R56 and bunch length measurement

Javier Barranco García for the CTF3 collaboration

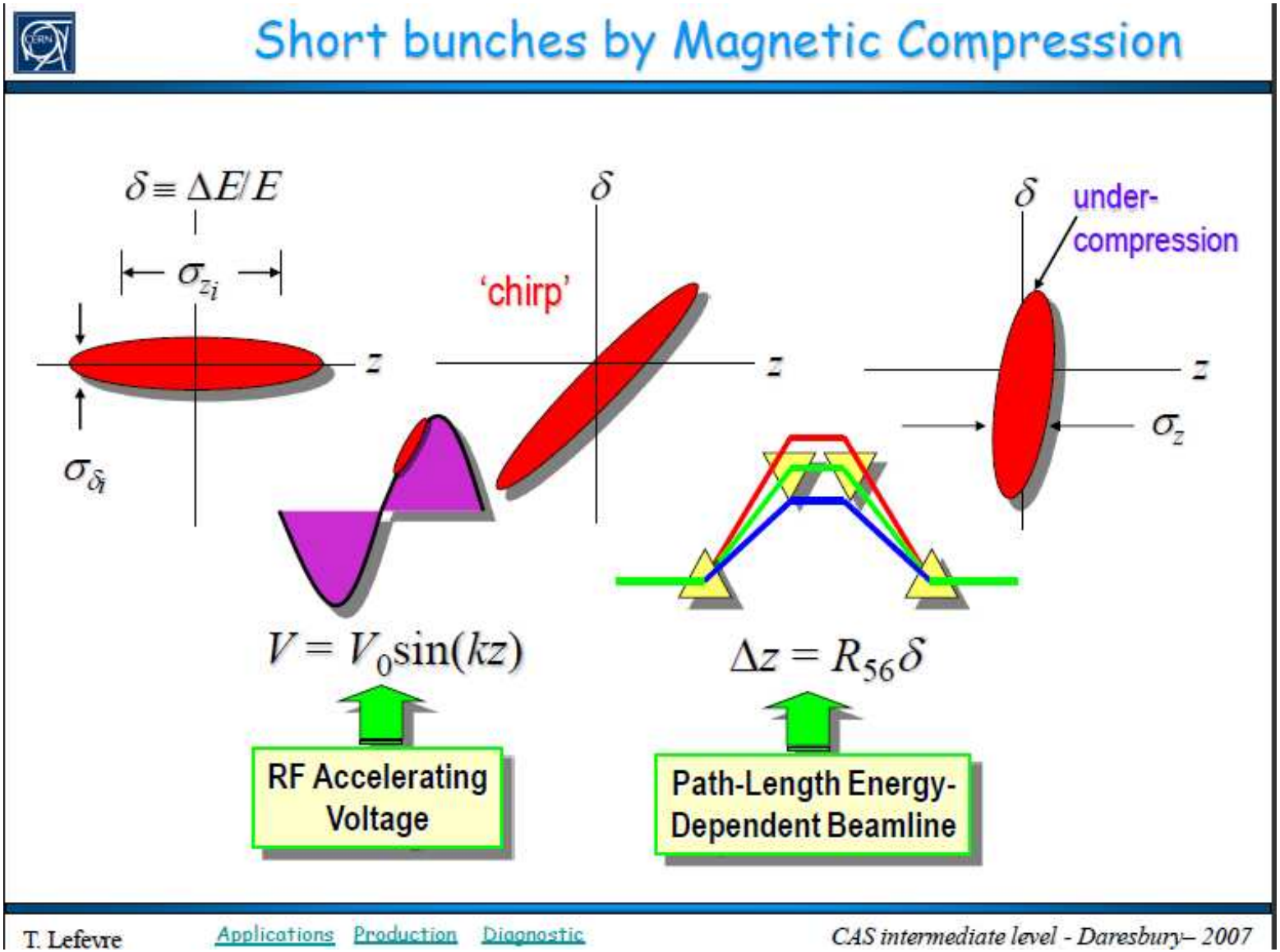
October 10, 2012

All bunch length measurements courtesy of Aurelie Goldblatt.

Experiment goal

Show that we can control the bunch length by changing the R_{56} in the Frascati chicane. Shorter bunches, a priori, should ease the combination process and improve the form factor in the CLEX experiments.

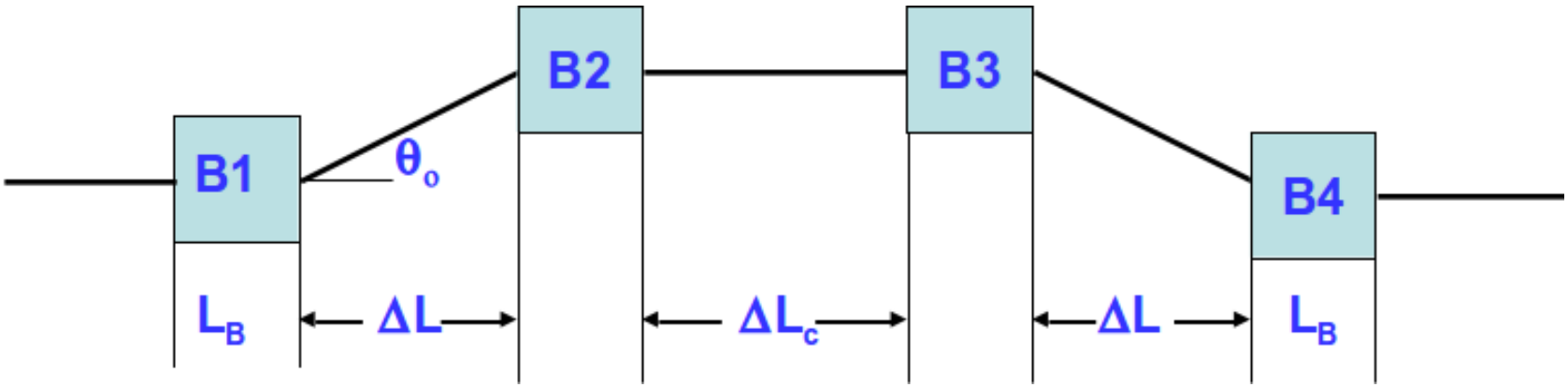
How does a chicane work?



R_{56} in a chicane

The natural value for the R_{56} is given by construction,

$$R_{56} \approx 2\theta^2 \left(\Delta L + \frac{2}{3} L_B \right) \tag{1}$$



For our Frascati chicane the natural R_{56}=0.45. However this value can be tuned with the aid of the quads inside the chicane. R_{56} range commissioned [-0.2,0.45].

R56 expected effect on bunch length

Uncorrelated case,

$$\sigma_{z_{\text{meas}}} = \sqrt{\sigma_{z_0}^2 + (R_{56}\delta E_i)^2}$$

Asumming $\sigma_{z_{\text{meas}}} = 18$ ps, $\sigma_E = 2.5$ and R_{56}=0.45

$$\sigma_{z_0}/\sigma_{z_{\text{meas}}} \approx 0.5$$

Correlated case (need a realistic distribution),

$$s_i = s_{i_0} + R_{56}\delta E_i$$

R_{56} Optics

Optics R_{56}=0.45

```
iqdd0110 = 9.73;
iqfd0130 = -0.90;
iqfd0150 = 9.73;
iqdd0220 = 0.0;
iqfe0230 = 0.0;
iqdf0245 = 0.0;
iqfe0250 = 0.0;
iqfd0310 = 9.73;
iqfd0330 = -0.90;
iqdd0350 = 9.73;
iqdf0410 = -5.02;
iqff0420 = 27.80;
iqdf0470 = 60.95;
iqff0480 = 63.51;
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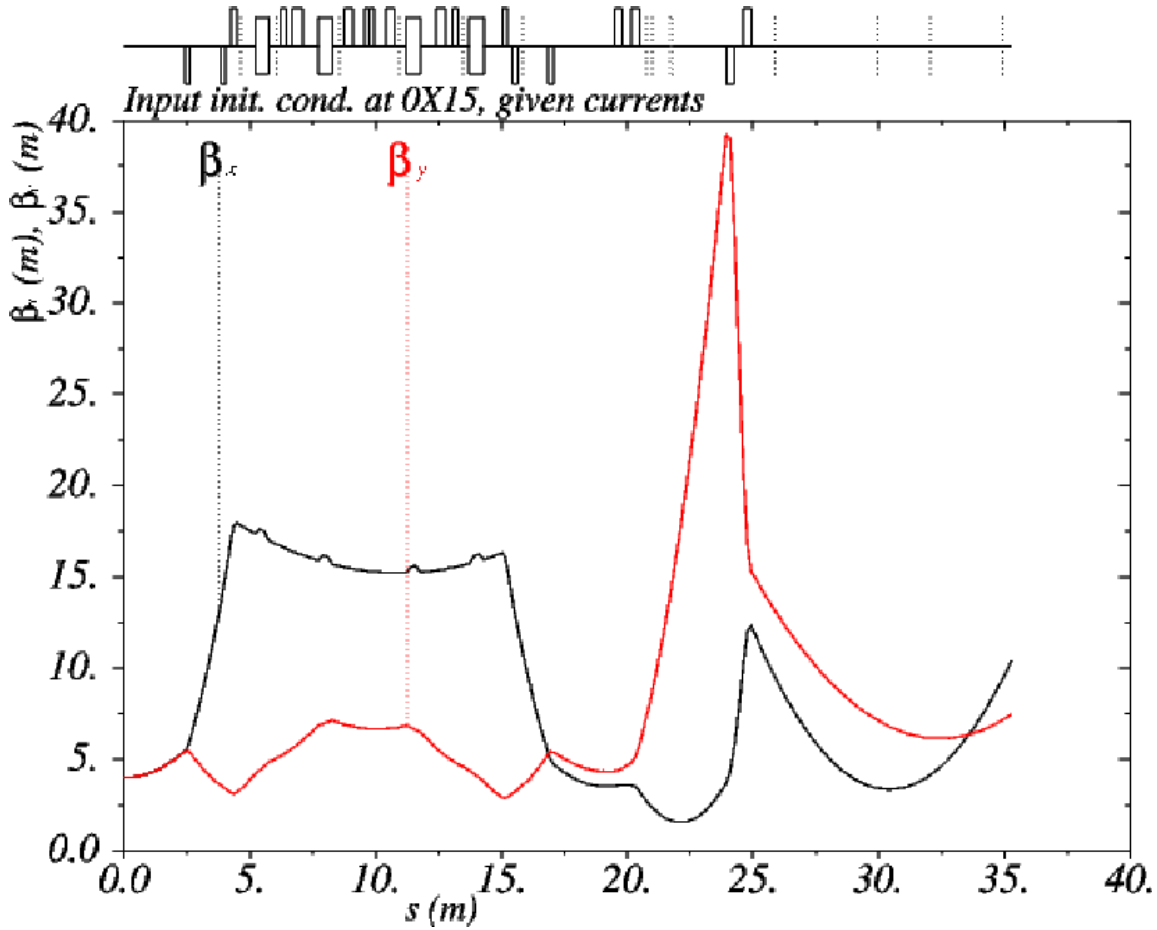

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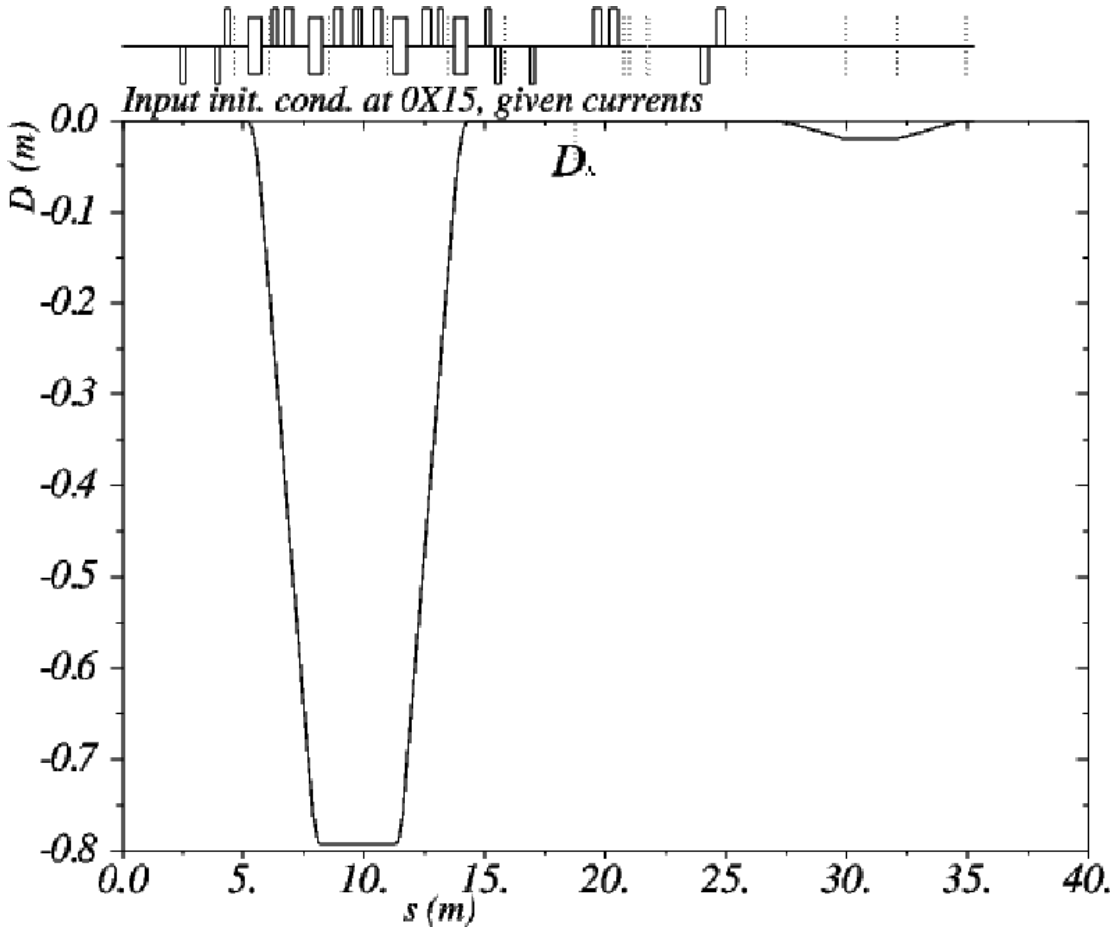

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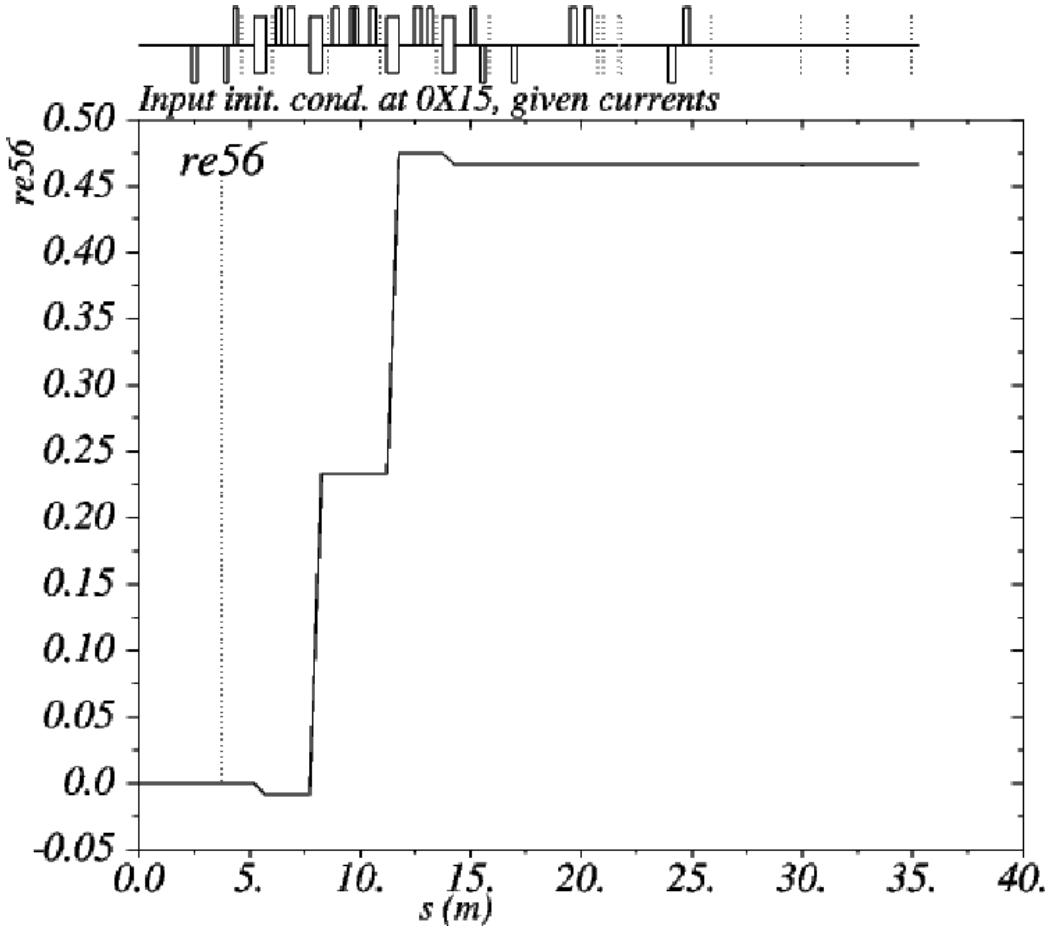

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iqdd0110 = 2.781361948;
iqfd0130 = 23.41400831;
iqfd0150 = 11.31428593;
iqdd0220 = 36.39982771;
iqfe0230 = 52.05423436;
iqdf0245 = 44.27923231;
iqfe0250 = 77.5967702;
iqfd0310 = 11.31428593;
iqfd0330 = 23.41400831;
iqdd0350 = 2.781361948;
iqdf0410 = -12.38004452;
iqff0420 = 14.14216163;
iqdf0470 = 56.79070466;
iqff0480 = 58.20781454;
```

