METAMAKO

What’s the reference for the reference?

Dr. David Snowdon – Founder & CTO

What do we do?

METAMAKO

BUILD
NETWORK
DEVICES

DEVELOP
APPLICATIONS

SUPPORT
IMPROVE
DELIVER
CONSULT

- Layer 1 switches – **patching**, **broadcast**, **tapping**
- **Low latency order-entry** switches
- Accurate **packet capture**
- **FPGA platform** for applications

MetaWatch

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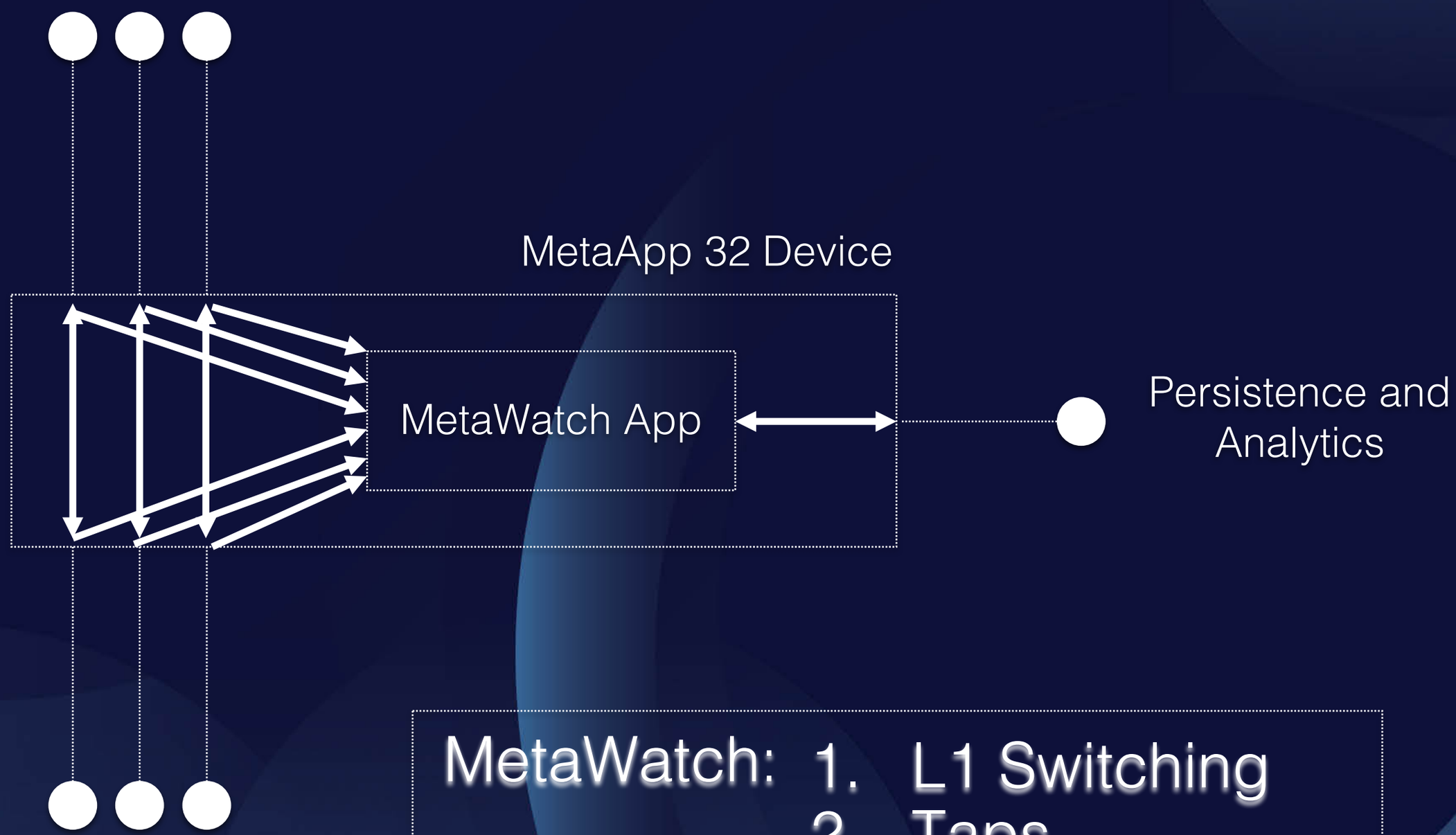
Capture *Everything*

- **32** optical or copper **taps built in**
- **Aggregation** switch
- Precise **timestamps**
- **Huge** packet **buffer**
- Time **synchronisation**
- **Industry standard** trailer format
- Compatible with third party analytics

MetaWatch



MetaWatch:

1. L1 Switching
2. Taps
3. Timestamping
4. Synchronisation
5. Buffering

The Issue

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Vendors regularly quote accuracies, but there is no standard accuracy measurement.

Basic Principles

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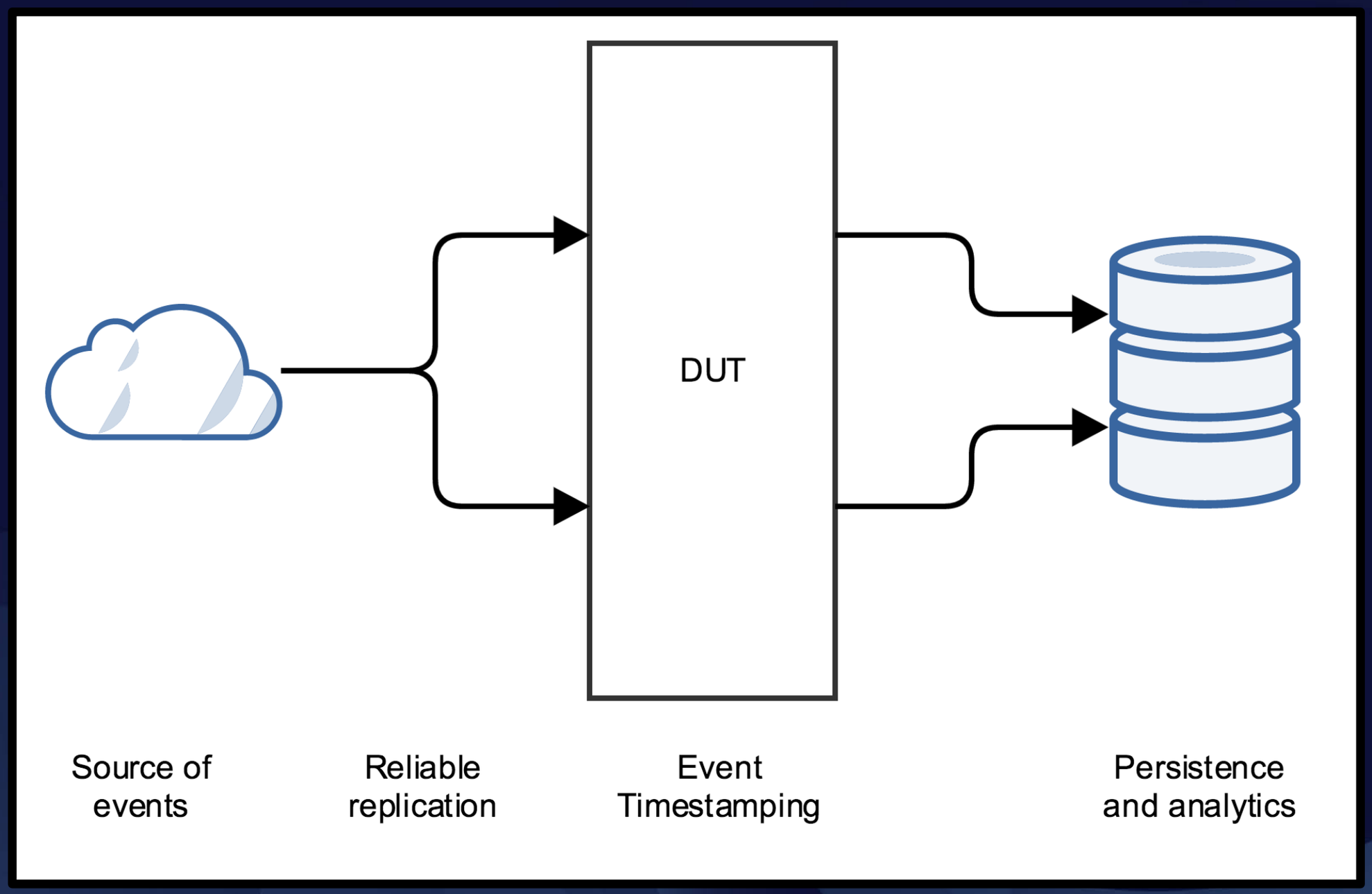
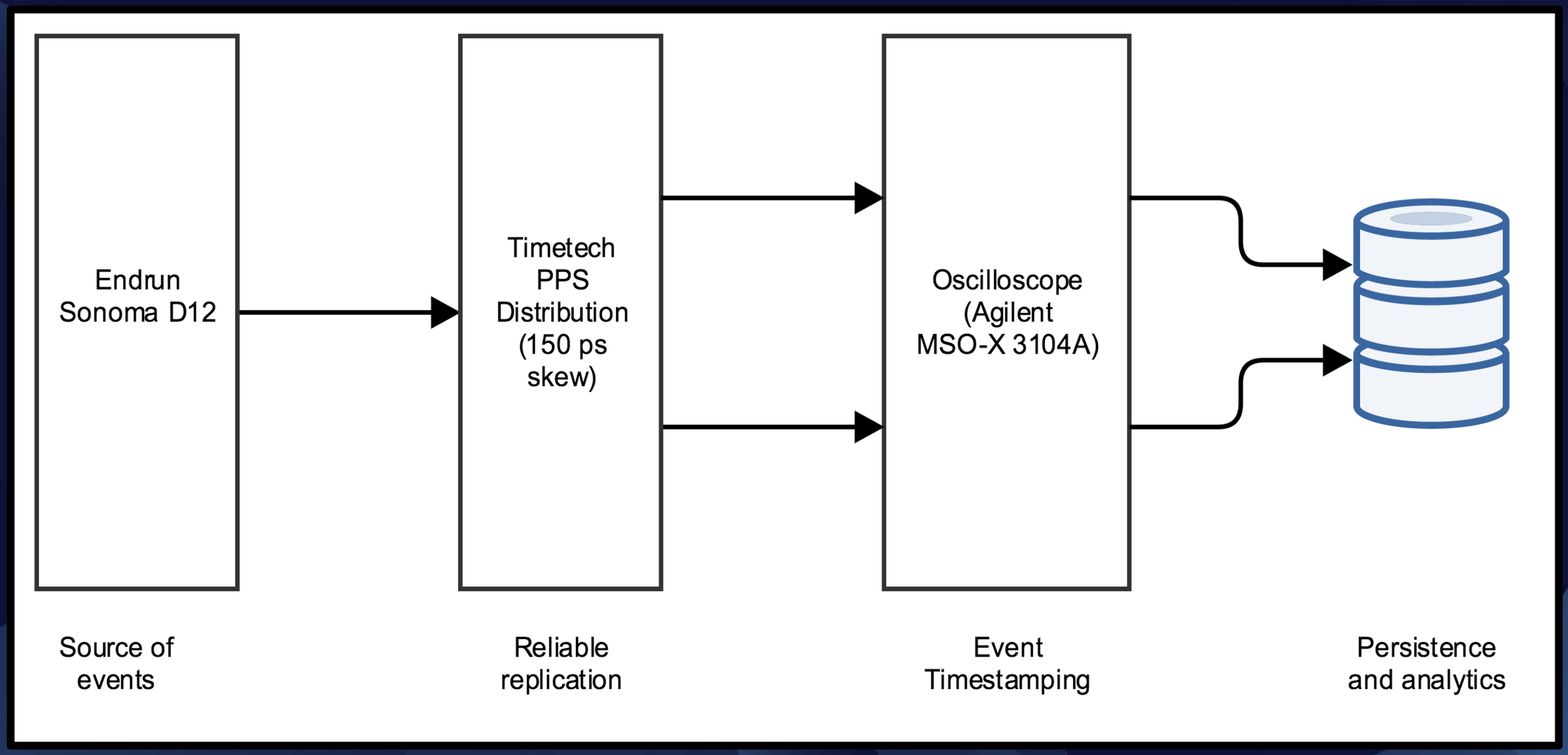


