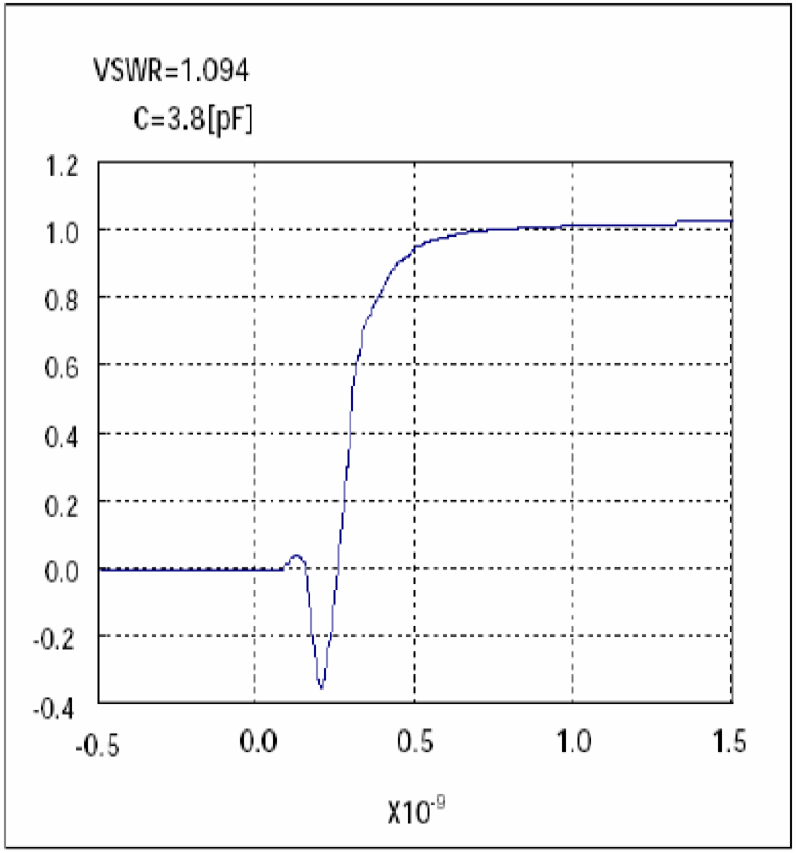
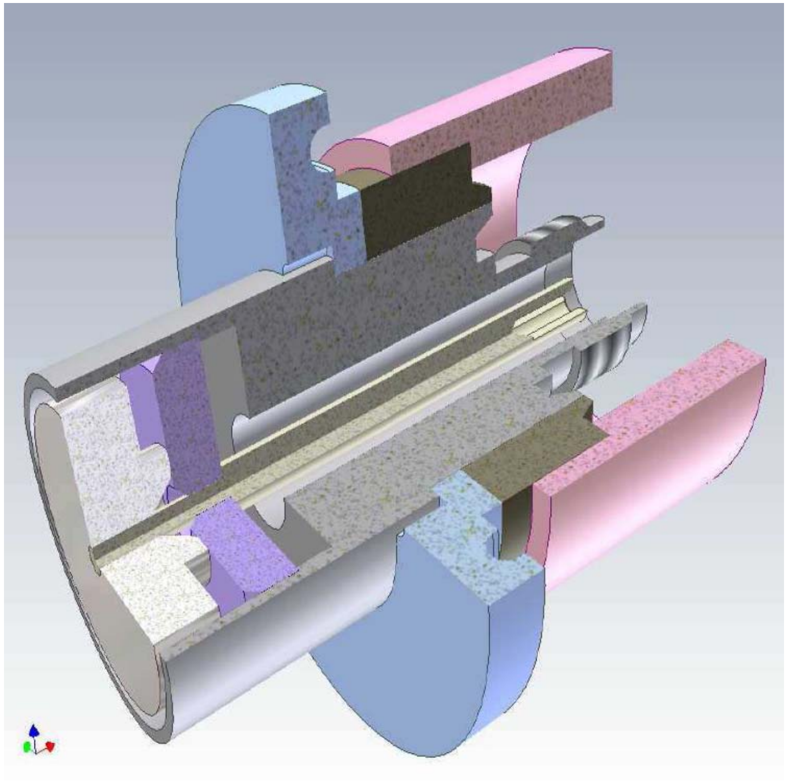
Laboratory testing of Buttons integrated in Phase II Collimator BPM prototype

Christian Boccard Marek Gasior Sept. 21 2009

Buttons

Prototype buttons were already made for the Spring-8 accelerator in Japan by Kyocera. We took advantage of the development and availability and also the fact that the diameter of 10.3mm of the electrode was compatible with the available space in the jaws.
The Buttons were measured, sorted by response and assembled by pairs on the Jaws.



