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Libera Single Pass H: Application

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Instrumentation Technologies

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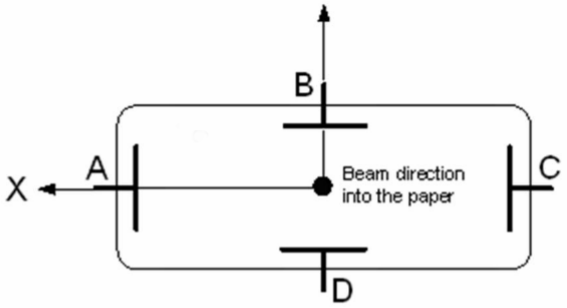
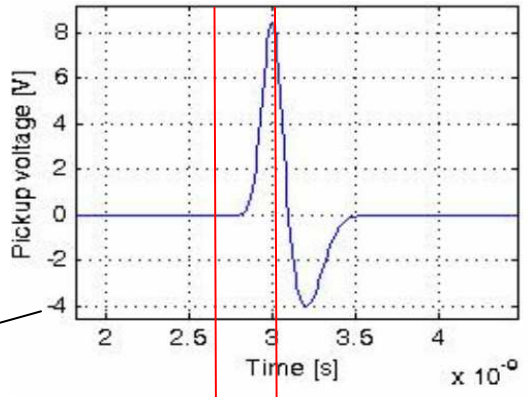
Single Pass Measurements in Heavy Particle Linear Machines

LANSCE LINAC (LANL)

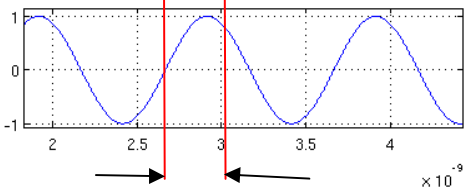


Beam position measurement:

$$X = K_X \frac{(V'_A - V'_C)}{(V'_A + V'_C)} - X_{OFFSET}$$



MO signal:



Beam phase measurement

- Single pass measurement: each bunch is involved once in the measurement
- For heavy, non relativistic particles: the beam arrival time needs to be controlled for acceleration purposes
- Integration of high resolution Beam Arrival Time functionatily into the BPM signal processing system is therefore needed.

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Examples of Required Performance from BPM Electronics

Parameter	LANSCE LINAC	pLINAC (GSI)	Spiral 2 LINAC
Bunch rep. rate	201.25 MHz	325.224 MHz	88.0505 MHz
Input power range	50 dB	60 dB	40 dB
Position repeatability	100 um	100 um*	±10/±100 um
Phase repeatability	0.25 deg	1 deg	±0.5 deg
Pickup position sensitivity	1.26 dB/mm	2.38 dB/mm	2.5 dB/mm

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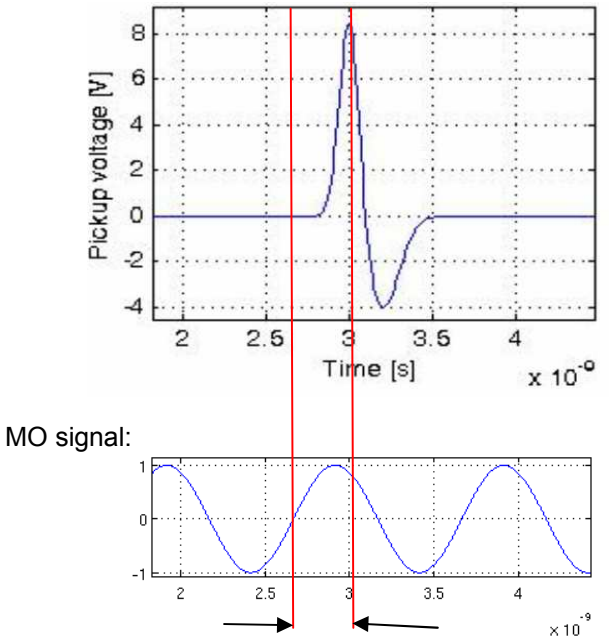
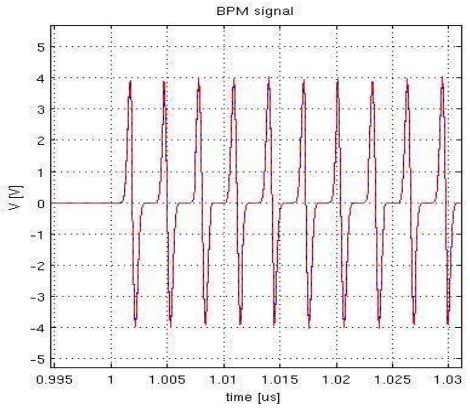
Beam Phase Measurements Basics

