Experimental point-to-multipoint distribution of WR-Based clock and PPS signals through µTCA Backplane

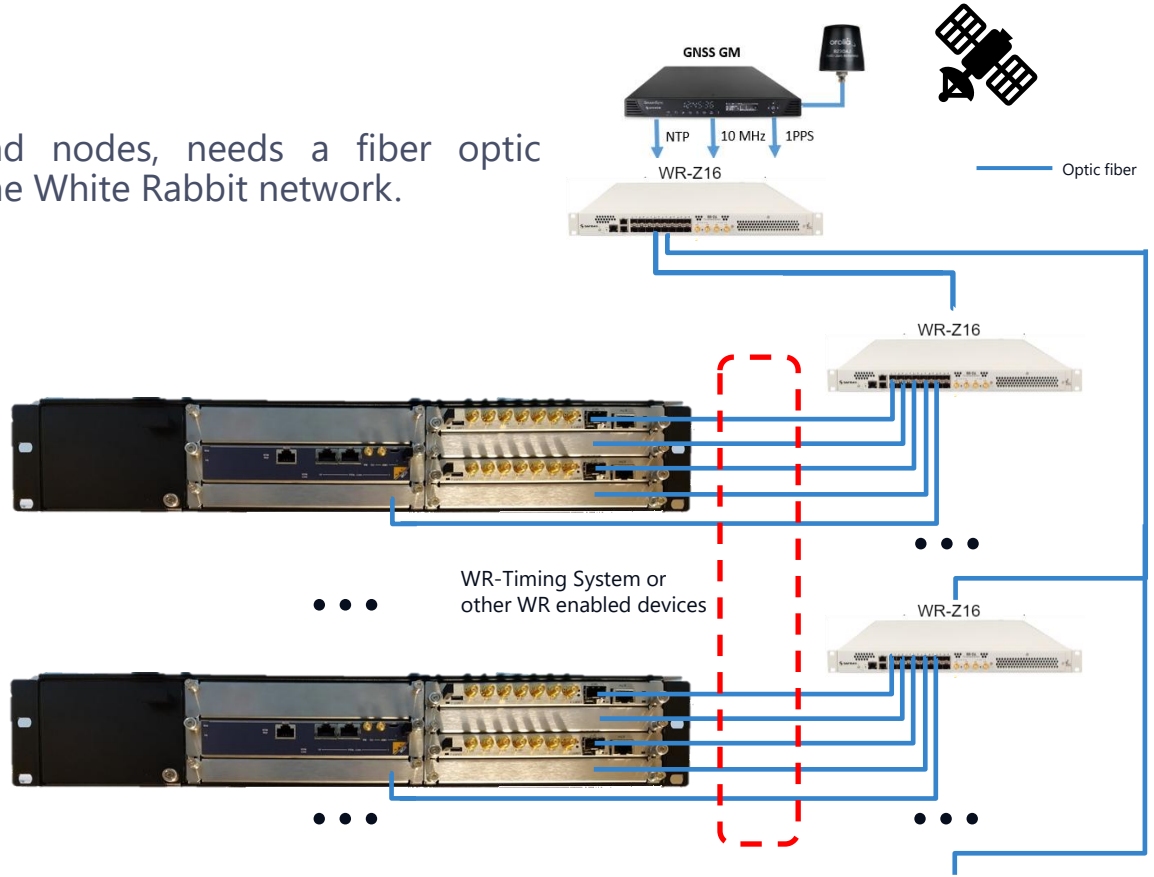
14th MicroTCA Workshop for Industry and Research

