Instrumentation Technologies

Design of cavity BPM electronics for the ELI-NP project

Manuel Cargnelutti, Instrumentation Technologies

Presentation outline

- The ELI-NP project
- Cavity BPM requirements
- Electronics layout and simulations
- Conclusions

The ELI-NP project

Magurele - Romania

Very high intensity laser

- 2x 10 PW lasers added coherently

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Very intense brilliant γ beam

- obtained by incoherent Compton back scattering

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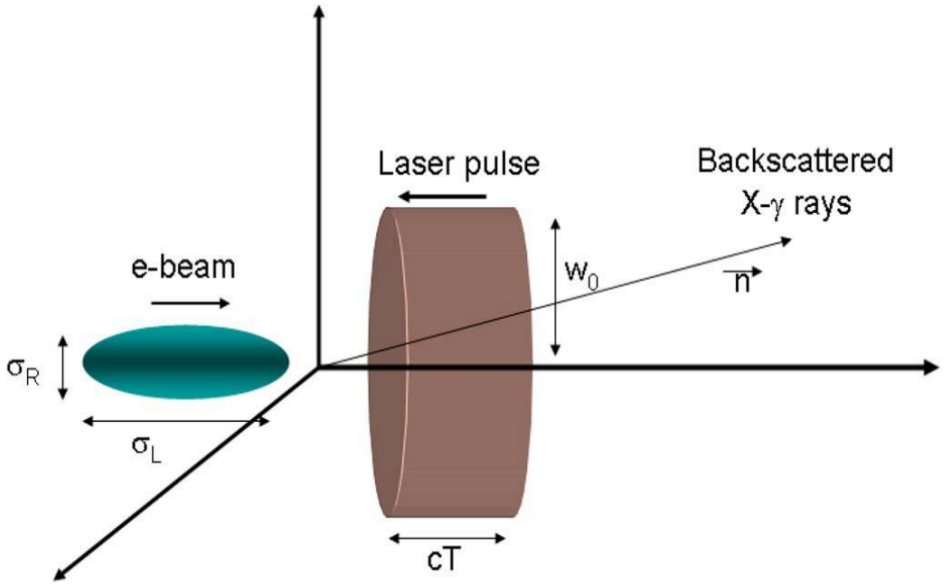
Single and Combined studies

Spectroscopy at high nuclear excitation energy and many others

Compton back scattering

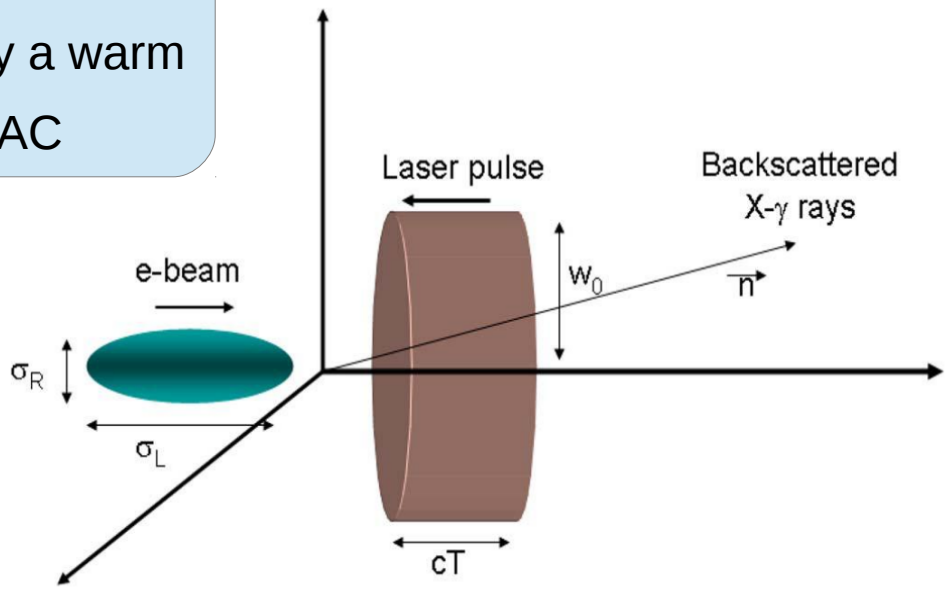
Interaction between relativistic electrons and laser pulses



Compton back scattering

Interaction between relativistic electrons and laser pulses

720 MeV electrons produced by a warm C-band LINAC



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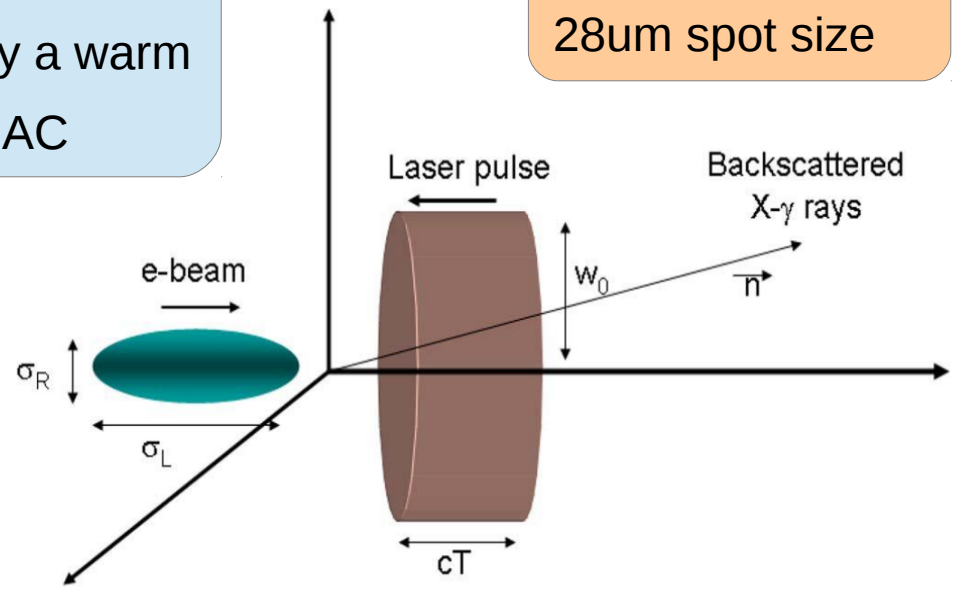
28um spot size



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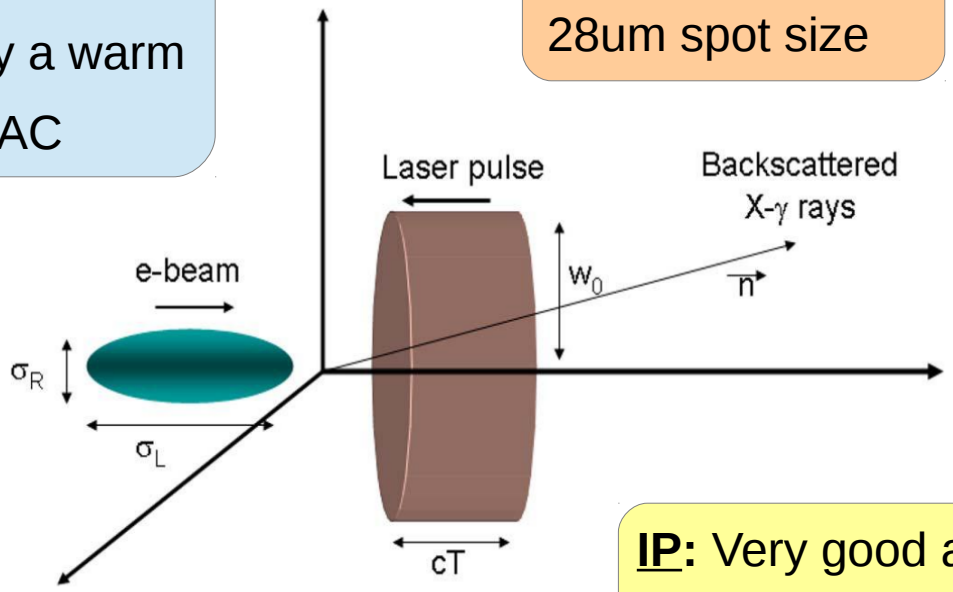

IP: Very good alignment is required → **BPM resolution**!

Electron Beam Parameters:

Parameter	Value
Energy (MeV)	80-720
Bunch charge (pC)	25-400
# bunches in the train	≤ 32
Bunch separation (ns)	**16.1**

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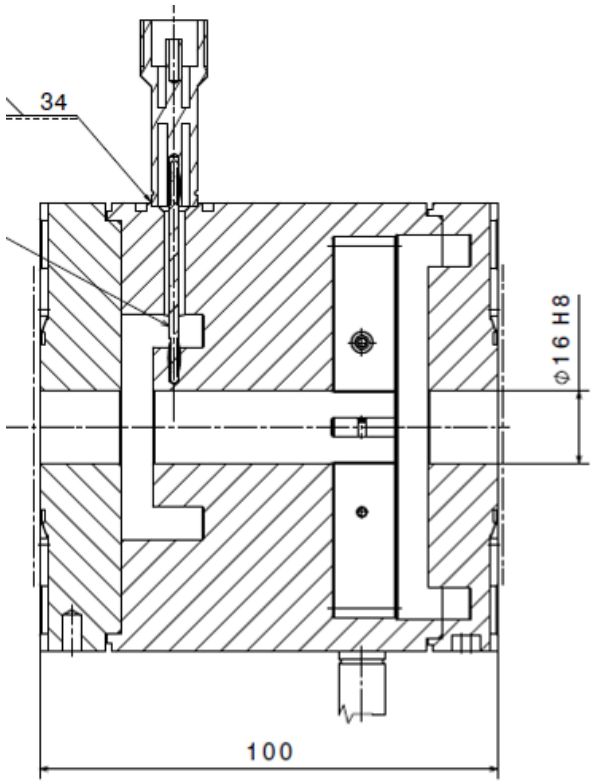
BPM requirements:

