Operational Selection of the healthiest (e)PRTC precision clocks

Anthony Flavin, MIET

Chronos Technology Ltd

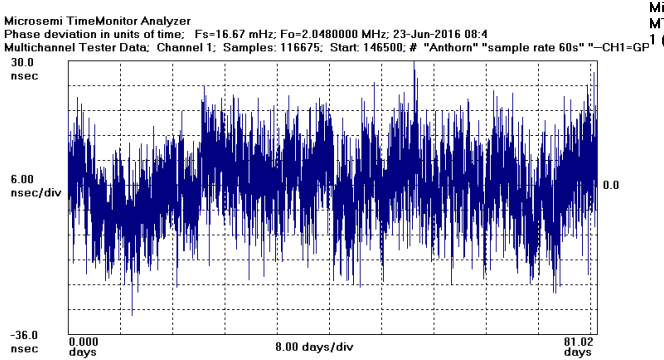
ITSF, Prague, November 8th 2016 – Sources of Time part II

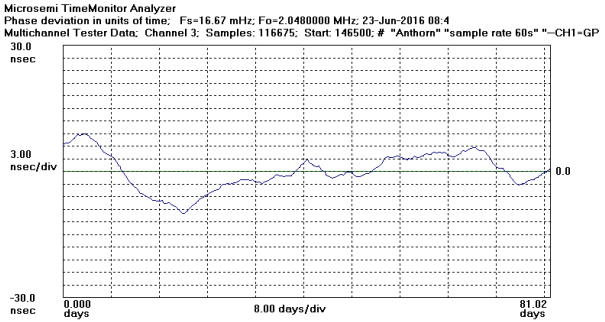
ITSF Last year :-

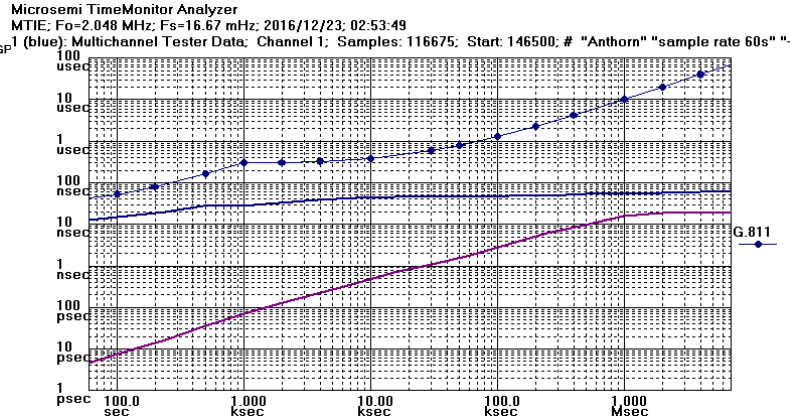
- Presented “Improved” 5071A
  - Added GNSS Steering
    - Ultra-long Time-constant
    - Maximum possible noise filtering
    - GNSS monitoring with auto switch to holdover.

- Any Caesium or better could be used.

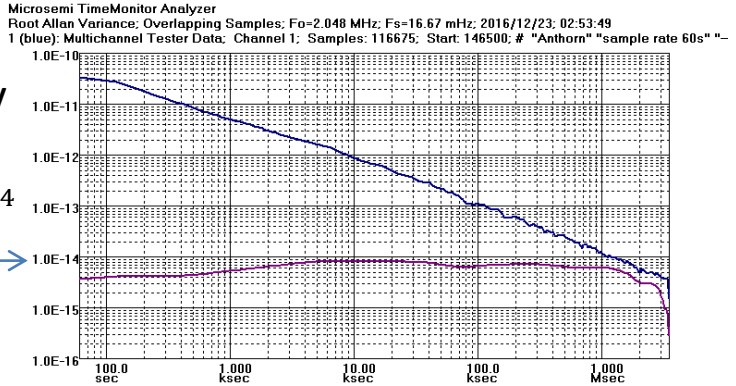
Real system results (60 days*)







