Sylvère Froidevaux

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About Us

Founded in 2006 in Neuchatel, Switzerland, T4Science is a leading designer and manufacturer of a full range of advanced, cost-effective and high-performance maser clock solutions. Its products are used in a wide variety of scientific applications and in the time and frequency industry.

Products

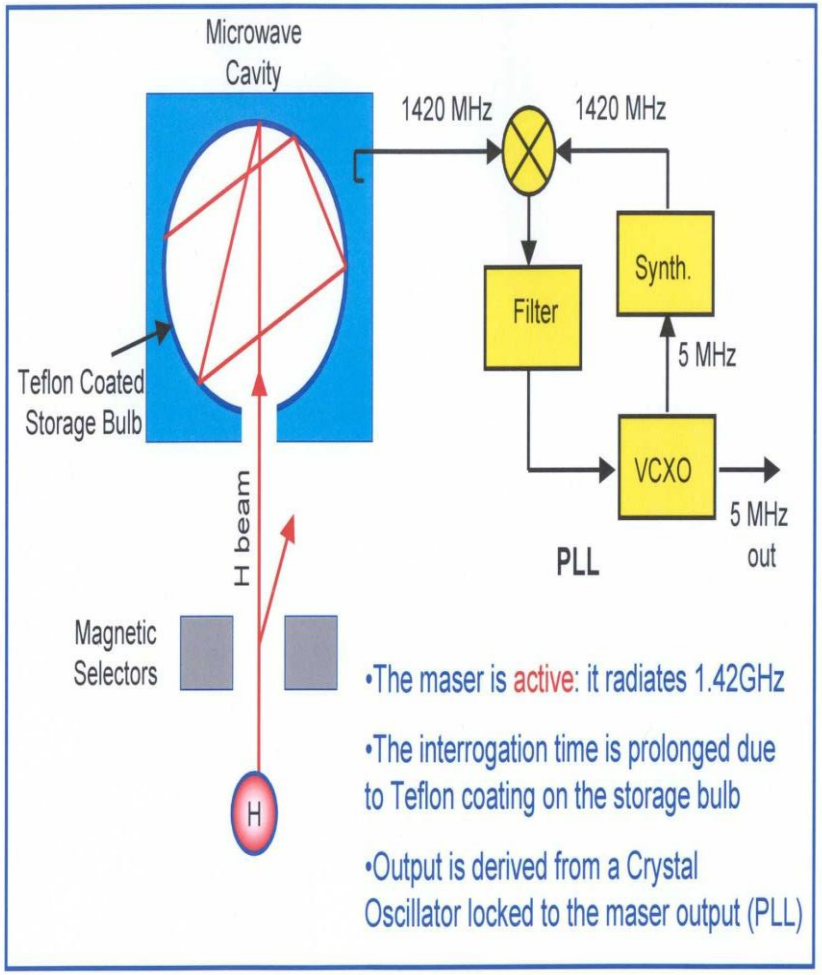
The iMaser™ is a high-performance, compact Active Hydrogen MASER. It features advanced phase noise and short term stability for high-precision Frequency & timing applications like VLBI, Deep space tracking, National Timing/Frequency Station, Navigation…
Passive hydrogen maser offers long term reference with excellent stability and price.

Services

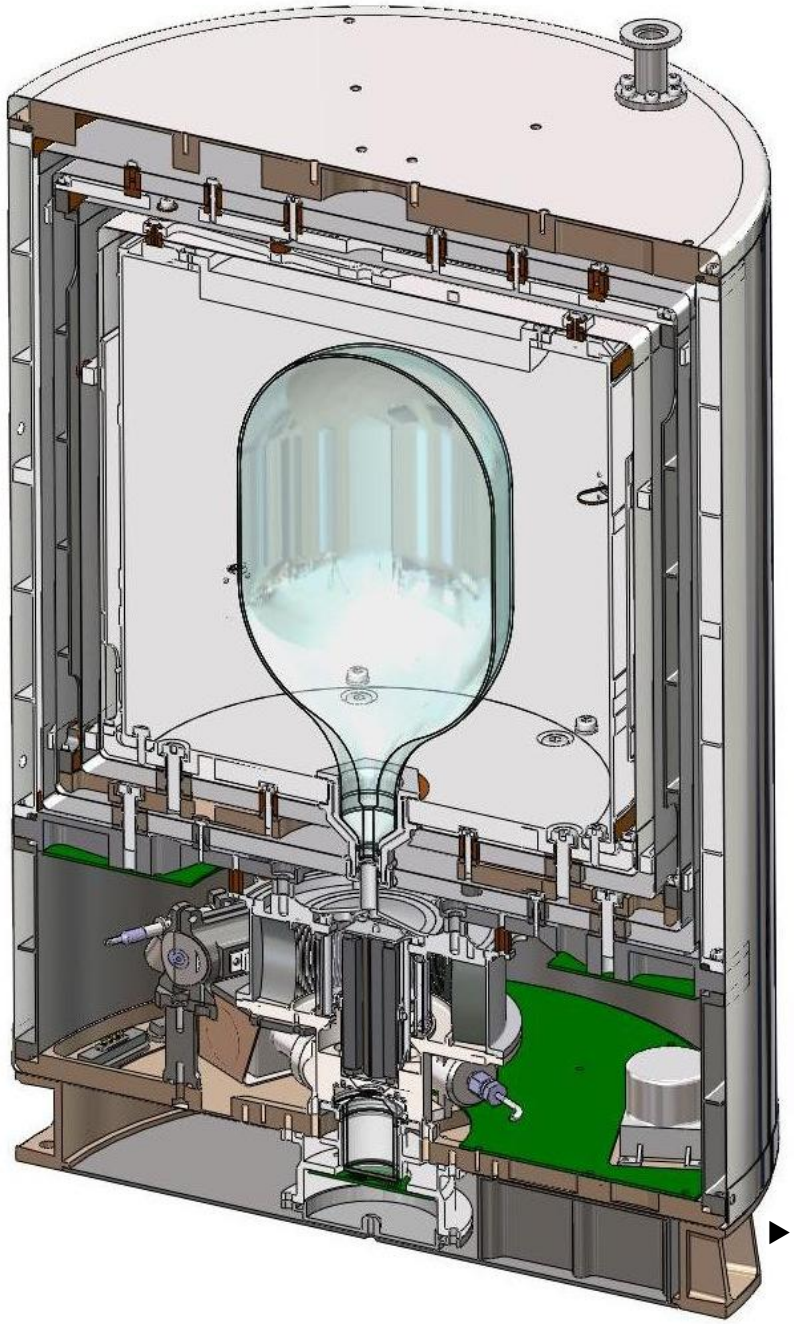
We offer a complete set of first-class services over the product lifecycle for total customer satisfaction. These services, include : Supply & Installation, Training, Remote & On-Site Maintenance and On-Site Support