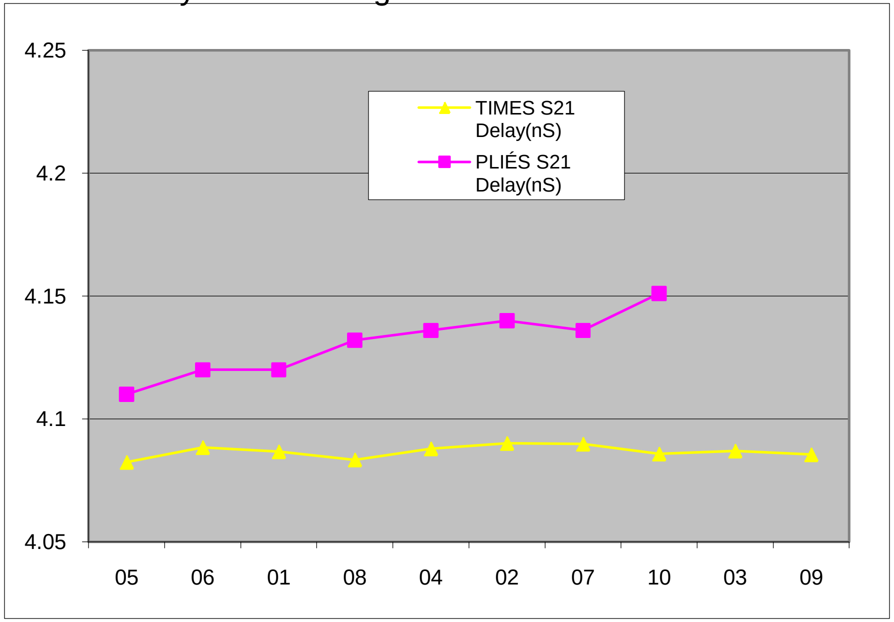


Coaxial Cables

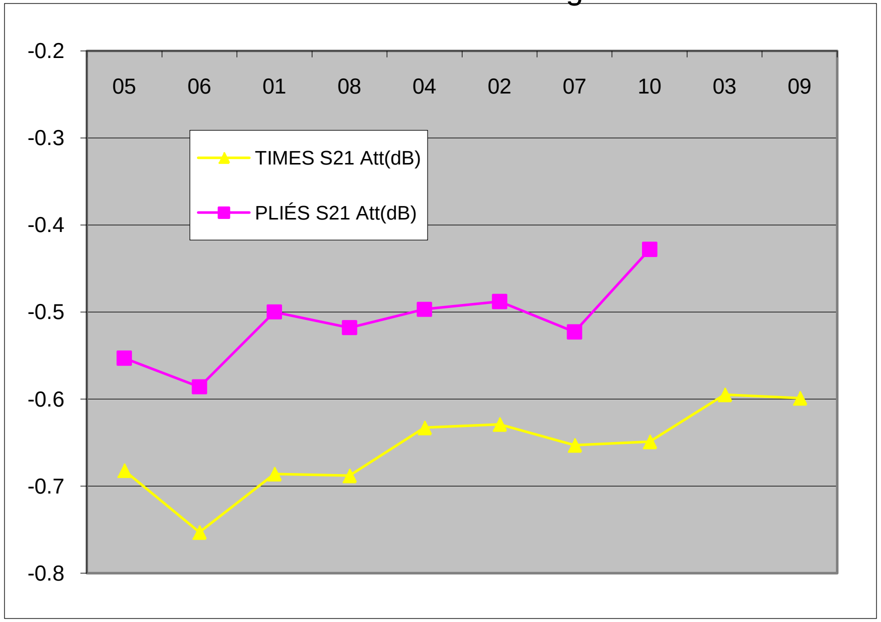
{SIO2 / 0.090 / 1000 mm / 3,5mm HT (600^{C}) / Male / Delay Matched (+-20pS)}

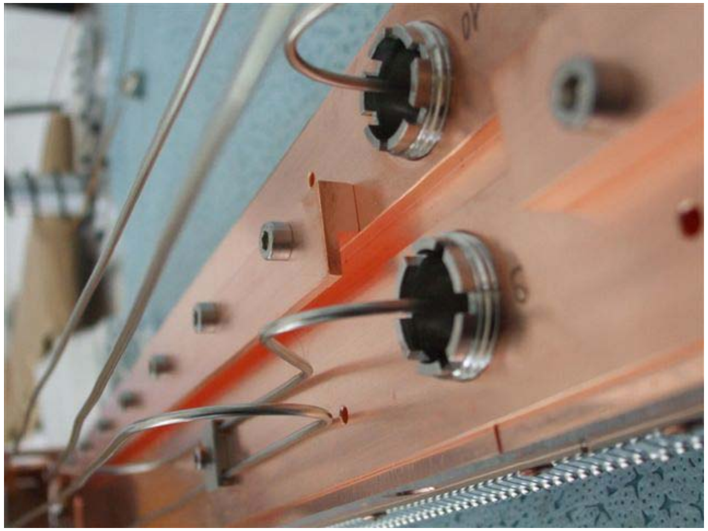
The SIO2 cables from Times Microwave were bent on the tooling assembly LHCTCSMP052, then measured in attenuation and delay and assembled by pairs of same attenuation on the Jaws.

