Review of irradiated cables in the SPS

Part I – Present strategy

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Part 1

- SPS radiation areas
- Radiation damage example,
- Present replacement strategy
    - Technique
    - Schedule
- Summary

Part 2

- Proposal for a future strategy (D. Ricci)

SPS radiation areas

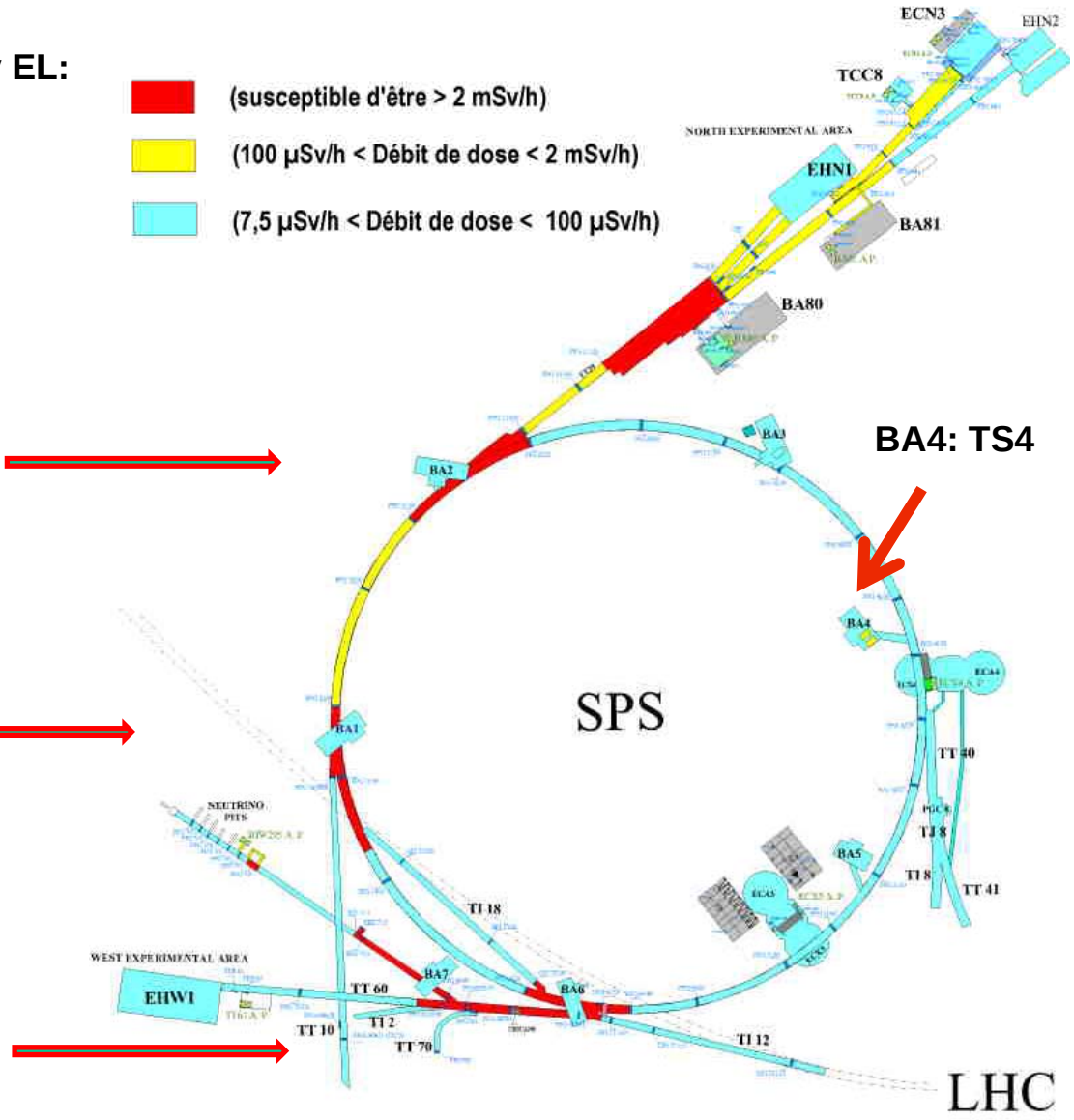
Total number of cables installed in SPS by EL:

54000 cables AC, DC , infrast.
73000 cables control machine.
Total length: 5400 km.