Hydrogen Maser principle

- MASER
  - **M**icrowave **A**mplification by **S**timulated **E**mission of **R**adiation
  - Oscillator based on quantum transitions of Hydrogen atoms
- High atomic quality factor
  - (> 10^9)
- Cavity factor
  - Qcav > 30000 Active
  - Qcav < 30000 Passive



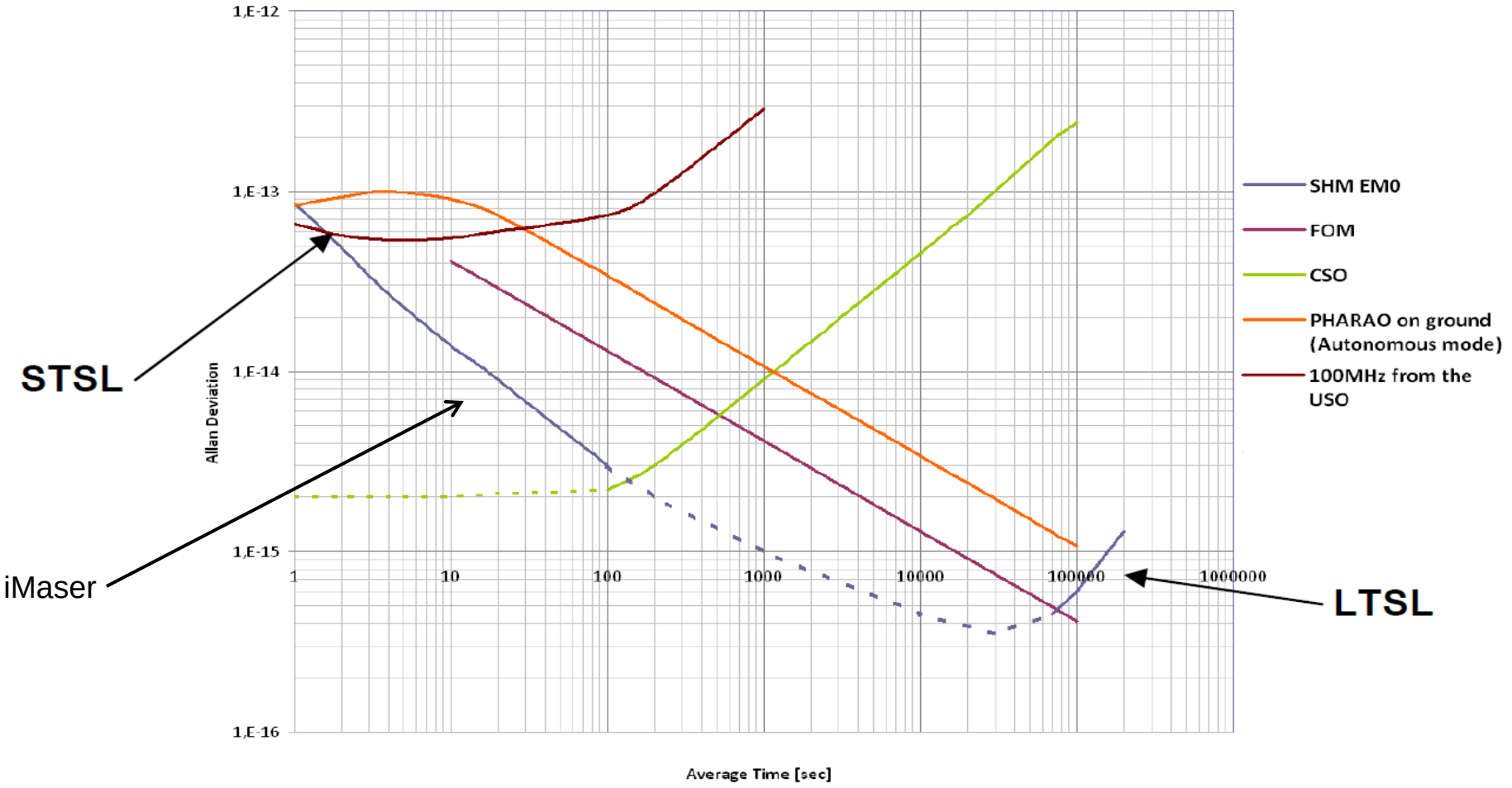
Physique Package



