LLRF Control and Synchronization System of the ARES Facility.

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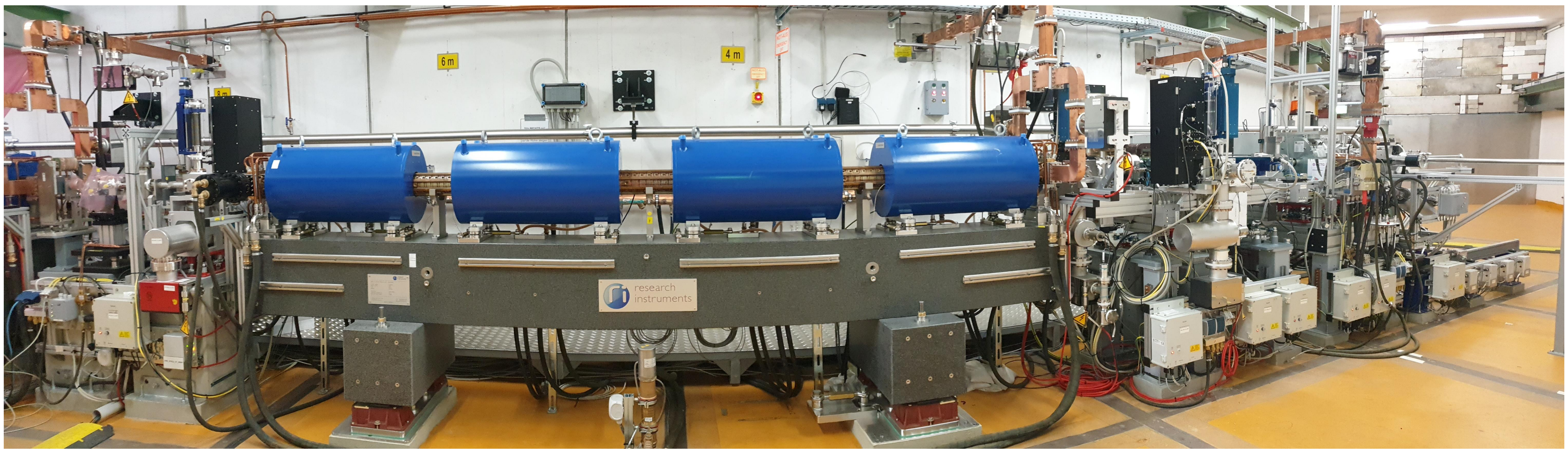
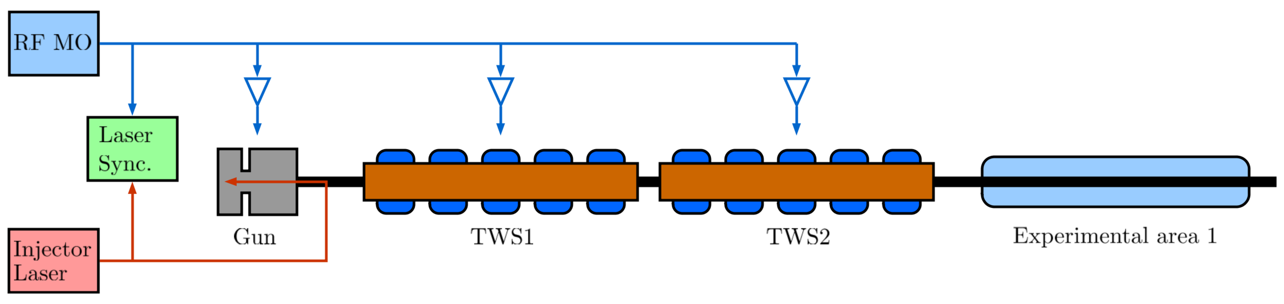
Abstract

