



The FERMI@Elettra Cavity BPM System: short description, status report and enhancements

Elettra Sincrotrone Trieste

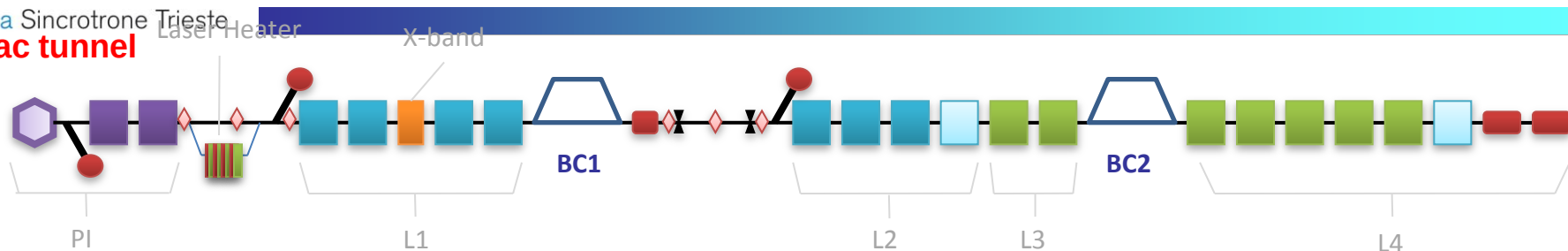


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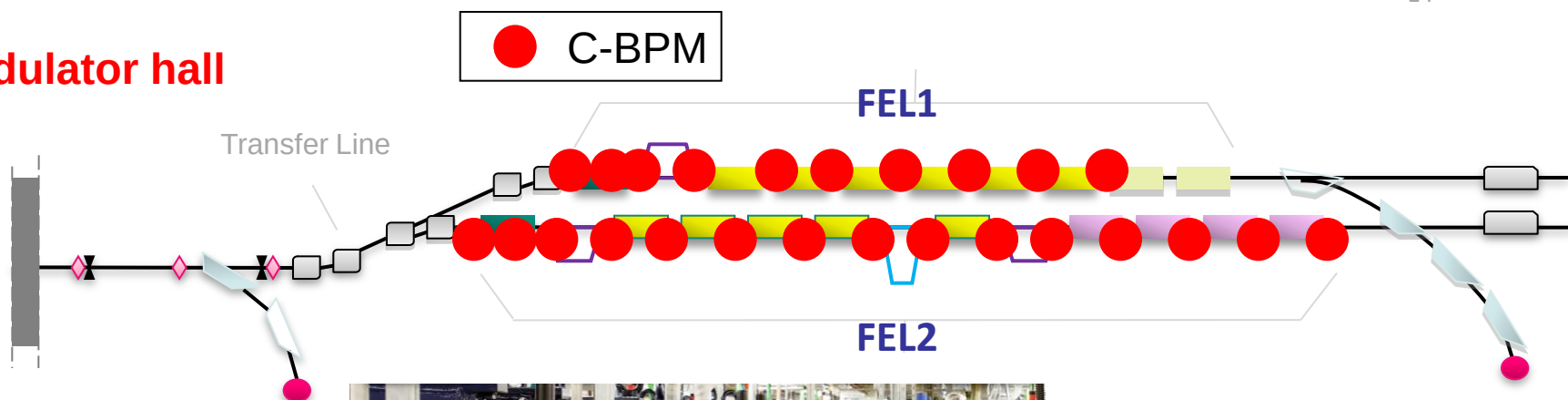


