MULTI-PIXEL MONOLITHIC Ge FLUORESCENCE DETECTOR, PULSE SIGNAL PROCESSING ELECTRONICS, AND REAL TIME DIGITAL DATA ACQUISTION SYSTEM FOR XAFS STUDIES

J.J. Bucher,[1] L. Fabris,[2] P.G. Allen,[3] N.M. Edelstein,[1] K.P. Osborne,[2] D.K. Shuh,[1] N.W. Madden,[2] P.N. Luke,[2] C.P. Cork,[2] R.H. Pehl,[2] D.F. Malone,[2] E.L. Hull,[2] P.S. Datte,[2] J.F. Beche,[2] and V.J. Riot[2]

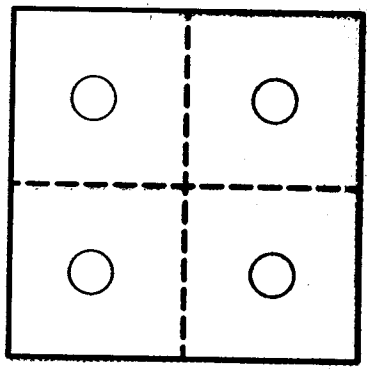
[1] Chemical Sciences Division and G.T. Seaborg Center, LBNL;
[2] Engineering Division, LBNL;
[3] G.T. Seaborg Institute, LLNL

OBJECTIVE

TO BUILD AN ENERGY DISPERSIVE DETECTOR, ASSOCIATED PULSE PROCESSING MODULES AND ACQUISTION ELECTRONICS TO ALLOW EFFECTIVE USE OF BEAM TIME ON OVER SUBSCRIBED SYNCHROTRON XRAY BEAM LINES.

Ge Fluorescence Detector and Electronics Development for Actinide XAFS

- Expertise in nuclear counting to XAFS detectors
- Detector Group at LBNL
- Novel and efficient design
- Simple to use, quiet, and rugged
- 12-element detector



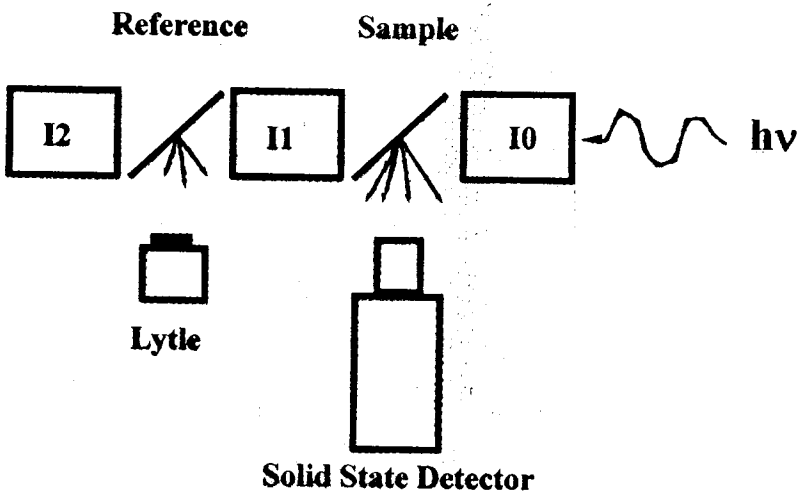
Back Contacts

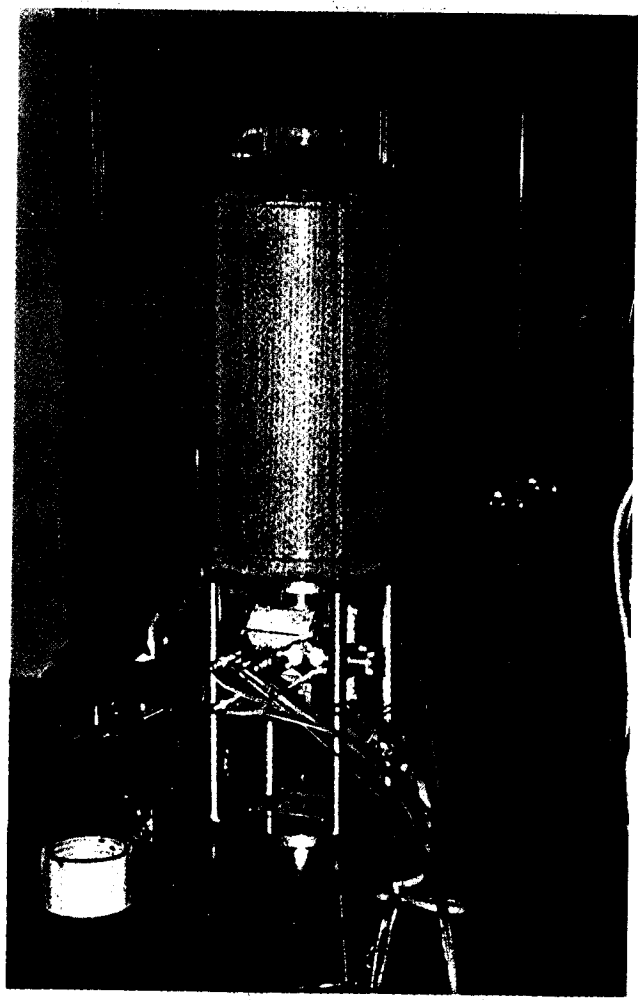
-600 V

Monolithic Ge 2x 2 cm

Electrically divided into four-pixels
No physical separation of pixels
Amorphous Si coated

Experimental





Wowser

Pulse Shaping Amplifier

- Choice of 250ns or 500ns Pulse Peaking Time
- Fast Input Count Rate(ICR) Channel with ~60ns Peaking Time and 50ns Logic Output
- Count Rates up to 1MHz

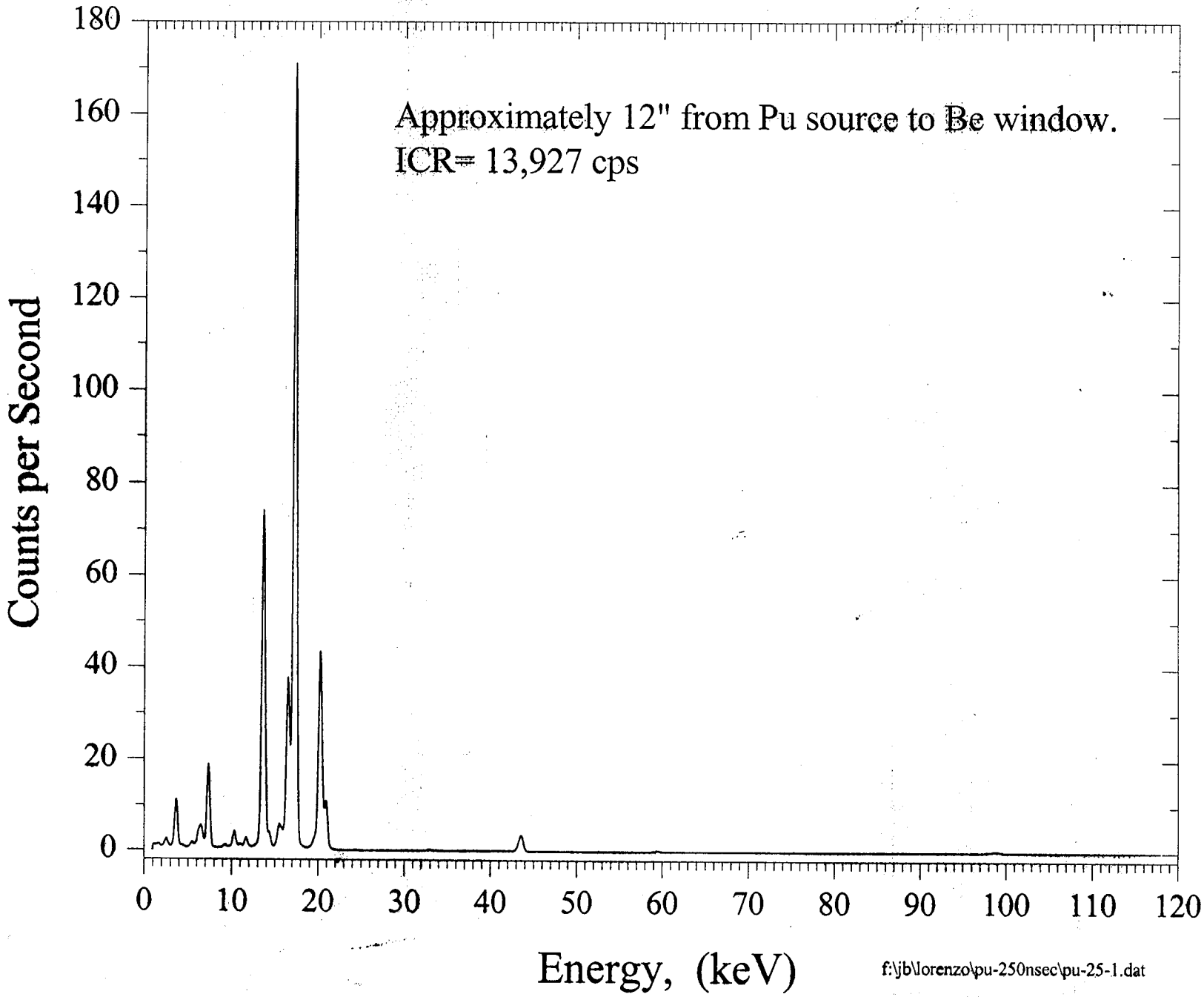
Zero Dead-Time Single Channel Analyzer(SCA)

