Beam Diagnostics in Delay Loop

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REFERENCE TO THE SYSTEMS REALIZED IN THE INJECTOR @ CERN

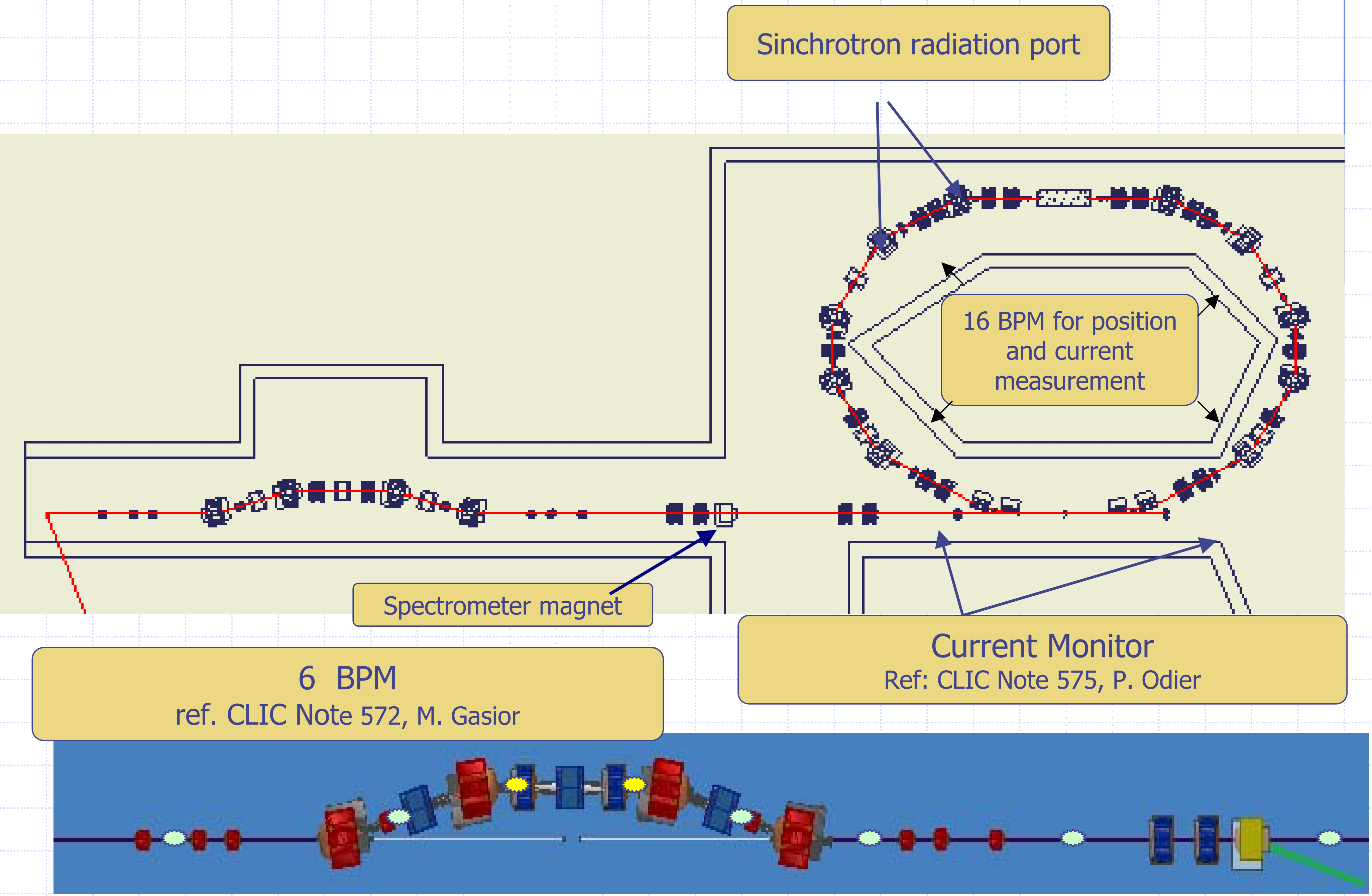
BEAM DEVICES, SIGNAL DETECTION, DATA ACQUISITION AS CLOSE AS POSSIBLE TO THE SYSTEMS REALIZED FOR THE LINAC.

