L'OASIS Facility at LBNL: Multi-terawatt, multi-beam laser for advanced accelerator R&D

Wim Leemans

AAC 2004, Stony Brook, NY

L'OASIS: Lasers Optical Accelerator Systems Integrated Studies

L'OASIS Team

Group (Scientists + postdocs + students)

Experiment: W. Leemans (Group Leader), C. Toth, P. Michel, B. Nagler (Fulbright Fellow), C. Geddes (UC Berkeley, Hertz Foundation Fellow), K. Nakamura (UTokyo), J. van Tilborg (TUE, NL)

Theory: E.Esarey (Deputy Group Leader), C. Schroeder, B. Shadwick (1/2), G. Fubiani (Univ. Paris)

Techs: M. Dickinson, D. Syversrud, J. Wallig, N. Ybarrolazza

Visitors/Postdocs (2004)

J. Faure (LOA, France)

C. Filip (UNR)

T. Gonsalvez (Oxford, UK)

Collaborators

S. Hooker (Oxford University, UK)

D. Schneider (LLNL+LBNL)

R.Donahue, D. Rodgers, A. Smith (Radiation Detection)

J. Wurtele(UCB+CBP)

T. Budinger, J. O'Neil, H. VanBrocklin (CFI/LSD-Radio Isotopes)

M. Martin, R. Kaindl, M. Carnahan, J. Byrd, J. Singley (ALS/UCB-Coherent IR/THz)

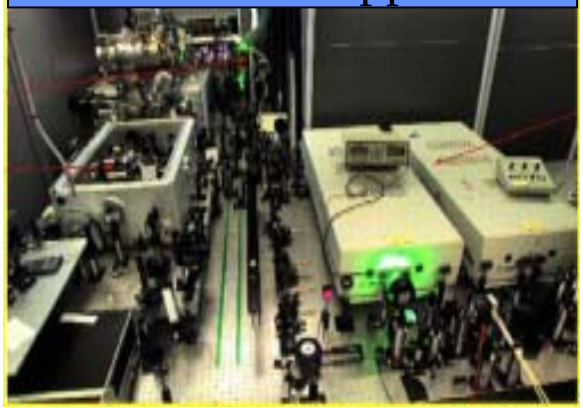
D. Bruhwihler, D. Dimitrov (TechX-Corp-Simulations)

J. Cary, R. Giacone (U. Colorado/TechX-Corp-Simulations)

T. Cowan, H. Ruhl (University of Nevada, Reno)

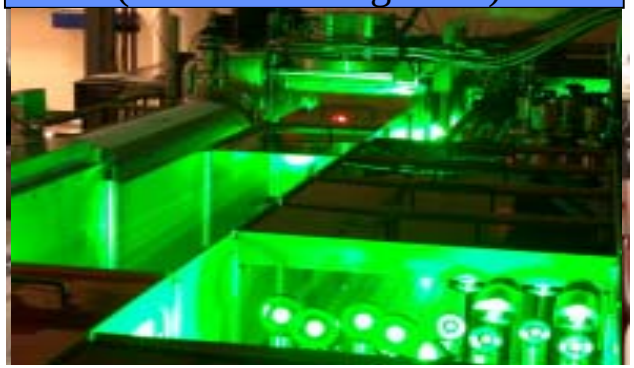
L'OASIS facility: high rep rate, high peak power Ti:sapphire system

