Simple Descriptions, Complex Metrics

A graphical approach to understanding packet clock metrics

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(Revision 3)

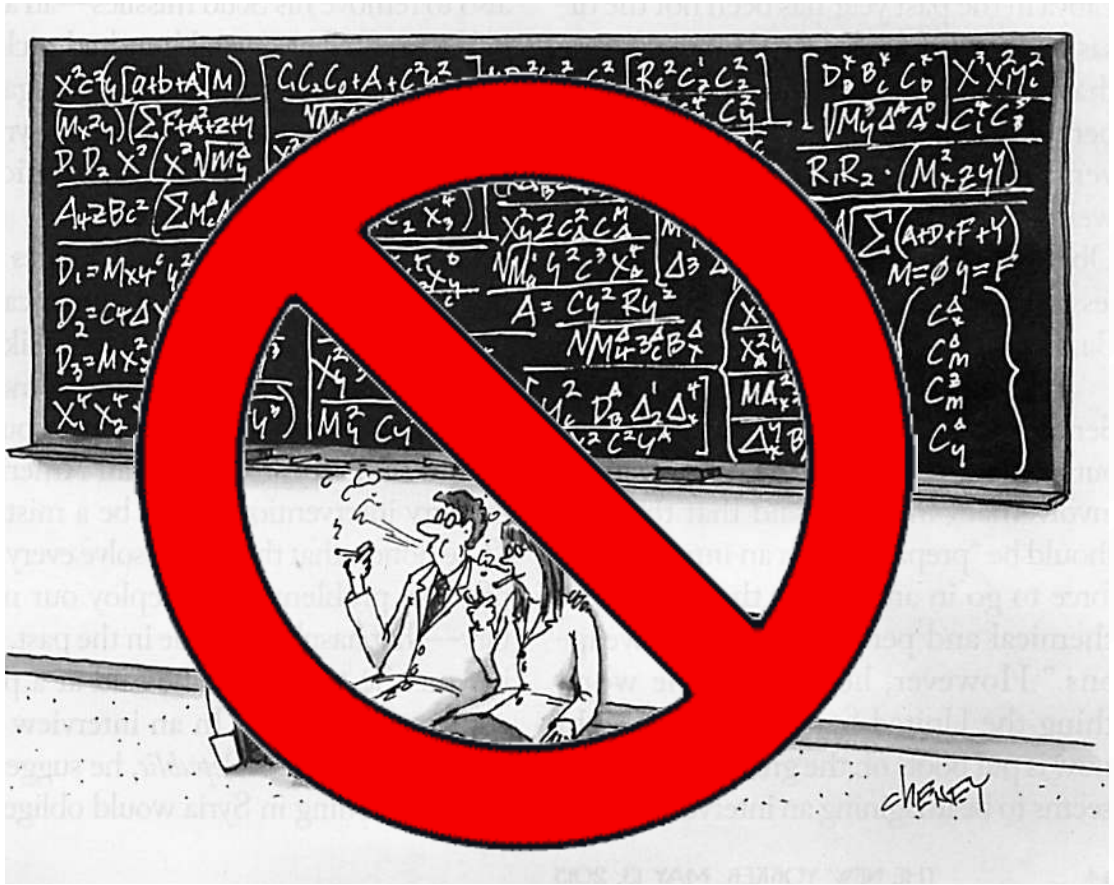
"Basically, we're all trying to say the same thing."

- **Introduction**
- New Metrics
- Lucky Packets
- Floor Population
  - Definitions
  - Limits
  - Example Measurement
- MAFE
  - Definition
  - Example Measurement
- Conclusion

Introduction

Chip Webb, IXIA, ITSF-2013

Introduction



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New Metrics

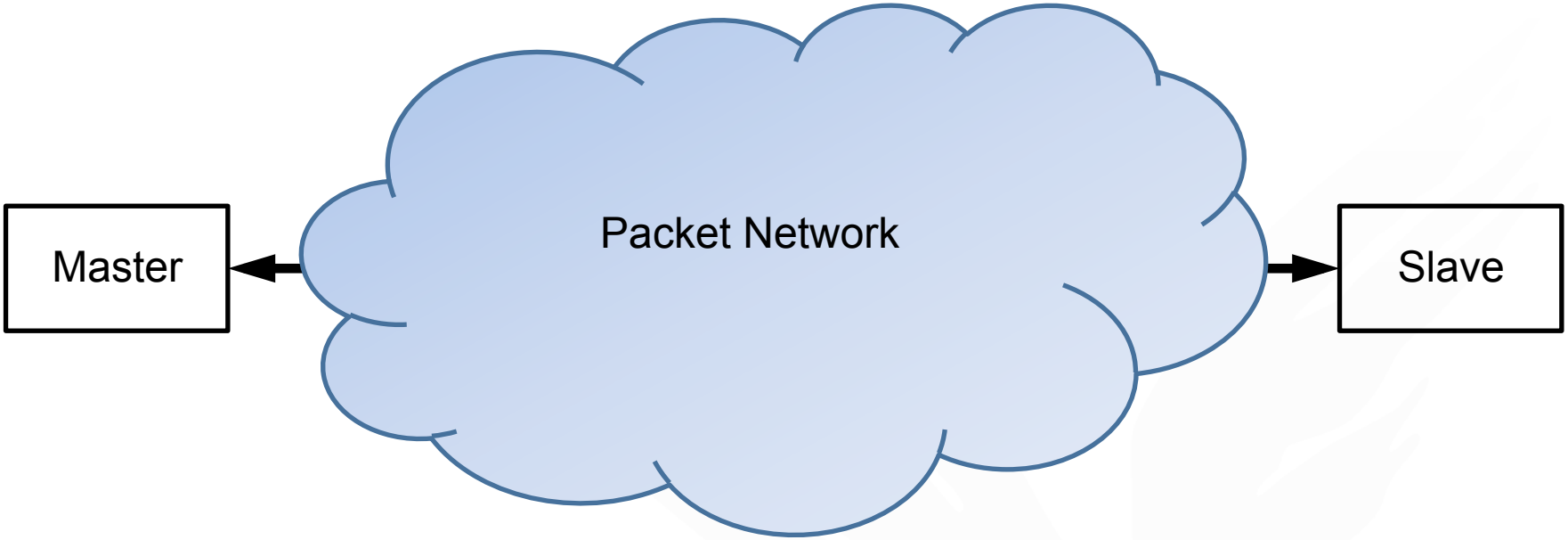
New Metrics

- What are the new metrics?
  - FP***C***, FP***P***, FP***R*** (***F***loor ***P***acket ***C***ount, etc.)
  - MAFE (***M***ax. ***A***bs. ***F***req. ***E***rr.)
- Where are they used? New ITU Rec's
  - FPP & MAFE: Defined in G.8260
  - FPP: Network limit in G.8261.1 (1%)
  - FPP: Slave tolerance limit in G.8263 (1%)

What do they measure?

- Floor packet metrics measure:
  - How many packets go fast
  - Plotted versus time
    - It will tell you ***when*** a problem happened
- MAFE measures:
  - Peak frequency error implied by lucky packets
  - Helps estimate packet slave performance
  - Plotted versus observation interval (τ)

Packet Timing System



The Floor Population Metrics & MAFE are ways to characterize Packet Delay Variation (PDV) in this system

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Quiz: Which of these shows Lucky Packets?

Lucky Packets

- Packets that experience near minimum delay are *Lucky*
  - They spend little or no time waiting in queues
  - They are fortunate to avoid congestion in the network
- KEY: PDV of lucky packets is relatively low
- Imagine driving home with all the traffic lights ***GREEN!***

Packet Selection

- Two ways:
  - Cluster range (e.g. within 150us of minimum)
  - Percentile range (e.g. 5% of fastest packets)
- Floor population metrics use cluster range
- We'll see MAFE with percentile range

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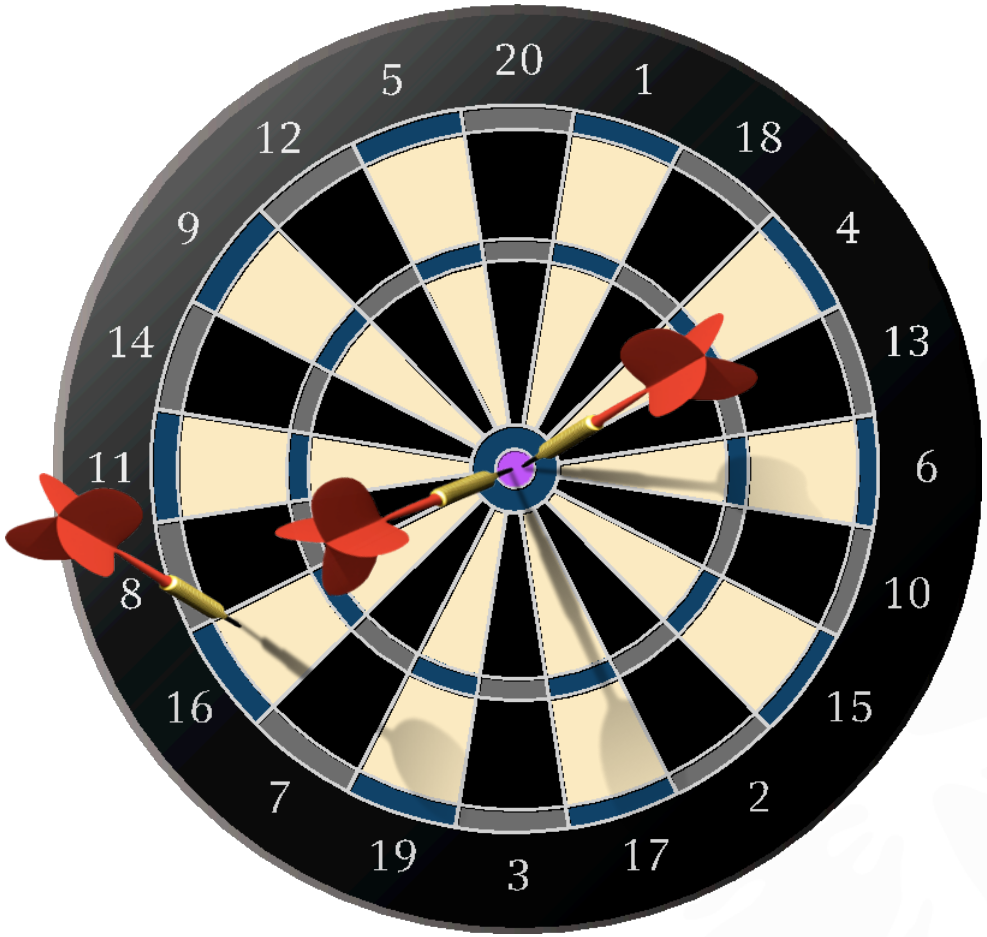
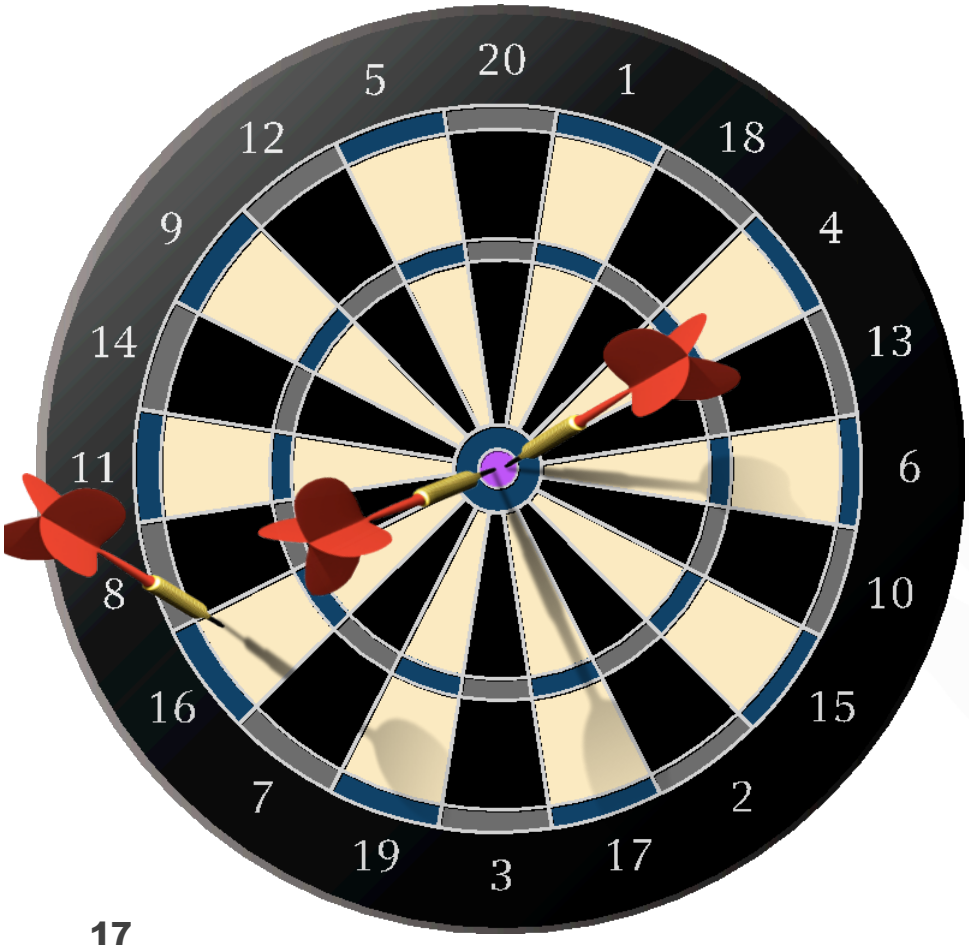
Cluster Selection Analogy



Cluster Selection Analogy



- Game lasted 1 minute
- Three darts thrown
- Two hit Bull's Eye
- 1 point for Bull's Eye

