Advanced and Novel Accelerator Development: WP Summary

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

1st ELAN workshop, B. CROS, May 2004
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
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)

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<thead>
<tr>
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<th>Available</th>
<th>Foreseeable improvements</th>
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<tbody>
<tr>
<td>High Brightness Injector</td>
<td>100 fs, 10 pC 7.5 MeV</td>
<td>75 fs, 100 pC 9.5 MeV</td>
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<tr>
<td>Plasma Waveguide</td>
<td>$2 \times 10^{18} \text{ cm}^{-3}$</td>
<td>$2 \times 10^{17} \text{ cm}^{-3}$ ??</td>
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<tr>
<td>Drive Laser</td>
<td>2 TW</td>
<td>2 TW</td>
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<tr>
<td>Expected Results</td>
<td>50±20 MeV</td>
<td>50±5 MeV</td>
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+ 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