BA2: LSS2 -, TCC2 , TDC2

BA1: LSS1+

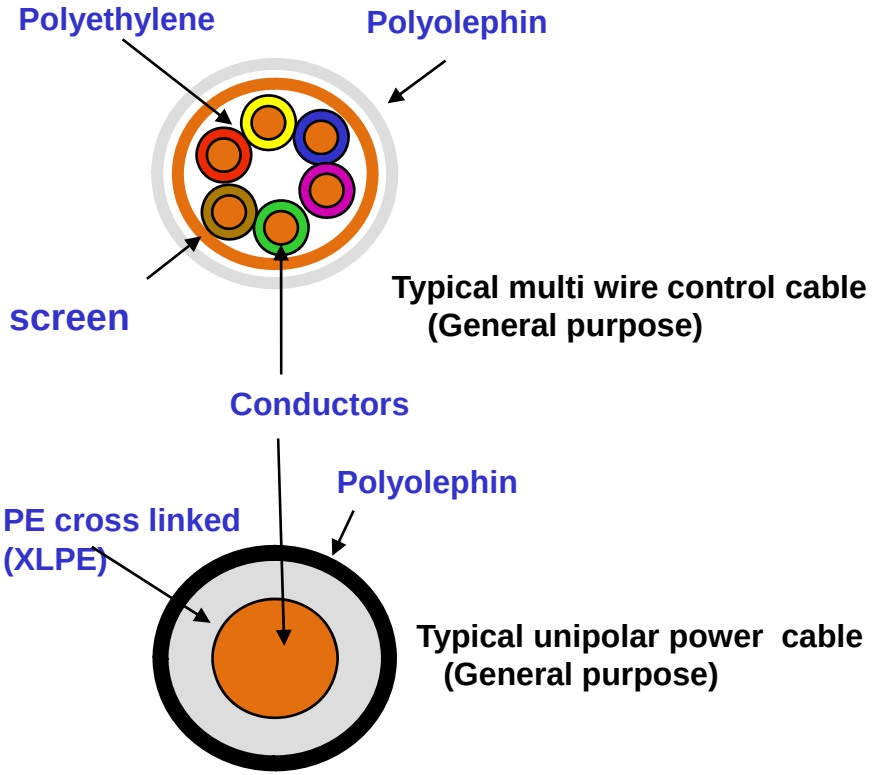
BA6: LSS6 - , TCC6, TT60, TT61, TNC



Concerning the resistance to radiations, the requirements for all types of cables are the following:

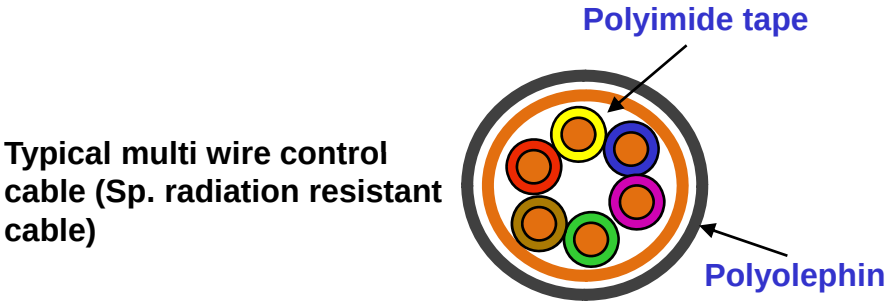
-Retention of functional capabilities up to the specified Radiation Index (up to an integrated radiation dose of 5 ×10 5 Gy for general purpose cables and 10 7 Gy for special radiation resistant cables).