PPS


Endrun
Sonoma D12
Timetech
PPS
Distribution
(150 ps
skew)
Oscilloscope
(Agilent
MSO-X 3104A)
Source of
events
Reliable
replication
Event
Timestamping
Persistence
and analytics

PPS

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Synchronisation on the same device

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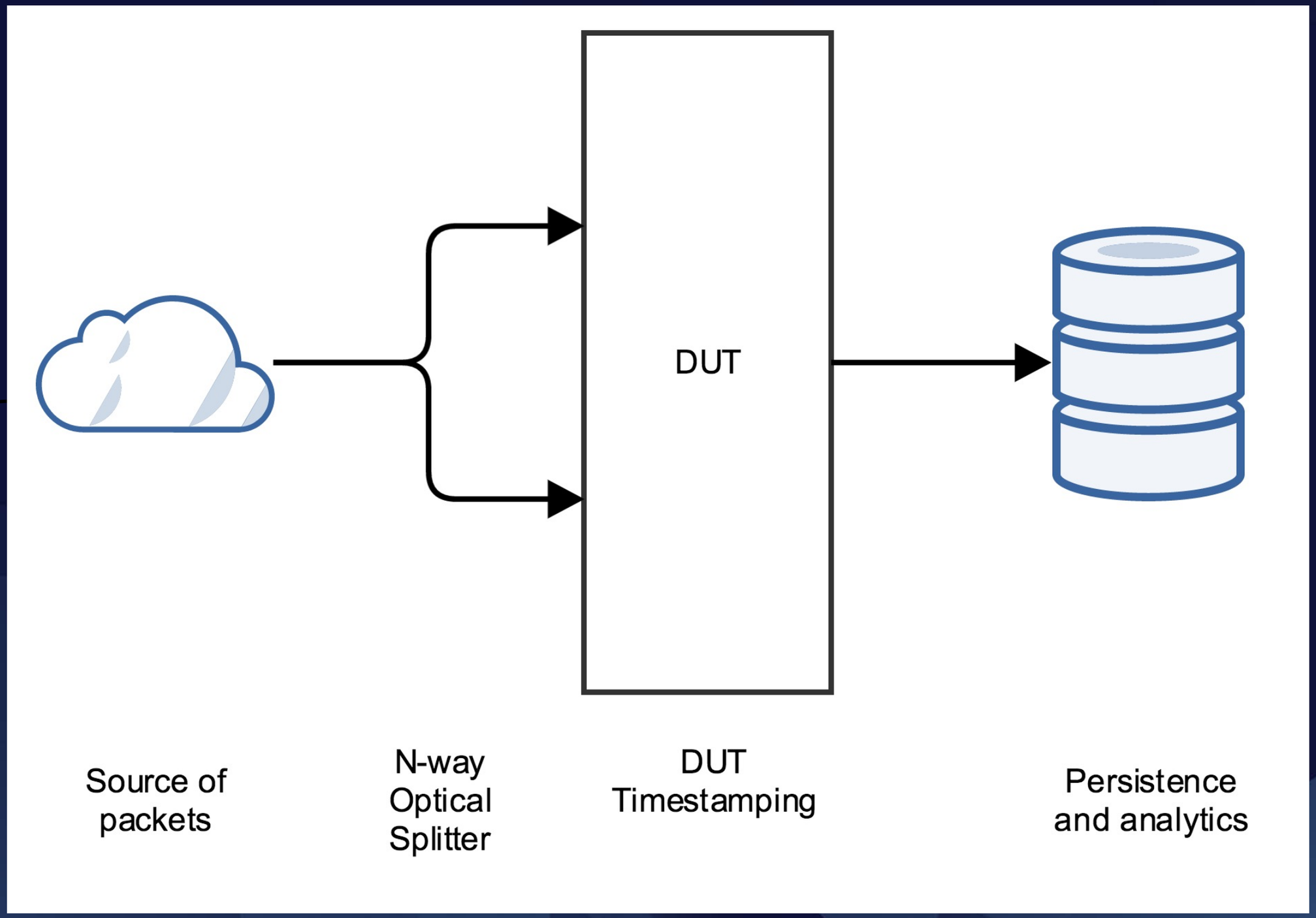

Synchronisation on the same device

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Capture Card

Packets

Any resemblance to a particular model
of capture card is purely coincidental.

Source of Packets

Passive Optical Splitter

Device Under Test

Persistence and Analytics

Synchronisation on the same device

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MetaWatch on
MetaApp 32

Packets

Capture Solar System

PPS

GM

Source of Packets

Passive Optical Splitter

Device Under Test

Persistence and Analytics

Port-sync test

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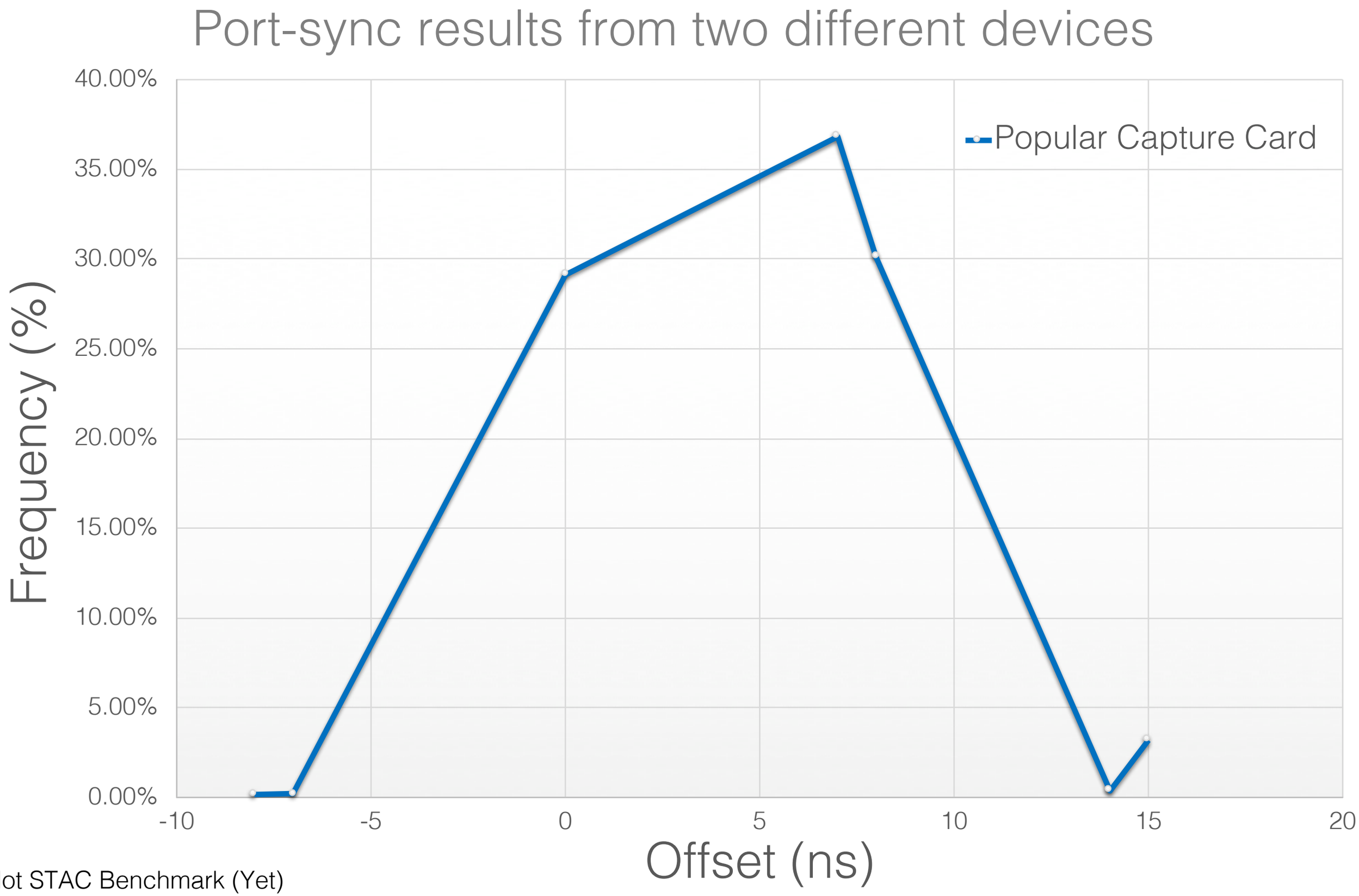

Not STAC Benchmark (Yet)

Port-sync test: MetaWatch

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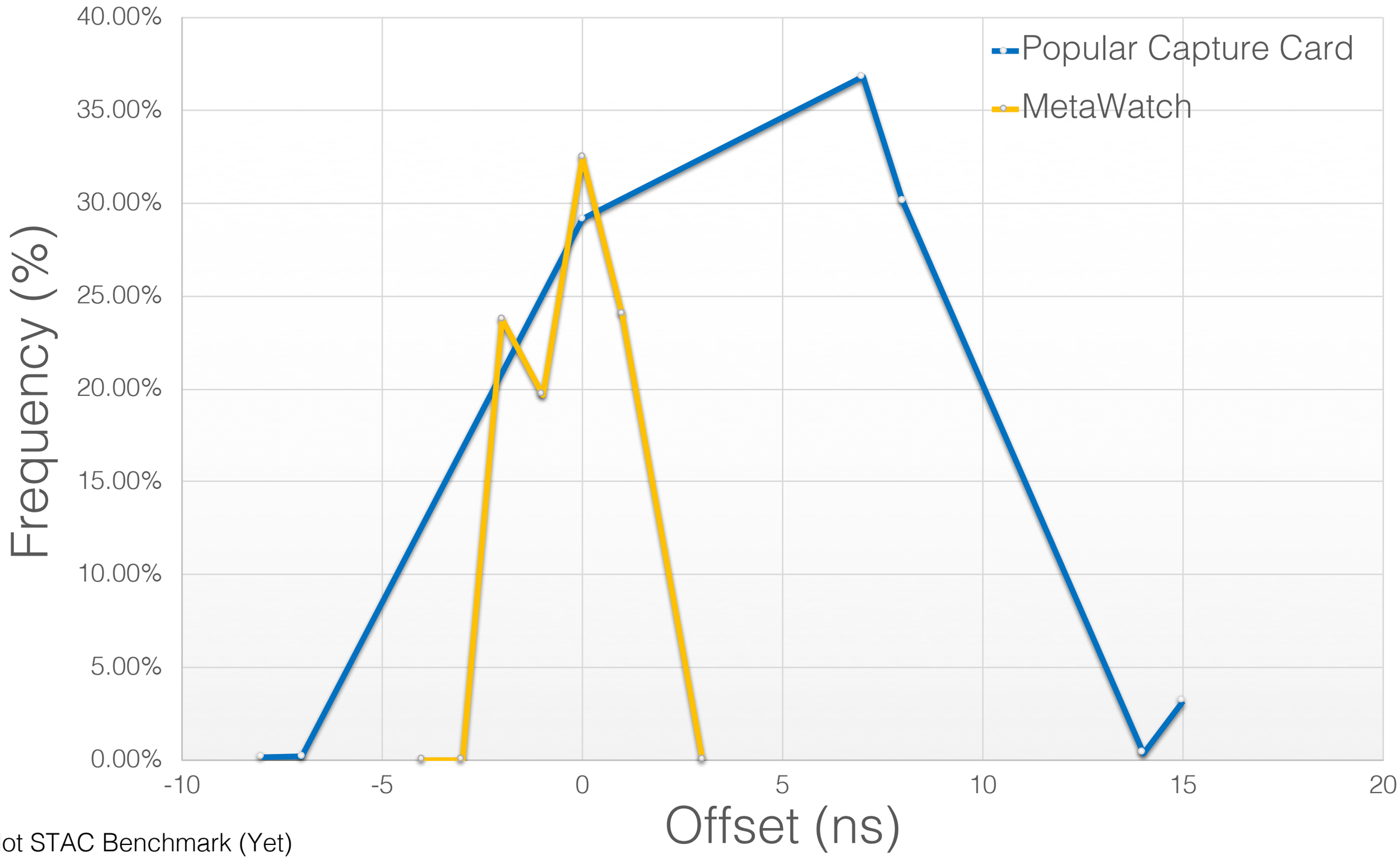

