EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN – TIS – 99–009 – TE
April 1999

# HIGH – LEVEL DOSIMETRY RESULTS FOR THE CERN HIGH – ENERGY ACCELERATORS

## Part 2: SPS complex 1998

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Abstract

This year, the high–level dosimetry results are presented in three separate reports: Part one concerns the doses in the machines of the PS complex, this one concerns the doses in the SPS and Part 3, the doses in the LEP complex. The results are presented in the form of graphs and are discussed separately for each area. The aim of this report is to provide a dose estimate for the components of the various accelerators, and to draw attention to possible radiation damage.

## 1. INTRODUCTION

Integrated radiation dose measurements at selected points in high-dose-level areas give reliable information on radiation ageing of accelerator materials, and provide an indication of their projected lifetime. The small radiation detectors allow the actual received dose to be sensed near the exposed component. We do not, however, keep track of the movement and exchange of equipment, although this needs to be taken into account for the determination of the total integrated doses of individual components.

The measurements have been carried out at the SPS since its start-up in April 1976 [1]. Target areas (e.g. TCC2, TCC6, Neutrinos) and transfer lines (e.g. TT4, TT5, TT20, TDC20, TT84, TT61, and TDC8) were included at the start of operation.
The new Neutrino Cave with the T9 target started operation in 1994 and was again equipped with dosimeters.

In each machine and transfer tunnels of the PS Complex, as well as in the LEP Main Ring and transfer tunnels, dosimeters have been installed since their respective starts. They are yearly renewed and read [2 – 5].

This report gives the integrated dose values for the SPS complex since the last exchange of dosimeters up to the end of 1998, as well as the integrated doses from the start of the machine. The standard dosimeter positions in the SPS, in the related primary beam transfer tunnels and target areas are given in Table 1.

No dosimeters neither from the sextants (magnet coils and cable trays), nor from beam transfer tunnels and targets areas (except from special positions on optical fibres in TCC8 and the Neutrino Cave) were read this year. The dosimeters for which the results are presented in this report were taken out from the six LSSs, and were read during the annual shutdown. The values measured earlier can be found in Refs. [4] and [5].

## 2. DOSIMETRY METHODS

At CERN, three methods for standard high-level dosimetry are usually used:

- radiophotoluminescent (RPL) glass dosimeters [6];
- polymer-alanine dosimeters (PAD) [7]
- hydrogen-pressure dosimeters (HPD) [8].

In proton machine and tunnels, such as the SPS, mainly RPL dosimeters are used. Electrons liberated in glass during irradiation may be trapped in vacancies or by impurities, forming more or less stable colour centres of different types. In silver-doped RPL glass the luminescent orange light, which is emitted after excitation by UV light, is evaluated to obtain the irradiation dose [6].

The dosimeters are calibrated with a $^{60}Co$ source. This means that all doses reported here are those that would be needed in order to produce the same signal, by a $^{60}Co$ gamma irradiation, in a $(CH_2)_n$-type material. This dosimetry method is sufficiently reliable, as can be seen from dosimeter inter-comparison experiments in accelerator radiation environments, and from our experience of radiation damage in plastic materials. Some parameters and the range of application for these dosimeters are listed in Table 1 of Ref. [9]. More details can be found in Refs [9] and [10]. In order to investigate their behaviour at cryogenic temperatures, RPL dosimeters have been irradiated at 77 K and 4.5 K. Results are published in Refs. [11].

## 3. RESULTS

As in the previous reports (Refs. [4] and [5]), the results presented here are in the form of graphs as summarised in the attached figures (Figs.1-11). The graphs either present the dose records for the year 1998 (or since the last exchange of dosimeters), or the total integrated doses from the beginning of the dose record up to the end of the year 1998.

Critical dose limits above which radiation damage to accelerator components could occur can be set at the following levels:

- $10^2$ Gy for electronic components;
- $10^5$ to $10^6$ Gy for organic cable-insulating materials;
- $10^7$ to $10^8$ Gy for magnet coil insulations.

Although we have placed over 960 dosimeters in the surveyed areas of the SPS complex, the record given above is far from being complete (only 271 dosimeters were read for the year 1998) and must be used as a general indication only.
For instance, the radiation-sensitive item of concern is not necessarily located at or close to the spot where the dosimeter is positioned. For locations further away from the radiation source, the dose may be estimated by applying a $1/r^{1.25}$ distance factor.

The results presented in the graphs are self-explanatory, a few additional comments are given below. No dose indication in a particular position means that the dosimeter has not been found. Statistical data about CERN accelerators operation were taken from Ref. [12].

### 3.1. SPS Main Ring

The Figures 1 to 6 give the results of dose measurements in the standard positions of the six LSSs.

Series a figures represent the absorbed dose since the last exchange of dosimeters up to 1998, i.e. integrated doses

from 1991 for LSS 3, 4 and 5,
from 1992 in LSS 1 and
from 1997 in LSS 2 and 6.

Series b figures represent the total absorbed dose since the machine start in 1976.

In addition, dose measurements were carried out in LSS1, LSS2 and LSS6 on special cable tray positions near the wall and on top of the tunnel. The results are shown in Figs 7 to 9.
In LSS2, many cables were replaced in the ZS area. Further downstream, important degradations were noticed on sheathing materials of cables laying on the cable tray on the left side of the beam to TT20. The sheathing material is crumbling at positions where the cable trays pass below the beam line. These cables were installed before 1980 (some of them are still PVC cables). Additional dosimeters have been placed for 1999 on these cable trays.
During this last shut-down, some cables have also been replaced in LSS4.

### 3.2. Target areas and tunnels to experimental areas

For the Neutrino Cave, the 1998 doses, and the integrated doses from 1994 to 1998, are given respectively in Fig. 10a and Fig. 10b. In 1998, there was a general tendency to dose decrease in this area. However, there are still two high dose records: above 1 MGy downstream from the magnet QTLD600 and on the reflector. It is in this position and on cable tray near the reflector that the dose diminution were the more important (by about a factor 2) compared to 1997. The doses integrated by the cables have been quite high for these five year of operation; conventional cables will have to be exchanged prior to any reuse of the area.

Dose measurements along optical fibres in TCC8 can be found in Fig. 11. The dose levels are again quite low this year.

References


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12. SPS machine statistics for 1998 available on the network: div_sl/Stat/ Spsstat/protons/compar/.

Table caption

1. Location of dosimeters in SPS complex.

Figure captions

**Figs. 1 a and b.** Integrated doses in the LSS1, from March '92 to Dec. '98 (Fig. 1a) and from 1976 to 1998 for Fig. 1b.

**Figs. 2 a and b.** Integrated doses in the LSS2, from March '97 to Dec. '98 (Fig. 1a) and from 1976 to 1998 (1b).

**Figs. 3 to 5,** Integrated doses in the LSS3 to LSS5, from Feb.'91 to Dec.'98 (figures **a**) and from 1976 to 1998 (figures **b**).

**Figs. 6a and b.** Integrated doses in the LSS6, from March '97 to Dec. '98 (Fig. 6a) and from 1976 to 1998 for 6b.

**Figs. 7 to 9.** Special dose measurements for cables in LSS1, LSS2 and LSS6 from March 1997 to December 1998.

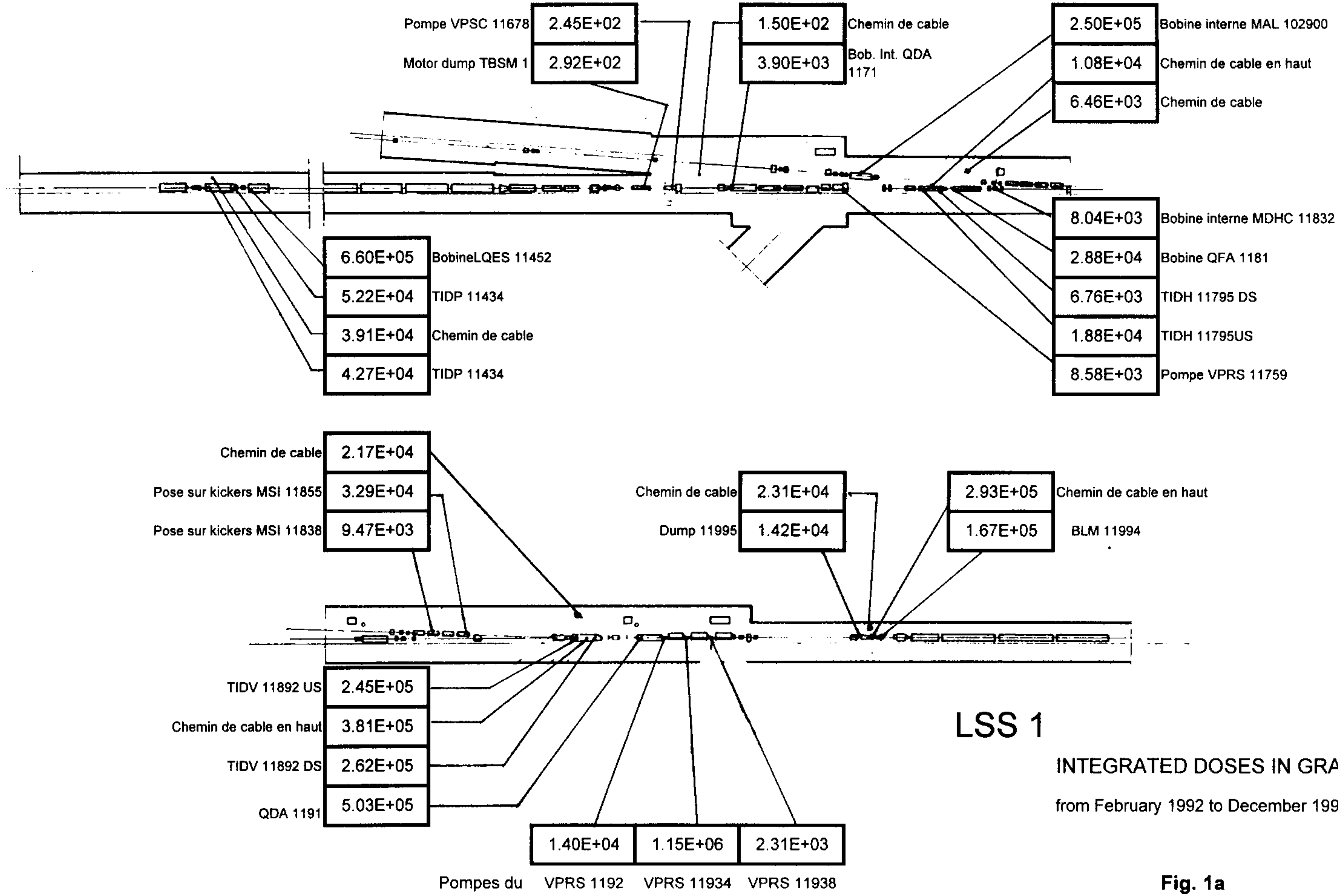
**Fig. 10a.** Integrated doses in the SPS Neutrino Cave from March '98 to Sept. '98. Number of ejected protons to the neutrino target T9: $1.82x\ 10^{19}$.