- Process either 250ns or 500ns Peaking Time Four Pole Pseudo-Gaussian
- "when the input pulse is gone, the SCA is ready to process another event and no dead-time has been introduced."
- A Fast Zero Dead-Time Single Channel Analyzer for Nuclear Spectroscopy Applications

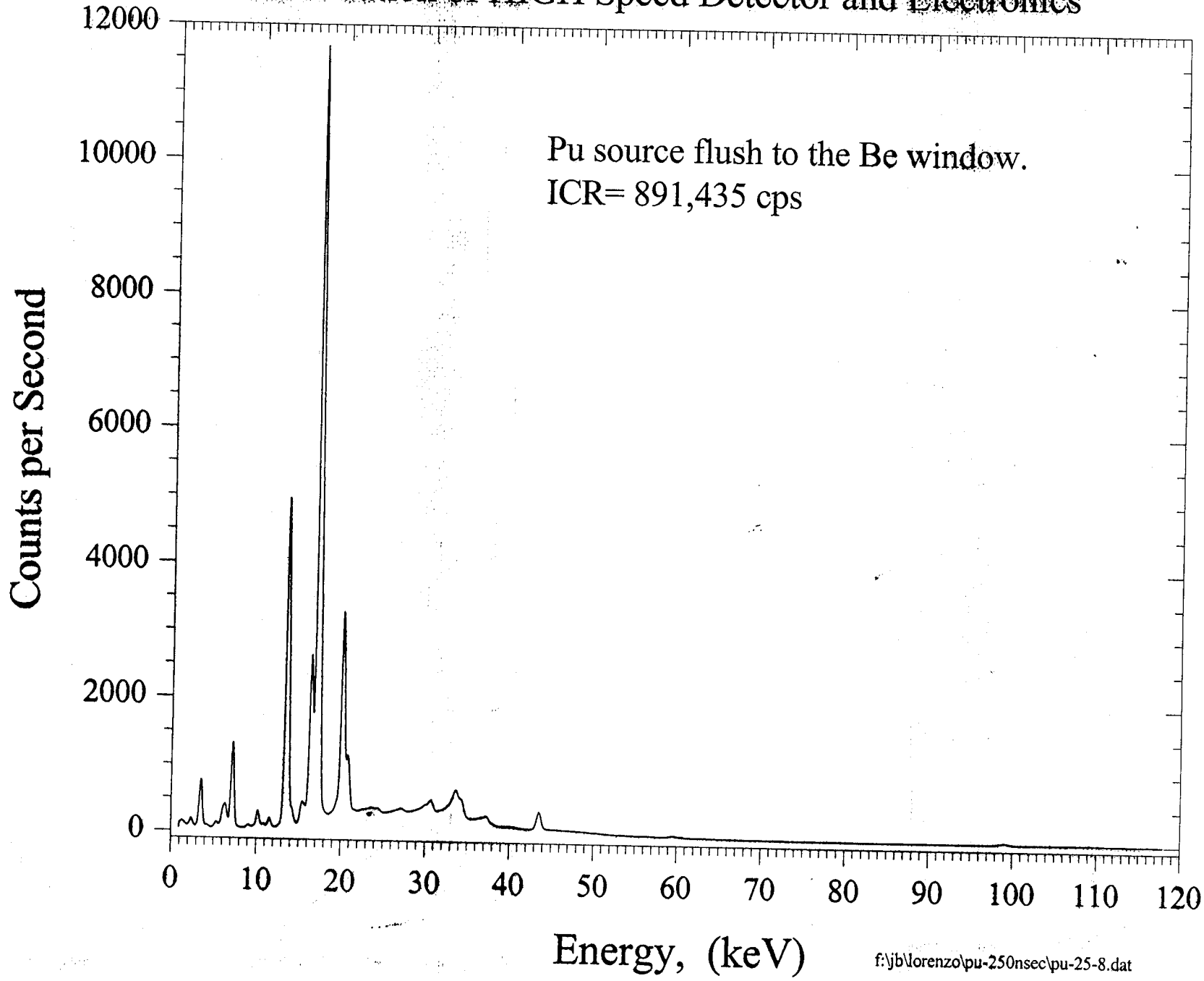
L. Fabris[1], P.G. Allen[2], J. J. Bucher[1], N.M. Edelstein[1], D.A. Landis[1], N.W. Madden[1], D.K. Shuh[1]
[1]Lawrence Berkeley National Laboratory, [2]Lawrence Livermore National Laboratory

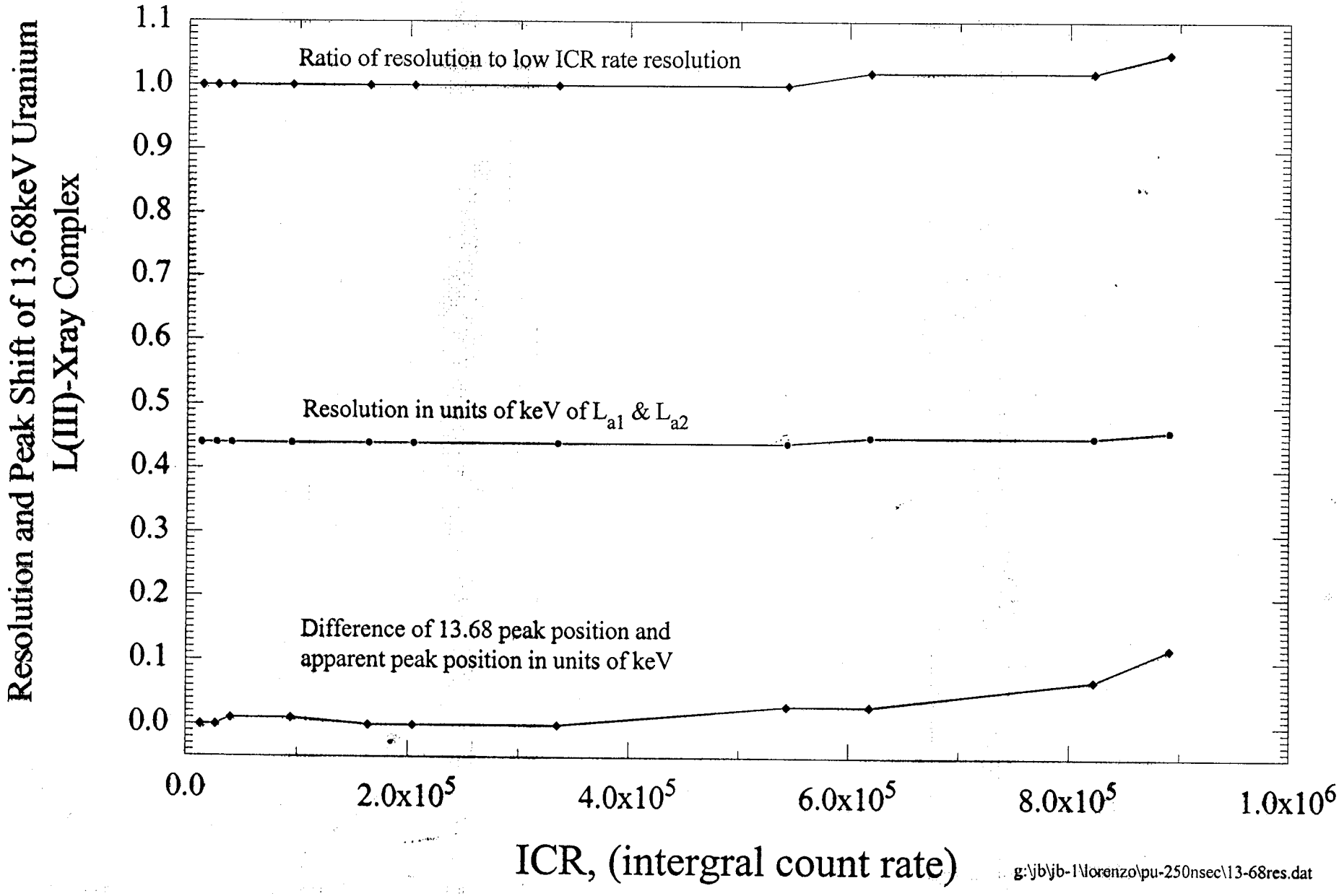
IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 46, NO. 3, JUNE 1999

Pu Spectrum @ 0.25 microsecond Peaking Time
for Evaluation of HIGH Speed Detector and Electronics



^{238}Pu Spectrum @ 0.25 microsecond Peaking Time for Evaluation of HIGH Speed Detector and Electronics



