Sept. 5, 2011

IZEST

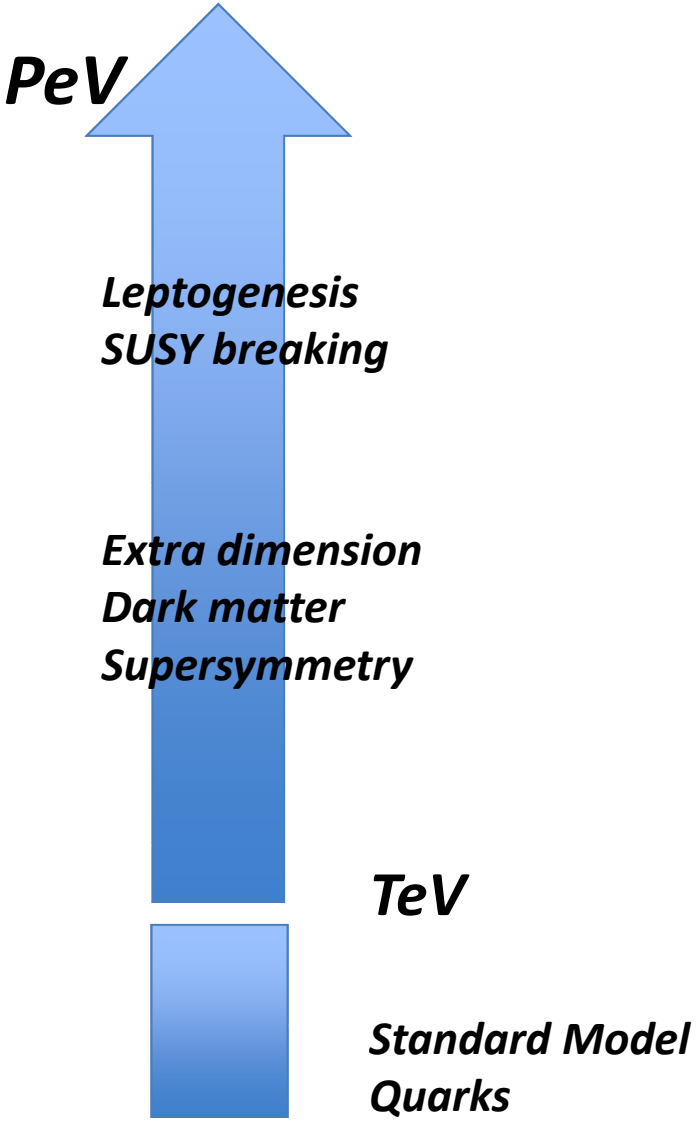
International Center for Zetta-Exawatt Science and Technology

Toshiki Tajima and Gerard Mourou
IZEST

IZEST's Mission: Responding to Suzuki's Challenge

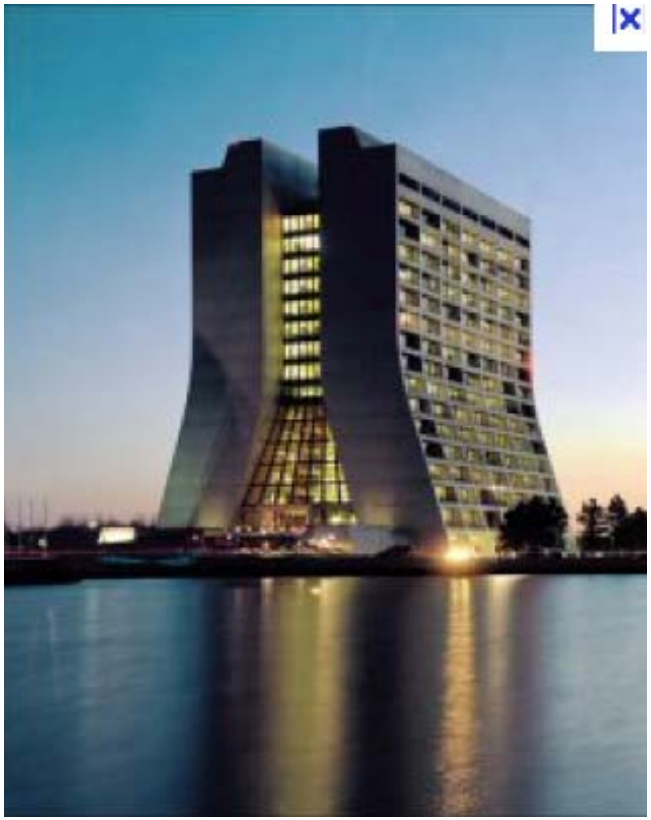
Atsuto Suzuki:
KEK Director General,
ICFA Chair

New Paradigm



IZEST High Energy Physics Supporters:

Young-Kee Kim
Fermilab Deputy Director



Fermilab

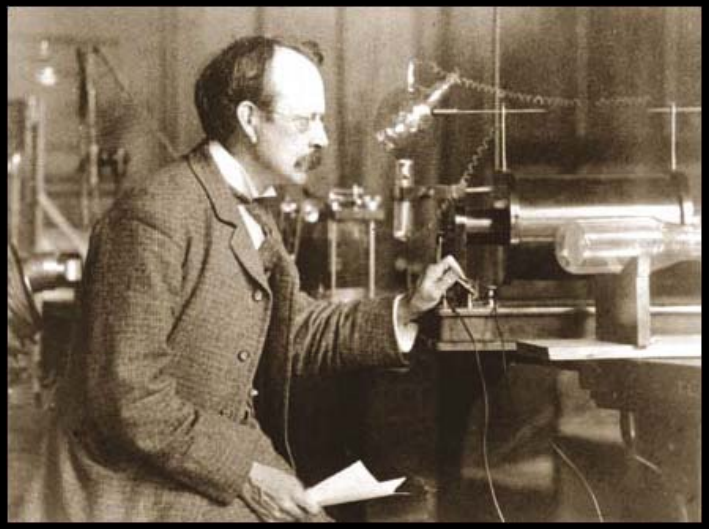
IZEST High Energy Physics Supporters

(The list is growing)