Fermi@elettra C-BPM FEL1 and FEL2 layout

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linac tunnel



undulator hall



The distance
between
FEL1 and FEL2
is ONLY **50cm**



Fermi@elettra C-BPM

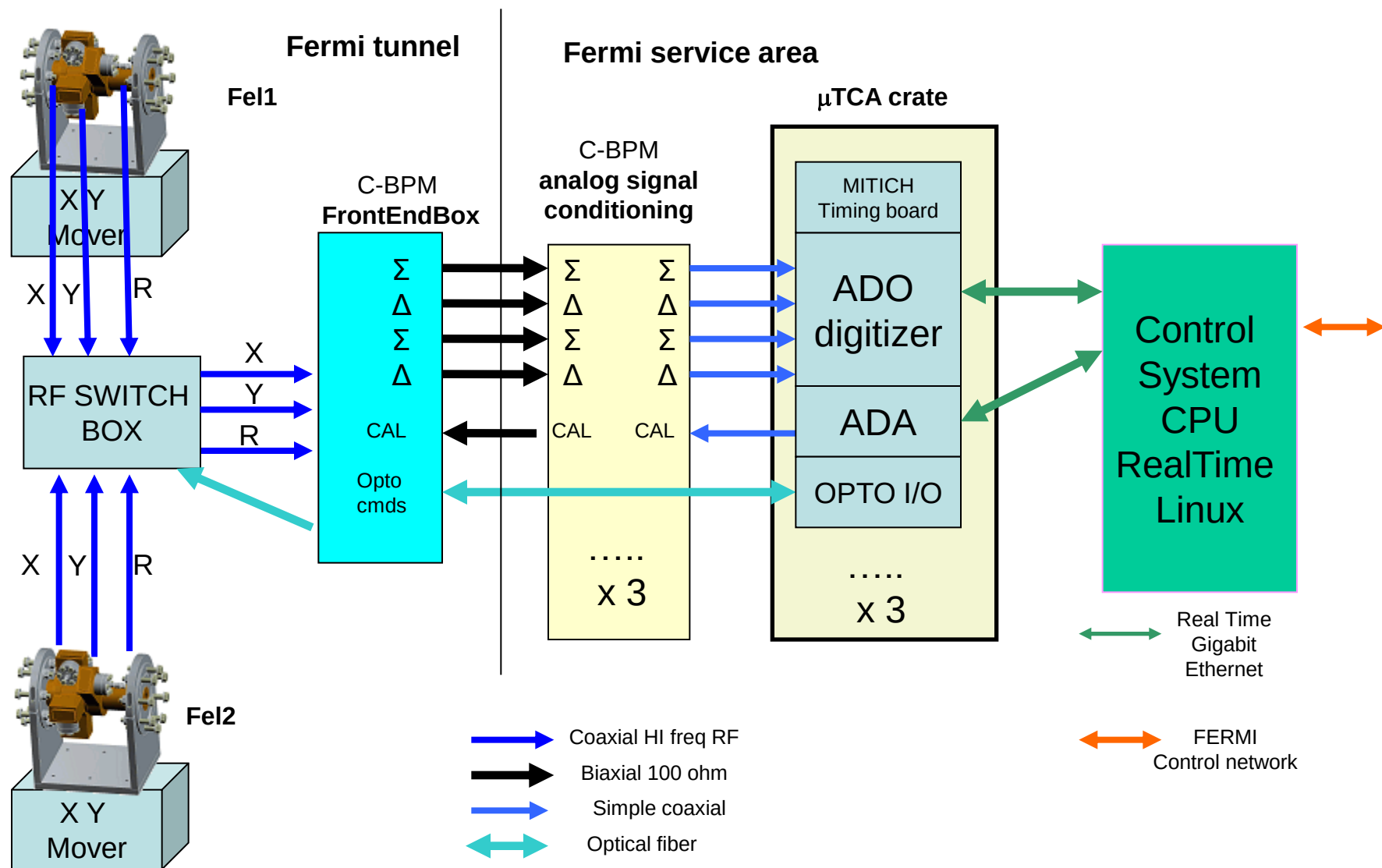
Overall system status

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- 10 C-BPM Installed , tuned and running on FEL1
- 15 C-BPM Installed , tuned and running on FEL2
- 9 of the C-BPM FEL2 have shared electronics with FEL1
- 16 C-BPM RF Front-end installed and calibrated
- 5 μ TCA Crates for signal acquisition with:
 - 16 ADO fast acquisition boards
 - 10 ADA fast Cal signal generation boards
 - 16 OPTO-IO to interface various digital control signals from Xilinx Virtex5 FPGA to a RF Front end in the Fermi tunnel.
 - 5 MiTich board to generate and manage all of the clocks required by fast acquisition.
- 3 RealTime Linux CPU with Tango server
- 10 Hz Real-Time acquisition and position computation
- 50 Hz Real time acquisition and position computation with the new implemented Gigabit Ethernet port on ADO with UDP protocol stack
- Dedicated Tango Graphical User Interface to manage C-BPM from control system
- Dedicated Tango server for real time trajectory control

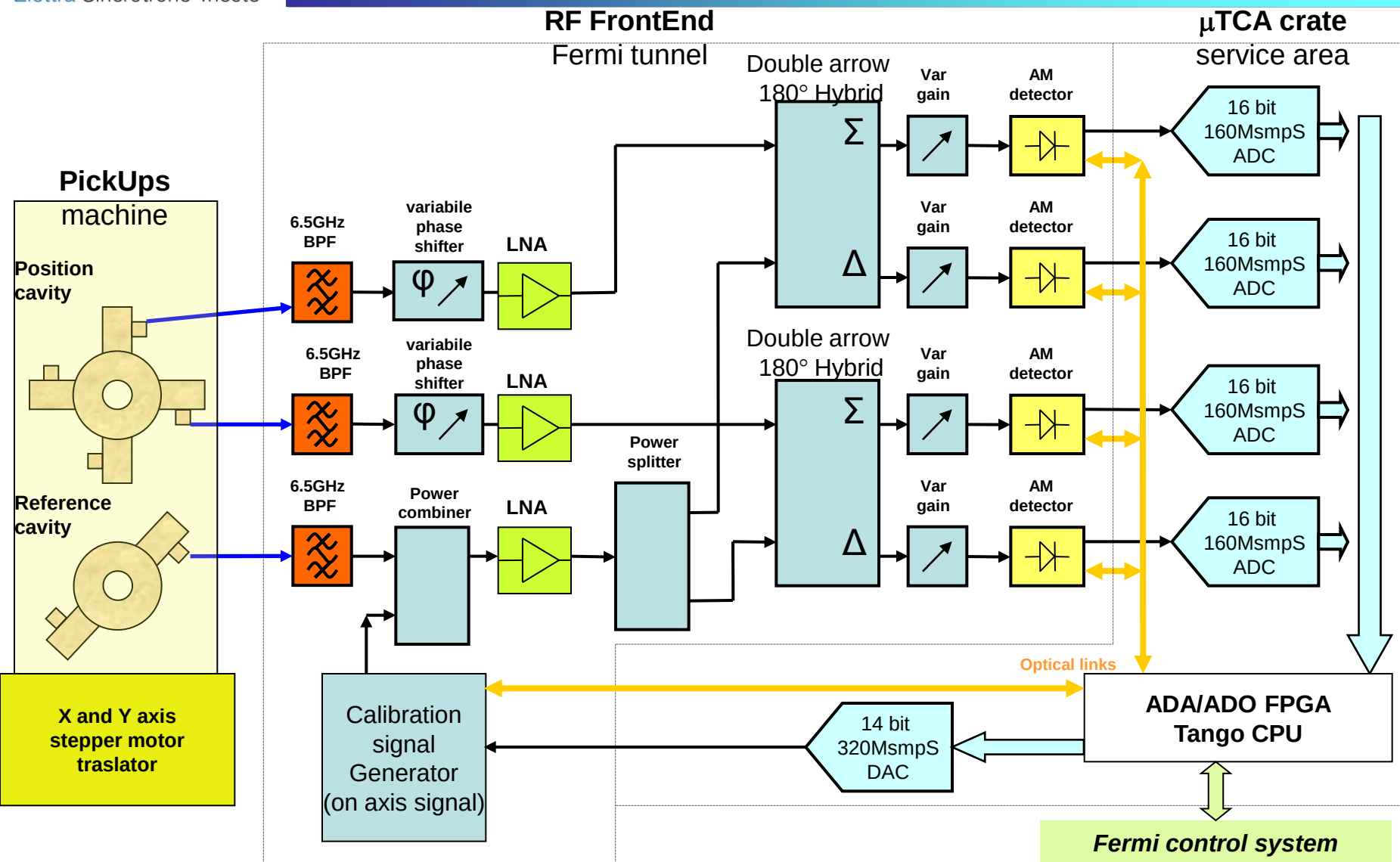
Fermi@elettra C-BPM FEL1- FEL2 system block diagram