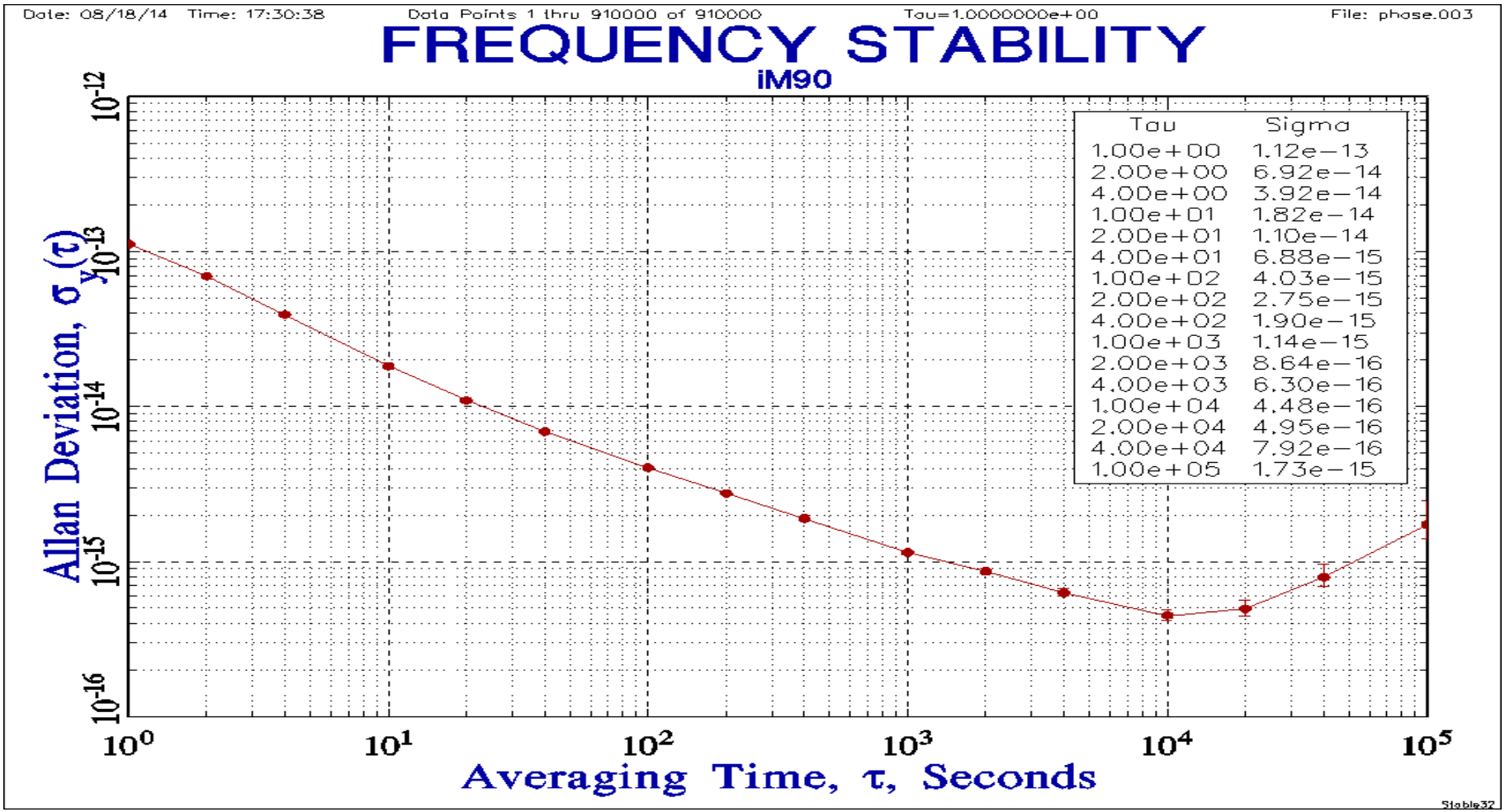
Application

- VLBI
- Deep space tracking
  - (ESA)
- Navigation
  - European Galileo, Indian and Chiniese
- Timing/Frequency Station
  - National (CH / Cn /Tw)
- Space
  - ACES on ISS
- Electronic
  - SLR / Radar

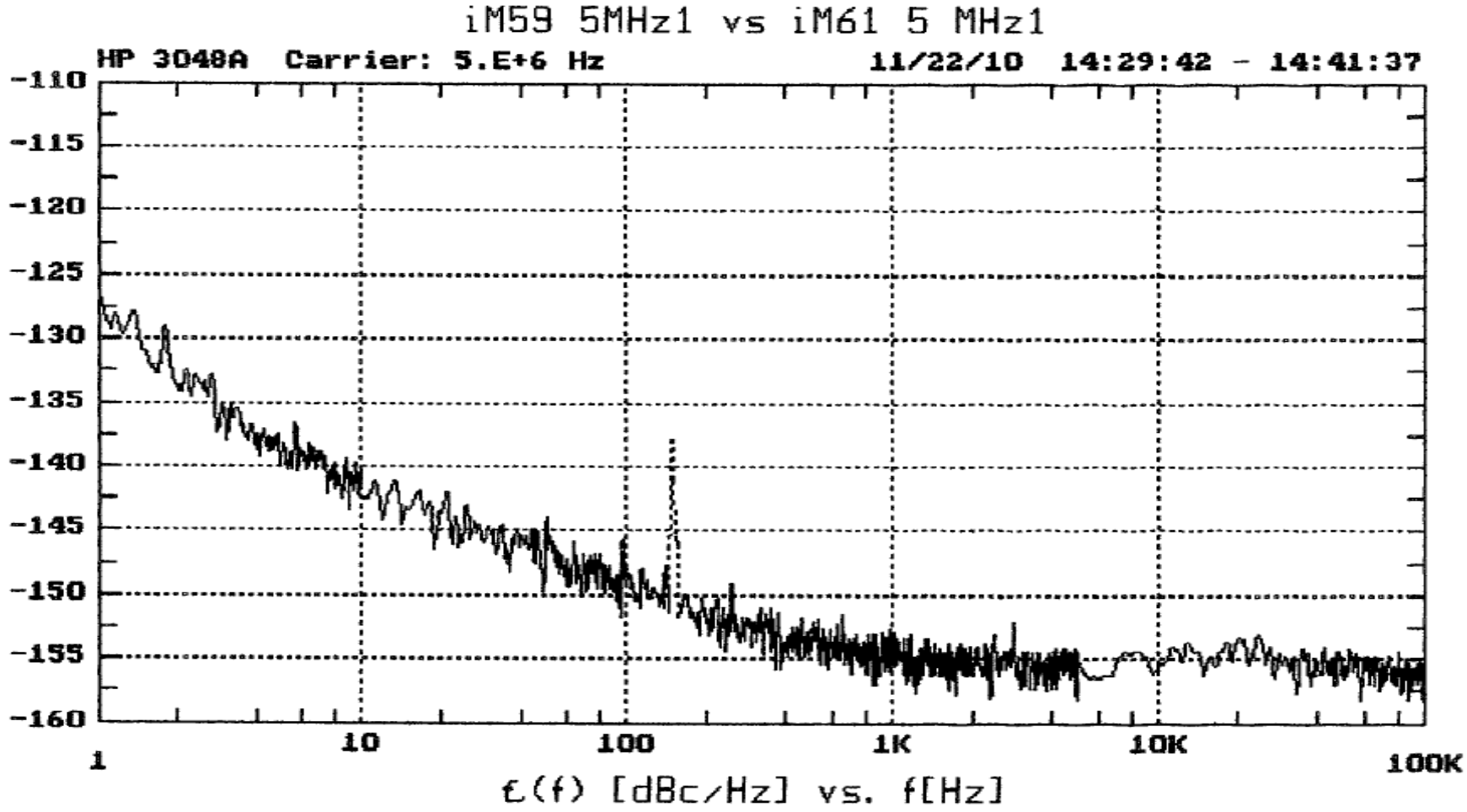
iMaser vs other clocks (EFTF 2010)



