1. The block diagram of resolution measurement is shown in Fig. 1. A part taken in a dashed frame, is shown in a photo Fig. 2.

A 12cm strip line pickup ML10 is used. The signals of either plane can be used. One of the strip lines in the opposite plane is used for Pickup-BPM cable propagation time balancing (see below).

The two BPMs share one coupler on the inputs of which Phase Shifters (PhS) are there for propagation time balancing. The inputs of the Phase Shifters are noted as INPUT1 and INPUT2.

The outputs of the coupler are split using a pair of splitters (ZESC-2-11, connected immediately to the coupler outputs).

The splitters' outputs through a pair of equal-length cables are fed into inputs (IN1 and IN2) of a sum-dif hybrid junction of each BPM.

Sum output and Dif output of each BPM are measured with two channels of GFT6004.

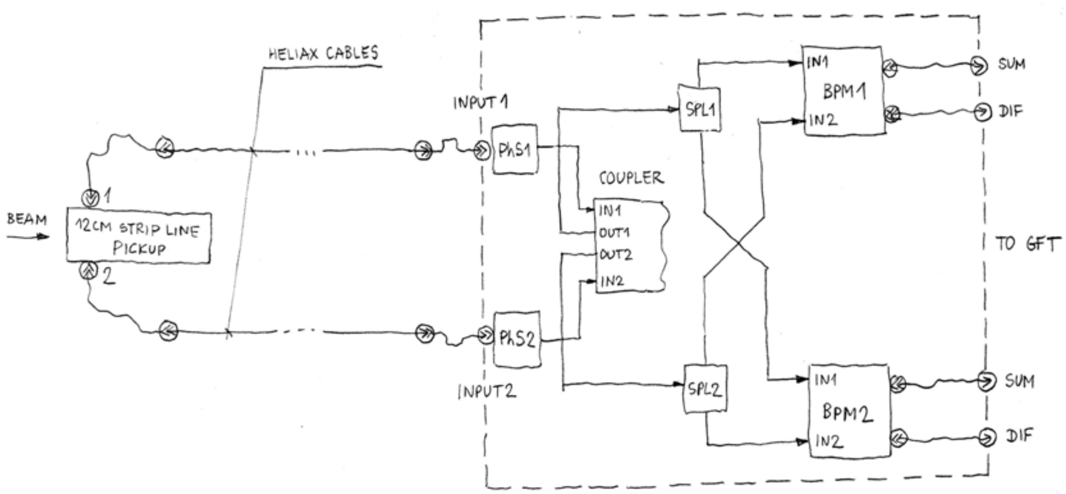

Fig. 1. Measurement Block Diagram.

2. A BPM block diagram is shown in Fig. 3. On the photo in Fig. 2, one BPM is seen as an assembly on a perforated board.

The Hybrid Junction (Anzac in the photo) inputs are IN1 and IN2. The Dif signal of the Junction through a 20dB Amplifier and a cable Delay is fed into Synchronous Detector. Its output (amplified 12dB by ADC Driver) comes to the GFT.

The Sum signal through an Attenuator 10dB and a similar 20dB Amplifier is fed into a SD Clock circuit. In this circuit, the signal is split into two signals one of which comes out as OUT/SUM. The latter through a cable delay is fed into another Synchronous Detector and ADC driver and is measured with another channel of the GFT.

