EUROPEAN
PLASMA RESEARCH
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APPLICATIONS

EuPRAXIA

Design of High Gradient Laser Plasma Accelerating Structure (WP3) Laser-plasma Injector

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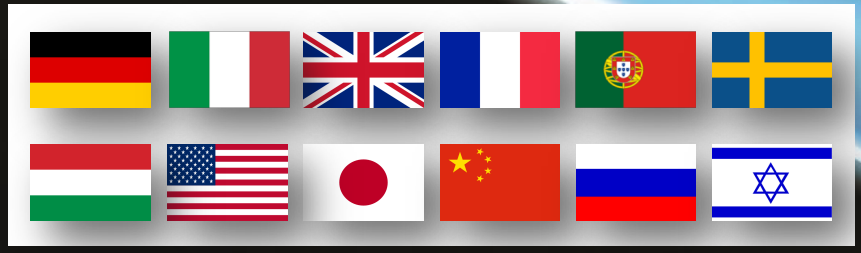

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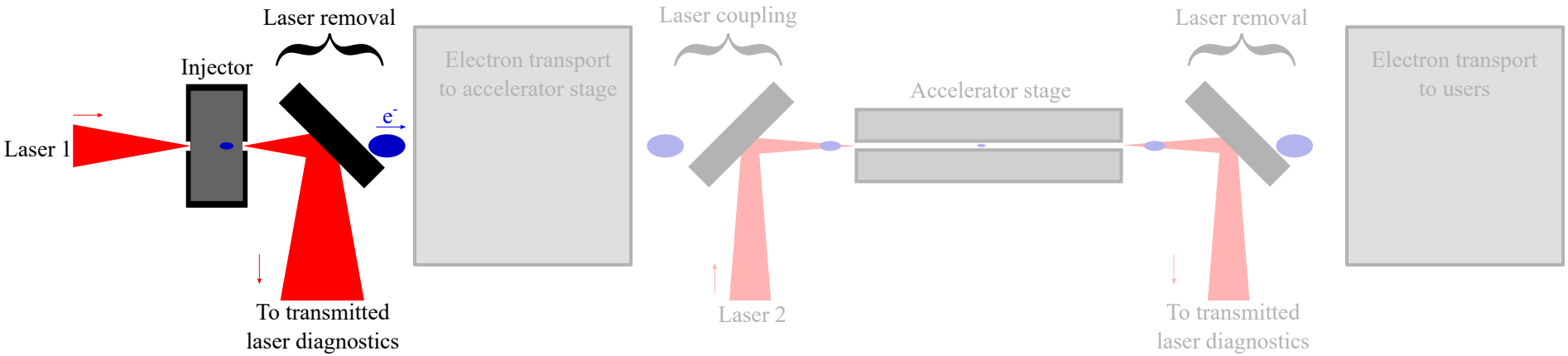
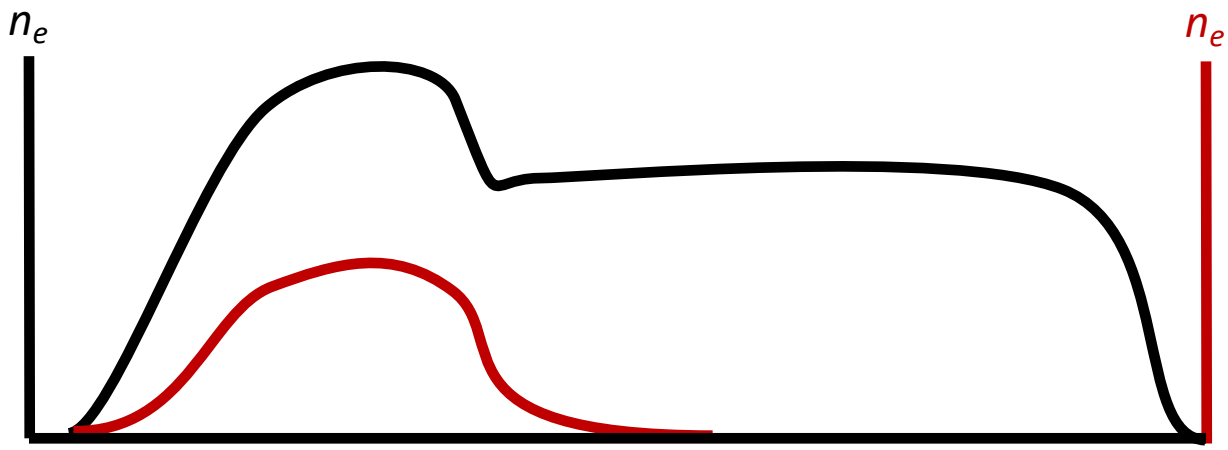
Laser Plasma Injector

