Emittance preservation of an electron bunch in a loaded quasi-linear plasma wakefield

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We investigate beam loading and emittance preservation for a high-charge electron beam being accelerated in quasi-linear plasma wakefield driven by a short proton beam. The structure of the wakefield is similar to that of a long, modulated proton beam. By selecting transverse and longitudinal electron beam parameters in order to appropriately load of the wake, we show that the bulk of the electron beam can be accelerated without significant emittance growth.

I. INTRODUCTION

- interested from SMI/AWAKE
- requirements for AWAKE Run 2

The preliminary design of AWAKE Run 2 will split the plasma cell into two sections. The first section of 4m is the SMI stage. The electron beam will be injected into the modulated proton beam before stage two, where acceleration will occur. As the e_z field will decrease due to the gap between the two cells, it is desireable to keep this as short as possible [1].

II. METHOD

The main focus of this study has been on the beam loading of the electron beam. In order to eliminate other factors that may affect this, we have tried several approaches to create a stable drive beam structure based on previous SMI studies [citations].

Our first approach was to use a premodulated, short proton beam with the same structure as a section of the full AWAKE proton drive beam. These studies were done using the full PIC code Osiris [2] using 2D cylindrical-symetric simulations. The proton beam was pre-modulated by a clipped cosine function to the longitudinal density profile, with a period matching the wavelength, λ_p, of the plasma. The length was limited to $26 \cdot \lambda_p$, and the electron beam injected after the 20th micro-bunch [3]. We performed several parameter scans with this setup, testing for optimal charge as well as beam length [1, 4].

[Add something about the optimal results]

In order to evaluate the quality of the beam, we also needed to study its emittance. Full PIC codes like Osiris are voulnerable to numerical growth of emittance caused by what is usually referred to as the "umerical Cherenkov effect" [5]. The effect is caused by the EMF solver which will cause the phase velocity of electromagnetic fields to be lowet than c, while the beam moves very close to c. The effect can be mitigated somewhat by a the Lehe solver [6], but the effect is still prominent in the the high density regions of the electron beam.

A. Simulationn Setup

III. BEAM LOADING

- discussion of the main physics and results; beam loading, bubble creation, emittance preservation

IV. DISCUSSION

V. CONCLUSION

- discussion of optimal electron beam parameters
- implications for AWAKE Run 2

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[1] E. Adli and AWAKE Collaboration, in *Proceedings of IPAC 2016*, International Particle Accelerator Conference (JACoW, Busan, Korea, 2016) pp. 2557–2560.

[2] R. A. Fonseca, L. O. Silva, F. S. Tsung, V. K. Decyk, W. Lu, C. Ren, W. B. Mori, S. Deng, S. Lee, T. Katsouleas, and J. C. Adam, in *Computational Science ICCS 2002*, Lecture Notes in Computer Science No. 2331, edited by P. M. A. Sloot, A. G. Hoekstra, C. J. K. Tan, and J. J. Dongarra (Springer Berlin Heidelberg, 2002) pp. 342–351.

[3] V. K. Berglyd Olsen, E. Adli, P. Muggli, L. D. Amorim, and J. Vieira, in *Proceedings of IPAC 2015* (Richmond,

VA, USA, 2015) pp. 2551–2554.
[4] V. K. Berglyd Olsen, E. Adli, P. Muggli, and J. Vieira, in *Proceedings of NAPAC 2016* (Chicago, IL, USA, 2016).
[5] B. B. Godfrey, Journal of Computational Physics **15**, 504 (1974).
[6] R. Lehe, A. Lifschitz, C. Thaury, V. Malka, and X. Davoine, Physical Review Special Topics - Accelerators and Beams **16**, 021301 (2013).