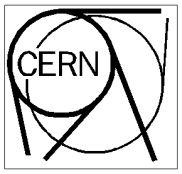



**ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE**
**EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH**
Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

# Market Survey

## MS–2691/EP/CMS

## Supply of Optical Connectors and Adaptors for the CMS Tracker

Contains:

## I. Technical Description

## II. Qualification Criteria

## III. Questionnaire

**Abstract**

The purpose of this Market Survey is to establish a list of firms able to supply mono-mode optical connectors and adaptors for single-fibre and ribbon based patch panels. A total of approximately 150000 fibre joints will be needed in the CMS-tracker detector.

# Table of Contents

# I. Technical Description

## 1. Introduction

The European Organisation for Nuclear Research, CERN, is an Intergovernmental Organisation with 19 European member states. CERN has its seat in the Canton of Geneva (Switzerland) but its laboratories are located on both sides of the Swiss-French border. CERN is running a number of particle accelerators the largest being the Large Electron Positron Collider (LEP).
The Large Hadron Collider (LHC) project, a large proton-proton collider and superconducting accelerator of 27km in circumference, was approved in 1994. The LHC will be the next major research tool for world particle physics and it is expected to be commissioned in 2005.
CMS is one of the two main experiments which will be installed at this accelerator to measure hadron-hadron collisions. The CMS-tracker detector is situated closest to the particles interaction point and is equipped with approximately 12 million micro-strip channels distributed in a volume of 37 cubic meters. Analogue and digital optical links will transmit data between the detector and processing electronics situated approximately 100m away.
A total of about 50000 optical links will be required to readout and control the detector. There will be three break points in each link, arranged in two patch panels inside CMS and one outside. Inside the CMS detector, all components will have to withstand very harsh environmental constraints during an expected experiment-lifetime of 10 years.

## 2. Purpose and scope of the Market Survey

The purpose of this market survey is to identify companies specialised in the manufacturing of optical connectors for single-fibre and/or ribbon-based patch panels; it encompasses single-mode connectors and adaptors, but excludes fibres, ribbons, cables or mechanical assembly structures.
Every CMS tracker optical link needs three connectorised break-points, each with different requirements and optimisation criteria. In this document, these are grouped into distributed, in-line and backend patch panels. The suppliers can propose connectors for any, or all three patch panels.
Connectors mounted on individual fibres and/or ribbons are requested as evaluation samples. CERN will qualify companies in accordance with the qualification criteria set out in part II of this document. Based on the suppliers response to the questionnaire (part III of this document), CERN will freeze the connectors specifications and reduce the number of options open for every patch panel. CERN then intends to issue one or more Invitations to Tender for the optical connectors production, assembly and test on CERN specified fibre, ribbon and cables. Only companies which have thoroughly answered the Questionnaire and have been qualified by CERN in accordance with the qualification criteria will be consulted for the forthcoming invitation to tender.
CERN reserves the right to split the contract between different suppliers.

# 3. Quantity and Delivery

A total volume of approximately 150000 optical fibre joints is required for the CMS tracker. One joint is understood as a mated pair of single fibres, possibly joined via an adaptor. The ratio between single-way and multi-way joints is unknown at this stage, but could vary between 0% and 33% (single/multi-way joints ratio).
It is foreseen to place a contract for connectors mounted on CERN specified fibre/cable between 2000 and 2001.
The optical connectors should be available in pre-production quantities (100-1000 optical joints/year) in 2000 and 2001, and in volume quantities (greater than 50000 optical joints/year) from 2001 to 2003.

# 4. Technical requirements

Recent evaluations by CERN of several single-way and multi-way connectors have suggested that standard commercial components can satisfy the CERN requirements for analogue and digital operation in the CMS environment (high radiation levels, high magnetic field).
As CERN is targeting the use of commercial off-the-shelf connectors, no special requirements are imposed upon the manufacturer apart from the set of features specified in this section 4. However, all candidate connectors shall be evaluated by CERN in order to assess their suitability for operation in CMS (see Section 5, operating environment). They will be technically accepted or rejected on the basis of these evaluations. The CERN evaluation procedure is expected to last about 6 months.

## 4.1. Description

Figure 1 shows a schematic representation of the generic optical link architecture: on the left is the laser transmitter hybrid (component 3) situated on the CMS-tracker front end. At the connection end of the transmitter pigtail, the fibre count per ferrule is typically 1 to 4. This connection point is referred to as the *distributed patch panel* (component 7). Single-way 1.25mm ferrules, Mini-MT and MT compatible connectors are considered for the distributed patch panel.

