

# Operational Selection of the healthiest (e)PRTC precision clocks



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Chronos Technology Ltd

ITSF, Prague, November 8<sup>th</sup> 2016 – Sources of Time part II

# ITSF Last year :-

- Presented “Improved” 5071A
  - Added GNSS Steering
    - Ultra-long Time-constant
    - Maximum possible noise filtering
    - GNSS monitoring with auto switch to holdover.
- Any Caesium or better could be used.

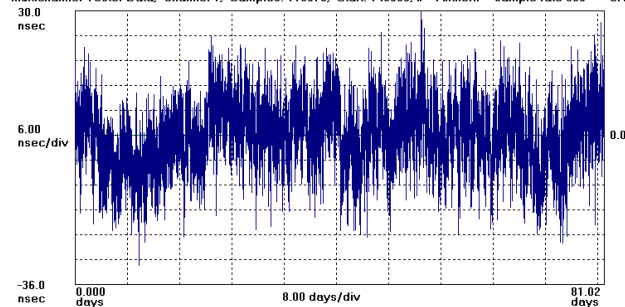


# Real system results (60 days\*)

Microsemi TimeMonitor Analyzer

Phase deviation in units of time: Fs=16.67 MHz; Fo=2.0480000 MHz; 23-Jun-2016 08:4

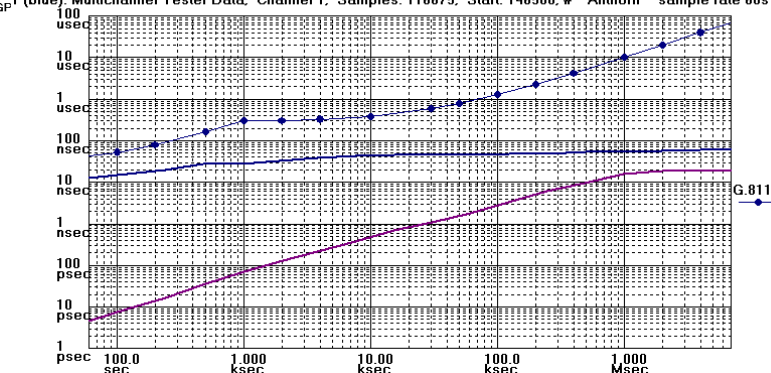
Multichannel Tester Data; Channel 1; Samples: 116675; Start: 146500; # "Anthorn" "sample rate 60s" "-CH1-GP



Microsemi TimeMonitor Analyzer

MTIE: Fo=2.048 MHz; Fs=16.67 MHz; 2016/12/23; 02:53:49

1 (blue): Multichannel Tester Data; Channel 1; Samples: 116675; Start: 146500; # "Anthorn" "sample rate 60s" "-

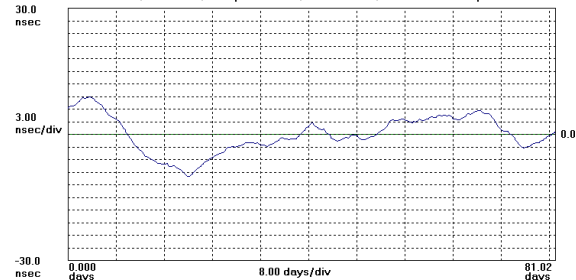


MTIE

Microsemi TimeMonitor Analyzer

Phase deviation in units of time: Fs=16.67 MHz; Fo=2.0480000 MHz; 23-Jun-2016 08:4

Multichannel Tester Data; Channel 3; Samples: 116675; Start: 146500; # "Anthorn" "sample rate 60s" "-CH1-GP



ADEV

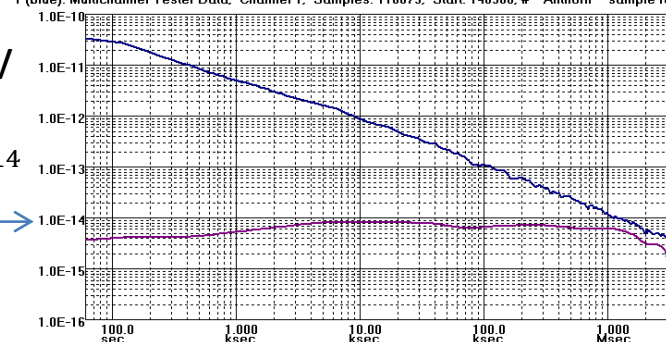
-14

ADEV Below  $1 \times 10^{-14}$

Microsemi TimeMonitor Analyzer

Root Allan Variance: Overlapping Samples; Fo=2.048 MHz; Fs=16.67 MHz; 2016/12/23; 02:53:49