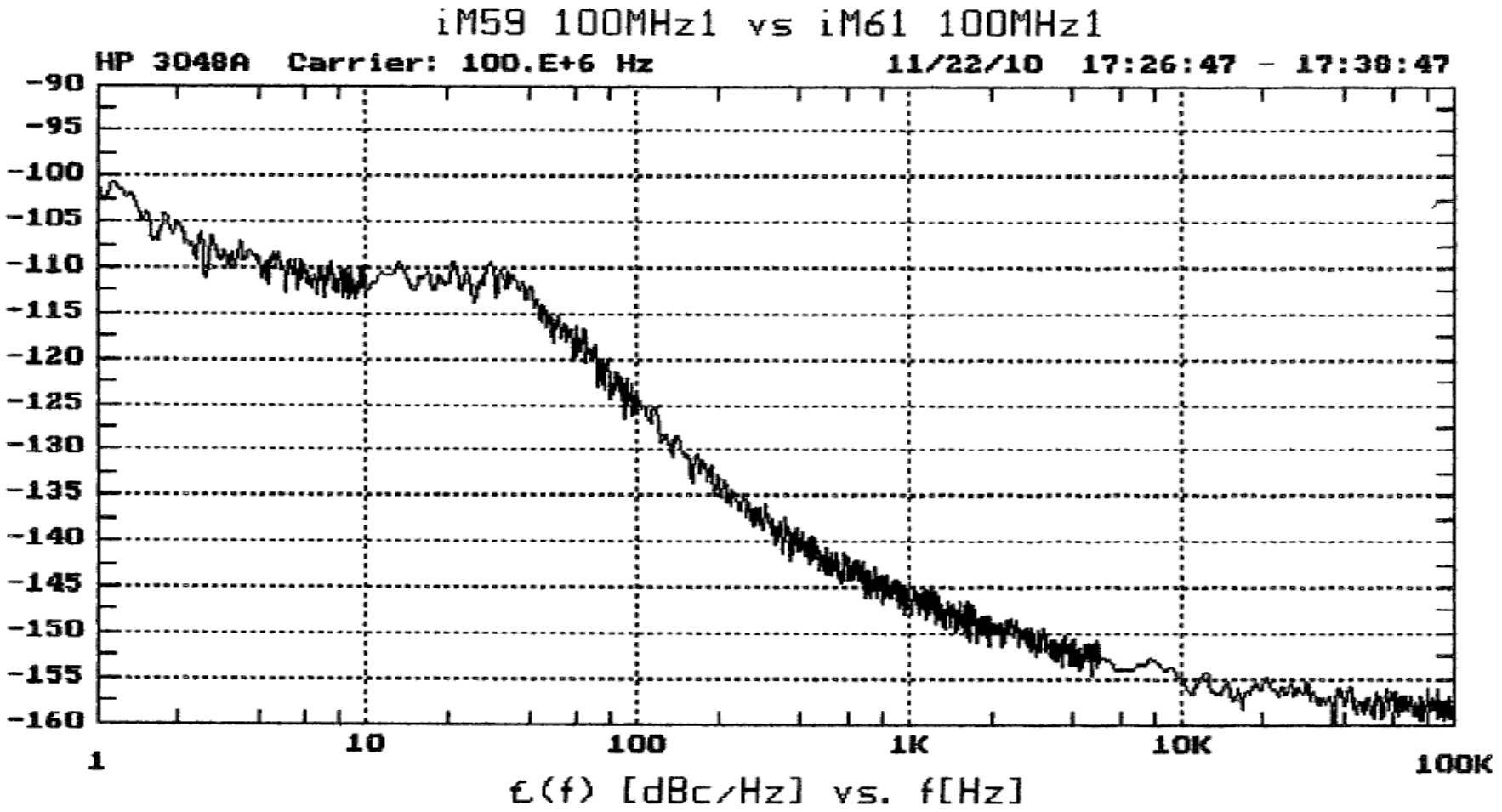
Typical Performance raw data between 2 masers (no compensation)



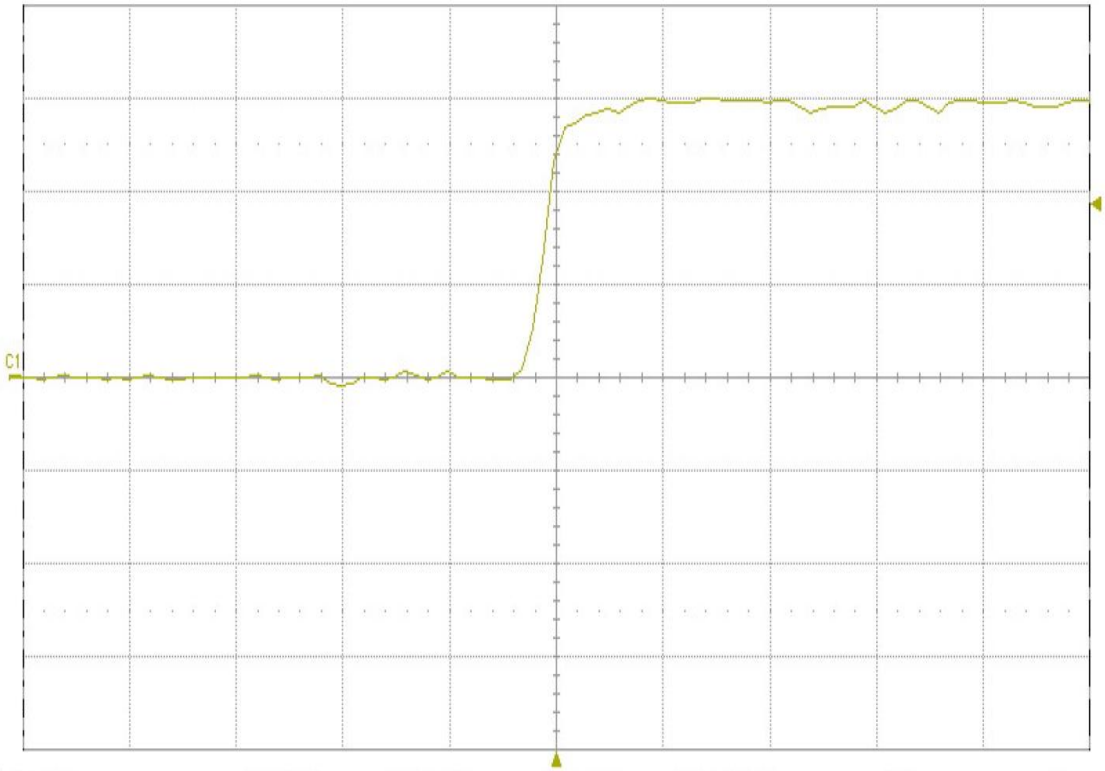
Typical Phase noise 5MHz 1Hz -100kHz (raw data)



Typical Phase noise 100 MHz (raw data)



Typical 1 PPS output



Measure	P1:min(C1)	P2:max(C1)	P3:pkpk(C1)	P4:rise2080(C1)	P5:- - -	P6:- - -
value	-94 mV	3.00 V	3.09 V	1.033 ns		
mean	-67.7 mV	3.0078 V	3.0755 V	1.00962 ns		
min	-94 mV	3.00 V	3.06 V	931 ps		
max	-63 mV	3.03 V	3.13 V	1.105 ns		
sdev	11.6 mV	13.5 mV	20.0 mV	41.41 ps		

