

TITOLO A computer program for numerical calculations of
undulator spectra.

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The FORTRAN code URTEO, written by A. Luccio (ref. 1) for CDC computers, has been adapted to the VAX/11-780 machine and considerably modified to perform various calculations of radiation spectra from a plane undulator. It uses the 'far field approximation', while assuming an ideal sinusoidal trajectory, and performs a numerical integration of the Lienard-Wiechert potentials at ~~for~~ a given energy of the emitted photon. In this paper ~~we~~ I give a full description of how to use this program and to get graphic output from it.

This modified version of URTEO requires an input file (filetype on VAX machines is .DAT) and produces 2 output files (type .LST and .OUT). The former is a list of ^{the} input parameters and ~~of~~ the most relevant computed results, the latter can be used as an input data file for fast histogramming or more sophisticated graphic displays which can be obtained from the VERSATEC plotter or Tektronix storage tube.

A typical set of input parameters is shown in Tab. 1 below. All data are in free format. In the following I give a short description of each parameter:

65,0,036,1,4142
0.2935E4,2.2E-7,8.72,8.0E-9,3.34
.15,1.0,0.010,1
0.0,-1.60,0.100,17,1
0.,0.0,0.050,1,1

Tab. I

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1st line : $N0, LA0, K$ $N0$ = number of periods of the undulator $LA0$ = period length (m.) K = rms value of K according to $K = .93 B_0(T) \cdot \lambda_0(\text{um.}) / \sqrt{2}$ 2nd line : $GA, EPSX, BETX, EPSY, BETY$ $GA = \gamma$ $EPSX$ = radial emittance $BETX$ = radial β $EPSY$ = vertical emittance $BETY$ = vertical β 3rd line : $DT, OMRS, DOMR, NOMR$ DT = integration step $OMRS$ = starting photon energy, expressed as ω/ω_c $DOMR$ = step in photon energy $NOMR$ = number of required energies4th line : $PHR, THR, DANR, NANR, FLAG$ PHR = observation angle of emitted photon in the xz plane (rad * γ) THR = observation angle of emitted photon in the yz plane (rad * γ)
(z is along the electron beam) $DANR$ = step in observation angle (rad * γ) $NANR$ = number of required angles $FLAG$ = selects various options for URTEO: $FLAG = 0/1$ means angular distribution at fixed θ_R/φ_R

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FLAG = 2 means flux (both total and through a pinhole)
and on-axis brightness. (PHR = 0. = THR)

FLAG = 3 means brightness at given θ_R, φ_R (THR, PHR)

5th line : PHB1, THB1, DANB, N1, N2

PHB1, THB1 = definition of the pinhole in $(\varphi_R, \theta_R) * \gamma$

DANB = step in the beam angles (rad * γ)

N1, N2 = not used

With respect to the original version the program now is able to take into account both the electron beam divergence and 2 dimensional pinhole simultaneously. This result is achieved by performing a 2 dimensional integration only, in order to save a considerable amount of CPU-Time. This is on the average about 9 minutes per wavelength and so much is required for taking into account the beam angular spread carefully. In case of angular distribution the CPU-Time can be estimated roughly from the following : $t(\text{sec.}) = \text{NANR} * 3. * \gamma * \sigma' / \text{DANB} / \text{DT} / 3.86$. For the case reported in Table I, it is 8'49".

As an example, the parameters of Table I have been used to produce some nice plots on the VERSATEC printer/plotter. I choose the undulator axis to be the z axis of the Cartesian Coordinate system and the electron orbit to lie in the xz plane. I introduce the angles θ_R, φ_R which are formed by the z axis and the projections of the unit vector in the radiation direction on the yz plane and the xz plane, respectively. The angles are in unit of rad * γ and the output power is in photons/amp / (mrad)² / 1% BW / sec.

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Figs. 1-4 show the angular distributions versus θ_R at $\lambda = \lambda_c = 62.7 \text{ \AA}$ and $\lambda = \lambda_c / 0.9 = 69.6 \text{ \AA}$ in case of 'flat' beam. Figs. 5-8 have been obtained with $\epsilon_y = .8 \times 10^{-8} \text{ rad.m}$ and $\beta_y = 3.34 \text{ m}$, which are typical values of the vertical ~~values~~ emittance and β for ADONE at 1500 MeV.

Figs. 9-12 show the angular distribution versus φ_R for the two λ 's mentioned above, without beam emittance.

With reference to the half-logarithmic plot of fig 2, the contribution of higher harmonics at fixed angles, although small, is shown clearly.

The relation $\lambda = \frac{1}{i} \frac{\lambda_0}{2\gamma^2} \{1 + K^2 + \gamma^2 \theta^2\}$, with $\lambda = \lambda_c$, gives:

$\gamma \theta_2 = 1.73$ for $i=2$, $\gamma \theta = 2.45$ for $i=3$, $\gamma \theta = 3.0$ for $i=4$, which correspond at the narrow peaks in Fig 2.

Figs. 13-14 show the brightness at ($\varphi_R = 0 = \theta_R$) and the flux through a pinhole defined by ~~-2x~~ $-0.2 < \gamma \theta_R, \gamma \varphi_R < +0.2$ versus the photon wavelength. The units are photons/sec/Amp/(mrad)²/0.1% BW for the brightness and photons/sec/Amp/0.1% BW for the flux. Unfortunately the VERSATEC was unavailable when these results were obtained. The undulator and beam parameters are those used by R. Walker (unpublished note) and reported in Table II. The results are in rather good agreement with both theoretical and Walker's calculations.

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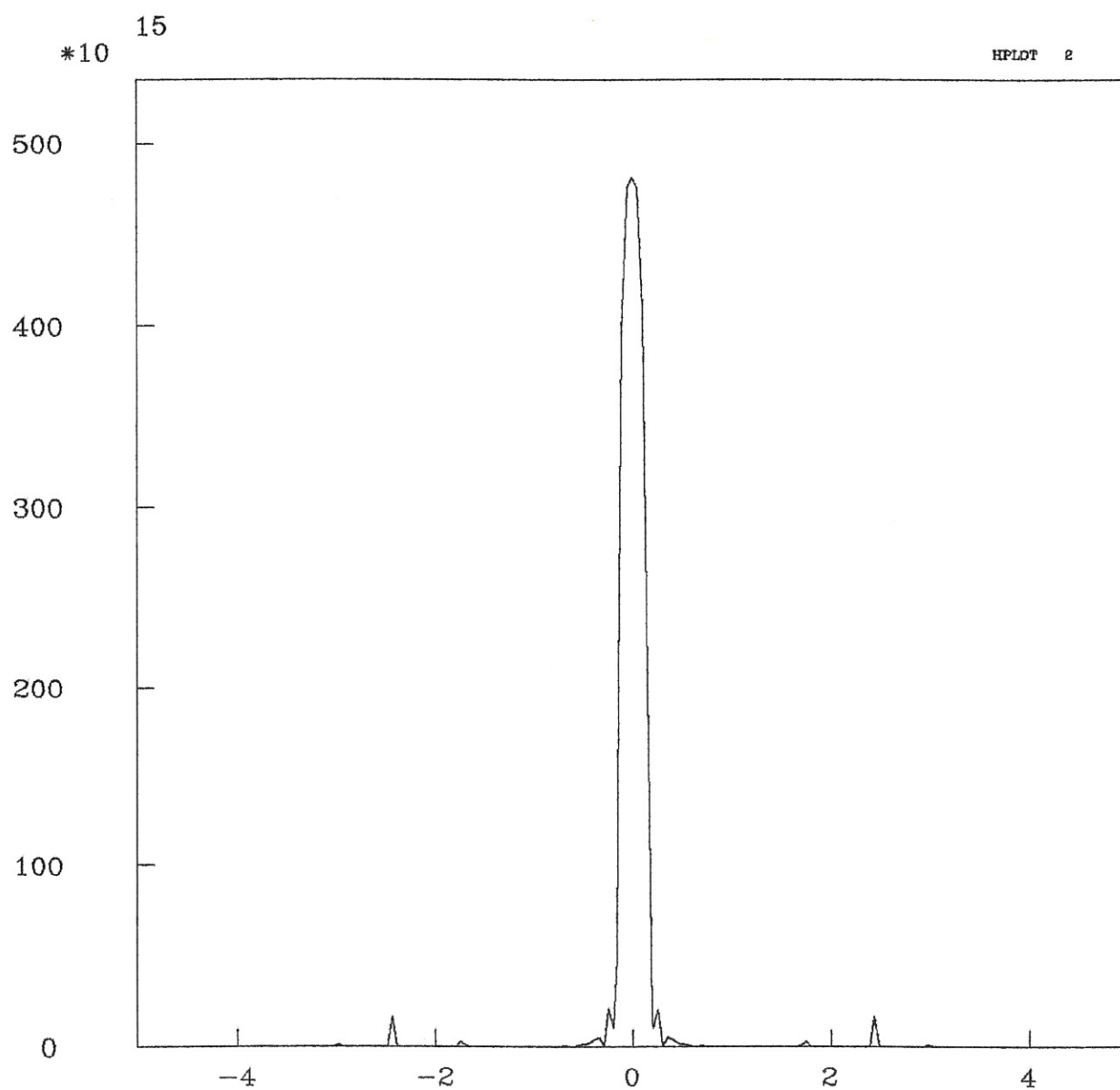
 $100, 0.016, 0.1709$ $0.9785E4, 1.42E-8, 25.67, 0.07E-8, 4.10$ $1.2, .9920, 0.0040, 7$ $0.0, 0., 0.0250, 1, 2$ $-0.20, -0.20, 0.0250, 1, 1$