1 (blue): Multichannel Tester Data; Channel 1; Samples: 116675; Start: 146500; # "Anthorn" "sample rate 60s" "-

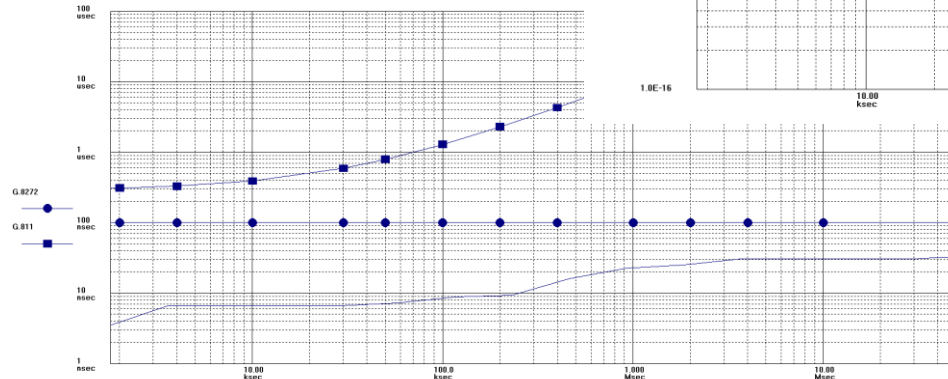


\* Last 60 days only to avoid space weather event in live data

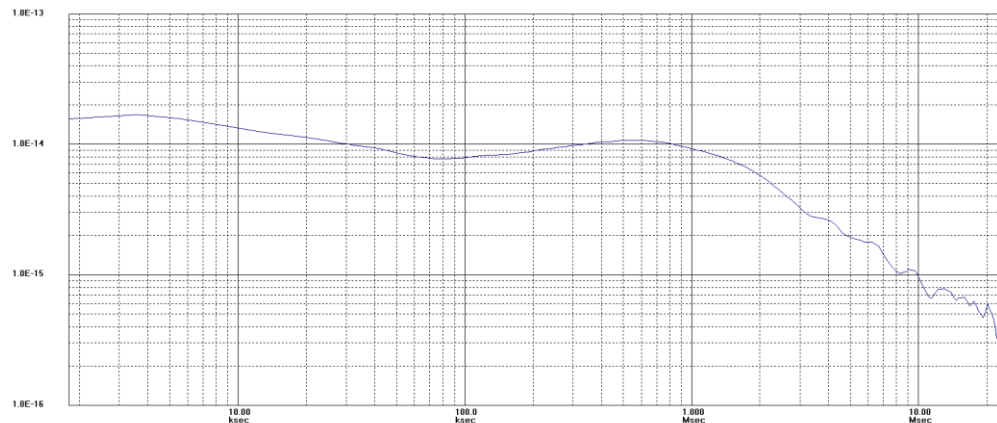
# Real system results (600 days)

- Estimated output
- (GPS DATA has spikes and non availability)

Microsemi TimeMonitor Analyzer  
 MTE: Fo=1.800 Hz; Fp=555.5 MHz; 2017/11/03; 07:27:25  
 Multichannel Tester Data, Channel 3, Samples: 27983, Stop: 27983  
 # "Anthon" "sample rate 60s" "-CH1-GPS 1PPS" "-CH2-Anthon RFS Caesium" "-CH3-Estimated Phase of Caesium out" "-CH4-Caesium 1PPS" "-"



