# LLRF Control and Synchronization System of the ARES Facility.

Sven Pfeiffer<sup>\*</sup>, J. Branlard, F. Burkart, M. Hoffmann, T. Lamb, F. Ludwig, H. Schlarb, S. Schulz, B. Szczepanski, M. Titberidze, DESY, Hamburg, Germany

## 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**

#### RF MO Laser Sync. Gun TWS1 TWS2 Experimental area 1 TWS2 Experimental area 1 Multiview Phase Noise Signal Frequency 2.997924428 GHz RBW 10 % Signal Frequency 2.997924428 GHz ABW 10 % Signal Level 2.318 dBm XCORR Factor 1000 Meas Time ~32 m Meas: Phase Noise Meas: Phase Meas: Pha

## 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)

#### **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)

# **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

#### **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 1<sup>st</sup> 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

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roceedings of IBIC2019, Malmö, Sweden - Pre-Release Snapshot 12-Sep-2019 10:30 C FIRST RESULTS ON FEMTOSECOND LEVEL PHOTOCATHODE LASER SYNCHRONIZATION AT THE SINBAD FACILITY M. Titberidze<sup>\*</sup>, M. Felber, T. Kozak, T. Lamb, J. Müller, H. Schlarb, S. Schulz, F. Zummack Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany C. Sydlo, Paul Scherrer Institut (PSI), Villigen, Switzerland reference frequency  $f_{\rm RF} = 2.998$  GHz. The following s tion covers the general concept of direct conversion base SINBAD, the "short-innovative bunches and accelerators laser-to-RF synchronization using heterodyne detection a at DESY" is an accelerator research and development facil-ity which will host various experiments. SINBAD-ARES presents the technical impler linac is a conventional S-band linear accelerator which will be capable of producing ultra-short electron bunches with luration of few femtoseconds and energy of up to 100 MeV. DIRECT CONVERSION BASED rder to fully utilize the potential of ultra-short electron LASER-TO-RF SYNCHRONIZATIO

### **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

\* sven.pfeiffer@desy.de



#### Achieved probe stability of 0.013% and 0.016 deg by pulse to pulse adaptation

## **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

IPAC 2021 Virtual Edition, Hosted by LNLS/CNPEM, May 24-28, 2021 12th International Particle Accelerator Conference