**Fig. 10b.** Integrated doses in the SPS Neutrino Cave from Feb. '94 to Sept. '98. Number of ejected protons to the neutrino target T9: $6.82 \times 10^{19}$.

**Fig. 11.** Special dose measurements on optical fibers in TCC8 for 1998.

**Table 1.** Location of RPL dosimeters in the SPS machine

| Area | Location | Results |
|---|---|---|
| Sextant 1 to 6. | On quadrupole coils dowstream; on cable tray positions near the wall upstream the quadrupole. | This year, no measurements (n.m.) |
| LSS 1 to 6 (injection, ejection, dump, etc.) | On special equipement.<br>On cables. | Figs.1 to 6 a and b<br>Figs.7 to 9 |
| Targets, Neutrino. | Up and downstream T9. | Figs. 10a and 10b |
| Targets, West Area. | Up and downstream T1, TCC6.<br>On cables. | n.m. |
| North transfer tunnels (TT20, TDC20, TDC8, TT84) | At particular loss points.<br>On cables. | n.m. |
| Targets, North Area. | Up and downstream T2, T4, T6.<br>On cables. | n.m. |
| Targets, TCC8. | Up and downstream T8, T10.<br>On cables (optical fibres). | Fig.11 |
| At loss points in the rings and in the target areas. | Together with radiation damage test samples. | n.m. |

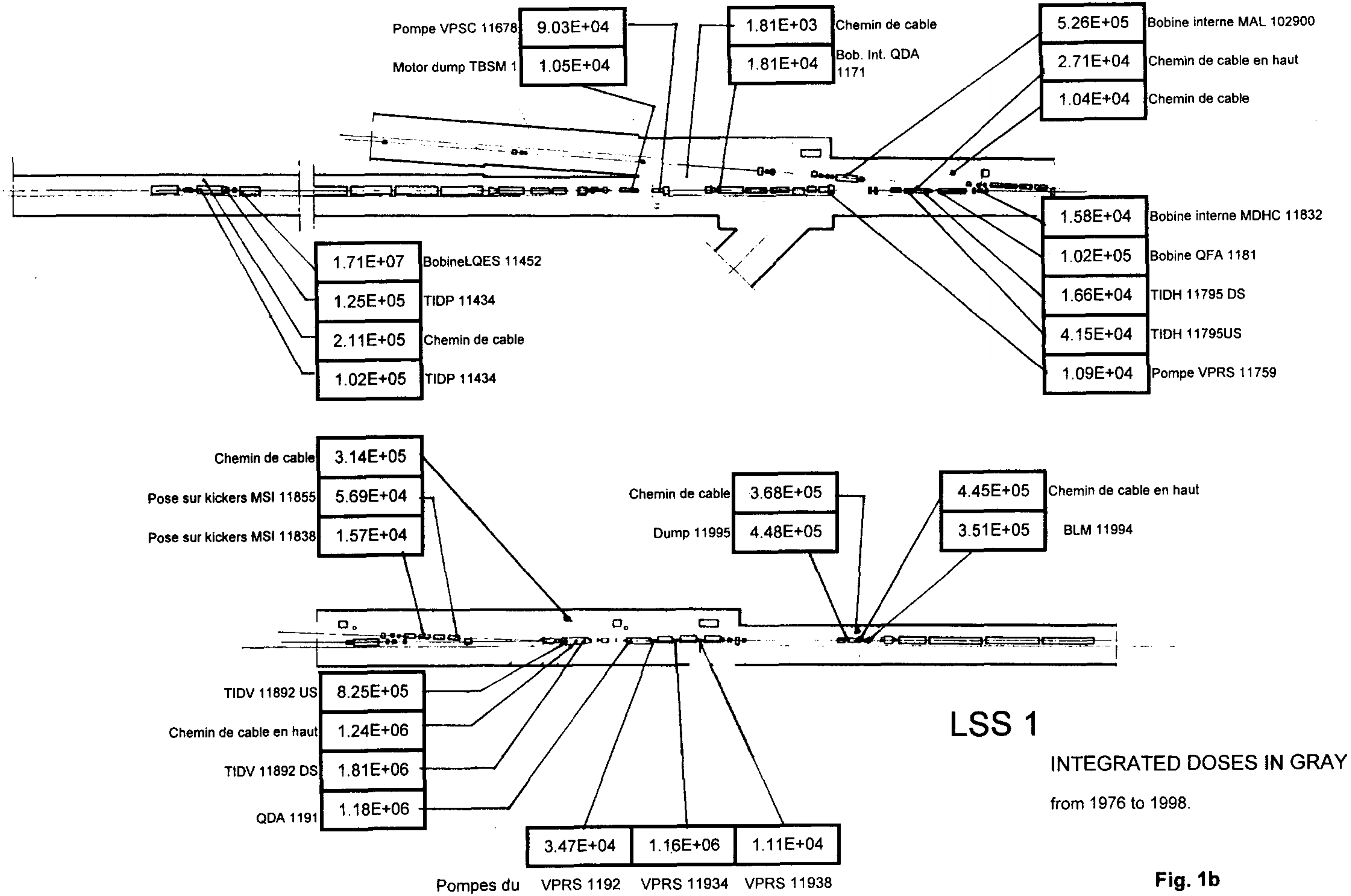



LSS 1

INTEGRATED DOSES IN GRAY

from February 1992 to December 1998.

**Fig. 1a**




LSS 1

INTEGRATED DOSES IN GRAY

from 1976 to 1998.

**Fig. 1b**

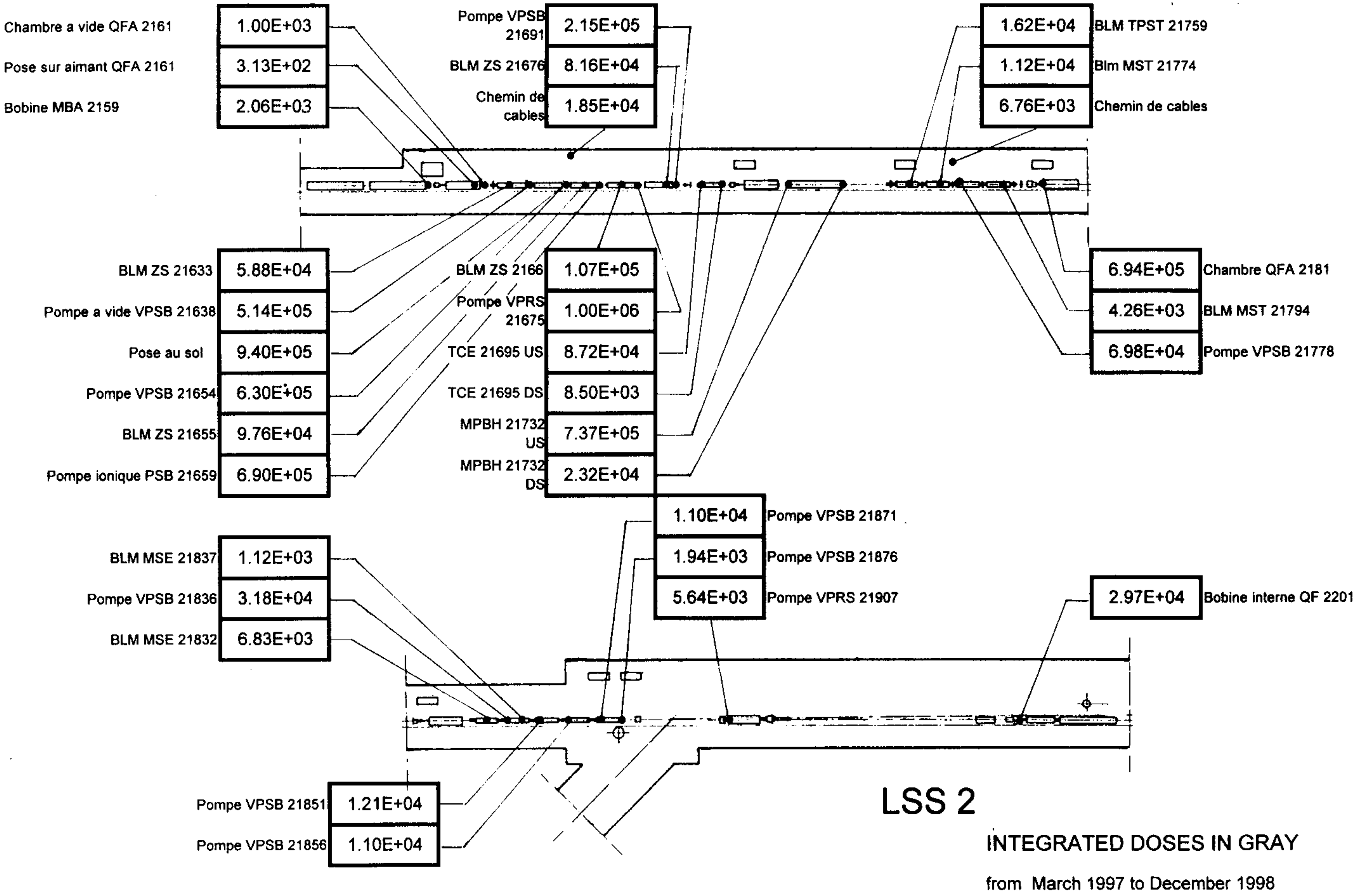

Chambre a vide QFA 2161 1.00E+03
Pose sur aimant QFA 2161 3.13E+02
Bobine MBA 2159 2.06E+03
Pompe VPSB 21691 2.15E+05
BLM ZS 21676 8.16E+04
Chemin de cables 1.85E+04
1.62E+04 BLM TPST 21759
1.12E+04 Blm MST 21774
6.76E+03 Chemin de cables
BLM ZS 21633 5.88E+04
Pompe a vide VPSB 21638 5.14E+05
Pose au sol 9.40E+05
Pompe VPSB 21654 6.30E+05
BLM ZS 21655 9.76E+04
Pompe ionique PSB 21659 6.90E+05
BLM ZS 2166 1.07E+05
Pompe VPRS 21675 1.00E+06
TCE 21695 US 8.72E+04
TCE 21695 DS 8.50E+03
MPBH 21732 US 7.37E+05
MPBH 21732 DS 2.32E+04
6.94E+05 Chambre QFA 2181
4.26E+03 BLM MST 21794
6.98E+04 Pompe VPSB 21778
1.10E+04 Pompe VPSB 21871
1.94E+03 Pompe VPSB 21876
5.64E+03 Pompe VPRS 21907
BLM MSE 21837 1.12E+03
Pompe VPSB 21836 3.18E+04
BLM MSE 21832 6.83E+03
2.97E+04 Bobine interne QF 2201
Pompe VPSB 21851 1.21E+04
Pompe VPSB 21856 1.10E+04
LSS 2
INTEGRATED DOSES IN GRAY
from March 1997 to December 1998