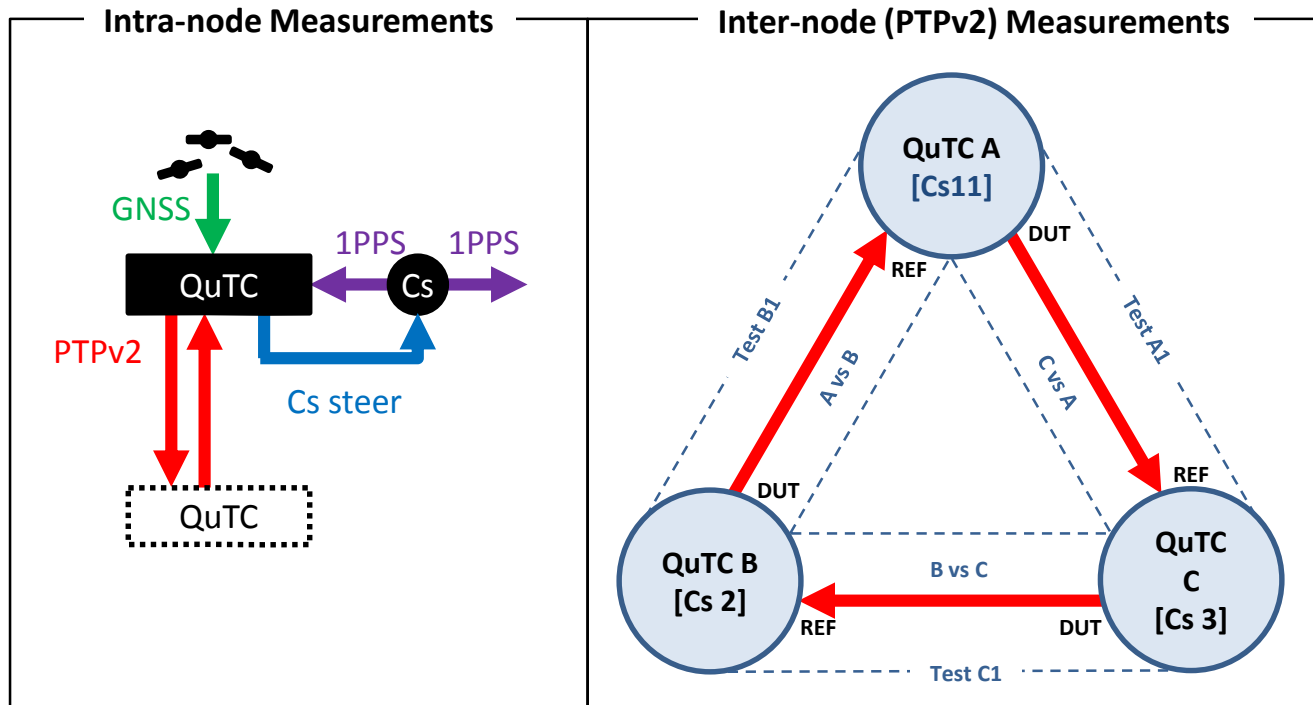
Microsemi TimeMonitor Analyzer  
 Root Allan Variance: Overlapping Samples; Fo=1.800 Hz; Fp=555.5 MHz; 2017/11/03; 07:27:25  
 Multichannel Tester Data, Channel 3, Samples: 27983, Stop: 27983  
