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PS/ LP/ Note 94-30 (Tech.)

THE CTF RUN N° 1 1994
RESULTS AND COMMENTS

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The CTF Run N°1 1994
Results and Comments

by H. Braun, JHB. Madsen and S.S chreiber - 6/07/1994

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1. General

Start : 28/04/94
End : 10/06/94

Modifications

Beamline :
- gun moved back to make room for the 4 cell booster
- spectrometer BHZ385 with MTV 386 and Faraday Cup (FC)
- added TCM390 behind the gun-booster
- added TCM445 behind TRS, removed TCM630
- line for testing CLIC Beam Pick-Ups (BPM's) - see fig. 1

RF-network: via two 3 dB splitters power to LAS, gun and booster - see fig. 2

RF pulse : the pulse length set to 2.5 us.

Gun: the same (n° 3b) as used during the last run

Booster: a large water leak has been collimated but we hope to have soon another booster

Photocathode : Cu for the initial rf conditioning
Cs2Te for the e-beam, constructed in G. Suberlucq's photocathode lab; one cathode used during the whole run, thickness of layers :

Te 12.7 nm
Cs 8.5 nm
diameter 12 mm
QE in lab 4.1% at 266 nm
0.9% after run

Photocathode transfer system : re-positioned,
introduction cathodes into gun difficult due to too tight tolerances on rf-spring (changed for next run)

Laser : layout as during last run but optics improved with relay imaging and spatial filtering,laser pulse 8 ps FWHH; new HV pulser for Pockelcell

Pulse train generator : as during last run.
Again a train of 24 pulses was most effective for generating 30 GHz power by the CLIC structure. A robust laser pulse selector : the 'Lino select' brought in use (made by M. Frauchiger) P.32

Vacuum in chamber downstream of gun : VGI04 2.0 10-9 T with rf.

2. Objectives of the run. (as written in PS/LP Note 94-09)

- Test the gun-booster ensemble

- Study the lack of charge in bunch trains('memory effect') In the first instance this implies a comparison between the UMA and the FC

- Study the discrepency between the measured 30 GHz from TRS and the computed one using UMA readings.

- Make a suitable beam for the BPM's tests

- Increase the 30 GHz power from TRS and find a stable high-power regime

- Measure beam characteristics as bunch length,transverse emittance.

3. Gun

To measure the momentum of the gun beam we put the attenuator in the waveguide to the booster to its maximum.(about -23 db) The field in the booster still can contribute to the momentum. By varying the phase between gun and booster and changing the current in BHZ385 to centre the beam on screen MTV386 one finds for the gun beam 3.8MeV/c. (fig.3 and page 12,13 of logbook). Expected for the 30 MW at the klystron output : 4.5 MeV/c. Later it was found that the power meter was reading about 10 % too low and the losses in the network are -1.3 dB instead off -1.0 dB. (p 65,66)
Taking this into account the expected momentum is 4.0 MeV/c and the max. field in the gun 89 MV/m.

4. Booster

The construction of the booster suffered from many mishappenings and the cavities had to be cleaned chemically. Nevertheless, the rf conditioning went without any problem. The p of the gun + booster was found by putting behind BHZ385 a 1 mm wide vert slit made of Pb 30 mm thick and followed by a FC. The booster phase was set for min. energy spread. Result : fig.4 , P.28. During the calibration the power into the gun and the booster was 4.8 MW.
Expected p = 9.4 MeV/c. From fig.4 : av. p = 9.5 MeV/c , max.9.9 MeV/c

5. Comparison UMA - FC

The FC is put behind BHZ385. Its calibration is done by J. Durand. Note that a similar cup is compared in the beamline of the photoemission lab with a WCM.

Single bunch.

The charge measured with the UMA agrees with the FC up to 13.4 nC, see p. 29 and 39. The FC gives about 5 % less. Above 13 nC the beam dimension becomes too large for fully entering the FC (checked on screen MTV386).

Train of 8 bunches with intra-pulse spacing of 333 ps

FC : the total charge of the train (54.7 nC) is 6.4 % less than the sum of the individual bunches. Page 53

UMA375 : the total charge is 50 % less than the sum of the bunches given by the digital readout but the peak value of the analogue signal, seems to compare well with the FC, Fig..5

We looked during the bunch-adding experiments as well at the streakcamera picture from TCM390C and saw no effect by adding/removing bunches. P.50

Conclusion : the gun has no 'memory' defect for a 8-bunch train up to 7 nC per bunch. The defect observed previously is instrumental.

Train of 24 bunches spaced at 333 ps

The laser energy was varied and the charge measured with UMA375 and the FC, Fig. 6 , p. 82/83/84. UMA digital agrees with the FC up to a total charge of 30 nC. Note that a record total charge of 146 nC was achieved at UMA375, P. 84.

6. Single bunch performances

As the UMA digital reading agrees with the FC at least up to 13 nC, we can now validate the results found last year on the relation laser energy on the cathode - charge behind gun. (PS/LP Note 94-07,Min, fig .6).

We did not try to get the highest possible charge through TRS but achieved with a large laser spot on the cathode, about 11 by 15 mm, for UMA375/395/406/455 : 4.51 / 4.38 / 4.35 / 3.87 nC (av. over 100 pp) and a bunch length before TRS of 15 ps FWHH,
a mean 30 GHz peak power of 340 kW , max. peak power 500 kW, P. 39.

Taking the charge at the TRS input - 4.35 nC - we find that 340 kW is generated if the spectral factor F = 0.78, corresponding to bunch length is 8.7 ps. The peak power is more difficult to relate to the charge as the measurements are not correlated.

7. The 24 bunch train performances

For optimal 30 GHz power generation the intra-bunch spacing must be set to 333 +- 2 ps. The position of the mirrors of the laser pulse train generator (ptg) determines this spacing. The ptg is checked by making a phase - charge scan for each of 12 bunches.

As a final check one measures the 30 GHz power from each bunch alone and then sees if each bunch adds its power to that of the reference bunch 1.

To find the sensitivity of the timing adjustment for the 30 GHz power generation the following experiment was made. The power from bunch 1 and from bunch 9 alone and both together were measured. Then the timing of bunch 9 was changed by a mirror shift in the laser path keeping the position on the cathode constant. For a 0.5 mm shift which corresponds to a timing change of 3.3 ps the power from bunch 1 + 9 changed by 2.7 % only, see fig. 7 and note the effect of phase compression in the gun at low phases.