**Fig. 2a**

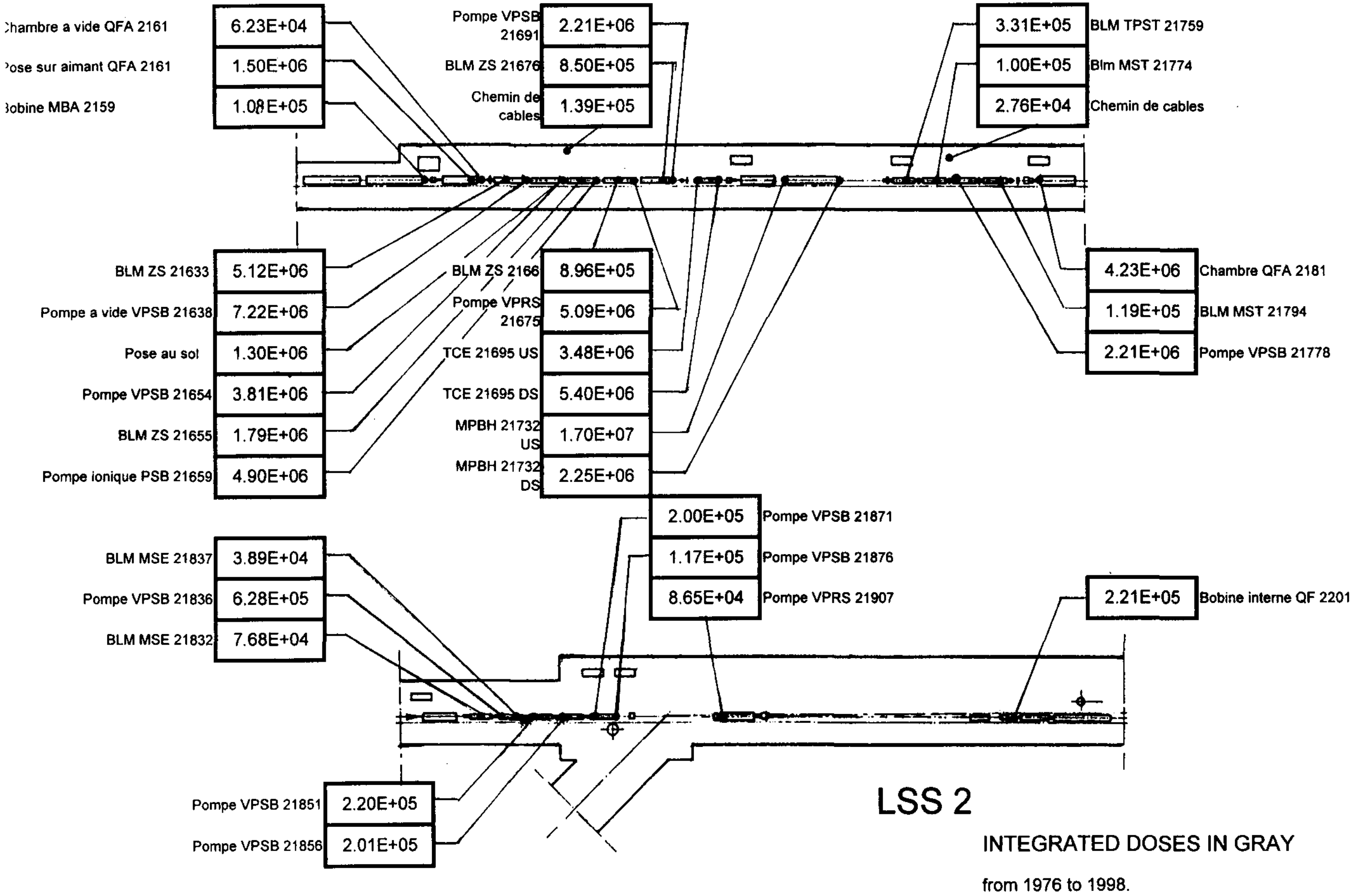
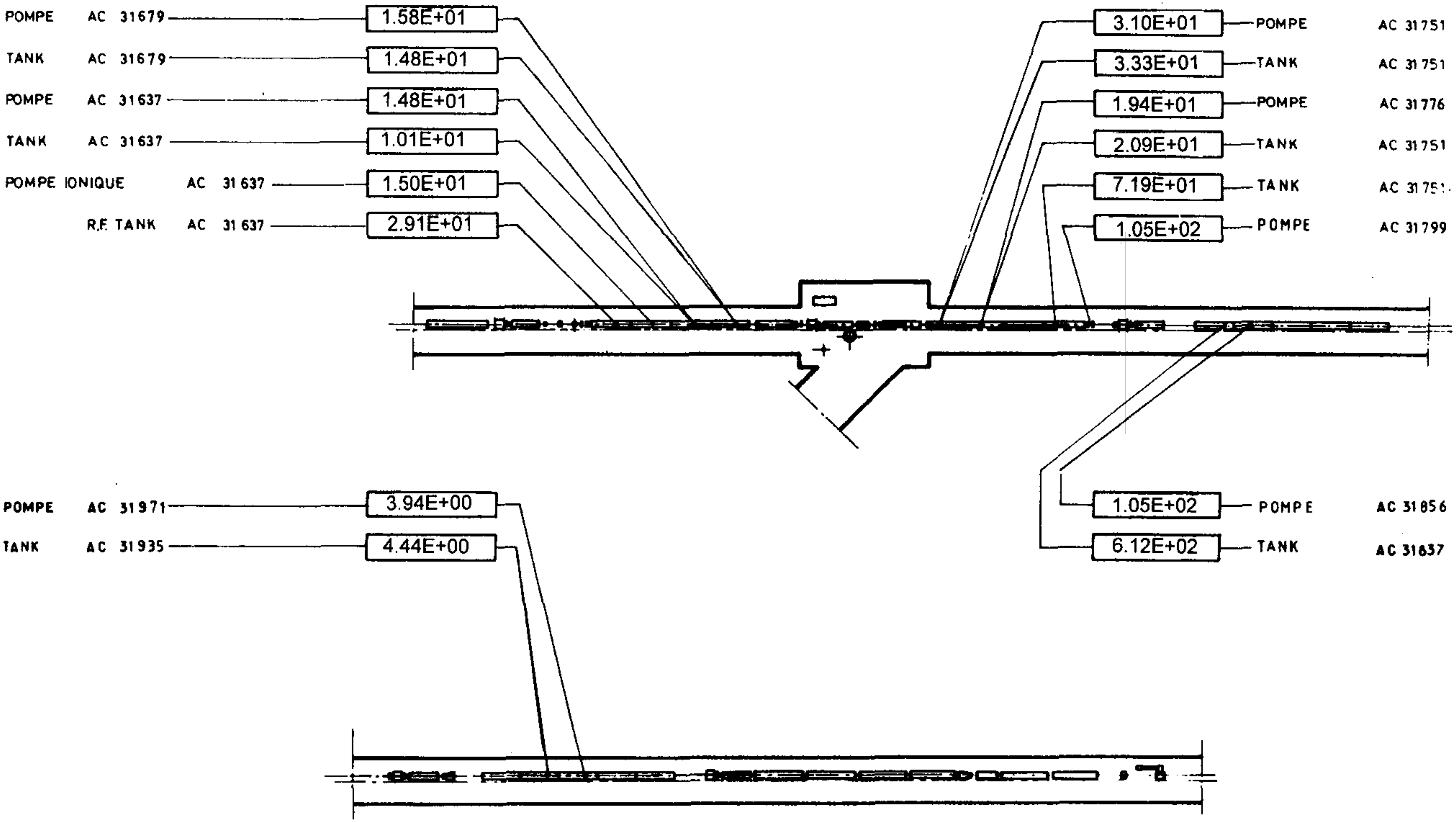

Chambre a vide QFA 2161 6.23E+04
Pose sur aimant QFA 2161 1.50E+06
Bobine MBA 2159 1.08E+05
Pompe VPSB 21691 2.21E+06
BLM ZS 21676 8.50E+05
Chemin de cables 1.39E+05
3.31E+05 BLM TPST 21759
1.00E+05 Blm MST 21774
2.76E+04 Chemin de cables
BLM ZS 21633 5.12E+06
Pompe a vide VPSB 21638 7.22E+06
Pose au sol 1.30E+06
Pompe VPSB 21654 3.81E+06
BLM ZS 21655 1.79E+06
Pompe ionique PSB 21659 4.90E+06
BLM ZS 2166 8.96E+05
Pompe VPRS 21675 5.09E+06
TCE 21695 US 3.48E+06
TCE 21695 DS 5.40E+06
MPBH 21732 US 1.70E+07
MPBH 21732 DS 2.25E+06
4.23E+06 Chambre QFA 2181
1.19E+05 BLM MST 21794
2.21E+06 Pompe VPSB 21778
2.00E+05 Pompe VPSB 21871
1.17E+05 Pompe VPSB 21876
8.65E+04 Pompe VPRS 21907
BLM MSE 21837 3.89E+04
Pompe VPSB 21836 6.28E+05
BLM MSE 21832 7.68E+04
2.21E+05 Bobine interne QF 2201
Pompe VPSB 21851 2.20E+05
Pompe VPSB 21856 2.01E+05
LSS 2
INTEGRATED DOSES IN GRAY
from 1976 to 1998.