10 TW Ti:sapphire



Shielded target room

100 TW Ti:sapphire
(commissioning 2004)



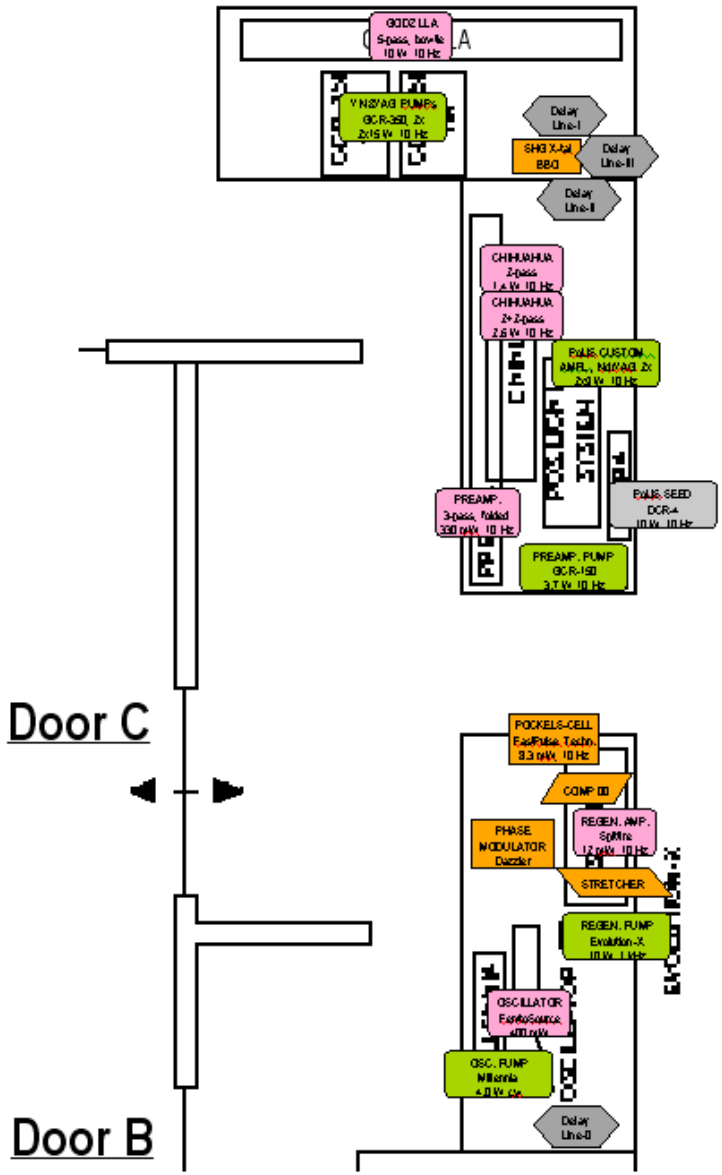
10 TW Ti:sapphire laser system:
500 mJ/pulse
t > 40 fs
10^{19} W/cm^2
10 Hz
6 μm spot size