- uniformity along all the machine
- ease of maintanance
- costs

TRANSFER LINE -> possible use of devices installed in the LINAC

DELAY LOOP -> dedicated BPM system for trajectory measurements

DIAGNOSTIC DEVICES TO BE INSTALLED IN TRANSFER LINE

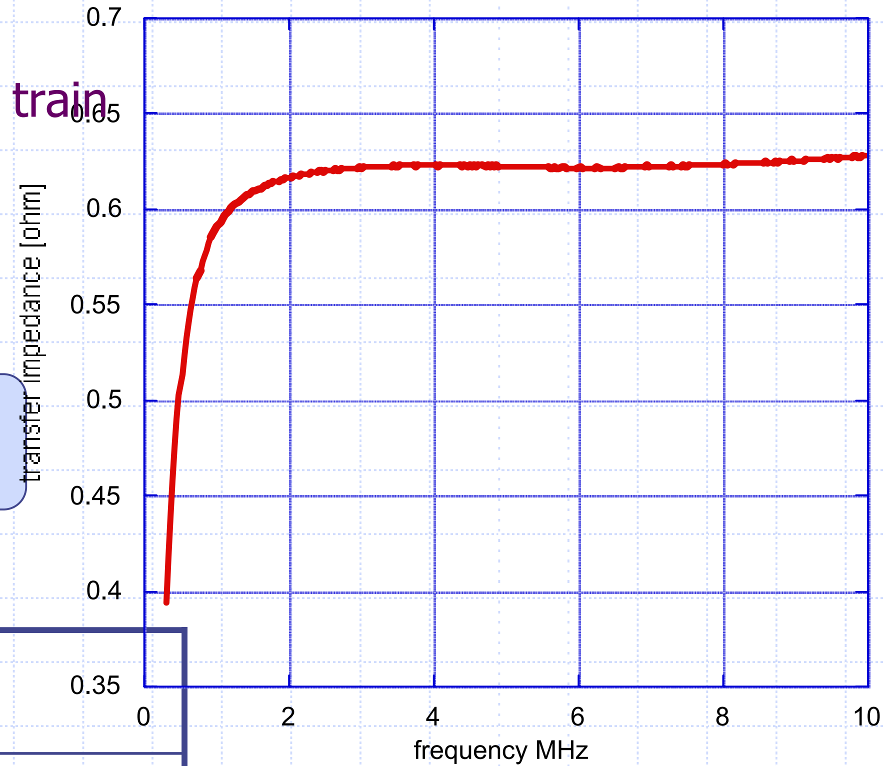


BPM for the delay loop

Measurement of the average position of the bunch train

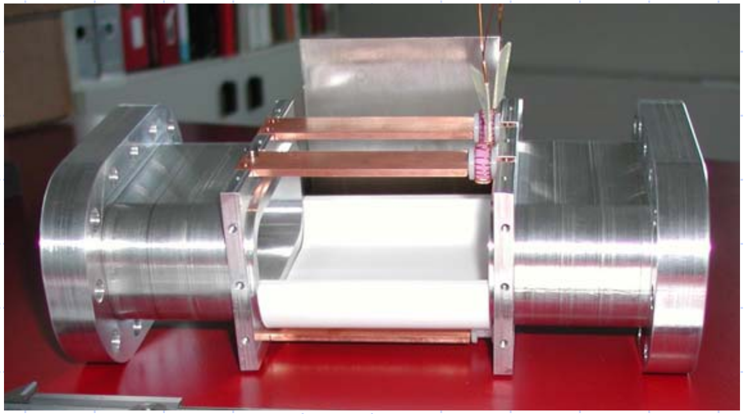
characteristics of the beam and the different vacuum chamber section impose a dedicated configuration for the BPM.