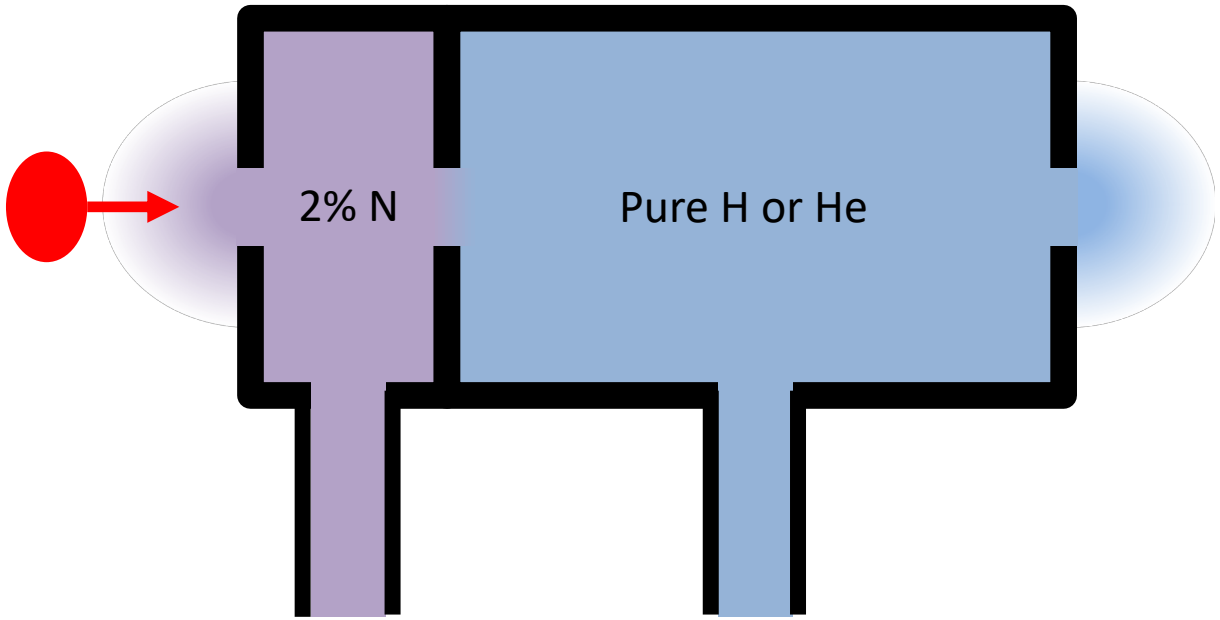


LPI schemes

Property	Low energy injector	GeV Injector
Electron energy [MeV]	150-400	1000
Plasma length [mm]	0.6-1.6	9-20
Exit gradient length [mm]	0.3-0.8	0.9-2.1
Laser a_0	1.4-4.5	1.2-3.9
Laser power [TW]	10-30	40-250

Plasma source





- Gas cell offers good stability
- Controlled injection necessary for stability and beam quality
- Proven technology but requires multi-Hz experiments

