

# EXPERIMENTAL HEVA PROGRAMME

## 1/ The Partners

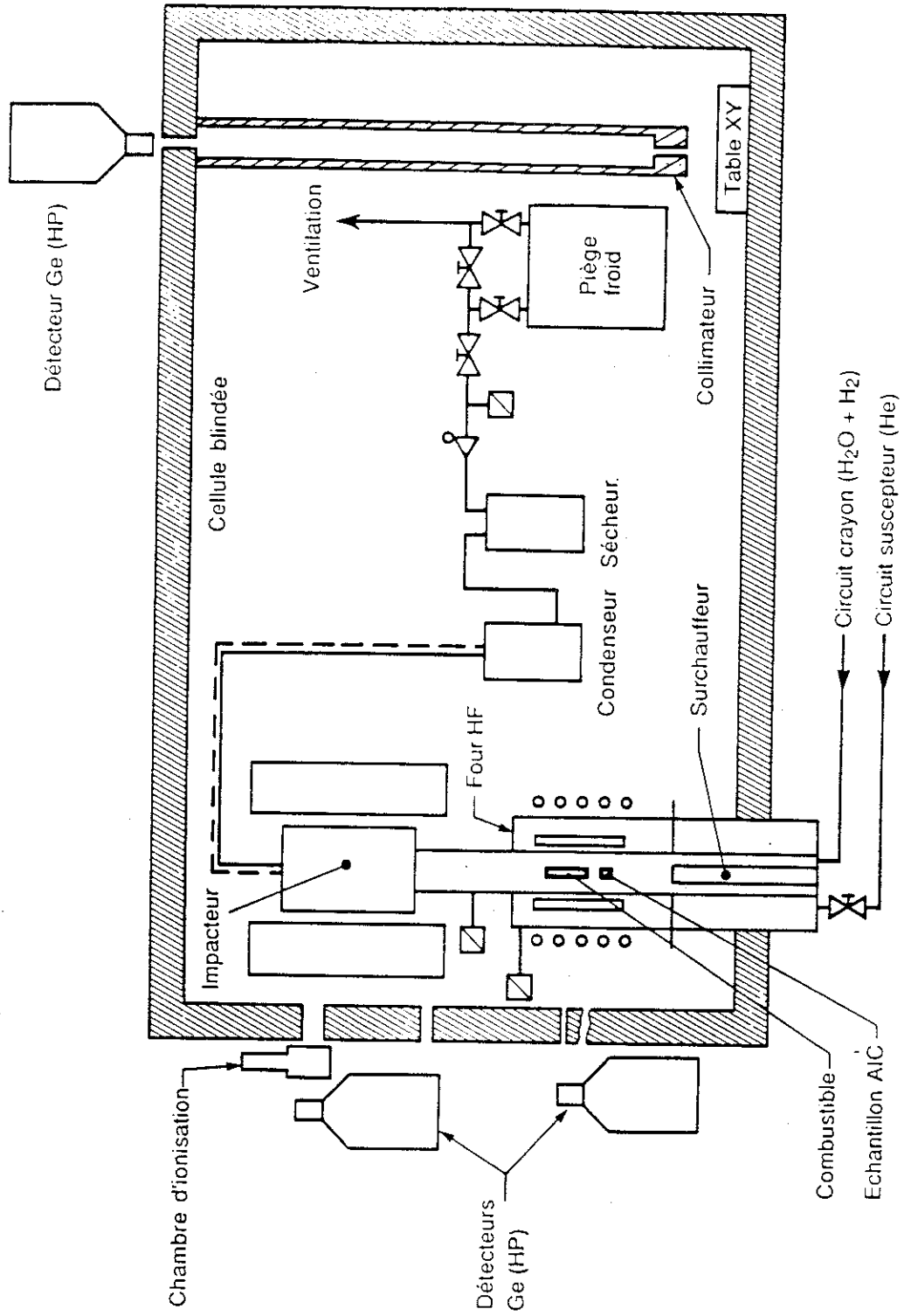
- \* Definition : IPSN - CEA
- \* Funding : CEA and EDF
- \* Implementation: CEA - DRN

## 2/ Objectives of the programme

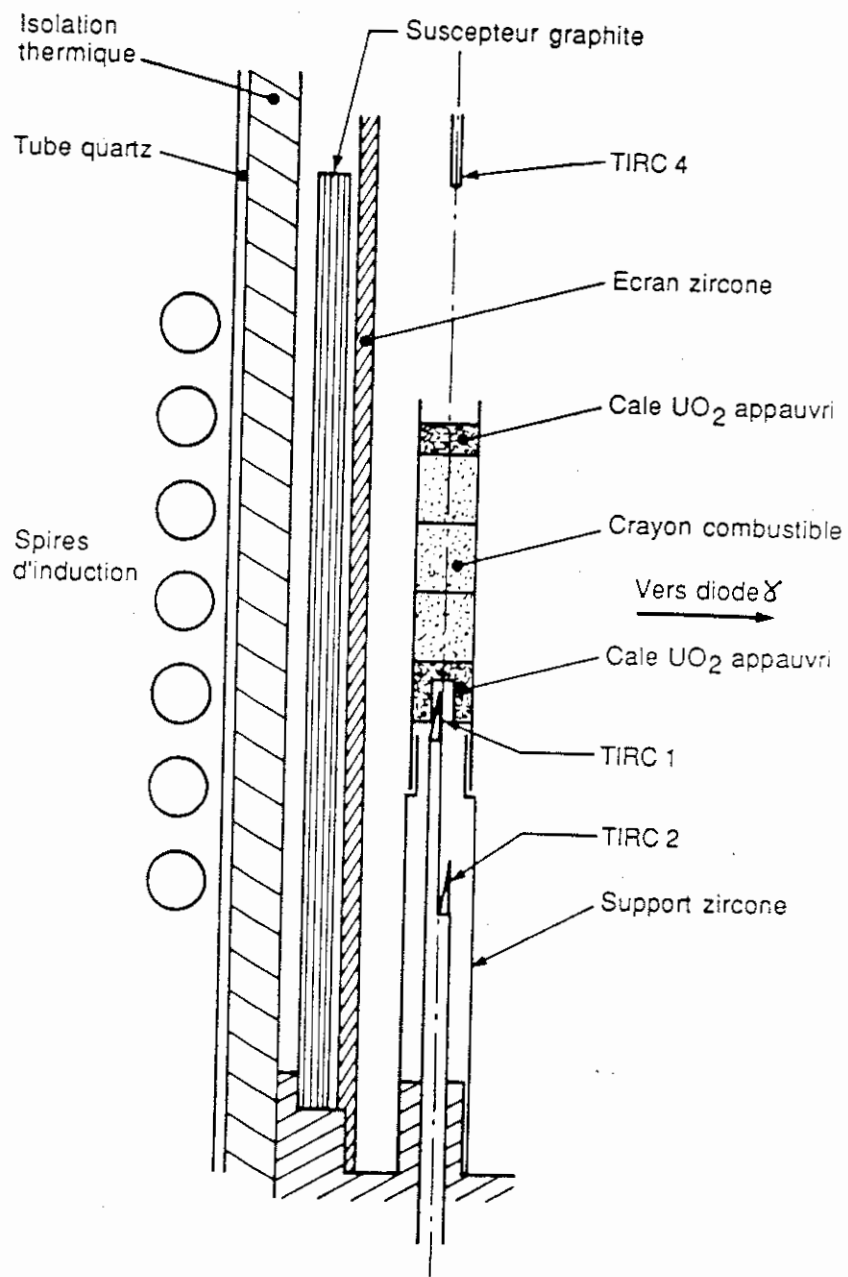
- \* Improvement and validation of the models (ESCADRE system)
- \* Realistic data base

## 3/ Objectives of the measurements

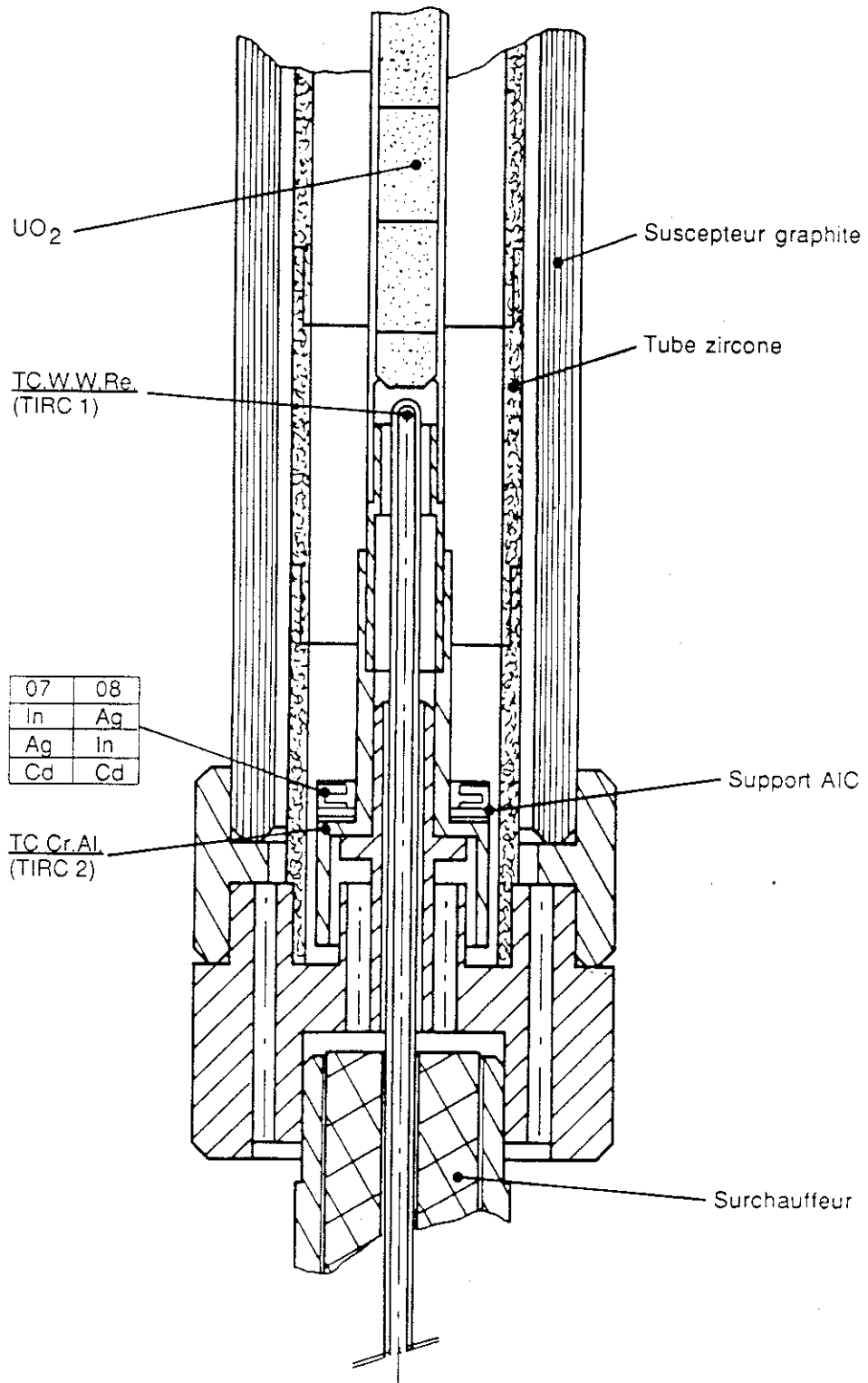
- \* Release kinetics of the FP
- \* Particulate source from the Fuel
- \* Chemical behaviour of the FP



HEVA experimental installation  
(HEVA test 08. For HEVA test 07, the cold trap was absent)

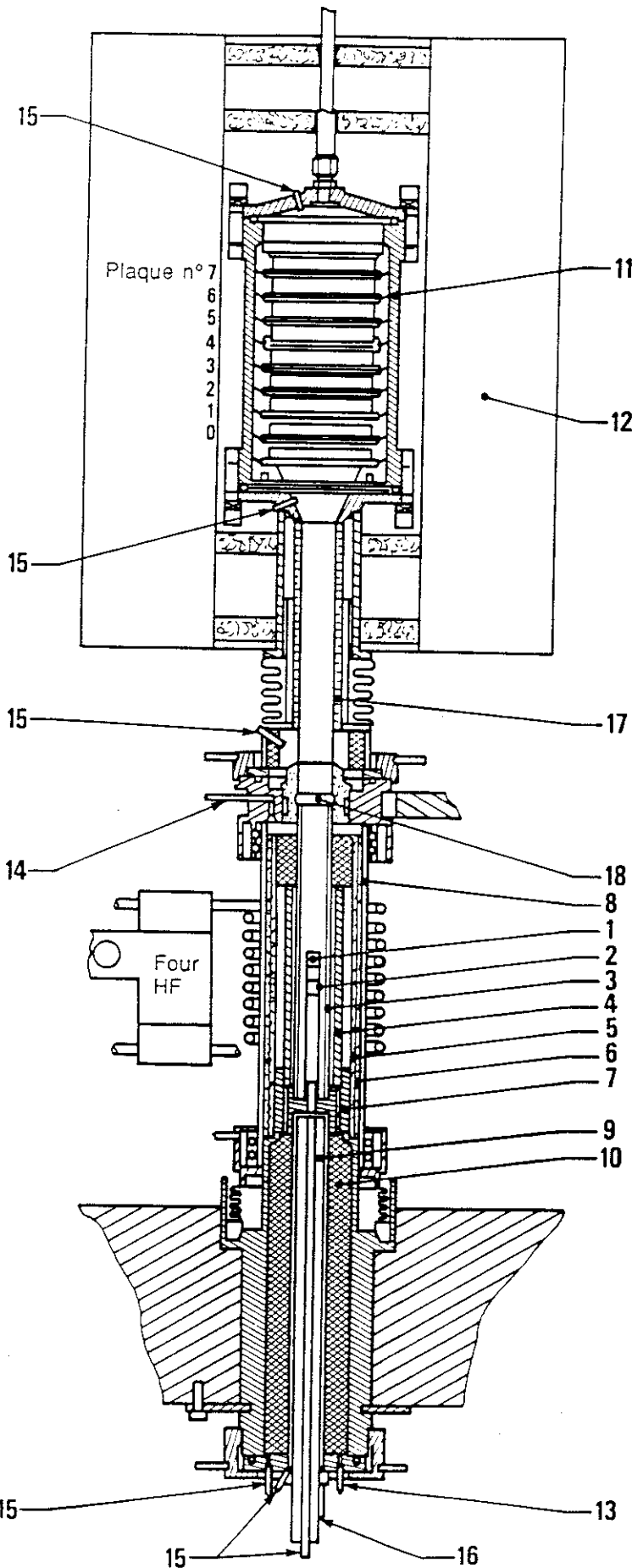


Fuel rod arrangement in HF furnace (HEVA tests 03 to 05.  
 For HEVA test 06, the bottom retaining pellet did not have a hole).