Requested by cable Technical Specifications:



Typical multi wire control cable (General purpose)

Typical unipolar power cable (General purpose)



Typical multi wire control cable (Sp. radiation resistant cable)

Cable code	Price (CHF/m)		Ratio
	Normal	Radiation resistant	
NE48	5.3	43	
NE4	1	5.4	
NG28	5.7	31	
NF12	2.5	15	
SVA3	1.74	5.1	

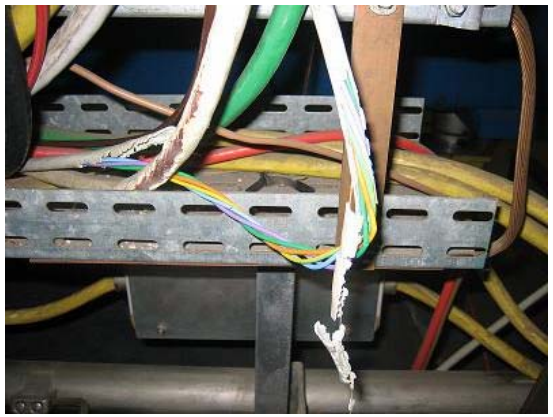
Example of radiation damages.

Not irradiated

5x10^6 Gy

10^7 Gy

In the SPS tunnel:



Example of radiation damages.

Classification of materials according to their radiation resistance.

(Comp. of radiation damage test data : M. Talvet – H. Schönbacher - 1989)

Polyethylene/Polyolefin.

Dose in Gy: **$10^{E}+3$** **$10^{E}+4$** **$10^{E}+5$** **$10^{E}+6$** **$10^{E}+7$** **$10^{E}+8$**

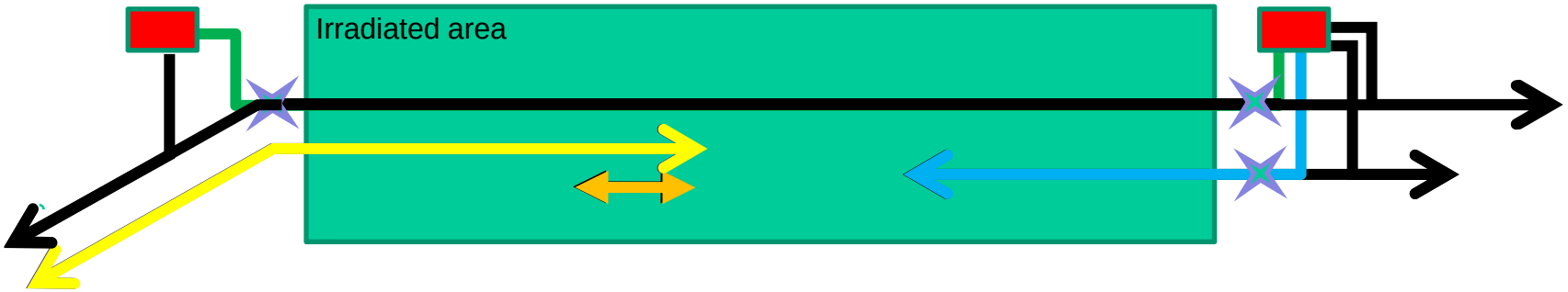
From 1990 to 1996, cables sample have been irradiated in situ in LSS6. Mechanical tests have been done by TIS.

Conclusion:

- For the SPS cables irradiated about 0.1 MGy, the inner insulations were falling apart. The degradation of the sheath was less pronounced.

