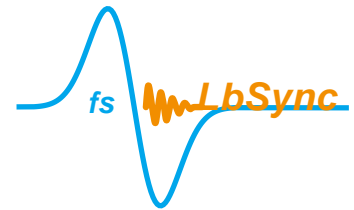


# Sub-10 fs Synchronization of the SINBAD Injector-Laser

Thorsten Lamb on behalf of the DESY MSK LbSync Team

**Virtual MT ARD ST3 Meeting 2020**

September 24<sup>th</sup>, 2020



**HELMHOLTZ** RESEARCH FOR  
GRAND CHALLENGES



**SINBAD**



# Short Innovative Bunches and Accelerators at DESY (SINBAD)

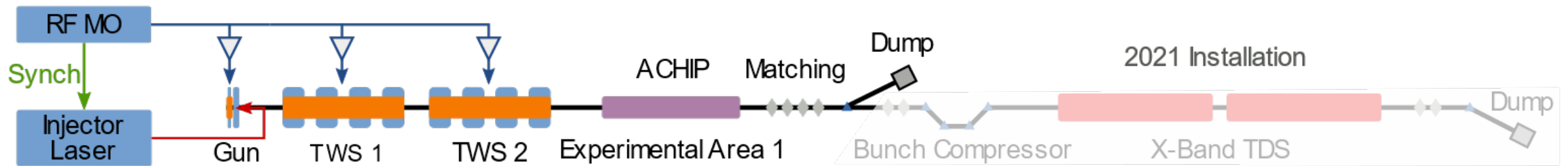
## Accelerator Research Experiment at SINBAD (ARES)

### ARES

- ... is a normal conducting S-band linac for the production of **ultra-short electron bunches**
- target parameters:
  - 50 - 150 MeV
  - 0.5 - 200 pC
  - single pulse @ 50Hz
  - few fs / sub-fs pulse length
- ACHIP: Dielectric Laser Acceleration Experiment

### Injector Laser Synchronization

- Injector Laser:  $\lambda_{IL} = 1030 \text{ nm}$ ,  $f_{rep} = 83.3 \text{ MHz}$
- RF reference (MO):  $f_{RF} = 2.998 \text{ GHz}$
- **sub-10 fs (rms) synchronization requirement**
- no optical reference / sync system available
- direct conversion based synchronization (**RF lock**)
  - basic sync principle, does not fully meet the requirements
- upgrade: MZM-based Laser-to-RF Synchronization