The position of each of the laser pulses on the cathode has to be checked and adjusted. Before entering the beam chamber a fraction of the laser pulse is deflected to a screen acting as a virtual cathode in air. Each laser pulse is adjusted with the screen/TV monitor Laser spot on cathode: diam. 10 mm

Results : typically UMA375/395/406/455 - 42.9 / 43.2 / 43.1 / 32.7 nC generating over hours between 35 and 44.5 MW peak power at 30 GHz, p. 78-81, see fig. 8.

Power calculated with charge entering TRS (UMA406) :
54.2 MW for F=1, implying a bunch length of 0 ps
and 40.0 MW for F=0.86, " " 7 ps
and 15.8 MW for F=0.54 " " 14 ps

Power calculated with charge leaving TRS (UMA455) : 31. MW for F=1

It seems we need more data and analysis for explaining the above results. Also, is there a systematic error in the TCM bunch length measurement? Note that the bunch train behind TRS (TCM452T) is very much disturbed. (photo's next time)

The '93 record of 34.5 MW was beaten and is now 44.5 MW. Due to the beneficial effect of the booster, of the improved laser beam, of the better overall beam tuning or a mixture of all that ? The laser contributed with a good position and amplitude stability, with its large and more uniform spot size.

8. A long laser pulse

From the ptg two pulses are selected and one of them shifted in time. In this way two double pulses were created : one with a spacing of 6.5 ps the other with 24 ps.

The 6.5 ps pair : each alone gave in the FC 15 nC; the pair : 23.3 nC
The 24. ps " : the first alone 15 nC, second 16.5 nC; pair : 26. nC

The 24. ps pair gave a bunch seen with TCM445C with a length of 23.5 ps FWHH. Fig. 9: a single bunch !

Next time we shall observe the bunch behind the gun-booster with TCM390C to see if the rf bunching has then taken place already. Note that with a laser 'pair pulse' (or by bypassing the stretcher) we hope to make a bunch suitable for the magnetic bunch compressor. We know now that more charge can be obtained in a single bunch by increasing the laser pulse length.

9. Comparing results from beam simulations with experimental data

PARMELA predicts a bunch length of 6.3 ps , TCM390C gives 14 ps FWHH, page 73. We can and should suspect the TCM measurement but we should remember that a similar detector gave for the micro bunches in LIL the expected value.

The beam momenta from gun and booster agree well with the simulations but the p behind LAS, measured with BHZ430,is 59.6 MeV/c while predicted by L. Rinofi : 69.3 MeV/c, p. 73. However, we found earlier already that according BHZ500 the p is 1.15 times higher....thus 68.7 MeV/c.

There is a discrepancy as well between the theoretical optics and the experimental settings, p. 68.

Theory : SNF350/370 : 61 / 72 A or 63 / 93 A
Exp. : „ : 51 / 53 A

This problem has to be solved as the settings for the bunch compressor optics will largely be theoretical. (too many knobs for fiddling).

10. The beam line for the BPM's testing

At the input of the line is a W-collimator with l = 20 mm, diam = 30 mm and a 1 mm diam hole on the axis. Due to the good alignment of the collimator a beam could be set-up with the help of MTV510.

First result : fig. 10 ,measured by J. Sladen, I. Wilson and W. Wuensch.