MTIE



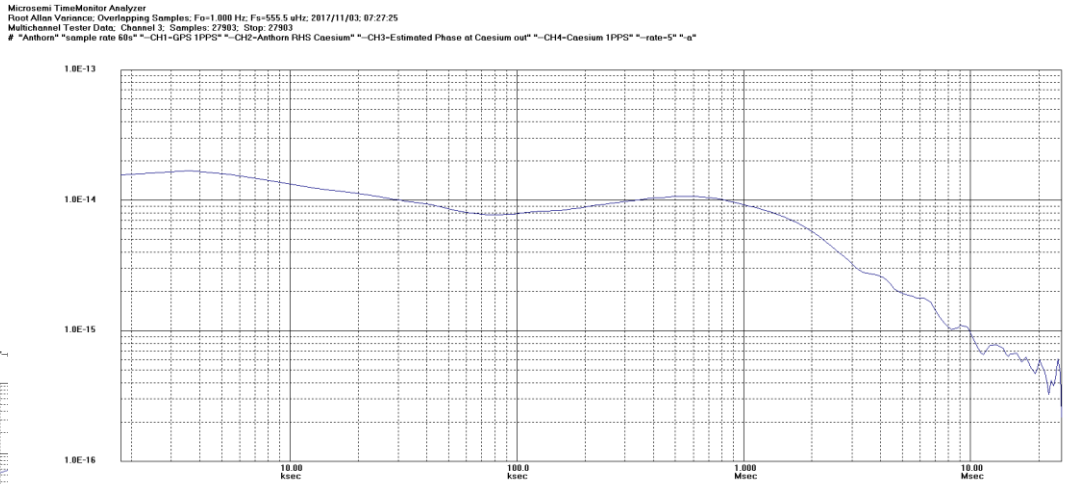
ADEV

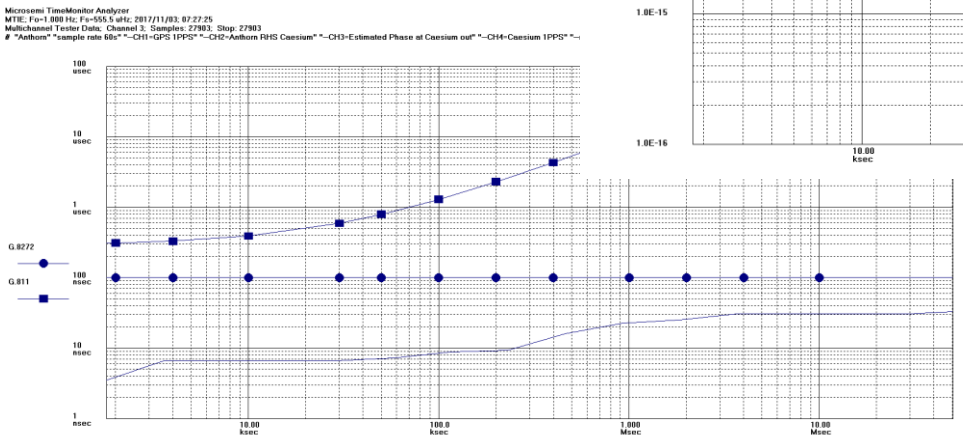
ADEV Below $1 * 10^{-14}$

* 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

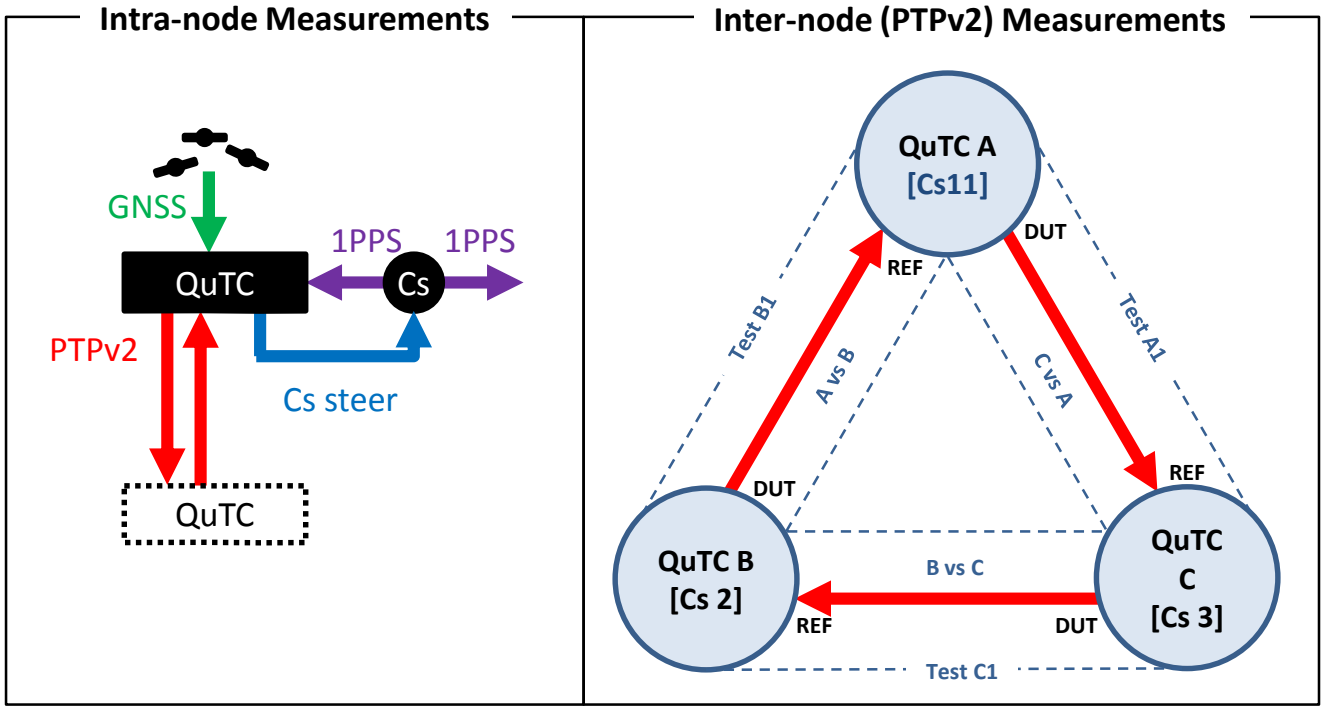