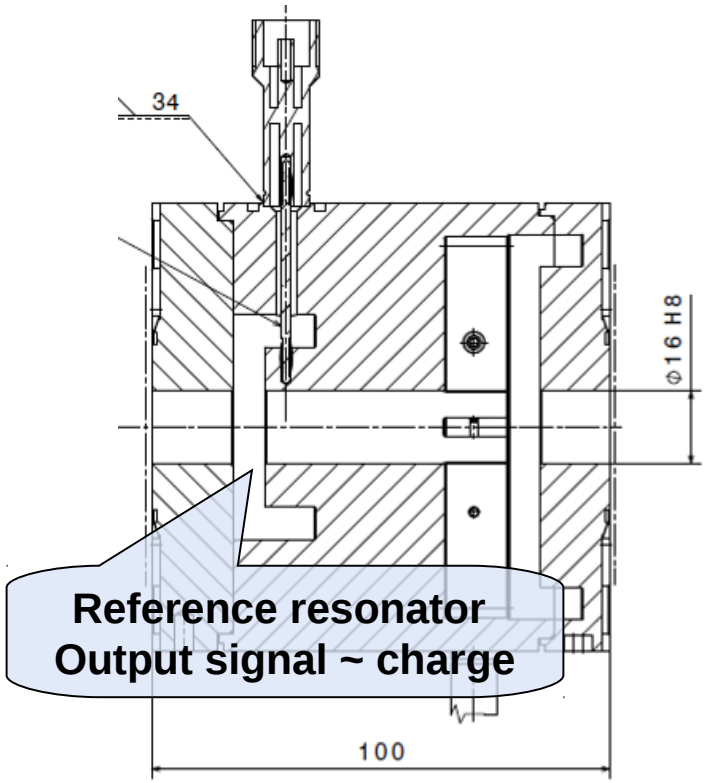
- Sub-μm position resolution in the range of +/- 1mm
- Bunch-by-bunch position measurement

Cavity BPM pickup



PSI – BPM16 pickup

Cavity BPM pickup



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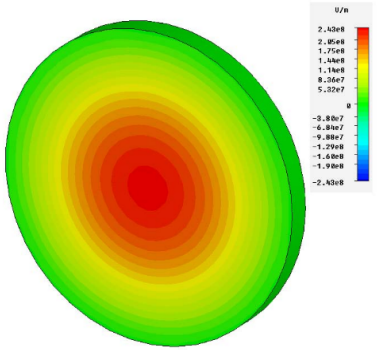
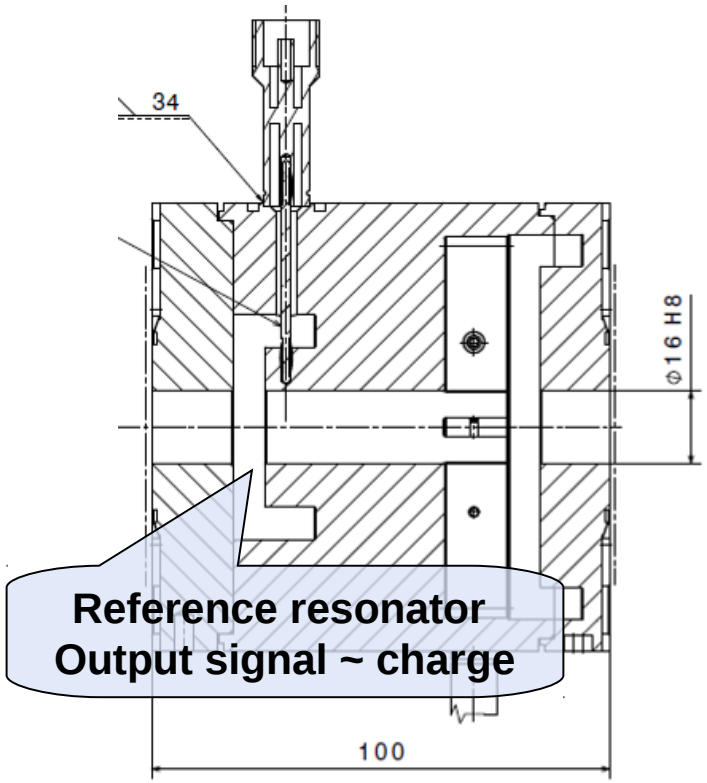


Mode TM_{110}



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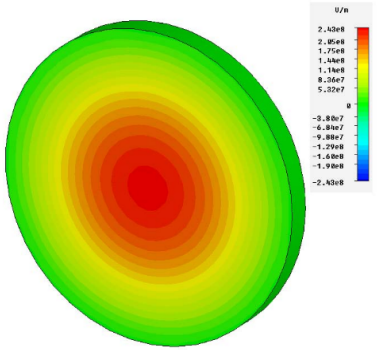

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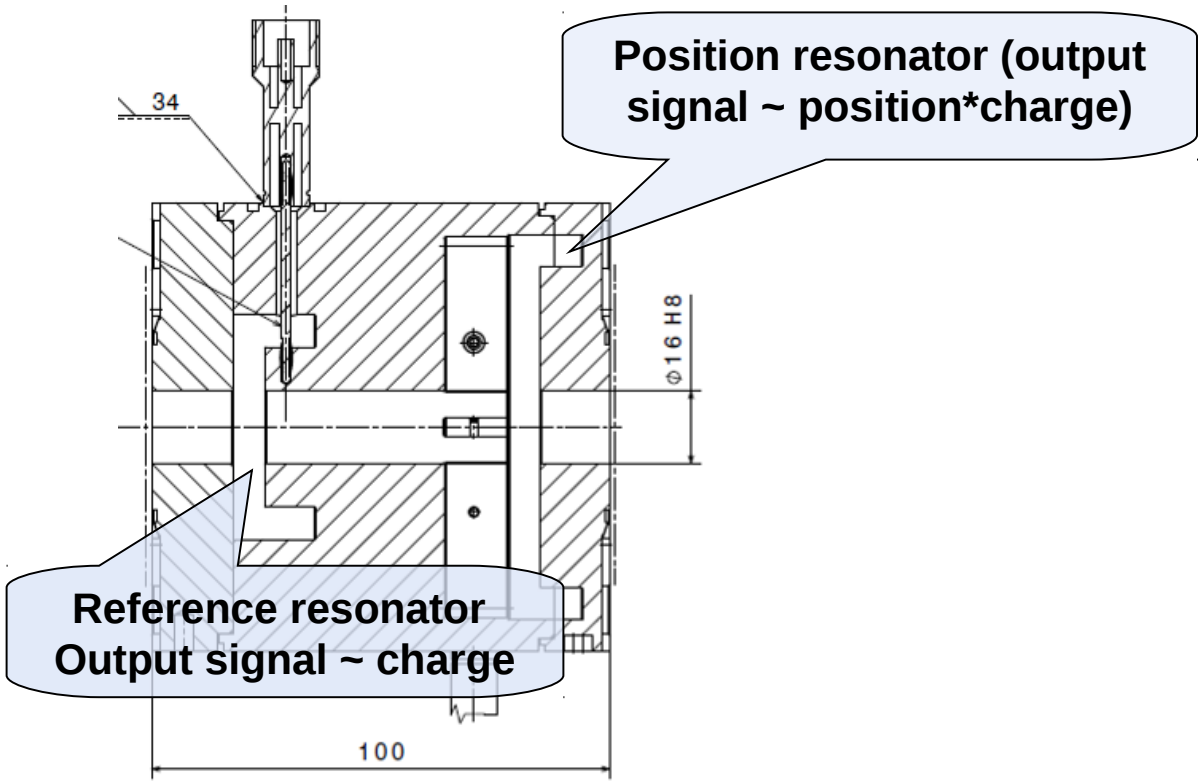

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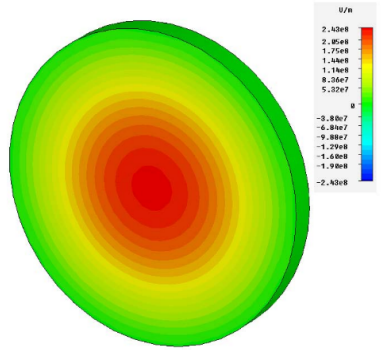