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*

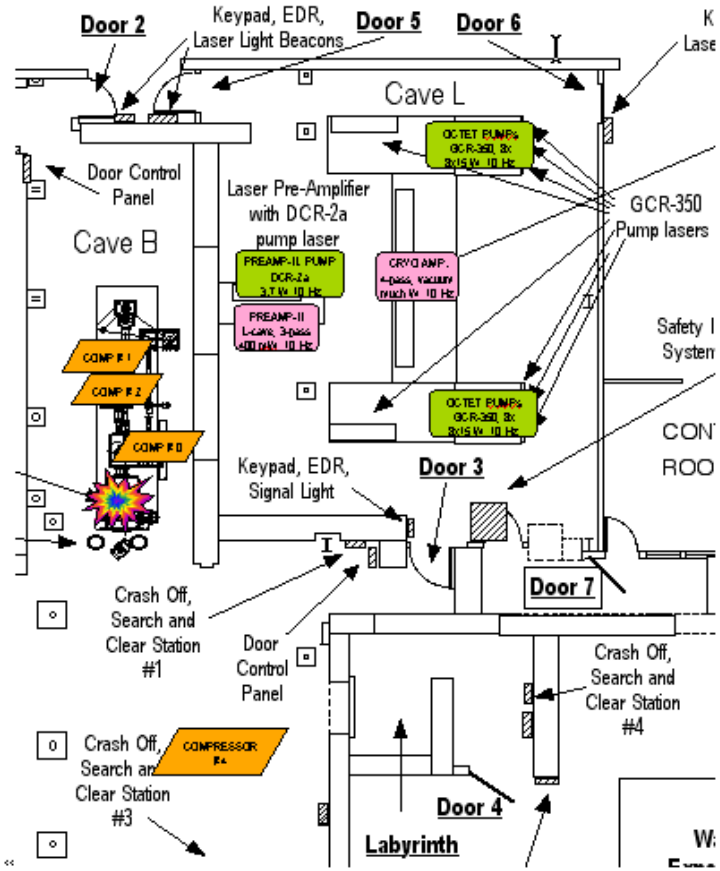
May 2003

L'OASIS LASER SYSTEMS – GENERAL LAYOUT Upstairs

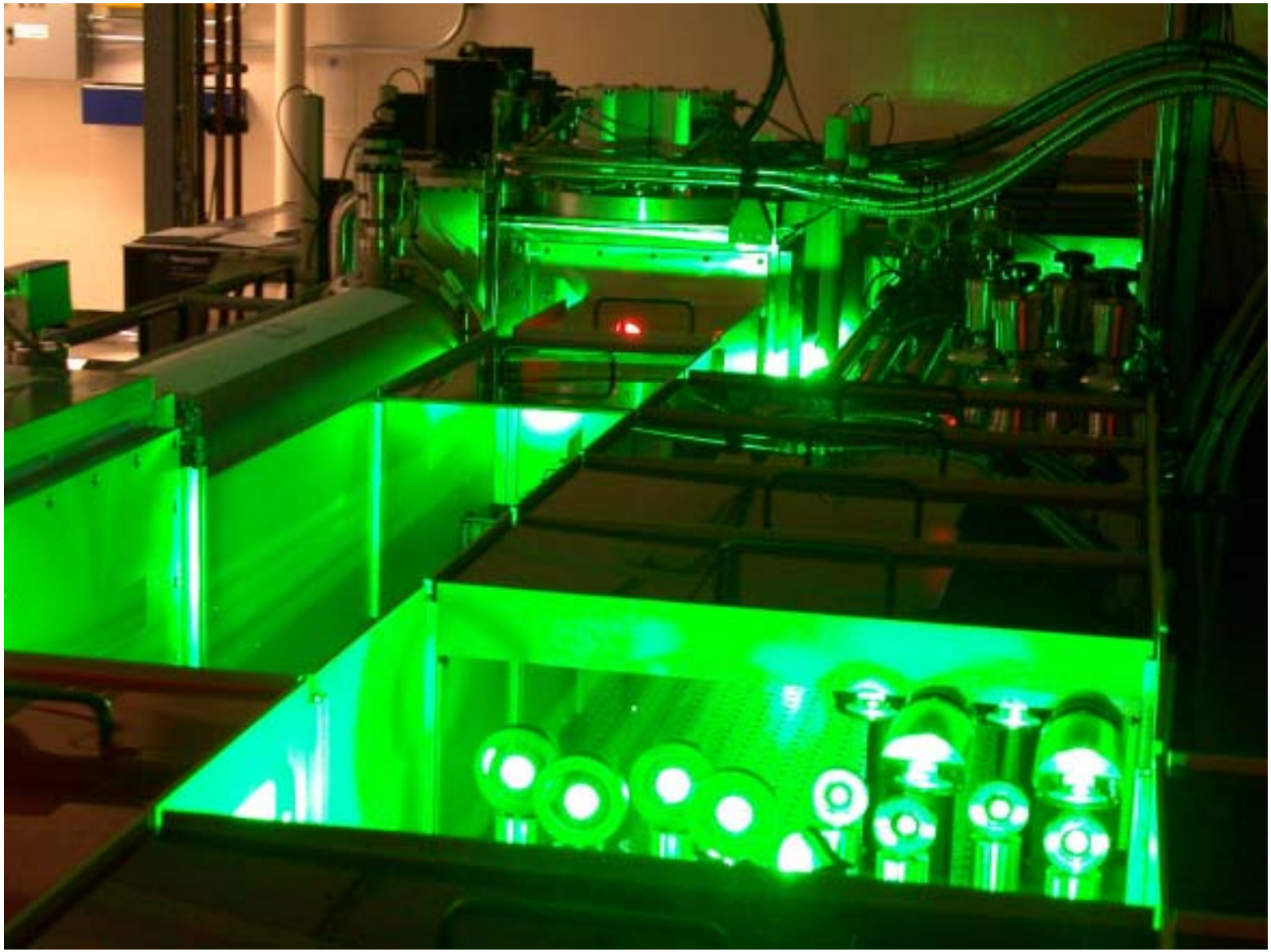


May 2003

L'OASIS LASER SYSTEMS – GENERAL LAYOUT Caves



Relay imaged pumping of 100 TW cryo-cooled amplifier system (under construction)

