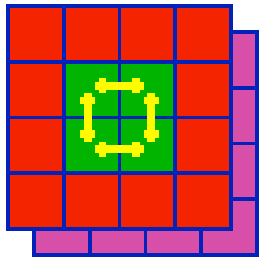
Characterizing FOX Demonstrator Test Setups for LArDPS to FEX Modules at CERN

MICHIGAN STATE UNIVERSITY



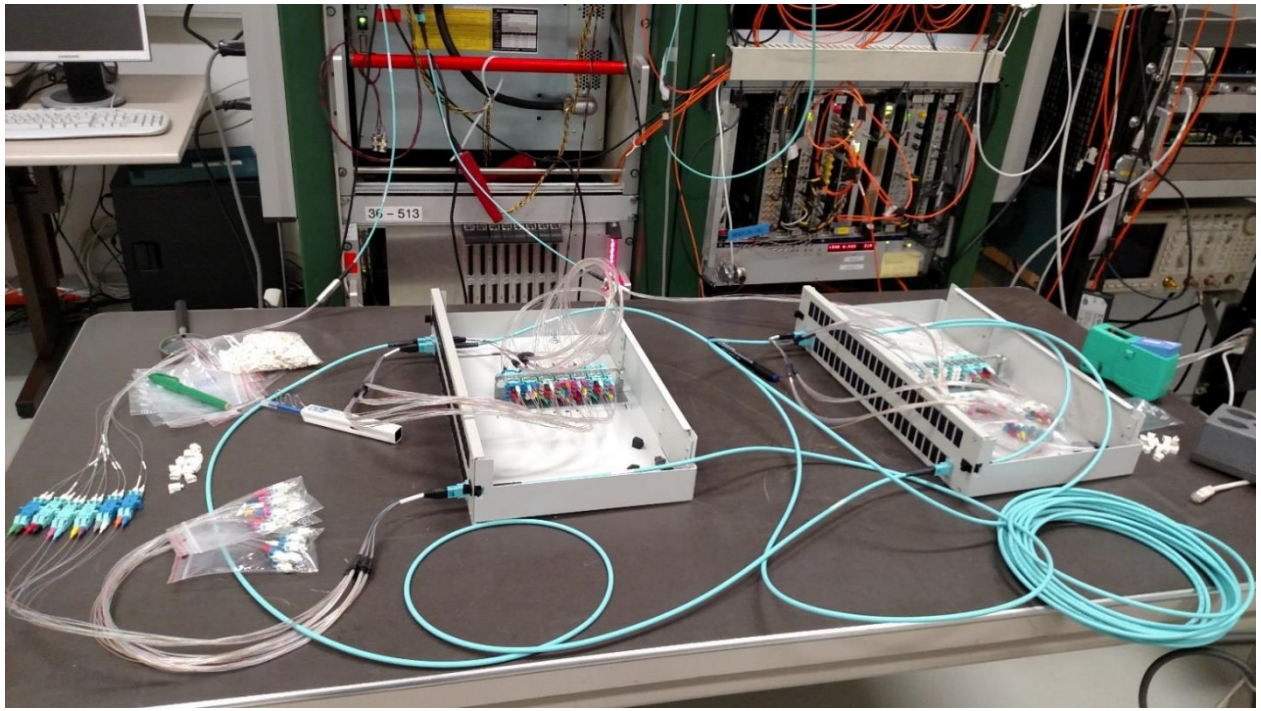
RuthAnn Gregory

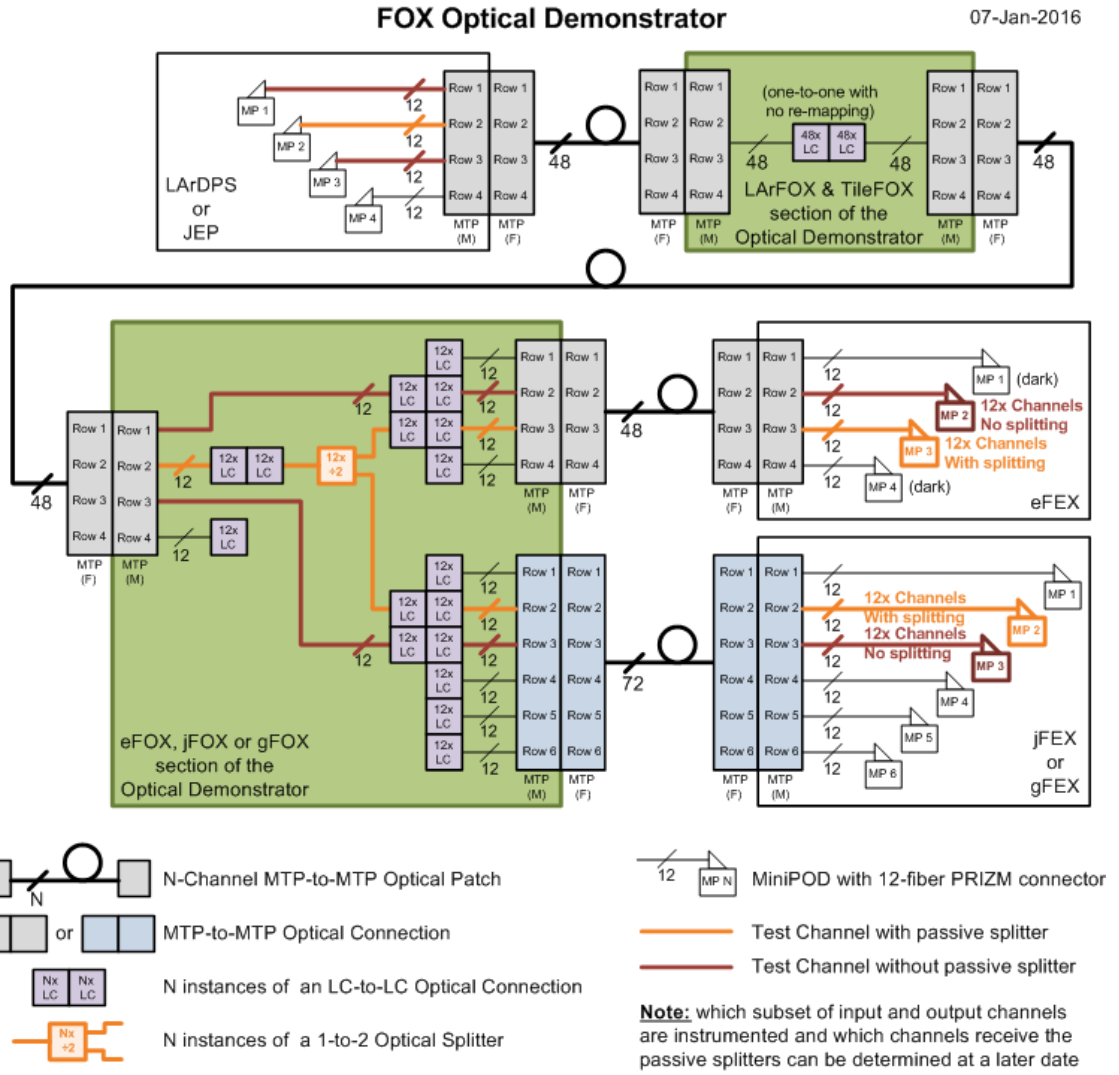
Outline

- FOX demonstrator introduction
- Review conclusions from tests at MSU
- Introduction
- Testing the ‘zero’ reference points for insertion loss measurement procedure
- Measuring the insertion loss for the systems of optical components to be used in the L1Calo system:
  - LArDPS to eFEX test configuration without and with splitters
  - LArDPS to j/gFEX test configuration without and with splitters
- More Tests:
  - Fluke meter vs CMX board
- Conclusions

FOX Demonstrator

- Fiber Optic eXchange (FOX): Refers to an upgrade for the L1Calo system.
- FOX demonstrator was used to test the optical components
- Maximum light loss tolerated by the optical components is ~ 10 dB





Review of tests done at MSU

- Tests were done to better understand the behavior and reproducibility of the components (MiniPods, cables, attenuators, splitter, etc.) that the FOX and L1Calo will be using.
- The light output and input measurements show similar reproducibility and stability under different conditions (different temperatures, before/after cleaning, etc.)
- Receiver optical power variations:
  - 0.2 dB for disconnecting and reconnecting MTP connectors
  - 0.2 dB for a temperature increase from 36.4 to 38.2°C
  - 0.9 dB from one MiniPod channel to another
  - .4 dB from disconnecting, cleaning, and reconnecting

Review of tests done at MSU

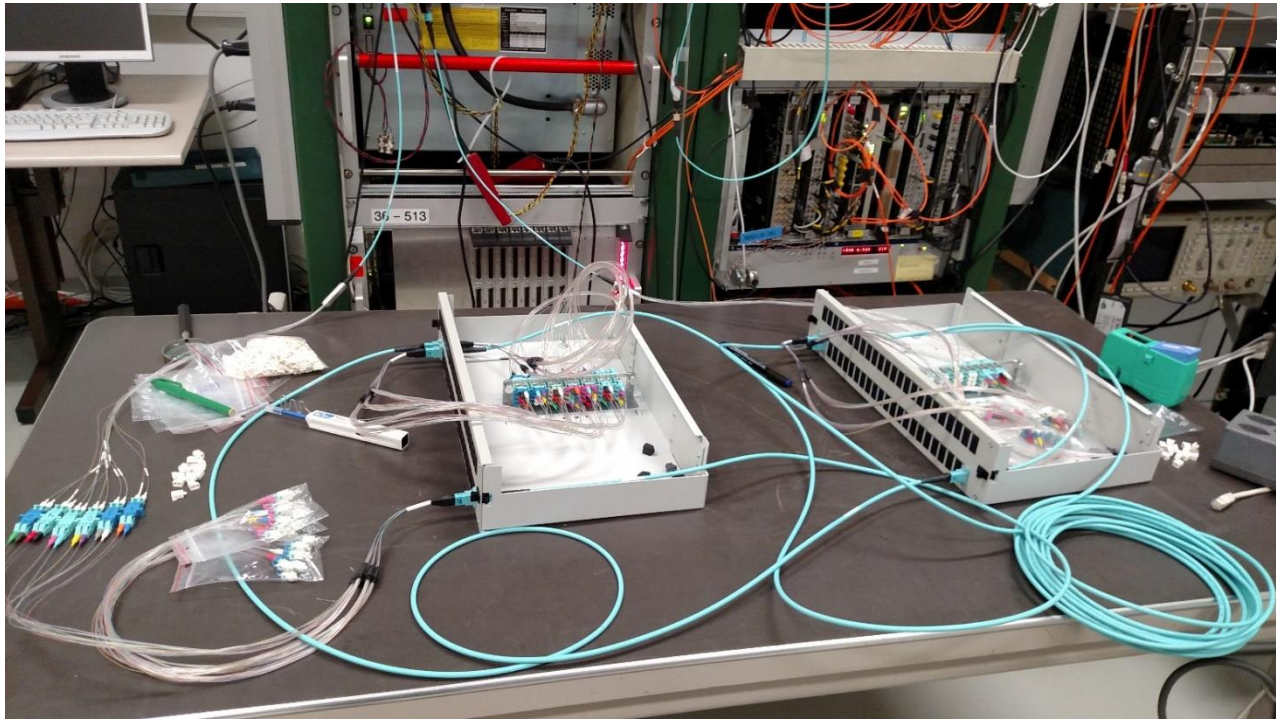
- The attenuator measurements are not very reproducible.
  - Manufacturer specifications, and measurements done with Fluke and CMX yield different results
- The splitter behaves as expected:
  - Measures about 3dB loss for each output
  - Outputs are split about 50%
- Next Step (in progress): Bit Error Tests
  - Empirical measurement of the “light power budget”
  - Characterization of the steepness of that empirical limit.
  - Synchronization is lost at around 10 dB of attenuation

FOX Demonstrator Tests

- Motivation:
  - To measure the insertion loss of the systems of optical components that will be used in the L1Calo system.
- Purpose of measurements of test setups for LArDPS to FEX modules:
  - To fully characterize the FOX demonstrator.
- Purpose of tests with Fluke meter:
  - To explore the stability and reproducibility of the system using a different measuring device.