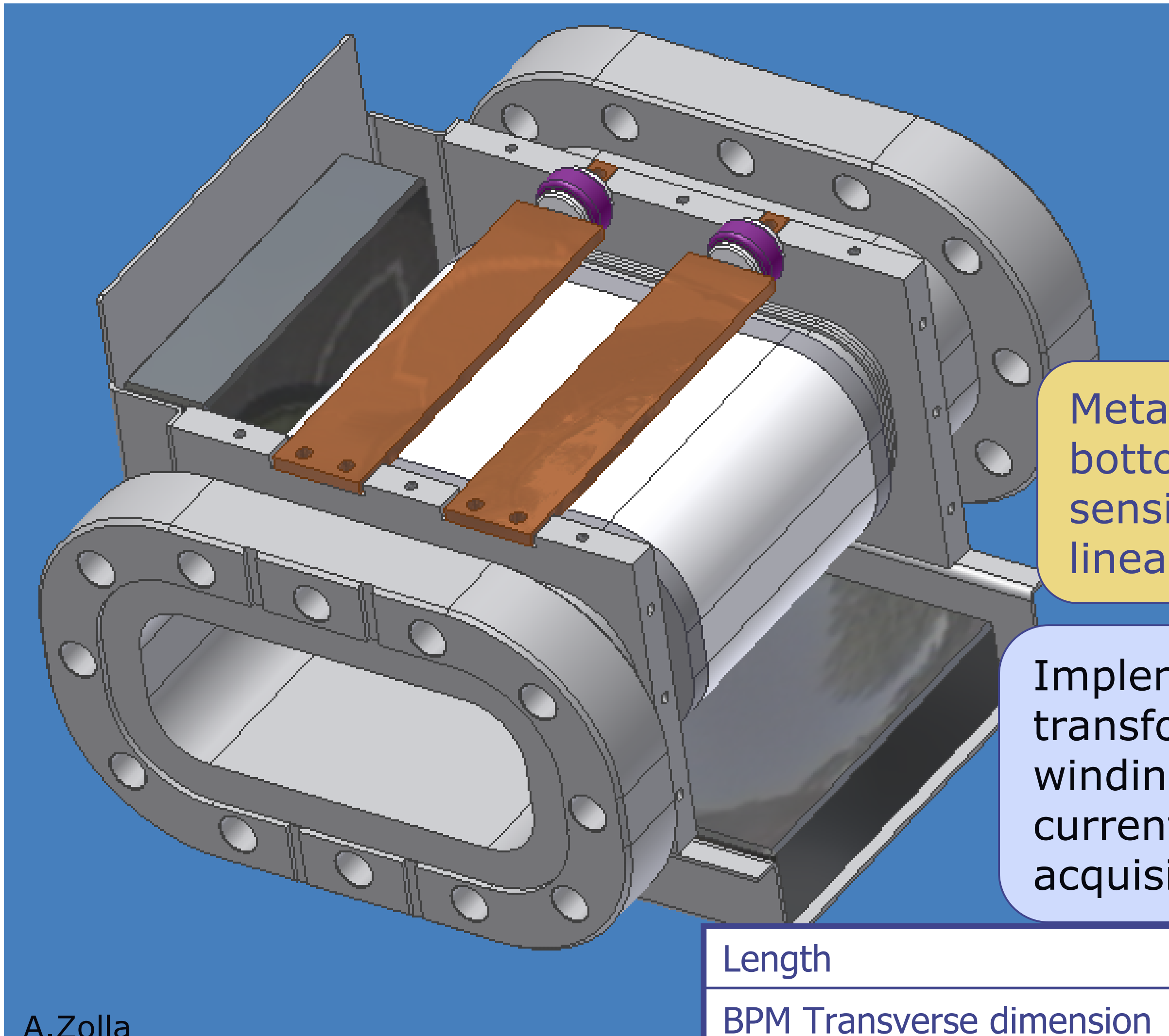
beam pulse 140ns: low cutoff frequency required to avoid droop of the signal.



Prototype measurements
(cfr. COLLABORATION MEETING 2002)

Lower cut-off frequency	400 KHz	
Higher cut-off frequency	200 MHz	
Sensitivity	0.2 V/A	Peak output
Position Sensitivity	0.029 mm^{-1}	Horizontal
Position Sensitivity	0.032 mm^{-1}	Vertical
Max Signal Difference	20 dB	@ 75% chamber dimension



