Note PS/LP (IN FO) 95-01
25. 1. 95

# The CTF Run N° 3 - 1994

## Results and Comments

**H. Braun, M. Comunian and JHB. Madsen**

Participants : H. Braun, R. Bossart, J. P. Delahaye, M. Comunian, S. Hutchins, J.C. Godot, I. Kamber, J. H. B. Madsen, J. Mourier, G. Rossat, L. Rinolfi, S. Schreiber, J. Sladen, G. Suberlucq, J.C. Thomi, I. Wilson, W. Wuensch, E. Chevallay

## 1. General

| | |
|---|---|
| *Start:* | *29/08/94* |
| *End:* | *14/12/94* |

### Modifications in respect to Run 2 (see: PS/LP/Note94-45)

| | |
|---|---|
| RF : | KLY97 feeding LAS via LIPS |
| MTV630: | in probe beam in front of CAS |
| Laser pulse train generator : | another splitting stage added to get a continuous train of 48 pulses spaced by 333 ps |

### Mishappenings

This run was plagued by a number of hardware problems and without going into the details - too many - we just list the important ones:

- KLY97 with tank was used as a LIL spare and went to pos. 13, the replacement tube oscillated and had to be exchanged ,
- breakdowns in the line KLY98 - gun/booster; an rf window and a waveguide bend were replaced,
- wanting to operate at a high gradient in LAS we encountered periods of breakdowns in this section,
- a series of Cs2Te cathodes did not stand the field in the gun and we worked for many days at 2/3 of the nominal field,

- a serious fault on the laser system caused for one week repair (the flash lamp power supply and its interlocks broke down, repair time-consuming due to lack OF documentation and spare parts )

In spite of all these troubles practically all objectives of this run were met. We could unfortunately not use the probe beam and run for a prolonged period of time at high 30 GHz power from TRS. Neither could we test extensively new types of cathodes.

In fact this run was 'saved' by the dedicated efforts of the teams in charge of the different systems.

**2. LIPS and momentum gain in LAS**

From the beginning of the run, LAS was powered by KLY97 + LIPS. We aimed at the highest possible accelerating gradient expecting to suffer less from the wakefields in the section.

Without LIPS we fed LAS with a square RF pulse,PKI97 = 30 MW, final beam momentum 83 MeV/c and no breakdowns in the section.

By using LIPS with the classical 180° phase step, we were limited by breakdowns in the section, max. beam momentum 78 MeV/c (at entrance of LAS: 11 MeV/c ).

Suspecting that the sharp power peak after the phase switching caused the breakdowns, we turned to the programmed phase switching technique studied by C. Schieblich (ref. 1). Soon PKI97 could be raised and the beam momentum became 86 MeV/c still limited by breakdowns.

On the 5th of December - thus after a long conditioning of LAS - an experiment was made together with R. Bossart, J. Mourier and G. Rossat to find the energy gain with LAS for different ways of operating LIPS (see logbook p. 118 - 121).

LIPS mode a) : 180° phase step at inversion - (SRFIMDK97), timing
optimzed: SRFMDK97 = 32703
SRFIMDK97= 32747
ERFMDK97 = 32760
see fig.1a , beam 700 ns after phase step.

mode b) : from start rf pulse a linear change in phase of - 55°, then a 68° step followed by a linear change to 180° and start, stop rf pulse as mode a); for maximum momentum gain SRFIMDK97 set to 32743 - see fig. 1b

mode c) : 68° step at SRFIMDK97 followed by a linear change to 180°, timings as b), see fig.1c

mode d) : LIPS detuned and thus square rf pulse to LAS. Reduced pulse length by setting SRFMDK97 to 32733 (see fig. 1d).

**For PKI97 = 13 MW, momentum gain by LAS for the different LIPS modes:**

| mode | MeV/c | less than a) in % |
|---|---|---|
| a) | 67.7 | - |
| b) | 63.8 | 5.8 |
| c) | 59.8 | 11.7 |
| d) | 45.2 | 33.2 |

**Maximum momentum gain achieved, limited by breakdowns in LAS :**

| mode | MeV/c | more than a) in % | |
|---|---|---|---|
| a) | 70 | - | |
| b) | 87 | 24 | (PKI97 = 24.6 MW) |
| c) | 83 | 19 | |
| d) | 83 | 19 | (limited by klystron power, from last run) |

**3. Increasing the charge per bunch and more 30 GHz peak power from TRS**

At the beginning of the run with the Cs2Te cathode still being 'fresh' and with the maximum laser energy the following record charges were measured with UMA375 (behind the booster ):

train of 24 bunches, total charge 211 nC , 8.8 nC / pb, page 7/8
train of 48 bunches, total charge 452 nC , 9.4 nC / pb

These results show that the high charges we need in the future can be produced by the cathode.

A continuous train of 48 laser pulses - pulse spacing 333 ps - was set up by S. Schreiber.

LIPS used with programmed phase switching, mode c). Beam momentum for low charge: 87 MeV/c. The 30 GHz peak power from TRS topped soon our 60 MW goal :

| | | | | |
|---|---|---|---|---|
| UMA375 | 109 nC | or | 2.27 nC | per bunch |
| UMA385 | 106 nC | or | 2.21 nC | per bunch |
| UMA406 | 109 nC | or | 2.27 nC | per bunch, 100 % of beam acc. |
| UMA455 | 81 nC | or | 1.69 nC | per bunch 74 % through TRS |

Resulting in a max. 30 GHz peak power of 67.4 MW.

By increasing further the charge of the train the transmission through TRS became less but the peak power increased :

| | | | | |
|---|---|---|---|---|
| UMA375 | 147 nC | or | 3.06 nC | per bunch |
| UMA395 | 143 nC | or | 2.98 nC | per bunch |
| UMA406 | 146 nC | or | 3.04 nC | per bunch, 100 % of beam acc. |
| UMA455 | 75 nC | or | 1.56 nC | per bunch, 52 % through TRS |

Resulting in a max. 30 GHz peak power of 76.5 MW (see p 17/18).

The duration of the 48 bunch train - 15.7 ns - is longer than the fill time of TRS - 11.5 ns. Therefore, the TRS output pulse as observed on the storage scope shows a flattop (Fig. 2). As a comparison, see the signal from a 24 bunch train on fig. 3.

The TRS output pulse shortens if there are high beam losses in TRS (Fig .4)..At some shots the reflected signals disappeared (Fig. 5).

Two overlapping trains of 24 laser pulses with the pulses in the trains spaced by 33 ps (one 30GHz wavelength) were made (see fig. 6). It turned out to be more difficult to achieve good transmission through TRS than with a train spaced by 333 ps. Nevertheless a peak power of 65 MW was obtained (p. 20 - 22).

Adjusting the position on the cathode of the individual laser pulses is in the 48 pulse train difficult. We went back to the 24 pulse train to find the best performance with the increased accelerating gradient in LAS. Maximum beam momentum : 92 MeV/c Large laser spot on cathode, about 10 by 10 mm.

| | | | | |
|---|---|---|---|---|
| UMA375 | 55.8 nC | or | 2.33 nC | per bunch |
| UMA395 | 58.4 nC | or | 2.43 nC | per bunch |
| UMA406 | 57.6 nC | or | 2.40 nC | per bunch, 100 % of beam acc. |
| UMA455 | 51.7 nC | or | 2.15 nC | per bunch, 90 % through TRS |

Resulting in a max. 30 GHz peak power of 53.7 MW.

| | | | | |
|---|---|---|---|---|
| UMA375 | 77.4 nC | or | 3.23 nC | per bunch |
| UMA395 | 80.1 nC | or | 3.34 nC | per bunch |
| UMA406 | 80.3 nC | or | 3.34 nC | per bunch, 100 % of beam acc. |
| UMA455 | 59.3 nC | or | 2.47 nC | per bunch, 74 % through TRS |

Resulting in a max. 30 GHz peak power of 75.6 MW. See p 56

Taking the charge into TRS then the form factor for the bunch is 0.62 and with the charge out TRS 0.84.

Having set up the high charge train we measured the energy difference between the first and last bunch of a train with 64 nC, max. 91 MeV/c.
Found: 0.198 MeV/c per nC ( p 58 ), close to the theoretical beam loading parameter of LAS : 0.196 MeV/nC.

**4. Bunch length measurements with TCM's and streakcamera**

Extensive measurements having been made during the last run, a couple of checks were made only and they confirmed the values found earlier. Laser pulse width unchanged: 8 ± 2 ps FWHH.

Depending on phase : 9 to 13 ps, bunch charge 2.1 nC (see p. 102).

A couple of weeks later we found: 9 ps for 1.6 nC (see p. 130).

**5. Transverse bunch emittance** **M. Comunian**

On the measurement principles see: PS/LP Note 94-57(Min).

We found that the optics of the streakcamera influences the calibration factor for the transverse beam profile measurements. The three small holes in the detector plate of TCM445T are used to determine this calibration factor.

Transverse bunch emittances measured in December are reported on fig. 7 and fig. 8a). Comparisons of these results with data obtained with PARMELA are in progress.

**6. Wakefield in LAS studied with the YIG filter** **H. Braun**

To detect higher order modes excited by the beam in LAS, a YIG type tuneable filter with an RF detector behind was connected to the directional coupler just upstream of the main input coupler of the LAS (see fig. 8b).

Two measurement sessions were performed. The first one (logbook p. 71 -73) was used to verify the functioning in single bunch mode and to detect HOM frequencies.

The YIG is limited to f < 12.5 GHz and signals close to 3 and 9 GHz are suppressed by the band rejection filter for the fundamental.

Measurements were done with 1 nC bunch charge and the signal levels quoted for the dipole modes are obtained with the beam mis-steered with DHZ388 so that it is just not loosing transmission in LAS.

| Freq. GHz | signal peak, mV | type |
|---|---|---|
| 4.42-4.51 | 70 | dipole |
| 6.0 | | 2nd harm of klystron |
| 6.8 | 40 | monopole |
| 7.1 | 40 | dipole |
| 11.0 | 2 | dipole |

The second session (p. 93-95 ) was used to investigate the effect of bunch trains on the lowest dipole mode. The measurement conditions were the same as above. The interesting result of this measurement was that the fields almost cancel for bunch pairs spaced by 2 (n-1) wavelengths (fig. 9) due to the dipole mode frequency being almost equal to 3/2 of the fundamental.

**7. Experiences with different photocathodes**
**Cs2Te**

Cathode prepared in the photocathode lab. The thickness of the evaporated layers differs slightly from one to the other cathode. Last cathode used - p. 116 - : 10 nm Te , 12.6 nm Cs and cathode at 110°C during evaporation.

To find the effective quantum efficiency the relation between the laser energy at the output of the laser system and on the cathode has been established (see p. 51).

The charge is measured with UMA375. Bunch charge around 1 nC. A new cathode has typical a QE of 5% and then drops slowly with the rf hours. Unfortunately, a series of cathodes suffered from a fabrication fault - afterwards discovered - and after some running breakdowns in the gun occurred.

