Approach in Italy to T/F distribution

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Outline

- GARR Optical Network Update

- INRIM T&F distribution in Italy

- Time Over WAN – White Rabbit distribution

- Conclusions

Status of the current infrastructure

(2011) Huawei 1/10 G

- 10G/40Gbps channels not enough for the needs of the core
- Close to the end-of-life
- Maintenance (+2Y) ends 2020
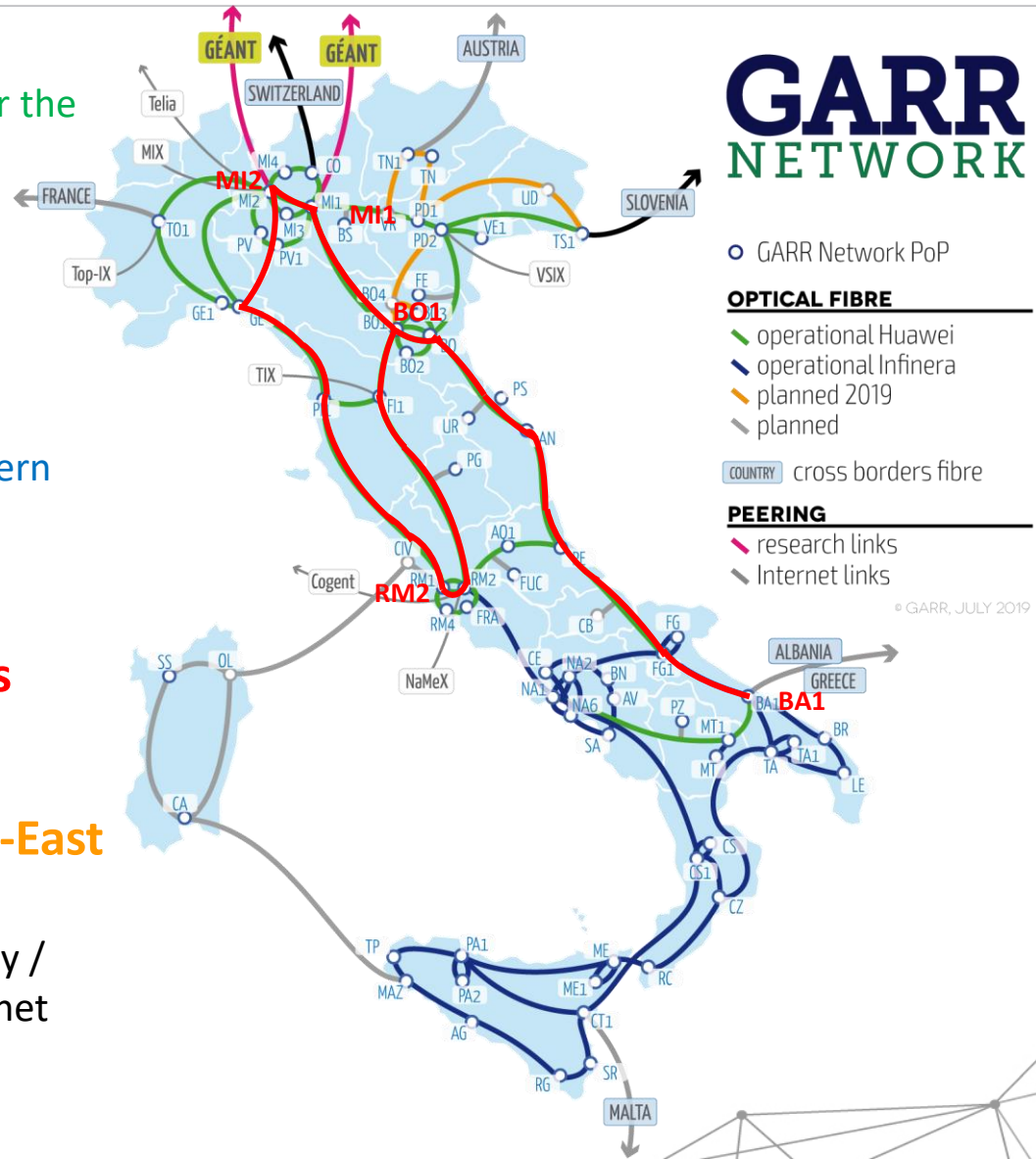
(2015) Infinera 10/40/100 G