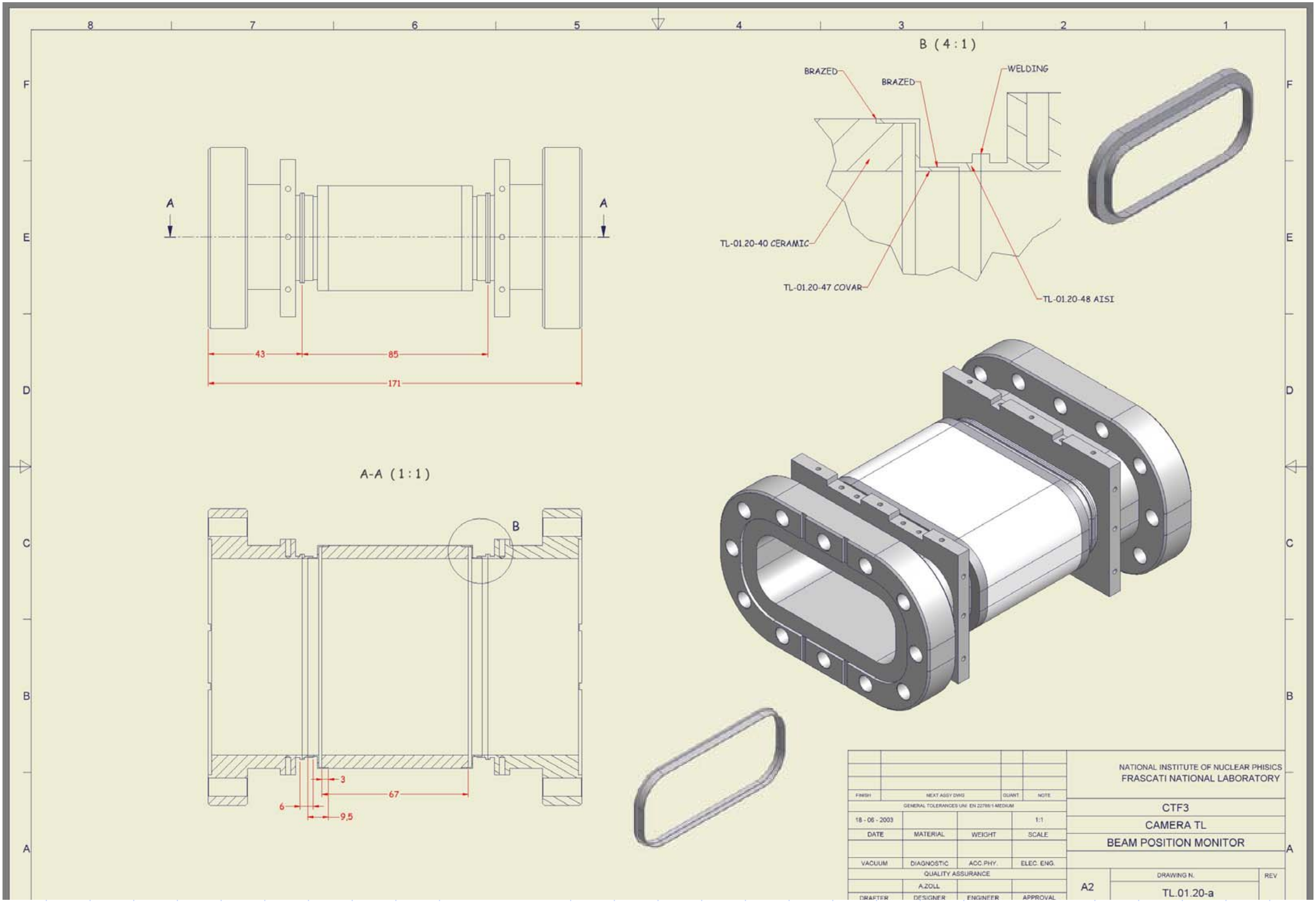


According to measurements performed on the prototype a final drawing of the BPM for the delay loop has been realized.

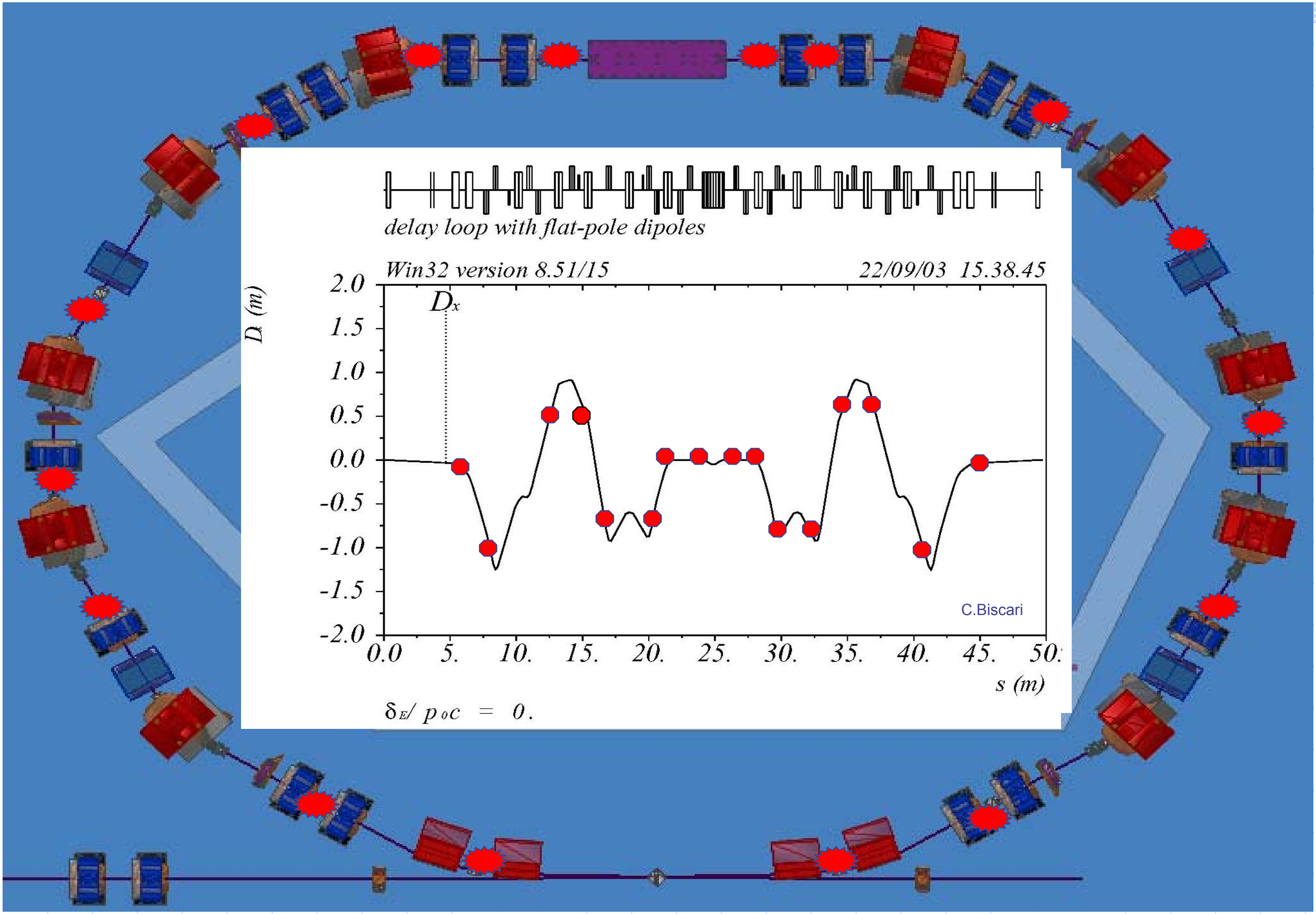
Metallic strip are placed on the top and bottom of the ceramic gap to gain position sensitivity in the centre and reduce non linearity for large beam offsets

