



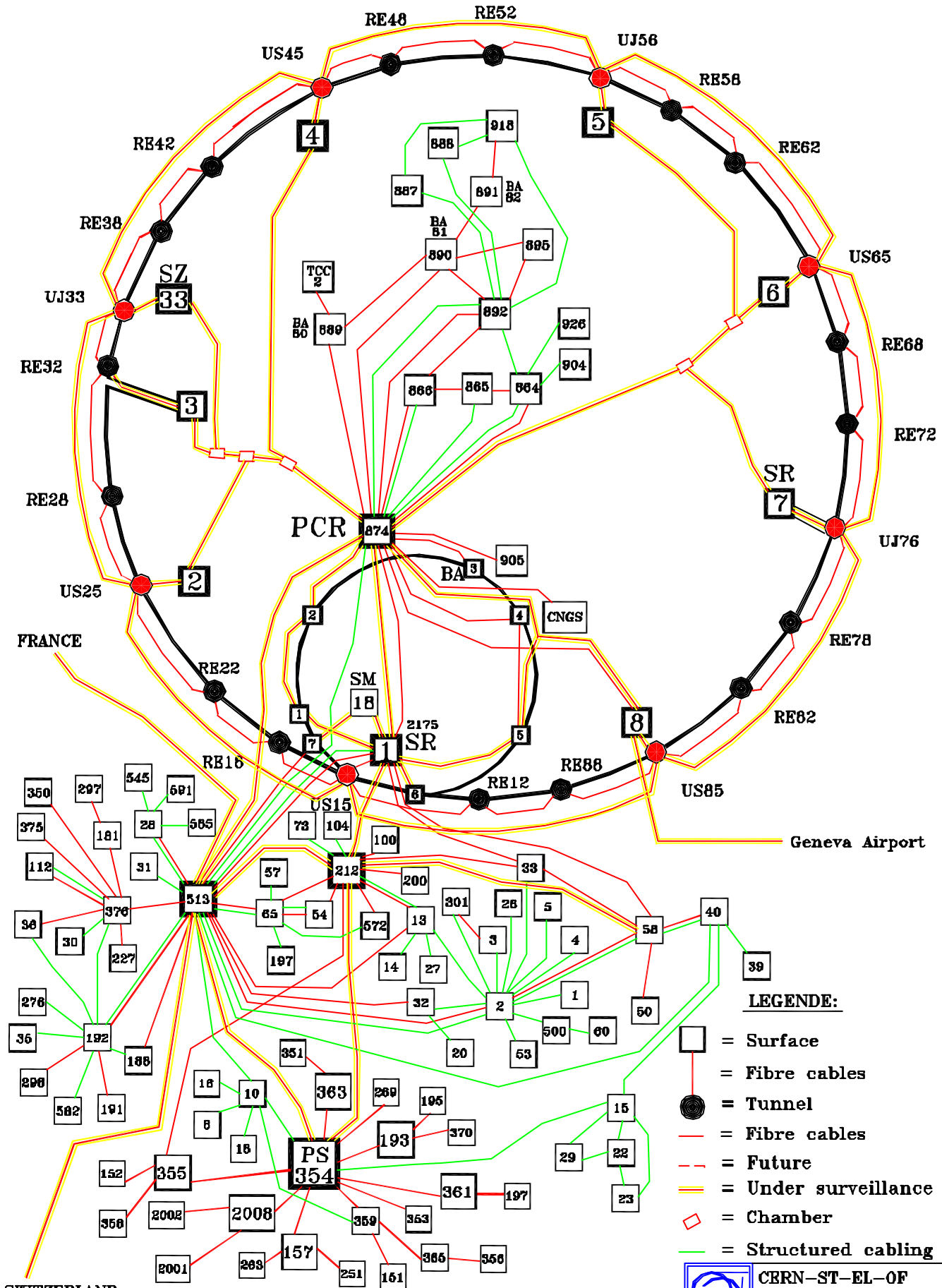
Optical Fibres for the LHC Machine and Experimental Areas

Luit Koert de Jonge/ST-EL-OF

The optical network policy

- The CERN Optical Network is built of Optical Trunks connecting STAR points
- IT and ST plan the Optical Network together
- The optical fibres in and between STAR points are managed and allocated by IT-CS
- Individual fibre usage (dark fibres) out of a STAR point is handled by ST-EL
- Users shall use the IT-CS IP/Ethernet Network for all their Communications needs

CERN MAIN OPTICAL FIBRE LINKS



LEGENDE:

- = Surface
- = Fibre cables
- = Future
- = Under surveillance
- = Structured cabling
- = Tunnel
- = Chamber



SWITZERLAND

FRANCE

Geneva Airport

L H C

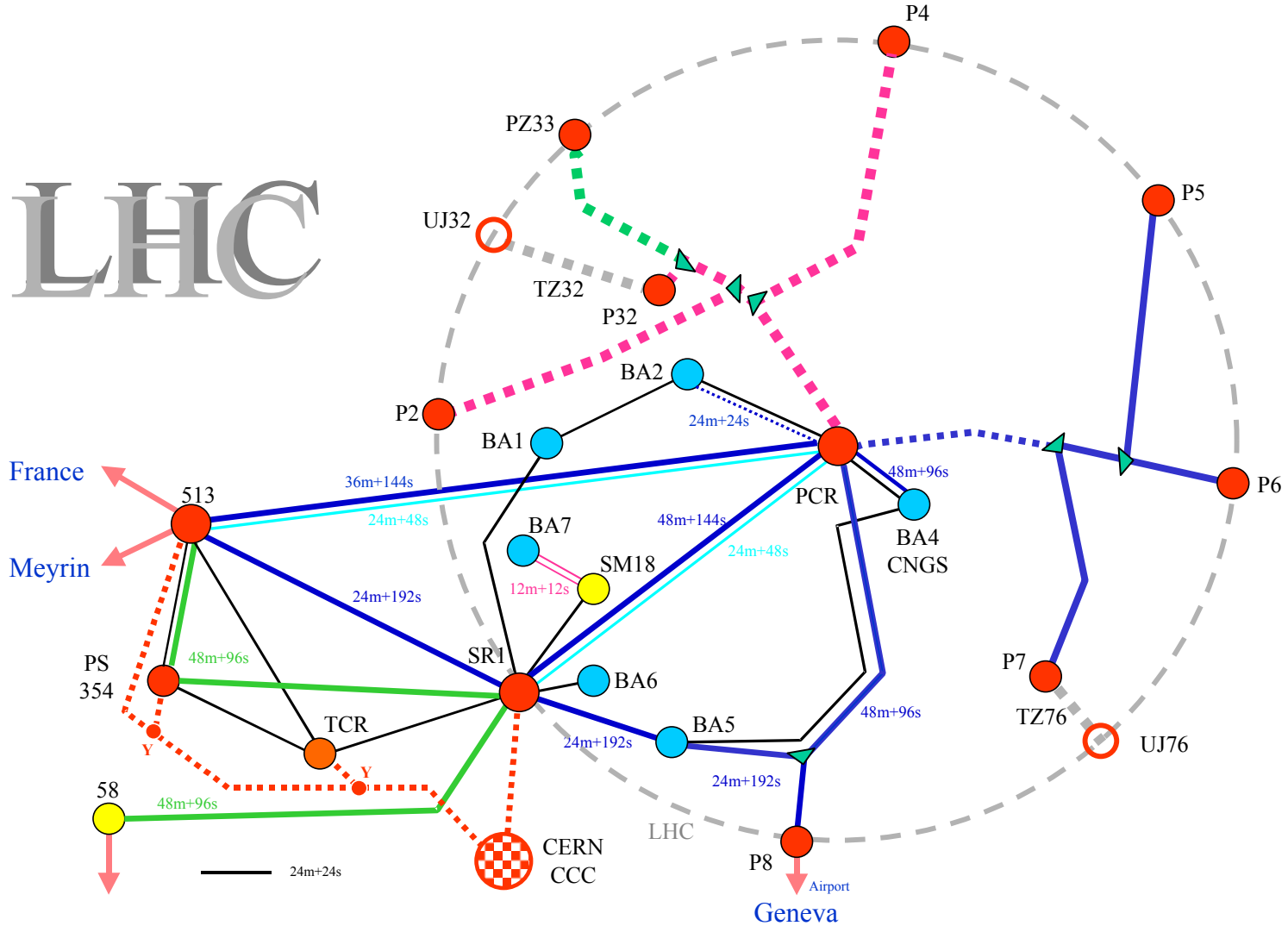
Optical fibre cabling

- SURFACE
- SURFACE TO UNDERGROUND (SHAFTS)
- TUNNEL
- BETWEEN EQUIPMENTS
- BEAM INSTRUMENTATION
- EXPERIMENTAL AREAS

LHC The main surface STAR points

C

LHC





"LAME VIBRANTE"