STATS

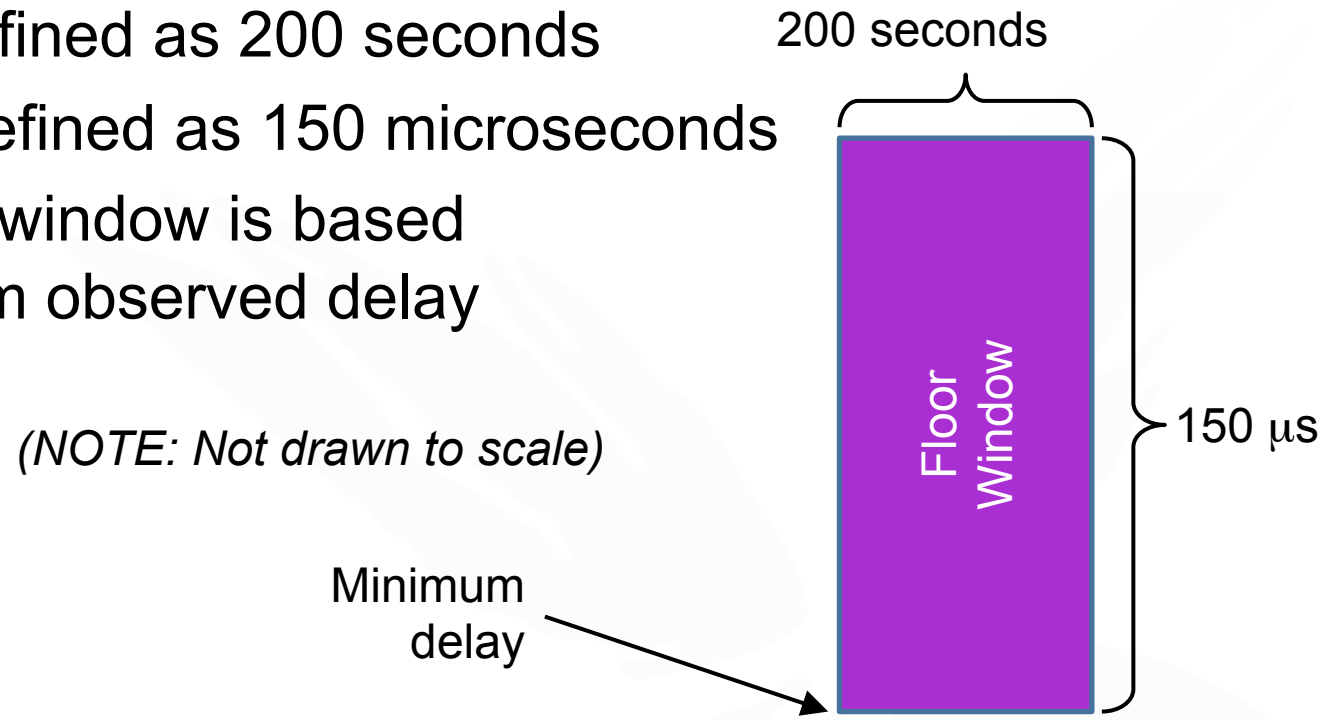
- Score=2
- Percent=67% (2/3)
- Rate=2/minute

Metric Definitions via Dart Board Analogy

- Floor Packet Count (FPC)
  - The number of times a dart landed in the Bull's Eye
- Floor Packet Percentage (FPP)
  - The percentage of times a dart landed in the Bull's Eye
- Floor Packet Rate (FPR)
  - The rate that darts land in the Bull's Eye (e.g. per minute or hour)
- To apply to packet timing systems:
  - Replace "dart" with "timing packets"
  - Replace "land" with "have delay" (or "are delivered")
  - Replace "Bull's Eye" with "Floor Window"
    - (size of Bull's Eye is analogous to the "cluster range"

The Floor Window
(a.k.a. the Bull's Eye)

- Window has width, height and vertical position
  - Width is defined as 200 seconds
  - Height is defined as 150 microseconds
  - Position of window is based on minimum observed delay



(NOTE: Not drawn to scale)

Network PDV Limit (G.8261.1)

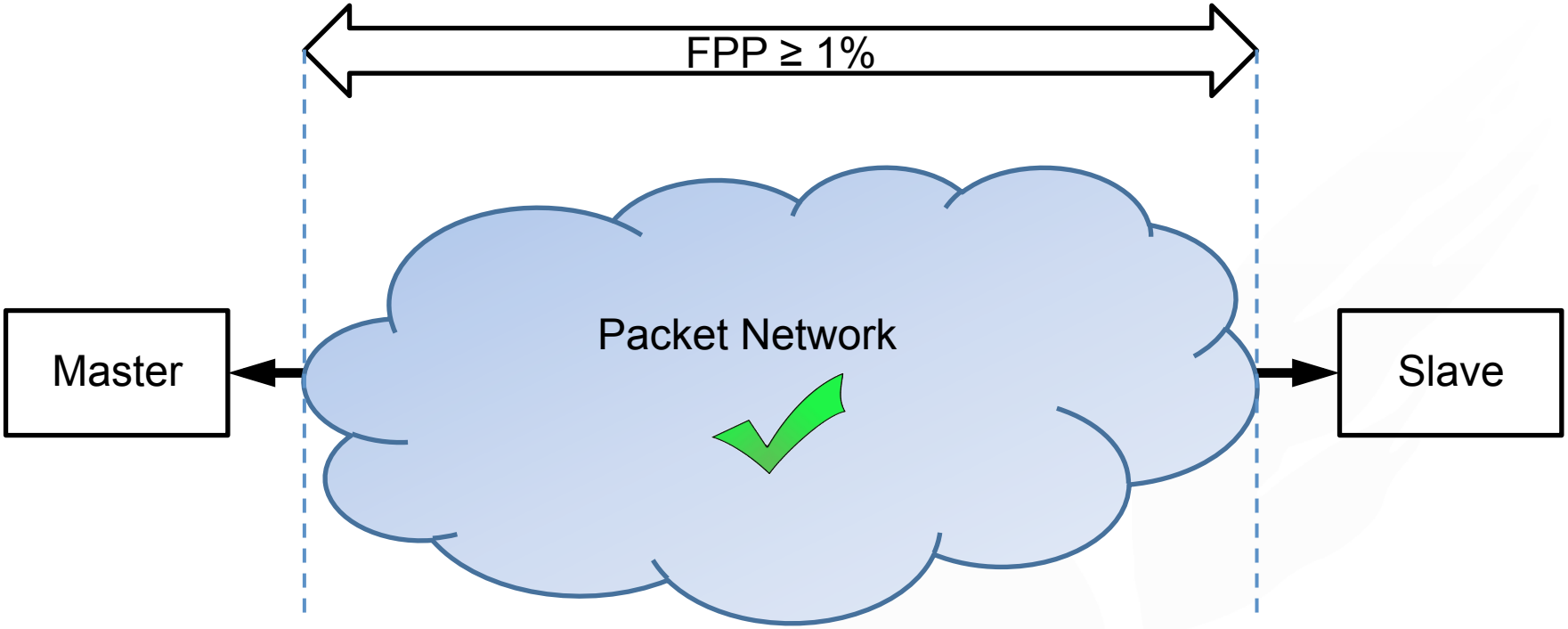
The Packet Delay Variation network limit at the point C of figure 3/G.8261.1 for the HRM-1 shown in figure 1/G.8261.1 is defined as follows:

With window interval $W = 200$s and fixed cluster range $\delta = 150\mu$s starting at the floor delay, the network transfer characteristic quantifying the proportion of delivered packets that meet the delay criterion should satisfy

$$\mathbf{FPP}\ (n, W, \delta) \geq 1\%$$

That is, the floor packet percentage must exceed 1%.

Network PDV Limit



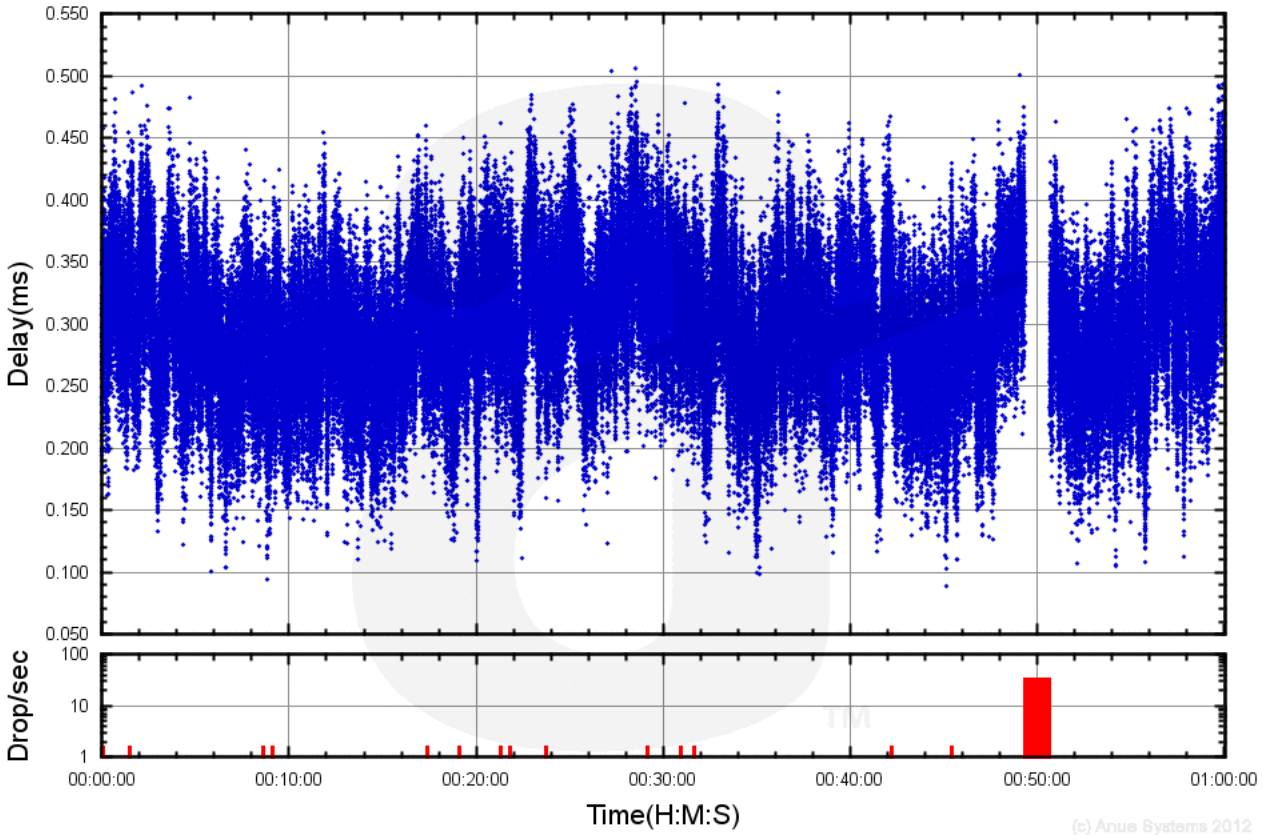
NOTE: This is a relative measurement
and doesn't depend on timing packet rate

Example Measurement

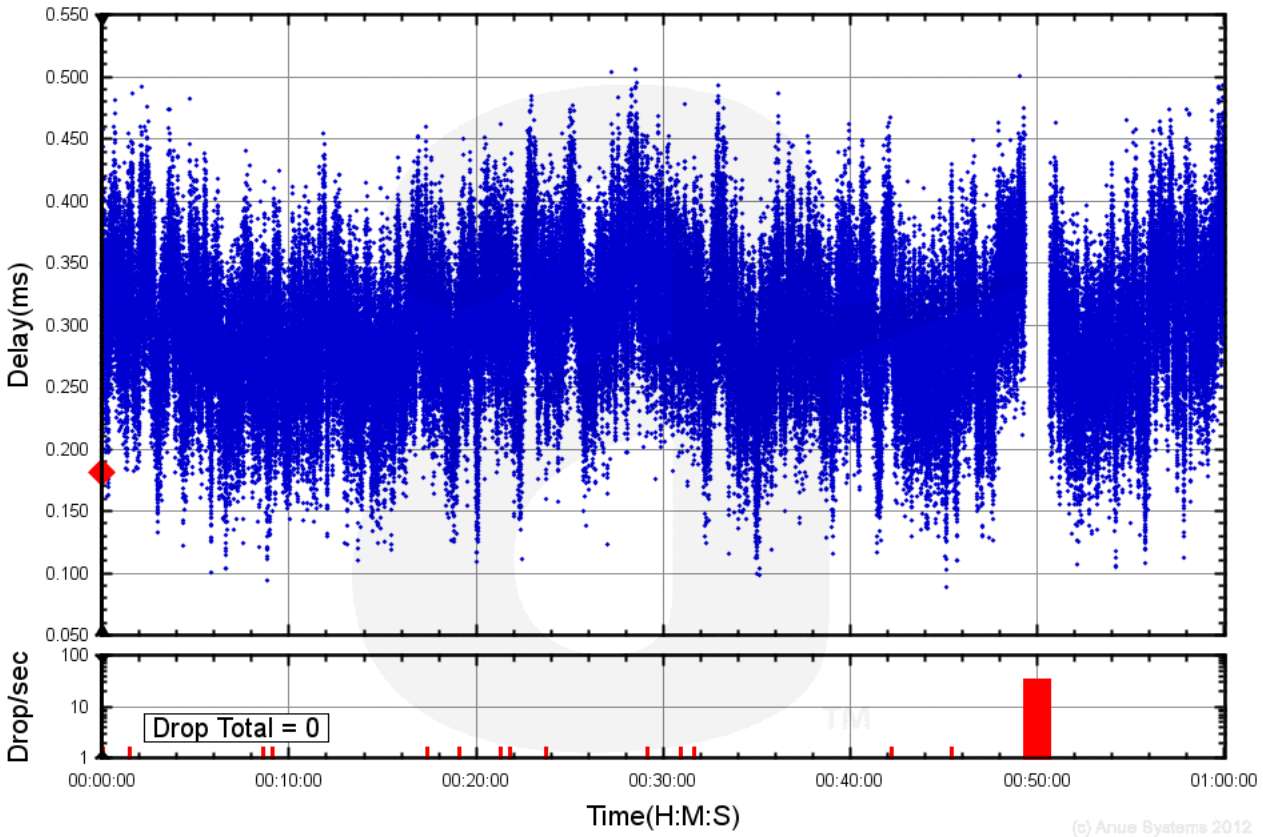
- Packet timing system operating at 32 packets per second
- Packet Delay Variation (PDV) based on flicker noise
- Low level of random packet loss (0.01%)
- Brief network outage (80 seconds)

- Steps for calculating FPC, FPP & FPR
  - Find minimum delay
  - Draw FPC graph, explain axes
  - Calculate with sliding window