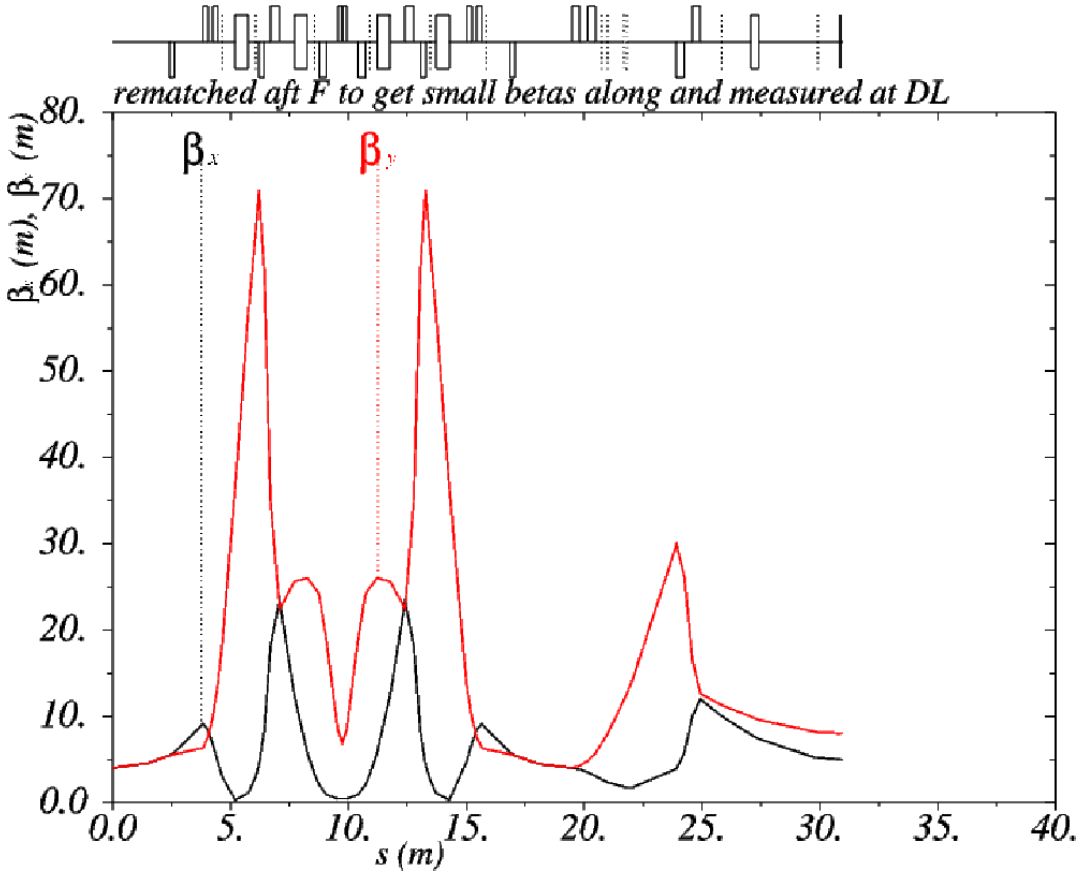

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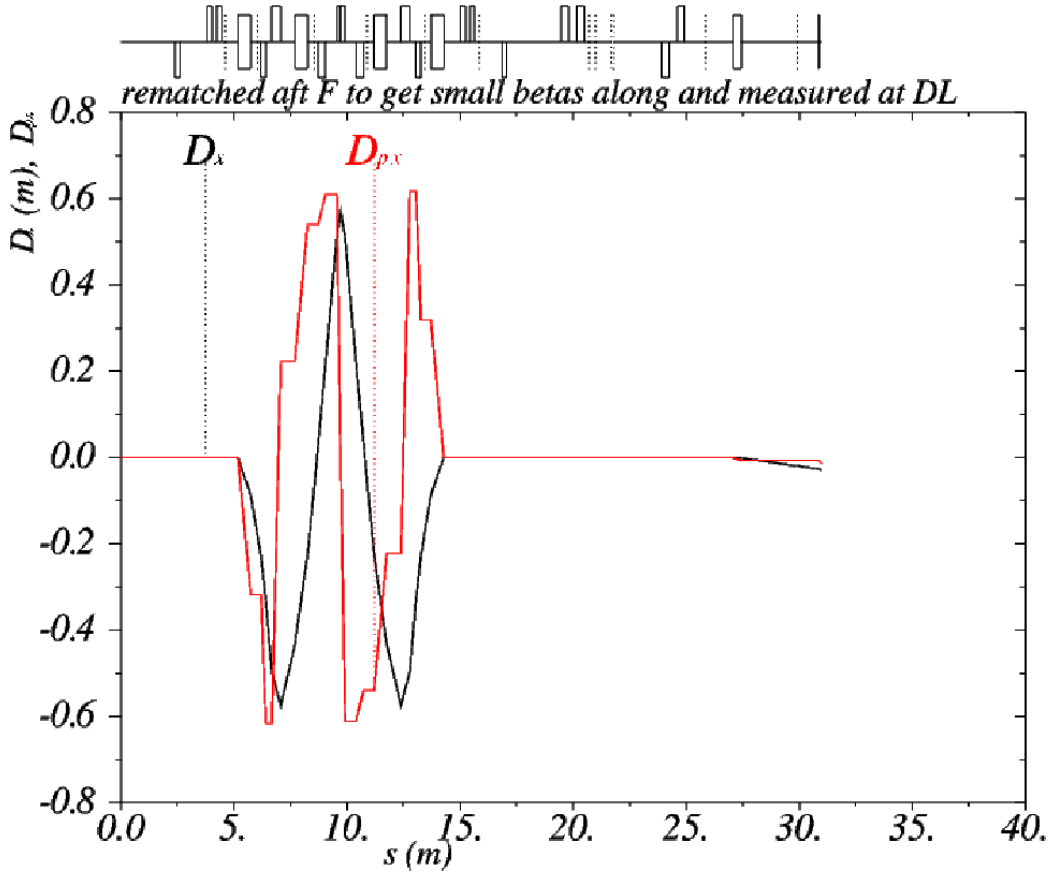

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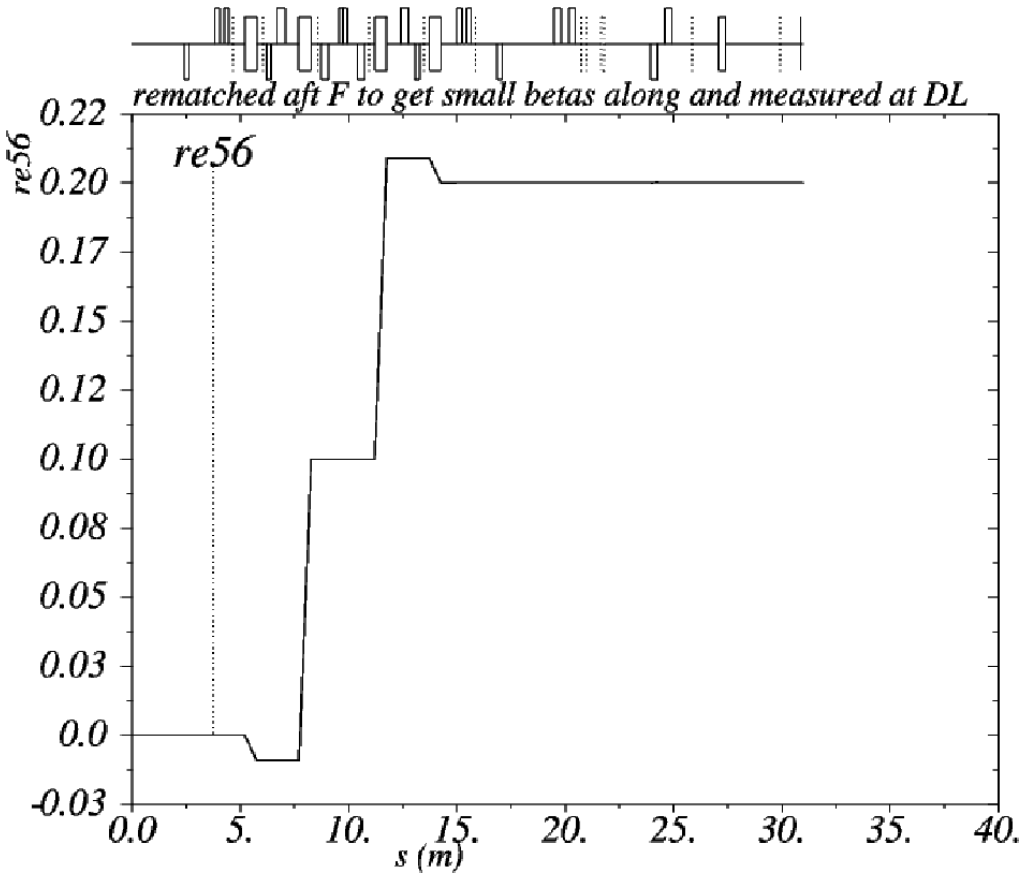