Pre-terminated fibre ribbon patch cords (component 4) link this patch panel with the second break point at the *in-line patch panel* (component 8). Here the modularity will be 96: 8 ferrules with 12 fibres in each ferrule. Ferrules will be MT12 compatible.

A 96 fibres cable (component 5), links the in-line patch panel with the final break point of the system, which is situated on the Electronics module located in the counting room. This is referred to as the *backend patch panel* (component 9). The Electronics module houses the 12-way receiver photodiode arrays, terminated with either a ribbon pigtail and connector (component 6), or a connector receptacle. The modularity of the backend patch panel will be the same as for the in-line patch panel. Ferrules will be MT12 compatible.

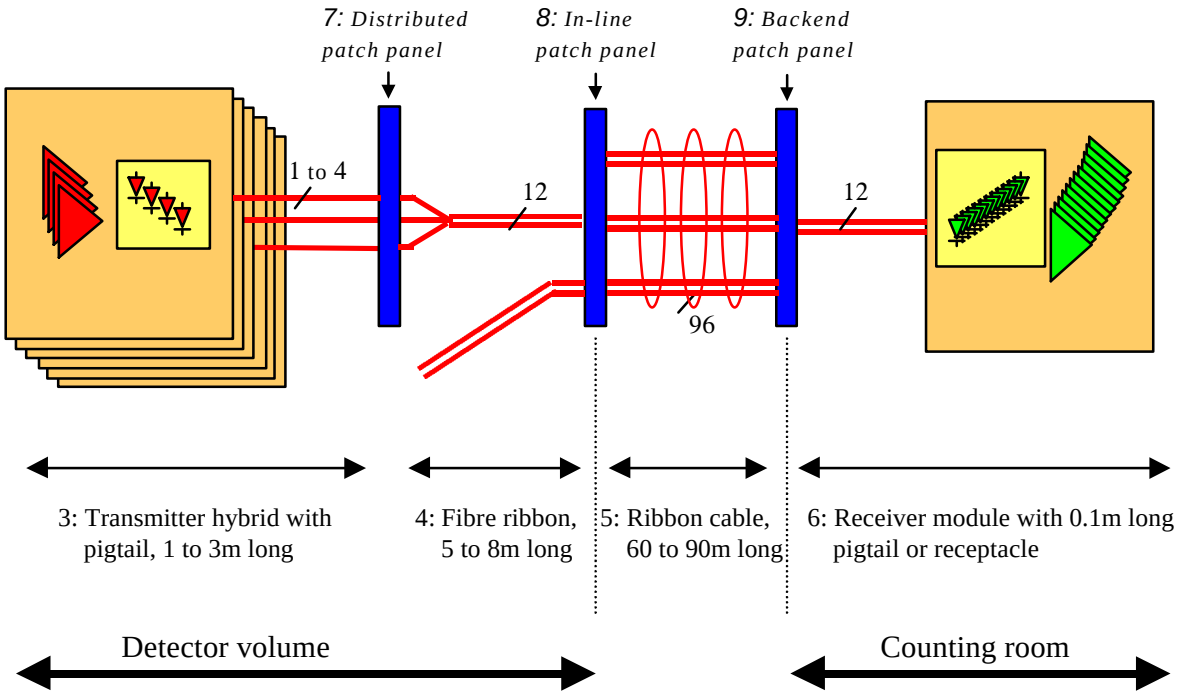



Figure 1: Generic optical link architecture with system parts.

## 4.2. Definitions and schematic representation

Figure 2 defines the schematic representation of fibres, ferrules, housings, adaptors and cables used in this document. Different symbols are used to distinguish whether the fibre-count is single-way or multi-way. A connector is defined as a ferrule in a housing. A connection is defined as two mated connectors, possibly joined via an adaptor if the connectors are hermaphroditic.