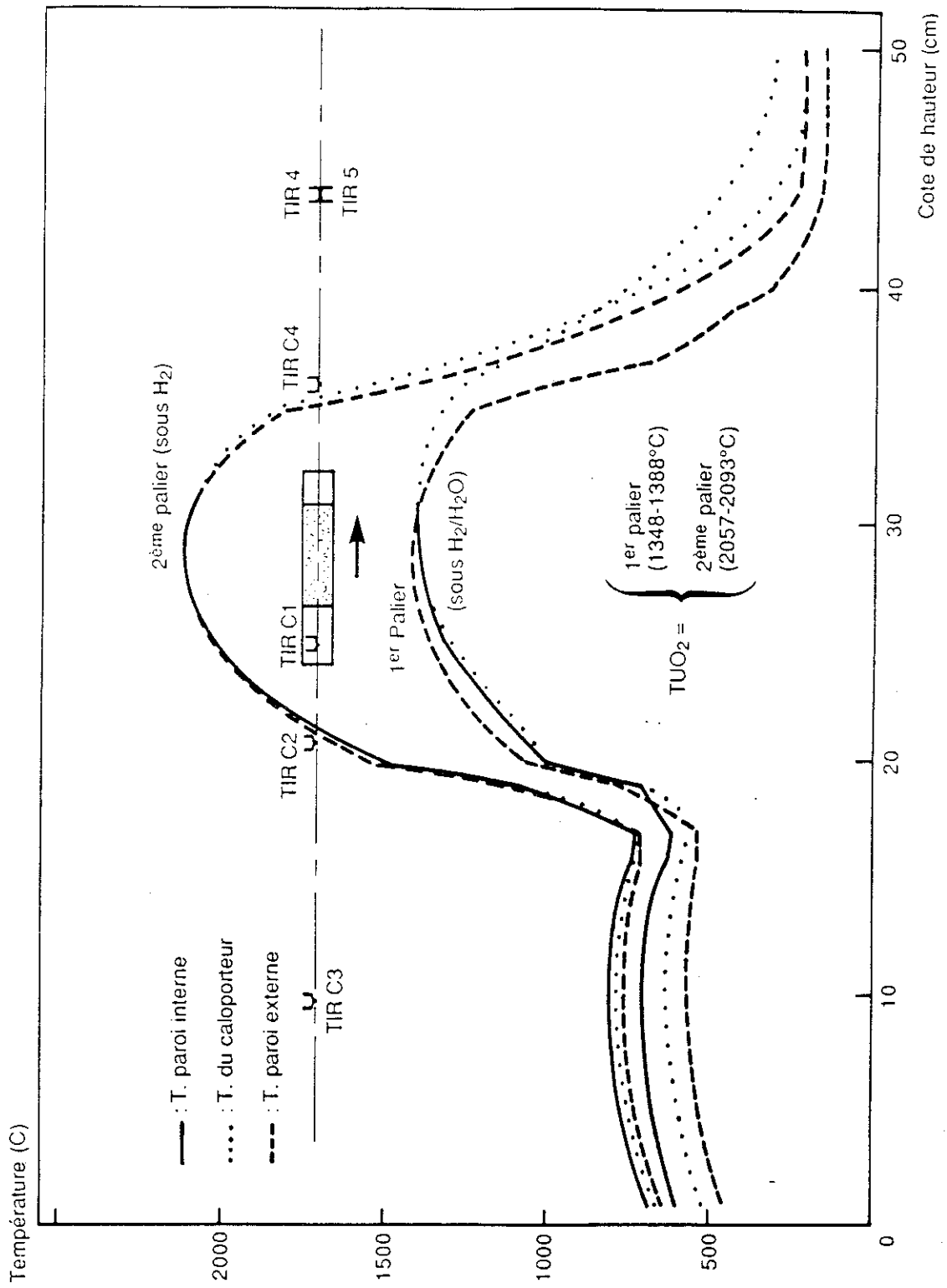
AIC sample arrangement in furnace (HEVA tests 07 and 08)

Plafond cellule



- 1. Combustible
- 2. Gaine Zy 4
- 3. Ecran thermique  $ZrO_2$
- 4. Suscepteur graphite
- 5. Ecran thermique externe  $ZrO_2$
- 6. Ecran thermique externe  $Al_2O_3$
- 7. Centreur support  $ZrO_2$
- 8. Tube quartz
- 9. Surchauffeur vapeur
- 10. Ecran thermique surchauffeur
- 11. Impacteur
- 12. Four impacteur
- 13. Arrivée He
- 14. Sortie He
- 15. Thermocouples
- 16. Introduction vapeur
- 17. Bride inférieure impacteur
- 18. Rotule

HEVA furnace. High temperature assembly (HEVA tests 03 to 06.  
For tests 07 and 08, the fuel rod arrangement is as shown in figure 3.2)



Calculated temperature profiles (HEVA 06)

# **HEVA TEST PARAMETERS**

**1 - Impactor temperature**

**2 - Fluid composition (oxy. red / flow)**

**3 - Control rod components**

**+**

**Fuel temperature**

## HEVA TEST PARAMETERS

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Test n°	01	02	03	04	05	06	07	08
Burn up (GWd/tU)	19,4	19,4	27,7	36,7	36,7	36,7	0	36,7
réirradiation	no	no	no	yes	yes	yes		yes
Fluid flow (mg/s) :								
H <sub>2</sub>	0	0	0,5	0,5	0,5	0,2	0,5	0,5
H <sub>2</sub> O	100	30	37	30	25	0	25	25
Temperature slope (°C/s)	1	1	1	1	1	2	1	1
Fuel temperature (°C)	1630	1870	1800	2000	1800	2100	1800	1800
Plateau duration (s)	900	900	1800	420	5760	1800	1800	600
Impactor temperature (°C)	non	non	800	600	250	250	250	250
Ag/In/Cd	no	no	no	no	no	no	yes	yes
Test date	06/83	11/83	02/86	12/86	07/87	03/88	06/88	03/89



