بسم الله الرحمن الرحيم

السلام عليكم ورحمة الله وبركاته

New Energy Resources _ the Latest Achievements

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ABSTRACT

- Initiate unprecedented large experiments provided by high technological measuring equipments that are widely used in international laboratories.

- The study of the interaction of high density laser fields with matter is an important rapidly expanding branch of physics since the last five years. The potential applications of this research are numerous, not only in physics, but also in new energy resources, chemistry, biology, material science, in the fast ignition approach to fusion, in accelerators, for relativistic electrons and for Nuclear effects and charged ion acceleration.

- Since their starting steps in 2000, high density short pulse (HDSP) lasers have been developed to generate very short pulses with typical high performance parameters:

Agenda

- Oulinte of Basic Research to create new science & applications in Energy Production, Industrialization & Commercialization
- Abstract: Performance of HDSP Lasers, Created Conditions, nonlinearities, Interdisciplinary Fields & Innovation
- Introduction
- CPA Technique
- Advances in Laser Performance
- Suggested Innovation
- How Inertial Fusion Power Works
- Big High Density Science & Applications
- Conclusion
- Memorandum for Cooperation

OUTLINE: NEW DEVELOPENTS of HDS

- The study of the interaction of high density laser fields with matter is an important rapidly expanding branch of physics since the last five years.

- The potential applications of this research are numerous, not only in physics, but also in Chemistry, Biology, Material Science and in the:

- Fast Ignition Approach to Inertial Confinement Fusion as:

  - NEW ENERGY   SOURCES

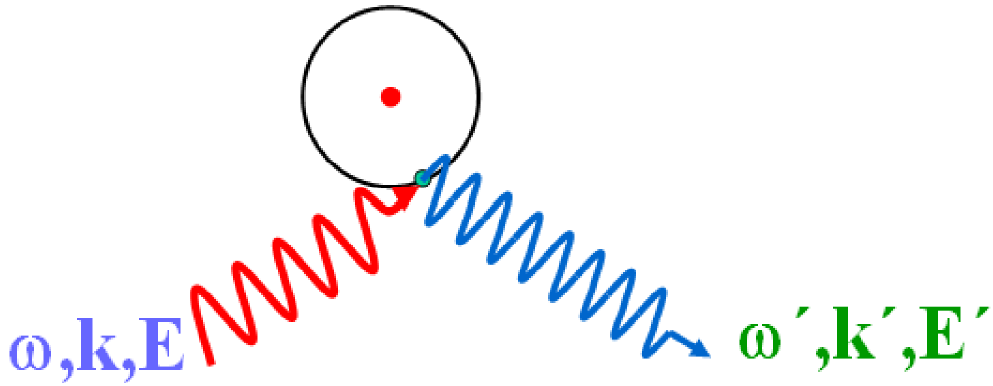
Performance Parameters of HDSP Lasers

Since their starting steps in 1985, high density short pulse (HDSP) lasers have been developed to generate very short pulses with typical high performance parameters:

- Peak Power up to ~ 1000 TW = PW
- Pulse Duration ~ less than 20 fs
- Pulse Energy ~ 2 Joules
- Rep. Rate ~ 10 Hz
- Wavelength ~ 800 nm

Light – Matter Interaction

Normally, Induced Dipole Reradiation
(electronic response)



1. Optical interactions depend on the
   Electric field in the light wave.

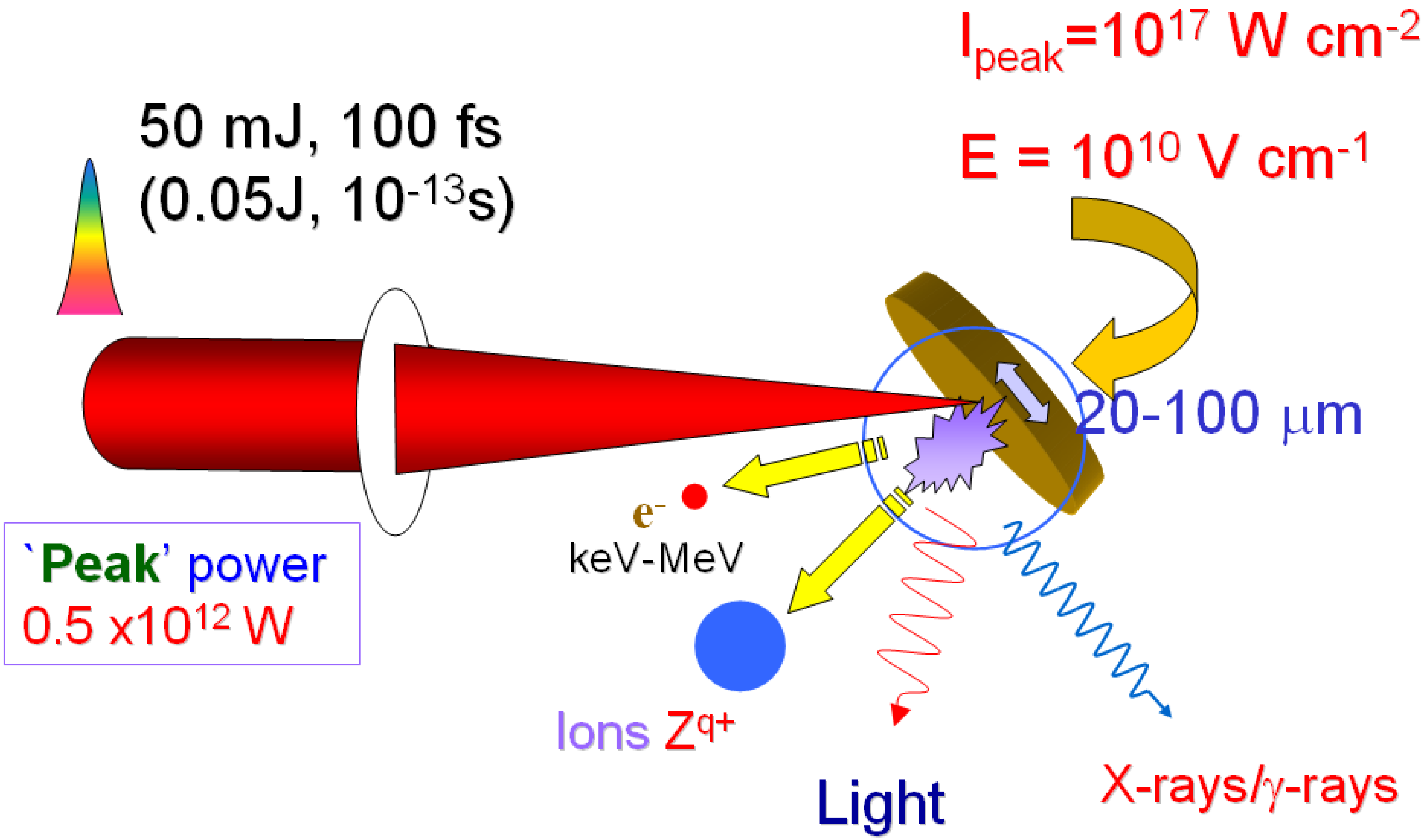
2. Valence/outer `bound' electrons that respond to this field.