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iqdd0110 = 20.04283364;
iqfd0130 = 28.93148582;
iqfd0150 = 8.05744559;
iqdd0220 = -80.22262382;
iqfe0230 = -55.52379988;
iqdf0245 = -109.2662098;
iqfe0250 = 1.900035334;
iqfd0310 = 25.68349718;
iqfd0330 = 17.71345828;
iqdd0350 = 23.93370099;
iqdf0410 = 34.12780244;;
iqff0420 = 47.7867982;
iqdf0470 = 72.44905072;
iqff0480 = 67.56892315;
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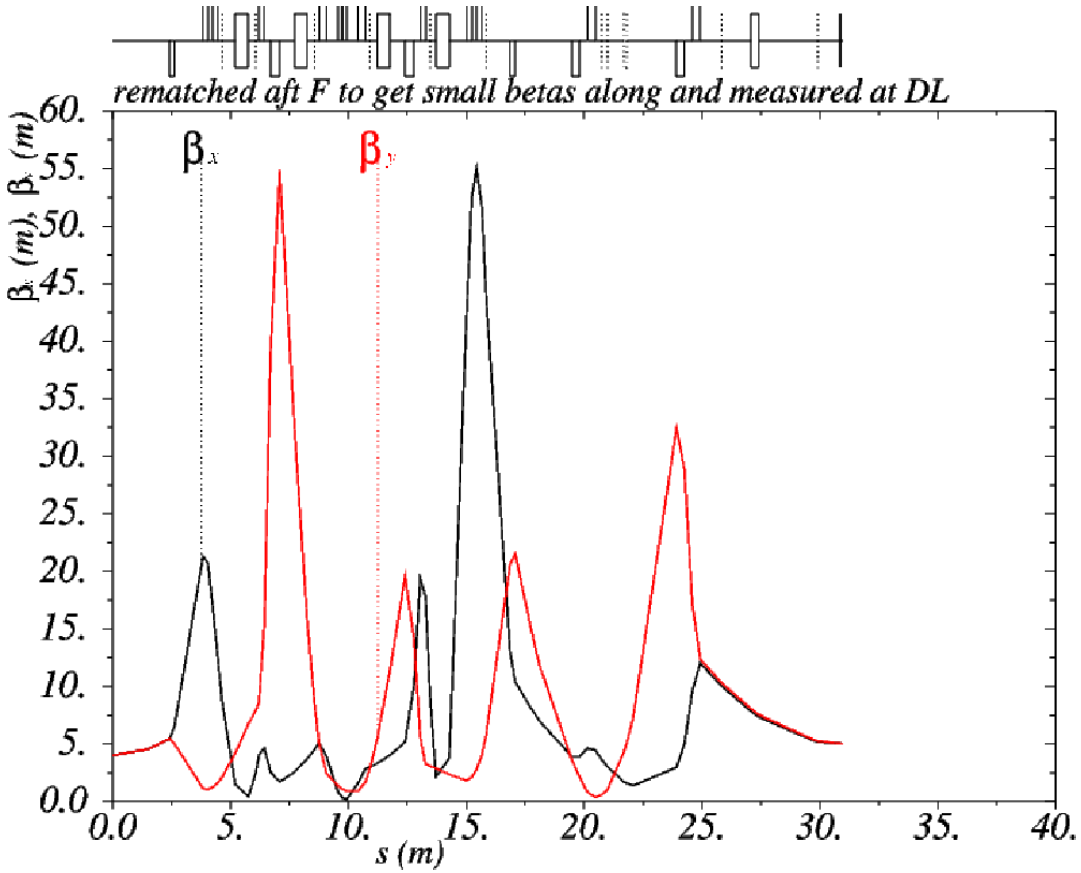

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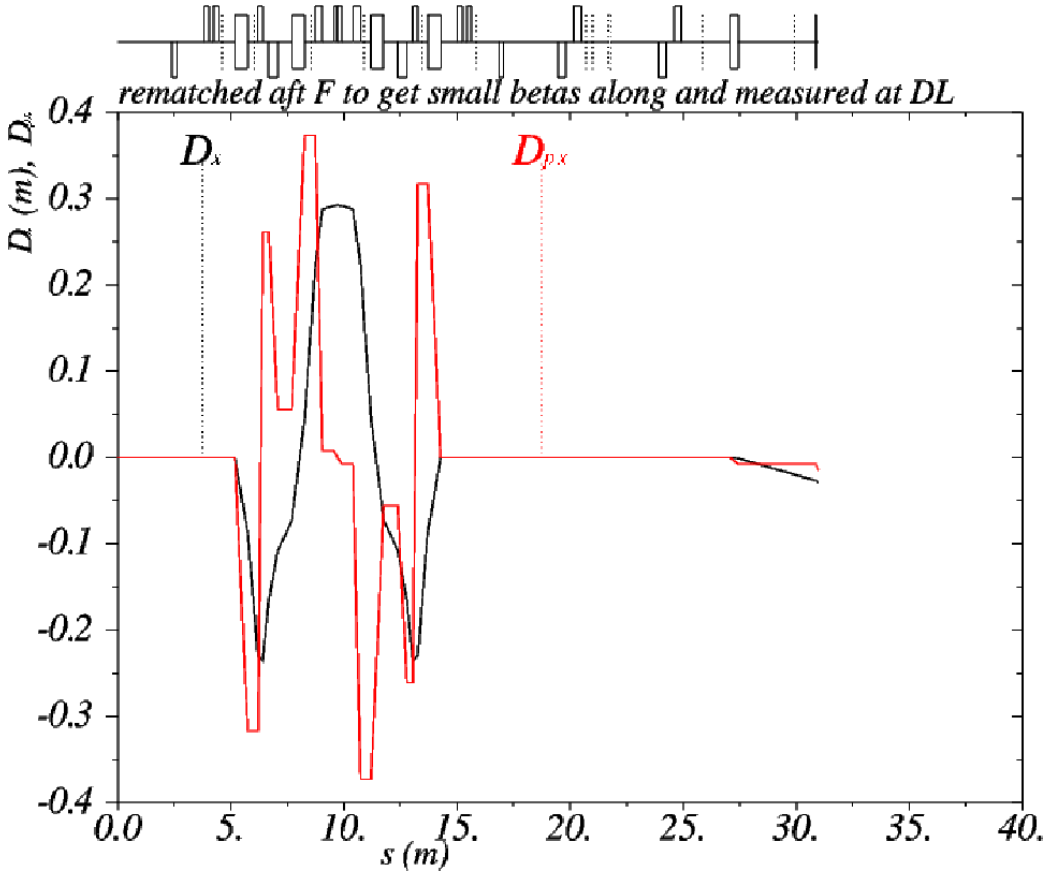

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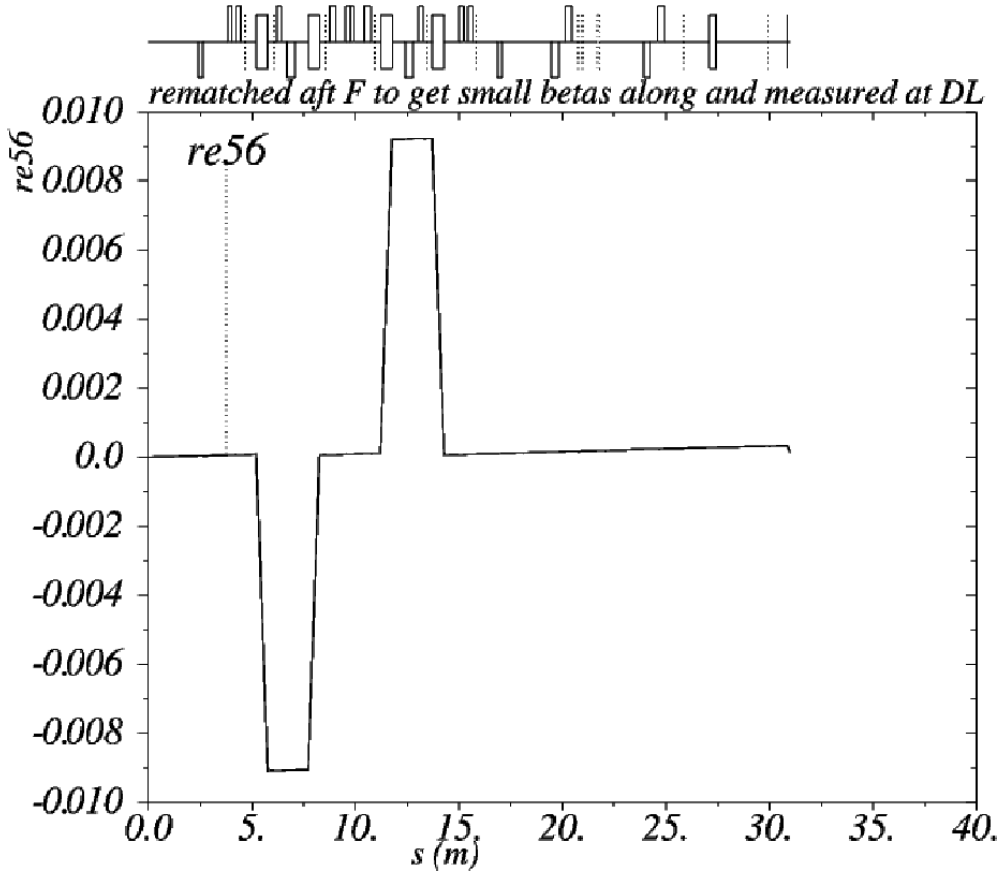


Streak Camera Measurement Options

The streak camera software offers the possibility to:

- do single shots
- stack images and then process them by doing an average (from which the measured jitter from single shots is substracted afterwards)
- stack images and then process them by doing a jitter correction (recalage)

Preliminary conclusions after the measurements:

- The best method is the single shot measurement as the intensity is enough in order to perform good fits.
- The jitter measured from single shots is clearly underestimated.
- The software jitter correction is not bad.

Limitations in the measurement procedure

Limitations of the measurements:

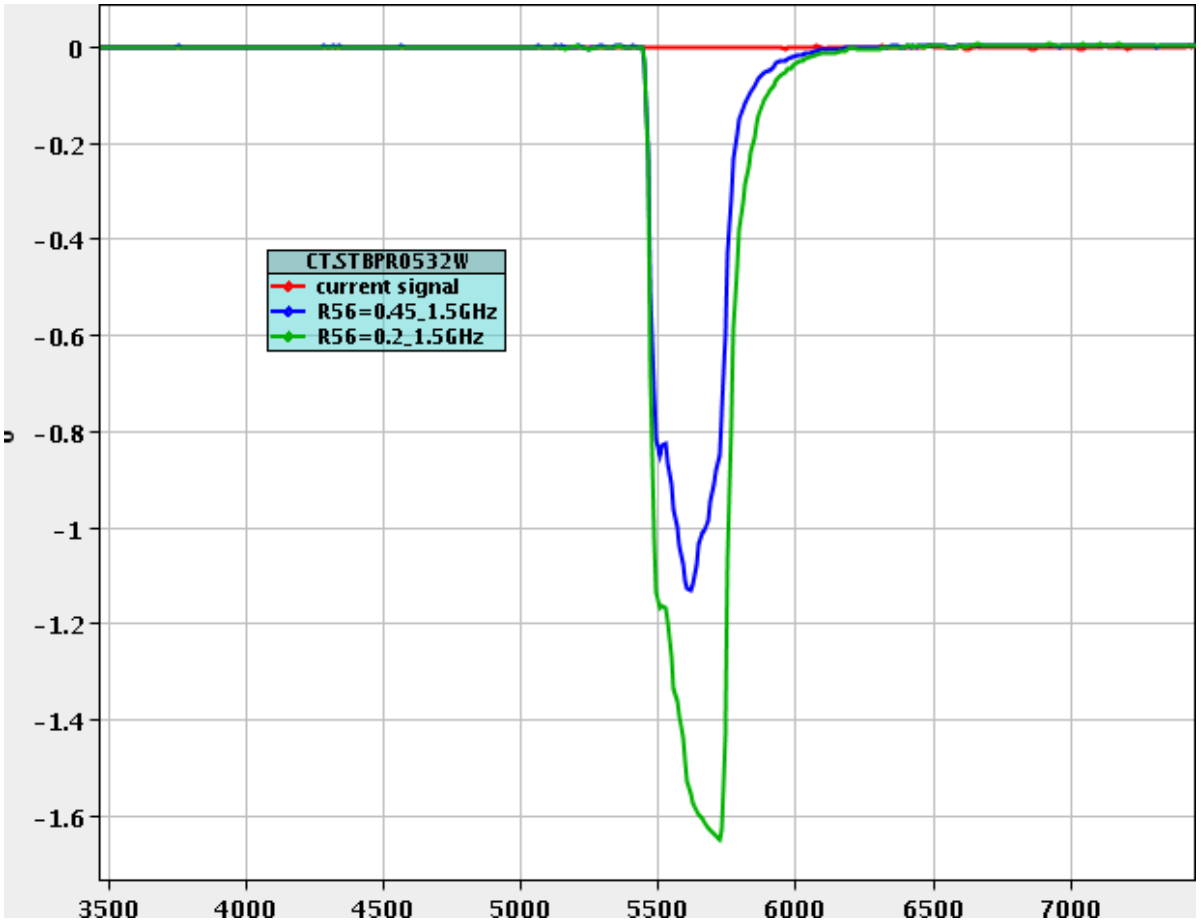
- Intensity of the light collected by the camera (depends of the light source and the optics of the line). The resolution of the measurement is dependent of the intensity: camera time window, quality of the fit of the temporal profile. All the measurement here were done with a 100ps window.
- Dispersion in the lenses due to the light wavelength range: this can be calculated and subtracted in quadrature from the measurement, and can be reduced by adding a color filter in the line (which was done for these measurements)
- Calibration of the streak camera (ps/px of the CCD camera)
- Error on the fit
- For non single shot measurement, jitter, which can be subtracted in quadrature
- Optics alignment

Measurements 6th August 2012

Summary Bunch Length Measurements 15th August

- 1.5/3 GHz beam, RF injection first turn in CR.
- Results:
  - 3 GHz beam: $\sigma_z^{R_{56}=0.45}$=19.2 ps, $\sigma_z^{R_{56}=0.2}$=16.4 ps
  - 1.5 GHz beam: $\sigma_z^{R_{56}=0.45}$=12.9 ps, $\sigma_z^{R_{56}=0.2}$=13.2 ps

6th August: Waveguides



Unfortunately there were not references saved during the 3 GHz measurements. Good agreement between bunch length and BPR0505.

