This report contains a detailed description of the IERS products related to the Terrestrial Reference System for the period of the IERS Annual Report for 1991. It gives a detailed analysis about the ITRF91 and its associated combined velocity field.

This description intends to be the continuation of the previous reports: the IERS Technical Note 4 , 6 and 9. In particular, methodological presentation will be followed here.

1) INPUT DATA

1.1) Sites included

The list of sites considered in the 1991 solution is given in Table T1 of the appendix.

A more detailed list of points and marks for these sites is also provided by the Table T2 of the appendix.

Table T3 also gives a summary of the occupancies of these sites by SLR, GPS, LLR or VLBI instruments. We have distinguished the IERS sites into the following data sets:

1) colocation (at least two techniques)

2) multiple SLR (simultaneous or successive)

3) single SLR

4) multiple VLBI (simultaneous or successive)

5) single VLBI

1.2) Input data sets

The data sets received for the 1991 solution and included in the global combination performed by the ITFS, under the label ITRF91 are summarized in Table 1.

The distribution of the corresponding coordinates for each solution are given in Table T4 of the appendix.

1.3) Description of individual data sets

For all solutions, no permanent tidal correction has been performed, and the adopted velocity of light is $c = 299792458$ m s^{-1}.

As the formal errors σ_f provided by the analysis centers are in most cases too optimistics, the input errors σ are adopted according to the following formula:

$$\sigma = \sqrt{A^2 + B^2\sigma_f^2} \qquad (1)$$

where A is an additive variance and B is a factor. The values of A and B are determined by an empirical estimation. Figures 1 to 16 show for all the solutions, the histograms of the formal errors and those after applying the previous formula.

1.3.1) GSFC VLBI solution

Identifer : SSC(GSFC) 92 R 03, also named GLB833

Model : CALC-7 software, with local earth relativistic scale (Hellings model).

Adjusted parameters :

X,Y,Z and VX, VY, VZ of stations with sufficient data

Constraints for the CTS :

- Westford X,Y,Z fixed at a nominal value on Oct 17 1980,
- ERP fixed on Nov 6 1986 at BIH Circular D values,
- Westford velocities fixed at NUVEL1 NNR values,
- Westford-Richmond azimut moving with NUVEL1 NNR value.

Raw data :

Yearly values of positions were available, with formal errors (from 1979 to 1992)

Input data (RG) :

The 1988 values, with formal errors modified using the formula (1) with A = 0.5 cm and B = 1.5.

1.3.2) NOAA VLBI solution

Identifer : SSC(NOAA) 92 R 01

Model : CALC software, with Hellings relativistic model

Adjusted parameters :

Positions at 1988.0 and velocities (except for stations with short time span),

Constraints for the CTS :

- Westford velocity at AM0-2 value

- ERP fixed at 1985 Oct. 25 and 1990 Jan. 27

Raw data :

1988 positions and velocity change with respect to AM0-2 for sites with sufficient data, with formal errors

Input data (RN) :

The 1988 values, with formal errors modified using the formula (1) with A = 0.5 cm and B = 1.5.

1.3.3) USNO VLBI solution

Identifer : SSC(USNO) 92 R 03

Model : CALC-7 software with LE relativistic scale. Motion with NUVEL 1 NNR model

Adjusted parameters: X, Y, Z at Oct 17 1980

Constraints for the CTS :

- Richmond position fixed at ITRF90 value
- fixed NUVEL1 NNR motion

Raw data : X, Y, Z and formal errors

Input data (RO) :

X, Y, Z transformed at 1988.0 with NUVEL 1 NNR . Formal errors modified with A = 0.5 cm and B = 1.5

1.3.4) JPL VLBI solution

Identifer : SSC(JPL) 92 R 01, also named 1992-1.

Model : Modest software. Motion with AM0-2 model

Adjusted parameters : X, Y, Z at 1988.0

Constraints for the CTS :

- six constraints (with 1 cm uncertainty) : 3 translations and 3 rotations between 1992-1 and ITRF88

- fixed AM0-2 motion

Raw data : X, Y, Z and formal errors

Input data (RJ)

X, Y, Z, with formal errors modified with A = 1 cm and B = 1.0

1.3.5) NAOMZ VLBI solution

Identifer : SSC(NAOMZ)92 R 01

Model : CALC software, with LE relativistic scale

Adjusted parameters :

Positions at 1988.0, velocity changes to AM0-2 for some stations

Constraints for the CTS :

- Westford coodinates fixed to the ITRF90 and velocity to AM0-2 value

- Mean orientation of a set of stations move with AM0-2

Raw data :

1988 positions and velocity change with respect to AM0-2 for sites with sufficient data, with formal errors

Input data (RM) :

The 1988 values, with formal errors modified using the formula (1) with A = 0.5 cm and B = 1.5.

1.3.6) CSR SLR solution

Identifer : SSC(CSR) 92 L 01

Model : Horizontal velocities adjusted for 42 sites. For all other sites velocities fixed to NUVEL 1 NNR. GM = 398600.4415 km^3/s^2

Adjusted parameters: X, Y, Z at 1988.0 and horizontal velocities for 42 sites

Constraints for the CTS :

- system oriented to agree with IERS combined in a mean sense over period 1984 - 1990,
- latitude and longitude of 7210 and latitude of 7105 fixed,
- rate of latitude and longitude of 7210 and latitude of 7105 fixed to NUVEL-1 NNR velocities.

Raw data : X, Y, Z, and 2D velocities for 42 sites and formal errors

Input data (LC) :

X, Y, Z at 1988.0 with formal errors modified with A = 1.5 cm and B = 1.0.

1.3.7) GSFC SLR solution

Identifer : SSC(GSFC) 92 L 01

Model : GEODYN II software. SL7.1 and NUVEL1 NNR model, GM = 398600.4415 km^3/s^2

Adjusted parameters : X, Y, Z at July 1 1986

Constraints for the CTS :

- latitude and longitude of 7105, the latitude of 7210, and the longitude of 7907 were fixed

- apriori values of ERP from IERS 90 C 04

Raw data : X, Y, Z and formal errors

Input data (LG) :

X, Y, Z with formal errors modified with A = 1.5 cm and B = 3.0

1.3.8) DGFII SLR solution

Identifer : SSC(DGFII) 92 L01

Model : DOGS software, GM = 398600.4396 km^3/s^2

Adjusted parameters : X, Y, Z, and horizontal velocities

Constraints for the CTS :

- forcing of rotation angles between initial and adjusted coordinates of 10 stations to becomes zero in the average,
- rotation drift rates around the three coordinate axes are forced to become zero with respect to a given set of AM0-2 horizontal station position drift rates,

Raw data : X, Y, Z at 1988.0 with error estimate and 2D velocities

Input data (LD) :

X, Y, Z at 1988.0 and the formal errors modified with A = 1.5 cm and B = 3.0

1.3.9) DUT SLR solution

Identifer : SSC(DUT) 92 L 01

Model : GEODYN-II software, estimation of station motions,

GM = 398600.4360 km^3/s^2

Adjusted parameters : X, Y, Z, and velocities

Constraints for the CTS :

- ERP a priori values from IERS Bulletin B
- NUVEL-1 NNR values for 12 stations

Raw data : X, Y, Z at 1988.0 and VX, VY, VZ

Input data (LU) :

X, Y, Z at 1988.0 with formal errors modified with A = 1.5 cm and B = 1.0

1.3.10) GFZ SLR solution

Identifer : SSC(GFZ) 92 L 01

Model : POTSDAM-5 software. Adjusted velocities. GM = 398600.442 km^3/s^2

Adjusted parameters : r, lambda, phi at 1988.0 and 3D velocities

Constraints for the CTS :

- latitude and velocities fixed for stations 7105,7840

- longitude fixed for station 7105

Raw data : X, Y, Z and formal errors

Input data (LZ) :

X, Y, Z with formal errors modified with A = 1.5 cm and B = 2.0

1.3.11) GAOUA SLR solution

Identifer : SSC(GAOUA)92 L 01

Model : KIEV-GEODYNAMICS - 3 software. Motion with AM0-2 model,

GM = 398600.440 km^3/s^2

Adjusted parameters : X, Y, Z at 1988.0

Constraints for the CTS :

- fixed AM0-2 motion
- ERP values from IERS Bulletin B

Raw data : X, Y, Z and formal errors

Input data (LK) :

X, Y, Z and formal errors modified with A = 2.5 cm and B = 2.0

1.3.12) NAL SLR solution

Identifer : SSC(NAL) 92 L 01

Model : COSMOS software, motion with AM0-2 model, GM = 398600.4415 km^3/s^2

Adjusted parameters : X, Y, Z at 1991.0

Constraints for the CTS :

- latitude and longitude of 7105 and latitude of 7907 fixed
- fixed AM0-2 motion
- ERP values from IERS Bulletin B

Raw data : X, Y, Z and formal errors

Input data (LT) :

X, Y, Z and formal errors modified with A = 1.5 cm and B = 2.0

1.3.13) UT/McD LLR solution

Identifer : SSC(UTXMO)92 M 01

Model : Motion with AM0-2 model, GM = 398600.440 km^3/s^2

Adjusted parameters : lambda, phi, h at 1984.0

Constraints for the CTS :

- fixed AM0-2
- ERP fixed at 1985 Jan. 11 to CSR LGN7692 series

Raw data : X, Y, Z and formal errors

Input data (MX) :

X, Y, Z transformed at 1988.0 with AM0-2. Formal errors modified with A = 1.5 cm and B = 0.2.

1.3.14) JPL LLR solution

Identifer : SSC(JPL) 92 M 01

Model : Motion with AM0-2 model

Adjusted parameters : X, Y, Z at 1991.0

Constraints for the CTS :

- ERP from 1976 to 1991 taken from a file provided by R. Gross
- fixed AM0-2

Raw data : X, Y, Z without error estimate

Input data (MJ) :

X, Y, Z with 3 cm as error.

1.3.15) SHA LLR solution

Identifer : SSC(SHA) 92 M 01

Model : Motion with AM0-2 model

Adjusted parameters : X, Y, Z at 1988.0

Constraints for the CTS :

- DE303/LE303 planetary ephemeris

Raw data : X, Y, Z without error estimate

Input data (MS) :

X, Y, Z with 5 cm as error.

1.3.16) JPL GPS solution

Identifer : SSC(JPL) 91 P 01

Model : GIPSY software, free network

Adjusted parameters : X, Y, Z at 1991.1

Constraints for the CTS :

Loose a priori constraints on all GPS epoch states, station coordinates and polar motion from Bulletin B forces crude alignment with ITRF90 to within several meters

Raw data : X, Y, Z with error estimate

Input data (PJ) :

X, Y, Z transformed to 1988.0 with NUVEL-1 NNR. Formal errors not modified.

Table 1

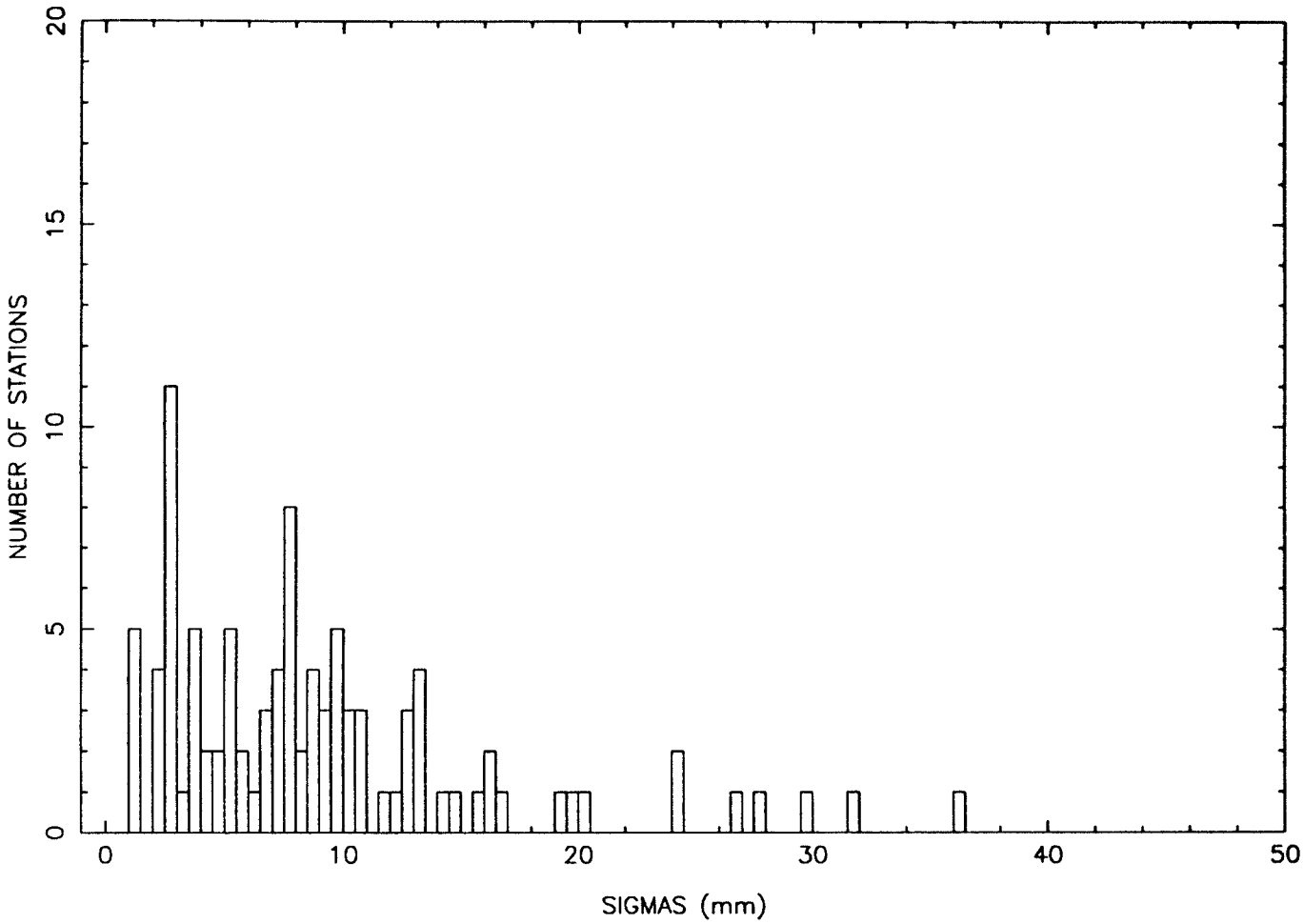
Input data sets

LABEL	DESIGNATION	MOTION MODEL	REFERENCE EPOCH	OTHER NAME
RG91	SSC(GSFC) 92 R 03	ESTIM/NUVEL-1 NNR	POS. FROM 79 TO 92	GLB833
RN91	SSC(NOAA) 92 R 01	ESTIM/AM0-2	1988.0	
RJ91	SSC(JPL) 92 R 01	AM0-2	1988.0	1992-1
RO91	SSC(USNO) 92 R 03	NUVEL 1 NNR	17 Oct. 1980	1992-3
RM91	SSC(NAOMZ)92 R 01	ESTIM/AM0-2	1988.0	
LC91	SSC(CSR) 92 L 01	ESTIM/NUVEL-1 NNR	1988.0	
LG91	SSC(GSFC) 92 L 01	ESTIM/NUVEL-1 NNR	01 Jul. 1986	
LD91	SSC(DGFII)92 L 01	ESTIM/AM0-2	1988.0	
LU91	SSC(DUT) 92 L 01	ESTIM/NUVEL-1	1988.0	
LZ91	SSC(GFZ) 92 L 01	ESTIM/NUVEL-1	1988.0	
LK91	SSC(GAOUA)92 L 01	AM0-2	1988.0	
LT91	SSC(NAL) 92 L 01	AM0-2	1991.0	
MJ91	SSC(JPL) 92 M 01	AM0-2	1991.0	
MX91	SSC(UTXMO)92 M 01	AM0-2	1984.0	
MS91	SSC(SHA) 92 M 01	AM0-2	1988.0	
PJ91	SSC(JPL) 91 P 01		1991.1	

1.4) Excentricites

The excentricities used for ITRF91 are given in Table T5 of the appendix.

