ATLAS Level-1 Calorimeter Trigger

FOX Demonstrator

Design document

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Document Change Record

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0	3	20 May 2015	Chapters 2.1.2, 2.2.4, 2.3.2
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0	7	10 November 2015	Different corrections and improvements
0	8	27 November 2015	Demonstrator drawings, male trunk cables, corrections
0	9	28 January 2016	Added info on cleaning tools and MTP adapters

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1. INTRODUCTION

1.1. FOX DEMONSTRATOR OVERVIEW

This document describes the Fiber Optics eXchange (FOX) demonstrator for integration tests in 2016 (in the Lab. 104) and for future integration and studies. The demonstrator pursues two main goals:

- Provide the light path between the transmitter MiniPODs of the FEX Test Module (FTM), Liquid Argon (LAr) and Tile Calorimeter (Tile) Front-Ends and the receiver MiniPODs of the Feature Extractor (FEX) modules of l1calo.
- Provide mechanical building blocks necessary to construct an overall physical plant providing the required management and mapping of all the fibers and its installation in USA15.

The initial proposal for the FOX demonstrator was presented in the FOX Project Specification [1] and shown in Figure 1:

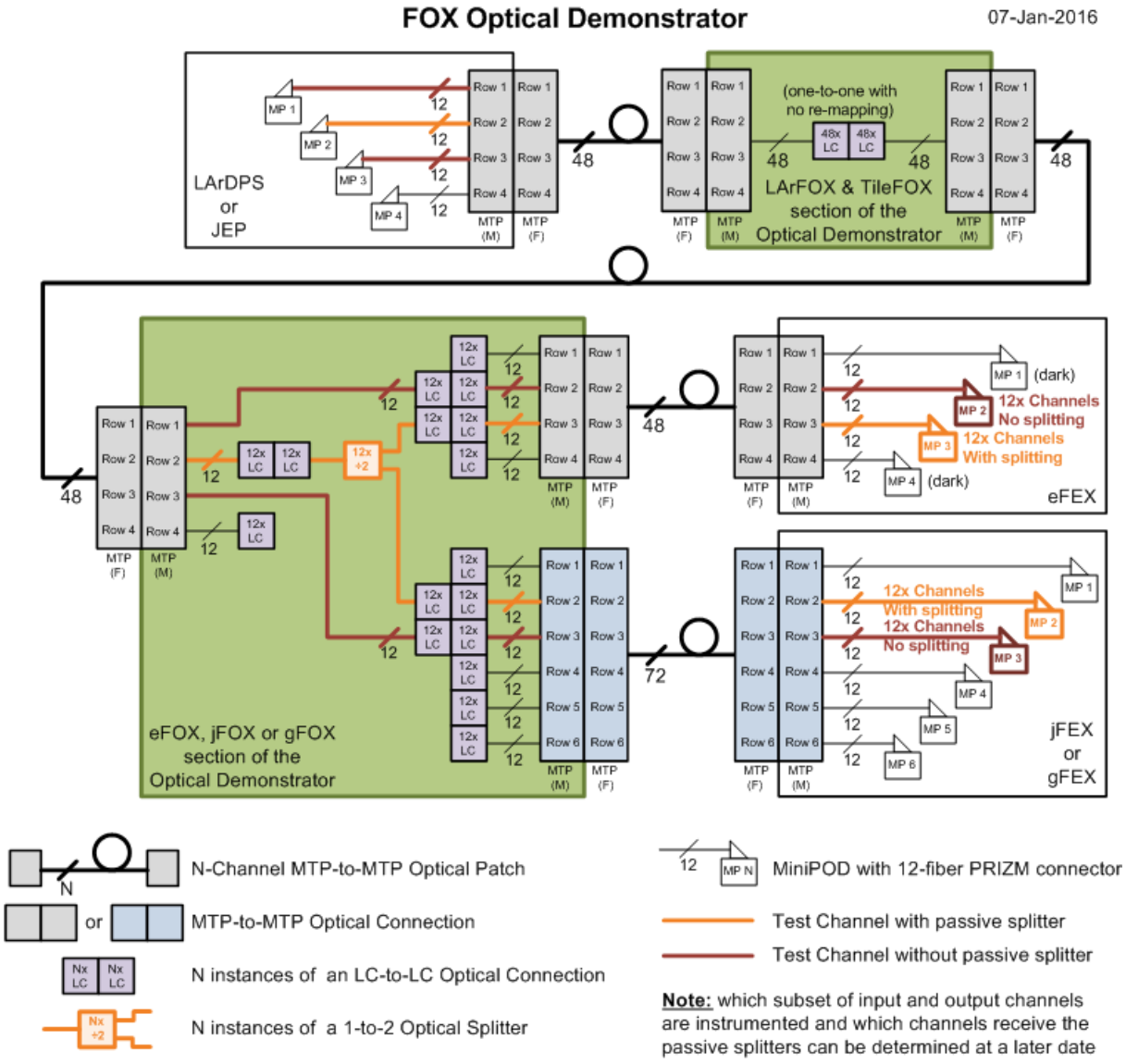


Figure 1: Draft diagram of the FOX Optical demonstrator.

This drawing shows the light path between transmitting and receiving MiniPODs. The input side is defined as a 48-fiber MTP connector(s) (LAr and Tile side) or a 24-fiber MTP connector(s) (FTM, not

shown on the initial proposal); the output side is defined as a 48-fiber (eFEX side) or 72-fiber MTP connector(s) (jFEX and gFEX side).

The FOX demonstrator will map each of the input fibers to a specific FEX destination. It will also provide passive duplication (optical splitting) of some of the fibers.

Reminder: the initial idea of the FOX partitioning (see Figure 2) is that it separated into five sets of modules by mapping functionality. The two input module sets are the LArFOX and the TileFOX which organize the fibers by destination. The three output module sets are eFOX, jFOX and gFOX, which provide the final fiber ribbon by fiber ribbon mapping and provide fiber duplication as required.

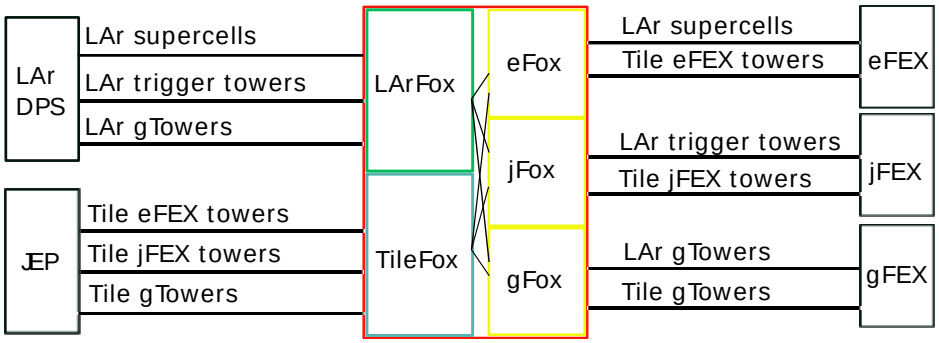


Figure 2: Overview of optical plant partitioning.

1.2. CONVENTIONS

The following conventions are used in this document:

- The term "FOX" is used to refer to the Phase-I L1Calo Optical Plant – Fex Optics eXchange or Fiber Optics eXchange (FOX). Alternate names are "fiber plant" or "optical plant" or "FEX optical plant".
- eFEX – electron Feature EXtractor.
- jFEX – jet Feature EXtractor.
- gFEX – global Feature EXtractor.

1.3. RELATED PROJECTS

[1] FOX Project Specification, v0.14, 11 November 2014.
[2] ATLAS Liquid Argon Phase 1 Technical Design Report, CERN-LHCC-2013-017,
[3] ATLAS Tile Calorimeter,
[4] Electromagnetic Feature Extractor (eFEX) Prototype, v0.3, 6 February 2014,
[5] Jet Feature Extractor (jFEX) Prototype, v0.2, 14 July 2014,
[6] Global Feature Extractor (gFEX) Prototype, v0.3, 16 October 2014,
[7] FEX Test Module (FTM), v0.0, 18 July 2014,
[8] Specification of the LAr-L1Calo 1 Link-Speed Tests, Draft 09, 14 January 2016

1.4. REFERENCE MATERIALS

The Fiber Optic Association Guide: http://www.thefoa.org/tech/ref/contents.html

2. FOX DEMONSTRATOR

The inputs and outputs to/from the FOX demonstrator are optical signal carried by multi-fiber ribbon cables with parallel Multi-fiber Termination Push-On (MTP) connectors – improved version of the MPO connector (known as multi-fiber push-on and also as multi-path push-on) – a multi-fiber connector defined according to IEC 61754-7 and TIA/EIA 604-5 that can accommodate12-72 fibers:

Figure 3: MPO cable female connector for accommodating 24 fibers.

The following convention will apply to the optical connectors:

- All MTP connectors part of all modules in LAr, Tile, eFEX, jFEX, gFEX and FOX are male,
- All MTP trunk cables used to connect any two L1Calo modules are female at both ends.

Note: this is already the case for CMX and L1Topo.

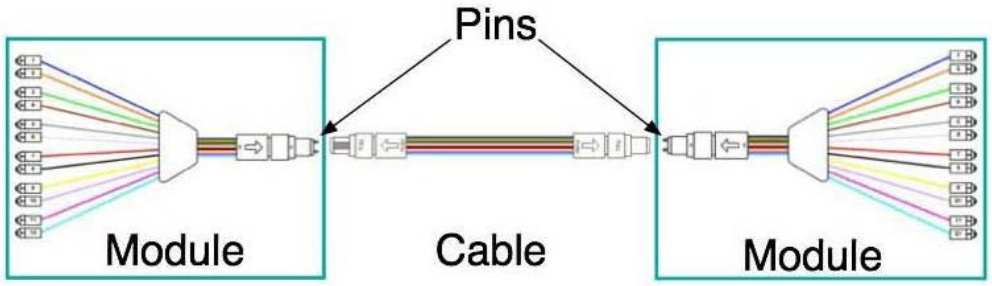
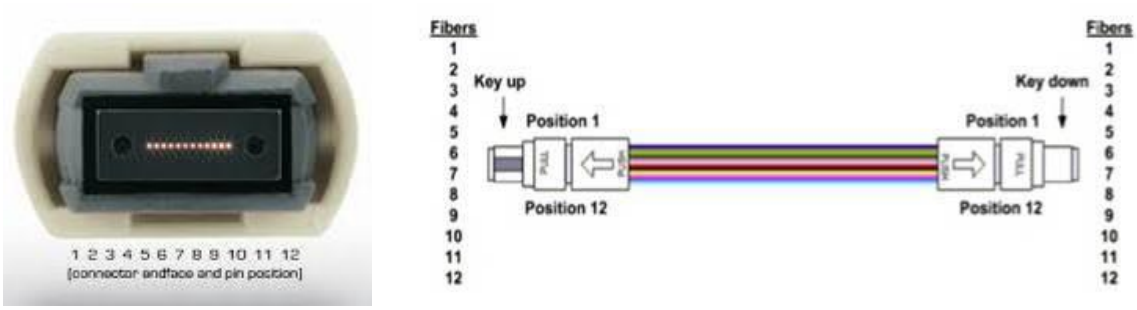


Figure 4: Convention for optical connectors: module has male connector and cable has female connector.