6th August: Waveguides

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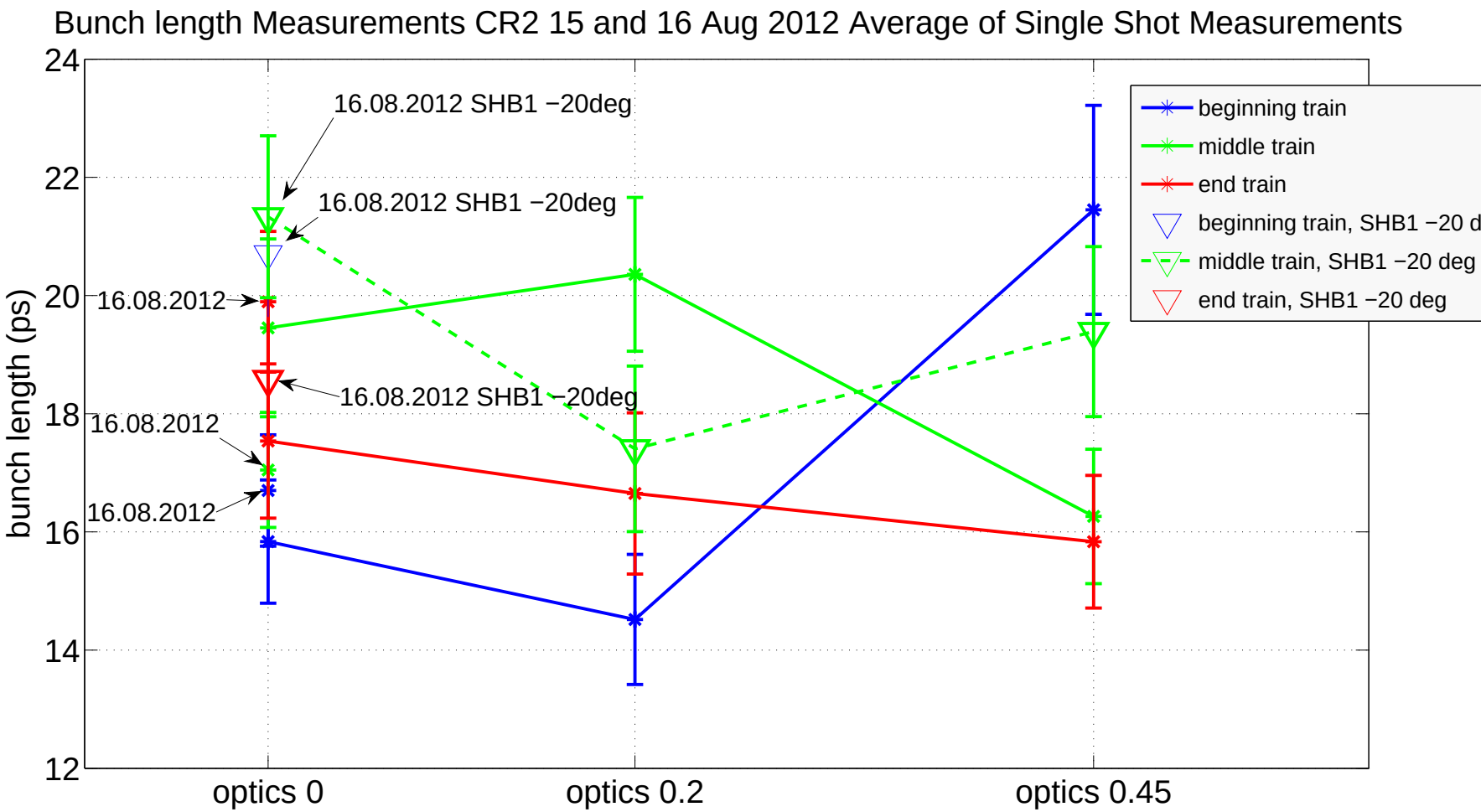
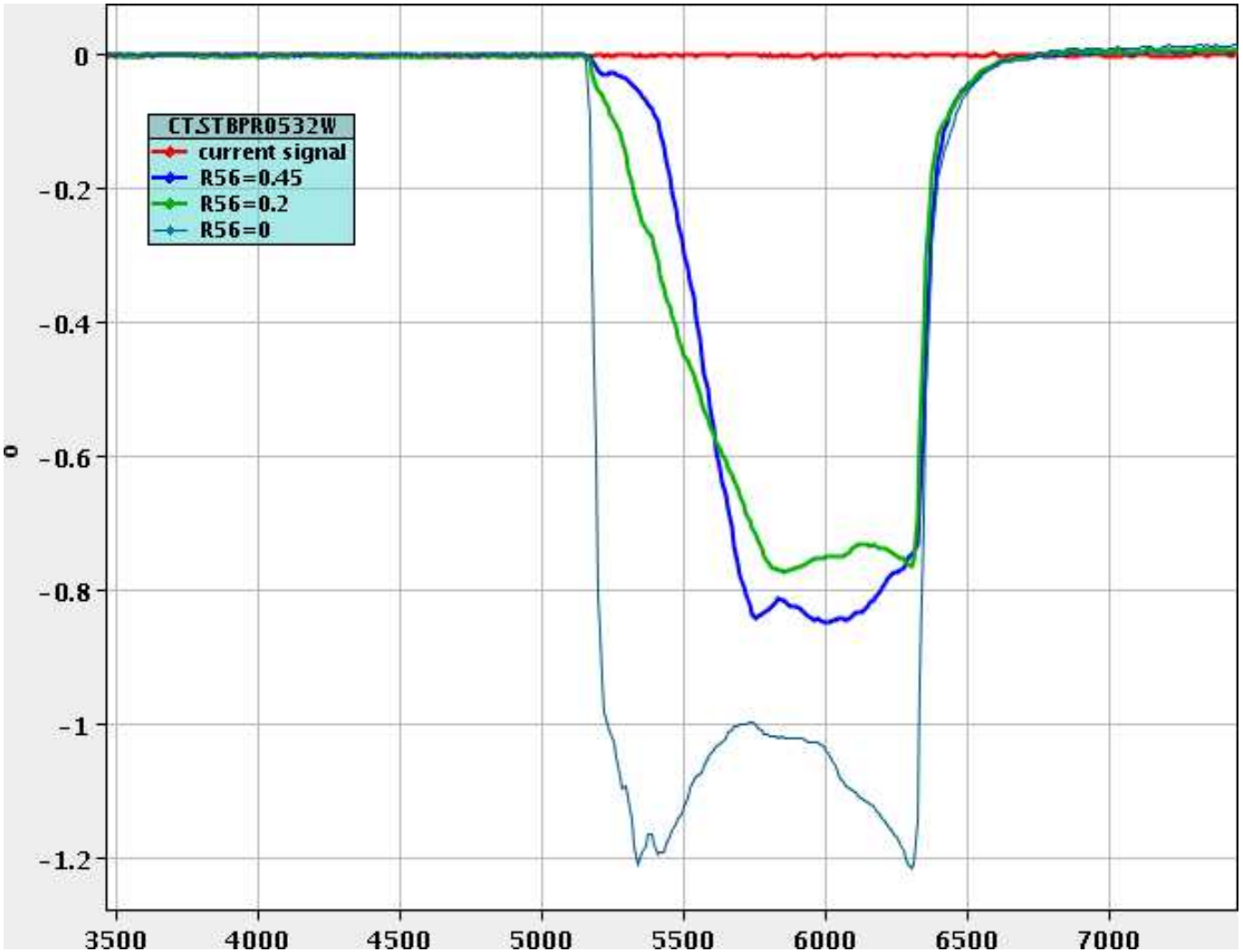
Measurements 15th August 2012

Summary Bunch Length Measurements 15th August

- 3 GHz beam, magnetic injection long pulse 1.2 μs in CR.
- Measurements R_{56}=0,0.2,0.45 / 3 positions along the pulse / 20 deg off SHB1

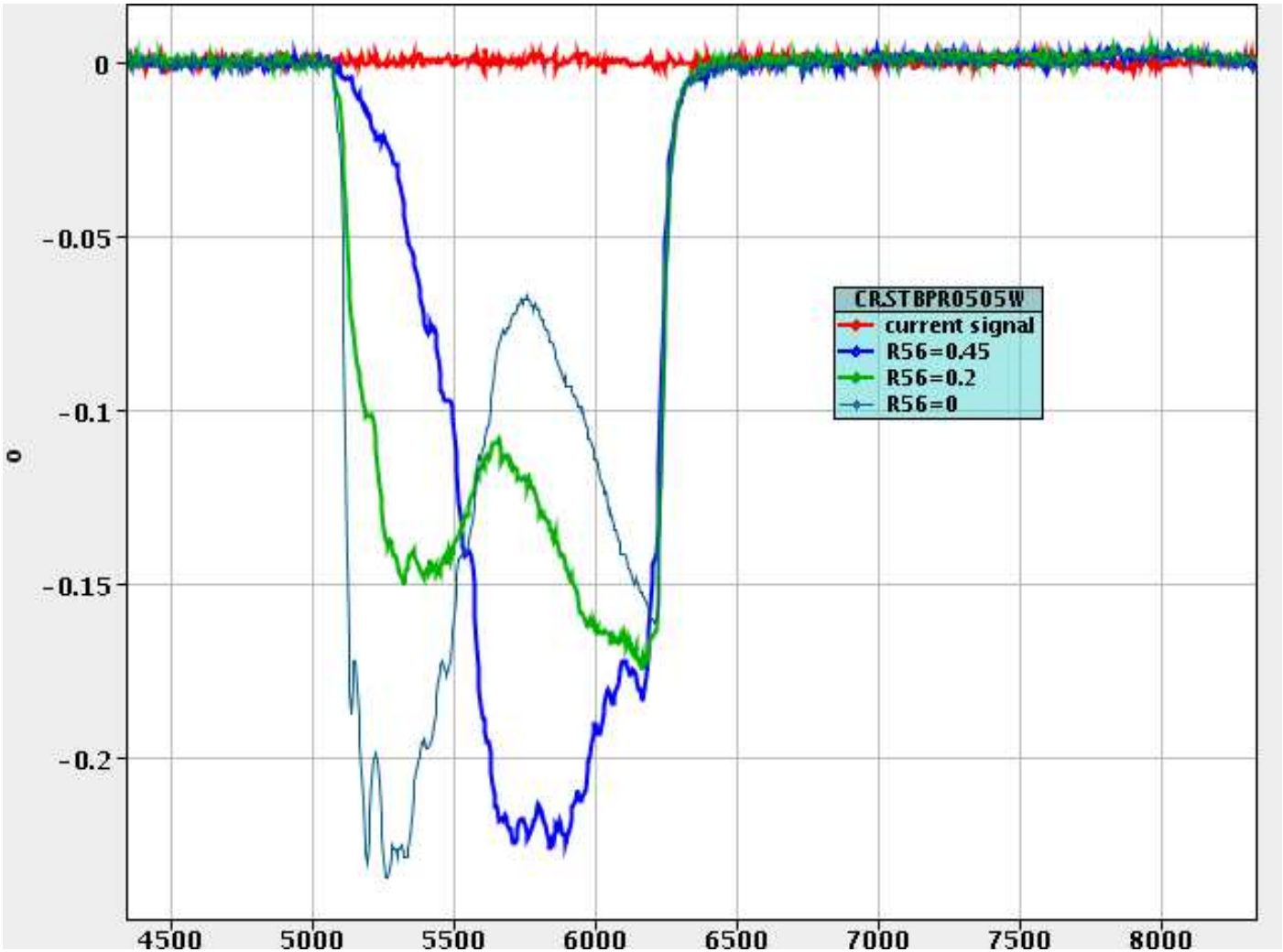


15th August: Waveguides



Again bunch length profiles along the pulse match qualitatively well with BPR signals in the CR but not in CT.

15th August: Waveguides



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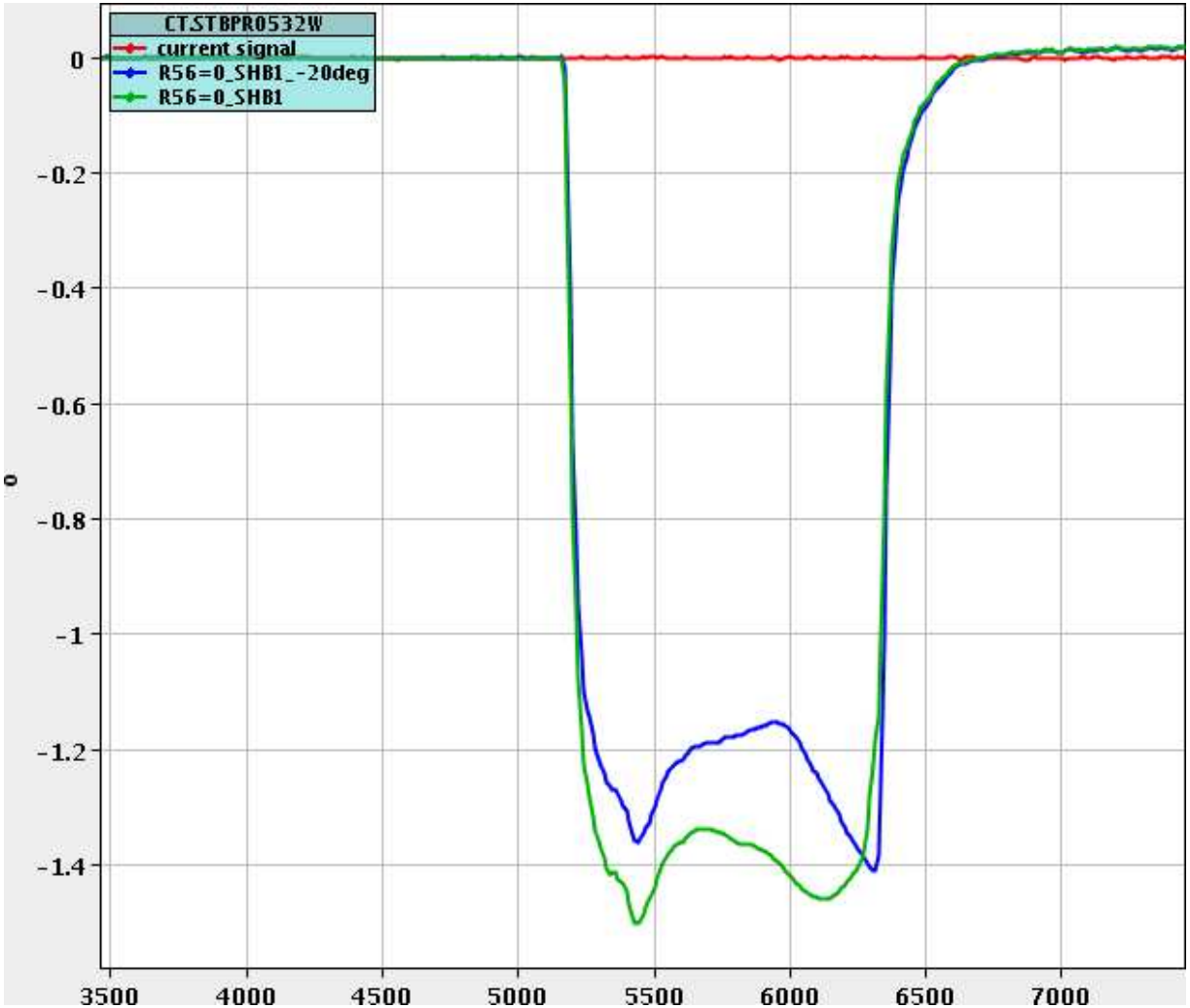

