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Experimental Determination of the Atmospheric Dispersion Parameters at the Karlsruhe Nuclear Research Center for 60 m and 100 m Emission Heights

Part 2: Evaluation of Measurements

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Abstract

Experiments are carried out at the Karlsruhe Nuclear Research Center in order to determine the atmospheric diffusion of pollutants. The influence on atmospheric diffusion by conditions specific to the site will be investigated.

For evaluation of the measurements the diffusion is assumed to be a steady-state process. A two-dimensional Gaussian distribution is used as the theoretical approximation of the concentrations. The dependence of the dispersion parameters σ_y and σ_z on the downwind distance is described by a power function. A least squares fit is applied to calculate the horizontal and vertical dispersion parameters and the normalized diffusion factor with the respective errors from the measured wind velocity, emission rate and concentration distribution. The dispersion parameters determined are assigned to stability classes by the measured standard deviation of the vertical wind direction.

The reported dispersion parameters are derived from 19 experiments with mostly two sampling periods of 30 min duration each. In eight experiments different tracers were released simultaneously at 60 m and 100 m height.

In Part 1 of this report the diffusion experiments are described and the measured data are presented in detail. The results of earlier experiments performed at the Karlsruhe Nuclear Research Center for only one emission height of 100 m have been published already.

Experimentelle Bestimmung der atmosphärischen Ausbreitungsparameter für Emissionshöhen von 60 m und 100 m am Kernforschungszentrum Karlsruhe

Teil 2: Auswertung der Meßergebnisse

Zusammenfassung

Am Kernforschungszentrum Karlsruhe werden Experimente durchgeführt, um die Ausbreitung von Schadstoffen in der Atmosphäre zu erforschen. Standortspezifische Einflüsse sollen dabei untersucht werden.

Mittels der Methode der kleinsten Fehlerquadrate werden aus der gemessenen Konzentrationsverteilung die horizontalen und vertikalen Ausbreitungsparameter und der normierte Ausbreitungsfaktor mit den zugehörigen Fehlerbreiten ermittelt. Für die Konzentration wird eine zweidimensionale Gaußverteilung zugrunde gelegt. Die Ausbreitung wird als stationär angenommen. Ein Potenzansatz beschreibt die Abhängigkeit der Ausbreitungsparameter von der Quelldistanz. Die Zuordnung der ermittelten Ausbreitungsparameter zu Ausbreitungskategorien erfolgt über die gemessene Standardabweichung der vertikalen Windrichtung.

Die angegebenen Ausbreitungsparameter stammen von 19 Experimenten mit zumeist zwei Sammelperioden von 30 min Dauer. In acht Experimenten wurden jeweils verschiedene Tracer simultan in 60 m und 100 m Höhe freigesetzt.

Im ersten Teil dieses Berichtes werden die Ausbreitungsexperimente beschrieben und die Meßergebnisse in Form von Tabellen und Abbildungen dargestellt. Die Ergebnisse früherer Experimente am Kernforschungszentrum mit nur 100 m Emissionshöhe wurden bereits veröffentlicht.

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1. Introduction

Conventional and nuclear facilities release pollutants into the atmosphere during routine operation and in case of accidents. To assess the resulting impact on the health of the population living in the vicinity of the facility, atmospheric diffusion calculations must be performed. In general, a double Gaussian function is used as the basis of these calculations. The extension of the plume in the vertical and cross wind directions is described by the dispersion parameters σ_z and σ_y, i.e. the standard deviations of the double Gaussian function. The dispersion parameters depend on the meteorological and topographical conditions prevailing at the respective sites. Tracer experiments are appropriate for the determination of the dispersion parameters.

Those experiments in which the emission rate and downwind concentration of a tracer are measured under various meteorological conditions have been performed both elsewhere [1], [2], [3], [4] and at the Karlsruhe Nuclear Research Center (KNRC). At the KNRC the dispersion parameters have been determined as a function of the downwind distance, source height, and stability class. A first series of the KNRC-experiments, including experiments Nos. 1 to 25 for an emission height of 100 m, have been published in [5] and [6]. The measured data of experiments No. 26 to 51 for emission heights of 60 m and 100 m have been compiled in [7]. In this report the data of [7] are evaluated by a least squares fit to deduce dispersion parameters. Finally, these parameters are pooled with those of [6] to establish a family of dispersion parameters for stability classes A to F applicable to emission heights up to 100 m.

The experimental program of dispersion parameter evaluation has not yet been terminated at the KNRC. Now experiments are being performed for emission heights of 160 m and 195 m.

2. Evaluation Technique

The concentration distributions measured at ground level in the diffusion experiments are used to determine the dispersion parameters. For this purpose the least squares technique is applied to fit the double Gaussian function to the concentrations measured. The evaluation technique is described in detail in [6]. It is repeated here for convenience.

2.1 The Double Gaussian Function

The double Gaussian function describing the concentration C(x,y) close to the ground level at the field point P(x,y) downwind of the source reads

$$C(x,y) = \frac{\chi\ (x,y)\ \dot{A}_o}{u} = \frac{\dot{A}_o}{\pi\ u\ \sigma_y(x)\ \sigma_z(x)} \exp\left[-\frac{y^2}{2\ \sigma_y^2(x)} - \frac{H^2}{2\ \sigma_z^2(x)}\right] \quad (1)$$

This follows from the diffusion equation for steady-state conditions, constant emission rate and reflection of the tracer at ground level, where

- $\dot{A}_o$ emission rate in g/s,
- u mean wind velocity in m/s,
- $\chi\ (x,y)$ normalized diffusion factor in m^{-2},
- x downwind distance in m,
- y crosswind distance in m,
- H emission height in m,
- σ_y, σ_z horizontal and vertical dispersion parameters, respectively, in m.

The foot of the source coincides with the origin of the Cartesian coordinate system.

2.2 Dispersion Parameters

The dispersion parameters σ_y and σ_z describe the horizontal and vertical distributions, respectively, of the concentration perpendicular to the transport direction. They are functions of the downwind distance x.

For this dependence on x, the power functions

$$\sigma_y = \sigma_{oy} \, x^{p_y}, \qquad \sigma_z = \sigma_{oz} \, x^{p_z} \tag{2}$$

are chosen.

2.3 Least Squares Method

The measured values C_i determined at field points with coordinates x_i and y_i are available from the experiments ($i = 1, 2 \ldots\ldots, n;\ n \geq 4$). A weighting factor g_i is assigned to each measured value.

Four coefficients $q_j(\sigma_{oy}, p_y, \sigma_{oz}, p_z)$ must be found to fit the function $f(x,y,\bar{q})$ to the measured values C_i in such a way that the sum of the square deviations,

$$Q = \sum_{i=1}^{n} g_i \, (f_i - C_i)^2 \tag{3}$$

becomes minimum.

$$f_i = f(x_i, y_i, \bar{q}) \tag{4}$$

The vector $\bar{q}$ stands for the four coefficients q_j, and $f(x,y,\bar{q})$ for $C(x,y)$ from Eq. (1).

In order to minimize the sum Q,

$$\frac{\partial Q}{\partial q_j} = 0 \tag{5}$$

must hold for j = 1, 2, 3, 4.

These are four equations determining the four parameters q_j. Since the function f is not a linear function of the parameters q_j, an approximation technique with iterative improvement must be applied to solve the system of equations (5).

For the parameters it is postulated that

$$q_j = q_{oj} + \delta q_j. \tag{6}$$

In a first approximation

$$f(x,y,\bar{q}) = f(x,y,\bar{q}_o) + \sum_{j=1}^{4} \frac{\partial f(x,y,\bar{q}_o)}{\partial q_{oj}} \delta q_j. \tag{7}$$

If (7) is substituted in (3), (5) supplies a system of linear equations:

$$\frac{\partial Q}{\partial \delta q_m} = 2 \sum_{i=1}^{n} g_i \left[f_i(\bar{q}_o) + \sum_{j=1}^{4} \frac{\partial f_i(\bar{q}_o)}{\partial q_{oj}} \delta q_j - C_i \right] \frac{\partial f_i(\bar{q}_o)}{\partial q_{om}} = 0 \tag{8}$$

or

$$\sum_{j=1}^{4} N_{jm}\,\delta q_j = \sum_{i=1}^{n} g_i \left[C_i - f_i(\overline{q_o}) \right] \frac{\partial f_i(\overline{q_o})}{\partial q_{om}} \;,\; m = 1,2,3,4 \tag{9}$$

for determining δq_j.

For this purpose, the standard matrix

$$N_{jm} = \sum_{i=1}^{n} g_i \; \frac{\partial f_i(\overline{q_o})}{\partial q_{oj}} \; \frac{\partial f_i(\overline{q_o})}{\partial q_{om}} \tag{10}$$

must not be singular.

The improved parameters

$$q_{1j} = q_{oj} + \delta q_j \tag{11}$$

are substituted in the function f_i. They are improved by further iteration steps. This process is continued until the change ΔQ of the sum of the square deviations between two iteration steps is less than an optional small value.

For better convergence, a damping factor $\beta < 1$ is introduced:

$$q_{rj} = q_{(r-1)j} + \beta^S \,\delta q_{rj}, \tag{12}$$

where r is the rth iteration step. After each iteration step the sum of the square deviations Q_r is calculated and compared with Q_{r-1}, to choose S in the following manner:

$S = 0$ for $Q_r < Q_{r-1}$,

$S = 1$ for $Q_r > Q_{r-1}$.

Next, another comparison is made. If $Q_r > Q_{r-1}$ still holds, S will be incremented by 1. This is continued until $Q_r < Q_{r-1}$ or a given number of damping steps have been achieved.

2.4 Error Considerations

The inverse standard matrix

$$I_{j,m} = (N_{j,m})^{-1}$$

can be used to determine the errors of the coefficients q_j and the errors of any functions of the coefficients. The error of the coefficients is

$$\Delta q_j = R \sqrt{I_{jj}} \tag{13}$$

The error Δh of any function $h(\bar{q})$ is

$$\Delta h = R \sqrt{\sum_{j=1}^{4} \sum_{m=1}^{4} \frac{\partial h(\bar{q})}{\partial q_j} I_{jm} \frac{\partial h(\bar{q})}{\partial q_m}} . \tag{14}$$

$$R = \sqrt{\frac{Q}{n-4}} \tag{15}$$

is the square root of the reduced sum of the least squares. The errors in the dispersion parameters σ_y and σ_z being functions of q_j are calculated according to (14). They qualify the least squares fit and, hence, the reliability of the deduced dispersion parameters. The errors are due to differences existing between the measured concentration distribution and the theoretical double Gaussian function. Compared with theses differences the errors in measurement are hardly significant.

2.5 Weighting Procedure and Initial Approximations

First computer runs showed a disadvantage of the evaluation technique. If different ensembles of first approximations q_{oj} were used, the same concentration distribution gave rise to different coefficients q_j. But the dispersion parameters σ_y and σ_z showed good agreement at the downwind distances of maximum concentration. The respective sums of least squares differed only slightly in most cases. To avoid this disadvantage a weighting procedure is chosen that prefers low concentration values at small and large downwind distances. The weighting procedure is performed in the following manner.

In the first iteration step all concentration data of the same zone, i.e., obtained at approximately the same downwind distance, are equally weighted. The weighting factor g_i in a zone is the ratio between the maximum concentration of all sampling positions and the maximum concentration within the respective zone. In the following step each weighting factor is calculated separately by

$$g_i = C_{max}/C(x_i,0). \qquad (16)$$

C_{max} is the maximum value of all values $C(x_i,0)$ of (1). In Eqs. (1) and (16) the dispersion parameters σ_y, σ_z, which have been determined in the previous step are taken into account. This iteration process is continued until the change in parameters between two succeeding steps is less than an optional small value.

To avoid an undue increase of the weighting factors g_i, these are limited to a maximum value. This maximum value is twice the ratio between the maximum concentration of all sampling positions and the smallest value of the maximum concentrations within the individual zones.

Despite the weighting procedure, different ensembles q_{oj} of first approximations are used for each evaluation. These are taken from the results of earlier KNRC diffusion experiments published in [6]. If different results with different ensembles of first approximations were still found, the representative ensemble q_j would have to meet the following conditions: The downwind distance of maximum concentration calculated from the ensemble q_j must coincide approximately with the measured one. The least squares sum Q must be small as compared to those of the other ensembles.

2.6 Transport Direction

The best fit to the measured concentrations can be reached if transport directions are chosen which differ slightly from that deduced from measurements of the wind direction. For this reason, several evaluation runs are carried out while varying the transport direction in steps of 1°. Again, that direction is deemed to be representative whose respective least squares sum is smallest.

2.7 Wind Velocity

The wind velocity must be known for Eq. (1). For emission heights of 60 m and 100 m it is measured at 40 m and 60 m heights, respectively, of the meteorological tower and averaged over the sampling time. The velocity averaged up to the emission height corresponds approximately to this assignment. This averaged wind velocity should be used in diffusion calculations together with the dispersion parameters from this report.

3. Evaluation

3.1 Experiments Suited for Evaluation

The concentrations measured in some of the sampling periods do not furnish physically meaningful dispersion parameters by the evaluation technique described in this paper. This may happen if only the background concentrations or one wing of the crosswind distribution are measured, because of changes in the wind direction. It may also apply to periods in which several zones show two peaks of concentration or where there is more than one peak in the downwind direction. During these periods extremely non-steady state conditions prevailed which are not described by the double Gaussian function.

The measured data of these experiments performed under extremely non-steady-state conditions have been compiled in [7] but assigned dispersion parameters are missing in that paper.

3.2 Combination of Several Sampling Periods in One Experiment

In order to obtain more reliable results, the individual periods in one experiment are combined in a further least squares fit. For this purpose, the results of the evaluation of individual periods are used as a first approximation. The optimum transport directions as determined in the evaluation of the individual periods are used without further variation. The combination is performed by treating the different periods as one period. The number of concentration values is increased by a factor equal to the number of combined periods. Obviously, such combination is possible only if the same stability class prevails during both periods.

In some cases (experiments Nos. 32/$CFCl_3$, 46/CF_2Br_2, 50/$CFCl_3$) this combination of results did not furnish meaningful dispersion parameters though the individual periods showed reasonable results. In these cases the periods are combined by forming the geometric mean value:

$$\bar{\sigma}_o = (\prod_{i=1}^{N} \sigma_{oi})^{1/N} \tag{17}$$

$$p = \frac{1}{N} \sum_{i=1}^{N} p_i \tag{18}$$

$$\sigma = \bar{\sigma}_o \, x^{\bar{p}} \tag{19}$$

σ_{oi}, p_i being defined in (2). N is the number of periods referring to the same experiment. (17) to (19) are applicable to σ_y and σ_z.

4. Presentation of the Dispersion Parameters Determined

Table 1 shows the coefficients σ_{oy}, σ_{oz}, p_y, p_z as determined and the dispersion parameters σ_y and σ_z with the respective error widths at three downwind distances for all sampling periods suited for evaluation. The three distances roughly represent the shortest and the longest downwind distances of the sampling locations and that distance at which the maximum of concentration is found. The parameters obtained in a combination of the individual periods of an experiment are also indicated. In addition, Table 1 contains the stability class prevailing during the experiment and the mean transport directions Θ and Θ' deduced from wind measurements and from the least squares fit, respectively.

Figs. 1 to 65 show the dispersion parameters σ_y and σ_z determined and the normalized diffusion factor χ as a function of the downwind distance x. All periods suited for evaluation of one experiment are combined. The error widths are indicated as shaded areas. If two tracers had been released simultaneously in one experiment, the results of both tracers are drawn to facilitate comparison.

The dispersion parameters published in [6] and in this report, which belong to the same stability class have been combined by forming the geometric mean value according to Eqs. (17) to (19). By a smoothing and centering method the dispersion parameters have been attributed to the mean intensity of turbulence within each stability class. The combining, smoothing, and centering techniques and the results have been described in detail in [8]. The resulting family of dispersion parameters σ_y and σ_z and normalized diffusion factors χ are also plotted as dashed lines in Figs. 1 to 81. In the following table the number of experiments (number of periods) which have been used to establish this family of dispersion parameters, are given as a function of the stability class and emission height.

Stability Class	Emission Height	
	60 m	100 m
A	2 (2)	3 (7)
B	1 (2)	3 (7)
C	4 (10)	3 (11)
D	6 (10)	8 (22)
E	3 (5)	3 (6)
F	2 (4)	

5. Discussion of the Results

The results of the diffusion experiments are mainly influenced by the structure of the surface in the environment of the KNRC. Buildings, trees and the forest around our Center produce a roughness length of more than 1 m. If comparisons with other experimental results are performed, this fact has to be taken into account.

5.1 Vertical Dispersion Parameter σ_z

For the experiments relating to the stability class A two cases can be distinguished: those with strong variations of the wind direction and those with minor variations. In the second case the slope of the derived σ_z curves is steep, whereas a rather small value of the σ_z exponent is determined in the first case. The evaluation of the σ_z-curves for the other stability classes do not show such differences. For that reason the vertical dispersion parameters, if averaged for each stability class [8], are ordered according to the classes. As expected, they decrease with increasing atmospheric stability. Nevertheless, it seemed necessary to smooth and to center them for practical applications in diffusion calculations. Centering means a shift of the curves of the dispersion parameters to the center of each stability class [8]. Especially for the stability class D most of the experiments were performed during daytime. Without centering the averaged σ_z-curve would not be representative of the entire stability class D.

The downwind distance x_{max} of the maximum concentration calculated from the dispersion parameters of individual experiments within the same stability class agree better with each other than the dispersion parameters themselves. Therefore, this distance x_{max}, which is influenced most by σ_z, is used for a comparison with the dispersion parameters derived from diffusion experiments carried out in

Brookhaven [2], St. Louis [3] and Jülich [4](see Tab. 2). The distance x_{max} for the stability classes A to C calculated with the Karlsruhe parameters agrees well with the corresponding values determined at the other sites. Except for the Brookhaven parameters, this is still true for classes D to F.

5.2 Horizontal Dispersion Parameter σ_y

The horizontal dispersion parameters are influenced most by variations in the wind direction and by the structure of the topography. Both effects are reflected in the concentration distributions which have a more direct influence on the σ_y- than on the σ_z-curves. This more direct dependence is the reason why the error widths of the σ_y-curves are greater than those of the σ_z-curves.

The concentration distribution under stable conditions (stability classes E and F) is broader than in case of neutral stability (class D). This is a rather surprising result. Under stable conditions the wind velocity near ground level, where the tracers are sampled, is often very low, although high velocities are observed at great heights. These low velocities are combined with local wind variations which, together with the heterogeneous topography, lead to the rather broad concentration distributions. Only one experiment (No. 42) of these classes furnished small σ_y-values as expected from the St. Louis and Brookhaven σ_y-curves. On the other hand, the experiments performed at Jülich confirm our results.

The slopes of the σ_y-curves belonging to the same stability class vary greatly. Therefore, it seemed appropriate to smooth the σ_y-curves. An average slope value for all curves was assumed. After smoothing and centering the σ_y-curves, an order according to the stability class was stated. With increasing stability the σ_y-values decrease up to class D in order to increase then again.

5.3 Normalized Diffusion Factor χ

The normalized diffusion factor χ summarizes the maximum pollutant burden to be expected from short-term emissions. Since σ_z has a stronger influence upon the χ-curves than σ_y, they are ordered according to the stability classes too. The error widths are small as compared to the σ_y-curves. The influence of σ_y is the cause that the maximum χ_{max} of the χ-curve for class C is higher than χ_{max} of classes A and B. The increase of σ_y with stability from D to F is reflected also in the χ_{max} values. For the classes E and F, they are much smaller than the corresponding values calculated with the St. Louis or the Brookhaven dispersion parameters (s. Table 2).

6. Final Remarks

The families of the dispersion parameters derived from our experiments can be used for sites with major surface roughnesses. To get still more general σ-curves for a source height of 100 m the Jülich and Karlsruhe experimental results were combined. The method of combination and the derived σ-curves are published in [9].

The Karlsruhe diffusion experiments are now being completed for tracer release heights of 160 m and 195 m. Some of the results have already been published [8]. The publication of the details is scheduled for 1982.

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Stab. class	No. of exp.	Tracer and emission height (m)	Period	θ	θ'	y: σ_o	y: p	z: σ_o	z: p	x (m)	σ_y (m)	$\frac{\Delta\sigma_y}{\sigma_y}$ (%)	σ_z (m)	$\frac{\Delta\sigma_z}{\sigma_z}$ (%)
A	35	CF_2Br_2 60 m	1	258°	270°	0.0198	1.89	2.56	0.513	100	119	47	27	9
										300	952	24	48	38
										800	6074	36	79	67
A	47	CF_2Br_2 60 m	1	289°	206°	0.0350	1.76	3.57	0.464	100	116	28	30	9
										400	1333	19	58	30
										2000	22653	49	122	58
			2	255°	228°	0.0768	1.77	4.92	0.522	100	271	13	54	40
										400	3163	69	112	112
										2000	54923	148	259	197
		$\overline{1+2}$				0.0428	1.74	4.16	0.450	100	128	23	33	9
										400	1426	16	62	33
										2000	23384	43	127	61
		$CFCl_3$ 100 m	1	285°	202°	2.54	0.993	6.91	0.418	100	246	72	47	20
										400	974	32	85	46
										2000	4819	72	166	81
			2	251°	271°	0.0194	1.97	7.83	0.458	100	168	25	65	19
										400	2571	33	122	72
										2000	60971	84	255	136
		$\overline{1+2}$				0.0397	1.82	5.94	0.483	100	171	30	55	13
										400	2120	22	107	44
										2000	39491	60	232	84
B	26	CF_2Br_2 60 m	1	203°	209°	6.39	0.504	0.414	0.989	100	65	17	39	10
										150	80	12	59	10
										1000	208	38	383	36
			2	215°	219°	9.98	0.590	0.317	1.01	100	151	37	33	14
										150	192	21	49	19
										1000	587	77	333	58
		$\overline{1+2}$				6.27	0.567	0.258	1.08	100	85	18	37	8
										150	107	12	57	10
										1000	315	43	438	34
C	28	CF_2Br_2 60 m	1	40°	38°	2.09	0.585	6.65	0.488	100	31	11	63	17
										300	59	6	108	8
										1500	151	19	236	20
			2	52°	40°	5.64	0.481	0.0426	1.28	100	52	16	15	7
										300	88	5	63	6
										1500	191	25	495	21
		$\overline{1+2}$				2.75	0.590	0.103	1.13	100	41	14	19	9
										300	80	6	65	7
										1500	206	24	400	22
C	31	$CFCl_3$ 60 m	1	202°	201°	5.73	0.578	0.0772	1.15	100	82	68	15	15
										400	183	19	75	28
										1200	344	70	265	55
			2	188°	185°	7.34	0.463	2.20	0.472	100	62	30	19	4
										400	118	12	37	7
										1200	196	26	63	13
		$\overline{1+2}$				2.49	0.650	3.23	0.410	100	50	28	21	5
										400	122	13	38	8
										1200	250	26	59	15

Table 1: Determined dispersion parameters σ_y and σ_z

x: downwind distance

θ: mean transport direction from wind measurements

θ': mean transport direction from least squares fit

Stab. class	No. of exp.	Tracer and emission height (m)	Period	θ	θ'	y: σ_0	y: p	z: σ_0	z: p	x (m)	σ_y (m)	$\frac{\Delta\sigma_y}{\sigma_y}$ (%)	σ_z (m)	$\frac{\Delta\sigma_z}{\sigma_z}$ (%)
C	32	CF_2Br_2 60 m	1	43°	38°	2.13	0.713	0.0627	1.24	100	57	26	19	6
										250	109	10	60	11
										1200	334	41	420	34
			2	37°	29°	0.287	1.01	0.121	1.12	100	30	44	21	15
										250	75	14	59	18
										1200	366	66	340	57
		$\overline{1+2}$				2.27	0.681	0.0546	1.27	100	52	24	19	6
										250	98	9	61	10
										1200	284	38	445	31
		$CFCl_3$ 60 m	1	43°	38°	3.38	0.646	0.0283	1.40	100	66	25	18	6
										250	120	9	63	10
										1200	330	41	563	31
			2	37°	29°	0.922	0.847	0.0226	1.44	100	46	39	17	11
										250	100	13	66	16
										1200	373	67	632	51
		$\overline{1+2}$				3.86	0.613	0.0220	1.45	100	65	21	17	5
										250	113	8	66	9
										1200	297	36	636	27
C	34	CF_2Br_2 100 m	1	54°	56°	0.0760	1.03	0.00154	1.67	150	13	89	7	42
										600	56	19	68	12
										1300	123	29	248	40
			2	44°	55°	4.83	0.470	0.00424	1.51	150	51	306	8	137
										600	98	65	67	46
										1300	140	98	212	148
		$\overline{1+2}$				0.249	0.880	0.00160	1.67	150	21	98	7	47
										600	70	21	67	14
										1300	137	32	254	45
		$CFCl_3$ 60 m	1	59°	54°	0.472	0.894	1.99	0.481	150	42	22	22	7
										600	144	11	43	12
										1300	287	18	62	22
			2	48°	47°	1.38	0.624	1.32	0.564	150	32	13	22	5
										600	75	7	48	10
										1300	122	12	76	18
		$\overline{1+2}$				0.545	0.831	0.904	0.632	150	35	14	22	5
										600	111	7	51	11
										1300	211	12	84	19
D	27	CF_2Br_2 100 m	1	204°	204°	0.00289	1.78	0.805	0.621	100	11	56	14	11
										400	124	21	33	9
										1500	1301	41	76	25
D	36	$CFCl_3$ 60 m	1	78°	72°	0.333	1.39	0.872	0.629	100	20	35	16	6
										300	91	16	31	6
										1200	622	24	75	16
			2	77°	79°	0.113	1.13	0.564	0.741	100	21	26	17	5
										300	71	12	39	7
										1200	342	23	108	18
		$\overline{1+2}$				0.0450	1.32	0.731	0.675	100	20	23	16	4
										300	84	10	34	5
										1200	522	18	88	13
D	44	CF_2Br_2 60 m	1	281°	280°	0.401	0.799	0.0276	1.11	500	57	42	27	37
										1200	115	20	71	20
										9900	622	65	737	58
			2	284°	280°	0.804	0.746	0.646	0.642	500	83	13	35	11
										1200	159	9	61	10
										9900	768	30	238	33
		$\overline{1+2}$				0.597	0.765	0.105	0.907	500	69	13	29	9
										1200	135	8	65	9
										9900	680	31	442	31
		$CFCl_3$ 100 m	1	280°	279°	1.71	0.628	0.0575	1.05	500	84	37	39	13
										1200	147	19	98	14
										9900	552	54	894	51
			2	283°	281°	6.22	0.535	1.89	0.501	500	173	29	43	8
										1200	277	16	66	10
										9900	857	32	191	37
		$\overline{1+2}$				2.73	0.612	0.238	0.819	500	122	25	39	7
										1200	209	12	79	9
										9900	758	35	447	34

Table 1 continued /1

Stab. class	No. of exp.	Tracer and emission height (m)	Period	θ	θ'	y: σ_0	y: p	z: σ_0	z: p	x (m)	σ_y (m)	$\frac{\Delta\sigma_y}{\sigma_y}$ (%)	σ_z (m)	$\frac{\Delta\sigma_z}{\sigma_z}$ (%)
D	45	CF_2Br_2 60 m	1	75°	77°	0.0830	0.968	2.46	0.410	100	7	36	16	5
										1000	66	13	42	6
										2700	174	27	63	9
			2	74°	74°	1.94	0.603	2.78	0.415	100	31	35	19	7
										1000	125	20	49	15
										2700	228	35	74	23
		$\overline{1+2}$				0.716	0.744	2.08	0.460	100	22	24	17	4
										1000	122	13	50	10
										2700	256	24	79	15
		$CFCl_3$ 100 m	1	73°	77°	0.0846	1.05	0.00183	1.57	100	11	51	3	27
										1000	123	11	92	8
										2700	349	25	434	22
			2	69°	77°	3.42	0.519	0.145	0.911	100	37	52	10	18
										1000	122	13	79	8
										2700	206	30	195	20
		$\overline{1+2}$				0.957	0.703	0.0316	1.14	100	24	43	6	30
										1000	123	10	83	9
										2700	247	24	258	25
D	48	CF_2Br_2 60 m	1	249°	243°	2.04	0.612	0.366	0.680	300	67	28	18	7
										1800	200	13	60	15
										10000	572	35	192	33
			2	251°	246°	1.47	0.665	0.162	0.828	300	65	35	18	10
										1800	214	19	80	24
										10000	670	55	332	51
		$\overline{1+2}$				1.69	0.643	0.287	0.727	300	66	21	18	6
										1800	210	11	67	13
										10000	632	30	233	28
		$CFCl_3$ 100 m	1	247°	250°	1.32	0.771	2.70	0.402	300	107	60	27	9
										1800	425	26	55	11
										10000	1594	36	110	26
			2	248°	251°	0.0229	1.23	2.59	0.404	300	26	59	26	12
										1800	236	24	53	11
										10000	1962	38	107	30
		$\overline{1+2}$				0.174	1.00	2.64	0.403	300	53	39	26	7
										1800	317	16	54	7
										10000	1769	26	108	19
D	51	CF_2Br_2 60 m	1	272°	260°	0.00729	1.47	0.00323	1.42	400	48	23	16	6
										1000	183	7	58	10
										9900	5297	52	1484	41
		$CFCl_3$ 100 m	1	268°	257°	0.00137	1.83	1.95	0.424	400	77	71	25	7
										1000	407	50	36	6
										9900	26740	50	96	28
E	40	$CFCl_3$ 60 m	1	218°	215°	1.30	0.929	0.982	0.471	600	496	85	20	12
										2200	1659	37	37	20
										8000	5506	31	68	33
			2	230°	219°	3.12	0.854	0.781	0.516	600	735	85	21	12
										2200	2229	31	41	24
										8000	6640	30	81	39
		$\overline{1+2}$				2.01	0.890	0.870	0.490	600	597	55	20	7
										2200	1897	23	38	13
										8000	5983	19	71	22
E	42	$CFCl_3$ 60 m	1	255°	251°	1.36	0.523	0.670	0.504	700	42	56	18	10
										3400	96	20	40	17
										6500	135	44	56	28

Table 1 continued /2

Stab. class	No. of exp.	Tracer and emission height (m)	Period	θ	θ'	y: σ_o	y: p	z: σ_o	z: p	x (m)	σ_y (m)	$\frac{\Delta\sigma_y}{\sigma_y}$ (%)	σ_z (m)	$\frac{\Delta\sigma_z}{\sigma_z}$ (%)
E	43	$CFCl_3$ 60 m	1	296°	297°	4.15	0.412	0.238	0.779	600	58	46	35	38
										1900	93	30	85	42
										5600	146	73	199	85
			2	297°	300°	0.169	0.898	1.68	0.488	600	53	59	38	89
										1900	149	24	67	41
										5600	392	54	113	66
		$\overline{1+2}$				0.216	0.847	1.10	0.552	600	49	27	38	29
										1900	129	18	71	25
										5600	322	38	130	47
		CF_2Br_2 100 m	1	294°	298°	2.35	0.525	1.44	0.520	600	68	60	40	18
										1900	124	32	73	40
										5600	219	63	129	86
			2	295°	302°	3.66	0.573	0.719	0.634	600	143	69	42	19
										1900	276	30	86	39
										5600	513	60	171	84
		$\overline{1+2}$				5.73	0.444	2.16	0.464	600	98	42	42	14
										1900	164	20	72	27
										5600	264	33	118	58
E	50	$CFCl_3$ 100 m	1	292°	283°	0.0203	1.37	0.742	0.504	300	51	158	13	37
										5100	2484	41	55	18
										9900	6201	53	76	31
			2	307°	276°	0.000885	1.82	0.722	0.529	300	28	156	14	22
										5100	4787	36	66	21
										9900	15967	45	86	31
		$\overline{1+2}$				0.00424	1.59	0.732	0.517	300	37	108	14	20
										5100	3330	25	60	13
										9900	9559	30	85	20
F	41	$CFCl_3$ 60 m	1	9°	10°	3.24	0.603	1.10	0.423	300	101	162	12	25
										3500	443	60	34	22
										6300	631	94	44	30
			2	3°	5°	1.23	0.798	1.09	0.431	300	117	224	14	41
										3500	825	73	36	39
										6300	1325	102	47	56
		$\overline{1+2}$				1.23	0.789	1.09	0.431	300	111	105	13	19
										3500	769	36	37	19
										6300	1223	50	47	26
F	46	CF_2Br_2 60 m	1	285°	279°	0.0633	1.54	0.417	0.585	300	412	916	12	22
										2000	7667	302	36	153
										9000	77731	198	86	268
			2	301°	281°	0.0222	1.04	0.137	0.654	300	8	440	6	505
										2000	59	236	20	77
										9000	280	87	53	530
		$\overline{1+2}$				0.0375	1.29	0.239	0.620	300	59	150	8	21
										2000	680	60	27	10
										9000	4732	31	68	30

Table 1 continued /3

Stability class	Karlsruhe [8]		Jülich [4]		St. Louis [3]		Brookhaven [2]	
	x_{max} in km	χ_{max} in m^{-2}	x_{max} in km	χ_{max} in m^{-2}	x_{max} in km	χ_{max} in m^{-2}	x_{max} in km	χ_{max} in m^{-2}
A	0.21	$7.71 \cdot 10^{-6}$	0.38	$1.34 \cdot 10^{-5}$	-	-	-	-
B	0.39	$1.22 \cdot 10^{-5}$	0.46	$1.45 \cdot 10^{-5}$	0.45	$1.42 \cdot 10^{-5}$	0.29	$2.40 \cdot 10^{-5}$
C	0.62	$1.40 \cdot 10^{-5}$	0.61	$1.56 \cdot 10^{-5}$	0.68	$1.26 \cdot 10^{-5}$	0.51	$2.15 \cdot 10^{-5}$
D	1.18	$8.56 \cdot 10^{-6}$	0.87	$1.52 \cdot 10^{-5}$	1.09	$1.08 \cdot 10^{-5}$	1.64	$1.61 \cdot 10^{-5}$
E	3.02	$2.87 \cdot 10^{-6}$	1.54	$0.54 \cdot 10^{-5}$	2.21	$1.11 \cdot 10^{-5}$	-	-
F	7.68	$0.54 \cdot 10^{-6}$	-	-	-	-	21.17	$0.45 \cdot 10^{-5}$

Table 2: Source distance x_{max} and amount χ_{max} of the maximum of the normalized diffusion factor for an emission height of 100 m