- 500Gbps superchannels
- Fine for the capacity needs of Southern Italy
- High power and space consumption

(2017) AW 2x100G among Core PoPs
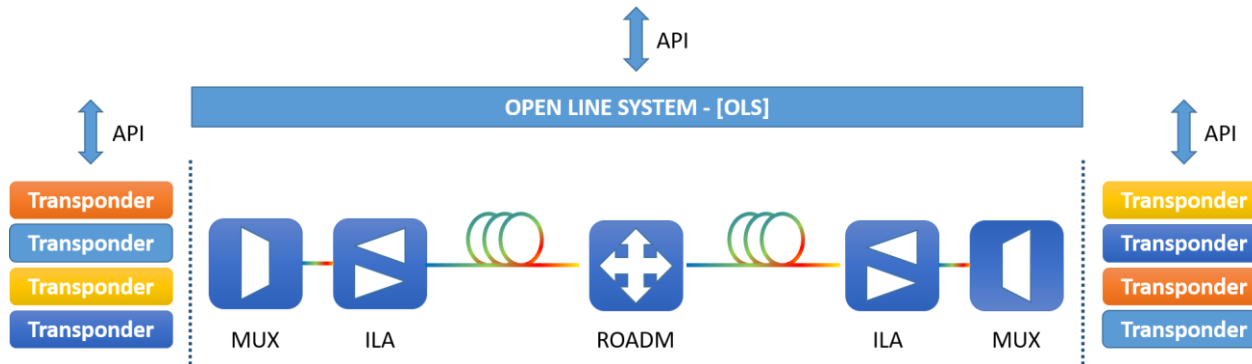
- Buffer solution – it works super fine

(2019) New fiber footprint on North-East Area

- North-Eastern region: closed topology / ARNES direct Interconnection / Lightnet interconnection
- ECMWF new site in Bologna

How GARR sees its optical evolution

- Open Line System (partially disaggregated) to replace the oldest infrastructure

- April 2019: we issued a RFI on open line systems and optical transport network equipment (Juniper, ADVA, ECI, Huawei, Infinera)

- August: tender for DCI (Infinera G30) for an INFN-GARR joint project on Distributed Datalake for Science

- February 2020 – GARR-T Optical Transmission Network Tender

- September 2020 – start of the deployment phase

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Time & Frequency in Italy

INRIM in Italy has a **dedicated fiber infrastructure for Frequency dissemination and quantum technologies**

- **T/F**
- **Quantum Tech (sensing, QKD)**
- Radioastronomy
- Ultracold atoms
- Space – Galileo
- Industry, finance

7 Research Institutes linked:
    CNR – National Research Council
    ASI – Italian Space Agency
    INAF – Italian Astrophysics Institute

5 Industrial Users
   1 infrastructure NIS (Network and Information Security)

Build 2012-2018, operational since 2013

Funding: Inrim, MIUR, Euramet (programs EMRP and EMPIR), EU-H2020, ASI, Regione Piemonte

Time & Frequency in Italy

- ✓ Dedicated pair of fibers owned by GARR and fully operated by INRIM
  - 1850 km
  - avg ILA distance 70km
  - Attenuation < 30 dB

  1 fiber dedicated to frequency dissemination
  - ultrastable frequency 1542 nm

  1 fiber dedicated to pre-production trials, research and pilots

- ✓ INRIM is the owner of the service and is fully independent in operating fibers, equipment and access all the PoPs.

- ✓ The fiber is mainly on the same path of the GARR DWDM backbone, so fiber cuts and fixing slices are heavily coupled

- ✓ One of the key element is to avoid each other impact on network operations and on the network evolution path

T/F Italian Research Infrastructure Pillars
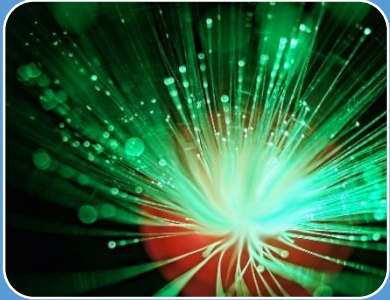
Dedicated Dark Fiber

