SMU

Fermilab

Versatile Link Plus
WP5 – Passive Components

Stefano Meroli
21 September 2022
CERN, Fibre Optics section (EN-EL-FO)

Summary

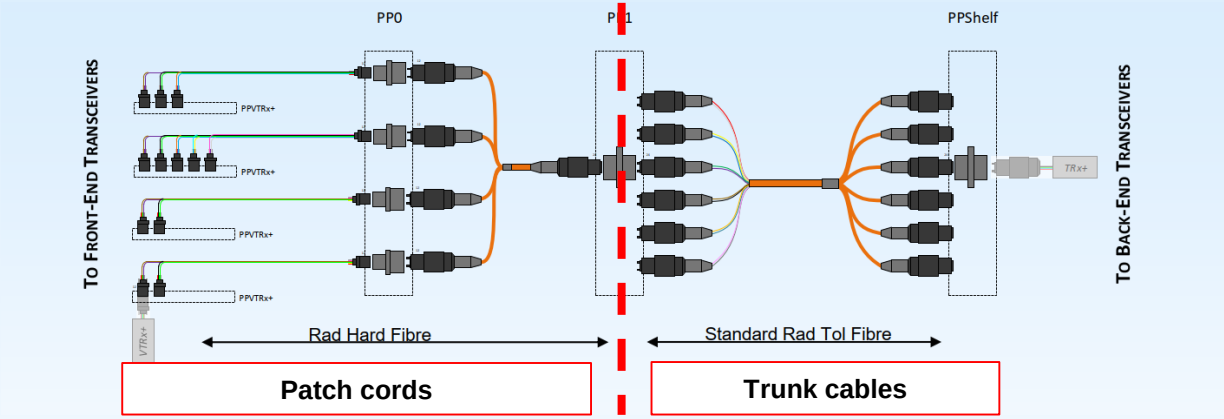
- Introducing the VL+ WP5
- Patch cord procurement
- Trunk cable procurement
- Supply workflow
- Conclusions

Introducing the VL+ Work Package 5 Passive components

Introducing the VL+ WP5

Requirements and Specifications

- **Defined a cabling plant optimized to meet the specific requirements of the CMS and ATLAS subdetectors**

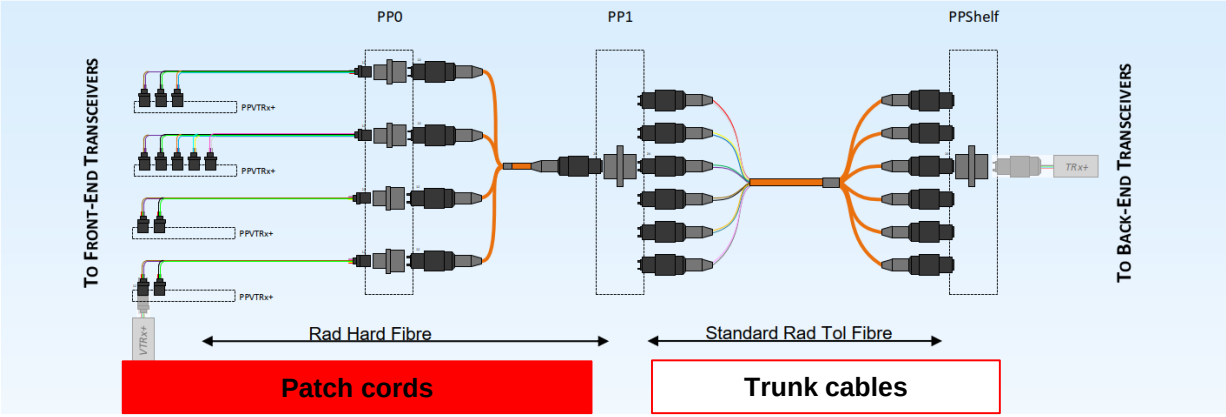


- Harsh environment
  - Temperature down to -35C
  - Magnetic field up to 4T
  - Radiation dose up to 1 MGy
- Standard industrial environment

- **Versatile Link Plus project requires the development of a radiation resistant data link:**
  - Up to 10 Gb/s data rate upstream and 2.5 Gb/s downstream over ~100m
  - Based on Multi-Mode Fibres (MMF) operating with a centre wavelength of 850 nm
  - Concatenation of different types of fibres suited for different radiation levels