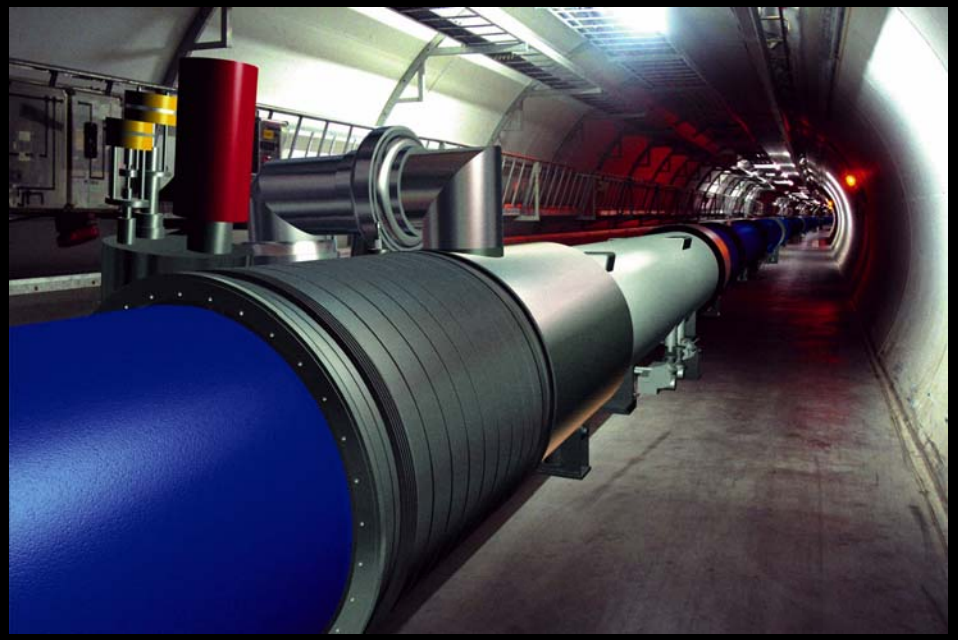
1. KEK
2. Fermilab
3. CERN(to be confirmed)
4. DESY(to be confirmed)
5. John Adams Institute
6. Heisenberg Institute (to be confirmed)
7. QuBS Kansai JAEA
8. Princeton University
9. Russia

XCELS (Russia)

20th Century, the Electron Century
Basic Research Dominated by
Massive and Charged Particles



J.J. Thompson



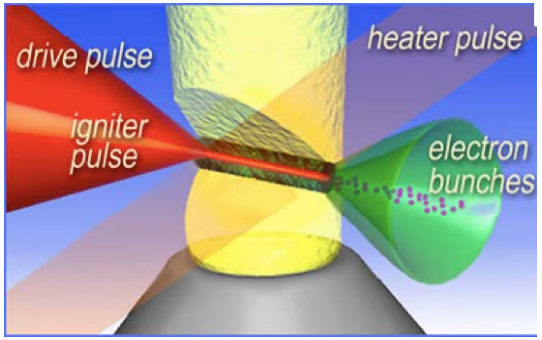
21st Century; the Photon Century
Could basic research be driven
by the massless and chargeless particles;
Photons?

C. Townes

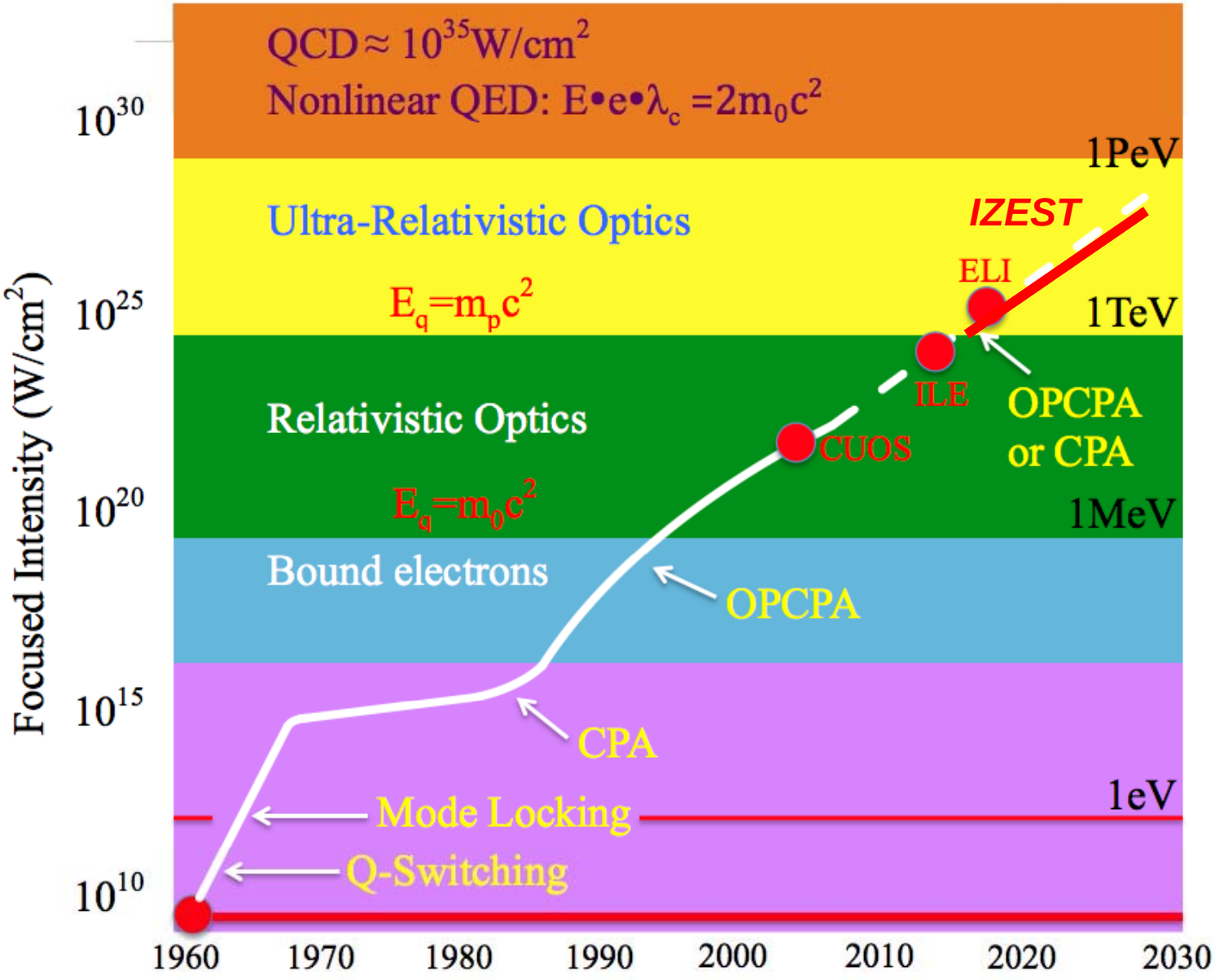
PeV Accelerator

With conventional Technology
The accelerator would Girdle the Earth:
Fermi's vision (1954)