Patchs

Initial technique



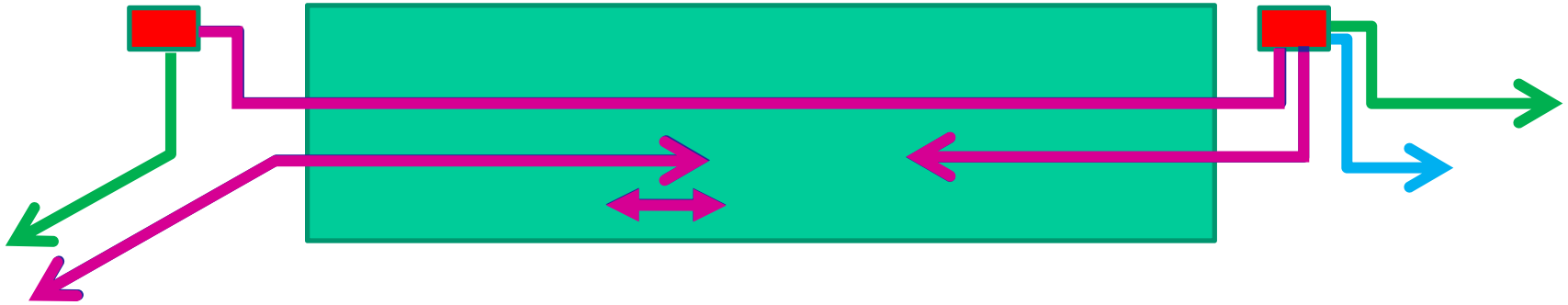
1: Lines passing through the irradiated area - Possible jonction.

2: Lines with one extremity in the irradiated area – Possible jonction.

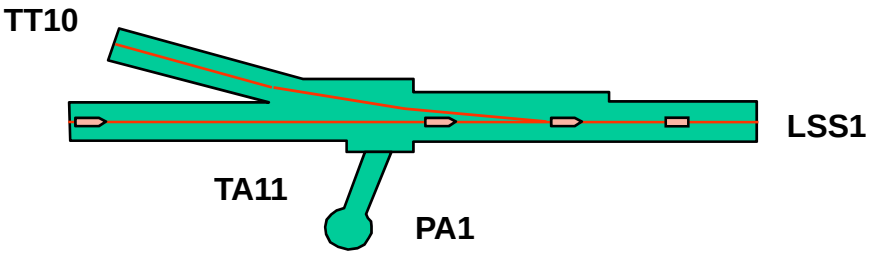
3: Lines with two extremities in the irradiated area.

4: Lines with one extremity in the irradiated area – No possible jonction.

Present technique



Example: LSS1



- Vacuum
- Radiation monitors,
- SEM detectors,
- Beam Transfert.

- Kikers

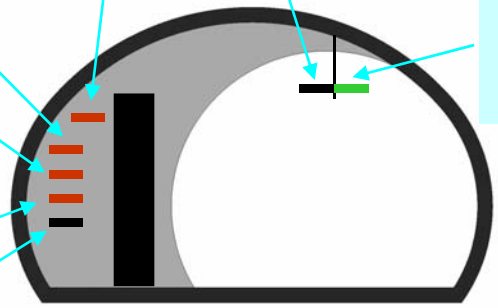
-Power distribution F1-F2
-Urgency stop network
-Phone, light

- Communication
- Alarms lev 3
- TDM,
- Personal protection

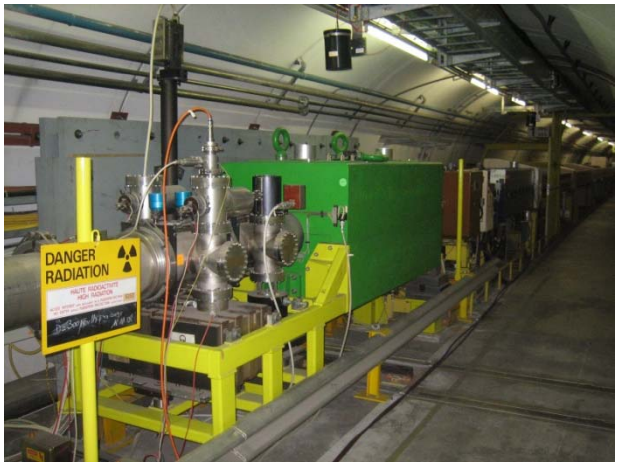
- Vacuum
- Beam Transfert interl.
- TV machine.