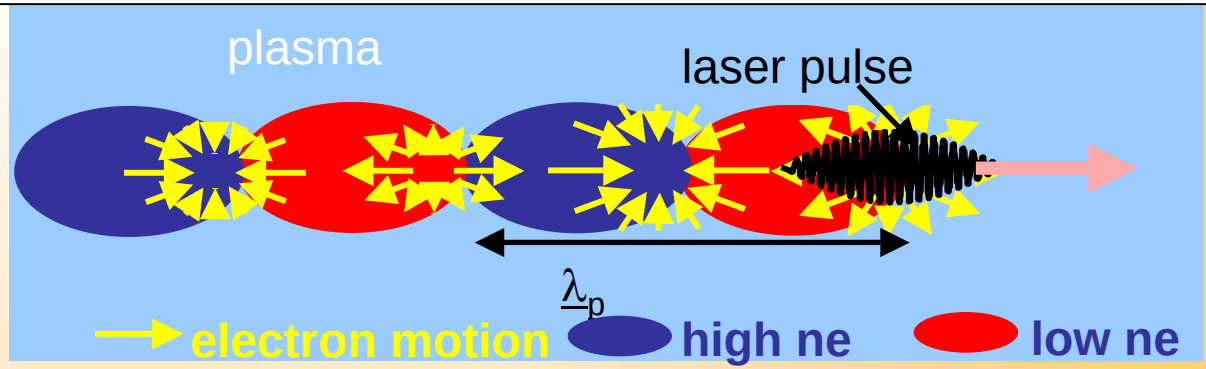


Beam parameters

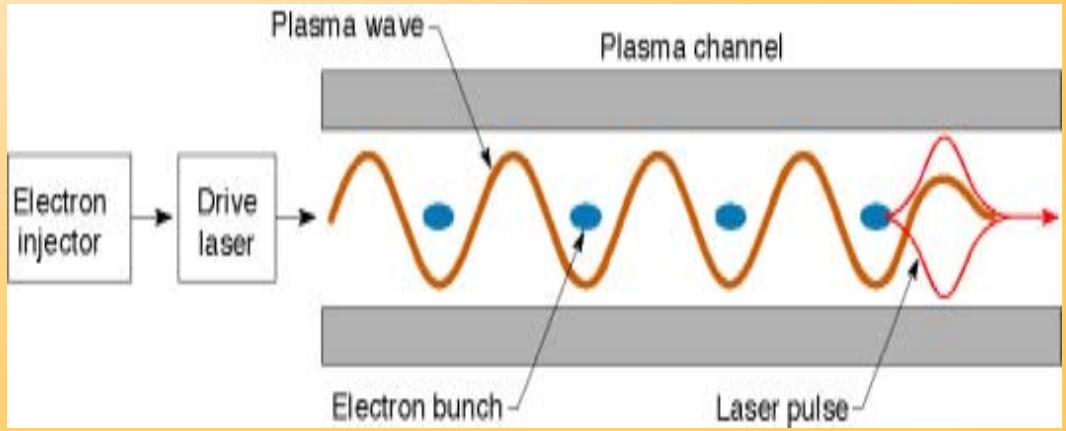
Amplifier	Purpose	Energy/pulse	Pulse duration	Peak power	Average power
Main Power Amplifier	Wake-field Driver	550 mJ	46 fs	12 TW	5.5 W
Secondary Amp. 2nd pass/Comp#1	Collider Beam	50 mJ	50 fs	1 TW	0.5 W
Secondary Amp. 2nd pass/Comp#2	Plasma Ignitor	50 mJ	50 fs	1 TW	0,5 W
Secondary Amp. 4th pass	Plasma Heater	250 mJ	220 ps	1.1 GW	2.5 W
Regen.Amp. partial output	Probe Ğblue interferometry	~30 μJ	50 fs	~0.6 GW	~0.3 mW
Cryo.Amp.(under construction)	Wake-field Driver & Solid Targets	3.5 J	35 fs	100 TW	35 W