**Fig. 2b**

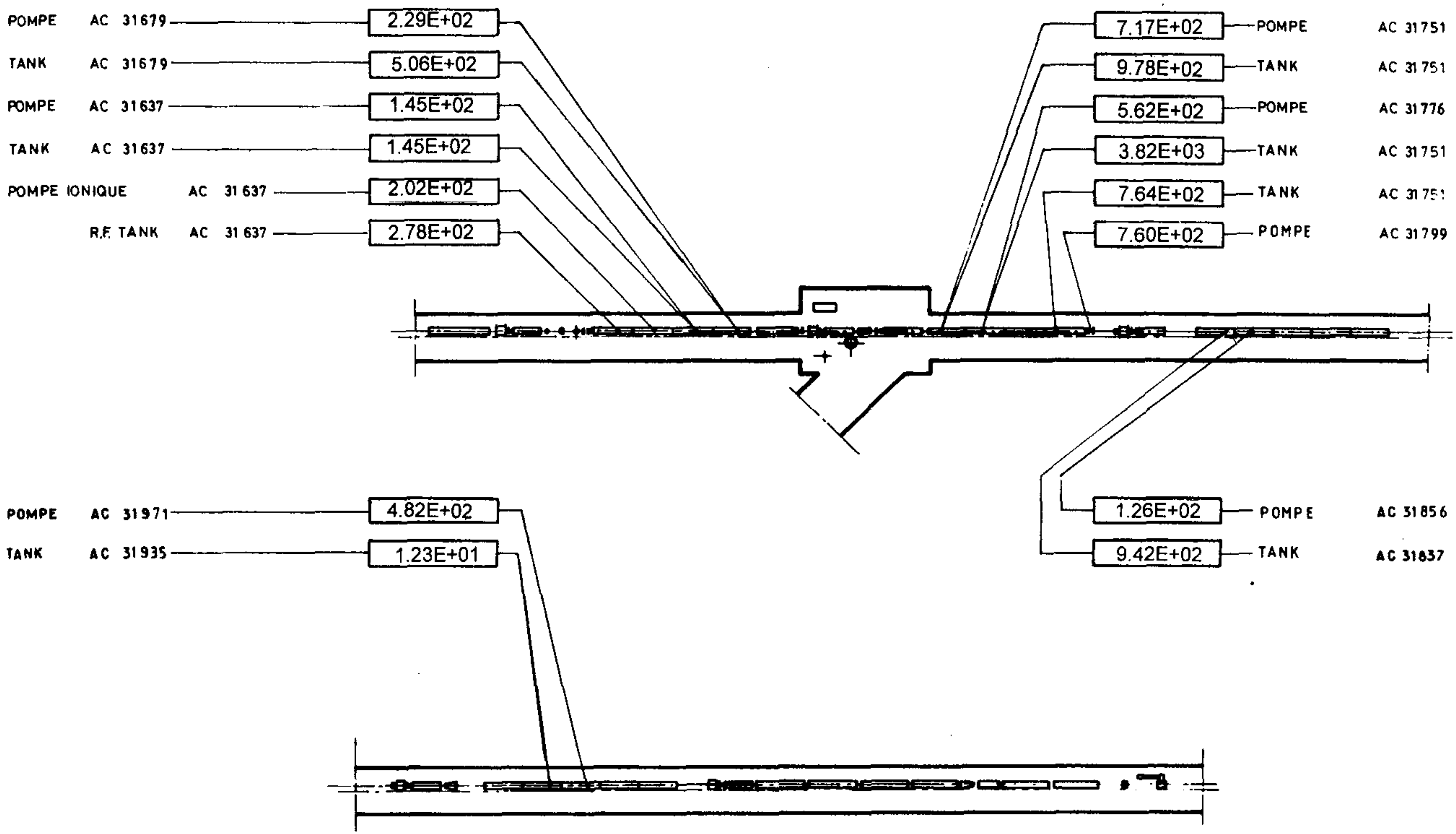



INTEGRATED DOSES IN GRAY

**Fig. 3a**

LSS 3

From February 1991 to December 1998

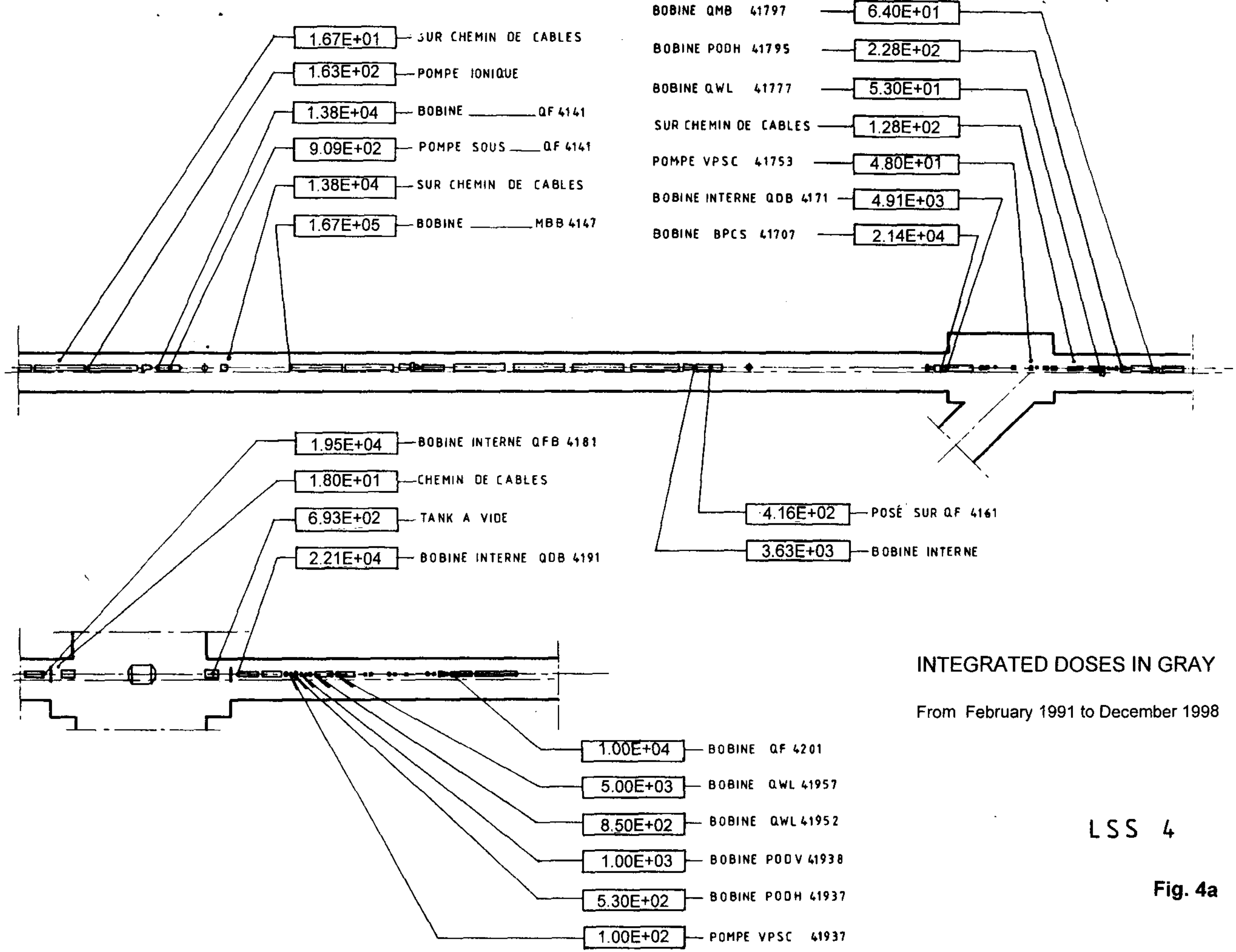



INTEGRATED DOSES IN GRAY

**Fig. 3b**

LSS 3

From 1976 to 1998

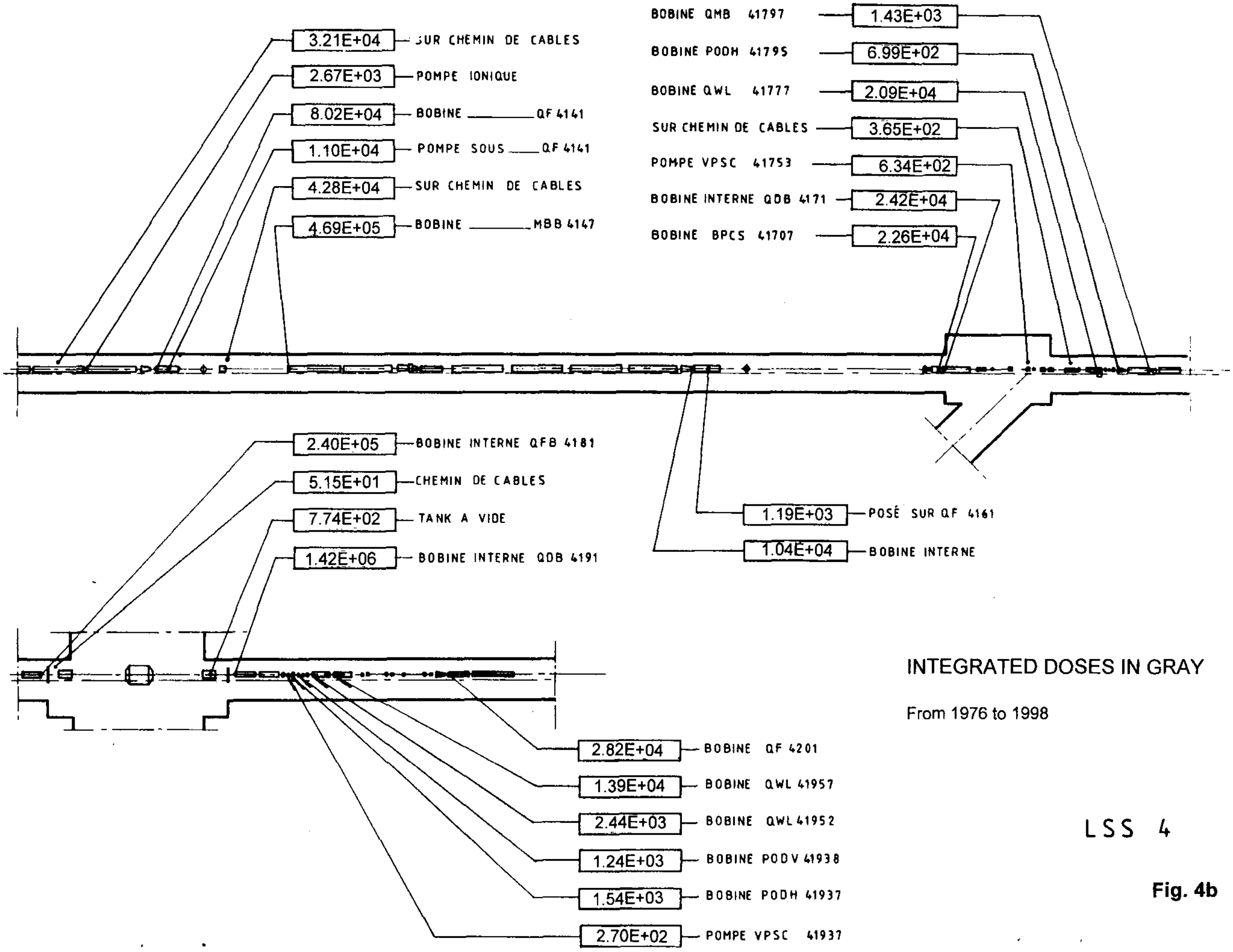



INTEGRATED DOSES IN GRAY