FOX Demonstrator Tests at CERN

- In order to make insertion loss measurements a reference or ‘zero’ offset measurement needs to be measured.



Actual setup for LArDPS to eFEX FOX demonstrator

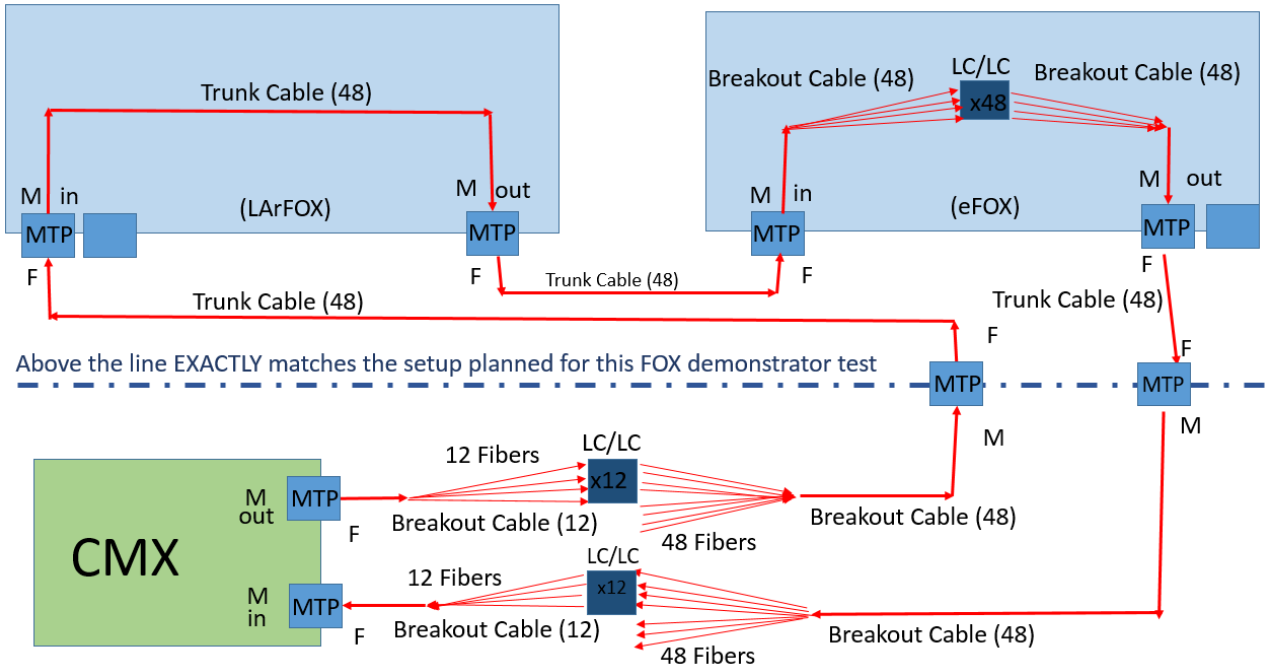
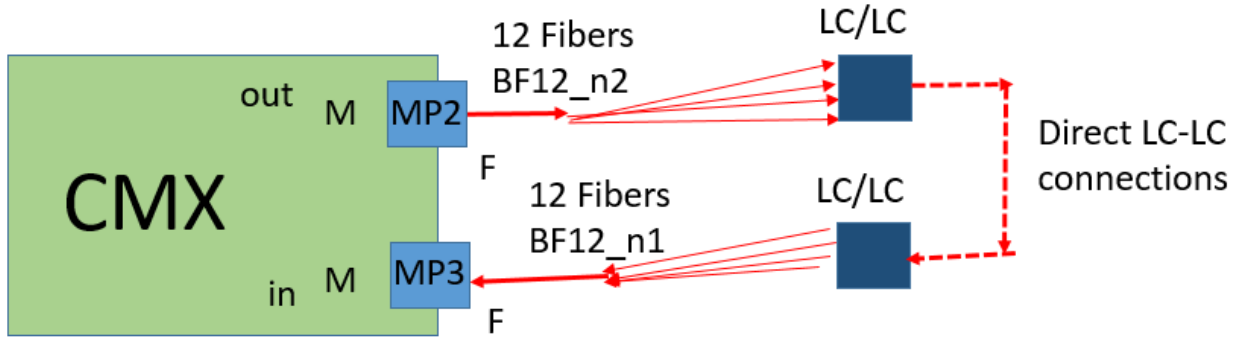


Diagram for LArDPS to eFEX FOX demonstrator (details to be explained later)

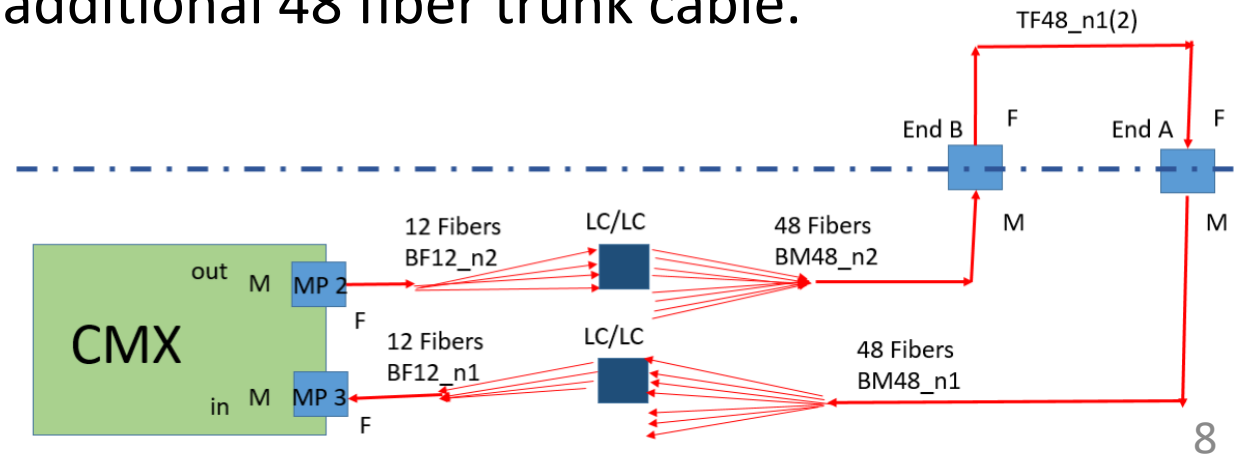
Testing the ‘zero’ reference points for insertion loss

- These references were used in the light loss calculations.
- Two configurations of the ‘zero’ reference points were used.
- A defective fiber was found on one of the breakout cables. This defect is in the breakout cable and is not part of the FOX.

Configuration 1: Two 12 fiber breakout cables with direct LC-LC connections

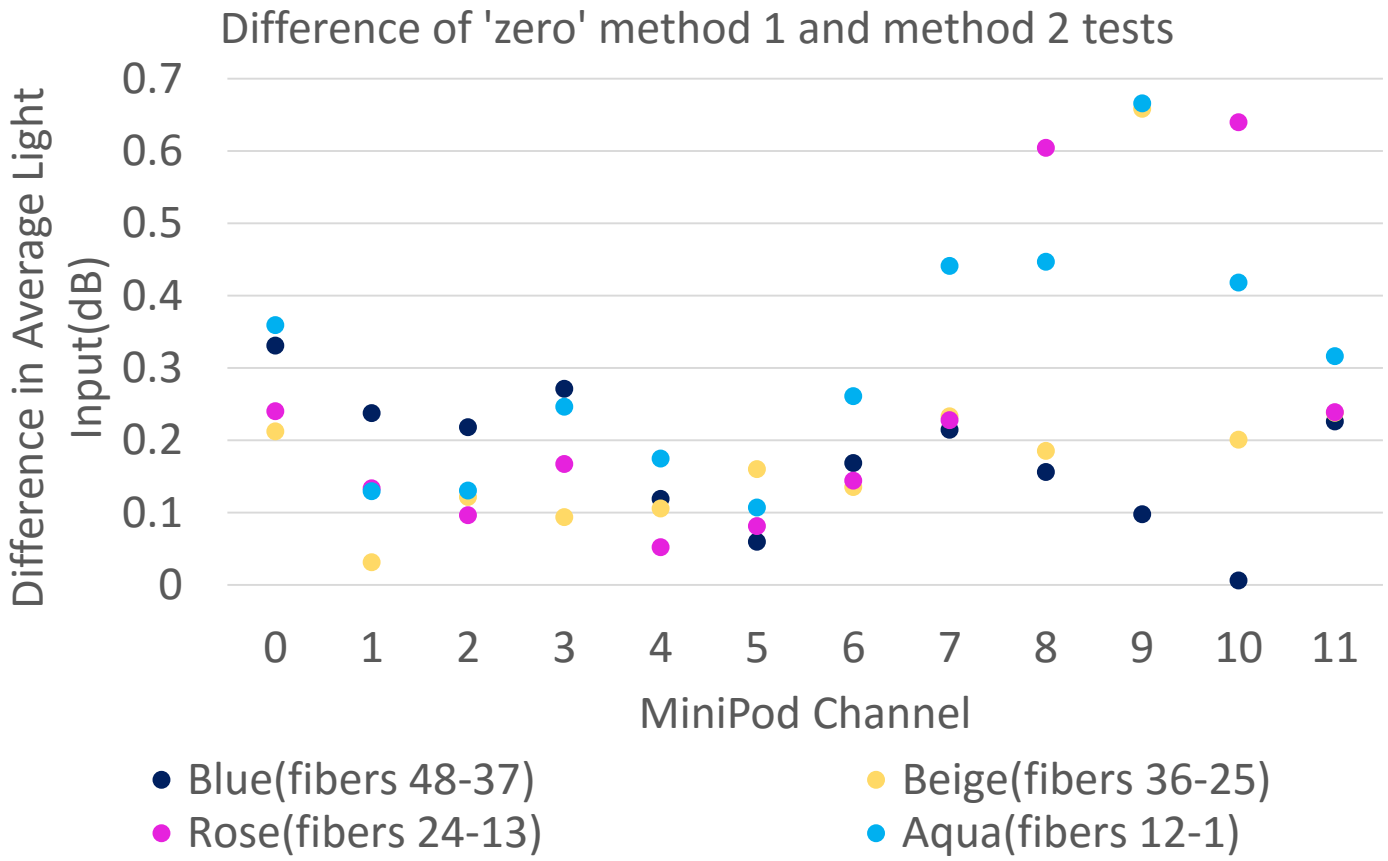


Configuration 2: Configuration 1 with two additional 48 fiber breakout cables and one additional 48 fiber trunk cable.