The fiber numbering within a connector and fiber colours:



Position	1	2	3	4	5	6	7	8	9	10	11	12
Fiber Color	Blue	Orange	Green	Brown	Gray	White	Red	Black	Yellow	Violet	Rose	Aqua

Figure 5: Fiber numbering in 12-fibers female MTP.

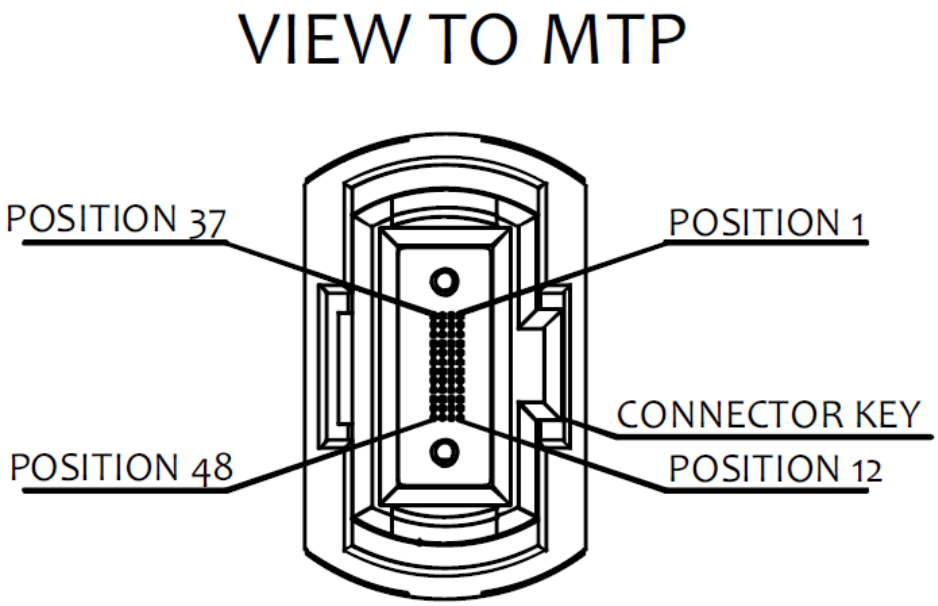


Figure 6: Fiber numbering in 48-fibers female MTP.

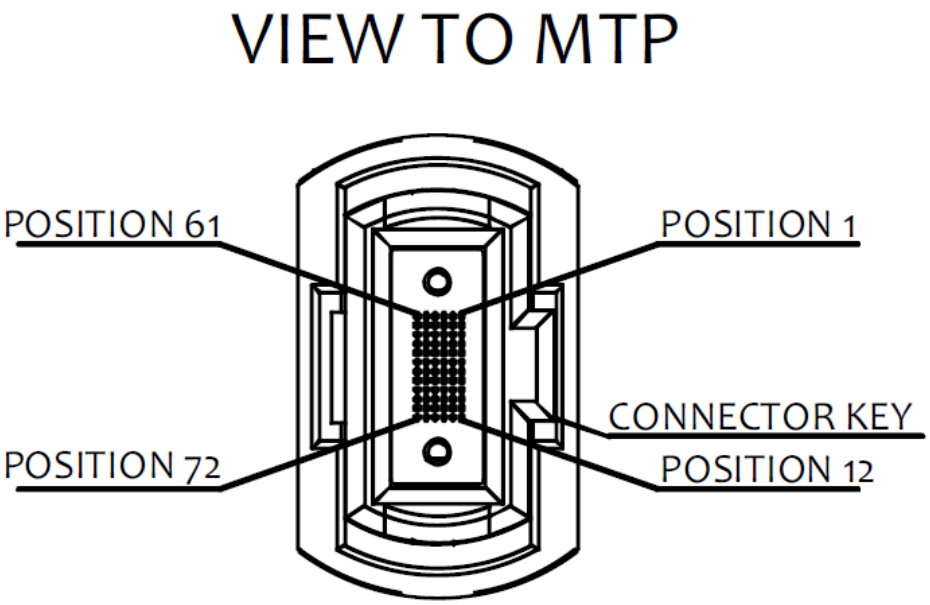


Figure 7: Fiber numbering in 72-fibers female MTP.

The male-female MTP connectors/adapters (or feedthrough) use the "Opposed" key adapter (also called "key-up to key-down" or "Type A"). The fiber mapping, while connecting MTP connector on the cable to the MTP connector on the box, is not one-to-one, but:

12F: 1-1, 2-2, 3-3…12-12

24F: 1-13, 2-14, 3-15..12-24; 13-1.. 24-12

44F: 1-37, 2-38, 3-39..12-48; 13-25..24-36; 25-13..36-24; 37-1….48-12

72F: 1-61, 2-62, 3-63..12-72; 13-49..24-60; 25-37..36-48; 37-25..48-36; 49-13..60-24; 61-1..72-12

2.1. INPUTS TO THE DEMONSTRATOR

The FOX demonstrator will provide a set of MTP feedthroughs for different input connectors from several possible data sources – from the L1Calo modules and from the calorimeter electronics. The MTP feedthroughs are the same for all fibers count in the MTPs.

The FOX demonstrator will connect to any of those modules using an MTP cable with a female connector. The MTP connector, which is part of each module, needs to be male.

2.1.1. Input from CMX module

The contact persons from CMX: Wojtek Fedorko, wojtek.fedorko@gmail.com

The CMX module may be the only possible data source/destination at the beginning of the demonstrator integration studies. It is based on the Virtex 6 FPGAs, has both – 12-fiber transmitters and 12-fiber receivers – but can only test a transmission speed of 6.4 Gbps.

2.1.2. Input from FTM module

The contact persons from FTM: Richard Staley, r.j.staley@bham.ac.uk

The eFEX/jFEX Tester Module (FTM, [7] must be capable of running high-speed links with bit rates up to at least 9.6 Gbps with parts specified for operation up to 12.8 Gbps.

The FTM provides two connectors with 48 fibers each of transmitters, and one connector with 24 receivers.

2.1.3. Input from LAr (LDPS)

The contact persons from Lar: Reina Coromoto Camacho Toro, reina.camacho@cern.ch

The trigger information from the entire LAr calorimeter to the three FEX systems will be sent by the LAr Digital Processor System (LDPS). The LDPS is a set of about 30 ATCA modules called LAr Digital Processor Blades (LDPBs) housed in three ATCA shelves (crates).

Each LDPB acts as a carrier board for four mezzanine cards (AMCs) each of which has a single FPGA with 48 output optical fibers providing data to the FEXes over 48-fiber MTP connector. One of these fibers will contain gTower information, 4 to 8 will contain trigger tower information, 24 to 32 fibers will contain super cell information, and the rest are spares.

2.1.4. Input from Tile (TREX)

The contact persons from TREX: Rainer Stamen, stamen@kip.uni-heidelberg.de

The Tile calorimeter data will be sent to the FOX demonstrator from the existing L1Calo Pre-Processor modules (PPMs) via new rear transition cards - the TREX board.

2.2. OUTPUTS FROM THE DEMONSTRATOR

The FOX demonstrator will provide a set of MTP feedthroughs for different output connectors for several possible data destinations to the L1Calo modules.

2.2.1. Outputs to CMX and FTM

The FOX demonstrator will provide output connectors to the CMX and the FTM modules in order to test the demonstrator with 6.4 Gbps and 9.6 Gbps before getting access to the other modules.

2.2.2. Output to eFEX module

The contact persons from L1Calo to discuss issues: Weiming Qian, Weiming.Qian@cern.ch

Each eFEX module receives three cables of four ribbons with 12 fibers, i.e. the eFEX has three 48-fiber MTP eFEX input connectors.

2.2.3. Output to jFEX module

The contact persons from L1Calo to discuss issues: Ulrich Schäfer, uschaefe@uni-mainz.de

Each jFEX module receives four cables of six ribbons with 12 fibers, i.e. the jFEX has four 72-fiber MTP input connectors.

2.2.4. Output to gFEX module

The contact persons from L1Calo to discuss issues: Michael Begel, michael.begel@cern.ch

The gFEX module receives four cables of six ribbons with 12 fibers, i.e. the gFEX has four 72-fiber MTP input connectors.

2.3. DEMONSTRATOR PARTITIONING AND HOUSING

2.3.1. Demonstrator partitioning

Follow the initial proposal for the FOX demonstrator (Figure 1) and the initial idea of the FOX partitioning (Figure 2), the demonstrator will be implemented in two logical/physical parts:

- First part will represent the LArFOX/TileFOX in Figure 2.
- Second part will represent eFOX/jFOX/gFOX in Figure 2.

Mechanically they are implemented in separate boxes. The optical milti-fiber trunk cables connect the boxes to other parts of the L1Calo test setup in the integration tests; the 48-fiber trunk cable also connects the two boxes.

Inside the boxes, internal optical assemblies (breakout cables, LC connector couplers, passive splitters, trunk cables) provides mapping/splitting/distribution of the optical signals from the input connectors to the output optical connectors.

First part - LArFOX/TileFOX demonstrator

For the final design this part may be implemented using a custom build commercial mapping module, which redistributes the input signals to output connectors, as described in 3.2.4 of the FOX Project Specification [1] or by connecting fibers by fusion splicing , as described in 3.2.3 of [1] .

For the FOX demonstrator this part will initially implement mapping by LC connectors, as described in 3.2.2 of [1] and at the later stage may be implemented by fusion splicing upon availability of the fusion-splicing machine. Input to output connection by male-male trunk cable will be also possible - to "emulate" a possible custom build mapping module assembly with defined input-output connections.

The LArFOX/TileFOX demonstrator part will have 2 MTP feed-troughs for two possible input male connectors out of four, described in 2.1 and 1 MTP output feed-trough. Figure 8 shows four possible input "logical" connections to two physical MTP feed-troughs.

Internal mapping of the input-output fibers will be provided by the MTP breakout split cables – male MTP to male LC connectors – or by trunk cable without mapping.

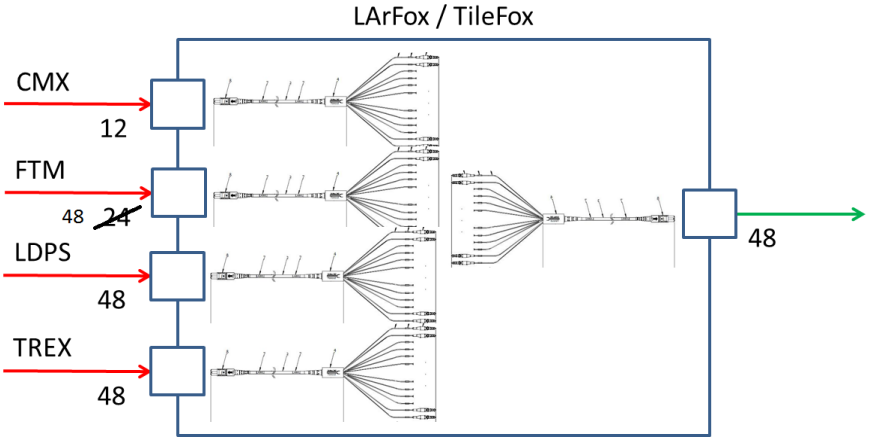


Figure 8: LArFOX/TileFOX part for the FOX demonstrator – possible "logical" inputs.