From February 1991 to December 1998

LSS 4

**Fig. 4a**

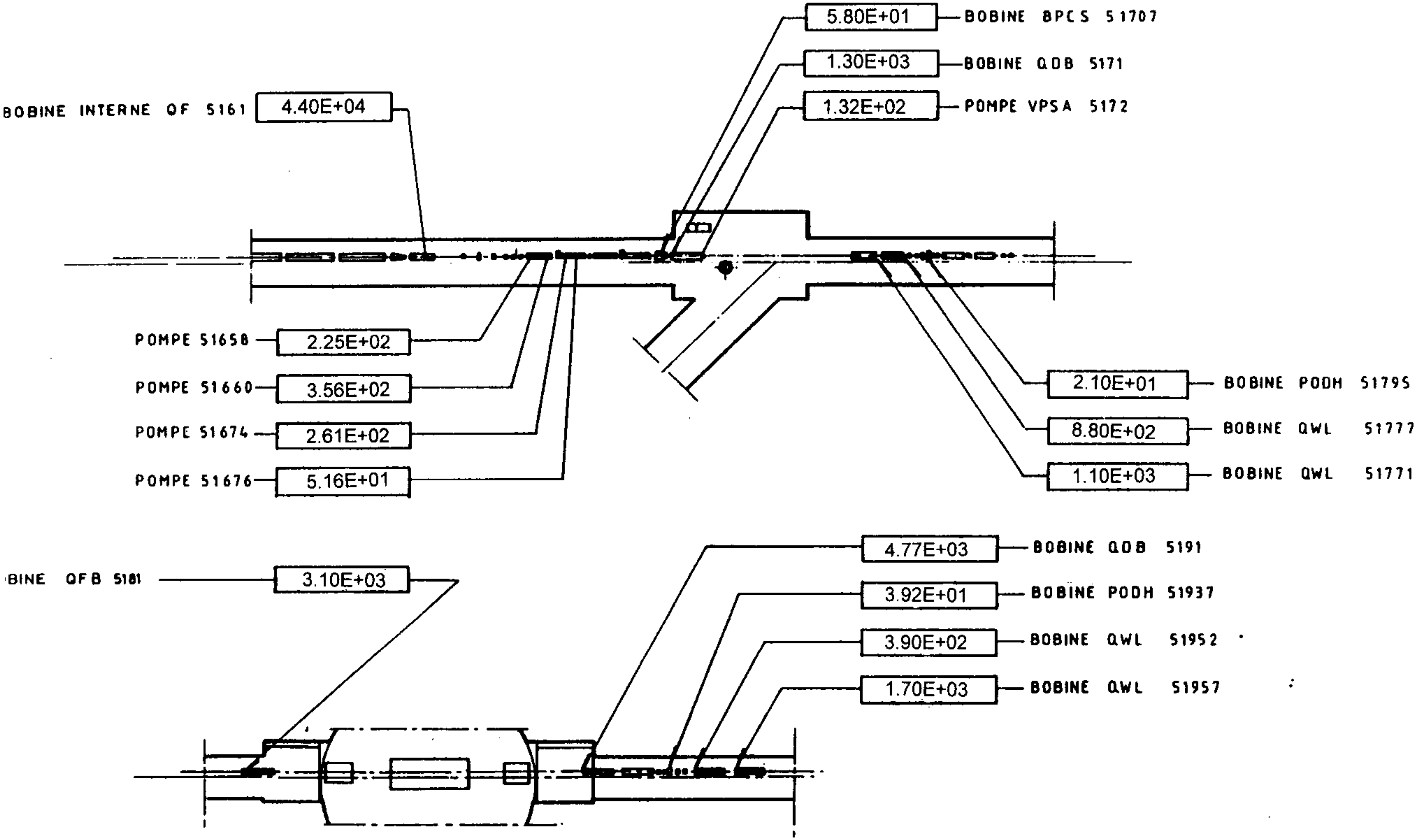



INTEGRATED DOSES IN GRAY

From 1976 to 1998

LSS 4

**Fig. 4b**

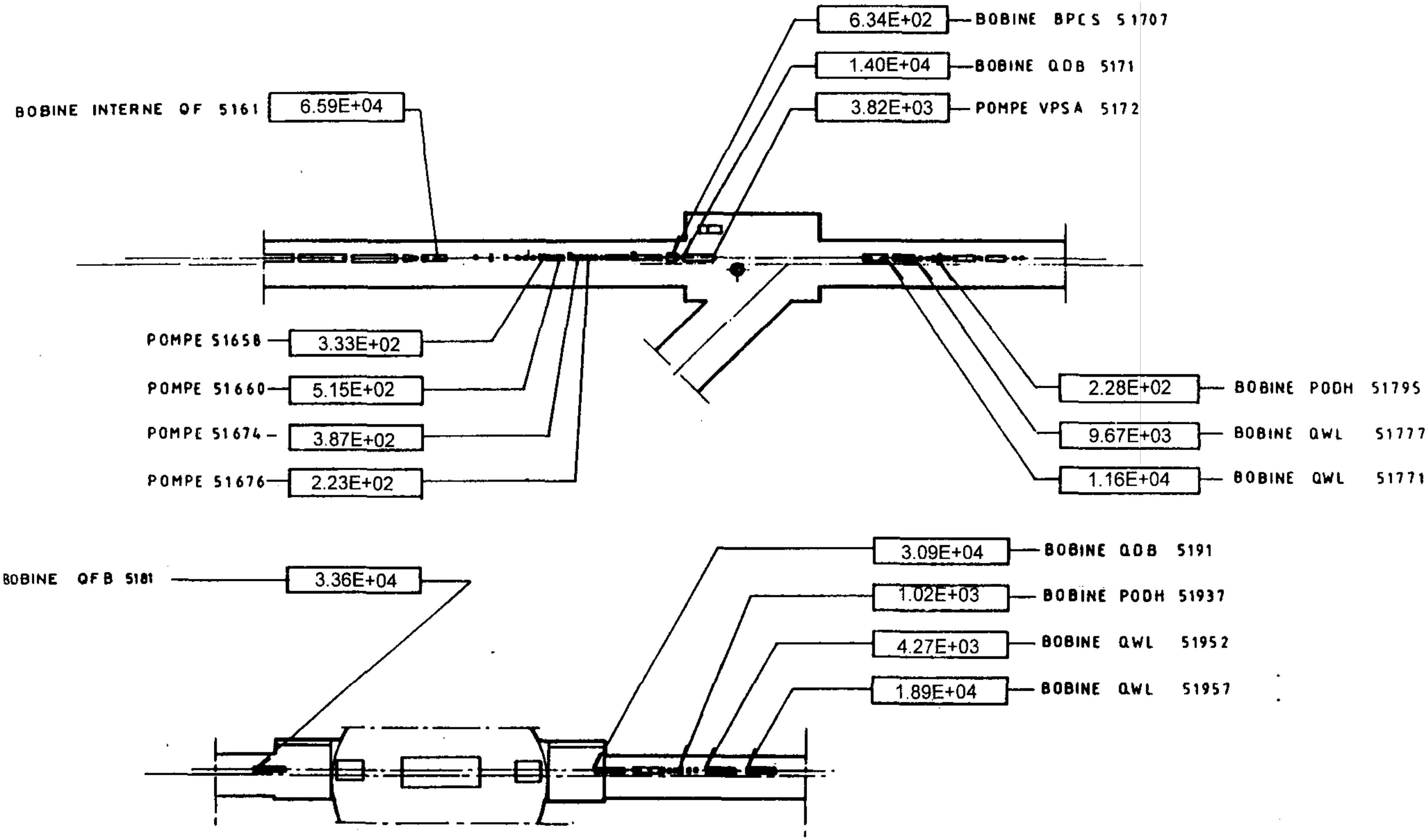



INTEGRATED DOSES IN GRAY

From February 1991 to December 1998

LSS 5

Fig. 5a

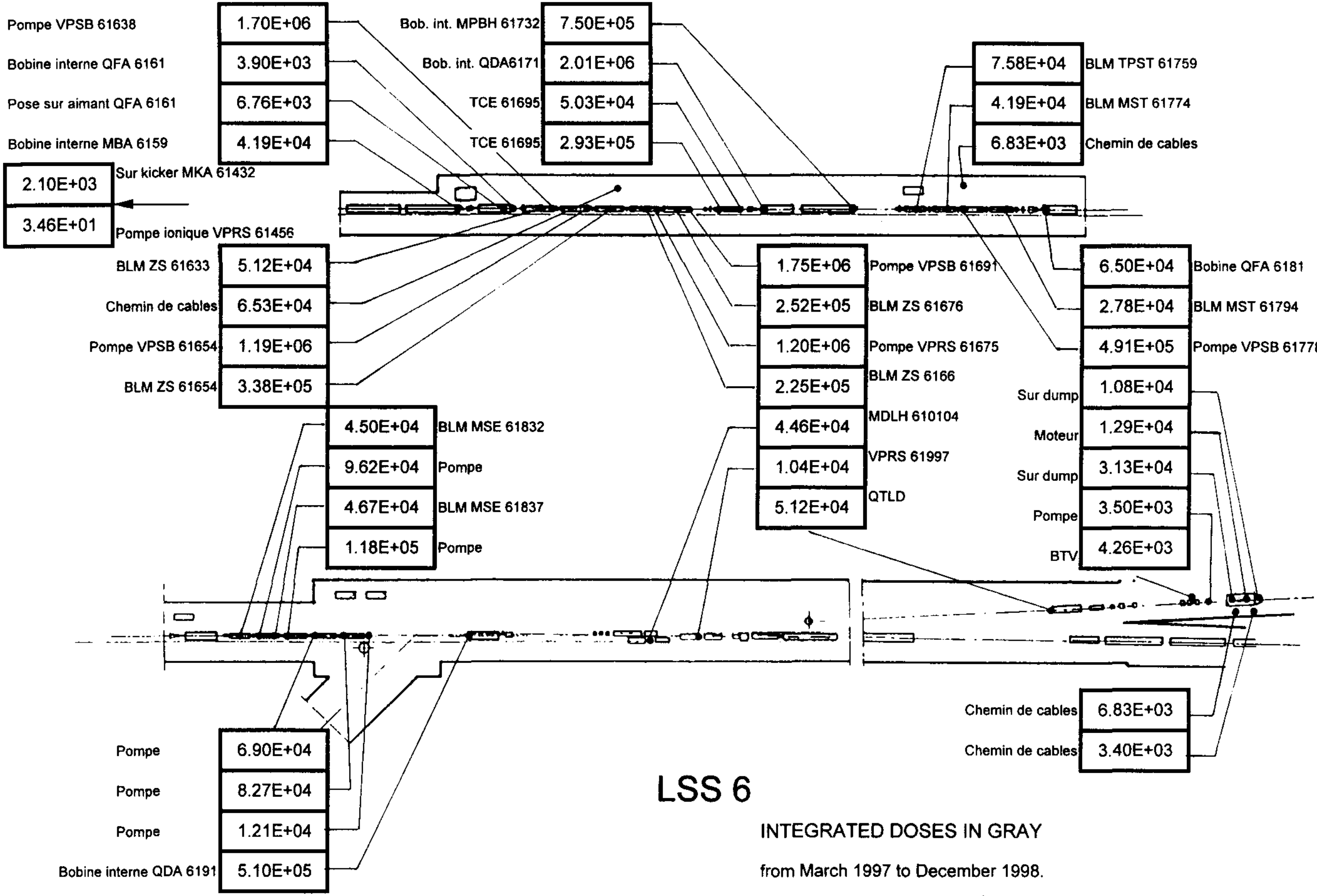