FIGURE 1: SSC(GSFC) 92 R 03 /POS. 88.0



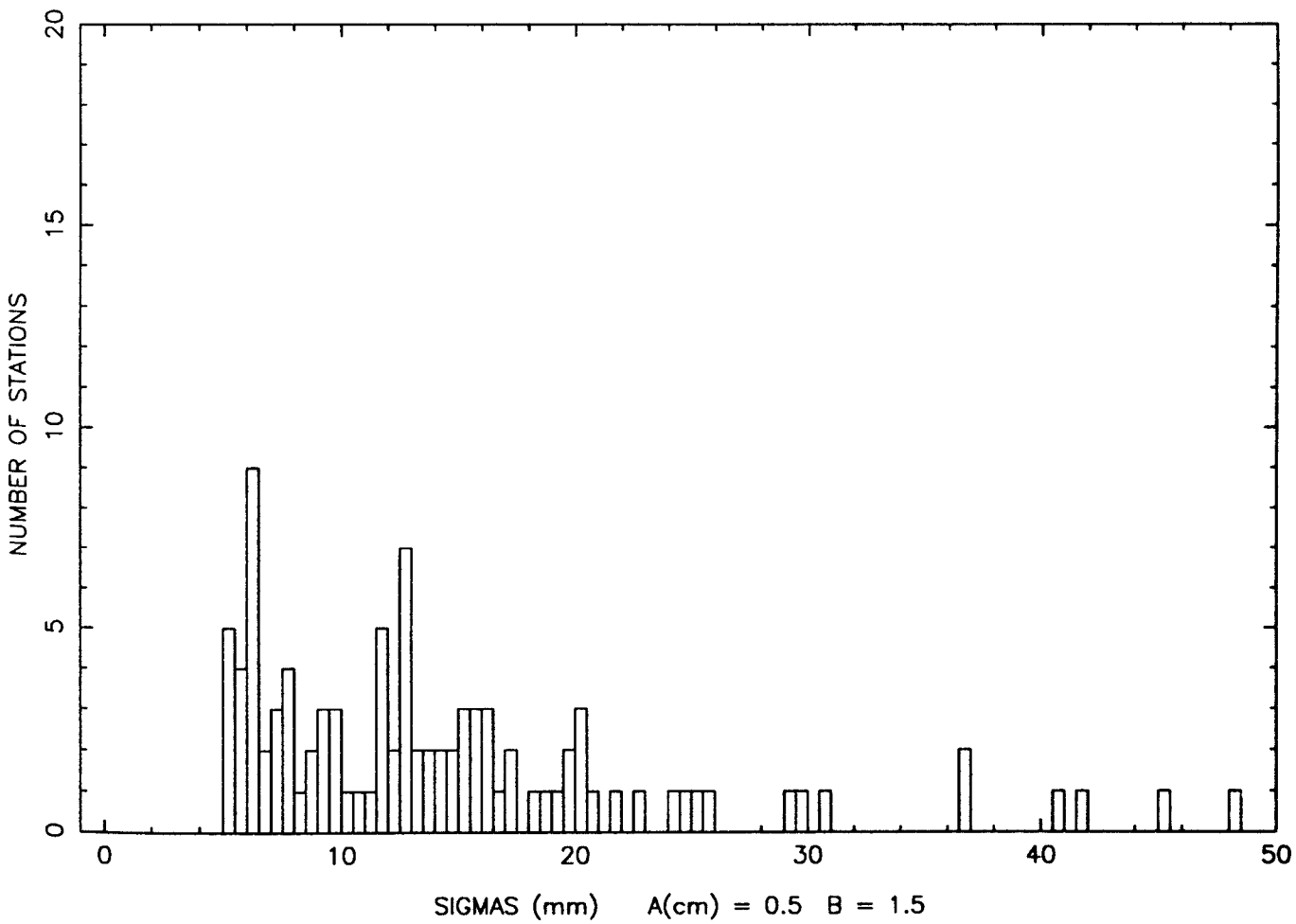
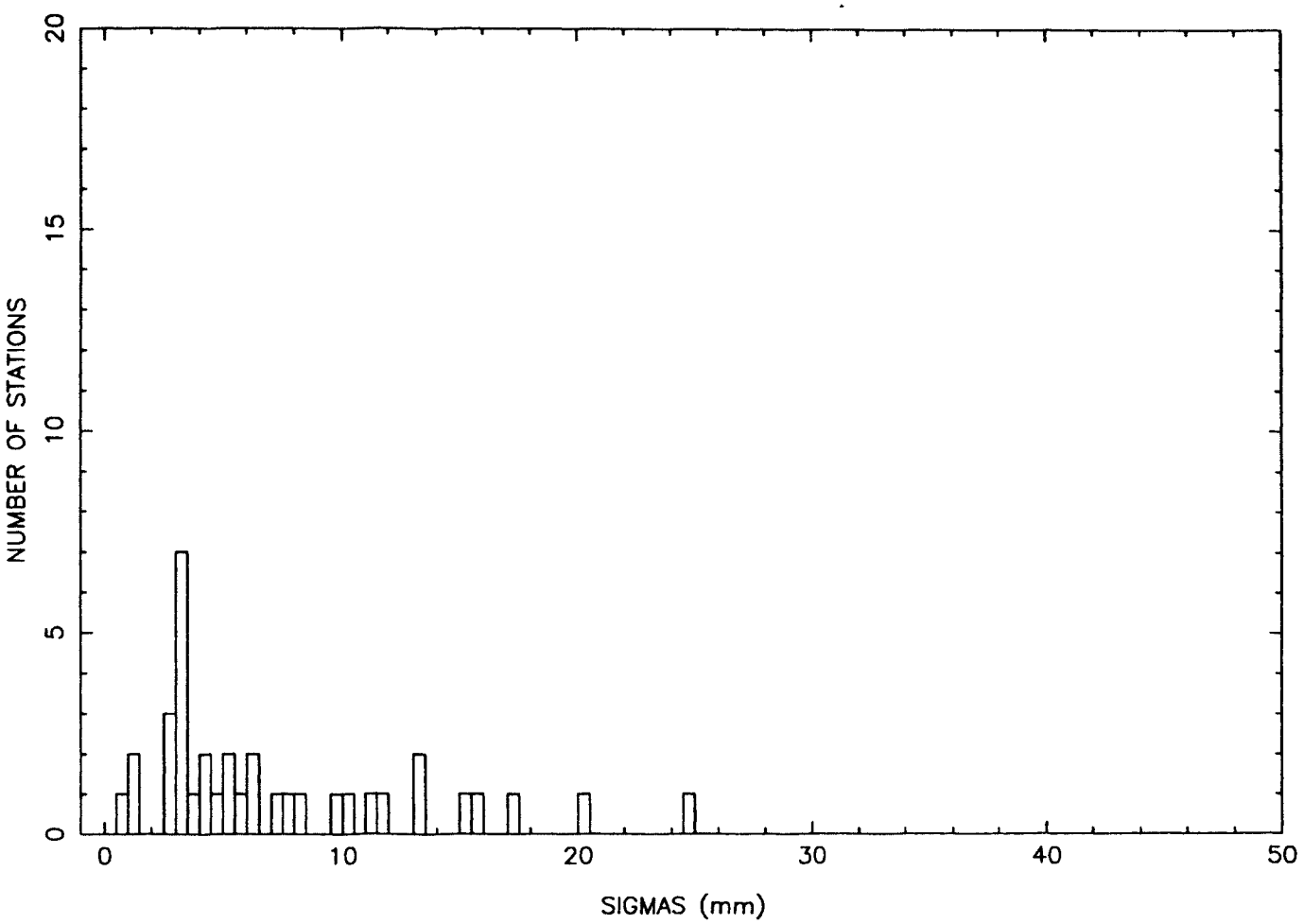


FIGURE 2 : SSC(NOAA) 92 R 01



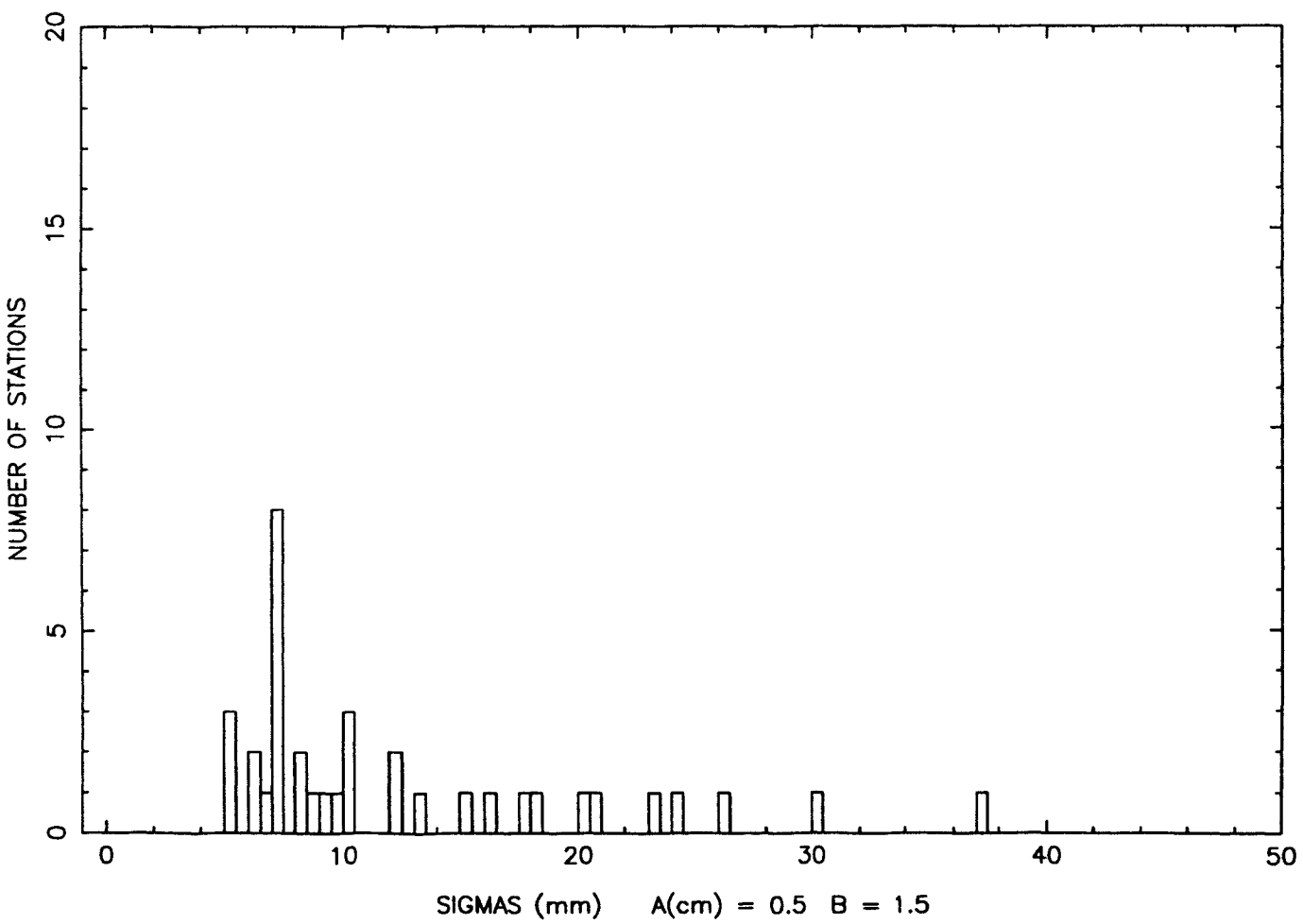
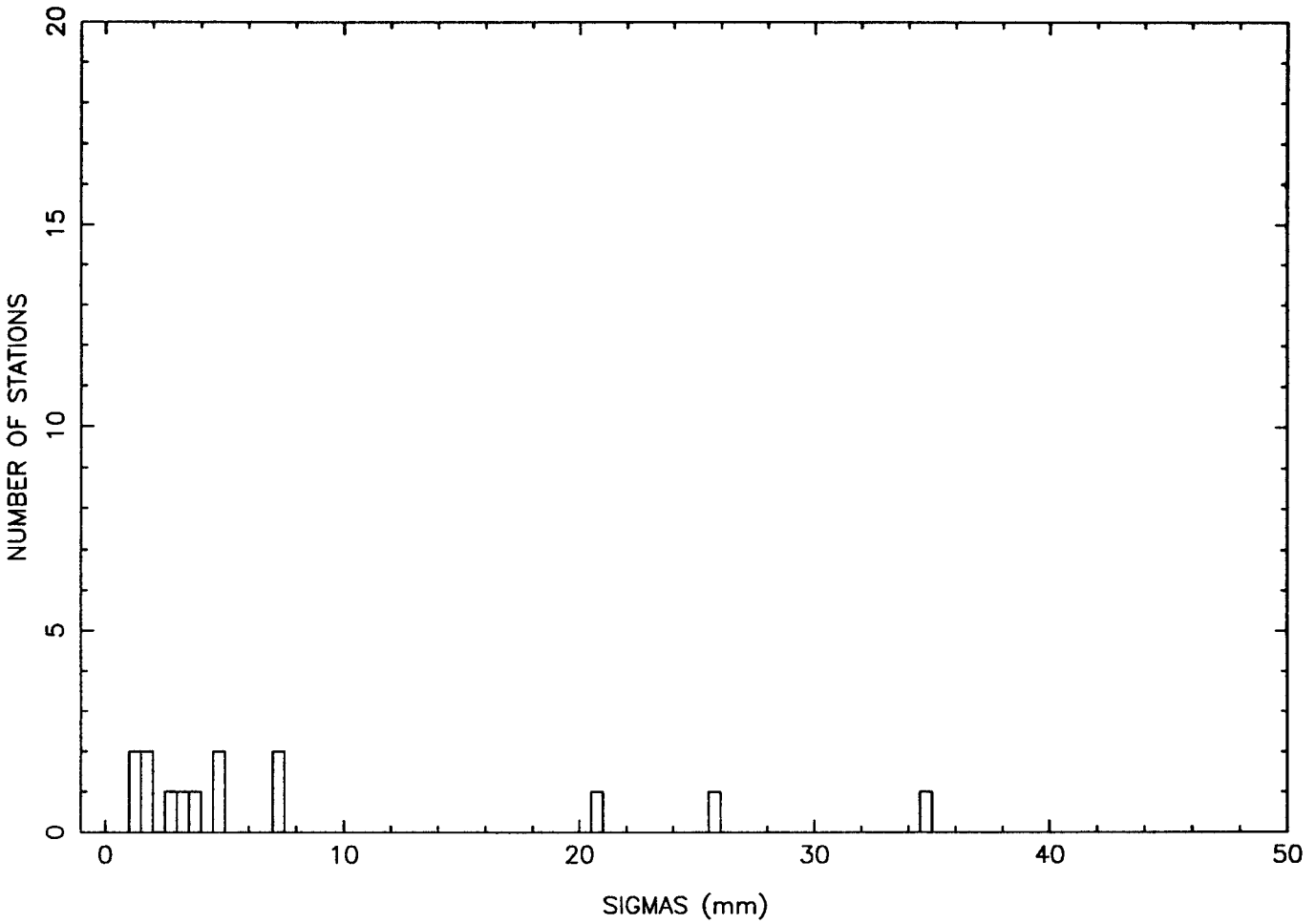


