Riccardo Pompili
Oct 6, 2022

WA 5 – PLASMA

On going actions	Outcome closed actions & Decisions	To Do

• Vacuum tests @ PLASMA Lab
• Transverse matching tests with PMQs @ SPARC
• Alternative methods of plasma ignition with laser filaments instead of electrical discharge (for higher rep. rates)
    • Tests done at FLAME, then SPARC
	• 40 cm discharge was successfully achieved in a plastic capillary. Discharge is working well and plasma density completely characterized.
	• Vacuum tests with plasma in SPARC and PLASMA Lab. Here high rep rates (100 Hz) have been reached
		• PLASMA_LAB
		    • Test with 40 cm long <u>sapphire</u> capillary to avoid wall erosion
		• SPARC linac
		    • Test with Nitrogen and filament

Istituto Nazionale di Fisica Nucleare

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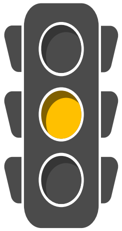
Upcoming milestones

- Tests with different gases (Ar,N) doped with few % of H

Potential risks

- We’re currently involved in the definition of the plasma vacuum chamber layout. However, it cannot be finalized until we don’t define the magnetic optics downstream the capillary (FODO vs APL)

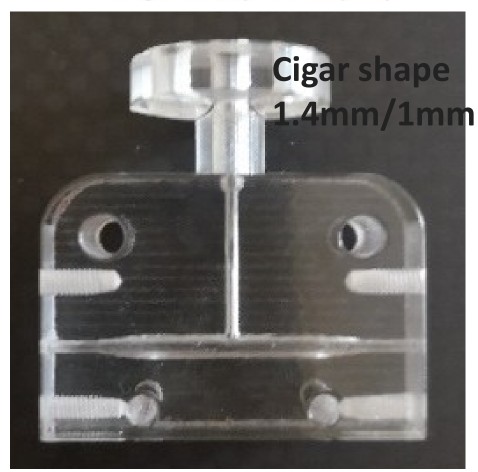
General Status

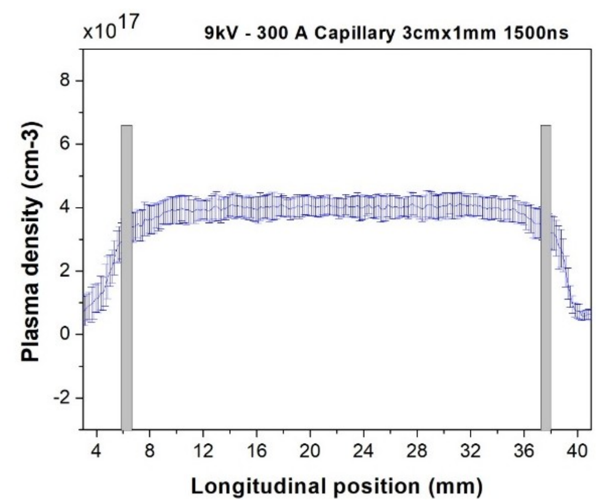


Business as usual
But some issues
might become
critical

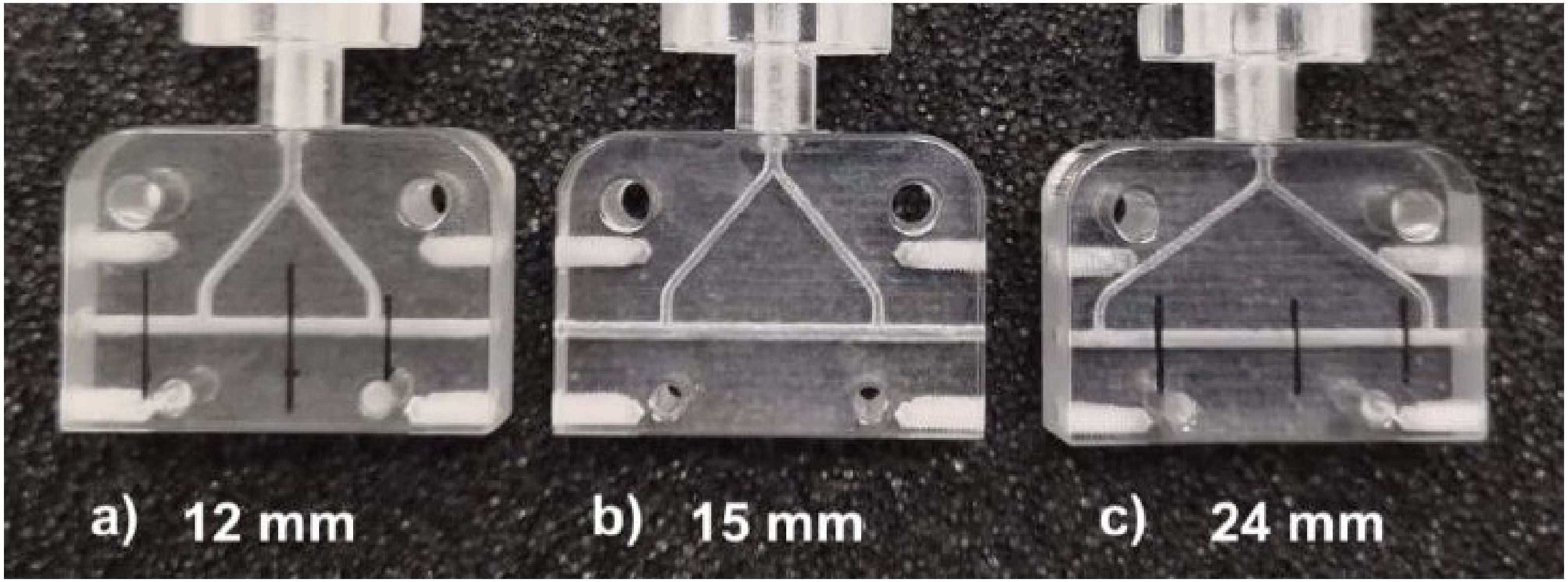
> The RC recommends that capillaries with tapered radius to compensate for the (non-constant) longitudinal plasma density profile measured in the constant-radius capillaries be tested very soon. This test can be done with the short capillary. For consistency, requirements in terms of uniformity of the longitudinal plasma density should be determined from simulation studies. Alternatively, numerical simulations may be performed to determine the effect of the observed non-uniformity on the beam and FEL parameters. Density ramps at the plasma entrance and exit of the capillary should also be carefully characterized and included in numerical simulations.

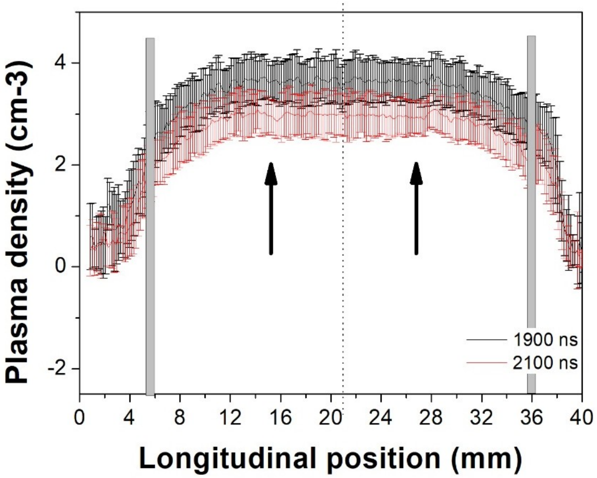
- Tests with short capillaries were already performed and showed that, by using smaller apertures toward the electrodes, the plasma density flattens inside
- Need to repeat tests with longer capillaries
- Need to understand the effects of having 1...N inlets