# **HEVA TEST INSTRUMENTATION**

## **1 - TEMPERATURES**

fuel, junction, impactor + structures

## **2 - FLOW RATES**

Inlet, outlet

## **3 - PRESSURES**

Before the impactor and the cold trap

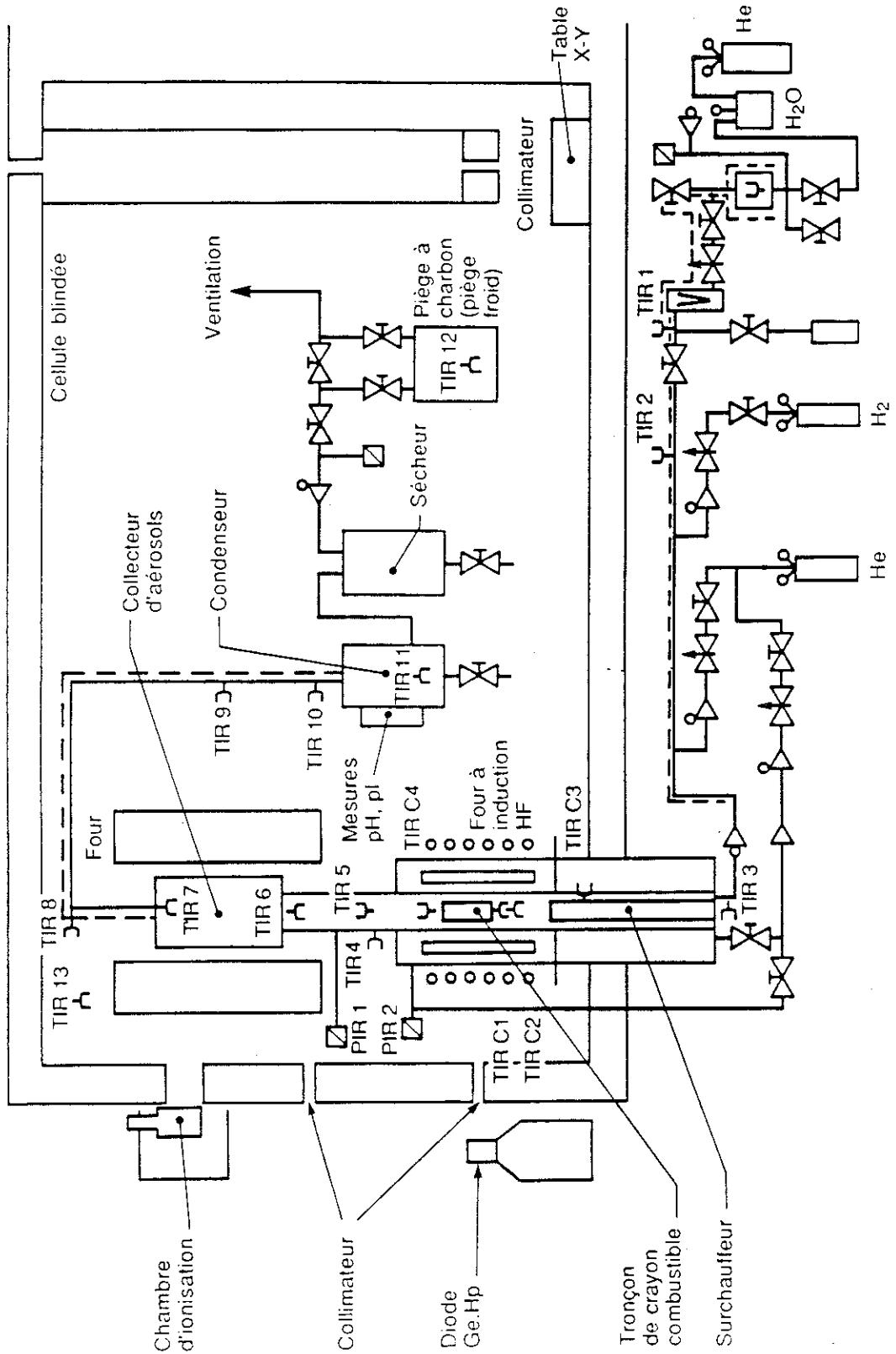
## **4 - GAMMA RAY EMITTERS**

On line gamma spectrometry on fuel,  
impactor

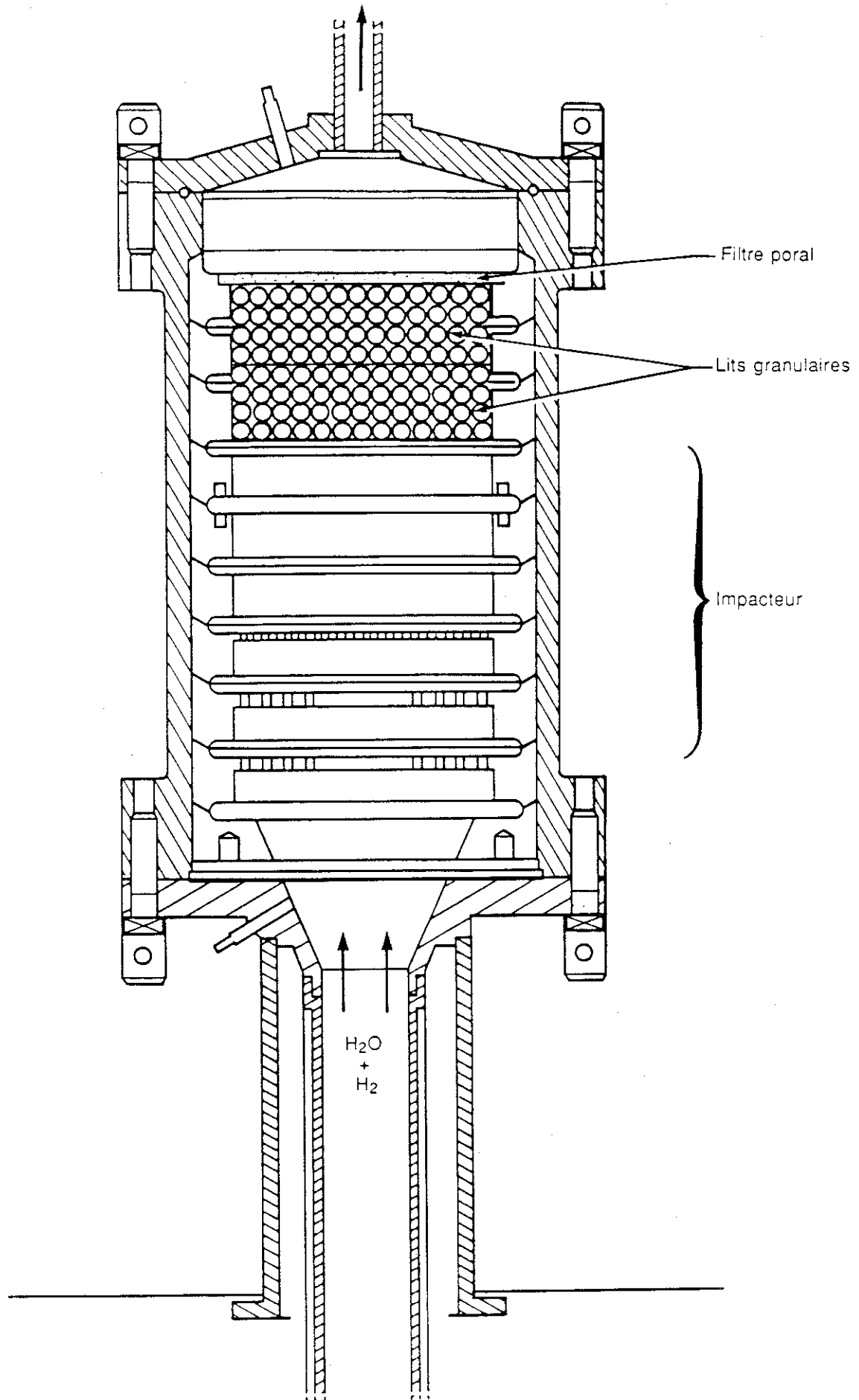
## **5 - AEROSOLS**

Impactor

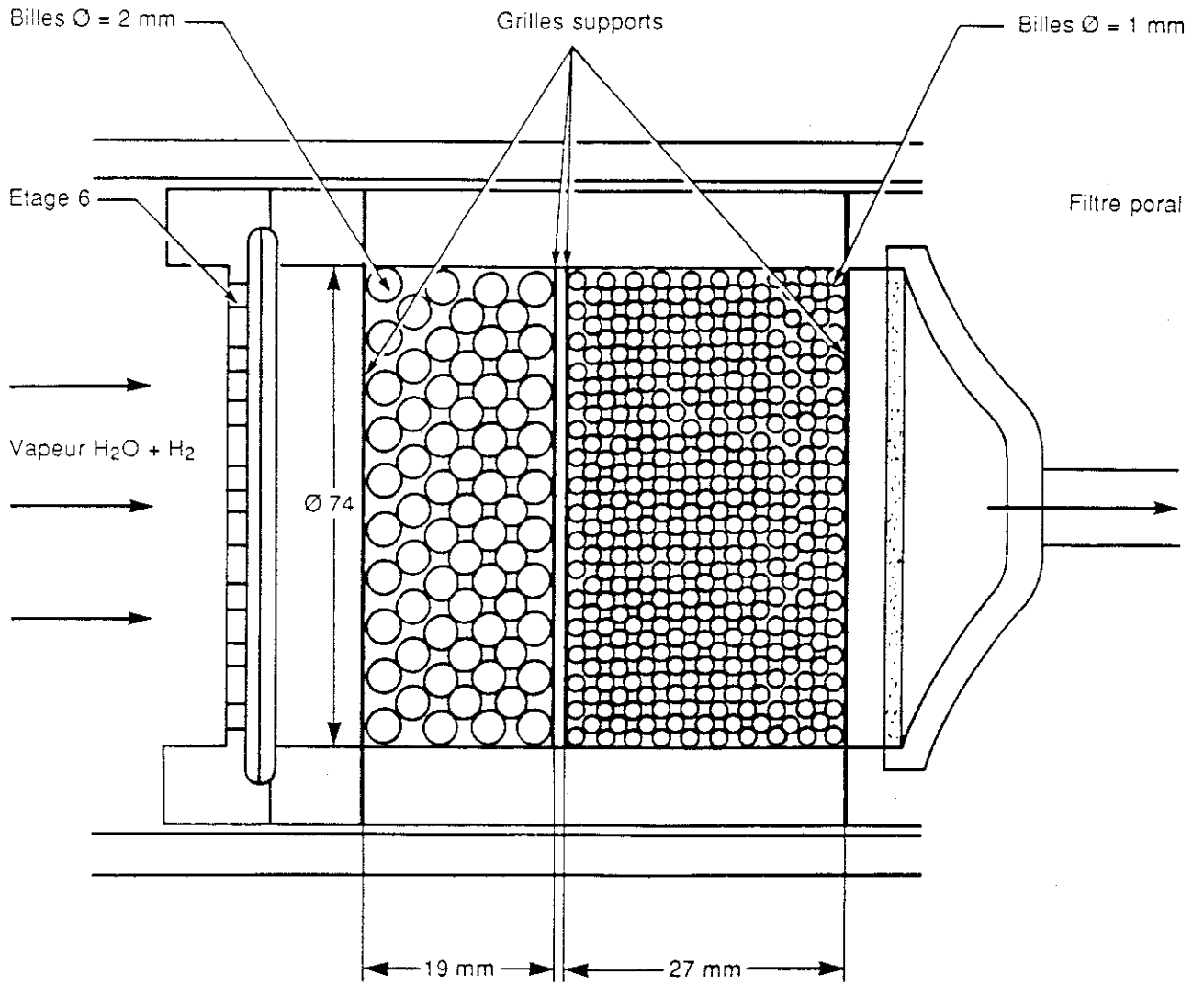
## **6 - pH, pI**



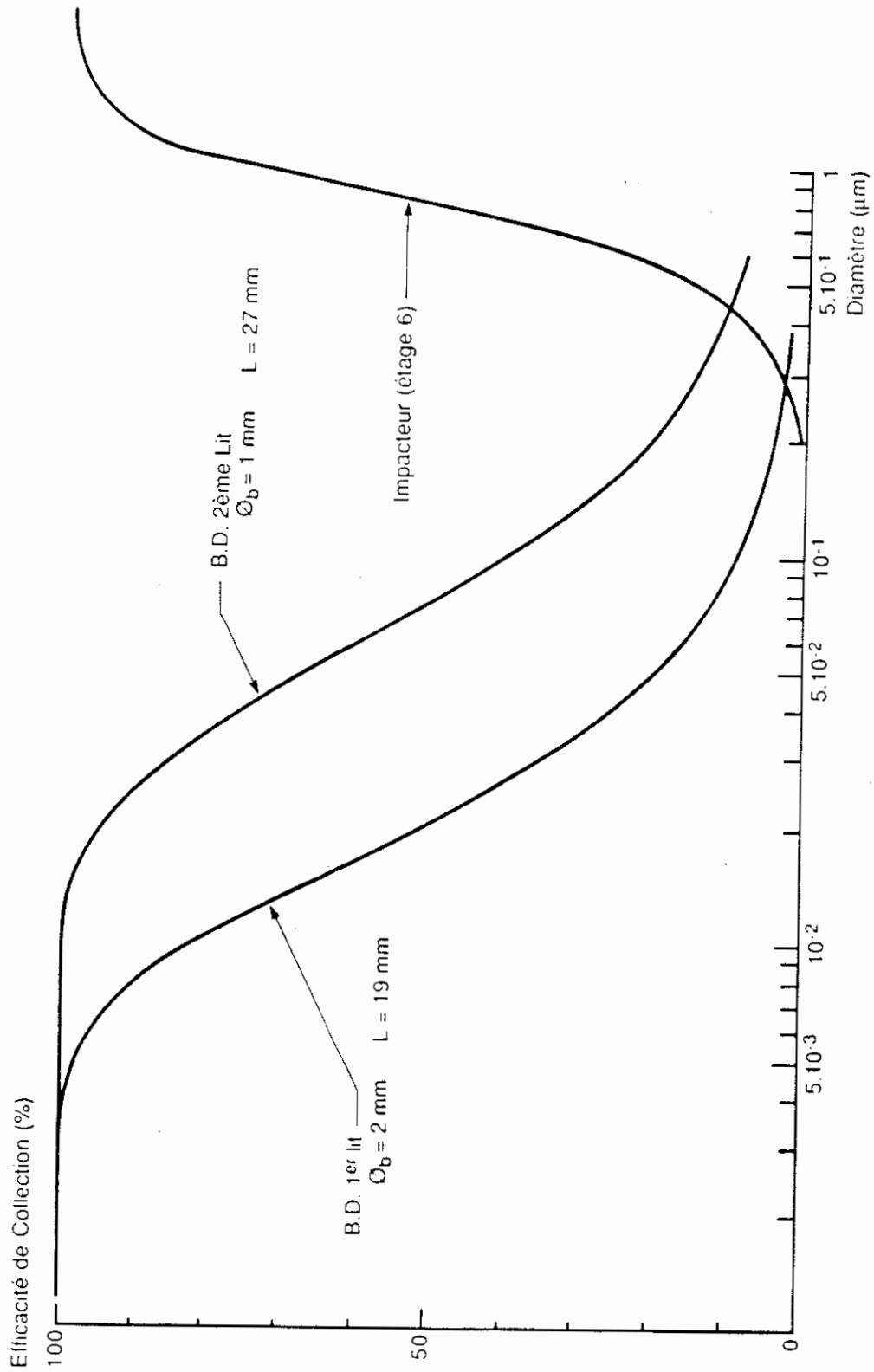
Instrumentation of the HEVA experimental installation  
(HEVA tests 03 to 06)



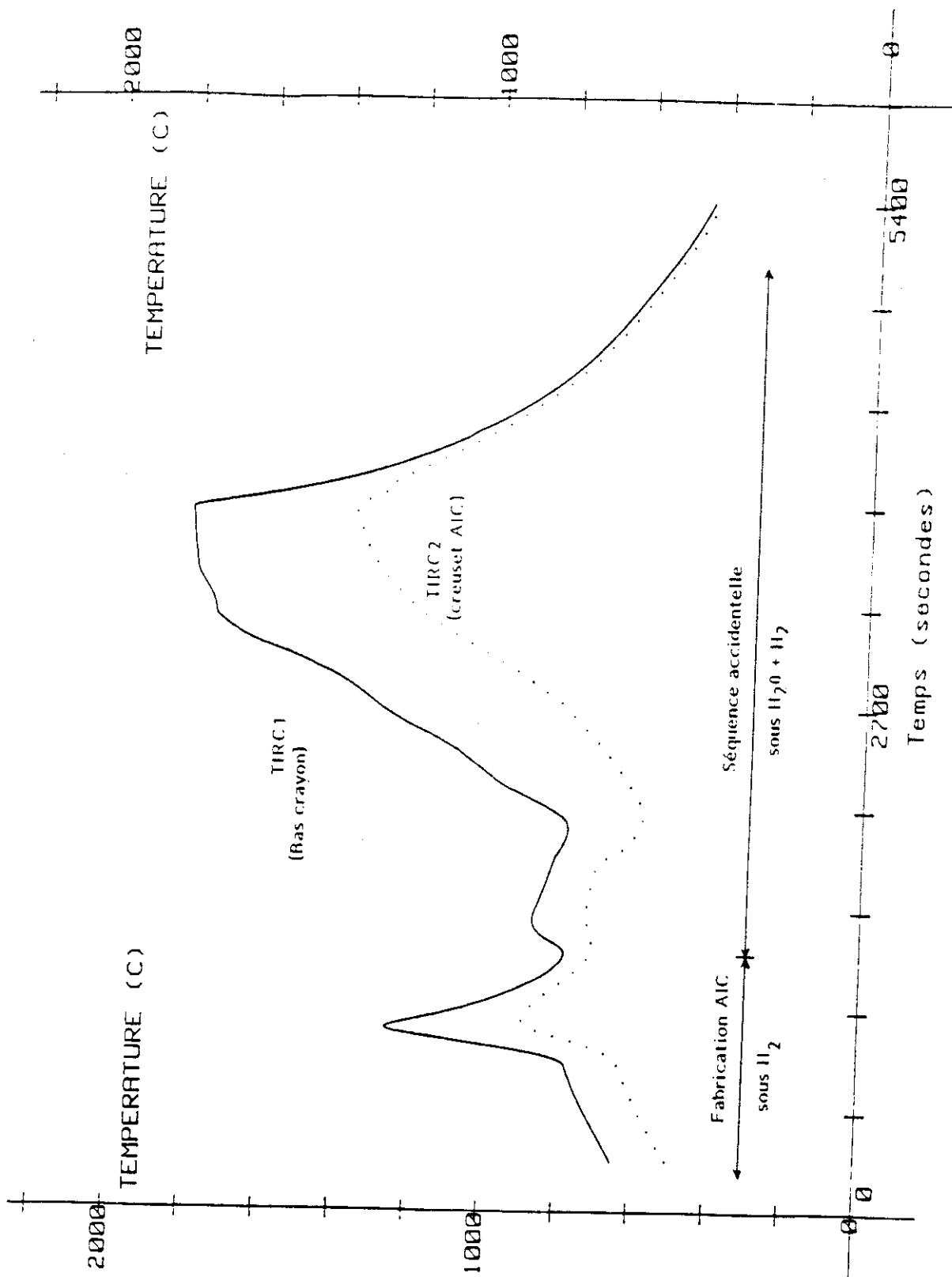
Aerosol collector. Simplified diagram of the extension to the collector measurement domain with a granular bed (HEVA 05 to 08)



Detail of granular beds

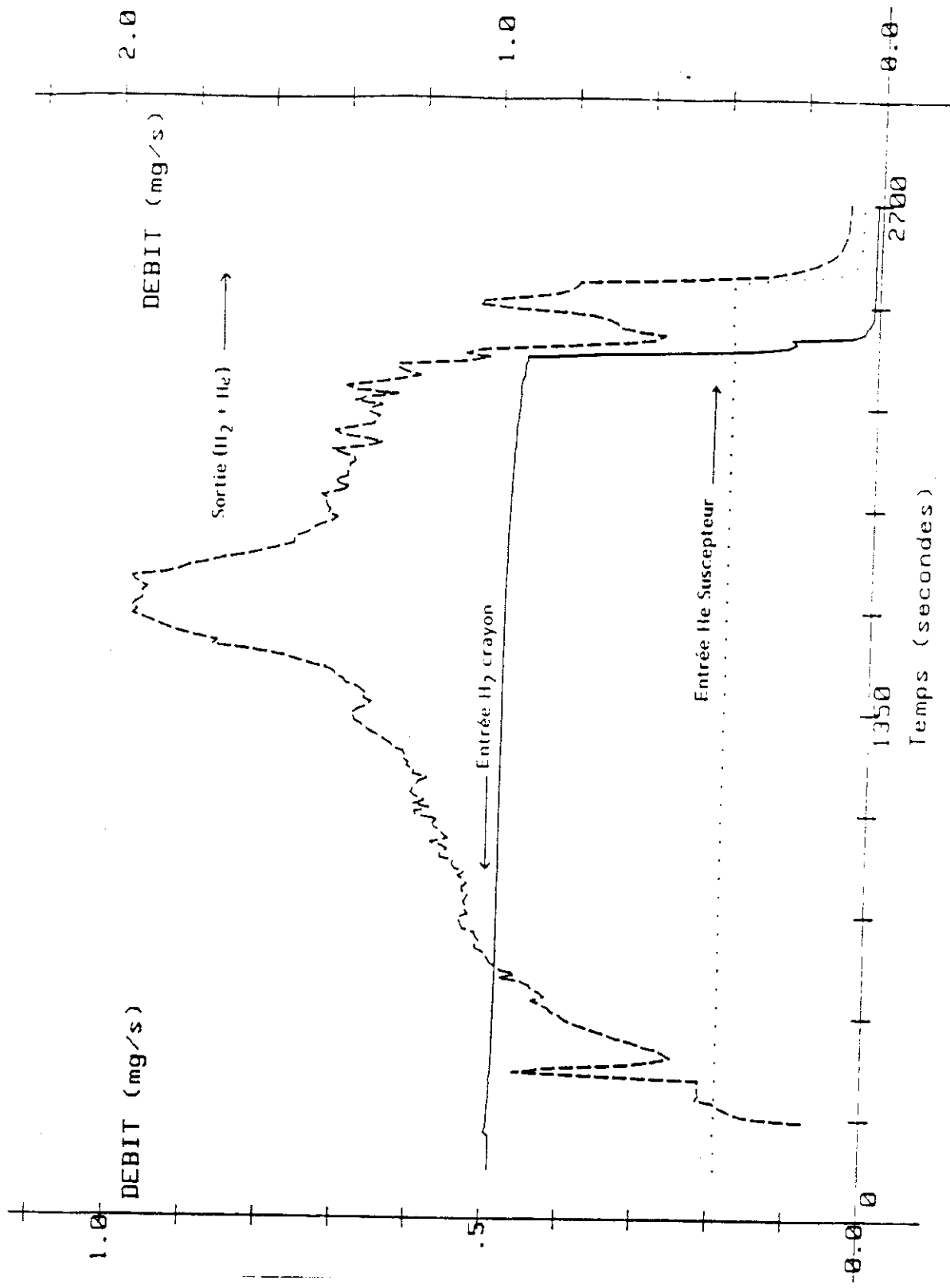


Collection efficiency as a function of particle diameter for the two granular beds and last stage of the impactor (HEVA test 05).



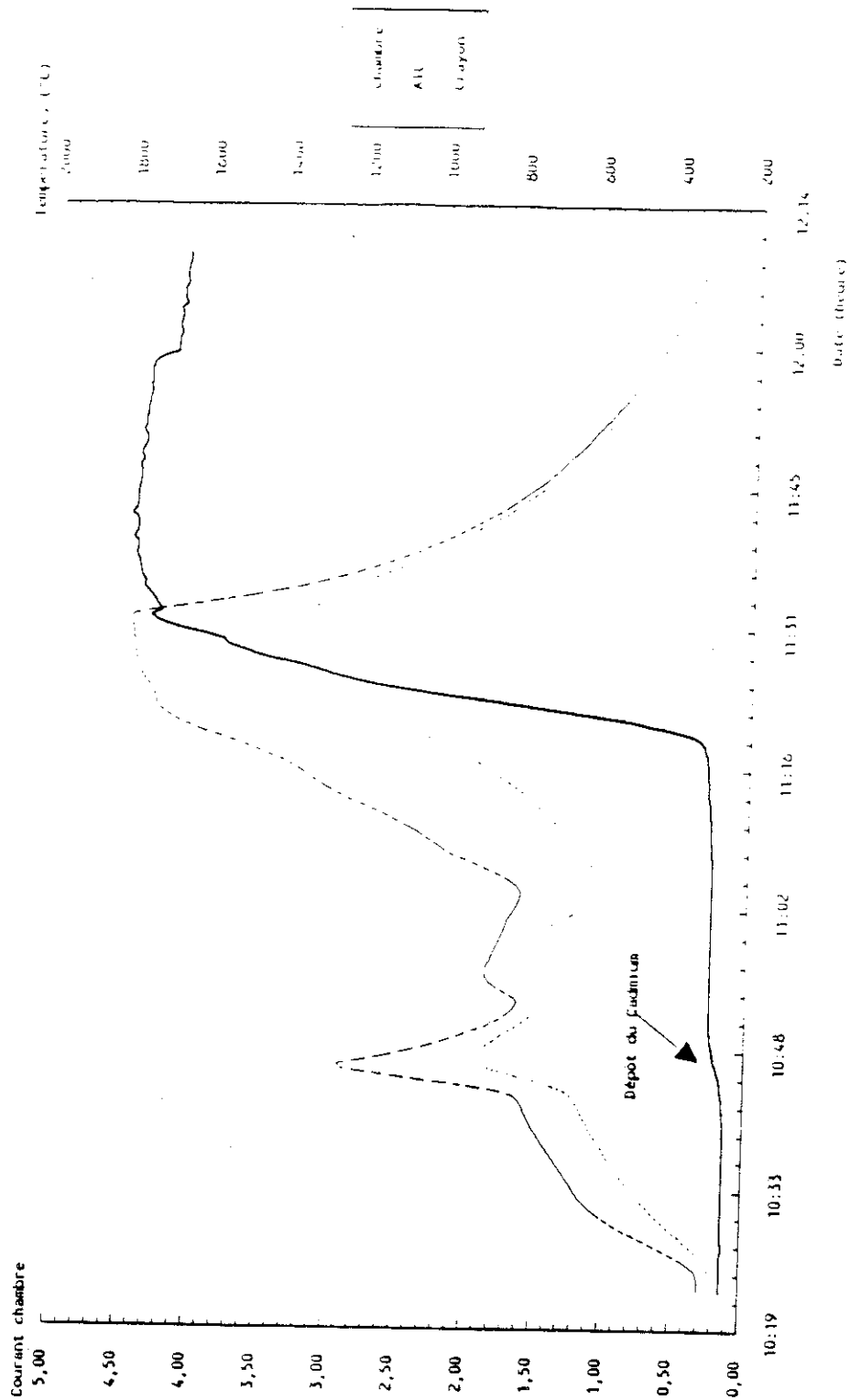
Temperature variation as a function of time (HEVA 08)

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Flow rate variation as a function of time (HEVA 08)