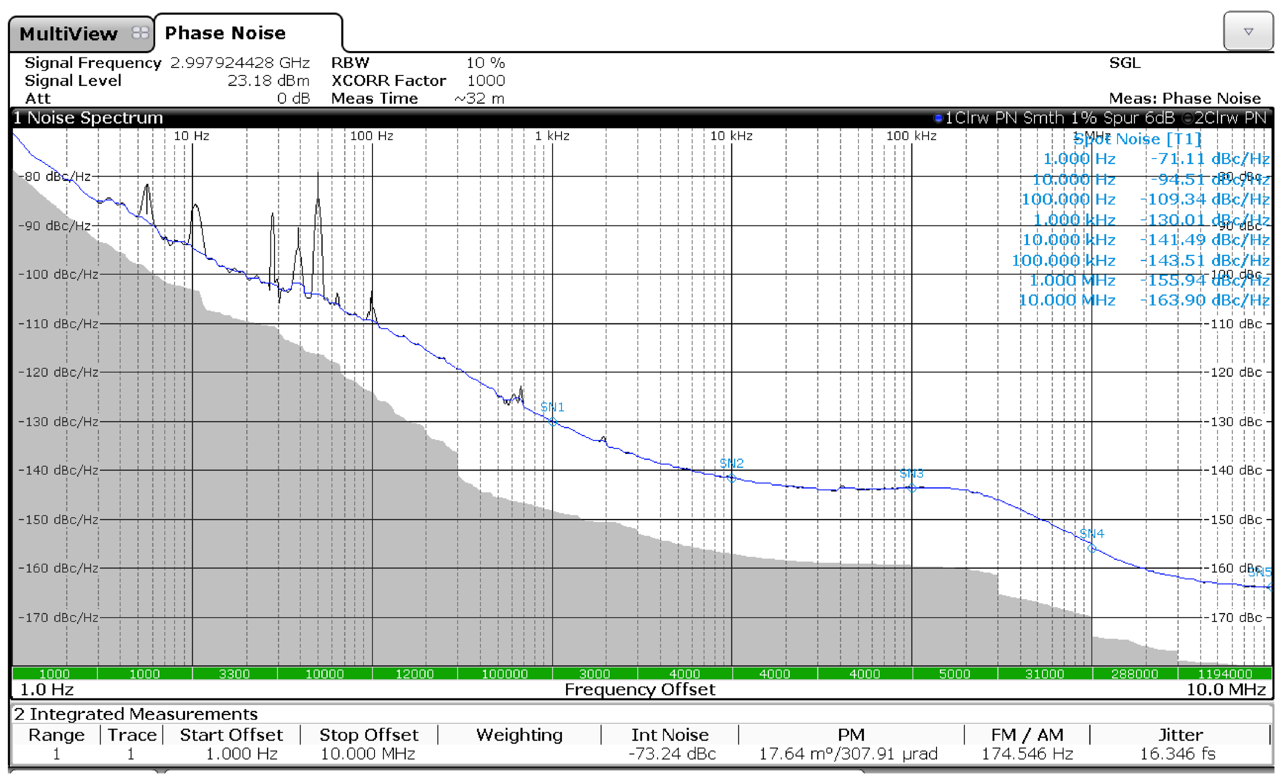
The linear accelerator ARES (Accelerator Research Experiment at SINBAD) is a new research facility at DESY. Electron bunches with a maximum repetition rate of 50 Hz are accelerated up to 155 MeV. The facility aims for ultra-stable sub-femtosecond arrival-times and high peak-currents at the experiment, placing high demands on the reference distribution and field regulation of the S-band RF structures. In this paper, we report on the current status of the RF reference generation, facility-wide distribution, and the LLRF systems of the RF structures.

ARES Injector Overview



RF Synchronization System





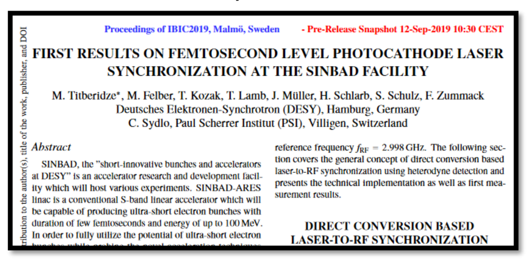
Main Oscillator

- > R&S ® SMA100B
- > RF reference 2.998GHz
- > ~1GHz (phase locked) for the timing system
- > 4.4fs in [100Hz … 10MHz]

New MO x(4-5) improvement

Laser Synchronization

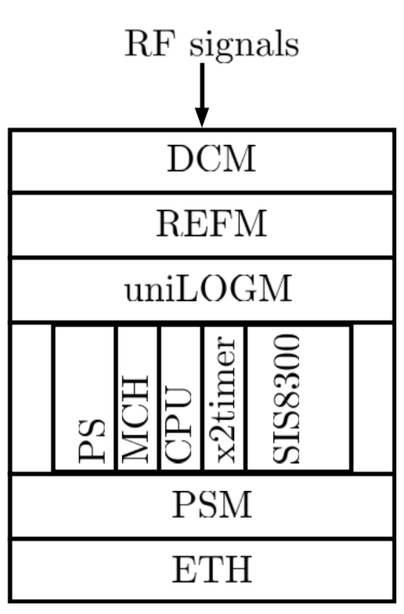
- > 2 concepts have been tested
- > Direct conversion based laser to RF synchronization
- > Mach-Zehnder Modulator based laser to RF synchronization (low noise, low drift)



RF Synchronization

- > Passive RF distribution (only short distances)
- > Reference Modules (REFM) in each rack
  - Currently for signal amplification and distribution
  - Upgrade option for interferometric transmission line stabilization

