High energy physics applications of the AWAKE acceleration scheme

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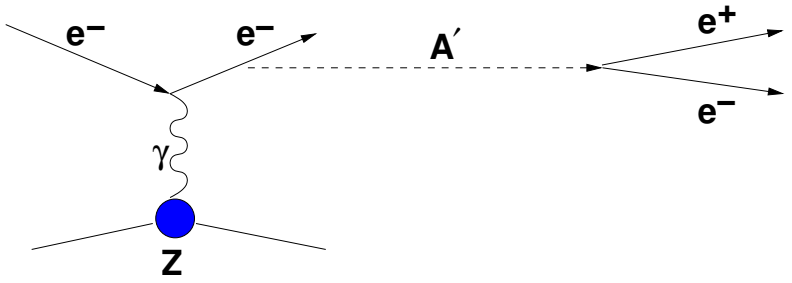
- Basic idea.
- Search for dark photons using a beam-dump experiment.
- Deep inelastic scattering experiments.

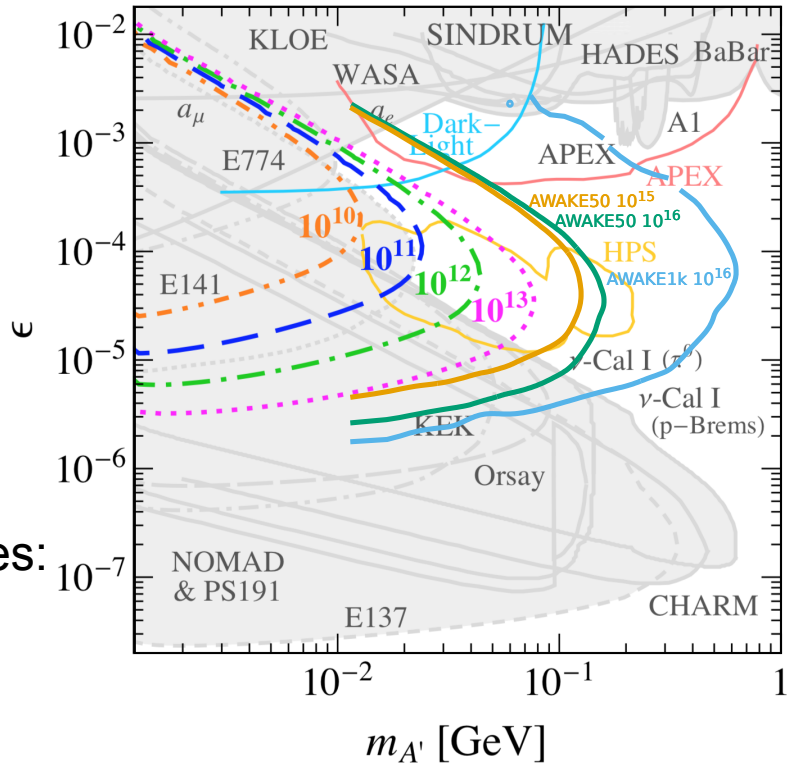
Basic idea

- Assuming success of AWAKE Run 2 (see LoI #68, P. Muggli et al.):
  - Possibility of *O(50 GeV)* electron beams by end of decade.
  - Ideas and demonstration of principles to achieve higher energies.
  - Using the LHC, simulations suggest multi-TeV electron beams could be achieved.
  - Restricted to facilities with high energy proton beams. RHIC protons @BNL could also be used to drive strong wakefields.
- Survey and brainstorm on possible HEP experiments with an electron beam from tens of *GeV* up to *TeV* scale.
  - A high energy e^+e^- may be the ultimate application, but not the first !
  - Are there experiments with less challenging beam parameters ?
  - Need HEP experiments that can be done with the accelerator technology but have compelling particle physics cases.
- Ideas on integration into proton accelerator complex.
  - Fixed-target experiments, electrons at *50 GeV*, would need adaptation of AWAKE facility.
  - Add-ons to LHC facility needed for high energy electron beams