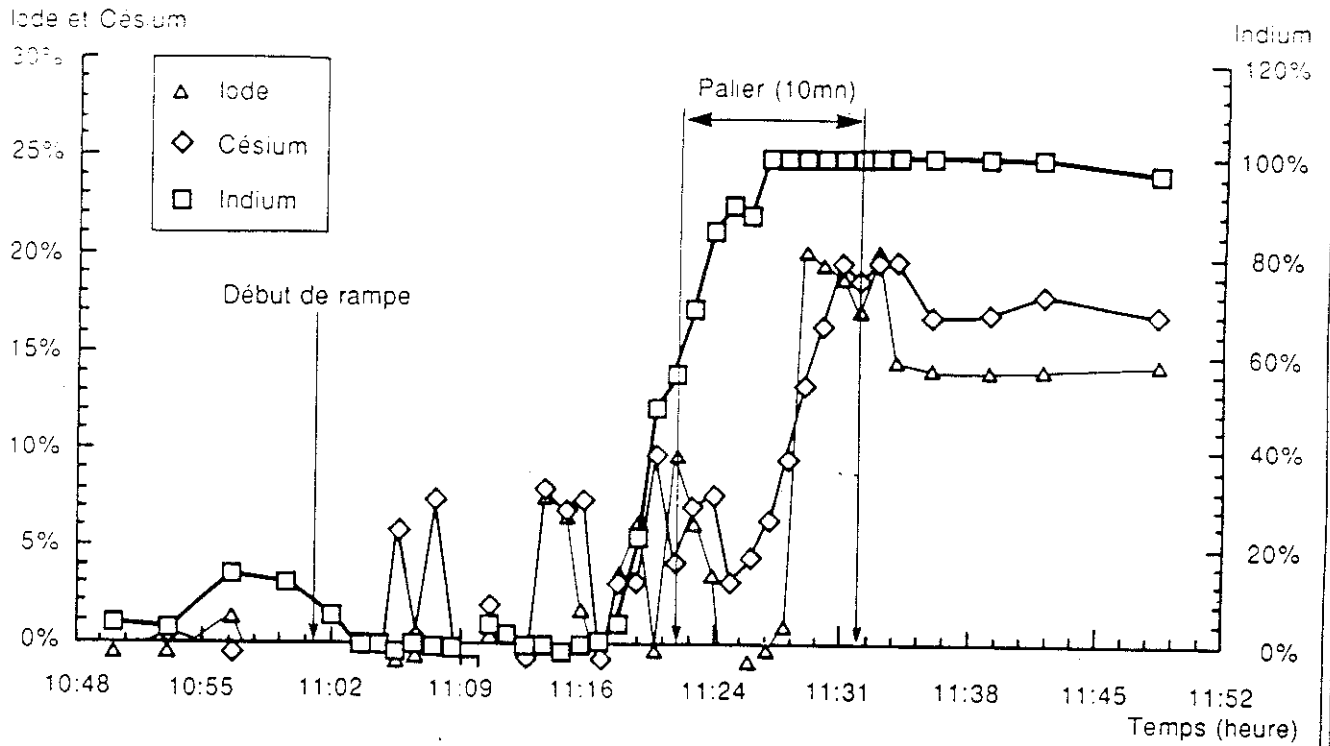
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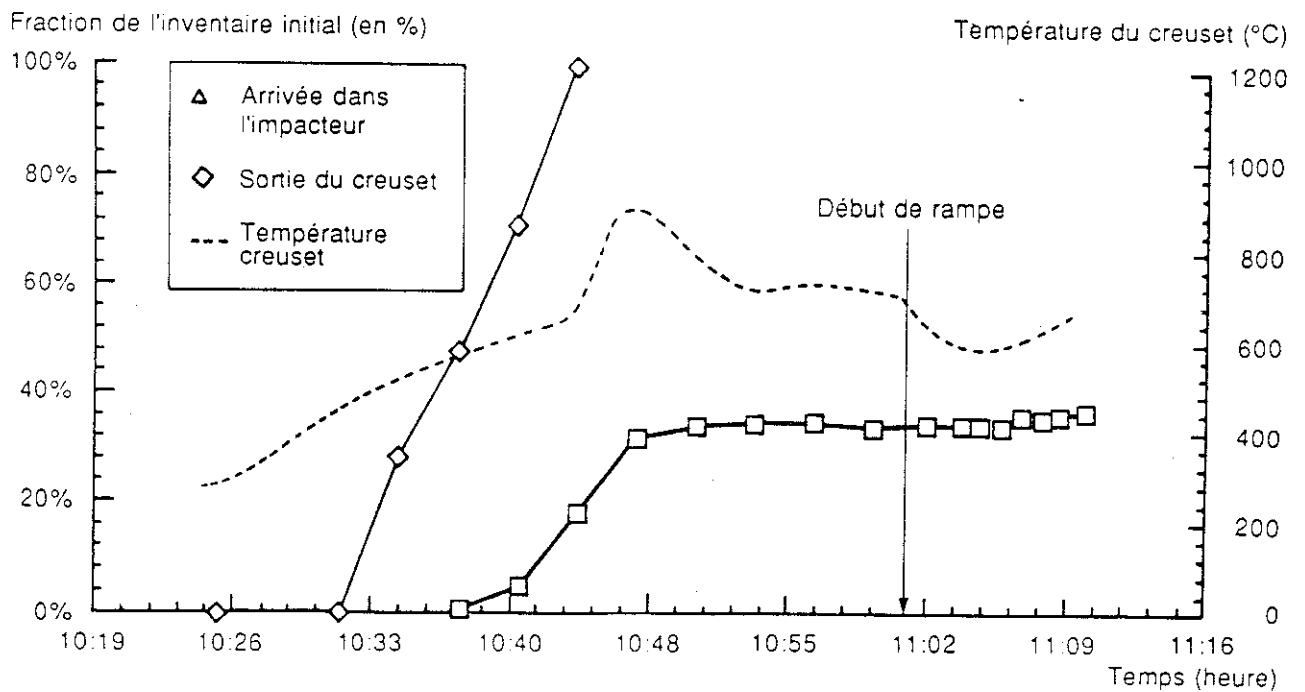
Activity variation in the impactor as a function of time (HEVA 08)

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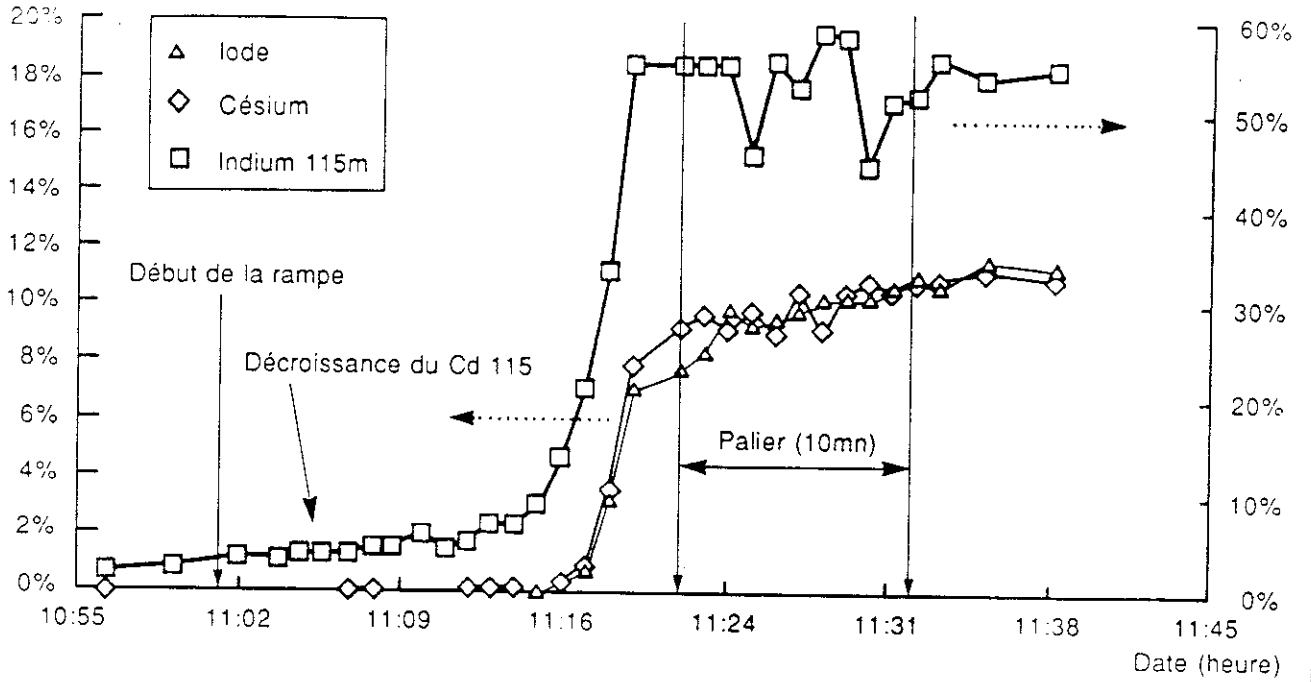


HEVA 08 - Iodine, caesium and indium release kinetics (% of initial inventory).



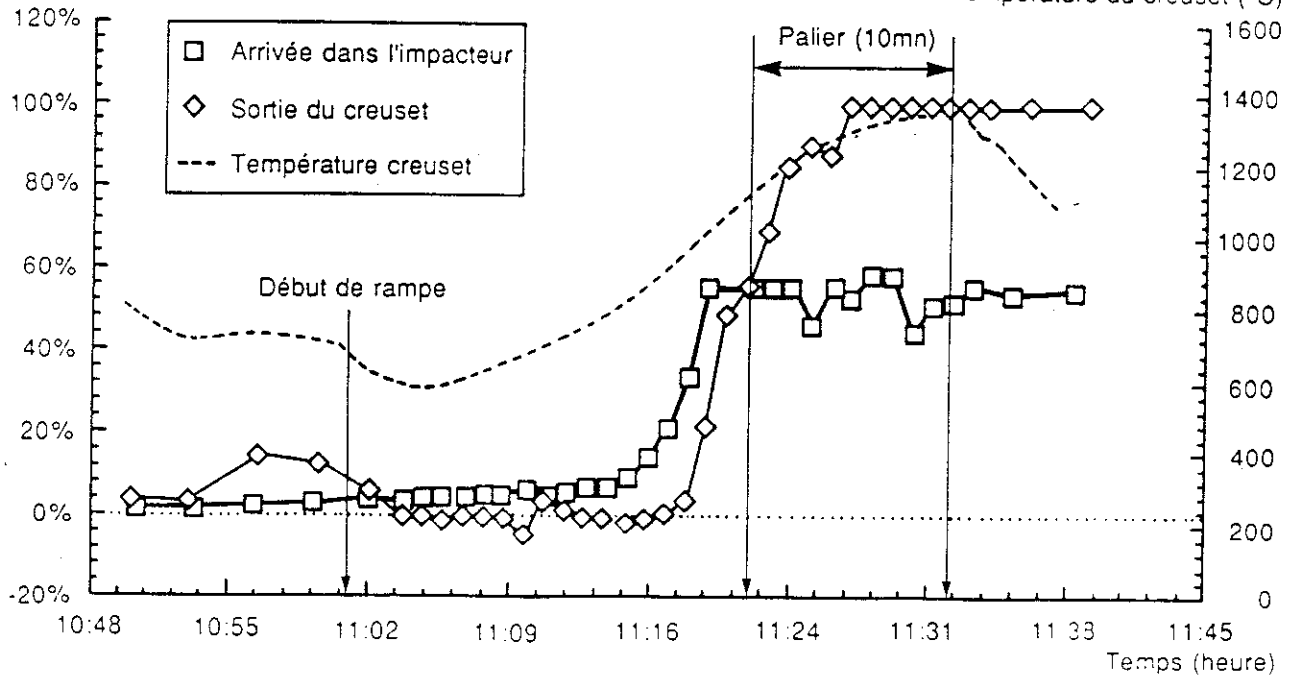
HEVA 08 - Cadium release and deposition in the impactor

Fractions relâchées (en %)

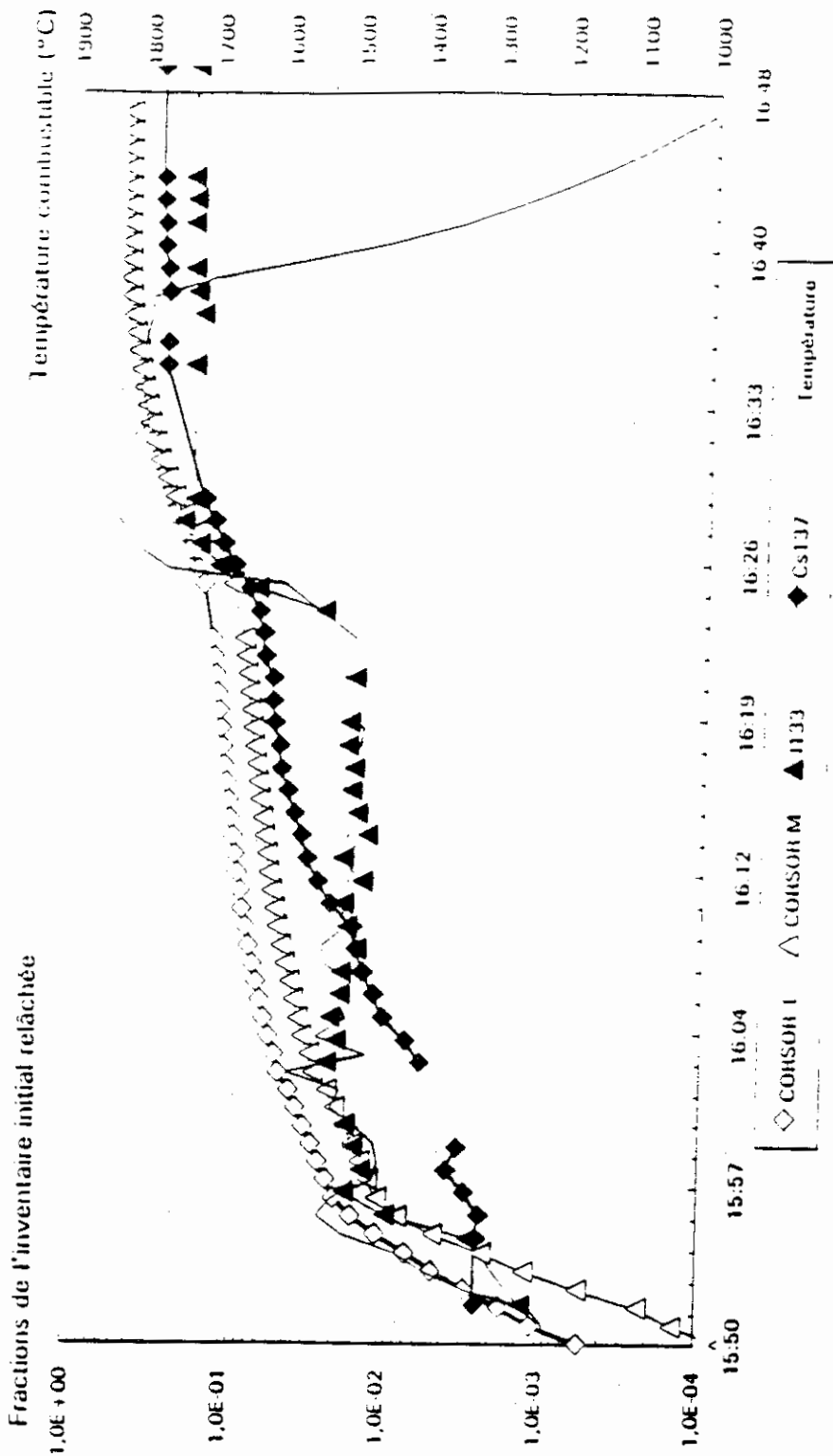


HEVA 08 - Iodine, caesium and indium deposition kinetics in the impactor

Fraction de l'inventaire initial (en %)