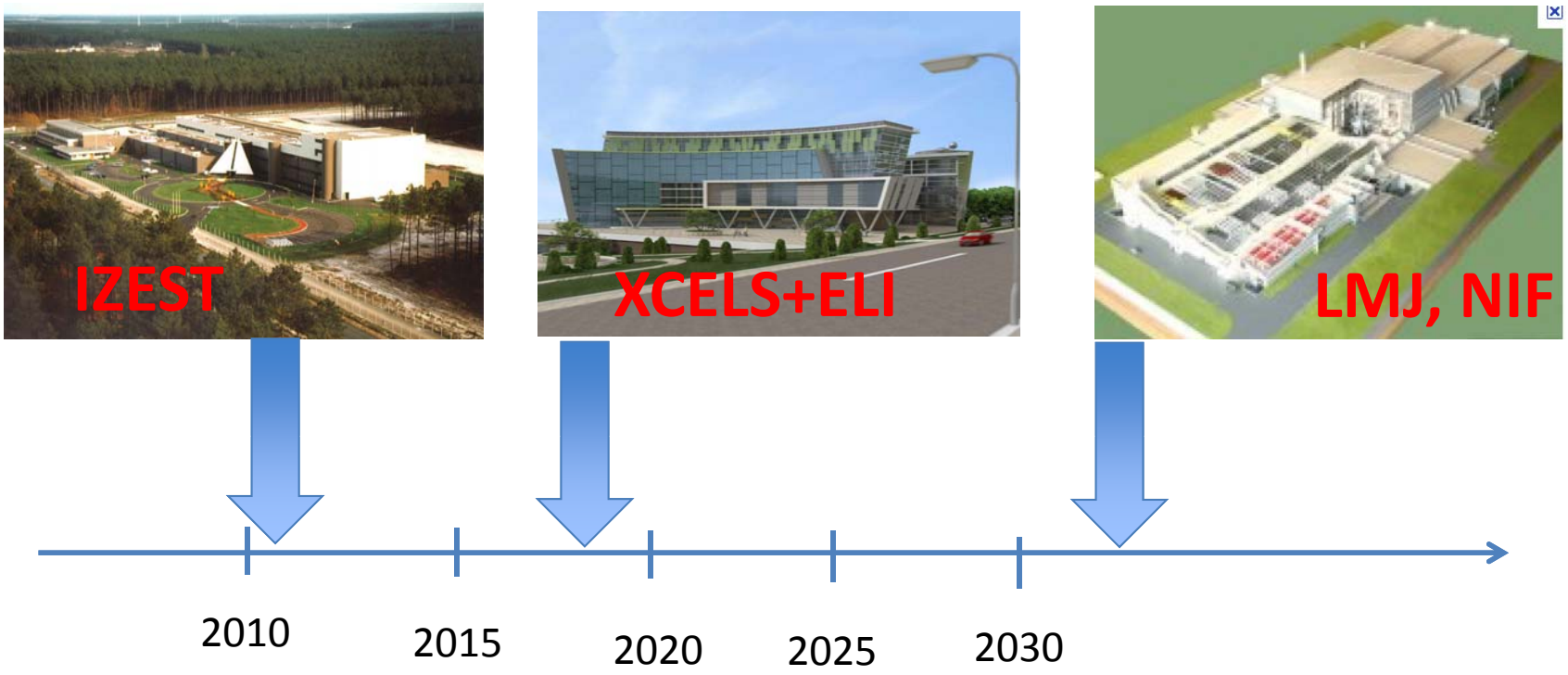
1km laser Plasma accelerator
with LIL or LMJ
(Vision 2011)



Laser Intensity vs. Years



Laser-Based High Energy and Fundamental Physics: *Exawatt to Zettawatt*



IZEST: Next Actions

1. Increase the IZEST membership around the world
2. Need to secure commitments from members: legal and administrative aspects as well as science/technology
3. Organize/staff the team:
    1. On laser: work on C^3, with the High intensity community
    2. Scheduling LIL (relatively near horizon ~ 10 years)
    3. Theory
    4. Experiments
    5. ICAN
4. Organize workshops:
    a. *Launching Workshop* (Nov. 28-29, 2011), Paris
    b. *Innovation Forum* at Brussels (Dec. 5, 2011): 'From electronic to photonic paradigm in high energy and fundamental physics'

IZEST
Launching Workshop:
Laser-based High Field Fundamental Physics
Preparing for the future

28-29 November, 2011

Ministery of Research, Auditorium Gay-Lussac, Paris

Fundamental High Energy Physics has been mainly driven by the high energy fermionic colliding beam paradigm. Today the possibility to amplify laser to extreme energy and peak power offers, in addition of possibly more compact and cheaper way to help HEP, a complementary new alternative underpinned by single shot, large field laser pulse, that together we could call High Field Fundamental Physics. The main mission of the International center on Zetta-Exawatt Science and Technology (IZEST) is to muster the scientific community behind this new concept. As an example, we project to use the laser field to probe the nonlinearity of vacuum due to nonlineairities and light-mass weak coupling fields such as Heisenberg-Euler QED, dark matter and dark energy. The advancement of intense short-pulsed laser energy by 2-3 orders of magnitude empowers us a tremendous potential of unprecedented discoveries. These include: TeV physics, new light-mass weak-coupling field discovery potential, nonlinear QED and QCD fields, radiation physics in the vicinity of the Schwinger field, and zeptosecond dynamical spectroscopy of vacuum.