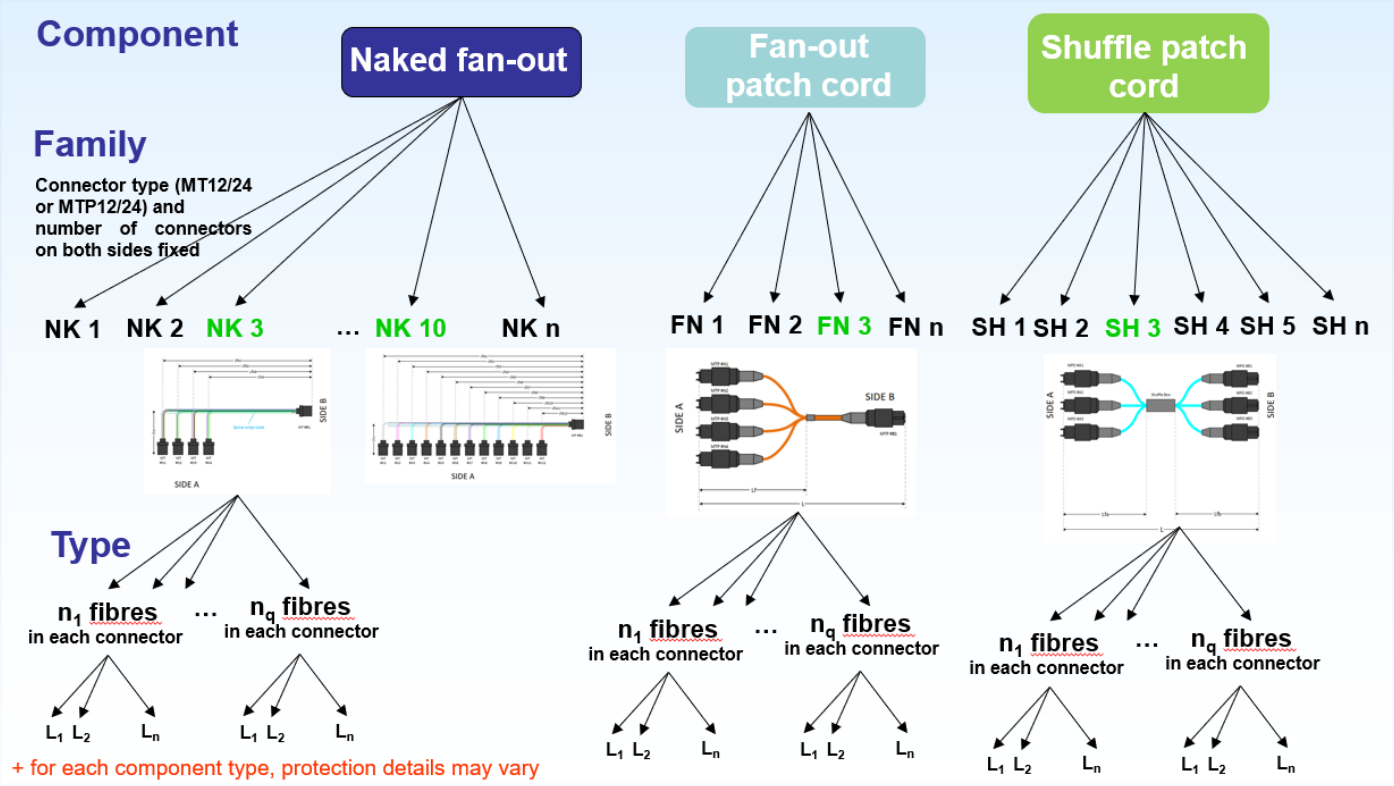
Summary

Patch cords procurement



Patch Cords Procurement

Selection tree

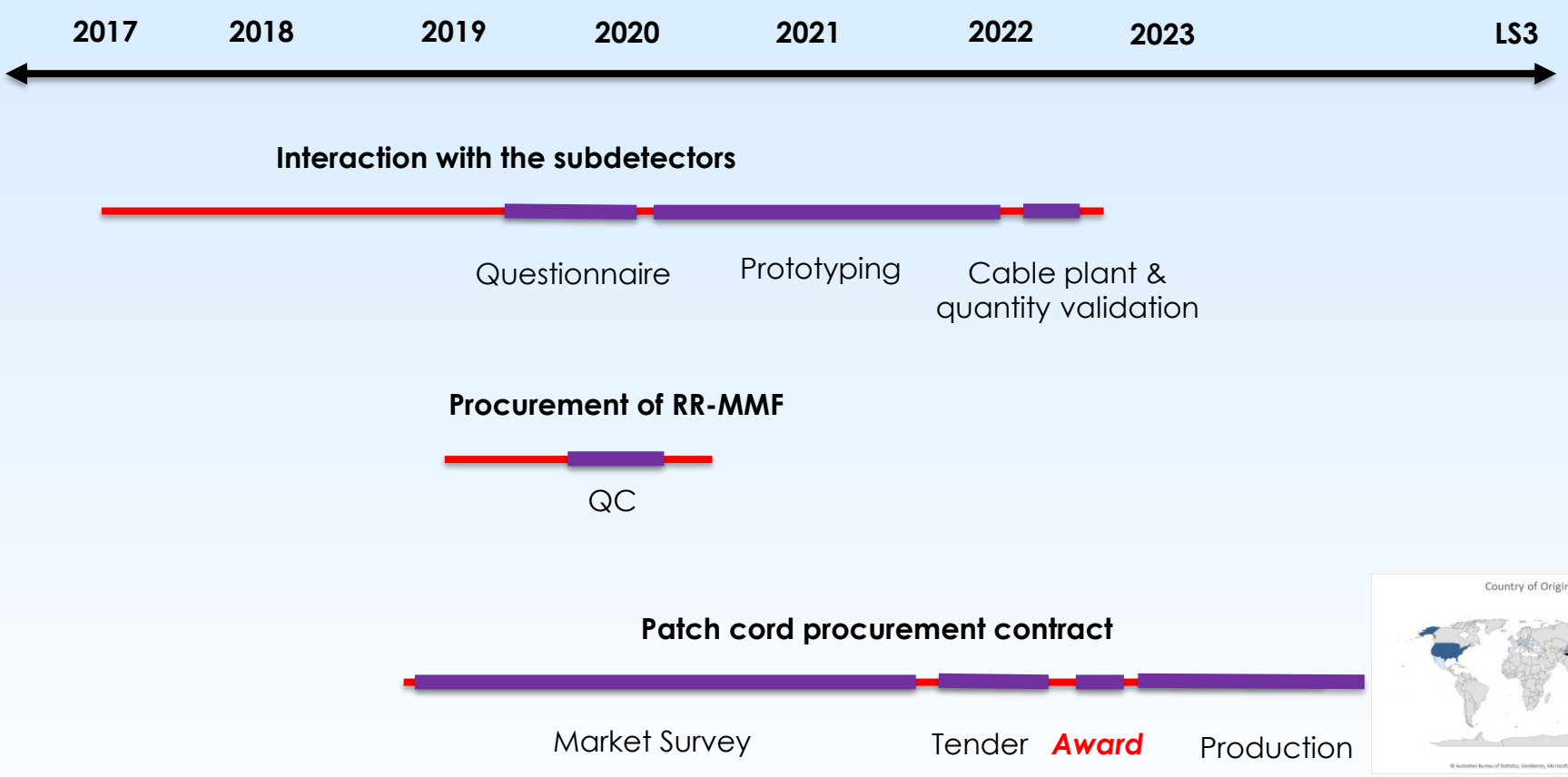


- Different flavors to take into consideration specific space constraints, bending radius... while trying to remain as standard as possible.

Patch Cords Procurement

Timeline

Versatile Link+



- Contract awarded in August 2022 and signed in September 2022
  - Company with long experience in fibre optics and multi-fibre assemblies
  - Competitive prices

Patch Cords Procurement

Next steps

- **Pre-series** as of November 2022
  - Ensure that each patch cord type meets the technical requirement
  - ➢ Pre-series patch cords for each sub-detector cable plant will be ordered
  - ➢ The pre-series patch cords will be tested by EN-EL and made available to the sub-detectors for their own evaluation
    - Feedback or requests for modifications will be collected by EN-EL-FO and discussed with the supplier
  - ➢ An excel file will be made available in October where each each sub-detector can:
    - Specify quantity and flavors (e.g. fan-out lengths, fibre type, …)
    - Get a price for each flavor
- **Series** production as of April 2023
  - Orders passed every three months (Jan-Apr-July-Oct)
  - ➢ The updated excel file template will be again used. Each sub-detector can:
    - Specify quantity and flavors (e.g. fan-out lengths, fibre type, …)
    - Get the **overall price** for the supply of the patch cords