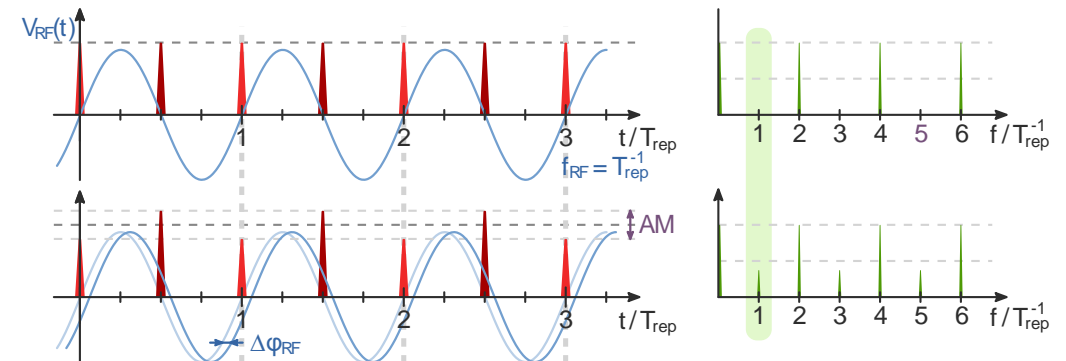
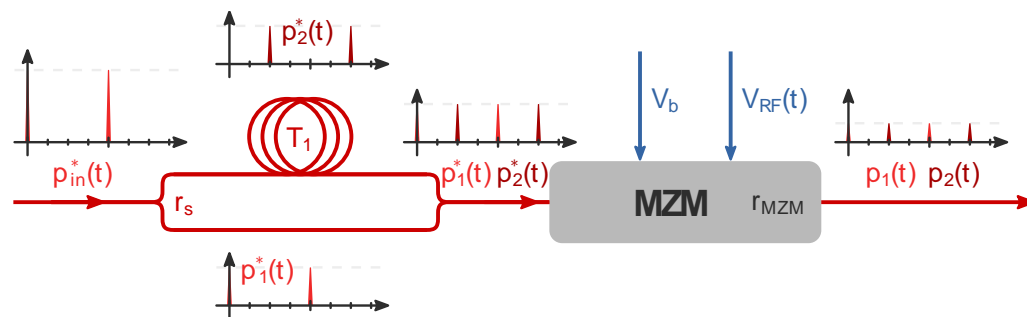
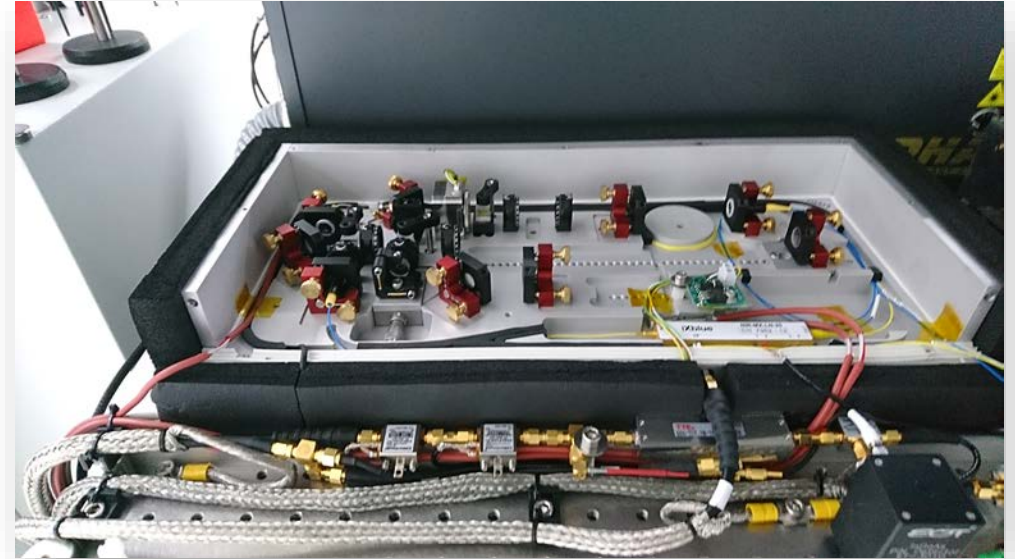