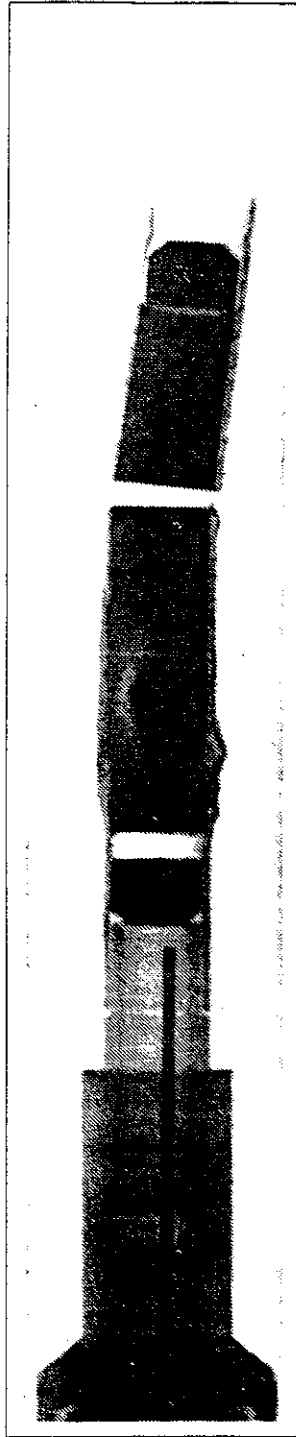


HEVA 08 - Indium release and deposition kinetics



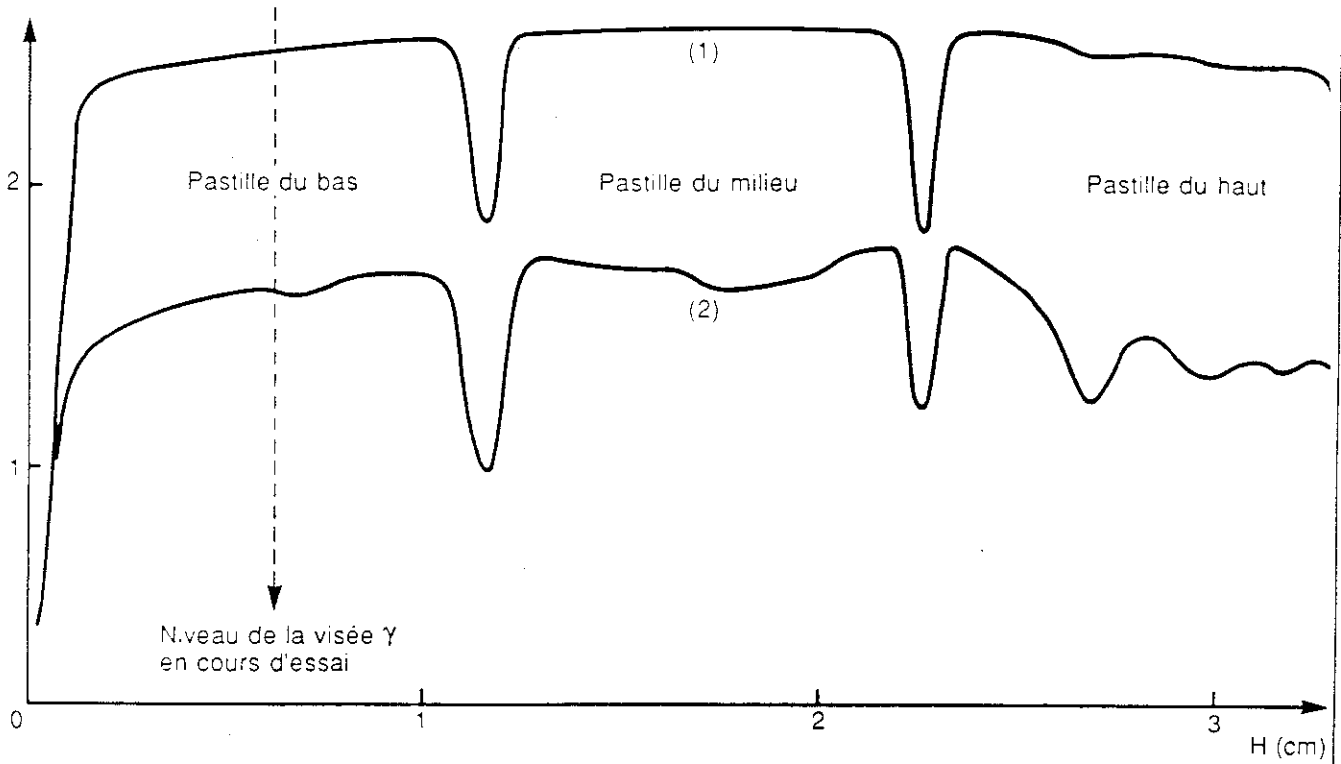
Comparison between calculation and on-line measurement for iodine and caesium release during a high temperature sequence

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Fuel rod X-ray picture after test (HEVA test 06)

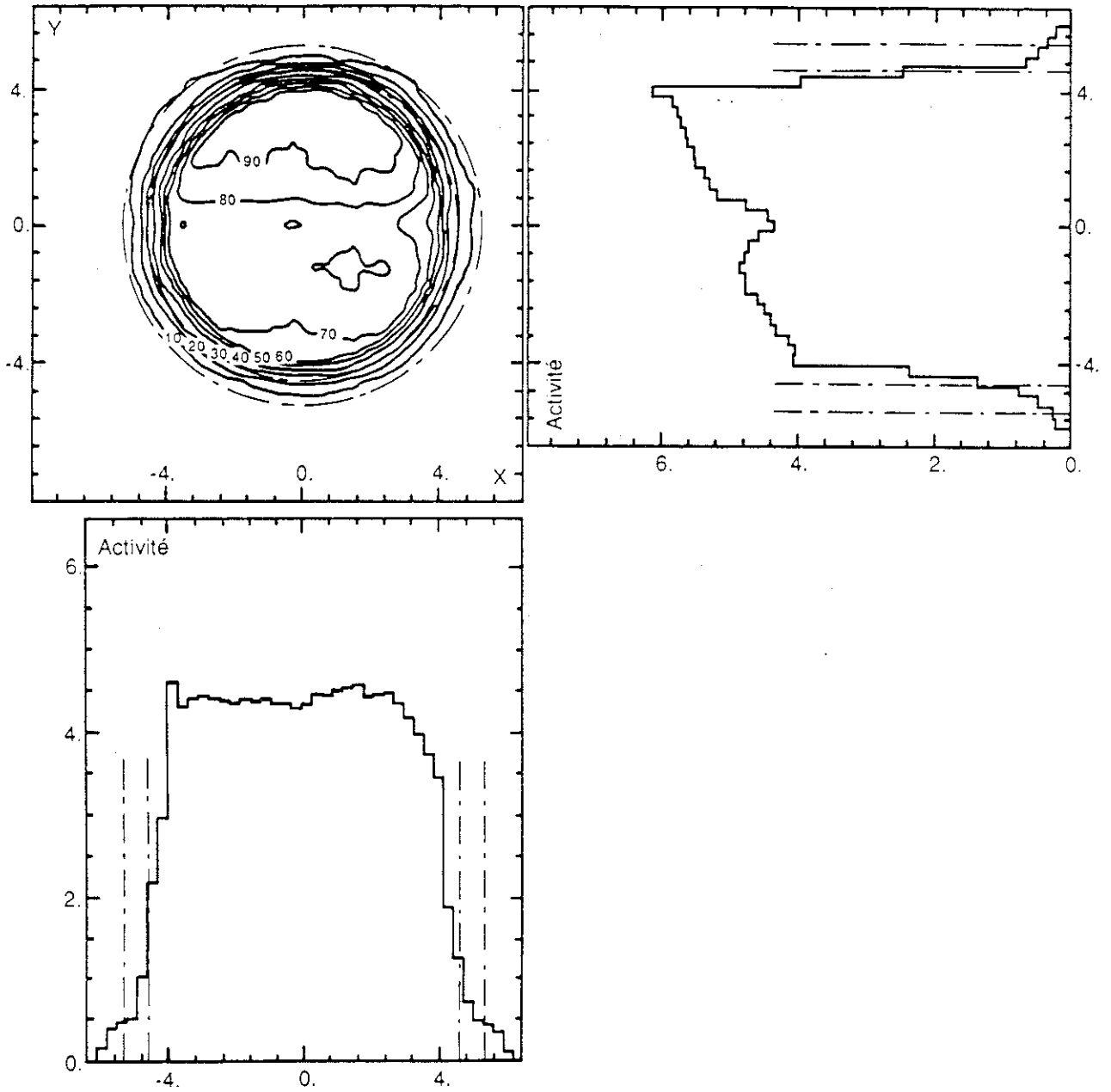
Activité délivrée par l'ictomètre  
(unités arbitraires)



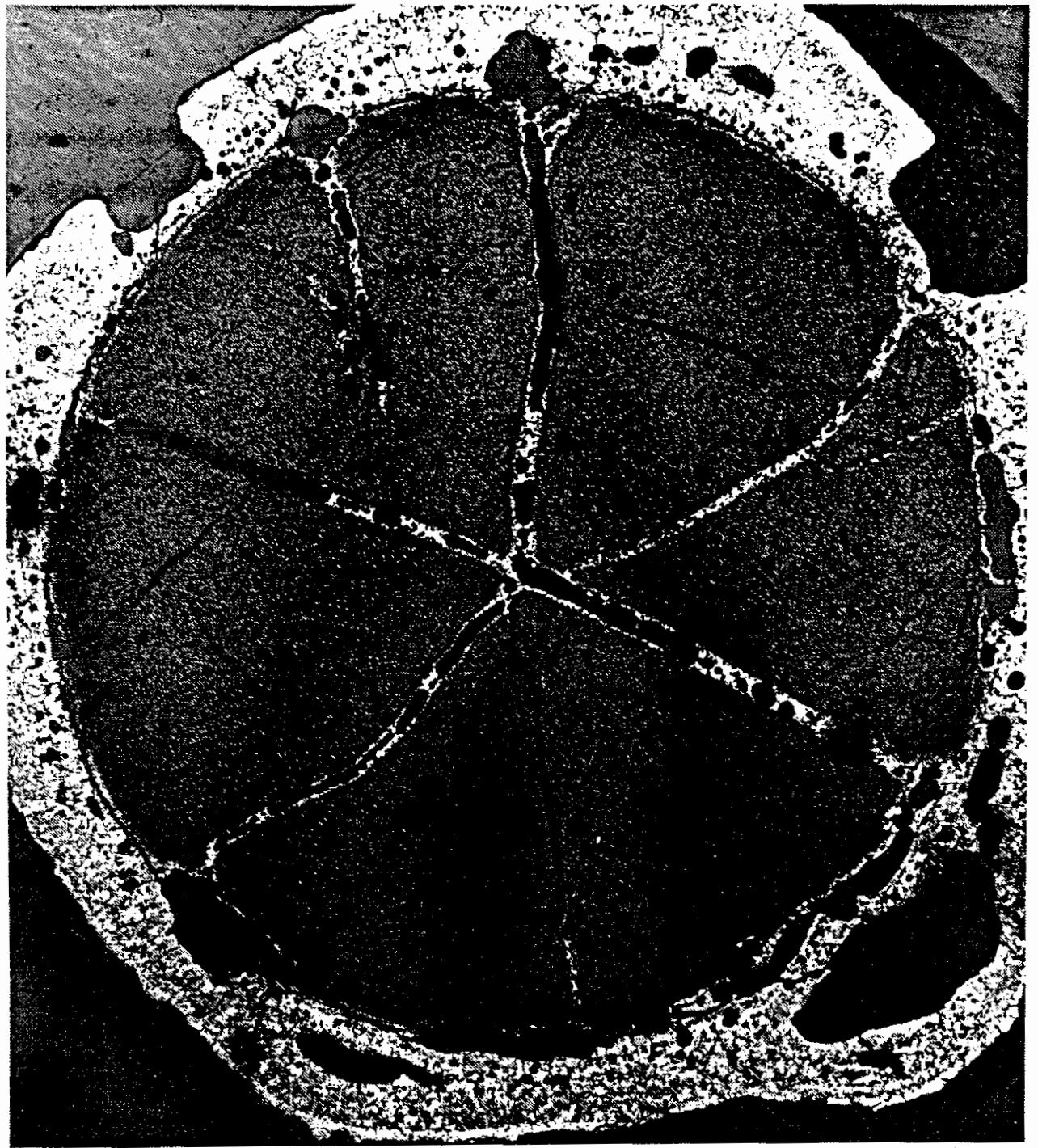
Axial  $\gamma$ scanning of the fuel rod (HEVA test 03)

(1) : Before test

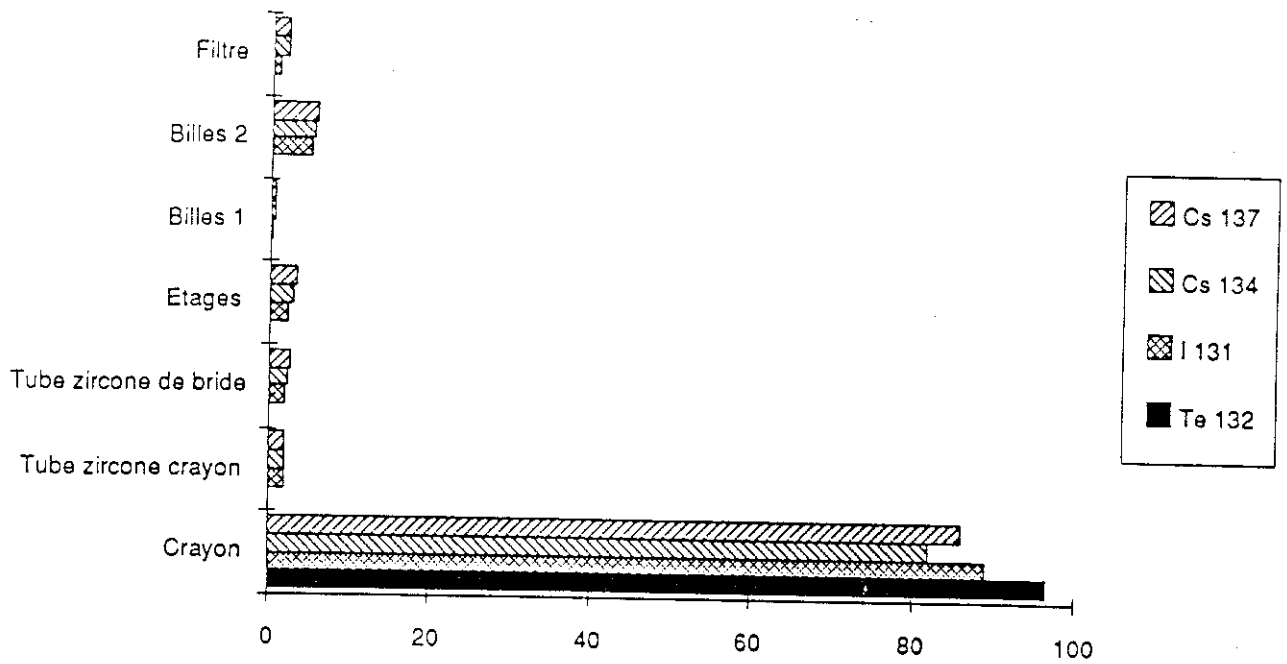
(2) : After test



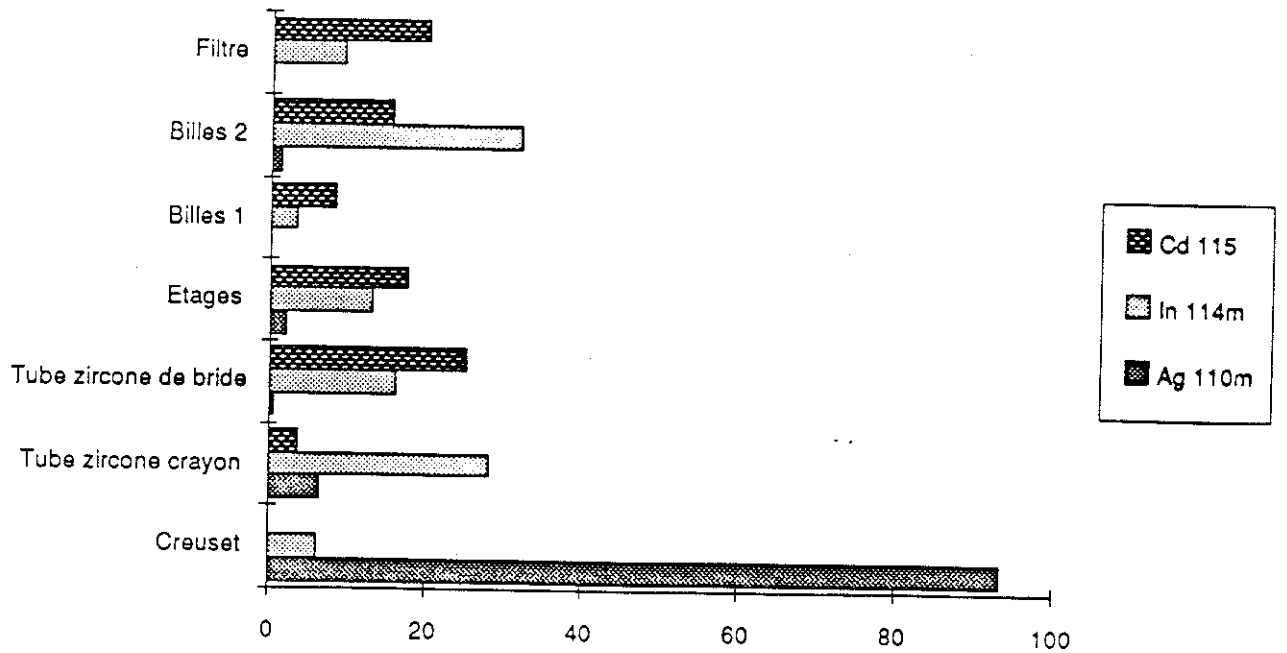
$\gamma$  tomograph.  $\text{Te}^{132}$  distribution in the rod and cladding  
(HEVA test 06)



Macrograph of fuel pellet (HEVA test 06. Bottom pellet)