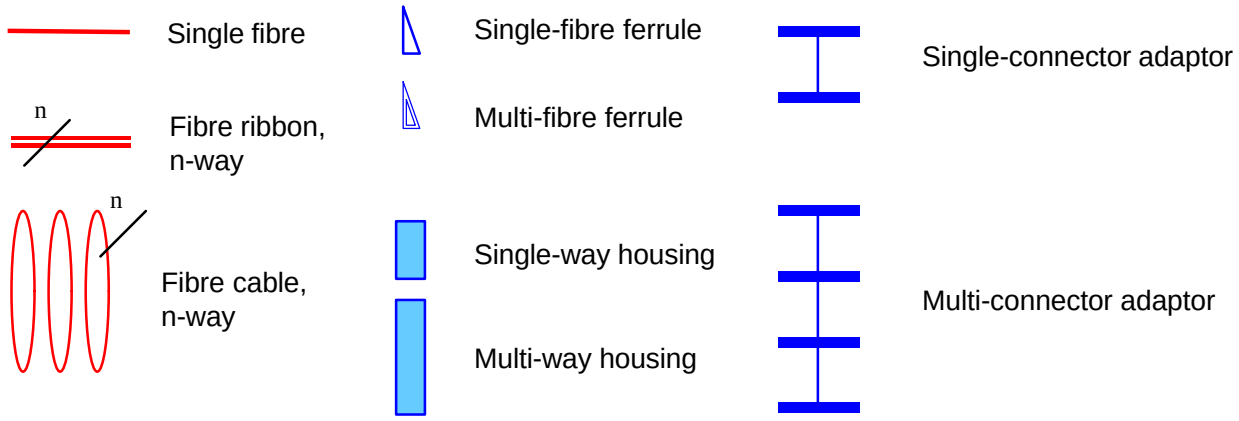



Figure 2: Legend for schematic representation of components.

The following three sub-sections 4.3 to 4.5 detail the requirements for the distributed, in-line and backend patch panels. Specifications are labelled with a 3 digit number x.y.z. x refers to the type of specification (1=operational, 2=optical, 3=mechanical), y is the row-number in the specification table, z refers to the patch panel number to which the specification applies (1=distributed patch panel, 2=in-line patch panel, 3=backend patch panel).

## 4.3. Target connector specifications for distributed patch panel

The distributed patch panel allows to match the irregular modularity (1,2,3 or 4 fibres) of the transmitter hybrid pigtail (component 3 in Fig. 1) to the regular modularity (12 fibres) of the fibre-ribbon (component 4 in Fig. 1). Various options are being considered in an attempt to find the optimal solution to the following constraints:

- High fan-in flexibility (in particular, it must be possible to disconnect the pigtail(s) coming from one hybrid separately from the neighbouring pigtail(s))
- Minimal connection volume (including fan-in to ribbon section)
- Low cost
- Non-magnetic connector, adaptor, joining and aligning parts
- Typically less than 10 connection/disconnection cycles in lifetime

### *4.3.1. Specifications*

Connector specifications have to be met by all channels over the full operating temperature range (section 5, specification 4.5.1) unless otherwise noted.

| # | operational specifications | min | Typ | max | unit | note |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1.1.1 | Number of channels per ferrule | | 1 | | | Options a) and b) |
| | | 2 | | 4 | | Options c) to e) |
| 1.2.1 | Number of mating cycles | 20 | | | | |

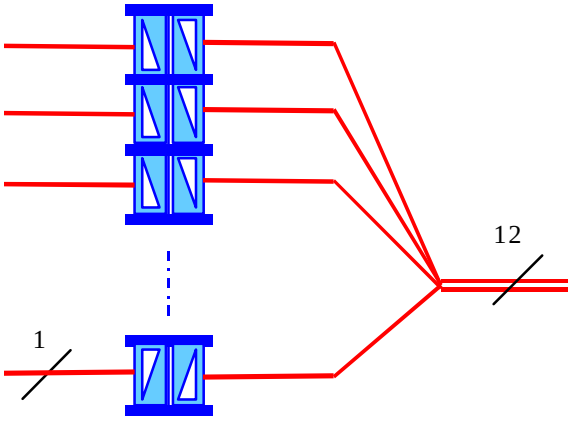
| # | optical specifications | min | typ | max | unit | note |
|---|---|---|---|---|---|---|
| | | | | | | |
| 2.1.1 | Wavelength | 1260 | 1310 | 1360 | nm | |
| 2.2.1 | Random mate insertion loss | | | 1.2 | dB | |
| 2.3.1 | Random mate return loss | 45 | | | dB | |

| # | mechanical specifications | | note |
|---|---|---|---|
| | | | |
| 3.1.1 | Fibre type | 9/125/250/900µm | Options a) and b) |
| | | 9/125/250µm ribbon | Options c) to e) |
| 3.2.1 | Ferrule type | 1.25mm single-way | Options a) and b) |
| | | MT multi-way | Options c) to e) |
| | | Mini MT multi-way | Options c) to e) |
| 3.3.1 | Materials | Low mass (ceramic or plastic preferred)<br>Non magnetic<br>Low smoke<br>Halogen-free | |

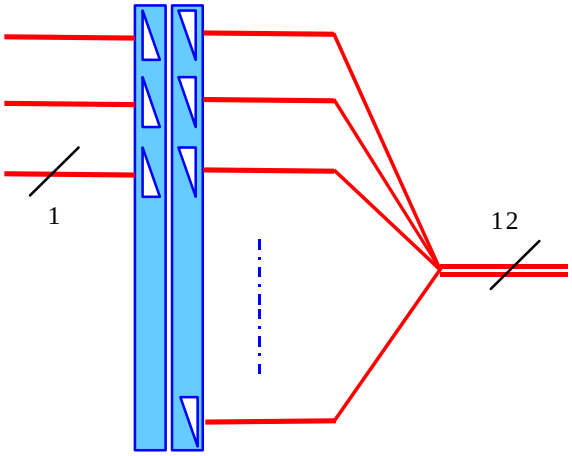
### *4.3.2. Options*

The 5 following options are possible ways to achieve the required functionality. The manufacturers can suggest additional options. Only one or possibly two of these will be implemented in the final system.