Table II

References:

1) A. Luccio, ~~Numerical~~ ESRP Int. Report ESRP-IRM-12/84

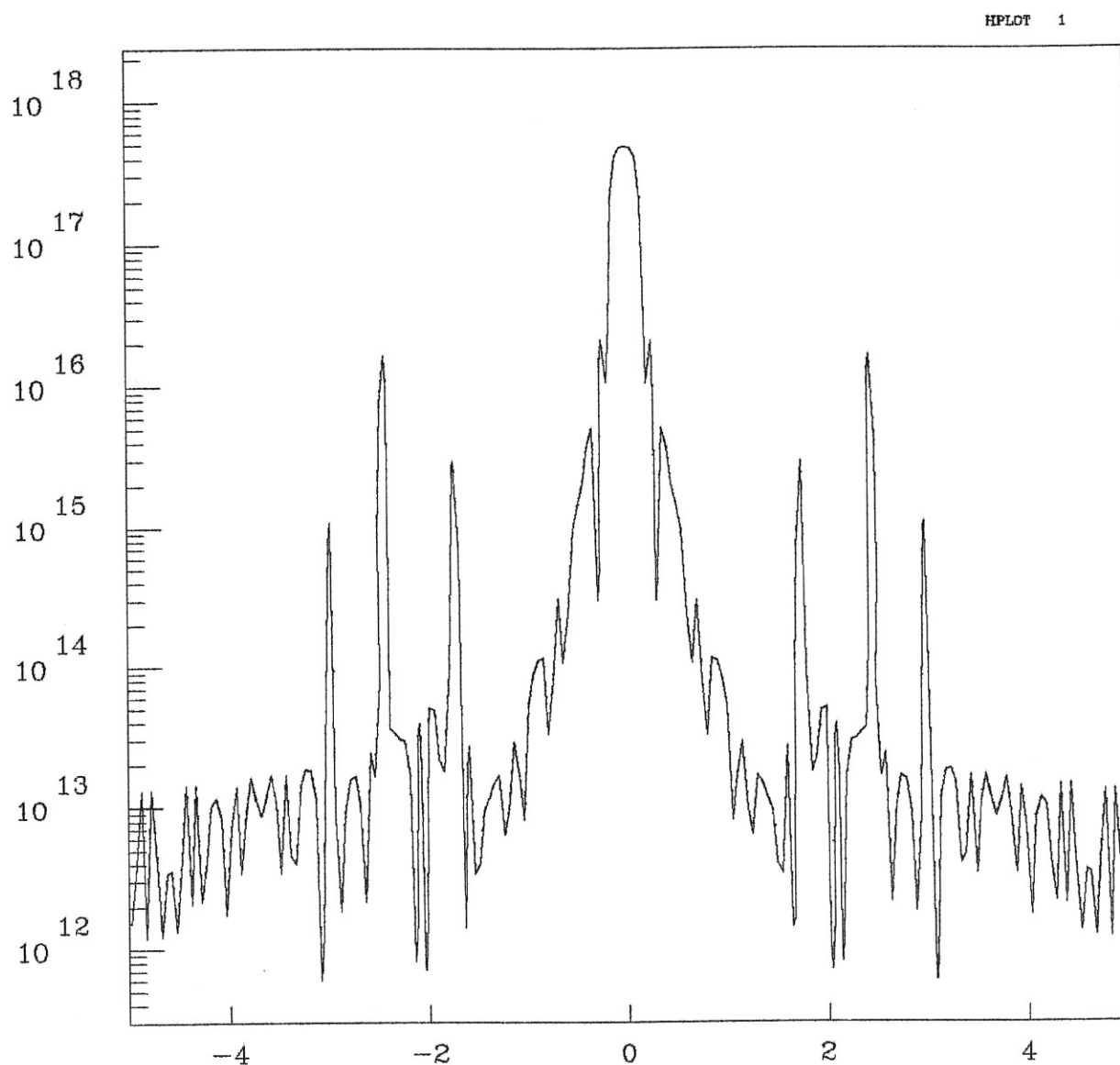
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ANG. DISTR. NO BEAM EMITT.