After the breakdowns some cathodes had a lower QE , others in addition did not stand the 100 MV/m any longer and had to be used at about 66 MV/m. As illustration: fig.10, p. 57

We measured a dependency of the QE with the field in the gun. Fig. 11, p. 65. This dependency is not due to losses by beam dynamics effects.

**Mg**

Cathode prepared in the lab of A. Braem, PPE - TA1
Deposited on the Cu cathode surface 200 nm Al and then 369 nm Mg.

Field raised in gun to 100 MV/m in about 1 hr with a few breakdowns only.

QE = 2.7 10-4

In the dc gun in the photocathode lab. : QE = 5 10-5. This cathode can be transported in air.

**CsI with a layer of Ge**

This cathode was made as well in the lab of A. Braem.
Deposited : 200 nm Al, 350 nm CsI and then 2 nm Ge.

CsI was used in CTF gun up to Nov.'93. From that time onwards we can transport cathodes under vacuum and use the laser fourth's harmonic. The QE of CsI at 262 nm is 7 $10^{-5}$, too low for our purposes.

As we have an interest in using a cathode which can be exposed to air and used at 262 nm it was decided to try this CsI with Ge.

The field in the gun was increased to 100 MV/m in 1 1/2 hr. The cathode remained 5 hr only in the gun at full field due to lack of time. During this period breakdowns occurred relatively frequently in the gun.

QE = 0.19 % for a bunch charge of 2.3 nC.
Bunch length measured with TCM390C : 12 ps.

More testing is required with this cathode to define its performances (life time, saturation, bunch length as function of charge and phase,...).

**8. Testing beam position monitors**

A prototype beam position monitor for the TESLA Test Facility was tried out from 5th to 9th September (p. 12 - 14). The monitor was installed in the BHZ430 spectrometer line in air.

R. Lorenz, from TU Berlin, prepared the monitor (see Ref. 2).

We are still looking for a monitor to get an analogue display of the bunch charges in the trains. The WCM used in the photocathode lab can perhaps be adapted for the job.

A prototype, made by J. Durand, was tried in the BHZ430 line. (p. 34 , 38). Work on this monitor is still in progress.

In the frame of the CERN/Uppsala University Collaboration two button type monitors were tried. One mounted under vacuum downstream of TRS and another behind BHZ430 in air.

The analogue signal from the monitor was observed with the wide bandwidth (50GHz) sampling scope. By applying adequate filtering it was possible to display three bunches separated by 333 ps.

The monitor, constructed by Mrs Yan Yin, was tested with F. Caspers and E. Schulte (p. 127,128 ).

The CLIC BPM, installed behind BHZ500,was tested with and without collimator in front. Without collimator one had to measure in the H or the V plane to get a small beam for measuring the monitor signal as function of position (p. 99). Better conditions were obtained with the collimator. (W cylinder 20 mm long, hole diam. of 2 mm). The off set with the beam centered was 15 $10^{-6}$ m at best. The jitter in beam position was rather large as the laser had not its best form (see p. 125).

**9. Testing a CLIC Transfer Structure. ( CTS ) - made by L. Thorndahl et al.**

The 30 GHz power generated by the TRS was fed into the CTS. With a train of 24 bunches the 30 GHz peak power touched the 60 MW. In the 40 - 50 MW range the signals from TRS and CTS were stable. Fig. 12. At higher power levels now and then a signal appeared at the end of the TRS signal (Fig. 13). This spurious signal remained when all signals to the measurement - except the one from TRS - were disconnected (Fig.14, see p. 139 to 142).

**10. Radiation measurements J-M. Hanon, A. Muller and J.W.N. Tuyn TIS - RP**

Planning to increase by a factor - roughly - ten the average current in the CTF and considering an extension to the present CTF building, we badly needed experimental data.

Measurements were made for two beam situations:

the low energy beam from the booster with BHZ385 directed into the wall of the entrance chicane

- the 85 MeV/c beam steered with BHZ430 into a 5 cm thick Pb brick.

Beam intensity: 45 nC and 42 nC resp., 10 Hz.

The low energy beam gave 9 mrem/h at the entrance door 611 and 65 mrem/h in the hole in the streakcamera room at ground level.

The beam lost in the Pb gave no measurable levels outside the shielding. Radiation is found in the cable holes.

The neutron flux around the Pb brick is important - 10+6 $n.cm^2.s^{-1}$ - and can cause damage to electronic components.

Details: 'Rapport de surveillance radiation', RSR/PS/94-19/jmh, by J.,M. Hanon/ A. Muller

**11. Checking UMA response in low and high gain**

The UMA signal is attenuated - since run 2 - by a factor 10 .

At low gain - amplification 1 - one bit equals 1.1 nC. At high gain - amplification 10 - the digital readout starts to saturate above 1 nC (see fig. 15).

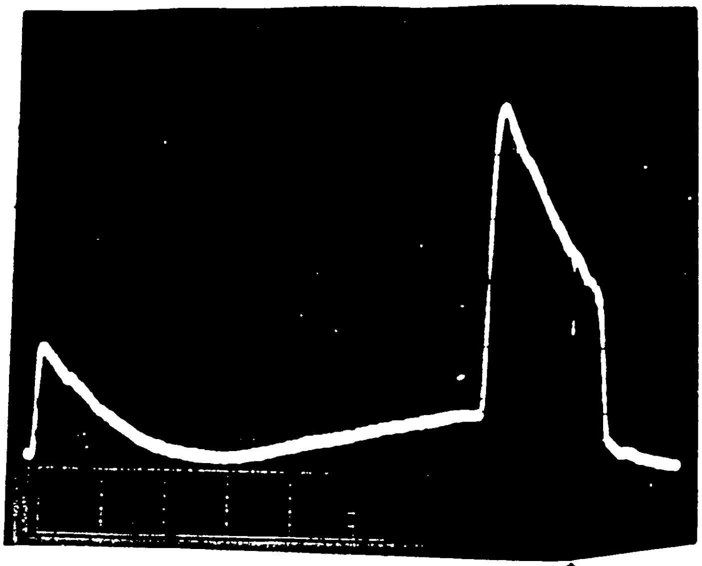
Obviously, the overlap between high and low gain has to be improved and M. Le Gras has been requested to make the necessary steps.

References:.

1. C. Schieblich, CERN/PS/89 - 51 (RF)

2. R.Lorenz, K.Yezza : Test Results on a BPM Prototype for the TTF, presented at the EPAC94, London, June'94

PSI : power into LAS

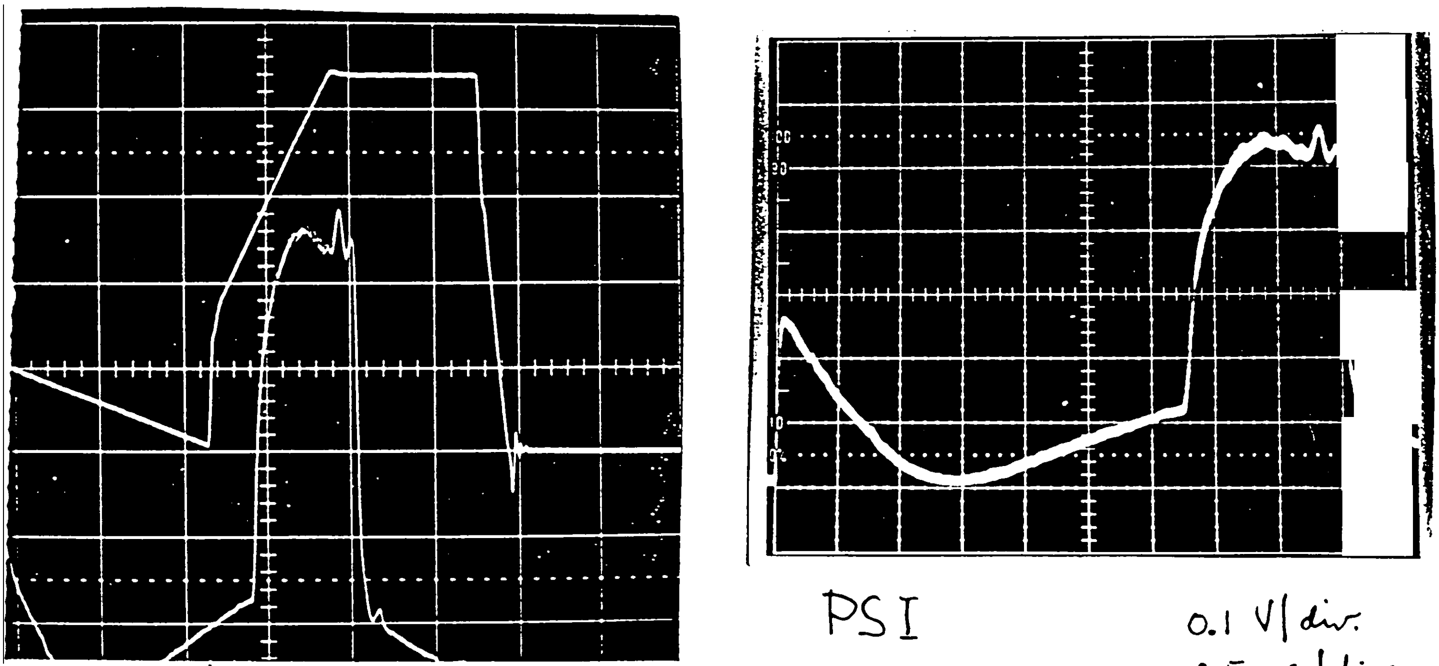


↑ BEAM

0.1 V/div

0.5 μs/div

Fig 1a



↓ SRFIMDK

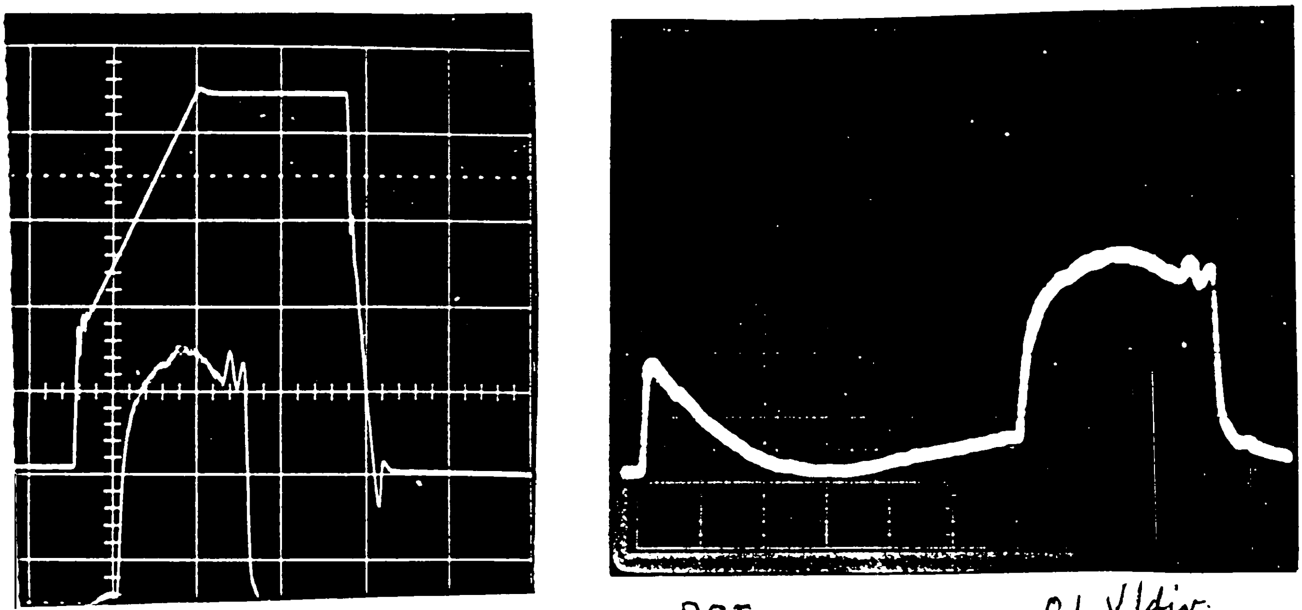
UPPER TRACE : RF PHASE SIGNAL

PSI

0.1 V/div.

0.5 μs/div.

