A Data Acquisition System for Transverse Dynamics Measurements

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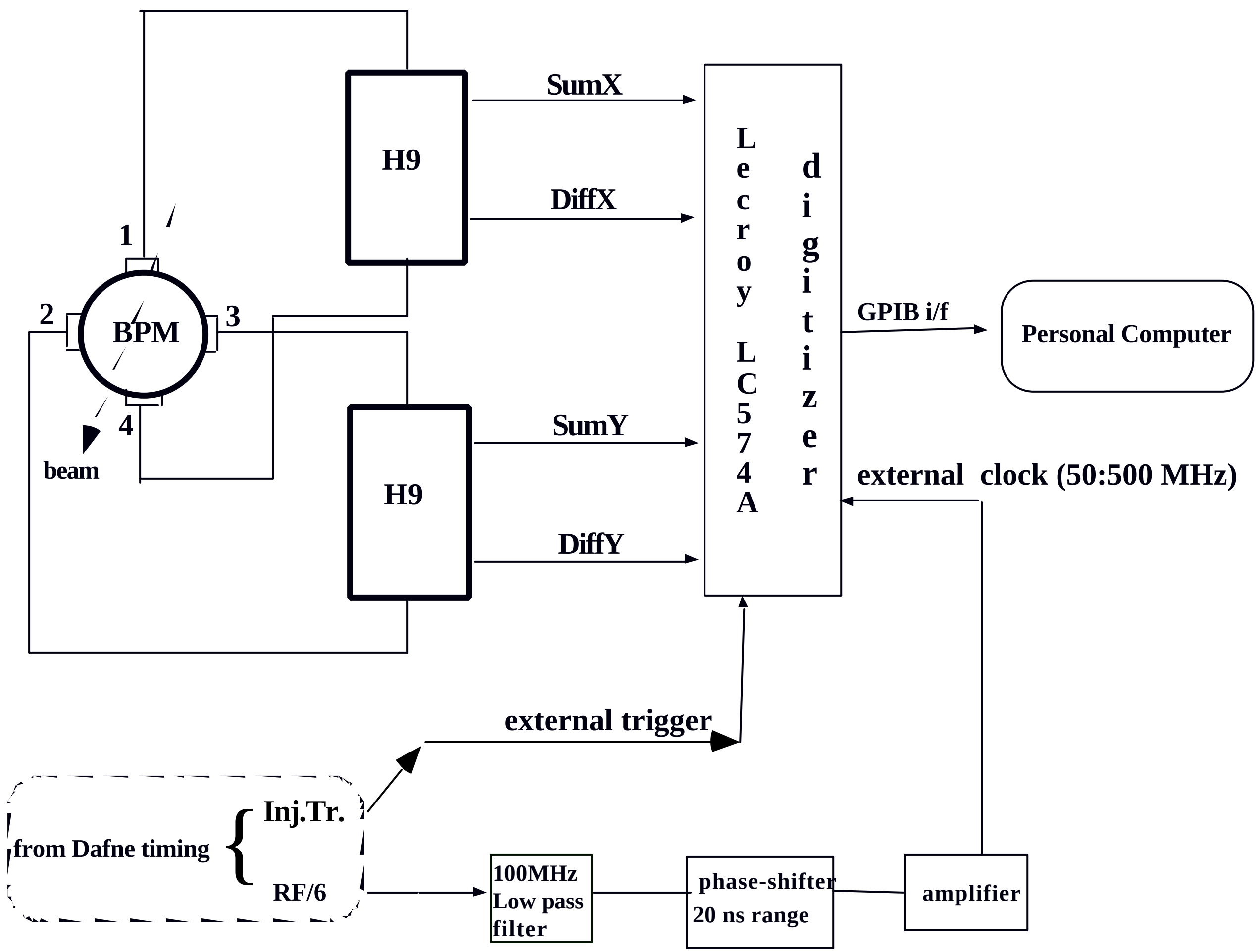
- Aim of this presentation is to describe a transverse dynamic tracking data acquisition system.
- In the Daϕne ϕ-Factory, the high Luminosity asks for a careful tune-up of many machine parameters.
- It is useful to study the transverse dynamic behavior of the beam versus different sextupole and octupole magnet setups.

Basics

- A four button BPM is used to obtain sum and difference signals in the horizontal and vertical transverse planes (of the beam motion).
- A second BPM with a suitable betatron phase advance in respect of the first one can be used to obtain sum and difference signals relative to the passage of the bunch in an other point of the ring.
- After kicking the beam, these signals are sampled and acquired at every turn (up to 25k), converted in mm and stored in a data-base.