 # "Anthon" "sample rate 60s" "-CH1-GPS 1PPS" "-CH2-Anthon RFS Caesium" "-CH3-Estimated Phase of Caesium out" "-CH4-Caesium 1PPS" "-rate-5" "-a"



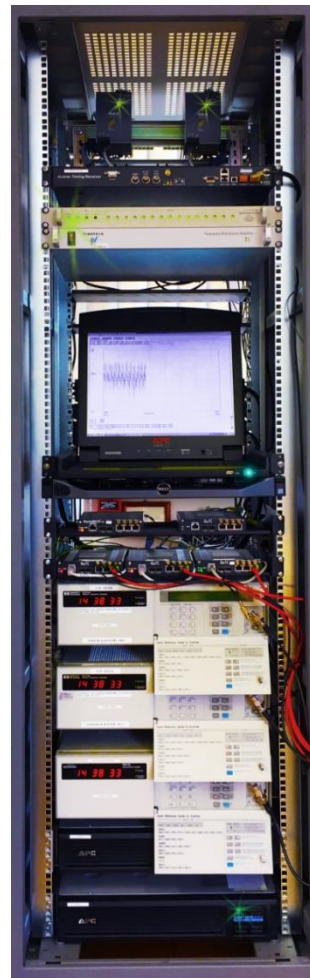
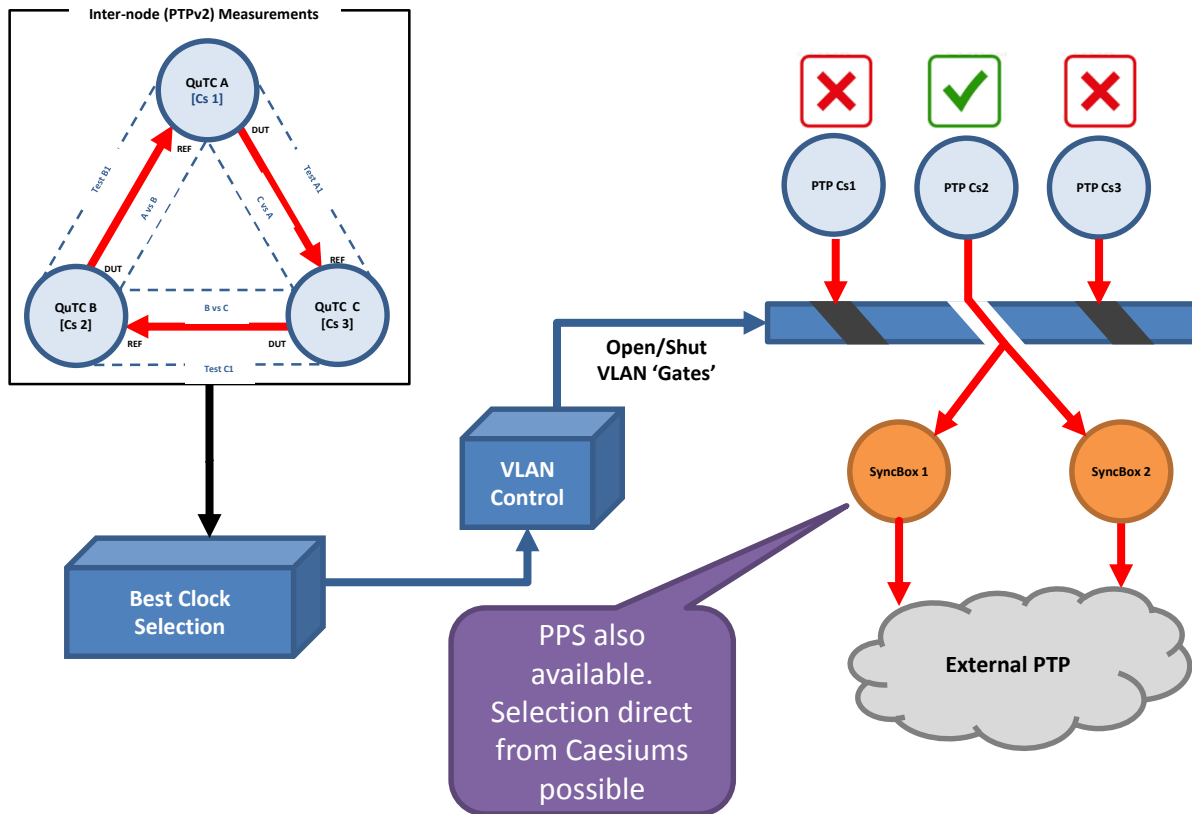
# Confidence