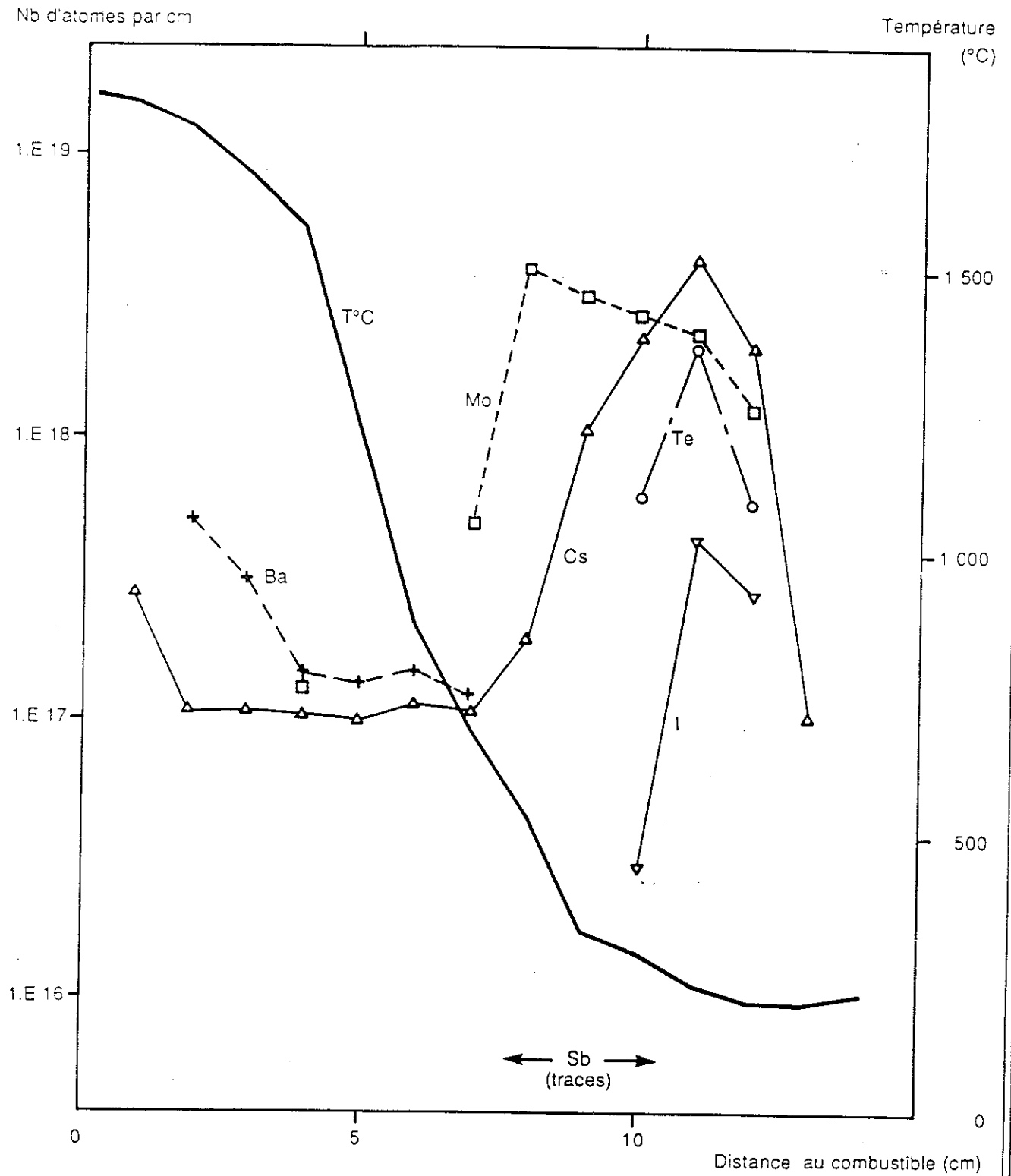


HEVA 08 - Percentage of initial inventory found in the components of the experimental device (fission products)

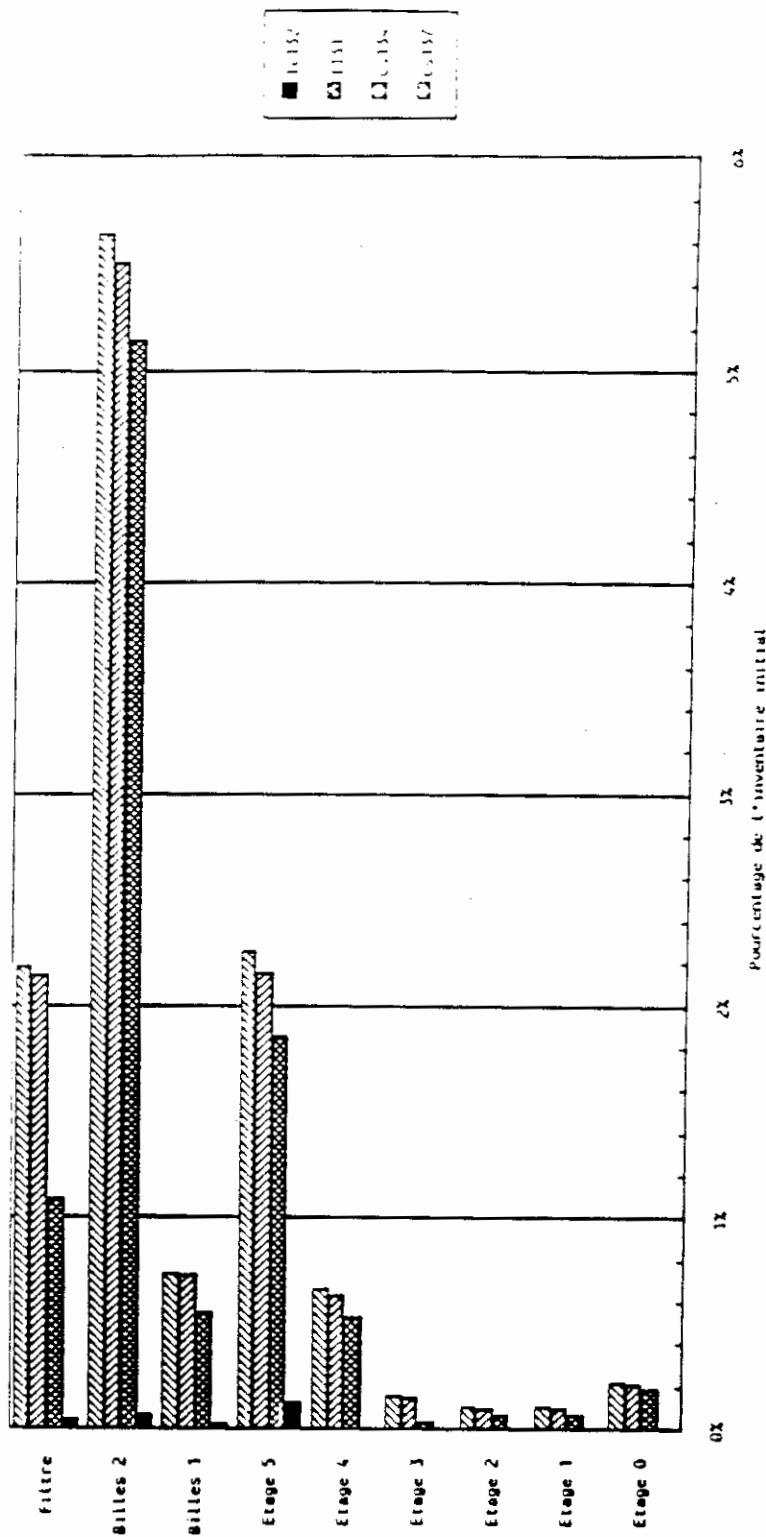


HEVA 08 - Percentage of initial inventory found in the components of the experimental device (silver, cadmium, indium)



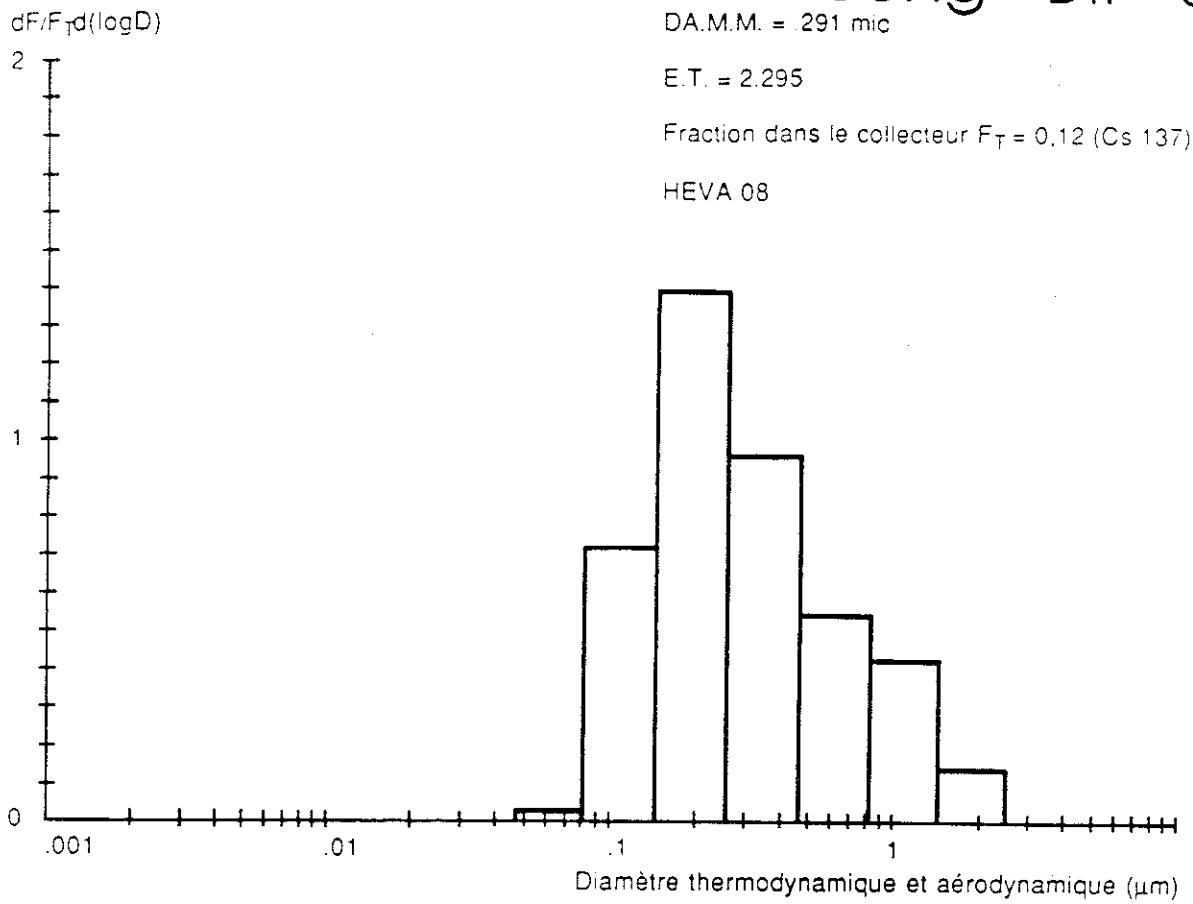


HEVA 05 - Deposition profile of I, Cs, Te, Mo, Ba, Sb on ZrO<sub>2</sub> tube above the fuel rod

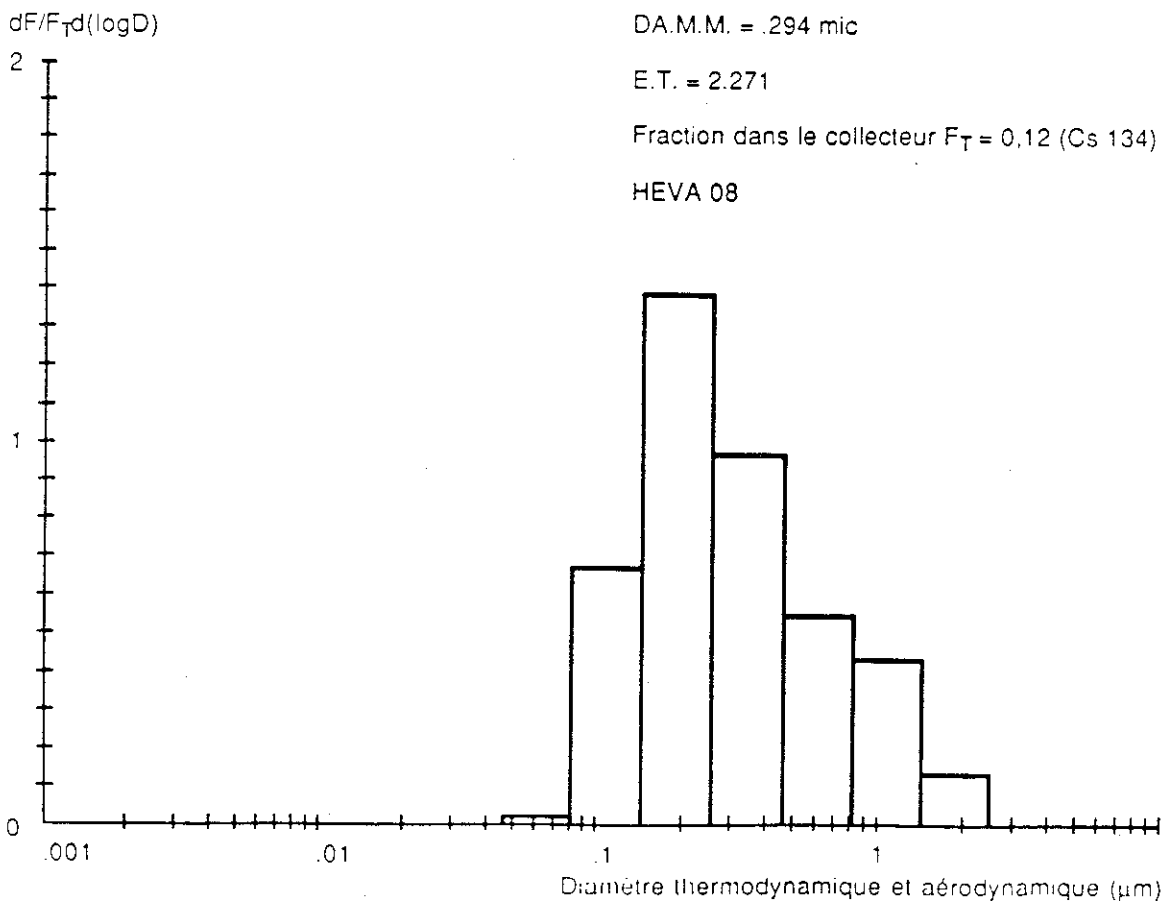


Measurement of fission product activity in the impactor components (HEVA 08)