The Acquisition System

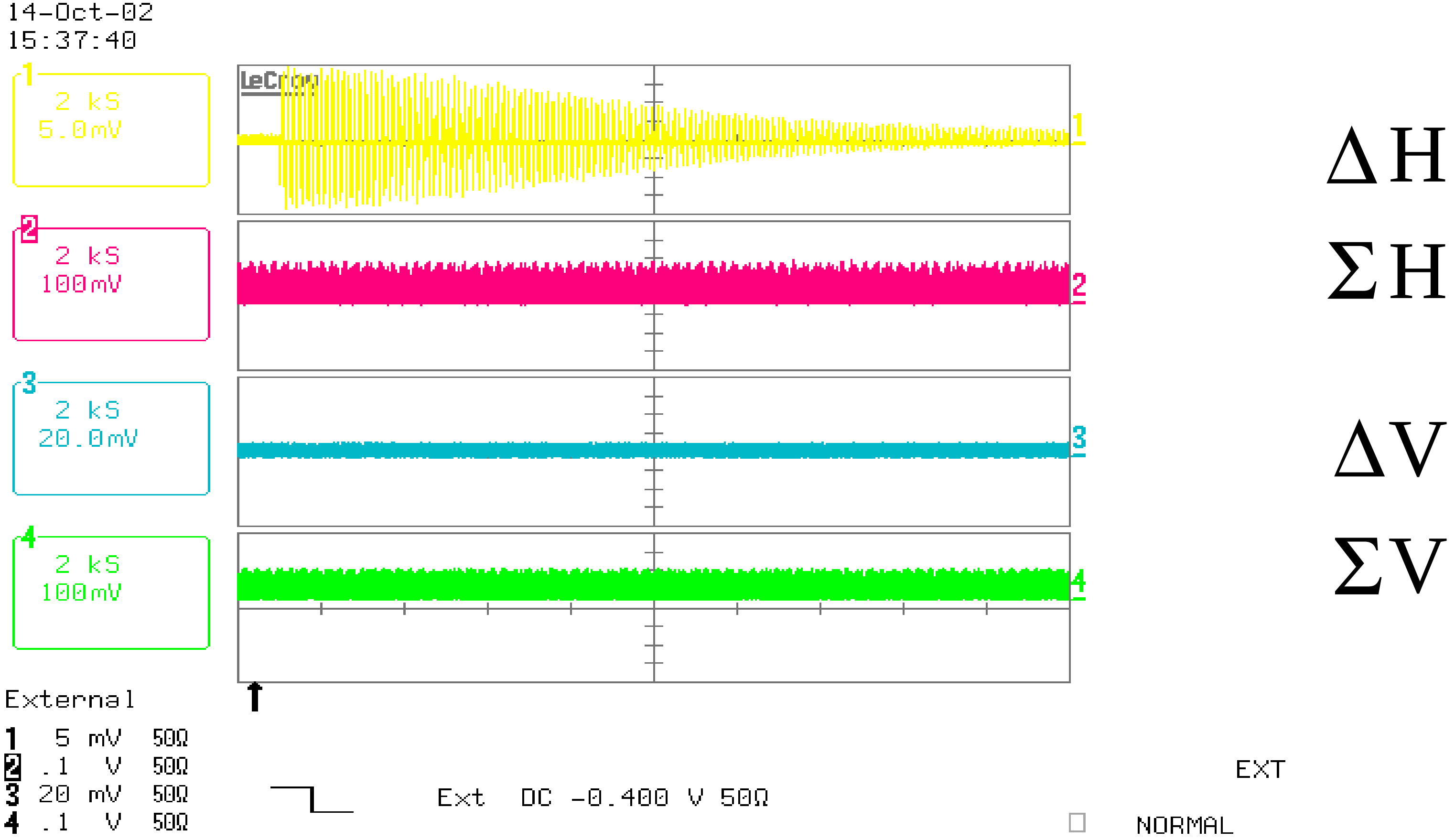


The Digitizer

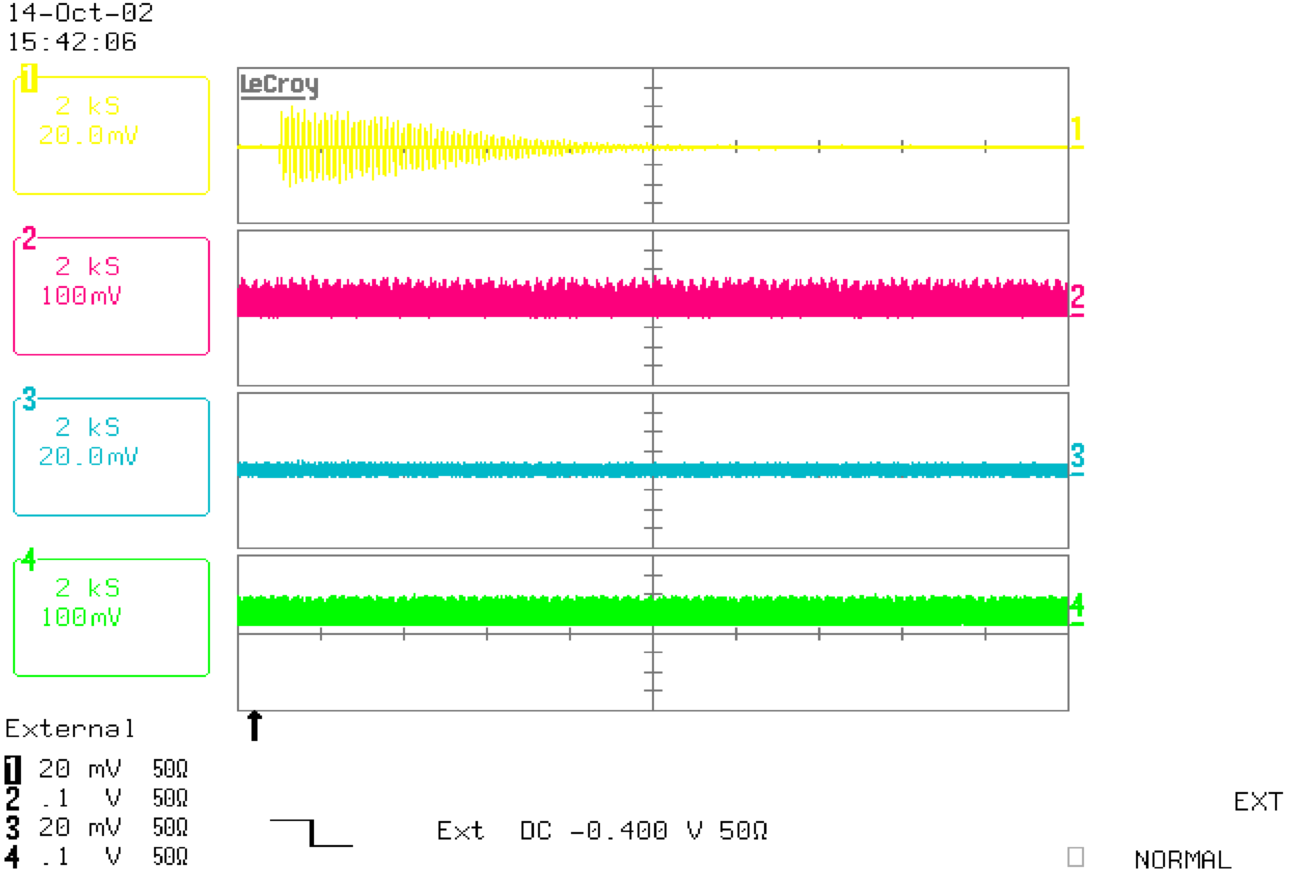
LeCroy test & measurement

- LeCroy LC584AM Digital Oscilloscope
- Built around a PowerPC working @ 96MHz
- Floppy Disk, 16 M RAM
- IEEE 488 parallel i/f
- RS232 serial i/f
- VGA out connector
- 1 GHz Bandwidth
- 4 Acquisition channels
- 8GS/s (2 GS/s per channel)
- 2M points acquisition memory (500k points per channel)
- External trigger, external clock

Through the VGA out port the signals acquired are shown in the control room



It is easy to check what happens after a kick (horiz. in this case)

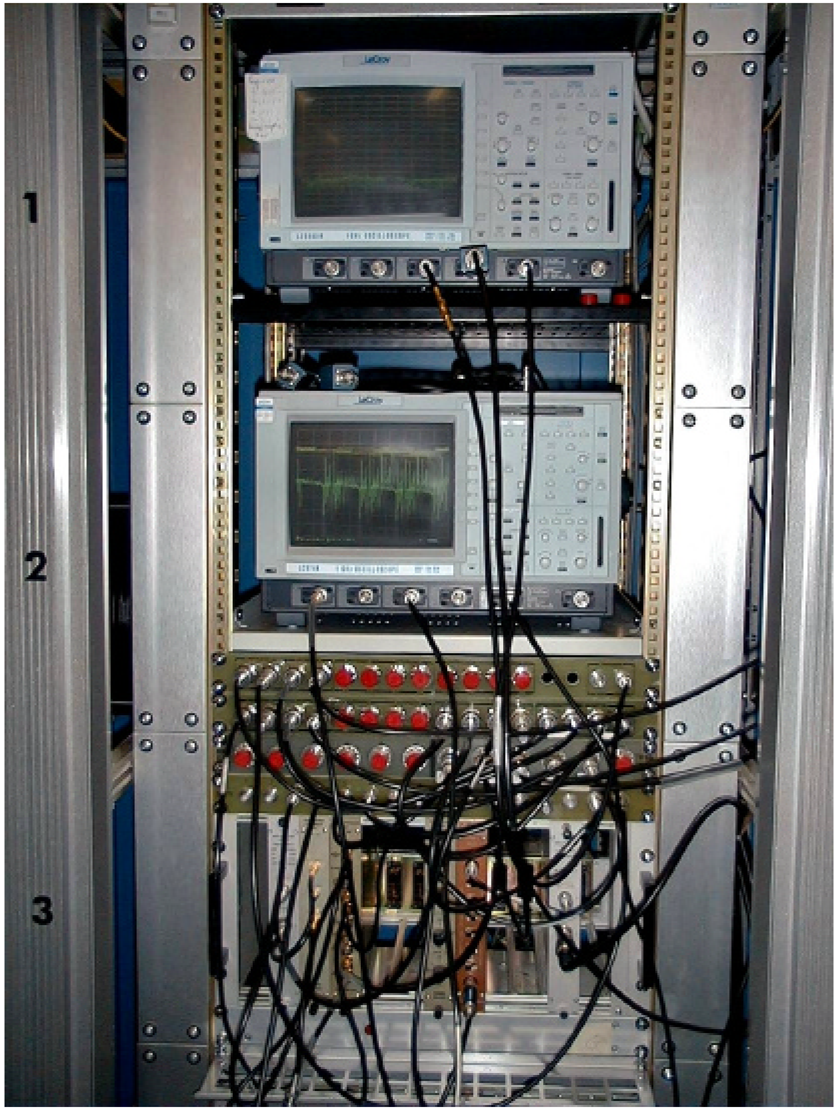


ΔH

ΣH

ΔV

ΣV



The system with two digitizers with 8 acquisition channel and the setup bringing the BPM signals from the DAΦNE hall.

High-Performance GPIB Interface for PCI

PCI-GPIB

TNT4882C ASIC
- Complete IEEE 488.2 compatibility
- FIFO buffers to decouple GPIB transfers from PCI transfers
- GPIB monitor port for board and bus-level diagnostics
- Complete in-system functional testing with loop-back mode
- Reduced software overhead

Maximum GPIB transfer rates
- 1.5 Mbytes/s using IEEE 488.1 handshake
- 7.7 Mbytes/s using HS488 handshake

MITE PCI ASIC
- Complete PCI 2.1-compatible interface
- Bus-master DMA Controller

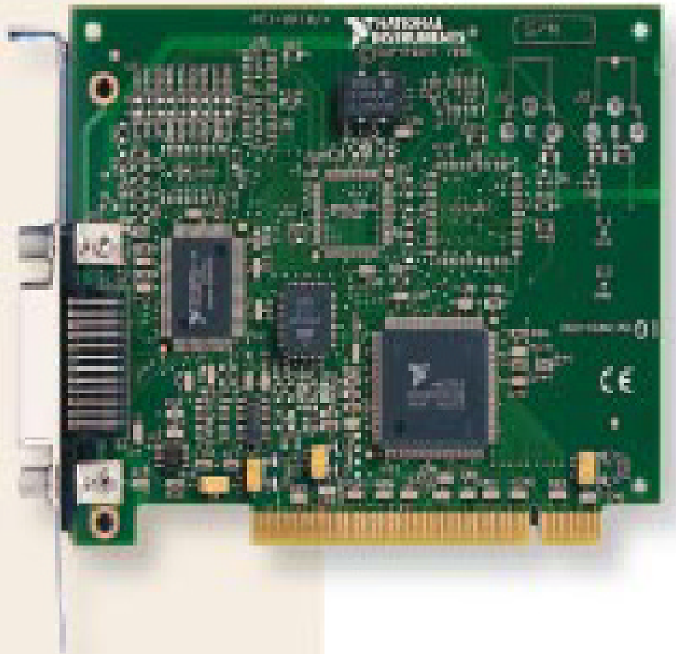
Contact National Instruments for OEM pricing on PCI-GPIB and other products.