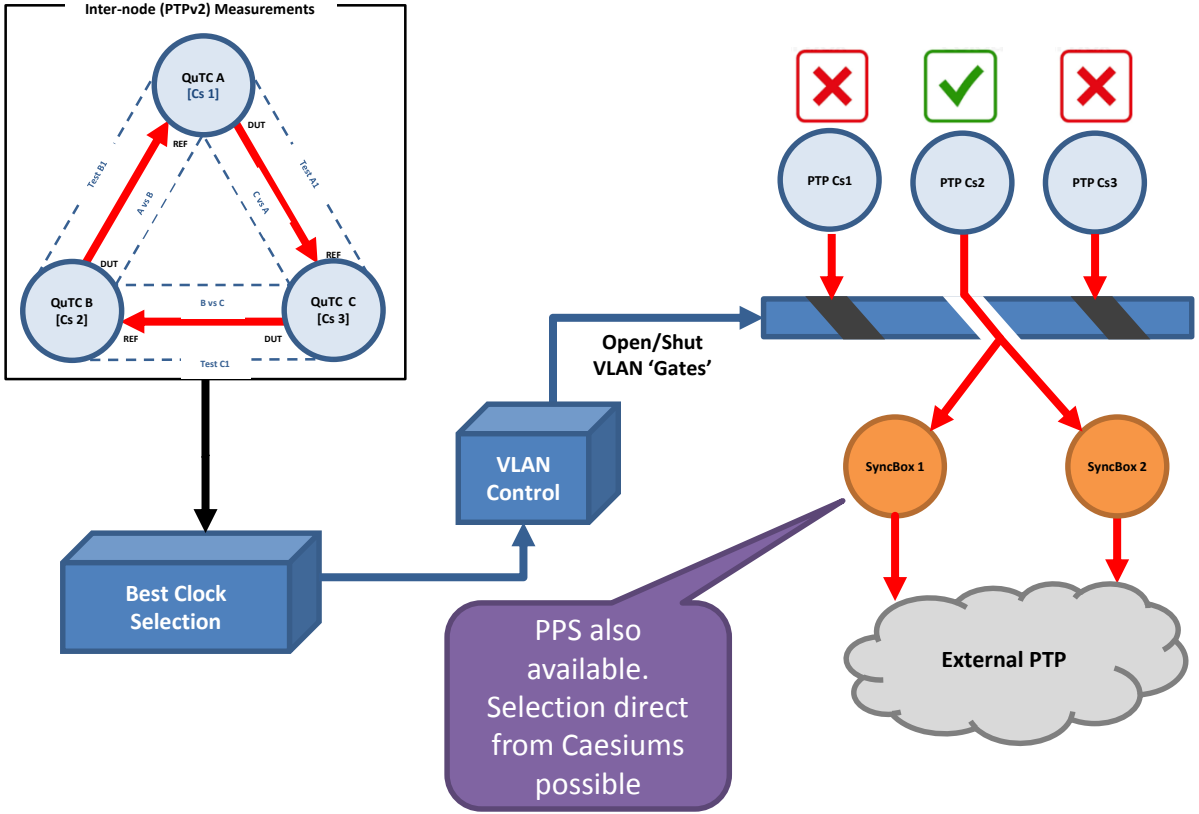
Confidence

- 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

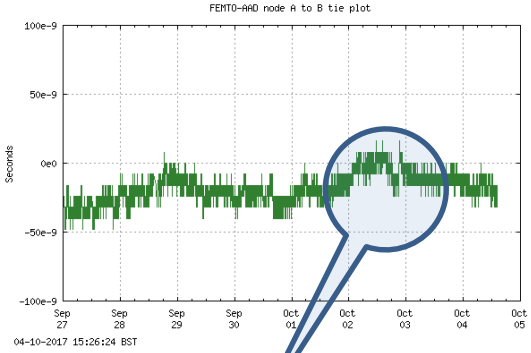


PTP As comparison

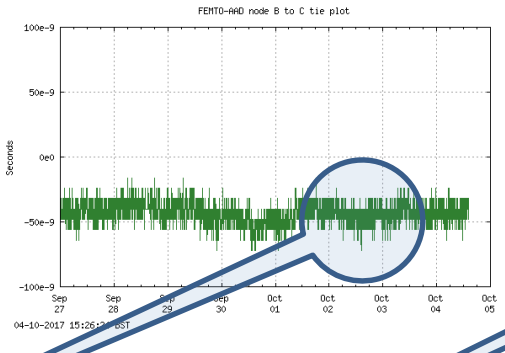
- Noisy
  - Timescales allow sufficient averaging to mitigate
- Allows considerable distance between systems with no compensation required with in LAN
- Could be operated over WAN’s
- Could be extended to more than three clocks