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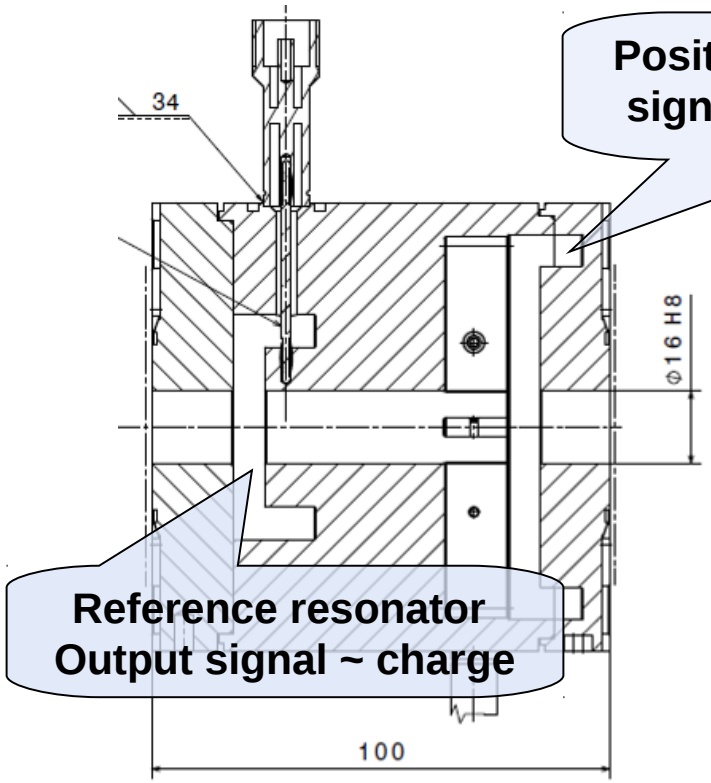
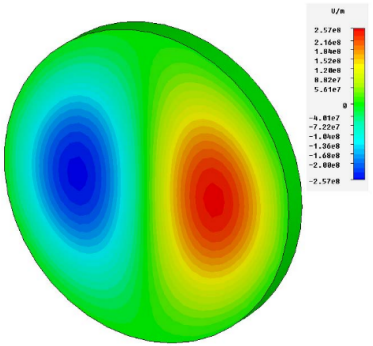
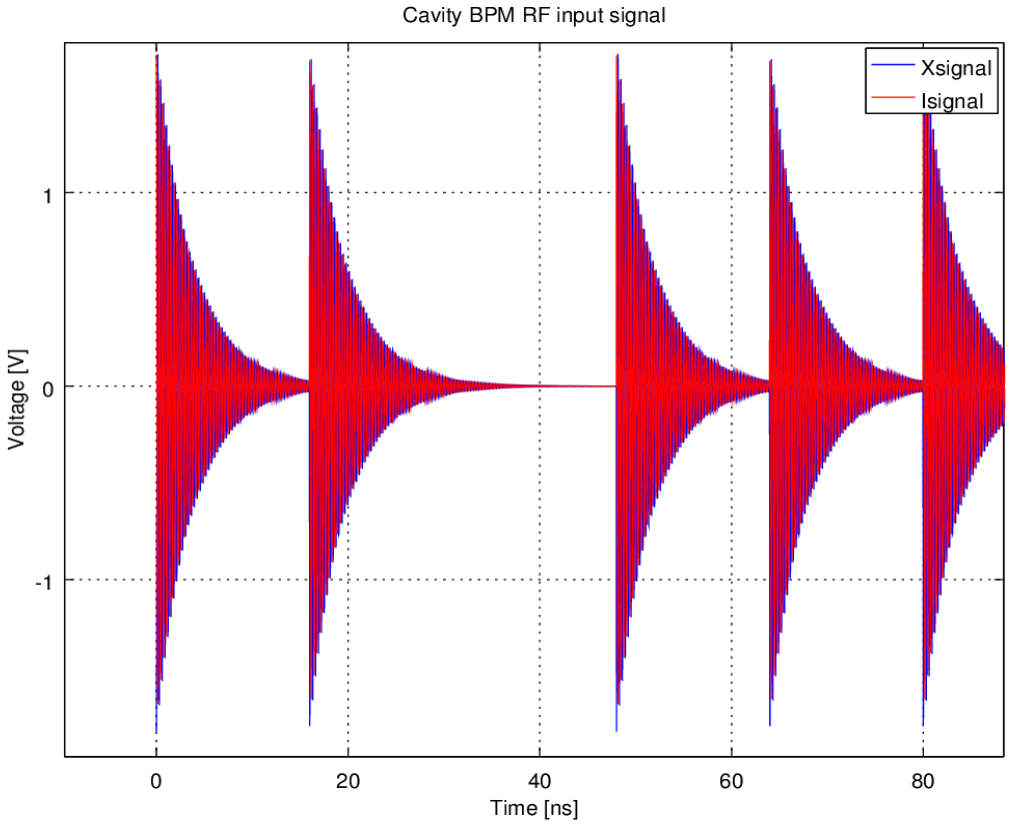




Mode TM_{010}

PSI – BPM16 pickup

Cavity BPM output signal



$$f_{res} = 3.284 GHz$$

$$Q = 40$$

$$T_{decay} \cong Q/f_{res} = 12.1 ns$$

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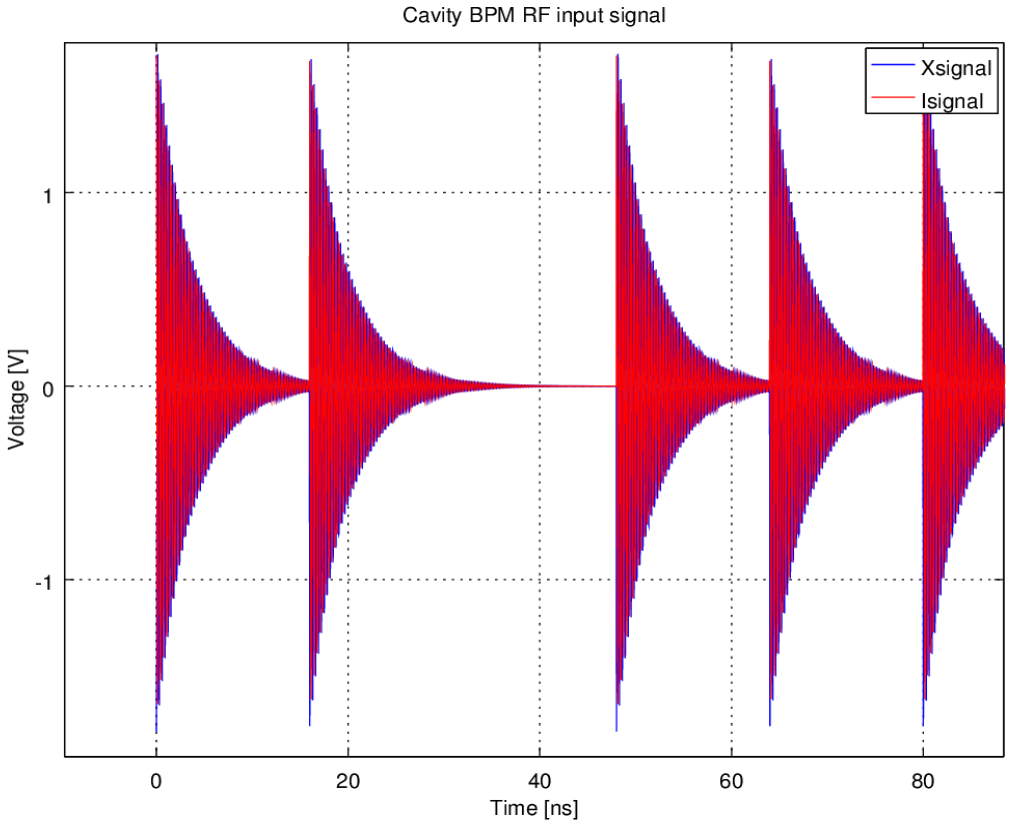

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$$V_{ref} : -3 \div 18\, dBm$$

$$V_{x,y} : 23 \div 45\, dBm$$

Cavity BPM electronics

Libera Spark

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Libera Spark

+

- Down-conversion
- ADCs @ 500MHz
- Xilinx ZYNQ 7045
- Specific algorithms

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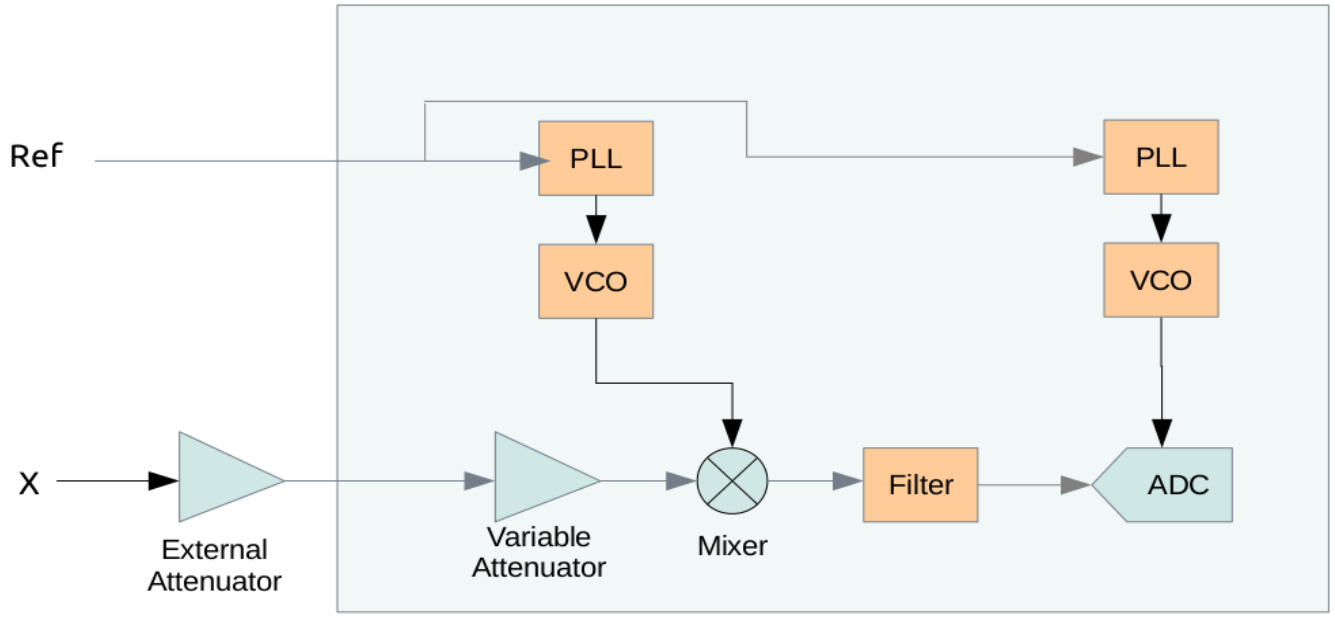
- S-band, C-band and X-band
- High-Q and Low-Q
- Single bunch and bunch trains