   But,

3. Does this idea work when you go to high light Intensities?

NO!

What is this talk all about?



Light pulse - Spatial Packet (Length approx. 65 micrometers !)

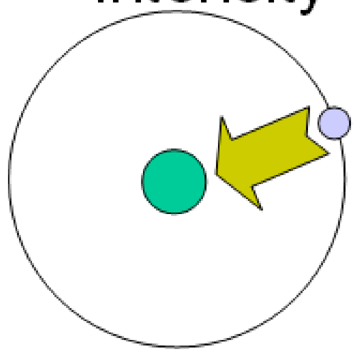
less than the breadth of human hair!

Intense Light Fields

Extremely large E fields generated
by short pulse, high energy lasers

Comparison with the intra-matter Coulomb field

Hydrogen atom - 1s electron
E ~ 10^9 V/cm → Intensity $I = 2\left(\frac{\varepsilon_0}{\mu_0}\right)^{1/2} |\mathbf{E}|^2 \cong 10^{16} W/cm^2$



Current Highest Intensity – 10^{21} W/ cm^2 !
(about 10^{12} V/cm)

Created Exotic Conditions

- When such photons are properly focused on a target, creation of simultaneous exotic conditions within an extremely short time are developed, which have never been achieved before in labs, namely:

- Intensities ~ 10^{20} Watts/cm2
- Electric field ~ 10^{11} Volts/cm
- Magnetic field ~ 10^{9} gauss
- Temperature ~ 10^{10} K (10 eV)
- Pressure ~ 10^{9} bars
- Acceleration ~ 10^{26} cm/s2

Physics In ULTRA-INTENSE Light Fields

Matter totally ionized → Large charge densities (> 10^{24} cm^{-3})

→ Energetic electrons (10^3 - 10^6 eV)

Sun

Nonequilibrium dynamics - violently driven systems

→ Non-Maxwellian particle distributions

Gigantic magnitudes	
Magnetic fields 10^9 G	Electric field 10^{10} V cm^{-1}
Pressure 10^9 bars	Temperature 10^8 K (for e^-)

neutron star

Relativistic and QED effects

multiphoton Compton scattering, pair production

Nuclear excitation and fusion

Nonlinerities

- These conditions would definitely initiate severe nonlinearities. Matter exposed to these extreme conditions behaves in ways that produce new insight to the fundamental phenomena from condensed matter studies to nuclear physics, high energy physics, astrophysics, etc...

- This means NEW SCIENCE DOMAIN which one can call High Density Science (HDS).

Breakthroughs

- In this study we shall summarize the breakthroughs achieved by some researchers exploring novel uses of the existing HDSP lasers.
- We shall also point out important innovative projects that are expected to raise the Scientific Research Capabilities in EGYPT specifically CAIRO UNIVERSITY

