High Intensity Laser-Plasma Science
(at the small to intermediate scale)

Wim Leemans

Eric Esarey

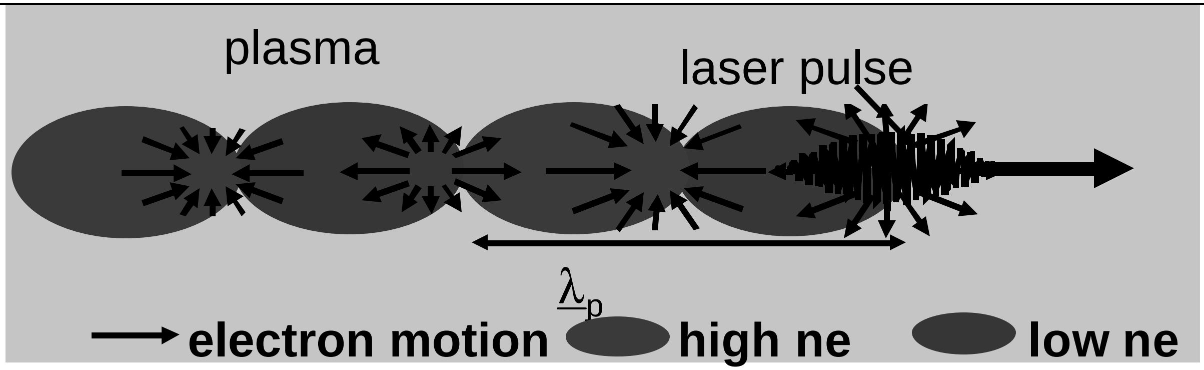
L'OASIS Group

Outline

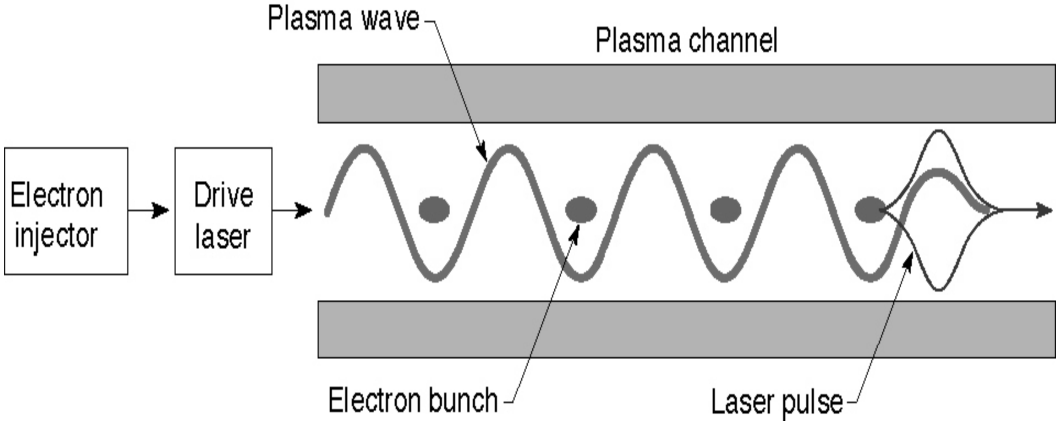
1. Laser driven accelerator: principle
2. L'OASIS Facility and multi-beam experiments
3. Recent acceleration results
4. "Roadmap" element: Advanced accelerators+high power, high rep rate lasers for HED Science

Laser wakefield accelerator: principle

Standard regime (LWFA): pulse duration matches plasma period



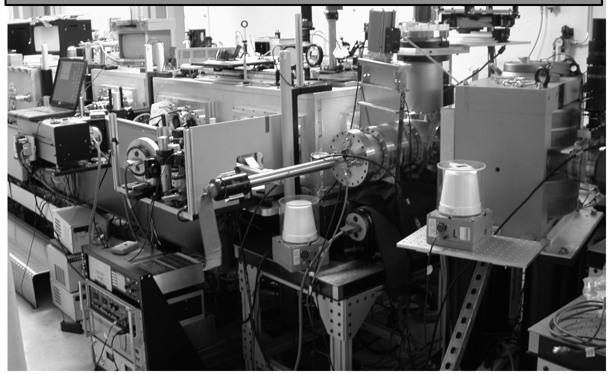
Ultrahigh axial electric fields
=> Compact electron accelerators
Plasma wakefields
E_z > 10-100 GV/m, fast waves
(Conventional RF accelerators
E_z ~ 10 MV/m)
Plasma channel: Guides laser pulse and supports plasma wave