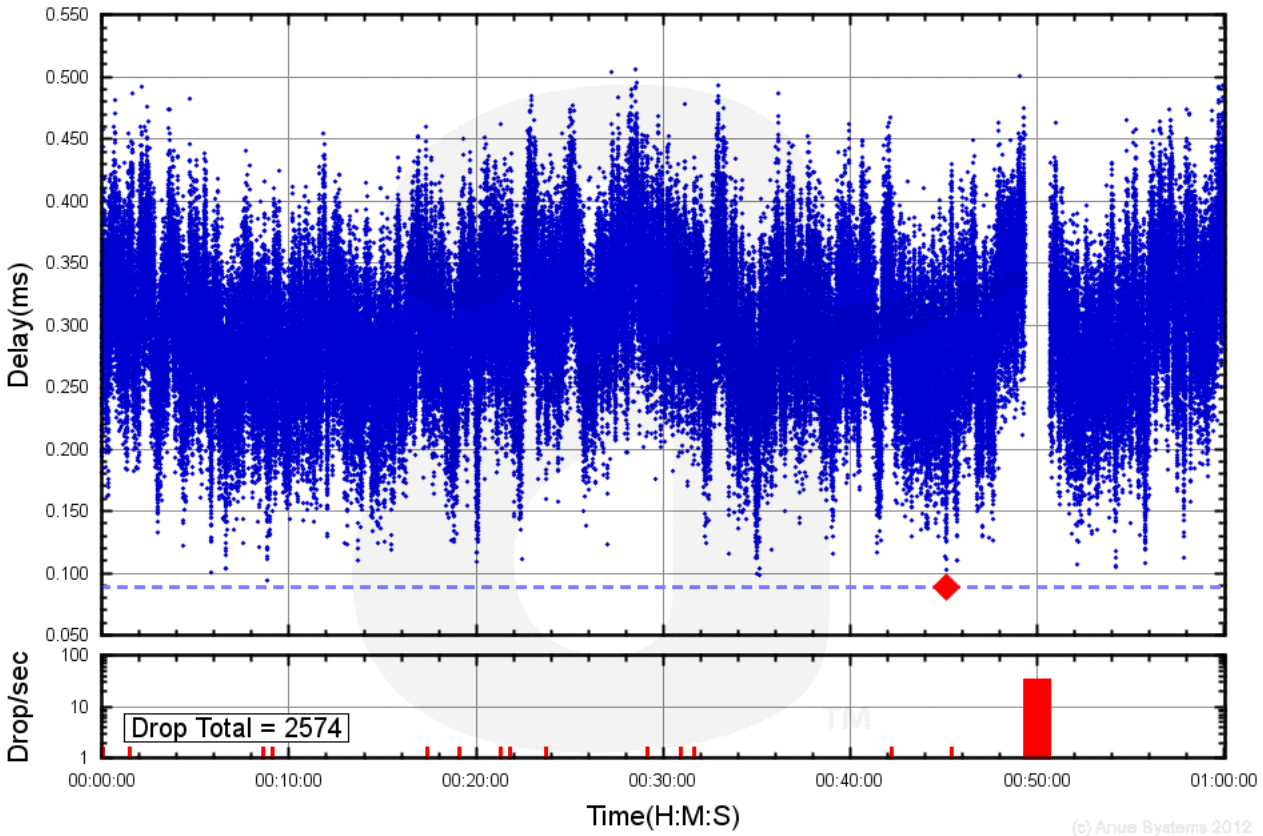
Example PDV with 0.01% Loss (@32 pkt/sec)