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Fermi@elettra C-BPM acquisition block diagram

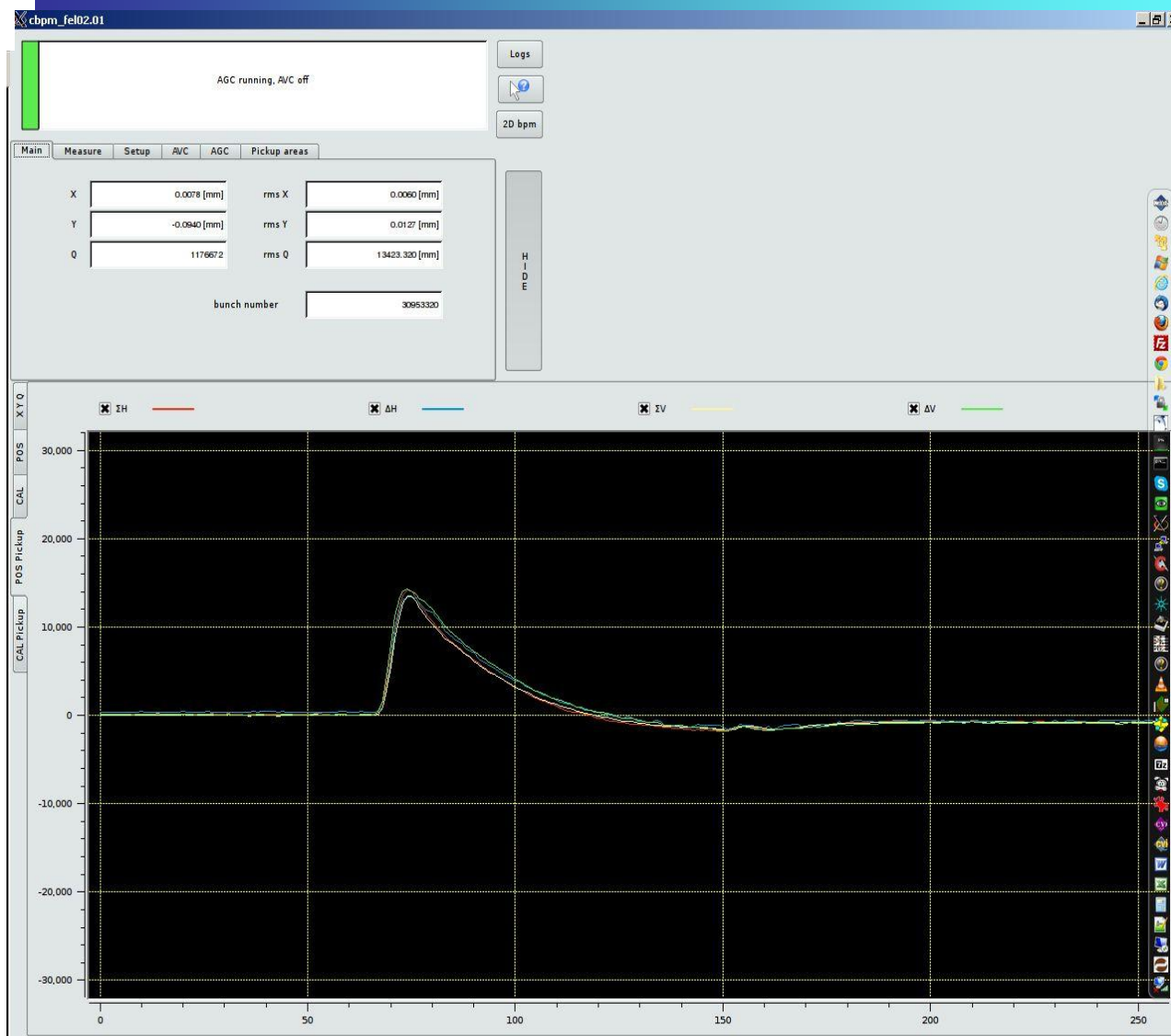
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Fermi@elettra C-BPM Acquisition waveforms

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$$\text{Gain}_{\Sigma} = \text{Area}_{\text{cal}\Delta} / ((\text{Area}_{\text{cal}\Sigma} + \text{Area}_{\text{cal}\Delta}) / 2)$$

$$\text{Gain}_{\Delta} = \text{Area}_{\text{cal}\Sigma} / ((\text{Area}_{\text{cal}\Sigma} + \text{Area}_{\text{cal}\Delta}) / 2)$$

