



ATLAS Level-1 Calorimeter Trigger FOX Demonstrator

Design document

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Document Change Record

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59 **1. INTRODUCTION**

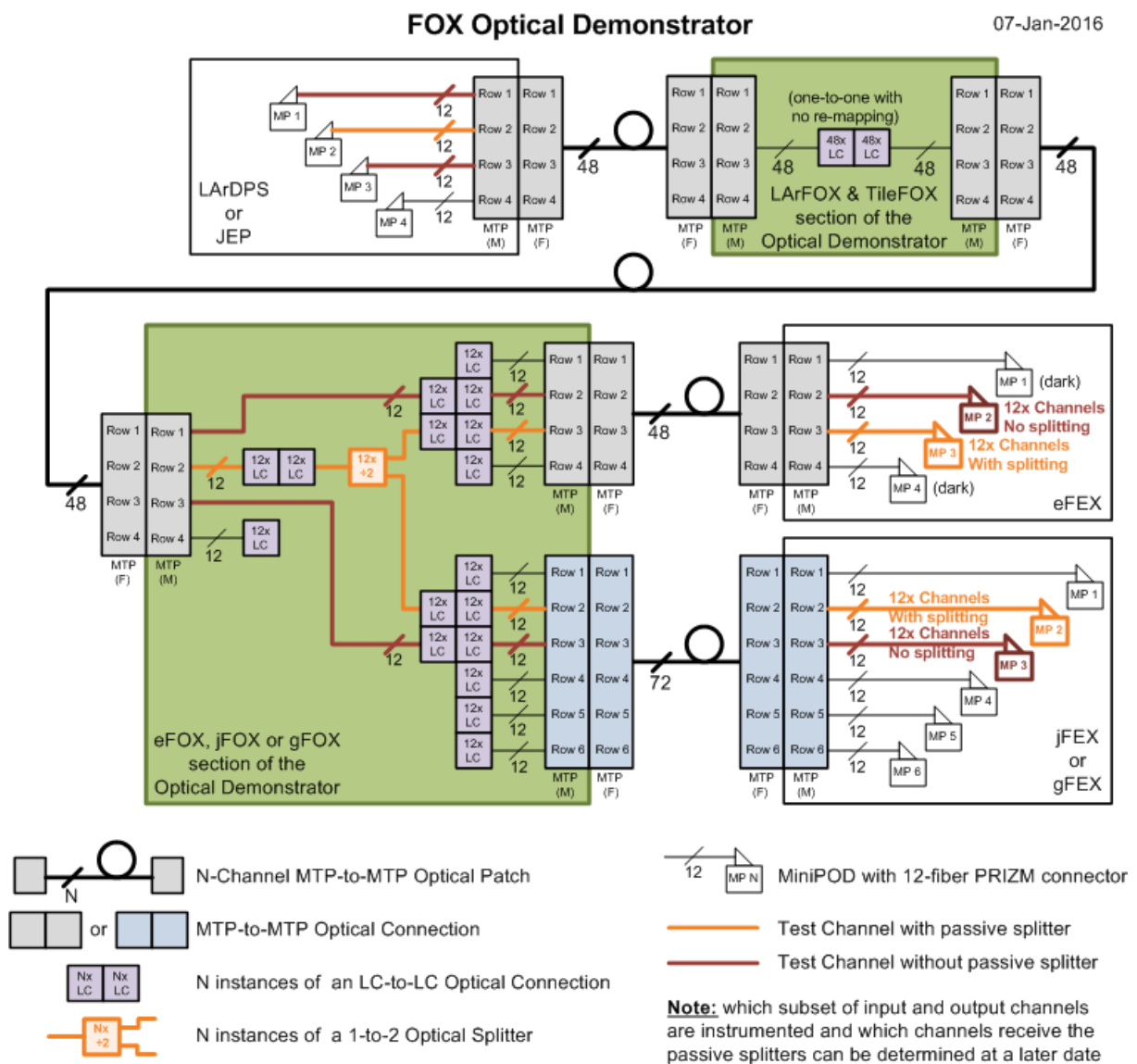
60 **1.1. FOX DEMONSTRATOR OVERVIEW**

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

- 63 • Provide the light path between the transmitter MiniPODs of the FEX Test Module (FTM), Liquid
 64 Argon (LAR) and Tile Calorimeter (Tile) Front-Ends and the receiver MiniPODs of the Feature
 65 Extractor (FEX) modules of 11calo.
- 66 • Provide mechanical building blocks necessary to construct an overall physical plant providing the
 67 required management and mapping of all the fibers and its installation in USA15.

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

70



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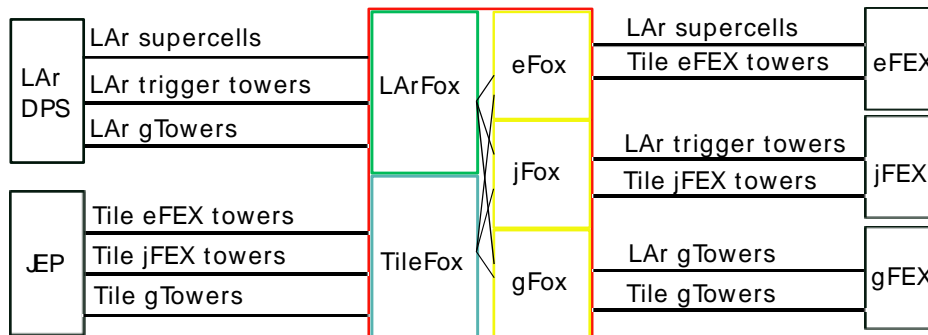
Figure 1: Draft diagram of the FOX Optical demonstrator.

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

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

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

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



83

84

Figure 2: Overview of optical plant partitioning.

85 1.2. CONVENTIONS

86 The following conventions are used in this document:

- 87 • The term “FOX” is used to refer to the Phase-I L1Calo Optical Plant – Fex Optics eXchange or
88 Fiber Optics eXchange (FOX). Alternate names are “fiber plant” or “optical plant” or “FEX
89 optical plant”.
- 90 • eFEX – electron Feature EXtractor.
- 91 • jFEX – jet Feature EXtractor.
- 92 • gFEX – global Feature EXtractor.

93 1.3. RELATED PROJECTS

94 [1] [FOX Project Specification, v0.14, 11 November 2014.](#)

95 [2] [ATLAS Liquid Argon Phase 1 Technical Design Report, CERN-LHCC-2013-017,](#)

96 [3] [ATLAS Tile Calorimeter,](#)

97 [4] [Electromagnetic Feature Extractor \(eFEX\) Prototype, v0.3, 6 February 2014,](#)

98 [5] [Jet Feature Extractor \(jFEX\) Prototype, v0.2, 14 July 2014,](#)

99 [6] [Global Feature Extractor \(gFEX\) Prototype, v0.3, 16 October 2014,](#)

100 [7] [FEX Test Module \(FTM\), v0.0, 18 July 2014,](#)

101 [8] [Specification of the LAr-L1Calo 1 Link-Speed Tests, Draft 09, 14 January 2016](#)

102 1.4. REFERENCE MATERIALS

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

104

105 **2. FOX DEMONSTRATOR**

106 The inputs and outputs to/from the FOX demonstrator are optical signal carried by multi-fiber ribbon
 107 cables with parallel Multi-fiber Termination Push-On (MTP) connectors – improved version of the
 108 MPO connector (known as multi-fiber push-on and also as multi-path push-on) – a multi-fiber
 109 connector defined according to IEC 61754-7 and TIA/EIA 604-5 that can accommodate 12-72 fibers:
 110

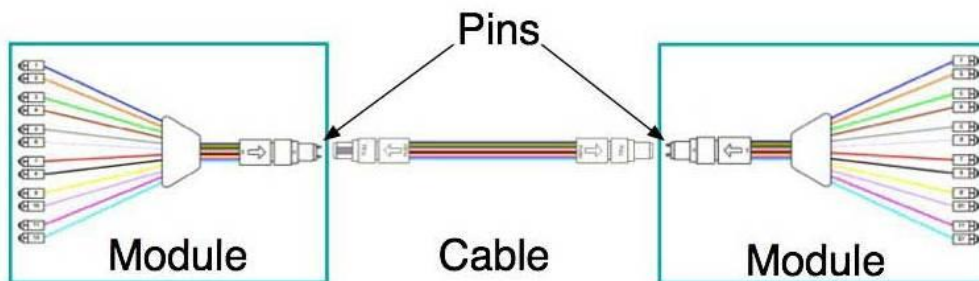


111
 112 **Figure 3: MPO cable female connector for accommodating 24 fibers.**

113 The following convention will apply to the optical connectors:

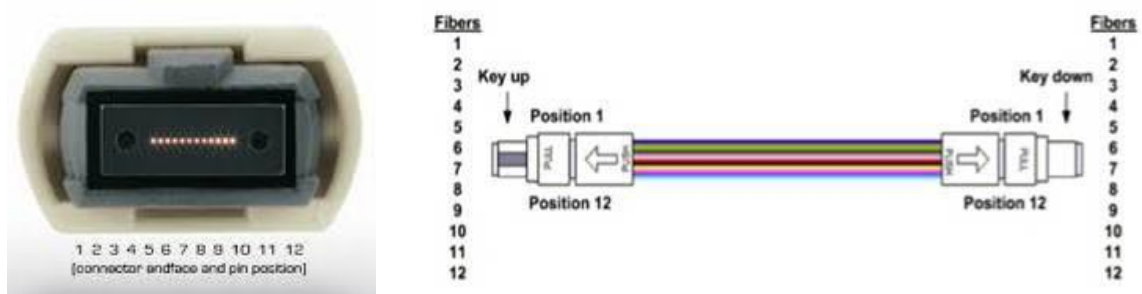
- 114 • All MTP connectors part of all modules in LAr, Tile, eFEX, jFEX, gFEX and FOX are male,
- 115 • All MTP trunk cables used to connect any two L1Calo modules are female at both ends.