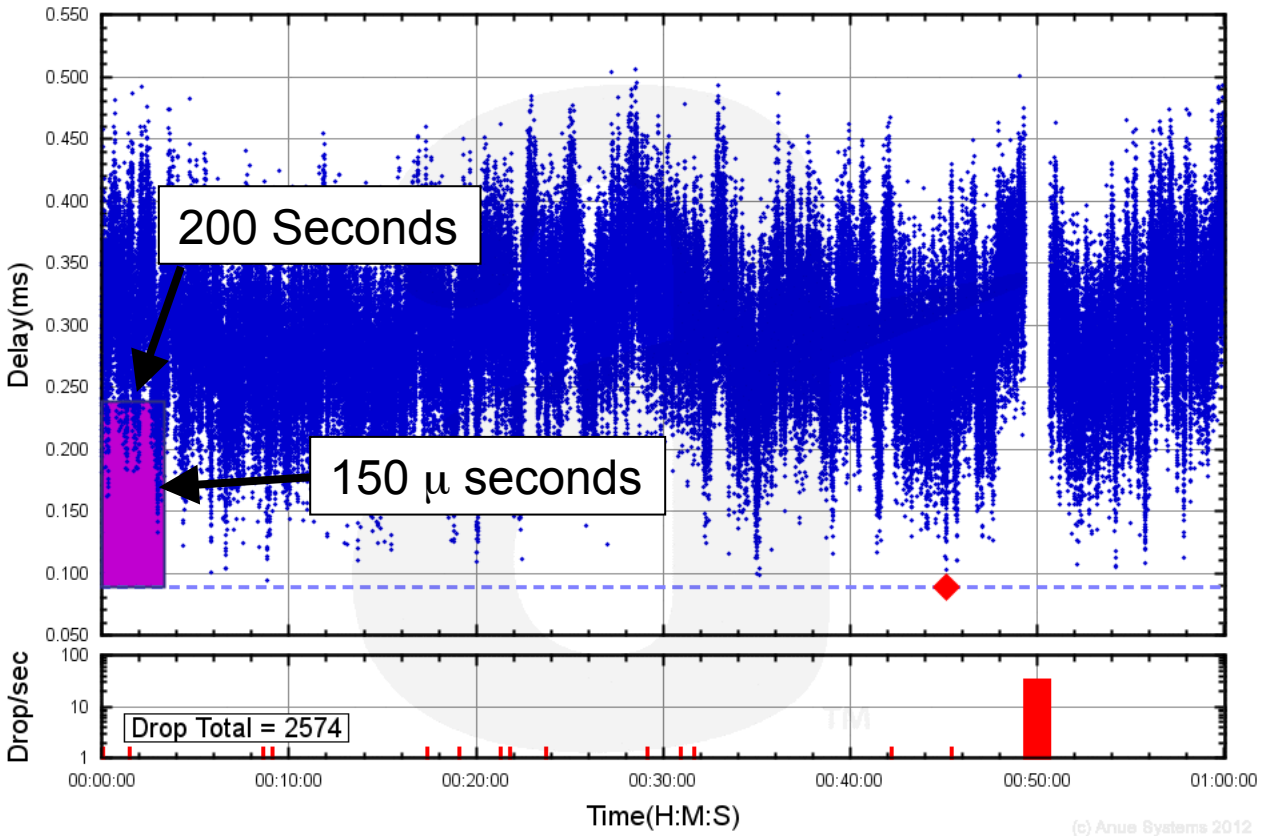
Search for minimum delay value



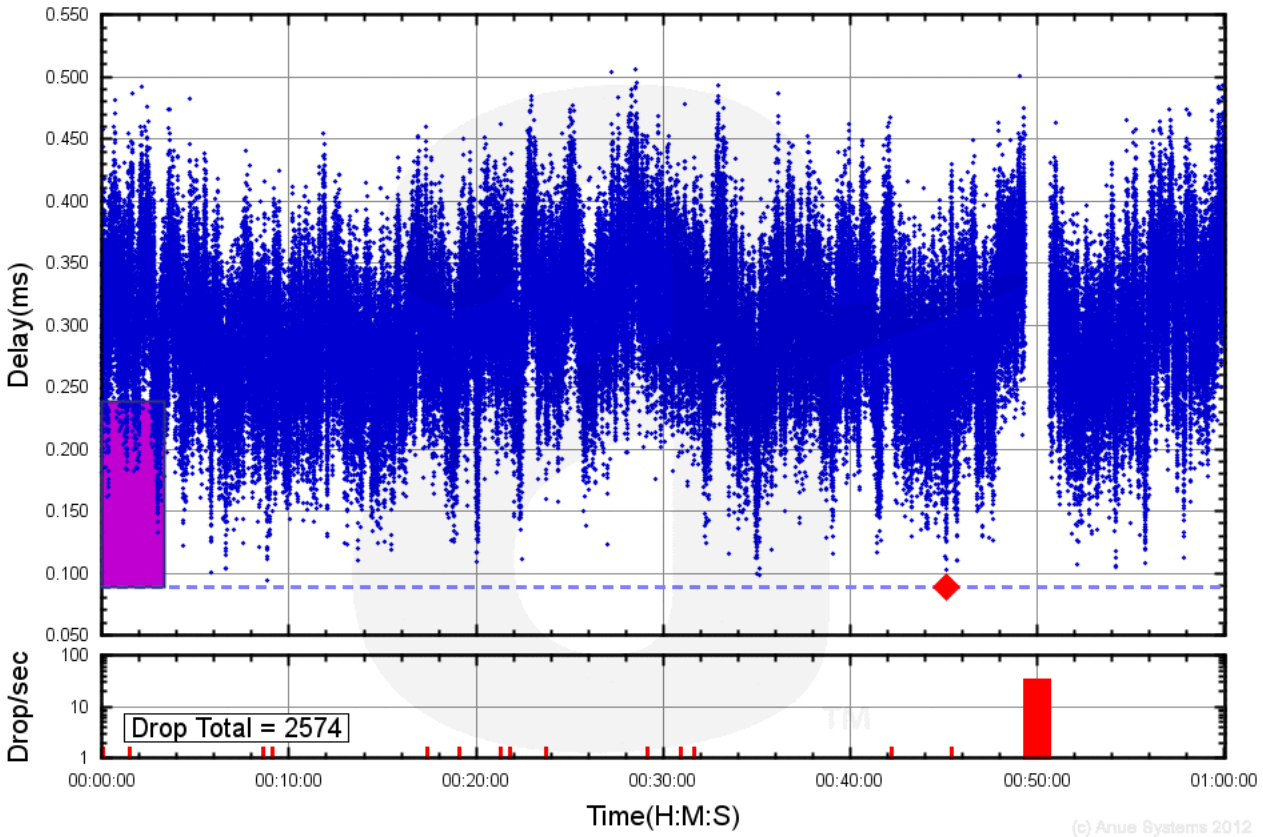
Draw horizontal line for minimum delay



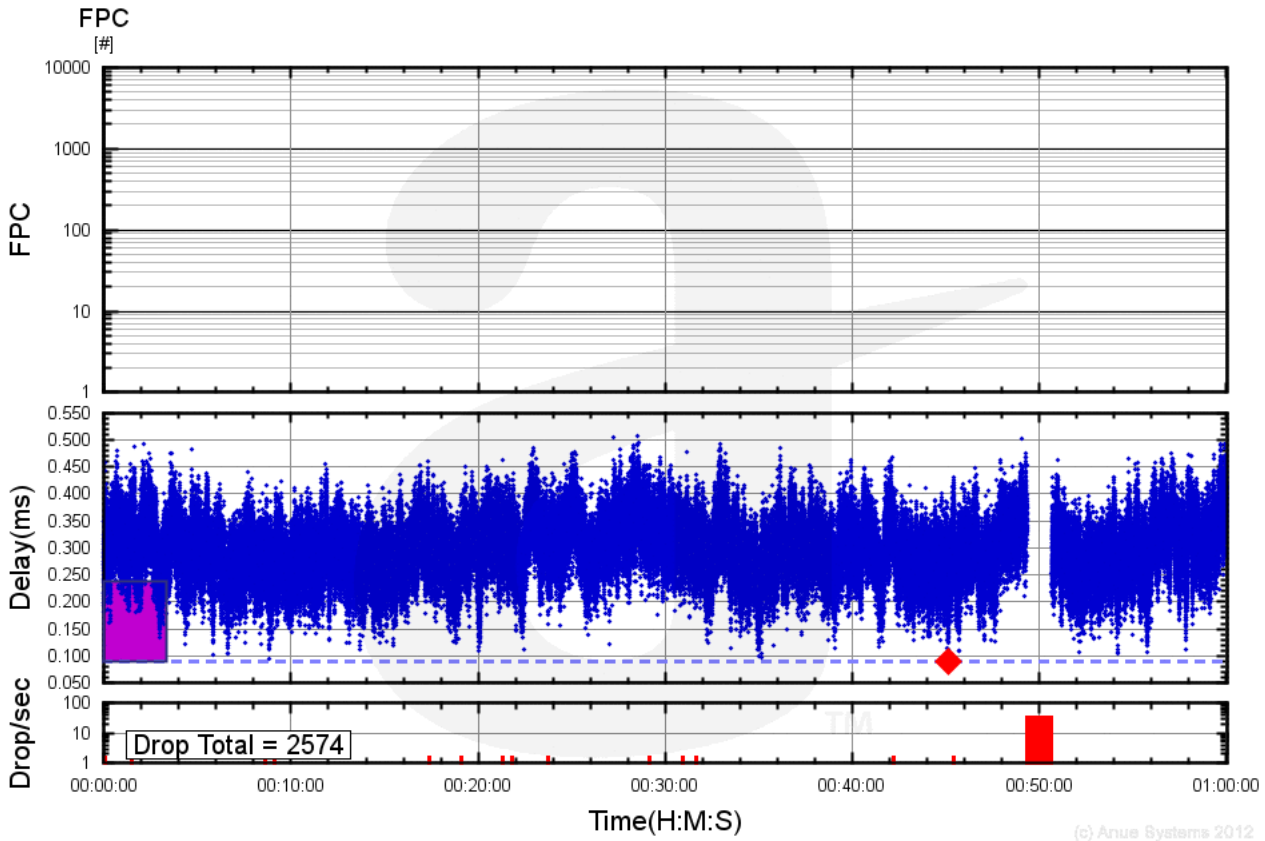
Draw the Floor Window



Add the FPC graph



Look at just the FPC Axis



Look at just the FPC Axis

Largest possible value is 6400 pkt.
*(32pkt/sec * 200 sec)*

Axis has logarithmic scale

Smallest countable value is one packet

Compare FPC to FPP

Largest possible value is 6400 pkt.
*(32pkt/sec * 200 sec)*

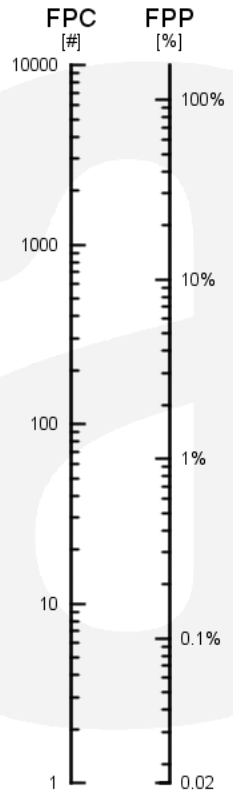
6400 pkt is 100%

64 pkt is 1%

Smallest countable value is one packet

Compare FPC and FPP to FPR

Largest possible value is 6400 pkt. *(32pkt/sec * 200 sec)*

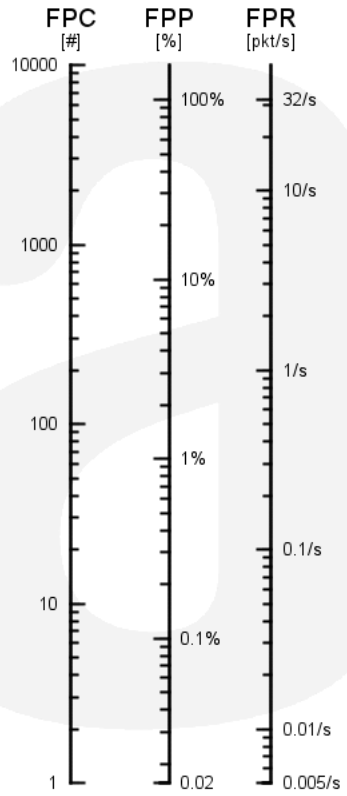


32 pkt/sec is max *(same as 100% FPP)*

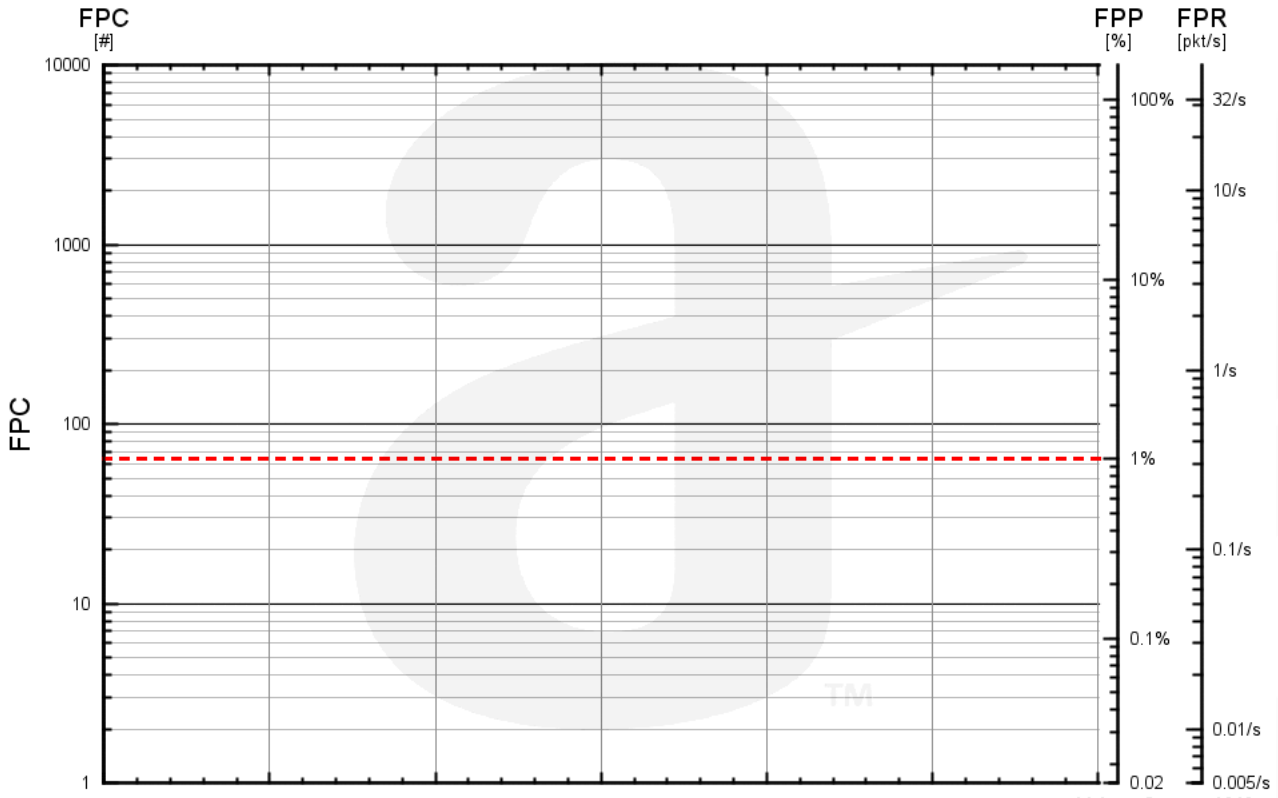
1% is 0.32pkt/sec and is 64 pkt

Smallest countable value is one packet

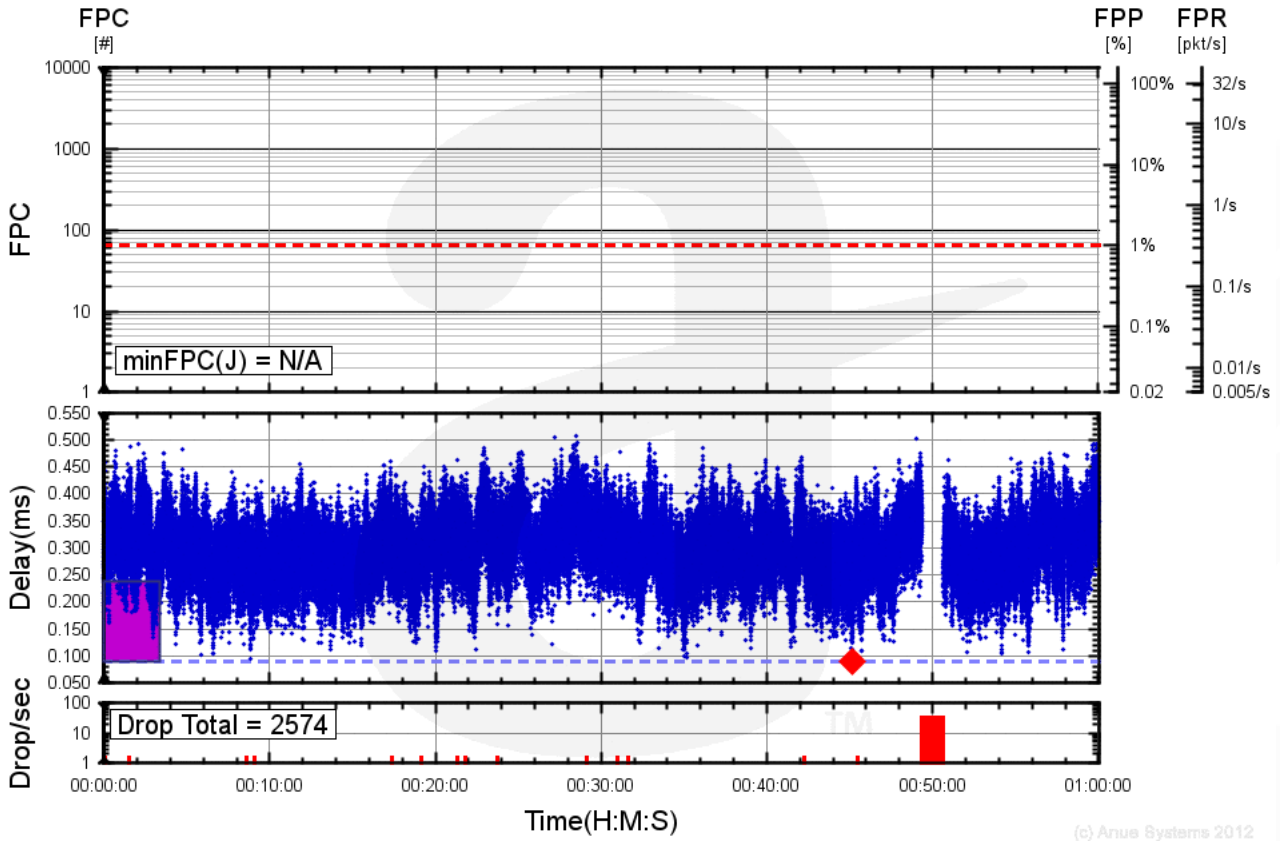