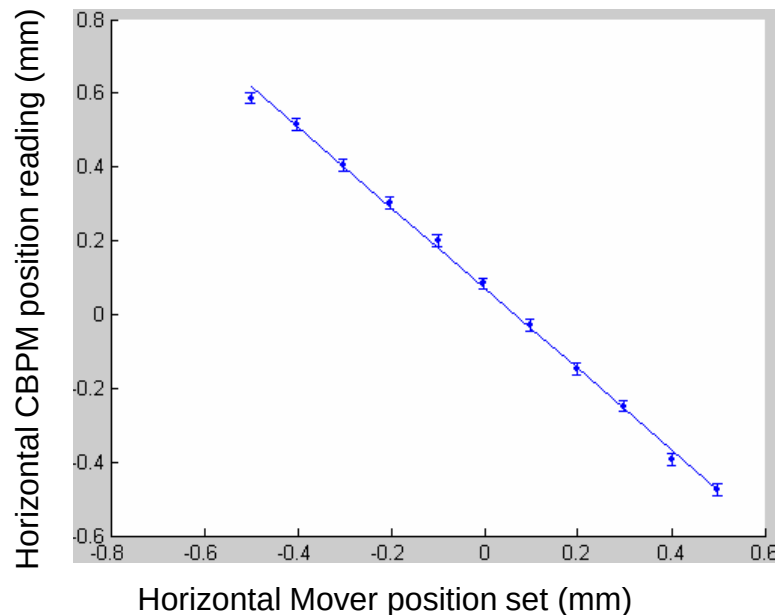
$$A_{\Sigma} = \text{Area}_{\text{beam}\Sigma} * \text{Gain}_{\Sigma}$$

$$A_{\Delta} = \text{Area}_{\text{beam}\Delta} * \text{Gain}_{\Delta}$$

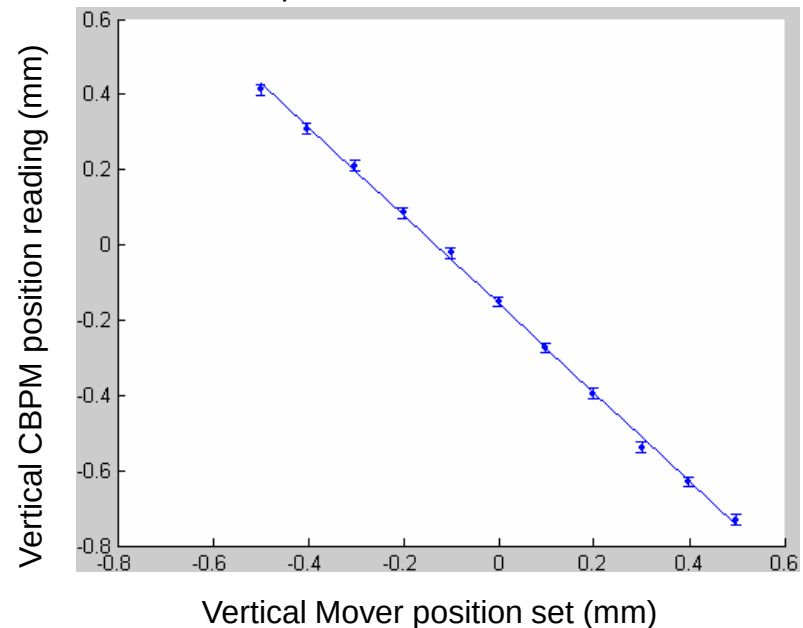
$$\text{Pos}[mm] = k \frac{(A_{\Sigma} - A_{\Delta})}{(A_{\Sigma} + A_{\Delta})}$$

Where **k** is a constant conversion factor from arbitrary units (areas) to mm, and comes from known movement.