L'OASIS facility: high rep rate, high peak power Ti:sapphire system

10 TW Ti:sapphire

Shielded target room



100 TW Ti:sapphire
(commissioning 2004)

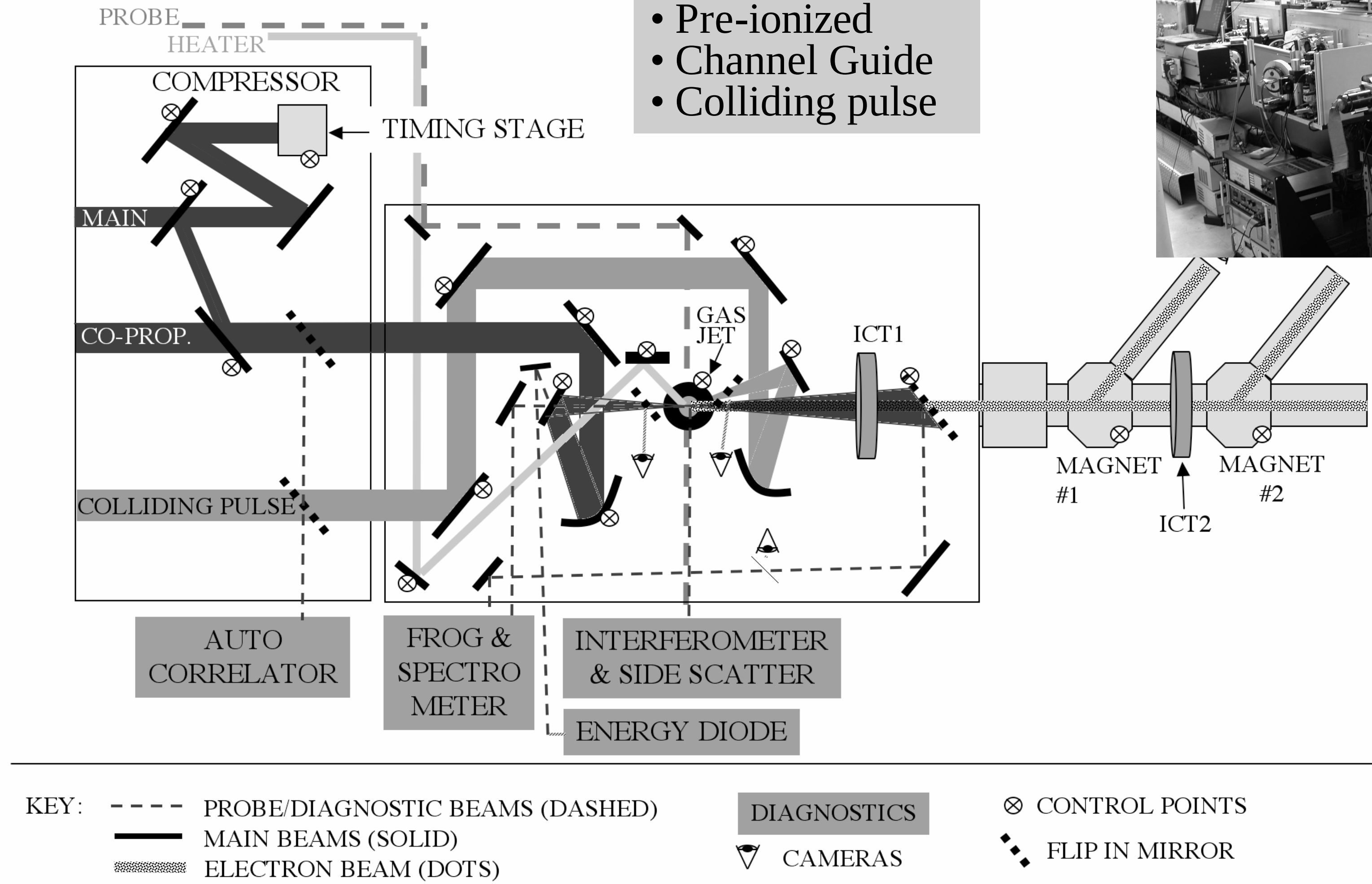
10 TW Ti:sapphire
laser system:
500 mJ/pulse
t > 40 fs
10^{19} W/cm^2
10 Hz
6 μm spot size