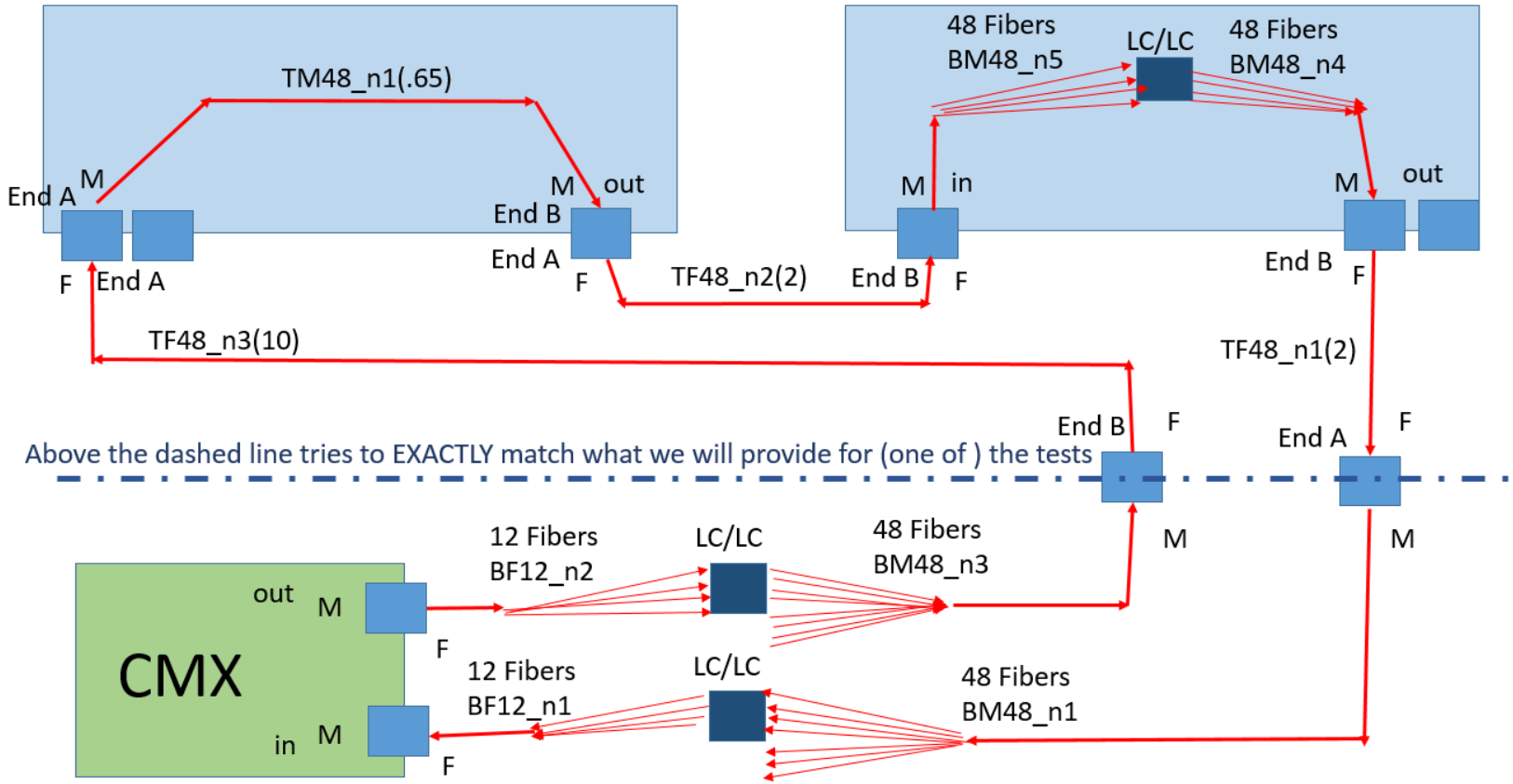
Testing the ‘zero’ reference points for insertion loss

- One of the 48 fiber breakout cables used in this setup had bad fiber on a breakout cable with significantly more light loss than the rest of the fibers
- This fiber is omitted from the plot shown here.
- Plot shows very little light loss through two 48-fiber MTP connectors + one LC connector
- Sets the scale for the light loss to expect from two 48 fiber MTP connections.



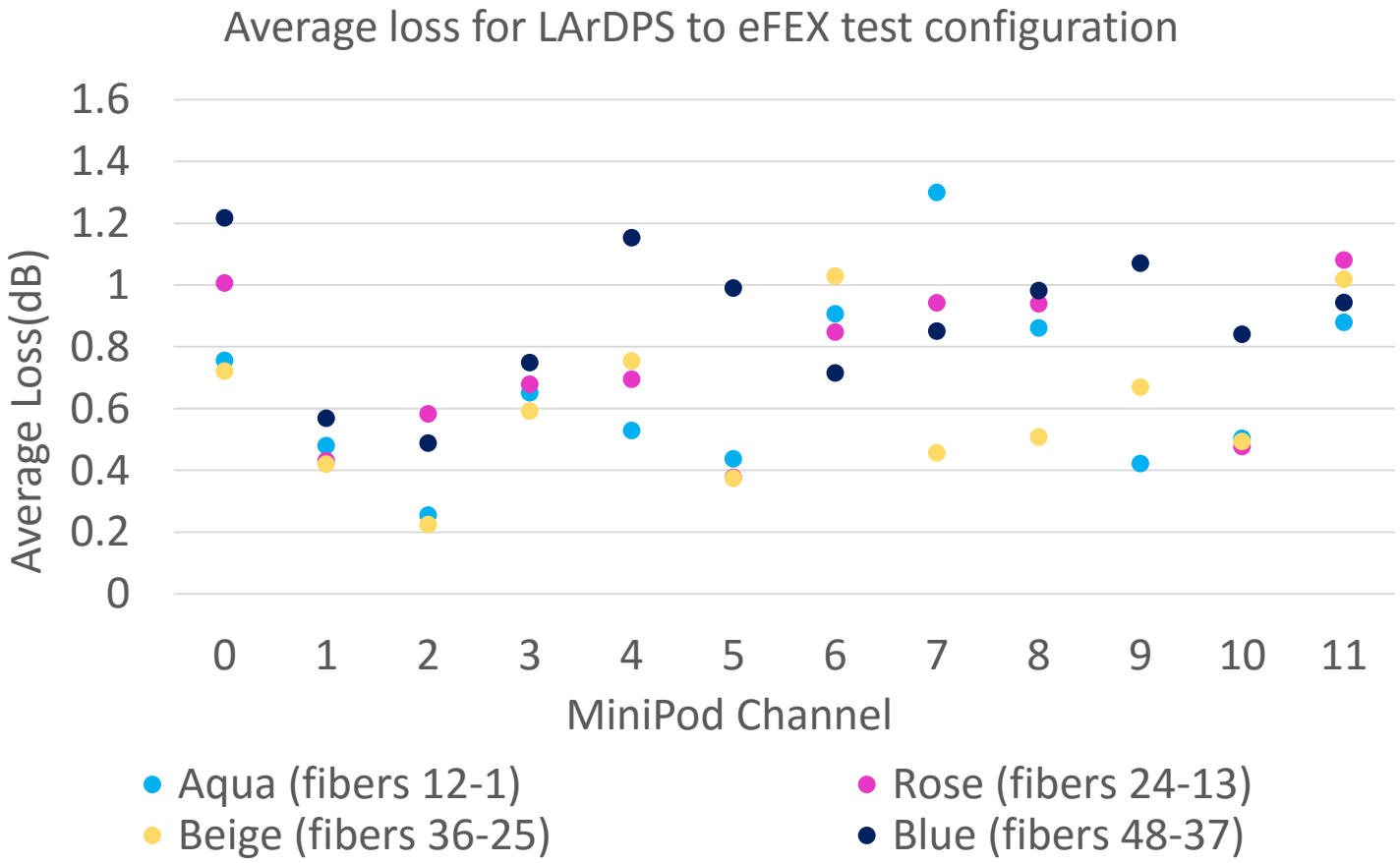
LArDPS to eFEX test configuration without splitters

- The diagram below shows the test configuration used including specific cables and connectors.



LArDPS to eFEX test configuration without splitters

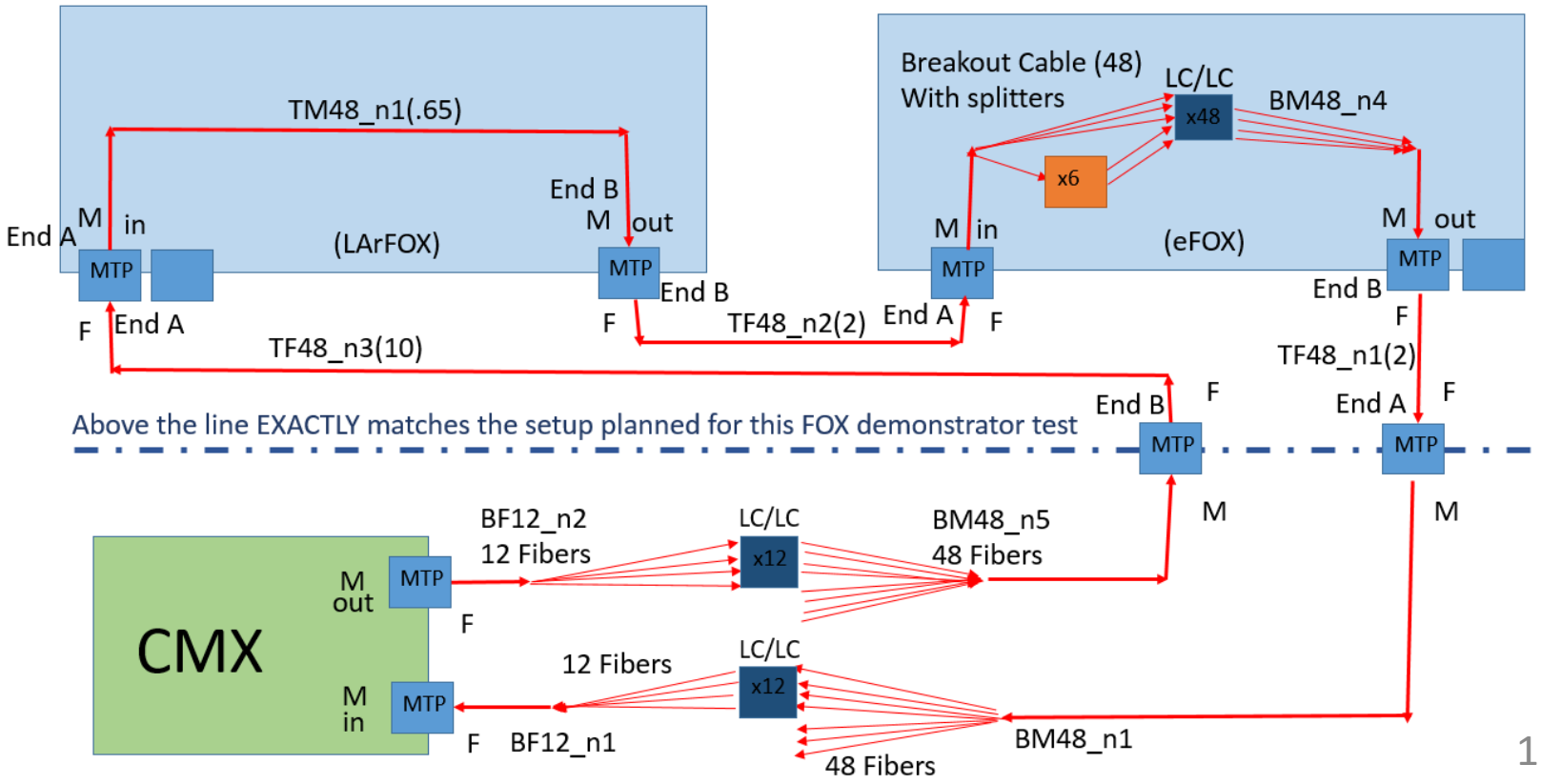
- The outlier from the bad fiber was omitted from this graph.
- A very small amount of light loss (about 0.2-1.4 dB) was measured for this setup.
- This is compatible with and reinforces the results from slide 9.