Draw the 1% FPP Limit Line



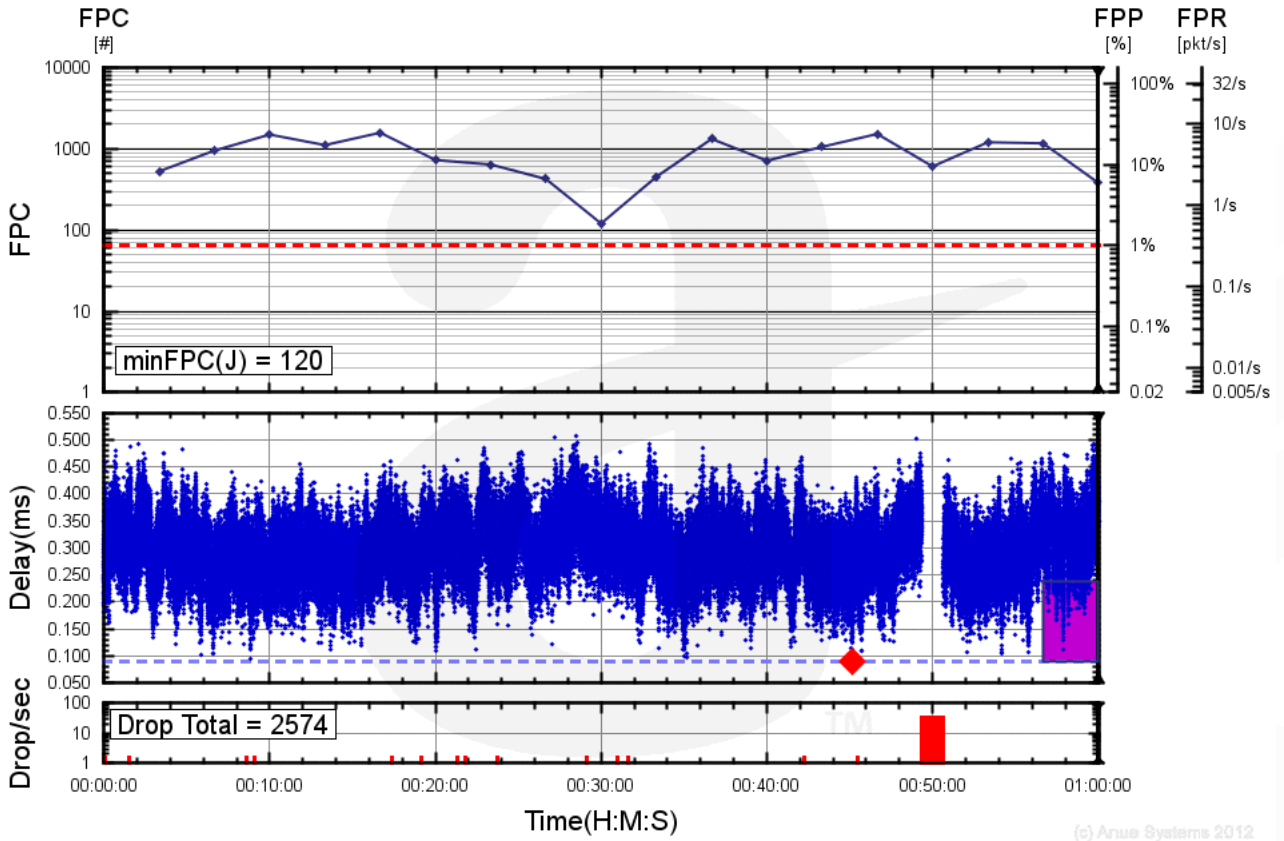
Draw the 1% FPP Limit Line



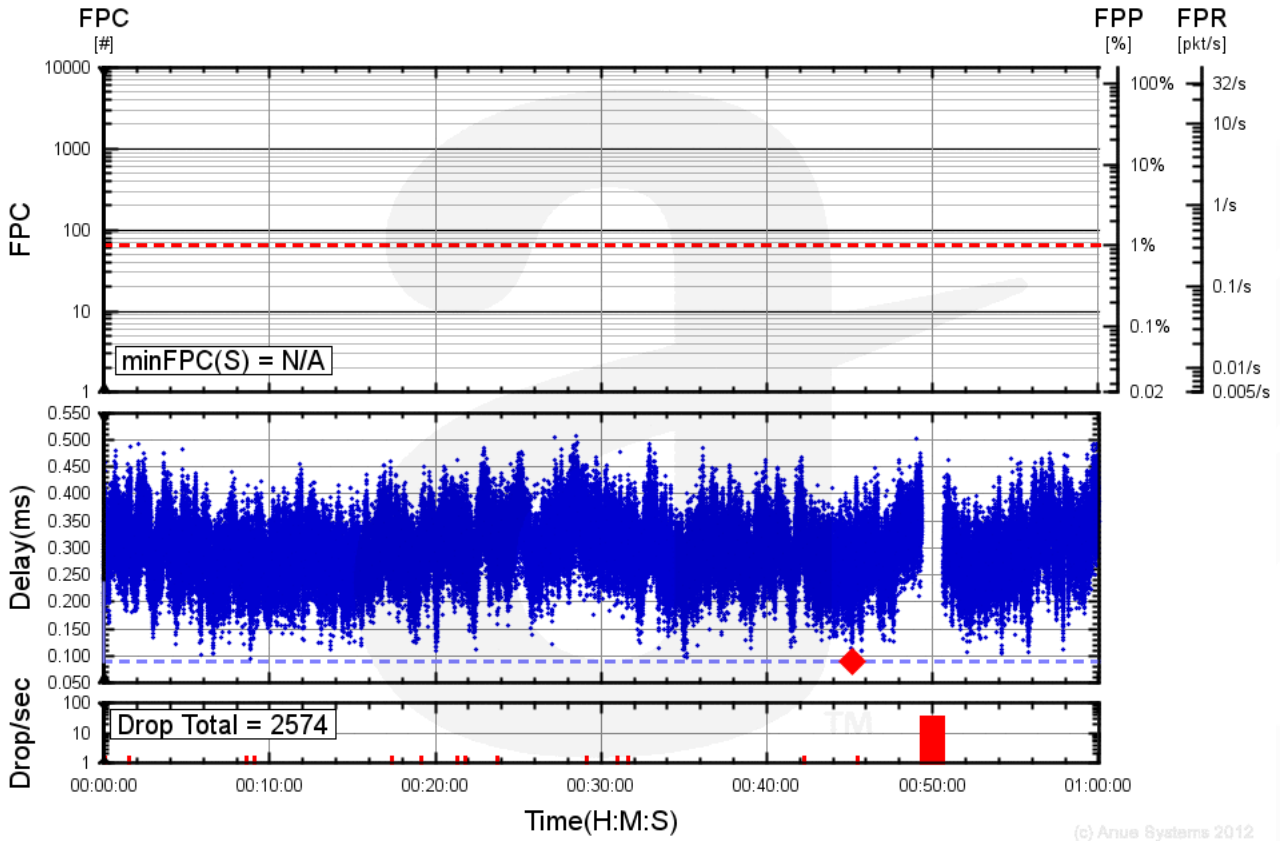
Calculate with Jumping Window



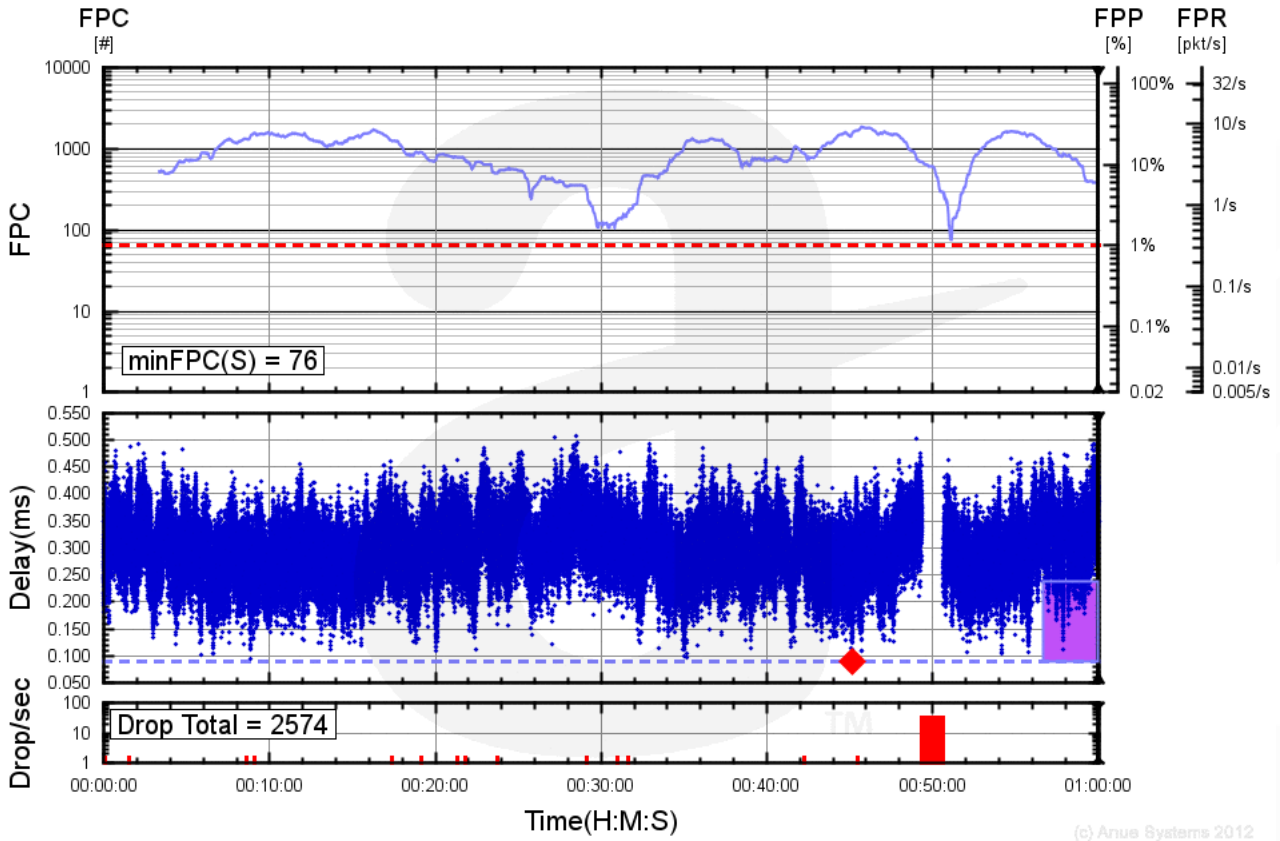
Calculate with Jumping Window



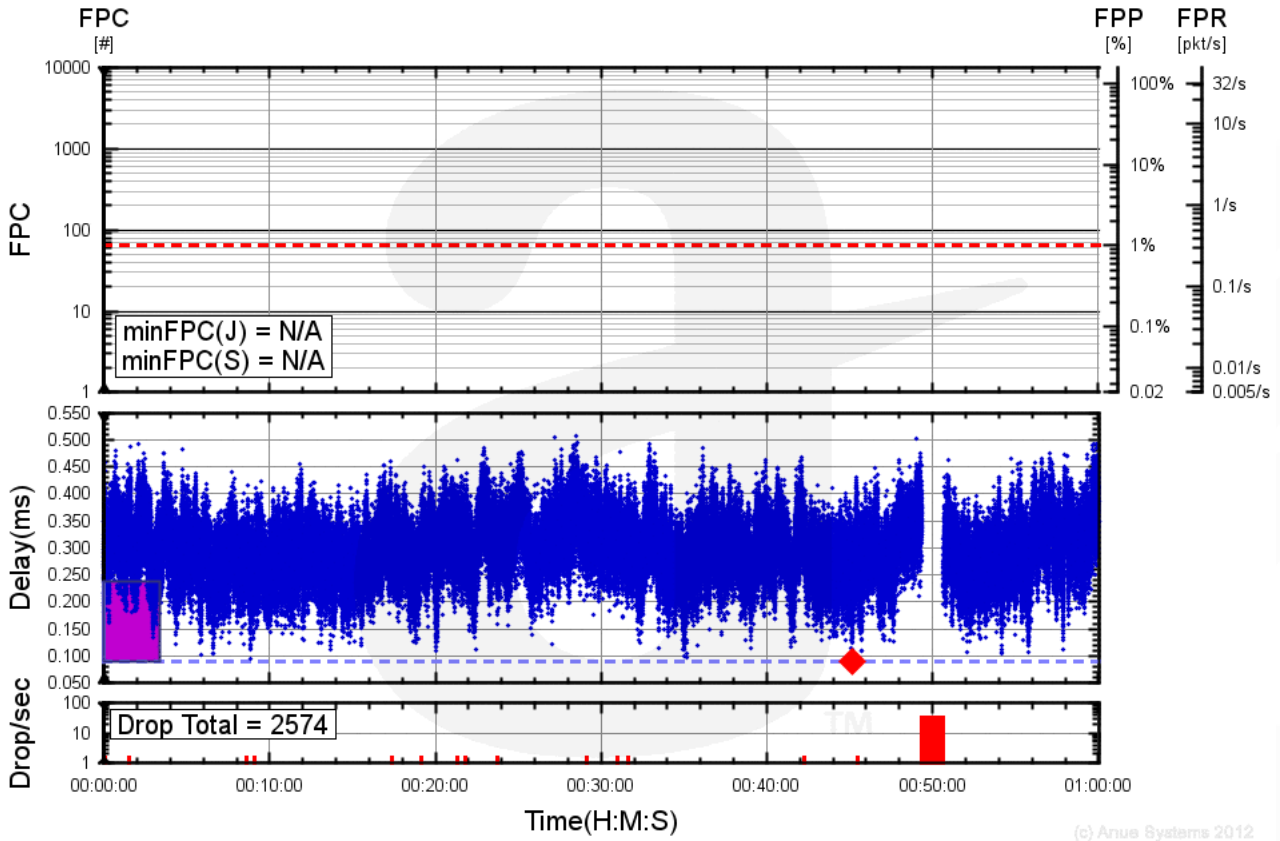
Calculate with Sliding Window



Calculate with Sliding Window



Compare: Jumping/Sliding



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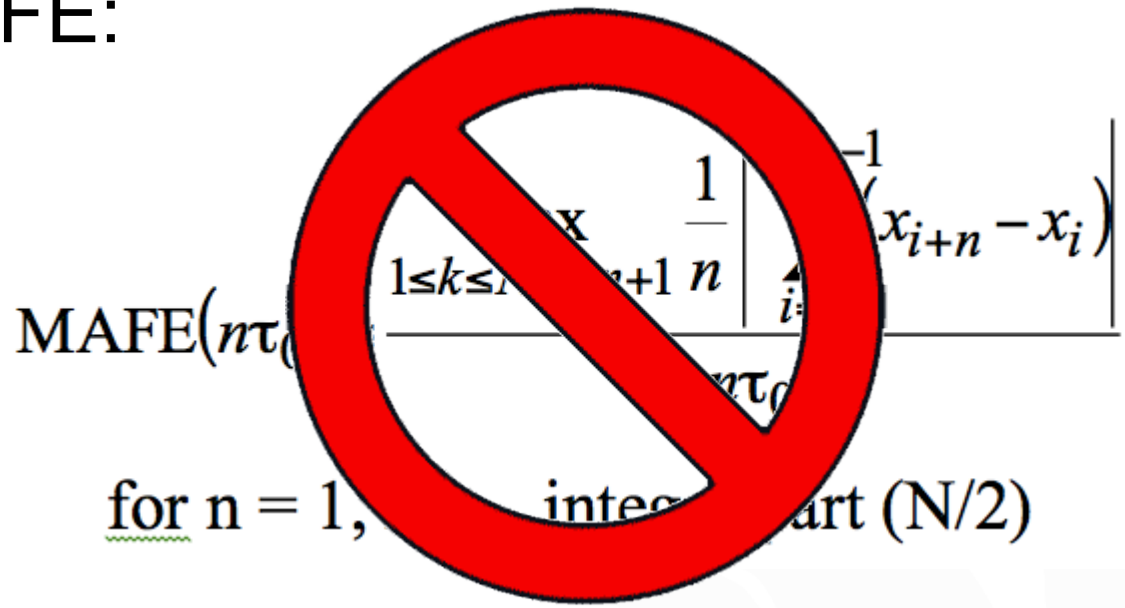
MAFE (in words)

- MAFE measures:
  - Peak frequency error implied by lucky packets
  - Helps estimate packet slave performance
- Helps answer questions like:
  - With a 1 hour averaging period, what is the worst-case frequency offset that will be seen?
- Closely related to MATIE
  - Max. Abs. Time Interval Error

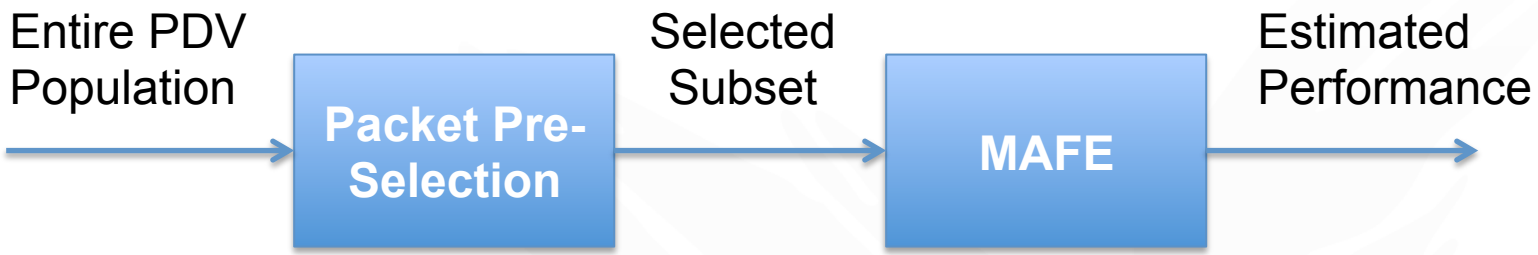
MAFE (in equations)

- MAFE:

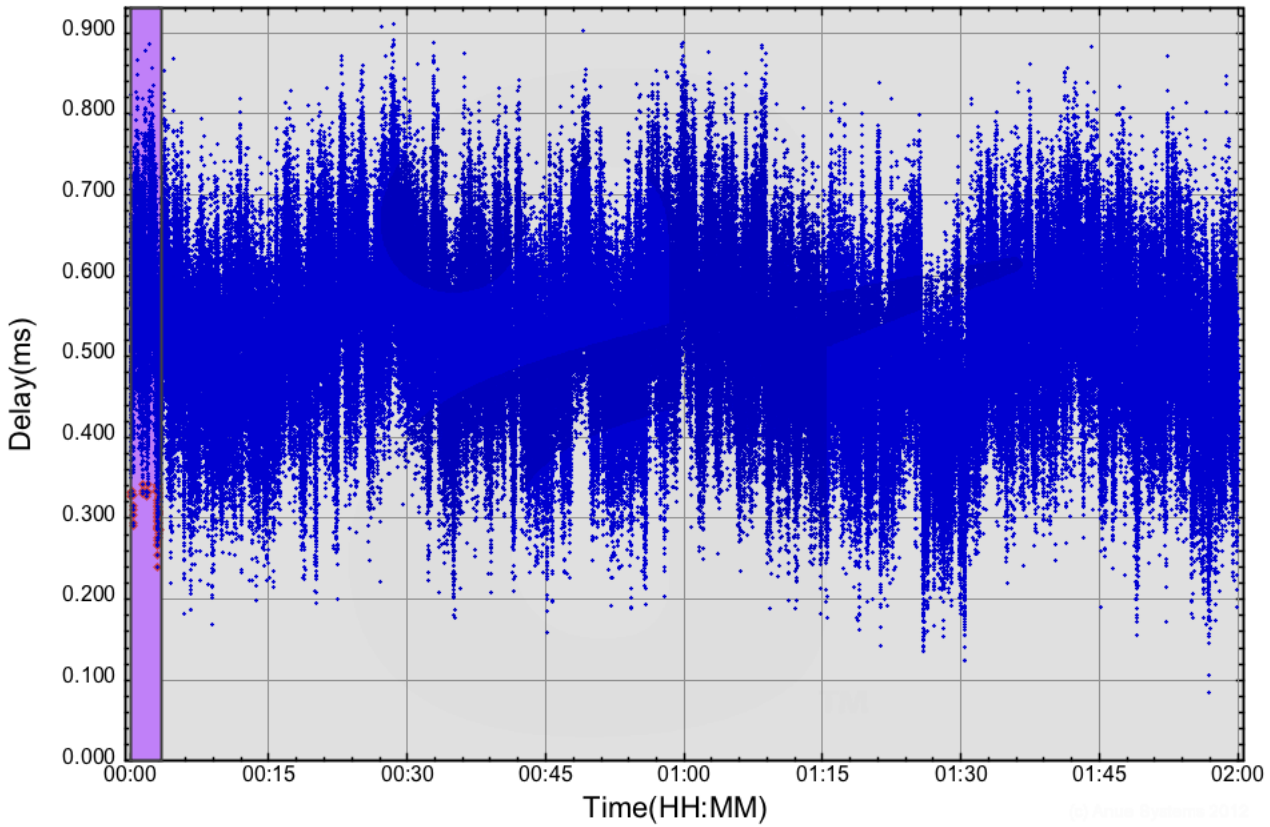


(Note: this is the MAFE estimator formula from G.8260, eq. I-21)