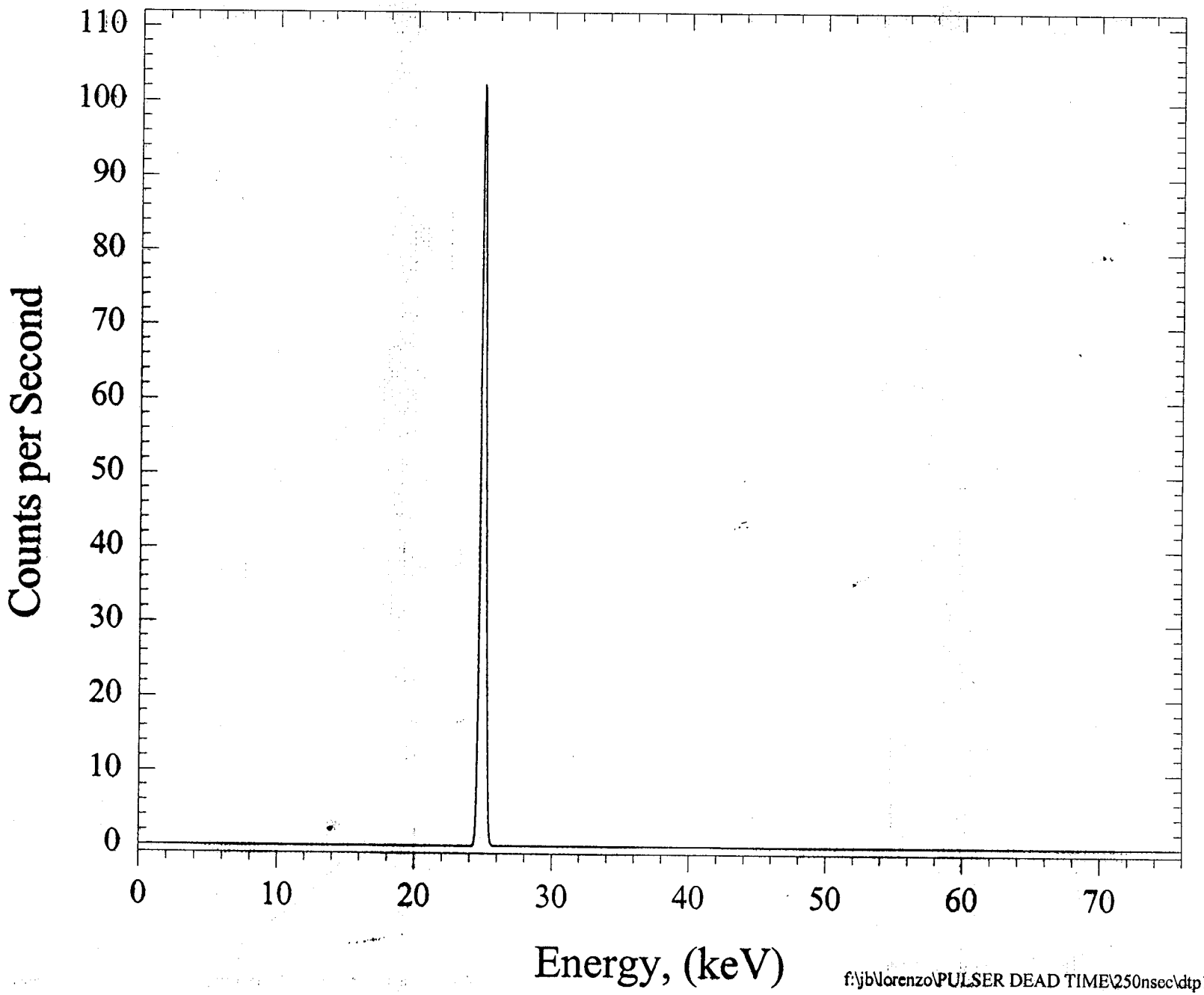

Resolution and Peak Shift of 13.68keV Uranium
L(III)-Xray Complex
Ratio of resolution to low ICR rate resolution
Resolution in units of keV of L_{a1} & L_{a2}
Difference of 13.68 peak position and
apparent peak position in units of keV
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0
2.0x10^5
4.0x10^5
6.0x10^5
8.0x10^5
1.0x10^6
ICR, (intergral count rate)
g:\jb\jb-1\lorenzo\pu-250nsec\13-68res.dat

DEAD TIME CORRECTION

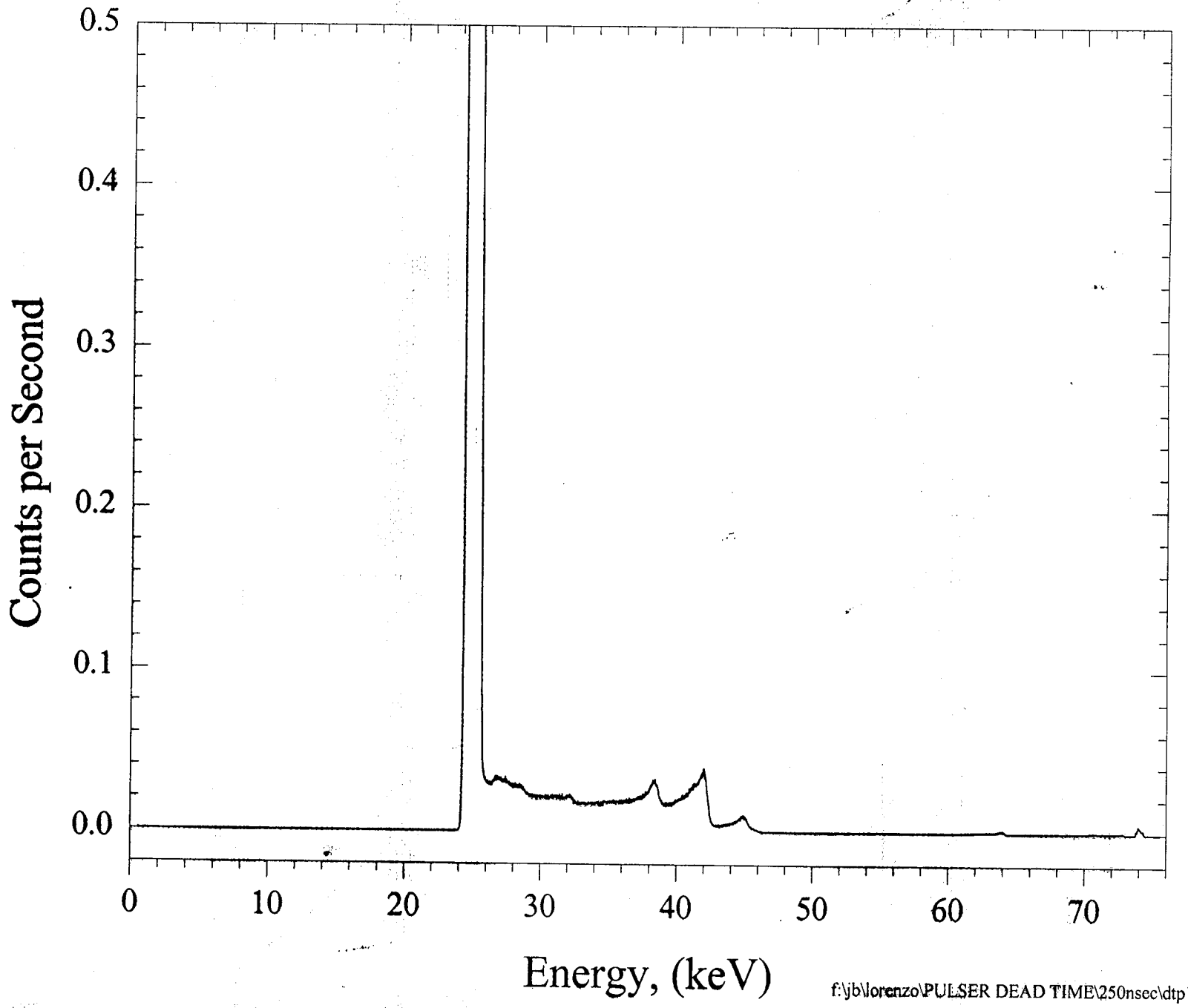
Periodic Pulser Method:

- Inject a low rate(~10KHz), fixed time interval pulse from an ultra stable generator.
- Pulse normally has sufficient amplitude to be located beyond the normal and pulse-pileup XASF data regions.
- Monitor the count-rate. Pulse count rate loses, as a function of ICR rates, are directly related to the overall counting system dead time(s).

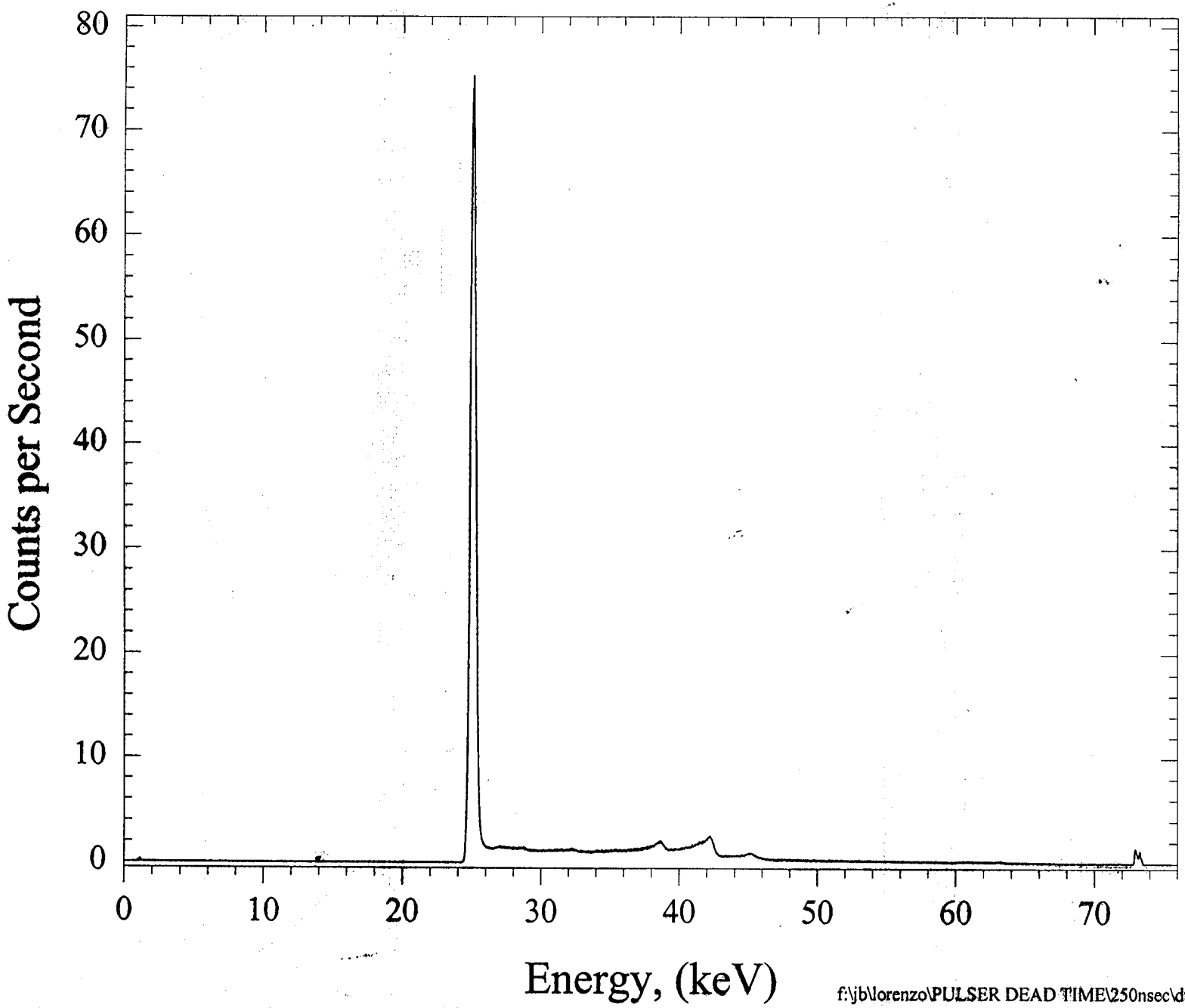
^{238}Pu Source ~12 inches from Detector Face