Cavity BPM electronics



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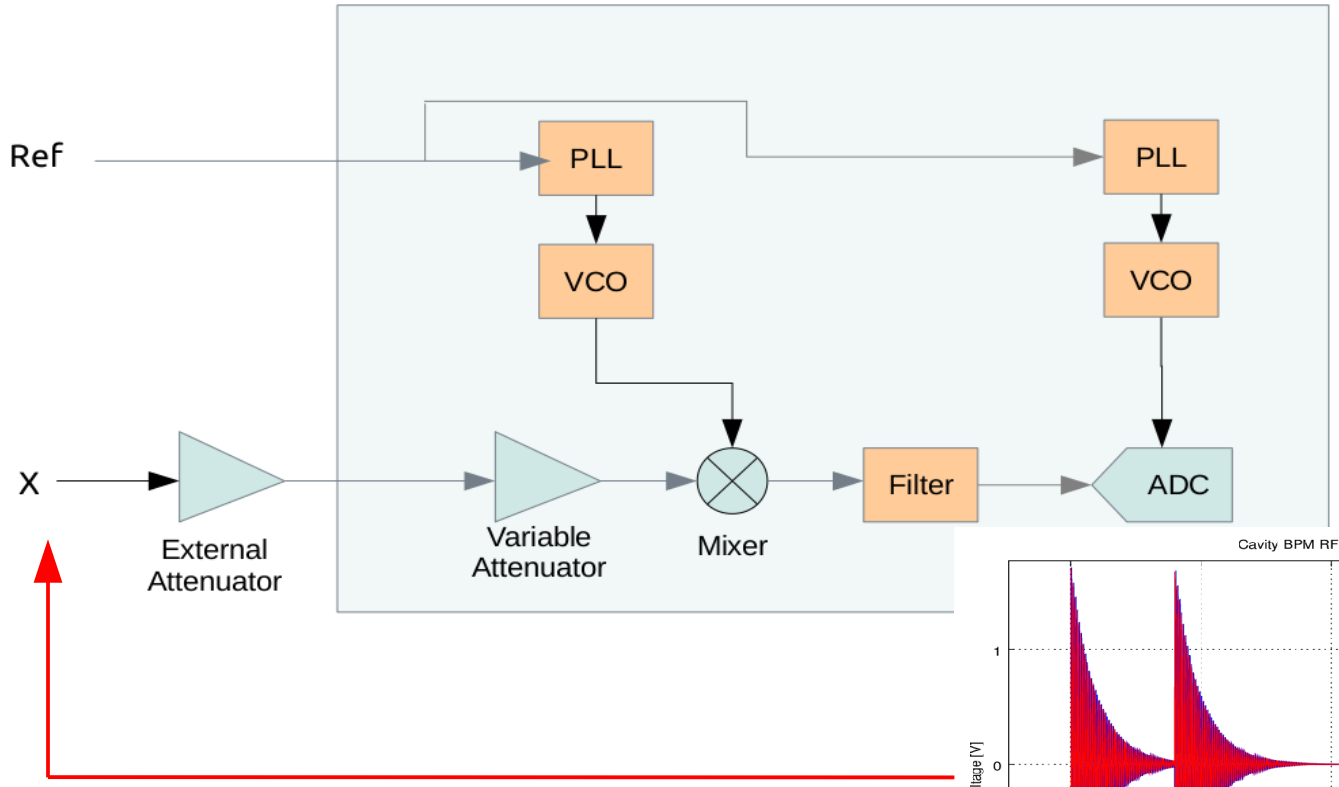

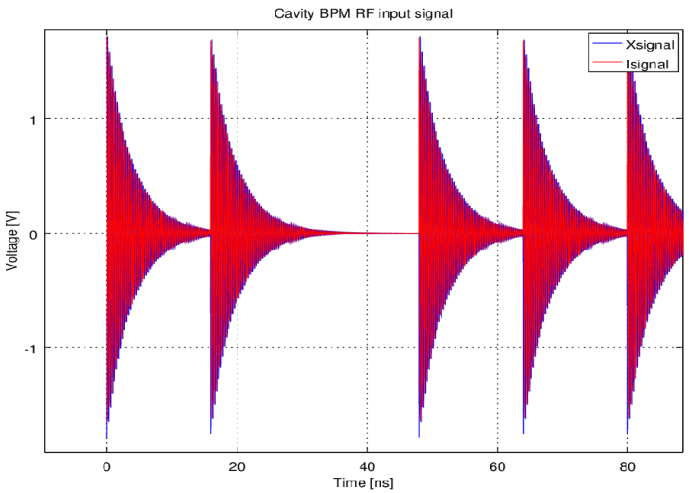

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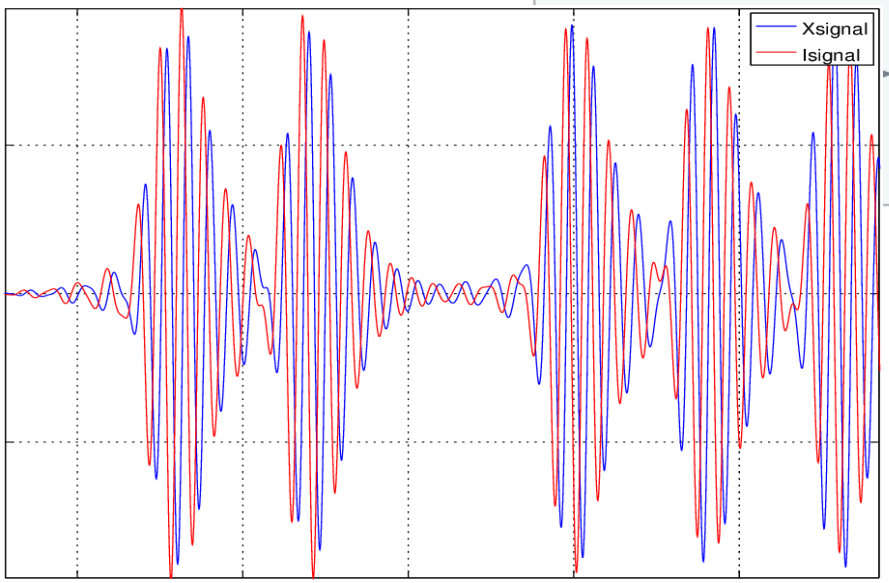