NI-488.2M Software
Windows NT/98/95
Solaris 2
Digital Unix (OSF/1)

NI-488.2 Software
Mac OS

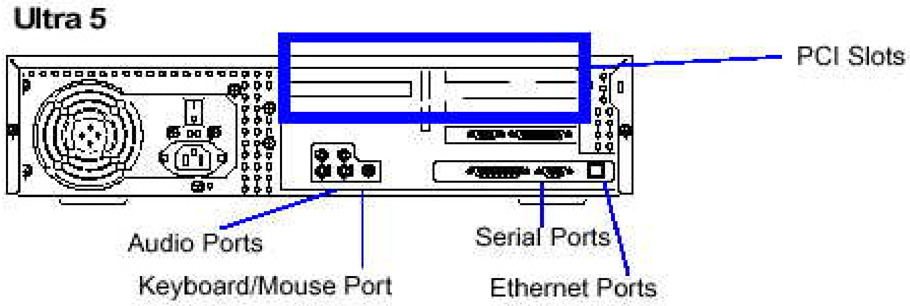
NI-488 DDK Software
For any operating system
Includes example OS implementations:
- VxWorks
- DOS
- IRIX
- Digital Unix

Application Software
LabVIEW
LabWindows/CVI
Measure
ComponentWorks
Visual Basic
Visual C++

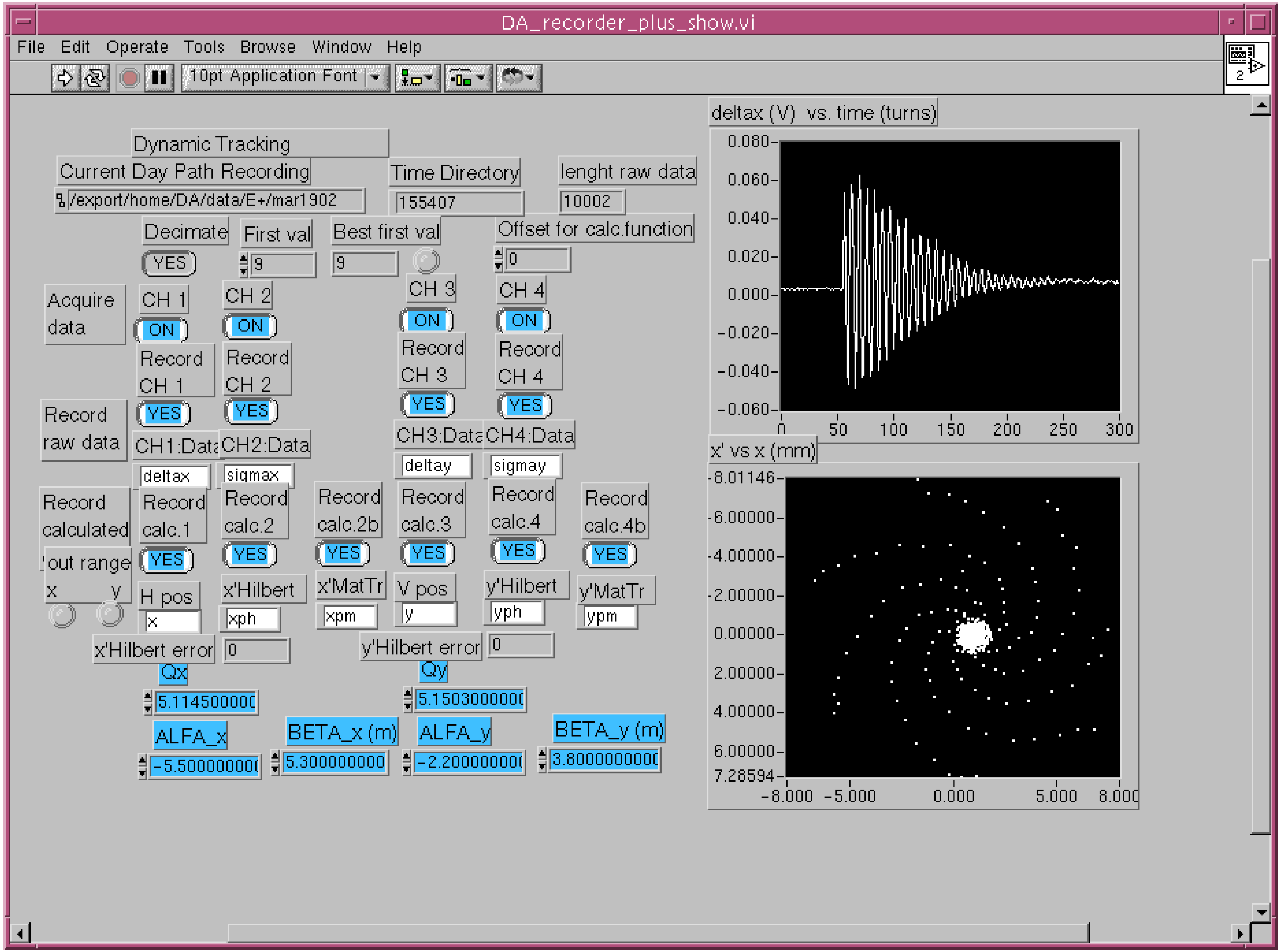


National Instruments

- **SUN Ultra 5 Workstation** • Desktop system
- **Processors** • 400-MHz UltraSPARC-Iii
- • 2-MB ECache
- **Memory**
- • 4 DIMM slots
- • Up to 512-MB memory
- **Internal Storage**
- • 8-GB disk
- • 1.44-MB floppy
- • 48x CD-ROM drive
- **System I/O** • Three 33-MHz 32-bit PCI slots
- • Two independent PCI I/O buses
- **Graphics** • Built-in PGX24 ™ 24-bit graphics
- **Performance** • 16.5 SPECint95
- • 21.3 SPECfp95
- **Operating Environment**: Solaris 7