SAFRAN

White Rabbit timing and clock distribution

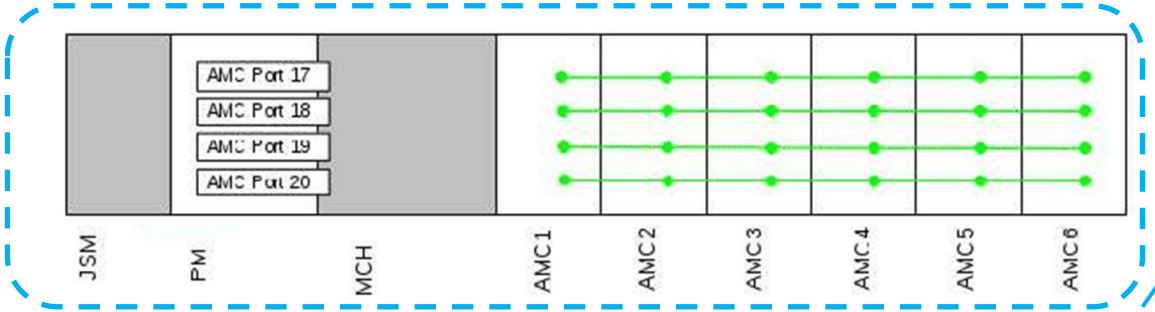
- **Typical tree structure**
  - Each node, down to the end nodes, needs a fiber optic connection to synchronize to the White Rabbit network.

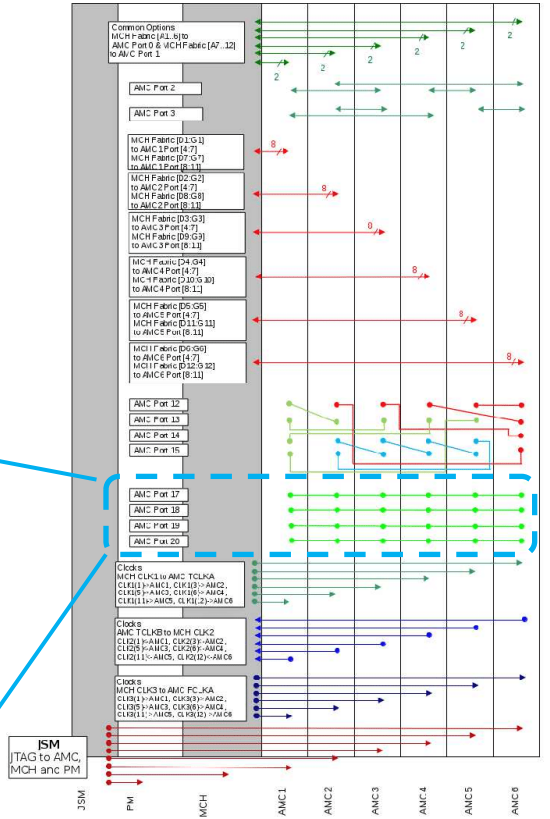
- **Features**
  - Reliable timing information
  - Common clock across all devices generated internally
  - PPS generated on each end node



White Rabbit timing and clock distribution

- **New approach to connections**
  - Use uTCA crate backplane multipoint lanes
  - Can connect all devices internally without cables
  - Master device retrieve White Rabbit clock and PPS from WR network and relay it to all the slaves.
  - Need custom master-slave configuration, not standardized.





