

# A High Transformer Ratio Scheme for PITZ PWFA Experiments.



Gregor Loisch, Matthias Gross, Holger Huck, Anne Oppelt, Yves Renier, Frank Stephan (DESY Zeuthen)  
 Alexander Aschikhin, Alberto Martinez de la Ossa, Jens Osterhoff (DESY Hamburg)  
 M. Hochberg, M. Sack (KIT Karlsruhe)

## Abstract

In the field of plasma wakefield acceleration (PWFA) significant progress has been made throughout the recent years. However, an important issue in building plasma based accelerators that provide particle bunches suitable for user applications will be a high transformer ratio, i.e. the ratio between maximum accelerating field in the witness and maximum decelerating fields in the driver bunch. The transformer ratio for symmetrical bunches in an overdense plasma is naturally limited to 2\*. Theory and simulations show that this can be exceeded using asymmetrical bunches. Experimentally this was proven in RF-structures\*\*, but not in PWFA. To study transformer ratios above this limit in the linear regime of a plasma wake, an experimental scheme tailored to the unique capabilities of the Photoinjector Test Facility Zeuthen PITZ, a 25-MeV electron accelerator at DESY, is being investigated. This includes numerical simulations of beam transport and plasma wakefields, as well as preparatory studies on the photocathode laser system and the plasma sources.

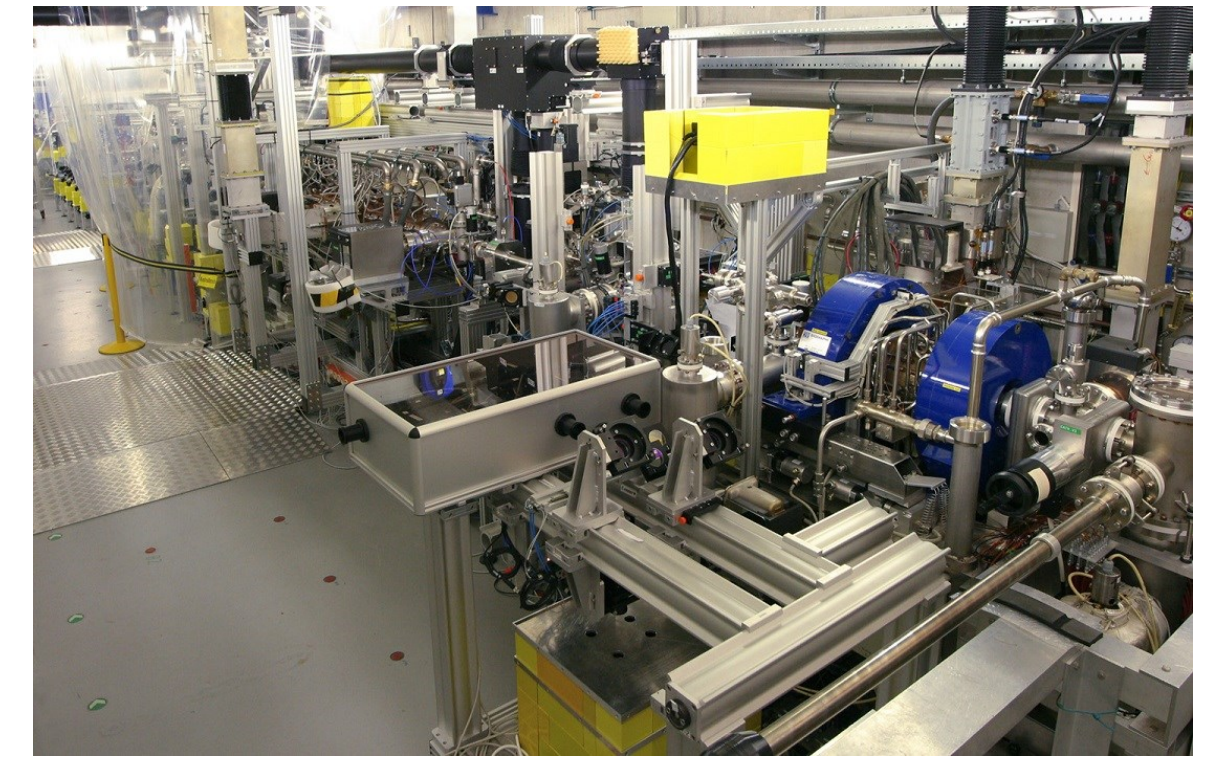
\* K. L. F. Bane, P. B. Wilson and T. Weiland, AIP Conference Proceedings 127, p. 875, 1984  
 \*\* C. Jing et al., Physical Review Letters 98, 144801, 2007