- But is it working?
- The only way to find out is by comparison with a trusted known source of UTC
  - If that is working?
- Or multiple comparison with similar systems.

# Timing Quality Measurements



# Best Clock Selection



# PTP As comparison

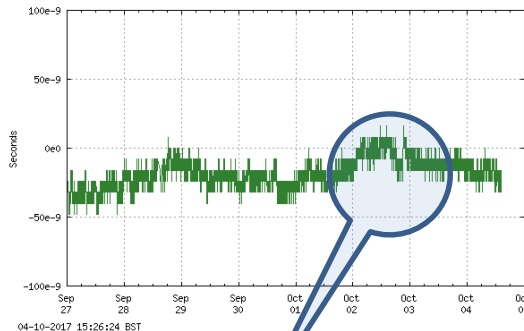
- Noisy
  - Timescales allow sufficient averaging to mitigate
- Allows considerable distance between systems with no compensation required with in LAN
- Could be operated over WAN's
- Could be extended to more than three clocks



# Example

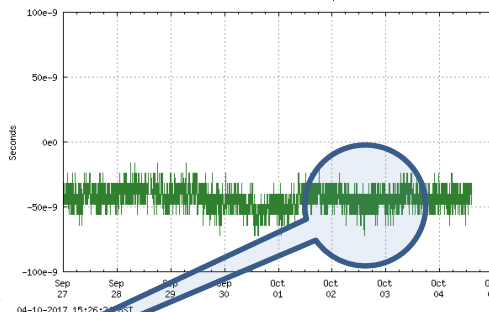
A – B Tie

FEMTO-RHD node A to B tie plot



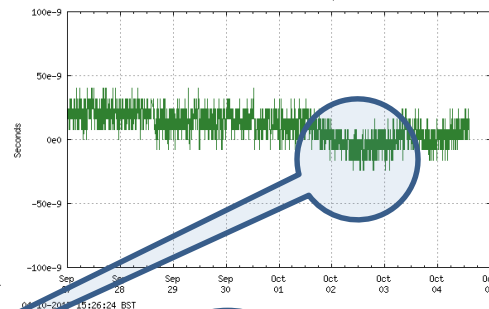
B - C Tie

FEMTO-RHD node B to C tie plot



C - A Tie

FEMTO-RHD node C to A tie plot



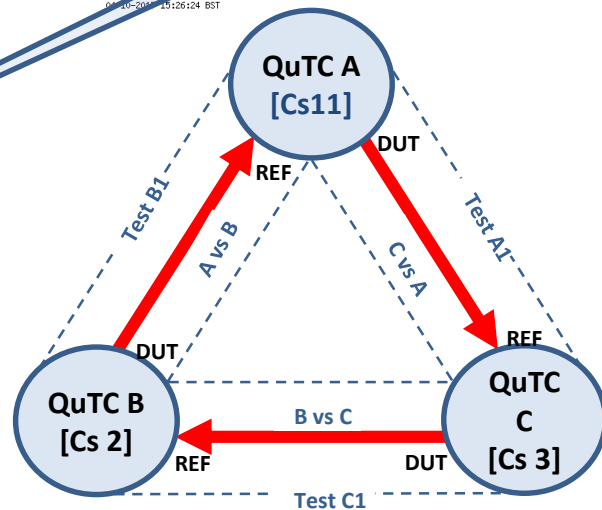
A – B Sees positive hump

B – C Flat

C – A Sees negative hump

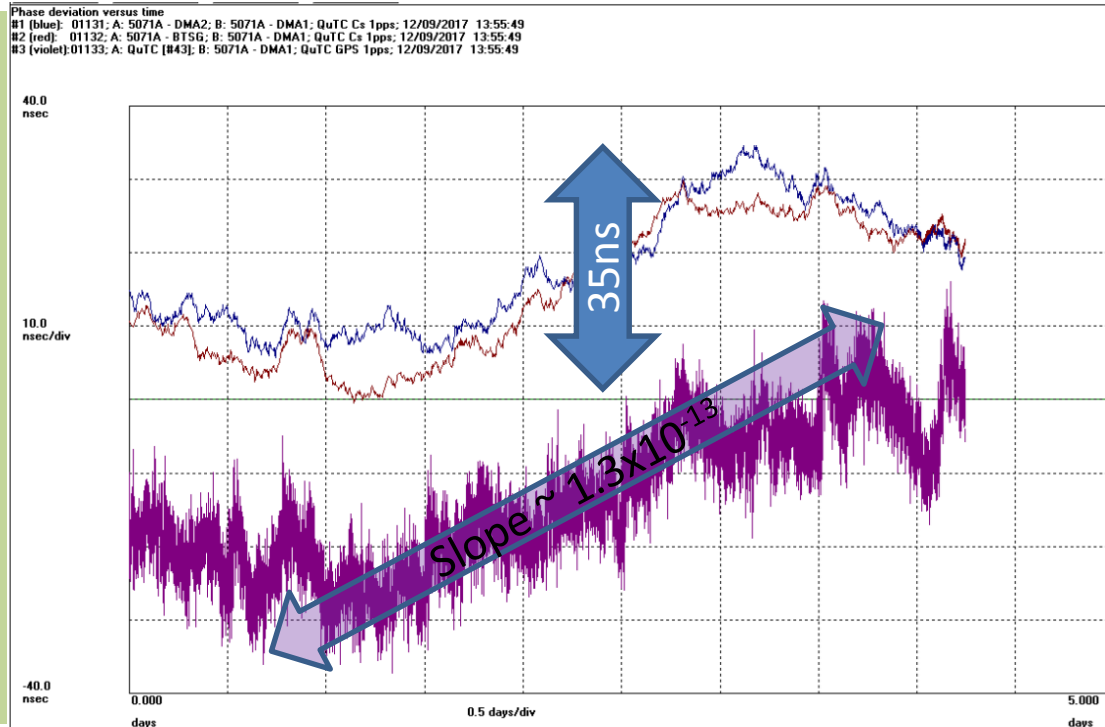
Measurement direction means that the C – A hump is inverted

Therefore Node A has had an excursion



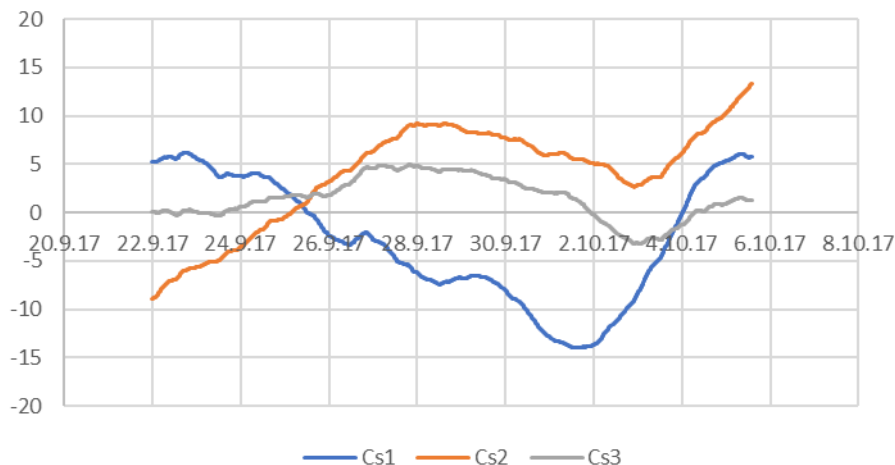
# External timer counter comparison

- Cs 1 is reference
- Shows that the other Caesiums have moved around +30ns
- Also shows that the GPS reference also moved a similar amount
- In reality it is CS 1 that has moved as detected on the previous slide.
- CS 2 & 3 are in close agreement