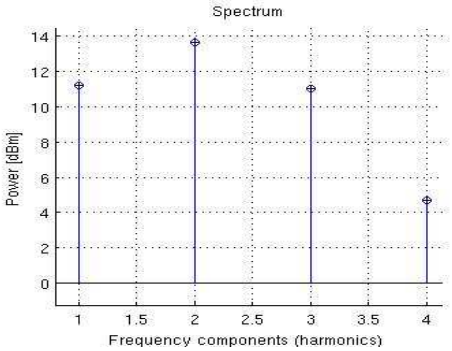


Beam phase measurement

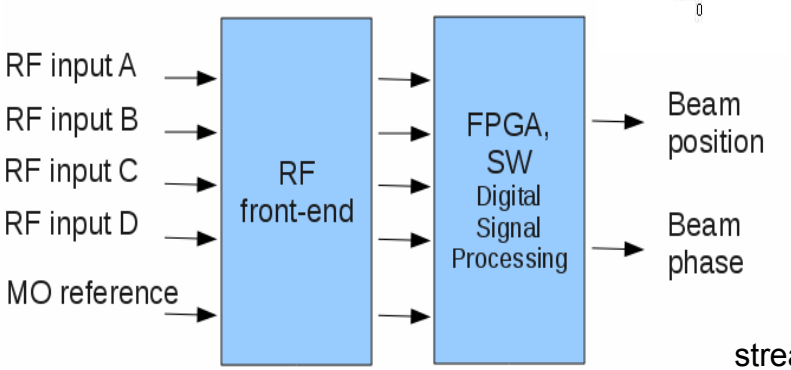
- The sequence of pickup pulses can be decomposed into a sum of frequency components.
- The phase relation between the bunch signal and the Master Oscillator signal is used for the time of arrival measurement.
- In LLRF application typically a phase measurement in the order of 0.01 degrees can be achieved. (corresponds to 30 fs at 1 GHz)
- These measuring techinques can be applied to the beam diagnostics field.

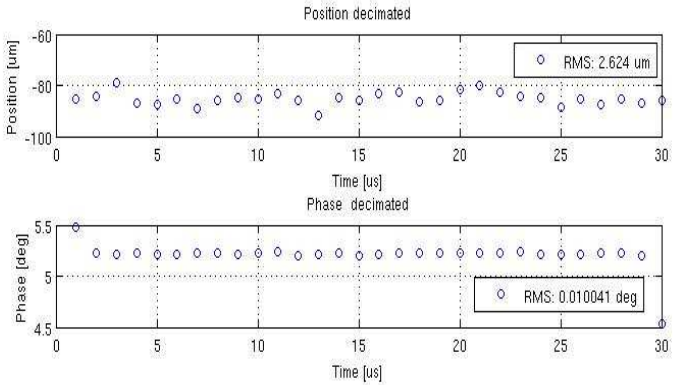
Hadron Beam Phase and Position Processing System





The system extracts from the train of pulses the amplitude and phase information.





The beam position and phase stream is provided for each pulse at a decimated rate. (e.g. 1 MHz)

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Platform B Technology: Libera LLRF Phase Measurements (1)

- Libera LLRF demonstration ad Daresbury Laboratory (EMMA): (Two Libera LLRF units in service at EMMA.)
  - High power test 10 kW
    - Amplitude stabilization 0.005 % RMS
    - Phase stabilization 0.008 deg RMS @ 1.3 GHz
- Libera LLRF demonstration ad DESY (FLASH ACC456):
  - 3 interconnected LLRF units controlling FLASH ACC456 (24 SC cavities; 72 RF signals)
  - (Amp: 0.009 %, Ph: 0.0095 deg RMS @ 1.3 GHz, at a gradient of 10 MV/m)
- Libera LLRF demonstration ad FERMI@Elettra:
  - Pulse by pulse feedback control at 25 MW (Amp: 0.027 %, 0.033 deg RMS @ 3 GHz)

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Platform B Technology: Libera LLRF Phase Measurements (2)

- High performance, high frequency RF design
- Real time digital signal processing on up to 38 RF input channels, up to 12 GHz
- Built in calibration and temperature stabilization systems
- Built in sophisticated RF system diagnostics and automatic RF feedback configuration.

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Libera Single Pass H

A powerful computing module based on Intel Core 2 Duo processors can be integrated with the distributed FPGA signal processing power.

The unit can be populated with up to 4 hadron phase and position processors. Each module can process 4 pickup signals +1 reference MO signal.

An additional module can be used to further process the signals and stream the data through the SFP slots.

A dedicated timing module is used to for generation and distribution of the synchronization signals among modules.