LArDPS to eFEX test configuration with splitters

- The configuration with splitters uses a 48 fiber breakout cable with three built-in passive splitters as part of one group of 12 fibers

- Three built-in passive splitters plus three discrete splitters were used to split the fibers for one group of 12 fibers in the special 48 fiber breakout cable.

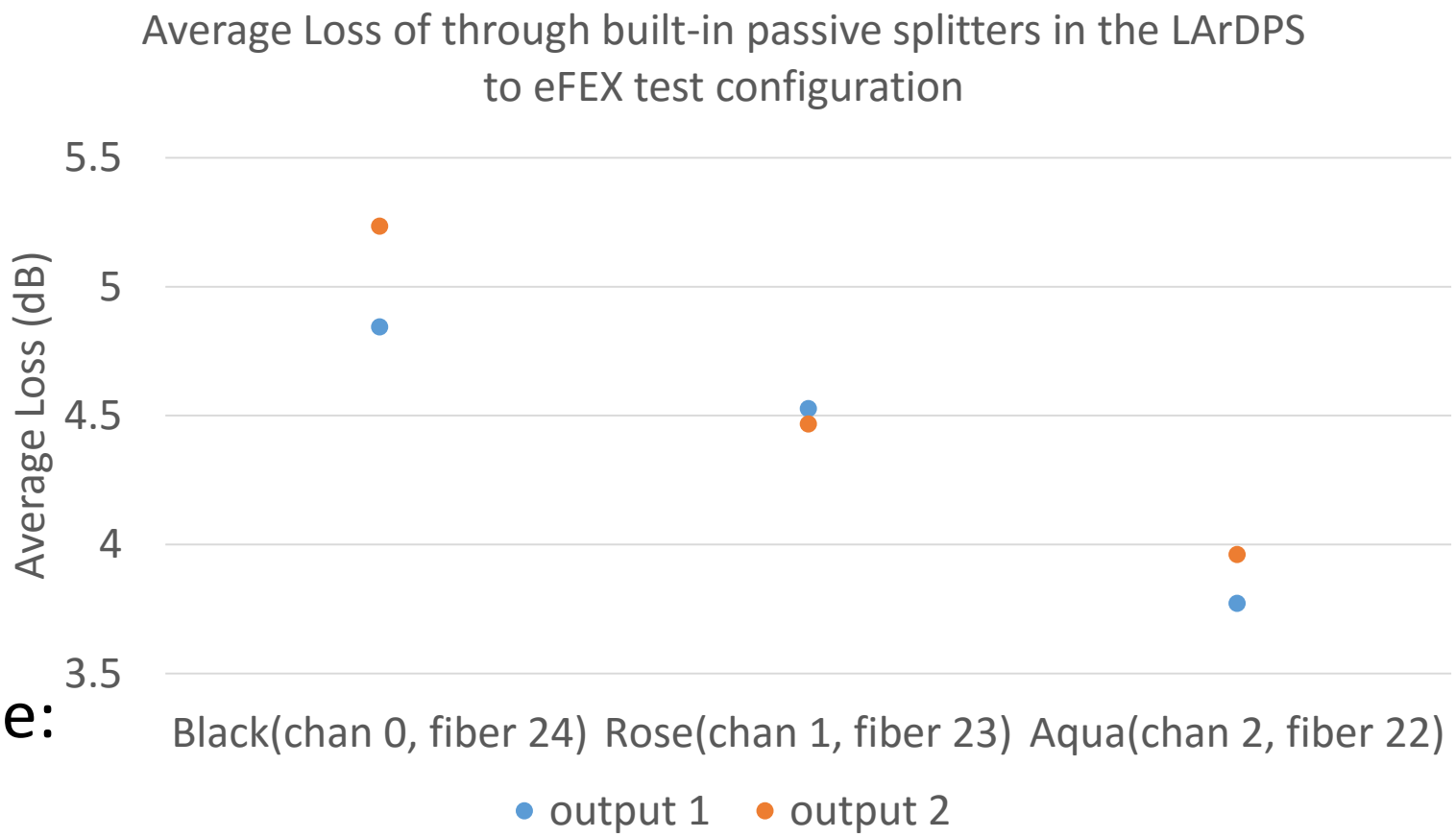


LArDPS to eFEX test configuration with splitters

- Plot shows light loss through LArDPS to eFEX test setup plus loss through built-in splitters.

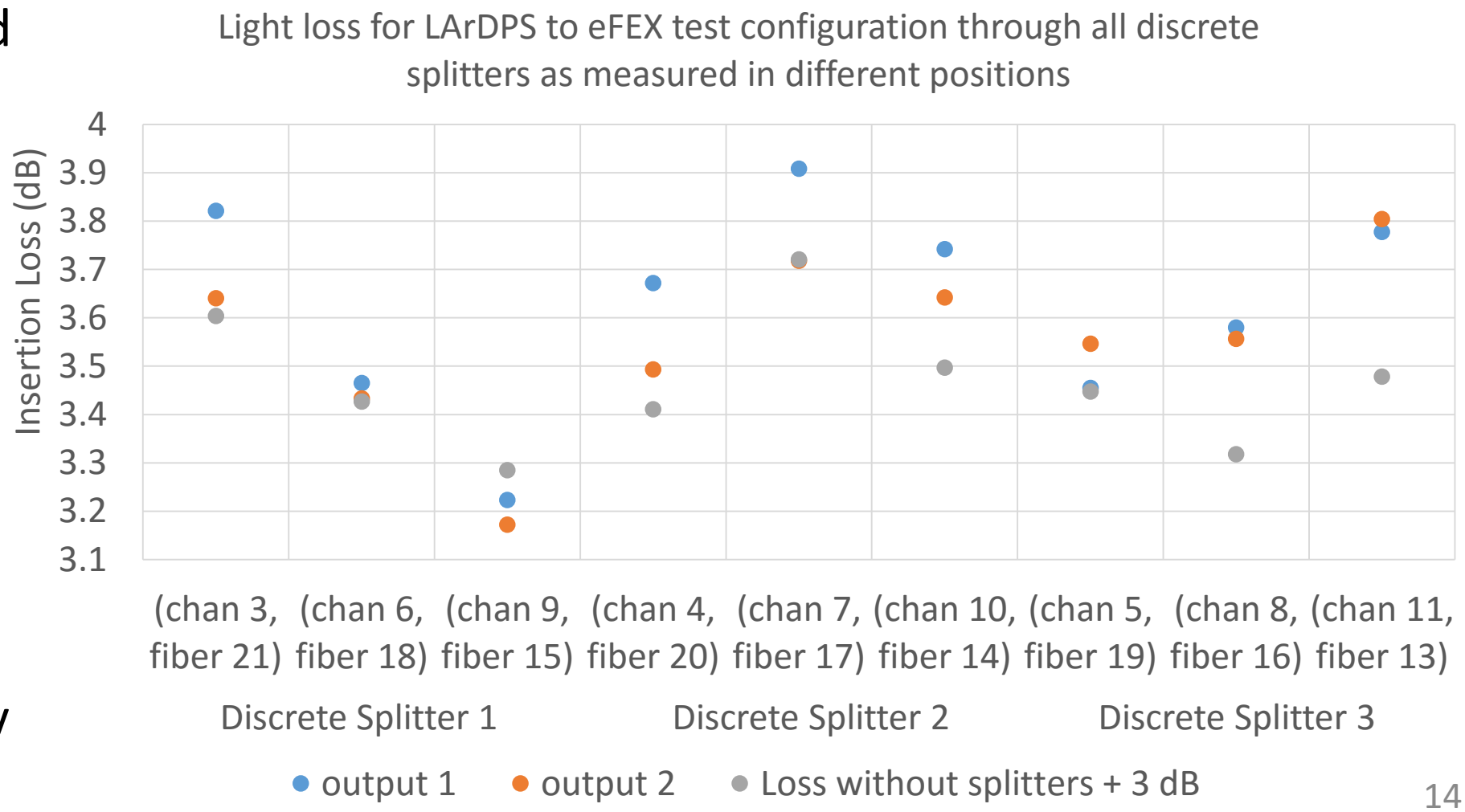
- Expected loss for splitters is about 3dB per output
- The amount of light loss was similar between the two outputs

- Individual discrepancies for splitters is expected. Example: ± 0.3 dB corresponds to a 53/47% split.