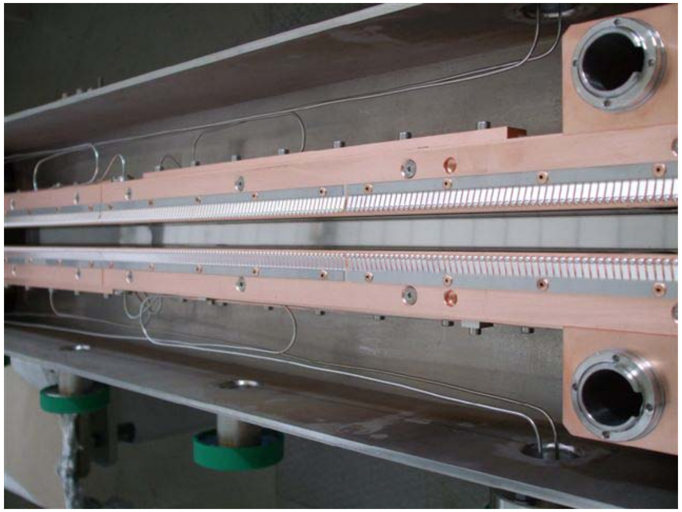
Delay after bending



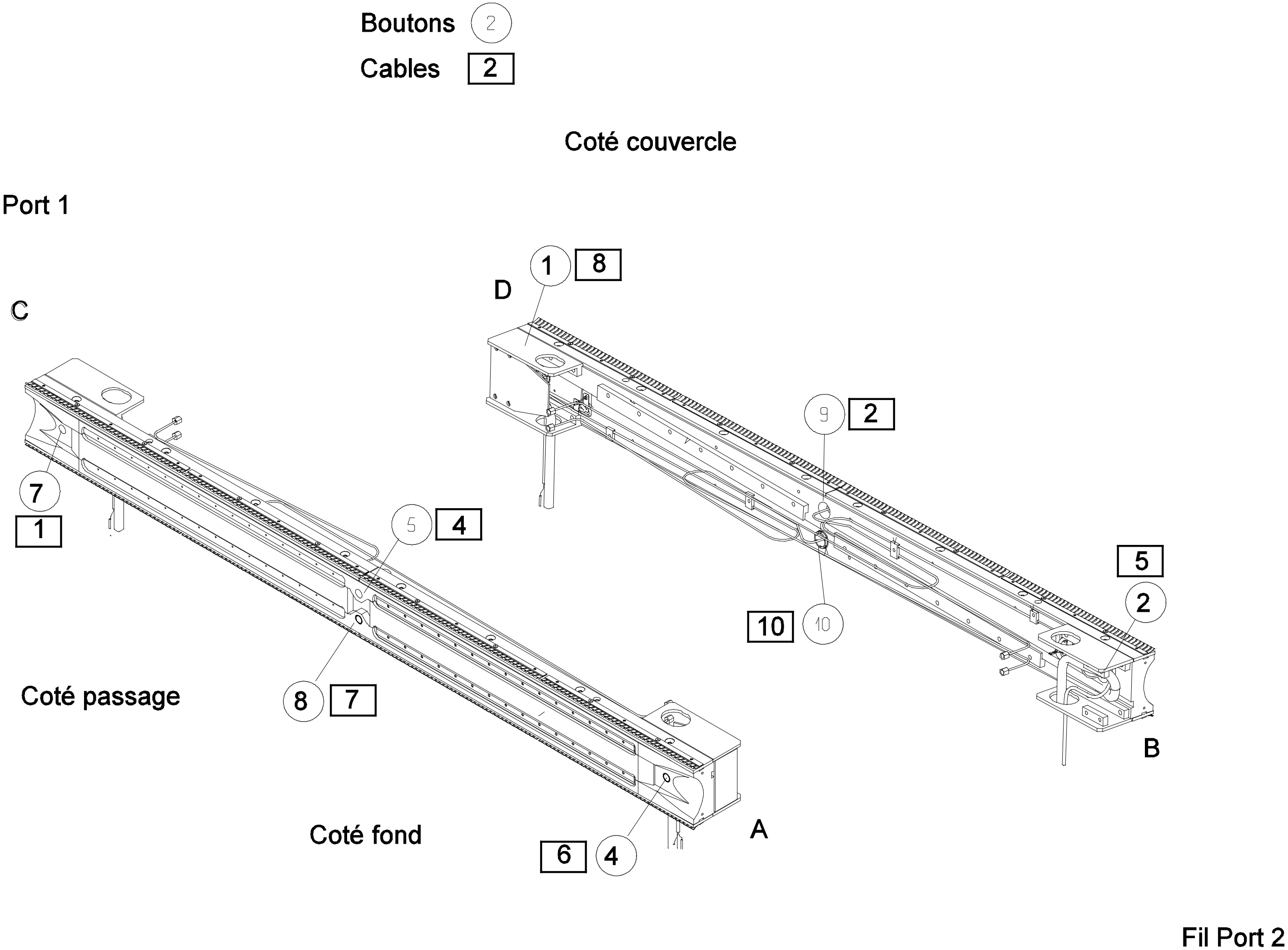
Attenuation at 600 MHz after bending





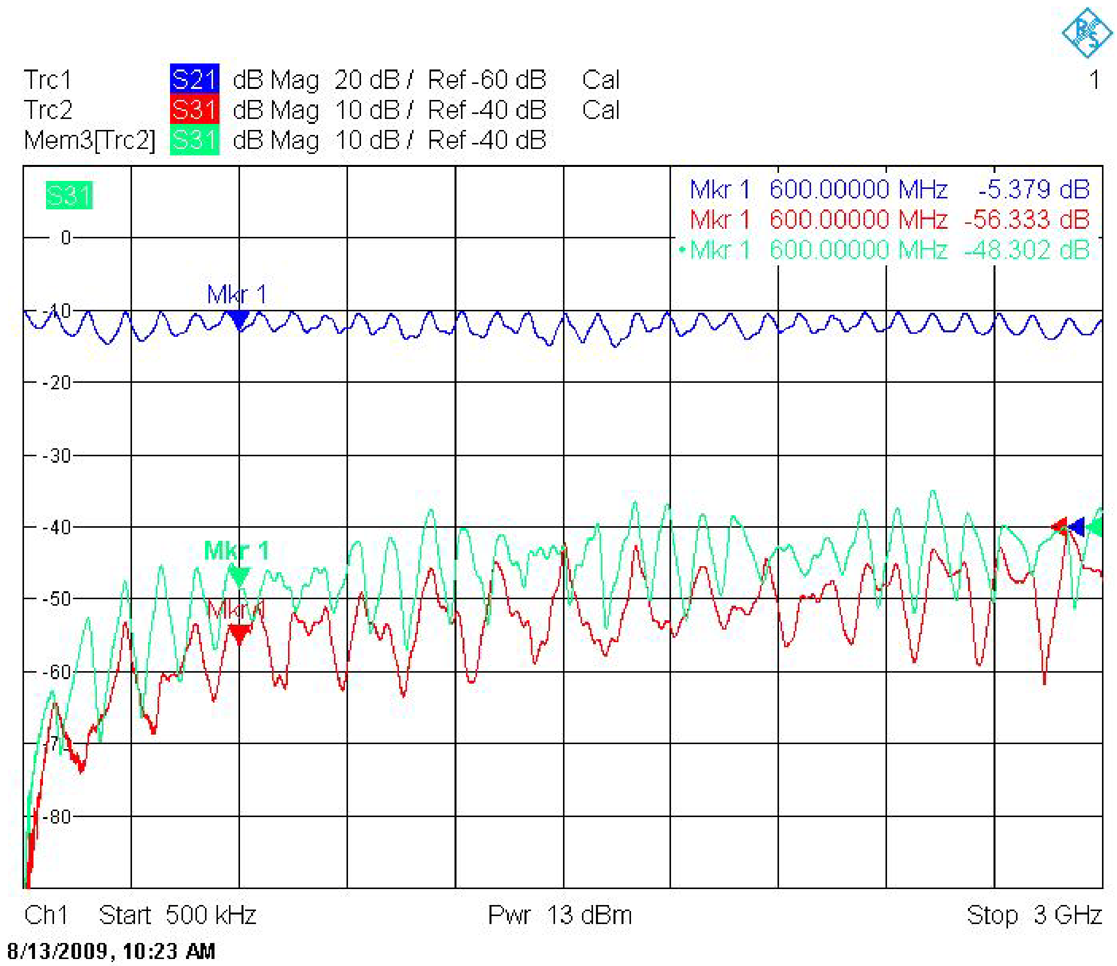


BPM components assembly setup

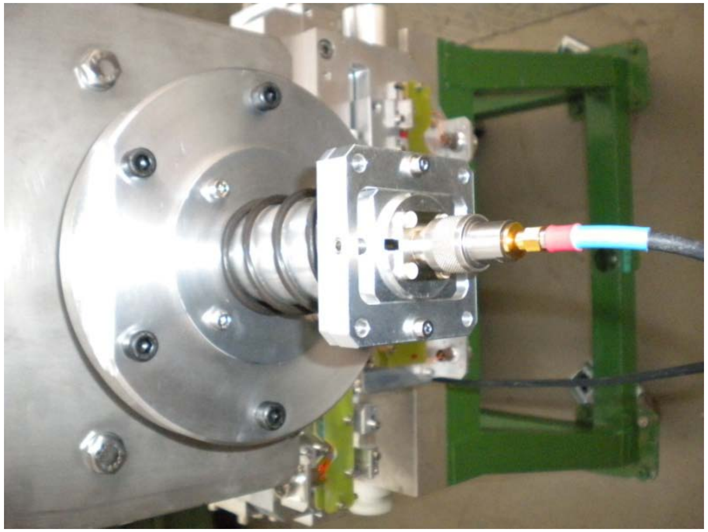


The 2 jaws are assembled in the setup bench (see drawing LHCTCSMP024)
The aperture between jaws is 25 mm for this 1st series of measurements.
A single CuBe wire diameter of 2mm was used for measurements in the setup bench (see drawing LHCTCSMP068)
The wire was not matched.
The CuBe wire is very stiff, so the center and sag of the wire is not well defined.