Introduction

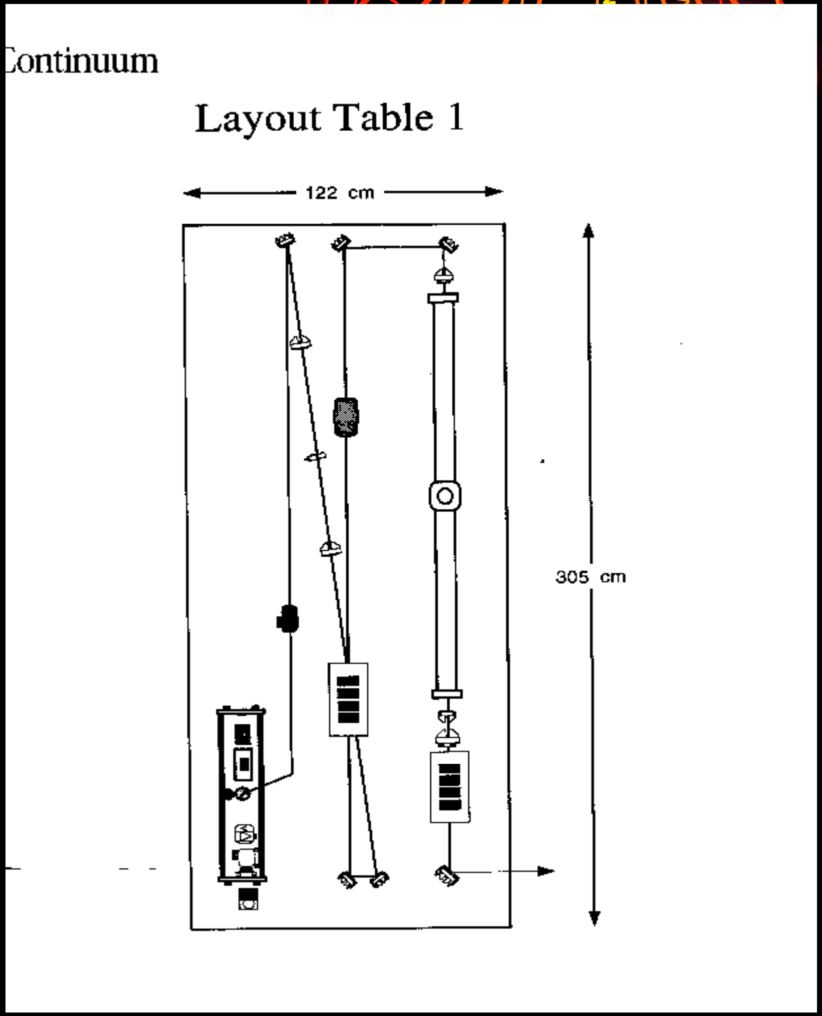
- Facilities around the

The Existing Facilities at IC-SAS

Picosecond Silicate glass laser

- Oscillator CW mode-locked Nd:YAG Laser. 120ps, E 1 micro J

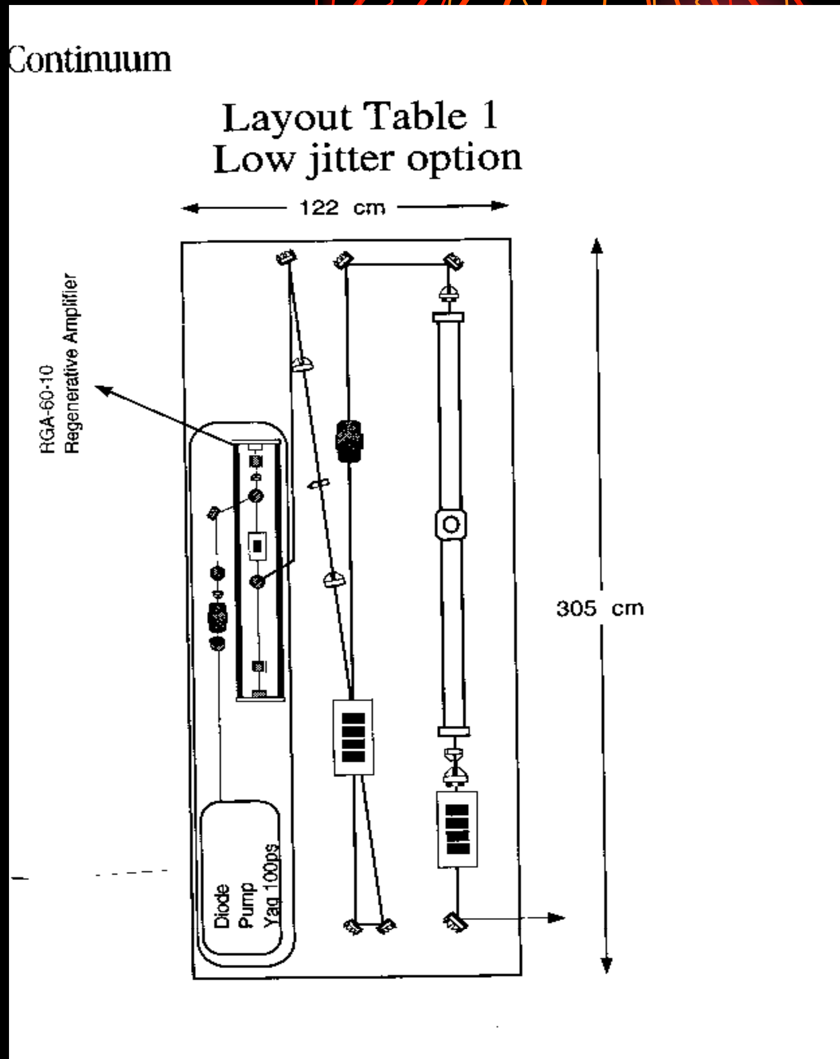
- Output 25 mm beam 120ps E 1 J