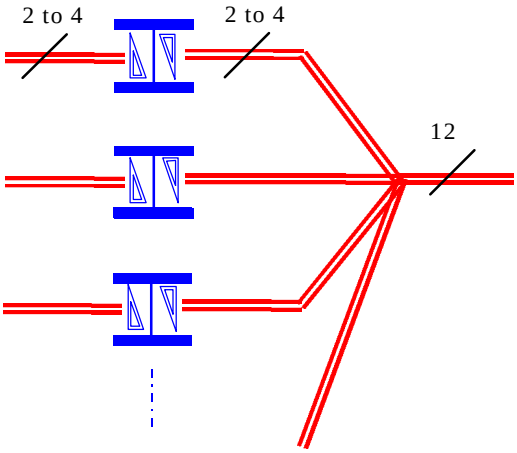
*4.3.2a)* Single-way ferrule in single-way housing (for example LC or equivalent), possibly with multi-connector adaptor, followed by fan-in to ribbon




*4.3.2b)* Single-way ferrule in multi-way housing (for example high density MU or equivalent), followed by fan-in to ribbon

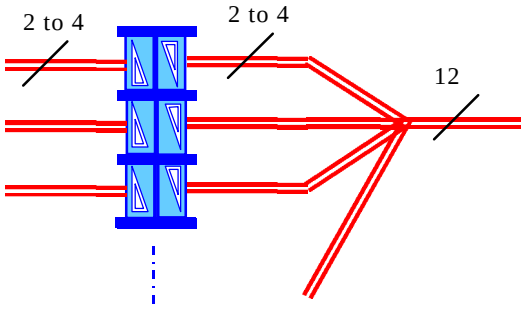



*4.3.2c)* Multi-way ferrule alone with spring clip (for example MT or mini-MT)



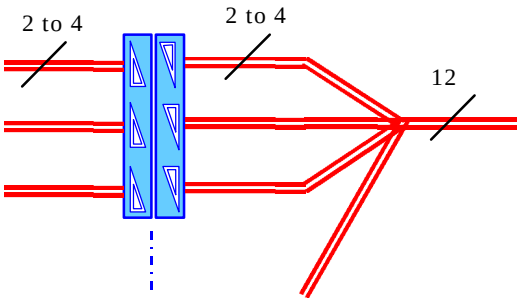

Fan-in continues until total fiber-count equals 12. No dark fiber allowed.

*4.3.2d)* Multi-way ferrule in single-way housing (for example MPO, mini-MPO or equivalent), possibly with multi-connector adaptor




Fan-in continues until total fiber-count equals 12. No dark fiber allowed.

*4.3.2e)* Multi-way ferrule in multi-way housing




Fan-in continues until total fiber-count equals 12. No dark fiber allowed.

## 4.4. Target connector specifications for in-line patch panel

The in-line patch panel connects eight 12-way ribbons (component 4 in Fig. 1) coming from the distributed patch panel, to a 96-way cable (component 5 in Fig. 1). The space available for optical connections is very limited. Various options are being considered in an attempt to find the optimal solution to the following constraints:

- Very high connection density
- Low cost
- Non-magnetic connector, adaptor, joining and aligning parts
- Typically less than 10 connection/disconnection cycles in lifetime

### *4.4.1. Specifications*

Connector specifications have to be met by all channels over the full operating temperature range (section 5, specification 4.5.2) unless otherwise noted.

| # | operational specifications | min | typ | max | unit | note |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1.1.2 | Number of channels per ferrule | | 12 | | | |
| 1.2.2 | Number of mating cycles | 20 | | | | |