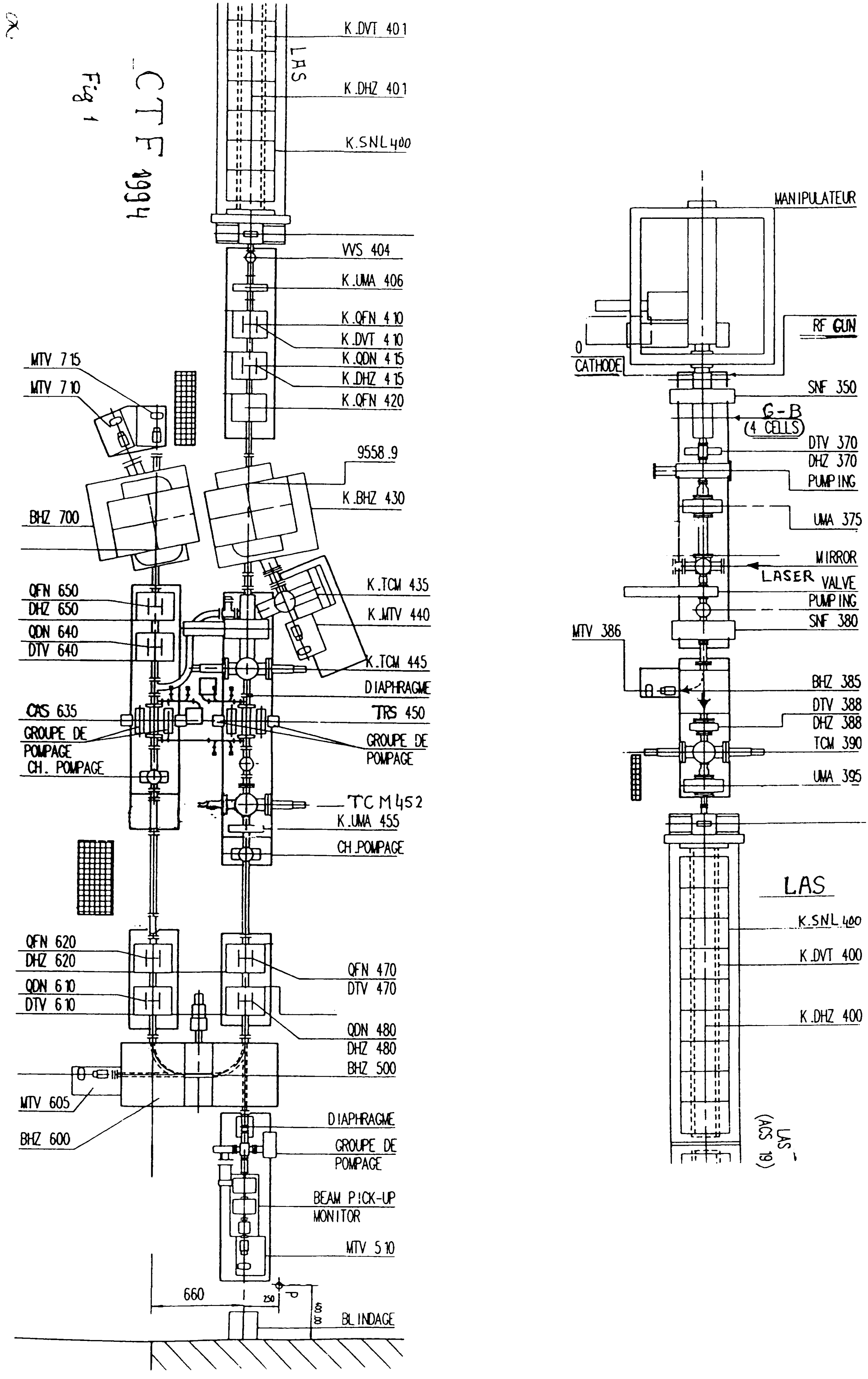

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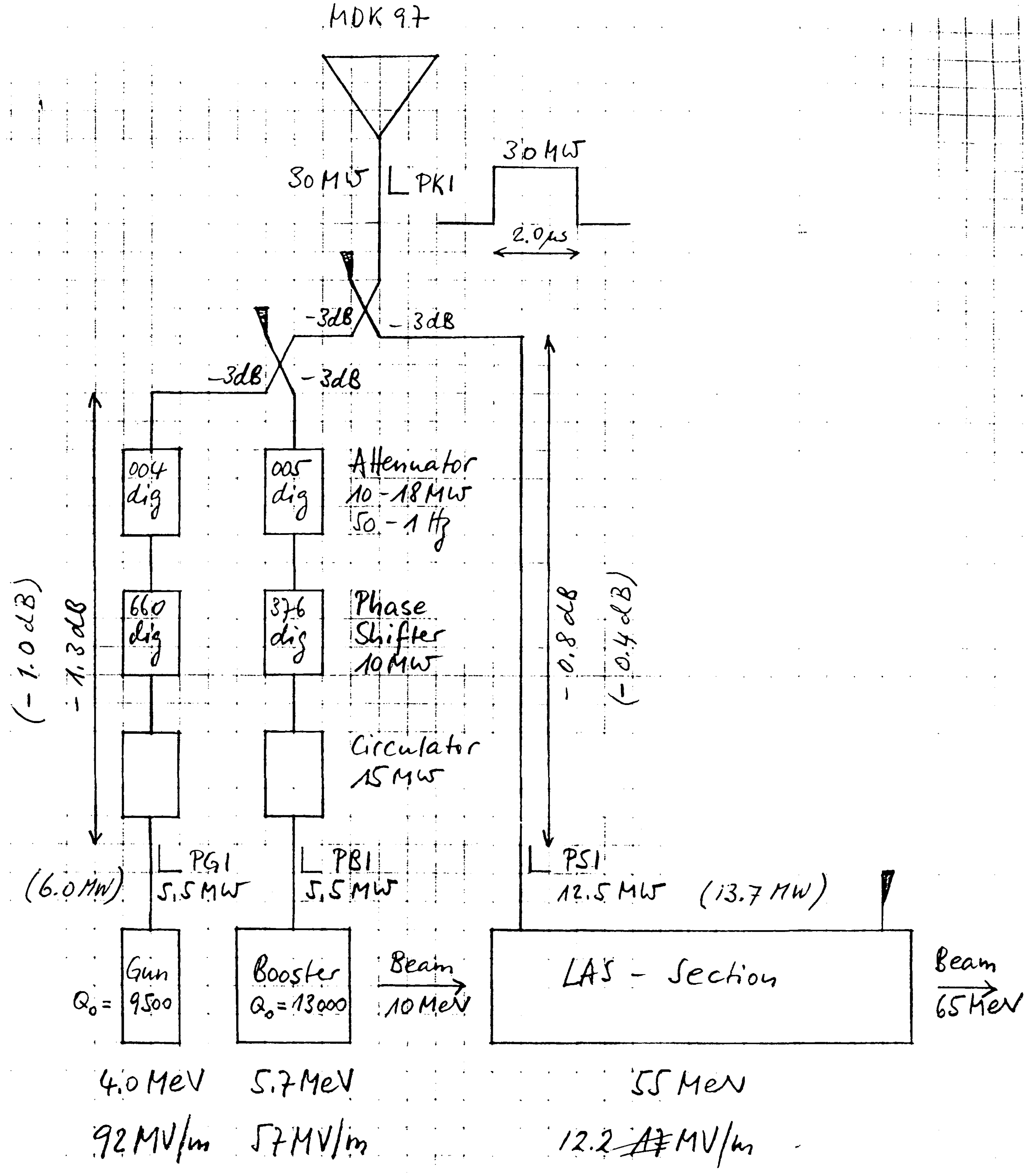
Fig 1
K.DVT 401
LAS
K.DHZ 401
K.SNL400
VWS 404
K.UMA 406
K.QFN 410
K.DVT 410
K.QDN 415
K.DHZ 415
K.QFN 420
9558.9
K.BHZ 430
MTV 715
MTV 710
BHZ 700
K.TCM 435
K.MTV 440
K.TCM 445
DIAPHRAGME
TRS 450
GROUPE DE POMPAGE
QFN 650
DHZ 650
QDN 640
DTV 640
CAS 635
GROUPE DE POMPAGE
CH. POMPAGE
TCM452
K.UMA 455
CH.POMPAGE
QFN 620
DHZ 620
QDN 610
DTV 610
QFN 470
DTV 470
QDN 480
DHZ 480
BHZ 500
MTV 605
BHZ 600
DIAPHRAGME
GROUPE DE POMPAGE
BEAM PICK-UP MONITOR
MTV 510
660
250
P
BLINDAGE
MANIPULATEUR
RF GUN
0
CATHODE
SNF 350
G-B
(4 CELLS)
DTV 370
DHZ 370
PUMPING
UMA 375
MIRROR
LASER
VALVE
PUMPING
SNF 380
MTV 386
BHZ 385
DTV 388
DHZ 388
TCM 390
UMA 395
LAS
K.SNL400
K.DVT 400
K.DHZ 400
LAS (ACS 19)

