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BEAM PROFILE MEASUREMENTS WITH SECONDARY EMISSION GRIDS

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Secondary emission grids (SEMGRIDS) have been in operation for a number of years at the CERN LINAC and LEAR machines , and have proved to be a most valuable tool in monitering the beam position in a semi-destructive manner along the E0 and E2 transfer lines . This report briefy describes how these SEMGRIDS work and how beam profiles can be obtained using a new acquisition programme running on the LEAR / LINAC PDP 11 computers .

For beam profile measurements in the LEAR momentum range of 0.1 GeV/c to 2 GeV/c , a secondary emission beam monitor was developed by the LINAC group in 1983 [1].It is based on the principle that a beam passing through a thin metal foil will emitt a few percent of secondary electrons from the superficial upper and lower layers of the foil , giving a corresponding electrical signal.The low energy of these secondary electrons (< 100 eV) means that the maximum depth at which they can escape is approximately 80 Angstroms. Thus the choice of material and the surface conditions play an important role in the emission of electrons.In LEAR the monitor is placed in ultrahigh vacuum and must be able to withstand repeated backing at 300 to 400 degrees centigrade for periods of more than 24 hours.It is therefore manufactured from titanium strips and frame , stainless steel connectors and ceramic supports.The strips are chemically machined from an 8 micron titanium foil , and are assembled and tensioned in the aluminium oxide combs by means of a specially constructed tool. The connectors are then spot welded to the titanium strips.To position the SEM grid monitor , a mechanism incorporating a pneumatic piston and bellows rotates the monitor by 16.5 degrees and places it in the vacuum chamber.Each monitor consists of 15 titanium strips 1.5 to 3.5mm wide placed 0.5mm apart.On each side of the grid , two large 100mm strips allow the measurement of the percentage of the beam not passing directly through the centre of the monitor.

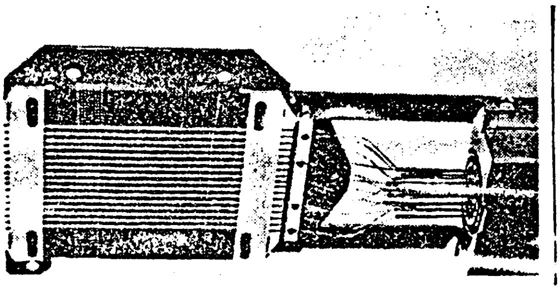


Fig 1. SEM grid beam profile head detector

Once mechanically positioned , the local electronics can then be switched on to either the vertical or the horizontal detector strips.Clean beam signals can then be obtained in what is an electrically noisy environment.The electronics raise the signal levels so that they can be transmitted with little degradation over distances of about 100 metres.For the LEAR machine the electronics is more elaborate than that used for the LINAC beams due to the fact that the LEAR beam is of very low intensity (10x9 particles) with a beam integration time of only 200-300 nsec.JFET operational amplifiers with an input resistance of >10x12 ohms feeding a polystyrene capacitor of 2pf in parallel with a 10 megohm resistor are used in its most sensitive range , and this is followed by an amplifier having a gain of 10 to 100 feeding a hold circuit via a high pass filter.The signals are then transmitted over a multiwire cable to a CAMAC crate with a multiplexer and a fast 12bit converter filling a 16 word buffer memory.