100 TW Ti: sapphire
laser system:
3-4 J/pulse
t > 30 fs
10^{20} W/cm^2
10 Hz
6 μm spot size

L'OASIS: *Lasers, Optical Accelerator Systems Integrated Studies*

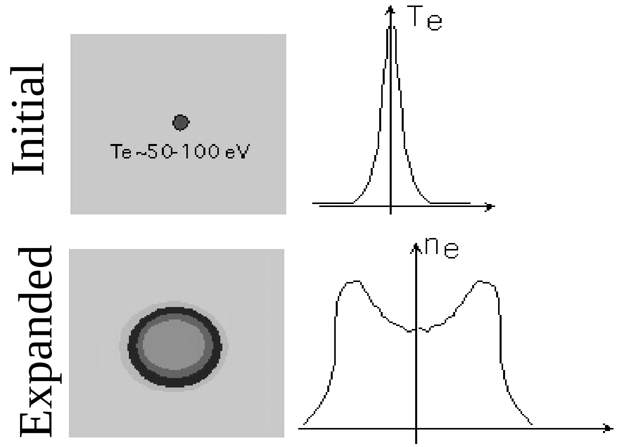
Multi-beam, multi-terawatt, high rep rate laser enables sophisticated experiments

Experiments:
- Self-modulated
- Standard LWFA
- Pre-ionized
- Channel Guide
- Colliding pulse



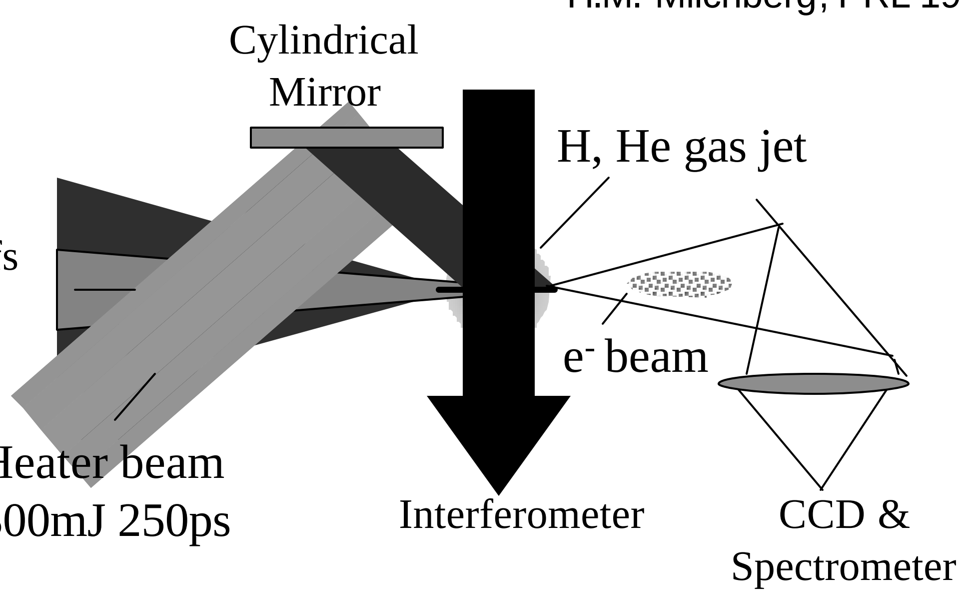
Plasma channel production: ignitor-heater method

Principle



H.M. Milchberg, PRL 1993

LBNL's Implementation



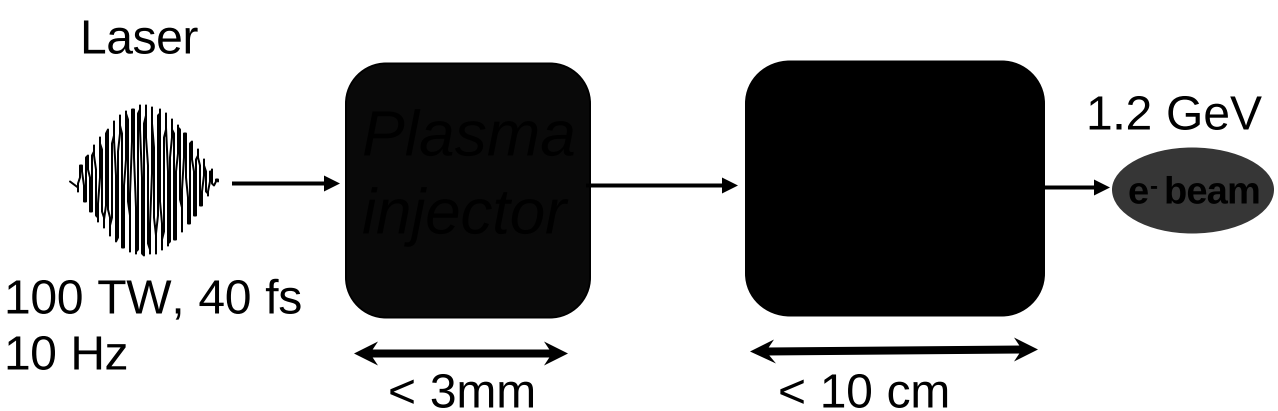
P. Volfbeyn, E. Esarey and W.P. Leemans, Phys. Plasmas (1999); C.G.R. Geddes et al., in preparation