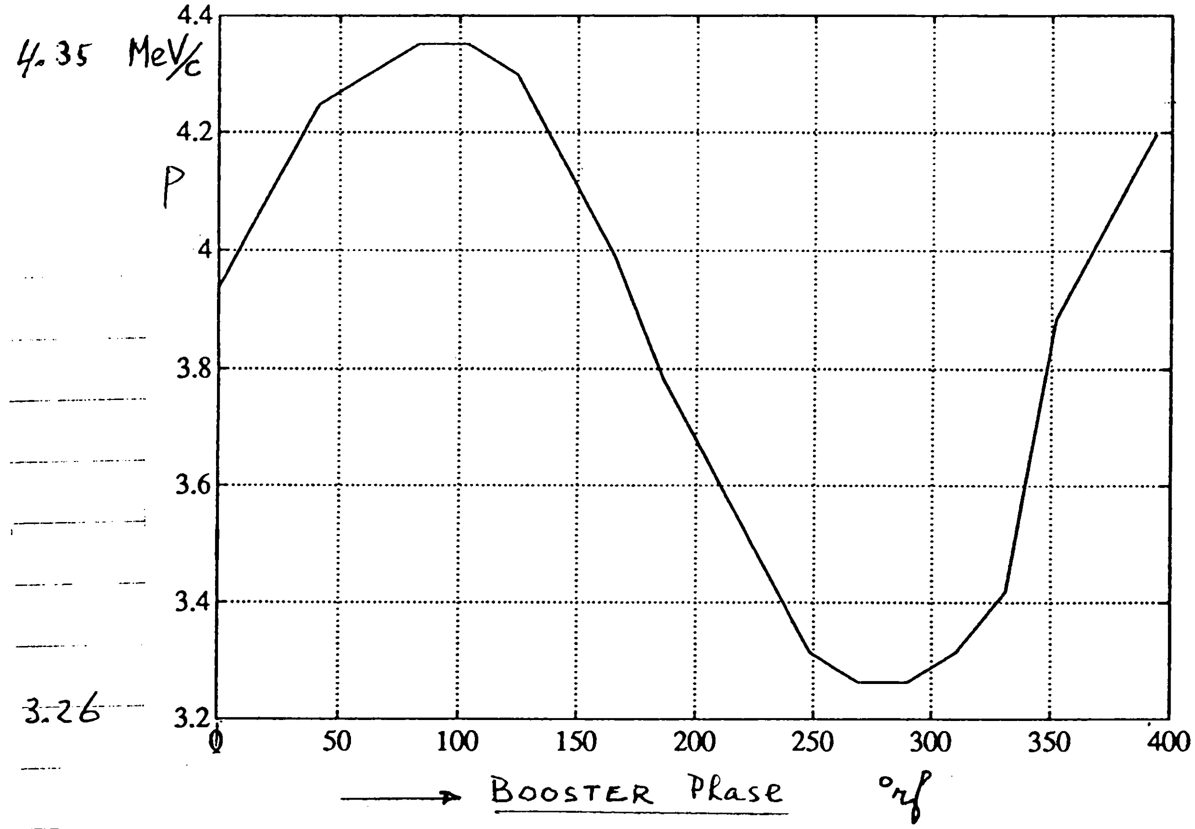
Fig 2



Calibration of RF Network for CTF

JM, GR, RB 3.6.94

(between brackets: values assumed up to 3.6.94)

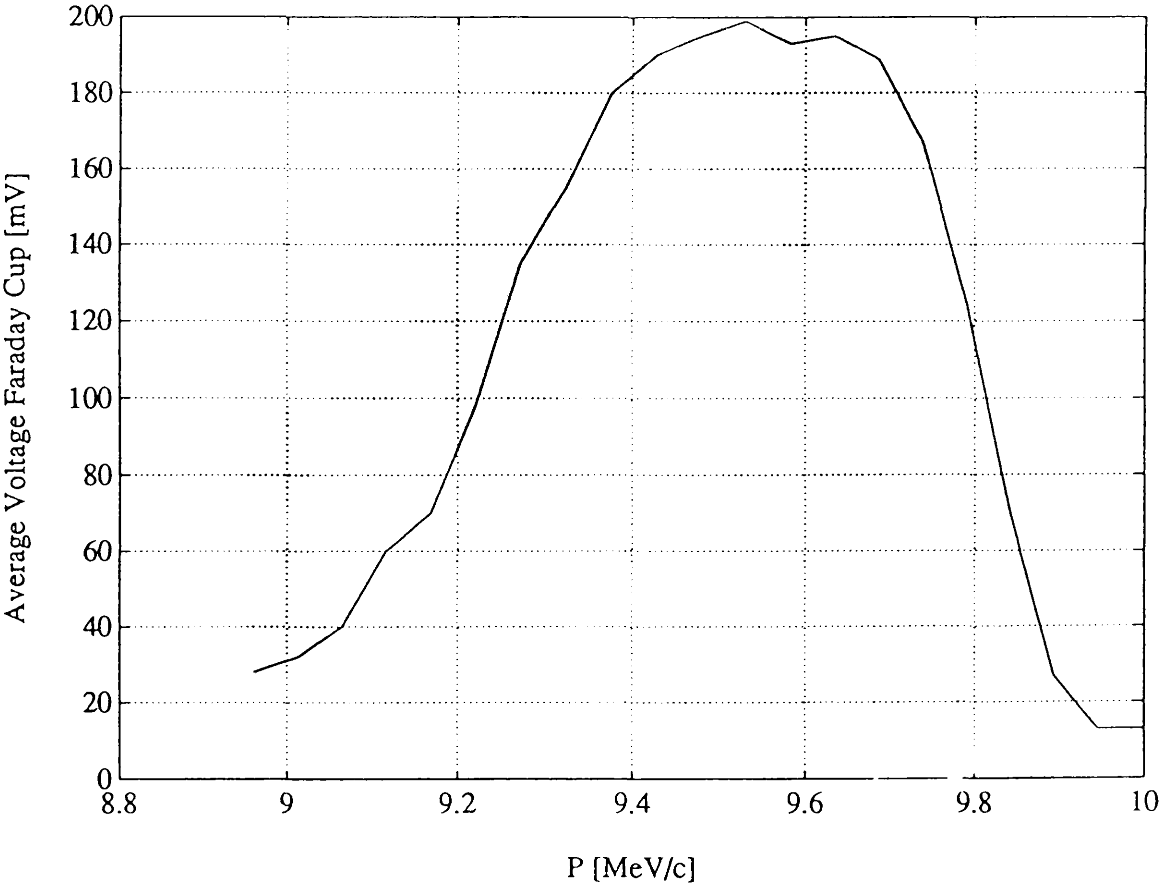


p = I(BHZ 385, A) · 0.518 MeV/c

BOOSTER ATTENUATOR AT −23 dB

BEAM : UMA375 − 3.2 nC

Fig. 3 Beam momentum from gun as function of booster phase with field in booster at its minimum.