Acquisition, analysis and storing tools

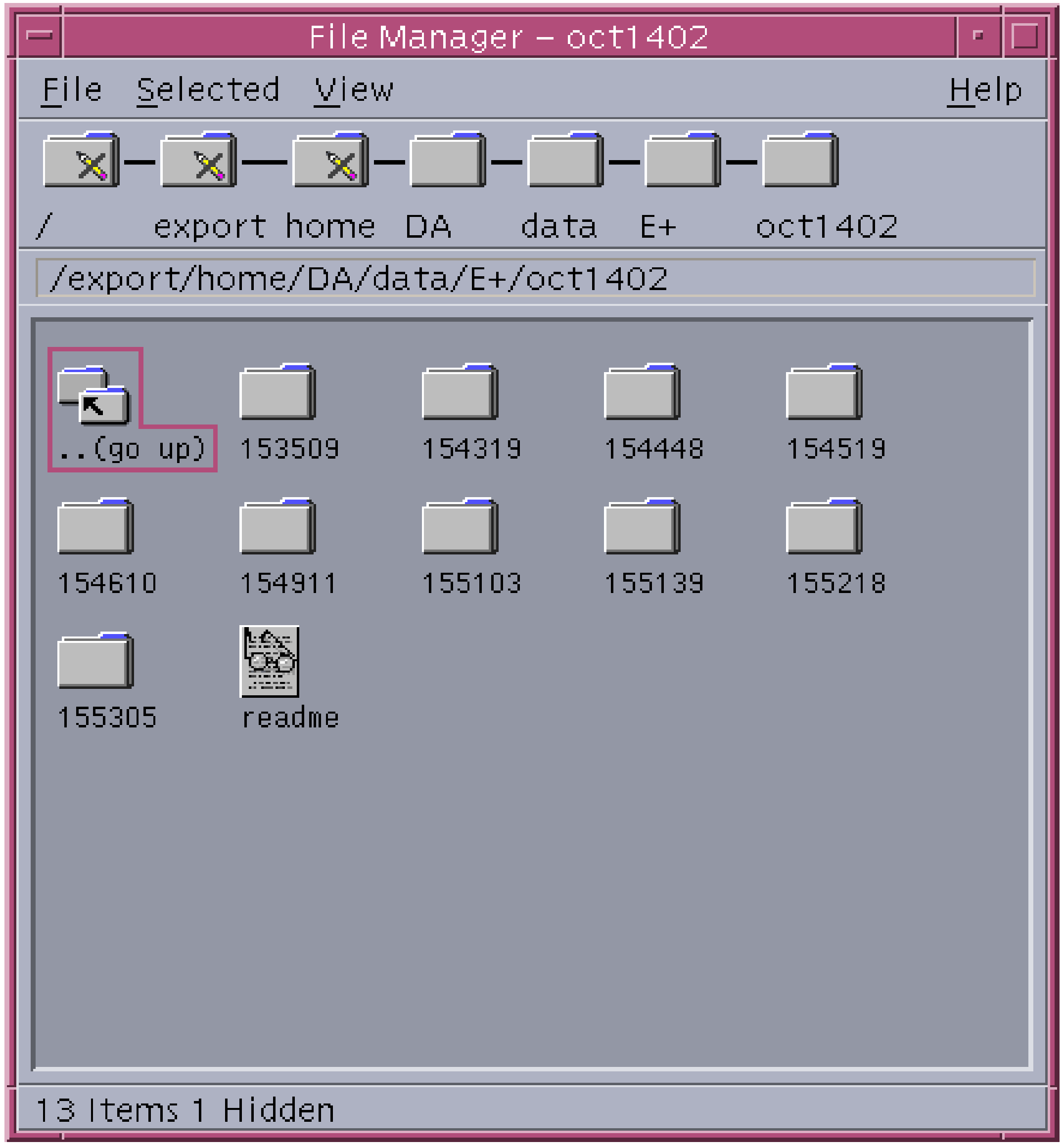

DA_recorder_plus_show.vi
File Edit Operate Tools Browse Window Help
10pt Application Font
Dynamic Tracking
Current Day Path Recording
/export/home/DA/data/E+/mar1902
Time Directory
155407
lenght raw data
10002
Decimate
YES
First val
9
Best first val
9
Offset for calc.function
0
Acquire data
CH 1
ON
CH 2
ON
CH 3
ON
CH 4
ON
Record CH 1
YES
Record CH 2
YES
Record CH 3
YES
Record CH 4
YES
Record raw data
CH1:Data
deltax
CH2:Data
sigmax
CH3:Data
deltay
CH4:Data
sigmay
Record calculated
Record calc.1
YES
Record calc.2
YES
Record calc.2b
YES
Record calc.3
YES
Record calc.4
YES
Record calc.4b
YES
out range
x y
H pos
x
x'Hilbert
xph
x'MatTr
xpm
V pos
y
y'Hilbert
yph
y'MatTr
ypm
x'Hilbert error
0
y'Hilbert error
0
Qx
5.114500000
Qy
5.1503000000
ALFA_x
-5.50000000
BETA_x (m)
5.300000000
ALFA_y
-2.20000000
BETA_y (m)
3.800000000
deltax (V) vs. time (turns)
0.080
0.060
0.040
0.020
0.000
-0.020
-0.040
-0.060
0
50
100
150
200
250
300
x' vs x (mm)
-8.01146
-6.00000
-4.00000
-2.00000
0.00000
2.00000
4.00000
6.00000
7.28594
-8.000
-5.000
0.000
5.000
8.000

Performances

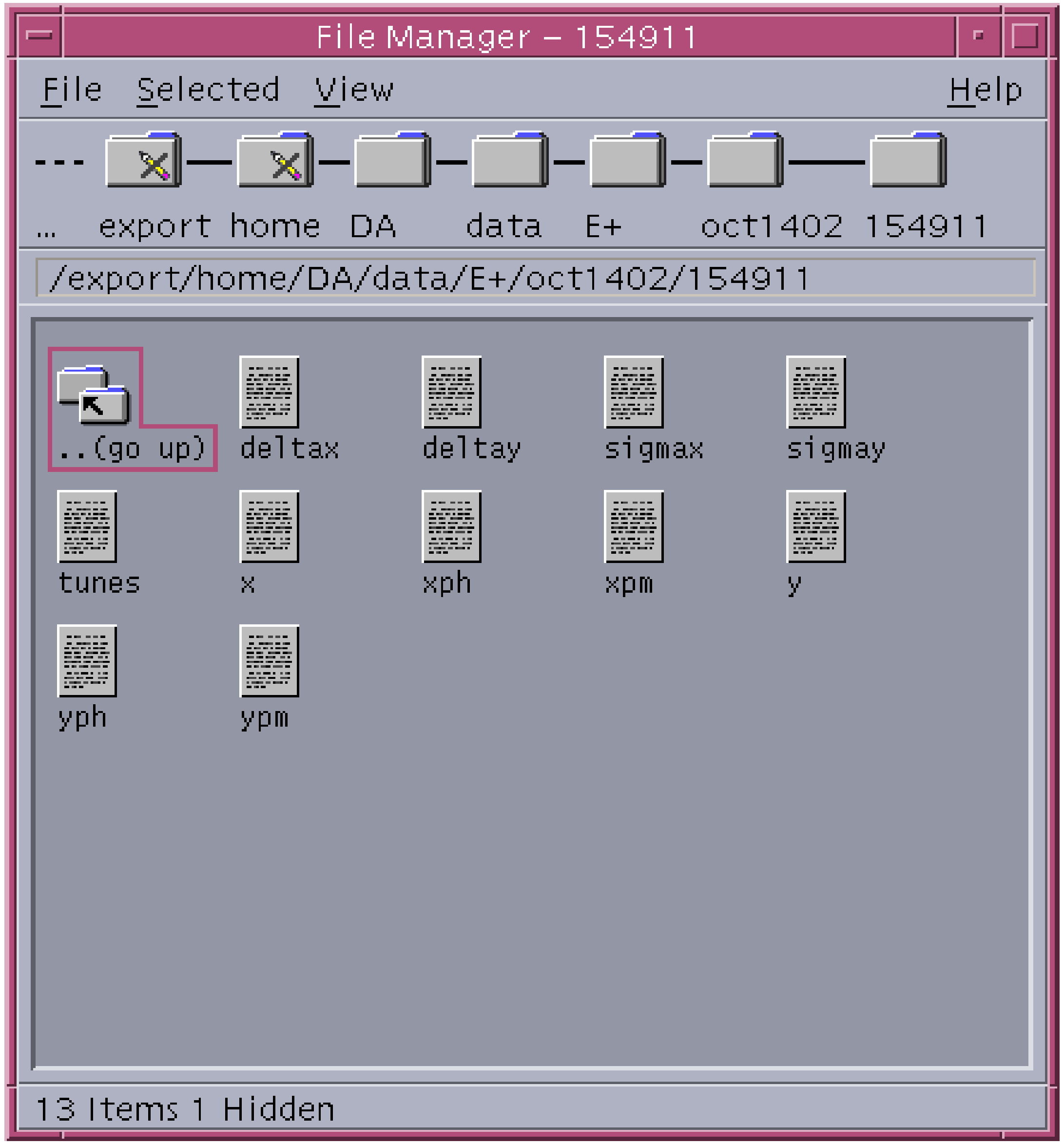
- All the programs are written using LABVIEW 6.0 and can run on different platforms.
- Acquisition, conversion and storing of 100k points x 4 channels (.8M bytes through IEEE488) takes more than 1 minutes using a Macintosh Quadra and only 12 sec with Sun Ultra 5.
- Acquisition, conversion and storing of 500k points x 4 channels (4M bytes through IEEE488) takes ½ minute on Sun Ultra 5, not possible on Macintosh Quadra.

Database

- A database tree is automatically generated by the acquisition program
- First level directories: E+ or E-
- Second level directories defined by the date: mmmddyy (for example apr1902)
- Third level directories defined by the time: hhmmss (for example 143207)
- Data files for spreadsheet application: rough data in voltage (deltax, sigmax, deltay, sigmay) and calculated data in mm (x, xph, xpm, y, yph, ypm).