Plasma source

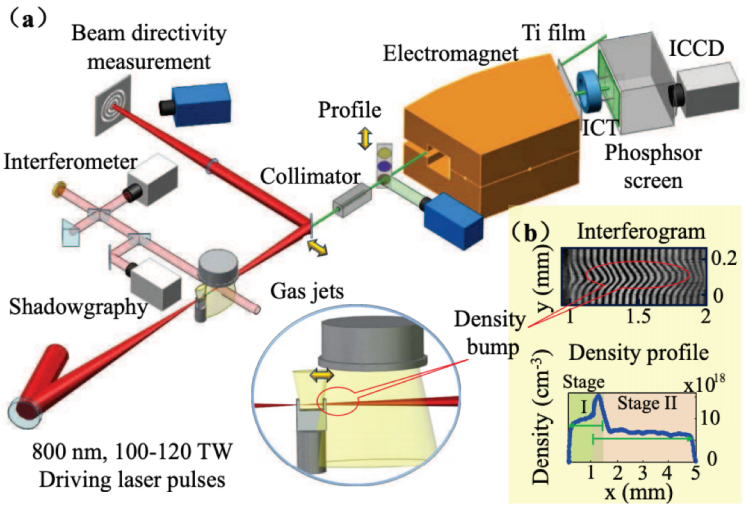
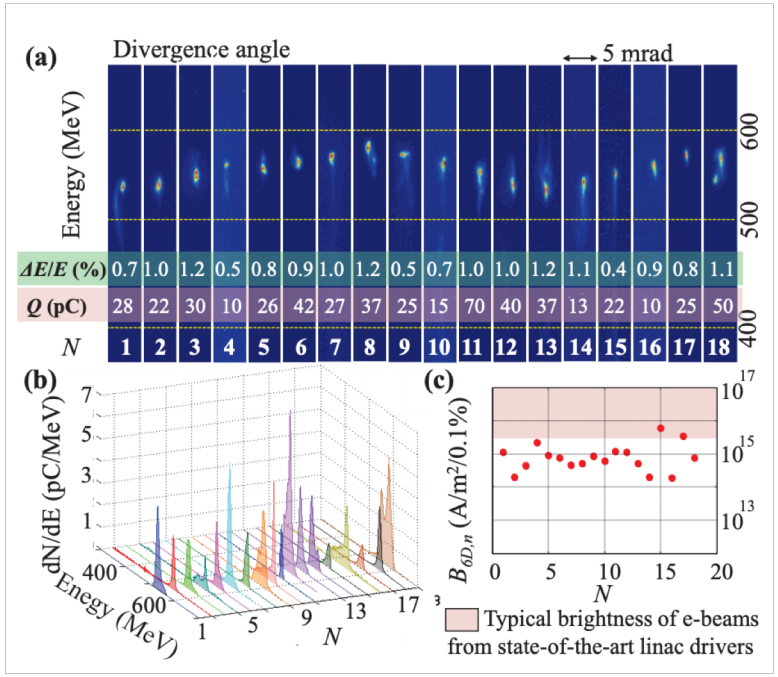
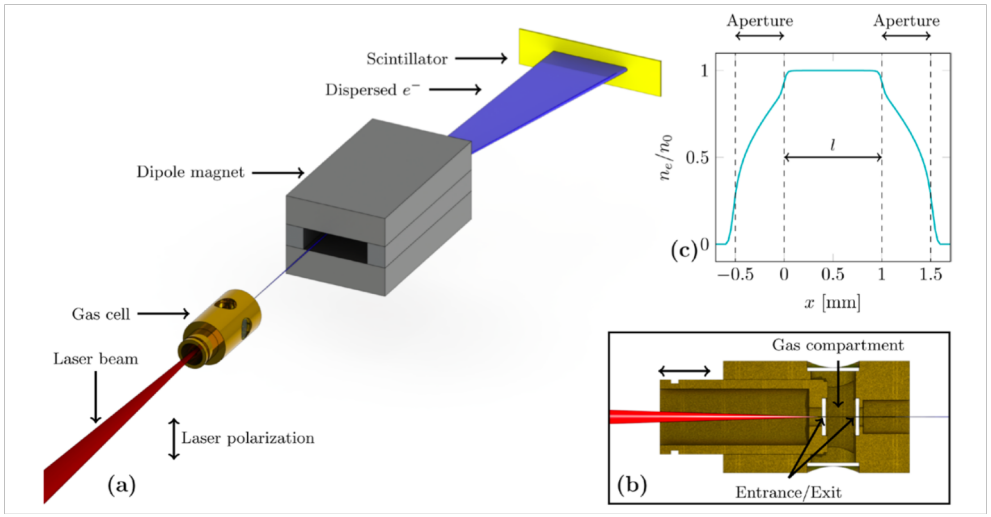