Measuring S21 and Buttons response for 25 mm aperture between jaws

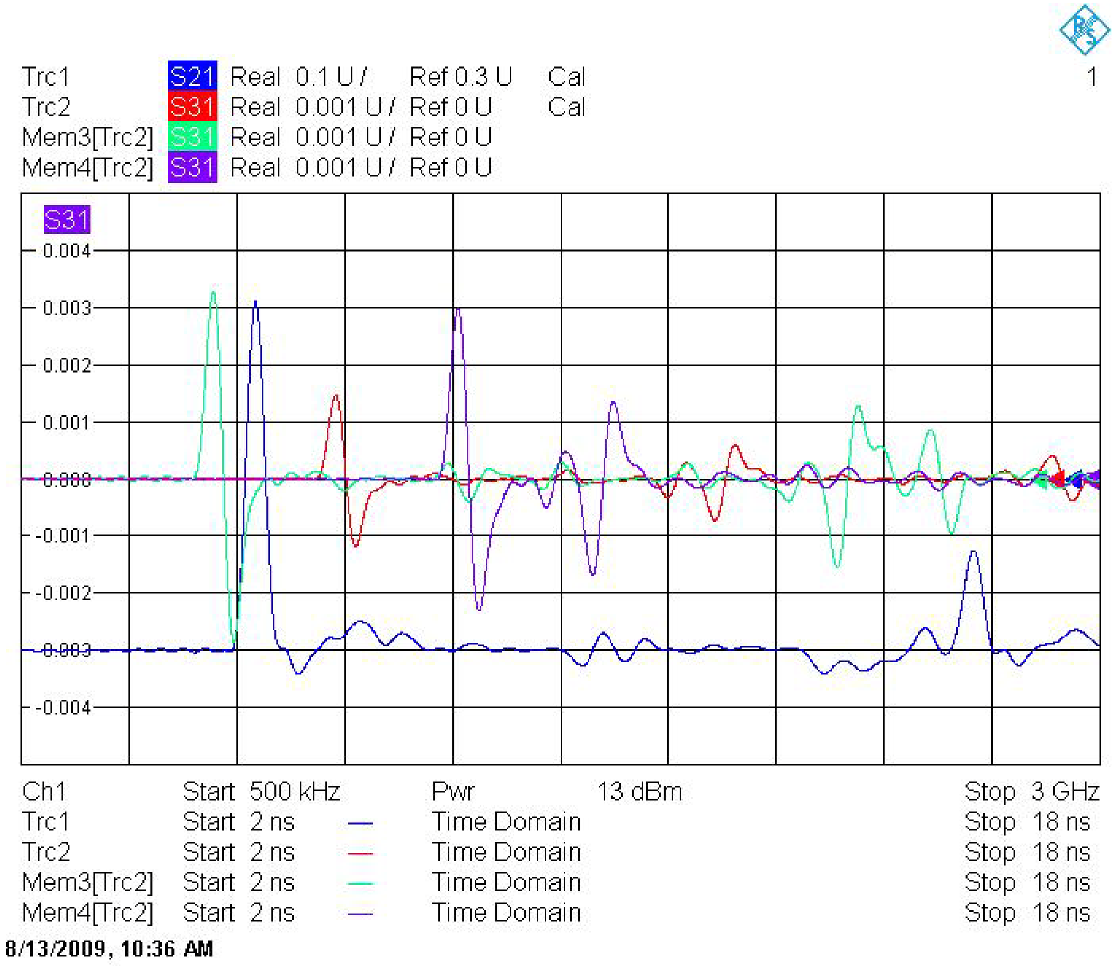


Detail of Port 2 N type connector



A Rhode & Schwartz ZVB8 3-port Vector Network Analyser (VNA) was used.
A full 3 port calibration is done over a frequency range of 500 KHz to 3GHz

Measuring S21 and Buttons response

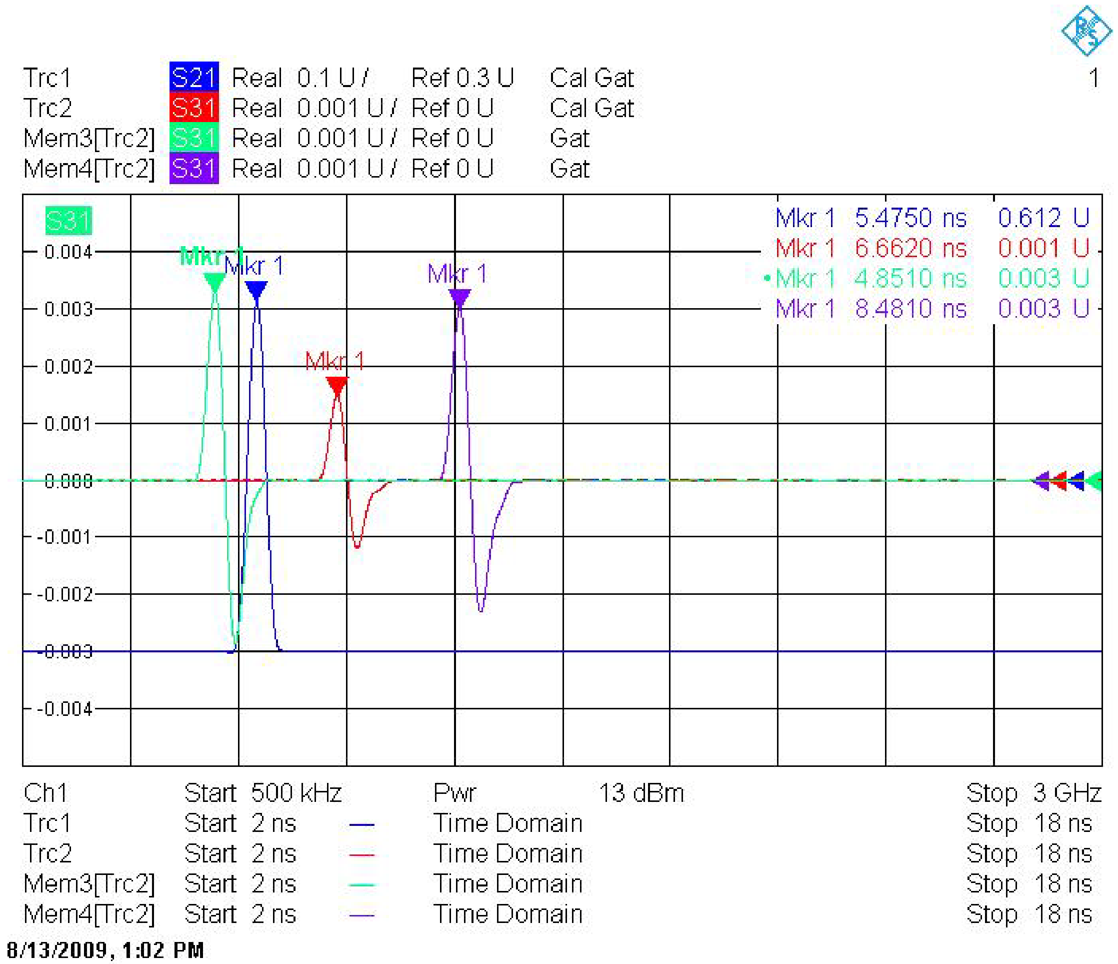


Time Domain Transform

Trace 1 shows in blue the transmitted pulse across the wire in Time Domain

Trace 2 shows button 5 response (center of jaw)
Mem 3 shows button 7 response.(port 1 side)
Mem 4 shows button 4 response.(port 2 side)