Fig. 1b

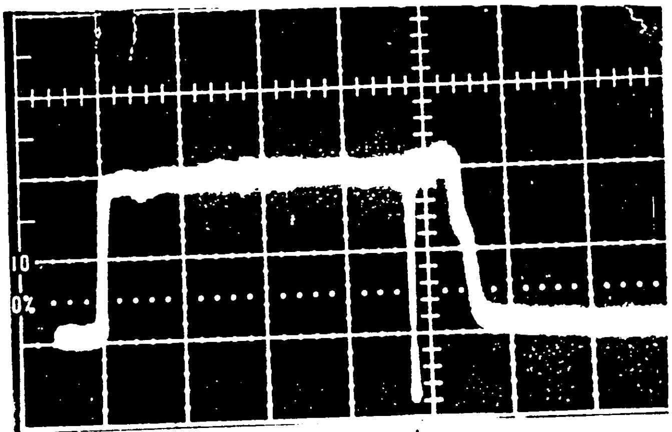


UPPER: RF PHASE

PSI

0.1 V/div
0.5 µs/div

Fig 1c



13. MV

0.1 V/div
0.5 µs/div

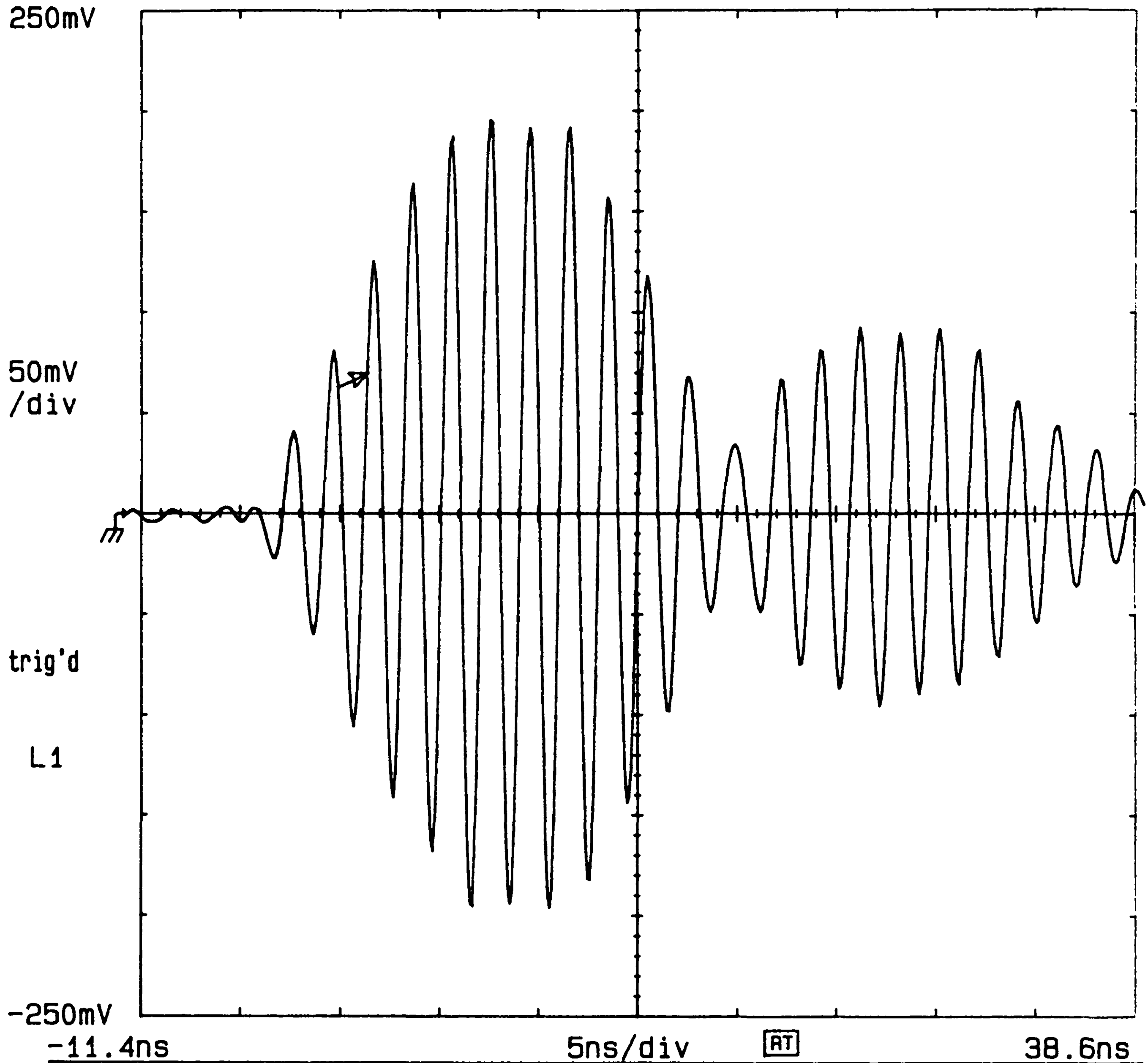
↓
BEAM

PSI

Fig. 1 d

date: 12-SEP-94 time: 18:40:30

Fig 2



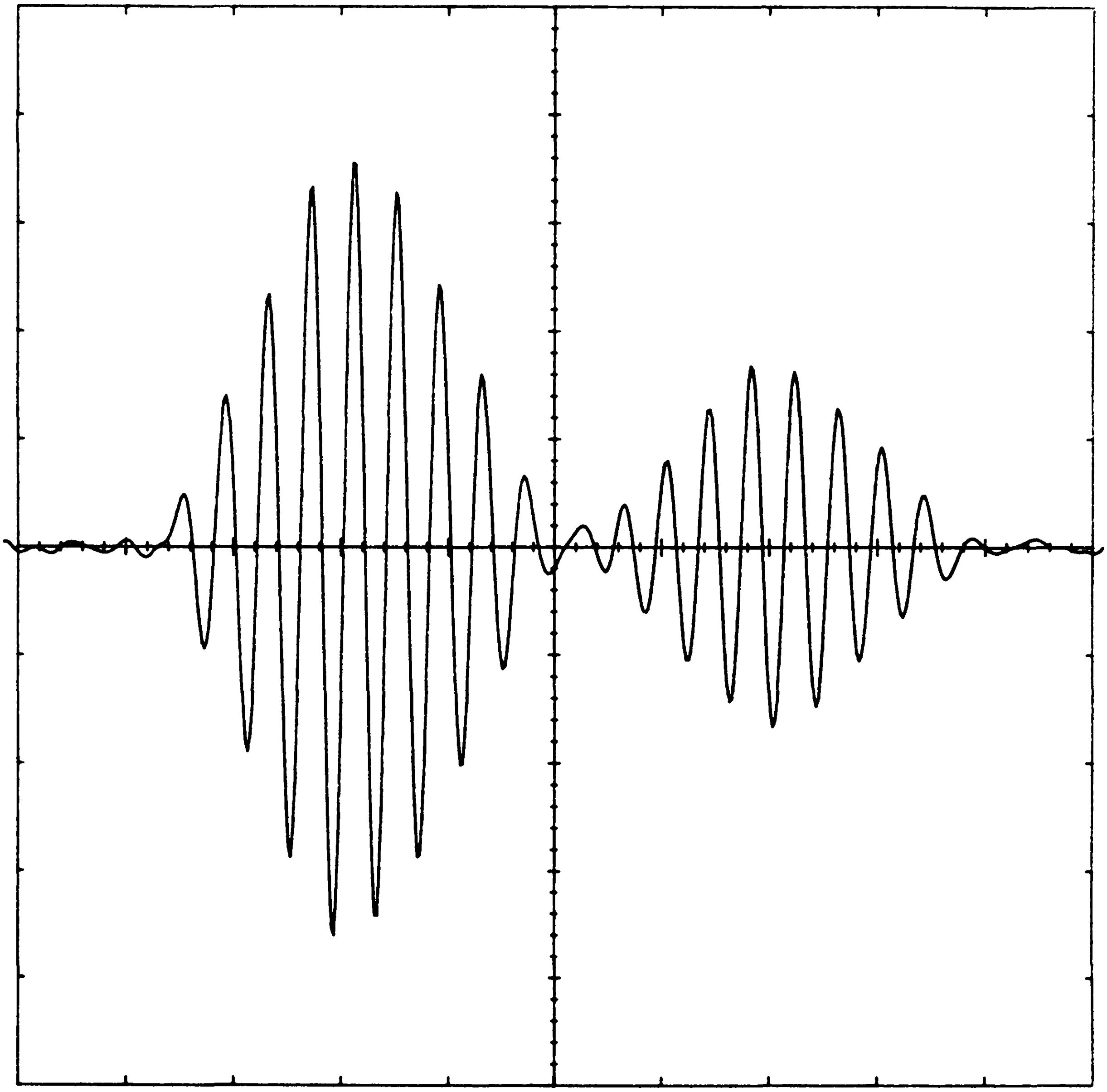

| | | | | | |
|---|---|---|---|---|---|
| Peak-Peak 356.2 mV | RMS 29.58 mV | | Measure-ments | Page to Statistics &Histogram | Rem Wfm 1 L1 Main |
| | | | Main Trig Level 70mV | Main Trig | Main Time Holdoff 2µs |

48 bunches.

aft. g + d.