Implementation on each toroidal transformer of an additional calibration winding to allow the injection of a known current pulse, to measure the gain of each acquisition channel.

Length	171 mm	
BPM Transverse dimension	145 x 115 mm	
beam aperture	90 x 37 mm	rectangular
Gap Length	8 cm	
strip electrode length	10 cm	Full length
Ferrite blocks	μr=100 @ 40MHz	Ferroperm Permax 56



B (4:1)
BRAZED
BRAZED
WELDING
TL-01.20-40 CERAMIC
TL-01.20-47 COVAR
TL-01.20-48 AISI
A
A
43
85
171
A-A (1:1)
B
3
67
6
9,5
NATIONAL INSTITUTE OF NUCLEAR PHISICS
FRASCATI NATIONAL LABORATORY
CTF3
CAMERA TL
BEAM POSITION MONITOR
FINISH
NEXT ASSY DWG
QUANT
NOTE
GENERAL TOLERANCES UNI EN 22768/1-MEDIUM
18 - 06 - 2003
1:1
DATE
MATERIAL
WEIGHT
SCALE
VACUUM
DIAGNOSTIC
ACC.PHY.
ELEC. ENG.
QUALITY ASSURANCE
A.ZOLL
DRAFTER
DESIGNER
ENGINEER
APPROVAL
A2
DRAWING N.
REV
TL.01.20-a


delay loop with flat-pole dipoles
Win32 version 8.51/15
22/09/03 15.38.45
D (m)
D_x
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0.0
5.
10.
15.
20.
25.
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35.
40.
45.
50.
s (m)
C.Biscari
$\delta_E / p_0 c$ = 0.

Outline of Data Acquisition

The orbit acquisition system will be developed following the same strategy and where possible the same hardware adopted for CTF3 injector.

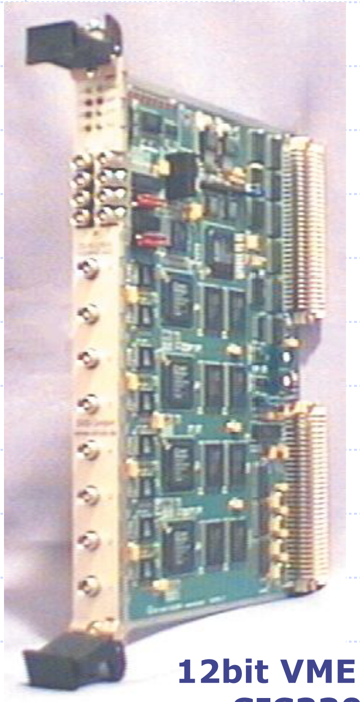
It will offer the same features to the user:

-Software controlled acquisition

-Availability of analogue signals from BPMs

-Testing and calibration of each pickup through current pulses

Digital acquisition of signal will rely on VME ADC boards built by STRUCK.



