RIASSUNTO

- LETTURE DI RIFERIMENTO
- CIRCOSTANZE OPERATIVE
  - SINGOLO PASSAGGIO
  - PRIMI GIRI
  - FASCIO ACCUMULATO
- STRUMENTAZIONE INTERCETTANTE
  - EMISSIONE SECONDARIA (SEM)
  - FLUORESCENZA
  - SCRAPER
  - BEAM LOSS MONITOR
- STRUMENTAZIONE NON INVASIVA
  - "LUCE" DI SINCROTRONE
  - PICKUP E KICKER
  - DISPOSITIVI ELETTROMAGNETICI
    - ELETTRICI
    - MAGNETICI
- ESEMPI A DAFNE
  - MISURA TUNE/ORBITE/FUNZIONI OTTICHE

LETTURE di RIFERIMENTO

R. Littauer:
"Beam Instrumentation",
"Physics of High Energy Particle Accelerators". Editor: M. Month - AIP Conference Proceedings No. 105, pp. 869-953 (1983).

J. Borer, R. Jung:
"**Diagnostics**",
Cern Accelerator School - Antiprotons for Colliding Beam Facilities. Proceedings. Editors: P. Bryant, S. Newman - CERN 84-15, p.385 (1984).

J.L. Pellegrin:
"**Review of Accelerator Instrumentation**",
Proceedings of the XI-th International Conference on High Energy Accelerators, CERN, Geneva, July 1980, p.459 (1980), also Slac Note SLAC-PUB-2522 (1980).

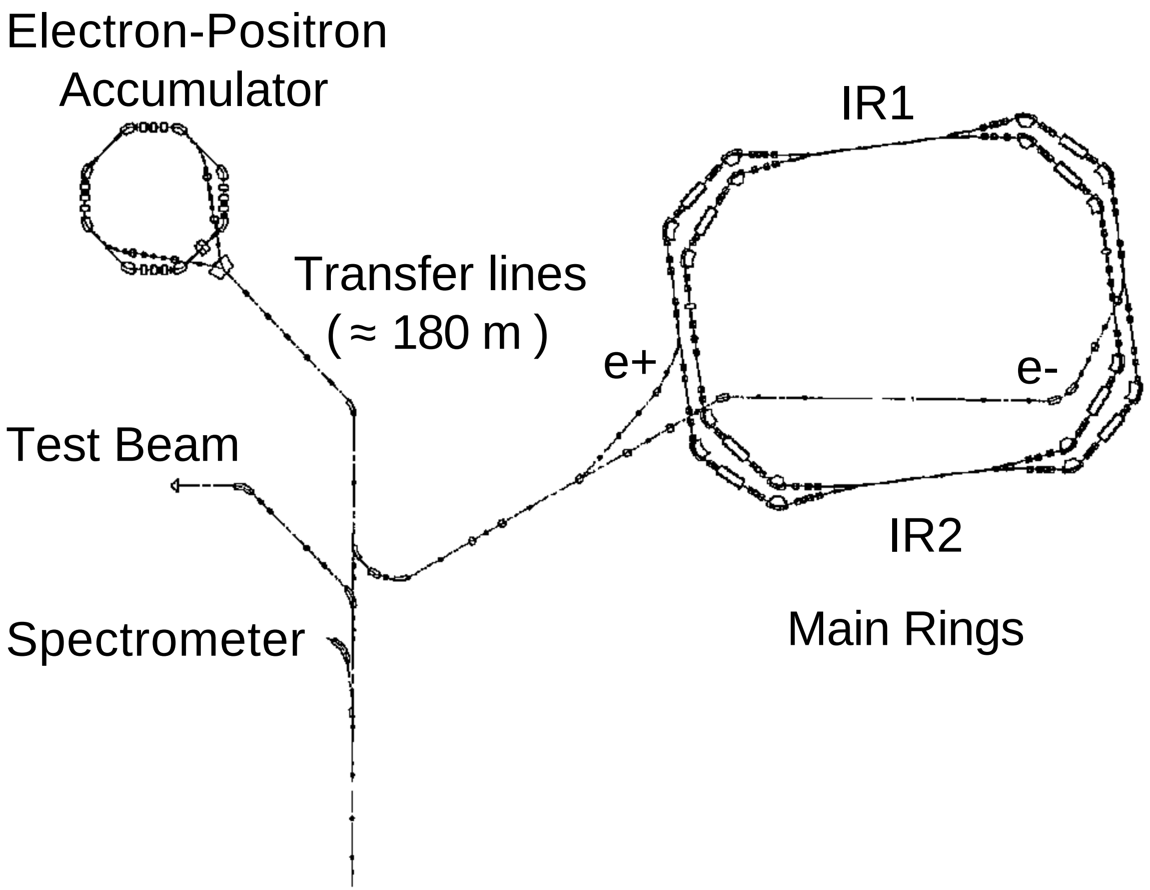
M. G. Billing:
"Beam Position Monitors for Storage Rings",
Nuclear Instruments and Methods in Physics Research, A266 (1988) 144-154.

R. E. Shafer:
"Beam Position Monitoring",
"The physics of particle accelerators". - Proceedings Accelerator Instrumentation, M. Dienes M. Month Eds., Upton 1989, - pp. 601-636 (1992).

M. Serio:
"**Tune Mesurements**",
Fourth General Accelerator Physics Course, Cern Accelerator School (CAS). CERN Yellow Report 91-04, pp. 136-160, (1991).

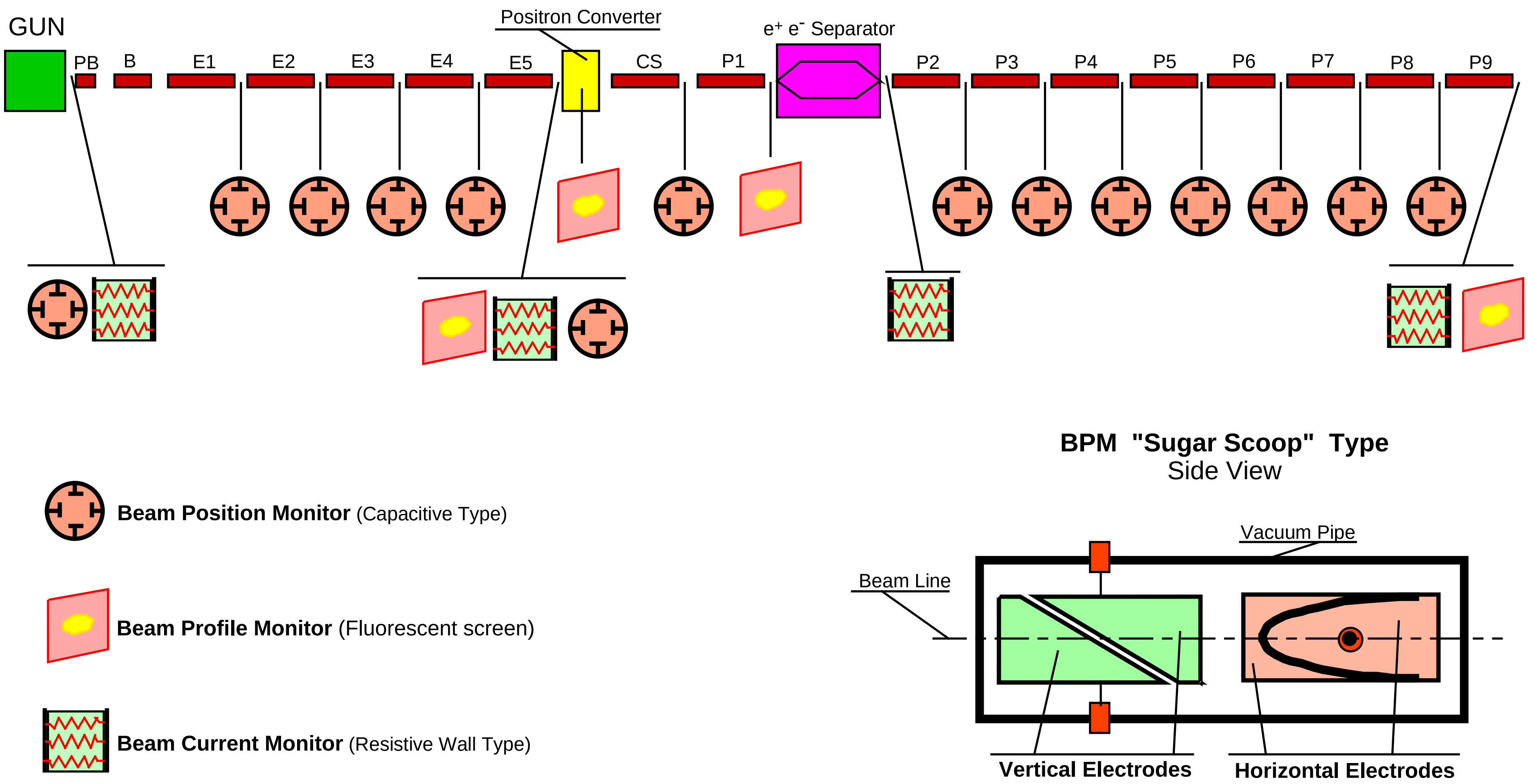
TABELLA RIASSUNTIVA STRUMENTAZIONE DIAGNOSTICA DAFNE

TIPO	TRANSFER LINES			STORAGE RINGS			IP's		
	TM/TS	TB TL/TR TT	TT TP/TE	ACC	MR e-	MR e+	D1	K	F
Odoscopio a Emissione Secondaria	1								
Faraday Cup	1								
Targhetta (*Flag*) OTR	1								
Flag Ceramiche Fluorescenti	1	7	9	2	1	1			
Slit/Scraper Orizzontali	1	2	1		2	2			
Slit/Scraper Verticali					1	1			
Beam Stopper	1	1	1						
Monitor di Corrente a Toroide	1	5	3	1					
Wall Current Monitor (MIR)					1	1			
Monitor di Corrente DC (DCCT)				1	1	1			
Beam Position Monitor - Stripline (BPS)	3	7	13	4+1			4		
Beam Position Monitor - *Bottoni* (BPB)				8	33	33	12	10	10
Beam Position Monitor - Speciali					3	3			
Kicker Trasverso - Stripline				1	2	2			
X/Y Tune Monitor/Transv. Feedback				1	1	1			
Monitor a Luce di Sincrotrone (LDS)				2	1	1			
Beam Loss Monitor				1	14	14	2	2	2
Monitor di Luminosità (Macchina)							2/4		



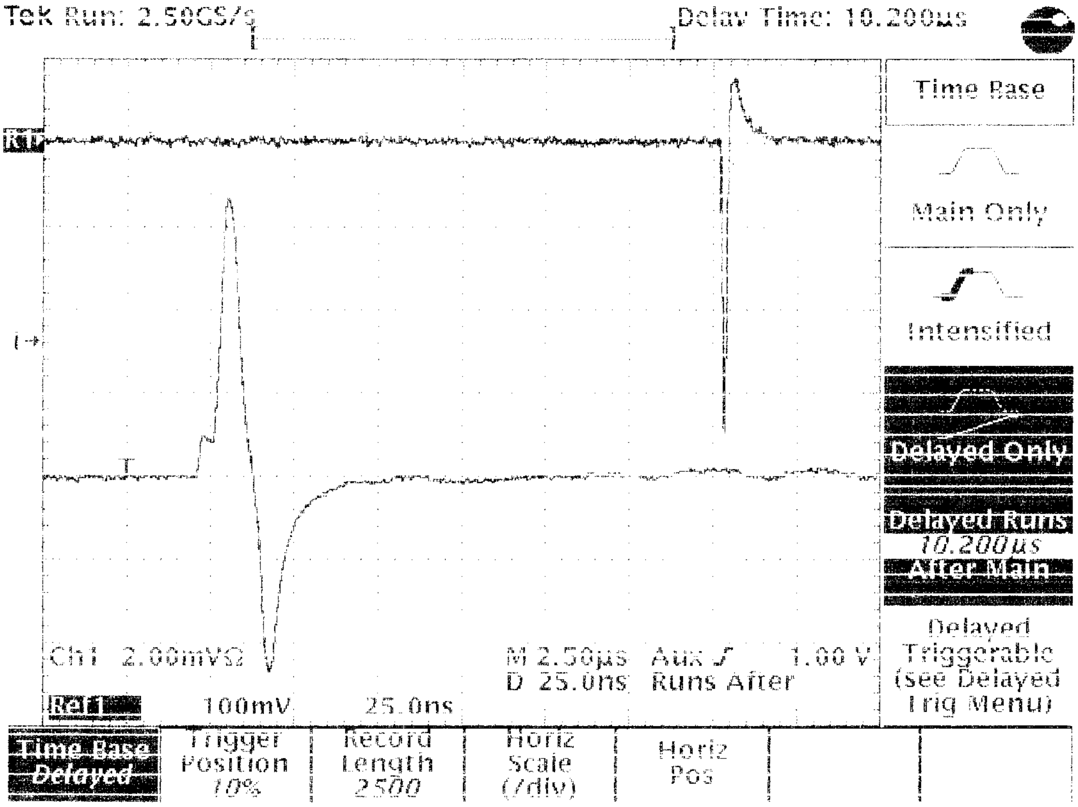
LINAC e+	**10-100 mA**	**T~10 ns**	**ΔE/E ±1.5%**	**1-....50/sec**
LINAC e-	**50-500 mA**	**T~10 ns**	**ΔE/E ±0.5%**	**1-....50/sec**
TRANSFER LINE LTA	**Efficienza di trasporto ≤60%**			**1-....50/sec**
ACCUMULATORE	**10-140 <mA> [1nC => 9.2 <mA>]**			**9.206 MHz**
TRANSFER LINE ATR	**Efficienza di trasporto ~95%**			**1-2/sec**

FIGURE 4. DAΦNE LINAC BEAM DIAGNOSTICS



TRANSFER LINE e+

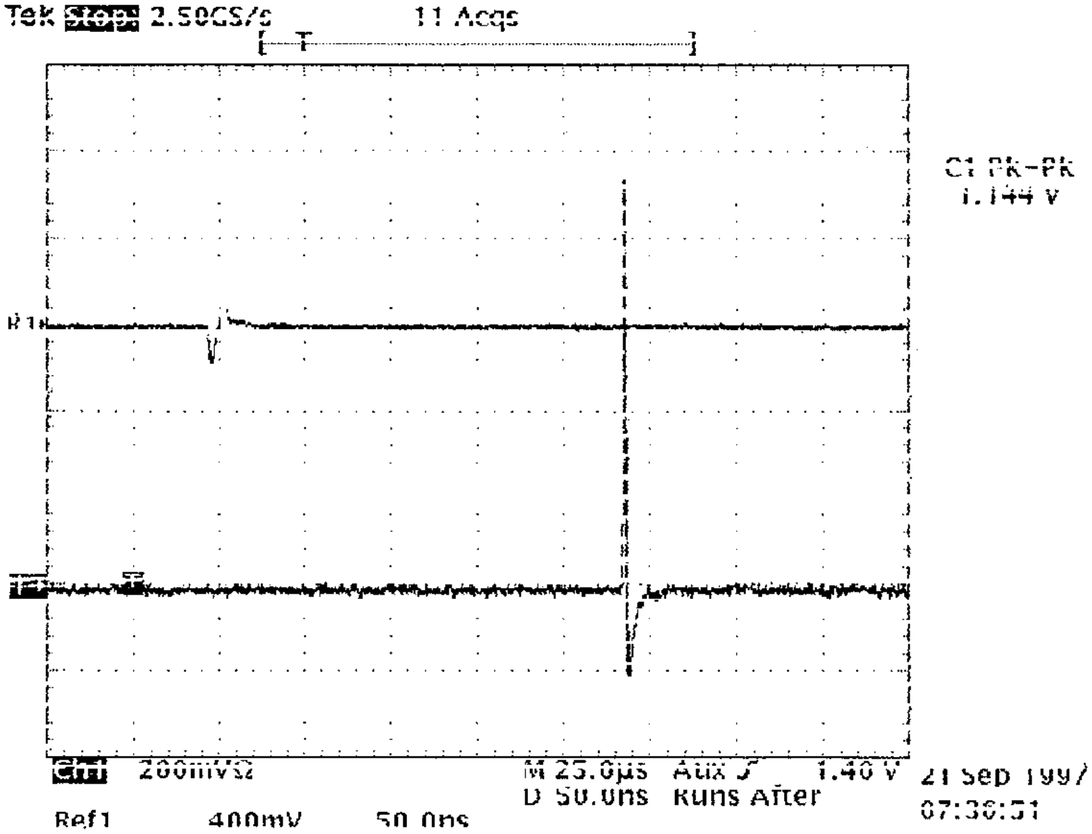
Tratto comune di iniezione e estrazione
Segnali dal medesimo BPM a Stripline (BPS)



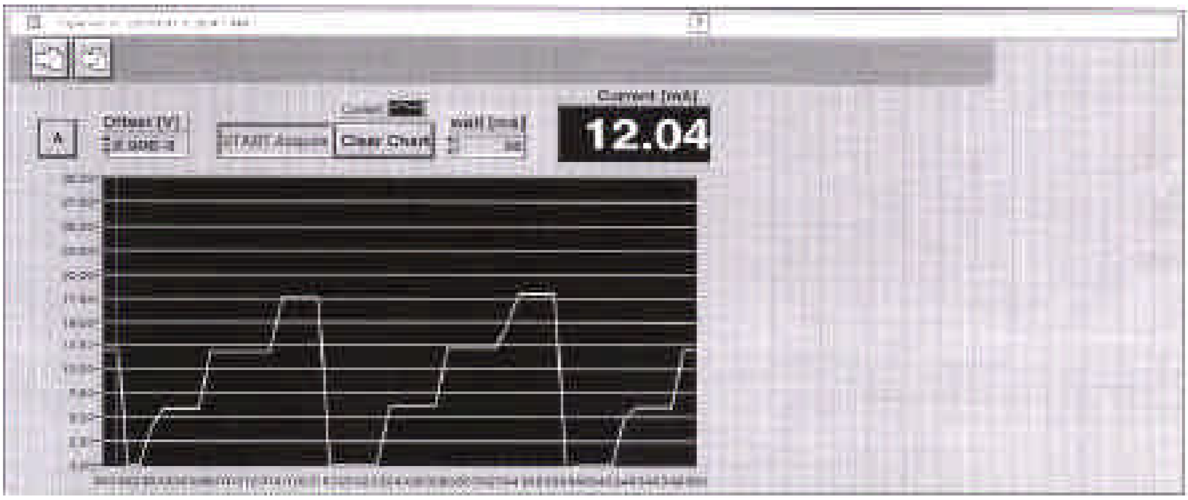
Traccia Inferiore(2mV/div):
Fascio dal Linac (lungo,debole)

Traccia Superiore (50 mV/div):
Fascio dall'Accumulatore(breve, intenso).

INIEZIONE IN ACCUMULATORE ED ESTRAZIONE VERSO DAFNE

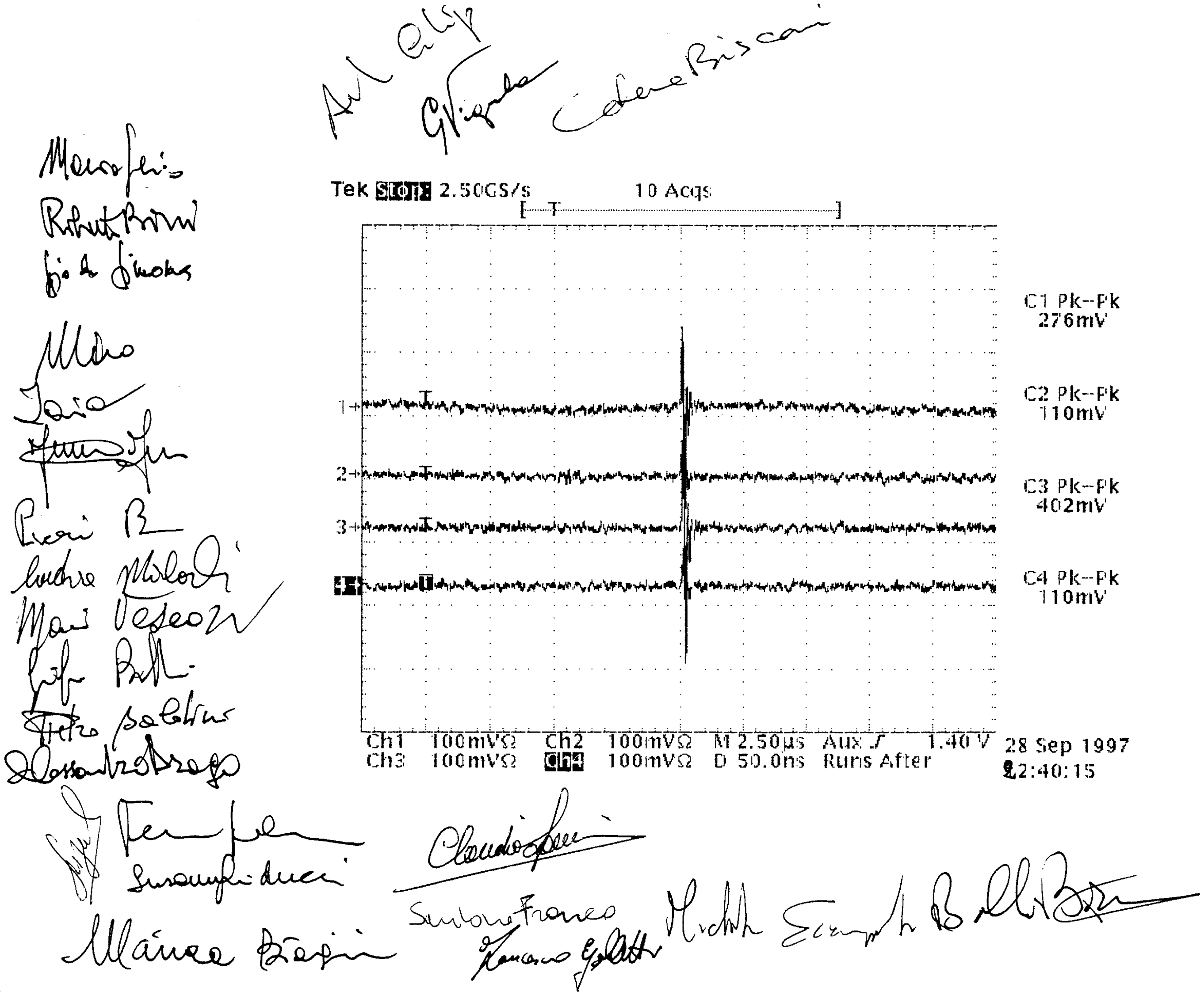


MONITOR A STRIPLINE



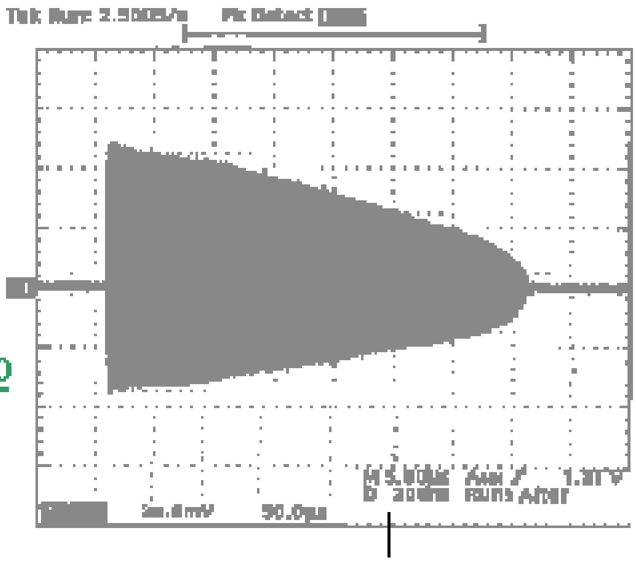
MONITOR DI CORRENTE TOTALE (DC)

Primo (singolo) passaggio di e- in DAFNE MR



Iniezione in Anello

$$\Delta_x = \eta \frac{\Delta p}{p}$$

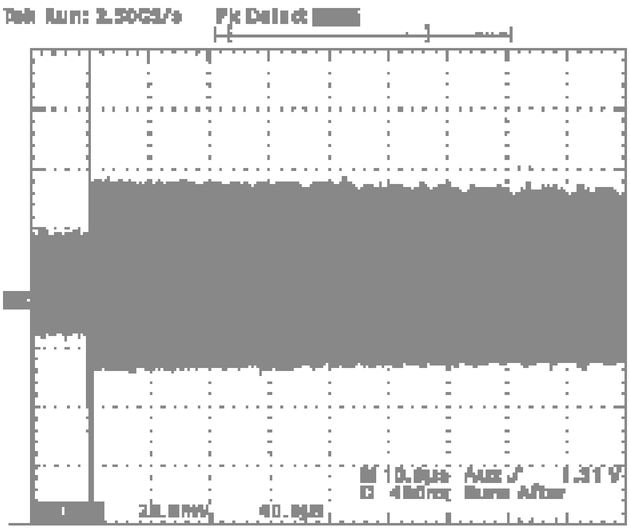


RF OFF

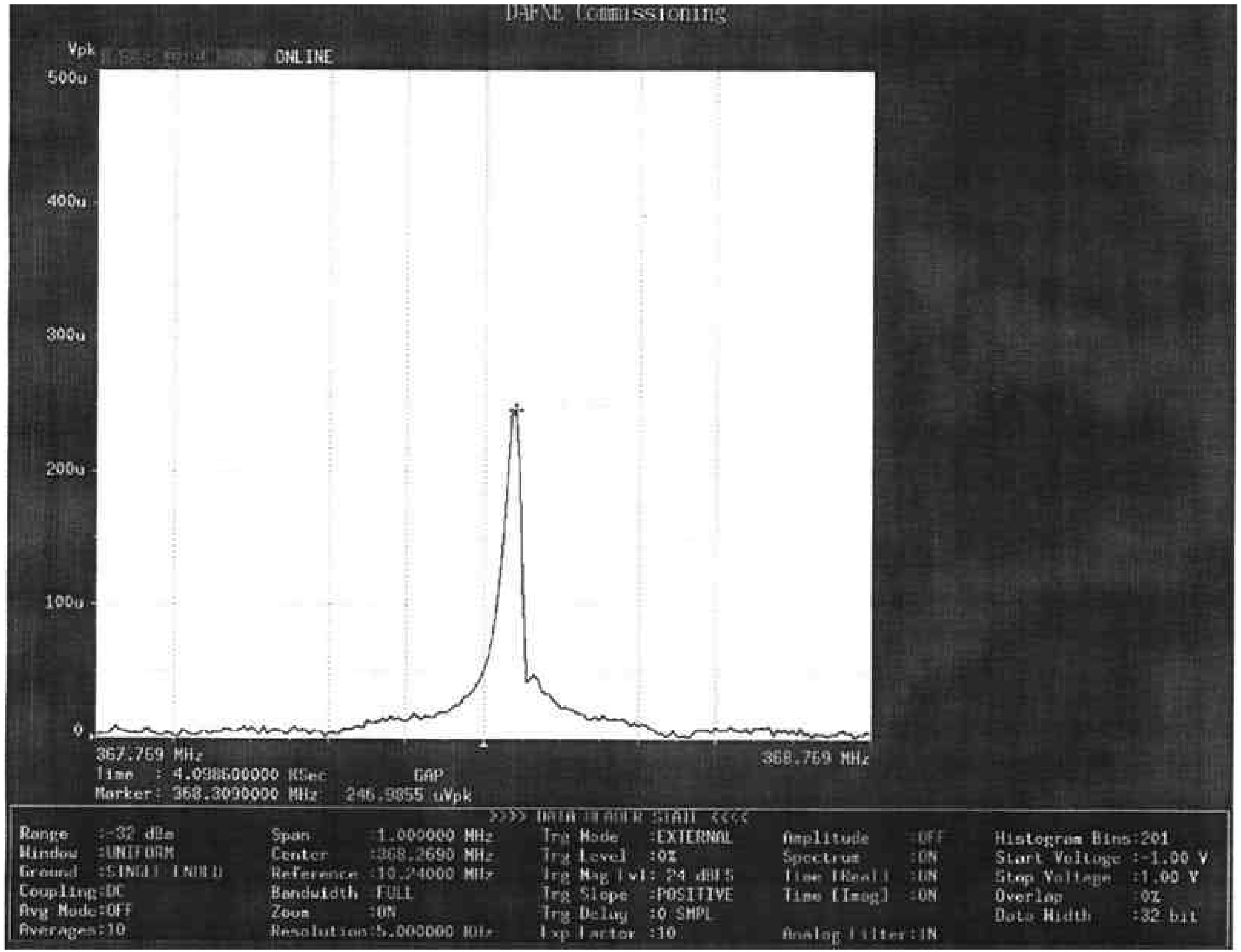
$$\Delta_x^{max} = \eta^{max} \frac{N^{max} U_0}{E_0}$$

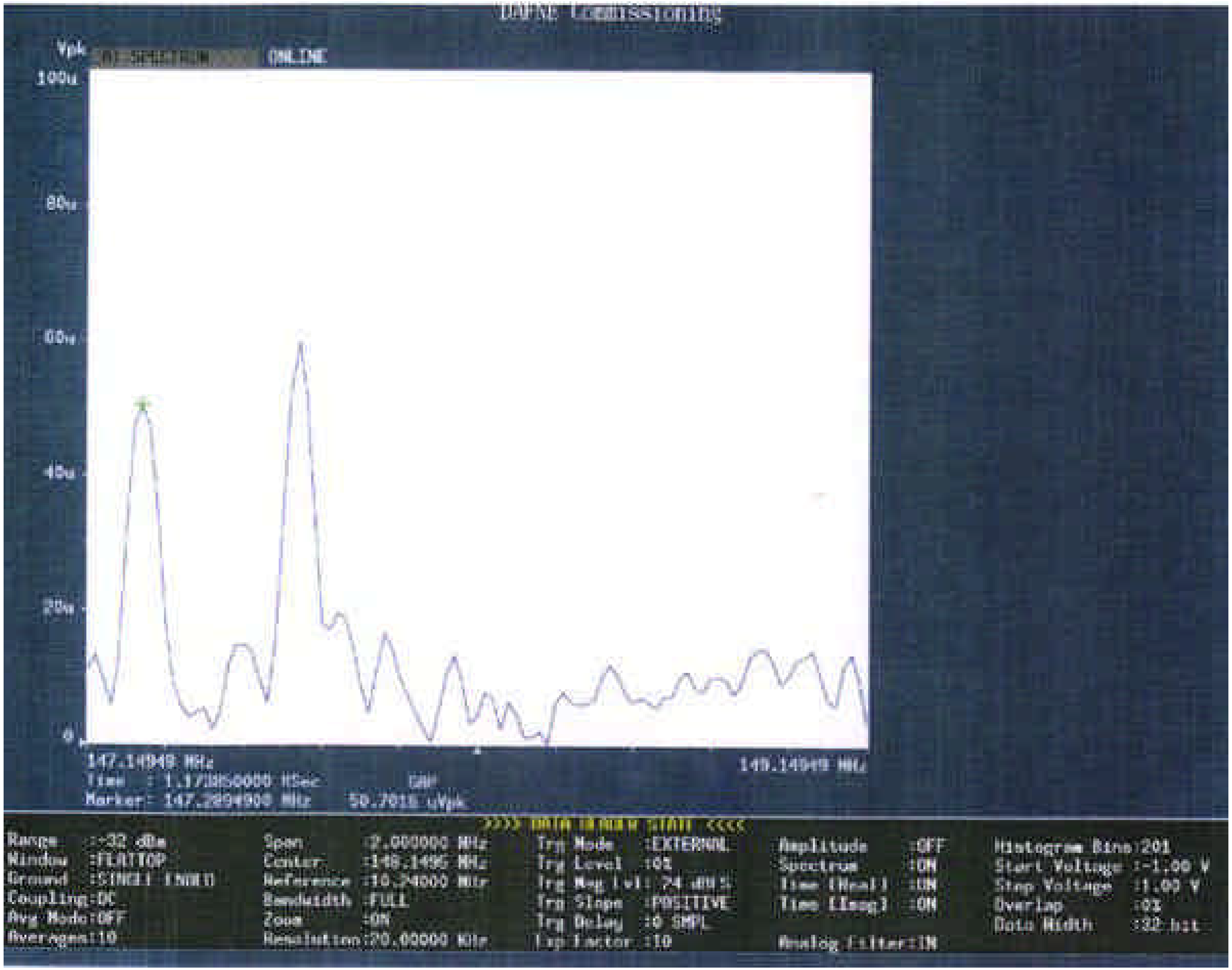
$$N^{max}(\text{theor.}) = 1200$$

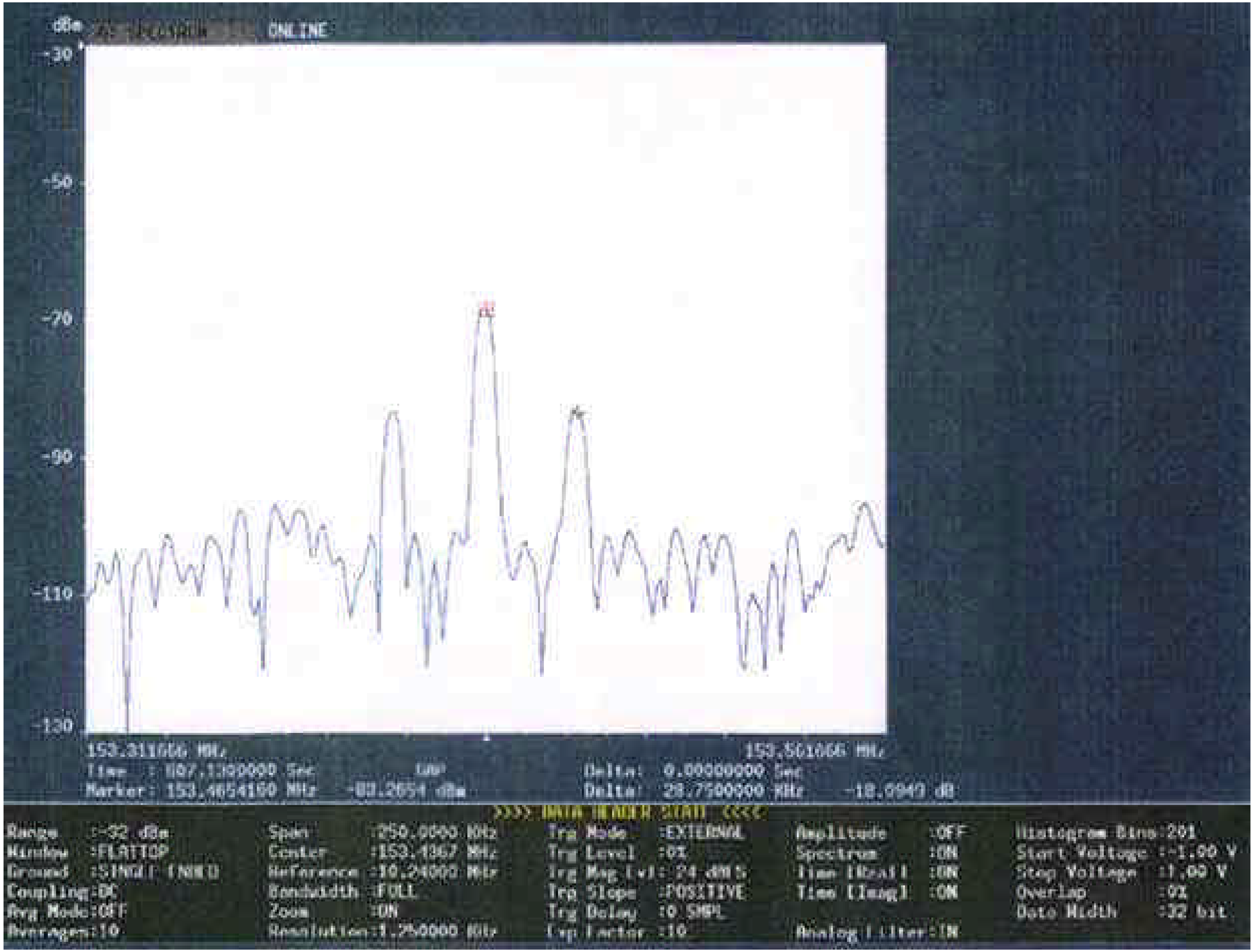
$$N^{max}(\text{meas.}) = 1100$$



RF ON

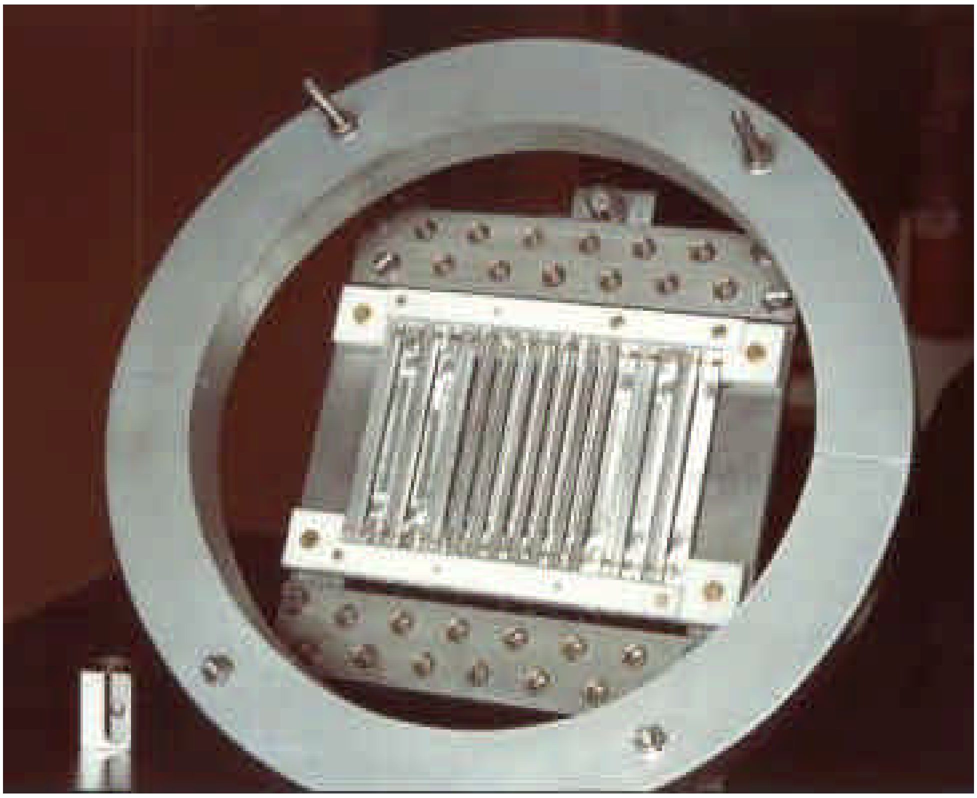

DAΦNE Commissioning
Vpk
ONLINE
500u
400u
300u
200u
100u
0
367.769 MHz
368.769 MHz
Time : 4.098600000 KSec
GAP
Marker: 368.3090000 MHz 246.9855 uVpk
>>>> DATA HEADER STAT <<<<
Range :-32 dBm
Window :UNIFORM
Coupling:DC
Avg Mode:OFF
Averages:10
Span :1.000000 MHz
Center :368.2690 MHz
Reference :10.24000 MHz
Bandwidth :FULL
Zoom :ON
Resolution:5.000000 KHz
Trg Mode :EXTERNAL
Trg Level :0%
Trg Mag lvl: 24 dBFS
Trg Slope :POSITIVE
Trg Delay :0 SMPL
Exp Factor :10
Amplitude :OFF
Spectrum :ON
Time [Real] :ON
Time [Imag] :ON
Analog Filter:ON
Histogram Bins:201
Start Voltage :-1.00 V
Step Voltage :1.00 V
Overlap :0%
Data Width :32 bit