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



117
 118 **Figure 4: Convention for optical connectors: module has male connector and cable has female connector.**

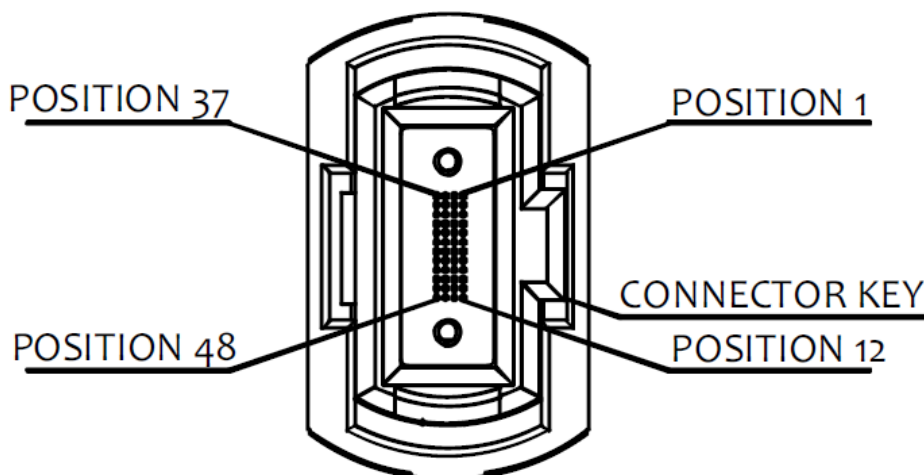
119 The fiber numbering within a connector and fiber colours:



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

121
 122 **Figure 5: Fiber numbering in 12-fibers female MTP.**

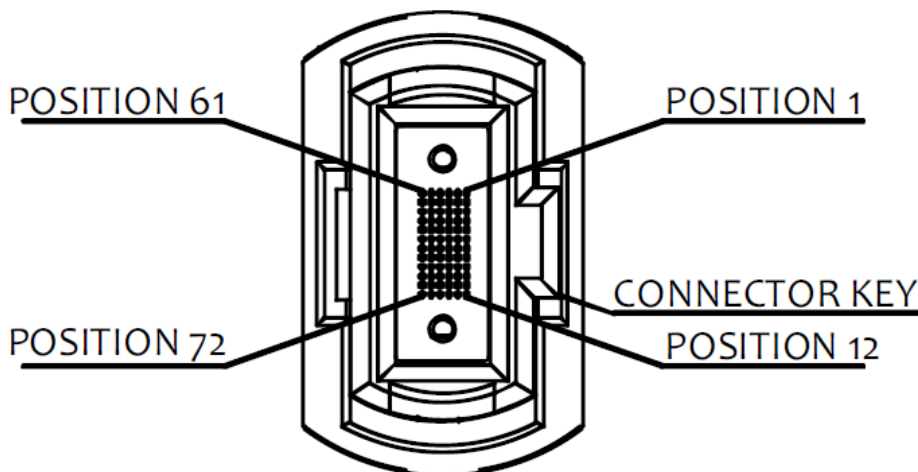
VIEW TO MTP



123
124
125

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

VIEW TO MTP



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133
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135
136

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

137 **2.1. INPUTS TO THE DEMONSTRATOR**

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

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

143 **2.1.1. Input from CMX module**

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

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

148 **2.1.2. Input from FTM module**

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

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

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

154 **2.1.3. Input from LAr (LDPS)**

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

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

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

163 **2.1.4. Input from Tile (TRES)**

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

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

167

168 **2.2. OUTPUTS FROM THE DEMONSTRATOR**

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

171 **2.2.1. Outputs to CMX and FTM**

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

174 **2.2.2. Output to eFEX module**

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

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

178 **2.2.3. Output to jFEX module**

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

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

182 **2.2.4. Output to gFEX module**

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

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

186

187 **2.3. DEMONSTRATOR PARTITIONING AND HOUSING**

188 **2.3.1. Demonstrator partitioning**

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

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

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

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

199

200 **First part - LArFOX/TileFOX demonstrator**

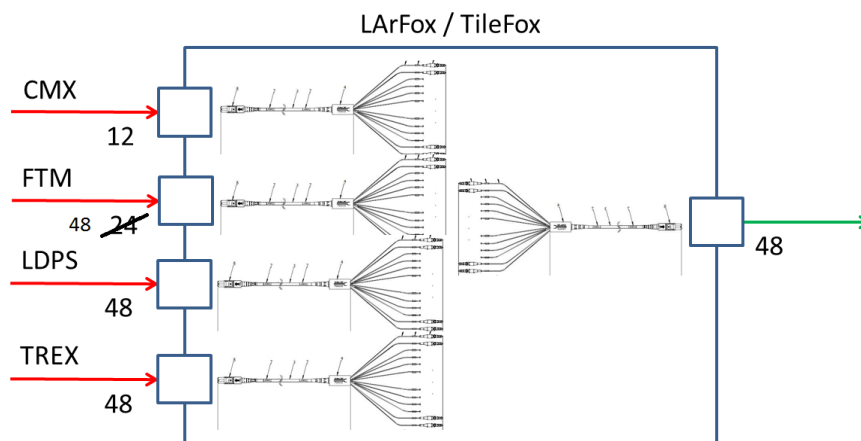
201 For the final design this part may be implemented using a custom build commercial mapping module,
 202 which redistributes the input signals to output connectors, as described in 3.2.4 of the FOX Project
 203 Specification [1] or by connecting fibers by fusion splicing, as described in 3.2.3 of [1].

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

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

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

213



214

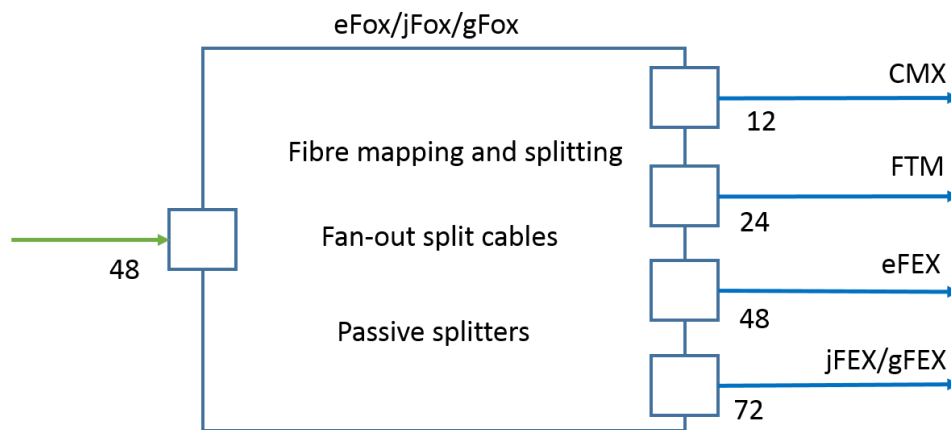
215 **Figure 8: LArFOX/TileFOX part for the FOX demonstrator – possible “logical” inputs.**

216

217 **Second part - eFOX/jFOX/gFOX demonstrator**

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

- 220 • The MTP breakout split cables will provide internal mapping of the input-output fibers – male
221 MTP to male LC connectors – or by trunk cable without mapping. The use of LC connectors
222 provides maximum flexibility. Any input fiber can be connected to any output fiber.
223 • For the data path that require passive splitting, we will use up to 3 connectorized passive splitters
224 with the LC connectors on both end, as described in 3.3 of [1] . It will be inserted in-situ upon
225 need. We would also like to have 3 passive splitters, connected directly to the 48-fiber MTP input
226 male connector with LC connectors on output fibers. The input breakout cable therefore will be 48
227 MTP(M) to 45 LC(F) + 3 splitters, connected directly to the MTP (first three fibers from the end,
228 on the second row), on the other side of the splitters – 2 LC(F). The LC connectors on the output
229 side of the splitters can be connected as needed, with maximum flexibility. Details are in 2.4.3.
- 230 On the input side, the eFOX/jFOX/gFOX part will have one feed-trough for one MTP input male
231 connector and on the output side - two feed-troughs for MTP output male connectors. Figure 9 shows
232 four possible output “logical” connections to two physical MTP feed-troughs.



233
234 **Figure 9: eFOX/jFOX/gFOX part for the FOX demonstrator – possible “logical” outputs.**
235

236 2.3.2. Demonstrator housing

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

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

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

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

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

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

256



257

258

Figure 10: FOX Demo boxes.