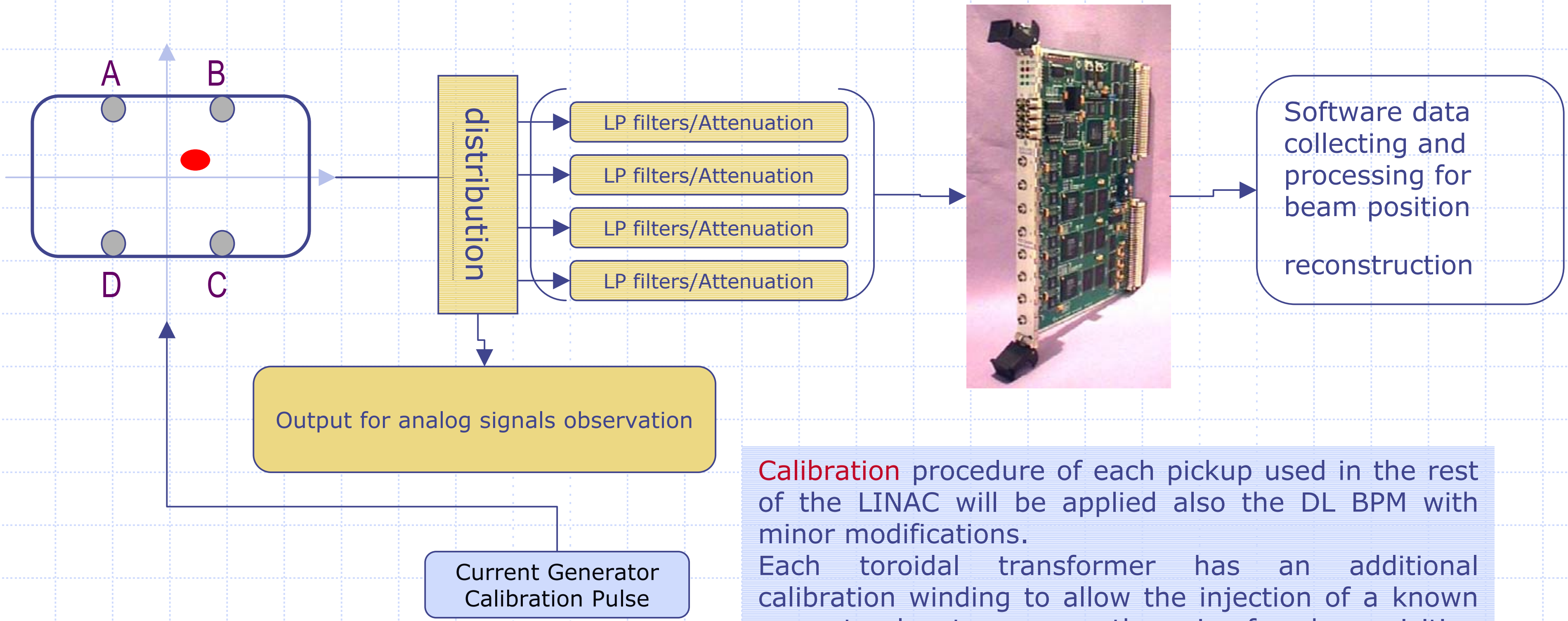
12bit VME ADC SIS3300

	pickup	Num of channels	Num of boards
BPM T/L	6+2	18+8	
BPM D.L.	16	64	
Current Monitor	2	2	
Tot.		92	**12 ADC boards**

15 Under shipment at CERN

Pickup signals will be transmitted through independent coaxial cables to the acquisition electronics for acquisition with fast digitisers of the same type used in the CTF3 LINAC.

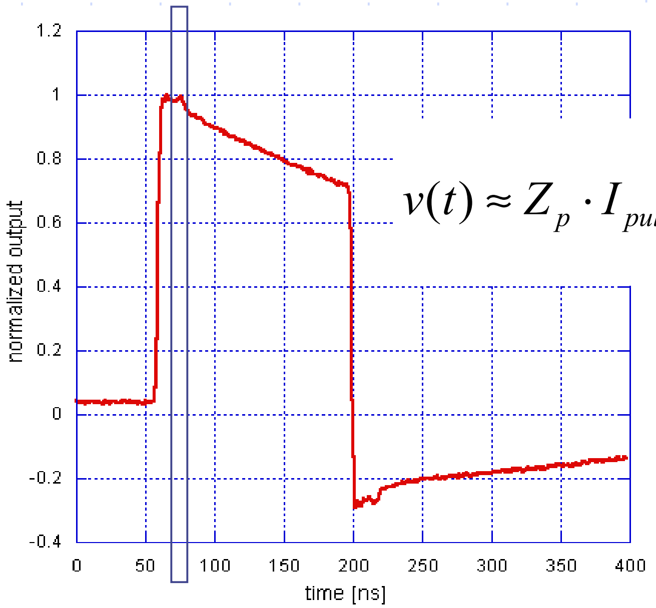
Sum of the signals can be used also for absolute current measurement



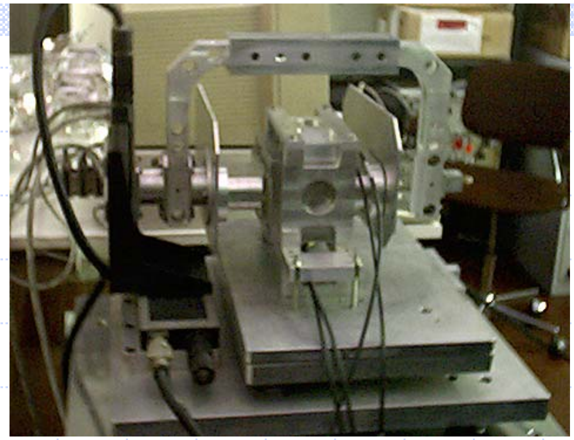
Calibration procedure of each pickup used in the rest of the LINAC will be applied also the DL BPM with minor modifications.