Second part - eFOX/jFOX/gFOX demonstrator

For the FOX demonstrator as for the final design, the eFOX/jFOX/gFOX part will provide both fiber mapping and splitting:

- The MTP breakout split cables will provide internal mapping of the input-output fibers – male MTP to male LC connectors – or by trunk cable without mapping. The use of LC connectors provides maximum flexibility. Any input fiber can be connected to any output fiber.
- For the data path that require passive splitting, we will use up to 3 connectorized passive splitters with the LC connectors on both end, as described in 3.3 of [1] . It will be inserted in-situ upon need. We would also like to have 3 passive splitters, connected directly to the 48-fiber MTP input male connector with LC connectors on output fibers. The input breakout cable therefore will be 48 MTP(M) to 45 LC(F) + 3 splitters, connected directly to the MTP (first three fibers from the end, on the second row), on the other side of the splitters – 2 LC(F). The LC connectors on the output side of the splitters can be connected as needed, with maximum flexibility. Details are in 2.4.3.

On the input side, the eFOX/jFOX/gFOX part will have one feed-trough for one MTP input male connector and on the output side - two feed-troughs for MTP output male connectors. Figure 9 shows four possible output "logical" connections to two physical MTP feed-troughs.

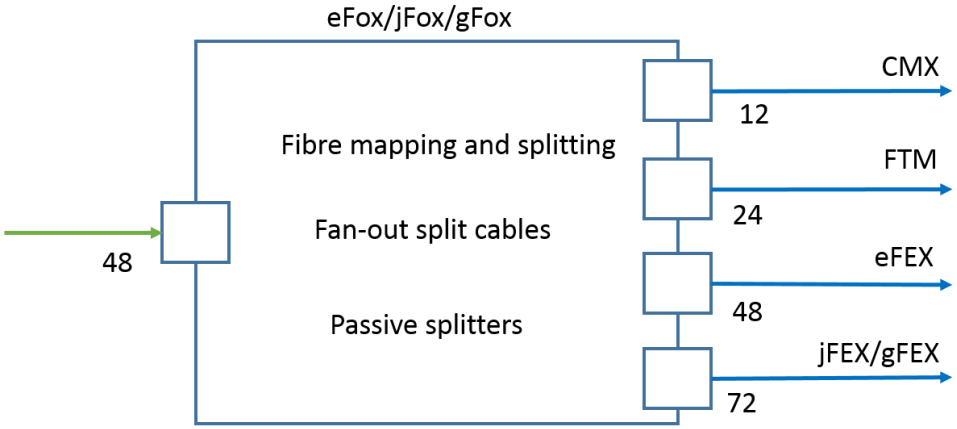


Figure 9: eFOX/jFOX/gFOX part for the FOX demonstrator – possible "logical" outputs.

2.3.2. Demonstrator housing

For the integration tests with other components of the L1Calo, the FOX demonstrator will be mounted in existing 19-inch rack infrastructure in USA15 in a 2U rack mounted boxes. The housing will provide the MTP feed-through for the patch cables connections. The current proposal is to split the FOX demonstrator into two separate parts and therefore have two separate 1U (2U) boxes:

- First box: with feed-troughs for 2 input connectors and 1 output connector on the front panel, as described in 2.3.1 and shown on Figure 8.
- Second box: with feed-troughs for 1 input connectors and 2 output connectors on the front panel, as described in 2.3.1.

The boxes will provide the access to internal connections. Mechanically, the FOX demonstrator is implemented as two almost identical boxes – 2U rack mounted (see Figure 10), LArFOX/TileFOX Demo box and eFOX/jFOX/gFOX Demo box. The difference between boxes is in the number of internal LC-LC adapters, located on the adapter port.

The outer housing can be fixed in the rack and inner mapping box moved in and out. On the front panel of the mapping box, there are three MTP feed-through for the patch cables connections:

- First box: the LArFOX/TileFOX Demo box with feed-troughs for 2 input and 1 output connectors, and 48 LC adapters port inside,
- Second box: the eFOX/jFOX/gFOX Demo box with feed-troughs for 1 input and 2 output connectors and 52 LC adapters port inside.

Sylex SYLEX, s.r.o., Bratislava, Slovak Republic, built the FOX demonstrator.

Figure 10: FOX Demo boxes.

2.3.3. Feed-through

The Figure 11 below shows an example of the feed-trough:

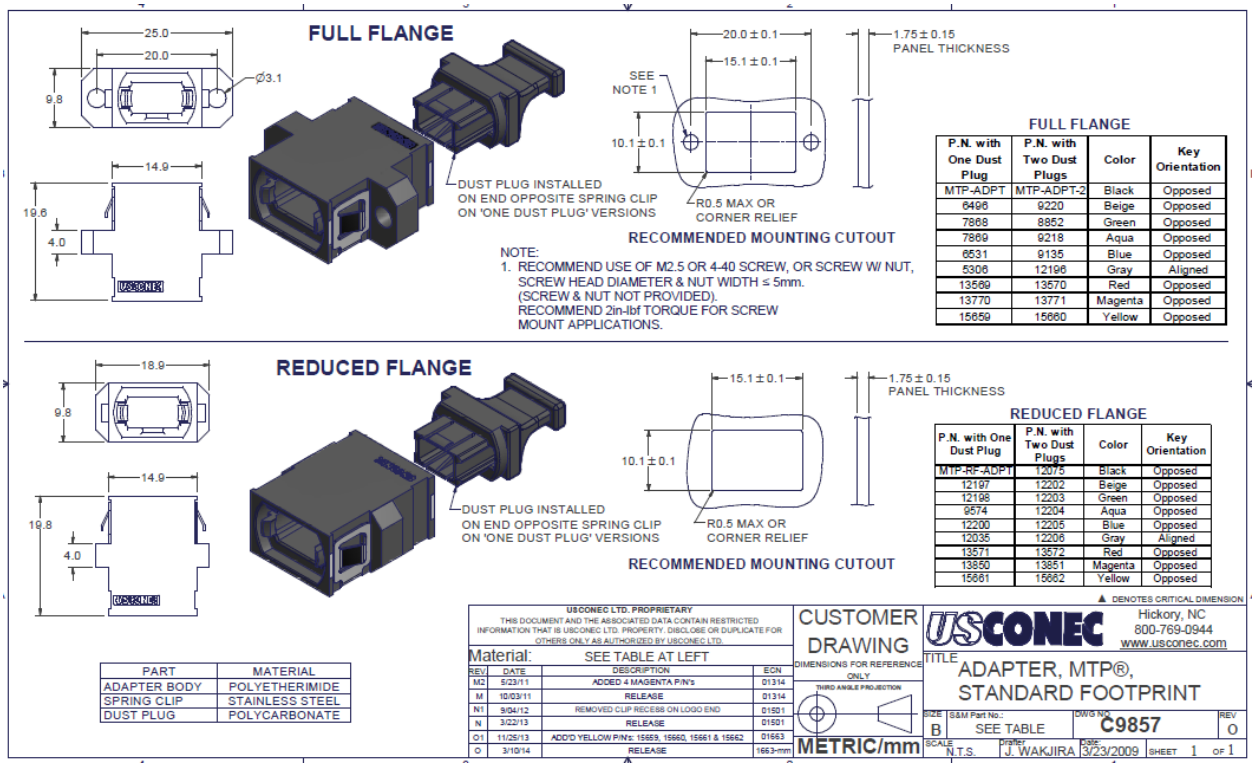


Figure 11: Individual adapter compatible with all MTP connectors.

Mechanically, the MTP feedthroughs are identical for all fibers count in the MTPs (from 12 to 72).

The following convention applies to the optical connectors:

- All optical connectors on the FOX demonstrator boxes – connectors on the internal breakout or trunk cables, connected to the front panel feedthroughs from ***inside*** the boxes - are MALE,
- All optical connectors on the trunk cables from other equipment, connected to the front panel feedthroughs from ***outside***, are FEMALE.

2.4. OPTICAL CABLES AND SPLITTERS

2.4.1. Trunk cables to/from FOX demonstrator

Initial assumptions during the FOX Demo design is:

- there will be not more than one input to the FOX demonstrator at the same time,
- there will be not more than one output of the FOX demonstrator at the same time,
- the connection between two parts of the FOX demonstrator will be 48-fibers trunk cable.

Trunk cables with female MTP connectors to connect input systems:

- 12-fibers trunk cable to connect the CMX output,
- 48-fibers trunk cable to connect the FTM, the LDPS, or the TREX output.

Trunk cables with female MTP connectors to connect output systems:

- 12-fibers trunk cable to connect the CMX input,
- 24-fibers trunk cable to connect the FTM input,
- 48-fibers trunk cable to connect the eFEX input.
- 72-fibers trunk cable to connect the jFEX or the gFEX input.

The 48-fibers trunk cable with female MTP connectors connects FOX demonstrator boxes. Therefore, the minimum number of cables to connect the FOX demonstrator to the outside systems:

- 2 x 12-fibers trunk cables for the CMX output and input,
- 1 x 24-fibers trunk cable for the FTM input,
- 3 x 48-fibers trunk cables for the FTM, LDPS, or TREX output, between boxes and eFEX input,
- 1 x 72-fibers trunk cable for the jFEX or gFEX input.

For the foreseen test with the FOX demonstrator, we will need a few trunk cables with male MTP connectors to be used inside the boxes instead of breakout cables. The idea behind it is to “emulate” a possible custom assembly with defined input-output connections (without LC-LC connection) inside the box.

The Table 1 below shows the minimum number trunk cables needed to connect the FOX demonstrator to outside systems, connect the demonstrator boxes and to “emulate” a possible custom assembly (the assumption is that the trunk cable between the boxes is always 48-fiber). The table also shows the number of available cables.

N fibers	Connector (M/F)	N cables needed	N cables available	Length available	System to connect
12	F	2	4	2x2m+2x?m	CMX output and input
24	F	1	1	2m	FTM input
48	F	3	6	2x1m+2x2m+2x10m	LDPS/TREX, between boxes, eFEX
72	F	1	4	2x1m+2x10m	jFEX/gFEX
48	M	2	4	0.65m	Inside the demonstrator boxes

Table 1: Trunk cables.