To lay the HDPE ducts P32-PZ33



PIANI

PIANI

QVA 4

L H C Surface optical links from PCR

- Sites 1, 5, 6, 7, 8, 513 and CNGS OK
- Sites 2, 32, 33 and 4 to be done
- Old HDPE ducts to above sites in bad state
 - they are in place since 1986
 - ducts to P6 had (have) to be replaced
 - ducts to P8 had to be repaired at several spots
- Blowing of cables difficult/impossible

Optical cabling with tube systems

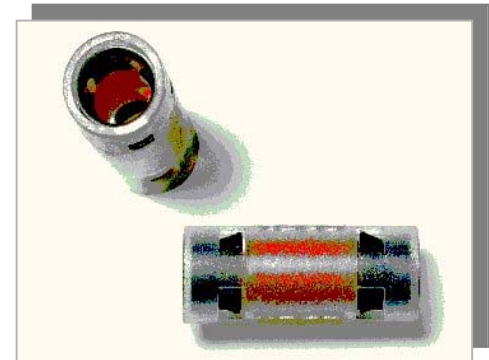
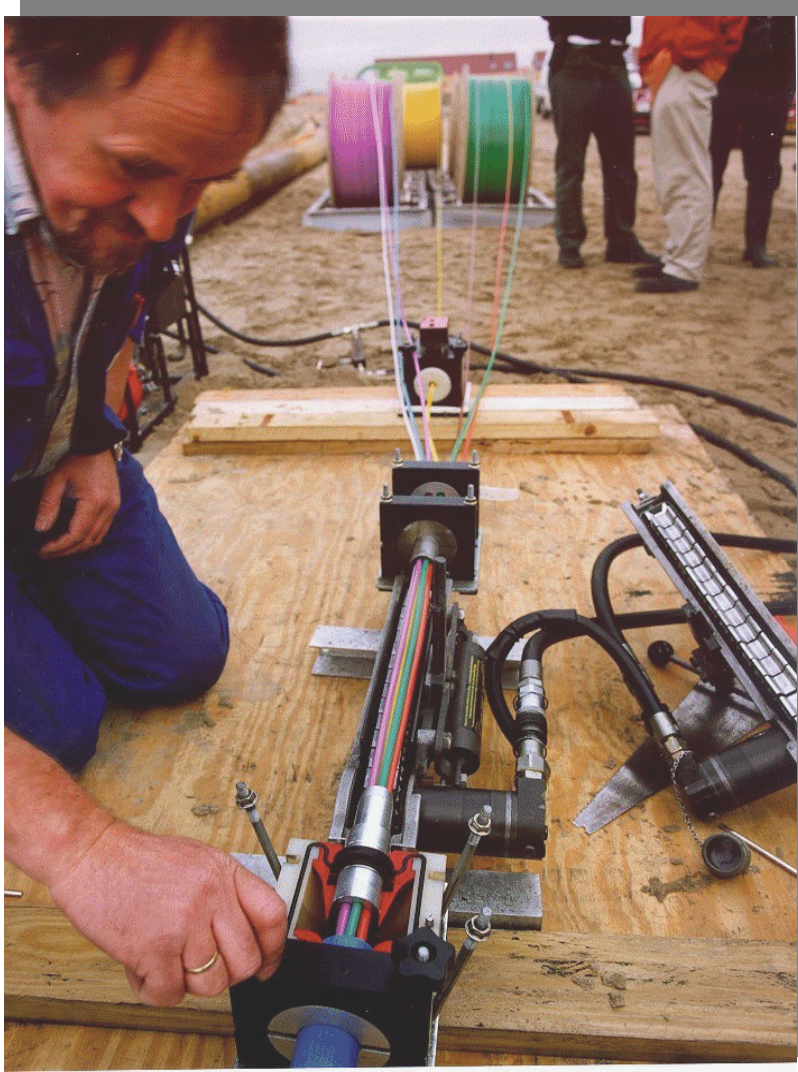
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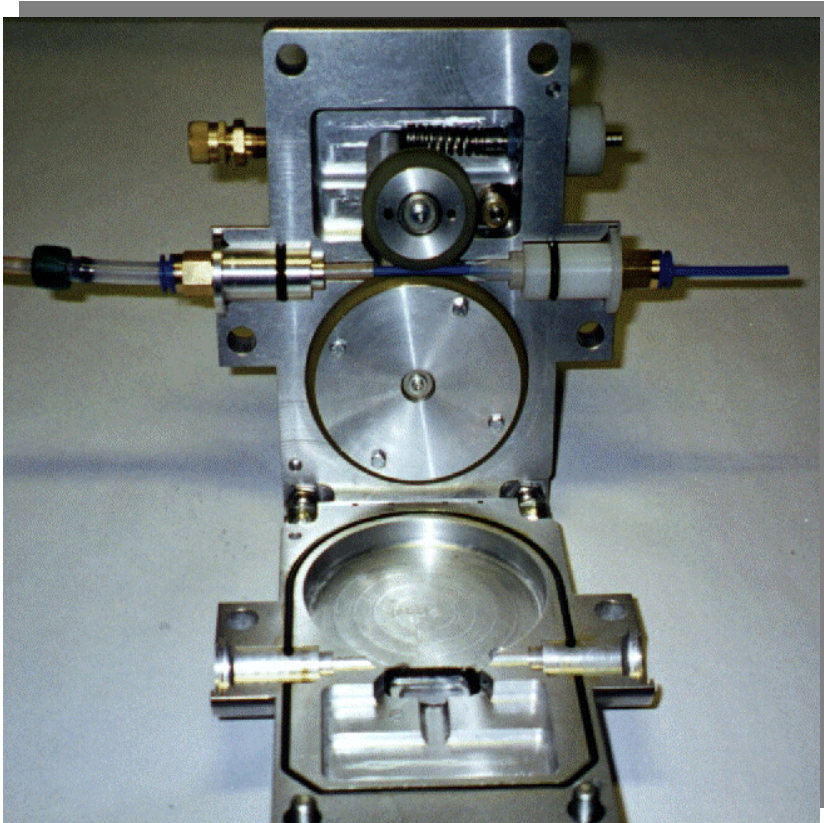
- Install (blow) guide tubes (low cost)
- Blow mini optical cables on demand
- Modular and Flexible
- Outdoor resistant
- Easy to replace cables

➤ Lower initial cost

Blowing of mini tubes



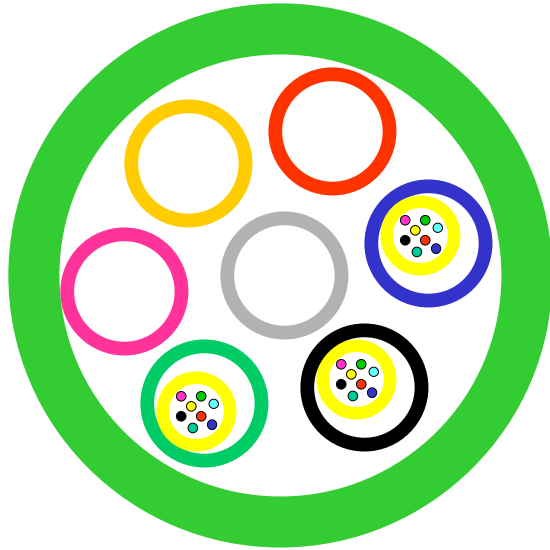
Blowing of mini optical fibre cables

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H
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Micro-Jet from Plumettaz/CH

- This Micro-Jet can blow mini optical fibre cables with (1- 72) fibres.
- Size of an A4 sheet and 10 cm high.
- Several units can be cascaded.
- Blowing pressure is 10 Bar.