259

260 **2.3.3. Feed-through**

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

FULL FLANGE

Dimensions: 25.0, 20.0, 9.8, 14.9, 19.8, 4.0, 10.1 ± 0.1, 20.0 ± 0.1, 15.1 ± 0.1, 1.75 ± 0.15 PANEL THICKNESS.

NOTE: 1. RECOMMEND USE OF M2.5 OR 4-40 SCREW, OR SCREW W/ NUT, SCREW HEAD DIAMETER & NUT WIDTH ≤ 5mm. (SCREW & NUT NOT PROVIDED). RECOMMEND 2in-lbf TORQUE FOR SCREW MOUNT APPLICATIONS.

P.N. with One Dust Plug	P.N. with Two Dust Plugs	Color	Key Orientation
MTP-ADPT	MTP-ADPT-2	Black	Opposed
6496	9220	Beige	Opposed
7868	8852	Green	Opposed
7868	9218	Aqua	Opposed
6531	9135	Blue	Opposed
5306	12196	Gray	Aligned
13560	13570	Red	Opposed
13770	13771	Magenta	Opposed
15650	15660	Yellow	Opposed

REDUCED FLANGE

Dimensions: 18.9, 9.8, 14.9, 19.8, 4.0, 10.1 ± 0.1, 15.1 ± 0.1, 1.75 ± 0.15 PANEL THICKNESS.

P.N. with One Dust Plug	P.N. with Two Dust Plugs	Color	Key Orientation
MTP-RF-ADPT	12075	Black	Opposed
12197	12203	Beige	Opposed
12198	12203	Green	Opposed
6574	12204	Aqua	Opposed
12200	12205	Blue	Opposed
12035	12206	Gray	Aligned
13571	13572	Red	Opposed
13550	13551	Magenta	Opposed
15661	15662	Yellow	Opposed

PART	MATERIAL
ADAPTER BODY	POLYETHERIMIDE
SPRING CLIP	STAINLESS STEEL
DUST PLUG	POLYCARBONATE

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CUSTOMER DRAWING
DIMENSIONS FOR REFERENCE ONLY
THIRD ANGLE PROJECTION
SCALE: N.T.S.
DATE: 3/23/2009
SHEET 1 of 1

REV	DATE	DESCRIPTION	ECN
M2	5/23/11	ADDED 4 MAGENTA PINS	01314
M1	10/23/11	RELEASE	01314
N1	3/02/12	REMOVED CLIP PINS ON LOGO END	01501
N	3/02/13	RELEASE	01501
O1	11/25/13	ADD'D YELLOW PINS: 15659, 15660, 15661 & 15662	01563
O	3/10/14	RELEASE	1563-1111

ADAPTER, MTP®, STANDARD FOOTPRINT
C9857

262

263

Figure 11: Individual adapter compatible with all MTP connectors.

264

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

265

The following convention applies to the optical connectors:

266

- 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.

267

268

269

270

271

272 **2.4. OPTICAL CABLES AND SPLITTERS**

273 **2.4.1. Trunk cables to/from FOX demonstrator**

274 Initial assumptions during the FOX Demo design is:

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

279 Trunk cables with female MTP connectors to connect input systems:

- 280 • 12-fibers trunk cable to connect the CMX output,
- 281 • 48-fibers trunk cable to connect the FTM, the LDPS, or the TREX output.

283 Trunk cables with female MTP connectors to connect output systems:

- 284 • 12-fibers trunk cable to connect the CMX input,
- 285 • 24-fibers trunk cable to connect the FTM input,
- 286 • 48-fibers trunk cable to connect the eFEX input.
- 287 • 72-fibers trunk cable to connect the jFEX or the gFEX input.

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

- 291 • 2 x 12-fibers trunk cables for the CMX output and input,
- 292 • 1 x 24-fibers trunk cable for the FTM input,
- 293 • 3 x 48-fibers trunk cables for the FTM, LDPS, or TREX output, between boxes and eFEX input,
- 294 • 1 x 72-fibers trunk cable for the jFEX or gFEX input.

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

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

304

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

305

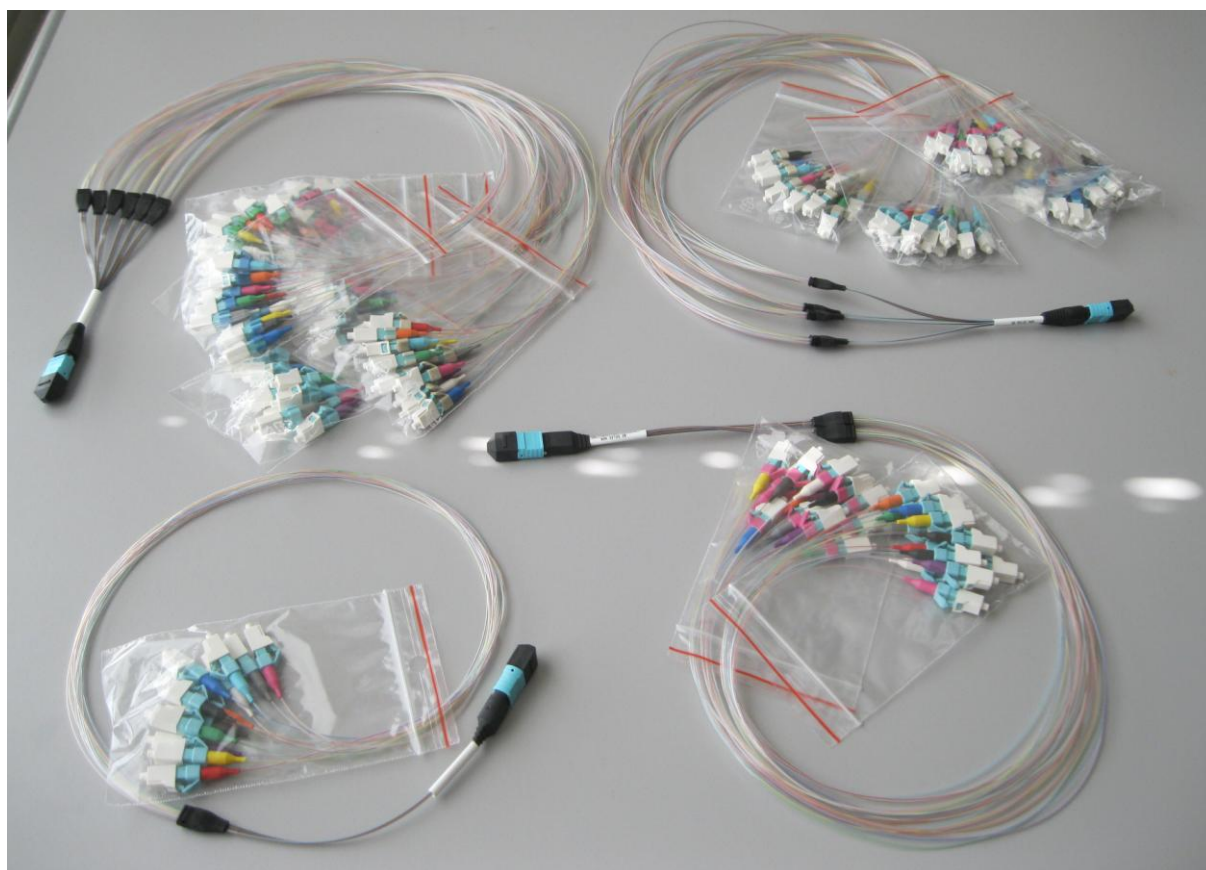
Table 1: Trunk cables.

306

307 **2.4.2. Breakout cables**

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

314



315

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

317

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

- 322 • fibers 1-12 terminated with AQUA connector heads, with AQUA latches, each connector will
323 have the same color of boot as the fiber
- 324 • fibers 13-24 terminated with AQUA connector heads, with MAGENTA latches, each
325 connector will have the same color of boot as the fiber
- 326 • fibers 25-36 terminated with AQUA connector heads, with BEIGE latches, each connector
327 will have the same color of boot as the fiber
- 328 • fibers 37-48 terminated with AQUA connector heads, with BLUE latches, each connector will
329 have the same color of boot as the fiber

330

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

335

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

336

Table 2: Breakout cables.

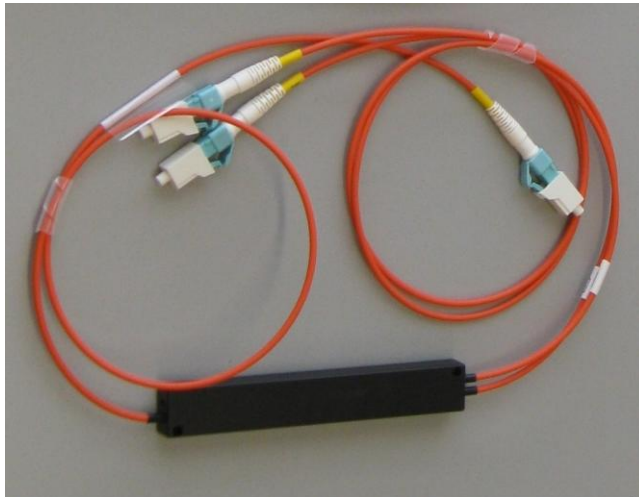
337 NB: The assumption is that the trunk cable between the boxes is always 48-fiber.