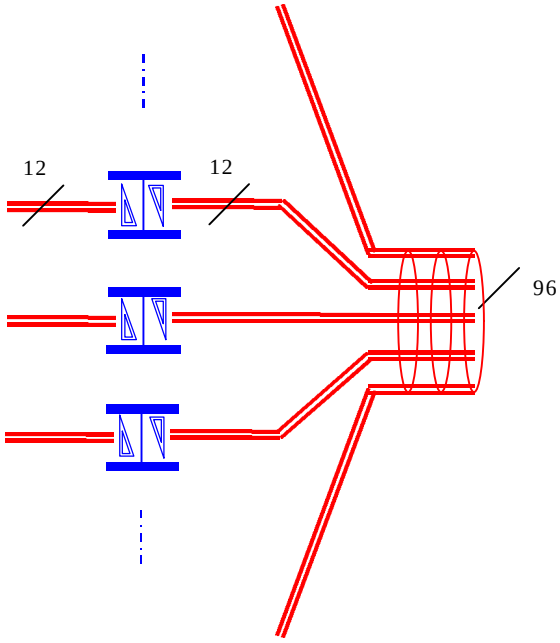
| # | optical specifications | min | typ | max | unit | note |
|---|---|---|---|---|---|---|
| | | | | | | |
| 2.1.2 | Wavelength | 1260 | 1310 | 1360 | nm | |
| 2.2.2 | Random mate insertion loss | | | 1.2 | dB | |
| 2.3.2 | Random mate return loss | 50 | | | dB | |

| # | mechanical specifications | | note |
|---|---|---|---|
| | | | |
| 3.1.2 | Fibre type | 9/125/250μm | 250μm pitch ribbon |
| 3.2.2 | Ferrule type | MT12 | |
| 3.3.2 | Materials | Low mass (ceramic or plastic preferred)<br>Non magnetic<br>Low smoke<br>Halogen-free | |

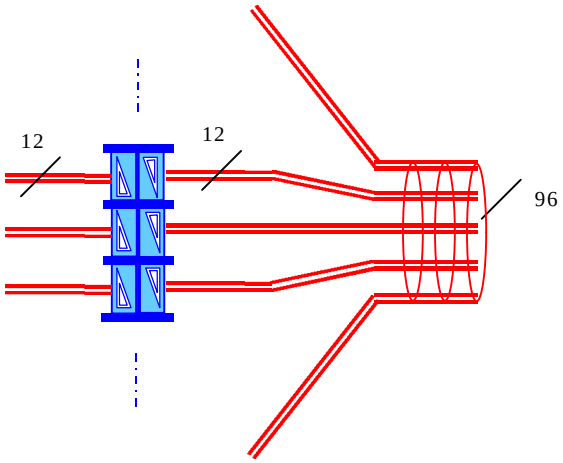
### *4.4.2. Options*

The 3 following options are possible ways to achieve the required functionality. The manufacturers can suggest additional options. Only one of these will be implemented in the final system.

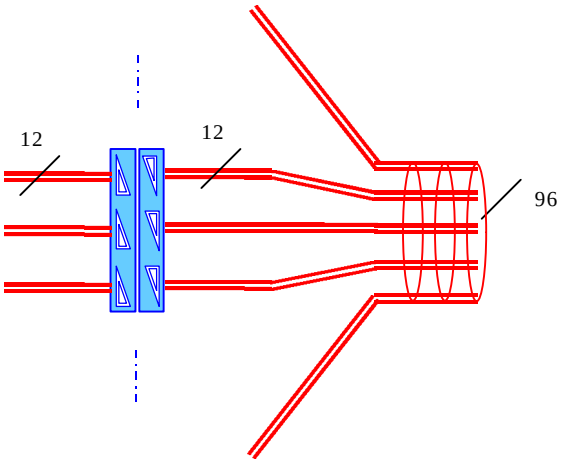
*4.4.2a)* Multi-way ferrule alone (for example MT with spring clip)




*4.4.2b)* Multi-way ferrule in single-way housing (for example MPO or equivalent), possibly with multi-connector adaptor




*4.4.2c)* Multi-way ferrule in multi-way housing



## 4.5. Target connector specifications for backend patch panel

At the optical link backend, the fibre cable (component 5 in Fig. 1) is broken out into its constituent ribbons and terminated with MT12 ferrules. The backend patch panel is situated outside the detector volume, with much less stringent environmental constraints than the two other in-detector patch panels.