Example

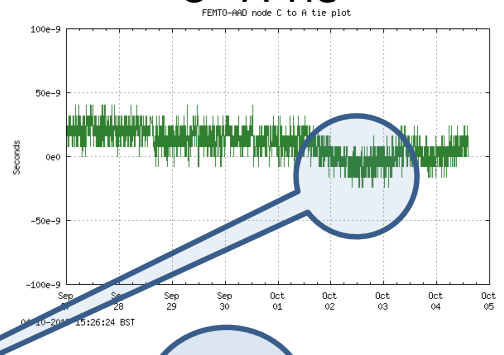
A – B Tie



B - C Tie



C - A Tie



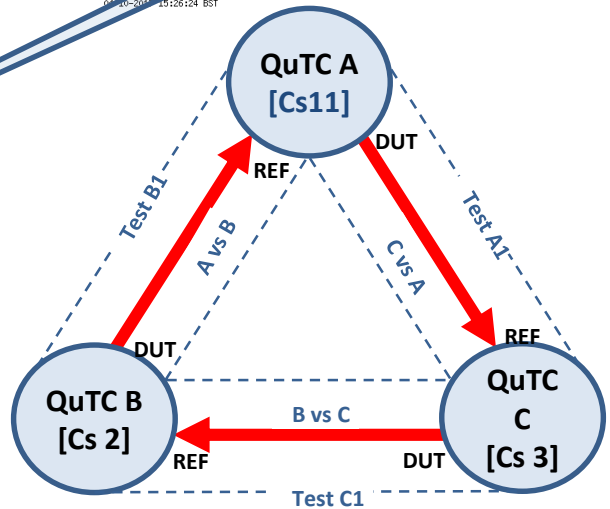
A – B Sees positive hump

B – C Flat

C – A Sees negative hump

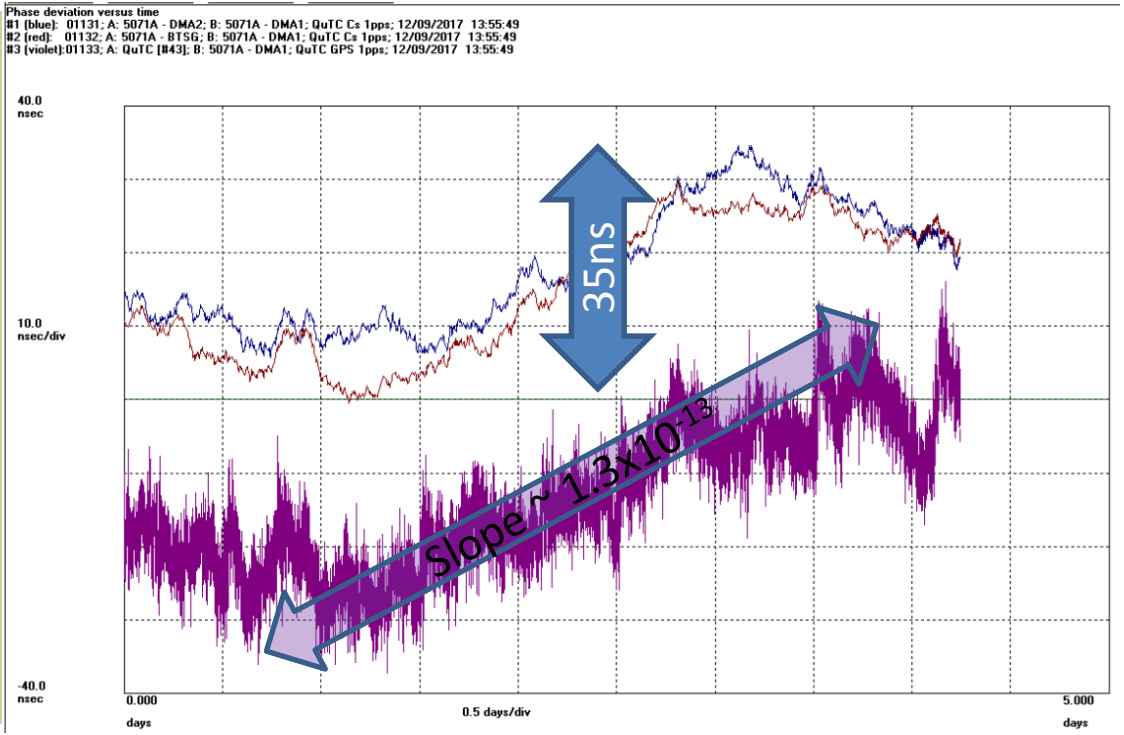
Measurement direction means that the C – A hump is inverted