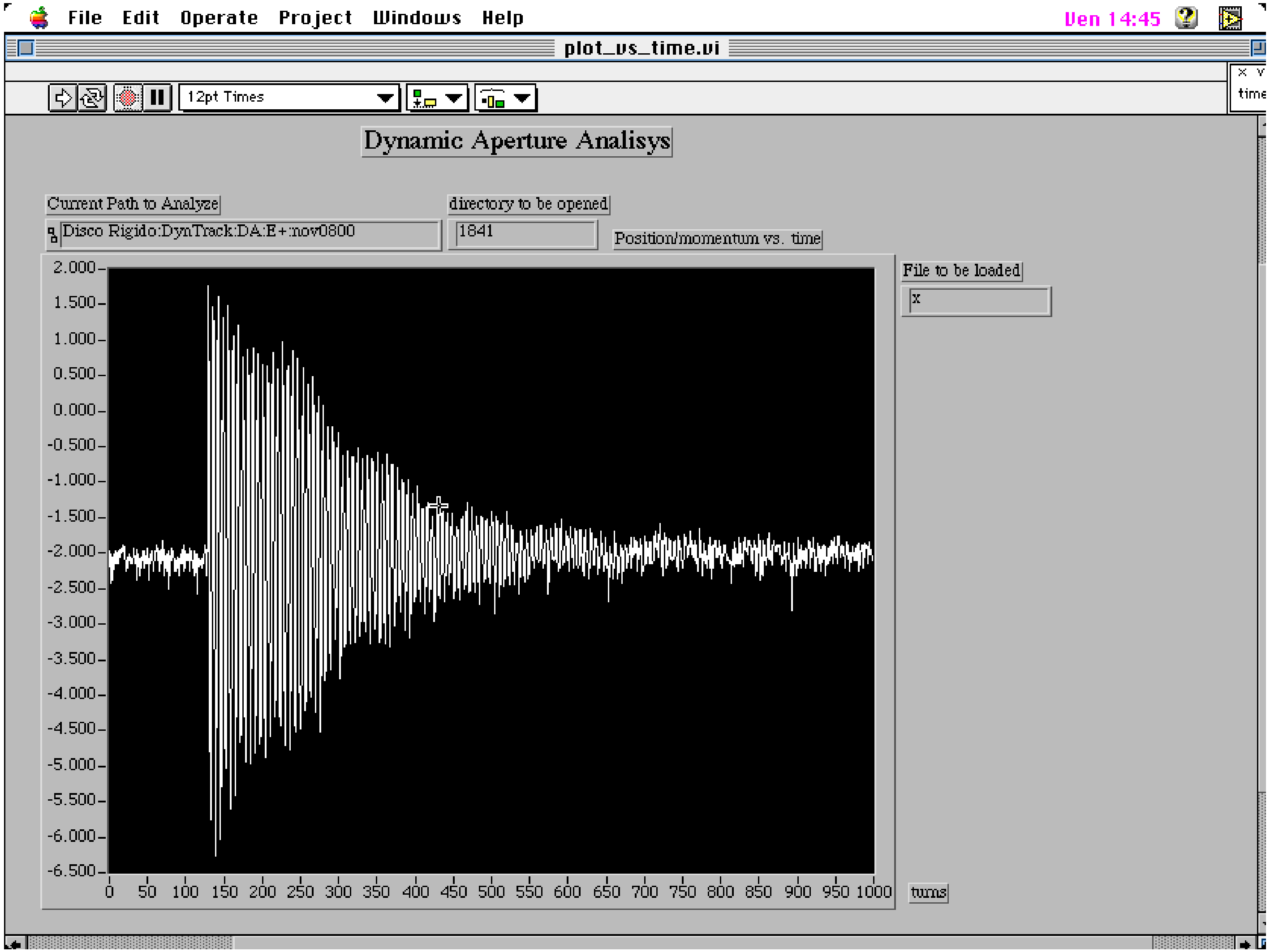
- Second level directories defined by the date
- The readme file contains every useful information about the machine conditions (current, kick value, magnets on/off)



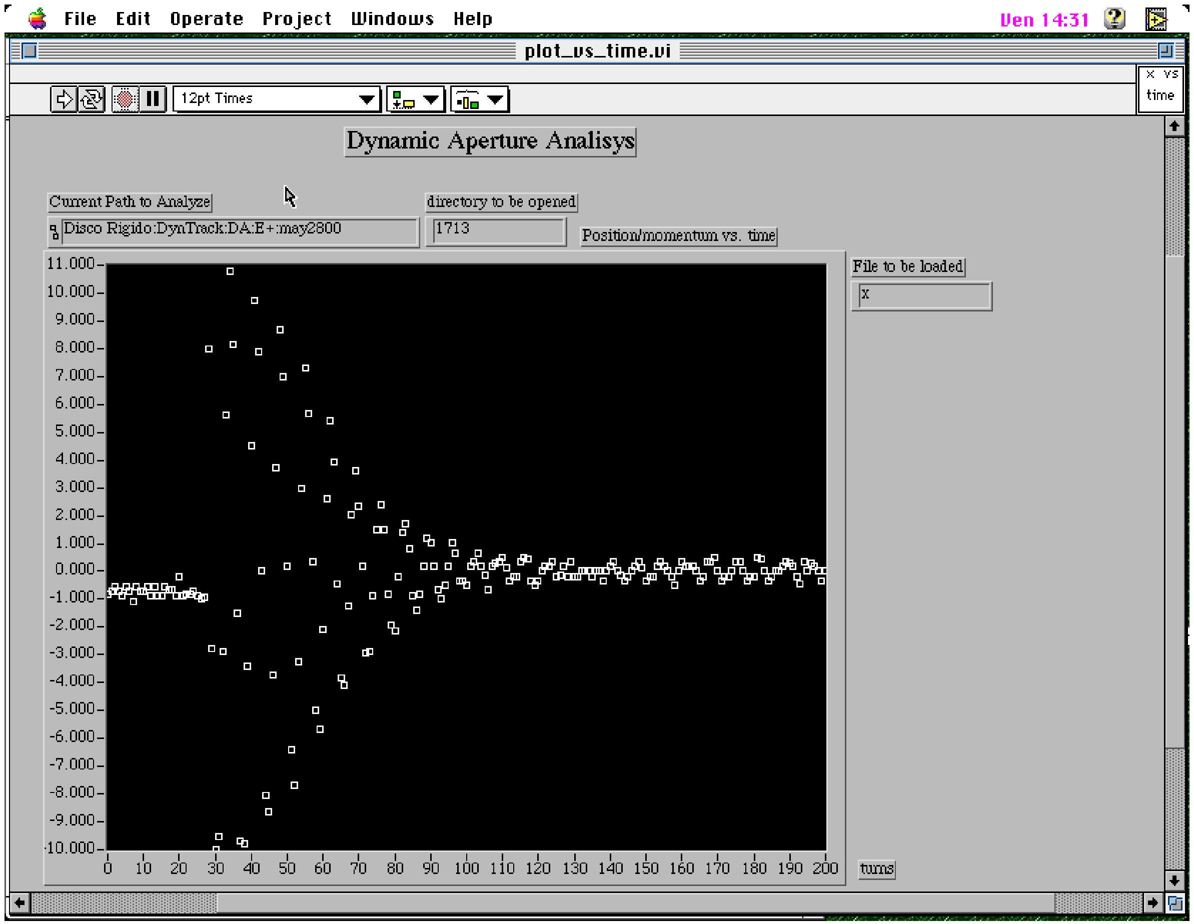
- Third level directories defined by the time
- Rough data in voltage and calculated data in mm
- Every file is composed by only column to be easily loaded in any spreadsheet

Data retrieval and browsing tools

Horizontal Displacement (in mm) Versus Number of Turns.



A coherent signal decay due to non-linear filamentation (displacements versus turns)



The transport matrix method uses the Twiss parameters α, β at the monitor position as computed by the machine model.