338

339 **2.4.3. Passive splitters**

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

343 In the data path, which may require data duplication to two data destinations, the connectorized
344 passive splitter may be inserted inside the box (see Figure 13). The passive splitter from SENKO has
345 even split ratio 50/50 and the LC connectors on both ends of 0.5m pigtails. 3 splitters are available.
346



- 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

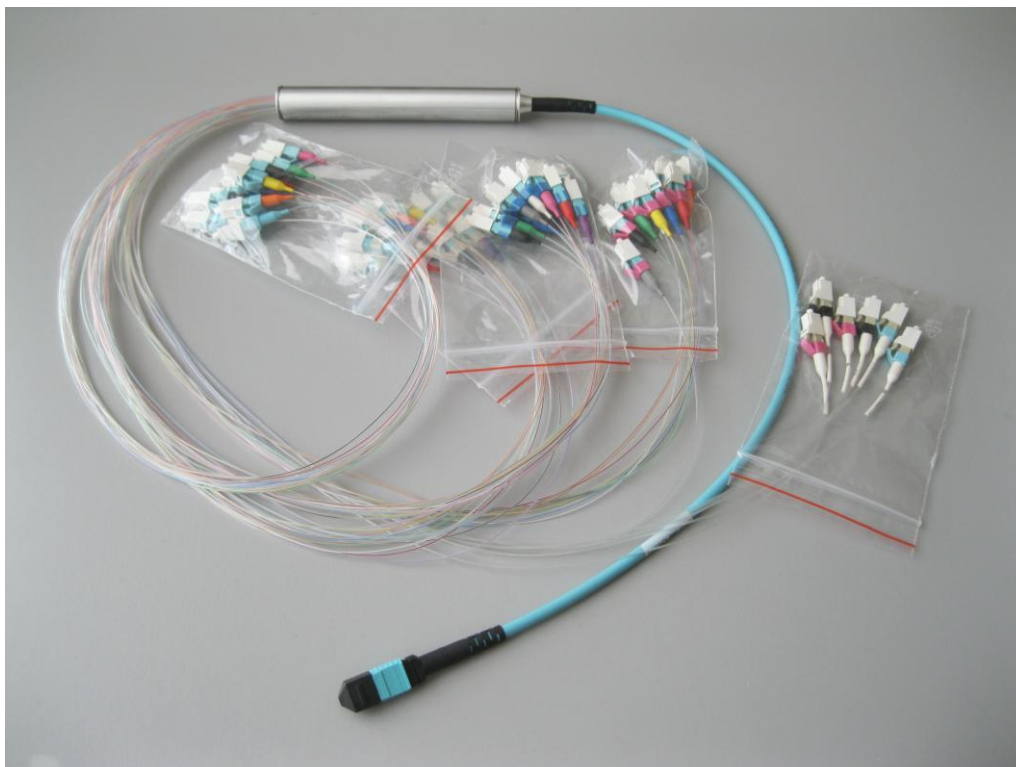
347

348

Figure 13: Passive splitter.

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

351



352

353

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

- 354 The 45 “direct” fibers from the MTP connector are terminated with the LC connectors with AQUA
355 color housings.
- 356 The three fibers, connected to the passive splitters, are from the second row of the 48-fibers MTP
357 connector – positions 22, 23 and 24. The six LC connectors on the fibers after the splitters have
358 BEIGE color housings.
- 359 Connectors terminated to the first row of the 48F-fiber MTP (positions 1-12) are with AQUA clip.
- 360 Connectors terminated to the second row (positions 13-21) are with MAGENTA clip (position 22, 23,
361 24 are with the splitter). The position 22 is marked on the LC side with a marking sleeve Nr.1 (LC clip
362 AQUA), position 23 - marking sleeve Nr.2 (LC clip MAGENTA); position 24 - marking sleeve Nr.3
363 (LC clip BLACK).
- 364 Connectors terminated to the third row (positions 25-36) are with BEIGE clip.
- 365 Connectors terminated to the fourth row (positions 37-48) are with BLUE clip.
- 366 The Figure 15 shows the passive splitter with bare fibers:
367



- 368
369

Figure 15: Passive splitter with bare fibers.

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

371



372

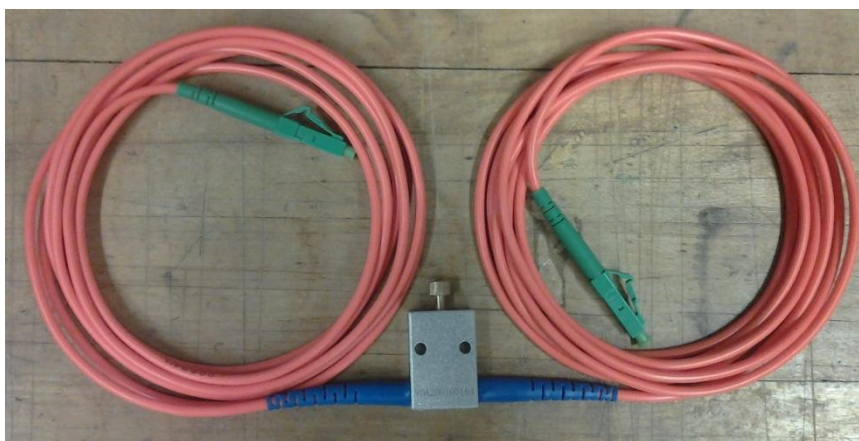
373

Figure 16: “Simulation” of the breakouts inside the box.

374 **2.4.4. Variable Optical Attenuator**

375 Collimator variable optical attenuator (VOA) is a fiber optic attenuator - Multimode 50 μ m fiber core,
376 2 meters, 850-1310nm, Return Loss < -0.8dB - 40dB, terminated with LC connectors. This is a useful
377 tool for the optical components power adjustment and systems test (Figure 17). Turn knob to change
378 attenuation.

379



380

381

Figure 17: Variable Optical Attenuator (VOA).

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

385 There are five variable optical attenuator available for the tests.

386

387 **2.5. POSSIBLE MAPPING SCENARIOS**

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

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

399
400 As an example, the scenario may looks like (see also the table entry example below in Table 3):

- 401 • The input to the first box (LArFOX/TileFOX) – 48-fiber trunk cable (In),
- 402 • Possible mappings in the first box: input and output 48-fiber breakout cables,
- 403 • 48-fiber trunk cable between the boxes (Between).
- 404 • Possible mappings in the second box (eFOX/jFOX/gFOX): input and output 48-fiber breakout
- 405 cables,
- 406 • 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

408 **Table 3: Entry example.**

409
410 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

412 **Table 4: Possible mapping scenarios without splitters.**

413
414 In a cases, where we have 48 input fibers and 72 output fibers, not all 72 output fibers will carry a
415 signal but only 48 of them (plus up to 6 fibers more if we use splitters).

