UPDATE ON THE SYNCHRONIZATION BETWEEN LASER AND LLRF AT AWA

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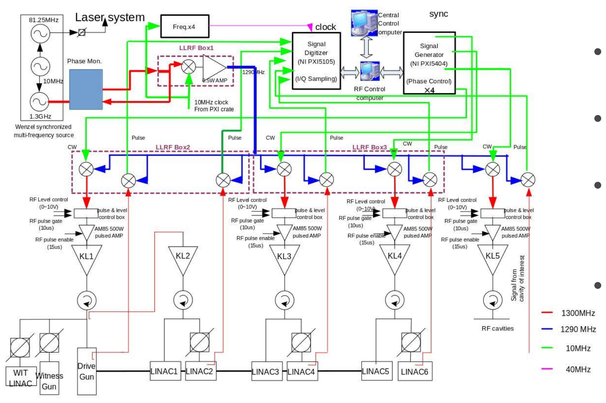
ABSTRACT

- The quality of synchronization between RF and laser is critical for the machine stability of Argonne Wakefield Accelerator(AWA) beamlines. There was a laser room temperature related phase drift between laser and RF at AWA for a long time until we finally found the solution to minimize it. Details are presented.

AWA LLRF AND LASER SYSTEM

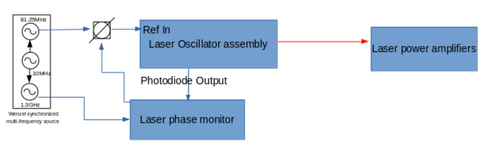
AWA LLRF System



- AWA LLRF system is made using all commercial products.
- 1.3GHz signal from Wenzel synchronized multi-frequency source is our master clock.
- Our IF is chosen to be 10MHz for cost efficiency.
- The LO signal is obtained by mixing mater clock with 10MHz clock from PXI crate backplane.
- There are 4 LLRF channels in our system. The IF of each channel is generated from a NI-PXI5404 using the 10MHz clock from PXI crate backplane.

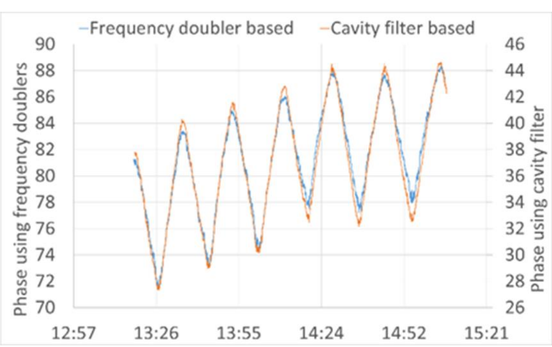
- The RF signals picked up from each associated cavities are mixed with 1.29GHz LO to convert them back to IF before IQ sampled using NI-PXI 5105.
- The 40MHz IQ sampling clock is obtained by multiply the 10MHz clock.
- A feedback control is implemented in LLRF control program to allow locking the LLRF phases to any given value.

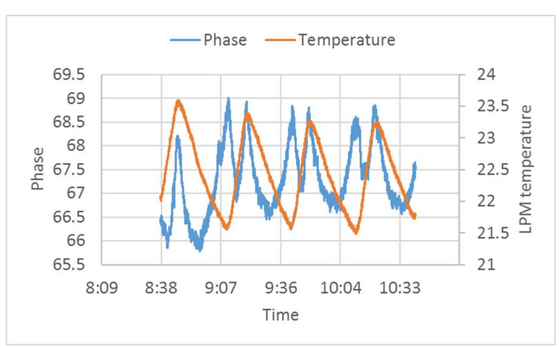
AWA Laser System



As showing in the laser system block diagram, AWA laser oscillators are locked to the 81.25MHz reference signal from Wenzel synchronized multi-frequency source. A laser phase monitor is added to monitor the phase of laser oscillator as referenced to the 1.3GHz LLRF signal. The laser phase feedback control is done by shifting the phase of 81.25MHz reference signal for laser oscillators.