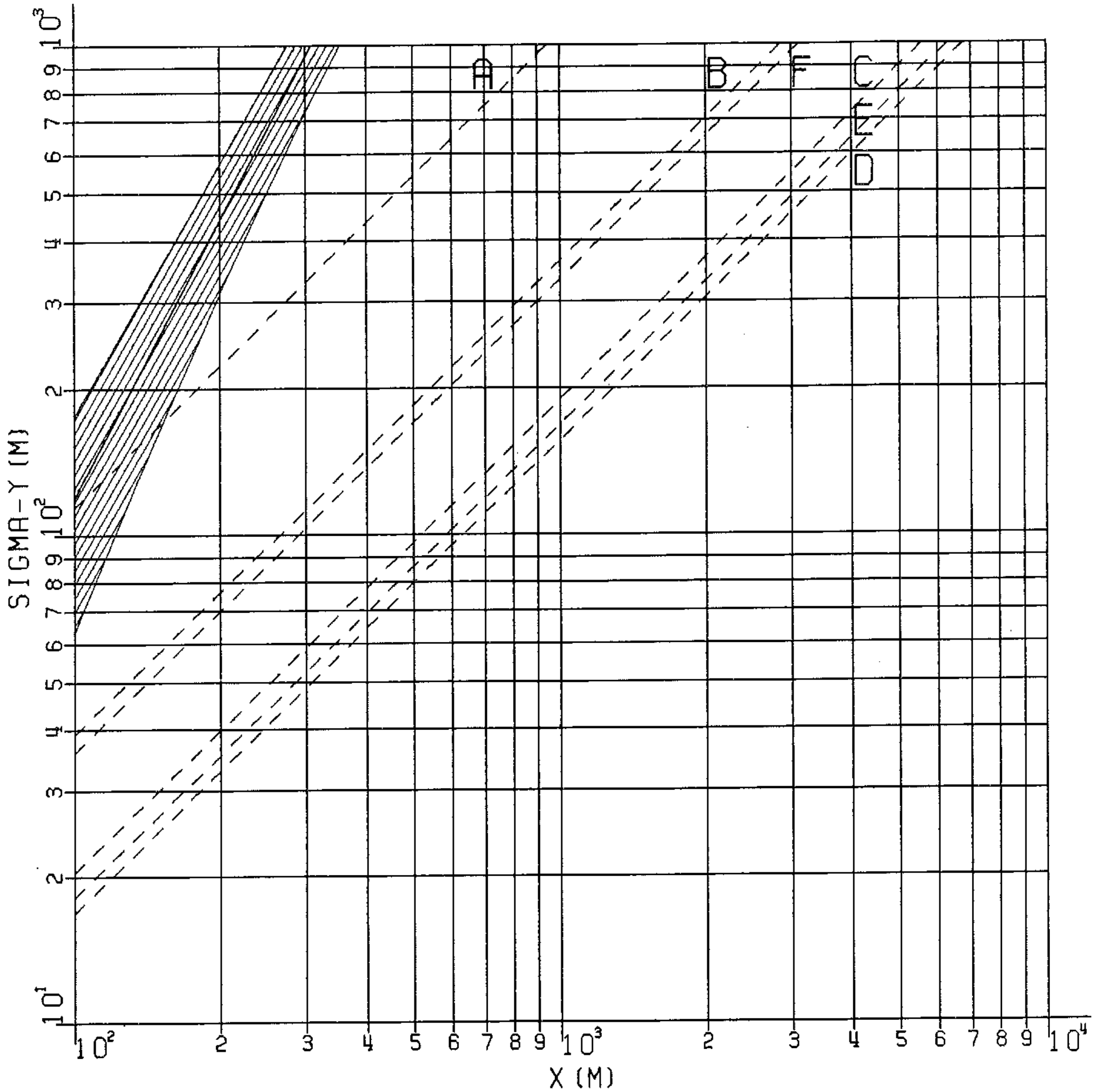

FIG. 1: HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.35, PERIOD 1
H= 60M, TRACER CF2BR2
----- COMBINED, SMOOTHED, AND CENTERED RESULTS

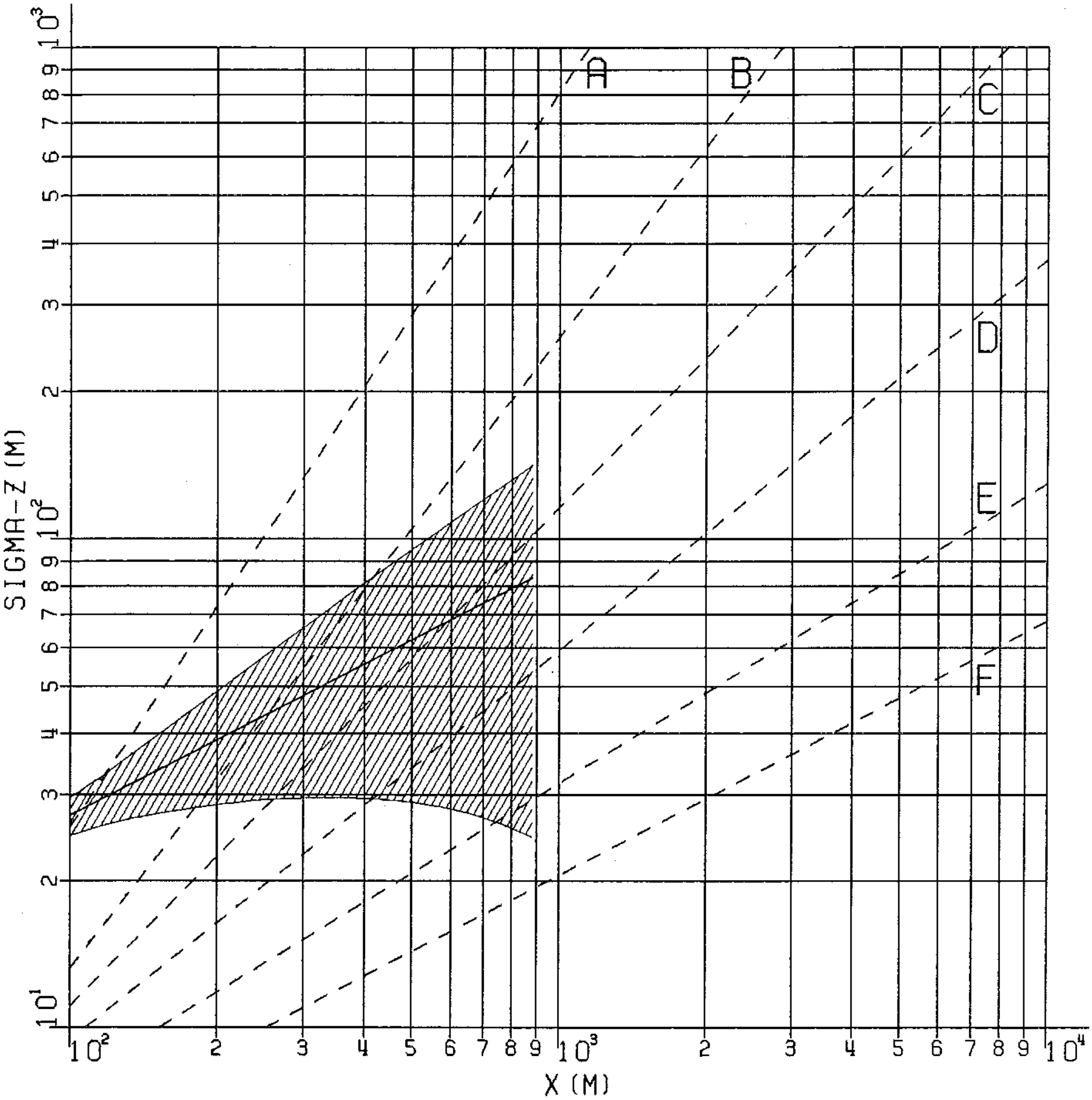

FIG. 2 : VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.35, PERIOD 1

H= 60M, TRACER CF2BR2

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

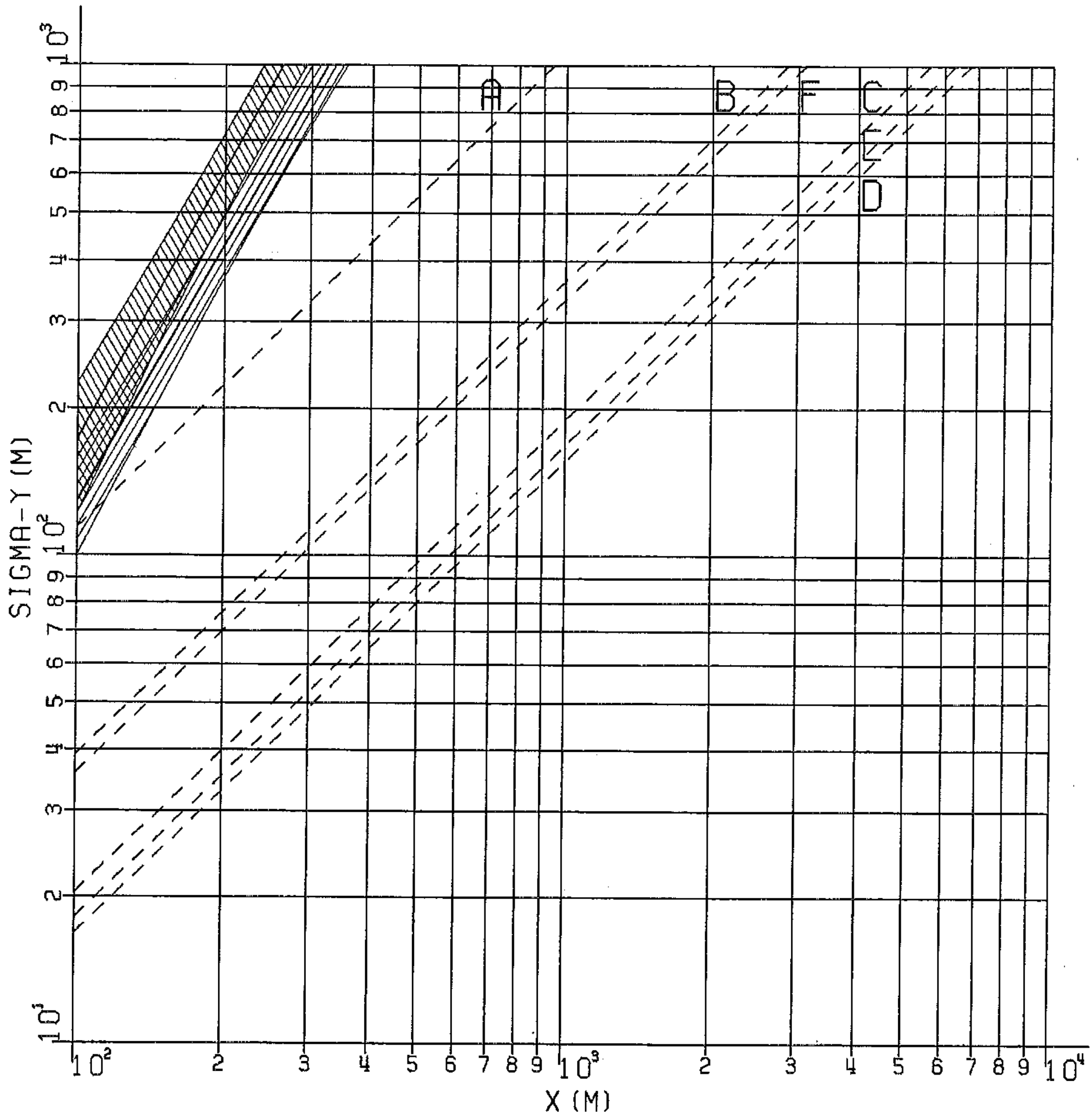

FIG. 4: HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.47, PERIODS 1+2
H= 60M, TRACER CF2BR2
H=100M, TRACER CFCL3
----- COMBINED, SMOOTHED, AND CENTERED RESULTS

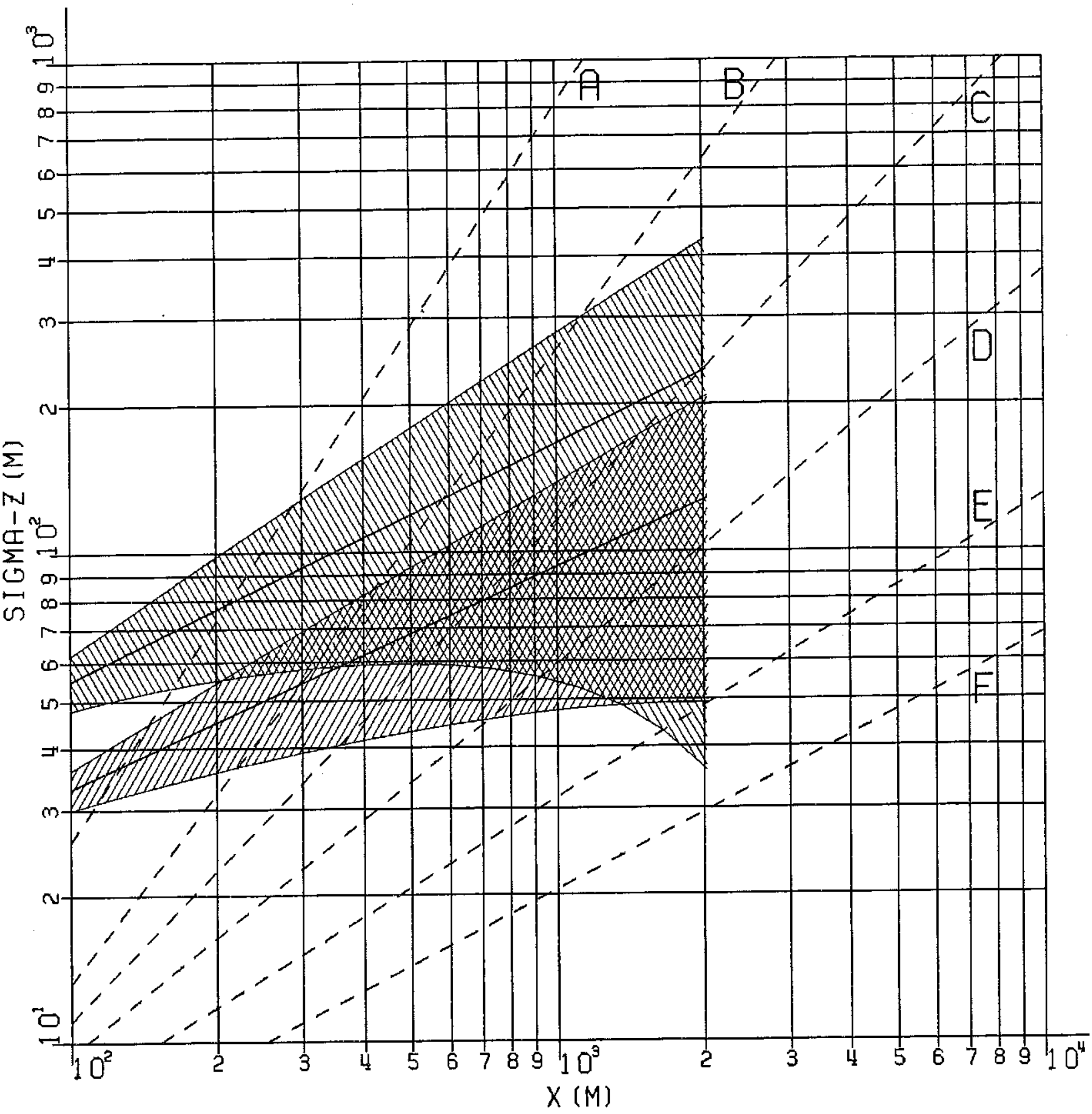

FIG. 5: VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.47, PERIODS 1+2

////////// H= 60M, TRACER CF2BR2

\\\\\\\\\\ H=100M, TRACER CFCL3

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

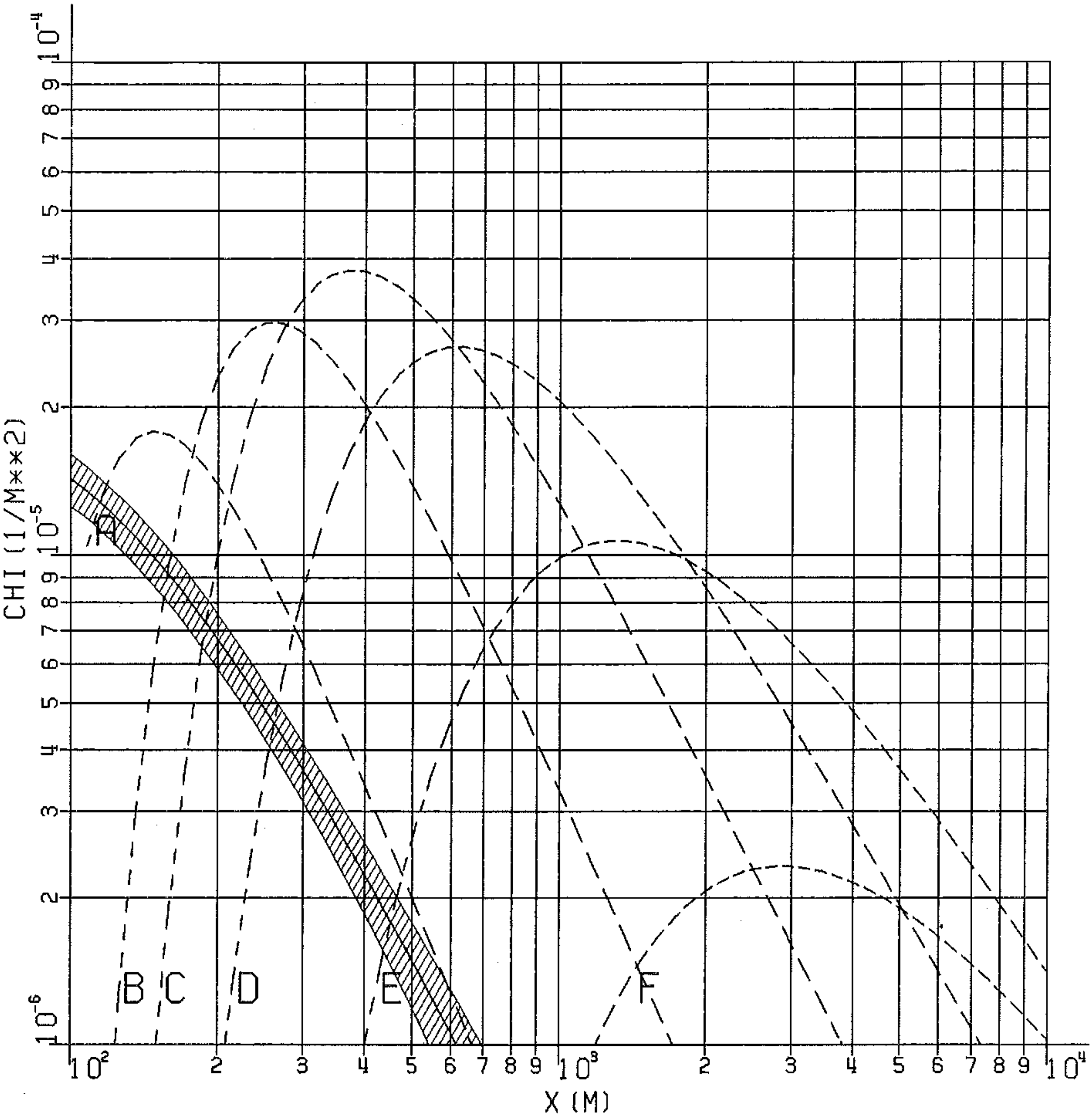

FIG. 6 : NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.47, PERIODS 1+2
////////////// H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

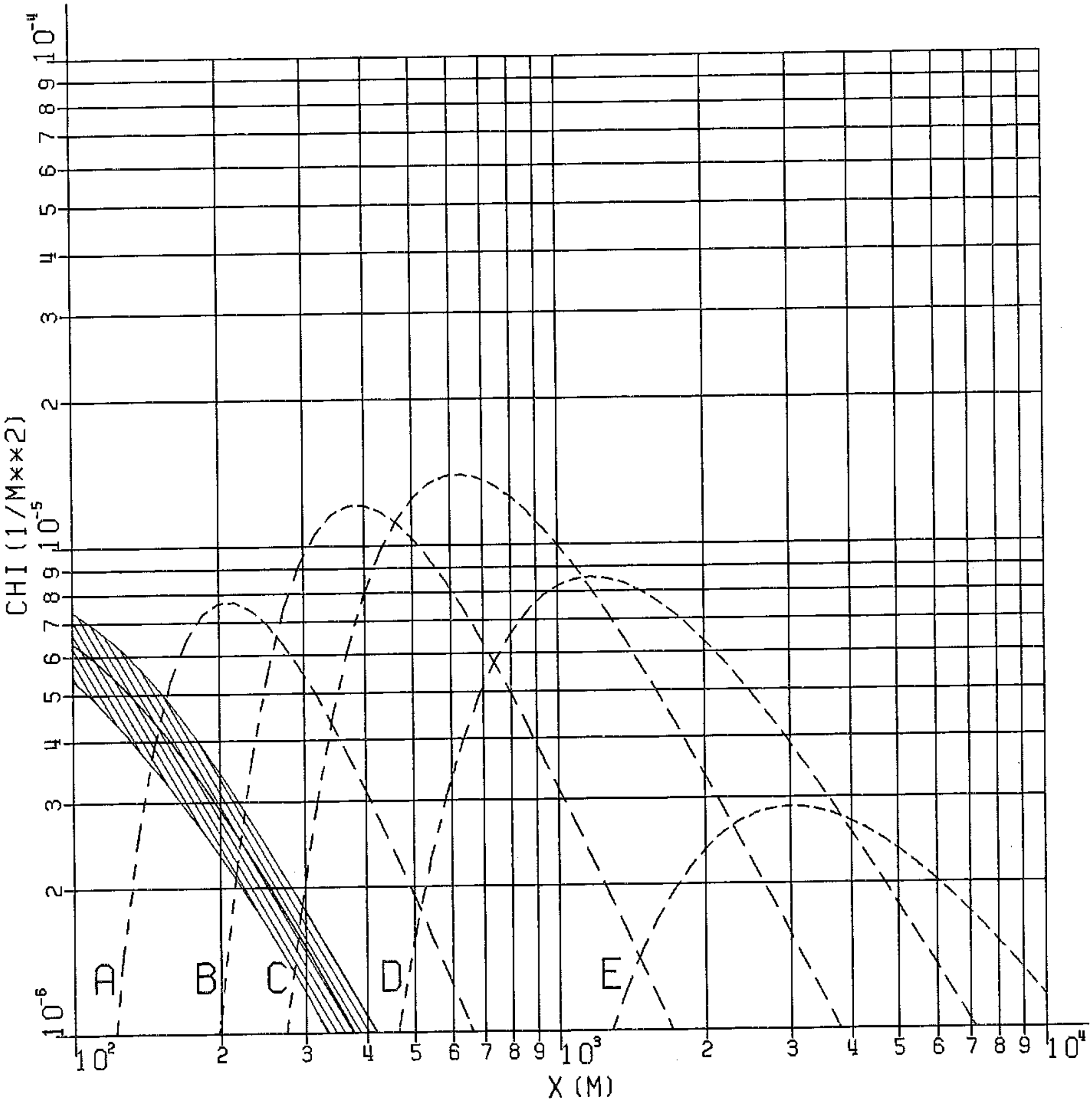

FIG. 7: NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.47, PERIODS 1+2
H=100M, TRACER CFCL3
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

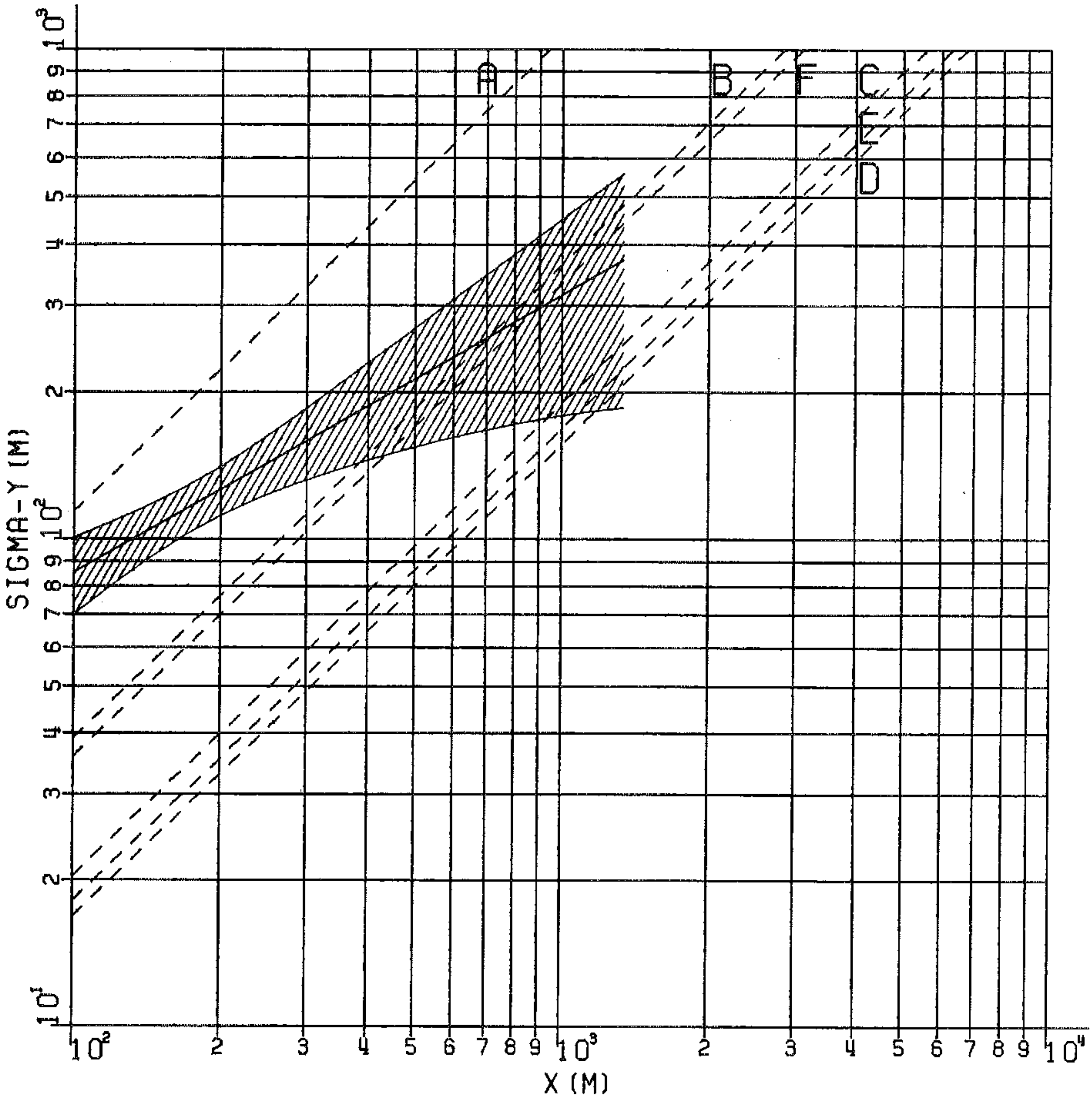

FIG. 8 : HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.26, PERIODS 1+2
//////////// H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

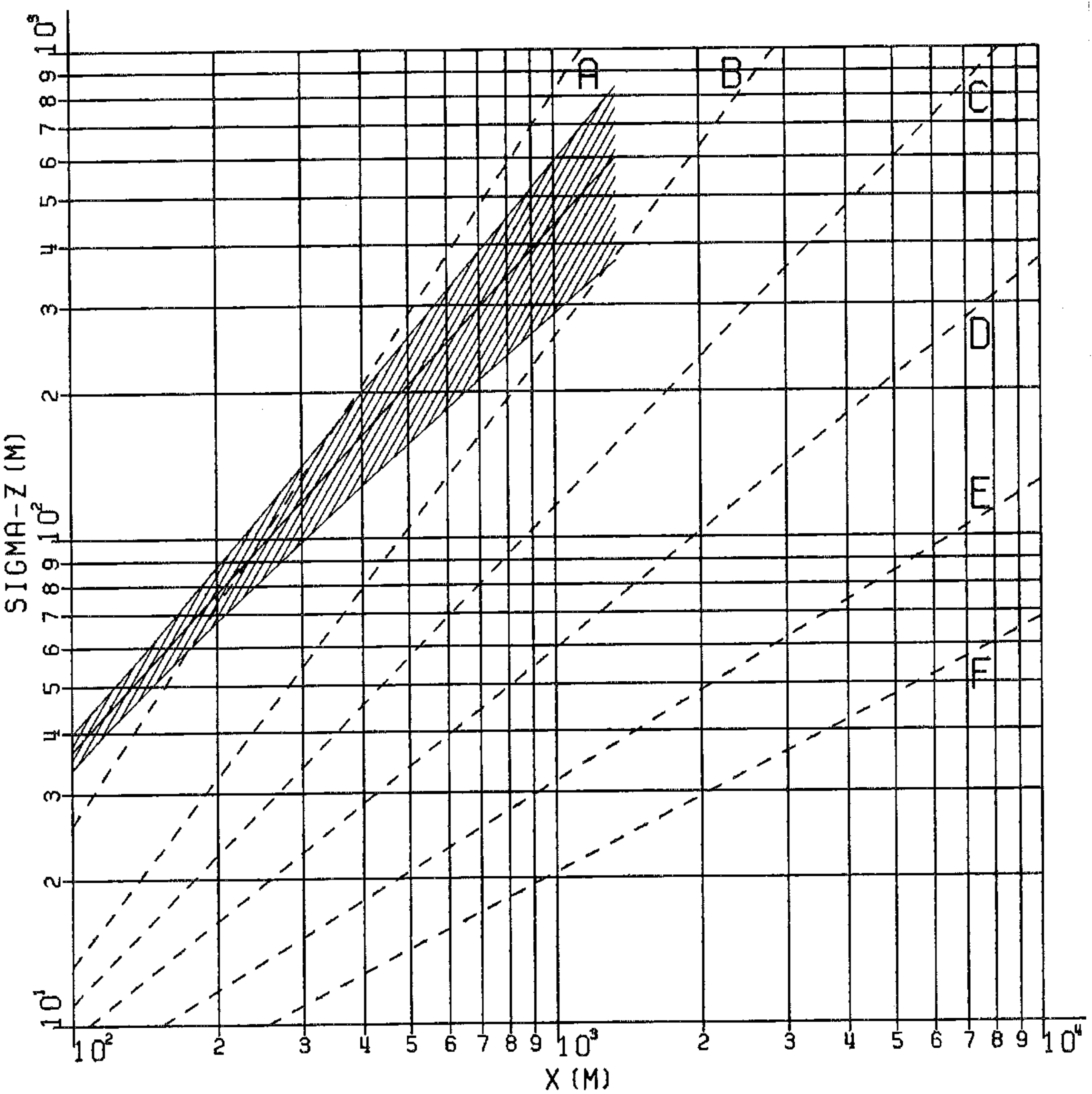

FIG. 9 : VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.26, PERIODS 1+2
////////////// H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

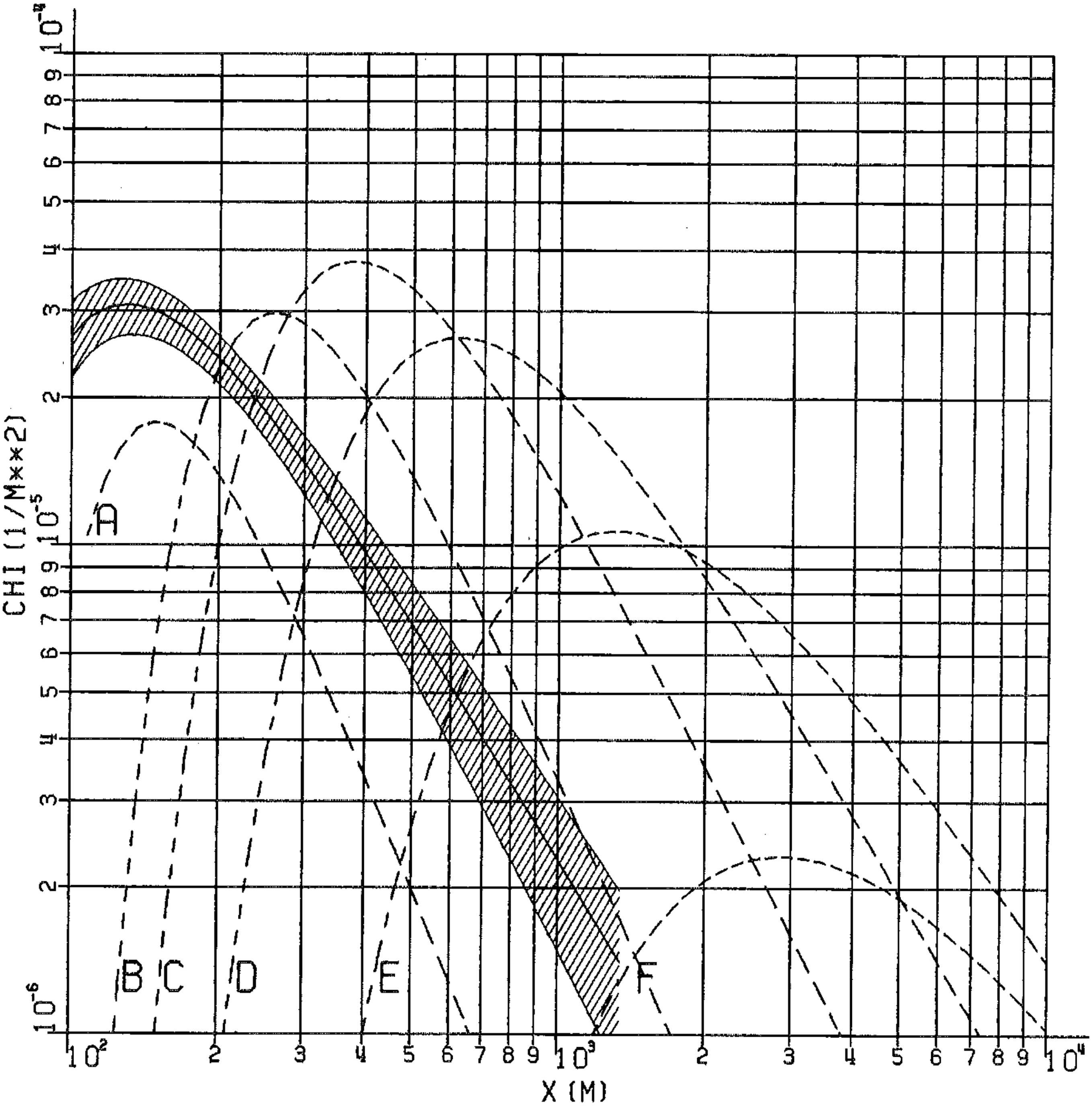

FIG. 10: NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.26, PERIODS 1+2
////////// H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