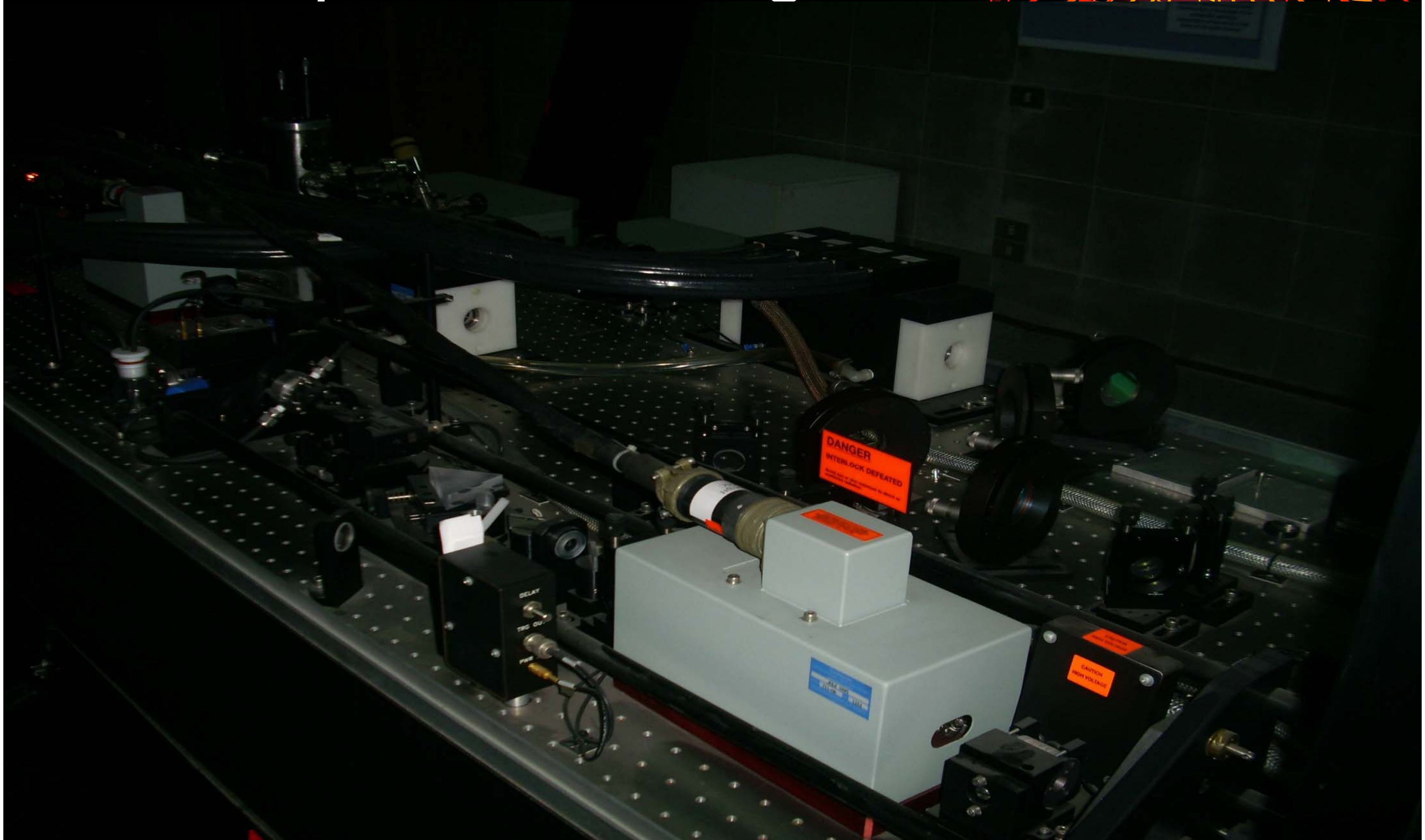
The Existing Facilities at IC-SAS

Additions

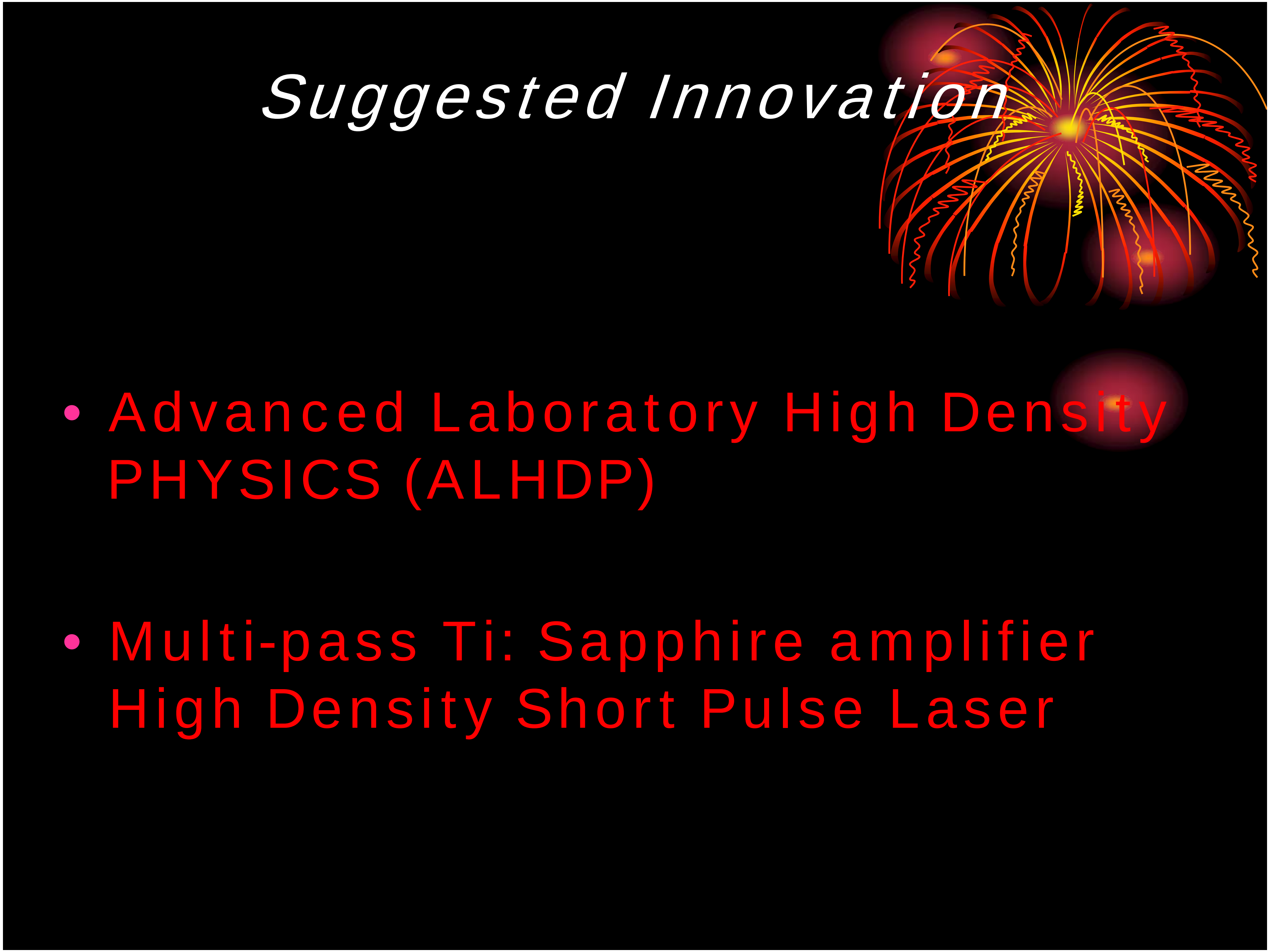
- Oscillator CW mode-locked Nd:YAG Laser. 120ps, E 1 micro J
- Regenerative amplifier E 50 mJ at 10 Hz
- Double path configuration E 400 mJ
- Output 25 mm beam 120ps E 2 J



