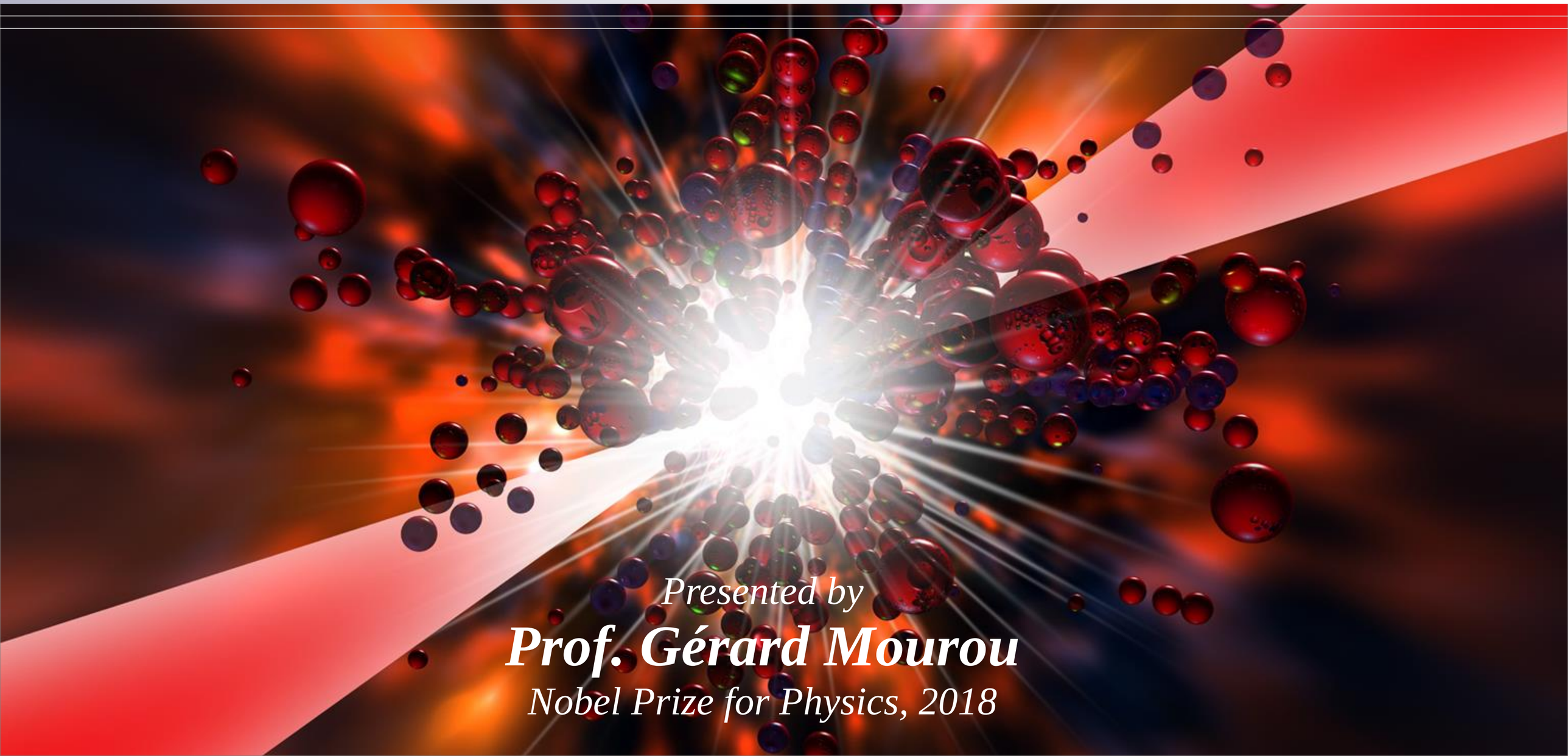
A PASSION FOR EXTREME LIGHT : CLEO MUNICH

For the Greatest Benefit of Human Kind



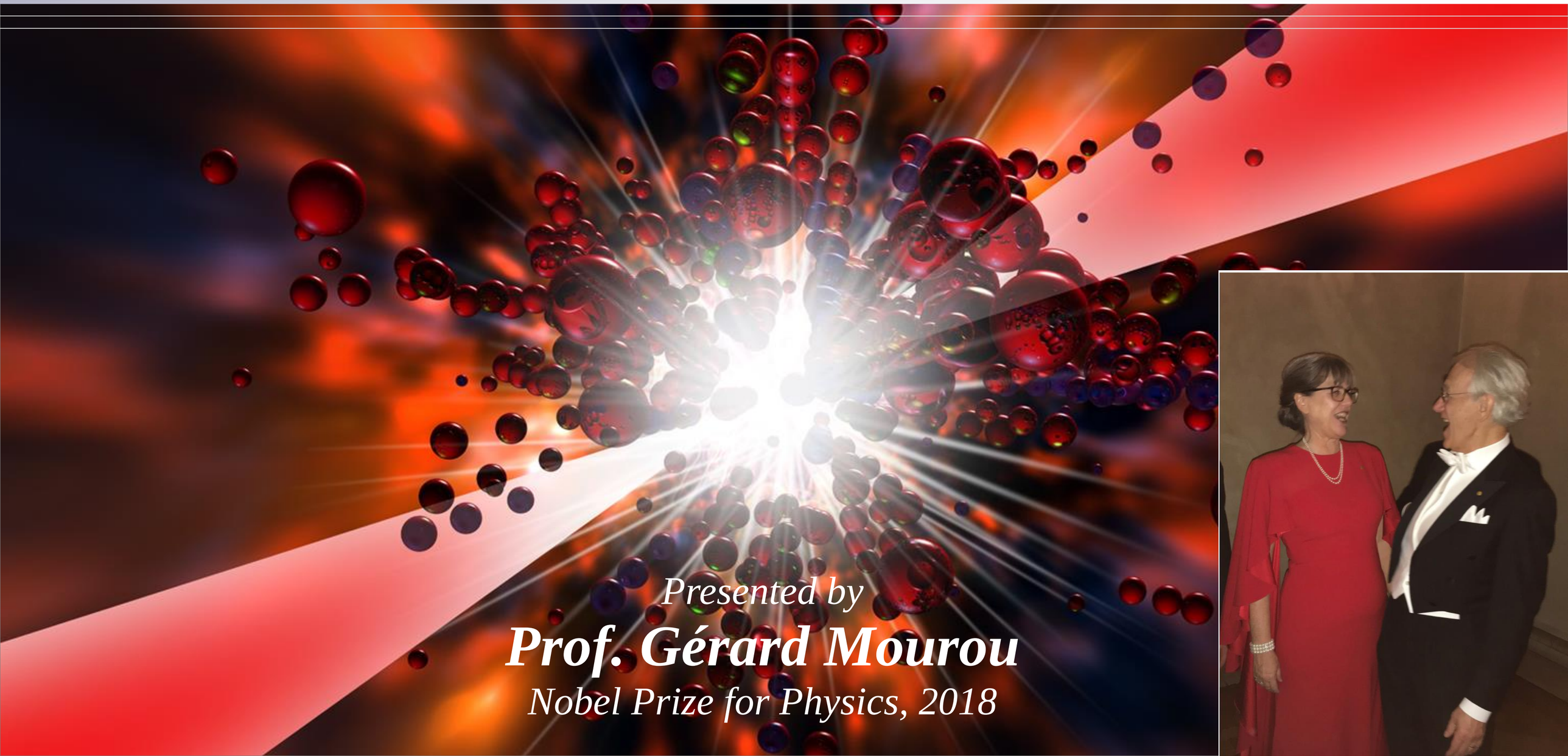
Presented by

Prof. Gérard Mourou

Nobel Prize for Physics, 2018

A PASSION FOR EXTREME LIGHT: MARSEILLE

For the Greatest Benefit of Human Kind



Presented by

Prof. Gérard Mourou

Nobel Prize for Physics, 2018

A PASSION FOR EXTREME LIGHT

For the greatest benefit to human kind (Alfred Nobel)

Theodore Maiman

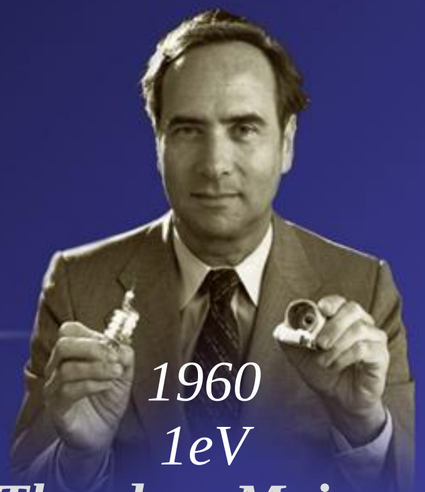
(July 11, 1927 – May 5, 2007)

A PASSION FOR EXTREME LIGHT

For the greatest benefit to human kind (Alfred Nobel)

Slowing down atoms

2018



1960

1eV

Theodore Maiman

(July 11, 1927 – May 5, 2007)

A PASSION FOR EXTREME LIGHT

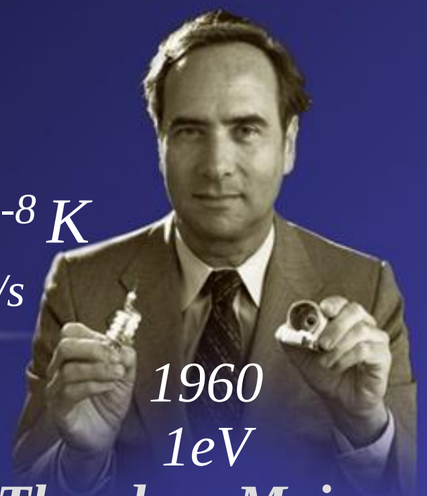
For the greatest benefit to human kind (Alfred Nobel)