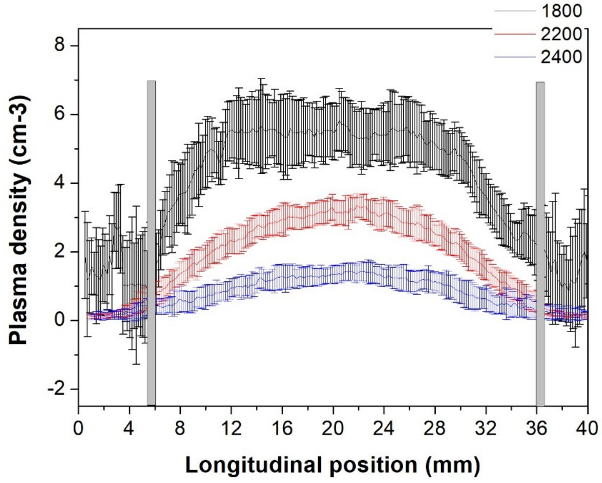


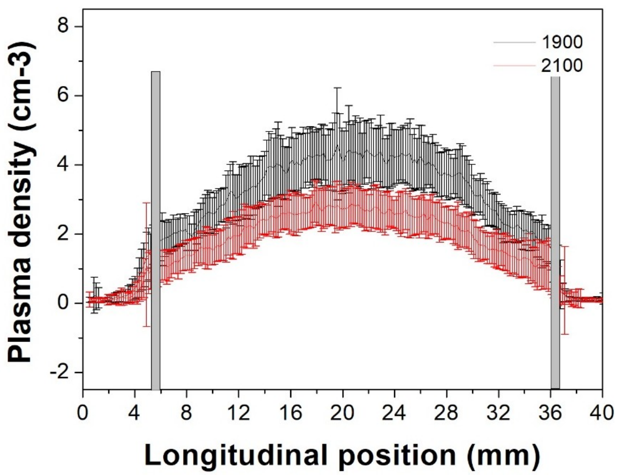


Different inlets configuration

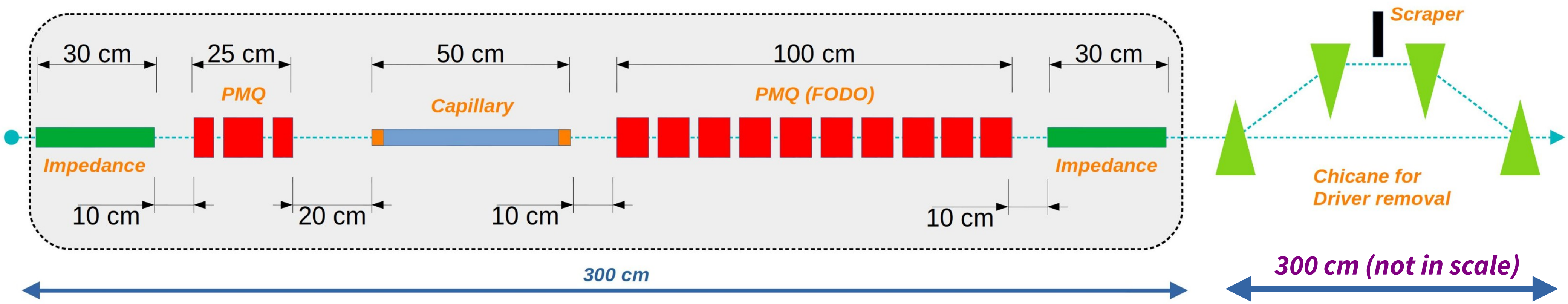








Plasma layout – option #1

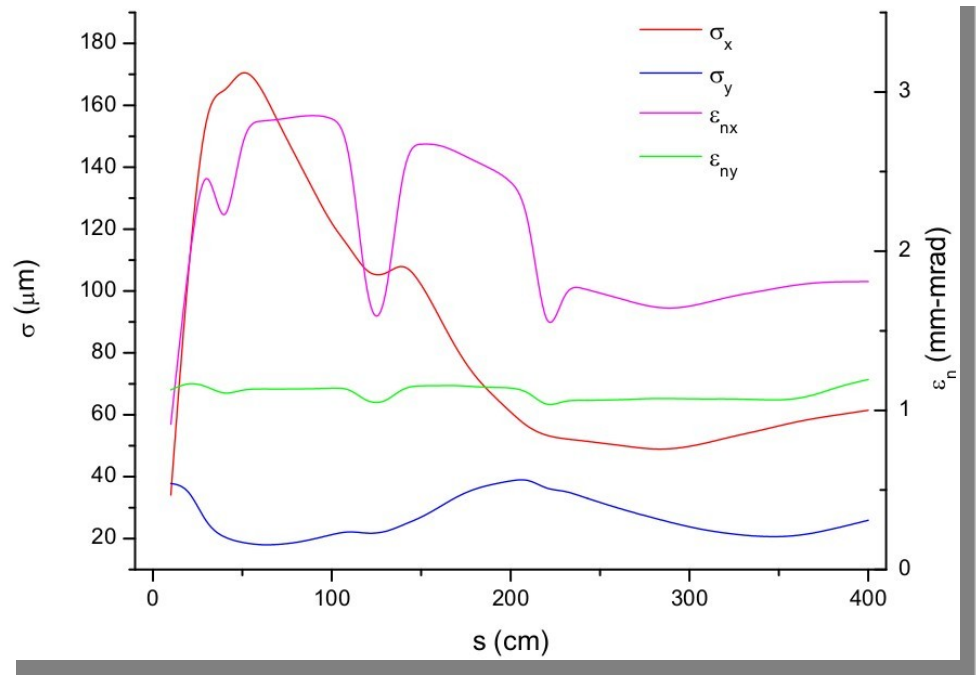


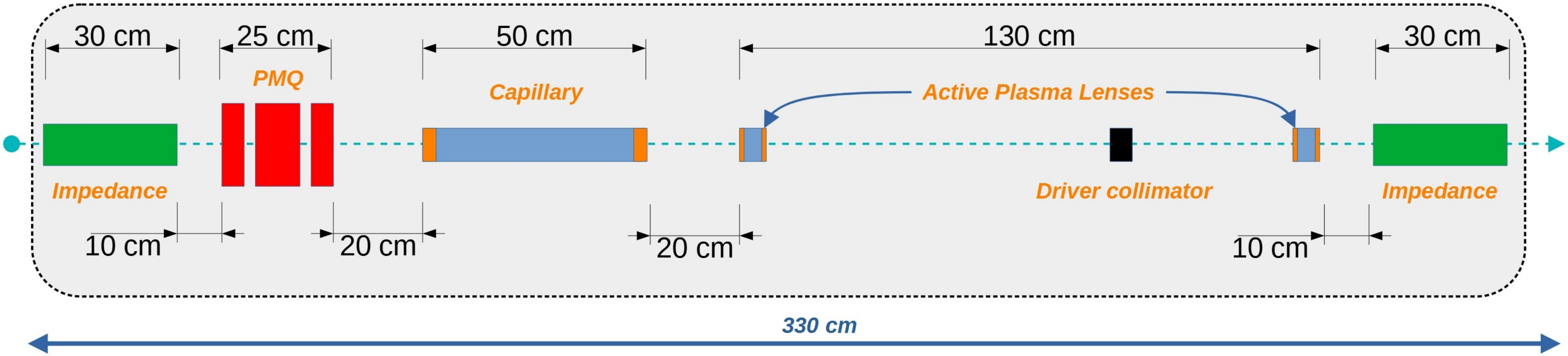
From CDR, first idea is to use a long “gentle” FODO to extract the witness.

Major part of the driver is still transported

- A magnetic chicane must be used to separate witness and driver in energy and cut the latter with a scraper

Simple solution but require some space and single independent tuning for each PMQ





Active-Plasma lenses to extract the witness and remove driver

- Witness is catch and transported without loss of charge
- Driver is over-focused at the collimator entrance and its charge removed

Pompili, R., et al. "Plasma lens-based beam extraction and removal system for plasma wakefield acceleration experiments." Physical Review Accelerators and Beams 22.12 (2019): 121302.

Study performed on the EuPRAXIA@SPARC_LAB reference working point

- It requires two active-plasma lenses and a lead collimator.
- Solution would benefit of compactness and tunability.
- However puts more load on the vacuum