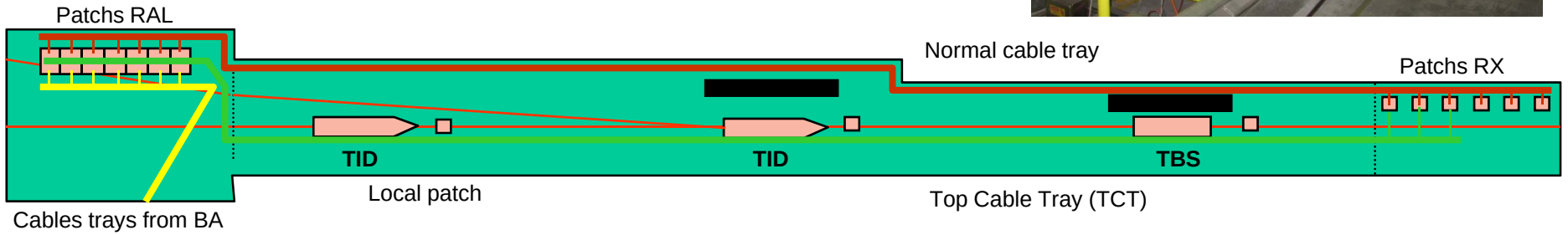
- Beam loss Dump
- BL Injection

- DC cables



Typical tunnel junction

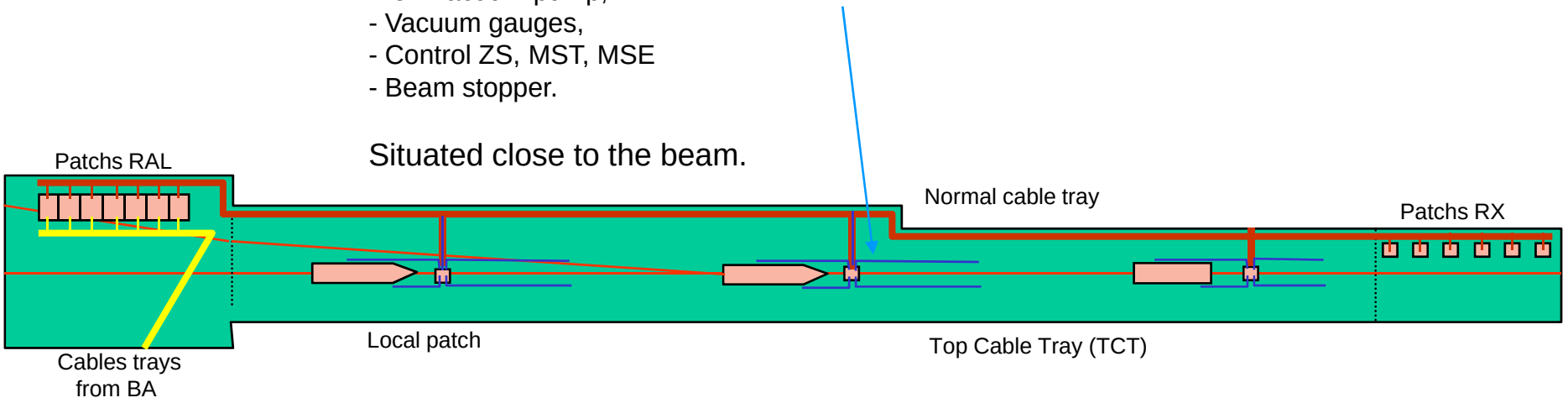




-The only special radiation resistant cables installed concern the following systems:

- The control of the target aperture limiter,
- SEM detectors,
- Ion Vacuum pump,
- Vacuum gauges,
- Control ZS, MST, MSE
- Beam stopper.

Situated close to the beam.