Not STAC Benchmark (Yet)

Port-sync test: MetaWatch Results

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	Capture Card	MetaWatch
Min	-8 ns	-4 ns
Average	5.49 ns	-0.43 ns
Median	7 ns	0 ns
Max	15 ns	3 ns
Stddev	3.9 ns	1.1 ns

Not STAC Benchmark (Yet)

Multi-device sync

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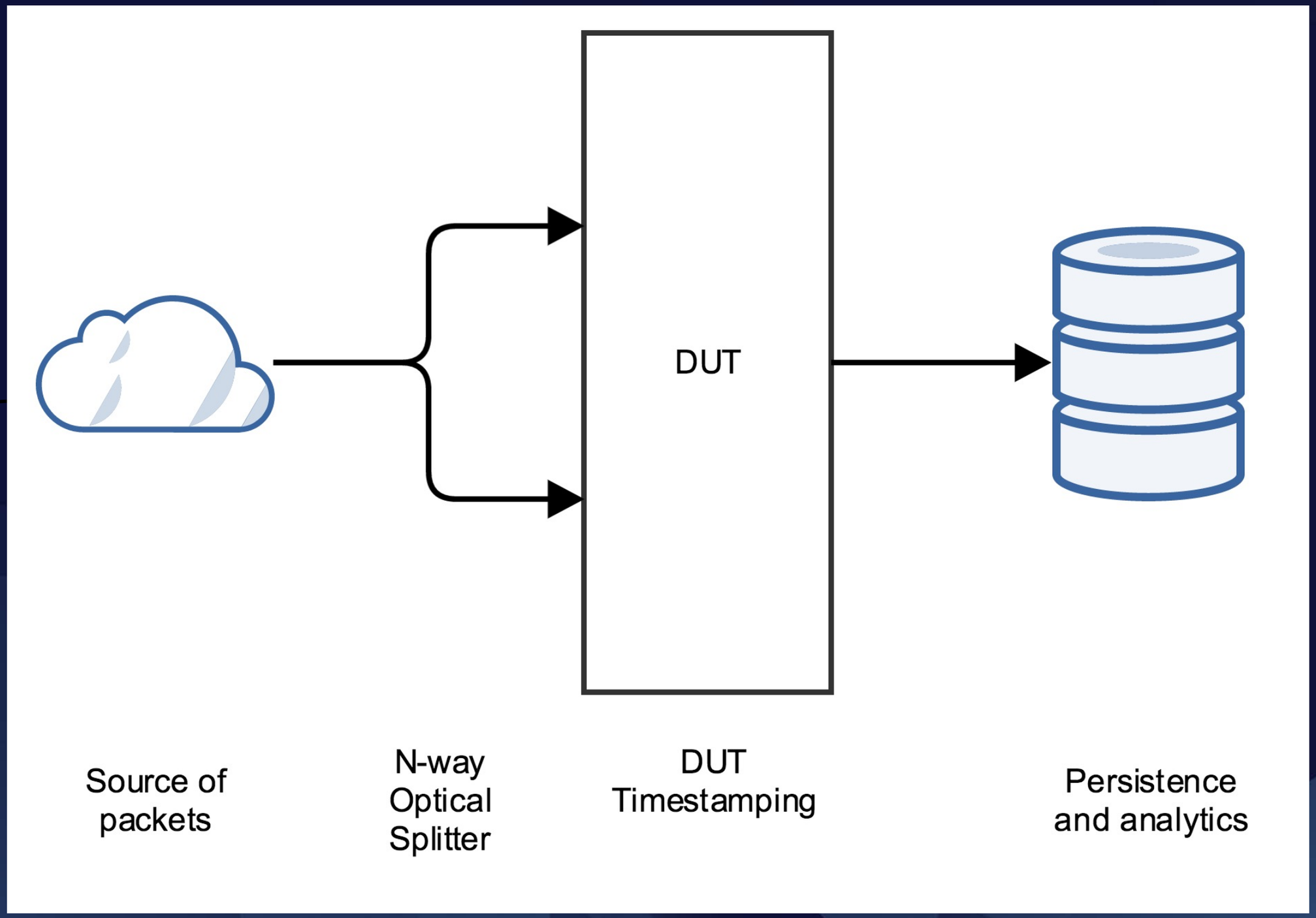
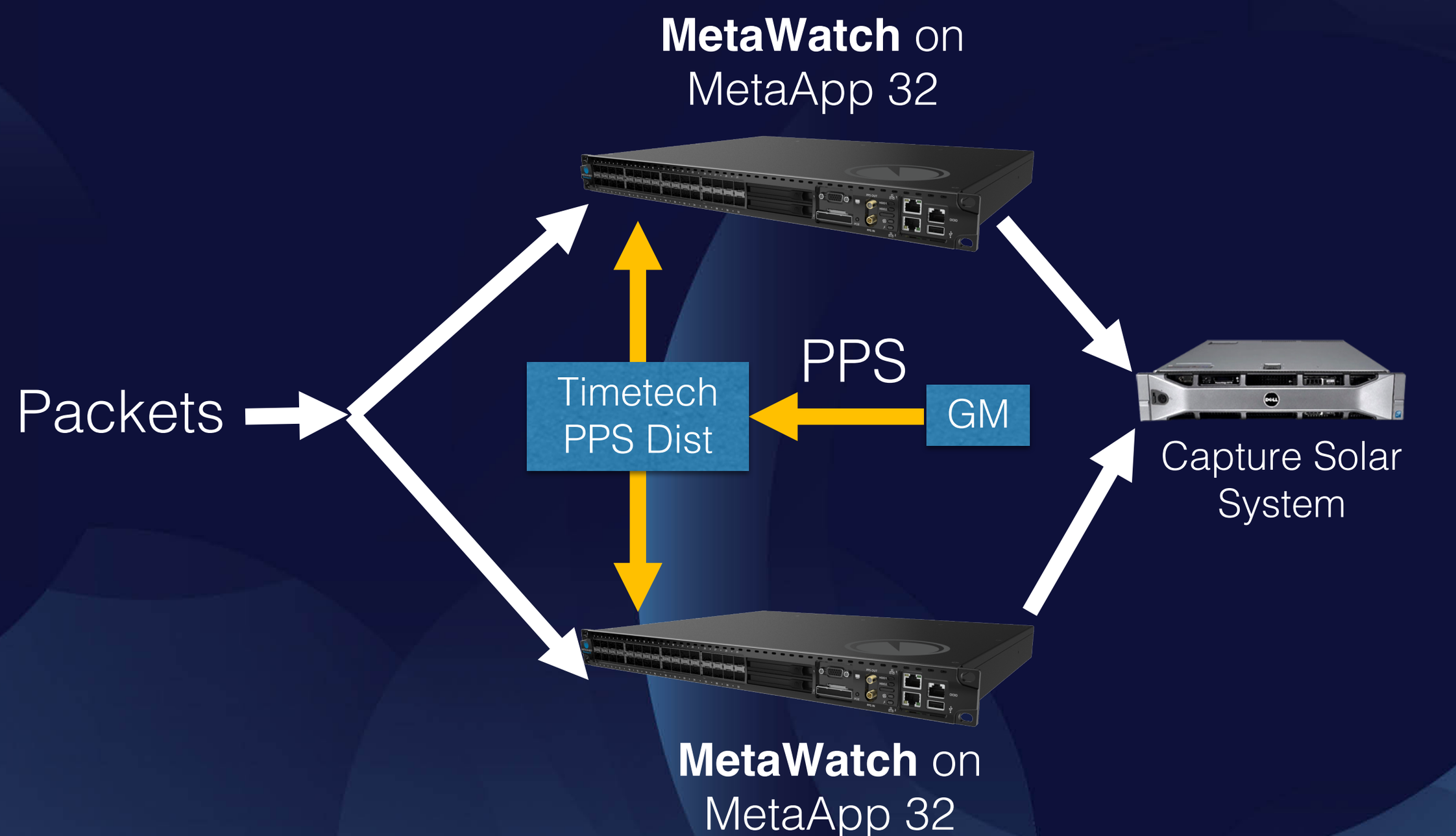


Multi-device sync



Multi-device sync results

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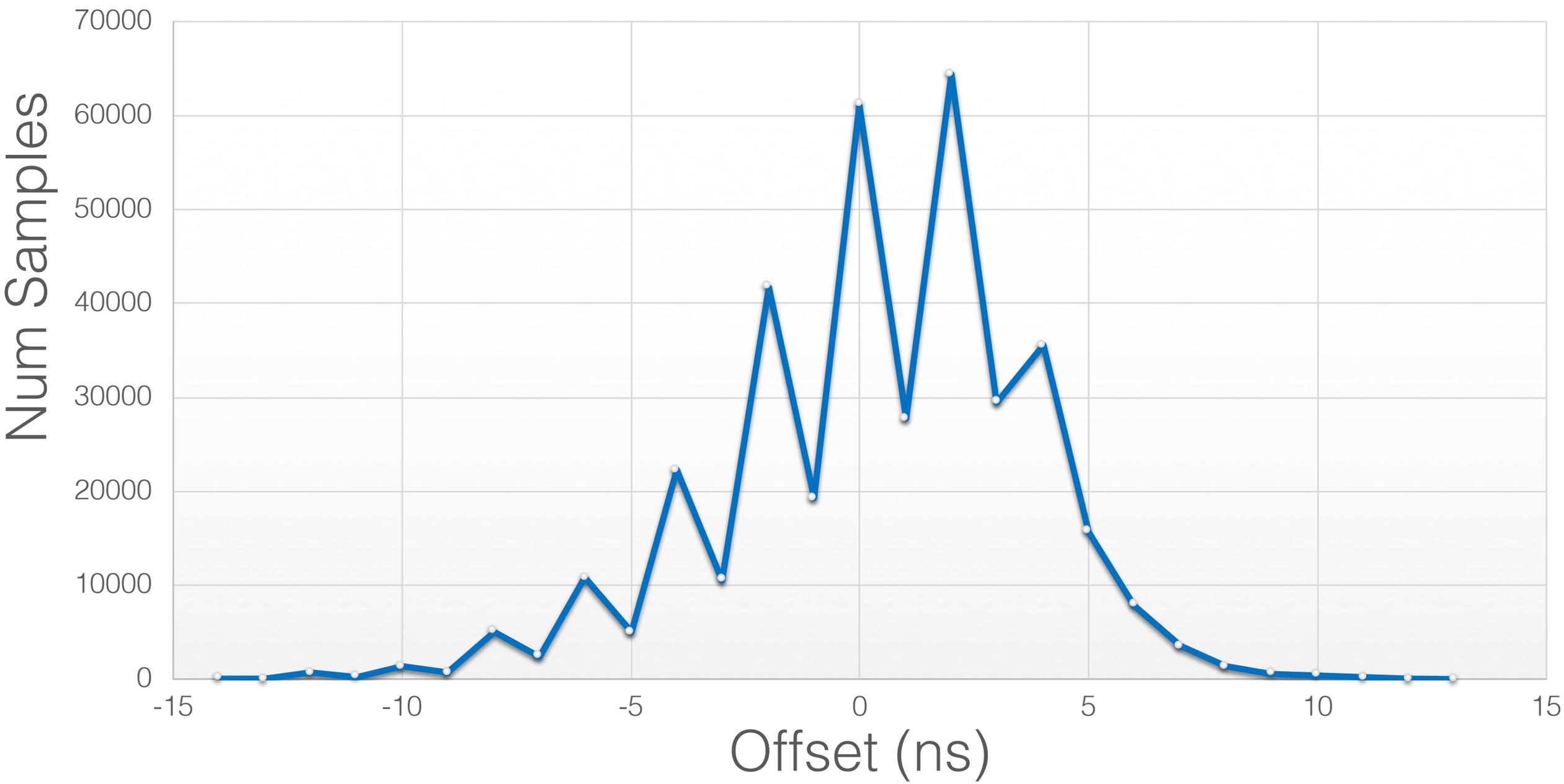
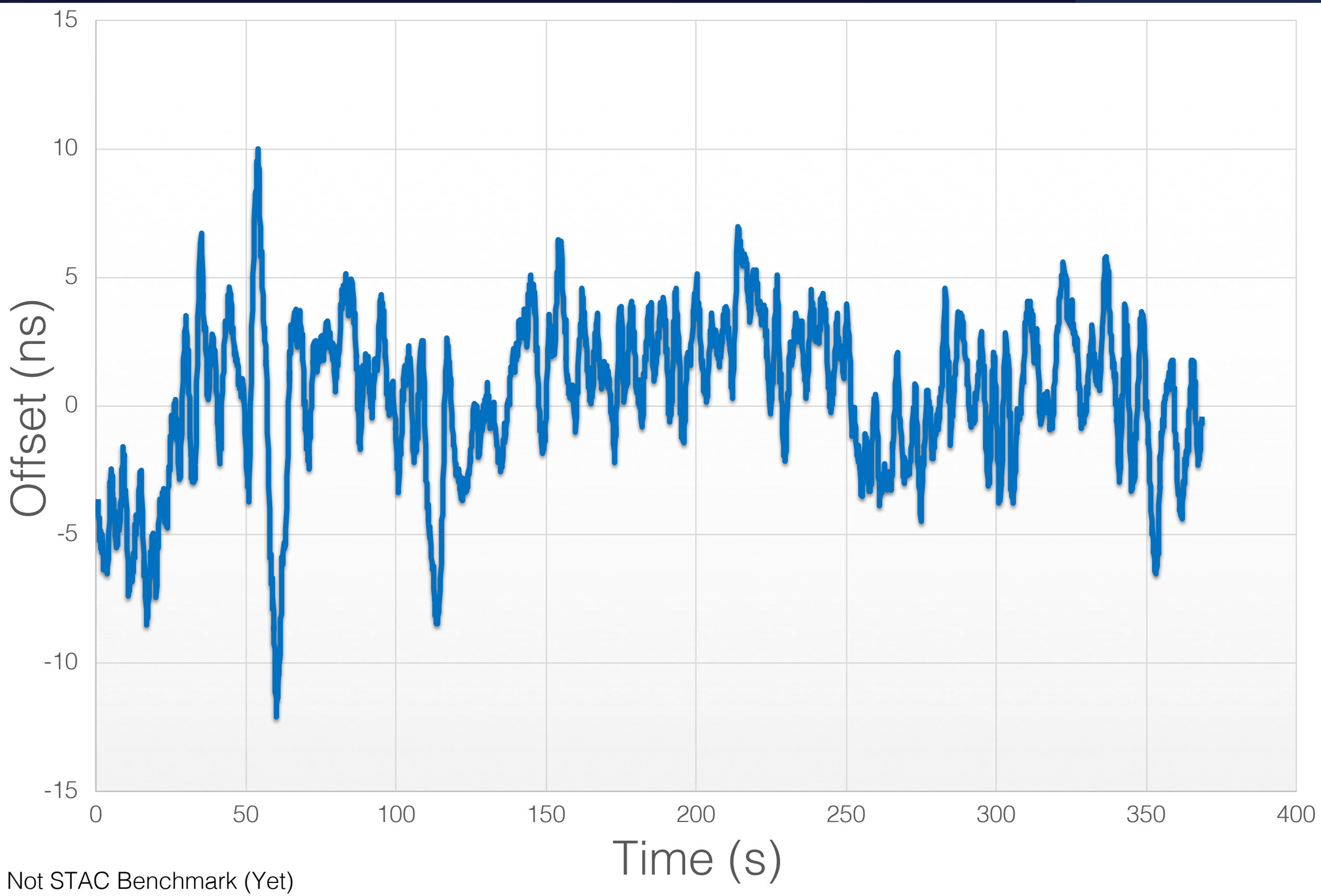
Port Sync Test For Two MetaWatch devices, synchronised via PPS from Timetech