2.4.2. Breakout cables

The FOX demonstrator will map each of the fiber on an input MTP connector to a fiber on an output MTP connector. The input and output parallel fiber ribbons break out in individual fibers with LC connectors – the MTP breakout split cables. Connecting two segments of optical fibers may be done through optical LC connectors on the end of the fibers and a connector coupler. Incoming and ongoing trunk cables of different fiber counts are connected to the corresponding breakout cables inside the boxes, as presented in the Figure 8 and Figure 9. The Figure 12 shows different breakout cables:

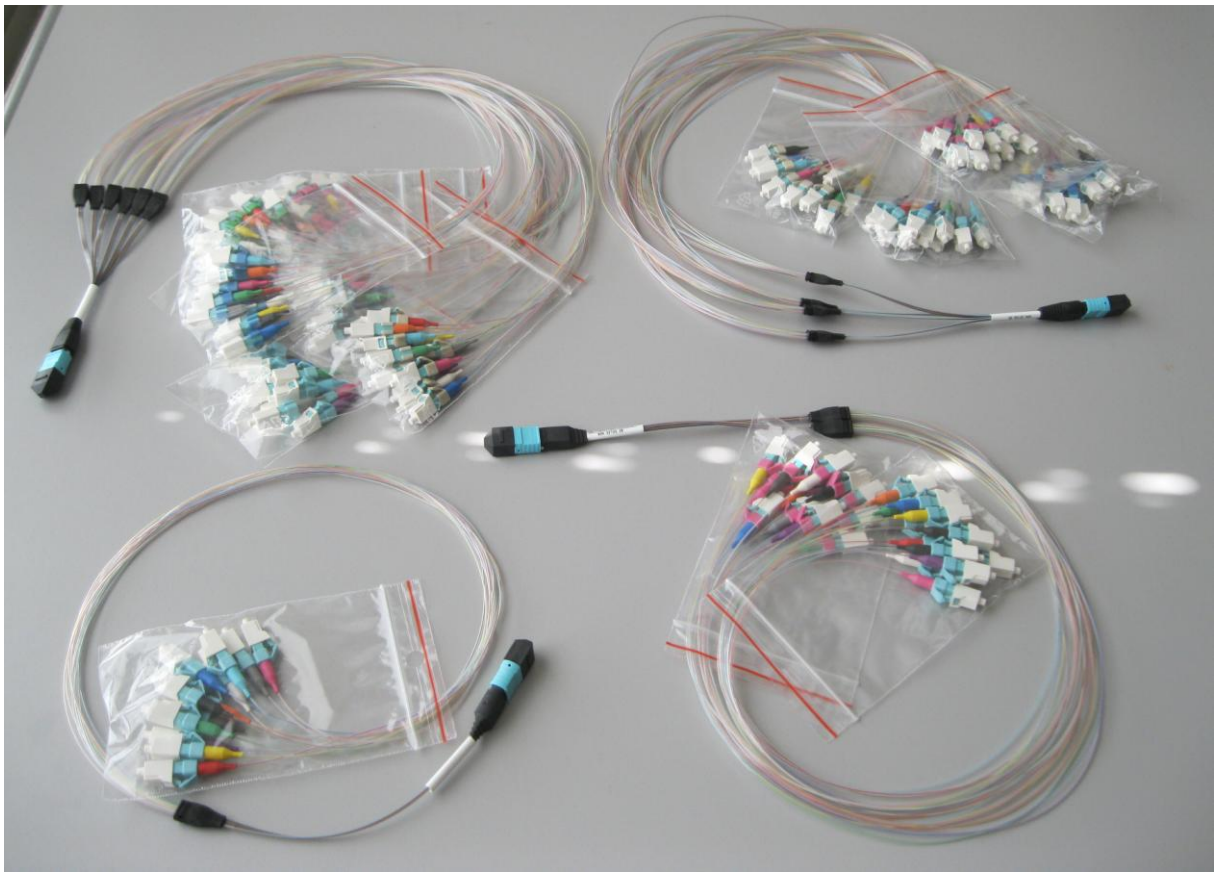


Figure 12: Different breakout cables - 12-, 24-, 48- and 72-fibers.

MTP to LC direct breakout cables use AQUA LC connector heads for all fibers. Each row of fibers from the MTP connector will be marked with different connector latch color. Each fiber will be identified by colored boot. This should allow very comfortable identification of each LC connector, an example for 48 fibers MTP(M) to 48xLC/PC connectors:

- fibers 1-12 terminated with AQUA connector heads, with AQUA latches, each connector will have the same color of boot as the fiber
- fibers 13-24 terminated with AQUA connector heads, with MAGENTA latches, each connector will have the same color of boot as the fiber
- fibers 25-36 terminated with AQUA connector heads, with BEIGE latches, each connector will have the same color of boot as the fiber
- fibers 37-48 terminated with AQUA connector heads, with BLUE latches, each connector will have the same color of boot as the fiber

Possible mapping scenarios, described in 2.5, defined the required number of breakout cables. The Table 2 below shows the minimum number fun-out cables (with the male MTP connector on one side and the individual LC connectors on the other side) to implement different mapping scenarios and the number of available cables:

N fibers	N cables needed	N cables available	Length available	System to connect
12	2	2	0.5m	CMX output and input
24	1	1	0.5m	FTM input
48	4	7	2x1m + 5x0.5m	LDPS/TREX, between boxes, eFEX
72	1	3	2x1m + 1x0.5m	jFEX/gFEX

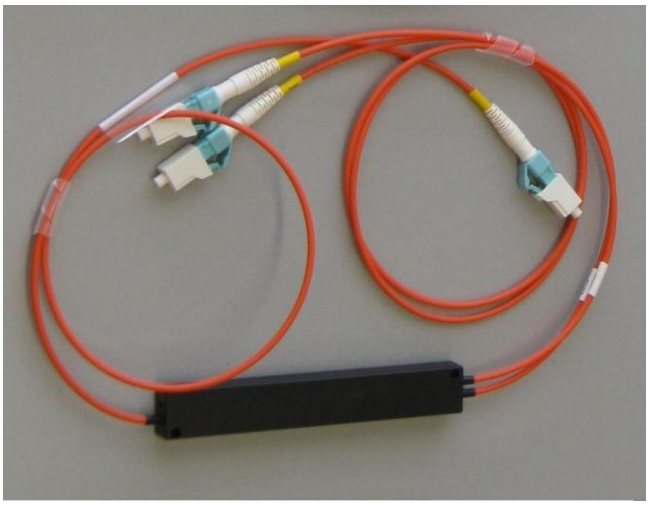
Table 2: Breakout cables.

NB: The assumption is that the trunk cable between the boxes is always 48-fiber.

2.4.3. Passive splitters

For the fibers that go to two destinations and therefore require splitting, a passive optical splitter with the even split ration (50/50) can be used. The splitter may be connected to the input/output fibers by LC connectors or by fusion splicing.

In the data path, which may require data duplication to two data destinations, the connectorized passive splitter may be inserted inside the box (see Figure 13). The passive splitter from SENKO has even split ratio 50/50 and the LC connectors on both ends of 0.5m pigtails. 3 splitters are available.



Notes:
1. Operating Wavelength: 850nm
2. Light source: VCSEL
3. Fiber type: OM3 Multimode Fiber
4. Coupling Ratio (%):
   —— Reflect Port (R): 50%; Pass Port (P): 50%
5. Maximal Insertion Loss (dB): 3.6/3.6
   —— Exclude connector (C→ R / C→ P)
6. Uniformity: <=0.8
7. Connector type: No connector
8. Cable type: 2.0mm Aqua LSZH cable
9. Pigtail length: 0.5m
10. Package dimension: 90x14x8.5mm
11. Operating Temperature (°C): -20~70
12. Storage Temperature (°C): -40~85

Figure 13: Passive splitter.

There is also the 48-fibers breakout cable (Figure 14) with 3 passive splitters (inside the silver barrel), connected directly to 3 fibers in the 48-fiber MTP input male connector:

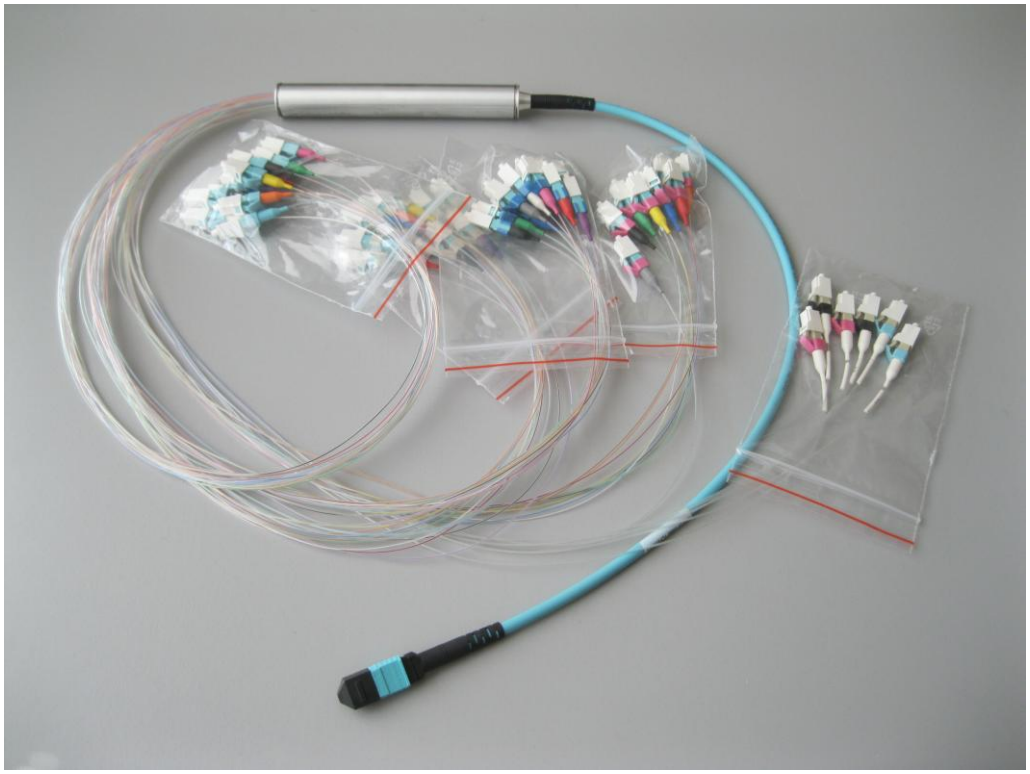


Figure 14: 48-fiber breakout cable with three passive splitters.

The 45 “direct” fibers from the MTP connector are terminated with the LC connectors with AQUA color housings.

The three fibers, connected to the passive splitters, are from the second row of the 48-fibers MTP connector – positions 22, 23 and 24. The six LC connectors on the fibers after the splitters have BEIGE color housings.

Connectors terminated to the first row of the 48F-fiber MTP (positions 1-12) are with AQUA clip.

Connectors terminated to the second row (positions 13-21) are with MAGENTA clip (position 22, 23, 24 are with the splitter). The position 22 is marked on the LC side with a marking sleeve Nr.1 (LC clip AQUA), position 23 - marking sleeve Nr.2 (LC clip MAGENTA); position 24 - marking sleeve Nr.3 (LC clip BLACK).

Connectors terminated to the third row (positions 25-36) are with BEIGE clip.

Connectors terminated to the fourth row (positions 37-48) are with BLUE clip.

The Figure 15shows the passive splitter with bare fibers:

Figure 15: Passive splitter with bare fibers.

A possible layout of the breakout cables inside the box may looks like on the Figure 16 below:

Figure 16: "Simulation" of the breakouts inside the box.

2.4.4. Variable Optical Attenuator

Collimator variable optical attenuator (VOA) is a fiber optic attenuator - Multimode 50µm fiber core, 2 meters, 850-1310nm, Return Loss < -.8dB - 40dB, terminated with LC connectors. This is a useful tool for the optical components power adjustment and systems test (Figure 17). Turn knob to change attenuation.