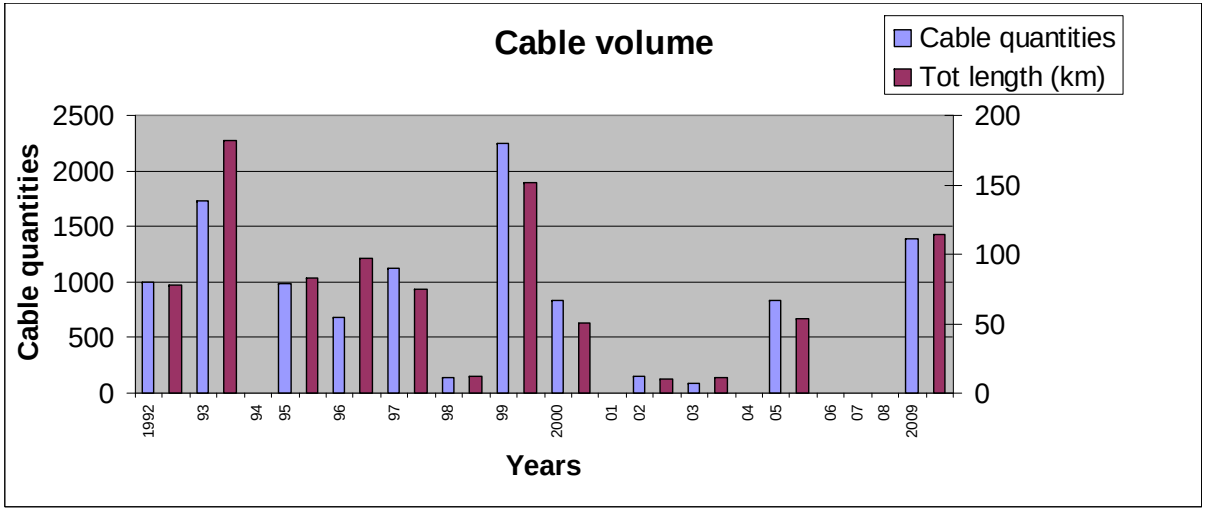


-The replacement concerns only control cables. Power cables (AC distribution and DC lines) have never been changed in this program.

Areas treated since 1990

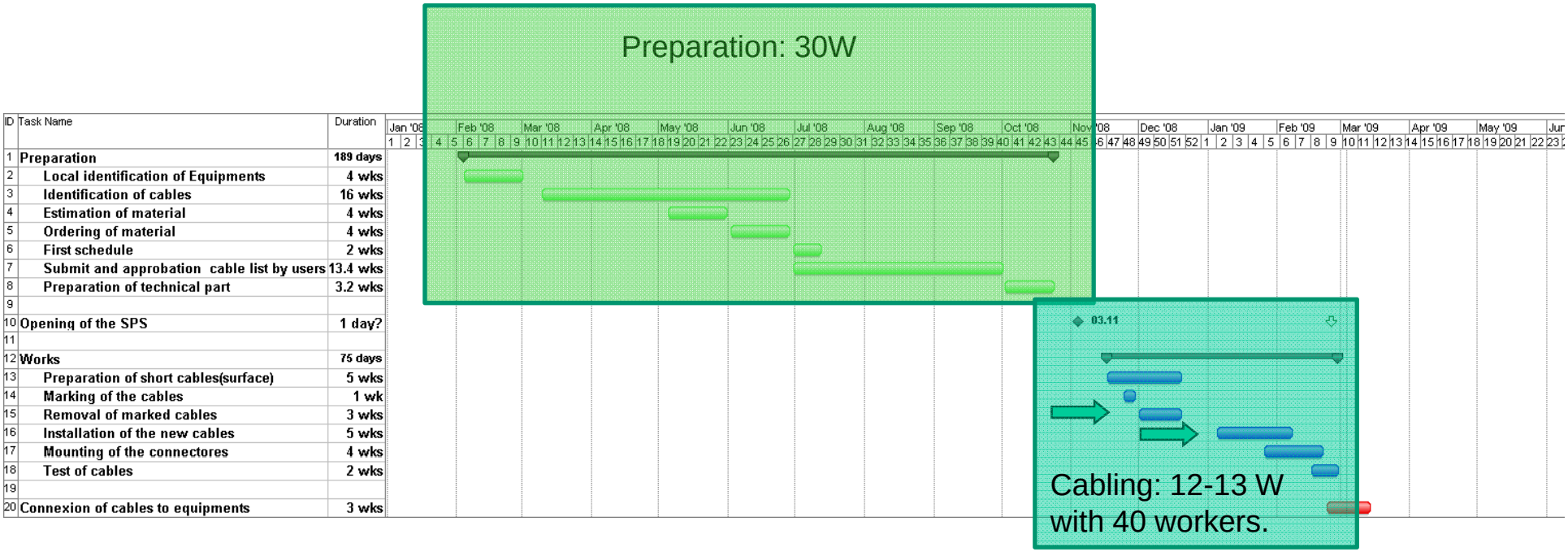
Areas	1990	91	92	93	94	95	96	97	98	99	2000	01	02	03	04	05	06	07	08	09
TS1	All					All								TCT						
TS2	ZS/MST/MSE			All		ZS/MST/Vac				Exc TCT										Exc TCT
TCC2			All								AA		R							
TDC2			All								All									
TS4										Part										
TS6	ZS/MST/MSE	Exc TCT	TCT			Exc TCT		Vac exc TCT	TCT							Rem. ZS, Inst MKE				
TT60							All													
TCC6							All													
TNC			All																	