Today, a number of exawatt class facilities in Europe and in the world are already in the planning stage, like the ELI-Fourth Pillar, French LIL, and the Russian Mega Science Laser as well as Japanese Exawatt Laser. IZEST should serve as a common platform opened to the international scientific community with a passion for this emerging opportunies and the desire to be engaged. Ist headquarter will be located at the Ecole Polytechnique, the center of ist theoretical facility. The experimental programs will be performed on the most powerful european laser, the LIL laser at the CEA-CESTA in Bordeaux. It is expected that a large part of the work will also be carried out in the IZEST-associated laboratories around the world.

November 28-29, 2011 at the Ministery of Research, Paris V, we intend to hold a three-day workshop with the participation of the main players to first review the role of high field in fundamental physics and to examine the new technology that needs to be brought to bear to accomplish the above mission. Second as one of the main objectives, we will establish a joint strategy, put together coordination groups, and provide recommendation for the facilities in the planning stage.

Among the main topics that will be discussed include:

Exawatt and Zettawatt laser technology
TeV physics
Nonlinear effects in Vacuum
Dark energy and dark matter
Radiation near the Schwinger field
Other fundamental physics issued addressable by extreme high fields

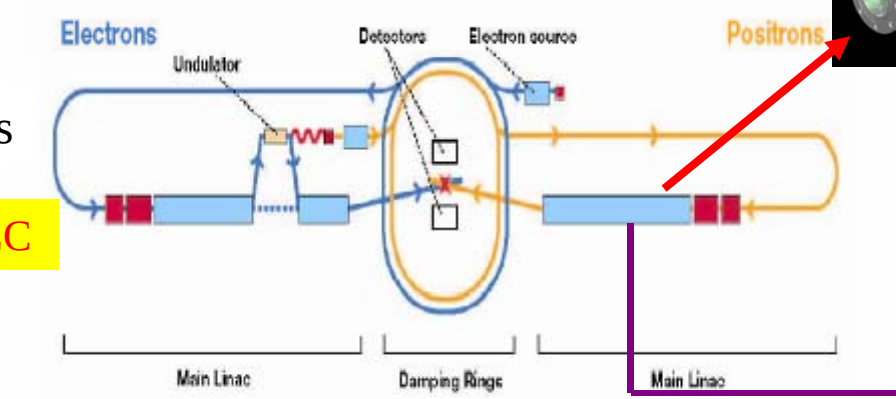
Accelerator

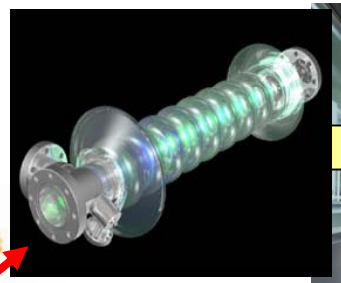
Evolution of Accelerators and their Possibilities （Suzuki,2008)