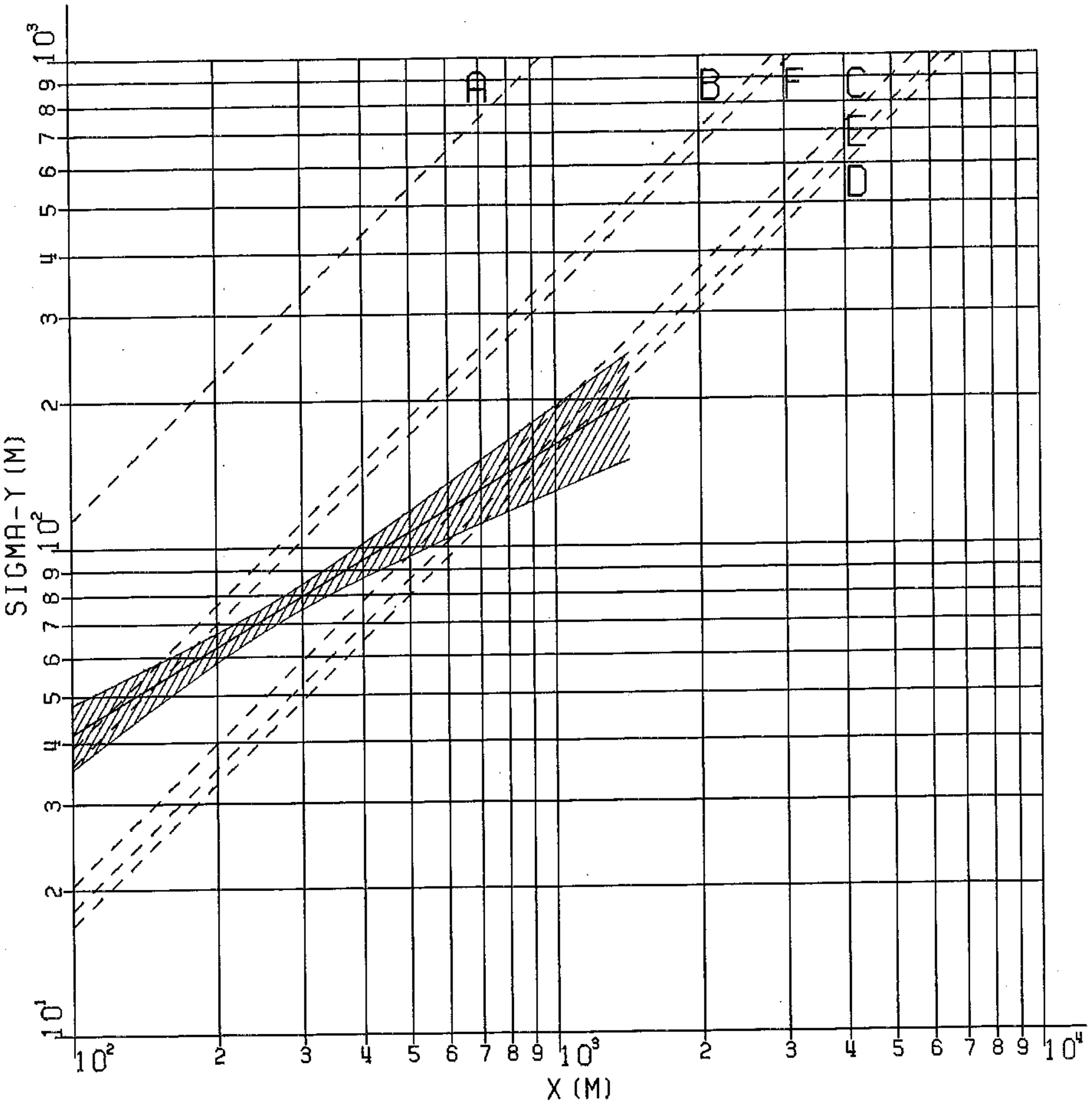

FIG. 11: HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.28, PERIODS 1+2
H= 60M, TRACER CF2BR2
----- COMBINED, SMOOTHED, AND CENTERED RESULTS

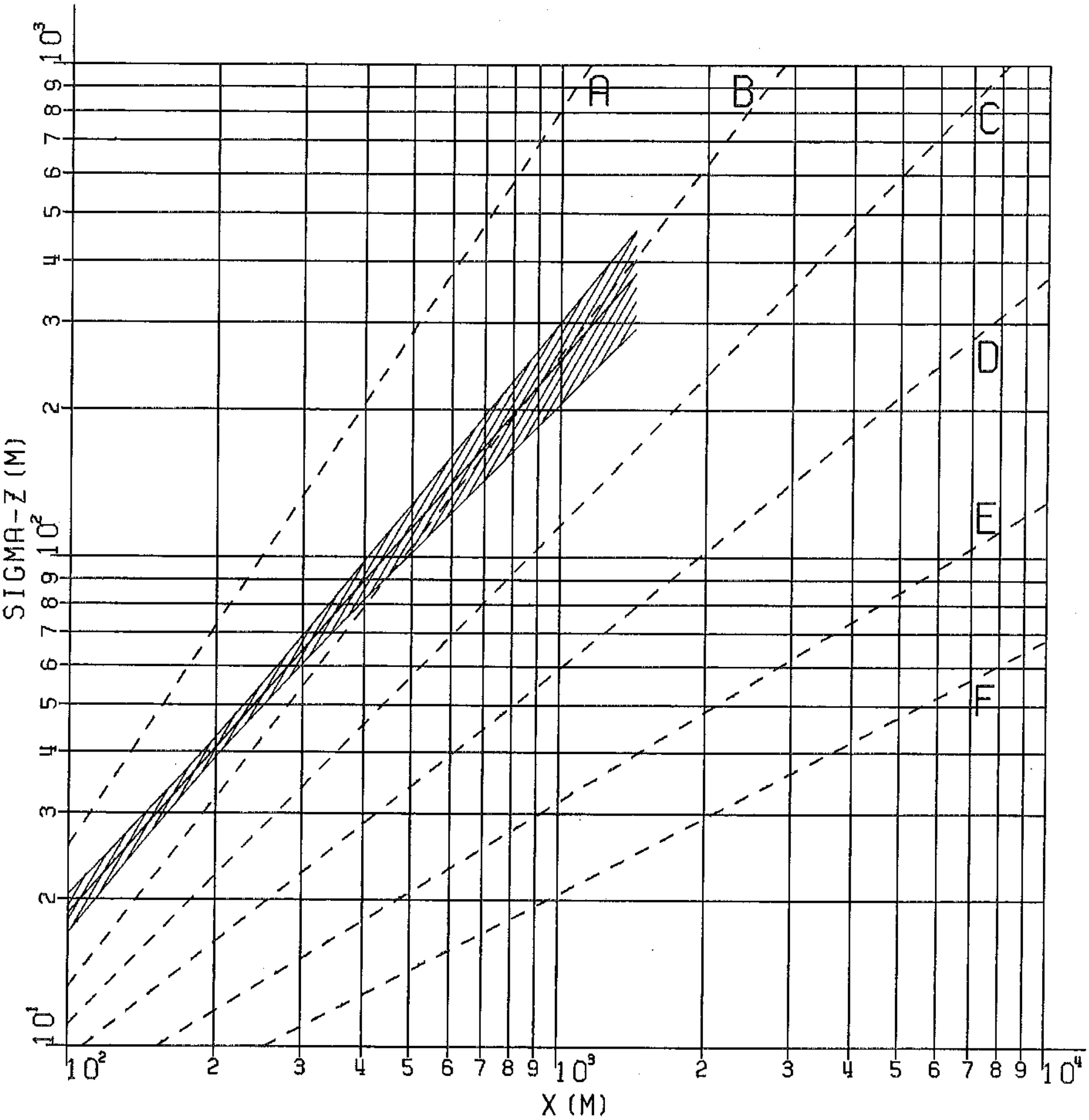

FIG. 12: VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.28, PERIODS 1+2
/////////////// H= 60M, TRACER CF2BR2
- - - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

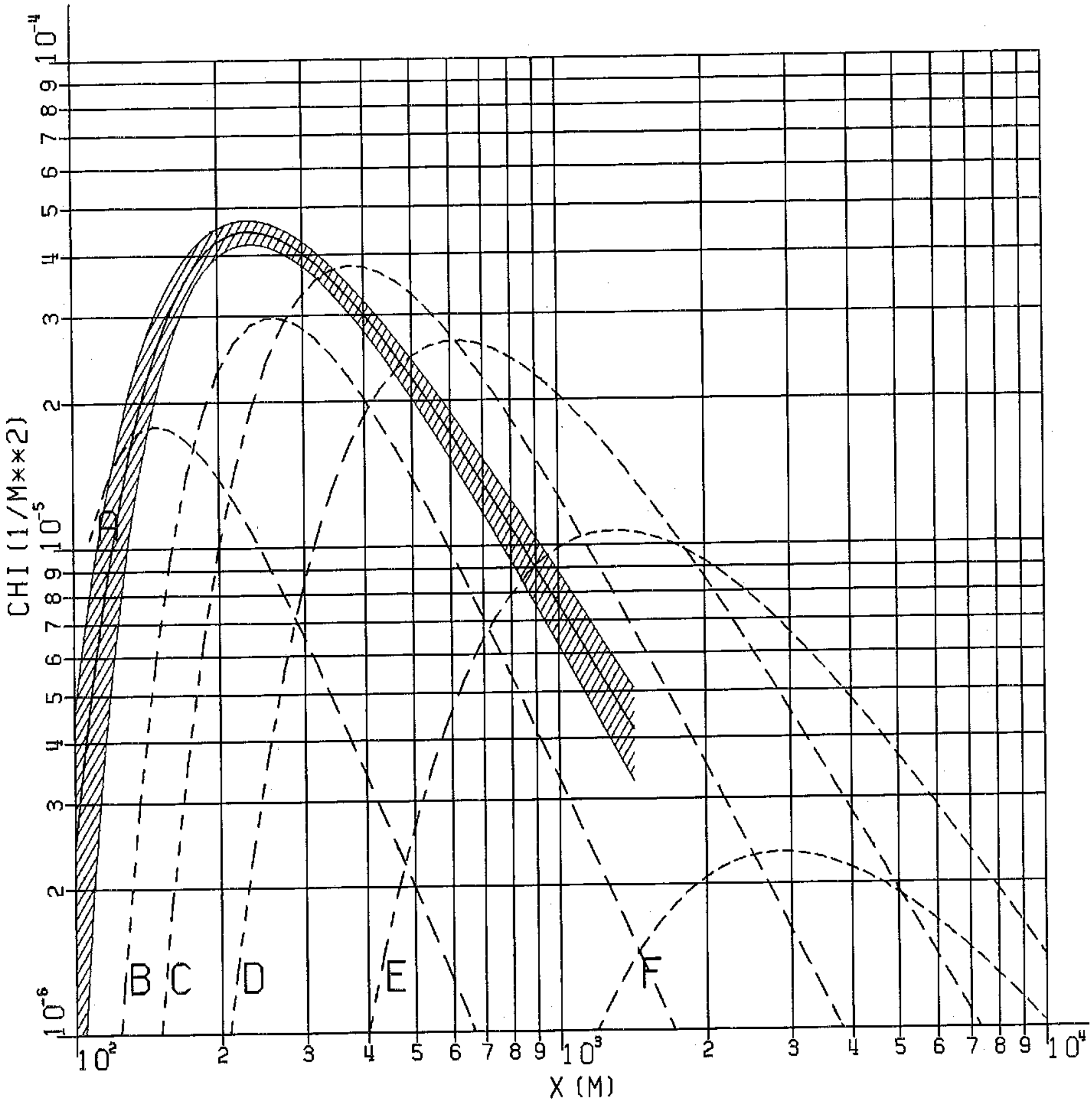

FIG. 13: NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.28, PERIODS 1+2
////////// H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

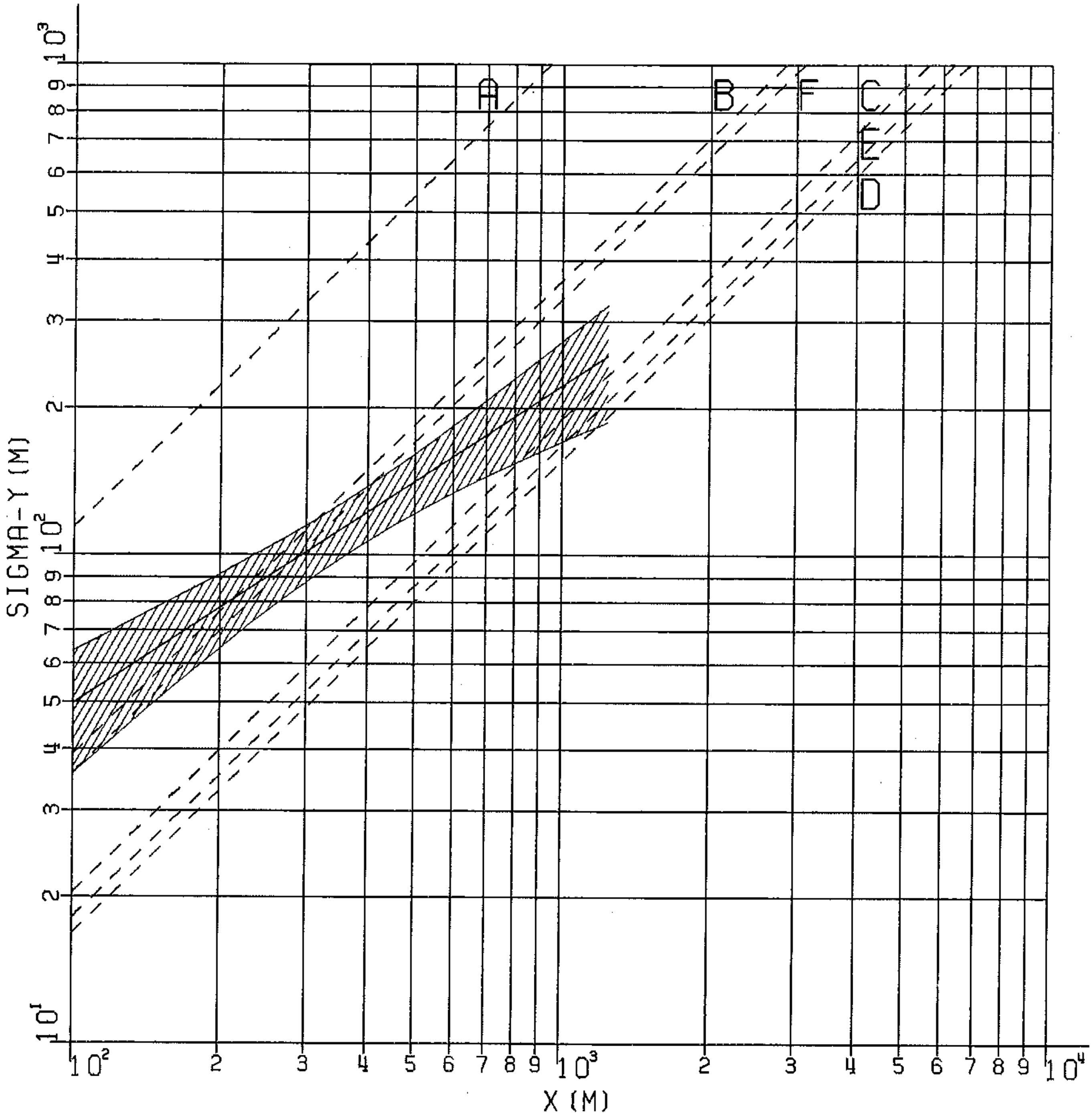

FIG. 14: HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.31, PERIODS 1+2
////////// H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

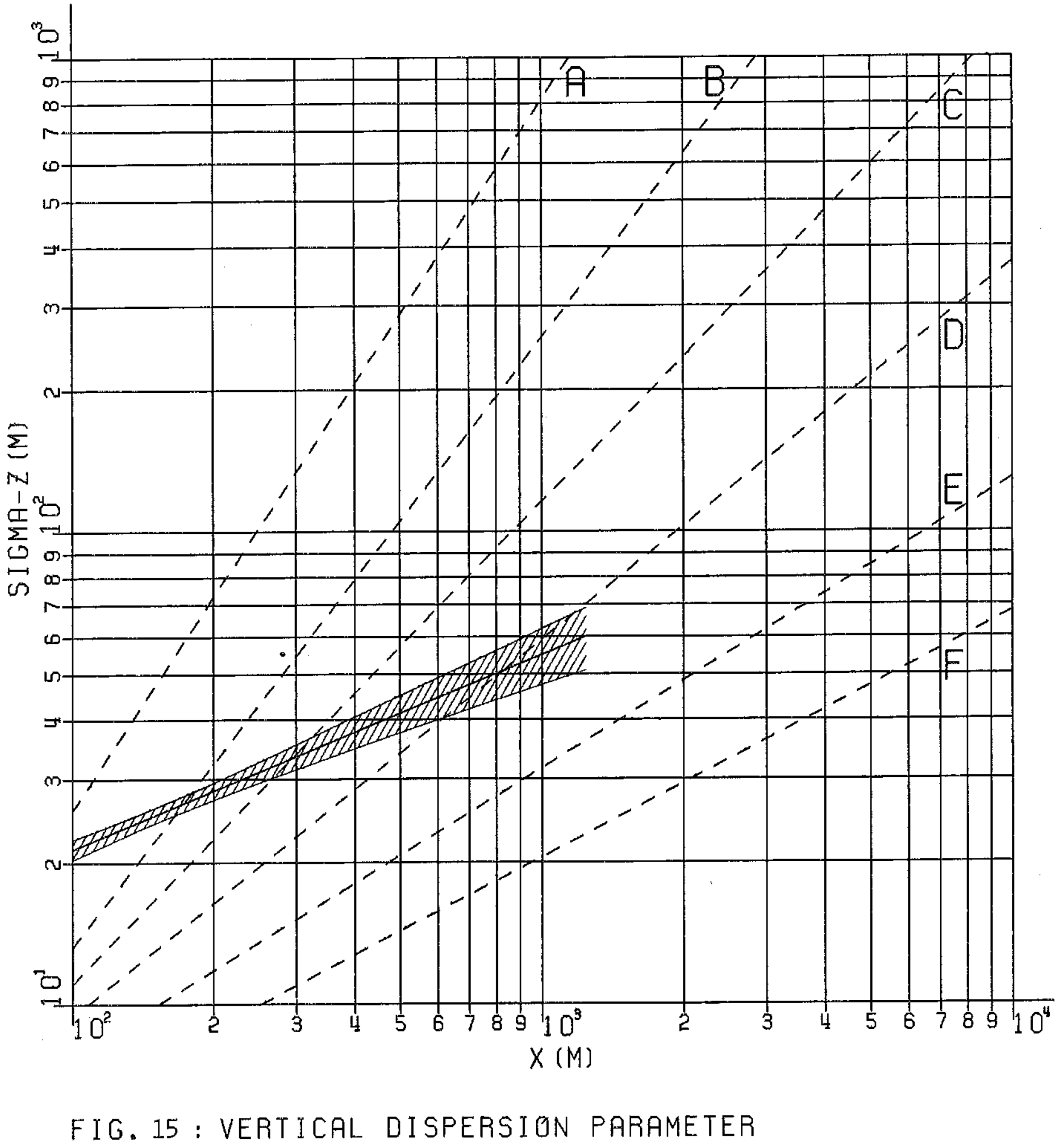

FIG. 15 : VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO. 31, PERIODS 1+2

////////////// H= 60M, TRACER CF2BR2

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

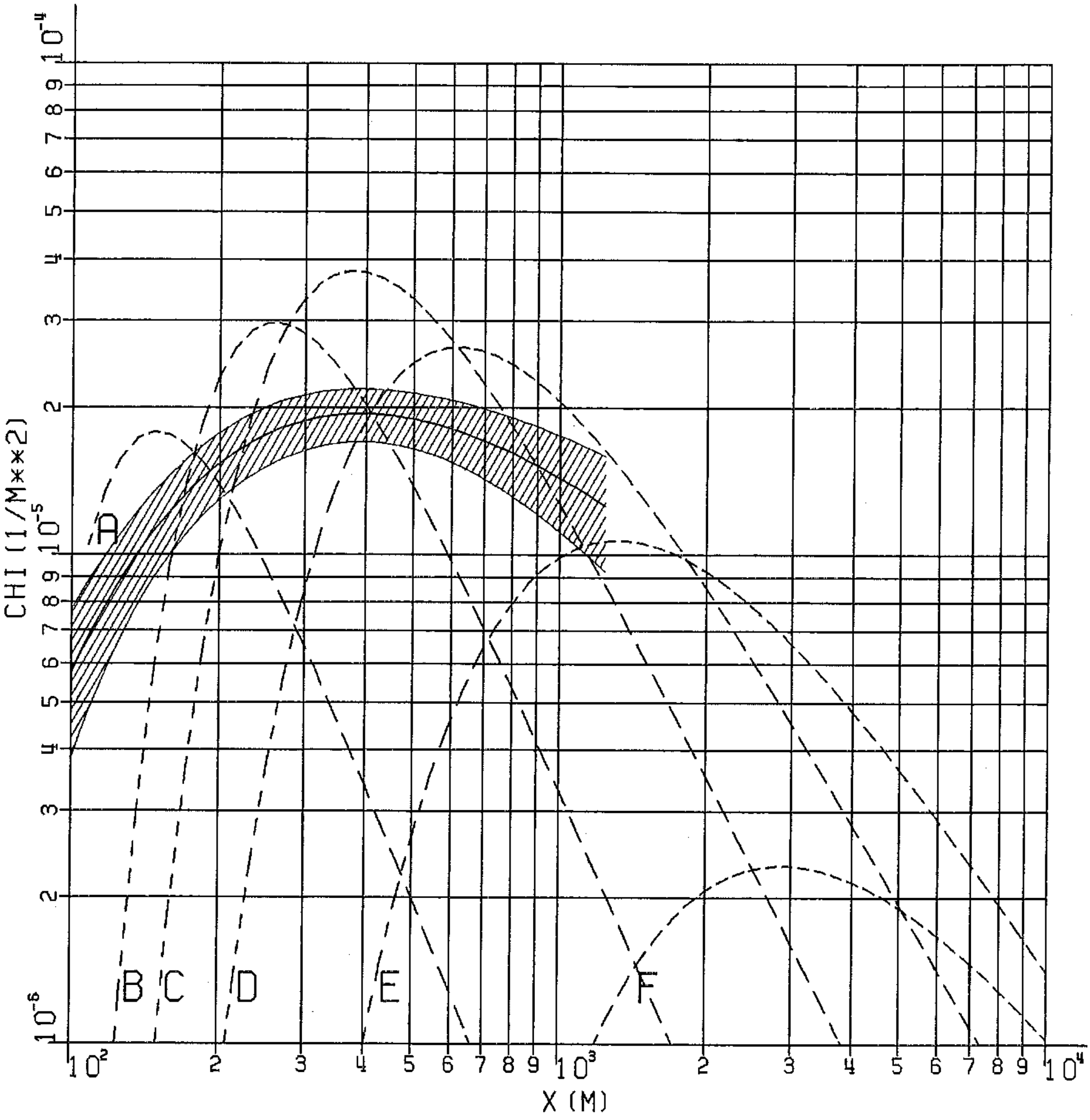

FIG. 16 : NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO. 31, PERIODS 1+2

////////////// H= 60M, TRACER CF_2Br_2

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

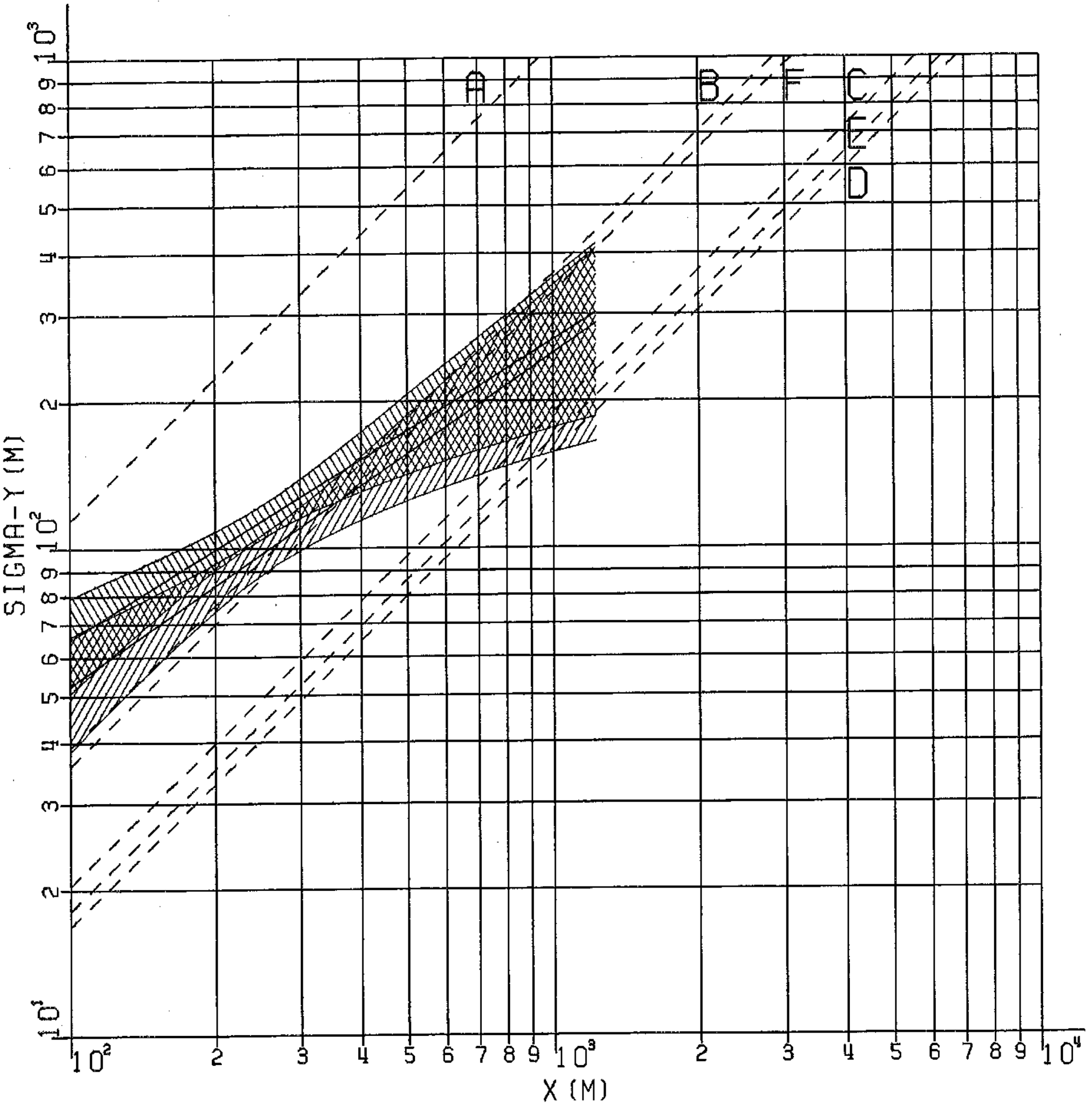

FIG. 17 : HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.32, PERIODS 1+2

H= 60M, TRACER CF2BR2

H= 60M, TRACER CFCL3

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

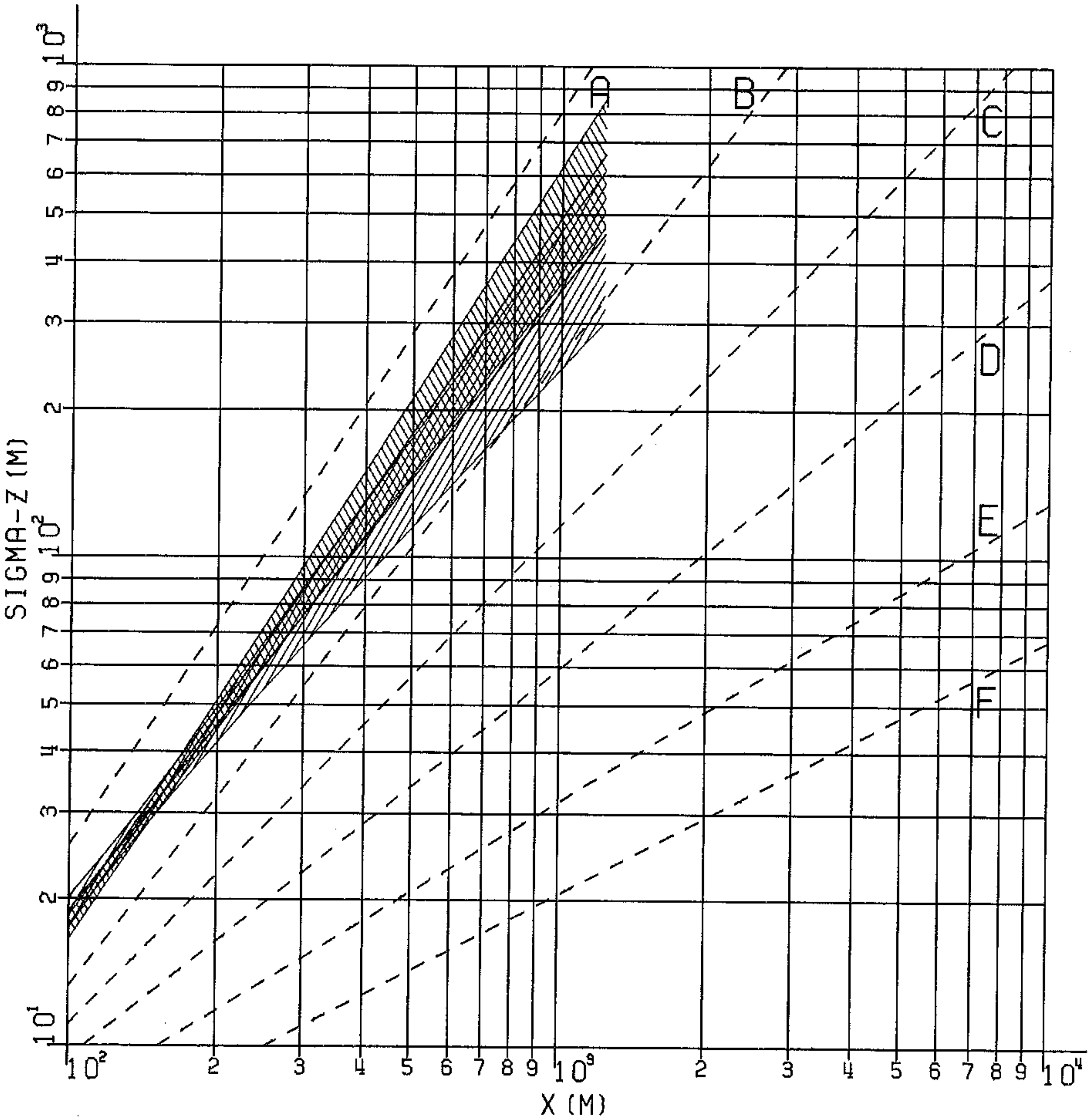

FIG. 18 : VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.32, PERIODS 1+2
H= 60M, TRACER CF2BR2
H= 60M, TRACER CFCL3
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

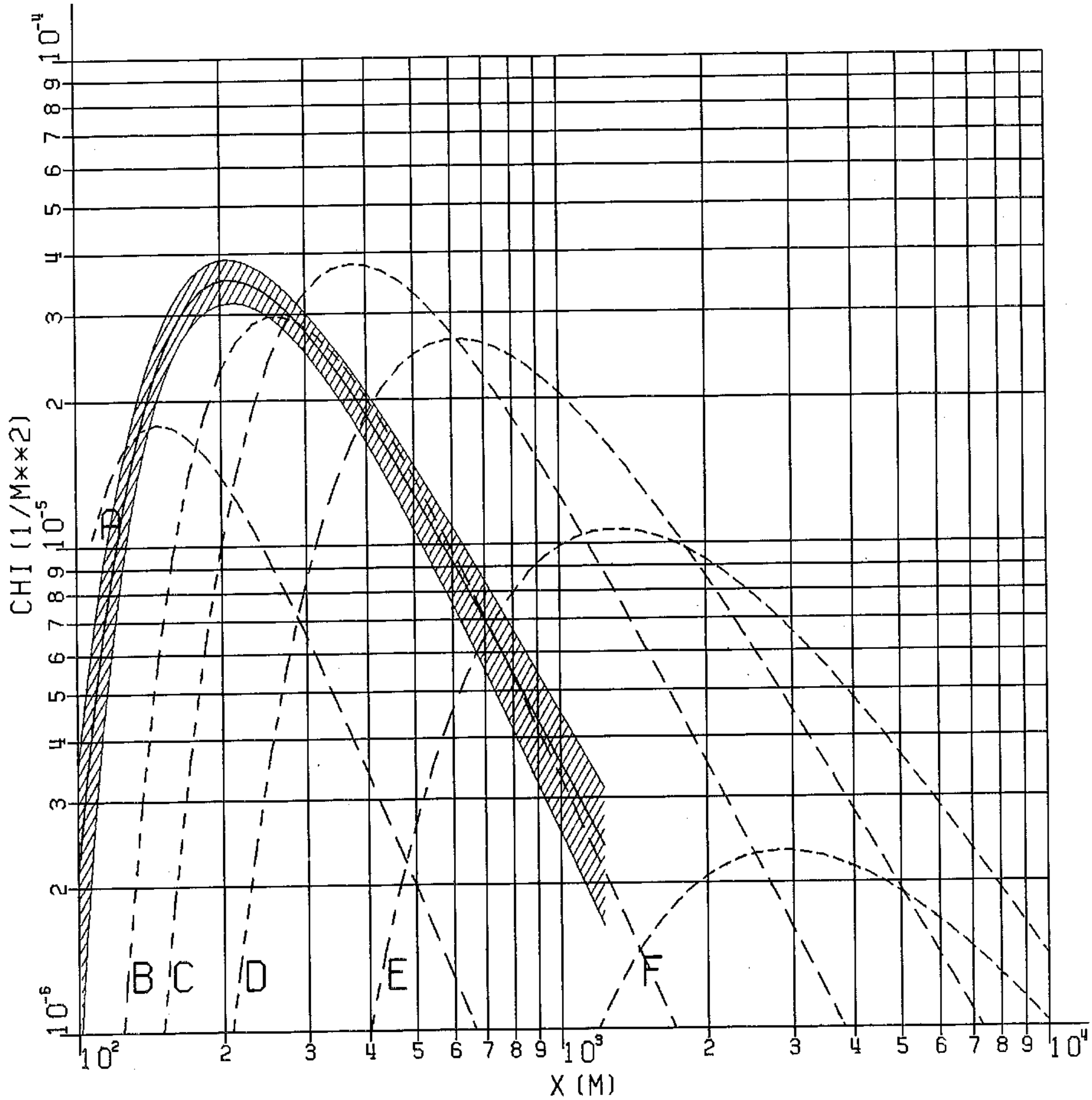

FIG. 19 : NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.32, PERIODS 1+2
H= 60M, TRACER CF2BR2
----- COMBINED, SMOOTHED, AND CENTERED RESULTS

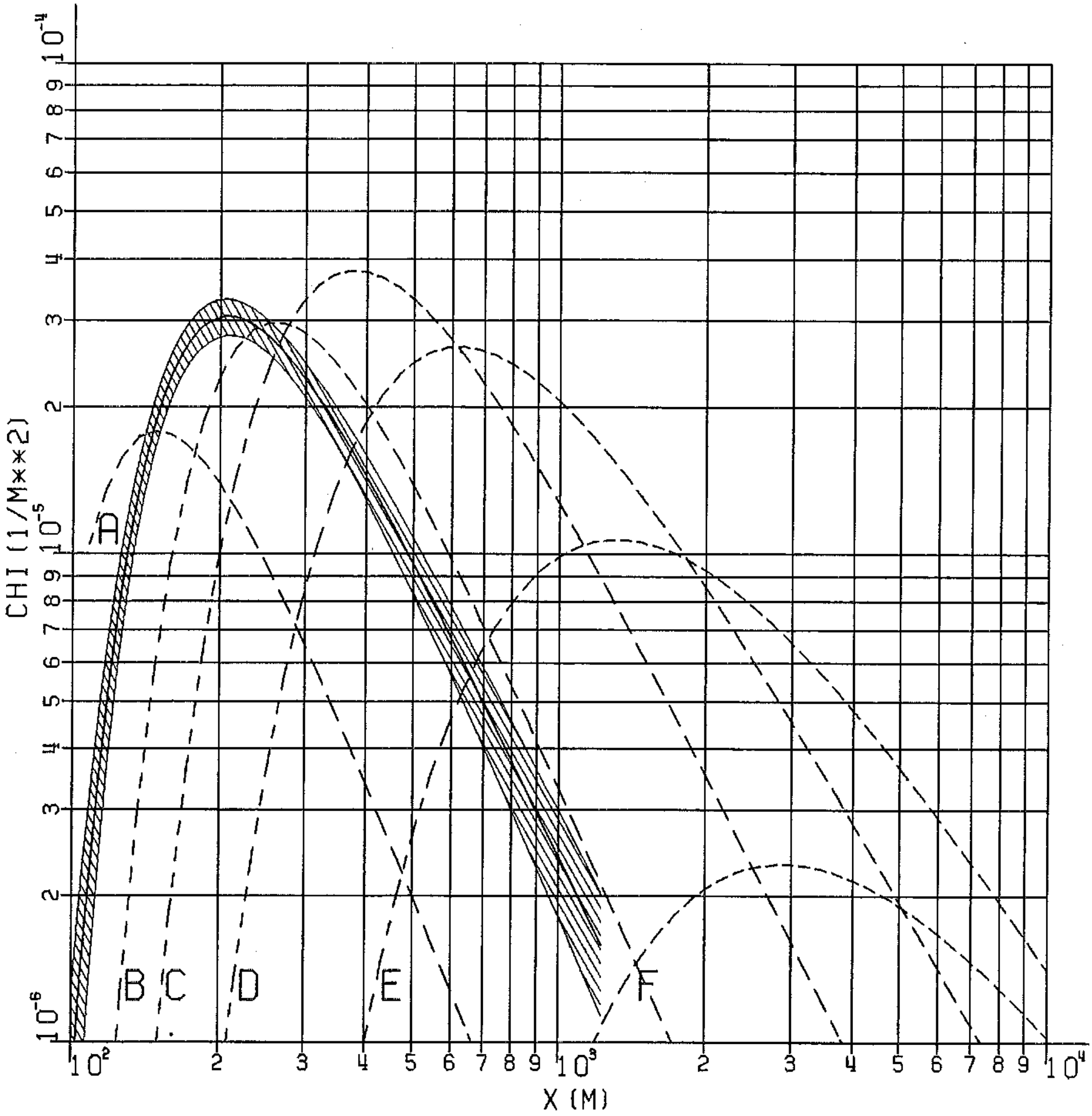

FIG. 20 : NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.32, PERIODS 1+2
H= 60M, TRACER CFCL3
----- COMBINED, SMOOTHED, AND CENTERED RESULTS

