Collaboration Meeting
October 2023

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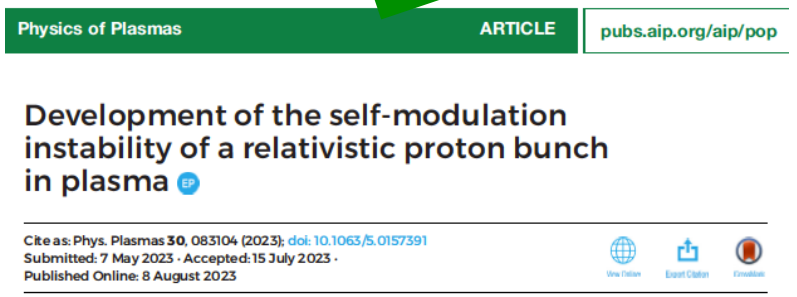
NOTABLY SINCE UPPSALA

- May run with discharge plasma source (DPS)
- two manuscripts well advanced: Livio: CFI, Marlene: ion motion
- August & September runs with vapor source with density step
  - in both cases, HUGE installation work!
- review of the program for the development of scalable plasma sources: DPS and helicon
- publications:
  - L. Verra (AWAKE Coll.), Phys. Plasmas 30, 083104 (2023)
  - and more ...
- submisson:
  - T. Nechaeva (AWAKE Coll.), to Phys. Rev. Lett., arXiv:2309.03785
- EPS Plasma Physics Thesis Prize: Livio
- Simon Van der Meer Award: Marlene
- third run with new vapor source starts on Sunday …

Editor's Pick!



✧QUITE SOME PROGRESS AND ACHIEVEMENTS …

DISCHARGE PLASMA SOURCE

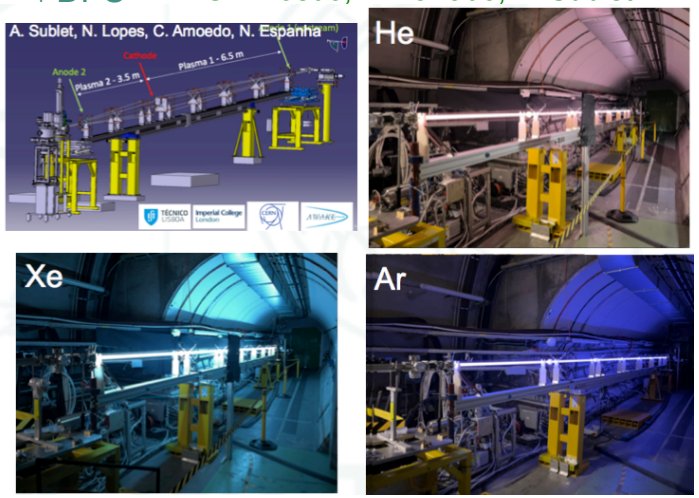
Research topics, 10m discharge plasma source (DPS), May 2023:

- ✧Plasma source: He, Ar, Xe ✓
- ✧Self-modulation instability: SMI(L_p) ✓
- ✧Current filamentation instability (CFI) ✓
- ✧Ion motion on SMI, He, Ar, Xe ✓
- ✧Hose instability at low plasma density, flat beams?
- ✧Plasma light: diagnostic for wakefields ✓

Very Successful, One-Time, Short Run!

✧Main results in preparation for submission

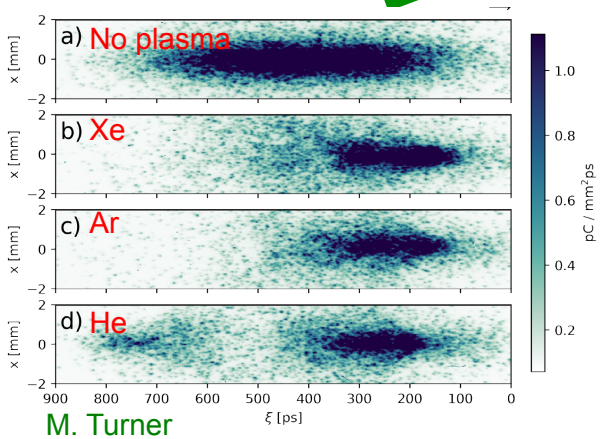
✧DPS C.Amoedo, N. Torrado, A. Sublet



✧DPS operated with three gases/plasmas
✧Great flexibility with parameters (n_{e0}, ions, …)
✧Systematically observe SMI