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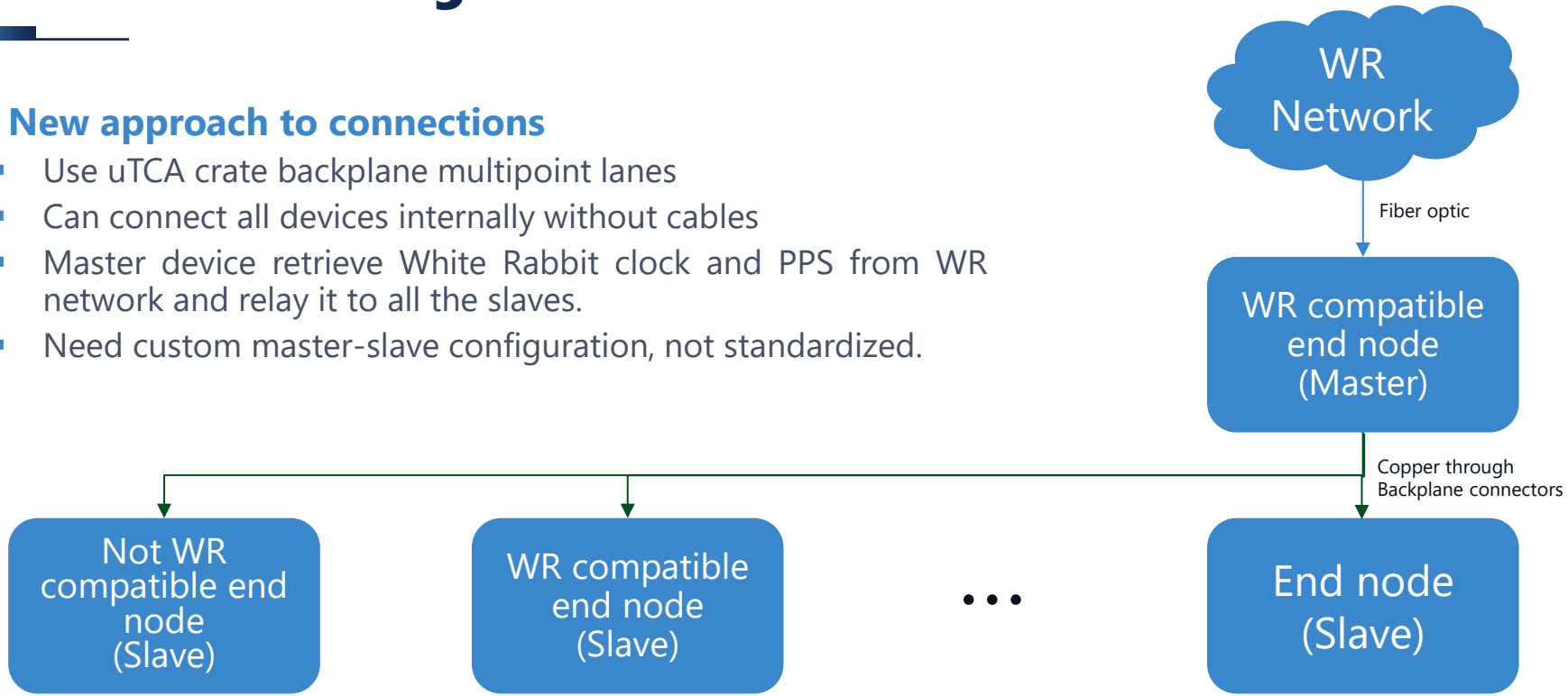