Surface ducts with guide tubes



Ø 40/50 mm duct

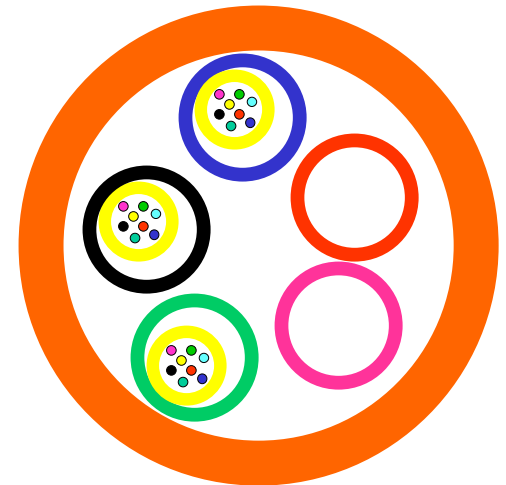
7 x Ø 10 mm guide tubes

Capacity 7 x 72 = 504 optical fibres

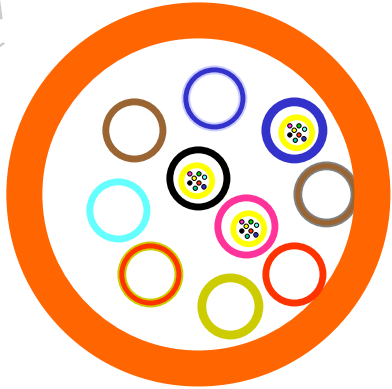
Ø 32/40 mm duct

5 x Ø 10 mm guide tubes

Capacity 5 x 72 = 360 optical fibres



3 ducts types with guide tubes



Ø 40 mm duct with 10 x Ø 7 mm guide tubes

10 x 24=240 optical fibres

Guide tubes replaceable (change size)



Ø 25 mm duct with 7 x Ø 7 mm guide tubes

Capacity 7 x 24=168 optical fibres



Ø 18 mm duct with 3 x Ø 7 mm guide tubes

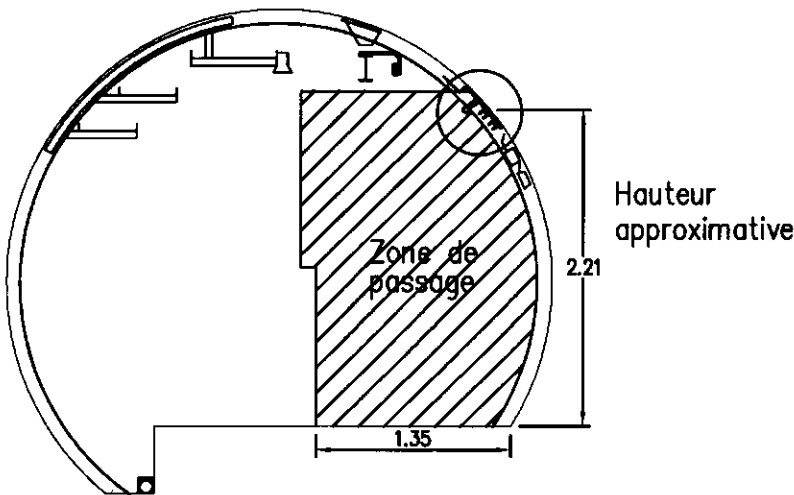
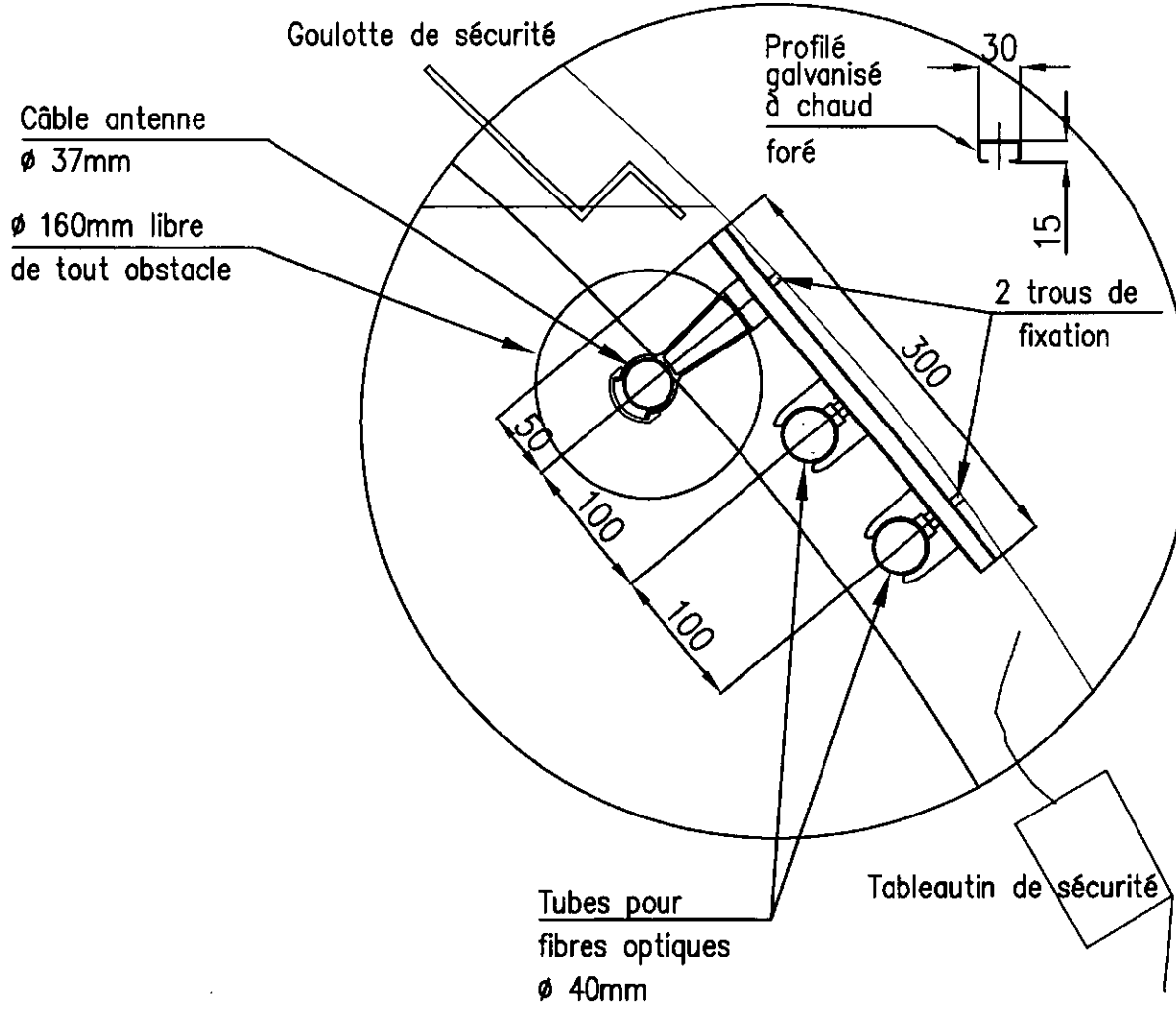
Capacity 3 x 24=72 optical fibres

LH Installation principles

- Ø 40 mm duct with 10 guide tubes between SR and US/UJ
- Ø 40 mm duct in the LHC tunnel with stops at US/UJ and partial stops at the alcoves RE
 - duct fixed together with leaky feeder cable to tunnel wall
- Ø 25 mm duct for SL-BI and medium installations
- Ø 18 mm duct for low capacity installations
- Once the above infrastructure is in place, the mini optical cables can be blown
- The tunnel fibres must be replaceable in case of radiation damage

DIMENSION	<=6	> 6	> 30	> 120	> 315	> 1000	> 2000
USINAGE MOYEN/MEDIUM MACHINING	± 0.1	± 0.2	± 0.3	± 0.5	± 0.8	± 1.2	± 2
METANO. Soudure/WELDED STRUCTURE	± 0.5	± 1	± 2	± 3	± 5	± 7	± 10

INDICE	DATE	NOM	MODIFICATION
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Distance maxi entre les supports : 1,30m