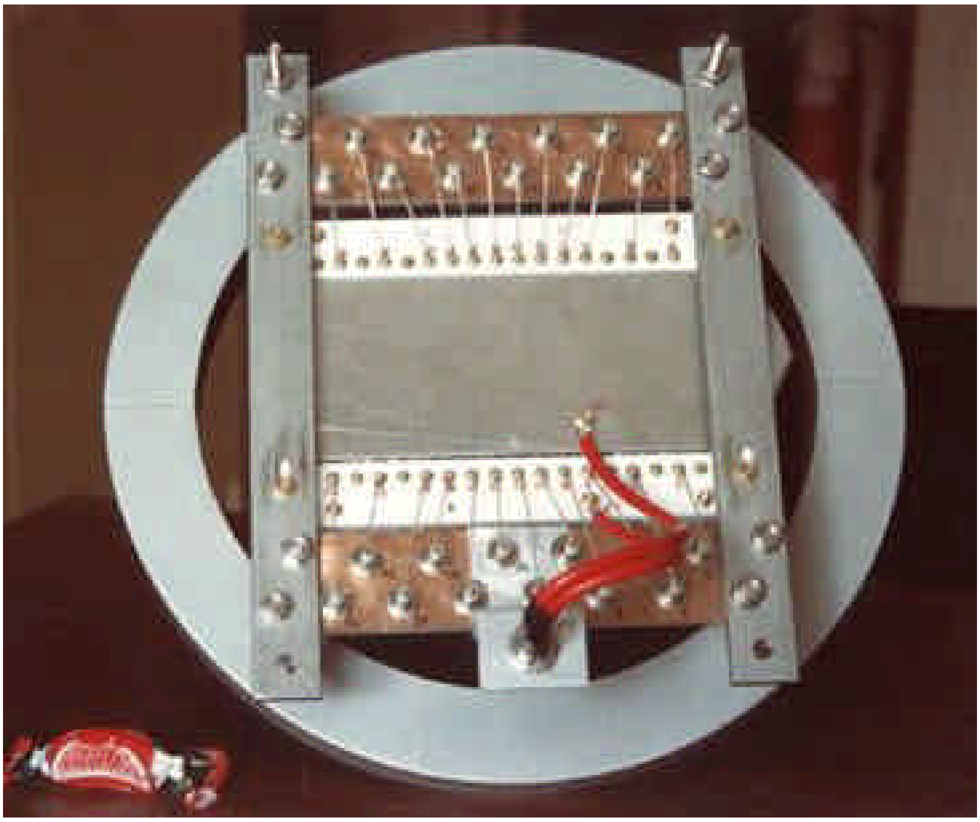

DAFNE Commissioning
Vpk
ONLINE
100u
80u
60u
40u
20u
0
147.14949 MHz
149.14949 MHz
Time : 1.17185000 MSec
Marker: 147.289900 MHz
50.7016 uVpk
Range :-32 dBm
Window :FLATTOP
Coupling:DC
Avg Mode:OFF
Averages:10
Span :2.000000 MHz
Center :148.1495 MHz
Reference :10.24000 MHz
Bandwidth :FULL
Zoom :ON
Resolution:20.00000 KHz
Trg Mode :EXTERNAL
Trg Level :0%
Trg Slope :POSITIVE
Trg Delay :0 SMPL
Amplitude :OFF
Spectrum :ON
Time (Real) :ON
Time (Imag) :ON
Analog Filter:IN
Histogram Bins:201
Start Voltage :-1.00 V
Stop Voltage :1.00 V
Overlap :0%
Data Width :32 bit

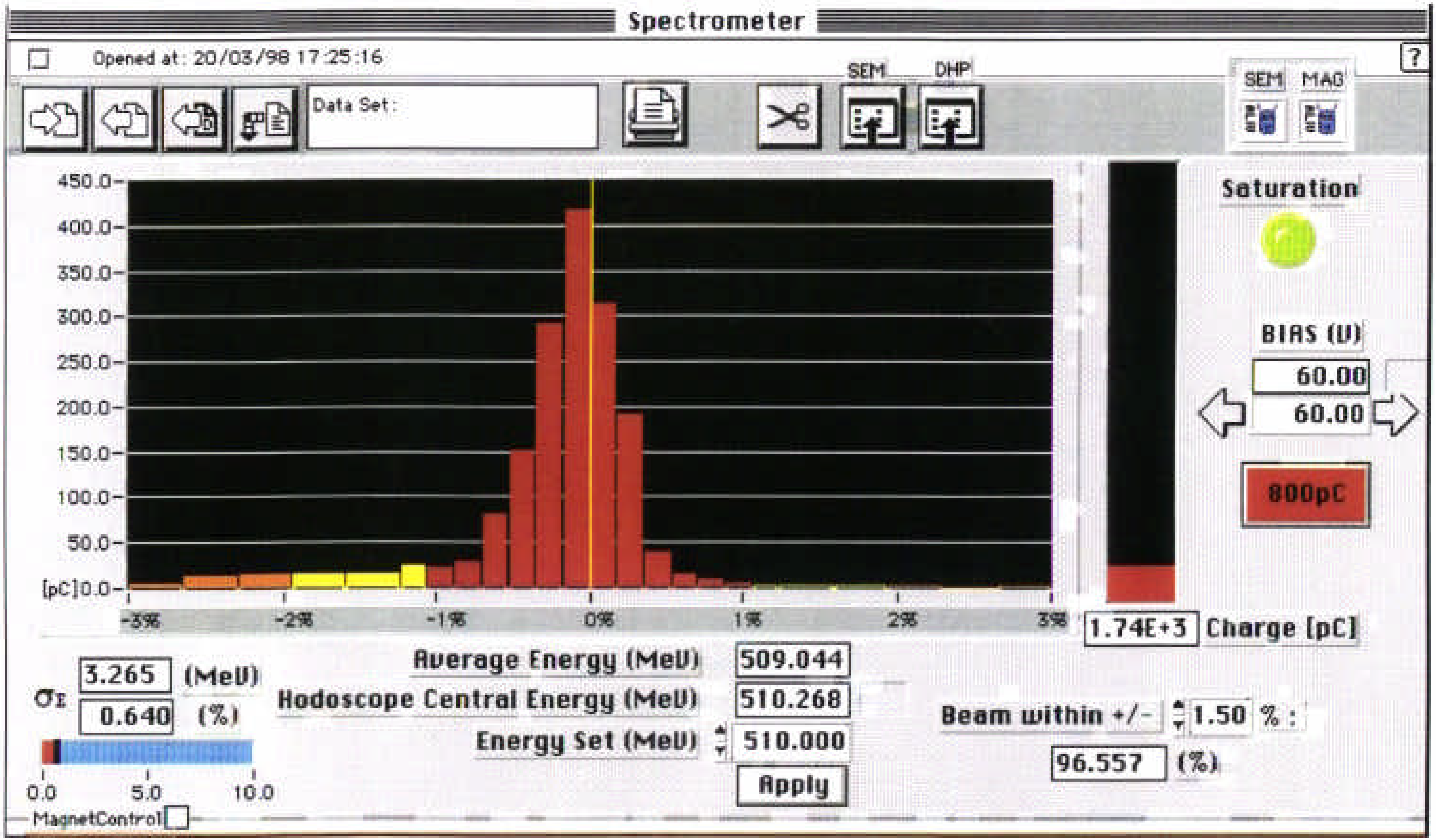

dBm
ONLINE
-30
-50
-70
-90
-110
-130
153.311666 MHz
153.561666 MHz
Time : 887.1300000 Sec
Marker: 153.4654160 MHz -83.2654 dBm
Delta: 0.00000000 Sec
Delta: 28.7500000 KHz -18.0949 dB
>>>> DATA HEADER START <<<<
Range :-32 dBm
Window :FLATTOP
Coupling:DC
Avg Mode:OFF
Averages:10
Span :250.0000 KHz
Center :153.4367 MHz
Reference :10.24000 MHz
Bandwidth :FULL
Zoom :ON
Resolution:1.250000 KHz
Trg Mode :EXTERNAL
Trg Level :0%
Trg Slope :POSITIVE
Trg Delay :0 SMPL
Amplitude :OFF
Spectrum :ON
Analog Filter:ON
Histogram Bins:201
Start Voltage :-1.00 V
Step Voltage :1.00 V
Overlap :0%
Data Width :32 bit

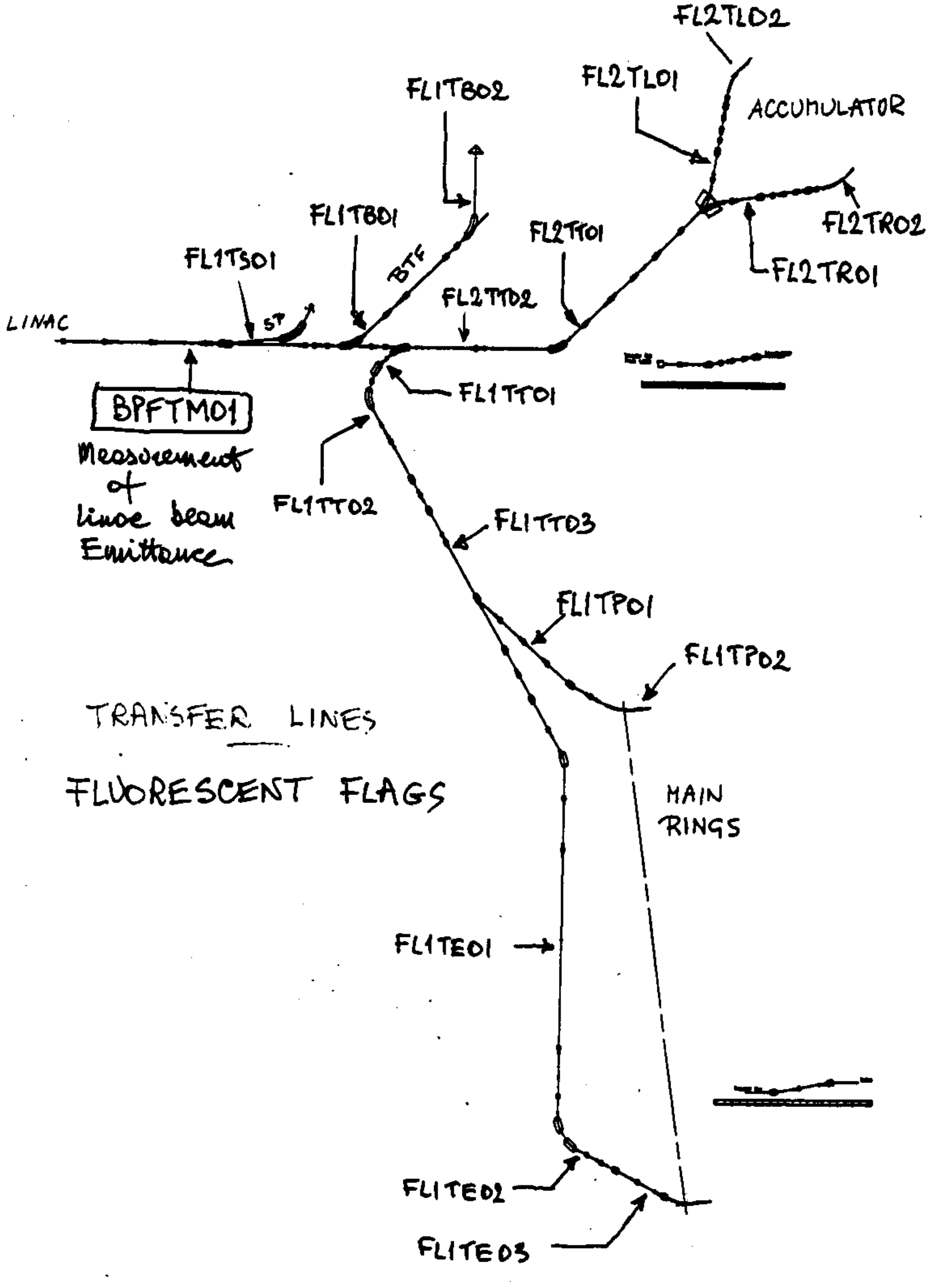
ODOSCOPIO A EMISSIONE SECONDARIA

Sullo Spettrometro. Usato per la misura di energia e di monocromaticità del fascio del Linac

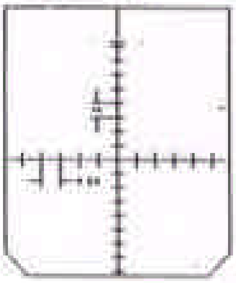




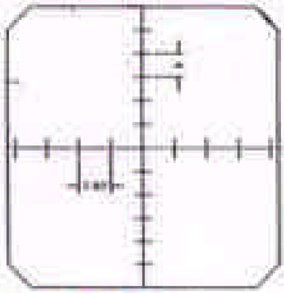

Spectrometer
Opened at: 20/03/98 17:25:16
Data Set:
SEM
DHP
SEM
MAG
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
[pC]0.0
-3%
-2%
-1%
0%
1%
2%
3%
Saturation
BIAS (V)
60.00
60.00
800pC
1.74E+3
Charge [pC]
σE
3.265
(MeV)
0.640
(%)
Average Energy (MeV)
509.044
Hodoscope Central Energy (MeV)
510.268
Energy Set (MeV)
510.000
Apply
Beam within +/-
1.50
%:
96.557
(%)
0.0
5.0
10.0
MagnetControl

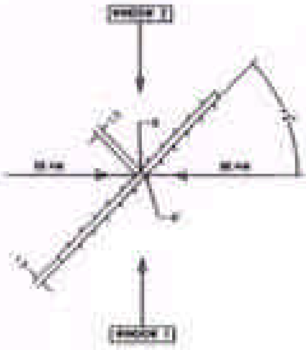

FL2TL02
FL2TL01
ACCUMULATOR
FL1TB02
FL1TB01
FL2TT01
FL2TR02
FL2TR01
FL1TS01
BTF
ST
FL2TT02
LINAC
BPFTM01
Measurement of linac beam Emittance
FL1TT01
FL1TT02
FL1TT03
FL1TP01
FL1TP02
TRANSFER LINES
FLUORESCENT FLAGS
MAIN RINGS
FL1TE01
FL1TE02
FL1TE03

Beryllium Oxide



Chromium-doped Alumina



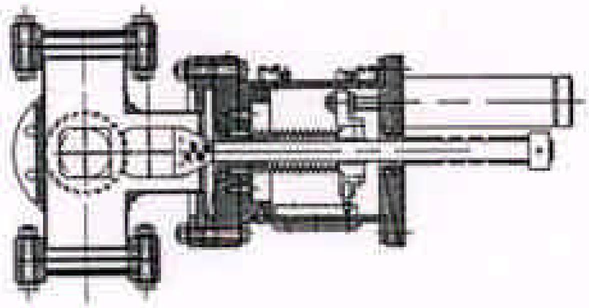


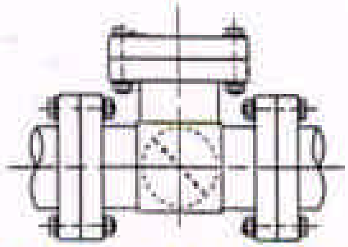
CHROMAX
CERN TYPE 6

MORGAN MATROC

Linear response vs. charge density
cfr. C.D. Johnson - CERN PS

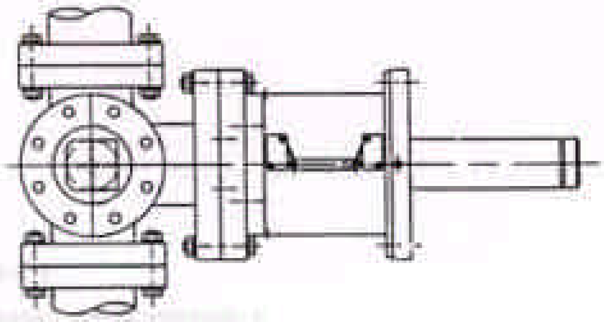
FL1

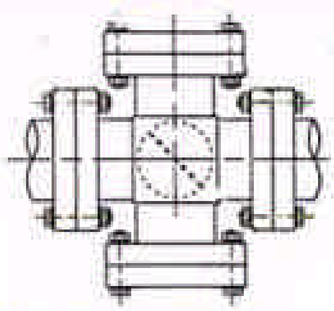




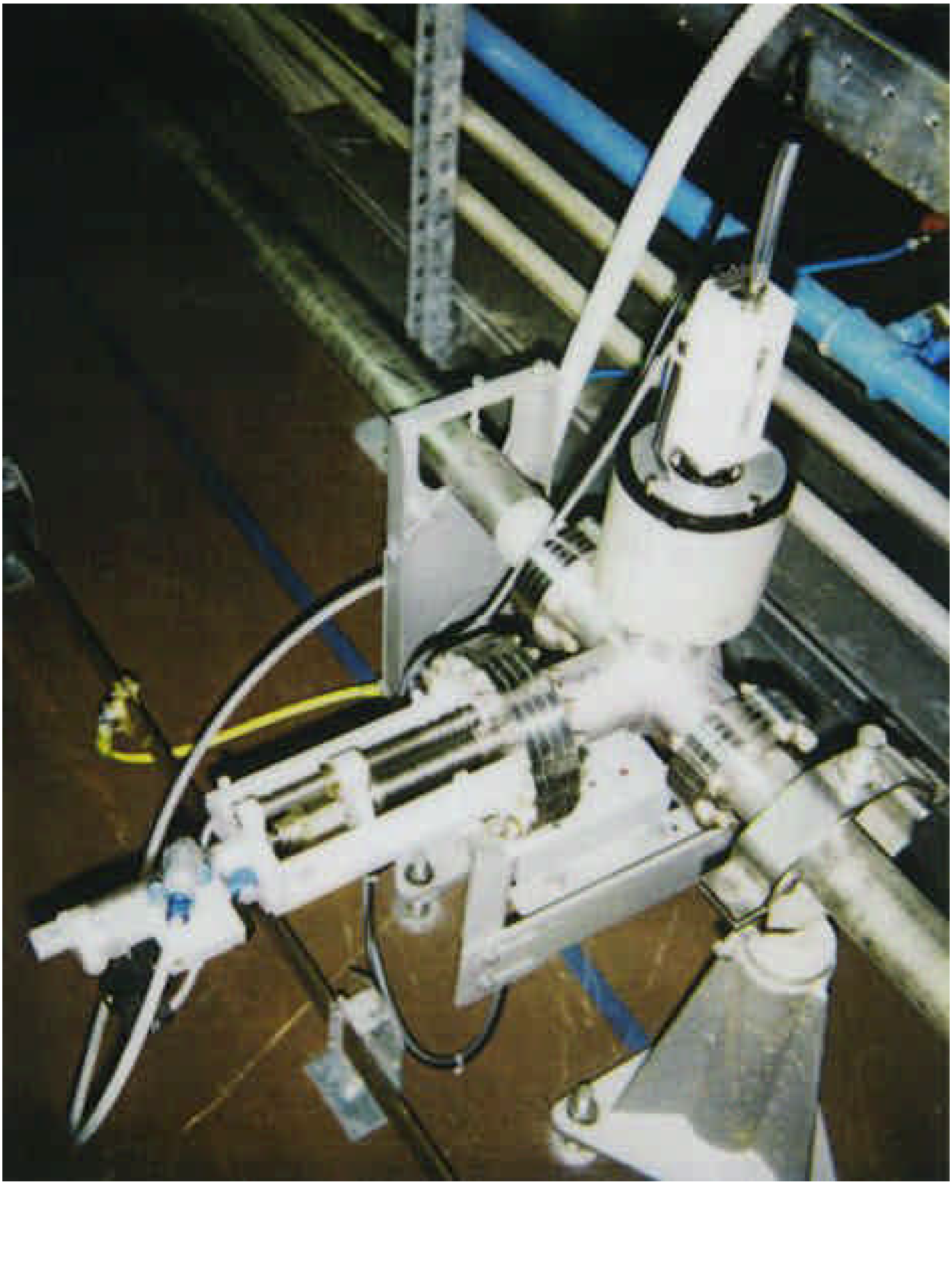
ONE WINDOW

FL2



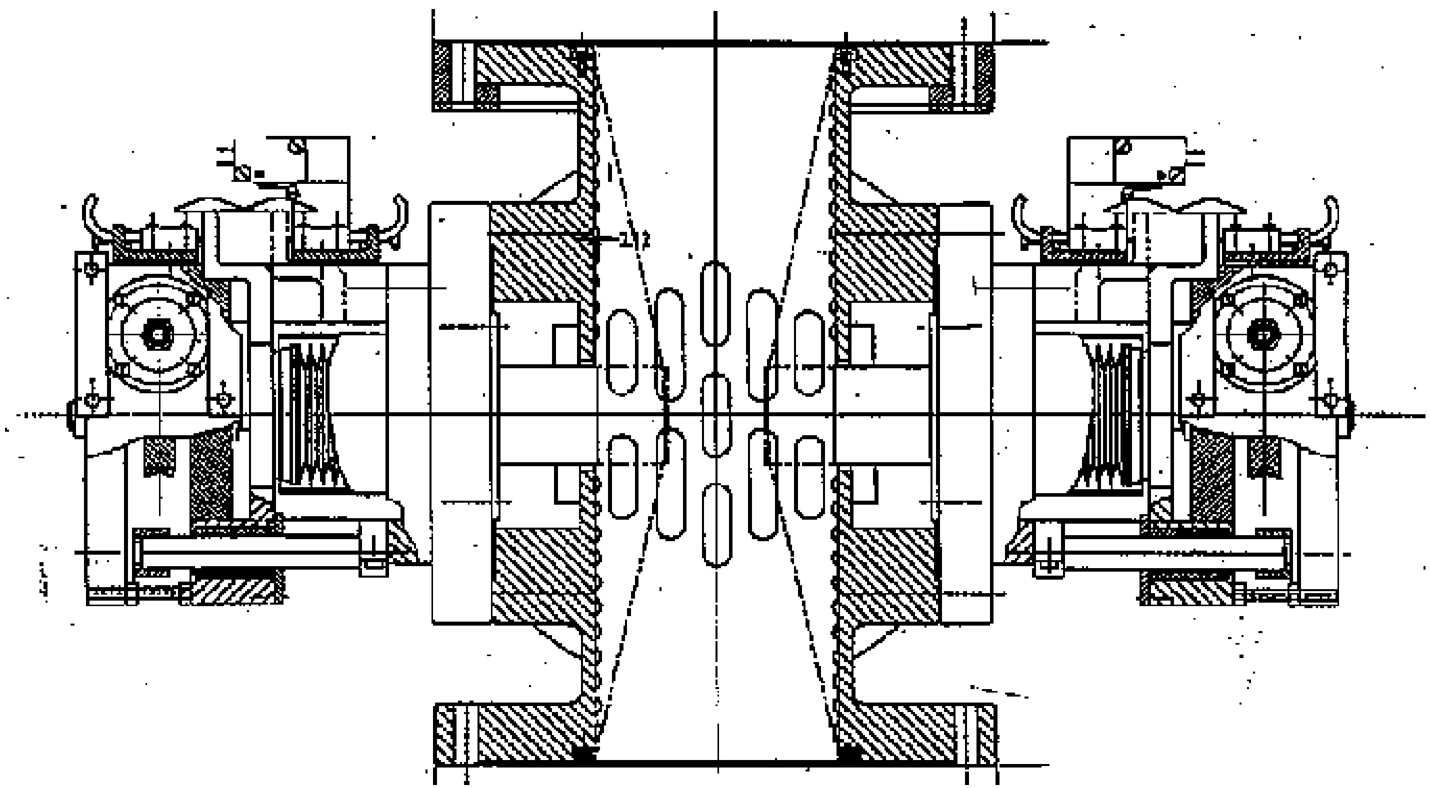


TWO WINDOWS

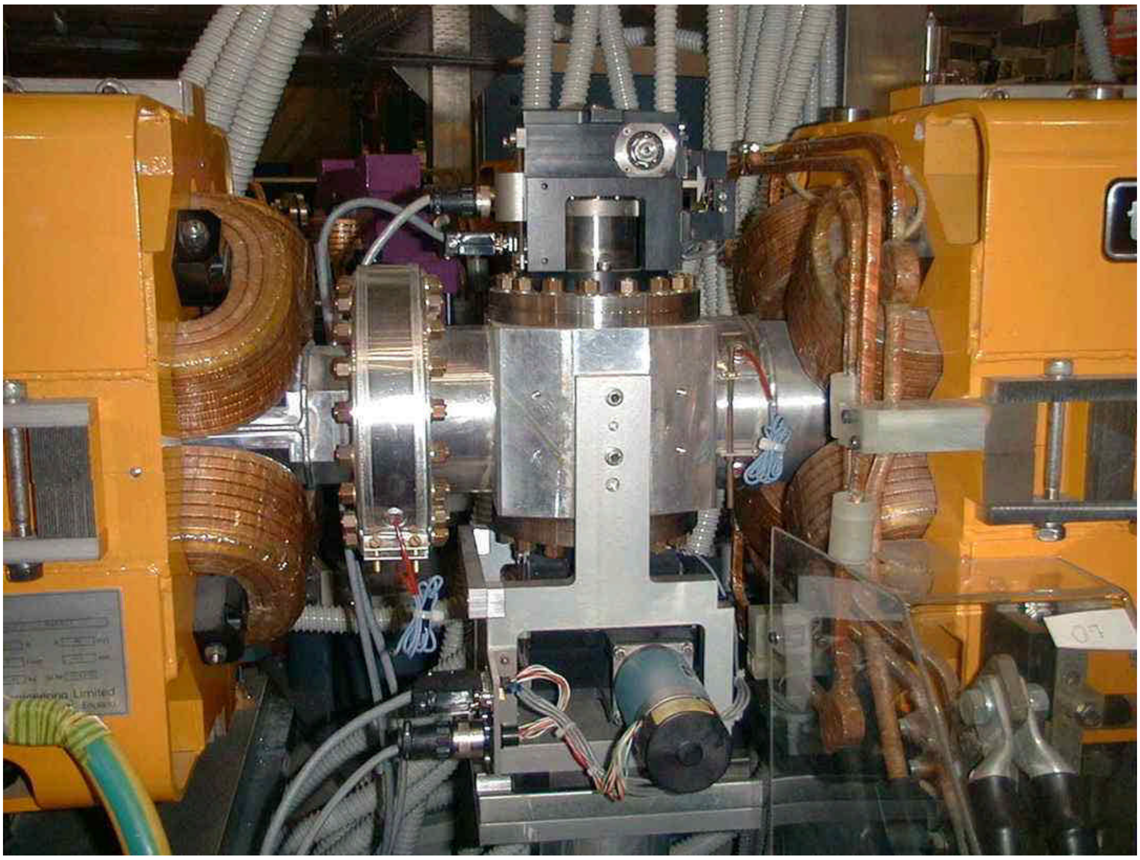


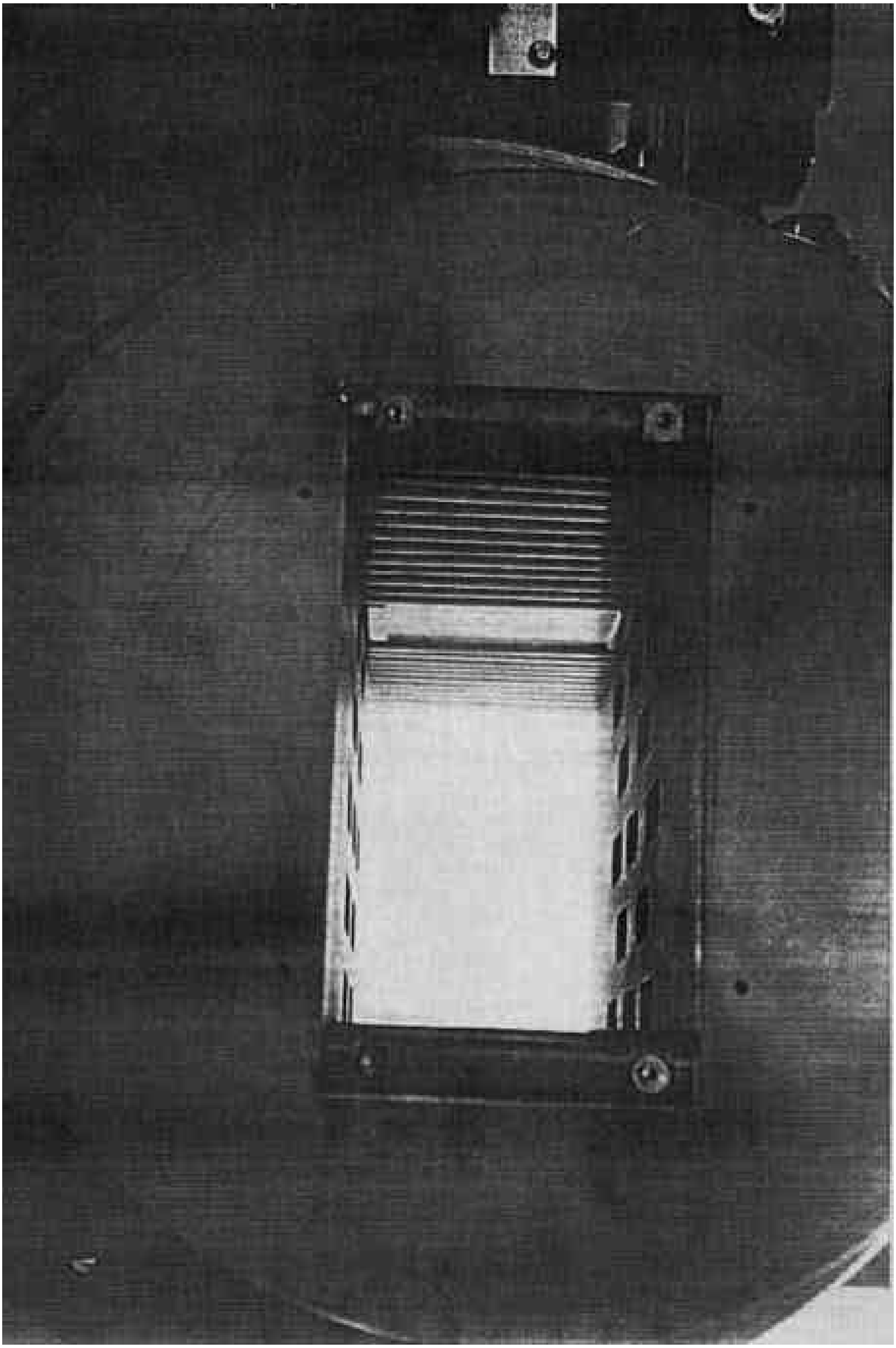
SCRAPER

Per limitare l'apertura in modo artificiale.
Serve a ridurre i fondi nelle zone sperimentali e per studi accurati sulla popolazione delle "code", misurando la vita media al variare dell'apertura.



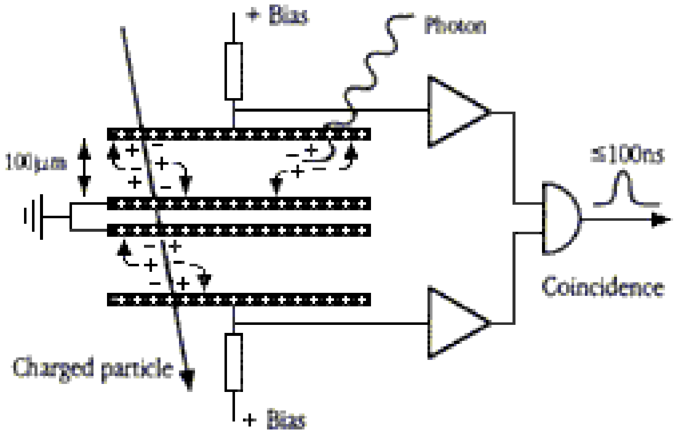
SCRAPER



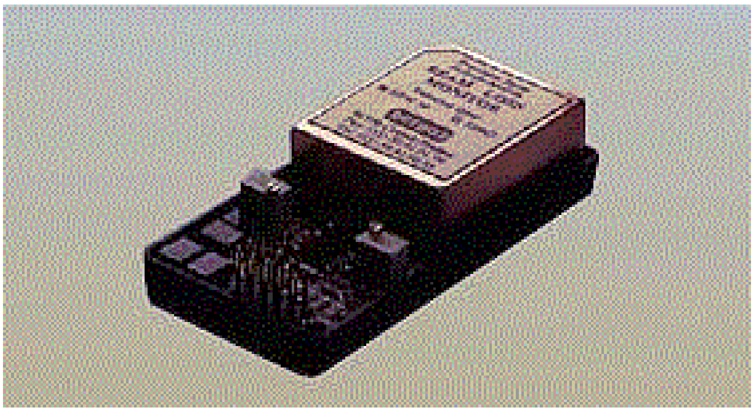


BEAM LOSS MONITOR

Due fotodiodi in coincidenza rivelano il passaggio di particelle cariche con buona reiezione dei fotoni e della "corrente nera".



