

**FEL09**

Liverpool, UK, August 28, 2009

# Femtosecond electro-optical synchronization system over distance up to 300 m

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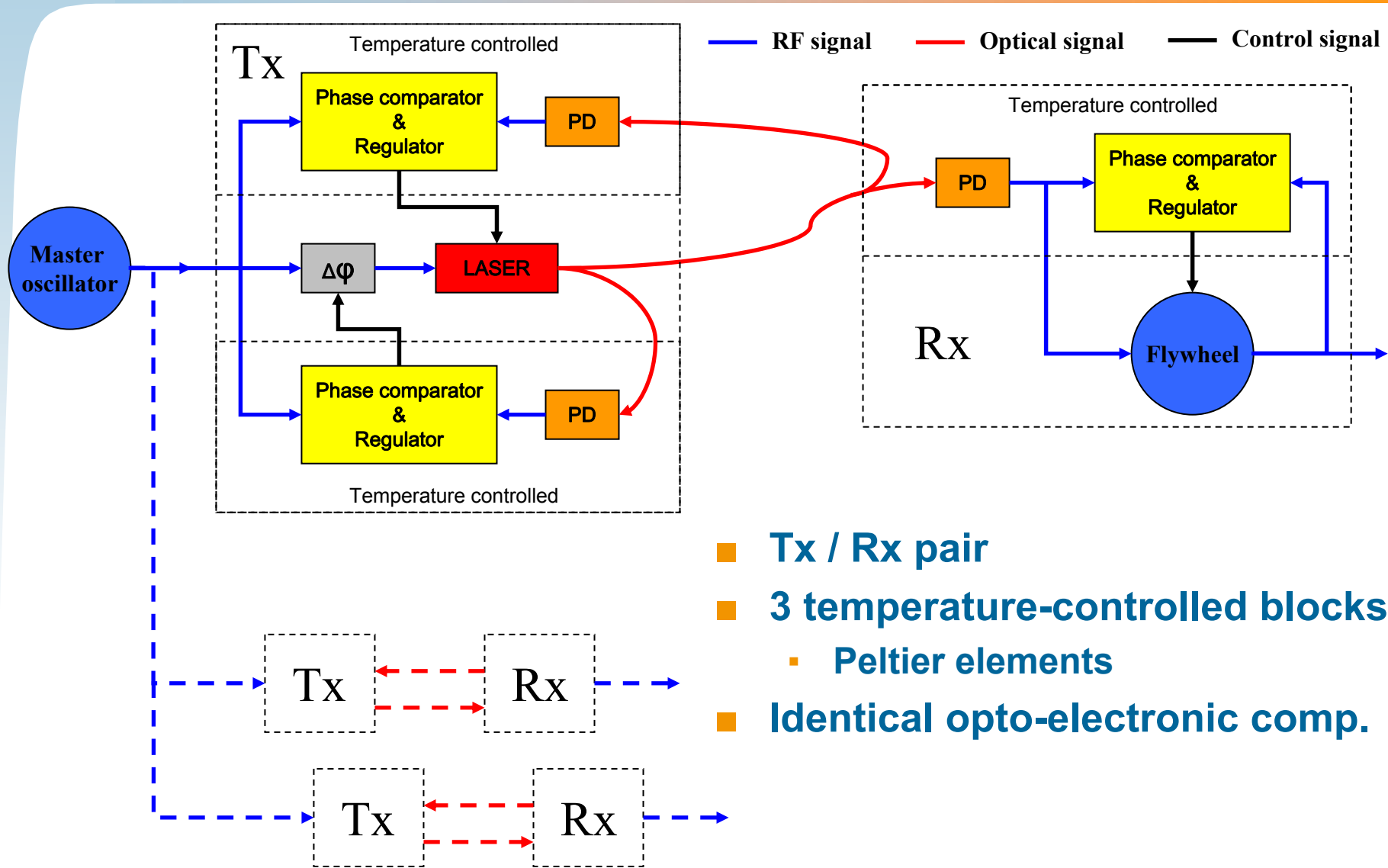


- **Electro-optical synchronization system**
  - Timing distribution & RF synchronization in the accelerator facilities
  - Tx-Rx topology
- **Working principle**
  - RF signal distribution
  - Compensation
- **Measurement results**
- **Industrialization**