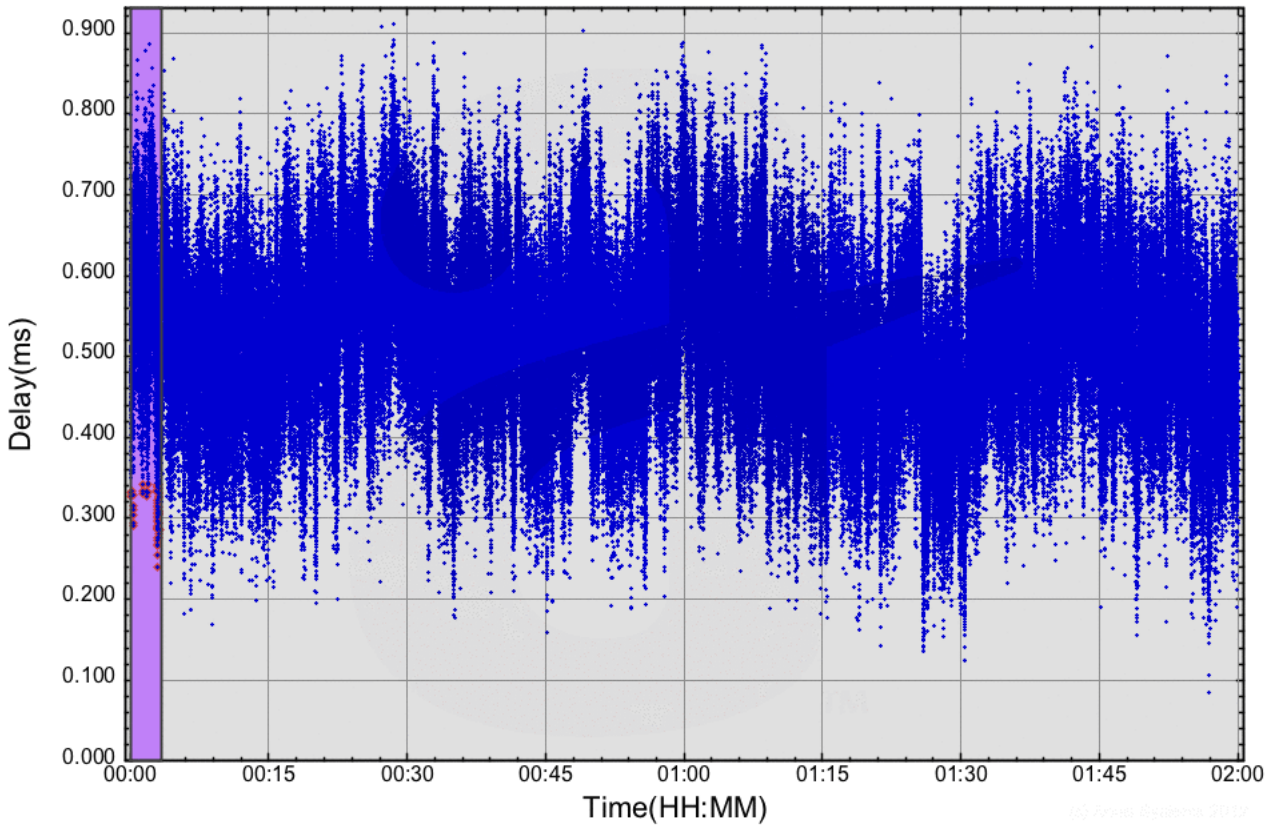
MAFE Overview



Example PDV for MAFE

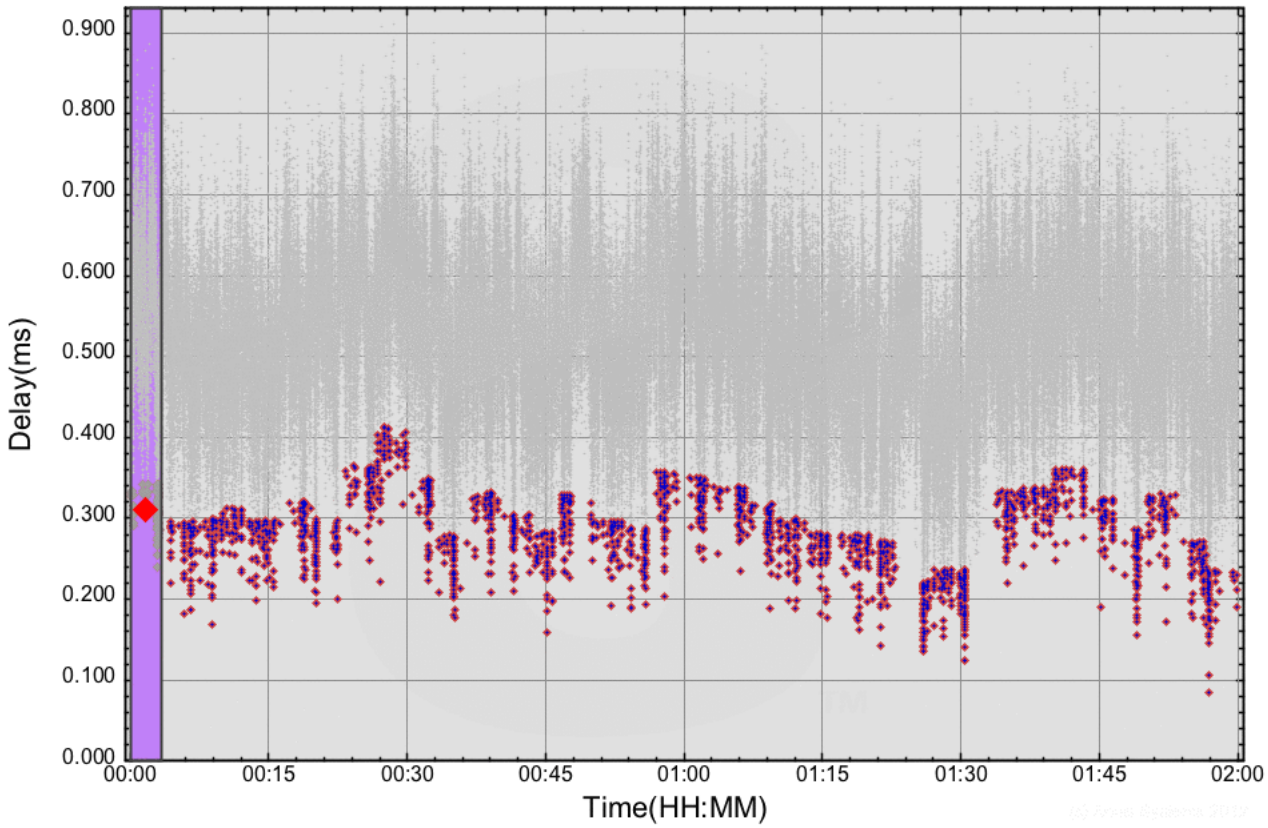


Packet Pre-Selection (pick fastest 1%)



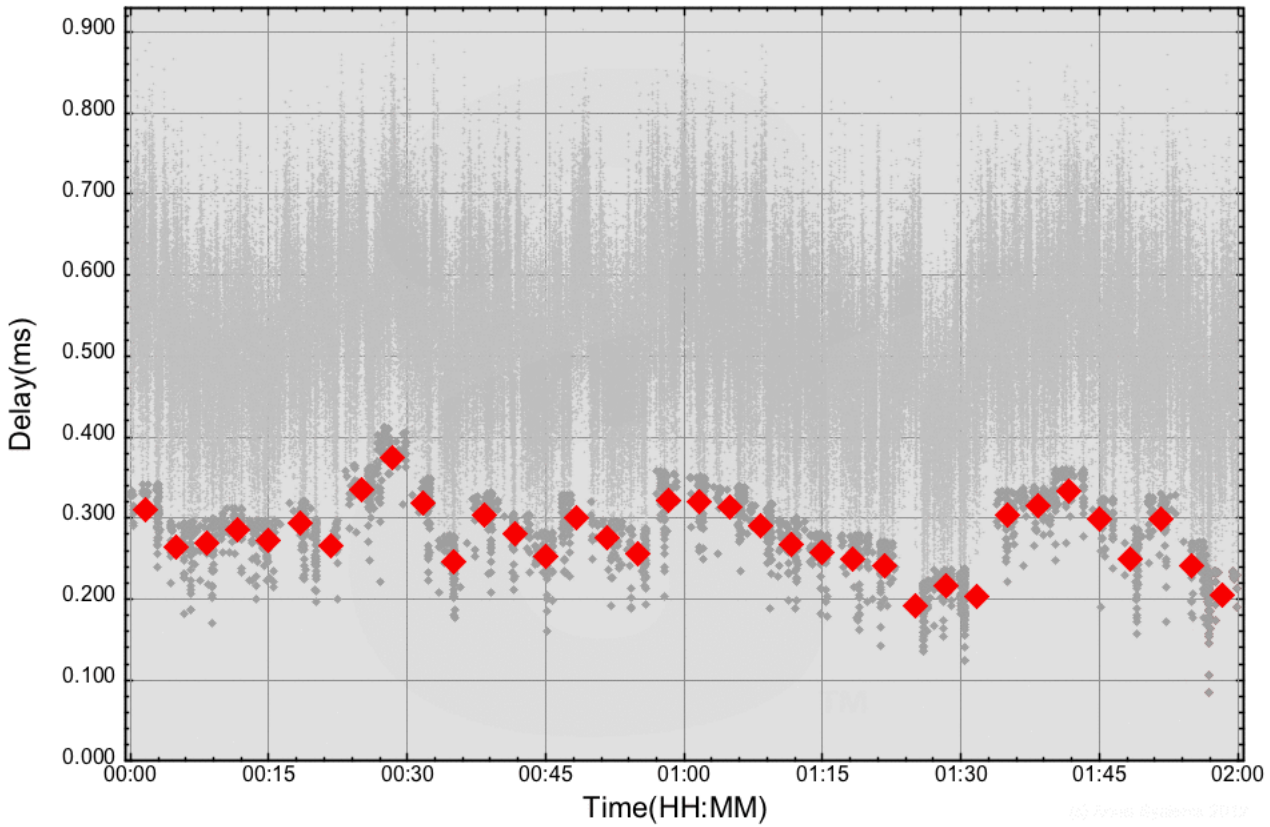
Pre-Selection:
Average of fastest 1% over 200s win. with "jumping"

Packet Pre-Selection (take the average of the 1%)



Pre-Selection:
Average of fastest 1% over 200s win. with “jumping”

Packet Pre-Selection Result

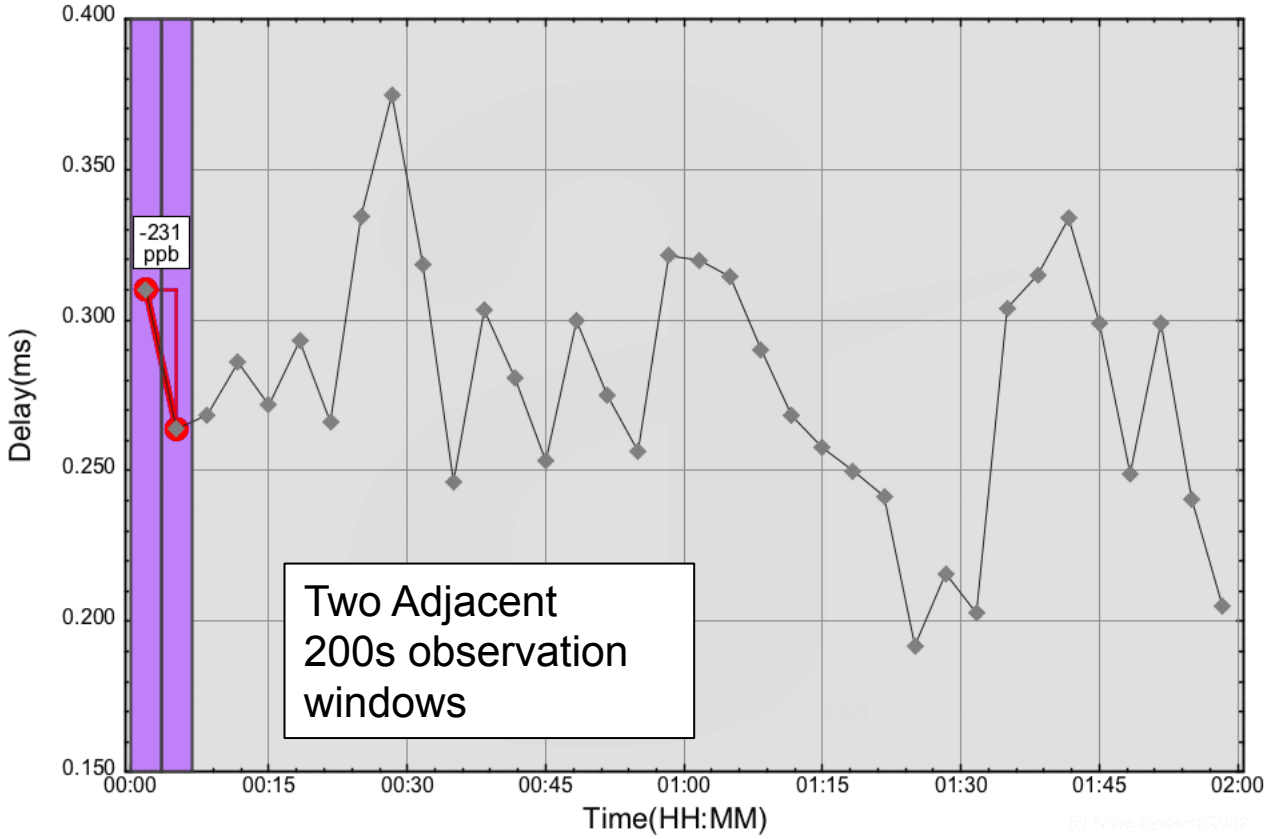


Pre-Selection:
Average of fastest 1% over 200s win. with "jumping"

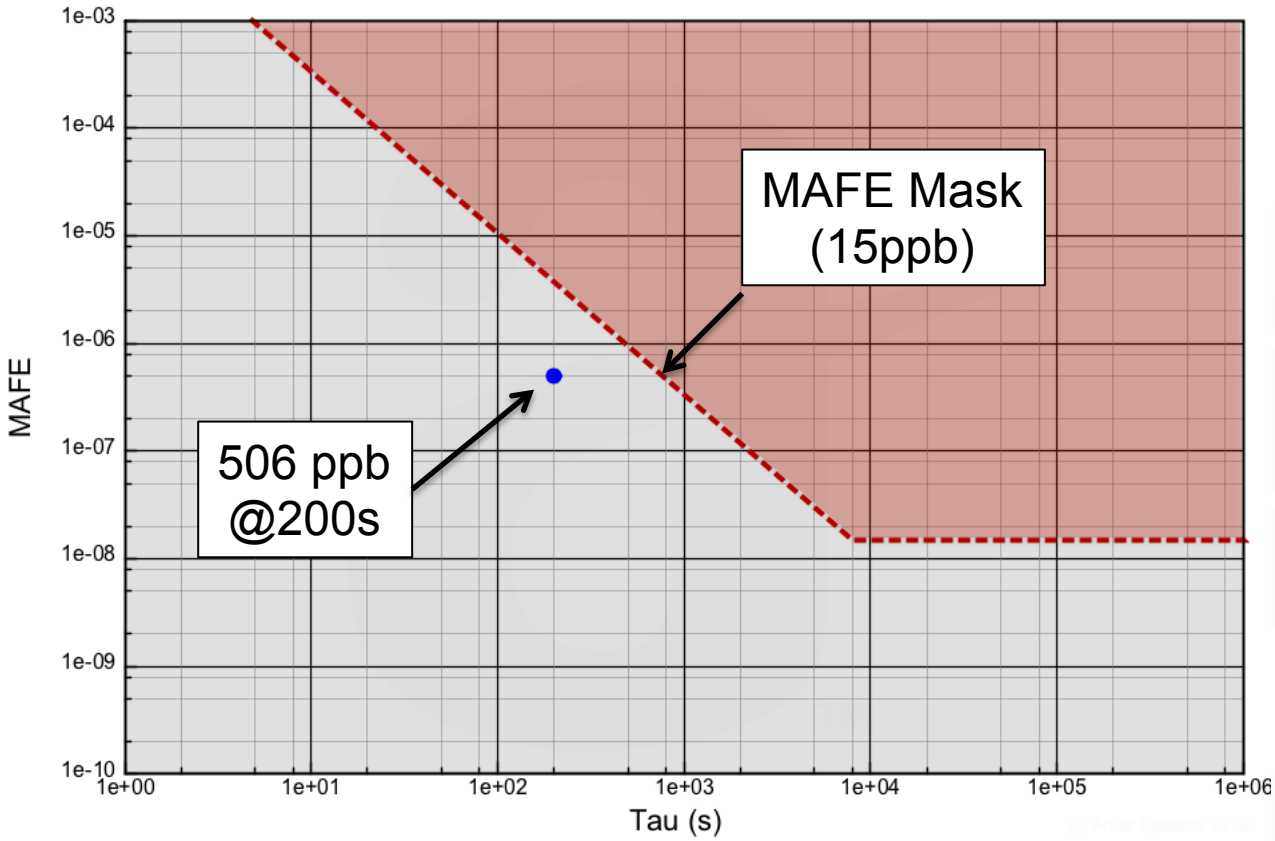
Focus on the selected & averaged values

Note: This pre-selection method reduces the number of samples by a factor of 6400