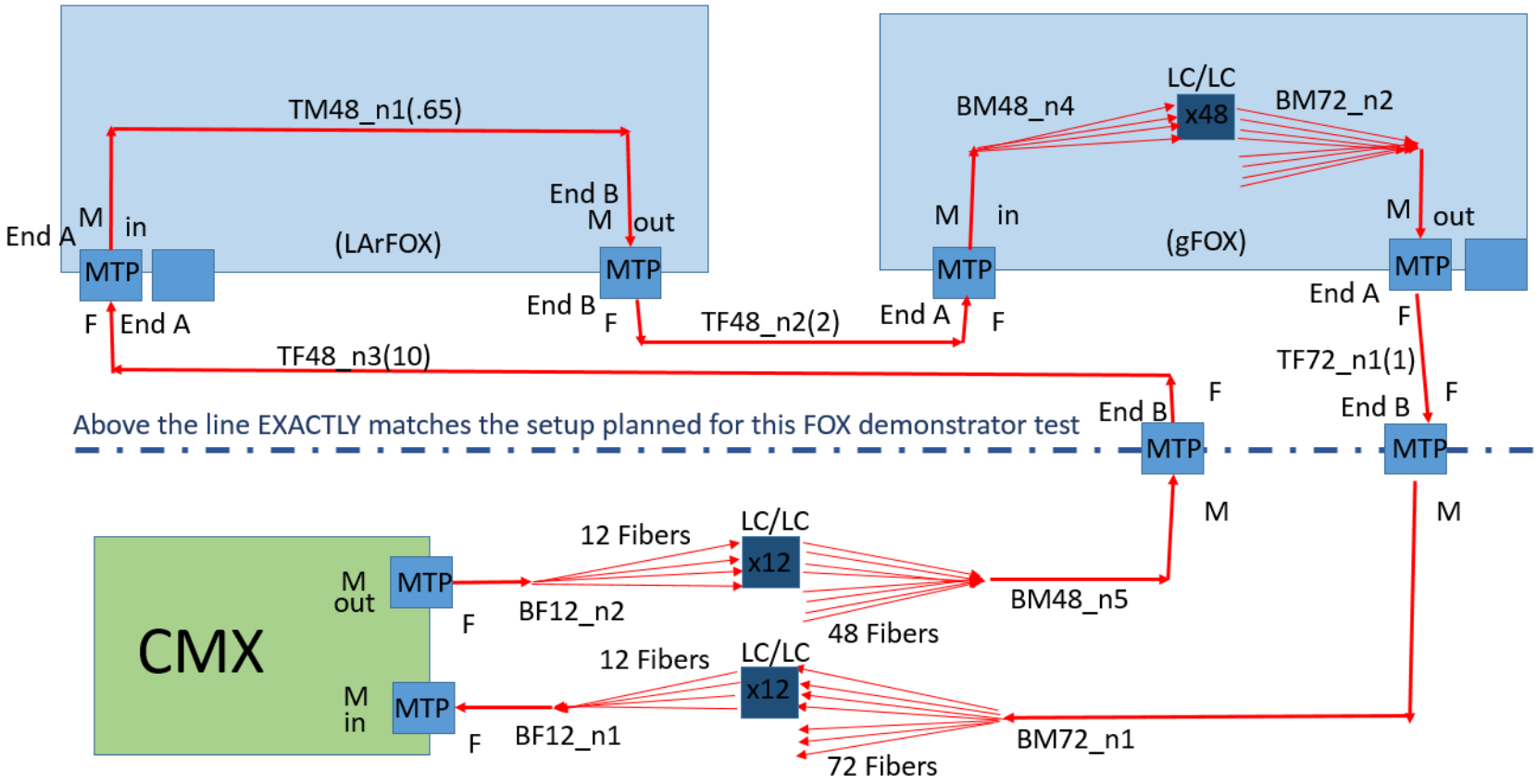
LArDPS to eFEX test configuration with splitters

- Insertion loss from three discrete splitters was measured in different positions.
- First, second and third group of three positions were measured by discrete splitters 1, 2, and 3, respectively.
- Discrete splitters add roughly 3 dB of light loss.
- Measurements can vary with position by up to about 0.3 dB.



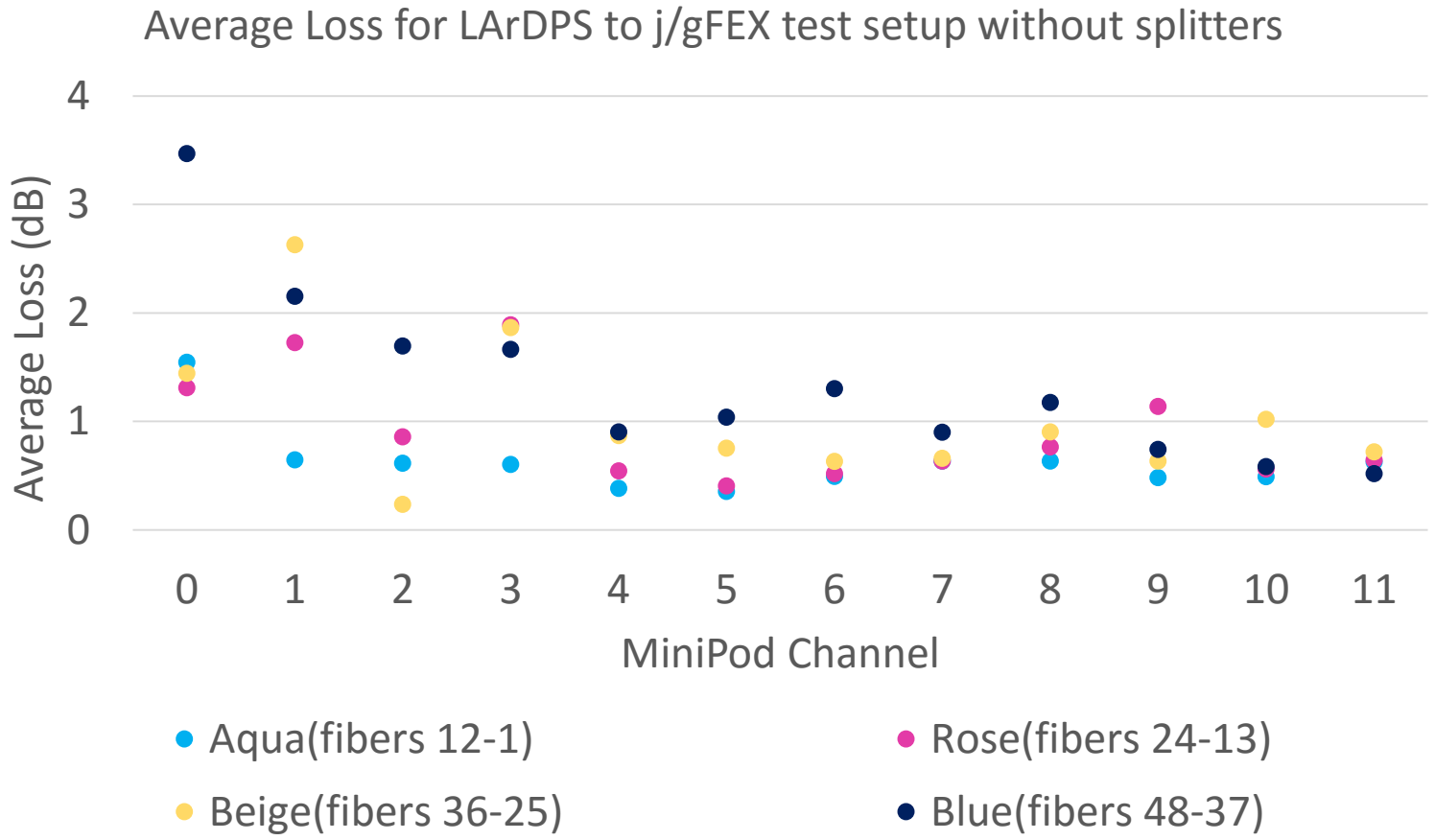
LArDPS to j/gFEX test configuration without splitters

- This configuration makes use of 72 fiber cables.



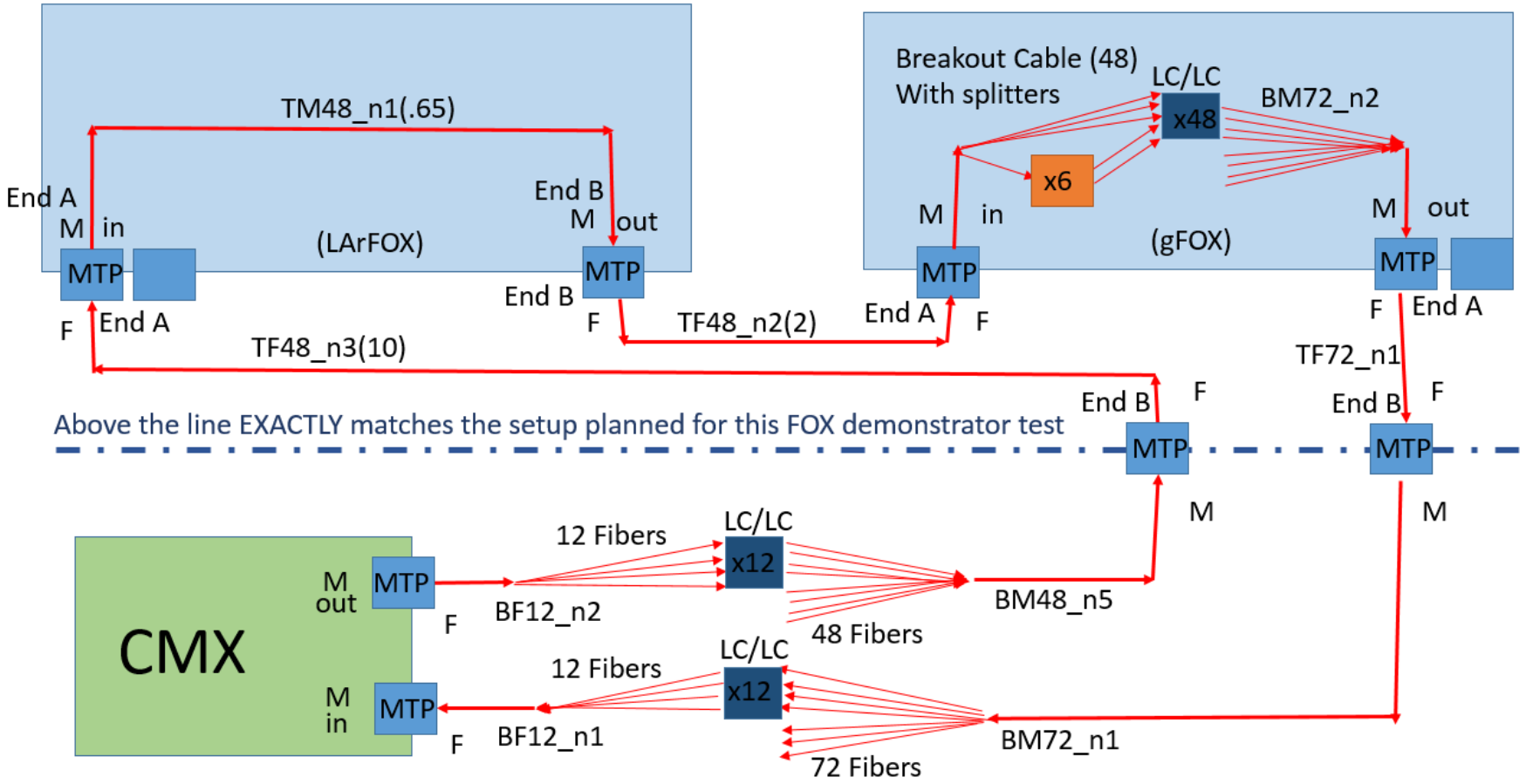
LArDPS to j/gFEX test configuration without splitters

- Most fibers in this setup continue to measure very little light loss.
- Some fibers near one side of the connector measure a larger amount of light loss