- High demanding users
- A single pair of fibers enables to separate production from R&D (pilots, prototypes, Quantum sensing, QKD)

Operational Independence

- T/F signal needs specific tuning and maintenance
- No impact on each other service during operations

Infrastructure lifecycle Independence

- Avoids dependencies in network evolution/update
- Free to innovate and deliver service without mutual constraints

Time over WAN White Rabbit

White Rabbit for a time service: a collaboration with INRIM

- **Several research institutions have more relaxed (order of nanosecond) requirements on the T/F signal however might profit receiving a T/F distribution from a source of "INRIM reference time"**

- In July 2019, in collaboration with INRIM, we started to test the White Rabbit protocol over DWDM in our network
  - The aim is to check which accuracy we can reach using the WR protocol on our optical infrastructure (using a pair of fibers, amplifiers and ROADMs)
  - We want to measure the average accuracy/stability we can get in different parts of our network
 - We want to understand the complexity of operating the WR devices

AW transport of UNIdirectional white rabbit signal

1G Alien Wave

1G Alien Wave

reference

user

White Rabbit

White Rabbit

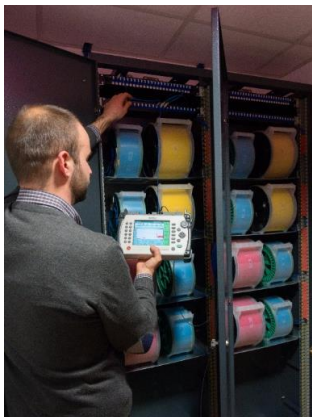MUX   ILA   ROADM   ILA   MUX
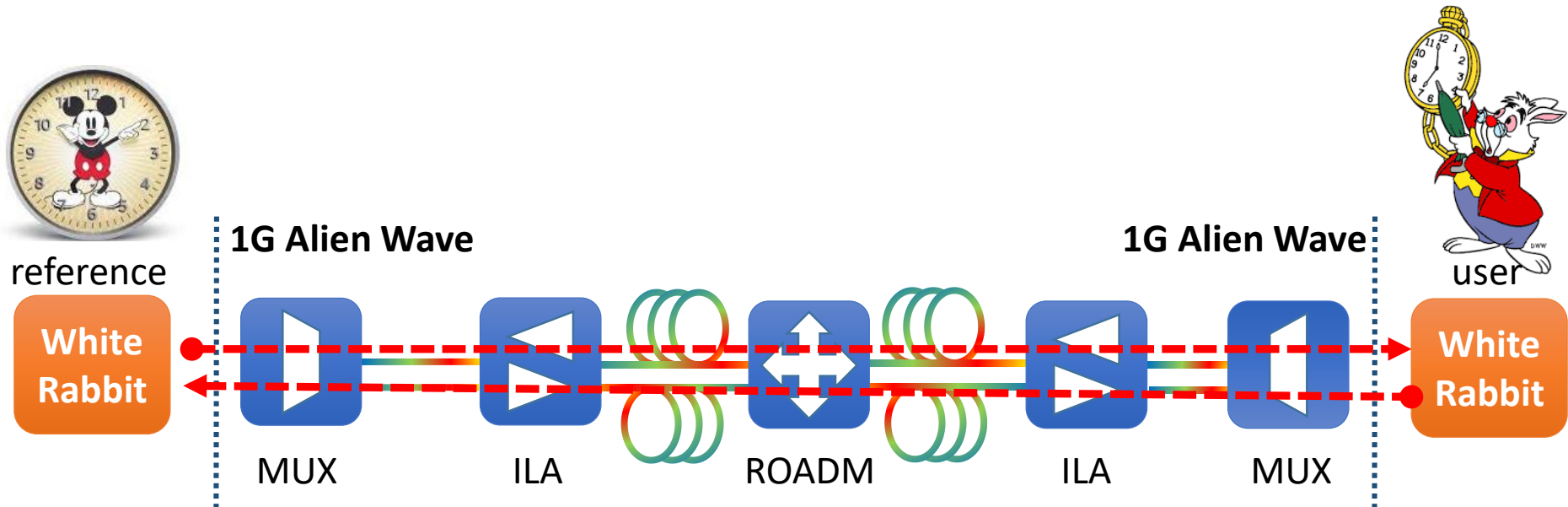
Standard AW transport across UNIDIRECTIONAL DWDM network