Laser wakefield accelerator: principle

Standard regime (LWFA): pulse duration matches plasma period

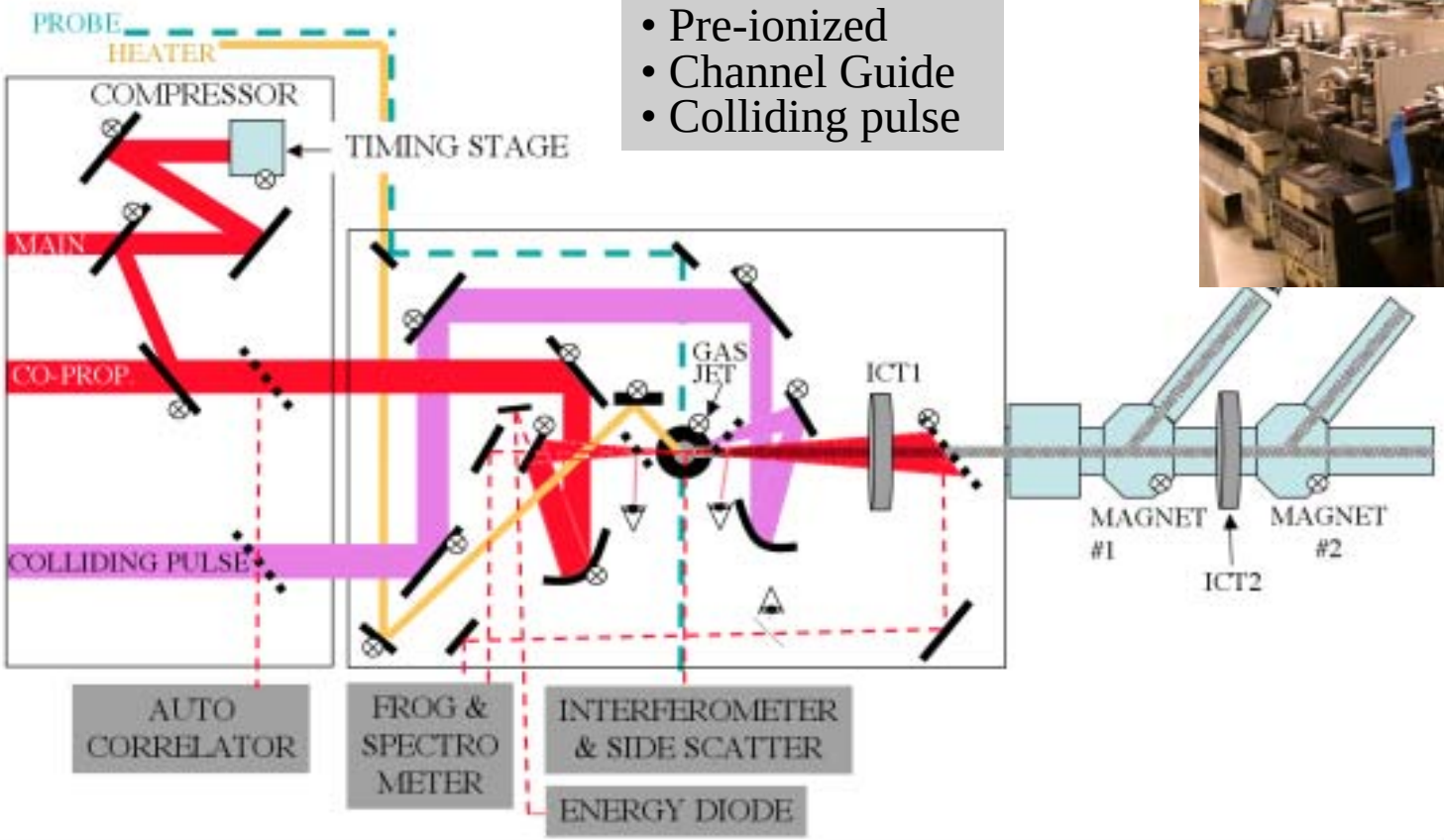


Ultrahigh axial electric fields
=> Compact electron accelerators
Plasma wakefields
E_z > 10-100 GV/m, fast waves
(Conventional RF accelerators
E_z ~ 10 MV/m)
Plasma channel: Guides laser pulse and supports plasma wave



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

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



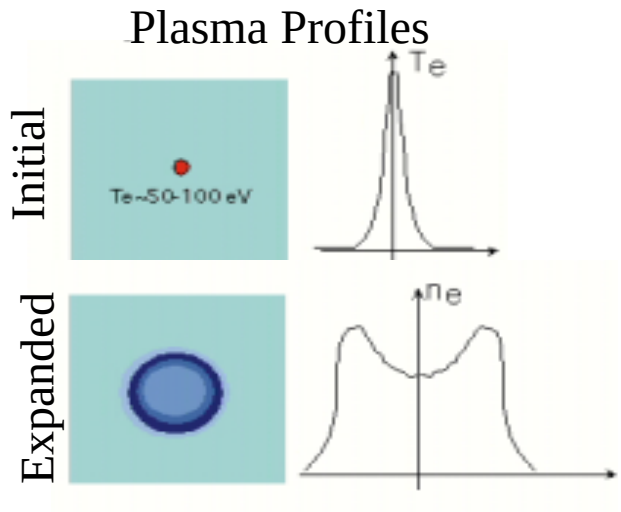
KEY:
- PROBE/DIAGNOSTIC BEAMS (DASHED)
- MAIN BEAMS (SOLID)
- ELECTRON BEAM (DOTS)