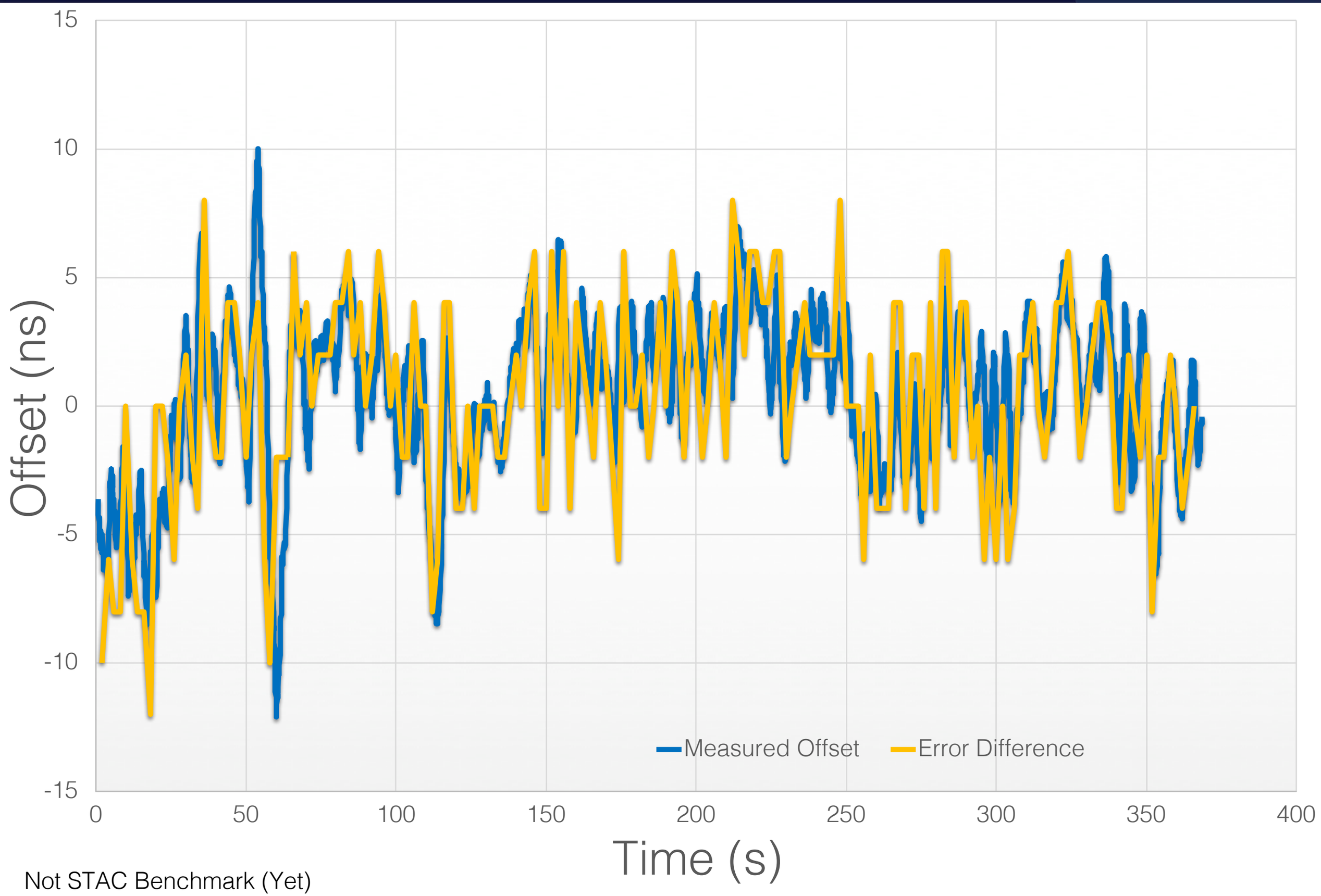
Not STAC Benchmark (Yet)

Multi-device sync results



Not STAC Benchmark (Yet)

Multi-device sync results



Not STAC Benchmark (Yet)

Multi-device sync results

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	MetaWatch
Min	-14 ns
Average	0.42 ns
Median	1 ns
Max	13 ns
Stddev	3.3 ns

Not STAC Benchmark (Yet)

What's the **actual** time?

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What are we trying to timestamp?

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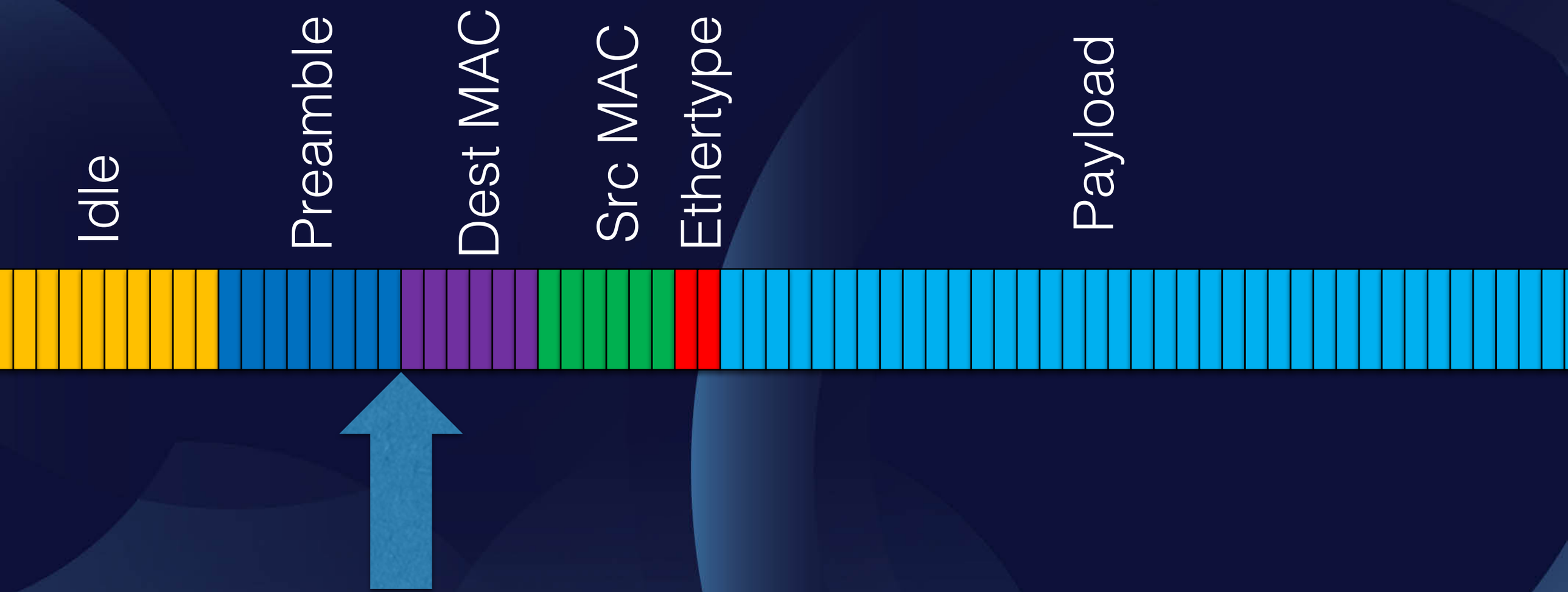

What are we trying to timestamp?

