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QUALIFICATION OF FISSION PRODUCT CROSS-SECTIONS BY REACTIVITY WORTH MEASUREMENTS IN MINERVE REACTOR

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Measurement of fission product effective cross sections using a reactivity-oscillator technique

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The effective capture cross sections of ^{95}Mo, ^{99}Tc, ^{103}Rh, ^{109}Ag, ^{133}Cs, ^{143}Nd, ^{145}Nd, ^{147}Sm, ^{149}Sm, ^{152}Sm, ^{153}Eu, ^{155}Gd and natural elements Sm, Nd are measured, relatively to that of boron and in a PWR-like spectrum, in the experimental reactor MINERVE, located at Cadarache.

The chosen nuclides are stable or long lived fission products (FP) of uranium or plutonium, liable for most of neutron capture by FPs. The study aims at showing that a load increase for some fuel processing devices is possible, if FPs are taken into account in the criticality safety analysis. However, it may contribute also to a better knowledge of nuclear data on fission products.

We used small samples (overall weight less than 80 g) containing the above nuclides or elements in a natural UO_2 matrix. They can be viewed as 10 cm long sections of PWR pins, contained in thin watertight zircaloy sleeves. Borated and variable enrichment UO_2 samples were used for calibration. The sample content is obtained from chemical or mass spectrometer analysis on pellets from the same batch.

The central pin of the MELODIE lattice in MINERVE is periodically oscillated through the core, so that the sample under study is alternatively in and out of the core. A rotating control rod is automatically operated so as to maintain the count rate of a flux detector. The corrected rotation amplitude is in a very closely linear relation with the sample reactivity. Effective FP cross sections are obtained in terms of the boron effective cross section, from the comparison between measured reactivities for FP and boron samples.

FP reactivity worths are computed from the 99 group libraries CEA86 (JEF1) and CEA93 (JEF2); neutron transport computations are performed by the APOLLO1 code in a multicell geometry, using the interface current method. The C/E ratios, mostly sensitive to cross sections, will point out possible weaknesses in recent European JEF2 evaluations.