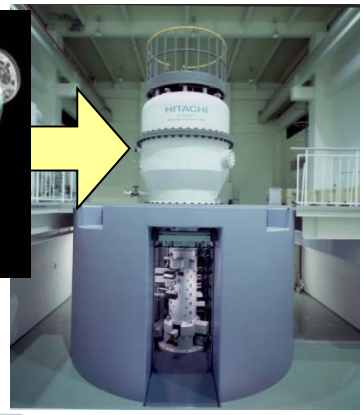
E=40 MV/m

2020s

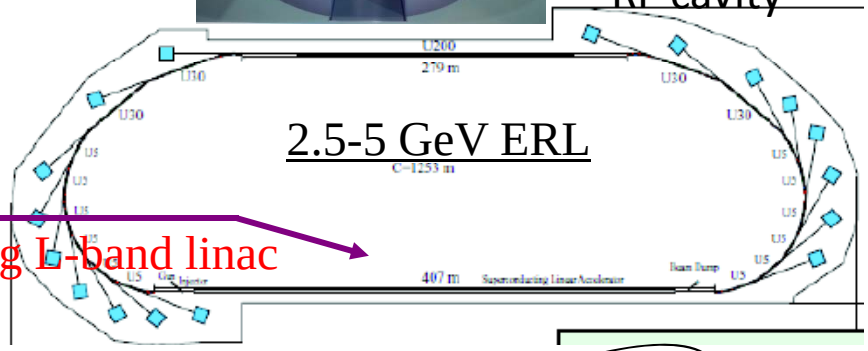
ILC







Ultra-High Voltage STEM with Superconducting RF cavity



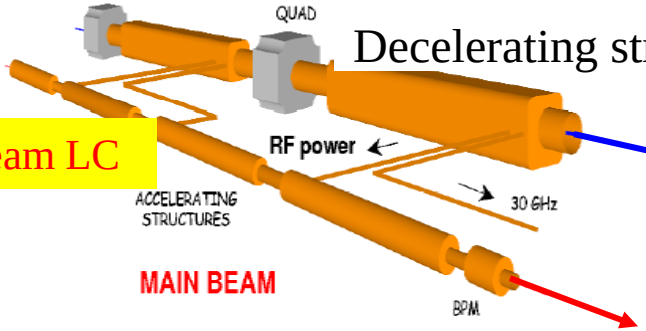
Superconducting L-band linac

E=200 MV/m

DRIVE BEAM

2030s

Two-beam LC



Decelerating structure

Earth-based space debris radar

E=10 GV/m

10cm-10GeV Plasma Channel Accelerator

2040s

Laser-plasma LC

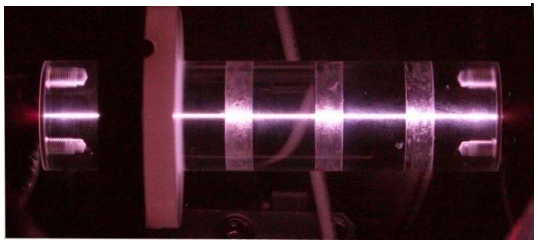


Table-top high energy accelerator

09/3/9

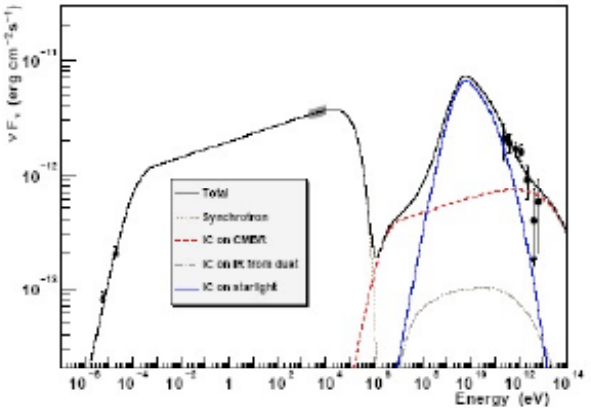
LIL Timeline: Laser Experiments

Year	Energy	Pulse duration/Intensity	High Energy Experiments
20111/2012-	10kJ	2ns 5 10^12W 1 0^20W/cm2	**No Compression** ***Search for Dark Matter and Energy***
2012-	10kJ	50ps 2 10^14W 2 10^22W/cm2	**Compression In Air** ***Search for Dark Matter and Energy***
2013-	15kJ	1ps 10^16 W 10^24W/cm2	Compression in Air 10-6 ***PoP TeV electron***
2014-	10kJ	10-100fs 10^17-10^18 10^25-10^26W/c	**C3 Demonstration**
2015-	5kJ-40kJ	10-100fs	Full compression ***Vacuum Structure***
			PoP TeV proton
			Preliminary, currently under review of CEA

New Physics

Short Term Goals with non-collider paradigm(within 10 years)

- Search for Dark Matter, and Dark Energy with intense lasers
- Generation of TeV gammas for astrophysics radiation signatures/applications
- Lorentz invariance test



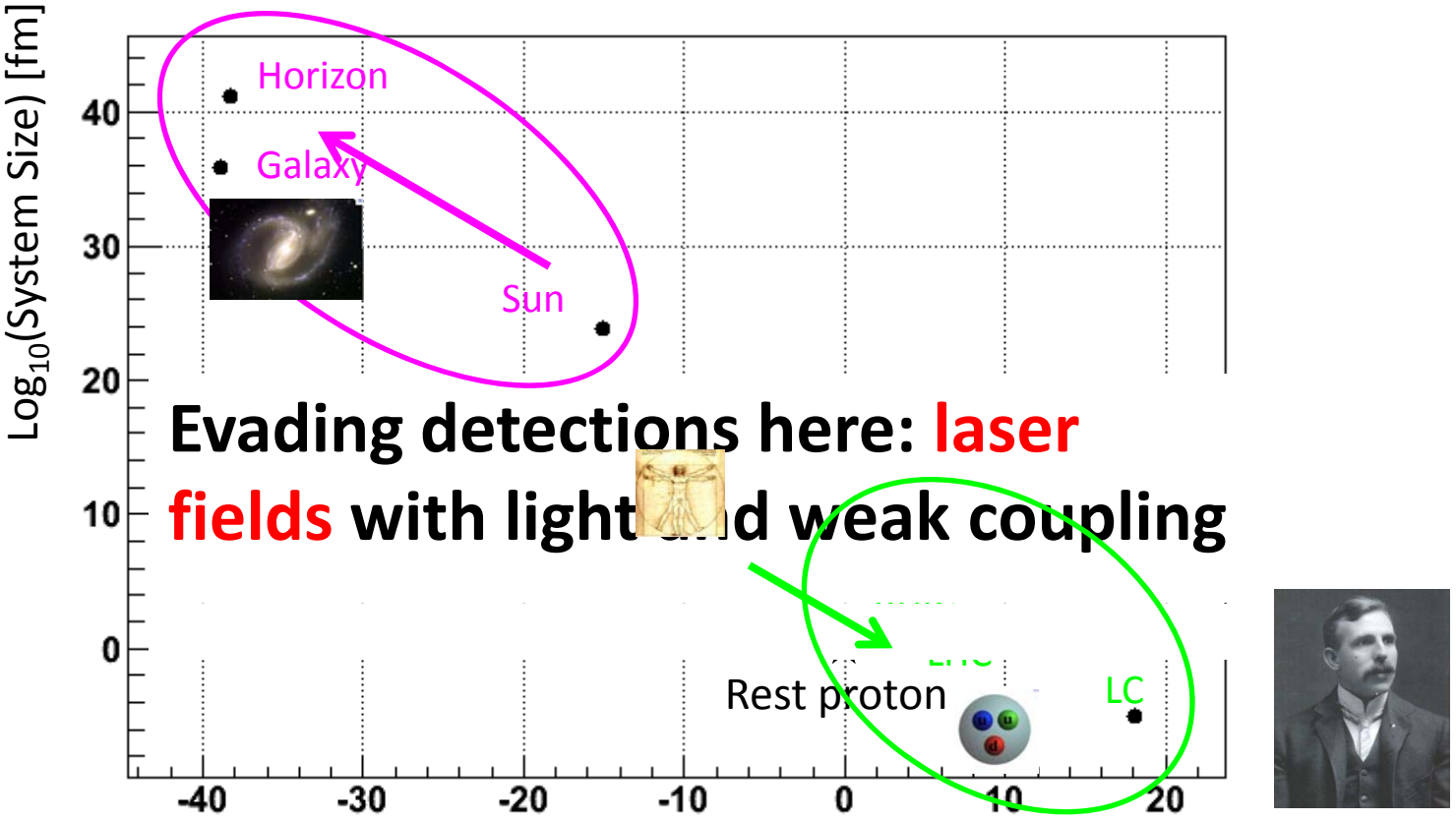
(Teshima, HI)

Laser fits the gaping hole

in search of unknown fields:
dark matter/dark energy

Cosmological observation

Weak coupling
m=0



Evading detections here: laser fields with light and weak coupling

Domains of physical laws

Strong coupling
Heavy m

High energy collider

Homma, Habs, Tajima (2011)