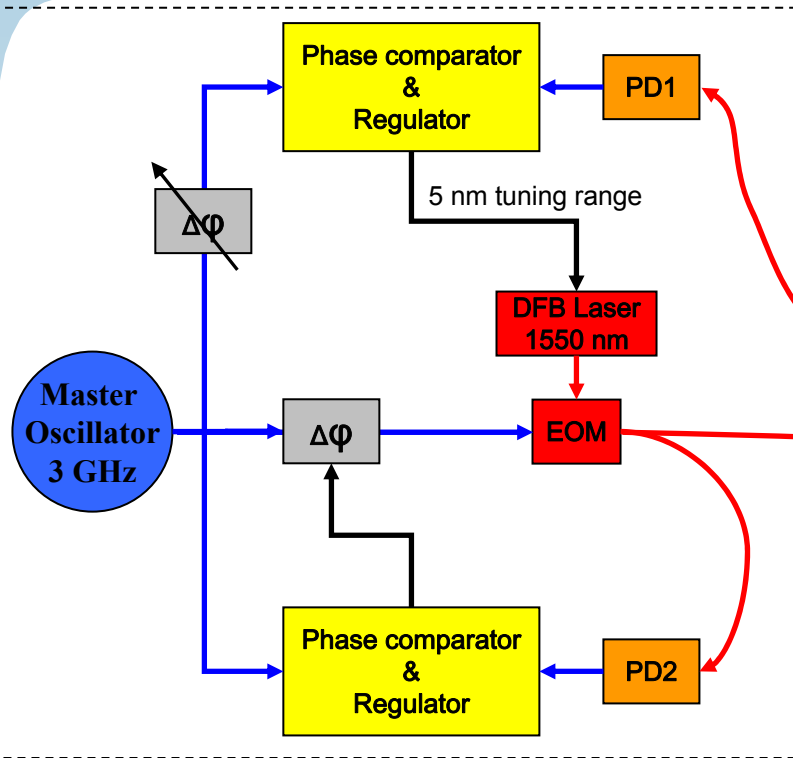


[Sincrotrone Elettra, Trieste]

# System structure



# Working principle

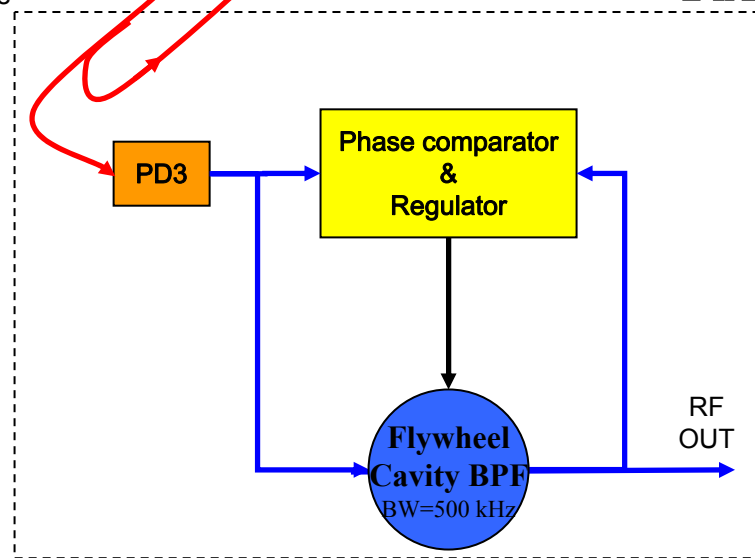
**Tx**


Chromatic dispersion used for corrections:  
**5 nm = 48 ps of time delay = 52° RF phase @ 3GHz = 4°C temp. change**  
 [600 m loop, D=16 ps/nm.km]

$$\Delta T = \frac{c \cdot D \cdot \Delta \lambda}{k_n + n \cdot k_t}$$

Parameters:  $16 \text{ ps/nm.km}$  (D),  $5 \text{ nm}$  ( $\Delta \lambda$ ),  $5.10^{-6} \text{ K}^{-1}$  ( $k_n$ ),  $7.5.10^{-7} \text{ K}^{-1}$  ( $k_t$ )