417 **2.5.1. Tests with CMX and FTM**

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

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

423 **2.5.2. Tests with eFEX**

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

425

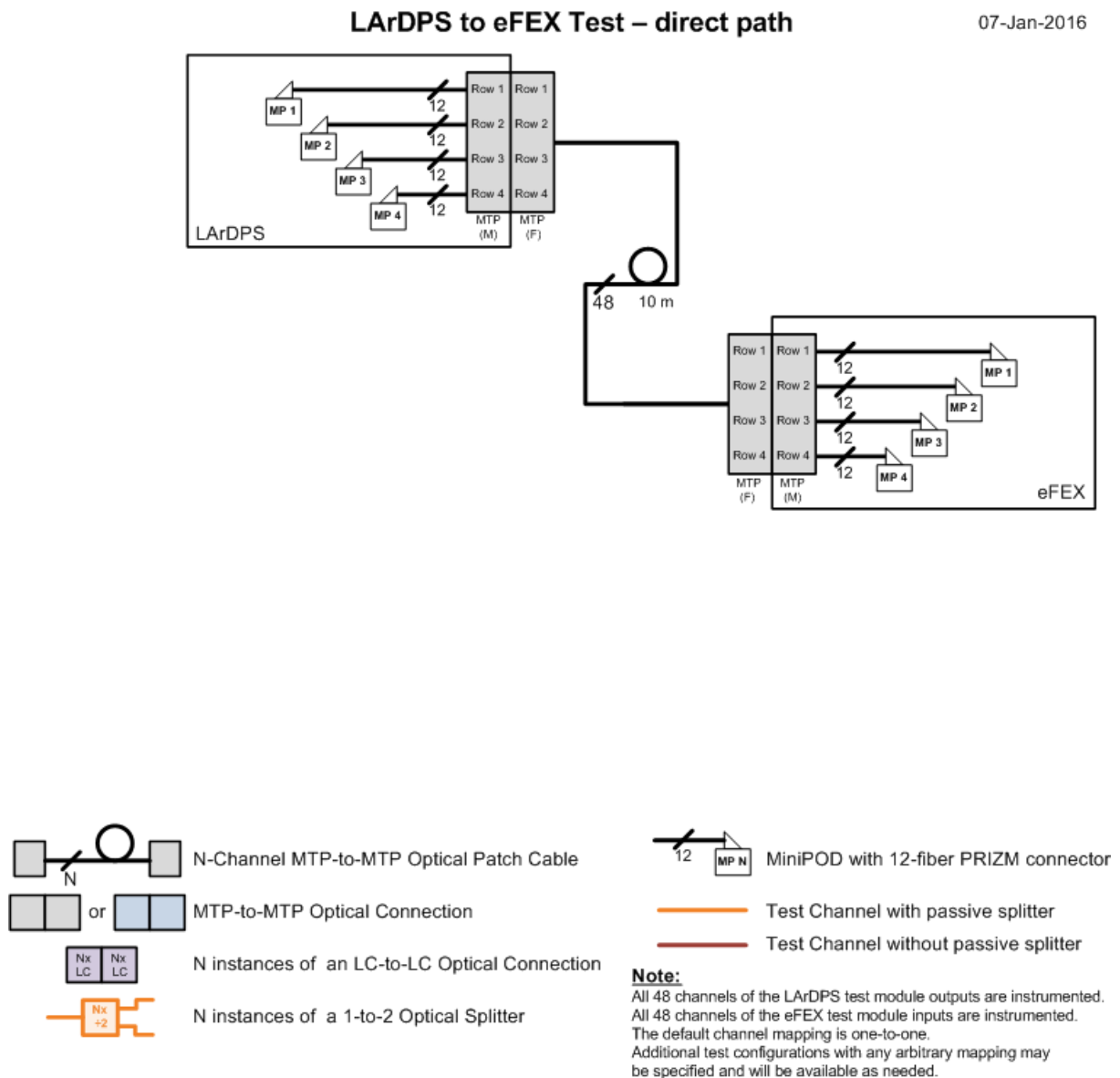
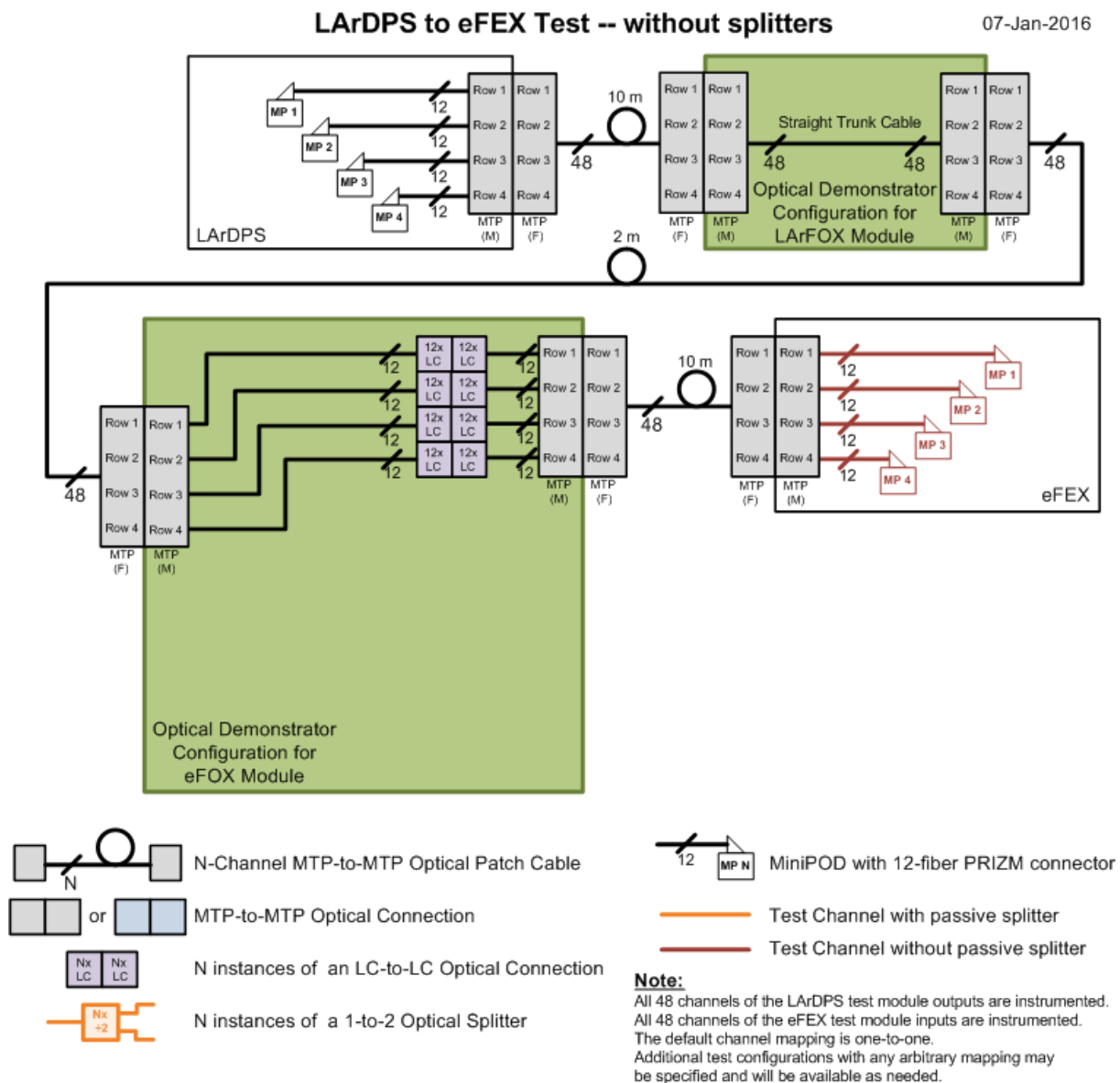


Figure 18: eFEX test with direct path.

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

433



434

435

Figure 19: eFEX test without optical splitters.

436

437

438

439

440

441

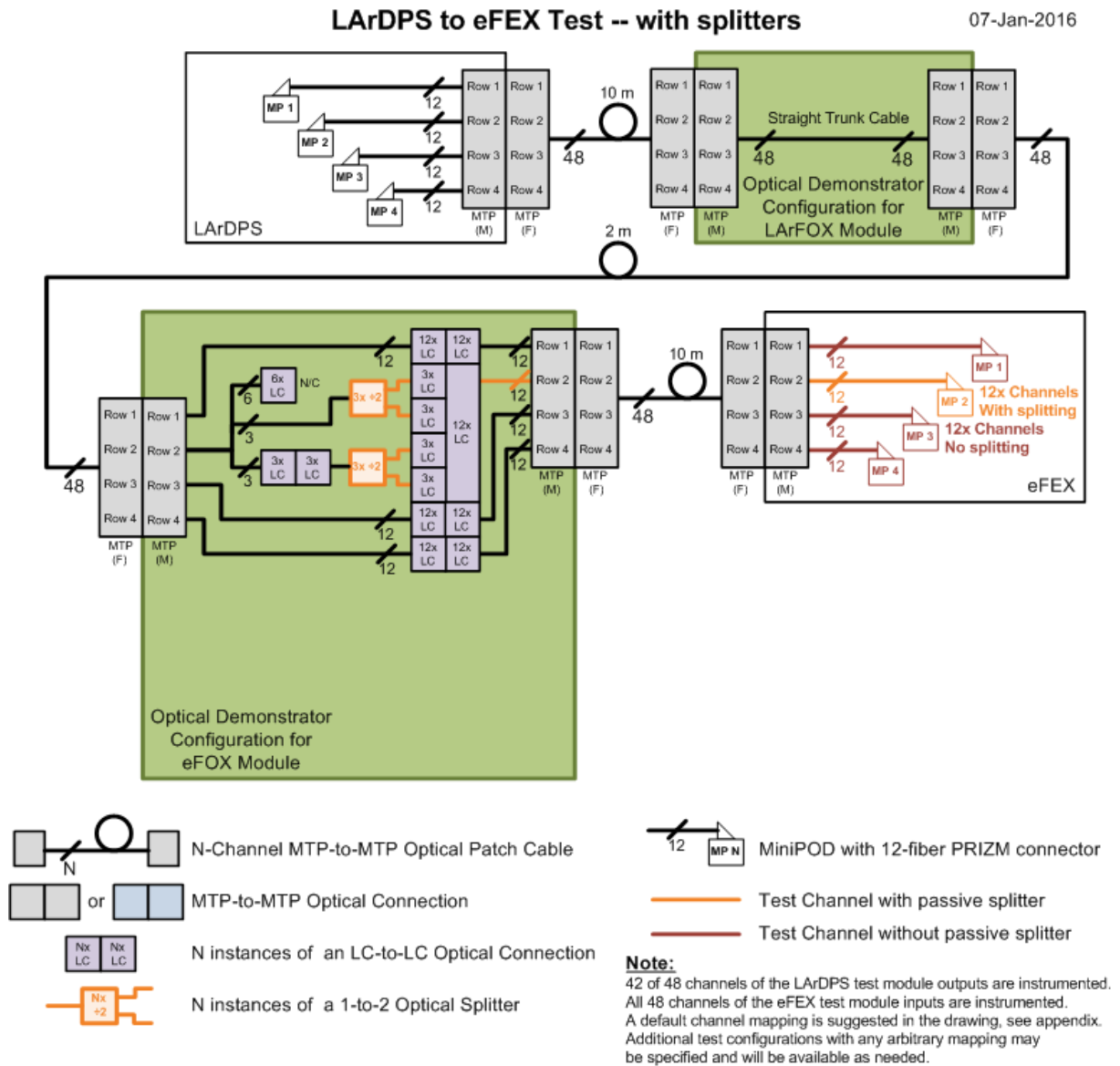
442

443

444

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

446



447

448

Figure 20: eFEX test with optical splitters.