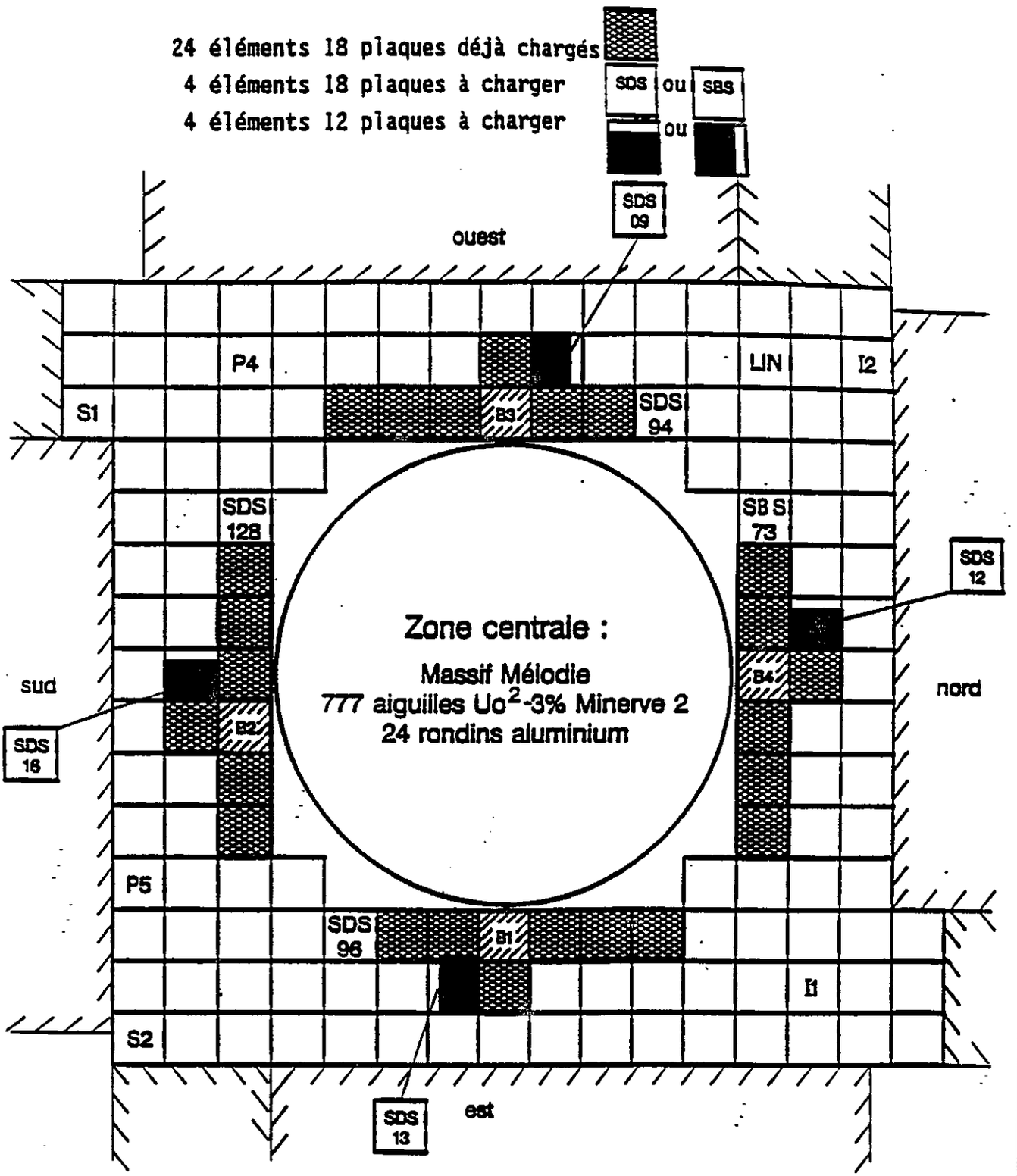
BURN-UP CREDIT

REACTIVITY WORTH OF THE FISSION PRODUCTS (pcm = 10^{-5} ΔK/K)