Preliminary

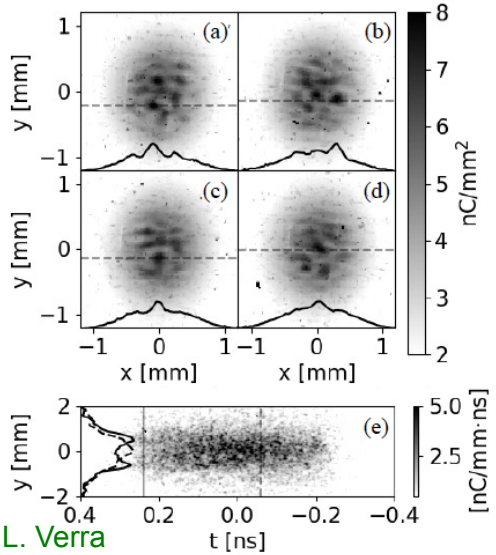
✧Ion motion



M. Turner

✧Effect of ion motion with He but not Ar and Xe plasma
✧Ion motion detunes SMI
✧"Tail" appears at later times (600-800ps, d))

✧Current filamentation instability



L. Verra

✧Filaments observed on time-resolved images (a to d)
✧Time resolved images show late CFI (t>200ps, (e))

New Vapor Plasma Source

Purpose: impose temperature/plasma density step, experiments, two weeks, August 2023:

- ✧Explore the effect of a plasma density on
  - ✧micro-bunch train
  - ✧bunch halo
  - ✧plasma light from dissipation of wakefields
  - ✧…

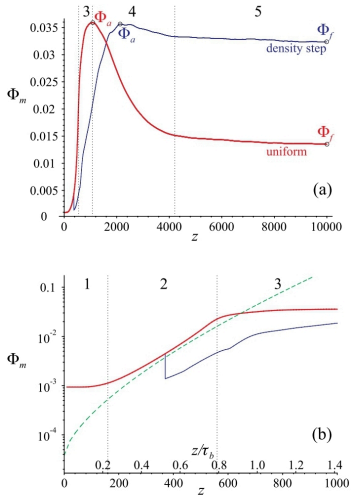
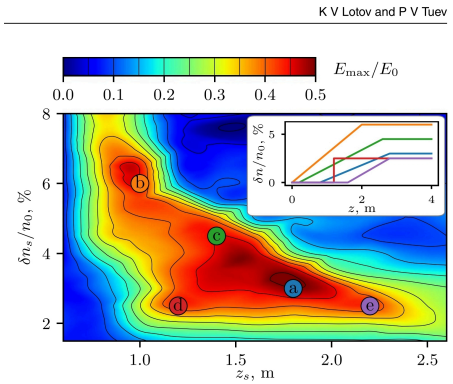
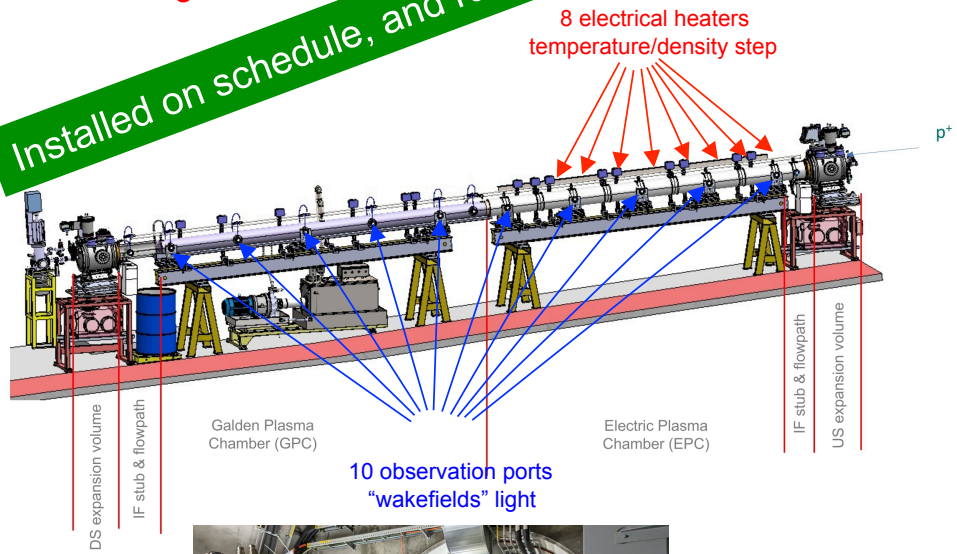