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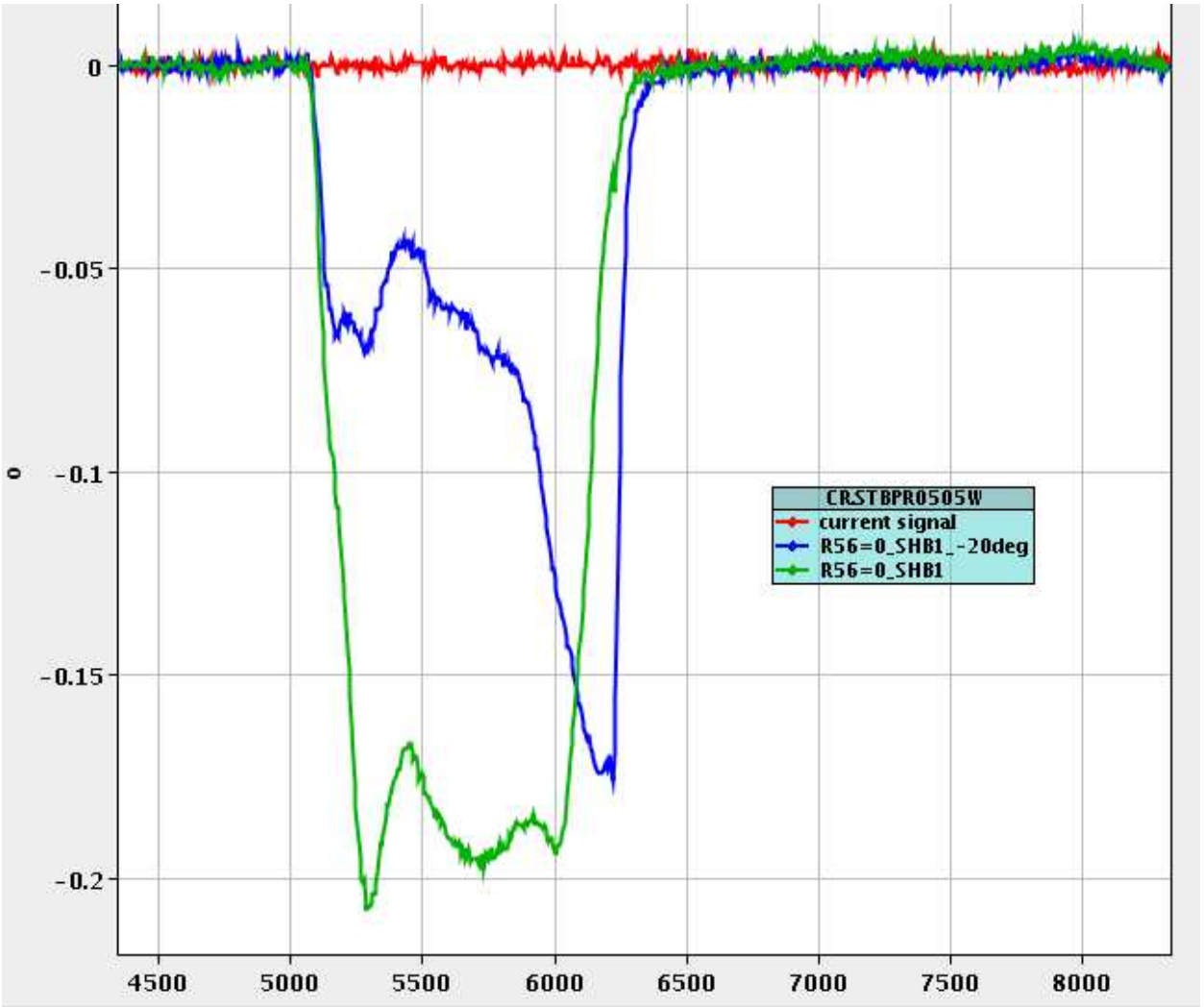

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Summary Bunch Length Measurements 17th August

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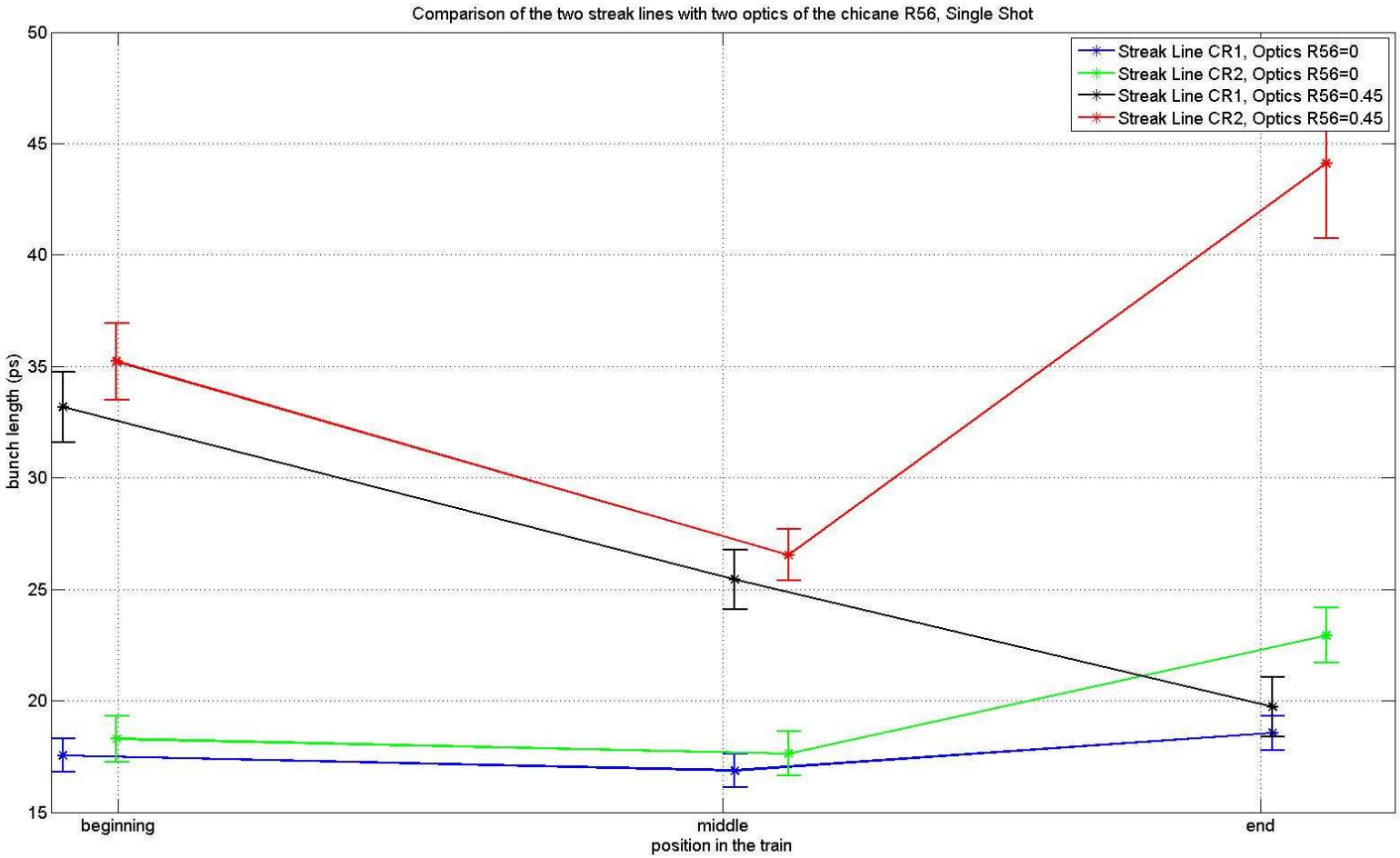
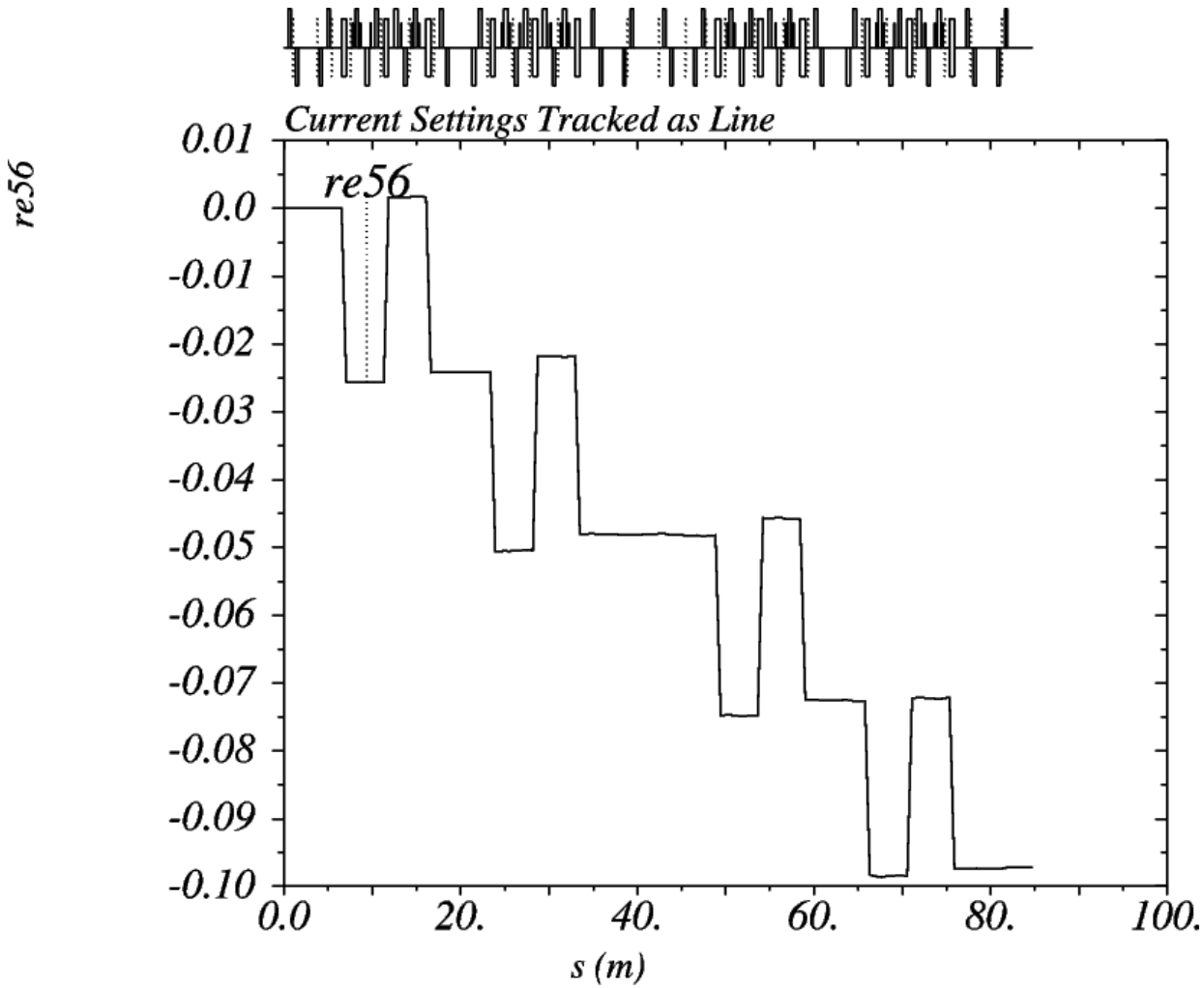