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Libera Single Pass H - Libera Brilliance Single Pass

Refer to: Libera Brilliance Single Pass presentation. (M. Znidarcic)

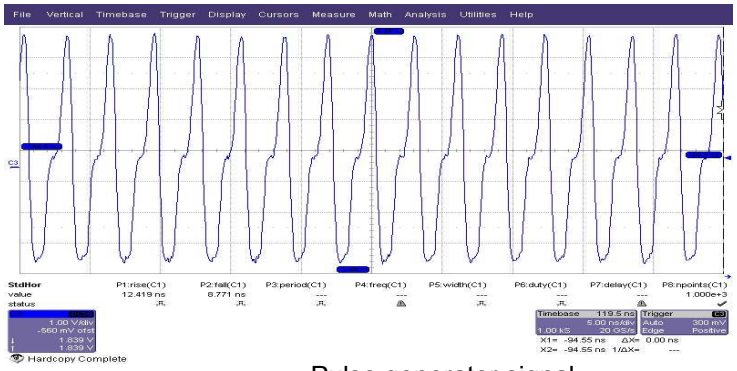
- Designed for hadron machines applications
- Built in phase measurement functionality

- Designed for electron machines applications
- Time domain pulse processing

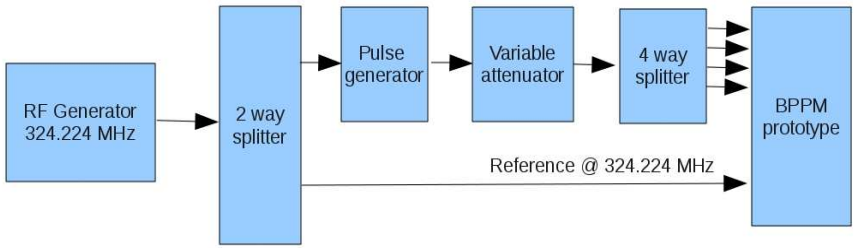
Instrumentation Technologies

Libera Single Pass H – First Measurements

- Libera Single Pass H is being developed on platform B
- A bipolar pulse signal generator based on PIN diode has been developed to simulate in laboratory the ±4V GSI pLINAC pulses
- The system was characterized by means of a power sweep in a 60 dB range.
- The system was set-up for the measurements of the second harmonic frequency component (650 MHz) of the pickup signal in order to avoid the coupling between the RF system and the diagnostic system through the vacuum pipe.



Pulse generator signal



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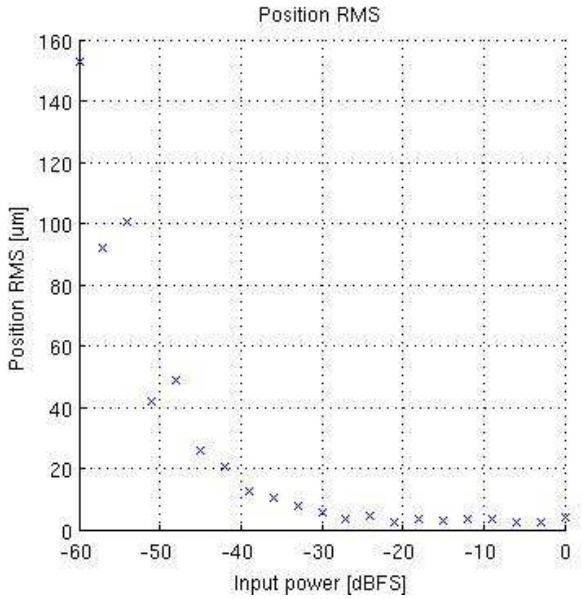
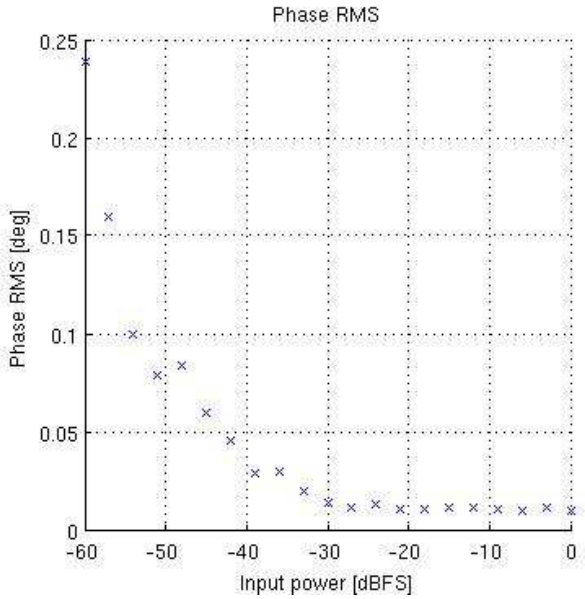
Preliminary Measurements

Measured position and phase uncertainty in the range of 60 dB at 650 MHz (the GSI pLINAC example).
(0 dBFS corresponds to ±4V input.)





Summary

- High resolution Beam Arrival Time (beam phase) measurement functionality has been integrated into Libera Single Pass H.
- The platform is flexible in allowing customization of the system for advanced processing schemes. E.g.:
  - Higher order approximation models can be implemented for the position and phase calculation. Beam energy parametrisation can be integrated in the model.
  - Libera Single Pass H can be used together with other instruments, particularly with the LLRF system to control the acceleration process of the particles.