STATUS UPDATE OF THE SINBAD-ARES LINAC UNDER CONSTRUCTION AT DESY

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Abstract

ARES (Accelerator Research Experiment at Sinbad) is a linear accelerator for the production of low charge (from few pC to sub-pC) electron bunches with 100 MeV energy, fs and sub-fs duration and excellent arrival time stability. This experiment is currently under construction at DESY Hamburg and it is foreseen to start operation by the beginning of 2018 with the commissioning of the RF-gun. After an initial beam characterization phase, ARES will provide high temporal resolution probes for testing novel acceleration techniques, such as Laser driven plasma Wake-Field Acceleration (LWFA), Dielectric Laser Acceleration (DLA) and THz driven acceleration. In this work we present an overview of the most up-to-date design of the linac with a special focus on 3D integration considerations and phases of the installation of the beamline.

INTRODUCTION

Novel high gradient acceleration techniques are characterized by a short wavelength accelerating field, which require the injection of ultra-short electron bunches.
The ARES accelerator hosted at SINBAD [1] aims for producing fs and sub-fs e-bunches with excellent arrival time stability [2, 3].

Table 1: Basic e-Bunch Parameters

Charge [pC]	0.5-30
Norm. RMS Emitt. [μm]	0.1-1
RMS Bunch Length [fs]	0.2-10
Beam Energy [MeV]	100-160
Rep. Rate [Hz]	10-50

The main parameters of the electron beam at the linac exit are summarized in Table 1, while a scheme of the accelerator is depicted in Fig. 1.
In the following Sections we will illustrate the current status of the technical design of the accelerator according to the phases of its installation, i.e.:

- RF gun commissioning;
- Linac commissioning;
- Bunch compressor, final diagnostics section and dogleg extensions.

We will comment on the status of the integration and we will give an overview of the general parameters of the machine and the foreseen beam diagnostics.

ARES PHOTO-INJECTOR

Electron Production

A sketch of the ARES photo-injector is represented in Fig. 2. It comprises a modified version of the 2.998 GHz REGAE RF gun [4]. Its RF station is constituted by a Toshiba E37326A Klystron and a Scandinova K1 modulator. 6 MW peak input power in the gun cavity corresponds to an accelerating gradient of almost 117 MV/m, which allows for a final energy of the electrons which is higher than 5 MeV. The design of the antenna connecting the coupler to the gun cavity has been elongated with respect to the original design in order to accommodate a second solenoid (coming with a bucking coil). The additional focusing allows for an improvement of the transverse quality of the beam because of the reduction of the non-linear emittance increase induced by the RF fields [5].
The first solenoid and the bucking coil have total minimum focal length of about 18 cm for a 5.1 MeV beam which is not sufficient e.g. to focus down the beam for emittance characterization via solenoid scan [6] or TEM grid interaction [7], therefore a second solenoid is installed after the coupler.

A UV laser having a wavelength of 257 nm is coupled to the beamline downstream the injector with about 90 degree angle with respect to the cathode surface. Opposite to the laser in-coupling mirror, a second mirror will be installed for future possible direct visualization of the laser spot-size on the cathode. The optical beamline is designed to allow flat-top transverse shaping of the beam up to a minimum RMS spot size of 80 μm. The laser pulse is longitudinally Gaussian and its FWHM duration can be tuned between 180 fs and 10 ps.

A load lock system allows for in vacuum cathode exchange. Both Cs_2Te and metallic cathodes are foreseen to be employed. The Cs_2Te cathodes are more suitable for tens of pC (or higher) charge electron generation because of their high quantum efficiency but slow emission time. On the other side the metallic cathodes are more suitable for the ultra

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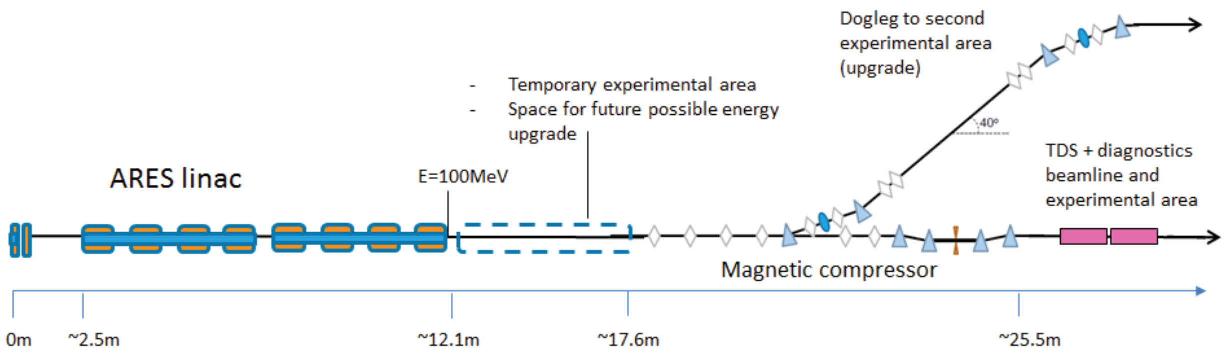

Figure 1: Layout of the ARES linac.