TCT: Top cable tray, AA: Almost All, R: Rest, Part: Partial.



Max. individual doses during the shut down 2009: 2 mSv **Irradiated cable wastes since 2000: 146 m3**

Typical schedule



ID	Task Name	Duration
1	Preparation	189 days
2	Local identification of Equipments	4 wks
3	Identification of cables	16 wks
4	Estimation of material	4 wks
5	Ordering of material	4 wks
6	First schedule	2 wks
7	Submit and approbation cable list by users	13.4 wks
8	Preparation of technical part	3.2 wks
9		
10	Opening of the SPS	1 day?
11		
12	Works	75 days
13	Preparation of short cables(surface)	5 wks
14	Marking of the cables	1 wk
15	Removal of marked cables	3 wks
16	Installation of the new cables	5 wks
17	Mounting of the connectores	4 wks
18	Test of cables	2 wks
19		
20	Connexion of cables to equipments	3 wks

- Removal of irradiated cables and pulling of the new cables are done in 2 shifts,

-Mounting of the new connectors cannot be done with more than 6-7 workers.
Only 2 people can work side by side during the assembly of the connectors on the patches.

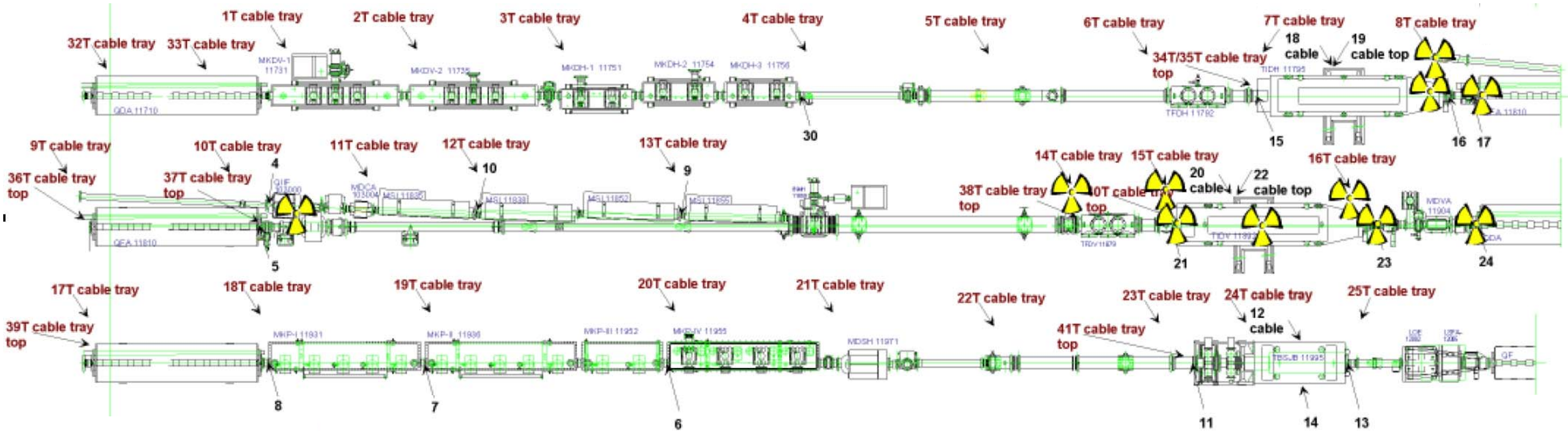
Is it possible to reduce the cabling time ?