Horizontal **k** computation for CBPM SFEL01.01



Vertical **k** computation for CBPM SFEL01.01

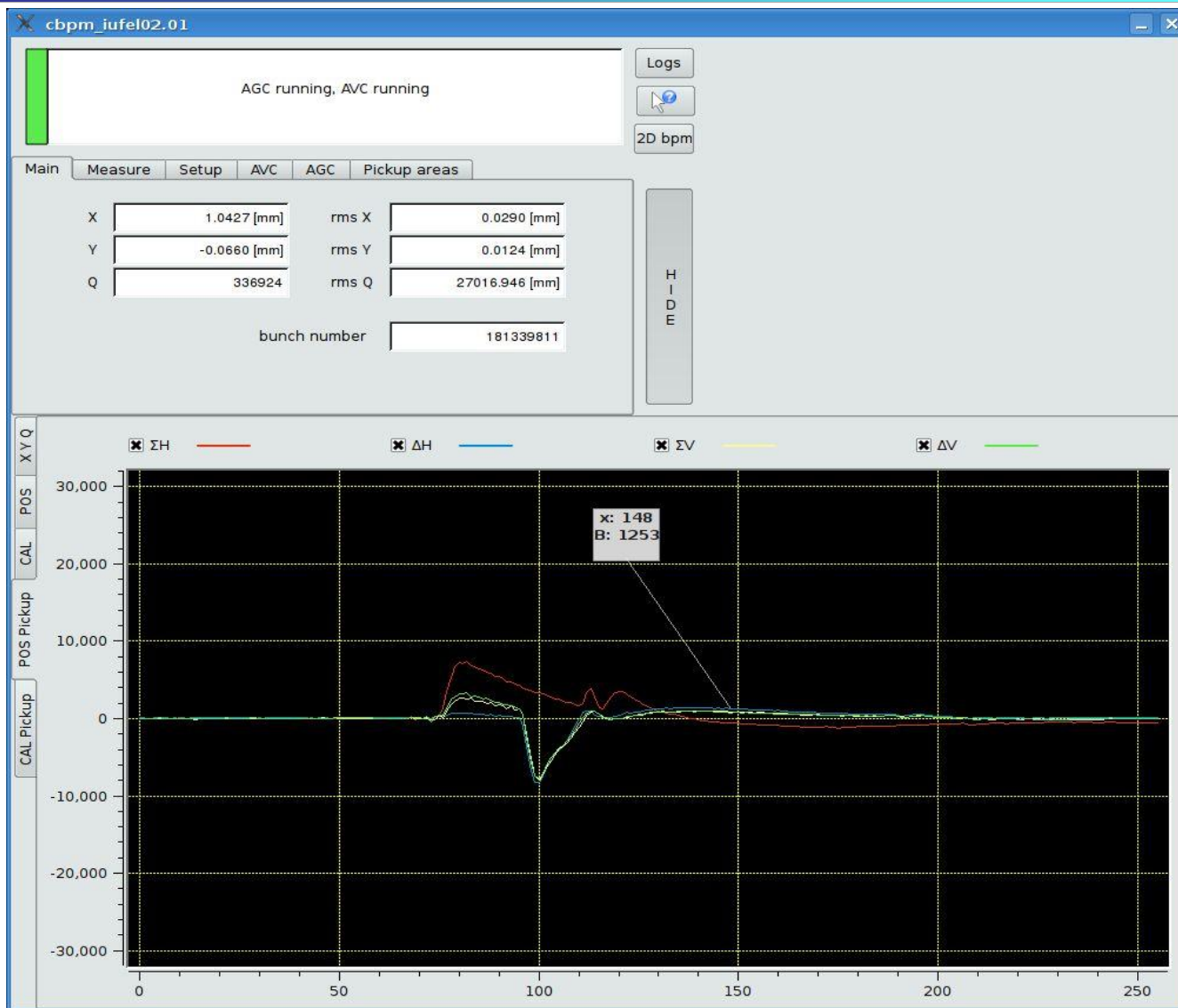




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Acquisition waveforms when beam is lost in the C-BPM

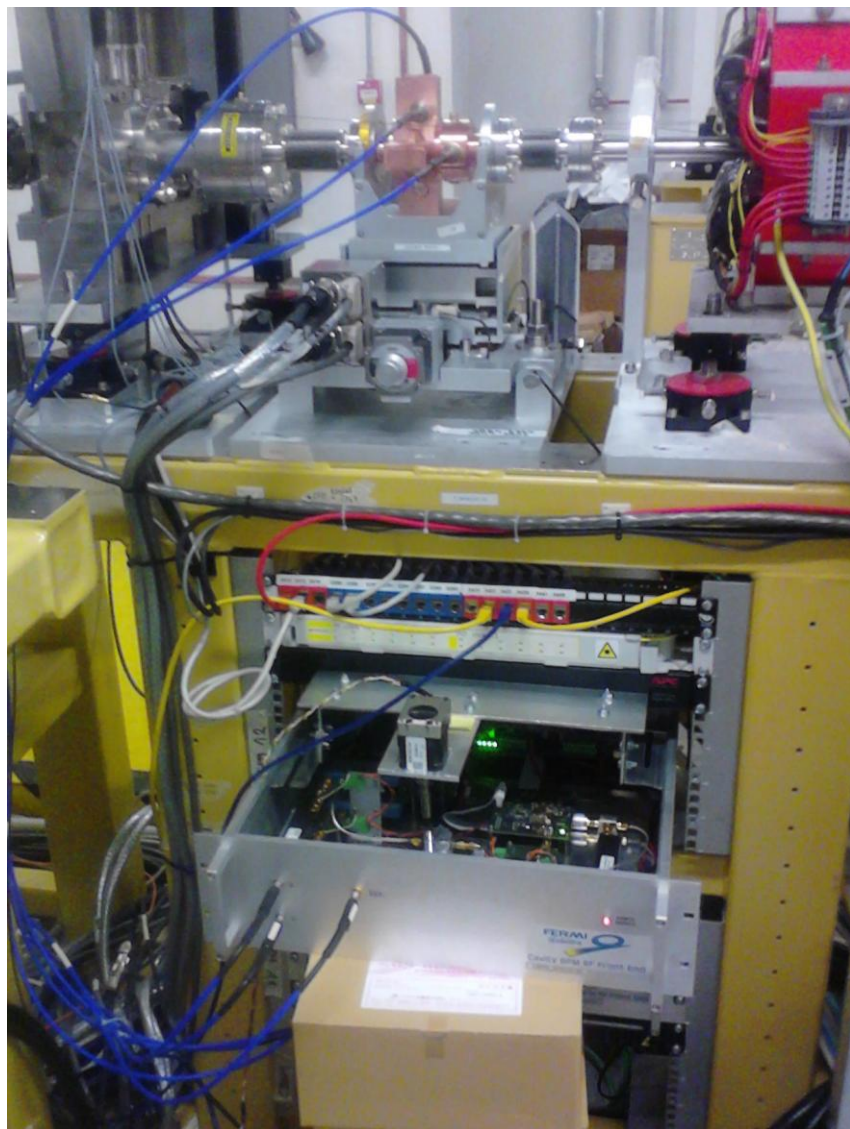
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Remote Fine Phase adjustment