FIGURE 3: SSC(USNO) 92 R 01



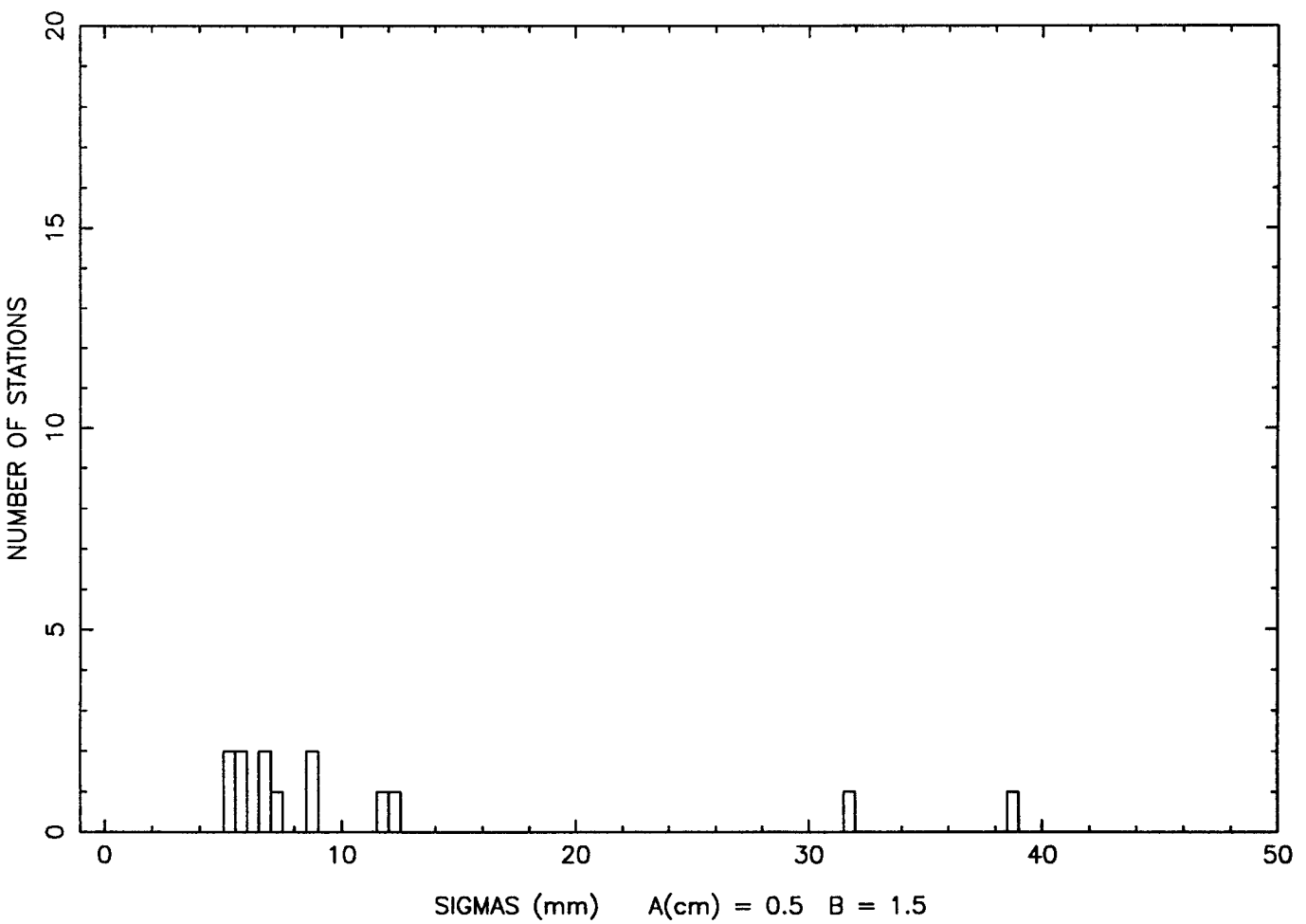
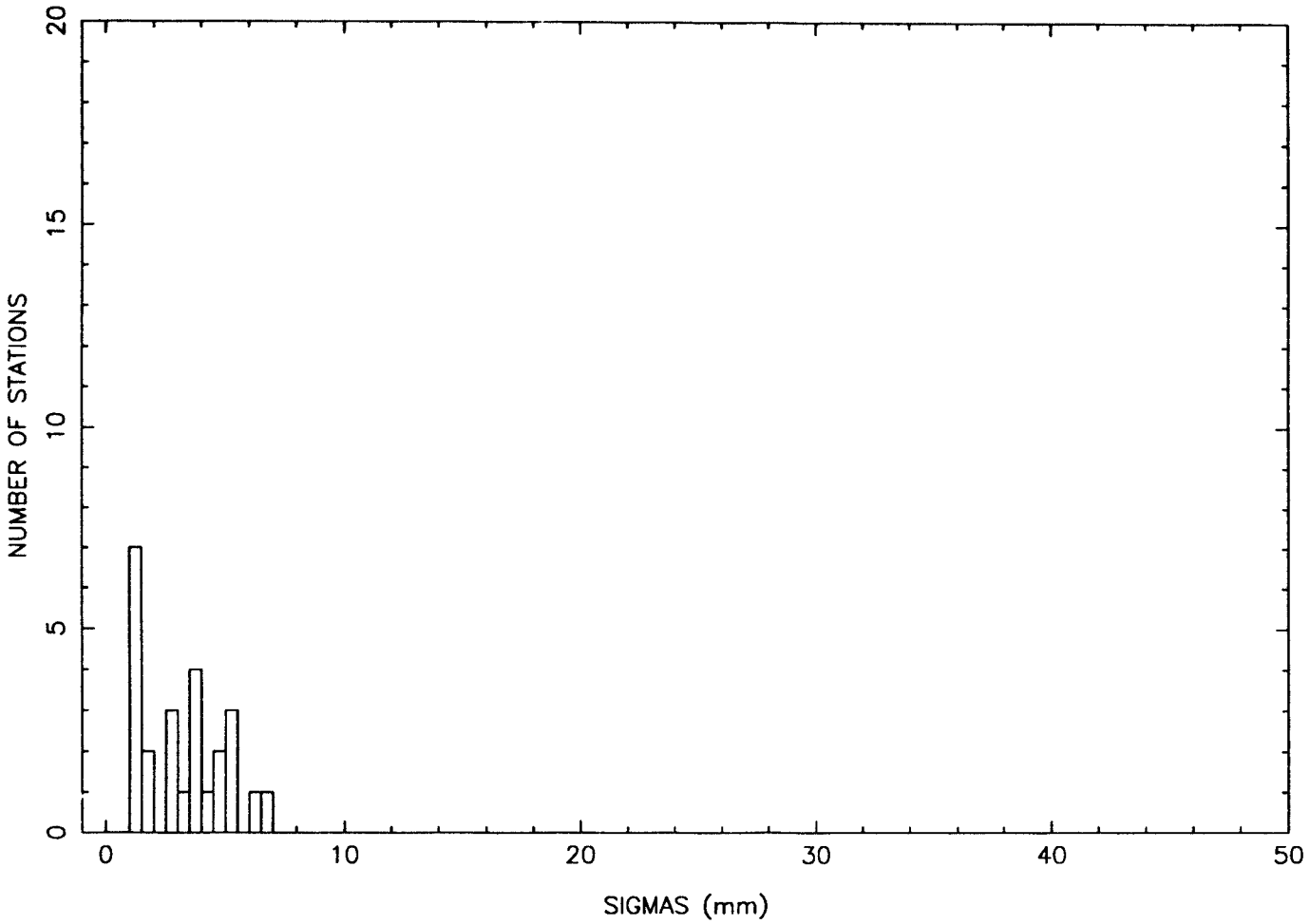


FIGURE 4 : SSC(NAOMZ)92 R 01



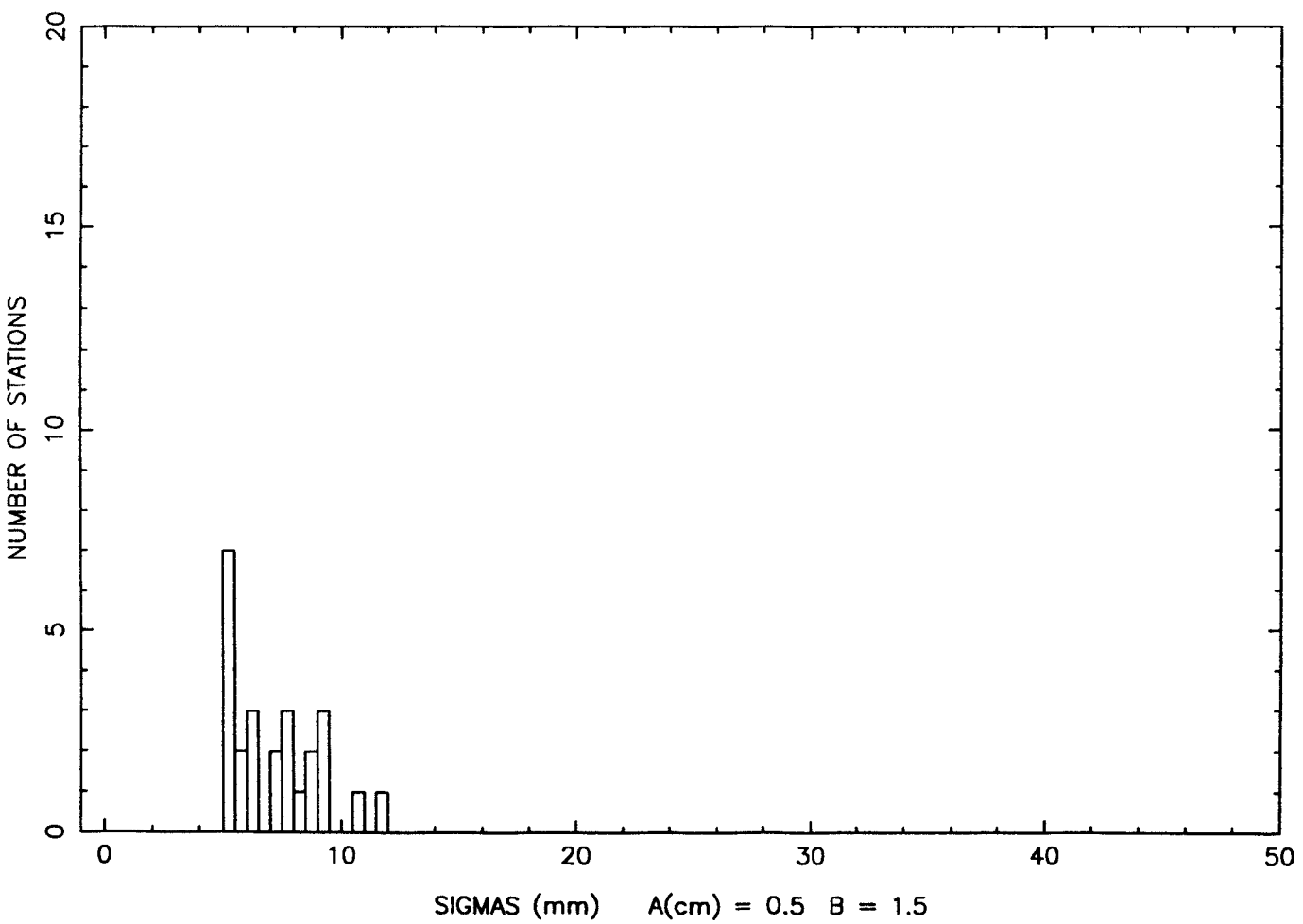
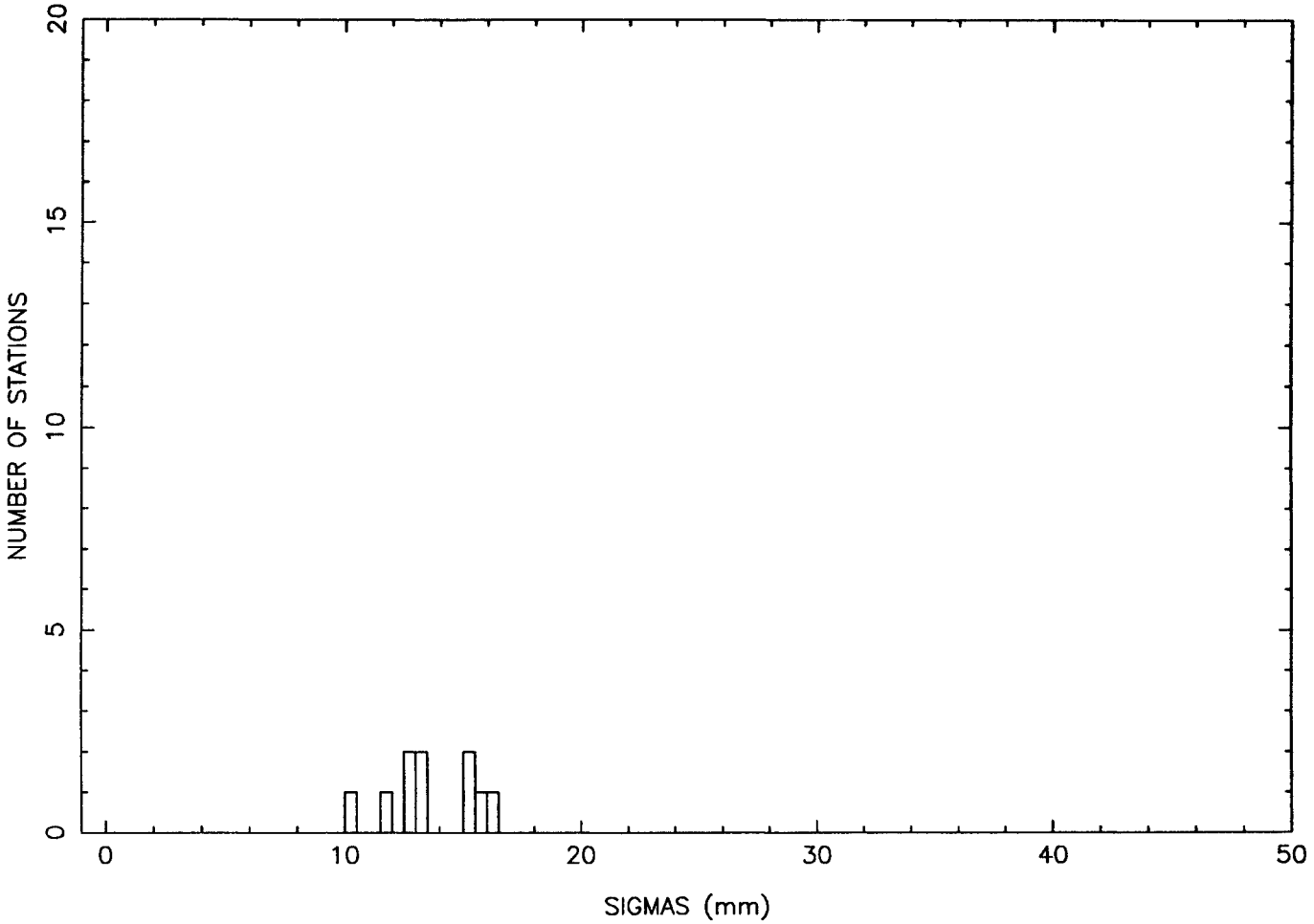