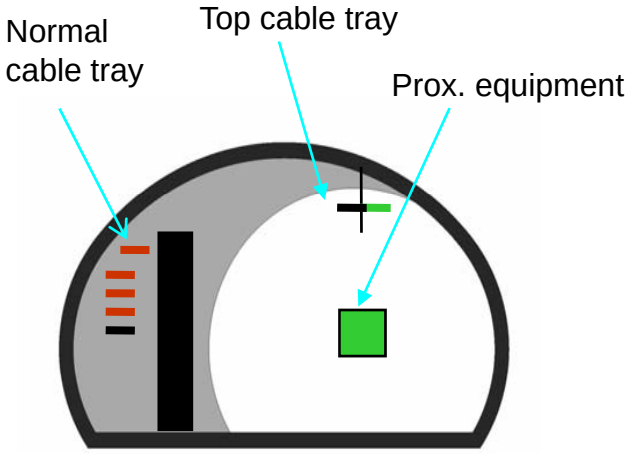
Very difficult to say in advance due to:

- Difficulties and renovation of the different systems,
- Not predictible things. (Problem during tests)
- Modifications requested during the Shut Down.

Position of the dosimeters

Since 1989, dosimeters have been placed by RP in the irradiated areas near the cables trays.





Actual cumulated doses since the last changement of cables (Gy) (warmest values)

Areas	Since	Cable trays	Top cable tray / near equip.	Max Last annual dose (2006)	Comments
TS1	1996			1.00E+06	
TS2	2009			1.10E+06	Changement in SD09
TCC2	2000			1.00E+06	Warmest point
TDC2	2000			2.89E+04	
TS6	1995			5.25E+05	Warmest positions removed with new configuration
TCC6	1996			6.16E+05	information 2000-2004 only

Present strategy summary

- In the beginning of the program, the replacement of the cables were made every 6 years and focused on 3 areas BA1, BA2 and BA6.

- Purchase of cables and connectors during the first year and the installation the following year.

- During the previous shut down, a meeting is organised in situ with the coordination, some users and EN-EL to determine the status of the cables (visual inspection).

- Users communicate the number of problem found during the run of the machine to the Technical Coordination.

In any case, the final decision of the replacement of the cables is taken by the Technical Coordination with the argument of the experts.

-Presently, the cables are changed an average of 10 years without any mechanical or chemical tests.
Since 1997, no sample have been installed and tested.

NOTA: If the decision is taken to postpone a campaign for one area:

-In case of local problem, EN-EL has the capacity to intervene through his contractor to replace the defect cable.
But these operation cannot be done often. (accumulated doses, damages to other cables, etc…)

Present strategy summary

- The areas are wellknown and the cables of the principal areas have been already changed twice.

- The program (preparation and installation) is very load for CERN and contractors. Only one complete area can be done during a shut down.

It means that the consequence of shifting the replacement of one year in a given point will produce a shift of one year for all the other points.