Dark photons search, $A' \rightarrow e^+ e^-$ channel



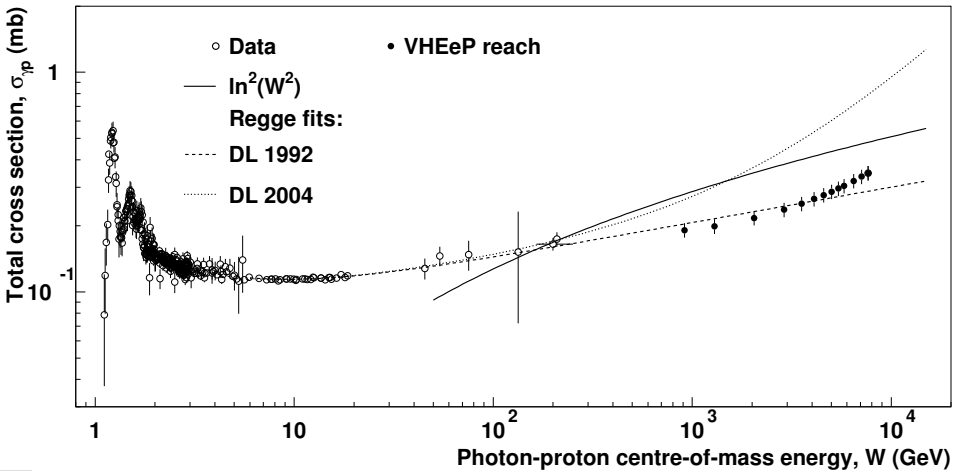
- Dark sectors with light, weakly-coupling particles are a compelling possibility for new physics.
- Given the paucity of high energy electron beams, a new *50 GeV* facility can make a real impact.
- Based around NA64 experiment but with bunches and more electrons on target.
- Can extend to higher dark photon masses in the region $\varepsilon \sim 10^{-3} - 10^{-5}$.
- Could realise such a beam/experiment within a decade.

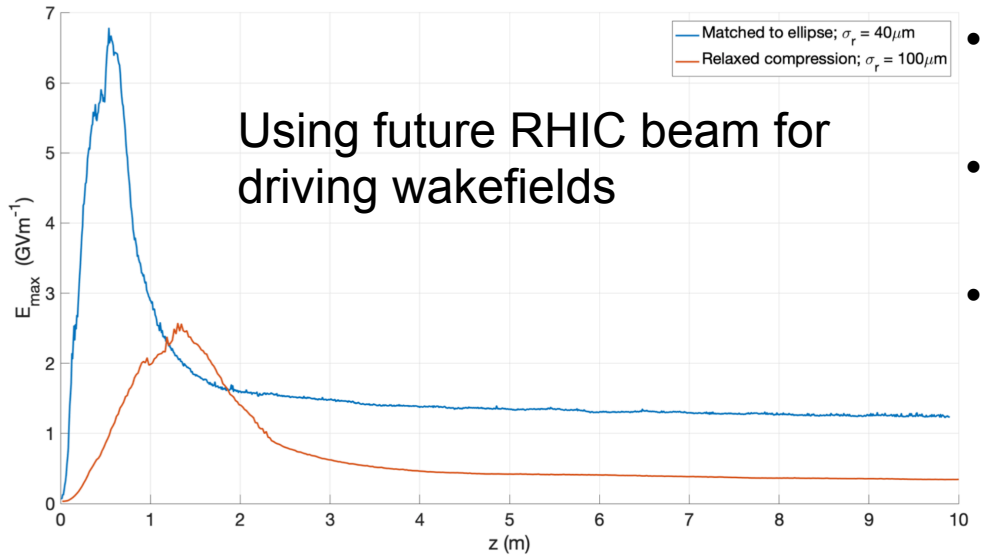


- With a *1 TeV* beam, can go to much higher masses:
  - Approaching *1 GeV* for same ε region.
  - Beyond other planned experiments.
- High energy electron beam can be used for measurements of strong-field QED:
  - See efforts at EuXFEL and FACET-II, etc..
  - Higher energy interesting.

Deep inelastic scattering

- *TeV* electrons on a fixed-target give $\sqrt{s} \sim 50$ *GeV*, similar to EIC energies.
- *50 GeV* electrons colliding with LHC protons gives $\sqrt{s} \sim 1$ *TeV*, i.e. LHeC energies.
- Use LHC as driver for $E_e = 3$ *TeV* and $\sqrt{s} = 9.2$ ***TeV***, but with modest luminosities, $O(10^{28}–10^{29}\ cm^{-2}\ s^{-1})$: VHEeP.
- Completely new regime, well beyond other *ep* colliders; exciting physics potential.
- Revolutionise QCD; new theories; links to gravity, cosmic rays, etc..





- Using saturated field of ~*1.2 GV/m*, could have *18 GeV* electron injector in ~*15 m*.
- Peak fields ~*6 GV/m*; optimising plasma density could harness these.
- RHIC proton beam is a very effective wakefield driver:
  - Possibility of upgrades to EIC ?
  - Future R&D programme or other applications ?