Circuito alla Wittenburg (Desy-Hera)

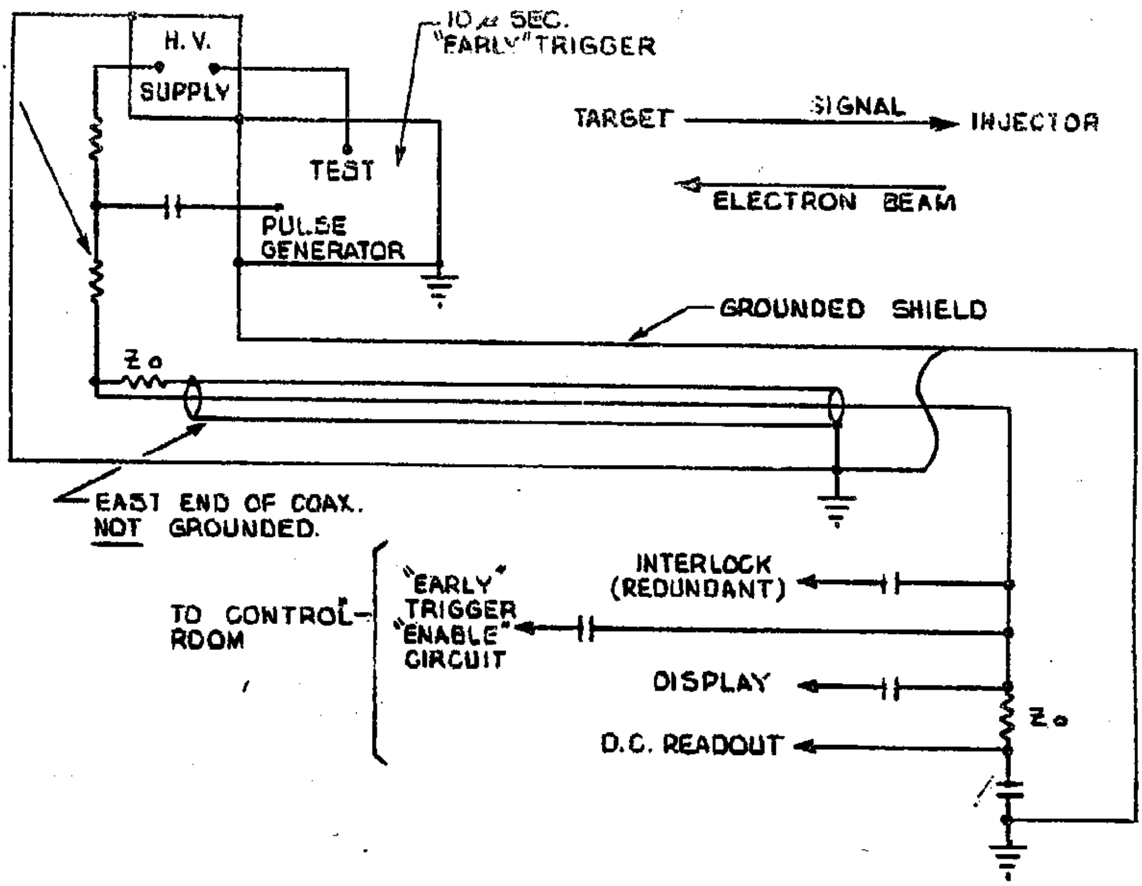


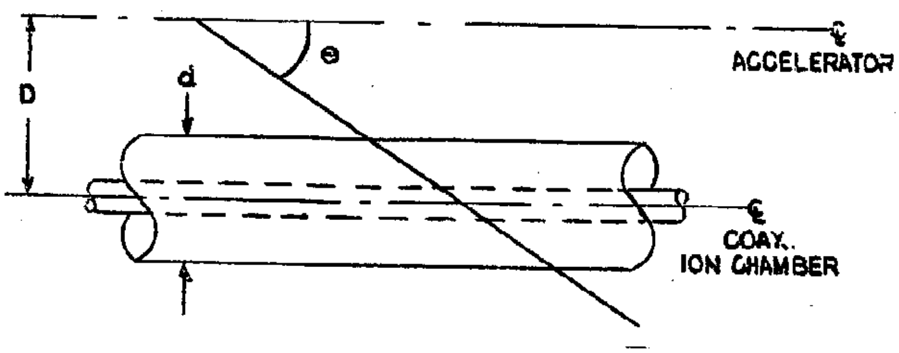
Commercializzato da BERGOZ

Panofsky Long Ion Chamber PLIC

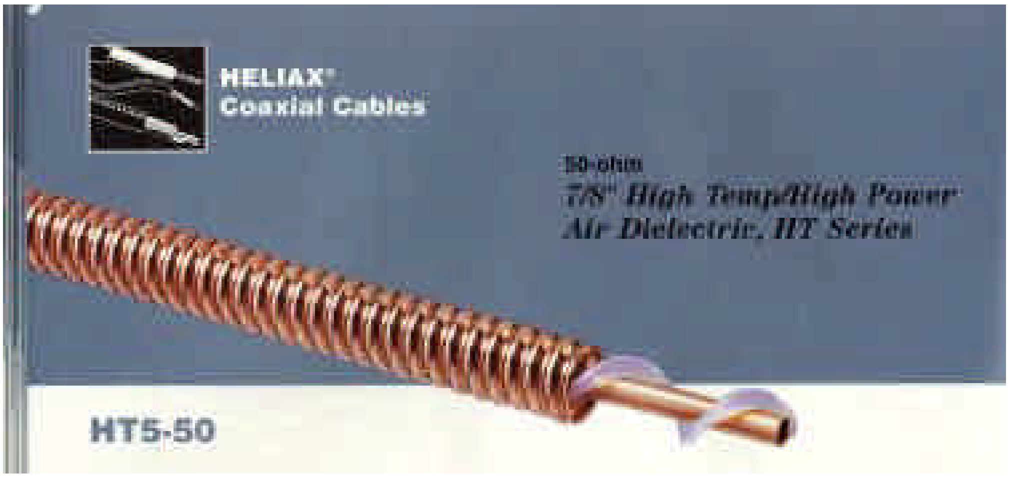
TN-63-57
W.K.H. Panofsky
July 1963

THE USE OF A LONG CO-AXIAL ION CHAMBER ALONG THE ACCELERATOR



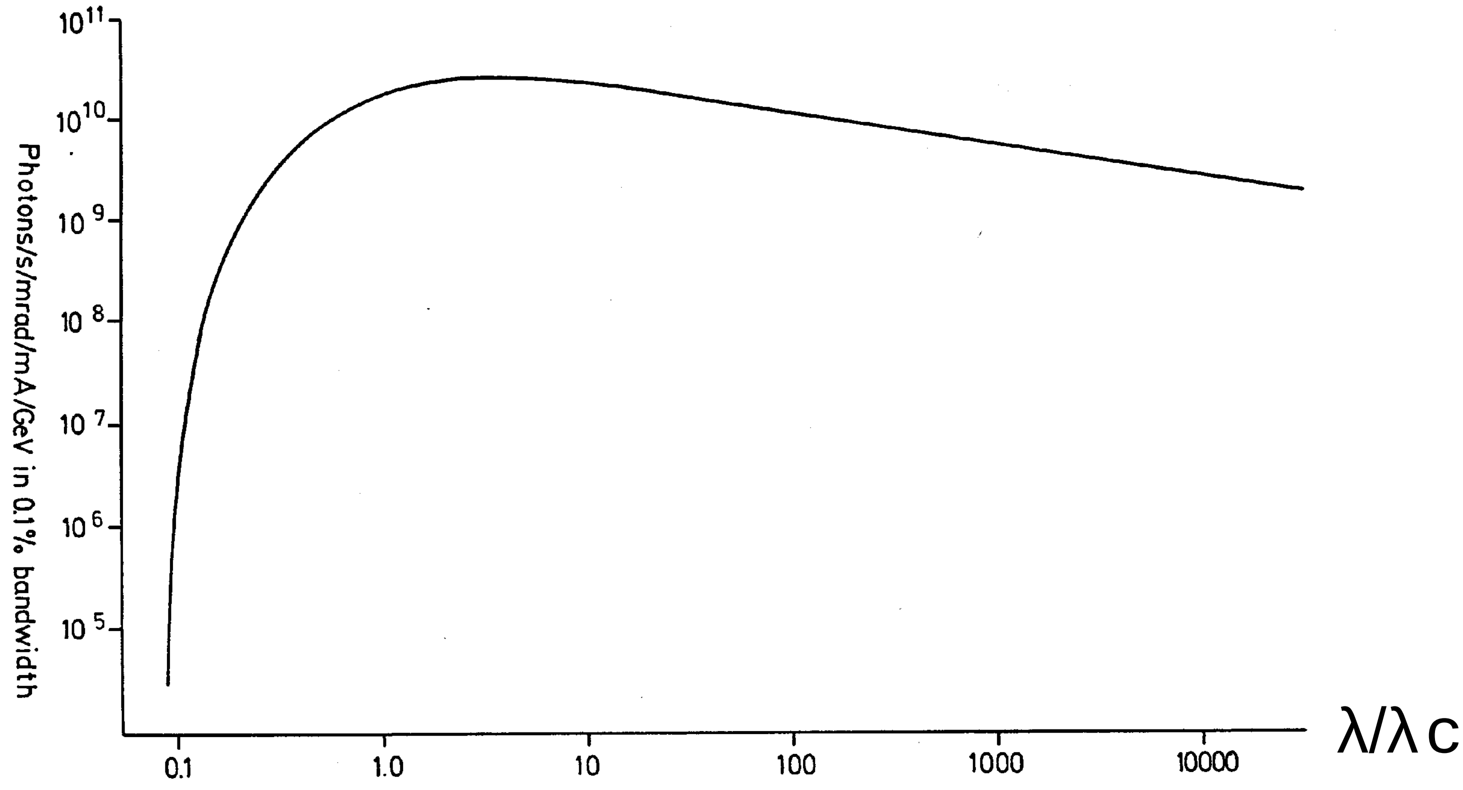


CAVI SENZA DIELETTRICO



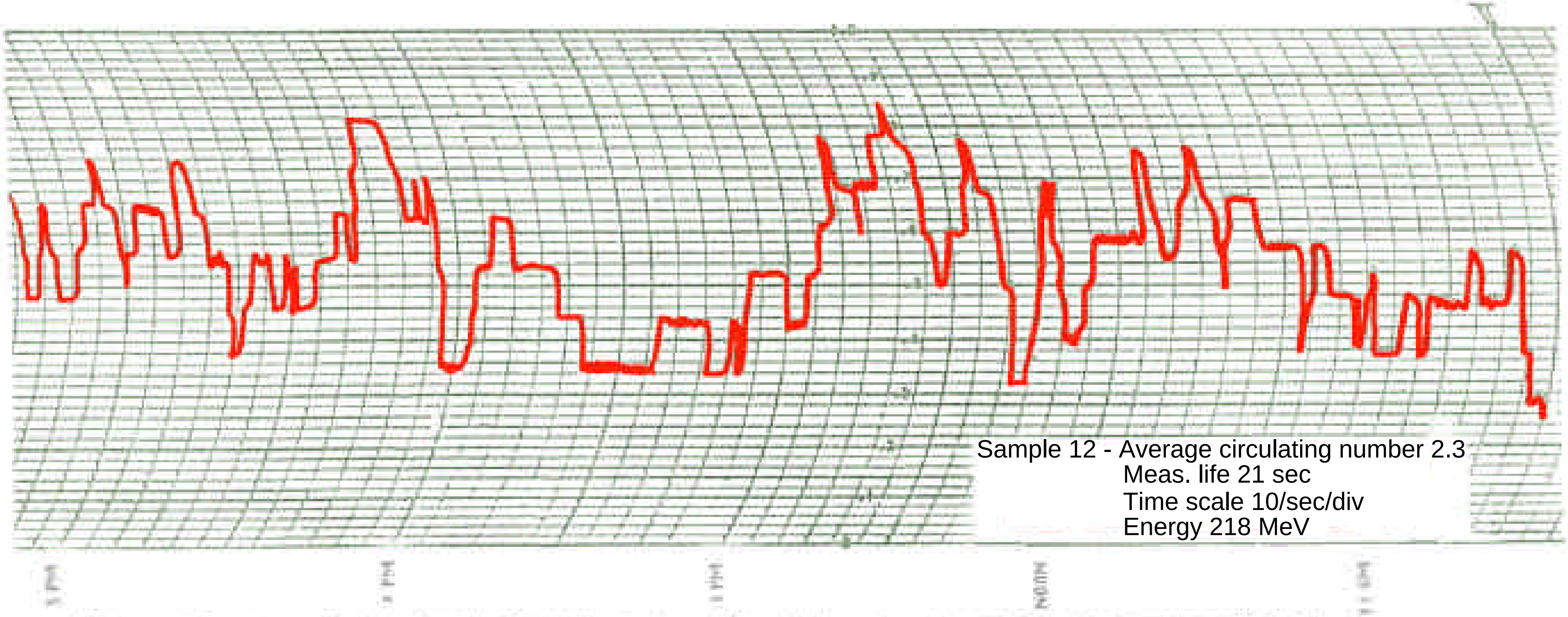
CONNETTORI PRESSURIZZATI

RADIAZIONE di SINCROTRONE
CURVA UNIVERSALE di EMISSIONE



λc[A]	Dipolo	Wiggler
510 MeV	60 UV	40 Soft X
700 MeV	23	21

ADA - Luce di Sincrotrone

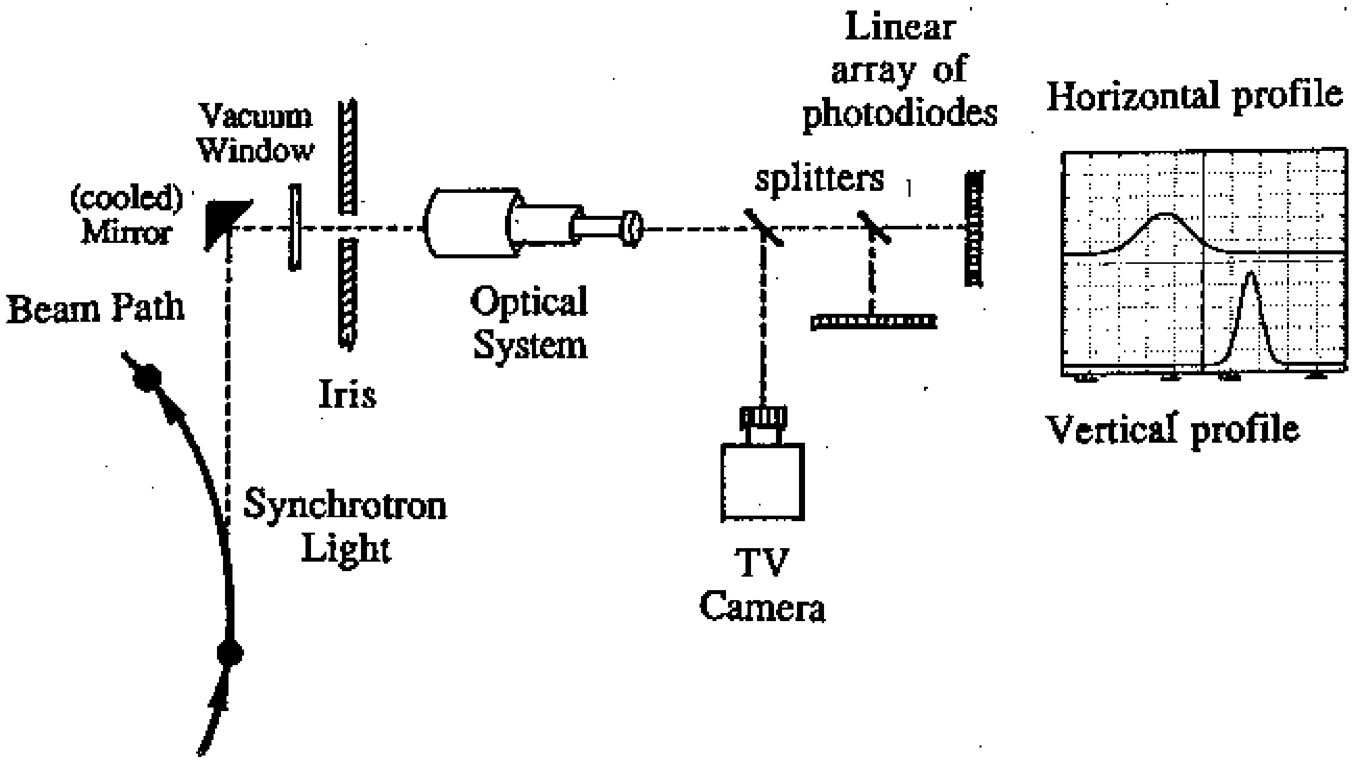


Il Nuovo Cimento
Vol. XVIII, n. 6
16 Dicembre 1960

Registrazione dei primi elettroni accumulati in Ada. La vita media era di 21 sec, il numero medio di 2.3.

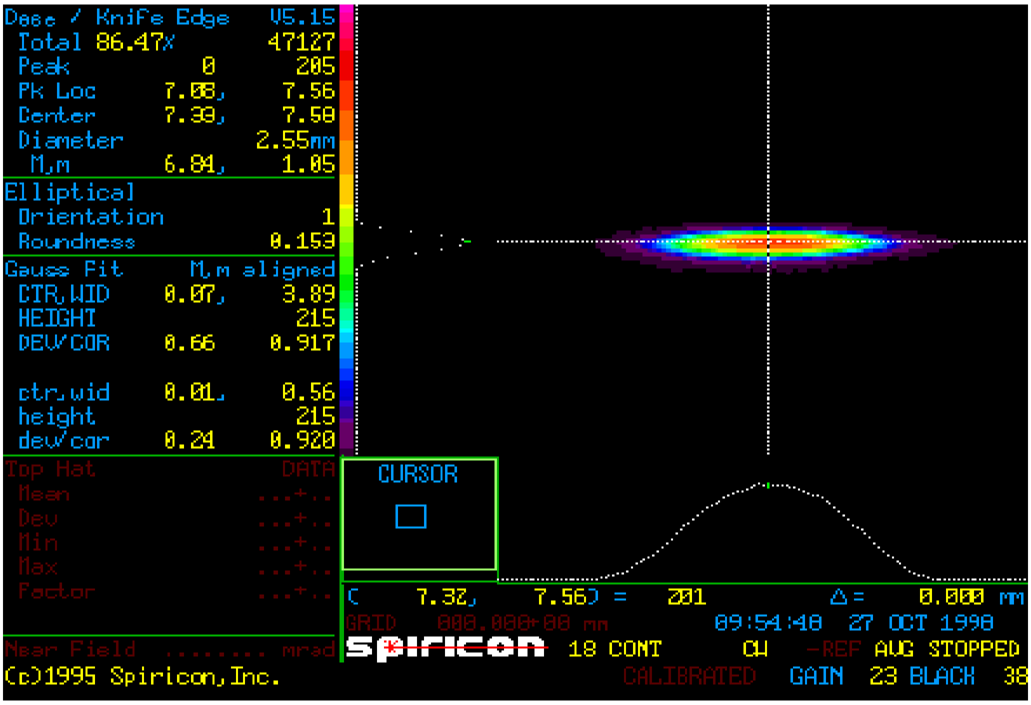
Record of the first electrons stored in AdA. Their half life was 21 sec, the average number was 2.3.

Monitor a Luce di Sincrotrone Disposizione Schematica

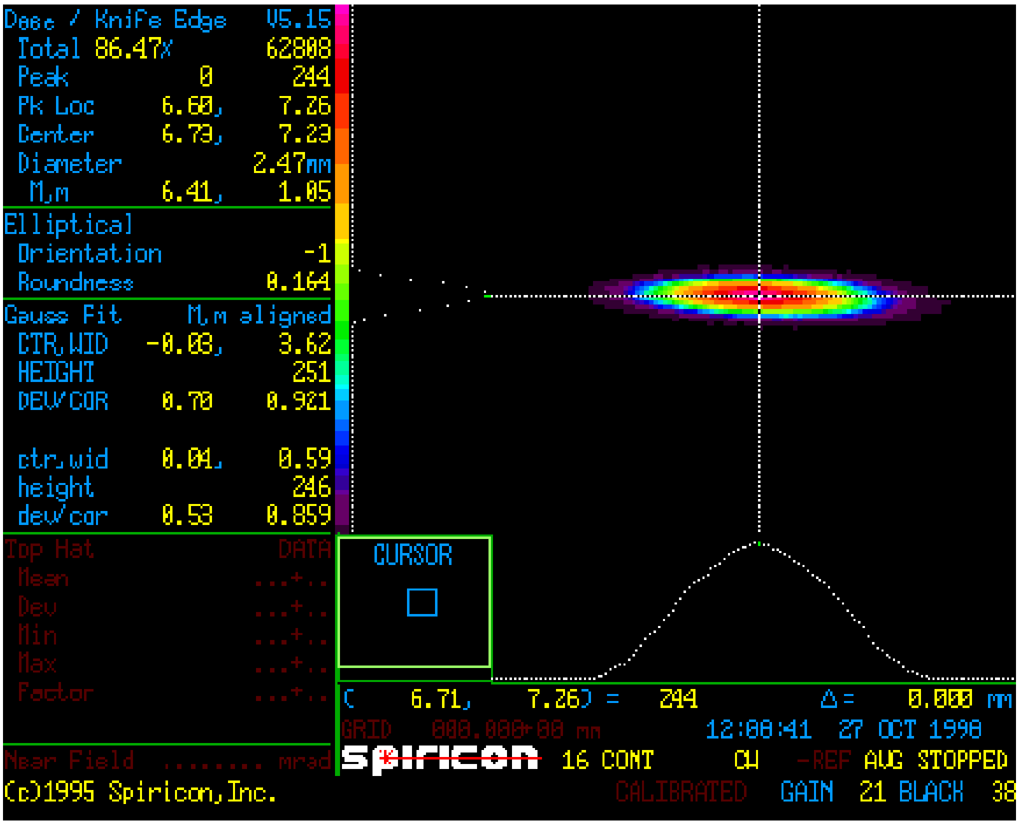


La funzione dello specchio (raffreddato) è di assorbire la radiazione X; la funzione della fionestra trasparente è di separare il vuoto dell'acceleratore

DENSITÀ TRASVERSALE MISURATA CON LUCE DI SINCROTRONE



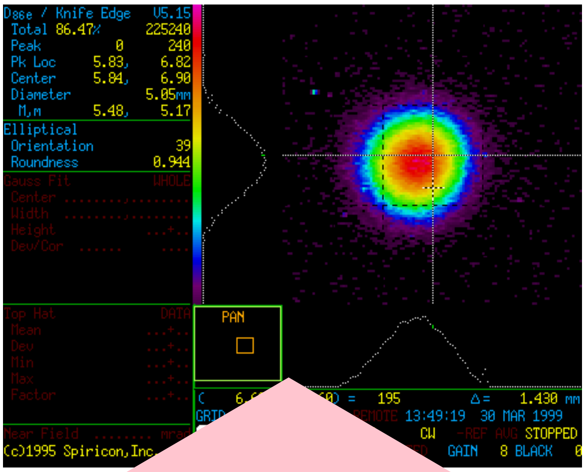
e^+

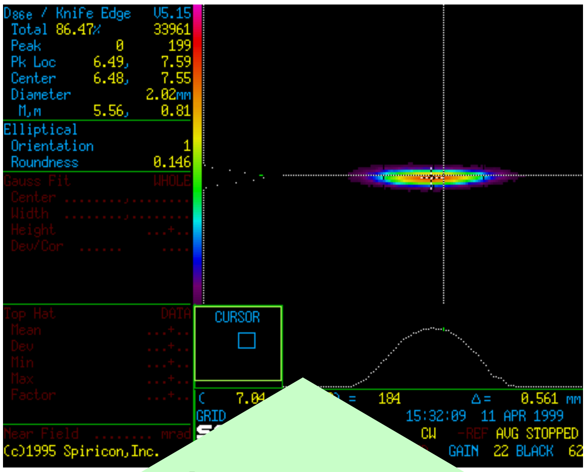


e^-

SLM Measurements

Coupling Measurement





First Stored e⁺ with KLOE Magnet ON:
45% Coupling!
(March 30, 1999)

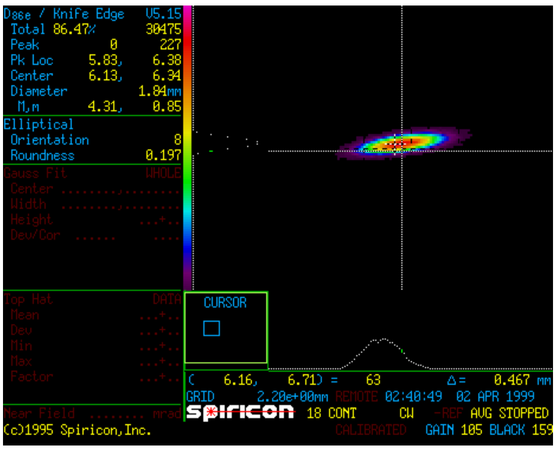
e⁺ beam after compensating the KLOE Magnet Field:
1.1% Coupling!
(April 11, 1999)

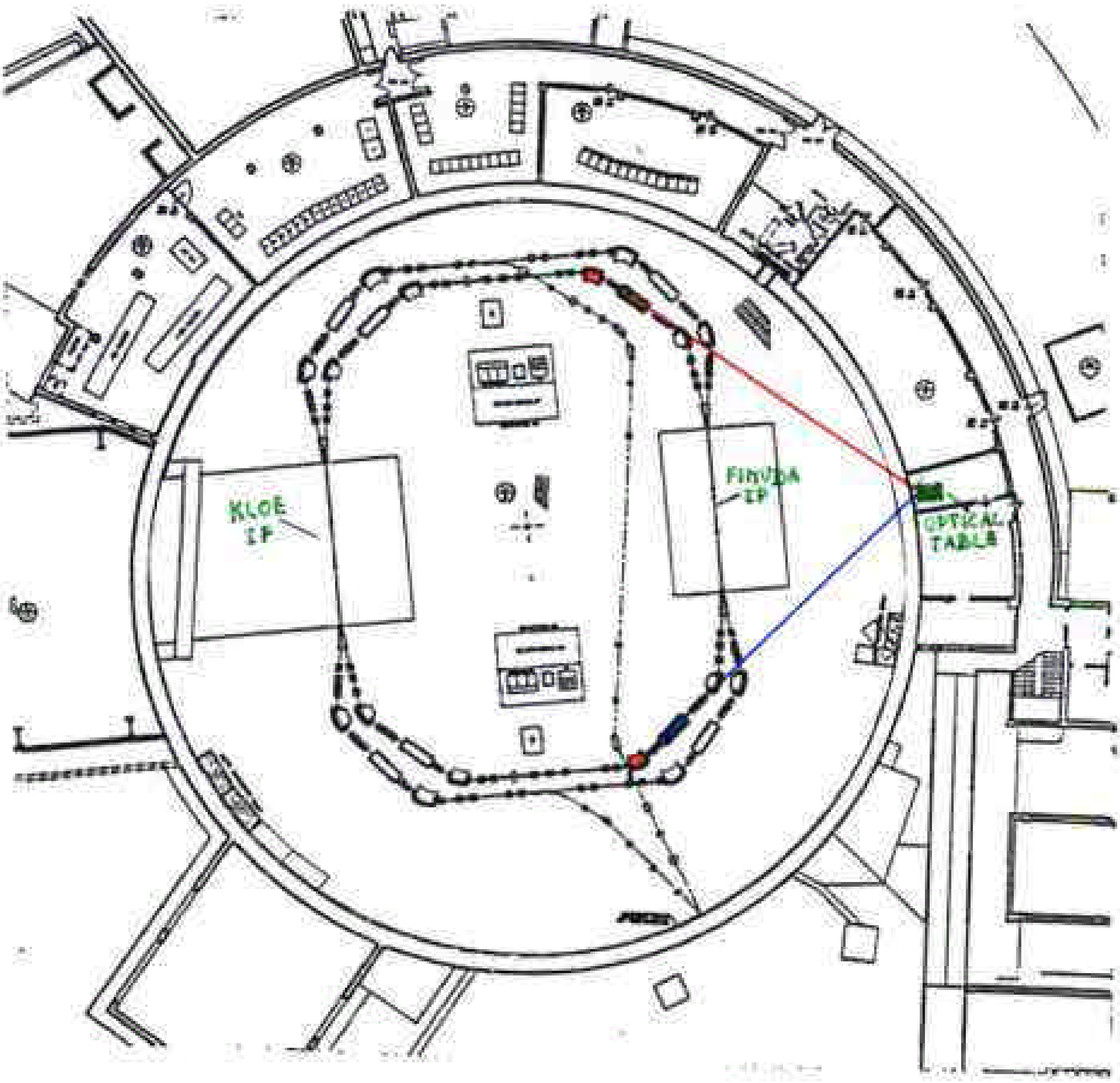
Emittance

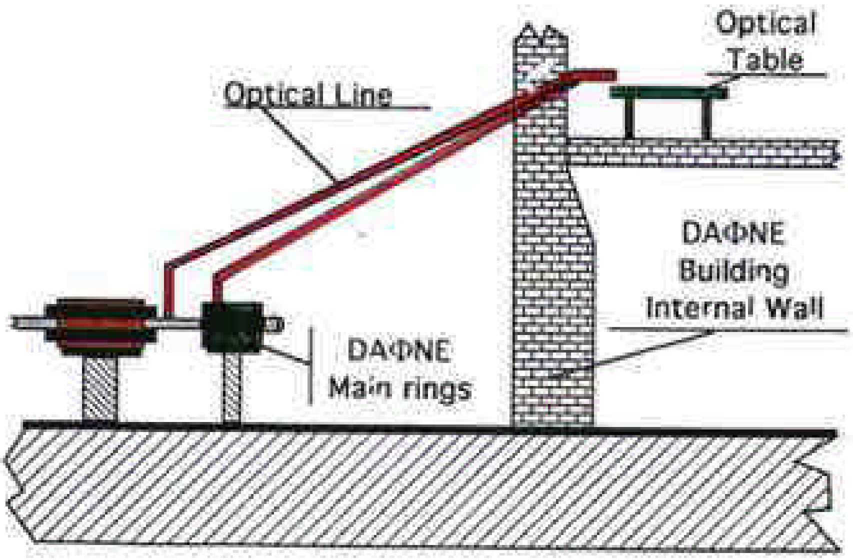
$$\varepsilon = (1+\kappa)\frac{\sigma_x^2}{\beta_x} \quad \text{if} \quad \eta_x = 0$$

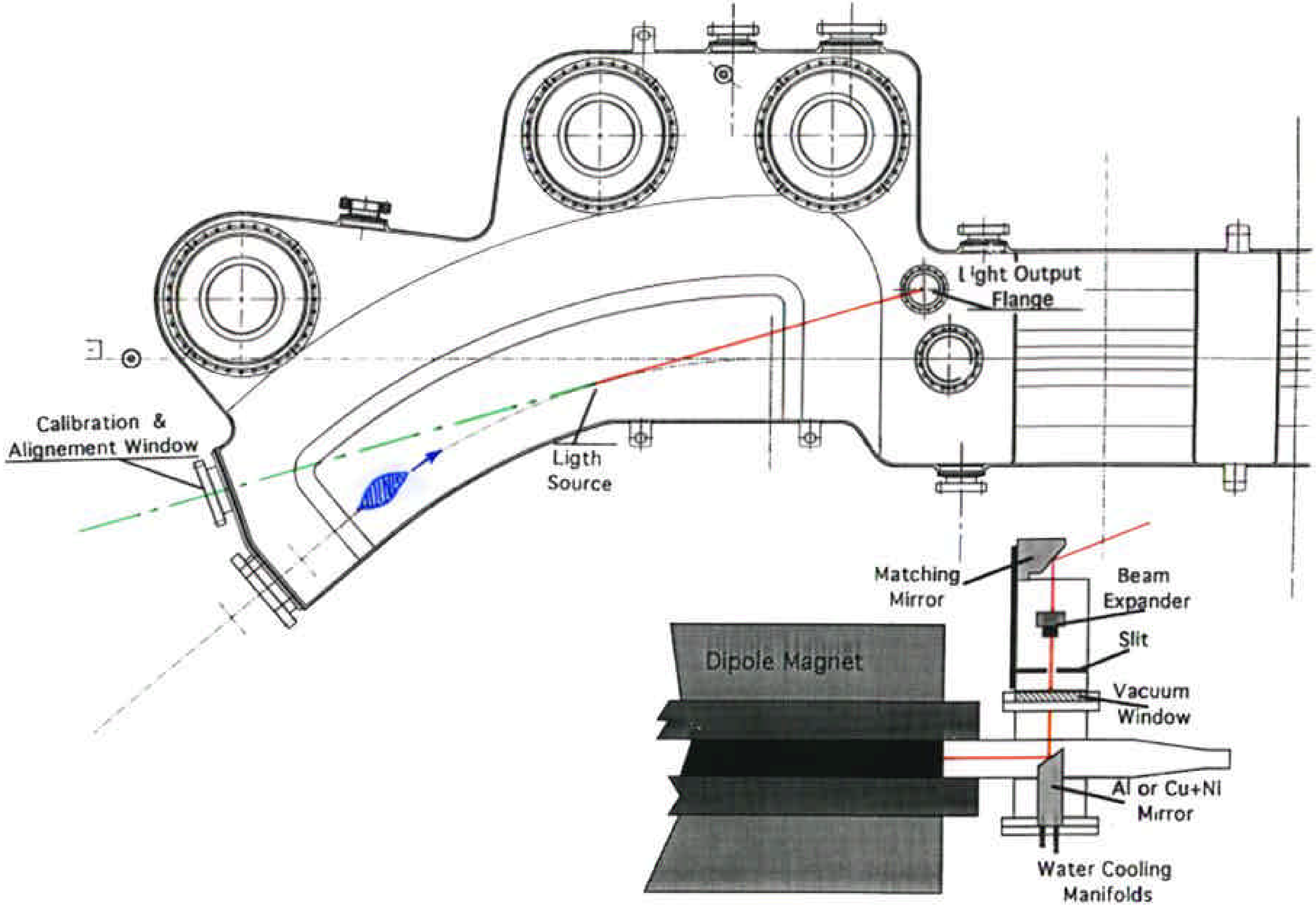
$\varepsilon^+ = (0.5 \pm 0.1)\ 10^{-6}$ m rad
$\varepsilon^- = (0.5 \pm 0.1)\ 10^{-6}$ m rad
April 25, 1999

Tilt Measurement

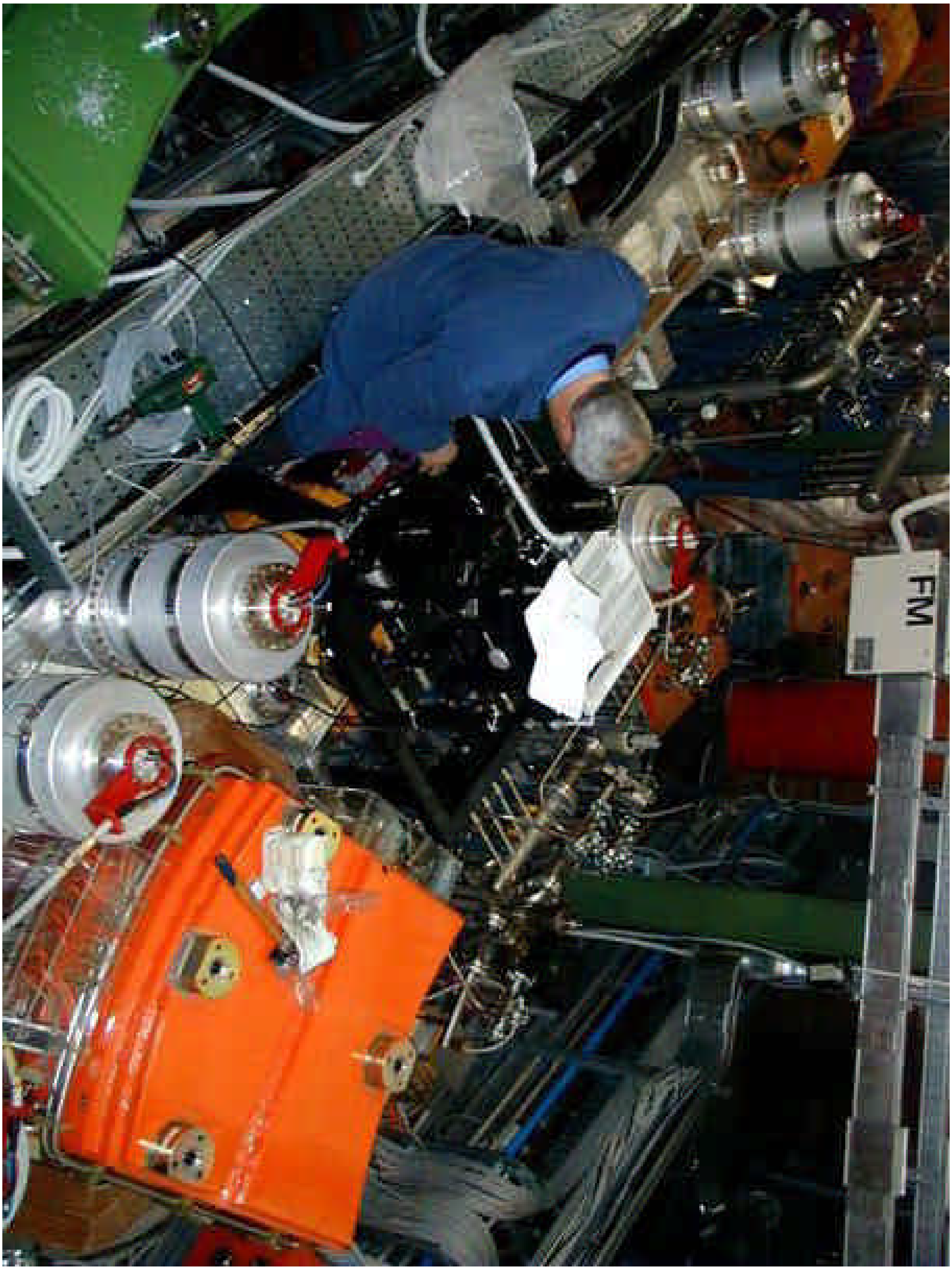


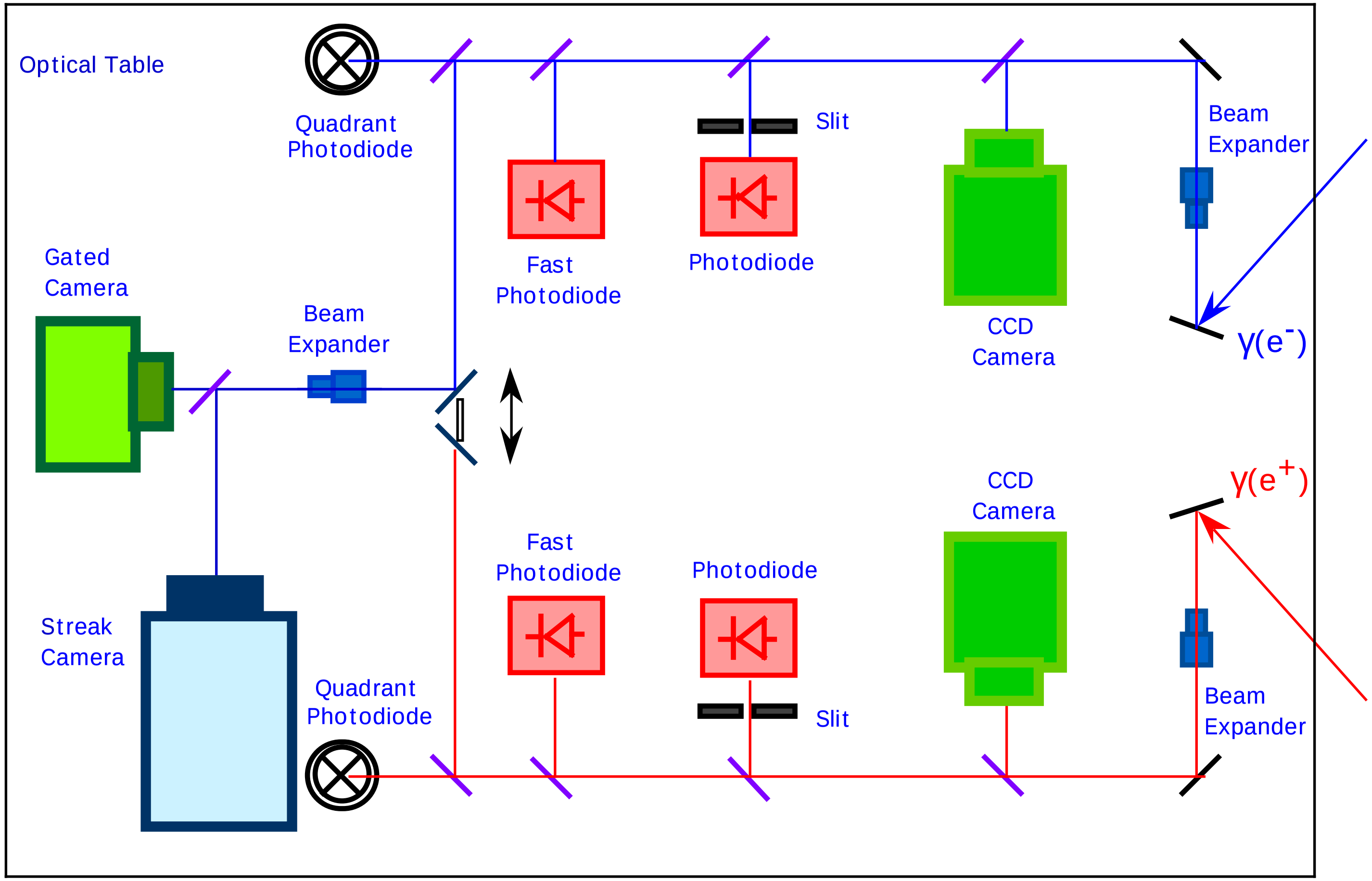

KLOE
IP
FINUDA
IP
OPTICAL
TABLE


Optical
Table
Optical Line
DAΦNE
Building
Internal Wall
DAΦNE
Main rings



Calibration &
Alignement Window
Ligth
Source
Light Output
Flange
Matching
Mirror
Beam
Expander
Slit
Vacuum
Window
Dipole Magnet
Al or Cu+Ni
Mirror
Water Cooling
Manifolds


FM



Optical Table
Quadrant Photodiode
Slit
Beam Expander
Gated Camera
Fast Photodiode
Photodiode
CCD Camera
γ(e⁻)
γ(e⁺)
Streak Camera
Quadrant Photodiode
Fast Photodiode
Photodiode
CCD Camera
Slit
Beam Expander

Now Available with Multi-mode Fibers for More Efficient Light Collection

New Focus now offers the 25-GHz photodetectors and 6-GHz receivers (Models 141X, 143X, and 151X) with multi-mode fibers for more efficient light collection. When you order the "-50" option, you receive a module which contains a 50-µm core multi-mode fiber whose optical output is focused onto our standard 25-µm detector using a GRIN lens assembly. With both single- and multi-mode versions, you may choose either an ST or an FC fiber-optic input connector.