FIGURE 5 : SSC(JPL) 92 R 01



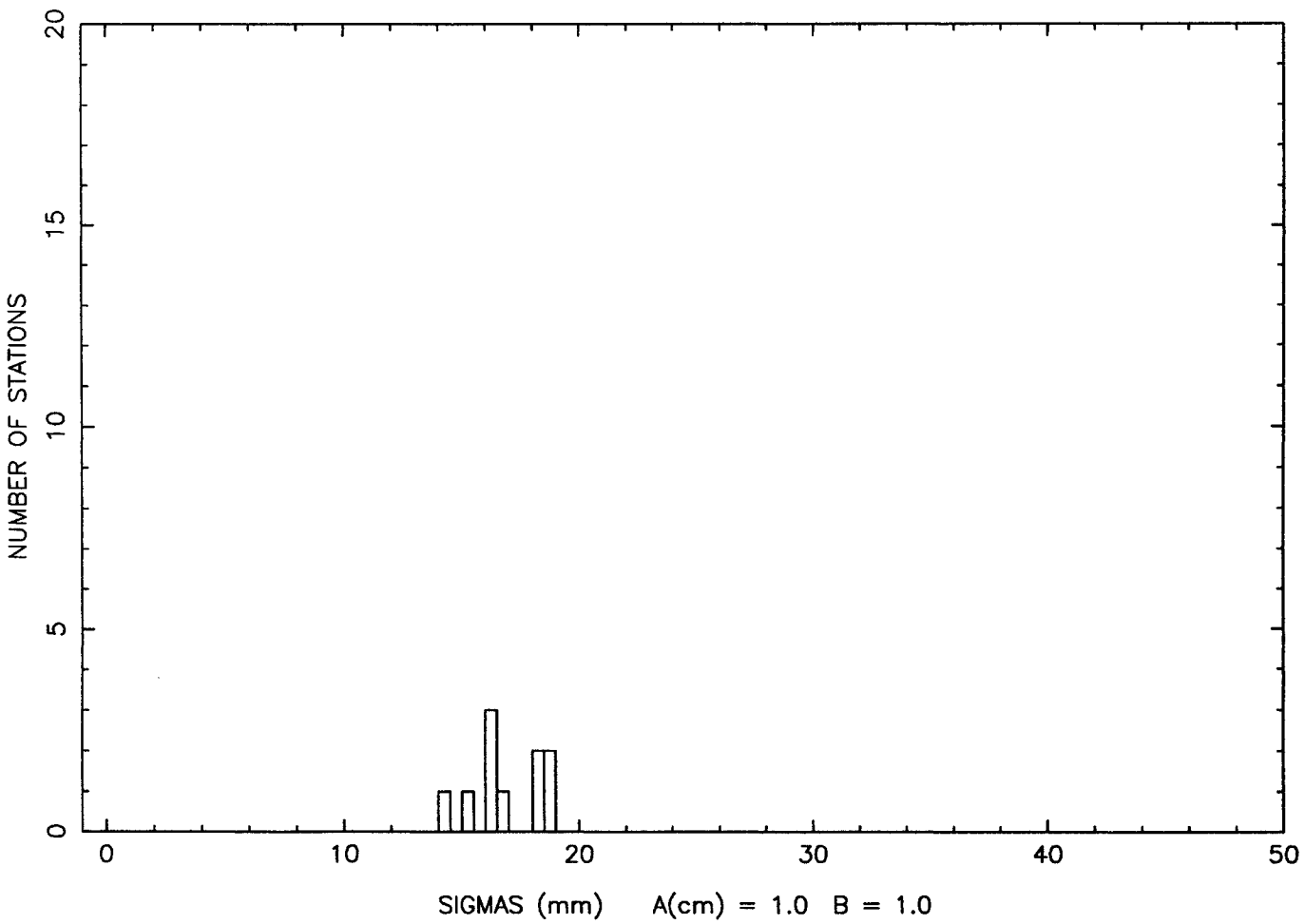
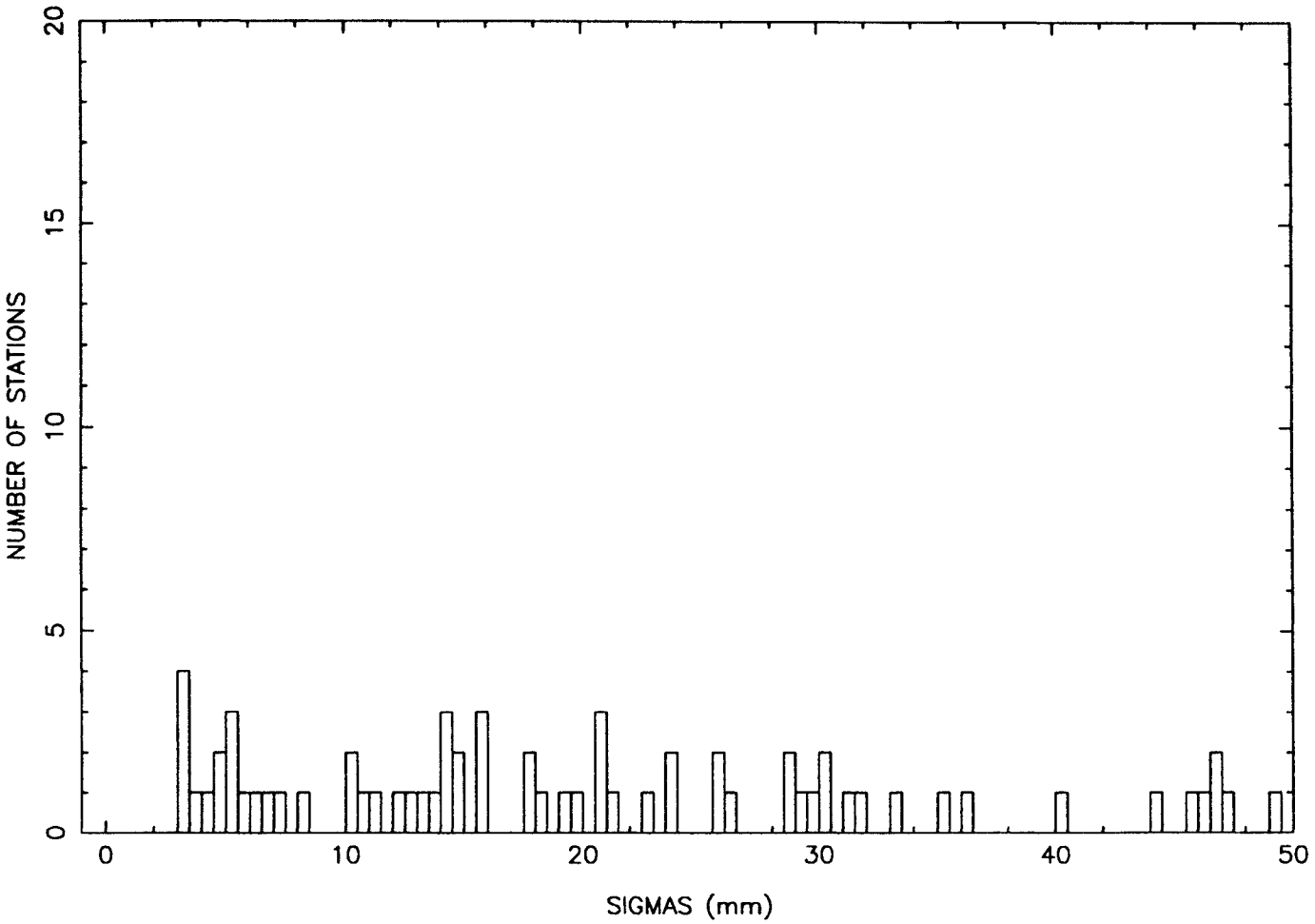


FIGURE 6: SSC(CSR) 92 L 01



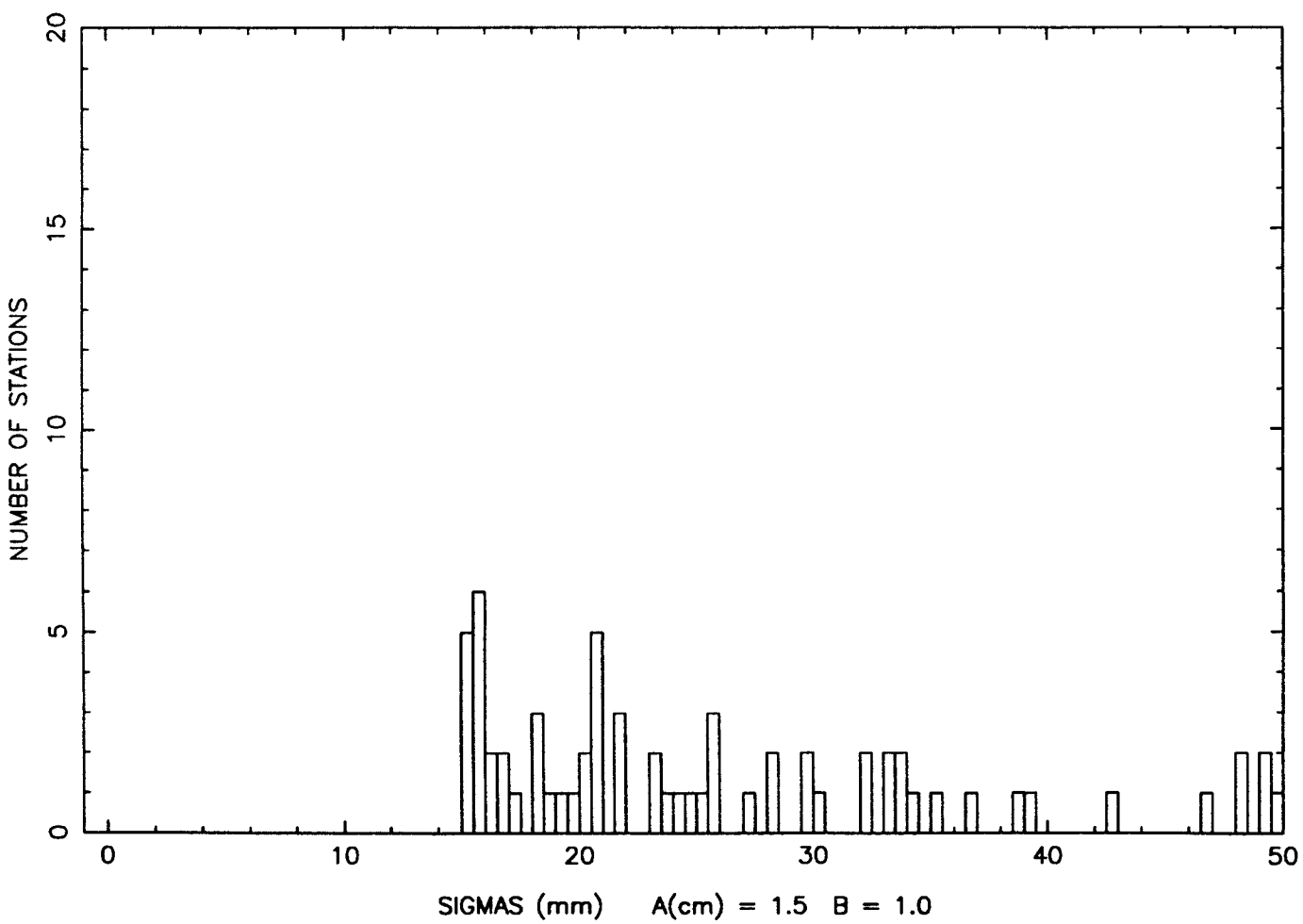
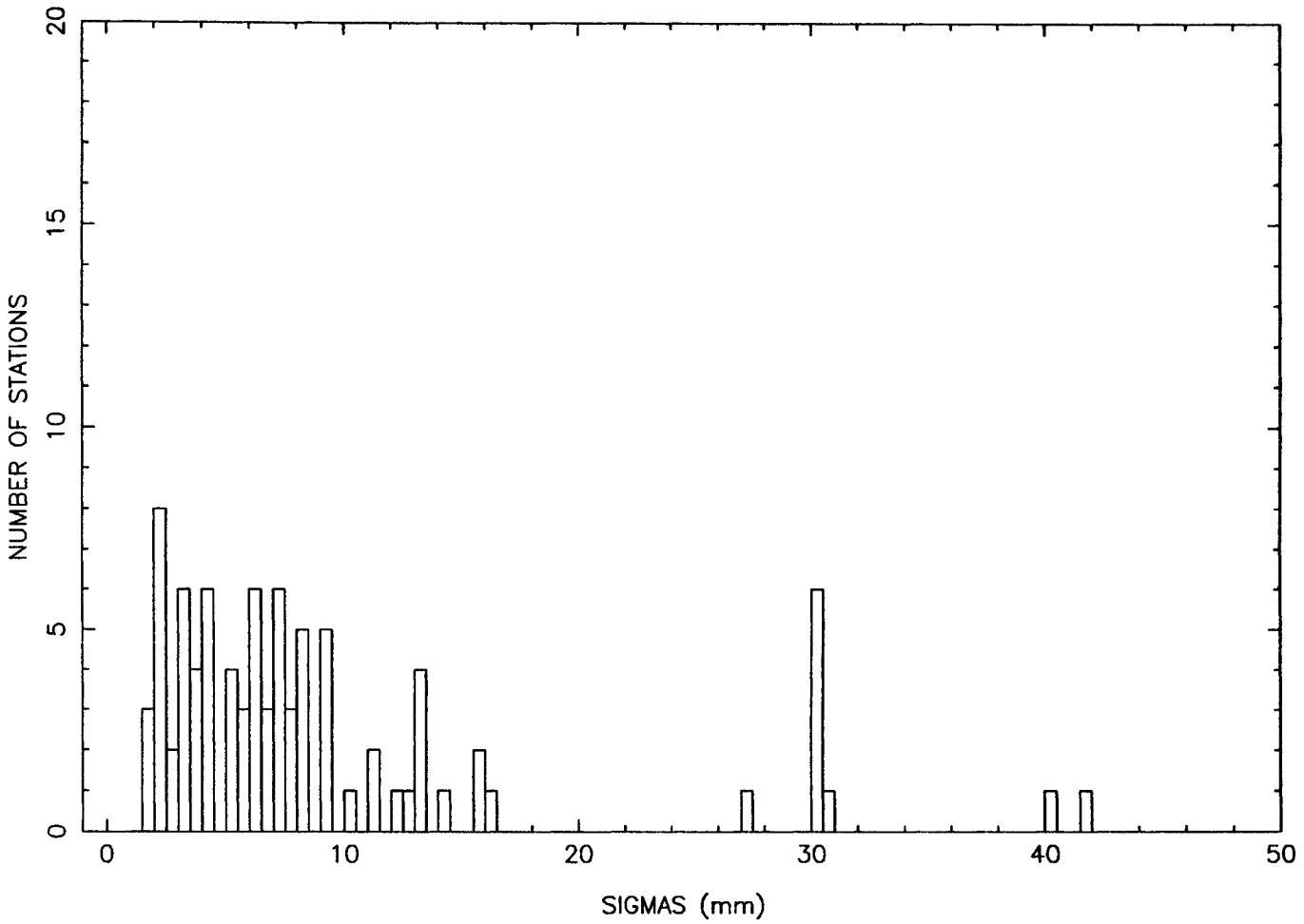