Patch Cords Procurement

Excel File

- Flavor specification

Item			Side A														Side B				Length				
Code	Description	Quantity	Nb of connectors	Type of connector	Type of boot	Lfa1 (cm)	Lfa2 (cm)	Lfa3 (cm)	Lfa4 (cm)	Lfa5 (cm)	Lfa6 (cm)	Lfa7 (cm)	Lfa8 (cm)	Lfa9 (cm)	Lfa10 (cm)	Lfa11 (cm)	Lfa12 (cm)	Nb of connectors_	Type of connector	Type of boot_	Lfb (cm)	Number of links	Avg. number of links per connector on side A	Type of fibre	Length Tolerance	Fibre Protection
NK5	NAKED F-OUT PCORD A 1xMT(12)|6xMT(12)	1	6	MT	STANDARD	10												1	MT	STANDARD	2.5	12	12	OM2 RR FIBRE	STANDARD	LOOSE TUBE

Patch cord type:
NK, FN or SH

MTP boot:
Standard, Flex, Angled, Short

Fan-out length side A

Fan-out or bundle length side B

Number of fibre links

Fibre Protection:

NK
Loose tube thickness 0.5mm
Wrap outer diameter:
- For 1 or 2 fibres: 2mm
- From 3 to 12 fibres: 3mm
- From 13 to 24 fibres: 7mm

Length Tolerance

NK
Standard : -0/+2 cm
Special: -0/+1 cm

FN or SH
Standard : -0/+5 cm
Special: -0/+2 cm

Fibre type:
radiation resistant, conventional

- Connectivity map

Connection TABLE B1												
SIDE B1	SIDE A1	SIDE A2	SIDE A3	SIDE A4	SIDE A5	SIDE A6	SIDE A7	SIDE A8	SIDE A9	SIDE A10	SIDE A11	SIDE A12
1	6											
2	7											
3		6										
4		7										
5			6									
6			7									
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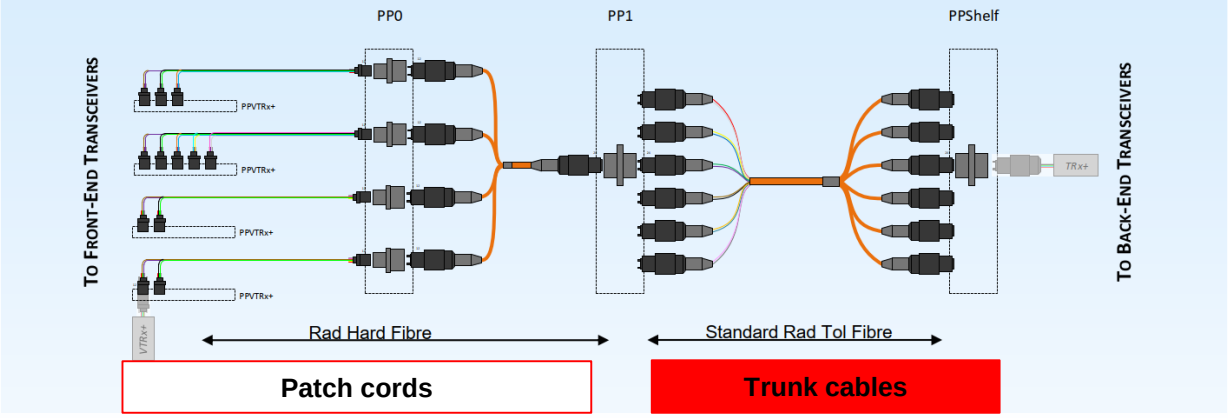
23												6
24												7

Preliminary

Summary

Trunk cables procurement

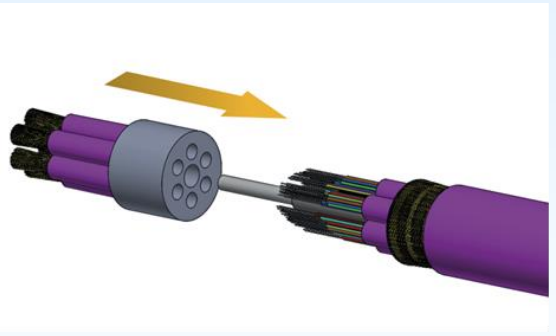


Trunk Cables Procurement

Series production and next steps

- Trunk cables supplied through the **CERN frame contract**
  - State-of-art components (very lightweight 9mm cable, US Conec connectors)
  - Qualified by the supplier and meeting CERN requirements (technical & safety)

- Trunk cable design discussed and validated by the sub-detectors
  - **Conventional fibre type**
  - **72 or 144** fibre cable
  - **12 or 24** MTP connectors
  - Very compact fan-out kits