Quantum Optics

μeV – peV Temp.= 10 $^{-8}$ K

K Slowing down atoms to cm/s

2018



1960

1eV

Theodore Maiman

(July 11, 1927 – May 5, 2007)

Atomic Molecular Optics

**** cold atoms***
**** metrology***
**** atom optics***
**** condensed-matter physics***
**** quantum information science***
**** chemistry***

A PASSION FOR EXTREME LIGHT

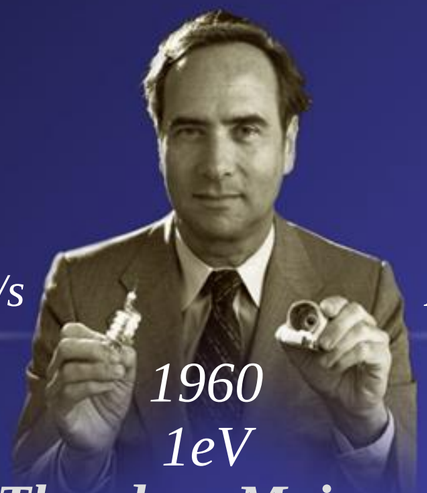
For the greatest benefit to human kind (Alfred Nobel)

Quantum Optics

μeV - neV

Slowing down atoms to cm/s

2018



1960

1eV

Theodore Maiman

(July 11, 1927 – May 5, 2007)

Accelerating particles to C

2018

Atomic Molecular Optics

**** cold atoms***
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A PASSION FOR EXTREME LIGHT

For the greatest benefit to human kind (Alfred Nobel)

Quantum Optics

μeV – peV Temp =10 $^{-8}$ K

Slowing down atoms to cm/s

2018

1960

1eV

Theodore Maiman

(July 11, 1927 – May 5, 2007)

Relativistic Optics

GeV - TeV

Accelerating particles to C

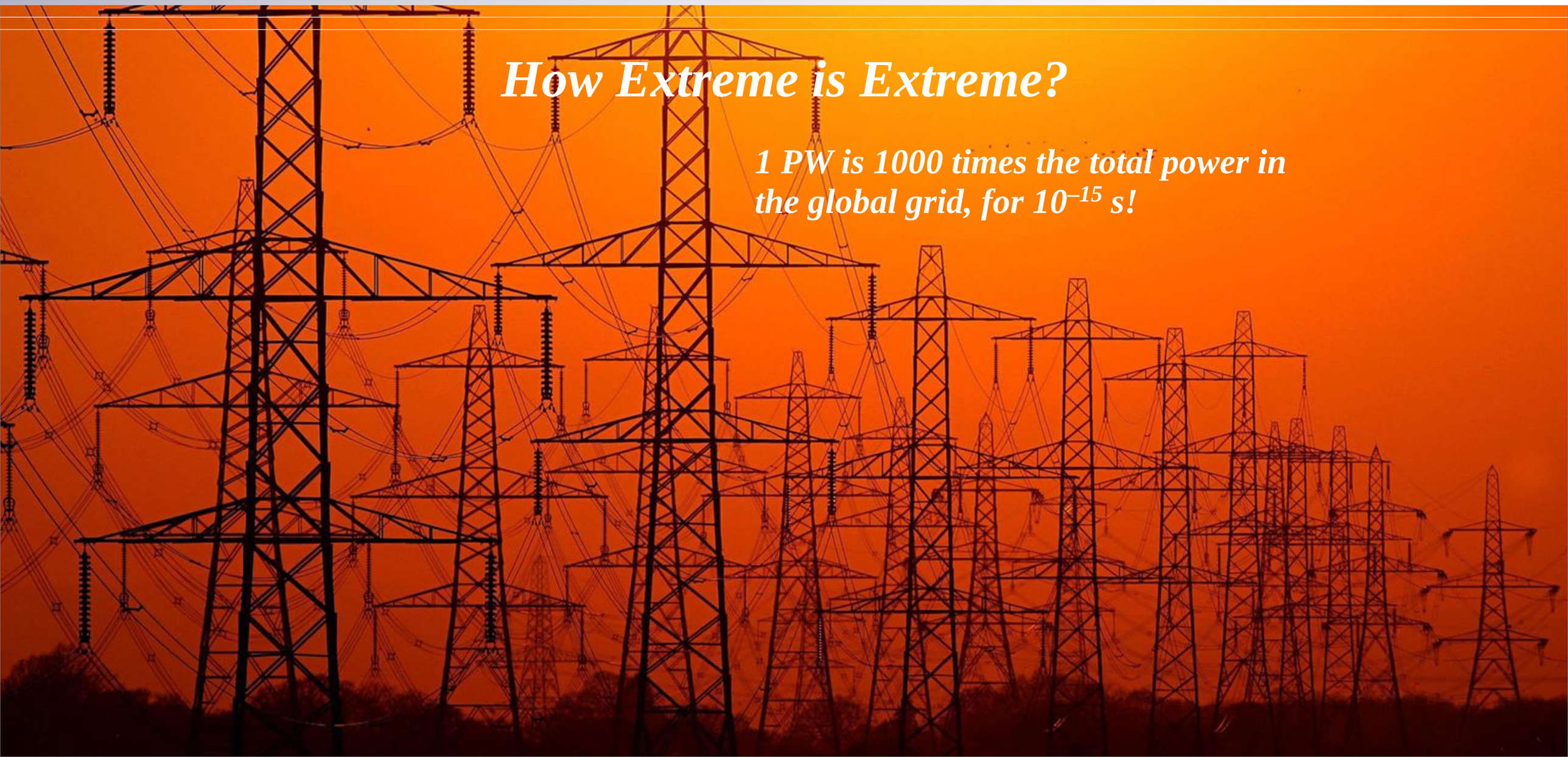
2018

Atomic Molecular Optics

**** cold atoms***
**** metrology***
**** atom optics***
**** condensed-matter physics***
**** quantum information science***
**** chemistry***

Relativistic and Ultra-relativistic Optics

**** accelerator physics***
**** nuclear physics***
**** cosmology***
**** NL QED***
**** general relativity***
**** extradimension physics***



How Extreme is Extreme?

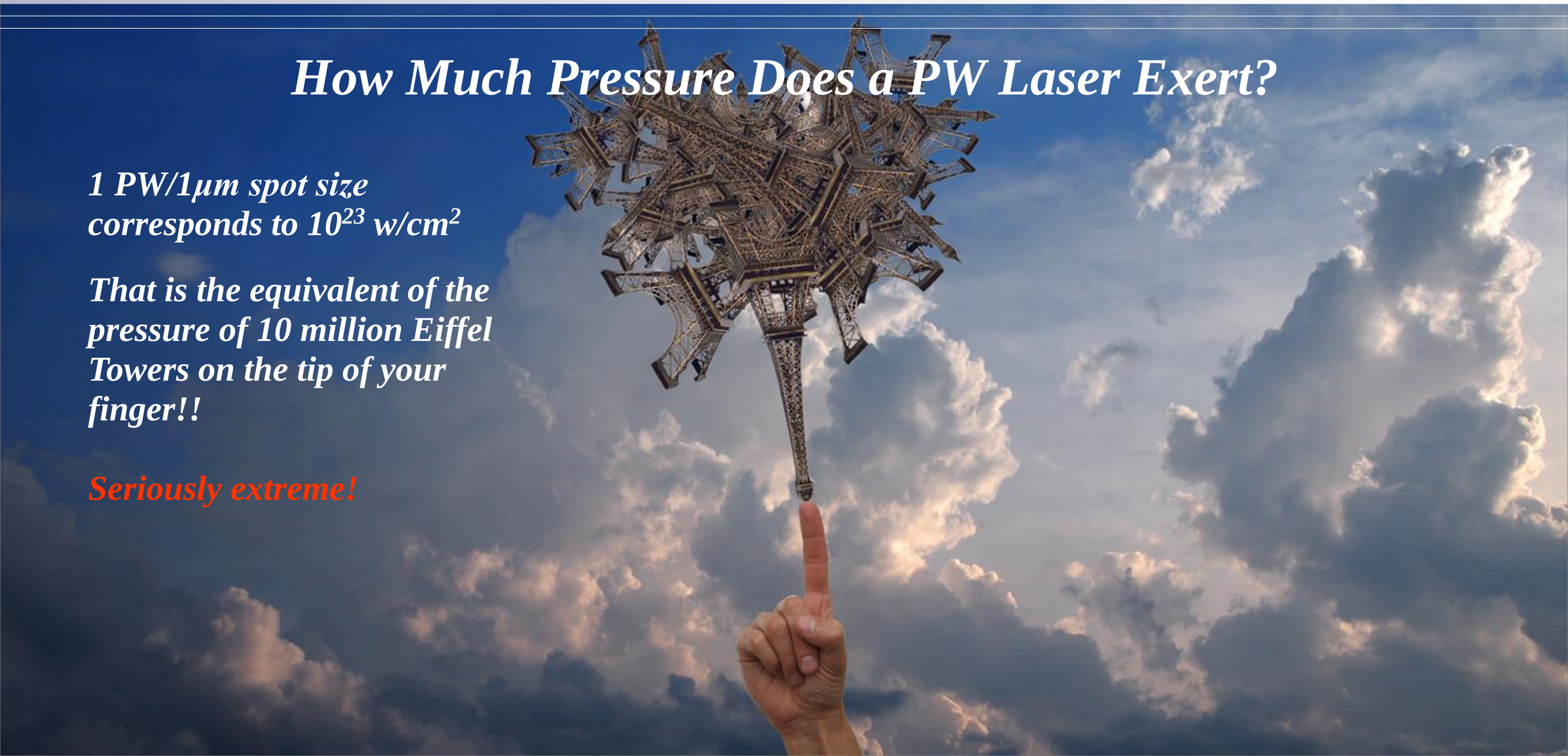
1 PW is 1000 times the total power in the global grid, for 10^{-15} s!

