Dark Sector Searches Driven by Plasma Wakefield Accelerators

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Beamdump Experiments Driven by a Plasma Wakefield Accelerator

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https://www.snowmass21.org/docs/files/summaries/AF/SNOWMASS21-AF5_AF6-170.pdf

HEP Applications for Plasma Acceleration

- Plasma Wakefield Acceleration (PWFA) is a novel acceleration technique.
- In order to demonstrate the viability of plasma accelerators, we need to identify near-term applications.
- The single-shot beam parameters required for Dark Sector searches have already been demonstrated in a variety of PWFA experiments.
- **The next step is to demonstrate high repetition rate acceleration.**

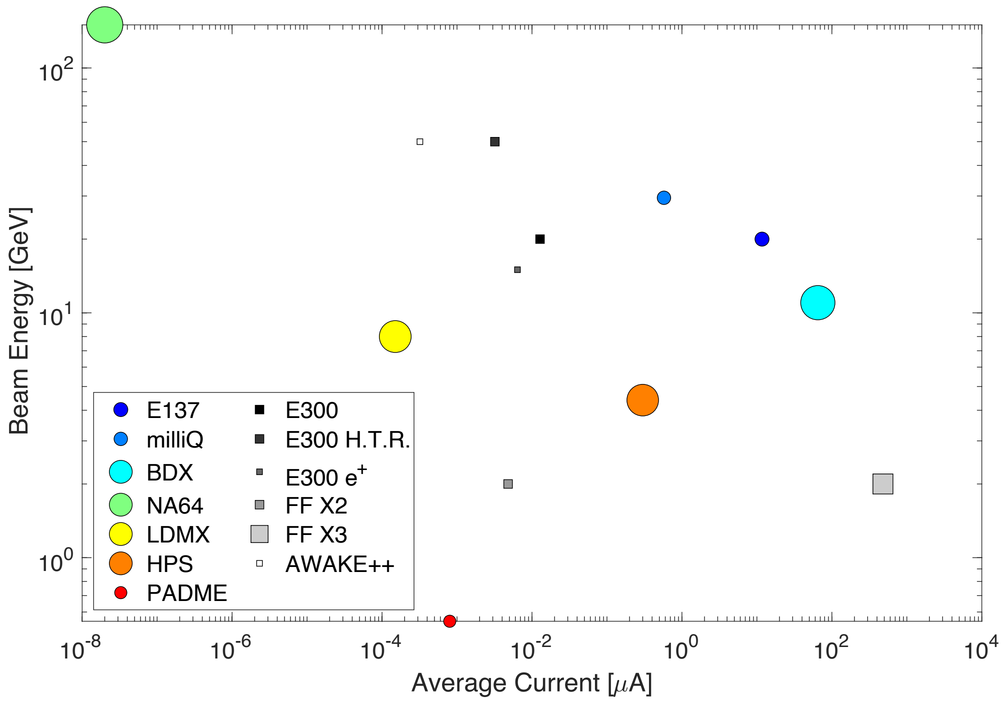
Beam Characteristics

SLAC

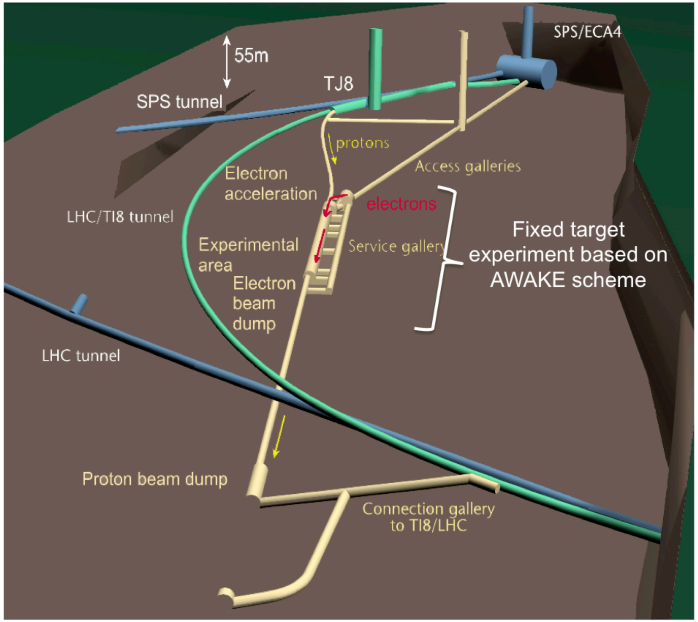
This plot shows past, current, and planned Dark Sector experiments as colored circles, and planned PWFA experiments as gray squares.

