLFB lengths weak correlation is present. As a result, for modeling purposes we can regard both sequences as independent. Please note that for many single traces there is substantial correlation (substantial higher values of the autocovariance function), however, this gets lost when turning to the timescale of the whole measurement. For the **longterm2** measurement we can observe that the packet loss burst lengths show strong correlation for lags up to 25, then weak correlation for higher lags. The packet loss free bursts are only for lag 1 strong correlated, then weakly correlated..

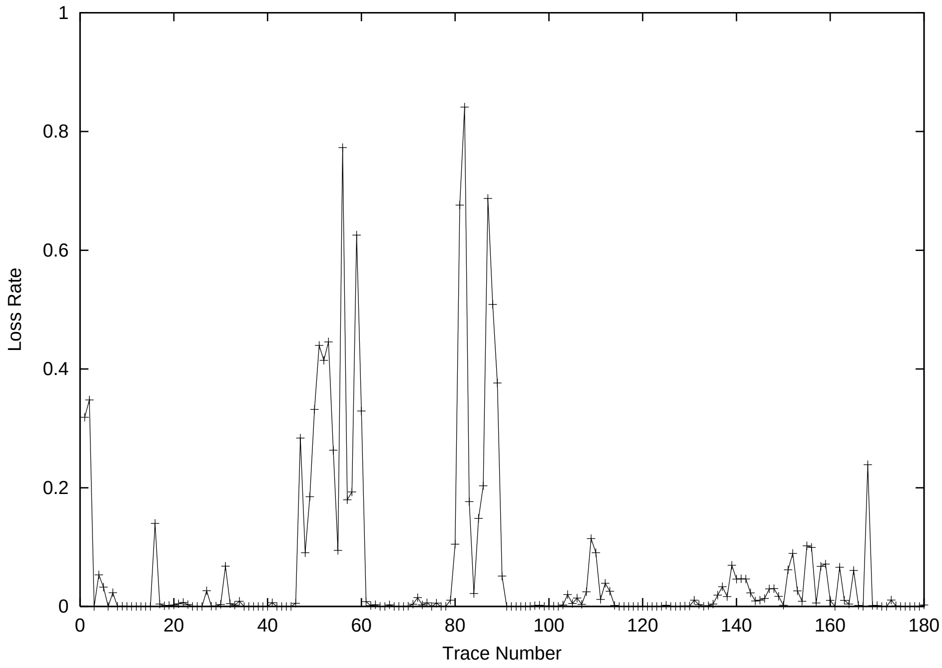


Figure 3.6: Rates of lost packets for **longterm1** measurement

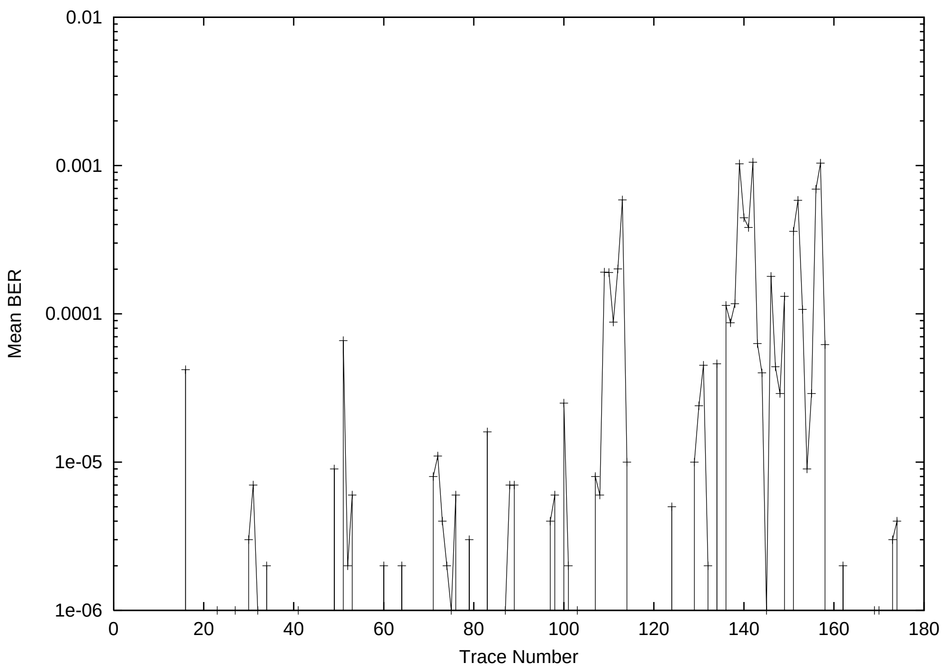


Figure 3.7: Mean bit error rates vs. trace number for **longterm1** measurement

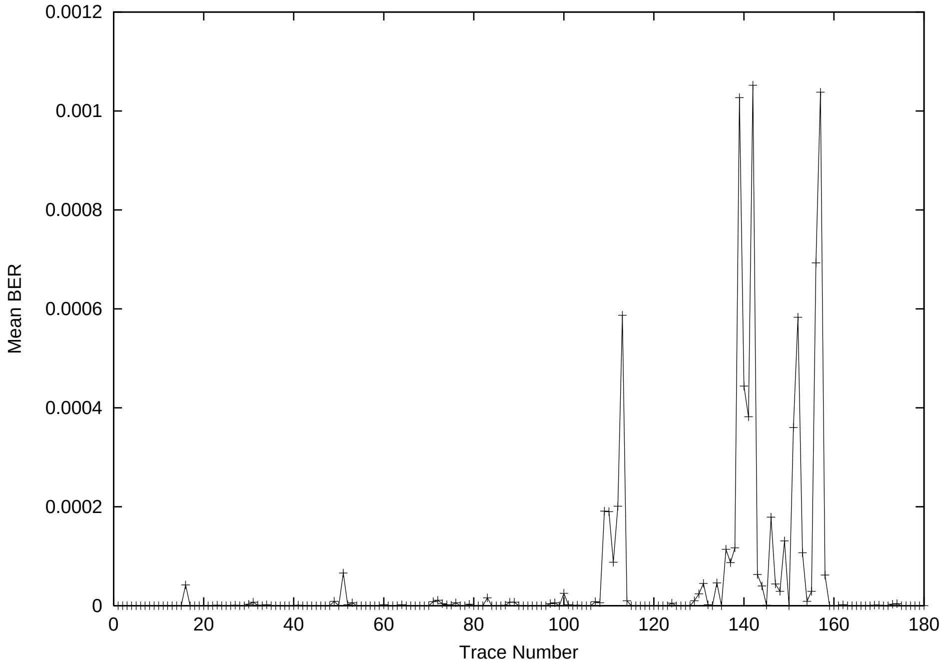


Figure 3.8: Mean bit error rates vs. trace number for **longterm1** measurement (nonlogarithmic scale)

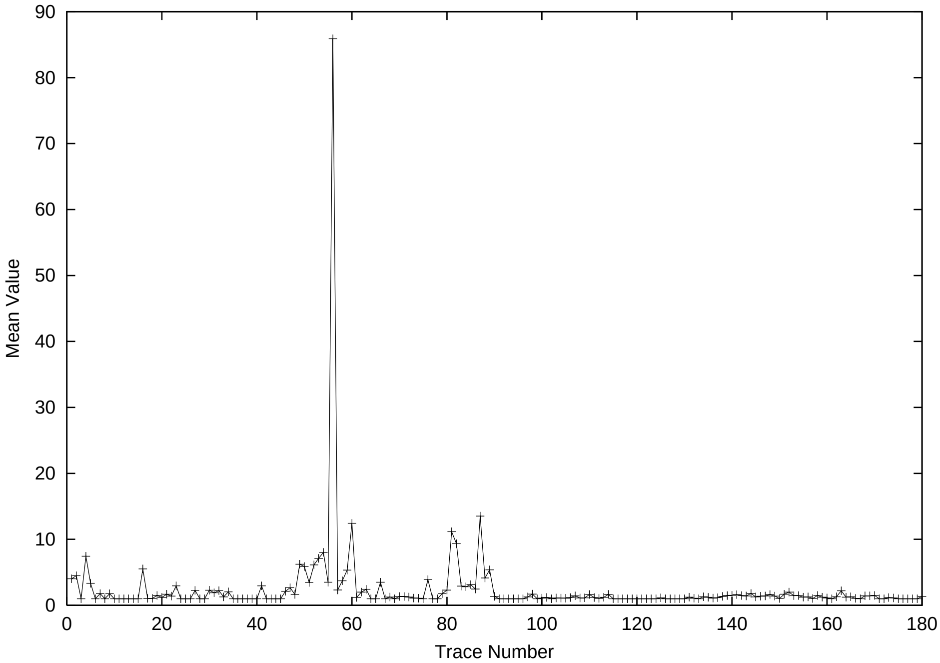


Figure 3.9: Mean packet loss burst lengths vs. trace number for **longterm1** measurement and burst order $k_0 = 1$.

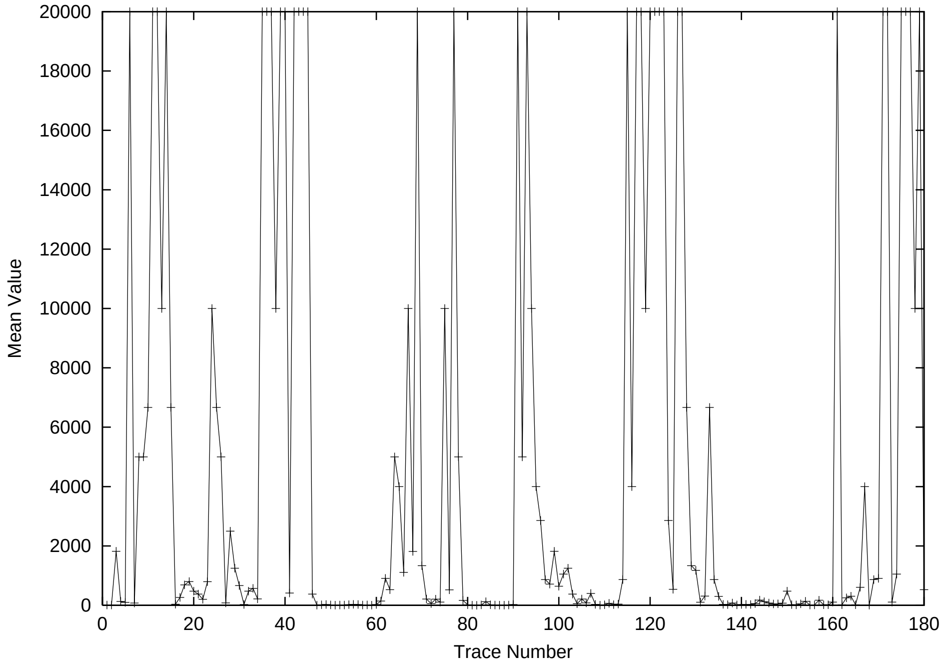


Figure 3.10: Mean packet loss free burst lengths vs. trace number for **longterm1** measurement and burst order $k_0 = 1$.

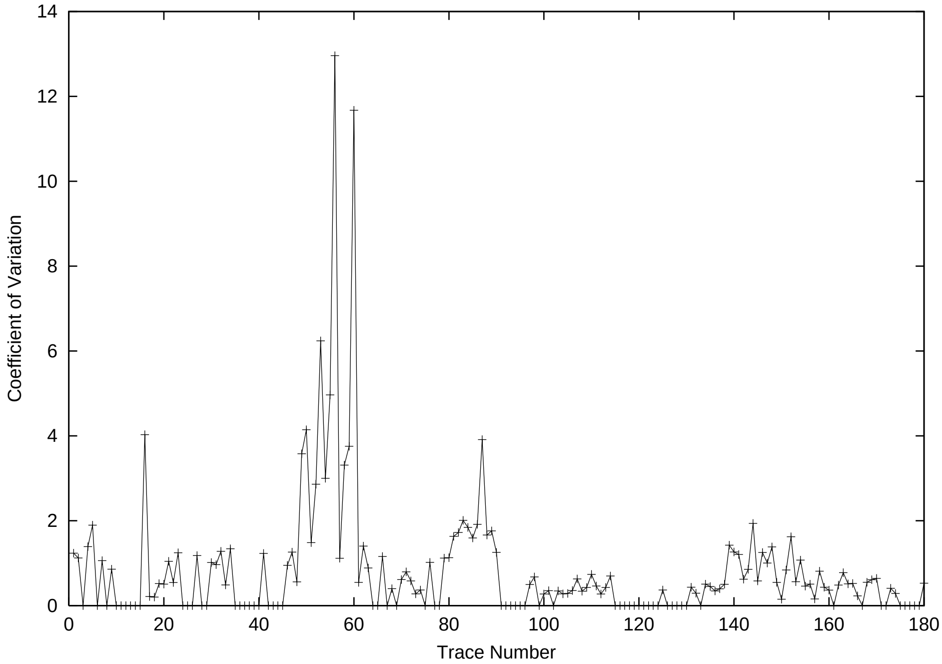


Figure 3.11: Coefficient of Variation of packet loss burst lengths vs. trace number for **longterm1** measurement and burst order $k_0 = 1$.

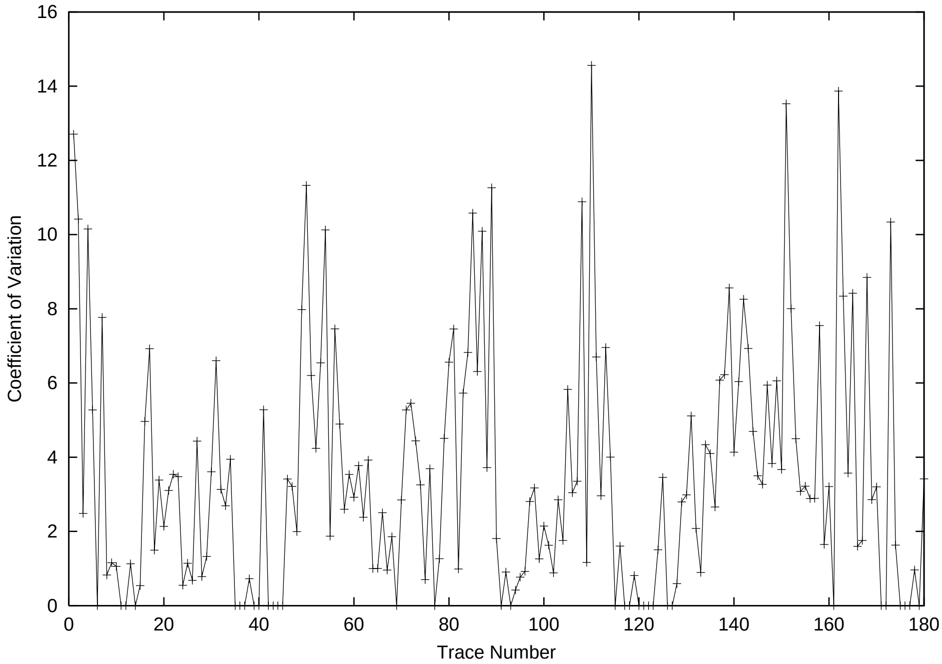


Figure 3.12: Coefficient of Variation of packet loss free burst lengths vs. trace number for **longterm1** measurement and burst order $k_0 = 1$.

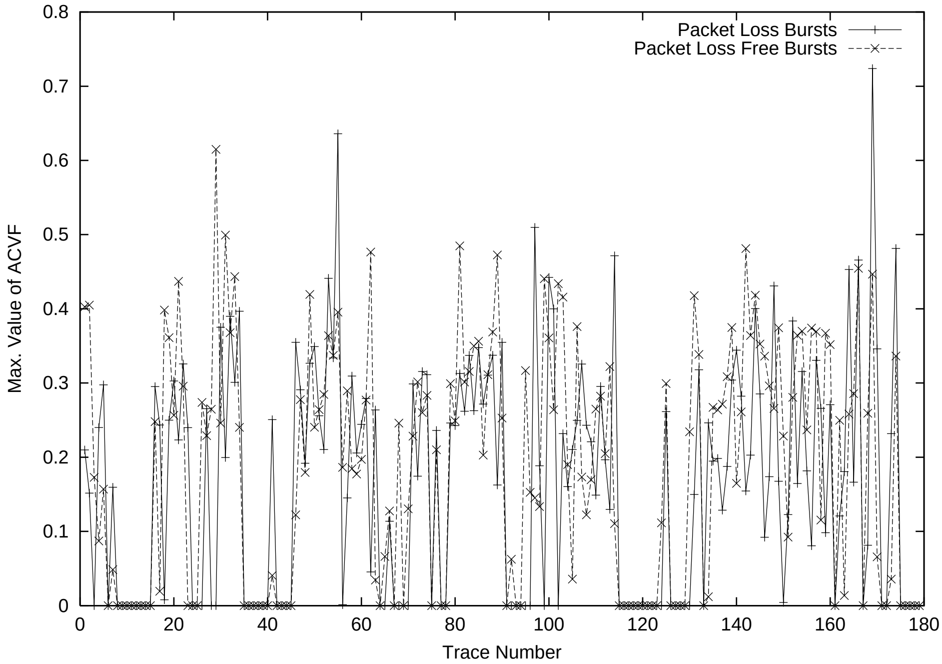


Figure 3.13: Max. values of autocovariance function for packet loss burst lengths and packet loss free burst lengths vs. trace number for **longterm1** measurement and $k_0 = 1$.