- Based on local USO
- Fast Rise time:<350ps/V
- Small Jitter : about 20ps
- User adjustable
- External calibration

Environment & sensitivity

- Environmental parameters influence stability:
- Significant effects:
  - Thermal (PP & EP)
    - $<5 \cdot 10^{-15}/K$
  - Vibration (OCXO, cables…)
    - $5 \cdot 10^{-10}/g$; For vibration < 1Hz
  - Magnetic (PP)
    - $1 \cdot 10^{-14}/G$ (on Z axis)

Environment & sensitivity

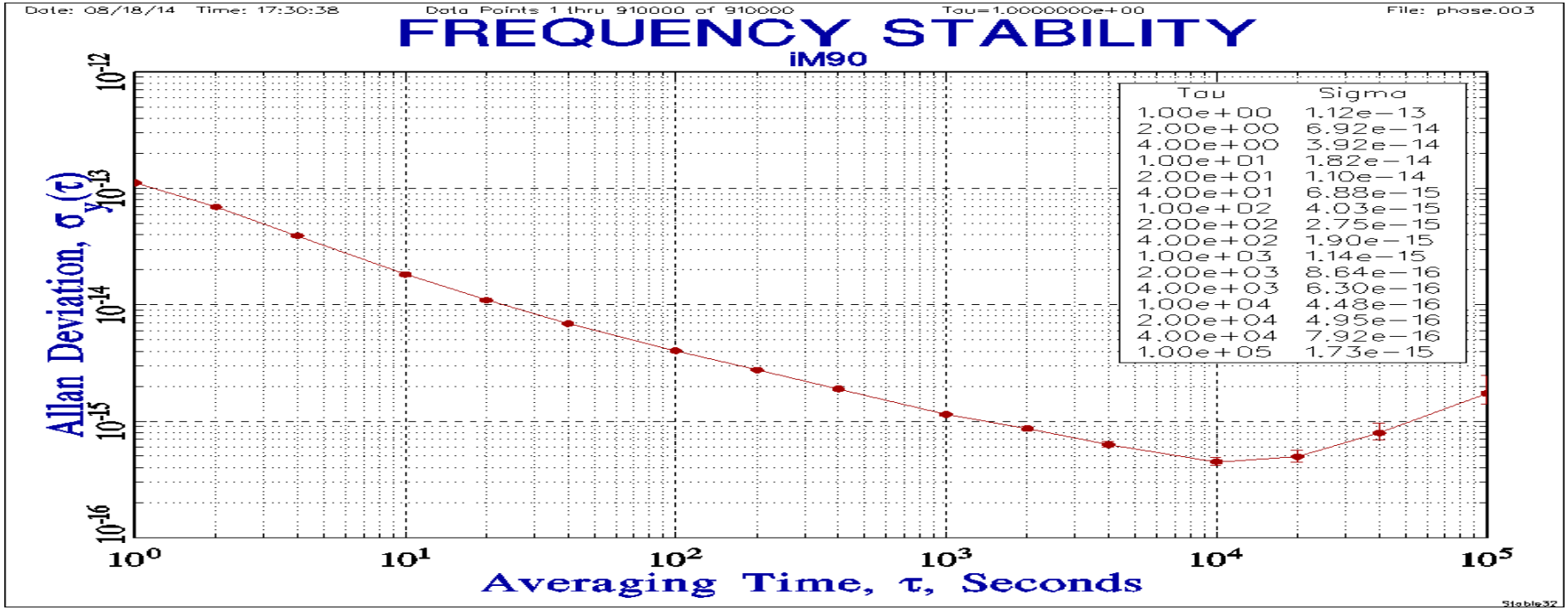
- Other effects (less significant):
  - Power supply
  - Pressure / altitude
  - Humidity

Actions for better measurement

- Thermal / magnetic / vibration
- Goal:
  - Stable temperature
  - Very low change speed
- Recommended
  - specific thermal room with heavy mass and closed door
  - Heater cooler box with active liquid regulation Pelletier elements
    - Higher mass ()
    - Longer Time constant → up to 10x less sensitive