INTEGRATED DOSES IN GRAY

From 1976 to 1998

Fig. 5b

LSS 5

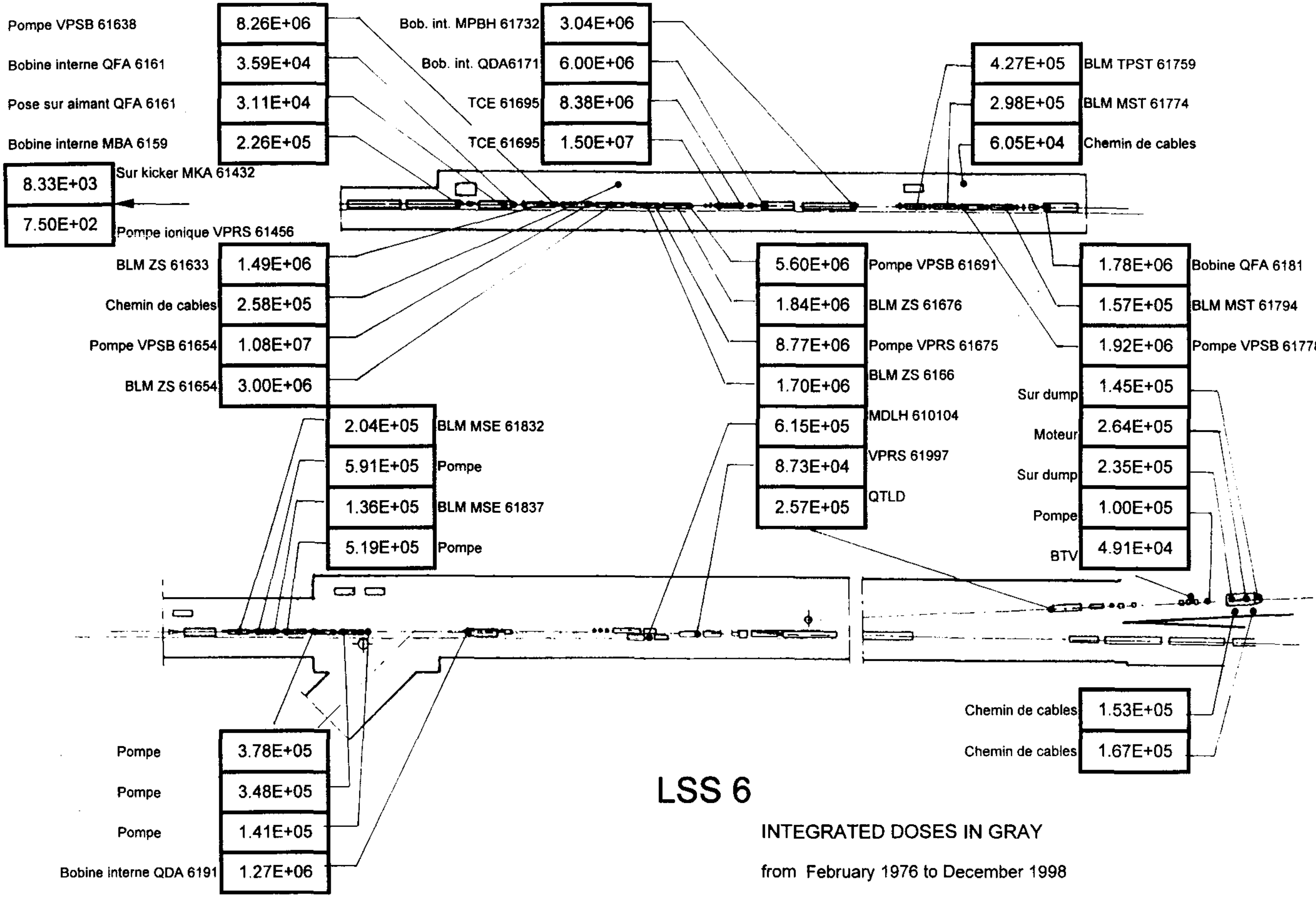



# LSS 6

INTEGRATED DOSES IN GRAY

from March 1997 to December 1998.

**Fig. 6a**




# LSS 6

INTEGRATED DOSES IN GRAY

from February 1976 to December 1998

**Fig. 6b**

# LSS1

INTEGRATED DOSES IN GRAY

from March 1997 to December 1998.