Nombre de pièces : 2900 p. / octant

DESSIN, RUGOSITE, TOLERANCE SELON NORMES ISO
DRAWING, RUGOSITY, TOLERANCES ACCORDING TO ISO STANDARDS



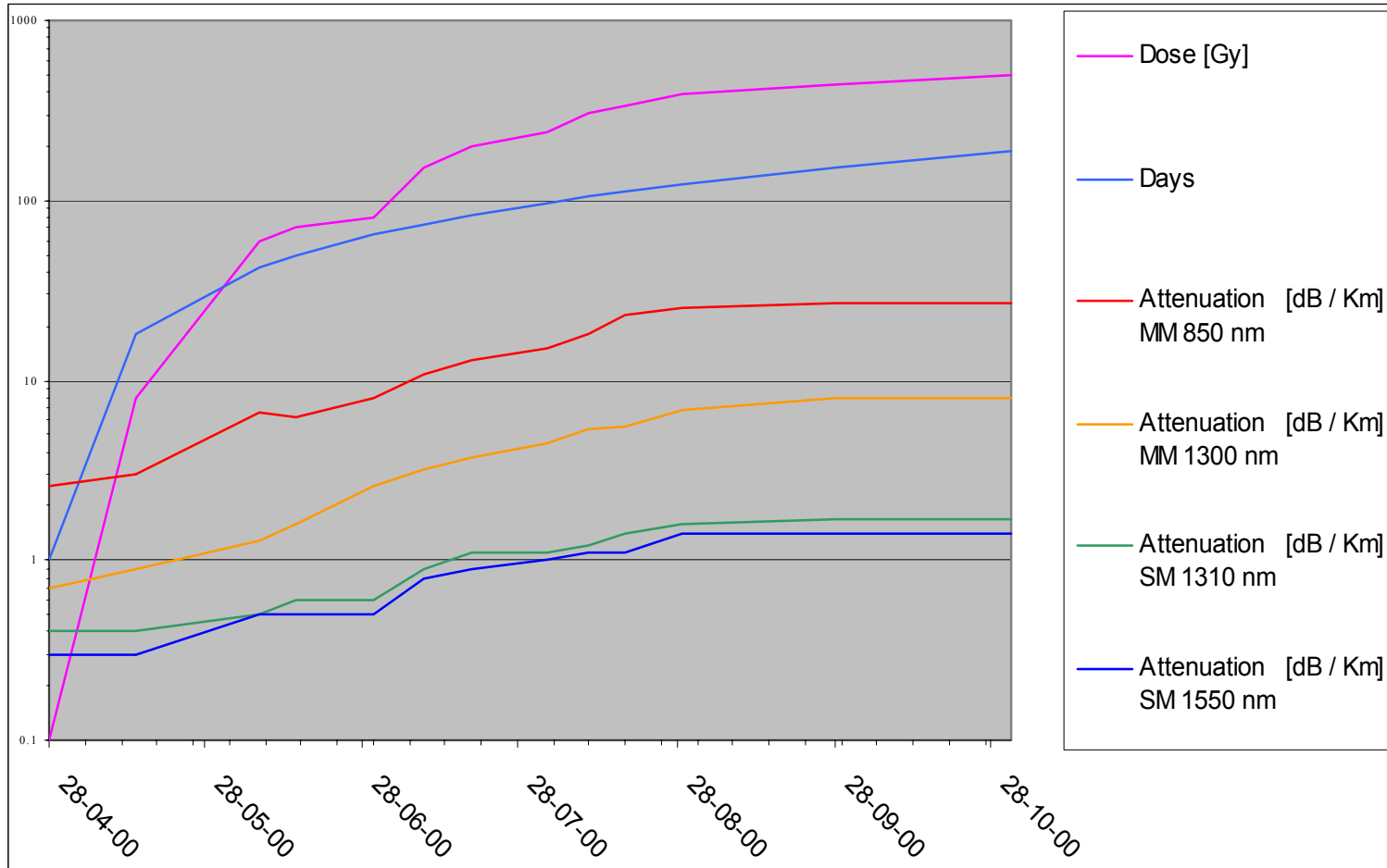
ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH GENEVE
Ce dessin ne peut être utilisé à des fins commerciales sans autorisation écrite
This drawing may not be used for commercial purposes without written authorisation

CLAMPING ANTENNA CABLE & OPTICAL FIBRE TUBES IN LHC TUNNEL FIX. CABLE ANTENNE & TUBES FIBRES OPTIQUES DANS TUNNEL L.H.C.	ECHELLE SCALE	DES/DRA.	DUPERIER	2001-08-28
	1:50	CONTROLLED		
	1:5	RELEASED		
		APPROVED		
	REPLACE/REPLACES			
NON VALABLE POUR EXECUTION NOT VALID FOR EXECUTION	QAC	LHCEIW__0002	SIZE 4	IND.



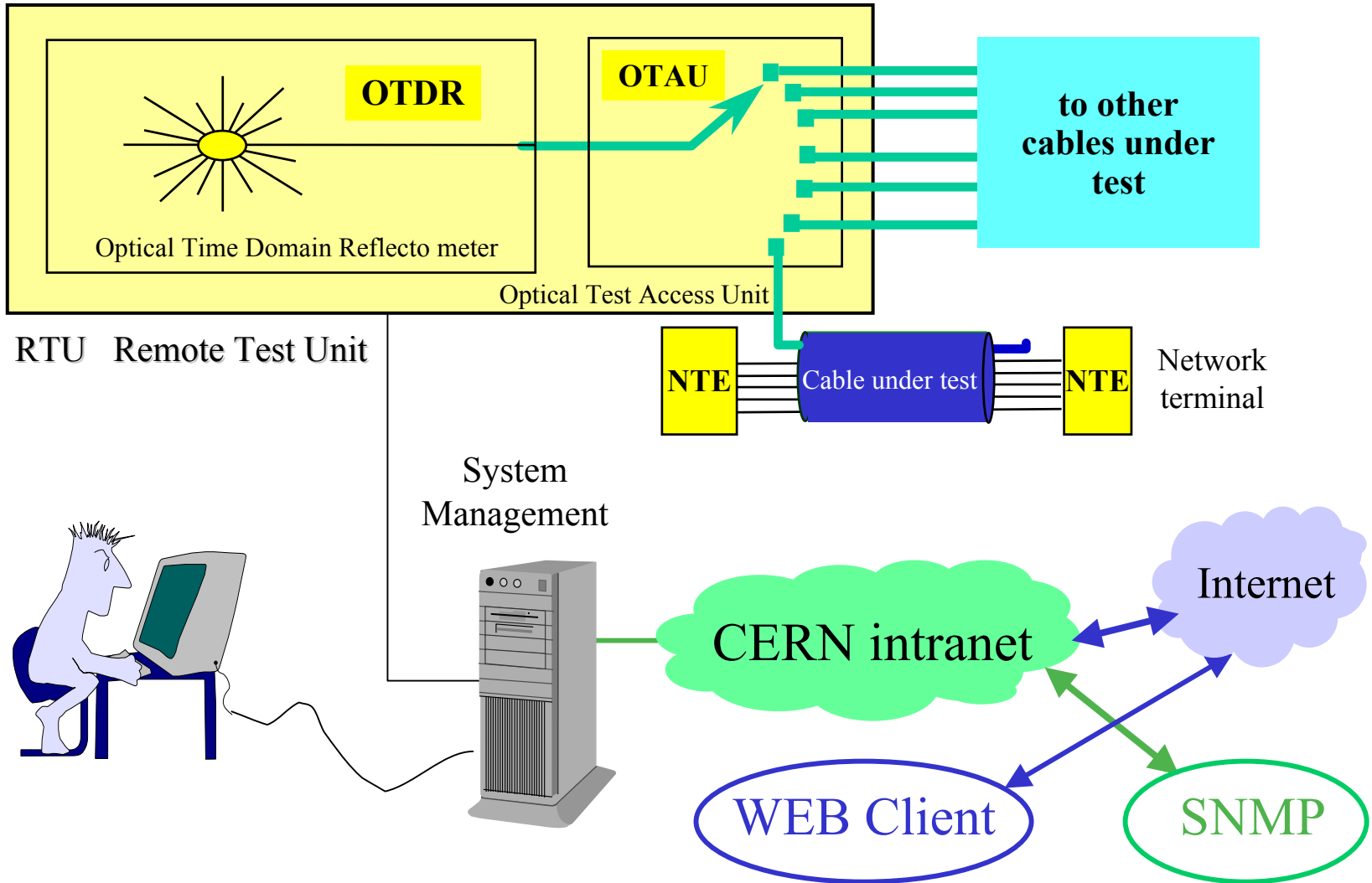


Radiation measurements (RADWG)