DSA 602A DIGITIZING SIGNAL ANALYZER
date: 12-SEP-94 time: 18:35:03

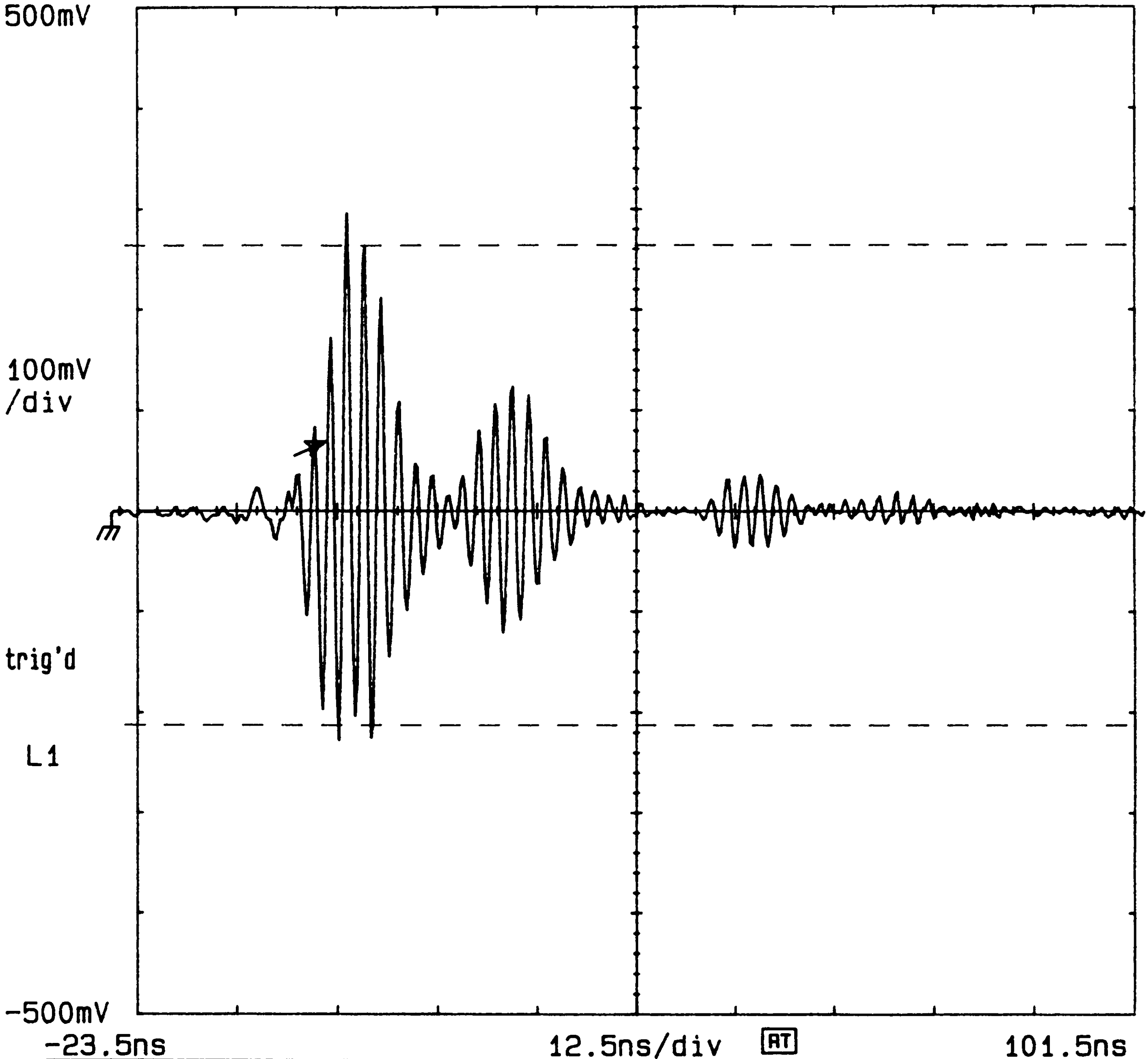
Fig 3



| Peak-Peak | RMS | | Measure-ments | Page to Statistics &Histogram | Rem Wfm 1 L1 Main |
|---|---|---|---|---|---|
| 318.7 mV | 48.90 mV | 24 bunches | | | |

DSA 602A DIGITIZING SIGNAL ANALYZER
date: 12-SEP-94 time: 19:32:32

*Fig 4*

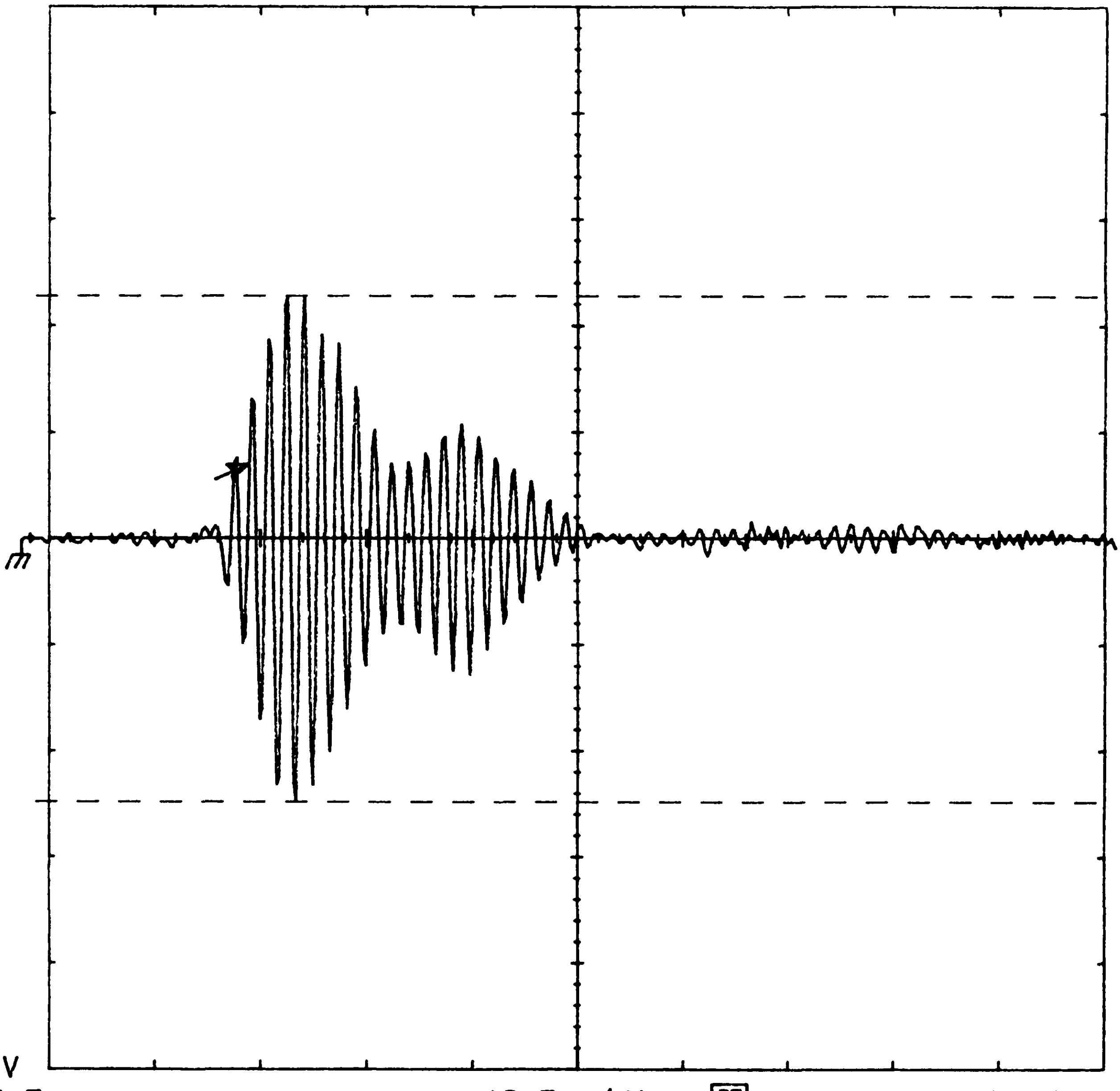



| | | | | | |
|---|---|---|---|---|---|
| Peak-Peak 493.3 mV | RMS 124.3 mV | | Measure-ments | Page to Statistics &Histogram | Rem Wfm 1 L1 Main |
| | | | Horizontal Magnify 2 x | Pan/ Zoom On | Horizontal Pos Gr 60 pts |

*48 bunch  all 0,6 + 0,54 ·  f + g*

DSA 602A DIGITIZING SIGNAL ANALYZER
date: 12-SEP-94 time: 19:11:35

Fig 5

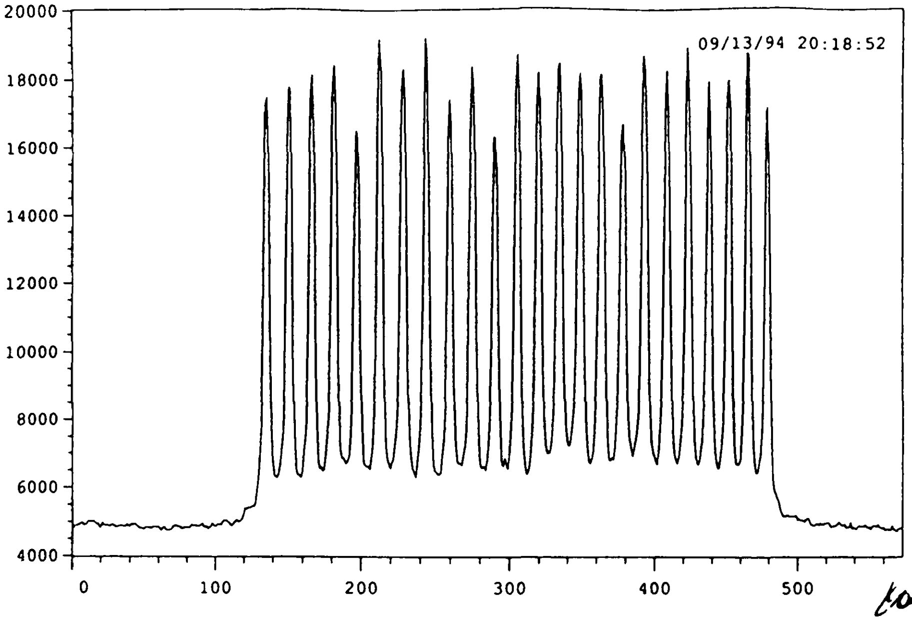



| Peak-Peak 475.2 mV | RMS 71.04 mV | | Measure-ments | Page to Statistics &Histogram | Rem Wfm 1 L1 Main |
|---|---|---|---|---|---|
| | | | Horizontal Magnify 2 x | Pan/ Zoom On | Horizontal Pos Gr 60 pts |