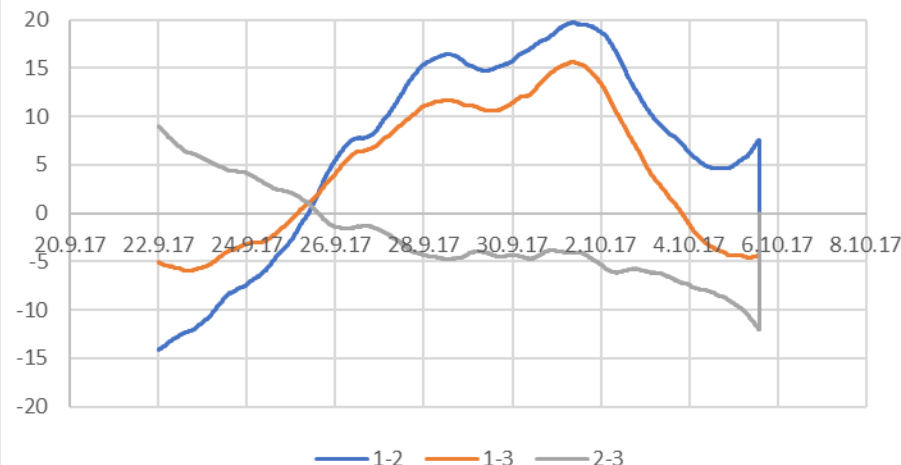


# Self analysis comparison

Caesium control variation

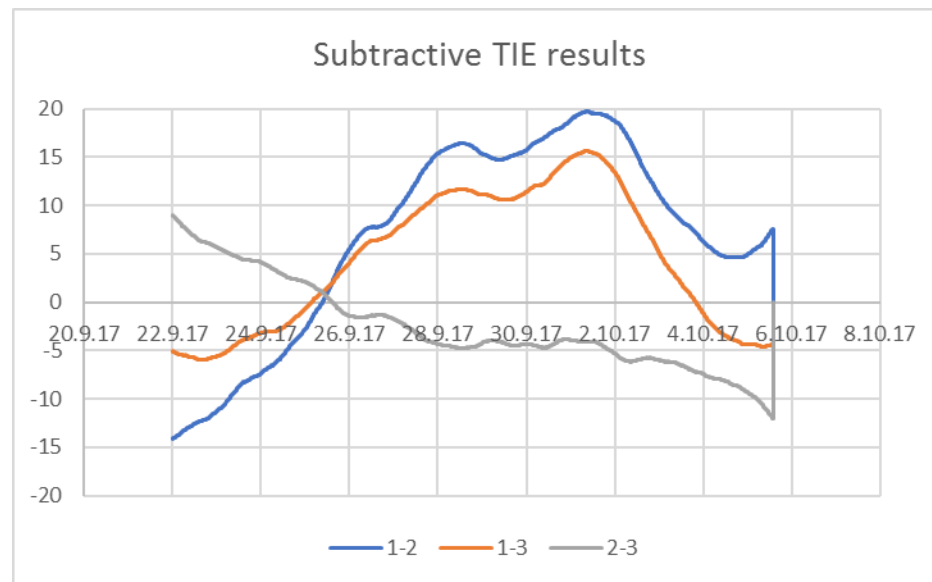


Subtractive TIE results



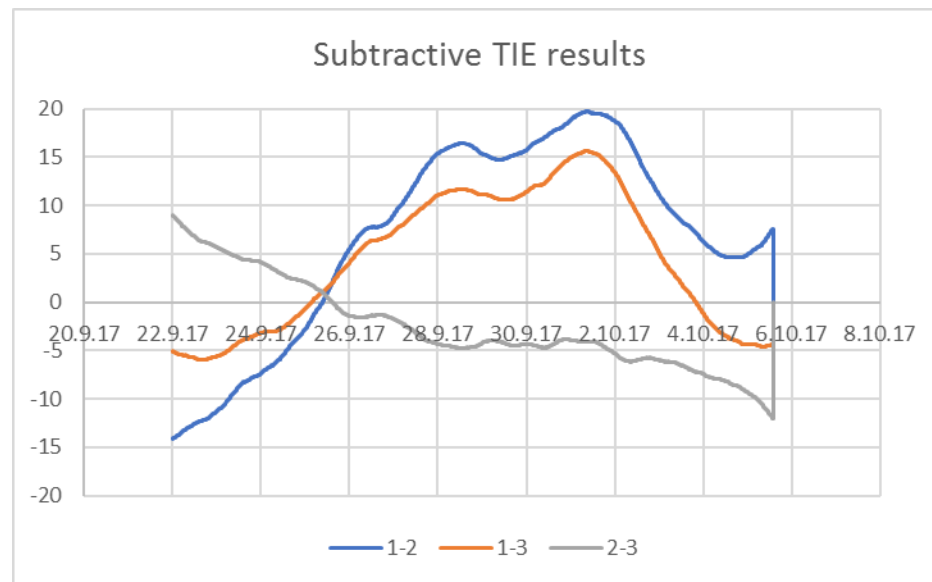
# Self analysis comparison

- Flattest line is the noisiest source and should be demoted/rejected
- Slope of that line is the offset between the two best sources
- From the MTIE of each of these we can infer the quietest of the last two
  - The 10000 second point is a good decision point
- Noise scaling with time.
  - Raise cosine edge
  - Filters odd PTP effects.



# Self analysis comparison

- Able to select “Best” Caesium
- Confidence of results  $\sim 10\text{ns}$



# Dashboard

FEMTO-AAD Dashboard

Summary

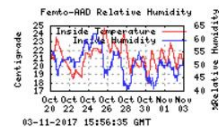