449

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

453

454

455

456

457

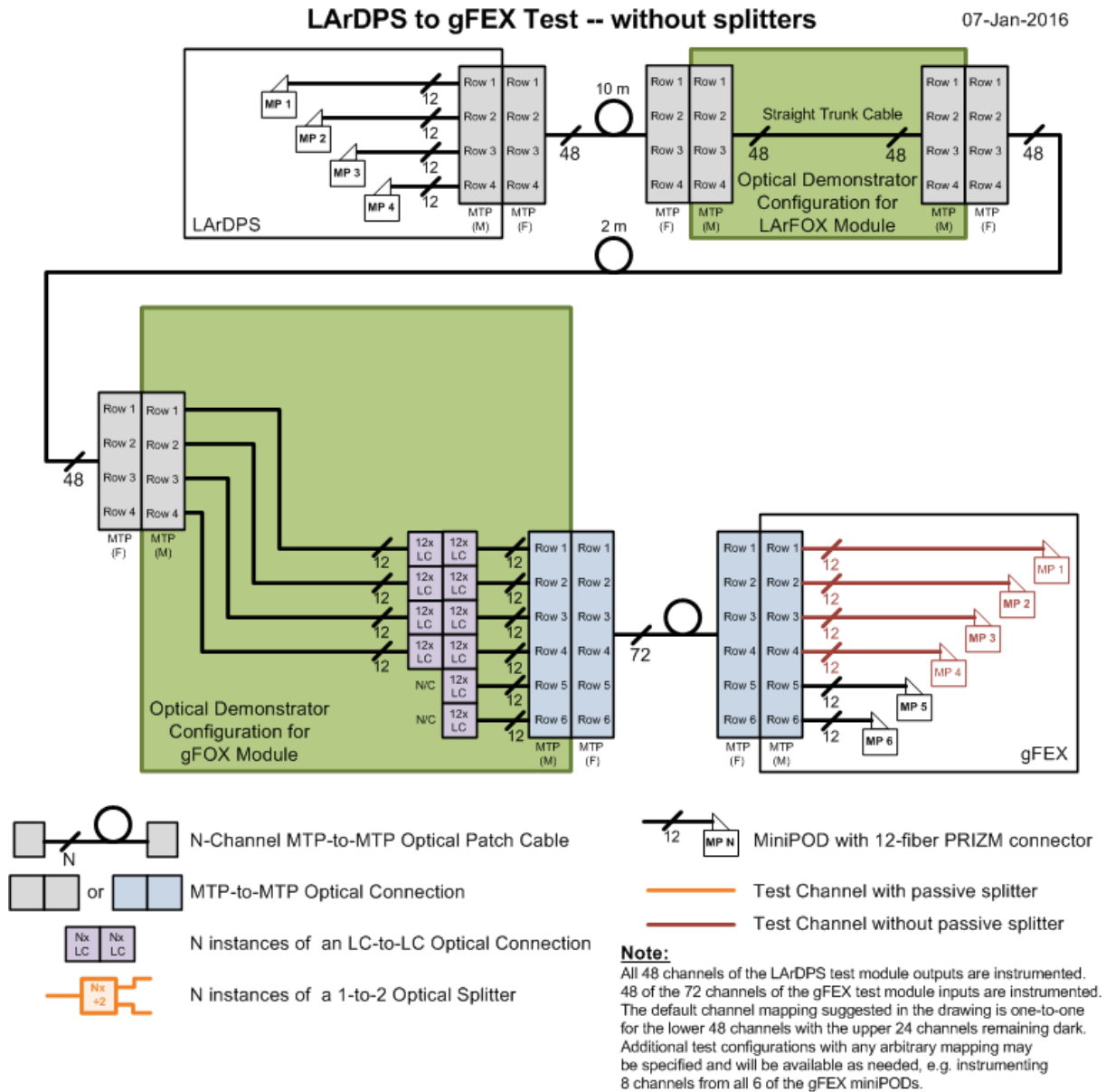
458

459 **2.5.3. Tests with gFEX/jFEX**

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

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

462



463

464

Figure 21: gFEX/jFEX test without optical splitters.

465

466

467

468

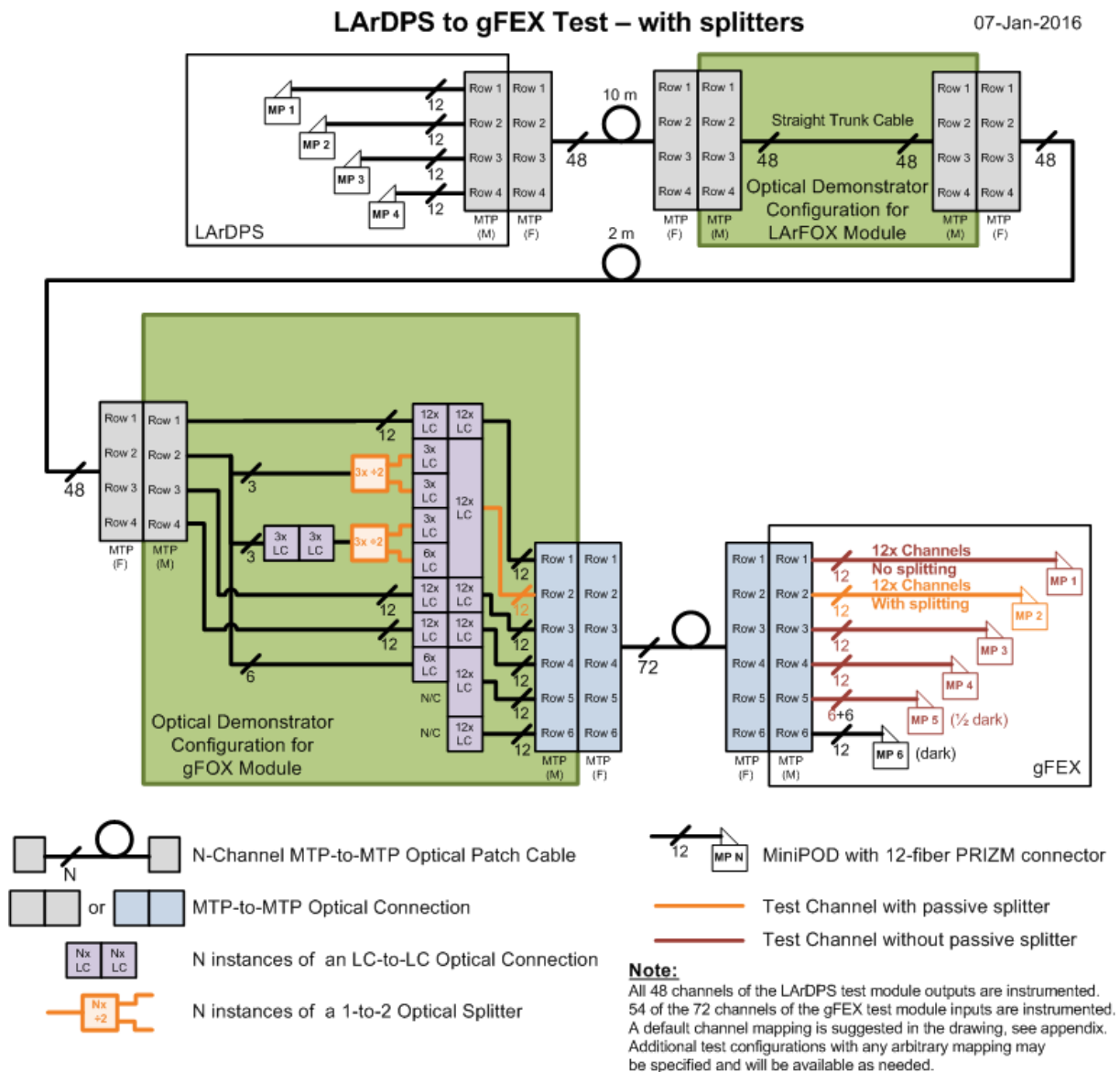
469

470

471

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

473



474

475

Figure 22: gFEX/jFEX test with optical splitters.

476 **Scenario 7:** all configurable mapping.

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

479

480 **2.6. TOOLS**

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

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

484 **2.6.1. MiniPOD light level monitoring**

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

489 **2.6.2. Optical power meter fluke networks FTK-1000**

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



492

493

Figure 23: Fluke FTK-1000 and reference set.

494 **2.6.3. LC/MPO cleaning sets**

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



496

497

Figure 24: LC connectors cleaning set.

498 Extra cassette and replacement cartridges also ordered.

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



500

501

Figure 25: LC/MPO connectors cleaning set.