How Much Pressure Does a PW Laser Exert?

1 PW/1μm spot size corresponds to 10^{23} w/cm^2

That is the equivalent of the pressure of 10 million Eiffel Towers on the tip of your finger!!

Seriously extreme!



Chirped Pulse Amplification

D. Strickland and G. Mourou 1985

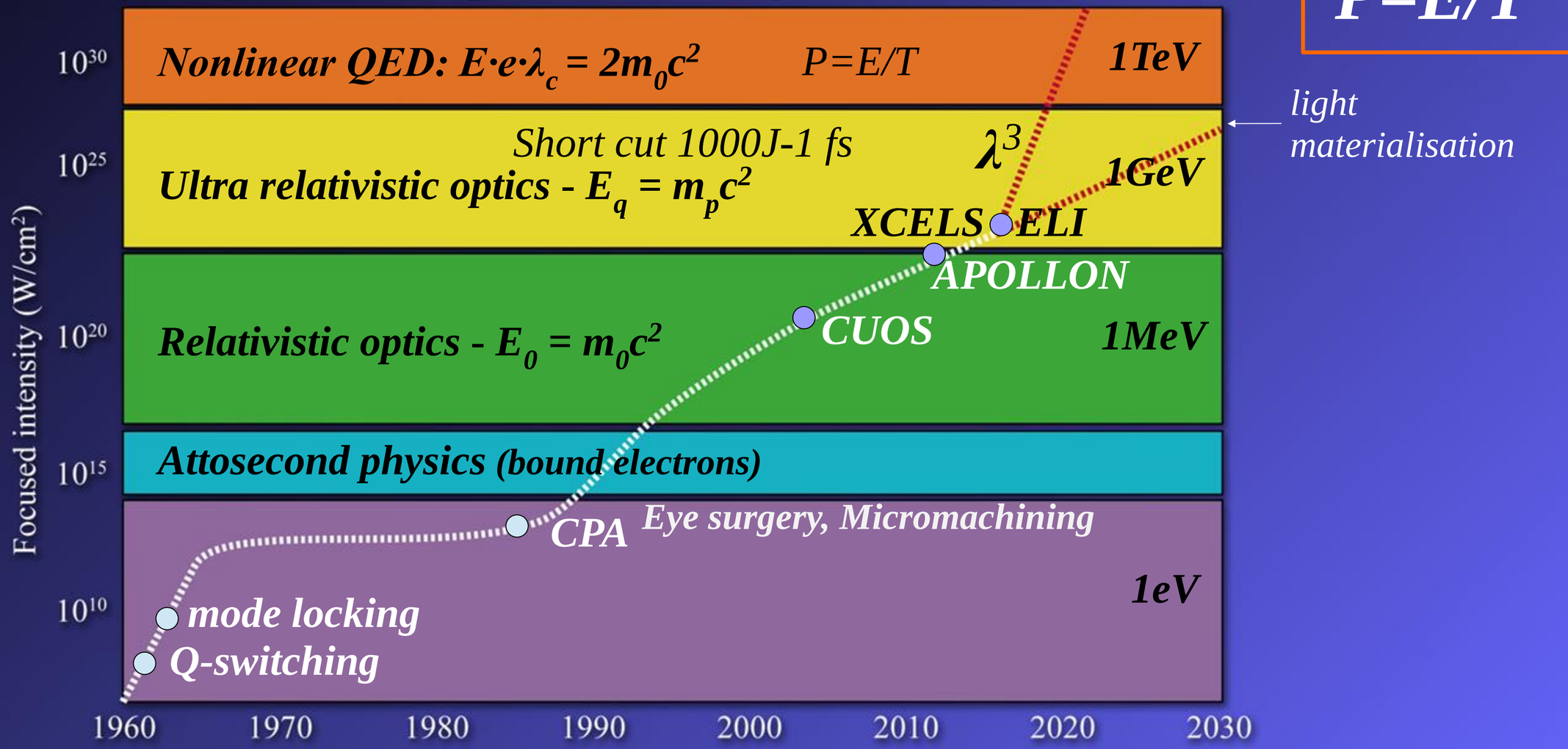
Chirped Pulses Amplification CPA

A PASSION FOR EXTREME LIGHT

For the greatest benefit to human kind (Alfred Nobel)

Extreme light roadmap and ultra high intensity shortcut

P=E/T



Extreme Light Infrastructure - ELI

The Largest Civilian Laser Infrastructure

Initiated and Coordinated(PP) by, G. Mourou (EP)
ELI (Delivery Consortium) W. Sandners

Czech Republic

Hungary

Romania

Trondheim University

IZEST
International Zeta-Exawatt Science Technology

International Year of Light 2015

A PASSION FOR EXTREME LIGHT

For the greatest benefit to human kind (Alfred Nobel)

Giant wakefield acceleration in gas and solid

Tajima et Dawson (1979)

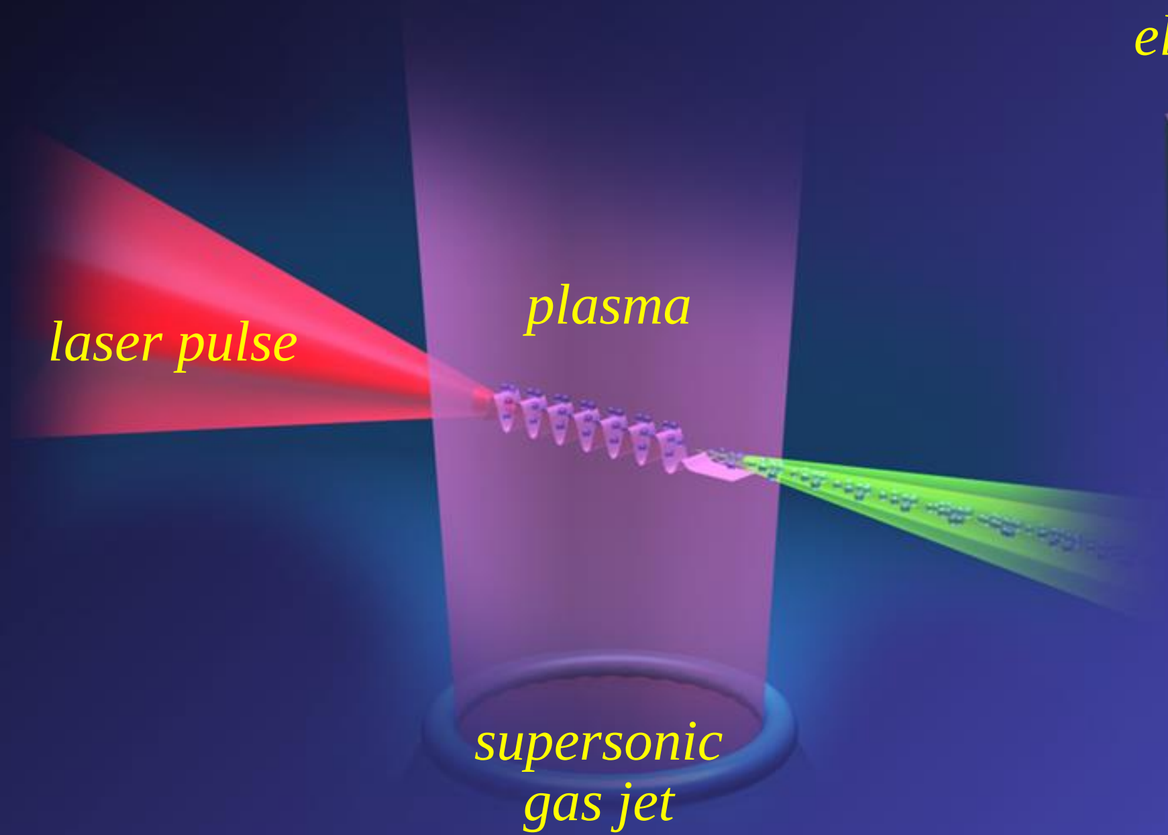
A surfer riding down the face of a wave is accelerated by energy of the wave