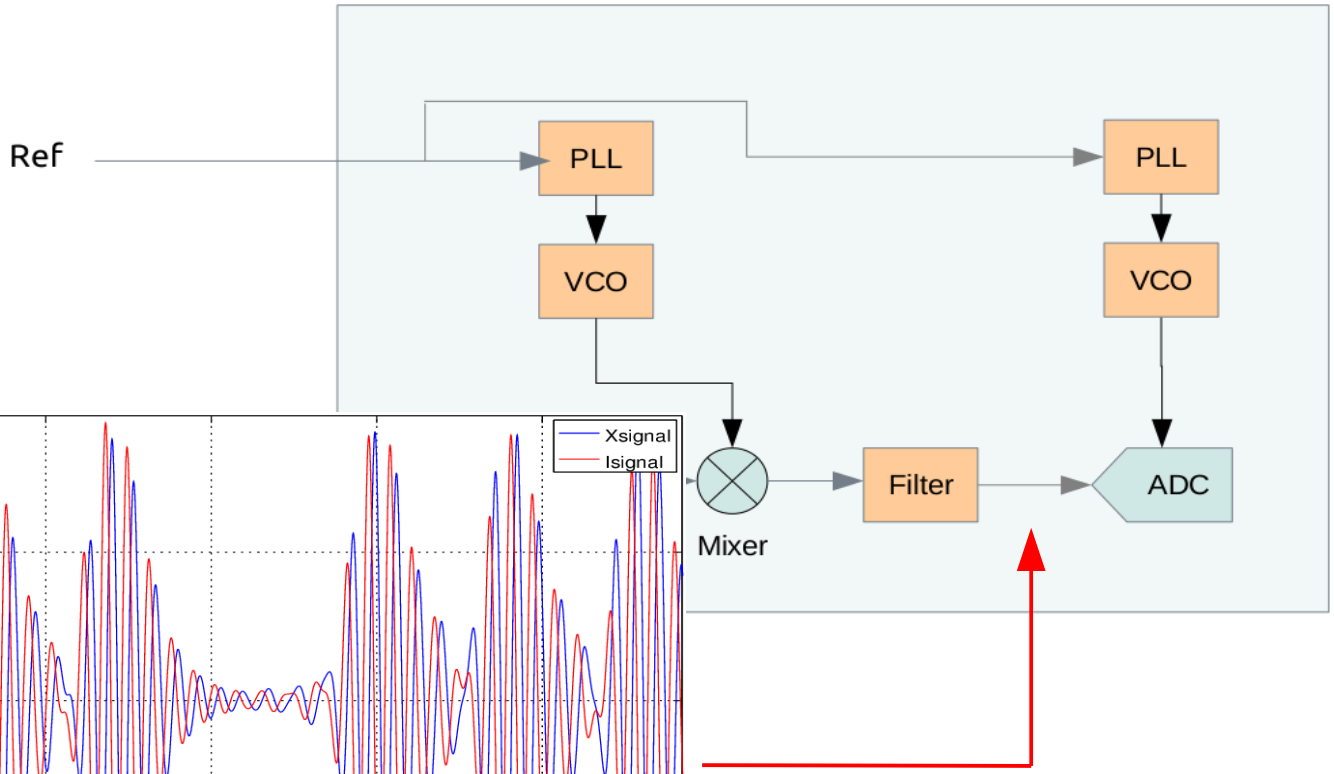

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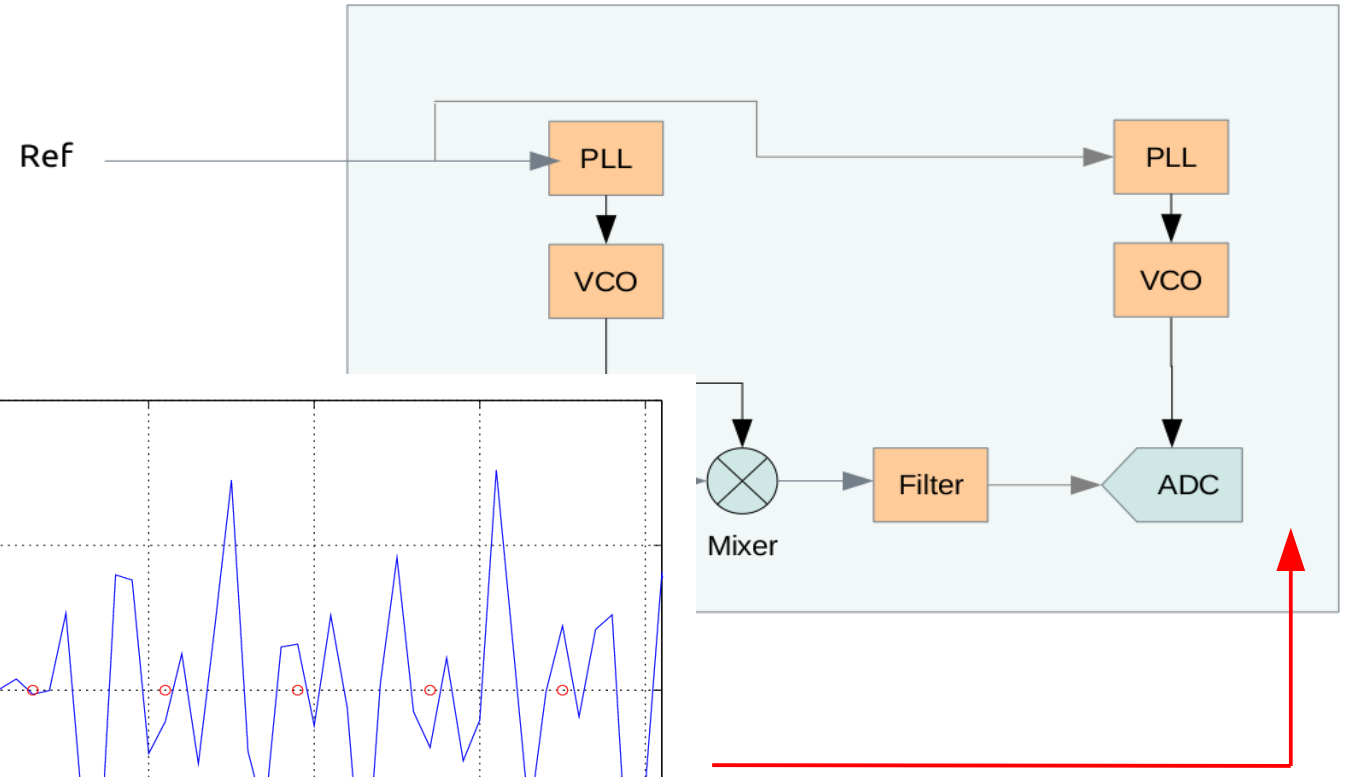
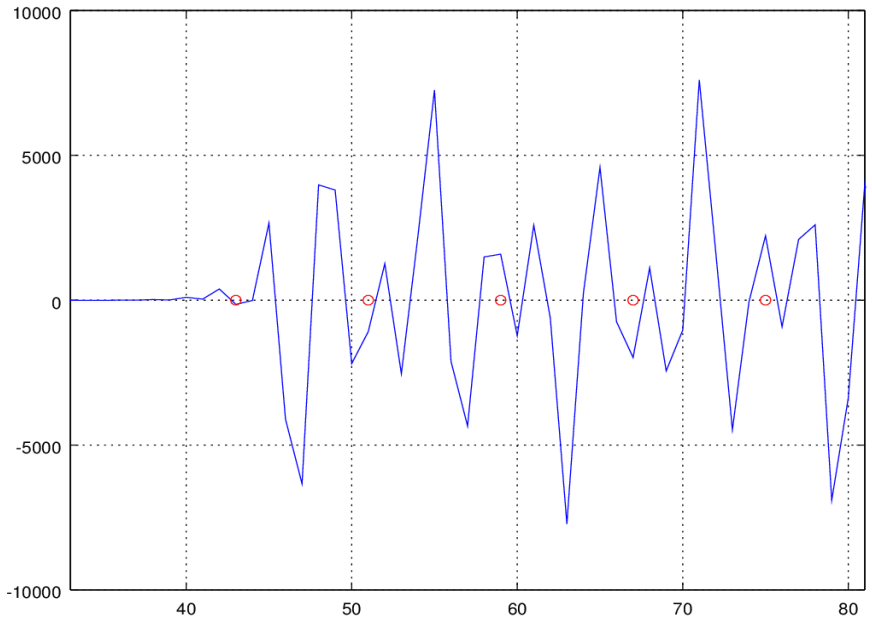
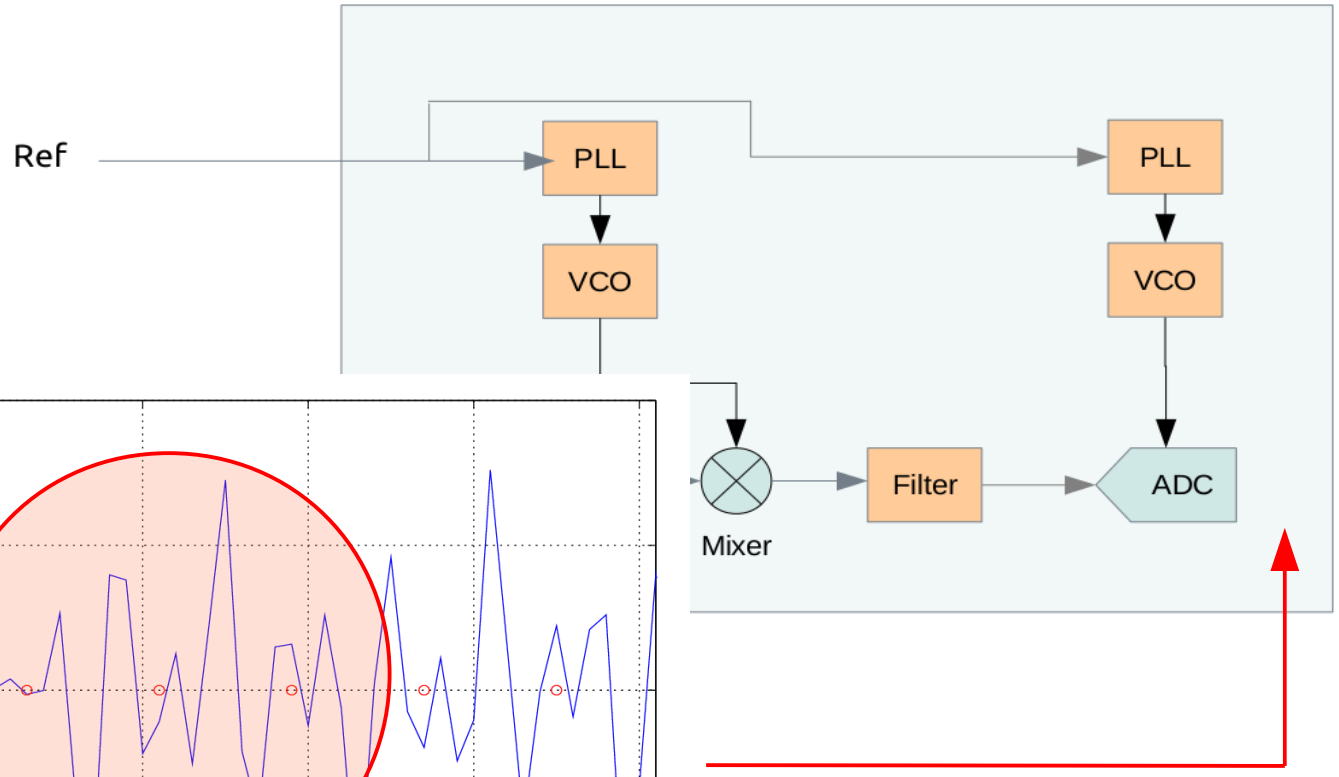
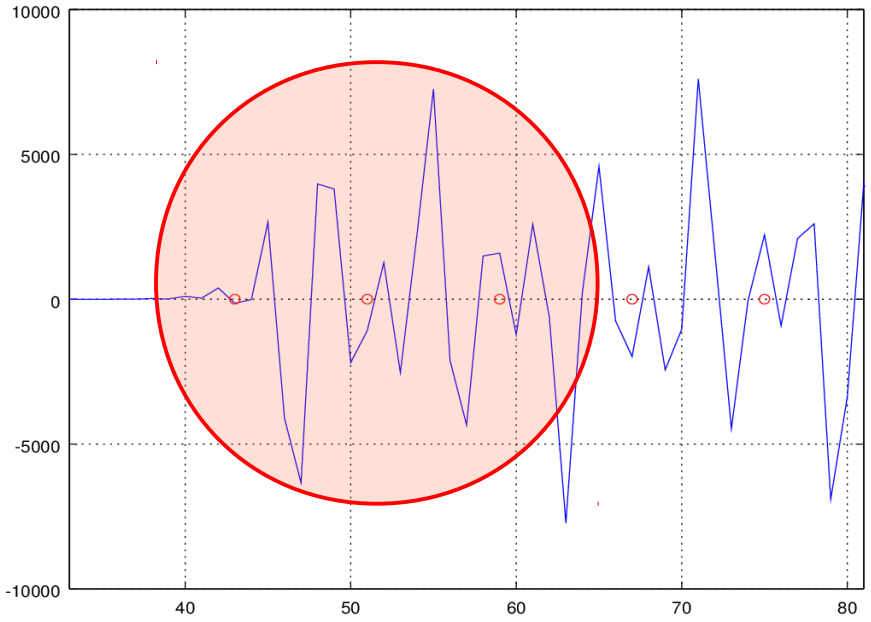




500MHz → 8 samples / bunch

Cavity BPM electronics



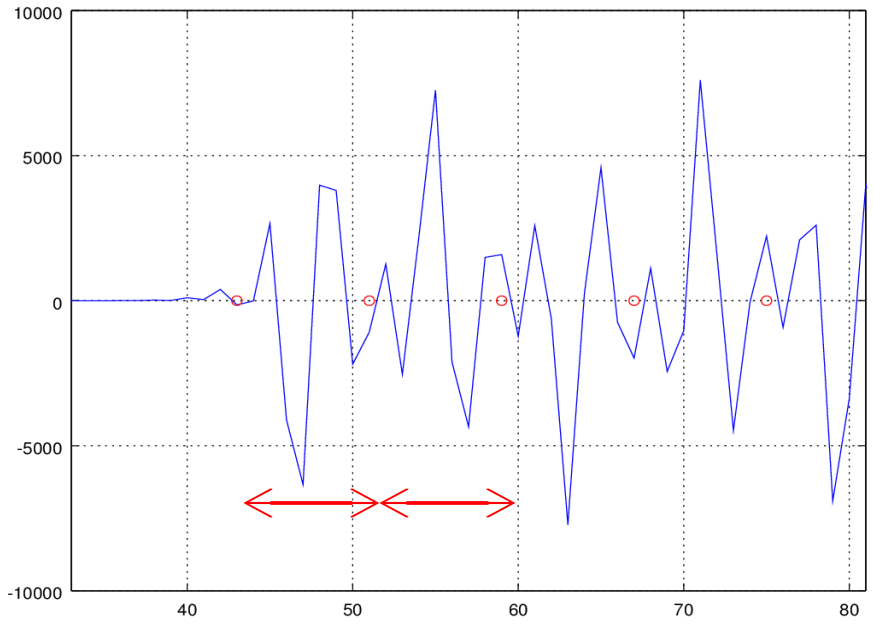


500MHz → 8 samples / bunch

How to decouple each bunch?