In addition, the Model 141X detectors now have 50-Ω terminations. This improves their output match, extends their frequency response from 20 to 25 GHz, and enhances their pulse fidelity.

Please note: to maintain a 25-GHz bandwidth, multi-mode fibers must be kept less than 2 meters long.

NEW! for 1993

Model 151X-50

Model 141X-50

Specifications

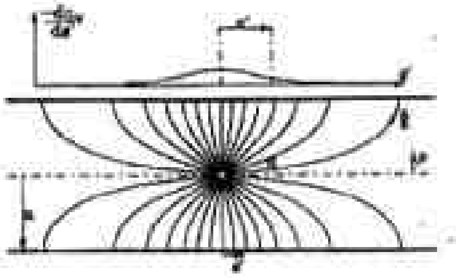
Model Number	141X	141X-50	143X	143X-50	151X	151X-50
Bandwidth	DC-25 GHz	DC-25 GHz	DC-25 GHz	DC-25 GHz	2 MHz-6 GHz	2 MHz-6 GHz
Conversion Gain	15 mV/mW	12 mV/mW	5 mV/mW	4 mV/mW	300 mV/mW*	250 mV/mW*
Wavelength Range	950-1650 nm	950-1650 nm	400-1650 nm	550-1330 nm	950-1650 nm	950-1650 nm
Optical Input**	ST, FC, direct	ST, FC	ST, FC, direct	ST, FC	ST, FC, direct	ST, FC
Max. Linear Input	2 mW		25 mW		2 mW	
Power Supply	Internal 9-V Battery				±15 V DC, <300 mA	
Base Price***	$3,200–$4,800				$3,200–$4,200	
"-50" Multi-mode	+$100				+$100	

* Includes internal GaAs heterojunction-bipolar-transistor, transimpedance amplifier of 500 V/A.

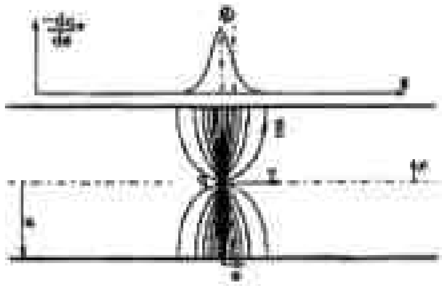
** When ordering replace the "X" in the model number with "1" for an ST version, "4" for an FC version, or "5" for a direct version.

*** For exact prices, see our 1993 Catalog.

Campo elettrico di una carica stazionaria in un conduttore cilindrico



Contrazione del campo elettrico di una carica in movimento

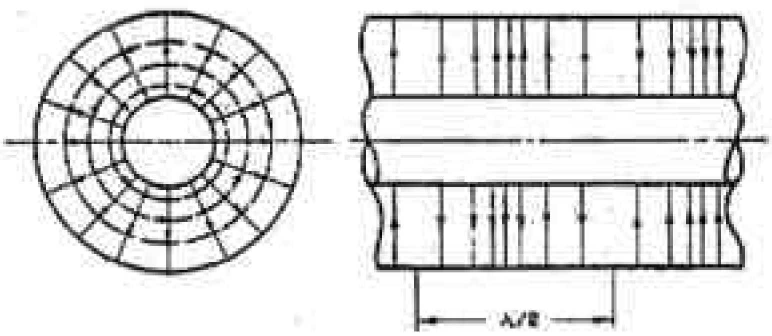


Il campo si restringe in un anello di estensione angolare~1/γ

γ = Energia/Energia a riposo

(γ ~ 1000 per elettroni a 510 MeV)

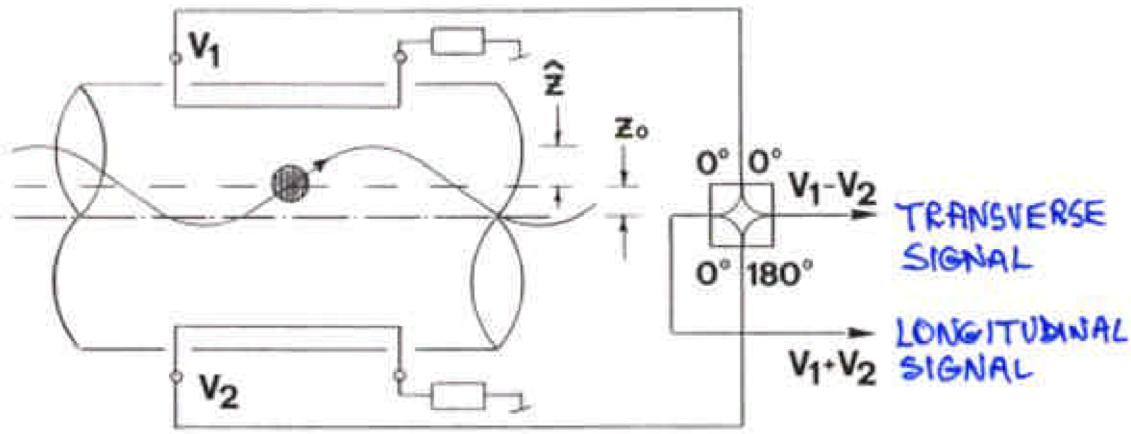
Campo Elettrico e Magnetico in un cavo coassiale



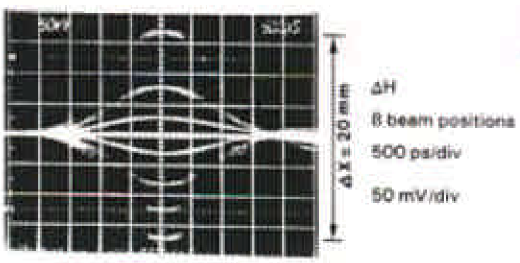
Beam Pick-up's

The pick-up transfer characteristics include the effects of the beam distance from it. By a suitable combination of pick-up's signals, it is possible to extract information about the longitudinal beam profile or its transverse position.

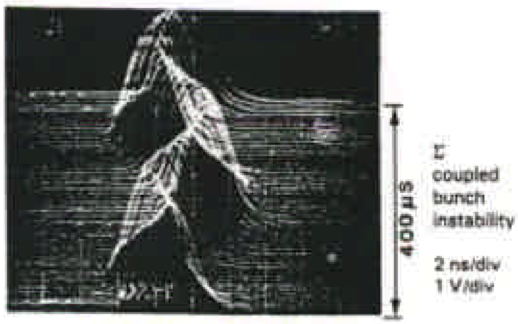
For example, by adding the signal from diametrical pickup's, one can remove the dependence on the transverse position and retain the intensity information. On the other hand, one can measure the linear dipole density (Beam Position Monitor), by subtracting the signals from two opposing pick-up's.



SIGNALS FROM A WALL-CURRENT MONITOR
(G.C. SCHNEIDER : PAC 89, p. 664)

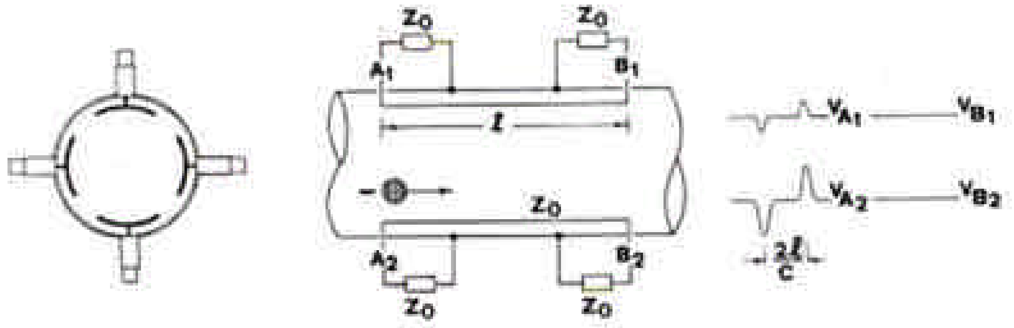


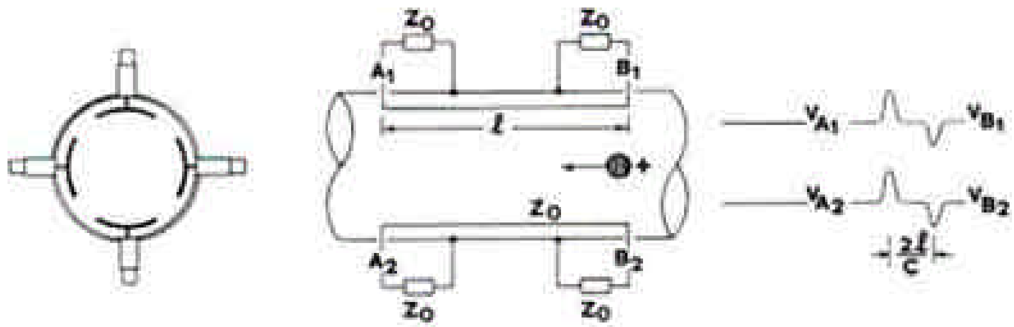
HORIZONTAL



LONGITUDINAL

Strip-Line Monitor





The strip-line is an electrode which forms with the vacuum pipe a transmission line of characteristic impedance Z_0. By a suitable choice of the ratio between the strip width and distance from the pipe, Z_0 is made 50 Ω. The electrode is terminated at both ends via coaxial vacuum feed-through's into loads matched to Z_0.

Both the electric and the magnetic field contribute to the output signal but the beam electromagnetic field and the wave field in the transmission line interfere constructively at one port and destructively at the other yielding directional properties.

In principle we get an useful signal only at the up-stream port . The voltage at the up-stream load resistor is a doublet of pulses of opposing polarity and separated in time by an interval $\Delta t = 2l/c$.

No signal appears at the down-stream port as long as the beam velocity and the propagation velocity in the strip are equal (this means ultra-relativistic beam and a minimum or null amount of dielectric in the vicinity of the strip) and the load resistor is exactly matched to the line impedance. In practice, any mismatch introduced, for example, by the feed-through's or by mechanical imperfections, spoils the directional properties of the monitor.

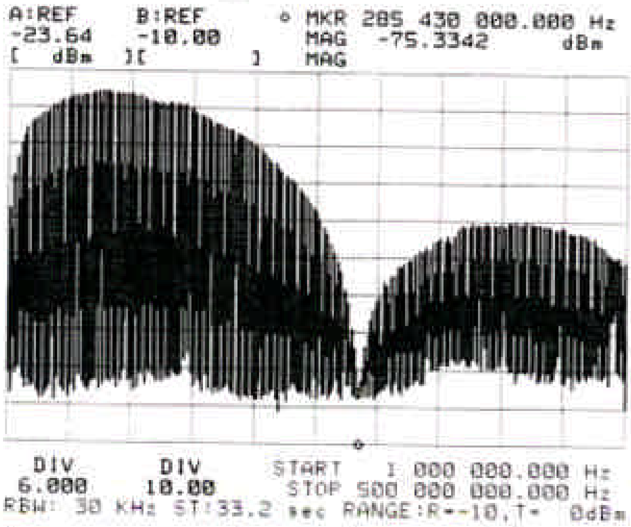
The directionality is particularly useful in colliding beams machines. One can measure only one beam's position in the presence of the other.

The time-domain v tage response of the matched strip-line is, at the up-stream port and for a centered beam

$$v(t) = \frac{Z_0}{2}\left(\frac{\alpha}{2\pi}\right)\left[i_b(t) - i_b\left(t - \frac{2l}{c}\right)\right] ,$$

with α the opening angle of the strip, $(\alpha/2\pi)$ the factor of coverage and $i_b(t)$ the instantaneous beam current. The strip-line coupling impedance as a function of frequency is

$$Z_c(j\omega) \equiv \frac{V(j\omega)}{I_b(j\omega)} \approx Z_0\left(\frac{\alpha}{2\pi}\right)\sin\left(\frac{\omega l}{c}\right) e^{j\left(\frac{\pi}{2} - \frac{\omega l}{c}\right)} .$$



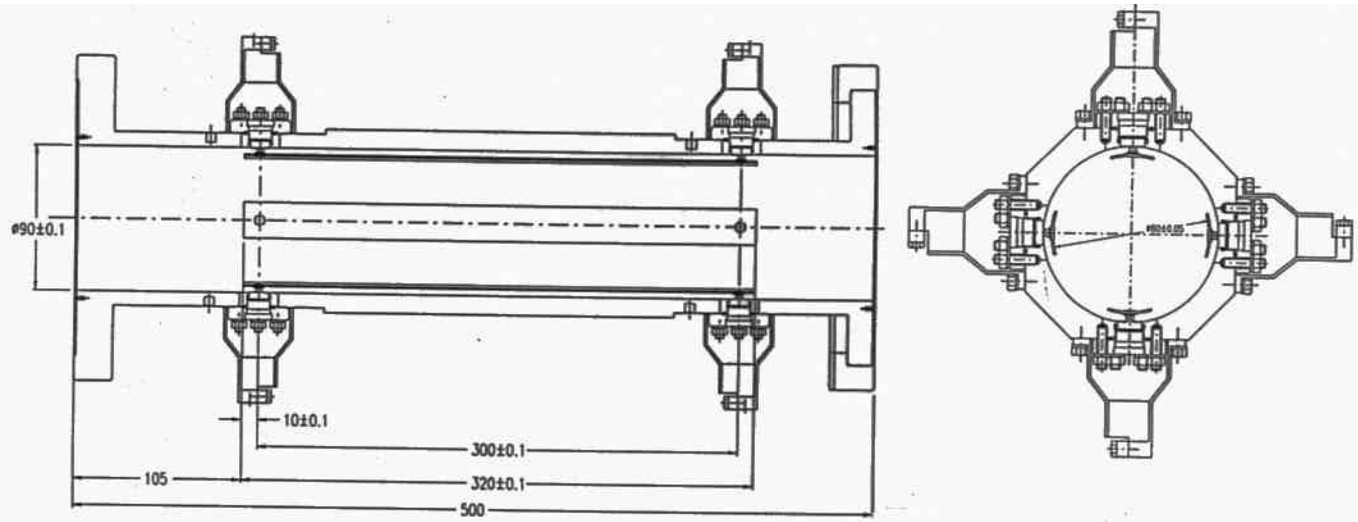
Strip-line response (~ 0.5 m) weighted by the bunch spectrum and long cable.

The response is maximum at frequency $f = c/4l$, or odd multiples, and zero at $f = c/2l$, or multiples.

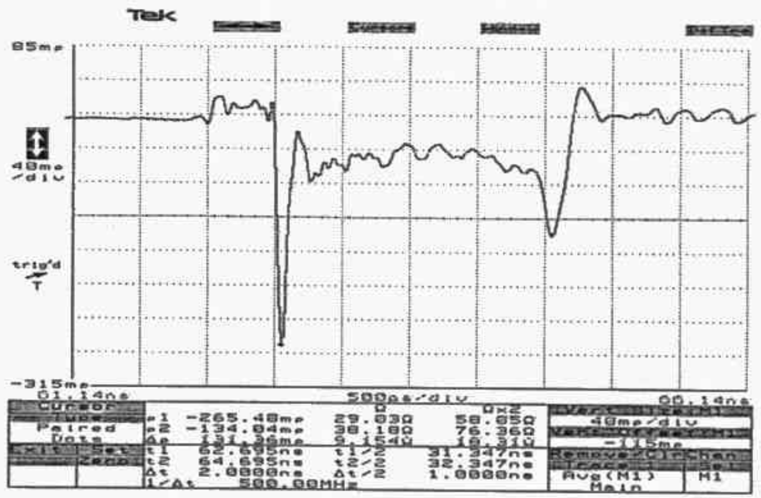
The position sensitivity of a pair of difference-connected strip-lines to a small beam displacement Δz from the center line is

$$\frac{b}{2}\frac{\Delta V}{\Sigma V} \approx \Delta z ,$$

where b is the vacuum chamber radius and ΔV, ΣV are the difference and sum voltages, resp.

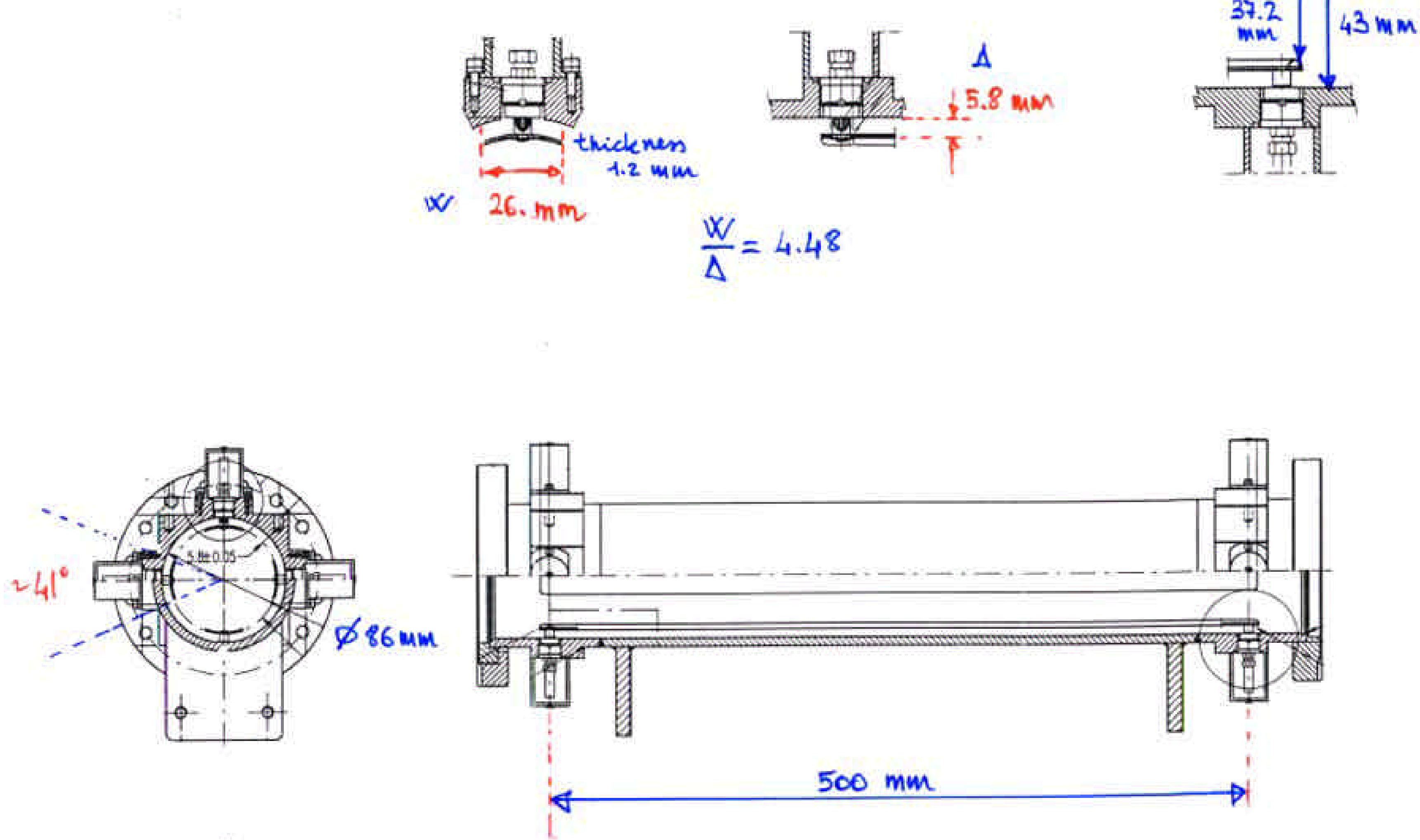


11801A DIGITAL SAMPLING OSCILLOSCOPE
date: 17-JUL-97 time: 17:05:44



STRIPLINE ZONA DI INTERAZIONE DAY-1

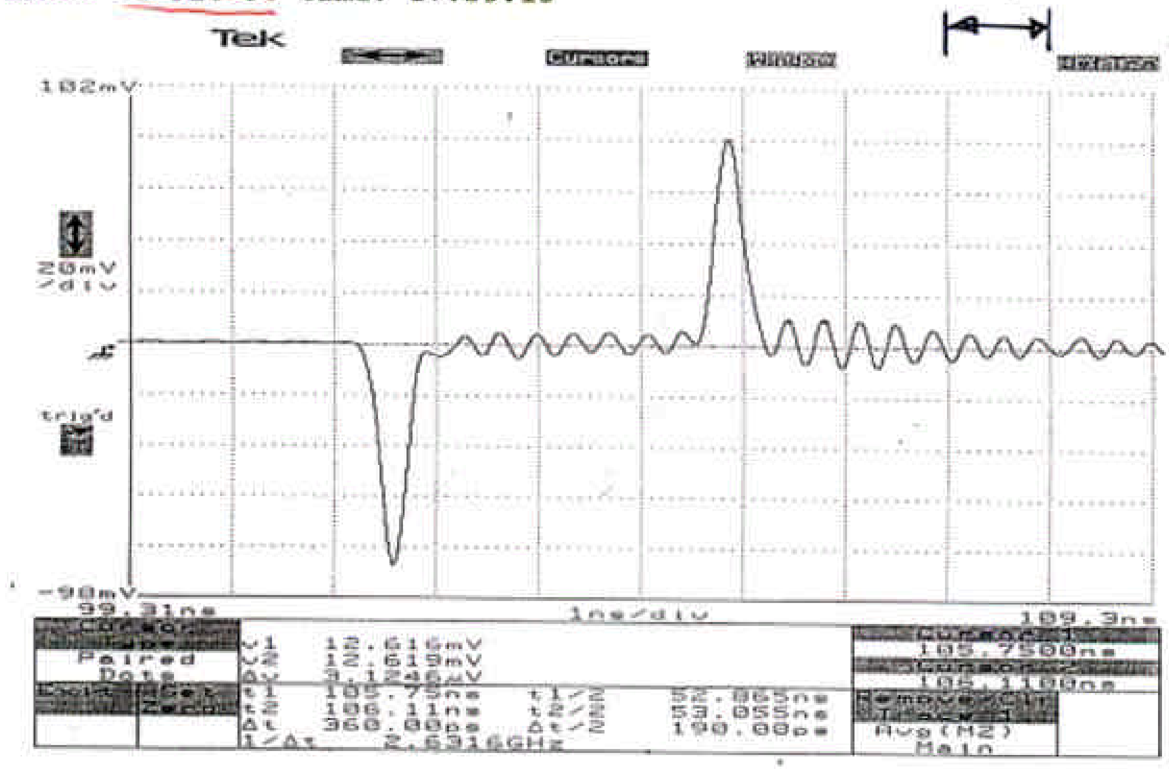
ACCUMULATOR RING - TRANSVERSE KICKER
(TRANSVERSE FEEDBACK/TUNE MEASUREMENT)



BUNCH LENGTH MEASUREMENT WITH A STRIP-LINE MONITOR

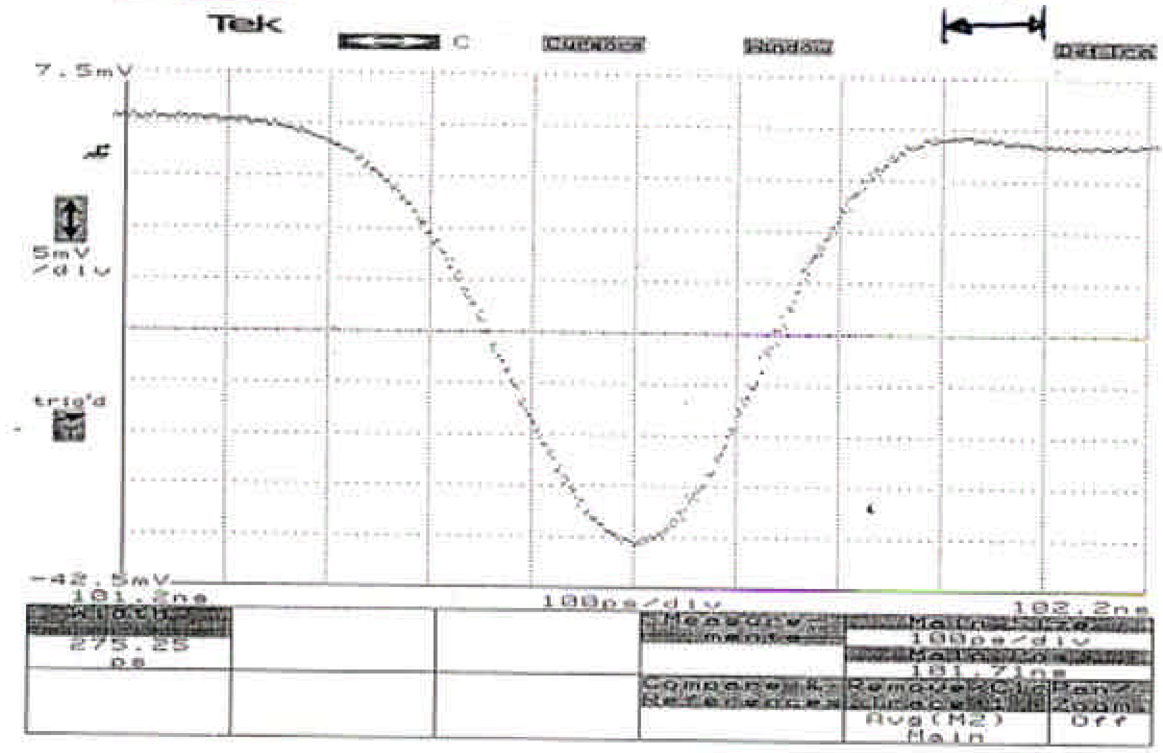
11801A DIGITAL SAMPLING OSCILLOSCOPE
date: 22-DEC-96 time: 17:39:13

1ns

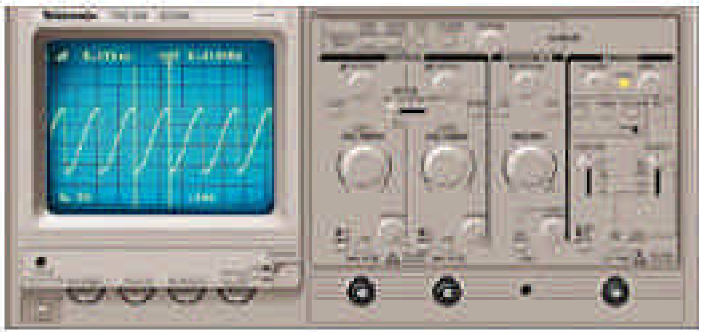


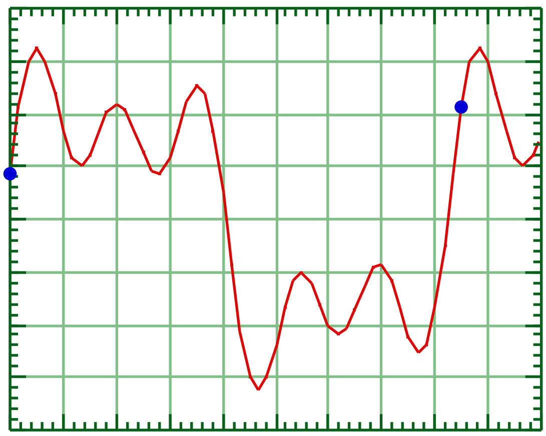
11801A DIGITAL SAMPLING OSCILLOSCOPE
date: 22-DEC-96 time: 17:50:45

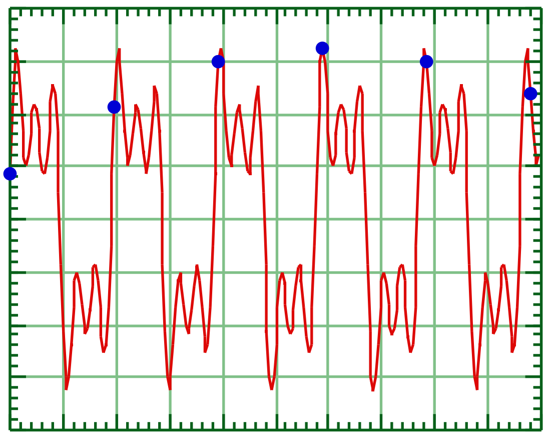
100ps

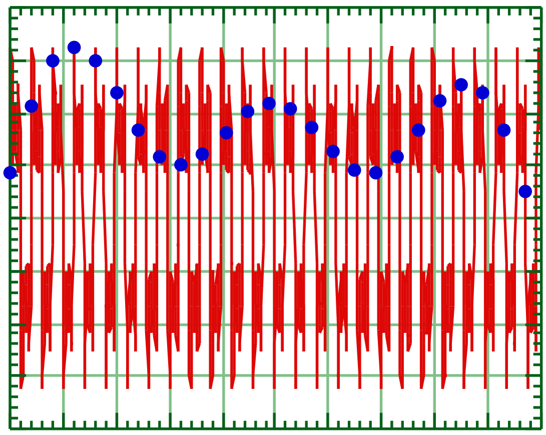


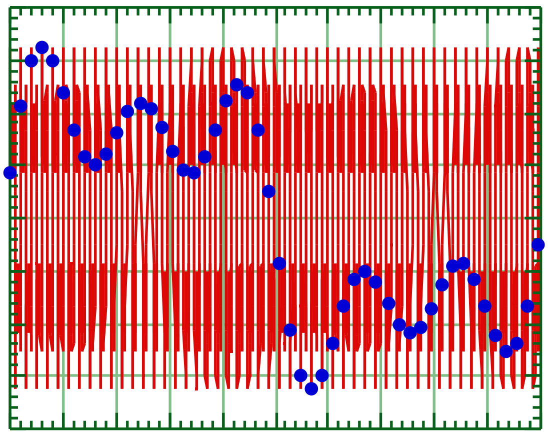
CAMPIONAMENTO DI UN SEGNALE RAPIDO



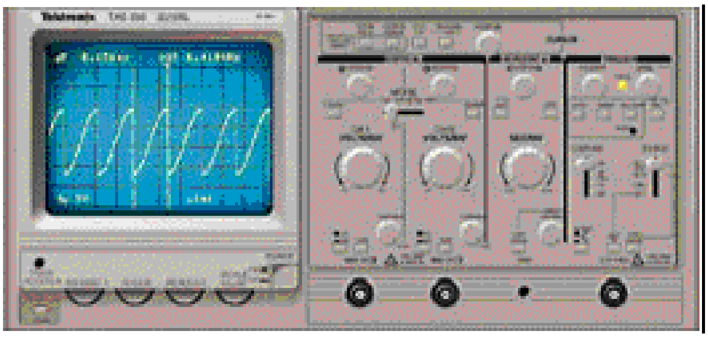




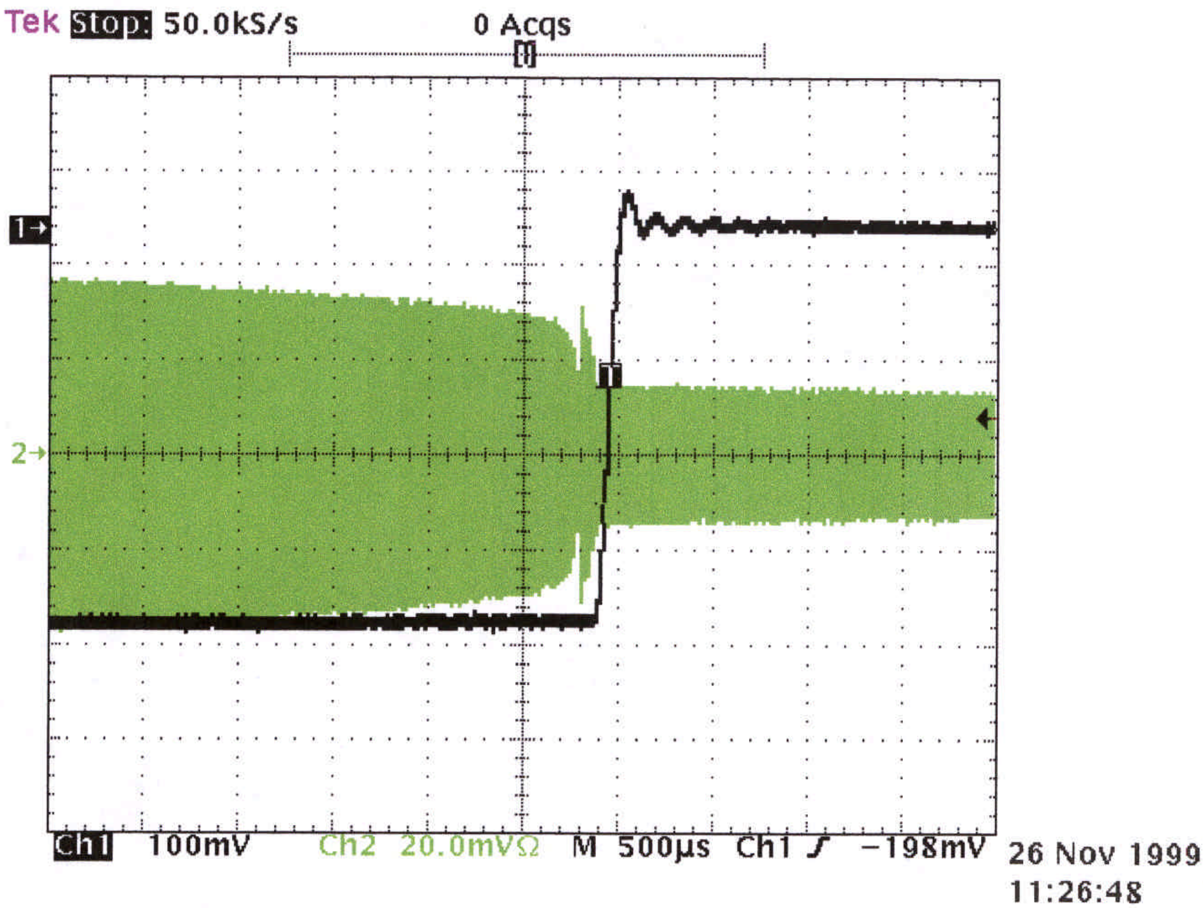




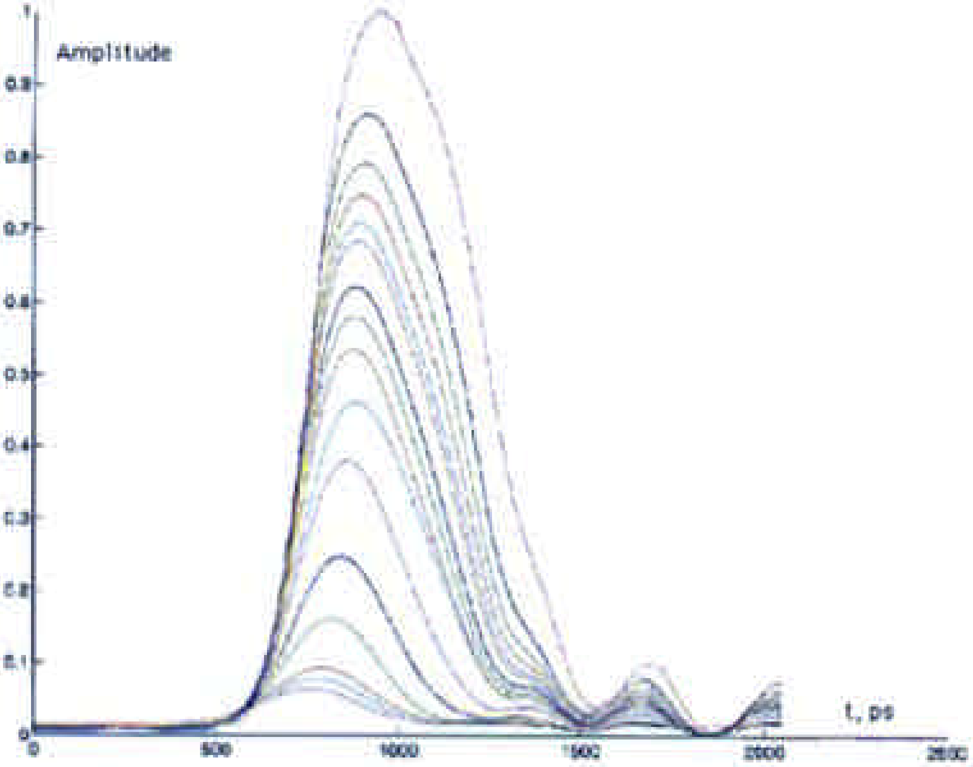
OSCILLOSCOPIO DIGITALE

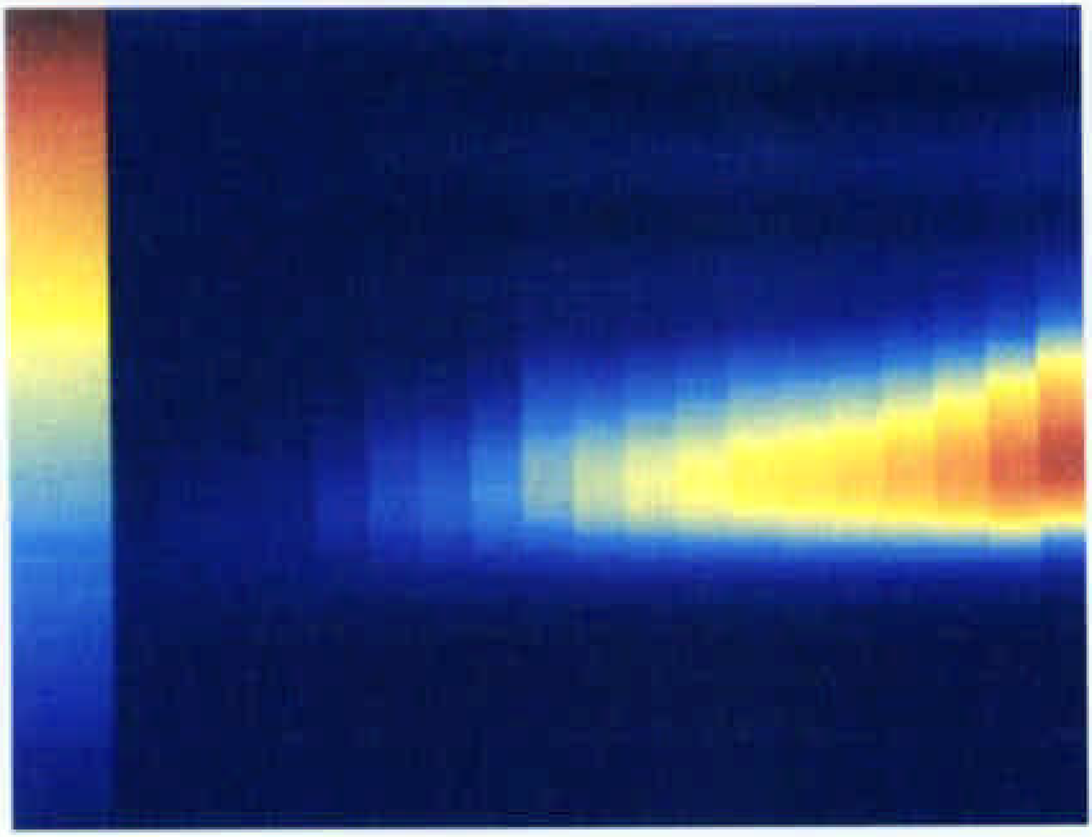


CONSENTE DI VEDERE COSA ACCADE PRIMA DEL TRIGGER



BUNCH LENGTH MEASUREMENTS (0.5 - 60 mA)

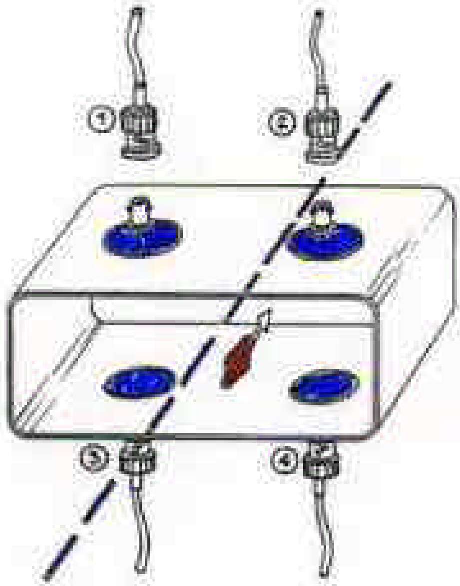




False colour representation of the bunch length measurement in the Accumulator ring. Each slice corresponds to a different stored current, increasing from left to right. Time is on the vertical scale. The intensity scale is displayed on the left.