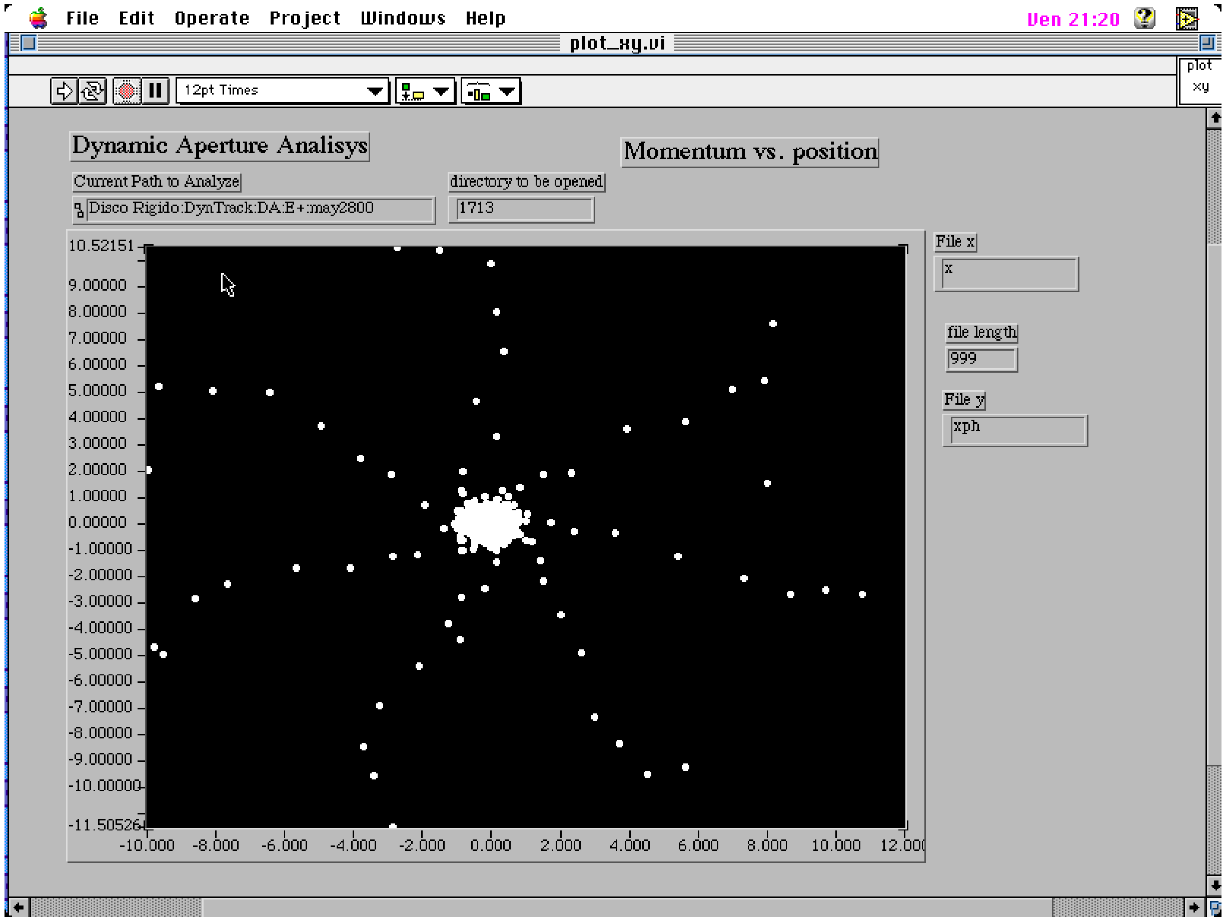
The transport matrix formula is

$$x'(i) = \frac{x(i+1) - (\cos(2 P\ Q) + a \sin(2 P\ Q))\ x(i)}{b \sin(2 P\ Q)}$$

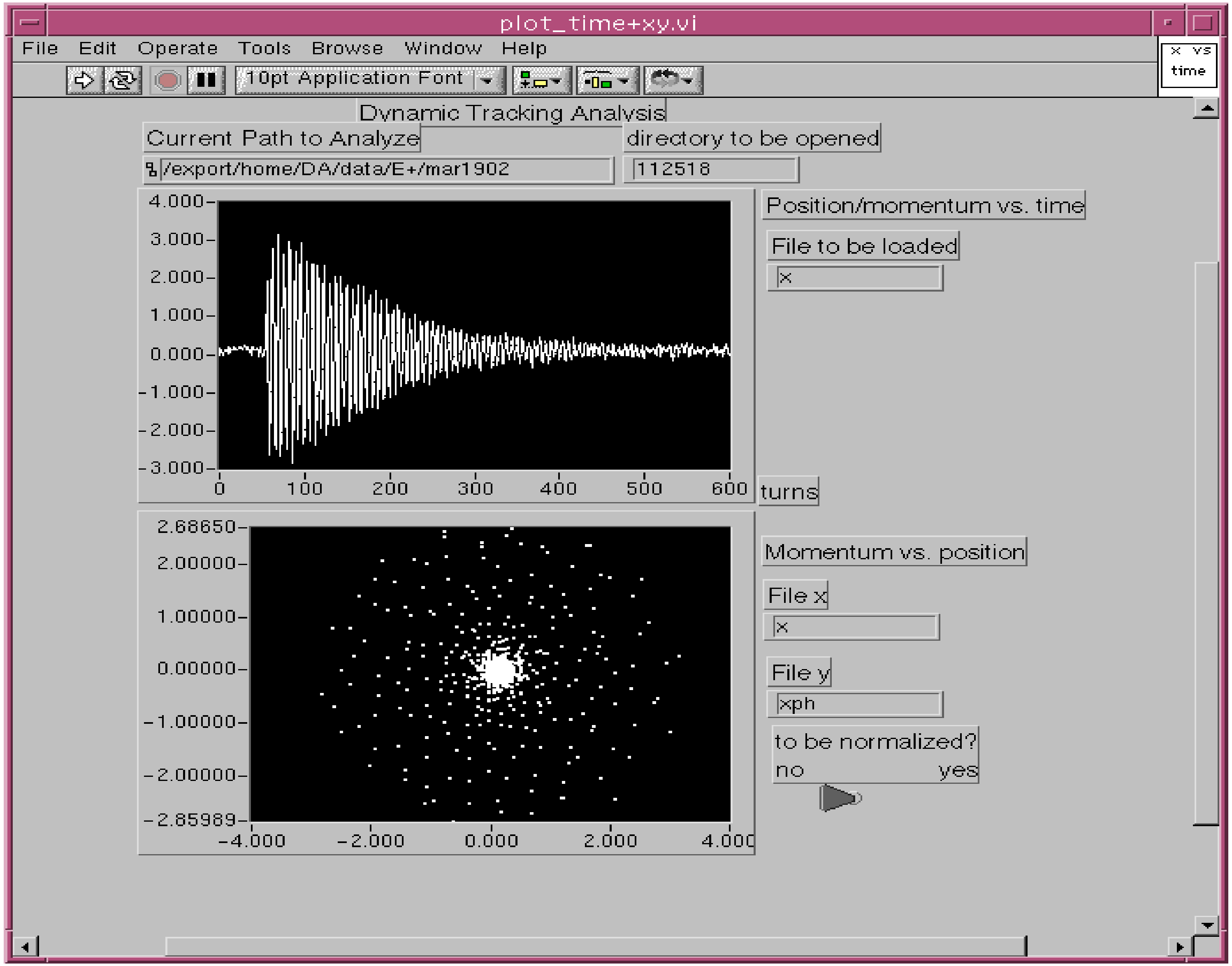
where α, β are the horizontal or vertical Twiss parameters, and Q is the betatron tune.

In alternative the Hilbert transform method can be used : a preliminary comparison has shown a good agreement between the the two methods.

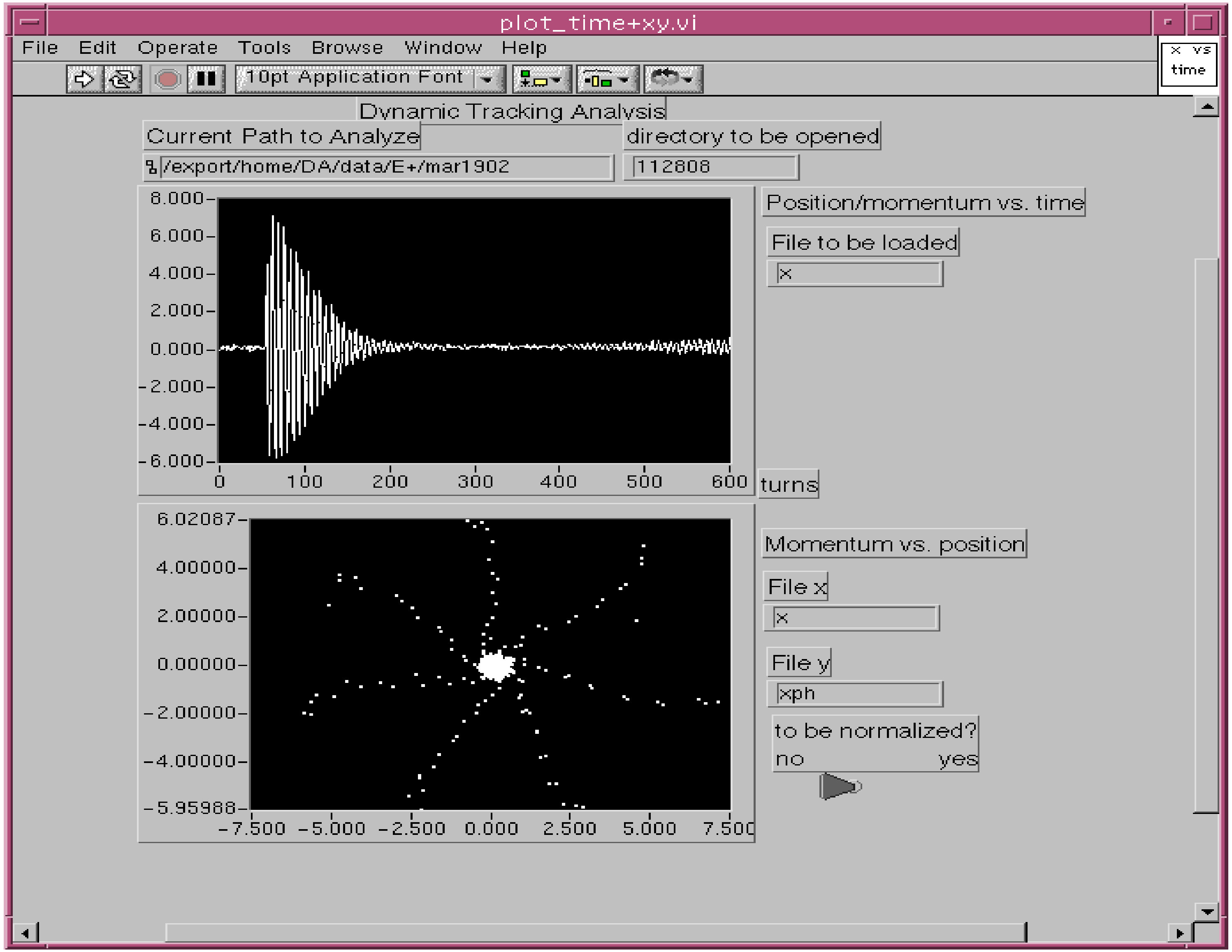
Horizontal phase space plot drawn using the Hilbert transform