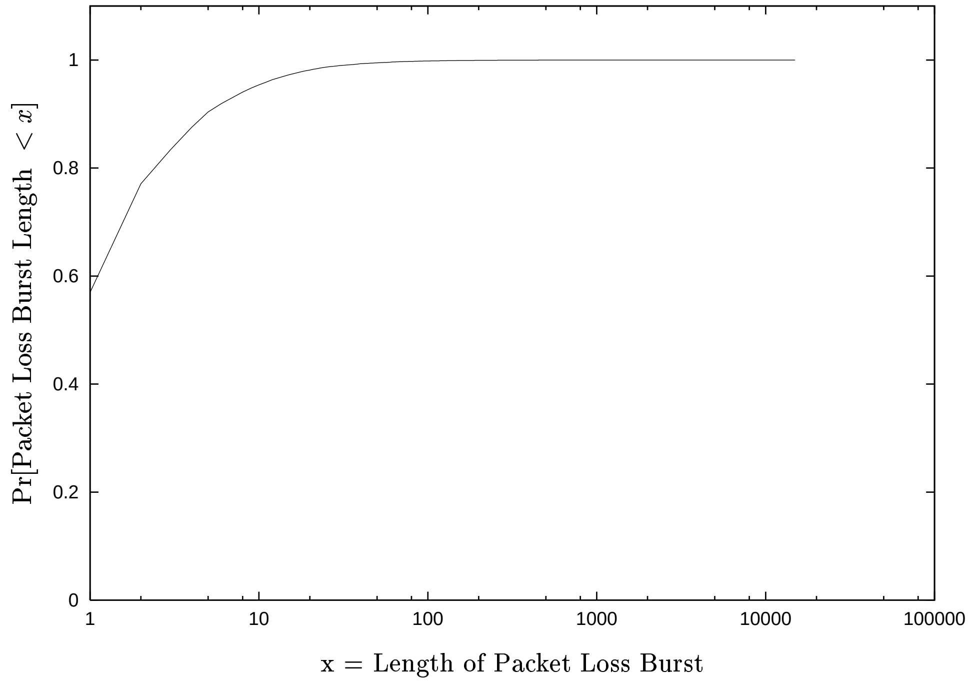


Figure 3.14: Cumulative Distribution Function of packet loss burst lengths for compound trace for **longterm1** measurement and $k_0 = 1$

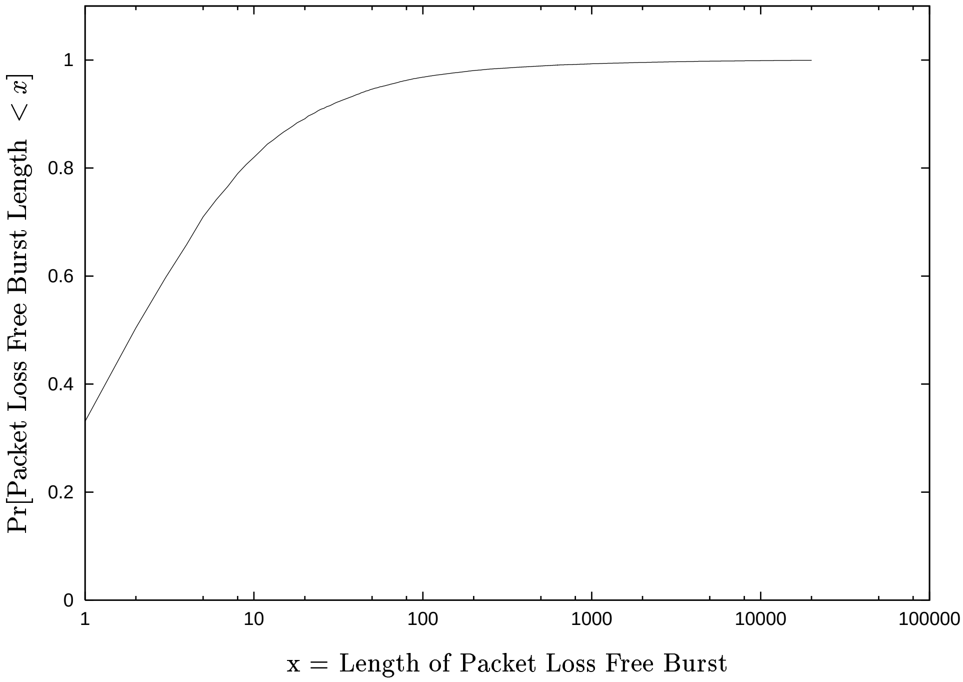


Figure 3.15: Cumulative distribution function of packet loss free burst lengths for compound trace for **longterm1** measurement and $k_0 = 1$

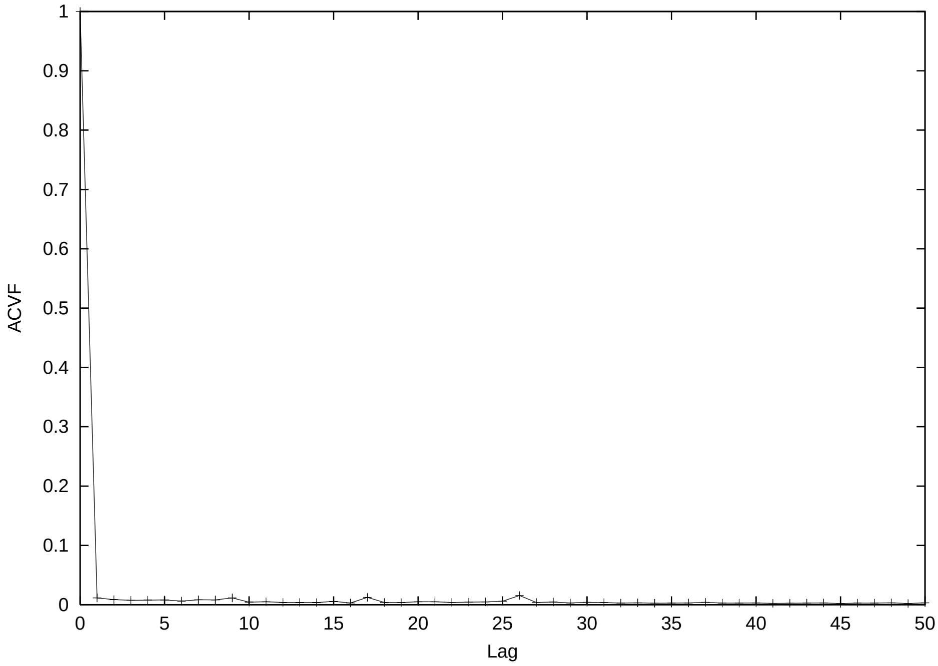


Figure 3.16: Autocovariance function of packet loss burst length sequence for the compound trace and $k_0 = 1$ for **longterm1** measurement

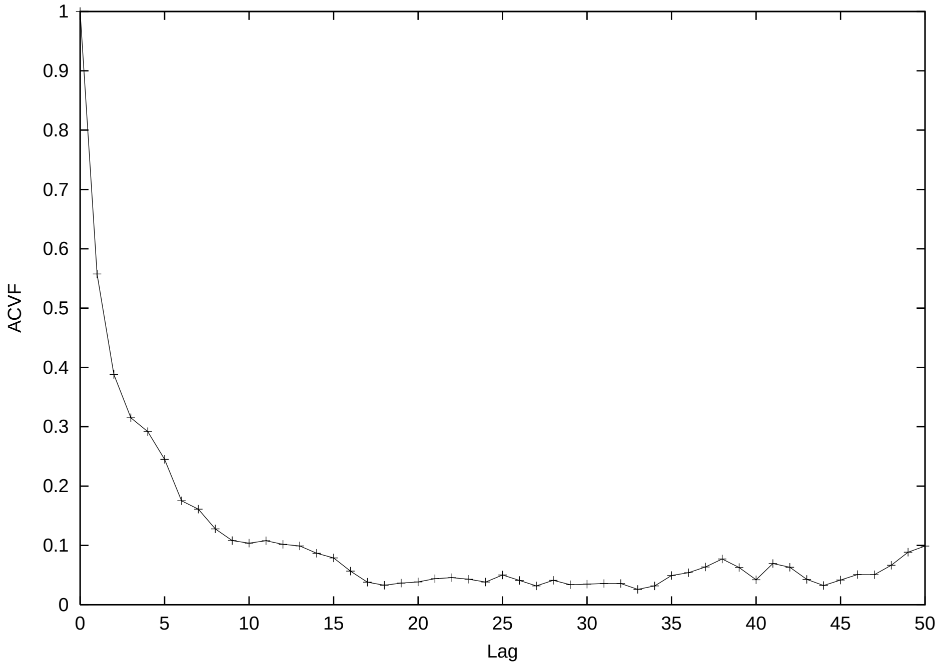
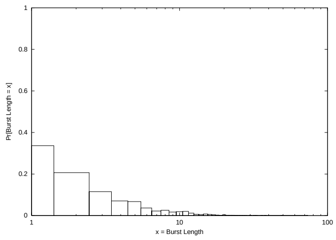
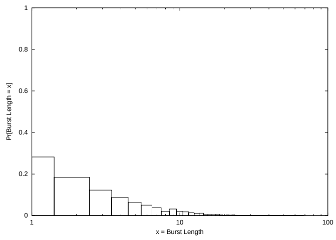


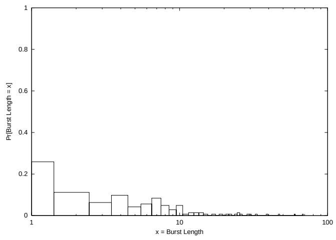
Figure 3.17: Autocovariance function of packet loss free burst length sequence for the compound trace and $k_0 = 1$ for **longterm1** measurement



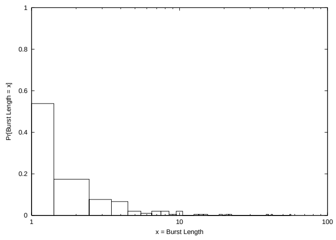
Trace 1, PLR = 0.31875



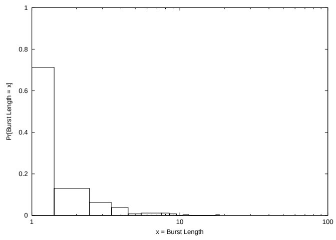
Trace 2, PLR = 0.348



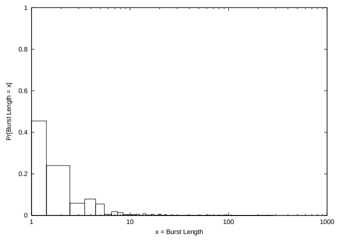
Trace 4, PLR = 0.05325



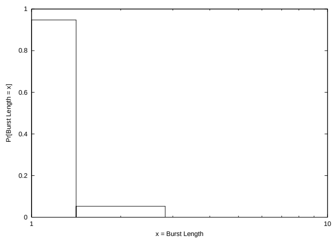
Trace 5, PLR = 0.0326



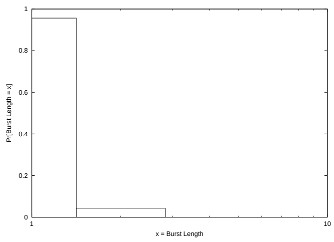
Trace 7, PLR = 0.0231



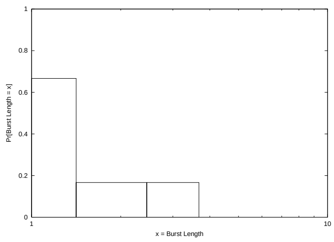
Trace 16, PLR = 0.14



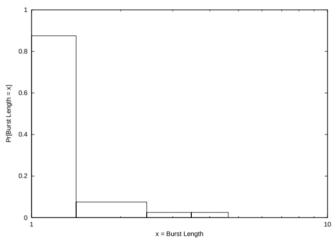
Trace 17, PLR = 0.004



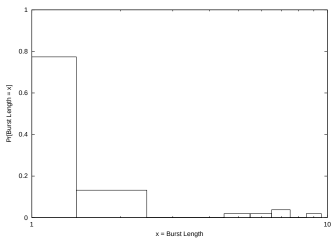
Trace 18, PLR = 0.0012



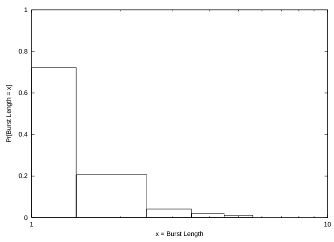
Trace 19, PLR = 0.0018



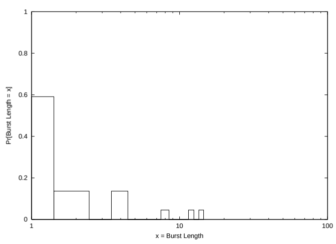
Trace 20, PLR = 0.0024



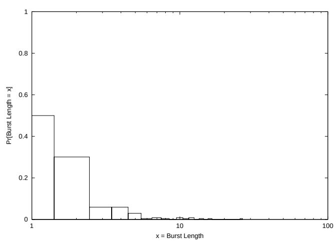
Trace 21, PLR = 0.00445



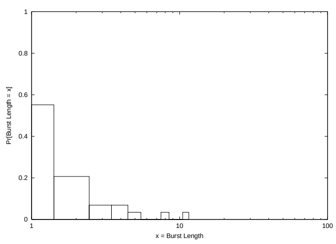
Trace 22, PLR = 0.00675



Trace 23, PLR = 0.00325

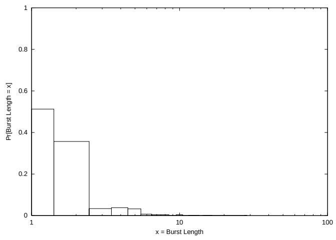


Trace 27, PLR = 0.0266

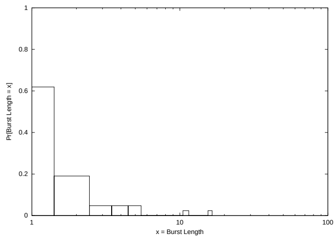


Trace 30, PLR = 0.0033

Table 3.7: Density of Packet Loss Burst Length (Burst Order $k_0 = 1$), Traces 1 to 30 for **longterm1** measurement

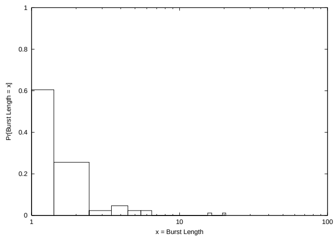


Trace 31, PLR = 0.06785

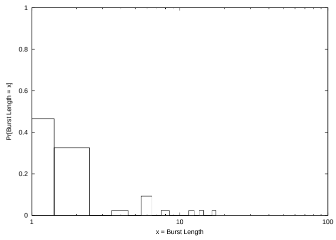


Trace 32, PLR = 0.00465

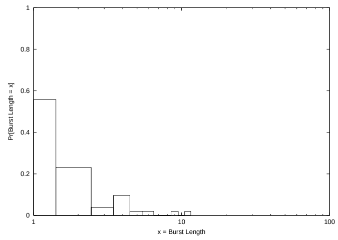
Trace 33, PLR = 0.00215



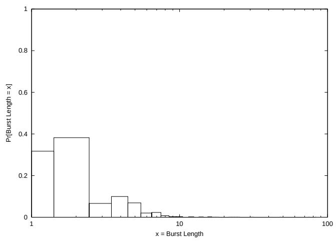
Trace 34, PLR = 0.0088



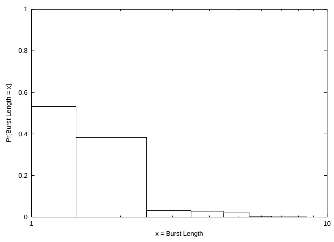
Trace 41, PLR = 0.00635



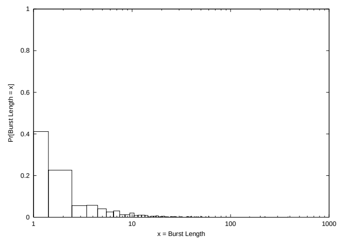
Trace 46, PLR = 0.0055



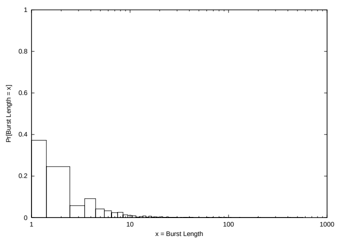
Trace 47, PLR = 0.28365



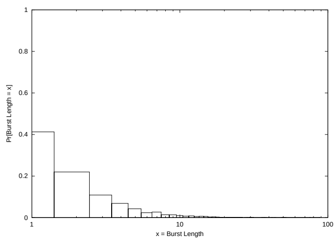
Trace 48, PLR = 0.09045



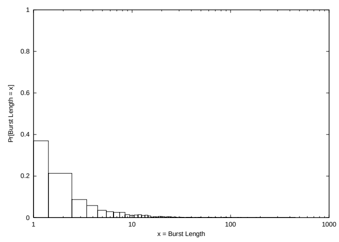
Trace 49, PLR = 0.18485



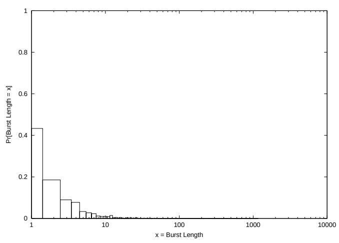
Trace 50, PLR = 0.3319



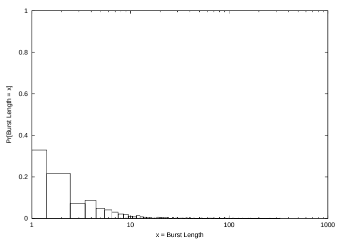
Trace 51, PLR = 0.4397



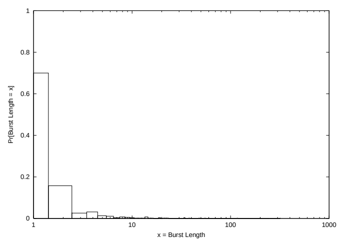
Trace 52, PLR = 0.4147



Trace 53, PLR = 0.44555

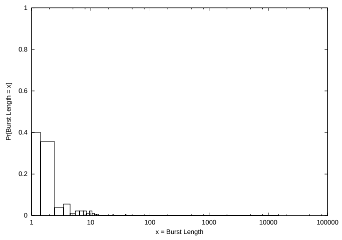


Trace 54, PLR = 0.26335

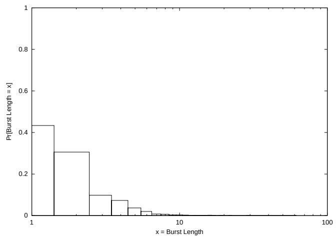


Trace 55, PLR = 0.0946

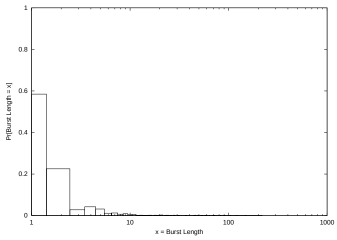
Table 3.8: Density of Packet Loss Burst Length (Burst Order $k_0 = 1$), Traces 31 to 55 for **longterm1** measurement