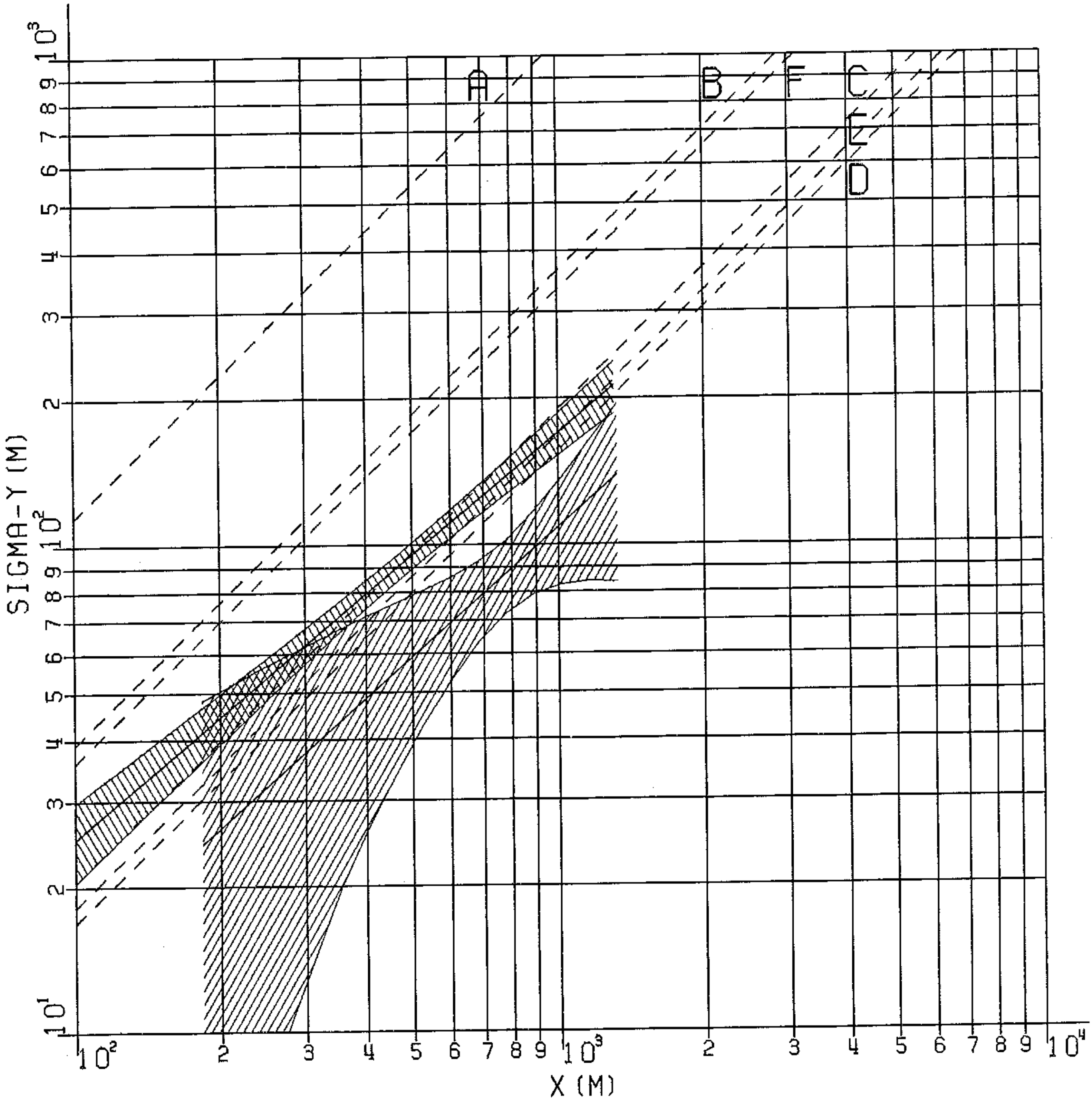

FIG. 21: HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.34, PERIODS 1+2

H=100M, TRACER CFCL3

H= 60M, TRACER CF2BR2

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

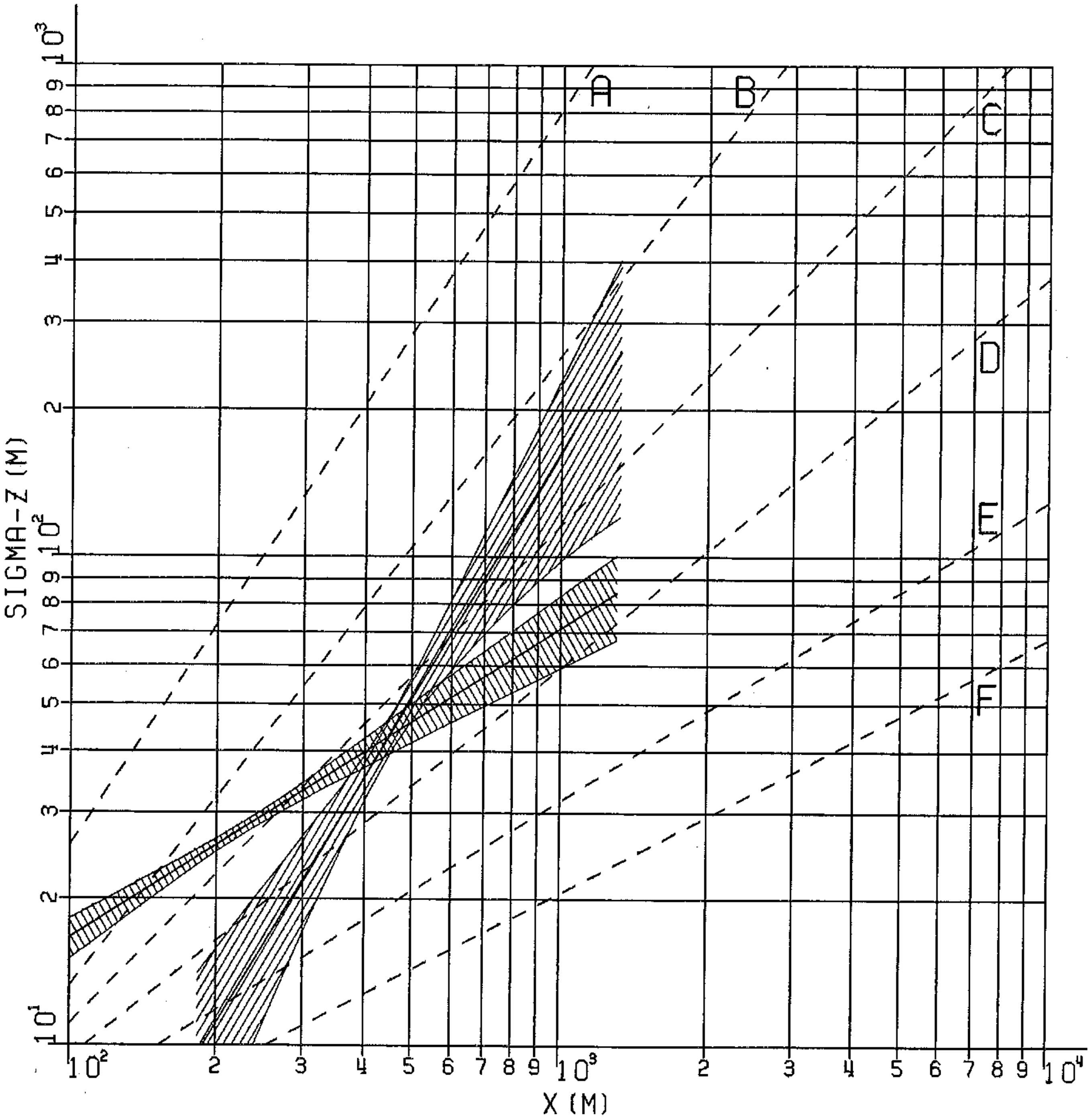

FIG. 22 : VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.34, PERIODS 1+2
H=100M, TRACER CFCL3
H= 60M, TRACER CF2BR2
– – – – – COMBINED, SMOOTHED, AND CENTERED RESULTS

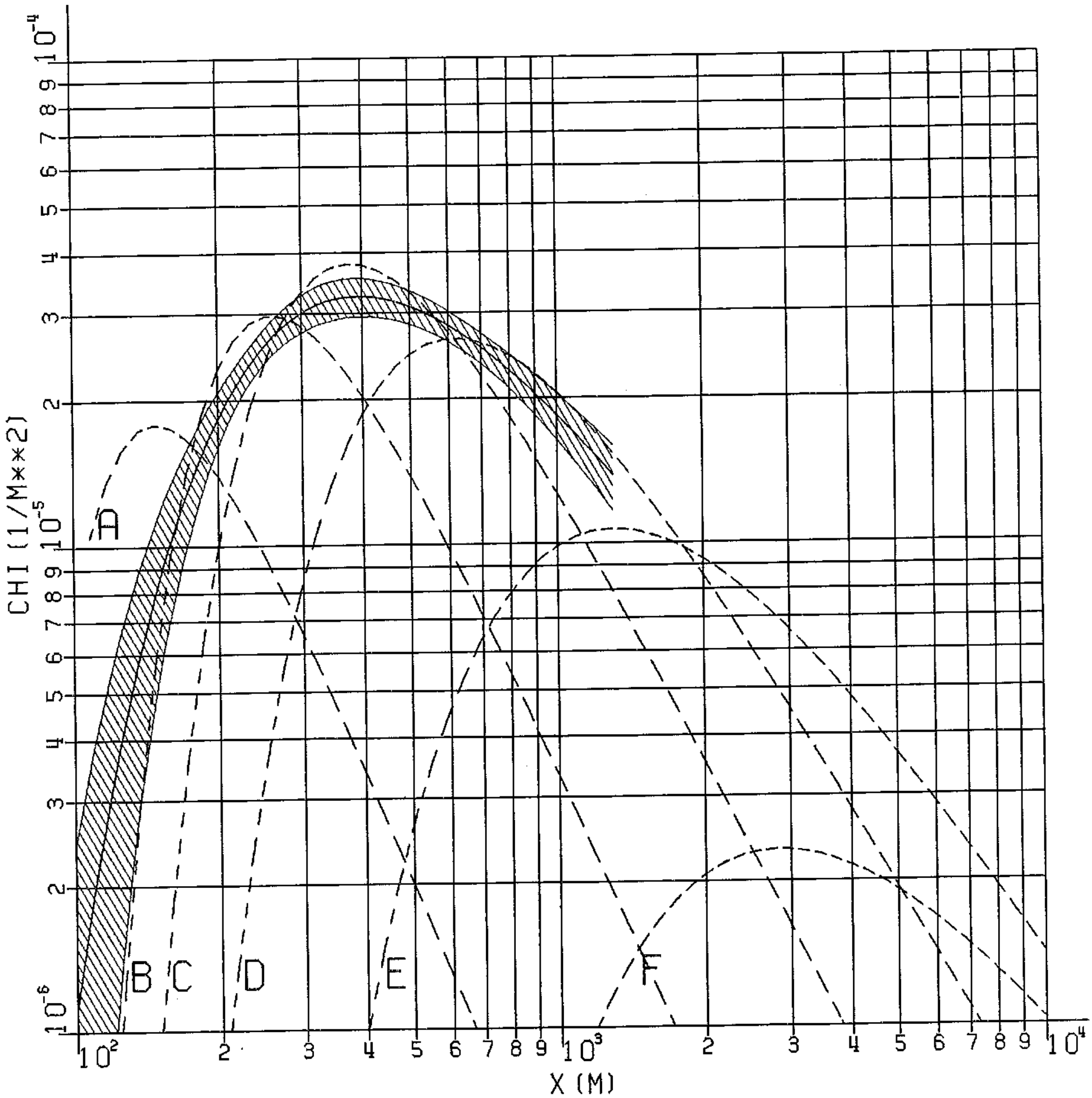

FIG. 23: NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.34, PERIODS 1+2

H= 60M, TRACER CF2BR2

– – – – – COMBINED, SMOOTHED, AND CENTERED RESULTS

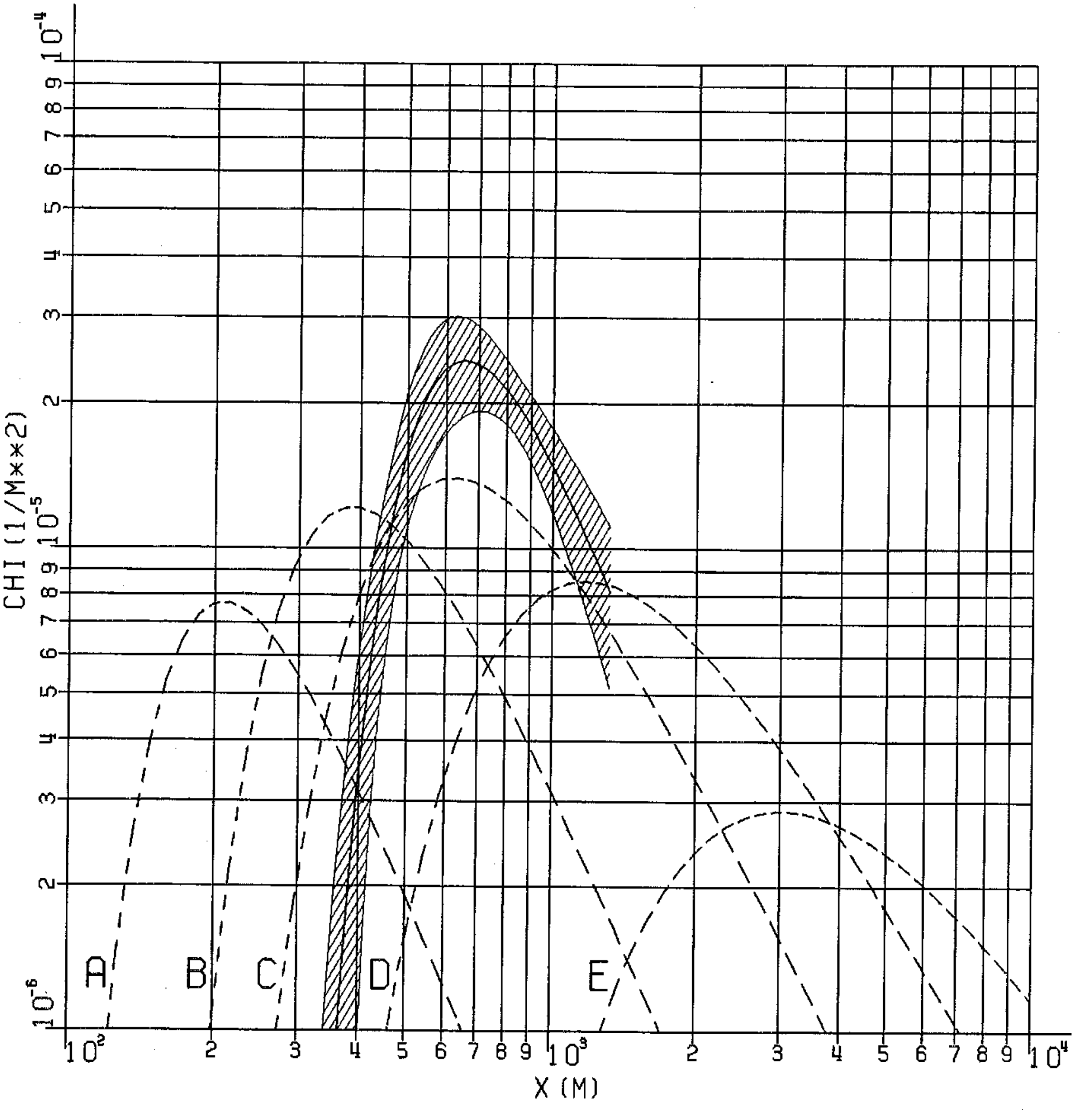

FIG. 24 : NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.34, PERIODS 1+2
H=100M, TRACER CFCL3
– – – – – COMBINED, SMOOTHED, AND CENTERED RESULTS

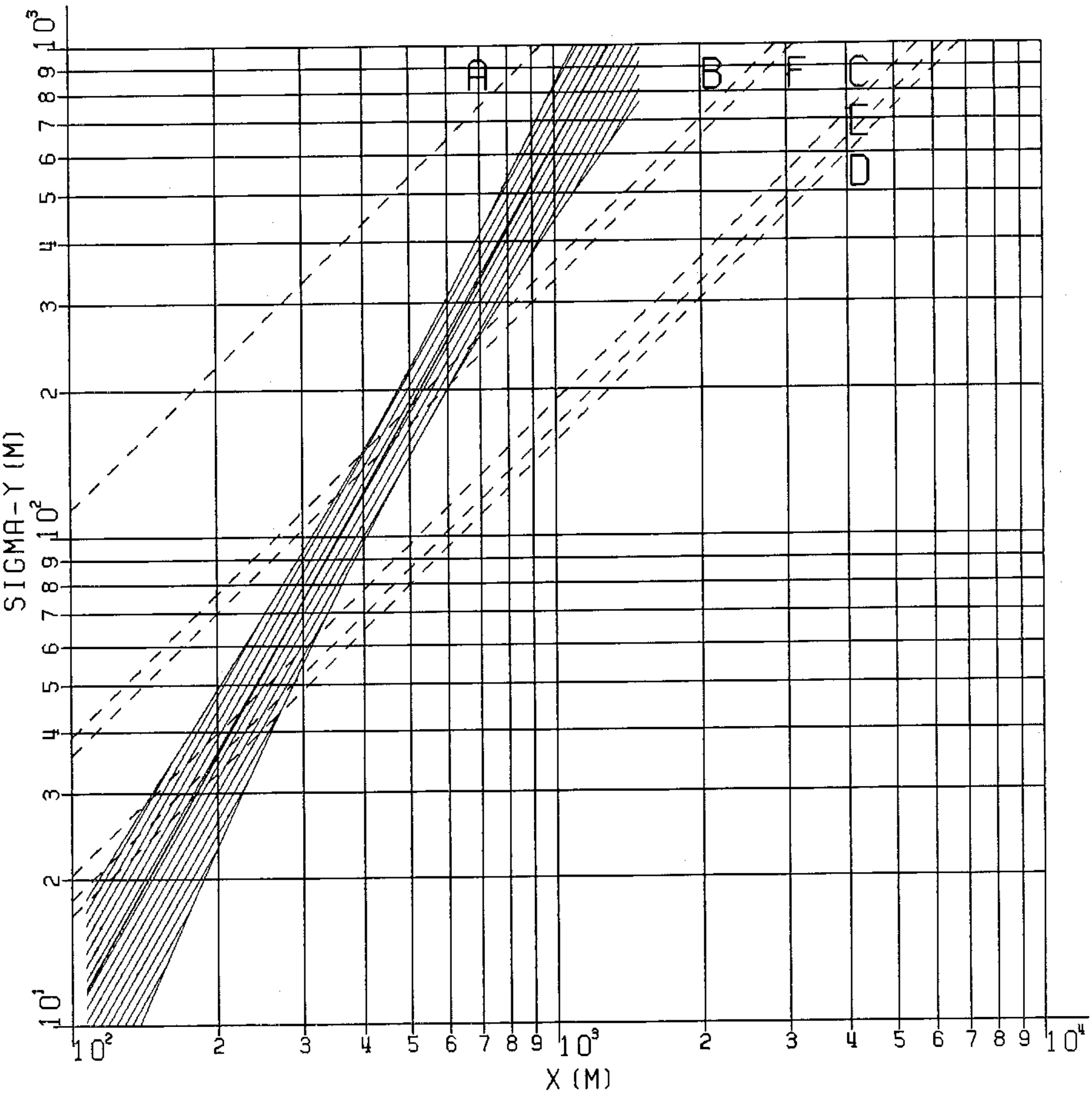

FIG.25 : HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.27, PERIOD 1
H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

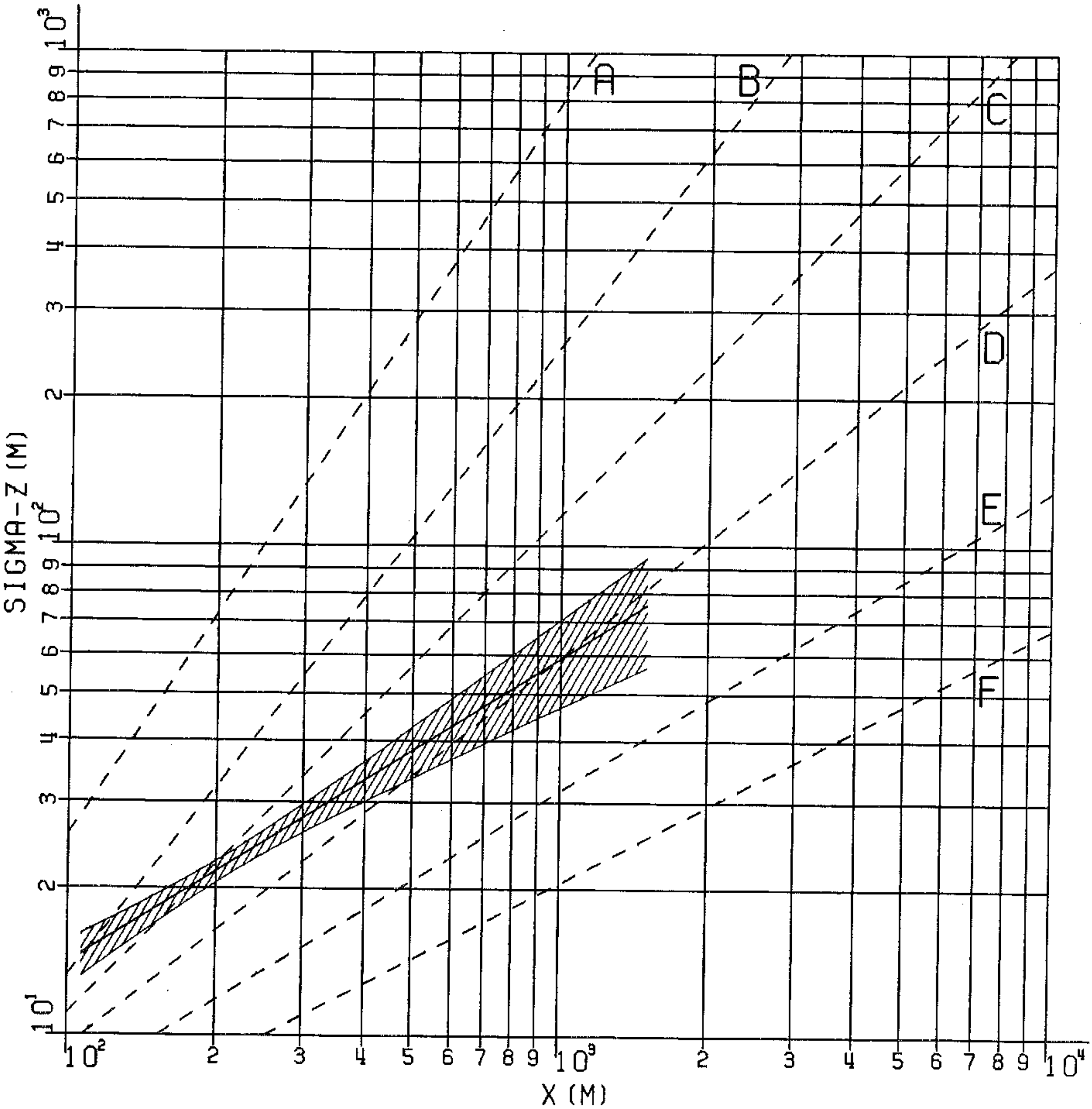

FIG. 26 : VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.27, PERIOD 1
H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

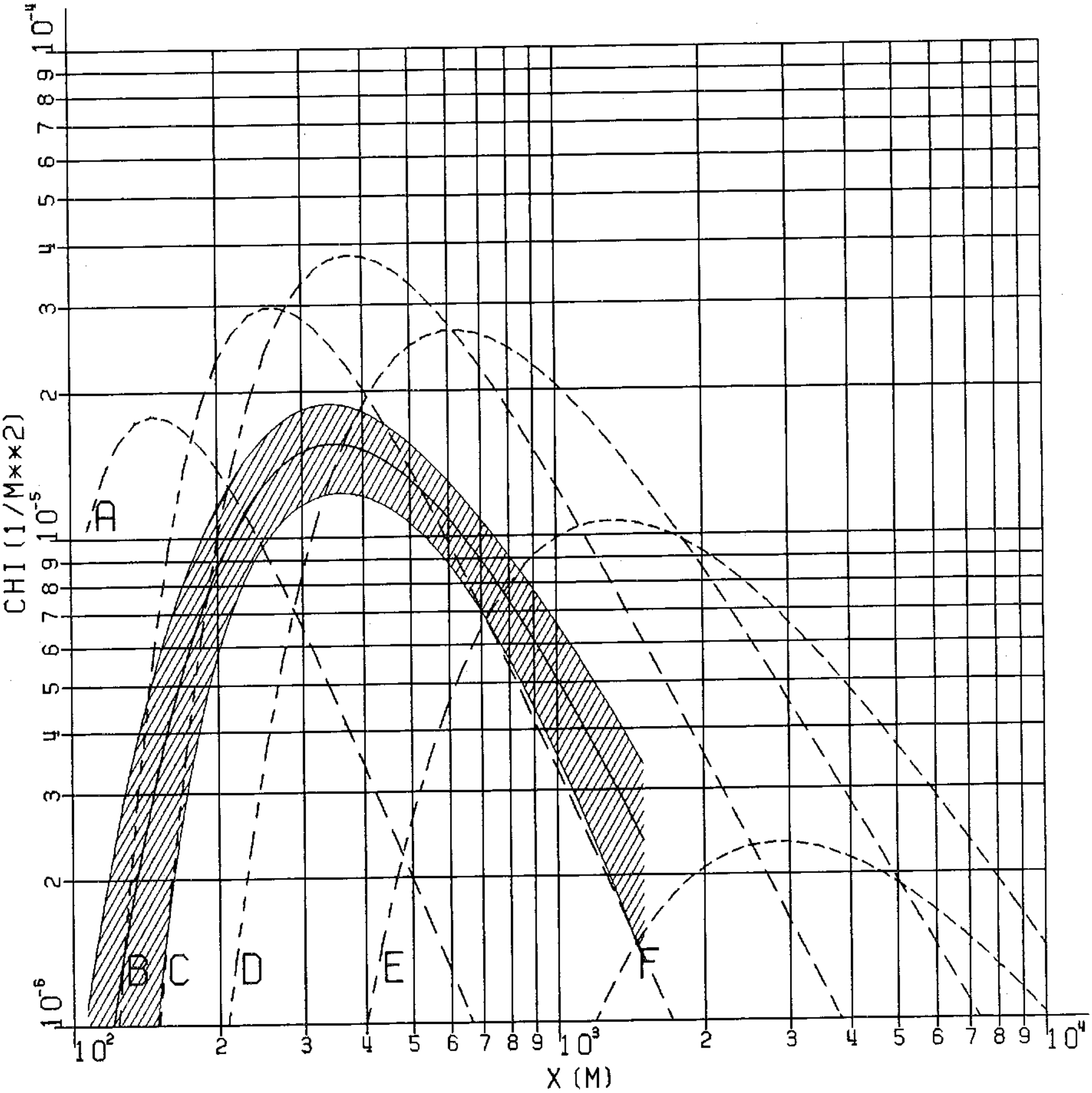

FIG. 27: NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.27, PERIOD 1

H= 60M, TRACER CF2BR2

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

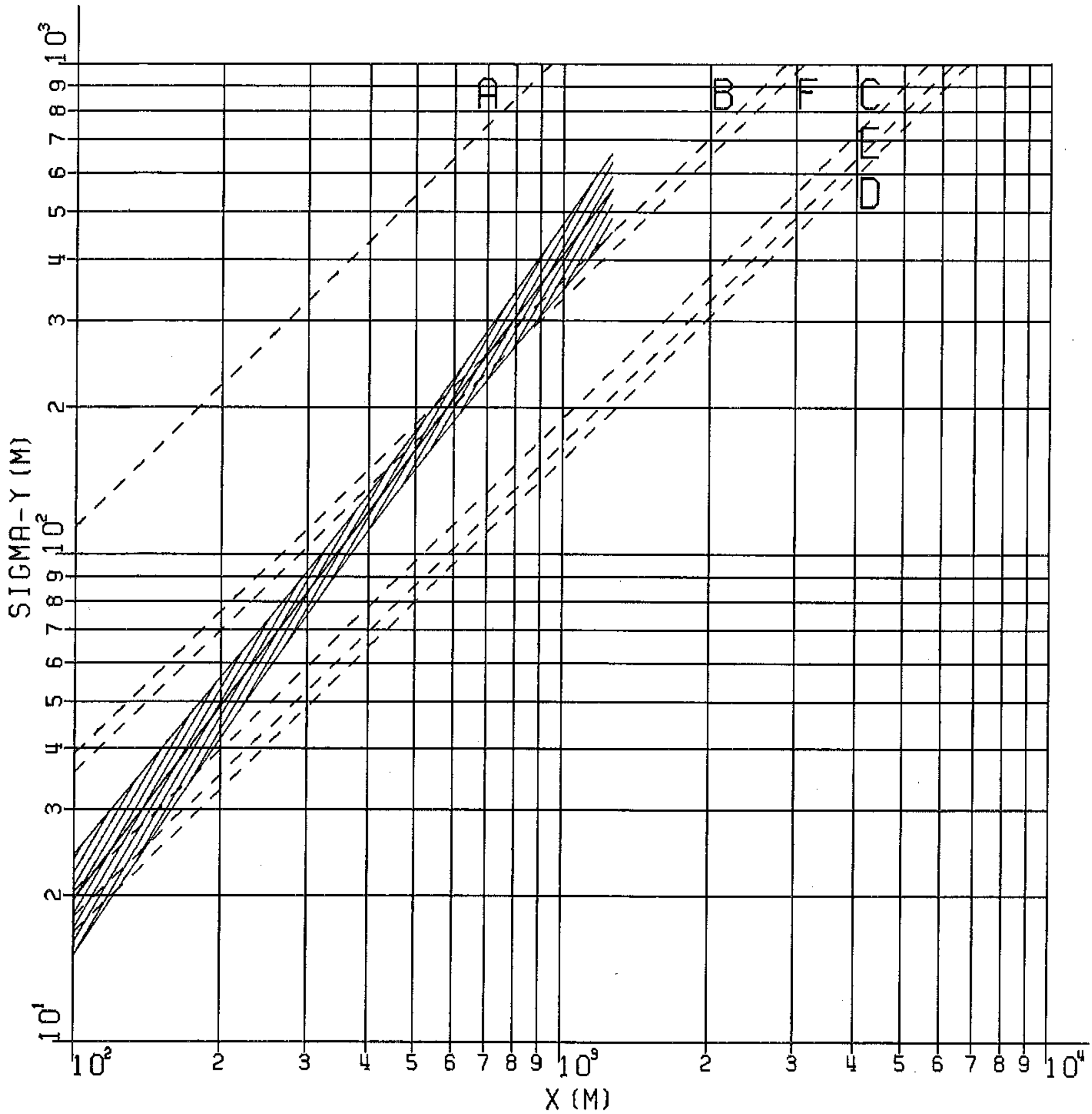

FIG. 28: HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.36, PERIODS 1+2
H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