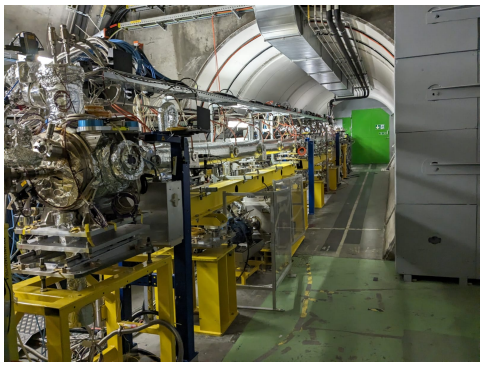
FIG. 2. The maximum wakefield amplitude Φ_m as a function of propagation distance z for the uniform plasma (red lines) and the plasma with the optimum density step (blue lines) in normal (a) and enlarged semi-logarithmic (b) scales. The green dashed line in (b) shows the theoretically predicted growth. The numbers and vertical lines indicate stages of beam evolution in the uniform plasma. Circles in (a) show points of absolute maximum Φ_a and established amplitude Φ_f.



K V Lotov, Physics of Plasmas 22, 103110 (2015)
K V Lotov and P V Tuev 2021 PPFC ***63 125027***

Installed on schedule, and running!





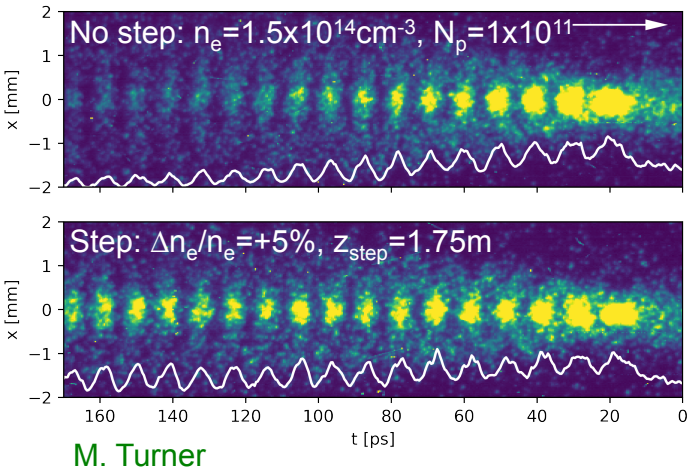
- ✧Numerical simulation results:
  - ✧Amplitude of wakefields larger w plasma density step
  - ✧Optimum position and amplitude of the step
- ✧New vapor source allows for imposing temperature step
- ✧Temperature step is vapor/plasma density step

PRELIMINARY RESULTS

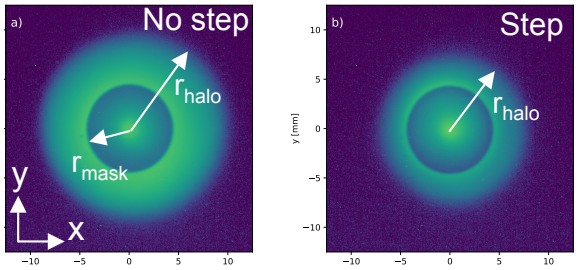
Research topics, plasma density step, experiments August 2023:

- ✧Effect of plasma density step on:
  - ✧Proton bunch, time-resolved images
  - ✧Proton bunch time-integrated images (halo)
  - ✧Plasma light from dissipating wakefields

Preliminary!

