TLEP3
How radiation issues could be studied through FLUKA simulations. Possible approaches/mitigation schemes

Alberto Fassò

Compared with present (and future!) times, computing resources for shielding design of LEP 1 and 2 were poor. But radiation studies were successful.

I will show:

- what the most important radiation problems were 30 years ago
- how they were solved
- which issues will become more important at TLEP3
- which of these will need improvements, not always easy to figure out yet

Three main classes of problems:

1. Protection of the machine (including electronics) ← the most critical!
2. Protection of people ← easy, not worse than for any other large accelerator
3. Protection of the environment ← technically not too difficult to calculate with modern tools. Very important politically and in order to avoid too conservative and costly solutions

Mitigation of 1. is problematic.
Mitigation easy for 2., provided deep underground
Mitigation of 3. needs dedicated studies

CERN 84-02
Technical Inspection
and Safety Commission
5 March 1984

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

RADIATION PROBLEMS IN THE DESIGN OF THE LARGE ELECTRON–POSITRON COLLIDER (LEP)

A. Fassò, K. Goebel, M. Höfert, G. Rau, H. Schönbacher,
G.R. Stevenson, A.H. Sullivan, W.P. Swanson and J.W.N. Tuyn

Table 3

Parameters of the LEP system as of 30 June 1983

Phase I (51.5 GeV)		
Circumference	26658.876	m
Average radius	4242.892	m
Minimum diameter	8.405	km
Maximum diameter	8.525	km
Bending radius	3099.2095	m
Number of intersections	4 + 4	
Equipped experimental areas	4 (at P2, P4, P6, P8)	
Number of lattice superperiods	4	
Total number of lattice periods	256	
Period length	79	m
Number of quadrupoles in lattice	504	
Number of quadrupoles in insertions	372	
Number of dipole magnets	3328	
Number of dipole magnets (weak)	64	
Total magnetic length (dipole magnets)	19427	m
Number of sextupole magnets	520	
Maximum luminosity	10^{31}	$cm^{-2} \cdot s$
Energy at maximum luminosity	51.5	GeV
Experimentation possible up to	60	GeV
Number of bunches per beam	4	
Particles per bunch	4.2×10^{11}	
Circulating current per beam (average)	3	mA
Circulating current per beam (max. possible)	6	mA
Revolution time	88.924	μs
Revolution frequency	11245	Hz

Number of straight sections with RF	2 (at P2 and P6)	
Number klystrons and RF modules	2 × 8	
Klystron power output (nominal)	1	MW
RF frequency	352.20914	MHz
Harmonic number	31320	
Installed RF power (P2 and P6)	16	MW
Number of five-cell RF cavities	2 × 64	
Active RF structure length	272.38	m
Synchrotron energy loss	200.5	MeV/turn
Synchrotron power (two beams)	1.2	MW
Required circumferential gradient	341.6	MV
Phase II (86 GeV)		
Energy at maximum luminosity	86	GeV
Circulating current per beam (average)	3.3	mA
Circulating current per beam (max. possible)	10.0	mA
Phase III (100 GeV)		
Energy at maximum luminosity	100	GeV
Circulating current per beam (average)	–	mA
Circulating current per beam (max. possible)	5.5	mA

Table 4

Assumptions made concerning beam currents and losses
in the LEP accelerator chain (86 GeV operation)

Location	Average current e^+	e^+	Loss[a)] (%)	Average energy (MeV)	Average power (W)[b)] e^+	e^-
Output gun	–	5.5 μA	55	5	–	15
Output buncher	–	5.2 μA	10	100	–	25
Output lst linac	–	2.2 μA	100	200	–	440
Output 2nd linac	18 nA	18 nA				
			40	300	2.2	2.2
Output (resolved)	11 nA	11 nA				
			81	600	5.4	5.4
Output EPA	2.1 nA	2.1 nA				
			20	600	0.26	0.26
Trapped by PS	1.7 nA	1.7 nA				
			20	3500	1.2	1.2
Trapped by SPS	1.4 nA	1.4 nA				
			10	20000	5.6	5.6
Output transfer	1.2 nA	1.2 nA				
			70	20000	17	17
Trapped by LEP	0.37 nA	0.37 nA				
Colliding in LEP	3.3 mA[c)]	3.3 mA[c)]	100	86000	42 kJ	42 kJ[b)]

a) Except for the first three lines, data in :he last four columns describe losses estimated to occur *between* locations listed at left.
b) Power is averaged over 20 min intervals, except for last line, where the total energy of circulating beams is given.
c) Current "colliding in LEP" is the total charge multiplied by 11245 orbits per second.

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

HS-RP/071

HS DIVISIONAL REPORT
17 December 1981

and LEP Note 348

DOSE ESTIMATIONS FOR THE LEP MAIN RING

K. Burn, A. Fasso, K. Goebel, M. Hoefert,
J. Jansen, H. Schoenbacher and Ye Sizong

Synchrotron Radiation

Critical energy:

Half power below it, half above

Proportional to E^3 / ρ
(E=electron energy, ρ = bending radius)

SR power: proportional to E^4 / ρ

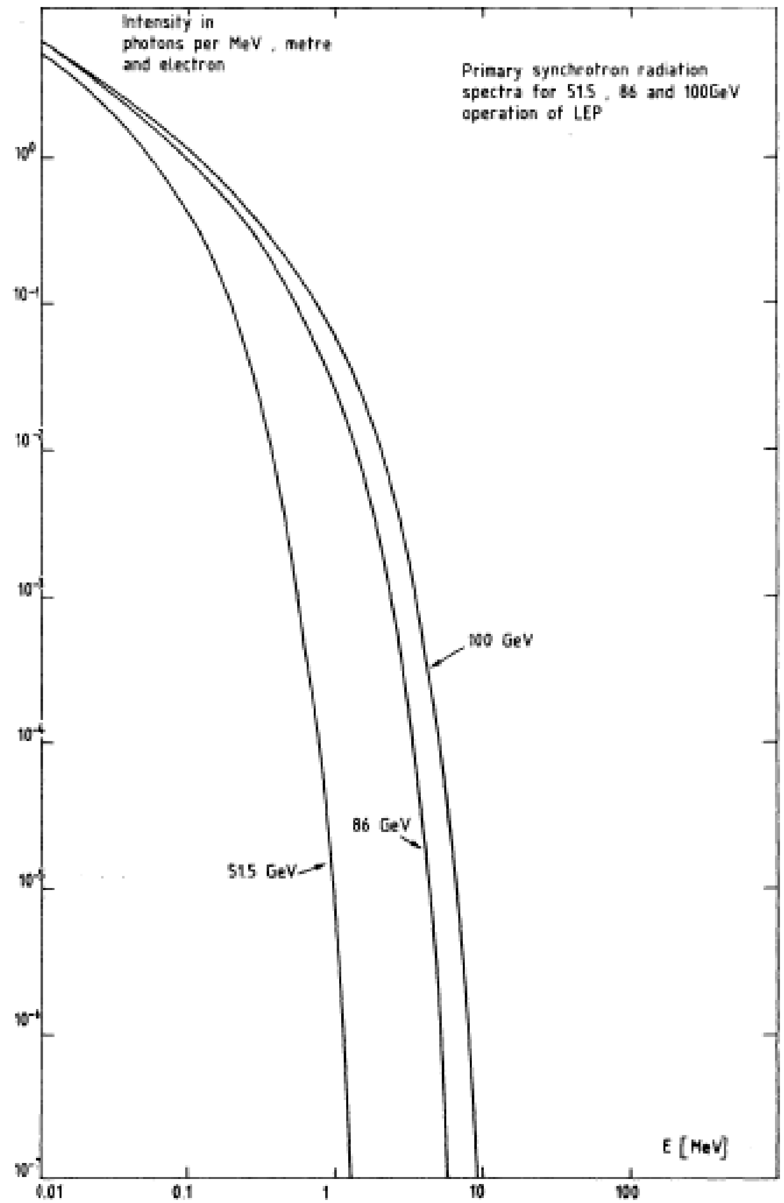
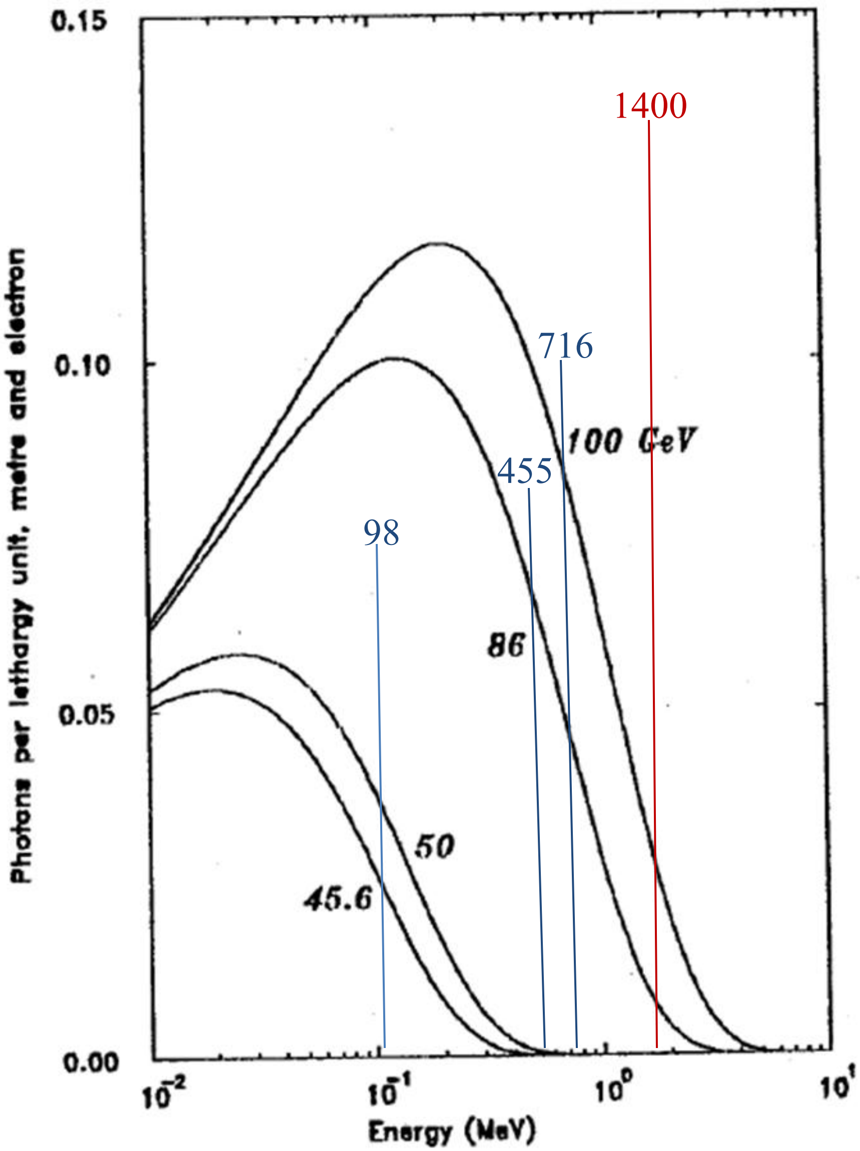


