

Advanced and Novel Accelerator Development: WP Summary



Coordinator: Brigitte CROS

Laboratoire de Physique des gaz et
des Plasmas – CNRS - UPXI

<http://www.lpgp.u-psud.fr/operations/interaction/anad.htm>

Several existing projects



- ❖ ALPHA-X project in the UK (Advanced Laser Plasma High Energy Accelerator)
- ❖ The Eindhoven High-brightness Electron Source Programme
- ❖ The laser based electron acceleration approach at LOA and in Germany (MPQ-TUVienna)
- ❖ The plasma based accelerator program at Golp-IST

ALPHA-X project

Main areas of research:

- ❖ Injectors (conventional and all-optical)
- ❖ Laser-plasma wake-field acceleration
- ❖ Plasma channel capillaries
- ❖ Free-electron laser (FEL)
- ❖ Beam transport systems
- ❖ Diagnostics (single shot Electro-optic measurement, down to 500 fs)
- Using a TW laser and a 10 MeV injector
- Operation of photo-injector + upgraded laser (1J, 20 TW) scheduled in 2005

Eindhoven Programme

- ❖ Emphasis on controlled acceleration (LWFA)

	Available	Foreseeable improvements
High Brightness Injector	100 fs, 10 pC 7.5 MeV	75 fs, 100 pC 9.5 MeV
Plasma Waveguide	$2 \times 10^{18} \text{ cm}^{-3}$	$2 \times 10^{17} \text{ cm}^{-3} ???$
Drive Laser	2 TW	2 TW
Expected Results	$50 \pm 20 \text{ MeV}$	$50 \pm 5 \text{ MeV}$

+ homemade code (GTP solver) for the simulation of the injector

All optical approach at LOA

- ❖ Laser particle acceleration in the forced LWF regime
 - ❖ Energy gains of 1 MeV to 200 MeV
 - ❖ E-fields of 1 GV/m to 1000 GV/m
 - ❖ Wide spectrum but large number of electrons and small emittance for higher energy electrons
- ❖ Future work
 - ❖ Electron sources up to ~ 1 GeV (nC, <1 ps)
 - ❖ Electron beam duration has to be measured
 - ❖ Very high energy gains mainly rely on guiding
 - ❖ Different schemes will be tested

All optical approach at MPQ- TUVienna

- ❖ Phase-stabilization of amplified 1 kHz 5-fs pulses has been demonstrated.
- ❖ Achieved accuracy: 200 attosecond
- ❖ Typical applications: HHG and Attosecond pulse generation

- ❖ Laser Based Electron Acceleration projet:
- ❖ Bubble acceleration
- ❖ 2 schemes for acceleration: LWFA , Laser vacuum acceleration

The plasma based accelerator program at Golp-IST

- ❖ Plasma channels for high intensity guiding (laser trigger + discharge)
- ❖ Laser guiding experiments to be performed
- ❖ Numerical experiments (OSIRIS code) showing
 - ❖ self-injection of 10 pC electron bunches
 - ❖ Acceleration of background plasma electrons to the GeV level in 1 cm length channel

Simulation efforts

- ❖ Powerful codes are used (Pukhov et al 3D code, and CALDER code, OSIRIS code)
 - ❖ Predict new regimes not yet reachable with existing experimental facilities (e.g. « the bubble »)
 - ❖ Benchmarking of these codes necessary
- ❖ Photon-in-cell code (treats photons as quasi-particles): new approach to PW turbulence
- ❖ Other codes (A. Reitsma et al., N. Andreev et al.) used to predict linear or NL regimes, including guiding over long distances
 - ❖ Reproduce or explain experimental results (good synergy with experimental efforts)

Challenges

- ❖ Non linear schemes
 - ❖ Control of the properties of the electron bunches
- ❖ Linear scheme
 - ❖ Inject a relativistic electron bunch into a small volume of phase space
 - ❖ Inject EM radiation and electron beam into the waveguide
- ❖ Diagnostics
- ❖ ...Coordinate the work