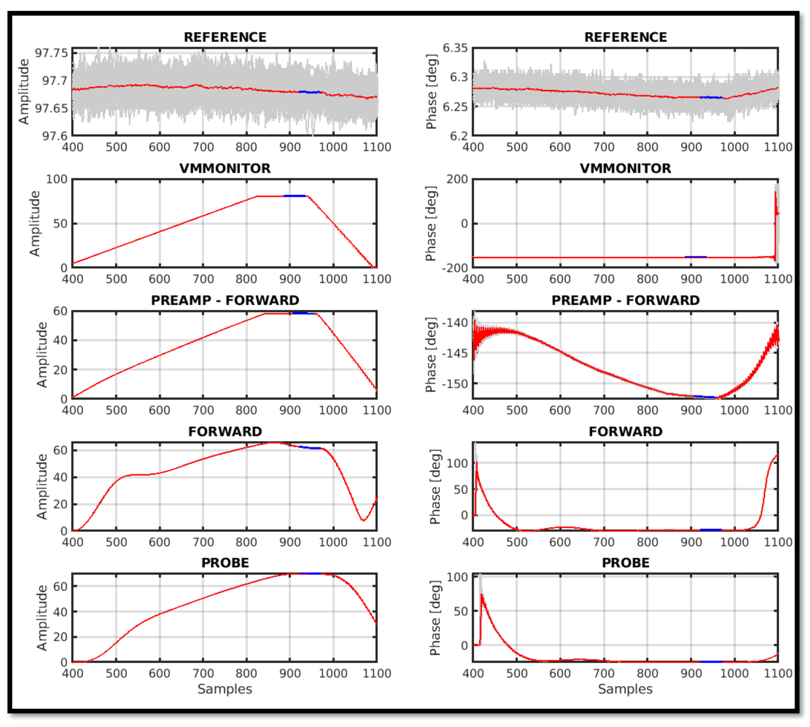
MicroTCA.4 based LLRF System

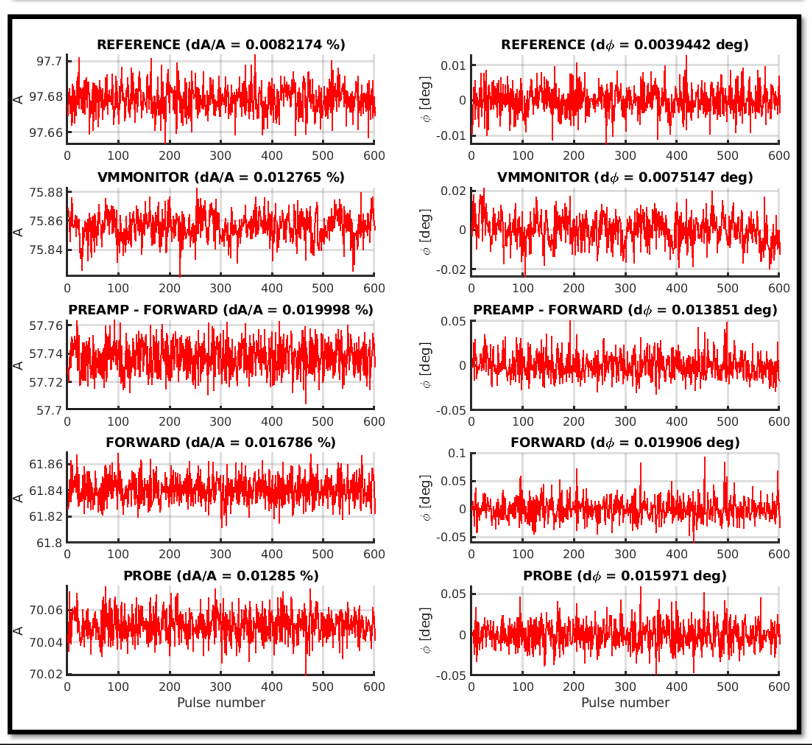


LLRF rack

- > Drift compensation module
- > Reference module
- > Universal local oscillator generation module
- > Power supply module (now shown)
- > Ethernet switch (not shown)
- > LLRF crate
  - Power supply
  - MicroTCA Carrier Hub (MCH)
  - CPU
  - Timer card (x2timer)
  - ADCs (SIS8300-L2, on the front) and down-converter/vector-modulator board (DWC8VM1, on the rear)

First LLRF Measurements





Current RF-gun Regulation

- > Optimized to 83% ADC dynamic range for max. operating point
- > Currently operated at 70MV/m (63%)
- > Pulse to pulse adaptation of the drive signal
- > Calibrated probe signal as regulation signal
- > First results:
  - Beam position as time of interest
  - Average of 51 sampling points
  - Expected noise bandwidth ~2.45MHz (factor 10 higher then gun BW)
  - Slow drifts are corrected
- > **Achieved probe stability of 0.013% and 0.016 deg by pulse to pulse adaptation**

Current TWS Regulation

- > Optimized to 100% ADC dynamic range for max. operating point
- > Currently operated at 75MV/m (75%)
- > Pulse to pulse adaptation of the drive signal
- > Regulation signal:
  1. Calibrated 1st probe signal or
  2. Sum of 5 calibrated probe signals to minimize temperature effects along the structure
- > Stability analysis for the 2 regulation concepts as next topic

Conclusion & Outlook

- > LLRF systems for gun and TWS1/TWS2 operational
- > RF chain analysis does not show larger noise sources
- > Systems calibrated with beam and optimized on digital level
- > Passive RF distribution and direct laser to RF synchronization sufficient for first commissioning
- > MO upgrade to reduce amplitude/phase noise Polari-X LLRF system will be installed
  - Up-conversion module from 3 GHz to 12 GHz
  - Down-conversion module from 12 GHz to 3 GHz
- > Upgrade REFMs for interferometric transmission line stabilization
- > TWS1 and TWS2 regulation optimization
- > Activate and optimize intra-pulse feedback

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