## PITZ: the Photo-Injector Test facility at DESY, Zeuthen site

Accelerator test facility for photoinjectors of FLASH and EU-XFEL

- Bunch charge 20 pC – 5 nC
- Variable bunch length and shape (min. 1 ps rms-length)
- 1.3 GHz RF gun
- 60 MV/m at photocathode
- 6 MeV photoelectrons from gun
- Up to 25 MeV after CDS booster cavity

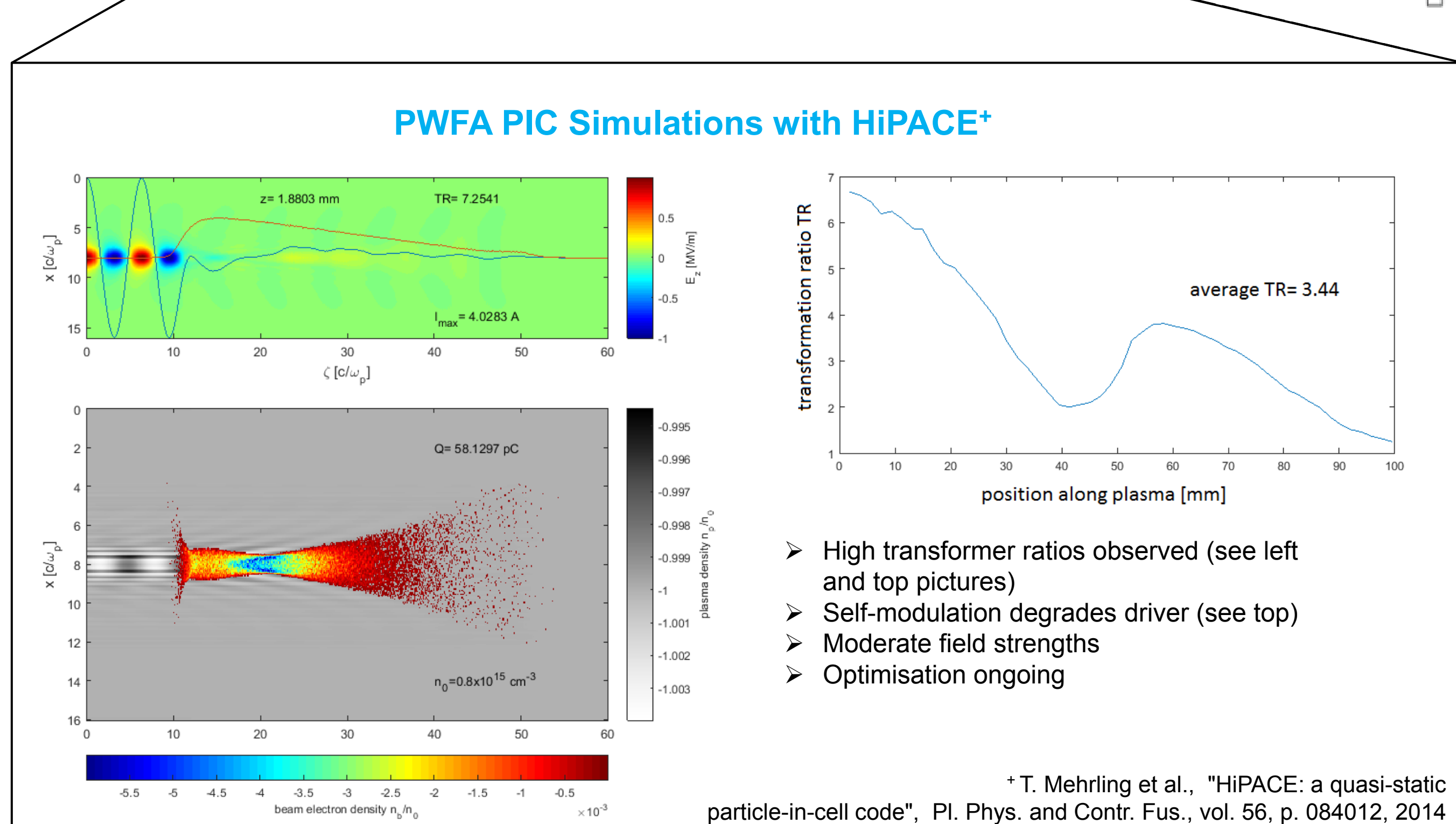
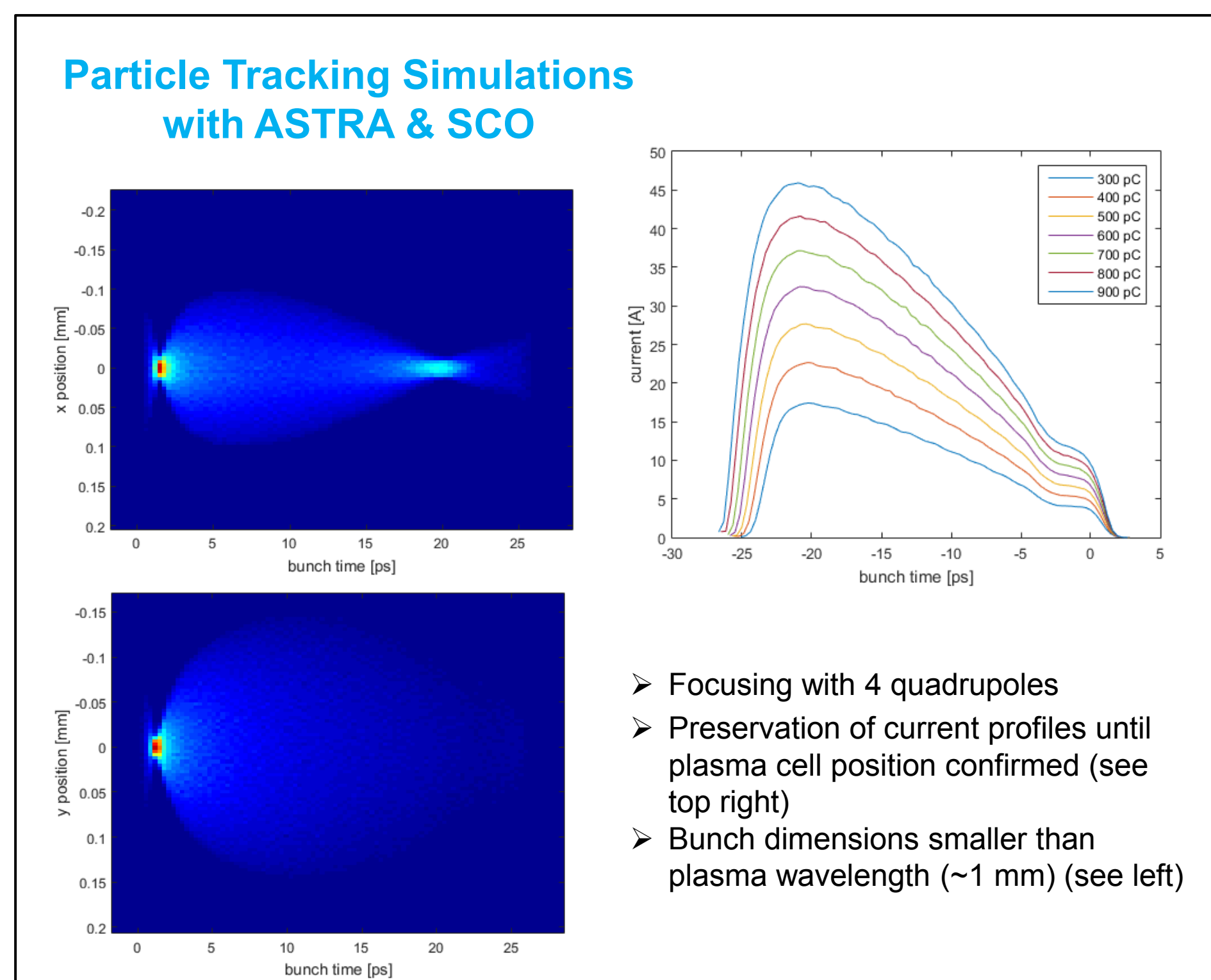
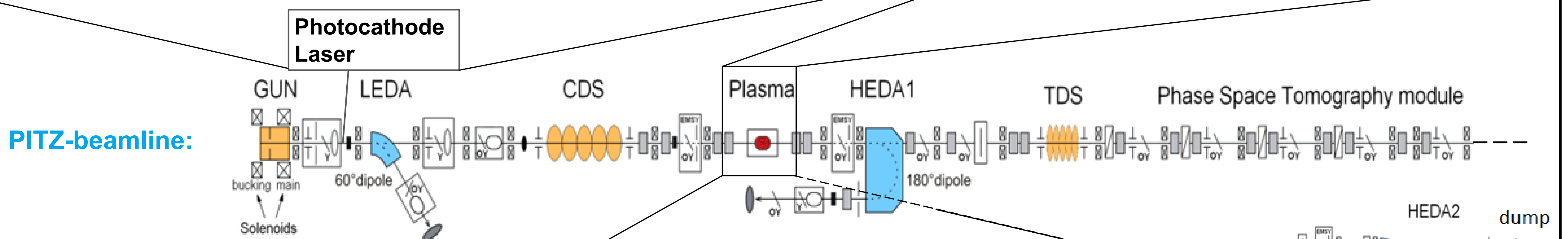
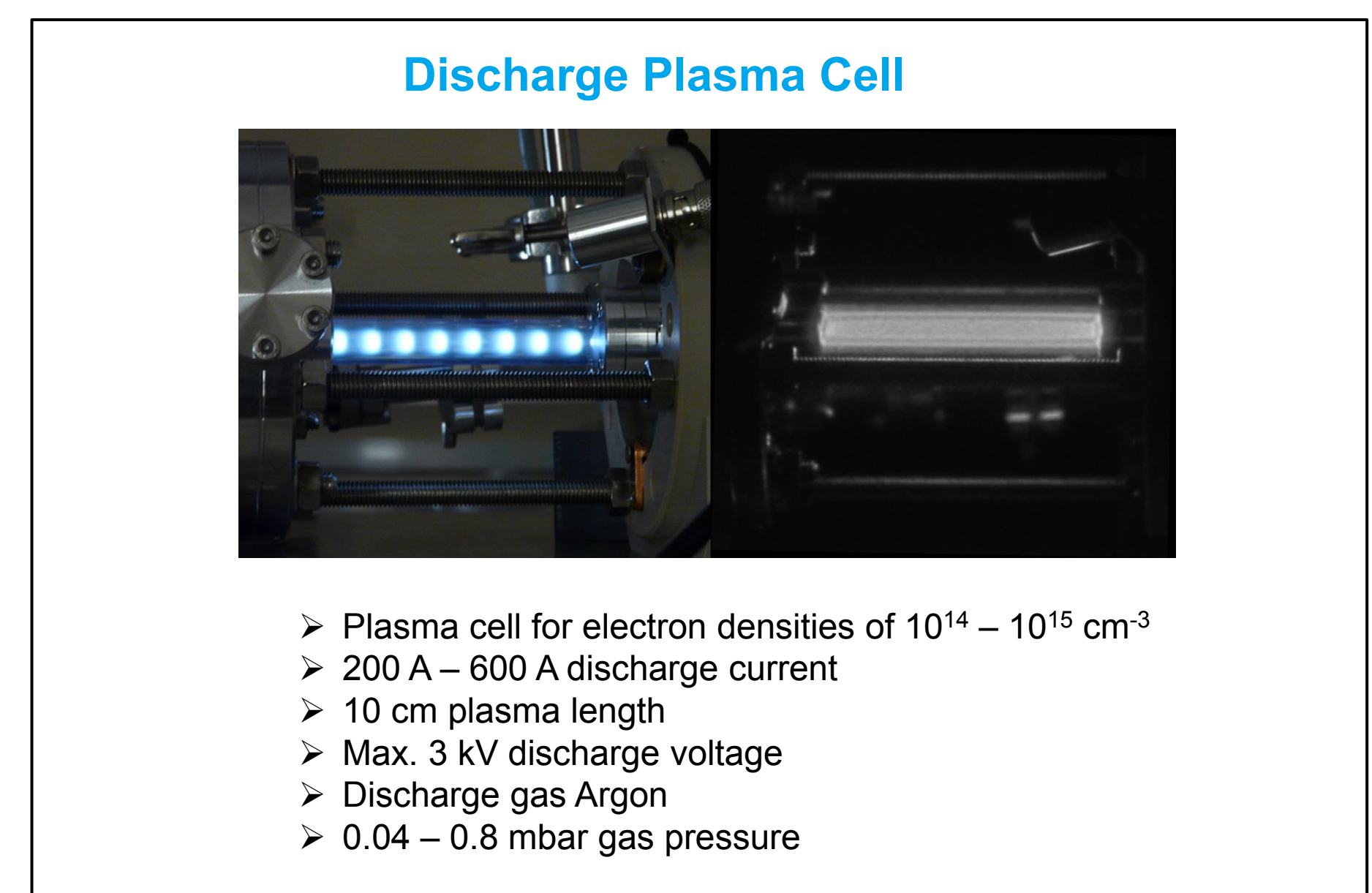