f:\jb\lorenzo\PULSER DEAD TIME\250nsec\dtp12-25.dat

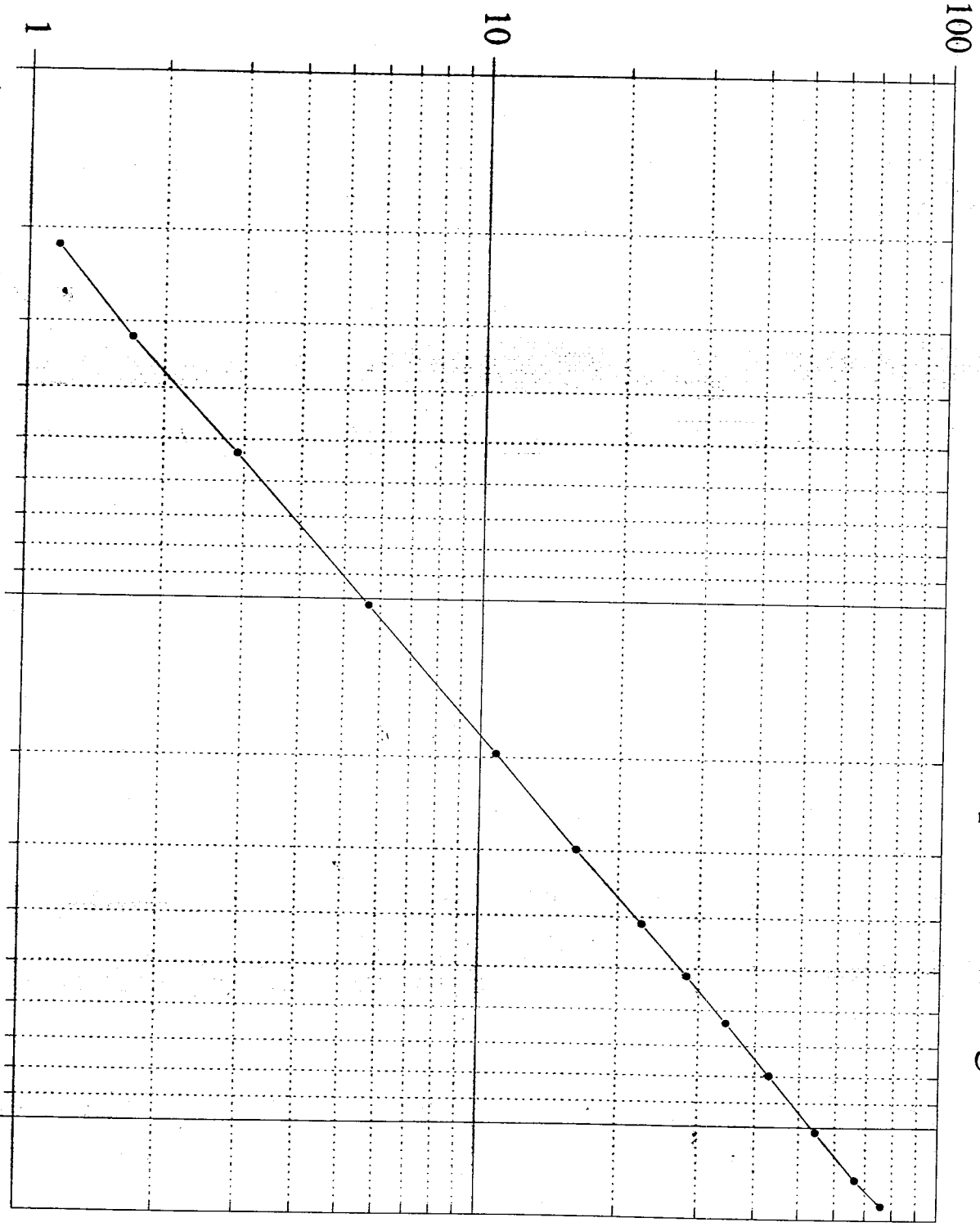

^{238}Pu Source ~12 inches from Detector Face
Counts per Second
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
Energy, (keV)
f:\jb\lorenzo\PULSER DEAD TIME\250nsec\dtp12-25.dat

^{238}Pu Source ~0.5 inch from Detector Face



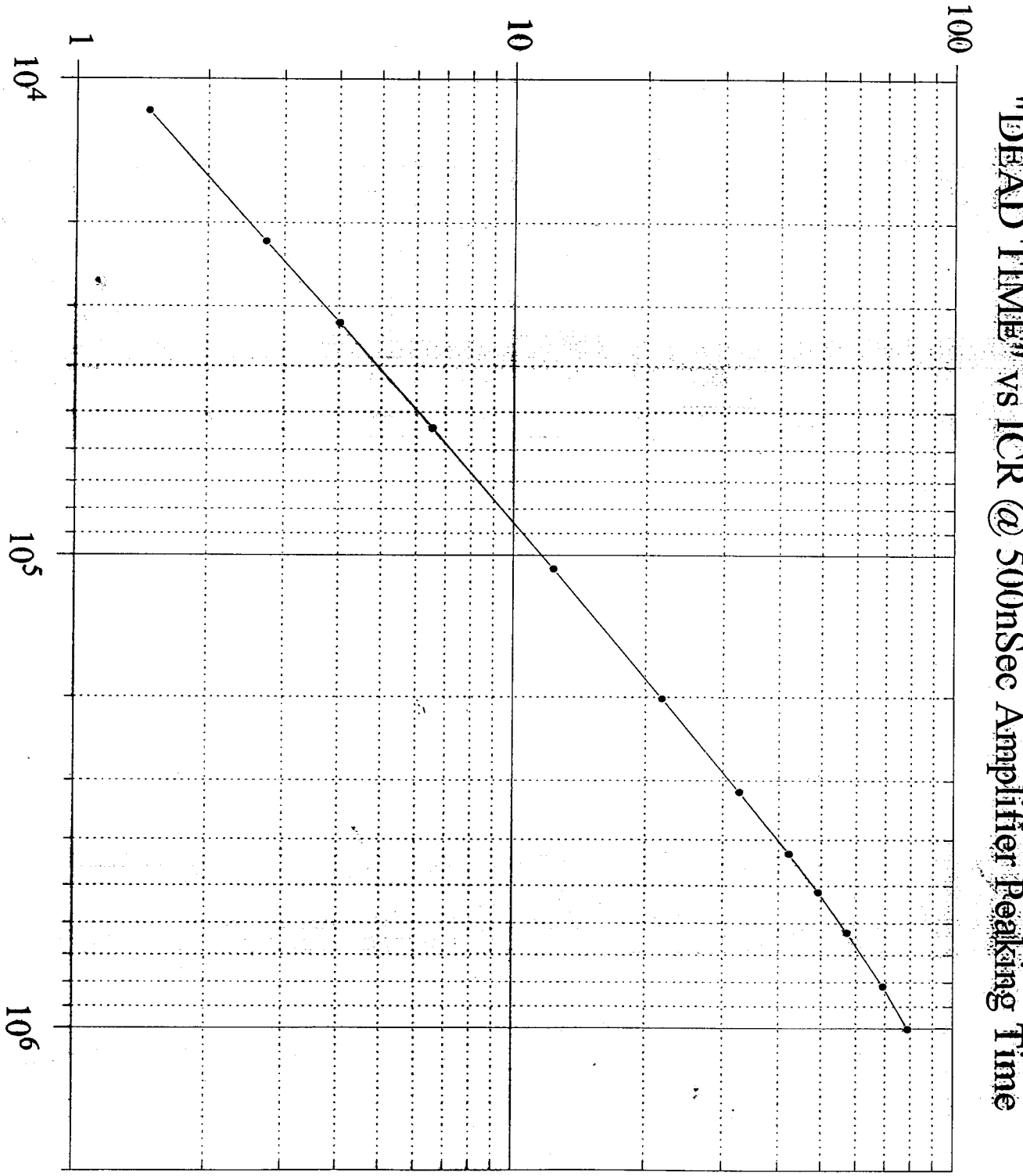
f:\jb\lorenzo\PULSER DEAD TIME\250nsec\dtp05-25.dat