502 **2.6.4. MPO cleaning tools**

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



504

505

Figure 26: MPO connectors cleaning tools.

506

507 **APPENDIX A. LARG-L1CALO LINK TESTS**

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

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

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

- 514 • With and without FOX
- 515 • With and without passive optical splitter (when FOX included)
- 516

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	“

517
518

519 **Table 5: Optical setups for the link speed tests.**

520
521
522
523
524



525
526
527
528
529

Figure 27: Link speed tests.

530 **APPENDIX B. OPTICAL CONNECTORS MAPPING**

531 **CMX**

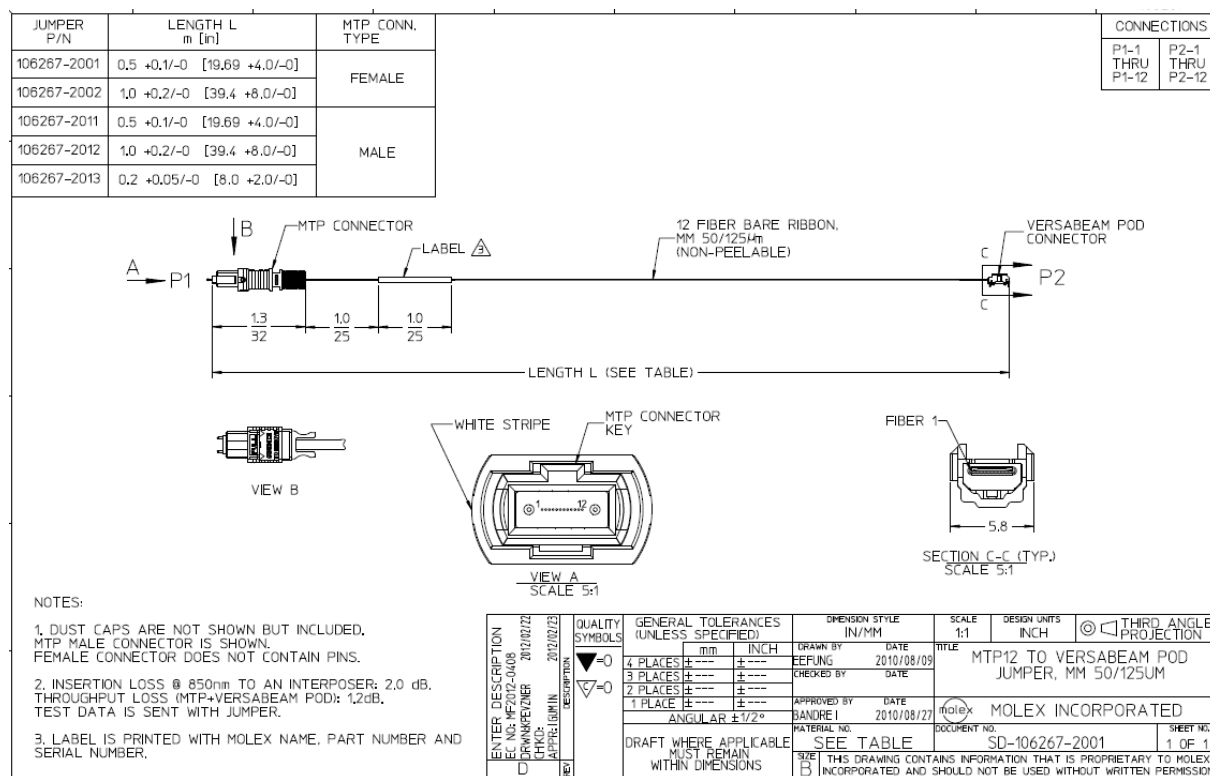
532 **OPTICAL CONNECTION TO THE MINIPOD:**

533 http://www.pa.msu.edu/hep/atlas/11calo/cmz/hardware/details/cmz_ab_high_speed_optical.txt

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

536 The MTP connector on these stub cables has male pins.

537



538
539

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

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

543 http://www.pa.msu.edu/hep/atlas/11calo/cmz/hardware/details/cmz_ab_high_speed_optical.txt

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

547 http://www.pa.msu.edu/hep/atlas/11calo/cmz/hardware/details/cmz_0_parts_orders_and_info.txt

548 Description: MTP Adapter Reduced Flange Standard

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

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

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

552

FULL FLANGE

25.0, 20.0, 9.8, 14.9, 19.6, 4.0, 20.0 ± 0.1, 15.1 ± 0.1, 10.1 ± 0.1, 1.75 ± 0.15 PANEL THICKNESS, ∅3.1, R0.5 MAX OR CORNER RELIEF, DUST PLUG INSTALLED ON END OPPOSITE SPRING CLIP ON 'ONE DUST PLUG' VERSIONS, RECOMMENDED MOUNTING CUTOUT, NOTE: 1. RECOMMEND USE OF M2.5 OR 4-40 SCREW, OR SCREW W/ NUT, SCREW HEAD DIAMETER & NUT WIDTH ≤ 5mm. (SCREW & NUT NOT PROVIDED). RECOMMEND 2in-lbf TORQUE FOR SCREW MOUNT APPLICATIONS.

P.N. with One Dust Plug	P.N. with Two Dust Plugs	Color	Key Orientation
MTP-ADPT-1	MTP-ADPT-2	Black	Opposed
6405	6220	Beige	Opposed
7868	8852	Green	Opposed
7868	8218	Aqua	Opposed
8531	9135	Blue	Opposed
5308	12198	Gray	Aligned
13569	13570	Red	Opposed
13770	13771	Magenta	Opposed
15659	15660	Yellow	Opposed

REDUCED FLANGE

18.9, 9.8, 14.9, 19.6, 4.0, 15.1 ± 0.1, 10.1 ± 0.1, 1.75 ± 0.15 PANEL THICKNESS, R0.5 MAX OR CORNER RELIEF, DUST PLUG INSTALLED ON END OPPOSITE SPRING CLIP ON 'ONE DUST PLUG' VERSIONS, RECOMMENDED MOUNTING CUTOUT.

P.N. with One Dust Plug	P.N. with Two Dust Plugs	Color	Key Orientation
MTP-ADPT-1	MTP-ADPT-2	Black	Opposed
12197	12202	Beige	Opposed
12198	12203	Green	Opposed
9574	12204	Aqua	Opposed
12200	12205	Blue	Opposed
12038	12206	Gray	Aligned
13571	13572	Red	Opposed
13850	13851	Magenta	Opposed
15661	15662	Yellow	Opposed

PART	MATERIAL
ADAPTER BODY	POLYETHERIMIDE
SPRING CLIP	STAINLESS STEEL
DUST PLUG	POLYCARBONATE

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DIMENSIONS FOR REFERENCE ONLY
THIRD ANGLE PROJECTION
SCALE: N.T.S.
DATE: 3/23/2009
REV: 0

USCONEC
Hickory, NC
800-769-0944
www.usconec.com

TITLE: ADAPTER, MTP®, STANDARD FOOTPRINT
SIZE: SEE TABLE
DWG NO: C9857
REV: 0

553

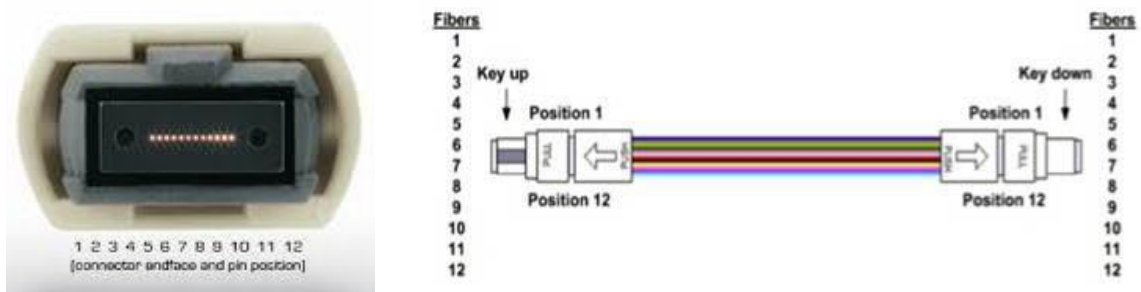
554

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

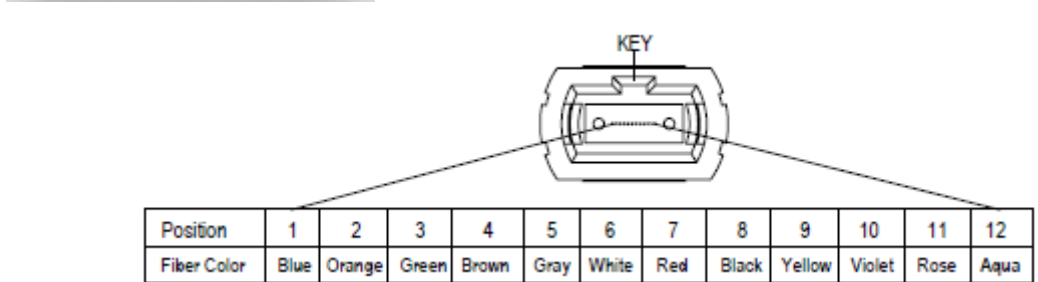
558 **MTP-MTP CABLE**

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

562 The fiber numbering within a connector and fiber colours:



563



564

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

567 1-610-610-123-6CB/04/0002.00 1x12f MTP(F) to 1x12f MTP(F) 12-fiber OM3 trunk cable, Polarity A