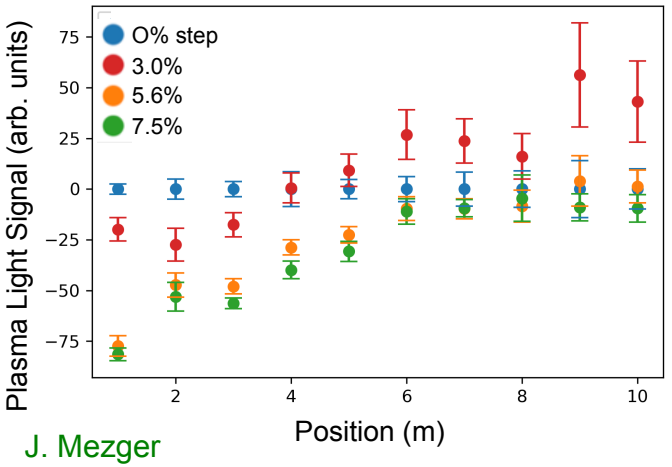


M. Turner



A. Clairembaud

n_e=3.7x10^{14}cm^{-3}, N_p=3x10^{11}, z_{step}=1.75m



J. Mezger
M. Bergamaschi

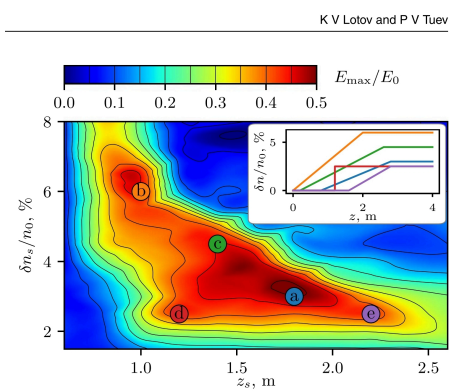
- ✧Longer train with more charge, and smaller beam halo with this step
- ✧Relatively (not calibrated) more plasma light with $\Delta n_e/n_e$=+3%, z=1.75m (red symbols, z>5m)

- ✧Plasma density step clearly influences SSM
- ✧Changes in amplitude of wakefields to be measured and optimized :
  - ✧with calibrated plasma light detectors
  - ✧by acceleration of externally-injected e$^-$
- ✧Quite successful first run with plasma density step!

PRELIMINARY RESULTS

Run October 8-21 2023:

- ✧Explore the effect of a plasma density
  - ✧Qualification of diagnostics
  - ✧Characterization of the “plasma light” diagnostics: 10PMTs and ten CCD cameras
  - ✧“diagnostic does not show the problem” let alone the solution …
  - ✧…



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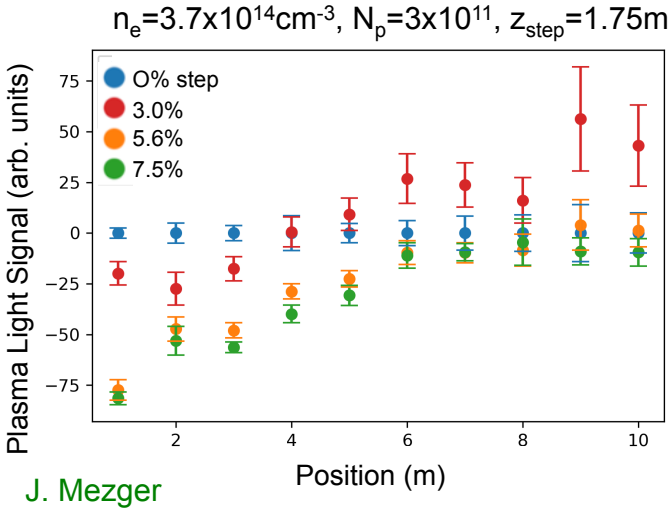

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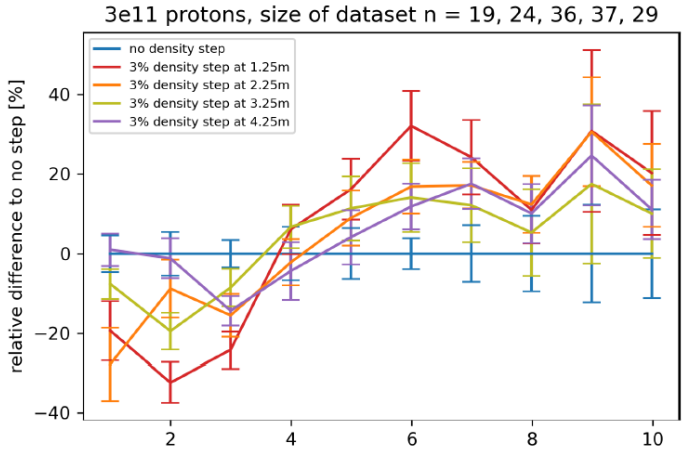

J. Mezger
M. Bergamaschi

- ✧Step position for this height make no measurable difference

- ✧Numerical simulation results:
  - ✧Amplitude of wakefields larger w plasma density step
  - ✧Optimum position and amplitude of the step