- 1G lambda in C-band
- System based on fiber pair
- CD Compensation Fibers
- Unidirectional Signal
- Required Asymmetry Compensation
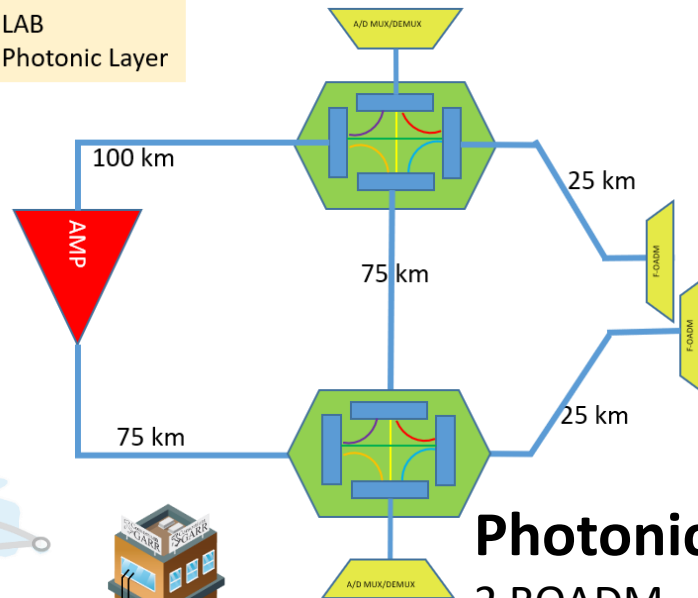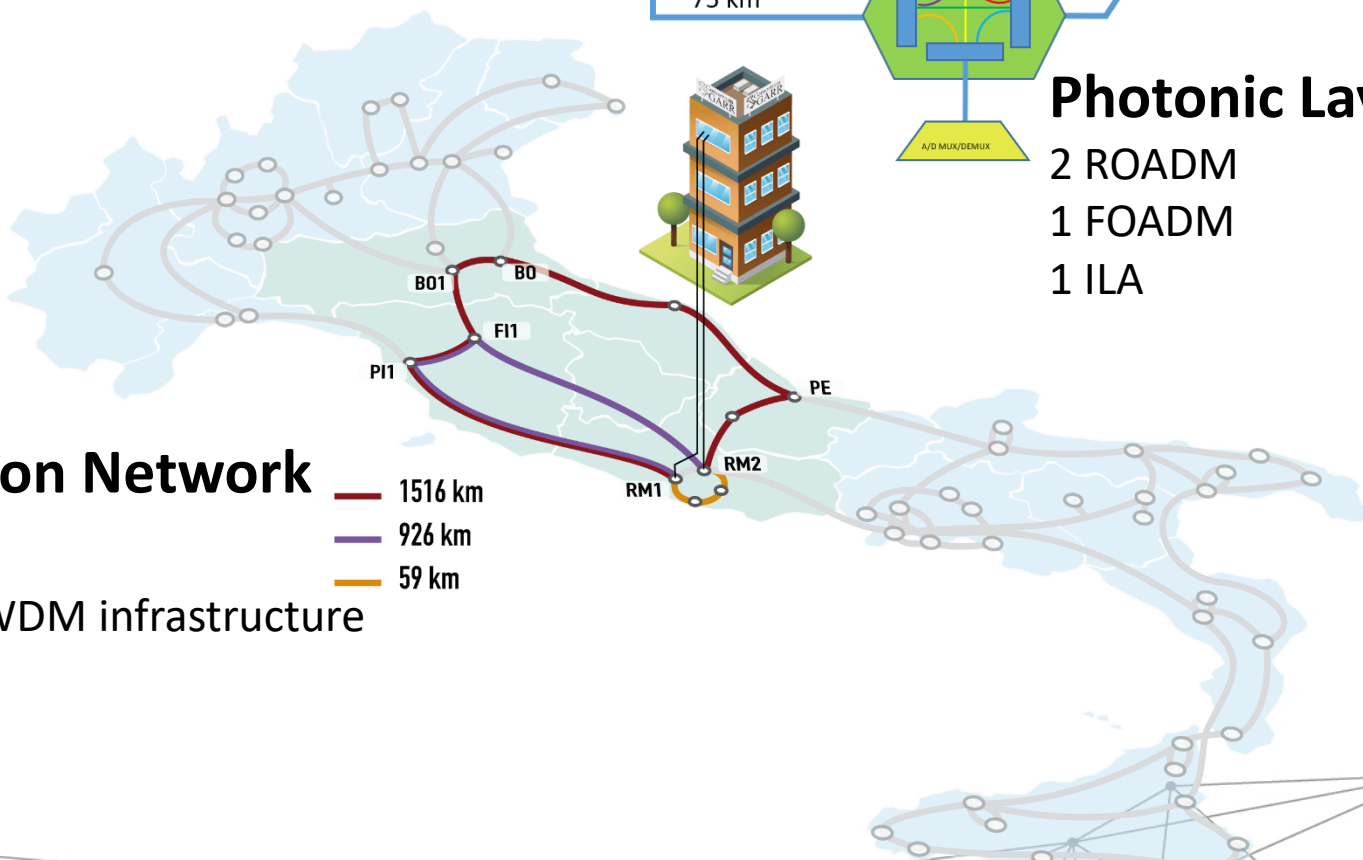
Service Release Approach