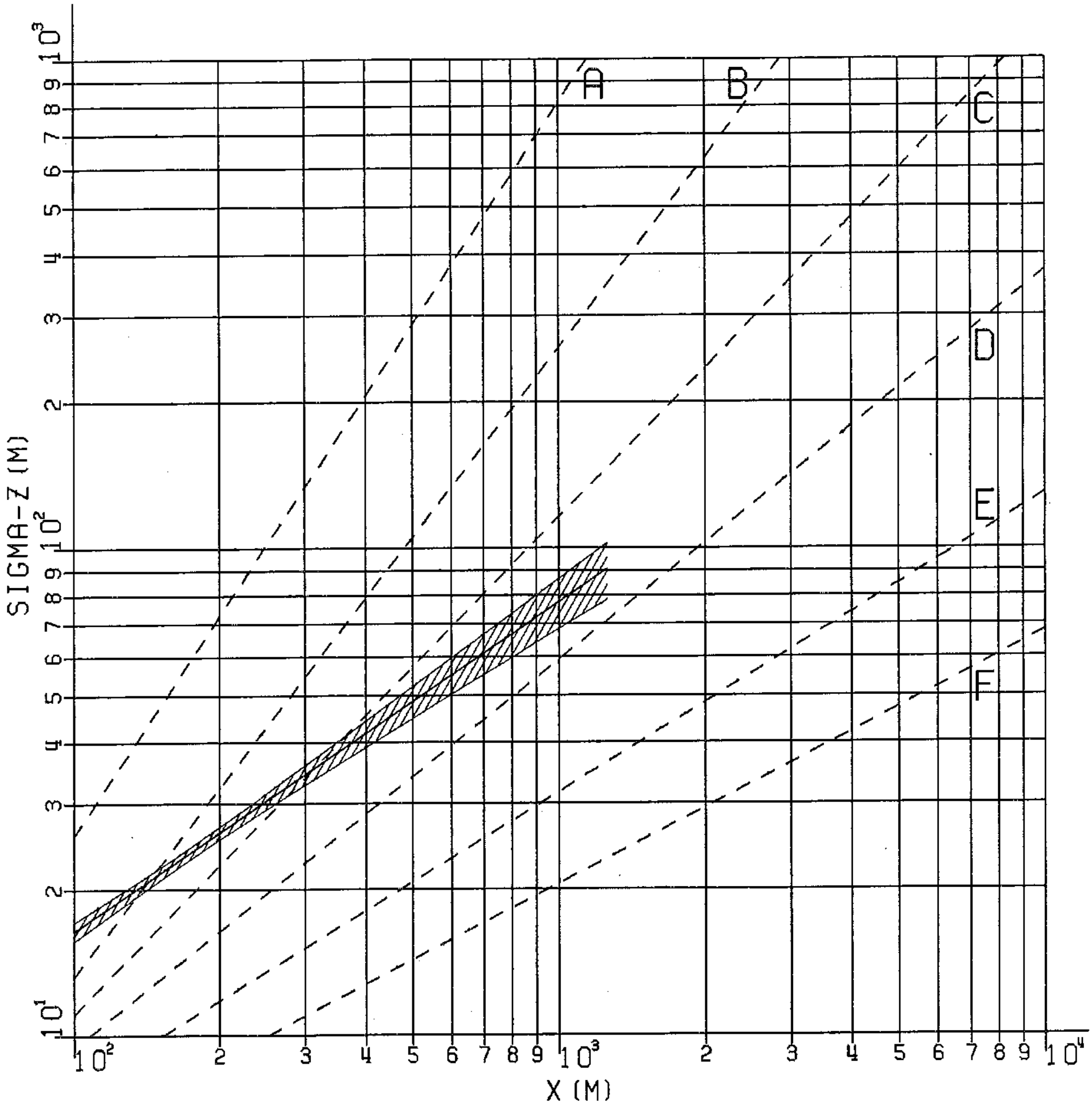

FIG. 29: VERTICAL DISPERSION PARAMETER OF EXPERIMENT NO.36, PERIODS 1+2

////////////// H= 60M, TRACER CF2BR2

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

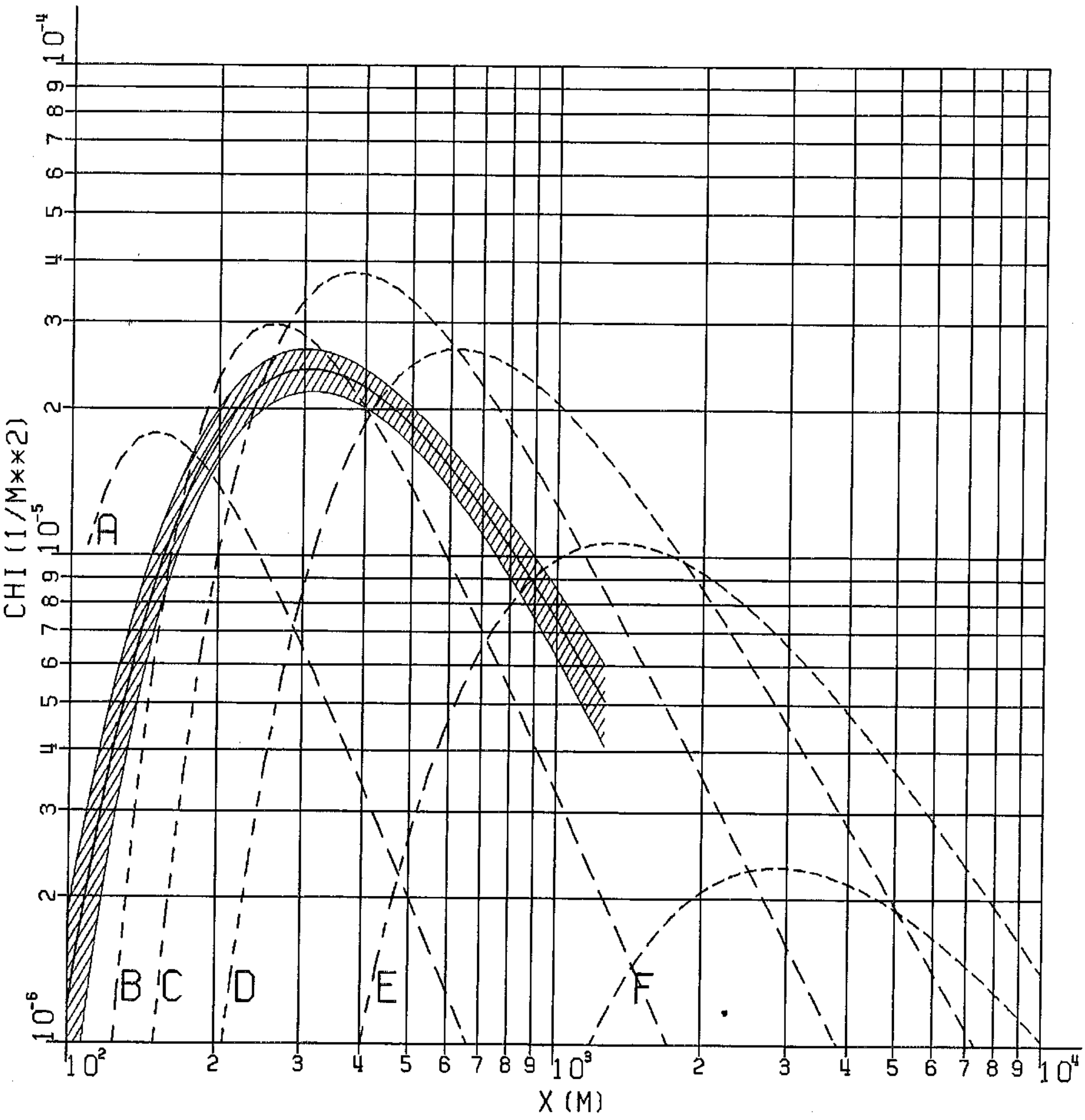

FIG. 30: NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.36, PERIODS 1+2

////////////// H= 60M, TRACER CF2BR2

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

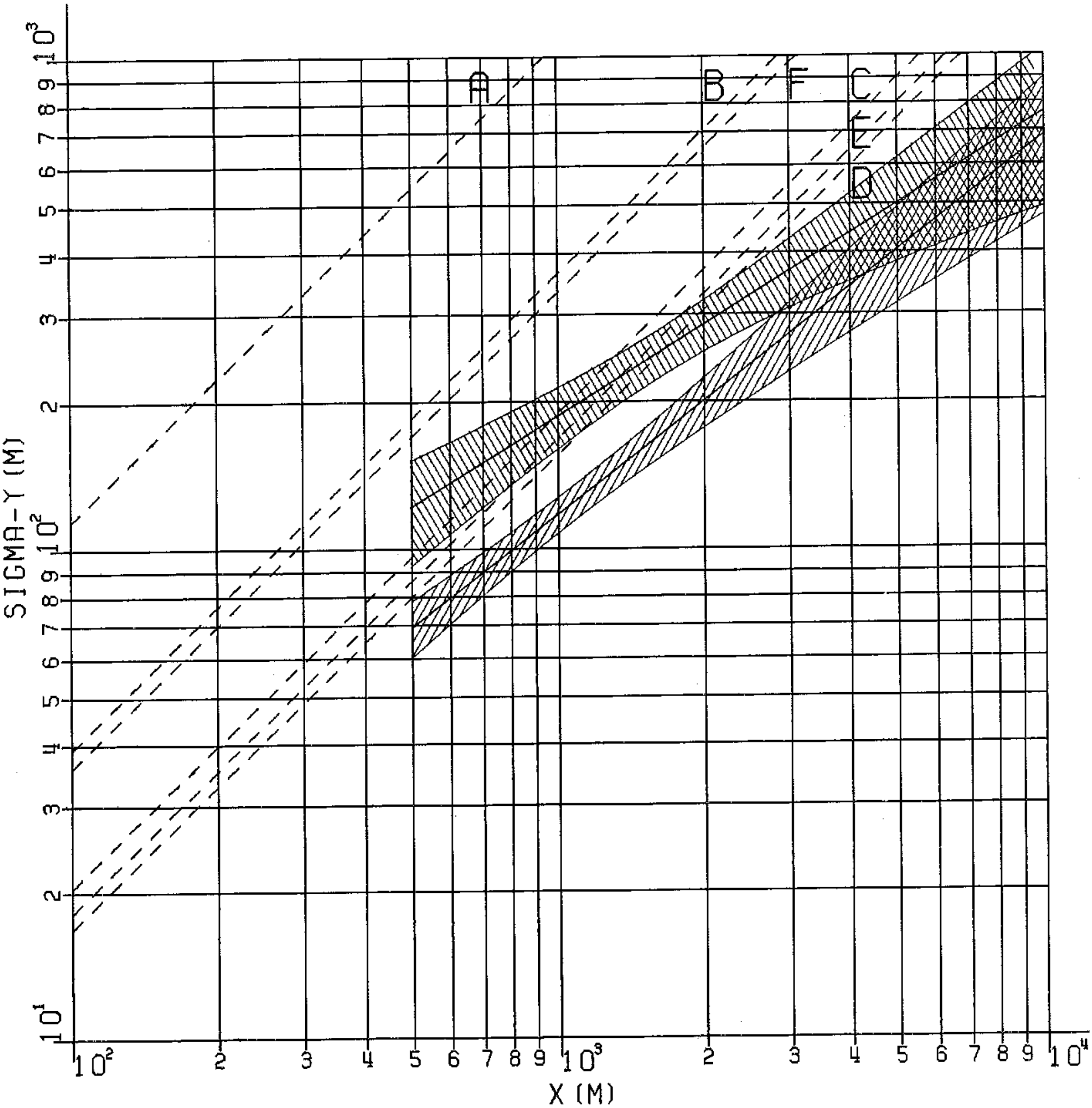

FIG. 31: HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.44, PERIODS 1+2
H= 60M, TRACER CF2BR2
H=100M, TRACER CFCL3
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

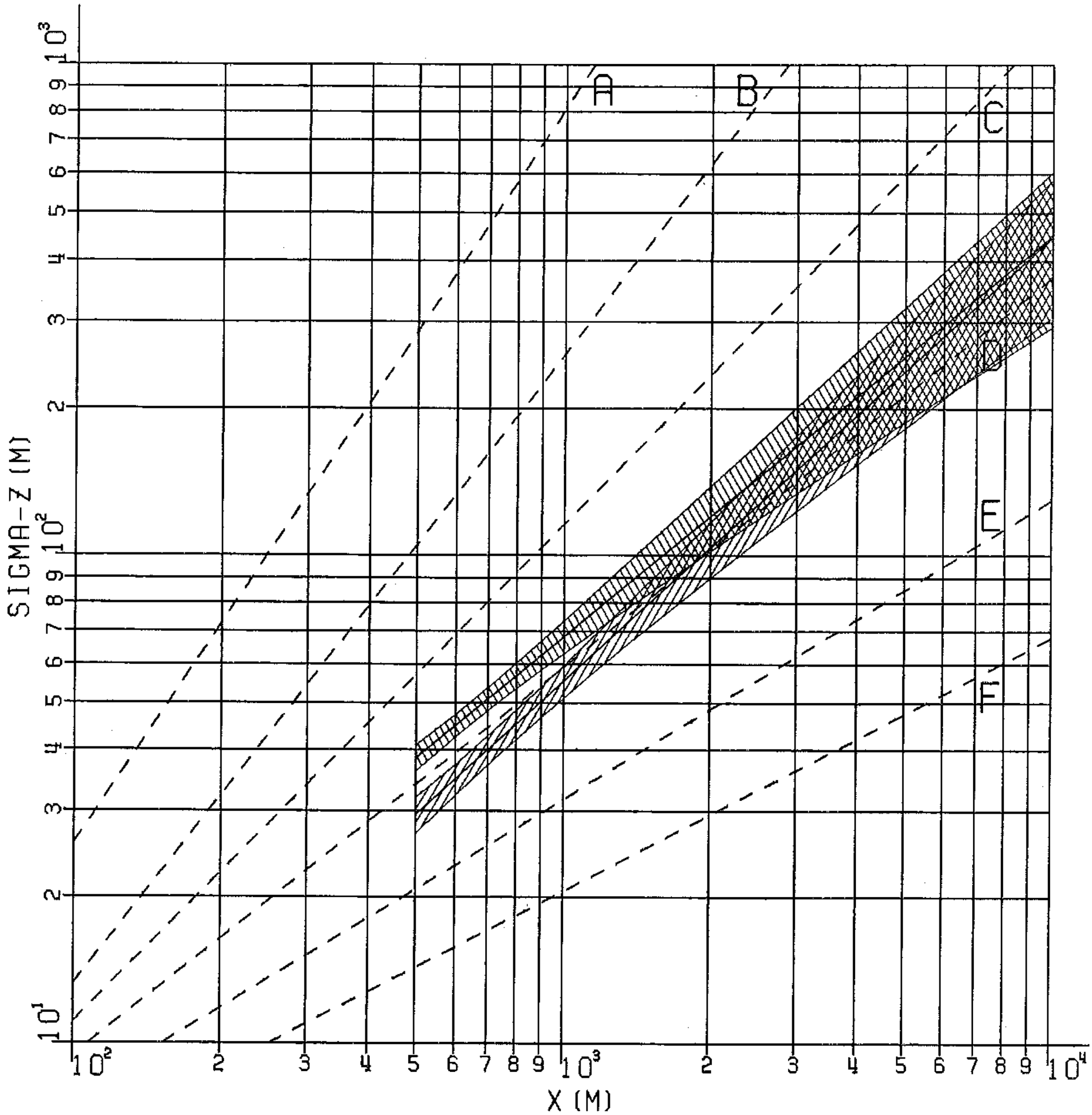

FIG. 32: VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.44, PERIODS 1+2

H= 60M, TRACER CF2BR2

H=100M, TRACER CFCL3

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

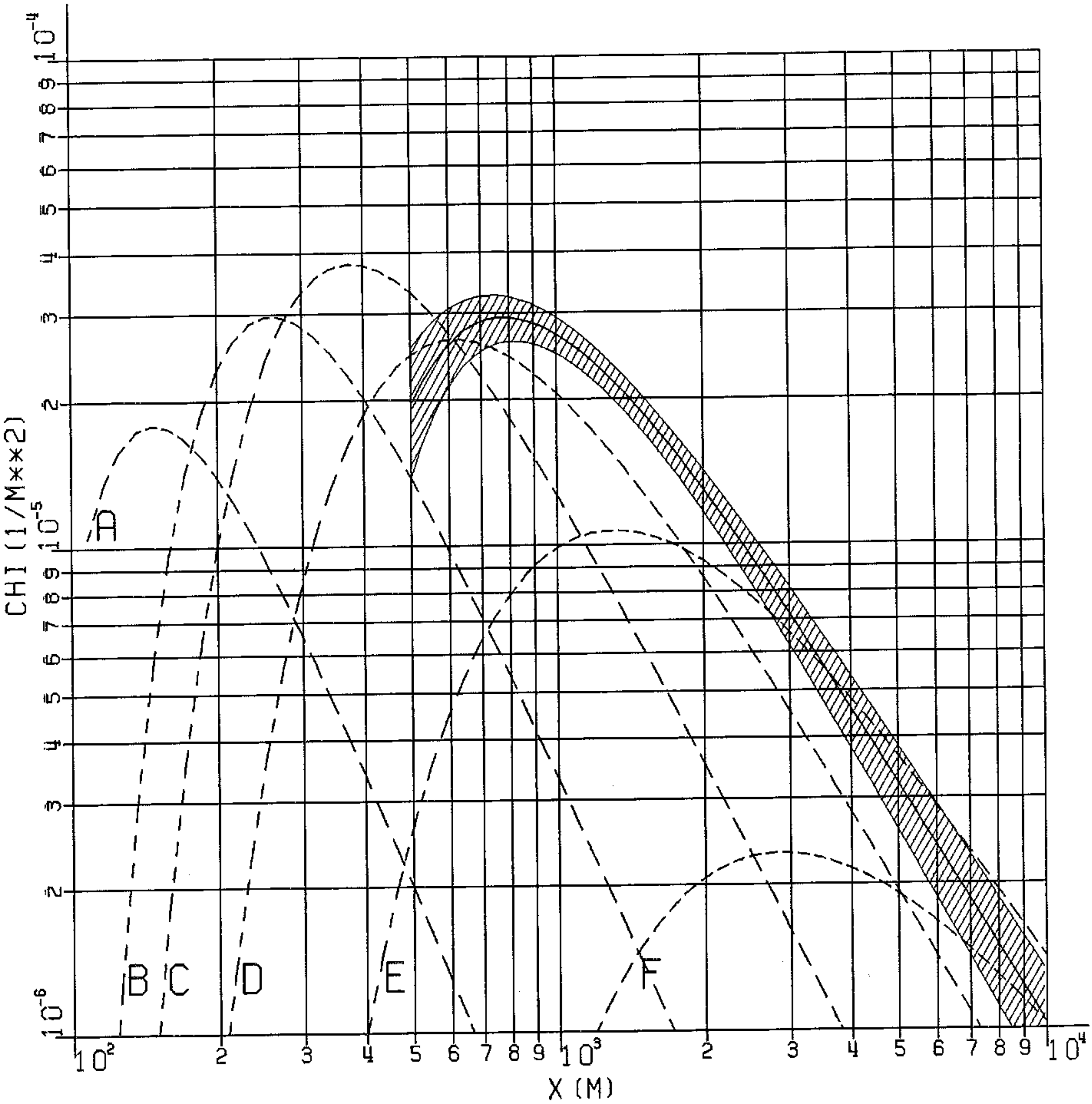

FIG. 33 : NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.44, PERIODS 1+2
////////// H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

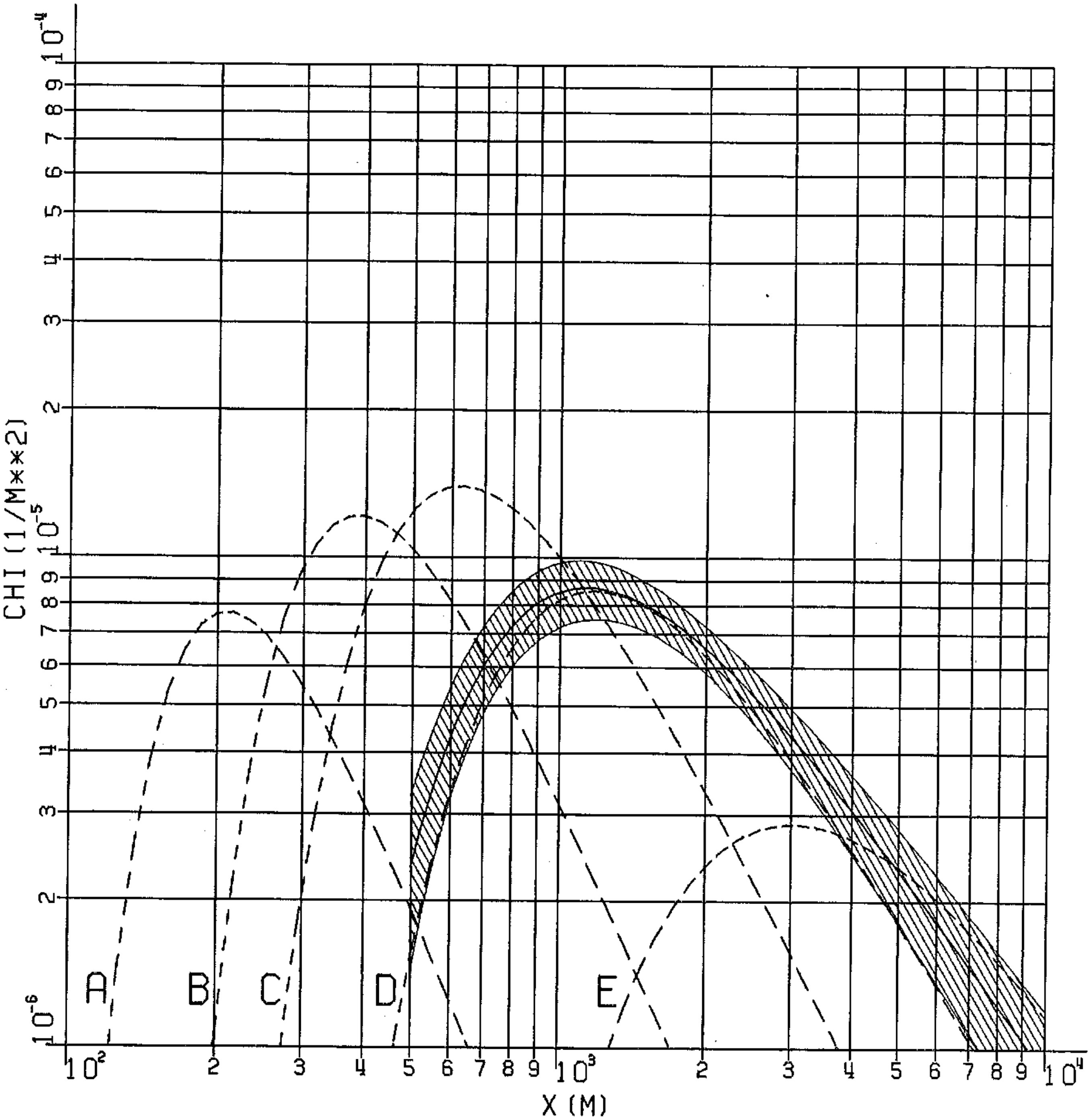

FIG. 34: NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.44, PERIODS 1+2

H=100M, TRACER CFCL3

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

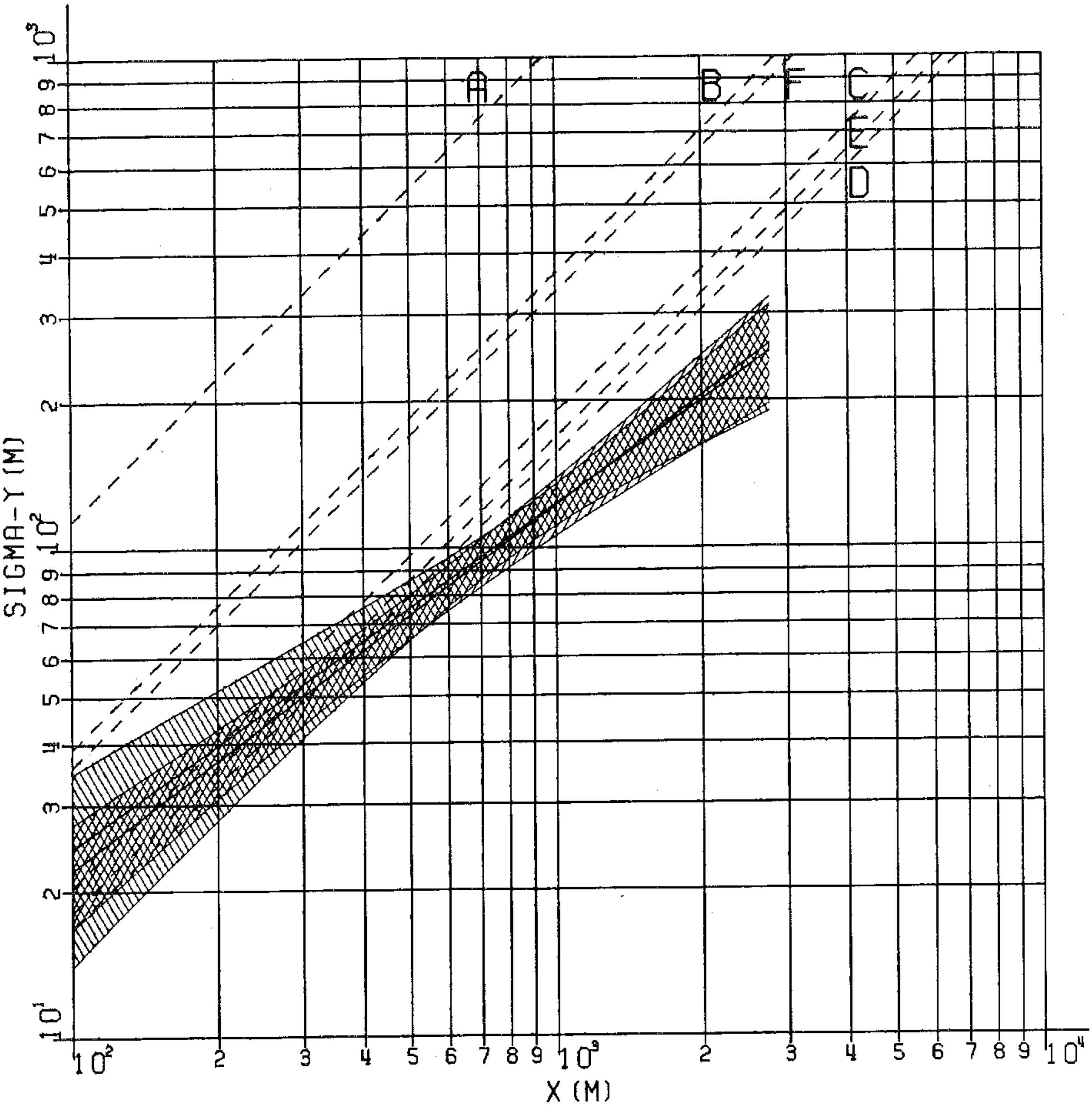

FIG. 35 : HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO. 45, PERIODS 1+2
H= 60M, TRACER CF2BR2
H=100M, TRACER CFCL3
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

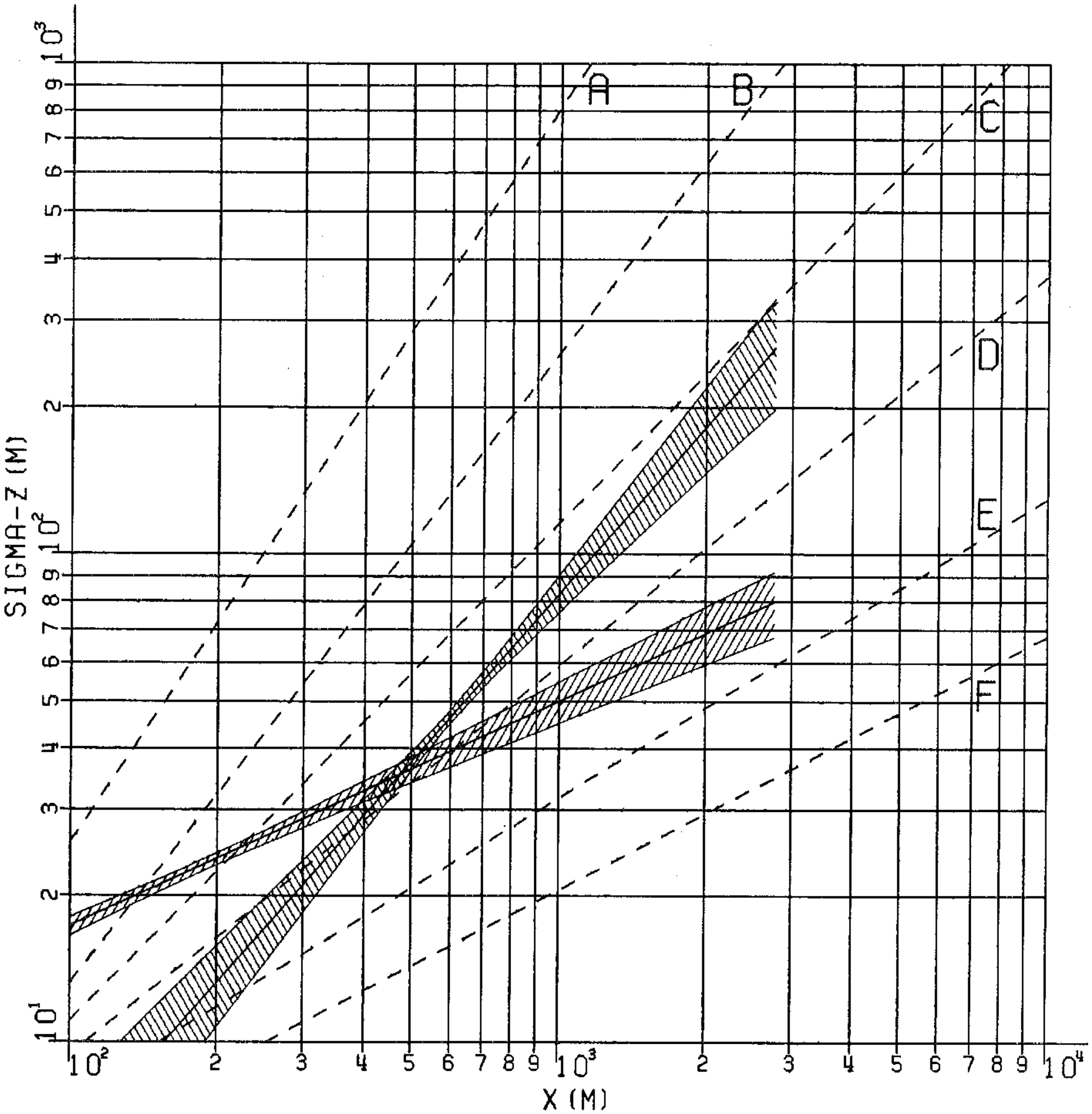

FIG. 36 : VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.45, PERIODS 1+2
H= 60M, TRACER CF2BR2
H=100M, TRACER CFCL3
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

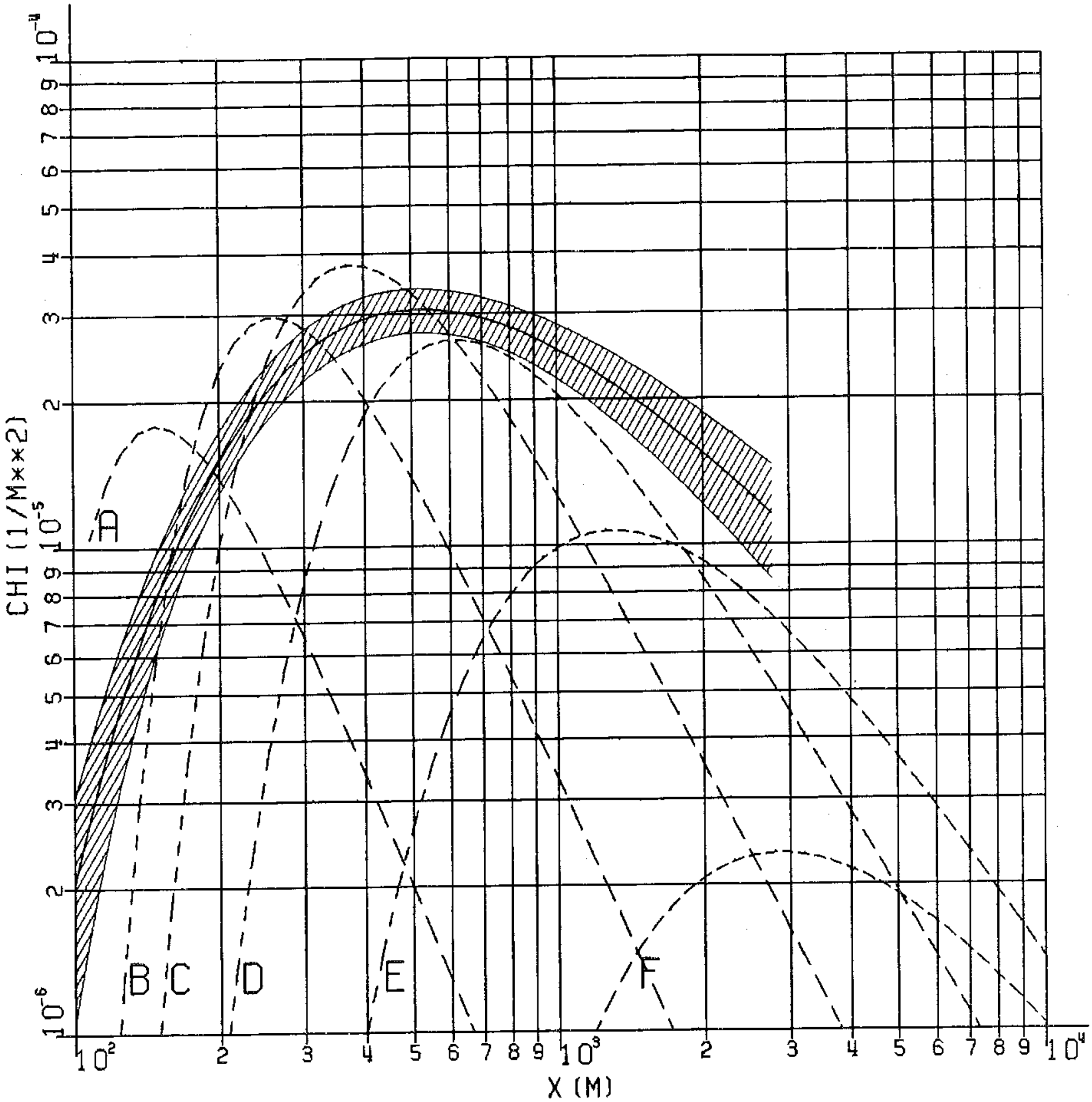

FIG. 37: NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO. 45, PERIODS 1+2
H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

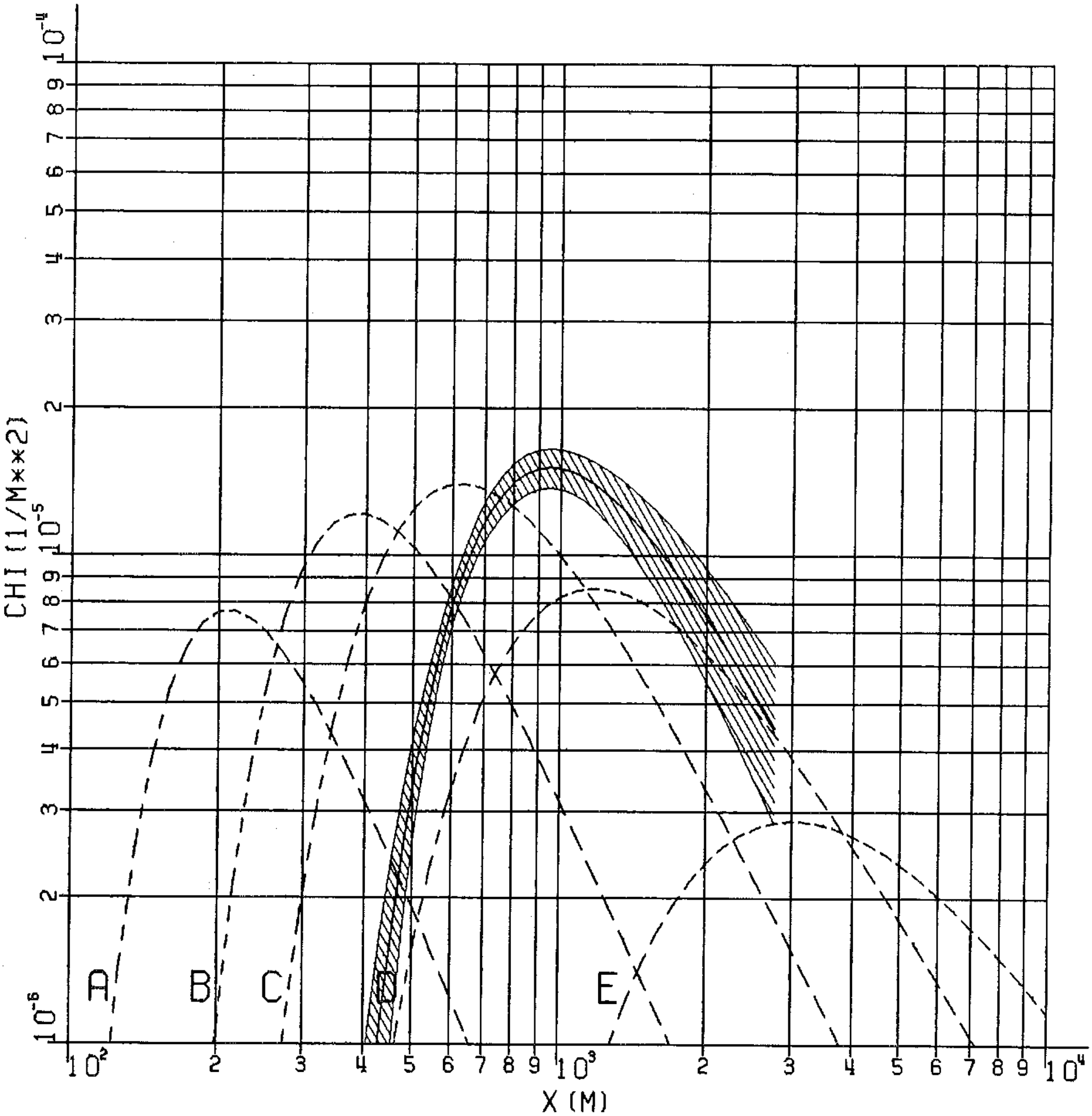

FIG. 38: NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.45, PERIODS 1+2
H=100M, TRACER CFCL3
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