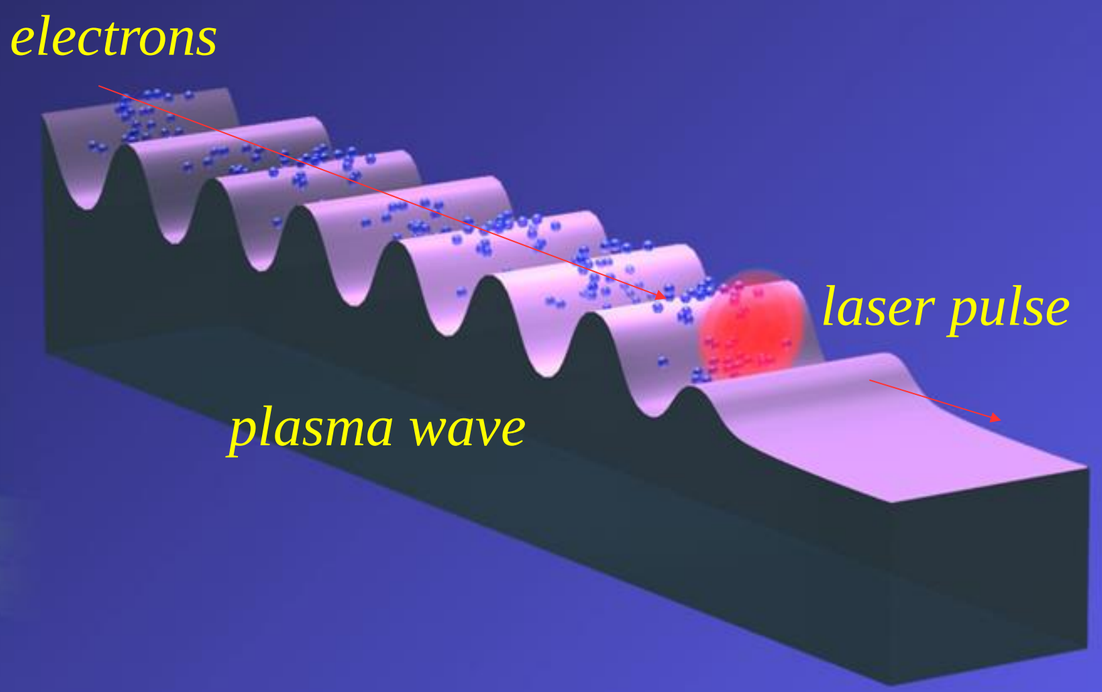
A PASSION FOR EXTREME LIGHT

For the greatest benefit to human kind (Alfred Nobel)

Giant wakefield acceleration

Tajima et Dawson (1979)

