# Full PIC simulation of first ACHIP experiment @ SINBAD.

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The Accelerator on a CHip International Program (ACHIP) is a research project funded by the Gordon and Betty Moore Foundation. It aims at the construction of a compact fully laser driven electron accelerator for radiation generation. Several Universities in Europe and the USA and the national Laboratories PSI, DESY and SLAC are involved. DESY Hamburg contributes with access to it's SINBAD accelerator research facility and support from the ARD and Laser groups.

We present simulation results with respect to the first ACHIP experiment at the SINBAD facility. It aims at the net-acceleration of a fs electron bunch in a gratin structure for 2  $\mu$ m wavelength towards a monoenergetic beam.

# Setup

A full PIC simulation in CST [3] was set up with a feasible working point from the ARES linac. Fifty grating periods were simulated with a maximum incoming laser field of 4 GV/m.

The working point was derived from a model of the linac simulated with ASTRA [4]. Its parameters are shown in table 1. The bunch length is short enough to stretch over a limited part of the laser-to-electron phase, thus theoretically allowing a net-energy gain. For longer bunches only a modulation of the energy is to be expected.

The incoming laser parameters are shown in table 2. The laser pulse is assumed to be temporally and spatially gaussian shaped. A pulse-front-tilt of 45° is assumed for the calculation of the pulse energy.

Dielectric materials recently gained more attention in accelerator research due to their high damage thresholds at optical frequencies. Lasers with high intensities can be used to realize high accelerating gradients, thus rendering the accelerator more compact.

The periodic diffraction fields in the gap along the z-axis can be described via spatial harmonics. If the grating period matches the incoming wavelength, the first spatial harmonic has a speed of light phase velocity [2]. The acceleration is transversely uniform over the gap, if it is small enough.



### Table 1: e-beam

E-beam parameters @ IP (15.5 m)	Value (WP 2)
Charge [pC]	0.5
Bunch Length [fs,fwhm]	2.1 (0.3 * λ <sub>L</sub> )
E [MeV]	99.1
ΔE/E [%]	0.12
σ <sub>x,y</sub> [μm]	7.8
ε <sub>n,x,y</sub> [nm]	105

## Table 2: laser

Laser parameters @ IP (15.5 m)	Value
Wavelength [µm]	2
σ <sub>t</sub> [fs]	120
Energy [µJ]	7
σ <sub>x</sub> [μm]	50
σ <sub>y</sub> [μm]	10

## **Simulation results**

One simulation was carried out with zero emittance point source test beams to learn about the relationship of focusing and acceleration. The figures show a detail of the whole scan at maximum energy gain envelope. The spectrum is calculated from a superposition with the particle distribution of the working point from an ASTRA simulation. The resulting acceleration gradient



is calculated from the structure length to the average energy gain.

# **Conclusion & Outlook**

It was shown that a net-acceleration experiment at SINBAD is possible with a drive laser wavelength of 2 µm with 14 µJ pulse energy. The altered spectrum is well measurable with the expected spectrometer resolution. The absolute energy gain can still be optimized. A VSim [5] simulation will be set up to compare the results. The codes developed by our group will be evaluated against the retrieved results.

#### References

[1] ACHIP - https://achip.stanford.edu/
[2] R. J. England et al., Rev. Mod. Phys. 86, 1337-1389 (2014).
[3] CST - Computer Simulation Technology, available from www.cst.com.
[4] K. Floettmann, ASTRA - A space charge tracking algorithm, http://www.desy.de/~mpyflo/.
[5] Vsim – http://www.txcorp.com