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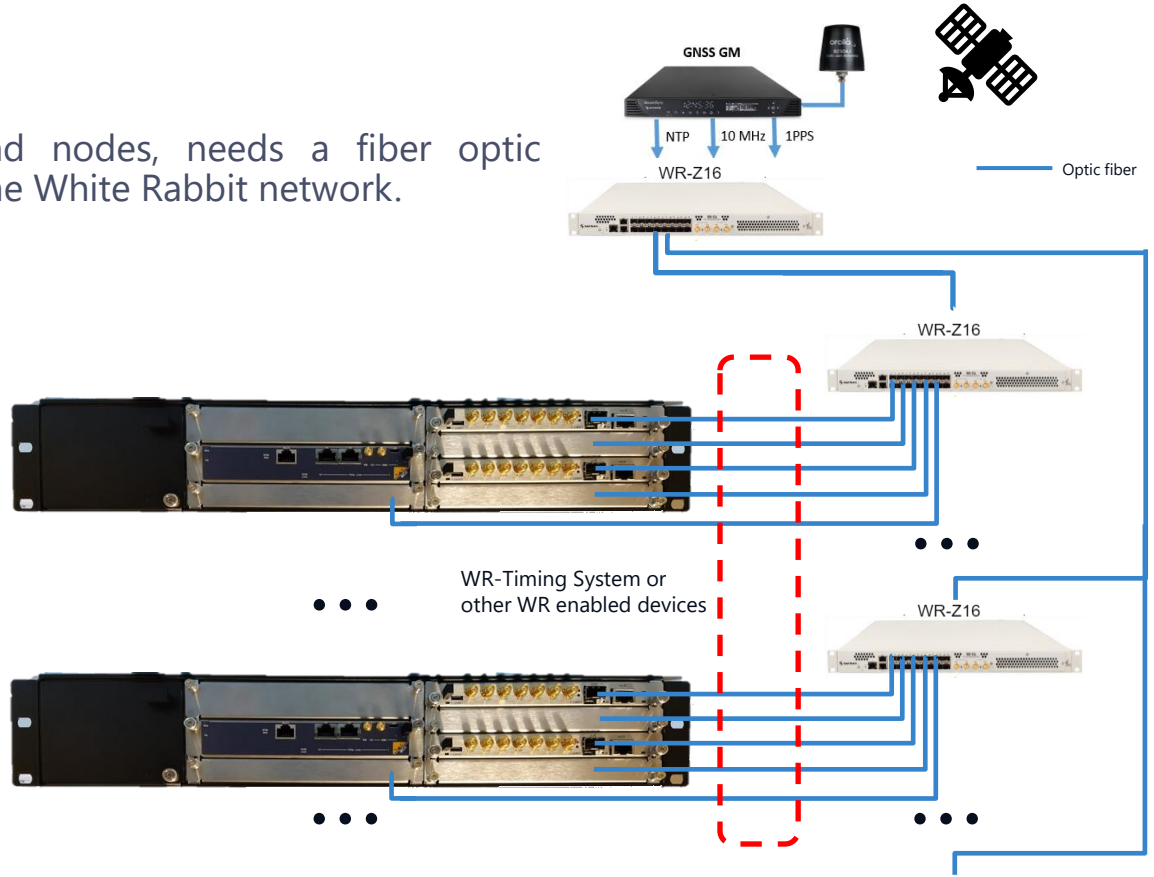
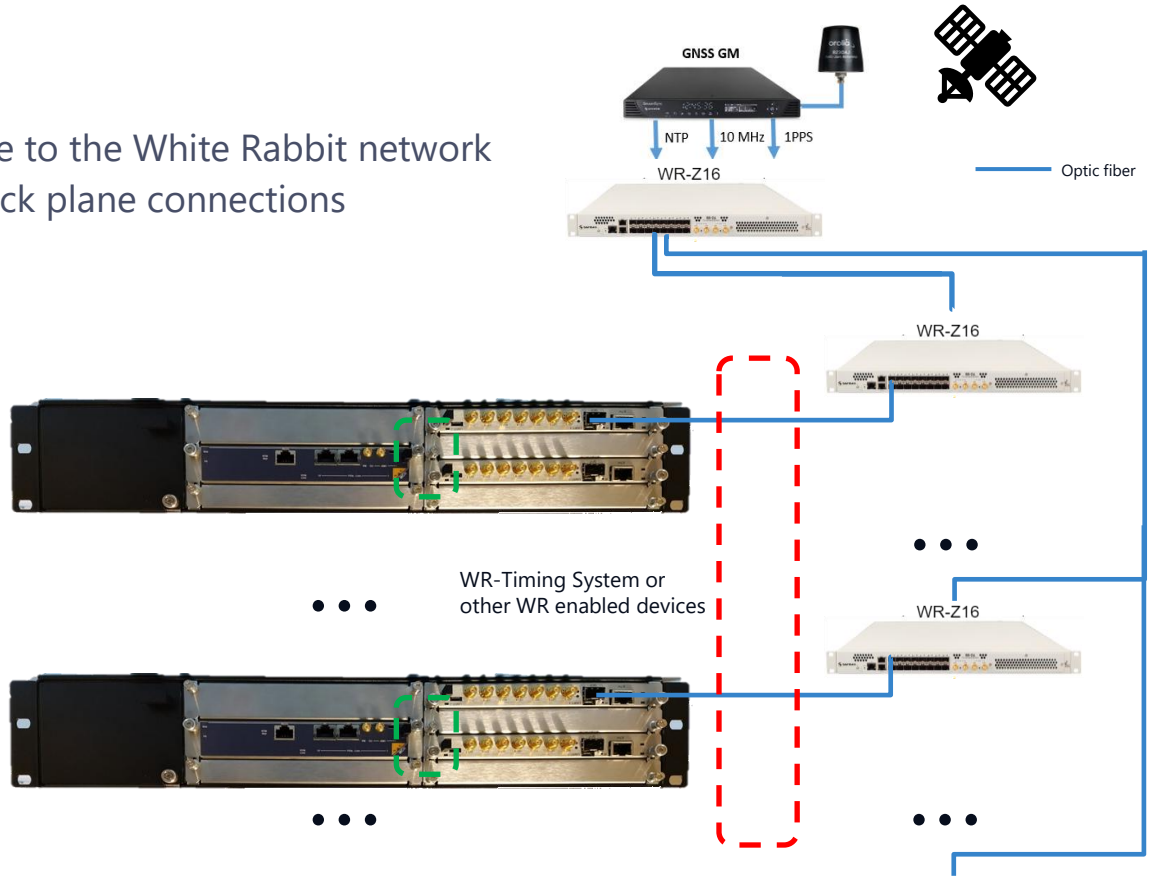