Starting from the strip-line we can think of some variations (no longer directional):

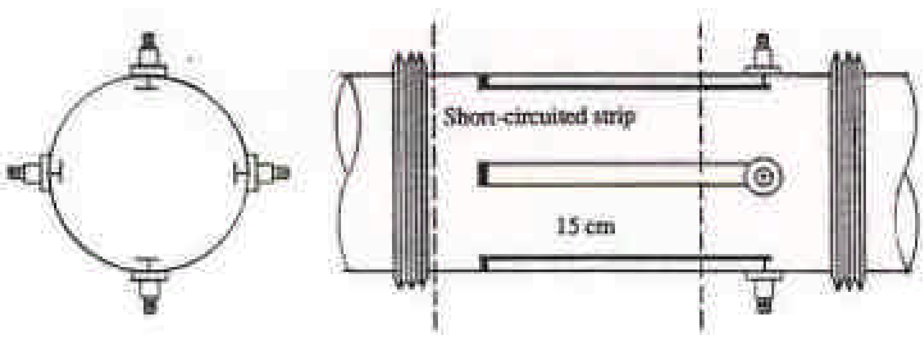
- Electrostatic monitor. A short, unterminated strip, in the form of a plate (or button), with an outside connection in the middle is mainly sensitive to the beam electric field.



$$x = k_x \left(\frac{V_2 - V_3}{V_2 + V_3} + \frac{V_4 - V_1}{V_4 + V_1} \right)$$

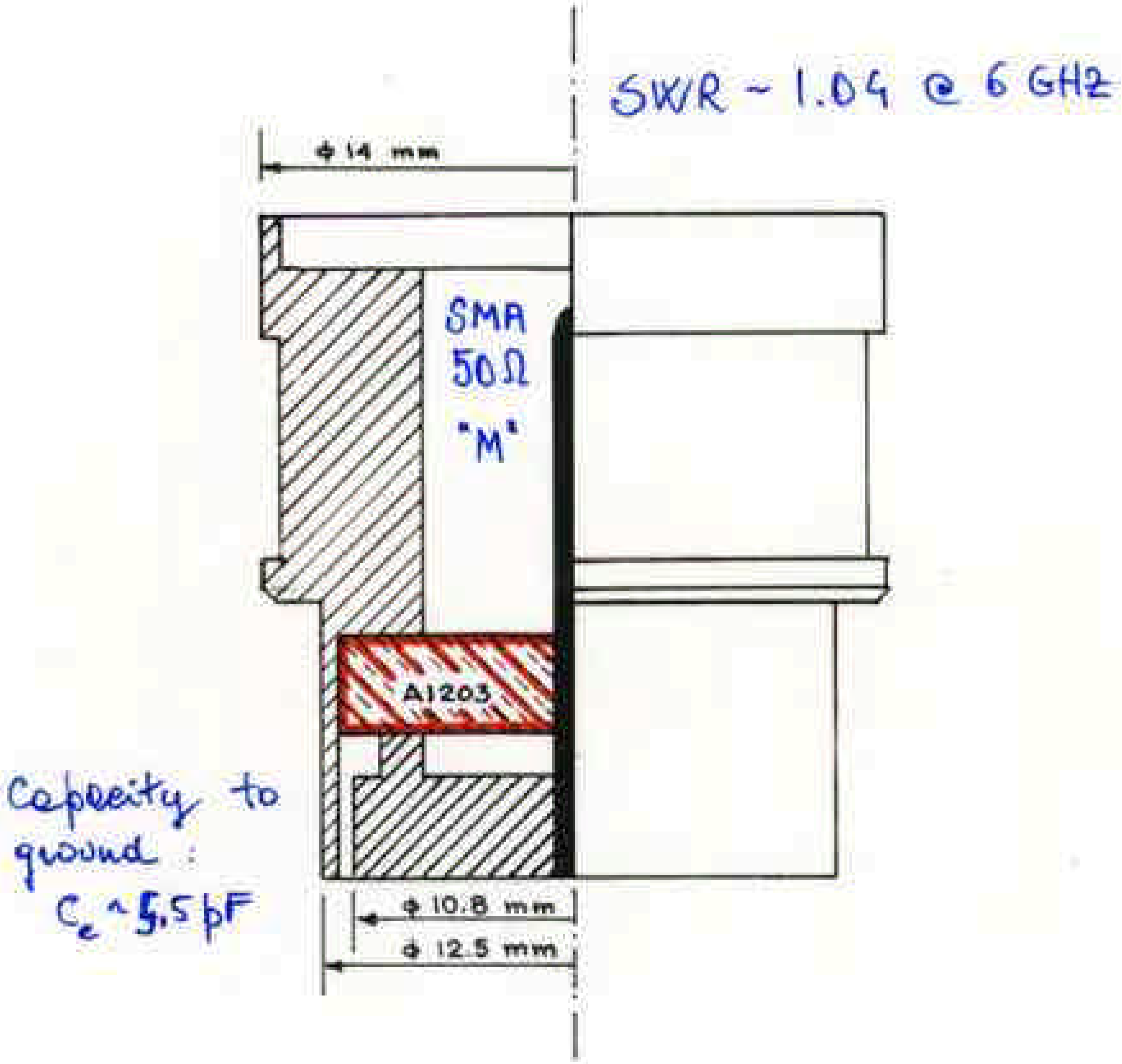
$$y = k_y \left(\frac{V_2 - V_3}{V_2 + V_3} - \frac{V_4 - V_1}{V_4 + V_1} \right)$$

- Magnetic monitor. A strip, shorted to the vacuum chamber at the other side of the output port, forms a loop mainly sensitive to the beam magnetic field.

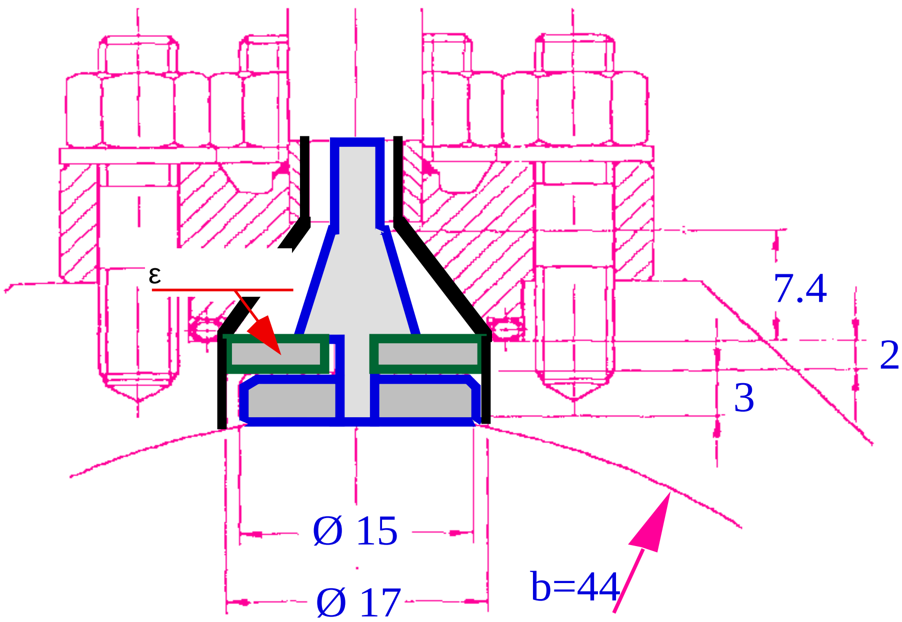


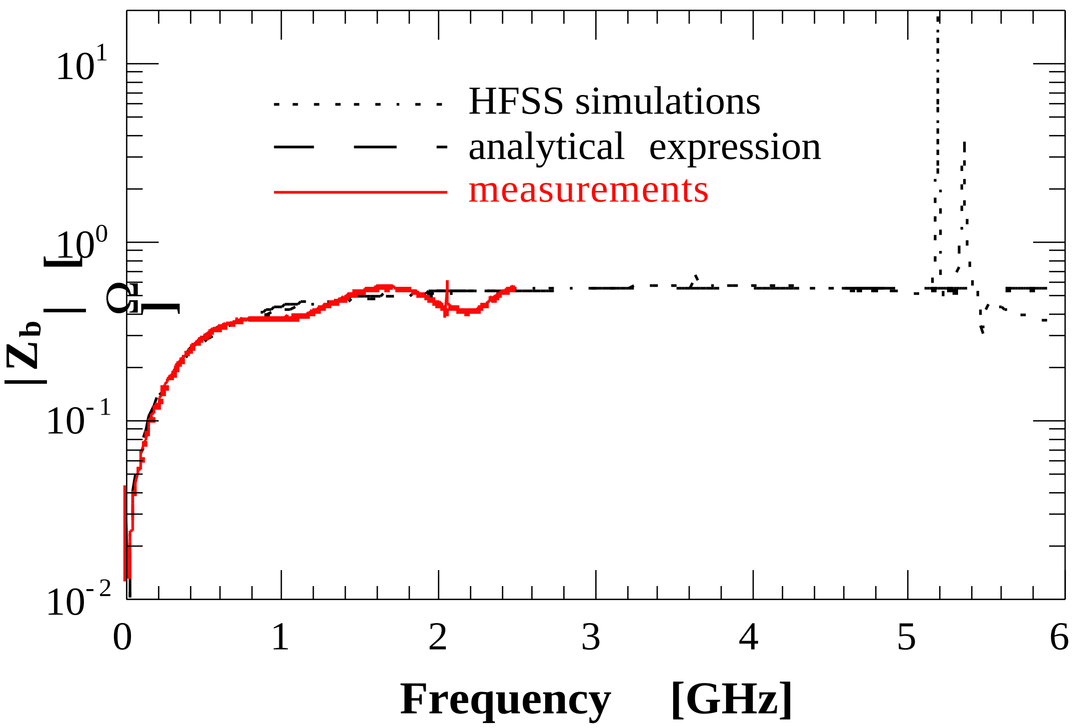
It is possible to obtain a tuned monitor by making the plate or loop part of an L-C resonant circuit. The sensitivity can be very high, at the expenses of a bandwidth reduction.

BPM ELECTRODE
(CERAMEX - FR)



Monitor *a bottone* e risposta elettrica





Beam position monitor BPM

- button - type

Signal impedance :

$$\hat{Z}_p(\omega) = R_0 \left(\frac{\omega_1}{\omega_2}\right) \frac{j\omega/\omega_1}{1+j\omega/\omega_1} \cdot F$$

$$\omega_1 = \frac{1}{R_0 C} \qquad \omega_2 = \frac{2bc}{r^2}$$

R_0 - termination resistance

C - Electrode capacitance to ground

b - vacuum chamber radius

c - light velocity

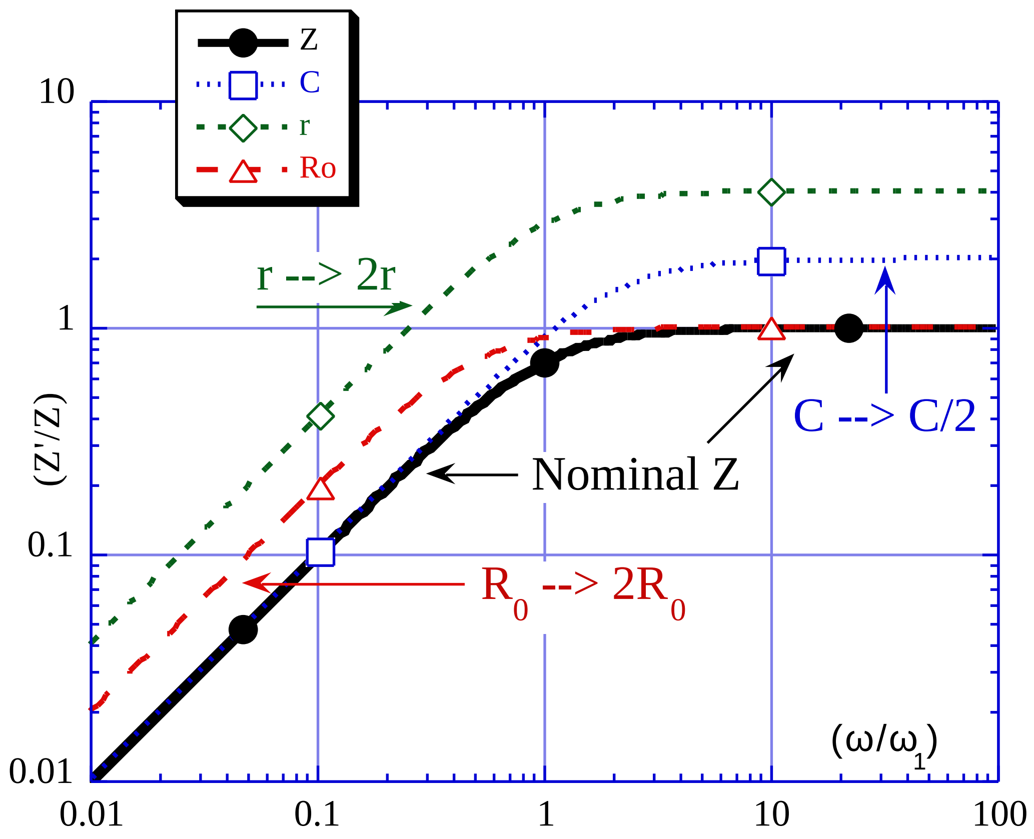
r - button radius

F - Form factor. $F=1$ for a circular chamber

$F = 0.6 \div 0.8$ for a rectangular chamber of half-height b

Comportamento dell'impedenza di accoppiamento di un pick-up a bottone al variare di:

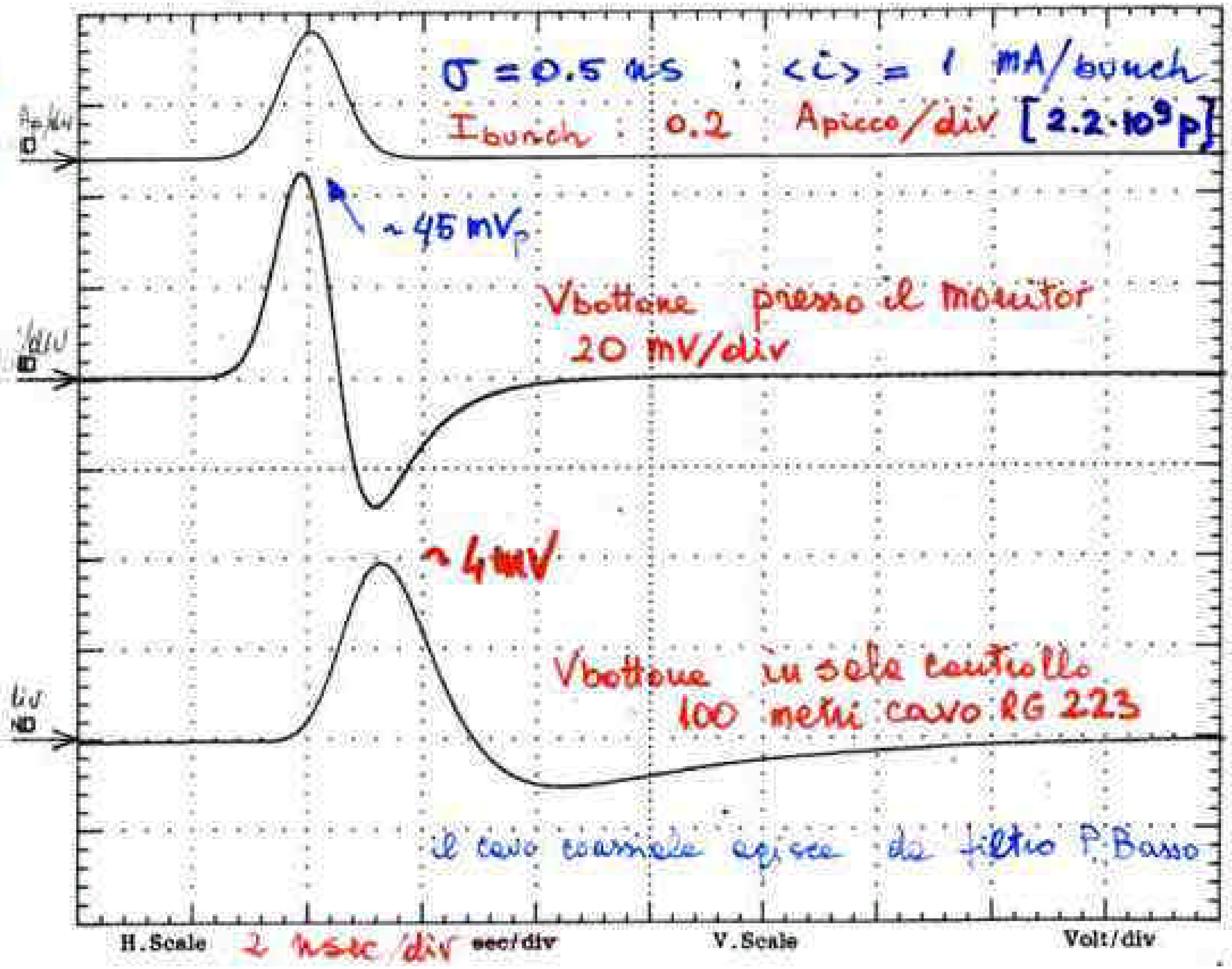
- Raggio r
- Capacità C
- Resistenza di carico Ro (impedenza caratteristica)



LABORATORI NAZIONALI DI FRASCATI DELL'INFN

Divisione Macchine - Elettronica

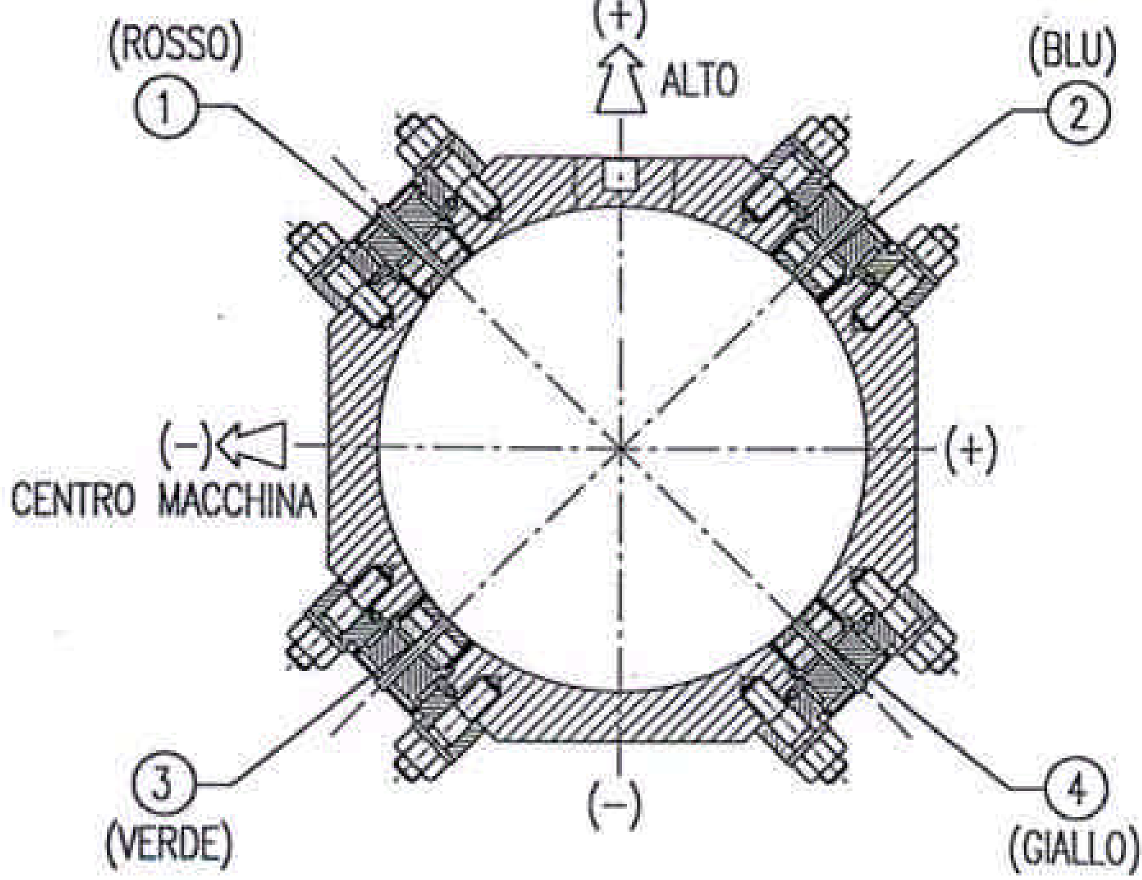
```
<i>tot  18      mA
Cel  =   0.00   pF
f PB= $$$$$$  MHz
Tcable   0.00   ns

MAX     2.792E-01
MIN    -3.784E-10
sigma=   0.500  ns
T pp  =  0.000  ns
max/0   -3.943  ns
min/0   -3.743  ns
PWR     -13.40  dBm

<i>tot  18.00   mA
Cel  =  17.00   pF
f PB= $$$$$$  MHz
Tcable   0.00   ns

MAX     4.472E-02
MIN    -2.896E-02
sigma=   0.500  ns
T pp  =  1.216  ns
max/0    0.600  ns
min/0   -0.600  ns
PWR    -26.40   dBm

<i>tot  18.00   mA
Cel  =  17.00   pF
f PB= $$$$$$  MHz
Tcable   2.23   ns

MAX     3.860E-03
MIN    -1.101E-03
sigma=   0.500  ns
T pp  =  3.113  ns
max/0    1.595  ns
min/0   -1.520  ns
PWR    -46.53   dBm

000000
```



SCHEDA ASSEGNAZIONE PASSANTI

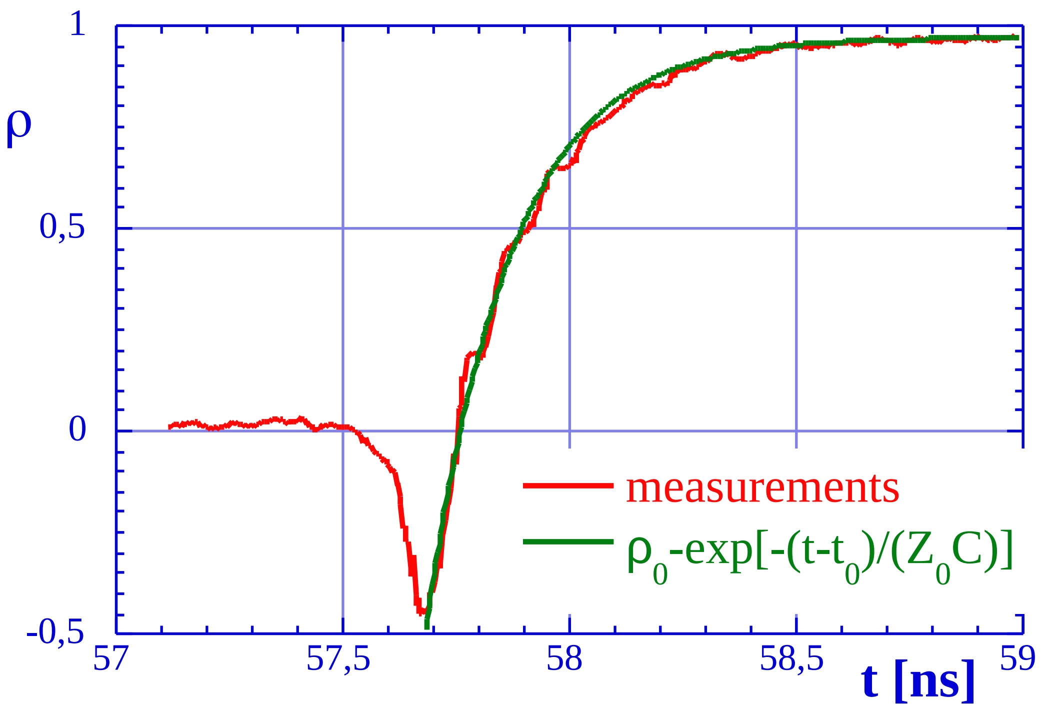
STANDARD FLANGE BPB EL101

Ø 88 mm

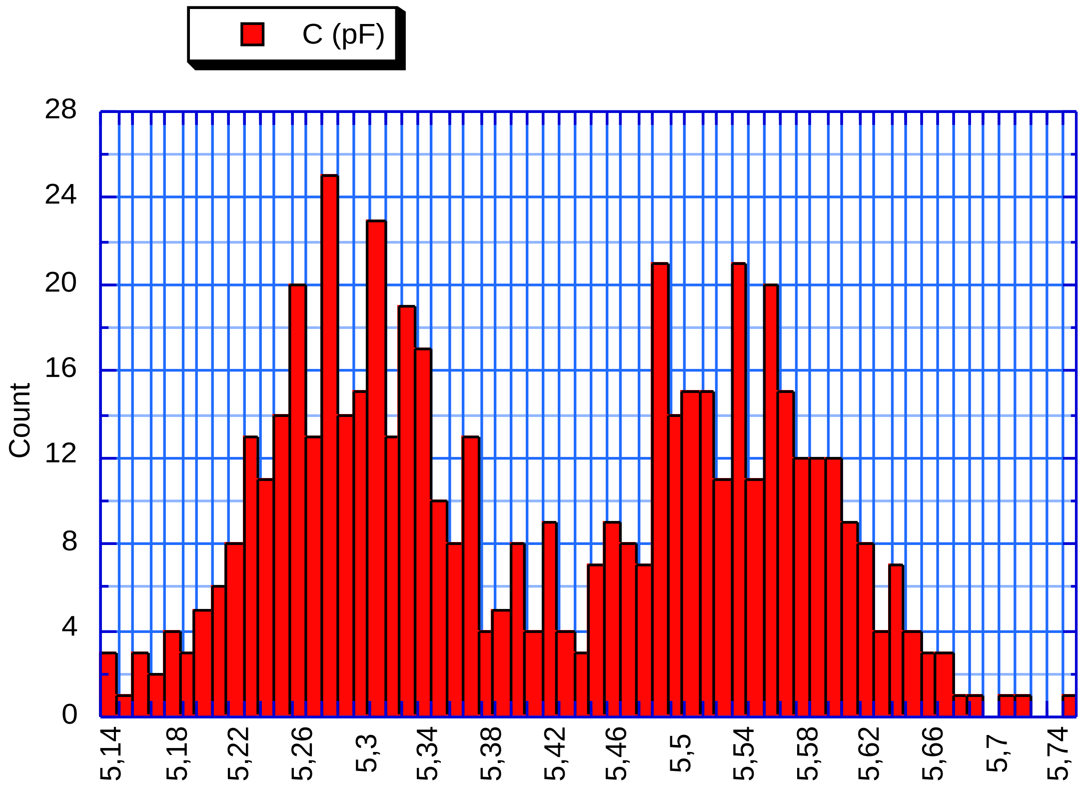


#		C(pF)
1	007	5.32
2	021	5.32
3	080	5.32
4	089	5.32

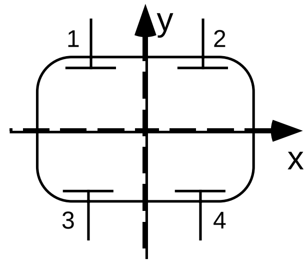
TDR MEASUREMENT OF
BUTTON ELECTRODE CAPACITANCE



CAPACITANCE MATCHING



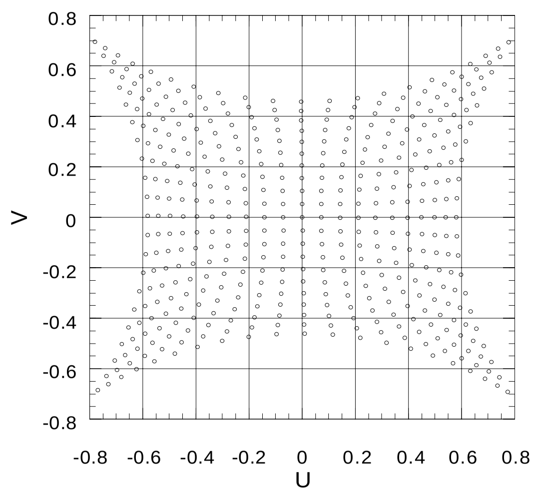
BPM calibrazione



$$U = \frac{V_2 + V_4 - V_1 - V_3}{V_1 + V_2 + V_3 + V_4}$$

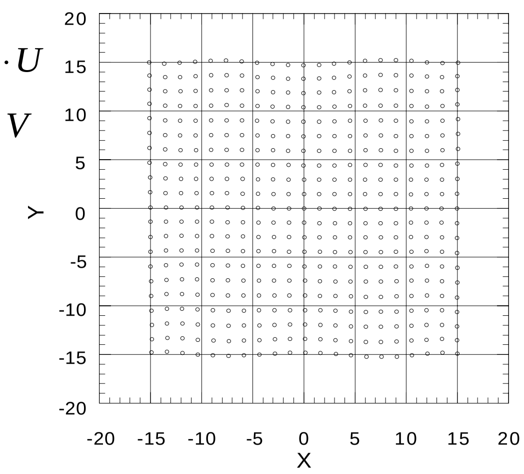
$$V = \frac{V_1 + V_2 - V_3 - V_4}{V_1 + V_2 + V_3 + V_4}$$

La posizione del fascio e' calcolata, a partire dalle tensioni indotte sugli elettrodi del BPM, attraverso un algoritmo ricorsivo. I coefficienti (a_i,b_i) (per ogni diverso tipo di BPM) sono stati ricavati con un fit ai minimi quadrati dei dati ottenuti dalle misure di calibrazione.

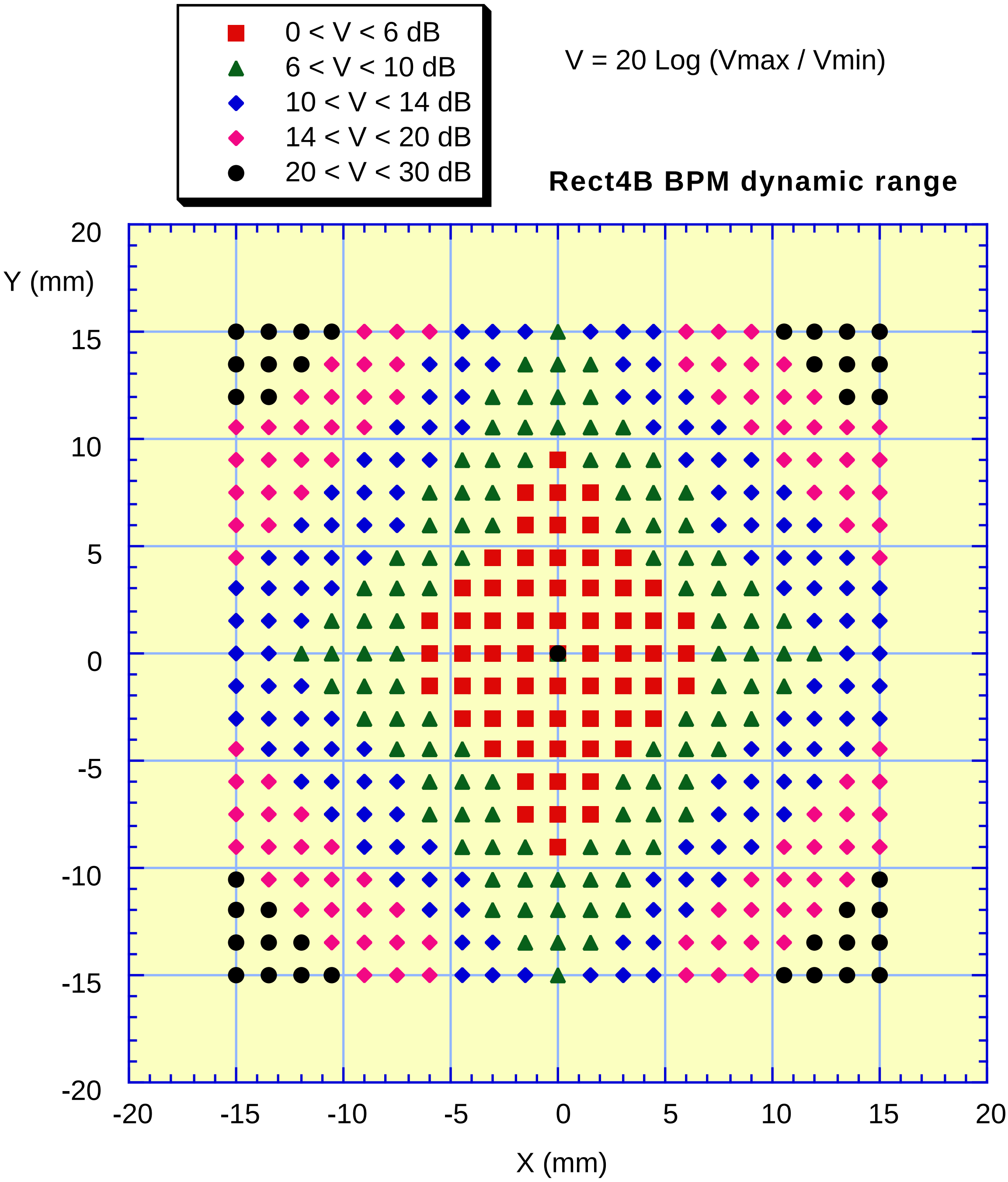


$$x = (a_0 + a_1 \cdot y^2 + a_2 \cdot y^4 + a_3 \cdot x^2 + a_4 \cdot x^2 y^2 + a_5 \cdot x^4) \cdot U$$

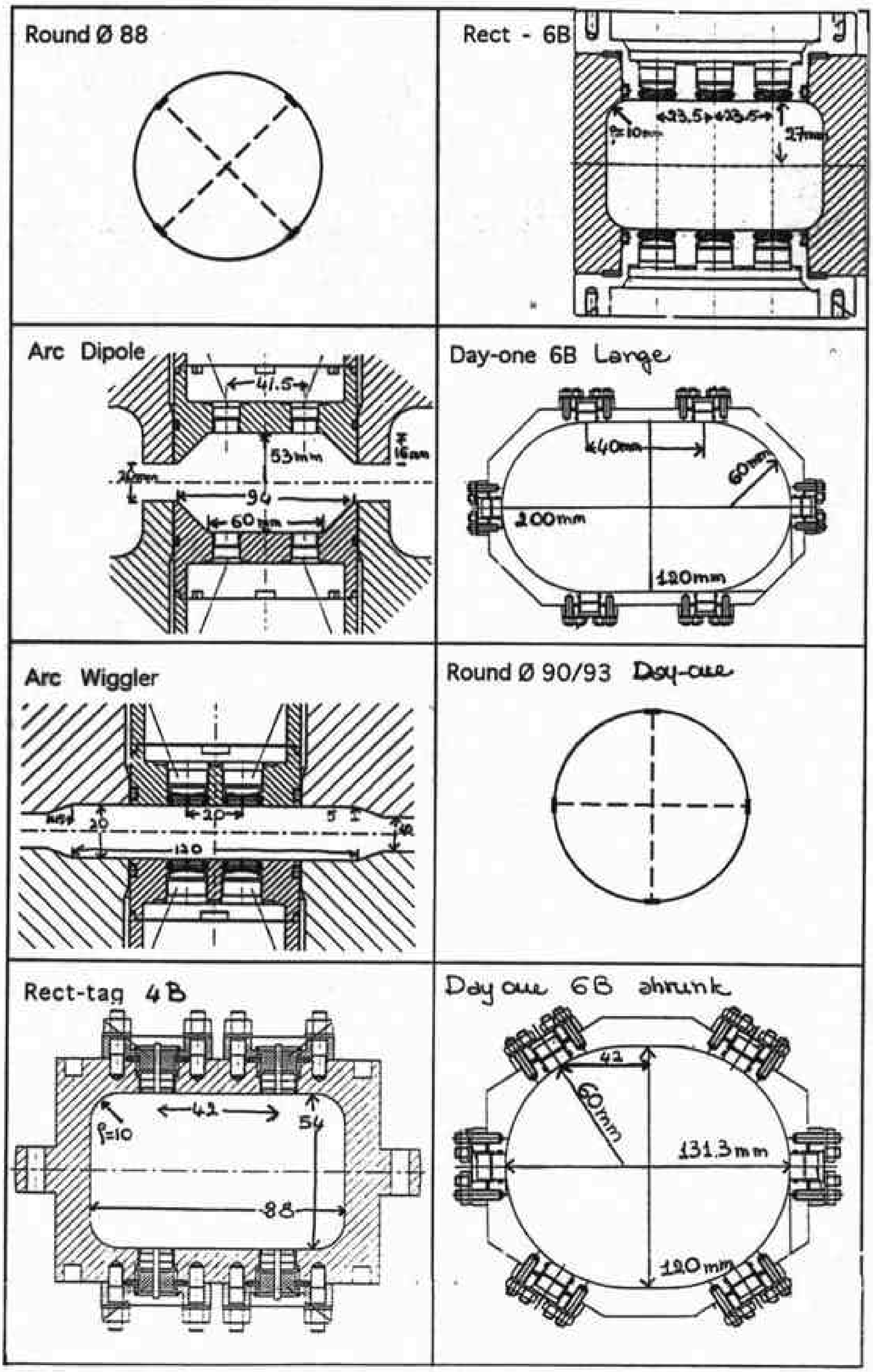
$$y = (b_0 + b_1 \cdot y^2 + b_2 \cdot y^4 + b_3 \cdot x^2 + b_4 \cdot x^2 y^2 + b_5 \cdot x^4) \cdot V$$