New Scientific Regimes Call for New Technologies

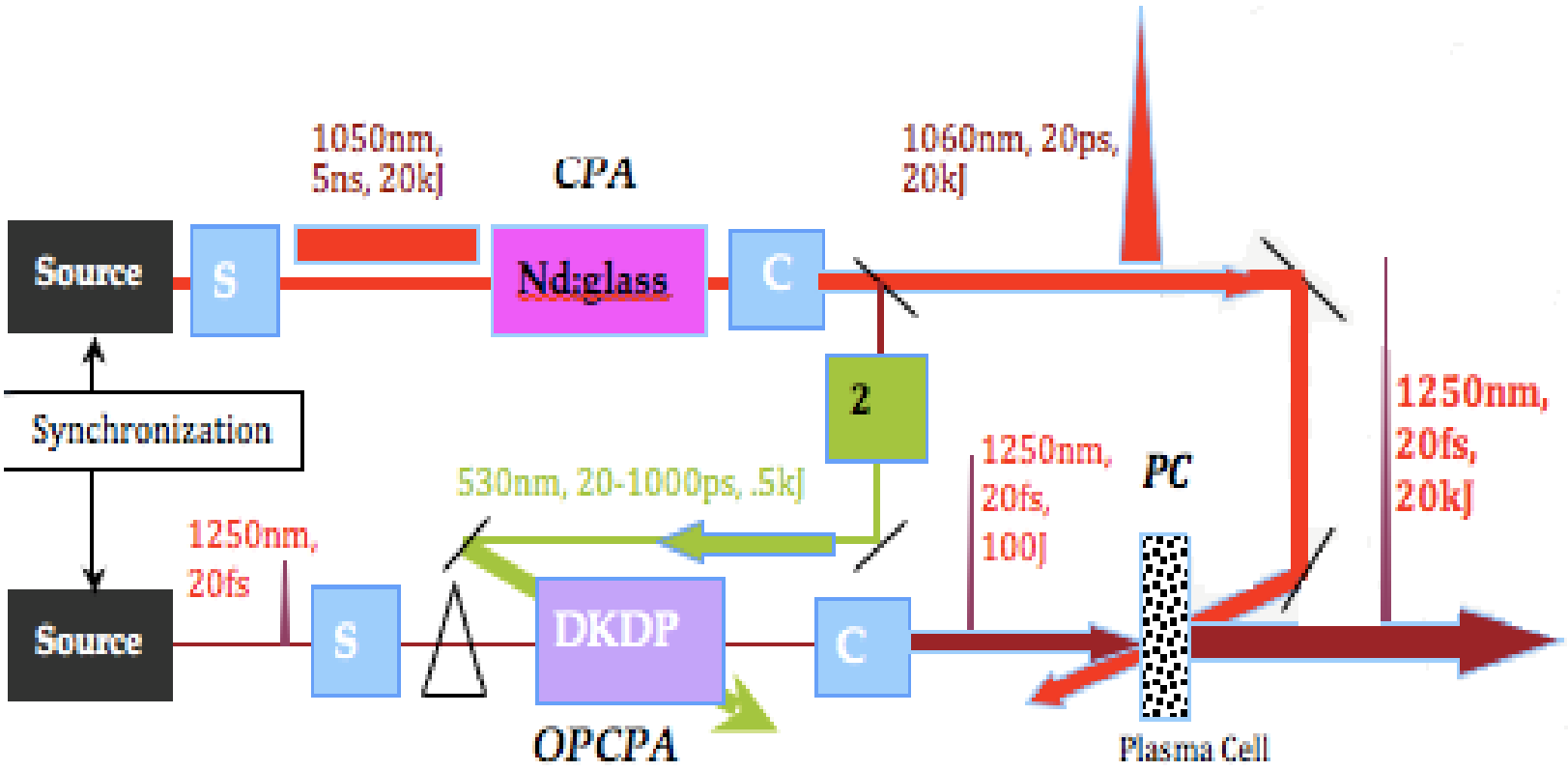
(Non recurrent)

- Exawatt-Zetawatt laser, **Concept C^3** ,where 10-1000kJ could be compressed in femto second pulses.
  - C^3 results from the cascaded actions of the three basic techniques, CPA, OPCPA and Plasma compression.

- Development of new optical elements working at kJ/cm^2 level: **plama optics**.

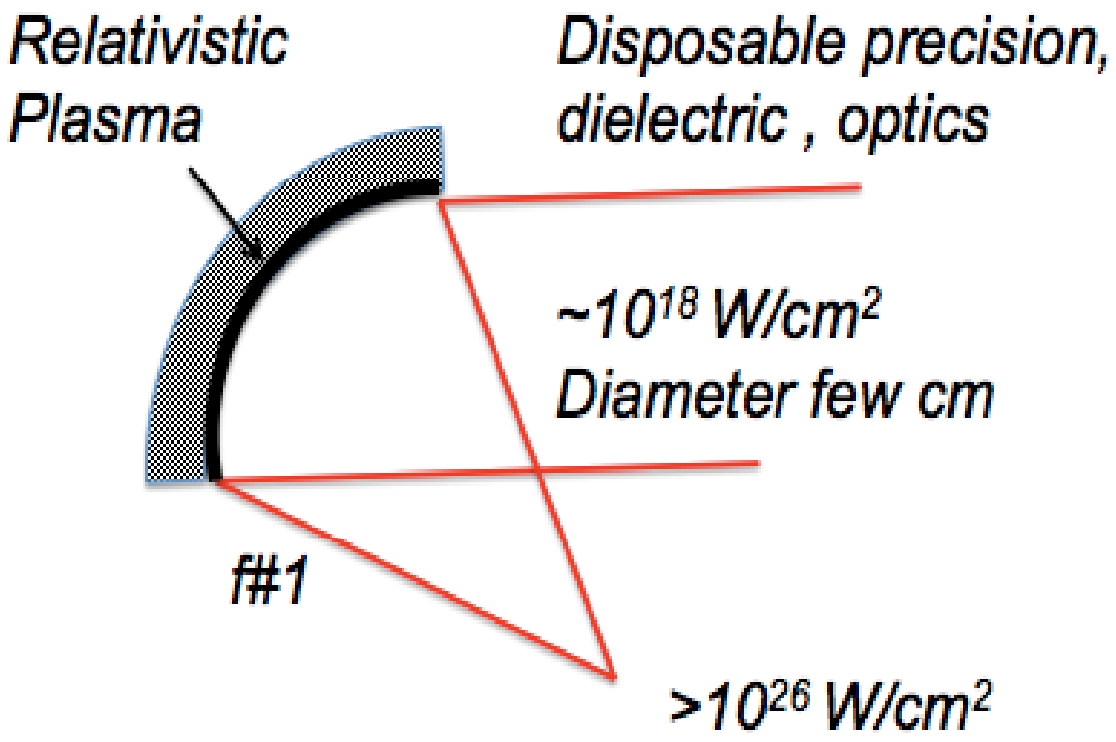
New Laser Concept: C^3

(Cascaded Compression Conversion)