White Rabbit timing and clock distribution

- **Using uTCA backplane**
  - Connect one end node per crate to the White Rabbit network
  - Relay clock and PPS through back plane connections

- **Features**
  - Simplify connections and reduce costs
  - Common clock and PPS across all devices in the same crate
  - No direct information of absolute time, it needs to be obtained through other mechanisms.
  - Similar performance than point to point classical connections



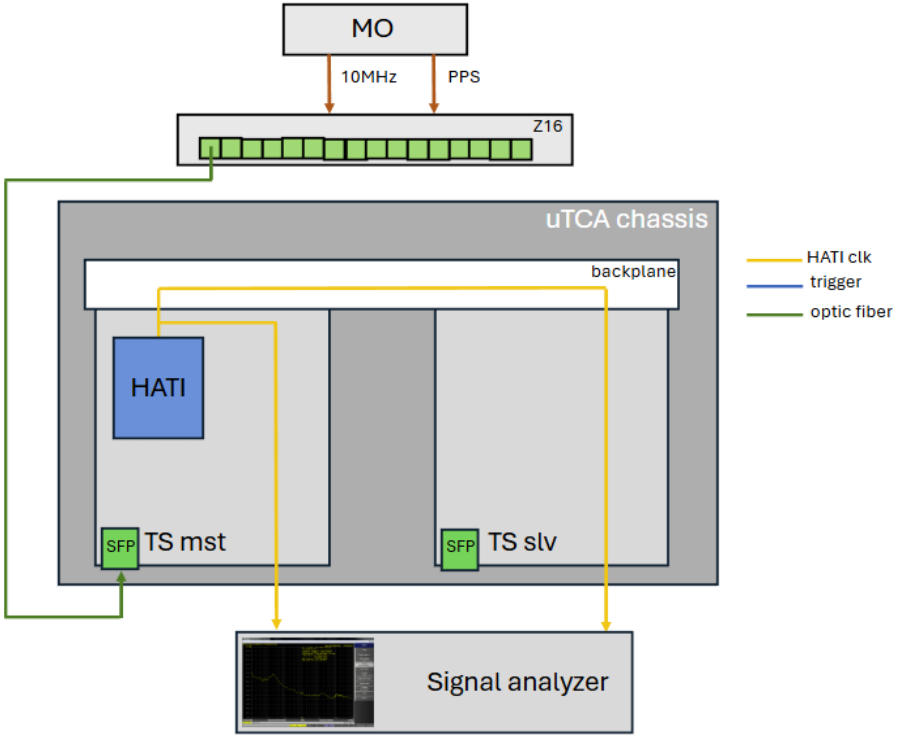
White Rabbit timing and clock distribution