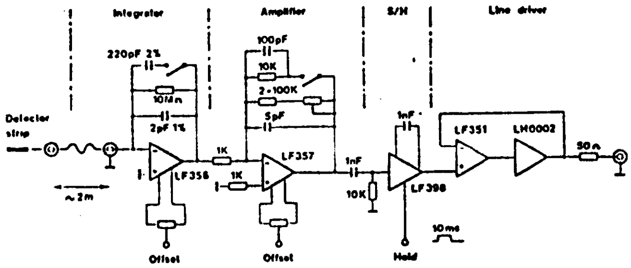


Fig 2. One channel low intensity beam integrator

Software applications programs

Up until now , beam profiles measured by the SEM grids were displayed on the colour TV screens of the consoles by means of an assembler program.Having the advantage of being extremely fast , this program was found to contain certain faults (e.g. the calculation of the mean beam position is a false and its sign is incorrect) , and it also takes the absolute value of the signal thus making it very difficult for one to distinguish the beam signal from the background signal , especially when one has particles such as antiprotons or H- atoms where the semgrid signals are inverted.Thus it was decided in the LINAC group that a new program should be written in a high level language , FORTRAN or PASCAL , to enable any programmer to alter the software should there be any future ameliorations to the hardware.This new program has now been modified to run with the LEAR SEM grids as thess have different command and status acquisition formats for the mechanics and electronics than those used at the CERN LINAC.So far this program has given better results than the existing assembler program.

Brief guide to the new program

To gain acces to this new program,the user should start from the LEAR home page on the touch panel and move on to LEAR BEAM MEASUREMENT.Button 4 of this page will then run the program.One then has the choice of either using the SEM grids in the E2 injection line or in the LEAR machine E4 { E0 will follow once the electronics is moved to LEAR & and there will also be a SEM grid in E5 }.Once the line chosen ,the user must then select the SEM grid and the plane he wishes to use.The program then calls a resident picture file which contains a frame for the grid spectrum and some unalterable text .This is then displayed on the colour TV screen of the LEAR console.The SEM grid is positioned in the vacuum chamber and the appropriate electronics is switched on.All the main parameters concerning the SEM grid are read from a file containing the default values and are printed on the screen .These parameters can be refreshed via the CHECK SEMGRID STATUS button.In order to start the acquisition of the SEM grid channels the START/STOP ACQUIS. button must be pressed.The signal read is then displayed in the form of a histogram in the area on the left of the screen reserved for this effect.To exit the SEM grid the PREVIOUS PAGE button must be pressed and then the user finds himself back at the SEM grids choice page.Pressing PREVIOUS PAGE sends the user back to the LEAR lines choice page and then EXIT will simply terminate execution of the program.While the SEM grid is running , the user has a certain number of options available for his own convenience.The software gain can be changed from any value between 0.5 and 100.0 in steps of 0.5.The profile already has a much greater resolution than what was available in the assembler program and with such a wide range of software gains , any particular part of the beam can be enhanced.The hardware gain is defined by the instrumentation and the user only has four possible settings from 0 to 3 (equivalent values with the assembler program are shown in the table below).The sampling time can also be changed from within the program , even though this is normally predetermined and should not be modified without good reason.The SEM grid polarity is very useful as it enables the program to distinguish between the signal induced by the beam and the signal due to noise. It should be noted that no attempt is made to subtract this noise level , and that it is displayed in the form of negative histogram bars.To save time in parameter settings between each SEM grid the SAVE PARAMETERS button enables one to store the settings in a file which will be automatically recalled at any later stage when the SEM grid is used again.As the LEAR control system is in normal operational conditions heavily overworked , the status of the SEM grids is only checked when a monitor is placed in the vacuum chamber or when it is removed.If a check on the mechanical or electronic status is required , a CHECK STATUS button is available , and if any faults are found the appropriate message is displayed. All the beam parameters and beam profile are refreshed approximately every second , which includes a pause of 0.5 sec to enable the system to perform any other tasks already installed.

The main differences between the assembler and the fortran programs can be summarised as follows :

Parameter	FORTRAN program	ASSEMBLER program
Software gain	0.5 to 100.0 in steps of 0.5. 0.0 implies autoscale	0.5 , 0.75 , 1.0 , 1.25 , 1.5 , 2.0 , 4.0
Hardware gain	0 , 1 , 2 , & 3	1 , 1/10 , 1/100 & 1/1000
Sampling time	Can be modified via the	No modification

	program	possible
Turning angle	Not yet implemented	Not available
SEM grid polarity	POS =>antiprotons NEG =>protons	Program takes absolute value of the signal
SEM grid status	Checks mechanical & electronics status	Status check performed each scan
Save parameters	Enables the user to save all the above parameters as default settings	Not available

Future improvements

The next version of this program will incorporate routines for the subtraction of the noise level and for the elimination of bad points.A useful , but not absolutely necessary , option would be to display up to four SEM grid beam profiles simultaneously , as will be done for the multi-wire proportional chambers in the experimetal zones.One could also envisage a precise calibration of the SEM grids in order to evaluate , by integration of the signal read on all 16 wires , the intensity of the beam passing through the SEM grid.One could also think of using the SEM grids for beam emittance measurements along the E2 injection line in conjunction with a program , which is presently under development , which will calculate the Twiss parameters along this line .