- **Pre-series and Series** production as per November 2022
  - A second (simpler) excel file will also be made available to the sub-detectors to specify the trunk cable flavors
  - Orders can be passed every three months (Jan-Apr-July-Oct)

Patch Cords and Trunk Cables Supply Workflow

Supply workflow

Subdetector to create a SNOW ticket

- Technical contact
- Budget Code
- Deadline
- **Excel files**

EN-EL to validate the request and create the EDH order request

Subdetector to sign the EDH

- Price
- Delivery time

Order to the supplier

Material shipped to CERN

EN-EL to quality control the material

Material made available to the subdetector

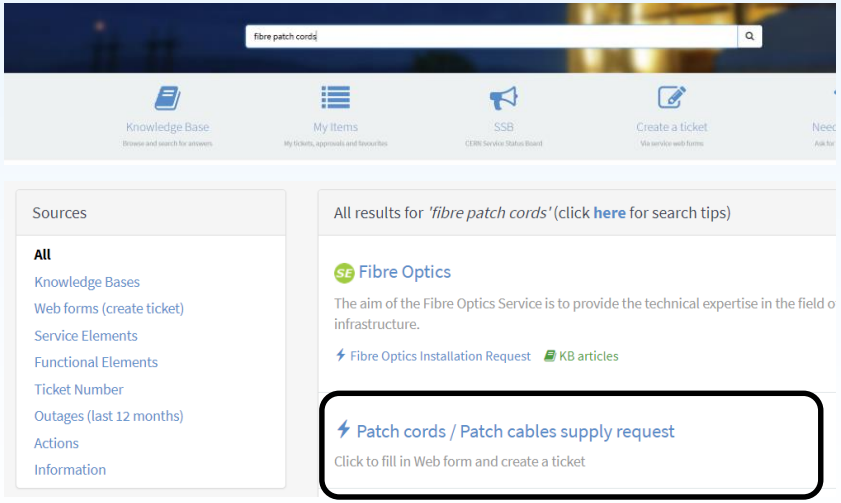


Table 11: Lead times for interconnecting devices and patch cords

Components	Quantity (pieces)	Lead time for delivery within (working days)
Adapters of all types (according to DQE)	1 to 200	15
	> 200	To be agreed (partial deliveries may be requested)
Patch cords (i.e. naked fan-out, rugged fan-out and shuffle patch cords)	1 to100	20
	101 to 500	30
	> 500	To be agreed (partial deliveries may be requested)

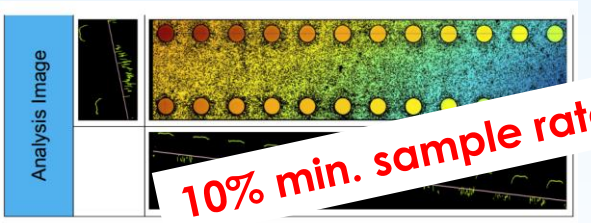
Quality Control

Patch cords and trunk cables will be quality controlled at CERN

- Visual inspection
  - Packing
  - Article type
  - Quantity
  - Termination quality (e.g. silicone wrap tube, fan-out kits)
  - Supplier test report check

100% sample rate

- Optical inspection
  - Optical performance (i.e. insertion loss)
  - End face inspection
  - Physical and optical length
  - Pin-out and key orientation



10% min. sample rate

	Max	Min	1	2	3	4	5	6	7	8	9	10	11	12
Fiber Height(nm	3500,00	1000,00	2234	2295	2325	2334	2338	2323	2308	2275	2231	2209	2179	2135
DH Ave(nm)	300,00	-300,00	11	73	102	112	116	101	86	53	8	-13	-43	-88
DH Adj(nm)	300,00	-300,00	0	61	29	10	4	-14	-15	-33	-44	-21	-31	-44
CoreDip(nm)	150,00	-150,00	37	23	20	15	37	48	29	28	23	31	46	35
Roughness Ra	20,00	0,00	0,83	0,74	0,61	0,58	0,60	0,63	0,60	0,71	0,71	0,66	0,62	0,60
Roughness Rq	20,00	0,00	1,05	0,94	0,83	0,76	0,78	0,78	0,78	0,89	0,91	0,83	0,79	0,74
TiltX(°)	0,20	-0,20	0,07	0,03	0,03	0,00	-0,01	-0,02	-0,01	-0,02	-0,02	-0,03	-0,04	-0,06
TiltY(°)	0,20	-0,20	0,06	0,06	0,05	0,05	0,03	0,04	0,04	0,02	0,02	0,03	0,03	0,03
Fiber.ROC(mm	INF	1,00	3,70	4,09	3,79	3,88	4,09	4,09	4,11	4,20	4,21	4,18	4,14	4,32