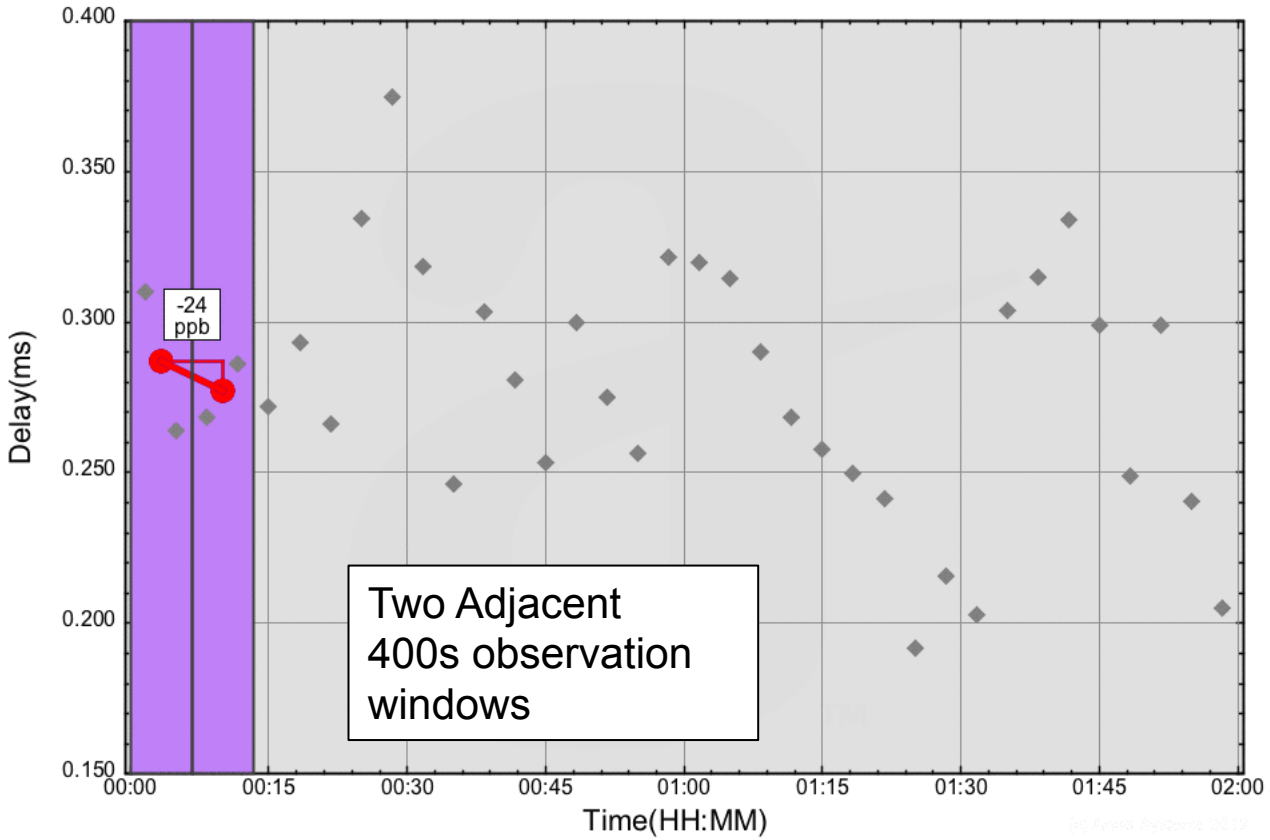
MAFE Computation (Tau=200s)



MAFE Plot

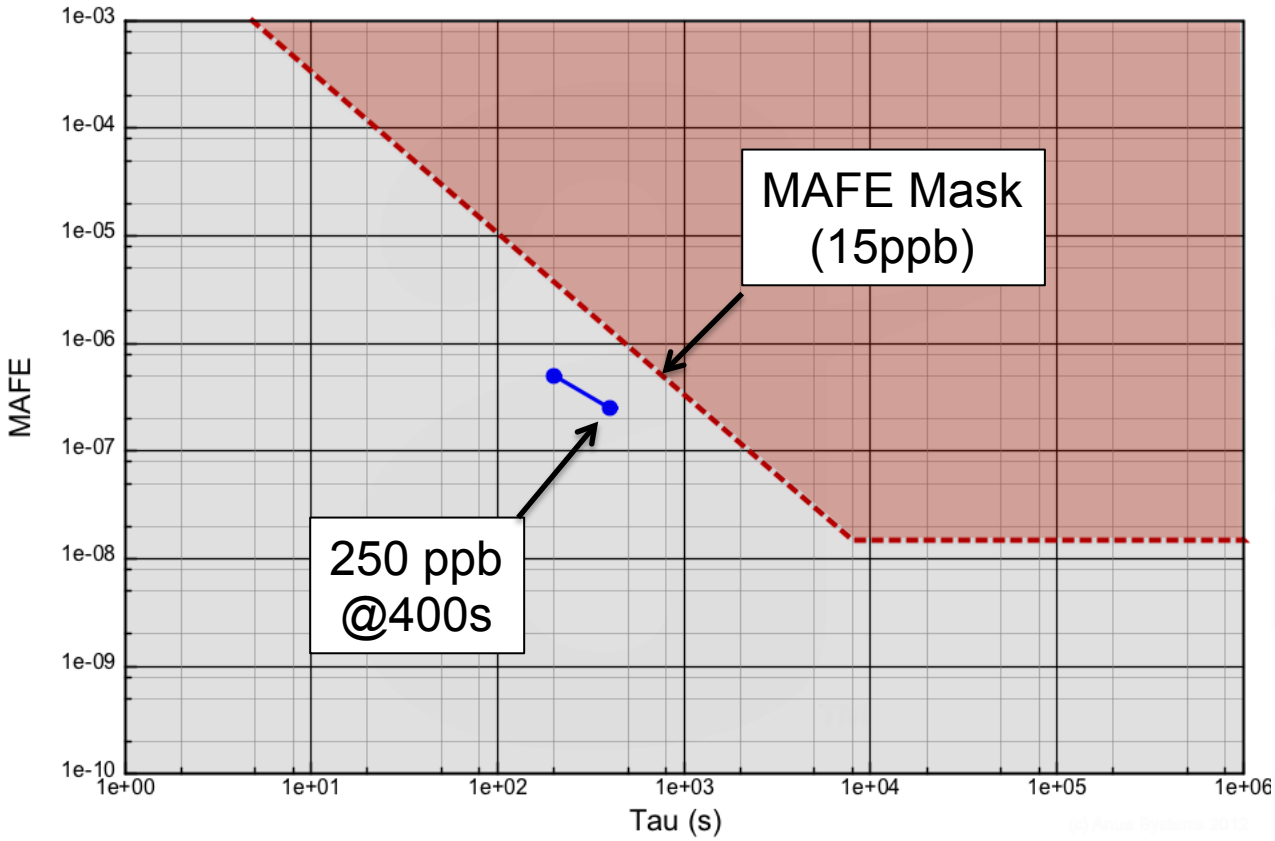

1e-03
1e-04
1e-05
1e-06
1e-07
1e-08
1e-09
1e-10
MAFE
1e+00
1e+01
1e+02
1e+03
1e+04
1e+05
1e+06
Tau (s)
MAFE Mask
(15ppb)
506 ppb
@200s

MAFE Computation (Tau=400s)

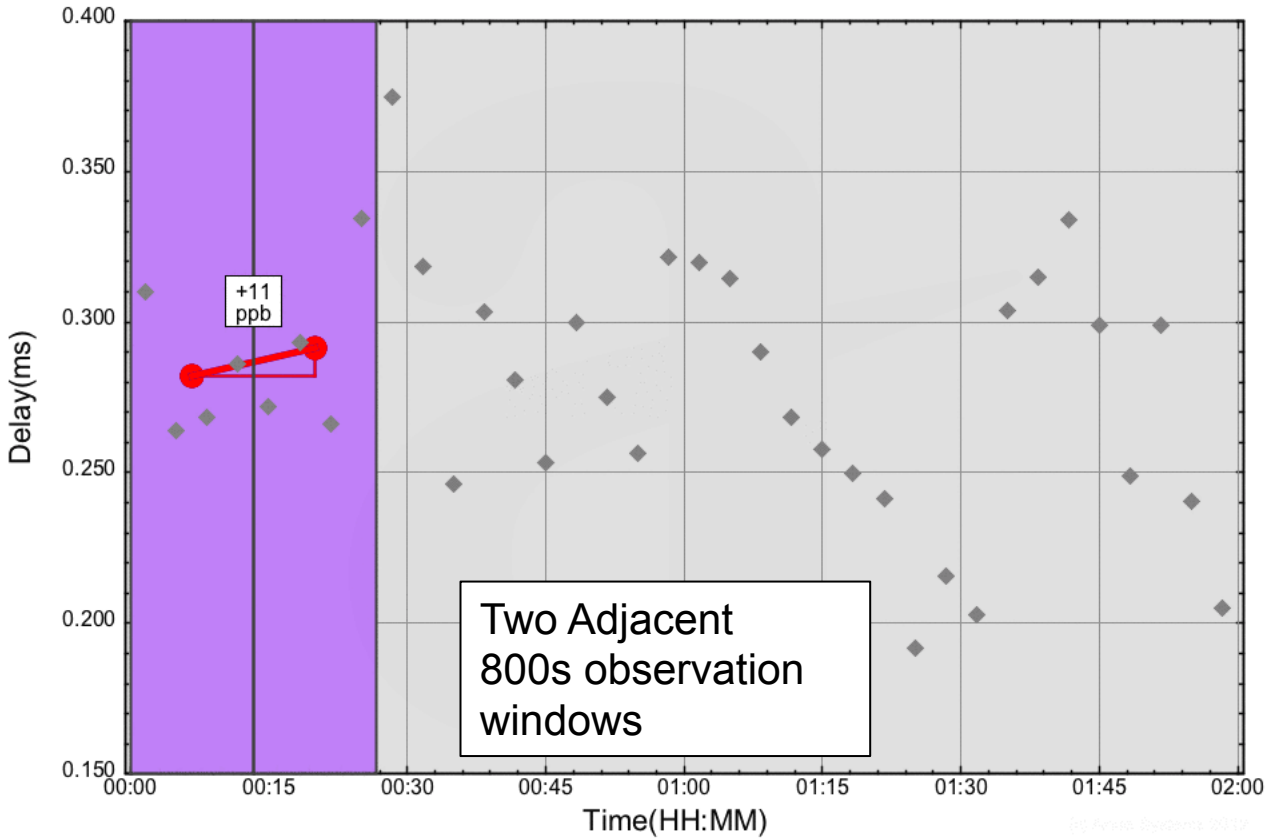


Note: Average the two consecutive selected samples in each window

MAFE Plot

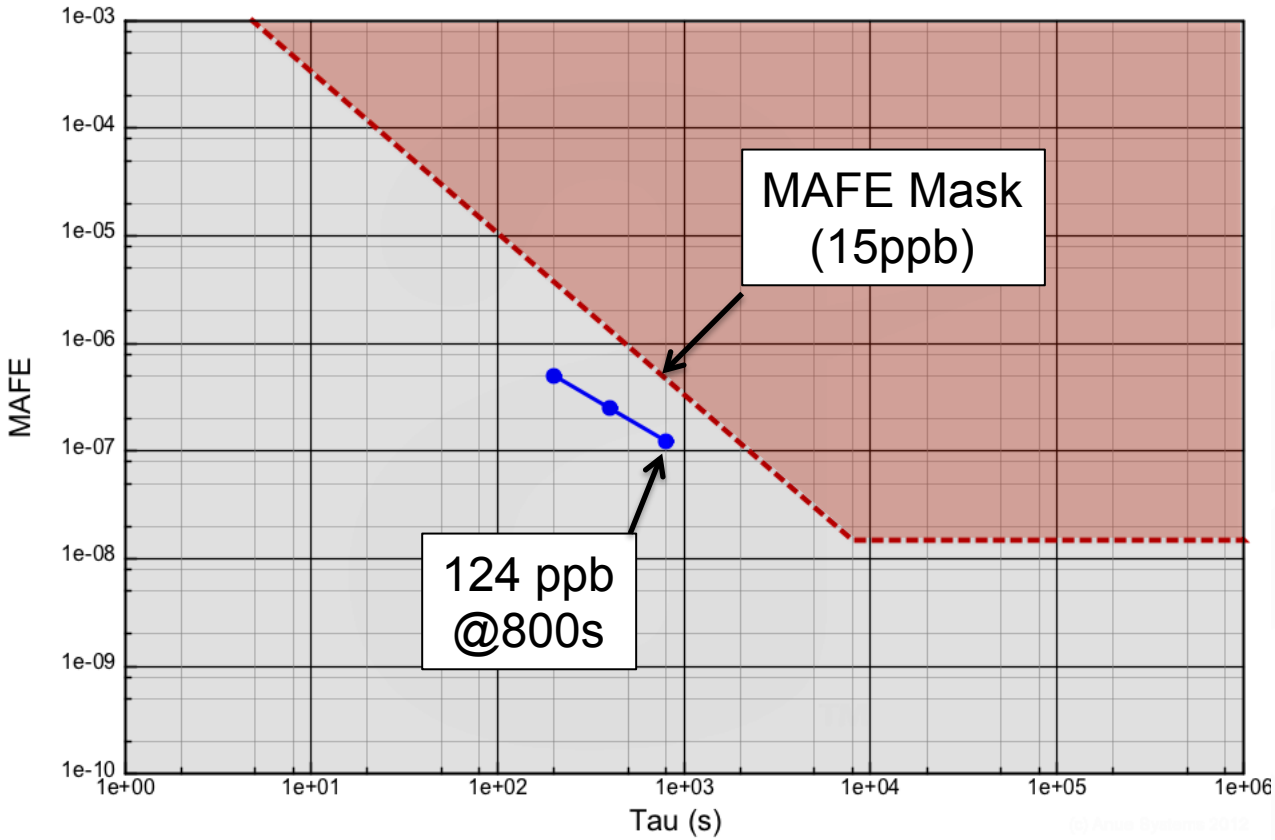

MAFE Mask
(15ppb)
250 ppb
@400s
MAFE
Tau (s)
1e-03
1e-04
1e-05
1e-06
1e-07
1e-08
1e-09
1e-10
1e+00
1e+01
1e+02
1e+03
1e+04
1e+05
1e+06

MAFE Computation (Tau=800s)