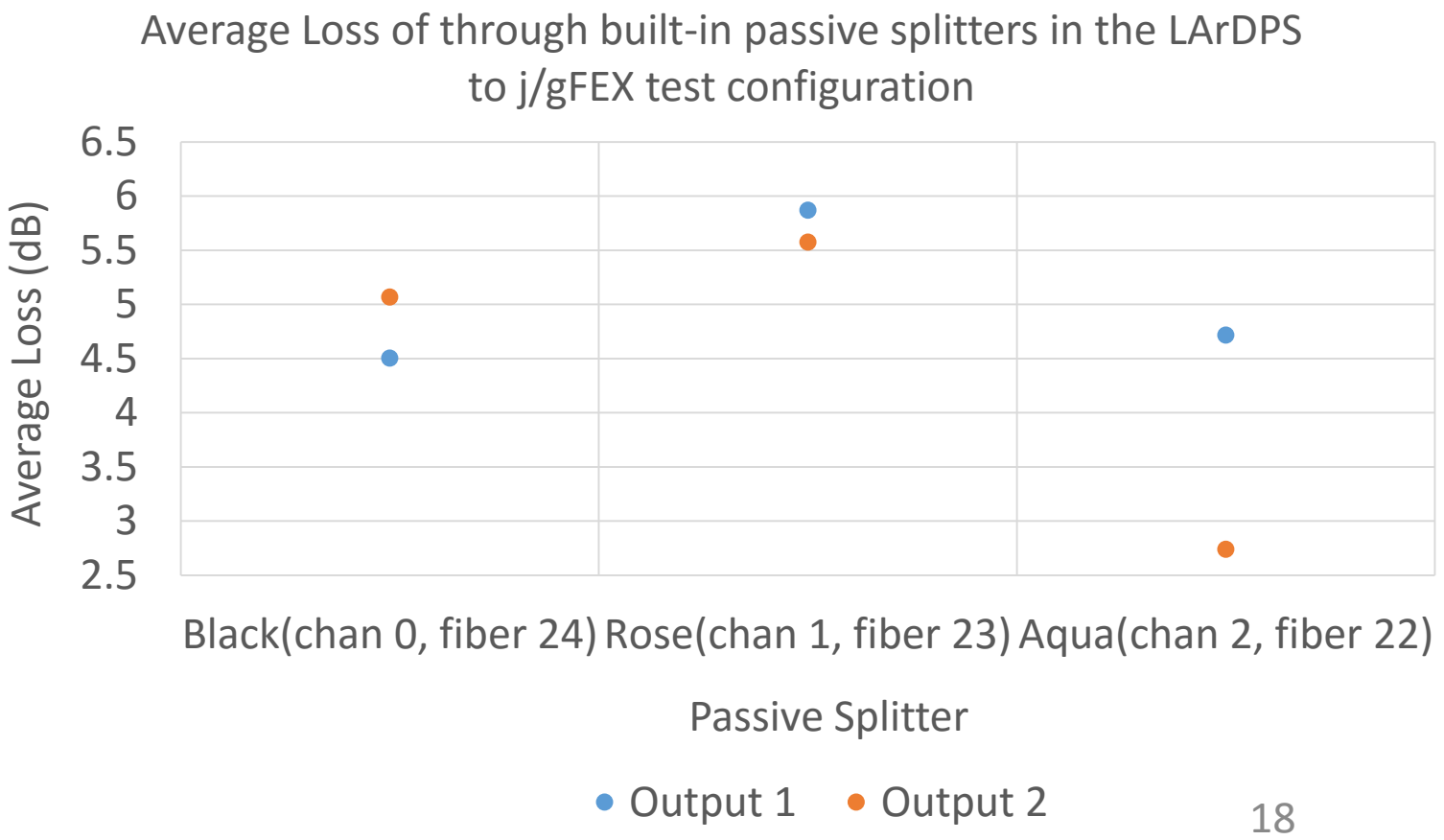
LArDPS to j/gFEX test configuration with splitters

- As before, the 48 fiber breakout cable with built-in passive splitters and discrete splitters were inserted into the light path.



LArDPS to j/gFEX test configuration with splitters

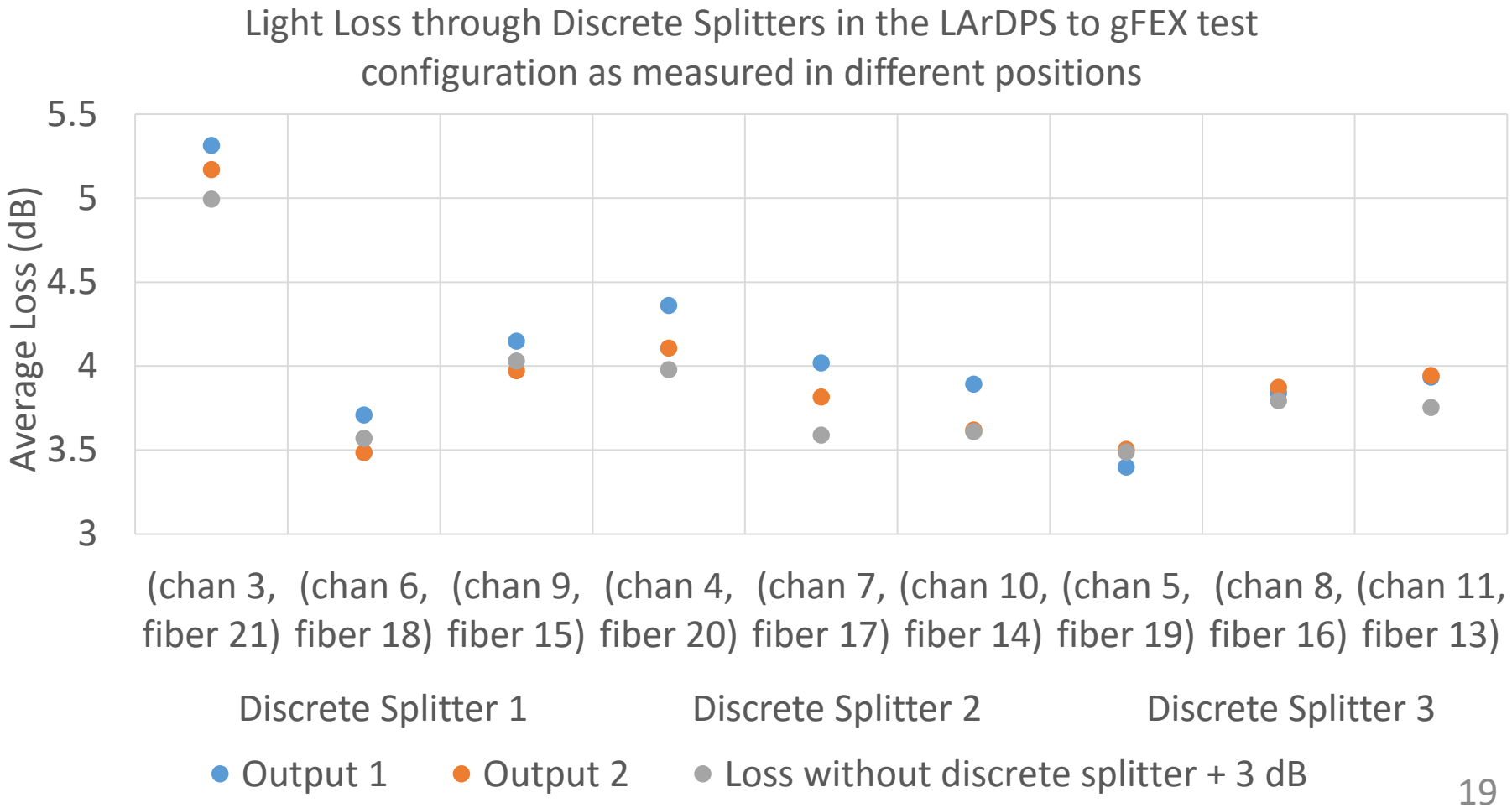
- As before, the light loss through the built-in passive splitters was significantly higher than the light loss without splitters.
- The Black and Rose built-in passive splitters measure similar light loss for both outputs.
- Output 2 on the Aqua built-in splitter measured about 2dB less light loss than output 1 (even though it is the same splitter as on slide 13)



LArDPS to j/gFEX test configuration with splitters

- The discrete splitters typically add about 3 dB of insertion loss as expected.

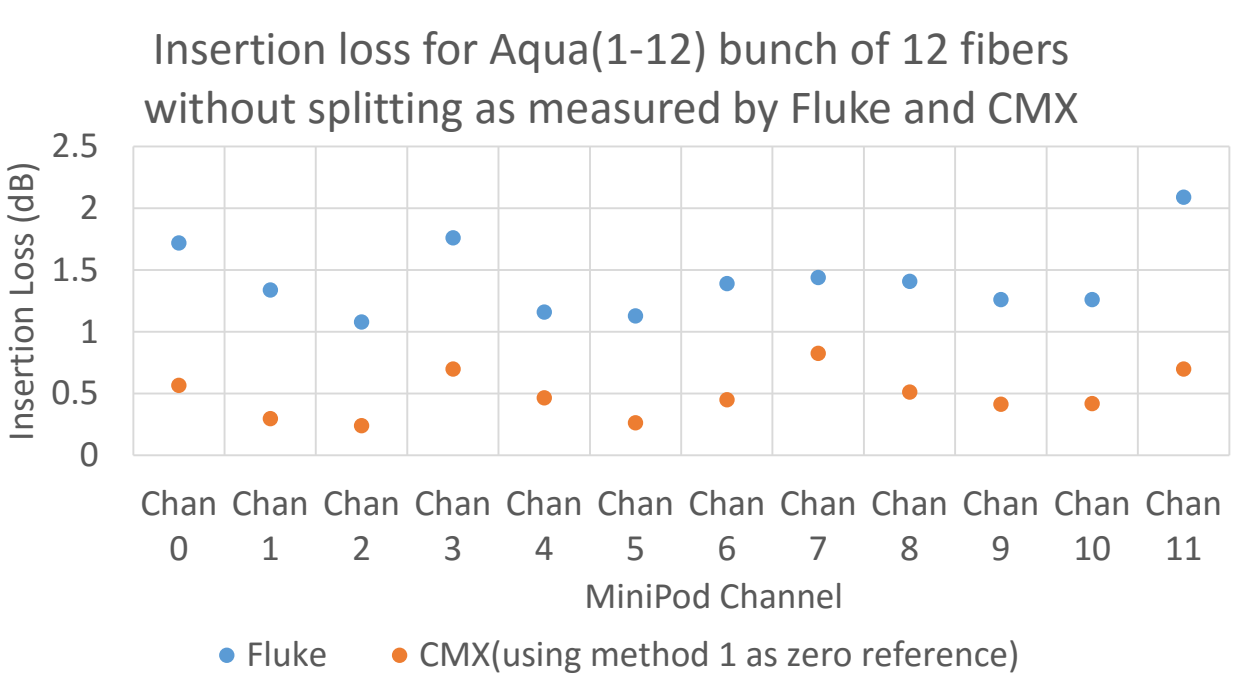
- Channel 3 shows higher light loss than the rest of the channels, which is attributable to the higher light loss measured on channel 3 without splitters shown on slide 16.