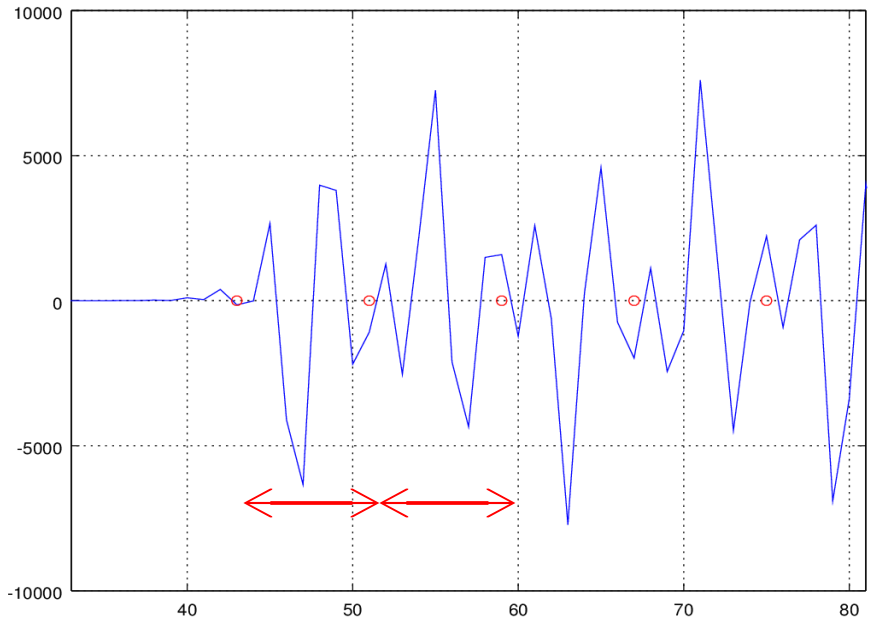
FPGA: deconvolution filter

- Define bunch processing windows



FPGA: deconvolution filter

- Define bunch processing windows
- Center of mass of bunch → center of window



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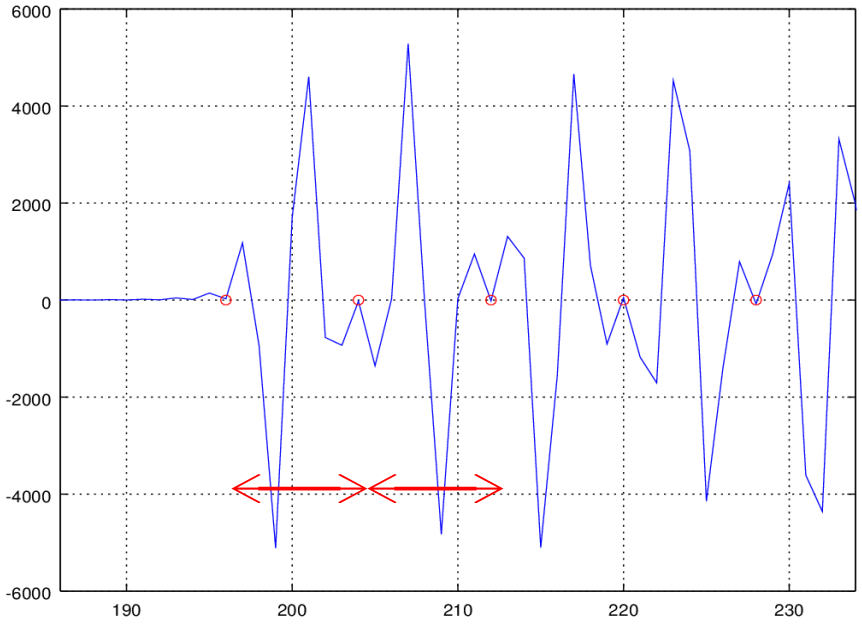

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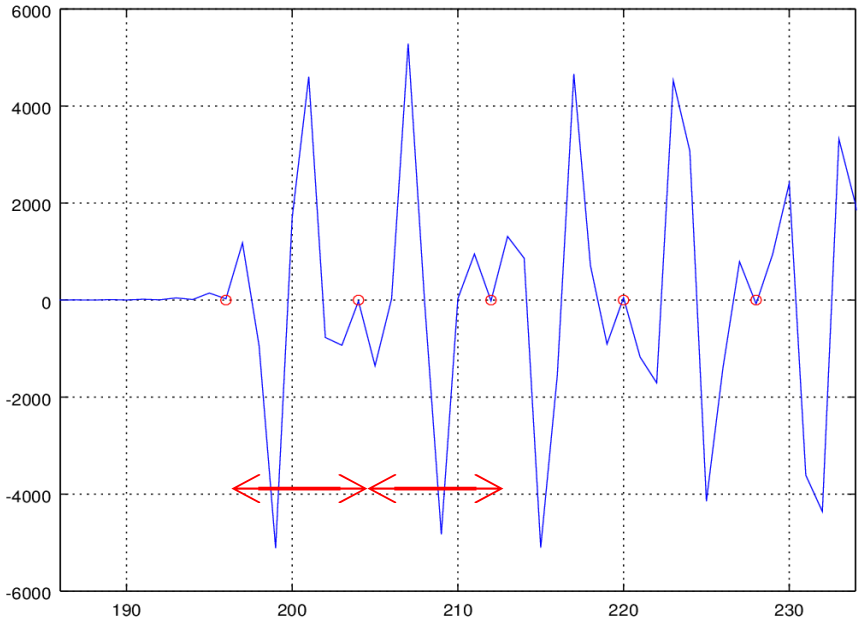

$$V_r, V_x, V_y$$

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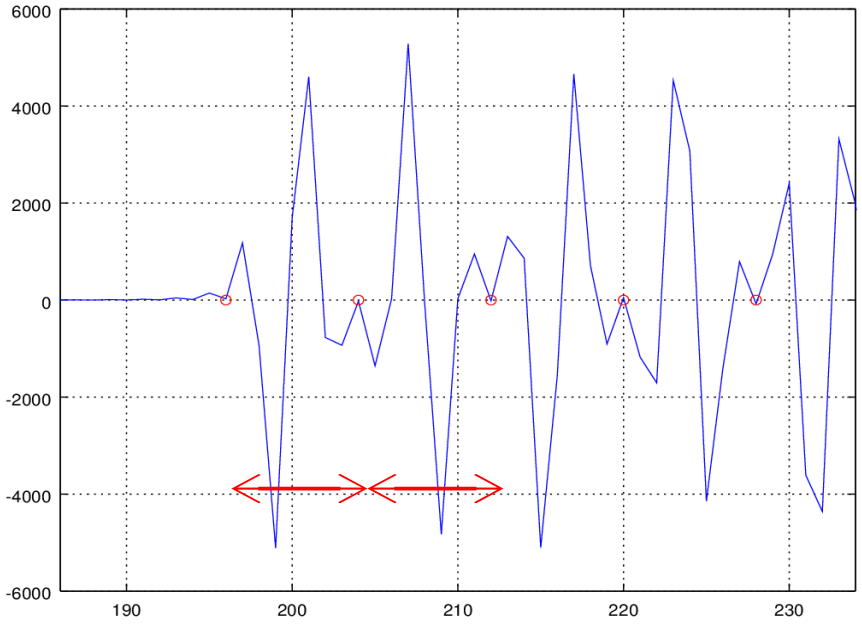
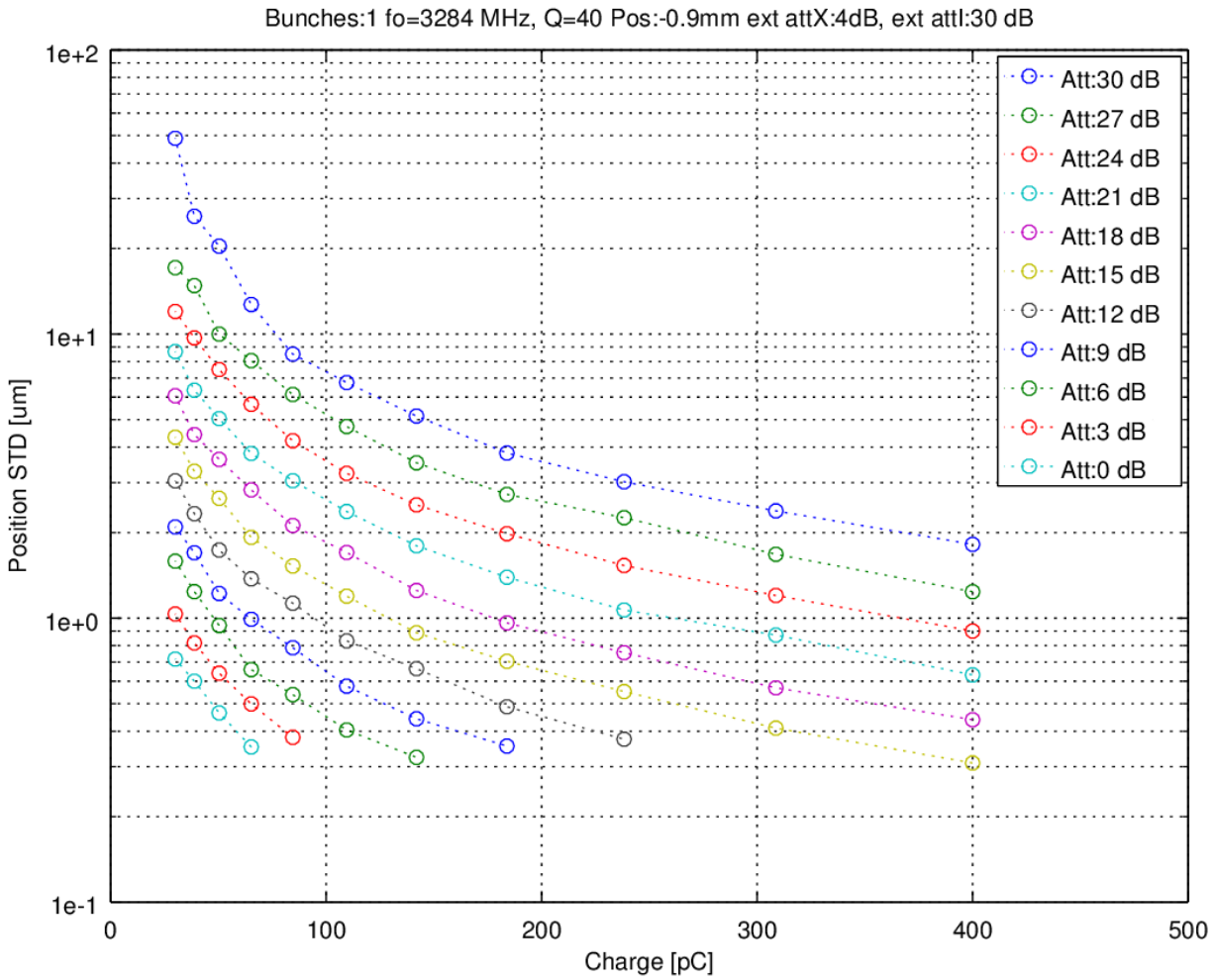