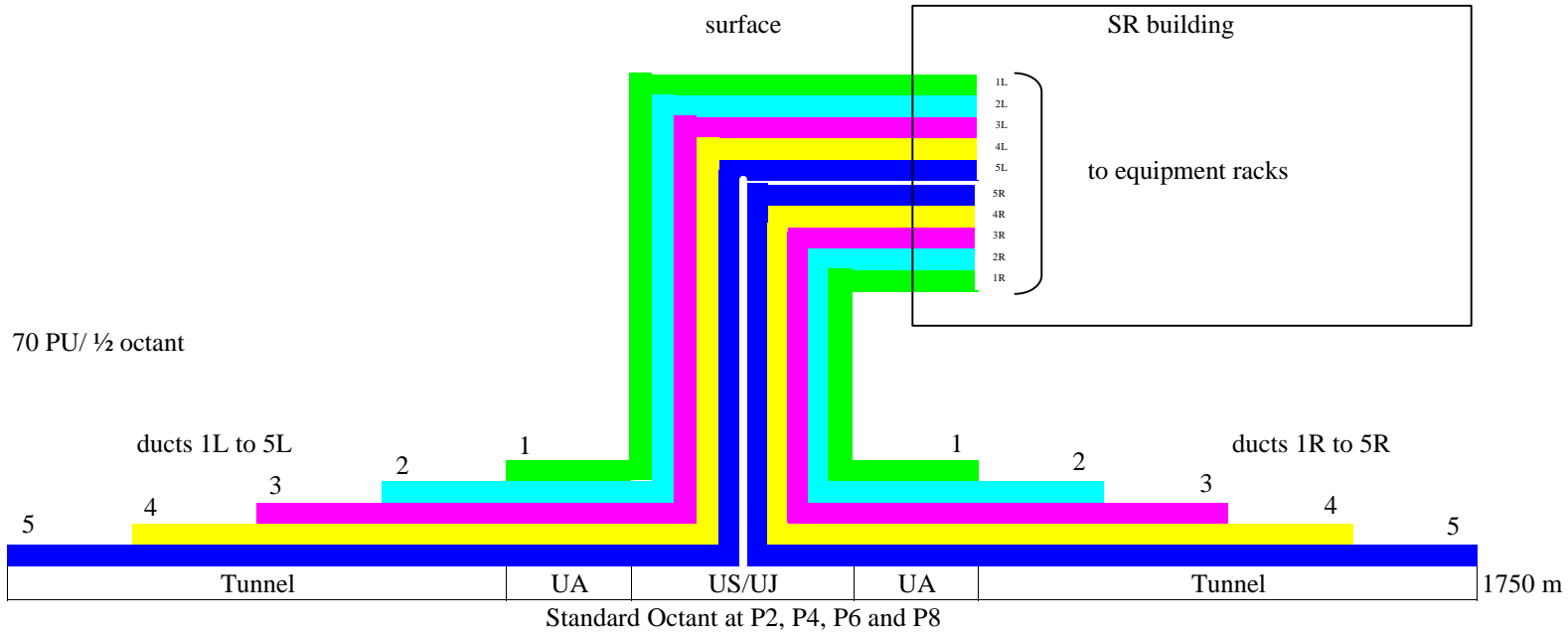
Measurements of optical cable (multimode and single-mode fibre)

Fibre monitoring system "ATLAS"



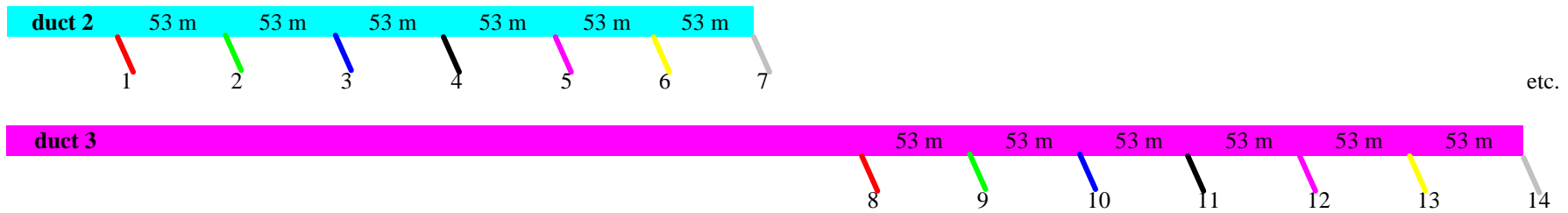
Duct installations for the Beam Instrumentation

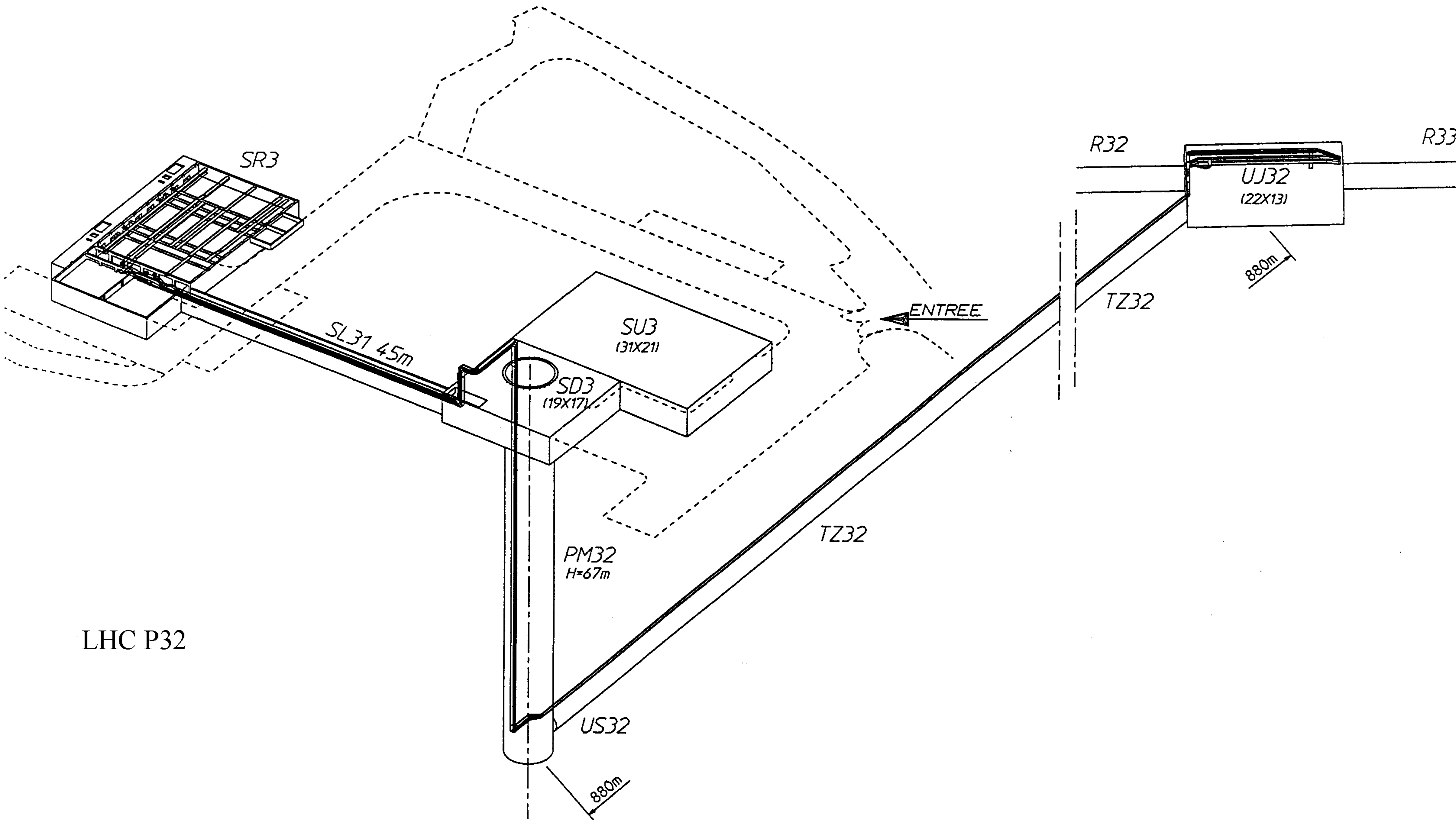
Tunnel installations from middle of octant (US/UJ) in 371 m long sectors with 7 outlets, 1 each 53 m.



duct 1 serves the straight sectors

371 m long sectors





LHC P32

CERN, SR3-UJ32 (1100 m)



*** BERGIT2000 v1.02 * Only for use within KPN, NKF and Plumettaz S.A. ***

Title: CERN / Draka Comteq - NKF
Description: Jetting nonmetallic 8-fibre cable into 7 mm tube for CERN,
first part

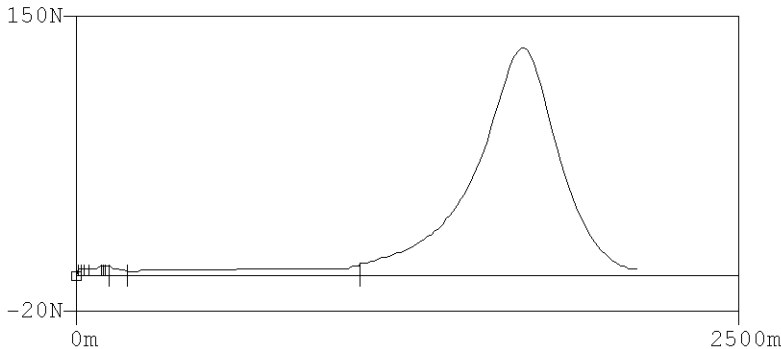
Cable diameter (mm) = 3.90
Cable weight (N/m) = 0.12
Cable stiffness (Nm²) = 0.04
Intrinsic cable curvature = No
Duct diameter (mm) = 5.50
Coefficient of friction = 0.08
Wiggling amplitude (cm) = 0.20
Wiggling period (m) = 2.00
Compressor pressure (bar) = 10.00
Compressor capacity (l/s) = 125.00
Max. push force (N) = 140.00
Blowing factor = 1.00
Pulling force (N) = 0.00
Number of curves = 10
Number of slopes = 4
Special features = No

