Status and prospects of the AWAKE experiment
ICHEP, Seoul 2018

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On behalf of the AWAKE Collaboration
AWAKE is an experiment to demonstrate proton driven plasma wakefield acceleration for the first time. We aim to accelerate electrons to GeV energies to prove the technique’s potential for HEP projects.
Plasma wakefield acceleration
Proton driven plasma wakefield acceleration

Previous plasma wakefield experiments have been driven by laser pulses and electron beams.

ILC/CLIC, 500 GeV with $2 \times 10^{10} e^- \rightarrow 1.6 \text{ kJ}$

Producing high energy bunches in a single stage requires high drive beam energy.

SPS, 400 GeV with $3 \times 10^{11} p \rightarrow 19.2 \text{ kJ}$

Proton drive beams can give high gradient ($> 1 \text{ GV m}^{-1}$) acceleration over 100’s of metres.
A WAKE at CERN

Electron source system

20 MeV RF structure
RF gun

Electron beam

Laser beam

20 MeV RF structure

Dipole

Proton beam

10 m Rb Plasma
Rb flask

Imaging station 1

OTR, CTR screens

Scintillator screen

Electron spectrometer

Laser dump

Imaging station 2

Accelerated electrons on the scintillator screen

Electron bunch
Long proton bunch
Ionising laser pulse

Proton microbunches
Captured electrons
Proton modulation results I

OTR images taken with a **streak camera**

Protons and low power laser

Protons and **high** power laser
Proton modulation results I

Clear microbunching at the **plasma frequency**
Blown-out protons give clear evidence of strong transverse fields acting on the bunch.
Stitching together multiple streak camera images shows the full bunch train. This is only possible because of how reproducible the self-modulation is.
Stitching together *multiple* streak camera images shows the full bunch train. This is only possible because of how *reproducible* the self-modulation is.

More self-modulation details in two *upcoming* papers.
Electron acceleration
AWAKE is very well doing
Electron acceleration results
Spectrometer analysis recipe

Position ↔ energy conversion

Geometric corrections

CCD count ↔ charge conversion

Background subtraction
Event at $n_{pe} = 1.8 \times 10^{14} \text{ cm}^{-3}$ with a $5\% / 10 \text{ m}$ density gradient.

Acceleration to $\sim 800 \text{ MeV}$. The energy is dependent on $n_{pe}$ and on the gradient.

Capture efficiency not yet optimised, leading to low accelerated bunch charge of $\sim 0.2 \text{ pC}$. We’re working to improve this now.

Spectrometer quadrupoles were focusing at $\sim 600 \text{ MeV}$ here.
Consecutive electron injection events at $n_{pe} = 1.8 \times 10^{14} \text{ cm}^{-3}$.

Quadrupole scan performed over this period and other parameters held constant.

This stability is crucial for further development.
Electron acceleration results III

Acceleration up to 2 GeV has been achieved.
Charge capture decreases with $n_{pe}$.
Into the future
Demonstrate the use of **scalable** plasma cells.

- New diagnostics for plasma, protons and electrons.
- Achieve **high energy** and high charge capture whilst **preserving emittance**.
Considering options for high energy but moderate luminosity $e^-$ bunches.

Fixed target experiments, such as dark matter searches, are being considered.

An $ep$ collider looking at saturation (and more) is a leading prospect.

We’d like to hear suggestions, both big and small.
AWAKE has demonstrated proton-driven plasma wakefield acceleration for the first time.

- Acceleration to 2 GeV has been observed.
- The reproducibility of the acceleration is already very promising for the future.
- Only small amounts of charge have been captured so far.
  - We’re working to improve the injection electron beam.
  - We will begin scanning the available parameters (injection angle, focal point, etc.) to maximise the charge.
- We’re increasingly looking beyond this year to AWAKE run 2.
- There are many good applications for this technology and we’re open to suggestions.

These are only the first results and there will be many more coming soon.
BACKUP
2 GeV projection