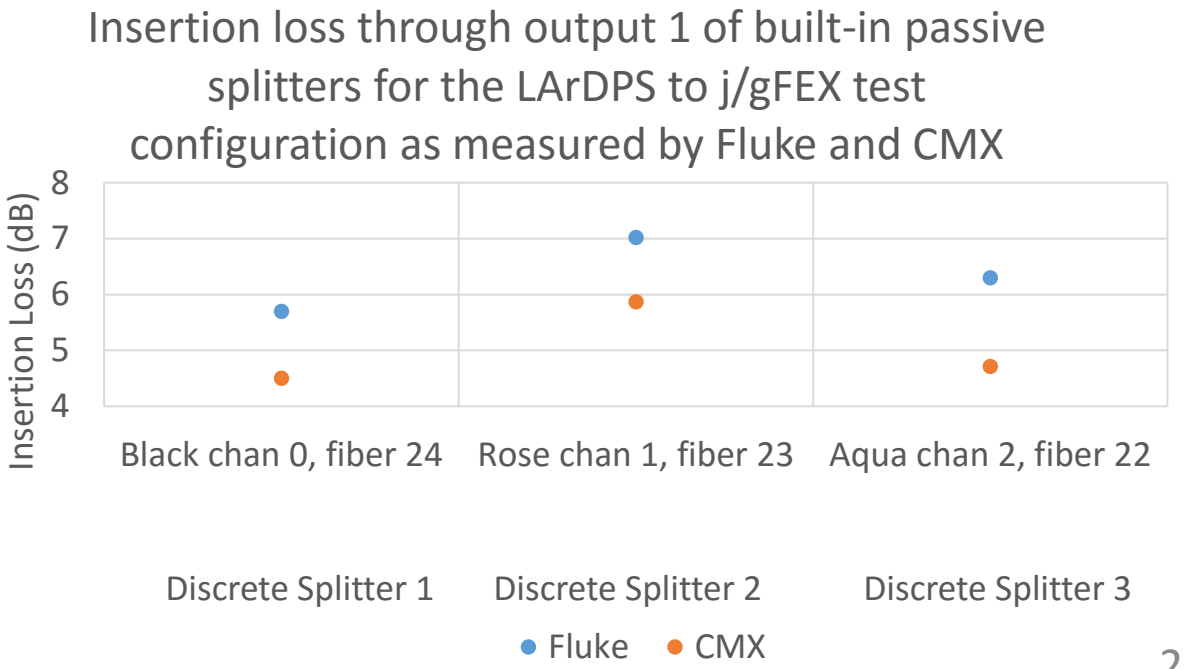


Fluke laser light source and light meter

Fluke Meter Tests

- Fluke meter light loss tests were done for the LArDPS to eFEX configuration without splitters and for the LArDPS to gFEX configuration with splitters using the ‘zero’ method 1 as the reference.
- The light loss measurements with the Fluke meter were consistently higher than the measurements with the CMX module.





Conclusions

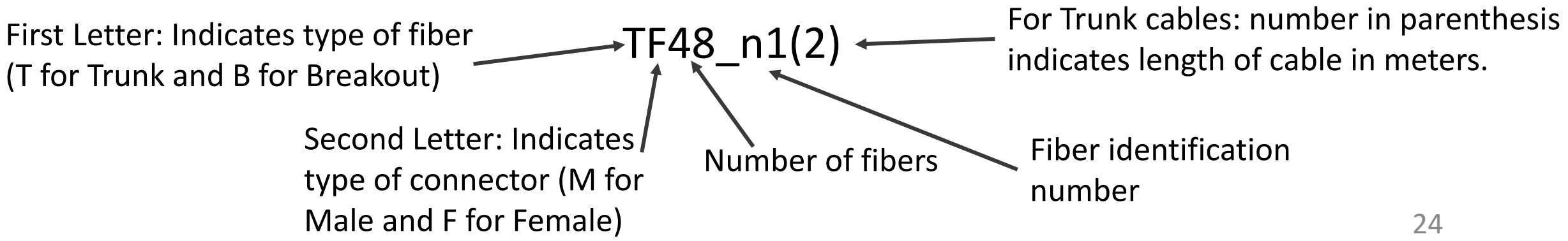
- Measurements were made with FOX demonstrator that mimic the systems of fibers and connectors to be used to map optical signals in the L1Calo system.
- The insertion loss through the FOX demonstrator was very small, most fibers had between about .2 and 1.5 dB of insertion loss (with the exception of two defective fibers).
- The splitters behaved as expected with about 3 dB light loss for each output.
- The Fluke meter consistently measured about 1 dB more light loss than the CMX module. (similar to the results of the tests done at MSU).

Backup Slides

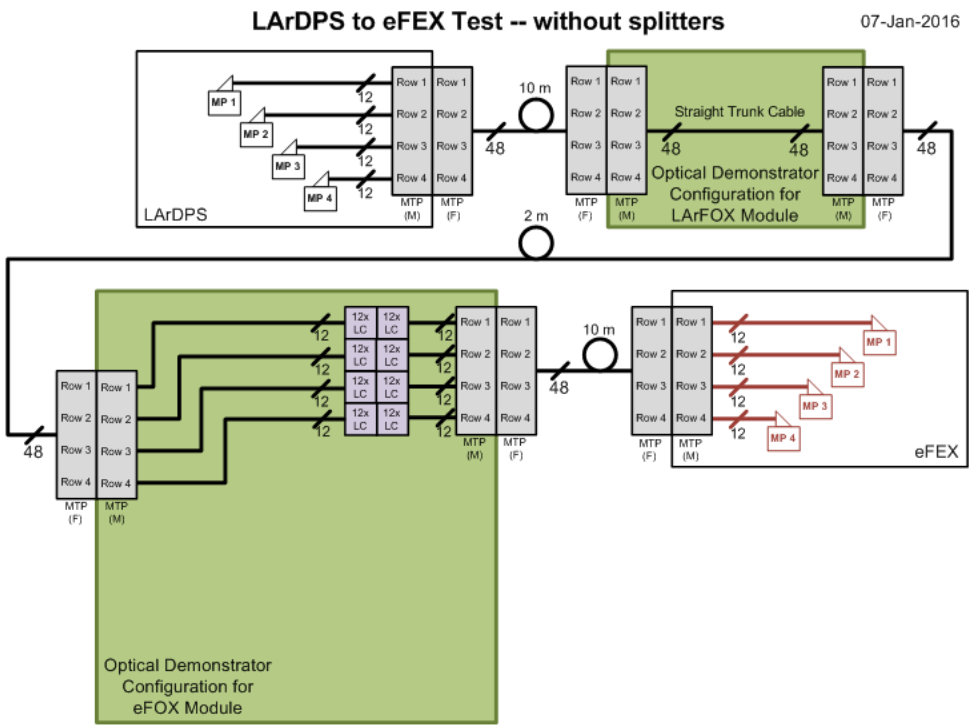
FOX Demonstrator Tests Notation

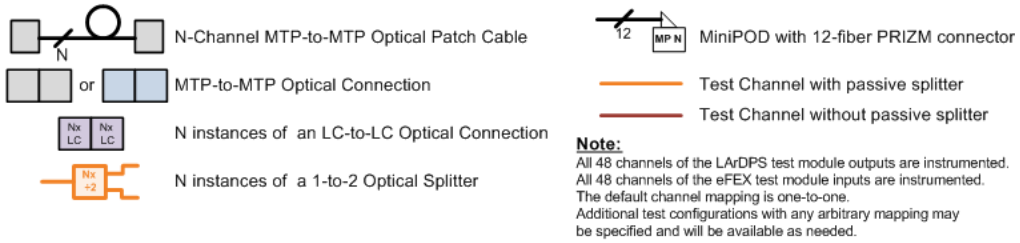
- In the 48 and 72 fiber cables, four groups of 12 fibers were used.
- These groups are referred to by color and relative position:
  - Aqua group of 12 fibers, contains fibers in positions 1-12.
  - Beige group of 12 fibers, contains fibers in positions 13-24.
  - Rose group of 12 fibers, contains fibers in positions 25-36.
  - Blue group of 12 fibers, contain fibers in positions 37-48.

Fiber naming convention example:

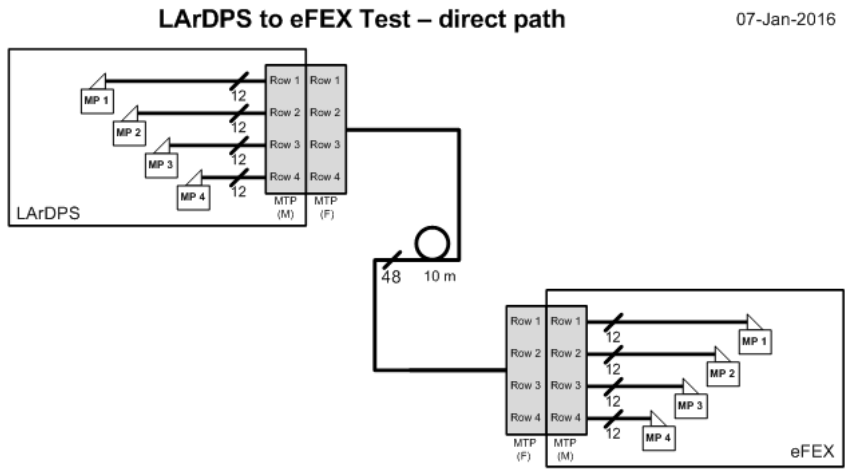


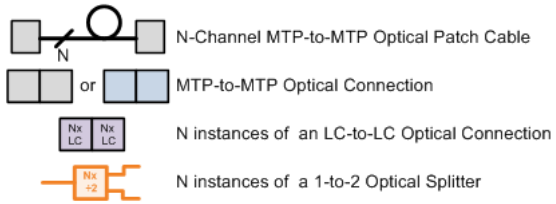
LArDPS to eFEX test configuration without splitters and ‘zero’ method 1

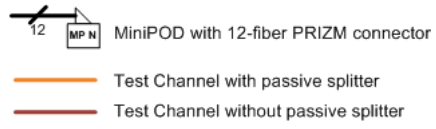




Note:
All 48 channels of the LArDPS test module outputs are instrumented.
All 48 channels of the eFEX test module inputs are instrumented.
The default channel mapping is one-to-one.
Additional test configurations with any arbitrary mapping may be specified and will be available as needed.