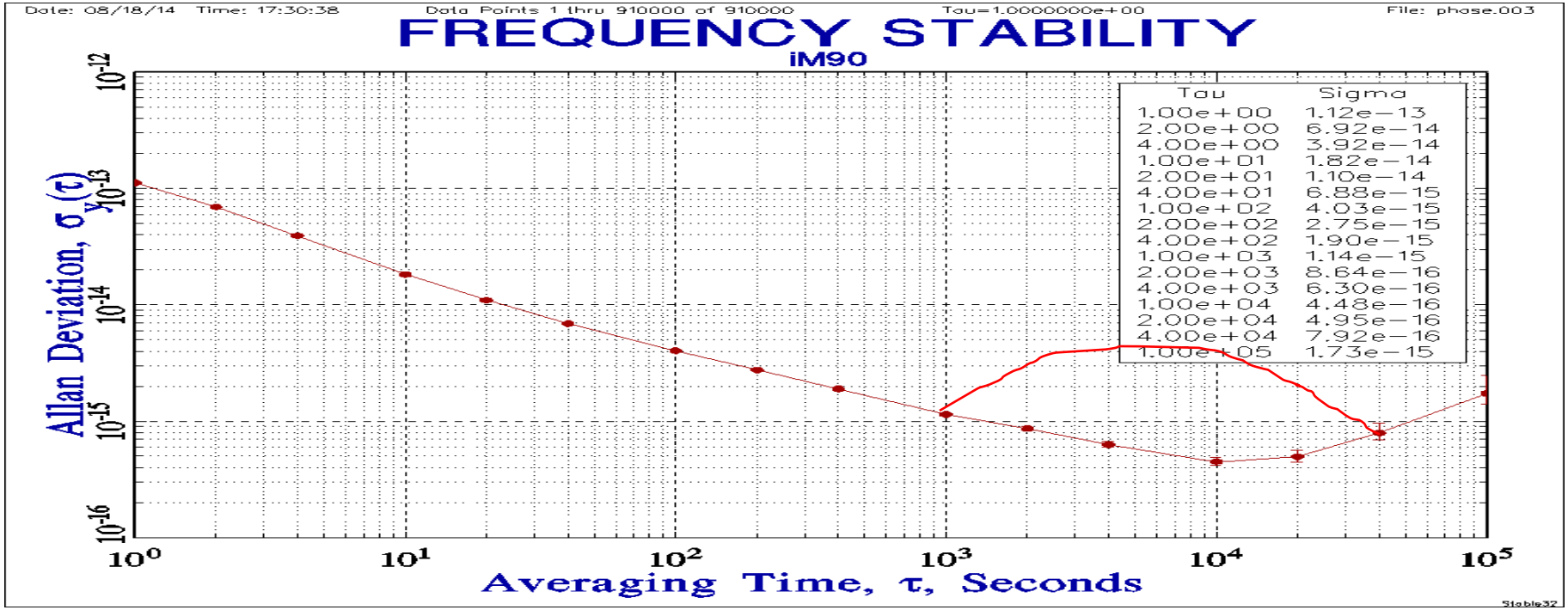
Actions for better measurement

- Example :Open laboratory
  - Standard air conditioning +/-1°C / 15 min



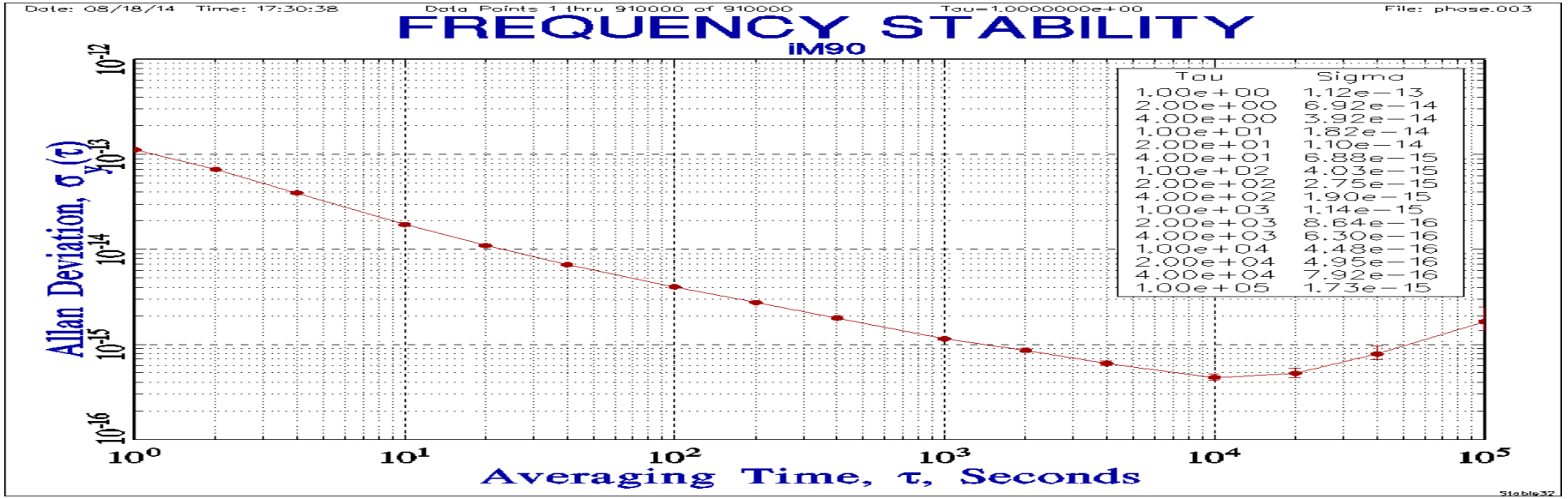
Actions for better measurement

- Example :Open laboratory
  - Standard air conditioning +/-1°C / 15 min
  - → will see a degradation at Tau 1ks about $3 \cdot 10^{-15}$

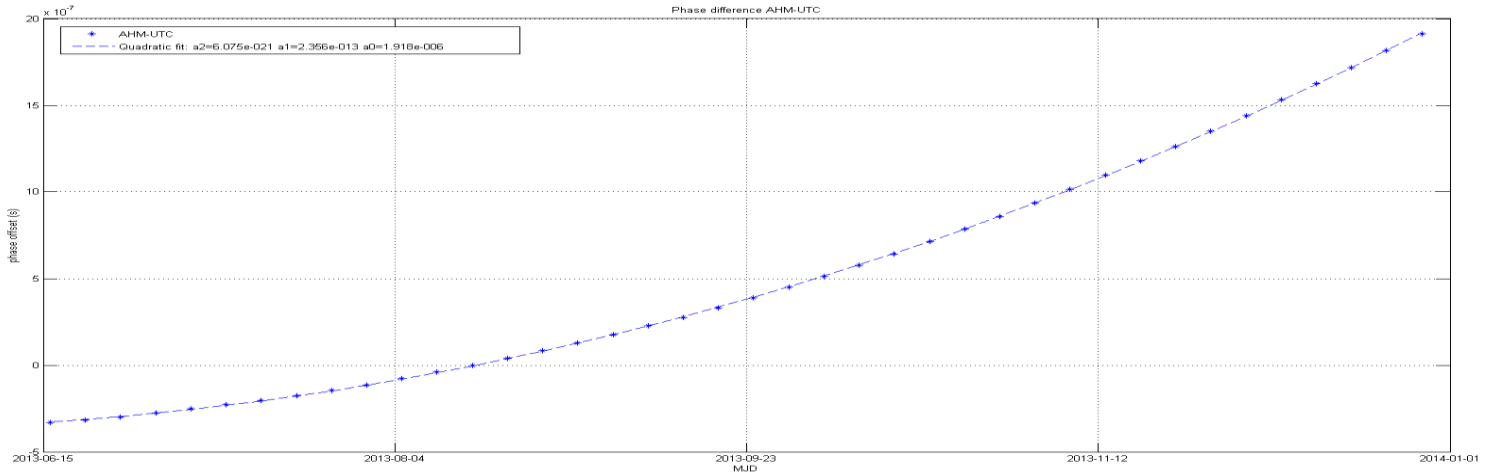


Aging

- Aging (EP & PP)
  - Cavity
  - Hydrogen source → Drift (and random walk)
  - Electronic