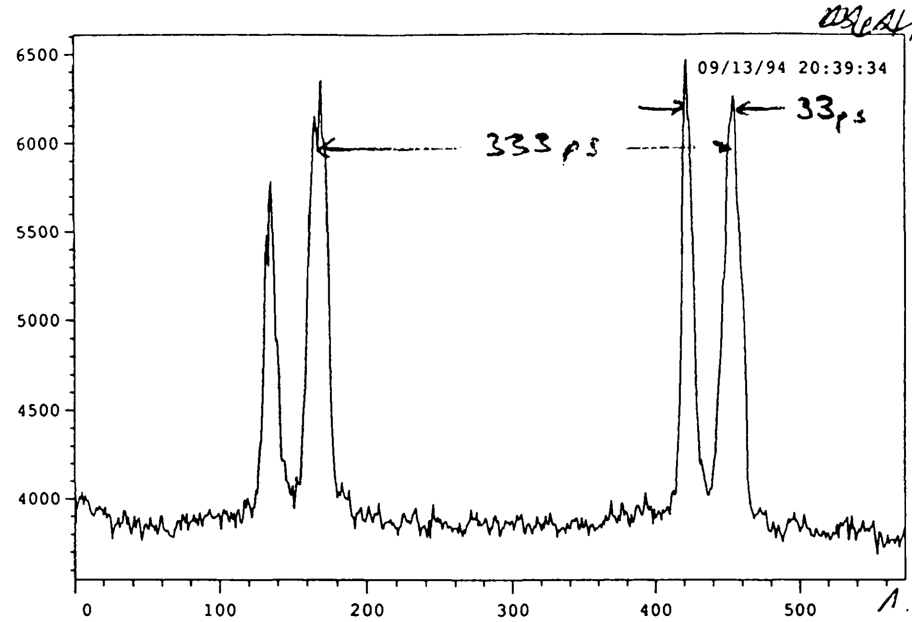
48 bunches

double train of 2 X 24 bunches

. 30 GHz pair in 3GHz train




23.05 ps/pixel




Pairs

1.14 ps/pixel

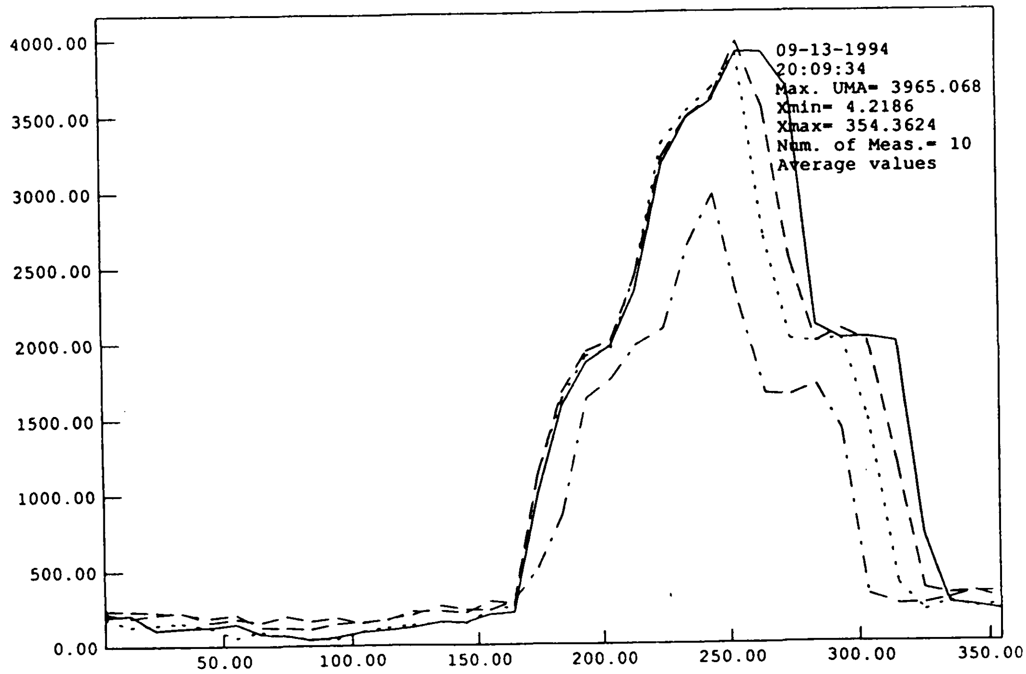



Fig. 6

| Charge | | Emittance | error | Spot size FWHH (V/√2) | | | | SNF380 | SNF350 | PHASE GUN |
|---|---|---|---|---|---|---|---|---|---|---|
| [total*10^8] | [nC per bunch] | [mm*mrad] | [mm*mrad] | [H mm] | [H error mm] | [V mm] | [V error mm] | [A] | [A] | [deg] |
| 530 | 4.2 | 46.3 | 6 | 4.55 | 0.3 | 8.70 | 0.2 | 55 | 53 | 25 |
| 290 | 2.3 | 39.9 | 6 | 5.00 | 0.2 | 5.20 | 0.2 | 55 | 53 | 25 |
| 93 | 0.7 | 36.3 | 4 | 4.29 | 0.2 | 5.95 | 0.4 | 55 | 53 | 25 |
| 72 | 0.6 | 39.1 | 6 | 4.28 | 0.4 | 2.53 | 1 | 55 | 53 | 25 |
| 530 | 4.2 | 146.4 | 16 | 2.40 | 0.07 | 3.56 | 0.3 | 53 | 58 | 35 |
| 290 | 2.3 | 75.2 | 8 | 2.40 | 0.07 | 3.56 | 0.3 | 53 | 58 | 35 |
| 200 | 1.6 | 38 | 4 | 2.40 | 0.07 | 3.56 | 0.3 | 53 | 58 | 35 |
| 72 | 0.6 | 22.3 | 2 | 2.40 | 0.07 | 3.56 | 0.3 | 53 | 58 | 35 |

1) Logbook 142 – 146

2) Logbook P 153, 154

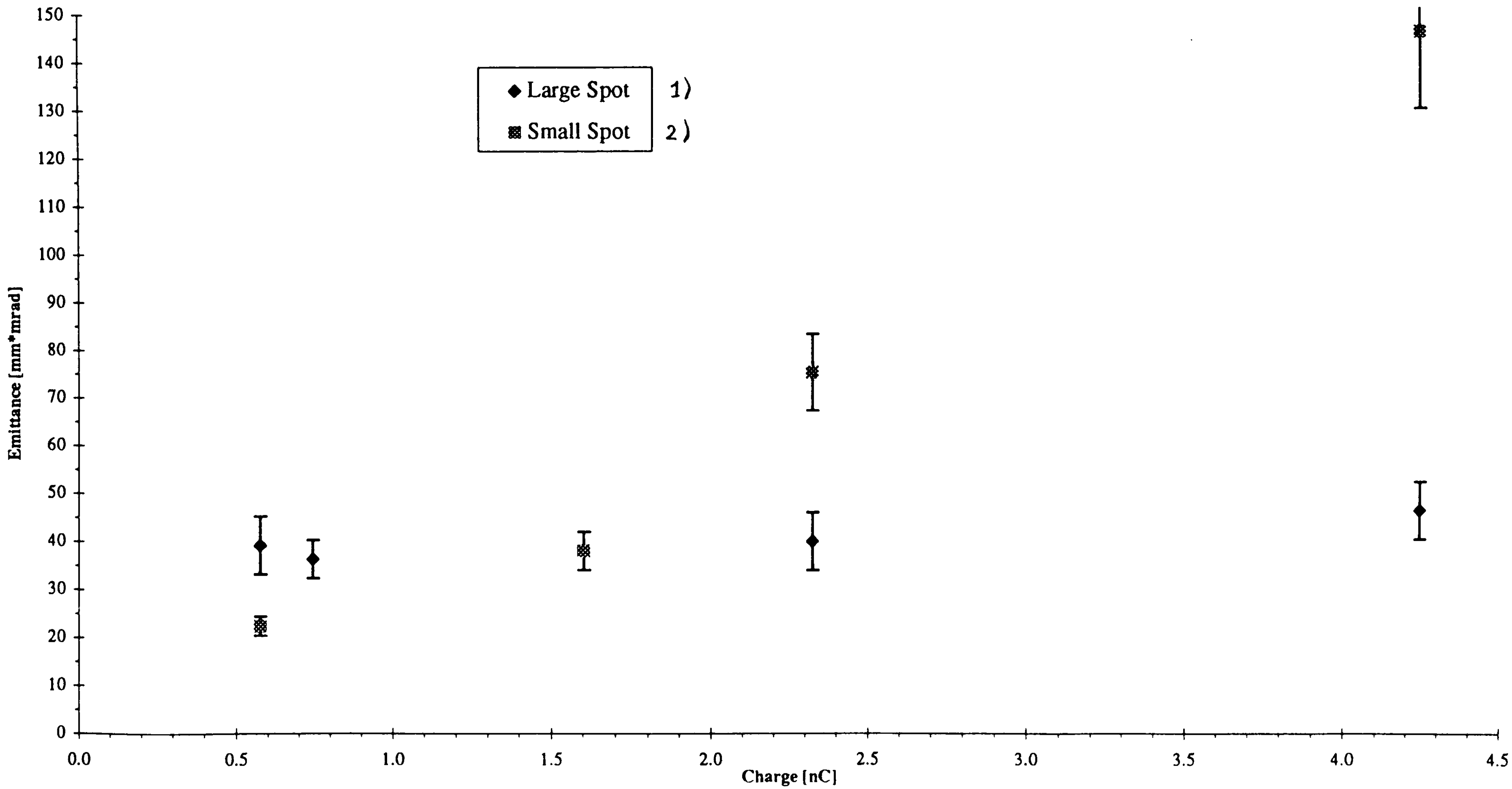
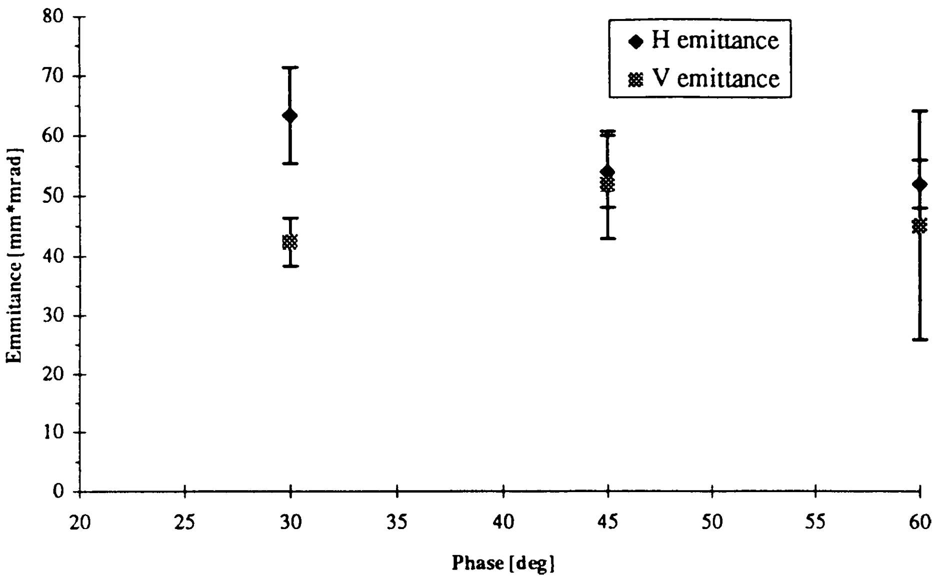



Fig 7.

| Charge | | Phase Gun | Emittance [mm*mrad] | | | | SNF380 | SNF350 |
|---|---|---|---|---|---|---|---|---|
| *10^8 | [nC] | deg | H | Error | V | Error | A | A |
| 60 | 1.0 | 30 | 63.3 | 8 | 42.2 | 4 | 60 | 25 |
| 75 | 1.2 | 45 | 53.8 | 6 | 51.6 | 9 | 60 | 25 |
| 60 | 1.0 | 60 | 51.7 | 4 | 44.8 | 19 | 60 | 25 |