Fig. 17 Primary synchrotron radiation spectra at three LEP energies, in units of photons per MeV and metre.



The same SR spectra in lethargy units

Critical energy:

51.5 GeV: 97.8 keV
86 GeV: 455.2 keV
100 GeV: 715.7 keV

120 GeV: 1400. keV

Calculations for LEP 1 and 2

1. SR doses to coils, cables in ring →damage
2. SR doses to electronics in alcoves →damage

   (would we now need also hadron fluence for SEU?)
3. SR streaming through ducts and mazes → dose to people
4. O_3, NO_x production → damage, impact on environment
5. Dose rate effects (transients) on pick-ups, sparking in high-tension cables (10^8 Gy/s!) → damage

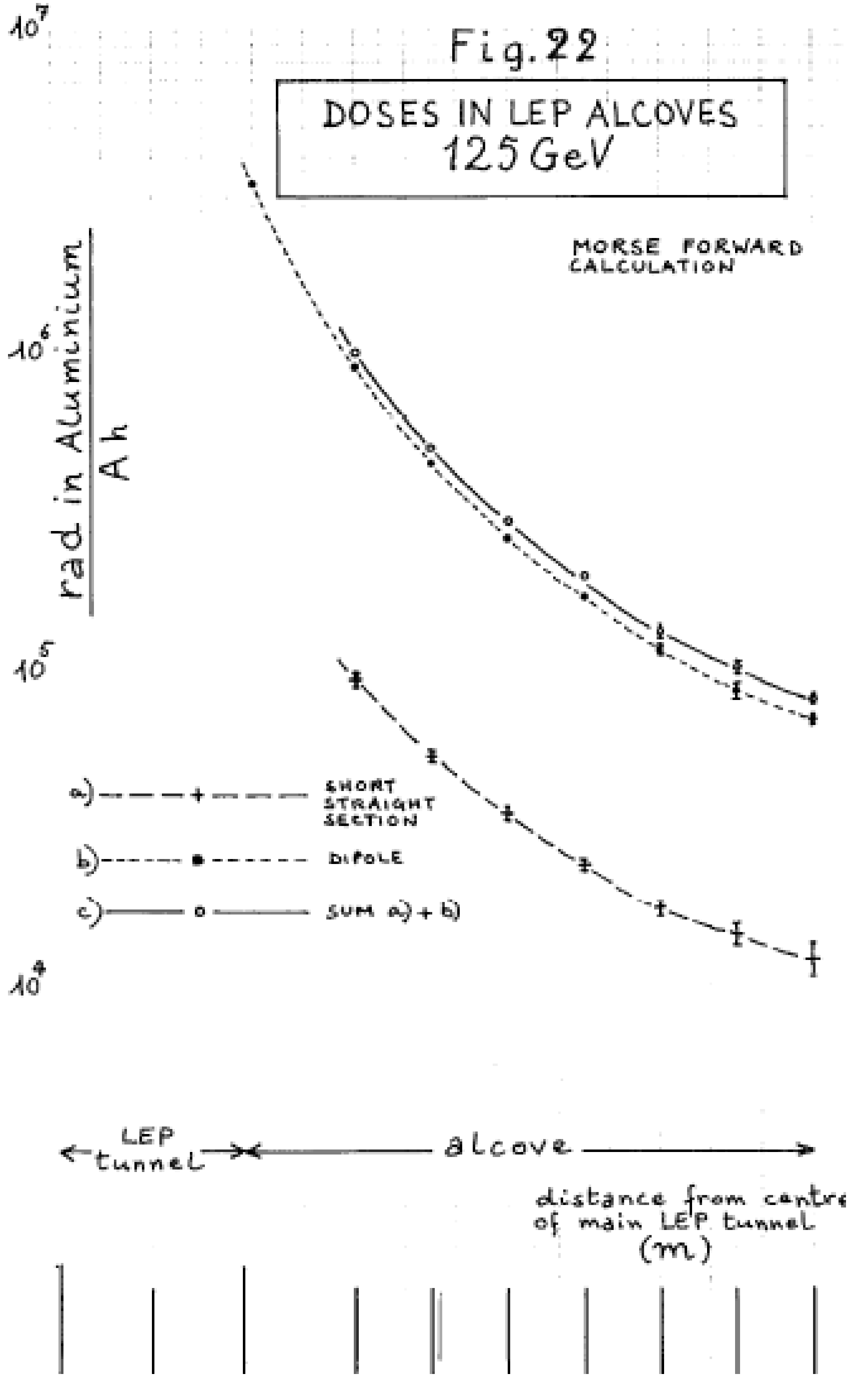
Calculations 2., 3. and 4. were made with MORSE
Calculations 1. and 5. with MORSE and EGS3

All could be done now with FLUKA, with much better accuracy

Photon streaming

- SR streaming in waveguide ducts, in long straight sections to the klystron galleries (ducts: 8m long, 80 cm diameter)
- Superconducting cavity radiation streaming in waveguide ducts (high-energy photons)

These calculations were made with MORSE.
FLUKA of course can do it much better



Example of SR streaming calculated with MORSE

An educational report explaining the ozone impact on environment, used in the discussions with local populations