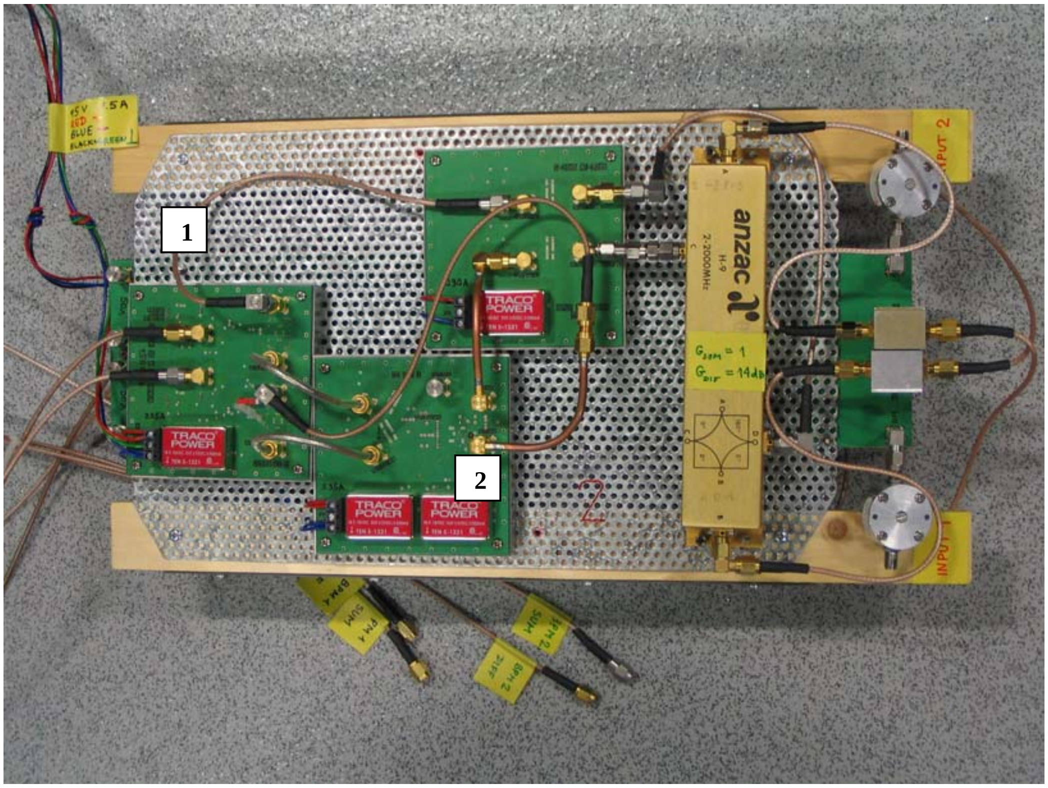

Fig. 2. A nice photo of the BPMs (the second BPM is beneath).
The Phase Shifters are round. INPUT1 and INPUT1 are coloured red. Two pairs of output cables to the GFT are shown marked with BPM number and signal name. On top left are there shown PS wires (15V, 1.5A, red +, blue −, black and green GND (optionally)).

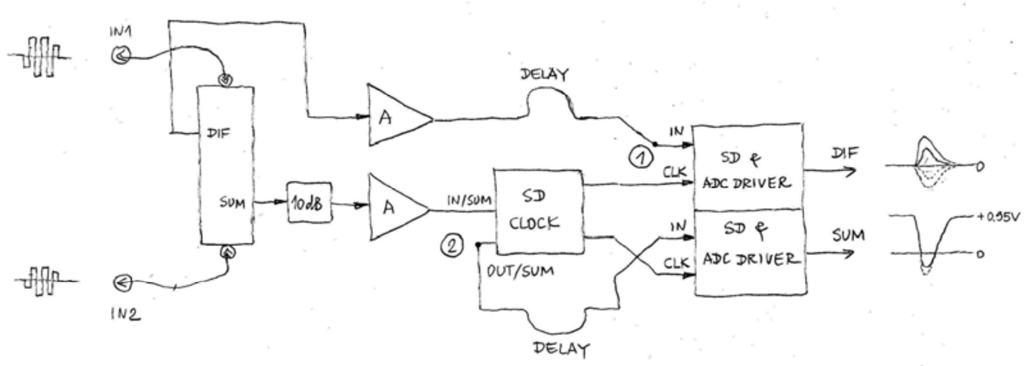

Fig. 3. BPM Block Diagram.

3. The BPMs need no adjustment. The inputs of each BPM are factory-balanced. The signal and Clock of each Synchronous Detector are factory-phased. If some failure occurs in some BPM input/internal cable, it can be changed for another one of the same propagation time (±1mm for the input cables and ±5mm for the internal cables).

4. BPM signals taken with a generator signal similar to the beam strip line signal are shown in Fig. 4 and 5.

   The Sum signal is blue. It is a negative pulse at a pedestal (+0.95)V.

Two Dif signals are shown black (from memory) and red (alive). They correspond to 'beam' full displacement ±9mm (attenuator 10dB in the Sum channel was removed) and were obtained by feeding the 'pickup' signal alternatively into each BPM input.

Their sum (obtained using Math of the scope) is shown light blue (50mV/div). It corresponds to 'beam on the pickup center'. The residue in the pulse peak vicinity is about 25mV. It is a BPM imbalance which is about 1/80 of the Dif pulse peak value which corresponds to 1/80 of 'pickup' radius. Note a scope granulation 'noise' in the Math signal, that is about sqrt2*(500mV*8div/2^8)~20mV.

5. The GFT channel scales are to be set to ±1V. It means that the BPM signals should never exceed ±1V. So, the Sum pulse peak value should not exceed (−1V) (i.e., the Sum negative pulse as regards to the pedestal 0.95V should be <2V). The Dif pulse peak value should not exceed ±1V.