"DEAD TIME" Percentage Determined Using PERODIC-PULSER-Method



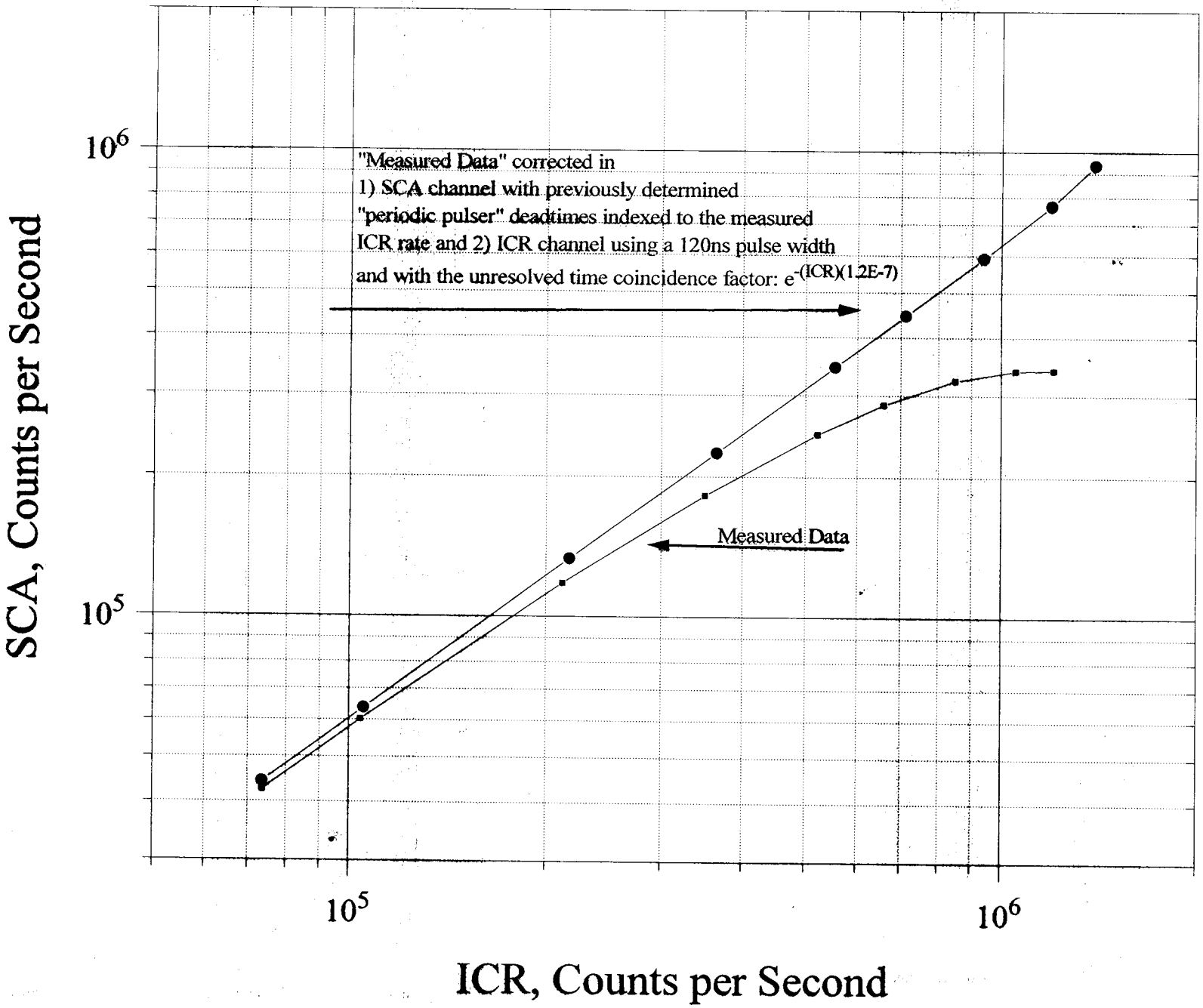
f:\jb\lorenzo\zPULSER DEAD TIMES\500nsec-scaldt-graf7-sca.dat

"DEAD TIME" Percentage Determined by Periodic Pulser Method



f:\jb\lorenzo\zPULSER DEAD TIMES\500nsec-sca\dt-graf11-500sca.dat

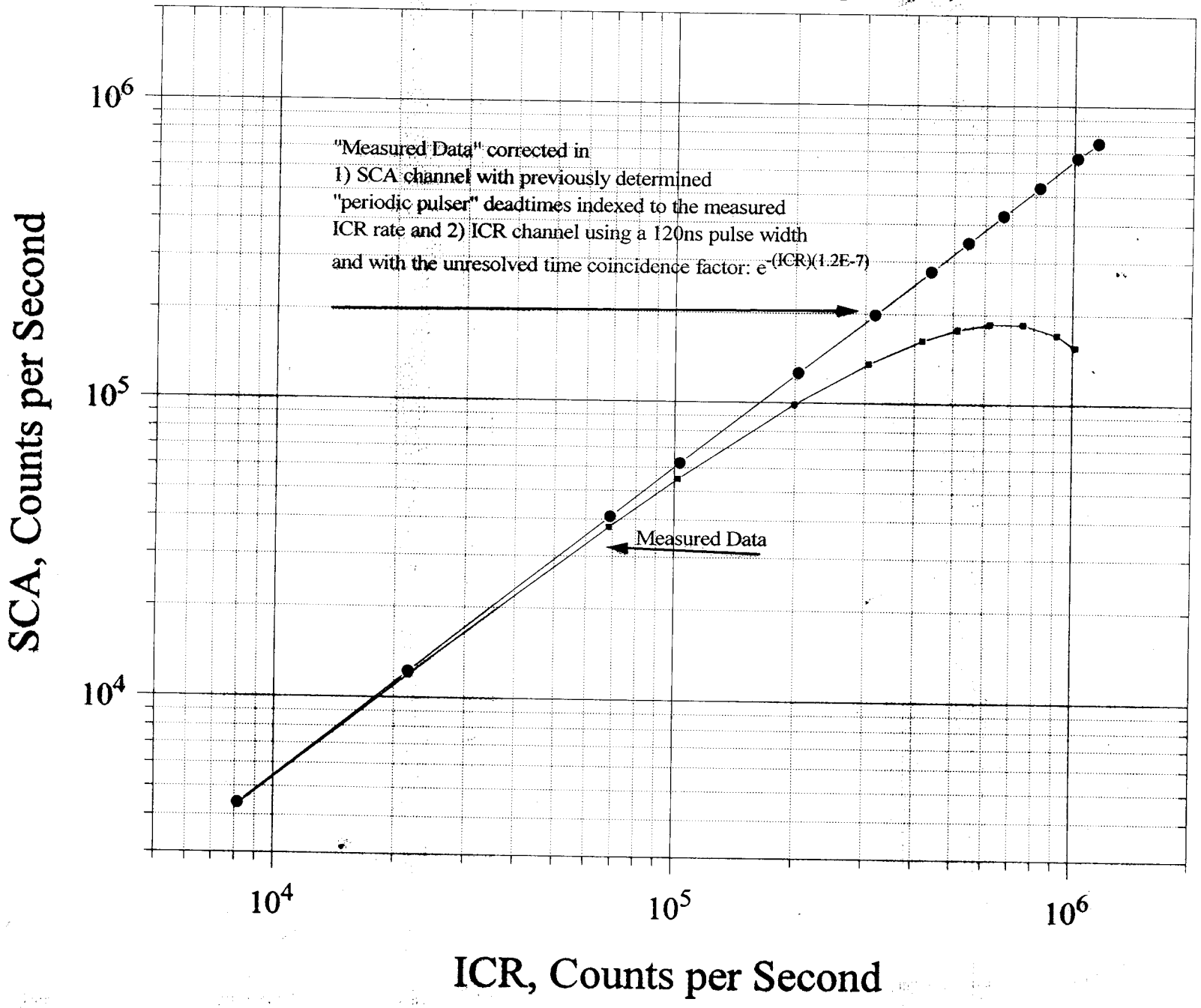
SCA Count Rate for Cu K xray Excitation @ 8980eV vs ICR (250nanosecond Peaking Time)



f:\jb\lorenzo\PULSER DEAD TIMES\Cu-SSRL Beamline\250ns-total-corr-SCA-Cu-Kxray.opj

h:\jb\jb-1\lorenzo\PULSER DEAD TIMES\Cu-SSRL Beamline\Cu-SSRL-Cu-Kxray-vs-ICR-250ns.dat & 250ns-total-corr-SCA-Kxray.da

SCA Count Rate for Cu K xray Excitation @ 8980eV vs ICR (500nanosecond Peaking Time)