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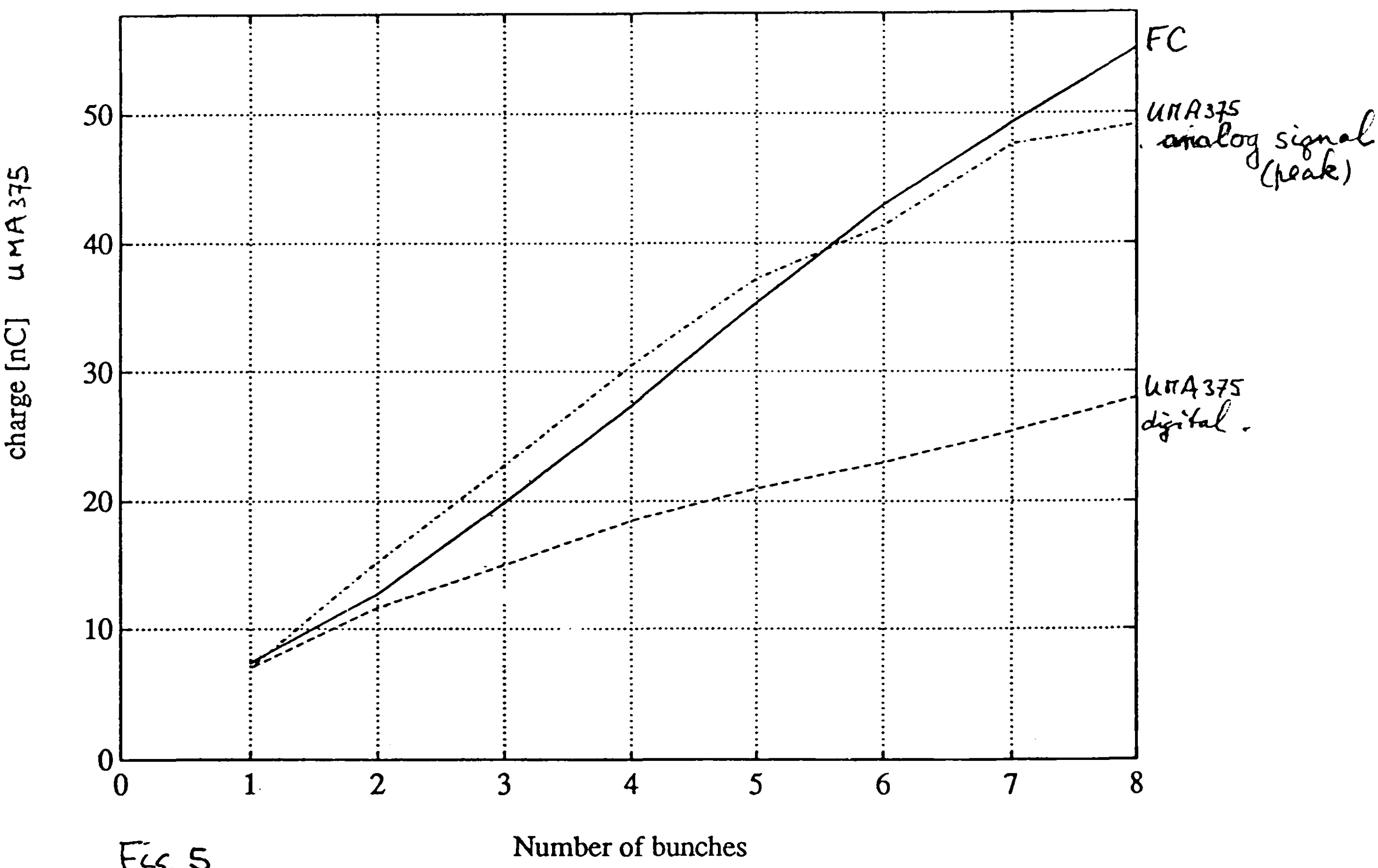
AH. Din page 28

UMA 375 → 235.10^8

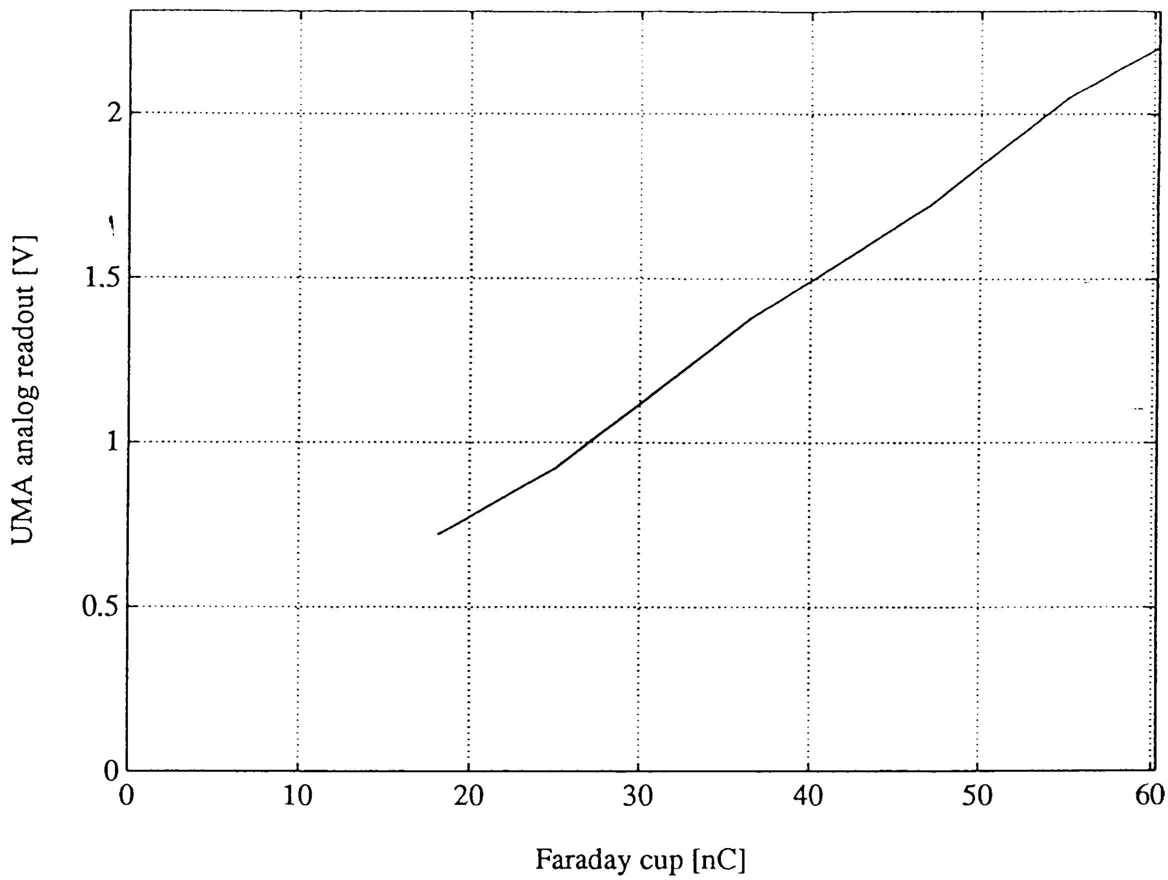
Fig. 4 Momentum spectrum of gun + booster beam



charge [nC] uMA375
0
10
20
30
40
50
0
1
2
3
4
5
6
7
8
FC
uMA375
analog signal
(peak)
uMA375
digital
Number of bunches