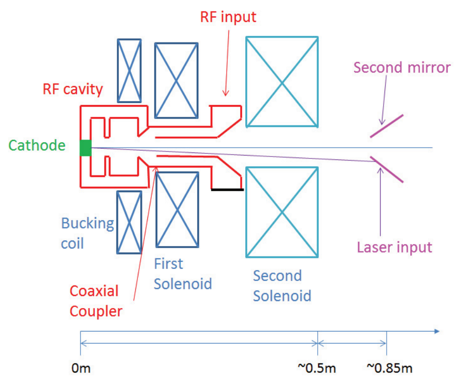

Figure 2: Schematic of the ARES photo-injector design.

low charge working points because they allow for producing electron bunches shorter than 1 ps thanks to the faster emission time.

Electron Characterization

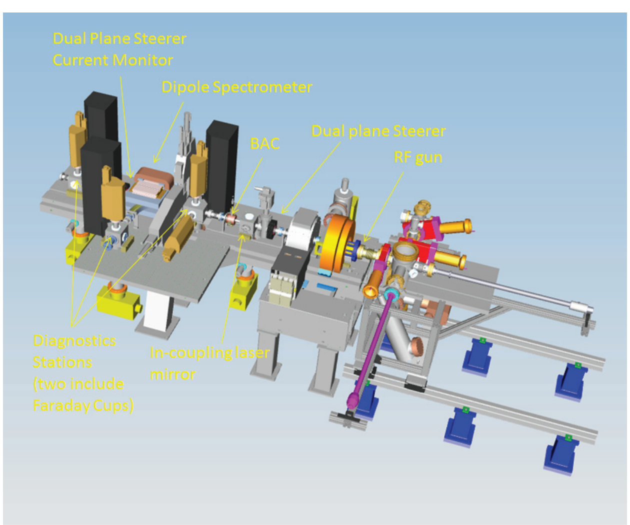

Figure 3: Preliminary 3D Model of the ARES RF gun area.

In the first stage of the installation of ARES, that is foreseen to take place by the end of this year, only the RF injector and its correlated diagnostics will be installed. The diagnostic line comprises the following elements:

- Two Faraday Cups and a beam current monitor [8] for the beam charge measurement;
- A Beam Arrival Time Cavity [9] for measuring the beam arrival time jitter;
- Three screen stations for high resolution spot-size measurement [10];
- A dipole spectrometer for beam energy and energy spread characterization;
- The transverse emittance measurement will be possible both via solenoid scan and using a TEM grid installed in the first diagnostics station.

Moreover a round collimator placed after the first diagnostics station will allow for eliminating the beam halo. The present status of the beamline integration is illustrated in Fig. 3.

ARES LINAC

In the second phase of the installation of ARES, that is foreseen to take place by the end of next year, the complete linac and matching beamline will be installed. The linac will be constituted by two 2.998 GHz traveling wave structures each one allowing for a maximum beam energy gain of 77 MeV. The RF cavities will be surrounded by solenoids for compensation of space charge driven beam defocusing. Each cavity will be fed by an independent RF station. The S-band linac allows for on-crest acceleration of the beam up to about 160 MeV. In order to operate bunch compression via velocity bunching or using the magnetic chicane downstream the linac [2], the linac cavities are operated off crest, therefore the final beam energy will be limited to about 100 MeV. In order to be able to monitor the stability of the trajectory of the low charge ARES beam, high resolution cavity Beam Position Monitors (<5 microns at 0.5 pC charge averaging over 50 bunches) are currently under development. Some space at the linac exit has been reserved for a future energy upgrade and will temporarily host an experimental area [11],

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while the matching lattice will temporarily be used for beam diagnostics purposes.

BUNCH COMPRESSOR, DOGLEG, DIAGNOSTIC LINE

After the linac commissioning a magnetic chicane and - as an upgrade - a dogleg are planned to be installed. A sketch of the complete magnetic lattice including place holders for beam diagnostics is shown in Fig. 4. The bunch compressor has been designed for allowing a variable R_{56} in the range −10 mm and −30 mm and it is characterized by the presence of a slit after the second dipole which allows for longitudinal beam slicing, as described in [2]. The dogleg design [12] makes possible the tuning of the R_{56} in the range 10 mm/−10 mm. The dogleg's purpose is both to compress the bunch and inject it into a second future experimental area. The positive R_{56} will enable to test also schemes for jitter compensation [3, 13].

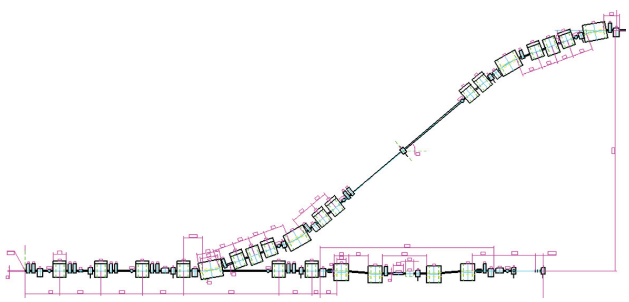

Figure 4: Layout of the ARES magnetic lattice including the bunch compressor and the dogleg.

Finally a diagnostic line for a complete beam characterization [14] will be installed. A novel X-band TDS system with variable polarization [15] will be located at the bunch compressor exit, where also the main experimental area is foreseen, allowing for fs longitudinal diagnostics and novel methods for full characterization of the beam distribution [16].

CONCLUSION

We have shown the progress towards the realization of the technical design and integration of the ARES linac. The 3D design of the gun region is almost completed and its installation is foreseen to take place by the end of this year. The linac technical design is still under iteration, therefore we have presented an overview of its present status. After an initial beam characterization phase, ARES will provide high temporal resolution probes for testing novel acceleration techniques. First experiments using the ARES beam are expected to take place starting from mid 2019.

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