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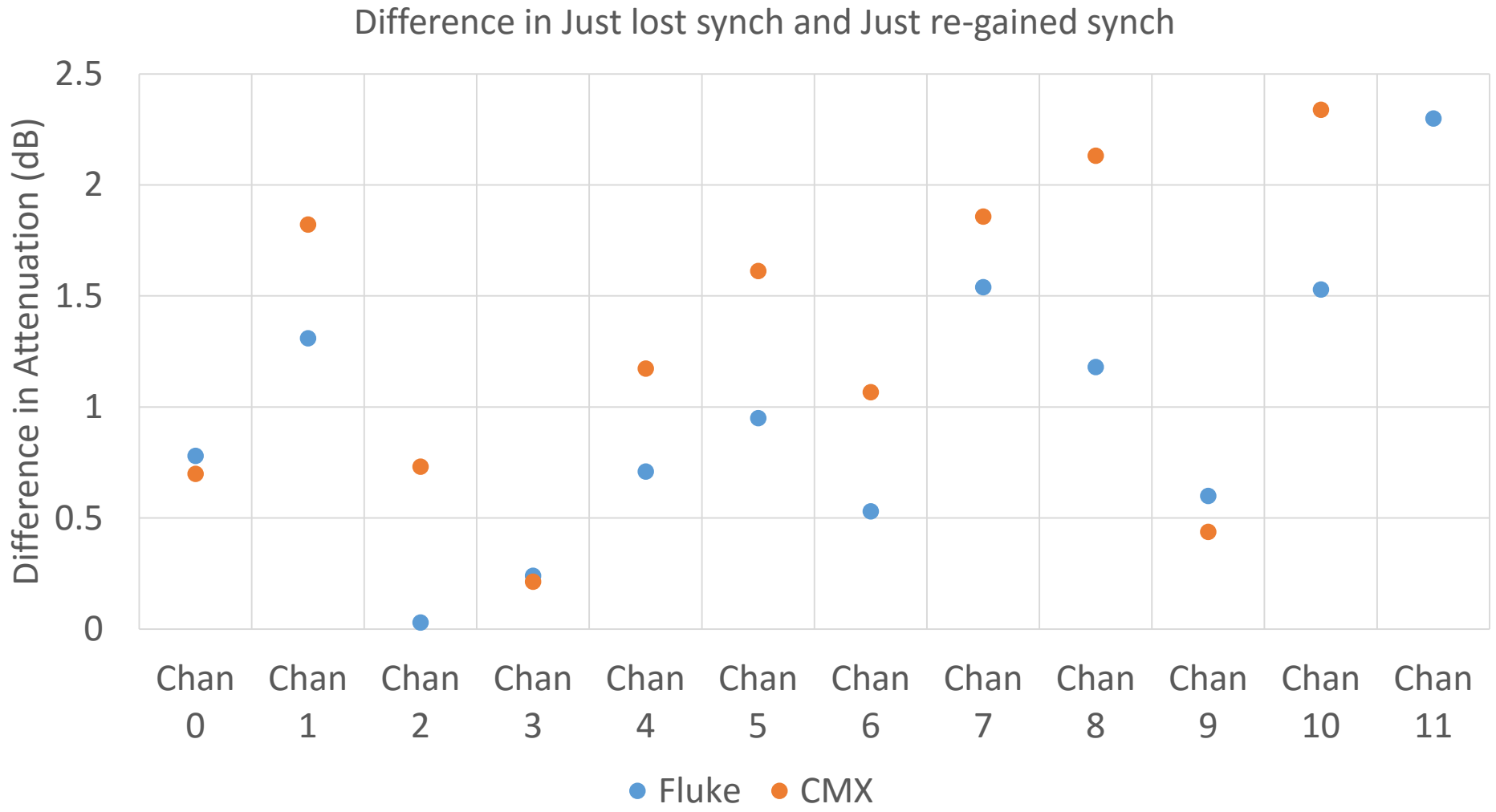
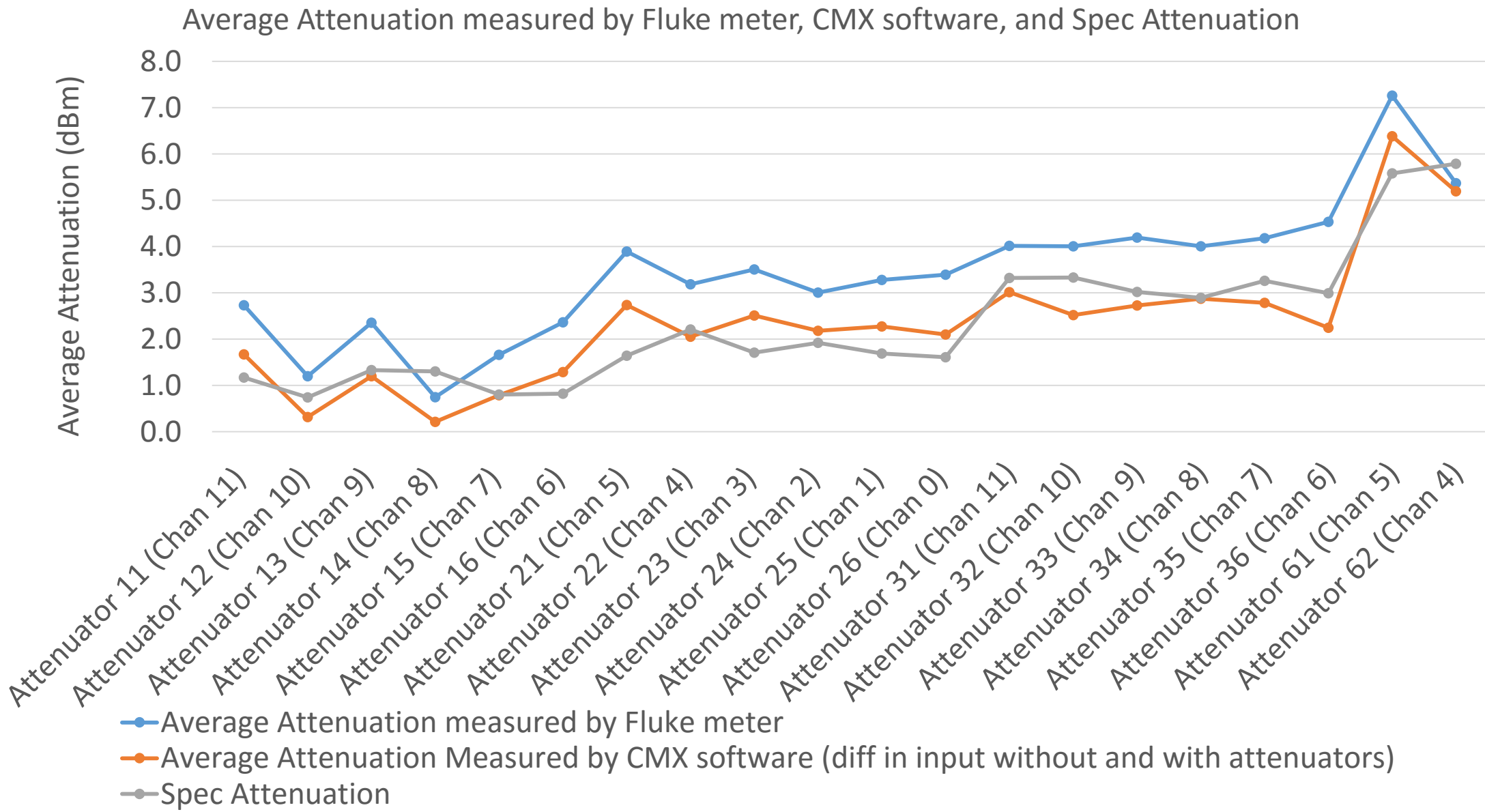
Bit Error Tests



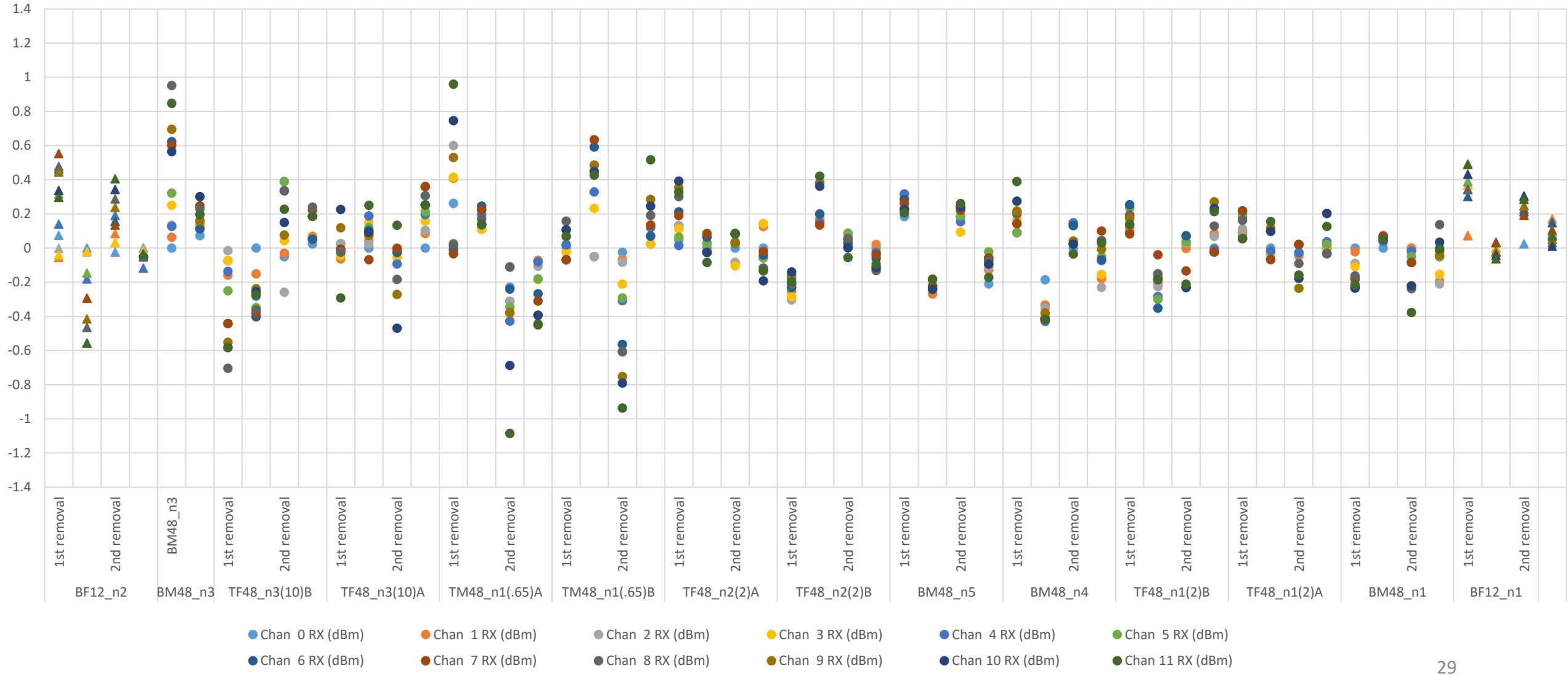
Discrete Attenuators



Disconnecting and Reconnecting MTP Connectors

- Each MTP connector was disconnected and reconnected for two trials in the LArDPS to eFEX configuration without splitters.
- Two measurements were taken after each disconnection/ reconnection
- There was little change in the average light output after disconnecting and reconnecting the MTP connectors

Disconnecting and Reconnecting MTP Connectors



Variable Attenuators