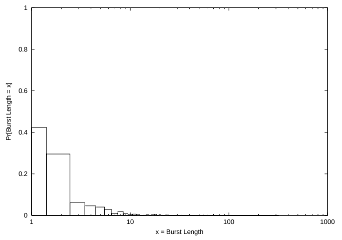
Trace 56, PLR = 0.773



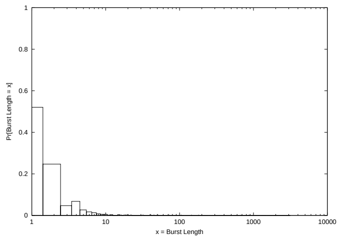
Trace 57, PLR = 0.1797



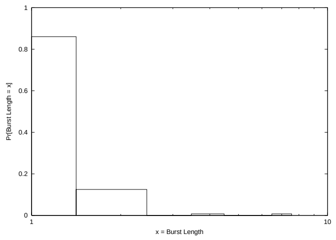
Trace 58, PLR = 0.193



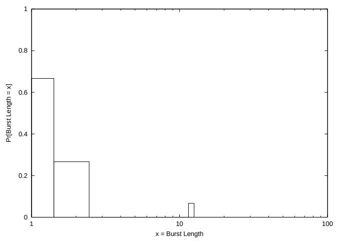
Trace 59, PLR = 0.62545



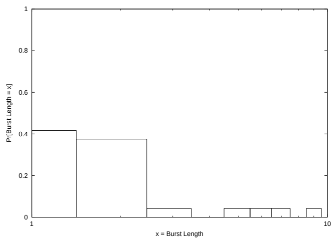
Trace 60, PLR = 0.32925



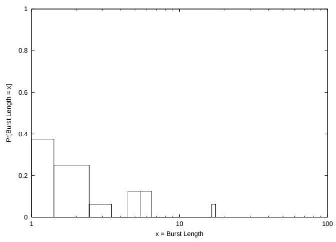
Trace 61, PLR = 0.0081



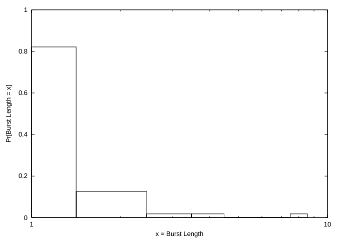
Trace 62, PLR = 0.0015



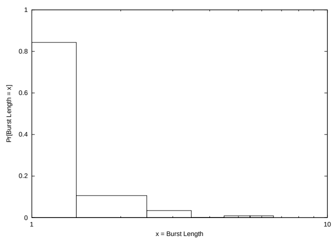
Trace 63, PLR = 0.0029



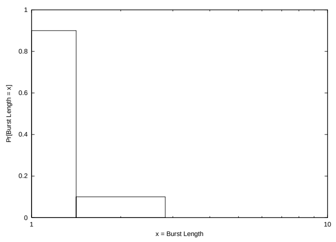
Trace 66, PLR = 0.0028



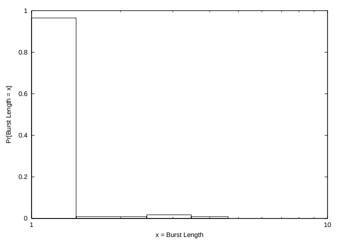
Trace 71, PLR = 0.00375



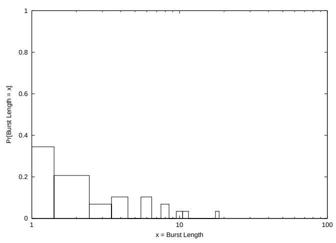
Trace 72, PLR = 0.01475



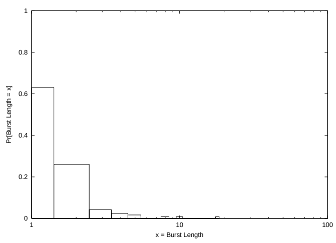
Trace 73, PLR = 0.00275



Trace 74, PLR = 0.0061

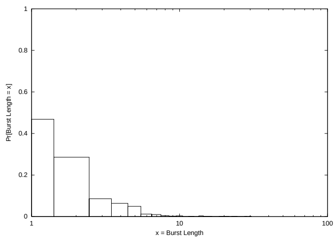


Trace 76, PLR = 0.00565

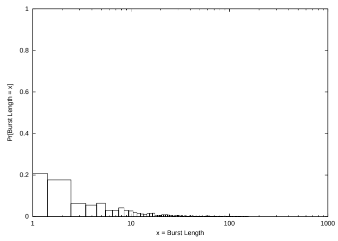


Trace 79, PLR = 0.0105

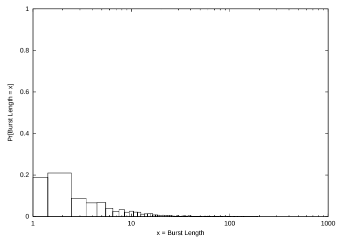
Table 3.9: Density of Packet Loss Burst Length (Burst Order $k_0 = 1$), Traces 56 to 79 for **longterm1** measurement



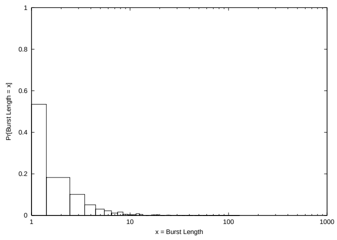
Trace 80, PLR = 0.1048



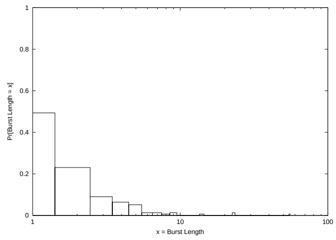
Trace 81, PLR = 0.676



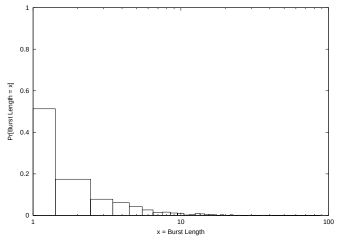
Trace 82, PLR = 0.8411



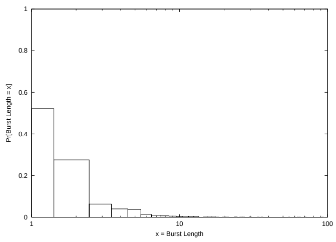
Trace 83, PLR = 0.1766



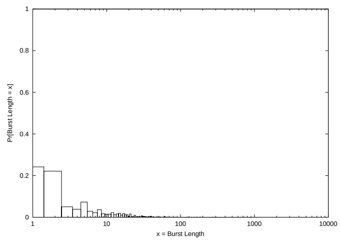
Trace 84, PLR = 0.0219



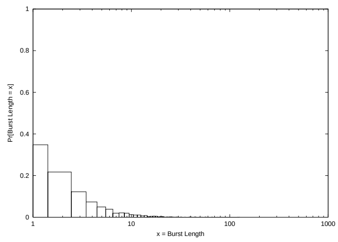
Trace 85, PLR = 0.14845



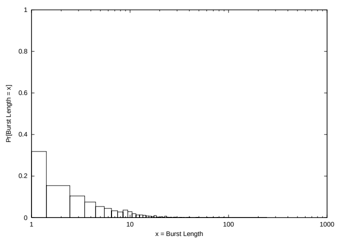
Trace 86, PLR = 0.20335



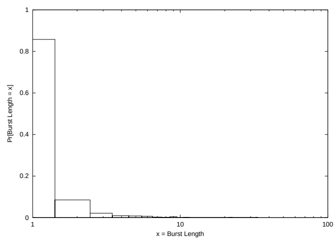
Trace 87, PLR = 0.6873



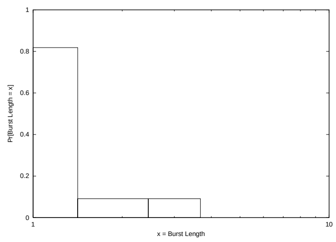
Trace 88, PLR = 0.5088



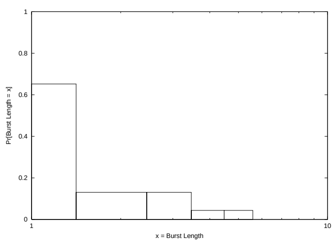
Trace 89, PLR = 0.3764



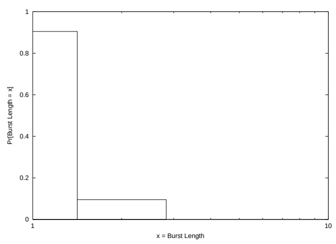
Trace 90, PLR = 0.05115



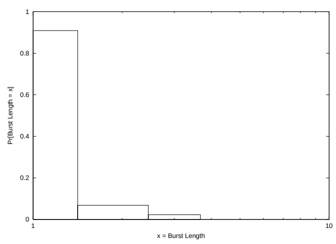
Trace 97, PLR = 0.0014



Trace 98, PLR = 0.00195

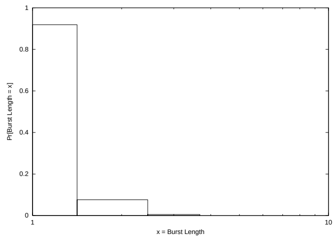


Trace 100, PLR = 0.00115

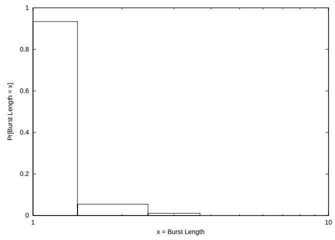


Trace 103, PLR = 0.00245

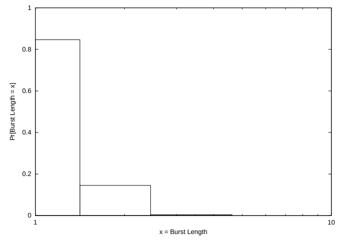
Table 3.10: Density of Packet Loss Burst Length (Burst Order $k_0 = 1$), Traces 80 to 103 for **longterm1** measurement



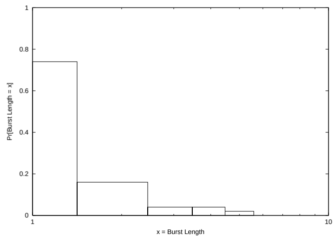
Trace 104, PLR = 0.02



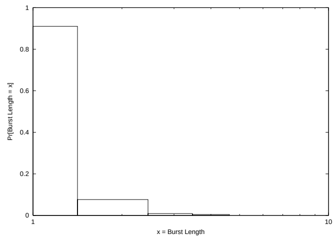
Trace 105, PLR = 0.0049



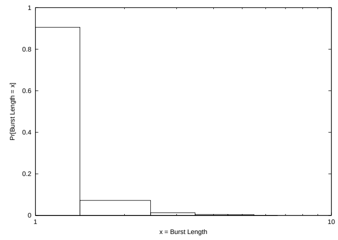
Trace 106, PLR = 0.01405



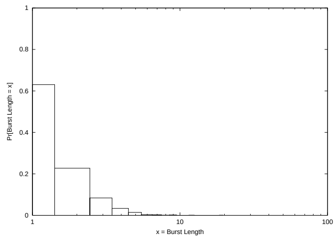
Trace 107, PLR = 0.0036



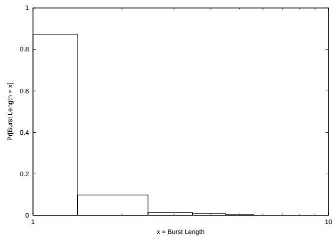
Trace 108, PLR = 0.02465



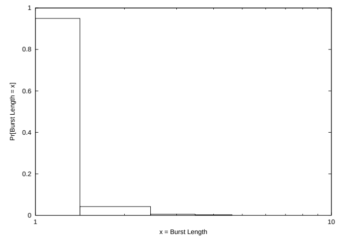
Trace 109, PLR = 0.1143



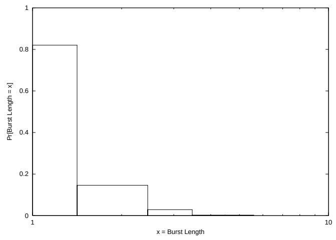
Trace 110, PLR = 0.0906



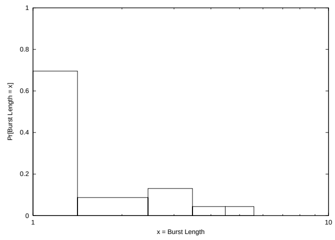
Trace 111, PLR = 0.012



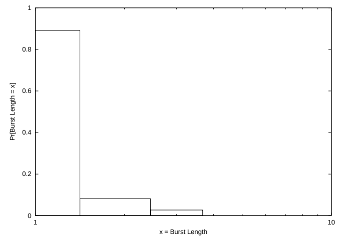
Trace 112, PLR = 0.039



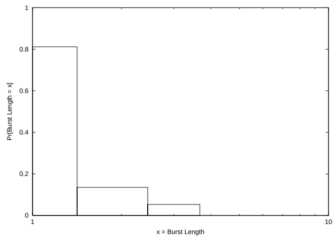
Trace 113, PLR = 0.0255



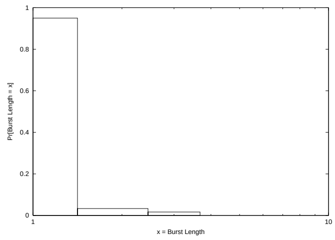
Trace 114, PLR = 0.0019



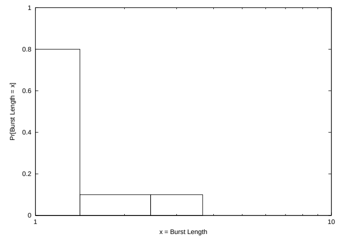
Trace 125, PLR = 0.0021



Trace 131, PLR = 0.01055



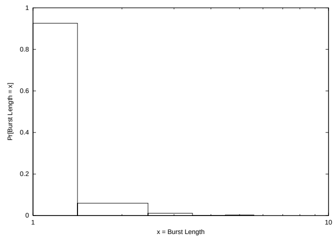
Trace 132, PLR = 0.0032



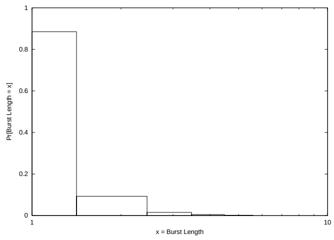
Trace 134, PLR = 0.0013

Table 3.11: Density of Packet Loss Burst Length (Burst Order $k_0 = 1$), Traces 104 to 134 for **longterm1** measurement

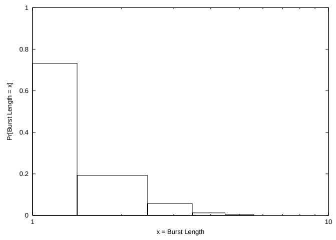
Trace 135, PLR = 0.00395



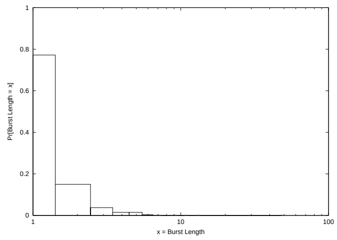
Trace 136, PLR = 0.0192



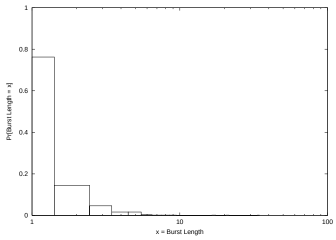
Trace 137, PLR = 0.0333



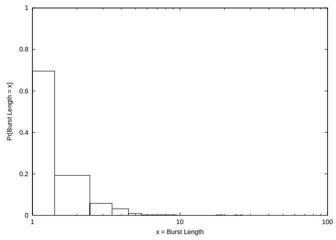
Trace 138, PLR = 0.01655



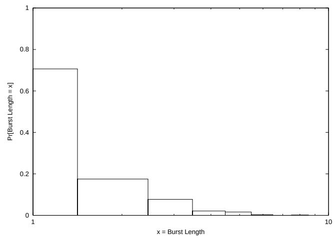
Trace 139, PLR = 0.06935



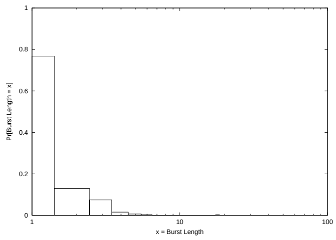
Trace 140, PLR = 0.046



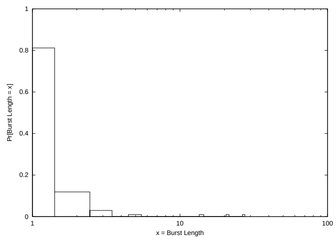
Trace 141, PLR = 0.04675



Trace 142, PLR = 0.0462

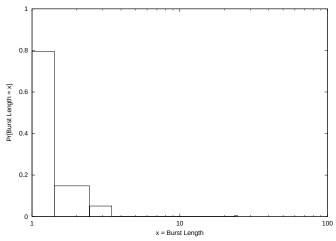


Trace 143, PLR = 0.0229

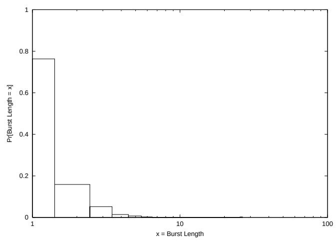


Trace 144, PLR = 0.0091

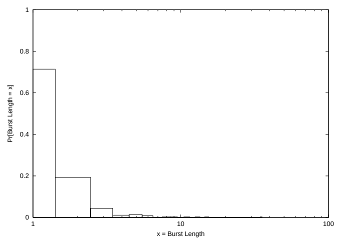
Trace 145, PLR = 0.0106



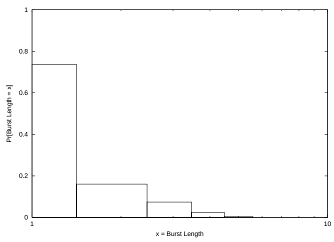
Trace 146, PLR = 0.0134



Trace 147, PLR = 0.02965

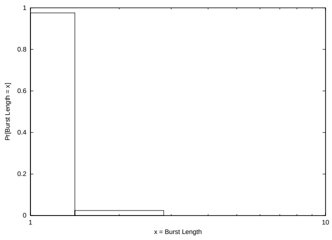


Trace 148, PLR = 0.0301

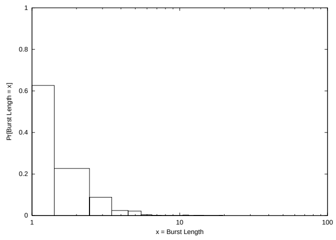


Trace 149, PLR = 0.017

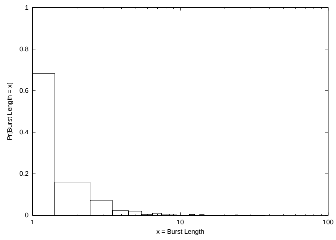
Table 3.12: Density of Packet Loss Burst Length (Burst Order $k_0 = 1$), Traces 135 to 149 for **longterm1** measurement