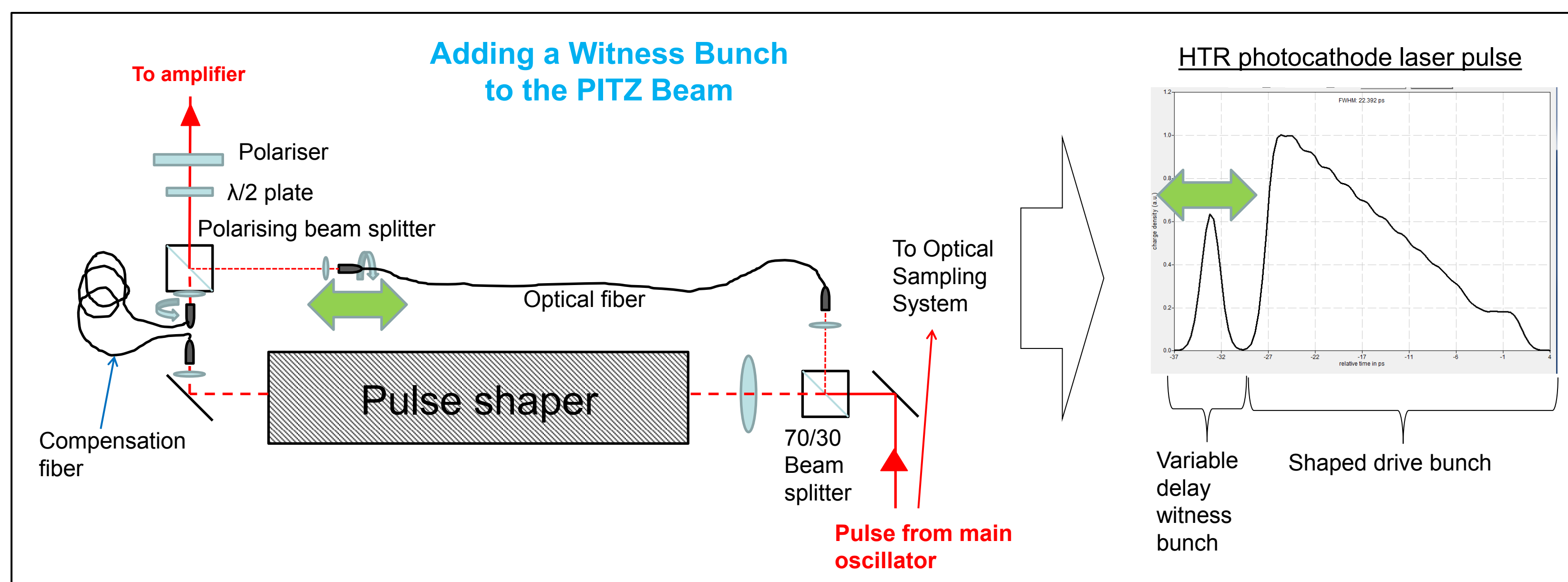
The highly flexible photocathode laser is crucial for PWFA experiments and will be further extended soon (see below).