LEP NOTE 379
27 mai 1982

FORMATION D'OZONE DANS L'ANNEAU PRINCIPAL DU LEP
ET SA DISPERSION DANS L'ATMOSPHERE PAR LE SYSTEME DE VENTILATION

A. Fassò, K. Goebel, M. Höfert, C. Nuttall et A. Perrot

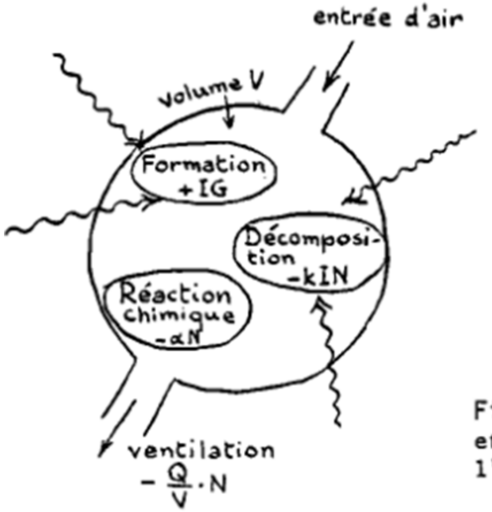


Fig. 2.2 Illustration de la formation et de la dissociation de l'ozone sous l'action d'un rayonnement ionisant

Production scaling with total escaping power

Ozone in the environment: calculated values much much smaller than measured background, but fierce opposition by some local communes

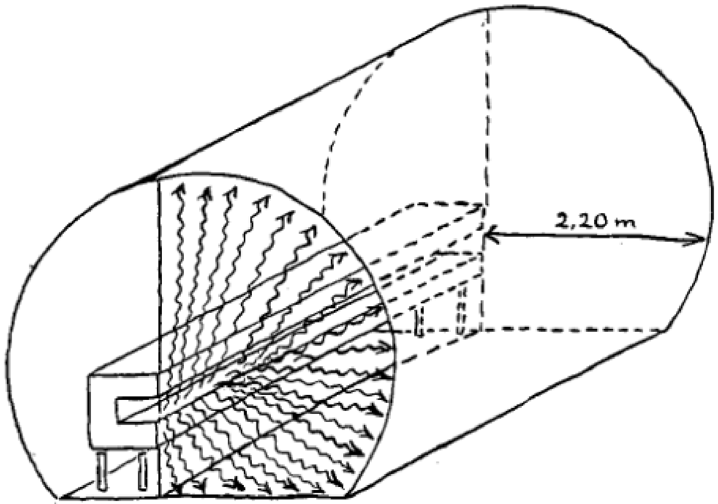


Fig. 2.8 Plage la plus irradiée du tunnel

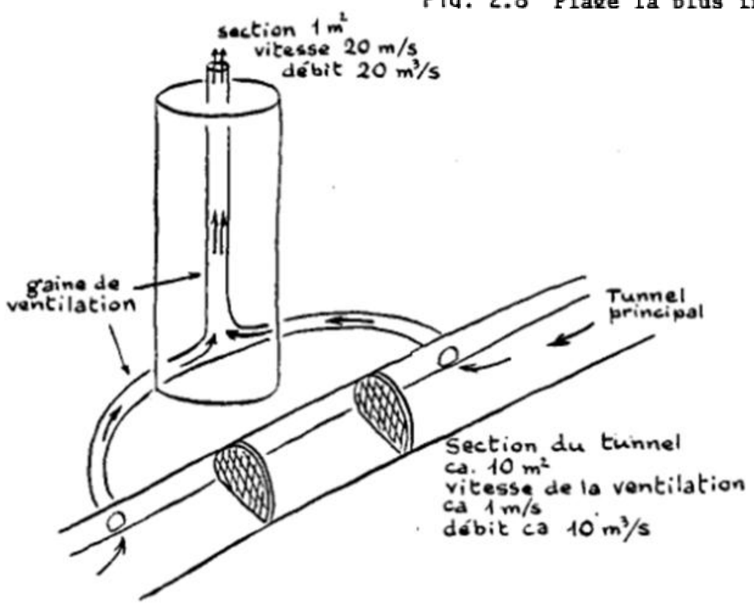


Fig. 2.9 Schéma d'un point de rejet

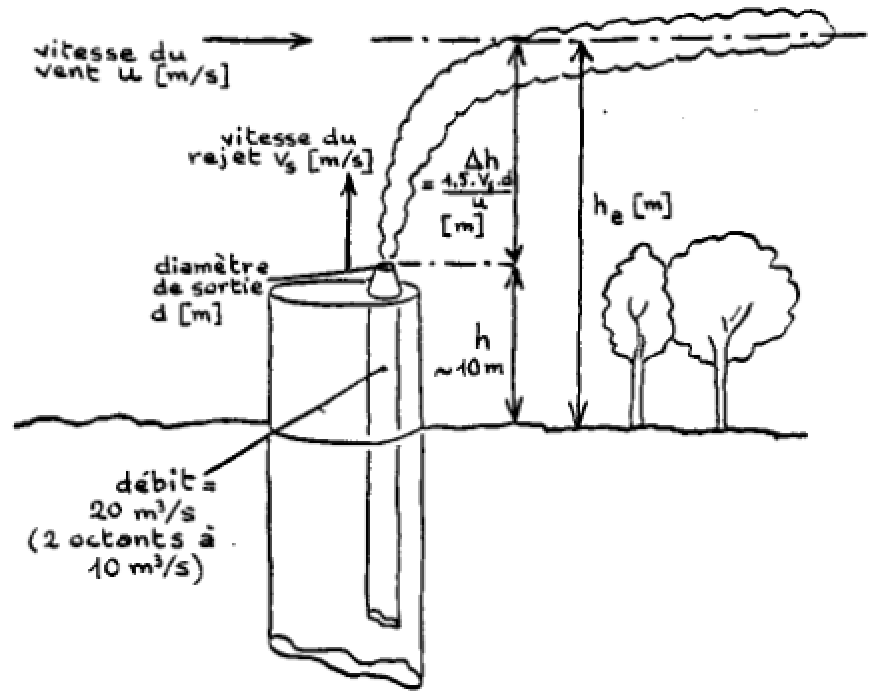
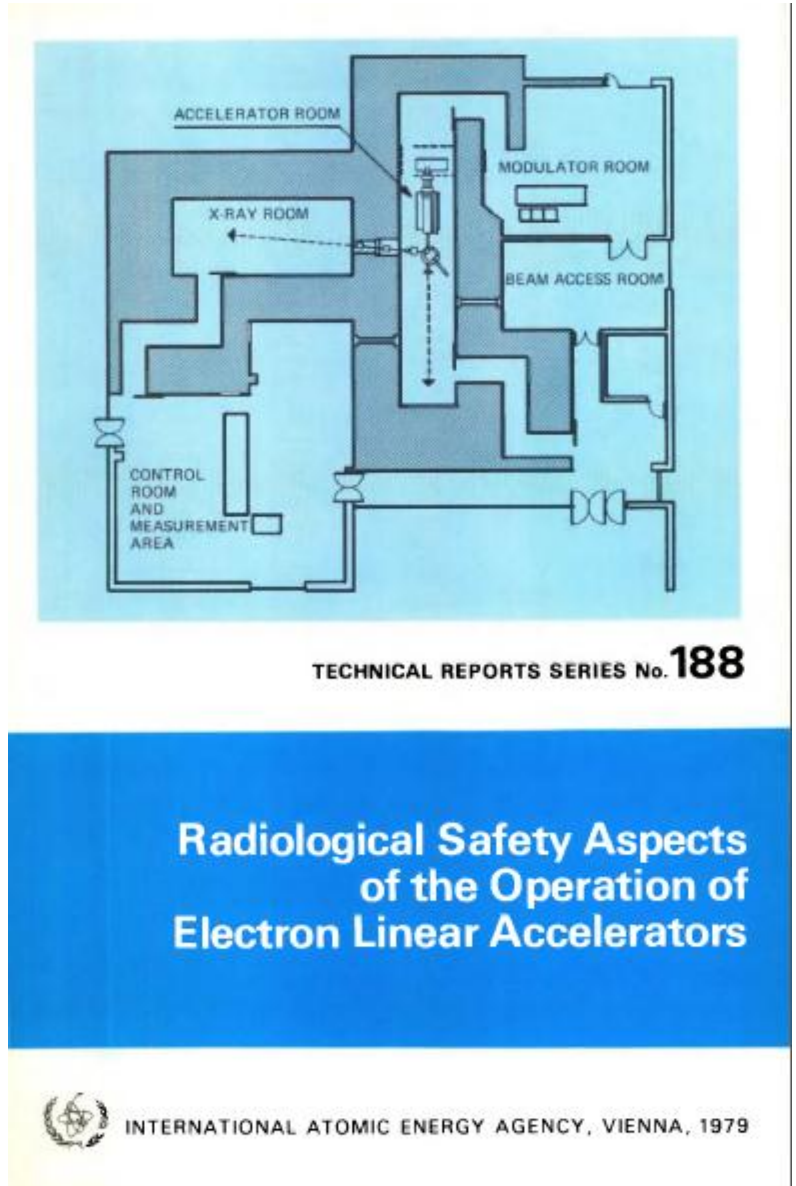