$$V_r, V_x, V_y$$

$$X = K_x \frac{V_x}{V_r}$$

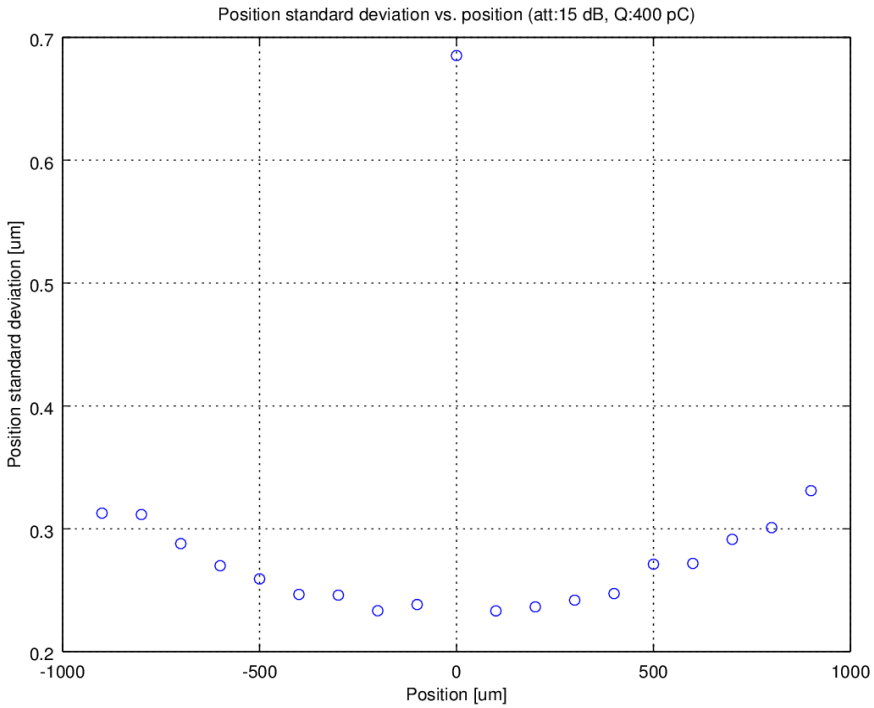
$$Y = K_y \frac{V_y}{V_r}$$

Position Resolution – single bunch



< 1µm

Position Resolution – single bunch



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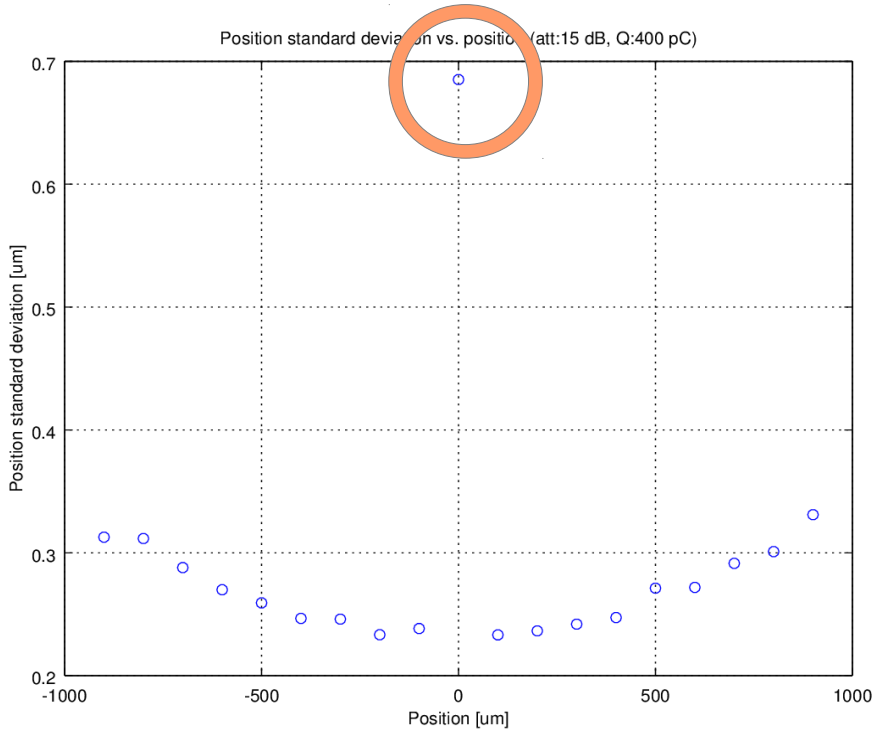

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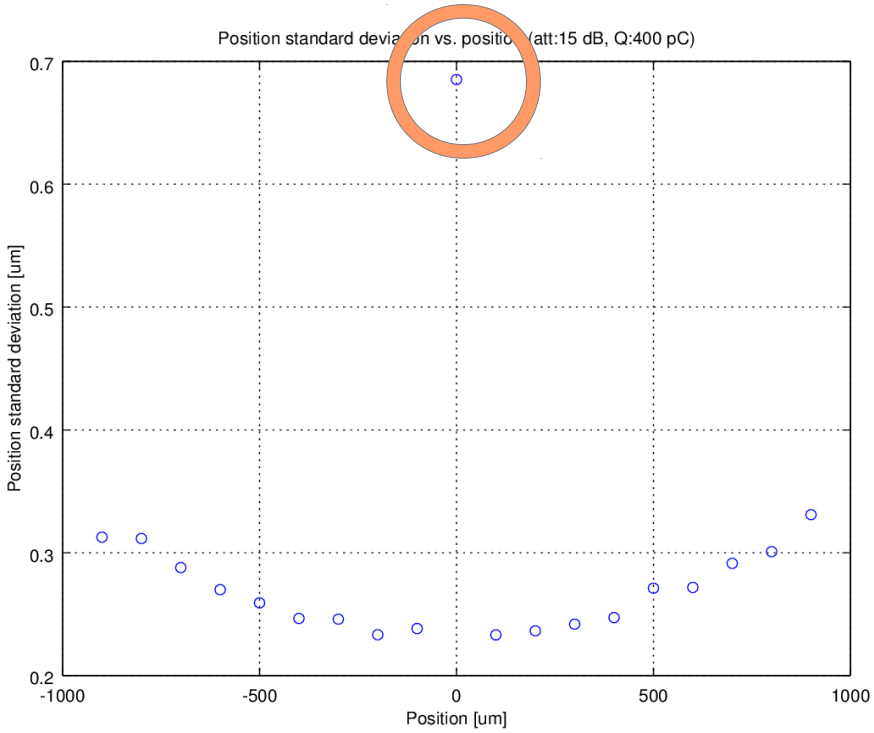
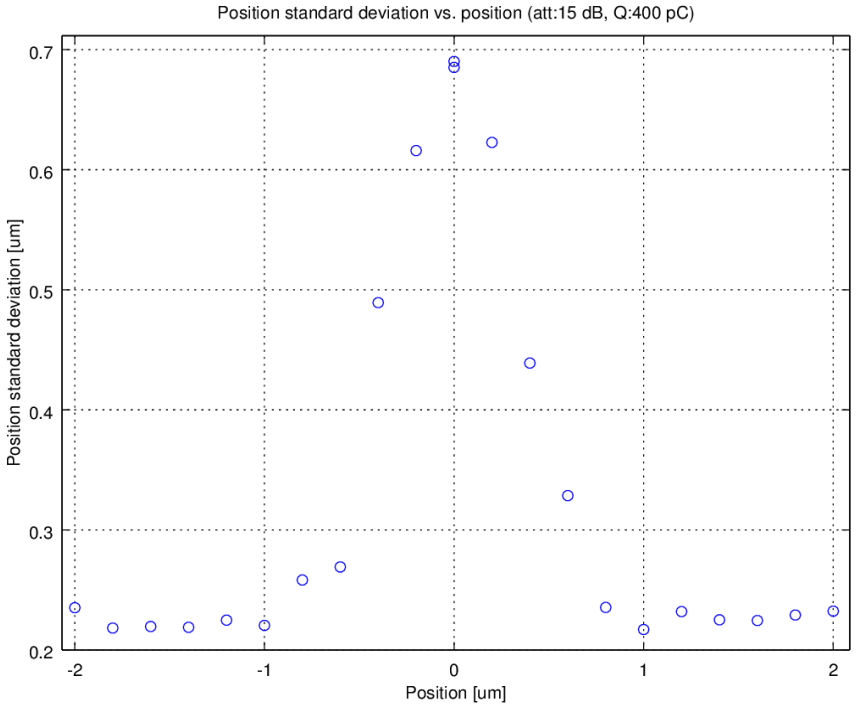
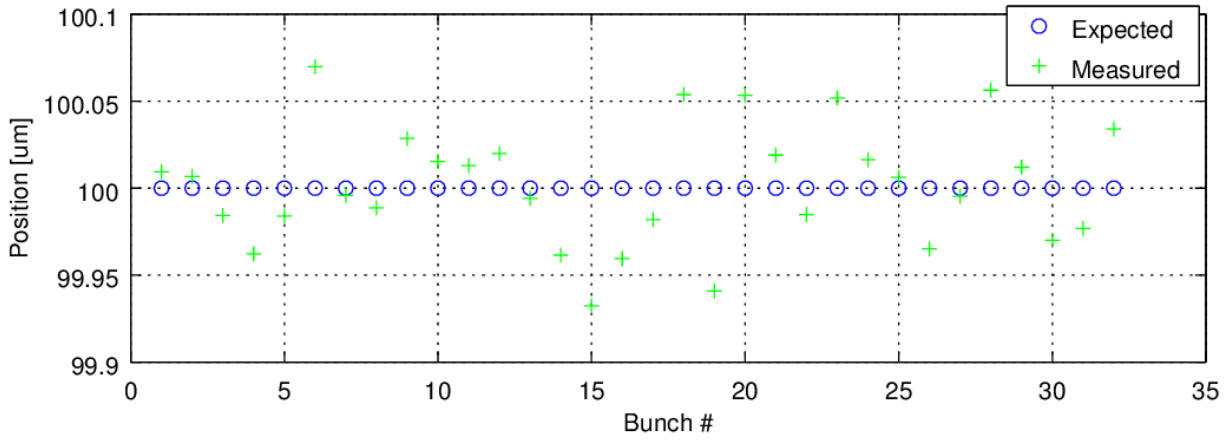
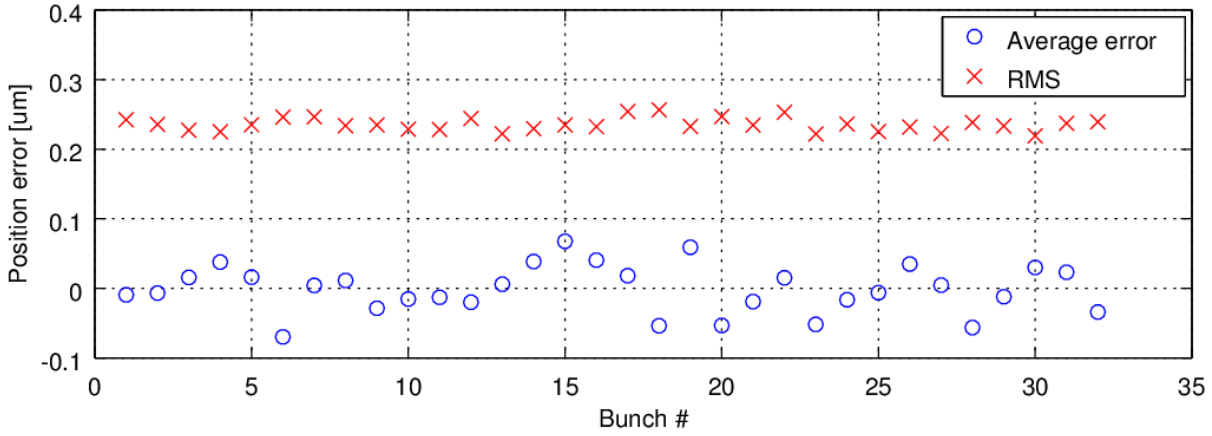