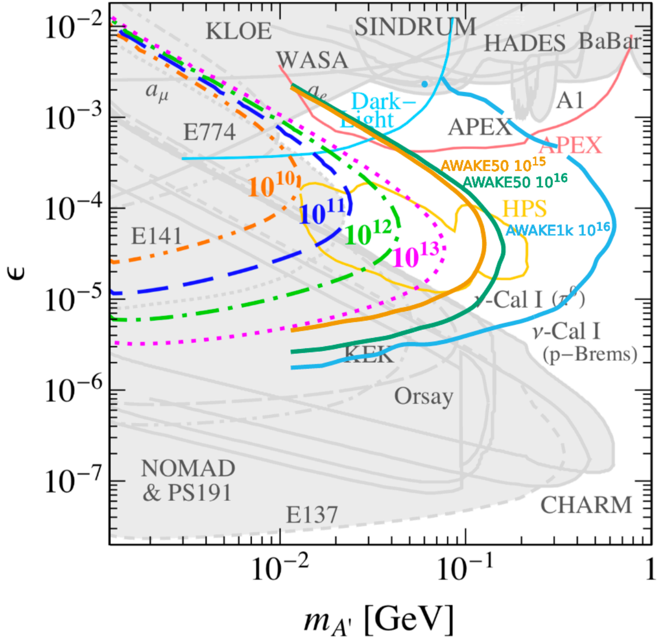
Plasma accelerators deliver high-charge, short-pulse bunches, which are good for suppressing out-of-time backgrounds in beamdump experiments.

In order to compete with other proposed beamdump (thick target) experiments, a plasma-based experiment should deliver 10^{19}-10^{21} electrons (or positrons) on target per year.



AWAKE++ @ CERN



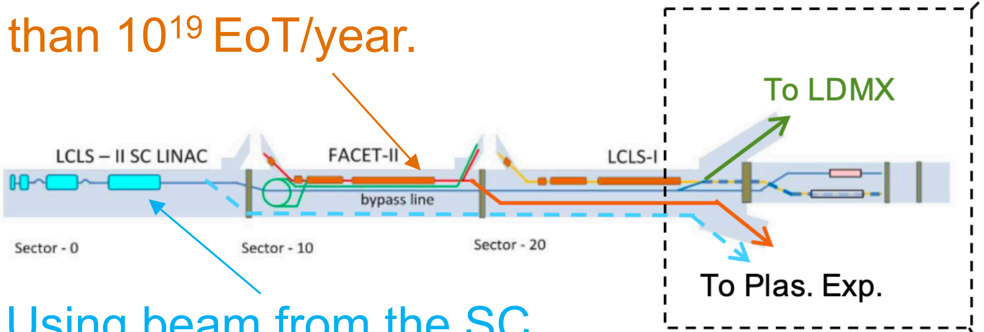


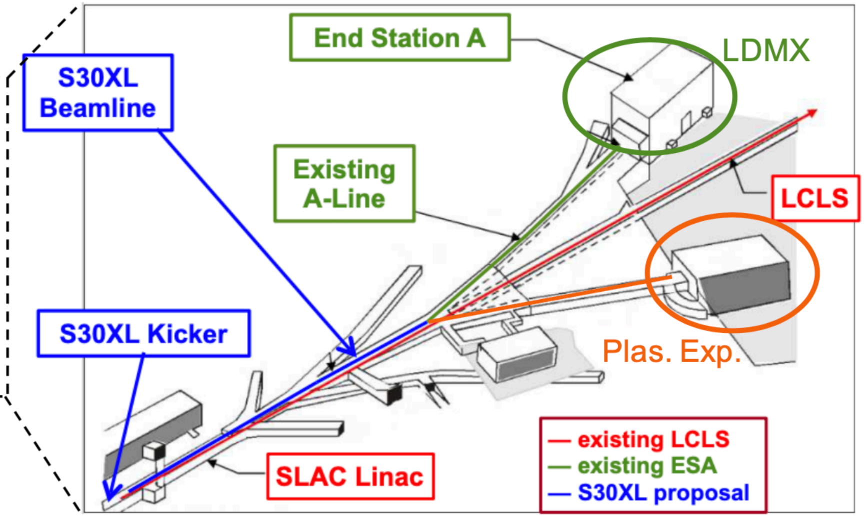
AWAKE++ is investigating Dark Photon searches with electron beam energies in the 50 GeV – 1 TeV range. There are no other facilities currently planned that will produce such high energy beams.