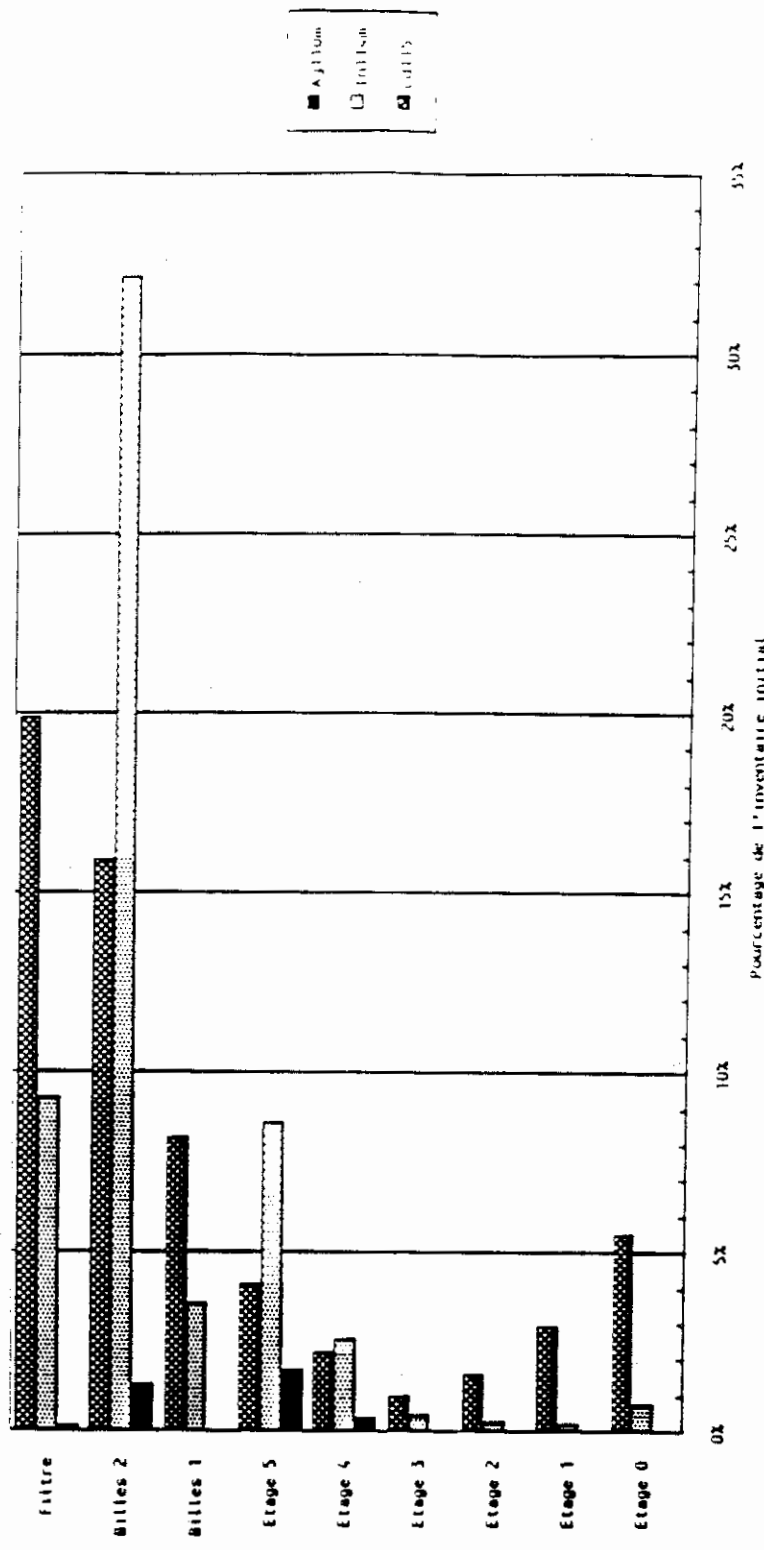
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HEVA 08 - Dimensional distribution of the inventory fraction measured by gamma spectrometry in the collector (Cs<sup>137</sup>)

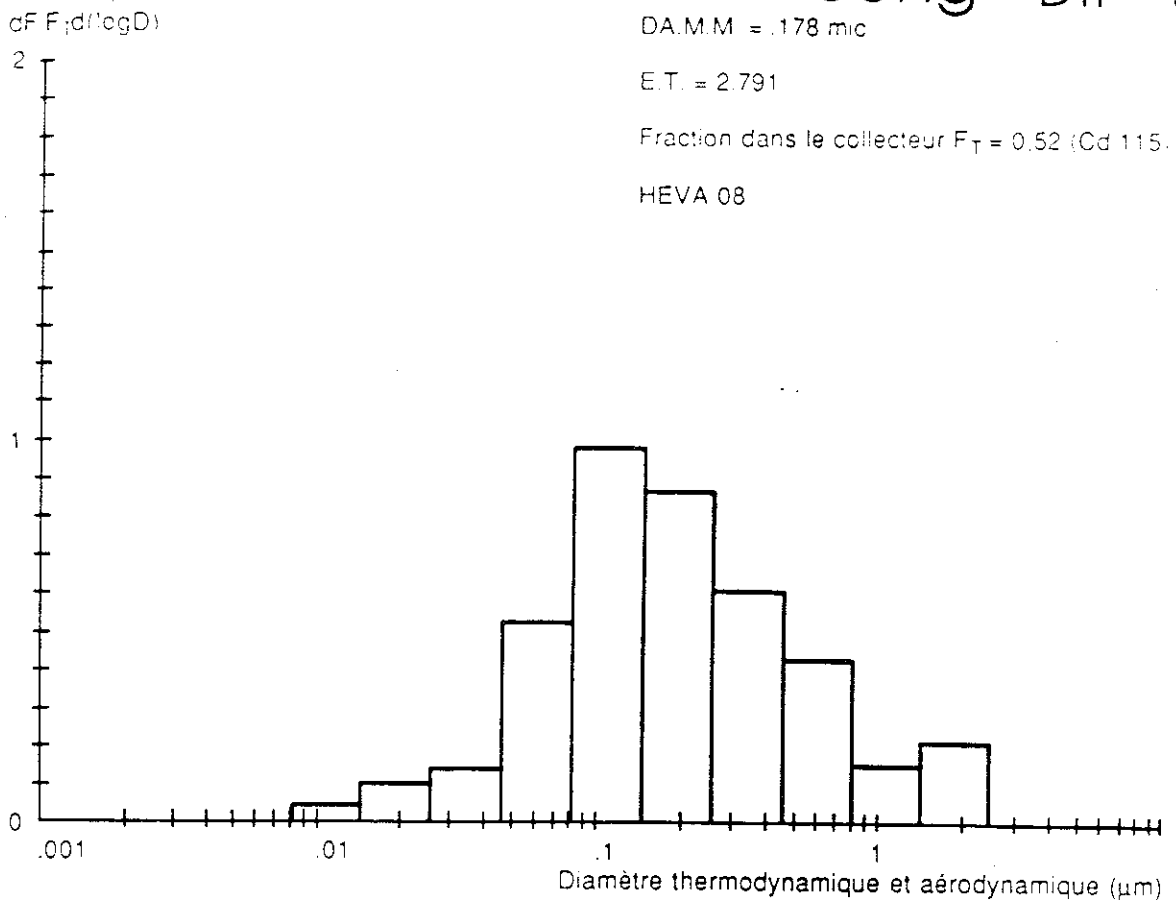


HEVA 08 - Dimensional distribution of the inventory fraction measured by gamma spectrometry in the collector (Cs<sup>134</sup>)

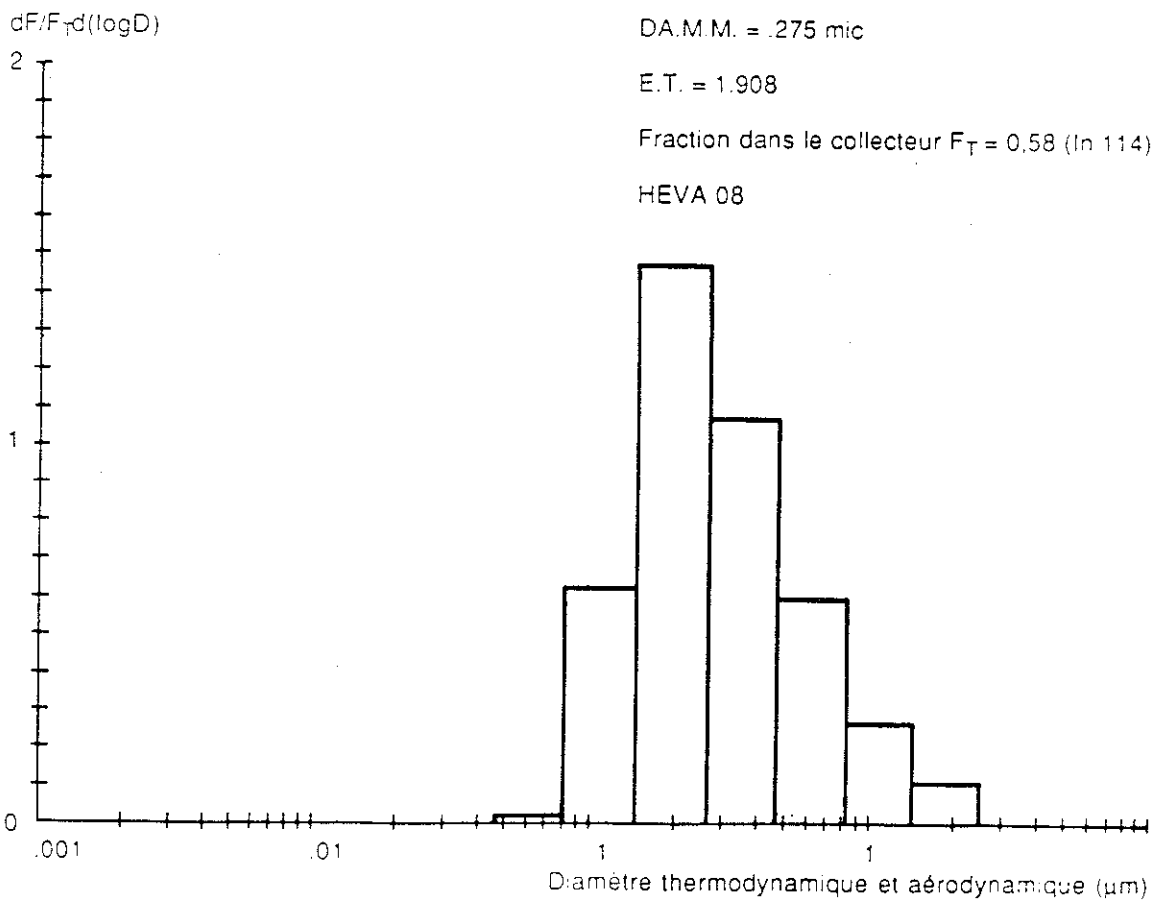


Measurement of AIC component activity in the impactor (HEVA 08)

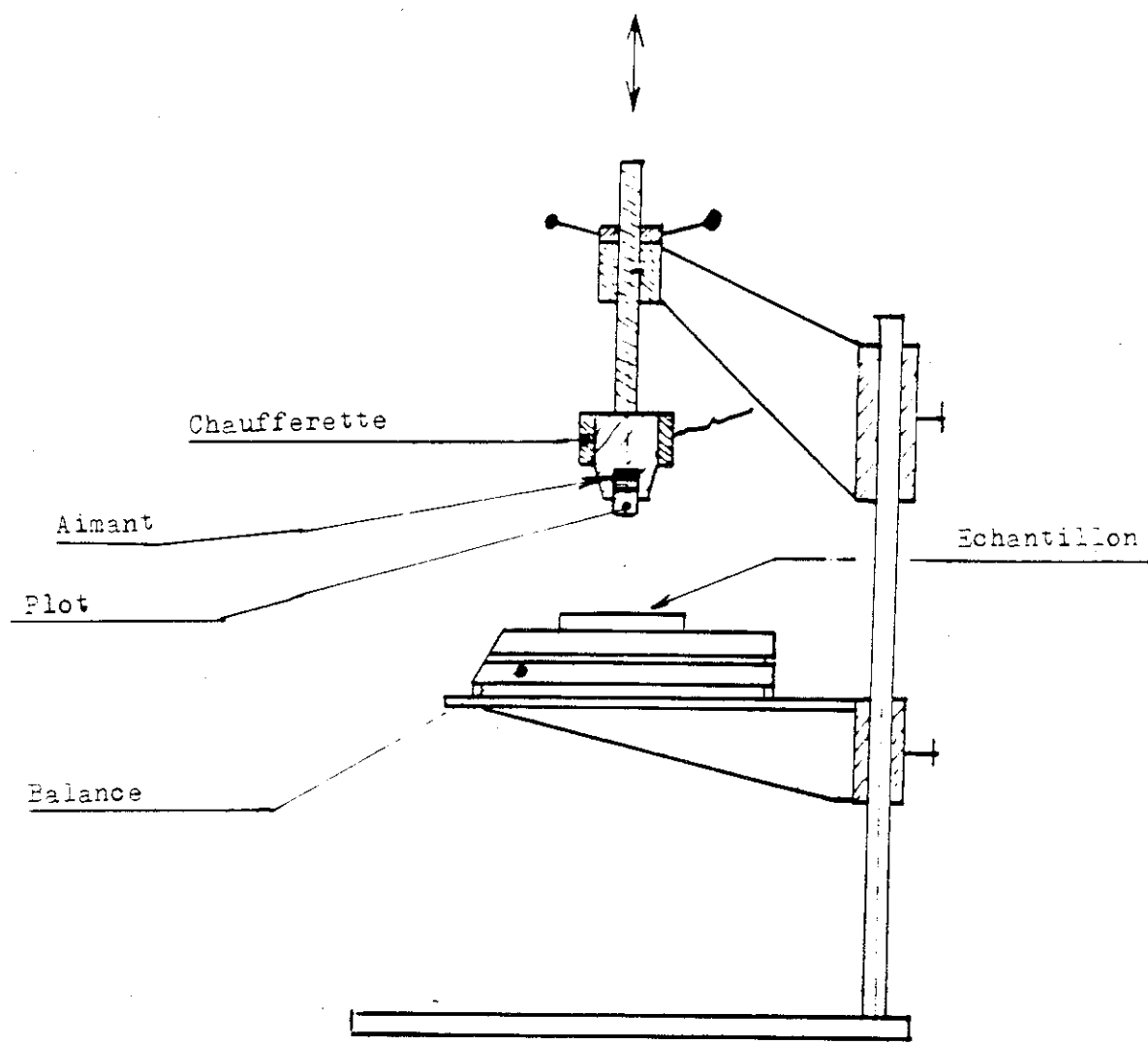
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HEVA 08 - Dimensional distribution of the inventory fraction measured by gamma spectrometry in the collector (Cd115)



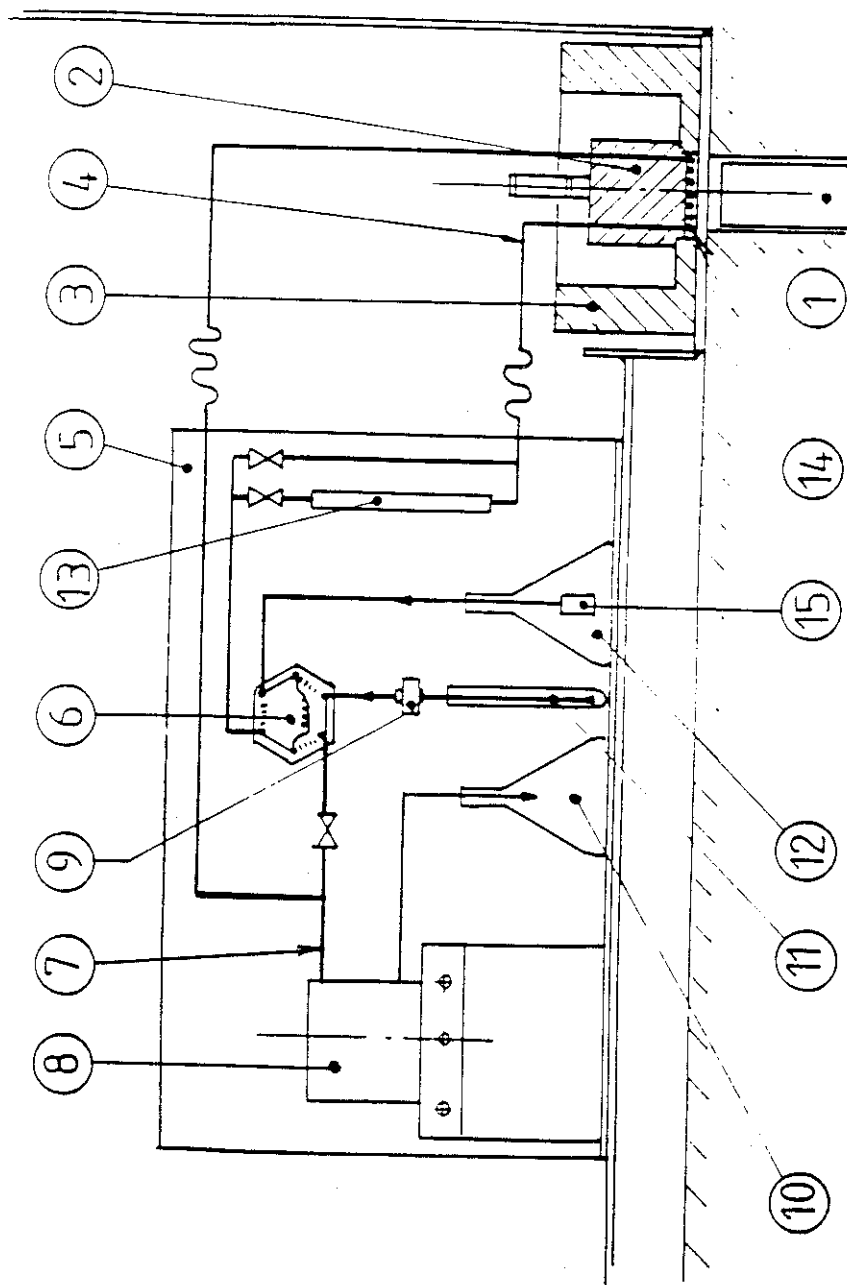
HEVA 08 - Dimensional distribution of the inventory fraction measured by gamma spectrometry in the collector (In 114)