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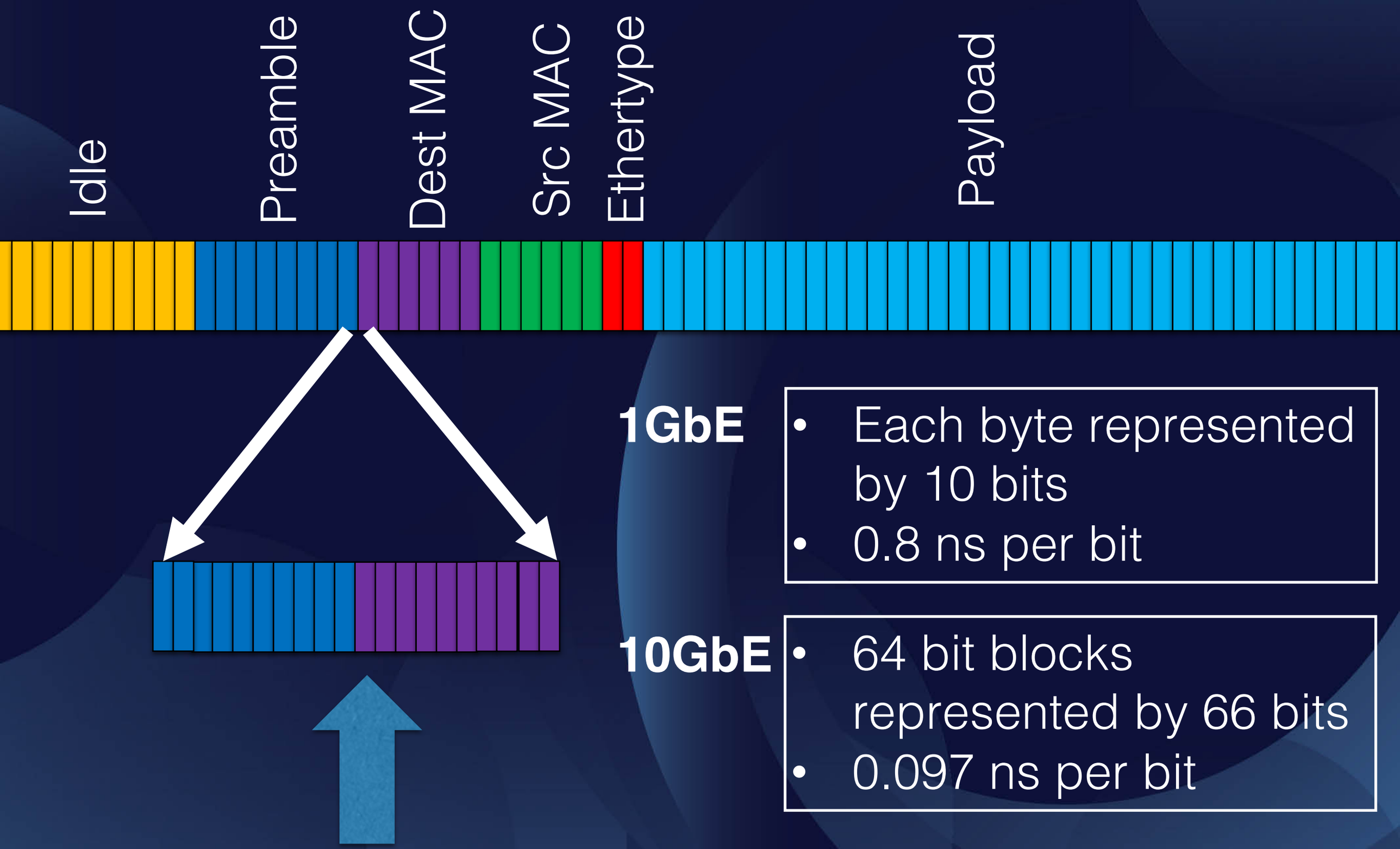

1GbE

- Each byte represented by 10 bits
- 0.8 ns per bit

10GbE

- 64 bit blocks represented by 66 bits
- 0.097 ns per bit

What are we trying to timestamp?

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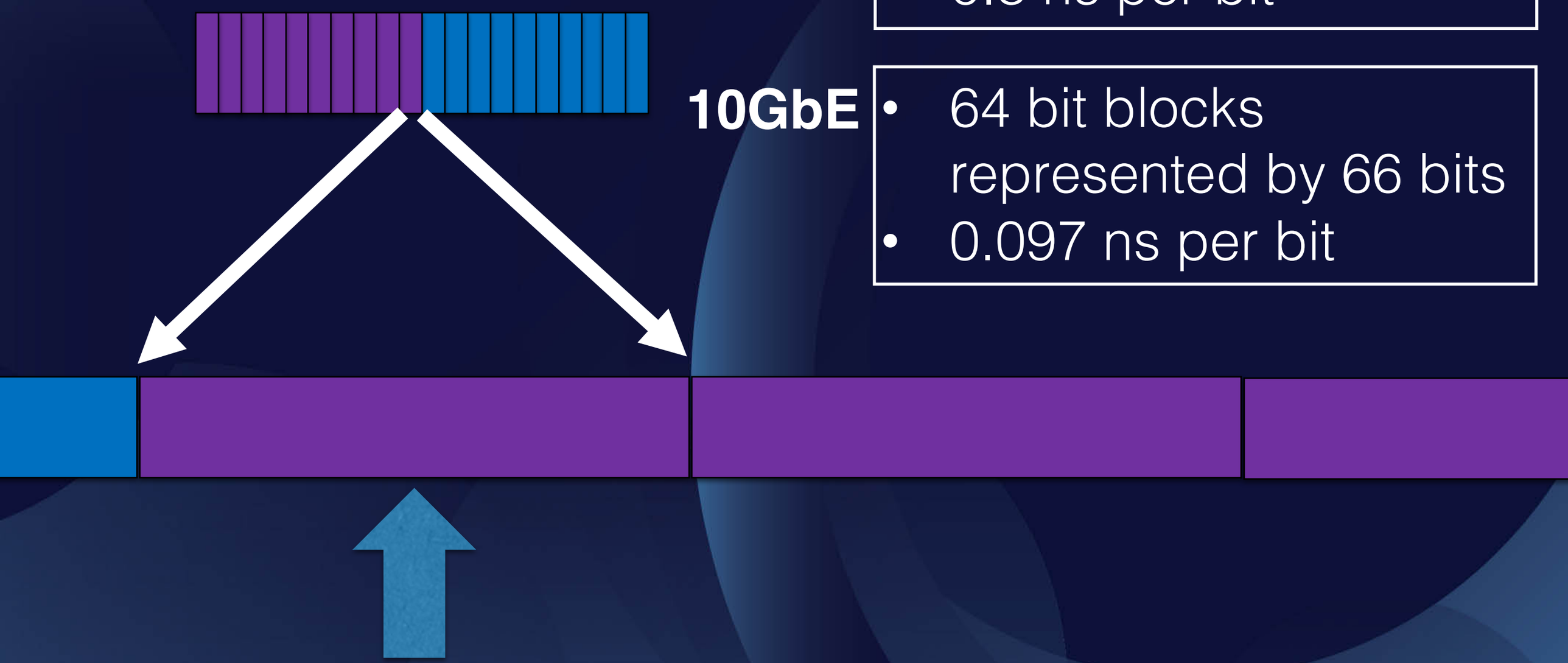
1GbE

- Each byte represented by 10 bits
- 0.8 ns per bit

10GbE

- 64 bit blocks represented by 66 bits
- 0.097 ns per bit



The correct time is the middle of the first bit after the preamble

Absolute Time Measurement

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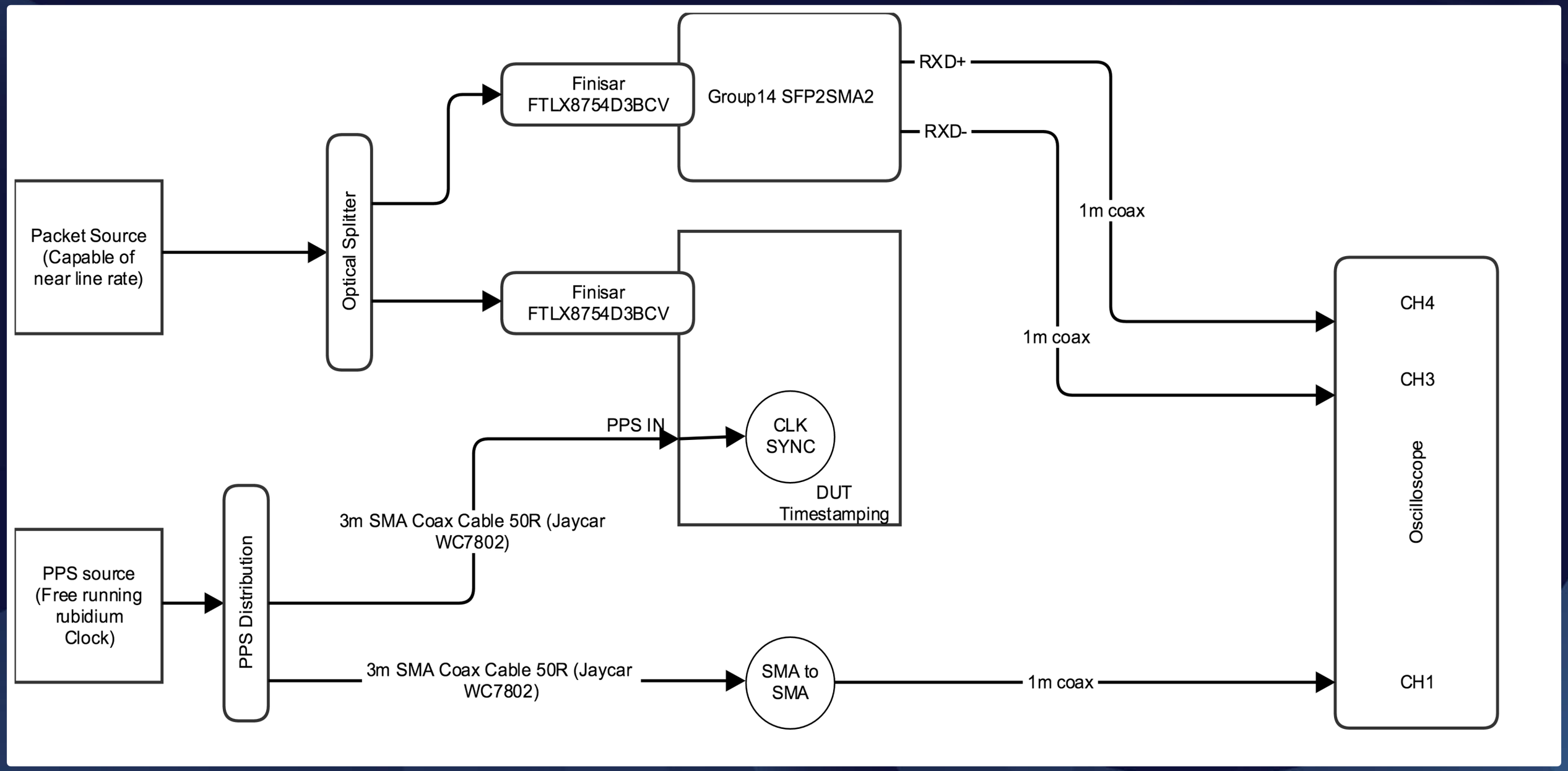
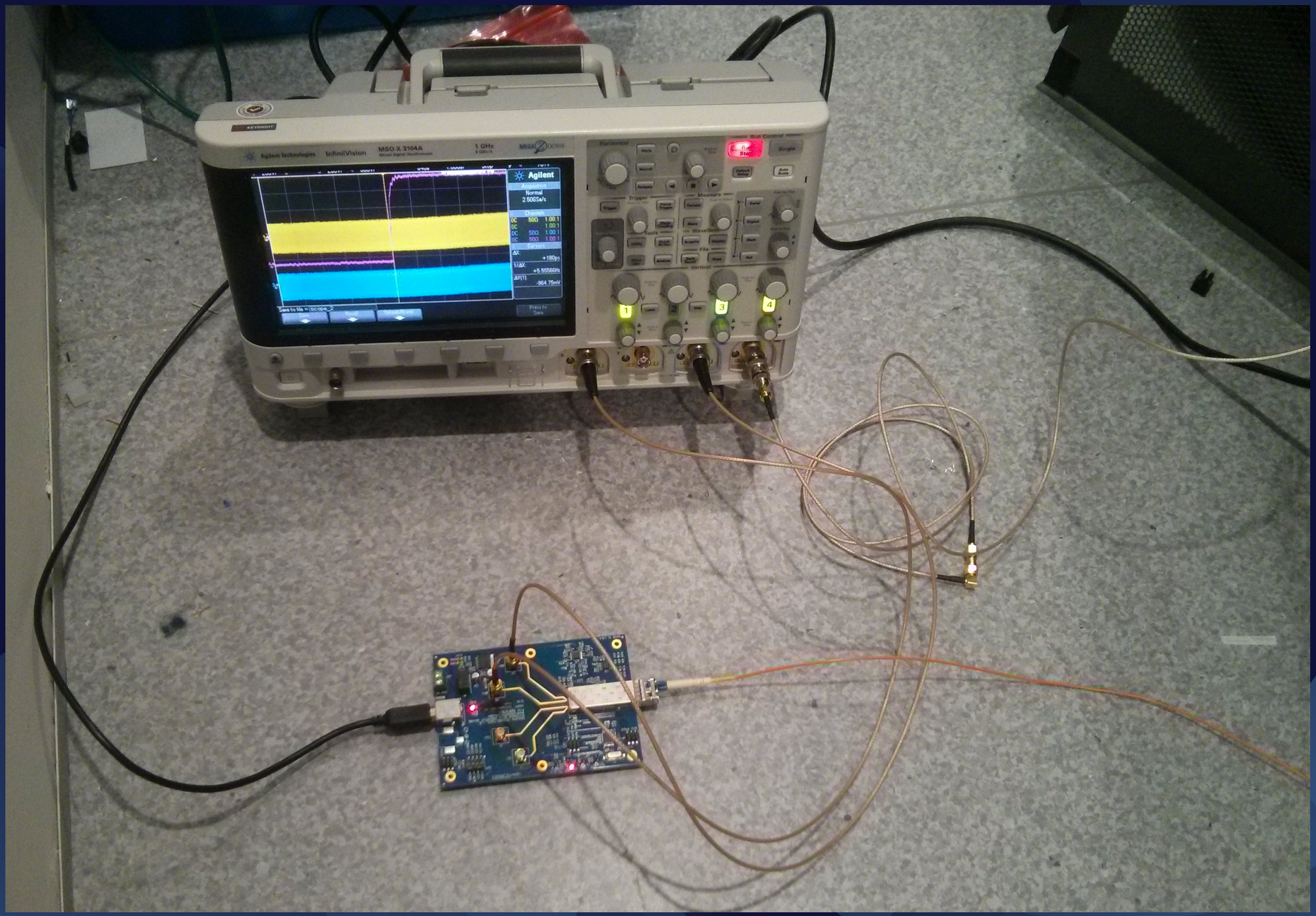
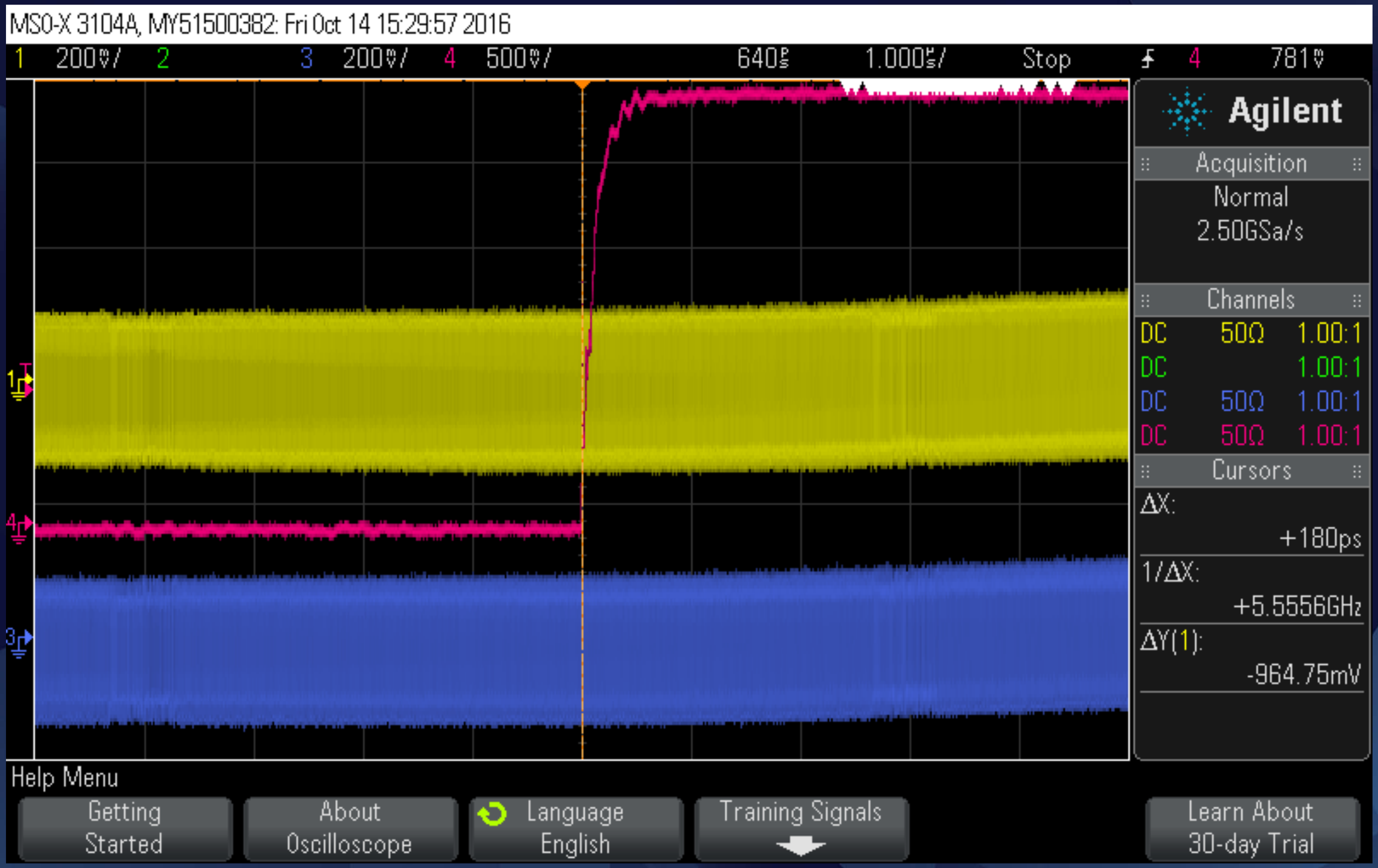