Fig. 3.1 Concept de hauteur effective

Beam losses at LEP 1 and 2

- Injection losses: assumed 1.55×10^{10} e±/s
  → 720 μSv/h at 4 m (can be much higher in top-off mode)
- Stored beam losses: assumed 1.1×10^{13} e±/s (2×10 mA) lost locally
  → 99 μSv integrated dose
  → in experiments, 1.20 m concrete equivalent (280 g/cm^2) required in all directions from loss point
- Experiments: assumed to be self-shielded (needs active collaboration between RP and experiment designers)
- Shielding high energy losses was calculated using Swanson's book (now everything could be done with FLUKA)

SWANSON’s BOOK



Calculations for LEP 1 and 2

6. Neutron production from SR and beam losses (from SR minimal at LEP, will increase with higher critical energies) ← dose to people near ducts and mazes
7. Neutron shielding in experimental areas (due to beam losses) ← dose to people
8. Muons in experimental areas (due to beam losses) ← dose to people

These calculations were done analytically by hand, using very crude assumptions. For calculation 8., a muon transport code TOMCAT was also used.

All could be done now with FLUKA, with much better accuracy

MORSE as used for LEP SR:

Multigroup photon transport: 21 γ-ray energy groups (max. energy 14 MeV)

P3 Legendre angular expansion → only 2 scattering angles at each collision)

No electron transport (pair production accounted for as scattering to 511 keV group!)

Special scoring and biasing prepared at CERN (later brought to FLUKA…)

FLUKA as can be used for LEP3 SR and beam losses:

Continuous transport of γ and electrons up to PeV energies.

Explicit effects: photoelectric, Compton, pair prod., e^{+} annihilation

Photon polarization (important for SR!)

Photonuclear reactions at all photon energies.

Photomuon production.

Induced activity

Low at LEP 1 and 2 (although important on dumps), but required a big effort at decommissioning time:

M. Silari and L. Ulrici,
Investigation of induced radioactivity in the CERN Large Electron Positron collider for its decommissioning
NIM A 526, 510-536 (2004)

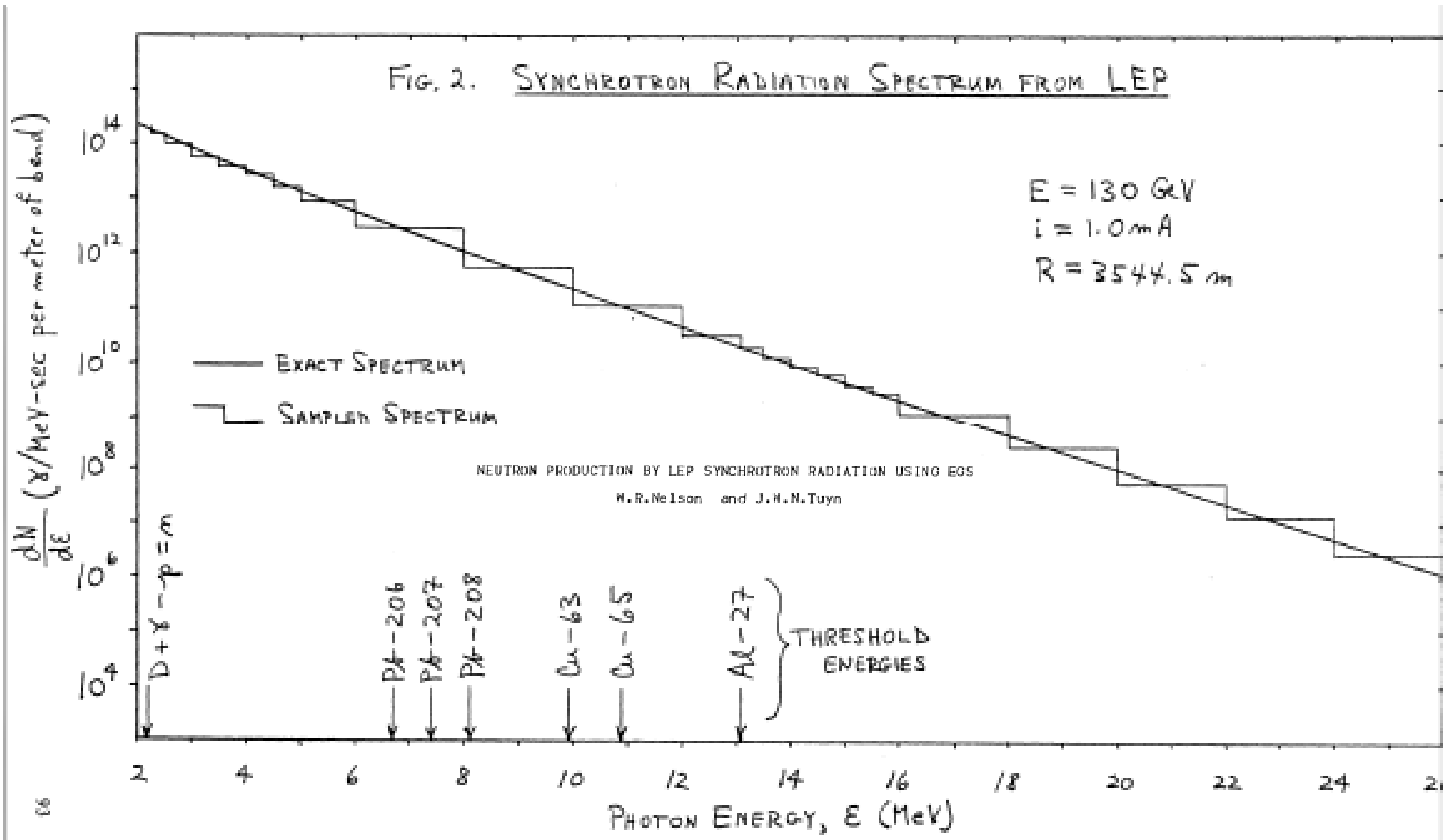
From beam losses, calculated first using Swanson's book, with FLUKA later.

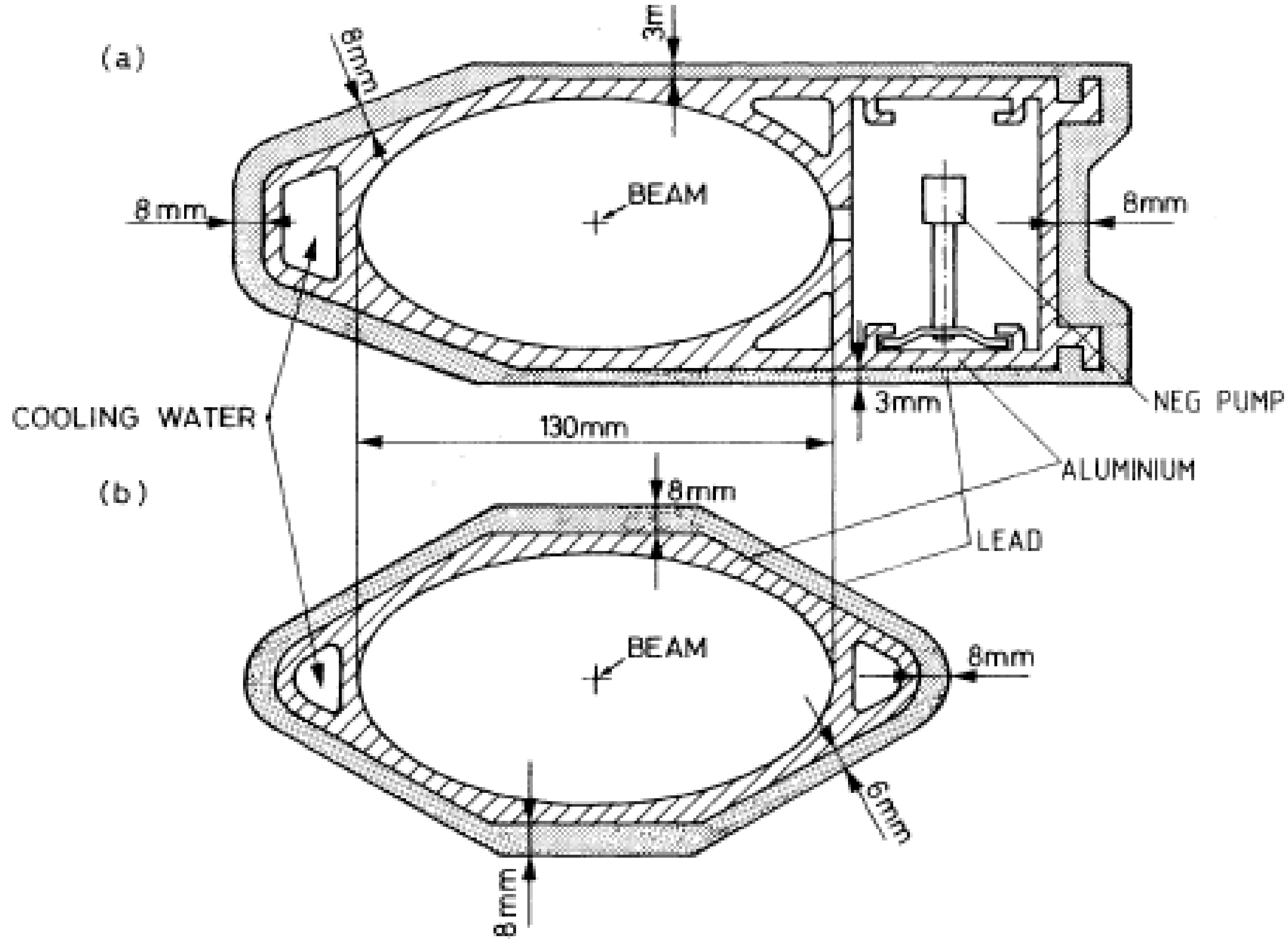
From SR, negligible at LEP 1 and 2, will not be so at LEP3. Photonuclear reactions in FLUKA are OK, but cross-sections near threshold will be critical, and are not all well known yet. Photofission possible in Pb.