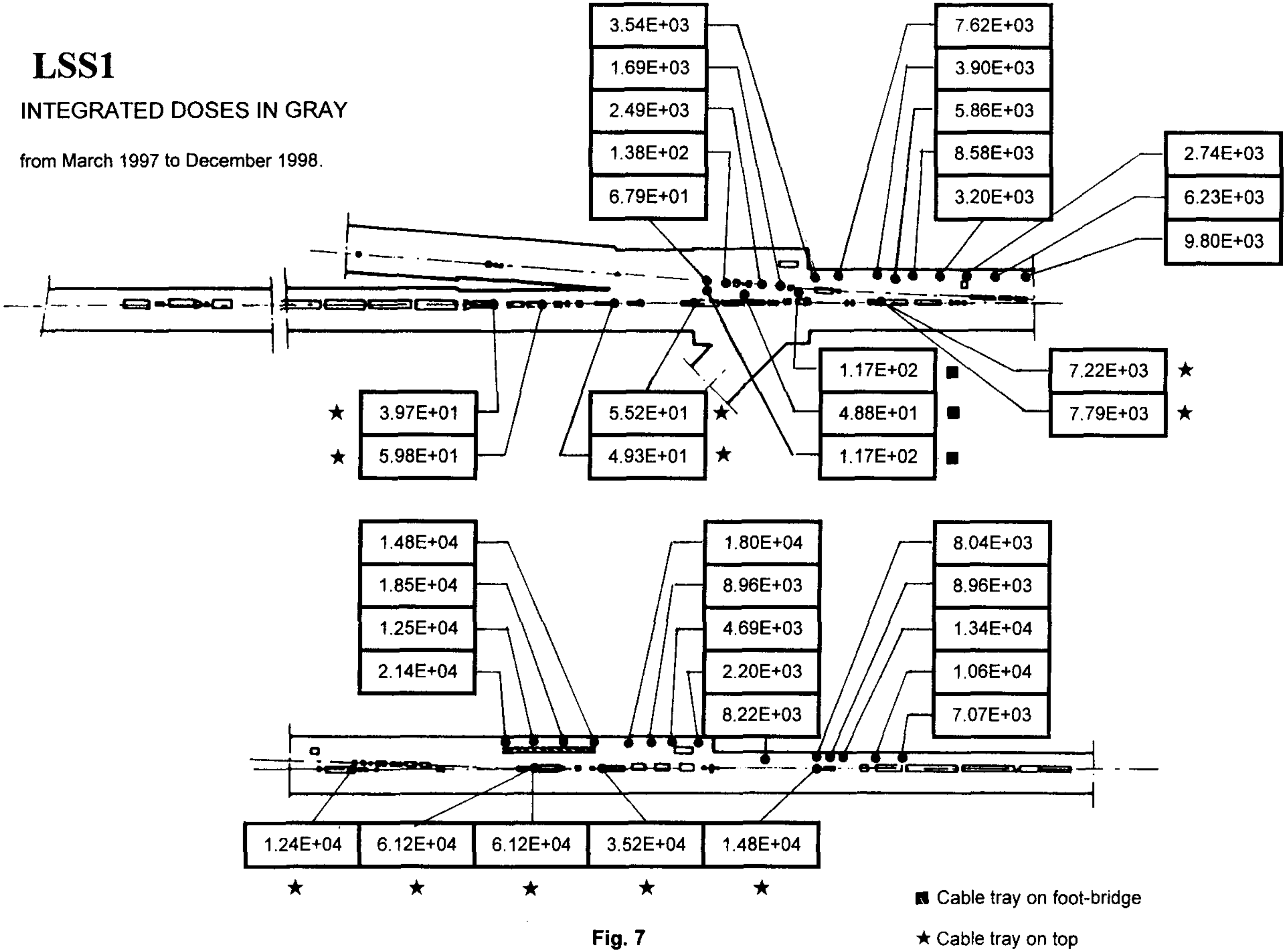
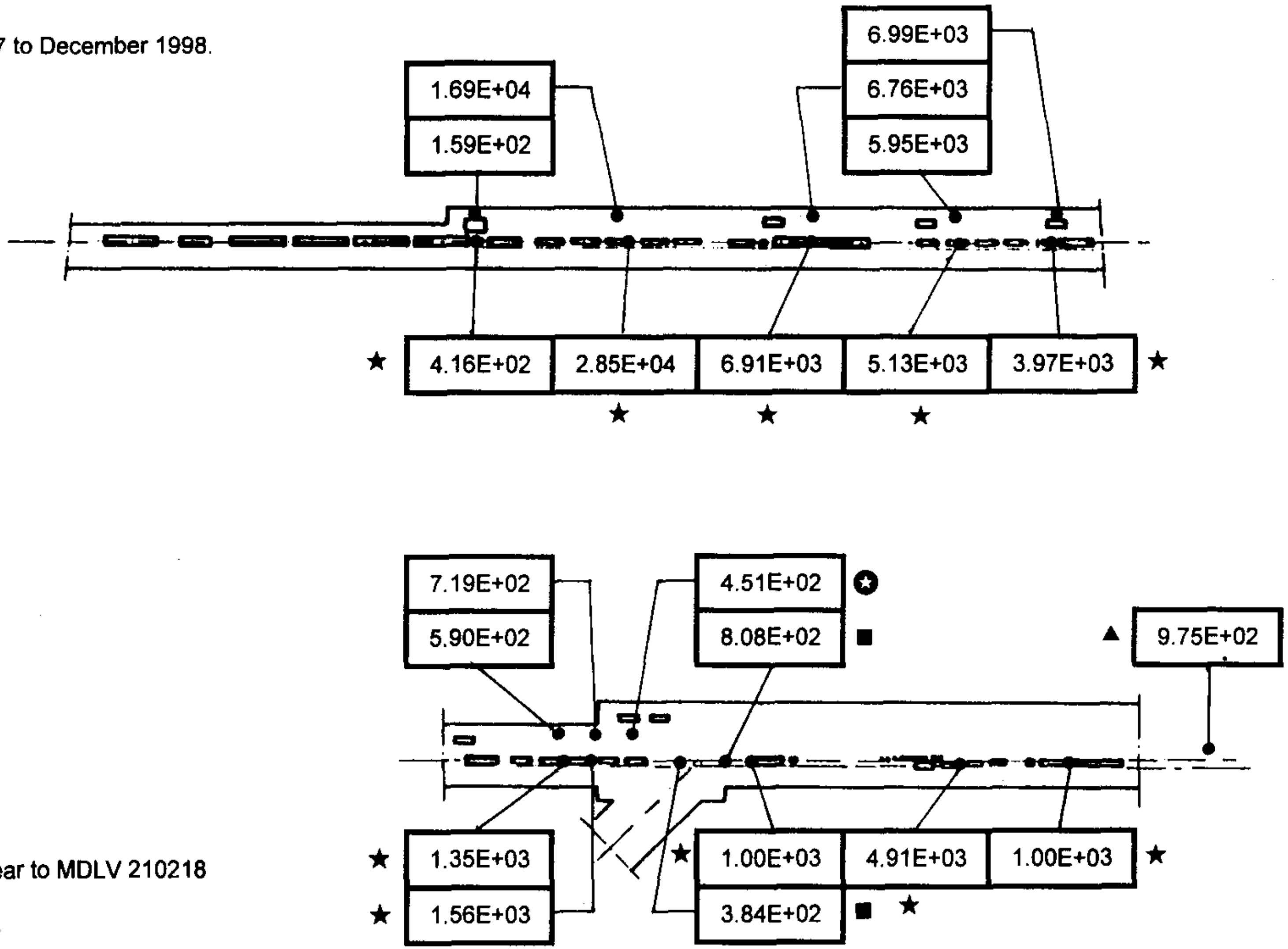



Fig. 7

# LSS2

INTEGRATED DOSES IN GRAY

from March 1997 to December 1998.



