The amplitude of the beam's electric field at the tight focus is of high interest in its own right, as field levels that access the barrier suppression ionization (BSI) regime [11] can be created in a wide variety of atomic species. This implies that the desired plasma density may be, as in previous SLAC FFTB experiments, created using the electron beam [12]. This has been the case in the FFTB scenarios, but with much longer beam time scales [12], and with a factor of 25 smaller fields, in which one attributes plasma formation to tunneling ionization. There is uncertainty in the applicability of the theoretical models [13] of field ionization, particularly in the case of ultra-short unipolar field pulses characteristic this type of charged particle beam, however. While we will employ such models [9] to illustrate ultra-fast ionization for plasma creation below, this uncertainty argues forcefully for the performing of experiments.

The self-consistent ionization of a high pressure gas by the beam fields must occur in 100's of as, to create the plasma quickly enough to give maximum amplitude plasma wakefields. Depending on the atomic species chosen, the fields at the front edge of the beam may yield ionization in the tunneling regime. Indeed, in OOPIC, a computational tool developed to describe ionization in the PWFA and related contexts, a tunneling model based on Ammosov-Delone-Krainov (ADK) theory [14] is employed, which is appropriate for fields in the region $> 2\sigma_t$ ahead of beam center - the region of highest interest - in our case. In the current scenario, the much higher fields in the beam core provoke ionization, for most atomic species considered, in the BSI regime. The boundary for the two regimes is delineated by a critical electric field value E_{cr}, which for hydrogen is $E_{cr} = 439$ GV/m, while for Li, used in the previous generation of PWFA experiments, $E_{cr} = 109$ GV/m.

Assuming the initial beam size given by ELEGANT simulations, in the absence of plasma $E_{r,max} \simeq 800$ GV/m. It is encouraging that, as seen in Figure 2, full ionization based on the tunneling model in OOPIC is achieved using 3.15 atm H_2 gas (with a mm-width jet envisioned for use), and it occurs within the first several 100 as of the beam pulse. This means that the plasma is created with appropriate n_0 well before the main portion of the beam passes, and longitudinal wake is nearly as in the pre-formed plasma case, >1.2 TV/m. Further, even though the field amplitude indicates ionization in the BSI regime in the beam core, we need not be concerned with this region, and may ignore the lack of BSI in the simulations.

To check the consistency of the OOPIC model of tunneling ionization with the transition