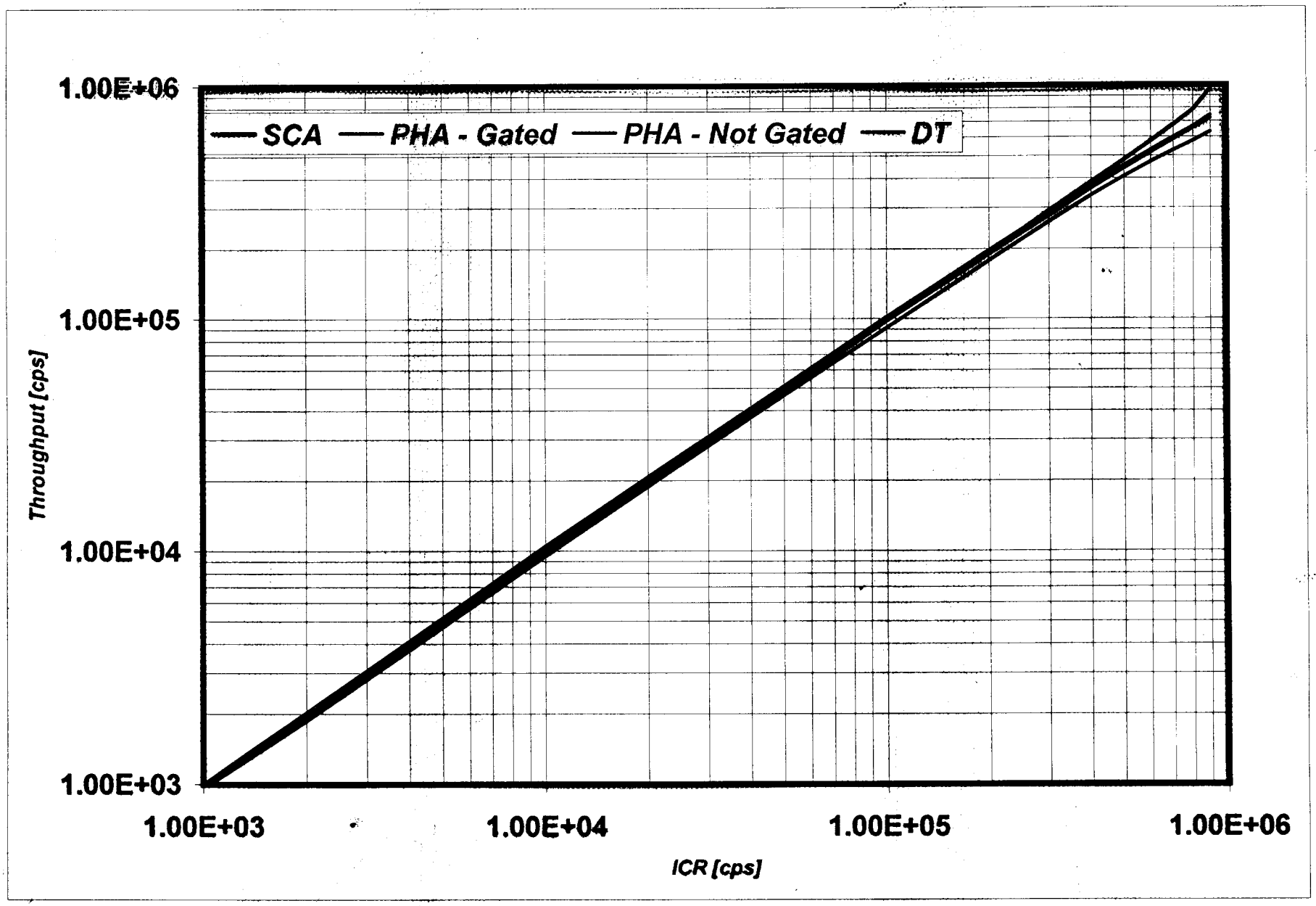


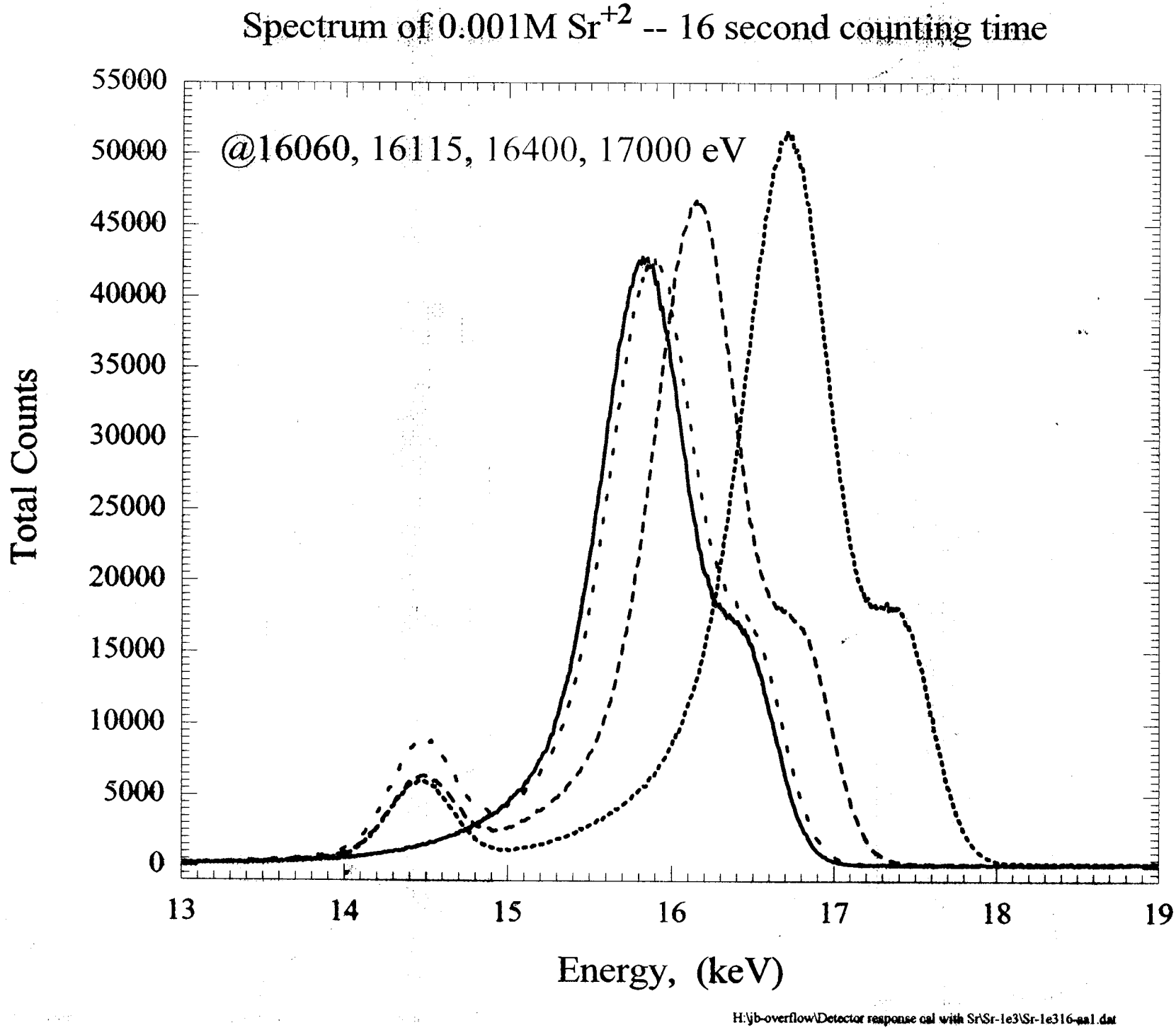
h:\jb\jb-1\lorenzo\PULSER DEAD TIMES\Cu-SSRL Beamline\500ns-total-corr-SCA-Cu-Kxray.opj

h:\jb\jb-1\lorenzo\PULSER DEAD TIMES\Cu-SSRL Beamline\Cu-SSRL-Cu-Kxray-vs-ICR-500ns.dat & 500ns-total-corr-SCA-Kxray.dat

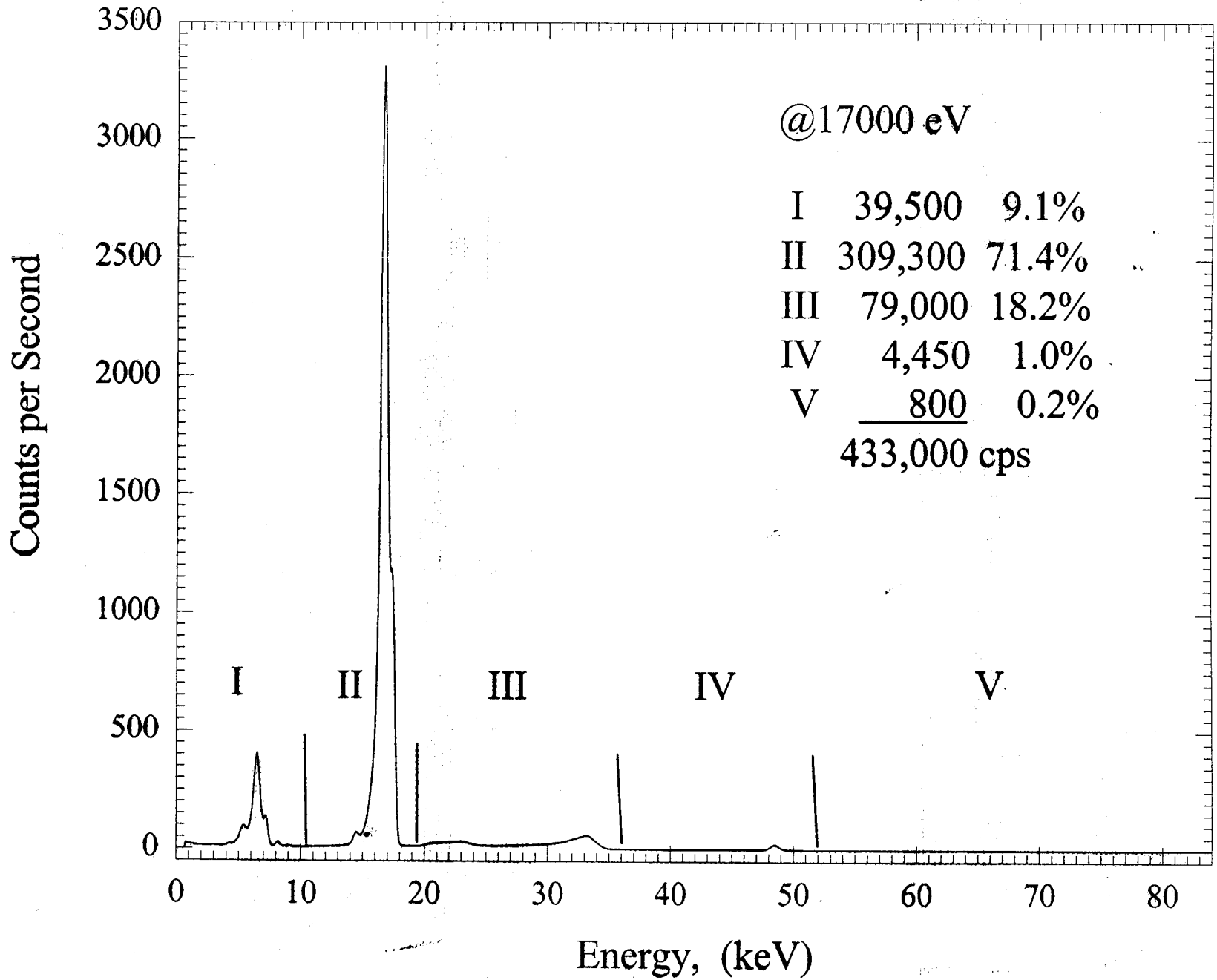
FAST PULSE HEIGHT ANALZYER (PHA)