Lab

Field Trial / Prototipe

Beta

Service Release
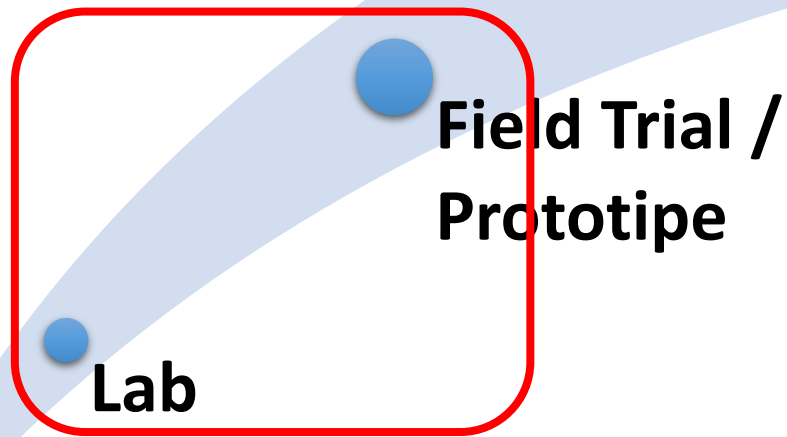
GARR Optical LAB

Fiber spools

300km G.652d fiber
Spools of 25 and 50 km

LAB
Photonic Layer

100 km

AMP

75 km

75 km

25 km

25 km

A/D MUX/DEMUX

F-OADM

F-OADM

A/D MUX/DEMUX

Photonic Layer

2 ROADM
1 FOADM
1 ILA