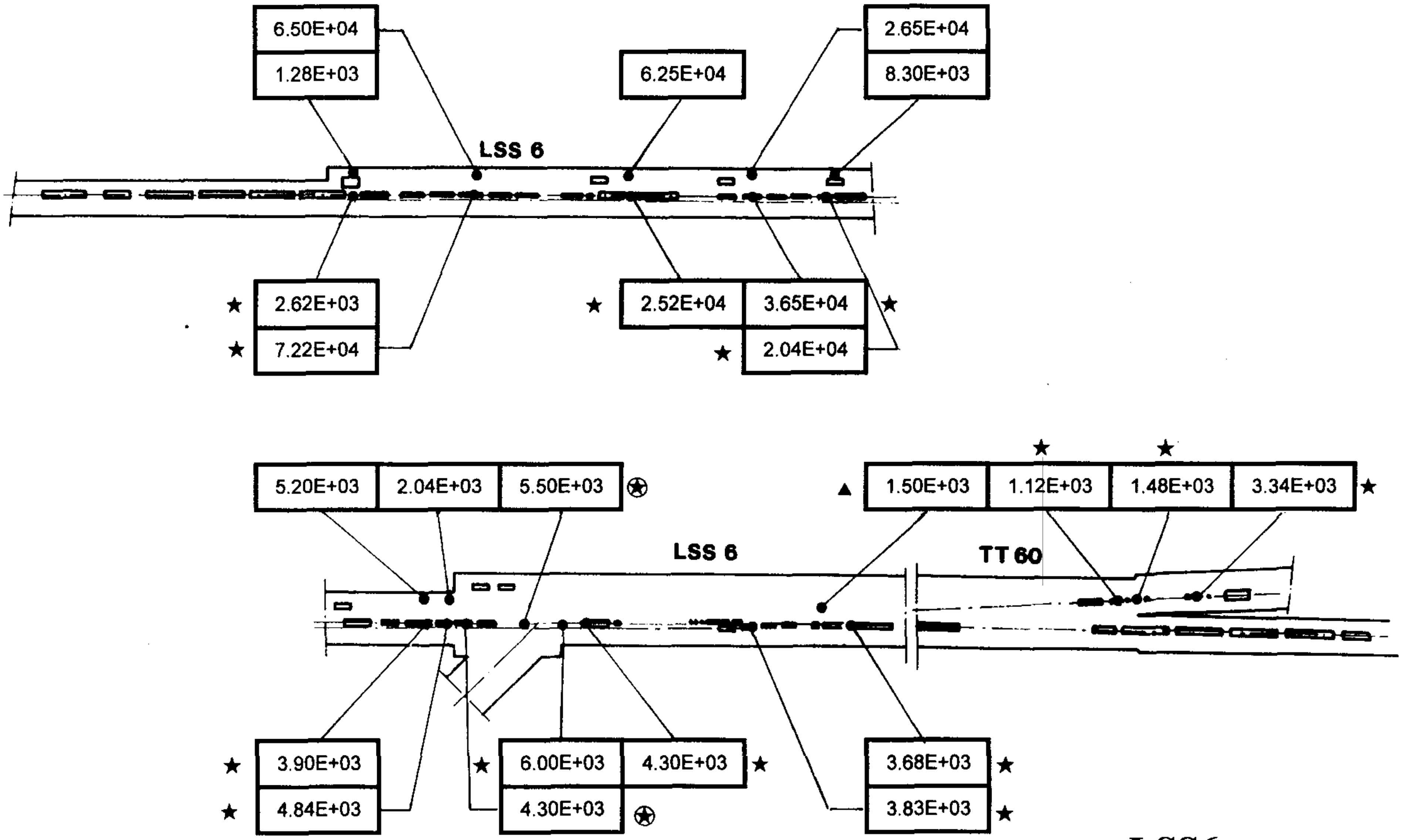

▲ On cable tray near to MDLV 210218

✪ Coloured cables

■ Cable tray on foot-bridge

★ Cable tray on top

Fig. 8




★ Cable tray on top

⊛ Power cables on cable tray

▲ On cable tray near to QP 6211

**LSS6**

INTEGRATED DOSES IN GRAY

from March 1997 to December 1998

**Fig. 9**

# NEUTRINO CAVE

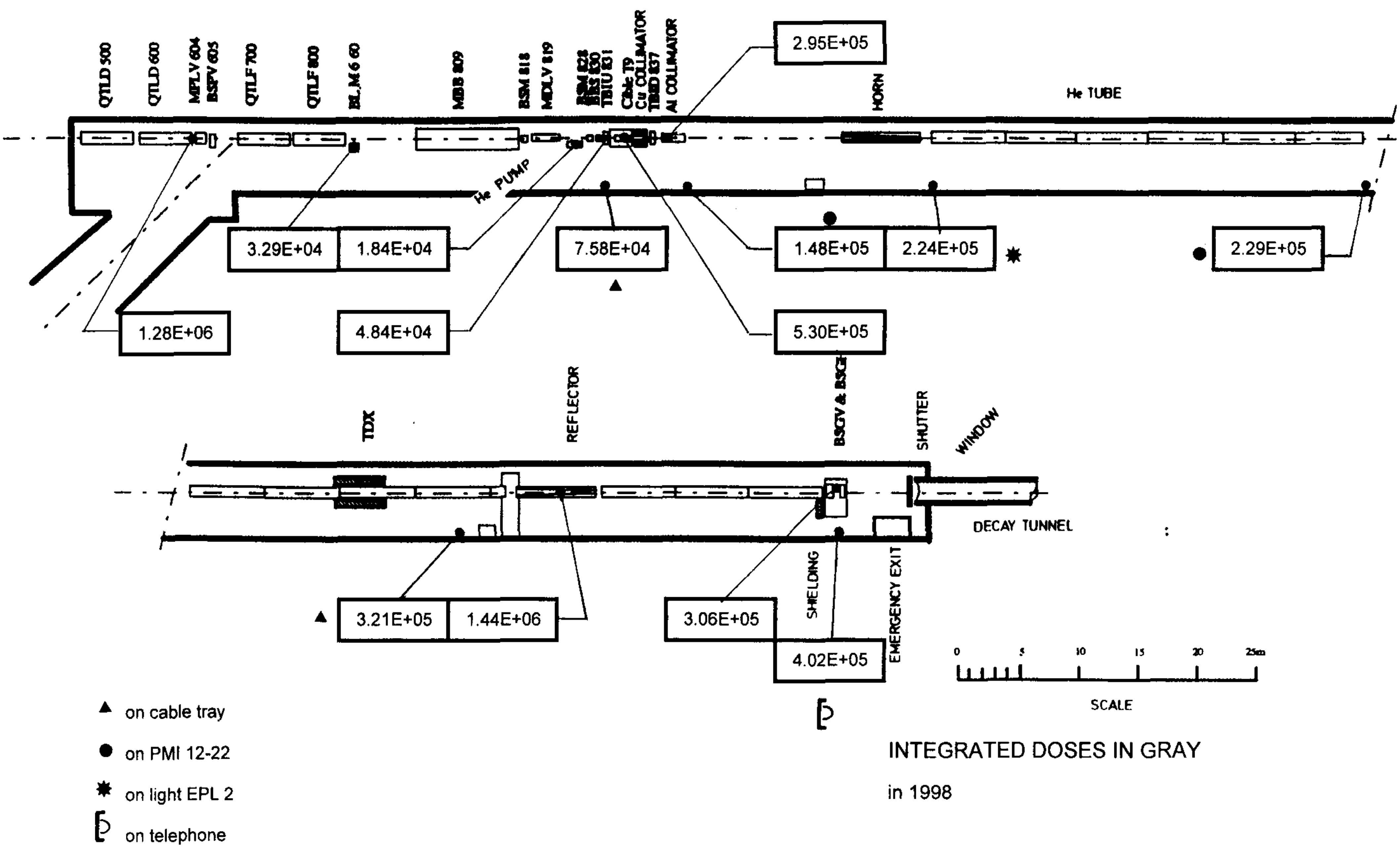



**Fig. 10a**

# NEUTRINO CAVE

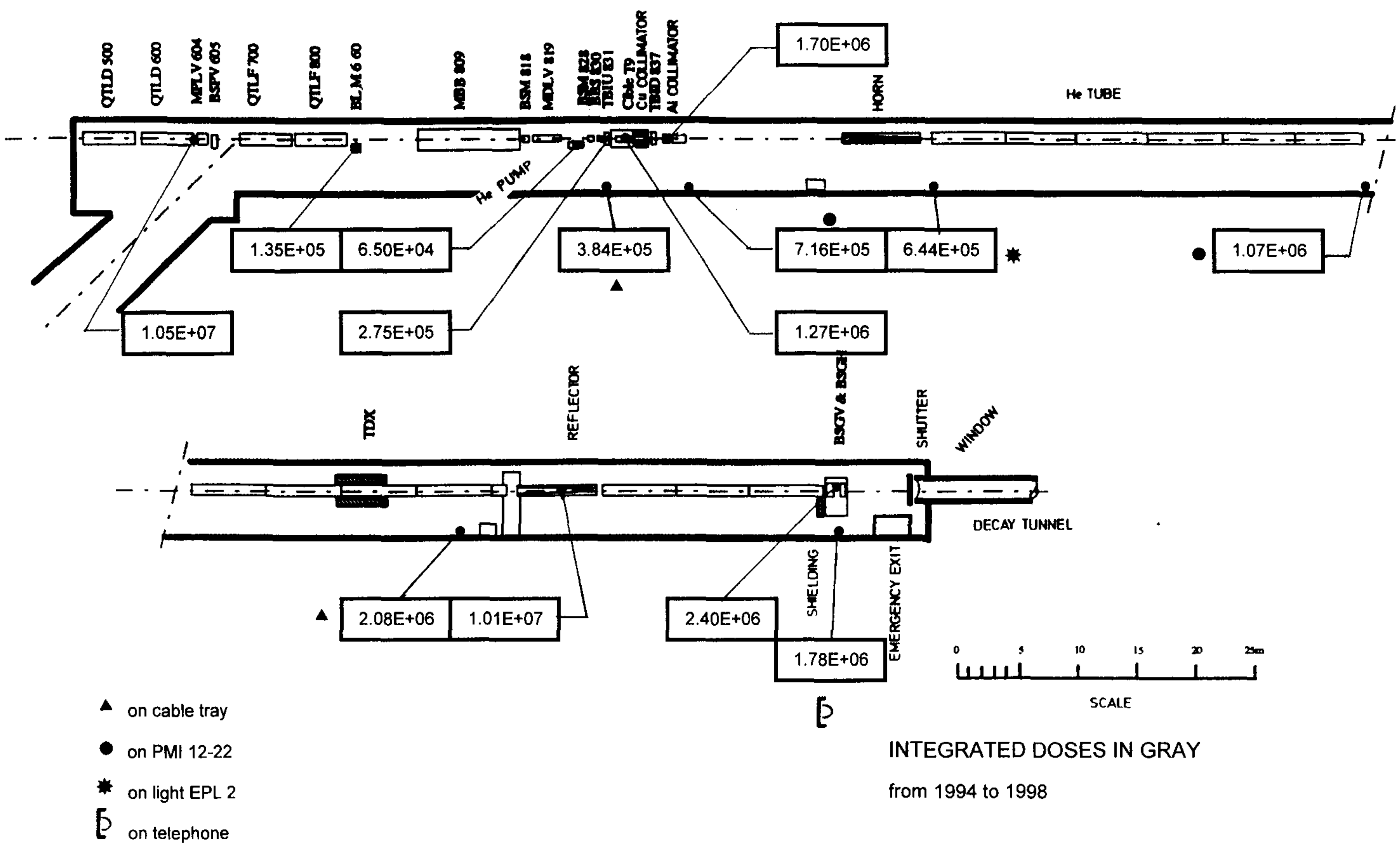
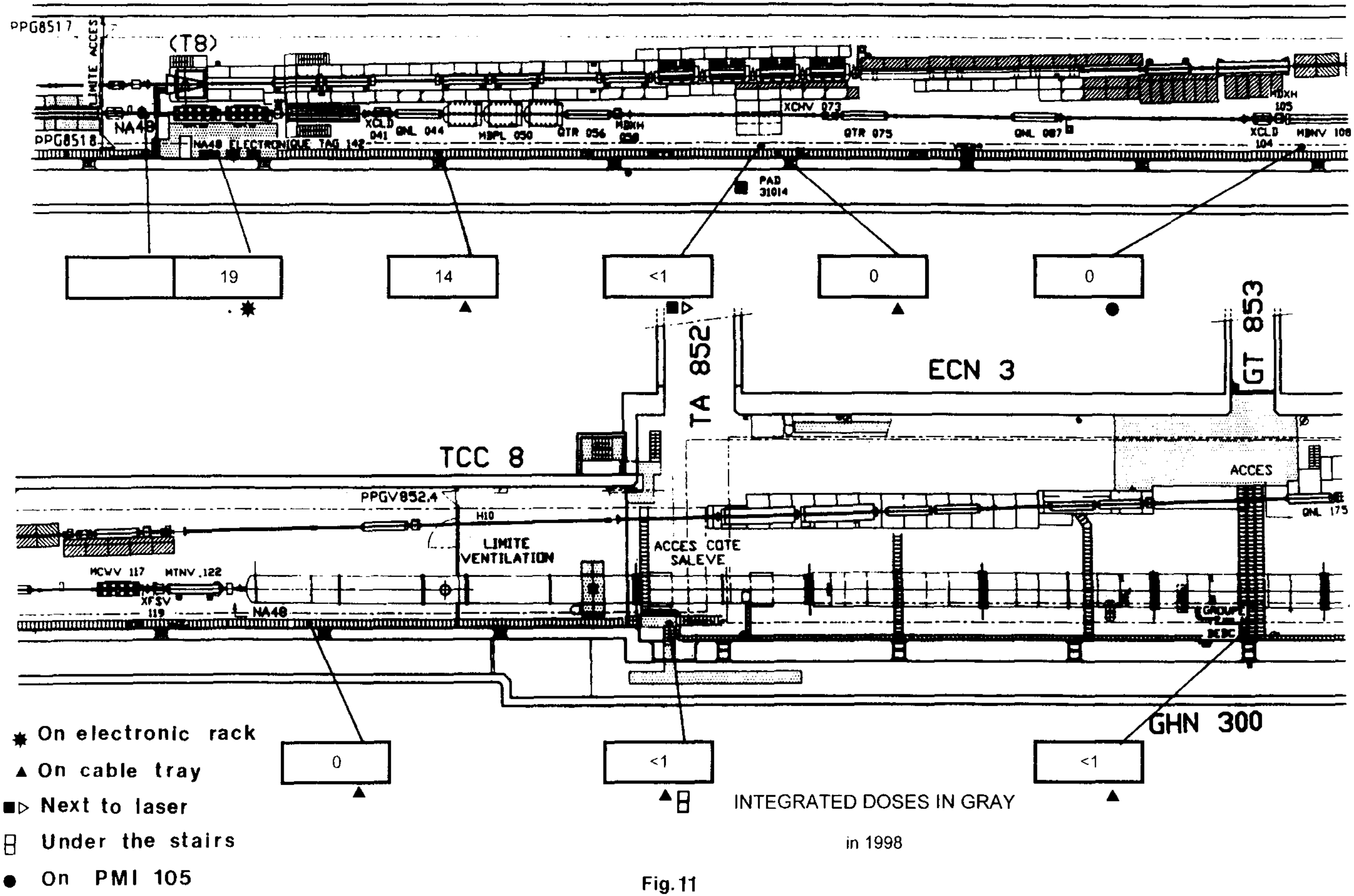



**Fig. 10b**

# TCC8 - Optical fibre




INTEGRATED DOSES IN GRAY

in 1998

Fig.11