FIG. 1 $\lambda = \lambda_c$

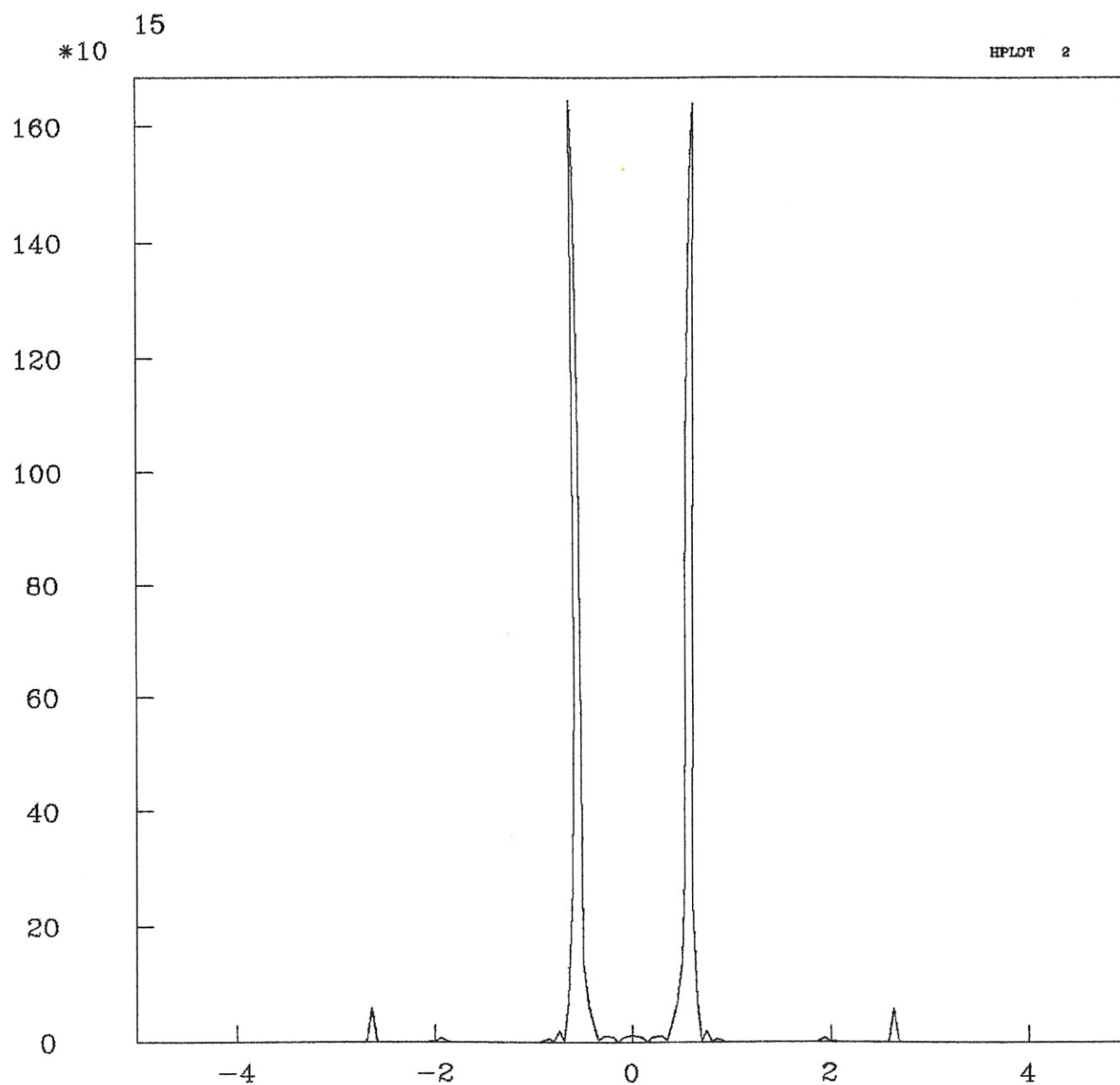
TITOLO



ANG. DISTR. NO BEAM EMITT.

FIG. 2 $\lambda = \lambda_c$

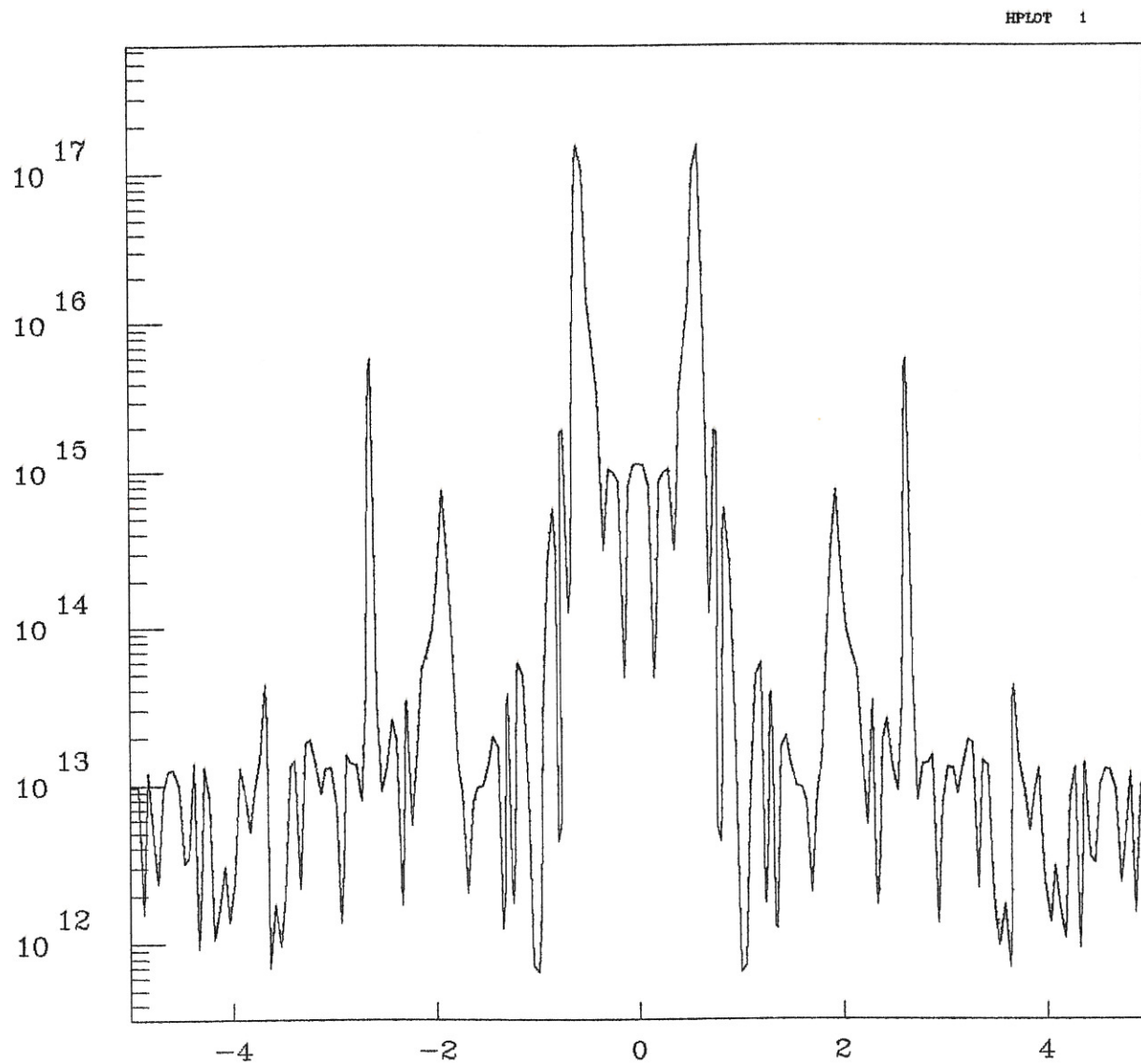
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FIG.3 $\lambda = \lambda_c / 0.9$