AWAKE++ Snowmass LoI
AWAKE++ Input to ESPP

Concept @ SLAC

Using beam from the NC linac, we can deliver more than 10^{19} EoT/year.





Using beam from the SC linac, we can deliver more than 10^{21} EoT/year.

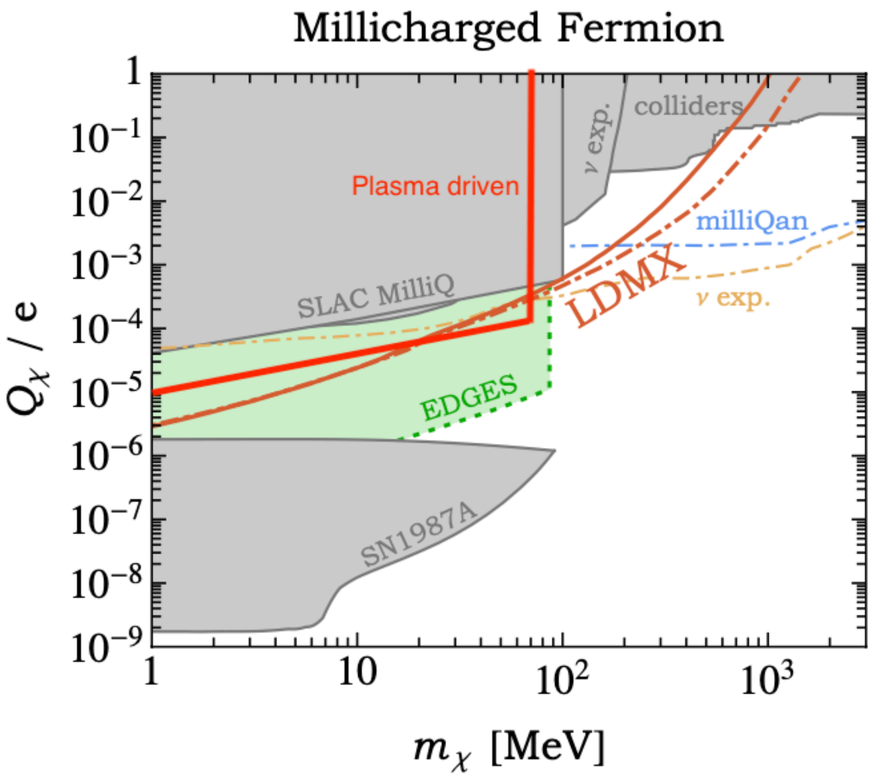
Accelerator	Linac Energy	After Plasma	Bunch Charge	Rate	Current	EOT/year
NC to ESB	10 GeV	20-50 GeV	$0.2\text{-}2.0\times10^{10}$	120 Hz	19-190 nA	$0.4\text{-}4\times10^{19}$
SC to ESB	8 GeV	16-40 GeV	$0.3\text{-}3.0\times10^{9}$	1-62.5 kHz	0.5-30 μA	$0.1\text{-}6.0\times10^{21}$

Example Search: Millicharged Particles

As an example, we examine the exclusion curve from the SLAC MilliQ experiment and assume:

- 10x increase in EoT over milliQ
- 10x increase in detector sensitivity
- Beam energy scaled down to 20 GeV from 30 GeV for the 1998 experiment.

Achieving 10x increase in EoT requires 2 years of operation with NCRF linac at SLAC or a few weeks of operation with the new SCRF LCLS-II linac.



Conclusion

We are using a two-pronged approach to identify potential applications of plasma accelerators in Dark Sector searches:

1. Identify beam parameters that are not produced by existing facilities (*e.g.* extend the energy reach).
2. Identify physics searches that may benefit from plasma accelerator bunch format (*e.g.* short bunches to suppress out-of-time backgrounds).

We hope to use the Snowmass Process to engage with physicists from the theory and detector communities to develop these ideas further. Please contact if interested! sgess@slac.stanford.edu