

19 August 2023

2023 CCPR WG-SP

To: Maria Nadal, NIST, Chairperson for CCPR WG-SP

From: John Lehman, NIST

Subject: TG13, Optical fibre power responsivity (John Lehman)

John Lehman (chair, NIST), Zeus Efrain Gutierrez (CENAM), Marek Šmid (CMI), Jacques Morel (METAS), (others?)

The objectives of the CCPR-WG-SP Task Group 13 are:

- to discuss a pilot study on optical fibre power responsivity to improve calibration uncertainties;
- to create a questionnaire about a pilot study on optical fibre power responsivity for possible additional participants of such a pilot study;
- to organize and carry out a pilot comparison on optical fibre power responsivity using fibre-coupled cryogenic radiometer.

We report some activity and technical progress. There has been exchange of information and extension measurement campaigns among CENAM and CMI and NIST. We continue to learn from the challenges of fibre-based measurements requiring low uncertainty.

Mr. Zeus Efrain Gutierrez of CENAM spent two months at CMI undertaking fibre connector, fibre switching, and other studies relevant to uncertainty of the optical fibre coupled radiometer. Intercomparison has been completed with calibration of two fibre-trap detectors calibrated at NIST, CMI, and CENAM. The results are very difficult to reproduce among the three labs within the expected uncertainty, particularly at 1550 nm.

The results so far emphasize (as we have stated) that that the fibre-connector and switching or splitter stability challenges should not be underestimated, particularly for single photon detectors and quantum networks requiring extremely high coupling efficiency, low loss, and high repeatability. The Optical Fiber Cryogenic Radiometer is sufficiently accurate to reveal fiber-coupling issues over inadequacy of other detection methods.

Some topics worthy of continued consideration:

- Polarisation and PM fibre
- Fibre bending and temperature dependence
- Beam splitter and/or switching ratios
- 1550 nm wavelength to achieve 0.1 % repeatability
- Free space comparisons ongoing at CENAM

Notes from the NIST/CENAM/CMI campaign:

- Measure the switching (SW) ratio multiple times with the same detectors.
 - Changing the attenuation level of the variable optical attenuator can change the SW ratio > 0.8%
- Measure the switching ratio before and after performing every measurement.
- Use only FC/APC bulkhead adapters.
- When possible, use a monitor channel (0.3% improvement).
- Use the fiber scope and clean the fibers frequently!
- The InGaAs trap designated for this campaign was observed to have extremely poor spatial uniformity at the stage of the CMI measurements. This may be the result of aging or shipping damage, but ultimately puts the near infrared measurements into question.