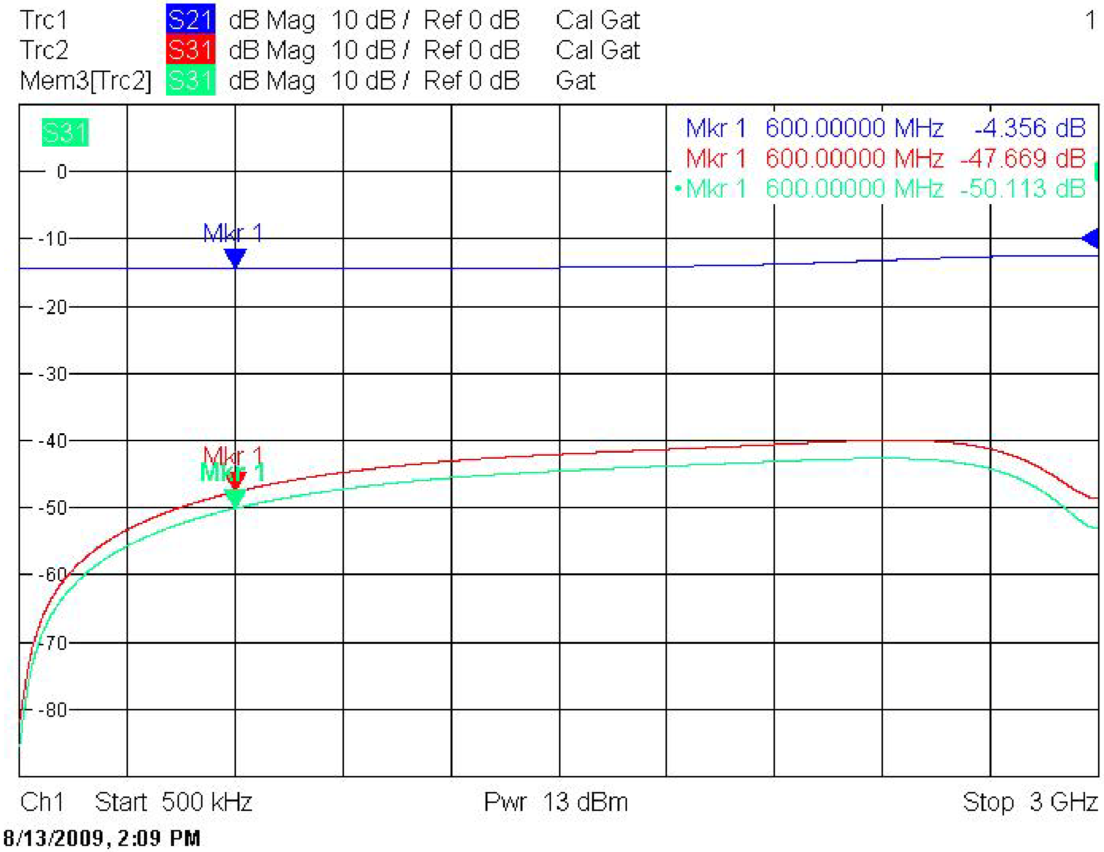
Measuring S21 and Buttons response



Time Gating is applied
Trace 1 in blue shows the transmitted pulse on the wire.
Mem 3 in green shows button 7 response.(on port 1 side)
Trace 2 in red shows button 5 response (center of jaw)
Mem 4 in purple shows button 4 response.(on port 2 side)

Note the weak response of button 5 situated at center of jaw.
Coaxial cables adds additional delay of 4.2nS.

Measuring S21 and Buttons response for a given aperture



Back in frequency domain with Time Gating.

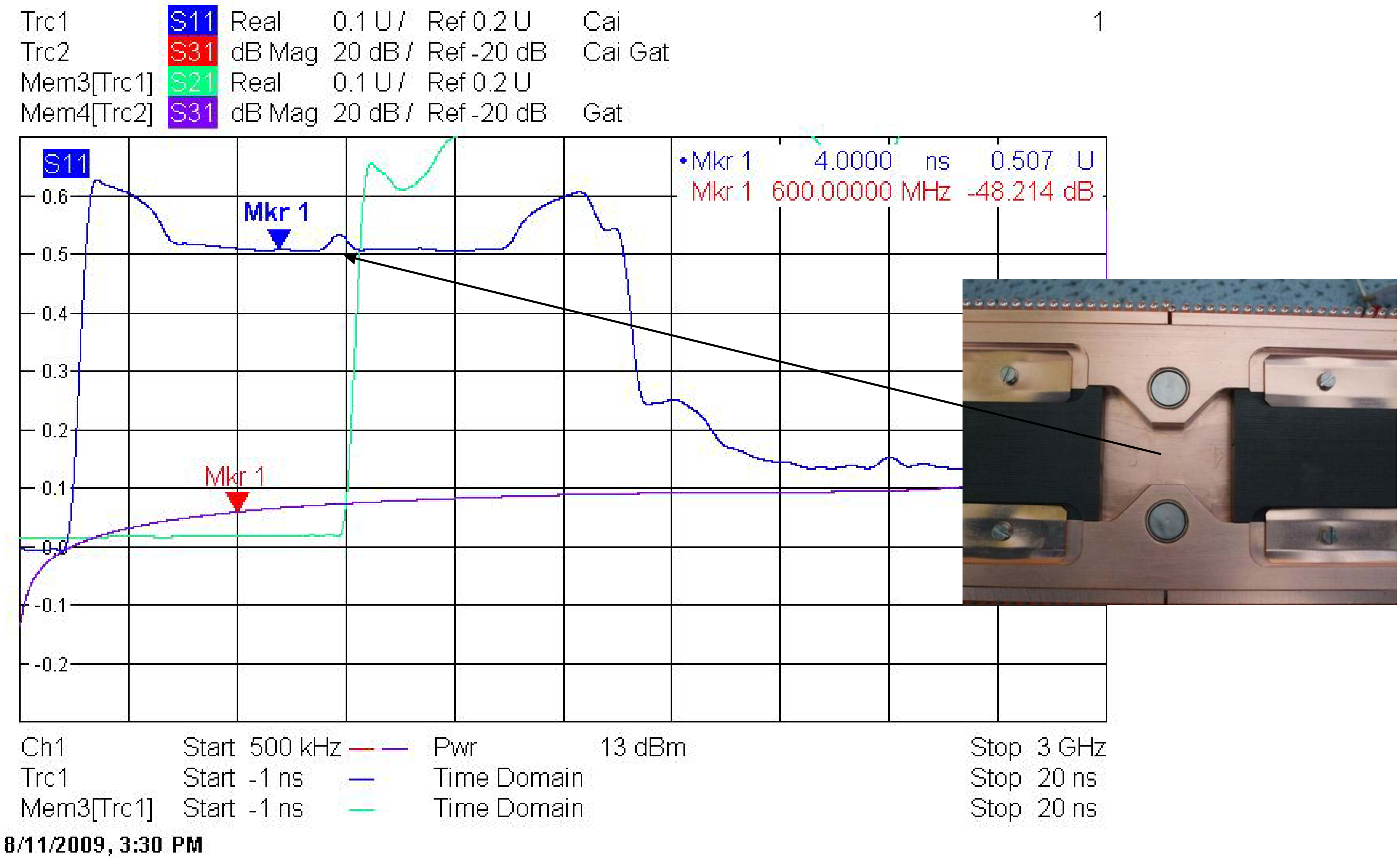
Response of 1st pair of buttons on port 1 side, demonstrating the badly centered wire.

Trace 2 shows button 1 response

Mem 3 shows button 7 response.