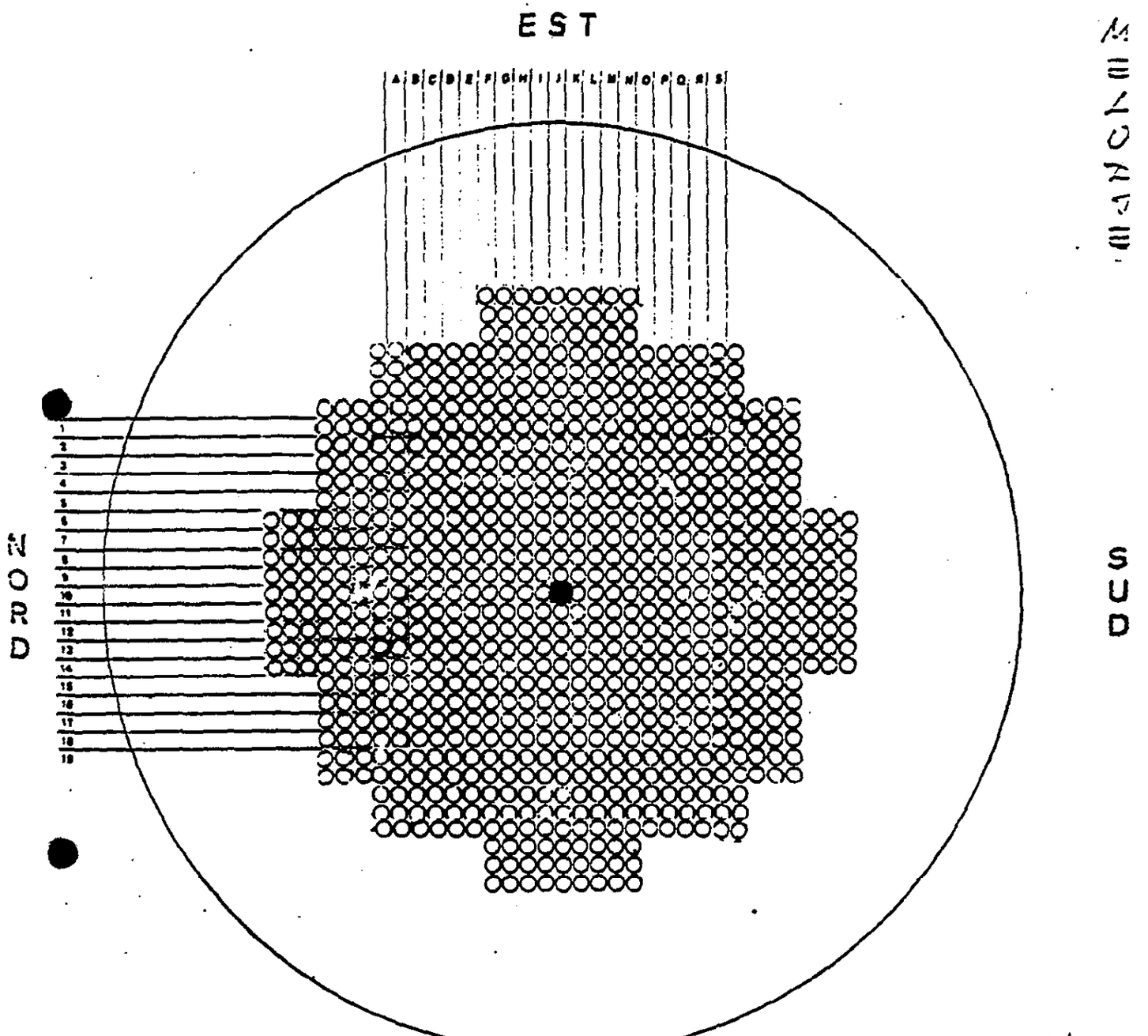
PWR 17 x 17 COOLING TIME = 5 YEARS

		Bu = 20 Gwd/t	Bu = 40 Gwd/t	Bu = 60 Gwd/t
1.	Sm149	960	1030	1050
2.	Rh 103	790	1360	1700
3.	Nd 143	530	900	1100
	Xe 131 (Volatile)	470	790	940
4.	Cs 133	420	750	1010
5.	Gd 155	390	1500	2990
	Sm 151 (T = 90 y)	350	500	600
6.	Sm 152	250	490	660
7.	Tc 99	240	440	610
8.	Nd 145	230	410	540
9.	Eu 153	160	390	610
10.	Sm 147	150	230	260
11.	Mo 95	150	290	400
	Pm 147 (T = 2.6 y)	120	140	130
12.	Sm 150	120	270	380
13.	Ag 109	110	250	360
14.	Ru 101	110	220	330
	SUM 14 F.P	4610 pcm (75 %)	8580 (75 %)	12010 (74 %)
	SUM 200 F.P	6120 pcm	11500	16200