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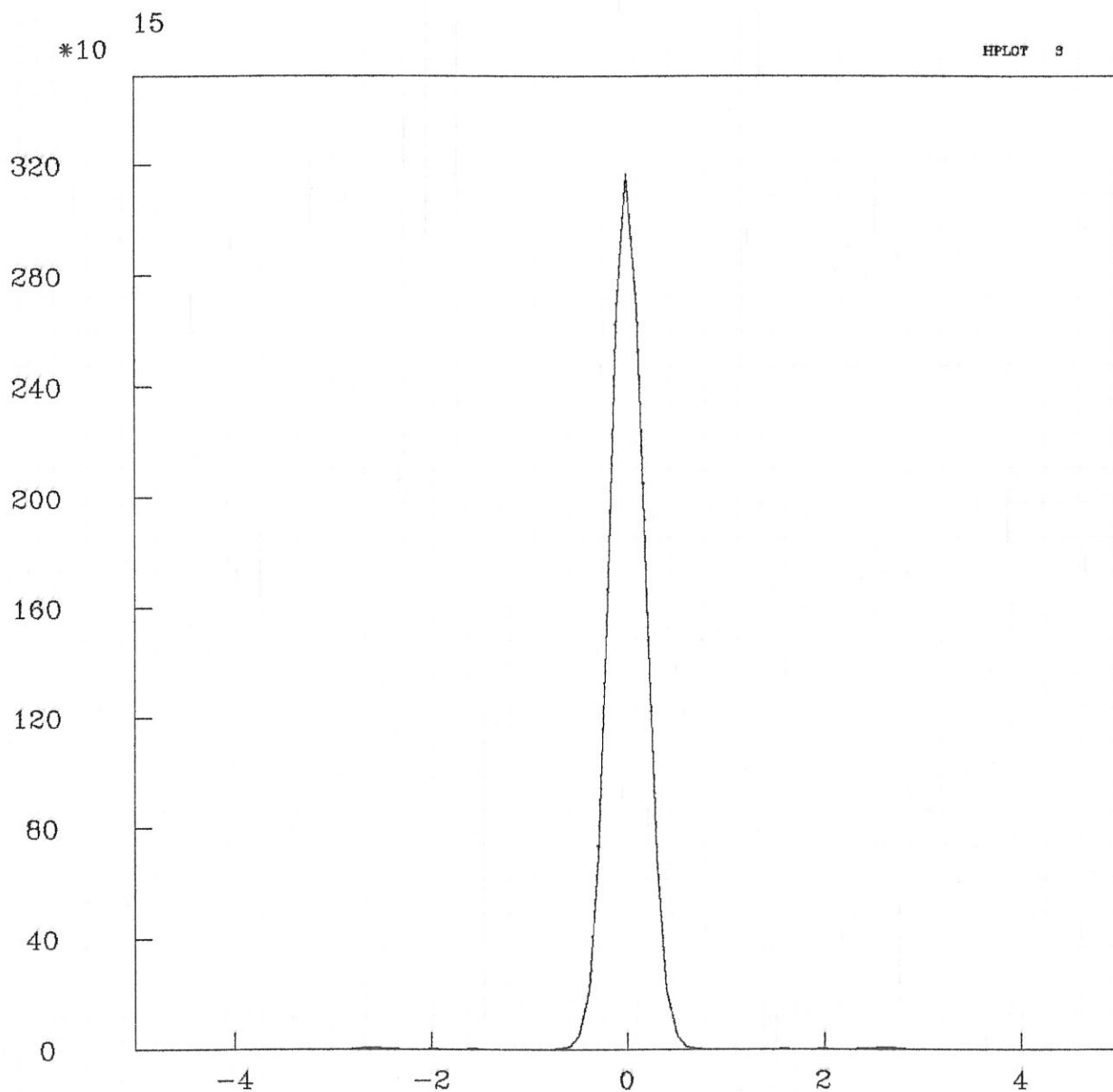


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FIG. 4 $\lambda = \lambda_c / 0.9$

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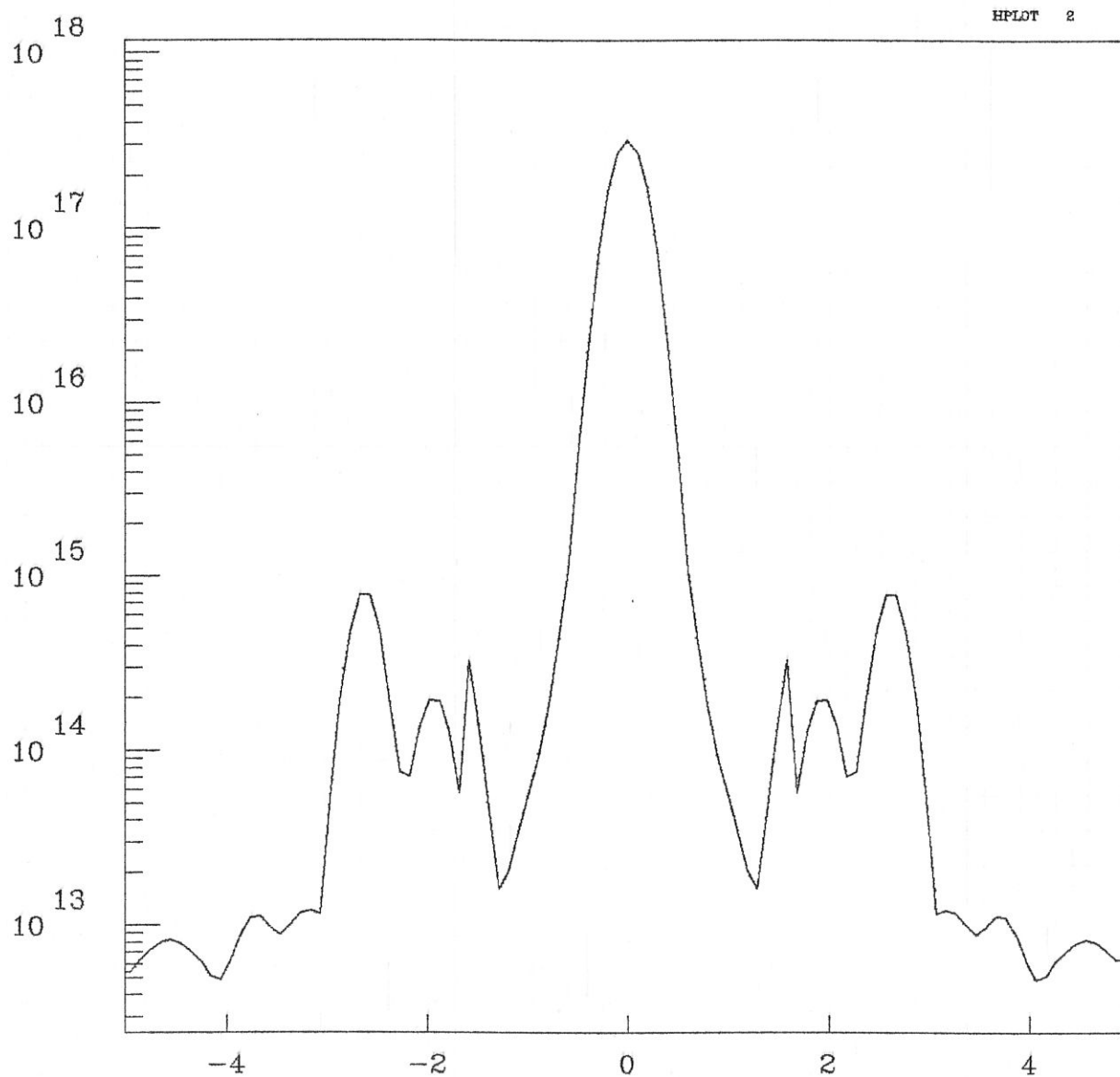
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ANG. DISTR. WITH BEAM EMITT.