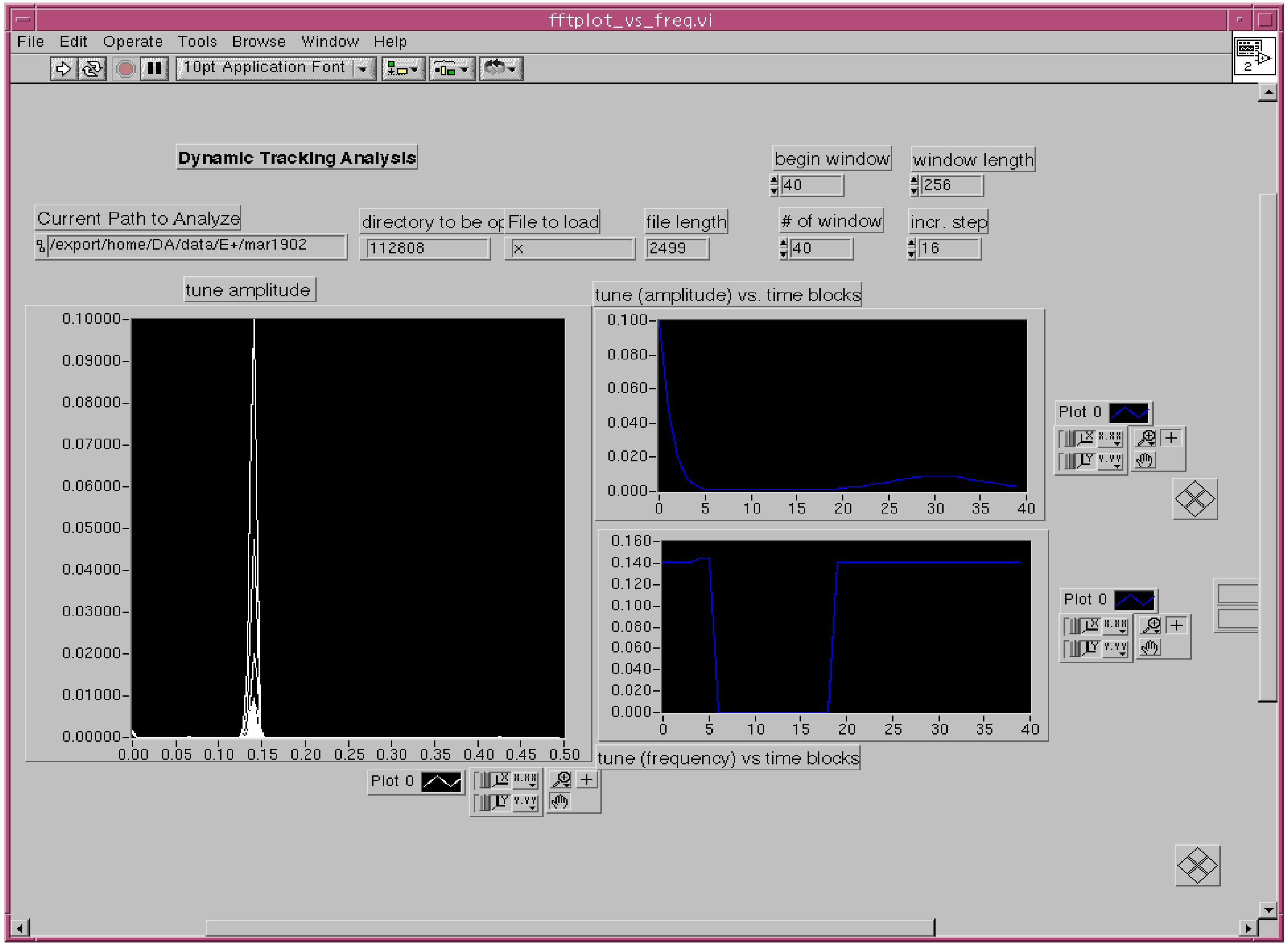
Plot x in time and x' versus x (3kV kick)



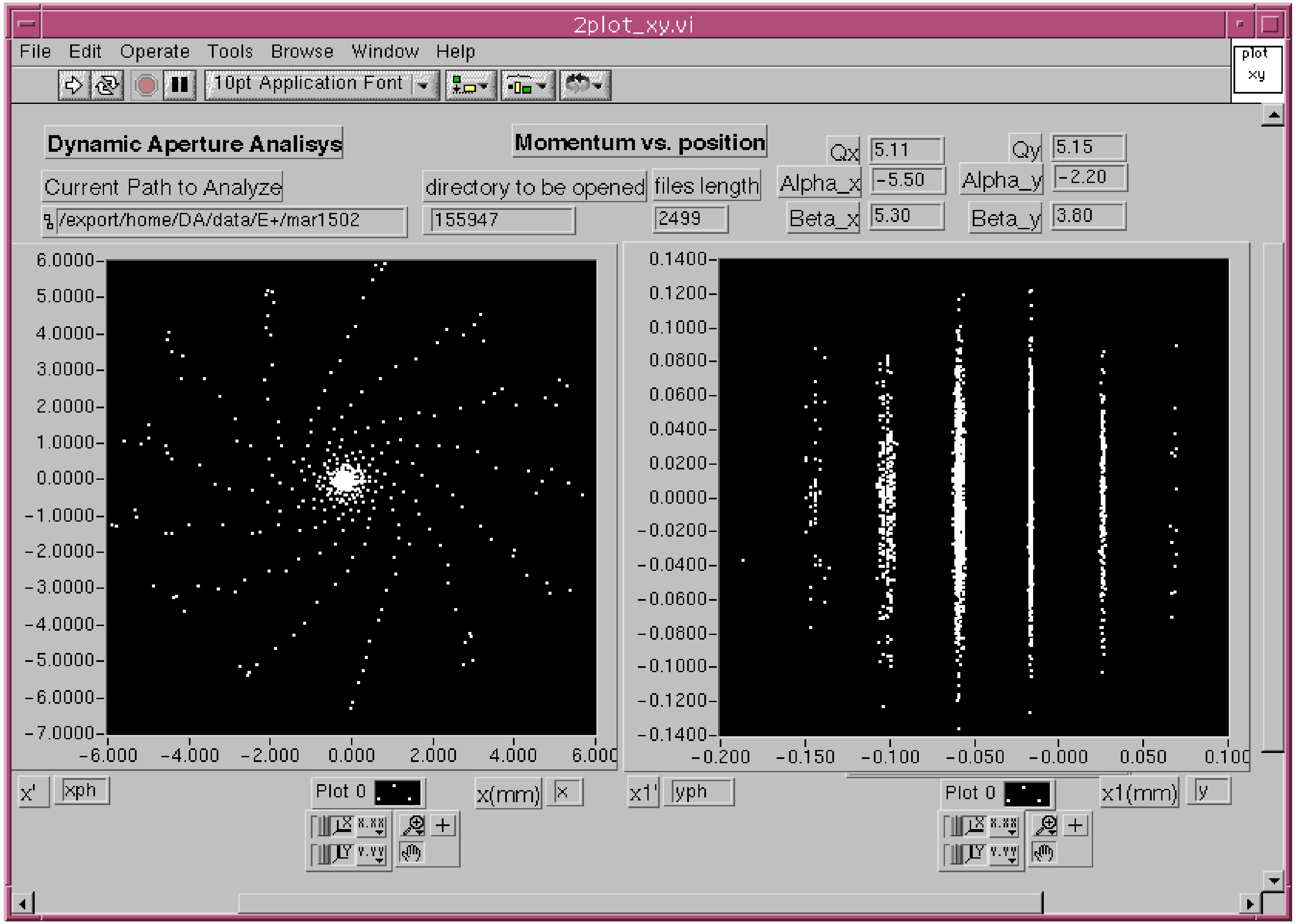
Plot x in time and x' versus x (6kV kick)