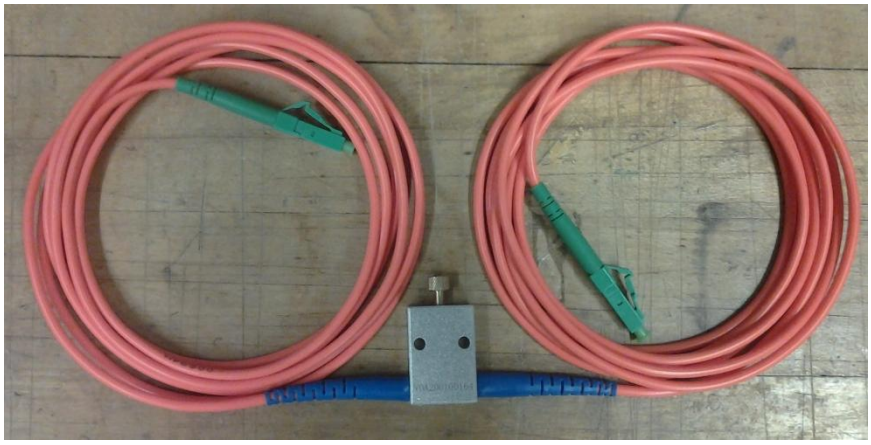


Figure 17: Variable Optical Attenuator (VOA).

Variable attenuator was tested at different levels of attenuation with the Fluke meter (2.6.2) and CMX software (2.6.1). The difference between the measurements at the two levels of attenuation was nearly identical for both the Fluke meter and CMX software.

There are five variable optical attenuator available for the tests.

2.5. POSSIBLE MAPPING SCENARIOS

The FOX demonstrator allows different mapping scenarios according to the test needs. While not all possible combinations may be implemented, the most probable were considered during the demonstrator design and implementation. The mapping scenario specify:

- The input to the first box (LArFOX/TileFOX) – multi-fiber trunk cable(s),
- Possible mappings in the first box:
  - input and output breakout cables with LC connectors and couples between,
  - as above with passive splitting,
  - trunk cable from input to output – "emulation" of custom mapping,
- Trunk cable between the boxes – default is 48-fiber trunk cable (see 2.4.1),
- Possible mappings in the second box (eFOX/jFOX/gFOX) – see above for the first box,
- The output from the second box – multi-fiber trunk cable(s),

As an example, the scenario may looks like (see also the table entry example below in Table 3):

- The input to the first box (LArFOX/TileFOX) – 48-fiber trunk cable (In),
- Possible mappings in the first box: input and output 48-fiber breakout cables,
- 48-fiber trunk cable between the boxes (Between).
- Possible mappings in the second box (eFOX/jFOX/gFOX): input and output 48-fiber breakout cables,
- The output from the second box – 48-fiber trunk cable (Out).

In	LArFOX/TileFOX	Between	eFOX/jFOX/gFOX	Out
48	48 + 48 breakouts	48	48 + 48 breakouts	48

Table 3: Entry example.

The Table 4 below lists several ***possible mapping scenarios for illustration*** (without splitters):

N	In	LArFOX/TileFOX	Between	eFOX/jFOX/gFOX	Out	System
1	12 (2m)	12 > 48 breakouts	48	48 > 12 breakouts	12 (2m)	CMX
2	24 (2m)	24 > 48 breakouts	48	48 > 24 breakouts	24 (2m)	FTM
3	48	48 trunk	48	48 trunk	48	eFEX
4	48	48 trunk	48	48 > 48 breakouts	48	eFEX
5	48	48 > 48 breakouts	48	48 > 48 breakouts	48	eFEX
6	48	48 trunk	48	48 > 72 breakouts	72	gFEX/jFEX
7	48	48 > 48 breakouts	48	48 > 72 breakouts	72	gFEX/jFEX
8	48+48	2x48 > 72 breakouts	72	72 >72 breakouts	72	gFEX/jFEX

Table 4: Possible mapping scenarios without splitters.

In a cases, where we have 48 input fibers and 72 output fibers, not all 72 output fibers will carry a signal but only 48 of them (plus up to 6 fibers more if we use splitters).

2.5.1. Tests with CMX and FTM

Scenarios 1 and 2 present possible tests of the FOX demonstrator with the CMX or the FTM. The trunk cable connects FOX demonstrator input and output to the module (CMX or FTM). Breakout cables inside the boxes provides fiber mapping.

It is also possible for the CMX to use only one box with 12-fibers breakout cables at the input and the output and 12-fibers trunk cables to the CMX input and output.

2.5.2. Tests with eFEX

Tests may start with the direct connection by the trunk cable, see Figure 18

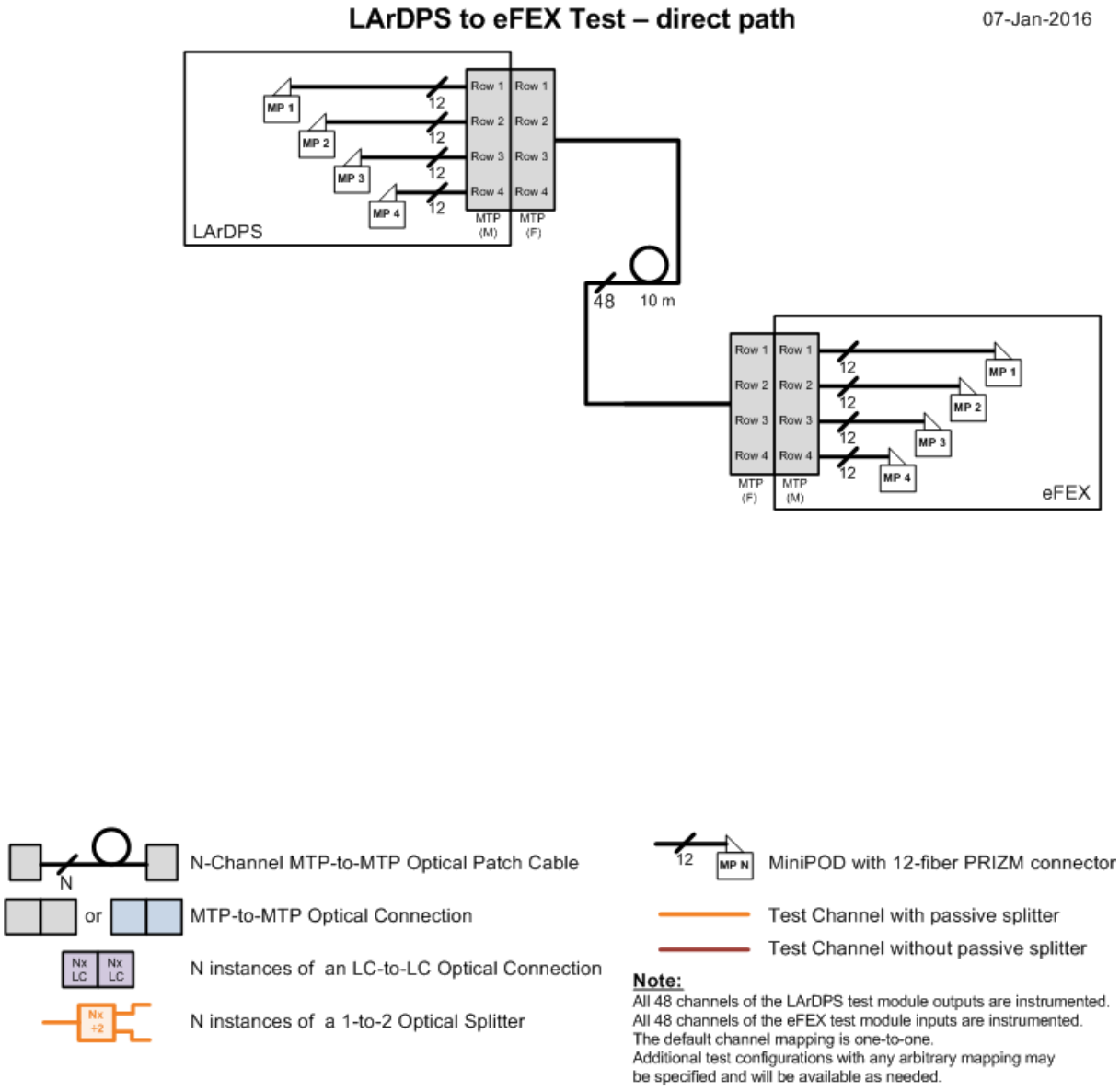


Figure 18: eFEX test with direct path.

Scenario 3: no breakout cables inside the boxes. This is an "emulation" of the custom-built well-defined (and final) mapping. No easy mapping changes, however…

Scenario 4: a combination of the custom and configurable mapping (trunk cable in the first box LArFOX/TileFOX and LC-LC connection in the second box), see Figure 19:

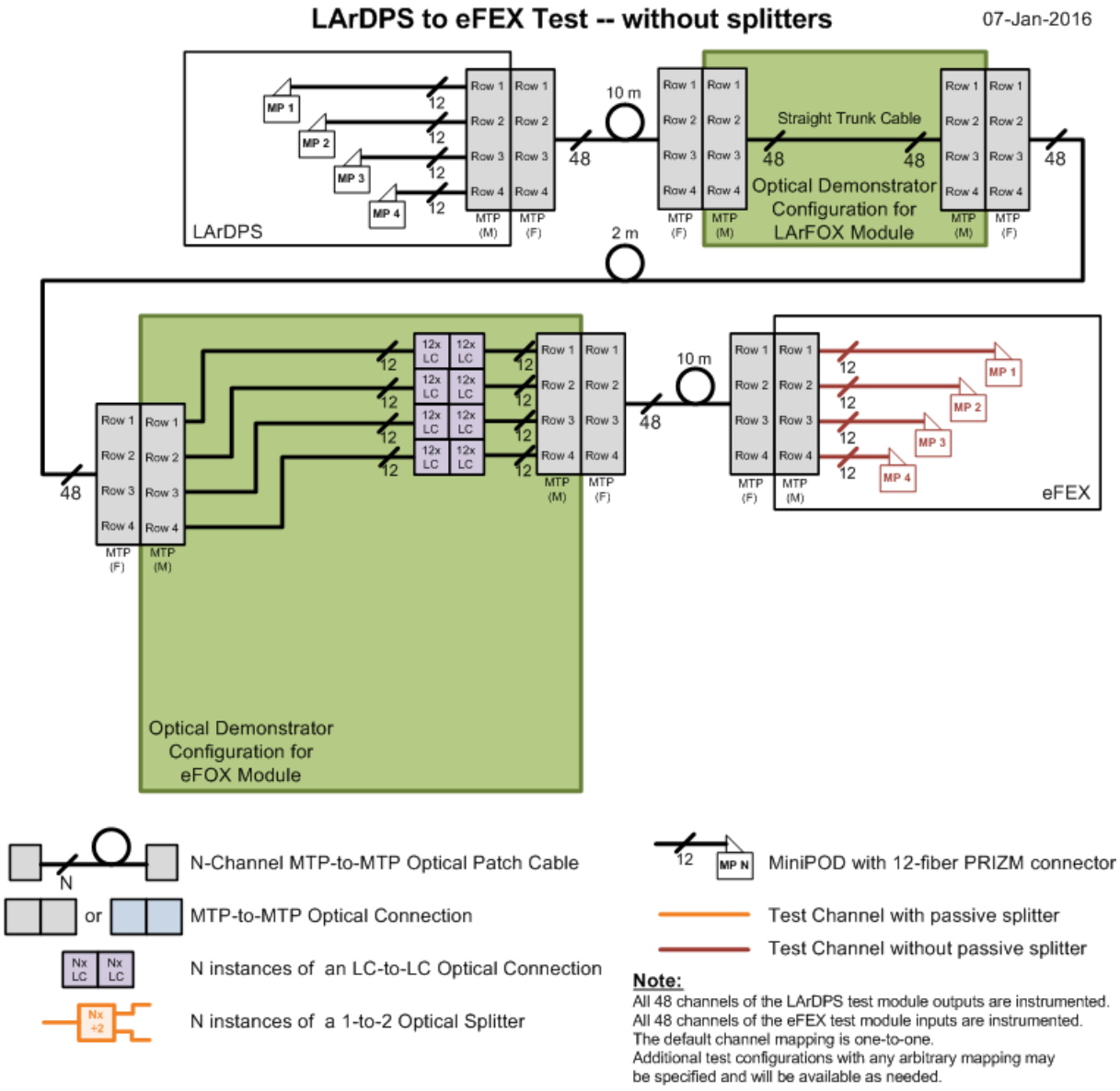


Figure 19: eFEX test without optical splitters.