## Scope of the HTR experiments at PITZ

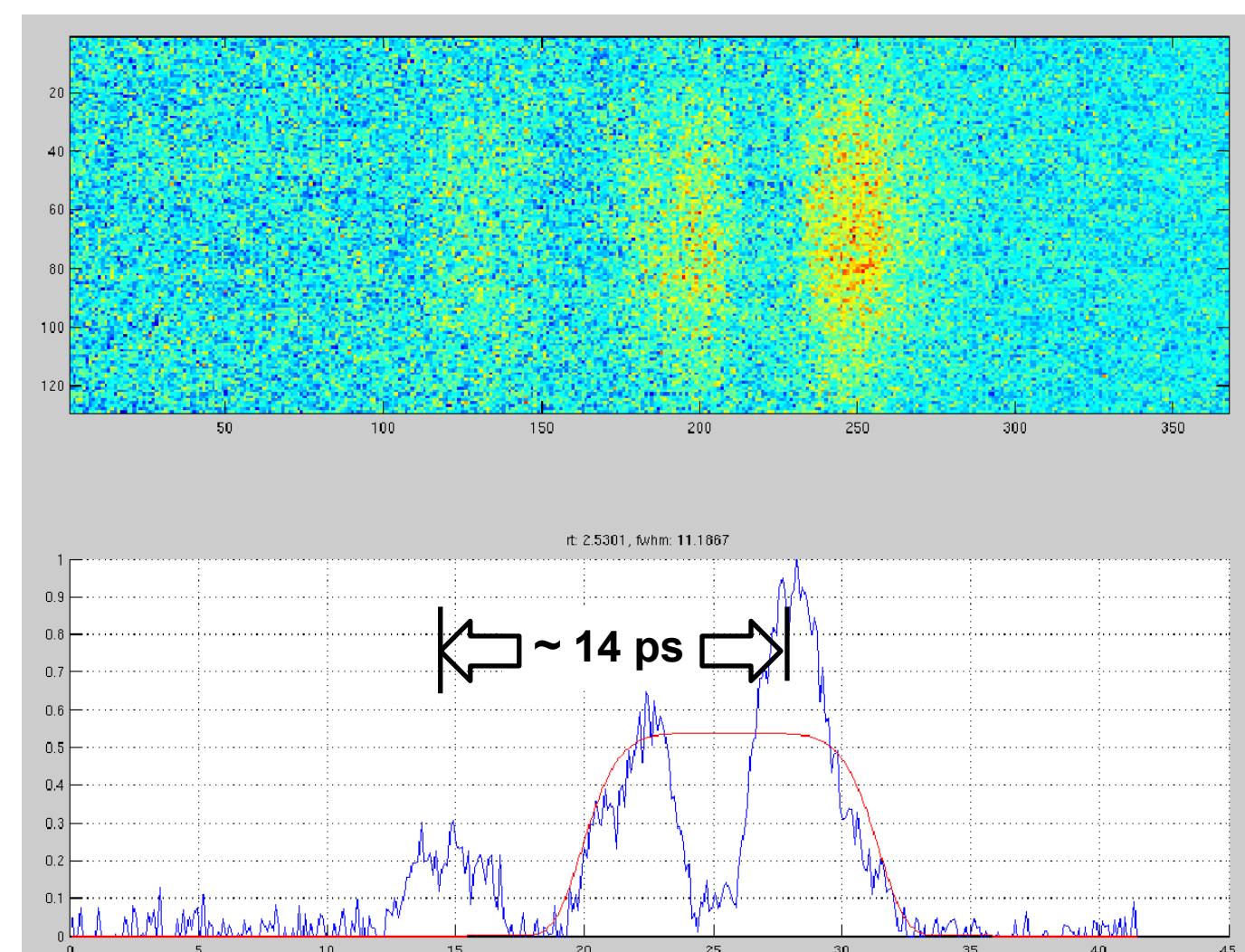
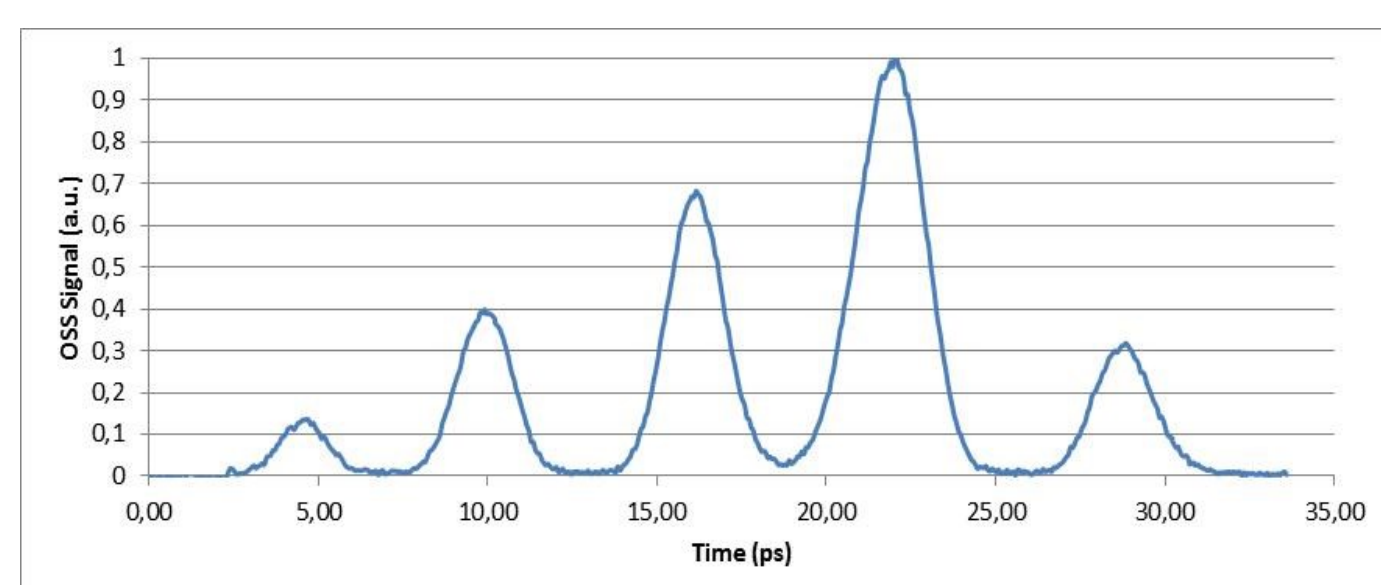
1. Demonstration of high transformer ratio (HTR), beam-driven PWFA
2. Experimental investigation of different HTR schemes
3. Applicability of photocathode-shaped bunches
4. Advanced photocathode bunch-shaping techniques

## Preparing PITZ for High Transformer Ratio Studies



## Prior Studies

- Versatility of photocathode laser was proven in various experiments (see cross-correlator measurement in bottom picture)
- Transport of asymmetric bunches through PITZ beamline was confirmed (see TDS measurement in right picture)



## Outlook

Proof of principle experiments and precision measurements of high transformer ratio Plasma Wakefield Acceleration schemes are scheduled for the summer run of PITZ this year.

Until then, further optimisation and final commissioning of all necessary equipment and simulations will be conducted.

Later investigations will employ e.g. longer plasmas, other HTR schemes and advanced bunch shaping techniques.