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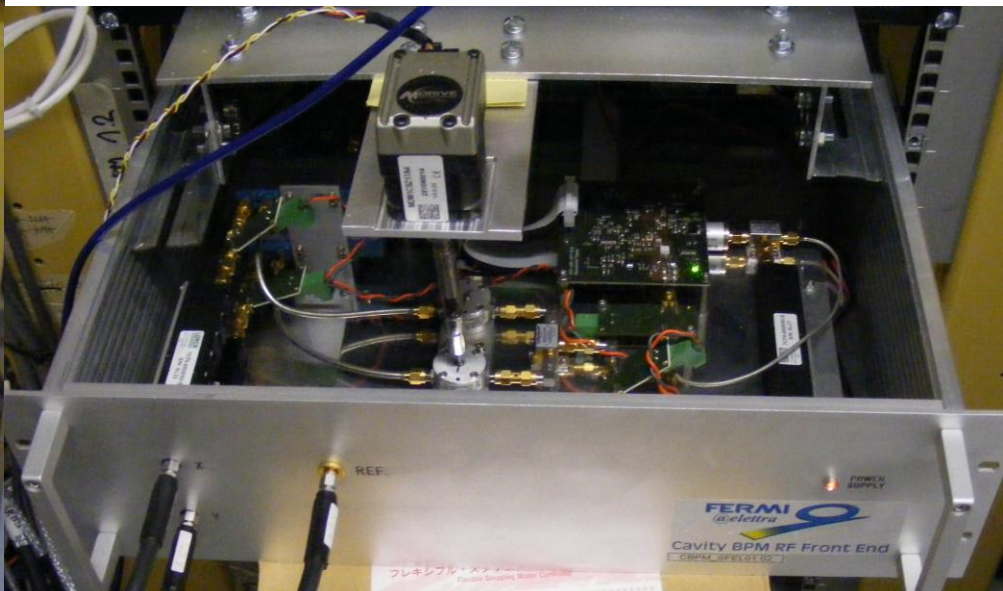


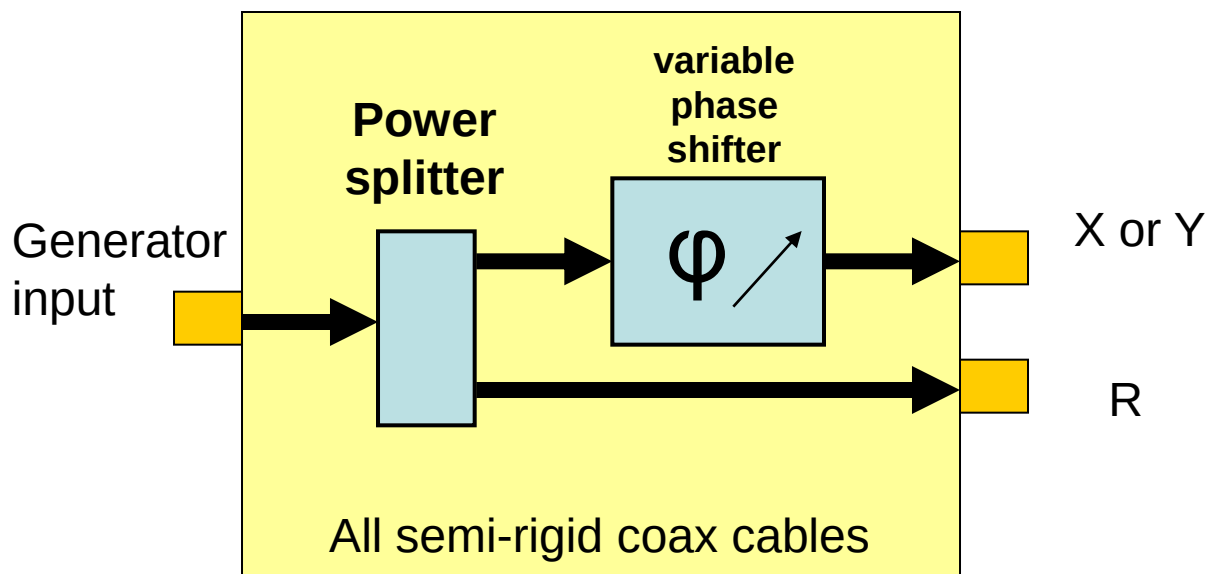
To maximize the electronic circuit response, a fine phase regulation has been made.

We remotize one of the two phase shifters that combine the dipole with the monopole cavity signal. The goal is to maximize the signal difference with the beam in a non center condition.

After this fine regulation we improved the resolution from 4 to 2 μm .

We report this new phase on all of the other electronics by using a C-BPM phase signal simulator.





The usage of this tool is very simple:

After the fine calibration with the machine beam of one of the electronics, we connect this tool with a 6.5GHz damped waveform generator (Agilent E4438C ESG vector signal generator). And we connect on X or Y port and to R port the cables that were connected to a C-BPM. We adjust the tool variable phase shifter to maximize the signal difference using the Tango panel. Now, we have a tool that can be used to calibrate the phase of all of the other electronics, since all C-BPM have the same phase difference.



Fermi@elettra C-BPM system stability and reproducibility

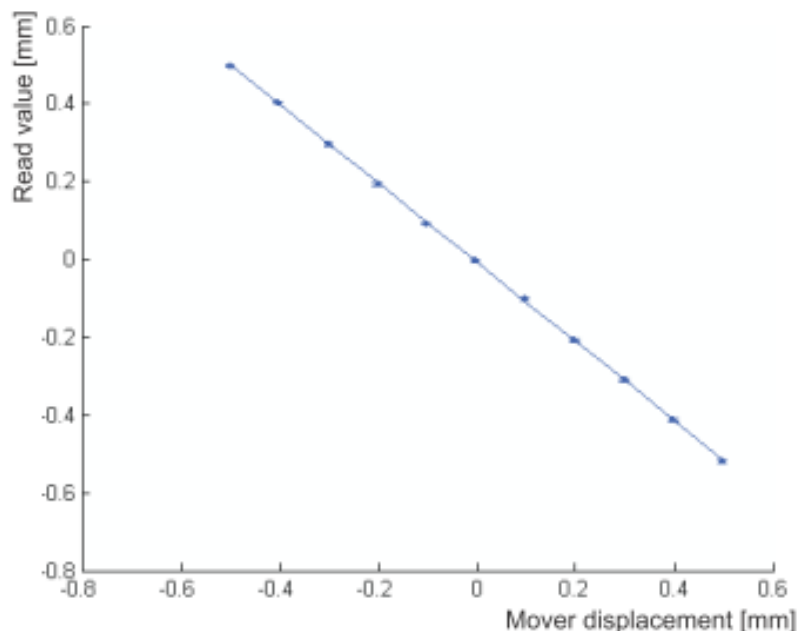
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The self-calibration mechanism is working fine, so no electronics drifts and "beam current dependency" has been observed until now.