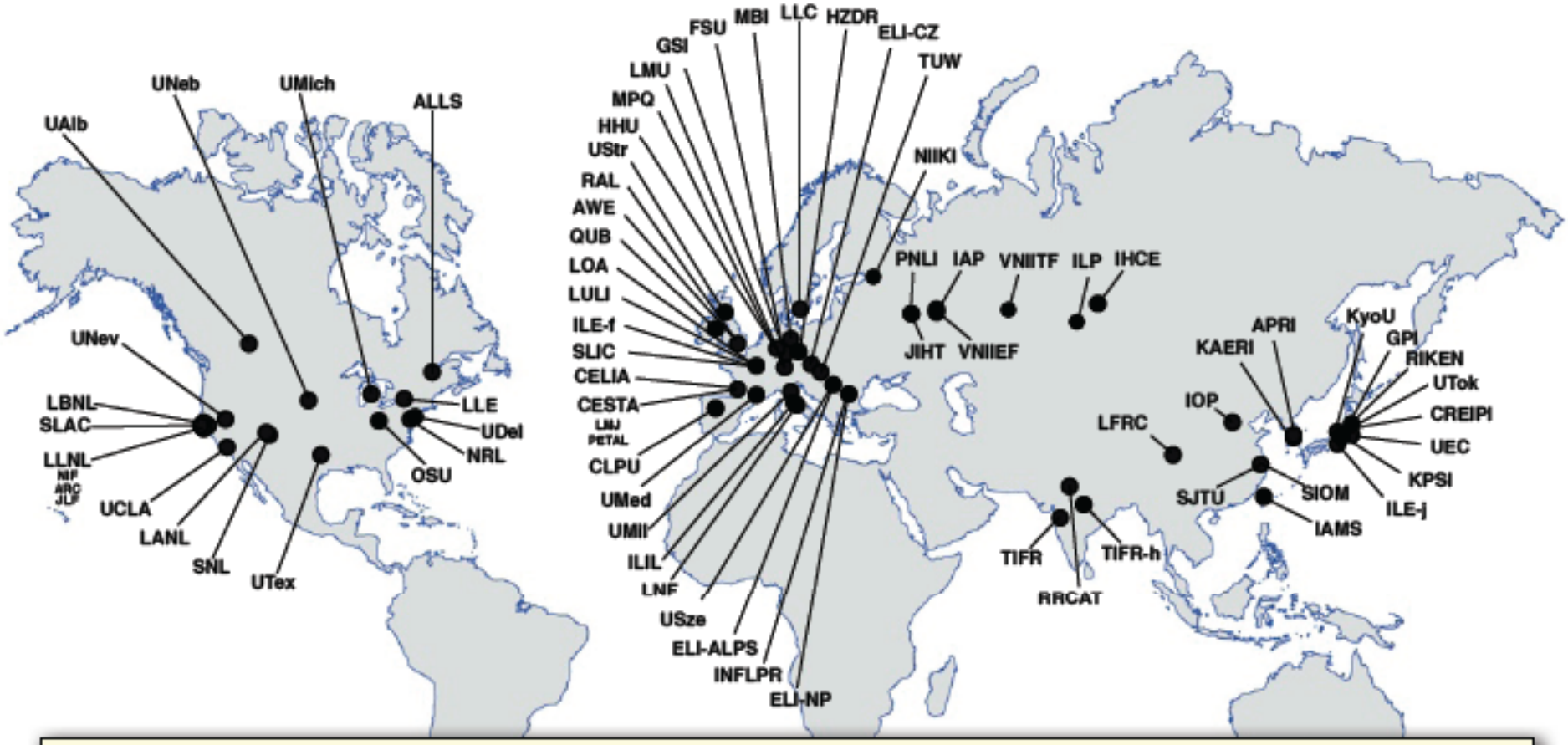


Plasma Optics

C³ *results from the cascaded actions of the three basic techniques, CPA, OPCPA and Plasma Compression(PC). This type of optics can handle several kJ/cm2. It leads to a size reduction of a 1000times in area. It must be disposed after each shot.*