FIG. 5 $\lambda = \lambda_c$

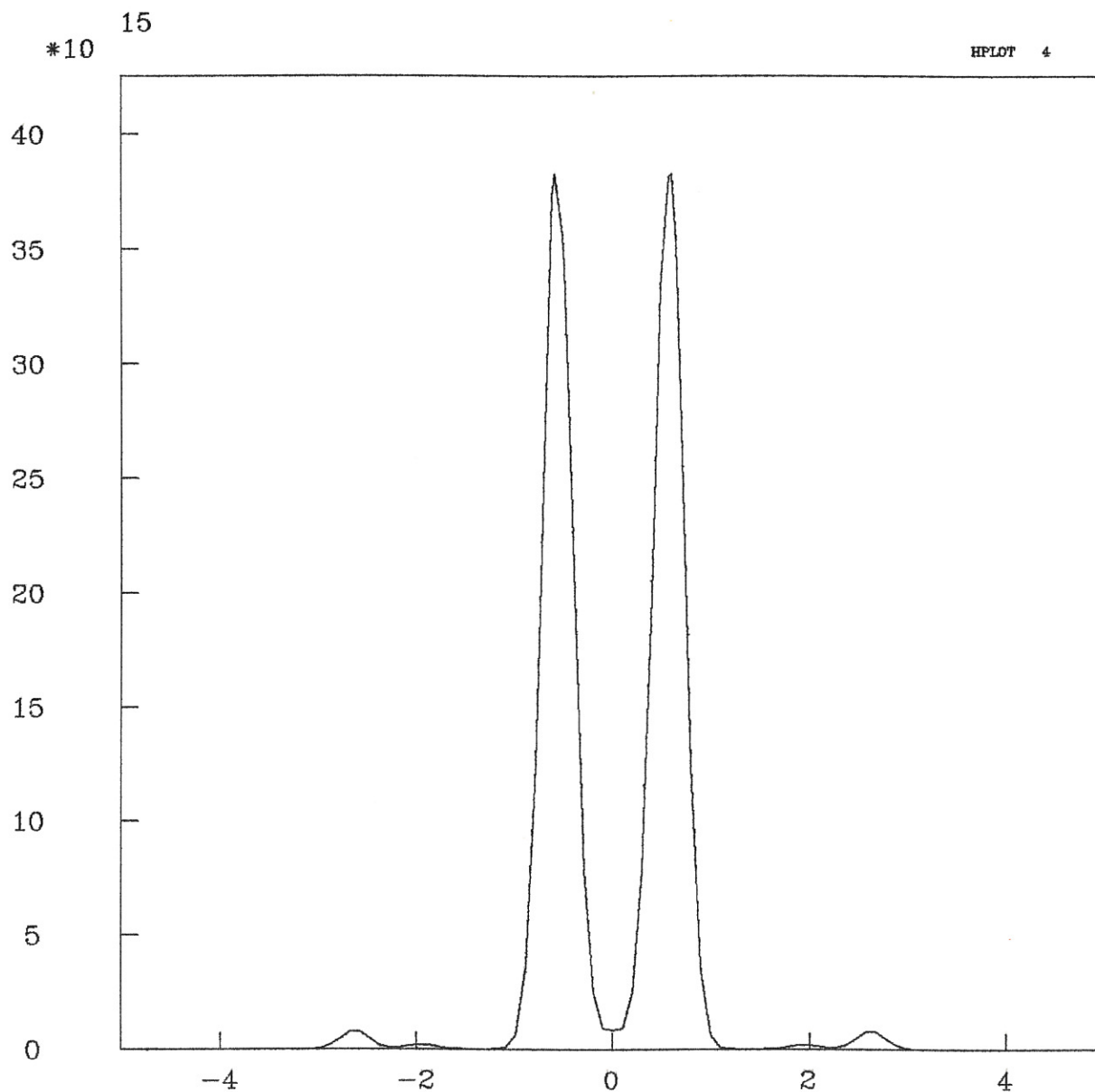
TITOLO



ANG. DISTR. ~~NO~~ BEAM EMITT.
WITH

FIG. 6 $\lambda = \lambda_c$

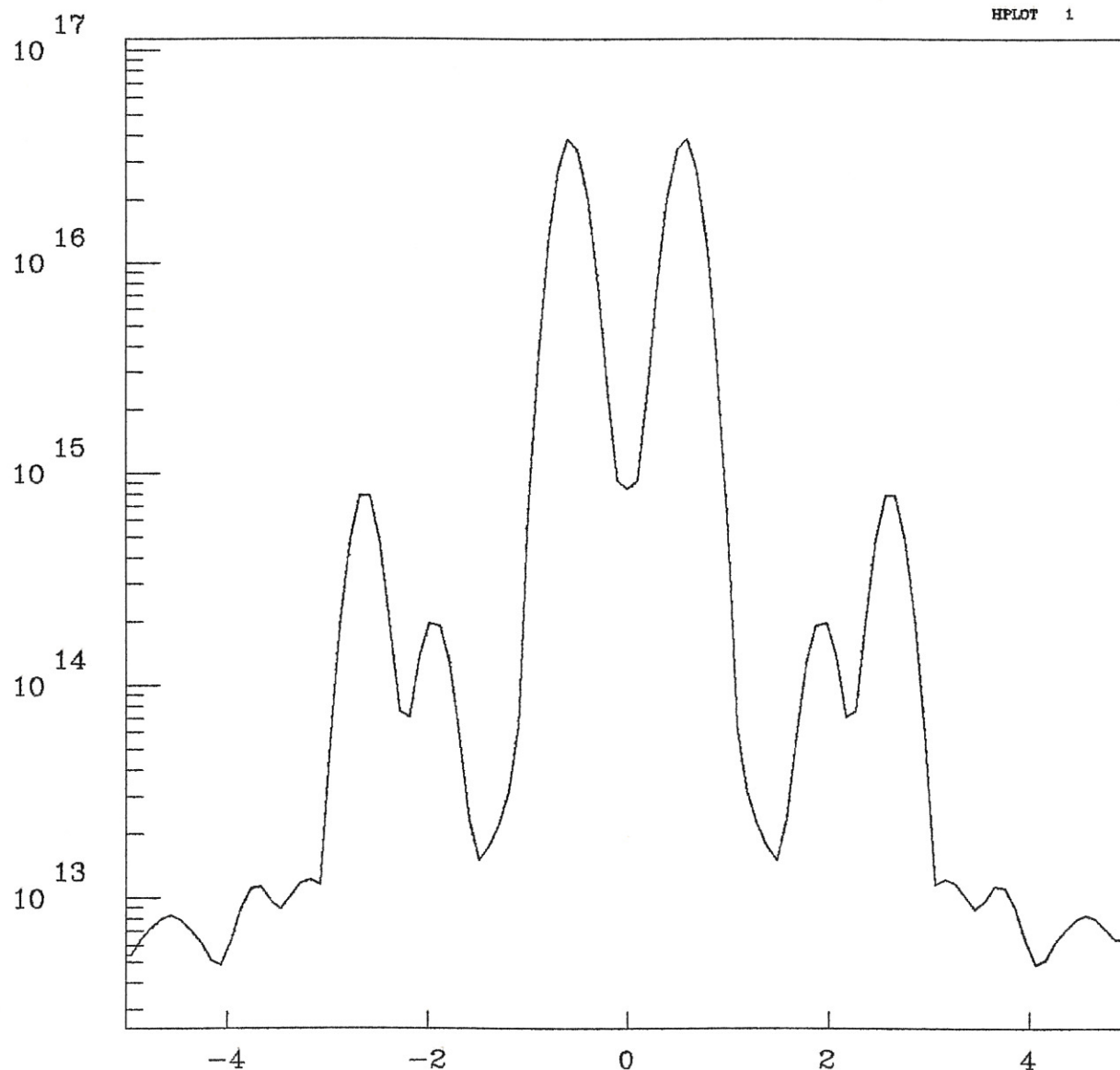
TITOLO



ANG. DISTR. WITH BEAM EMITT.