LAB/Production Network Integration

Paths on GARR DWDM infrastructure
60km
900km
1500km

BO1
BO
FI1
PI1
PE
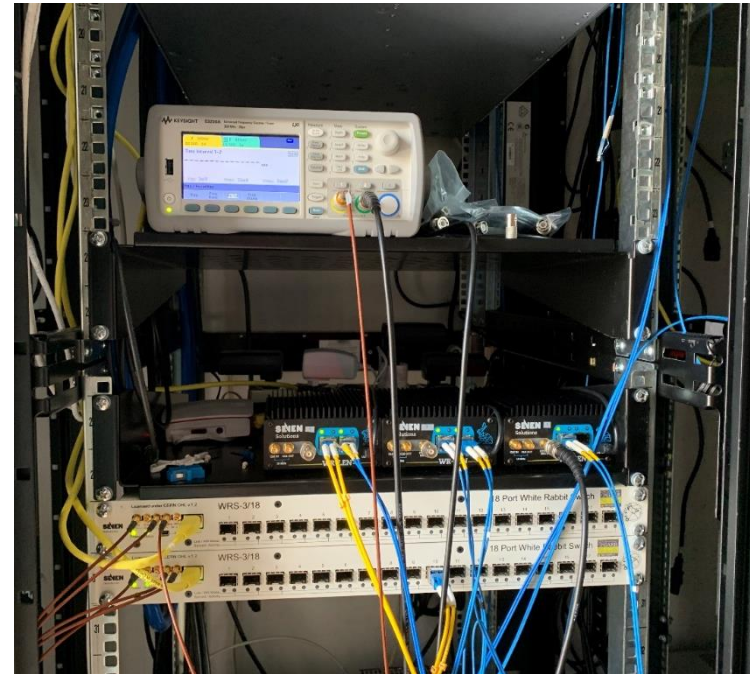RM2
RM1

— 1516 km
— 926 km
— 59 km

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Following the White Rabbit

Free running Clock

10 MHz
IN

WRS 1

10 MHz   pps

WRS 2