Curves on (m): (curve radius in parenthesis)
10 (1.0) 20 (1.0) 30 (1.0) 50 (1.0) 95 (1.0) 105 (1.0) 110 (1.0)
125 (1.0) 192 (1.0) 1072 (1.0)

Slope	from (m)	to (m)	incl. (deg)	end height (m)
1	0	125	0.0	0
2	125	192	-90.0	-67
3	192	1072	1.0	-52
4	1072	8000	0.0	-52

Section	from (m)	to (m)	mode
1	0	2122	free

Push force plot:



Mach's number = 0.089
Air flow = 0.7 l/s
buckelradius = 200 r_{cab}
fpush_max = 1294 N

Maximal installation length: 2122 m
Used time for the calculation: 0.05 sec
***** Output created on 12/05/02 at 11:27:01 *****
**** Current time and date: Thu Dec 05 11:27:25 2002 ****

CERN, UJ32-R3999 (2750 m)



*** BERGIT2000 v1.02 * Only for use within KPN, NKF and Plumettaz S.A. ***

Title: CERN / Draka Comteg
Description: Jetting nonmetallic 8-fibre cable into 7 mm tube for CERN,
tunnel part

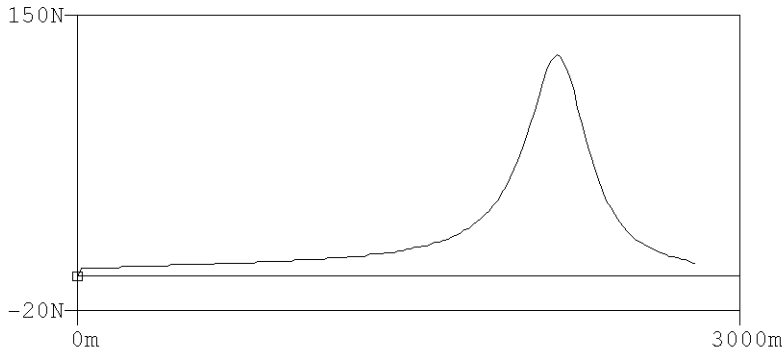
Cable diameter (mm) = 3.90
Cable weight (N/m) = 0.12
Cable stiffness (Nm2) = 0.04
Intrinsic cable curvature. = No
Duct diameter (mm) = 5.50
Coefficient of friction. = 0.08
Wigglng amplitude (cm) = 0.20
Wigglng period (m) = 2.00
Compressor pressure (bar) = 14.00
Compressor capacity (l/s) = 125.00
Max. push force (N) = 140.00
Blowing factor = 1.00
Pulling force (N) = 0.00
Number of curves = 0
Number of slopes = 1
Special features = No

No Curves

Slope	from (m)	to (m)	incl. (deg)	end height (m)
1	0	8000	0.0	0

Section	from (m)	to (m)	mode
1	0	2800	free

Push force plot:



Mach's number = 0.106
Air flow = 0.9 l/s
buckelradius = 208 rcab
fpush_max. = 1299 N

Maximal installation length: 2800 m
Used time for the calculation: 0.06 sec
***** Output created on 12/05/02 at 11:33:21 *****
**** Current time and date: Thu Dec 05 11:33:37 2002 ****

L H C Mini optical fibre cables

- Single-mode G.652.B 9/125 optical fibres
 - 4
 - 8 (6)
 - 12
 - 24
 - 48 (60) (72)
- Multimode G.651 50/125 optical fibres
 - 6
 - 12
 - 24

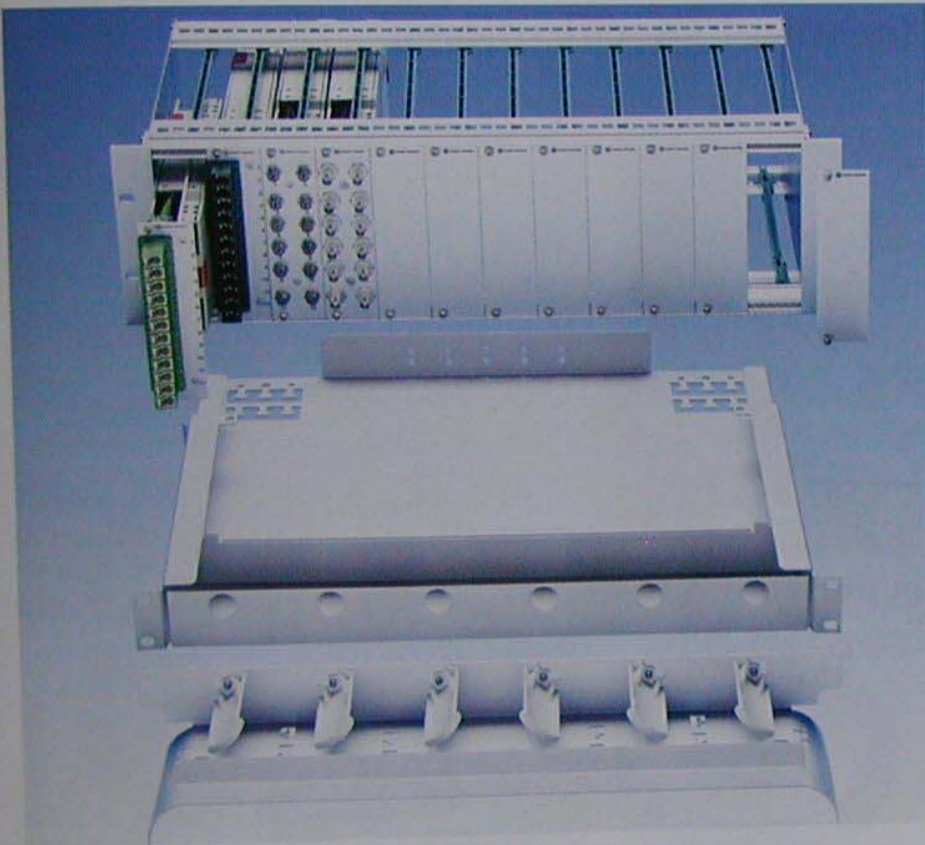
L H C

Optical terminations in STAR points

- Single-mode G.652.B 9/125 optical fibres are terminated with **E-2000/APC (8°)**
- Multimode G.651 50/125 optical fibres are terminated with **ST-HQ connectors**
- Other optical connectors are possible
SC or LC

LHC Optical termination equipment

L
H
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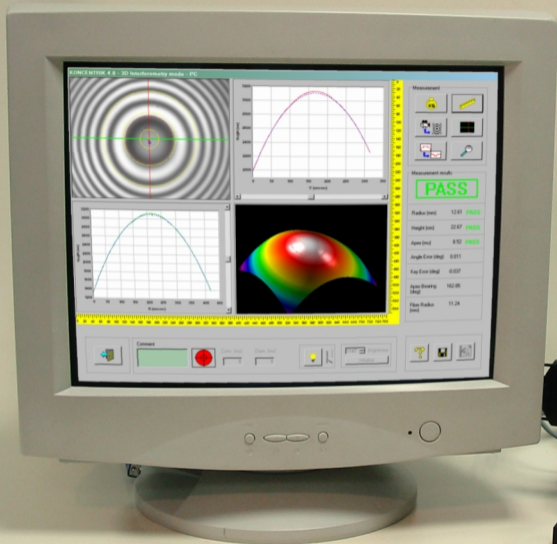
L H C Optical termination equipment

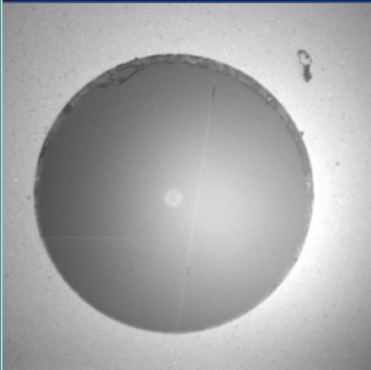


L H C

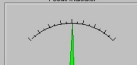
Optical patch cords

- Very large quantities of various optical patch cords will be required
- The Market Survey indicated 10'000 (40'000)
- Any patch cord type is possible
- The optical connectors shall be inspected to check the quality by interferometrie