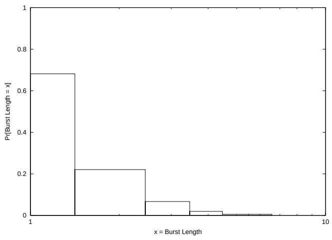
Trace 150, PLR = 0.0021



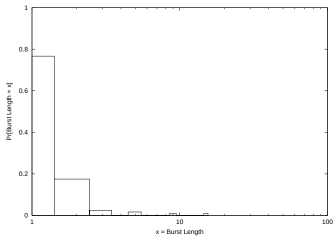
Trace 151, PLR = 0.06175



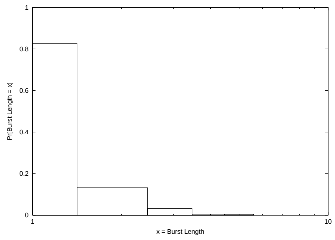
Trace 152, PLR = 0.0895



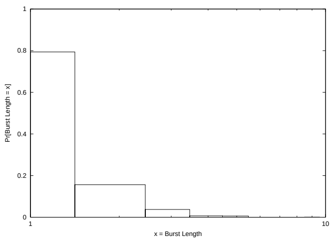
Trace 153, PLR = 0.0262



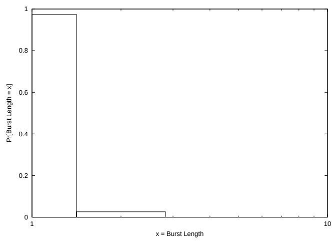
Trace 154, PLR = 0.00885



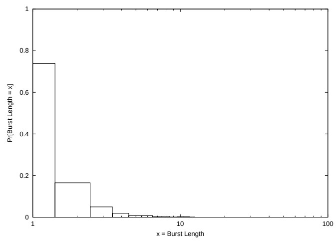
Trace 155, PLR = 0.10215



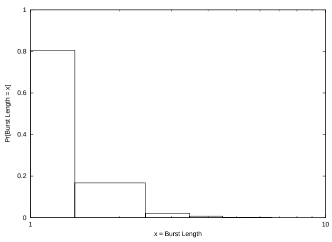
Trace 156, PLR = 0.09945



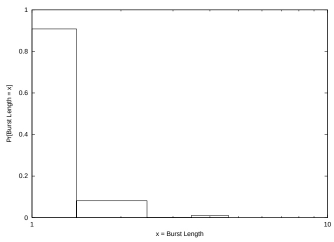
Trace 157, PLR = 0.0059



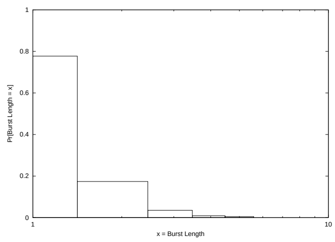
Trace 158, PLR = 0.06755



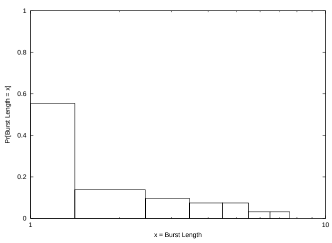
Trace 159, PLR = 0.07135



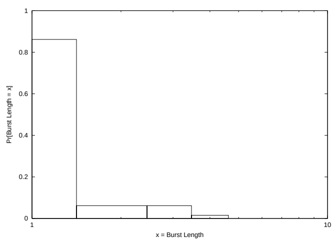
Trace 160, PLR = 0.0103



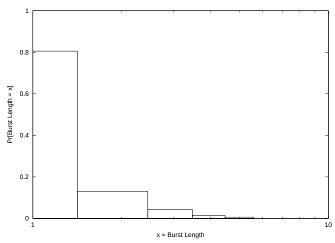
Trace 162, PLR = 0.06605



Trace 163, PLR = 0.01035

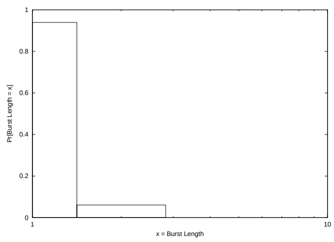


Trace 164, PLR = 0.004

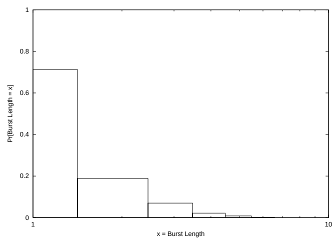


Trace 165, PLR = 0.06075

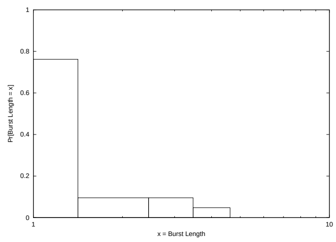
Table 3.13: Density of Packet Loss Burst Length (Burst Order $k_0 = 1$), Traces 150 to 165 for **longterm1** measurement



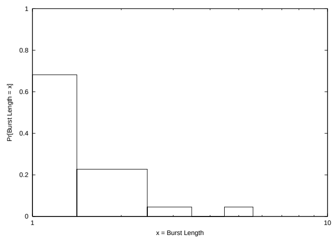
Trace 166, PLR = 0.00175



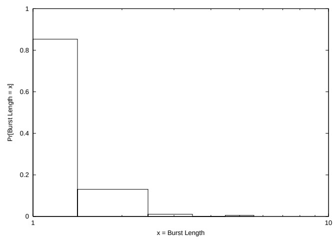
Trace 168, PLR = 0.23885



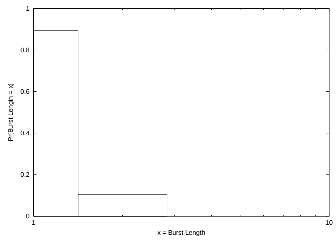
Trace 169, PLR = 0.0015



Trace 170, PLR = 0.00165

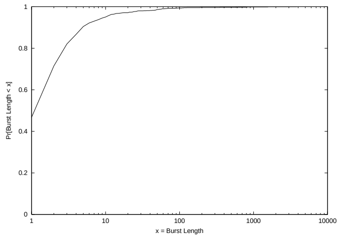


Trace 173, PLR = 0.0108

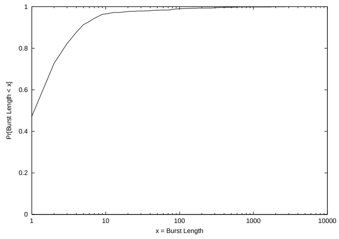


Trace 174, PLR = 0.00105

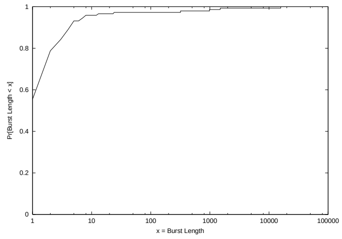
Table 3.14: Density of Packet Loss Burst Length (Burst Order $k_0 = 1$), Traces 166 to 174 for **longterm1** measurement



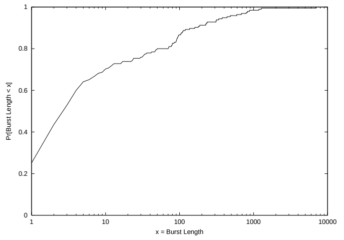
Trace 1, PLR = 0.31875



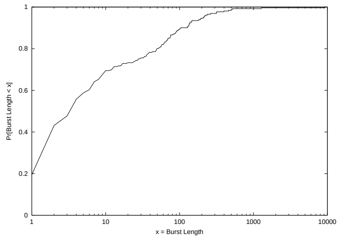
Trace 2, PLR = 0.348



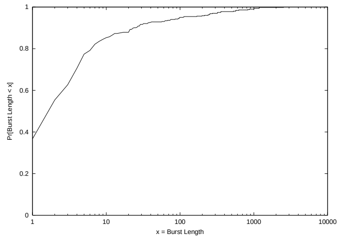
Trace 4, PLR = 0.05325



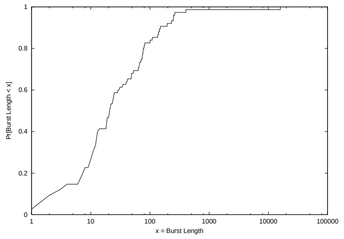
Trace 5, PLR = 0.0326



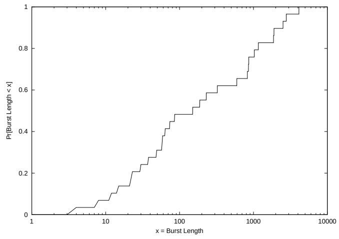
Trace 7, PLR = 0.0231



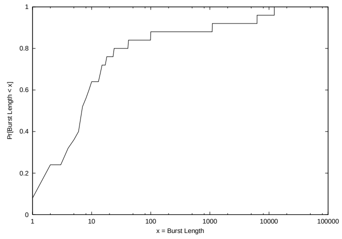
Trace 16, PLR = 0.14



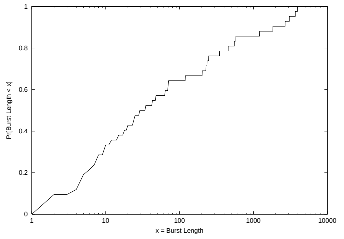
Trace 17, PLR = 0.004



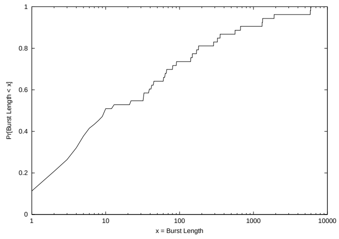
Trace 18, PLR = 0.0012



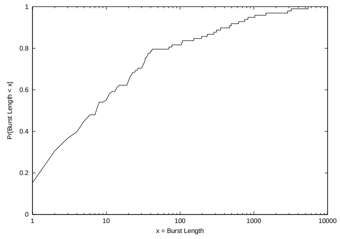
Trace 19, PLR = 0.0018



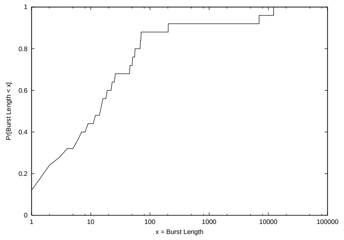
Trace 20, PLR = 0.0024



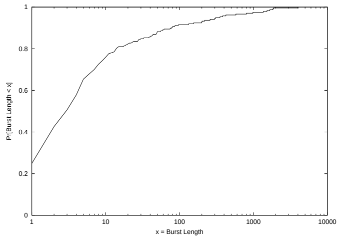
Trace 21, PLR = 0.00445



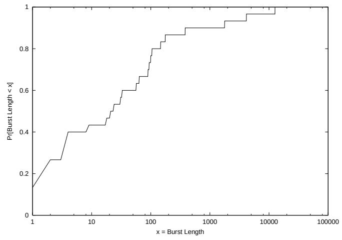
Trace 22, PLR = 0.00675



Trace 23, PLR = 0.00325

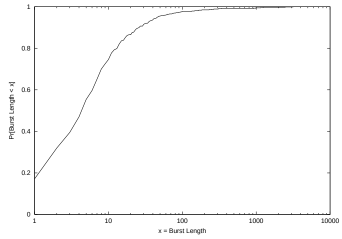


Trace 27, PLR = 0.0266

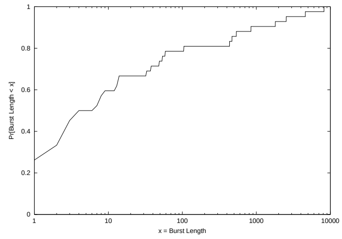


Trace 30, PLR = 0.0033

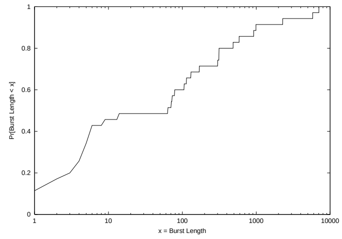
Table 3.15: Density of Packet Loss Free Burst Length ($k_0 = 1$), Traces 1 to 30 for **longterm1** measurements



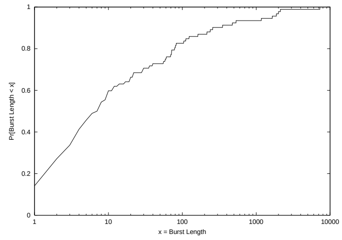
Trace 31, PLR = 0.06785



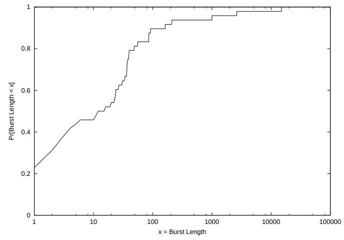
Trace 32, PLR = 0.00465



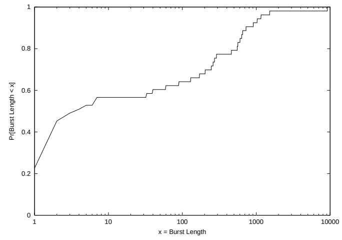
Trace 33, PLR = 0.00215



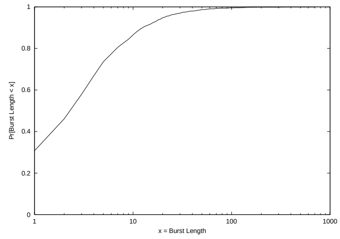
Trace 34, PLR = 0.0088



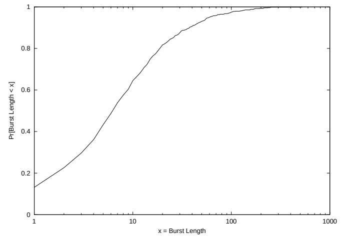
Trace 41, PLR = 0.00635



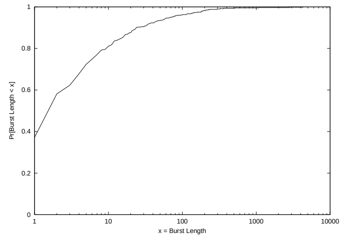
Trace 46, PLR = 0.0055



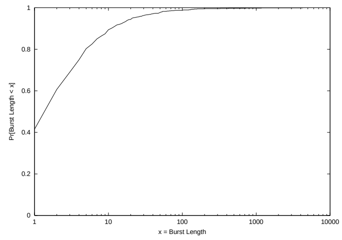
Trace 47, PLR = 0.28365



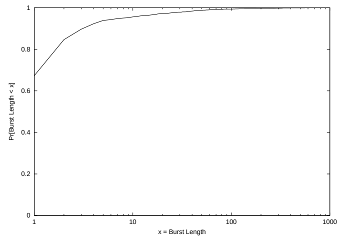
Trace 48, PLR = 0.09045



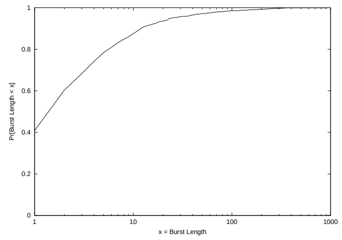
Trace 49, PLR = 0.18485



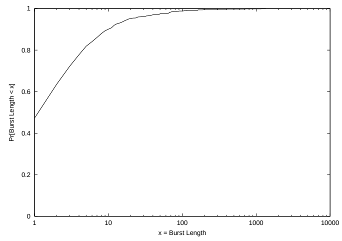
Trace 50, PLR = 0.3319



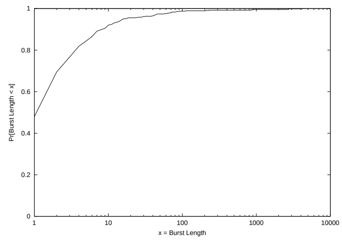
Trace 51, PLR = 0.4397



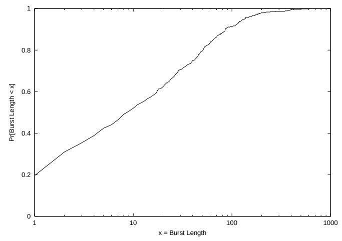
Trace 52, PLR = 0.4147



Trace 53, PLR = 0.44555

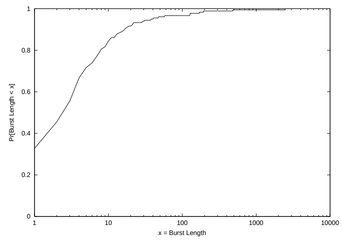


Trace 54, PLR = 0.26335

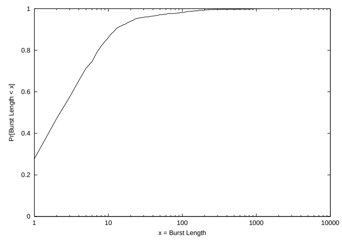


Trace 55, PLR = 0.0946

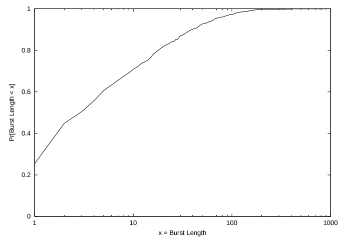
Table 3.16: Density of Packet Loss Free Burst Length ($k_0 = 1$), Traces 31 to 55 for **longterm1** measurements