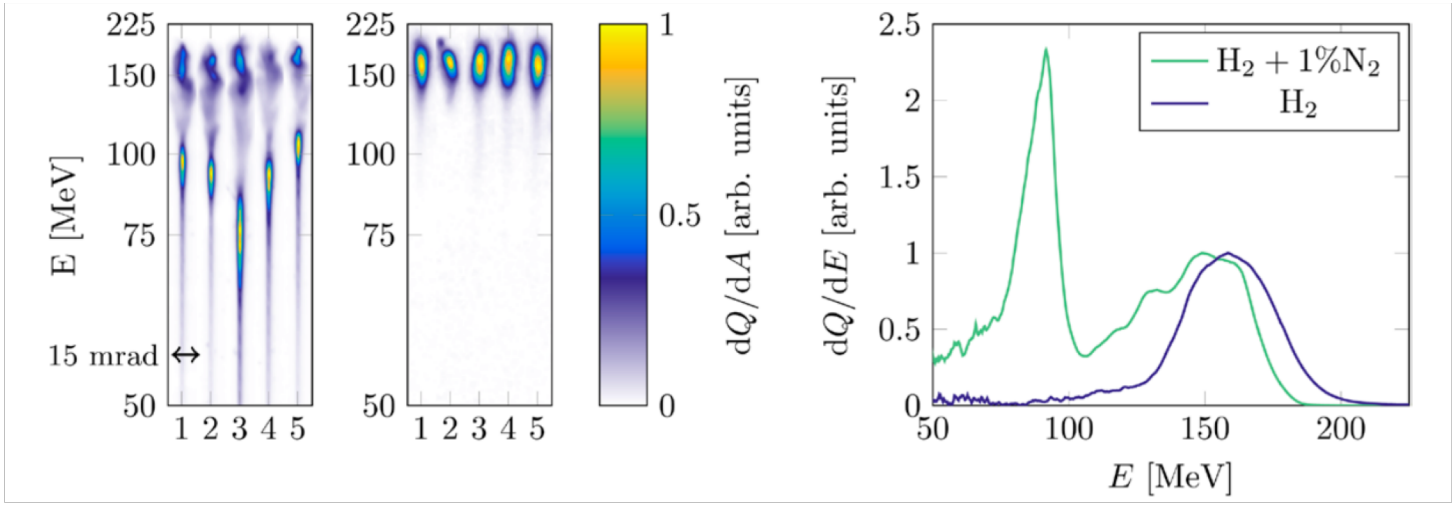
FIG. 1. (color) (a) Experimental layout of the cascaded LWFA using two gas jets. (b) The measured plasma density profile with a "density bump" between the two-segment plasmas.



Wang, W. T., *et al.* (2016). *Physical Review Letters*, *117*(12), 124801. https://doi.org/10.1103/PhysRevLett.117.124801