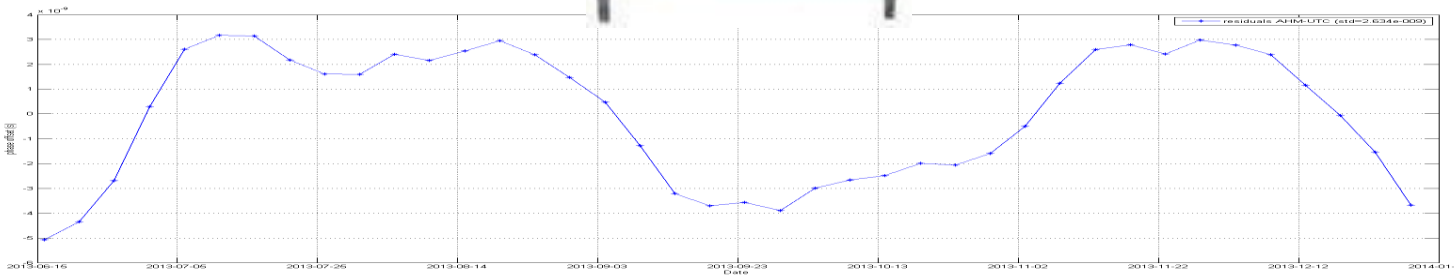


Actions for better measurement



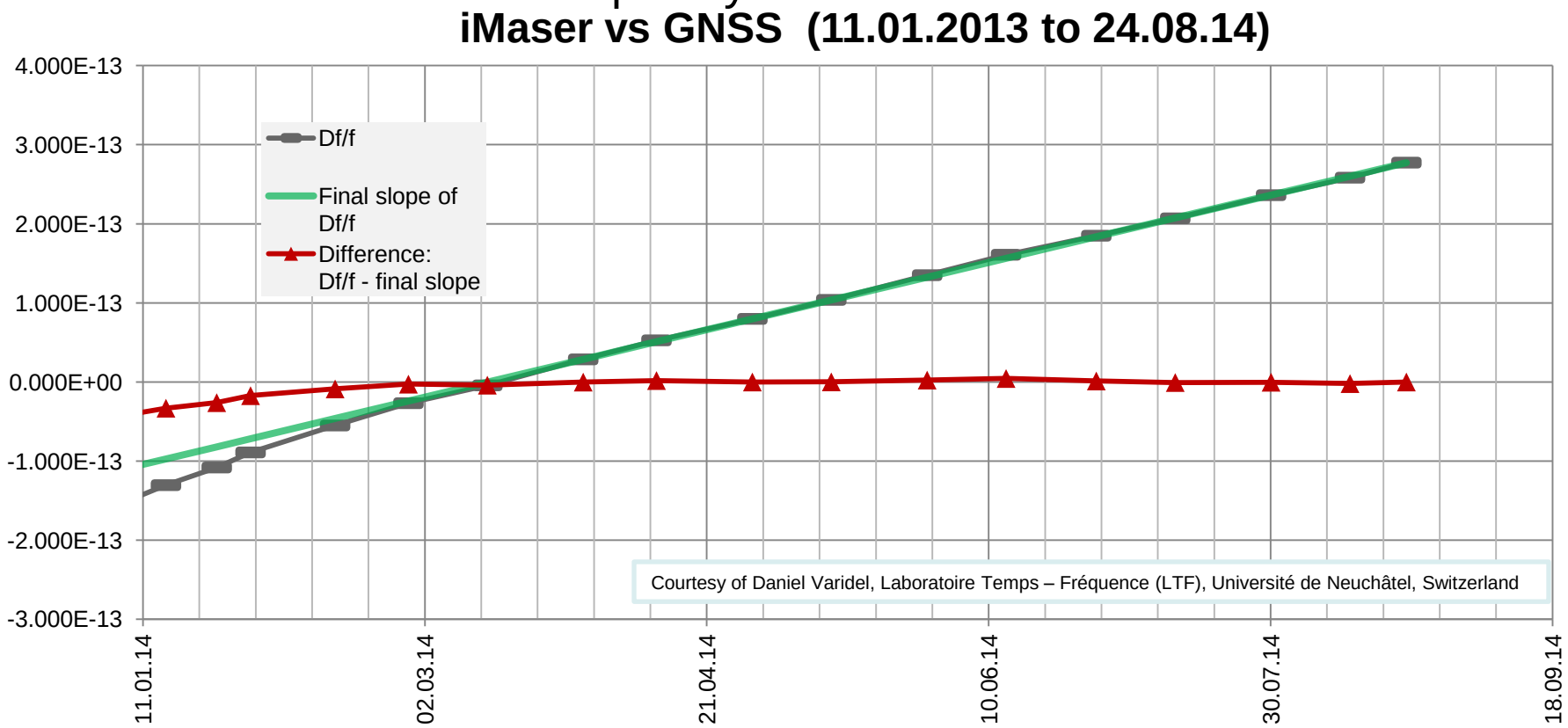
– Frequency drift removed with external compensation