Gran Master

M ——— S | LEN1 | M ——— S | LEN2 | M ——— S | LEN3 |

Counter

Ch1   Ch2

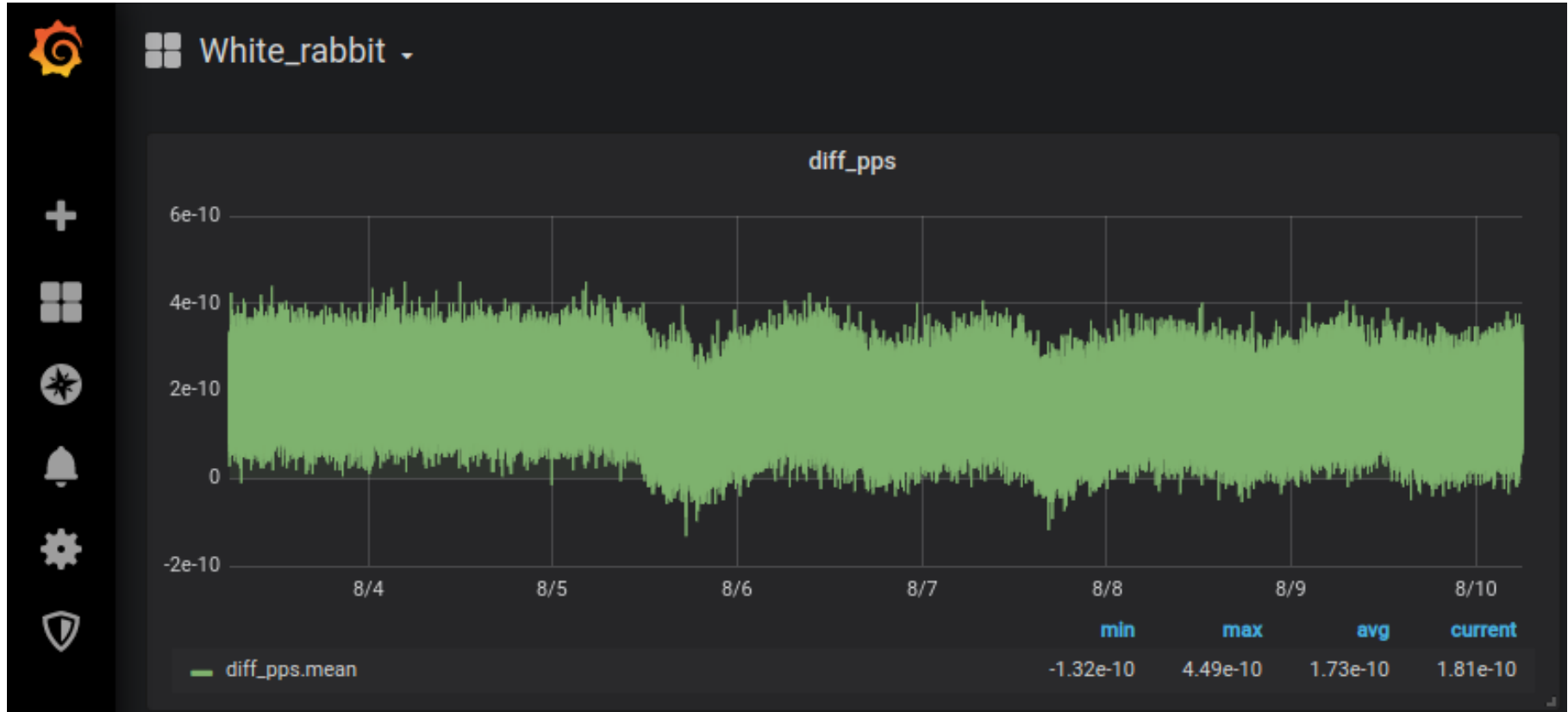**Int Ref out**
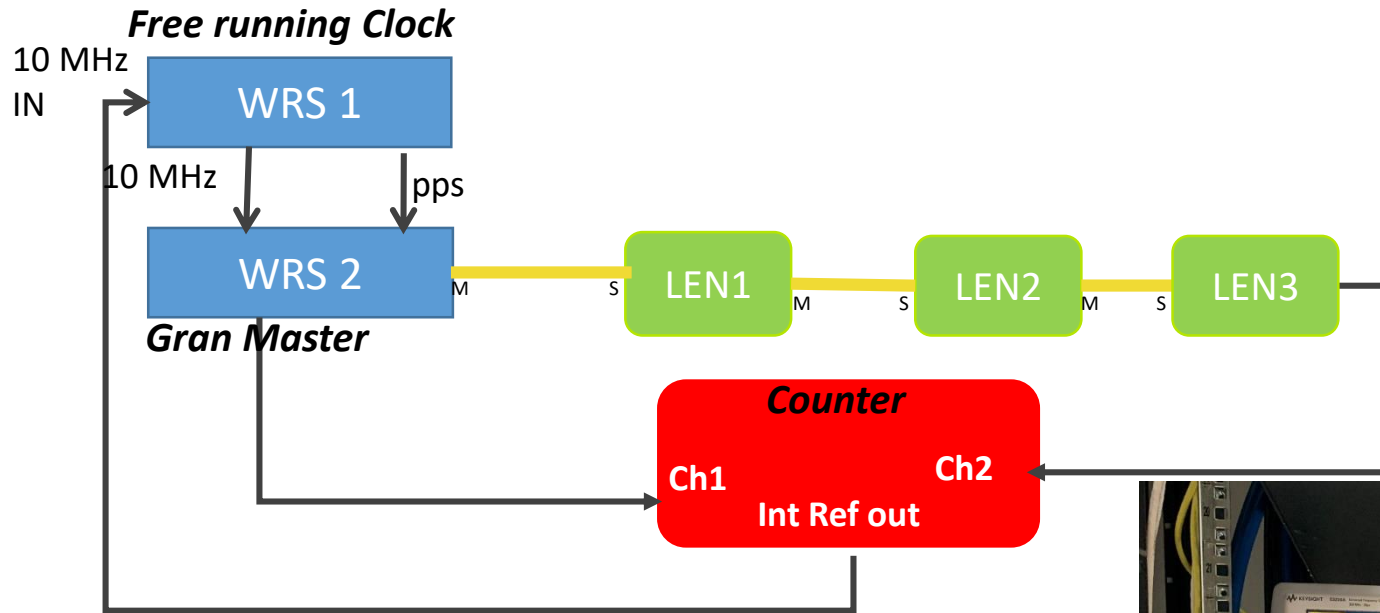
It is mandatory to perform calibration in order to compensate fiber pair asymmetry

White Rabbit: 50km fiber spool (span len1-len2)