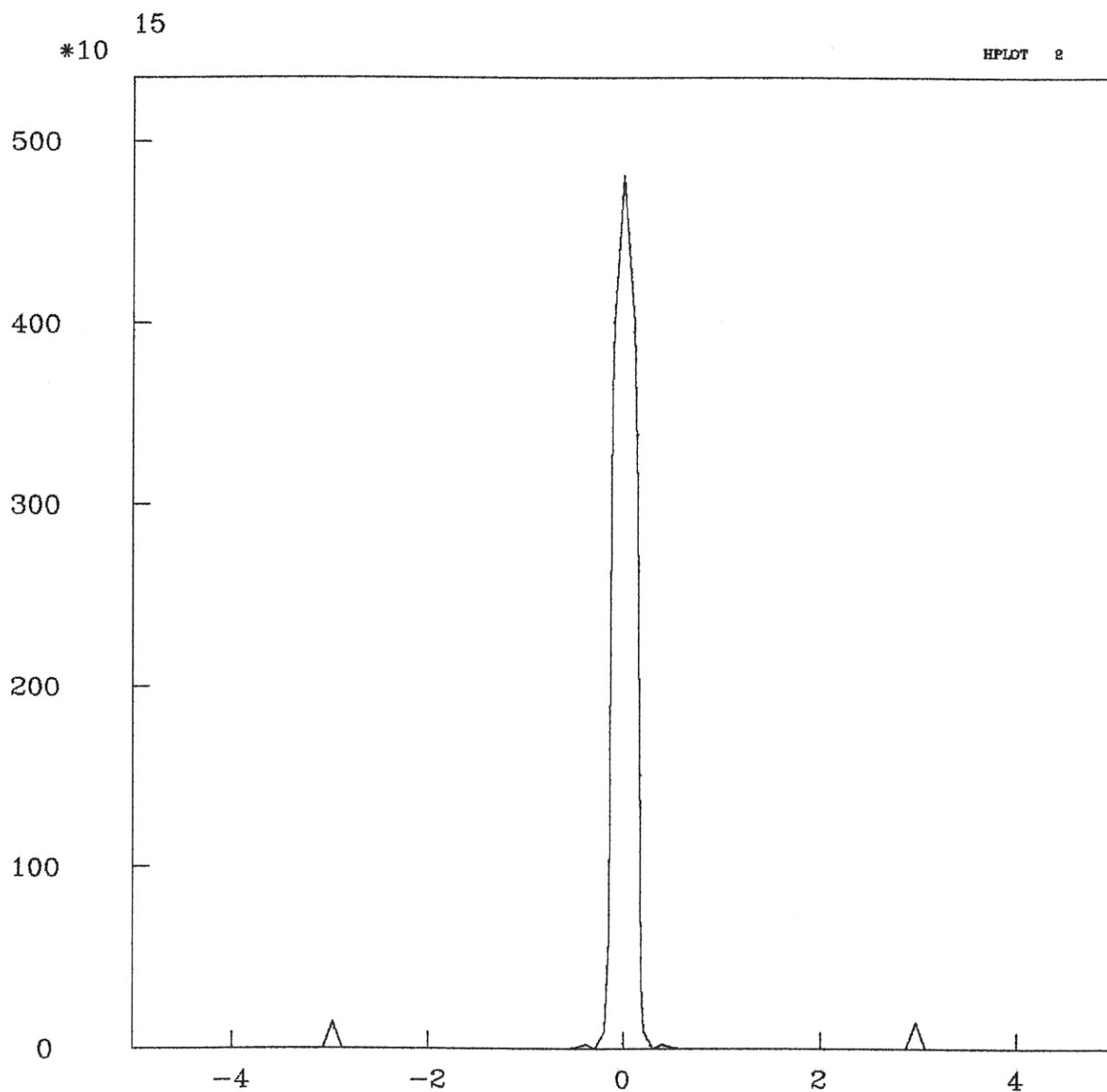
FIG. 7 $\lambda = \lambda_c / 0.9$

TITOLO



ANG. DISTR. WITH BEAM EMITT.

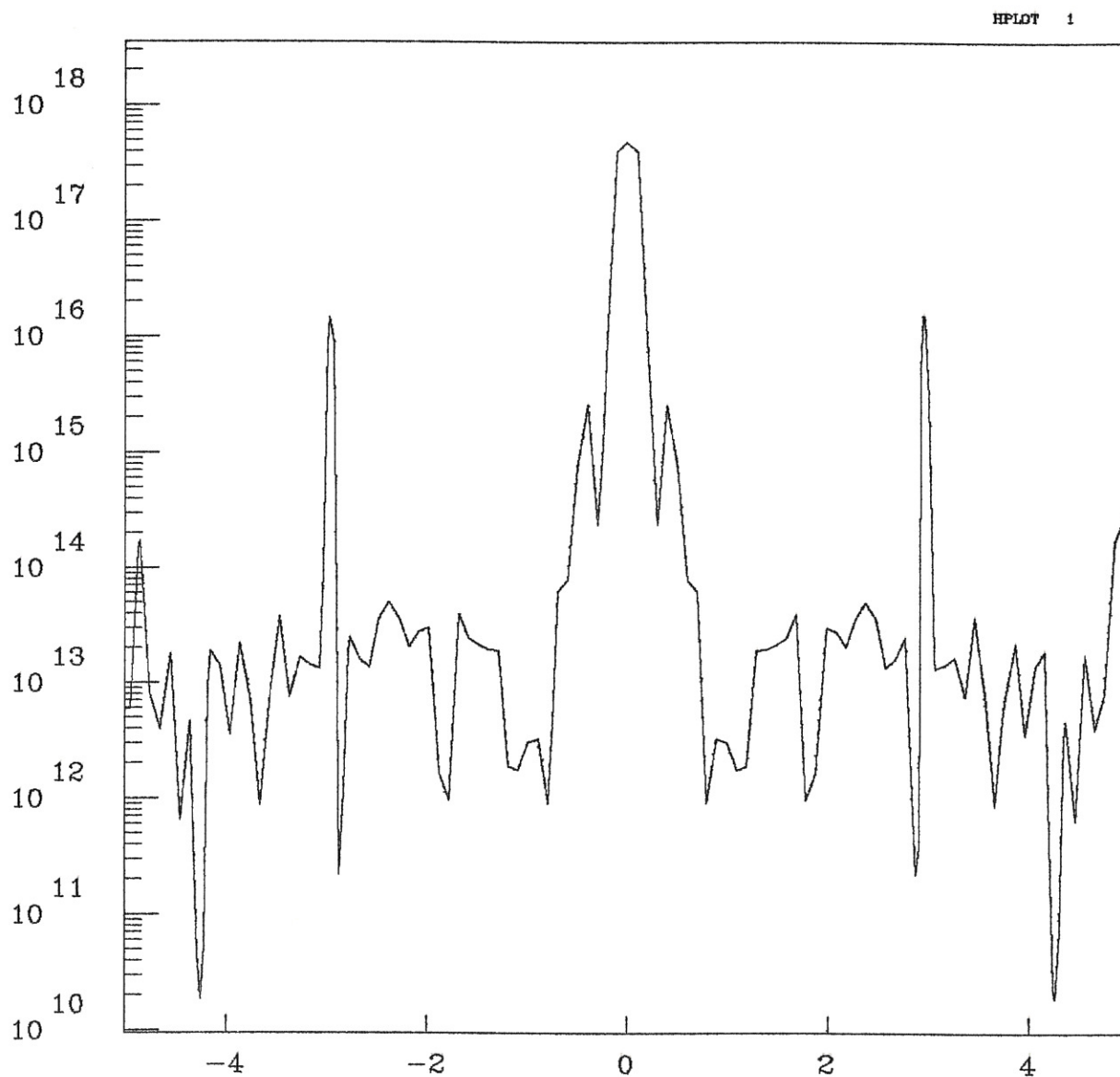
TITOLO



ANG. DISTR. NO BEAM EMITT.