Fig 5

24 Bunch calibration



Measurement from 9.6.94

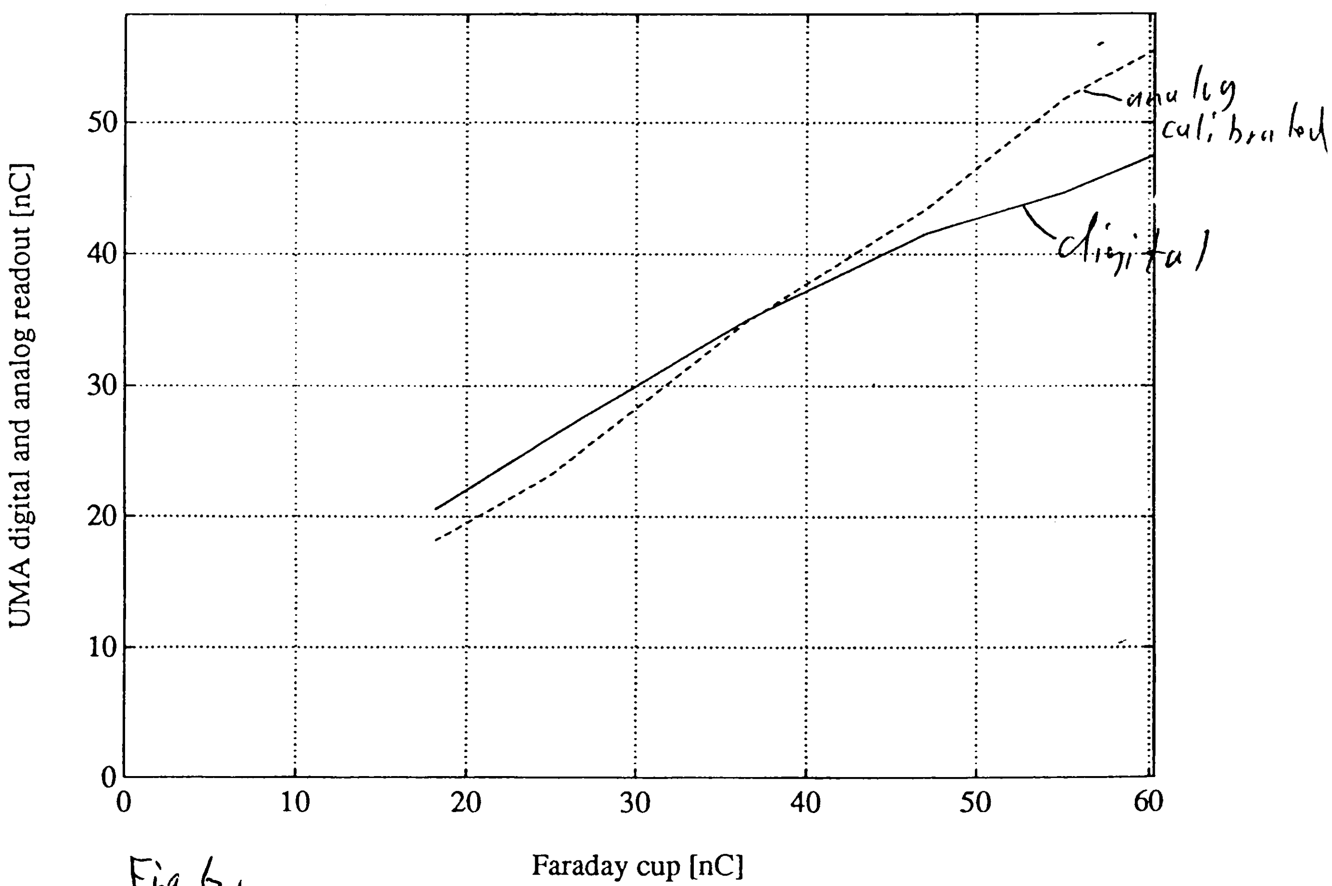
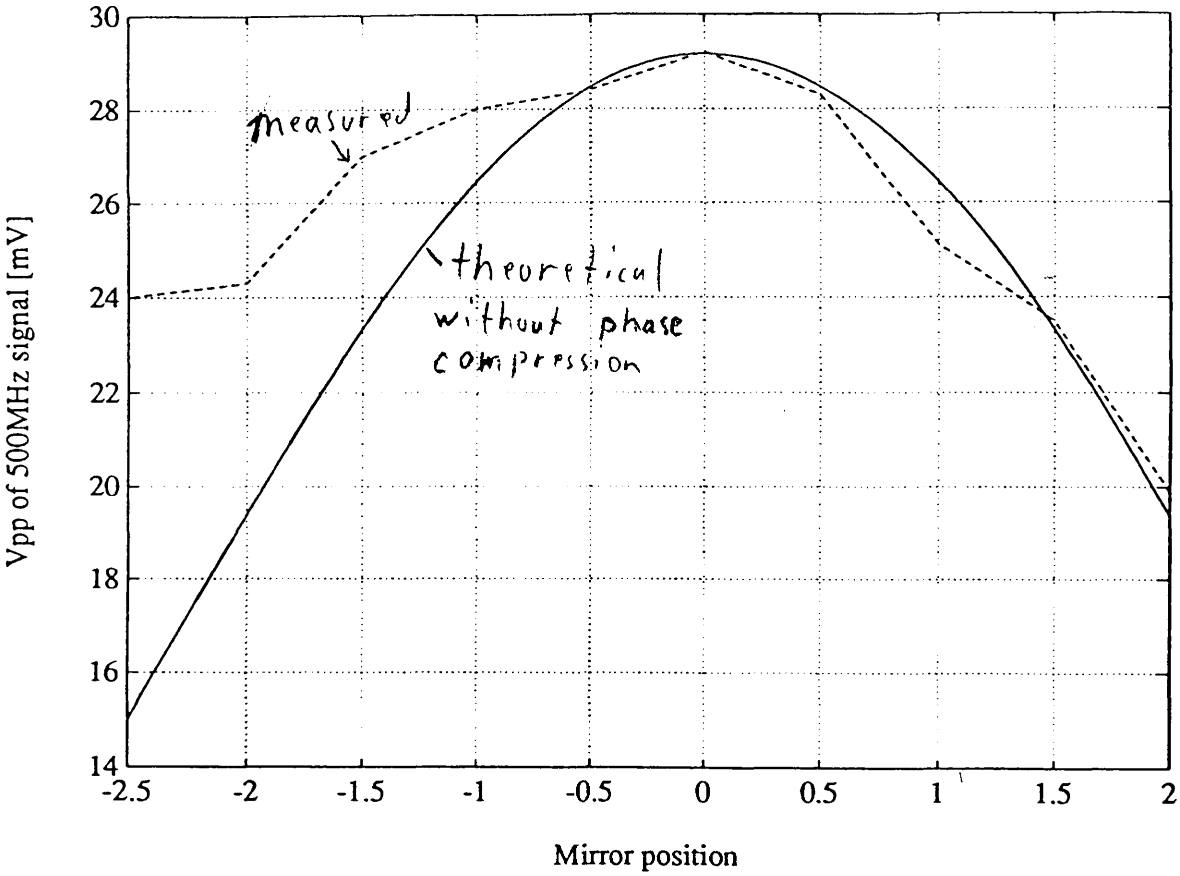