diff_pps = PPS_{ch2}-PPS_{ch1}

diff_pps order of 10^{-10} s

White Rabbit: 60km production DWDM line system (span len2-len3)
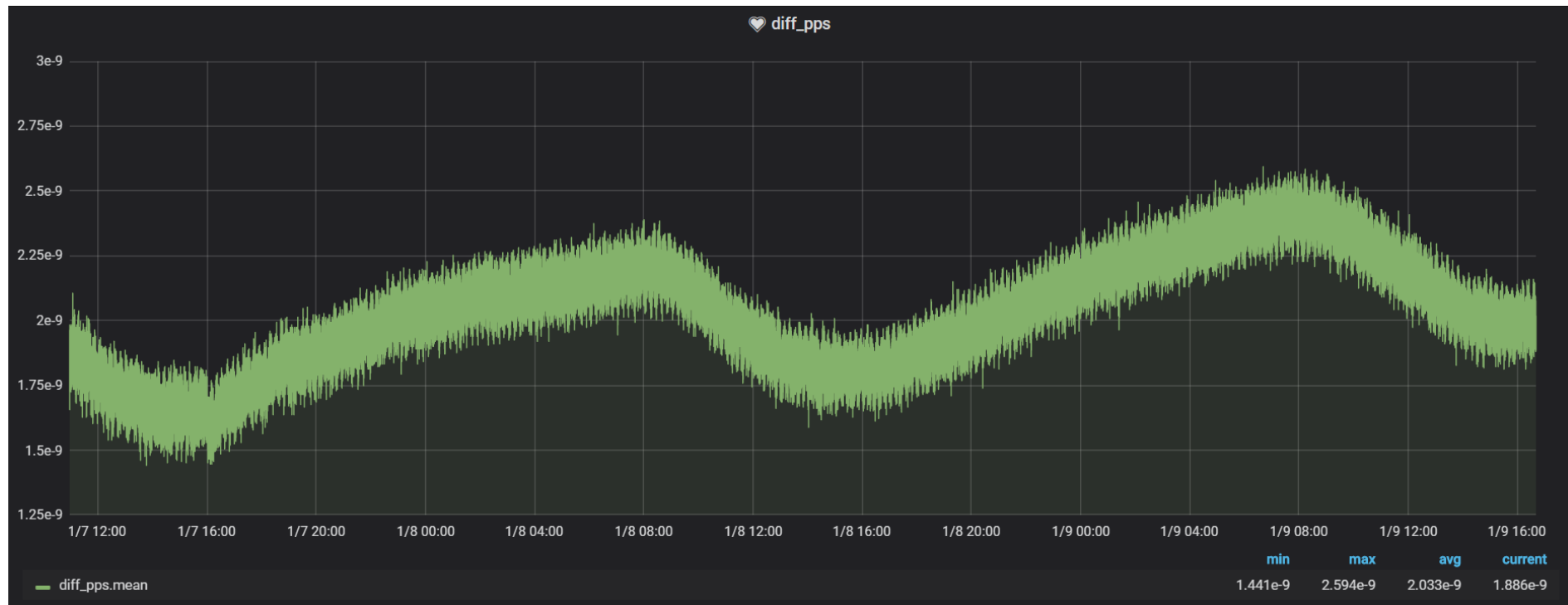
- diff_pps order of $10^{-9}\ s$
- Night-day variation in the range of 2ns

Note: Acquiring data from the 7th of January

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WR operational considerations

Main concerns on possible operational models:

1. Lack of management and control tools for the tested White Rabbit devices.

    *   no remote control possible for LEN devices, a console connection is mandatory
    *   device reboot required after calibration parameters change
    *   experienced several freezing states or crashes both on CLI and on service

2. Considering unidirectional signals, calibration with external reference (GPS) required after any path variation after fiber cuts and splicing fix.

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Conclusions

✓ A <u>dedicated dark fiber</u> infrastructure for high demanding T/F distribution is <u>the Italian reference model</u>.

✓ GARR and INRIM both doing their best in respective fields:

- GARR supports INRIM to build up and operate the fiber infrastructure, providing expertise only on network, infrastructure, fibers and telco market.
- INRIM is the owner of the service and fully in charge of the scientific and technical deployment of the infrastructure, and of the development of new systems.

✓ White rabbit or PTP over DWDM network can be explored for less demanding users.

- However, GARR will not force a strong requirement for these applications on the new optical network design, which can be considered as a plus for future evolutions and services.
- Again GARR will support INRIM for the network aspects, relying on NMI for the metrological topics.

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Q&A

Useful Links:

http://rime.inrim.it/labafs/frequency-dissemination-through-optical-fibers/

https://www.researchgate.net/publication/261160318_LIFT-the_Italian_link_for_time_and_frequency

https://www.garr.it/documenti/3474-garr-white-paper-maggio-2017

https://www.cesnet.cz/wp-content/uploads/2019/09/gloria.pdf

https://link.springer.com/article/10.1140/epjqt/s40507-019-0075-x