DIAGNOSTICS
- CAMERAS

- CONTROL POINTS
- FLIP IN MIRROR

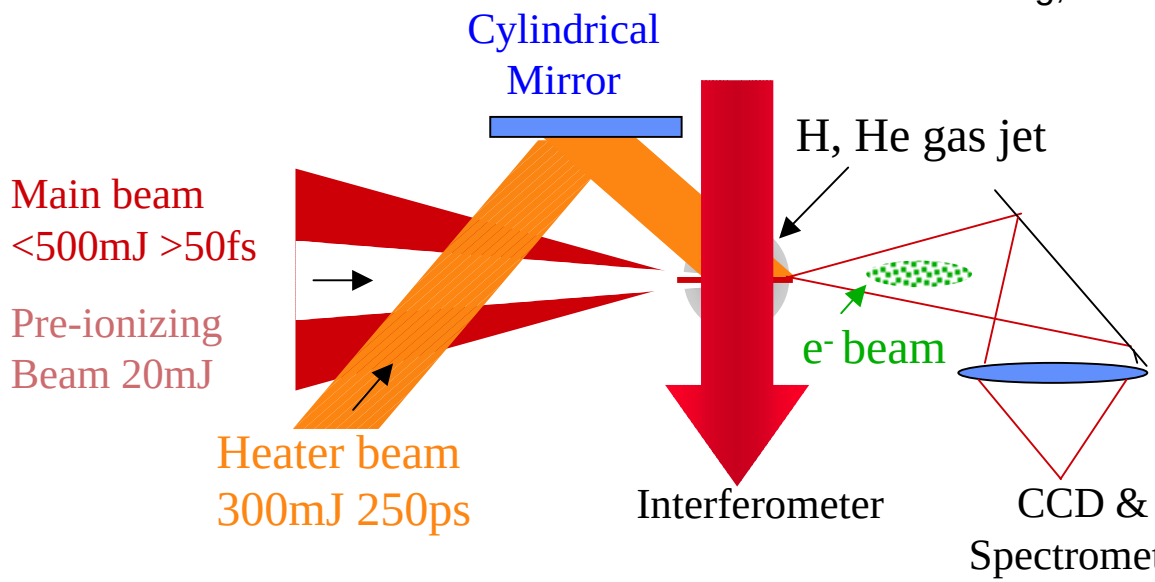
Plasma channel production: ignitor-heater method

Principle



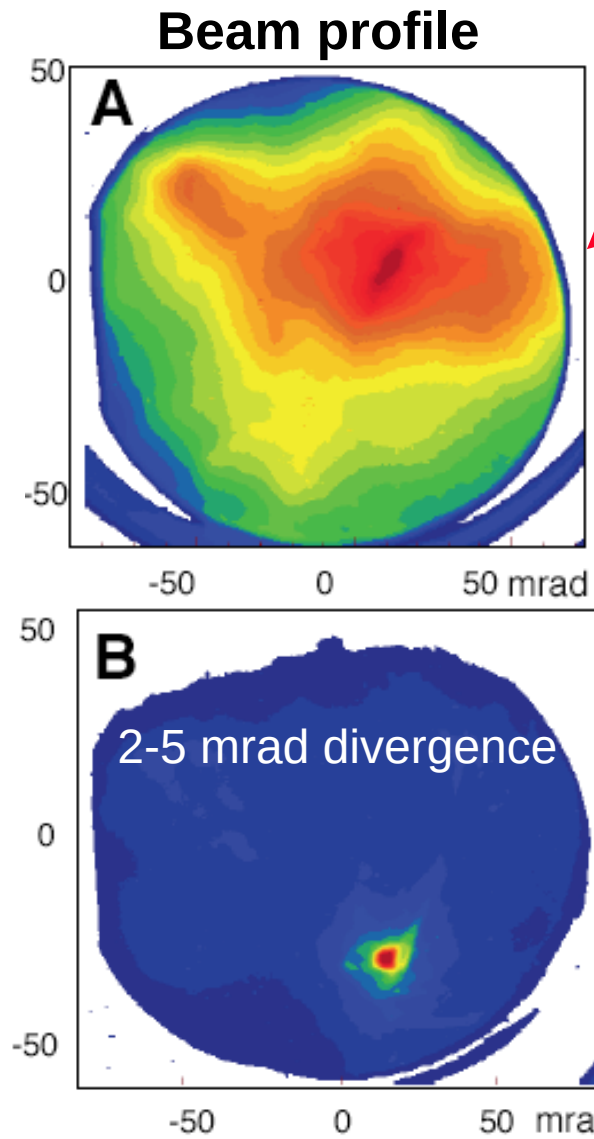
H.M. Milchberg, PRL 1993

LBNL's Implementation



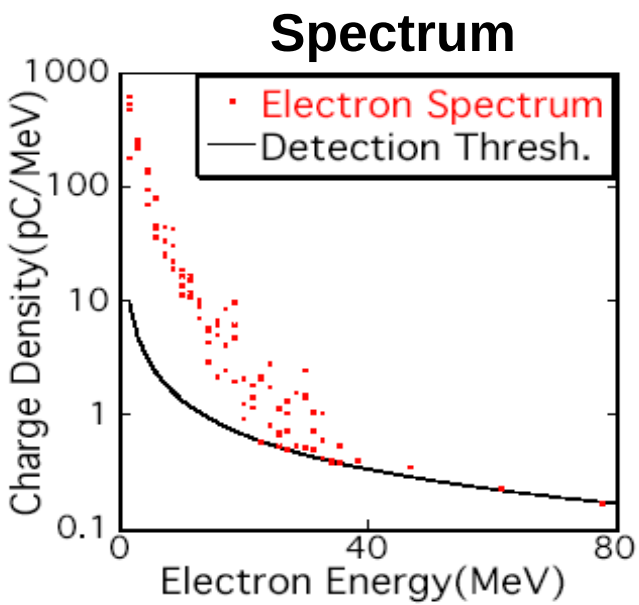
P. Volfbeyn, E. Esarey and W.P. Leemans, Phys. Plasmas (1999); C.G.R. Geddes et al., in preparation