NEUTRON PRODUCTION BY LEP SYNCHROTRON RADIATION USING EGS

W.R.Nelson and J.W.N.Tuyn

Also induced activity



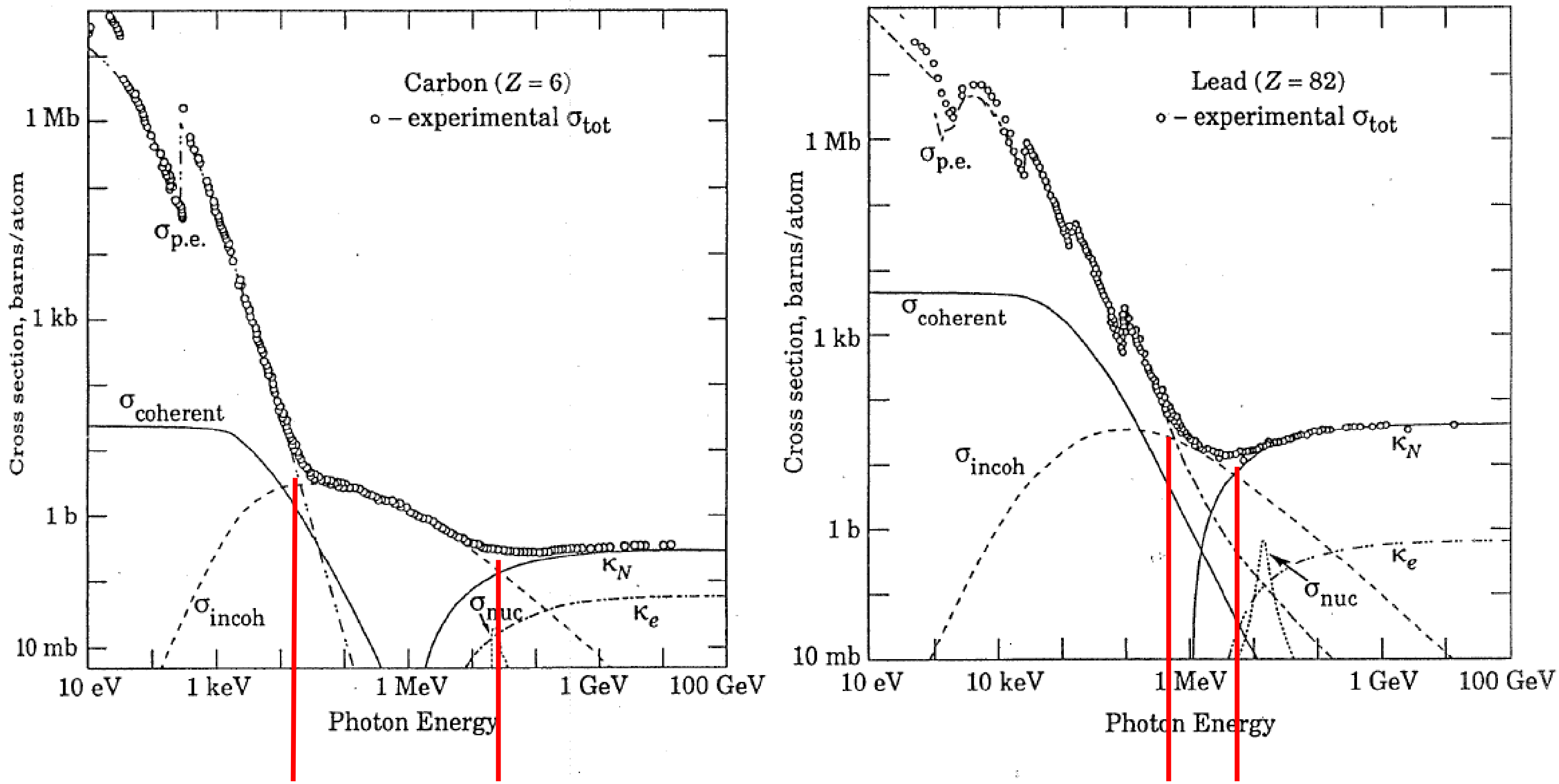


Pb thickness 3 or 8 mm, attenuates power by 98 to 99%

Would be very ineffective at higher SR energies!!!

How to mitigate? Don't know: needs new ideas

Photon cross sections



Photoelectric dominated | Compton dominated | Pair dominated

Photoelectric dominated | Compton dominated | Pair dominated

$\sigma_{p.e.}$=photoelectric cross section; σ_{incoh}=Compton cross section;
$\sigma_{coherent}$=Rayleigh cross section; σ_{nuc}=photonuclear cross section;
κ_N=pair production cross section, nuclear field;
κ_e=pair production cross section, electron field