# MZM-based Laser-to-RF (L2RF) Synchronization

## Principle and Implementation

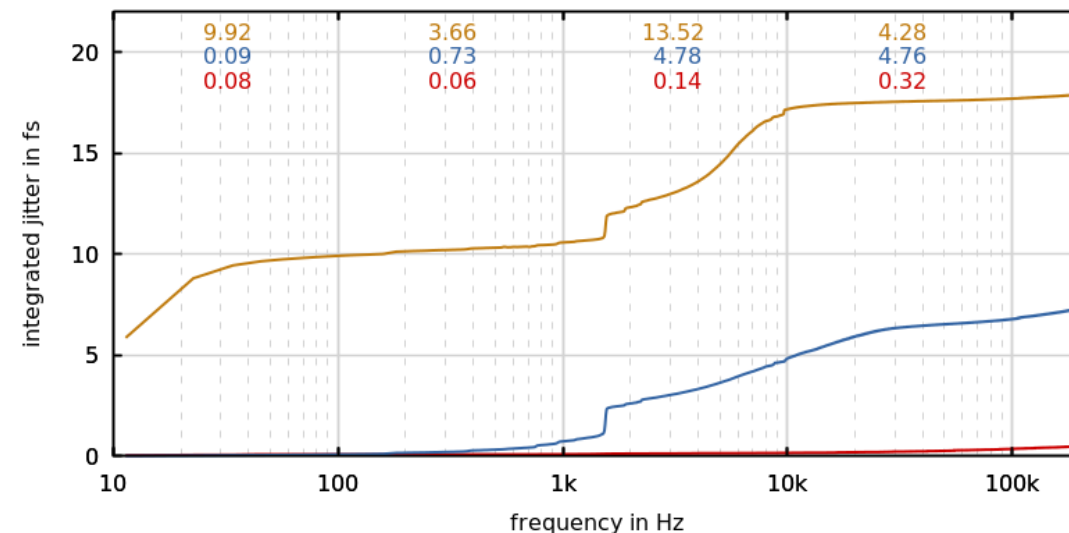
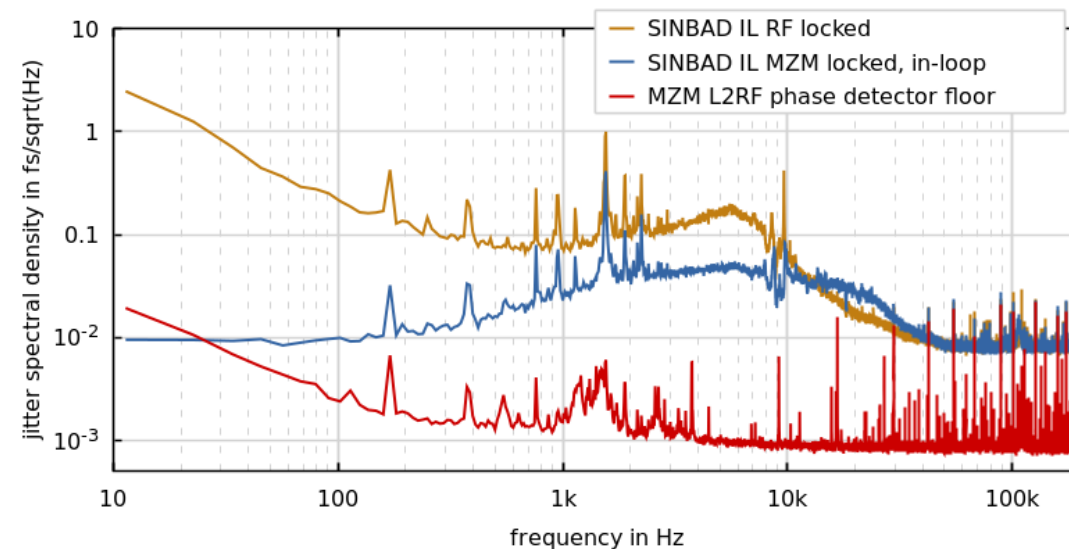
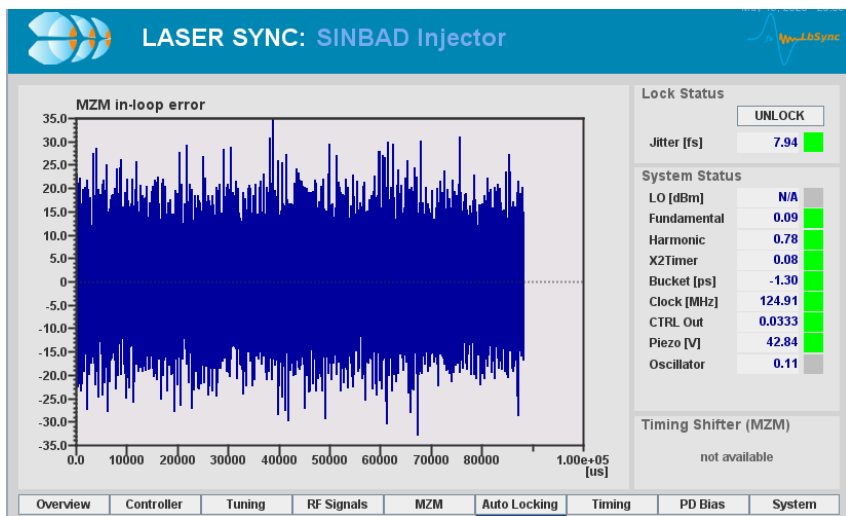
### Key Parameters

- single output Mach-Zehnder amplitude modulator
- bias voltage feedback
- laser pulses sample positive and negative slopes of the RF reference
- amplitude modulation of the laser pulse train proportional to the phase error
- to minimize drifts: installation close to the laser, temperature stabilized and humidity sealed setup



# Sub-10 fs Synchronization Performance

- measurement bandwidth: 10 Hz - 186 kHz
- integrated jitter:
  - detector noise floor (RF disconnected): **0.5 fs**
  - timing jitter (RF locked, measured with MZM): **17.9 fs**
  - timing jitter (MZM locked, in-loop): **7.2 fs**



# Thank you!

## Contact

**DESY.** Deutsches  
Elektronen-Synchrotron

[www.desy.de](http://www.desy.de)

Thorsten Lamb  
MSK / LbSync  
[Thorsten.Lamb@desy.de](mailto:Thorsten.Lamb@desy.de)  
+49 40 8998 2638