Coupe horizontale du coeur couple MINERVE-MELODIE



COUPE HORIZONTALE DU MASSIF MELODIE



○ UO_2 3% REP ⌀ 1.26

■ CELLULE D'OSCILLATION

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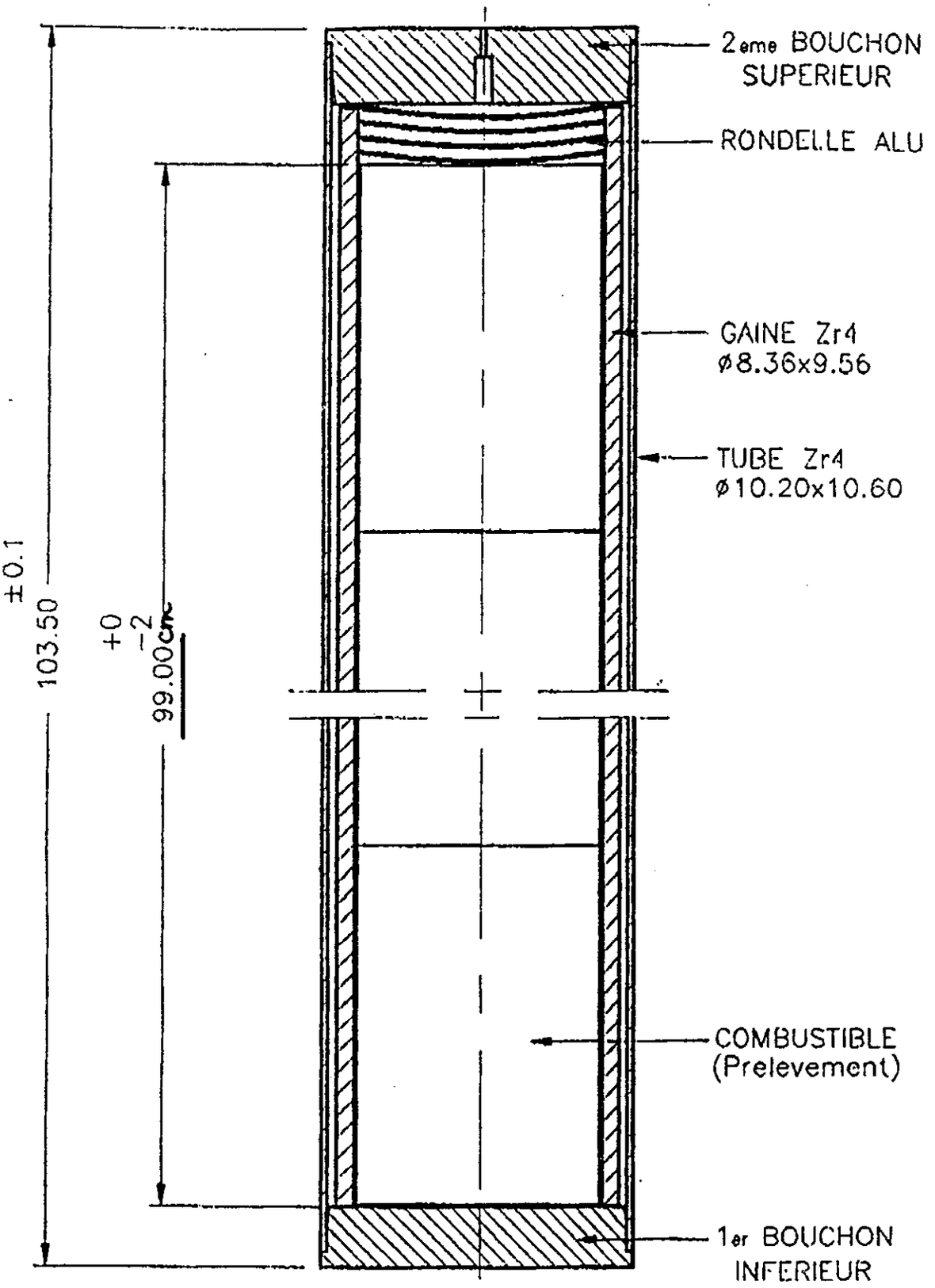


ECHANTILLON D'OSCILLATION MINERVE

CREDIT BURNUP : VALIDATION DES P.F

PROGRAMME EXPERIMENTAL CERES PHASE 2

LISTE DES ECHANTILLONS FRITTES

ORDRE DE FABRICATION	DOPANT	MASSE DE DOPANT (g) PAR COLONNE 10 cm d'UO_2
1	∅	0
2	Sm nat	0.028
3	Sm149	0.004
4	Sm152	0.7
5	Sm147	1.20
6	Nd nat	4
7	Nd143	0.8
8	Gd155	0.008
9	Eu153	0.5
10	Rh103	0.5
11	Rh103	0.05
12	Nd145	3.6

REPERE ECHANTILLON	MASSE UO_2 (g)	MASSE AJOUT (g)	NATURE AJOUT (g)
UC	30,6	0	-
CS1	31,0	0,62	Cs_2CO_3
CS6	28,0	3,77	Cs_2CO_3
Nd5	48,3	3,60	Nd_2O_3
Mo5	23,1	5,66	MoO_3
Tc99	23,0	4,32	$KTcO_4$