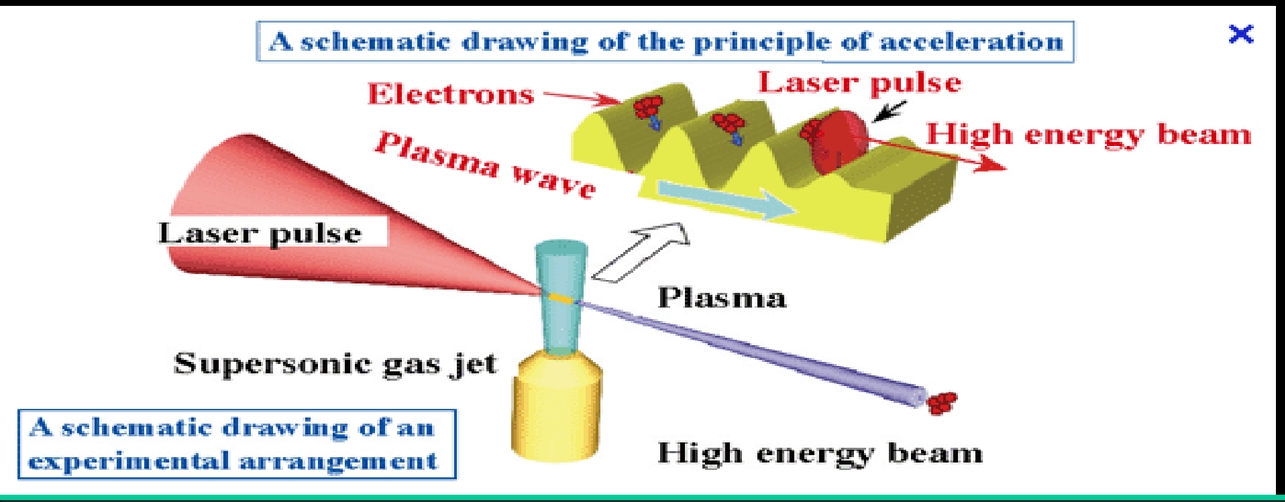




High Energy beam
GeV/cm

Giant Wake Field Acceleration in Gas and Solid

Femtosecond Visible Light Driver in Gas ***Tajima et Dawson 1979***



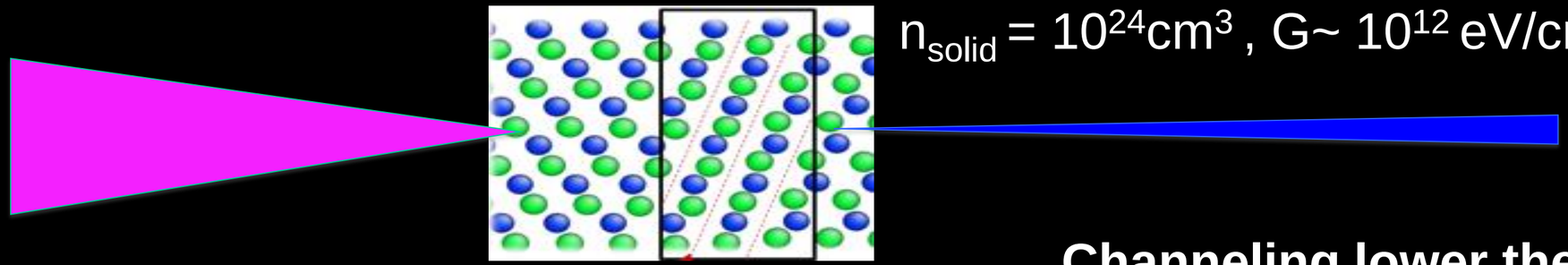
Plasma Acceleration Energy Gain

$G \alpha n^{1/2}$ eV/cm

1eV light $n_c \sim 10^{21} cm^{-3}$

$n_{gas} = 10^{18} cm^{-3}$, G~ 10^{9}, GeV/cm

Atto-zepto, X-ray Driver, Solid, ***Tajima et Cavenago 1987***

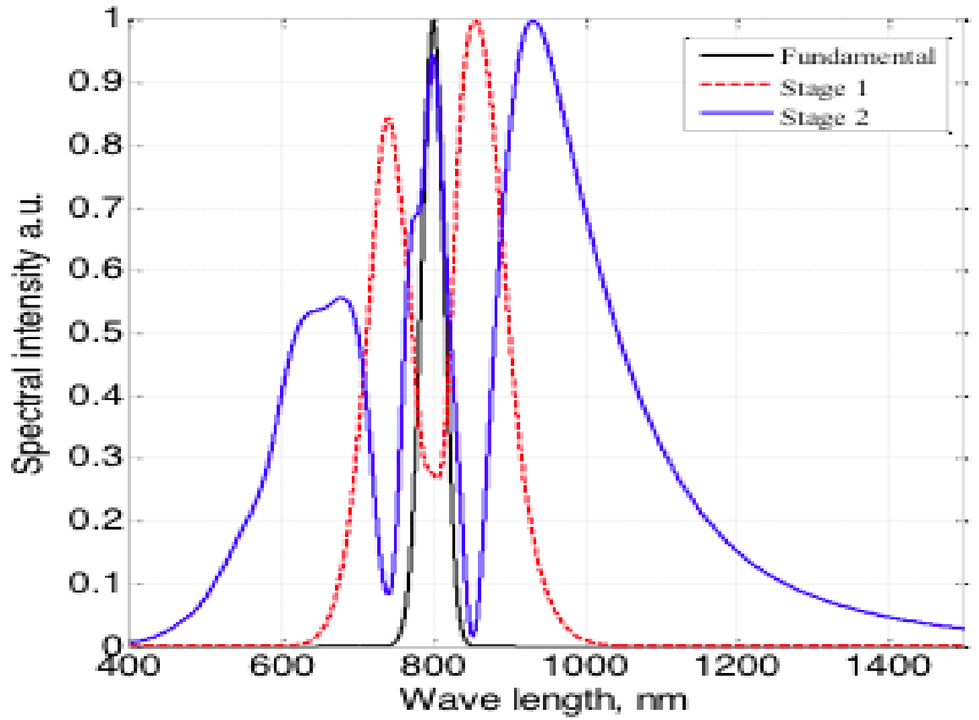


$n_{solid} = 10^{24} cm^{3}$, G~ 10^{12} eV/cm, TeVcm

Drive pulse X-Ray, 600zs
+ as electron pulse

Channeling lower the emittance
Valid for electron, muons, heavy ions

Thin Film Pulse Compression



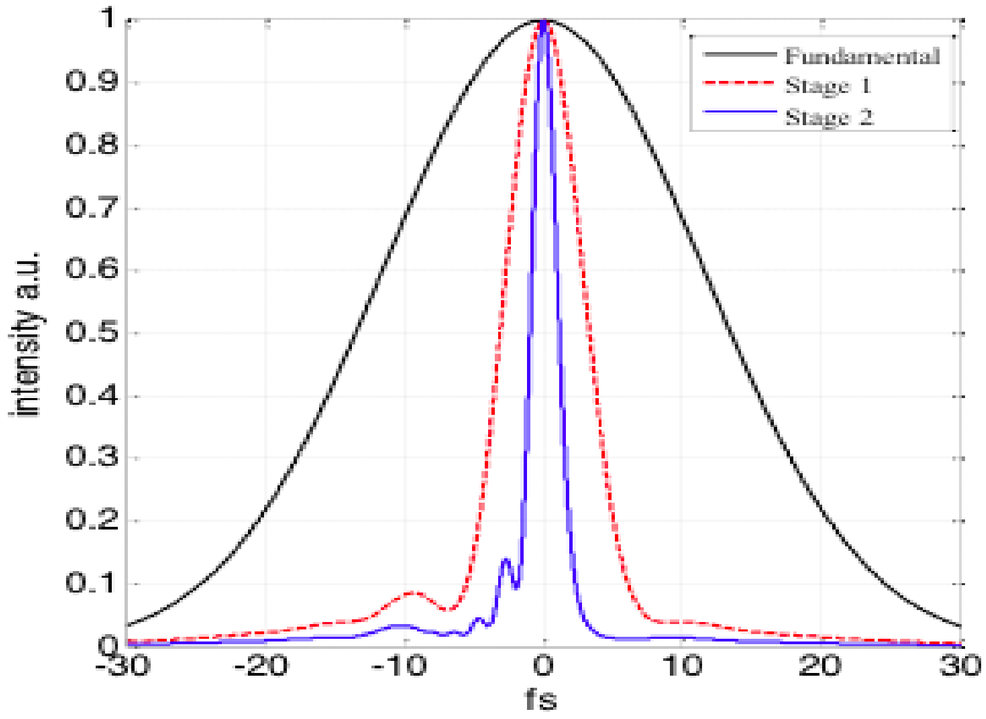


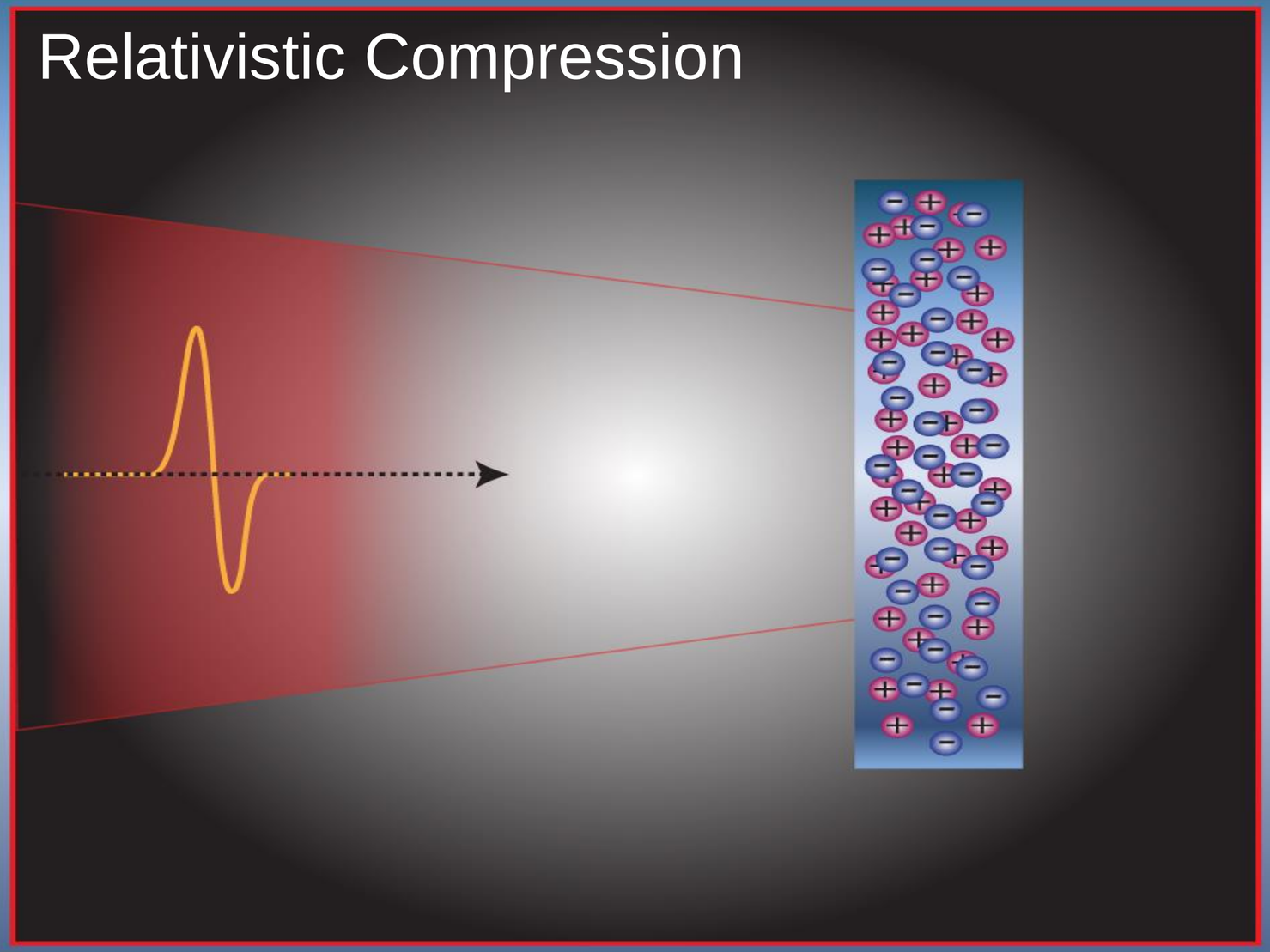
Fig. 4 shows the successive spectra and pulse durations corresponding to the laser out put, after the first stage and second stage. After the first stage the pulse 6.4fs, after the second stage the pulse is shrunk to 2.1fs

Relativistic Compression
Scalable Isolated Attosecond Pulses

N. M. Naumova, J. A. Nees, I. V. Sokolov, B. Hou, and G. A. Mourou,

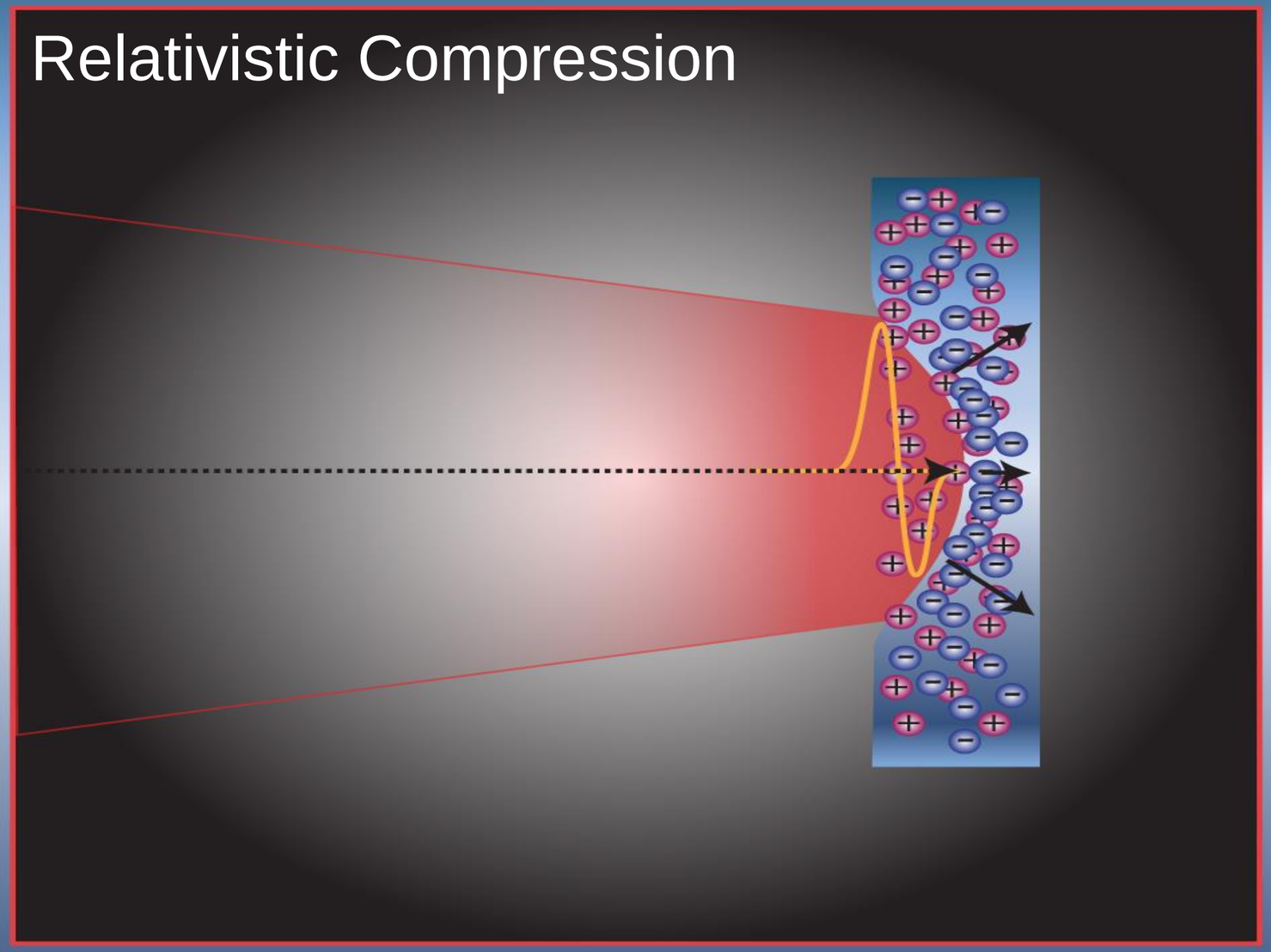
Relativistic generation
of Isolated attosecond Pulses in a λ^3 Focal Volume, Phys. Rev. Lett. 92, 063902-1 (2004).