FIG. 9 $\lambda = \lambda_c$

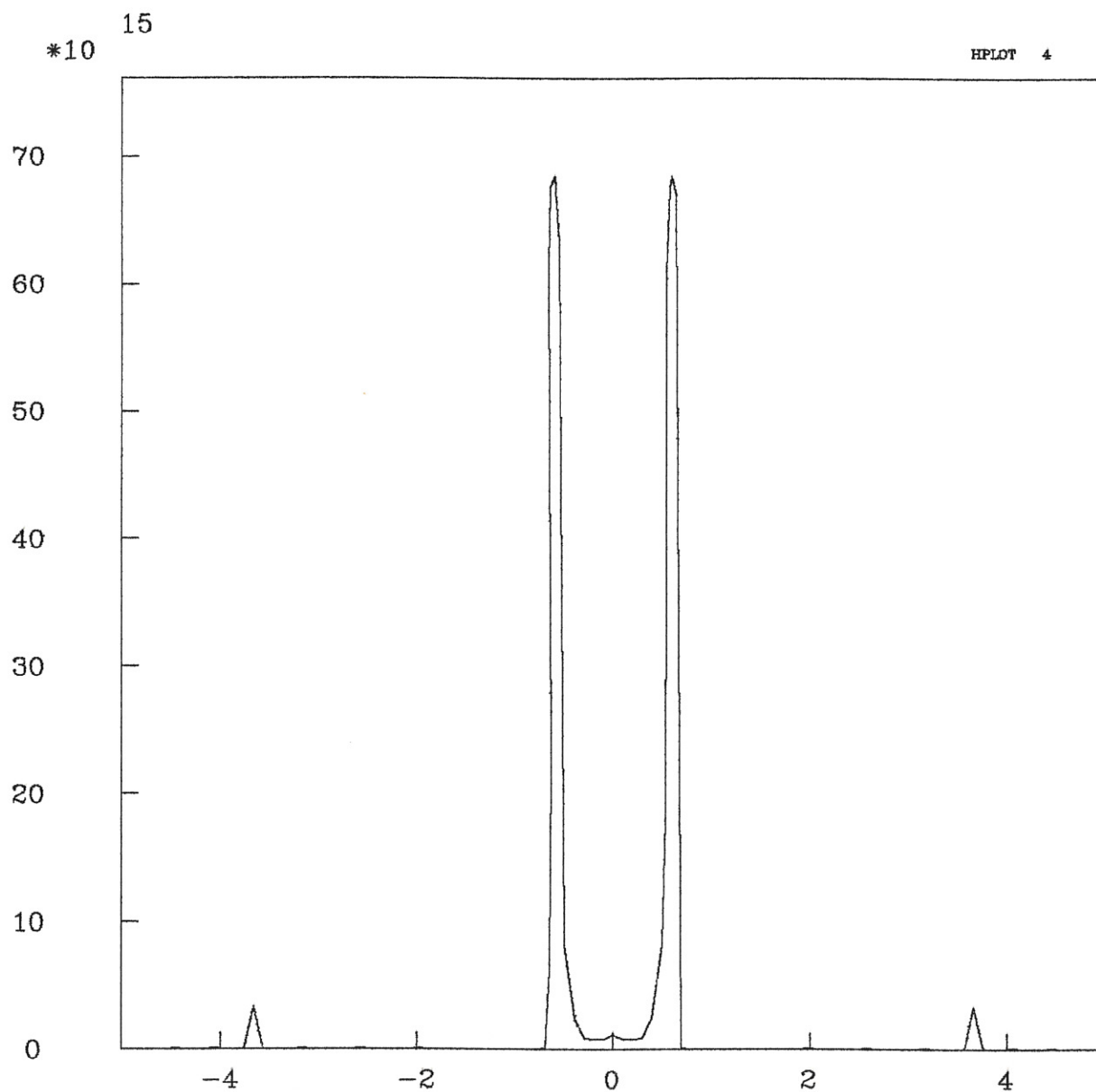
TITOLO



ANG. DISTR. NO BEAM EMITT.

FIG. 10 $\lambda = \lambda_c$

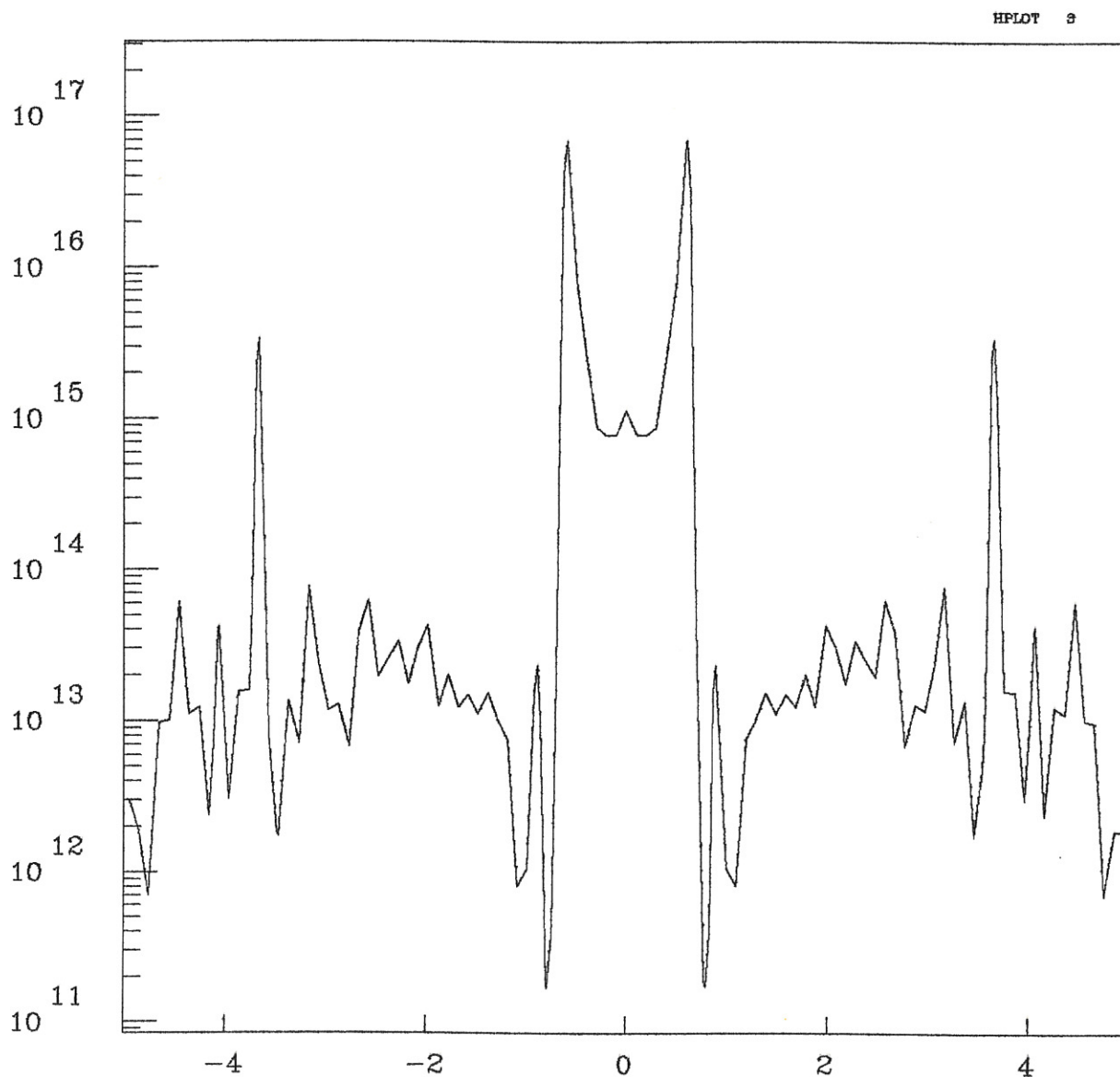
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ANG. DISTR. NO BEAM EMITT.