Position Resolution – bunch train





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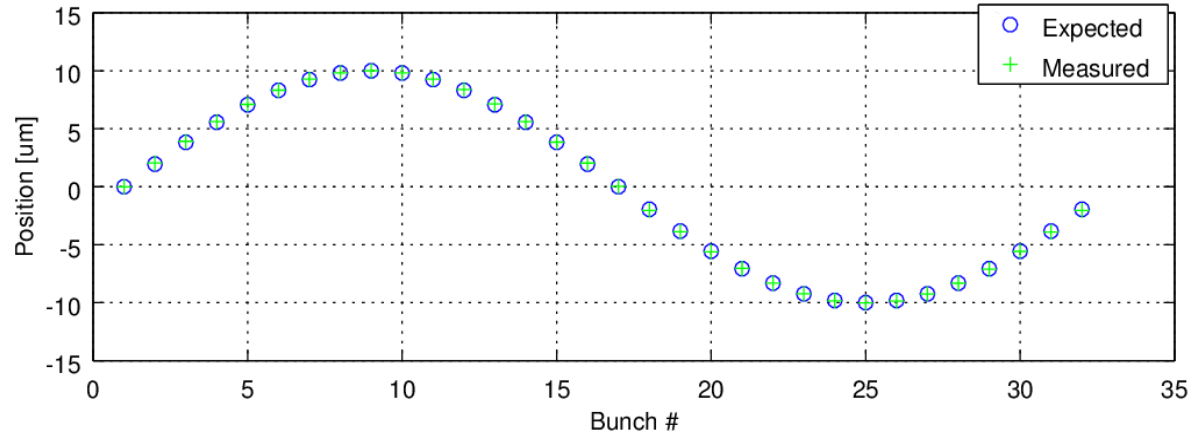

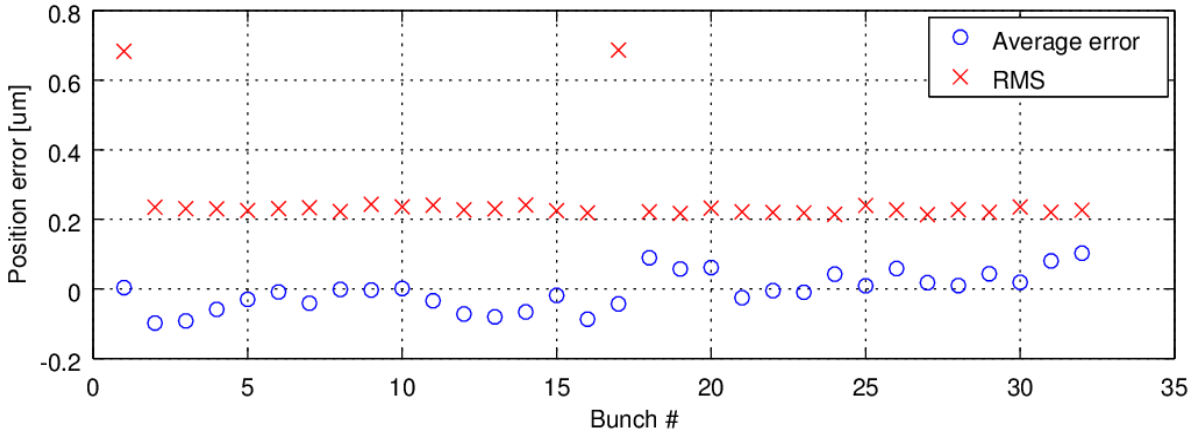

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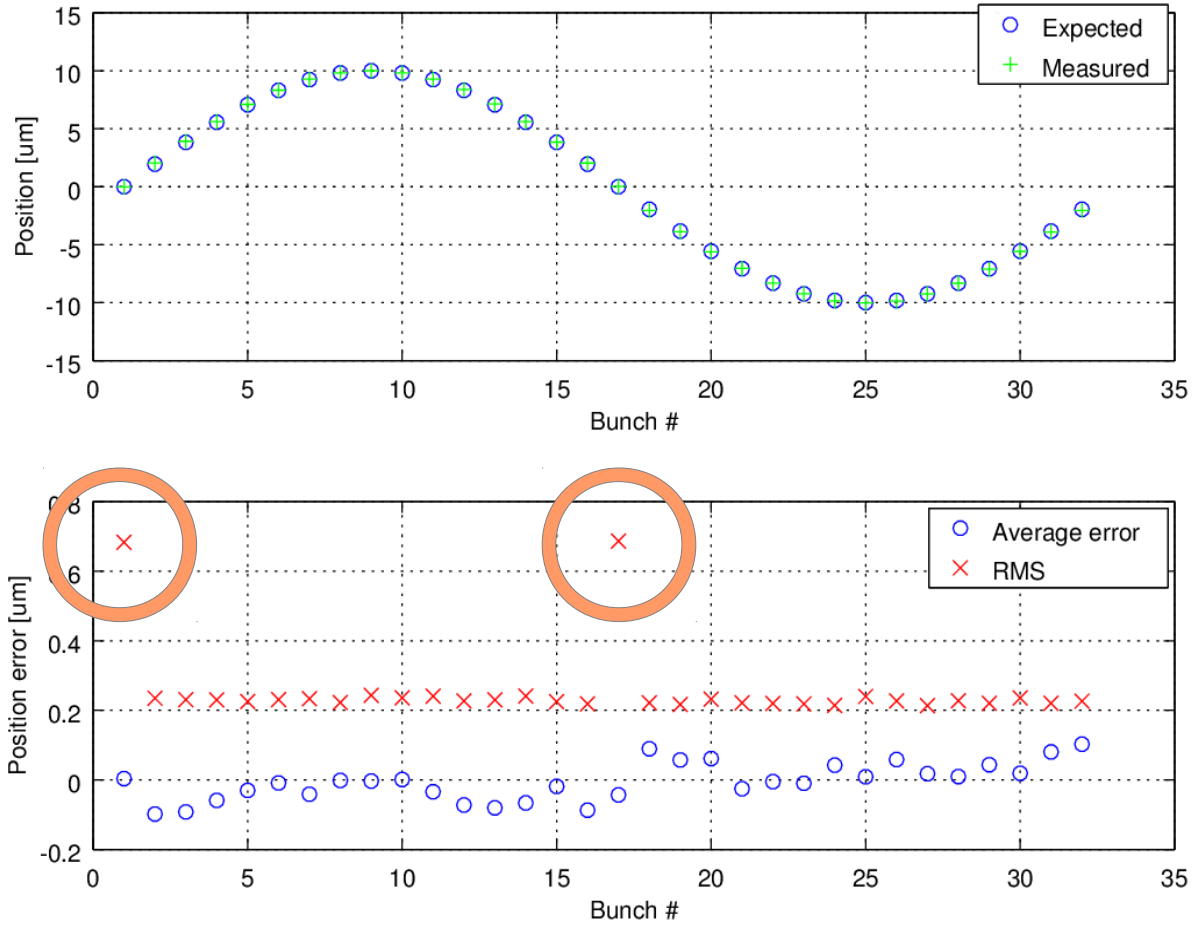

Conclusions

- New cavity BPM electronics are in development
- Can operate at different frequencies, cavities, beam modes
- Simulations anticipate sub-μm resolution
- Advantage of existing platform

Libera Spark

Instrumentation Technologies

Thanks for your attention!

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