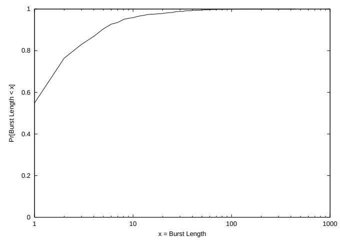
Trace 56, PLR = 0.773



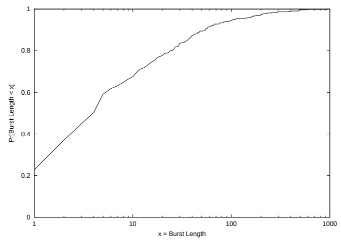
Trace 57, PLR = 0.1797



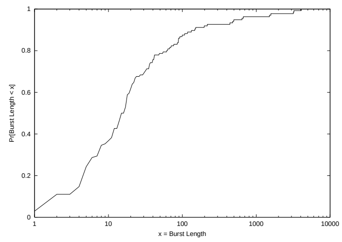
Trace 58, PLR = 0.193



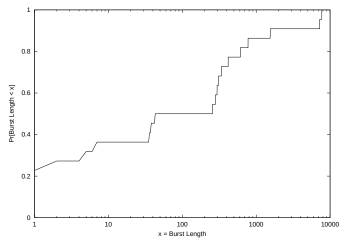
Trace 59, PLR = 0.62545



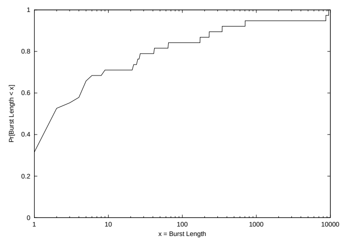
Trace 60, PLR = 0.32925



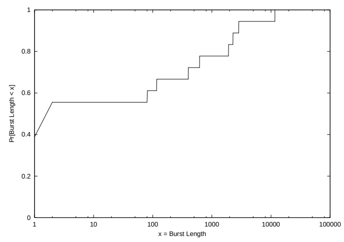
Trace 61, PLR = 0.0081



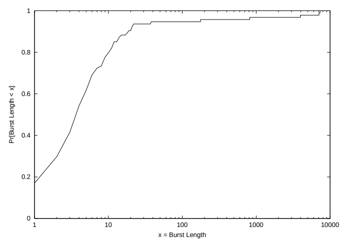
Trace 62, PLR = 0.0015



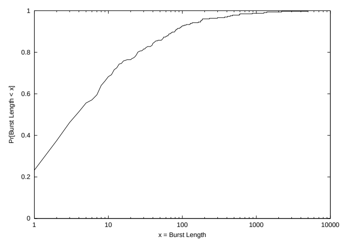
Trace 63, PLR = 0.0029



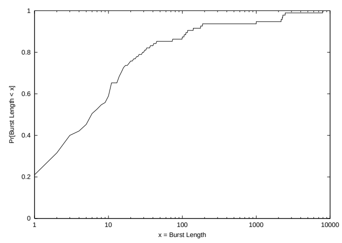
Trace 66, PLR = 0.0028



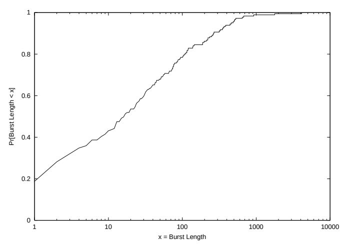
Trace 71, PLR = 0.00375



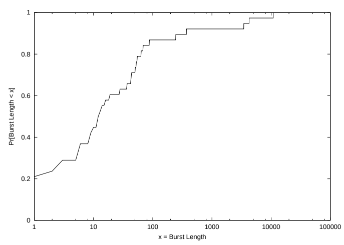
Trace 72, PLR = 0.01475



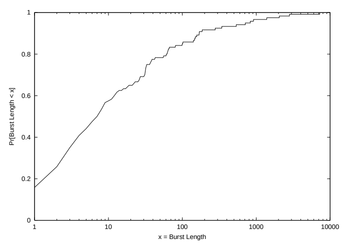
Trace 73, PLR = 0.00275



Trace 74, PLR = 0.0061

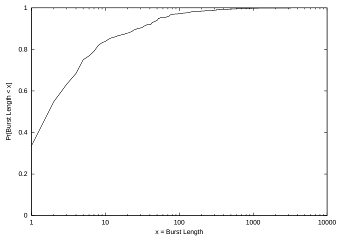


Trace 76, PLR = 0.00565

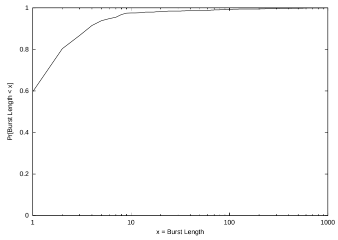


Trace 79, PLR = 0.0105

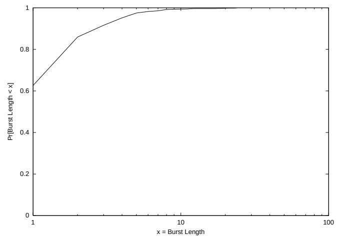
Table 3.17: Density of Packet Loss Free Burst Length ($k_0 = 1$), Traces 56 to 79 for **longterm1** measurements



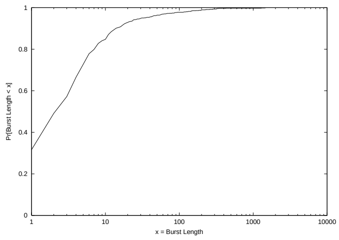
Trace 80, PLR = 0.1048



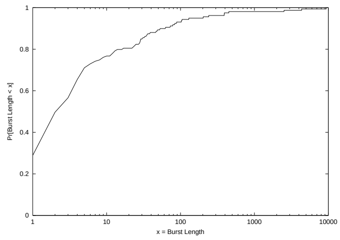
Trace 81, PLR = 0.676



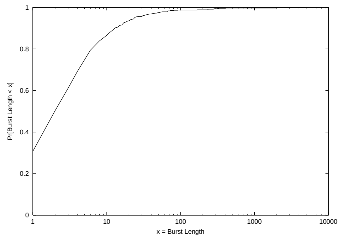
Trace 82, PLR = 0.8411



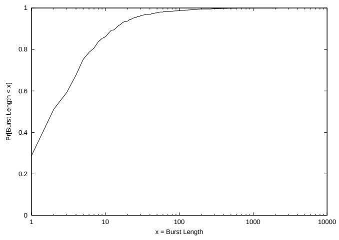
Trace 83, PLR = 0.1766



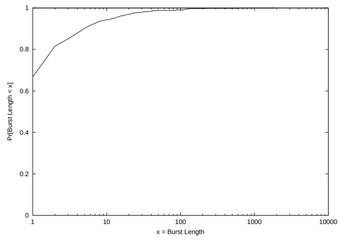
Trace 84, PLR = 0.0219



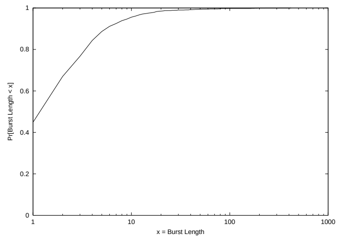
Trace 85, PLR = 0.14845



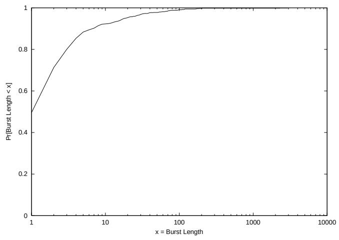
Trace 86, PLR = 0.20335



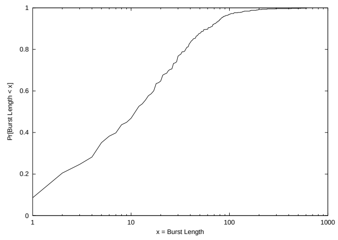
Trace 87, PLR = 0.6873



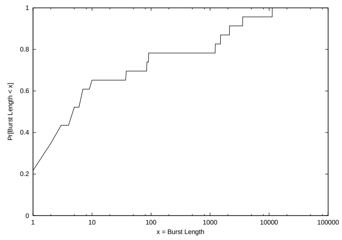
Trace 88, PLR = 0.5088



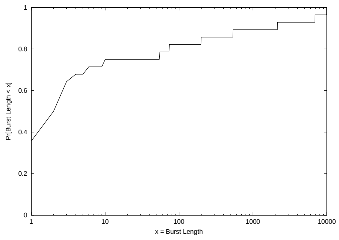
Trace 89, PLR = 0.3764



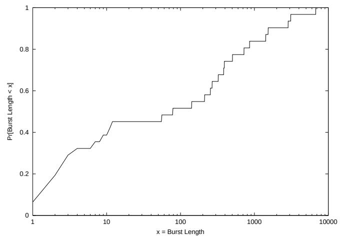
Trace 90, PLR = 0.05115



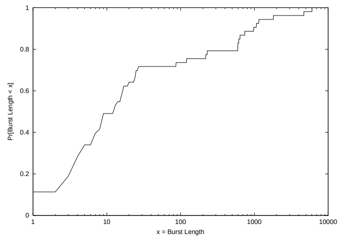
Trace 97, PLR = 0.0014



Trace 98, PLR = 0.00195

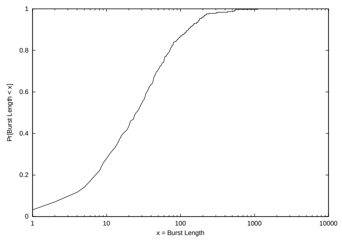


Trace 100, PLR = 0.00115

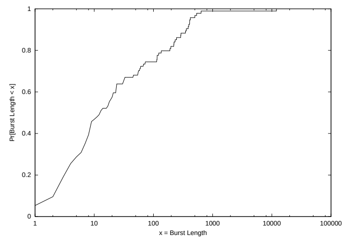


Trace 103, PLR = 0.00245

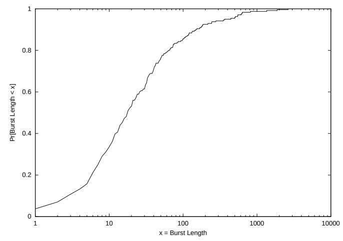
Table 3.18: Density of Packet Loss Free Burst Length ($k_0 = 1$), Traces 80 to 103 for **longterm1** measurements



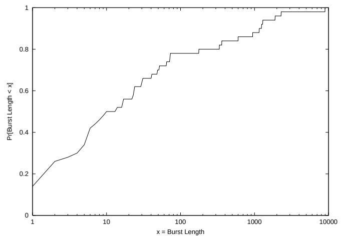
Trace 104, PLR = 0.02



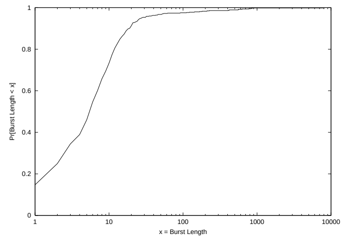
Trace 105, PLR = 0.0049



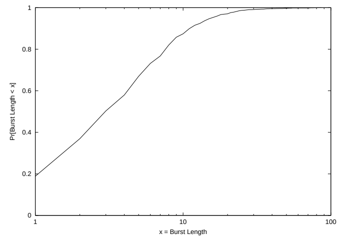
Trace 106, PLR = 0.01405



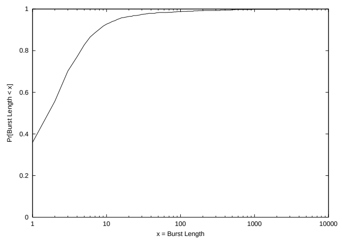
Trace 107, PLR = 0.0036



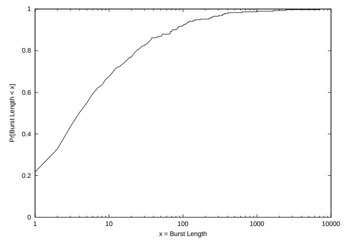
Trace 108, PLR = 0.02465



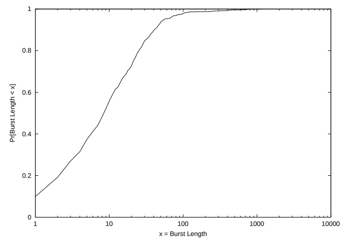
Trace 109, PLR = 0.1143



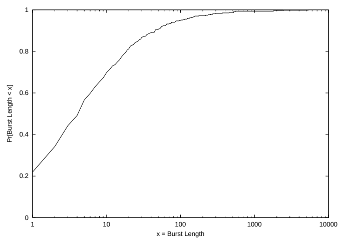
Trace 110, PLR = 0.0906



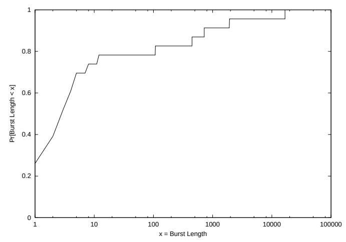
Trace 111, PLR = 0.012



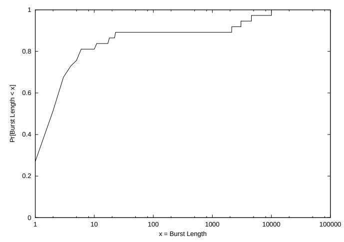
Trace 112, PLR = 0.039



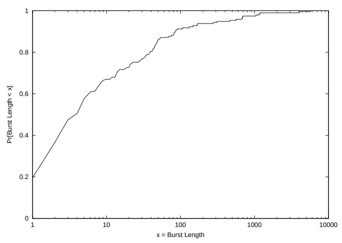
Trace 113, PLR = 0.0255



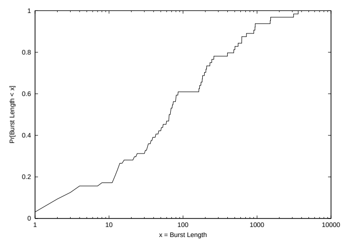
Trace 114, PLR = 0.0019



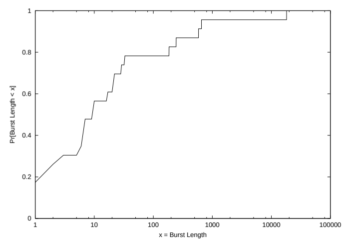
Trace 125, PLR = 0.0021



Trace 131, PLR = 0.01055

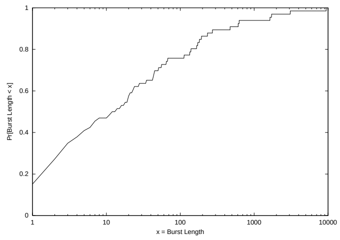


Trace 132, PLR = 0.0032

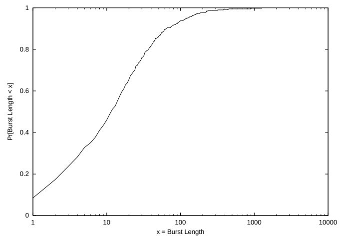


Trace 134, PLR = 0.0013

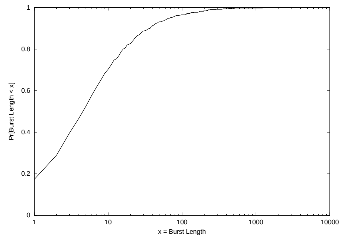
Table 3.19: Density of Packet Loss Free Burst Length ($k_0 = 1$), Traces 104 to 134 for **longterm1** measurements



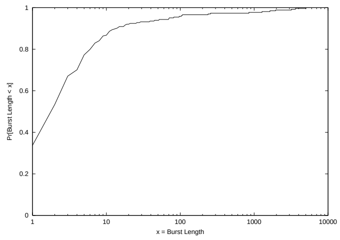
Trace 135, PLR = 0.00395



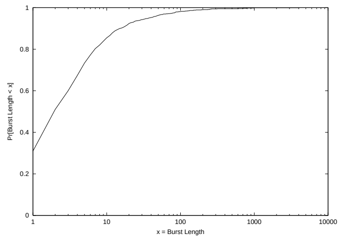
Trace 136, PLR = 0.0192



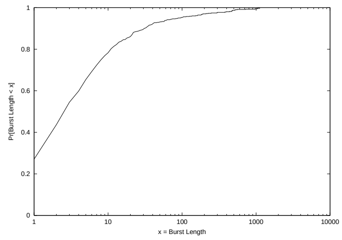
Trace 137, PLR = 0.0333



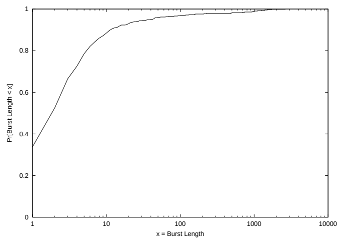
Trace 138, PLR = 0.01655



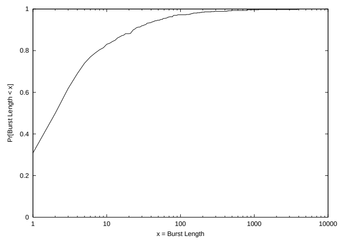
Trace 139, PLR = 0.06935



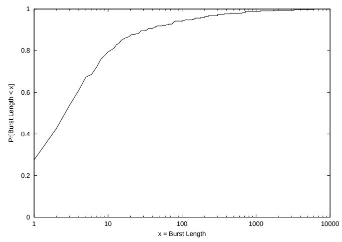
Trace 140, PLR = 0.046



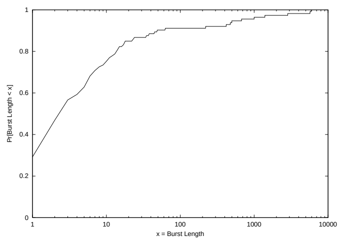
Trace 141, PLR = 0.04675



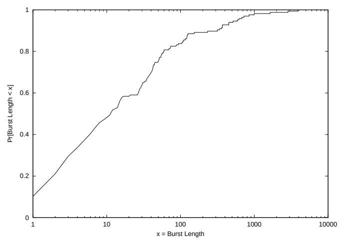
Trace 142, PLR = 0.0462



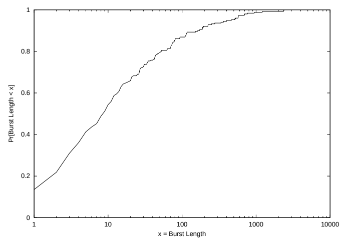
Trace 143, PLR = 0.0229



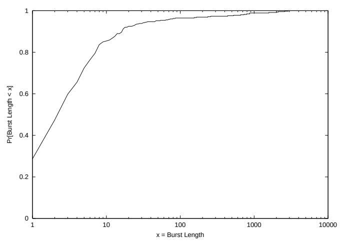
Trace 144, PLR = 0.0091



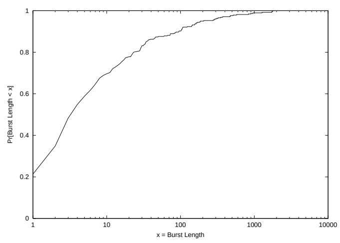
Trace 145, PLR = 0.0106



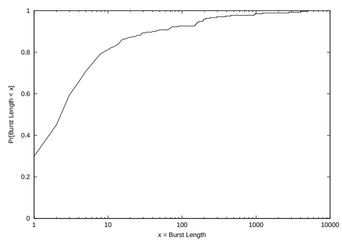
Trace 146, PLR = 0.0134



Trace 147, PLR = 0.02965

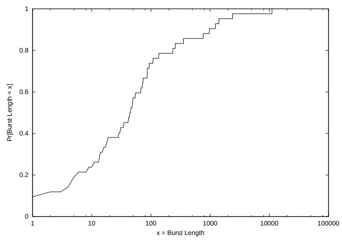


Trace 148, PLR = 0.0301

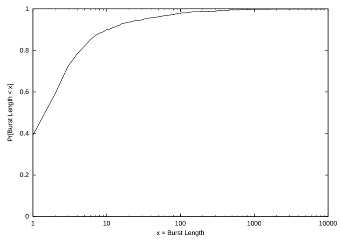


Trace 149, PLR = 0.017

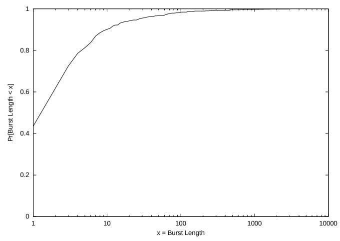
Table 3.20: Density of Packet Loss Free Burst Length ($k_0 = 1$), Traces 135 to 149 for **longterm1** measurements