- 12 Bit Resolution – 4096 Channels
- Many Bits Over Digitization to Yield no Bit Error at 12 Bit Resolution
- At Least 5-6MHz Digitizing Rate to Yield a
- REAL TIME DATA ACQUISITION MODULE
- ? No DEAD TIME Contribution
- One PHA unit per Detector Channel
- Can Digitize a Periodic Pulser Dead Time Correction at Every Data Point in Every Detector Pixel

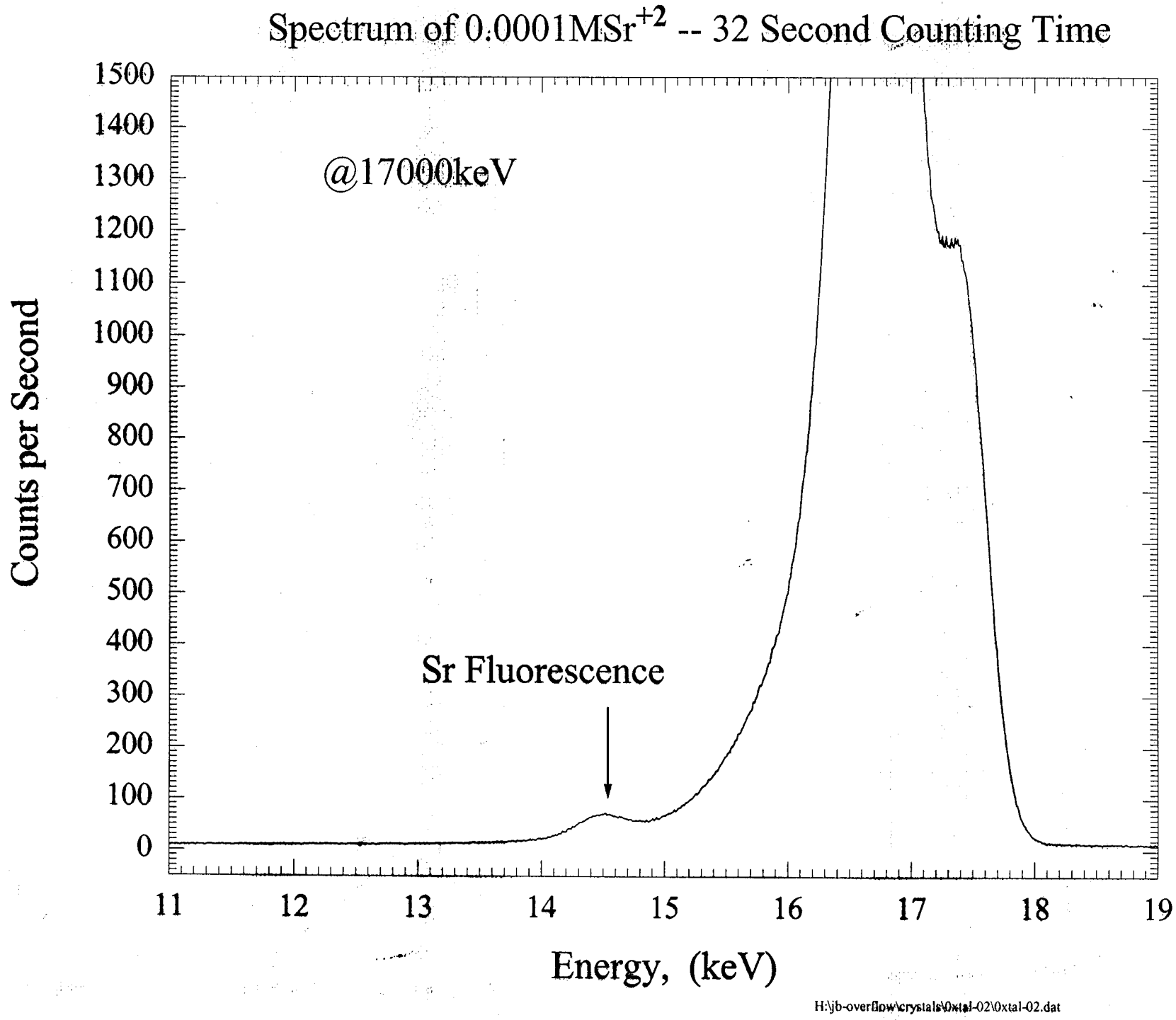

SCA
PHA - Gated
PHA - Not Gated
DT
1.00E+06
1.00E+05
1.00E+04
1.00E+03
Throughput [cps]
1.00E+03
1.00E+04
1.00E+05
1.00E+06
ICR [cps]


Spectrum of 0.001M Sr^{+2} -- 16 second counting time
@16060, 16115, 16400, 17000 eV
Total Counts
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
13
14
15
16
17
18
19
Energy, (keV)
H:\jb-overflow\Detector response cal with Sr\Sr-1e3\Sr-1e316-aa1.dat

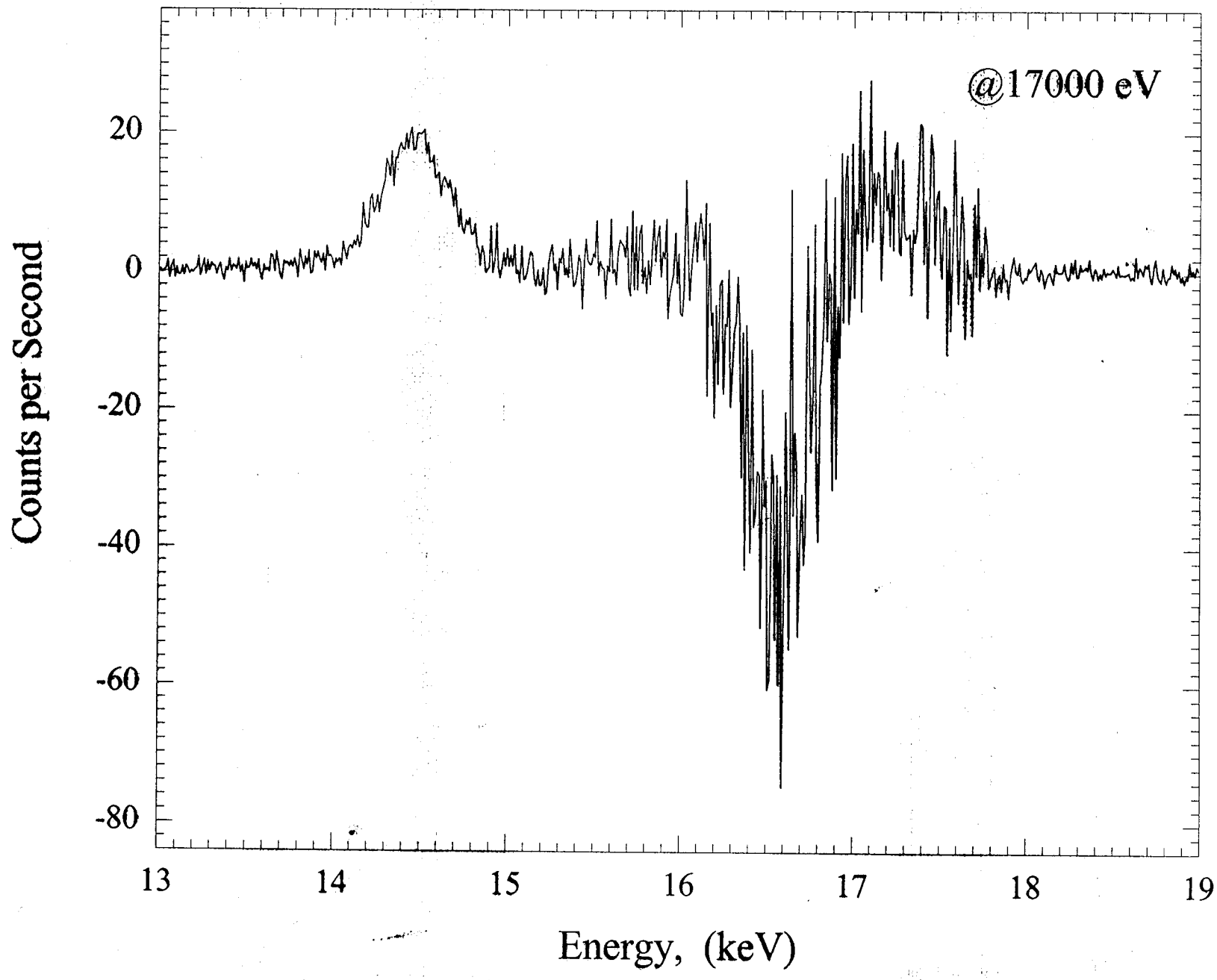
Spectrum of 0.0001M Sr^{+2} -- 32 second counting time