PS: For this aperture, response of button 5 at center of jaw is -57 dB @ 600 MHz

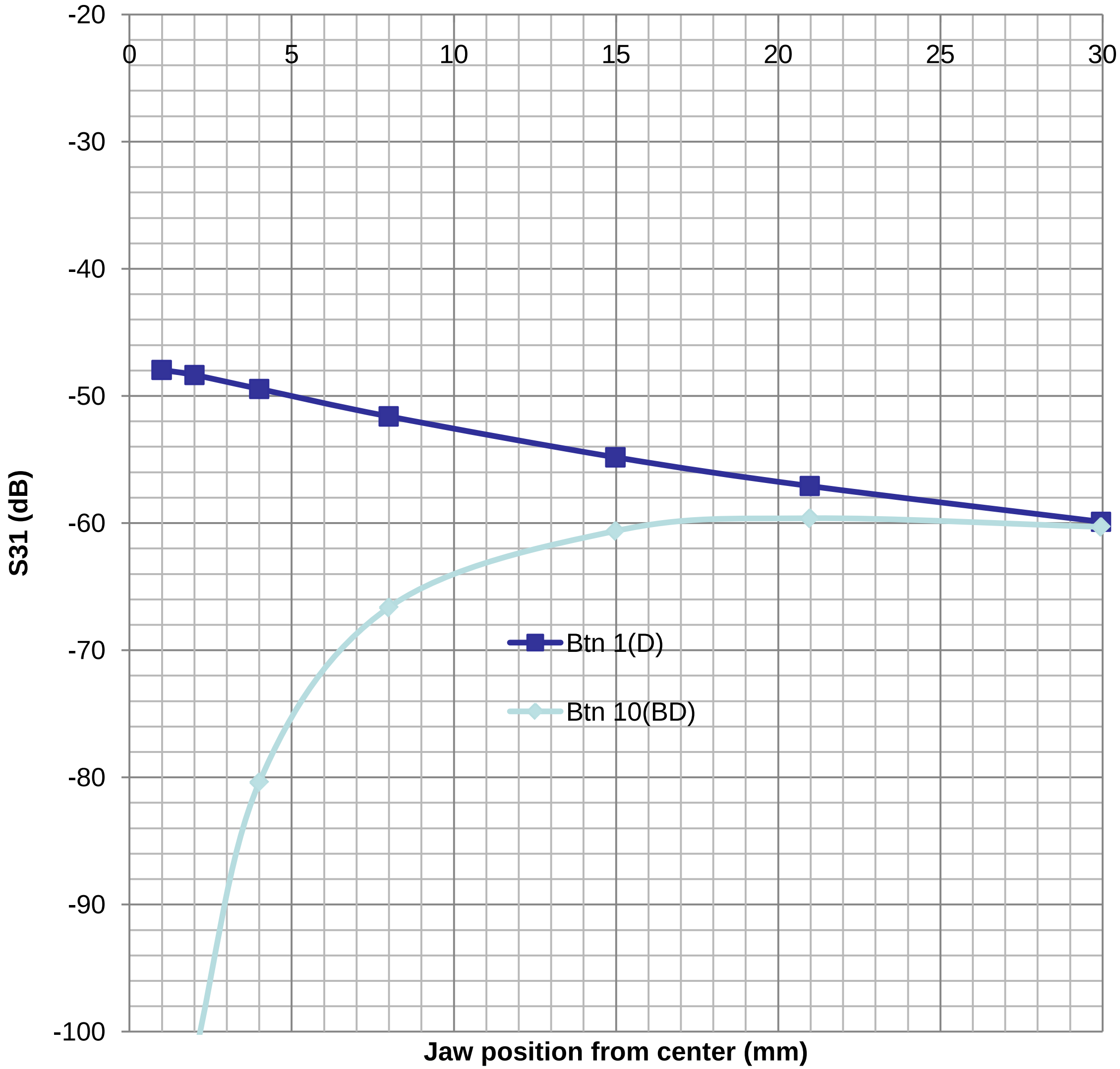
S11 in Time Domain



Characteristic impedance of the DUT for 25 mm aperture between jaws:

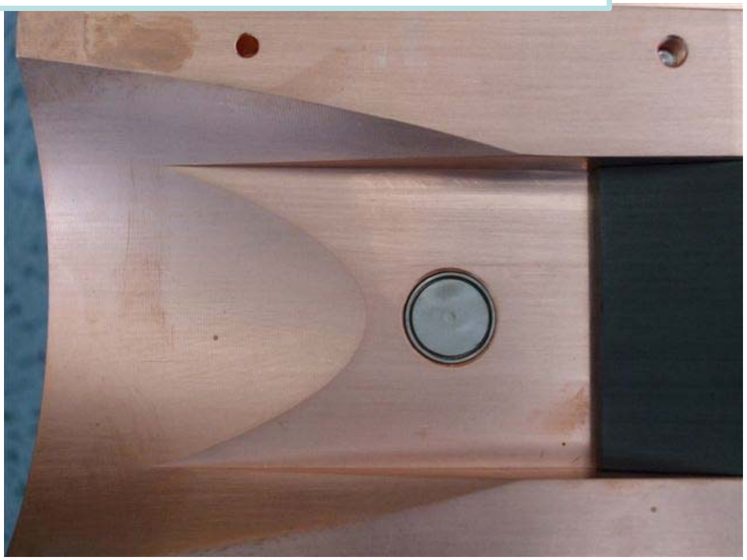
$Z_l = 60.\ln\left(1.27 * \frac{D}{d}\right) = 166\ \Omega$, measured: $Z_l = Z_0.\left(\frac{1+\Gamma}{1-\Gamma}\right) = 154\ \Omega$

Buttons Sensitivity with Jaws position

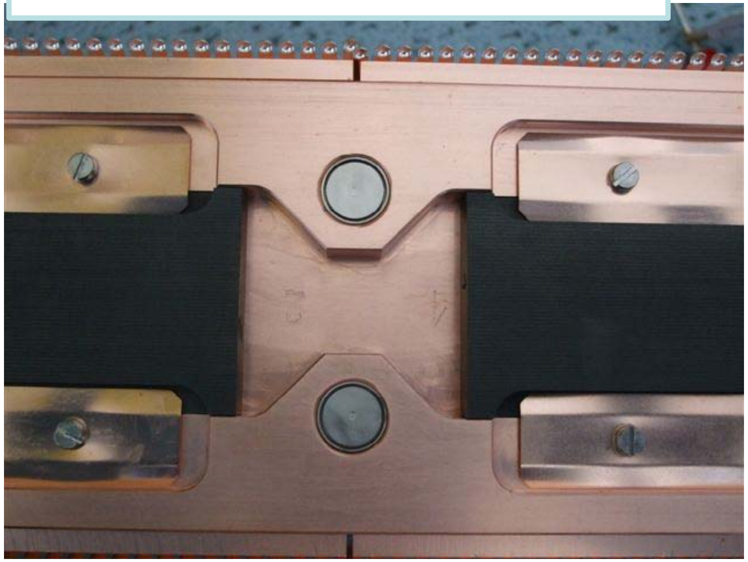


Jaws are moved symmetrically from center

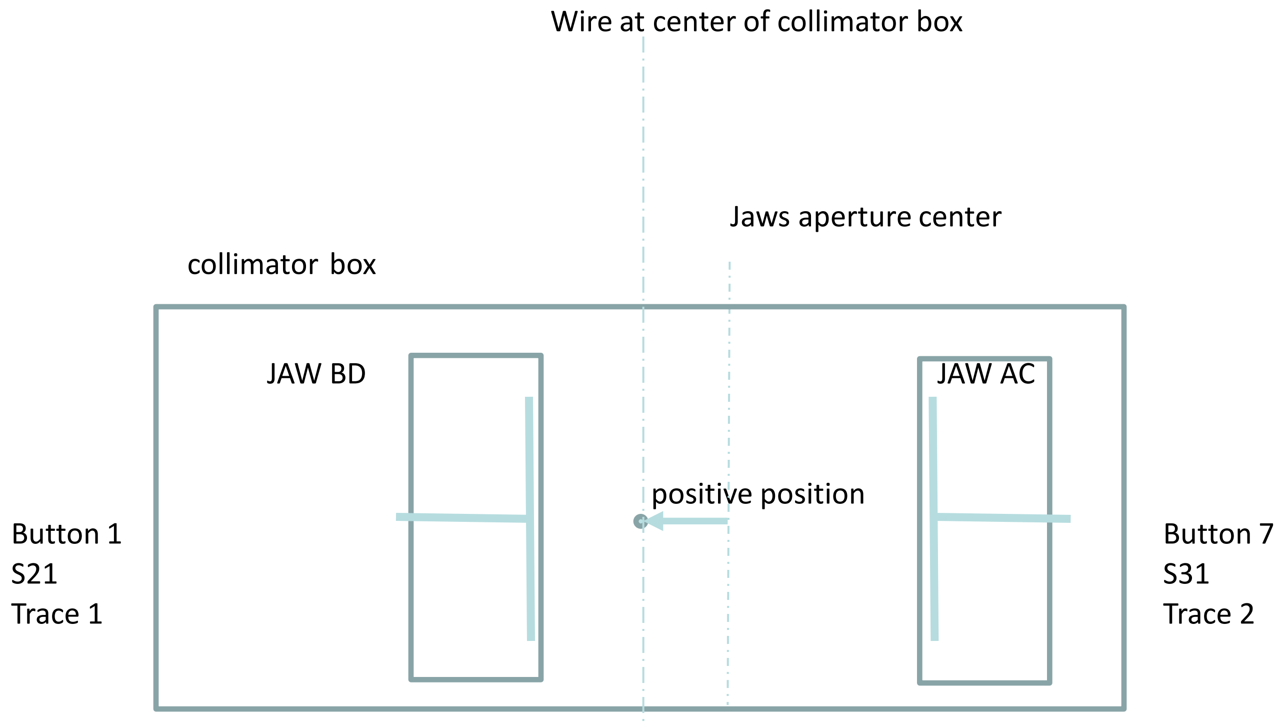
Button 1 at upstream port on D side
Distance from Jaw face: 10 mm