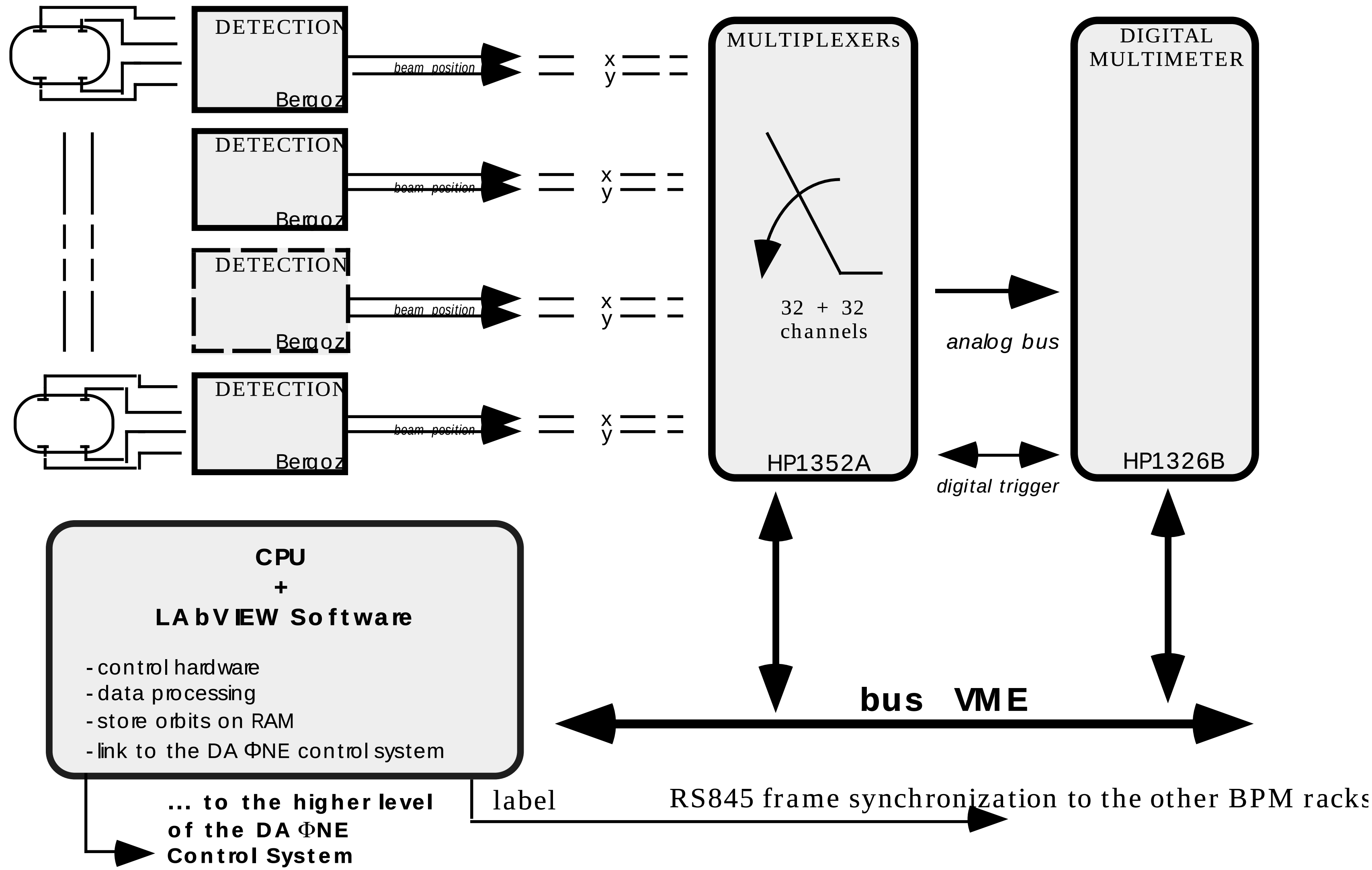
BPM type	dX fit error (rms)	dY fit error (rms)
Round diagonal	20.9 um	20.9 um
Dipole	20.6 um	39.2 um
Wiggler	32.3 um	92.6 um
Rectangular	26.0 um	29.4 um
Round orthogonal	13.7 um	13.7 um


0 < V < 6 dB
6 < V < 10 dB
10 < V < 14 dB
14 < V < 20 dB
20 < V < 30 dB
V = 20 Log (Vmax / Vmin)
Rect4B BPM dynamic range
Y (mm)
20
15
10
5
0
-5
-10
-15
-20
X (mm)

BPM's Schematic drawings :

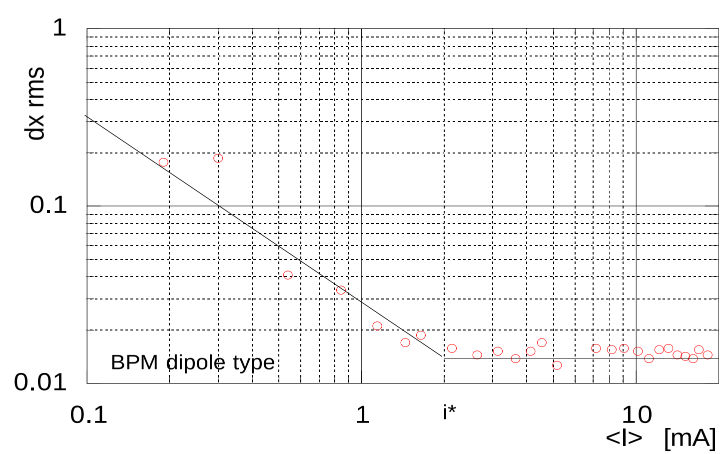


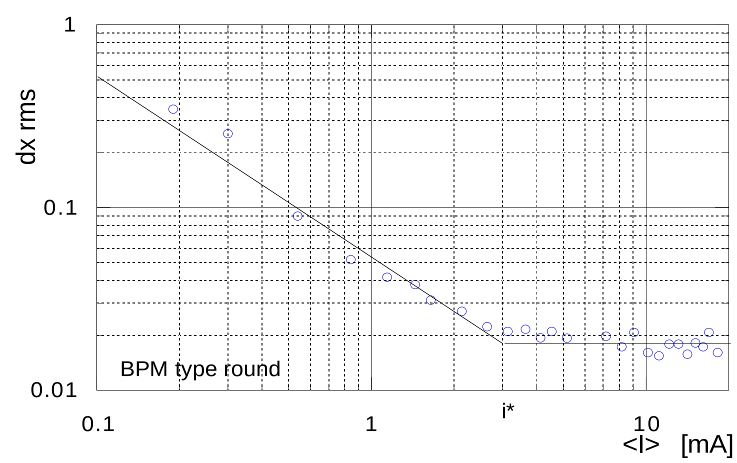
SISTEMA DI ACQUISIZIONE DELL'ORBITA

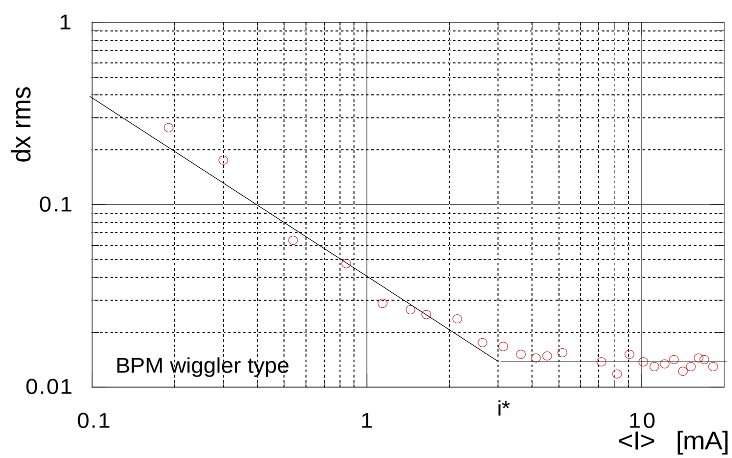


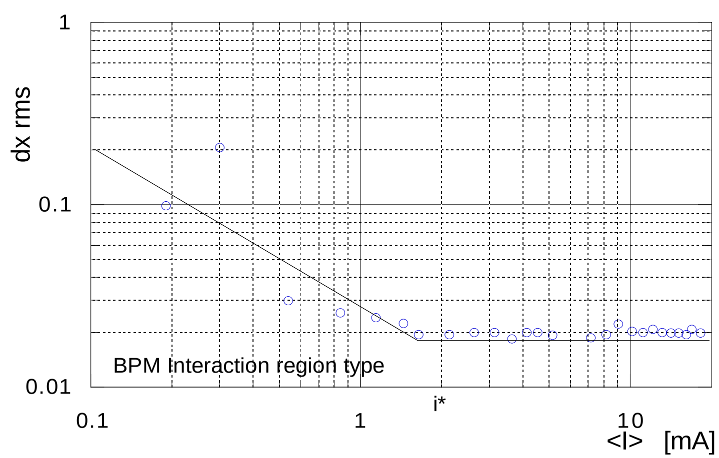
posizione vs corrente

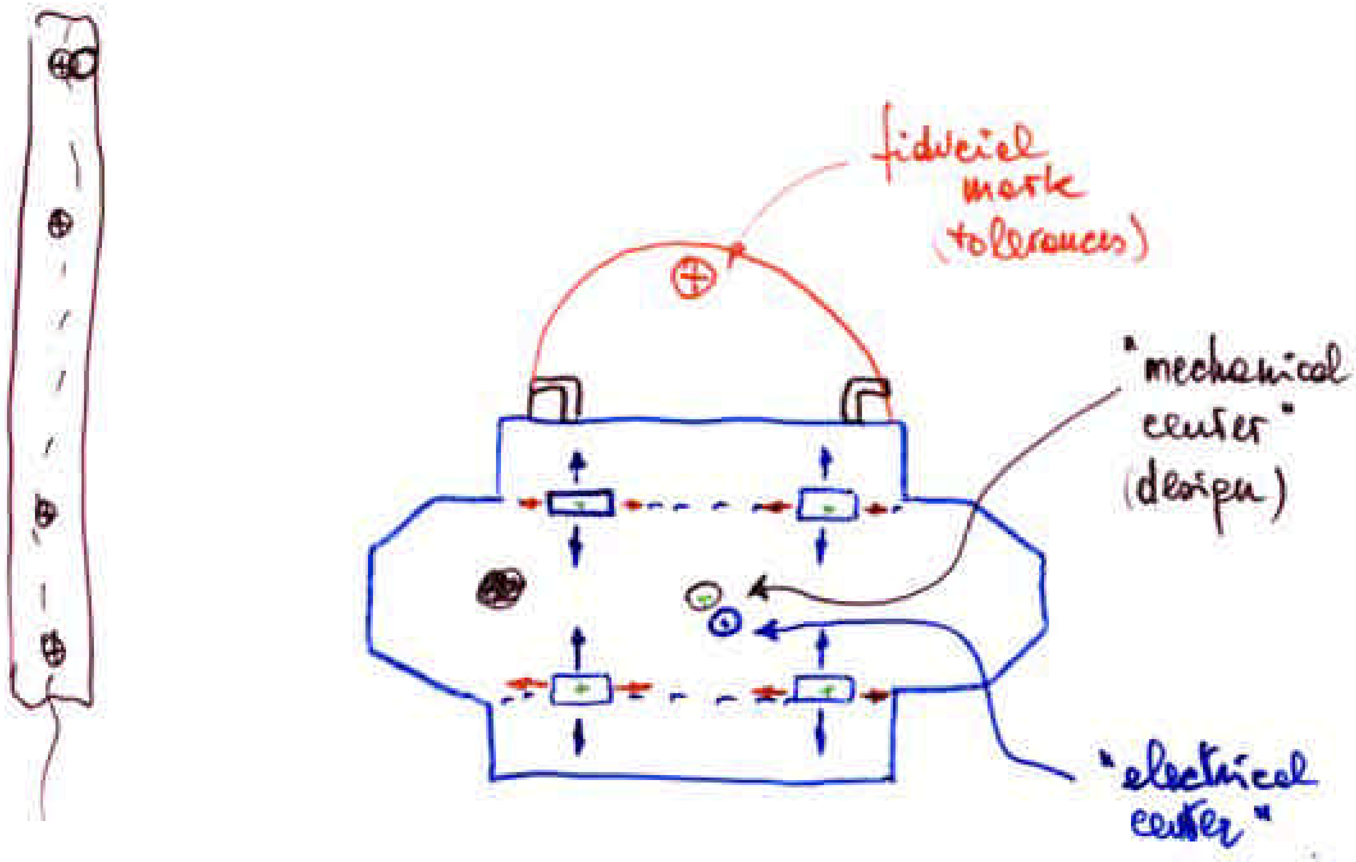
L'errore rms della misura di posizione dx_{rms} e' inizialmente inversamente proporzionale alla corrente media del fascio <I> e tende asintoticamente ad un valore di circa 0.02mm sopra il valore di soglia i*.







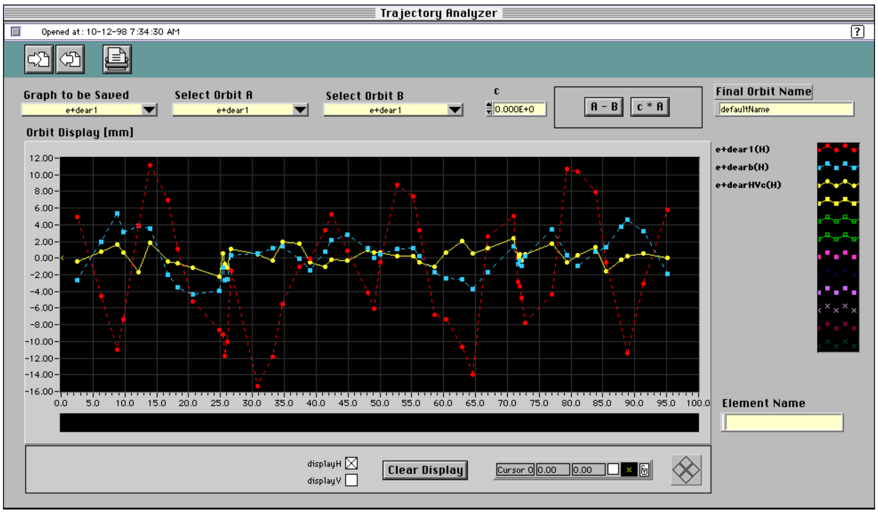




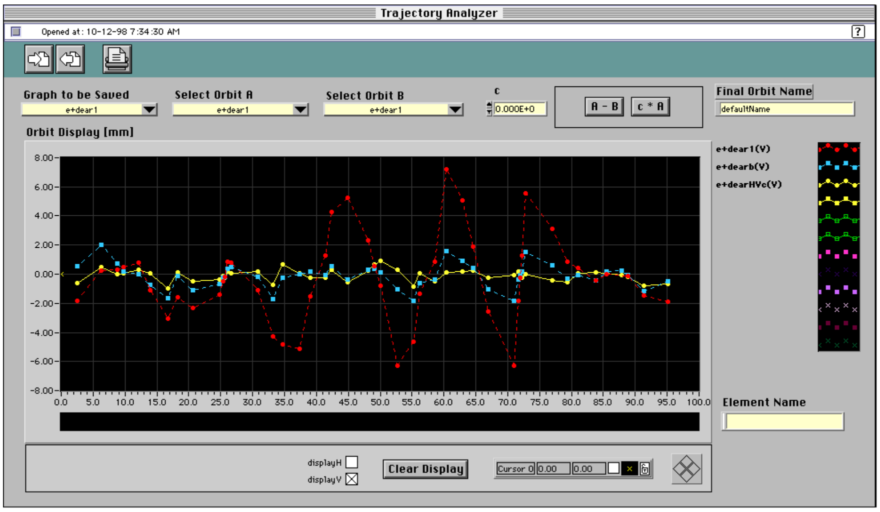
$$x_{meas} = x_{TRUE} + \underbrace{x_{0S} + \delta x_{0S}}_{SURVEY} + \delta x_{MECH} + \delta x_{EL} + \delta x_{DETECTOR} + \delta x_{CALIBRATION}$$

- δx_{MECH}: TOLERANCES ?
- δx_{EL}: can calibrate
- $\delta x_{DETECTOR}$: RANDOM
- $\delta x_{CALIBRATION}$: $f(x,y)$, ≈ 0 @ $x,y=0$

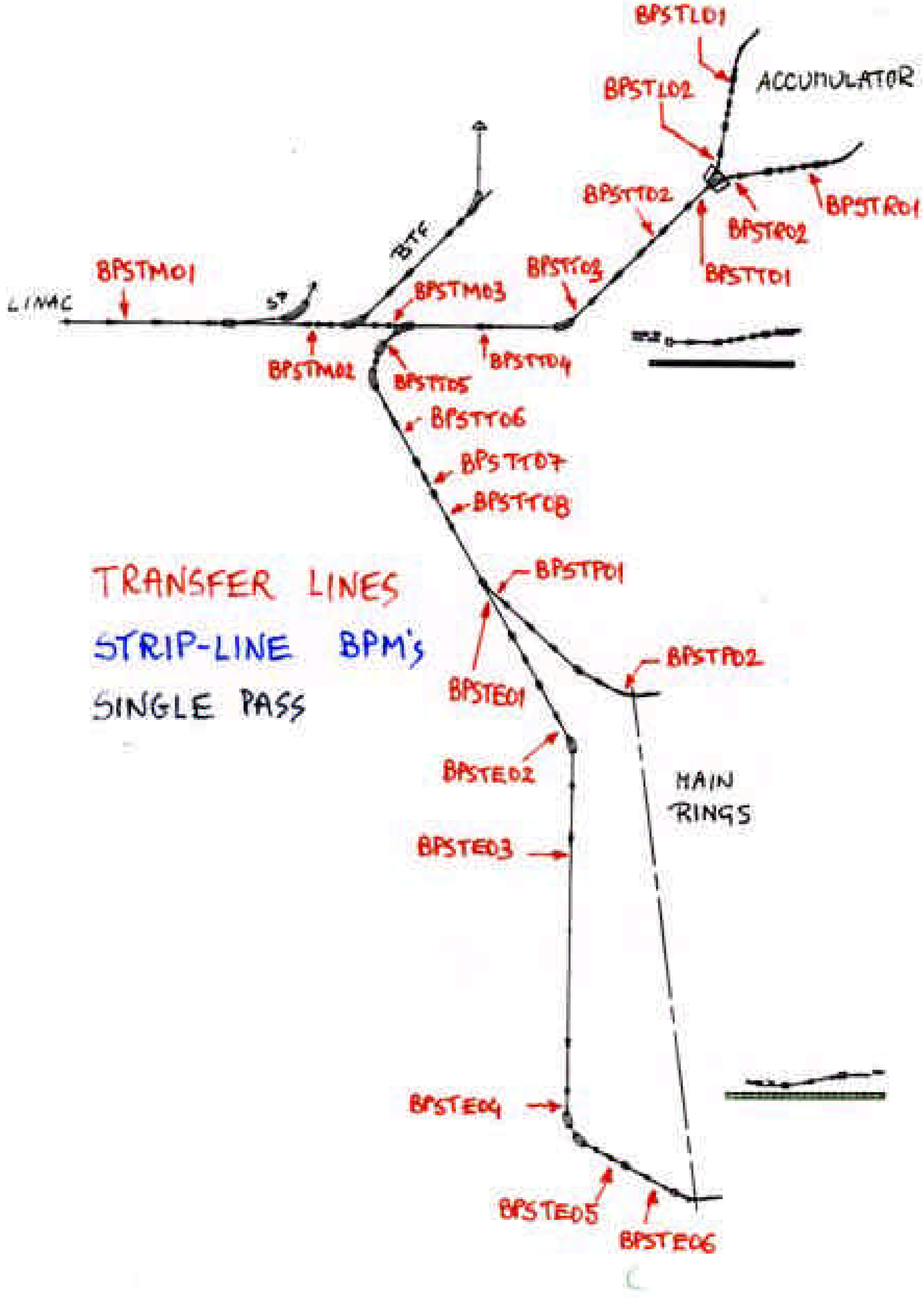
Main Ring e^+ Closed Orbit Correction



$$-2.\ [mm] < R_h^{measured} < 2.\ [mm]$$

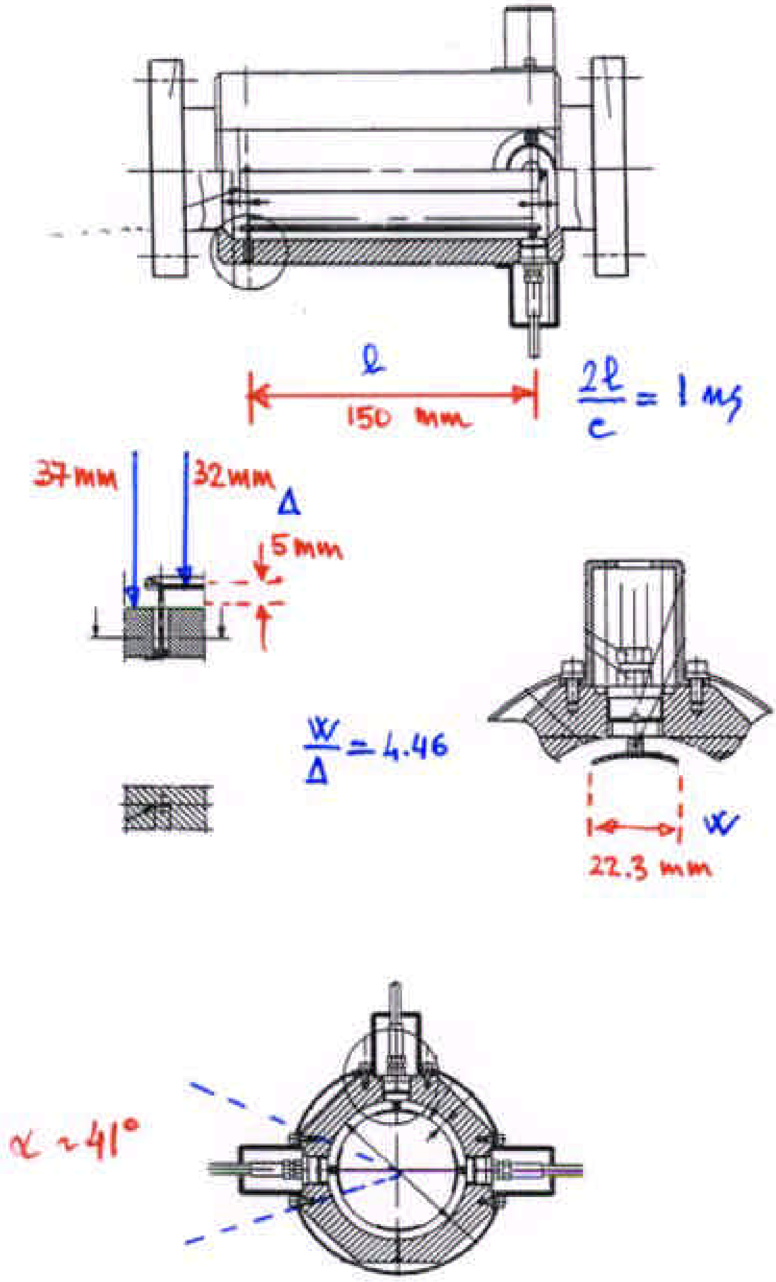


$$-1.\ [mm] < R_v^{measured} < 1.\ [mm]$$



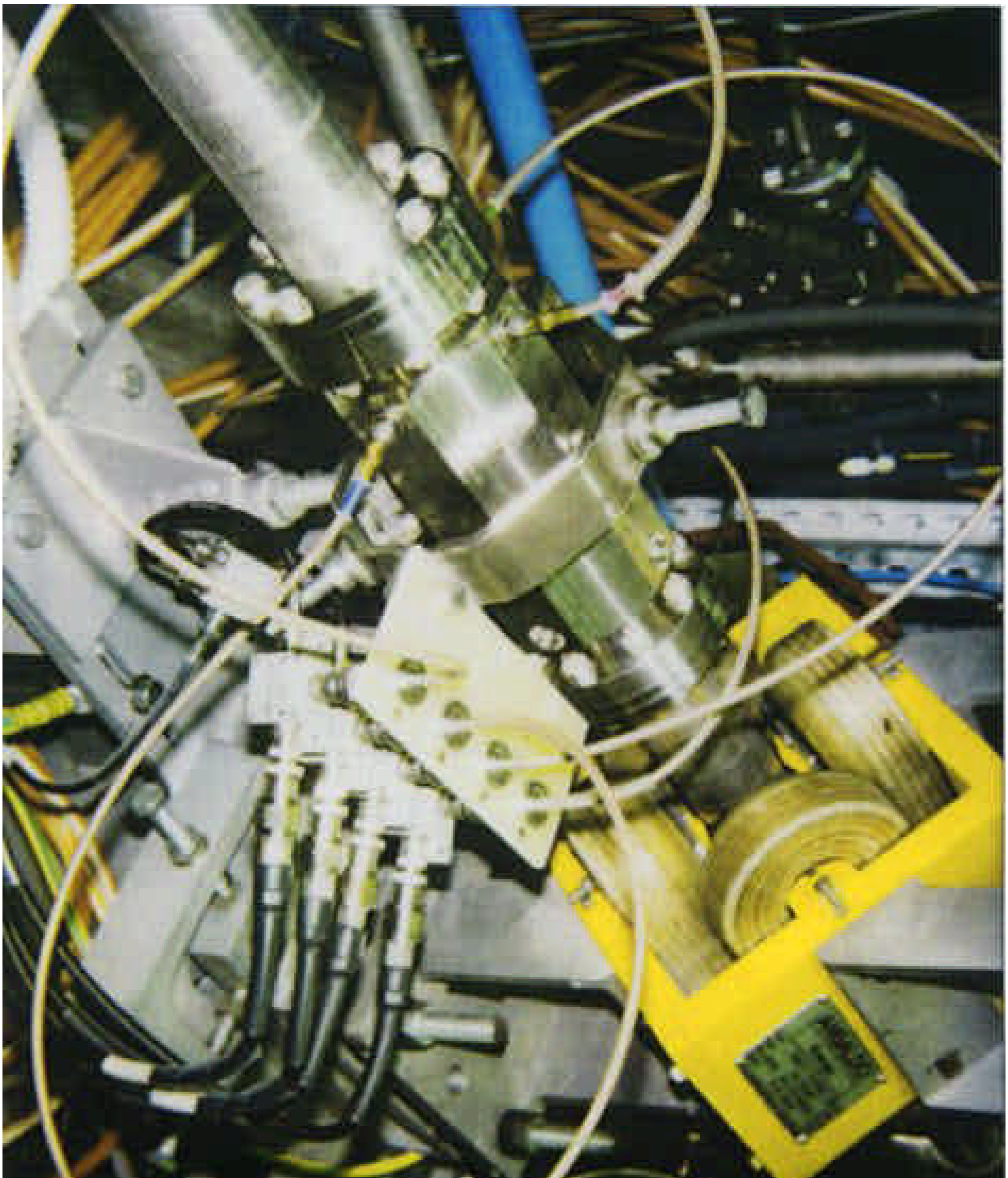
BPSTL01
ACCUMULATOR
BPSTL02
BPSTT02
BPSTR02
BPSTR01
BPSTT01
BTF
BPSTM01
LINAC
BPSTT03
BPSTM03
BPSTM02
BPSTT05
BPSTT04
BPSTT06
BPSTT07
BPSTT08
TRANSFER LINES
STRIP-LINE BPM's
SINGLE PASS
BPSTP01
BPSTP02
BPSTE01
BPSTE02
MAIN RINGS
BPSTE03
BPSTE04
BPSTE05
BPSTE06

TRANSFER LINES
BEAM POSITION MONITOR - STRIPLINE

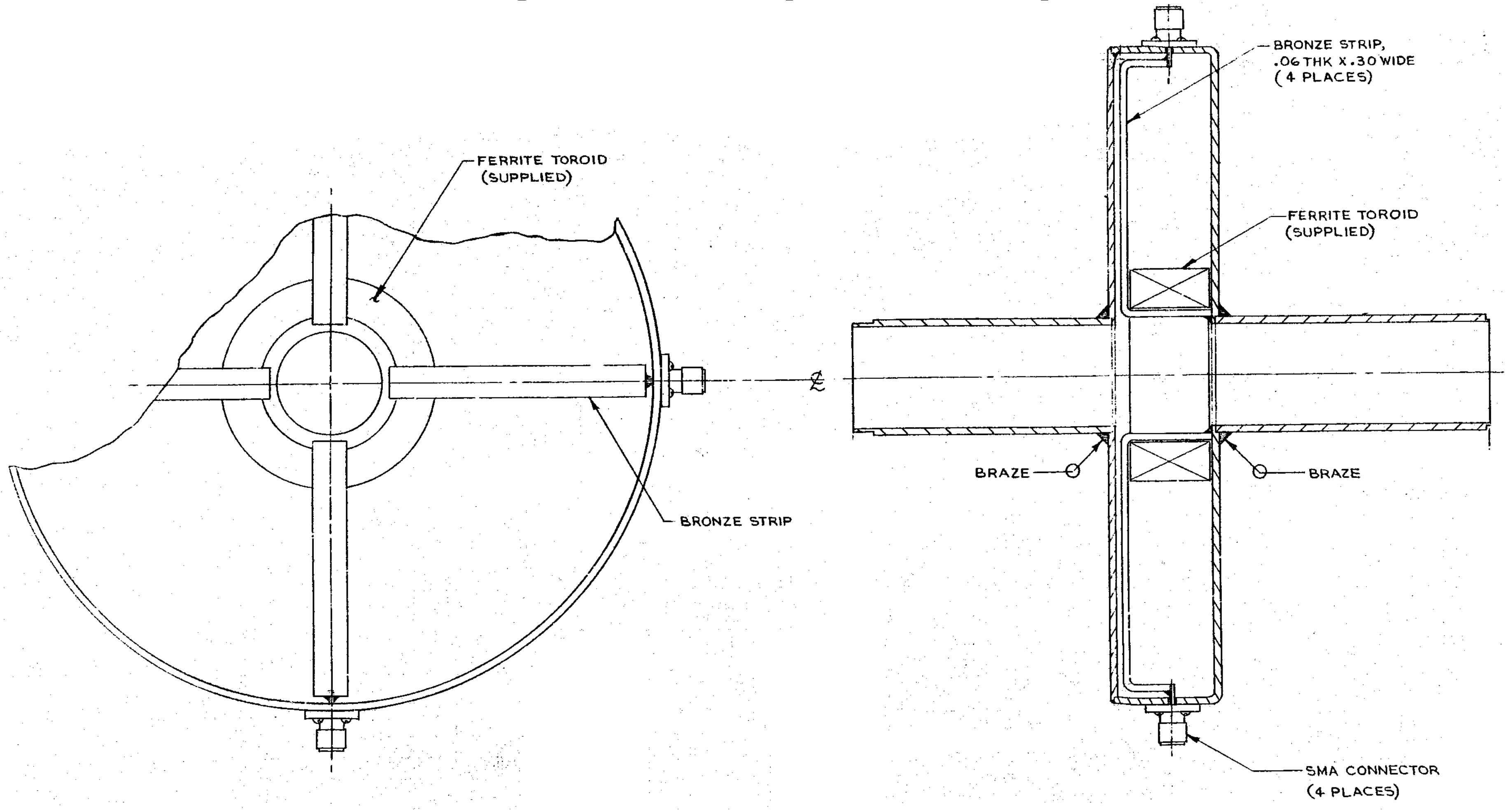


$$Z_p \sim 5.6\ \Omega \ @ \ 500\ \text{MHz}$$

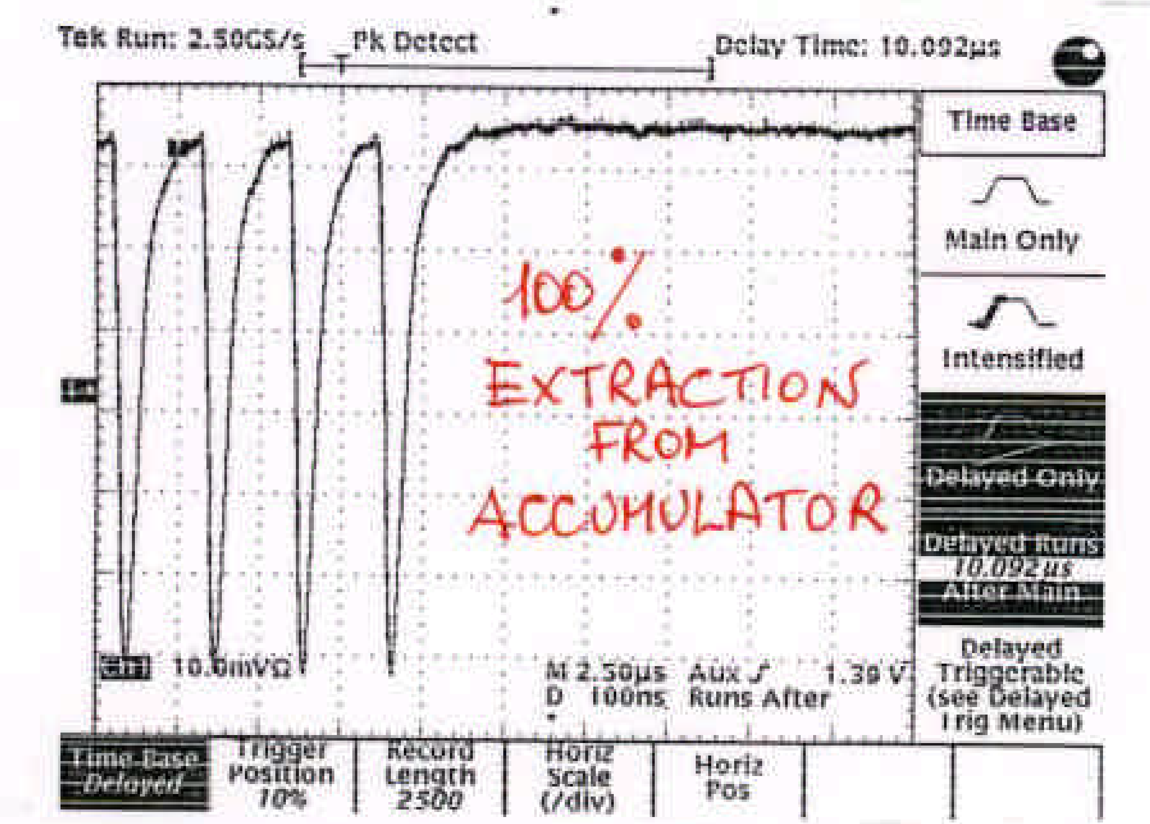
$$|Z_p| \sim 50 \cdot \left(\frac{\alpha}{2\pi}\right) \cdot \sin\left(\frac{\omega l}{c}\right)$$