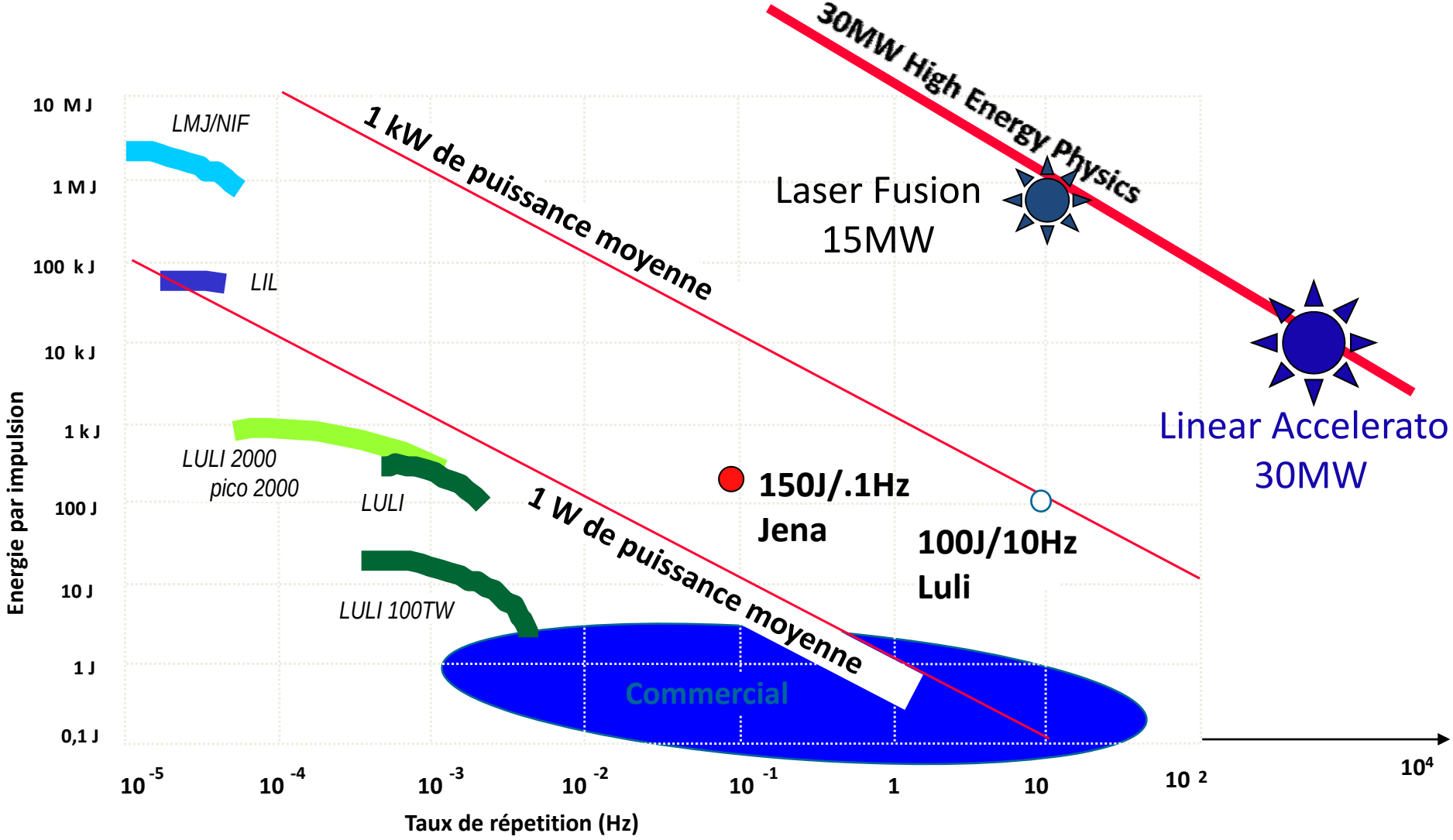
2010 ICUIL World Map of Ultrahigh Intensity Laser Capabilities
IZEST Constituency resides in UHI community



- the total peak power of all the CPA systems operating today is ~11.5 PW
- by the end of 2015 planned CPA projects will bring the total to ~127 PWs
- these CPA projects represent ~$4.3B of effort by ~1600 people (no NIF or LMJ)
- these estimates do not include Exawatt scale projects currently being planned

New Scientific Regimes Calls for New Technologies ICAN

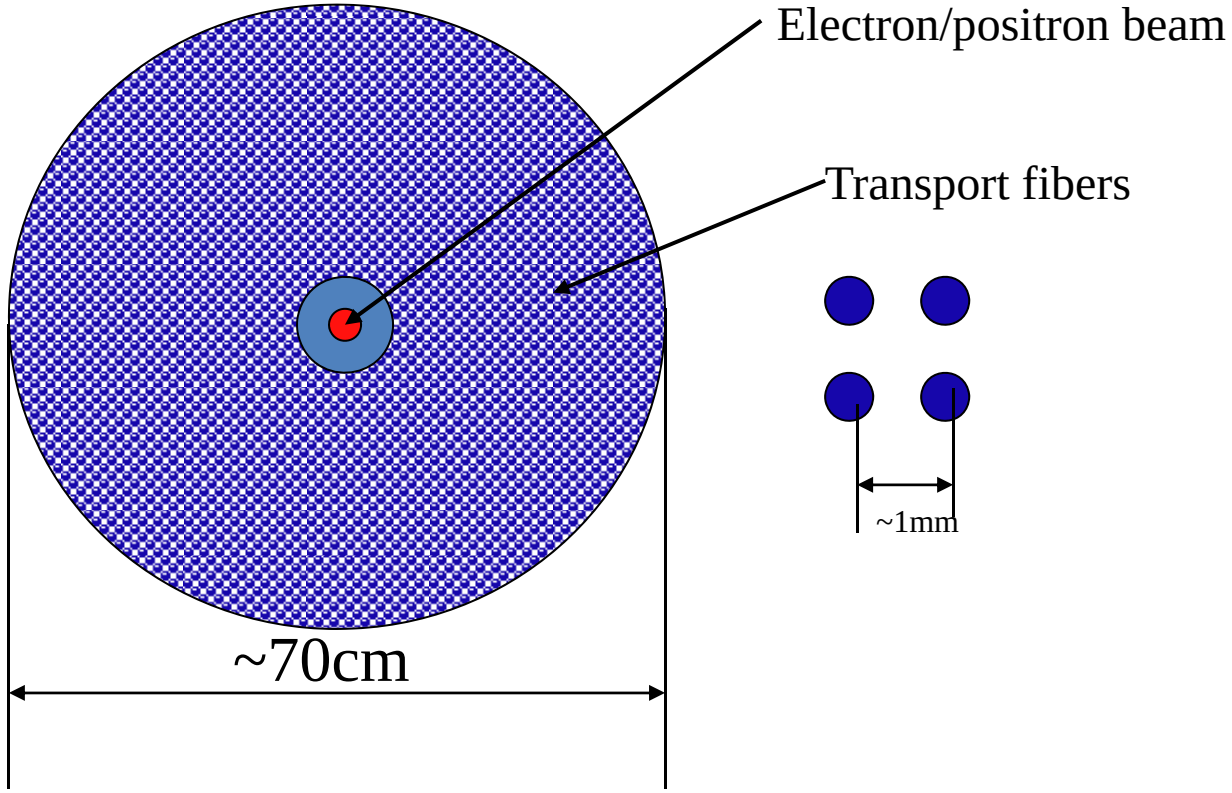
(recurrent)



G. Mourou (2005)

The CAN Concept

10^4 fibers all coherently phased.



Length of a fiber ~2m Total fiber length~ 5 10^4km