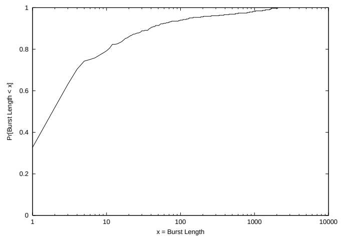
Trace 150, PLR = 0.0021



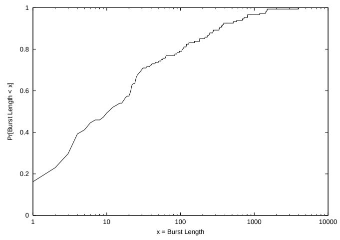
Trace 151, PLR = 0.06175



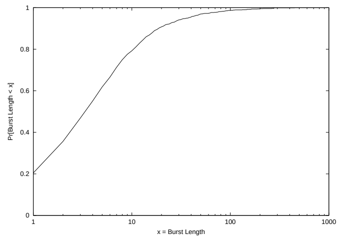
Trace 152, PLR = 0.0895



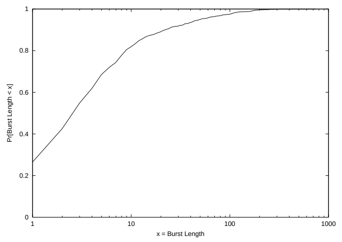
Trace 153, PLR = 0.0262



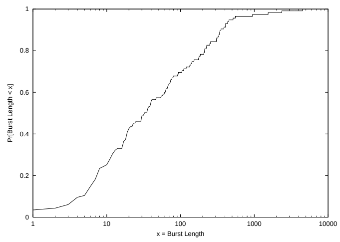
Trace 154, PLR = 0.00885



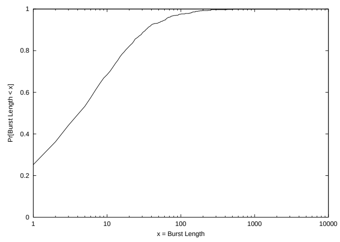
Trace 155, PLR = 0.10215



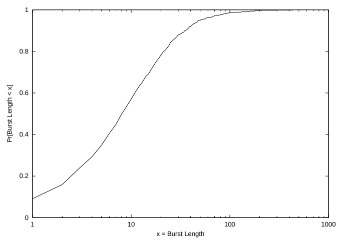
Trace 156, PLR = 0.09945



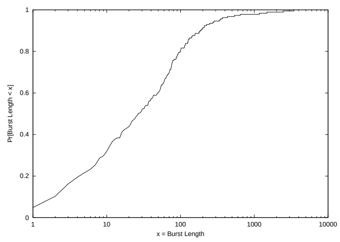
Trace 157, PLR = 0.0059



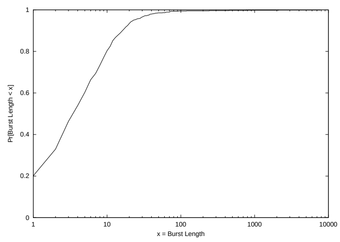
Trace 158, PLR = 0.06755



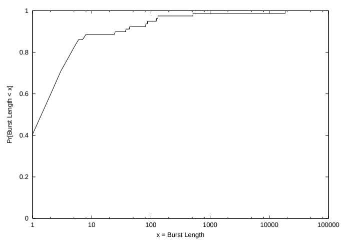
Trace 159, PLR = 0.07135



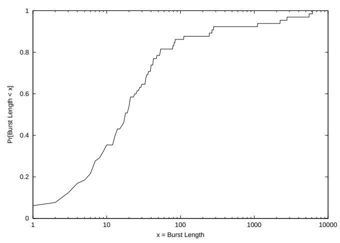
Trace 160, PLR = 0.0103



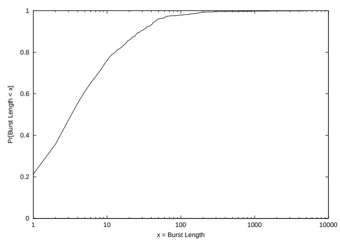
Trace 162, PLR = 0.06605



Trace 163, PLR = 0.01035

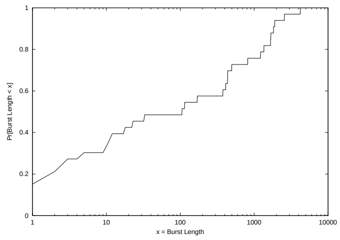


Trace 164, PLR = 0.004

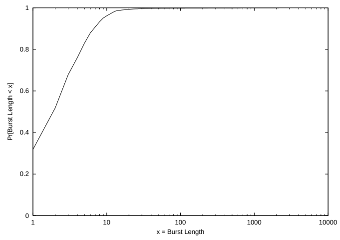


Trace 165, PLR = 0.06075

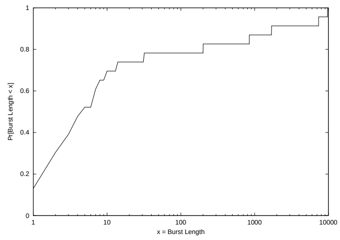
Table 3.21: Density of Packet Loss Free Burst Length ($k_0 = 1$), Traces 150 to 165 for **longterm1** measurements



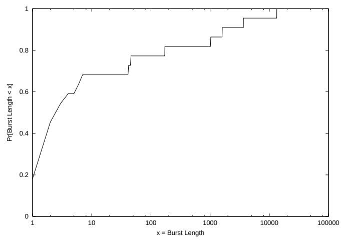
Trace 166, PLR = 0.00175



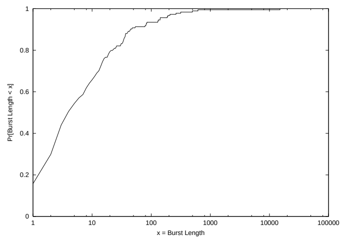
Trace 168, PLR = 0.23885



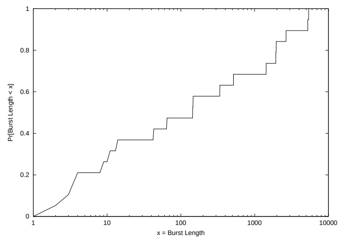
Trace 169, PLR = 0.0015



Trace 170, PLR = 0.00165



Trace 173, PLR = 0.0108

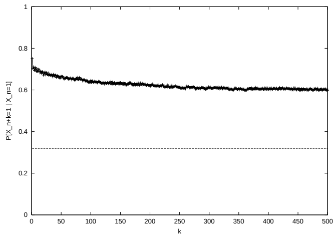


Trace 174, PLR = 0.00105

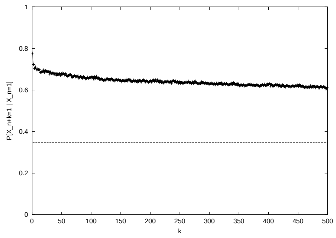
Table 3.22: Density of Packet Loss Free Burst Length ($k_0 = 1$), Traces 166 to 174 for **longterm1** measurements

3.2.3 Second Order Statistics

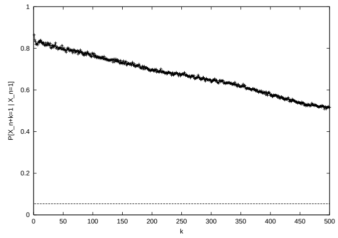
In tables 3.23, 3.24, 3.25, 3.26, 3.27, 3.28, 3.29, and 3.30 we show the conditional probability that packet $n+k$ is lost, given that packet n is lost, restricted to those traces with a minimum packet loss rate of 10^{-3}. Additionally, in the curves the mean packet loss rate is shown as a straight line. As discussed in [5] this probability is directly related to the autocorrelation function of the packet loss indicator sequence. Please not that for these curves we have treated ghost packets, bit shifted packets and missized packets as lost packets, which explains the slight variations in the packet loss rate as compared to the previous sections.



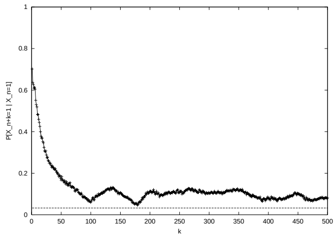
Trace 1, PLR = 0.3193



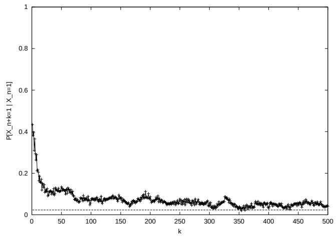
Trace 2, PLR = 0.34835



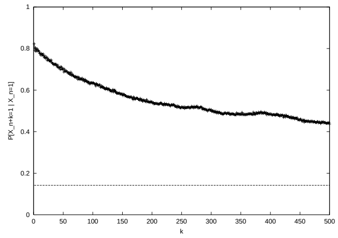
Trace 4, PLR = 0.0534



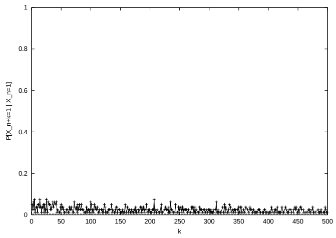
Trace 5, PLR = 0.03265



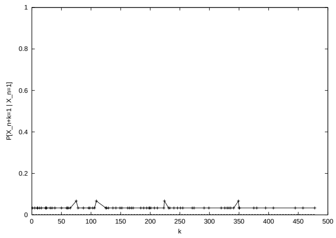
Trace 7, PLR = 0.02315



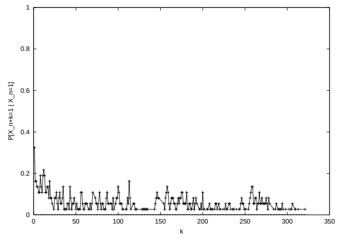
Trace 16, PLR = 0.14195



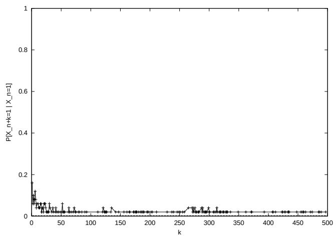
Trace 17, PLR = 0.004



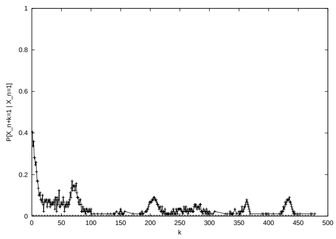
Trace 18, PLR = 0.0015



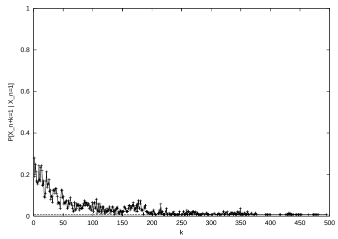
Trace 19, PLR = 0.00185



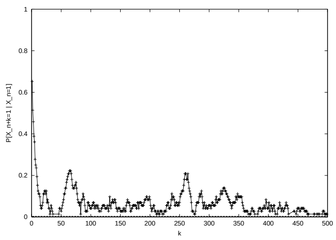
Trace 20, PLR = 0.0025



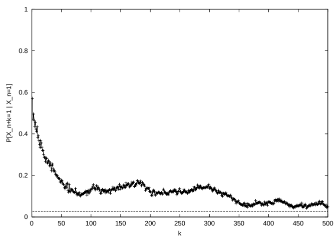
Trace 21, PLR = 0.00445



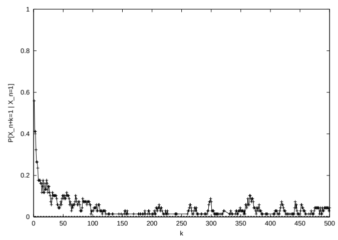
Trace 22, PLR = 0.0068



Trace 23, PLR = 0.0036

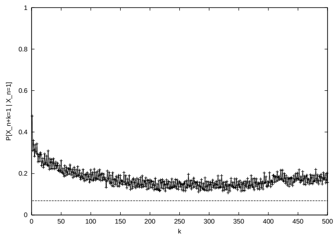


Trace 27, PLR = 0.02765

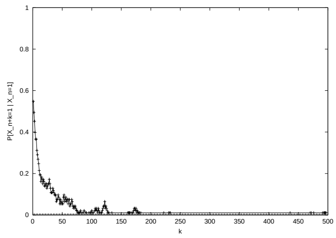


Trace 30, PLR = 0.0034

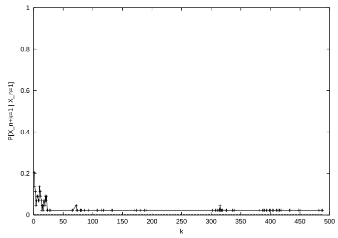
Table 3.23: Conditional Packet Loss Probabilities, Traces 1 to 30 for **longterm1** measurements



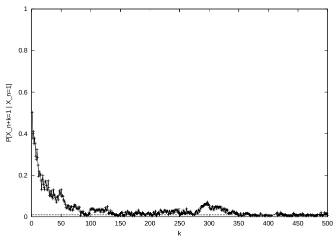
Trace 31, PLR = 0.06875



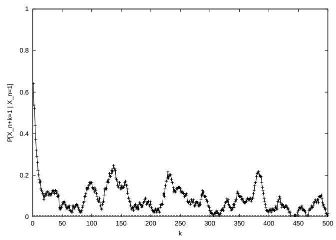
Trace 32, PLR = 0.00465



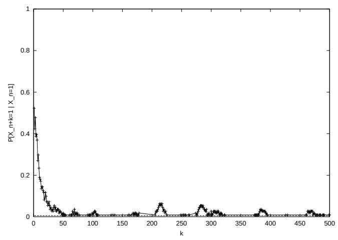
Trace 33, PLR = 0.0022



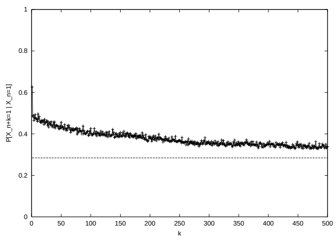
Trace 34, PLR = 0.00925



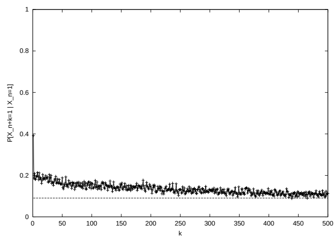
Trace 41, PLR = 0.0067



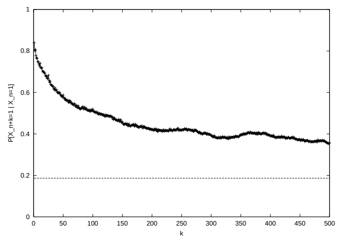
Trace 46, PLR = 0.00555



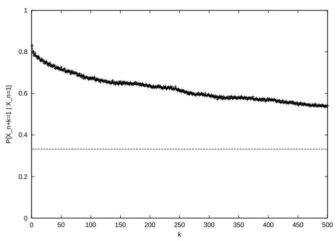
Trace 47, PLR = 0.28445



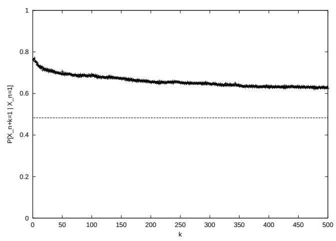
Trace 48, PLR = 0.0906



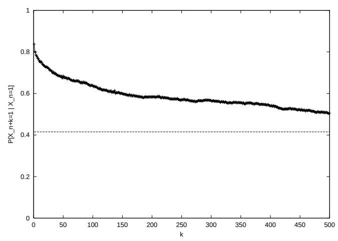
Trace 49, PLR = 0.18645



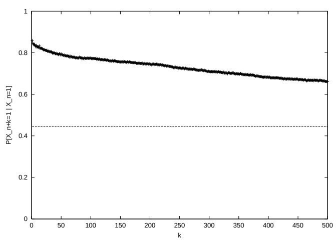
Trace 50, PLR = 0.33225



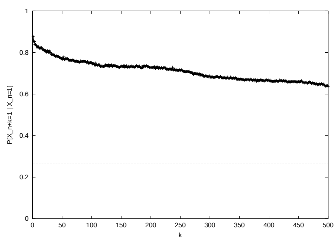
Trace 51, PLR = 0.4826



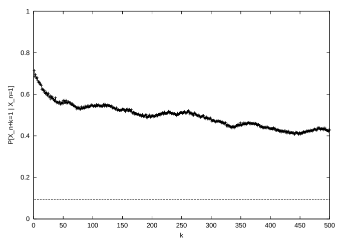
Trace 52, PLR = 0.4152



Trace 53, PLR = 0.446

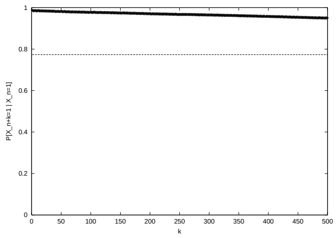


Trace 54, PLR = 0.26355

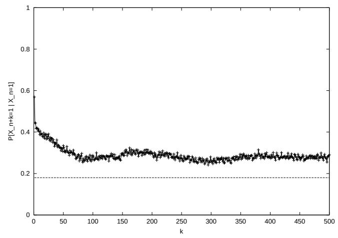


Trace 55, PLR = 0.0947

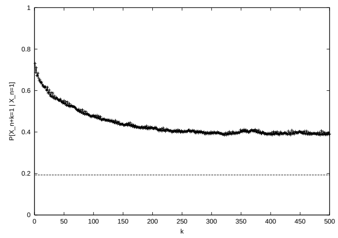
Table 3.24: Conditional Packet Loss Probabilities, Traces 31 to 55 for **longterm1** measurements