FIGURE 7: SSC(GSFC) 92 L 01/POS 88.0



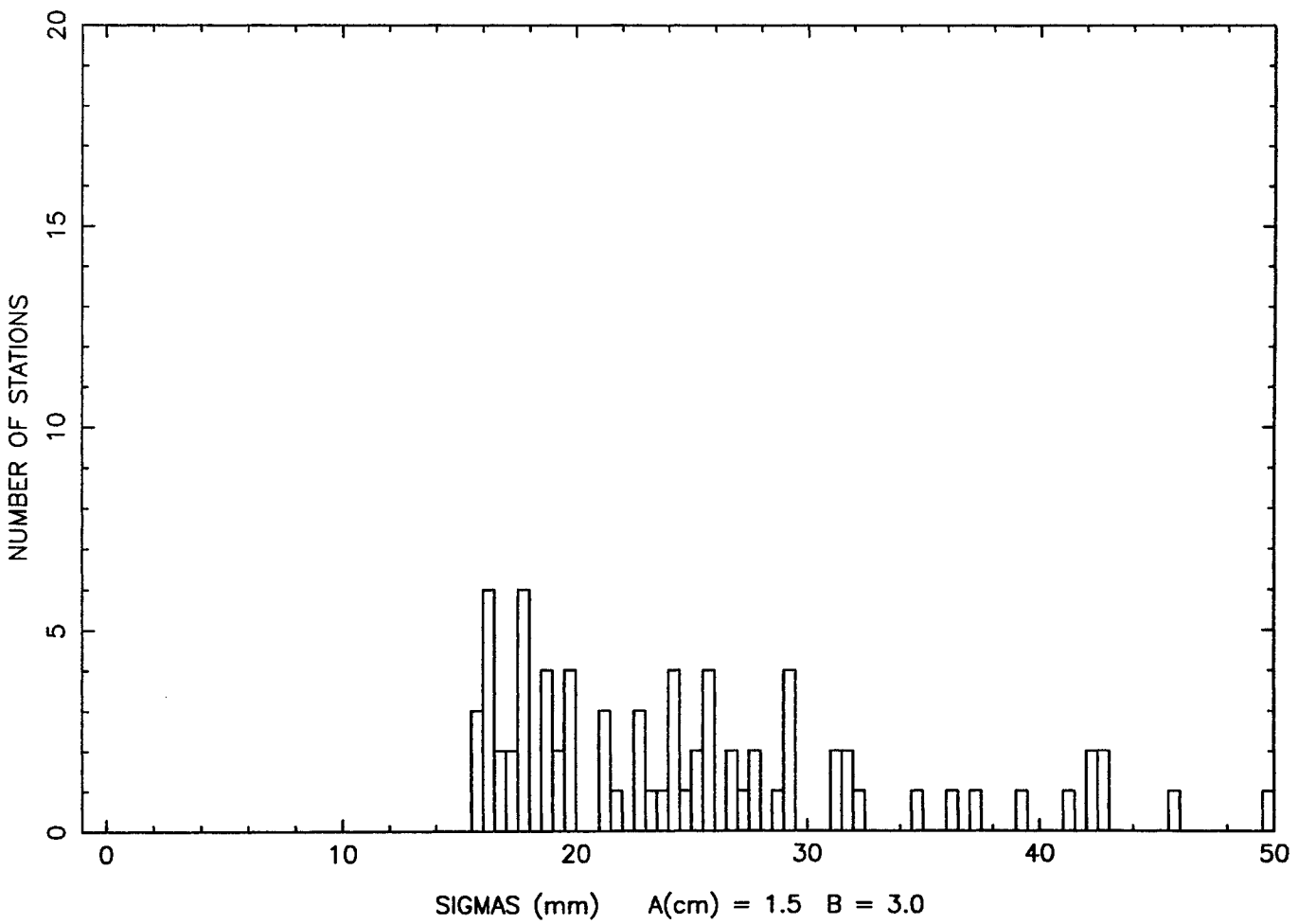
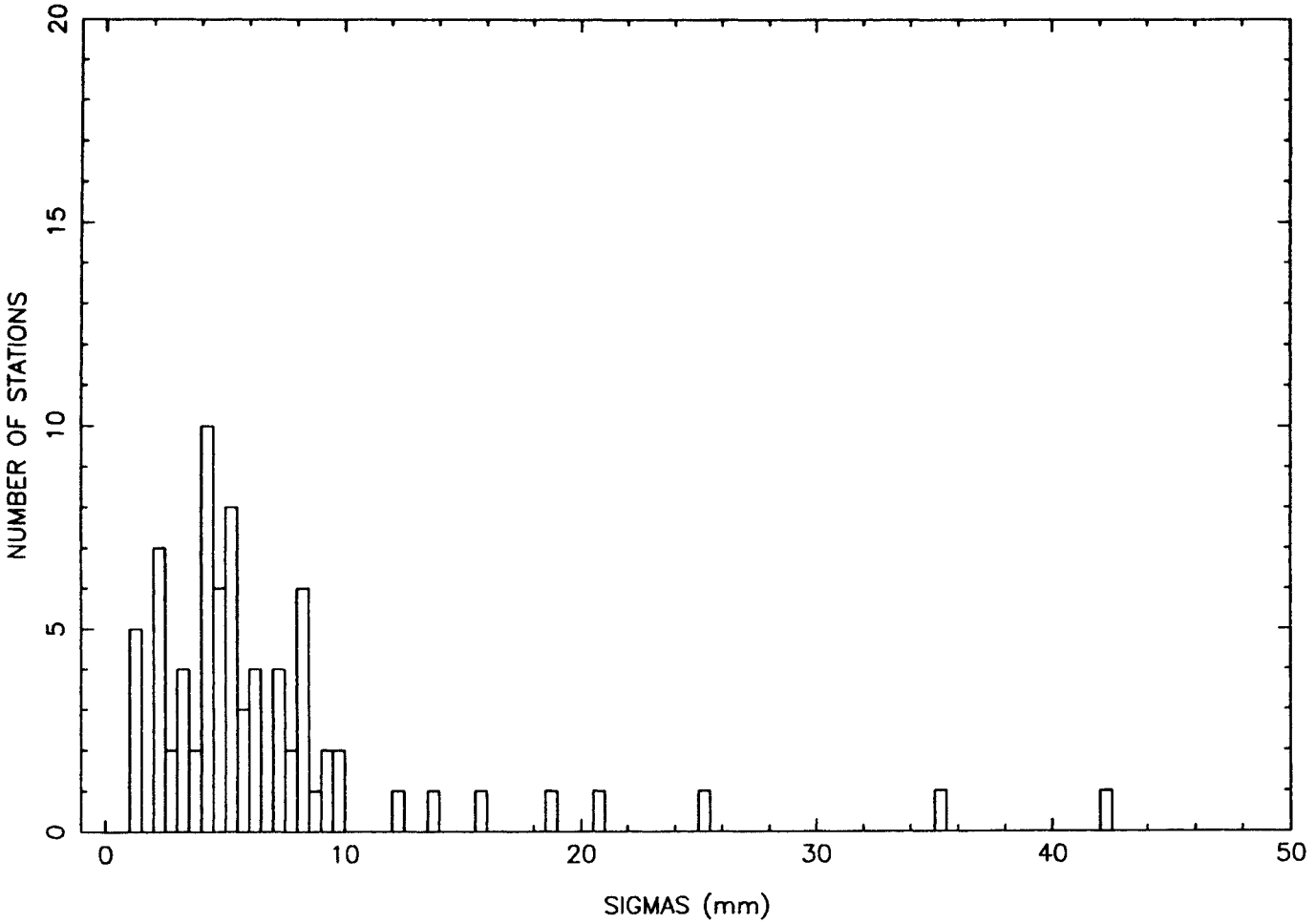


FIGURE 8 : SSC(DGFII)92 L 01



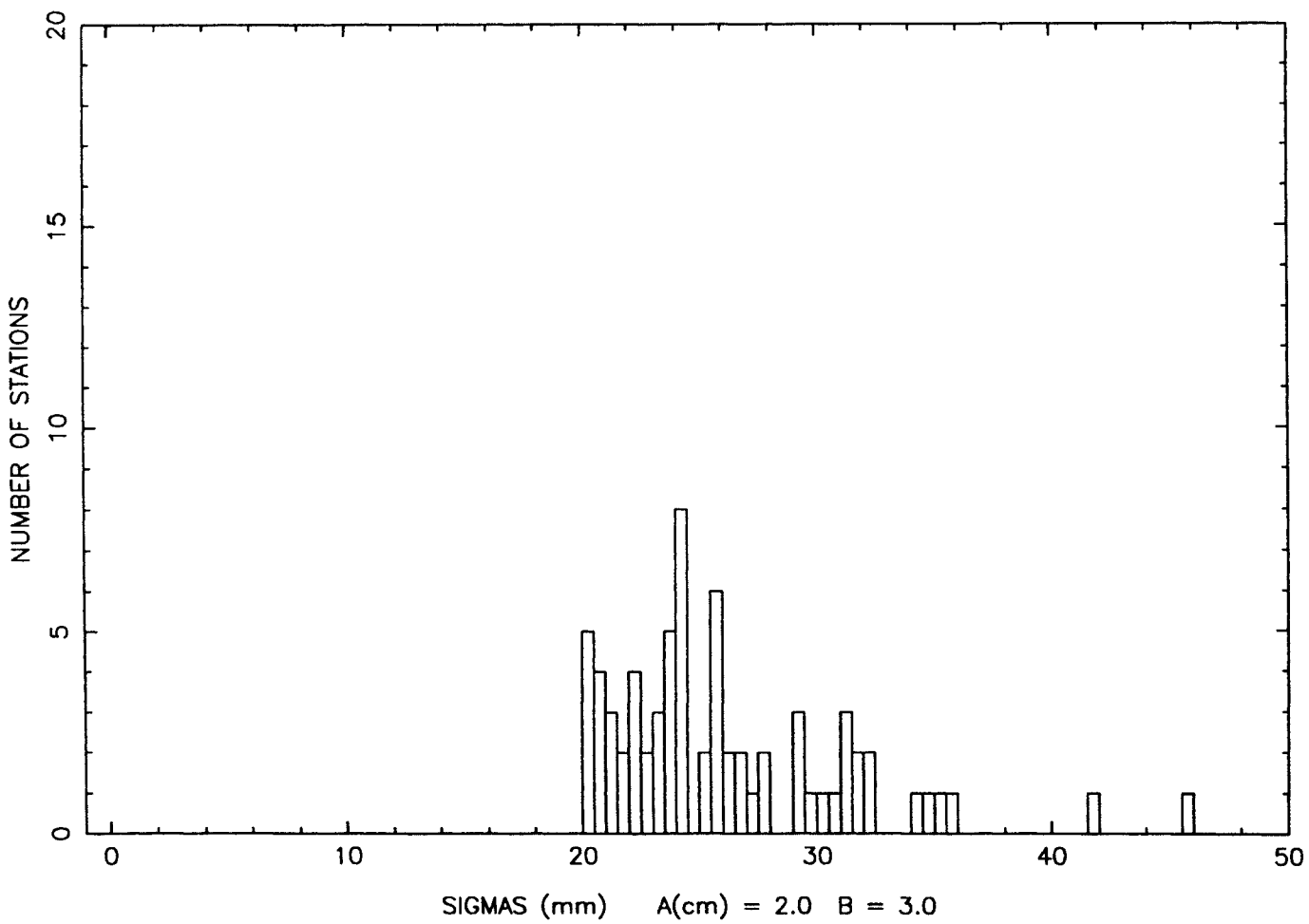
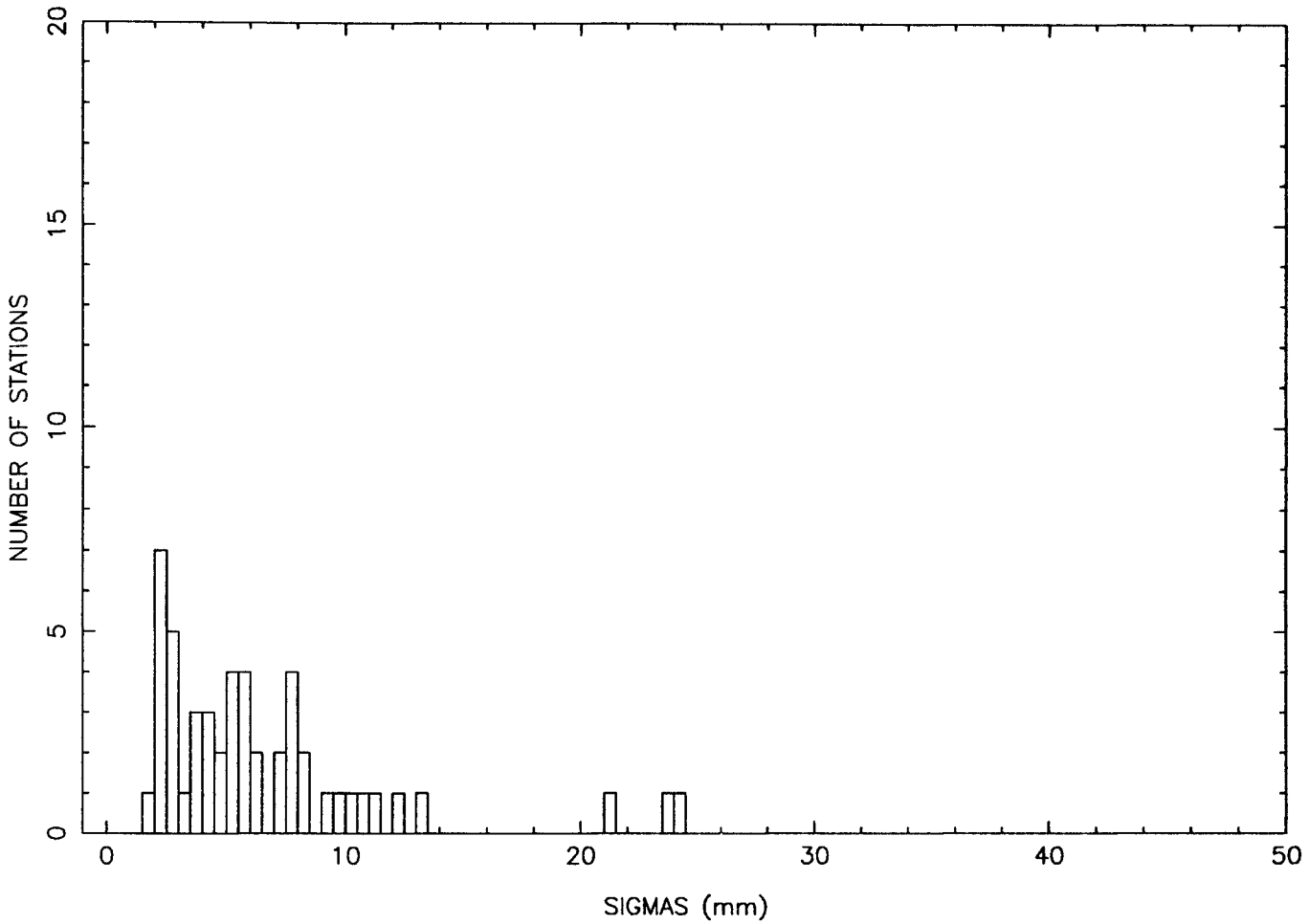