Relativistic Compression

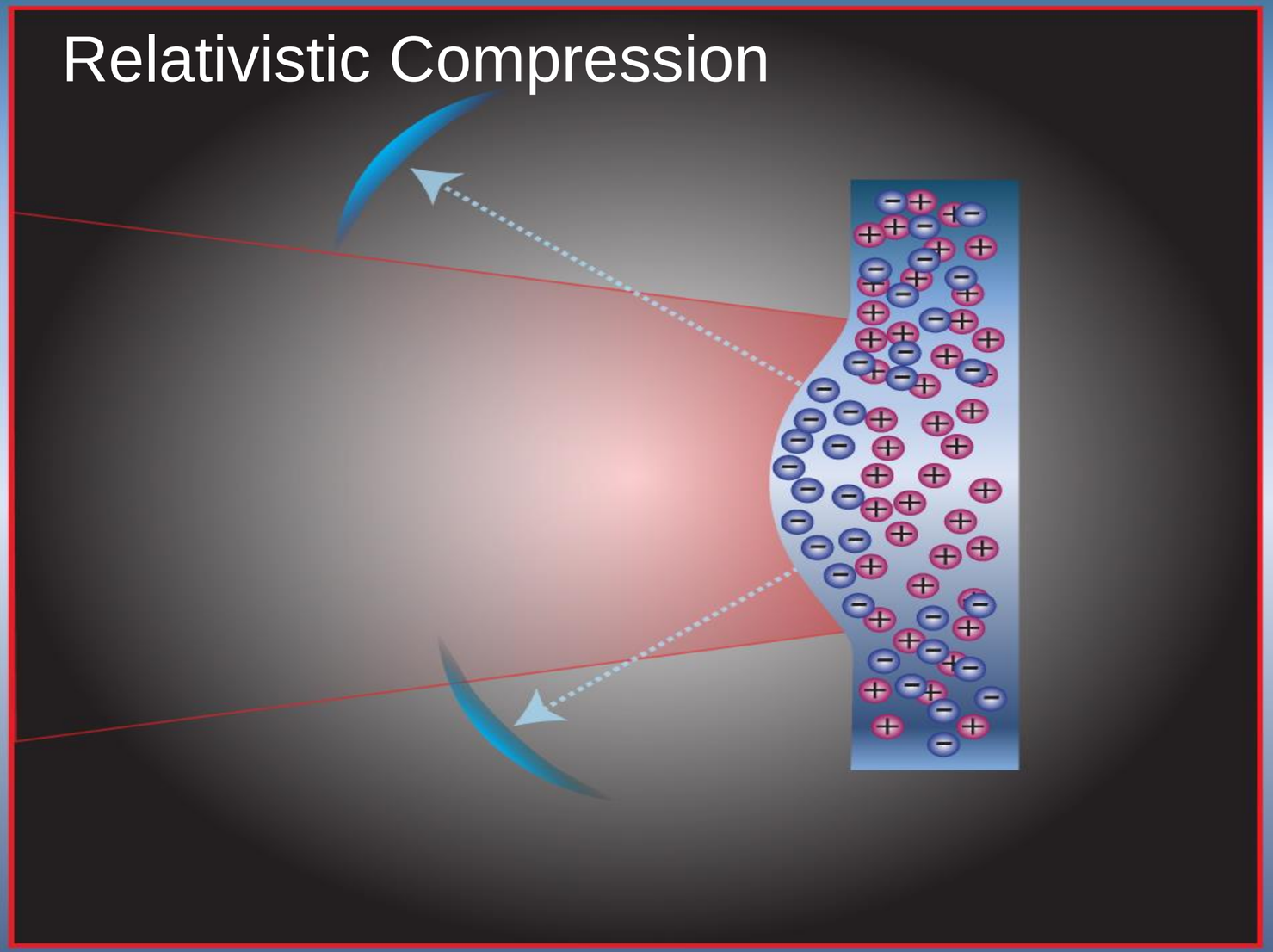


Georgia tech

Relativistic Compression



Relativistic Compression



Scalable Isolated Attosecond Pulses

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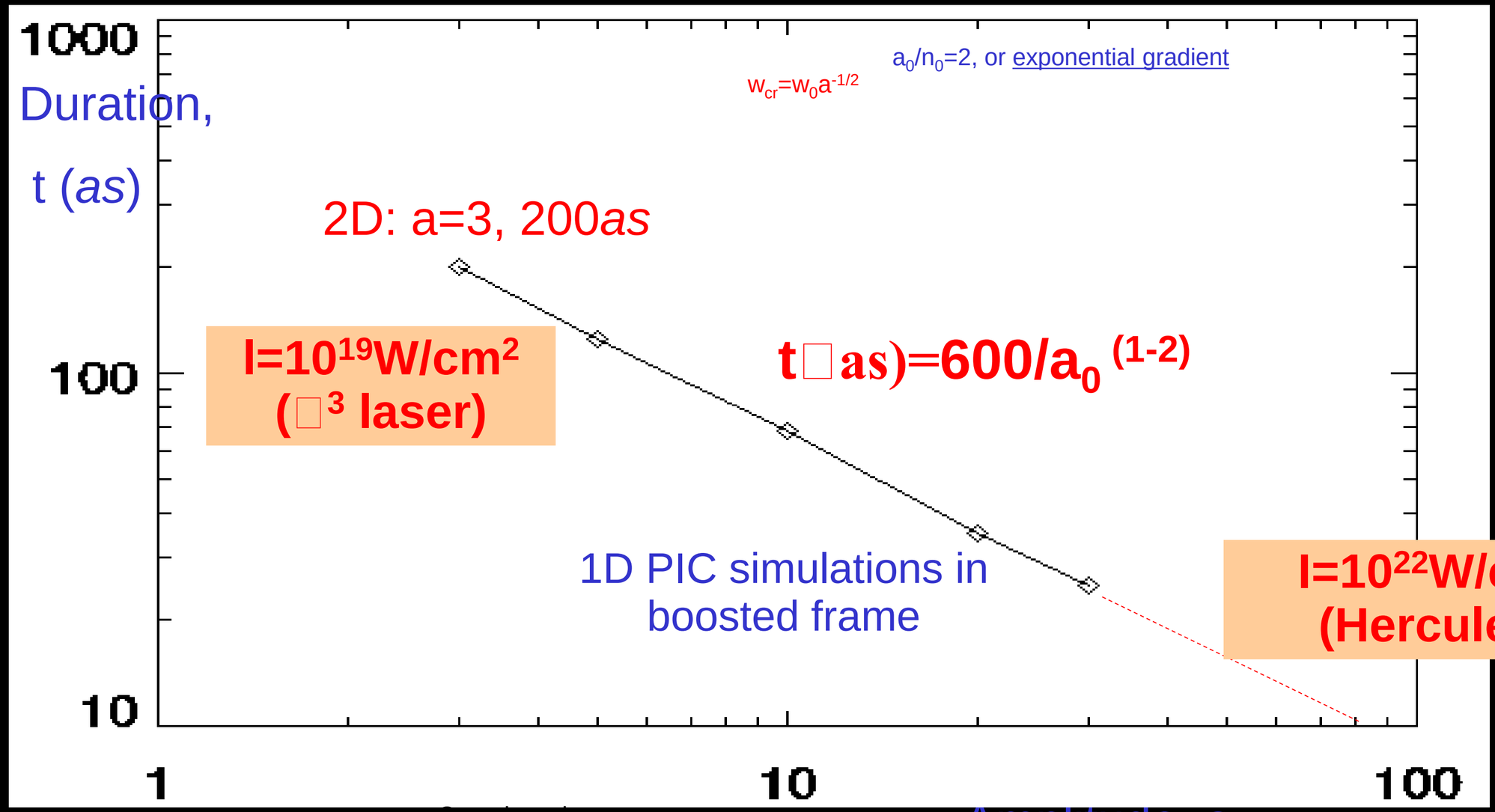
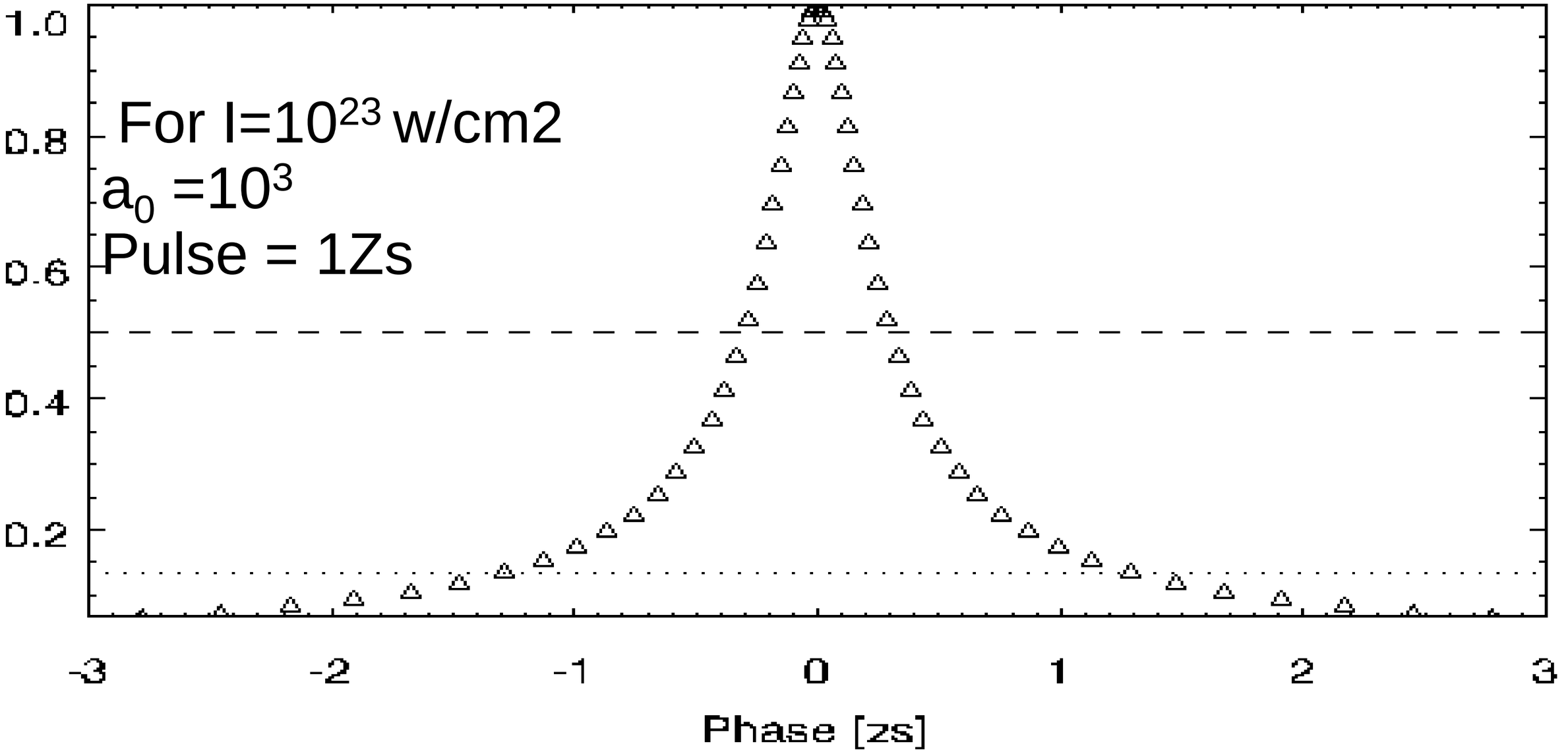