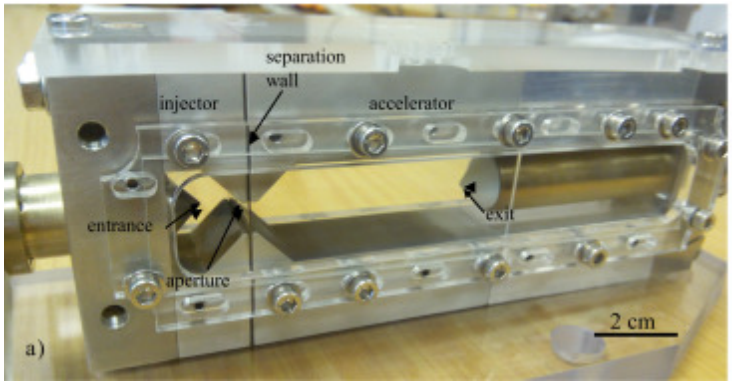
Plasma source

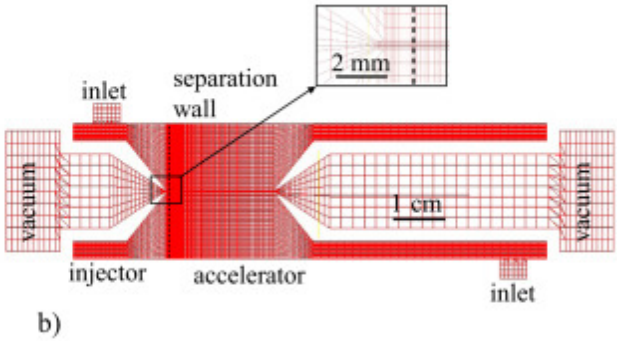


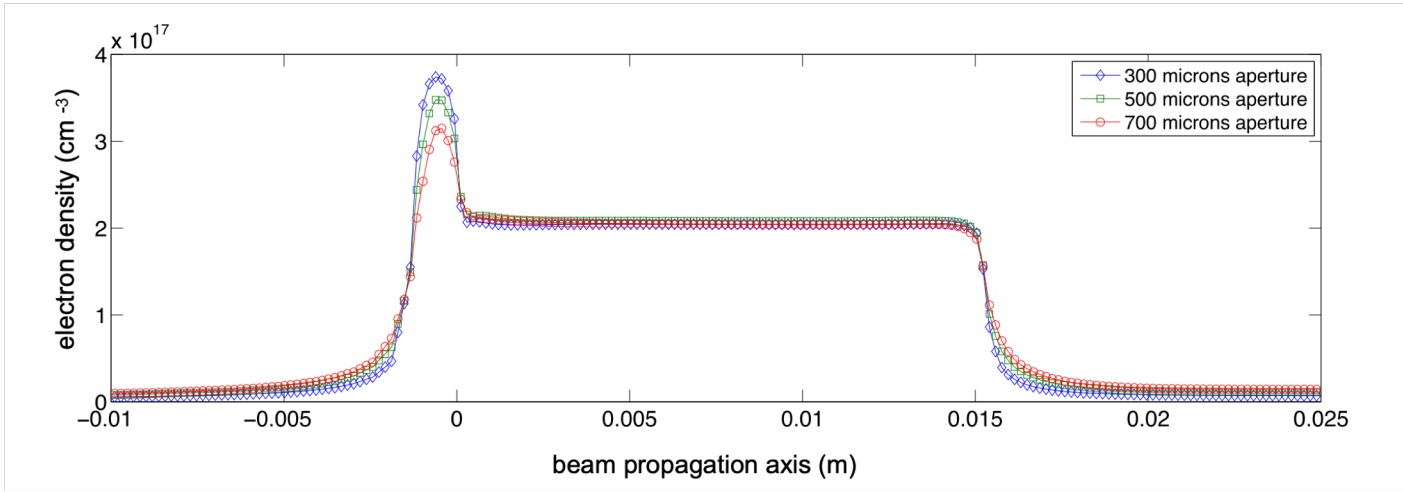


Hansson, M., *et al.*. (2016). *Plasma Physics and Controlled Fusion*, *58*(5), 055009. https://doi.org/10.1088/0741-3335/58/5/055009