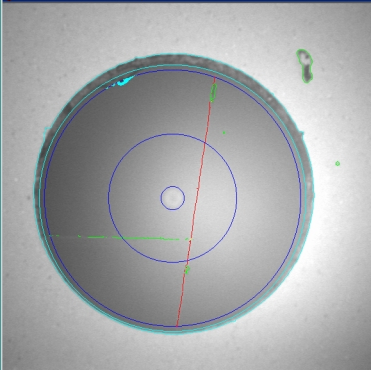


Focus Indicator

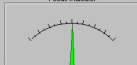


Initialize



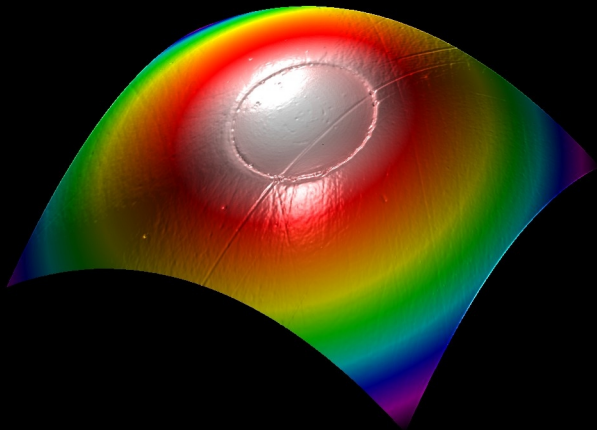


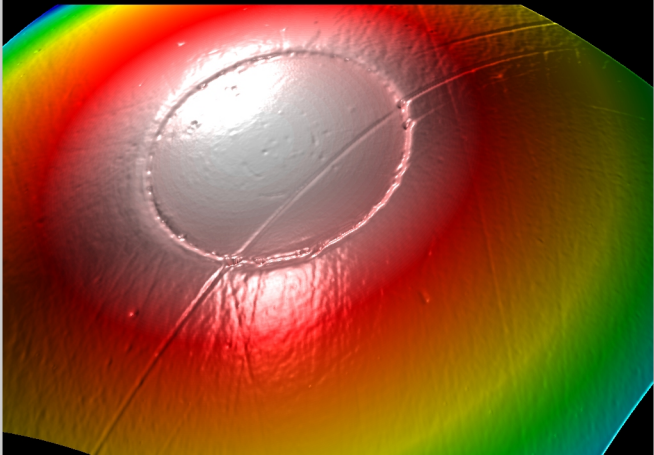
Focus Indicator

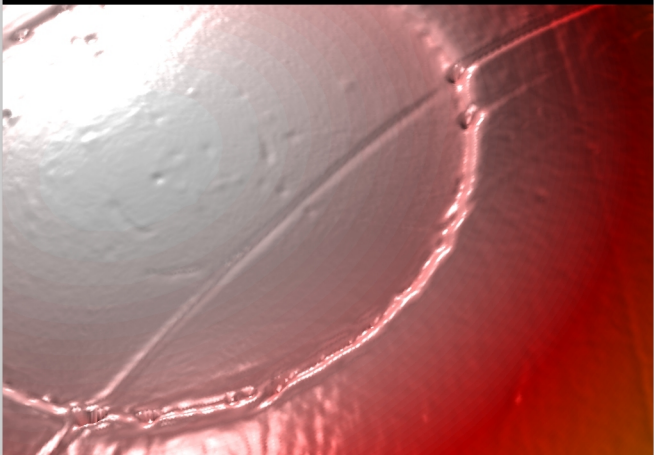


Initialize

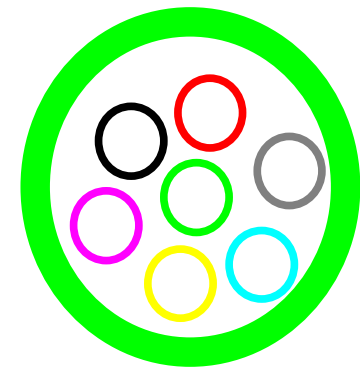
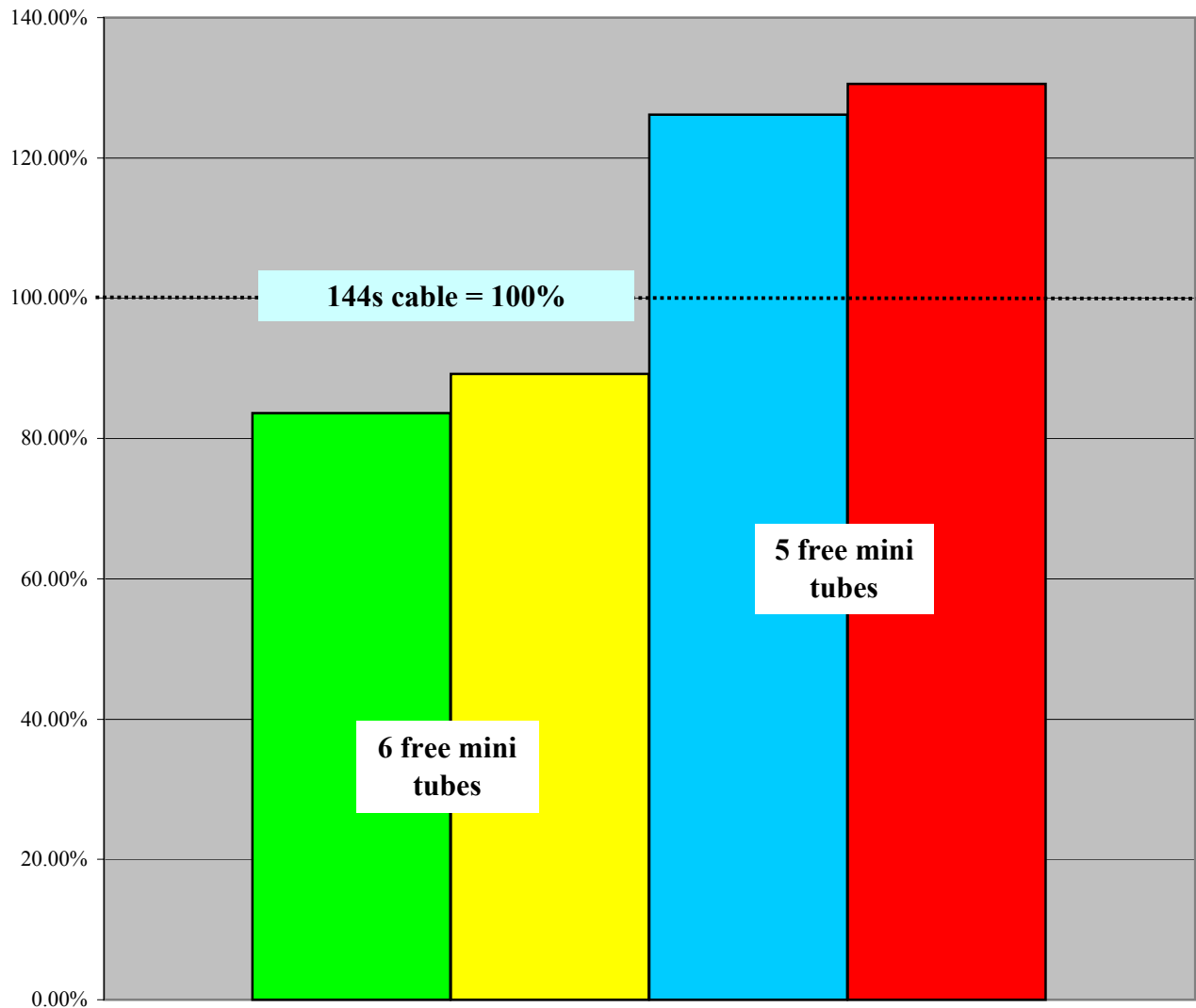