### *4.5.1. Specifications*

Connector specifications have to be met by all channels over the full operating temperature range (section 5, specification 4.5.3) unless otherwise noted.

| # | operational specifications | min | typ | max | unit | note |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1.1.3 | Number of channels | | 12 | | | |
| 1.2.3 | Number of mating cycles | 100 | | | | |
| 1.3.3 | Insertion mechanism | Push/pull, latched | | | | |

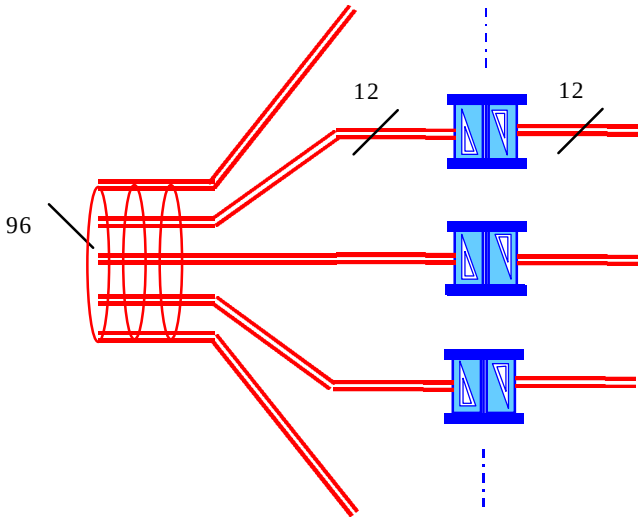
| # | optical specifications | min | typ | max | unit | note |
|---|---|---|---|---|---|---|
| | | | | | | |
| 2.1.3 | Wavelength | 1260 | 1310 | 1360 | nm | |
| 2.2.3 | Random mate insertion loss | | | 1.2 | dB | |
| 2.3.3 | Random mate return loss | 50 | | | dB | |

| # | mechanical specifications | | note |
|---|---|---|---|
| | | | |
| 3.1.3 | Fibre type | 9/125/250μm | 250μm pitch ribbon |
| 3.2.3 | Ferrule type | MT12 | |
| 3.3.3 | Materials | Low smoke<br>Halogen-free | |

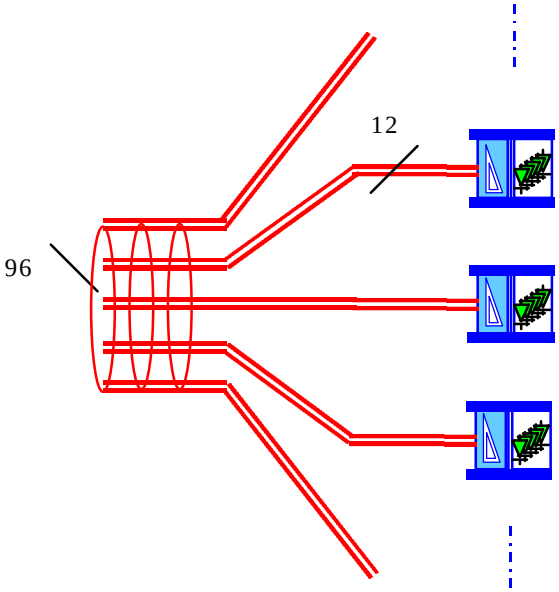
### *4.5.2. Options*

The 2 following options are possible ways to achieve the required functionality. The manufacturers can suggest additional options.

*4.5.2a)* multi-way ferrule in single-way housing, possibly with single-connector adaptor




*4.5.2b)* multi-way ferrule in single-way housing plugged into single-connector receptacle



# 5. Operating environment

## 5.1. Distributed and in-line patch panels

| # | environmental specifications | min | typ | max | unit | note |
|---|---|---|---|---|---|---|
| | | | | | | |
| 4.1.1 | Magnetic field [1] | | | 4 | T | parallel to any axis |
| 4.1.2 | | | | | | |
| 4.2.1 | Neutron fluence[1] | | | 2e14 | $n/cm^2$ (1MeV) | Integrated over lifetime |
| 4.2.2 | | | | | | |
| 4.3.1 | Charged particles fluence[1] | | | 4e14 | $part./cm^2$ (0.3GeV) | " |
| 4.3.2 | | | | | | |
| 4.4.1 | Gamma radiation dose[1] | | | 3e5 | Gy(Si) | " |
| 4.4.2 | | | | | | |
| 4.5.1 | Temperature | -20 | -10 | +70 | °C | |
| 4.5.2 | | -20 | +20 | +70 | | |
| 4.6.1 | Operating humidity | dry Nitrogen flow | | | | |
| 4.6.2 | | | | | | |

[1] The component resistance to magnetic field and radiation will be evaluated under the responsibility of CERN. No testing, validation or qualification under these particular conditions is pre-required from the suppliers.

## 5.2. Backend patch panel

| # | environmental specifications | min | typ | max | unit | note |
|---|---|---|---|---|---|---|
| | | | | | | |
| 4.5.3 | Temperature | +15 | +30 | +70 | °C | |
| 4.6.3 | Operating humidity | | | 60 | %RH | 13°C dew point |

## 6. Evaluation samples

For each proposed connector type, three evaluation samples are requested by CERN.