Scope setup


Agilent Technologies
InfiniiVision
MSO-X 3104A
1 GHz
Agilent
Acquisition
Normal
2.50GSa/s
Channels
Cursors
ΔX:
+180ps
1/ΔX:
+5.5556GHz
ΔY(1):
-964.75mV
Run Control
Single
Horizontal
Trigger
Measure
Tools
Waveform
File
Vertical

What that looks like



Not STAC Benchmark (Yet)

What that looks like

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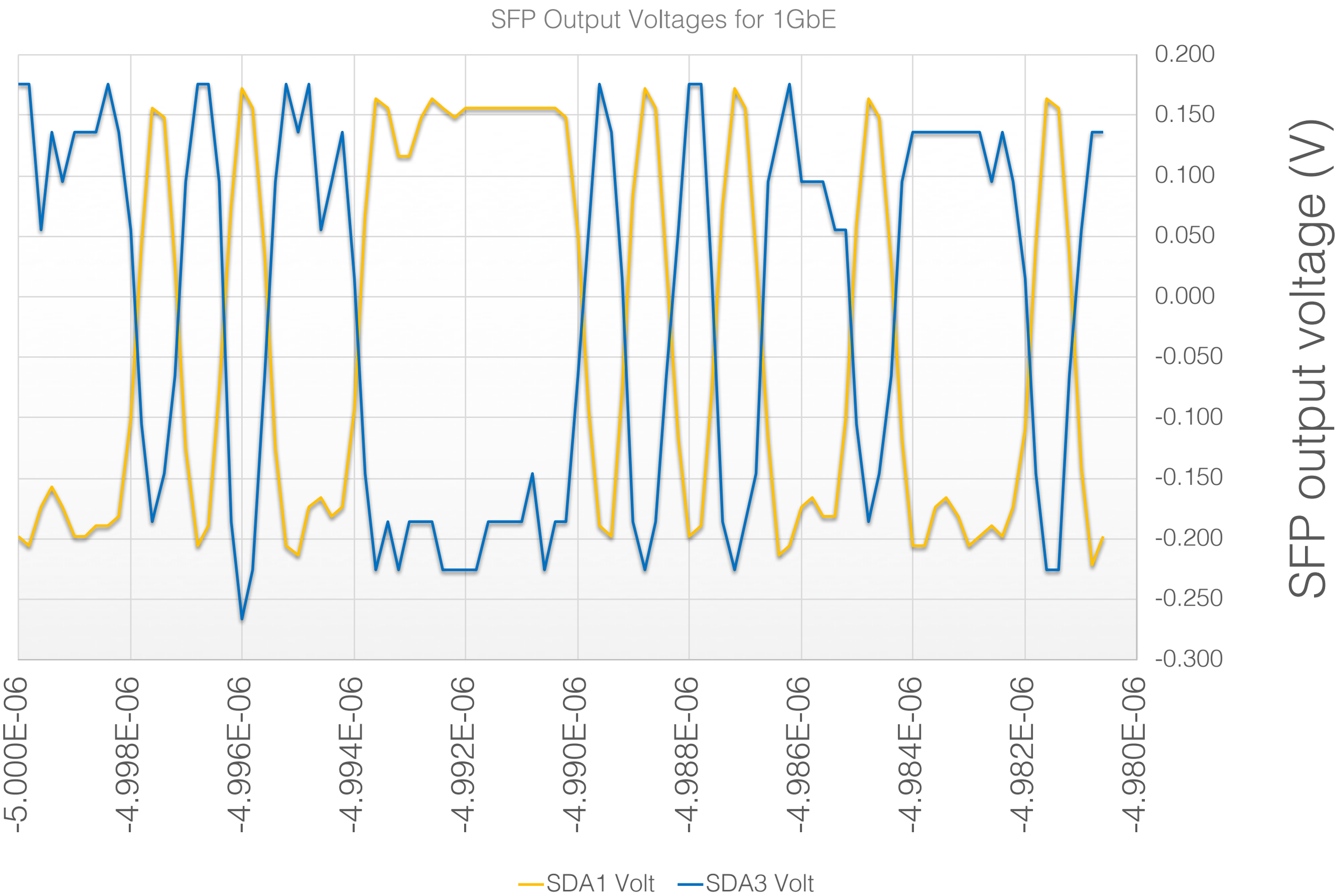
x-axis	SDA1	SDA3
second	Volt	Volt
-0.000005000000	-0.198	0.176
-0.000004999800	-0.206	0.176
-0.000004999600	-0.173	0.055
-0.000004999400	-0.157	0.136
-0.000004999200	-0.173	0.095
-0.000004999000	-0.198	0.136
-0.000004998800	-0.198	0.136
-0.000004998600	-0.190	0.136

What that looks like



After processing

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processed_scope_39.pcap

Apply a disp | Restart current capture | Expression... | +

No.	Time	Display Delta	Delta	Source	Destina
1	0.000000000	0.000000000	0.000000000	192.168.23.3	192.1

```
▼ Frame 1: 102 bytes on wire (816 bits), 102 bytes captured (816 bits)
    Encapsulation type: Ethernet (1)
    Arrival Time: Jan  1, 1970 10:00:00.999997964 AEST
    [Time shift for this packet: 0.000000000 seconds]
    Epoch Time: 0.999997964 seconds
    [Time delta from previous captured frame: 0.000000000 seconds]
    [Time delta from previous displayed frame: 0.000000000 seconds]
    [Time since reference or first frame: 0.000000000 seconds]
0000  7c 53 4a ce e3 04 d4 ae  52 85 83 ef 08 00 45 00   |SJ..... R.....E.
0010  00 54 f1 dc 40 00 40 01  99 77 c0 a8 17 03 c0 a8   .T..@.@. .w......
0020  17 01 08 00 03 ac 73 40  1b 1a e2 8e 90 57 00 00   ......s@ .....W..
0030  00 00 25 40 0f 00 00 00  00 00 10 11 12 13 14 15   ..%@.... ........
0040  16 17 18 19 1a 1b 1c 1d  1e 1f 20 21 22 23 24 25   ........ .. !"#$%
0050  26 27 28 29 2a 2b 2c 2d  2e 2f 30 31 32 33 34 35   &'()*+,- ./012345
0060  36 37 58 39 9a 06                                  67X9..
```

Epoch time when this frame was captured (frame.time_epoch) | Packets: 1 · Displayed: 1 (100.0%) · Load time: 0:0.0 | Profile: Default

Matching up the packets

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scope_39_watch_0.5.0beta1.pcap