Conclusions

Conclusions and Next Steps

- VL+ WP5 proceeding smoothly

- The cable plant of each sub-detectors was finalized and validated
  - Enough Radiation Resistant MMF was secured to meet the announced sub-detector needs

Subdetector	OVERVIEW			PATCH CORD			TRUNK		Contact person
	Cable plant	Quantity	Rad Hard Fiber	Quantity	RAD. Fibre length	Follow up	Quantity	Follow up	
ATLAS HGTD	-	-	ok	-	20	-	-	-	Suen Hou
ATLAS ITK Pixel	ok	ok	ok	374	0.0	-	56	Design validated	Laura Franconi
ATLAS ITK Strip (Barrel)	ok	ok	ok	148	9.1	-	20	Design validated	Tony Weidberg
ATLAS ITK Strip (End Caps)	ok	ok	ok	70	2.1	-	10	No feedback	Pepe Bernabeu
ATLAS Lar	ok	ok	ok	638	0.0	-	200	Design validated	Liu Tiankuan
ATLAS Muon	-	-	-	-	-	-	-	-	-
ATLAS TDAQ	-	-	-	-	-	-	-	-	-
CMS ETL	ok	ok	ok	320	23.0	-	25	No feedback	Natalia Koss
CMS BTL	ok	ok	ok	171	13.8	-	20	No feedback	Joao Varela
CMS ECAL	ok	ok	ok	258	48.3	-	129	Design validated	Werner Lustermann
CMS HGCAL	ok	ok	no	2340	192.2	Assembly length to be clarified	300	Design validated	-
CMS IT Pixel	ok	ok	ok	408	39.2	-	25	No feedback	Stella Orfanelli
CMS Muons	-	-	-	-	-	-	?	Design validated	Domenico Dattola
CMS OT Barrel (TB2S)	ok	ok	ok	739	63.6	-	50	No feedback	Antti Onnela
CMS OT Barrel (TBPS flat)	ok	ok	ok	196	20.5	-	15	No feedback	Antti Onnela
CMS OT Barrel (TBPS tilted)	ok	ok	ok	338	29.9	-	30	No feedback	Antti Onnela
CMS OT TEDD	ok	ok	ok	3046	93.9	-	100	No feedback	Christophe Delaere
TOTAL				**9076**	**556**		**980**		

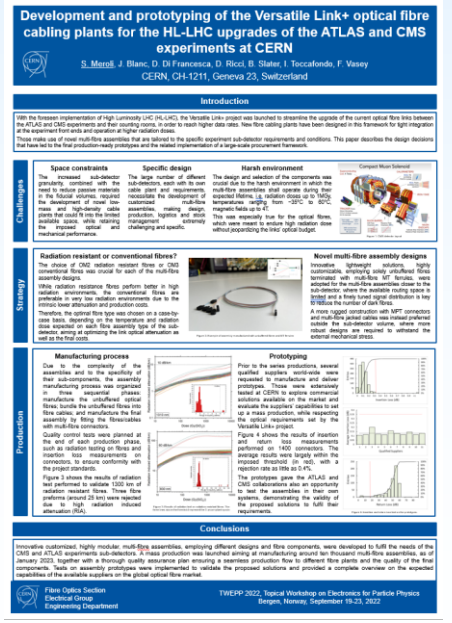
**** Trunk cable quantities to be confirmed***

- Getting ready to launch pre-series and series production of patch cords and trunk cables
  - Please use pre-series samples as an opportunity to confirm your requirements

Thank you for your attention!

Stefano.meroli@cern.ch

Questions?



Development and prototyping of the Versatile Link+ optical fibre cabling plants for the HL-LHC upgrades of the ATLAS and CMS experiments at CERN

S. Meroli, J. Blanc, D. Di Francesca, D. Ricci, B. Slater, I. Toccafondo, F. Vasey
CERN, CH-1211, Geneva 23, Switzerland

Introduction

Challenges

Space constraints

Specific design

Harsh environment

Strategy

Radiation resistant or conventional fibres?

Novel multi-fibre assembly designs

Production

Manufacturing process

Prototyping

Conclusions

Fibre Optics Section
Electrical Group
Engineering Department

TWEPP 2022, Topical Workshop on Electronics for Particle Physics
Bergen, Norway, September 19-23, 2022