Therefore Node A has had an excursion

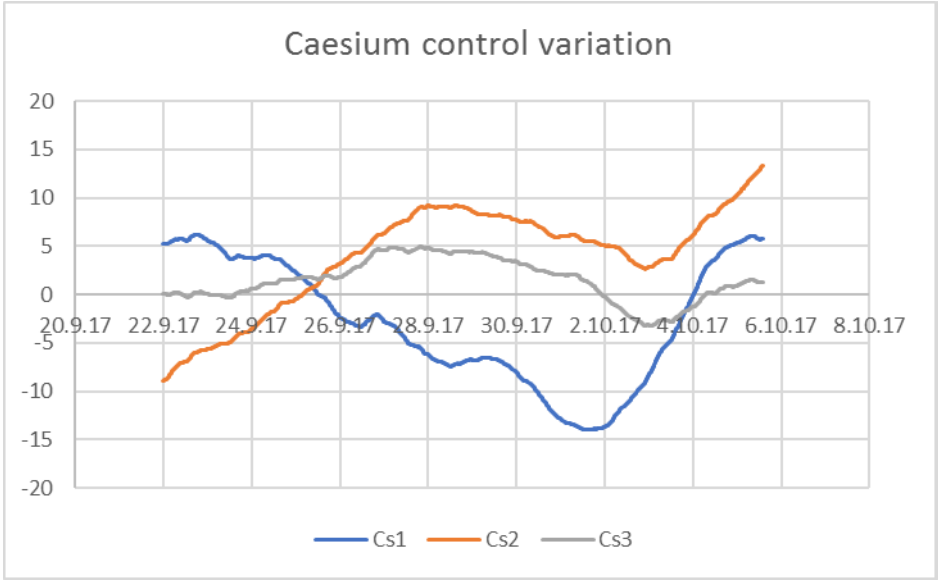


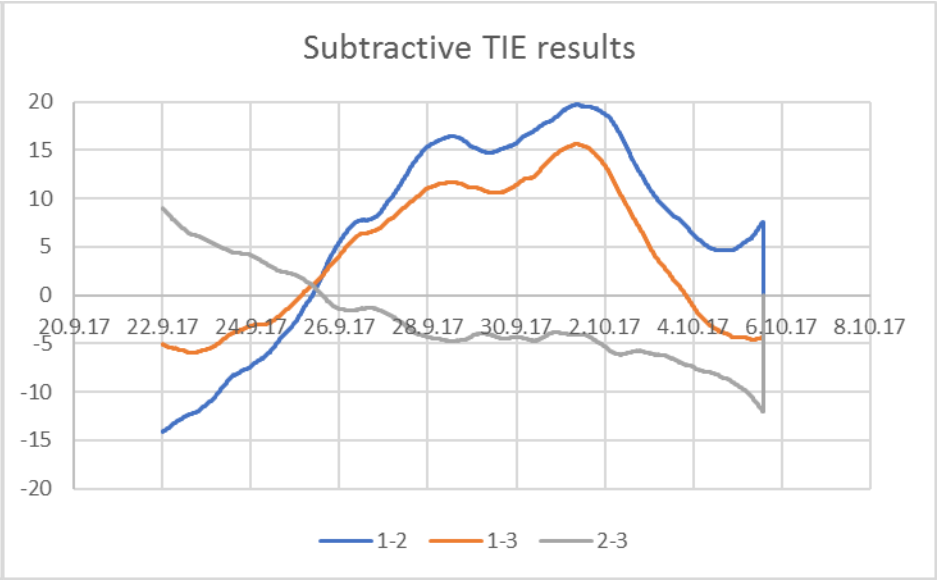
External timer counter comparison

- 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



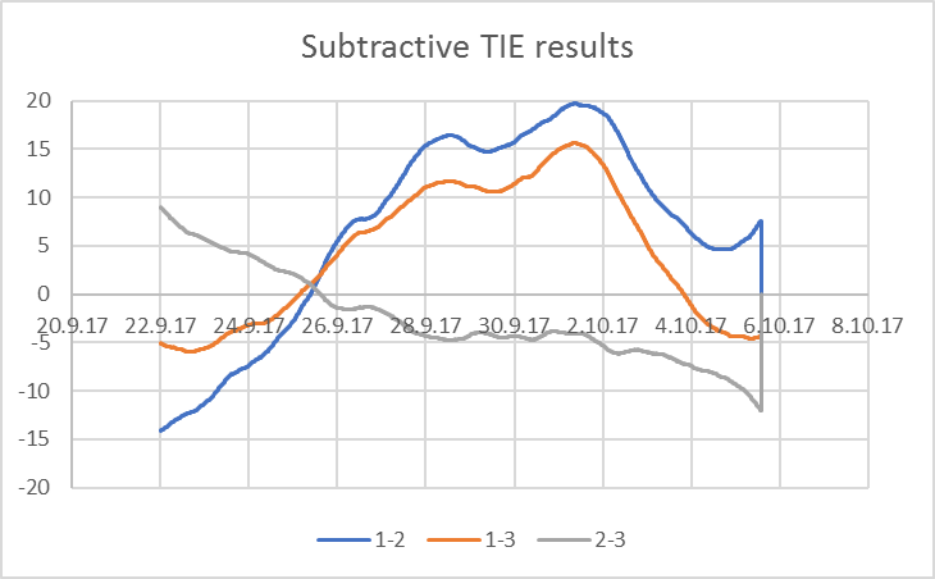
Self analysis comparison





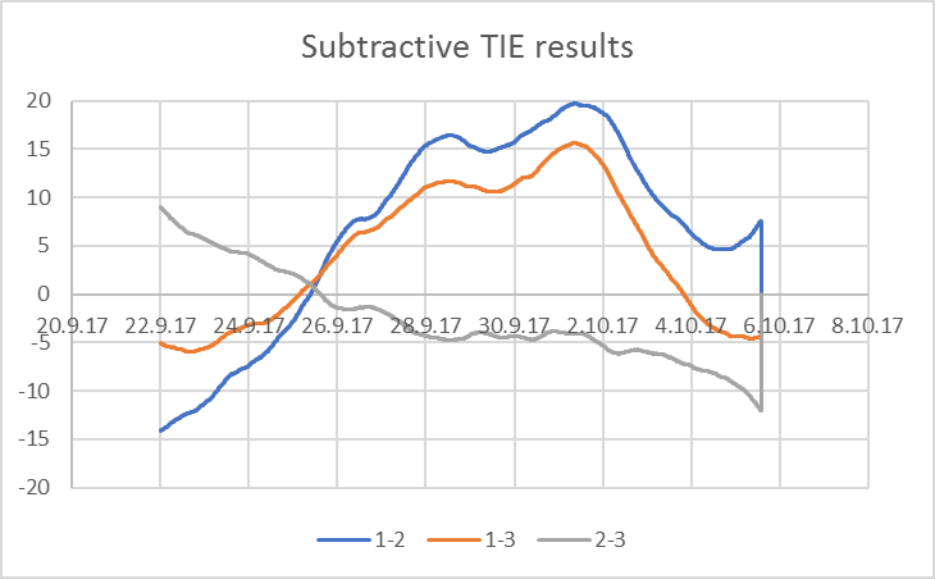
Self analysis comparison