Fig 6.



Damping time $T_{RS} = \frac{Q}{\omega} = \frac{4384}{2\pi \cdot 29{,}98\,GHz} = 23{,}3\,ns$

Spacing between bunch 1 & 9 $= 8 \cdot \frac{1}{2{,}998\,GHz} = 2{,}668\,ns$

⇒ Sum voltage for optimum phase $V_{pp} = 15\,mV \cdot \underbrace{e^{-\frac{2.668\,ns}{2 \cdot 23.3\,ns}}}_{=0{,}944} + 15\,mV = 29{,}2\,mV$

Adding up with phase error φ of 9th bunch:

$$V_{pp} \approx 15\,mV \left(0{,}944 + \cos\frac{\varphi}{2}\right)$$

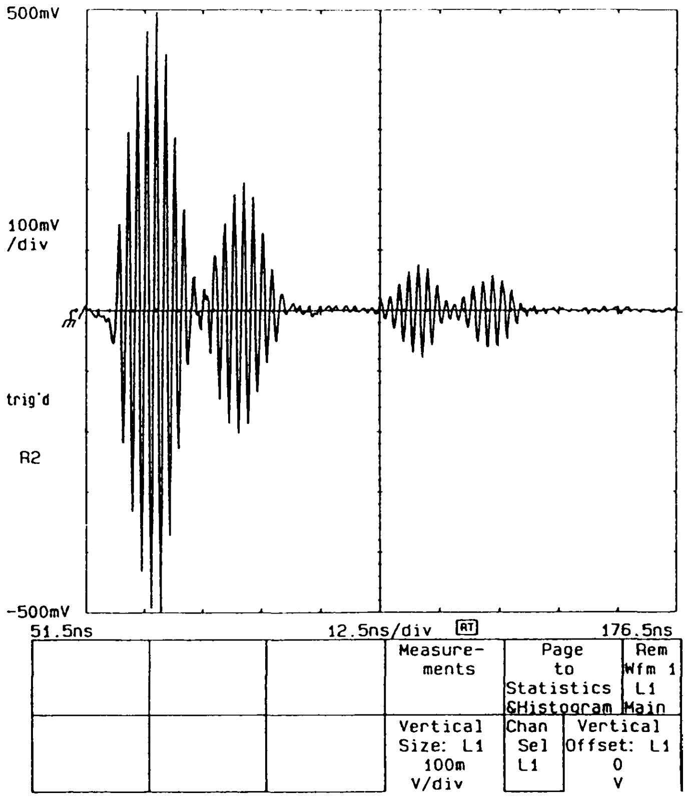
$$\varphi = 2 \cdot \text{mirror position} \cdot \frac{2\pi}{70\,mm}$$

H. Braun

Fig 7

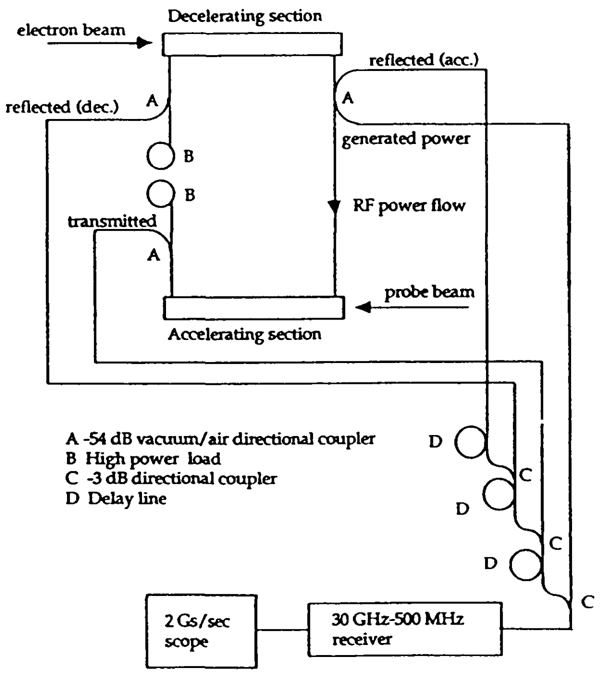
DSA 602A DIGITIZING SIGNAL ANALYZER
date: 9-JUN-94 time: 15:22:53

