

# Cost and Schedule Review of the AWAKE Project, 2017

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## Panel Members:

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## Introduction

The Advanced Proton Driven Plasma Wakefield Acceleration Experiment, AWAKE, is a proof-of-principle R&D experiment at CERN, using a high-energy proton bunch to drive a plasma wakefield for electron bunch acceleration. AWAKE is the first proton-driven plasma wakefield acceleration experiment and the goal is to study the physics of the interaction of long proton bunches with plasmas as a function of beam and plasma parameters and to demonstrate that large amplitude wakefields ( $\sim 1\text{GV/m}$ ) can be driven over large-scale plasmas (5-10m) by self-modulated proton bunches. The AWAKE experiment uses the 400 GeV proton beam from the SPS, which is sent to a plasma source. An electron beam will be injected into the plasma cell to probe the accelerating wakefield.

The Run 1 of the AWAKE experiment was approved in Aug. 2013 and installation and commissioning of the facility for phase 1 of Run 1 has been completed as scheduled in 2016. In 2016 AWAKE has achieved a major milestone and observed the strong modulation of high-energy proton bunches in plasma; the results represent the first ever demonstration of strong plasma wakes generated by proton beams. This is a significant step towards the goal of using the proton-driven plasma wakefield technique to accelerate electrons.

A Run 2 of AWAKE is proposed (not approved yet). The main objectives of Run 2 are: to demonstrate high-gradient acceleration of bunches of electrons up to many GeV while preserving reasonable beam quality, and to demonstrate scalable plasma source technology. Successful demonstration of these two objectives will open up the path towards high-energy physics applications for proton driven plasma wakefield acceleration.

## The Schedule

**Run 1** of the AWAKE experiment is divided in two phases:

Phase 1 for studies of proton beam self-modulation instabilities (SMI).

Phase 2 for studies of electron acceleration.

Phase 1 includes the partial dismantling of the CNGS area, the installation of the proton and laser beam line, the plasma cell, the laser source and SMI detectors and

all associated services during 2015 and 2016, the Hardware and Beam Commissioning during Q2 and Q3 2016 and physics from December 2016.

Phase 2 includes the design and installation of the electron source, klystron system, electron beam-line, laser beam to the electron source, electron diagnostics during 2017, alternating physics runs for SMI measurements, the Hardware and Beam Commissioning in 2017/2018 and electron acceleration physics in 2018 until the start of LS2.

The Run 2 is proposed to start right after LS2. A design study of Run 2 will be established during 2017 and presented to the CERN management by end of 2017. An option for Run 2 electron injection is on-axis injection between two plasma stages. In order to prepare Run 2, a significant research effort is required for a number of topics: scalable plasma sources, compact high peak current electron injectors, plasma staging, proton beam optimization, instrumentation development, numerical simulation studies and infrastructure studies.

In parallel a helicon plasma cell R&D effort is established between CERN, Swiss Plasma Center Lausanne and IPP Greifswald to develop scalable helicon plasma cells for Run 2 and beyond.

Within the Physics Beyond Collider Study Group first applications of proton driven plasma wakefield acceleration at CERN are required to be studied with additional personnel. The aim is to prepare a proposal by the end of 2018, in time for the update of the EESPP.

## The Resources

CERN is the host laboratory of the AWAKE experiment and is responsible of the design, installation, construction, commissioning and maintenance of the AWAKE experiment at CERN in all its different phases; this includes the AWAKE SPS beam, the proton, electron and laser transport lines, the electron source, the experimental area, RF synchronization, the associated services, the necessary civil engineering modifications, all matters of safety as well the infrastructure systems. In addition CERN is involved in the experiment itself with plasma simulations and data taking with experimental equipment.

The external collaborators today provide the plasma cell, the laser, the SMI diagnostics, electron beam-line elements, the electron spectrometer and simulations.

The CERN material budget (MTP of 2016) for Run 1 was estimated to 12.1 MCHF, the contribution of the collaboration to 6.8 MCHF. The Max Planck Institute of Munich provides most of the external funding; in 2016 they received an extra funding of 0.5MEUR to cover the cost increase of the plasma cell ends.

The CERN person power needs (MTP of 2016) for Run 1 correspond to 56 person-years, distributed until 2019 in the different CERN groups. The total budget for fellows foresees 2.5 MCHF. The installation and commissioning of phase 1 and phase 2 of Run 1 is on schedule. The first physics phase in Run 1 has started and scientific expertise on plasma wakefield physics is required at CERN. The MTP 2016 material estimates (including the external person power needs) and installation costs for the CERN contributions of Run 1 have been reviewed.

In addition resources are required for the design studies of Run 2, the helicon plasma cell R&D efforts at CERN as well as first application studies of proton driven plasma wakefield acceleration at CERN. These required resources are presented in the review.

This review is called to assess the situation.

### The Review

It is the wish of the CERN management to submit the AWAKE project to review asking the members of the Panel to assess whether:

1. The cost of the CERN AWAKE project for Run 1 is validated.
2. The personnel expected to be deployed by CERN during Run 1, is available and adequate.
3. The resources required for the design study of Run 2 and the new research efforts are properly estimated. The origin of potential resources for the Run 2 design study (collaborations, re-allocation of Run 1 resources ...) shall also be assessed.
4. The contingency strategy in terms of budget and impact on the experiment is validated.

### Organization of the Review

The Review Panel will meet on **20 March 2017**. The first half of the meeting will be devoted to presentations and discussions with the specialists, the second half will be devoted to the preparation of the draft recommendations that will be presented by the chair at the end of the meeting. The written recommendations of the Review Panel will be submitted in a written report within three weeks from the review to the Director for Accelerators and Technology and subsequently presented to the IEF.