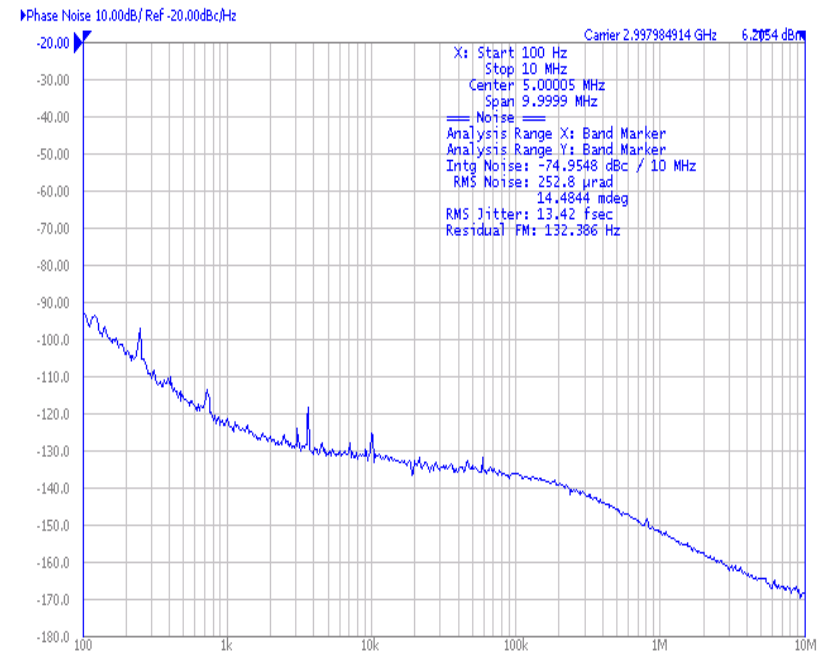
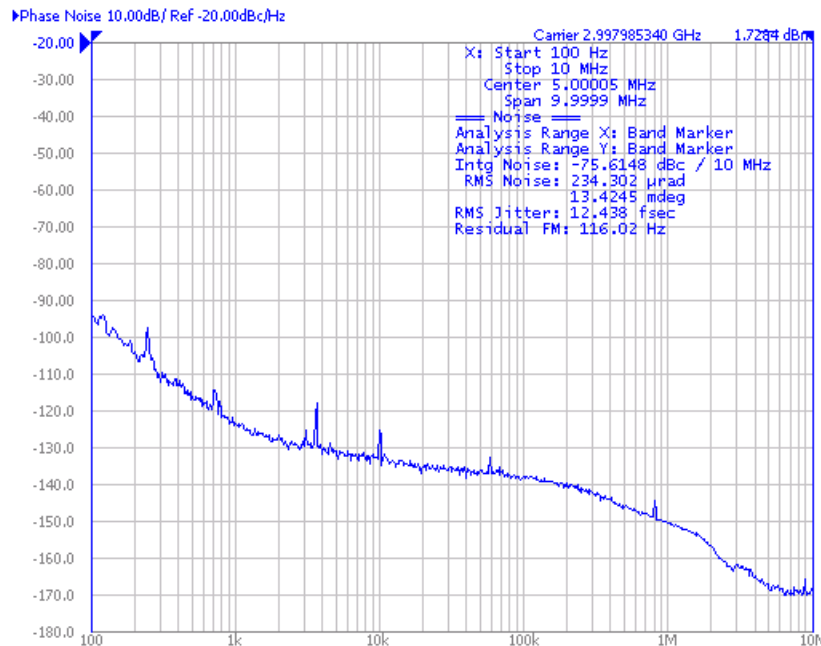
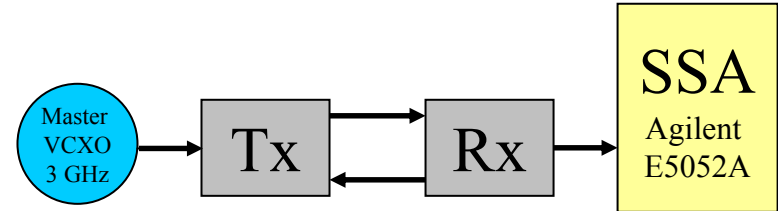
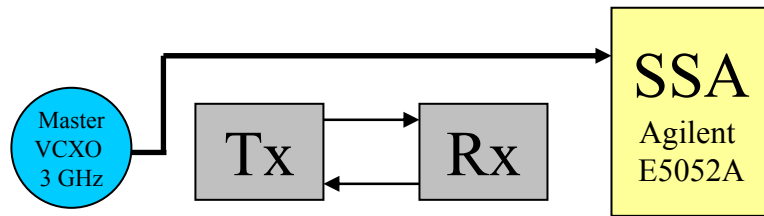
300 m SM fibre pair – duplex cable