From my experience, for the routine ATF bunch intensity about 6*10^^9e the present two parallel BPM arrangement will have the sum pulses about 1.3V. That is OK for resolution measurement and provides with a room for intensity jitter and slow variation. If it will happen that the sum pulses are excessively big, a pair of identical attenuators on INPPUT1 and INPUT2 (just before the Phase Shifters) should be used.

This pulse amplitude adjustment should be done in the very beginning, at least before cable propagation time adjustment.

6. Total attenuation of the Sum signal as regards to the Dif signal is set to 14dB. So, with the Dif signal equal to the Sum signal, for the BPM scale coefficient about 9mm the effective BPM aperture is ±2mm. For the sum pulse about 1.3V and the Dif pulse limits of ±1V the beam position must not exceed ±2mm/1.3~±1.5mm.

   So, watch a routine bunch position to keep the Dif pulse within ±1V!

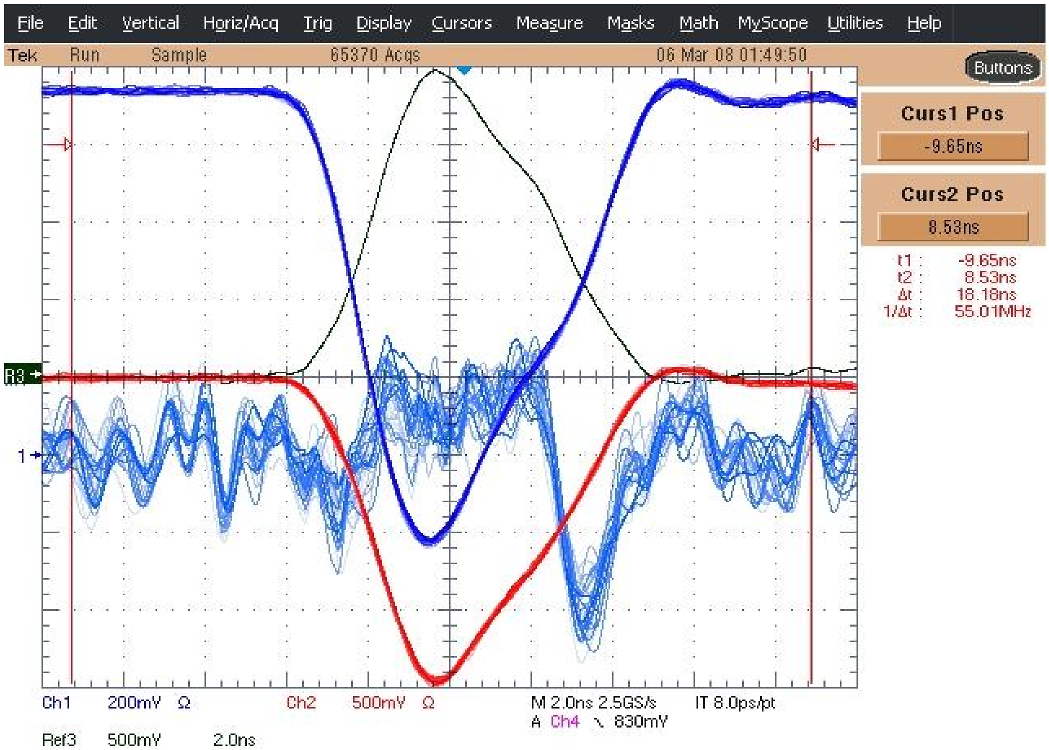

Fig. 4. The BPM1 signals.