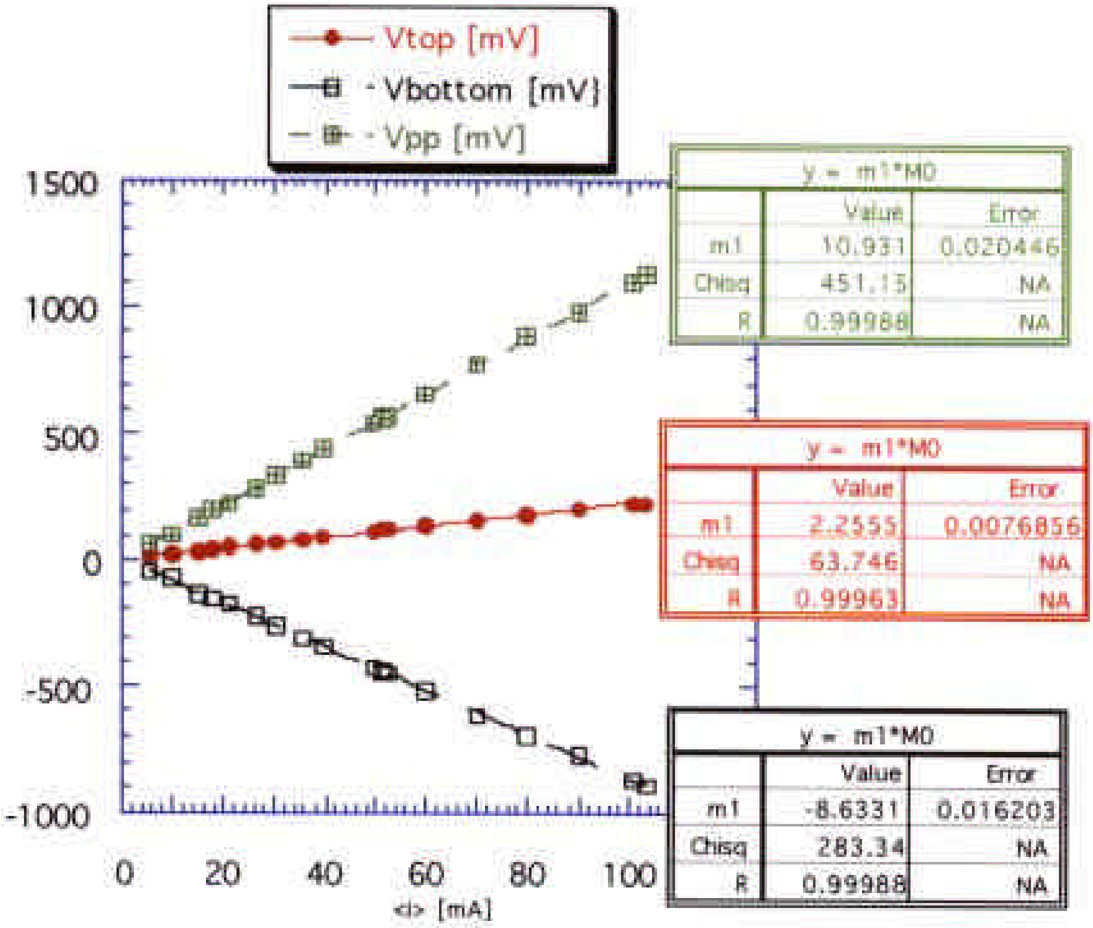


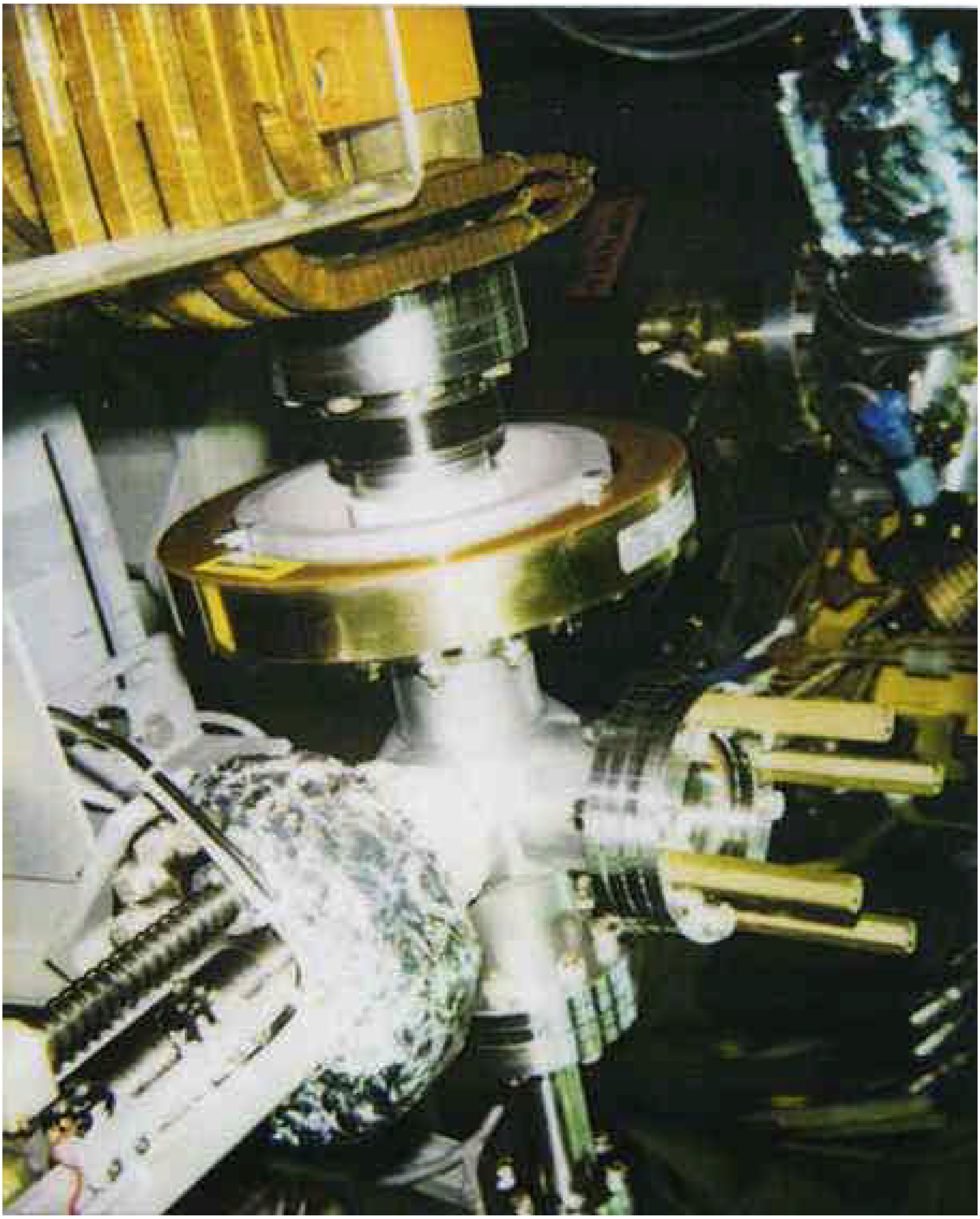
Monitor di posizione *caricato* con materiale magnetico (ferrite)



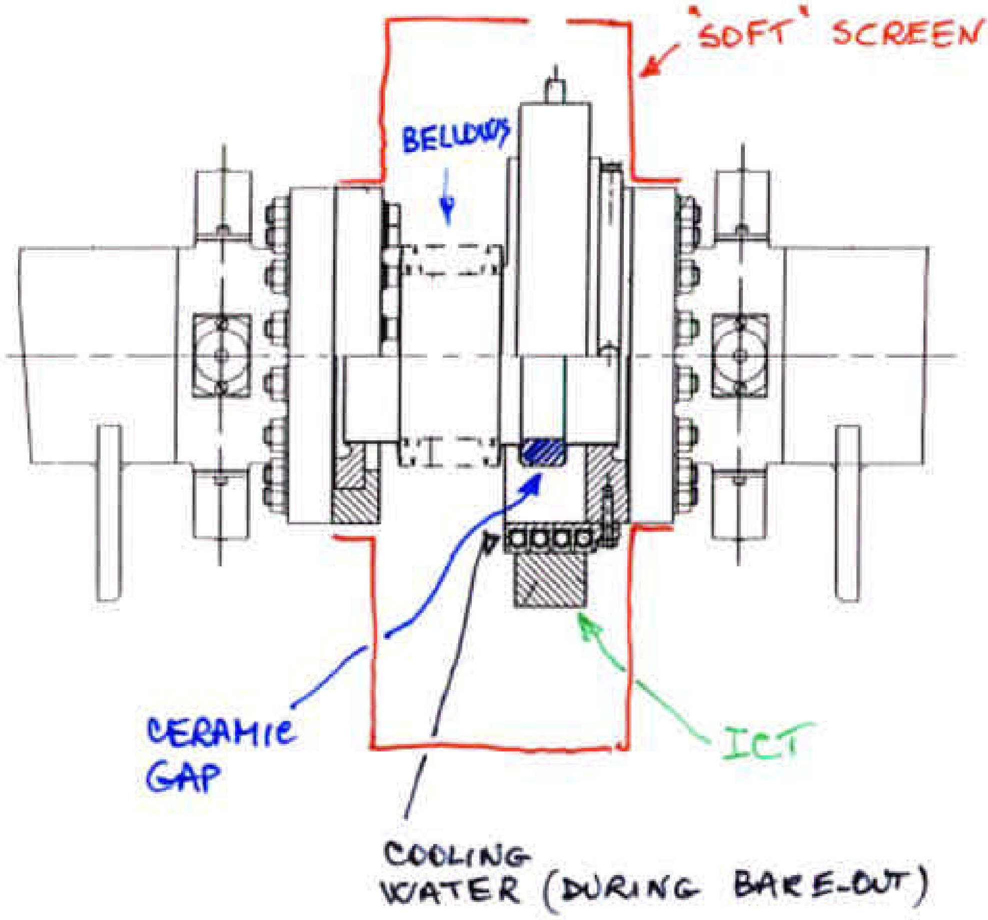
TOROIDAL CURRENT MONITOR



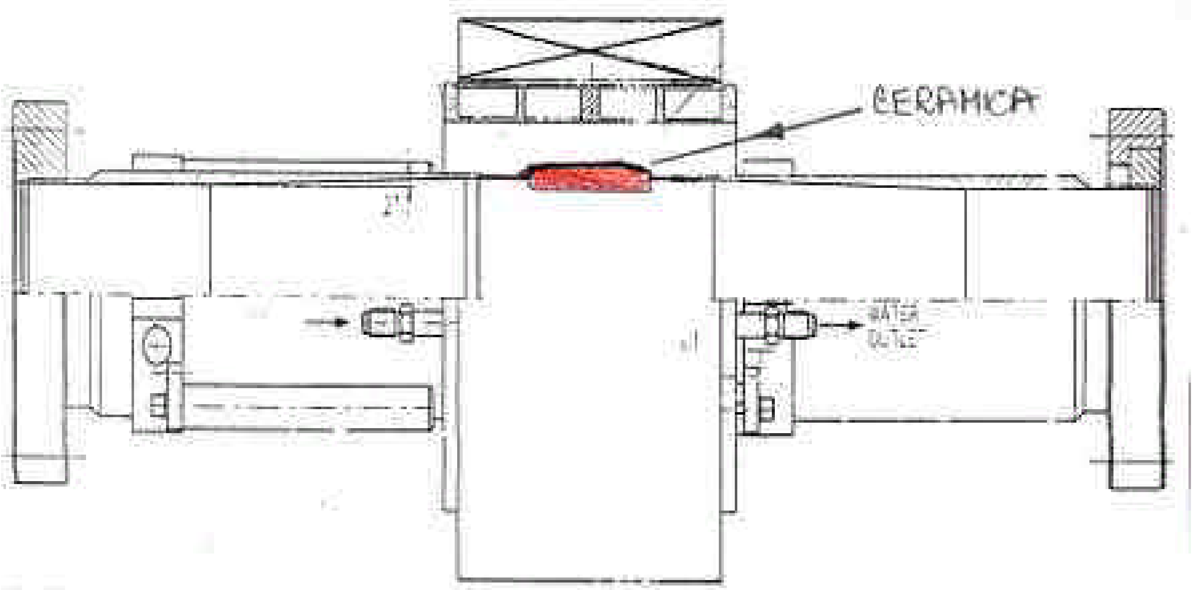


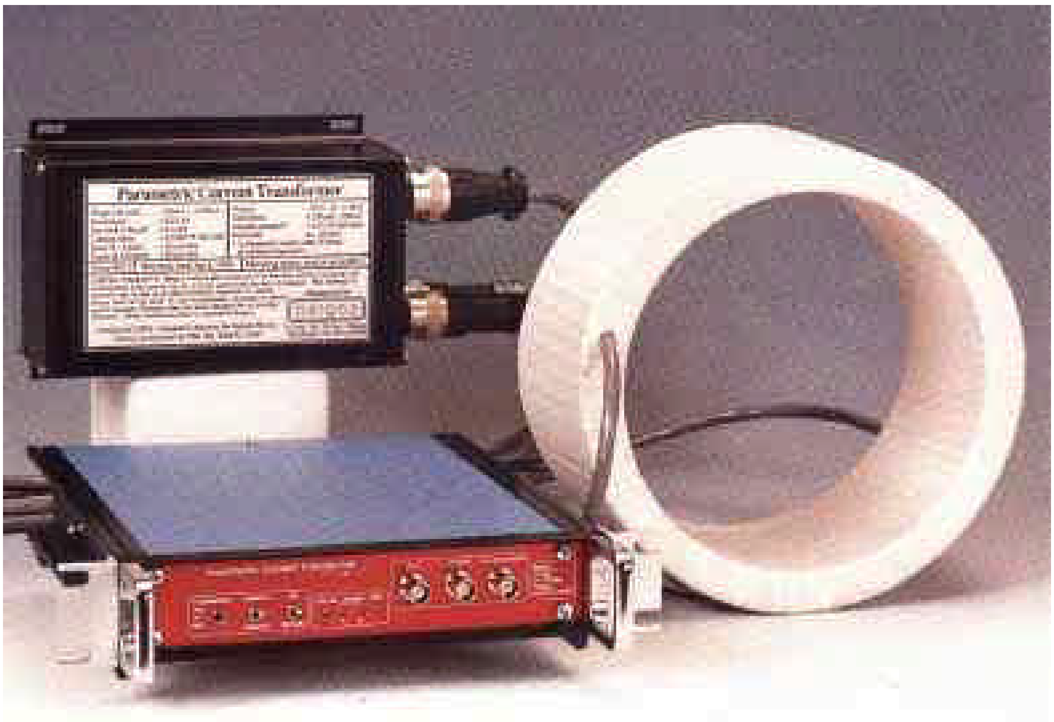


INTEGRATING CURRENT TRANSFORMER
– ACCUMULATOR RING

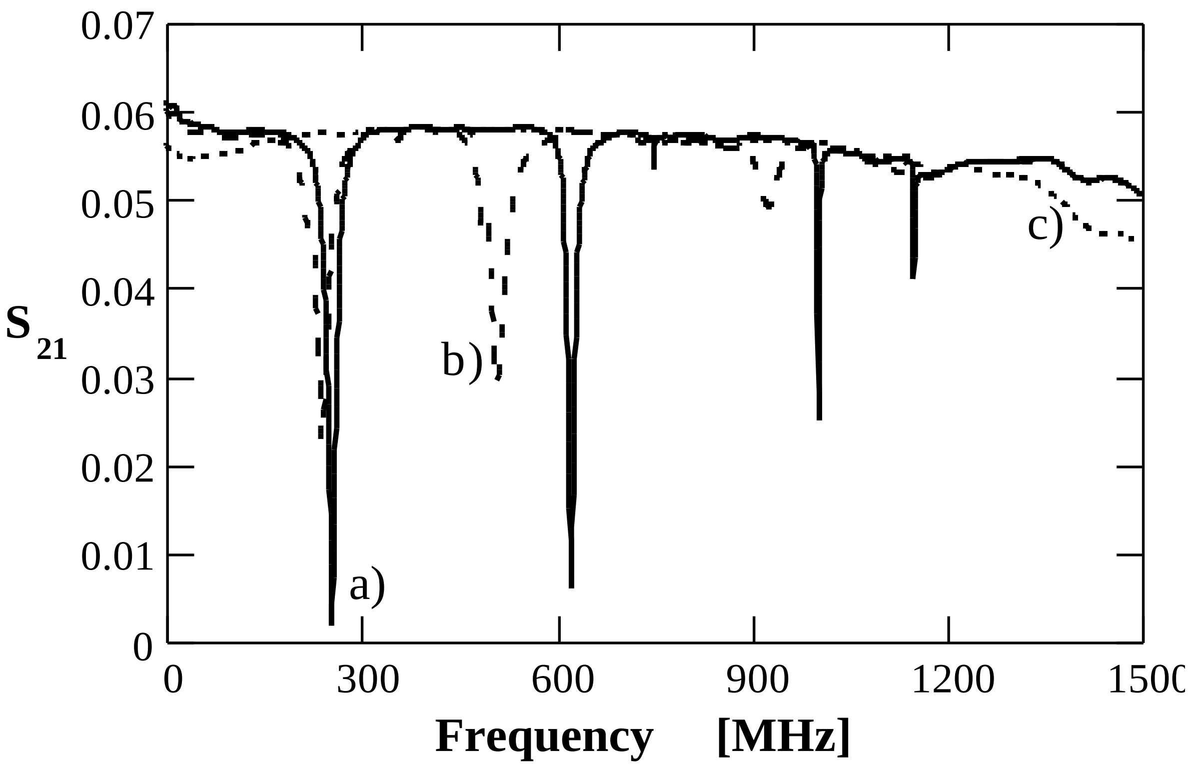


Monitor di Corrente Totale Media DCCT

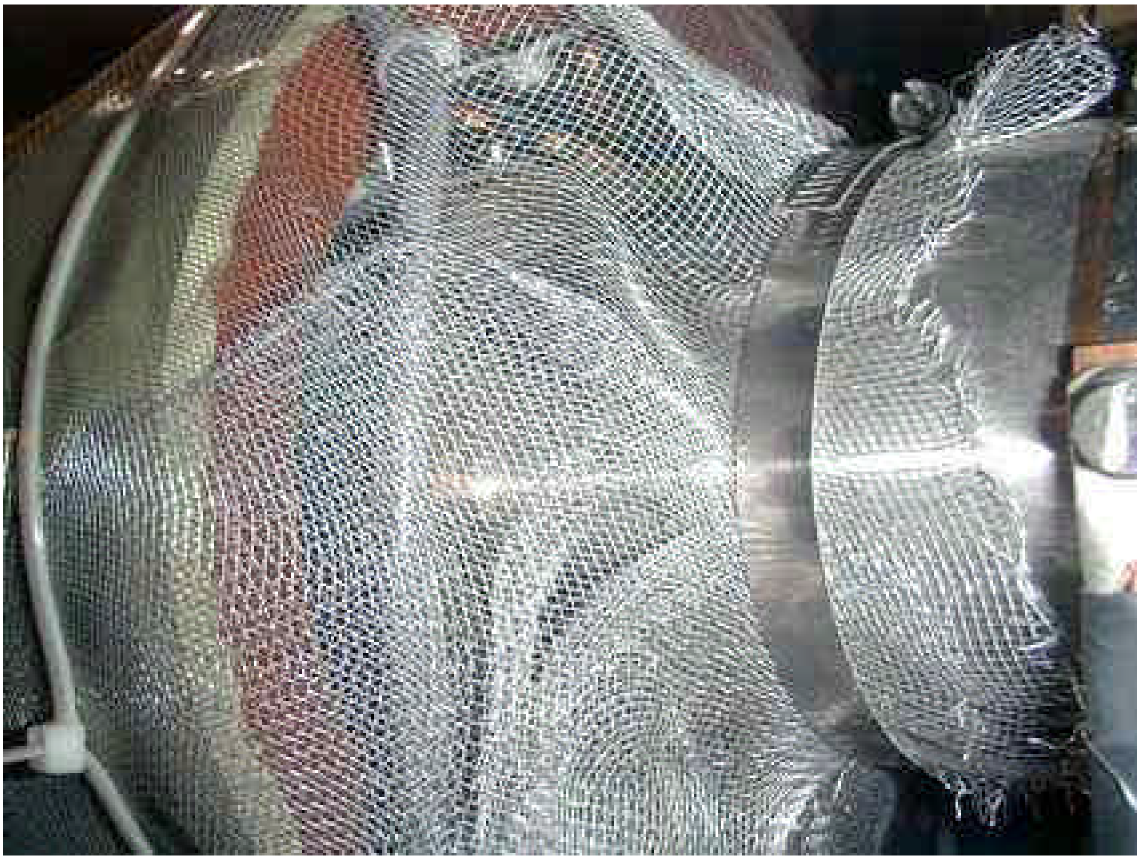




"MIR": Monitor di Corrente Resistivo



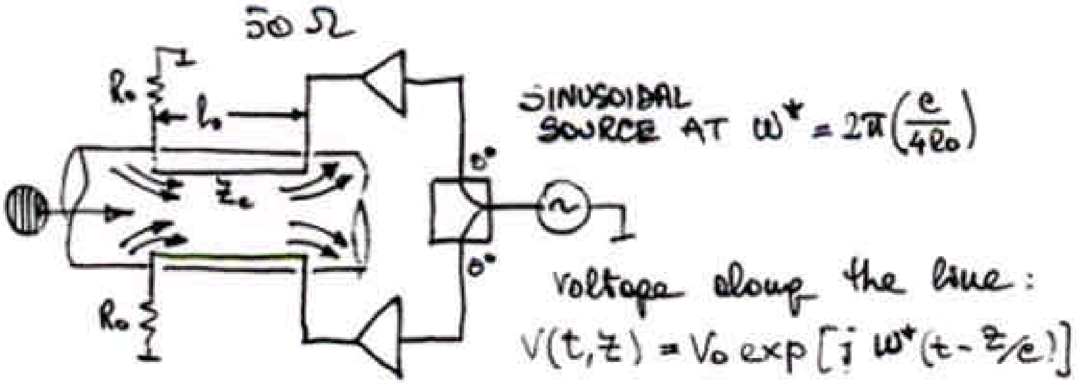
DCCT-MIR
SCHERMO DI CHIUSURA



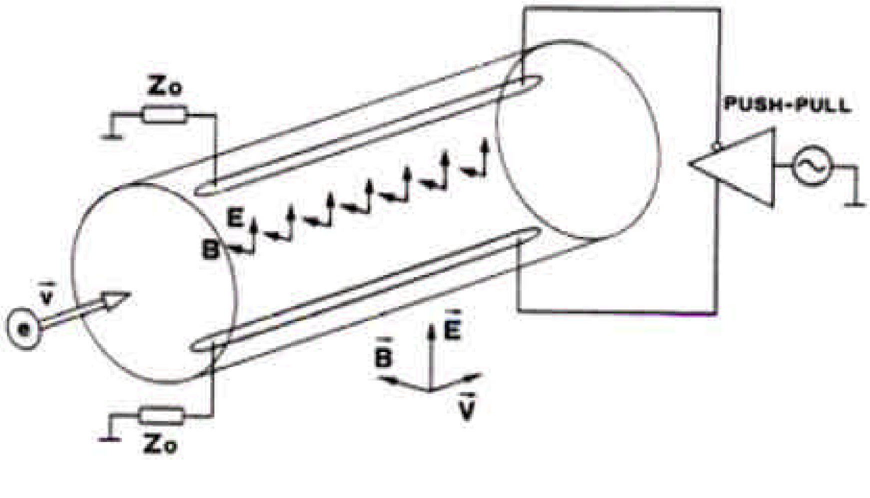
Kickers

By phase-modulating the voltage in an RF cavity it is possible to drive longitudinal dipole oscillations of a bunch. By amplitude-modulation of the RF voltage, longitudinal quadrupole oscillations can be excited, provided that the cavity bandwidth extends over the mode frequency.

We can turn a matched strip-line into a longitudinal kicker by applying in-phase deflecting voltages at the down-stream ports.

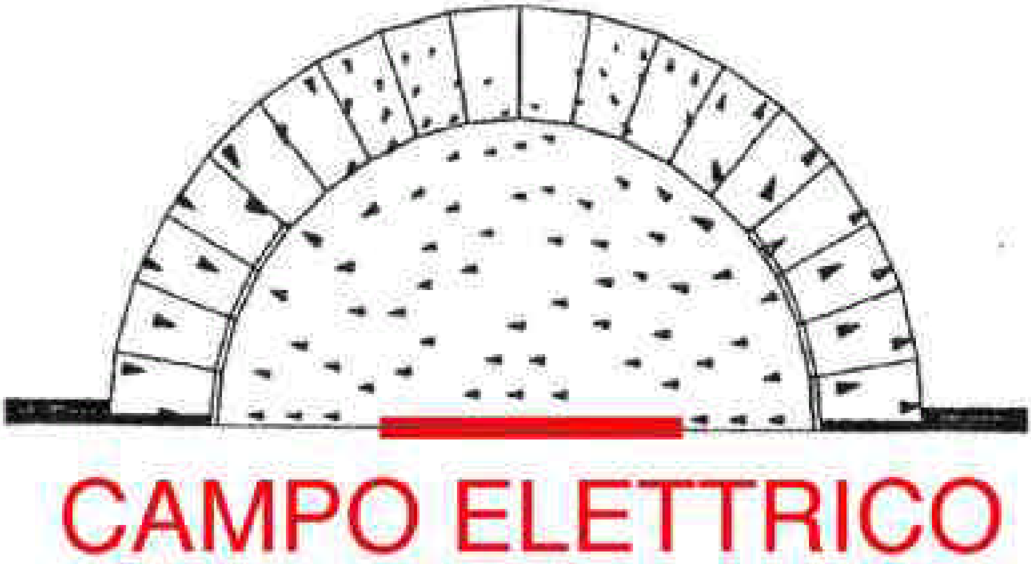


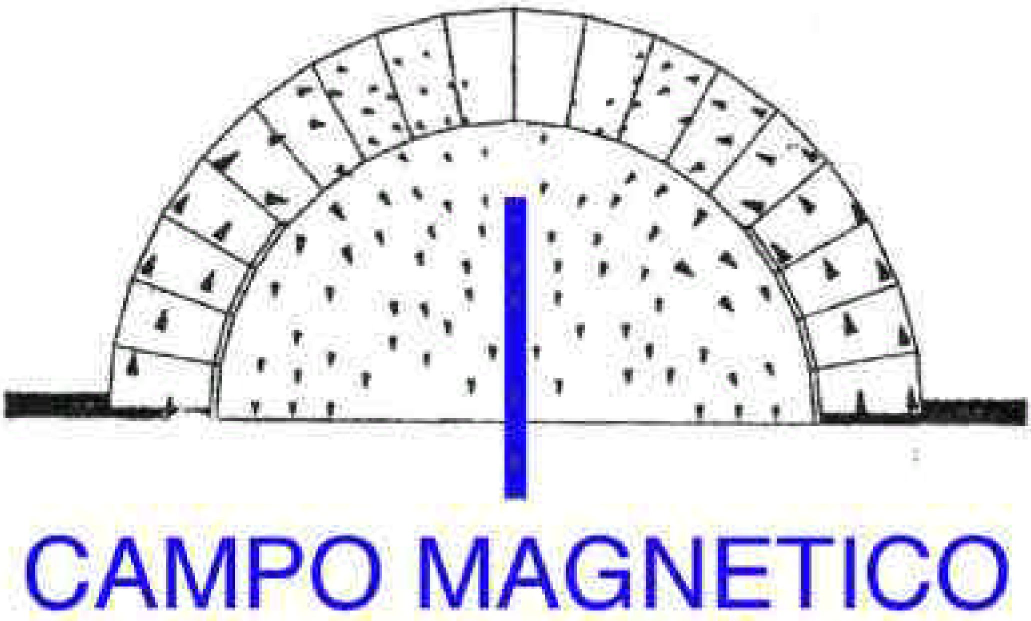
Strip-lines can also be used as transverse kicker. Two voltages of opposing polarity are applied down-stream the beam.



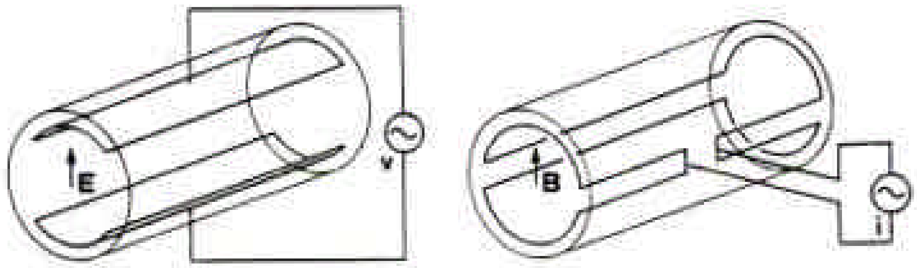
In the case of colliding beams, it is possible to excite selectively one beam without effect on the other.

STRIPLINES UTILIZZATE COME KICKER TRASVERSO





In the same way as BPM's are sensitive to electric or magnetic field, we can deflect a beam electrically by open plates driven by a voltage generator, or magnetically, by coils driven by a current generator.

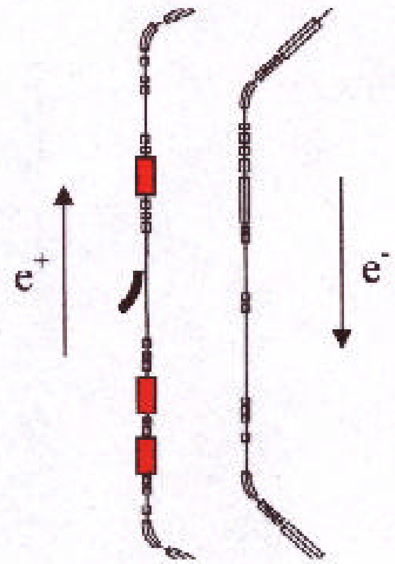


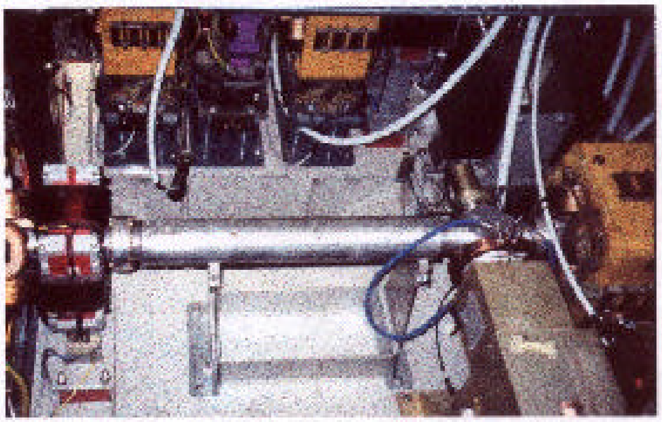
The capacitor formed by the plates and the inductor formed by the coils can be part of an L-C resonant circuit to reduce the power requirement of the driving amplifier.

Remark: by combining several strip-lines in series with $\lambda/2$ delay lines, it is possible to increase the sensitivity/strength at the peak frequency at the expense of a reduction of the bandwidth, but leaving the source/load impedance constant.