Apply a display filter ... <⌘/>

No.	Time	Display Delta	Delta	Source
28410	1.312798016	0.000041962	0.000041962	192.168.
28411	1.312807590	0.000009574	0.000009574	192.168.
28412	1.312815450	0.000007860	0.000007860	192.168.
28413	1.313111484	0.000296034	0.000296034	192.168.
28414	1.313160390	0.000048906	0.000048906	192.168.
28415	1.313168749	0.000008359	0.000008359	192.168.
28416	1.313176371	0.000007622	0.000007622	192.168.
28417	1.313183323	0.000006952	0.000006952	192.168.
28418	1.313208863	0.000025540	0.000025540	192.168.

```
Frame 28412: 114 bytes on wire (912 bits), 114 bytes captured (912 bits)
    Encapsulation type: Ethernet (1)
    Arrival Time: Jul 21, 2016 18:59:15.999749265 AEST
    [Time shift for this packet: 0.000000000 seconds]
    Epoch Time: 1469091555.999749265 seconds
    [Time delta from previous captured frame: 0.000007860 seconds]
    [Time delta from previous displayed frame: 0.000007860 seconds]
0000  d4 ae 52 85 83 ef 7c 53  4a ce e3 04 08 00 45 00   ..R...|S J.....E.
0010  00 54 75 25 00 00 40 01  56 2f c0 a8 17 01 c0 a8   .Tu%..@. V/......
0020  17 03 00 00 a1 c9 73 40  6e fc e3 8e 90 57 00 00   ......s@ n....W..
0030  00 00 3a 40 0f 00 00 00  00 00 10 11 12 13 14 15   ..:@.... ........
0040  16 17 18 19 1a 1b 1c 1d  1e 1f 20 21 22 23 24 25   ........ .. !"#$%
0050  26 27 28 29 2a 2b 2c 2d  2e 2f 30 31 32 33 34 35   &'()*+,- ./012345
0060  36 37 9e 38 d2 b1 57 90  8e e4 00 00 9c d3 01 ce   67.8..W. ........
```

Epoch time when this ...ed (frame.time_epoch) Packets: 50001 · Displayed: 50001 (100.0%) · Load time: 0:0.38

processed_sc

Restart current capture

	Time	Disp	Delta	De
1	0.000000000		0.000000000	

```
me 1: 102 bytes on wire (816 bits), 102 bytes ca
Encapsulation type: Ethernet (1)
Arrival Time: Jan  1, 1970 10:00:00.999997964 AE
[Time shift for this packet: 0.000000000 seconds]
Epoch Time: 0.999997964 seconds
[Time delta from previous captured frame: 0.000000000 seconds]
[Time delta from previous displayed frame: 0.000000000 seconds]
[Time since reference or first frame: 0.000000000 seconds]
7c 53 4a ce e3 04 d4 ae  52 85 83 ef 08 00 45 00   |SJ..... R.....E.
```

Not STAC Benchmark (Yet)

MetaWatch results

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Scope Trace Capture

Stop capturing packets

Apply a display filter ... <⌘/>

No.	Time
1	0.0000
2	0.000006976

```
▼ Frame 1: 64 bytes on wire (512 bi
    Encapsulation type: Ethernet (1
    Arrival Time: Dec 31, 1969 18:0
    [Time shift for this packet: 0.
    Epoch Time: 0.999996233 seconds
    [Time delta from previous captu
    [Time delta from previous displ
    [Time since reference or first
    Frame Number: 1
    Frame Length: 64 bytes (512 bit
    Capture Length: 64 bytes (512 b
    [Frame is marked: False]
    [Frame is ignored: False]
    [Protocols in frame: eth:ethertype:data]
▶ Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:0
▶ Data (50 bytes)

0000  00 00 00 00 00 00 00 00  00 00 00 00 44 55 e5 a0   ........ ....DU..
0010  26 ba 49 04 04 ca ed d5  ad 5e a2 d3 59 60 71 52   &.I..... .^..Y`qR
0020  8a 8e ff 80 c6 83 a5 13  a8 63 56 a5 97 c1 73 32   ........ .cV...s2
0030  d0 0f a6 28 60 0e 6b f6  d4 13 d7 5a ed 14 a8 5a   ...(`.k. ...Z...Z
```

Epoch time when this frame...aptured (frame.time_epoch) Packets: 2 · Displayed: 2 (100.0%) · Load time: 0:0.0 Profile: Default

tad6_port_9.pcap

Apply a display filter ... <⌘/> Expression... +

No.	Time	Display Delta	Delta	Source
910749	6.353375690	0.000006976	0.000006976	00:00:00_00:00:
910750	6.353382666	0.000006976	0.000006976	00:00:00_00:00:
910751	6.353389642	0.000006976	0.000006976	00:00:00_00:00:
910752	6.353396618	0.000006976	0.000006976	00:00:00_00:00:
910753	6.353403594	0.000006976	0.000006976	00:00:00_00:00:
910754	6.353410568	0.000006974	0.000006974	00:00:00_00:00:
910755	6.353417544	0.000006976	0.000006976	00:00:00 00:00:

```
▼ Frame 910753: 64 bytes on wire (512 bits), 64 bytes captured (512 bits)
    Encapsulation type: Ethernet (1)
    Arrival Time: Oct  6, 2016 20:08:16.999996235 CDT
    [Time shift for this packet: 0.000000000 seconds]
    Epoch Time: 1475802496.999996235 seconds
    [Time delta from previous captured frame: 0.000006976 seconds]

0000  00 00 00 00 00 00 00 00  00 00 00 00 44 55 e5 a0   ........ ....DU..
0010  26 ba 49 04 04 ca ed d5  ad 5e a2 d3 59 60 71 52   &.I..... .^..Y`qR
0020  8a 8e ff 80 c6 83 a5 13  a8 63 56 a5 97 c1 73 32   ........ .cV...s2
0030  d0 0f a6 28 60 0e 6b f6  d4 13 d7 5a ed 14 a8 5a   ...(`.k. ...Z...Z
```

Epoch time when th...(frame.time_epoch Packets: 1260547 · Displayed: 1260547 (100.0%) · Load time: 0:7.642 Profile: Default

MetaWatch Capture

= 2 ns

Trust chain

1. Measure the port-sync on the same device.

2. Measure the port-sync between two devices synchronised to PPS.

3. Measure the absolute timing accuracy to PPS using an oscilloscope.

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What do you do when you've got a really accurate measuring device?

Measure some stuff

Copper is faster than fibre

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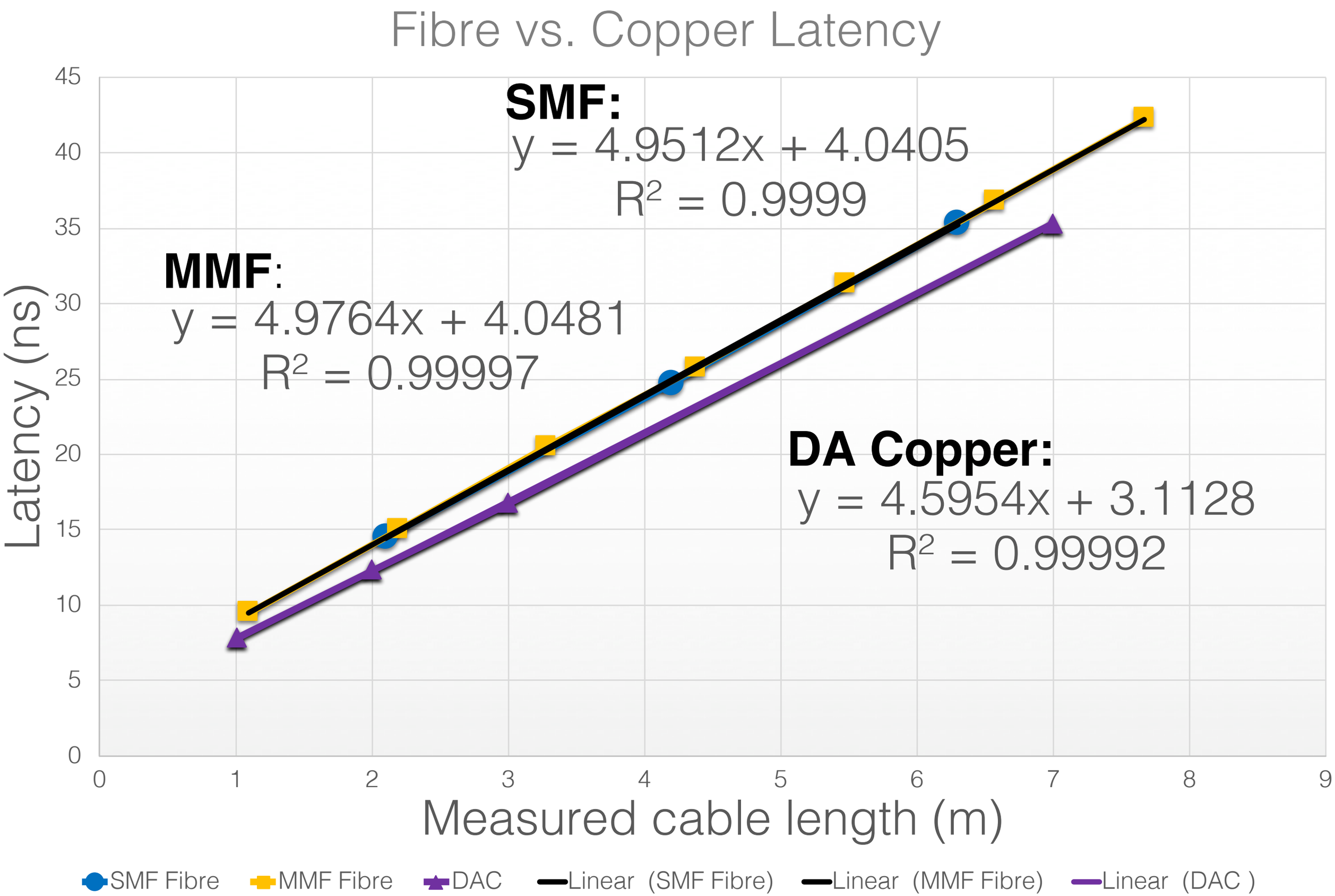
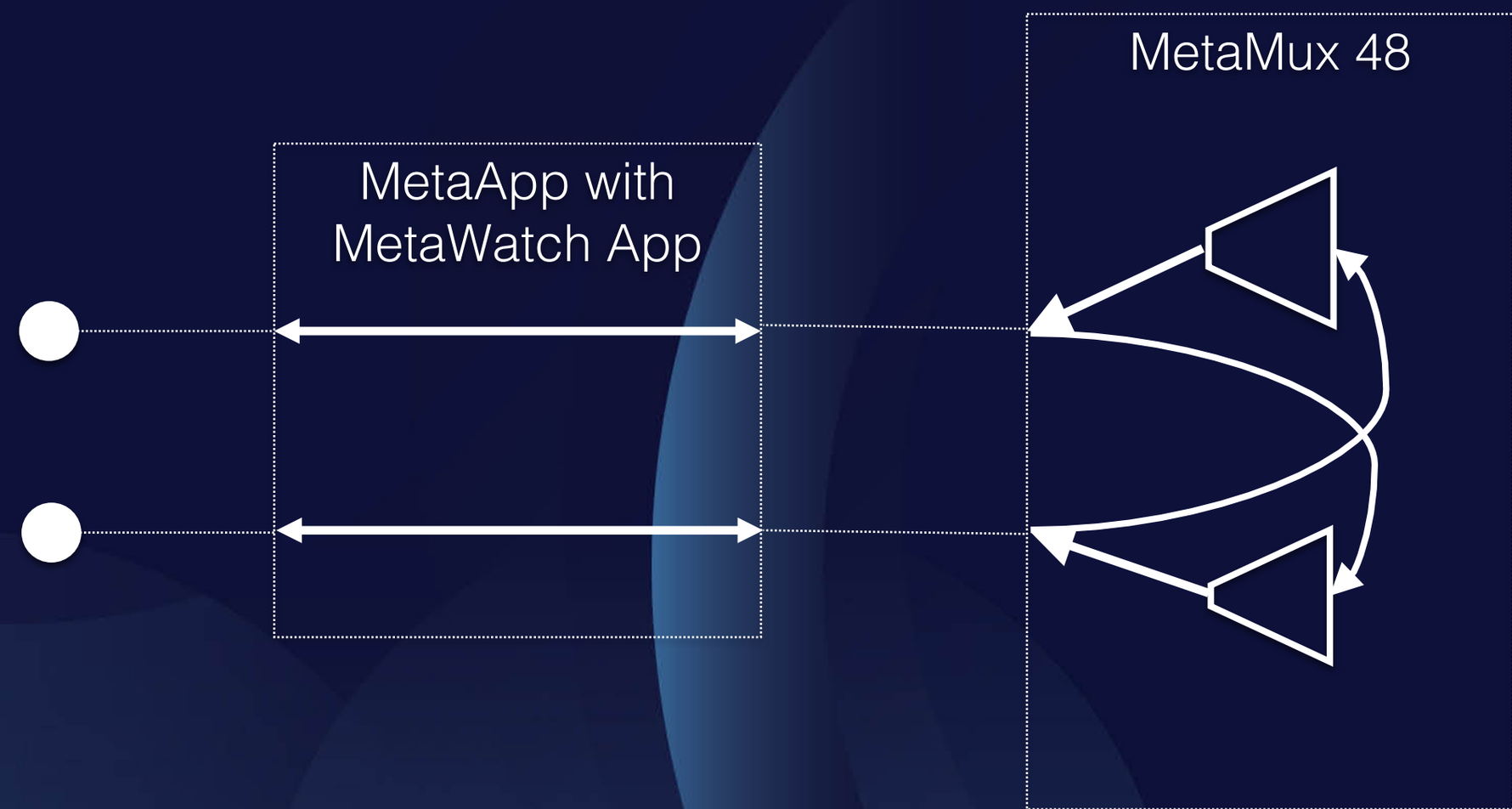
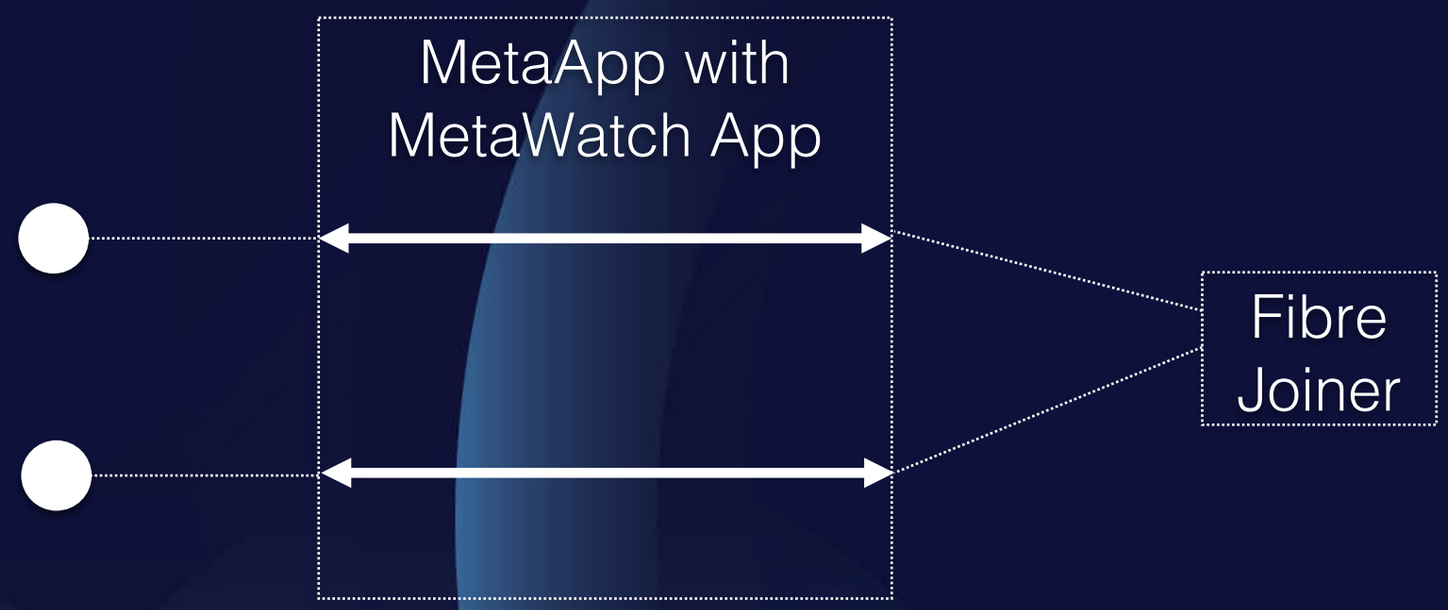