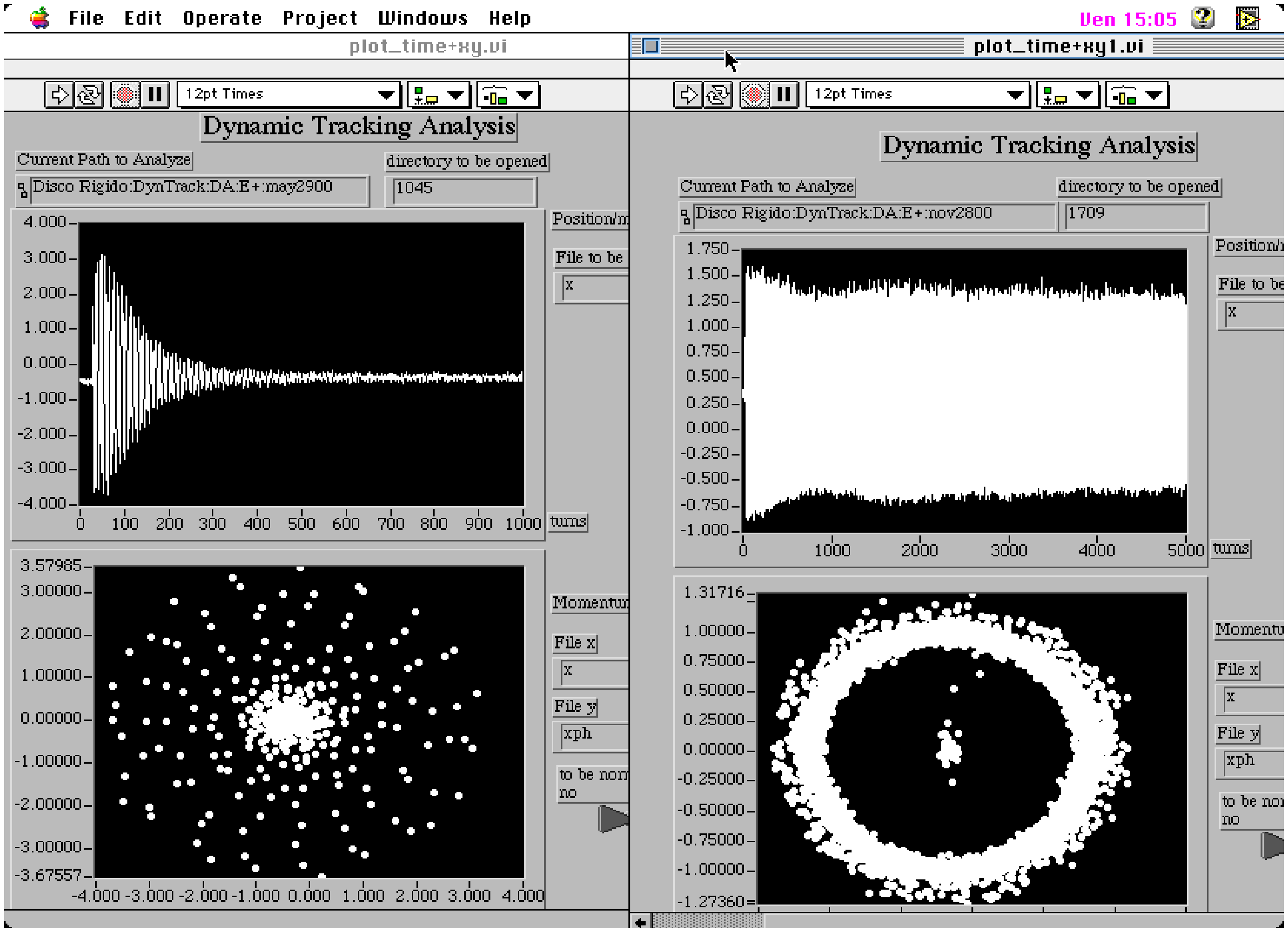
Betatron tune analysis versus time & amplitude



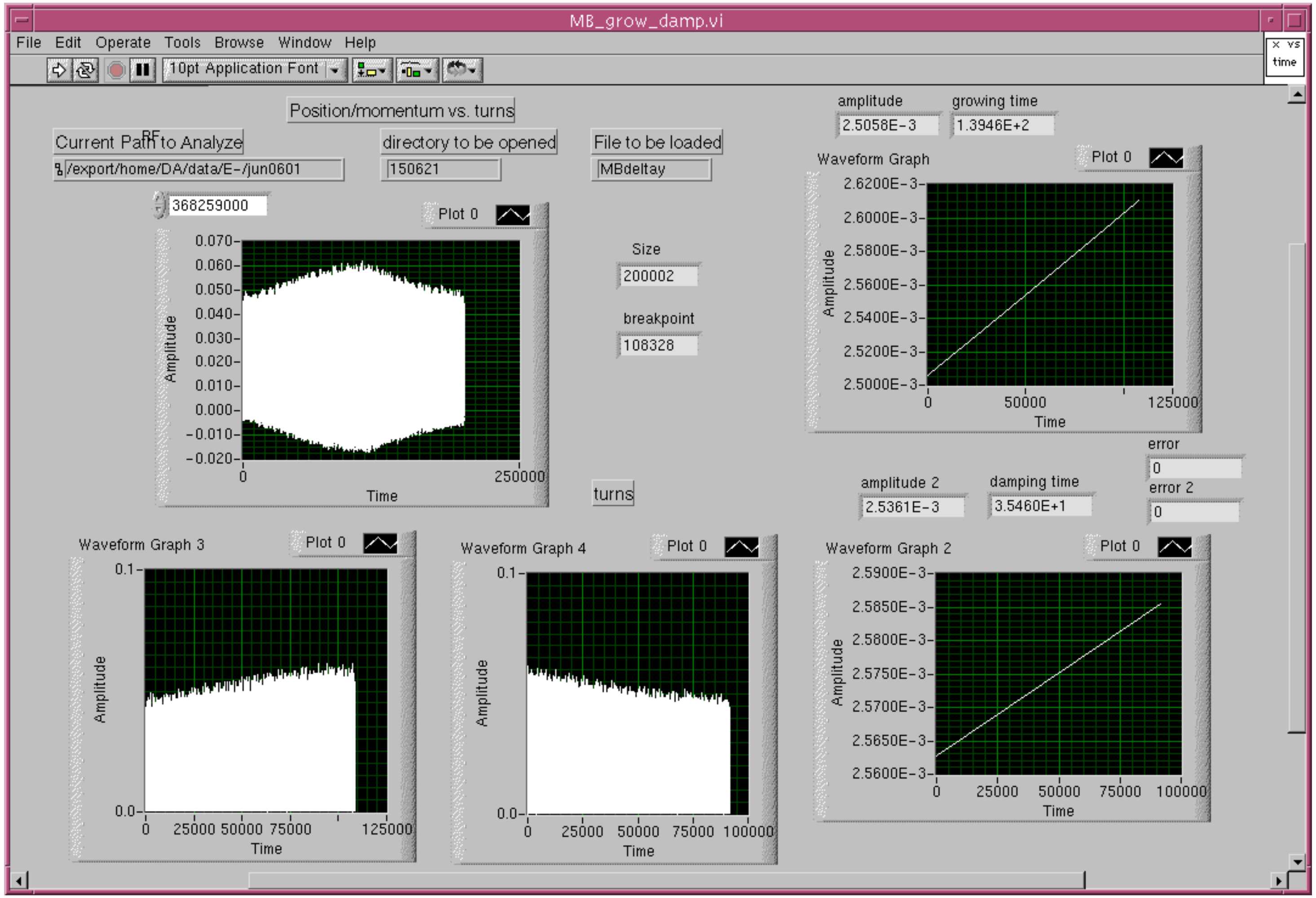
Angle versus position H and V



A comparison between two optics with wigglers on and off



Multibunch grow-damp analysis



Conclusions

- The dynamic tracking acquisition system has shown to be a very useful tool to investigate the non-linear behaviour of the Daϕne rings and to improve their performances.
- The first version of system has been upgraded to download data more quickly from the oscilloscope and to share the database with the control system.
- A second oscilloscope has been added with the goal to have eight channels and to acquire signals from two BPM's.
- It is possible to begin to develop multibunch software tools to extend the use of the system at the transverse modal analysis.

Acknowledgements

The authors wish to thank Oscar Coiro and Donato Pellegrini for the realization of the set-up, very critical on the equalization of the cables.

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