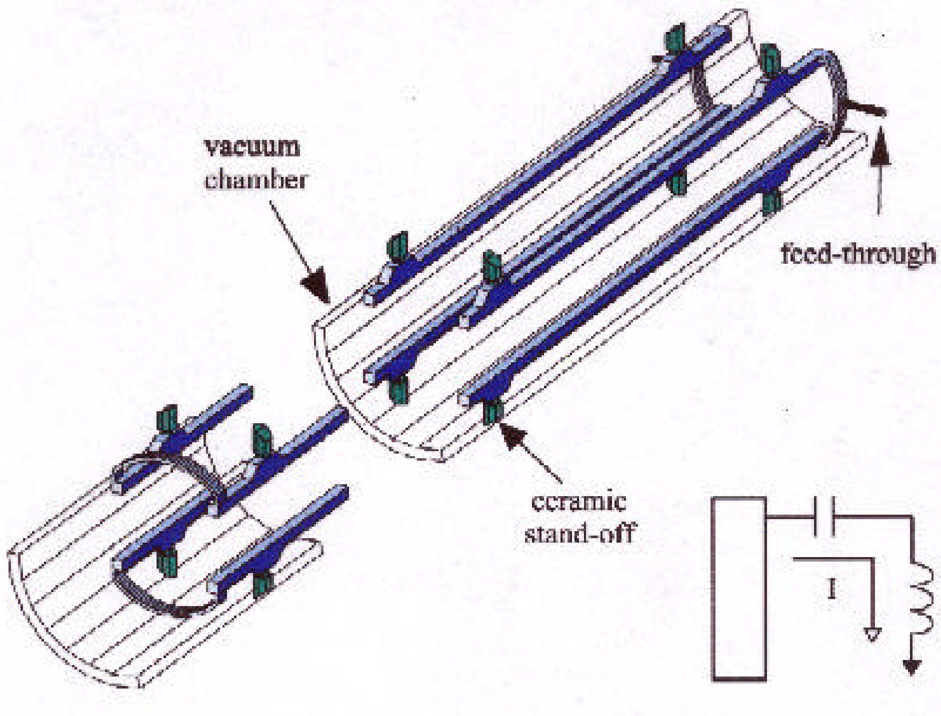
DAΦNE INJECTION KICKERS

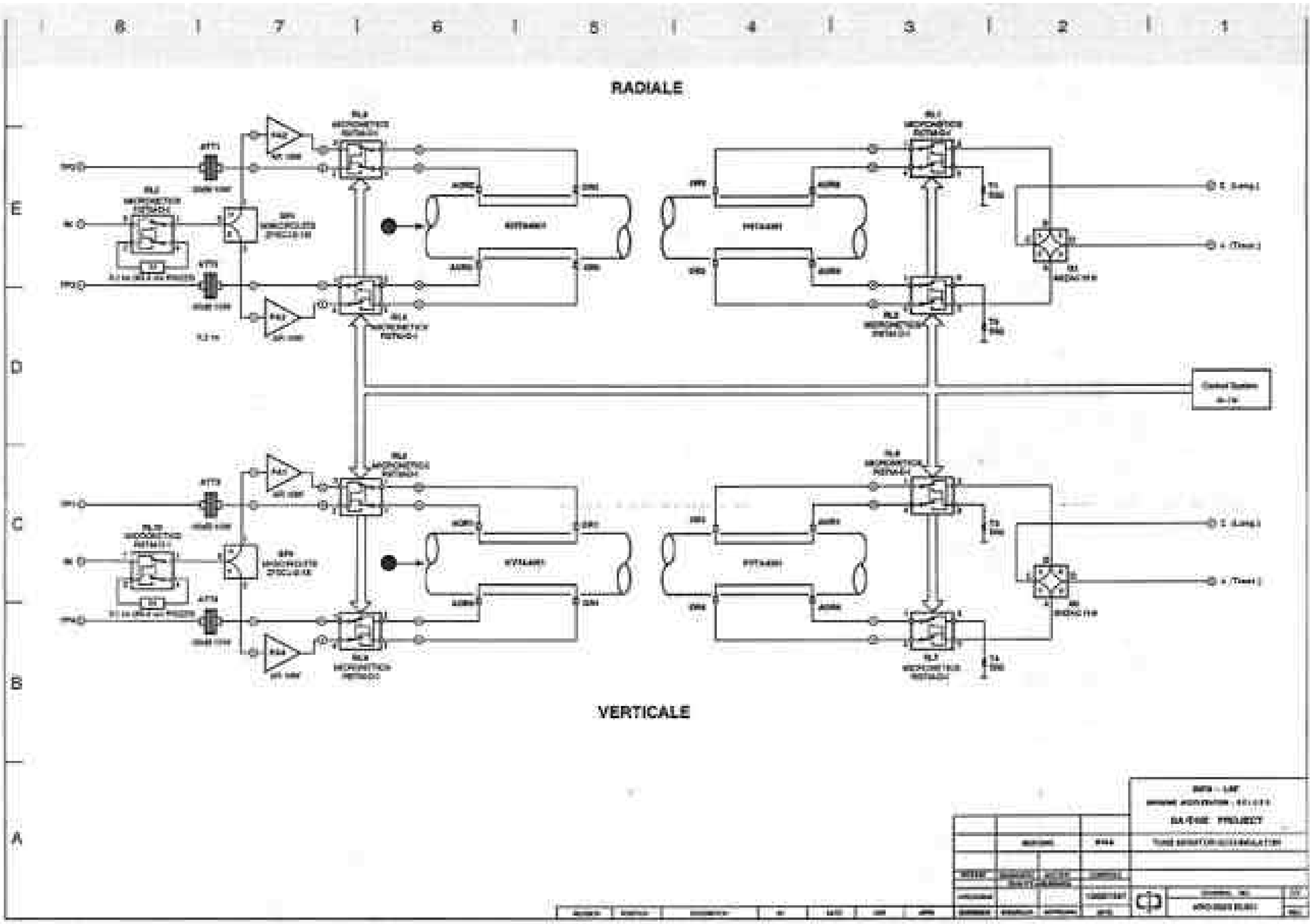
• LAYOUT



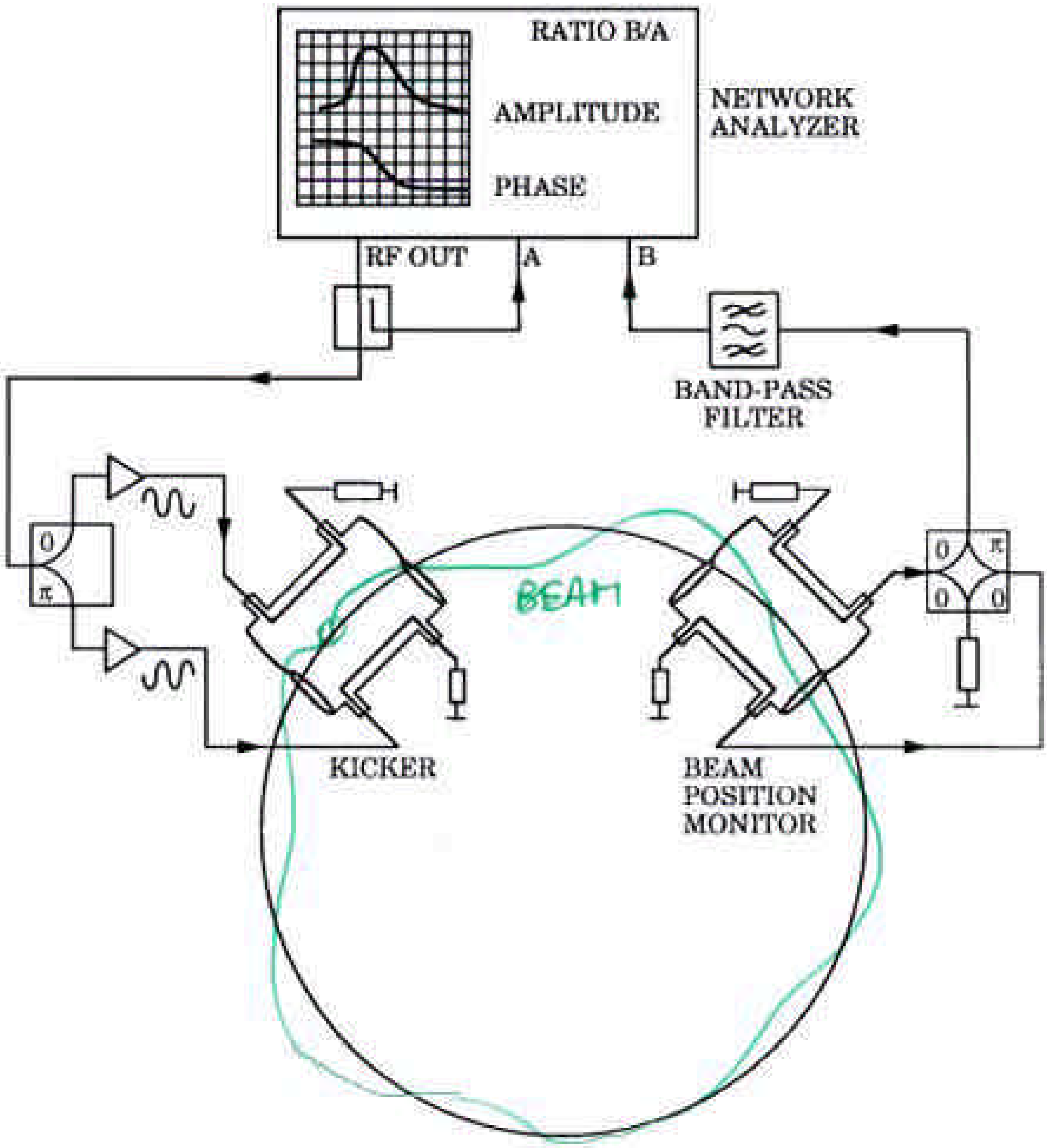


• SCHEMATIC VIEW

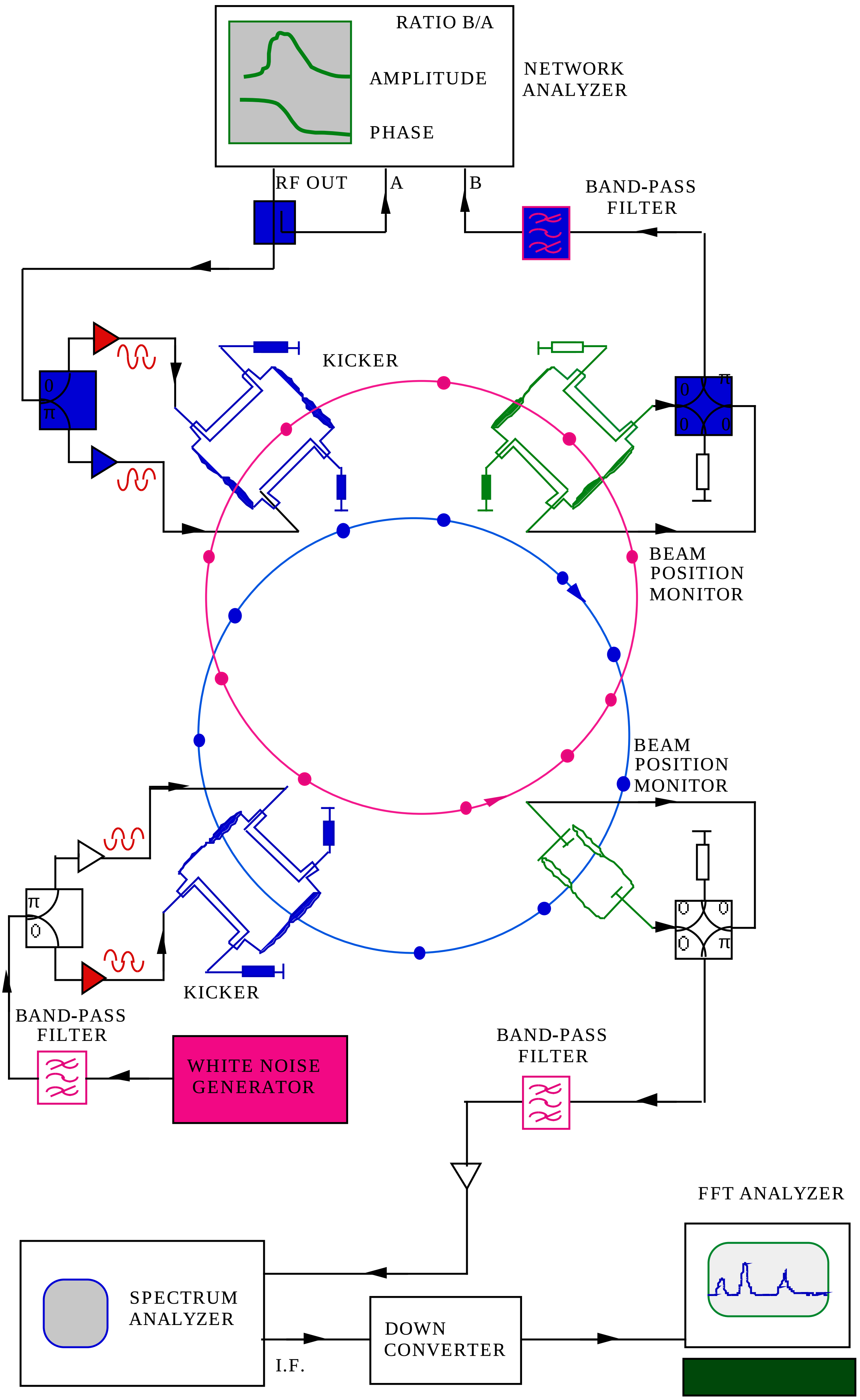




8
7
6
5
4
3
2
1
E
D
C
B
A
RADIALE
VERTICALE

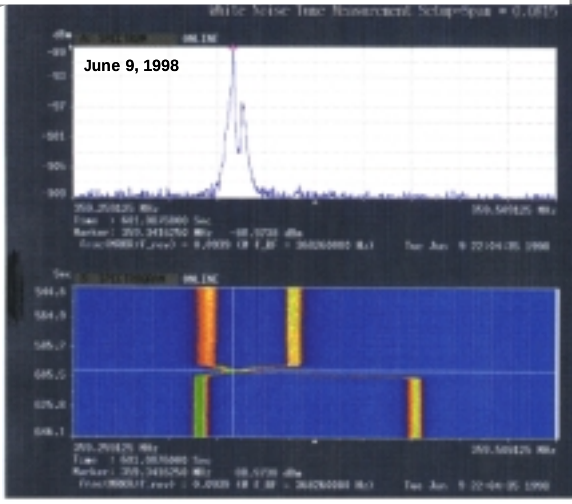


RATIO B/A
AMPLITUDE
PHASE
NETWORK ANALYZER
RF OUT
A
B
BAND-PASS FILTER
0
π
BEAM
KICKER
BEAM POSITION MONITOR


RATIO B/A
AMPLITUDE
PHASE
NETWORK ANALYZER
RF OUT
A
B
BAND-PASS FILTER
KICKER
BEAM POSITION MONITOR
BEAM POSITION MONITOR
KICKER
BAND-PASS FILTER
WHITE NOISE GENERATOR
BAND-PASS FILTER
FFT ANALYZER
SPECTRUM ANALYZER
I.F.
DOWN CONVERTER

Tune Monitor Measurements

Coupling Measurement

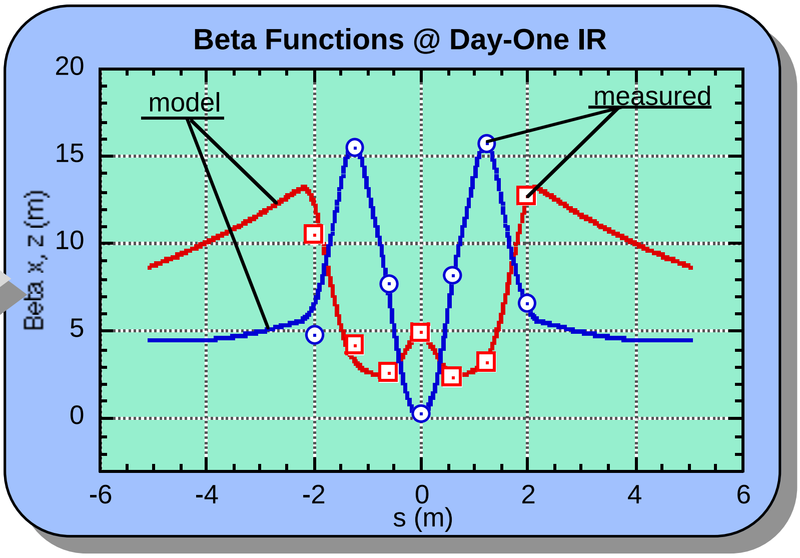


Closest Tune Approach

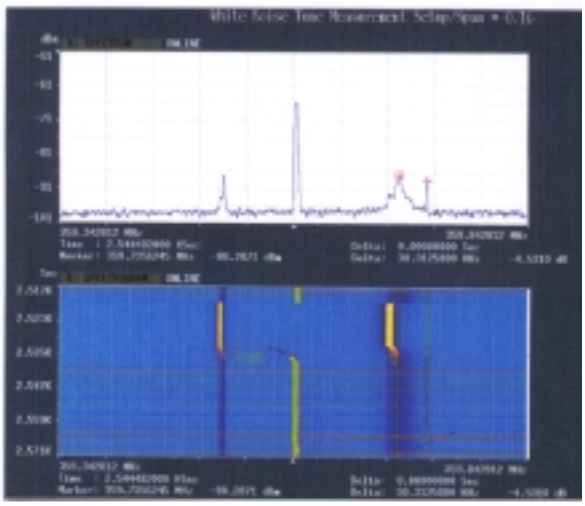
$$k = 1 - \frac{2r^2 + 1}{4r^2 + 1}$$

$$r = \frac{\Delta q}{2\left|q_H - q_V\right|}$$

$$\Delta q = -\frac{1}{4\pi} L \beta \Delta k^2$$



Coherent Beam-Beam



Tune Shift

and:

Ion Trapping,

Chromaticity,

Instabilities,

. . .

Beam-Beam Tune Shift Measurement

Incoherent B-B Tune Shift

$$\xi^{\pm}_{x,y} = \frac{r_e\,\beta^{*\pm}_{x,y}\,N^{\mp}}{2\pi\,\gamma\,\sigma^{*\mp}_{x,y}\left(\sigma^{*\mp}_{x} + \sigma^{*\mp}_{y}\right)}$$

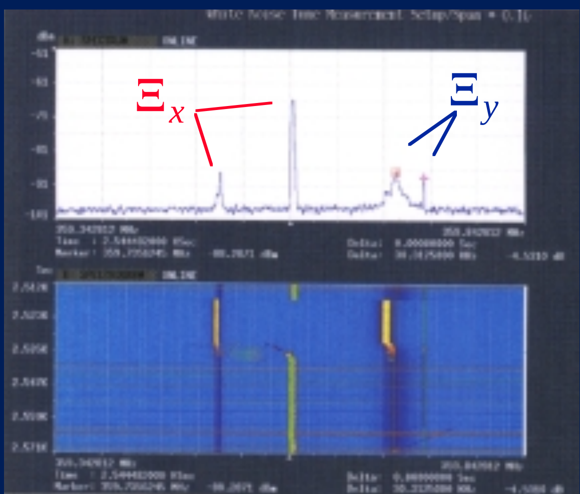
Flat Beam Coherent B-B Tune Shift

$$\Xi_x \cong 1.33\;\xi_x \qquad\qquad \Xi_y \cong 1.24\;\xi_y$$

K.Yokoya, H.Koiso

Example: (7 + 7) mA

(September 30, 1999)



$$\varepsilon = 5\cdot 10^{-7}\quad m\ rad$$

$$k = 0.029$$

$$E = 510\quad MeV$$

$$N = 1.42\cdot 10^{10}$$

$$\beta^*_x = 4.5\ \ m$$

$$\beta^*_y = 4.5\ \ cm$$

$$\xi^{Theor.}_x = 0.0129$$

$$\xi^{Theor.}_y = 0.0073$$

$$\Xi_x = 0.0169$$

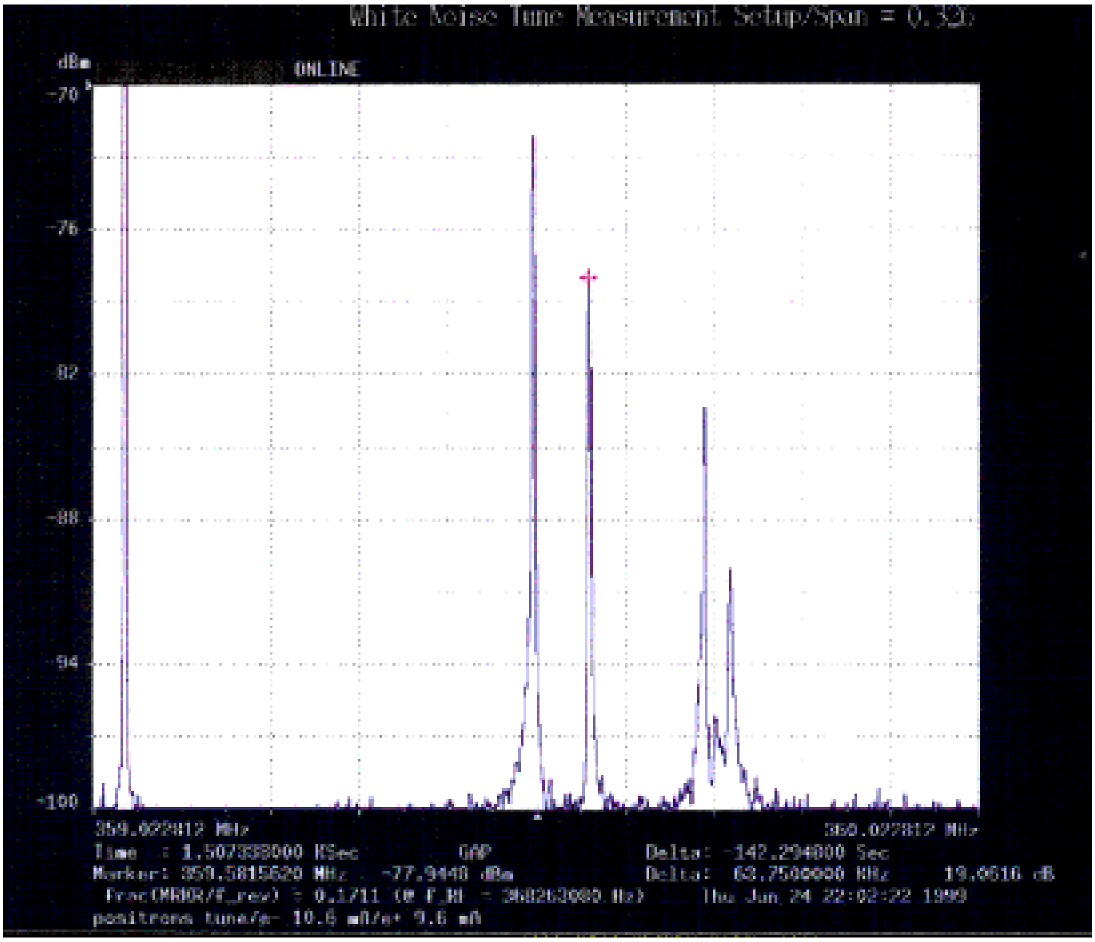
$$\Xi_y = 0.009$$

$$\xi^{Meas.}_x = 0.0127$$

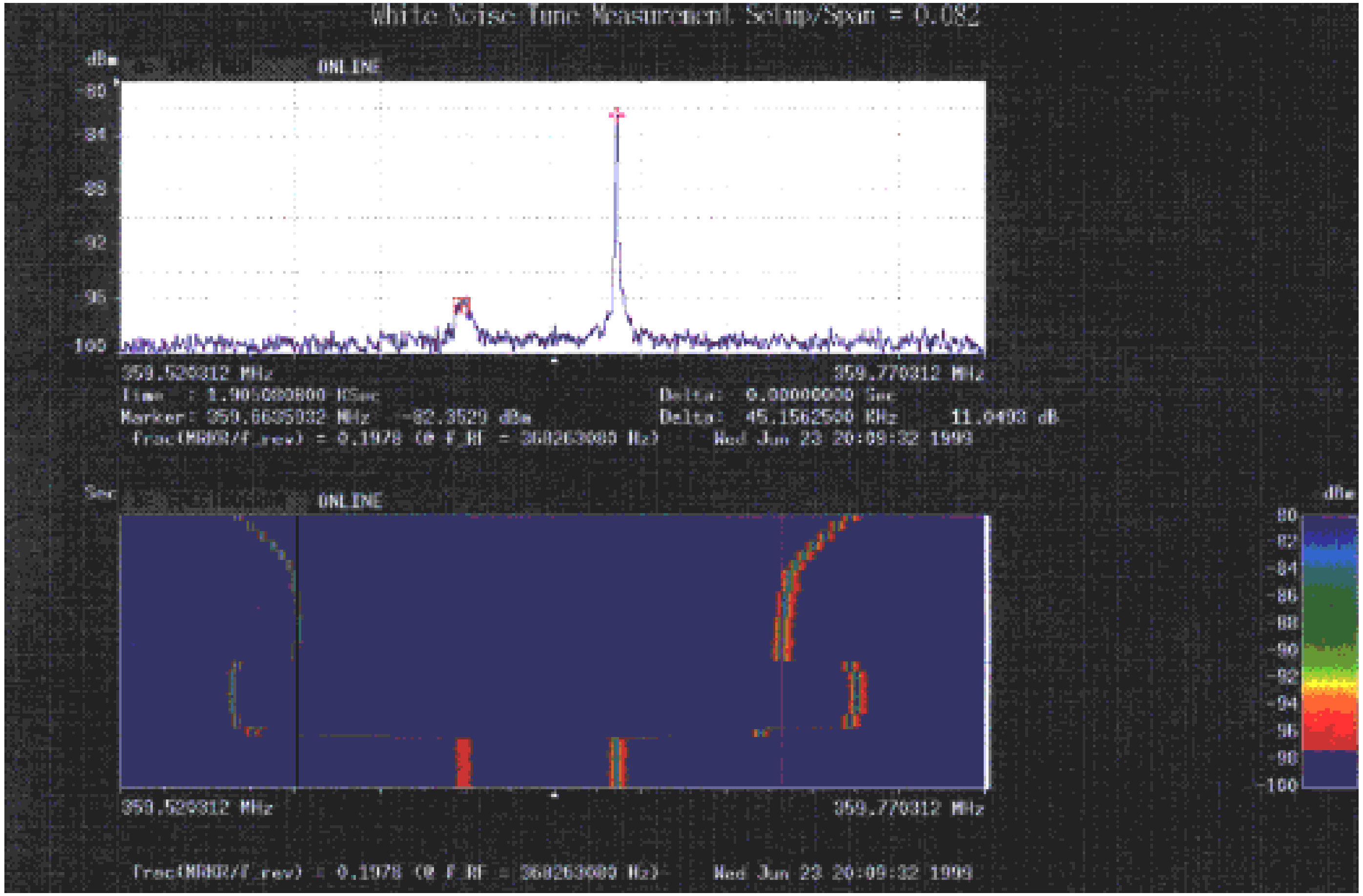
$$\xi^{Meas.}_y = 0.0074$$

WARNING: Perturbative Measurement !

Beam-Beam Tune Split

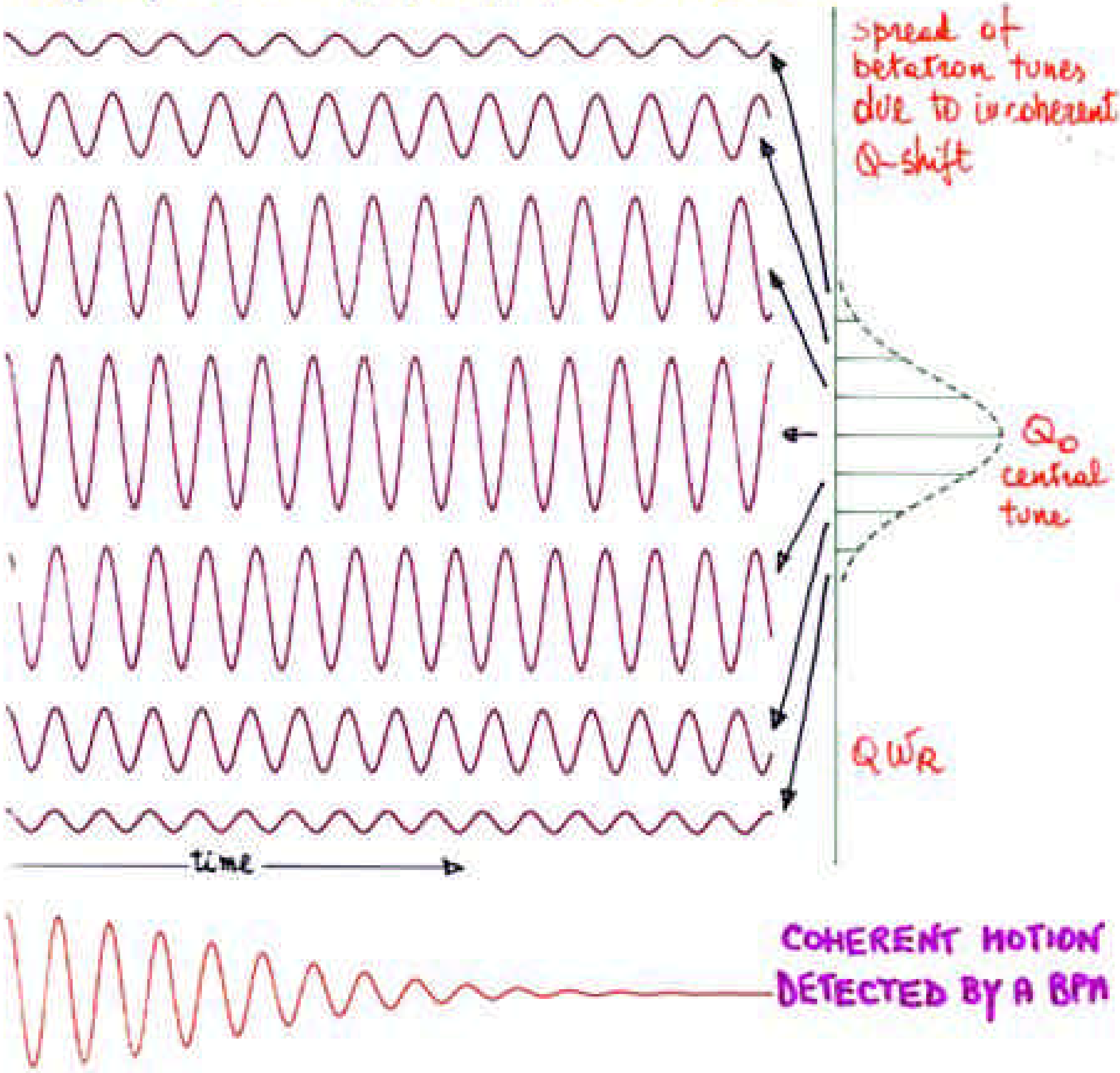


Correction of coupling - Closest tune approach ~ 0.015



LINEAR SUPERPOSITION

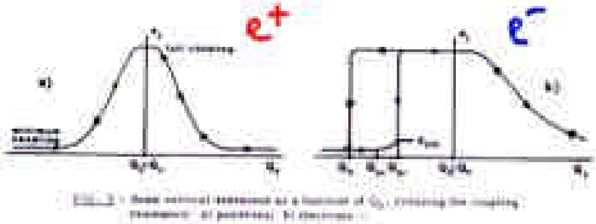
Upon an external kick each particle starts a betatron oscillation with the same initial phase but with slightly different frequency from each other



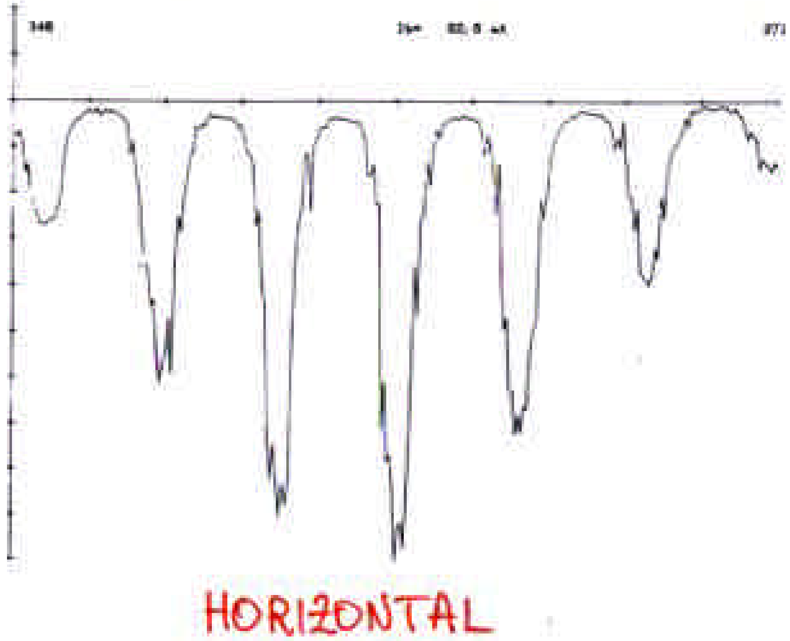
IF LOOKED AT A BEAM DIMENSION MONITOR (e.g. a synchrotron radiation monitor), THE BEAM DIMENSION TAKES MUCH LONGER TO RECOVER TO THE INITIAL VALUE (IF EVER!)

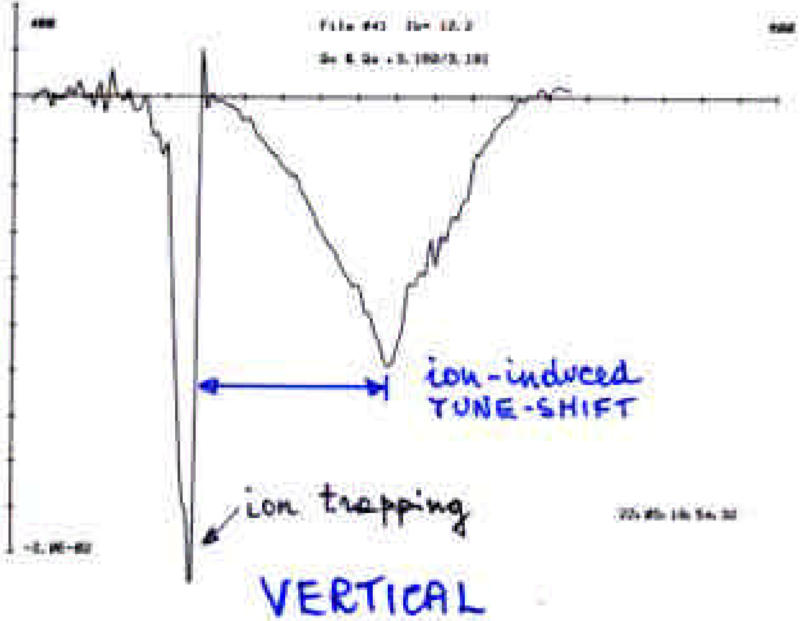
In some measurements the response of the transverse beam density is measured with a beam size monitor.

BIAGINI et al.
HEACC 80, p.687



DATA 14/05 ORE 16:58
FASCIO DI ELETTRONI (3 BUNCHES), Ibeam=62.5 mA
ENERGIA = 1500 MeV , t.r. damping = 11 msec
CORRENTE NEI Q-POLI "F" : 300 Amp.
CORRENTE NEI Q-POLI "D" : 305 Amp.
TENSIONE DI RADIO-FREQUENZA : 130 KV
AMPIEZZA TENSIONE DI ECCITAZIONE : 3.1 Vpp Twait = 33 msec
SWEEP UP
Qx = 3.1250
MASSIMO ALLARGAMENTO : 5.7 %
SIDEBANDS DI SINCROTRONE A 3.7 KHZ





Digital Analyzers

In the measurement with a conventional swept spectrum or network analyzer, since a single frequency is analyzed at a time and because of the indetermination relation mentioned before, a long observation time is involved .

The problem can be overcome by the use of a *dynamic signal analyzer, or digital spectrum analyzer*, which is based on high-speed digital Fourier analysis (Fast Fourier Transform-FFT) executed by an embedded processor.

N voltage samples over a period T are digitized and transformed into $N/2$ complex Fourier coefficients, spanning a frequency range from DC to $N/2T$, with a frequency resolution $\Delta f = 1/T$.

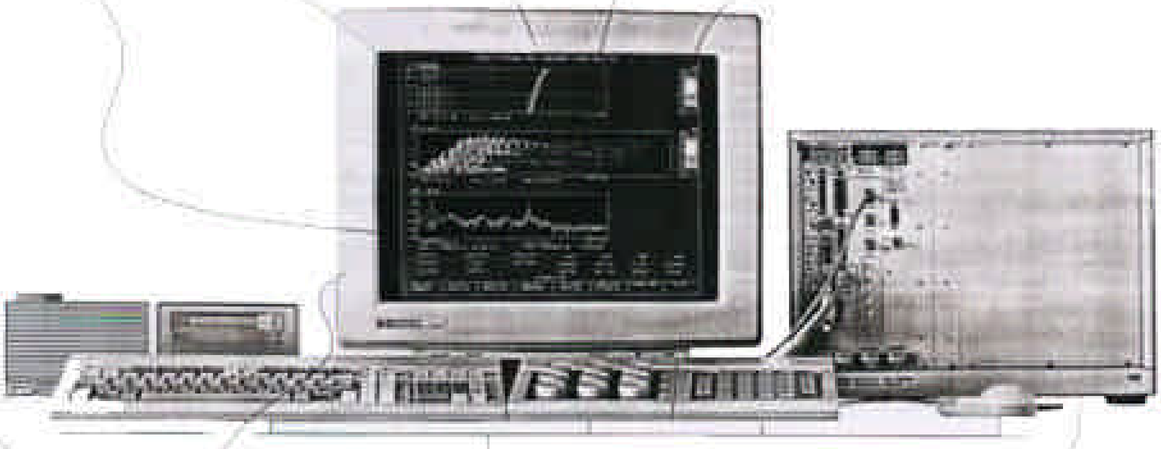
The whole spectrum is available almost instantly, thus the total measurement time is reduced by a nominal factor $2/N$ with respect to a conventional swept analyzer with the same frequency resolution.

The number of frequency points is typically ~ 400, with a real-time bandwidth (no dead-time or data loss between successive spectra computations) and a dynamic range nowadays extending up to ~ 100 KHz and up to ~90 dB (good, but worse than swept analyzers) respectively.

Some analyzers provide two independent channels for spectrum analysis, a pseudo-random noise generator and capability for complex transfer function calculations.

The relatively low operating frequency is no problem, as long as the band of interest is within the maximum frequency of the FFT analyzer. For example, the IF output of a conventional RF spectrum analyzer operating in the zero-span mode as a fixed frequency detector, can be mixed down to base-band and measured at narrow resolution bandwidth with the FFT analyzer.

HP 3587S
Measurement power and flexibility

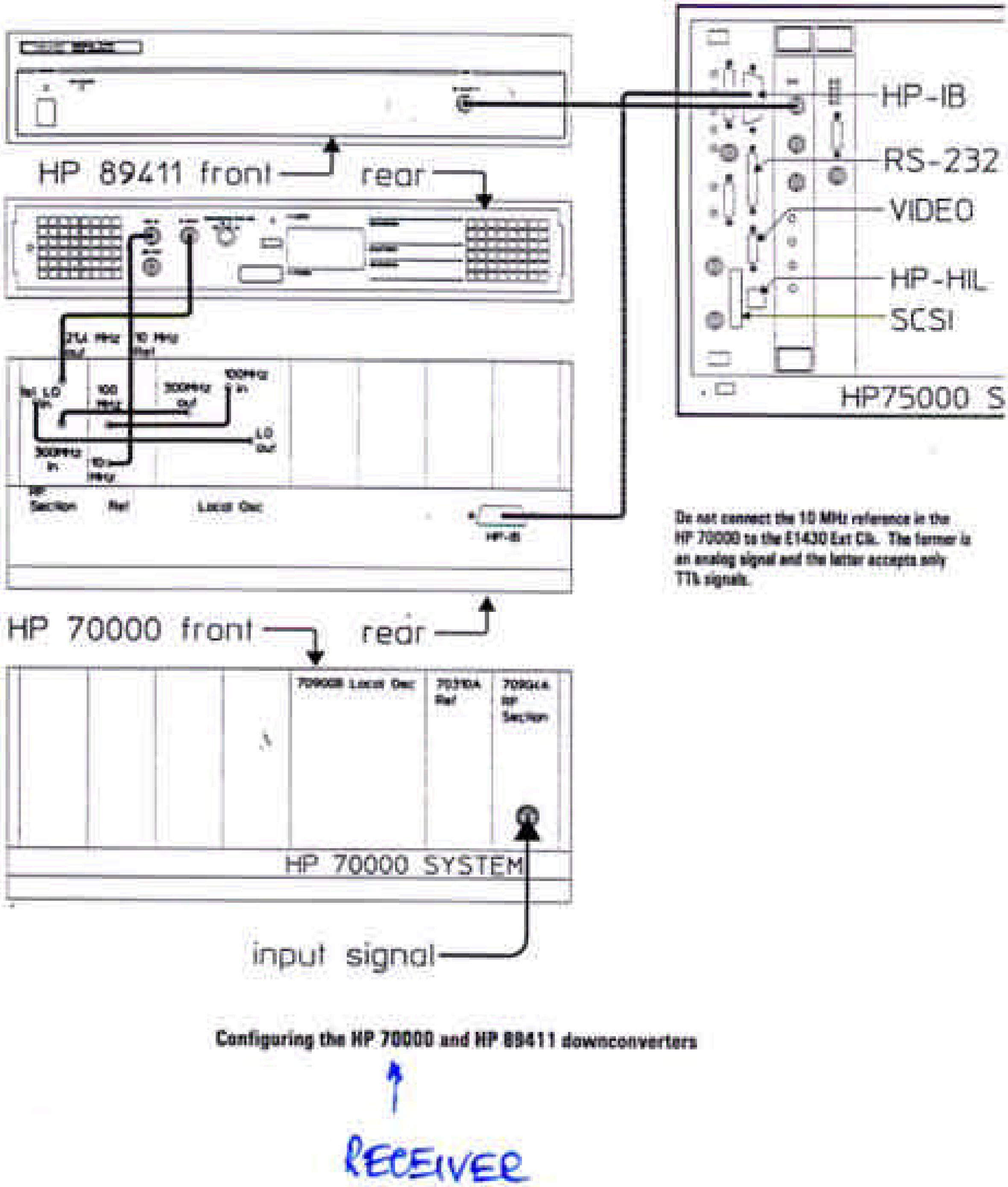


NEW GENERATION : DSP ANALYZER

23 bit

10 Msample/sec

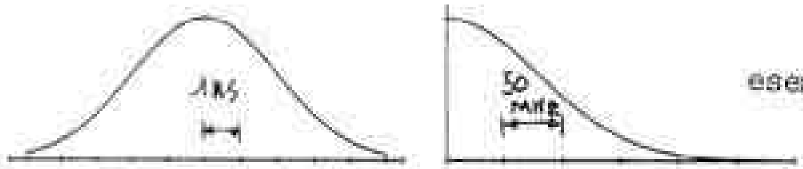
110 dB dyn range



Do not connect the 10 MHz reference in the HP 70000 to the E1430 Ext Clk. The former is an analog signal and the latter accepts only TTL signals.

Configuring the HP 70000 and HP 89411 downconverters

Dominio del Tempo Dominio della Frequenza



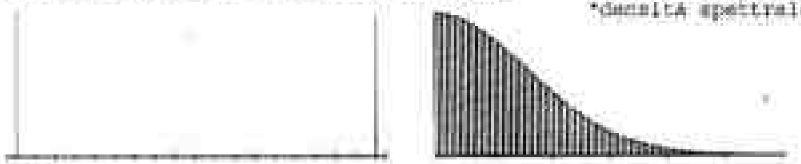
esempio: $\sigma_t = 2$ nsec

$$\sigma_f = 1/2\pi\sigma_t$$

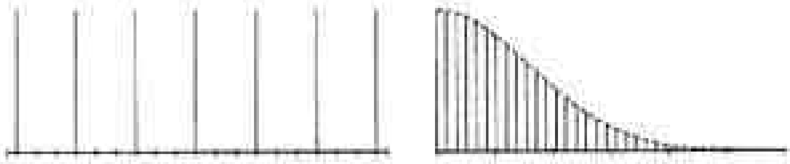
esempio: $\sigma_t = 0.5$ nsec

Tempo:
Convoluzione singola particella-distribuzione

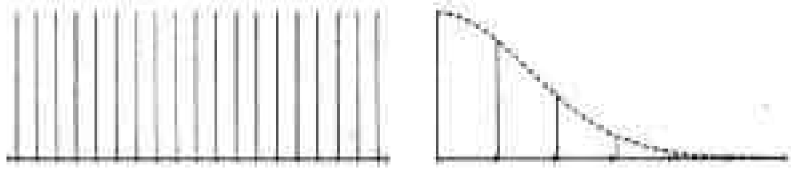
Frequenza:
Moltiplicazione spettro singola particella
*densità spettrale

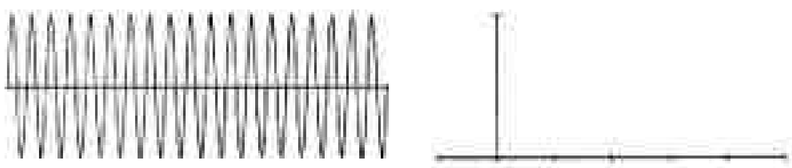


Bassa frequenza di ripetizione
(grande acceleratore, pochi bunches)



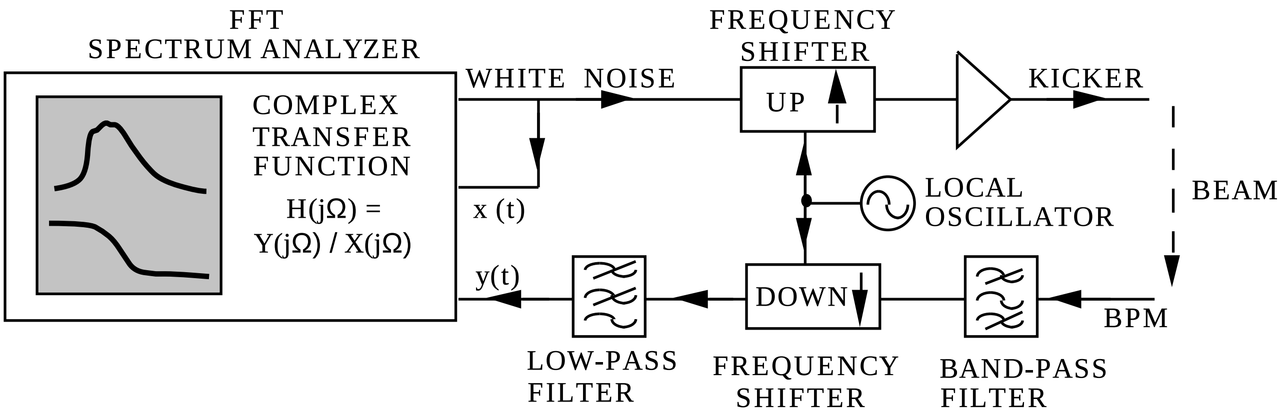
Alta frequenza di ripetizione
(piccolo acceleratore, molti bunches)





MISURA DELLA FREQUENZA DI BETATRONE (*TUNE*)

ANALIZZATORE DI SEGNALE FFT



PLL PHASE LOCKED LOOP