Zeptosecond pulses, (N. Naumova, I. Sokolov, G. Mourou)
(Preliminary Result)



Laser-Wake-Field Acceleration
Gas/Light vs Solid/ X-Ray

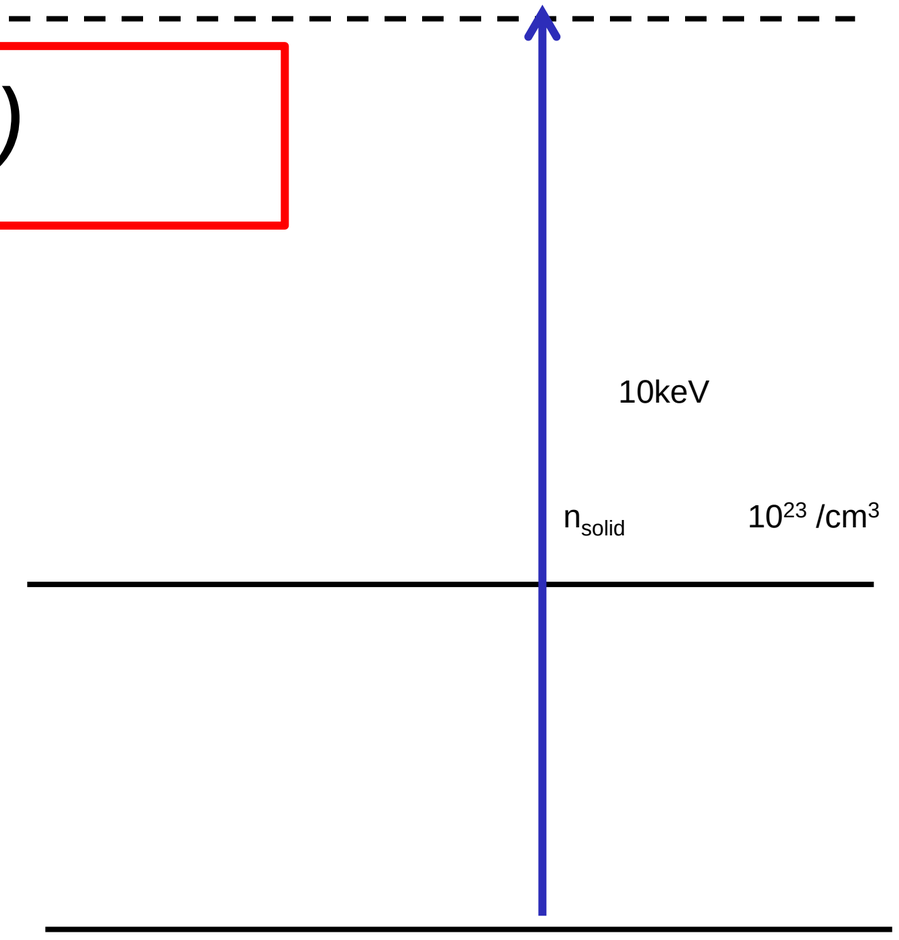
Serendipity at its best

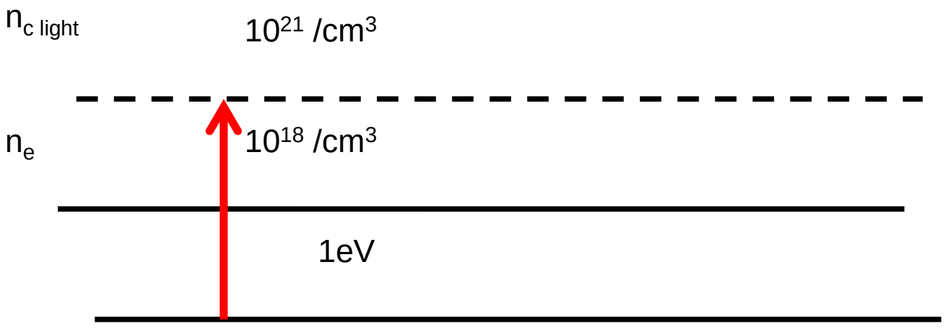
$n_{c\ for\ X\text{-}ray}$ 10^{29} /cm^3