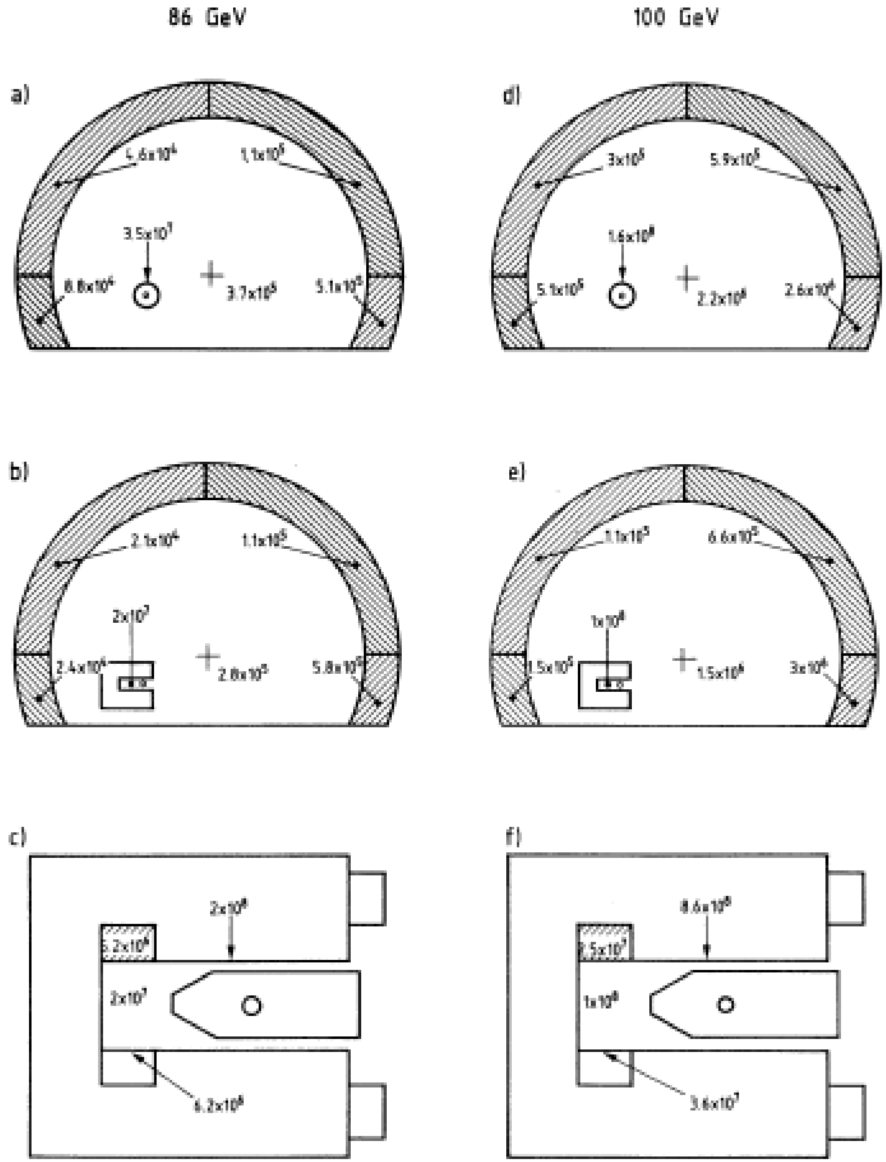


Fig. 40 Dose-distributions (in Gy) produced by synchrotron radiation in LEP tunnel. Solid circles indicate average doses within the volume shown. Arrows indicate a surface dose in the area shown. Values are calculated with the program MORSE. Portions (a), (b), and (c) are for nominal operating lifetime at 86 GeV (200 A · h).
a) Distribution in the LEP tunnel at the location of an intermagnet gap, shielded by 1 cm of Pb in all directions.
b) Distribution at the location of a bending magnet, shielded by 8 mm of Pb towards the walk-way (at right).
c) Distribution within the dipole magnet for the above conditions. The vacuum chamber is shielded by 8 mm towards the inside, 3 mm on the top and bottom, and 8 mm towards the walk-way.
Portions (d), (e), and (f) are similar to (a), (b), and (c), respectively, but are for maximum operation (330 A · h) at 100 GeV.

Table 45

Synchrotron-radiation doses in the LEP tunnel (in the vicinity of the dipole magnets) produced by 200 A · h of beam at 86 GeV with the Pb shielding arrangement described in text [a)]

System or component	Basic radiation-sensitive component	Dose limitation assumed (Gy)	Calculated dose (Gy)
Dipole magnet:	Glass-fibre-		
inner coil	reinforced	5×10^7	5×10^6
outer coil	epoxy resin	5×10^7	3×10^6
Quadrupole magnet: coils	Ditto	5×10^7	1×10^7
Magnet connections, such as bus-bars, hoses, etc.	Various thermoplastics	1×10^6	2.5×10^4
Cable trays: top, side	EPR, polyolefins	1×10^6	1×10^6
Electronic equipment under magnets	Various	$10^2 - 10^4$	1×10^4
Aux. equipment in passageway	Telephone, crane	1×10^6	5×10^5
Tunnel lighting	Fluorescent tubes	1×10^6	1×10^5
Air in tunnel (average)	(Noxious gas production; see text)	–	2.5×10^7

Radiation Damage

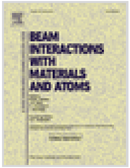
Assumed criterion for acceptability of materials: must survive after 200 Ah at 86 GeV

Coil insulation: glass-fiber reinforced epoxy resins
→ Survive at < 10^8 Gy

Cable insulation: no PVC or other that can produce corrosive gases (EPR: ethylene-propylene rubber, polyethylene) → survive < 10^6 Gy

Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms

Volume 217, Issue 1, March 2004, Pages 77–96



Absorbed doses and radiation damage during the 11 years of LEP operation

H Schönbacher, M Tavlet

Division TIS-DI, CERN, CH-1211 Geneva 23, Switzerland

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Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

Technical Inspection and Safety Division

CERN–TIS–2002–010–DI–PP

ABSORBED DOSES AND RADIATION DAMAGE DURING THE 11 YEARS OF LEP OPERATION

H. Schönbacher and M. Tavlet

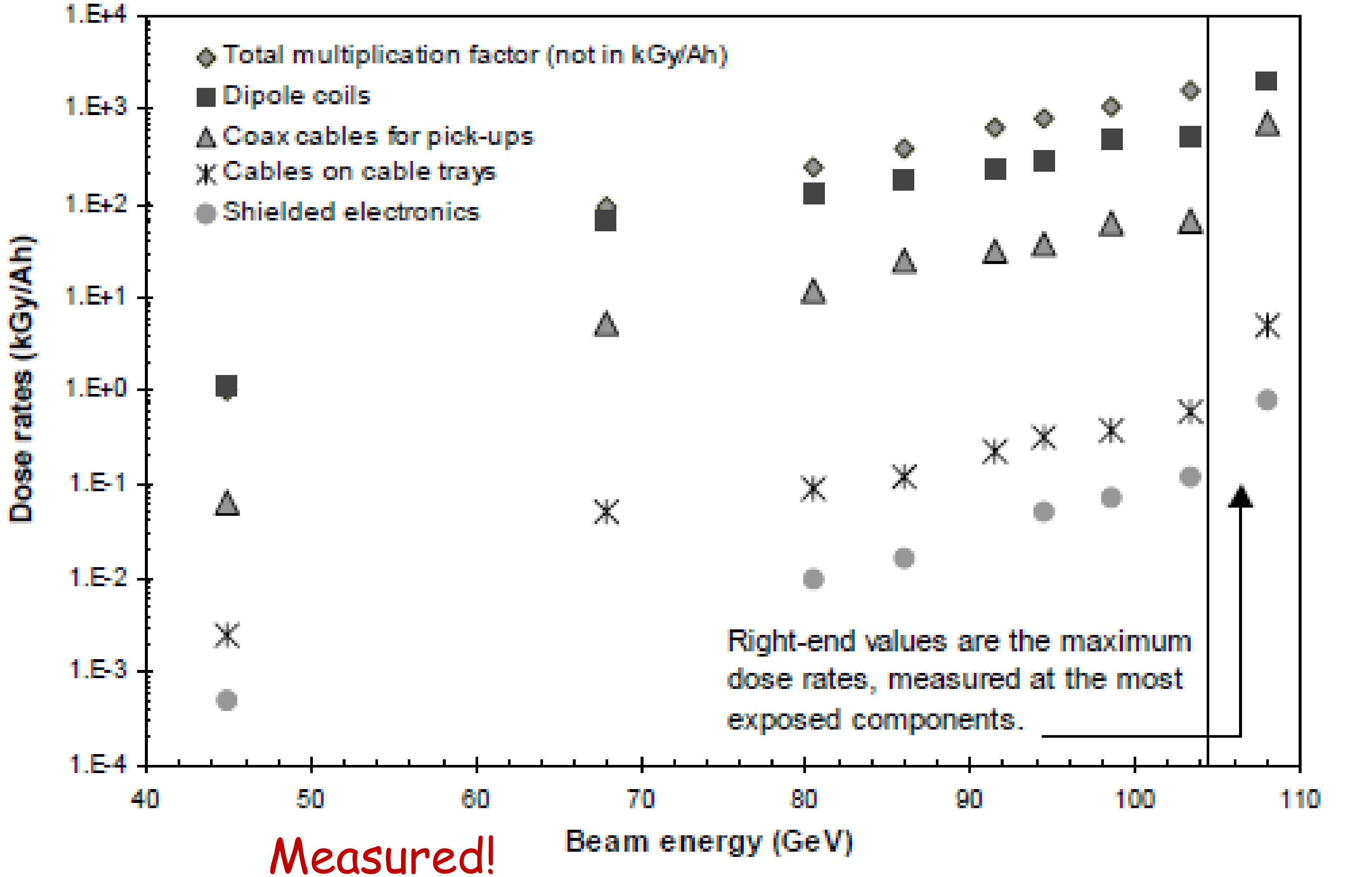

Fig. 1: Evolution of the dose rates (in kGy/Ah) in the curved section of the LEP tunnel, as a function of the beam energy (GeV), which increased over the years of operation (see Tables 1 and 2).