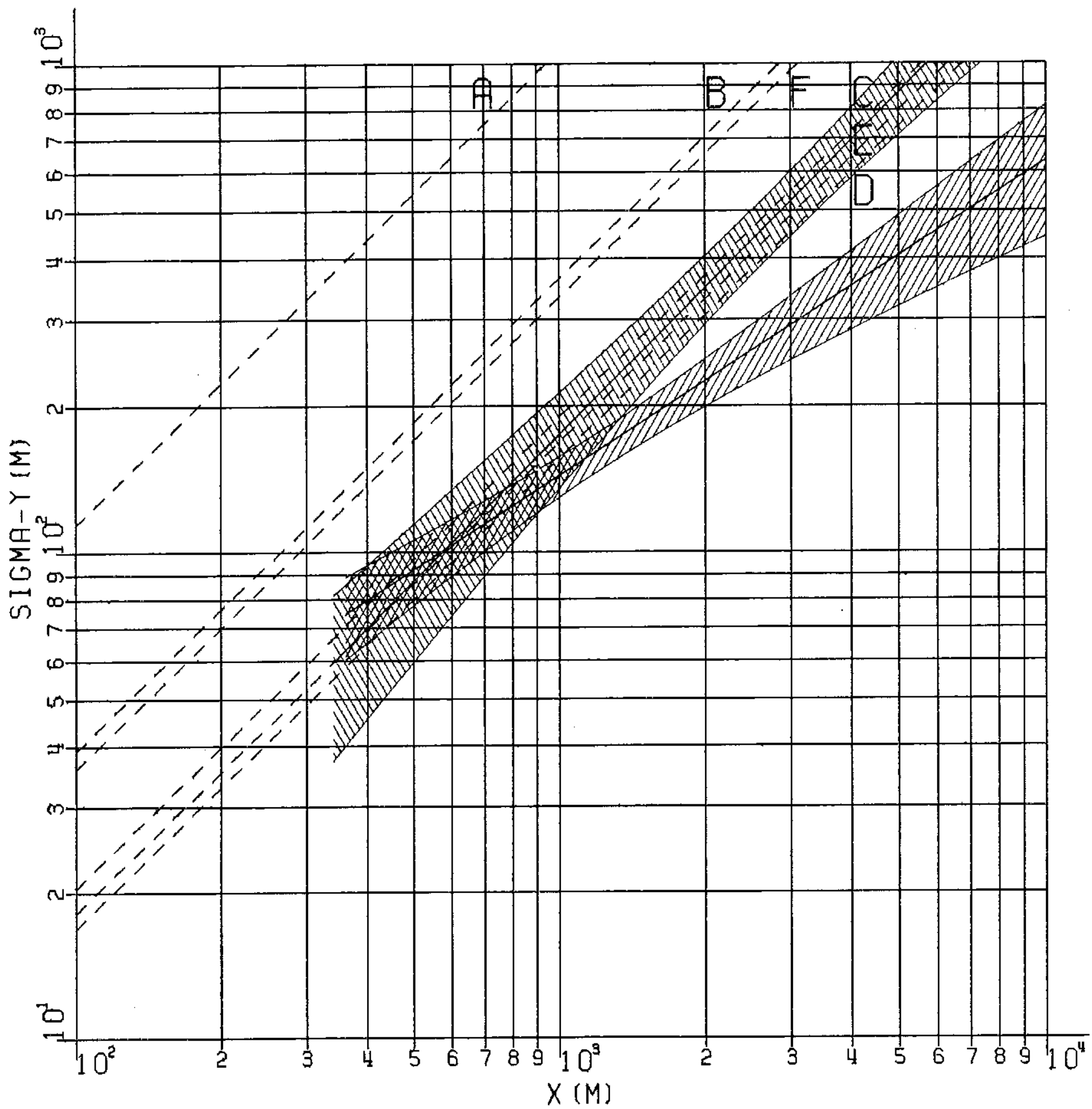

FIG. 39: HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.48, PERIODS 1+2

H= 60M, TRACER CF2BR2

H=100M, TRACER CFCL3

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

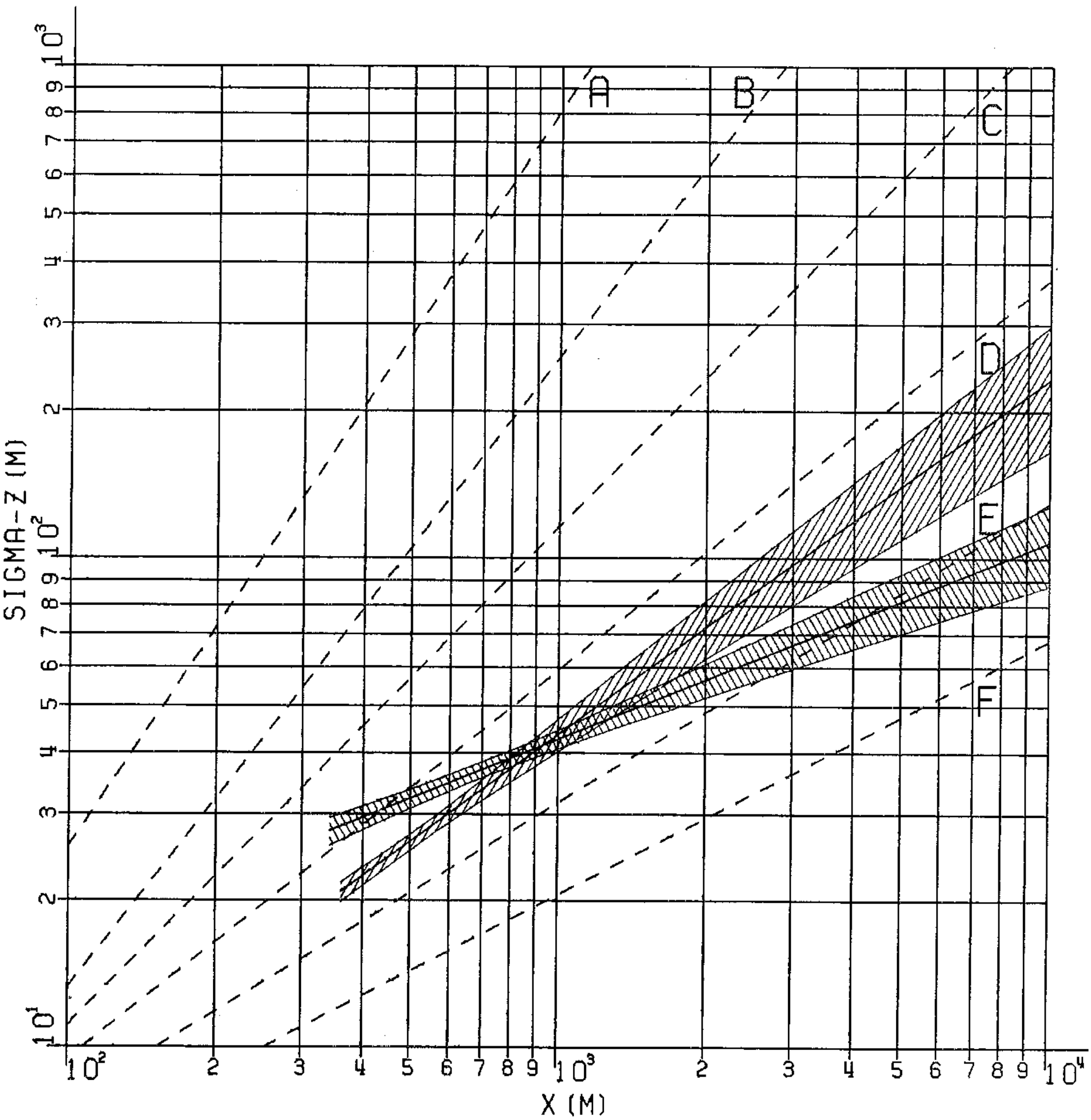

FIG. 40: VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.48, PERIODS 1+2

H= 60M, TRACER CF2BR2

H=100M, TRACER CFCL3

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

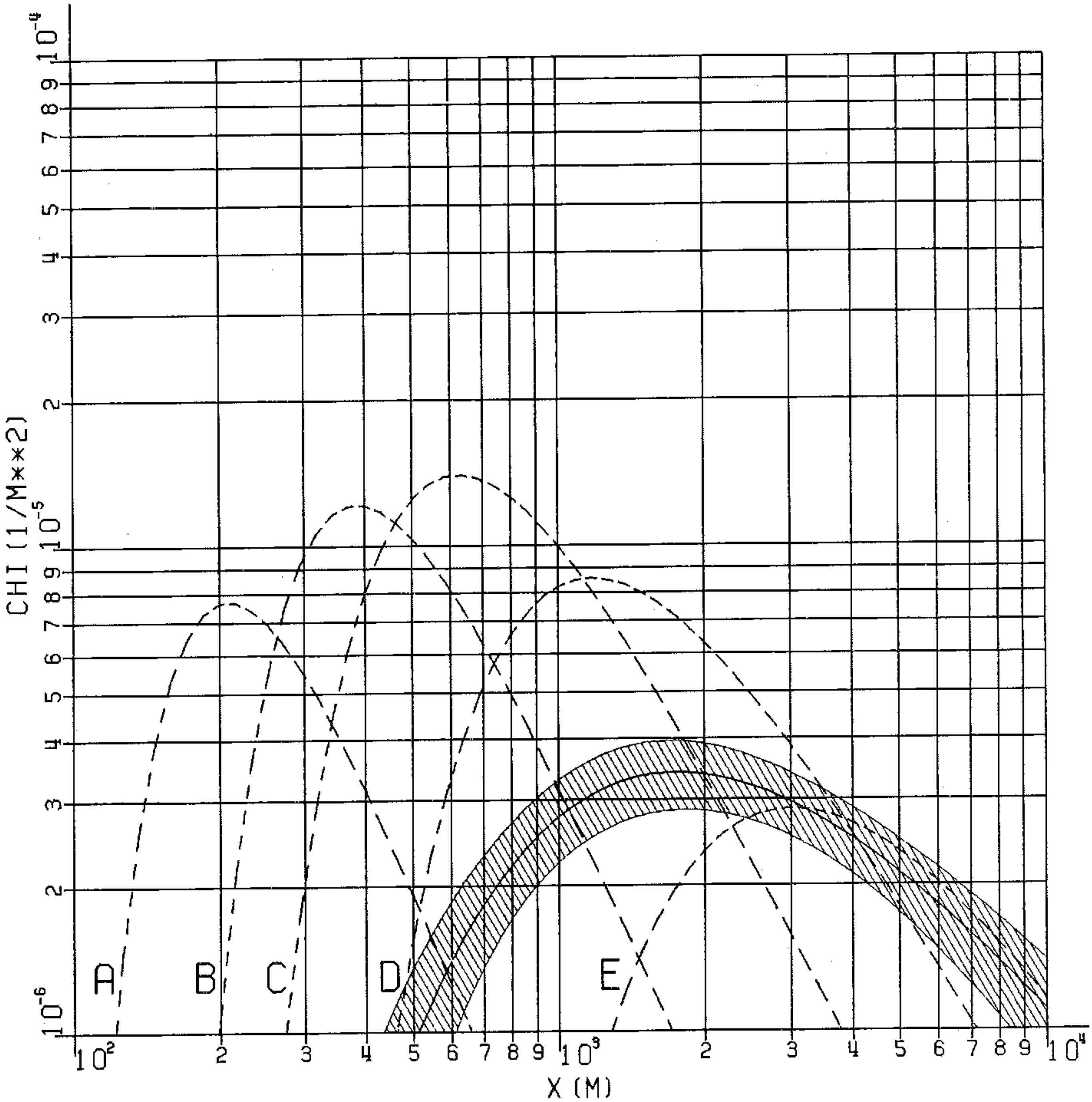

FIG. 41: NORMALIZED DIFFUSION FACTOR OF EXPERIMENT NO.48, PERIODS 1+2

H=100M, TRACER CFCL3

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

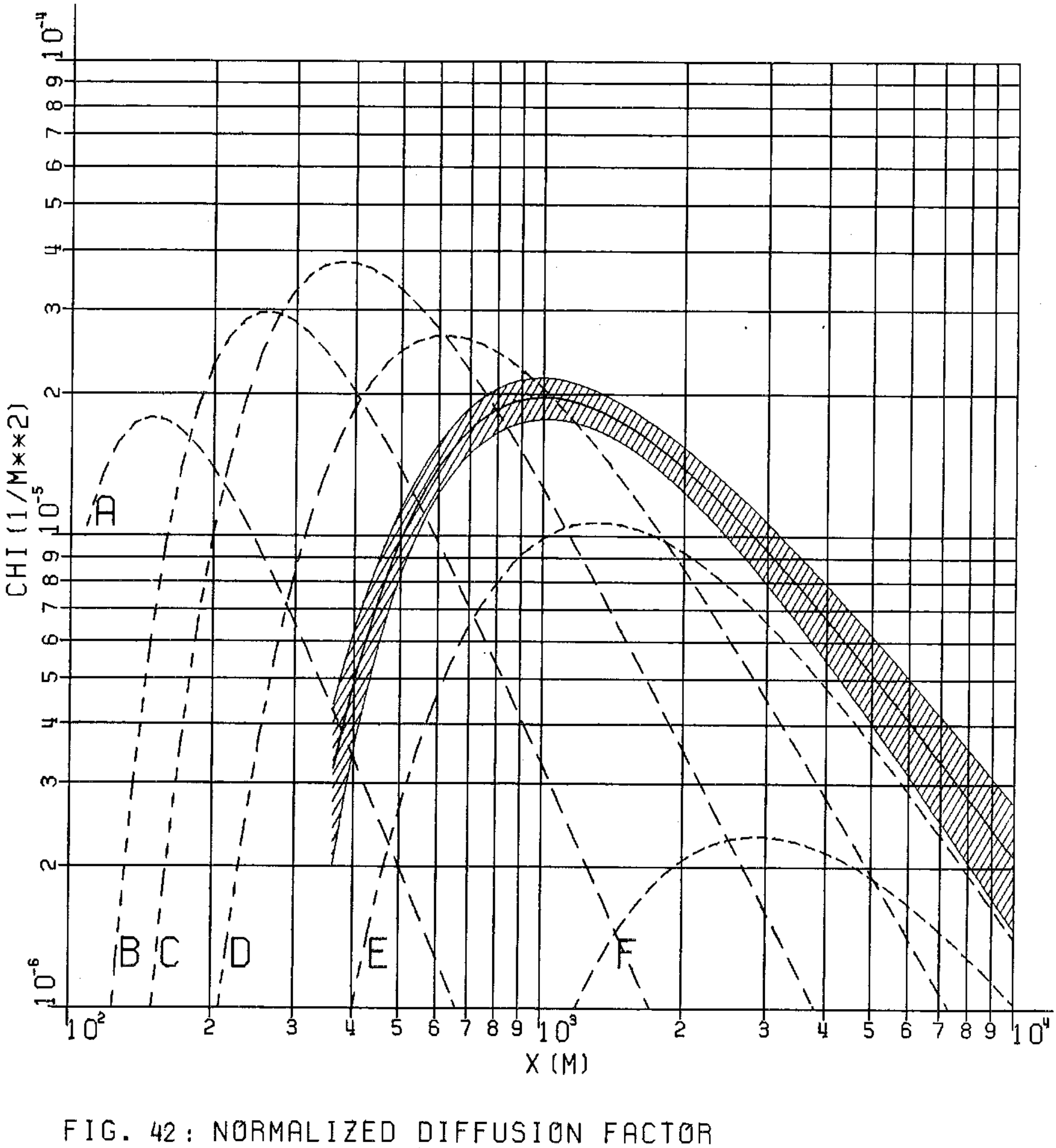

FIG. 42: NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.48, PERIODS 1+2
H= 60M, TRACER CF2BR2
----- COMBINED, SMOOTHED, AND CENTERED RESULTS

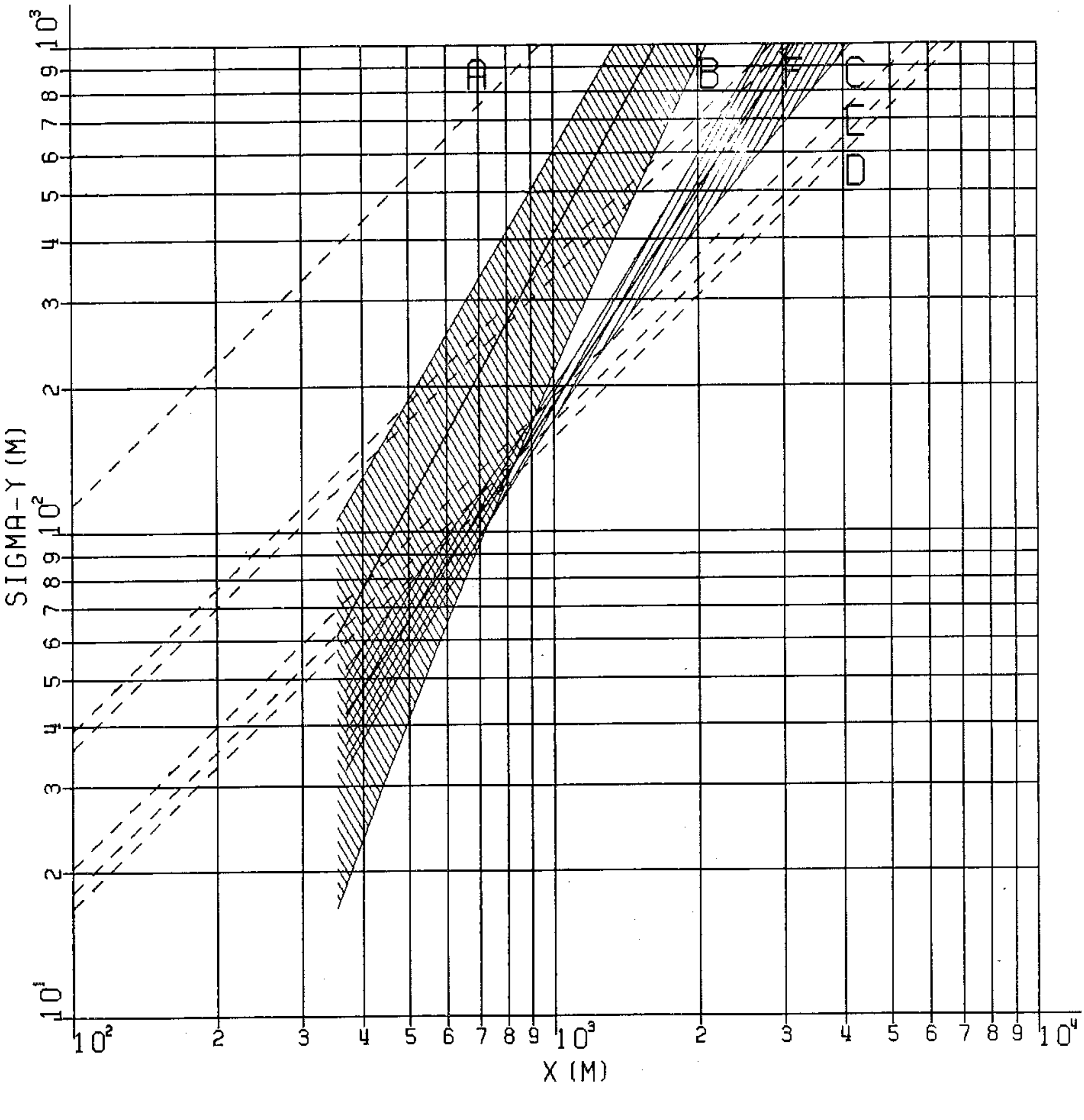

FIG. 43 : HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.51, PERIOD 1
H= 60M, TRACER CF2BR2
H=100M, TRACER CFCL3
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

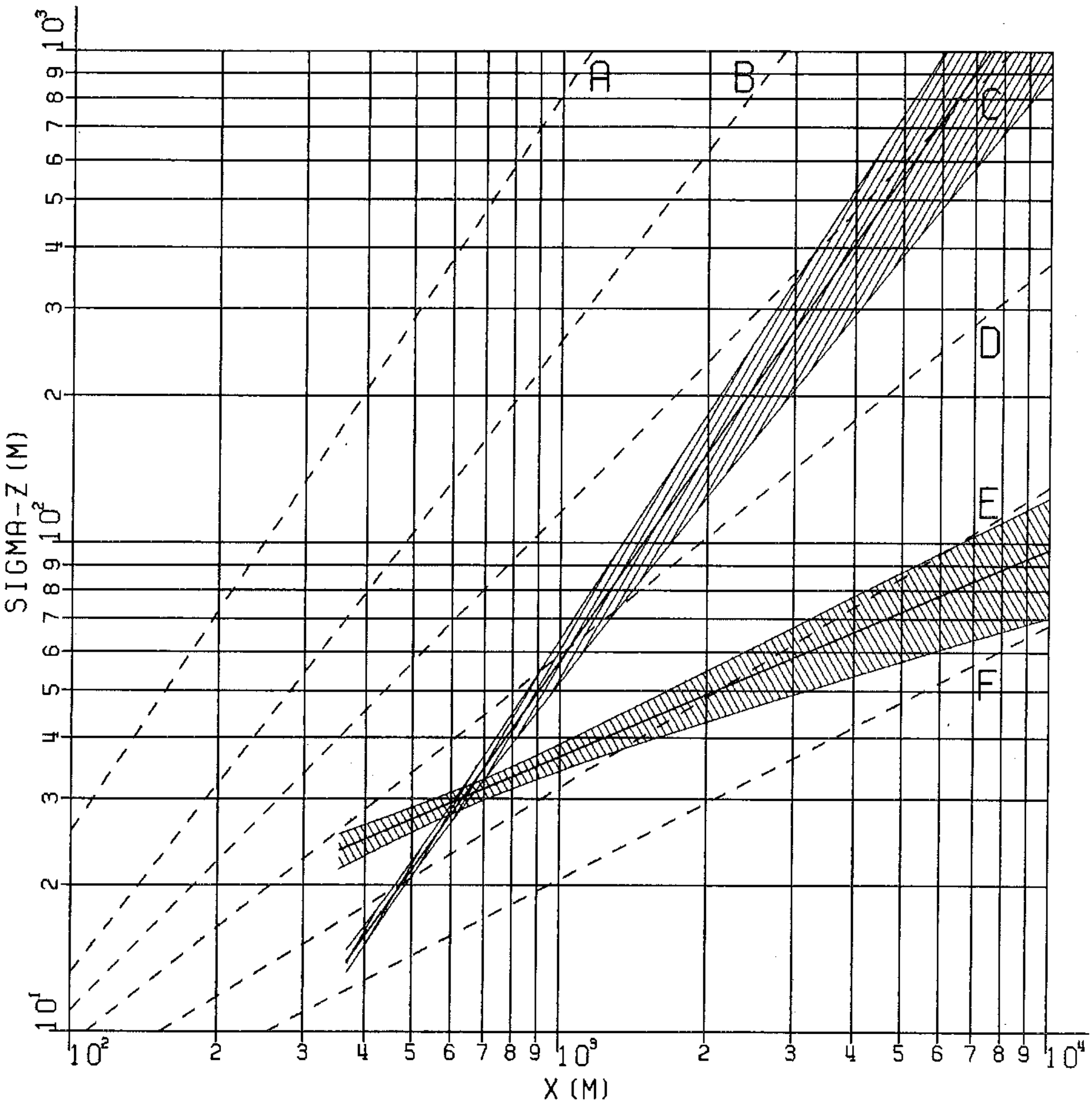

FIG. 44 : VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.51, PERIOD 1

H= 60M, TRACER CF2BR2

H=100M, TRACER CFCL3

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

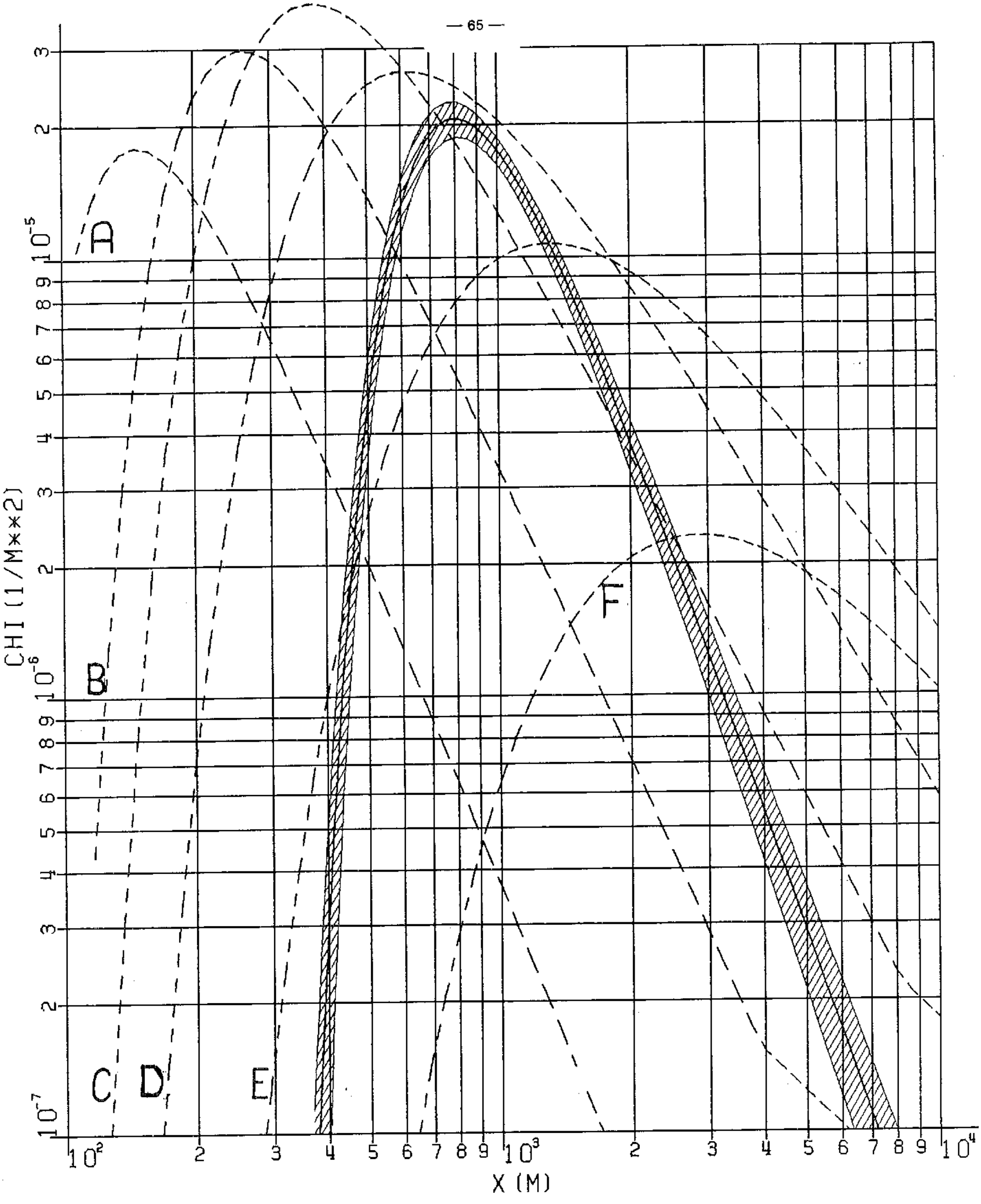

FIG. 45: NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.51, PERIOD 1

////////// H= 60M, TRACER CF2BR2

– – – – – COMBINED, SMOOTHED, AND CENTERED RESULTS

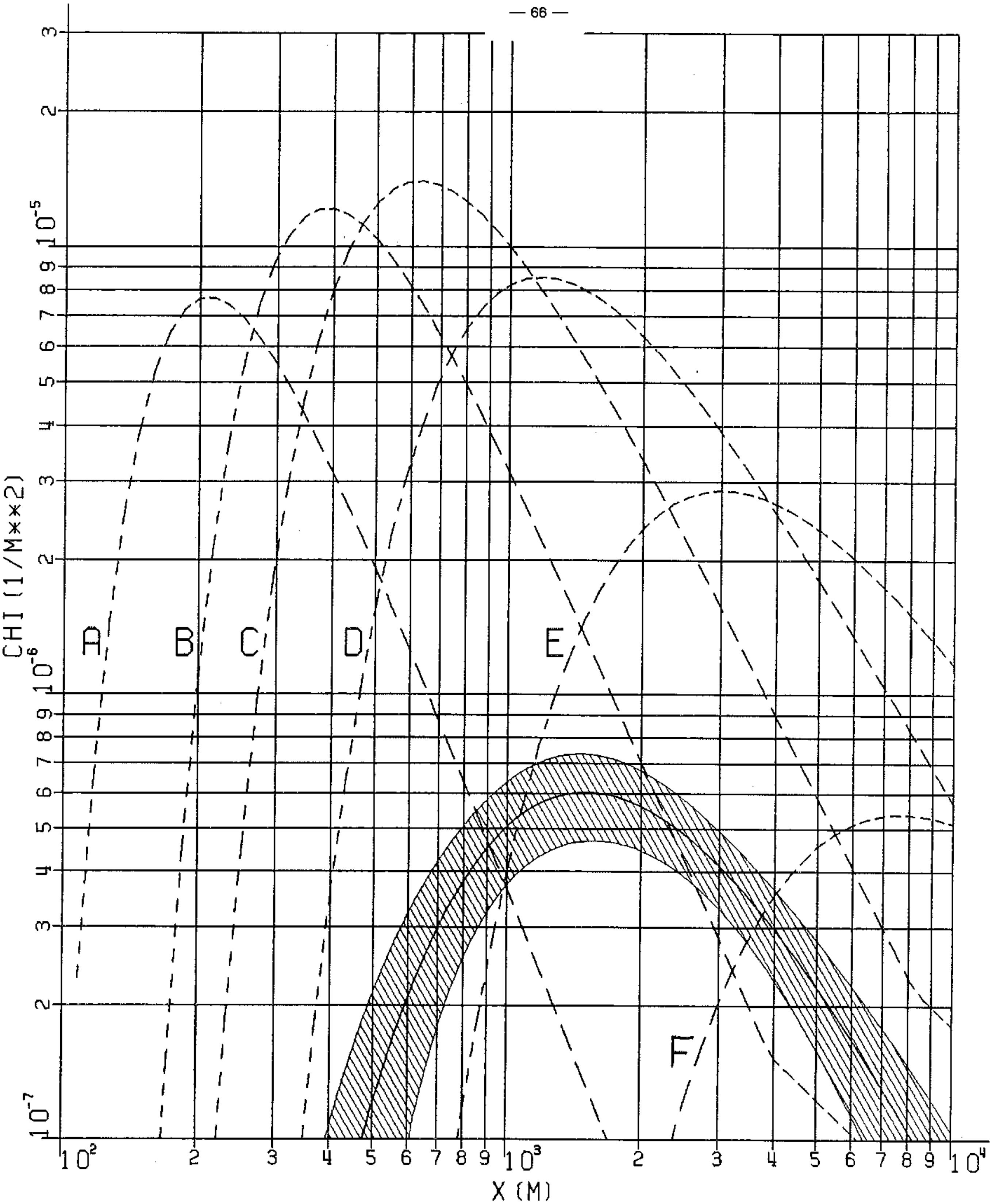

FIG. 46: NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.51, PERIOD 1
H=100M, TRACER CFCL3
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

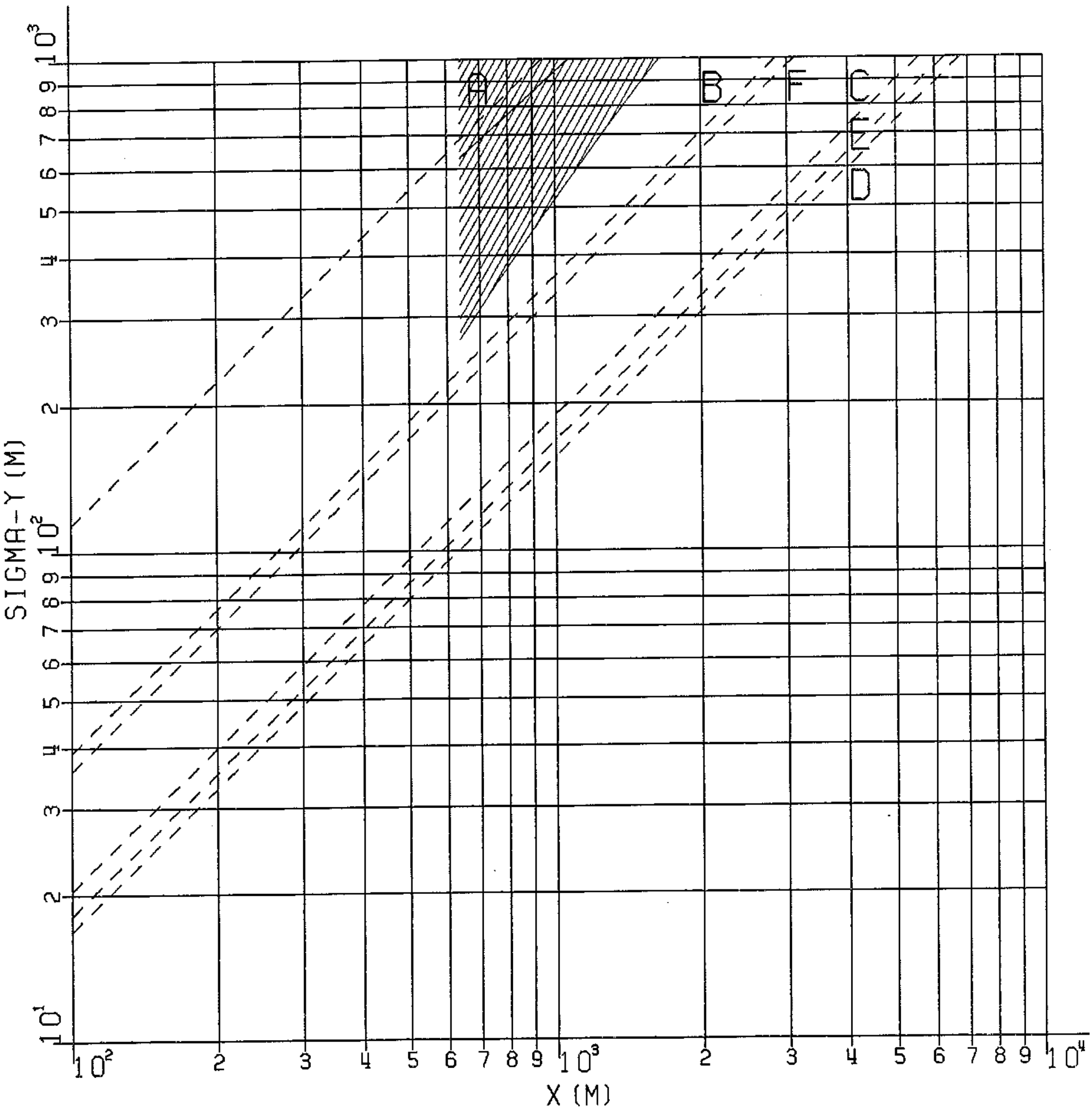

FIG. 47 : HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.40, PERIODS 1+2
/////////////// H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