**Rx**


PMD in the range of 10 fs  
 [fibre with PMD of 0.02 ps/ $\sqrt{\text{km}}$  is selected]

— RF signal    — Optical signal    — Control signal

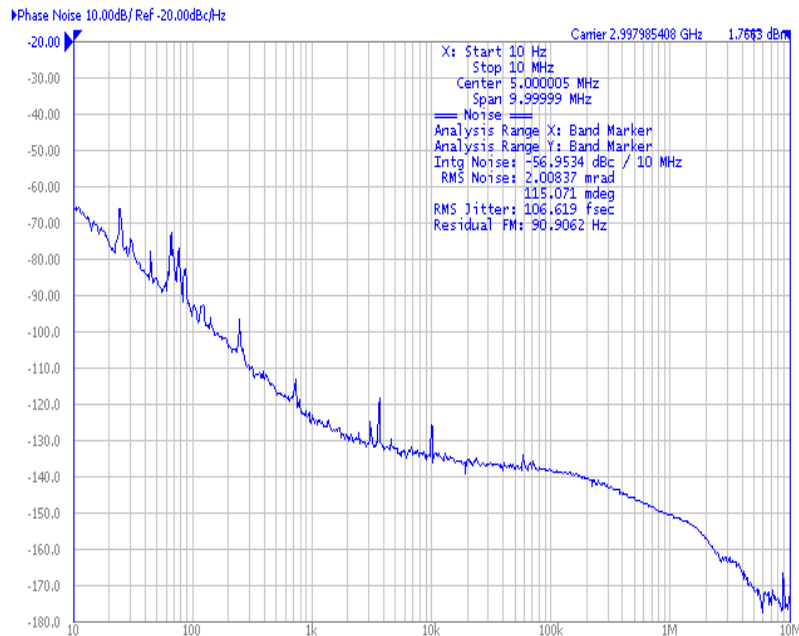
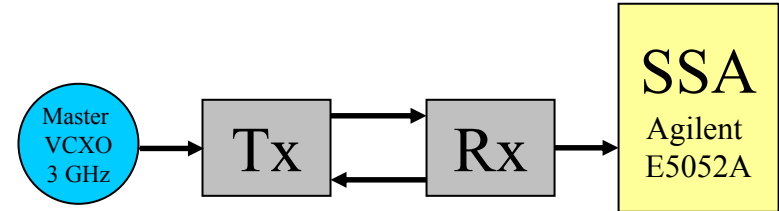
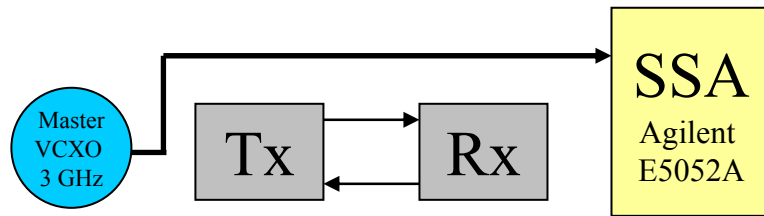
# Measurements 1



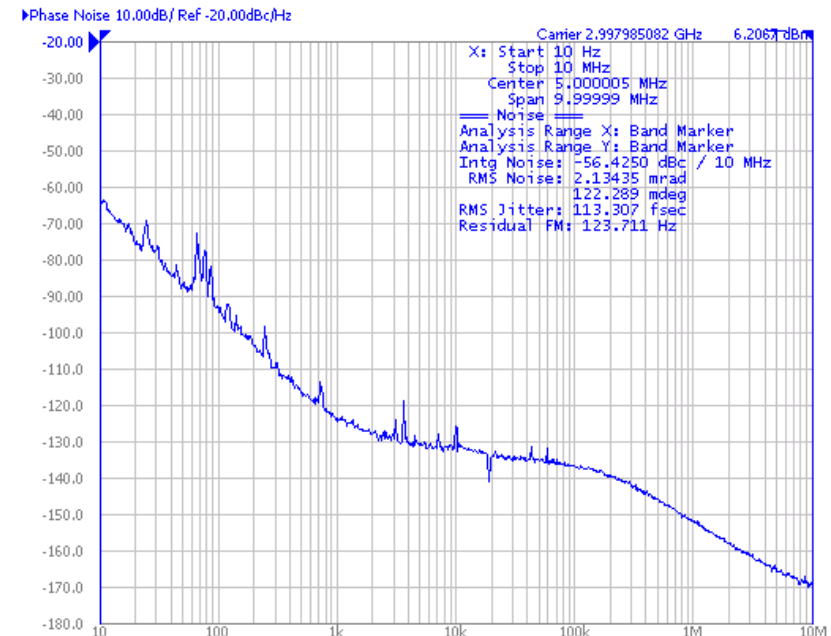
Fibre-link length of 360m placed  
at FERMI@Elettra, Italy