Button 10 at center of jaw on DB side
Distance from Jaw face: 0.05 mm



Position measurements

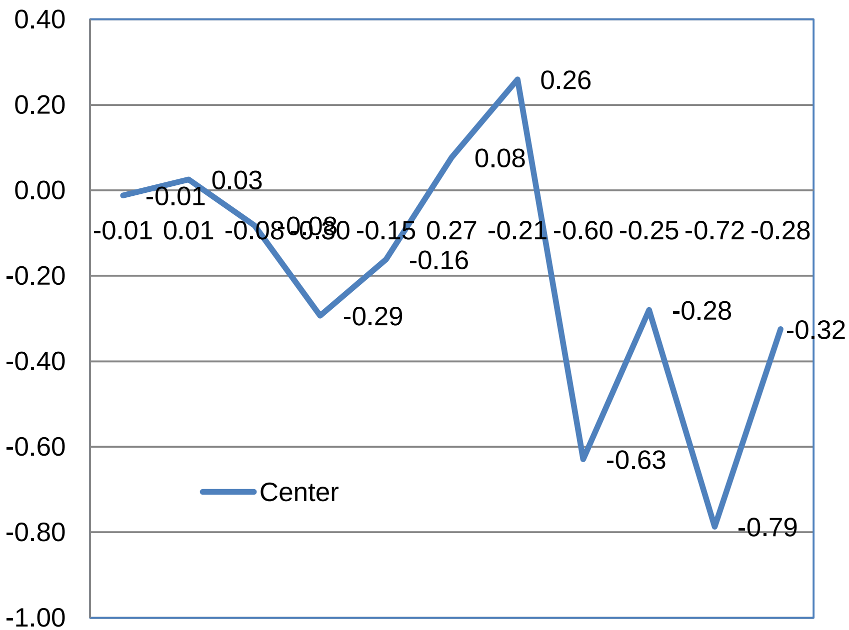


We look at position of first pair of buttons (1 & 7) on CD side of collimator which is connected to port 1 of VNA
A synthesized pulse is sent on wire. A time domain gating is done to clear from wire reflections
Port 2 & 3 are connected to button 1 & 7, measuring S21 & S31

The VNA is used to compute the normalized position : (1-7)/(1+7) on Trace 3
(A small 1% smoothing is applied)
Position is read with a marker on Trace 3 at 600MHz
Position in mm is given by (normalized position * Jaws Aperture) (PS: for a normal BPM we use a scaling factor more close to the 1/2 aperture)
Requested Jaws positions are given to step motors as Gap from the collimator box center.
Jaws positions are read back with micrometers from their external parking position.