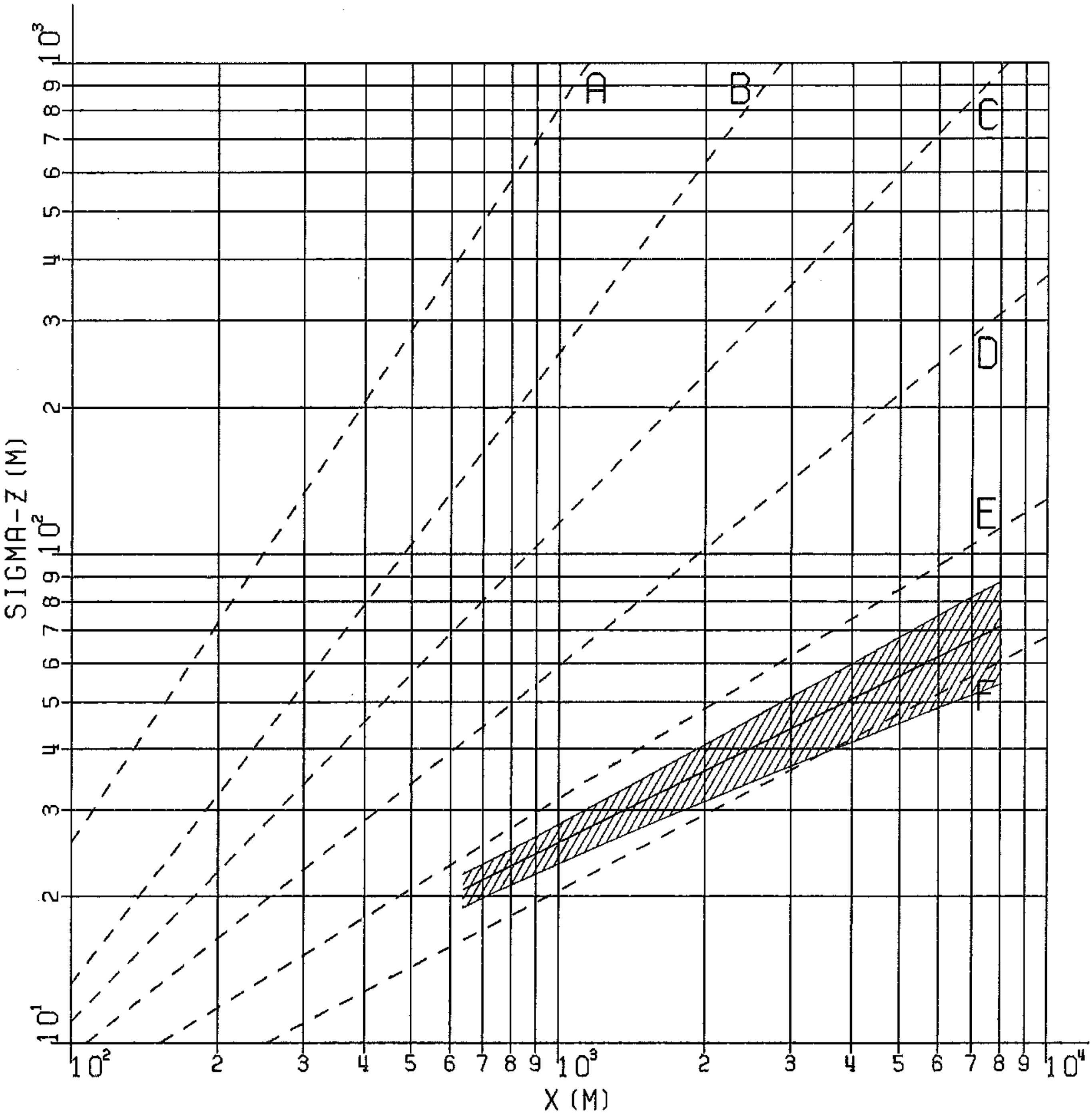

FIG. 48 : VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.40, PERIODS 1+2

////////////// H= 60M, TRACER CF2BR2

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

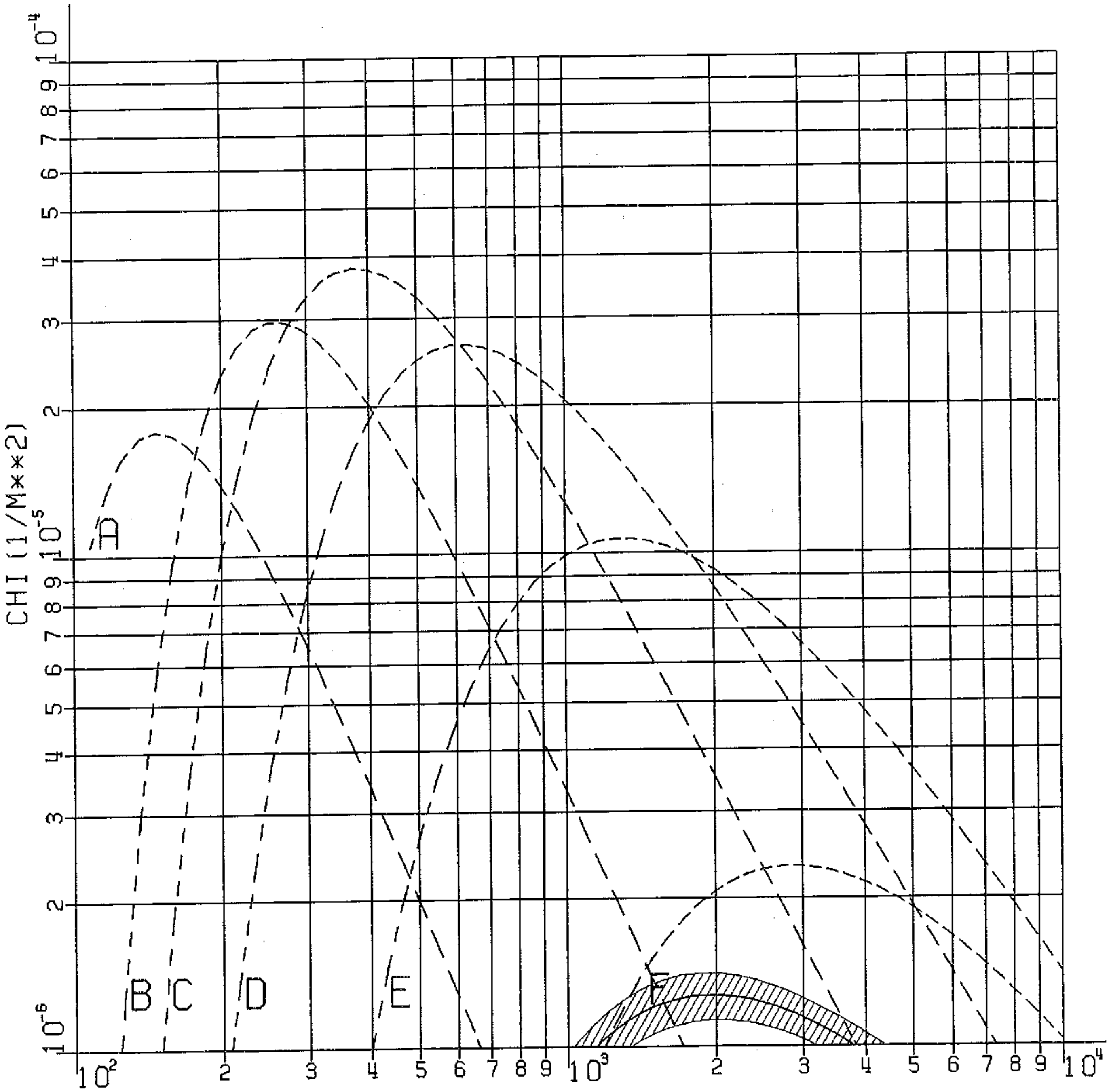

FIG. 49 : NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.40, PERIODS 1+2

/////////// H= 60M, TRACER CF2BR2

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

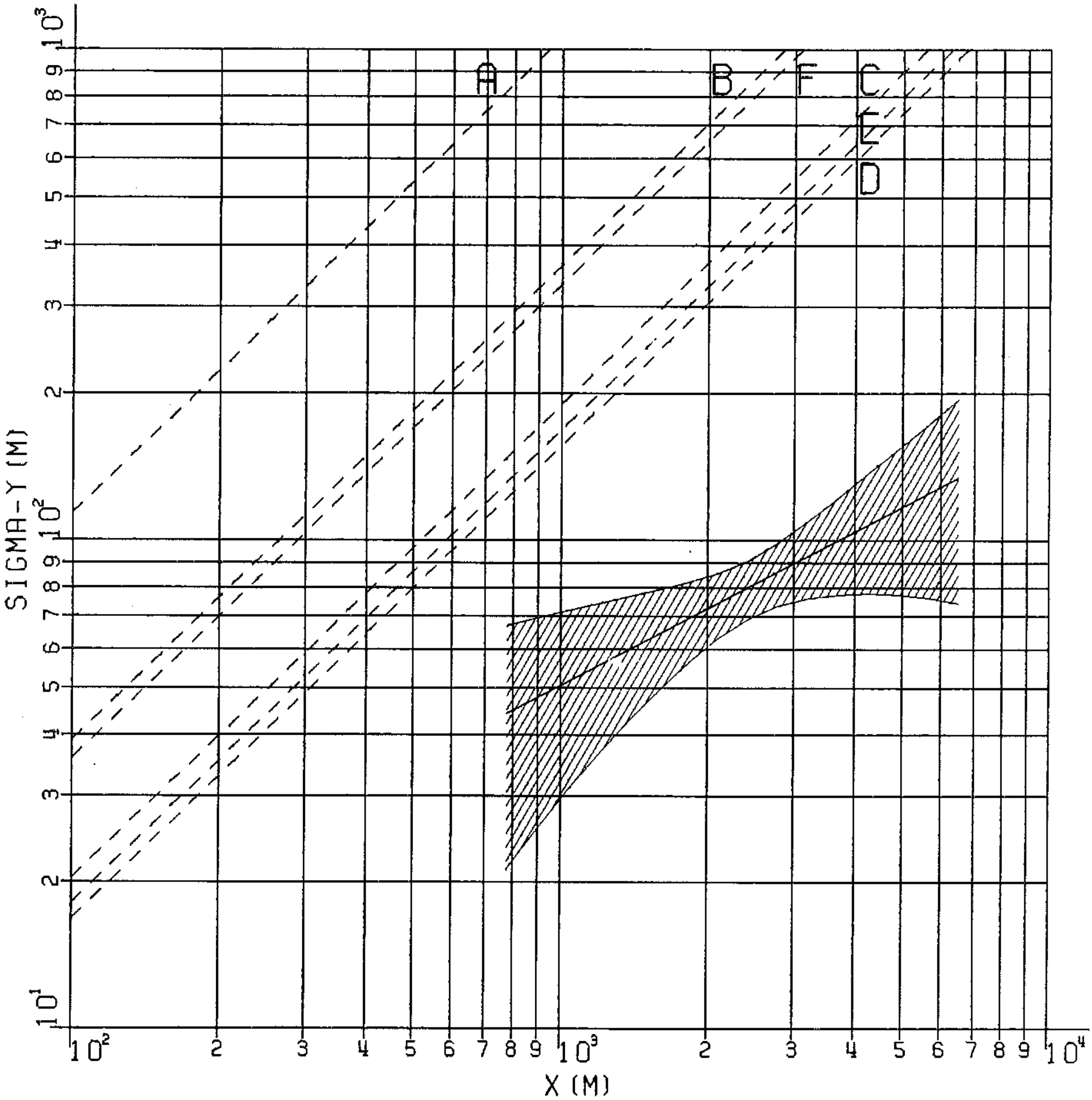

FIG. 50 : HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.42, PERIOD 1
////////////// H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

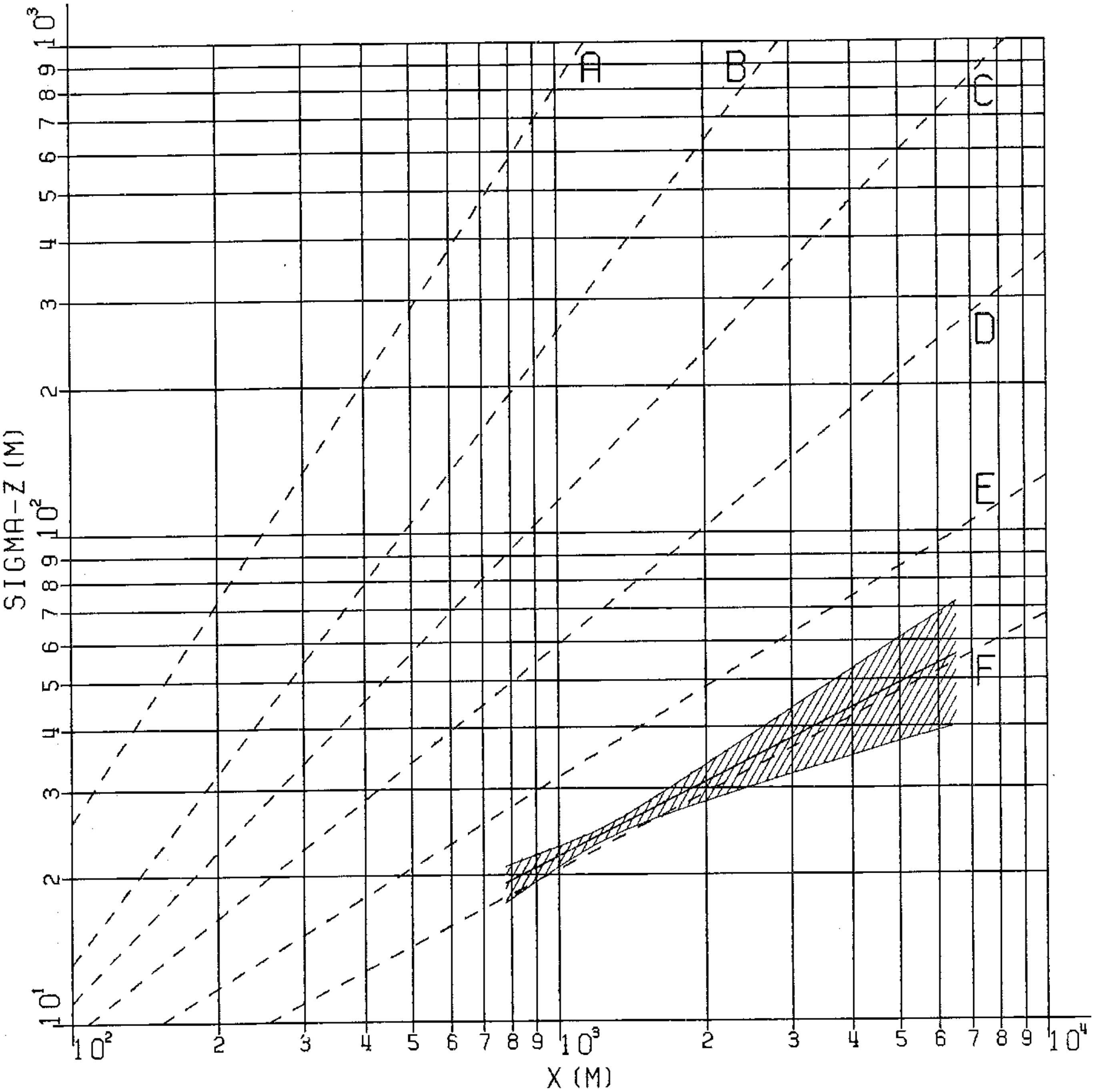

FIG. 51: VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.42, PERIOD 1
////////////// H= 60M, TRACER CF2BR2
– – – – – COMBINED, SMOOTHED, AND CENTERED RESULTS

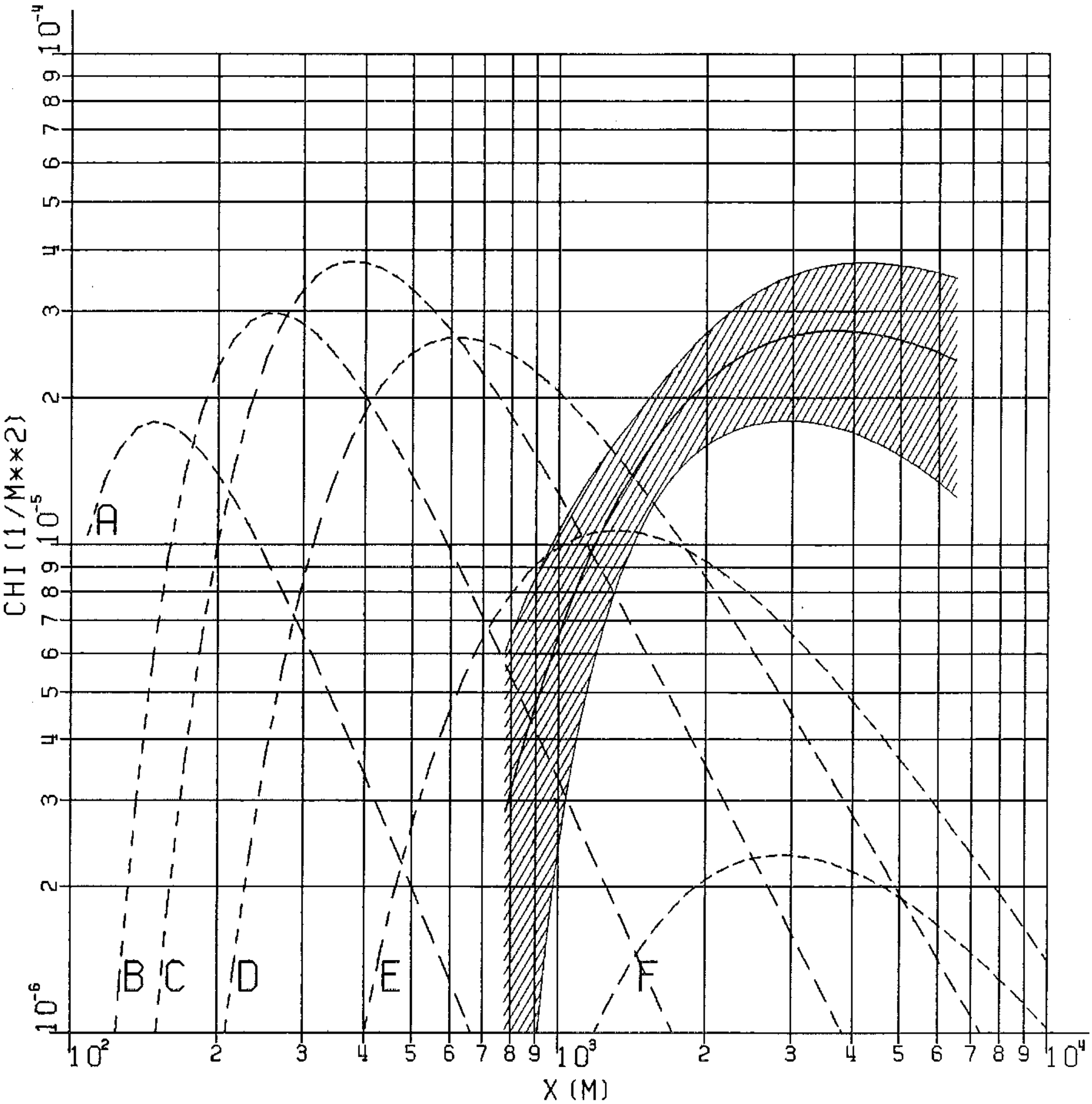

FIG. 52: NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.42, PERIOD 1
H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

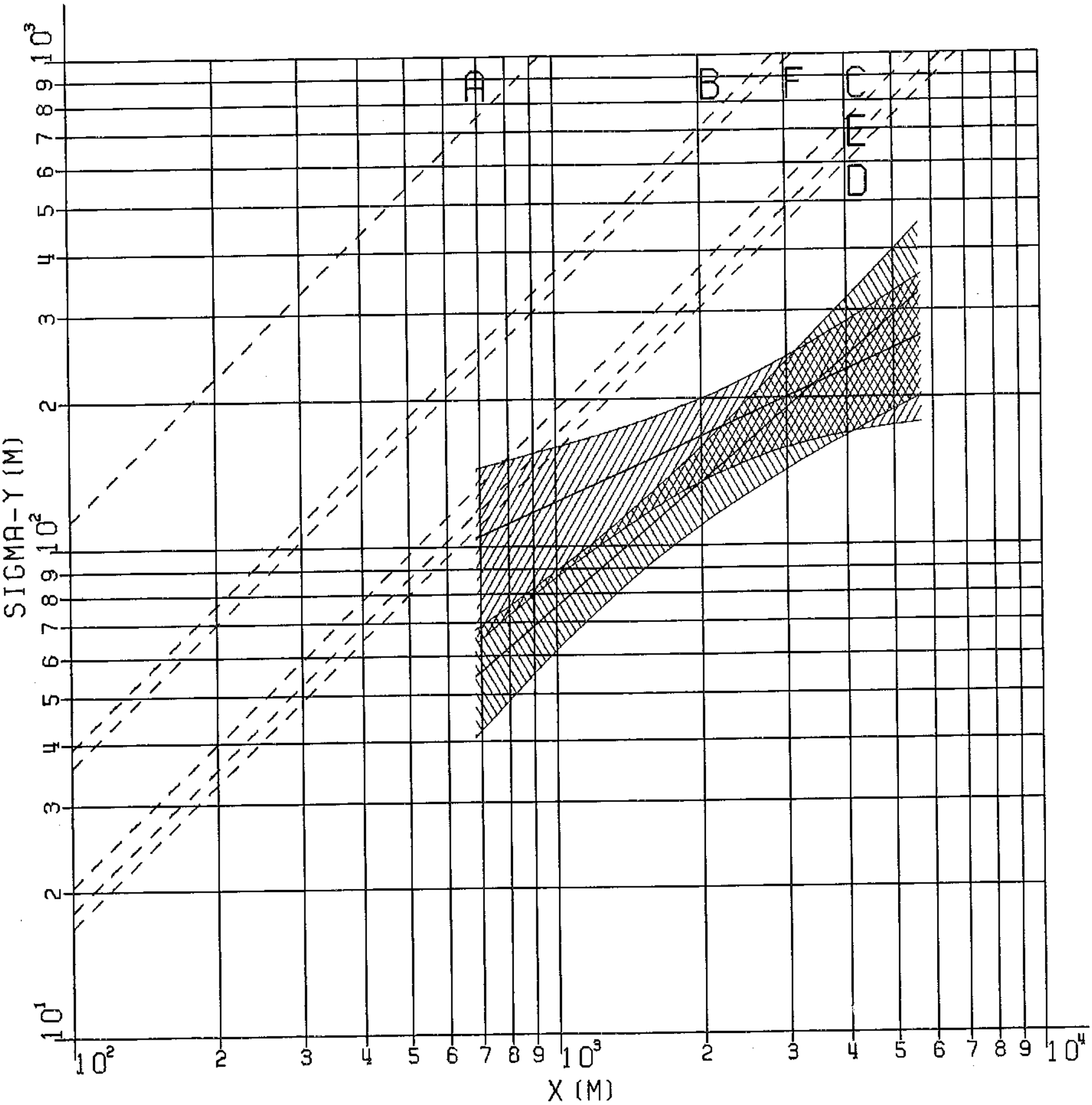

FIG. 53 : HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.43, PERIODS 1+2

H=100M, TRACER CFCL3

H= 60M, TRACER CF2BR2

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

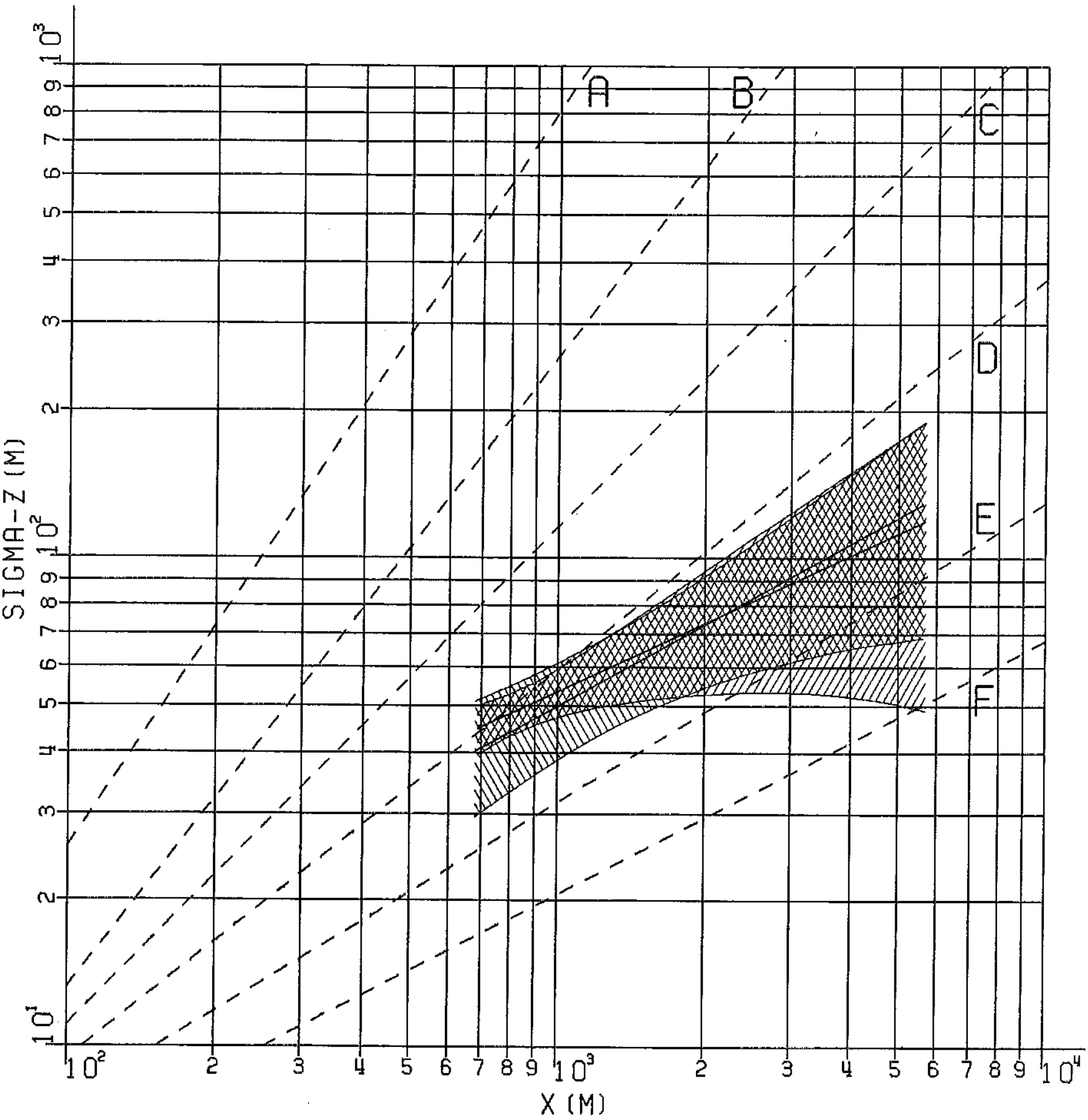

FIG. 54 : VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.43, PERIODS 1+2
H=100M, TRACER CFCL3
H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

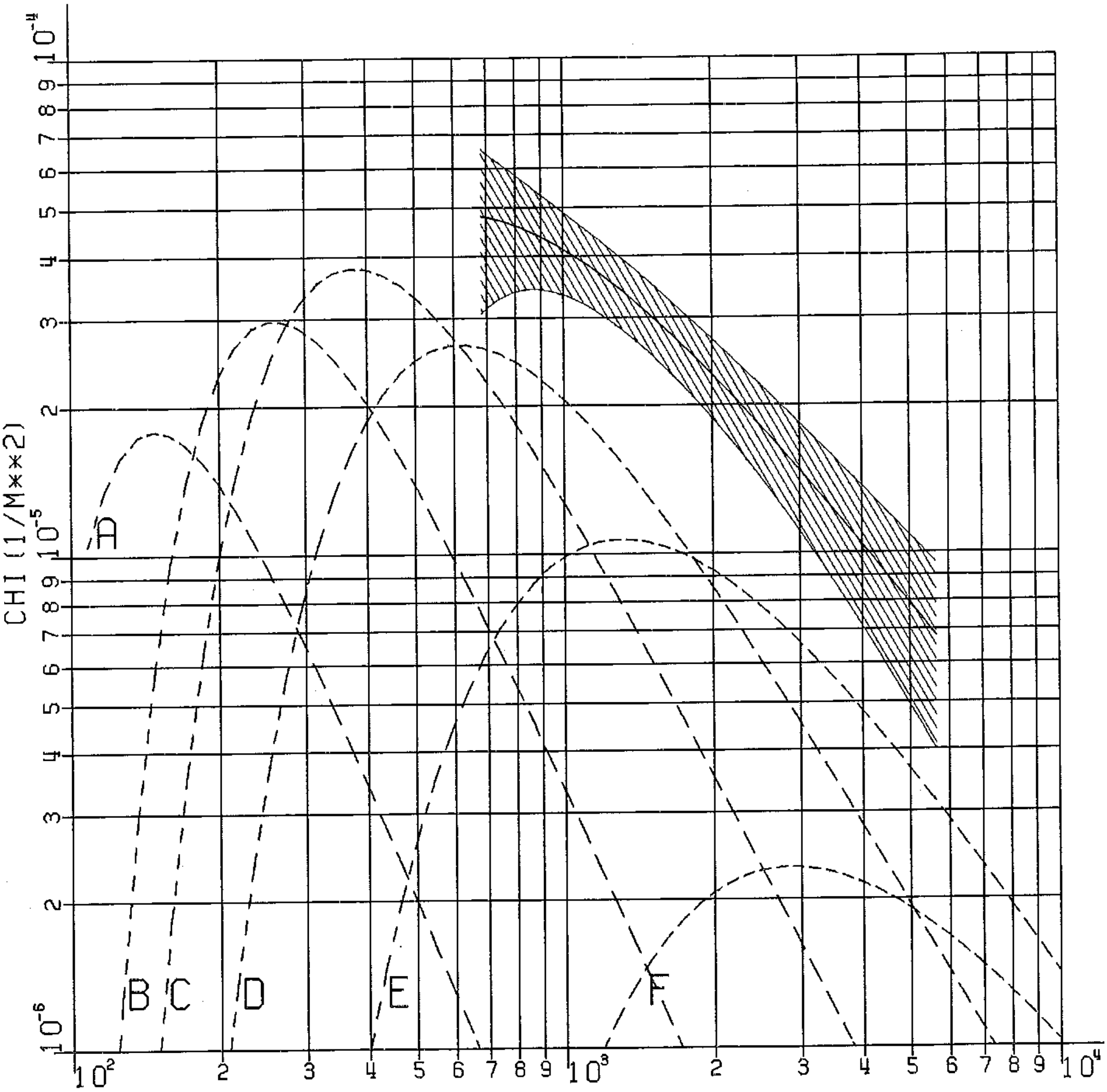

FIG. 55: NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.43, PERIODS 1+2
H= 60M, TRACER CF2BR2
– – – – – COMBINED, SMOOTHED, AND CENTERED RESULTS

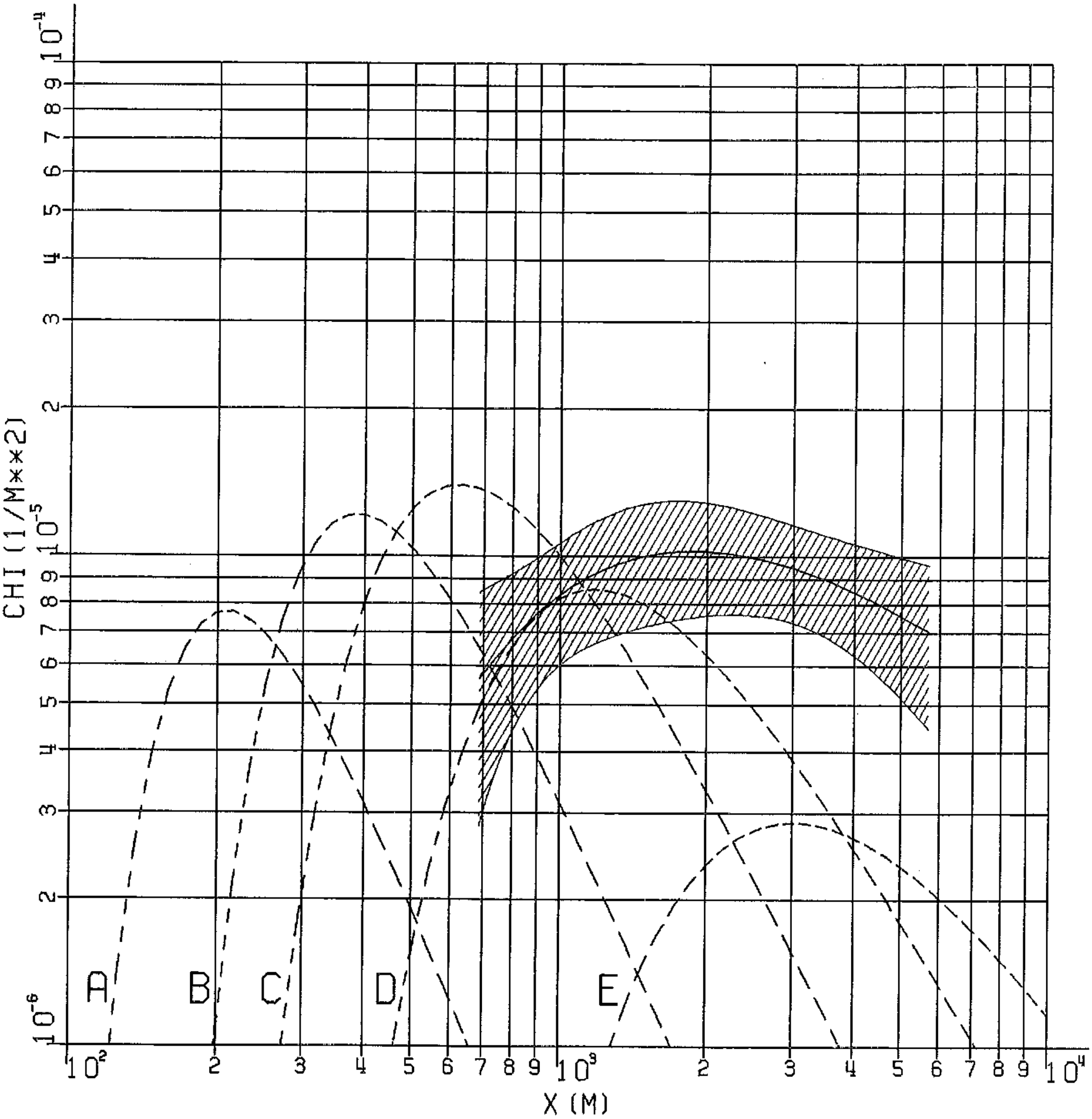

FIG. 56: NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.43, PERIODS 1+2
////////////// H=100M, TRACER CFCL3
– – – – – COMBINED, SMOOTHED, AND CENTERED RESULTS