- **Timing System -** Every installation requires timing and synchronization
  - Crucial component used to synchronize and control the operations and events that occur during experiments or beam delivery in a particle accelerator

  - Main functions are:
    - Timing: ensuring that all the components operate at the correct time relative to each other
    - Triggering: generation of signals based on predefined criteria or events detected by detectors. These signals are used to initiate specific actions.
    - Pulse generation: generation of precise pulse that control the operation of various components. For example, these pulses determine the timing of particle bunches..
    - Distribution: Timing and trigger signals need to be distributed throughout the accelerator facility with minimal delay and jitter (this is especially critical in lasers)
    - Control interface: for configuration and monitoring of the system (EPICS or TANGO are the commonly used frameworks)
    - RF distribution: allows the reconstruction of the RF signal in the end-nodes (synchrotrons)
    - Interlocks distribution: enables the stop of the complete installation in case of failure

White Rabbit timing and clock distribution

- **Tests and results**
  - Set-up of Master-Slave configuration
  - Master is synchronized to the WR network through a Z16 device and a HATI IP core.
  - If it is configured as a Master, it directly uses the synchronized clock and PPS and share them through the backplane to the slaves.
  - If it is configured as a Slave, it retrieves from the backplane both, the clock and PPS.
  - WR reference clock is routed to the front SMA connectors and measured directly.



White Rabbit timing and clock distribution

- **Tests and results**
  - Very slight degradation of the RMS jitter, but overall the same behavior