Energy Gain $E=a_0^2 m_o c^2 (n_c/n_e)$

In the visible $n_c = 10^{21}$/cm^3 Low gaz density

In the X-ray, $n_c = 10^{29}$/cm^3 Solid density

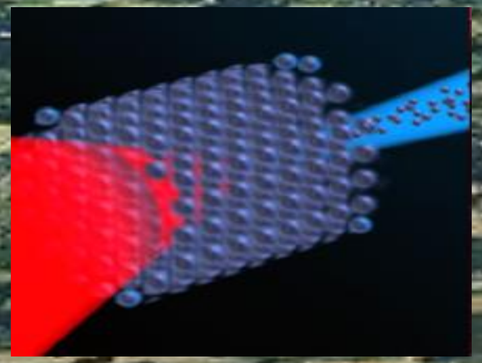


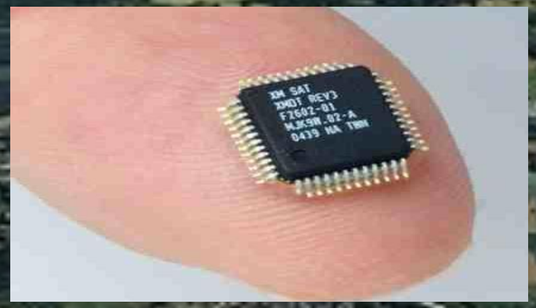


Outlook for Laser-Particle acceleration TeV

Microwave cavity

Laser wakefield X-ray, 1cm

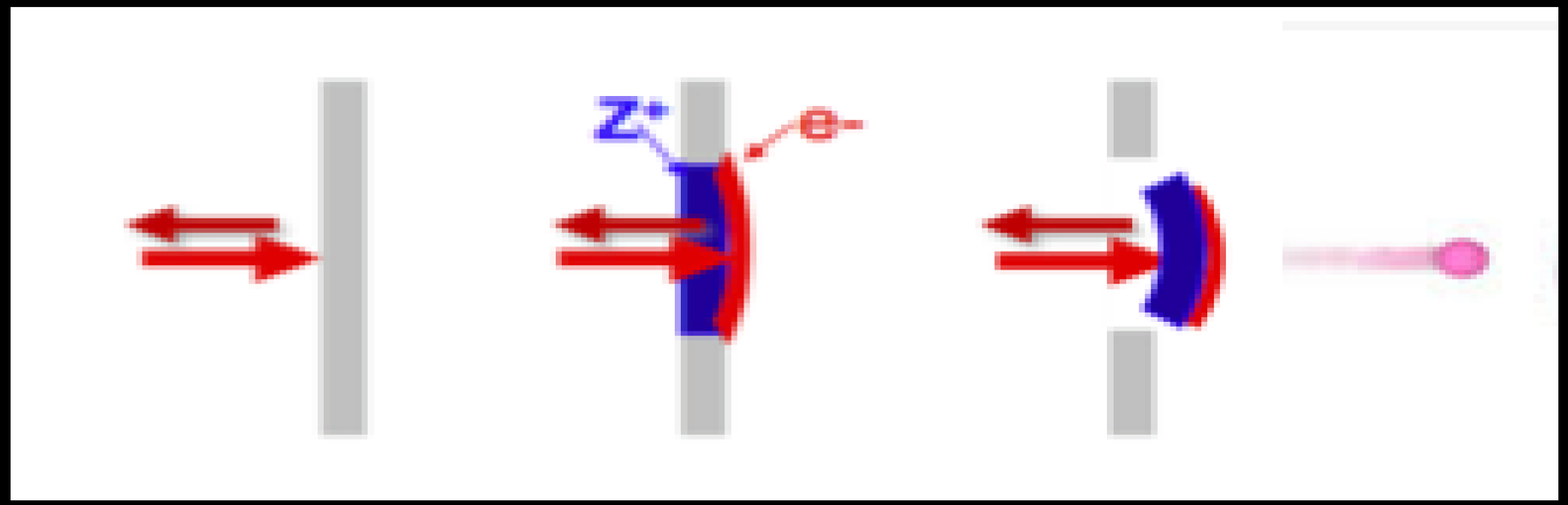




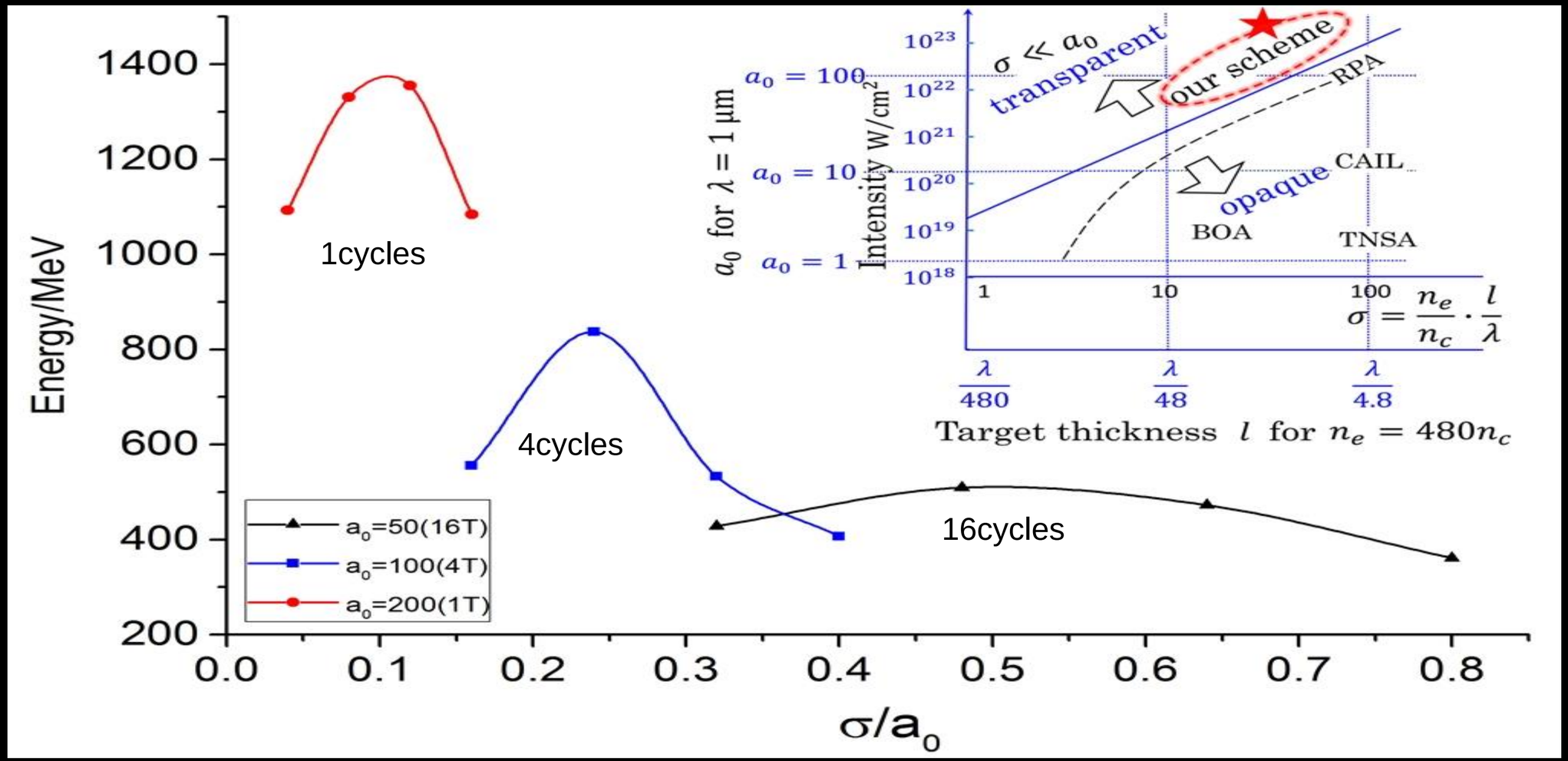
Laser wakefield Visible 100m

Low Hanging Fruit: High Energy Proton Generation

GeV Proton Generation



Applications of Single Cycle to Proton Generation vs a_0



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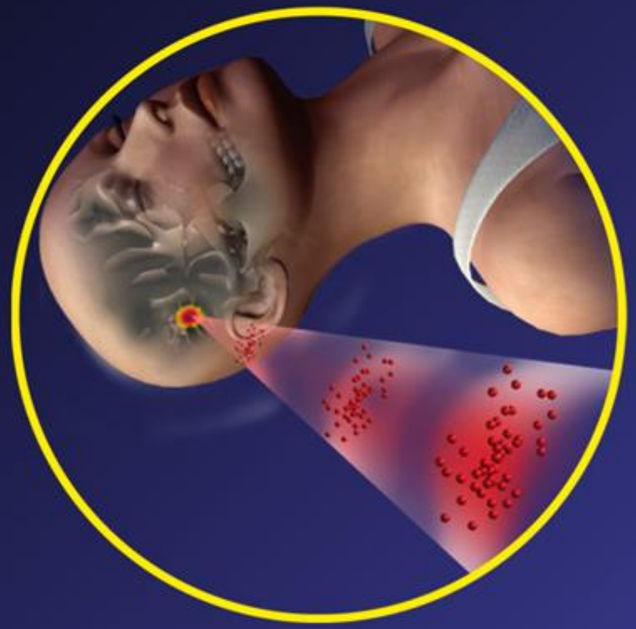
For the greatest benefit to human kind (Alfred Nobel)

RELATIVISTIC PROTON ACCELERATOR for TRANSMUTATION

Projet MYRRHA

CPA in Nuclear Medicine

Proton therapy



Extreme light technology will be tens of times more compact, more precise and less expensive

Nuclear therapy

Radionuclides are used to implant radioactive pellets directly into a tumour

Nuclear diagnostics

When a scanner needs a radioisotope, extreme laser acceleration in the clinic would make this fast and safer

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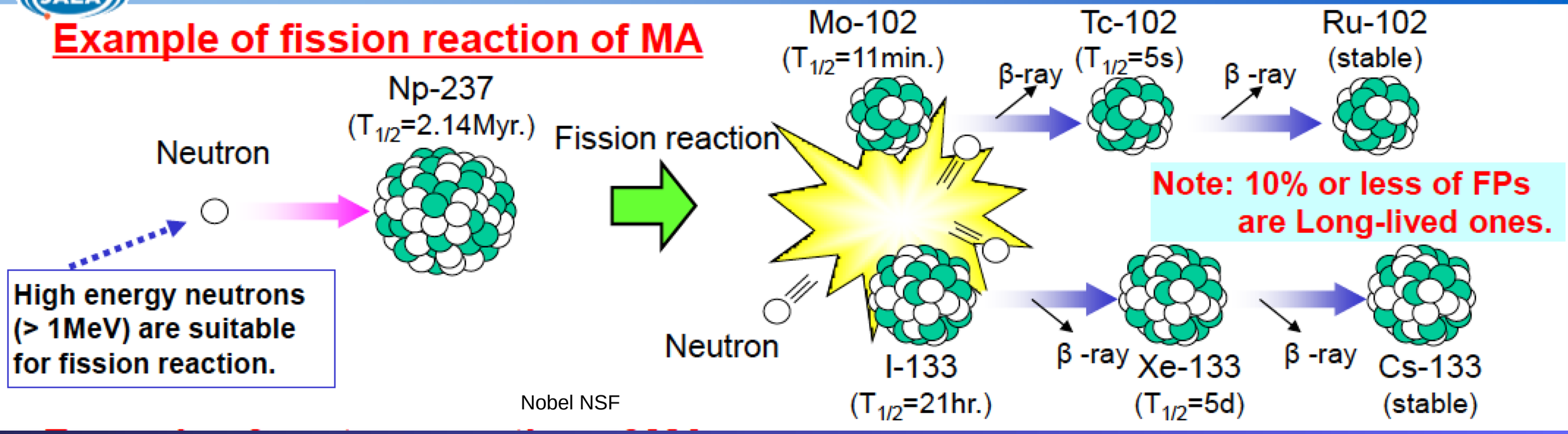
CPA Mitigating Nuclear waste

NUCLEAR TRANSMUTATION CONCEPT

How to Transmute MA and LLFP

JAEA

Example of fission reaction of MA



Nobel NSF

Extreme Light Grand Challenges: Scientific and Societal Applications

Scientific Applications

Laser Astrophysics and Cosmology

Polarization of Vacuum, Materialization of Light

Beyond the Standard Model

Higgs Factory

Dark Matter

Societal Applications

Transmutation of Nuclear Waste

Under Critical Reactor

Nuclear Pharmacology

Proton Therapy

Orbital Debris Elimination by Deorbitation

IZEST
International Zeta-Exawatt Science Technology

International Year of Light 2015

In conclusion, extreme light is capable of generating the largest fields, largest accelerations, the largest temperatures and the largest pressures

It carries the best hopes and opportunities for the future of science and society

The best is yet to come!


gettyimages
JONATHAN NACKSTRAND
1071247972

A PASSION FOR EXTREME LIGHT

For the greatest benefit to human kind (Alfred Nobel)

Thank you!!