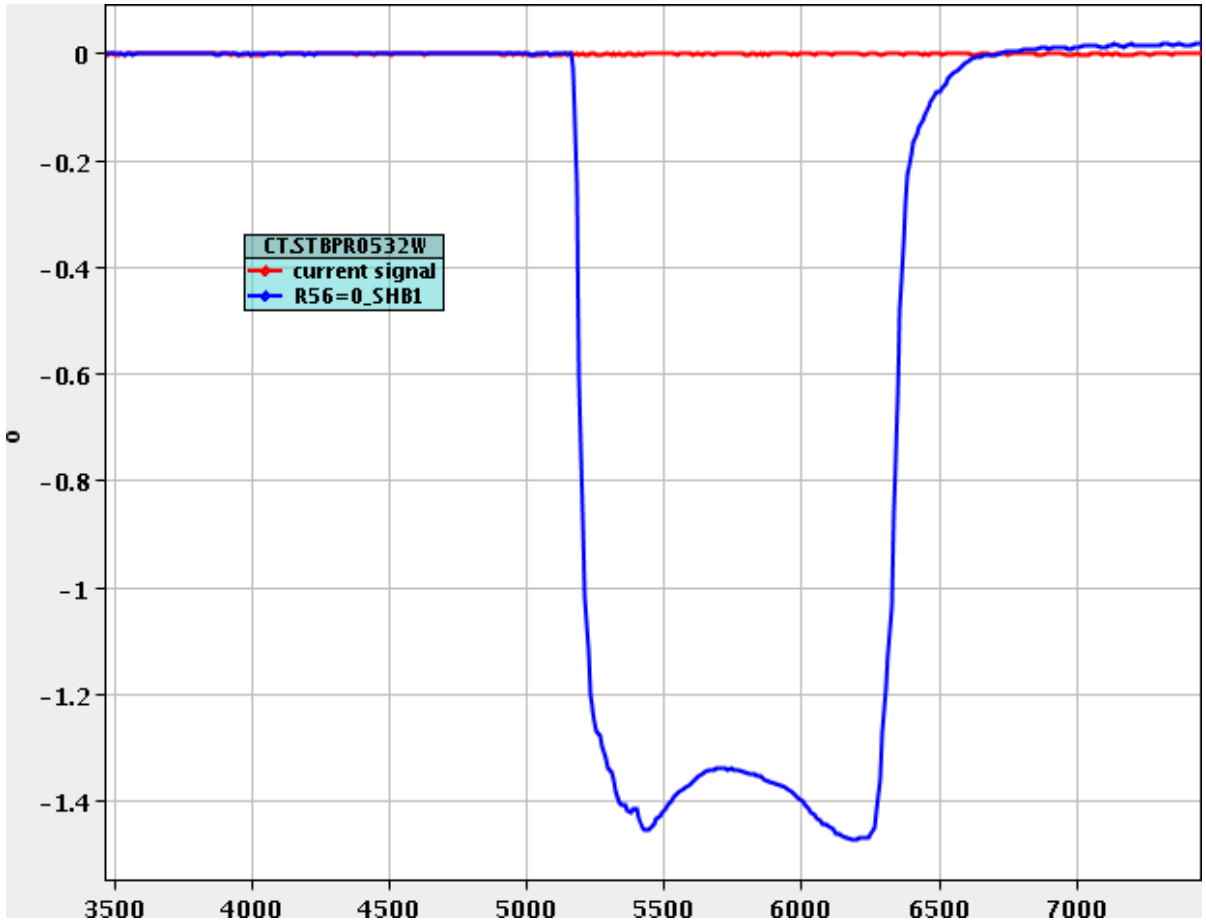
Optics CR1 vs CR2



TL1 and CR are isochronous with the current settings according to the MADX model prediction. Dispersion is very small in both lines as well.

17th August: Waveguides

R_{56}=0.0



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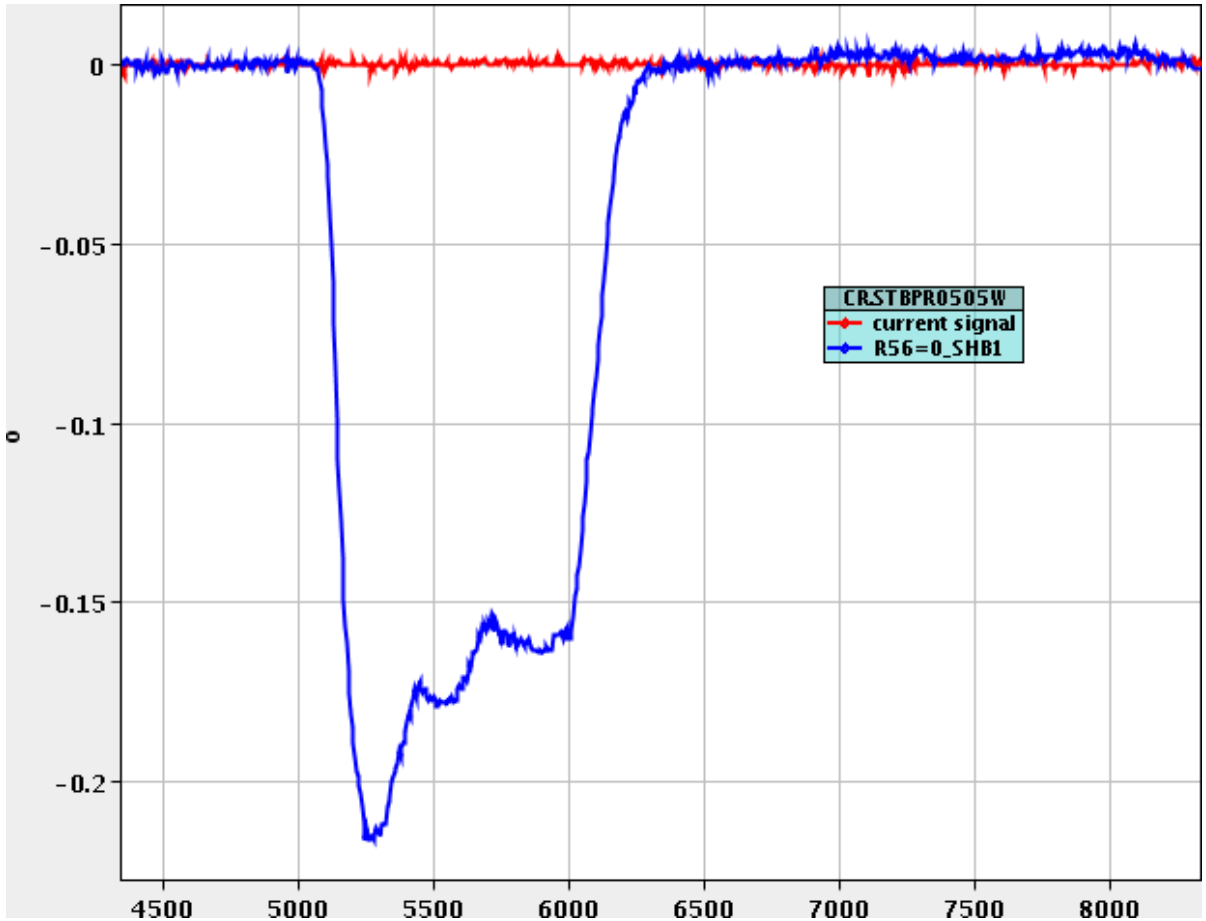

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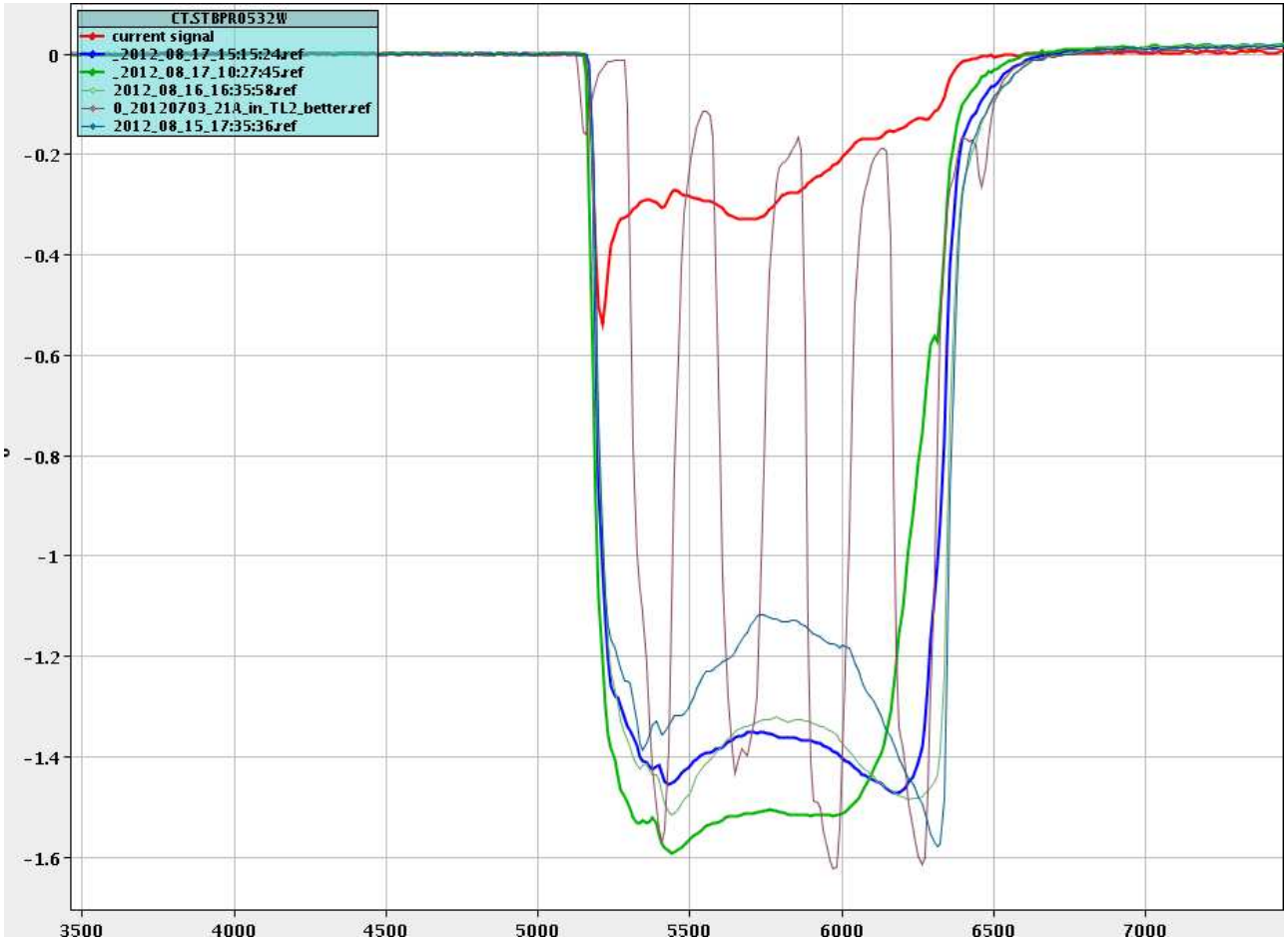

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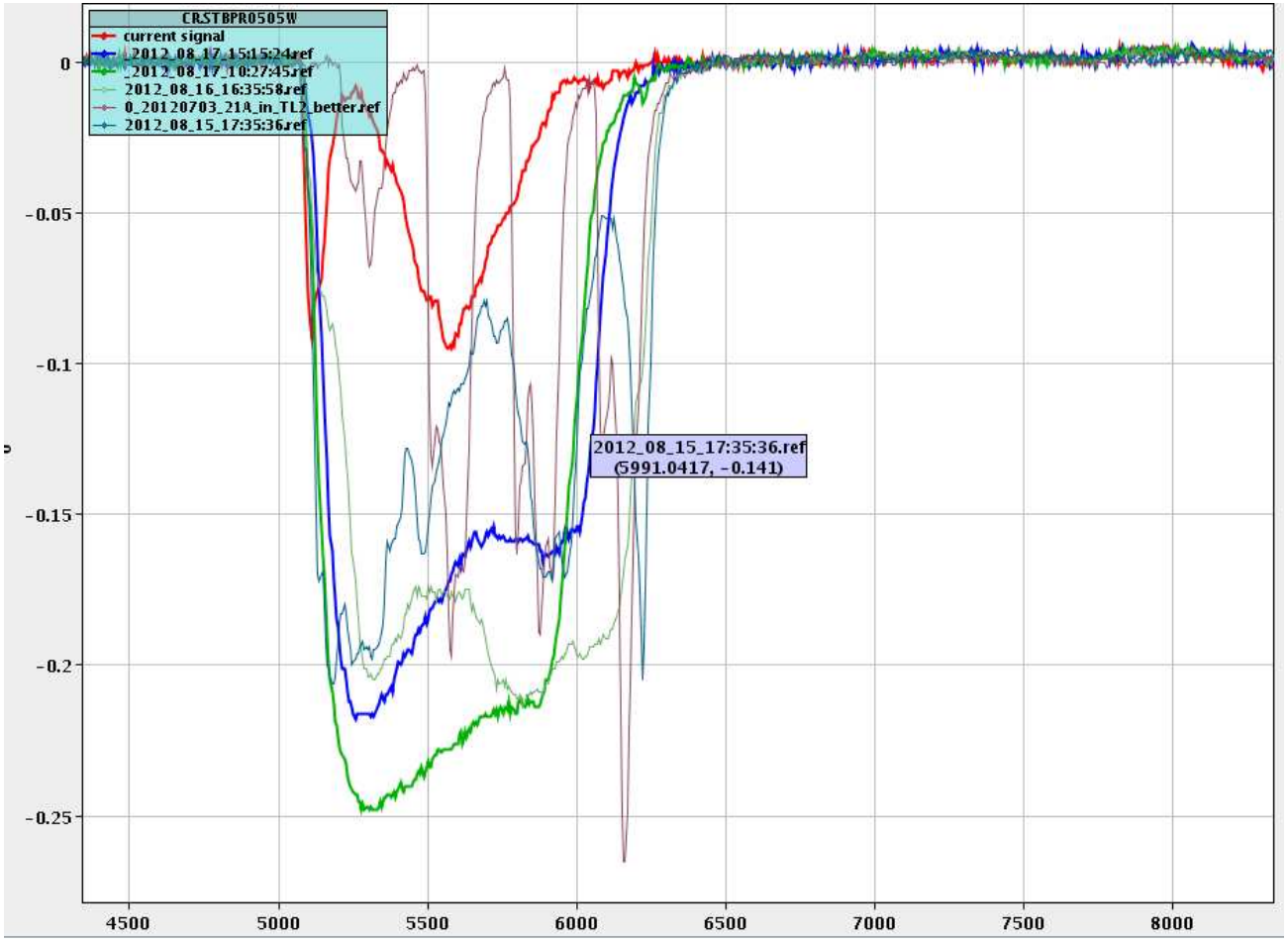