- 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 ~10ns



Dashboard

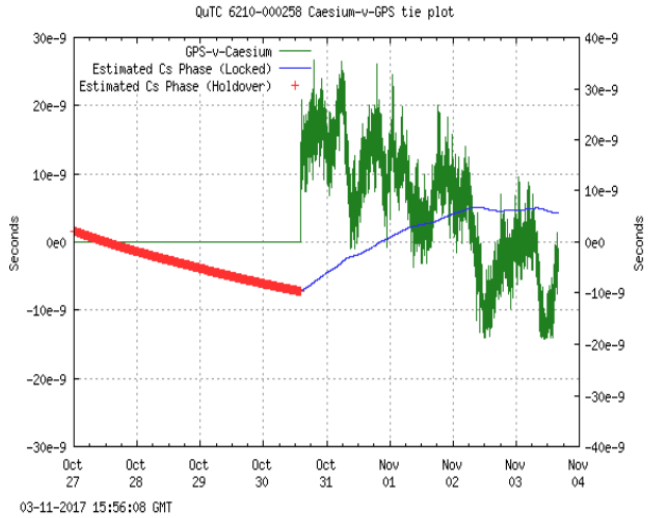
Dashboard

FEMTO-AAD Dashboard | Summary | Temp/Pressure | MTIE | Inter-node TIE

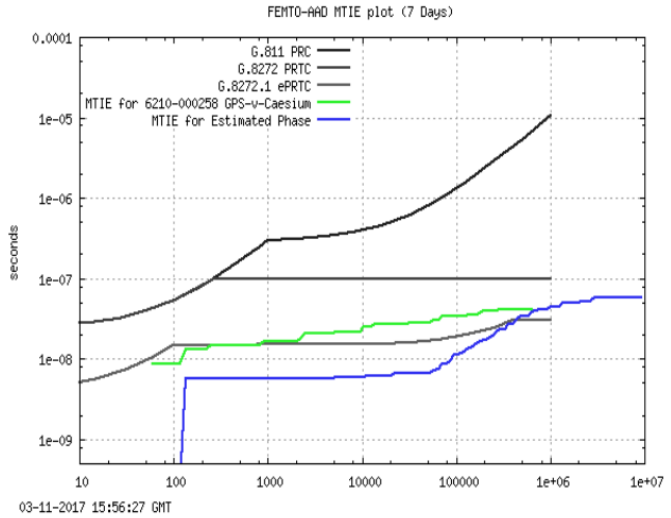
Node TIE and MTIE

Caesium-v-GPS on 6210-000258

DMA2 TIE plot



DMA2 MTIE plot



Comparison of UTC(k's)