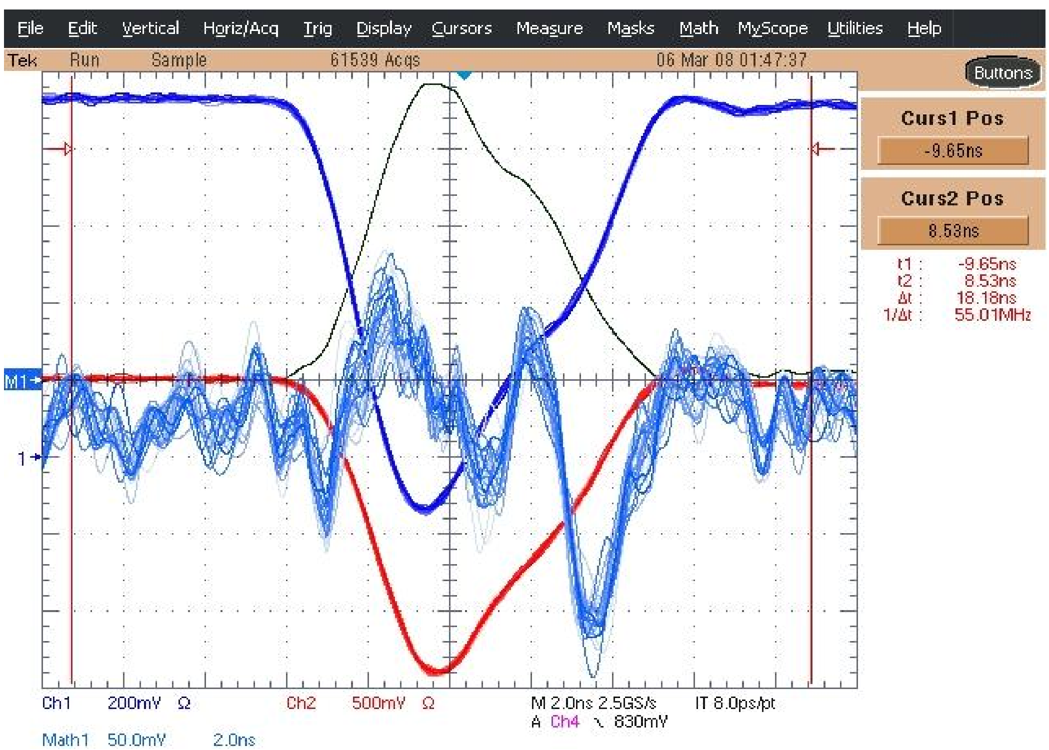

Fig. 5. The BPM2 signals.

7. A block diagram of Pickup-BPM cable propagation time adjustment is shown in Fig. 6.

   The adjustment is done using an external 700MHz sine/square wave signal. The ATF RF reference signal 714MHz used in the FONT system, can be used. If necessary, this signal can be amplified with an amplifier enclosed (a green PCB, two parallel channels, the output should not exceed 4V ampl, the PS is same 15V).

   This signal through an additional Heliax cable (of arbitrary length) is fed into SMA T-connector loaded on 50Ohm and connected to an opposite plane strip of the pickup. Inside pickup, this strip is electro-magnetically coupled with the strips 1 and 2. The induced signals on these strips are supposed to be identical.

   Note an opposite plane strip impedance measured at the pickup connector is expected to be considerably larger than 50Ohm in spite of being the strip short-circuited on its far end as the strip length is about a quarter of the 714MHz wavelength. A parasitic capacitance of the T-connector somewhat shunts the signal but the effect is expected to be negligible.

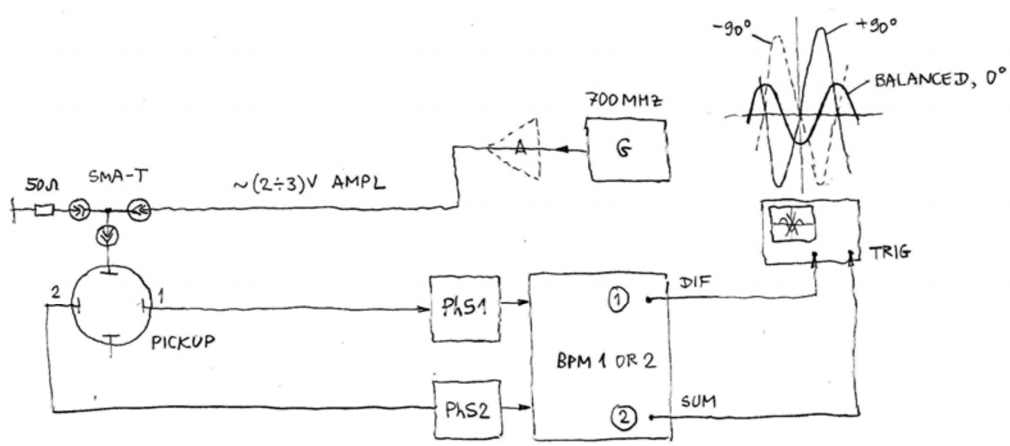

Fig. 6. Pickup-BPM cable propagation time adjustment.

For a significant (but much lower than a quarter of the 714MHz wavelength divided by c) propagation time imbalance, the 714MHz imbalance signal on the Hybrid Dif output is shifted by about 90deg as regards to the input signals. With the times balanced, a residue that may take place due to amplitude imbalance has zero shift. These signals are shown in Fig. 6 top right.

The amplitude imbalance residue causes a BPM zero offset. It is small and is not crucial in resolution measurement as it will be self-subtracted while processing.

To balance the times, a scope is used triggered either by a sum signal taken from a BPM connector marked 2 in Fig. 2 and 3, or directly by the incident 714MHz signal split using one more T-connector. The Hybrid Dif output is taken from a cable marked 1 in Fig. 2 and 3.

Using the Phase Shifters, make and observe a significant imbalance. Adjusting the Shifters as to get a cosine residue, balance the times.