Added RMS jitter = 5 fs  
[100 Hz – 10 MHz]

# Measurements 2



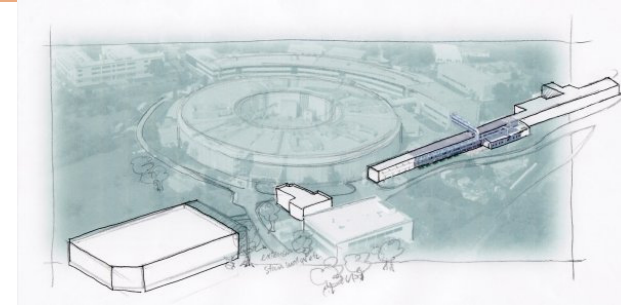
Fibre-link length of 360m placed  
at FERMI@Elettra, Italy



Added RMS jitter = 38 fs  
[10 Hz – 10 MHz]

# Future plans

- **Long-term stability measurements**
  - FERMI@Elettra
- **Extend the locking range of the system**
  - 5 nm => 4°C
  - Additional temperature-controlled fibre spool
  - Piezo controllers
- **One optical fibre**
  - Faraday mirror
- **Extend the distribution-fibre length up to 2 km**
- **Improved on-site and remote control + diagnostics**
- **Industrialization**
  - Instrumentations Technologies & University of Ljubljana



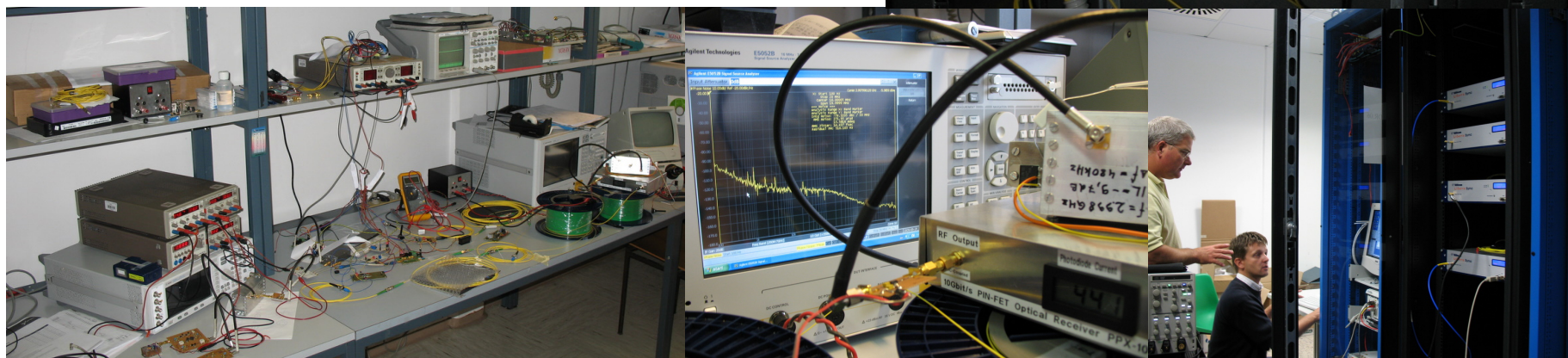
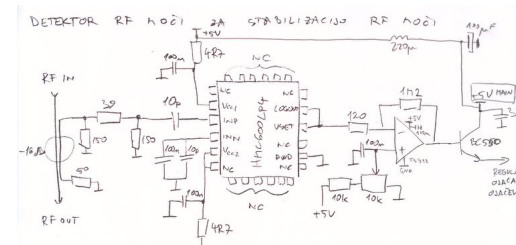
# Industrialization



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## ■ Libera Sync

- 19" 2U form factor (prototypes & regular units)
- Redesign for production is undergoing, including new features
- First units available in January 2010





# Acknowledgments



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- **FERMI@Elettra**
  - Sponsorship for 2 prototypes
  - On-site testing
- **University of Padua, Italy**
  - Optical fibres measurements (PMD)
- **Instrumentation Technologies**
- **University of Ljubljana**



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# Thank You!



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