Also a k factor (constant conversion factor from arbitrary units to mm) has been monitored.

The monitoring for a year and a half of the calibration factor showed no major differences of 1%. Below there is a response curves

C-BPM SFEL 01.02 Mover scan on Feb. 2012





Fermi@elettra C-BPM system stability and reproducibility (2)

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Jul 2011	R. Cav.	pos H.	pos V.		R-H	R-V
CBPM SFEL1.1	6503.03	6503.12	6503.03		-0.09	0
CBPM SFEL1.2	6507.48	6507.58	6507.68		-0.1	-0.2
CBPM SFEL1.3	6507.41	6507.65	6507.39		-0.24	0.02
CBPM FEL 01.01	6504.6	6504.66	6504.7		-0.06	-0.1
CBPM IUFEL 01.01	6503.58	6503.69	6503.63		-0.11	-0.05
CBPM IUFEL 01.02	6504.25	6504.04	6504.11		0.21	0.14
CBPM IUFEL 01.03	6504.78	6504.94	6505.04		-0.16	-0.26
CBPM IUFEL 01.04	6503.98	6503.89	6504.11		0.09	-0.13
CBPM IUFEL 01.05	6505.64	6505.71	6505.67		-0.07	-0.03
CBPM IUFEL 01.06	6502.52	6502.56	6502.53		-0.04	-0.01

Resonance
frequency
measure in MHz.
All tuners left
untouched

Aug 2012	R. Cav.	pos H.	pos V.		R-H	R-V
CBPM SFEL1.1	6503.14	6503.25	6503.17		-0.11	-0.03
CBPM SFEL1.2	6507.73	6507.81	6507.92		-0.08	-0.19
CBPM SFEL1.3	6507.53	6507.73	6507.4		-0.2	0.13
CBPM FEL 01.01	6504.1	6504.21	6504.21		-0.11	-0.11
CBPM IUFEL 01.01	6504	6504.14	6504.11		-0.14	-0.11
CBPM IUFEL 01.02	6504.65	6504.48	6504.61		0.17	0.04
CBPM IUFEL 01.03	6505.48	6505.62	6505.79		-0.14	-0.31
CBPM IUFEL 01.04	6504.73	6504.69	6504.92		0.04	-0.19
CBPM IUFEL 01.05	6506.44	6506.52	6506.57		-0.08	-0.13
CBPM IUFEL 01.06	6503.26	6503.31	6503.31		-0.05	-0.05



The system resolution has been measured with the beam $\sim 1.5\mu\text{m}$ (**was $4\mu\text{m}$ in 2011**)

After some measures, we know that this limit comes mainly from the envelope detector.

We also have implemented a “test mode”. Test mode means that the calibration signal is generated also at the time of the machine signal, when the machine is not running.

This simulates a zero position reading. In these conditions we measure an RMS value on the reading positions approx of $\sim 1.4\mu\text{m}$.

We expect to have a resolution **better than $0.5\mu\text{m}$ @500nC**, by replacing the envelope detector with a frequency downconverter and demodulating digitally the 30MHz damped waveform.