- Each evaluation sample should consist of:

a) *Single-way connectors*: a pair of 5 metre long 9/125/250/900μm hybrid patch cords terminated on one side with the connector to be evaluated, on the other side with an FC/APC(8°) connector;

b) *Multi-way connectors*: a pair of 5 metre long 9/125/250μm hybrid ribbon patch cords terminated on one side with the connector to be evaluated, on the other side with an MPO/AP(8°) connector;

- Adaptors for single or multi-way connectors should also be supplied if necessary.

- A detailed product data-sheet and a list of materials used in the supplied components should be delivered for every connector and/or adaptor type.

- Connector and adaptor samples for the distributed and in-line patch panels should be non-magnetic.

- Before supplying the samples, the manufacturer should measure insertion loss and return loss of every connector pair, during at least 10 consecutive mate/re-mate cycles. In the event the samples are returned to the supplier for re-characterisation, a brief test report comparing pre- and post-evaluation results will be requested.

## 7. Persons in Charge

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E-mail: Karl.Gill@cern.ch

# II. Qualification criteria

Acceptance of a candidate optical connector is subject to testing by CERN. To this end, the manufacturer is requested to free-issue at least 3 evaluation samples to CERN by October 31st 1999, with a set of measured characteristics, a detailed product data-sheet and a list of materials used in the supplied components (see part I, section 6). Test-procedure details and test-reports will be made available upon request. After testing by CERN, the supplied components may be returned to the manufacturer for re-characterisation, and a short test report comparing pre- and post-evaluation performance may be requested from the company.

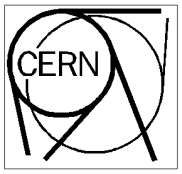
In order to be considered for the forthcoming call for tenders, the following criteria must be met:

## Technical criteria

1. The proposed connector (and adaptor if applicable) must fulfil all technical requirements applicable to the patch panel being considered, as specified in part I, section 4;
2. The supplied samples must be verified by CERN to meet the operating-environment requirements, as specified in part I, section 5;
3. The company must guarantee a direct technical contact with the CERN engineers;
4. The company must be in a position to communicate promptly to CERN any change(s) in the product. Modified products will be subject to re-qualification by CERN;

## Other criteria

5. The company must have proven experience in the manufacture of optical connectors. In case the company intends to subcontract part of the work, experience of all major subcontractors must also be demonstrated;
6. The company must demonstrate its ability to produce over 30000 (if single-way) or 5000 (if 12-way) optical connectors/year;
7. The company must have had an average annual turnover of at least 3M CHF over the last 3 years in the field of optical connectors;
8. The company must have a registered Quality Assurance Plan satisfying the requests of ISO9000 or equivalent national standards;
9. The company shall accept a contract for either the full or part of the overall supply.




**ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE**
**EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH**
Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

# Market Survey

## MS–2691/EP/CME

## Supply of Optical Connectors and Adaptors for the CMS Tracker

## III. Questionnaire

(To be returned in duplicate, by the companies interested in tendering)

Company .....

**Company:**

Name: .....

Address: .....

.....

**Commercial Contact Person** .....
Telephone Number .....
Fax Number .....
Electronic Mail .....

***In case of absence:***

Commercial Contact Person .....
Telephone Number .....
Fax Number .....
Electronic Mail .....

**Technical Contact Person** .....
Telephone Number .....
Fax Number .....
Electronic Mail .....

***In case of absence:***

Technical Contact Person .....
Telephone Number .....
Fax Number .....
Electronic Mail .....

# 1. Questions to the company

## General Information

1. Are you interested in receiving the Invitation to Tender ?

❑ Yes ❑ No

2. Financial information

When established: .....
Registered capital: .....
Turnover in 1996 (optical connectors field): .....
Turnover in 1997 (optical connectors field): .....
Turnover in 1998 (optical connectors field): .....
Number of employees in 1998: .....

3. Did you already reply to a CERN call for tender or market survey?

❑ Yes ❑ No

If yes, specify for which product(s):

.....

.....

.....

4. What connector options is your company suggesting to supply (see technical requirements, section 4 of part I)?

*a) For the distributed patch panel :*

| **Connection option** | **a** | **b** | **c** | **d** | **e** |
|---|---|---|---|---|---|
| Ferrule type | | | | | |
| Number of fibres per ferrule | | | | | |
| Housing type | | | | | |
| Number of ferrules per housing | | | | | |
| Adaptor type (if needed) | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Number of connectors per adaptor (if applicable) | | | | | |
| Is the fan-in section to a 12-way ribbon part of the connector? | | | | | |
| Favoured option, comments | | | | | |