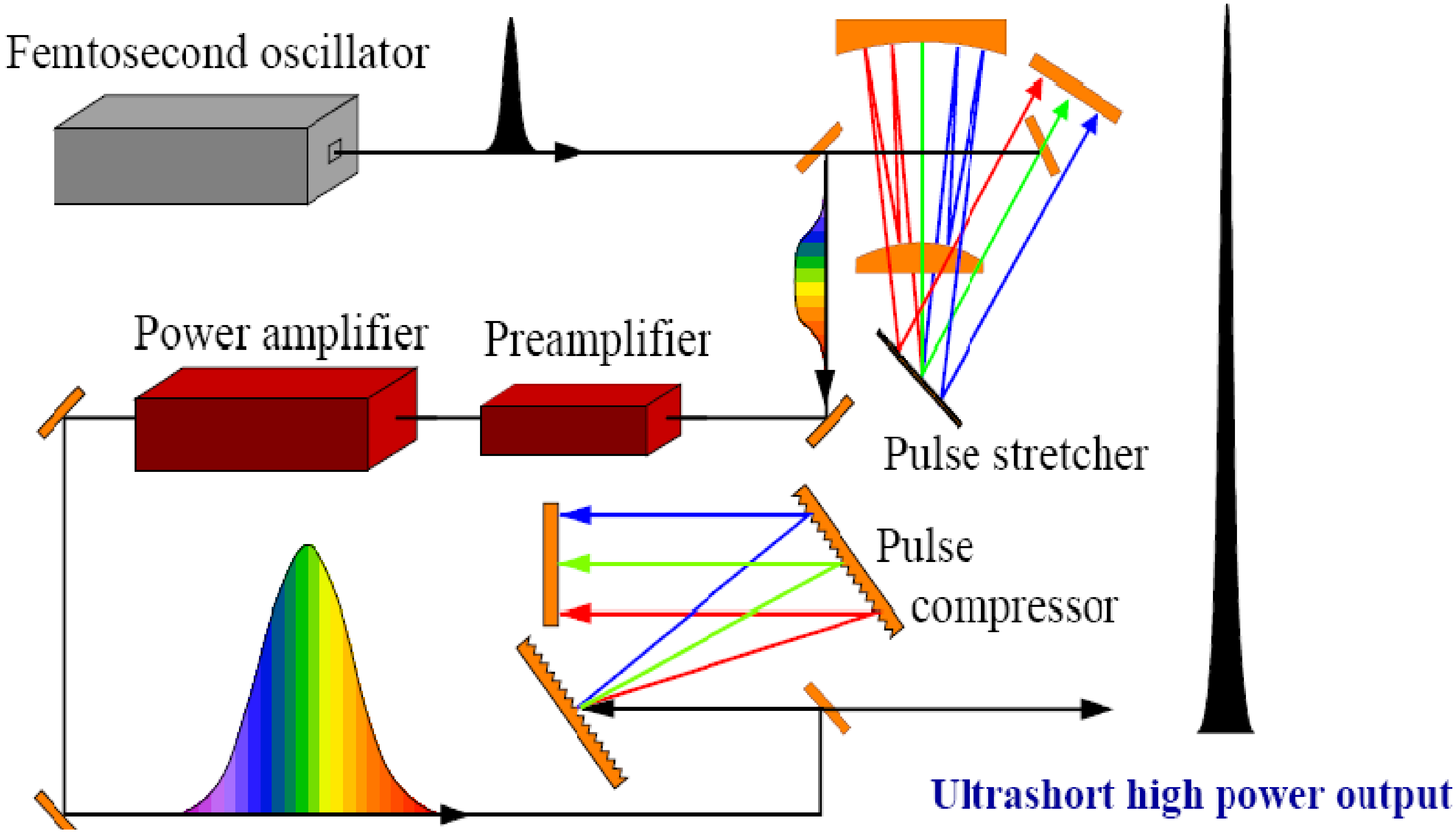
120 ps / 2J Nd glass Laser



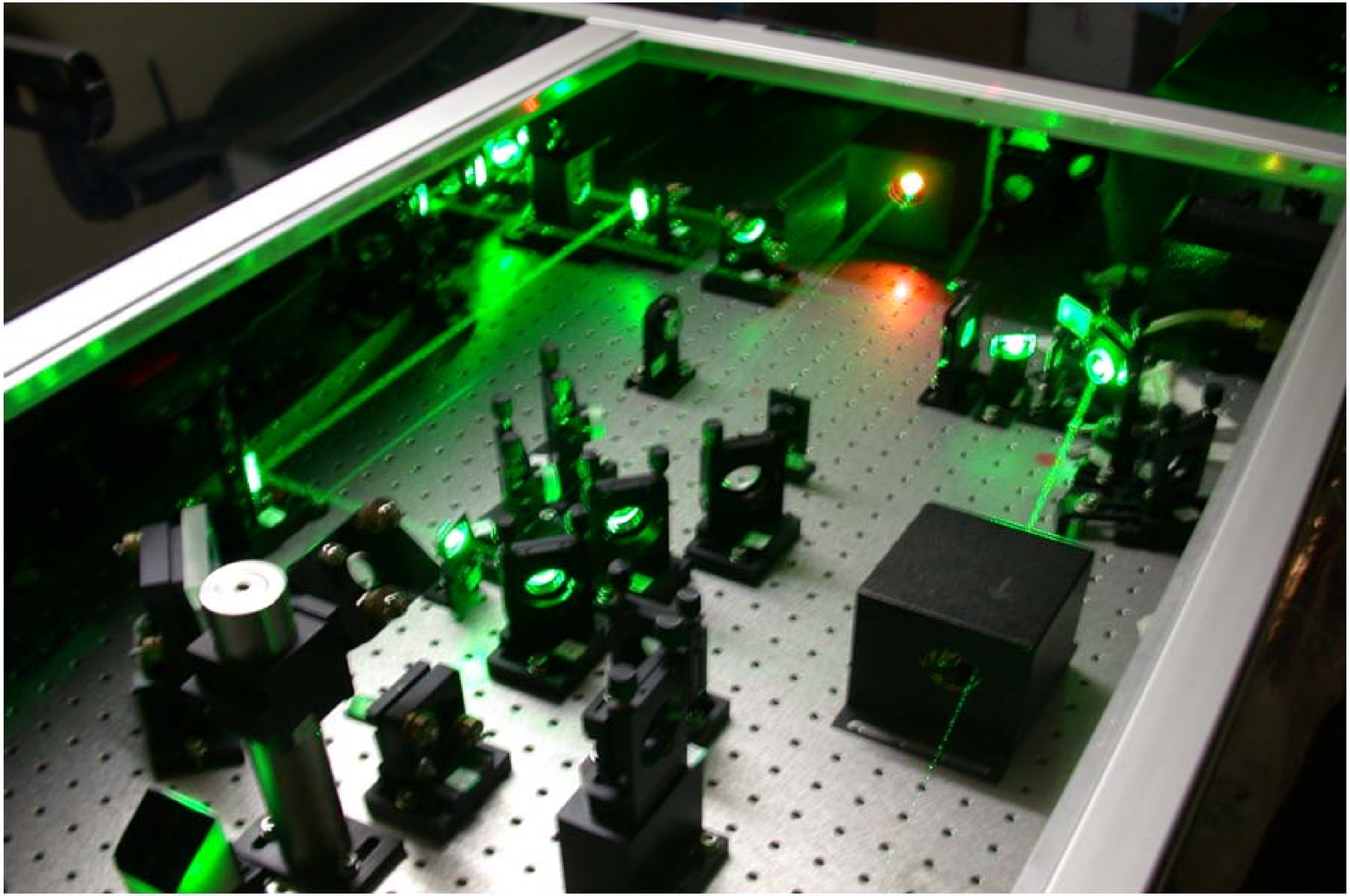
Target chamber inside view


Suggested Innovation
• Advanced Laboratory High Density PHYSICS (ALHDP)
• Multi-pass Ti: Sapphire amplifier High Density Short Pulse Laser