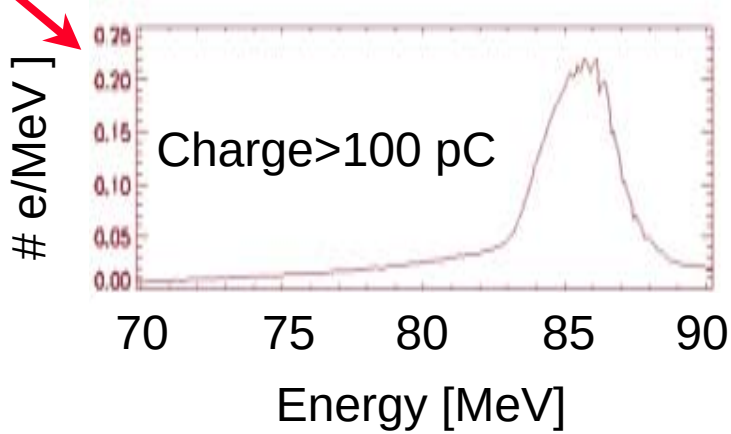
Breakthrough: 85 MeV e-beam with %-level energy spread from laser accelerator



Unguided

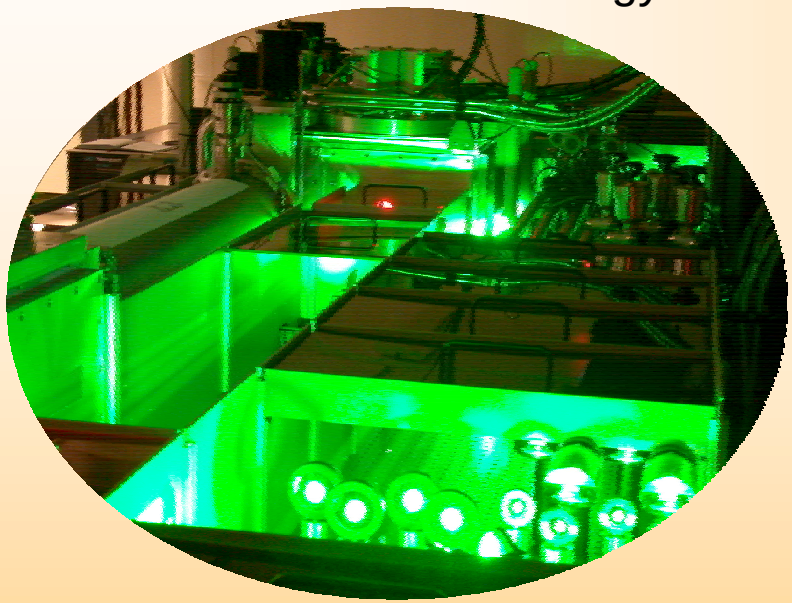
Guided





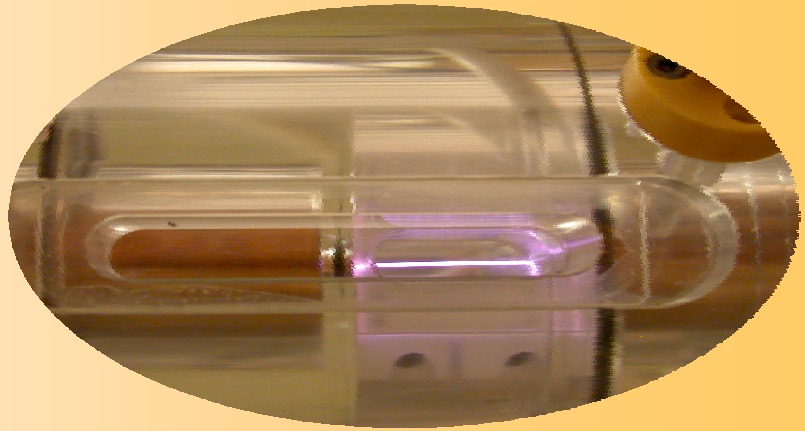
Next step: 1 GeV compact module
100 TW laser + plasma channel