NPL - London

USNO - Washington

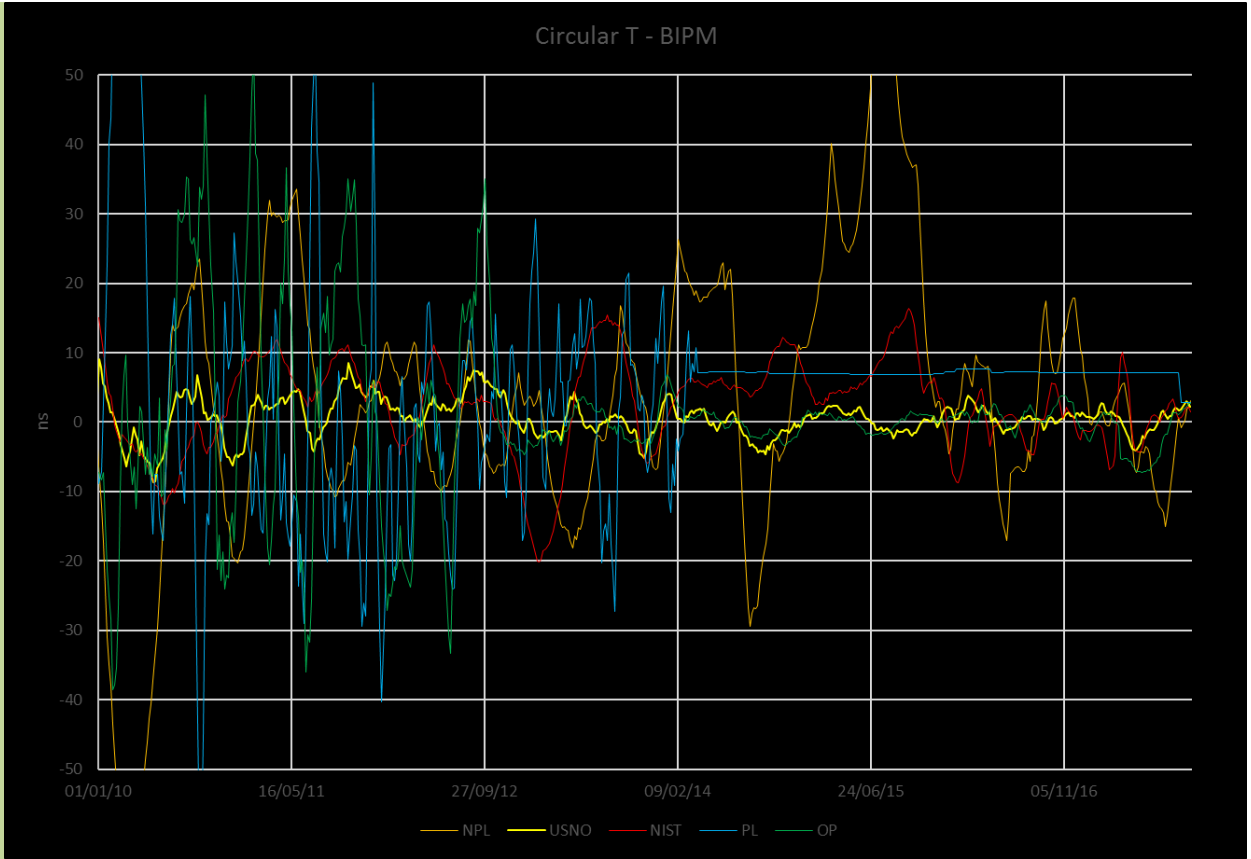
NIST - Boulder

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 ~ 10ns to $UTC_{(k)}$
- 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

http://www.chronos.co.uk/
tony.flavin@chronos.co.uk