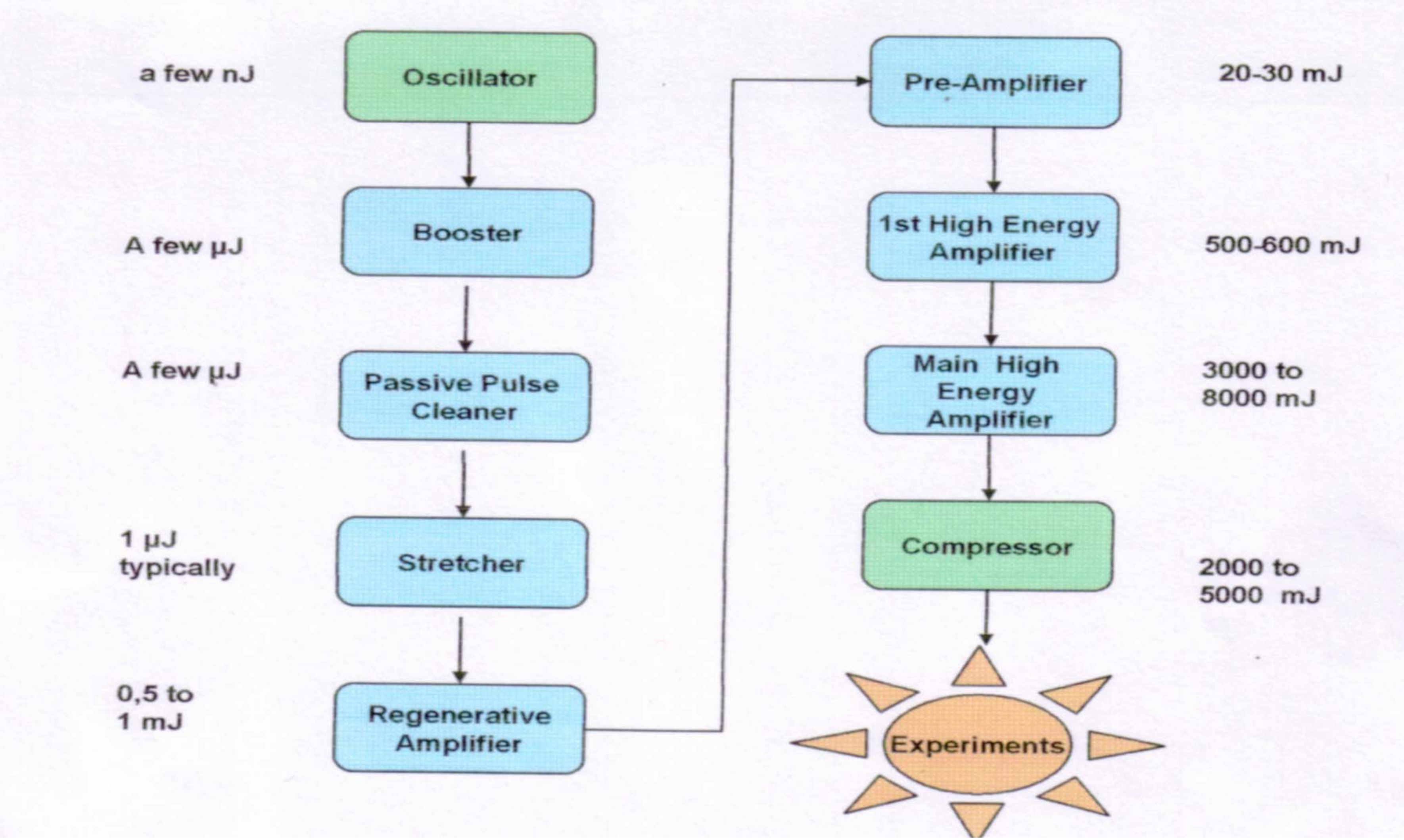
Chirped Pulse Amplification CPA



A glance at the laser …



Multi-pass Ti:Saphire amplifier HDSP



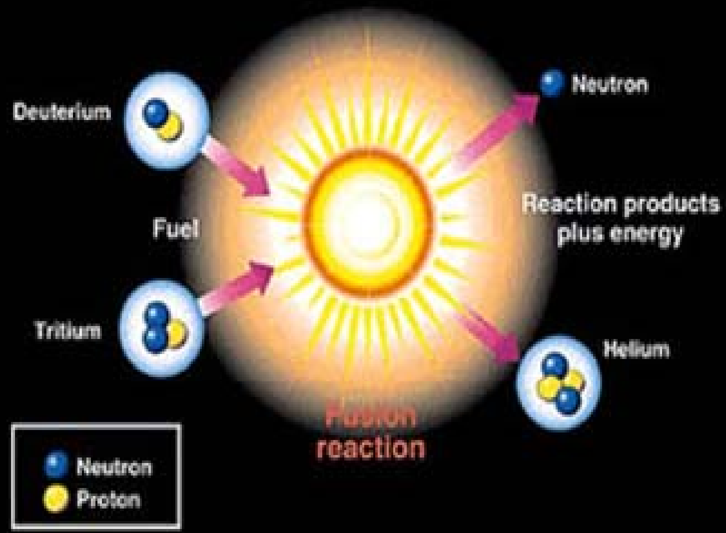
Injection demonstration at GA to simulate the full length of a LIFE fueling system have demonstrated many objectives

- Injection at 6 Hz (burst mode) 400 m/sec to 200 µm demonstrated
- Additional R&D needed for Cryogenic targets and >10 Hz

I-Fusion Fuels, the heavy isotopes of H (D & T)

- Are derived from water and the metal lithium, a relatively abundant resource.