FIGURE 9 : SSC(DUT) 92 L 01 /POS. 88.0



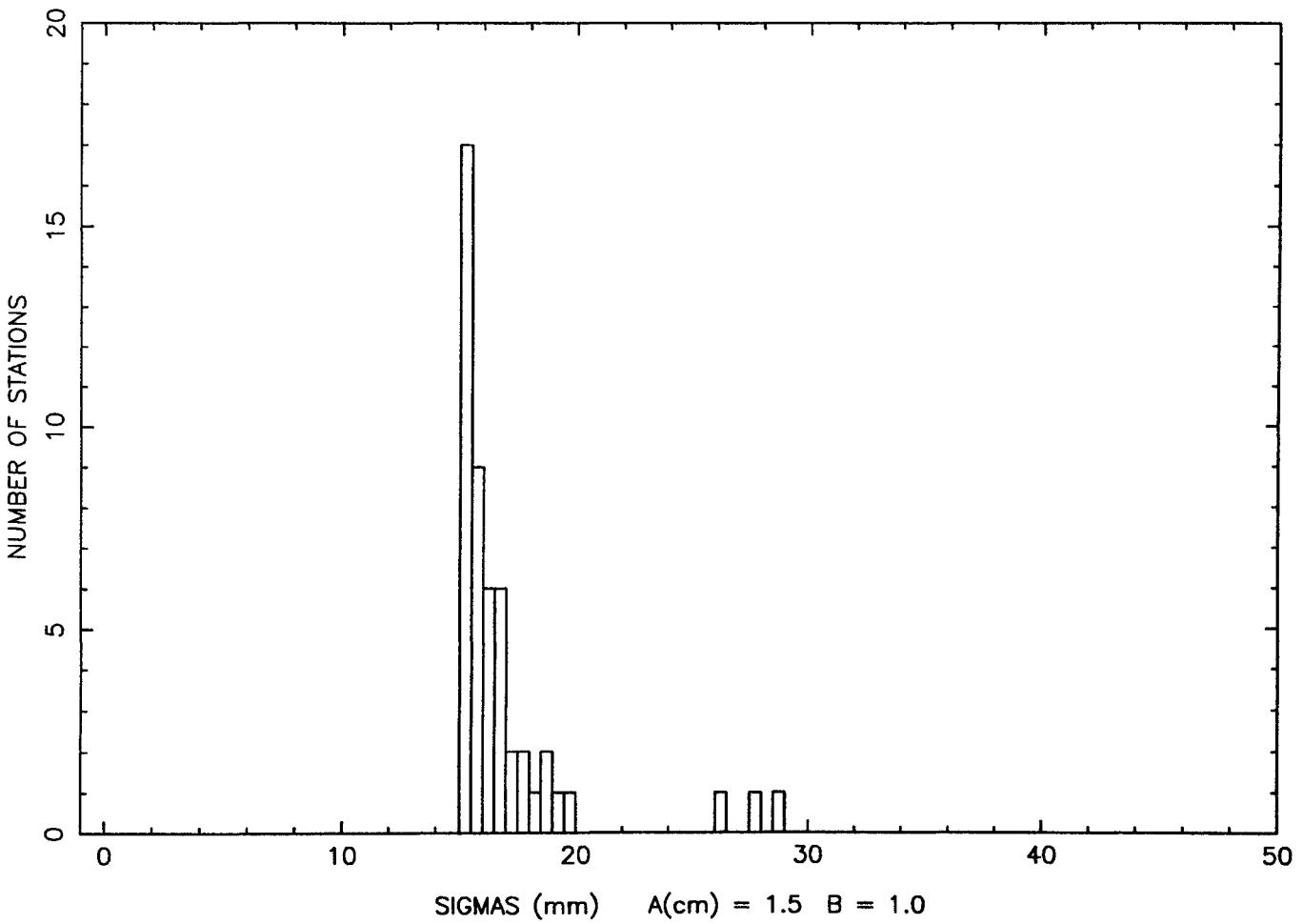
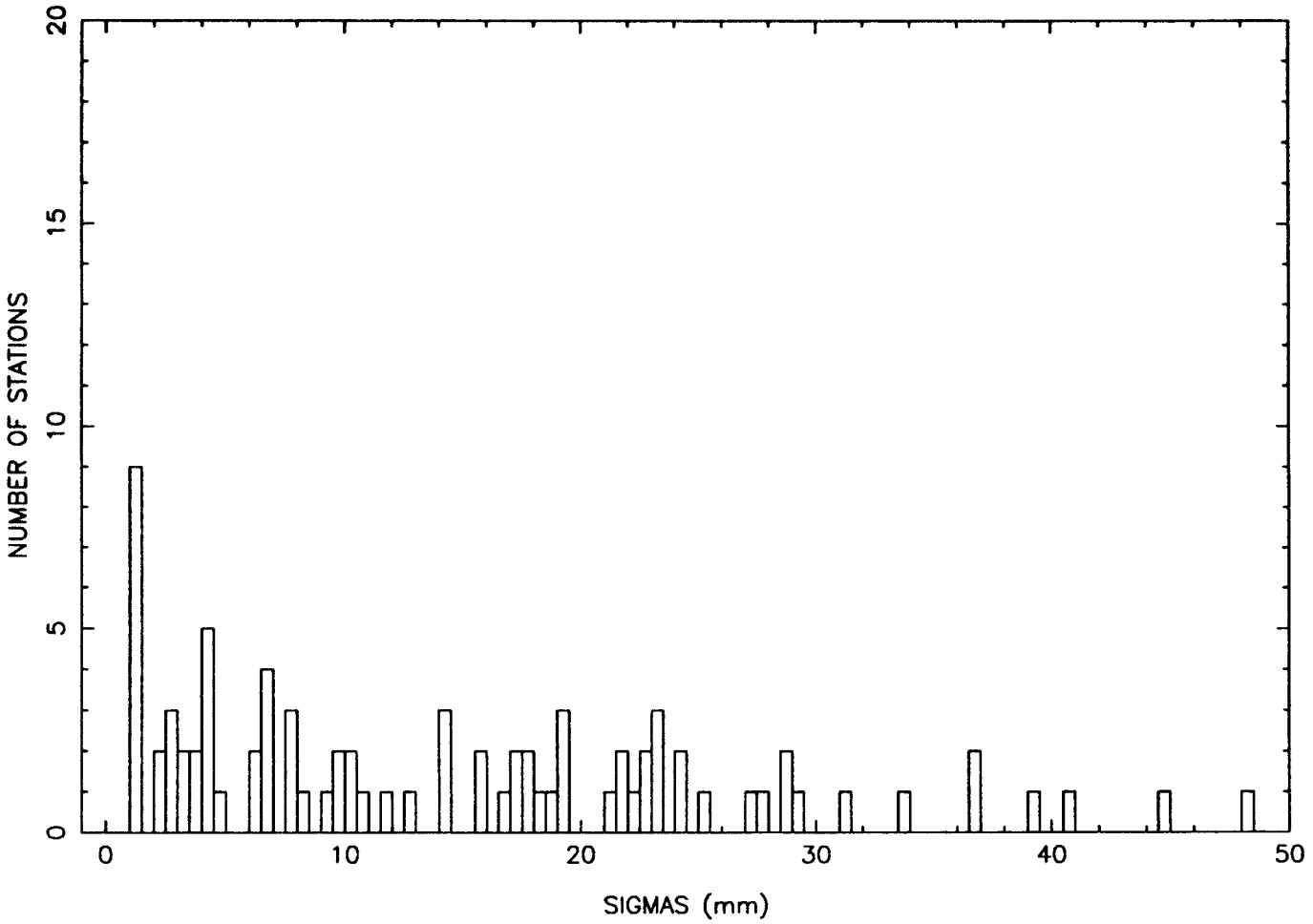


FIGURE 10: SSC(GFZ) 92 L 01



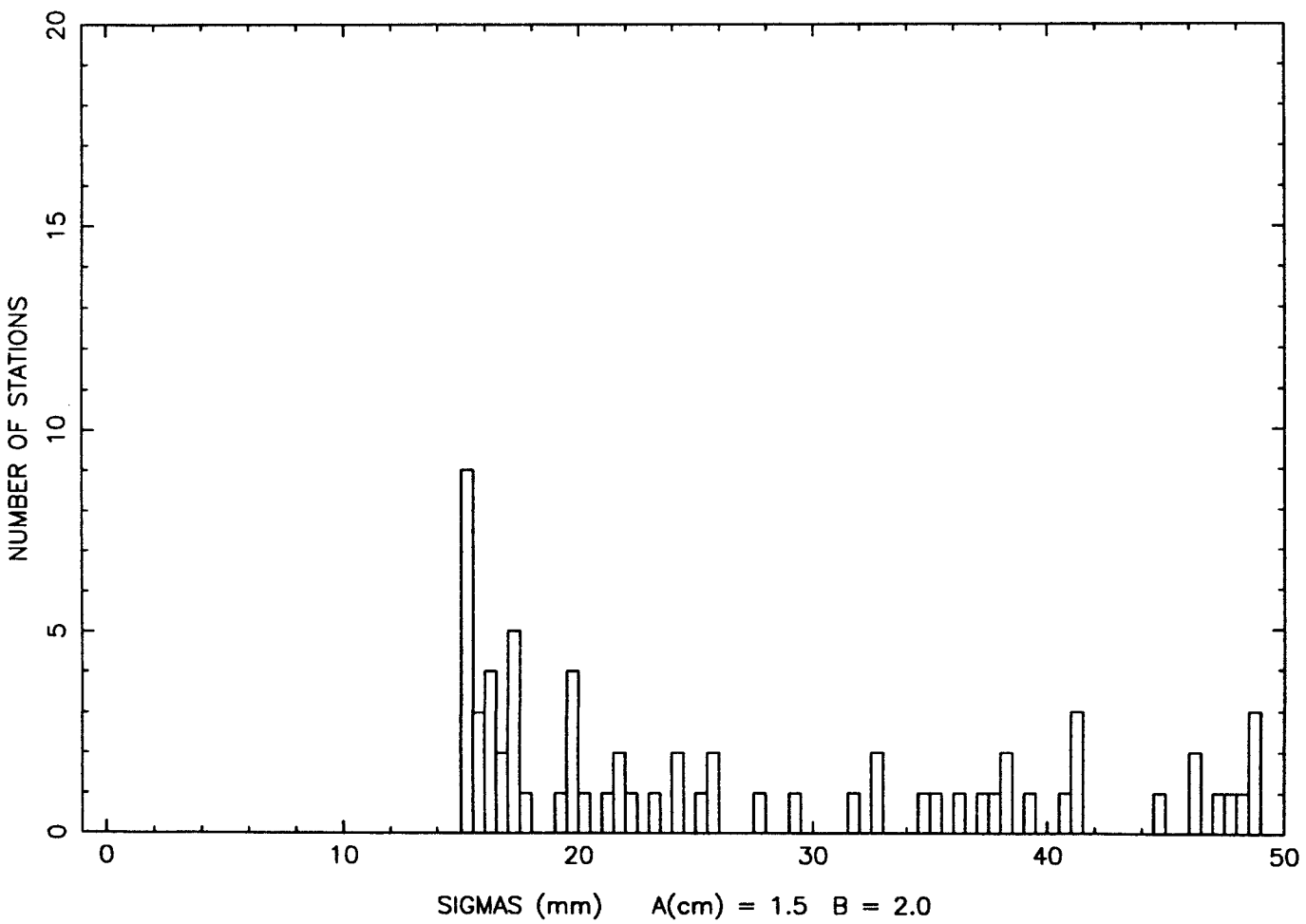
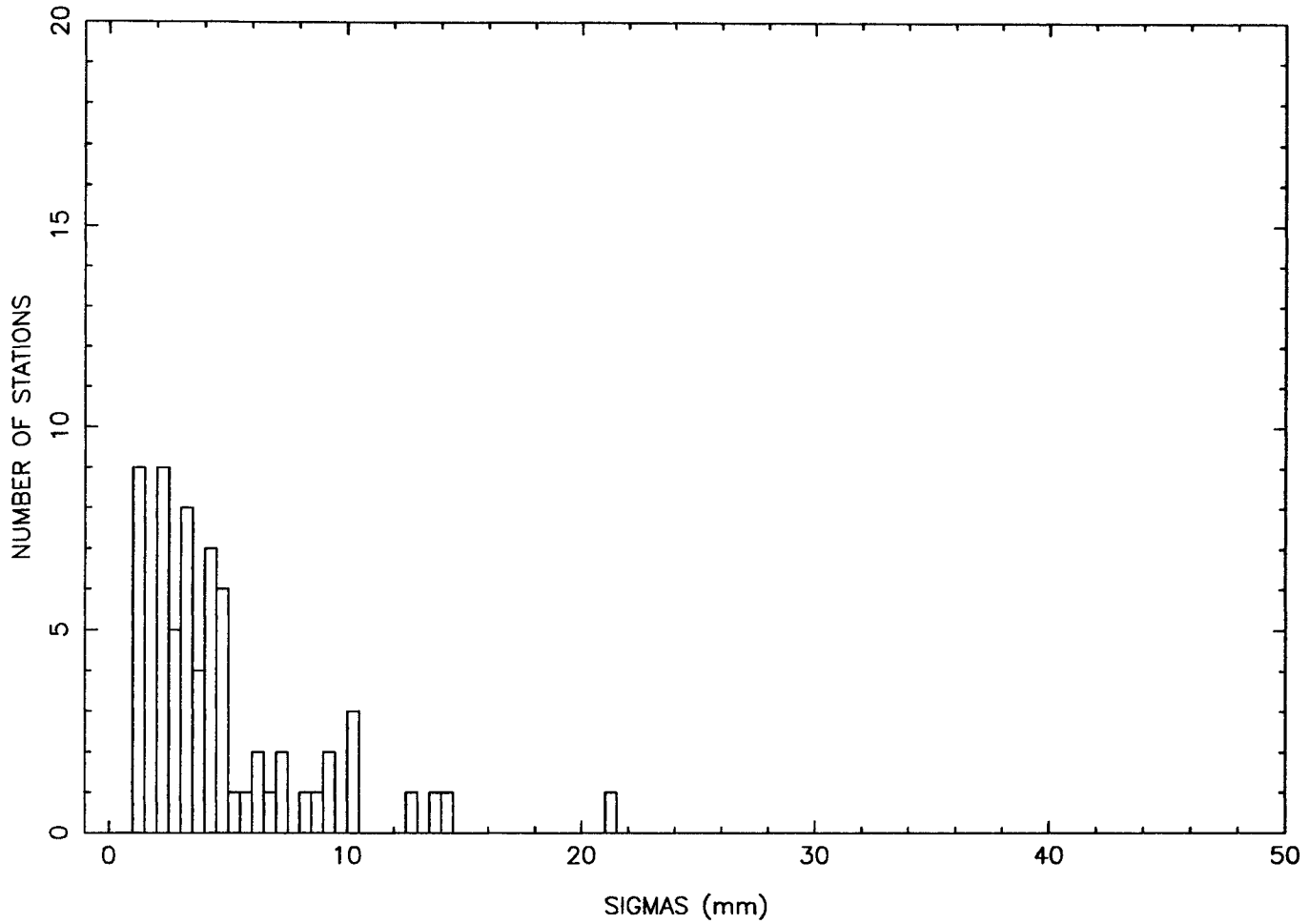