Summary Bunch Length Measurements 17th August

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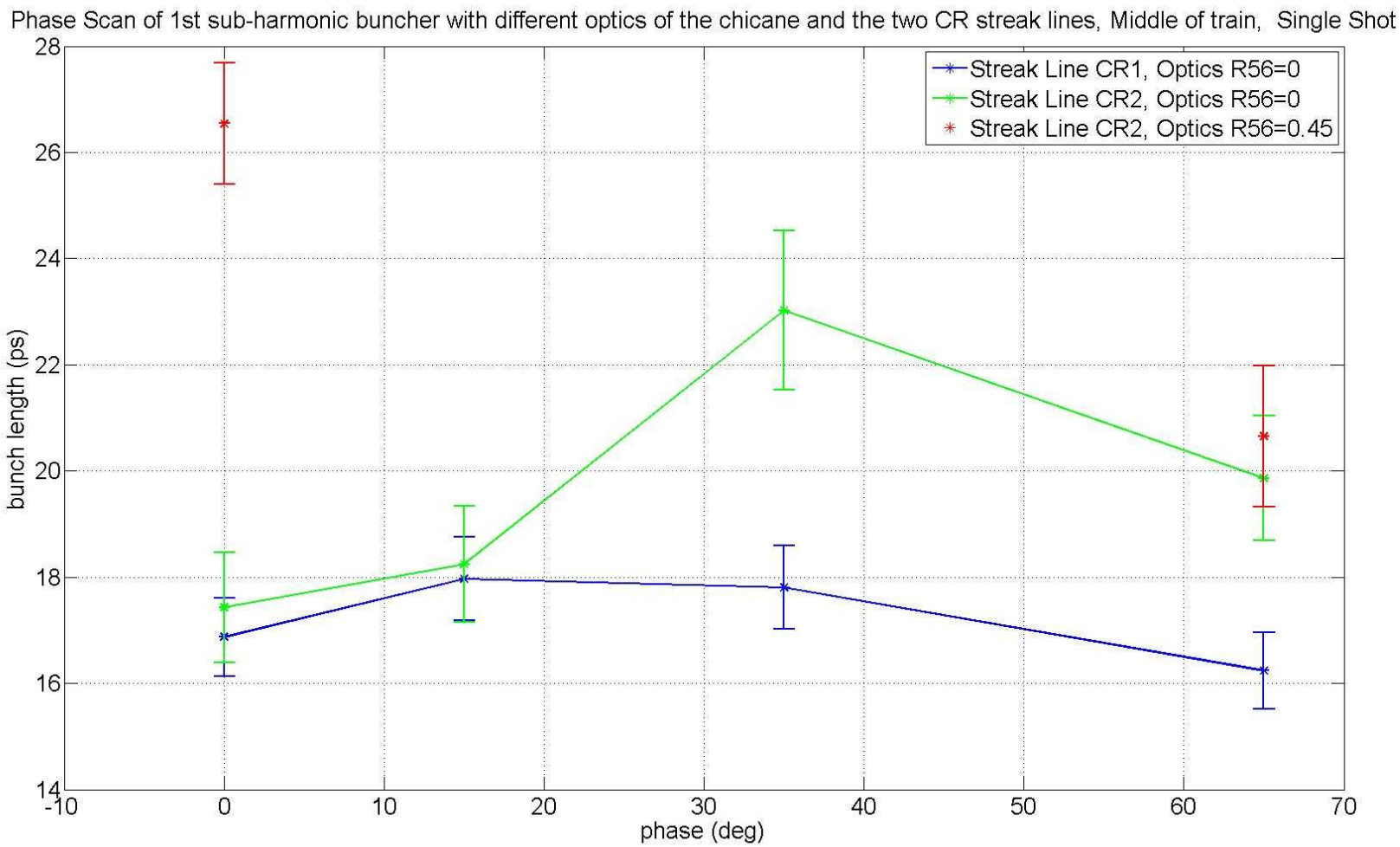
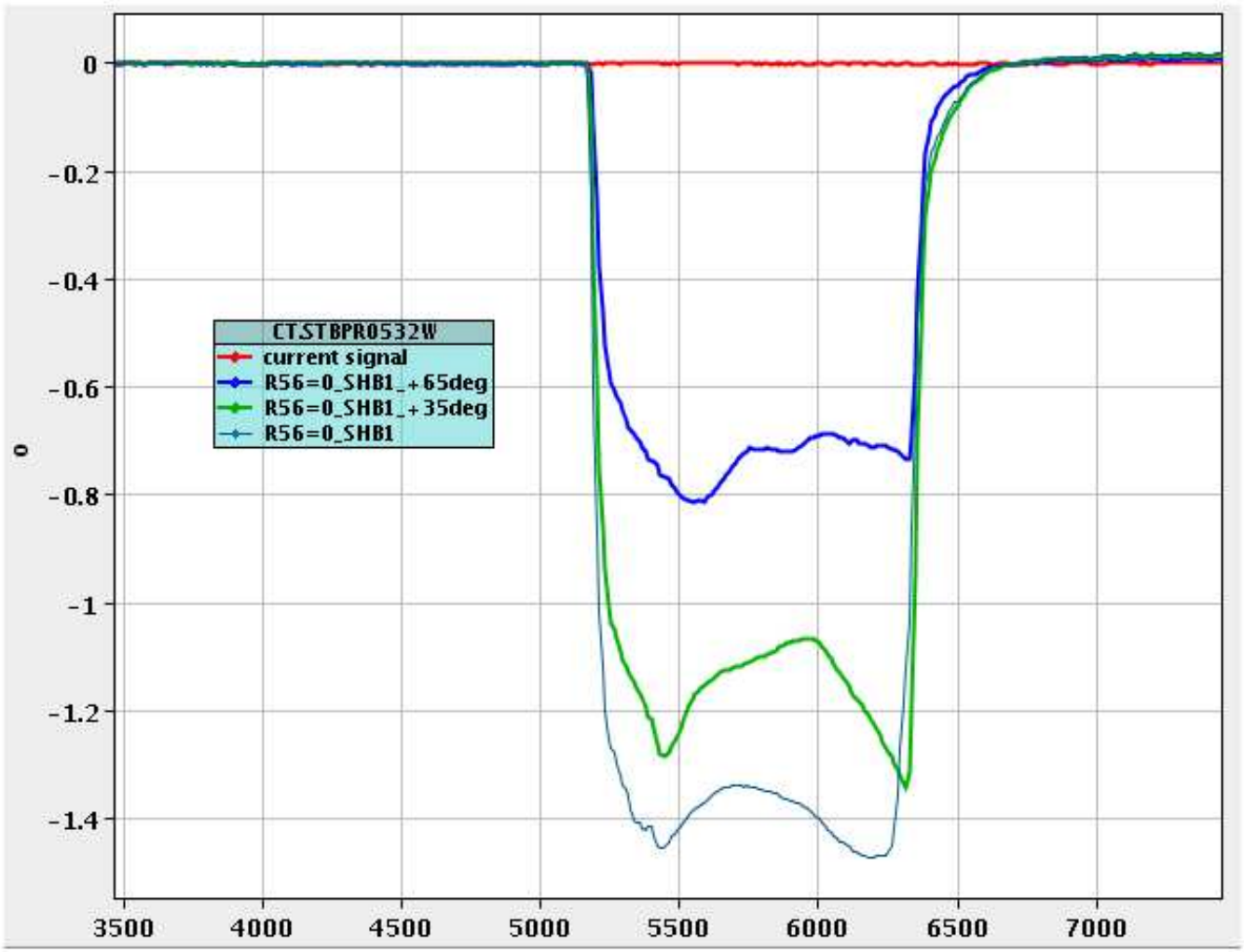


17^{th} August: Waveguides

R_{56}=0.0 SHB1 + 0,35,65 deg



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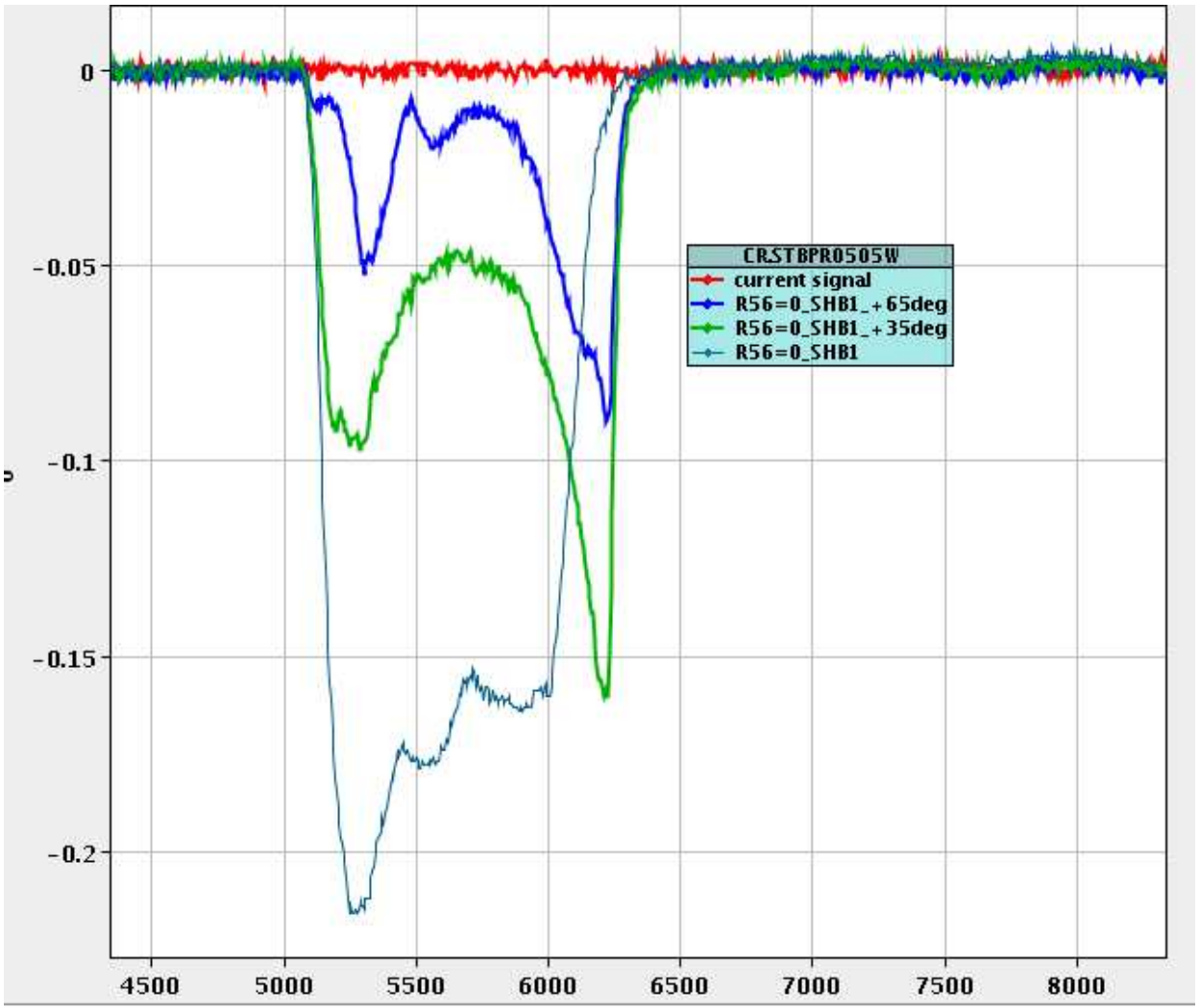

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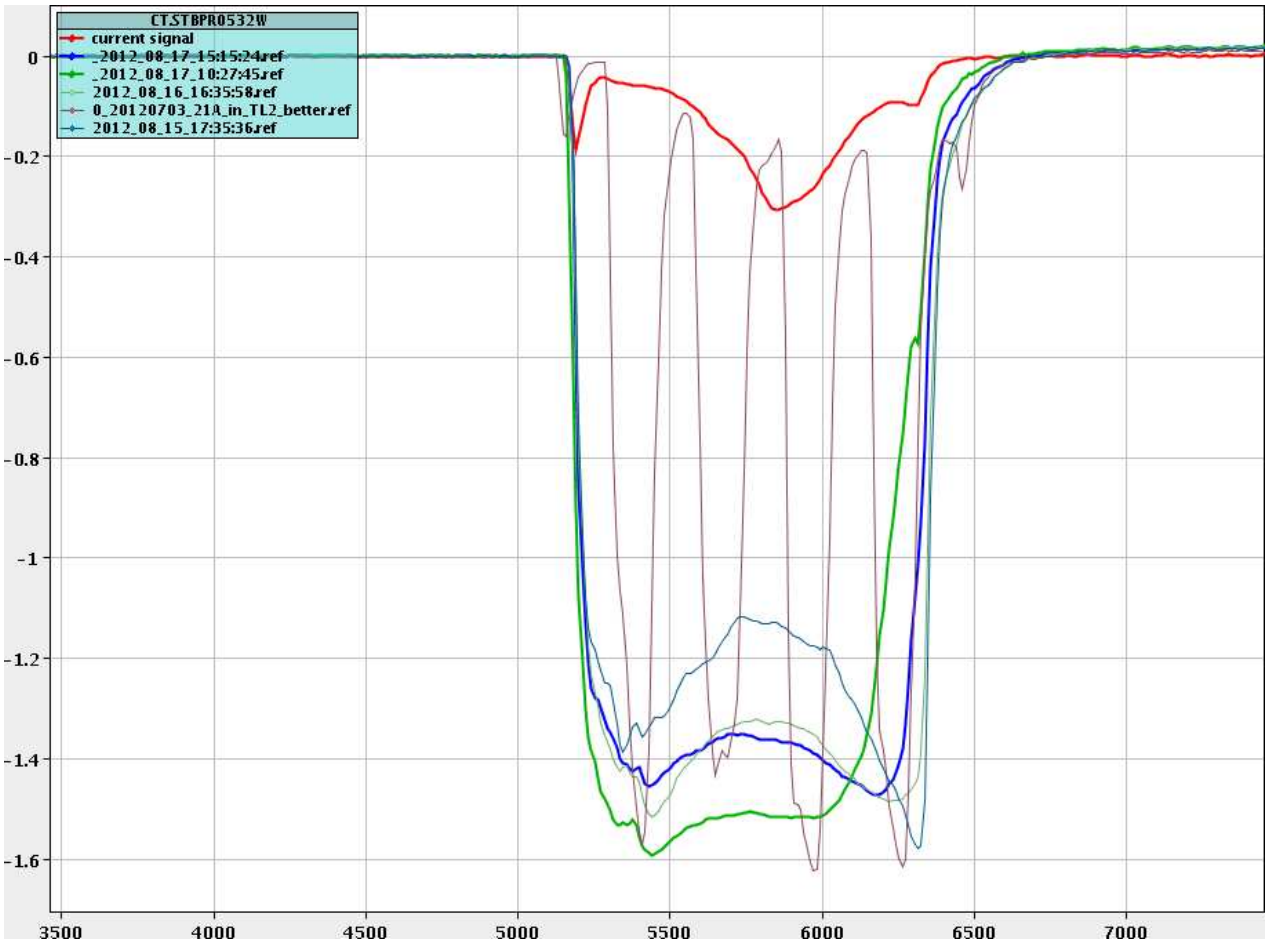