- The fuels are virtually inexhaustible – one in every 6,500 atoms on Earth is a deuterium atom – and they are available worldwide.
- One gallon of seawater would provide the equivalent energy of 300 gallons of gasoline; fuel from 50 cups of water contains the energy equivalent of two tons of coal.
- A fusion power plant would produce no climate-changing gases, as well as considerably lower amounts and less environmentally harmful radioactive byproducts than current nuclear power plants.
- And there would be no danger of a runaway reaction or core meltdown in a fusion power plant

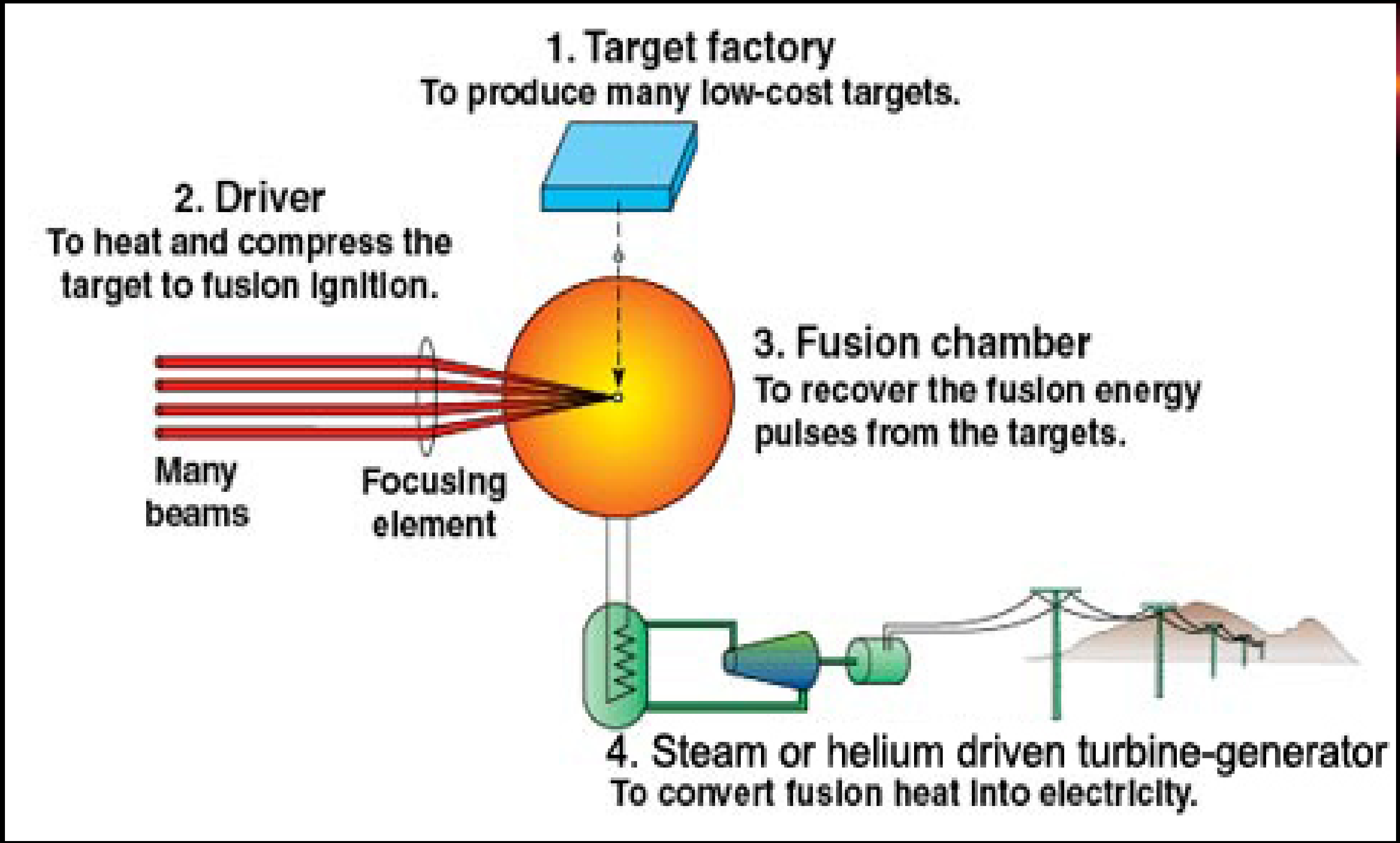
II-Fusion Fuels, the heavy isotopes of H (D & T)