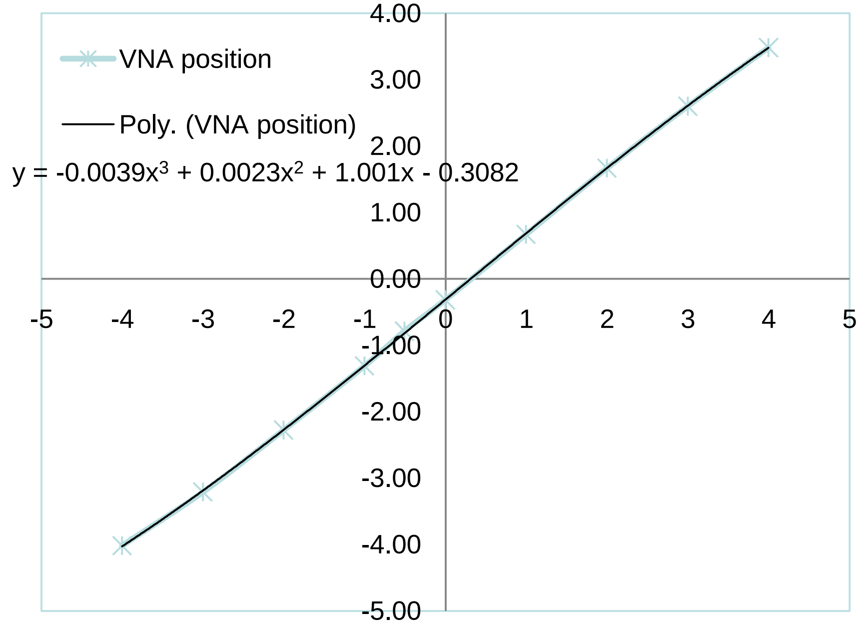
Position measurements

Finding center with small increasing aperture



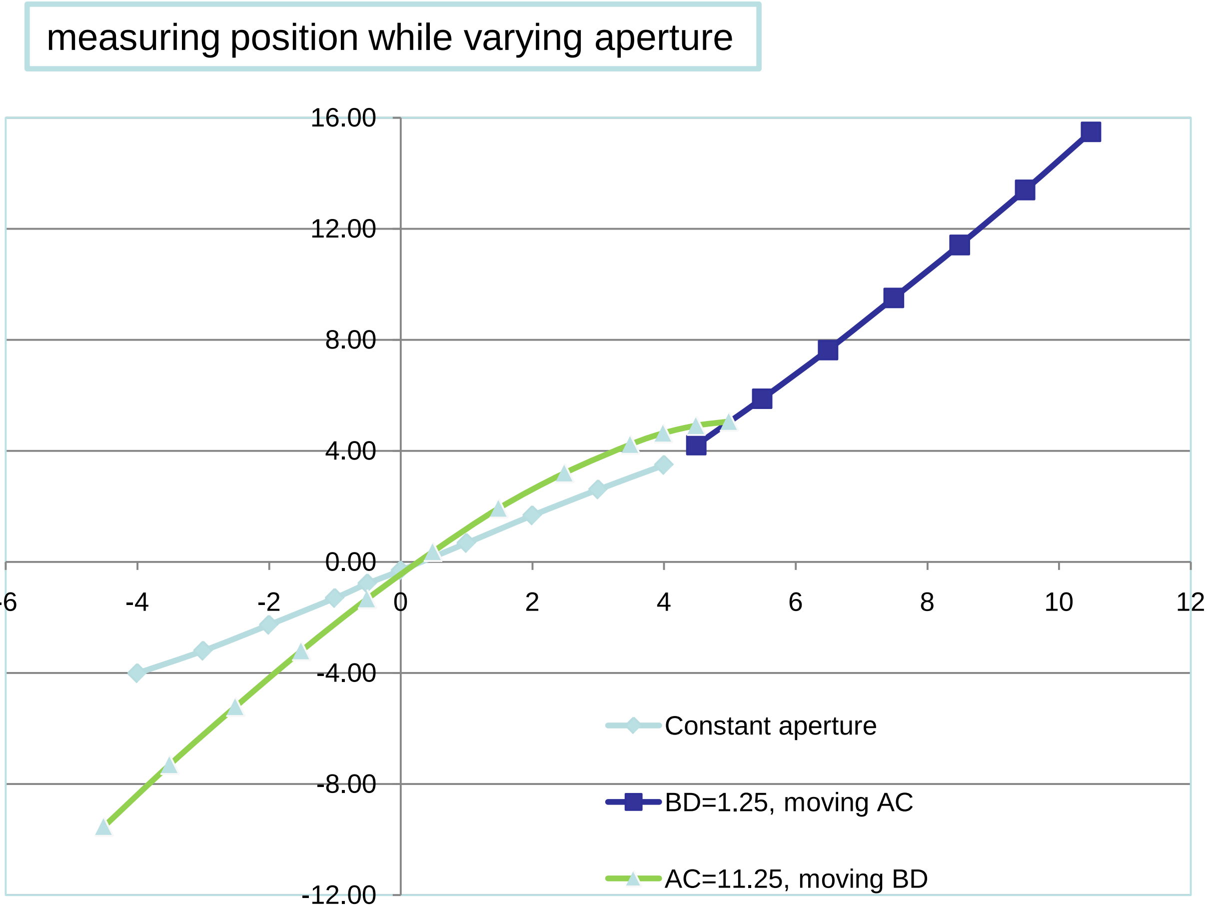
Trying to find the center of the setup.

measuring wire position with constant aperture



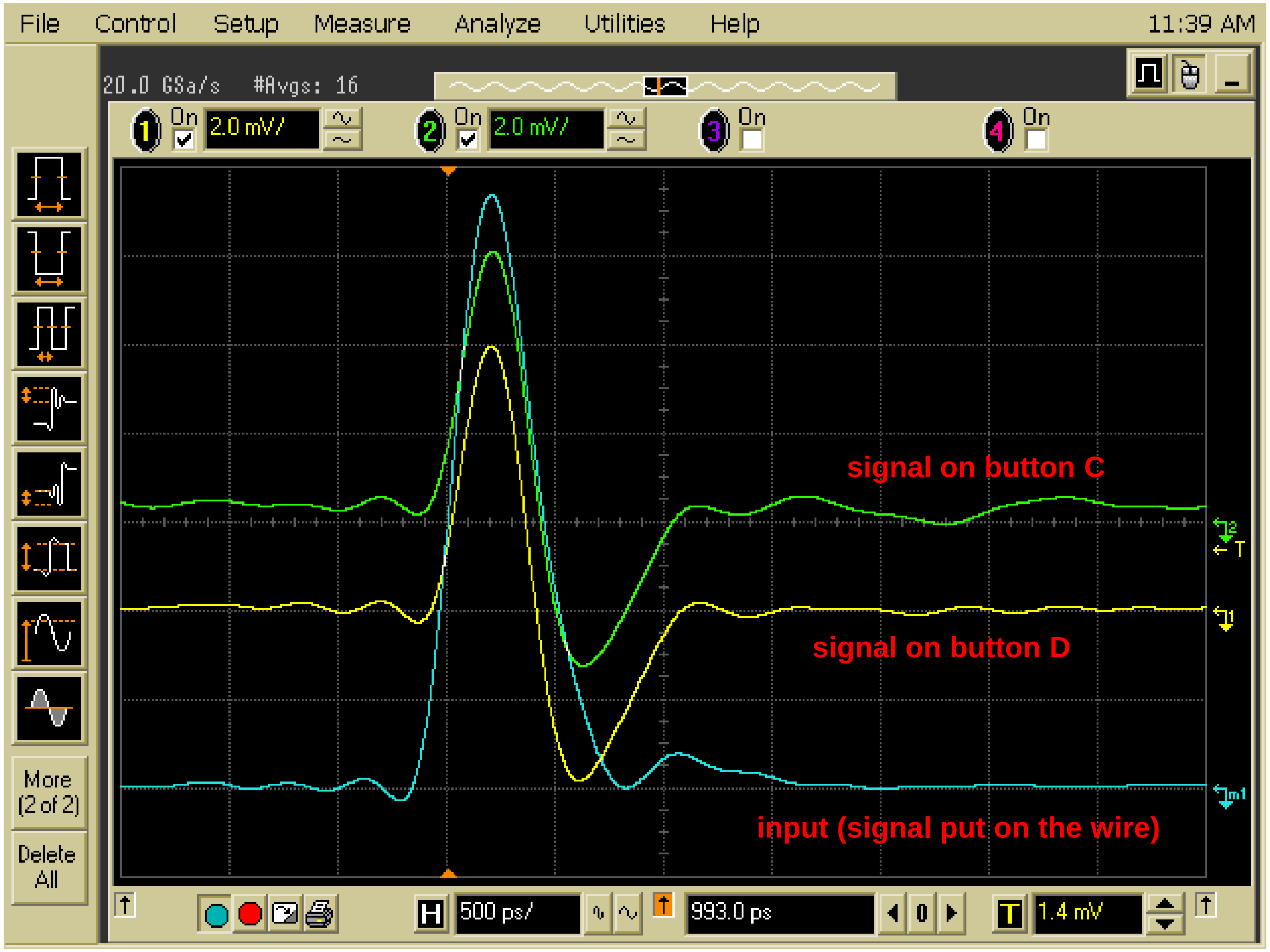
With a constant aperture of 10mm, we found the -0.3 mm wire offset and the beginning of a 3rd order non linearity.

Position measurements



With a moving or asymmetric aperture we start to see the challenge of linearity and scaling factor vs other parameters like aperture and extreme beam postions.

Complementary oscilloscope measurements in the time domain



- jaws fully open (62 mm)
- input ≈7 Vp
- output ≈6 mVp

- line imp. ≈340 Ω
- input Γ ≈0.75
- input power ≈1 Wp
- wire line power ≈0.4 Wp
- wire line current ≈35 mAp

$$Z_T = \frac{V_{button}}{I_{beam}}$$

- $Z_T \approx 0.17\ \Omega$

Complementary oscilloscope measurements in the time domain

- signal levels calculated as:

$$V_{button\ col.} = \frac{Z_{T\ col.}}{Z_{T\ std.}} V_{button\ std.}$$

- $Z_{button\ std} = 1.37\ \Omega$
- $V_{button\ std.} = 60V$ @ 1.7e11 protons

Jaw distance [mm]	V_{button} / I_{beam} [Ω]	V_{button} [V_p] @ 1.7e11 protons	V_{button} [mV_p] @ 1e9 protons
62	0.17	7.4	44
20	0.35	15.3	90
10	0.41	17.8	105
2	0.38	16.5	97

Conclusions:

- The test bench was a good tool for measuring the transfer characteristics of buttons.
- The central pair of buttons is inefficient for small apertures due to the local configuration.

Next step: measurements in the SPS