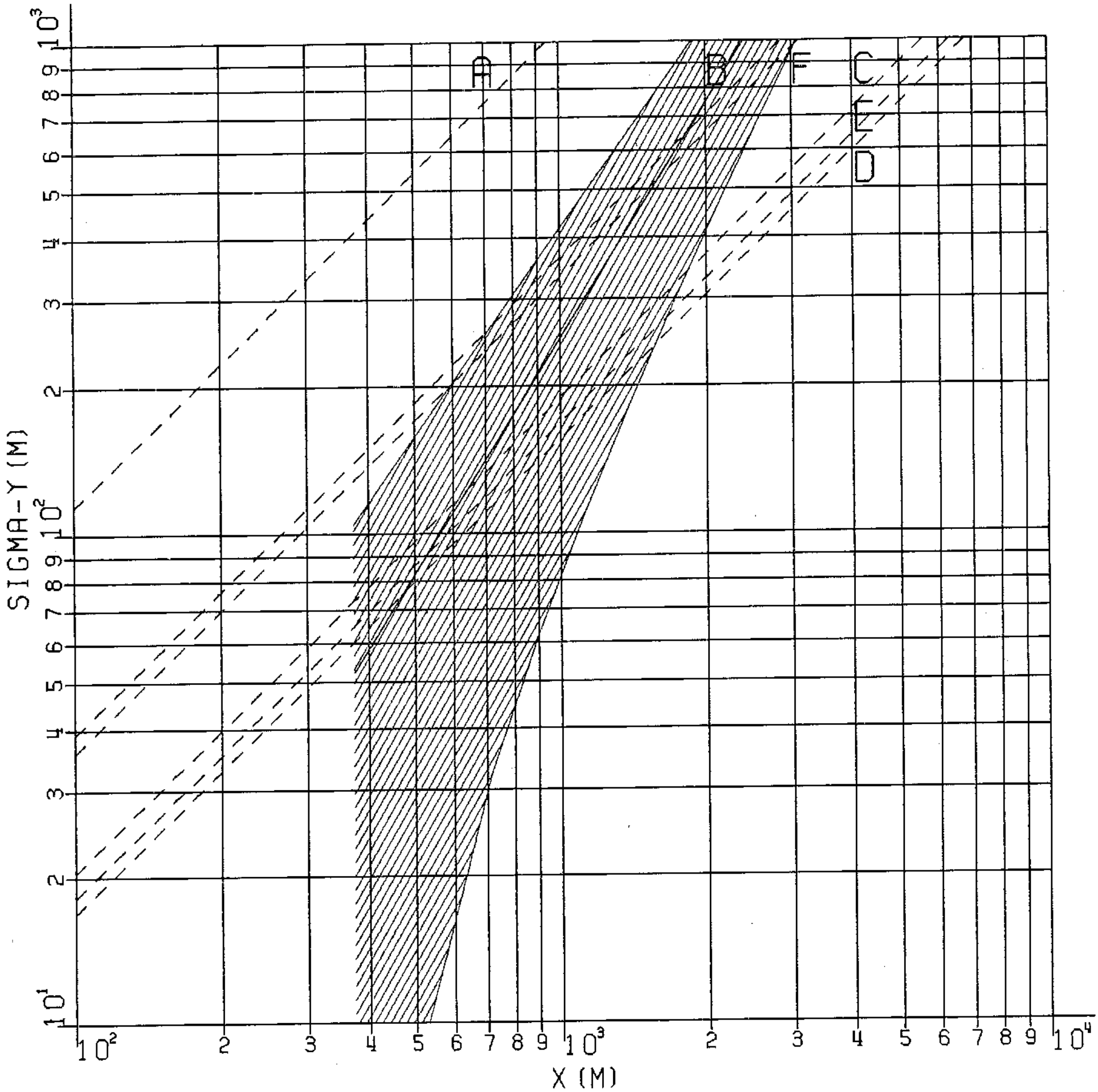

FIG. 57 : HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.50, PERIODS 1+2
////////// H=100M, TRACER CFCL3
– – – – – COMBINED, SMOOTHED, AND CENTERED RESULTS

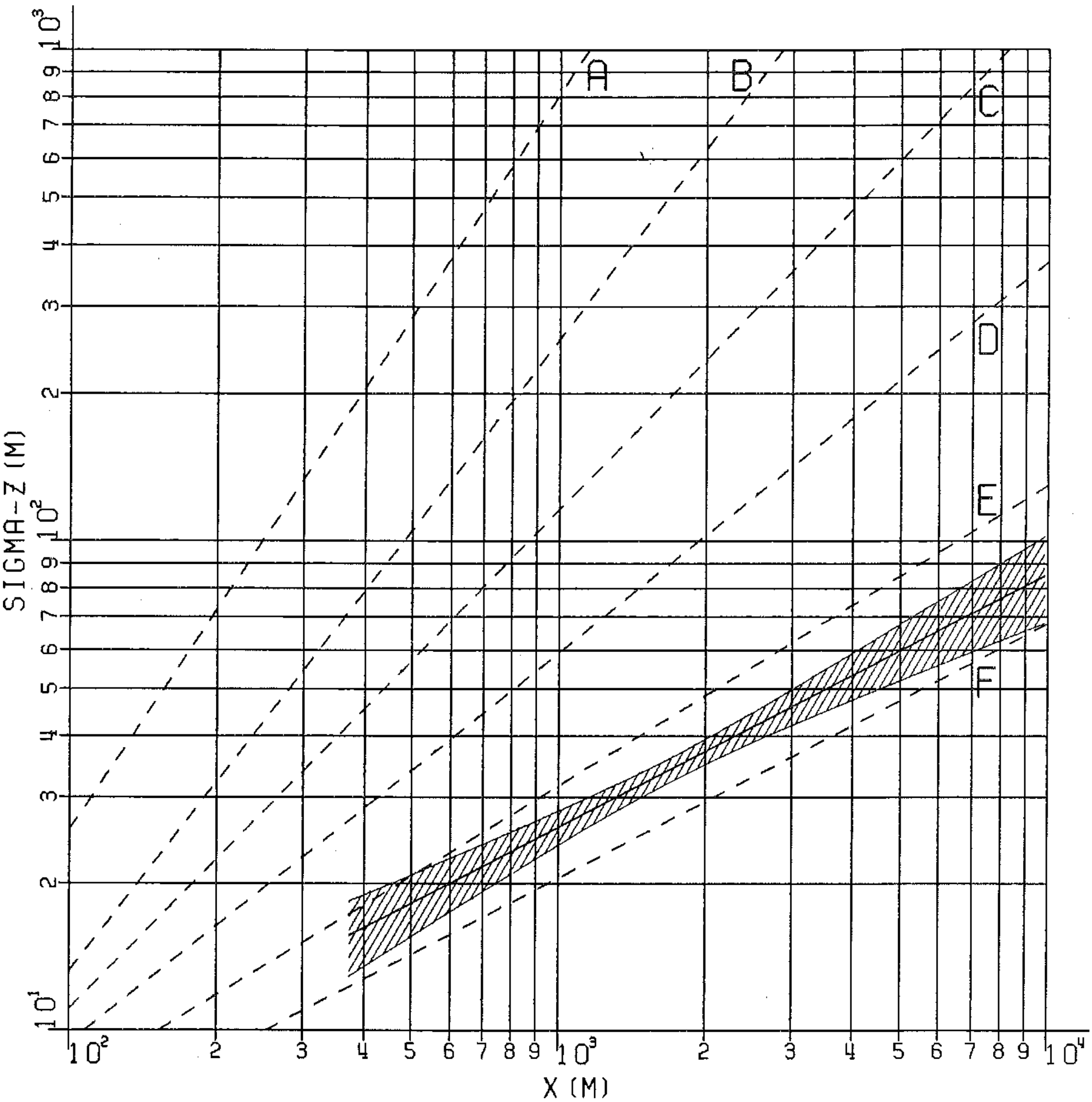

FIG. 58 : VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.50, PERIODS 1+2
////////////// H=100M, TRACER CFCL3
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

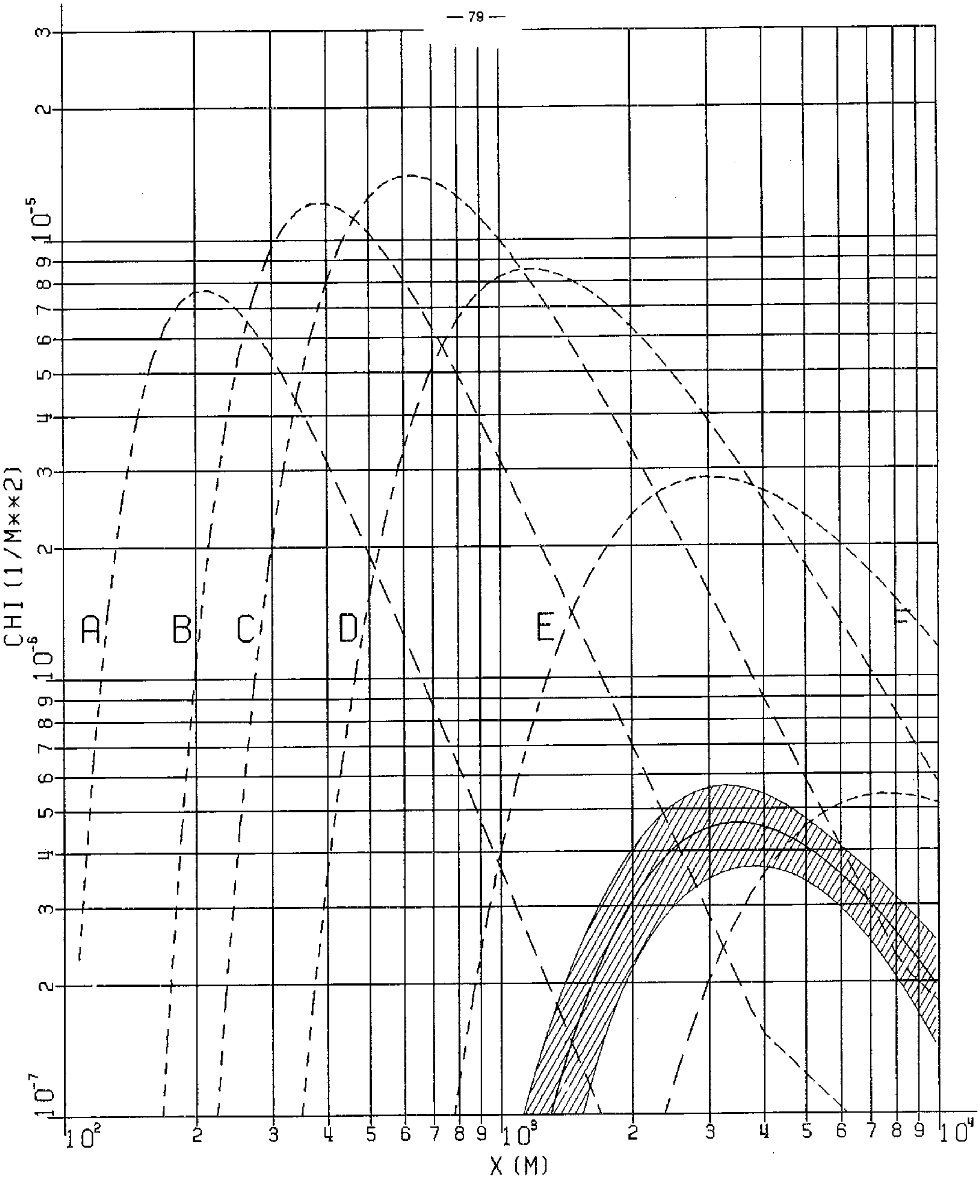

FIG. 59 : NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.50, PERIODS 1+2
H=100M, TRACER CFCL3
– – – – – COMBINED, SMOOTHED, AND CENTERED RESULTS

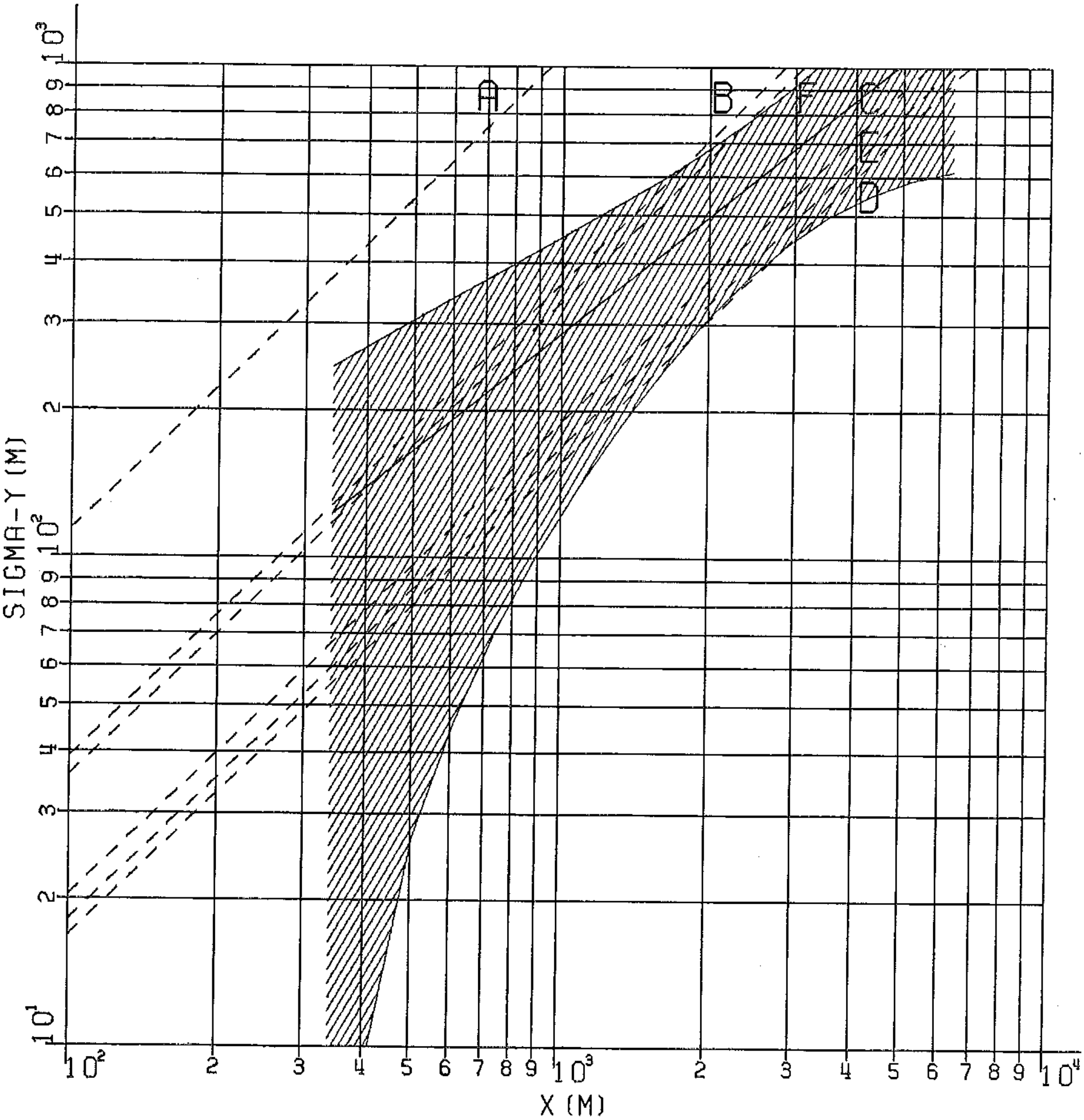

FIG. 60: HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.41, PERIODS 1+2
////////////// H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

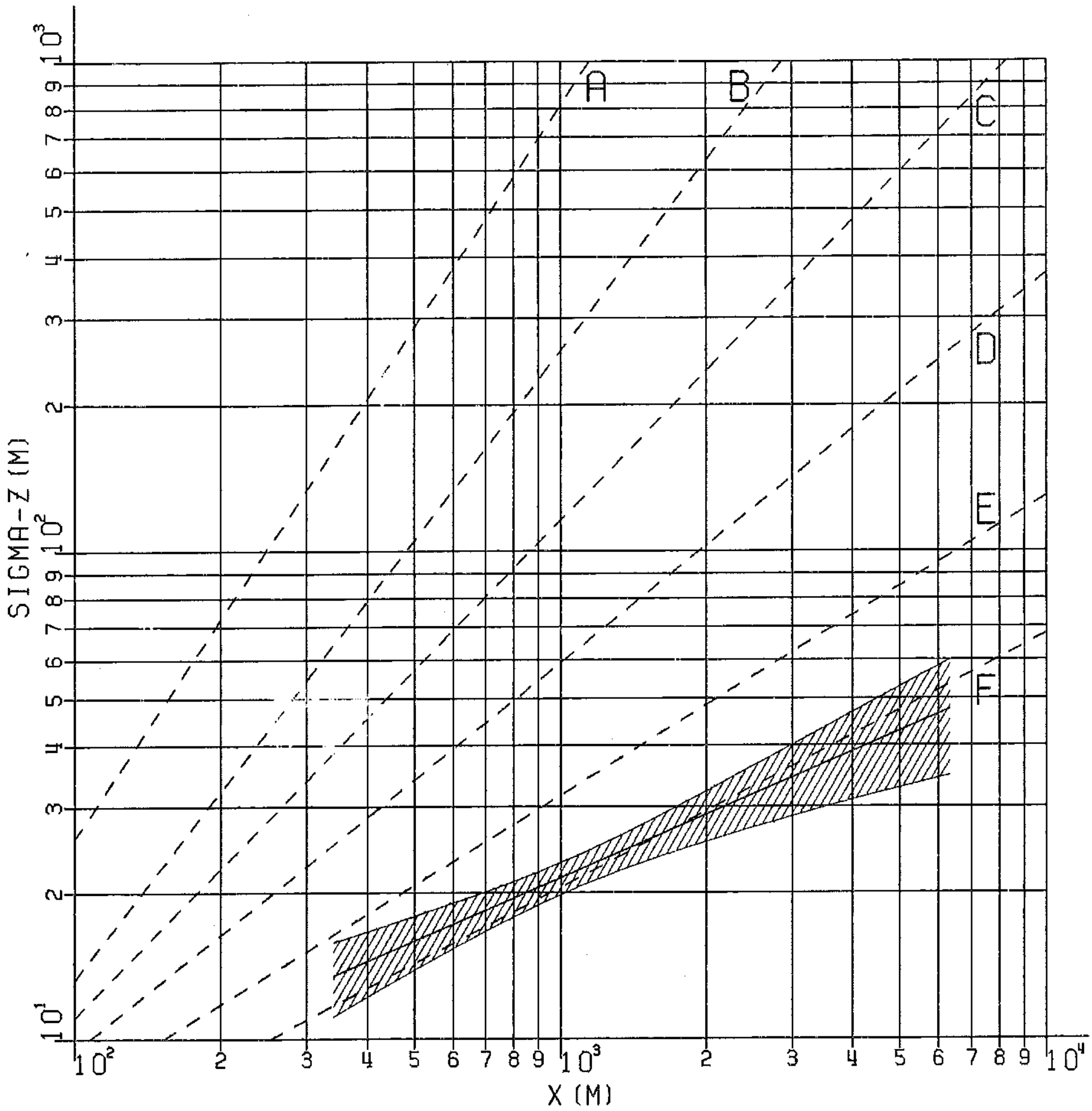

FIG. 61 : VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO.41, PERIODS 1+2
H= 60M, TRACER CF2BR2
– – – – – COMBINED, SMOOTHED, AND CENTERED RESULTS

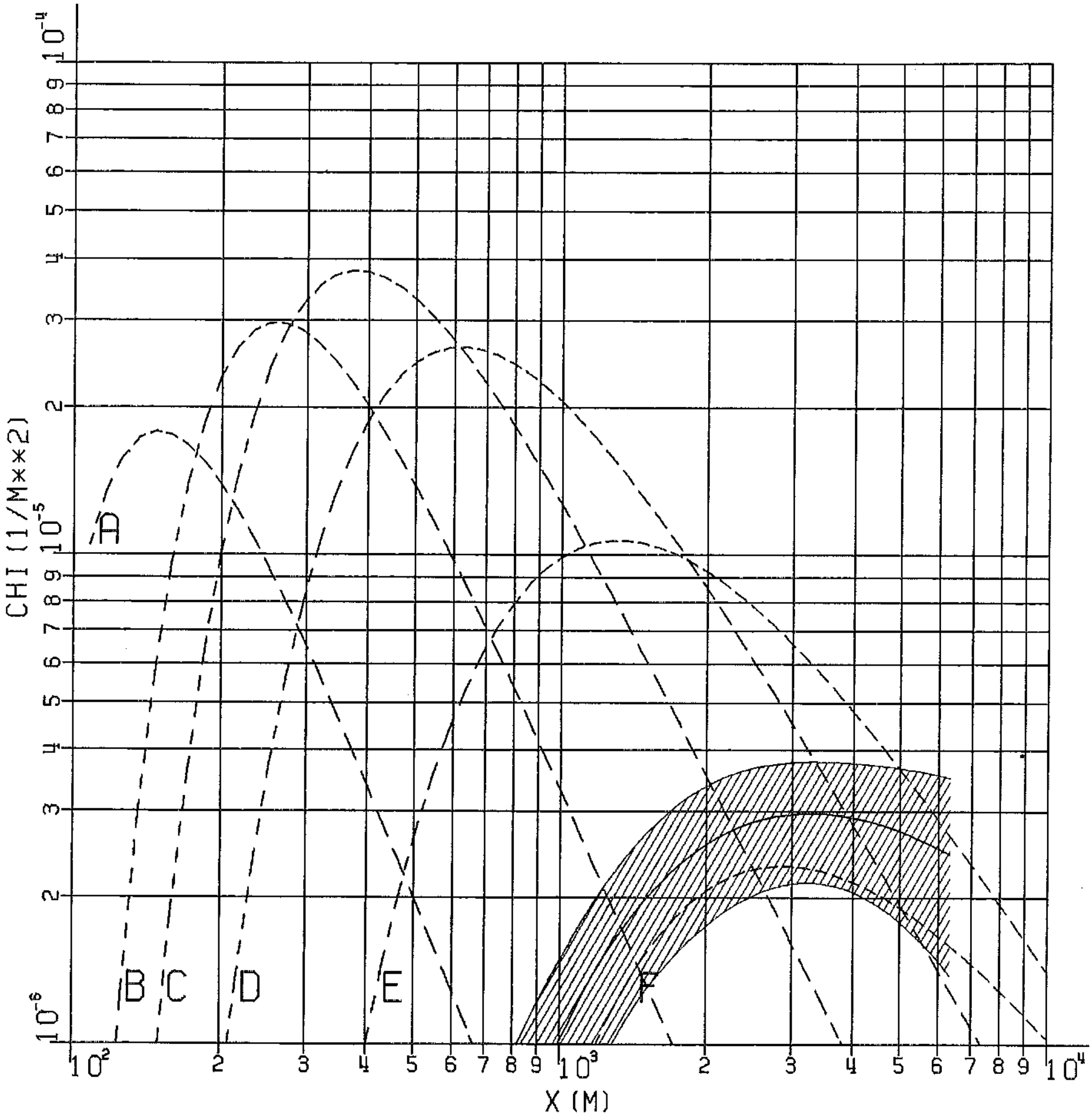

FIG. 62 : NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.41, PERIODS 1+2
////////////// H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

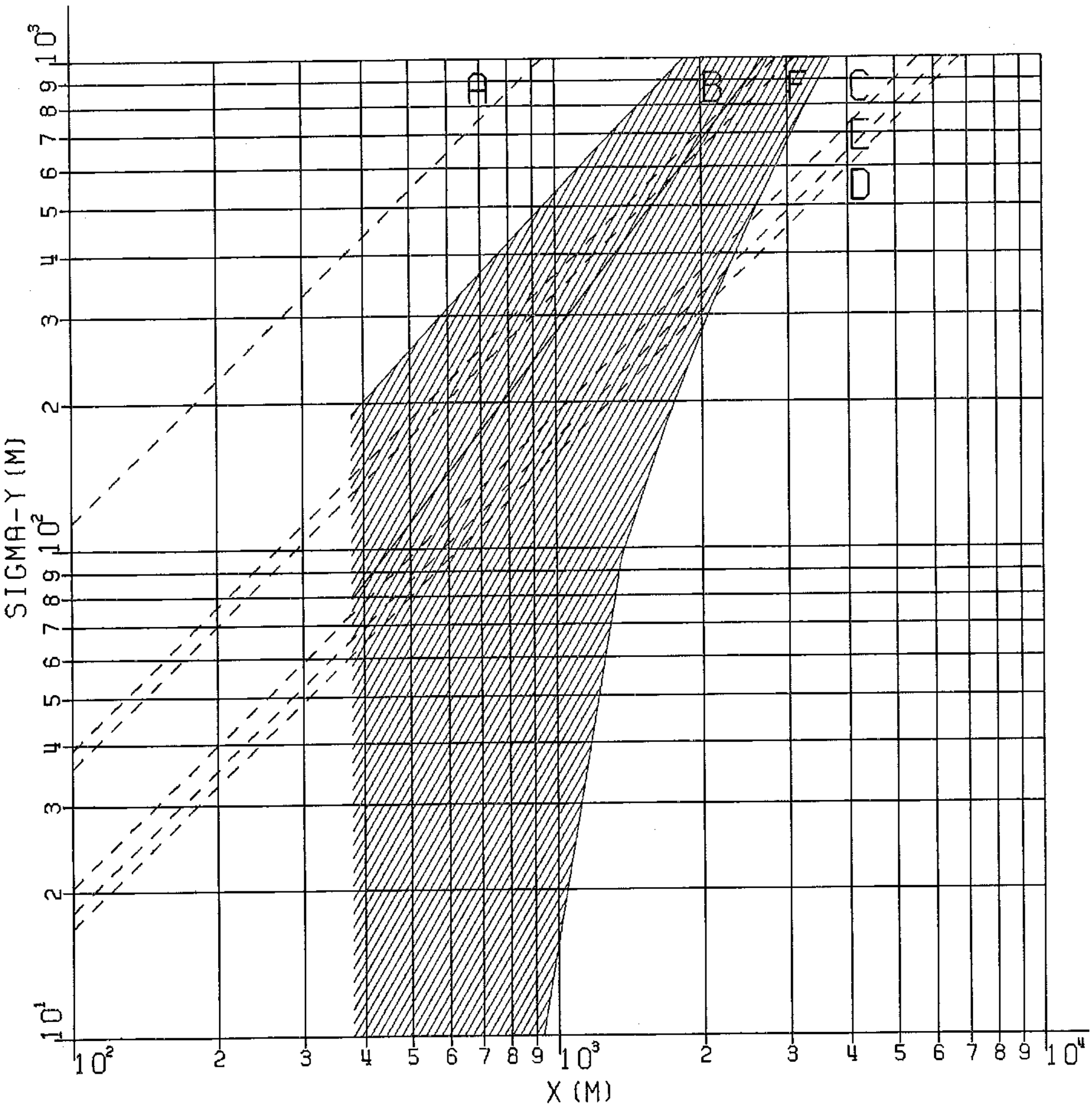

FIG. 63 : HORIZONTAL DISPERSION PARAMETER
OF EXPERIMENT NO.46, PERIODS 1+2
H= 60M, TRACER CF2BR2
- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

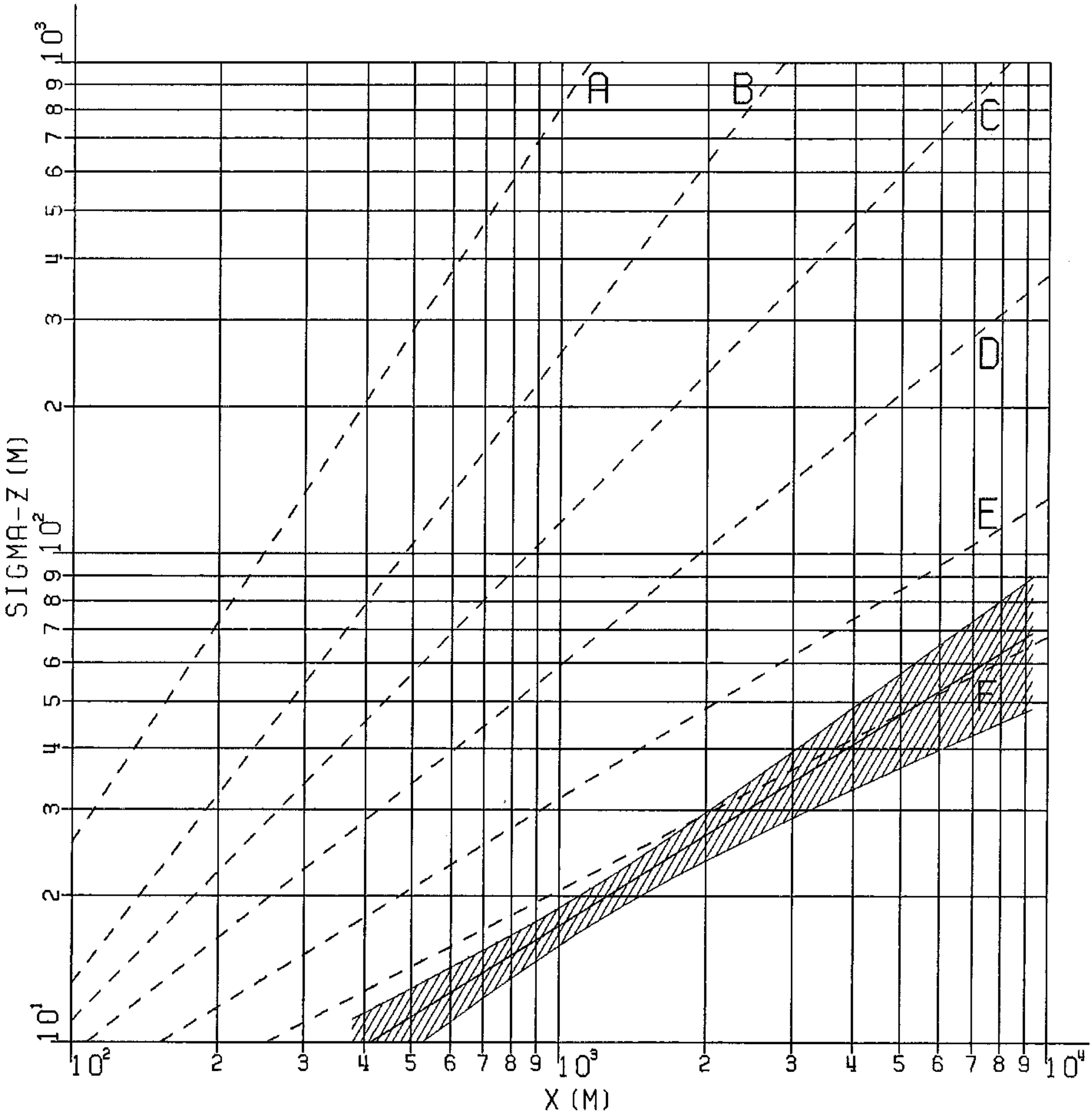

FIG. 64 : VERTICAL DISPERSION PARAMETER
OF EXPERIMENT NO. 46, PERIODS 1+2

////////// H= 60M, TRACER CF2BR2

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS

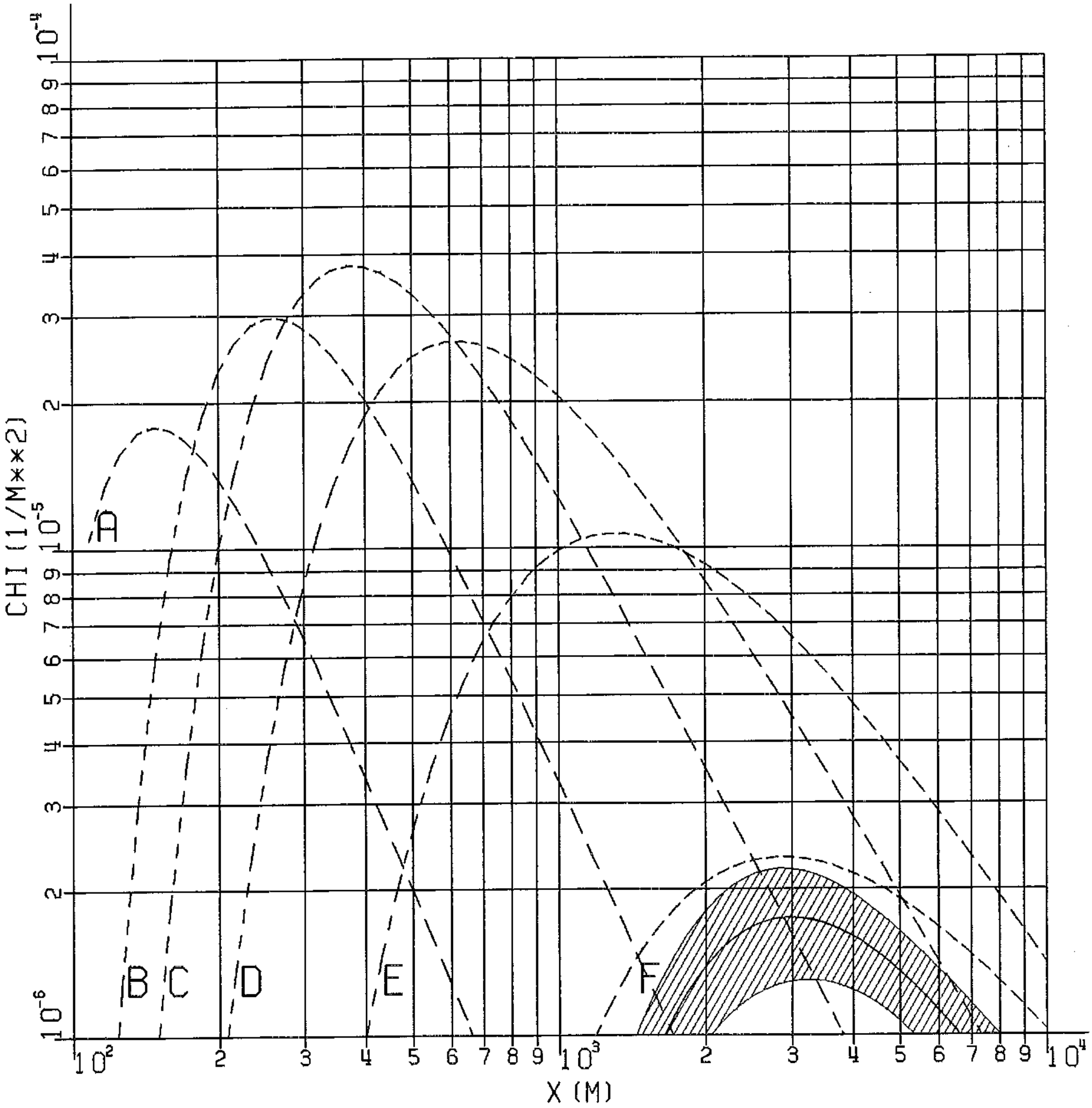

FIG. 65 : NORMALIZED DIFFUSION FACTOR
OF EXPERIMENT NO.46, PERIODS 1+2

H= 60M, TRACER CF2BR2

- - - - - COMBINED, SMOOTHED, AND CENTERED RESULTS