Each toroidal transformer has an additional calibration winding to allow the injection of a known current pulse, to measure the gain of each acquisition channel.

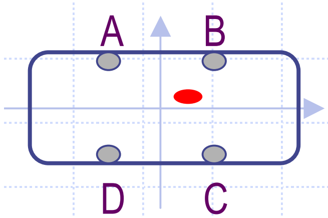
100Ms/s sampling rate



$$v(t) \approx Z_p \cdot I_{pulse} \cdot \left(e^{-\frac{t}{\tau_l}} \right)$$

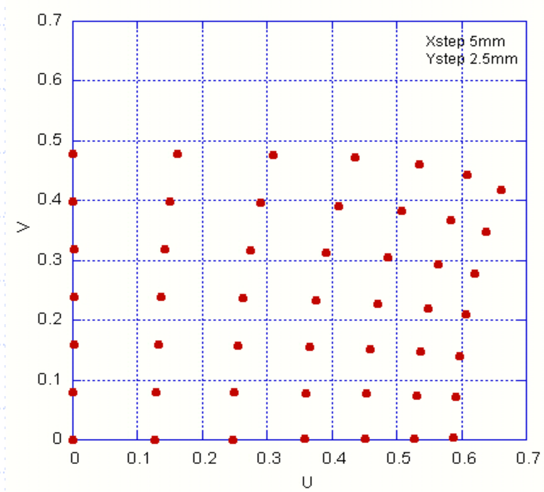


Expected BPM signals



$$U = \frac{(B+C)-(A+D)}{A+B+C+D}$$

$$V = \frac{(A+B)-(C+D)}{A+B+C+D}$$



FIT ERRORS	X µm	Y µm
X &Y max errors	135	172
X & Y min errors	0.94	0.32
X & Y AVER ERR	47	31

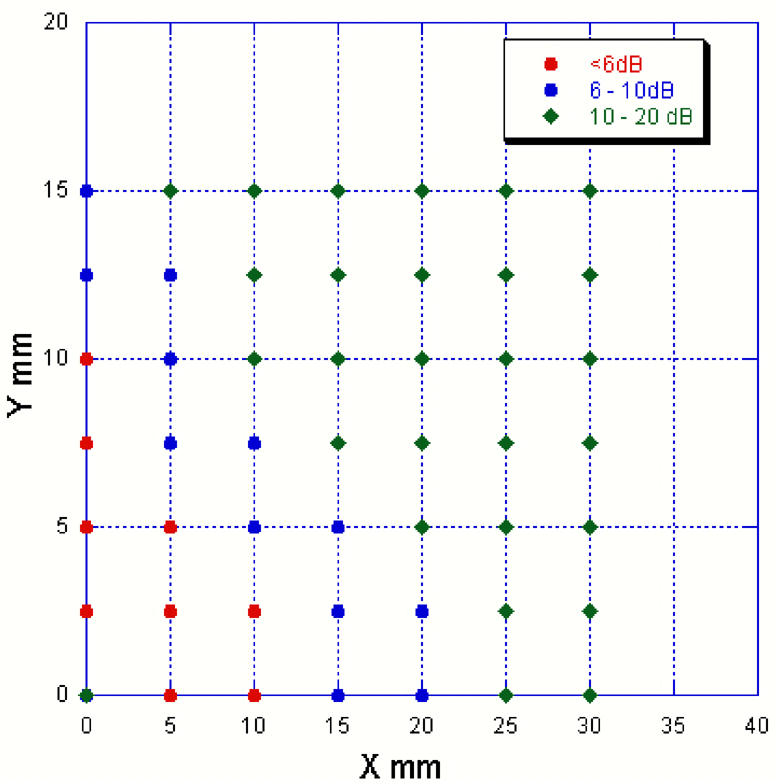
$$X = k_{x0} \cdot U + k_x(U,V)$$

$$Y = k_{y0} \cdot V + k_y(U,V)$$

$$K_x(x_0, y_0) = a_0 + a_1 y_0^2 + a_2 y_0^4 + a_3 x_0^2 + a_4 x_0^2 y_0^2 + a_5 x_0^4$$

$$K_y(x_0, y_0) = b_0 + b_1 y_0^2 + b_2 y_0^4 + b_3 x_0^2 + b_4 x_0^2 y_0^2 + b_5 x_0^4$$