Too good to be true!

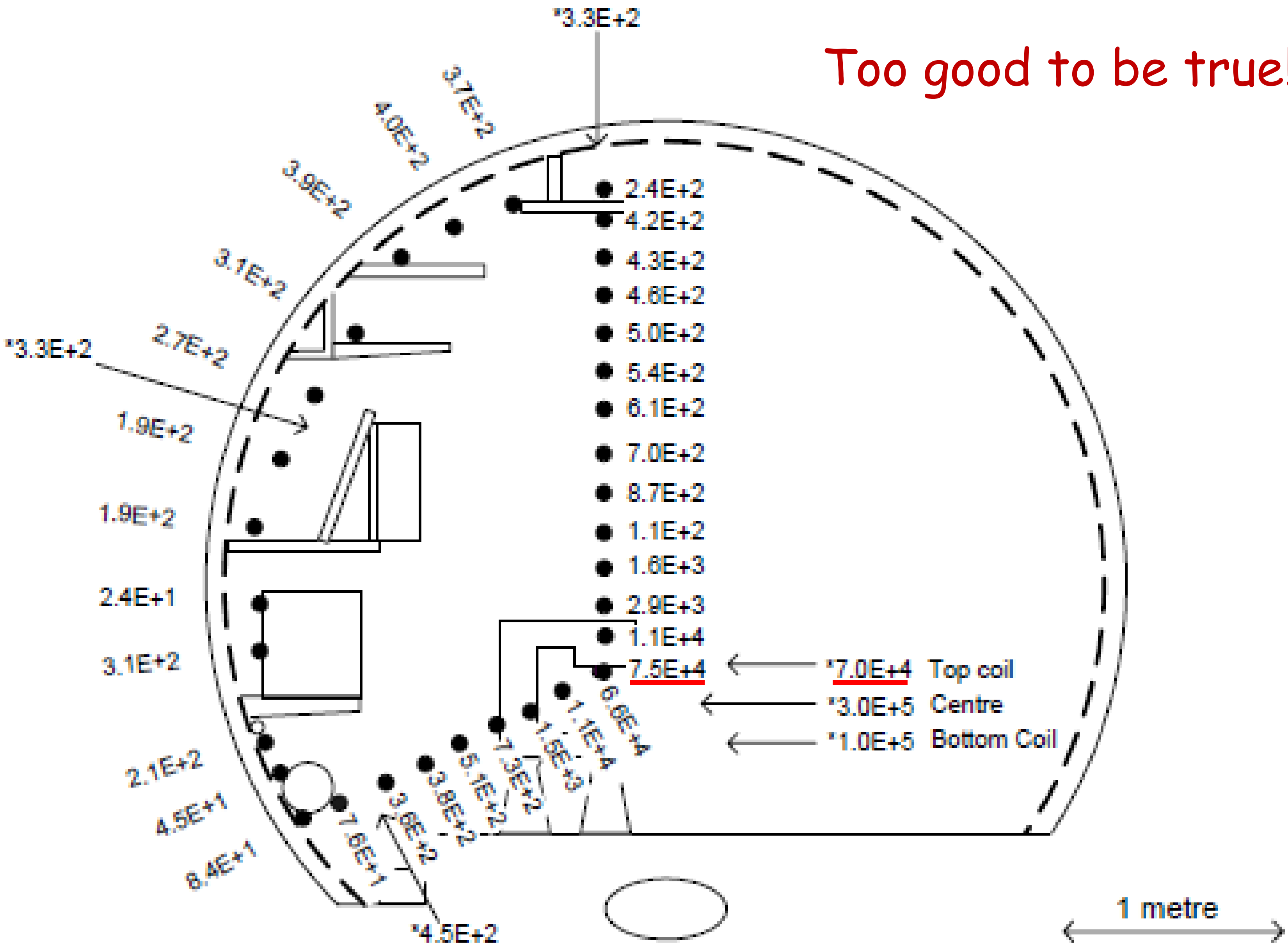

Fig. 3: Dose distribution in Gy/Ah at 98.6 GeV in a dipole section (HC 216)
Values with * show the normalized predicted doses in Ref [3].

Fig. 17: some coaxial and control cables damaged by the radiation in LEP. Also seen on the picture is a metallic box containing samples of magnet insulating resins and dosimeters.

CERN 81-08
20 July 1981

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

THE RADIOLOGICAL IMPACT OF THE LEP PROJECT ON THE ENVIRONMENT

Edited by K. Goebel

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7.4 Conclusions

APPENDICES

A) LEP Radiation Working Group
B) Internal Reports, Technical Memoranda, LEP Notes, and Unpublished Reports

Effects on environment were minimal, but were calculated in a very crude way (e.g. induced activities calculated as integrated values over all soil thicknesses).

But politically VERY important!!!

Very accurate and detailed calculations are now possible with FLUKA, and needed due to the constraining evolution of legal limits and the excessive cost of a too conservative approach

Table 6.2

Maximum concentrations of ozone and NO_x for a LEP operation at 85 GeV, and various stack charge velocities and wind speeds

Exit velocity v_s (m/s)	Wind speed v_w (m/s)	Δh (m)	h_e (m)	$c_{max}(O_3)$ (ppm)	$c_{max}(NO_x)$ (ppm)
10	0.5	48	58	1.7×10^{-3}	8.3×10^{-4}
	1	24	34	2.4×10^{-3}	1.2×10^{-3}
	2	12	22	2.8×10^{-3}	1.4×10^{-3}
	5	5	15	2.4×10^{-3}	1.2×10^{-3}
20	0.5	68	78	9.2×10^{-4}	4.6×10^{-4}
	1	34	44	1.4×10^{-3}	7.2×10^{-4}
	2	17	27	1.9×10^{-3}	9.6×10^{-4}
	5	7	17	1.9×10^{-3}	9.7×10^{-4}

It should be noted that these values are 3-minute averages. According to experience, 24-hour averages are of the order of one tenth lower, while yearly averages could be derived by dividing the figures in Table 6.2 by a factor of 100[6.12].

For comparison with calculated values in the case of LEP operating at 85 GeV, measurements have been made on the actual CERN site using Draeger colorimetric tubes (precision ±20%). The results are given in Table 6.3.

Table 6.3

Result of ozone measurements on the CERN site

Date	Place	Weather conditions	Ozone concentration in 10^{-2} ppm
23.1.81 a.m.	BA 2	Sunny	2.0
23.1.81 p.m.	BA 2	Sunny	3.0
26.1.81 a.m.	EHN 2	Cold fog	1.0
27.1.81 a.m.	892	Cold mist	1.5
28.1.81 a.m.	EHN 1	Cold mist	1.5
30.1.81 a.m.	867	Cold mist	1.5

EDMS#359574

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Technical Inspection and Safety Division

CERN-TIS-2002-017-RP

BILAN RADIOLOGIQUE DU DEMANTELEMENT DU LEP

N. Conan, T. Nguyen, M. Silari, L. Ulrici

Résumé

Ce rapport constitue le bilan radiologique final du démantèlement du LEP. Il résume le contrôles de radioprotection effectués tout au long du projet. Différents sujets sont abordés: l dosimétrie opérationnelle, les mesures de routine effectuées dans les zones souterraines sur tout l matériel sortant de la machine, les écarts par rapport à l'étude zonage, les mesures aléatoires d spectrométrie gamma, les cas d'alarmes au portique, la récupération des sources radioactives, l déclassement des zones, les expéditions de matériel du LEP vers divers instituts. La fin officielle des travaux de démantèlement a été le 28 février 2002.

CERN, 1211 Genève 23, Suisse
27 Août 2002

Tableau 2 - Bilan dosimétrique pour les mois de novembre 2000 à février 2002.

MOIS	Nombre de personnes	Dose maximum* (µSv)	Dose cumulée (µSv)
Novembre 2000	102	13	57
Décembre 2000	86	82	432
Janvier 2001	83	33	526
Février 2001	92	93	947
Mars 2001	71	75	851
Avril 2001	70	113	941
Mai 2001	53	146	1426
Juin 2001	23	66	267
Juillet 2001	11	45	134
Août 2001	8	45	135
Septembre 2001	8	48	145
Octobre 2001	7	51	196
Novembre 2001	6	48	110
Décembre 2001	6	46	154
Janvier 2002	6	36	110
Février 2002	6	32	117
Total	236**	/	6867

* La dose maximale est intégrée sur une période de 1 mois.
** Total des personnes enregistrées dans la base de données dosimétrique.