*b) For the in-line patch panel:*

| **Connection option** | **a** | **b** | **c** | | |
|---|---|---|---|---|---|
| Ferrule type | | | | | |
| Number of fibres per ferrule | | | | | |
| Housing type | | | | | |
| Number of ferrules per housing | | | | | |
| Adaptor type (if needed) | | | | | |
| Number of connectors per adaptor (if applicable) | | | | | |
| Favoured options, comments | | | | | |

*c) For the backend patch panel :*

| **Connection option** | **a** | **b** | | | |
|---|---|---|---|---|---|
| Ferrule type | | | | | |
| Number of fibres per ferrule | | | | | |
| Housing type | | | | | |
| Number of ferrules per housing | | | | | |
| Adaptor type (if needed) | | | | | |
| Number of connectors per adaptor (if applicable) | | | | | |
| Favoured options, comments | | | | | |

## Qualification criteria

5. Does your company comply with the qualification criteria stipulated in this market survey?

❑ Yes ❑ No

If not, indicate which criterion(a) is (are) not satisfied and why:

.....

.....

.....

.....

.....

6. Does your product comply with the technical requirements stipulated in this market survey? (Qualification criterion 1)

❑ Yes ❑ No

If not, indicate which requirement(s) is (are) not satisfied and why:

.....

.....

.....

.....

.....

7. Is your company in a position to communicate promptly any change(s) in the product and its sub-components? (Qualification criterion 4)

❑ Yes ❑ No

8. Would you sub-contract part of the work? (Qualification criterion 4)

❑ Yes ❑ No

If yes, please specify which part of the work would be sub-contracted, and give the name, address, person in charge and the telephone number of the potential sub-contractors. CERN reserves the right to contact the subcontractors directly.

.....

.....

9. Can your company assure that identical products can be supplied for product evaluation and during volume production? (Qualification criterion 4)

❑ Yes ❑ No

If yes, volume production should start within a period of:

.....

10. Please indicate major customer references: (Qualification criterion 5)

.....

.....

.....

If your company has supplied optical connectors to CERN before, please indicate references:

.....

.....

.....

11. How many optical connectors do you produce yearly (please indicate type, whether single or multi-mode, whether single or multi-way)? (Qualification criterion 6)

.....

.....

.....

12. Do you have a registered Quality Assurance Plan? (Qualification criterion 8)

❑ Yes ❑ No

If yes, indicate which one:

.....

.....

## Further Technical Information

13. Are the proposed components commercial off-the-shelf products?

❑ Yes ❑ No

14. Does your company intend to modify the standard product to meet the specifications?

❑ Yes ❑ No

If yes, indicate which specification(s) is (are) causing a modification and describe the changes:

.....

.....

15. Has your product (or major parts of it) been internally qualified?

❑ Yes ❑ No

If yes, indicate to which standard and supply a qualification report. If no, indicate plans:

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16. Is the connector or adaptor magnetic (any part)?

❑ Yes ❑ No

If yes, indicate the part and the magnetic material:

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If yes, and if the connector is intended to be used in the distributed or in-line patch panels, please suggest a non-magnetic alternative solution:

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17. Can the company suggest a way to permanently label and automatically identify its connectors?

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18. What kind of technical support can the company provide during the pre-production and production phase?

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19. Please summarise in the following table the properties of all connectors you are proposing to supply. Connectors for the distributed and in-line patch panels must be non-magnetic. Fill-in one column for each connector type. Add engineering drawings if appropriate.

| **Connector type** ⇒ | | | | | |
|---|---|---|---|---|---|
| Based on ferrule type | | | | | |
| To be used in patch panel number | | | | | |
| To be inserted into adaptor type | | | | | |
| | | | | | |
| Connector length (mm) | | | | | |
| Connector width (mm) | | | | | |
| Connector depth (mm) | | | | | |
| Strain relief length (if applicable, to be added to connector length, mm) | | | | | |
| | | | | | |
| Connector overall mass (g) | | | | | |
| Connector non-metallic mass (g) | | | | | |
| Connector metallic mass (g) | | | | | |

| **Adaptor type** ⇒ | | | | | |
|---|---|---|---|---|---|
| To be used in patch panel number | | | | | |
| Joining connector type | | | | | |
| Number of connectors per adaptor | 2 x..... | 2 x..... | 2 x..... | 2 x..... | 2 x..... |
| | | | | | |
| Adaptor length (mm) | | | | | |
| Adaptor width (mm) | | | | | |
| Adaptor depth (mm) | | | | | |
| | | | | | |
| Adaptor overall mass (g) | | | | | |
| Adaptor non-metallic mass (g) | | | | | |
| Adaptor metallic mass (g) | | | | | |

## 2. Questions from the company

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*Date* *Company seal and signature*