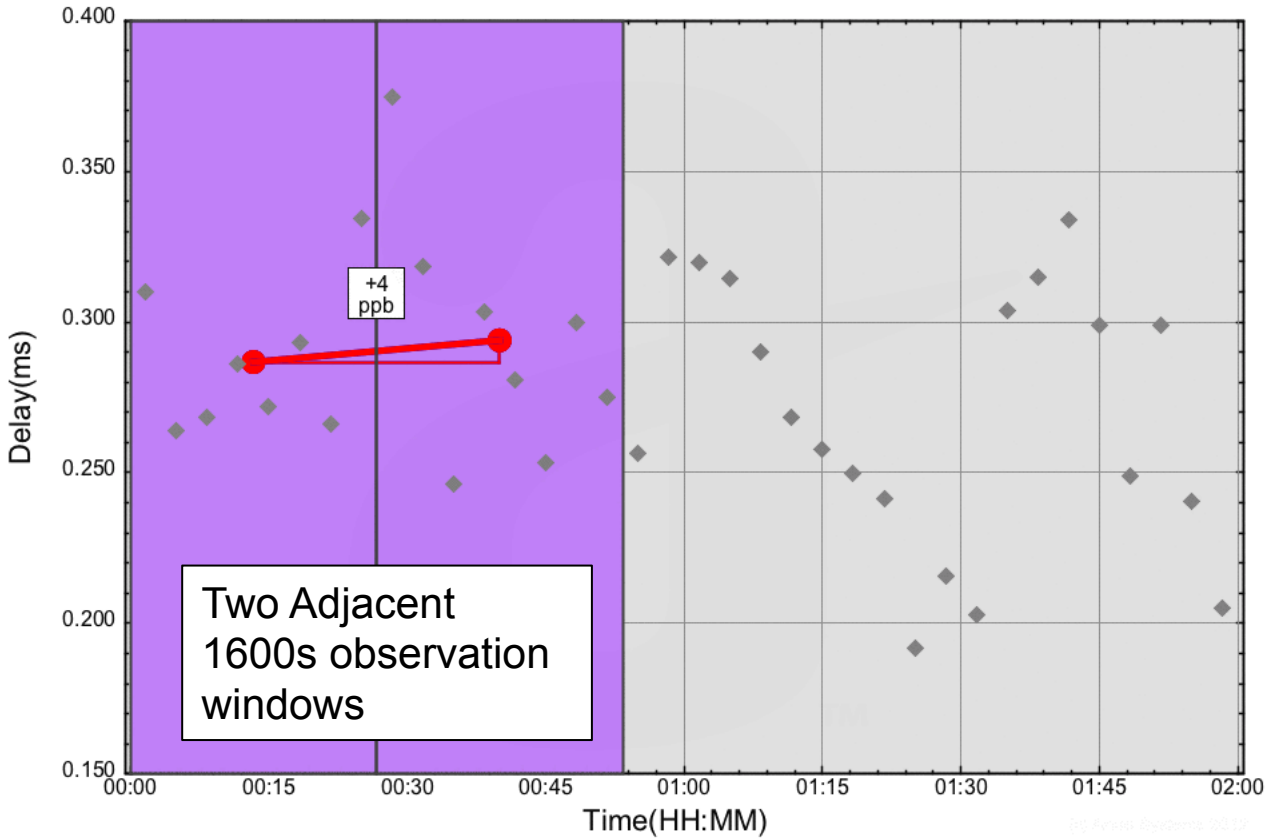


Note: Average the four consecutive selected samples in each window

MAFE Plot

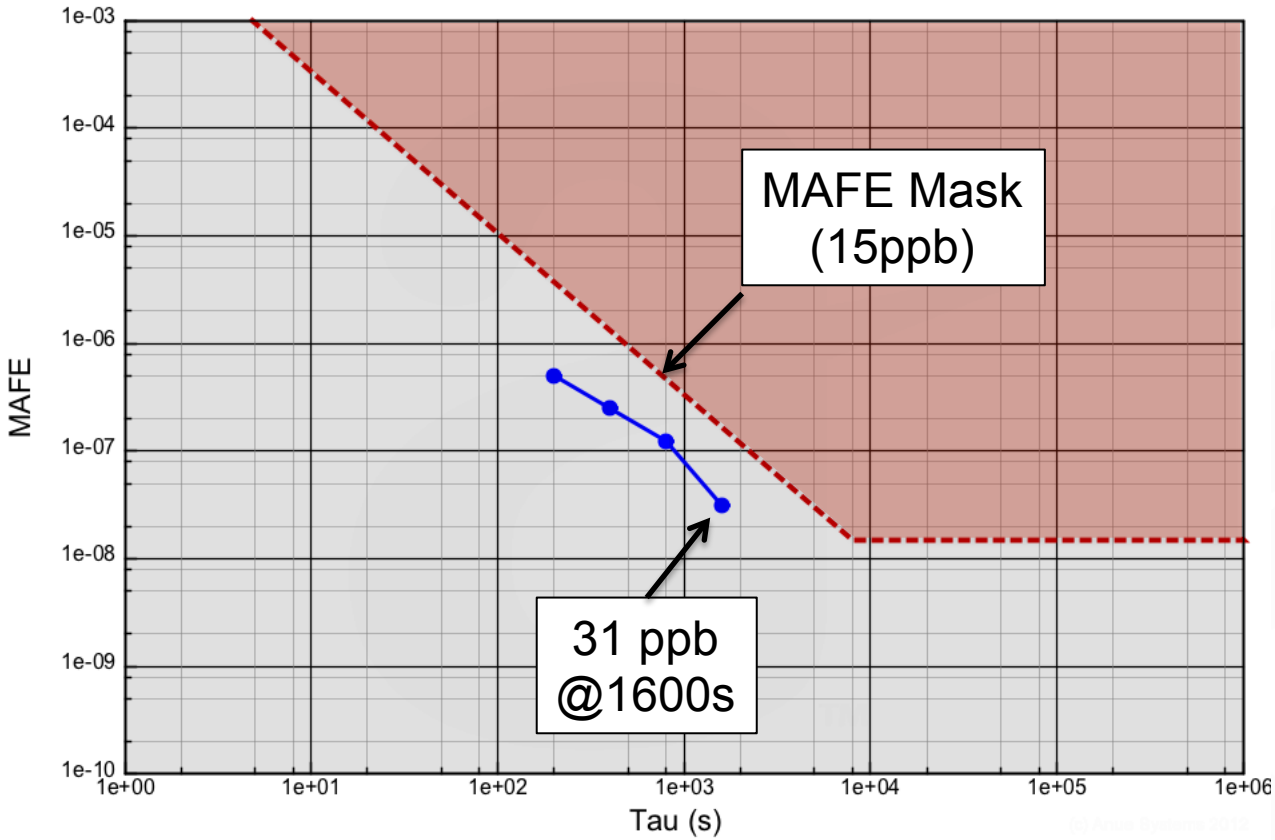

1e-03
1e-04
1e-05
1e-06
1e-07
1e-08
1e-09
1e-10
MAFE
1e+00
1e+01
1e+02
1e+03
1e+04
1e+05
1e+06
Tau (s)
MAFE Mask
(15ppb)
124 ppb
@800s

MAFE Computation (Tau=1600s)

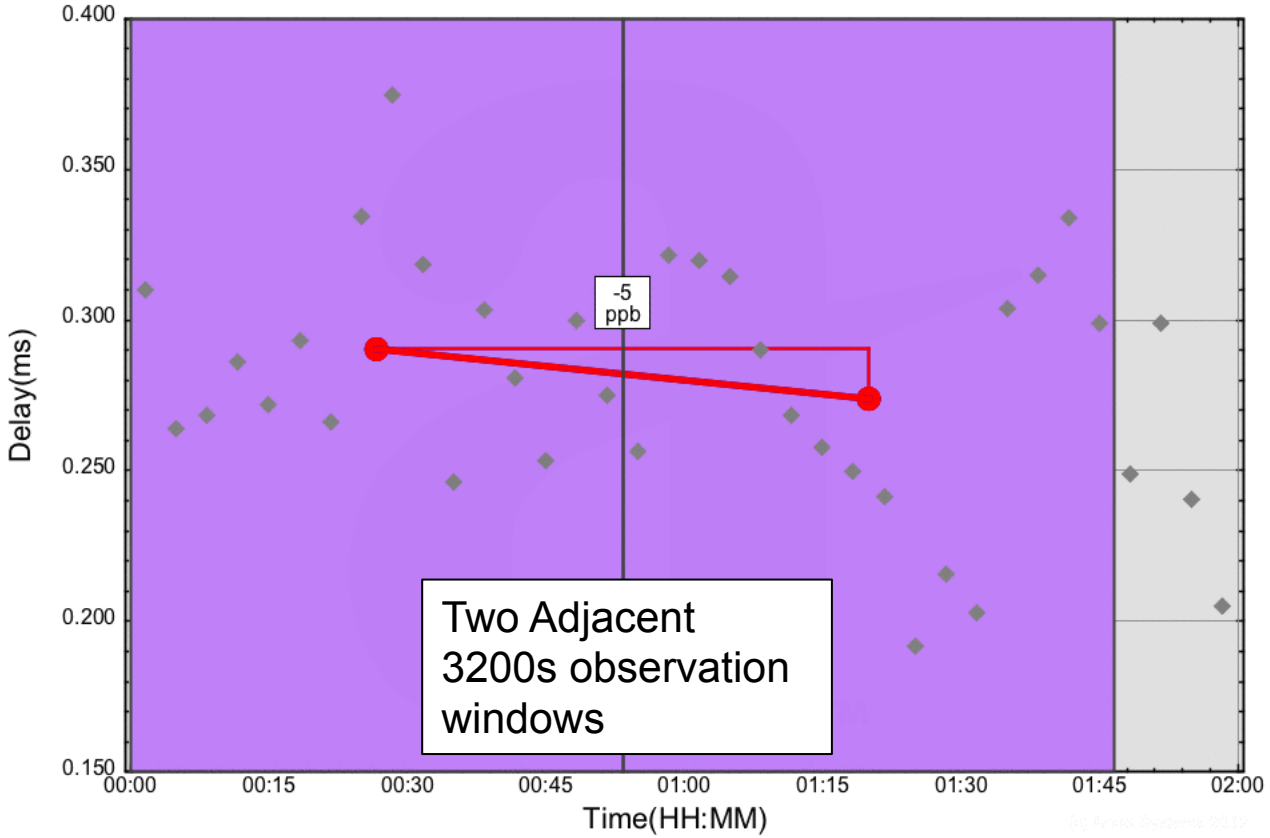


Note: Average the eight consecutive selected samples in each window

MAFE Plot

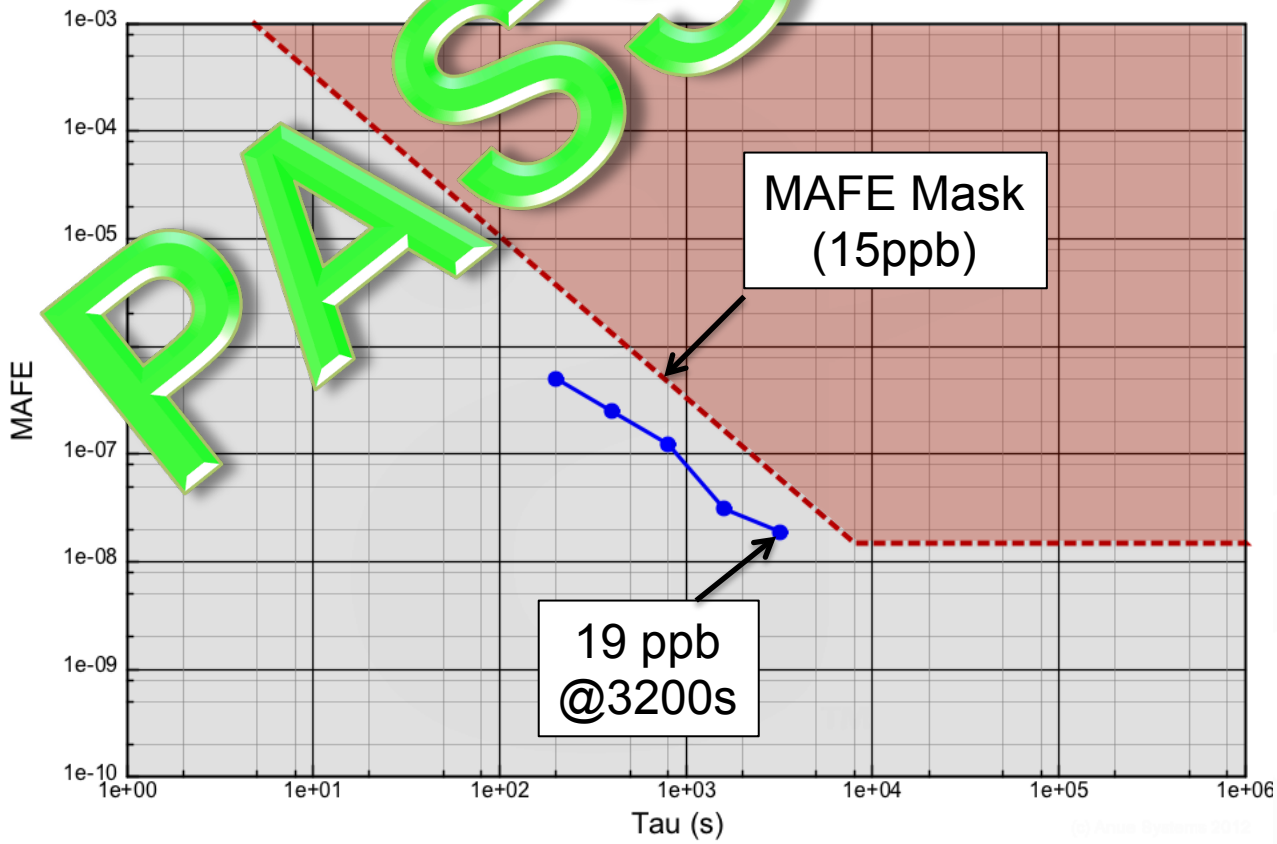

MAFE Mask
(15ppb)
31 ppb
@1600s
MAFE
Tau (s)
1e-03
1e-04
1e-05
1e-06
1e-07
1e-08
1e-09
1e-10
1e+00
1e+01
1e+02
1e+03
1e+04
1e+05
1e+06

MAFE Computation (Tau=3200s)



Note: Average the sixteen consecutive selected samples in each window

MAFE Plot


PASS
MAFE Mask
(15ppb)
19 ppb
@3200s
MAFE
1e-03
1e-04
1e-05
1e-07
1e-08
1e-09
1e-10
1e+00
1e+01
1e+02
1e+03
1e+04
1e+05
1e+06
Tau (s)

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  - Limits
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- **Conclusion**

Floor Population Metrics: In a nutshell

MAFE: In a nutshell

Thank You! Questions?

About the Presenter

About Ixia

Ixia provides the industry's most comprehensive converged IP network validation and network visibility solutions.
Equipment manufacturers, service providers, enterprises, and government agencies use Ixia's solutions to design, verify, and monitor a broad range of wired, Wi-Fi, and 3G/LTE equipment and networks. Ixia's test solutions emulate realistic media-rich traffic and network conditions so that customers can optimize and validate the design, performance, and security of their pre-deployment networks. Ixia's intelligent network visibility platforms provide clarity into physical and virtual production networks for improved performance, security, resiliency, and application delivery of cloud, data center, andservice provider networks.

For more information, visit www.ixiacom.com.

About Chip

Chip is VP, Technology at Ixia, after its acquisition of Anue Systems, where he was co-founder and CTO. He has 20+ years of experience in the design of high-speed networking products. Prior to founding Anue Systems, Chip was a Distinguished Member of Technical Staff at Bell Laboratories. Chip received a Master's degree in Electrical Engineering from Columbia University, and a Bachelor's degree, with honors, from RPI. He has been awarded 14+ patents.