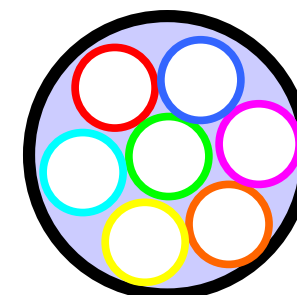
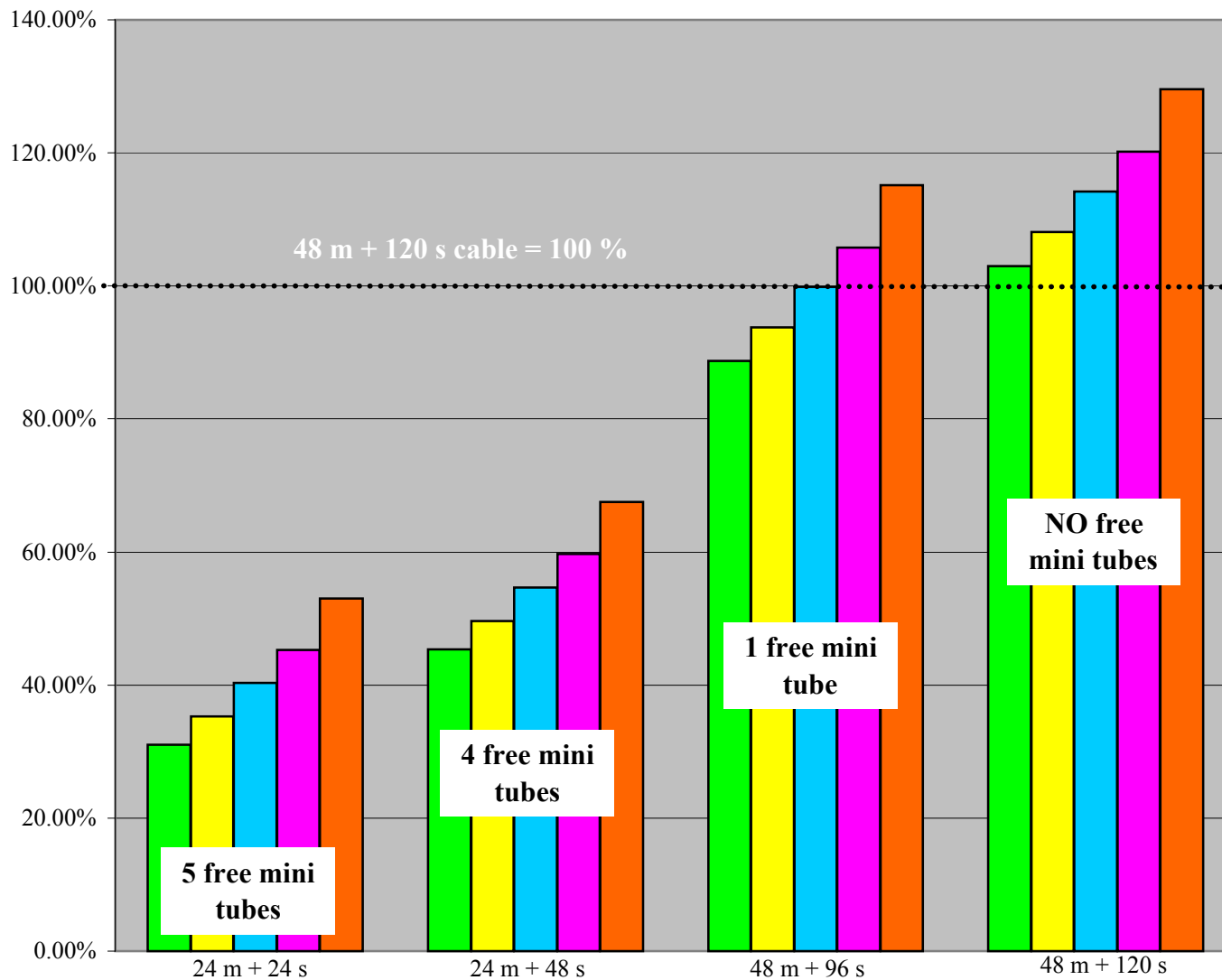
Cost of 7 x Ø 10 mini surface duct system with 1 or 2 72 fibre mini cables compared with cable 144 s



- 72 s / 4500 m
- 72 s / 9000 m
- 144 s / 4500 m
- 144 s / 9000 m

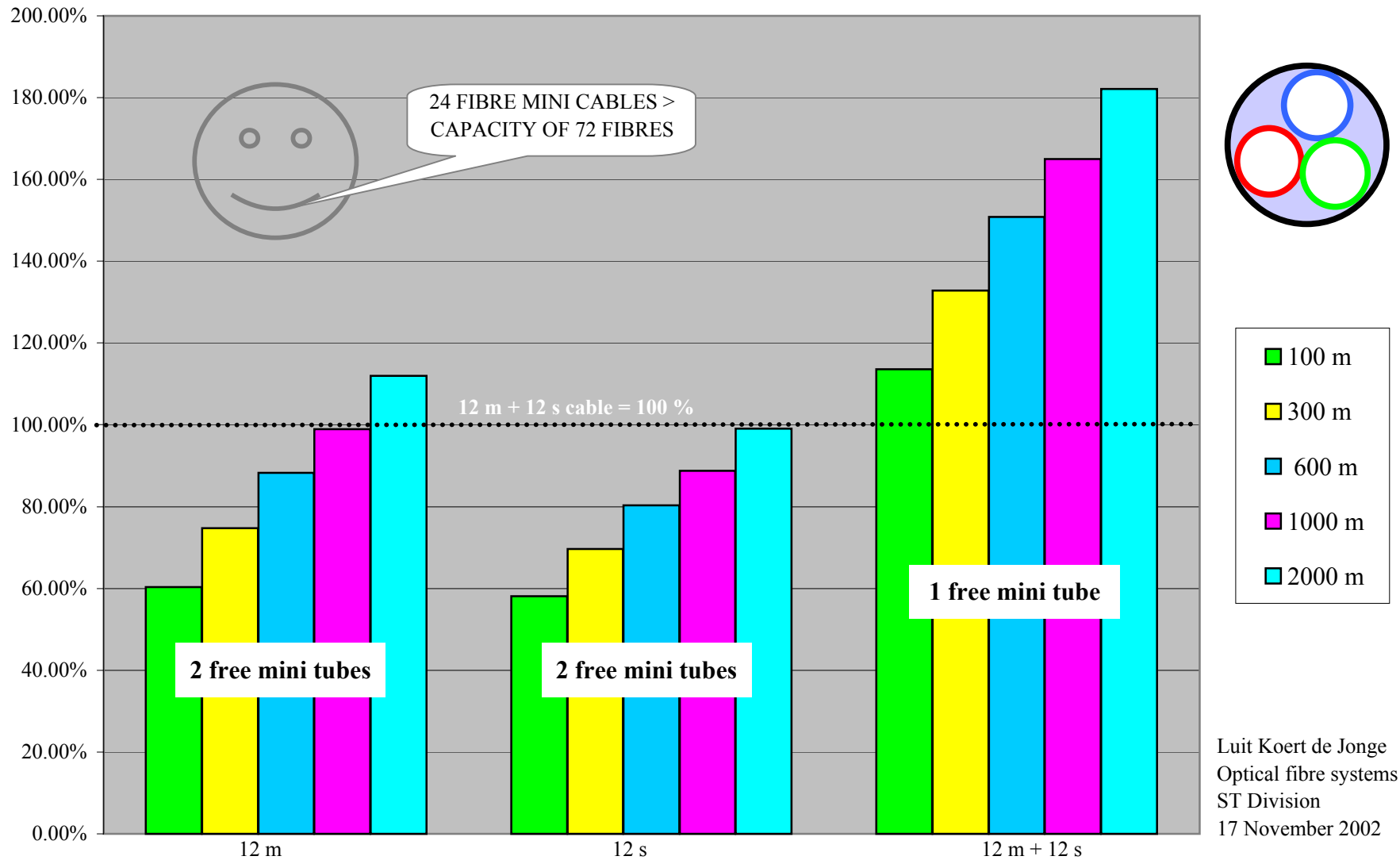
Luit Koert de Jonge
 Optical fibre systems
 ST Division
 13 November 2002

Cost of 7 x Ø 7 mini duct system with 24 fibre mini cables compared with cable 48 m +120 s



- 100 m
- 300 m
- 600 m
- 1000 m
- 2000 m

Cost of 3 x Ø 7 mini duct system with 12 fibre mini cables compared with cable 12 m +12 s



L H C

Optical fibre management

- With such a dense optical network, we need to **manage** it
- We are actually studying ways how to integrate our data into a common data base which should be linked to **geographical** information
- We want make make use of the existing geographical information systems (GIS) and databases

LHC Market Survey MS-3120/ST/LHC

C ➤ Supply, Installation, Test and Commissioning of Optical Fibre Cabling Systems for LHC

CERN's preference for tube systems

- Received 12 replies
- 7 Companies visited/ Selection in progress
- Tender IT-3120/ST/LHC - FC June 2003
- Contract with unit prices
- **Users get what they pay**
- First installations September 2003