Figure 20 illustrates the use of splitters in the second box:

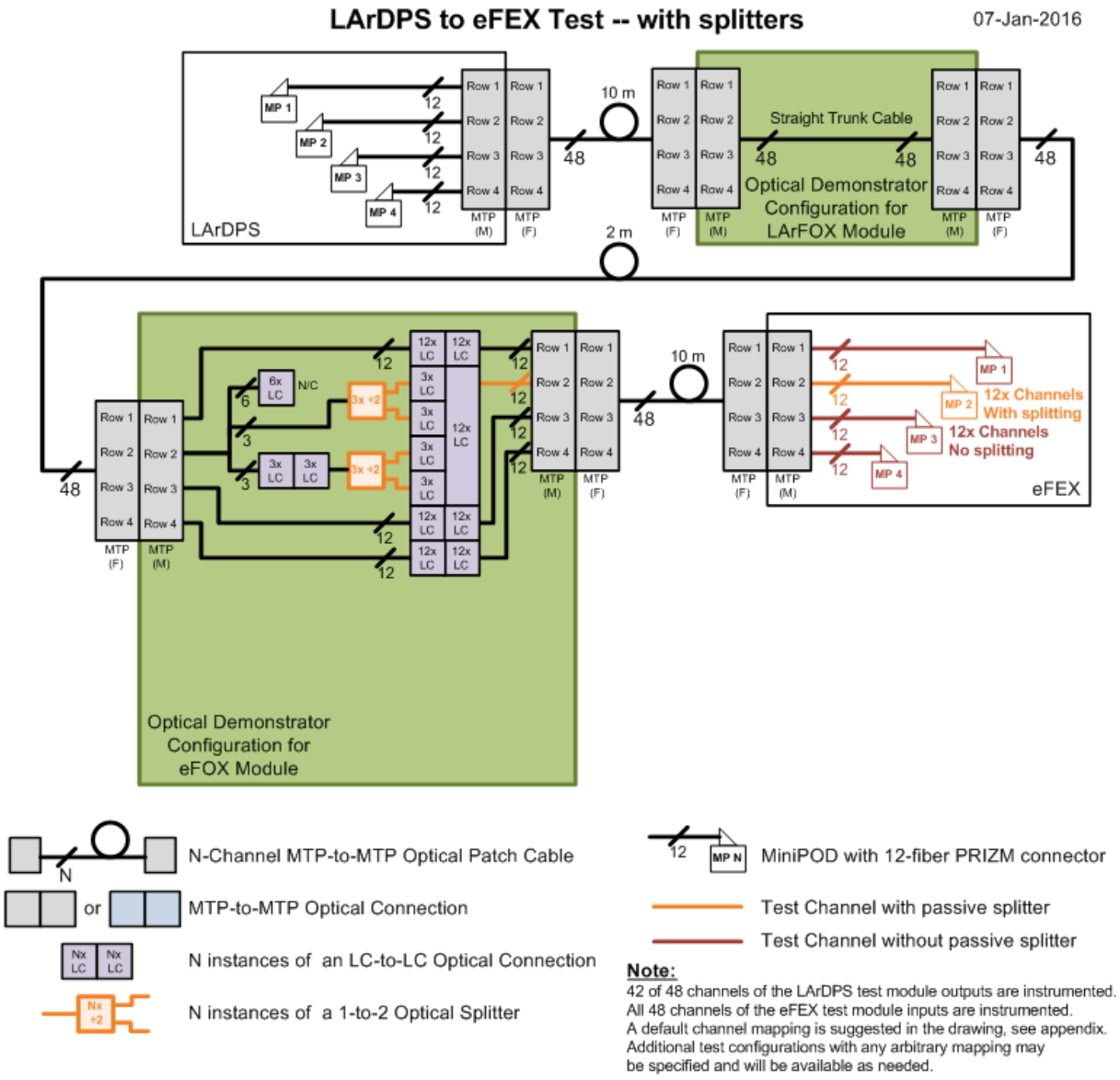


Figure 20: eFEX test with optical splitters.

Scenario 5: all configurable mapping – breakout cables and LC-LC connectors in both boxes, to test data duplication (data transmission via splitters) either the connectorised passive splitters (Figure 13) or the 48-fibers breakout cable (Figure 14) with 3 passive splitters can be added.

2.5.3. Tests with gFEX/jFEX

Scenarios 6 to 8 present possible tests of the FOX demonstrator with the gFEX/jFEX.

Scenario 6: a combination of the custom and configurable mapping.

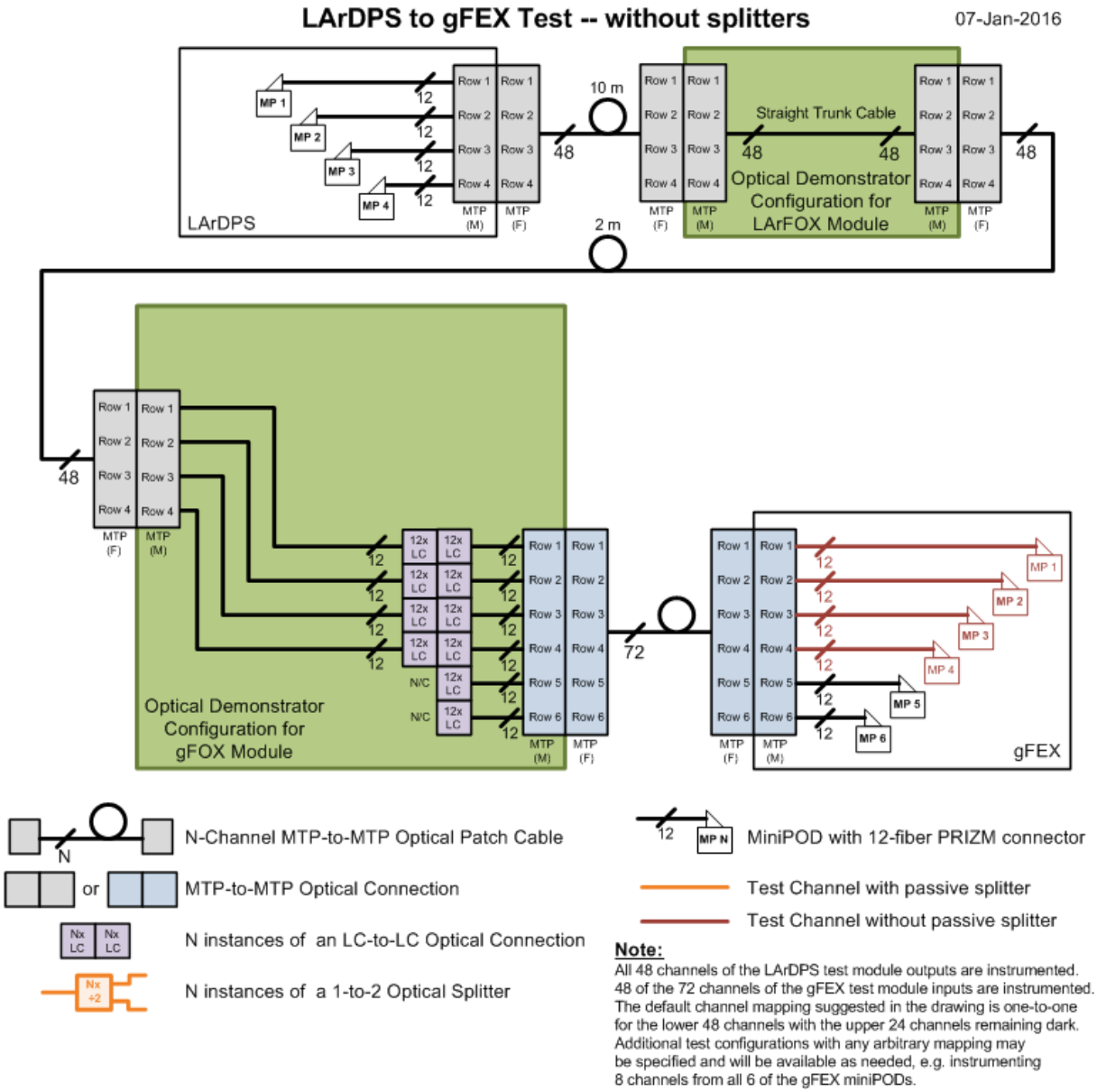


Figure 21: gFEX/jFEX test without optical splitters.