Next step: 1 GeV compact module
100 TW laser + plasma channel

L'OASIS Laser technology

+

Plasma channel technology



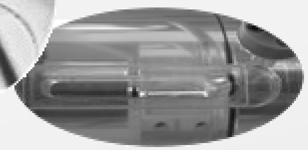
- High energy e-beams
- Femtosecond x-rays
- THz radiation
- Radio-isotopes

All Optical Accelerators

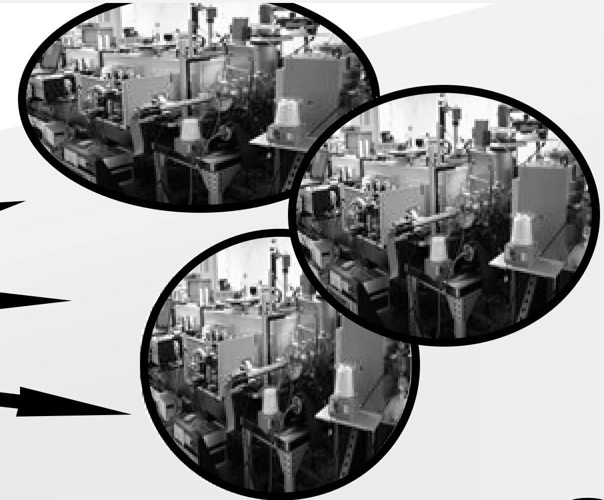
2003

100 TW L'OASIS

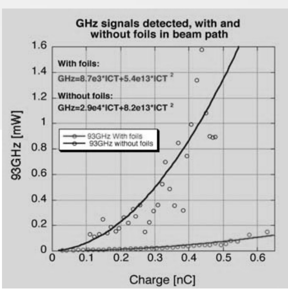
1 GeV Demo



Multi-User Laser/Radiation Facility

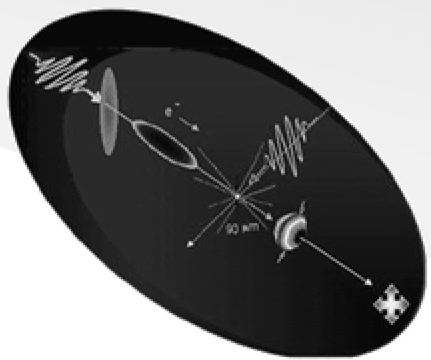


2009



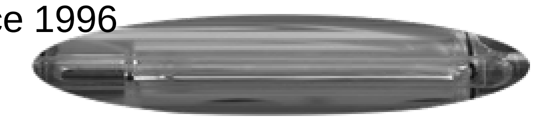
Coherent T-rays

PRL 2003

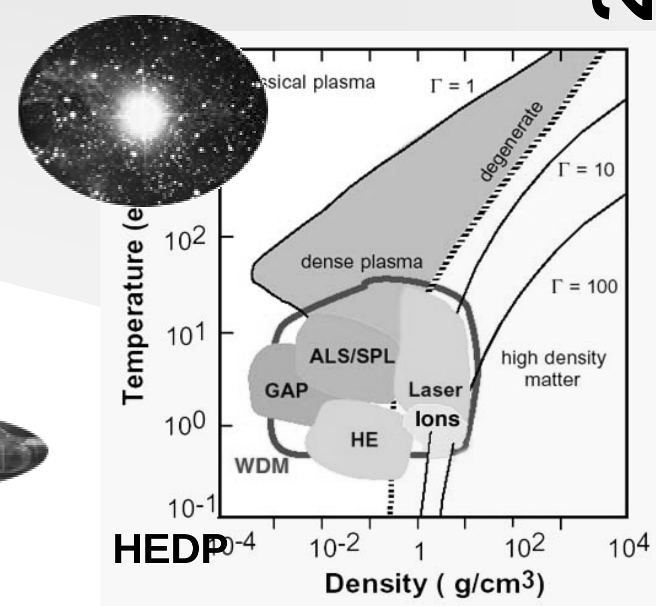


fs hard X-rays

Science 1996



Multi-GeV beams



HEDP

BERKELEY LAB

Time line and funding profile

Accelerator development

Proof-of-principle experiments

(x-rays, THz, etc…)