Measuring MetaMux Latency



Measuring MetaMux Latency



Measuring MetaMux Latency

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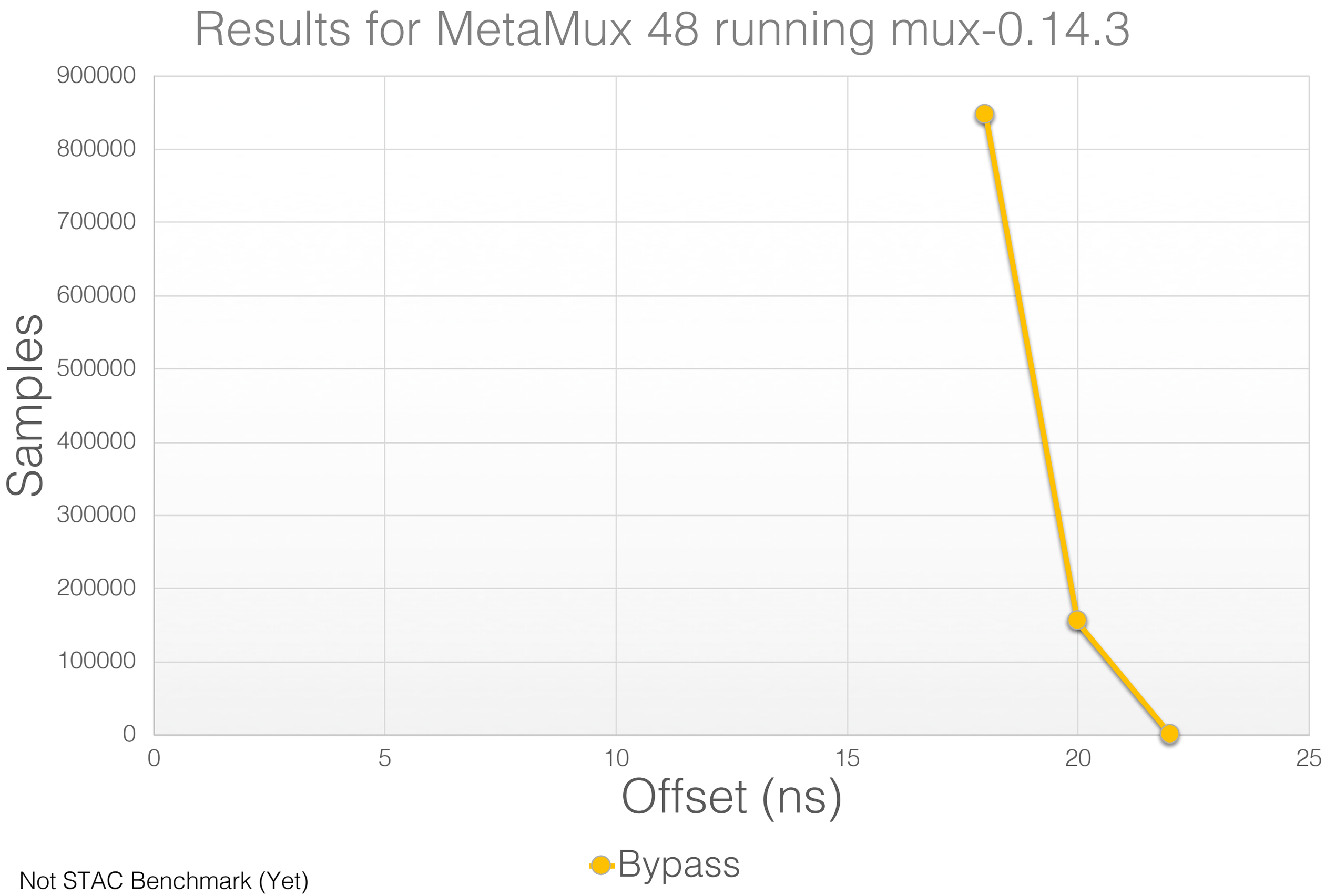

Not STAC Benchmark (Yet)

Measuring MetaMux Latency

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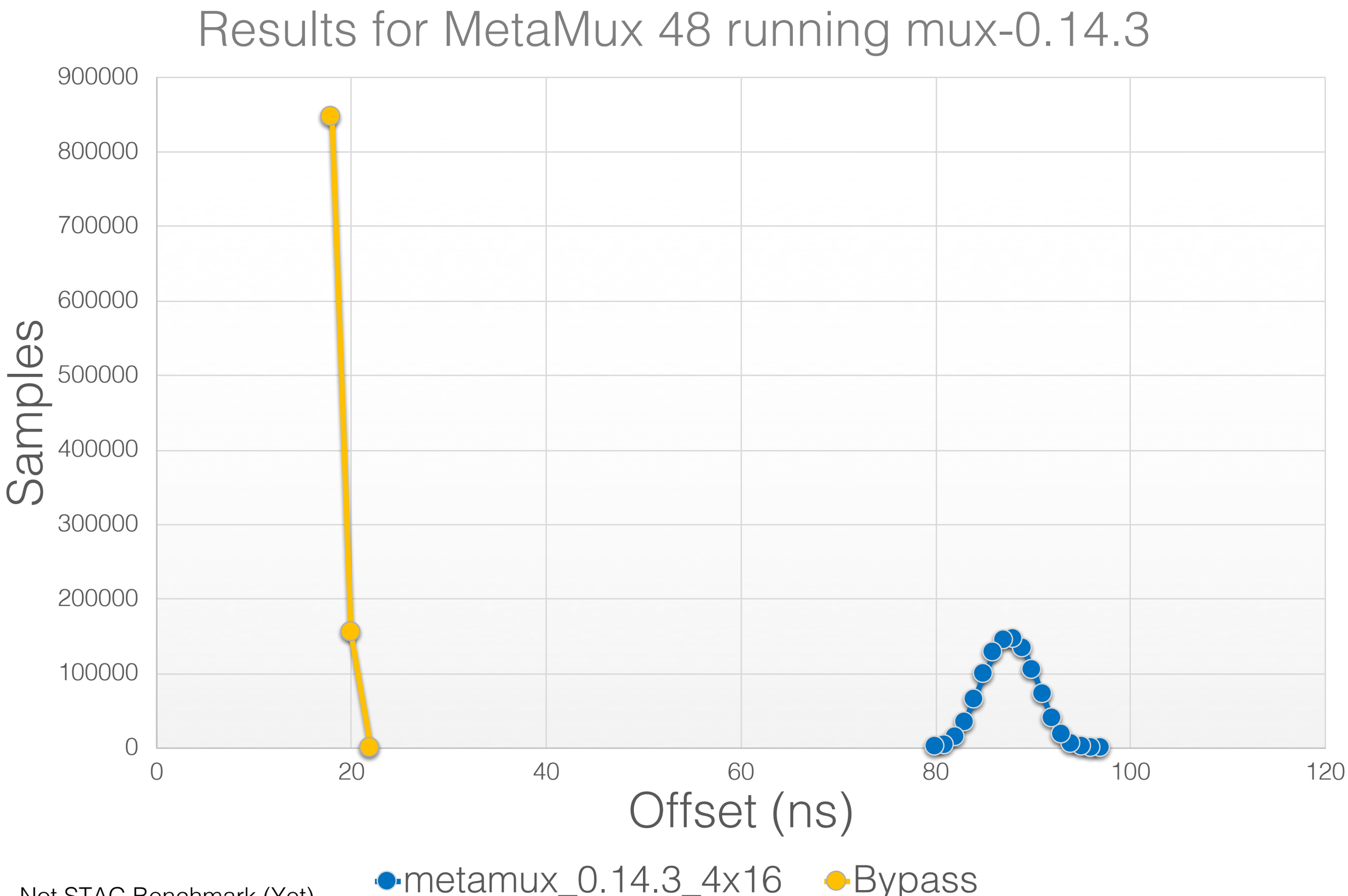

Not STAC Benchmark (Yet)

Measuring MetaMux Latency

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	bypass	mux_4x16
Min	18	80
Average	18.31	87.61
Median	18	88
Max	22	97
Stddev	0.7	2.5

*Not STAC benchmark (yet!)

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69 ns

*Not STAC benchmark (yet!)

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