maximum difference between signals for a given beam position

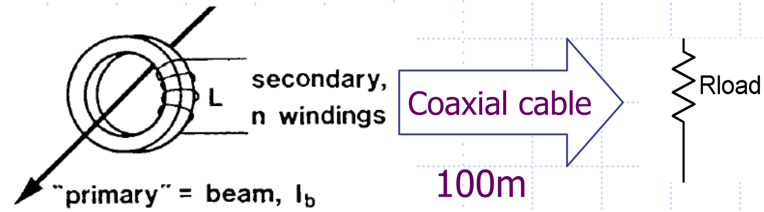


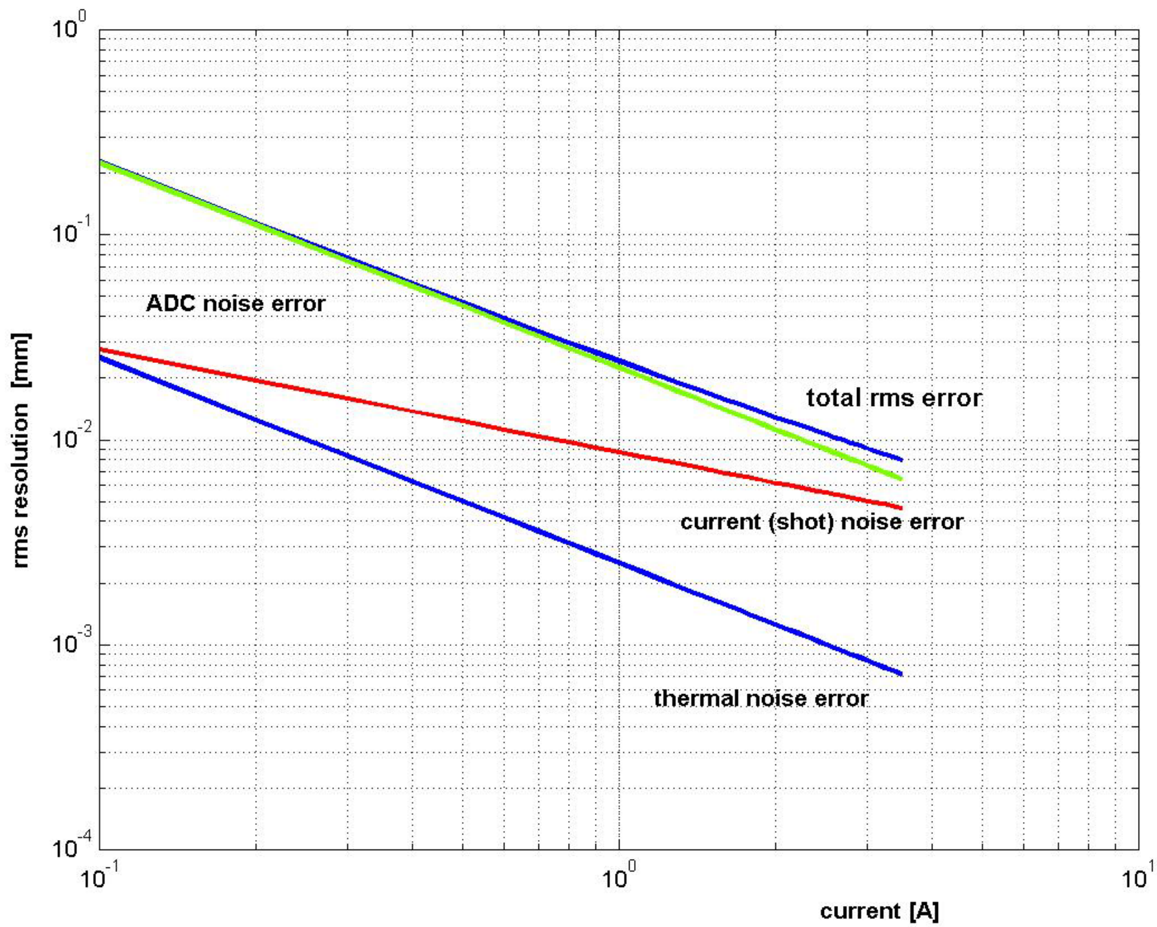
Quarter of vacuum chamber section

DIRECT DIGITISATION OF SIGNAL FROM BPM FOR THE DELAY LOOP	
No direct analog delta / sum signal: NOT IMMEDIATE FOR THE DL BPM	Simple realization and implementation
Careful adjustment for coaxial cable lengths needed: CALIBRATION OF THE DEVICE	No active electronics in the signal chain and/or exposed to radiation
1 more acquisition channel and cable for each BPM	Flexibility in software reconstructing algorithm
	Direct observation of signal from individual pickups if needed for debugging

Limits to BPM Resolution

$$\Delta x_{noise} \approx \frac{1}{S_x} \cdot \frac{(B+C)-(A+D)}{A+B+C+D} \approx \frac{1}{S_x} \cdot \frac{\sqrt{2} \cdot \Delta v_{noise}}{Z_{peak} \cdot I_{pulse} \cdot Att_{cabl}}$$





Main contributions to Δv_{noise}

current noise $\sqrt{2qI \cdot \Delta f}$

+

Thermal noise on load impedance

$\sqrt{4kT \cdot R_L \cdot \Delta f}$

+

ADC Noise
12bit quantization error

Evaluation of expected BPM resolution in DelayLoop