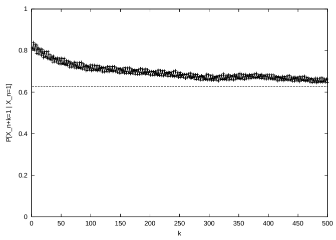
Trace 56, PLR = 0.77305



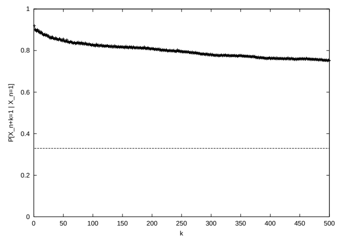
Trace 57, PLR = 0.17985



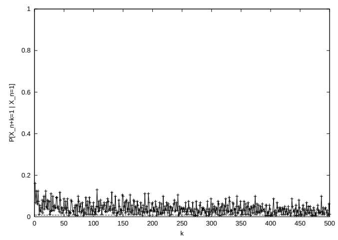
Trace 58, PLR = 0.19305



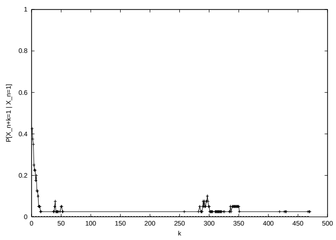
Trace 59, PLR = 0.62625



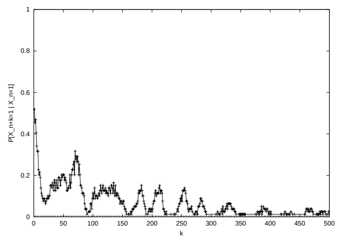
Trace 60, PLR = 0.3294



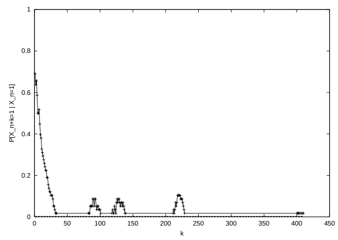
Trace 61, PLR = 0.0081



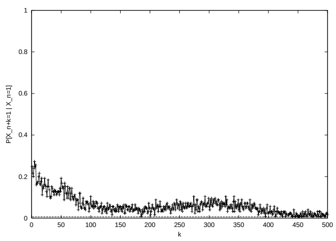
Trace 62, PLR = 0.002



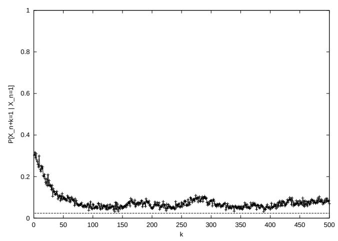
Trace 63, PLR = 0.00395



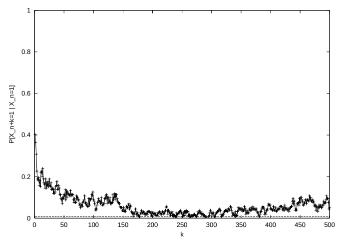
Trace 66, PLR = 0.0029



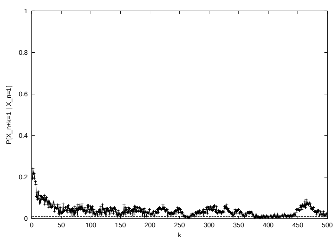
Trace 71, PLR = 0.00625



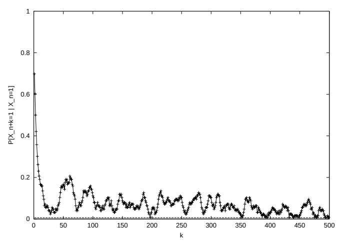
Trace 72, PLR = 0.02375



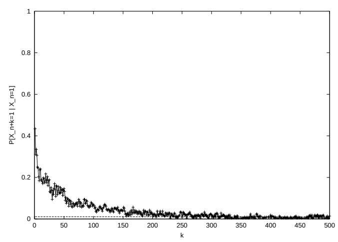
Trace 73, PLR = 0.00795



Trace 74, PLR = 0.0112

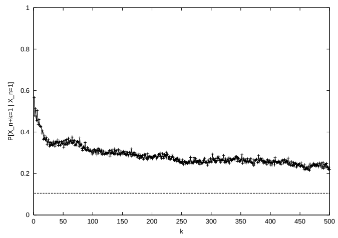


Trace 76, PLR = 0.0063

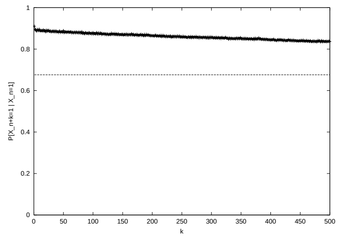


Trace 79, PLR = 0.0106

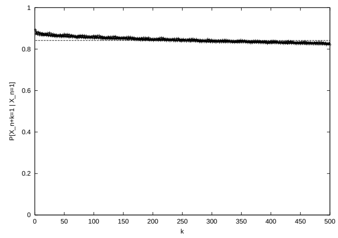
Table 3.25: Conditional Packet Loss Probabilities, Traces 56 to 79 for **longterm1** measurements



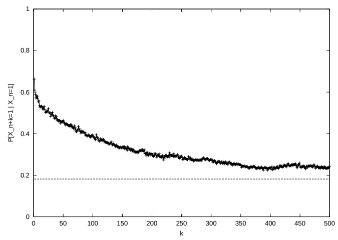
Trace 80, PLR = 0.105



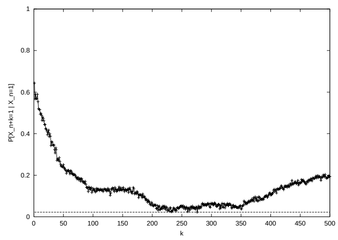
Trace 81, PLR = 0.6761



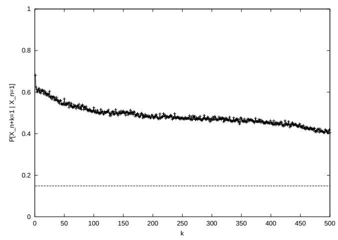
Trace 82, PLR = 0.84165



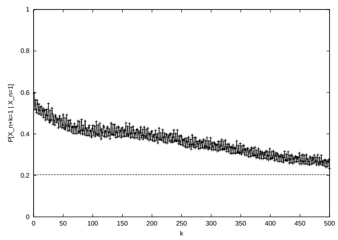
Trace 83, PLR = 0.1818



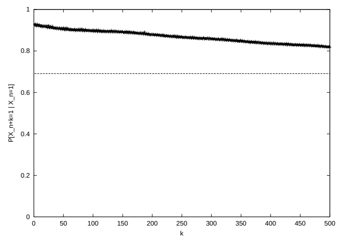
Trace 84, PLR = 0.0223



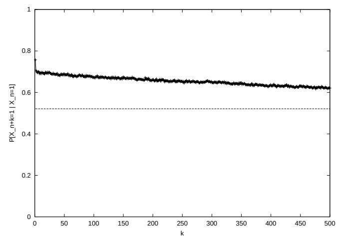
Trace 85, PLR = 0.1485



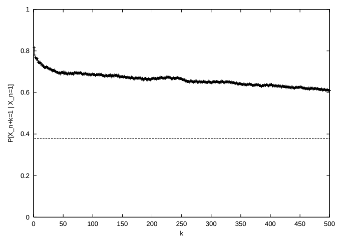
Trace 86, PLR = 0.20355



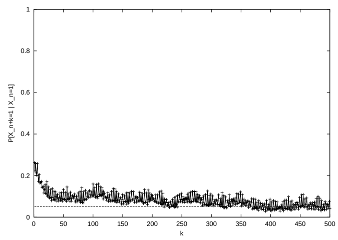
Trace 87, PLR = 0.69075



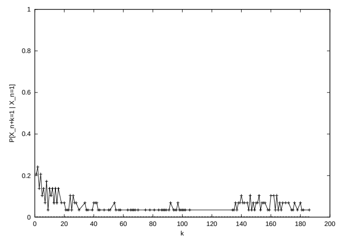
Trace 88, PLR = 0.52105



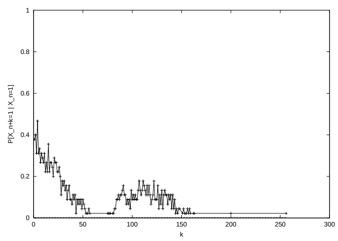
Trace 89, PLR = 0.37885



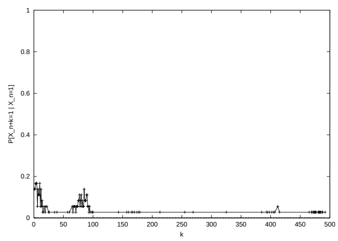
Trace 90, PLR = 0.05195



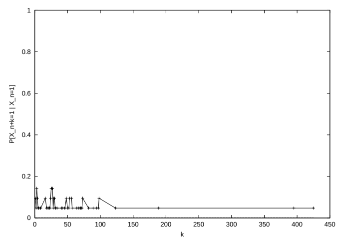
Trace 97, PLR = 0.00145



Trace 98, PLR = 0.00225

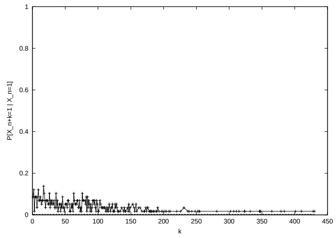


Trace 100, PLR = 0.0018

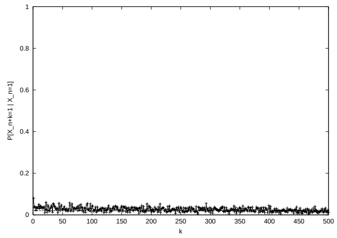


Trace 101, PLR = 0.00105

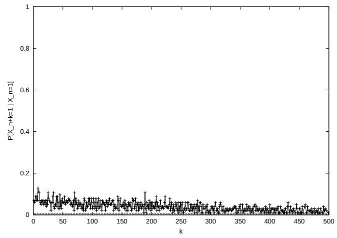
Table 3.26: Conditional Packet Loss Probabilities, Traces 80 to 101 for **longterm1** measurements



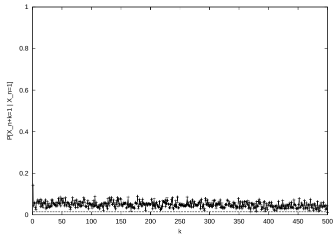
Trace 103, PLR = 0.0029



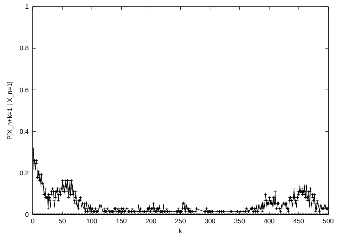
Trace 104, PLR = 0.02



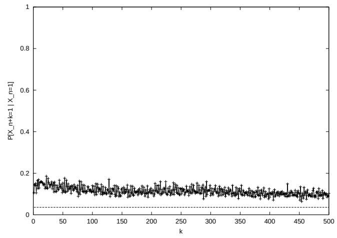
Trace 105, PLR = 0.00505



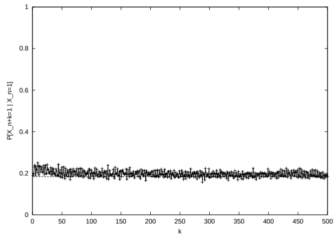
Trace 106, PLR = 0.01405



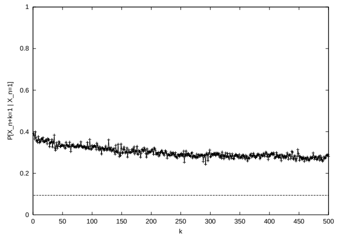
Trace 107, PLR = 0.00365



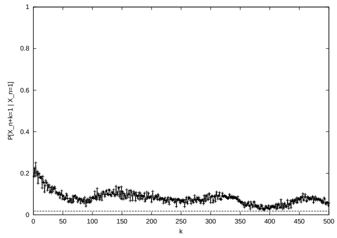
Trace 108, PLR = 0.03605



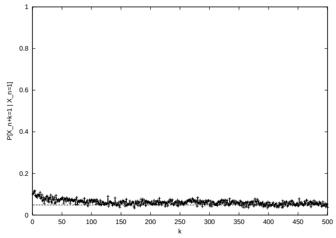
Trace 109, PLR = 0.18345



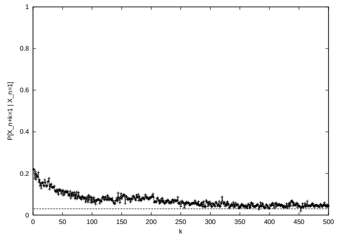
Trace 110, PLR = 0.0939



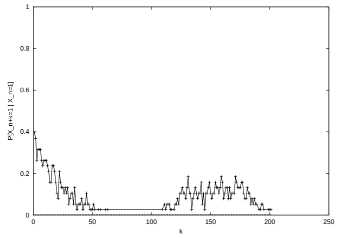
Trace 111, PLR = 0.0178



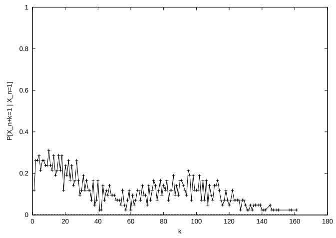
Trace 112, PLR = 0.0488



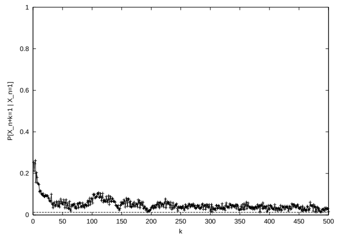
Trace 113, PLR = 0.03015



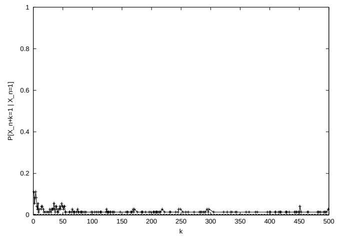
Trace 114, PLR = 0.0019



Trace 125, PLR = 0.0021

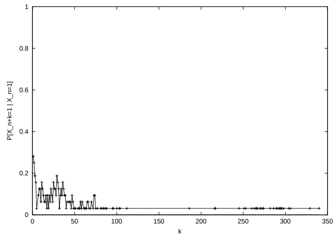


Trace 131, PLR = 0.013

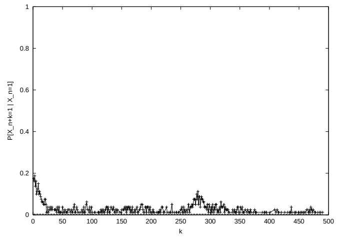


Trace 132, PLR = 0.0036

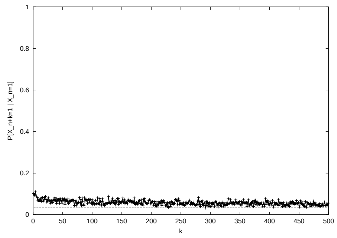
Table 3.27: Conditional Packet Loss Probabilities, Traces 103 to 132 for **longterm1** measurements



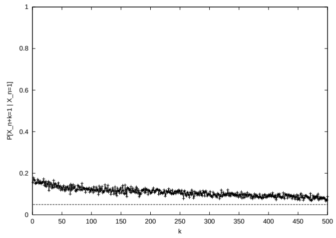
Trace 134, PLR = 0.0016



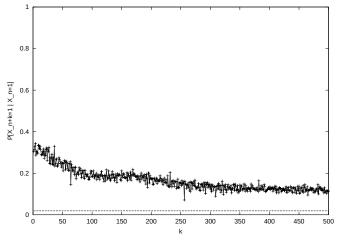
Trace 135, PLR = 0.004



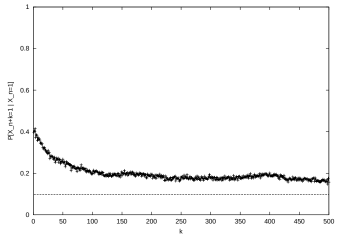
Trace 136, PLR = 0.0328



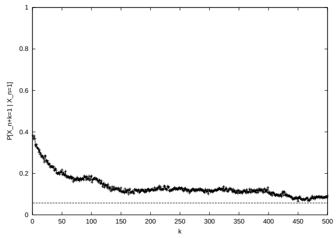
Trace 137, PLR = 0.04925



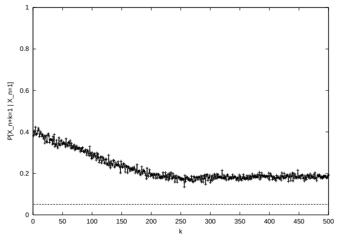
Trace 138, PLR = 0.01895



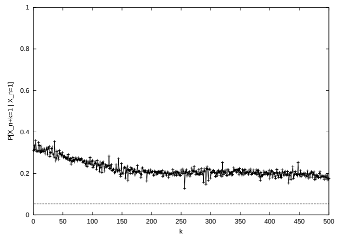
Trace 139, PLR = 0.09775



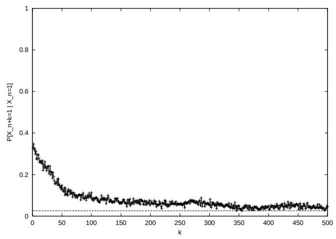
Trace 140, PLR = 0.05695



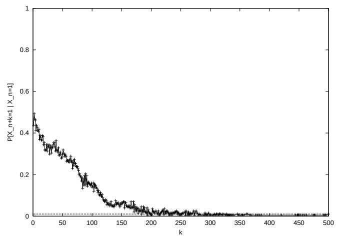
Trace 141, PLR = 0.05045



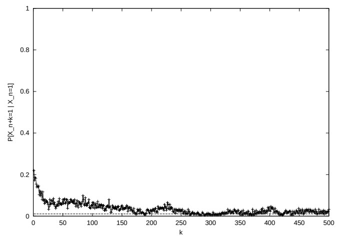
Trace 142, PLR = 0.0527



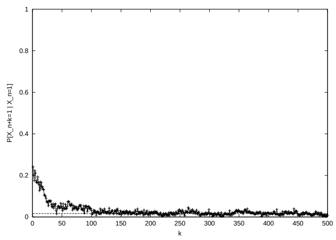
Trace 143, PLR = 0.02565



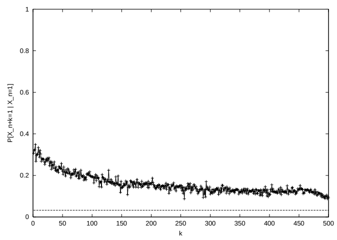
Trace 144, PLR = 0.01005



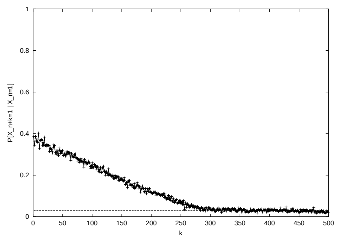
Trace 145, PLR = 0.0107



Trace 146, PLR = 0.0166

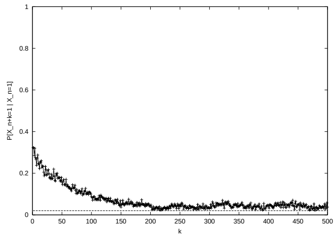


Trace 147, PLR = 0.03265

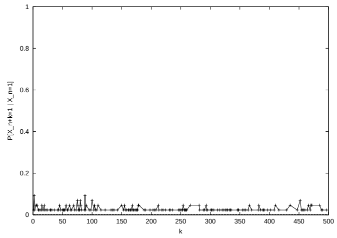


Trace 148, PLR = 0.0308

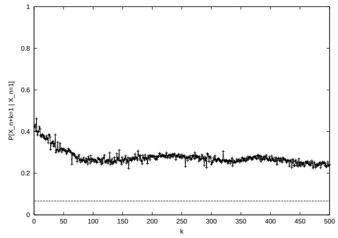
Table 3.28: Conditional Packet Loss Probabilities, Traces 134 to 148 for **longterm1** measurements



