FIPS @ AWAKE

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- Recap of AWAKE
- Plans for AWAKE Run 2
- HEP Applications
- Dark sector studies
Recap of AWAKE

500mJ
120fs Laser beam

Electron source system
20 MeV
4x10^9 e, 2ps

Dipole

10 m Rb Plasma

Proton beam
400 GeV
3x10^{11} p
400ps

20 MeV RF structure


AWAKE Run 2

Demonstrate possibility to use AWAKE scheme for high energy physics applications in mid-term future.

- Accelerate electron bunches to high energy (gradient $0.5 - 1 \text{ GV/m}$).
- Preserve electron bunch quality (emittance preservation ~ $10 \mu m$).
- Demonstrate scalable plasma source technology.

- Run 2a): Demonstrate electron seeding of self-modulation in first plasma cell.
- Run 2b): Demonstrate stabilisation of micro-bunches with a density step.
- Run 2c): Demonstrate electron acceleration and emittance preservation.
- Run 2d): Demonstrate scalable plasma sources.

Then applications to particle physics experiments by end of decade
HEP applications

Considered applications with electron bunches:

- Up to $E_e \sim 50$ GeV, wakefields driven by SPS protons
- $E_e \sim $ TeV, wakefields driven by LHC protons.

Possible ideas are:

- Accelerator or detector test facility.
- Injector for e.g. EIC.
- Fixed-target/beam-dump experiments for deep inelastic scattering or dark-photon searches.
- TeV-scale electron–proton colliders, either $E_e = 50$ GeV or $E_e = 3$ TeV.

Other possible ideas:

- Accelerate muons (rather than electrons) to high energy.
- Heavy ions as the driver.

A. Caldwell et al., arXiv:1812.11164.
Dark photon studies

- $5 \times 10^9$ electrons/bunch gives $10^{16}$ electrons on target for 3 months.
- Using an AWAKE-like beam extends sensitivity:
  - around $\varepsilon \sim 10^{-3} - 10^{-5}$.
  - to high masses $\sim 0.1$ GeV.
- At 1 TeV reach even higher masses:
  - similar $\varepsilon$ values.
  - approaching $m_{A'} \sim 1$ GeV.
  - beyond any other planned experiments.

Recent simulations indicate $E_e \sim 200$ GeV with SPS proton driver possible. Sensitivity $\sim$ in between above.
Electron–laser collisions: ALPs sensitivity

- Electron–laser collisions lead to high flux of photons, \( \sim 10^9 \).
- See investigations by LUXE experiment*.
- After 1 year of data taking, competitive with other experiments.

An electron–laser experiment using electrons from AWAKE would also have such sensitivity.

* H. Abramowicz et al., arXiv:2102.02032