Sampling on preglued stub

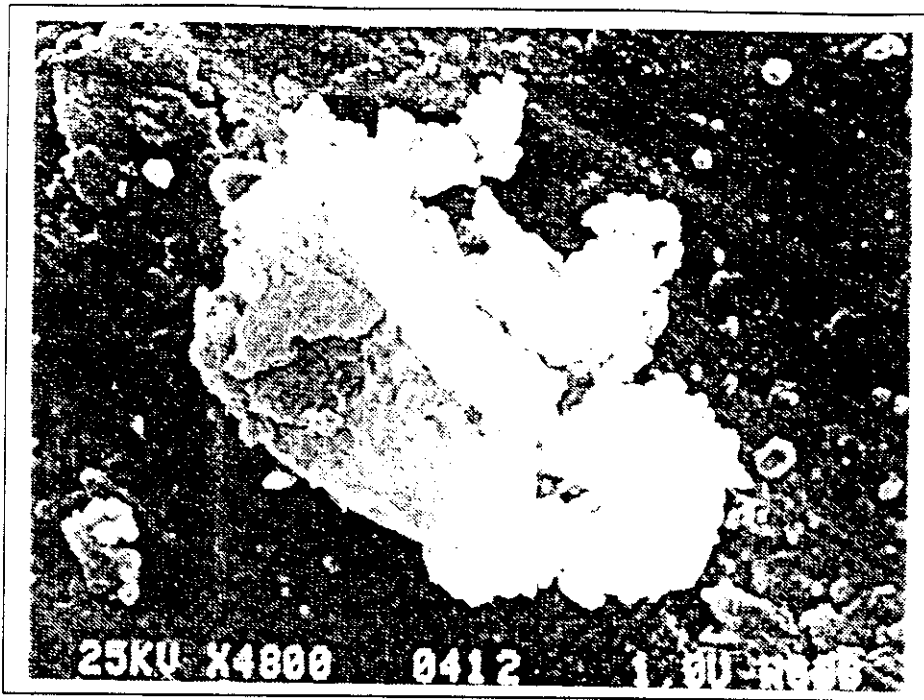
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- 1 : Diode portable
- 2 : Support
- 3 : Protection de plomb
- 4 : Ligne (aller)
- 5 : Platine
- 6 : Vanne 6 voies
- 7 : Ligne souple (retour)
- 8 : Pompe péristaltique
- 9 : Filtre avec raccord
- 10 : Recueil des effluents
- 11 : Echantillon à analyser
- 12 : Récipient d'eau
- 13 : Colonne de séparation
- 14 : Volume d'analyse
- 15 : Filtre



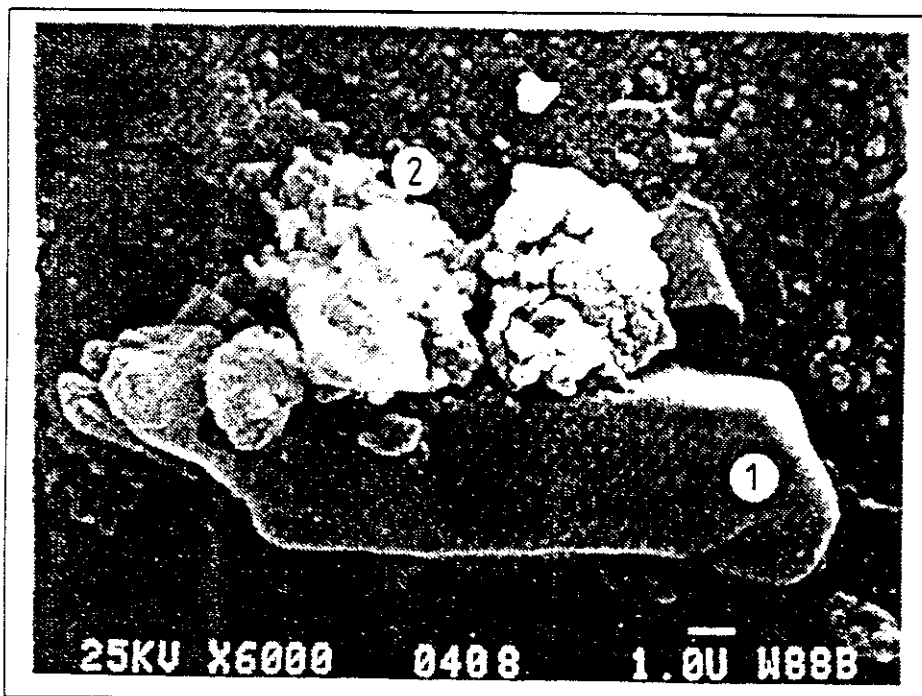
Ion chromatography

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Composition

Elément	Wt %
Al	18,1
Si	3,1
Mo	9,9
Cs	3,4
Cr	5,8
Fe	15,8
Ni	5,4
Zr	4,6
Ti	30,5



Composition

Elément	Wt %	
	1	2
Na	5,5	5,6
Al	8,1	9,0
Si	4,4	3,5
Mo	4,0	36,1
Cs	52,7	11,4
Cr	7,7	3,4
Fe	11,1	17,9
Ni	3,0	2,3

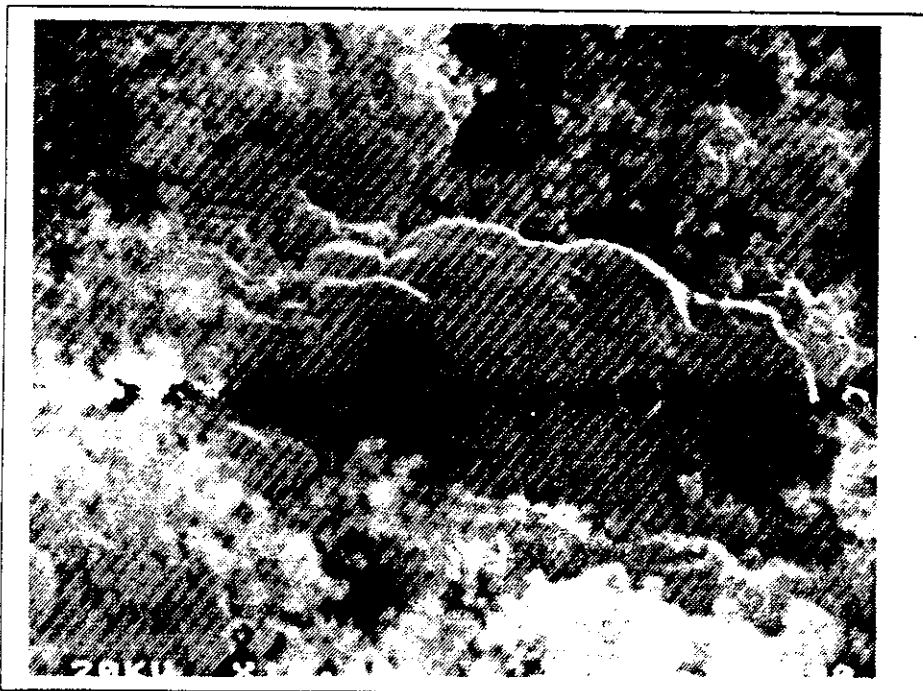
HEVA 04 - View of a fragment of the last stage of the impactor.  
 Particles rich in caesium and molybdenum (after 15)





	at. %
Cs	2
Rb	< 1
I	< 1
Te	3
Ag	10
In	70
Cd	6
Sn	6

Aspect général et analyse moyenne



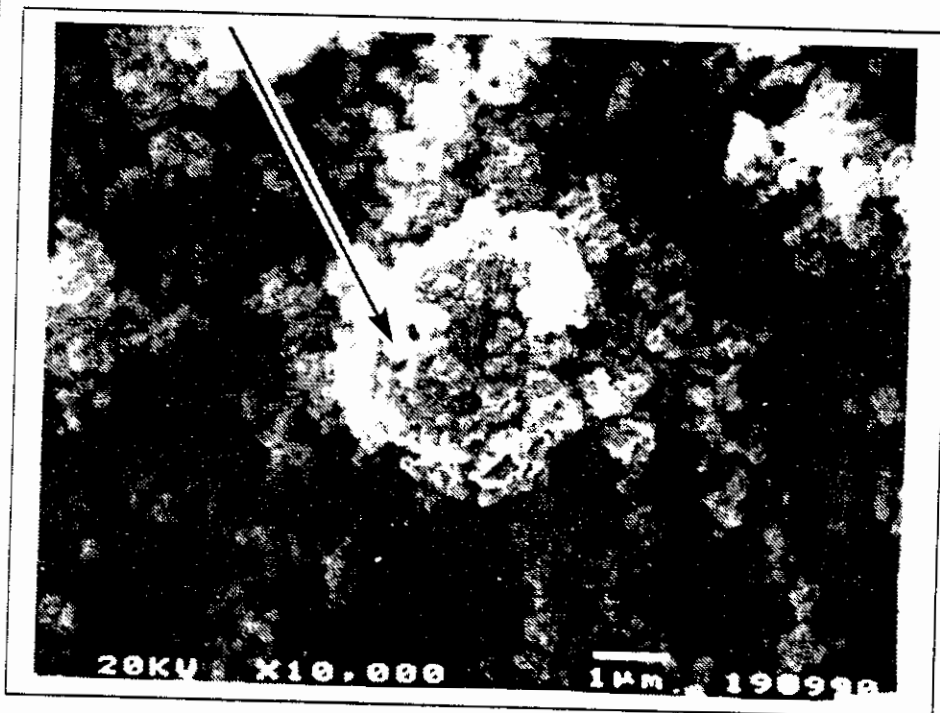
	at. %	
	(*)	(**)
Cs	6	48
Rb	2	2
I	< 1	< 1
Te	< 1	< 1
Ag	10	2
In	66	43
Cd	5	3
Sn	8	< 1

(\*) : hors particule  
 (\*\*) : particule

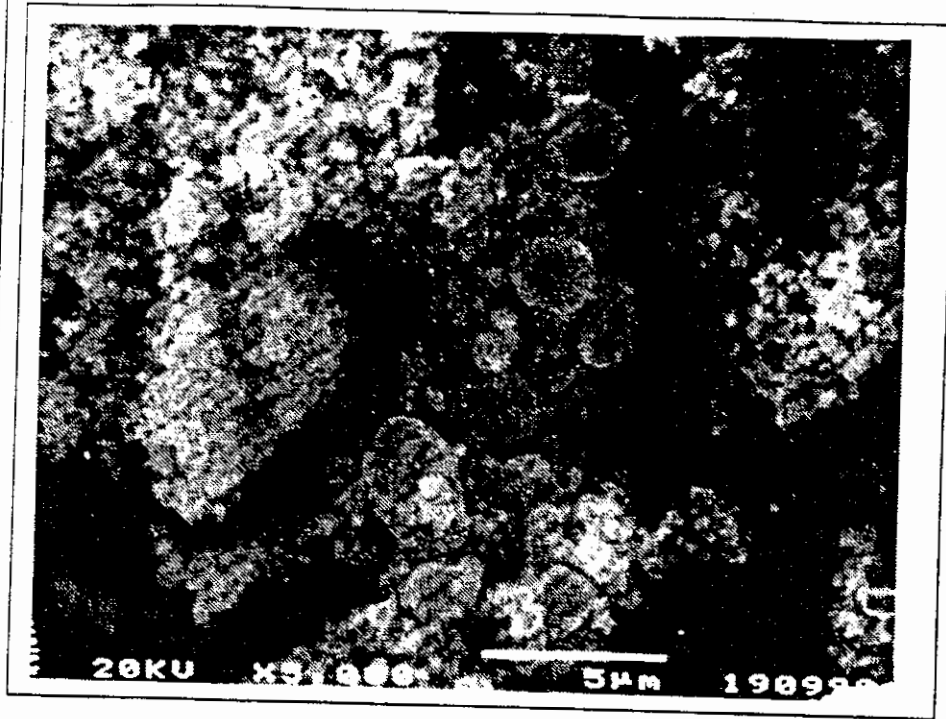
Particule riche en césium

Scanning electron microscopy examination of a sample on TEMPFIX glue  
 (HEVA 08)

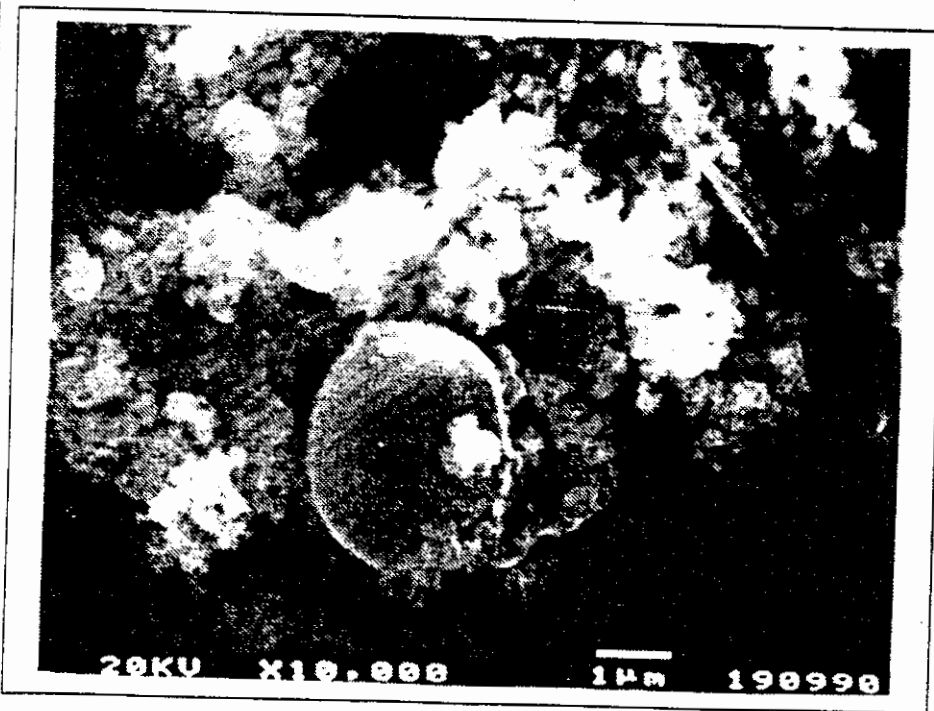
Ag	4	1
In	54	30
Cs	3	42
Cl	1	2
Cd	34	17
Te	2	.
Sn	.	.
I	.	.
Rb	.	8



HEVA 08 - Sample taken from filter surface. Caesium-rich cluster.



Ag	17	17	17	7
In	3	2	.	.
Cs	0	.	.	.
Cl	0	.	.	.
Cd	78	80	82	91
Te	.	.	.	.
Sn	.	.	.	.



Ag	16
In	2
Cs	.
Cl	.
Cd	80
Te	.
Sn	.

HEVA 08 - Sample taken from filter surface. Cadmium-rich spherical particles.

# HEVA. SOME RESULTS

## 1 - Fractional release rate coefficients

F (mn E-1 ) compared to CORSOR

- Cs,I,Xe,Kr : ~ / 3
- Sb : ~ \* 3
- Mo : ~ \* 5 a 10
- Ba : ~ =
- Ru,Zr : ~ \* 10

In H2O + H2

## 2 - Reducing conditions

F ( mn E-1 ) compared to H2O + H2

- Cs,I : ~ / 3
- Te,Mo : ~ / 10
- Ba : ~ \* 10

## 3 - Control rod components

?

## 4 - Aerosol sizing

- 800 C = Vapour phase
- 250 C = DAMM < 0.3 micron

WEAK INFLUENCE OF

- Reducing atmosphere
- Control rod components

## 5 - Chemistry

- Cs : Mainly CsOH silicates, carbo.
- I : I and Cs not deposited in the same places
- Te : + CsOH  $\xrightarrow{?}$  Cs<sub>2</sub>Te, SnTe
- Mo : MoO<sub>3</sub> ( ESCA )
- Sn : SnO<sub>2</sub> ( ESCA )
- U : UO<sub>2</sub> + 0,25

# VERCORS Improvements

## 1 - High temperature furnace

Low volatile F.P. release (up to fuel melting)

## 2 - Instrumentation

- Pyrometry : HT measurement

- Gas chromatography : Zy oxidation )  
( on line

- Gas spectrometry : NG release )

- T.G.T. : vapour phase deposits

=> DEVAP tests

- Sequential impactor : imp. aerosol sizing

- Iodine filter : Iodine chemistry

## 3 - PTA . chemistry

- Specific dissolutions

- Ion chromatography

- ESCA + IR

Chemical bondings

## 4 - Silver, Indium, Cadmium.

Injection studies (Flow, size)

=> EMAIC tests