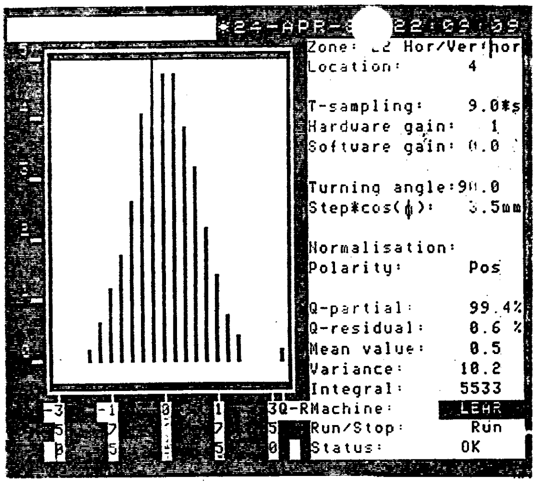


Fig 3a. Beam profile at MGH04 with new program

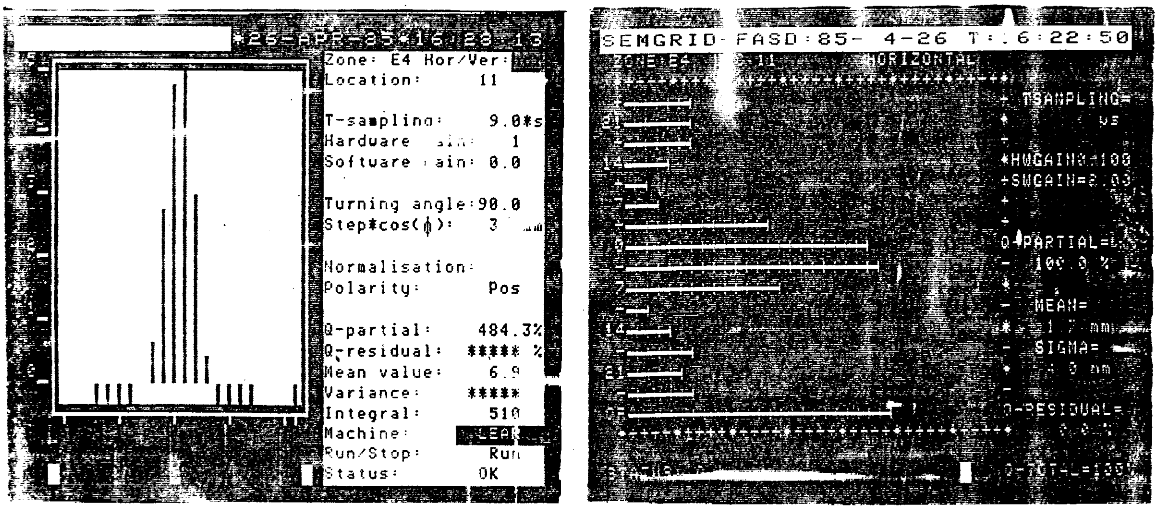


Fig 3b. Comparison of a beam profile at MGH11 using the assembler and the new FORTRAN programs