Normal spot size




Log book p 109,110

Fig 8 a)

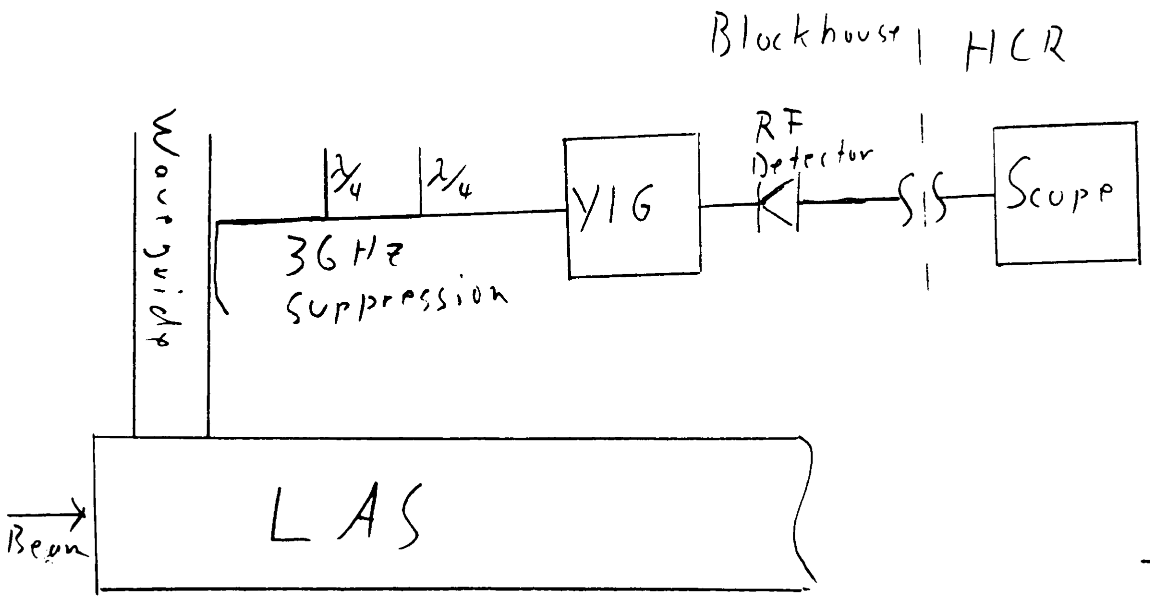



Fig 8 b)

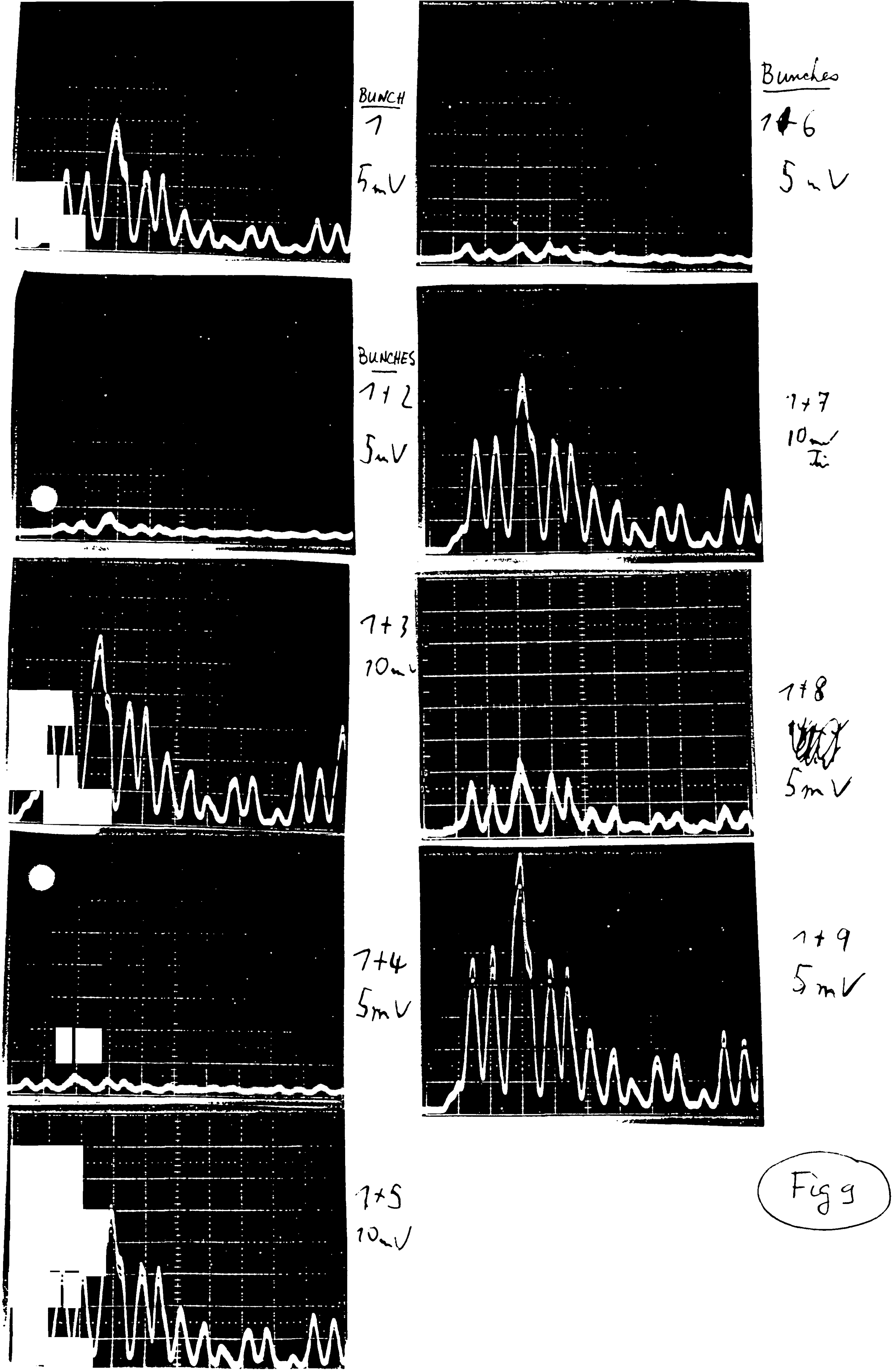
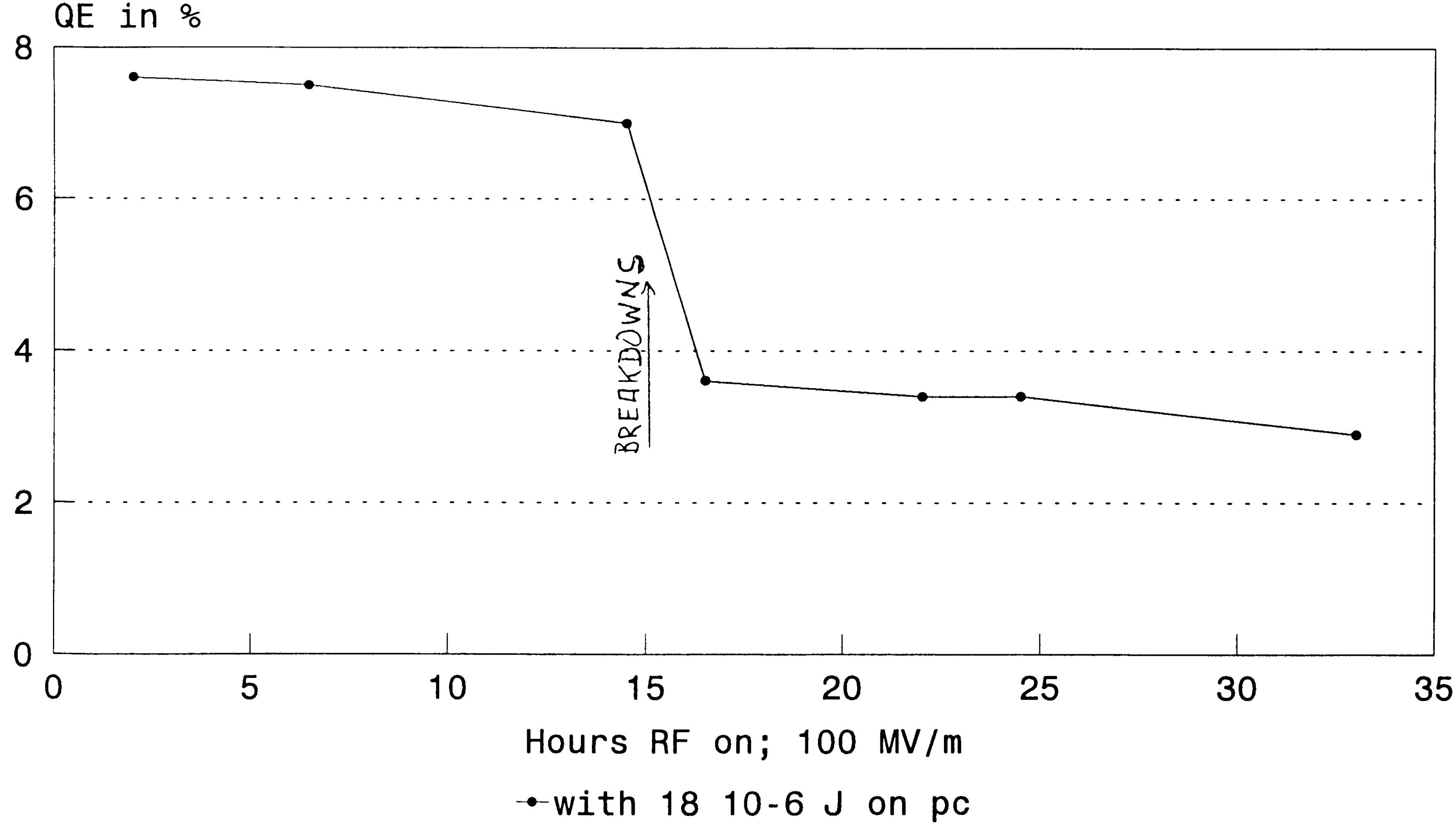

BUNCH
1
5 mV
Bunches
1+6
5 mV
BUNCHES
1+2
5 mV
1+7
10 mV
1+3
10 mV
1+8
5 mV
1+4
5 mV
1+9
5 mV
1+5
10 mV

Fig 9

Life time of a CS2Te cathode in RF gun

as function of hours RF and laser on.