PRELIMINARY RESULTS

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- ✧Explore the effect of a plasma density
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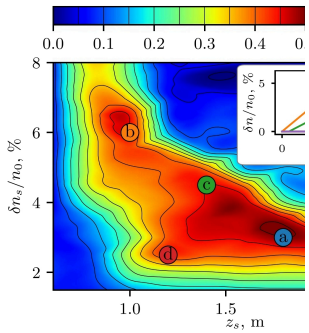
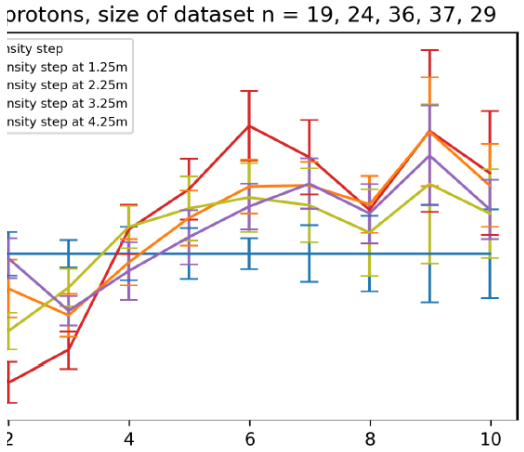


K V Lotov, Physics of Plasm (2015)
K V Lotov and P V Tuev 202

WARNING

(Some) Freshly Painted Results!



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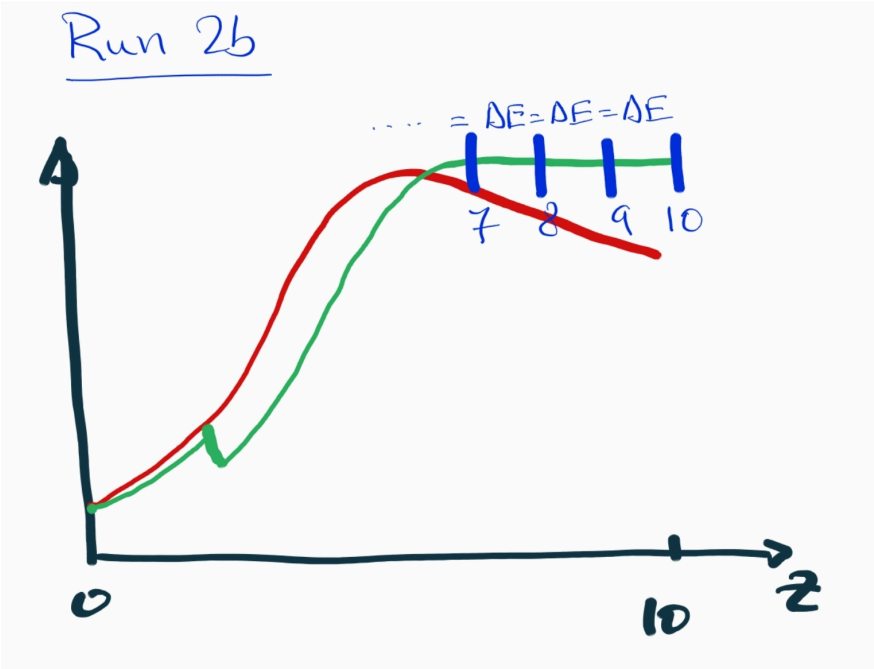
Run 2b Goal

Long term view:

- Demonstrate that a density step can make the wakefield amplitude constant and at high amplitude
  - Operate with a density step
  - Demonstrate that the amplitude of the wakefields is constant over the last x-meters of the plasma
  - Demonstrate that the energy gain per meter of plasma by test electrons is constant over the last …
  - …



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SUMMARY

AWAKE

- Successful experimental time since the last collaboration meeting
  - Operate with a discharge plasma source
    - A scalable plasma source is ESSENTIAL for the future of AWAKE
  - At least two manuscripts in the making
- Installed a new vapor source with temperature/vapor/plasma density step
  - Observed positive effect of the step on plasma light signals
    - Operation with a density step (or other) is ESSENTIAL for the future of AWAKE
- Manuscript on hosing submitted to Phys. Rev. Lett. (T. Nechaeva)
    - Publishing is ESSENTIAL for AWAKE
- Last run of 2023 starts on Sunday …
- Challenges
  - One more year to “finish” Run 2b, i.e., to validate experimental concepts for Run 2c
  - Get ready for Run 2c, concepts, simulations, etc.
    - Already a lot of work done … but …
  - **CERN scientific (PWFA) review of the AWAKE program (end 23, beginning 24)**
  - Develop scalable plasma source
    - Program/lab at CERN and IST/IC/SPC/IPP/Madison
  - Choice of plasma sources, SM length, e-injector (linac, LWFA-earli)
  - Diagnostic(s) for emittance
  - Design of the injection region
  - Prepare report to SPSC …
  - …

- Need YOUR collaboration … participation …