$3-3.5 M/yr

User Facility Construction

$ 18- 20 M for lasers

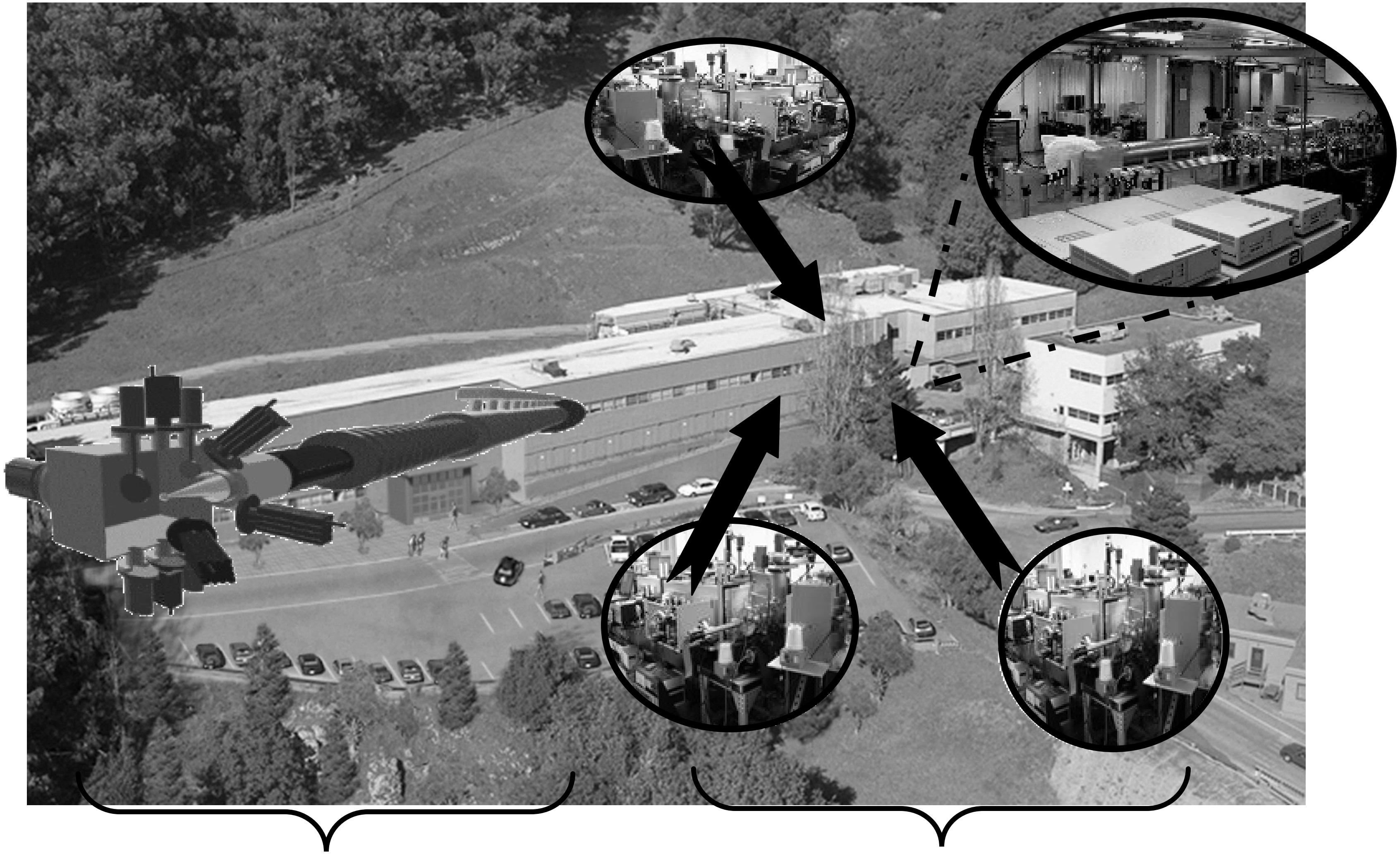
$10-20 M for bldg

National User Facility

$ 6.5-7 M/yr operating cost

'04 '06 '08 '10 '12 '14

Multi-beam HEDP User Facility



Ion HEDP - 2014 **Laser-based HEDP - 2009**