Logbook R3 p57 , 2 - 9 Nov.1994

Fig 10

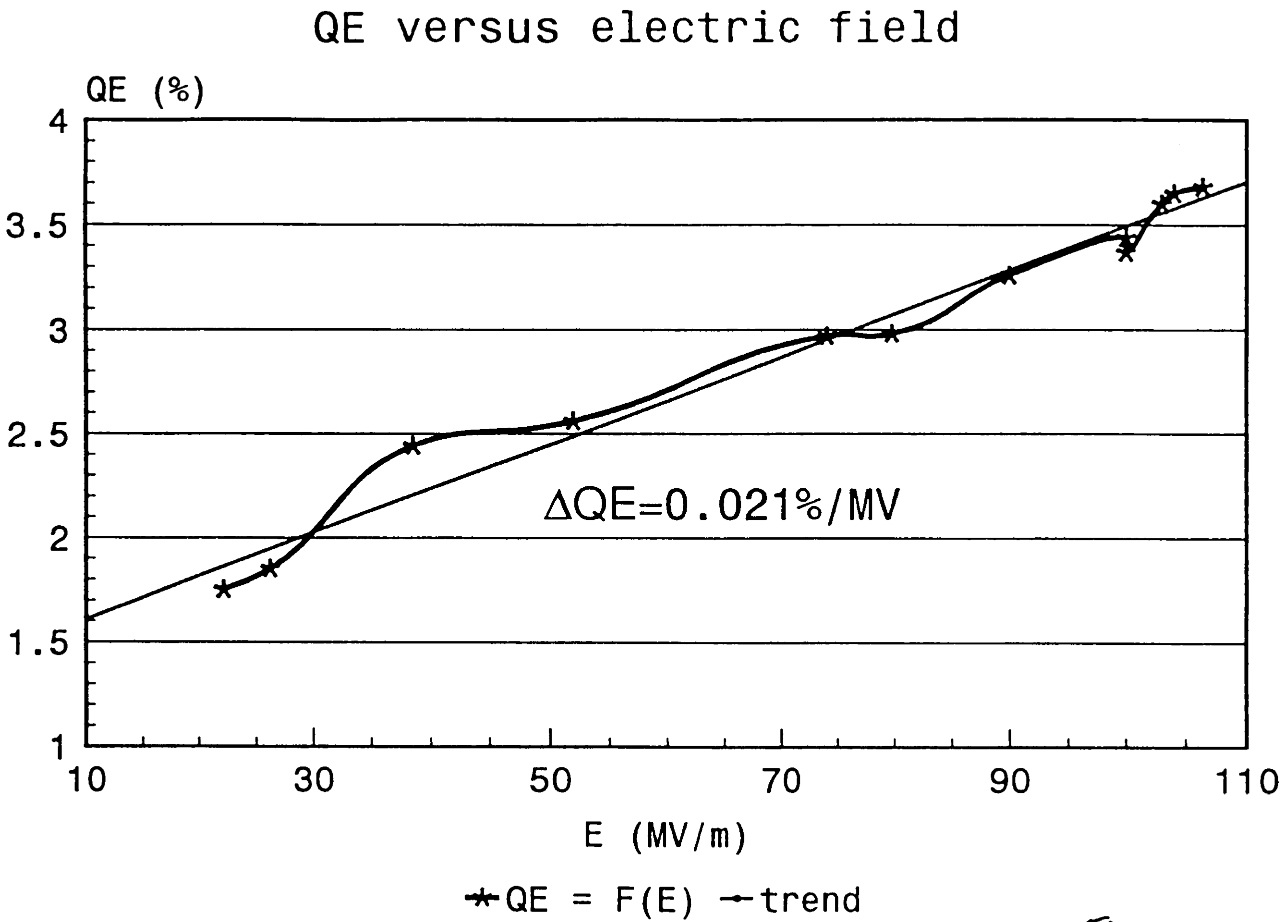

QE versus electric field
QE (%)
4
3.5
3
2.5
2
1.5
1
10
30
50
70
90
110
E (MV/m)
ΔQE=0.021%/MV
QE = F(E)
trend

Fig 11

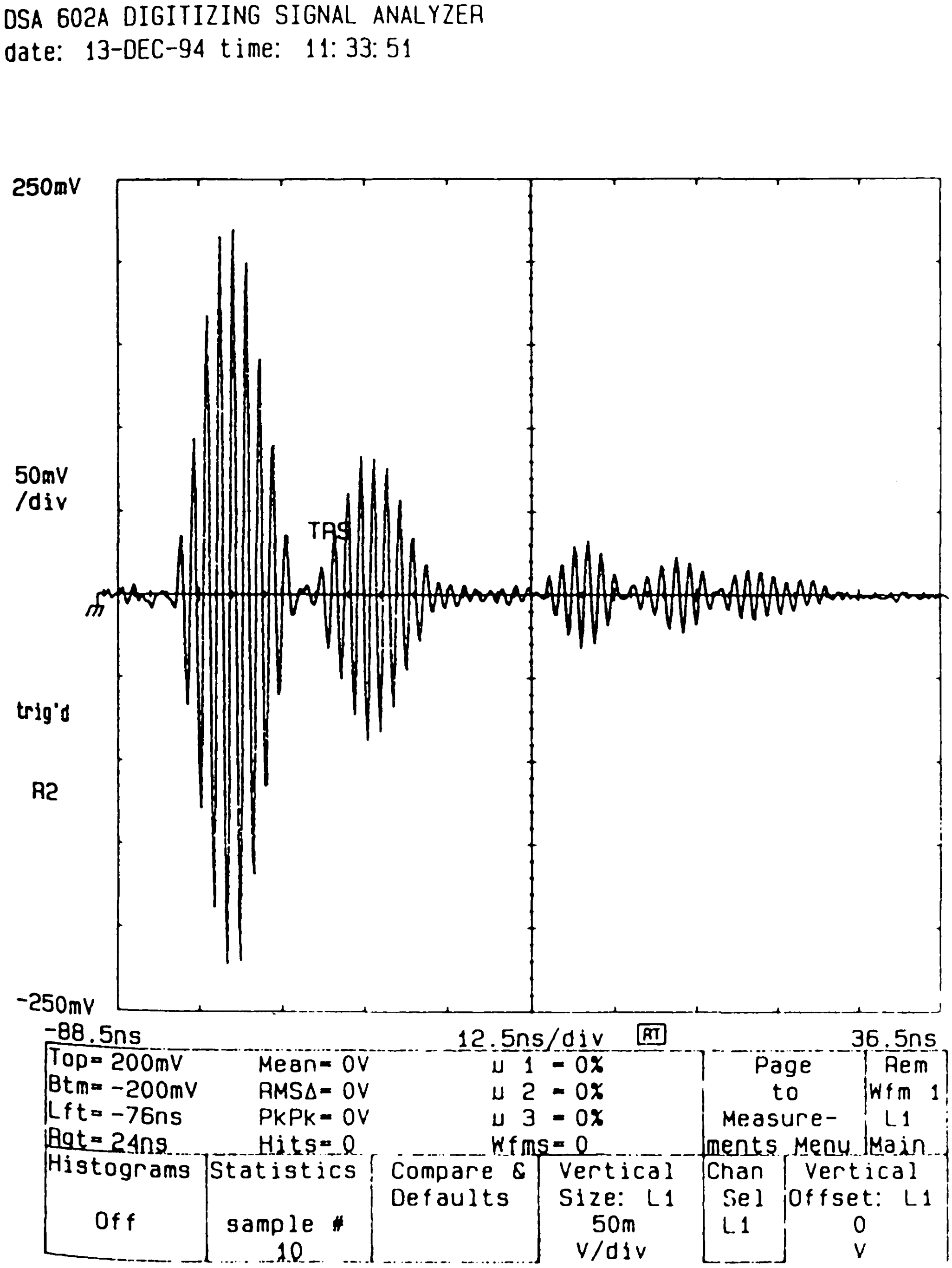

DSA 602A DIGITIZING SIGNAL ANALYZER
date: 13-DEC-94 time: 11:33:51
250mV
50mV
/div
trig'd
R2
-250mV
TRS
-88.5ns
12.5ns/div
36.5ns
Top= 200mV
Btm= -200mV
Lft= -76ns
Rgt= 24ns
Mean= 0V
RMSΔ= 0V
PkPk= 0V
Hits= 0
u 1 = 0%
u 2 = 0%
u 3 = 0%
Wfms= 0
Page to Measure-ments Menu
Rem Wfm 1 L1 Main
Histograms Off
Statistics sample # 10
Compare & Defaults
Vertical Size: L1 50m V/div
Chan Sel L1
Vertical Offset: L1 0 V