Temp/Pressure

MTIE

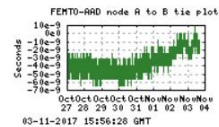
Inter-node TIE ▾



Temperature & humidity



Node A-B TIE Plot



Node A (DMA1 6210-000347)



Output node 1 (6200-000062)

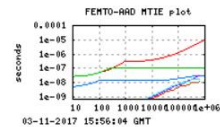


Status: **Good**

Node B (DMA2 6210-000258)

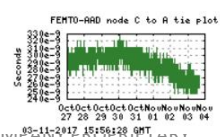


Combined MTIEs

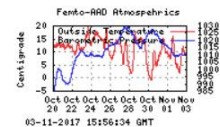


Best clock determined at  
2017-11-03 15:56:31  
is node A DMA1

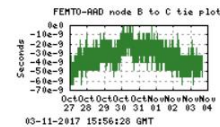
Node C-A TIE Plot



Temperature & pressure



Node B-C TIE Plot



Node C (BTSG 6210-000060)



Output node 2 (6200-000283)



Status: **Good**

# Dashboard

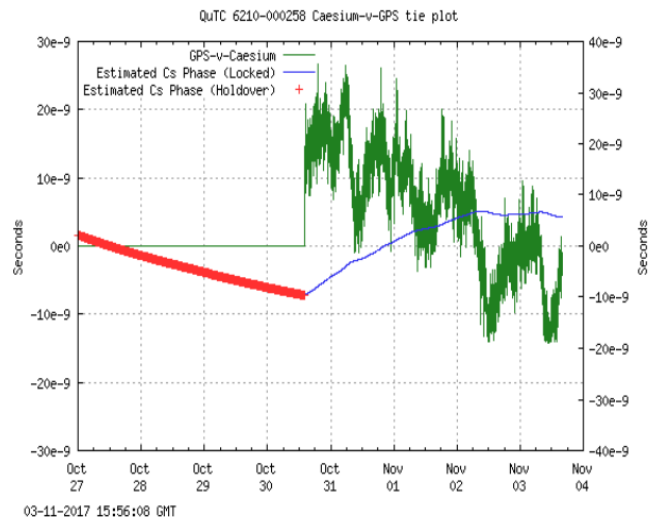
## FEMTO-AAD Dashboard

[Summary](#)[Temp/Pressure](#)[MTIE](#)[Inter-node TIE ▾](#)