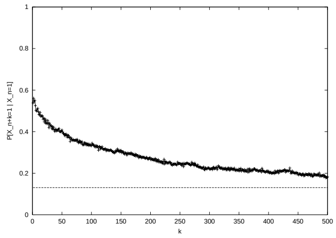
Trace 149, PLR = 0.02



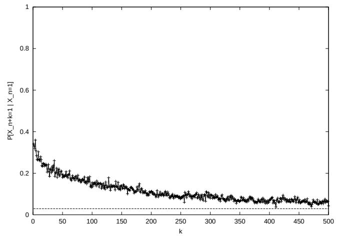
Trace 150, PLR = 0.00215



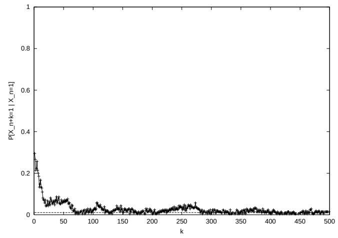
Trace 151, PLR = 0.0667



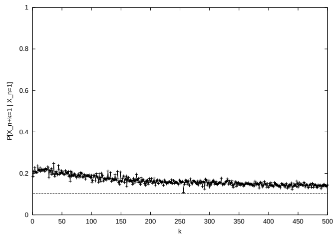
Trace 152, PLR = 0.1307



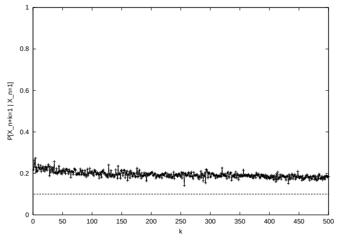
Trace 153, PLR = 0.0292



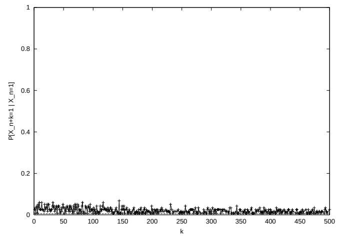
Trace 154, PLR = 0.0105



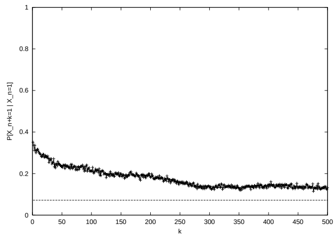
Trace 155, PLR = 0.10235



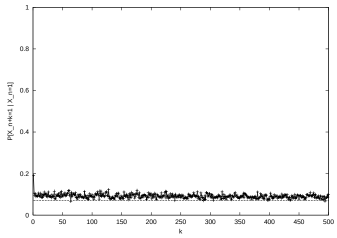
Trace 156, PLR = 0.09985



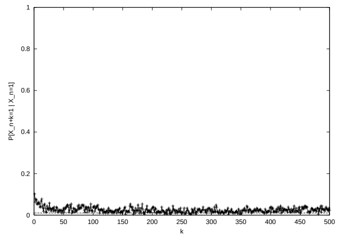
Trace 157, PLR = 0.0059



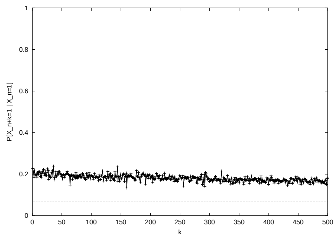
Trace 158, PLR = 0.07205



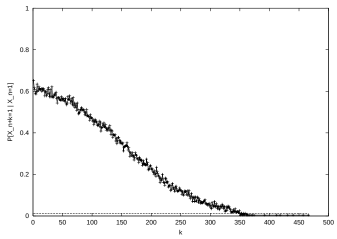
Trace 159, PLR = 0.07135



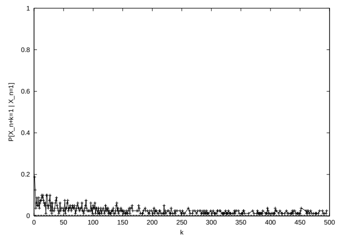
Trace 160, PLR = 0.0103



Trace 162, PLR = 0.0662

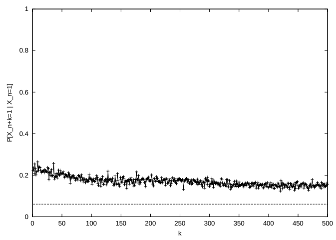


Trace 163, PLR = 0.0115

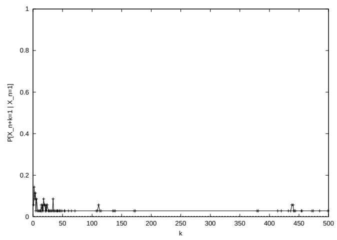


Trace 164, PLR = 0.004

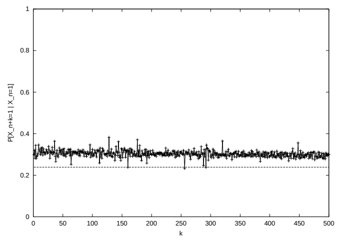
Table 3.29: Conditional Packet Loss Probabilities, Traces 149 to 164 for **longterm1** measurements



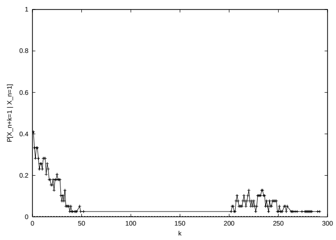
Trace 165, PLR = 0.06095



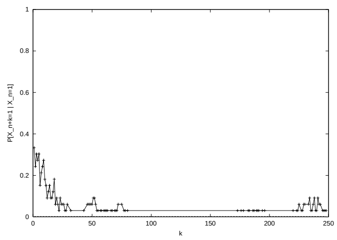
Trace 166, PLR = 0.00175



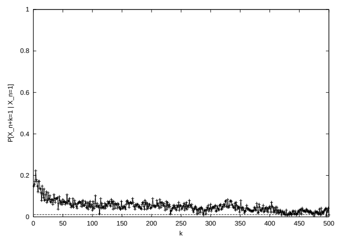
Trace 168, PLR = 0.23885



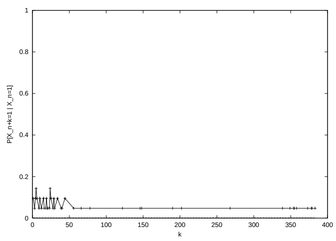
Trace 169, PLR = 0.00195



Trace 170, PLR = 0.00165



Trace 173, PLR = 0.0108



Trace 174, PLR = 0.00105

Table 3.30: Conditional Packet Loss Probabilities, Traces 165 to 174 for **longterm1** measurements

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Appendix A

Trace Numbers, Parameters and Main Statistics

In the following table we give for every trace its trace number, its parameters and the packet loss rate (not including ghost packets, missized packets, bit shifted packets). For the remaining packets of a trace (after removing all packets with one of the above impairments) we additionally give the mean bit error rate (MBER) and the packet error rate (PER). As an erroneous packet we count every remaining packet with at least one bit error.

Number	Parameters	Mean BER	PER	PLR
1	QPSK, 504, False	0.000000	0.00080	0.31875
2	QPSK, 504, False	0.000000	0.00046	0.348
3	QPSK, 504, False	0.000000	0.00050	5e-05
4	QPSK, 504, False	0.000000	0.00015	0.05325
5	QPSK, 504, False	0.000000	5.16876e-05	0.0326
6	QPSK, 504, False	0.000000	0	5e-05
7	QPSK, 504, False	0.000000	5.11849e-05	0.0231
8	QPSK, 504, False	0.000000	0	0.0002
9	QPSK, 504, False	0.000000	0	0.00035
10	QPSK, 504, False	0.000000	0	0.00015
11	QPSK, 504, False	0.000000	0	5e-05
12	QPSK, 504, False	0.000000	0	5e-05
13	QPSK, 504, False	0.000000	0	0.0001
14	QPSK, 504, False	0.000000	0	5e-05
15	QPSK, 504, False	0.000000	0.00010	5e-05
16	QPSK, 504, False	0.000042	0.00751	0.14
17	QPSK, 504, False	0.000000	0	0.004
18	QPSK, 504, False	0.000000	0.00030	0.0012
19	QPSK, 504, False	0.000000	5.00926e-05	0.0018
20	QPSK, 504, False	0.000000	0.00010	0.0024
21	QPSK, 504, False	0.000000	0	0.00445

Number	Parameters	Mean BER	PER	PLR
22	QPSK, 504, False	0.000000	5.03423e-05	0.00675
23	QPSK, 504, False	0.000001	0.00120	0.00325
24	QPSK, 504, False	0.000000	0	0.0001
25	QPSK, 504, False	0.000000	0.00010	5e-05
26	QPSK, 504, False	0.000000	0.00010	0.0001
27	QPSK, 504, False	0.000001	0.00169	0.0266
28	QPSK, 504, False	0.000000	0	0.0004
29	QPSK, 504, False	0.000000	5.00400e-05	0.00075
30	QPSK, 504, False	0.000003	0.00135	0.0033
31	QPSK, 504, False	0.000007	0.00461	0.06785
32	QPSK, 504, False	0.000001	0.00025	0.00465
33	QPSK, 504, False	0.000000	5.01102e-05	0.00215
34	QPSK, 504, False	0.000002	0.00146	0.0088
35	QPSK, 504, False	0.000000	0	5e-05
36	QPSK, 504, False	0.000000	0	5e-05
37	QPSK, 504, False	0.000000	0	5e-05
38	QPSK, 504, False	0.000000	0	0.0001
39	QPSK, 504, False	0.000000	0	5e-05
40	QPSK, 504, False	0.000000	0	5e-05
41	QPSK, 504, False	0.000001	0.00115	0.00635
42	QPSK, 504, False	0.000000	0	5e-05
43	QPSK, 504, False	0.000000	0	5e-05
44	QPSK, 504, False	0.000000	0	5e-05
45	QPSK, 504, False	0.000000	0	5e-05
46	QPSK, 504, False	0.000000	5.02790e-05	0.0055
47	QPSK, 504, False	0.000000	0.00111	0.28365
48	QPSK, 504, False	0.000000	0.00016	0.09045
49	QPSK, 504, False	0.000009	0.00774	0.18485
50	QPSK, 504, False	0.000000	0.00052	0.3319
51	QPSK, 504, False	0.000066	0.10668	0.4397
52	QPSK, 504, False	0.000002	0.00222	0.4147
53	QPSK, 504, False	0.000006	0.00388	0.44555
54	QPSK, 504, False	0.000000	0.00027	0.26335
55	QPSK, 504, False	0.000000	0.00011	0.0946
56	QPSK, 504, False	0.000000	0.00022	0.773
57	QPSK, 504, False	0.000000	0.00018	0.1797
58	QPSK, 504, False	0.000000	6.19617e-05	0.193
59	QPSK, 504, False	0.000000	0.00214	0.62545
60	QPSK, 504, False	0.000002	0.00260	0.32925
61	QPSK, 504, False	0.000000	0	0.0081
62	QPSK, 504, False	0.000000	0.00050	0.0015
63	QPSK, 504, False	0.000000	0.00095	0.0029
64	QPSK, 504, False	0.000002	0.00070	5e-05
65	QPSK, 504, False	0.000000	0.00020	5e-05
66	QPSK, 504, False	0.000000	0.00010	0.0028
67	QPSK, 504, False	0.000000	0.00010	5e-05
68	QPSK, 504, False	0.000000	0.00065	0.00025
69	QPSK, 504, False	0.000000	0	5e-05

Number	Parameters	Mean BER	PER	PLR
70	QPSK, 504, False	0.000000	0.00045	0.0004
71	QPSK, 504, False	0.000008	0.00528	0.00375
72	QPSK, 504, False	0.000011	0.01766	0.01475
73	QPSK, 504, False	0.000004	0.00670	0.00275
74	QPSK, 504, False	0.000002	0.00561	0.0061
75	QPSK, 504, False	0.000001	0.00035	0.0001
76	QPSK, 504, False	0.000006	0.00457	0.00565
77	QPSK, 504, False	0.000000	0	5e-05
78	QPSK, 504, False	0.000000	0	0.0002
79	QPSK, 504, False	0.000003	0.00085	0.0105
80	QPSK, 504, False	0.000000	0.00022	0.1048
81	QPSK, 504, False	0.000000	0.00030	0.676
82	QPSK, 504, False	0.000000	0.00347	0.8411
83	QPSK, 504, False	0.000016	0.01631	0.1766
84	QPSK, 504, False	0.000000	0.00051	0.0219
85	QPSK, 504, False	0.000000	5.87199e-05	0.14845
86	QPSK, 504, False	0.000000	0.00025	0.20335
87	QPSK, 504, False	0.000001	0.00889	0.6873
88	QPSK, 504, False	0.000007	0.03069	0.5088
89	QPSK, 504, False	0.000007	0.00982	0.3764
90	QPSK, 504, False	0.000000	0.00084	0.05115
91	QPSK, 504, True	0.000000	0	5e-05
92	QPSK, 504, True	0.000000	0.00015	5e-05
93	QPSK, 504, True	0.000000	0	5e-05
94	QPSK, 504, True	0.000000	5.00050e-05	5e-05
95	QPSK, 504, True	0.000000	0.00010	0.00015
96	QPSK, 504, True	0.000000	0.00020	0.00015
97	QPSK, 504, True	0.000004	0.00045	0.0014
98	QPSK, 504, True	0.000006	0.00125	0.00195
99	QPSK, 504, True	0.000000	0.00035	0.0002
100	QPSK, 504, True	0.000025	0.00370	0.00115
101	QPSK, 504, True	0.000002	0.00095	0.0006
102	QPSK, 504, True	0.000000	0.00075	5e-05
103	QPSK, 504, True	0.000001	0.00090	0.00245
104	QPSK, 504, True	0.000000	0	0.02
105	QPSK, 504, True	0.000000	5.02537e-05	0.0049
106	QPSK, 504, True	0.000000	0	0.01405
107	QPSK, 504, True	0.000008	0.00110	0.0036
108	QPSK, 504, True	0.000006	0.00606	0.02465
109	QPSK, 504, True	0.000191	0.21474	0.1143
110	QPSK, 504, True	0.000190	0.12603	0.0906
111	QPSK, 504, True	0.000088	0.02519	0.012
112	QPSK, 504, True	0.000201	0.05230	0.039
113	QPSK, 504, True	0.000587	0.10599	0.0255
114	QPSK, 504, True	0.000010	0.00170	0.0019
115	QPSK, 504, True	0.000000	0	5e-05
116	QPSK, 504, True	0.000000	0	0.00025
117	QPSK, 504, True	0.000000	0	5e-05

Number	Parameters	Mean BER	PER	PLR
118	QPSK, 504, True	0.000000	0	5e-05
119	QPSK, 504, True	0.000000	0	0.0001
120	QPSK, 504, True	0.000000	0	5e-05
121	QPSK, 504, True	0.000000	0	5e-05
122	QPSK, 504, True	0.000000	0	5e-05
123	QPSK, 504, True	0.000000	0	5e-05
124	QPSK, 504, True	0.000005	0.00105	0.0003
125	QPSK, 504, True	0.000000	0	0.0021
126	QPSK, 504, True	0.000000	0	5e-05
127	QPSK, 504, True	0.000000	0	5e-05
128	QPSK, 504, True	0.000000	0	0.00015
129	QPSK, 504, True	0.000010	0.00165	0.00065
130	QPSK, 504, True	0.000024	0.00385	0.0006
131	QPSK, 504, True	0.000045	0.00759	0.01055
132	QPSK, 504, True	0.000002	0.00090	0.0032
133	QPSK, 504, True	0.000000	0	0.00015
134	QPSK, 504, True	0.000046	0.00395	0.0013
135	QPSK, 504, True	0.000000	0.00025	0.00395
136	QPSK, 504, True	0.000114	0.12892	0.0192
137	QPSK, 504, True	0.000087	0.06573	0.0333
138	QPSK, 504, True	0.000117	0.02211	0.01655
139	QPSK, 504, True	0.001027	0.15239	0.06935
140	QPSK, 504, True	0.000444	0.06881	0.046
141	QPSK, 504, True	0.000382	0.07561	0.04675
142	QPSK, 504, True	0.001052	0.11010	0.0462
143	QPSK, 504, True	0.000063	0.01226	0.0229
144	QPSK, 504, True	0.000040	0.00934	0.0091
145	QPSK, 504, True	0.000001	0.00065	0.0106
146	QPSK, 504, True	0.000179	0.02308	0.0134
147	QPSK, 504, True	0.000044	0.01090	0.02965
148	QPSK, 504, True	0.000029	0.01279	0.0301
149	QPSK, 504, True	0.000131	0.02	0.017
150	QPSK, 504, True	0.000000	5.01077e-05	0.0021
151	QPSK, 504, True	0.000360	0.03675	0.06175
152	QPSK, 504, True	0.000583	0.11445	0.0895
153	QPSK, 504, True	0.000107	0.01689	0.0262
154	QPSK, 504, True	0.000009	0.00419	0.00885
155	QPSK, 504, True	0.000029	0.01487	0.10215
156	QPSK, 504, True	0.000693	0.21835	0.09945
157	QPSK, 504, True	0.001038	0.27291	0.0059
158	QPSK, 504, True	0.000062	0.01330	0.06755
159	QPSK, 504, True	0.000000	0	0.07135
160	QPSK, 504, True	0.000000	5.05203e-05	0.0103
161	QPSK, 504, True	0.000000	0	5e-05
162	QPSK, 504, True	0.000002	0.00085	0.06605
163	QPSK, 504, True	0.000000	0.00035	0.01035
164	QPSK, 504, True	0.000000	0	0.004
165	QPSK, 504, True	0.000000	0.00021	0.06075

Number	Parameters	Mean BER	PER	PLR
166	QPSK, 504, True	0.000000	0	0.00175
167	QPSK, 504, True	0.000000	0	0.00025
168	QPSK, 504, True	0.000000	0.00019	0.23885
169	QPSK, 504, True	0.000001	0.00085	0.0015
170	QPSK, 504, True	0.000001	0.00040	0.00165
171	QPSK, 504, True	0.000000	0	5e-05
172	QPSK, 504, True	0.000000	0	5e-05
173	QPSK, 504, True	0.000003	0.00202	0.0108
174	QPSK, 504, True	0.000004	0.00265	0.00105
175	QPSK, 504, True	0.000000	0	5e-05
176	QPSK, 504, True	0.000000	0	5e-05
177	QPSK, 504, True	0.000000	0	5e-05
178	QPSK, 504, True	0.000000	0	0.0001
179	QPSK, 504, True	0.000000	0	5e-05
180	QPSK, 504, True	0.000000	0.00010	0.00255

Table A.1: Mapping of trace numbers to measurement parameters for **longterm1** measurement