Fig 12

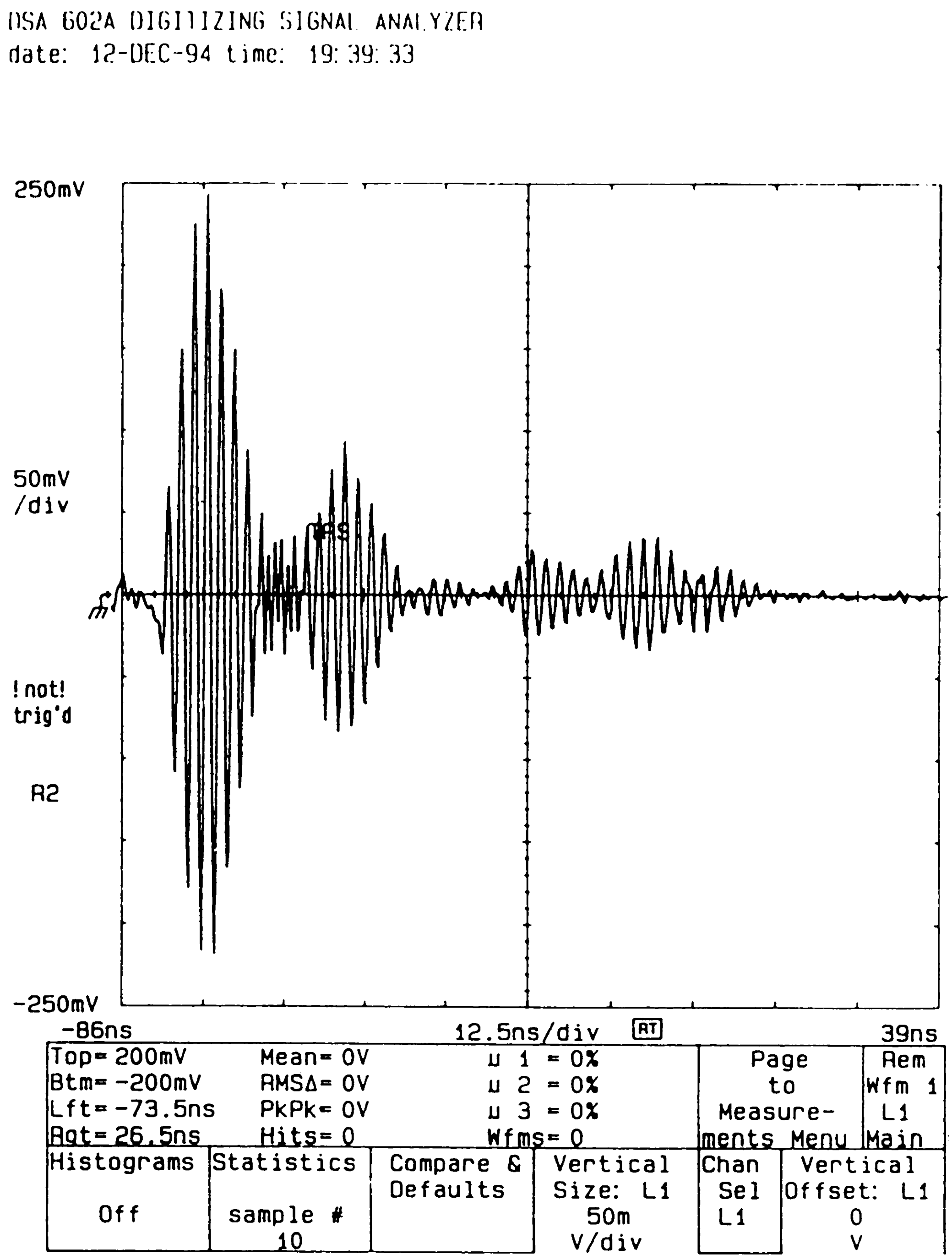
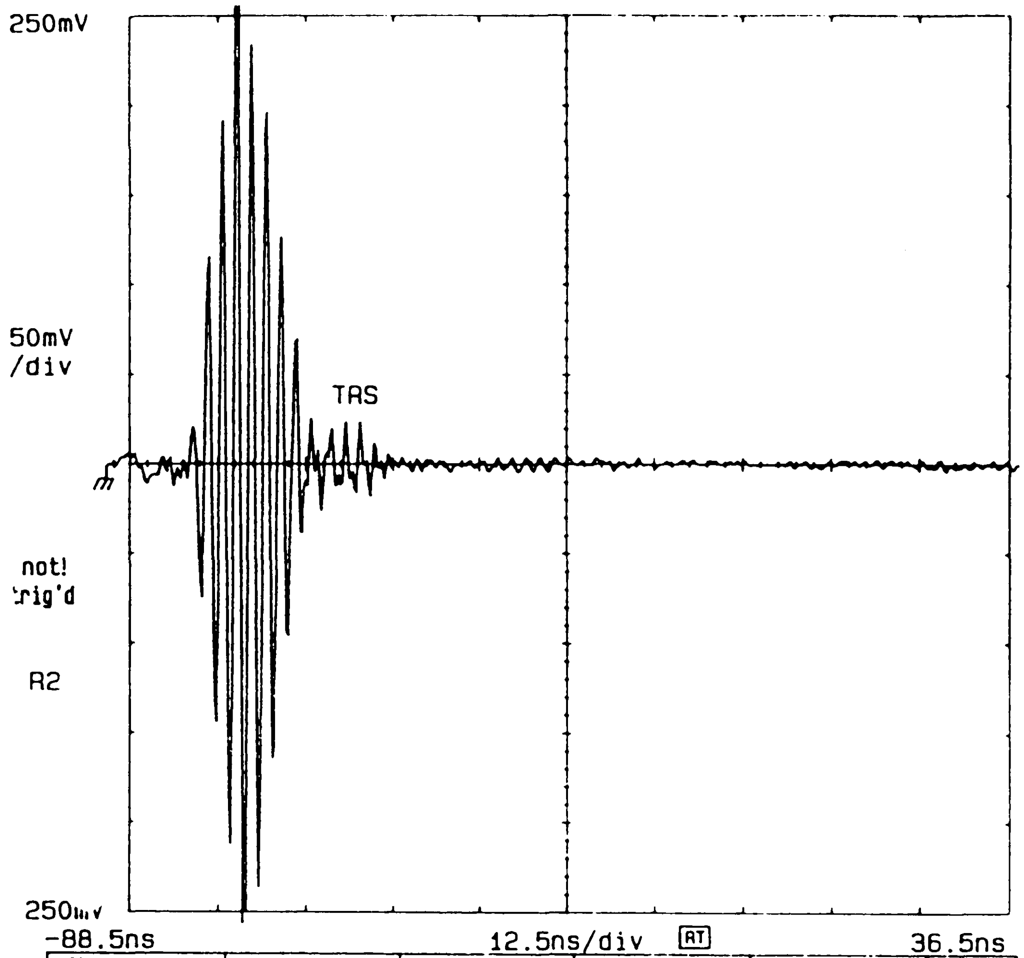

DSA 602A DIGITIZING SIGNAL ANALYZER
date: 12-DEC-94 time: 19:39:33
250mV
50mV
/div
!not!
trig'd
R2
-250mV
-86ns
12.5ns/div
RT
39ns
Top= 200mV
Btm= -200mV
Lft= -73.5ns
Rgt= 26.5ns
Mean= 0V
RMSΔ= 0V
PkPk= 0V
Hits= 0
μ 1 = 0%
μ 2 = 0%
μ 3 = 0%
Wfms= 0
Page to Measurements Menu
Rem Wfm 1 L1 Main
Histograms Off
Statistics sample # 10
Compare & Defaults
Vertical Size: L1 50m V/div
Chan Sel L1
Vertical Offset: L1 0 V

Fig 13

DSA 602A DIGITIZING SIGNAL ANALYZER
date: 13-DEC-94 time: 12:22:02

Fig 14




| | | | | | |
|---|---|---|---|---|---|
| Trigger Select Main | Source Desc R2 | Level 100mV | Time Holdoff 7μs | Mode Normal | Rem Wfm 1 L1 Main |
| Coupling DC | Slope + | Timer t1 Timer t2 2ns 1ms | Horizontal Magnify 2 x | Pan/ Zoom On | Horizontal Pos Gr 20 pts |

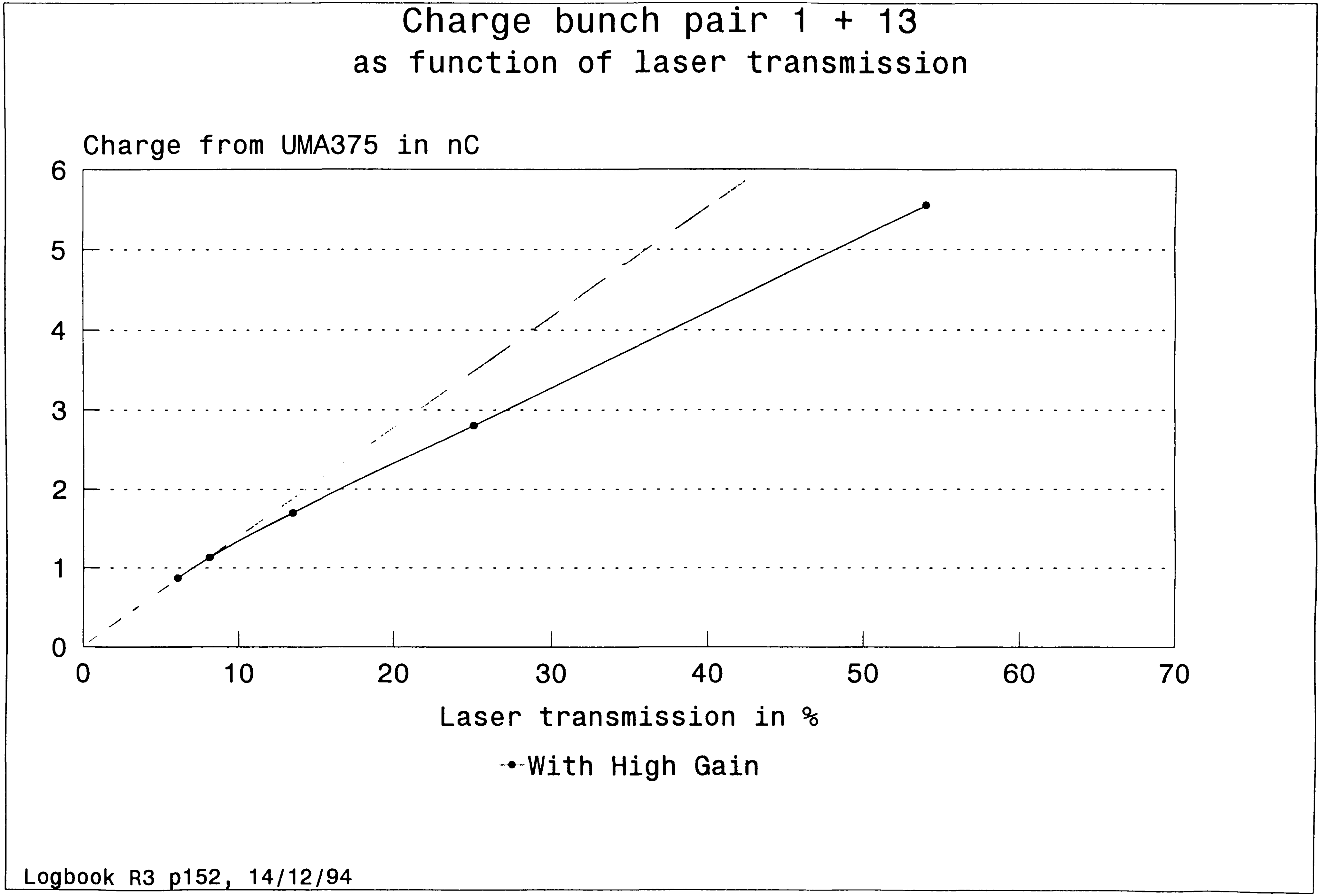

Charge bunch pair 1 + 13
as function of laser transmission
Charge from UMA375 in nC
0
1
2
3
4
5
6
0
10
20
30
40
50
60
70
Laser transmission in %
With High Gain
Logbook R3 p152, 14/12/94

Fig 15

Distribution:

| | |
|---|---|
| Autin B. | PS |
| Bossart R. | PS |
| Braun H. | PS |
| Brouet M. | AT |
| Chautard F. | PS |
| Chevallay E. | PS |
| Comunian M. | PS |
| Corsini Roberto | PS |
| Delahaye J.-P. | PS |
| Fischer Claude | SL |
| Garoby, R. | PS |
| Geissler K.K. | AT |
| Godot J.-Cl. | PS |
| Guignard G. | SL |
| Hübner K. | DG |
| Hutchins S. | PS |
| Jensen E. | PS |
| Johnson C. D. | PS |
| Kamber I. | PS |
| Koziol, H. | PS |
| Kugler H. | PS |
| Madsen J.H.B. | PS |
| Metral G. | PS |
| Millich A. | SL |
| Mourier J. | PS |
| Pearce P. | PS |
| Potier J.-P. | PS |
| Riche A.J. | PS |
| Riege Hans | AT |
| Rinolfi L. | PS |
| Rossat G. | PS |
| Schnell W. | Bât. 584 |
| Suberlucq G. | PS |
| Thomi J.C. | PS |
| Thorndahl L. | PS |
| Warner D.J. | PS |
| Wilson I. | SL |
| Wuensch W. | SL |

| | |
|---|---|
| D. Allard | AT |
| M. Lubrano | PS |
| J. Cavaggio | AT |
| B. Pincott | PS |
| A. Rueck | PS |
| G. Yvon | PS |
| M. LeGras | PS |
| J. Buttkus | PS |
| R. Riva | PS |
| A.Braem | PPE - TA1, |
| J-M. Hanon | TIS-RP |
| A. Muller, | TIS-RP |
| J.W.N.Tuyn | TIS - RP |