- NIF is designed to produce fusion burn and energy gain using a technique known as inertial confinement fusion (How to Make a Sun)
- NIF's intense laser beams, focused into a tiny gold cylinder called a holhlraum, will generate a "bath" of soft X-rays that will compress a tiny hollow shell filled with deuterium and tritium to 100 times the density of lead.
- In the resulting conditions – a temperature of more than 100 million degrees Celsius and pressures 100 billion times the Earth's atmosphere – the fuel core will ignite and thermonuclear burn will quickly spread through the compressed fuel, releasing ten to 100 times more energy than the amount deposited by the laser beams.

I-How Inertial Fusion Energy Work

- An inertial fusion energy (IFE) power plant consists of a target production facility (or target factory): 1-target injection and tracking systems,2- the laser,3- a fusion chamber, and 4- a power conversion system.



II-How Inertial Fusion Energy Work

- In the plant, many pulses of fusion energy per second (typically 10–20) would heat a low-activation coolant, such as lithium-bearing liquid metals or molten salts, surrounding the fusion targets.

- The coolant in turn would transfer the fusion heat to a turbine and generator to produce electricity.

- A NIF-scale laser operating at this repetition rate would produce over 1000 MW of electricity to the grid—enough to power a city the size of San Francisco.

Advanced Accelerator research in Israel

Electron Acceleration using Intense Lasers in Plasma

Arie Zigler

Hebrew Univ., Jerusalem

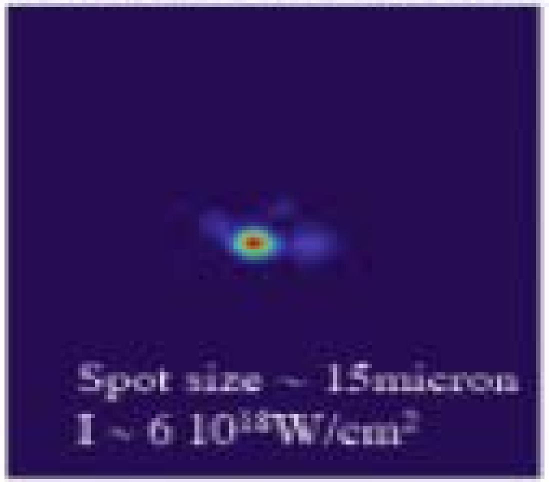
Electron Acceleration with Intense Lasers in Vacuum

Levi Schächter

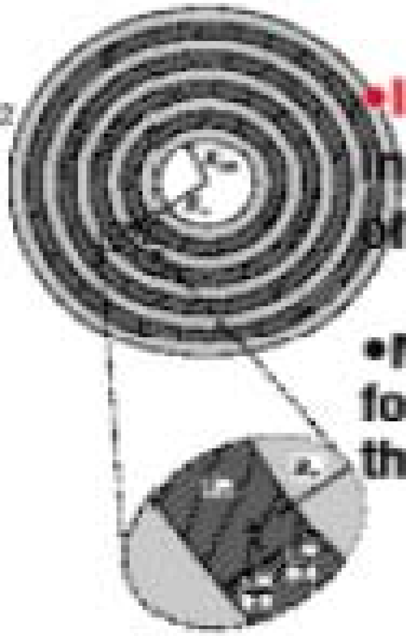
Technion-IIT, Haifa

- Plasma channels based on capillary discharge

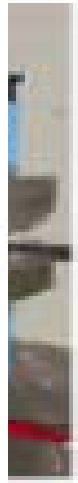
Optical guiding - guiding up to **6 cm** (hundreds of Rayleigh lengths) and laser intensities in range of 10^{18} W/cm^2



Optical Bragg Accelerator



- Interaction impedance in a Bragg structure of the order of **2000Ω**.
- Maximum surface field for 1GV/m gradient of the order of 2GV/m



How to Proceed

- Looking deep into the ongoing research fields worldwide, one could easily simulate them as s
- E
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Scientific Community

Coordination Mechanisms should be strengthened by:

- Stronger unity & sense of identifying science leaders
- Enhance meetings & workshops
- Create programs through which international cooperative activities could exist
- Understand the needs & concerns of researchers
- Implement new lines of research

- Attract more students to work and stay in the field

TENTATIVE PROJECTS

INVESTIGATING TARGET HOT SURFACE LAYERS formation using HDSP laser due to high pressure shock waves.

EXPLORATION EFFORTS to understand the energy transport physics and to clarify the merits of a FI / IFE power related to target design.

PHOTONICS AND NANOTECHNOLOGY experimental studies of surface nanostructure of silicon, titanium...etc by ablation with HDSP laser pulses in liquids.

POSSIBLE HDSP LASER EXPERIMENTS that will help in understanding exotic astrophysical events. These experiments include hydrodynamic studies of shocks generated by the short laser pulse, studies relevant to the study of supernovae dynamics and the structure of the interstellar medium

NUCLEAR REACTIONS & the PRODUCTION of ISOTOPES USING HDSP LASER (e.g.${}_{5}$Li, ${}_{7}$Be, 11C, 13N, 15O, 18F.........) positron emitters

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Memorandum for Cooperation

- *Implement Egyptian & International Research Action in HDS*
- *Decide Main Objectives*
- *Estimate Economic Dimensions*
- *Adopt cooperation with Int. countries*
- *Lay down capacity building projects*

IDEAL conditions for International and Local experts to cooperate and initiate new science and encourage young scientists to join HDS (Future Energy)

THANK YOU

Questions ?