Femtostepper



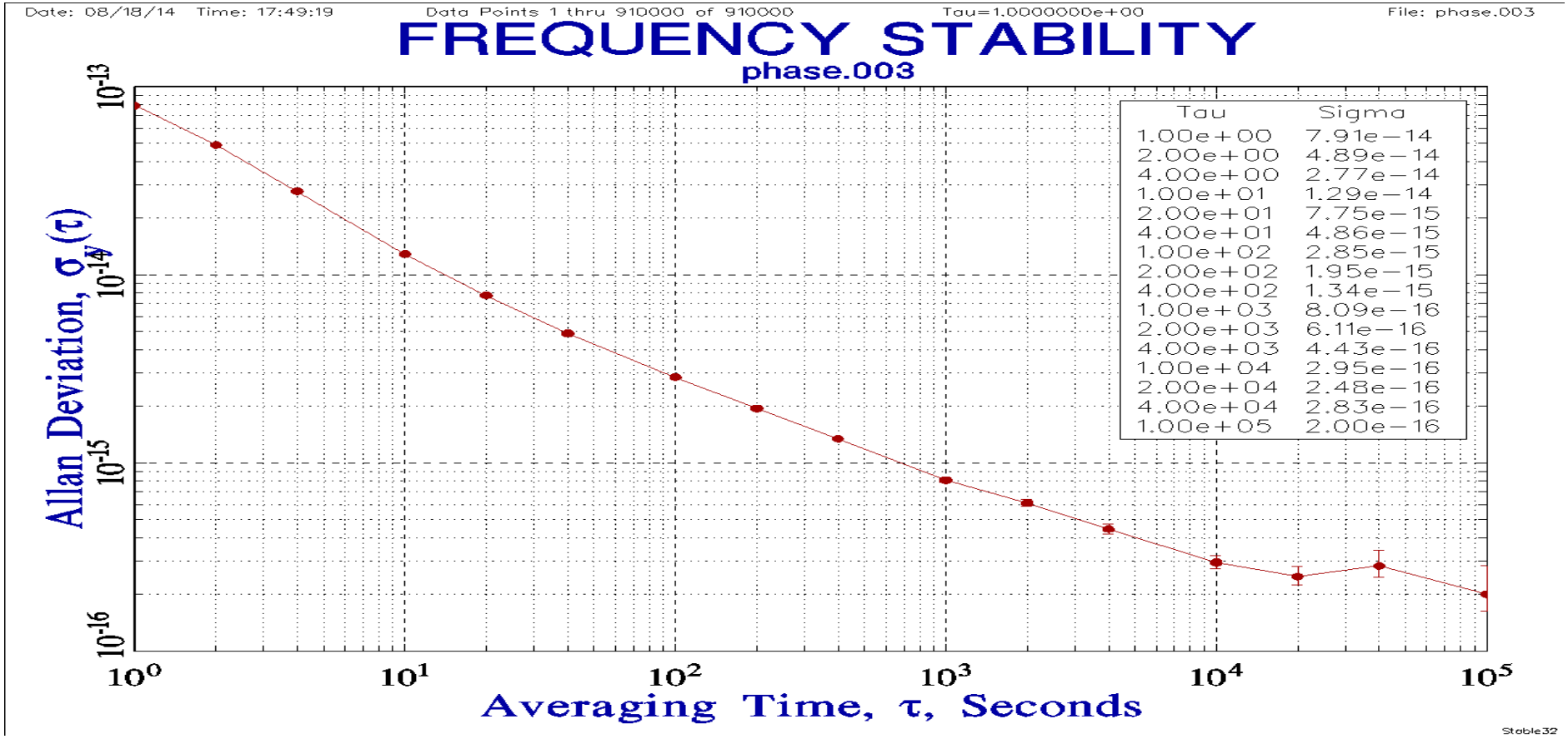
Actions for better measurement

- Aging on new equipment
  - 1-2 months of stability
    - Become better with time
  - then Linear drift in Frequency:

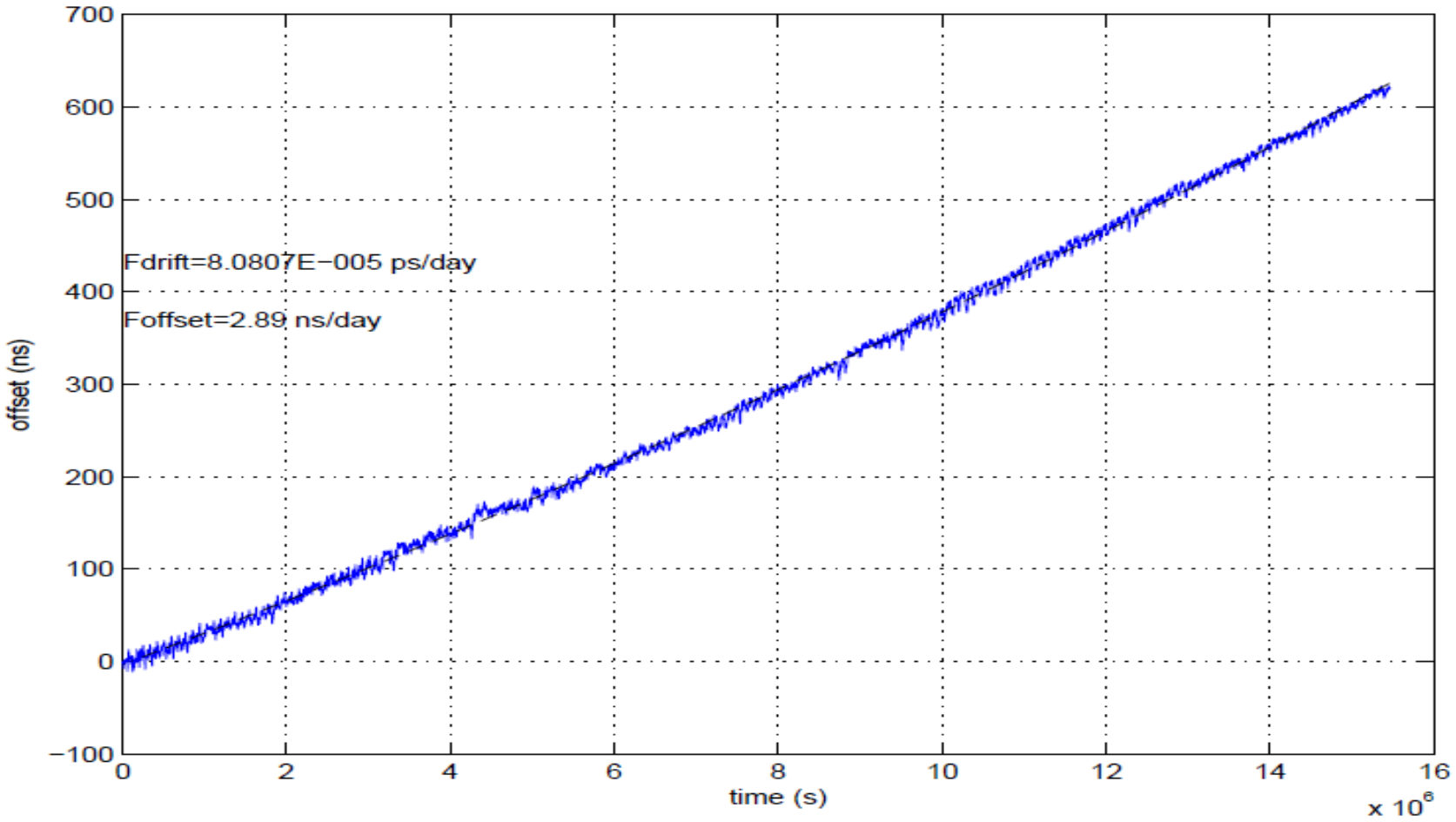


Typical Performance drift removed with internal stepper

- Predictive drift removed
- No degradation on phase noise



Measure: Maser vs GPS Jan14 -Jun14



Actions for better measurement

- To enhance the standard performance:
  - Location without vibration
  - Use the best cable
    - Use ½'' or ¼'' for small distance <30m
    - Check the sensitivity Φ/K
    - Terminated all outputs with 50 ohm
  - Use the best connector (N or SMA) never BNC nor plug

Actions for better measurement

- To enhance the standard performance:
  - Use isolation amplifiers at both ends
  - Avoid grounding loop (DC block…)
  - Avoid similar frequency reference too close (Xtalk)

Actions for better measurement

- To enhance the standard performance:
  - Don’t walk around, open the door or windows
  - Never touch the maser or cable

  - Check monitoring and note significant change on trends…
  - Use other reference to compare
  - Recalibration every 5 years
  - Maintenance recommended every 10 years

T4Science Features

- Particular Features
  - EMC Standard
  - CE Norm
  - Remote Ethernet control
  - Post Diagnostic software
  - Remote alarms
  - Telecommand
  - Remote operation

T4Science Cutomers & location

- 33 years operations
- 90 masers operating!
- Worldwide customers on all continents
- Solution for difficult environment
  - 5000 m altitude
  - Isolated Island
  - South pole

Thank you

T4 Science
iPRECISION MASER SOLUTIONS™

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