ECHANTILLONS CERES P.F. SEPARES
LOT N°2

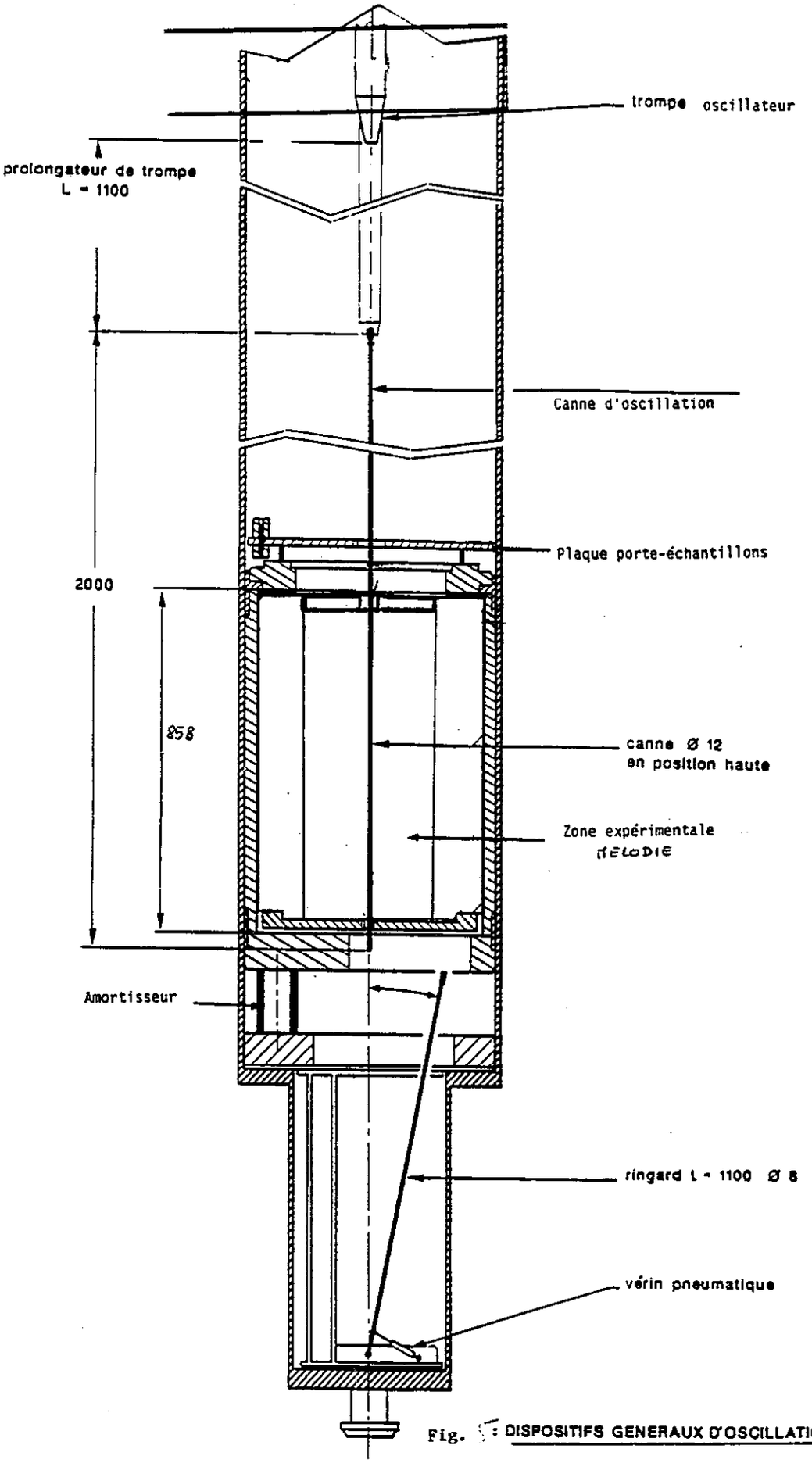
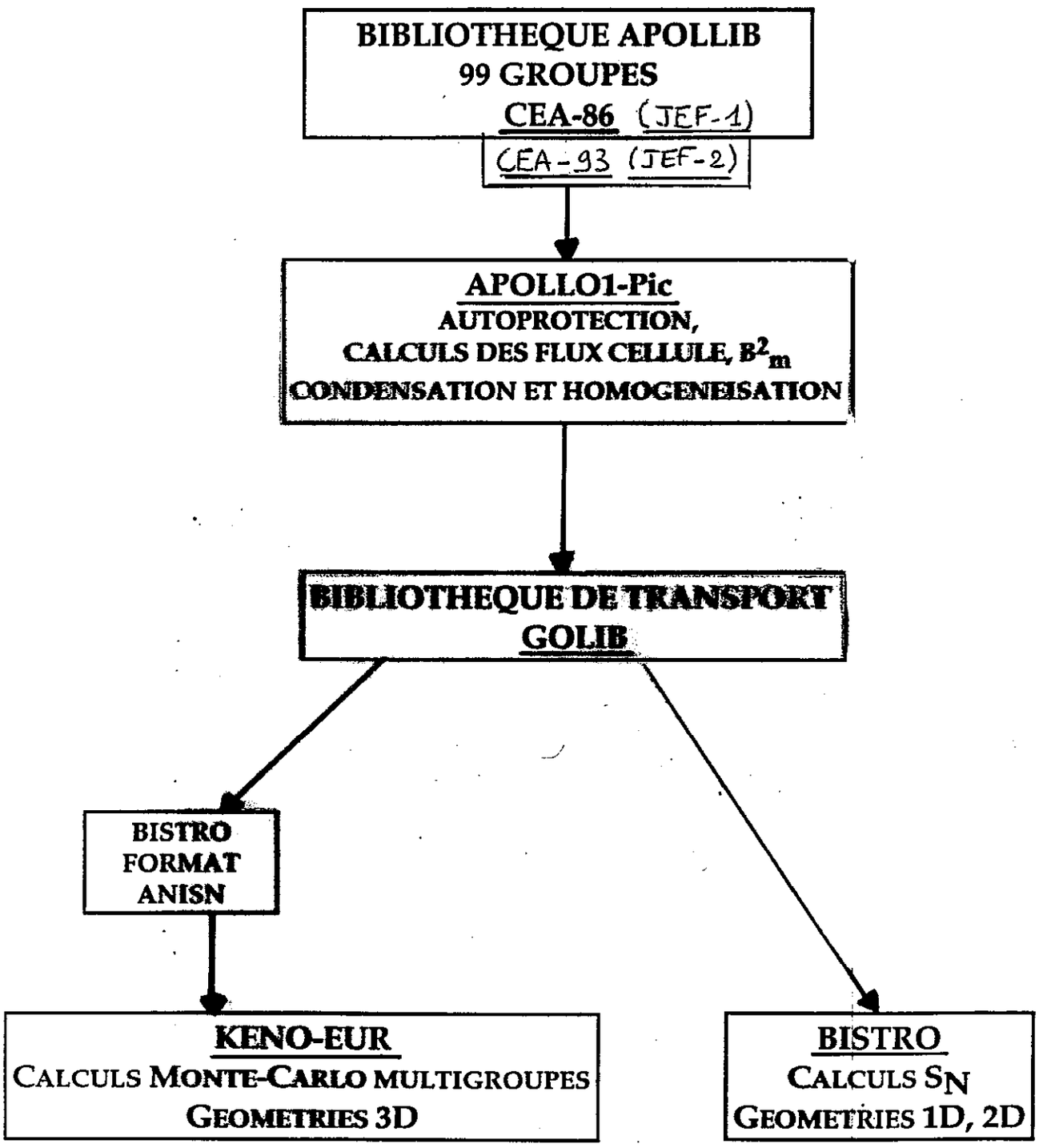


Fig. 5 : DISPOSITIFS GENERAUX D'OSCILLATION

LE FORMULAIRE DE CALCUL DE CRITICITE "CRIBLE"



FISSION PRODUCT REACTIVITY WORTH
MINERVE EXPERIMENT (C-E/E) in %

ISOTOPE	JEF-1	JEF-2	EXP. UNCERT. (1σ)
Sm	-7.4	-6.4	±1.0
Sm9	-8.2	-7.3	1.3
Sm2	5.1	6.0	3.0
Sm7	9.4	9.7	5.0
Nd	-1.0	0.7	3.0
Nd3	-10.2	-7.9	3.0
Nd5	17.8	41.9	10.0
Gd5	-0.3	-2.7	2.0
Eu3	0.0	0.6	2.0

... of content of isotope.

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