H:\jb-overflow\Detector response cal with Sr\Sr-1e4\Sr-1e432-ae1.dat

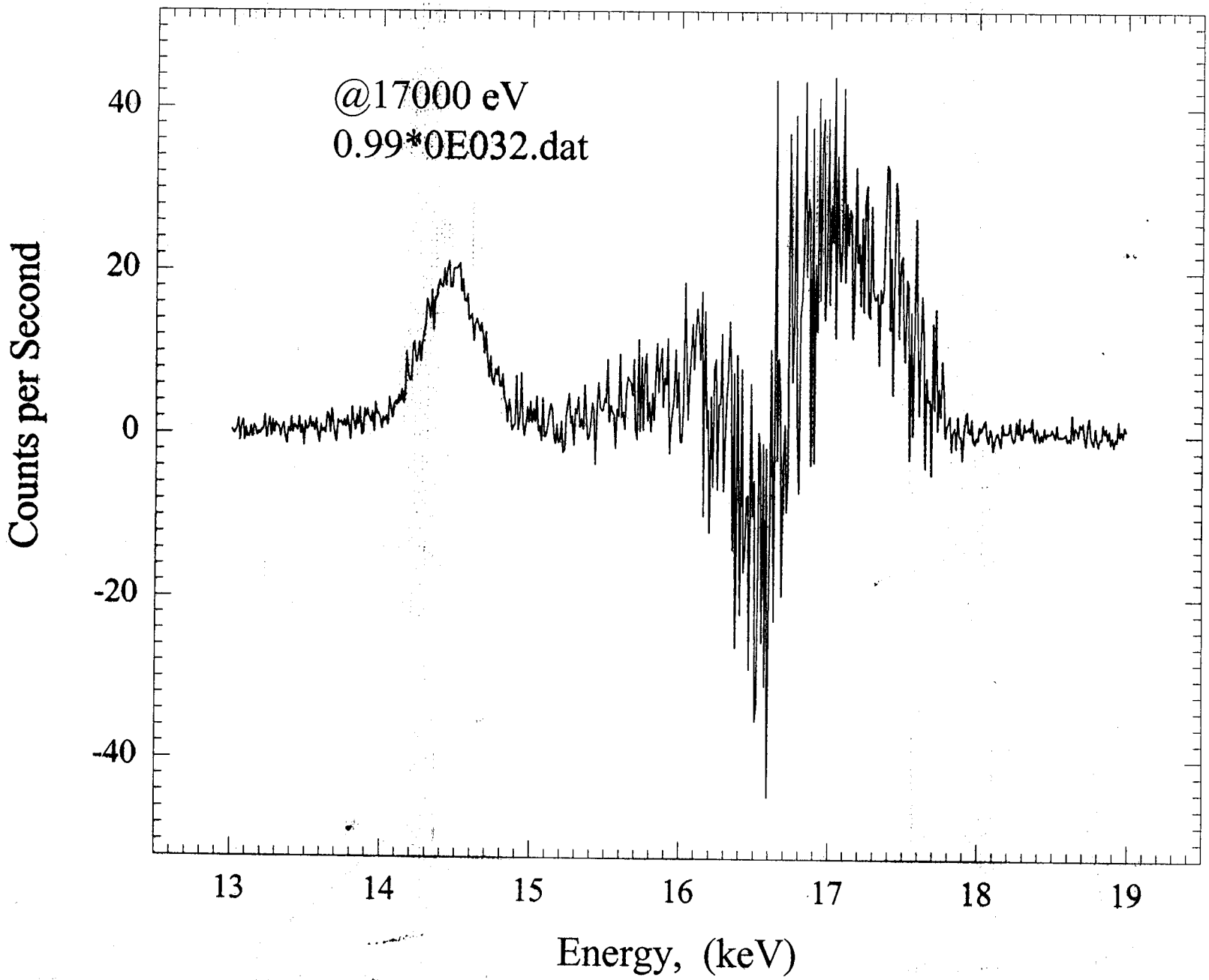

Spectrum of 0.0001MSr+2 -- 32 Second Counting Time
@17000keV
Sr Fluorescence
Counts per Second
Energy, (keV)
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
11
12
13
14
15
16
17
18
19
H:\jb-overflow\crystals\0xtal-02\0xtal-02.dat

Spectrum of 0.0001M Sr^{+2} -- 32 second counting time

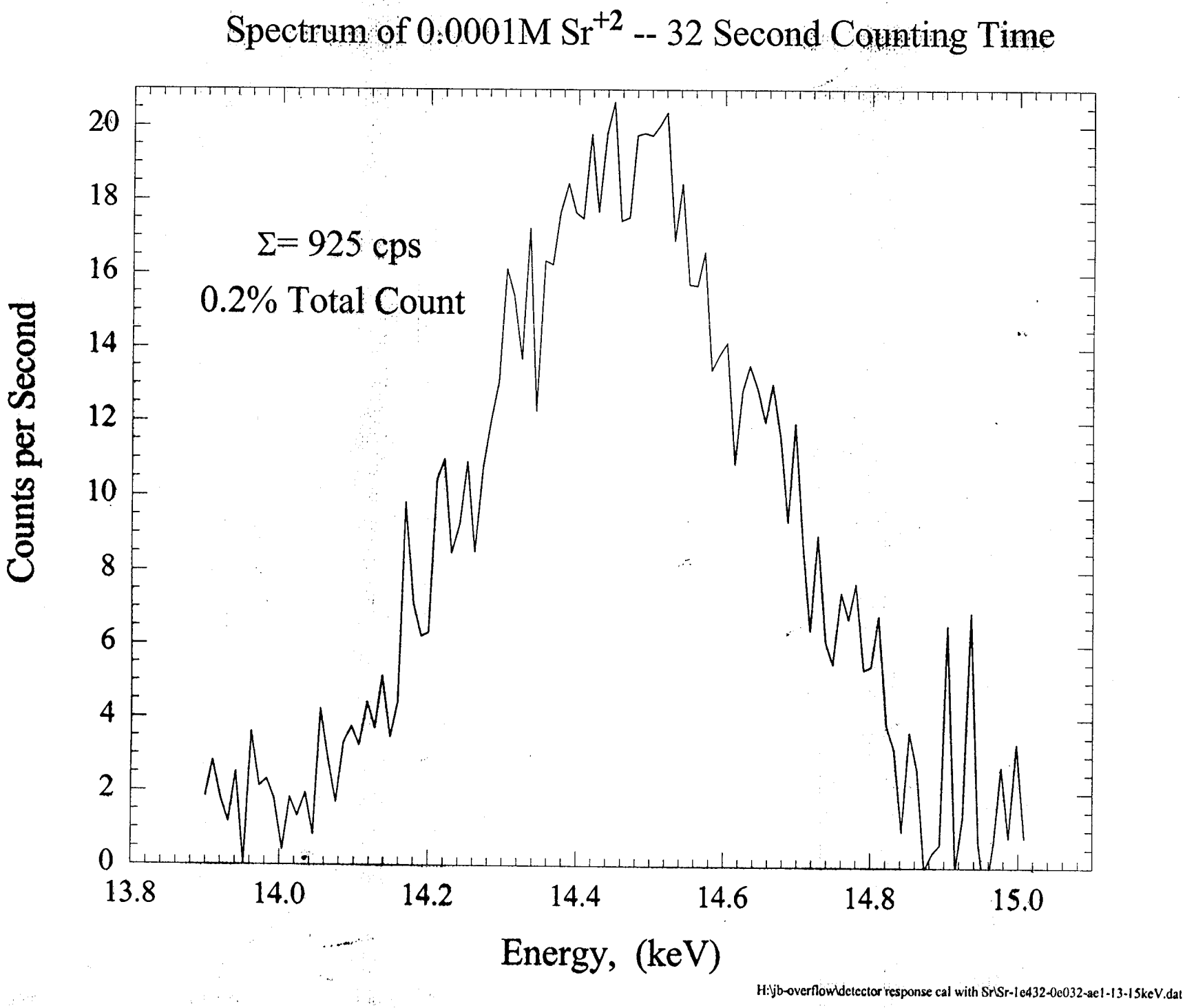


H:\jb-overflow\Detector response cal with Sr\Sr-1e432-0e032-ae1-13-19keV-aa1.dat

Spectrum of 0.0001M Sr^{+2} -- 32 second counting time



H:\jb-overflow\Detector response cal with Sr\Sr-1e432-0e032-ae1-13-19keV-adjust-graf.dat


Spectrum of 0.0001M Sr^{+2} -- 32 Second Counting Time
Σ= 925 cps
0.2% Total Count
Counts per Second
0
2
4
6
8
10
12
14
16
18
20
13.8
14.0
14.2
14.4
14.6
14.8
15.0
Energy, (keV)
H:\jb-overflow\detector response cal with Sr\Sr-1e432-0e032-ae1-13-15keV.dat