Figure 22 illustrates the use of splitters in the second box:

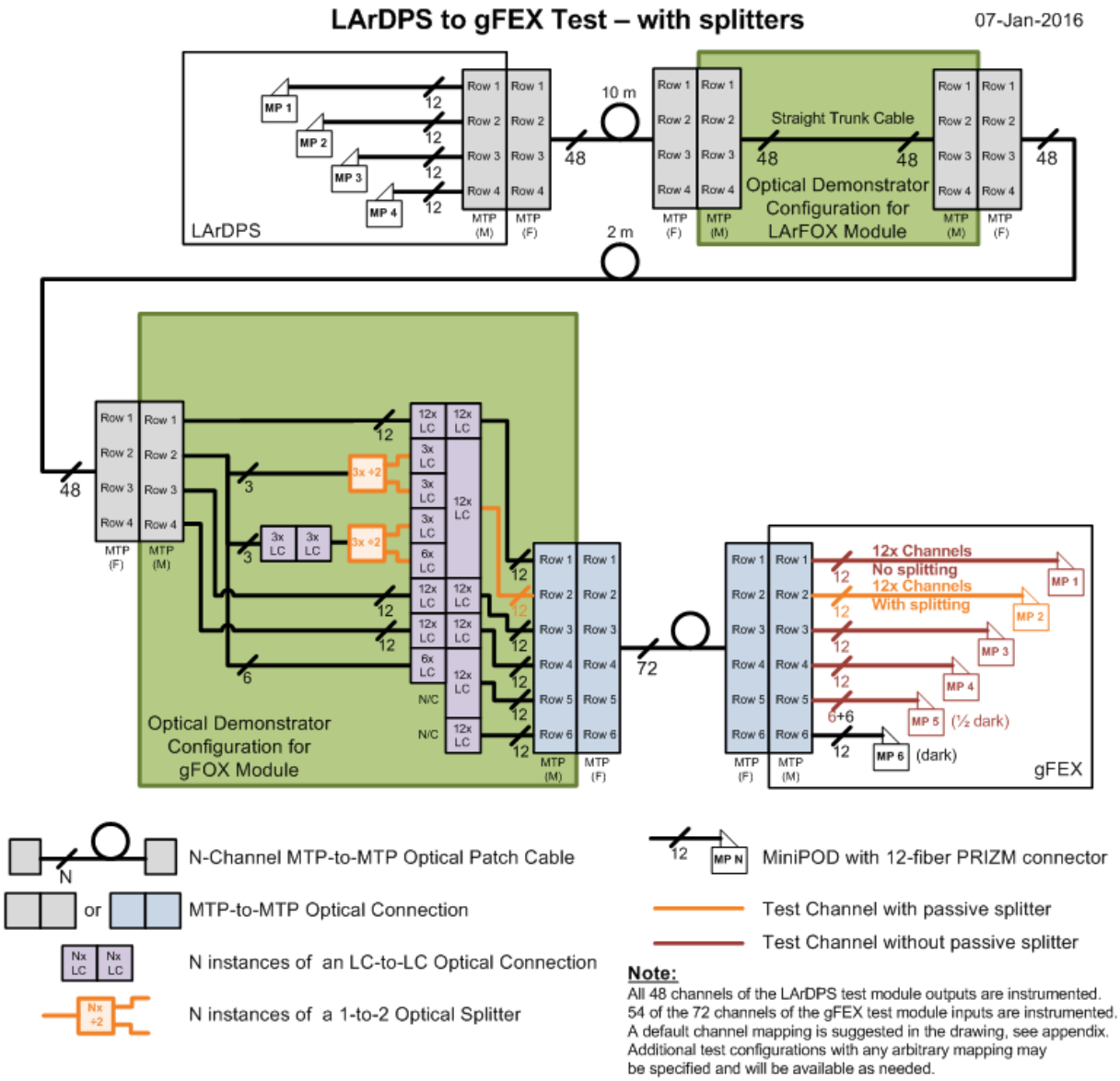


Figure 22: gFEX/jFEX test with optical splitters.

Scenario 7: all configurable mapping.

Scenario 8: a possibility to feed all 72 inputs of the gFEX/jFEX in a case two 48-fiber outputs from the LAr are available.

2.6. TOOLS

For the integration tests of the FOX demonstrator, several tools were acquired, namely:

- Optical power meter Fluke FTK-1000,
- LC/MPO connectors cleaning sets and individual tools.

2.6.1. MiniPOD light level monitoring

The miniPOD transmitters and receivers allow reading transmitters light output and receivers light input in µW and dBm. Besides the bit error rate tests, these can also be used to assess the quality of each optical link. The light loss in each connection in the FOX demonstrator was measured in preparation for the link tests.

2.6.2. Optical power meter fluke networks FTK-1000

The Figure 23 shows the Fluke Networks FTK1000 SimpliFiber Pro Multimode Fiber Verification Kit, Fiber Tester (ordered from DISTRELEC) and Simplex Reference Cord Set (from FARNELL):

Figure 23: Fluke FTK-1000 and reference set.

2.6.3. LC/MPO cleaning sets

The Figure 24 shows the LC connectors cleaning set. Cassette can also clean MPO female connectors.

Figure 24: LC connectors cleaning set.

Extra cassette and replacement cartridges also ordered.

Another cleaning set (Fluke Networks NFC-KIT-CASE-E Enhanced Fiber Optic Cleaning Kit):

Figure 25: LC/MPO connectors cleaning set.

2.6.4. MPO cleaning tools

These individual cleaning tools are used for MPO male and female connectors.

Figure 26: MPO connectors cleaning tools.

APPENDIX A. LARG-L1CALO LINK TESTS

The optical link speed test between LAr and L1Calo described in the document [8] .

Each link-speed will be tested for a number of different optical set-ups, progressing from simple to set-ups that are more complex. In order to minimise the potential damage and dirtying of the optical equipment, for any given optical set-up all desired link speeds should be tested before that set-up is changed.

Test plan includes different optical setups (see Table 5):

- With and without FOX
- With and without passive optcal spliter (when FOX included)

Test No.	Sink Module	Optical Set-Up	Link Speed / Gb/s	Test
1	gFEX / eFEX	Direct Connection	11.2	Short test with no readout links running
2				Short test with readout links running
3				Soak test with readout links running
4–6			9.6	Three tests as above
7–9			6.4	"
10–12		Via FOX demonstrator, with no splitting	11.2	"
13–15			9.6	"
16–18			6.4	"
19–21		via FOX demonstrator with splitting	11.2	"
22–24			9.6	"
25–27			6.4	"

Table 5: Optical setups for the link speed tests.

Figure 27: Link speed tests.

APPENDIX B. OPTICAL CONNECTORS MAPPING

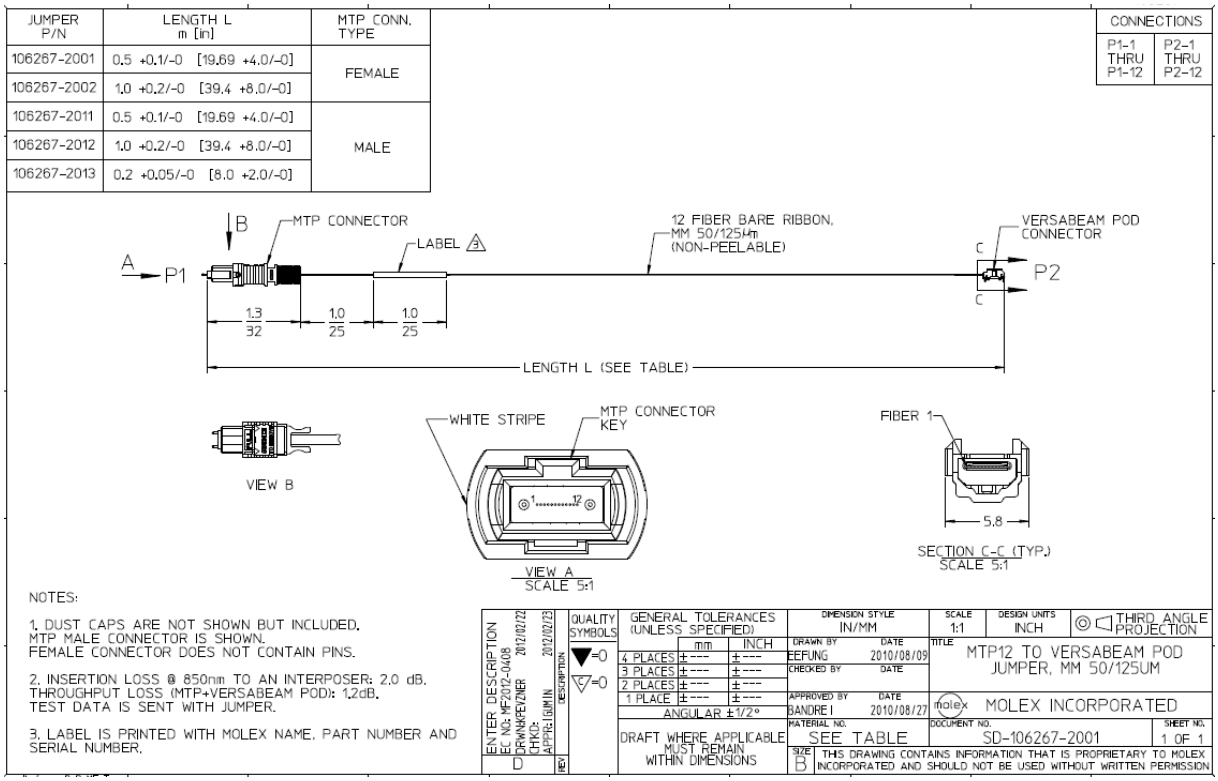
CMX

OPTICAL CONNECTION TO THE MINIPOD:

http://www.pa.msu.edu/hep/atlas/l1calo/cmx/hardware/details/cmx_ab_high_speed_optical.txt

For the optical run from the MiniPOD PRIZM connector to the front panel MTP feedthrough connector the CMX card uses Molex Part No. 106267-2011 cables (PRIZM-MTP(M) cable).

The MTP connector on these stub cables has male pins.



FRONT PANEL MTP/MPO ADAPTER (FEED-TROUGH):

MTP/MPO connectors/adapters connect male MTP/MPO to female MTP/MPO connectors, and are deployed at the faceplate where they interface the PRIZM-MTP cable to the external MTP-MTP cable.

http://www.pa.msu.edu/hep/atlas/l1calo/cmx/hardware/details/cmx_ab_high_speed_optical.txt

Front-Panel MTP Connectors: Short 12-fiber optical ribbon cables are used to make the MiniPOD inputs and outputs accessible from the CMX card front panel. Two MTP feedthrough connectors are mounted on the card's front panel.

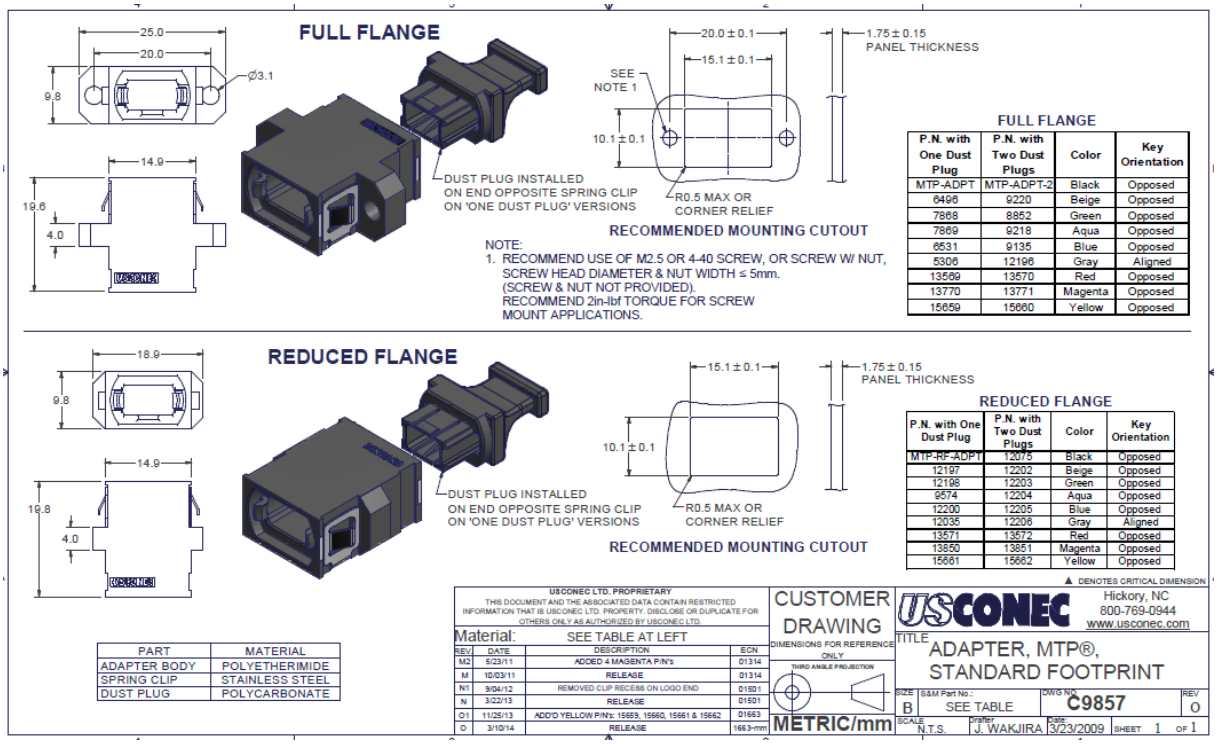
http://www.pa.msu.edu/hep/atlas/l1calo/cmx/hardware/details/cmx_0_parts_orders_and_info.txt