FIG. 11 $\lambda = \lambda_c / 0.9$

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FIG. 12 $\lambda = \lambda_c / 0.9$

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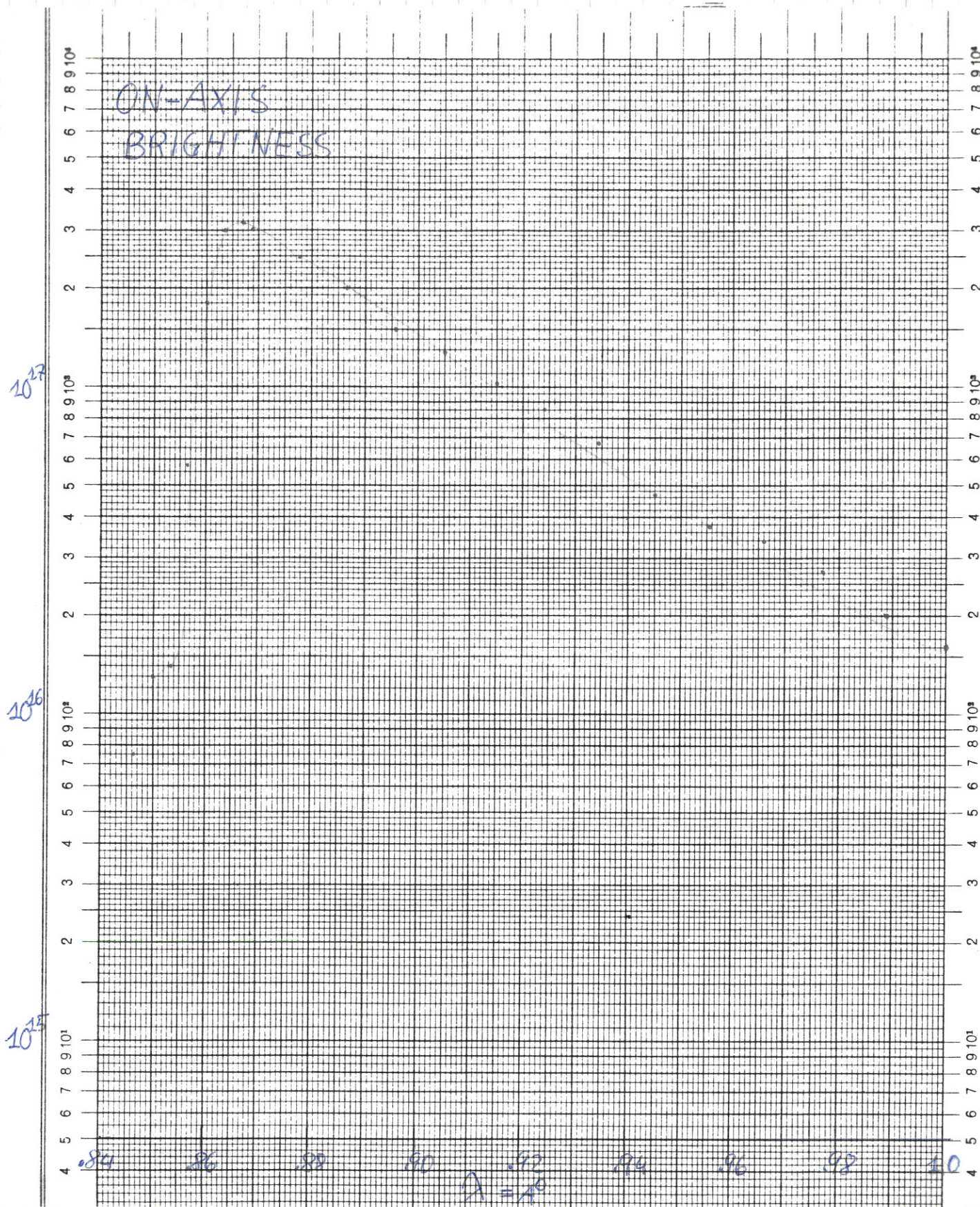


FIG. 13

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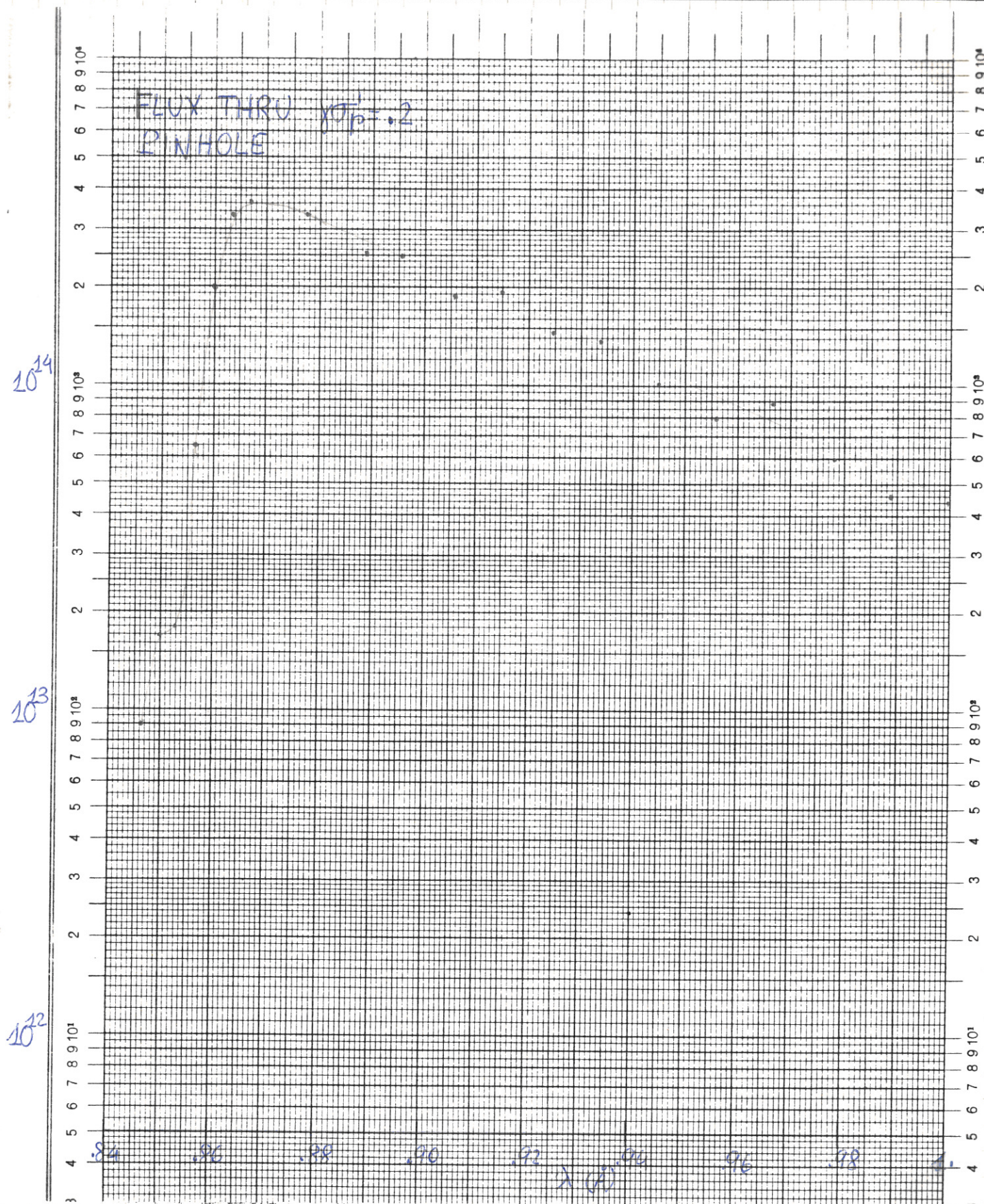


FIG. 14