LASER PHASE DRIFT FROM TSUNAMI AT AWA BEFORE SOLUTION WAS FOUND



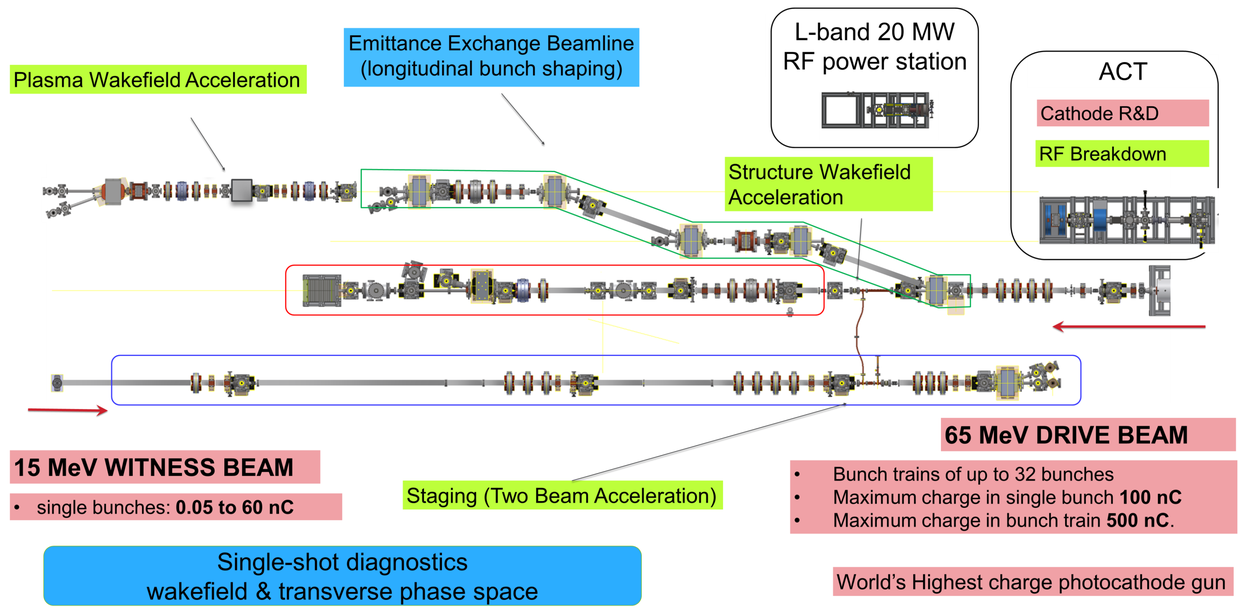


- As showing in the plots, on bad days the phase swing measured for the laser oscillator can be somewhere about 15degrees or more, while on good days it can be just about 2.5 degrees. But usually, the phase swing was about 5 to 6 degrees. The phase swings were closely tracking the laser room temperature cycles per our observations.
- Laser phase feedback controls was implemented to lock the laser phase. It has improved the machine stability. But laser room temperature related electron beam phase drift/swing were still observable.
- A straight forward solution would be to further minimize the laser room temperature fluctuation. But the capital cost for a better laser room is very high for a small facility like AWA to afford.

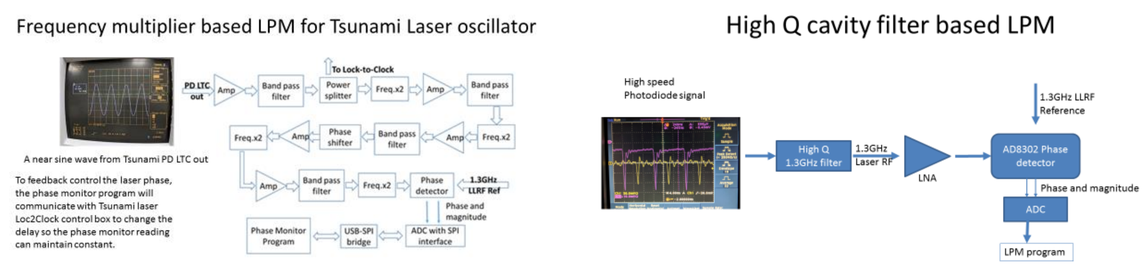
SUMMARY

- Laser phase monitors were successfully implemented to monitor and feedback control AWA laser oscillator. Small modifications have been made to AWA LLRF system to improve its phase stability. With Laser room temperature compensation added to laser phase monitor program and some changes, AWA beam stability has been greatly improved.

AWA FACILITY



AWA LASER PHASE MONITOR



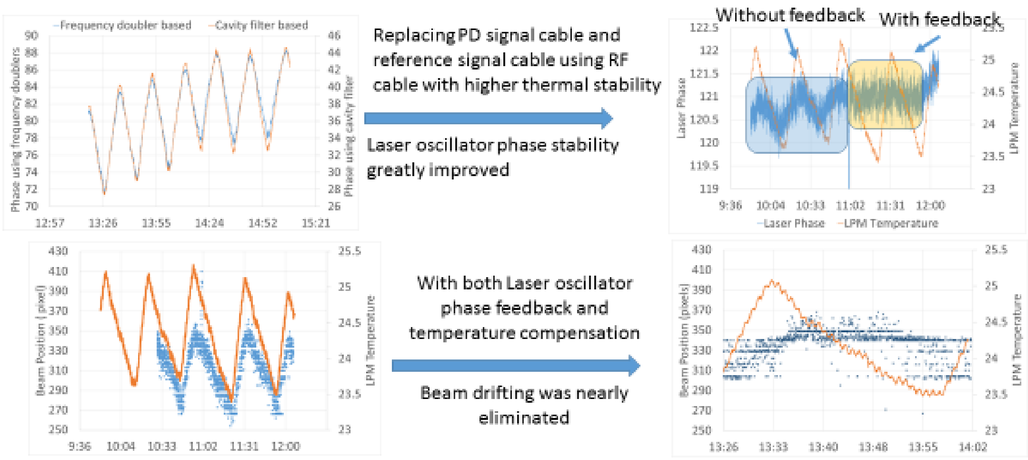
- Two different laser phase monitors were built and tested at AWA.
- The frequency multiplier based laser phase monitor is built using commercial components from mini-circuits. It is perfect for Tsunami laser oscillator where the PD signal is from a low speed photodiodes.
- The high Q cavity filter based laser phase monitor is perfect for laser oscillators with high speed photodiode output.

CHANGES WE MADE AND THE OUTCOME

- Some efforts were invested for better understanding of phase relation between laser, LLRF and electron beam.
- Some modifications to the LLRF system has been made based on studies.
  - 10MHz IF clock changed from Wenzel synchronized multi-frequency source to PXI crate backplane.
  - 1.29GHz LO signal generation has been changed as a result of change to 10MHz IF clock source.
  - A phase monitor for 1.29GHz LO signal was made.
  - 40MHz IQ sampling clock generation has been changed from using PXI-5404 to multiplying 10MHz clock up.
- Helix cables were used to pass reference signal to laser oscillator and PD signals from laser oscillator to its control electronics and laser phase monitor.

Beam Stability Greatly Improved

With our improved laser phase monitor and control system, beam stability is greatly improved.



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