FIGURE 11: SSC(GAOUA)92 L 01



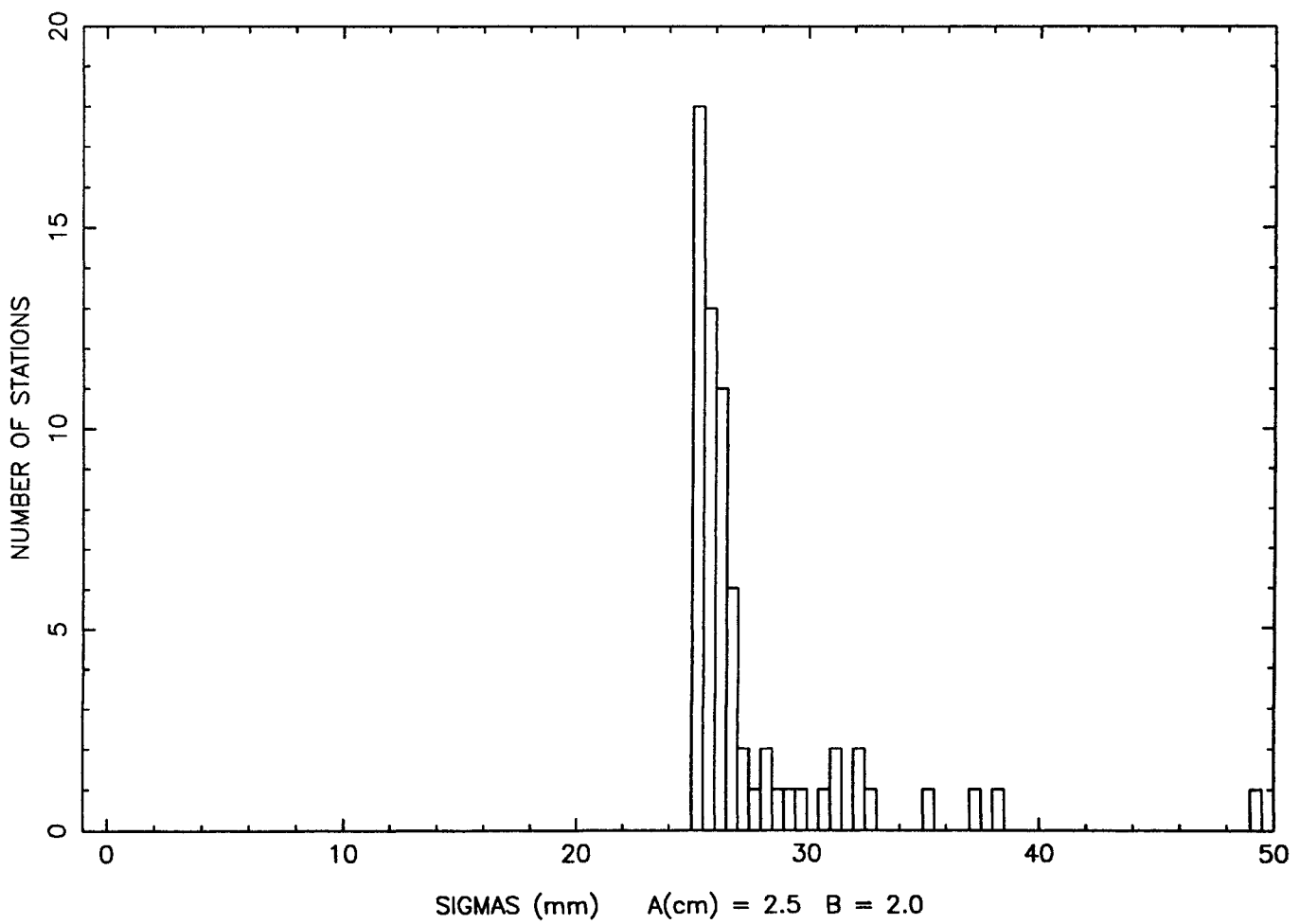
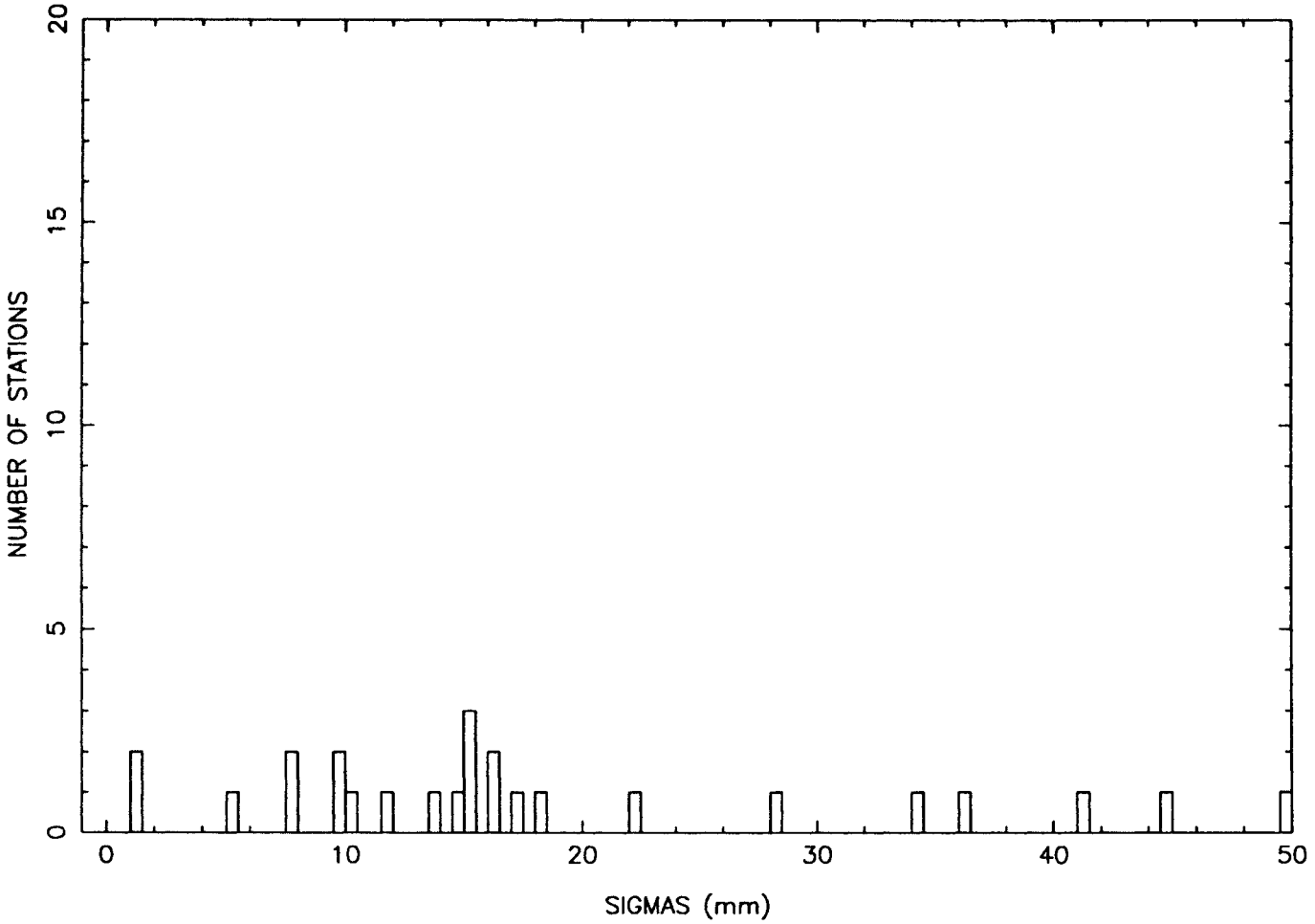


FIGURE 12: SSC(NAL) 92 L 01



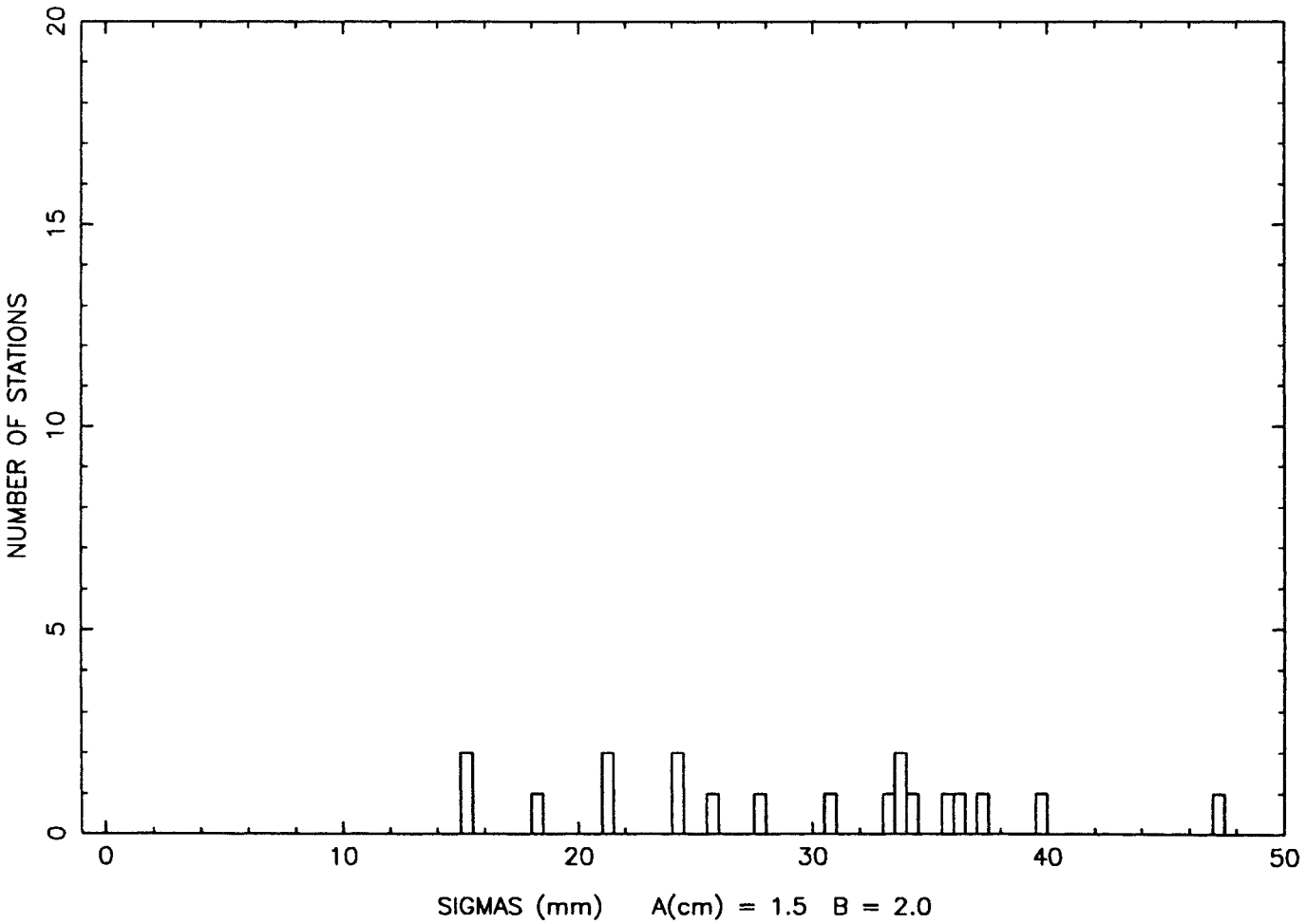
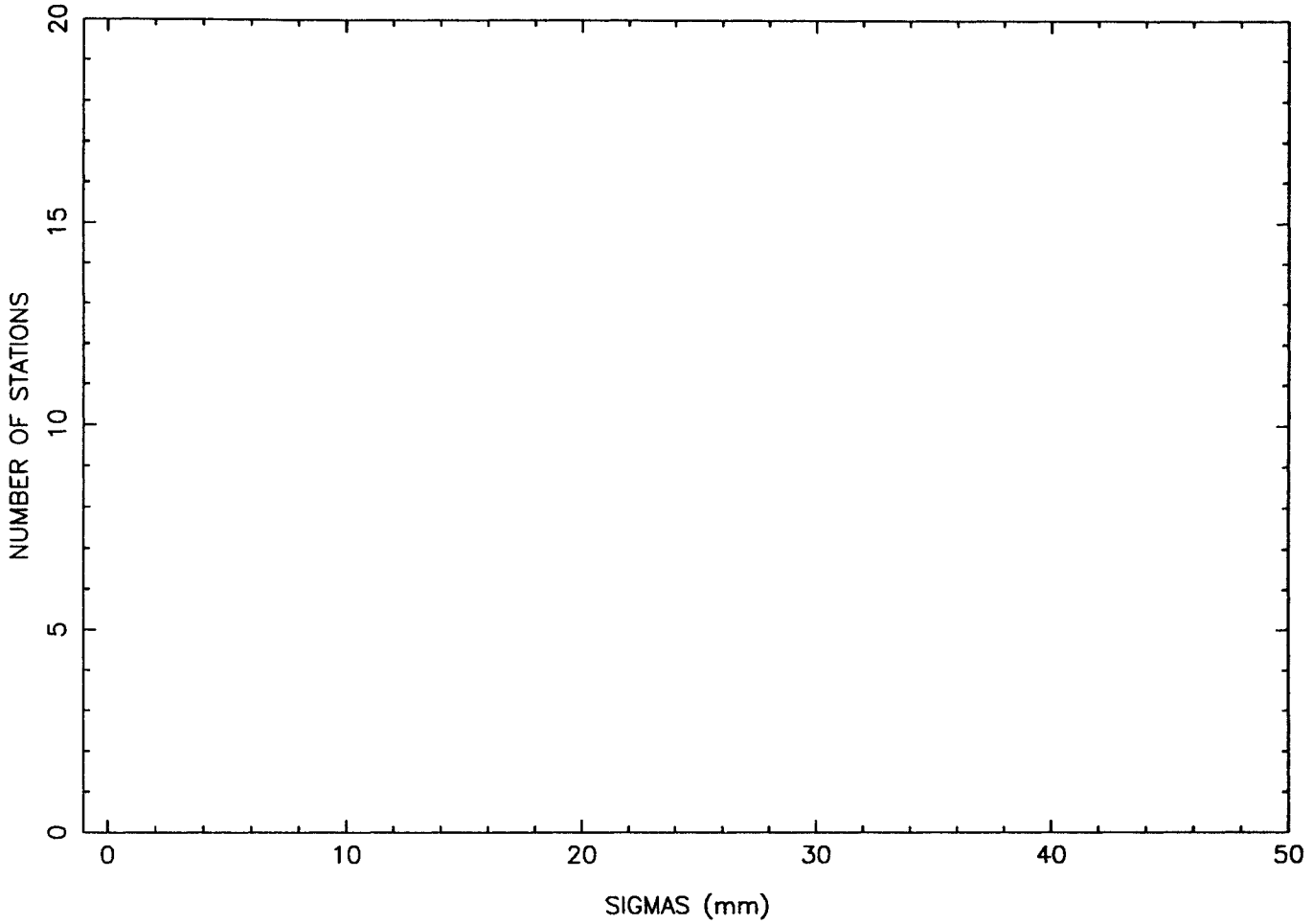