Description: MTP Adapter Reduced Flange Standard

USCONEC Part No: MTP-RF-ADPT 12075 MTP Standard Footprint Adapter

Reduced Flange, Black Color, Key Orientation: Opposed (“key-up to key-down” or “Type A”)

Reference URL: http://www.fiberoptics4sale.com/p/MTP-RFADPT.html

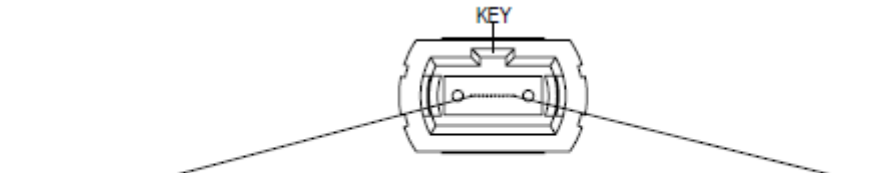


To align the corresponding channels of a transmit module to a receive module, a flip in the cable is required at some point along the connection interface. This can be achieved using either a key-up/key-down ribbon cable, or with a "key-up to key-down" MPO adapter.

MTP-MTP CABLE

External MTP-MTP cables are commonly Key-up/Key-down *(my understanding that this is visible and apply to the ribbon "flat" cable, in this case MTP connectors look the same from both ends, in the round cable it is not visible).*

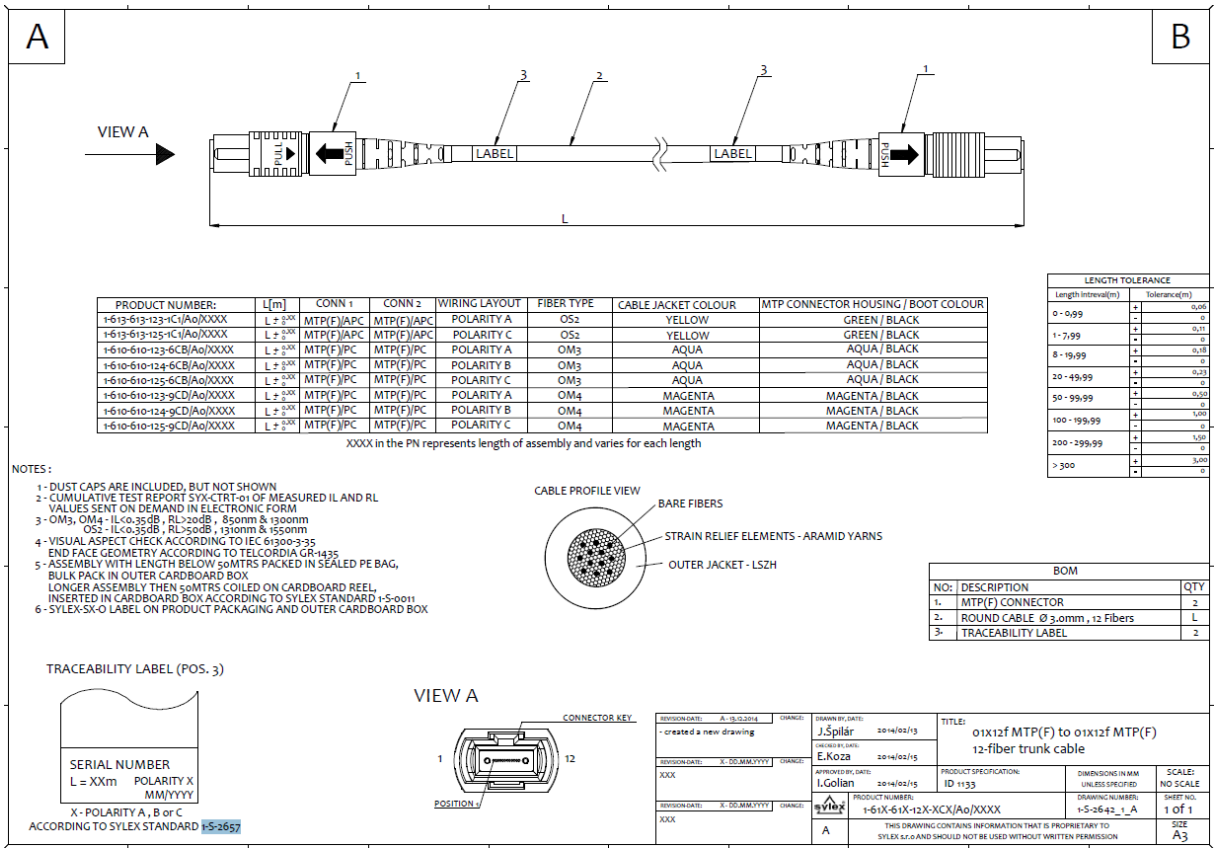
The fiber numbering within a connector and fiber colours:

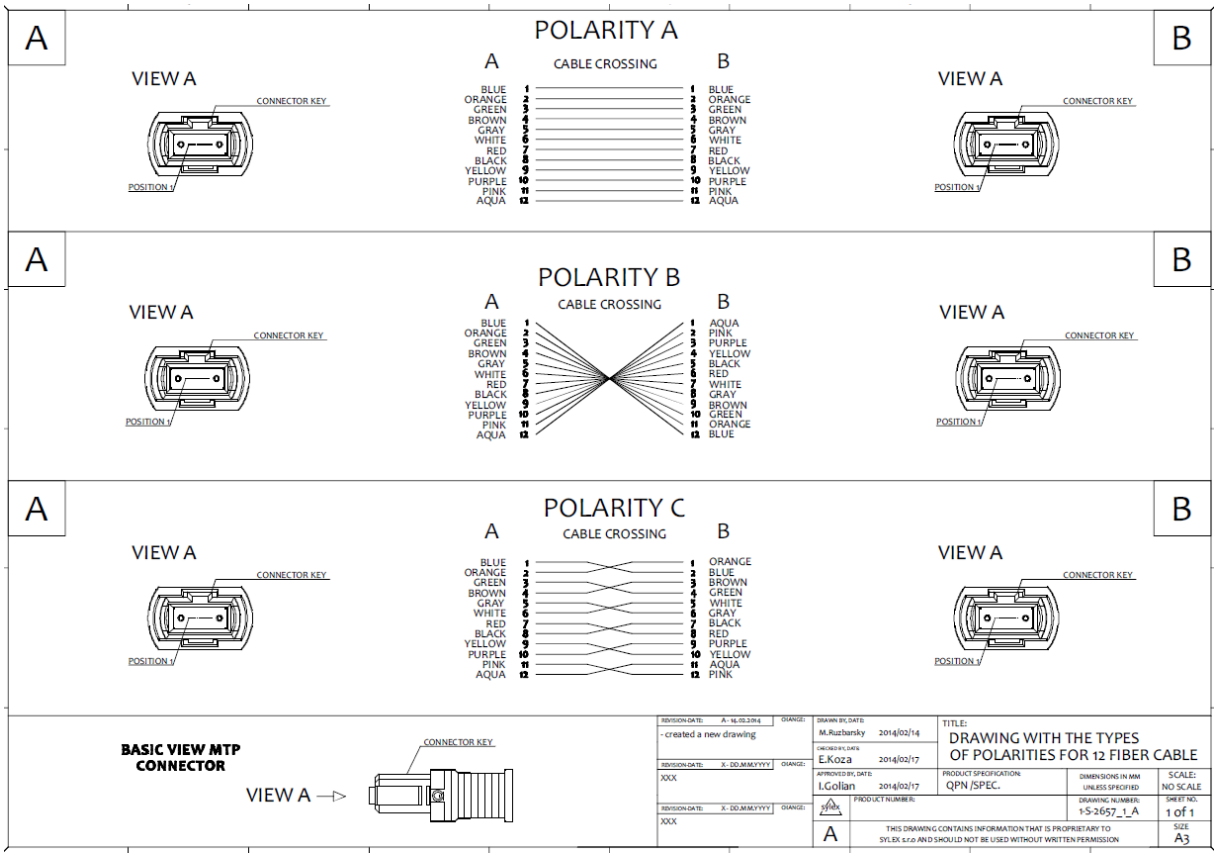


Position	1	2	3	4	5	6	7	8	9	10	11	12
Fiber Color	Blue	Orange	Green	Brown	Gray	White	Red	Black	Yellow	Violet	Rose	Aqua

http://www.sylex.sk/interconnections/mpomtp-interconnections/1x12f-mtp-to-1x12f-mtp-12-fiber-trunk-cable/

1-610-610-123-6CB/04/0002.00 1x12f MTP(F) to 1x12f MTP(F) 12-fiber OM3 trunk cable, PolarityA

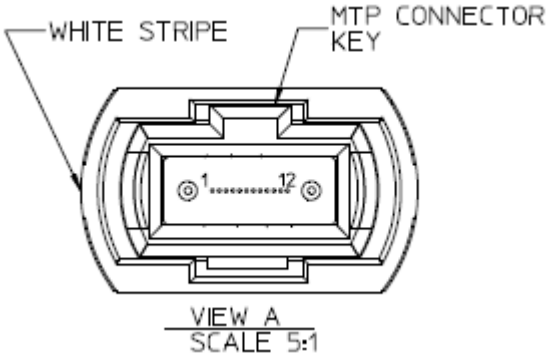




CMX OUTPUT-INPUT FIBER MAPPING WITH MTP-MTP CABLE

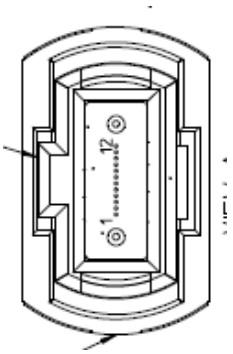
CMX output:

- PRIZM-MTP(M) cable – male MPT connector as seen from the front panel:



- MTP Adapter MTP-RF-ADPT 12075 MTP, Key Orientation: Opposed (Key-up/Key-down)
- MTP(F) connector on the Sylex 12-fiber OM3 trunk cable as seen from connector side:

After plugging the cable to the MTP Key-up/Key-down Adapter, the fiber mapping will be one-to-one:



Top, Key-up

Key Down

Top

Key-up/Key-down Adapter

It will be the same on the other side of the cable. Therefore, to receiver PRIZM-MTP(M) cable fibers will be connected in the same order as on the transmitter PRIZM-MTP(M) cable.

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