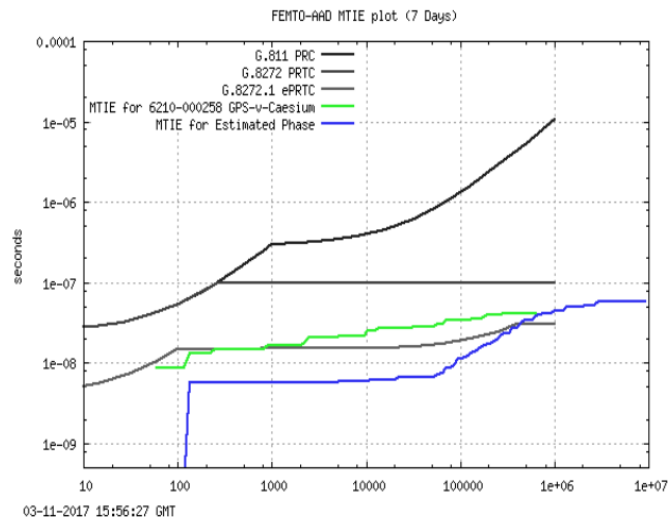
### Node TIE and MTIE

Caesium-v-GPS on 6210-000258

DMA2 TIE plot



DMA2 MTIE plot



# Comparison of UTC(k's)

NPL - London

USNO - Washington

NIST - Boulder

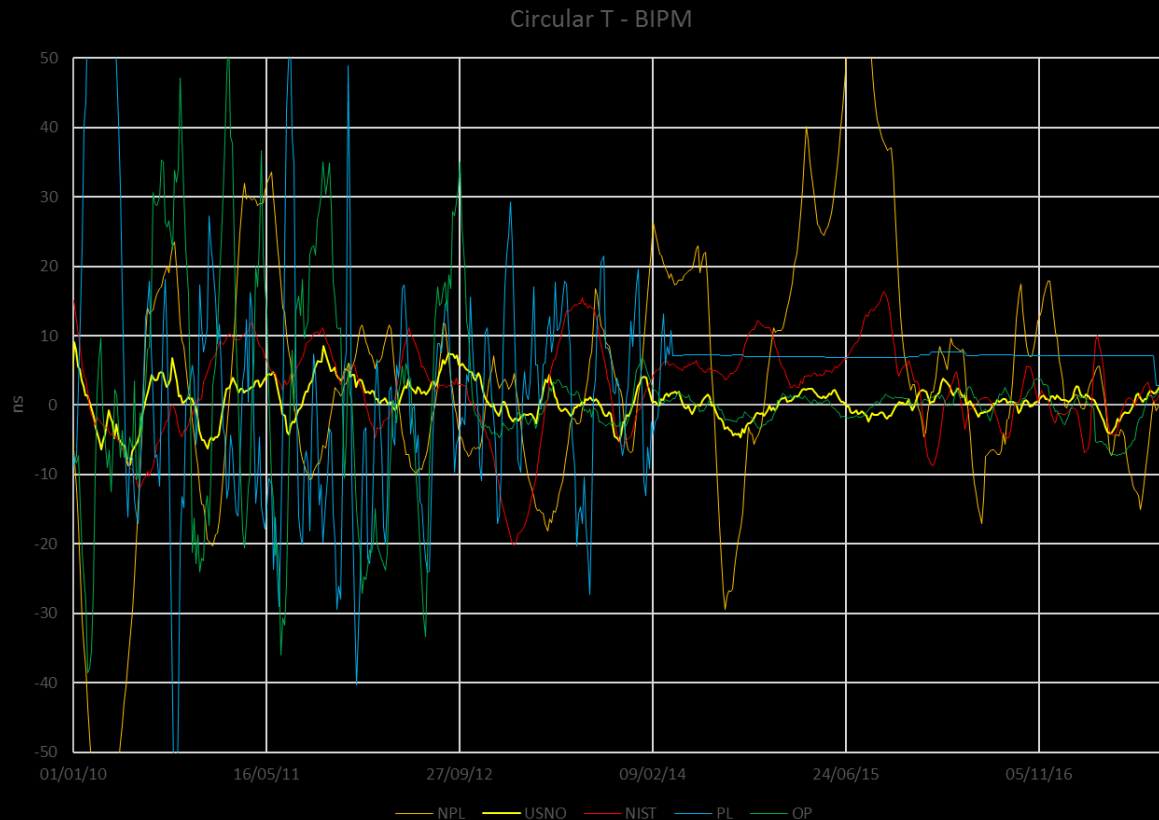
PL - Warsaw

OP – Paris

1 point every 5 days

Data from BIPM

Circular T





# Selection criteria

Individual Caesium	System
Source/GNSS good? (Holdover or Lock)	Reported Caesium Health
General health (System values in range)	Caesium visibility
Monitoring Caesium corrections	Direct comparison
Time since last state change	Data Age
Age of device (New better than old?)	
Manufactures performance data	

# Conclusions

- Can achieve  $\sim 10\text{ns}$  to  $\text{UTC}_{(k)}$
- Uncertainty can be determined
- Multiple sources can be used
  - Do not have to be GNSS
- All fits in a single rack or can be distributed
- Low cost (relatively)
- Managed
- Allows/Simplifies maintenance/downtime (per clock)





# Thankyou

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