Fig 8



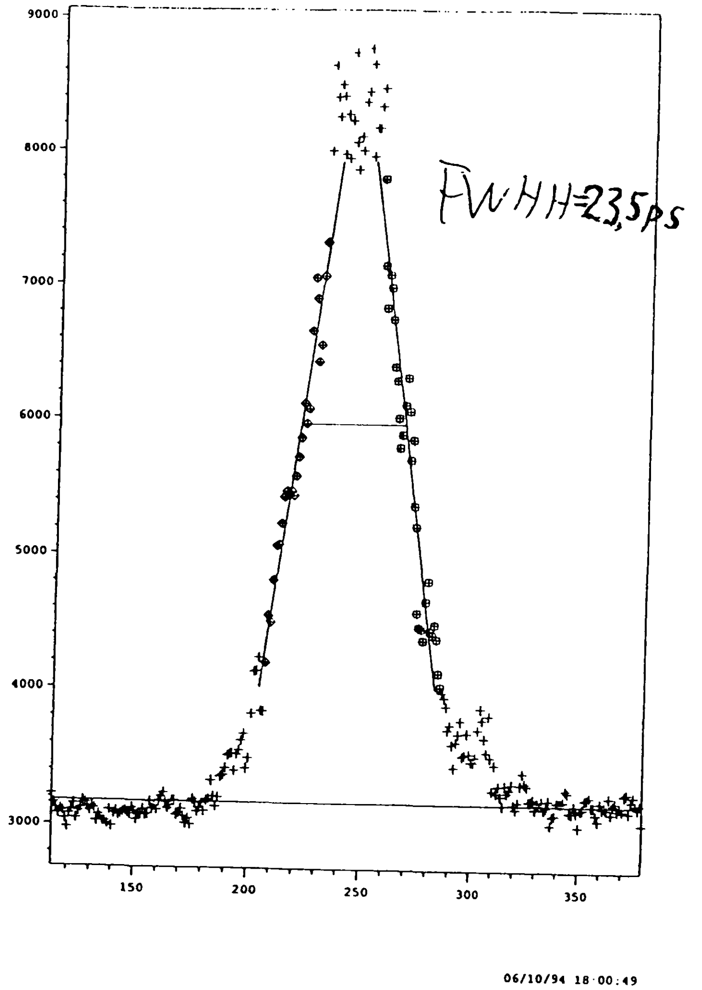
500 mV $\hat{=}$ 44.5 MW

First signal : power from TRS
Second : power out CAS
Third : reflected power from TRS (input coupler)
Fourth : " " " TRS (output ")



RF measurements on the CLIC structures

Fig 9



Streak Camera profile on TCM445C

for double bunch in 1 bucket, spaced by

{26°
{24 ps

Transmission through LAS = 70%.

No separation of bunches visible !

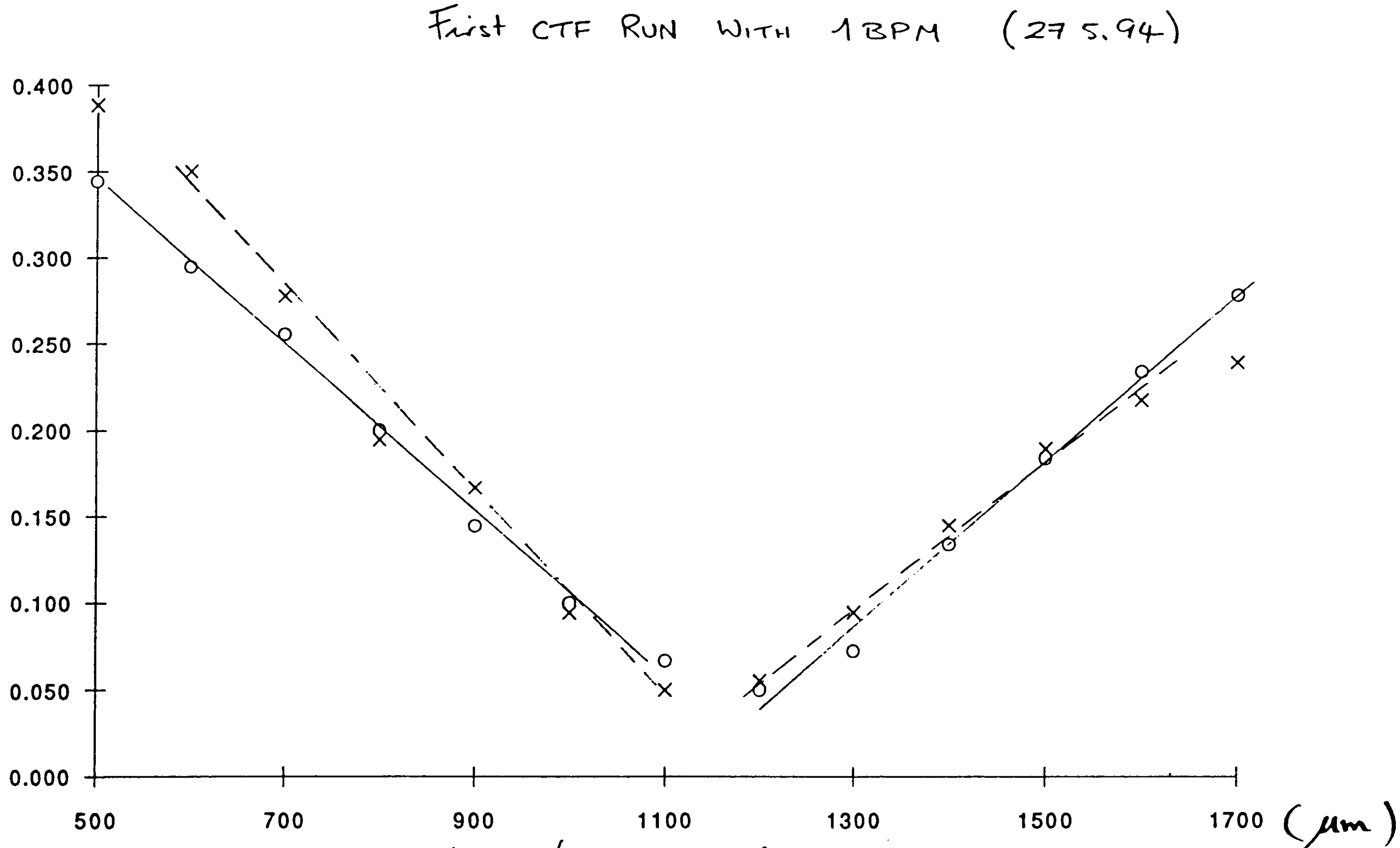


Fig10. BPM signal as function of its position

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
Michailichenko A.	PS
Millich A.	SL
Nation John	SL
Pearce P.	PS
Potier J.-P.	PS
Riche A.J.	PS
Riege Hans	AT
Rinolfi L.	PS
Rossat G.	PS
Schnell W.	SL
Schreiber S.	AT
Suberlucq G.	PS
Thomi J.C.	PS
Thorndahl L.	PS
Warner D.J.	PS
Wilson I.	SL
Wuensch W.	SL
Le Gras M.	PS
Durand J.	PS
J. Mourier	PS
Sladen J.	SL