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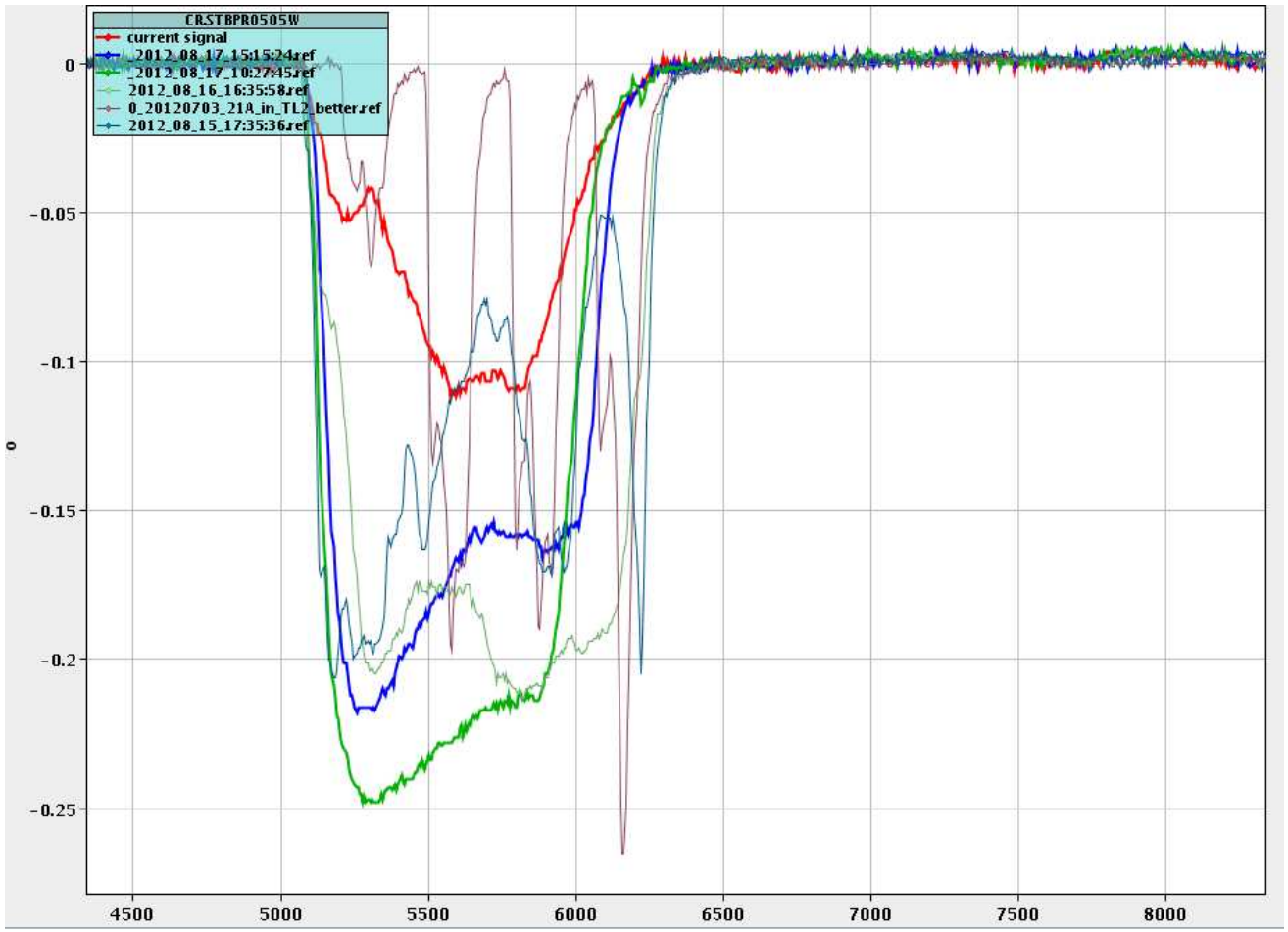
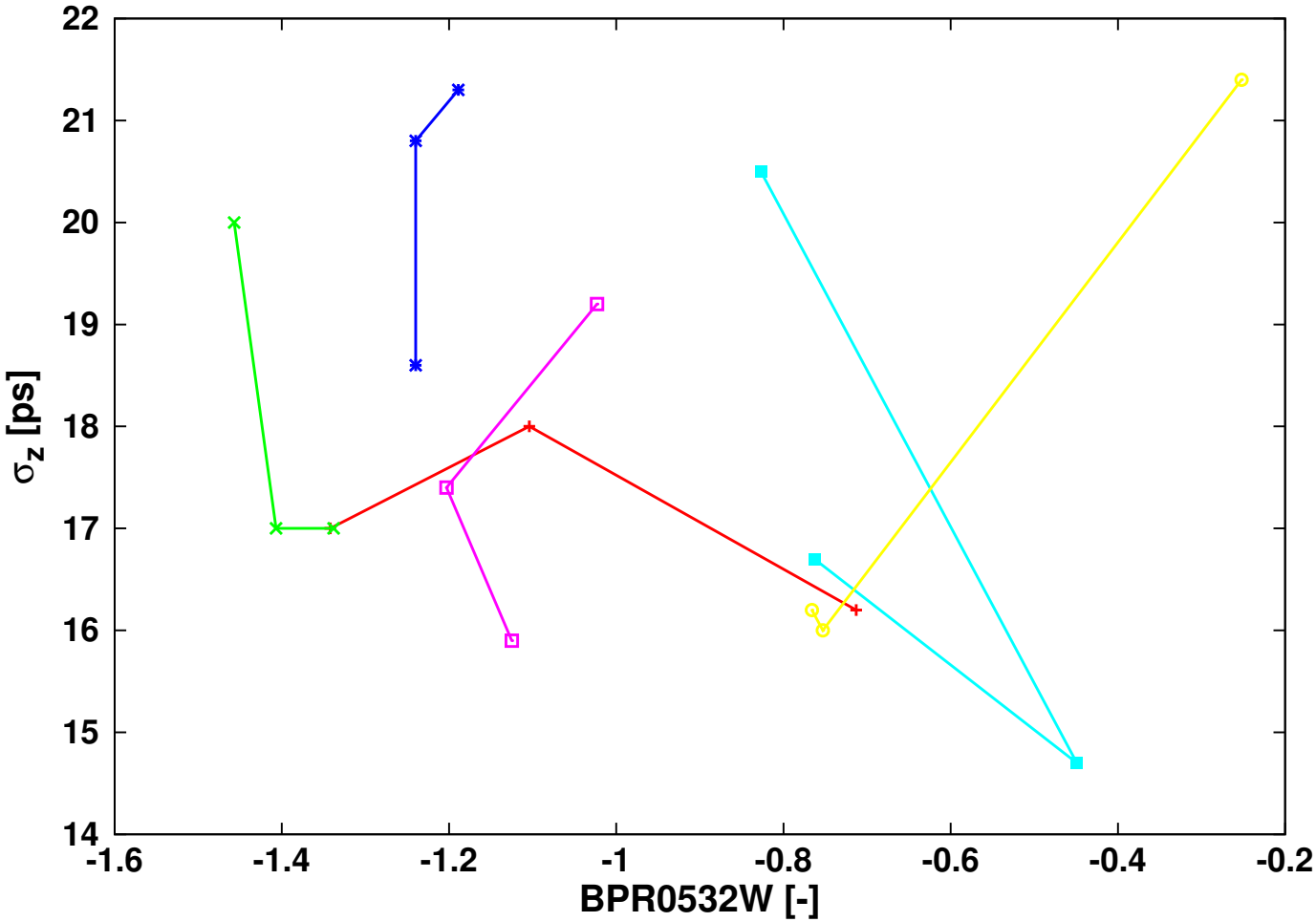


Summary BPR signals vs bunch length

Considering CT.BPR0532,



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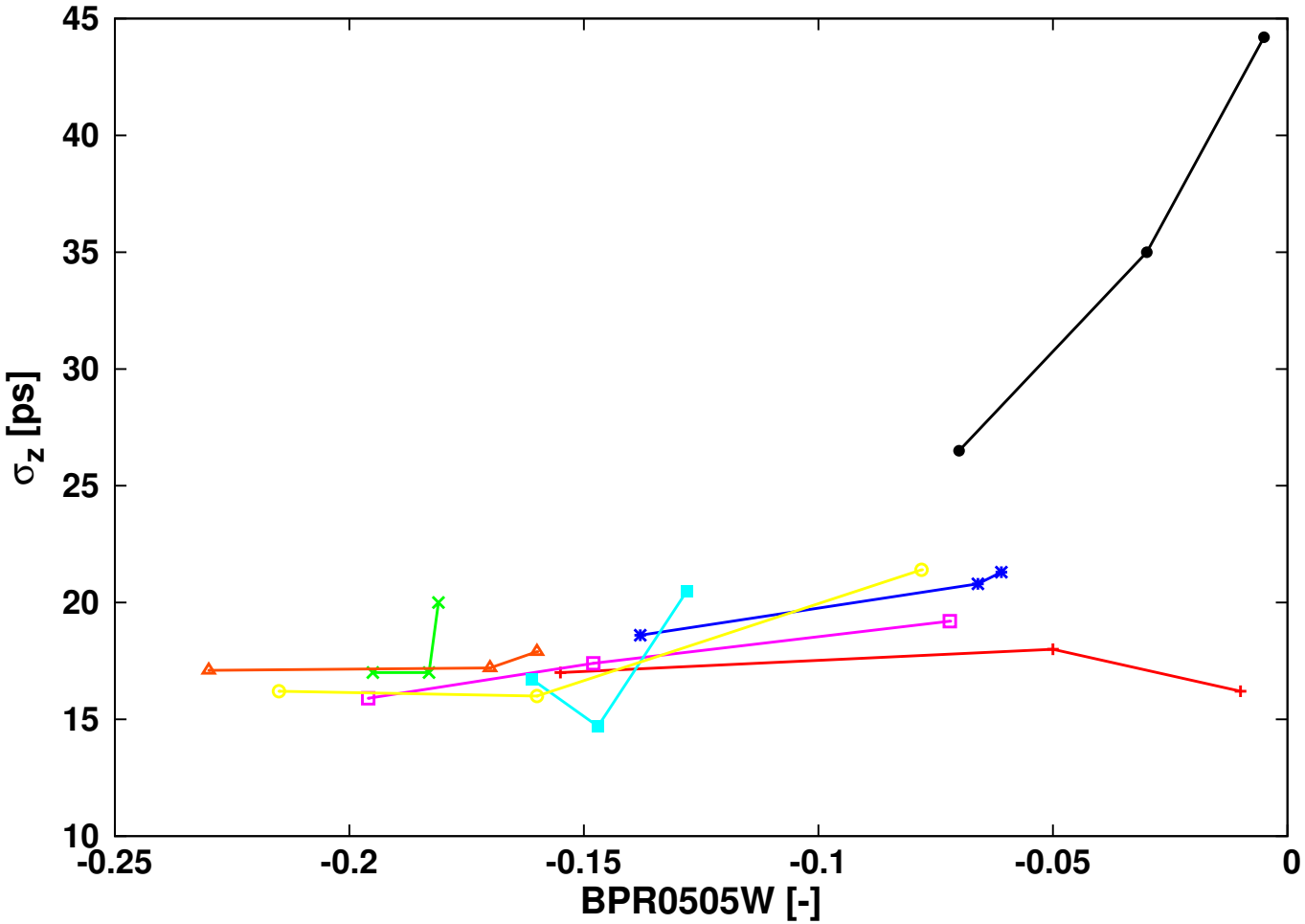

Conclusions & Further Steps

- Good qualitative agreement between bunch length measurements along the pulse and CR.BPR0505. Not so good with CT.BPR0532.
- Depending on the measurement there is a clear decrease of bunch length for smaller R_{56}.
- For relative measurements the streak camera should be precise as dispersion, jitter and optics alignement have no influence.
- Still some issues in the optics prediction forward propagating from MTV1025 and back propagating from MTV0435.
- Missing systematic measurements of bunch length measurement for different R_{56} optics together with power production in TBL/TBTS.
- Option of measuring the bunch length in the DL. The optics in the measurement point to be checked.