Fermi C-BPM

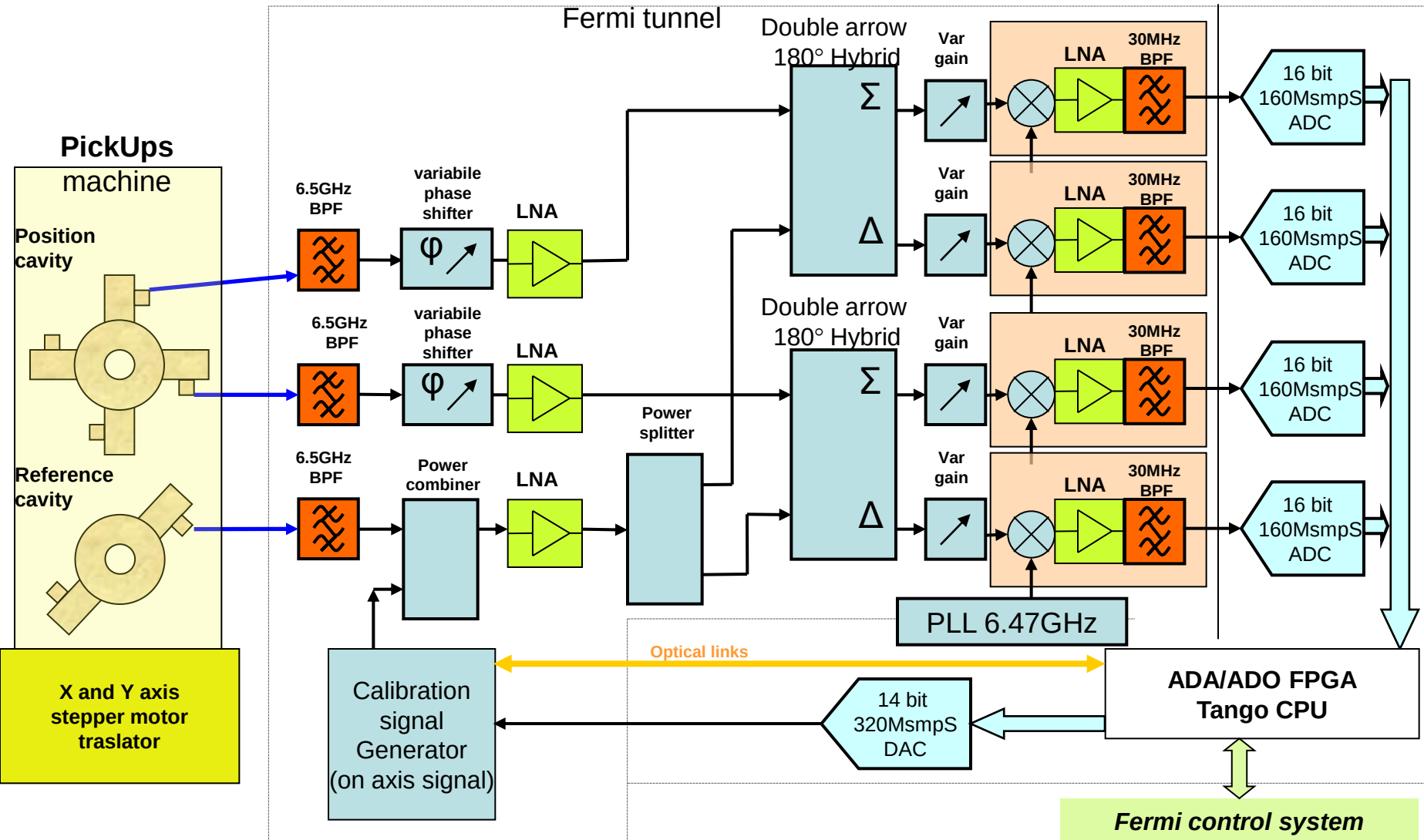
Modified acquisition block diagram

uTCA crate
service area

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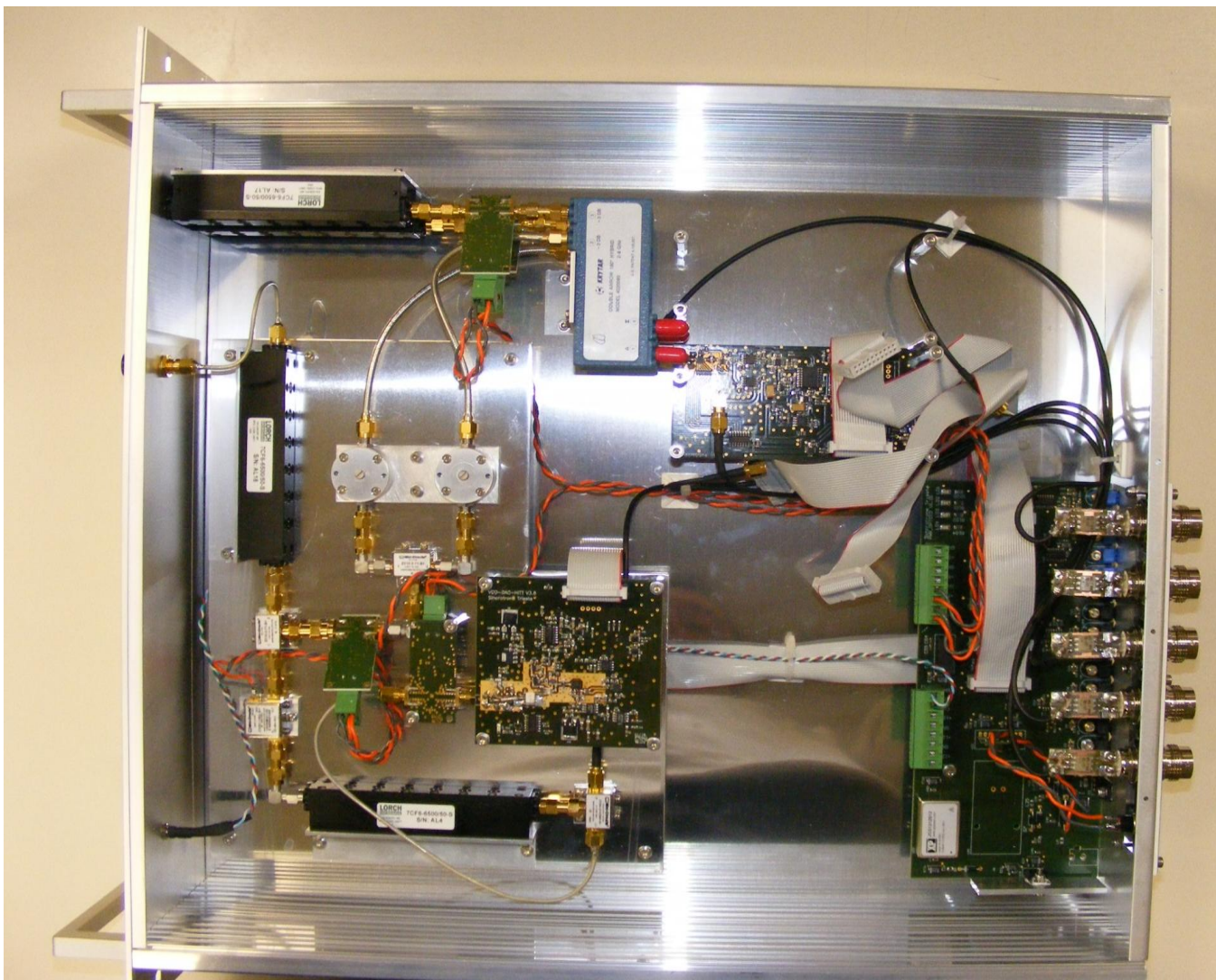
RF FrontEnd

Fermi tunnel



Fermi C-BPM RF Front end box internals

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- Damped waveform: 330nSec $\rightarrow$ 10 periods @30MHz IF
- Digitizer: 160 M/samp $\rightarrow$ 6.25nSec sampling rate
- IF: 30Mhz $\rightarrow$ 5.28 points per period

- What is the best way to treat this digitized signal?
- Simple digital radio technique ?
- Or more sophisticated DDC using IQ demodulation and power calculation from IQ signals?

- All suggestions are welcome!!!!
- Tanks for your attention