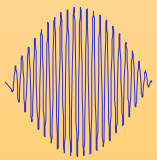
L'OASIS Laser technology



+

Plasma channel technology





Laser

100 TW, 40 fs
10 Hz

Plasma injector

< 3mm

Plasma channel

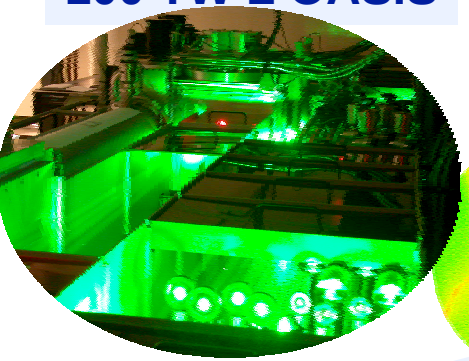
< 10 cm

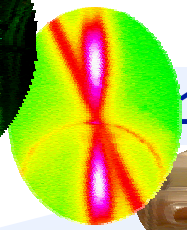
1.2 GeV

e- beam

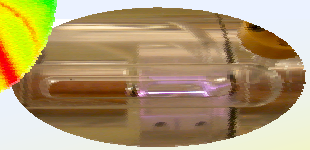
- High energy e-beams
- Femtosecond x-rays
- THz radiation
- Radio-isotopes

100 TW L'OASIS

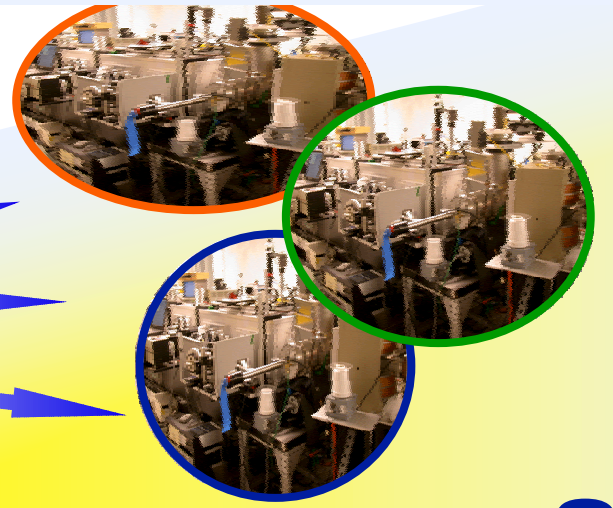




1 GeV Demo



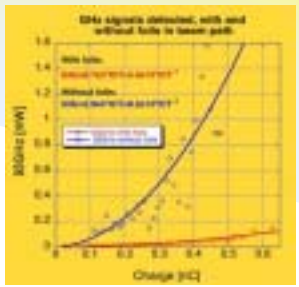
Multi-User Laser/Radiation Facility



2003

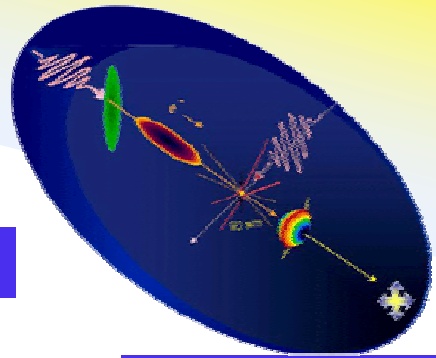
All Optical Accelerators

2009



Coherent T-rays

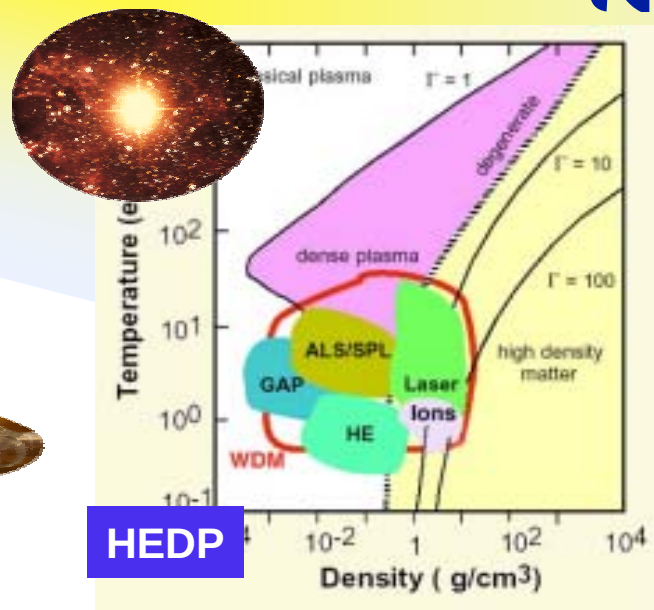
PRL 2003



fs hard X-rays

Science 1996

Multi-GeV beams



HEDP

BERKELEY LAB