Figure 2. Le portique radiologique

Pertes de faisceau localisées. Ce mécanisme a été la source prédominante d'activation dans le LEP. La radioactivité induite provient de l'interaction directe du faisceau avec les matériaux de la machine. En conséquence d'une perte localisée de faisceau, les matériaux qui ont été la cible du faisceau agissent comme des sources de rayonnement. Tous les matériels tels que les blocs absorbeurs d'arrêt de faisceau (dump), les collimateurs et tout autre élément de la machine dont la fonction est d'intercepter tout ou partie du faisceau étaient radioactifs - bien que très faiblement dans la plupart des cas - et classés comme tels pour le démantèlement du LEP. Par mesure de précaution, on a considéré comme TFA les composants situés en amont et en aval d'un point de perte localisée jusqu'à une distance d'un mètre, les composants situés au-delà étant considérés comme conventionnels. Dans les directions transverses à l'axe du faisceau, on a considéré comme TFA les composants situés autour du point de perte localisé jusqu'à une distance de 80 cm, les composants situés au-delà étant considérés comme conventionnels.

Pertes de faisceaux distribuées. Les pertes de faisceau distribuées ne représentent qu'une très faible fraction des pertes totales dans le LEP et les activités attendues ne sont pas décelables. Un cas spécifique est représenté par les électrons et positons émergeant à faible angle ("Bhabha scattering") des interactions au centre des quatre expériences du LEP et qui sont perdus en majorité sur des collimateurs équipés pour leur détection, mais aussi pour une infime partie au début des arcs de part et d'autre des quatre points pairs du LEP et représentent en conséquence un risque non nul de pertes de faisceaux distribuées. L'analyse de l'activité induite dans les composants du LEP en raison de ces processus de pertes distribuées a montré que la radioactivité spécifique induite dans les matériaux frappés par le faisceau dans ces conditions était négligeable.

Rayonnement Synchrotron. L'étude zonage a montré que l'activation, par les photons du rayonnement synchrotron et par les neutrons secondaires, dans la masse du dipôle (fer-béton), dans l'aluminium de la chambre à vide ainsi que dans le blindage en plomb de la chambre l'activité induite est négligeable. Ceci a été confirmé par des mesures de spectrométrie gamma sur des

Tableau 4 - Provenance des écarts constatés et, parmi ceux–ci, des écarts avec débit de dose inférieur à 100 nSv/h (bruit de fond inclus). Seules les zones de la machine avec une prédominance de composants classés TFA sont prises en compte. Les pourcentages de la troisième et quatrième colonne sont calculés par rapport au nombre d'éléments donnés dans la deuxième colonne.

1	2	3	4	5	6
Zone	Total des éléments (démantèles) classés conventionnels	Eléments TFA inattendus	Eléments TFA inattendus avec débit de dose inférieur à 100 nSv/h	Total des éléments (démantèles) classés TFA selon zonage	Eléments TFA selon zonage avec débit de dose inférieur à 100 nSv/h
Injection 1	76	20 (26%)	1 (1%)	140	64 (46%)
Injection 2	97	23 (24%)	3 (3%)	157	74 (47%)
Total injections	**173**	**43 (25%)**	**4 (2%)**	**297**	**138 (46%)**
RA 23	263	131 (50%)	8 (3%)	154	18 (12%)
RA 27	136	81 (59%)	12 (9%)	89	13 (15%)
RA 43	88	43 (49%)	18 (20%)	168	10 (6%)
RA 47	38	10 (26%)	1 (3%)	122	25 (20%)
RA 63	87	47 (54%)	6 (7%)	105	8 (8%)
RA 67	111	92 (83%)	12 (11%)	115	5 (4%)
RA 83	39	26 (67%)	2 (5%)	96	4 (4%)
RA 87	79	23 (29%)	3 (4%)	97	4 (4%)
Total RA	**841**	**453 (54%)**	**62 (7%)**	**946**	**87 (9%)**
Wigglers 3	202	1 (0.5%)	1 (0.5%)	275	269 (98%)
Wigglers 5 - 1	98	10 (10%)	1 (1%)	80	61 (76%)
Wigglers 5 – 2	110	17 (15%)	6 (5%)	89	58 (65%)
Wigglers 539	19	4 (21%)	1 (5%)	3	3 (100%)
Wigglers 7	263	21 (8%)	15 (6%)	333	221 (66%)
Wigglers	**692**	**53 (8%)**	**24 (3%)**	**777**	**609 (78%)**
Dumps	**78**	**45 (58%)**	**24 (31%)**	**21**	**15 (71%)**

Tableau 6 - Réactions nucléaires possibles dans différents matériaux. Seuls les principaux radioéléments avec demi-vie supérieure à 30 jour sont indiqués.

Radioélément	Réactions induites par les photons	Section efficace (mb)	Réactions induites par les neutrons	Section efficace (mb)
^{22}Na	$^{23}Na(\gamma,n)^{22}Na$ $^{24}Mg(\gamma,np)^{22}Na$ $^{27}Al(\gamma,n\alpha)^{22}Na$	2.0 0.05 0.0026	-	-
^{54}Mn	$^{55}Mn(\gamma,n)^{54}Mn$ $^{56}Fe(\gamma,np)^{54}Mn$	- 1.8	$^{54}Fe(n,p)^{54}Mn$	801.0
^{55}Fe	$^{56}Fe(\gamma,n)^{55}Fe$	5.0	$^{54}Fe(n,\gamma)^{55}Fe$	2646.0
^{57}Co	$^{58}Ni(\gamma,p)^{57}Co$	3.0	-	-
^{58}Co	$^{63}Cu(\gamma,n\alpha)^{58}Co$	0.012	$^{58}Ni(n,p)^{58}Co$	114.0
^{65}Zn	$^{66}Zn(\gamma,n)^{65}Zn$	17.0	$^{64}Zn(n,\gamma)^{65}Zn$	780.0
^{114m}In	$^{115}Sn(\gamma,p)^{114m}In$	1.3	$^{113}In(n,\gamma)^{114m}In$	8500
^{113}Sn	$^{114}Sn(\gamma,n)^{113}Sn$	305.0	$^{112}Sn(n,\gamma)^{113}Sn$	800.0
^{123}Sn	$^{124}Sn(\gamma,n)^{123}Sn$	-	$^{122}Sn(n,\gamma)^{123}Sn$	1.0
^{124}Sb	-	-	$^{123}Sb(n,\gamma)^{124}Sb$	4280.0
^{203}Hg	-	-	$^{206}Pb(n,\alpha)^{203}Hg$	0.686

The RAWOG (RAdiation WOrking Group)

The LEP radiation studies were organized by the RAWOG, in a way that proved very successful.

Members of RAWOG were radiation physicists, LEP engineers and physicists, and experts from various European electron accelerators (DESY, Frascati, Orsay…)

The working group met once every month to present and discuss one or two radiation issues. During the coming month, radiation physicists made relevant calculations whose results were presented and discussed in the next monthly meeting.

Examples: mazes, klystron galleries, alcoves, vacuum chamber shielding…

From H. Schopper: Lep: The Lord of the Collider Rings at CERN 1980-2000

It would take too much room here to describe all the additional actions which were taken to keep the relations with the neighbours as friendly as possible. Good contacts with the local authorities were essential and the help of G. Mazenot, Prefect of the Ain, L. Ducret, Mayor of St.-Genis-Pouilly, J. Raphoz, Mayor of Prévessin-Moens, and Senator Roland Ruet were much appreciated. When at the end of the civil engineering I met the mayors of the neighbouring villages at lunch (in France it is always better to meet people at meals!), they all expressed their satisfaction with the way we had handled their worries and they admitted that the economic advantages which LEP brought to the Pays de Gex overcompensated for the negative effects.

Of course, there are always some people who use dishonest arguments just to get some benefits for themselves. A local politician tried to organize an anti-LEP movement to get more publicity and influence in local politics. He was a partisan of the opposition, claiming that LEP would destroy the agricultural environment of the region. However, after LEP had been in operation for some time he wanted to sell some property and advertised it pointing out its particular advantage of being close to LEP and CERN! Another example was a bright student who had worked for some time at CERN and who understood perfectly what the implications of LEP and the general conditions at CERN were. Apart from environmental issues, he criticized CERN for being involved in military research and stated that LEP might intensify such activities. However, he knew quite well that CERN according to its Convention