Plasma source



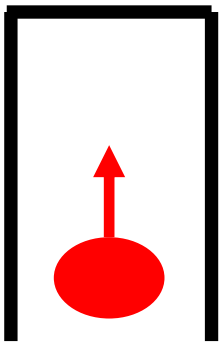




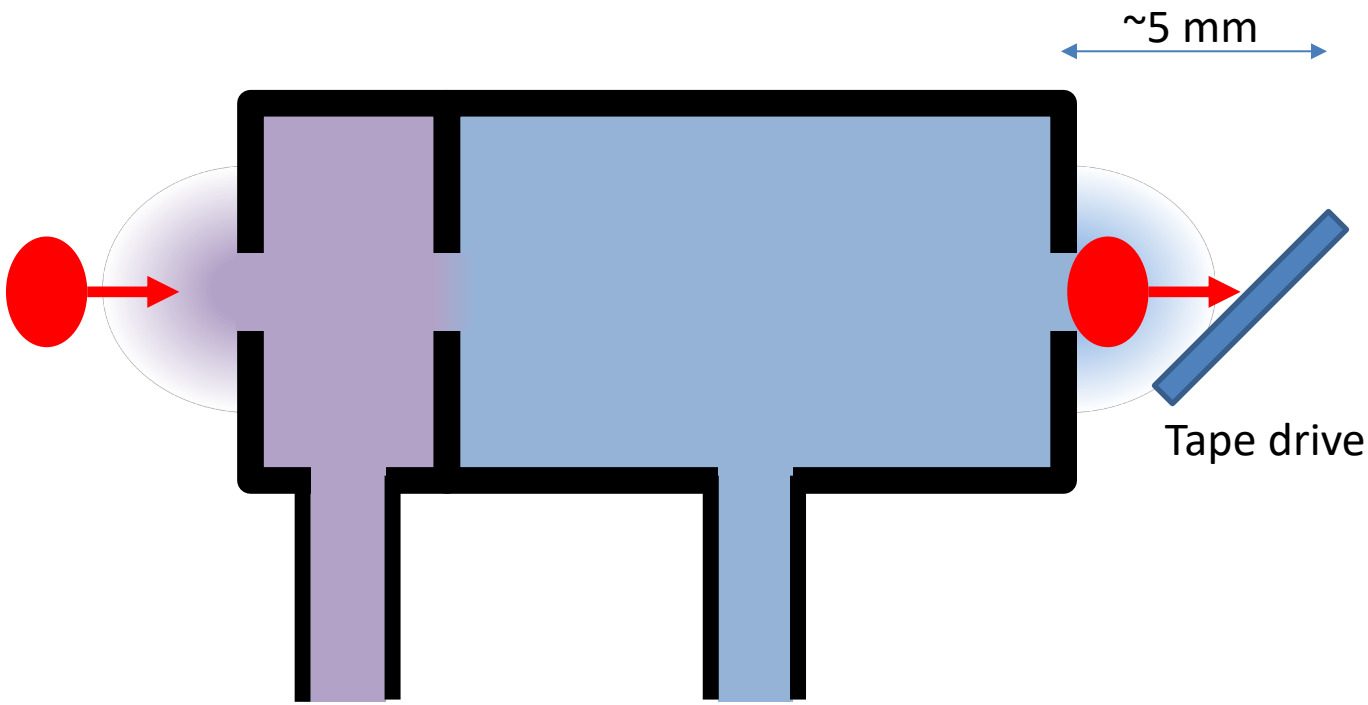
OpenFOAM simulations: Kononenko, O., *et al.* (2016). *NIMA*, *829*, 125–129. https://doi.org/10.1016/J.NIMA.2016.03.104

Laser dump

- Laser can be reflected/absorbed by foil
- Tape drive used to replenish foil each shot
- Tape can be ~10 microns Kapton with ~20nm Al
- Foil positioned close to exit of the plasma cell, after adiabatic downramp



Permanent beam dump



Electron beam quality

Bunch parameter	Baseline	Best →Acceptable
Energy spread	5%	1% → 10%
Charge	100 pC	100 → 30 pC
Transverse emittance	1 mm.mrad	1 → 10 mm.mrad
Duration	5	3→ 10
Repetition rate	10	100 → 1

- Parameters have each been met in individual experiments
- Need to be demonstrated simultaneously
- Ionisation injection may be limited in minimum emittance ~2 mm.mrad but has highly tunable charge
- Both down-ramp and ionization injection methods (and combination) allow for maximum flexibility with simple target

Stability and Synchronisation

- Controlled injection methods limit dependence on non-linear plasma optics
  - Increases stability
  - Fixes injection point for timing of subsequent stages
- Plasma source requires high precision gas fills and no structural damage
- Experimental and simulation campaigns still required to explore bunch properties dependence on laser and target parameters

Summary

- A LPI is capable of achieving EuPRAXIA design parameters
- Experimental campaigns focused on beam quality (emittance/energy spread) will be necessary
- Dependence of electron beam properties on experimental parameters needs to be investigated
- High rep-rate studies are required to examine damage/debris/heat load issues