FIGURE 13: SSC(UTXMO)92 M 01



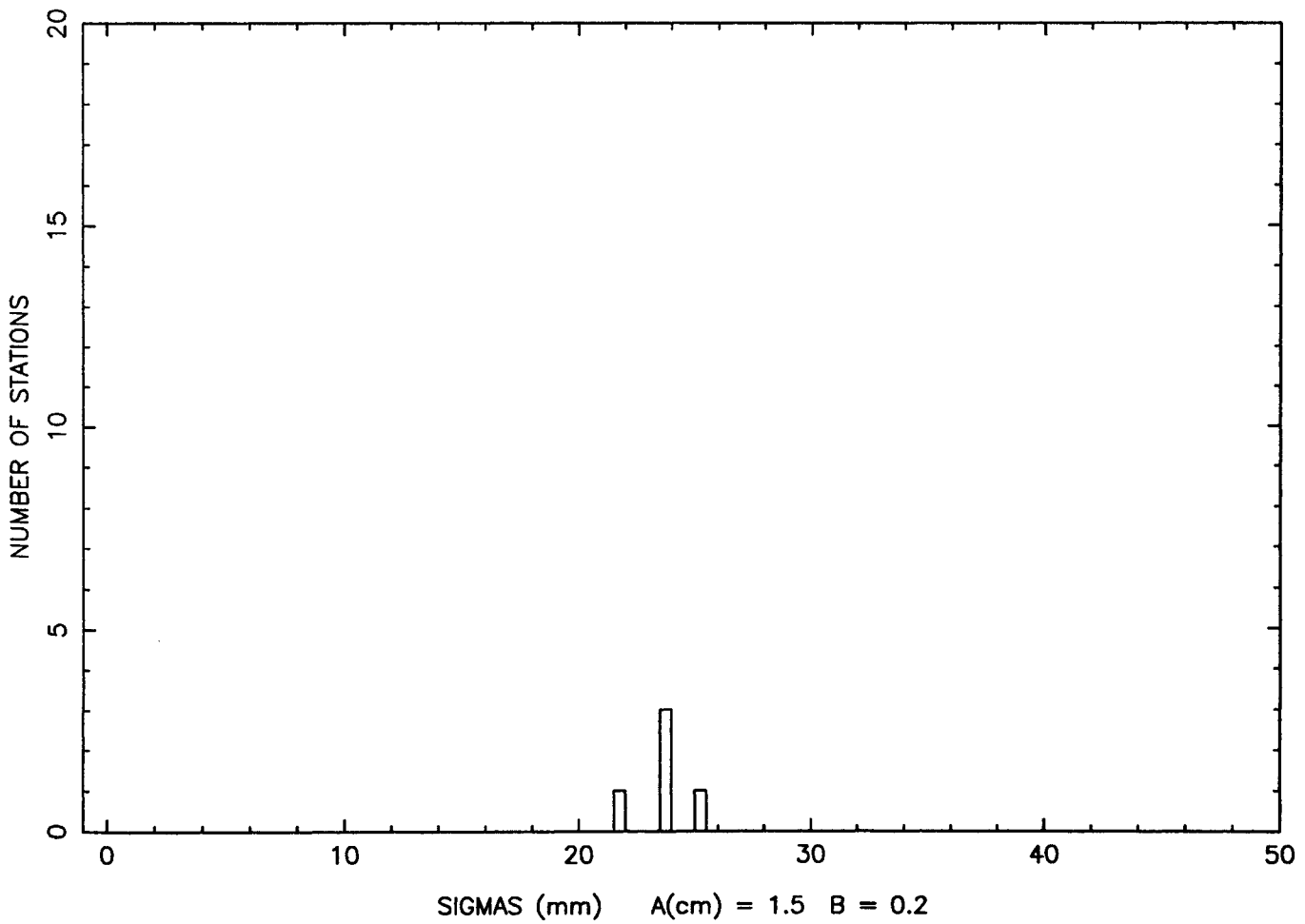
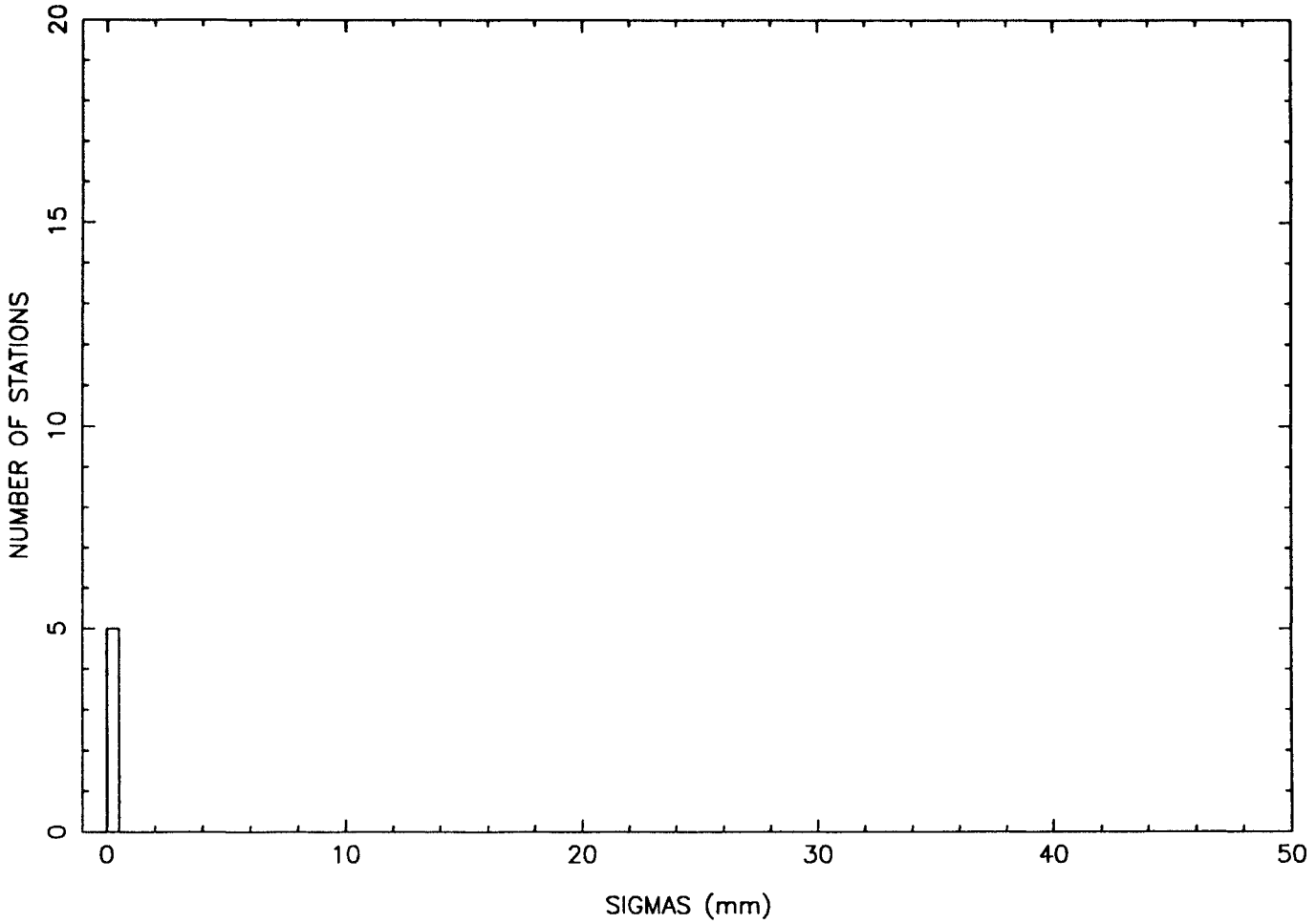


FIGURE 14 : SSC(JPL) 92 M 01



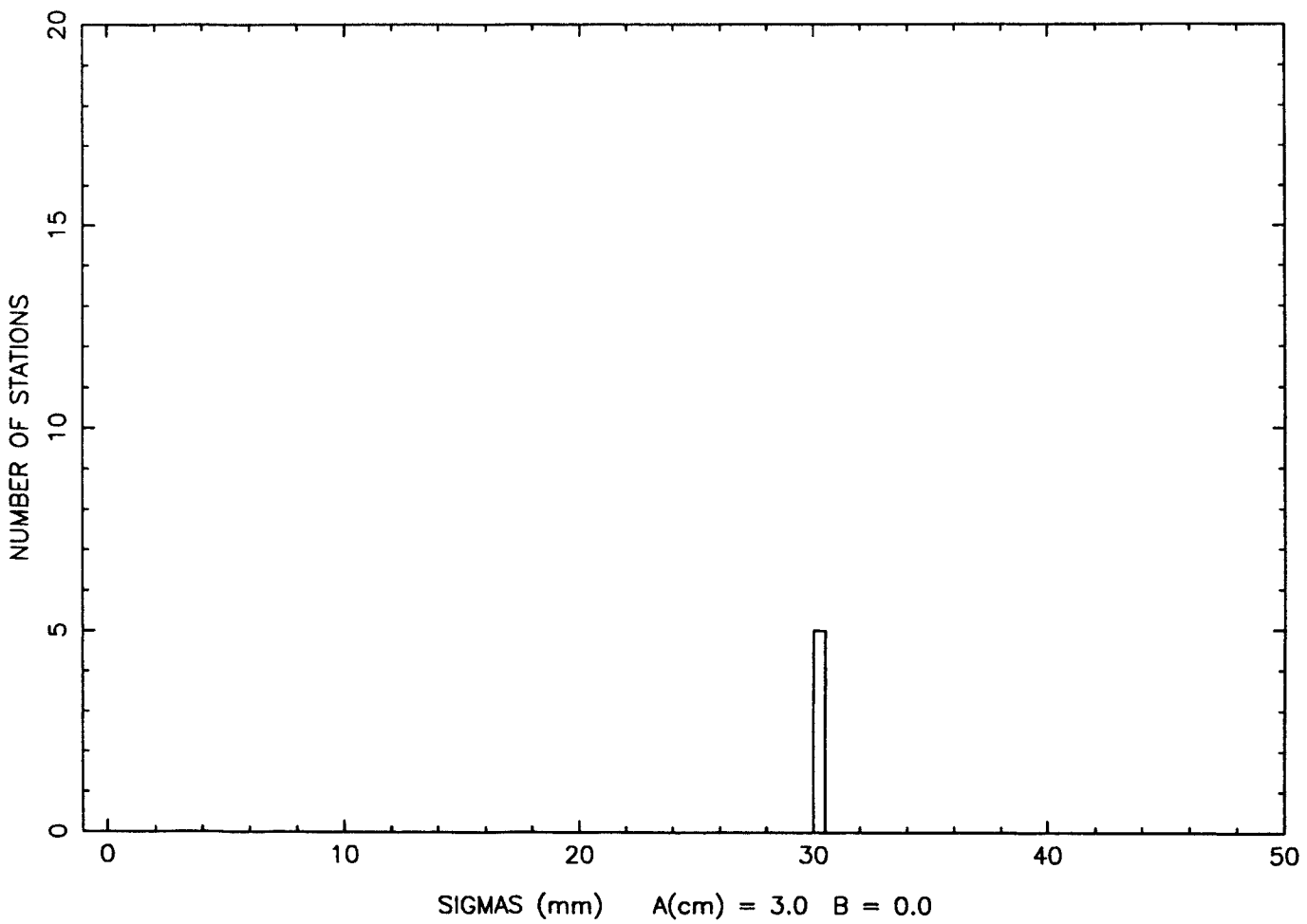
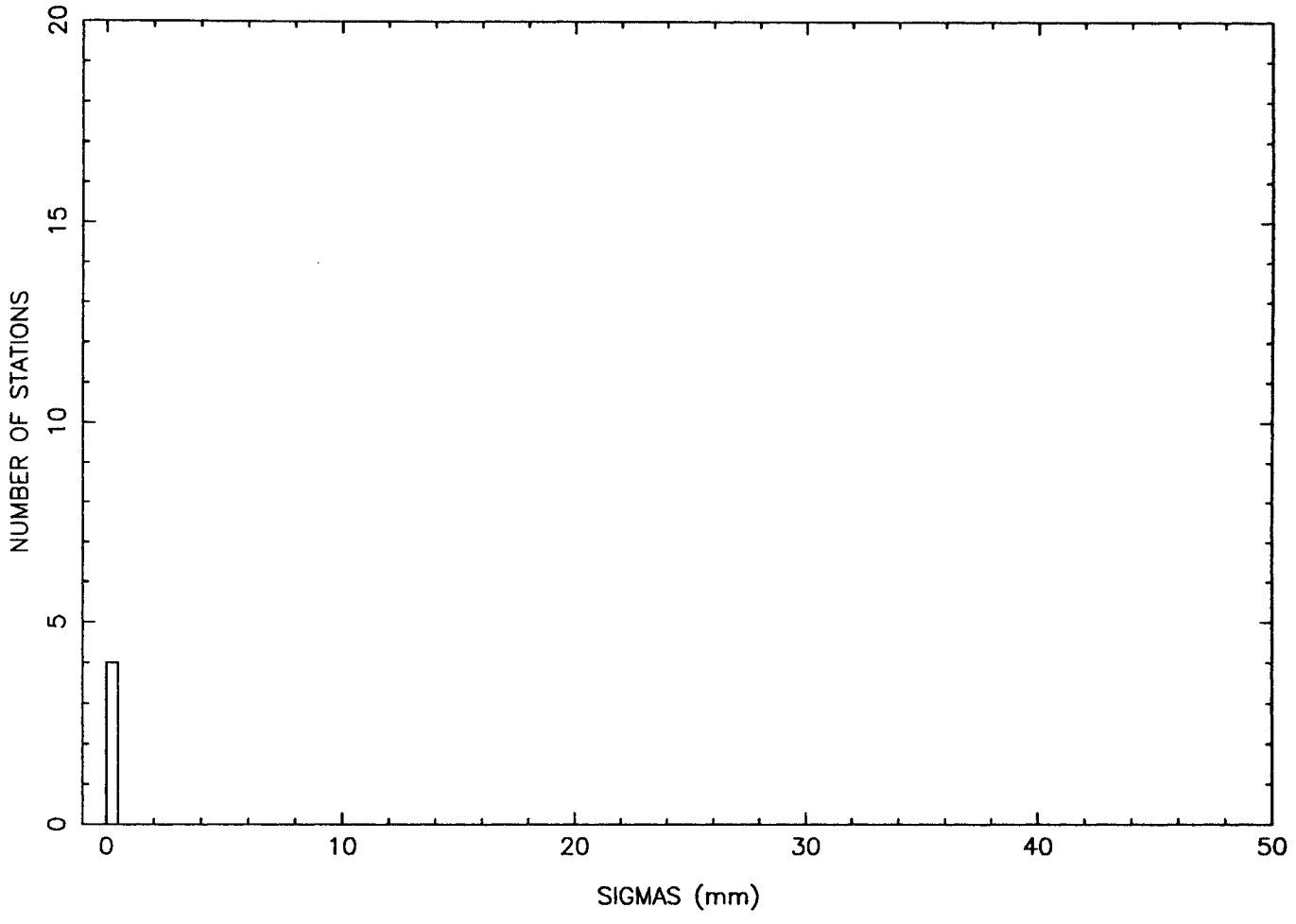


FIGURE 15 : SSC(SO) 92 M 01



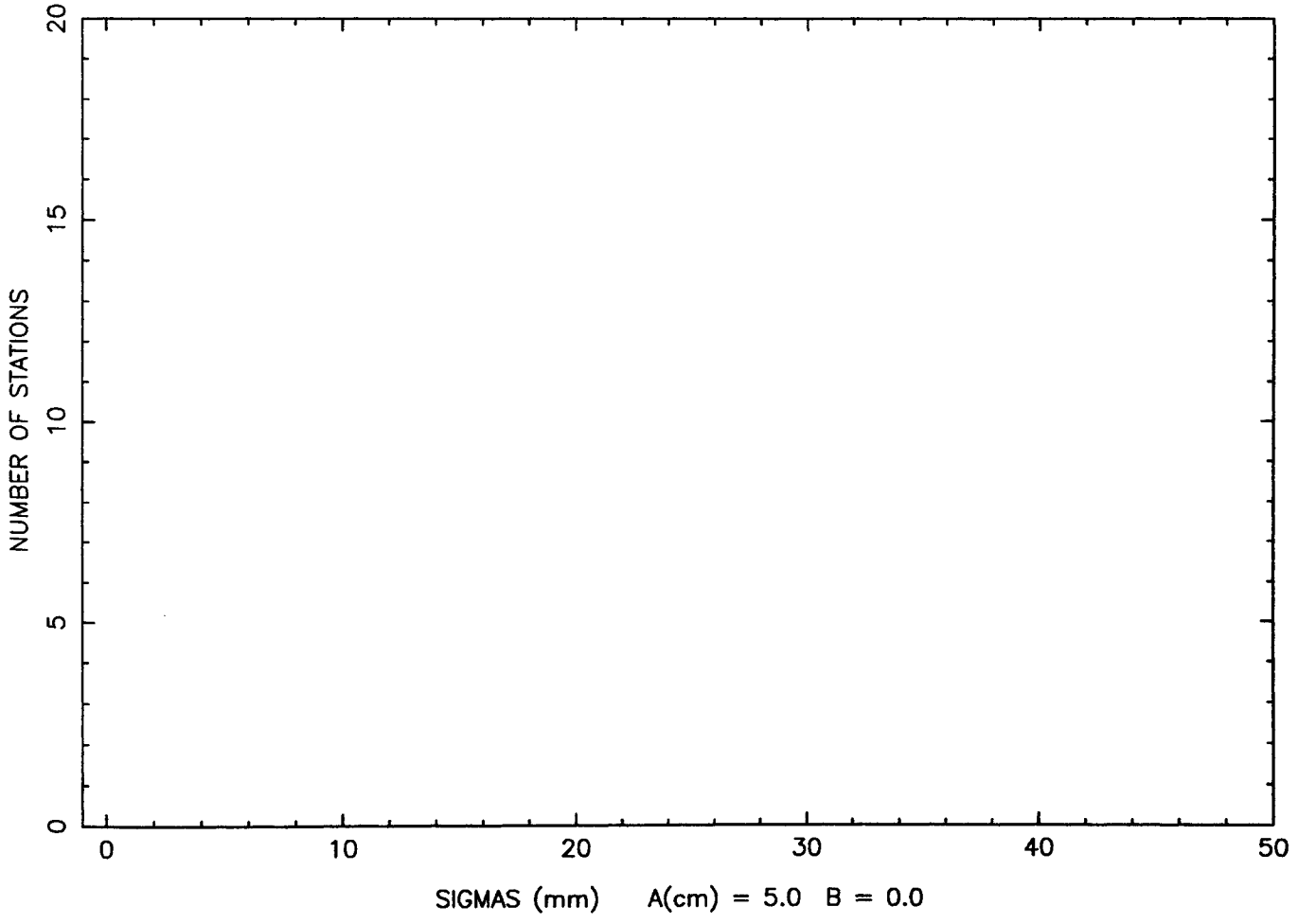


FIGURE 16: SSC(JPL) 91 P 01