LENGTH TOLERANCE	
Length Interval(m)	Tolerance(m)
0 - 0,99	+0,006
1 - 7,99	+0,011
8 - 19,99	+0,018
20 - 49,99	+0,023
50 - 99,99	+0,030
100 - 199,99	+0,039
200 - 299,99	+0,050
> 300	+0,060

PRODUCT NUMBER:	L[m]	CONN 1	CONN 2	WIRING LAYOUT	FIBER TYPE	CABLE JACKET COLOUR	MTP CONNECTOR HOUSING / BOOT COLOUR
+613-613-123-1C1/A0/XXXX	L ± 0,25	MTP(F)/APC	MTP(F)/APC	POLARITY A	OS2	YELLOW	GREEN / BLACK
+613-613-125-1C1/A0/XXXX	L ± 0,25	MTP(F)/APC	MTP(F)/APC	POLARITY C	OS2	YELLOW	GREEN / BLACK
+610-610-123-6CB/A0/XXXX	L ± 0,25	MTP(F)/PC	MTP(F)/PC	POLARITY A	OM3	AQUA	AQUA / BLACK
+610-610-124-6CB/A0/XXXX	L ± 0,25	MTP(F)/PC	MTP(F)/PC	POLARITY B	OM3	AQUA	AQUA / BLACK
+610-610-125-6CB/A0/XXXX	L ± 0,25	MTP(F)/PC	MTP(F)/PC	POLARITY C	OM3	AQUA	AQUA / BLACK
+610-610-123-9CD/A0/XXXX	L ± 0,25	MTP(F)/PC	MTP(F)/PC	POLARITY A	OM4	MAGENTA	MAGENTA / BLACK
+610-610-124-9CD/A0/XXXX	L ± 0,25	MTP(F)/PC	MTP(F)/PC	POLARITY B	OM4	MAGENTA	MAGENTA / BLACK
+610-610-125-9CD/A0/XXXX	L ± 0,25	MTP(F)/PC	MTP(F)/PC	POLARITY C	OM4	MAGENTA	MAGENTA / BLACK

XXXX in the PN represents length of assembly and varies for each length

NOTES:

- 1- DUST CAPS ARE INCLUDED, BUT NOT SHOWN
- 2- CUMULATIVE TEST REPORT SYX-CRAT-01 OF MEASURED IL AND RL VALUES SENT ON DEMAND IN ELECTRONIC FORM
- 3- OM3, OM4 - IL < 0,35dB, RL > 20dB, 850nm & 1300nm
OS2 - IL < 0,35dB, RL > 20dB & 1310nm & 1550nm
- 4- VISUAL ASPECT CHECK ACCORDING TO IEC 61300-3-35
- 5- END FACE GEOMETRY ACCORDING TO TELCORDIA GR-1435
- 5- ASSEMBLY WITH LENGTH BELOW 50MTRS PACKED IN SEALED PE BAG, BULK PACK IN OUTER CARDBOARD BOX
- 6- LONGER ASSEMBLY THEN 50MTRS COILED ON CARDBOARD REEL, INSERTED IN CARDBOARD BOX ACCORDING TO SYLEX STANDARD 1-S-0011
- 6- SYLEX-SX-O LABEL ON PRODUCT PACKAGING AND OUTER CARDBOARD BOX

BOM		
NO:	DESCRIPTION	QTY
1.	MTP(F) CONNECTOR	2
2.	ROUND CABLE Ø 3,0mm, 12 Fibers	L
3.	TRACEABILITY LABEL	2

TRACEABILITY LABEL (POS. 3)

SERIAL NUMBER
L = XXm POLARITY X
MM/YYYY

X- POLARITY A, B or C
ACCORDING TO SYLEX STANDARD 1-S-2657

REVISION DATE:	A: 16.02.2014	CHANGED:	DRAWN BY DATE:	J.Spišár 2014/02/13	TITLE:	01x12f MTP(F) to 01x12f MTP(F) 12-fiber trunk cable
REVISION DATE:	X: 02.06.2014	CHANGED:	APPROVED BY DATE:	E.Koza 2014/02/15	PRODUCT SPECIFICATION:	ID 1133
REVISION DATE:	X: 02.06.2014	CHANGED:	APPROVED BY DATE:	I.Golian 2014/02/15	DIMENSIONS IN MM UNLESS SPECIFIED:	DRAWING NUMBER: 1-S-2642_1_A
REVISION DATE:	X: 02.06.2014	CHANGED:	APPROVED BY DATE:	I.Golian 2014/02/17	SCALE:	NO SCALE
REVISION DATE:	X: 02.06.2014	CHANGED:	APPROVED BY DATE:	I.Golian 2014/02/17	SHEET NO:	1 OF 1
REVISION DATE:	X: 02.06.2014	CHANGED:	APPROVED BY DATE:	I.Golian 2014/02/17	SIZE:	A3

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568

POLARITY A

CABLE CROSSING

1 BLUE	1 BLUE
2 ORANGE	2 ORANGE
3 GREEN	3 GREEN
4 BROWN	4 BROWN
5 GRAY	5 GRAY
6 WHITE	6 WHITE
7 RED	7 RED
8 BLACK	8 BLACK
9 YELLOW	9 YELLOW
10 PURPLE	10 PURPLE
11 PINK	11 PINK
12 AQUA	12 AQUA

POLARITY B

CABLE CROSSING

1 BLUE	1 AQUA
2 ORANGE	2 PINK
3 GREEN	3 PURPLE
4 BROWN	4 YELLOW
5 GRAY	5 BLACK
6 WHITE	6 RED
7 RED	7 WHITE
8 BLACK	8 BROWN
9 YELLOW	9 GREEN
10 PURPLE	10 ORANGE
11 PINK	11 BLUE
12 AQUA	12 BLUE

POLARITY C

CABLE CROSSING

1 BLUE	1 ORANGE
2 ORANGE	2 BLUE
3 GREEN	3 BROWN
4 BROWN	4 GREEN
5 GRAY	5 WHITE
6 WHITE	6 GRAY
7 RED	7 BLACK
8 BLACK	8 RED
9 YELLOW	9 PURPLE
10 PURPLE	10 YELLOW
11 PINK	11 AQUA
12 AQUA	12 PINK

BASIC VIEW MTP CONNECTOR

REVISION DATE:	A: 16.02.2014	CHANGED:	DRAWN BY DATE:	M.Bucharský 2014/02/14	TITLE:	DRAWING WITH THE TYPES OF POLARITIES FOR 12 FIBER CABLE
REVISION DATE:	X: 02.06.2014	CHANGED:	APPROVED BY DATE:	E.Koza 2014/02/17	PRODUCT SPECIFICATION:	QPN /SPEC.
REVISION DATE:	X: 02.06.2014	CHANGED:	APPROVED BY DATE:	I.Golian 2014/02/17	DIMENSIONS IN MM UNLESS SPECIFIED:	DRAWING NUMBER: 1-S-2657_1_A
REVISION DATE:	X: 02.06.2014	CHANGED:	APPROVED BY DATE:	I.Golian 2014/02/17	SCALE:	NO SCALE
REVISION DATE:	X: 02.06.2014	CHANGED:	APPROVED BY DATE:	I.Golian 2014/02/17	SHEET NO:	1 OF 1
REVISION DATE:	X: 02.06.2014	CHANGED:	APPROVED BY DATE:	I.Golian 2014/02/17	SIZE:	A3

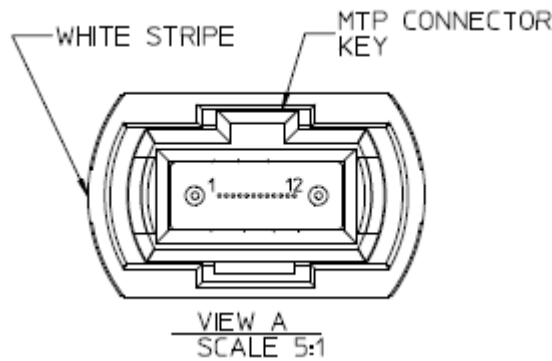
THIS DRAWING CONTAINS INFORMATION THAT IS PROPRIETARY TO SYLEX S.R.O AND SHOULD NOT BE USED WITHOUT WRITTEN PERMISSION

569

570 **CMX OUTPUT-INPUT FIBER MAPPING WITH MTP-MTP CABLE**

571 CMX output:

- 572
- PRIZM-MTP(M) cable – male MPT connector as seen from the front panel:



573

- 574
- MTP Adapter MTP-RF-ADPT 12075 MTP, Key Orientation: Opposed (Key-up/Key-down)

- 575
- MTP(F) connector on the Sylex 12-fiber OM3 trunk cable as seen from connector side:



576

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



579 Top, Key-up

Key Down

Top

580 Key-up/Key-down Adapter

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

583

584

FOX