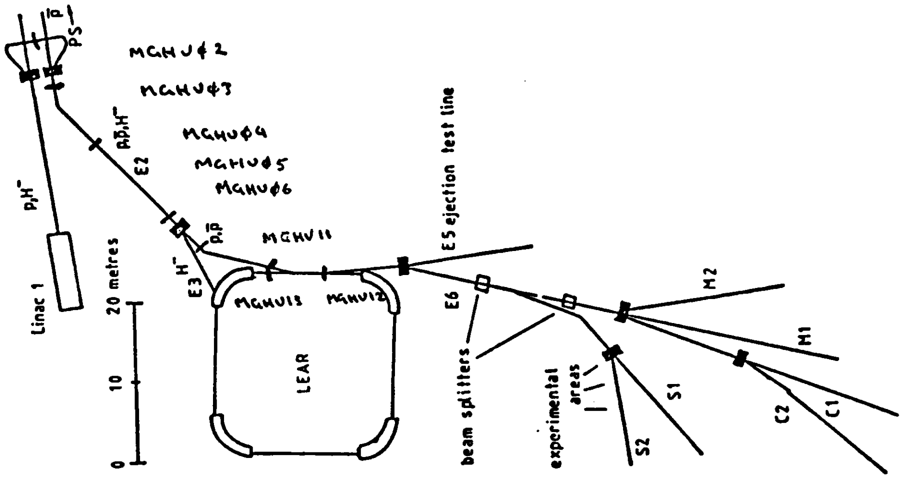


Fig 4. Position of the LEAR secondary emission grids

Fig 5. Sequence of calls on the touch panel needed to run a SEM grid (e.g. MGH11)

colour TV screen

touch panel

TOP V3.03
Page 2; Title: LEAR HOME PAGE
Page type = Standard
Previous page
Sideways linked to page:

LEAR PROCESS SYNOPTICS	LEAR BEAM TRANSFER	LEAR BEAM INJECTION	LEAR BEAM EJECTION
LEAR RF	LEAR TRANSV. FUNCTIONS	LEAR BEAM MEASUR.	LEAR MEASUR. LINES
LEAR TIMING	LEAR STOCHAS. COOLING	LEAR ELECTRON COOLING	LEAR EXPERIM. ZONES
LEAR OPERATION UTILITIES		LEAR INTERNAL PHYSICS	LEAR SERVICES

TOP V3.Ø3
Page 14; Title: LEAR BEAM MEASUREMENTS

Page type = Standard

Previous page 2; Title: LEAR HOME PAGE

Sideways linked to page:

ORBIT MEASUR.

EMITT. MEASURE

NEW SEMGRIDS PROGRAM

SEMGRIDS L4-L5 SLOW

SEMGRIDS EØ-E5 FAST

TOP V3.Ø3
Page 34; Title: SEMGRIDS ZONE OPTIONS

Page type = Standard

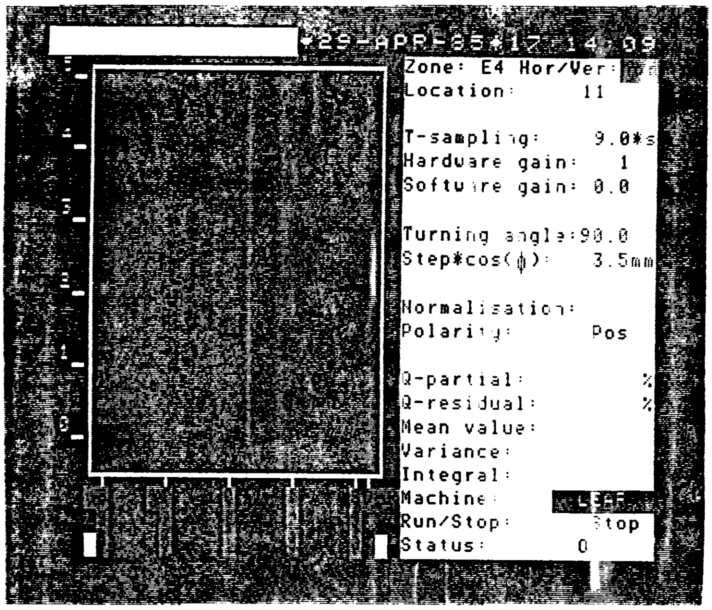
Previous page

Sideways linked to page:

EØ & E2 SEMGRIDS

E4 & E5 SEMGRIDS

EXIT



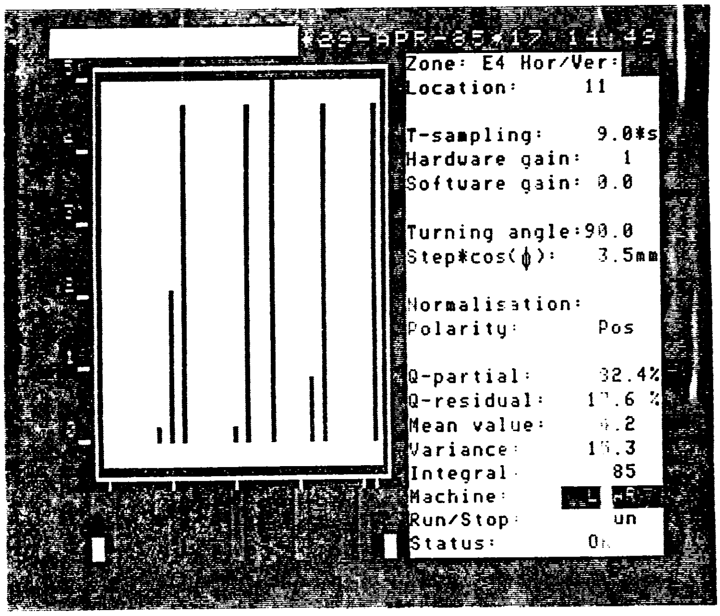
TOP V3.03
Page 33; Title: E4 - E5 SEMGRIDS

Page type = Standard

Previous page

Sideways linked to page:

E4 MGH 11	E4 MGH 12	E4 MGH 13
E4 MGV 11	E4 MGV 12	E4 MGV 13
E5 MGH 41		
E5 MGV 41		PREVIOUS PAGE



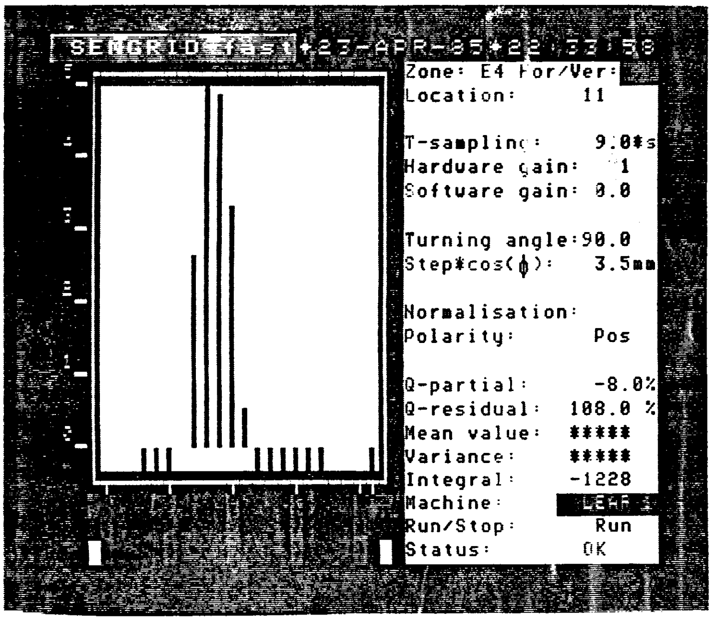
TOP V3.03
Page 24; Title: NEW PROG SEMGRIDS

Page type = Standard

Previous page

Sideways linked to page:

CHANGE SOFTWARE GAIN	CHANGE HARDWARE GAIN	CHANGE SAMPLING TIME	CHANGE TURNING ANGLE
SET POS/NEG BEAM	CHECK STATUS	START/ STOP ACQUIS.	SAVE PARAM.
			PREVIOUS PAGE



TOP V3.03
Page 25; Title: SAVE SEMGRID PARAMETERS
Page type = Standard
Previous page
Sideways linked to page:

SOFTWARE GAIN	HARDWARE GAIN	SAMPLING TIME	TURNING ANGLE
POS/NEG BEAM			ALL PARA-METERS
			PREVIOUS PAGE

References :

[1] Wide dynamic range (7 decades) beam position and profile measurement for the CERN LEAR.

L. Bernard et al. CERN / PS / LEAR / 83-15

[2] Program listing of SEMALL.FTN and subroutines.

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