Image	Device	RMS jitter
Left	Master	3.672 ps
Right	Slave	3.818 ps

White Rabbit timing and clock distribution

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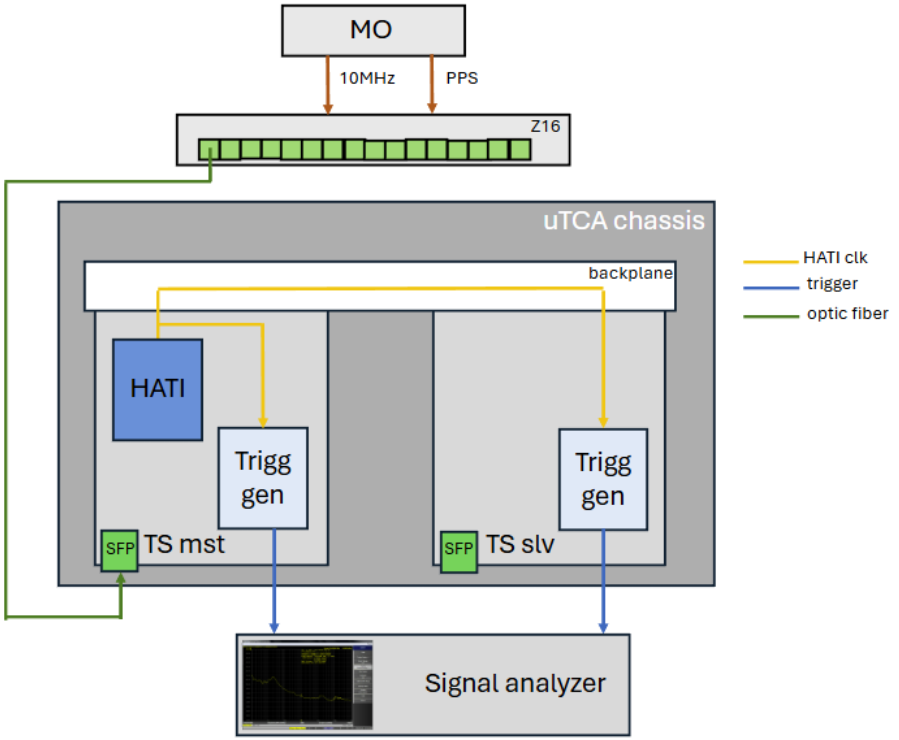
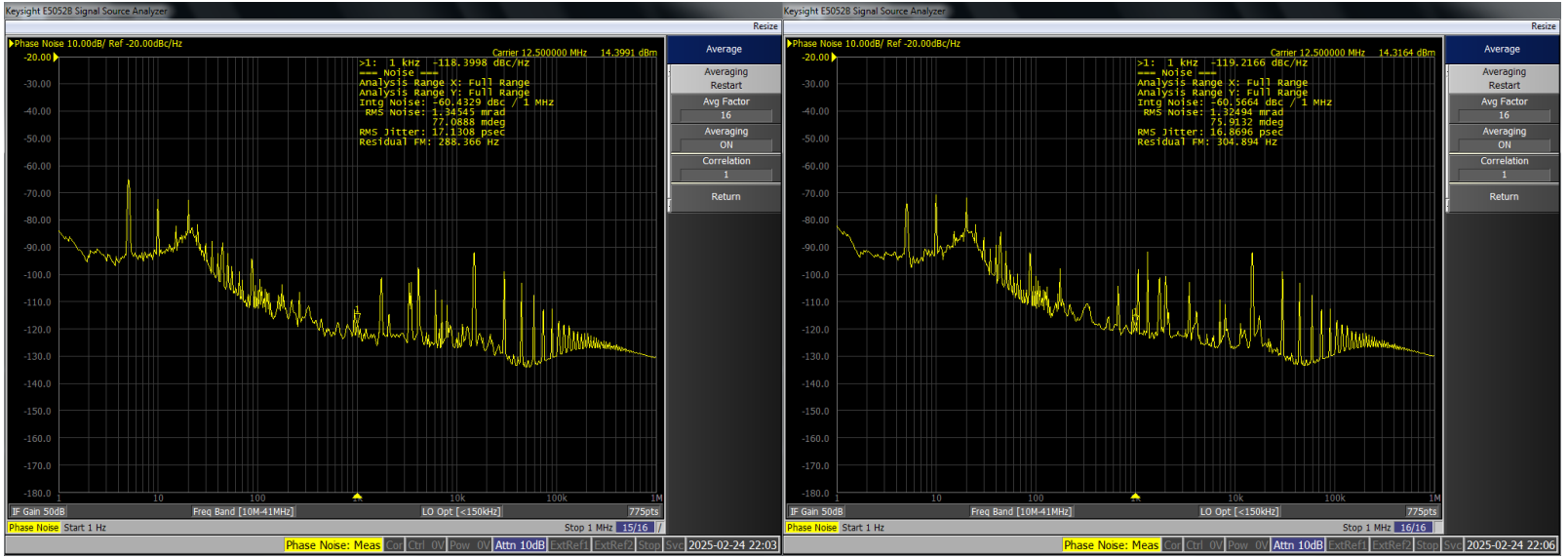
  - If it is configured as a Master, it directly uses the synchronized clock and PPS and share them through the backplane to the slaves.
  - If it is configured as a Slave, it retrieves from the backplane both, the clock and PPS.
  - Devices generate a 12.5 MHz trigger in the front SMA connectors



White Rabbit timing and clock distribution

- **Tests and results**
  - Both trigger signal show very similar characteristics.

Image	Device	RMS jitter
Left	Master	17.13 ps
Right	Slave	16.86 ps



Future developments and summary

Expand tests to verify and characterize with several slave end nodes.

New approach simplify connections and reduces cost.

Present similar performance as standard end nodes.

Absolute time is not transmitted to the slaves

Backplane lanes need to be available

Not standardized, need customized devices

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